MPLAB® Harmony Help - Volume I - Getting Started with MPLAB Harmony

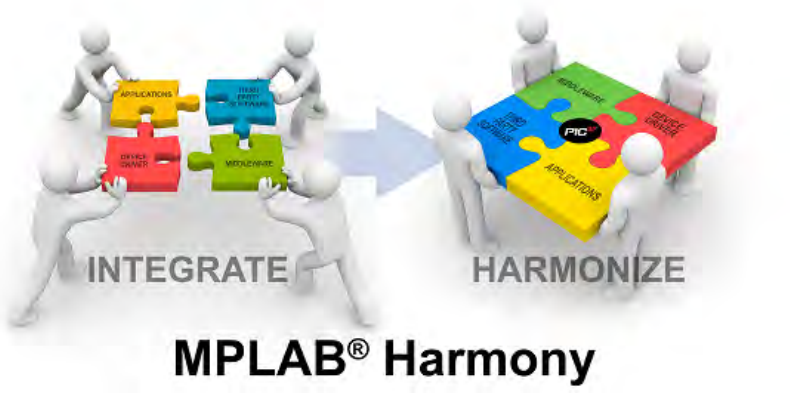
MPLAB Harmony Integrated Software Framework v1.11

Volume I: Getting Started With MPLAB Harmony

This volume introduces the MPLAB® Harmony Integrated Software Framework.

Description

MPLAB Harmony is a layered framework of modular libraries that provide flexible and interoperable software "building blocks" for developing embedded PIC32 applications. MPLAB Harmony is also part of a broad and expandable ecosystem, providing demonstration applications, third-party offerings, and convenient development tools, such as the MPLAB Harmony Configurator (MHC), which integrate with the MPLAB X IDE and MPLAB XC32 language tools.



Legal Notices

Please review the *Software License Agreement* prior to using MPLAB Harmony. It is the responsibility of the end-user to know and understand the software license agreement terms regarding the Microchip and third-party software that is provided in this installation. A copy of the agreement is available in the `<install-dir>/doc` folder of your MPLAB Harmony installation.

The OPENRTOS® demonstrations provided in MPLAB Harmony use the OPENRTOS evaluation license, which is meant for demonstration purposes only. Customers desiring development and production on OPENRTOS must procure a suitable license. Please refer to one of the following documents, which are located in the `<install-dir>/third_party/rtos/OPENRTOS/Documents` folder of your MPLAB Harmony installation, for information on obtaining an evaluation license for your device:

- `OpenRTOS Click Thru Eval License PIC32MXxx.pdf`
- `OpenRTOS Click Thru Eval License PIC32MZxx.pdf`

TIP!

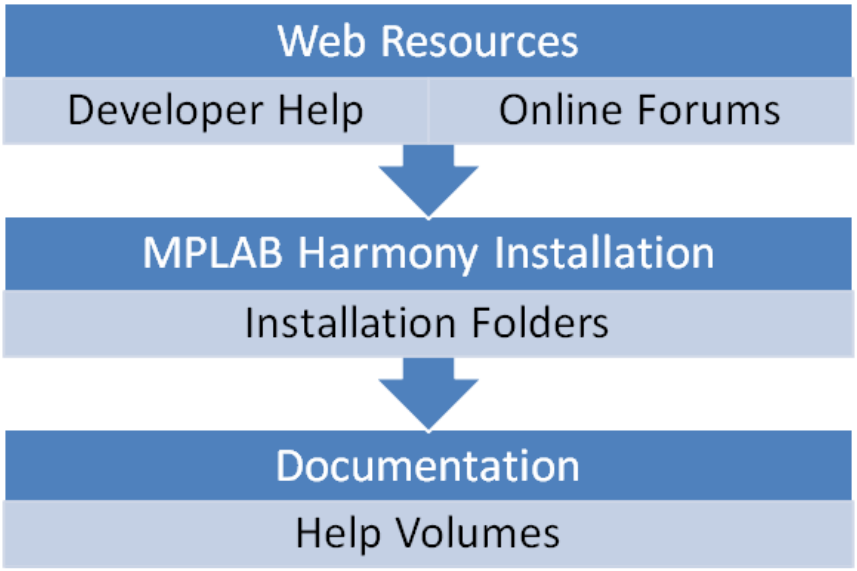
Throughout this documentation, occurrences of `<install-dir>` refer to the default MPLAB Harmony installation path:

- Windows: `C:/microchip/harmony/<version>`
- Mac OS/Linux: `~/microchip/harmony/<version>`

Guided Tour

Provides a quick guided tour of the MPLAB Harmony installation and documentation and describes where to find additional information and help.

Description



Where to Begin

The help documentation provides a comprehensive source of information on how to use and understand MPLAB Harmony. However, you don't need to read the entire document before you start working with MPLAB Harmony.

Prior to using MPLAB Harmony, it is recommended to review the Release Notes for any known issues. A PDF copy of the release notes is provided in the `<install-dir>/doc` folder of your installation.

New Users

If you are completely new to MPLAB Harmony, it is best to follow the Guided Tour.

More Experienced Users

If you are already somewhat familiar with the MPLAB Harmony installation and online resources and you want to jump right into a specific topic, you can use the links in the following table.

Start here...	If you...
Release Contents	...want to know what is included in this release.
Release Notes	...want to know what is new in this release and to learn of any known issues.
Prerequisites	...want to make sure that you have everything you need to begin working with MPLAB Harmony.
Using the Help	...want help using the documentation.
What is MPLAB Harmony?	...are new to MPLAB Harmony and need to understand the basic concepts.
MPLAB Harmony Development	...want to know how to develop MPLAB Harmony-compatible applications and libraries and how to best distribute and integrate them into an existing installation.
Creating Your First Project	...are ready to start creating your own MPLAB Harmony applications.
Porting and Updating to MPLAB Harmony	...are a MLA user and you need to port your application to MPLAB Harmony or you need information on updating an existing MPLAB Harmony project to a newer version of MPLAB Harmony.
Applications Help	...want to build and use the demonstration and example applications included in the installation.
MPLAB Harmony Framework Reference	...want to look up details on how to use the MPLAB Harmony framework libraries.
Third-Party Products Help	...need help with one of the third-party products included in this installation.
Board Support Package Help	...want to look up details on how to use MPLAB Harmony Board Support Packages.
Utilities Help	...need help using the MPLAB Harmony Configurator (MHC) or one of the other utilities included in this installation.
MHC Developer's Guide	...want information on how to create your own MPLAB Harmony library and integrated help.

MPLAB Harmony Compatibility Guide	...want to ensure software libraries you create are compatible with MPLAB Harmony.
Test Libraries Help	...want to know how to test your own MPLAB Harmony libraries.
Support	...need additional assistance.
Tips and Tricks	...want to learn more efficient and effective ways to use MPLAB Harmony.
Glossary	...need an explanation of the terms used in MPLAB Harmony.

Web Resources

Describes the main MPLAB Harmony Web site, from which you can download the installer and individual documents. Also describes where to find additional information, training, and the MPLAB Harmony online community.

Description

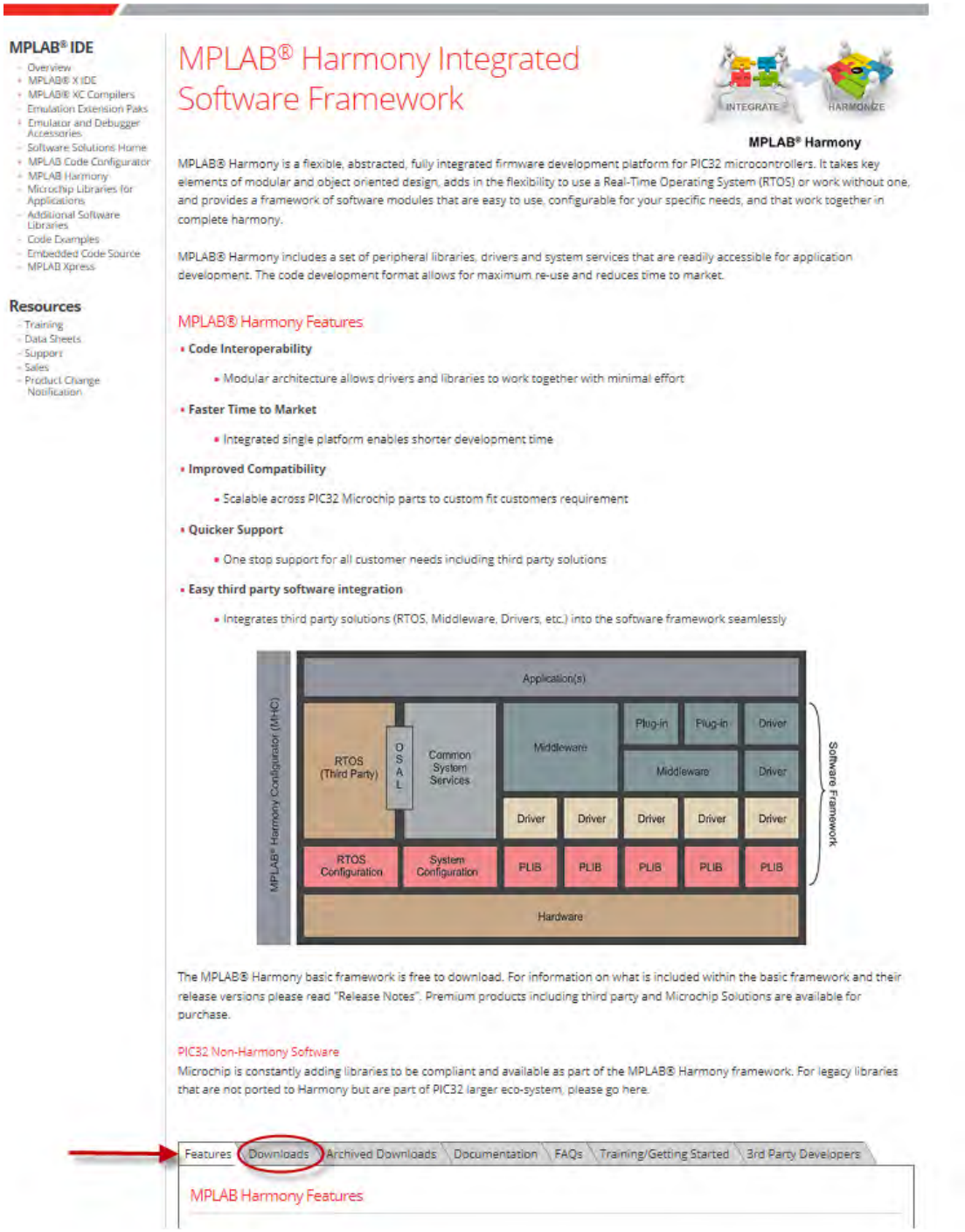
There are many Internet resources available for MPLAB Harmony, starting with the main MPLAB Harmony Web site:

www.microchip.com/harmony.

This site contains introductory information and links to download the MPLAB Harmony installer and related documentation (also included in the installation). It also provides links to other resources you may require such as the MPLAB X IDE and XC32 language tools.

If you have not already done so, you can download the appropriate installer for your development workstation from the MPLAB Harmony Web site using the Downloads tab, as shown in the following figure.

Note: The MPLAB Harmony installer is available for the Windows®, Linux, and Mac OS X platforms.



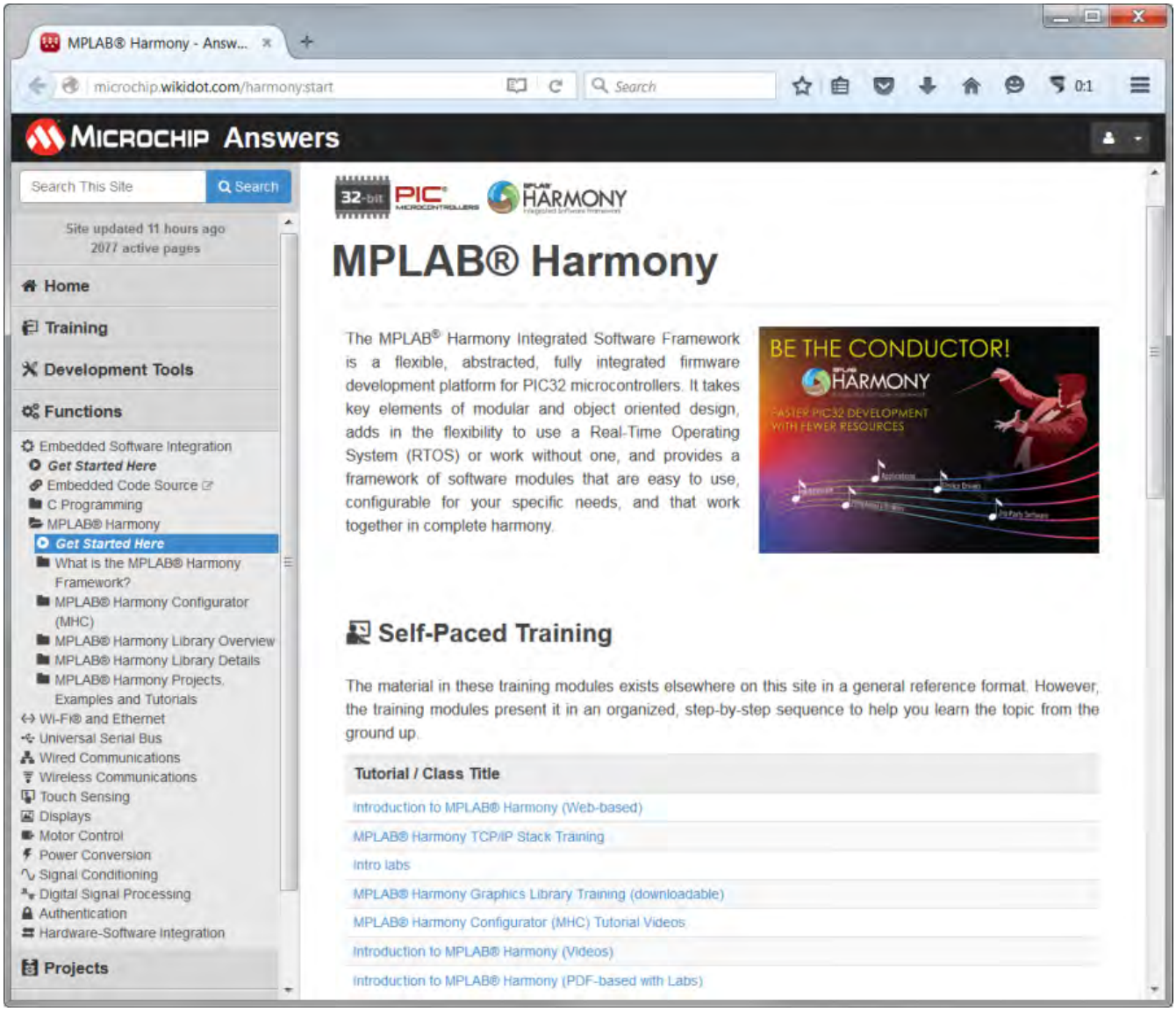
Note: Refer to The Microchip Web Site for additional information.

Developer Help

Describes the Microchip Developer Help wiki site, which includes instructional videos and training.

Description

If you're new to MPLAB Harmony development, online training is available from the Microchip Developer Help site: microchip.wikidot.com/harmony:start. This site provides short introductory videos, self-paced training modules, and answers to frequently asked questions.



Online Discussion Forum

Describes the MPLAB Harmony online community discussion forum.

Description

If you would like to interact with other MPLAB Harmony developers to share tips and tricks, you can sign onto the Microchip forums where you will find a forum dedicated to discussions about MPLAB Harmony. The Microchip Web Forums can be accessed online at: http://www.microchip.com/forums. From the Forums menu, select *Development Tools > MPLAB Harmony*.

Note: Refer to Microchip Forums for additional information.

Installation

Describes the contents and organization of the MPLAB Harmony installation.

Description

Default MPLAB Harmony Installation folders

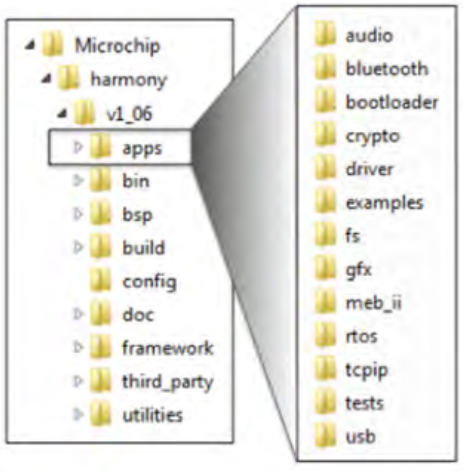
By default, MPLAB Harmony is installed into a version-specific folder.

- On Microsoft Windows Computers: `C:\Microchip\harmony\<version>`
- On Linux and Mac OS X Computers: `~/microchip/harmony/<version>`

Where `<version>` is the version number of the installation. For example, `v1_06`.

Top-level Installation Folders

Within the main installation folder, the top-level folders organize the contents of the installation by type. It is best to become familiar with the organization of the installation because it is mirrored in the documentation, in the configuration tree, and elsewhere for consistency.



apps Folder

The `apps` folder contains application projects that demonstrate how to use various MPLAB Harmony libraries. Applications are grouped by type into sub-folders, as follows:

- Technology (bluetooth, bootloaders,tcpip, rtos, usb)
- Market (audio, crypto, gfx)
- MPLAB Harmony Layer (drivers, fs)
- Board (examples, meb_ii, tests)

You can use these projects to explore the capabilities of MPLAB Harmony and the supported demonstration and development boards. They also provide excellent examples of how to use the libraries for different purposes and you can use them as a starting point for your own projects.

bin Folder

The `bin` folder contains prebuilt binary (`.a`) files for some of the MPLAB Harmony libraries. Most libraries are provided as source code or generated from templates, which are provided in source form. However, there are a few libraries for which source code must be specially licensed. Also, the MPLAB Harmony peripheral libraries (PLIBs), while provided in source form, are also provided prebuilt at a high-level of optimization (`-03`) so that users of the free version of the MPLAB XC32 C/C++ Compiler can take advantage of them.

bsp Folder

The `bsp` folder contains Board Support Packages (BSP) for the supported Microchip demonstration and development boards. An MPLAB Harmony BSP provides board-specific initialization and support code, configuration settings, and definitions that can be utilized by applications to more easily utilize the components provided on the selected board. Use of a BSP is not strictly required, because MPLAB Harmony libraries and applications can be configured without them. However, they are provided as a convenience to save the developer time tracing schematics and selecting configuration settings.

build Folder

The `build` folder provides MPLAB X IDE projects for the prebuilt libraries (in the `bin` folder) that are also provided in source form (like the PLIBs). This allows developers to modify settings such as optimization level or debug symbol support and rebuild the binary files, if desired.

config Folder

The `config` folder contains Hconfig configuration files for the MPLAB Harmony Configurator (MHC) graphical configuration utility used to simplify configuration of MPLAB Harmony projects. Hconfig files define the configuration options and menu choices for MPLAB Harmony libraries. They

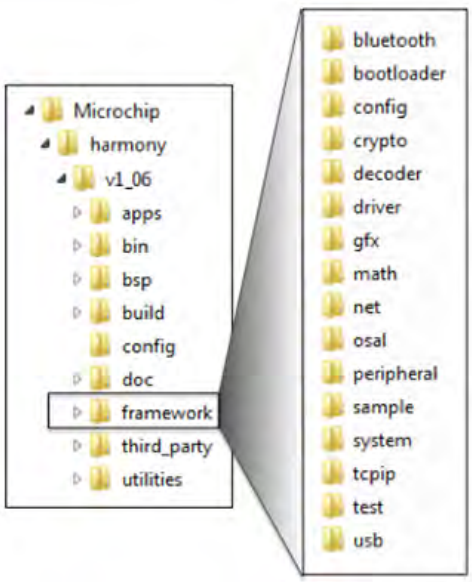
are linked together in a tree and you will find `config` folders and Hconfig files throughout the installation.

doc Folder

The `doc` folder contains the MPLAB Harmony Help documentation. It is provided in three formats: PDF, CHM, and HTML. The PDF format is an easily portable format, useful when viewing the documentation on a variety of devices and operating systems. When using this format, be sure to open your viewer's "Bookmarks" pane for easiest navigation. The CHM format is a popular Windows format that is useful when viewing the documentation on a Windows computer outside of the MPLAB X IDE. And, the MHC utilizes the HTML format (in the `html` subdirectory) to provide context-specific help from within the configuration tree. Refer to Using the Help for detailed information on each Help format.

framework Folder

The `framework` folder contains the MPLAB Harmony framework libraries, including all source code, interface header files, templates and configuration files.



Framework libraries are grouped in sub-folders by layer (drivers, system, peripheral, and osal) or by middleware library (bluetooth, crypto, decoder, gfx, math, tcpip, and usb) or by purpose (sample and test). Some of the groupings, particularly the layer groupings, are further broken down by peripheral or sub-system.

third_party Folder

The `third_party` folder groups all offerings provided by MPLAB Harmony third-party partners.

utilities Folder

The `utilities` folder contains development utilities, such as a the Microchip MIB Compiler (`mib2bib`) and most notably, the MPLAB Harmony Configurator (MHC) plug-in for MPLAB X IDE.

Documentation

Describes the documentation provided in the MPLAB Harmony installation.

Description

As mentioned in the Installation section, the documentation is provided in the `doc` folder in three formats (PDF, CHM, and HTML). All three formats of the documentation provide the same content. The Help content is organized into the following six volumes:

- Volume I: Getting Started With MPLAB Harmony
- Volume II: MPLAB Harmony Configurator (MHC)
- Volume III: MPLAB Harmony Development
- Volume IV: MPLAB Harmony Framework Reference
- Volume V: Third-Party Products
- Volume VI: Utilities

Note: The individual Help volumes are only provided as PDF files. In addition to these files, a combined PDF that contains all six volumes, is also provided in your installation of MPLAB Harmony.

Volume I: Getting Started With MPLAB Harmony contains this brief guided tour, release information such as release contents and release notes, and information about how to get started using installing the MHC, using applications and BSPs, and creating your first project.

Volume II: MPLAB Harmony Configurator (MHC) contains the MPLAB Harmony Configurator User's guide, describing how to use the MHC, and the MPLAB Harmony Configurator Developer's Guide, describing how to develop new configuration files and templates to integrate new libraries into the MHC. It also contains the MPLAB Harmony Graphics Composer User's Guide, describing how to use the composer to create graphical

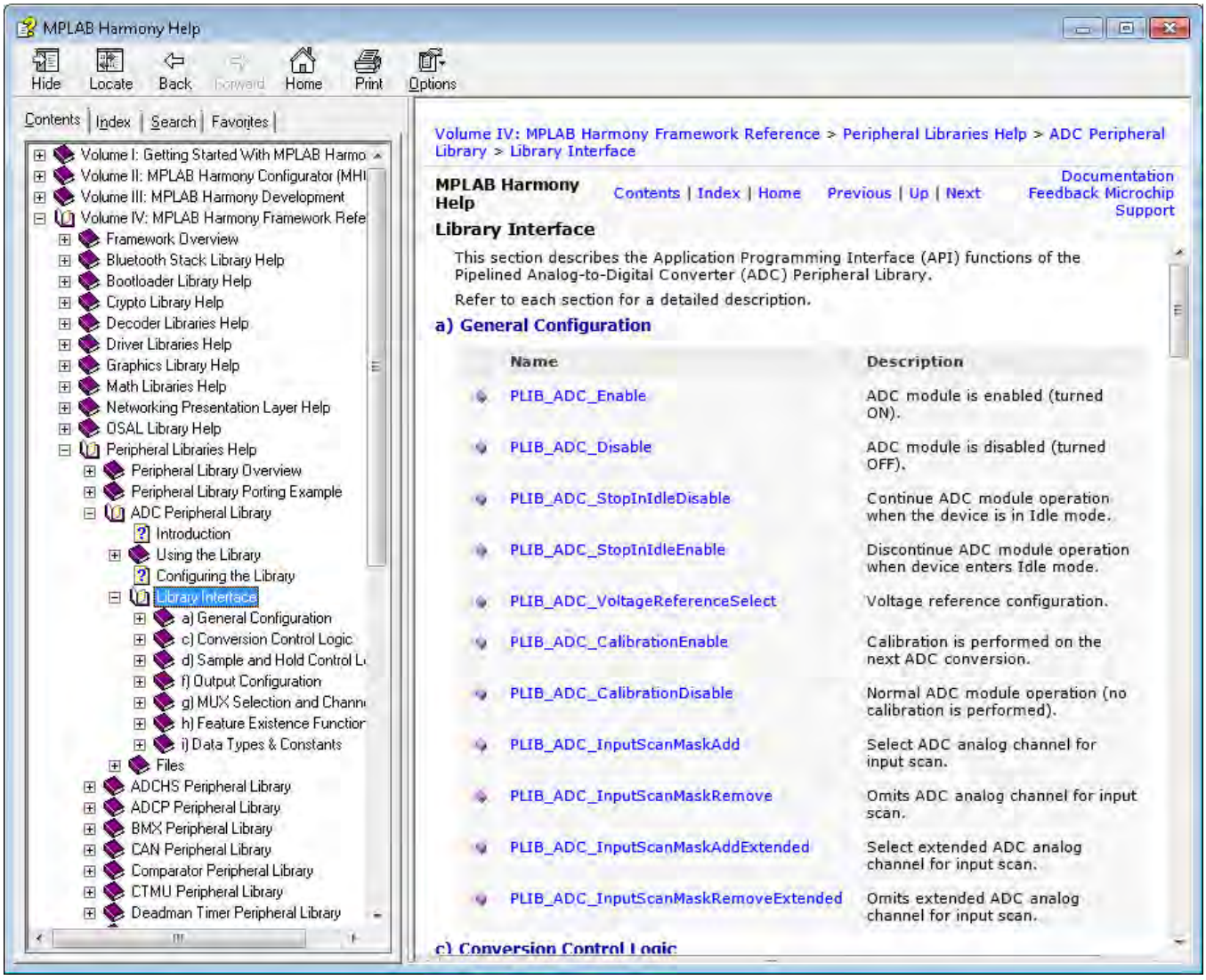
user interfaces for your embedded devices.

Volume III: MPLAB Harmony Development explains key MPLAB Harmony design concepts, provides information on porting existing libraries and applications to MPLAB Harmony, and lists general MPLAB Harmony development tips and tricks. It also contains guides for MPLAB Harmony compatibility, developing middleware and device drivers, and using the test harness library.

Volume IV: MPLAB Harmony Framework Reference is the interface definition usage reference for all MPLAB Harmony framework libraries. It provides a complete API reference for every library, each of which contains the following sections.

- *Introduction* – A brief description of the library
- *Using the Library* – An overview of the library and description of it's abstraction model, along with information on the common usage models for the library that include example code
- *Configuring the Library* – Information describing the libraries configuration and build options (the MHC's Help browser heavily references this section)
- *Library Interface* – The complete programmer's dictionary of interface functions, data types, and other definitions
- *Files* – A listing of the library's interface header files

When using a library for the first time, it is best to read through the **Introduction** and **Using the Library** sections to understand what the library does and how to use it. Then, when developing your own applications, refer to the **Library Interface** section for detailed information on function usage. The Help provides a convenient table of API functions, fully hyperlinked to complete descriptions for each. An example of the **Library Interface** section table for the ADC Peripheral Library from the CHM Help is shown in the following figure.



The help sections in this volume for the libraries are grouped and organized in the same way that the source code for the libraries are organize under the framework folder within the installation.

Volume V: Third-Party Products provides information on the third-party offerings included in the installation.

Volume VI: Utilities provides information on the development utilities provided in the installation, with the exception of the MHC, which has been provided in it's own volume due to its significance to MPLAB Harmony.

Note: Refer to Using the Help for detailed information on the Help formats provided in MPLAB Harmony.

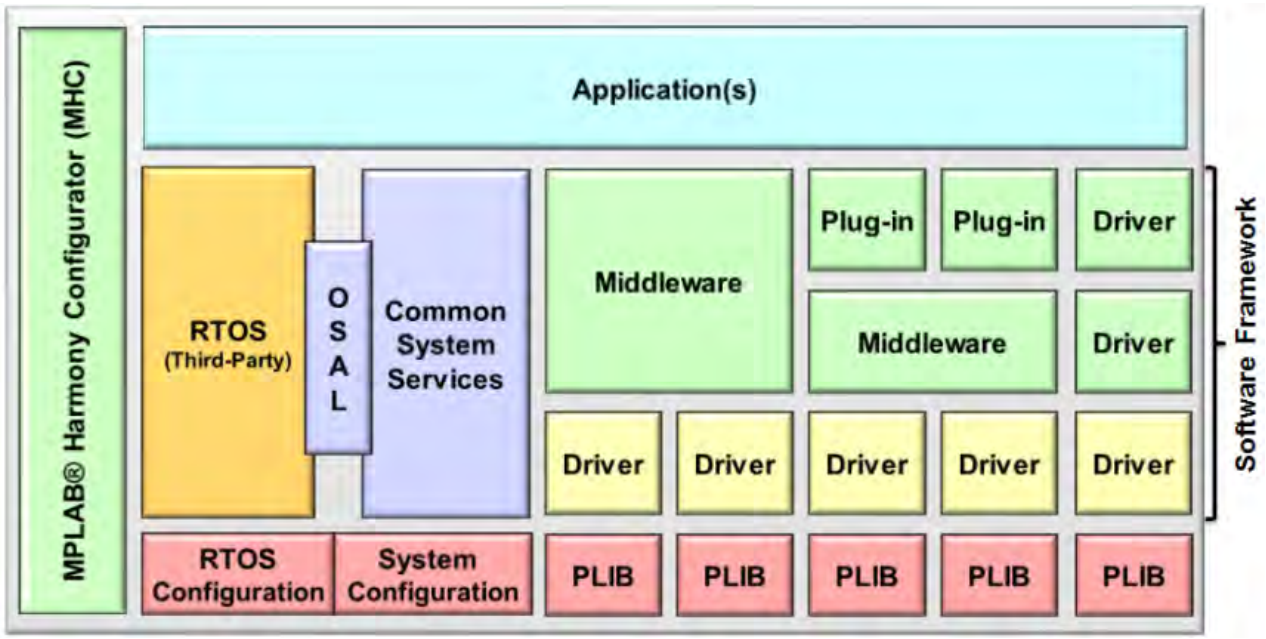
What is MPLAB Harmony?

This topic provides an overview of MPLAB Harmony.

Description

Microchip MPLAB® Harmony is the result of a holistic, aggregate approach to creating firmware solutions for embedded systems using Microchip PIC32 microcontrollers. As shown in the following diagram, MPLAB Harmony consists of portable, modular and compatible libraries provided by Microchip and third-party ecosystem partners. MPLAB Harmony also includes easy-to-use development utilities like the MPLAB Harmony Configurator (MHC) plug-in for the MPLAB X IDE, which accelerate development of highly capable and reusable PIC32 embedded firmware applications.

MPLAB® Harmony Block Diagram



Designed almost completely in the C language (see **Note**), MPLAB Harmony takes key elements of modular and object-oriented design, adds in the flexibility to use a Real-Time Operating System (RTOS) or work without one if you prefer, and provides a framework of software modules that are easy to use, configurable for your specific needs, and that work together in complete harmony.

Note: MPLAB Harmony has not been tested with C++; therefore, support for this programming language is not supported.

Portability

Portability is a concern that is often overlooked when a silicon manufacturer provides software. However, breadth of solutions is a hallmark strength of Microchip, and MPLAB Harmony provides simple libraries to abstract away part-specific details and make a Microchip device easy to use, regardless of which device you choose. Any time you design a new product or update an existing one, cost must be balanced with capabilities; however, cost is more than just the bill of materials – it's also the Non-Refundable Engineering (NRE) cost to design and develop your solution. MPLAB Harmony provides peripheral libraries, device drivers, and other libraries that use clear and consistent interfaces, requiring little or no change in your application code and minimizing the engineering time and effort for each new design.

Device Drivers

The primary purpose of a MPLAB Harmony device driver (or "driver") is to provide a simple and highly abstracted interface to a peripheral, allowing your application (or any other module in the system) to interact with a peripheral through a consistent set of functions. A driver is responsible for managing access to a peripheral, so that requests from different modules do not conflict with each other, and for managing the state of that peripheral so that it always operates correctly.

Peripheral Libraries

A Peripheral Library (PLIB) is a simple access library that provides a consistent (but very low level) interface to a peripheral that is "on board" the MCU. PLIBs hide register details, making it easier to write drivers that support multiple microcontroller families, but they are not normally used by applications directly to interact with peripherals, as they provide little abstraction, and because they require the caller to manage the detailed operation of a peripheral (including preventing conflicting requests from other modules). Because of the lack of conflict protection in a PLIB, only one module in a system should directly access the PLIB for a peripheral. Therefore, PLIBs are primarily used to implement device drivers (and some system services) to make them portable.

Modularity

MPLAB Harmony libraries are modular software "building blocks" that allow you to divide-and-conquer your firmware design. The interface to each library consists of a highly cohesive set of functions (not globally accessible variables or shared registers), so that each module can manage its own resources. If one module needs to use the resources of another module, it calls that module's interface functions to do so. Interfaces between modules are kept simple with minimal inter-dependencies so that modules are loosely coupled to each other. This approach helps to eliminate conflicts between modules and allows them to be more easily used together like building blocks to create the solutions you need.

Middleware Libraries

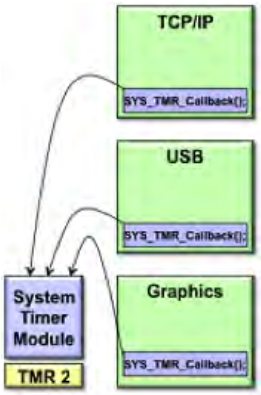
The normal usage models of some of the more complex peripherals, (i.e., USB or network interfaces) require interpreting complex protocols or may require substantial additional processing to produce useable results, such as drawing graphical images on an LCD screen with an LCD controller peripheral. Therefore, while a device driver may be completely sufficient for a simple peripheral like a UART, some peripherals require what is frequently called "middleware" (aptly named because it sits between your application and the hardware abstraction layer or "driver" layer). MPLAB Harmony provides several middleware library "stacks" to manage these more complex peripherals and provide the functionality you need and expect.

MPLAB Harmony middleware "stacks" are usually built upon device drivers and system services so that they can be supported on any Microchip microcontroller for which the required driver or service is supported. However, special purpose implementations may be available that integrate the driver, certain services, and various modules within the "stack" for efficiency.

System Services

MPLAB Harmony system services are responsible for managing shared resources so that other modules, such as drivers, middleware, and applications, do not conflict on shared resources. For example, if the TCP/IP, USB, and Graphics stacks attempted to concurrently use the Timer2 peripheral to perform some periodic task, they would very likely interfere with each other. However, if instead they used a timer system service (as the following image illustrates), it is the responsibility of the system service to keep the separate requests from interfering with each other. The timer service can be configured as desired for a specific system (for example, you may decide to use Timer3 instead of Timer2) isolating the necessary changes to the configuration of a single module and preventing potential conflicts.

The use of a system service is very similar the use of a device driver, except that a driver normally requires the caller to "open" it to create a unique client-to-driver association. A system service does not normally require the caller to open the service before using it because system services are frequently shared by many clients within the system.



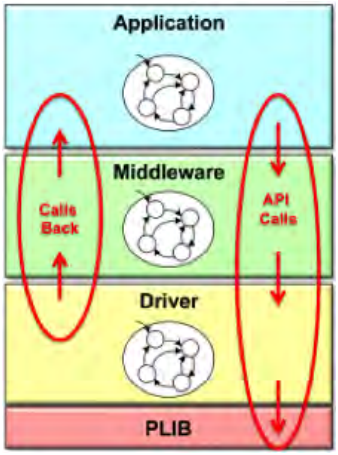
Compatibility

MPLAB Harmony modules (drivers, system services, and middleware – excluding PLIBs) are "active". This means when an application calls a module's interface function, the call will usually return immediately (unless a RTOS is in use) and the module will continue working on its own to complete the operation. Most modules will then provide a notification mechanism so the caller (i.e., client) can determine when the operation has finished.

Most MPLAB Harmony modules are implemented as cooperative state machines. The following image shows the basic idea of how this works. Each module has an "Initialize" function and each module has one (or more) "Tasks" function(s) to maintain its state machine(s). The state machines of all modules are initialized, shortly after the system comes out of reset in "main". After that (in a polled configuration, with no OS), the system drops into a "super loop" where each module's state machine function is repeatedly called, one after the other, to allow it to do the next "task" necessary to keep its state machine running. This allows the system to keep all modules running using a cooperative or shared "multi-tasking" technique. Modules (under control of your application) interact with each other by calling the interface functions of other modules (as illustrated in the following figure) and the system-wide "super loop" keeps all modules in the system running so they stay "active" and do their jobs.

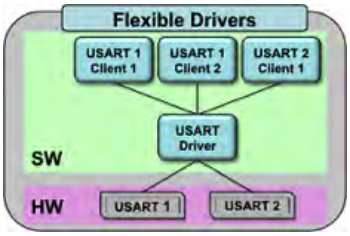
```
main()
{
    /* Call Function to Initialize State Machine 1 */
    /* Call Function to Initialize State Machine 2 */
    /* Call Function to Initialize State Machine 3 */

    while(true);
    {
        /* Call Function to Do Next
           State Machine 1 Task */
        /* Call Function to Do Next
           State Machine 2 Task */
        /* Call Function to Do Next
           State Machine 3 Task */
    }
}
```

This method is not suitable for all needs; therefore, other configurations are possible. However, a polled configuration is the simplest to understand and it best illustrates the basic concept of how MPLAB Harmony allows independent modules to operate cooperatively within an embedded system. To interact with each other, otherwise independent library and application modules make calls to each other's Application Program Interface (API) functions, as shown in the following diagram. Calls *into* a library are made through well-defined API functions and calls back to the client may be made through *callback* functions, statically linked (at build time) or dynamically registered at run-time and called using a function pointer.



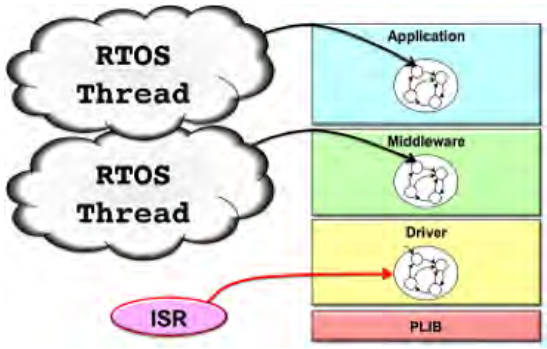
Flexibility

The basic MPLAB Harmony model of cooperating state machine driven modules, when combined with a little configurability, becomes flexible enough to meet the needs of almost any embedded system. For example, if you are using multiple identical peripherals, MPLAB Harmony has "dynamic" driver implementations that can manage all instances of a peripheral with a single instance of the driver code. You might also have a need for multiple "client" modules to use the same instance of a peripheral at the same time (such as the timer example, described previously). To manage this need, MPLAB Harmony has driver implementations that are intelligent enough to manage requests from multiple clients. On the other hand, your needs may be simpler than that. So, static and single client implementations are also available for key libraries to help reduce the amount of code and data storage needed for your system.



Or, your system may need to combine several middleware stacks and multiple, potentially independent, applications. If that is the case, the simple polling operation, using the "super loop" method frequently seen in simple embedded systems may not be sufficient. Wwhen you start adding more modules, it becomes more and more difficult to meet the timing requirements of all peripherals using a simple polled super loop.

Fortunately, MPLAB Harmony modules are written so that (where appropriate) their state machines can be run directly from an Interrupt Service Routine (ISR) or a RTOS thread. Using an ISR allows you to eliminate the latency of waiting for the execution of other modules in the loop to finish before a time-critical event is serviced, and it allows you to use the interrupt prioritization capabilities available on Microchip devices to ensure that your system responds to events in the real world in real-time.



Additionally, the ability to schedule and prioritize different tasks for different modules can be obtained for modules that are not associated with a specific processor interrupt (such as many middleware modules and your application) using a RTOS. In fact, that is one of the main reasons to use a RTOS. When your system becomes complex enough that you start struggling to meet your timing requirements using the super loop method, it's time to use a RTOS.

Fortunately, MPLAB Harmony module state machine functions can be called from a loop in a RTOS thread just as easily as they can be called from a polled "super loop" in a system without a RTOS. To allow this, modules are designed to be "thread safe" by calling semaphore, mutex, and critical section operations through an Operating System Abstraction Layer (OSAL). The OSAL provides a consistent set of functions to call, regardless of which RTOS is being used (or even if no RTOS is used). This method makes the choice of RTOS to use, if any, into a configuration option. MPLAB Harmony supports several OS and non-OS configurations and support for more operating systems is possible. All that is required is to implement the OSAL functions appropriately for the desired OS.

Configurability

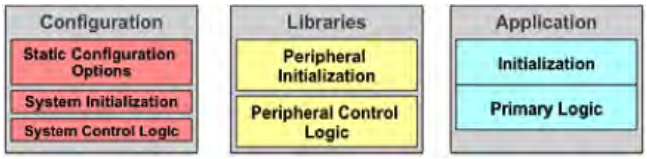
Most MPLAB Harmony libraries support a variety of build-time configuration options:

- Selection of the supported Microchip microcontroller
- Interrupt-driven or polled execution
- Static or Dynamic peripheral instance selection
- Single-client or Multi-client support
- Other library-specific options

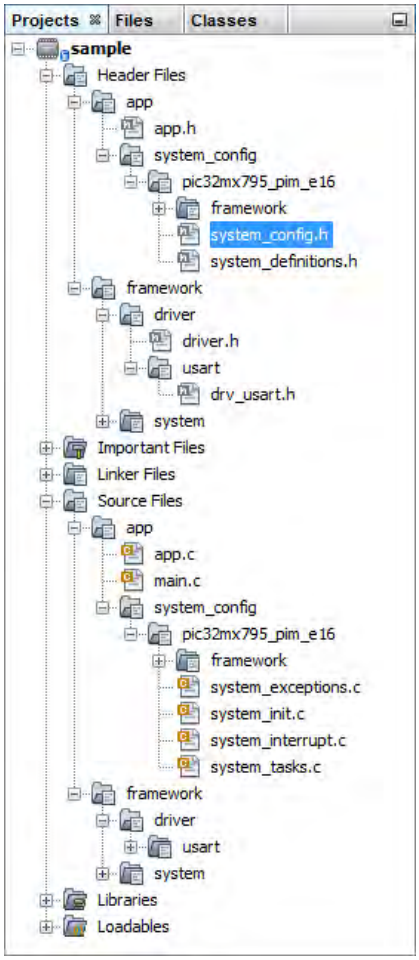
MPLAB Harmony libraries are designed to allow you to select a variety of configuration options to tailor them to your specific usage. For example, you may be able to select buffer sizes for data transfer modules or clock sources for timer modules. The set of configuration options for each library is identified and explained in the Help documentation (along with the interface and usage information) and the MPLAB Harmony Configurator (MHC) utility is provided to help simplify the process of configuring your system exactly the way you want and to get you started with a set of initial source files for your project.

Project Structure

To facilitate configurability, MPLAB Harmony projects are normally structured in a way that isolates the code necessary to configure a "system" from the library code and from your application code, as shown in the following figure.



The next figure shows how application, library, and configuration files are organized within the MPLAB X IDE project.



In a MPLAB Harmony project, the main.c file is kept very simple and consistent (containing primarily, just the super loop previously discussed). The application files (`app.c` and `app.h` in the previous figure) are separate from configuration files in the `system_config` sub-folders, so it is possible for a single application to have more than one configuration. (Usage of this capability can be seen in example and demonstration projects included with the installation of MPLAB Harmony.) The library modules that make up the MPLAB Harmony framework (in the framework folder) use the definitions provided in the selected configuration header (`system_config.h`, highlighted with a gray background in the previous figure) to specify the configuration options you selected when you configured the project. Finally the processor-specific peripheral libraries are provided as both a prebuilt binary (`.a` linker file) and as in-line source code to allow for maximum build efficiency for your firmware projects.

Summary

MPLAB Harmony provides a complete framework for developing your firmware solutions using Microchip microcontrollers and development tools. The firmware libraries and tools that make up the MPLAB Harmony framework are modular and compatible, making them simple to use. They're flexible and configurable, making them easy to tailor to your specific needs. And, they're portable across the full range of Microchip PIC32 microcontrollers, so you are sure to find a supported device that meets your needs.

Project Layout

This topic explains how a MPLAB Harmony project is organized.

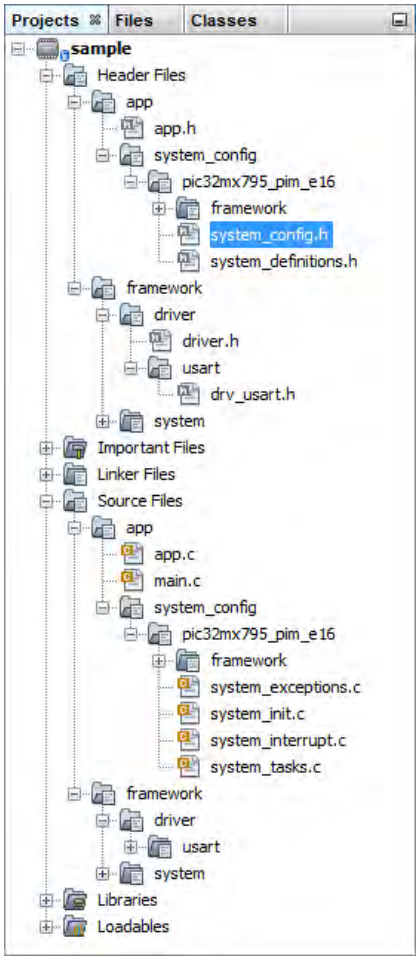
Description

A sample project has been created to show you the structure of a MPLAB Harmony project. The "sample" project is available in the following folder, within your MPLAB Harmony installation root folder:

`<install-dir>/apps/examples/sample/firmware/sample.X`

You should open this project in MPLAB X IDE and follow along with this guide.

A MPLAB Harmony project is organized within MPLAB X IDE, as shown in the following figure.



This organization consists of a few key "logical" folders and C language files, as follows.

The Header Files and Source Files Folders

The MPLAB X IDE separates C-language files into header (`.h`) files and source (`.c`) files by placing the header files in a top-level `Header Files` logical folder and the source files in a top-level `Source Files` logical folder. This distinction is for display only within the MPLAB X IDE and these folders do not appear on disk. Also, in most cases, logical folders that appear as sub-folders of these top-level folders are duplicated in both the `Header Files` and `Source Files` top-level logical folders because header and source files are kept together on disk.

The app Folder

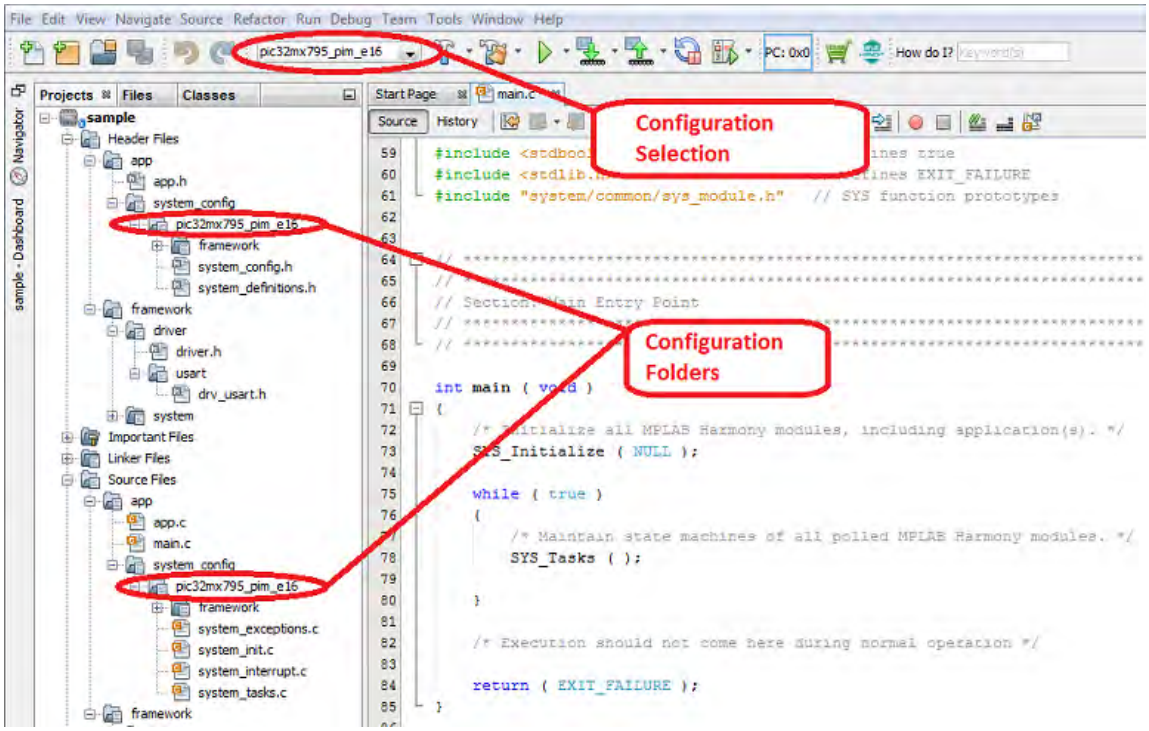
This folder contains the `main.c` and `app.c` source files and the `app.h` header file.

The `app` (i.e., application) folder and its sub-folders contain all of the project-specfic source and header files (but not the shared files stored in the framework folder, which are discussed later). In a simple project, the `app` folder contains the `main.c`, `app.c`, and `app.h` files and a `system_config` sub-folder. More complex projects will very likely contain additional files, as needed. In a MPLAB Harmony project, the `main.c` file normally contains the C language main function and little or nothing else. The logic of the `main` function is consistent across all MPLAB Harmony projects and should not need to be changed. The `app.c` file normally contains the logic of the application itself. This is where the desired overall behavior of your system is usually implemented (although complex systems may have multiple applications).

The `app.h` file defines data types and other definitions required by the application or interface prototypes for functions the application wants to share with other applications or the system.

The system_config Folder

The `system_config` folder contains one or more subdirectories, each of which corresponds to an individual configuration of your project. MPLAB Harmony projects may have multiple configurations. Each project configuration creates a different variation of your embedded system with potentially different hardware or features. In each configuration, you can select a different set of libraries or modules, select different build parameters for each module and even select different source files for your application(s). A configuration consists of a specific set of properties (tools settings) in MPLAB X IDE, a set of source files that define the build parameters, and a set of source and header files that control which modules are initialized and maintained in your system.



In MPLAB X IDE, the project configuration can be selected by using a pull-down menu in the tool bar at the top of the window or by right-clicking the project name and selecting **Properties**. In most example and demonstration projects distributed with MPLAB Harmony, the name of each MPLAB X IDE configuration will match the name of the associated folder within the `system_config` folder in the project (the 795_pim_e16 folder in the sample project). When a specific MPLAB X IDE configuration is selected, the configuration files for that configuration are included in the build and the configuration files in other configuration folders are excluded from the build.

Note: This is the project convention used by the example and demonstration projects provided with MPLAB Harmony. You, of course, may organize your own projects any way you desire. However, it is recommended to follow this convention if you use multiple configurations in your projects. We think you'll appreciate the power and flexibility it provides.

Configuration Files:

- `system_config.h`
- `system_init.c`
- `system_tasks.c`
- `system_interrupt.c`
- `system_exceptions.c`
- `system_definitions.h`

This set of files define a configuration of the system. The purpose of each of these files is described in more detail in the following sections. But, the basic idea is that you may want different configurations of your application for different hardware boards, different Microchip microcontrollers, or different feature sets, depending on your specific needs.

Allowing different configurations of the same application logic makes your application more flexible and provides a well-organized way to deal with the sort of variation that usually occurs in any project of sufficient size and complexity. This technique helps to eliminate the duplication of code (and labor) that would otherwise be necessary to manage multiple related projects. Of course, if you don't need or want that flexibility, all of these files are specifically created for your project and you can make any modifications to them that you like. The choice is always yours.

Note: The relative path, from the MPLAB X IDE project folder to the configuration folder (containing the `system_config.h` file) for each project configuration is automatically placed in the "Includes directories" list in the compiler properties for each configuration of the MPLAB X IDE project by the MHC.

The framework Folder

The `framework` logical folder contains the source files for the MPLAB Harmony framework and libraries. Depending on your project configuration, there can be many, many files and sub-folders within this folder. These files are for MPLAB Harmony libraries that you should not need to edit. In fact, the framework source files are not normally located in your project. Instead, these files are included in your project directly from the MPLAB Harmony installation (using relative directory paths). All of the actual files stay in the MPLAB Harmony installation folder, out of the way.

Notes:

1. You always have the option of copying the framework files directly into your project's source folder, if desired. In fact, doing so is a good idea if you plan to move or distribute your project separately from the MPLAB Harmony installation.
2. In most cases, the "logical folder" organization within the MPLAB X IDE project matches exactly with the physical directory organization within the MPLAB Harmony installation (and within your project directory) on your disk drive. This is done to keep things simple and consistent so you only need to learn a single layout. But, there are a couple of notable exceptions.
   - MPLAB X IDE has a convention of splitting out "Header Files" (`.h`) and "Source Files" (`.c`), so that the virtual folder organization in project separates the files in to these two groups and the physical directories on disk do not
   - In a MPLAB Harmony example or demonstration project, the `app` folder will correspond to the `src` directory on disk within the `firmware` folder of the project

The Main File

This topic describes the logic of the `main.c` file and the C language `main` function in a MPLAB Harmony project.

Description

The C language entry point for a MPLAB Harmony embedded application is the main function. This function is defined in the `main.c` file, generated in the project's `app` folder (or `src` directory on disk) by the MHC. The `main` function (see the following example) implements a simple "super loop", commonly used in embedded applications that do not make use of an operating system.

Example main Function Logic

```
int main ( void )
{
    /* Initialize all MPLAB Harmony modules, including application(s). */
    SYS_Initialize ( NULL );

    while ( true )
    {
        /* Maintain state machines of all polled MPLAB Harmony modules. */
        SYS_Tasks ( );
    }

    /* Execution should not come here during normal operation */
    return ( EXIT_FAILURE );
}
```

The SYS_Initialize Function

The first thing the main function does is to call a function named SYS_Initialize. The purpose of the SYS_Initialize function is to initialize every software module in the system. MPLAB Harmony is based upon a model of cooperating state machines. Therefore, this function must ensure that every module's state machine is placed in a valid initial state. The implementation of this function is one of the things generated by the MHC to configure a MPLAB Harmony system. This function's definition is generated in the `system_init.c` file, described in the system_init.c section.

Note: The SYS_Initialize function signature has a "`void *`" input parameter. This is so that it may later be implemented in a library and an arbitrary initialization data structure may be passed into it. However, for a statically implemented SYS_Initialize function (which will normally be the case if you implement it yourself), this parameter is unnecessary and can be passed as "NULL".

The "Super Loop"

After all of the modules in the system have been initialized, the main function executes an infinite loop to keep the system running. This is commonly called a "super loop" as it is the outer-most loop, within which the entire system operates. This loop never exits. So, the code that exists after the end of that loop should never be executed and is only included there for safety, clarity, and syntactical completeness.

The SYS_Tasks File and the SYS_Tasks Function

Inside of the "super loop", the `main` function calls the SYS_Tasks function. The purpose of the SYS_Tasks function is to poll every module in the system to ensure that it continues to operate. This is how the system maintains the state machines of all polled modules. (Note that some modules may be interrupt driven and thus, not called from the SYS_Tasks function.) The implementation of the SYS_Tasks function is generated by the MHC in the `system_tasks.c` file, which is described in the system_tasks.c section.

The Application File(s)

This topic describes the normal structure of MPLAB Harmony application files.

Description

From the point of view of a MPLAB Harmony system, an application consists of two basic functions:

- APP_Initialize
- APP_Tasks

The application's initialization function (APP_Initialize) is normally called from the SYS_Initialize function, which is called from `main` before entering the top-level loop. The application's "tasks" function (APP_Tasks) is normally called from the SYS_Tasks function, which is called from `main` from inside the top-level loop. This is how the application's state machine is initialized and "polled" so that it can do its job. The SYS_Initialize function is normally implemented in the `system_init.c` file and the SYS_Tasks function is normally implemented in the `system_tasks.c` file. That is the convention for example and demonstration projects distributed with MPLAB Harmony and that is the case for projects generated by the MHC. You may do as you choose in your own projects, but it is recommended to follow this convention as it will make it easier to manage multiple configurations if you need them and it will be consistent with the MHC and other tools.

Application Initialization

An application's initialization function places the application's state machine in its initial state and may perform additional initialization if necessary. This function must not block and it should not call the routines of any other modules that may block. If something needs to be initialized that may take time to complete, that initialization should be done in the application's state machine (i.e., in its "Tasks" function).

Sample Application Initialization Function:

```
void APP_Initialize ( void )
{
    /* Place the App state machine in its initial state. */
    appData.state       = APP_STATE_INIT;
    appData.usartHandle = DRV_HANDLE_INVALID;
}
```

The sample project's initialization function initializes an internal variable and places the application's state machine in its initial state by assigning the APP_STATE_INIT enumeration value into the "state" member of the data structure that contains all of the data required by the application (appData). This structure is defined globally, but is only ever accessed by the application itself. The application's initialization function is called from the SYS_Initialize function (defined in `system_init.c`), which is called from `main` after a system Reset. Using this technique, the application is initialized (along with the rest of the system) whenever the system comes out of Reset.

Application Tasks

The application's state machine breaks up the job that the application must do into several short "tasks" that it can complete quickly, but between which it must wait for some other module to complete some tasks of its own. (In this case the other module is the USART driver.) Once each short task has completed successfully, the application transitions to another state to perform the next short task.

Example Application Tasks Function:

```
void APP_Tasks ( void )
{
    /* Handle returned by USART for buffer submitted */
    DRV_HANDLE usartBufferHandle;

    /* Check the application's current state. */
    switch ( appData.state )
    {
        /* Keep trying to open the driver until we succeed. */
        case APP_STATE_INIT:
        {
            /* open an instance of USART driver */
            appData.usartHandle = DRV_USART_Open(APP_UART_DRIVER_INDEX,
                                                 DRV_IO_INTENT_WRITE);
            if (appData.usartHandle != DRV_HANDLE_INVALID )
            {
                /* Update the state */
                appData.state = APP_STATE_SEND_MESSAGE;
            }
            break;
        }

        /* Send the message when the driver is ready. */
        case APP_STATE_SEND_MESSAGE:
        {
            /* Submit message to USART */
            DRV_USART_BufferAddWrite(appData.usartHandle, &usartBufferHandle,
                                     APP_HELLO_STRING, strlen(APP_HELLO_STRING));
            if ( usartBufferHandle != DRV_HANDLE_INVALID )
            {
                /* Message is accepted. Driver will transmit. */
                appData.state = APP_STATE_IDLE;
            }
            break;
```

```
            }

            /* Idle state */
            case APP_STATE_IDLE:
            default:
            {
                /* Do nothing. */
                break;
            }
        }
    }
```

Sample Application States

The sample application's "tasks" function breaks the operation of the application down in to the following states using a "switch" statement with the following "cases".

- APP_STATE_INIT
- APP_STATE_SEND_MESSAGE
- APP_STATE_IDLE

The sample application is placed into the APP_STATE_INIT state by the application's initialization function before the "tasks" function is ever called. So, the first time the APP_Tasks function is called, the switch statement executes the code under this case and the first short "task" the sample application attempts to do is open the USART driver to obtain a handle so that it can transfer data over the USART. Notice that the application checks the value of the handle returned from the DRV_USART_Open function to ensure that it is valid before it transitions to the APP_STATE_SEND_MESSAGE state. If the value of the handle retuned be the driver's "open" function is invalid (equal to DRV_HANDLE_INVALID), the application stays in the APP_STATE_INIT state and continues trying to open the USART driver every time its "tasks" function is called. his technique allows a polled state machine to wait for something that it requires before continuing to avoid making inappropriate transitions to new states.

Once the application has a valid handle to the USART driver, it executes the code under the APP_STATE_SEND_MESSAGE case the next time its APP_Tasks function is called. In this state, the application calls a USART driver data transfer routine (DRV_USART_BufferAdd) to send the data data buffer string defined by the `system_config.h` header. Then, it checks the handle returned by the DRV_USART_BufferAddWrite function to see if it is valid. If the buffer handle is valid, it indicates that the USART driver has accepted the buffer and will take responsibility for the data transfer from that point forward. The application does not have to do anything else to cause the data transfer to occur. However, if the buffer is not accepted by the driver (in which case the handle returned by the DRV_USART_BufferAddWrite function would be invalid), the application stays in the APP_STATE_SEND_MESSAGE and tries again the next time the APP_Tasks function is called.

Once the application has successfully passed the buffer to the USART driver, it transitions to the APP_STATE_IDLE state where it stays and does nothing any time its "tasks" function is called. Its job is done! A more complex application would go on to some other task or potentially begin the process again. But, this is a simple "Hello World" sample application.

Note: The application is normally initialized last, after all other modules in the system have been initialized. But, it should never assume that any other module has completed its initialization when the application is initialized or when its "tasks" function is first called. Instead, it should always check the return value or status from any other module it calls to ensure that the call succeeded before moving on to the next state. Following this rule makes applications more robust and allows them to handle errors more effectively.

System Configurations

This section describes the files that make up a system configuration.

Description

In MPLAB Harmony, a system configuration consists of a set of files that define the build options, how the system is initialized, and how it runs after it has been initialized. The purpose of each of these files is described in the topics in this section.

system_config.h

This topic describes the purpose of system configuration header file.

Description

System Configuration

In MPLAB Harmony, most library modules require a set of build time configuration options that define a variety of parameters (such as buffer sizes, maximum or minimum limits, and default behavior). To configure a library for your specific needs, its configuration options can be defined using C language preprocessor `#define` statements. The set of configuration options supported is described for each library in the "Configuring the Library" section of its help document and most libraries provide a template and example configuration header files in a `config` sub-folder within their `src` folder.

To obtain its build configuration options, every library includes the same common top-level configuration file that is named `system_config.h`, and it is generated by the MHC as part of your system configuration. The relative directory path to configuration directory that contains this file is

defined in the build properties of your project configuration by the MHC so that the compiler can find it in its include file search path.

Example Configuration `system_config.h` Header

```
// ******************************************************************************
// ******************************************************************************
// Section: System Service Configuration
// ******************************************************************************
// ******************************************************************************

// *****************************************************************************
/* Common System Service Configuration Options
*/
#define SYS_VERSION_STR           "1.07"
#define SYS_VERSION               10700

// *****************************************************************************
/* Clock System Service Configuration Options
*/
#define SYS_CLK_FREQ                        80000000ul
#define SYS_CLK_BUS_PERIPHERAL_1            80000000ul
#define SYS_CLK_UPLL_BEFORE_DIV2_FREQ       7999992ul
#define SYS_CLK_CONFIG_PRIMARY_XTAL         8000000ul
#define SYS_CLK_CONFIG_SECONDARY_XTAL       32768ul

/*** Ports System Service Configuration ***/
#define SYS_PORT_AD1PCFG        ~0xffff
#define SYS_PORT_CNPUE          0x0
#define SYS_PORT_CNEN           0x0


// ******************************************************************************
// ******************************************************************************
// Section: Driver Configuration
// ******************************************************************************
// ******************************************************************************

// *****************************************************************************
/* USART Driver Configuration Options
*/

#define DRV_USART_INTERRUPT_MODE                    false
#define DRV_USART_BYTE_MODEL_SUPPORT                false
#define DRV_USART_READ_WRITE_MODEL_SUPPORT          true
#define DRV_USART_BUFFER_QUEUE_SUPPORT              true
#define DRV_USART_QUEUE_DEPTH_COMBINED              16
#define DRV_USART_CLIENTS_NUMBER                    1
#define DRV_USART_SUPPORT_TRANSMIT_DMA              false
#define DRV_USART_SUPPORT_RECEIVE_DMA               false
#define DRV_USART_INSTANCES_NUMBER                  1

#define DRV_USART_PERIPHERAL_ID_IDX0                USART_ID_2
#define DRV_USART_OPER_MODE_IDX0                    DRV_USART_OPERATION_MODE_NORMAL
#define DRV_USART_OPER_MODE_DATA_IDX0               0x00
#define DRV_USART_INIT_FLAG_WAKE_ON_START_IDX0      false
#define DRV_USART_INIT_FLAG_AUTO_BAUD_IDX0          false
#define DRV_USART_INIT_FLAG_STOP_IN_IDLE_IDX0       false
#define DRV_USART_INIT_FLAGS_IDX0                   0
#define DRV_USART_BRG_CLOCK_IDX0                    80000000
#define DRV_USART_BAUD_RATE_IDX0                    9600
#define DRV_USART_LINE_CNTRL_IDX0                   DRV_USART_LINE_CONTROL_8NONE1
#define DRV_USART_HANDSHAKE_MODE_IDX0               DRV_USART_HANDSHAKE_NONE
#define DRV_USART_XMIT_INT_SRC_IDX0                 INT_SOURCE_USART_2_TRANSMIT
#define DRV_USART_RCV_INT_SRC_IDX0                  INT_SOURCE_USART_2_RECEIVE
#define DRV_USART_ERR_INT_SRC_IDX0                  INT_SOURCE_USART_2_ERROR

#define DRV_USART_XMIT_QUEUE_SIZE_IDX0              10
#define DRV_USART_RCV_QUEUE_SIZE_IDX0               10

#define DRV_USART_POWER_STATE_IDX0                  SYS_MODULE_POWER_RUN_FULL
```

```
// *****************************************************************************
// *****************************************************************************
// Section: Application Configuration
// *****************************************************************************
// *****************************************************************************

#define APP_UART_DRIVER_INDEX           DRV_USART_INDEX_0
#define APP_HELLO_STRING                "Hello World\r\n"
```

The previous example defines configuration options for the application, system services, and USART driver used in the "pic32mx795_pim_e16" configuration of the sample project.

system_init.c

This topic describes the purpose of the system initialization file.

Description

In a MPLAB Harmony project, the SYS_Initialization function is called from the `main` function in order to initialize all modules in the system. This function is implemented as part of a system configuration by the MHC in a file named `system_init.c`. This file may also include other necessary global system items that must be implemented in order to initialize a system such as processor configuration bits and module initialization global data structures.

Example `system_init.c` File

```
// *****************************************************************************
// *****************************************************************************
// Section: Configuration Bits
// *****************************************************************************
// *****************************************************************************

/*** DEVCFG0 ***/

#pragma config DEBUG =      OFF
#pragma config ICESEL =     ICS_PGx2
#pragma config PWP =        OFF
#pragma config BWP =        OFF
#pragma config CP =         OFF

/*** DEVCFG1 ***/

#pragma config FNOSC =      PRIPLL
#pragma config FSOSCEN =    OFF
#pragma config IESO =       ON
#pragma config POSCMOD =    XT
#pragma config OSCIOFNC =   OFF
#pragma config FPBDIV =     DIV_1
#pragma config FCKSM =      CSDCMD
#pragma config WDTPS =      PS1048576
#pragma config FWDTEN =     OFF

/*** DEVCFG2 ***/

#pragma config FPLLIDIV =   DIV_2
#pragma config FPLLMUL =    MUL_20
#pragma config FPLLODIV =   DIV_1
#pragma config UPLLIDIV =   DIV_12
#pragma config UPLLEN =     OFF

/*** DEVCFG3 ***/

#pragma config USERID =     0xffff
#pragma config FSRSSEL =    PRIORITY_7
#pragma config FMIIEN =     OFF
#pragma config FETHIO =     OFF
#pragma config FCANIO =     OFF
#pragma config FUSBIDIO =   OFF
#pragma config FVBUSONIO =  OFF
```

```
// *****************************************************************************
// *****************************************************************************
// Section: Driver Initialization Data
// *****************************************************************************
// *****************************************************************************

const DRV_USART_INIT drvUsart0InitData =
{
    .moduleInit.value = DRV_USART_POWER_STATE_IDX0,
    .usartID = DRV_USART_PERIPHERAL_ID_IDX0,
    .mode = DRV_USART_OPER_MODE_IDX0,
    .modeData.AddressedModeInit.address = DRV_USART_OPER_MODE_DATA_IDX0,
    .flags = DRV_USART_INIT_FLAGS_IDX0,
    .brgClock = DRV_USART_BRG_CLOCK_IDX0,
    .lineControl = DRV_USART_LINE_CNTRL_IDX0,
    .baud = DRV_USART_BAUD_RATE_IDX0,
    .handshake = DRV_USART_HANDSHAKE_MODE_IDX0,
    .interruptTransmit = DRV_USART_XMIT_INT_SRC_IDX0,
    .interruptReceive = DRV_USART_RCV_INT_SRC_IDX0,
    .queueSizeTransmit = DRV_USART_XMIT_QUEUE_SIZE_IDX0,
    .queueSizeReceive = DRV_USART_RCV_QUEUE_SIZE_IDX0,
};

// *****************************************************************************
// *****************************************************************************
// Section: Module Initialization Data
// *****************************************************************************
// *****************************************************************************

const SYS_DEVCON_INIT sysDevconInit =
{
    .moduleInit = {0},
};


// *****************************************************************************
// *****************************************************************************
// Section: System Data
// *****************************************************************************
// *****************************************************************************

/* Structure to hold the object handles for the modules in the system. */
SYSTEM_OBJECTS sysObj;


// *****************************************************************************
// *****************************************************************************
// Section: System Initialization
// *****************************************************************************
// *****************************************************************************

void SYS_Initialize ( void* data )
{
    /* Core Processor Initialization */
    SYS_CLK_Initialize( NULL );
    sysObj.sysDevcon = SYS_DEVCON_Initialize(SYS_DEVCON_INDEX_0, (SYS_MODULE_INIT*)&sysDevconInit);
    SYS_DEVCON_PerformanceConfig(SYS_CLK_SystemFrequencyGet());
    SYS_PORTS_Initialize();

    /* Initialize Drivers */
    sysObj.drvUsart0 = DRV_USART_Initialize(DRV_USART_INDEX_0, (SYS_MODULE_INIT *)&drvUsart0InitData);

    /* Initialize the Application */
    APP_Initialize();
}
```

In addition to the SYS_Initialize function implementation, the previous example, the `system_init.c` file from the "pic32mx_795_pim_e16" configuration of the "sample" project, defines the processor configuration bits, data structures used to initialize the USART driver and device control service, and a global sysObj data structure used for the USART driver Device Control System Service returned by their initialization functions.

Note the SYSTEM_OBJECTS data type for the sysObj date structure is defined in the system_definitions.h section.

system_tasks.c

This topic describes the purpose of the system tasks file.

Description

Since MPLAB Harmony modules are state machine driven, they each have a "Tasks" function that must be called repeatedly (from the system-wide "super loop" in `main` or from an ISR or OS thread). The "Tasks" functions are all called from the top-level SYS_Initialize function that is normally implemented in a file called `system_tasks.c` that is generated by the MHC as part of a system configuration.

Example `system_tasks.c` File

```
void SYS_Tasks ( void )
{
    /* Maintain system services */
    SYS_DEVCON_Tasks(sysObj.sysDevcon);

    /* Maintain Device Drivers */
    DRV_USART_TasksTransmit(sysObj.drvUsart0);
    DRV_USART_TasksReceive(sysObj.drvUsart0);
    DRV_USART_TasksError (sysObj.drvUsart0);

    /* Maintain the application's state machine. */
    APP_Tasks();
}
```

The `system_tasks.c` file for the "pic32mx_795_pim_e16" configuration of the "sample" project, contains only the implementation of the SYS_Tasks function for that configuration. This function calls the tasks function of the Device Control System Service, the USART driver's tasks functions (it has three, one each for transmitter, receiver, and error-handling tasks), passing in the object handle returned from the driver's initialization routine, and it calls the application's tasks function APP_Tasks to keep the state machines of all three modules running.

system_interrupt.c

This topic describes the purpose of the system interrupts file.

Description

In an interrupt-driven configuration, any modules (such as drivers or system services) that can be driven from an interrupt must have their interrupt-capable tasks function(s) called from an Interrupt Service Routine (ISR) "vector" function instead of from the SYS_Tasks function. The form of the definition of the ISR vector function is dependent on what type of PIC32 microcontroller on which the system is running. So, any vector functions required are normally implemented as part of the a specific system configuration in a file normally named `system_interrupt.c`.

Since the sample application is entirely polled, its `system_interrupt.c` file does not contain any ISR vector functions. Refer to any interrupt-driven demonstration or example application to see how vector functions are implemented.

system_definitions.h

This topic describes the purpose of the system definitions header file.

Description

The system configuration source files (`system_init.c`, `system_tasks.c`, and `system_interrupt.c`) all require a definition of the system objects data structure and an `extern` declaration of it. The MHC generates these items in the `system_definitions.h` header file and the system source files all include that header file.

For example, the sample application defines the following structure definition and extern declaration.

```
typedef struct
{
SYS_MODULE_OBJ sysDevcon;
SYS_MODULE_OBJ drvUsart0;

} SYSTEM_OBJECTS;

extern SYSTEM_OBJECTS sysObj;
```

This structure holds the object handles returned by the Initialize functions for the device control and USART modules (in `system_init.c`) because they must be passed into the associated Tasks functions (called in `system_tasks.c`), which is why the system global sysObj structure requires an `extern` declaration. The MHC generates object handle variables in this structure for every instance of an active module in the system.

Additionally, the system configuration source files require the interface headers for all libraries and applications included in the system so that they have prototypes for their Initialize and Tasks functions. In the sample application, the `system_definitions.h` file includes the following interface headers (and standard C headers).

```
#include <stdint.h>
#include <stddef.h>
#include <stdbool.h>
#include "system/common/sys_common.h"
#include "system/common/sys_module.h"
#include "system/clk/sys_clk.h"
#include "system/clk/sys_clk_static.h"
#include "system/devcon/sys_devcon.h"
#include "driver/usart/drv_usart.h"
#include "system/ports/sys_ports.h"
```

Note: The `system_configuration.h` header file should not be included by the application (`app.c`, `app.h` , or other) source files because it provides direct `extern` access to system objects and these objects should not be utilized by the application directly. The application (or other modules) should only interact with a module through its defined Application Program Interface (API), or client interface, not through the system objects or system functions that require that object.

system_exceptions.c

This topic describes the purpose of the system exceptions source file.

Description

The `system_exceptions.c` source file provides a skeletal implementation of the general exception handler function (shown below), overriding the weak function implementation provide by the MPLAB XC32 C/C++ Compiler that simply hangs in an endless loop.

```
void _general_exception_handler ( void )
{
   /* Mask off the ExcCode Field from the Cause Register.
   Refer to the MIPs Software User's manual. */
   _excep_code = (_CP0_GET_CAUSE() & 0x0000007C) >> 2;
   _excep_addr = _CP0_GET_EPC();
   _cause_str = cause[_excep_code];

   SYS_DEBUG_PRINT(SYS_ERROR_ERROR,
   "\nGeneral Exception %s (cause=%d, addr=%x).\n",
   _cause_str, _excep_code, _excep_addr);

   while (1)
      {
          SYS_DEBUG_BreakPoint();
      }
}
```

If a general exception occurs, this implementation will capture the address of the instruction that caused the exception in the `_excep_addr` variable, the cause code in the `_excep_code` variable and use a look-up table indexed by the cause to provide a debug message describing the exception if debug message support is enabled. Then, the function will hit a hard-coded debug breakpoint (in Debug mode) and hang in a loop to prevent runaway execution.

This implementation is provided to assist with development and debugging. The user is encouraged to modify this implementation to suit the needs of their system.

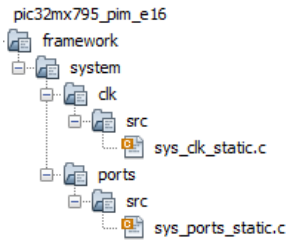
The Configuration-specific "framework" Folder

This topic describes the configuration-specific `framework` folder.

Description

The interface (i.e., API) headers and the source files for the dynamic implementations of all MPLAB Harmony libraries are contained in the main framework folder (`<install-dir>\framework`). However, the MHC generates any static implementations of the MPLAB Harmony libraries. These generated source files are all configuration specific because they are generated with knowledge of the configuration selections. Thus, they are placed in a configuration-specific framework folder. For consistency, the organization of the sub-folder tree of the configuration-specific framework folder matches the organization of the main framework folder.

For example, the configuration-specific `framework` folder for the pic32mx795_pim_e16 configuration of the sample project contains the source files for the static, MHC-generated implementations of the Clock System Service and the Ports System Service, as shown in the following figure.



Other Configuration-specific Files

This topic describes two other (non C-language) configuration-specific files.

Description

There are two additional (non-C language) files generated by the MHC and placed into the configuration-specific folder. The first file, `<config-name>.mhc`, captures the configuration selections made by the user. The second file, which is always named `configuration.xml`, captures the various checksums and additional information required by the MHC to identify which generated files have been edited externally and to store miscellaneous other information it requires (such as the path to the MPLAB Harmony installation).

Release Information

Provides MPLAB Harmony release information, include release notes, release contents, release types, and explains the version numbering system.

A PDF copy of the Release Notes is provided in the `<install-dir>/doc` folder of your MPLAB Harmony installation.

Release Notes

This topic provides the release notes for this version of MPLAB Harmony.

Description

MPLAB Harmony Version: v1.11 **Release Date:** April 2017

Software Requirements

Before using MPLAB Harmony, ensure that the following are installed:

- MPLAB X IDE 3.60
- MPLAB XC32 C/C++ Compiler 1.43
- MPLAB Harmony Configurator 1.11.xx

Updating to This Release of MPLAB Harmony

Updating to this release of MPLAB Harmony is relatively simple. For detailed instructions, please refer to Porting and Updating to MPLAB Harmony.

What is New and Known Issues

The following tables list the features that have been changed or added and any known issues that have been identified since the last release of MPLAB Harmony. Any known issues that have yet to be resolved were retained from the previous release.

MPLAB Harmony:

Feature	Additions and Updates	Known Issues
General		MPLAB Harmony has not been tested with C++; therefore, support for this programming language is not supported. The "-O1" optimization level is recommended when building any projects that include the MPLAB Harmony prebuilt binary (.a file) peripheral library. This is necessary so that the linker will remove code from unused sections (for peripheral library features that are not used). Alternately, you may select "Remove Unused Sections" in the General options for the xc32-ld (linker) properties dialog box. The MPLAB Harmony uninstaller will delete all files installed by the installer, even if they were modified by the user. However, the uninstaller *will not* delete new files added by the user to the MPLAB Harmony installation folder. The MPLAB Harmony Display Manager plug-in provides complete configuration and simulation support to the LCC generated driver, and also provides basic support for all other graphics controller drivers. Full configuration and simulation support for the other graphics controller drivers will be added in a future release of MPLAB Harmony.

Middleware and Libraries:

Feature	Additions and Updates	Known Issues
Bootloader Library		The UDP bootloader does not compile for PIC32MZ devices when microMIPS is selected.

Crypto Library	N/A	Migrating projects that use the hardware Crypto library, and have multiple configurations, may run into a compile issue after regenerating code. MPLAB X IDE will show that the `pic32mz-crypt.h` and `pic32mz-hash.c` files are excluded from the configuration, even though it tried to add them. The compiler will generate errors, saying that certain Crypto functions cannot be referenced. To work around this issue, remove both files (`pic32mz-crypt.h` and `pic32mz-hash.c`) from the project and use the MPLAB Harmony Configurator (MHC) to regenerate all configurations that use these files.
Decoder Libraries		Due to memory requirements and the amount of available SRAM, some decoders cannot operate concurrently with other decoders. However, each decoder will operate individually in the universal_audio_decoders demonstration.
File System	Found and fixed potential null pointer exception in the unmount function.	
Graphics Libraries		JPEG decoding does not support progressive scanned images. Some transparency-incorporated animated GIF images may demonstrate tearing. The generated LCCG driver supports display resolution up to WVGA or equivalent.
TCP/IP Stack		**SMTPC:** • API to abort a message, which is useful when retries are needed is currently not available • Multiple DNS addresses to provide a more reliable mail transmission is currently not available • Support for the optional mail header fields is currently not available
USB Device Library	N/A	The USB Device Stack has been tested in limited capacity with RTOS. While running the USB Device Stack on a PIC32MZ family device, the stack requires three seconds to initialize for PIC32MZ EC devices and three milliseconds for PIC32MZ EF devices.

USB Host Library	Removed MHC support for USB Host Beta software. Support for USB Host Beta APIs will be removed in future releases.	The following USB Host Stack functions are not implemented: • USB_HOST_BusResume • USB_HOST_DeviceSuspend • USB_HOST_DeviceResume The Hub, Audio v1.0, and HID Host Client Drivers have been tested in limited capacity. The USB Host Stack has been tested in limited capacity with RTOS. Polled mode operation has not been tested. Attach/Detach behavior has been tested in a limited capacity. While running the USB Host Stack on a PIC32MZ family device, the stack requires three seconds to initialize for PIC32MZ EC devices and three milliseconds for PIC32MZ EF devices. The USB Host Layer does not perform overcurrent checking. This feature will be available in a future release of MPLAB Harmony. The USB Host Layer does not check for the Hub Tier Level. This feature will be available in a future release of MPLAB Harmony. The USB Host Layer will only enable the first configuration when there are multiple configurations. If there are no interface matches in the first configuration, this causes the device to be become inoperative. Multiple configuration enabling will be activated in a future release of the of MPLAB Harmony. The MSD Host Client Driver has been tested with a limited number of commercially available USB Flash drives. The MSD Host Client Driver and the USB Host Layer have not been tested for read/write throughput. This testing will be done in a future release of MPLAB Harmony. The MSD Host Client Driver and SCSI block driver can only be used with the File system if the file system Auto-Mount feature is enabled. The MSD Host Client Driver has not been tested with Multi-LUN Mass Storage Device and USB Card Readers.
USB Host Library (continued)		The USB Host SCSI Block Driver, the CDC Client Driver, and the Audio Host Client Driver only support single-client operation. Multi-client operation will be enabled in a future release of MPLAB Harmony. USB HID Host Client driver has not been tested with multiple usage devices. Sending of output or feature report has not been tested. The USB Audio Host Client driver does not provide implementation for the following functions: • USB_HOST_AUDIO_V1_DeviceObjHandleGet • USB_HOST_AUDIO_V1_FeatureUnitChannelVolumeRangeGet • USB_HOST_AUDIO_V1_FeatureUnitChannelVolumeSubRangeNumbersGet • USB_HOST_AUDIO_V1_StreamSamplingFrequencyGet • USB_HOST_AUDIO_V1_TerminalIDGet

Device Drivers:

Feature	Additions and Updates	Known Issues
LCC	.	The MPLAB Harmony Graphics Composer (MHGC) is not capable of providing a palette table; therefore, users must supply a uint16_t array of 256 16 bpp RGB colors to the LCC Driver using the DRV_GFX_PalletteSet function. The content of this array will serve to map color indices to TFT display colors. The DMA Trigger Source setting in MHC has changed. If your project's setting is on 3, 5, 7 or 9, MHC will flag it as red. Please change to either 2, 4, 6, or 8. All the odd-numbered timers are removed from selection. While these timers are functional at default, only the even-numbered timers (2, 4, 6, 8) will accept changes in prescaler values.
I2C	N/A	**I2C Driver Using the Peripheral and the Bit-banged Implementation:** • Has only been tested in a single master environment • Does not support RTOS; therefore, it is not thread-safe when used in a RTOS environment • Has not been tested in a Polled environment • Operation in power-saving modes has not been tested **I2C Driver Using the Bit-banged Implementation**: • Non-blocking and uses a Timer resource for performing I2C operations. This Timer resource cannot be used for any other Timer needs. • The Timer Interrupt priority should be one of the highest priority interrupts in the application • Testing of this implementation has been done only with a system clock of 200 MHz and a peripheral bus clock of 100 MHz for the Timer • Can be configured to work only in Master mode • Only available in the dynamic driver setting • The baud rate is dependent on CPU utilization. It has been tested to run reliably up to 100 kHz. • Does not support PIC32MX family devices • Only works on the SCL and SDA pins of the corresponding I2C peripheral • Only works in Interrupt mode
MRF24WN Wi-Fi	New `wdrvext_mx.a`, `wdrvext_ec.a`, and `wdrvext_mz.a` library files.	
S1D13517		The S1D13517 Driver does not support the getting of a pixel or array of pixels from the S1D13517 framebuffer and does not support font rendering when Anti-aliasing is enabled.
Secure Digital (SD) Card	N/A	The SD Card Driver has not been tested in a high frequency interrupt environment.
SPI	N/A	The SPI Slave mode with DMA is not operational. This issue will be corrected in a future release of MPLAB Harmony.
SPI Flash		Flash features such as high-speed read, hold, and write-protect are not supported by the driver library. Static implementation of the driver library is not available.

USB		The USB Driver Library has been tested in limited capacity with RTOS. While running the USB Driver Library on a PIC32MZ family device, the stack requires three seconds to initialize for PIC32MZ EC devices and three milliseconds for PIC32MZ EF devices. Some APIs for USB Host Driver Library may change in the next release. USB Host Driver Library Polled mode operation has not been tested. USB Host Driver Library Attach/Detach behavior has been tested in a limited capacity.

System Services:

Feature	Additions and Updates	Known Issues
DMA		

Peripheral Libraries:

Feature	Additions and Updates	Known Issues
ADCHS	N/A	FIFO is not supported in this version of the peripheral library.
SQI	N/A	A SQI clock divider value higher than CLK_DIV_16 will not work. To achieve optimal SQI clock speeds, use a SQI clock divider value lower than CLK_DIV_16. **Note:** This issue is applicable to any applications that use the SQI module.

Applications:

Feature	Additions and Updates	Known Issues
Audio Demonstrations	Changed in Universal_audio_decoders to limit directory depth in the file system. This will prevent an exception if that otherwise would occur beyond 6 sub-directory levels.	usb_headset, usb_microphone, and usb_speaker Demonstrations: • When switching between these applications, the Windows driver may become confused by the type of device that is connected. For example, audio streaming is prevented by the driver. If a condition like this occurs, do the following to remedy the issue: 1. While the device is connected, uninstall the driver. 2. A restart of the Windows operating system may also be required. universal_audio_decoder Demonstration: • The 270f512lpim_bt_audio_dk and pic32mz_da_sk_meb2 configurations do not support the display. The display may appear to be ON but is blank because the backlight is illuminated. • The 270f512lpim_bt_audio_dk configuration does not support the WMA and AAC decoders. • Volume control is only available on the bt_audio_dk and 270f512lpim_bt_audio_dk configurations • Minor audio glitches are present for 96 kHz WAVE audio files by default buffer size. As a workaround, eliminating glitches by using a larger buffer size. • Audio glitches may appear when playing high sampling rate AAC files. The higher the sampling rate, the more severe the glitch. • Some USB Flash drives may not work with this demonstration • Due to memory limitations, the Speex Decoder and the WMA Decoder cannot operate concurrently with other decoders audio_tone Demonstration: • The display is static • Switch debounce is not implemented usb_speaker Demonstration: • The left and right output channels are swapped for the pic32mz_ef_sk_meb2 configuration at the output connector. **Note:** This is an issue with the MEB II hardware and not the application software. • The mute feature (as controlled from the PC) does not function usb_headset: The mute feature (as controlled from the PC) does not function. mac_audio_hi_res Demonstration: Muting the audio at the PC only works properly the first time
Bluetooth Demonstrations	Fixed issues found in WVGA display on a2dp_avrcp demo. This is a premium demonstration.	Graphics have been temporarily turned off/removed in all PIC32MZ DA configurations and will be made available in a future release
File System Demonstrations		LED_3, which is used to indicate demonstration success does not illuminate, which affects the following demonstrations: • sdcard_fat_single_disk (pic32mz_da_sk_adma configuration) • sdcard_msd_fat_multi_disk (pic32mz_da_sk_meb2 configuration) As a work around, the user can place a breakpoint in the application code to see the status of the demonstrations.

Graphics Demonstrations		Starter kit PKOB programming and debugging may produce the following error: *The programmer could not be started: Failed to program the target device*. If this message occur, repower the device and the application will start. If debugging is required, the suggested work around is to install the appropriate header onto the starter kit using MPLAB REAL ICE. The following issues apply to the external_resources demonstration: • Currently, JPEG decode support has been enabled for internal storage only • During the demonstration, latency is observed in fetching the images from external off-chip memory, which causes slow population of the display while rendering the images on screen memory. • A similar latency to the previous issue is also seen while displaying JPEG images on-screen due to the delay caused by JPEG run-time decoding
MEB II Demonstrations		The segger_emwin demonstration application does not yet include touch input.
RTOS Demonstrations		The SEGGER embOS Library with FPU support is required for PIC32MZ EF configuration and the user needs to explicitly include this. By default, the library without FPU support is included.
System Service Library Examples	N/A	The command_appio demonstration does not function using MPLAB X IDE v3.06, but is operational with v3.00.
TCP/IP Wi-Fi Demonstrations	N/A	The tcpip_tcp_client demonstration using the ENC24xJ600 or the ENC28J60 configurations does not work properly if the SPI Driver enables DMA. Please disable the SPI DMA option for these configurations. This will be corrected in a future release of MPLAB Harmony.
Test Applications	N/A	The FreeRTOS configurations for use with the PIC32MZ EF Starter Kit have the floating-point library disabled in the project options.
USB Demonstrations		The msd_basic Device demonstration application when built using PIC32MZ devices, requires that the SCSI Enquiry response data structure to be placed in RAM. Placing this data structure in program Flash memory causes the enquiry response to become corrupted. This issue will be corrected in a future release. The hid_basic_keyboard Host demonstration captures keystrokes from A-Z, a-z, 0-9, Shift and CAPS LOCK key *only*. The keyboard LED glow functionality and support for other key combinations will be updated in a future release. In the audio_speaker Host demonstration, Plug and Play may not work for the pic32mz_ef_sk_int_dyn and pic32mx_usb_sk2_int_dyn configurations. This issue will be corrected in a future release. In the hub_msd Host demonstration application, Hub plug and play detection may occasionally fail. However, if the hub is plugged in before the PIC32MZ device is released from reset, the demonstration application operates as expected. This issue is under investigation and a correction will be available in a future release of MPLAB Harmony. It is recommended to use a self-powered hub while attempting to use the available hub demonstration applications. The VBUS supply regulator on the starter kit may not be able to meet the current requirements of a bus-powered hub, which would then cause unpredictable demonstration application behavior.

Build Framework:

Feature	Additions and Updates	Known Issues
Bluetooth Stack Library		N/A
Math Libraries		DSP Fixed-Point Math Library: • Optimized only for PIC32MZ devices with microAptiv™ core features, which utilize DSP ASE • Will not function with the `_Fract` data type LibQ Fixed-Point Math Library: • Optimized for PIC32MZ devices with microAptiv core features • The `_fast` functions have reduced precision

Utilities:

Feature	Additions and Updates	Known Issues
MPLAB Harmony Configurator (MHC)	N/A	• The MHC does not support changing the relative path from the project to the source files within the MPLAB Harmony installation, once the project has been created • When viewing the MPLAB Harmony Help in the MHC, the Index is accessible, but is not functional. This is due to a limitation in the browser that is utilized by MHC. As a work around, the Index is accessible and functional when the HTML Help is opened in an external Web browser. • A tab character after `"---endhelp---"` in a `.hconfig` file may cause the next configuration symbol to be skipped

Third-Party Software:

Feature	Additions and Updates	Known Issues
SEGGER emWin Graphics Library	N/A	Only the LCC display controller is supported. Support for other display controllers is not available in this release. An API to retrieve the Dialog widget handle is not available in this release.

Release Contents

This topic lists the contents of this release and identifies each module.

Description

This table lists the contents of this release, including a brief description, and the release type (Alpha, Beta, Production, or Vendor).

Middleware and Libraries:

<install-dir>/framework/	Description	Release Type
bluetooth/cdbt	Bluetooth Stack Library (Basic)	Production
bluetooth/premium/audio/cdbt	Bluetooth Audio Stack Library (Premium)	Production
bluetooth/premium/audio/decoder/sbc	SBC Decoder Library (Premium)	Production
bootloader	Bootloader Library	Production
classb	Class B Library	Production
crypto	Microchip Cryptographic Library	Production

decoder/bmp/BmpDecoder decoder/bmp/GifDecoder decoder/bmp/JpegDecoder decoder/audio_decoders/decoder_opus decoder/speex decoder/premium/decoder_aac decoder/premium/decoder_mp3 decoder/premium/decoder_wma	BMP Decoder Library GIF Decoder Library JPEG Decoder Library Opus Decoder Library Speex Decoder Library AAC Decoder Library (Premium) MP3 Decoder Library (Premium) WMA Decoder Library (Premium)	Beta Beta Beta Beta Beta Beta Beta Beta
gfx	Graphics Library	Production
math/dsp	DSP Fixed-Point Math Library API header for PIC32MZ devices	Production
math/libq	LibQ Fixed-Point Math Library API header for PIC32MZ devices	Production
net/pres	MPLAB Harmony Network Presentation Layer	Beta
test	Test Harness Library	Production
tcpip	TCP/IP Network Stack	Production
usb	USB Device Stack USB Host Stack	Production Beta

Device Drivers:

<install-dir>/framework/driver/	Description	Release Type
adc	Analog-to-Digital Converter (ADC) Driver *Dynamic Implementation* *Static Implementation*	 Beta Beta
camera/ovm7690	OVM7690 Camera Driver *Dynamic Implementation only*	Beta
can	Controller Area Network (CAN) Driver *Static Implementation only*	 Beta
cmp	Comparator Driver *Static Implementation only*	Beta
codec/ak4384 codec/ak4642 codec/ak4953 codec/ak7755	AK4384 Codec Driver *Dynamic Implementation only* AK4642 Codec Driver *Dynamic Implementation only* AK4953 Codec Driver *Dynamic Implementation only* AK7755 Codec Driver *Dynamic Implementation only*	 Production Production Production Production
cpld	CPLD XC2C64A Driver *Static Implementation only*	 Production
enc28j60	ENC28J60 Driver Library *Dynamic Implementation only*	Beta
encx24j600	ENCx24J600 Driver Library *Dynamic Implementation only*	 Beta
ethmac	Ethernet Media Access Controller (MAC) Driver *Dynamic Implementation only*	 Production
ethphy	Ethernet Physical Interface (PHY) Driver *Dynamic Implementation only*	 Production
flash	Flash Driver *Static Implementation only*	 Beta

gfx/controller/lcc	Low-Cost Controllerless (LCC) Graphics Driver *Dynamic Implementation only*	 Production
gfx/controller/otm2201a	OTM2201a LCD Controller Driver *Dynamic Implementation only*	 Production
gfx/controller/s1d13517	Epson S1D13517 LCD Controller Driver *Dynamic Implementation only*	 Production
gfx/controller/ssd1289	Solomon Systech SSD1289 Controller Driver *Dynamic Implementation only*	Production
gfx/controller/ssd1926	Solomon Systech SSD1926 Controller Driver *Dynamic Implementation only*	 Production
gfx/controller/tft002	TFT002 Graphics Driver *Dynamic Implementation only*	 Production
i2c	Inter-Integrated Circuit (I2C) Driver *Dynamic Implementation* *Static Implementation*	 Alpha Alpha
i2s	Inter-IC Sound (I2S) Driver *Dynamic Implementation only*	 Beta
ic	Input Capture Driver *Static Implementation only*	 Beta
nvm	Non-Volatile Memory (NVM) Driver *Dynamic Implementation* *Static Implementation*	 Beta Beta
oc	Output Compare Driver *Static Implementation only*	 Beta
pmp	Parallel Master Port (PMP) Driver *Dynamic Implementation* *Static Implementation*	 Production Beta
rtcc	Real-Time Clock and Calendar (RTCC) Driver *Static Implementation only*	 Beta
sdcard	SD Card Driver (client of SPI Driver) *Dynamic Implementation only*	 Beta
spi	Serial Peripheral Interface (SPI) Driver *Dynamic Implementation* *Static Implementation*	 Production Beta
 spi_flash/sst25vf016b spi_flash/sst25vf020b spi_flash/sst25vf064c spi_flash/sst25	SPI Flash Drivers *Dynamic Implementation only* *Dynamic Implementation only* *Dynamic Implementation only* *Dynamic Implementation only*	 Alpha Alpha Alpha Aplha
tmr	Timer Driver *Dynamic Implementation* *Static Implementation*	 Production Beta
touch/adc10bit touch/ar1021 touch/mtch6301 touch/mtch6303	ADC 10-bit Touch Driver *Dynamic Implementation only* AR1021 Touch Driver *Dynamic Implementation only* MTCH6301 Touch Driver *Dynamic Implementation only* MTCH6303 Touch Driver *Static Implementation only*	 Beta Beta Beta

usart	Universal Synchronous/Asynchronous Receiver/Transmitter (USART) Driver	
	Dynamic Implementation	Production
	Static Implementation	Beta
usbfs	PIC32MX Universal Serial Bus (USB) Controller Driver (USB Device)	
	Dynamic Implementation only	Production
usbhs	PIC32MZ Universal Serial Bus (USB) Controller Driver (USB Device)	
	Dynamic Implementation only	Production
usbfs	PIC32MX Universal Serial Bus (USB) Controller Driver (USB Host)	
	Dynamic Implementation only	Beta
usbhs	PIC32MZ Universal Serial Bus (USB) Controller Driver (USB Host)	
	Dynamic Implementation only	Beta
wifi/mrf24w	Wi-Fi Driver for the MRF24WG controller	
	Dynamic Implementation only	Production
wifi/mrf24wn	Wi-Fi Driver for the MRF24WN controller	
	Dynamic Implementation only	Production

System Services:

<install-dir>/framework/system/	Description	Release Type
clk	Clock System Service Library	
	Dynamic Implementation	Production
	Static Implementation	Production
command	Command Processor System Service Library	
	Dynamic Implementation only	Production
common	Common System Service Library	Beta
console	Console System Service Library	
	Dynamic Implementation	Beta
	Static Implementation	Alpha
debug	Debug System Service Library	
	Dynamic Implementation only	Beta
devcon	Device Control System Service Library	
	Dynamic Implementation only	Production
dma	Direct Memory Access System Service Library	
	Dynamic Implementation	Production
fs	File System Service Library	
	Dynamic Implementation only	Production
int	Interrupt System Service Library	
	Static Implementation only	Production
memory	Memory System Service Library	
	Static Implementation only	Beta
msg	Messaging System Service Library	
	Dynamic Implementation only	Beta
ports	Ports System Service Library	
	Static Implementation only	Production
random	Random Number Generator System Service Library	
	Static Implementation only	Production
reset	Reset System Service Library	
	Static Implementation only	Beta
tmr	Timer System Service Library	
	Dynamic Implementation only	Beta
touch	Touch System Service Library	
	Dynamic Implementation only	Beta

wdt	Watchdog Timer System Service Library *Static Implementation only*	Beta

Peripheral Libraries:

<install-dir>/framework/	Description	Release Type
peripheral	Peripheral Library Source Code for all Supported PIC32 Microcontrollers	Production
	PIC32MX1XX/2XX 28/36/44-pin Family	Production
	PIC32MX1XX/2XX/5XX 64/100-pin Family	Production
	PIC32MX320/340/360/420/440/460 Family	Production
	PIC32MX330/350/370/430/450/470 Family	Production
	PIC32MX5XX/6XX/7XX Family	Production
	PIC32MZ Embedded Connectivity (EC) Family	Production
	PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Family	Production

Operating System Abstraction Layer (OSAL):

<install-dir>/framework/	Description	Release Type
osal	Operating System Abstraction Layer (OSAL)	Production

Board Support Packages (BSP):

<install-dir>/bsp/	Description	Release Type
bt_audio_dk	BSP for the PIC32 Bluetooth Audio Development Kit.	Production
chipkit_wf32	BSP for the chipKIT™ WF32™ Wi-Fi Development Board.	Production
chipkit_wifire	BSP for the chipKIT™ Wi-FIRE Development Board.	Production
pic32mx_125_sk	BSP for the PIC32MX1/2/5 Starter Kit.	Production
pic32mx_125_sk+lcc_pictail+qvga	BSP for the Low-Cost Controllerless (LCC) Graphics PICtail Plus Daughter Board with the Graphics Display Truly 3.2" 320x240 Board connected to the PIC32MX1/2/5 Starter Kit.	Production
pic32mx_125_sk+meb	BSP for the PIC32MX1/2/5 Starter Kit connected to the Multimedia Expansion Board (MEB).	Production
pic32mx_bt_sk	BSP for the PIC32 Bluetooth Starter Kit.	Production
pic32mx_eth_sk	BSP for the PIC32 Ethernet Starter Kit.	Production
pic32mx_eth_sk2	BSP for the PIC32 Ethernet Starter Kit II.	Production
pic32mx_pcap_db	BSP for the PIC32 GUI Development Board with Projected Capacitive Touch.	Production
pic32mx_usb_digital_audio_ab	BSP for the PIC32 USB Audio Accessory Board	Production
pic32mx_usb_sk2	BSP the PIC32 USB Starter Kit II.	Production
pic32mx_usb_sk2+lcc_pictail+qvga	BSP for the Low-Cost Controllerless (LCC) Graphics PICtail Plus Daughter Board with the Graphics Display Truly 3.2" 320x240 Board connected to the PIC32 USB Starter Kit II.	Production
pic32mx_usb_sk2+lcc_pictail+wqvga	BSP for the Low-Cost Controllerless (LCC) Graphics PICtail Plus Daughter Board with the Graphics Display Powertip 4.3" 480x272 Board connected to the PIC32 USB Starter Kit II.	Production
pic32mx_usb_sk2+meb	BSP for the Multimedia Expansion Board (MEB) connected to the PIC32 USB Starter Kit II.	Production
pic32mx_usb_sk2+s1d_pictail+vga	BSP for the Graphics Controller PICtail Plus Epson S1D13517 Daughter Board with the Graphics Display Truly 5.7" 640x480 Board connected to the PIC32 USB Starter Kit II.	Production
pic32mx_usb_sk2+s1d_pictail+wqvga	BSP for the Graphics Controller PICtail Plus Epson S1D13517 Daughter Board with the Graphics Display Powertip 4.3" 480x272 Board connected to the PIC32 USB Starter Kit II.	Production

pic32mx_usb_sk2+s1d_pictail+wvga	BSP for the Graphics Controller PICtail Plus Epson S1D13517 Daughter Board with Graphics Display Truly 7" 800x400 Board connected to the PIC32 USB Starter Kit II.	Production
pic32mx_usb_sk2+ssd_pictail+qvga	BSP for the Graphics LCD Controller PICtail Plus SSD1926 Daughter Board with Graphics Display Truly 3.2" 320x240 Board connected to the PIC32 USB Starter Kit II.	Production
pic32mx_usb_sk3	BSP for the PIC32 USB Starter Kit III.	Production
pic32mx270f512l_pim+bt_audio_dk	BSP for the PIC32MX270F512L Plug-in Module (PIM) connected to the PIC32 Bluetooth Audio Development Kit.	Production
pic32mx460_pim+e16	BSP for the PIC32MX460F512L Plug-in Module (PIM) connected to the Explorer 16 Development Board.	Production
pic32mx470_pim+e16	BSP for the PIC32MX450/470F512L Plug-in Module (PIM) connected to the Explorer 16 Development Board.	Production
pic32mx795_pim+e16	BSP for the PIC32MX795F512L Plug-in Module (PIM) connected to the Explorer 16 Development Board.	Production
pic32mz_ec_pim+bt_audio_dk	BSP for the PIC32MZ2048ECH144 Audio Plug-in Module (PIM) connected to the PIC32 Bluetooth Audio Development Kit.	Production
pic32mz_ec_pim+e16	BSP for the PIC32MZ2048ECH100 Plug-in Module (PIM) connected to the Explorer 16 Development Board.	Production
pic32mz_ec_sk	BSP for the PIC32MZ Embedded Connectivity (EC) Starter Kit.	Production
pic32mz_ec_sk+meb2	BSP for the Multimedia Expansion Board II (MEB II) connected to the PIC32MZ Embedded Connectivity (EC) Starter Kit.	Production
pic32mz_ec_sk+meb2+wvga	BSP for the Multimedia Expansion Board II (MEB II) with the 5" WVGA PCAP Display Board (see **Note**) connected to the PIC32MZ Embedded Connectivity (EC) Starter Kit. **Note:** Please contact your local Microchip Sales Office for information on obtaining the 5" WVGA PCAP Display Board.	Production
pic32mz_ec_sk+s1d_pictail+vga	BSP for the Graphics Controller PICtail Plus Epson S1D13517 Daughter Board with the Graphics Display Truly 5.7" 640x480 Board connected to the PIC32MZ Embedded Connectivity (EC) Starter Kit.	Production
pic32mz_ec_sk+s1d_pictail+wqvga	BSP for the Graphics Controller PICtail Plus Epson S1D13517 Daughter Board with the Graphics Display Powertip 4.3" 480x272 Board connected to the PIC32MZ Embedded Connectivity (EC) Starter Kit.	Production
pic32mz_ec_sk+s1d_pictail+wvga	BSP for the Graphics Controller PICtail Plus Epson S1D13517 Daughter Board with the 5" WVGA PCAP Display Board (see **Note**) connected to the PIC32MZ Embedded Connectivity with Floating Point Unit (EC) Starter Kit. **Note:** Please contact your local Microchip Sales Office for information on obtaining the 5" WVGA PCAP Display Board.	Production
pic32mz_ef_pim+bt_audio_dk	BSP for the PIC32MZ2048EFH144 Audio Plug-in Module (PIM) connected to the PIC32 Bluetooth Audio Development Kit.	Production
pic32mz_ef_pim+e16	BSP for the PIC32MZ2048EFH100 Plug-in Module (PIM) connected to the Explorer 16 Development Board.	Production
pic32mz_ef_sk	BSP for the PIC32MZ Embedded Connectivity with Floating Point (EF) Starter Kit.	Production
pic32mz_ef_sk+meb2	BSP for the Multimedia Expansion Board II (MEB II) connected to the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit.	Production
pic32mz_ef_sk+meb2+wvga	BSP for the Multimedia Expansion Board II (MEB II) with the 5" WVGA PCAP Display Board (see **Note**) connected to the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit. **Note:** Please contact your local Microchip Sales Office for information on obtaining the 5" WVGA PCAP Display Board.	Production
pic32mz_ef_sk+s1d_pictail+vga	BSP for the Graphics Controller PICtail Plus Epson S1D13517 Daughter Board with the Graphics Display Truly 5.7" 640x480 Board connected to the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit.	Production
pic32mz_ef_sk+s1d_pictail+wqvga	BSP for the Graphics Controller PICtail Plus Epson S1D13517 Daughter Board with the Graphics Display Powertip 4.3" 480x272 Board connected to the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit.	Production
wifi_g_db	BSP for the Wi-Fi G Demo Board.	Production

Audio Applications:

<install-dir>/apps/audio/	Description	Release Type
audio_microphone_loopback	Audio Microphone Loopback Demonstration	Production
audio_tone	Audio Tone Demonstration	Production
mac_audio_hi_res	Hi-resolution Audio Demonstration	Production
sdcard_usb_audio	USB Audio SD Card Demonstration	Beta
universal_audio_decoders	Universal Audio Decoder Demonstration	Production
usb_headset	USB Audio Headset Demonstration	Production
usb_microphone	USB Audio Microphone Demonstration	Production
usb_speaker	USB Audio Speaker Demonstration	Production

Bluetooth Applications:

<install-dir>/apps/bluetooth/	Description	Release Type
data/data_basic	Bluetooth® Basic Data Demonstration	Production
data/data_temp_sens_rgb	Bluetooth Temperature Sensor and RGB Data Demonstration	Production
premium/audio/a2dp_avrcp	Bluetooth Premium Audio Demonstration	Production

Bootloader Applications:

<install-dir>/apps/bootloader/	Description	Release Type
basic	Basic Bootloader Demonstration	Production
LiveUpdate	Live Update Demonstration	Production

Class B Applications:

<install-dir>/apps/classb/	Description	Release Type
ClassBDemo	Class B Library Demonstration	Production

Cryptographic Applications:

<install-dir>/apps/crypto/	Description	Release Type
encrypt_decrypt	Crypto Peripheral Library MD5 Encrypt/Decrypt Demonstration	Production
large_hash	Crypto Peripheral Library Hash Demonstration	Production

Driver Applications:

<install-dir>/apps/driver/	Description	Release Type
i2c/i2c_rtcc	I2C RTCC Demonstration	Production
nvm/nvm_read_write	NVM Demonstration	Production
spi/serial_eeprom	SPI Demonstration	Production
spi/spi_loopback	SPI Demonstration	Production
spi_flash/sst25vf020b	SPI Flash SST25VF020B Device Demonstration	Production
usart/usart_echo	USART Demonstration	Production
usart/usart_loopback	USART Loopback Demonstration	Production

Example Applications:

<install-dir>/apps/examples/	Description	Release Type
my_first_app	MPLAB Harmony Tutorial Example Solution	N/A
peripheral	MPLAB Harmony Compliant Peripheral Library Examples	Production
system	MPLAB Harmony Compliant System Service Library Examples	Production

External Memory Programmer Applications:

<install-dir>/apps/programmer/	Description	Release Type
external_flash	External Flash Bootloader Demonstration	Production
sqi_flash	External Memory Programmer SQI Flash Demonstration	Production

File System Applications:

<install-dir>/apps/fs/	Description	Release Type
nvm_fat_single_disk	Single-disk Non-Volatile Memory FAT FS Demonstration	Production
nvm_mpfs_single_disk	Single-disk Non-Volatile Memory MPFS Demonstration	Production
nvm_sdcard_fat_mpfs_multi_disk	Multi-disk Non-Volatile Memory FAT FS MPFS Demonstration	Production
nvm_sdcard_fat_multi_disk	Multi-disk Non-Volatile Memory FAT FS Demonstration	Production
sdcard_fat_single_disk	Single-disk SD Card FAT FS Demonstration	Production
sdcard_msd_fat_multi_disk	Multi-disk SD Card MSD FAT FS Demonstration	Production
sst25_fat	SST25 Flash FAT FS Demonstration	Alpha

Graphics Applications:

<install-dir>/apps/gfx/	Description	Release Type
basic_image_motion	Basic Image Motion Graphics Library Demonstration	Production
emwin_quickstart	SEGGER emWin Quick Start Demonstration	Production
external_resources	Stored Graphics Resources External Memory Access Demonstration	Production
graphics_showcase	Graphics Low-Cost Controllerless (LCC) WVGA Demonstration	Production
lcc	Low-Cost Controllerless (LCC) Graphics Demonstration	Production
media_image_viewer	Graphics Media Image Viewer Demonstration	Production
object	Graphics Object Layer Demonstration	Production
primitive	Graphics Primitives Layer Demonstration	Production
resistive_touch_calibrate	Resistive Touch Calibration Demonstration	Production
s1d13517	Epson S1D13517 LCD Controller Demonstration	Production
ssd1926	Solomon Systech SSD1926 Controller Demonstration	Production

Multimedia Expansion Board II (MEB II) Applications:

<install-dir>/apps/meb_ii/	Description	Release Type
gfx_camera	Graphics Camera Demonstration	Production
gfx_cdc_com_port_single	Combined Graphics and USB CDC Demonstration	Production
gfx_photo_frame	Graphics Photo Frame Demonstration	Production
gfx_web_server_nvm_mpfs	Combined Graphics and TCP/IP Web Server Demonstration	Production
emwin	SEGGER emWin® Capabilities on MEB II Demonstration	Beta

RTOS Applications:

<install-dir>/apps/rtos/	Description	Release Type
embos	SEGGER embOS® Demonstrations	Production
freertos	FreeRTOS™ Demonstrations	Production
openrtos	OPENRTOS Demonstrations	Production
threadx	Express Logic ThreadX Demonstrations	Production
uC_OS_II	Micriμm® μC/OS-II™ Demonstrations	Beta
uC_OS_III	Micriμm® μC/OS-III™ Demonstrations	Production

TCP/IP Applications:

<install-dir>/apps/tcpip/	Description	Release Type
berkeley_tcp_client	Berkeley TCP/IP Client Demonstration	Production
berkeley_tcp_server	Berkeley TCP/IP Server Demonstration	Production
berkeley_udp_client	Berkeley TCP/IP UDP Client Demonstration	Production
berkeley_udp_relay	Berkeley TCP/IP UDP Relay Demonstration	Production
berkeley_udp_server	Berkeley TCP/IP UDP Server Demonstration	Production
wolfssl_tcp_client	wolfSSL TCP/IP TCP Client Demonstration	Production
wolfssl_tcp_server	wolfSSL TCP/IP TCP Server Demonstration	Production
snmpv3_nvm_mpfs	SNMPv3 Non-Volatile Memory Microchip Proprietary File System Demonstration	Production
snmpv3_sdcard_fatfs	SNMPv3 Non-Volatile Memory SD Card FAT File System Demonstration	Production
tcpip_tcp_client	TCP/IP TCP Client Demonstration	Production
tcpip_tcp_client_server	TCP/IP TCP Client Server Demonstration	Production
tcpip_tcp_server	TCP/IP TCP Server Demonstration	Production
tcpip_udp_client	TCP/IP UDP Client Demonstration	Production
tcpip_udp_client_server	TCP/IP UDP Client Server Demonstration	Production
tcpip_udp_server	TCP/IP UDP Server Demonstration	Production
web_server_nvm_mpfs	Non-Volatile Memory Microchip Proprietary File System Web Server Demonstration	Production
web_server_sdcard_fatfs	SD Card FAT File System Web Server Demonstration	Production
wifi_easy_configuration	Wi-Fi® EasyConf Demonstration	Production
wifi_g_demo	Wi-Fi G Demonstration	Production
wifi_wolfssl_tcp_client	Wi-Fi wolfSSL TCP/IP Client Demonstration	Production
wifi_wolfssl_tcp_server	Wi-Fi wolfSSL TCP/IP Server Demonstration	Production
wolfssl_tcp_client	wolfSSL TCP/IP Client Demonstration	Production
wolfssl_tcp_server	wolfSSL TCP/IP Server Demonstration	Production

Test Applications:

<install-dir>/apps/meb_ii/	Description	Release Type
test_sample	MPLAB Harmony Test Sample Application	Alpha

USB Device Applications:

<install-dir>/apps/usb/device/	Description	Release Type
cdc_com_port_dual	CDC Dual Serial COM Ports Emulation Demonstration	Production
cdc_com_port_single	CDC Single Serial COM Port Emulation Demonstration	Production

cdc_msd_basic	CDC Mass Storage Device (MSD) Demonstration	Production
cdc_serial_emulator	CDC Serial Emulation Demonstration	Production
cdc_serial_emulator_msd	CDC Serial Emulation MSD Demonstration	Production
hid_basic	Basic USB Human Interface Device (HID) Demonstration	Production
hid_joystick	USB HID Class Joystick Device Demonstration	Production
hid_keyboard	USB HID Class Keyboard Device Demonstration	Production
hid_mouse	USB HID Class Mouse Device Demonstration	Production
hid_msd_basic	USB HID Class MSD Demonstration	Production
msd_basic	USB MSD Demonstration	Production
msd_fs_spiflash	USB MSD SPI Flash File System Demonstration	Production
msd_sdcard	USB MSD SD Card Demonstration	Production
vendor	USB Vendor (i.e., Generic) Demonstration	Production

USB Host Applications:

<install-dir>/apps/usb/host/	Description	Release Type
audio_speaker	USB Audio v1.0 Host Class Driver Demonstration	Production
cdc_basic	USB CDC Basic Demonstration	Production
cdc_msd	USB CDC MSD Basic Demonstration	Production
hid_basic_keyboard	USB HID Host Keyboard Demonstration	Production
hid_basic_mouse	USB HID Host Mouse Demonstration	Production
hub_cdc_hid	USB HID CDC Hub Demonstration	Production
hub_msd	USB MSD Hub Host Demonstration	Production
msd_basic	USB MSD Host Simple Thumb Drive Demonstration	Production

Prebuilt Binaries:

<install-dir>/bin/framework	Description	Release Type
bluetooth	Prebuilt PIC32 Bluetooth Stack Libraries	Production
bluetooth/premium/audio	Prebuilt PIC32 Bluetooth Audio Stack Libraries (Premium)	Production
decoder/premium/aac_microaptiv	Prebuilt AAC Decoder Library for PIC32MZ Devices with microAptiv Core Features (Premium)	Beta
decoder/premium/aac_pic32mx	Prebuilt AAC Decoder Library for PIC32MX Devices (Premium)	Beta
decoder/premium/mp3_microaptiv	Prebuilt MP3 Decoder Library for PIC32MZ Devices with microAptiv Core Features (Premium)	Production
decoder/premium/mp3_pic32mx	Prebuilt MP3 Decoder Library for PIC32MX Devices (Premium)	Production
decoder/premium/wma_microaptiv	Prebuilt WMA Decoder Library for PIC32MZ Devices with microAptiv Core Features (Premium)	Beta
decoder/premium/wma_pic32mx	Prebuilt WMA Decoder Library for PIC32MX Devices (Premium)	Beta
math/dsp	Prebuilt DSP Fixed-Point Math Libraries for PIC32MZ Devices	Production
math/libq	Prebuilt LibQ Fixed-Point Math Libraries for PIC32MZ Devices	Production
math/libq/libq_c	Prebuilt Math library with C-implementations compatible with both Pic32MX and Pic32MZ devices. (NOTE: These routines are not compatible with the functions of the libq library)	Beta
peripheral	Prebuilt Peripheral Libraries	Production/ Beta

Build Framework:

<install-dir>/build/framework/	Description	Release Type
math/libq	LibQ Library Build Project	Production
math/libq	LibQ_C Library Build Project	Alpha
peripheral	Peripheral Library Build Project	Production

Utilities:

<install-dir>/utilities/	Description	Release Type
mhc/plugins/displaymanager/displaymanager.jar	MPLAB Harmony Display Manager Plug-in	Beta
mhc/com-microchip-mplab-modules-mhc.nbm	MPLAB Harmony Configurator (MHC) Plug-in MPLAB Harmony Graphics Composer (included in the MHC plug-in)	Production Beta
mib2bib/mib2bib.jar	Compiled Custom Microchip MIB script (`snmp.mib`) to generate `snmp.bib` and `mib.h`	Production
mpfs_generator/mpfs2.jar	TCP/IP MPFS File Generator and Upload Utility	Production
segger/emwin	SEGGER emWin utilities used by MPLAB Harmony emWin demonstration applications	Vendor
tcpip_discoverer/tcpip_discoverer.jar	TCP/IP Microchip Node Discoverer Utility	Production

Third-Party Software:

<install-dir>/third_party/	Description	Release Type
decoder	Decoder Library Source Distribution	Vendor
gfx/emwin	SEGGER emWin® Graphics Library Distribution	Vendor
rtos/embOS	SEGGER embOS® Distribution	Vendor
rtos/FreeRTOS	FreeRTOS Source Distribution with Support for PIC32MZ Devices	Vendor
rtos/MicriumOSII	Micriμm® μC/OS-II™ Distribution	Vendor
rtos/MicriumOSIII	Micriμm® μC/OS-III™ Distribution	Vendor
rtos/OpenRTOS	OPENRTOS Source Distribution with Support for PIC32MZ Devices	Vendor
rtos/ThreadX	Express Logic ThreadX Distribution	Vendor
segger/emwin	SEGGER emWin® Pro Distribution	Vendor
tcpip/wolfssl	wolfSSL (formerly CyaSSL) Embedded SSL Library Open Source-based Demonstration	Vendor
tcpip/iniche	InterNiche Library Distribution	Vendor

Documentation:

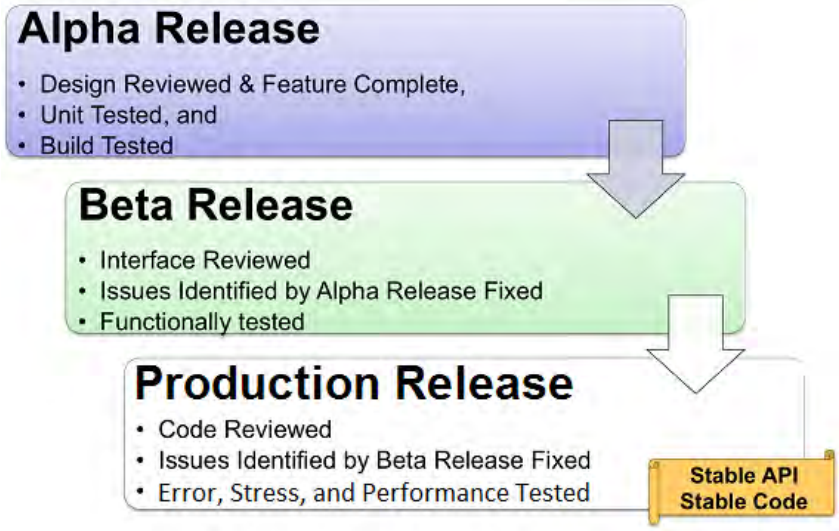
<install-dir>/doc/	Description	Release Type
harmony_help.pdf	MPLAB Harmony Help in Portable Document Format (PDF)	Production
harmony_help.chm	MPLAB Harmony Help in Compiled Help (CHM) format	Production
html/index.html	MPLAB Harmony Help in HTML format	Production
harmony_compatibility_worksheet.pdf	PDF form for use in determining the level of MPLAB Harmony compatibility and to capture any exceptions or restrictions to the compatibility guidelines	Production
harmony_release_brief_v1.11.pdf	MPLAB Harmony Release Brief, providing "at-a-glance" release information	Production
harmony_release_notes_v1.11.pdf	MPLAB Harmony Release Notes in PDF	Production
harmony_license_v1.11.pdf	MPLAB Harmony Software License Agreement in PDF	Production

Release Types

This section describes the release types and their meaning.

Description

MPLAB Harmony module releases can be one of three different types, as shown in the following illustration.



Alpha Release

An alpha release version of a module is usually an initial release. Alpha releases will have complete implementations of their basic feature set, they are functionally unit tested and will build correctly. An alpha release is a great "preview" of what a new development Microchip is working on and it can be very helpful for exploring new features. However, it has not gone through the complete formal test process and it is almost certain that some of its interface will change before the production version is released, and therefore, is not recommended for production use.

Beta Release

A beta release version of a module has gone through the internal interface review process and has had formal testing of its functionality. Also, issues reported from the alpha release will have been fixed or documented. When a module is in a beta version, you can expect it to function correctly in normal circumstances and you can expect that its interface is very close to the final form (although changes can still be made if required). However, it has not had stress or performance testing and it may not fail gracefully if used incorrectly. A beta release is not recommended for production use, but it can be used for development.

Production Release

By the time a module is released in a production form, it is feature complete, fully tested, and its interface is "frozen". All known issues from previous releases will have been fixed or documented. The existing interface will not change in future releases. It may be expanded with additional features and additional interface functions, but existing interface functions will not change. This is stable code with a stable Application Program Interface (API) that you can rely on for production purposes.

Version Numbers

This section describes the meaning of MPLAB Harmony version numbers.

Description

MPLAB Harmony Version Numbering Scheme

MPLAB Harmony uses the following version numbering scheme:

`<major>.<minor>[.<dot>][<release type>]`

Where:

`<major>` = Major revision (significant change that affects many or all modules)

`<minor>` = Minor revision (new features, regular releases)

`[.<dot>]` = Dot release (error corrections, unscheduled releases)

`[<release type>]` = Release Type (a for alpha and b for beta, if applicable). Production release versions do not include a release type letter.

Version String

The SYS_VersionStrGet function will return a string in the format:

"`<major>.<minor>[.<patch>][<type>]`"

Where:

`<major>` is the module's major version number

`<minor>` is the module's minor version number

`<patch>` is an optional "patch" or "dot" release number (which is not included in the string if it equals "00")

`<type>` is an optional release type of "a" for alpha and "b" for beta. This type is not included if the release is a production version (i.e., not an alpha or a beta)

Note: The version string will not contain any spaces.

Example:
```
"0.03a"
"1.00"
```

Version Number

The version number returned from the SYS_VersionGet function is an unsigned integer in the following decimal format (not in a BCD format).

```
<major> * 10000 + <minor> * 100 + <patch>
```

Where the numbers are represented in decimal and the meaning is the same as described in Version String.

Note: There is no numerical representation of the release type.

Example:

For version "0.03a", the value returned is equal to: 0 * 10000 + 3 * 100 + 0.

For version "1.00", the value returned is equal to: 1 * 100000 + 0 * 100 + 0.

Prerequisites

This section describes the required set of tools that should be installed before using MPLAB Harmony.

Description

Before using MPLAB Harmony, ensure that the following development tools and plug-in are installed:

Development Tools:

- MPLAB X IDE v3.40 or later
- MPLAB XC32 C/C++ Compiler v1.42

MPLAB X IDE plug-in:

MPLAB Harmony Configurator v1.09.xx

Installing a Plug-in Module

This topic provides information on installing a MPLAB X IDE plug-in module.

Description

Before you begin using MPLAB Harmony, it is recommended to install any MPLAB X IDE plug-in modules that you may need. These plug-ins are included in your MPLAB Harmony installation. Refer to the *Release Contents > Utilities* section of the MPLAB Harmony Release Notes PDF for the list and locations of the available plug-ins. A copy of the release notes are provided in the `<install-dir>/doc` folder of your installation.

As an example, the MPLAB Harmony Configurator plug-in module is used. This file is located at:
`<install-dir>/utilities/mhc/com-microchip-mplab-modules-mhc.nbm`.

TIP!

Throughout this documentation, occurrences of `<install-dir>` refer to the default MPLAB Harmony installation path:

- Windows: `C:/microchip/harmony/<version>`
- Mac OS/Linux: `~/microchip/harmony/<version>`

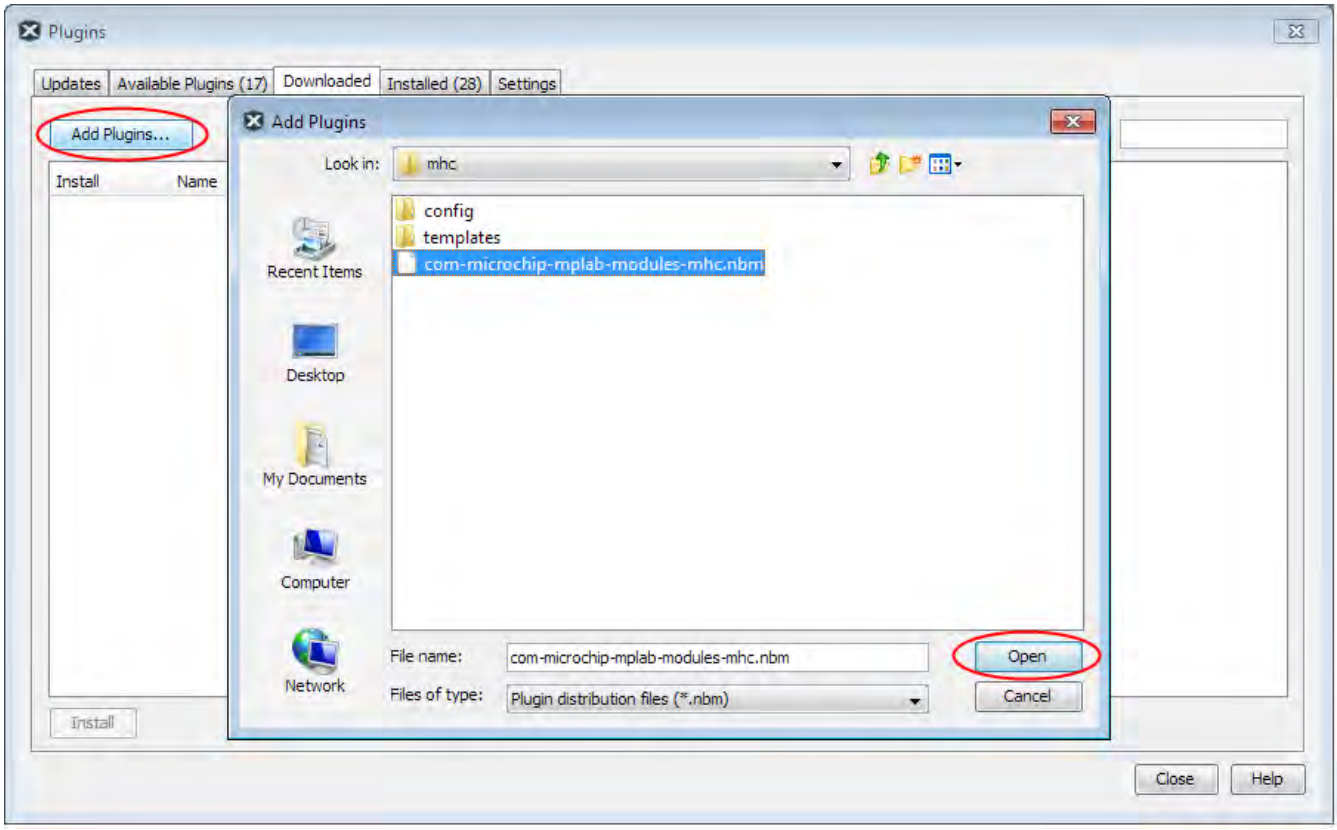
Installing a Plug-in Module

Notes:

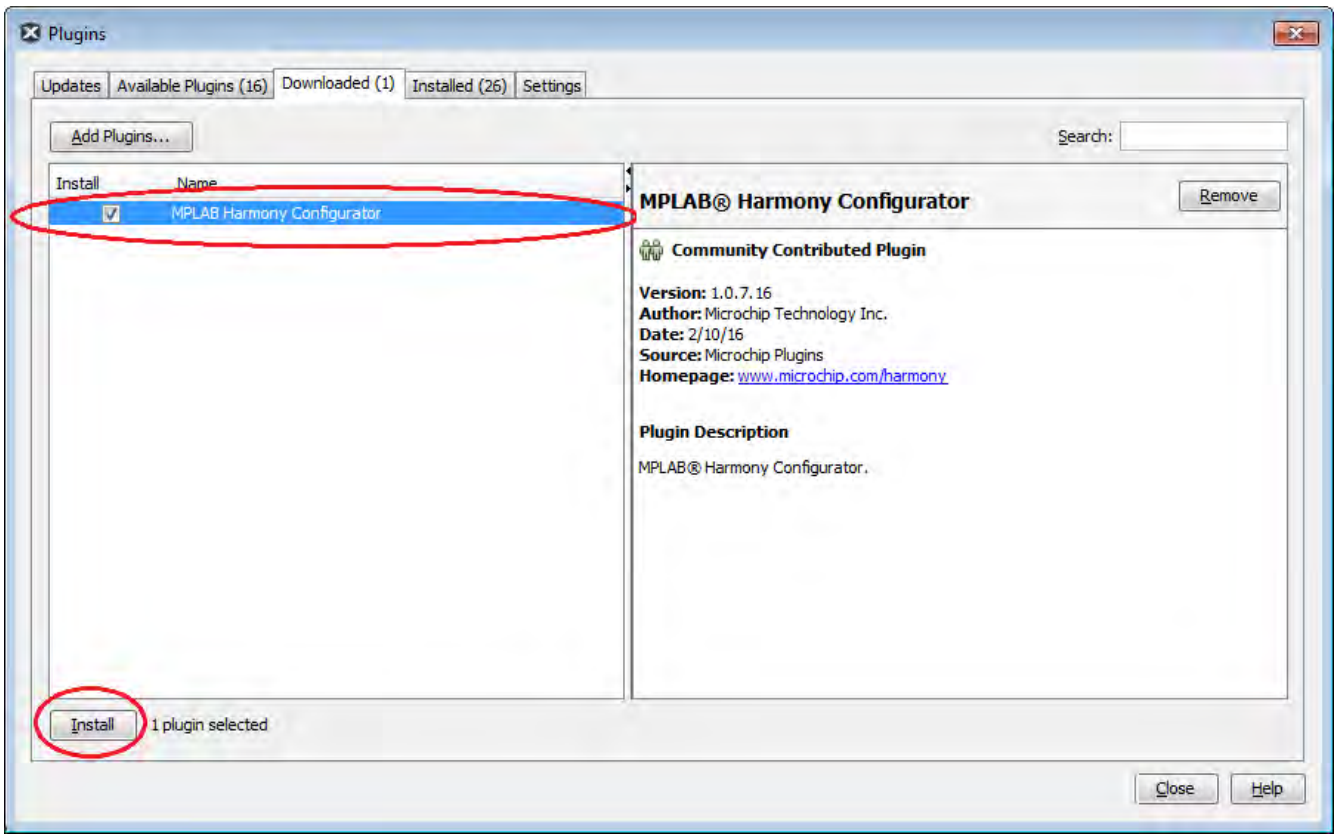
1. If any plug-ins were previously installed, MPLAB X IDE will inform you of any available updates from the update center.
2. Refer to the **"Add Plug-in Tools"** section of the *"MPLAB X IDE User's Guide"* (DS50002027) for more information on how to install a plug-in through the update center. This document is available from the MPLAB X IDE web site at: http://www.microchip.com/mplab.

The following example describes how to install the MHC plug-in module. This procedure can be applied to any of the plug-ins by substituting the name of the plug-in you want to install.

1. Start MPLAB X IDE and select *Tools > Plugins*.
2. Select the **Downloaded** tab and click **Add Plugins...**.
3. Navigate to the desired.nbm plug-in file, and then click **Open**.



3. Ensure that the Install check box for the plug-in is selected and click **Install**.



4. Follow the prompts from the installation and continue until the installation completes. (Do not be concerned if the version you are installing is *signed* but not *trusted*, simply click **Continue**). Once the installation has finished you can close the **Plugins** dialog box.
5. To verify the installation, select *Tools > Plugins* and select the **Installed** tab. The plug-in you installed should be included in the list.

Applications Help

This section provides information on the various application demonstrations that are included in MPLAB Harmony.

Description

Applications determine how MPLAB Harmony libraries (device drivers, middleware, and system services) are used to do something useful. In a MPLAB Harmony system, there may be one main application, there may be multiple independent applications or there may be one or more Operating System (OS) specific applications. Applications interact with MPLAB Harmony libraries through well defined interfaces. Applications may operate in a strictly polling environment, they may be interrupt driven, they may be executed in OS-specific threads, or they may be written so as to be flexible and easily configured for any of these environments. Applications generally fit into one of the following categories.

Demonstration Applications

Demonstration applications are provided (with MPLAB Harmony or in separate installations) to demonstrate typical or interesting usage models of one or more MPLAB Harmony libraries. Demonstration applications can demonstrate realistic solutions to real-life problems.

Sample Applications

Sample applications are extremely simple applications provided with MPLAB Harmony as examples of how to use individual features of a library. They will not normally accomplish anything useful on their own. They are provided primarily as documentation to show how to use a library.

Audio Demonstrations

This section provides information on the Audio Demonstrations provided in your installation of MPLAB Harmony.

Introduction

MPLAB Harmony Audio Demonstrations Help.

Description

This help file contains instructions and associated information about MPLAB Harmony Audio demonstration applications, which are contained in the MPLAB Harmony Library distribution.

Demonstrations

Provides instructions on how to run the demonstration applications.

audio_microphone_loopback

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Description

In this demonstration application, the AK4642 Codec Driver sets up the AK4642 Codec, which is the on-board device on the Audio Codec Daughter Board AK4642EN, and can receive audio data through the microphone onboard the daughter board and sends this audio data out through the on-board headphones. The Audio Codec Daughter Board AK4642EN, which is available for purchase from Microchip, can be connected to the PIC32 Bluetooth Audio Development Kit.

The demonstration application also shows how to configure the I2S client and DMA channels for applications that need two-way data communication between the Codec and the PIC32 microcontroller.

Refer to the *Framework Help* > *Driver Libraries Help* > *Decoder Libraries Help* > AK4642 Codec Driver Library section for more information on the driver, including configuration details as well as the available APIs.

The DRV_CODEC_IO_INTENT_READWRITE mode of the AK4642EN Codec Driver is useful when the application can guarantee that the I2S playback buffers (even if it is zeros) are the same size and same sampling rate as the microphone (record) buffers that are received over I2S.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the demonstration.

Description

To build this project, you must open the `audio_microphone_loopback.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/audio/audio_microphone_loopback`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
audio_microphone_loopback.X	<install-dir>/apps/audio/audio_microphone_loopback/firmware

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within ./firmware/src/system_config.

Project Configuration Name	BSP Used	Description
bt_audio_dk_16bit	bt_audio_dk	This demonstration runs on the PIC32MX470F512L PIM mounted on the PIC32 Bluetooth Audio Development Kit and the Audio Codec Daughter Board AK4642EN. The default configuration is for 16-bit data width, 48000 Hz sampling frequency, and I2S Audio protocol. In MHC, the Audio protocol can be changed in the I2S driver and the Codec Driver is automatically configured for the appropriate audio data format corresponding to I2S protocol set. The Data width can be changed to be 24-bit as that is supported by the Codec. The SPI communication width setting and the I2S audio data format should be selected corresponding to 24-bit width by the application user. The Codec Driver automatically configures itself to the correct data format once the I2S format is specified.
pic32mx270f512l_pim_bt_audio_dk	pic32mx270f512l_pim+bt_audio_dk	This demonstration runs on the PIC32MX270F512L PIM mounted on the PIC32 Bluetooth Audio Development Kit and the Audio Codec Daughter Board AK4642EN. The default configuration is for 16-bit data width, 48000 Hz sampling frequency, and I2S Audio protocol. In MHC, the Audio protocol can be changed in the I2S driver and the Codec Driver is automatically configured for the appropriate audio data format corresponding to I2S protocol set. The Data width can be changed to be 24-bit as that is supported by the Codec. The SPI communication width setting and the I2S audio data format should be selected corresponding to 24-bit width by the application user. The Codec Driver automatically configures itself to the correct data format once the I2S format is specified.
pic32mz_ef_pim_bt_audio_dk	pic32mz_ef_pim+bt_audio_dk	This demonstration runs on the PIC32MZ2048EFH144 PIM mounted on the PIC32 Bluetooth Audio Development Kit and the Audio Codec Daughter Board AK4642EN. The default configuration is for 16-bit data width, 48000 Hz sampling frequency, and I2S Audio protocol. In MHC, the Audio protocol can be changed in the I2S driver and the Codec Driver is automatically configured for the appropriate audio data format corresponding to I2S protocol set. The Data width can be changed to be 24-bit as that is supported by the Codec. The SPI communication width setting and the I2S audio data format should be selected corresponding to 24-bit width by the application user. The Codec Driver automatically configures itself to the correct data format once the I2S format is specified.

Configuring the Hardware

This section describes how to configure the supported hardware.

Description

PIC32 Bluetooth Audio Development Kit with PIC32MX270F512L PIM for Bluetooth Audio Development Kit and the Audio Codec Daughter Board AK4642EN (see **Note**)

Switch S1 on the PIC32 Bluetooth Audio Development Board should be set to PIM_MCLR.

PIC32 Bluetooth Audio Development Kit with the PIC32MX470F512L and the Audio Codec Daughter Board AK4642EN (see **Note**)

Switch S1 on the PIC32 Bluetooth Audio Development Board should be set to PIC32_MCLR.

PIC32 Bluetooth Audio Development Kit with PIC32MZ2048EFH144 Plug-in Module (PIM) and the Audio Codec Daughter Board AK4642EN (see **Note**)

Switch S1 on the PIC32 Bluetooth Audio Development Board should be set to PIM_MCLR.

Note: The PIC32 Bluetooth Audio Development Kit includes an Audio DAC Daughter Board; however, the Audio DAC Daughter Board must be replaced by the Audio Codec Daughter Board AK4642.

Running the Demonstration

This section demonstrates how to run the demonstration.

Description

Important! Prior to using this demonstration, it is recommended to review the MPLAB Harmony Release Notes for any known issues. A PDF copy of the release notes is provided in the `<install-dir>/doc` folder of your installation.

Do the following to run the demonstration:

1. Compile and program the target device. While compiling, select the appropriate MPLAB X IDE project configuration based on the demonstration board. Refer to Building the Application for details.
2. Connect speakers or headphones to the line-out line connector on the Audio Codec Daughter Board AK4642EN.
3. The on-board microphone (MIC3) will begin capturing surrounding audio and start looping it through the Codec to the microprocessor and back to the Codec headphones where you should be able to audibly observe the microphone input. An easy way to test this is to gently rub the microphone with your fingertip and listen for the resulting sound in your speaker or headphones.

audio_tone

This section provides instructions and information about the MPLAB Harmony Codec Driver demonstration application, which is included in the MPLAB Harmony Library distribution.

Description

In this demonstration application, the Codec Driver sets up the Codec, which is present on the development board. The demonstration sends out generated audio waveforms (sine tone and chirp) with parameters modifiable through a Graphic User Interface (GUI) based on the MPLAB Harmony Graphics Library graphics and on-board push buttons. Success is indicated by an audible output corresponding to displayed parameters.

The sine tone is of any frequency that is four times less than the sampling rate using a 32-bit fixed point algorithm. The tone can be continuously modified in frequency so as to also generate a chirp waveform. A timer is used control the duration of the sine tone or chirp, based on displayed settings modified by the buttons.

To know more about the MPLAB Harmony Codec Drivers, configuring the Codec Drivers, and the APIs provided by the Codec Drivers, refer to Codec Driver Libraries.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the demonstration.

Description

To build this project, you must open the `audio_tone.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/audio/audio_tone`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`audio_tone.X`	`<install-dir>/apps/audio/audio_tone/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
bt_audio_dk_16bit_48000_RJ	bt_audio_dk	This demonstration runs on the PIC32MX470F512L device on the PIC32 Bluetooth Audio Development Kit and the Audio DAC Daughter Board. The configuration is for a sine tone or chirp signal with 16-bit data width, 48000 Hz sampling frequency, and right-justified audio protocol.

bt_audio_dk_24bit_44100_I2S	bt_audio_dk	This demonstration runs on the PIC32MX470F512L device on the PIC32 Bluetooth Audio Development Kit and the Audio DAC Daughter Board. The configuration is for a sine tone or chirp signal with 24-bit data width, 44100 Hz sampling frequency, and right-justified audio protocol.

Configuring the Hardware

This section describes how to configure the supported hardware.

Description

PIC32 Bluetooth Audio Development Kit and Audio DAC Daughter Board

Switch S1 on the PIC32 Bluetooth Audio Development Board should be set to PIC32_MCLR.

Running the Demonstration

This section demonstrates how to run the demonstration.

Description

Both continuous sine tones and finite length sine tones and chirps can be generated. **Table 1** provides a summary of the button actions that can used to control the audio output waveform characteristics. **Figure 2** shows the location of the display functionality that interacts with the buttons controls and how it reflects the current state of the audio output.

Compile and program the target device. While compiling, select the appropriate MPLAB X IDE project configuration based on the demonstration board. Refer to Building the Application for details.

1. Connect speakers or headphones to the line-out line connector of the Audio DAC/Codec Daughter Board (see **Figure 1**).
2. The tone can be quite loud, especially when using a pair of headphones. Before running the demonstration, turn the volume control, P2, which is located on the back of the PIC32 Audio DAC Daughter Board, all the way clockwise, and then turn it counterclockwise until the tone can be heard clearly.
3. Initially, a continuous 440 Hz sine tone can be heard, as indicated on the "f1 Hz" digital meter display.
4. SW4 will turn the audio on or off, as indicated by the audible output and the display of "Sine Tone - OFF" or "Sine Tone - ON"
5. Modifiable parameters are selected by pressing SW1, which cycles through the parameters displayed as "f1 (Hz)", f2 (Hz), and "t (ms)". Initially, the "f1 (Hz)" parameter is selected. The value of any selected parameter can be changed by using SW5/SW6 to raise or lower the value, respectively. The "f2 (Hz)" parameter, is the chirp final frequency. The "t (ms)" parameter is the duration of the signal in milliseconds. Note that as SW1 is pressed, there will be no change on the display; however, the demonstration is advancing to the next parameter, and then wraps around.

Note: A long press (5 seconds) of SW 1 will set the selected parameter value to its minimum allowable value. A long press of SW2 will set the maximum value.

5. The Sine Tone or Chirp modes are selected by pressing SW2. The output automatically turns off when a new mode is selected. Pressing SW4 initiates the audible output based on the current settings of the parameters.

Notes:
1. When the "t (ms)" parameter is displayed as 99999, a continuous sine tone is generated at the "f1 (Hz)" frequency for either mode. Incrementing the value by pressing SW3 will initiate finite length chirps or sine tones starting from 0 and increasing by 10 ms steps for each increment/decrement.
2. Long presses of SW5/SW3 will accelerate the incrementing/decrementing of the selected value.

6. The displayed sampling frequency can be verified by probing the point "LRCK Pin Point" of the Audio DAC/Codec Daughter Board (PIC32 Bluetooth Audio Development Kit configurations), as shown in **Figure 1**.
7. The signal frequency of the continuous Sine Tone output can be verified by probing the "Line Out Point" of the Audio DAC/Codec Daughter Board, as shown in **Figure 1**. The frequency should match the "f1 (Hz)" display value. Finite length sine tones and chirp parameters can also be verified by probing this point with a storage oscilloscope.

Figure 1: Audio DAC Daughter Board on PIC32 Bluetooth Audio Development Kit

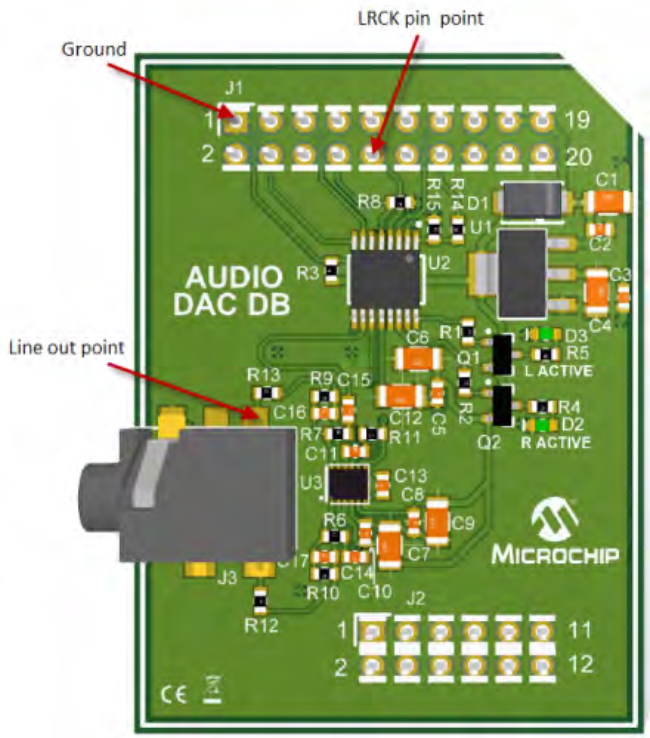
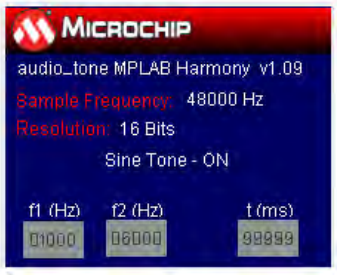


Figure 2: Audio Tone Graphics Display



Control Descriptions

Table 1: Button Controls

Control	Description
SW1	f1/f2/t parameter selection (long press - parameter minimum value).
SW2	Chirp/Sine mode selection (long press - parameter maximum value).
SW3/SW5	Parameter increment/decrement (long press - accelerates increment/decrement).
SW4	Audio ON/OFF **Note:** Finite length waveforms will play, and then turn OFF.

mac_audio_hi_res

Demonstrates a USB Audio 2.0 Device that emulates a USB speaker.

Description

This demonstration application uses the USB Audio 2.0 Device class to implement a speaker. This demonstration is considered a Beta version and will be updated in a future release of MPLAB Harmony.

Note: This demonstration can be used only with an Apple Mac personal computer such as the Apple MacBook Air OS X 10.9.4 with iTunes 11.2.1 or VLC media player version 2.2.1. Any versions prior to those listed may not work with this demonstration.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the High-resolution Audio Demonstration.

Description

To build this project, you must open the `mac_audio_hi_res.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/audio/mac_audio_hi_res`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`mac_audio_hi_res.X`	`<install-dir>/apps/audio/mac_audio_hi_res/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mz_ef_pim_bt_audio_dk	pic32mz_ef_pim+bt_audio_dk	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32 Bluetooth Audio Development Kit configured for Interrupt mode and dynamic operation. This configuration also requires the PIC32MZ2048EFH144 Audio PIM.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32 Bluetooth Audio Development Kit or PIC32MZ2048EFH144 Audio Plug-in Module (PIM)

1. Insert the PIC32MZ Audio PIM onto the PIC32 Bluetooth Audio Development Kit.
2. Switch S1 on the PIC32 Bluetooth Audio Development Kit should set to PIM_MCLR.
3. Connect headphones to the jack on the Audio DAC Daughter Board, which is included with the PIC32 Bluetooth Audio Development Kit.

Running the Demonstration

Provides instructions on how to build and run the High-resolution Audio Demonstration.

Description

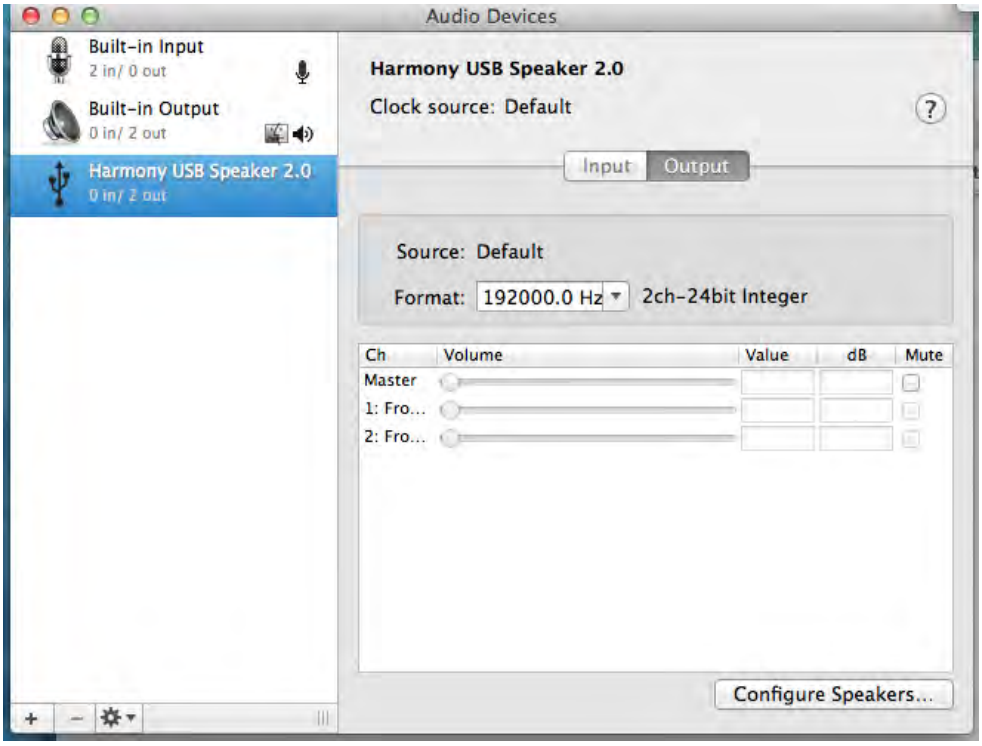
This demonstration functions as a speaker when plugged into a computer that supports USB Audio 2.0 devices.

Notes:
1. At the time of release, only Apple MAC personal computers natively support Audio 2.0 USB devices.
2. The demonstration has been tested with a third-party Audio 2.0 USB device driver on Windows® 7.

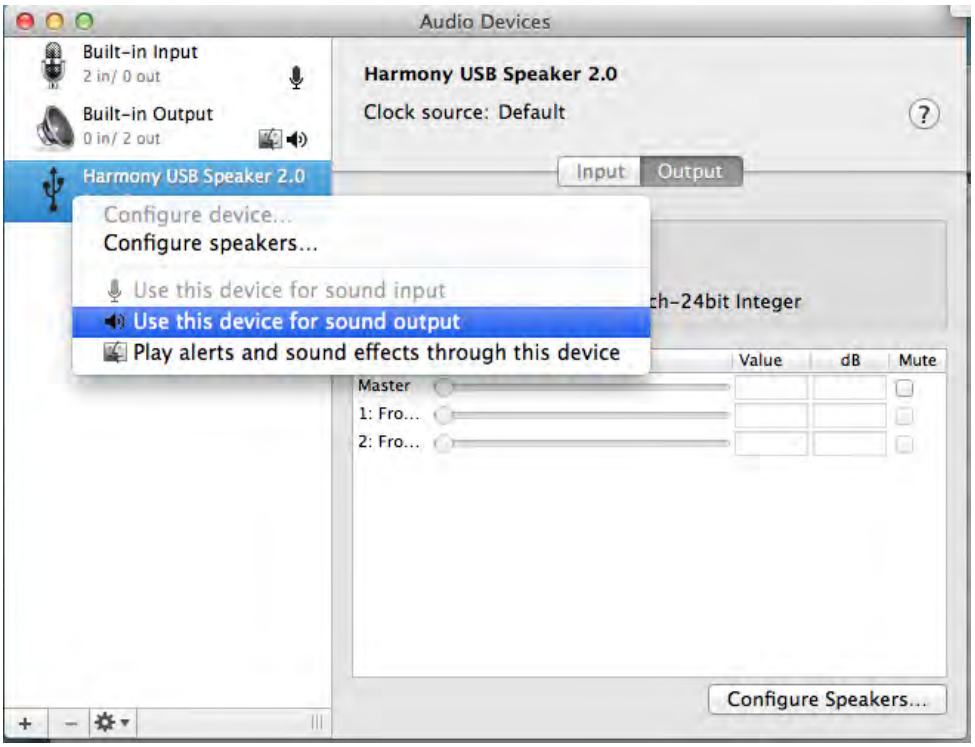
Do the following to run the demonstration:

1. Build the demonstration application and program the device.
2. Connect the device to a computer. For example, an Apple Mac book.
3. Use a feature of the computer that outputs sound to a speaker. On the Apple Mac book with OS X 10.9.4, the Audio MIDI Setup application could be used, as follows:

- Open Audio MIDI Setup



- Right click **Harmony USB Speaker 2.0**, which is listed in the left column
- Select **Use this device for sound output**



4. Open the Audio player (iTunes or VLC) and play the audio of your choice.
5. The feature unit only supports Mute control. Audio being played can also be muted using switch SW4 on the development board.
6. The audio volume can be controlled through the computer media player (iTunes or VLC on Apple Mac book) and also through the switches SW1 and SW2 on the development board.
7. Note that some applications lock into a sound source when they open or close (such as some Web browsers or plug-ins). Therefore, if the speaker is plugged in with a Web page or an already playing video, the sound may not be redirected to the USB-based speakers until the browser is closed and reopened.
8. The audio device created in this demonstration has the following characteristics:
   - Supported sampling rates:
     - 32000 Hz

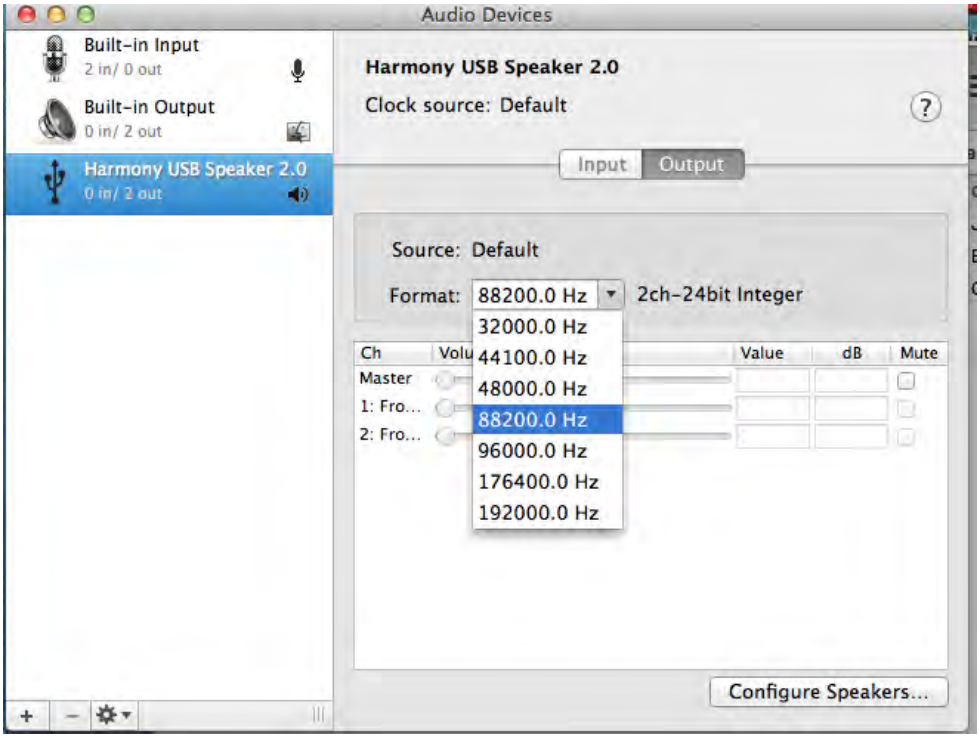
- 44100 Hz
- 48000 Hz
- 88200 Hz
- 96000 Hz
- 176400 Hz
- 192000 Hz

- 2-Channel (Stereo)
- PCM format (24 bits per sample)

Sampling Rate

The demonstration application allows the default sampling rate (set to 192000 Hz) to be changed. This can be done using the following procedure on an Apple Mac book.

1. If audio is being played, Stop it (PAUSE on iTunes).
2. Open the Audio MIDI Setup application.
3. Select Harmony USB Speaker 2.0 listed in the left column.
4. In the right pane, select the desired sampling rate from the *Format* drop-down menu, as shown in the following figure.



5. Verify that the sampling rate has changed on the display on the board.
6. Select 'PLAY' on the Audio player to play the audio with the changed sampling rate.

sdcard_usb_audio

Demonstrates playback of audio files stored on a SD card and audio data streamed over a USB interface.

Description

This application demonstrates an audio player application by playing audio files stored on a SD card. This demonstration also acts as a USB speaker with audio data streaming from a personal computer to PIC32 device.

Full-Speed USB is used for communication between the host computer and PIC32 device. The application also provides a Graphical User Interface with touch screen support to access and randomly select media tracks, and also provides controls to increase or decrease volume and mute or unmute the audio output. Additionally, the demonstration provides an option to select the media source, either a SD card or USB. The application supports playing 48 kHz, 16-bit audio.

Note: The Audio Player application only support playback of WAVE (`.wav`) files.

Bulding the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the demonstration.

Description

To build this project, you must open the `sdcard_usb_audio.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/audio/sdcard_usb_audio`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`sdcard_usb_audio.X`	`<install-dir>/apps/audio/sdcard_usb_audio/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mz_ef_sk_meb2	pic32mz_ef_sk+meb2	This configuration runs on the PIC32MZ EF Starter Kit connected to the MEB II. The micro SD card is used in SPI mode and is configured for Interrupt mode and dynamic operation. The USB library is configured for Full-Speed operation in Audio Device mode. The Codec is interfaced over I2C for command and I2S for data and uses DMA for data transfers. The Codec is also configured for 16-bit data width and 4 8kHz sampling frequency. The graphical display is driven by the LCC driver and uses DMA for data transfers. The touch screen driver is interfaced using I2C configured for Interrupt mode and dynamic operation.

Configuring the Hardware

This section describes how to configure the supported hardware.

Description

PIC32MZ EF Starter Kit and MEB II

No hardware related configuration or jumper setting changes are necessary. However, ensure that the micro SD card with `.wav` audio files is inserted into the SD Card slot.

Running the Demonstration

This section demonstrates how to run the demonstration.

Description

Note: Prior to using this demonstration, it is recommended to review the MPLAB Harmony Release Notes for any known issues. A PDF copy of the release notes is provided in the `<install-dir>/doc` folder of your installation.

In MPLAB X IDE, compile and program the target device. While compiling, select the appropriate MPLAB X IDE project configuration for the demonstration board. These configurations set the target processor and the board, to be used in the output interface.

This demonstration plays .wav audio files stored on SD card as the storage media, when the source of audio is selected as SD card (default audio source).

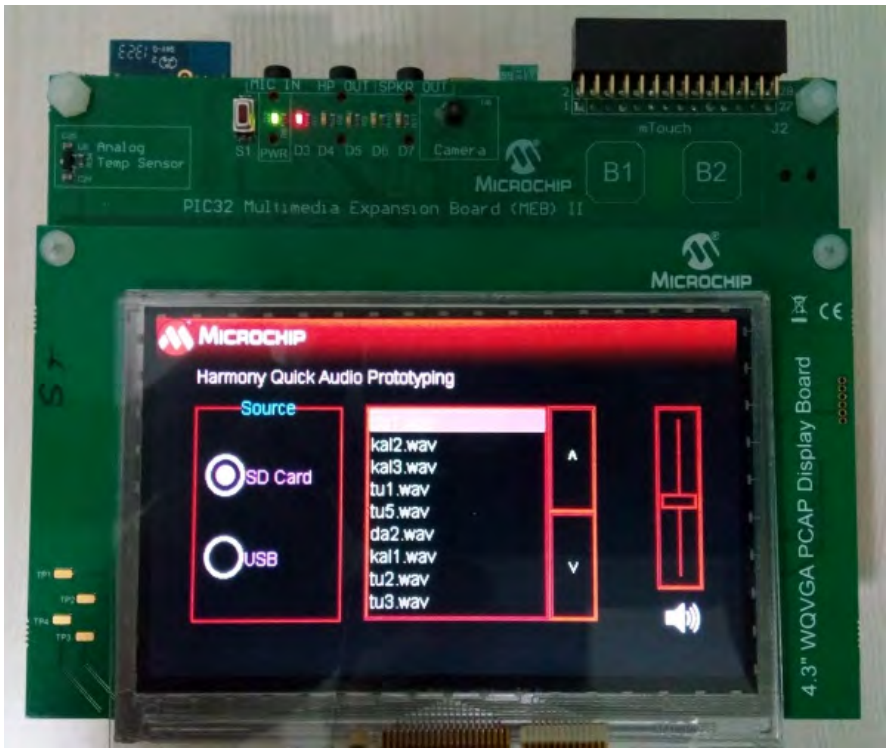
When the source of audio is selected as USB, the demonstration plays audio data streamed by PC over a USB interface. The device can then be used as USB speaker.

Refer to Building the Application for details.

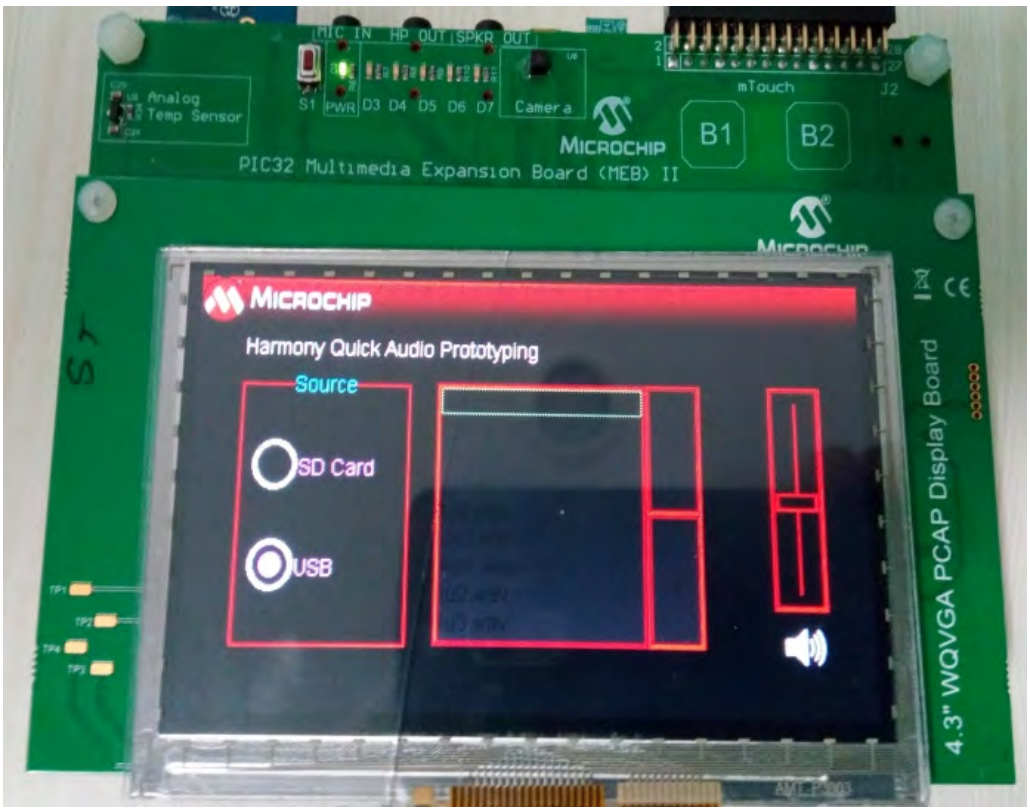
Do the following to run the demonstration:

1. Insert your micro SD card into the SD card slot (J8) on the MEB II board. Ensure that the SD card contains `.wav` audio files.
2. Connect speakers or headphones to the headphone out (HP OUT) on the MEB II.
3. Connect power to the board.
4. By default, the application has the SD card selected as the audio source. After the board powers up, the GUI should appear like the following figure. As shown in the figure, the default audio source selected is SD card, with tracks displayed in the tracks list box. You can scroll through the tracks list using the up/down scroll buttons allowing you to select and play random tracks. The volume slider will allow you to

increase/decrease the volume and the mute button to mute/unmute audio.



6. Plug in the headphones and you should be able to hear the audio track being played from the SD card.
7. Connect the board using the USB micro-B connector for the MEB II to the Host computer with a standard USB cable.
8. Change the audio source to USB, by selecting the ‘USB’ radio button on the GUI. The GUI should now appear like the following figure. The track list will be blank and the scroll buttons disabled, as the audio will be streamed by the host computer.



9. Allow the Host computer to acknowledge, install drivers (if needed), and enumerate the device. No special software is necessary on the host side.
10. If needed, configure the Host computer to use the MPLAB Harmony USB speaker as the selected audio device. This may be done in the system configuration or Control Panel depending on the operating system.
11. Play audio on the Host computer. This may be done with a standard media player or through a variety of sources including operating system

generated sounds or video.

12. Listen to the audio output on the speakers or headphones connected to the board. You can adjust the volume and mute/unmute either by the application running on the host, or from the on board GUI.
13. You can easily switch between the two sources of audio, SD card and USB, through the radio button selection on the GUI.

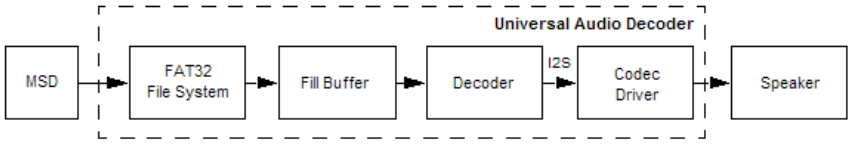
universal_audio_decoders

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Description

The Universal Audio Decoder application configures the development board to be in USB Host mode. The application supports the FAT32 file system. When a mass storage device is connected to the development board, the application begins to scan the root directory. Once the scan is complete, the first track in the list will be opened and played. The fill buffer routine will read a chunk of data as an input to the decoder of the supported file format. The decoder will decode the packet and send the first frame of audio data to the codec driver through I2S Driver and the output will be audible through the speakers. The following block diagram depicts a representation of the application.

Button controls provide support to traverse the directory tree and play audio files from other directories or sub-directories. By default, the application only supports WAVE (`.wav`) format files.



In addition to WAVE formats, the application also supports MP3, AAC, WMA, ADPCM, and Speex provided the decoder libraries and the supported source files are added as plug-ins. The MP3, AAC, and WMA are premium packages and must be purchased. Refer to the Microchip Premium MPLAB Harmony Audio web page (www.microchip.com/pic32harmonypremiumaudio) for information.

Once purchased, the MP3, AAC, and WMA decoder modules can be added to the application as described in Selecting the Decoders Using MHC.

If support for any decoder is not available or was removed using MHC, the particular file format will not be scanned.

Audio Format	Package	Sampling Rates (kHz)	Description
ADPCM	Free of charge	8, 16	Adaptive Delta Pulse Code Modulation (ADPCM) is a sub-class of the Microsoft waveform (`.wav`) file format. In this demonstration, it only decodes ADPCM audio, which has a WAV header. The extension name for this format is pcm or PCM.
Speex	Free of charge	8, 16	Speex is an Open Source/Free Software patent-free audio compression format designed for speech. In this demonstration, only Speex bit-streams within an Ogg container can be decoded. The extension name for this format is spx or SPX.
WAVE	Free of charge	8 through 96	The WAVE file format is the native file format used by Microsoft Windows for storing digital audio data.
AAC	Premium (must be purchased)	8, 11.025, 12, 16, 22.05, 24, 32, 44.1, 48, 64, 88.2, and 96	The AAC format is a lossy digital compression format of audio data with an ADTS header. The AAC decoder supports MPEG-2 and MPEG-4 AAC. To make sure the AAC audio files work with the AAC decoder, you can always convert any audio files to MPEG-2, 4 AAC files by a MPEG-2, 4 AAC encoder, one known working encoder is FAAC (Freeware Advanced Audio Coder).
MP3	Premium (must be purchased)	32, 44.1, and 48	The MPEG1 Layer 3 is a lossy digital compression format for audio data.
WMA	Premium (must be purchased)	8, 11.025, 16, 22.05, 32, 44.1, and 48	The Windows Media Application (WMA) format allows storing digital audio using lossy compression algorithm. The WMA decoder supports the ASF container format. The Windows Media Encoder 9 Series can be downloaded from the Microsoft website to convert any audio files to WMA v9.2 files to work with this WMA decoder.

Note: The AAC and MP3 Decoder Libraries have two versions: PIC32MX (for use with PIC32MX devices) and microAptiv (for use with PIC32MZ devices with the microAptiv core). When selecting either the AAC or MP3 library in MHC, for PIC32MX devices, the PIC32MX version of the library will be automatically added in the project. For PIC32MZ devices that have the microAptiv core, the microAptiv version of the library will be added in the project. Theoretically, MHC will automatically add the correct library; however, be sure to use the correct libraries on different devices.

The macro DISK_MAX_DIRS and DISK_MAX_FILES in `system_config.h` under each configuration, determines the maximum number of directories that should be scanned at each level, and the maximum number of songs in total the demonstration should scan. For each

configuration, the value could be different. For example, for the PIC32MX270F512L PIM, DISK_MAX_FILES can be approximately 600, while for the PIC32MZ EF Starter Kit, DISK_MAX_FILES may be as large as 800.

Refer to AAC Decoder Library, MP3 Decoder Library, and WMA Decoder Library in the Framework Help, as well as the Microchip Premium MPLAB Harmony Audio web page (www.microchip.com/pic32harmonypremiumaudio) for additional information on the Decoder Libraries.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the demonstration.

Description

To build this project, you must open the `universal_audio_decoders.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/audio/universal_audio_decoders`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`universal_audio_decoders.X`	`<install-dir>/apps/audio/universal_audio_decoders/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
ak7755_bt_audio_dk	bt_audio_dk	This configuration runs on the PIC32 Bluetooth Audio Development Kit with the AK7755 Codec Daughter Board.
bt_audio_dk	bt_audio_dk	This configuration runs on the PIC32 Bluetooth Audio Development Kit with the Audio DAC Daughter Board included with the kit.
270f512lpim_bt_audio_dk	pic32mx270f512l_pim+bt_audio_dk	This configuration runs on the PIC32MX270F512L PIM and the PIC32 Bluetooth Audio Development Kit with the Audio DAC Daughter Board included with the kit.
pic32mz_da_sk_meb2	pic32mz_da_sk+meb2+wvga	This configuration runs on the PIC32MZ DA Starter Kit and the Multimedia Expansion Board II.

Configuring the Hardware

This section describes how to configure the supported hardware.

Description

PIC32 Bluetooth Audio Development Kit

Attach the desired Codec Daughter Board (AK7755 or PIC32 DAC Audio) to the PIC32 Bluetooth Development Board. Switch S1 should be set to PIC32_MCLR.

PIC32 Bluetooth Audio Development Kit and PIC32MZ Audio PIM or PIC32MX270F512L Plug-in Module (PIM)

Attach the PIC32 DAC Audio Daughter Board to the PIC32 Bluetooth Development Board. Switch S1 should be set to PIM_MCLR.

PIC32MZ DA Starter Kit and MEB II with the 5" WVGA PCAP Display Board (see **Note**)

No hardware related configuration or jumper setting changes are necessary.

Note: Please contact your local Microchip sales office for information on obtaining the 5" WVGA PCAP Display Board.

Selecting the Decoders Using MHC

This topic describes how to select the decoders using the MPLAB Harmony Configurator (MHC).

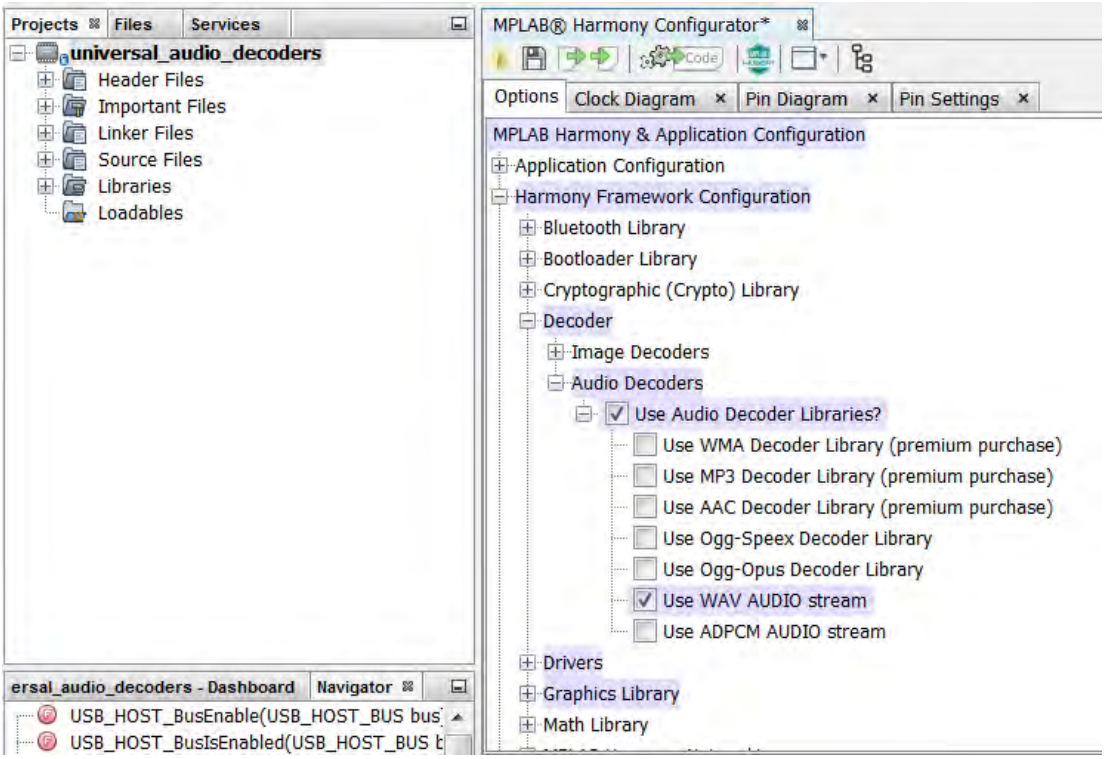
Description

The application supports the WAVE, Compact MP3, AAC (ADTS header), WMA (v9.2), ADPCM (WAV header), and Speex (Ogg container) audio formats.

Note: The MP3, AAC, and WMA Decoder Libraries are premium packages and must be purchased. Refer to the Microchip Premium MPLAB Harmony Audio web page (www.microchip.com/pic32harmonypremiumaudio) for information.

The audio format can be chosen as required using MHC as follows:

1. Open the project on MPLAB X IDE and select the project configuration depending upon the hardware.
2. Open the MHC and select the Decoder, as shown in the following figure.



3. Select **Use audio decoders libraries?** and the list of available decoders will be listed in the drop-down menu.
4. Select the decoders that are required and click **Generate** to add the supporting decoder files and libraries to the project.

Running the Demonstration

This section demonstrates how to run the demonstration.

Description

Note: Prior to using this demonstration, it is recommended to review the MPLAB Harmony Release Notes for any known issues. A PDF copy of the release notes is provided in the `<install-dir>/doc` folder of your installation.

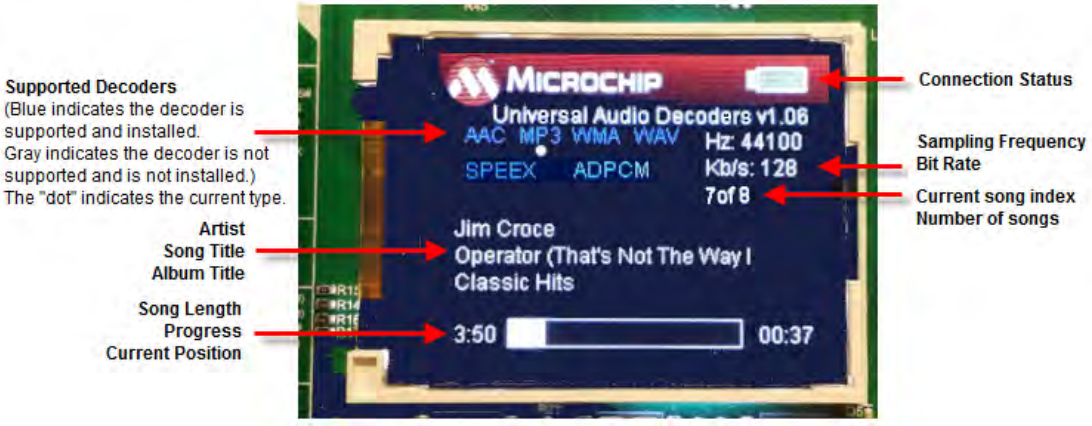
Compile and program the target device. While compiling, select the appropriate MPLAB X IDE project configuration based on the demonstration board. These configurations set the target processor, the board and the Codec to be used in the output interface.

Refer to Building the Application for details.

Do the following to run the demonstration:

1. Connect speakers or headphones to the output line connector on the Audio DAC Daughter Board (included with the PIC32 Bluetooth Audio Development Kit), or the headphone (HP Out) connector on the Audio Codec Daughter Board AK7755, or the Speaker Out/Line Out connectors on the Multimedia Expansion Board II (MEB II), as appropriate.
2. Connect power to the board. The system will be in a wait state for USB to be connected. The LEDs, D5, D6, and D7 (PIC32 Bluetooth Audio Development Board only), will be OFF during the wait state. Screen displays are for the PIC32 Bluetooth Audio Development Board configurations.

3. Connect a USB mass storage device that contains songs of supported audio format. The application by default can stream WAVE (`.wav`) format audio files.
4. When the USB device is connected the system will scan for audio files. The LEDs, D5 and D7 (PIC32 Bluetooth Audio Development Board only), will be ON during scanning.
5. Once the scanning is complete, listen to the audio output on the speakers or headset connected to the board. The LED, D5, will be ON for WAVE audio, the LED, D6, will be ON for AAC, and the LED, D7, will be ON for MP3 (PIC32 Bluetooth Audio Development Board only).



LED States (PIC32 Bluetooth Audio Development Board only)

State	D5	D6	D7
Wait for USB	OFF	OFF	OFF
Scan for files	ON	OFF	ON
WAVE audio stream	ON	OFF	OFF
AAC audio stream	OFF	ON	OFF
MP3 audio stream	OFF	OFF	ON
WMA audio stream	OFF	ON	ON

Demonstration Controls

Component	Label	PIC32 Bluetooth Audio Development Kit	PIC32MZ EF Starter Kit
Switch	SW1	N/A	Next Track (Toggle)/Fast Forward (Long Hold)
Switch	SW2	N/A	Play/Pause (Toggle)
Switch	SW3	Next Track (Toggle)/Fast Forward (Long Hold)	Previous Track (Toggle)/Fast Rewind (Long Hold)
Switch	SW4	Play/Pause (Toggle)	N/A
Switch	SW5	Previous Track (Toggle)/Fast Rewind (Long Hold)	N/A

usb_headset

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Description

In this demonstration application, the system is configured as a USB headset. The system will interface to a USB Host (such as a personal computer), which can accommodate a USB device class headset. The embedded system will enumerate with a USB audio device endpoint and enable the system to send playback audio and receive record audio simultaneously from the USB port. This uses a standard USB Full-Speed implementation.

The system is capable of multiple configurations that deal with different hardware platforms and Codecs.

The output audio stream is then available in analog format via a hardware connection, typically to headphones or speakers. The input audio stream is an internal onboard microphone when using the AK4642EN Daughter Board on the PIC32 Bluetooth Audio Development Kit, or from and external condenser microphone connected to the MEB II.

The AK4642 Codec with I2S audio is used for the PIC32 Bluetooth Audio Development Kit. The AK4953 Codec drivers with I2S audio is utilized for the PIC32MZ EF Starter Kit. The Codec Driver uses a common API for each Codec type with the application requiring separate read and write clients to handle record data from the microphone and playback to the speaker.

The embedded system will configure the AK4642 or AK4953 Codec using the I2C port. Bidirectional audio will be streamed over the I2S port to or from the Codec. The embedded system will take the data from the audio USB interface, and format it for output using a Codec driver. The Codec Driver sets up the audio output interface, timing, DMA channels and buffer to enable a continuous audio stream to or from the Codec I2S channel. A I2S data channel can operate at various sampling rates. Stereo (utilizing a left and right audio channel) is used for both audio playback and recording from the microphone, despite only one channel (mono) audio provided by the microphone. The microphone audio will be on only one of the channels with the other being zero (0). The stereo I2S data that is received on the record channel of the USB is converted to single channel audio before being sent over USB. Three sampling rates are provided by the USB connection: 16, 32, and 48 kHz. The I2S sampling rate is changed to match the USB rate whenever USB rate is changed.

The usb_headset demonstration application uses the MPLAB Harmony USB Library and Codec Driver to demonstrate simultaneous speaker playback and microphone record functions at a selectable 16, 32, or 48 kHz sampling rate to a windows computer.

When either the record or playback channel sampling rate is changed, it also changes to the same rate for the other. Therefore, the rates on the Host computer must be consistent for both record and playback.

The demonstration has two working configurations, for the following implementation hardware:

- bt_audio_dk_ak4642 configuration:
  - Board - PIC32 Bluetooth Audio Development Kit
  - Processor - PIC32MX470F512L
  - Codec - AK4642
  - Mic - mems internal
- pic32MZ_ef_sk_meb2 configuration:
  - Board - PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit (SK) mounted on a Multimedia Expansions Board II (MEB II)
  - Processor - Pic32MZ2048EFM144
  - Codec - AK4953 (on the MEB II)
  - Mic - external condenser

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the demonstration.

Description

To build this project, you must open the `usb_headset.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/audio/usb_headset`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`usb_headset.X`	`<install-dir>/apps/audio/usb_headset/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
bt_audio_dk_ak4642	bt_audio_dk	This configuration runs on the PIC32 Bluetooth Audio Development Kit with the Audio Codec Daughter Board AK4642EN.
pic32mz_ef_sk_meb2	pic32mz_ef_sk+meb2	This configuration runs on the PIC32MZ EF Starter Kit with the MEB II.

Configuring the Hardware

This section describes how to configure the supported hardware.

Description

PIC32 Bluetooth Audio Development Kit and Audio Codec Daughter Board AK4642EN

Switch S1 on the PIC32 Bluetooth Audio Development Board should be set to PIC32_MCLR.

PIC32MZ EF Starter Kit and MEB II

LCD_PCLK should be jumpered to the EBIOE pin for the EBI Memory. This jumper is located on the bottom of the starter kit when it is connected.

Running the Demonstration

This section demonstrates how to run the demonstration.

Description

Important! Prior to using this demonstration, it is recommended to review the MPLAB Harmony Release Notes for any known issues. A PDF copy of the release notes is provided in the `<install-dir>/doc` folder of your installation.

Compile and program the target device. While compiling, select the appropriate MPLAB X IDE project configuration based on the demonstration board. These configurations set the target processor, the board and the CODEC to be used in the output interface. Refer to Building the Application for details.

Do the following to run the demonstration:

1. Connect speakers or headphones to the Line Out or headphone (HP Out) connector on the PIC32 Audio DAC Daughter Board AK4642EN or the HP Out connector on the MEB II. The MEB II requires than an external condenser microphone be attached to the MIC IN.
2. Connect power to the board.
3. Connect the development hardware (Device) to the Host computer with a standard USB cable (mini-B connector for the PIC32 Audio Development Board, or micro-B connector for the MEB II).
4. Allow the Host computer to acknowledge, install drivers (if needed) and enumerate the device. No special software is necessary on the host side.
5. Configure the Host computer to use the "USB Headset Example" as both the playback and recording device at the same sampling rate. This is done by opening the Sound Window (i.e., right clicking the Loudspeaker icon, located at the lower right of the tool bar), and selecting ether **Record devices** or **Playback devices**. First, find the record and playback devices associated with the demonstration and make them the default device. The sample rate can be changed for both record and playback devices and must be the same. This is done by right clicking the device and using the Advanced tab.

Note: The Skype Echo/Sound Recorder Test is a simple way to demonstrate headset operation, where you will hear audio from a remote source and it will record voice for playback from this source.

6. Play audio on the host computer. This may be done with a standard media player or through a variety of sources. You should hear this audio through the headphones connected to the HP Out jack of the board.
7. At the same time as playback, audio can be recorded via the microphone connected to the MIC IN jack of the board using an application such as Windows Sound Recorder or Audacity.

Note: The Codec Record/Playback sampling rate may not align with the separate USB playback and record sampling rates until the "Record and Playback" tabs of the "Sound" window have been selected in sequence.

usb_microphone

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Description

In this demonstration application, the system is configured as a USB microphone. The system will interface to a USB Host (such as a personal

computer), which can accommodate a USB device class microphone. The embedded system will enumerate with a USB audio device endpoint and enable the system to input audio from the USB port. This demonstration uses a standard USB Full-Speed implementation.

The embedded system will take the data from a microphone via the Codec Driver and send it to the audio USB interface. The Codec Driver sets up the audio output interface, timing, DMA channels and buffer to enable a continuous audio stream. The digital audio is processed through an I2S data channel at typically 16 kHz. The input audio stream is then available to the host computer. The AK4642 Codec is utilized with the PIC33MX470F512L microcontroller on the PIC32 Bluetooth Audio Development Kit.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the demonstration.

Description

To build this project, you must open the `usb_microphone.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/audio/usb_microphone`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`usb_microphone.X`	`<install-dir>/apps/audio/usb_microphone/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
bt_audio_dk_ak4642	bt_audio_dk	This configuration runs on the PIC32 Bluetooth Audio Development Kit with the Audio Codec Daughter Board AK4642EN.

Configuring the Hardware

This section describes how to configure the supported hardware.

Description

PIC32 Bluetooth Audio Development Kit with the Audio Codec Daughter Board AK4642EN

Switch S1 on the PIC32 Bluetooth Audio Development Board should be set to PIC32_MCLR/

Running the Demonstration

This section demonstrates how to run the demonstration.

Description

Important! Prior to using this demonstration, it is recommended to review the MPLAB Harmony Release Notes for any known issues. A PDF copy of the release notes is provided in the `<install-dir>/doc` folder of your installation.

Compile and program the target device. While compiling, select the appropriate MPLAB X IDE project configuration based on the demonstration board. These configurations set the target processor, the board and the Codec to be used in the output interface. Refer to Building the Application for details.

Do the following to run the demonstration:

1. PIC32 Audio DAC Daughter Board AK4642EN provides an on-board microphone. Place it near the source of audio to be recorded.
2. Connect power to the board.
3. Connect the board using the USB mini-B connector (Device) to the Host computer with a standard USB cable.
4. Allow the Host computer to acknowledge, install drivers (if needed), and enumerate the device. No special software is necessary on the Host side.
5. If needed, configure the Host computer to use the usb_microphone as the selected audio recording device. For Windows, this is done in the "Recording Devices" dialog accessed by right clicking the loudspeaker icon in the taskbar.

Note: The device "Harmony USB Microphone Example" should be available along with a sound level meter indication audio input.

6. Open a recording application and record from the USB microphone source.

7. Playback of the recording should demonstrate that the audio is being received from the microphone and saved on the Host Computer.

usb_speaker

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Description

In this demonstration application, the system is configured as a USB speaker. The system will interface to a USB Host (such as a personal computer), which can accommodate a USB device class headset. The embedded system will enumerate with a USB audio device endpoint and enable the system to output audio from the USB port. This demonstration uses a standard USB Full-Speed implementation.

The embedded system will take the data from the audio USB interface, and format it for output using a Codec driver. The Codec driver sets up the audio output interface, timing, DMA channels and buffer to enable a continuous audio stream. The digital audio is processed through an I2S data channel at typically 48 kHz.

The output audio stream is then available in analog format via a hardware connection, typically to headphones or speakers.

The system is capable of multiple configurations that deal with different hardware platforms and Codecs.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the demonstration.

Description

To build this project, you must open the `usb_speaker.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/audio/usb_speaker`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`usb_speaker.X`	`<install-dir>/apps/audio/usb_speaker/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
bt_audio_dk	bt_audio_dk	This configuration runs on the PIC32 Bluetooth Audio Development Kit using the Audio DAC Daughter Board included with the kit.
bt_audio_dk_ak4642	bt_audio_dk	This configuration runs on the PIC32 Bluetooth Audio Development Kit with the Audio Codec Daughter Board AK4642EN.
pic32mx270f512l_pim_bt_audio_dk	pic32mx270f512l_pim+bt_audio_dk	This configuration runs on the PIC32 Bluetooth Audio Development Kit configured with the PIC32MX270F512L PIM and the Audio DAC Daughter Board included with the kit.
pic32mz_ef_pim_bt_audio_dk	pic32mz_ef_pim+bt_audio_dk	This configuration runs on the PIC32 Bluetooth Audio Development Kit configured with the PIC32MZ2048EFH144 PIM and the Audio DAC Daughter Board included with the kit.
pic32mz_ef_sk_meb2	pic32mz_ef_sk+meb2	This configuration runs on the PIC32MZ EF Starter Kit with the MEB II.

Configuring the Hardware

This section describes how to configure the supported hardware.

Description

PIC32 Bluetooth Audio Development Kit and the Audio DAC Daughter Board (included in the kit)

Switch S1 on the PIC32 Bluetooth Audio Development Board should be set to PIC32_MCLR.

PIC32 Bluetooth Audio Development Kit and the Audio Codec Daughter Board AK4642EN (see **Note**)

Switch S1 on the PIC32 Bluetooth Audio Development Board should be set to PIC32_MCLR.

Note: The PIC32 Bluetooth Audio Development Kit includes an Audio DAC Daughter Board; however, the Audio DAC Daughter Board must be replaced by the Audio Codec Daughter Board AK4642.

PIC32 Bluetooth Audio Development Kit with PIC32MX270F512L PIM and the Audio Codec Daughter Board AK4384EN

Switch S1 on the PIC32 Bluetooth Audio Development Board should be set to PIC32_MCLR.

PIC32MZ EF Starter Kit and the Multimedia Expansion Board II (MEB II)

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

This section demonstrates how to run the demonstration.

Description

Important! Prior to using this demonstration, it is recommended to review the MPLAB Harmony Release Notes for any known issues. A PDF copy of the release notes is provided in the `<install-dir>/doc` folder of your installation.

Compile and program the target device. While compiling, select the appropriate MPLAB X IDE project configuration based on the demonstration board. These configurations set the target processor, the board and the CODEC to be used in the output interface. Refer to Building the Application for details.

Do the following to run the demonstration:

1. Connect speakers or headphones to the headphone (HP) or line-out connector on the Audio DAC Daughter Board or the PIC32 Audio Codec Daughter Board AK4642EN, or the MEB II, as appropriate.
2. Connect power to the board.
3. Connect the board using the USB mini-B connector (Device) for the PIC32 Bluetooth Audio Development Board, or the USB micro-B connector for the MEB II to the Host computer with a standard USB cable.
4. Allow the Host computer to acknowledge, install drivers (if needed) and enumerate the device. No special software is necessary on the host side.
5. If needed, configure the Host computer to use the usb_speaker outputs as the selected audio device. This may be done in the system configuration or "Control Panel" depending on the operating system. For Windows, this is done in the Playback Devices dialog, which is accessed by right clicking the loudspeaker icon in the taskbar.
6. Play audio on the Host computer. This may be done with a standard media player or through a variety of sources including operating system generated sounds or video.
7. Listen to the audio output on the speakers or headphones connected to the board. The volume will typically be adjusted by the host.

Bluetooth Demonstrations

This section provides descriptions of the PIC32 Bluetooth® Stack Library demonstrations.

Introduction

PIC32 Bluetooth Stack Library Demonstration Applications Help.

Description

The standard installation of MPLAB Harmony contains a variety of Bluetooth-related firmware projects that demonstrate the capabilities of the MPLAB Harmony PIC32 Bluetooth Stack Library. This library, which is considered the "basic" Bluetooth Stack , includes basic demonstrations that are referred to as "Data Demonstrations". This section describes the hardware requirement and procedures to run these Basic Bluetooth Stack firmware projects on Microchip demonstration and development boards.

In addition to the Data Demonstrations provided with the PIC32 Bluetooth Basic Stack Library, additional "Premium Demonstrations", which are available for purchase, demonstrate the capabilities of the PIC32 Bluetooth Audio Stack Library. Information is provided in the Premium Demonstrations section on how to obtain, configure, and run these demonstrations.

To learn more about MPLAB Harmony stacks and libraries refer to the related documentation in Volume IV: MPLAB Harmony Framework Reference.

Demonstrations

This section provides information on the standard Data Demonstrations, as well as the purchased Premium Demonstrations.

Demonstration Functionality

Describes the functionality of the demonstrations.

Description

Basic Functionality

Bluetooth Module

The PIC32 Bluetooth Starter Kit and the PIC32 Bluetooth Audio Development Kit provide hardware support for the BlueCore® CSR8811™.

CSR8811

The CSR8811 is a single-chip radio and baseband IC for Bluetooth 2.4 GHz systems including Enhanced Data Rate (EDR) to 3 Mbps and Bluetooth low energy. The CSR8811 supports Bluetooth Class 1 transmission, and supports multiple device connection. The PIC32 Bluetooth Starter Kit and the PIC32 Bluetooth Audio Development Kit use a module based on the CSR8811 radio in its default configuration (see **Note**).

Note: The Flairmicro BTM805 module using the CSR8811 device is integrated in the PIC32 Bluetooth Starter Kit and is integrated in the BTM805 Bluetooth Daughter Board that is mounted on the PIC32 Bluetooth Audio Development Kit.

Bluetooth Device IDs

The Bluetooth software remembers and stores in Flash memory the last 10 unique Bluetooth device IDs to which it successfully paired to facilitate faster automatic reconnection when there is no currently active Bluetooth connection. If Bluetooth is turned OFF on a user smartphone that is currently connected and re-enabled later, it will automatically reconnect if in range or when it comes back into range.

Note: Currently, the demonstration does not have support for SPI Flash memory due to limitations in MPLAB Harmony, and therefore, the pairing information will not be stored or recovered on a power or hardware reset.

Bluetooth Device Address

When the development kit is powered on, it generates a random unique Bluetooth Device Address for any given development kit hardware. Optionally, at design time, the user can specify a Bluetooth Device Address in the application code of the development kit.

The device address is a six byte hexadecimal value. The macro, BT_DEVICE_ID, defines the first four bytes of the hexadecimal value and BT_DEVICE_ID_2LSB defines the last two bytes of the hexadecimal value. The last two bytes of the device address can be randomized by enabling BT_DEVICE_ID_2LSB_RANDOMIZE. These macros are defined in `btconfig.h`.

Setting a specific hard-coded device address is not recommended during the design and development state, as Bluetooth connection problems may be experienced if another development board with the same Bluetooth Device Address is within range.

Additional Bluetooth Resources

Provides information on additional Bluetooth demonstration resources.

Description

In addition to the demonstration capabilities described in the Demonstrations section, additional Bluetooth demonstration resources are available.

Other Android Applications

The Bluetooth data smartphone demonstration can also be executed using the Bluetooth SPP-pro application. This app can be downloaded by visiting:

https://play.google.com/store/apps/details?id=mobi.dzs.android.BLE_SPP_PRO&hl=en

Once installed, the commands can be sent and received in CMD line mode/Keyboard mode of the terminal emulator of the application. The commands will be sent and received in the format shown in the following table.

Windows Handset Applications

For a Windows mobile handset, the commands can be sent and received via data terminal. The application can be downloaded by visiting:

http://www.windowsphone.com/en-us/store/app/bt-terminal/09d679af-bdd8-40b2-b54e-56d68aeb03e0

Once installed, the commands can be sent and received from the terminal emulator of the application. The commands can be sent and received in the format shown in the following table.

Bluetooth Data Windows Personal Computer Demonstration Setup

Program the device with the hex file, `data_temp_sens_rgb.X.production.hex`.

1. On the Windows personal computer, select *Start> Control Panel > Hardware and Sounds > Add a device*. A list of available Bluetooth devices appears.
2. From the list, select **BTSK**.
3. Open a terminal emulator. For this example PuTTY was used. This Windows application can be obtained by visiting:

   http://www.chiark.greenend.org.uk/~sgtatham/putty/download.html
4. A connection is required to be established between PuTTY and the PIC32 Bluetooth Starter Kit development board. This can be done by selecting the "Serial" Connection type and the COM port assigned to the board in the PuTTY configuration window. The assigned COM ports can be identified from *Device Manager > Ports*.

5. Once connection is established, the following commands can be sent.

Command	Description
R	Programs LED for 100% of Red
G	Programs LED for 100% of Green
B	Programs LED for 100% of Blue
r	Programs LED for 50% of Red
g	Programs LED for 50% of Green
b	Programs LED for 50% of Blue

Data Demonstrations

This topic provides information on how to run the PIC32 Bluetooth Basic Stack Library "Data Demonstration" applications that are included free-of-charge in this release of MPLAB Harmony.

data_basic

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Description

This demonstration performs full duplex data transfer over the Bluetooth link. The demonstration allows a user to perform terminal emulation and echo characters from an Android Smartphone over a Bluetooth connection to the development boards, and then back to the Smartphone emulation application screen.

The data transfer from the smartphone to the development board is demonstrated by the user sending (by keying in characters from the Android Smartphone application. The reception of data is shown by blinking of two LEDs from OFF to ON and back to the OFF state.

The data transfer from the development board to the smartphone is demonstrated by the user sending (by pressing buttons on top of the board). The data received by the smartphone is displayed on its screen as ‘Button 1’, ‘Button 2’, etc.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the Bluetooth Demonstration.

Description

To build this project, you must open the `data_basic.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/bluetooth/data_basic`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`data_basic.X`	`<install-dir>/apps/bluetooth/data_basic/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
bt_audio_dk	bt_audio_dk	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32 Bluetooth Audio Development Kit.
pic32mx270f512l_pim_bt_audio_dk	pic32mx270f512l_pim+bt_audio_dk	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32 Bluetooth Audio Development Kit using the PIC32MX270F512L PIM.
pic32mz_ef_sk_meb2	pic32mz_ef_sk+meb2	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32MZ EF Starter Kit attached to the Multimedia Expansion Board II (MEB II).

bt_audio_dk_freertos	bt_audio_dk	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32 Bluetooth Audio Development Kit.
pic32mz_ef_pim_bt_audio_dk	pic32mz_ef_pim+bt_audio_dk	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32 Bluetooth Audio Development Kit using the PIC32MZ2048EFH144 Audio Plug-in Module (PIM).

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32 Bluetooth Audio Development Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32 Bluetooth Audio Development Kit and PIC32MX270F512L Plug-in Module (PIM)

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

Provides instructions on how to build and run the Bluetooth basic data demonstration.

Description

This demonstration performs basic SPP full-duplex data transmission.

Note: Before running the demonstration, it is necessary to install the Bluetooth SPP-pro Android application. See *Additional Bluetooth Resources > Other Android Applications* in the Demonstrations section for details.

Running the Demonstration

1. Compile and program the target device. While compiling, select the appropriate MPLAB X IDE project configuration based on the demonstration board. Refer to Building the Application for details.
2. The running of Bluetooth device demonstration is indicated when LED1 and LED2 turn ON.
3. Enable Bluetooth on your smartphone.
4. Start the Android application on your smartphone.
5. Scan for the available Bluetooth devices. The target Bluetooth device should also be displayed in the list of available devices on your smartphone.
6. The name of the target Bluetooth device will be one of the following:

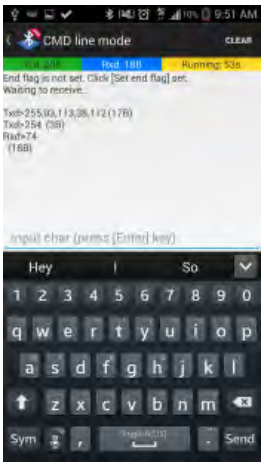
Configuration	Device Name
bt_audio_dk	BTAD
pic32mx270f512l_pim_bt_audio_dk	BTAD

Note: Occasionally, the name of the Bluetooth device is not resolved and will appear as "null". After some time the name will change from "null" to the configuration specific name mentioned previously. The visible MAC Address will be fixed for the first eight digits and the last four will vary (12:34:45:78:XX: XX).

7. Select the device to pair and connect.

8. If the connection is successful, the message "connected to <Device Name>" appears on top of the screen.
9. Select the "CMD Line Mode" tab, enter characters and press the "Send" button. The reception of characters by the Bluetooth device is indicated by the LEDs, ‘LED4’ and ‘LED5’, switching from OFF to ON and back to OFF. Every time data is received the Bluetooth device repeats this sequence.

9. Data can also be sent from the Bluetooth device to the connected smartphone. This can be done by pressing the switches SW1 to SW5 placed on the development board. When the switch is pressed the two LEDs, 'LED4' and 'LED5', should toggle from OFF to ON and back to OFF. The smartphone receives the data and displays "Button 1" for the SW1/S1 switch, "Button 2" for the SW2 switch, "Button 3" for the SW3 switch, "Button 4" for the SW4 switch, and "Button 5" for the SW5 switch.



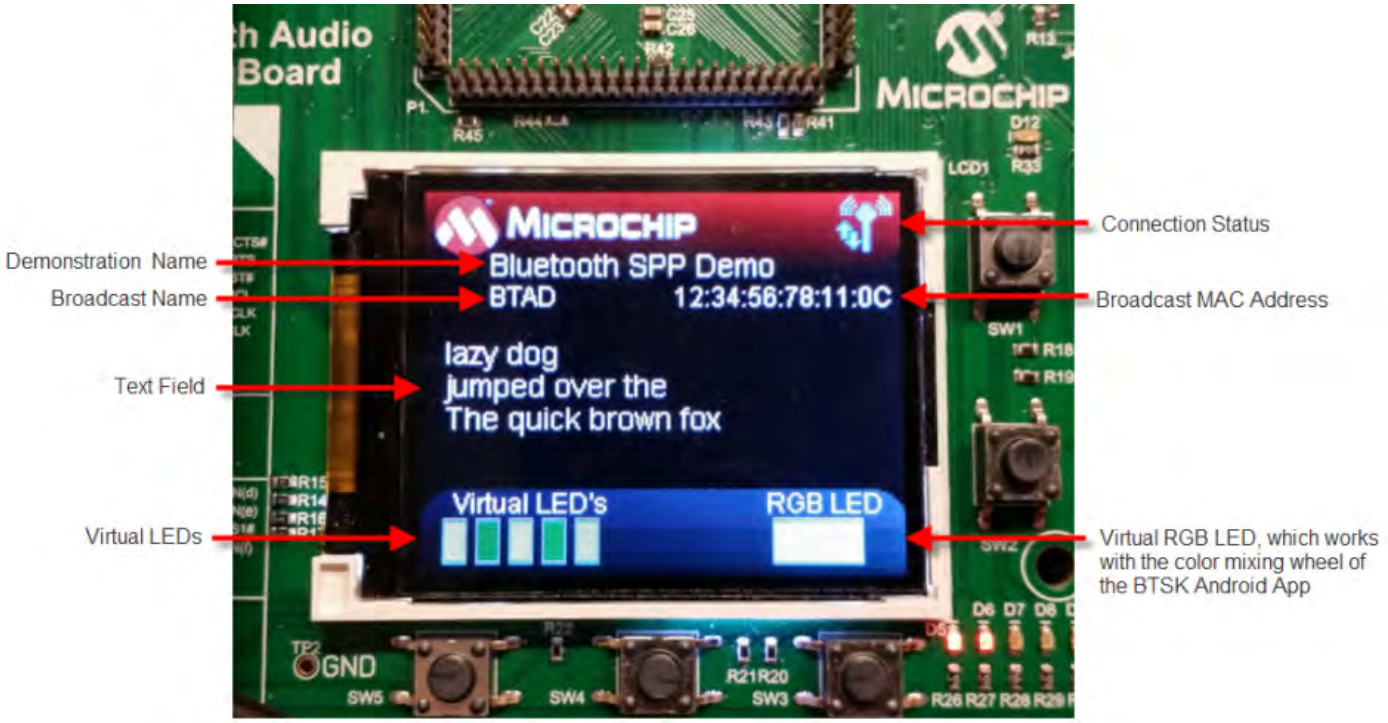
The following table describes the controls used in the supported configuration of the demonstration.

Control	bt_audio_dk
LED1	Red Color LED 'D5' on the PIC32 Bluetooth Audio Development Kit development board.
LED2	Red Color LED 'D6' on the PIC32 Bluetooth Audio Development Kit development board.

LED3	Red Color LED 'D7' on the PIC32 Bluetooth Audio Development Kit development board.
LED4	Red Color LED 'D8' on the of the PIC32 Bluetooth Audio Development Kit development board.
LED5	Red Color LED 'D9' on the PIC32 Bluetooth Audio Development Kit development board.
SW1/S1	SW1 switch located on the PIC32 Bluetooth Audio Development Kit development board.
SW2	SW2 switch located on the PIC32 Bluetooth Audio Development Kit development board.
SW3	SW3 switch located on the PIC32 Bluetooth Audio Development Kit development board.
SW4	SW4 switch located on the PIC32 Bluetooth Audio Development Kit development board.
SW5	SW5 switch located on the PIC32 Bluetooth Audio Development Kit development board.

Demonstration Display

The following figure describes the display format when running the demonstration.



Connection Status

The color of the Connection Status icon on the display indicates the Bluetooth status of the demonstration, as described in the following table.

Icon Color	Display Example	Description
Gray		Bluetooth is not paired and connected.
White		Bluetooth is paired, but is not connected.
Blue		Bluetooth is paired and connected.

Demonstration Commands

Commands to control different aspects of the demonstration are listed in the following table. Note that all commands are case-sensitive and commands that are recognized by the demonstration will not display in the Text Field by default. To see all text that is transmitted, a "DISPLAY_ALL" or "DAI" command must be sent first.

Commands Sent Over Bluetooth

Command	Shortcut	Action	Example
DISPLAY_ALL	DAI	Displays all text.	DISPLAY_ALL

DISPLAY_ALL_STOP	DAS	Stop displaying all messages and will only display non-recognized commands (default).	DISPLAY_ALL_STOP
ledx on ('x' = 1-5)		Turns on the specified virtual LED (LED1 = left, LED5 = right).	led3on
ledx off ('x' = 1-5)		Turns off the specified virtual LED (LED1 = left, LED5 = right).	led3off
ledx toggle ('x' = 1-5)		Toggles the state of the specified virtual LED (LED1 = left, LED5 = right).	led3toggle
Lx ('x' = 1-31)		Displays a binary pattern using the virtual LEDs (MSB = left, LSB = right).	L21
255,03,R,G,B		The color of the virtual RGB LED is modified to the specified RGB value, varying from 0-254, respectively.	255,03,127,127,127

data_temp_sens_rgb

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Description

This demonstration performs full duplex data transfer over the Bluetooth link. The demonstration allows the user to send and receive SPP data with an Android OS-based Smartphone using Microchip's PIC32 Bluetooth Starter Kit application. The PIC32 Bluetooth Starter Kit Android Application allows users to send and receive SPP data with an Android OS-based smartphone to Microchip's PIC32 Bluetooth Starter Kit. Please refer to the *"PIC32 Bluetooth Starter Kit User's Guide"* (DS70005190) for additional information. The application file, `BTSK_Android_App.apk`, is located in the `<install-dir>/apps/bluetooth/data_temp_sens_rgb/android_app` folder of your MPLAB Harmony installation.

The data transfer from the Android phone to the PIC32 Bluetooth Starter Kit is demonstrated by the user sending the red, green, and blue data by operating the 'COLOR' tab on the intuitive GUI of the Android application to create a color. The resulting color, once received, would be displayed by the Cree high output multi-color LED on the PIC32 Bluetooth Starter Kit.

The data transfer from the PIC32 Bluetooth Starter Kit to the Android phone is demonstrated by the user requesting the temperature measurement value by operating the 'TEMPERATURE' tab on the intuitive GUI of the Android application. The request, once received by the PIC32 Bluetooth Starter Kit application, sends the latest values by reading the temperature sensor on the starter kit. The Android application receives the temperature values and displays them on the dynamically updating 'TEMPERATURE' tab.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the Bluetooth Demonstration.

Description

To build this project, you must open the `data_temp_sens_rgb.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/bluetooth/data_temp_sens_rgb`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`data_temp_sens_rgb.X`	`<install-dir>/apps/bluetooth/data_temp_sens_rgb/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx_bt_sk	pic32mx_bt_sk	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32 Bluetooth Starter Kit.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32 Bluetooth Starter Kit

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

Provides instructions on how to build and run the Bluetooth temperature sensor and RGB data demonstration.

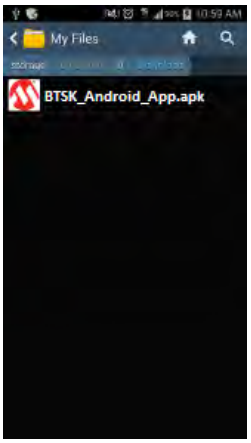
Description

This demonstration allows the SPP data transfer/receive of temperature sensor and RGB data.

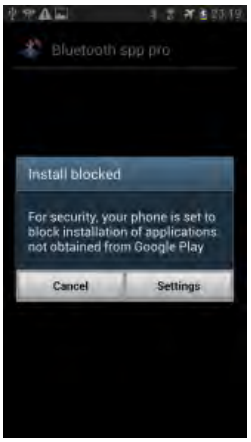
Note: Before running the demonstration, it is necessary to install the PIC32 Bluetooth Starter Kit Android application to your Android v4.0 or later smartphone.

Installing the PIC32 Bluetooth Starter Kit Android Application

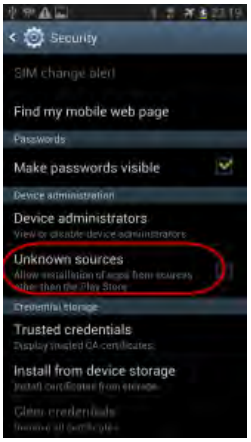
1. Install the Android application, `BTSK_Android_App.apk`, to your Android 4.0 or later smartphone. This file is available in the following MPLAB Harmony installation folder: `<install-dir>/apps/bluetooth/data_temp_sens_rgb/android_app`.
2. Connect the Android device to a computer using a mini-B USB connector.
3. It is suggested to copy the Android application into the `Download` folder of the Android device.
4. On the Android device, select *My Files>All Files>Download>BTSK_Android_App.apk*.



5. After selecting the `.apk` file, the warning message, "blocking installation", will appear.

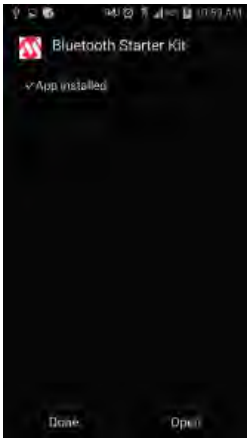


6. Select **Settings** and the security window will appear.
7. Choose the option to install applications from unknown sources.



8. Once the option is selected, a warning will appear, as shown in the following figure.

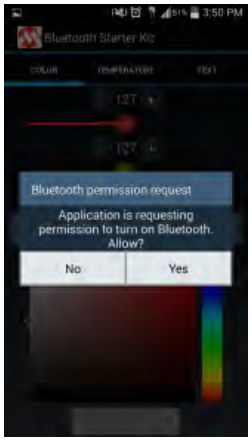
9. After selecting **OK** a window will appear requesting confirmation for installing the application.
10. Once the installation is complete, select **Open** to run the application, as shown in the following figure.



Running the Temperature Sensor and RGB Demonstration

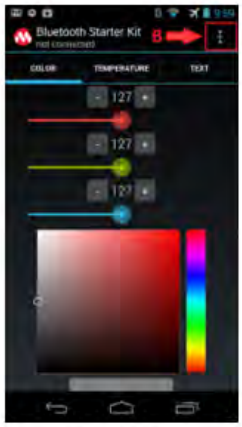
1. Compile and program the target device with the hex file, `data_temp_sens_rgb.X.production.hex`.
2. Select the PIC32 Bluetooth Starter Kit on the Android device and a window will appear, as shown in the following figure.

3. Select the Bluetooth Starter Kit icon in the application window.
4. If prompted, turn on Bluetooth by selecting **Yes**.



5. There are three methods for performing the next steps depending on the phone and Android version you are using. **[A]** Pressing the Microchip logo and the words "Bluetooth Starter Kit", [B] pressing the on-screen Menu button **[B]** (if supported), or **[C]** Pressing the Menu button (hardware). In general, if you have a hardware button you will not have an on-screen button and vice versa. After opening the menu, select **Connect a device - Insecure**.

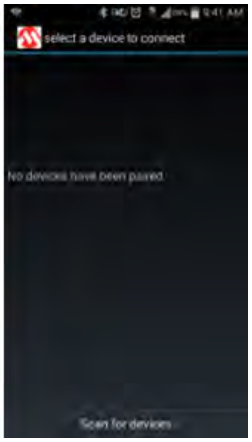
Method [A]



Method [B]

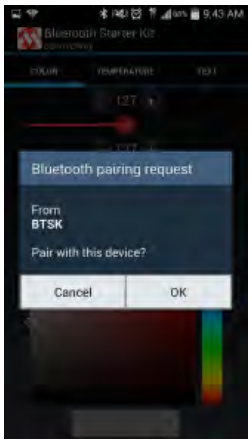
Method [C]

6. Select the option "Connect a device – Insecure" and a window will appear showing a list of paired device and option to scan for devices, as shown in the following figure.



7. A list of paired devices will appear. If this is the first time connecting with the PIC32 Bluetooth Starter Kit, select **Scan for Devices**. It should be noted that sometimes the name is not resolved and will appear as "null". After some time the name will change from "null" to "BTSK". The MAC Address will be fixed for the first eight digits and the last four will vary (12:34:45:78: XX: XX) when the device is programmed with code.

8. When selected, the Android application will pair and connect with the PIC32 Bluetooth Starter Kit. Accept any pair requests, as follows.



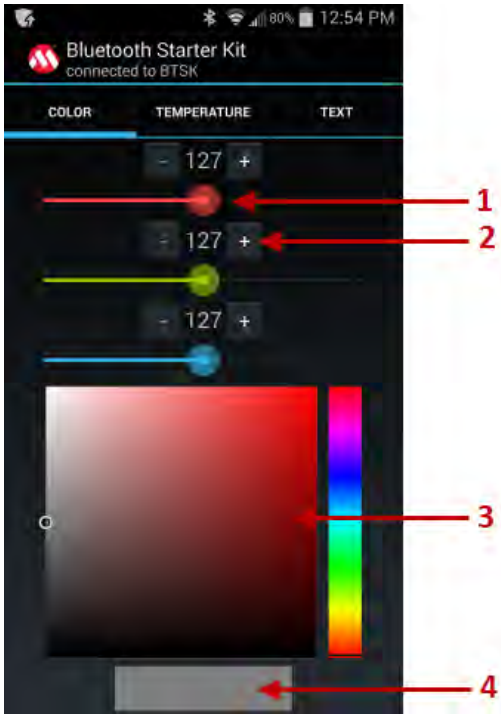
9. Status indicators will confirm that the connection was successful, as shown in the following figure.

Note: If the application was unable to connect, verify that the PIC32 Bluetooth Starter Kit is powered on, within range, and is not connected to another Bluetooth device.

LED Color Control

The application consists of three color sliders for Red (R), Green (G), and Blue (B), respectively. The color of the LED is programmed as the slider **(1)** is modified. The color of the LED can also be modified using the increment button or the decrement button **(2)**. Similarly, the color can be modified by selecting the color based on hue and saturation on the color palette **(3)**. The slider and the increment/decrement buttons send commands to the PIC32 Bluetooth Starter Kit via SPP to program the LED color. The colors of R, G, and B can vary from 0 to 254, respectively. The color bar **(4)** indicates the resulting modified color of the RGB combination. The LED changes in real-time to approximate the color in the color bar. The LED color will be of an uncalibrated nature of the integrated three color diodes.

This is a demonstration of full-duplex data transmission from and to the Android device to the development board. Each time the color is modified, a command is sent in a string format via SPP to the development board. The command sent can be viewed in the Text menu.



Temperature Sensor

Select the Temperature menu on the Android application and the window will appear as shown in the next figure. Fahrenheit temperature readings are shown in a graph, which updates automatically as new readings are received. The graph is zoomable and scrollable in the X direction. The last received reading is also displayed as large text.

The PIC32 Bluetooth Starter Kit has a temperature sensor and once Start is selected, the temperature will be updated for every second by default in a periodic mode. The update rate can be modified from 250 milliseconds to 8 seconds by using the increment or the decrement button **(1)**. The time duration can also be modified by the slider provided in the application **(2)**. Once the time duration is set, select **Set Timer** to initiate periodic update for the modified duration. The temperature update can be halted by selecting **Stop**. Start/Stop and Set Timer sends/receives commands to/from the PIC32 Bluetooth Starter Kit through SPP full-duplex transmission. The commands sent and received can be viewed in the Text menu.

Text Control

LED Control

The LED color can be modified by sending command via Terminal emulator of the app. Select the Text menu to view the terminal window of the application. To modify the LED color the following command is sent in the format, `255, 03, R, G, B`, where:

- `255` is the command to modify the LED color.
- `03` determines the number of Bytes to be sent, currently it is 3 (R, G, B)
- `R` specifies the value for Red color from 0-254
- `G` specifies the value for Green color from 0-254
- `B` specifies the value for Blue from 0-254

For example, `255, 03, 127, 60, 128` (R = 127, G = 60, B = 128)

The commands ‘r' or ‘g' or ‘b' set the LED to 50% of Red, Green, or Blue, respectively. Similarly, the commands ‘R' or ‘G' or ‘B' set the LED to 100% of Red, Green, or Blue, respectively. Refer to **Table 1: Text Commands** for details.

Temperature Control

The command 254 is sent to the PIC32 Bluetooth Starter Kit via SPP data transmission. This command transmits the current temperature to the Android device terminal emulator once on request. Similarly, command 253 is sent to the PIC32 Bluetooth Starter Kit to receive the current temperature on a periodic time period for every one second by default. The rate of the update can be modified by the following command 252, with the time in milliseconds.

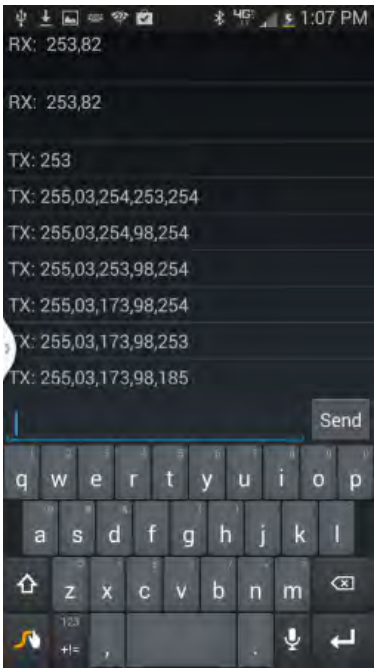
252 - Command the update timer rate change. The periodic temperature update can be stopped by sending command 253.

Refer to **Table 1: Text Commands** for details.

Table 1: Text Commands

Feature	Command	TX Format	RX Format	Description	Example
LED	255	255,03,R,G,B	N/A	The led color is modified depending on the value of R, G and B varying from 0-254 respectively.	255,03,127,127,127
LED	R	R	N/A	Programs LED for 100% of Red	R
LED	G	G	N/A	Programs LED for 100% of Green	G
LED	B	B	N/A	Programs LED for 100% of Blue	B
LED	r	r	N/A	Programs LED for 50% of Red	r
LED	g	g	N/A	Programs LED for 50% of Green	g
LED	b	b	N/A	Programs LED for 50% of Blue	b
Temperature	254	254	Temperature in Fahrenheit	On transmitting 254 command , the PIC32 Bluetooth Starter Kit sends the current temperature once per request	254
Temperature	253	253	253, temperature in Fahrenheit	On transmitting 253, the PIC32 Bluetooth Starter Kit updates the temperature for every one second	TX: 253 RX:253,80

Temperature	252	252, rate in milliseconds	253, temperature	Programs LED for 100% of Green	TX: 253,399 RX: 253,80
Temperature	253	253	N/A	The periodic display can be halted by resending 253	N/A



Premium Demonstrations

This topic provides information on how to obtain, build, configure, and run the purchased "Premium" demonstration.

Description

For information on purchasing the premium demonstration, please refer to the Microchip Premium MPLAB Harmony Audio web page (www.microchip.com/pic32harmonypremiumaudio).

a2dp_avrcp

Note: The Premium Demonstrations are not included in the standard release of MPLAB Harmony and must be purchased. Refer to the Microchip Premium MPLAB Harmony Audio web page (www.microchip.com/pic32harmonypremiumaudio) for more information.

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Description

This demonstration performs streaming of wireless Bluetooth audio from any smartphone (i.e., Apple, Samsung, Google, etc.), personal computer, or Bluetooth-enabled device. The demonstration supports the following features:

- A2DP
- AVRCP
- SSP
- SBC Decoder

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the Premium Demonstration.

Description

To build this project, you must open the `a2dp_avrcp.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/bluetooth/premium/audio/a2dp_avrcp`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
a2dp_avrcp.X	<install-dir>/apps/bluetooth/premium/audio/a2dp_avrcp/firmware

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within ./firmware/src/system_config.

Project Configuration Name	BSP Used	Description
ak7755_bt_audio_dk	bt_audio_dk	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32 Bluetooth Audio Development Kit with the AKM AK7755 Codec.
bt_audio_dk	bt_audio_dk	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32 Bluetooth Audio Development Kit.
pic32mz_da_sk_meb2	pic32mz_da_sk+meb2	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32MZ DA Starter Kit attached to the Multimedia Expansion Board II (MEB II).
pic32mz_ef_sk_meb2	pic32mz_ef_sk+meb2	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32MZ EF Starter Kit attached to the Multimedia Expansion Board II (MEB II).
pic32mz_ec_sk_meb2	pic32mz_ec_sk+meb2	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32MZ EC Starter Kit attached to the Multimedia Expansion Board II (MEB II).
pic32mz_ef_sk_meb2_wvga	pic32mz_ef_sk+meb2+wvga	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32MZ EF Starter Kit attached to the Multimedia Expansion Board II (MEB II) and the 5.0" WVGA display.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32 Bluetooth Audio Development Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ DA Starter Kit and MEB II

No hardware related configuration or jumper setting changes are necessary.

PIC32 Bluetooth Audio Development Kit and AK7755 Codec

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ EF Starter Kit and MEB II

Move jumper J9 to short pins 1 and 2 (external LCCG mode).

PIC32MZ EC Starter Kit and MEB II and 5.0" WVGA Display

Move jumper J9 to short pins 1 and 2 (external LCCG mode).

Running the Demonstration

Provides instructions on how to build and run the Premium audio demonstration

Description

1. Build and program the target device. While building, select the appropriate MPLAB X IDE project configuration based on the demonstration board. Refer to Building the Application for details.
2. When LED2 and LED3 turn ON, this indicates that the demonstration is running on the PIC32 Bluetooth Audio Development Kit.
3. Enable Bluetooth on the Bluetooth audio device (for example, Smartphone).
4. Scan for the available Bluetooth devices. The target Bluetooth device should also be displayed in the list of available devices on your Bluetooth audio device.
5. The name of the target Bluetooth device will be as follows:

Configuration	Device Name
bt_audio_dk	Microchip A2DP
ak7755_bt_audio_dk	Microchip A2DP
pic32mz_da_sk_meb2	BT_DA + MEB-II
pic32mz_ec_sk_meb2	BT_MZ EC + MEB-II
pic32mz_ef_sk_meb2	BT_MZ EF + MEB-II
pic32mz_ef_sk_meb2_wvga	BT_MZ EF + MEB-II + WVGA

Note: Occasionally, the name of the Bluetooth device is not resolved and will appear as "null". After some time the name will change from "null" to the configuration-specific name previously mentioned. The visible MAC Address will be fixed for the first eight digits and the last four will vary (12:34:45:78:XX: XX).

6. Select the device to pair and connect.
7. If prompted by your device for a PIN, enter 0000.
8. If the connection is successful, the message "connected to <Device Name>" appears at the top of the screen of your Bluetooth audio device.
9. Connect a speaker or headphones to the line-out/headphone jack of the development board.
10. Select the music track and tap **Play**.

Demonstration Controls

Bluetooth Mode	Control	bt_audio_dk and ak7755_bt_audio_dk	pic32mz_da_sk_meb2
Shuffle (Toggle) / Force Bluetooth Device to Unpair	SW1	Switch, SW1, located on top of the board.	N/A
Repeat Track (Toggle) / Bluetooth Device Disconnect	SW2	Switch, SW2, located on top of the board.	N/A
Next Track/Fast Forward	SW3	Switch, SW3, located on top of the board.	N/A
Play/Pause (Toggle) / Soft Mute (toggle)	SW4	Switch, SW4, located on top of the board.	N/A
Previous Track / Rewind	SW5/S1	Switch, SW5, located on top of the board.	N/A
N/A	LED1	Red LED, D5, located on top of the board.	Red LED, D3, located on top of the board.
Bluetooth Device Connection Ready	LED2	Red LED, D6, located on top of the board.	Red LED, D4, located on top of the board.
Bluetooth Device Connection Ready	LED3	Red LED, D7, located on top of the board.	Red LED, D5, located on top of the board.
Audio Stream Indication	LED4	Red LED, D8, located on top of the board.	Red LED, D6, located on top of the board.
N/A	LED5	Red LED, D9, located on top of the board.	Red LED, D7, located on top of the board.
CPU Exception Error	LED1-LED5	Red LEDs, D5-D9, located on top of the board.	Red LEDs, D3-D7, located on top of the board.

a2dp_avrcp Premium Demonstration Touch Display Controls

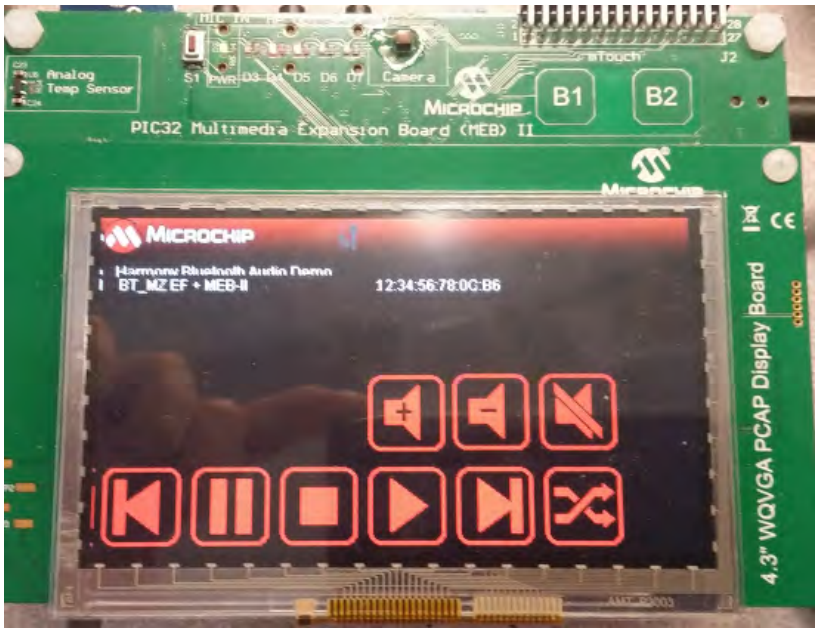
The touch screen demonstration controls listed in the following table are available for these configurations:

- pic32mz_ec_sk_meb2
- pic32mz_ef_sk_meb2
- pic32mz_ef_sk_meb2_wvga

Icon	Function
	Plays music and audio.
	Stops music and audio, and in most instances, will also close the device application.

	Pauses music and audio.
	Plays the previous track.
	Plays the next track.
	Increases the volume using the AVRCP Volume Up command. **Note:** Not all device applications will change volume with this command.
	Decreases the volume using the AVRCP Volume Down command. **Note:** Not all device applications will change volume with this command.
	Mutes (silences) the device using the AVRCP Volume Mute command. **Note:** Not all device applications will change volume with this command.
	Shuffles tracks.

The following figure illustrates the display.



Bootloader Demonstrations

This section provides descriptions of the Bootloader demonstrations.

Introduction

Bootloader Demonstration Applications Help.

Description

This distribution package contains firmware projects that demonstrate the capabilities of the MPLAB Harmony Bootloader. This section describes the hardware requirement and procedures to run these firmware projects on Microchip demonstration and development boards.

To learn more about MPLAB Harmony stacks and libraries refer to the related documentation in Volume IV: MPLAB Harmony Framework Reference.

Demonstrations

This topic provides information on how to run the Bootloader demonstration applications included in this release.

basic

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Description

This demonstration implements a Bootloader that resides in boot Flash. With the Bootloader operating on the target device, the device can then be programmed with application code without the need for an external programmer or debugger.

The Bootloader is, operationally, similar to the bootloader described in AN1388 *"PIC32 Bootloader"*, and will work with the personal computer application provided with the related source archive file. The application note and archive file are available for download from the Microchip web site (www.microchip.com).

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the Bootloader Demonstration.

Description

To build this project, you must open the `basic.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/bootloader/basic`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`basic.X`	`<install-dir>/apps/bootloader/basic/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are within `./firmware/src/system_config`.

Project Configuration Name	BSP(s) Used	Description
udp_pic32mx_eth_sk	pic32mx_eth_sk	Demonstrates the UDP Ethernet mode on the PIC32 Ethernet Starter Kit.
udp_pic32mz_ec_sk	pic32mz_ec_sk	Demonstrates the UDP Ethernet mode on the PIC32MZ EC Starter Kit.
udp_pic32mz_ef_sk	pic32mz_ef_sk	Demonstrates the UDP Ethernet mode on the PIC32MZ EF Starter Kit
udp_pic32mz_da_sk	pic32mz_da_sk	Demonstrates the UDP Ethernet mode on the PIC32MZ DA Starter Kit.
usart_pic32mx_eth_sk	pic32mx_eth_sk	Demonstrates the UART bootloader on the PIC32 Ethernet Starter Kit.
usart_pic32mz_ec_sk	pic32mz_ec_sk	Demonstrates UART bootloader on the PIC32MZ EC Starter Kit. **Note:** This demonstration does not rely on the hardware encryption module.
usart_pic32mz_ef_sk	pic32mz_ef_sk	Demonstrates UART bootloader on the PIC32MZ EF Starter Kit. **Note:** This demonstration does not rely on the hardware encryption module.
usart_pic32mz_da_sk	pic32mz_da_sk	Demonstrates UART bootloader on the PIC32MZ DA Starter Kit. **Note:** This demonstration does not rely on the hardware encryption module.
usbdevice_pic32mx_usb_sk2	pic32mx_usb_sk2	Demonstrates the USB Device mode on the PIC32 USB Starter Kit II.
usbdevice_pic32mz_ec_sk	pic32mz_ec_sk	Demonstrates the USB Device mode on the PIC32MZ EC Starter Kit.
usbdevice_pic32mz_ef_sk	pic32mz_ef_sk	Demonstrates the USB Device mode on the PIC32MZ EF Starter Kit.
usbhost_pic32mx_usb_sk2	pic32mx_usb_sk2	Demonstrates the USB Host bootloader on the PIC32 USB Starter Kit II.
usbhost_pic32mz_ec_sk	pic32mz_ec_sk	Demonstrates the USB Host bootloader on the PIC32MZ EC Starter Kit. **Note:** This demonstration does not rely on the hardware encryption module.

usbhost_pic32mz_ef_sk	pic32mz_ef_sk	Demonstrates the USB Host bootloader on the PIC32MZ EF Starter Kit. **Note:** This demonstration does not rely on the hardware encryption module.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

The following configuration information is for UART mode.

PIC32 Ethernet Starter Kit, PIC32 Ethernet Starter Kit II, or PIC332 USB Starter Kit II

UART communication is done through the UART2 module. The U2RX and U2TX pins can be accessed through the Starter Kit I/O Expansion Board. One way to do this is with the MCP2200 Breakout Module. Connect the TX pin of the module to pin 46 on connector J11. Connect the RX pin of the module to pin 48 on connector J11. Connect GND pins together to ensure shared grounding.

Figure 1 and Figure 2 show the hardware configuration and close-ups of the jumper wire connections.

Figure 1 - Hardware Configuration

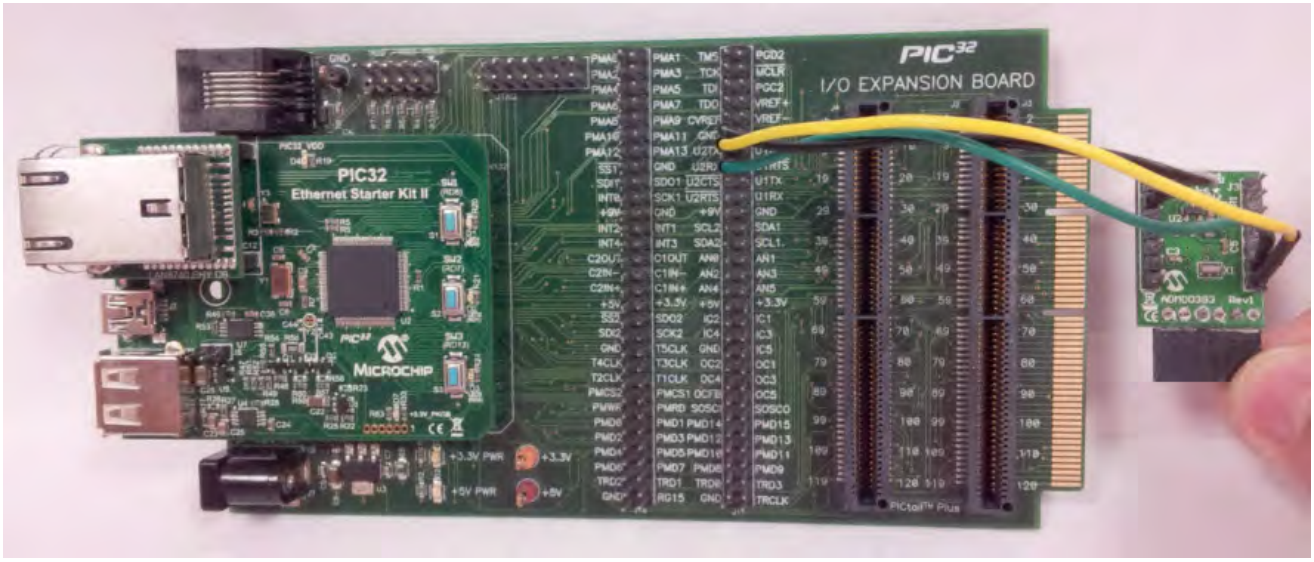
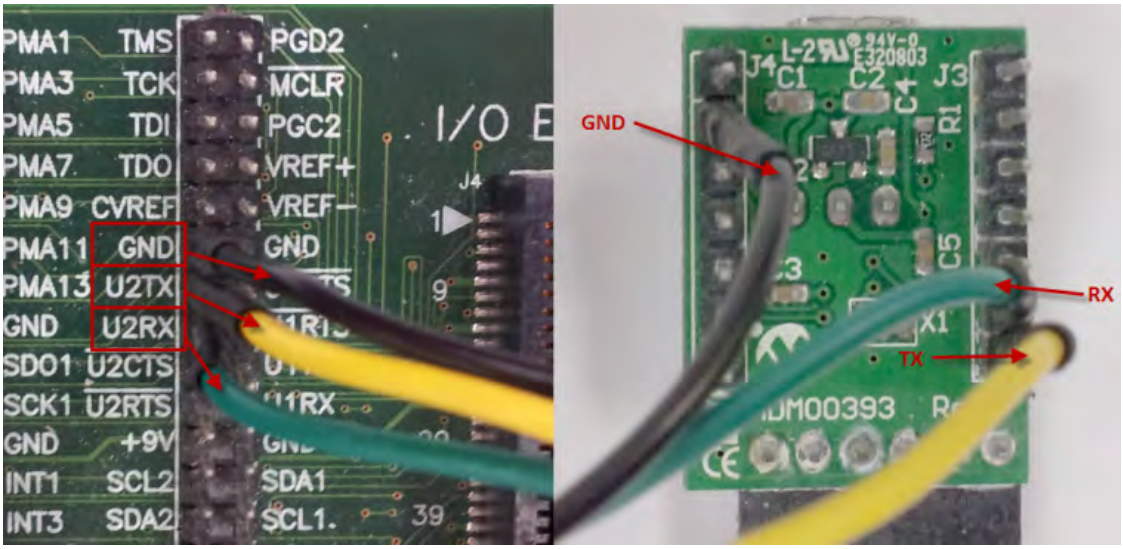


Figure 2 - Jumper Wire Connections



PIC32MZ EC Starter Kit

UART communication is done through the UART1 module, routed through PPS to RPF0 and RPF1. The U1RX and U1TX pins can be accessed through the PIC32MZ Starter Kit Adapter Board. One way to do this is with the MCP2200 Breakout Module. Connect the TX pin of the module to the EBID10 pin of JP3 on the underside of the adapter. Connect the RX pin of the module to the EBID11 pin of JP1 on the underside of the adapter. Connect grounds between the module and the starter kit to ensure shared grounding.

Note: When running the UDP bootloader on the PIC32MZ EC Starter Kit, the bootloader may not run due to a connection issue between the starter kit and the LAN8740 PHY daughter card.

Please refer to the Product Change Notice for the LAN8740 PHY Daughter card for options to correct this issue. This PCN is available from the PIC32MZ EC Starter Kit web page at:

http://www.microchip.com/Developmenttools/ProductDetails.aspx?PartNO=Dm320006

Figure 3 and Figure 4 show the hardware configuration.

Figure 3 - Hardware Configuration (Front)

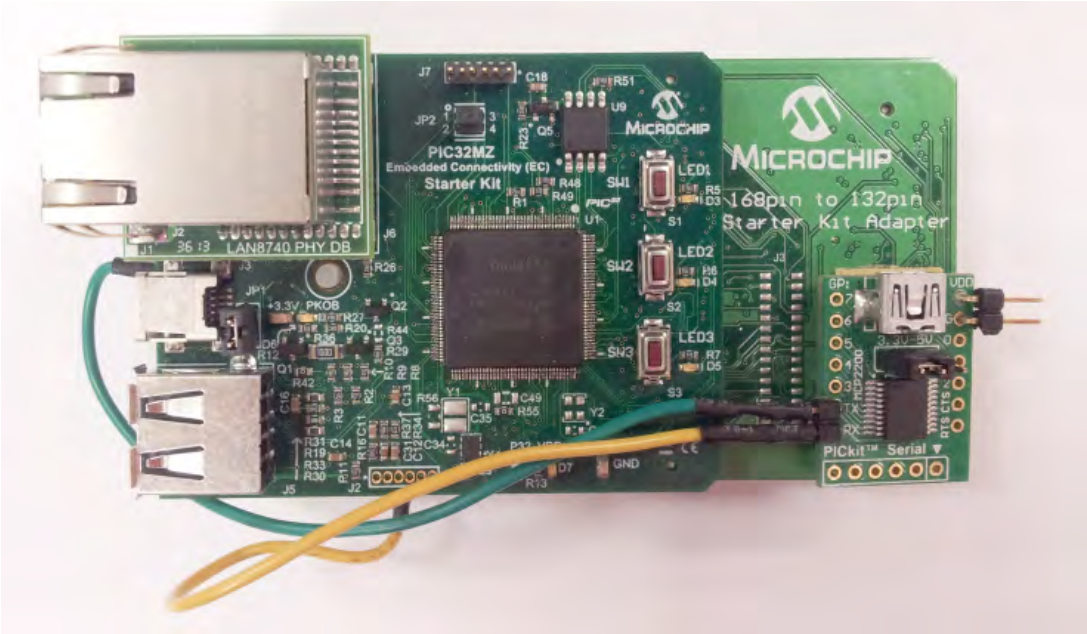
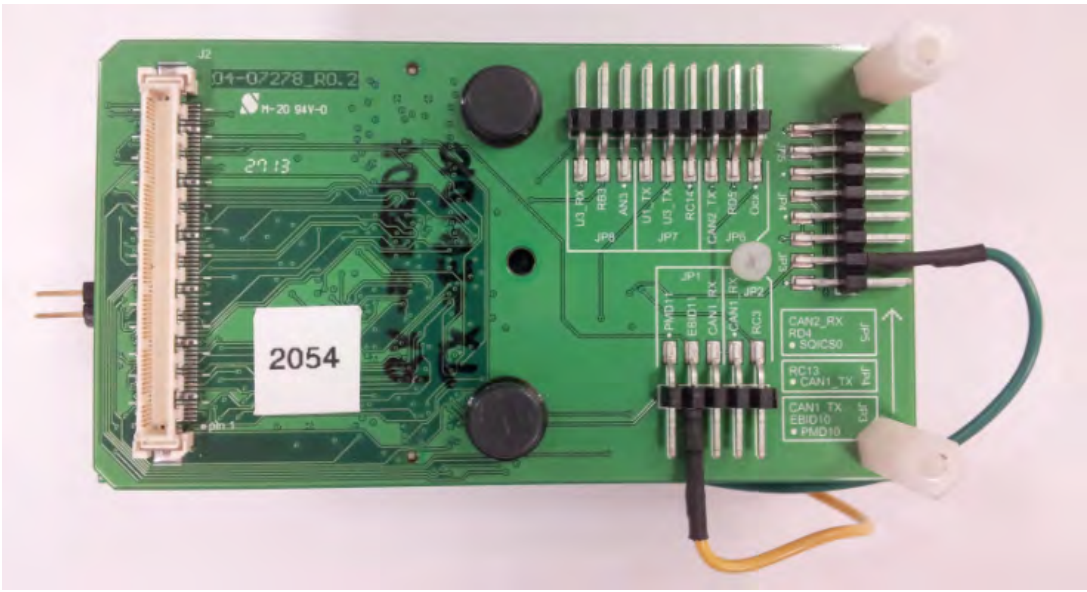


Figure 4 - Hardware Configuration (Back)



PIC32MZ EF Starter Kit

Connect the host computer to J11 of the PIC32MZ EF Starter Kit.

PIC32MZ Graphics (DA) Starter Kit

Connect the host computer to J5 of the PIC32MZ DA Starter Kit.

Running the Demonstration

Provides instructions on how to build and run the Bootloader demonstration.

Description

Personal Computer-based Host Demonstration

Do the following when using the configurations:

Operation

The bootloader is operated as follows:

1. Select the configuration suitable for the target hardware.
2. Compile and program the device.
3. Hold down SW3 on the starter kit to force bootloader operation.
4. LED1 will start blinking to indicate the bootloader is operating. If a program had previously been programmed, it may be necessary to hold down SW3 prior to applying power to the board or resetting the board.
5. Open the personal computer Host program from the AN1388 source archive file.
6. Select the appropriate communication path:
   - UART - Leave the baud rate at 115,200
   - UDP - Keep the IP address at 192.168.1.11 and the UDP port at 6234
   - USB Device - Keep the VID at 0x4D8 and the PID at 0x03C
7. Click **Connect** to connect to the bootloader and get the version.
8. If the bootloader connects, the personal computer Host application will indicate the version of the bootloader.

At this point, the bootloader is ready to accept a new application for programming into the program Flash. A demonstration application is provided, which is configured in a linker script to only operate in program Flash.

Setup

The demonstration application is prepared as follows:

1. Open the `dma_led_pattern.X` project from `<install-dir>/apps/examples/peripheral/dma/firmware`.
2. Select the configuration suitable for the target hardware.
3. Compile the program, but **do not program the device**.

Programming the Device

With the demonstration application compiled, the generated hex file can now be programmed into the device using the bootloader.

To program the application into the device:

1. On the personal computer Host application described in AN1388, click **Load Hex File**.
2. Navigate to `<install-dir>/apps/examples/peripheral/dma/firmware/dma_led_pattern.X/dist/<configuration>/production/<configuration>.X.production.hex`.
   Select it and click **Open**.
3. Click **Erase-Program-Verify**.
4. The program will then be transferred to the bootloader, which will program the application.
5. When the program has been programmed, click **Run Application** to start the program.
6. If the application has been programmed correctly, the green and red LEDs will blink in an alternating pattern.
7. Click **Disconnect** to release the Host Application.

USB Host-based Demonstration

Do the following when using the configurations:

Operation

The bootloader is operated as follows:

1. Select the configuration suitable for the target hardware.
2. Compile and program the device.
3. Hold down SW3 on the starter kit to force bootloader operation.

If a program had previously been programmed, it may be necessary to hold down SW3 prior to applying power to the board or resetting the board.

Setup

The demonstration application is prepared as follows:

1. Open the `dma_led_pattern.X` project from `<install-dir>/apps/examples/peripheral/dma/firmware/`.
2. Select the configuration suitable for the target hardware.
3. Compile the program, but do not program the device.
4. Copy the resultant .hex file to the flash drive that will be inserted into the target USB port. The file can be located at `<install-dir>/apps/examples/peripheral/dma/firmware/dma_led_pattern.X/dist/<platform>/production/dma_led_pattern.X.production.hex`.
5. Rename the hex file on the Flash drive to `image.hex`.

Programming the Device

With the demonstration application compiled, the generated hex file can now be programmed into the device using the bootloader.

To program the application into the device:

1. Insert the Flash drive into the type-A USB port on the starter kit.
2. The program will be loaded from the Flash drive and programmed into the device.
3. Remove the Flash drive when the program starts running.

LiveUpdate

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Description

This demonstration implements a live update bootloader that looks for a change during start-up that swaps the Flash panels on the PIC32MZ EC Starter Kit. The same sample application as the basic bootloader demonstration can be used as the application source for a programming example with this bootloader demonstration.

The bootloader is, operationally, similar to the bootloader described in AN1388 *"PIC32 Bootloader"*, and will work with the personal computer application provided with the related source archive file. The application note and archive file are available for download from the Microchip web site (www.microchip.com).

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the Bootloader Demonstration.

Description

To build this project, you must open the `liveUpdate.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/bootloader/LiveUpdate`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`liveUpdate.X`	`<install-dir>/apps/bootloader/LiveUpdate/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are within `./firmware/src/system_config`.

Project Configuration Name	BSP(s) Used	Description
usart_pic32mz_ec_sk	pic32mz_ec_sk	Demonstrates the UART bootloader on the PIC32MZ EC Starter Kit. **Note:** This demonstration does not rely on the hardware encryption module.
usart_pic32mz_ef_sk	pic32mz_ef_sk	Demonstrates the UART bootloader on the PIC32MZ EF Starter Kit. **Note:** This demonstration does not rely on the hardware encryption module.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32MZ EC Starter Kit

UART communication is done through the UART1 module, routed through PPS to RPF0 and RPF1. The U1RX and U1TX pins can be accessed through the PIC32MZ Starter Kit Adapter Board. One way to do this is with the MCP2200 Breakout Module. Connect the TX pin of the module to the EBID10 pin of JP3 on the underside of the adapter. Connect the RX pin of the module to the EBID11 pin of JP1 on the underside of the adapter. Connect grounds between the module and the starter kit to ensure shared grounding.

Figure 3 and Figure 4 show the hardware configuration.

Figure 3 - Hardware Configuration (Front)

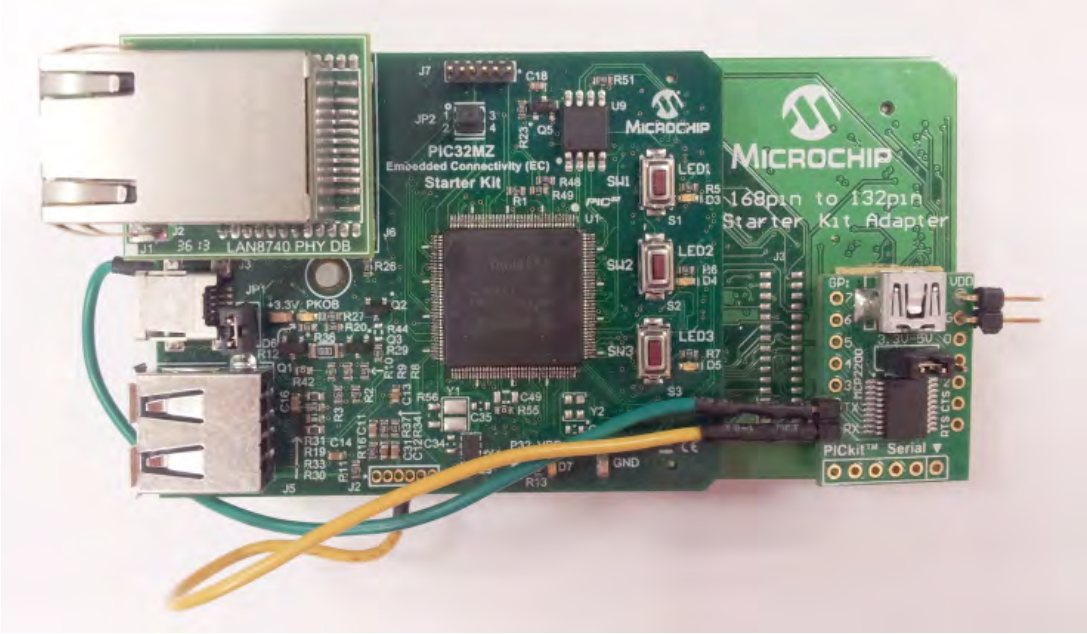
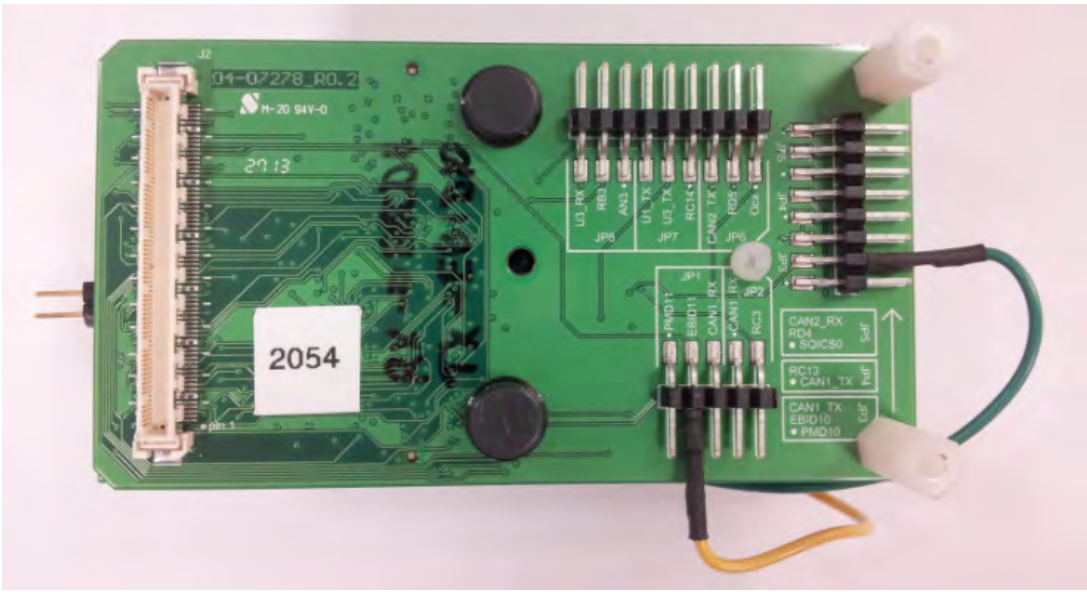


Figure 4 - Hardware Configuration (Back)



PIC32MZ EF Starter Kit

Connect the host computer to J11 of the PIC32MZ EF Starter Kit.

PIC32MZ Graphics (DA) Starter Kit

Connect the host computer to J5 of the PIC32MZ DA Starter Kit.

Running the Demonstration

Provides instructions on how to build and run the Bootloader demonstration.

Description

Personal Computer-based Host Demonstration

Do the following when using the configurations:

Operation

The bootloader is operated as follows:

1. Select the configuration suitable for the target hardware.
2. Compile and program the device.
3. LED1 will start blinking to indicate the program is operating.

4. Open the personal computer Host program from the AN1388 source archive file.
5. Select the appropriate communication path:
   - UART - Leave the baud rate at 115,200
   - UDP - Keep the IP address at 192.168.1.11 and the UDP port at 6234
   - USB Device - Keep the VID at 0x4D8 and the PID at 0x03C
6. Click **Connect** to connect to the bootloader and obtain the version.
7. If the program connects, the personal computer Host application will indicate the version of the bootloader.

At this point, the bootloader is ready to accept a new application for programming into the program Flash. A demonstration application is provided, which is configured in a linker script to only operate in program Flash.

Setup

The demonstration application is prepared as follows:

1. Open the `dma_led_pattern.X` project from `<install-dir>/apps/examples/peripheral/dma/firmware`.
2. Select the configuration suitable for the target hardware.
3. Compile the program, but **do not program the device**.

Programming the Device

With the demonstration application compiled, the generated hex file can now be programmed into the device using LiveUpdate.

To program the application into the device:

1. On the personal computer Host application described in AN1388, click **Load Hex File**.
2. Navigate to `<install-dir>/apps/examples/peripheral/dma/firmware/dma_led_pattern.X/dist/<configuration>/production/<configuration>.X.production.hex`.
   Select it and click **Open**.
3. Click **Erase-Program-Verify**.
4. The program will then be transferred to the device, which will program the application into the second Flash panel.
5. When the program has been programmed, click **Run Application** to start the program.
6. If the application has been programmed correctly, the green and red LEDs will blink in an alternating pattern.
7. Click **Disconnect** to release the Host Application.

USB Host-based Demonstration

Do the following when using the configurations:

Operation

The bootloader is operated as follows:

1. Select the configuration suitable for the target hardware.
2. Compile and program the device.

Setup

The demonstration application is prepared as follows:

1. Open the `dma_led_pattern.X` project from `<install-dir>/apps/examples/peripheral/dma/firmware/`.
2. Select the configuration suitable for the target hardware.
3. Compile the program, but do not program the device.
4. Copy the resultant `.hex` file to the flash drive that will be inserted into the target USB port. The file can be located at `<install-dir>/apps/examples/peripheral/dma/firmware/dma_led_pattern.X/dist/<platform>/production/dma_led_pattern.X.production.hex`.
5. Rename the hex file on the Flash drive to `image.hex`.

Programming the Device

With the demonstration application compiled, the generated hex file can now be programmed into the device using the bootloader.

To program the application into the device:

1. Insert the Flash drive into the type-A USB port on the starter kit.
2. The program will be loaded from the Flash drive and programmed into the device.
3. Remove the Flash drive when the program starts running.

Class B Library Demonstrations

This section provides descriptions of the Class B Library demonstrations.

Introduction

Class B Library Demonstration Applications Help.

Description

This distribution package contains one Class B-related firmware project that demonstrates the capabilities of the MPLAB Harmony Class B Library. This section describes the hardware requirement and procedures to run these firmware projects on Microchip demonstration and development boards.

To learn more about MPLAB Harmony stacks and libraries refer to the related documentation in Volume IV: MPLAB Harmony Framework Reference.

Demonstrations

This topic provides information on how to run the Class B Library demonstration applications included in this release.

ClassBDemo

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Description

This application invokes each of the Class B Safety software Library interfaces one at a time and collects the responses into a single structure. This demonstrates the use of the library, as well as some of the prerequisites that must be met to use the library.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the Class B Library demonstration.

Description

To build this project, you must open the `ClassBDemo.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/crypto/ClassBDemo`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`ClassBDemo.X`	`<install-dir>/apps/crypto/ClassBDemo/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are within `./firmware/src/system_config`.

Project Configuration Name	BSP(s) Used	Description
pic32mx_eth_sk2	pic32mx_eth_sk2	Demonstrates each of the Class B Safety Library functions on the PIC32 Ethernet Starter Kit II.
pic32mz_ef_sk	pic32mz_ef_sk	Demonstrates each of the Class B Safety Library functions on the PIC32MZ EF Starter Kit.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32 Ethernet Starter Kit II

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ EF Starter Kit

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

Provides instructions on how to build and run the Class B Library demonstration.

Description

This demonstration tests device core components and demonstrates the use of the Class B Software Safety Library API.

1. Select the desired MPLAB X IDE project configuration:
   - pic32mz_ef_sk (for PIC32MZ EF devices)
   - pic32mx_eth_sk (for PIC32MX devices)
2. Build the selected configuration in the MPLAB X IDE project and program the demonstration board by selecting Debug Main Project from the Debug Menu. The program should build, download, and run.
3. Either single step into, or step over each test in turn. As each test completes, look at the appropriate bit of the ClassB_Test_Flags structure. They will be set with either a '1' indicating failure or a '0' indicating success.

Crypto Demonstrations

This section provides descriptions of the Crypto demonstrations.

Introduction

Crypto Library Demonstration Applications Help.

Description

This distribution package contains three Crypto-related firmware projects that demonstrate the capabilities of the MPLAB Harmony Crypto Library. This section describes the hardware requirement and procedures to run these firmware projects on Microchip demonstration and development boards.

To learn more about MPLAB Harmony stacks and libraries refer to the related documentation in Volume IV: MPLAB Harmony Framework Reference.

Demonstrations

This topic provides information on how to run the Crypto Library demonstration applications included in this release.

encrypt_decrypt

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Description

This demonstration exercises several cryptographic functions, including MD5, TDES, DES, AES, RSA, ECC, and Random Number Generation, to verify that the software or hardware is performing correctly. While the demonstration is running, the yellow LED on the starter kit will light to indicate processing. If all functions execute successfully, the green LED on the starter kit will illuminate.

When testing hardware encryption, the Starter Kit with Crypto Engine (DM320006-C) must be used. Software encryption can be performed on either PIC32MX795F512L or any version of PIC32MZ device.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the Crypto Demonstration.

Description

To build this project, you must open the `encrypt_decrypt.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/crypto/encrypt_decrypt`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
encrypt_decrypt.X	<install-dir>/apps/crypto/encrypt_decrypt/firmware

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are within ./firmware/src/system_config.

Project Configuration Name	BSP(s) Used	Description
pic32mx_eth_sk	pic32mx_eth_sk	Demonstrates encryption, decryption, hashing, and random number generation using Software Libraries on the PIC32 Ethernet Starter Kit.
pic32mz_ec_sk_hw	pic32mz_ec_sk	Demonstrates encryption, decryption, hashing, and random number generation using the Hardware Encryption module on the PIC32MZ Embedded Connectivity (EC) Starter Kit with Crypto.
pic32mz_ef_sk_hw	pic32mz_ef_sk	Demonstrates encryption, decryption, hashing, and random number generation using the Hardware Encryption module on the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit with Crypto.
pic32mz_da_sk_hw	pic32mz_da_sk	Demonstrates encryption, decryption, hashing, and random number generation using the Hardware Encryption module on the PIC32MZ DA Starter Kit with Crypto.
pic32mz_ec_sk_sw	pic32mz_ec_sk	Demonstrates encryption, decryption, hashing, and random number generation using Software Libraries on the PIC32MZ Embedded Connectivity (EC) Starter Kit.
pic32mz_ef_sk_sw	pic32mz_ef_sk	Demonstrates encryption, decryption, hashing, and random number generation using Software Libraries on the PIC32MZ Embedded Connectivity with Floating Point Unit (EC) Starter Kit.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32 Ethernet Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ DA Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ EC Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ EF Starter Kit

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

Provides instructions on how to build and run the Crypto demonstration.

Description

This demonstration exercises various encryption, decryption, hashing, and random number functions.

1. First compile and program the target device. While compiling, select the configuration for the hardware in use.
2. Observe the status of LEDs on the starter kit. The yellow LED will be illuminated while the demonstration executes. If all function passes succeed, the green LED will illuminate. If an error occurred, the red LED is illuminated.

large_hash

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Description

This application demonstrates how to execute hashes on large blocks of data. In this case, the demonstration performs MD5, SHA-1, SHA-256, SHA-384, and SHA-512 hashing on a 512 * 1024 block of the letter 'a'.

On PIC32MZ devices, which have adequate Flash memory, the linker script is configured to create the 512 * 1024 block starting at physical address 0x9D08_0000.

The application runs the hashes in two ways:

- On PIC32MZ devices, the first way it runs it is by passing the entire 512 * 1024 block in one function call.
- With the second way, which is the only one that runs on PIC32MX devices, it passes a 1024 block of the letter 'a' that is allocated on the stack to the engine, doing it 512 times.

After the hashing has been performed, the application outputs via the system console the results of the hashing, and the time it took to perform each form. It then compares the generated hashes with known values for each algorithm. If all tests pass, the green LED is lit, and a message is presented through the system console. If any tests fail, the red LED is lit, and a corresponding message is presented through the system console.

When testing hardware encryption, the PIC32MZ EC Starter Kit configured with the Crypto Engine (DM320006-C) must be used. Software encryption can be performed on any version of a PIC32MX or PIC32MZ device.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the Crypto Demonstration.

Description

To build this project, you must open the `large_hash.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/crypto/large_hash`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`large_hash.X`	`<install-dir>/apps/crypto/large_hash/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are within `./firmware/src/system_config`.

Project Configuration Name	BSP(s) Used	Description
pic32mx_eth_sk	pic32mx_eth_sk	Demonstrates hashing large blocks of data using Software Libraries on the PIC32 Ethernet Starter Kit.
pic32mz_ec_sk_hw	pic32mz_ec_sk	Demonstrates hashing large blocks of data using the Hardware Encryption module on the PIC32MZ Embedded Connectivity (EC) Starter Kit with Crypto.
pic32mz_ef_sk_hw	pic32mz_ef_sk	Demonstrates hashing large blocks of data using the Hardware Encryption module on the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit with Crypto.
pic32mz_da_sk_hw	pic32mz_da_sk	Demonstrates hashing large blocks of data using the Hardware Encryption module on the PIC32MZ Graphics (DA) Starter Kit with Crypto.
pic32mz_ec_sk_sw	pic32mz_ec_sk	Demonstrates hashing large blocks of data using Software Libraries on the PIC32MZ Embedded Connectivity (EC) Starter Kit.
pic32mz_ef_sk_sw	pic32mz_ef_sk	Demonstrates hashing large blocks of data using Software Libraries on the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32 Ethernet Starter Kit

UART communication is done through the UART2 module. The U2RX and U2TX pins can be accessed through the Starter Kit I/O Expansion Board. One way to do this is with the MCP2200 Breakout Module. Connect the TX pin of the module to pin 46 on connector J11. Connect the RX pin of the module to pin 48 on connector J11. Connect GND pins together to ensure shared grounding.

Figure 1 and Figure 2 show the hardware configuration and close-ups of the jumper wire connections.

Figure 1 - Hardware Configuration

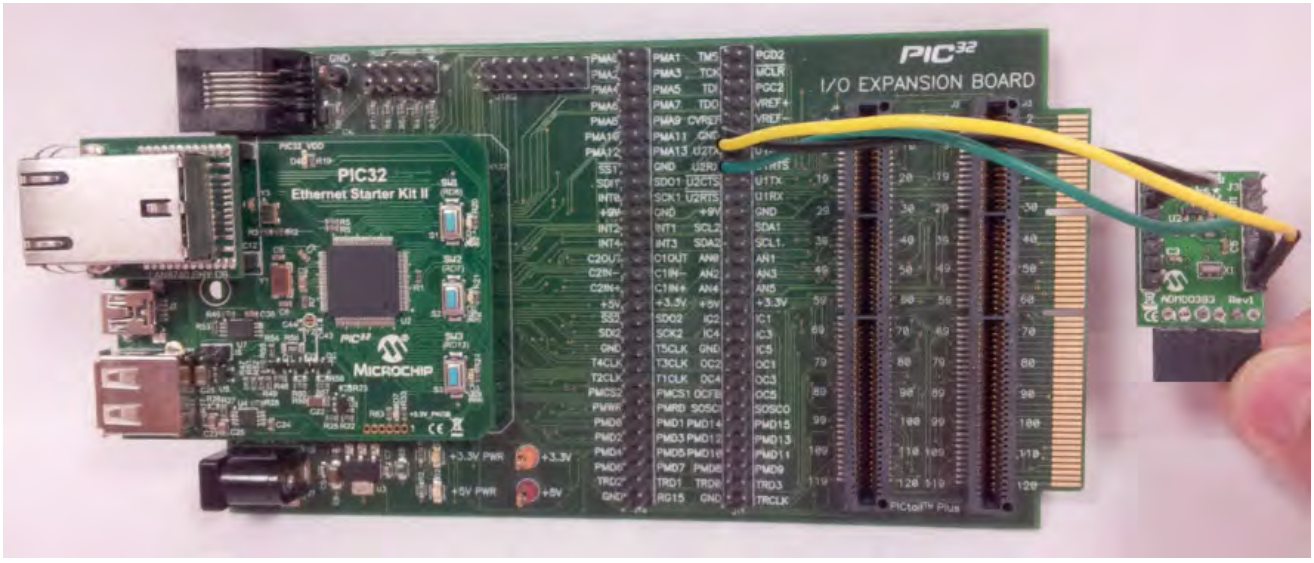
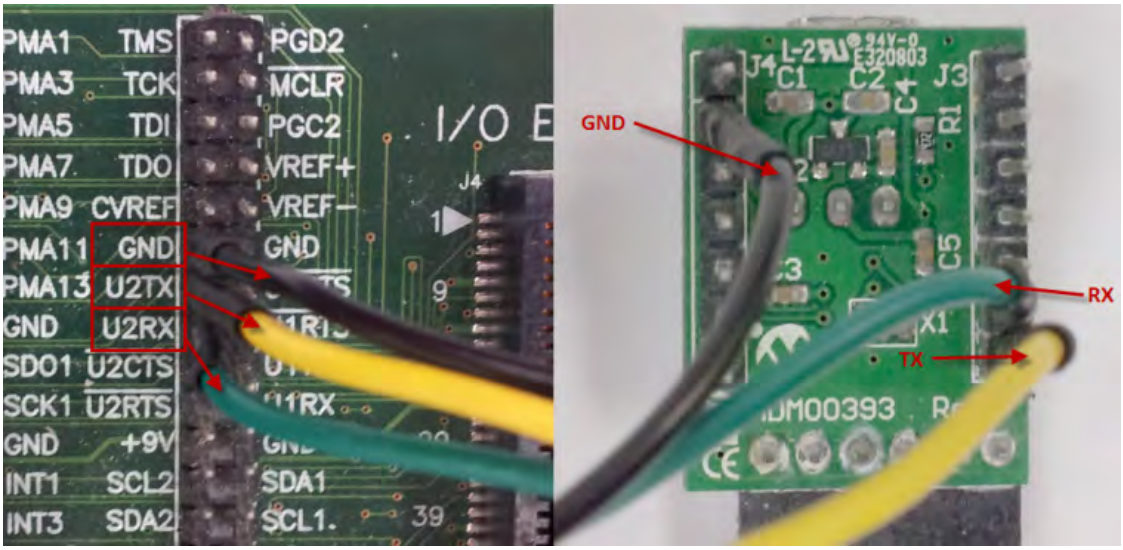


Figure 2 - Jumper Wire Connections



PIC32MZ EF Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ DA Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ Embedded Connectivity (EC) Starter Kit

UART communication is done through the UART1 module, routed through PPS to RPF0 and RPF1. The U1RX and U1TX pins can be accessed through the PIC32MZ Starter Kit Adapter Board. One way to do this is with the MCP2200 Breakout Module. Connect the TX pin of the module to the EBID10 pin of JP3 on the underside of the adapter. Connect the RX pin of the module to the EBID11 pin of JP1 on the underside of the adapter. Connect grounds between the module and the starter kit to ensure shared grounding.

Figure 3 and Figure 4 show the hardware configuration.

Figure 3 - Hardware Configuration (Front)

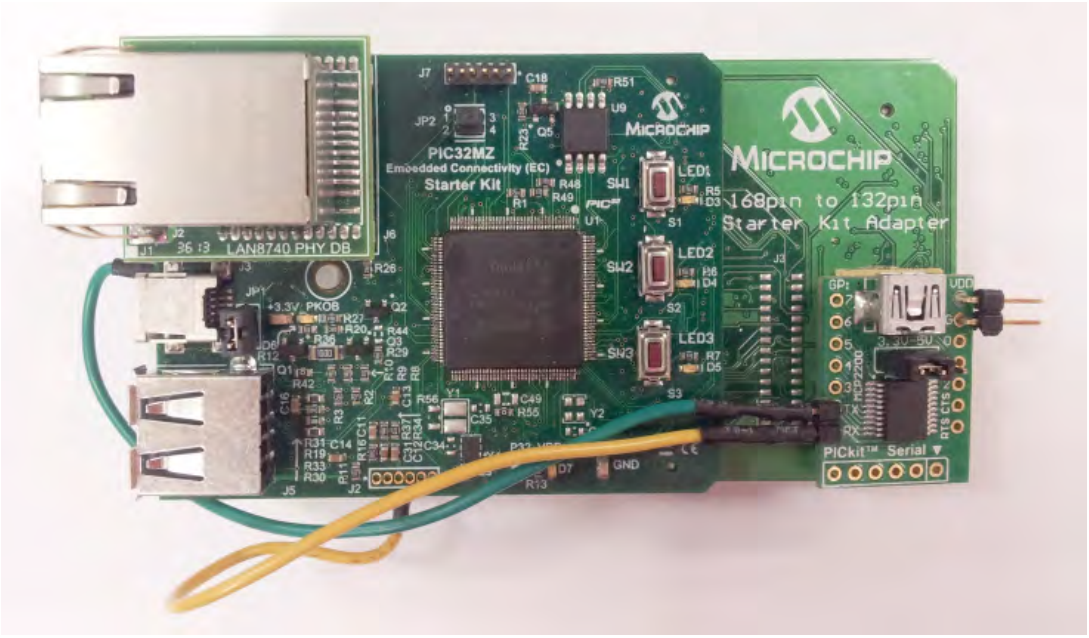
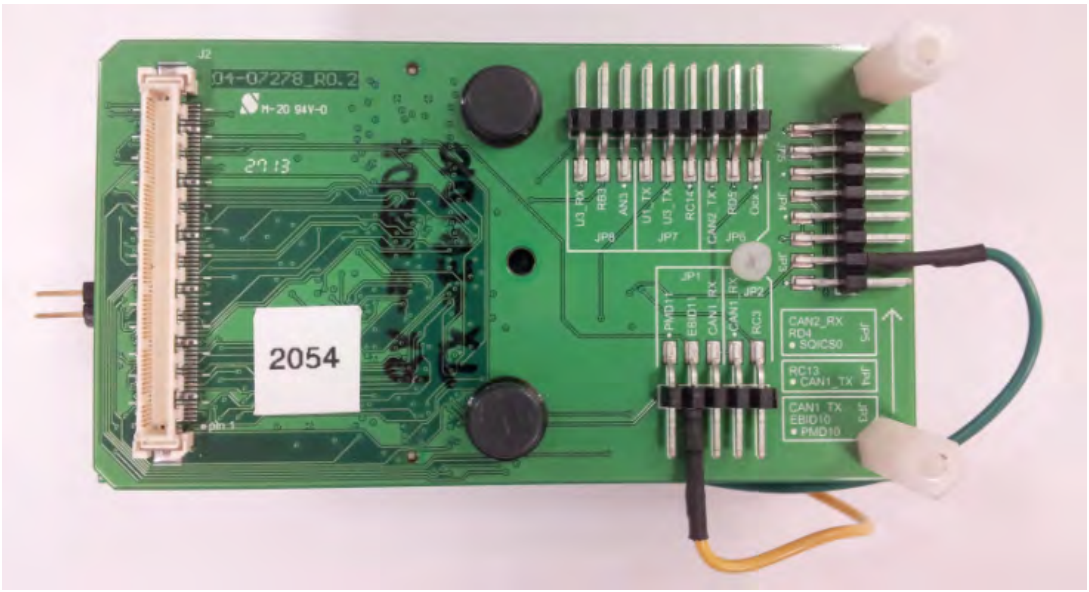


Figure 4 - Hardware Configuration (Back)



Running the Demonstration

Provides instructions on how to build and run the Crypto demonstration.

Description

This demonstration exercises hashing functions on large blocks of data.

1. First, compile and program the target device. While compiling, select the configuration suitable for hardware.
2. Open a serial terminal program, such as PuTTY or TeraTerm, and connect it to the serial port for the MCP2200 Breakout Module. The serial configuration is 115200 baud, 8 data bits, no parity bit, 1 stop bit.
3. Observe the status of LEDs on the starter kit. The yellow LED will be illuminated while the demonstration executes. If all function passes succeed, the green LED will illuminate. If an error occurred, the red LED is illuminated.
4. Observe the output of the program in the serial terminal program. It will report the results of the hashes, and the cycles taken to execute. The actual cycles taken will depend on the hardware used, and the size of the buffers available to the hardware engine. The following example shows the output using the PIC32MZ EC Starter Kit configured with the Crypto Engine:

```
Starting the test.

MD5 from Flash: 30C2557E8302A5BEB290C71520D87F42 took 481405 clock cycles
MD5 from feed: 30C2557E8302A5BEB290C71520D87F42 took 804934 clock cycles
SHA from Flash: F7FEC128D7FCD59222BA37368D3B7210D4C7B6EF took 481151 clock cycles
```

```
SHA from feed: F7FEC128D7FCD59222BA37368D3B7210D4C7B6EF took 804901 clock cycles
SHA256 from Flash: 85A84A75886E8A526DBEC4E16E3375FAA307B4AEAD79C9ED3264C0477A6F6EBA took 702033 clock cycles
SHA256 from feed: 85A84A75886E8A526DBEC4E16E3375FAA307B4AEAD79C9ED3264C0477A6F6EBA took 806480 clock cycles
SHA384 from Flash:
A550561A6330048EFE826A97E5FED843FA1CE646A9BF546CCB433C2FCB0E54821C4C945EED9A592B5BF43157E212F277 took
45452328 clock cycles
SHA384 from feed:
A550561A6330048EFE826A97E5FED843FA1CE646A9BF546CCB433C2FCB0E54821C4C945EED9A592B5BF43157E212F277 took
45391039 clock cycles
SHA512 from Flash:
7F49157FB359B39EA6DA934DC9A10709FEDF8846D139D0E637A3C0FC833B6F42703858DBACEE28F4489B5E95FAB5E5655A25F838B0DC
7BF3C84C7CC0264F6A4F
took 45807606 clock cycles
SHA512 from feed:
7F49157FB359B39EA6DA934DC9A10709FEDF8846D139D0E637A3C0FC833B6F42703858DBACEE28F4489B5E95FAB5E5655A25F838B0DC
7BF3C84C7CC0264F6A4F
took 45775518 clock cycles
All tests passed.
```

Driver Demonstrations

This section provides descriptions of the Driver demonstrations.

I2C Driver Demonstrations

This topic provides descriptions of the I2C Driver demonstrations.

Introduction

This help file contains instructions and associated information about MPLAB Harmony I2C Driver application demonstrations, which are included in the MPLAB Harmony Library distribution.

Description

This application demonstrates the capabilities of the MPLAB Harmony I2C Driver. This section describes the hardware requirements and procedures to build and run the demonstration project using Microchip development tools.

One demonstration application is provided:

- i2c_rtcc - In this demonstration, one instance of the I2C peripherals acts as a Master and sends and receives data from two an external slave device. The slave device is the external MCP7049N Real-Time Clock Calendar (RTCC) device.

To know more about the MPLAB Harmony I2C Driver, configuring the driver and APIs provided by the I2C Driver, refer to the I2C Driver Library Help documentation.

Demonstrations

This topic provides information on how to run the I2C Driver demonstration applications included in this release.

i2c_rtcc

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the I2C RTCC demonstration.

Description

To build this project, you must open the `i2c_rtcc.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/driver/i2c/i2c_rtcc`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
i2c_rtcc.X	<install-dir>/apps/driver/i2c/i2c_rtcc/firmware

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within ./firmware/src/system_config.

Project Configuration Name	BSP Used	Description
pic32mx795_pim_e16	pic32mx795_pim+e16	The purpose of this configuration is to demonstrate I2C Master mode transfer setup in Interrupt mode and dynamic operation. The hardware used is the PIC32MX795F512L PIM connected to the Explorer 16 Development Board.
pic32mz_ec_sk_meb2	pic32mz_ec_sk+meb2	The purpose of this configuration is to demonstrate I2C Master mode transfer setup in Interrupt mode and dynamic operation. The hardware used is the PIC32MZ EC Starter Kit connected to the MEB II.
pic32mz_ef_sk_meb2	pic32mz_ef_sk+meb2	The purpose of this configuration is to demonstrate I2C Master mode transfer setup in Interrupt mode and dynamic operation. The hardware used is the PIC32MZ EF Starter Kit connected to the MEB II.
pic32mz_da_sk_meb2_wvga	pic32mz_da_sk+meb2+wvga	The purpose of this configuration is to demonstrate I2C Master mode transfer setup in Interrupt mode and dynamic operation. The hardware used is the PIC32MZ Graphics (DA) Starter Kit connected to the MEB II.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

Note: The i2c_rtcc demonstration was tested on the Microchip MCP7949N RTCC device. The address of this device is 0xDE.

Explorer 16 Development Board with the PIC32MX795F512L PIM

- Before attaching the PIC32MX795F512L PIM to the Explorer 16 Development Board, ensure that the processor select switch (S2) is in the PIM Position
- Short JP2 on the Explorer 16 Development Board to enable the LEDs

If a Starter Kit I/O Expansion Board is used, make the following connections:

- Jumper I/O Expansion board J11 pin 36 (SDA2) and J11 pin 38 (SCL2) should be pulled up to 3.3V through a 2.2k ohm resistor

If an external RTCC is used, make the following connections:

- Jumper I/O Expansion board J11 pin 36 (SDA2) and J11 pin 38 (SCL2) to the corresponding lines of an external I2C device
- If an external I2C device is connected, ensure that the Master and Slave device share a common ground.

If a PICtail™ Plus Daughter Board is used, make the following connections:

- PICtail Plus Daughter Board pins RA2 (SCL2) and RA3 (SDA2) should be pulled up to 3.3V through a 2.2k ohm resistor

If an external RTCC is used, make the following connections:

- Jumper PICtail Plus Daughter Board pins RA2 (SCL2) and pin RA3 (SDA2) to the corresponding SCL and SDA lines of an external I2C device
- If an external I2C device is connected, ensure that the Master and Slave device share a common ground

PIC32MZ EC Starter Kit or PIC32MZ EF Starter Kit or PIC32MZ Graphics (DA) Starter Kit connected to the MEB II

The jumper JP2 on PIC32MZ EC/EF Starter Kit should connected according to the debugger/programmer used, as follows:

- If PKOB is used, pins 1 and 3 and pins 2 and 4 should be shorted
- If MPLAB REAL ICE or MPLAB ICD 3 is being used, pins 1 and 3 and pins 2 and 4 should be left open

The connections pertaining to I2C are as follows:

- Connect MEB II J2 pin 3 (SCL2) to the corresponding SCL line of the external I2C device
- Connect MEB II J2 pin 5 (SDA2) to the corresponding SDA line of the external I2C device
- If an external I2C device is connected, ensure that the Master and Slave device share a common ground

Running the Demonstration

Provides instructions on how to build and run the I2C RTCC demonstration.

Description

1. This demonstration shows how to configure and make use of the I2C Driver APIs to support buffered operation of I2C in Interrupt mode. In this

demonstration, the I2C is configured as single instance and single client.

Once the demonstration application is compiled successfully for the selected configuration, the firmware can be programmed into the target device.

To run the demonstration in Debug mode, perform the following steps:

1. Select the appropriate configuration from the MPLAB X IDE Project Properties based on the target hardware.
2. Select your device programmer from the Hardware Tool menu in MPLAB X IDE.
3. Select either *Debug > Debug Main Project* or click **Debug Main Project** in the toolbar.
4. Build the selected configuration in the MPLAB X IDE project and program the demonstration board.

The I2C Driver configures the I2C2 instance of the I2C peripheral in Master mode. The SDA and SCL lines are connected to the Microchip MCP7940N RTCC device as described in Configuring the Hardware. The Master writes to sequential memory locations in SRAM memory of the RTCC device. The Master then reads back the content from the same page.

The contents of the buffer variable can be checked to determine the result of the operation.

The expected results are shown in the following table.

Test Case	Contents of Buffer
I2C2 (Master)	`RXbuffer_4[] = "3RTCCSLAVE"` (data received from RTCC device)

NVM Driver Demonstration

This topic provides descriptions of the NVM Driver demonstration.

Introduction

This help file contains instructions and associated information about MPLAB Harmony NVM Driver Library application demonstrations, which are included in the MPLAB Harmony Library distribution.

Description

This application demonstrates the capabilities of the MPLAB Harmony NVM Driver Library. This section describes the hardware requirement and procedures to build and run the demonstration project on Microchip development tools. In this demonstration application, the NVM driver is used to access the internal Flash memory of PIC32MX and PIC32MZ Devices to perform Write and Read operations and indicates the result by LED.

To know more about MPLAB Harmony NVM driver, configuring the NVM driver and the APIs provided by the NVM driver, refer to the MPLAB Harmony NVM Driver Library documentation.

Demonstrations

This topic provides information on how to run the NVM Driver demonstration applications included in this release.

nvm_read_write

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the NVM Read/Write Demonstration.

Description

To build this project, you must open the `nvm_read_write.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/driver/nvm/nvm_read_write`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`nvm_read_write.X`	`<install-dir>/apps/driver/nvm/nvm_read_write/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx_usb_sk2	pic32mx_usb_sk2	The purpose of this configuration is to execute the demonstration on a PIC32MX family device using the PIC32 USB Starter Kit II with the dynamic NVM Driver implementation.
pic32mx_usb_sk2_sta	pic32mx_usb_sk2	The purpose of this configuration is to execute the demonstration on a PIC32MX family device using the PIC32 USB Starter Kit II with the static NVM Driver implementation.
pic32mz_ec_sk	pic32mz_ec_sk	The purpose of this configuration is to execute the demonstration on a PIC32MZ EC family device using the PIC32MZ Embedded Connectivity (EC) Starter Kit with the dynamic NVM Driver implementation.
pic32mz_ec_sk_sta	pic32mz_ec_sk	The purpose of this configuration is to execute the demonstration on a PIC32MZ EC family device using the PIC32MZ Embedded Connectivity (EC) Starter Kit with the static NVM Driver implementation.
pic32mz_ef_sk	pic32mz_ef_sk	The purpose of this configuration is to execute the demonstration on a PIC32MZ EF family device using the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit with the dynamic NVM Driver implementation.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32 USB Starter Kit II

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ EC Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ EF Starter Kit

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

This section describes how to run the NVM Driver demonstration.

Description

This is a simple demonstration to show how to configure and make use of NVM Driver APIs to implement and access the on-board Flash memory of PIC32MX and PIC32MZ devices.

How to Run This Demonstration Application

Once the demonstration application is compiled successfully, you are ready to program the firmware in the target device.

To run the demonstration in Debug mode, perform the following steps:

1. Select the appropriate configuration from the MPLAB X IDE Project Properties based on the target hardware.
2. Select your device programmer from the Hardware Tool menu in MPLAB X IDE.
3. Select either *Debug > Debug Main Project* or click **Debug Main Project** in the toolbar.
4. Build the selected configuration in the MPLAB X IDE project and program the demonstration board.

The execution status (pass/fail) of the demonstration is indicated by LEDs on the demonstration board, as shown in the following table.

Demonstration Board	Success Indication	Failure Indication
PIC32 USB Starter Kit II	Green LED	Red LED
PIC32MZ EC Starter Kit PIC32MZ EF Starter Kit	Green LED	Red LED

The demonstration application makes use of 32 KB of NVM memory area starting at address DRV_NVM_MEDIA_START_ADDRESS.

The application does the following:

- Erases the entire 32 KB of memory and verifies the erase operation by reading back the data
- Performs sequential writes within a page by queuing the write operations. Reads back and verifies the data.
- Repeats step 1 to erase all data of the previous operation
- Performs random writes to addresses spread across the available memory area. This operation demonstrates the queuing of the write operations at the driver layer. It also demonstrates the usage of the driver event handler to track the completion of the queued operations.

Reads back and verifies the data.

- Repeats step 1 to erase all data from the previous operation
- Performs an EraseWrite operation. This operation demonstrates the usage of the EraseWrite feature

SPI Driver Demonstrations

This topic provides descriptions of the SPI Driver demonstrations.

Introduction

This help file contains instructions and associated information about MPLAB Harmony SPI driver application demonstrations, which are included in the MPLAB Harmony Library distribution.

Description

This application demonstrates the capabilities of the MPLAB Harmony SPI Driver. This section describes the hardware requirements and procedures to build and run the demonstration project using Microchip development tools.

Three demonstration applications are provided:

- serial_eeprom - In this demonstration application, the SPI Driver is used to access the external EEPROM in the Explorer 16 Development Board to perform Write and Read operations and indicates the result by LED
- spi_loopback - In this demonstration application, the SPI driver is used to transfer data between the SPI master and slave on the same device and indicates the result by LED
- spi_multislave - In this demonstration application, the SPI Driver is used to transfer data between a single master and two slaves on the same device by using the Slave Select (SS) feature and indicates the result by LED

To know more about the MPLAB Harmony SPI driver, configuring the SPI driver and APIs provided by the SPI driver, refer to the SPI Driver Library documentation.

Demonstrations

This topic provides information on how to run the SPI Driver demonstration applications included in this release.

serial_eeprom

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

In this demonstration application, the SPI Driver is used to access the external EEPROM in the Explorer 16 Development Board to perform Write and Read operations and indicates the result by LED.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the Serial EEPROM Demonstration.

Description

To build this project, you must open the `serial_eeprom.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/driver/spi/serial_eeprom`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`serial_eeprom.X`	`<install-dir>/apps/driver/spi/serial_eeprom/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx360_pim_e16	pic32mx795_pim+e16	The purpose of this configuration is to execute the demonstration using the PIC32MX360F512L PIM connected to the Explorer 16 Development Board configured for Interrupt mode and dynamic operation.
pic32mx795_pim_e16	pic32mx795_pim+e16	The purpose of this configuration is to execute the demonstration using the PIC32MX795F512L PIM connected to the Explorer 16 Development Board configured for Interrupt mode and dynamic operation.
pic32mx795_pim_e16_sta	pic32mx795_pim+e16	The purpose of this configuration is to execute the demonstration using the PIC32MX795F512L PIM connected to the Explorer 16 Development Board configured for Interrupt mode and static operation.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

Explorer 16 Development Board with the PIC32MX795F512L PIM

- Before attaching the PIC32MX795F512L PIM to the Explorer 16 Development Board, ensure that the processor select switch (S2) is in the PIM Position
- Short JP2 on the Explorer 16 Development Board to enable the LEDs

Explorer 16 Development Board with the PIC32MX360F512L PIM

- Before attaching the PIC32MX360F512L PIM to the Explorer 16 Development Board, ensure that the processor select switch (S2) is in the PIM Position
- Short JP2 on the Explorer 16 Development Board to enable the LEDs

Running the Demonstration

This section demonstrates how to run the SPI Driver Serial EEPROM Demonstration.

Description

This demonstration shows how to configure and make use of the SPI Driver APIs to implement and access the on-board EEPROM of the Explorer 16 Development Board.

How to run this demonstration application:

Once the demonstration application is successfully compiled, you are ready to program the firmware in the target device.

To run the demonstration in debug mode, perform the following steps:

1. Select your device programmer from *Project Properties > Hardware Tools* in MPLAB X IDE.
2. Select either *Debug > Debug Main Project* or click **Debug Main Project** in the toolbar.

Once the device is successfully programmed, you can observe that the LED in the Explorer 16 Development Board has been turned ON. This shows the demonstration project ran successfully. The result of the programming can be read through the other LEDs. If LED "D9" is turned ON, it indicates the EEPROM W/R functionality has failed. If LED "D10" is turned ON, it indicates the EEPROM W/R functionality has passed.

spi_loopback

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

In this demonstration application, the SPI driver is used to transfer data between the SPI Master and Slave on the same device and indicates the result by LED.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the SPI Loopback Demonstration.

Description

To build this project, you must open the `spi_loopback.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/driver/spi/spi_loopback`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
spi_loopback.X	<install-dir>/apps/driver/spi/spi_loopback/firmware

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within ./firmware/src/system_config.

Project Configuration Name	BSP Used	Description
pic32mx_usb_sk2_int_dyn	pic32mx_usb_sk2	Demonstrates SPI loopback on the PIC32 USB Starter Kit II configured for Interrupt mode and dynamic operation.
pic32mx_usb_sk2_int_sta	pic32mx_usb_sk2	Demonstrates SPI loopback on the PIC32 USB Starter Kit II configured for Interrupt mode and static operation.
pic32mx_usb_sk2_poll_dyn	pic32mx_usb_sk2	Demonstrates SPI loopback on the PIC32 USB Starter Kit II configured for Polled mode and dynamic operation.
pic32mz_ec_sk_int_dyn	pic32mz_ec_sk	Demonstrates SPI loopback on the PIC32MZ Embedded Connectivity (EC) Starter Kit configured for Interrupt mode and dynamic operation.
pic32mz_ec_sk_int_dyn_dma	pic32mz_ec_sk	Demonstrates SPI loopback on the PIC32MZ Embedded Connectivity (EC) Starter Kit configured for Interrupt mode and dynamic operation using DMA.
pic32mz_ec_sk_int_sta	pic32mz_ec_sk	Demonstrates SPI loopback on the PIC32MZ Embedded Connectivity (EC) Starter Kit configured for Interrupt mode and static operation.
pic32mz_ec_sk_poll_dyn	pic32mz_ec_sk	Demonstrates SPI loopback on the PIC32MZ Embedded Connectivity (EC) Starter Kit configured for Polled mode and dynamic operation.
pic32mz_ef_sk_int_dyn	pic32mz_ef_sk	Demonstrates SPI loopback on the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit configured for Interrupt mode and dynamic operation.
pic32mz_ef_sk_poll_dyn	pic32mz_ef_sk	Demonstrates SPI loopback on the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit configured for Polled mode and dynamic operation.
pic32mz_da_sk_int_dyn	pic32mz_da_sk	Demonstrates SPI loopback on the PIC32MZ Graphics (DA) Starter Kit configured for Interrupt mode and dynamic operation.
pic32mz_da_sk_poll_dyn	pic32mz_da_sk	Demonstrates SPI loopback on the PIC32MZ Graphics (DA) Starter Kit configured for Polled mode and dynamic operation.
pic32mz_ef_sk_int_dyn_16b	pic32mz_ef_sk	Demonstrates SPI multi-slave on the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit configured for Interrupt mode and dynamic operation in microMIPS mode.
pic32mz_ef_sk_int_dyn_freertos	pic32mz_ef_sk	Demonstrates SPI multi-slave on the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit configured for Interrupt mode and dynamic operation with FreeRTOS.
pic32mx_usb_sk2_int_dyn_freertos	pic32mx_usb_sk2	Demonstrates SPI loopback on the PIC32 USB Starter Kit II configured for Interrupt mode and dynamic operation with FreeRTOS.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

Required Hardware

This demonstration requires the following hardware:

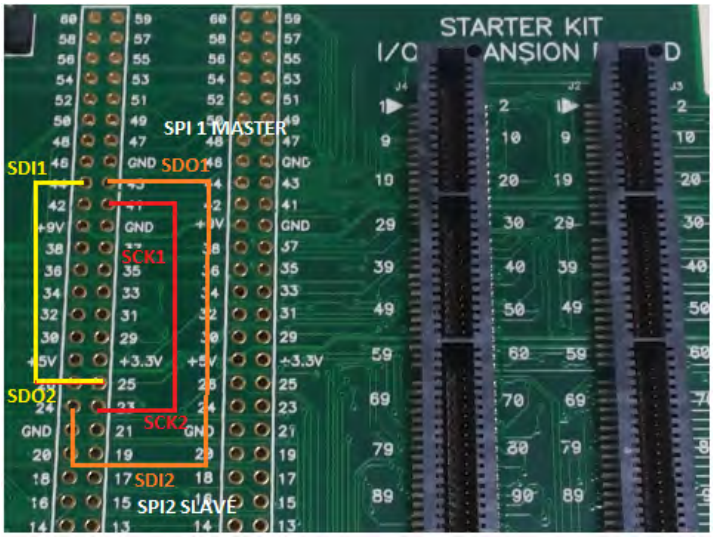
- PIC32MZ EC Starter Kit or PIC32MZ EF Starter Kit or PIC32MZ DA Starter Kit
- PIC32MZ Starter Kit Adapter Board
- Starter Kit I/O Expansion Board

Depending on the starter kit in use, the SPI1 and SPI2 modules or SPI1 and SPI3 modules are used in this demonstration. PIC32MZ devices support the Peripheral Pin Select (PPS) feature. The SPI Pins of the SPI modules on this device are required to be configured using the PPS. Any related pin mapping (PPS) configuration code along with other port initialization can be found in the sys_port_static.c file.

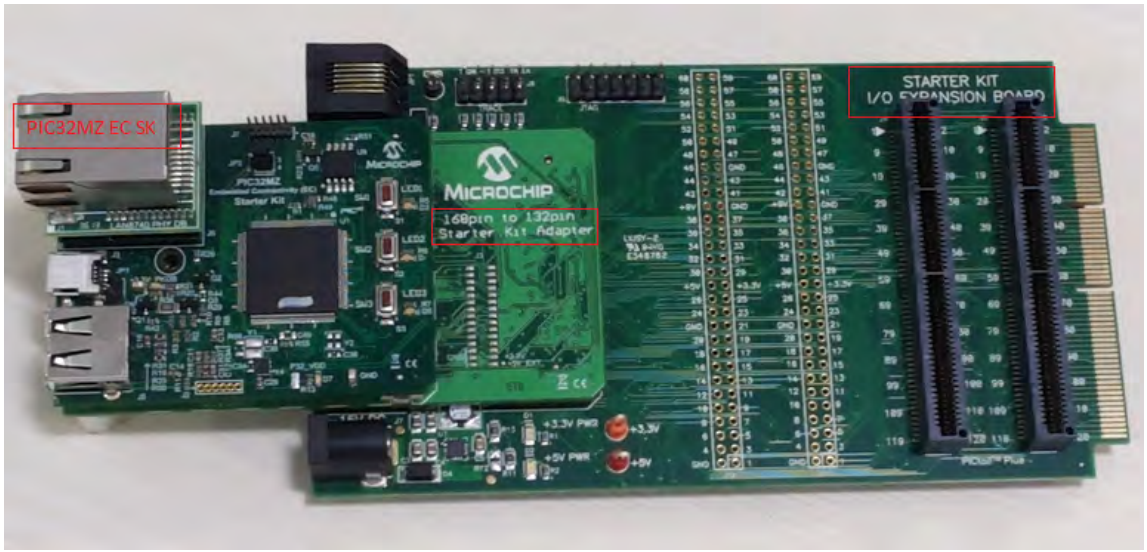
Note: To know more about the PIC32MZ PPS feature and pin configuration, please refer to **Section 12.3 "Peripheral Pin Select (PPS)"** in the **"I/O Ports"** chapter of the specific device data.

PIC32MZ EC Starter Kit and PIC32MZ EF Starter Kit Configuration

1. Connect (using wires) the pins on the Starter Kit I/O Expansion Board, as shown in the following figure. This hardwired connection would connect the SPI1 lines to the SPI2 lines of the PIC32MZ2048ECH144 device on the PIC32MZ EC Starter Kit or the PIC32MZ2048EFM144 device on the PIC32MZ EF Starter Kit.



2. Next, attach the desired starter kit, the PIC32MZ Starter Kit Adapter Board, and the Starter Kit I/O Expansion Board, as shown in the following figure (in this example the PIC32MZ EC Starter Kit is shown).



PIC32MZ EC and PIC32MZ EF Pin Mapping

The following table illustrates how the SPI1 and SPI2 pins for the PIC32MZ EC and PIC32MZ EF devices are mapped and connected to each other through the Starter Kit I/O Expansion Board.

SPI Module	SPI Lines	PIC32MZ2048ECH144 or PIC32MZ2048EFM144 Device Pin #	Analog Pin	PIC32MZ2048ECH144 or PIC32MZ2048EFM144 Port Pin Name/Function	Pin # on I/O Expansion Board J10 Connector	For this demonstration, attach this pin to:
SPI1	SCK1	109	No	SCK1	41	SCK2
SPI1	SDI1	69	AN32	RPD14	44	SDO2
SPI1	SDO1	98	No	RPD10	43	SDI2
SPI1	/SS	Not Used	Not Used	Not Used	Not Used	Not Used
SPI2	SCK2	14	AN14	SCK2	23	SCK1
SPI2	SDI2	121	No	RPD7	24	SDO1
SPI2	SDO2	25	AN45	RPB5	25	SDI1
SPI2	/SS	Not Used	Not Used	Not Used	Not Used	Not Used

PIC32MZ DA Starter Kit Configuration

1. Connect (using wires) the pins on the Starter Kit I/O Expansion Board, as shown in the following figure. This hardwired connection would connect the SPI1 lines to the SPI3 lines of the PIC32MZ2048DAB288 device on the PIC32MZ DA Starter Kit.
2. Jumper JP5, which is located on the back of the PIC32MZ Starter Kit Adapter Board, should have pin 1 and pin 2 shorted.
3. Next, attach the desired starter kit, the PIC32MZ DA Adapter Board, and the Starter Kit I/O Expansion Board, as shown in the following figure.

PIC32MZ DA Pin Mapping

The following table illustrates how the SPI1 and SPI3 pins for the PIC32MZ DA devices are mapped and connected to each other through the Starter Kit I/O Expansion Board.

SPI Module	SPI Lines	PIC32MZ2064DAB288 Device Pin #	Analog Pin	PIC32MZ2064DAB288 Port Pin Name/Function	Pin # on I/O Expansion Board J10 Connector	Pin # on I/O Expansion Board J11 Connector	For this demonstration, attach this pin to:
SPI1	SCK1	M04	No	SCK1	41	N/A	SCK3
SPI1	SDI1	E18	AN22	RPD14	44	N/A	SDO3
SPI1	SDO1	J18	AN5	RPB10	N/A	52	SDI3
SPI1	/SS	Not Used	Not Used	Not Used	Not Used	Not Used	Not Used
SPI3	SCK3	J17	AN29	SCK3	N/A	21	SCK1
SPI3	SDI3	A12	AN12	RPC1	N/A	54	SDO1
SPI3	SDO3	A14	AN9	RPB1	37	N/A	SDI1
SPI3	/SS	Not Used	Not Used	Not Used	Not Used	Not Used	Not Used

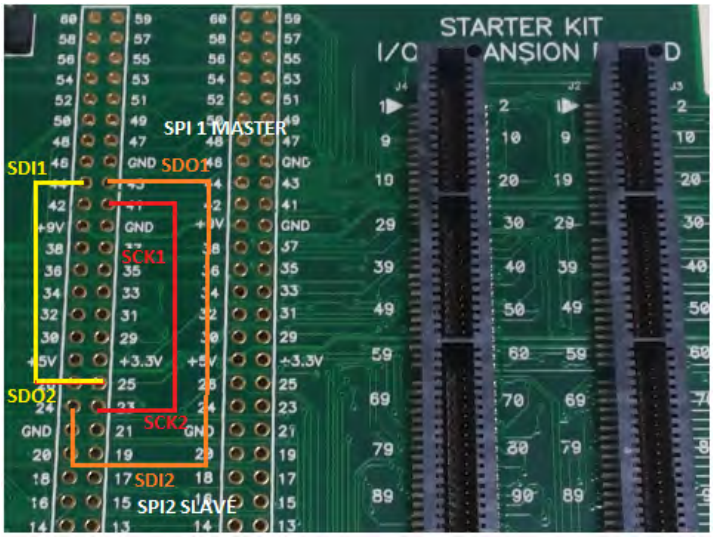
PIC32 USB Starter Kit II

This demonstration requires the following hardware:

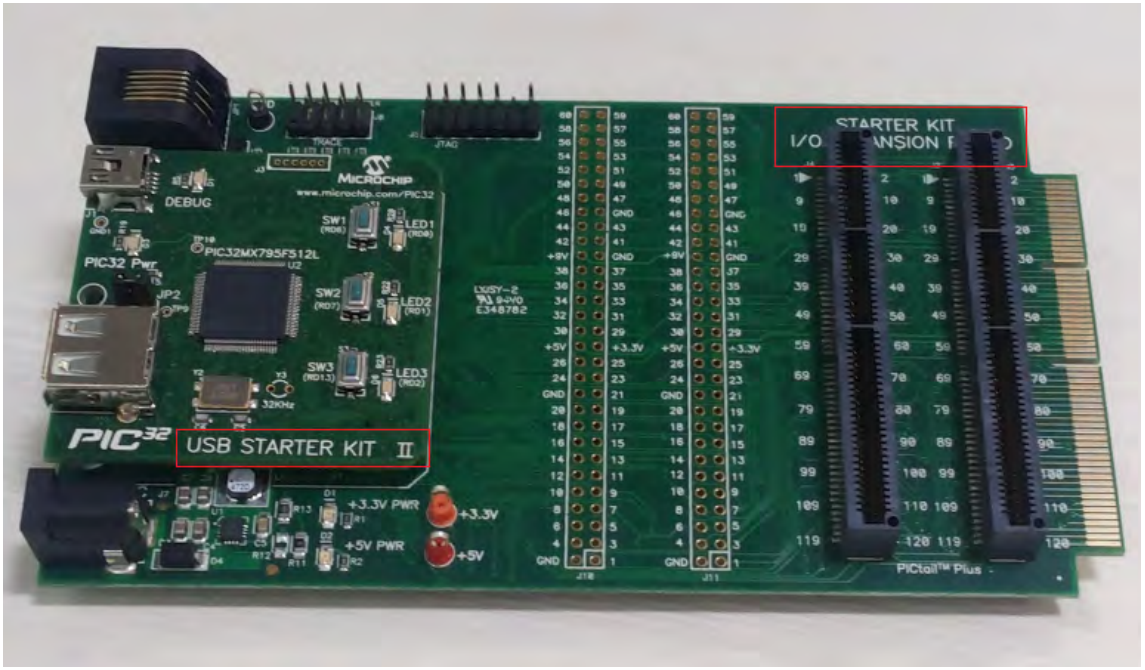
- PIC32 USB Starter Kit II
- Starter Kit I/O Expansion Board

In this demonstration application, the SPI1 and SPI2 modules are used.

1. Connect (using wires) the pins on the Starter Kit I/O Expansion Board, as shown in the following figure. This hardwired connection would attach the SPI1 lines to the SPI2 lines of the PIC32MX795F512L device on the PIC32 USB Starter Kit II through the Starter Kit I/O Expansion Board.



2. Next, connect the PIC32 USB Starter Kit II and the Starter Kit I/O Expansion Board, as shown in the following figure.



For the PIC32MX795F512L device, the SPI modules has dedicated I/O pins.

PIC32 USB Starter Kit II Pin Mapping

The following table illustrates how the SPI1 and SPI2 pins are mapped and connected to each other through the Starter Kit I/O Expansion Board.

SPI Module	SPI Lines	PIC32MX795F512L Device Pin #	PIC32MX795F512L Port Pin Name/Function	Pin # on I/O Expansion Board J10 Connector	For this demonstration, attach this pin to:
SPI1	SCK1	70	SCK1	41	SCK2
SPI1	SDI1	9	SDI1	44	SDO2
SPI1	SDO1	72	SDO1	43	SDI2
SPI1	/SS	Not Used	Not Used	Not Used	Not Used
SPI2	SCK2	10	SCK2	23	SCK1
SPI2	SDI2	11	SDI2	24	SDO1
SPI2	SDO2	12	SDO2	25	SDI1
SPI2	/SS	Not Used	Not Used	Not Used	Not Used

Running the Demonstration

This section demonstrates how to run the SPI Driver SPI Loopback Demonstration.

Description

This demonstration shows how to configure and make use of the SPI Driver APIs to support multiple SPI hardware instances to multiple clients of the driver in both interrupt mode and polled mode. This demonstration shows the SPI driver's "multi-instance multi-client" feature.

Once the demonstration application is compiled successfully, you are ready to program the firmware in the target device.

To run the demonstration in Debug mode, perform the following steps:

1. Select the appropriate configuration from the MPLAB X IDE Project Properties based on the target hardware.
2. Select your device programmer from the Hardware Tool menu in MPLAB X IDE.
3. Select either *Debug > Debug Main Project* or click **Debug Main Project** in the toolbar.
4. Build the selected configuration in the MPLAB X IDE project and program the demonstration board.

The SPI Driver configures the SPI1 as Master and SPI2 as Slave on the same PIC32 device (SPI3 is configured as the Slave when using the PIC32MZ DA Starter Kit). The SPI1 and SPI2 lines are connected to each other as described in Configuring the Hardware. The Master sends a chunk of data (64 bytes) to the Slave. The data is sent and received back on the same PIC32 device through the SPI. The data is looped back to the sender.

Upon execution of the program, the SPI Master (SPI1) will transmit a sequence of character string/data through the SPI channel using the settings defined in the application to SPI1.

After transmitting the data from SPI1, the driver will read SPI2 for any data received. if the data is received, the program will verify the validity of the received data. Based on the verification result, the program will go either to a success or error state.

If an error occurs, or if the transmitted data is not the same as the received data, LED2 (Yellow) of the starter kit will illuminate, which indicates the demonstration has failed.

If the transmitted data is exactly the same as the received data, LED3 (Green) of the starter kit will illuminate, which indicates the demonstration was successful.

spi_multislave

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Description

In this demonstration application, the SPI driver is used to demonstrate the single Master and multiple Slaves capability of the SPI protocol using the `DRV_SPI_ClientConfigure` function of the SPI Driver to switch between slaves.

There are two data transfers in this demonstration, where the Master transfers a chunk of data to each Slave.

The Slaves are selected using the Slave Select (/SSx) pins, which means that when the Slave /SSx pin is active-low, only the Slave can receive the data. Therefore, while one Slave is receiving the data, the other Slave is kept idle by making the /SSx pin of that Slave high.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the SPI Multi-slave Demonstration.

Description

To build this project, you must open the `spi_multislave.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/driver/spi/spi_multislave`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`spi_multislave.X`	`<install-dir>/apps/driver/spi/spi_multislave/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mz_ec_sk_int_dyn	pic32mz_ec_sk	Demonstrates SPI multi-slave on the PIC32MZ Embedded Connectivity (EC) Starter Kit configured for Interrupt mode and dynamic operation.
pic32mz_ec_sk_int_sta	pic32mz_ec_sk	Demonstrates SPI multi-slave on the PIC32MZ Embedded Connectivity (EC) Starter Kit configured for Interrupt mode and static operation.
pic32mz_ef_sk_int_dyn	pic32mz_ef_sk	Demonstrates SPI multi-slave on the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit configured for Interrupt mode and dynamic operation.
pic32mz_ef_sk_int_dyn_16b	pic32mz_ef_sk	Demonstrates SPI multi-slave on the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit configured for Interrupt mode and dynamic operation in microMIPS mode.
pic32mz_ef_sk_int_dyn_freertos	pic32mz_ef_sk	Demonstrates SPI multi-slave on the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit configured for Interrupt mode and dynamic operation with FreeRTOS.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

Required Hardware

This demonstration requires the following hardware:

- PIC32MZ EC Starter Kit or PIC32MZ EF Starter Kit
- PIC32MZ Starter Kit Adapter Board
- Starter Kit I/O Expansion Board

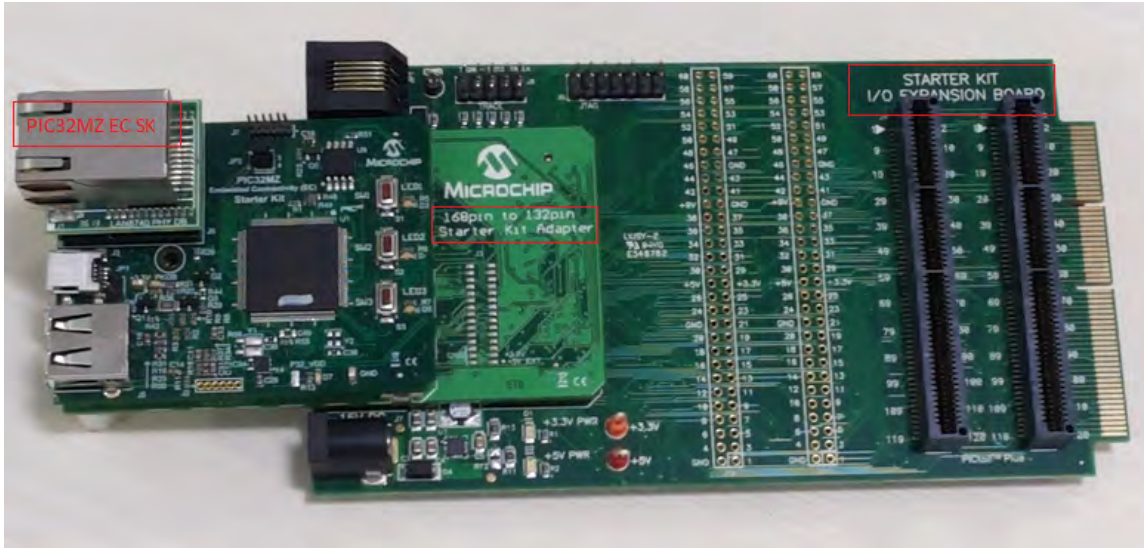
SPI1, SPI2 and SPI3 modules are used in this demonstration as Master, Slave 1 and Slave 2 respectively. In addition, two GPIO pins are used to control the Slave Select (/SSx) pins.

PIC32MZ devices support the Peripheral Pin Select (PPS) feature. The SPI Pins of the SPI modules on this device must be configured using the PPS.

Note: To know more about the PIC32MZ PPS feature and pin configuration, please refer to **Section 12.3 "Peripheral Pin Select (PPS)"** in the **"I/O Ports"** chapter of the specific device data.

PIC32MZ EC Starter Kit and PIC32MZ EF Starter Kit Configuration

1. Short the pins on the J10 and J11 headers of the Starter Kit I/O Expansion Board, as follows:
   - Pin 41 (J10), pin 23 (J10) and pin 48 (J11): SCK1, SCK2, and SCK3
   - Pin 43 (J10), pin 24 (J10) and pin 52 (J11): SDO1, SDI2, and SDI3
   - Pin 44 (J10), pin 25 (J10) and pin 37 (J11): SDI1, SDO2, and SDO3
   - Pin 34 (J10) and pin 26 (J10): RH10 and SS2
   - Pin 33 (J10) and pin 46 (J11): RH15 and SS3
2. Next, attach the desired starter kit, the PIC32MZ EC Adapter Board, and the Starter Kit I/O Expansion Board, as shown in the following figure (in this example the PIC32MZ EC Starter Kit is shown).



PIC32MZ EC and PIC32MZ EF Pin Mapping

The following table illustrates how the SPI1, SPI2, and SPI3 pins for the PIC32MZ EC and PIC32MZ EF devices are mapped and connected to each other through the Starter Kit I/O Expansion Board.

Module	Function	Device Pin #	Port Pin Name	Starter Kit I/O Expansion Board Pin #	Demonstration Setup Connection
SPI1	SCK1	109	SCK1	41 (J10)	SCK2, SCK3
	SDI1	69	RPD14	44 (J10)	SDO2, SDO3
	SDO1	98	RPD10	43 (J10)	SDI2, SDI3
	/SS1	Not Used	Not Used	Not Used	Not Used
SPI2	SCK2	14	SCK2	23 (J10)	SCK1
	SDI2	121	RPD7	24 (J10)	SDO1
	SDO2	25	RPB5	25 (J10)	SDI1
	/SS2	104	RPD0	26 (J10)	RH10
SPI3	SCK3	61	SCK3	48 (J11)	SCK1
	SDI3	49	RPB10	52 (J11)	SDO1
	SDO3	96	RPA15	37 (J11)	SDI1
	/SS3	62	RPB15	46 (J11)	RH15
GPIO (for Slave Select)	Output	83	RH10	34 (J10)	SS2
	Output	103	RH15	33 (J10)	SS3

Running the Demonstration

This section demonstrates how to run the SPI Driver SPI Multi-slave Demonstration.

Description

Once the demonstration application is compiled successfully, you are ready to program the firmware in the target device.

To run the demonstration in Debug mode, perform the following steps:

1. Select the appropriate configuration from the MPLAB X IDE Project Properties based on the target hardware.
2. Select your device programmer from the Hardware Tool menu in MPLAB X IDE.
3. Select either *Debug > Debug Main Project* or click **Debug Main Project** in the toolbar.

Once the device is successfully programmed, you can observe that the LEDs in the starter kit have turned ON. This indicates that the demonstration project ran successfully. The result of the programming can be read through the LEDs.

The SPI Driver configures SPI1 as the Master and SPI2 and SPI3 as Slaves on the same PIC32 device. The SPI1, SPI2 and SPI3 lines are connected to each other as described in Configuring the Hardware.

The Master sends a chunk of data (numbers 0 to 63, total 64 bytes) to the Slave 1 in the first transfer and sends one more chunk of data (numbers 64 to 1, total 64 bytes) to the Slave 2 in the second transfer.

The respective Slaves are selected in the each transfer using the /SS2 and /SS3 pins, which are driven by the GPIO pins RH10 and RH15, respectively.

The following table explains the states of SPI Slaves in different stages of the application:

Application State	RH10 State (Connected to /SS2)	RH15 State (Connected to /SS3)	Slave 1	Slave 2
Initialization	High	High	Inactive	Inactive
Transfer 1	Low	High	Active	Inactive
Transfer 2	High	Low	Inactive	Active
Idle	High	High	Inactive	Inactive

After the completion of both transfers, the received data for both of the slaves is verified with the transmitted data:

- If the data received by SPI2 matches with the data transmitted in the first transfer, LED2 (YELLOW) will illuminate
- If the data received by SPI3 matches with the data transmitted in the second transfer, LED3 (GREEN) will illuminate
- If both the transfers were not completed or the data of any Slave does not match, LED1 (RED) will illuminate

SPI Flash Driver Demonstrations

This topic provides descriptions of the SST25VF020B SPI Flash Driver demonstrations.

Introduction

This help file contains instructions and associated information about the MPLAB Harmony SPI Flash Driver application demonstration, which is included in the MPLAB Harmony Library distribution.

Description

This application demonstrates the capabilities of the MPLAB Harmony SPI Flash Driver. This section describes the hardware requirements and procedures to build and run the demonstration project using Microchip development tools.

Demonstrations

This topic provides information on how to run the SPI Flash Driver demonstration application included in this release.

sst25vf020b

This demonstration uses the SST25VF020B SPI Flash Driver to erase, write, and read from the on-board SST25VF020B Flash through SPI and verifies whether or not operation occurred correctly.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the SPI Flash Driver Demonstration.

Description

To build this project, you must open the `sst25vf020b.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/driver/spi_flash/sst25vf020b`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`sst25vf020b.X`	`<install-dir>/apps/driver/spi_flash/sst25vf020b/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
bt_audio_dk_int_dyn	bt_audio_dk	This configuration runs on the PIC32 Bluetooth Audio Development Kit. The SPI Driver and SST25VF20B SPI Flash Driver are configured for Interrupt mode and dynamic operation.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32 Bluetooth Audio Development Kit

- Ensure Switch S1 is set to PIC32_MCLR

Running the Demonstration

This section describes how to run the SPI Flash Driver demonstration.

Description

To run this demonstration:

1. First compile and program the target device. While compiling, select the configuration suitable for hardware.
2. Observe the status of LEDs on the development kit. If LED 8 and LED 9 are illuminated, this indicates the demonstration is working correctly. If either of LED 5 or LED 6 are illuminated, this indicates the demonstration is not working correctly.

USART Driver Demonstrations

This topic provides descriptions of the USART Driver demonstrations.

Introduction

This section provides instructions and information about the MPLAB Harmony USART Driver demonstration applications, which are included in the MPLAB Harmony Library distribution.

Description

This application demonstrates how to use the MPLAB Harmony USART Driver. This section describes the hardware requirement and procedures to build and execute the demonstration project on Microchip development tools. Two demonstration are provided:

- usart_echo - In this demonstration application, the USART Driver will initially transmit strings of data, and then accept any characters received and transmit the data back. Error or success status is indicated by LED.
- usart_loopback - In this demonstration application, the USART driver "multi-instance multi-client" feature is used. The application uses two USART hardware instances of the same PIC32 device. Application transmits chunk of data (64 bytes) on USART1, receives it at USART2, transmits back from USART2 to USART1. USART1 receives back all the data that was transmitted. The data is looped back to USART1.

To know more about the MPLAB Harmony USART driver, configuring the USART Driver and the APIs provided by the USART Driver, refer to USART Driver Library documentation.

Demonstrations

This topic provides information on how to run the USART Driver demonstration applications included in this release.

usart_echo

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the USART Echo Demonstration.

Description

To build this project, you must open the `usart_echo.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/driver/usart/usart_echo`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
usart_echo.X	<install-dir>/apps/driver/usart/usart_echo/firmware

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within ./firmware/src/system_config.

Project Configuration Name	BSP Used	Description
pic32mx795_pim_e16_int_dyn	pic32mx795_pim+e16	This demonstration runs on the PIC32MX795F512L PIM and the Explorer 16 Development Board configured for Interrupt mode and dynamic operation.
pic32mx795_pim_e16_int_sta	pic32mx795_pim+e16	This demonstration runs on the PIC32MX795F512L PIM and the Explorer 16 Development Board configured for Interrupt mode and static operation.
pic32mx795_pim_e16_poll_dyn	pic32mx795_pim+e16	This demonstration runs on the PIC32MX795F512L PIM and the Explorer 16 Development Board configured for Polled mode and dynamic operation.
pic32mx795_pim_e16_poll_sta	pic32mx795_pim+e16	This demonstration runs on the PIC32MX795F512L PIM and the Explorer 16 Development Board configured for Polled mode and static operation.
pic32mx795_pim_int_dyn_freertos	pic32mx795_pim+e16	FreeRTOS version of this demonstration, which runs on the PIC32MX795F512L PIM and the Explorer 16 Development Board configured for Interrupt mode and dynamic operation.

Configuring the Hardware

This section describes how to configure the supported hardware.

Description

Explorer 16 Development Board

Following are the hardware configuration settings required to execute this demonstration.

1. Before attaching the PIC32MX795F512L PIM to the Explorer 16 Development Board, ensure that the processor select switch (S2) is in the PIM Position.
2. Short JP2 on the Explorer 16 Development Board to enable the LEDs.

PIC32MX795F512L PIM

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

This section demonstrates how to run the USART Driver Demonstration.

Description

Once the demonstration application has been compiled successfully for the intended configuration, program the firmware into the target device.

Upon execution, the application will transmit the following strings through the USART using the settings defined in the application.

```
**************************************************
Welcome to Microchip USART Driver Demo Application.
Press any character, the character will be echoed back.
Press 'ESC' key to exit the Demo Application.
**************************************************
```

After transmitting the text, the firmware will read any characters received through the USART and it will transmit back the same data. If the received character is "ESC" (0x1B), the program will enter into Idle mode. Once in Idle mode, the firmware will neither transmit nor receive any data. If the application enters Idle mode, LED 5 of the Explorer 16 Development Board will illuminate. If any error occurs, LED 9 of the Explorer 16 Development Board will illuminate.

usart_loopback

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the USART Loopback

Demonstration.

Description

To build this project, you must open the `usart_loopback.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/driver/usart/usart_loopback`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`usart_loopback.X`	`<install-dir>/apps/driver/usart/usart_loopback/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx_usb_sk2_int_dyn	pic32mx_usb_sk2	Demonstrates USART loopback on the PIC32 USB Starter Kit II configured for Interrupt mode and dynamic operation.
pic32mx_usb_sk2_int_sta	pic32mx_usb_sk2	Demonstrates USART loopback on the PIC32 USB Starter Kit II configured for Interrupt mode and static operation.
pic32mx_usb_sk2_poll_dyn	pic32mx_usb_sk2	Demonstrates USART loopback on the PIC32 USB Starter Kit II configured for Polled mode and dynamic operation.
pic32mz_ec_sk_int_dyn	pic32mz_ec_sk	Demonstrates USART loopback on the PIC32MZ Embedded Connectivity (EC) Starter Kit configured for Interrupt mode and dynamic operation.
pic32mz_ec_sk_int_sta	pic32mz_ec_sk	Demonstrates USART loopback on the PIC32MZ Embedded Connectivity (EC) Starter Kit configured for Interrupt mode and static operation.
pic32mz_ec_sk_poll_dyn	pic32mz_ec_sk	Demonstrates USART loopback on the PIC32MZ Embedded Connectivity (EC) Starter Kit configured for Polled mode and dynamic operation.
pic32mz_ef_sk_int_dyn	pic32mz_ef_sk	Demonstrates USART loopback on the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit configured for Interrupt mode and dynamic operation.
pic32mz_ef_sk_poll_dyn	pic32mz_ef_sk	Demonstrates USART loopback on the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit configured for Polled mode and dynamic operation.
pic32mz_da_sk_int_dyn	pic32mz_da_sk	Demonstrates USART loopback on the PIC32MZ Graphics (DA) Starter Kit configured for Interrupt mode and dynamic operation.
pic32mz_da_sk_poll_dyn	pic32mz_da_sk	Demonstrates USART loopback on the PIC32MZ Graphics (DA) Starter Kit configured for Polled mode and dynamic operation.
pic32mz_ef_sk_int_dyn_16b	pic32mz_ef_sk	microMIPS version of the demonstration, which demonstrates USART loopback on the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit configured for Interrupt mode and dynamic operation.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32MZ EC Starter Kit or PIC32MZ EF Starter Kit or PIC32MZ DA Starter Kit

Note: For space consideration, only the PIC32MZ EC Starter Kit is shown. However, the following configuration information applies to either starter kit.

This demonstration requires the following hardware:

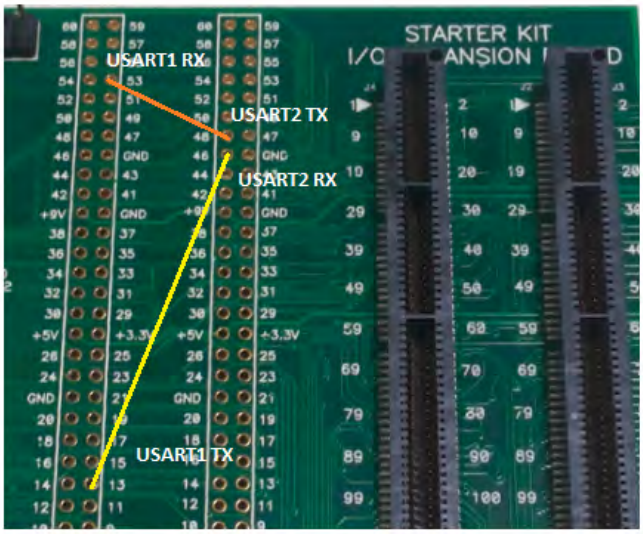
- PIC32MZ EC Starter Kit or PIC32MZ EF Starter Kit or PIC32MZ DA Starter Kit
- PIC32MZ Starter Kit Adapter Board
- Starter Kit I/O Expansion Board

PIC32MZ EC and PIC32MZ EF Starter Kit

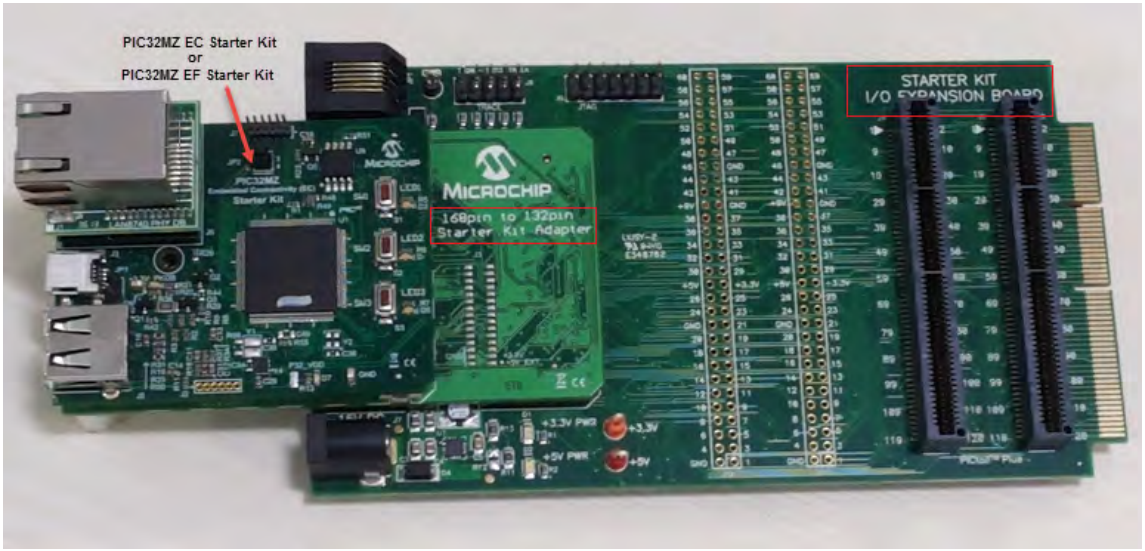
In this demonstration application, the USART1 and USART2 modules are used. PIC32MZ devices support the Peripheral Pin Select (PPS) feature. The USART pins of the USART modules on this device are required to be configured using the PPS.

Note: To learn more about the PIC32MZ PPS feature and pin configuration, please refer to **Section 12.3 "Peripheral Pin Select (PPS)"** in the **"I/O Ports"** chapter of the specific device data sheet. These documents are available for download from the Microchip web site (www.microchip.com).

1. Connect (using wires) the pins on the Starter Kit I/O Expansion Board, as shown in the following figure. This hardwired connection would connect the USART1 lines to the USART2 lines of the PIC32MZ2048ECH144 device on the PIC32MZ EC Starter Kit or the PIC32MZ2048EFM144 device on the PIC32MZ EF Starter Kit.

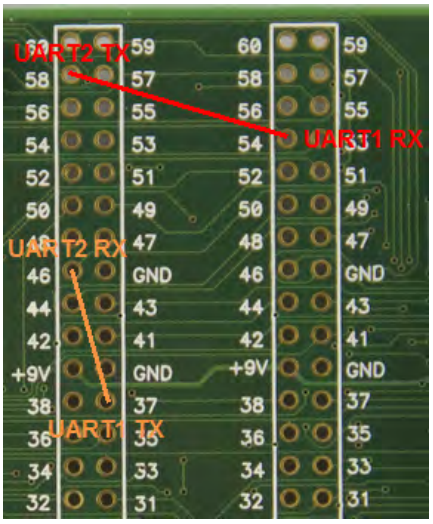


2. Next, connect either the PIC32MZ EC Starter Kit or the PIC32MZ EF Starter Kit, the PIC32MZ Starter Kit Adapter Board, and the Starter Kit I/O Expansion Board, as shown in the following figure.



PIC32MZ DA Starter Kit

1. Connect (using wires) the pins on the Starter Kit I/O Expansion Board, as shown in the following figure. This hardwired connection would connect the USART1 lines to the USART2 lines of the PIC32MZ2064DAB288 device on the PIC32MZ DA Starter Kit.



For this demonstration, the PIC32MZ Port Pins are mapped with USART functionality. The PPS mapping and Port Pin Mode Configuration to Digital mode (Only for the Analog pins) source code is in the `system_init.c` file `SYS_Initialize` function.

PIC32MZ EC Starter Kit or PIC32MZ EF Starter Kit

The following table illustrates how the USART1 and USART2 pins are mapped and connected to each other through the Starter Kit I/O Expansion Board.

USART Module	USART Lines	PIC32MZ2048ECH144 or PIC32MZ2048EFM Device Pin #	Analog Pin	PIC32MZ2048ECH144 or PIC32MZ2048EFM Port Pin Name/Function	Pin # on I/O Expansion Board J10 Connector	Pin # on I/O Expansion Board Pin J11 Connector	For this Demonstration, attach this pin to:
USART1	TX	13	AN19	PMRD	13	N/A	USART2 RX
USART1	RX	48	AN49	PMA7	53	N/A	USART2 TX
USART2	TX	61	AN9	RPB14	N/A	48	USART1 RX
USART2	RX	62	AN10	RPB15	N/A	46	USART1 TX

PIC32MZ DA Starter Kit

The following table illustrates how the USART1 and USART2 pins are mapped and connected to each other through the Starter Kit I/O Expansion Board.

USART Module	USART Lines	PIC32MZ2064DAB288 Device Pin #	Analog Pin	PIC32MZ2064DAB288 Port Pin Name/Function	Pin # on I/O Expansion Board J10 Connector	Pin # on I/O Expansion Board Pin J11 Connector	For this Demonstration, attach this pin to:
USART1	TX	A14	AN9	RPB1	37	N/A	USART2 RX
USART1	RX	A12	AN12	RPC1	54	N/A	USART2 TX
USART2	TX	B09	AN23	RPG9	N/A	58	USART1 RX
USART2	RX	B10	AN26	RPE09	N/A	46	USART1 TX

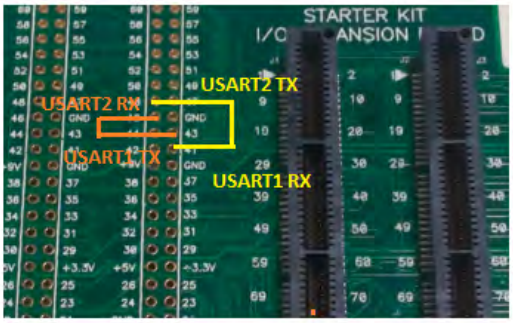
PIC32 USB Starter Kit II

This demonstration requires the following hardware:

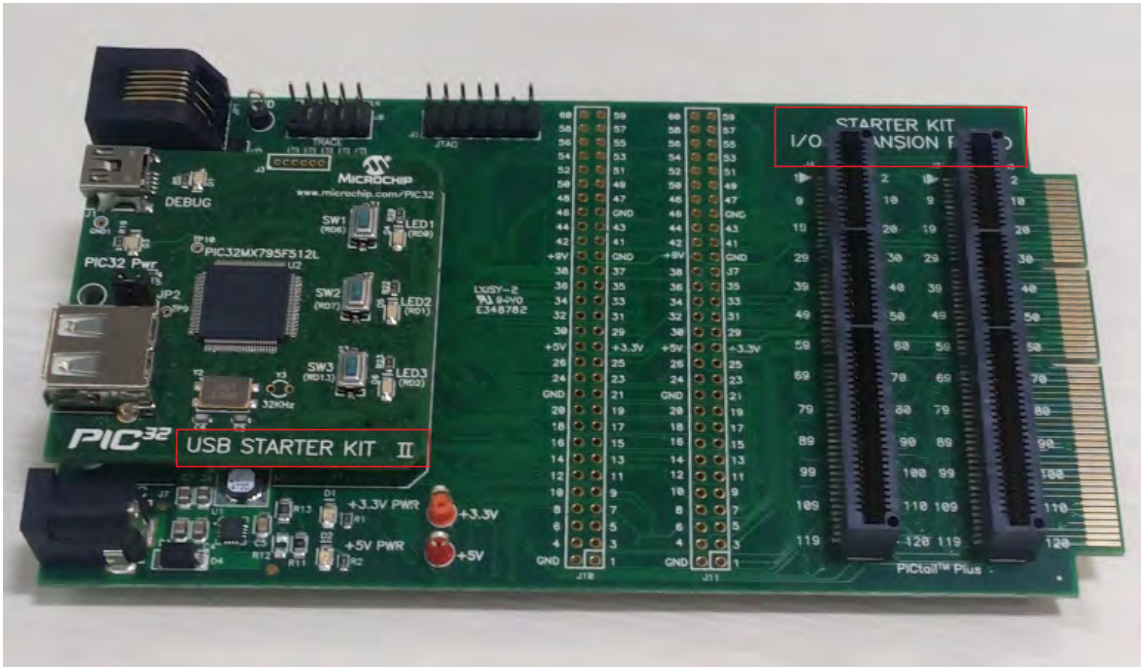
- PIC32 USB Starter Kit II
- Starter Kit I/O Expansion Board

In this demonstration application, the USART and USART2 modules are used.

1. Connect (using wires) the pins on the Starter Kit I/O Expansion Board, as shown in the following figure. This hardwired connection would connect the USART1 lines to the USART2 lines of the PIC32MX795F512L device on the PIC32 USB Starter Kit II through the Starter Kit I/O Expansion Board.



2. Next, connect the PIC32 USB Starter Kit II and the Starter Kit I/O Expansion Board, as shown in the following figure.



For the PIC32MX795F512L device, the USART modules has dedicated I/O pins.

The following table illustrates how the USART1 and USART2 pins are mapped and connected to each other through the Starter Kit I/O Expansion Board.

USART Module	USART Lines	PIC32MX795F512L Device Pin #	PIC32MX795F512L Port Pin Name/Function	Pin # on I/O Expansion Board J11 Connector	For this demonstration, attach this pin to:
USART1	TX	53	U1TX	43	U2RX
USART1	RX	52	U1RX	41	U2TX
USART2	TX	50	U2TX	48	U1RX
USART2	RX	49	U2RX	46	U1TX

Running the Demonstration

This section demonstrates how to run the USART Driver USART Loopback Demonstration.

Description

This demonstration shows how to configure and make use of the USART Driver APIs to support multiple USART hardware instances to multiple clients of the driver in both interrupt mode and polled mode. This demonstration shows the USART driver's "multi-instance multi-client" feature.

Once the demonstration application is compiled successfully, you are ready to program the firmware in the target device.

To run the demonstration in Debug mode, perform the following steps:

1. Select the appropriate configuration from the MPLAB X IDE Project Properties based on the target hardware.
2. Select your device programmer from the Hardware Tool menu in MPLAB X IDE.
3. Select either *Debug* > *Debug Main Project* or click **Debug Main Project** in the toolbar.
4. Build the selected configuration in the MPLAB X IDE project and program the demonstration board.

The USART Driver configures the USART1 and USART2 modules on the same PIC32 device as defined in the `system_config.h` file. The

USART1 and USART2 lines are connected to each other as described in Configuring the Hardware. USART1 sends a chunk of data (64 bytes) to USART2. USART2 sends back the same data to USART1. The data is sent and received back on the same USART module through another USART. The data is looped back to the sender.

Upon execution of the program, the USART1 will transmit a sequence of character string/data through the USART1 TX channel using the settings defined in the application for USART1.

After transmitting the data from USART1, the driver will read USART2 for any data received. If the data is received, the same data is sent back to USART1. The program will verify the received data to the transmitted data and enter into Idle mode.

Once in Idle mode, the firmware will neither transmit nor receive any data. If the application enters Idle mode, LED2 (Yellow) of the starter kit will illuminate.

If any error occurs, or if the transmitted data is not same to received data, LED1 (Red) of the starter kit will illuminate, which indicates the demonstration has failed.

If the transmitted data and received data on UART1 is same, LED3 (Green) of the starter kit will illuminate, which indicates the demonstration was successful.

Examples

Provides information on MPLAB Harmony example applications. The MPLAB Harmony example applications provide simple single-purpose application projects that illustrate how to use a selected MPLAB Harmony library. These are the working examples of source code that is provided throughout the MPLAB Harmony documentation.

my_first_app

Describes the `my_first_app` example.

Description

The MPLAB Harmony `my_first_app` example application provides the solution described in the Creating Your First Project tutorial.

Peripheral Library Examples

This topic describes the peripheral library examples.

Introduction

The example applications for MPLAB peripheral libraries (PLIBs) provide very simple single-purpose examples of how to use MPLAB Harmony peripheral libraries.

Description

Peripheral libraries (PLIBs) are the lowest level libraries provided with MPLAB Harmony. They provide a functional abstraction of the peripherals available on Microchip microcontrollers to hide differences in register details that can exist from device to device. However, they do not maintain any state data (at least not any that isn't stored in the hardware registers) from call to call and they do not provide any protection of the peripheral's resources. As such, any code that calls the PLIB for a peripheral must take responsibility for ownership of that peripheral and is responsible for managing the behavior of that peripheral.

As such, PLIBs are normally only used by MPLAB Harmony device drivers or system services. However, there are some times when it is necessary and appropriate to interact with a PLIB directly from an application. Therefore, simple examples are provided to show how to use the interfaces to the peripheral libraries. These examples are available in the MPLAB Harmony installation in the following location: `<install-dir>/apps/examples/peripheral`.

PIC32MX device examples are written for the Explorer 16 Development Board with a PIC32MX795F512L PIM. PIC32MZ device examples are written for the PIC32MZ Embedded Connectivity (EC) Starter Kit. The examples are tested and working on the Explorer 16 Development Board, the PIC32 USB Starter Kit II, and the PIC32MZ Embedded Connectivity (EC) Starter Kit, and the appropriate board configuration for each project can be selected in MPLAB X IDE.

ADC Peripheral Library Examples

This topic provides descriptions of the ADC Peripheral Library examples.

Introduction

ADC Peripheral Library Demonstration Applications Help

Description

This distribution package contains one ADC related firmware project that demonstrates the capabilities of the MPLAB Harmony ADC Peripheral Library.

This section describes the hardware requirement and procedures to run this firmware project on Microchip demonstration and development boards.

To learn more about MPLAB Harmony stacks and libraries refer to the related documentation in Volume IV: MPLAB Harmony Framework Reference.

Demonstrations

This topic provides information on how to run the ADC Peripheral Library demonstration applications included in this release.

adc_pot

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Description

This example reads the potentiometer, R6 on the Explorer 16 Development Board using a PIC32MX795F512L PIM. The results of the read are displayed on the LEDs. As the potentiometer is adjusted, the LEDs displayed will "slide" up or down.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the ADC Peripheral Library demonstration.

Description

To build this project, you must open the `adc_pot.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/examples/peripheral/adc/adc_pot`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`adc_pot.X`	`<install-dir>/apps/examples/peripheral/adc/adc_pot/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx795_pim_e16	pic32mx795_pim+e16	Demonstrates the ADC reading potentiometer R6 on the PIC32MX795F512L PIM and the Explorer 16 Development Board.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32MX795F512L PIM, Explorer 16 Development Board, and Starter Kit I/O Expansion Board

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

Provides instructions on how to build and run the ADC demonstration.

Description

This demonstration reads the setting of the potentiometer through the ADC.

1. First compile and program the target device. While compiling, select the available configuration for the hardware in use.
2. Turn the potentiometer R6 in either direction. Check the state of the LEDs on the Explorer 16 Development Board. As the potentiometer is turned clockwise, more LEDs will be lit. As the potentiometer is turned counter-clockwise, fewer LEDs are lit.

adc_pot_dma

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Description

This example reads the potentiometer, R6 on the Explorer 16 Development Board (PIC32MX795F512L PIM) using the ADC while storing data on RAM using DMA.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the ADC Peripheral Library demonstration.

Description

To build this project, you must open the `adc_pot_dma.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/examples/peripheral/adc/adc_pot_dma`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`adc_pot_dma.X`	`<install-dir>/apps/examples/peripheral/adc/adc_pot_dma/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx795_pim_e16	pic32mx795_pim+e16	Demonstrates the ADC using a DMA channel to read the potentiometer R6 on the PIC32MX795F512L PIM and the Explorer 16 Development Board.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32MX795F512L PIM, Explorer 16 Development Board, and Starter Kit I/O Expansion Board

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

Provides instructions on how to build and run the ADC demonstration.

Description

This demonstration reads the setting of the potentiometer through the ADC.

1. First compile and program the target device. While compiling, select the available configuration for the hardware in use.
2. Turn the potentiometer R6 in either direction. Check the state of the LEDs on the Explorer 16 Development Board. As the potentiometer is turned clockwise, more LEDs will be lit. As the potentiometer is turned counter-clockwise, fewer LEDs are lit.

12-bit High-Speed SAR ADC (ADCHS) Peripheral Library Examples

This topic provides descriptions of the 12-bit High-Speed SAR ADC (ADCHS) Peripheral Library examples.

Introduction

12-bit High-Speed SAR ADC (ADCHS) Peripheral Library Demonstration Applications Help

Description

This distribution package contains one ADC-related firmware project that demonstrates the capabilities of the MPLAB Harmony ADCHS Peripheral Library.

This section describes the hardware requirement and procedures to run this firmware project on Microchip demonstration and development boards.

To learn more about MPLAB Harmony stacks and libraries refer to the related documentation in Volume IV: MPLAB Harmony Framework Reference.

Demonstrations

This topic provides information on how to run the ADCHS Peripheral Library demonstration applications included in this release.

adchs_3ch_dma

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Description

This example demonstrates the use of system DMA to automatically store conversion data of three ADC channels into three separate buffers. Each channel is set to sample at a conversion rate of 2 Msps using a single timer trigger to synchronize the conversion of all three channels. An average converted data displays on a terminal emulator, such as RealTerm.

This application is to be used with PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit using the Starter Kit I/O Expansion Board with the Adapter Board, or PIC32MZ Graphics (DA) Starter Kit.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the ADCHS Peripheral Library demonstration.

Description

To build this project, you must open the `adchs_3ch_dma.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/examples/peripheral/adchs/adchs_3ch_dma`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`adchs_3ch_dma.X`	`<install-dir>/apps/examples/peripheral/adchs/adchs_3ch_dma/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mz_ef_sk	pic32mz_ef_sk	Demonstrates operation of three system DMA channels to store conversion of a Class 1 analog input (potentiometer) when connected to the PIC32MZ EF Starter Kit using the Starter Kit I/O Expansion Board and the PIC32MZ EC Starter Kit Adapter Board.
pic32mz_da_sk	pic32mz_da_sk	Demonstrates operation of three system DMA channels to store conversion of a Class 1 analog input when connected to the PIC32MZ DA Starter Kit.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit

1. Connect the PIC32MZ EF Starter Kit to the PIC32MZ EC Starter Kit Adapter Board.
2. Connect the combination of two boards (as described in Step 1) on the Starter Kit I/O Expansion Board.
3. Three analog signals or three potentiometers of suitable value (4.7K or 10K, with two ends to 3.3V and the GND pin of J11) should be connected; and wipers of the potentiometers to J11 pin 34 and 33 (AN0 and AN2) and J10 pin 32 (AN2) on the Starter Kit I/O Expansion Board.
4. Connect a mini-USB cable from a PC to the mini-USB connector J11 on the PIC32MZ EF Starter Kit.
5. Power the Starter Kit I/O Expansion Board with a 9V power supply.

PIC32MZ Graphics (DA) Starter Kit

1. A 3 analog signal or 3 potentiometer of suitable value (4.7K or 10K) should be connected with two ends to 3.3V and the GND pin of J11; and wiper of potentiometer to J15 pin 16, 36, and 13 (AN2, AN3, and AN4) PIC32MZ EF Starter Kit.
2. Power and download firmware to the Starter Kit by connecting a mini-USB cable from a PC to the mini-USB connector J19 (DEGUG) on the PIC32MZ EF Starter Kit.

3. Connect a mini-USB cable from a PC to the mini-USB connector J11 on the PIC32MZ EF Starter Kit.

Running the Demonstration

Provides instructions on how to build and run the ADCHS Peripheral Library demonstration.

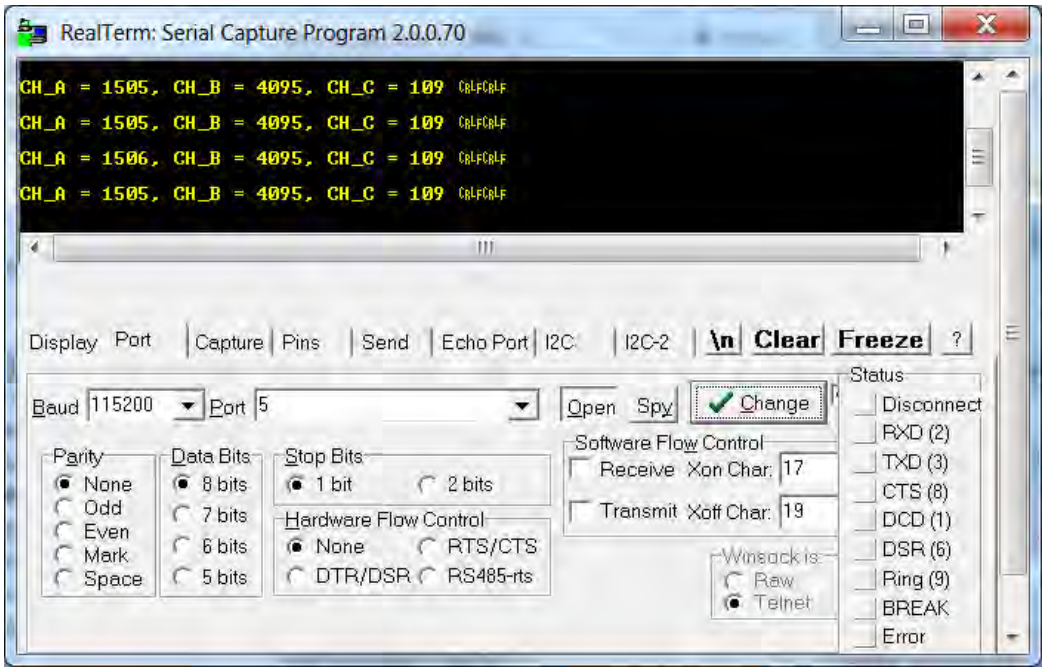
Description

To build this project, you must open the `adchs_3ch_dma.X` project in MPLAB X IDE, and then select the desired configuration.

Do the following to run the demonstration:

1. First compile and program the target device. While compiling, select the available configuration for the hardware in use.
2. Launch a terminal emulator (RealTerm/Tera Term, etc.,) and select the appropriate COM port and set the serial port settings to 115200-N-1.
3. Launch the demonstration. The following message will appear in the console window: Result: 3171.
4. This example demonstrates the use of system DMA to automatically store conversion data of three ADC channels into three separate buffers. Each channel is set to sample at a conversion rate of 2 Msps using a single timer trigger to synchronize the conversion of all three channels. An average converted data displays on a terminal emulator, such as RealTerm.

The following figure shows a working terminal emulator window.



adchs_oversample

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Description

This example demonstration reads the potentiometer that is connected to the PIC32MZ DA Starter Kit or the PIC32MZ EF Starter Kit using the Starter Kit I/O Expansion Board with the PIC32MZ EC Starter Kit Adapter Board, and performs oversampling of the converted data and displays the higher resolution ADC converted readings on a terminal emulator (such as RealTerm).

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the ADCHS Peripheral Library demonstration.

Description

To build this project, you must open the `adchs_oversample.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/examples/peripheral/adchs/adchs_oversample`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`adchs_oversample.X`	`<install-dir>/apps/examples/peripheral/adchs/adchs_oversample/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mz_ef_sk	pic32mz_ef_sk	Demonstrates operation of a digital filter in Oversampling mode, while converting a Class 1 analog input (potentiometer) when connected to the PIC32MZ EF Starter Kit using the Starter Kit I/O Expansion Board and the PIC32MZ EC Starter Kit Adapter Board.
pic32mz_da_sk	pic32mz_da_sk	Demonstrates operation of a digital filter in Oversampling mode, while converting a Class 1 analog input (potentiometer) when connected to the PIC32MZ DA Starter Kit.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit

1. Connect the PIC32MZ EF Starter Kit to the PIC32MZ EC Starter Kit Adapter Board.
2. Connect the combination of two boards (as described in Step 1) on the Starter Kit I/O Expansion Board.
3. A potentiometer of suitable value (4.7K or 10K) should be connected with two ends to 3.3V and the GND pin of J11; and wiper of potentiometer to pin 34 of J11 on the Starter Kit I/O Expansion Board.
4. Connect a mini-USB cable from a PC to the mini-USB connector J11 on the PIC32MZ EF Starter Kit.
5. Power the Starter Kit I/O Expansion Board with a 9V power supply.

PIC32MZ Graphics (DA) Starter Kit

1. A potentiometer of suitable value (4.7K or 10K) should be connected with two ends to 3.3V and the GND pin of J11; and the wiper of the potentiometer to pin 36 of J15 on the PIC32MZ DA Starter Kit.
2. Connect a mini-USB cable from a PC to the mini-USB connector J11 on the PIC32MZ DA Starter Kit.
3. Connect a mini-USB cable from a PC to the DEBUG mini-USB connector J19 to power the starter kit.

Running the Demonstration

Provides instructions on how to build and run the ADCHS Peripheral Library demonstration.

Description

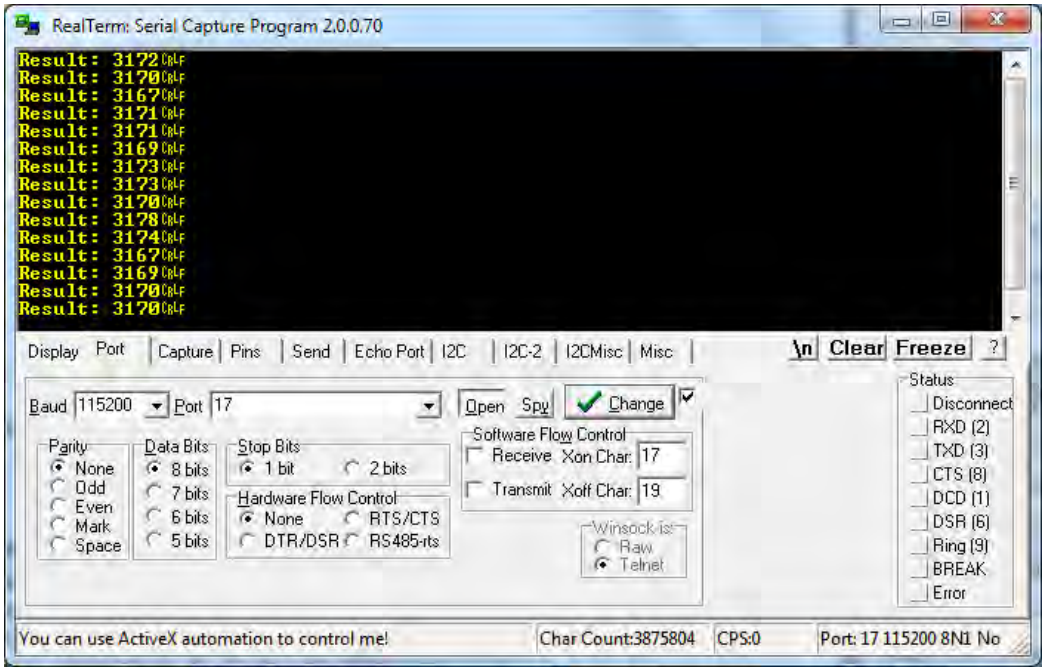
This demonstration oversamples the converted data of the potentiometer using digital filters. Do the following to run the demonstration:

1. First compile and program the target device. While compiling, select the available configuration for the hardware in use.
2. Launch a terminal emulator (RealTerm/Tera Term, etc.,) and select the appropriate COM port and set the serial port settings to 115200-N-1.
3. Launch the demonstration. The following message will appear in the console window: Result: 3171.
4. As the potentiometer is turned, the "Result:" on the console shows the high resolution ADC converted value.
5. The higher resolution data can be verified by first running the adchs_pot demonstration and observing the 12-bit converted data. Later, keeping the potentiometer setting same, the adchs_oversample demonstration is run and the higher resolution 15-bit converted data can be observed and verified. Theoretical calculation is as follows:
   - Max count of 12 bit resolution: 4096
   - Max count of 15 bit resolution: 32768
   - ADC Ref input voltage: 3.3 Volts

Consider an analog input of 0.319 Volts:

- 12-bit resolution ADC reading (obtained by adchs_pot): ((4096/3.3) * 0.319) = 396
- 15-bit resolution ADC reading (oversampled by adchs_oversample): ((32768/3.3) * 0.319) = 3167

The following figure shows a working terminal emulator window.



adchs_pot

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Description

This example demonstration reads the potentiometer that is connected to the PIC32MZ DA Starter Kit or the PIC32MZ EF Starter Kit using the Starter Kit I/O Expansion Board with the PIC32MZ EC Starter Kit Adapter Board.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the ADCHS Peripheral Library demonstration.

Description

To build this project, you must open the `adchs_pot.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/examples/peripheral/adchs/adchs_pot`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`adchs_pot.X`	`<install-dir>/apps/examples/peripheral/adchs/adchs_pot/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mz_ef_sk	pic32mz_ef_sk	Demonstrates a read of the potentiometer by the ADC when connected to the PIC32MZ EF Starter Kit using the Starter Kit I/O Expansion Board and the PIC32MZ EC Starter Kit Adapter Board.
pic32mz_da_sk	pic32mz_da_sk	Demonstrates a read of the potentiometer by the ADC when connected to the PIC32MZ DA Starter Kit.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit

1. Connect the PIC32MZ EF Starter Kit to the PIC32MZ EC Starter Kit Adapter Board.
2. Connect the combination of two boards (as described in Step 1) on the Starter Kit I/O Expansion Board.
3. A potentiometer of suitable value (4.7K or 10K) should be connected with two ends to 3.3V and the GND pin of J11; and wiper of potentiometer to pin 34 of J11 on the Starter Kit I/O Expansion Board.
4. Connect a mini-USB cable from a PC to the mini-USB connector J11 on the PIC32MZ EF Starter Kit.
5. Power the Starter Kit I/O Expansion Board with a 9V power supply.

PIC32MZ Graphics (DA) Starter Kit

1. A potentiometer of suitable value (4.7K or 10K) should be connected with two ends to 3.3V and the GND pin of J11; and the wiper of the potentiometer to pin 36 of J15 on the PIC32MZ DA Starter Kit.
2. Connect a mini-USB cable from a PC to the mini-USB connector J11 on the PIC32MZ DA Starter Kit.
3. Connect a mini-USB cable from a PC to the DEBUG mini-USB connector J19 to power the starter kit.

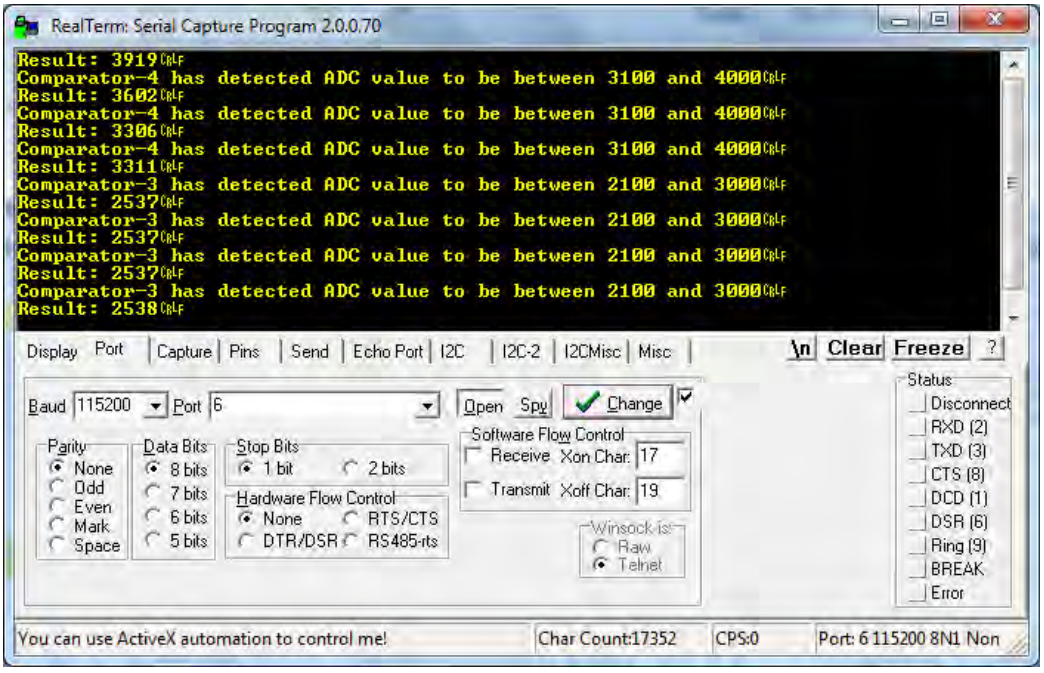
Running the Demonstration

Provides instructions on how to build and run the ADCHS Peripheral Library demonstration.

Description

This demonstration reads the setting of the potentiometer through the ADC.

1. First compile and program the target device. While compiling, select the available configuration for the hardware in use.
2. Launch a terminal emulator (RealTerm/Tera Term, etc.,) and select the appropriate COM port and set the serial port settings to 115200-N-1.
3. Launch the demonstration. The following messages will appear in the console window:
   - Comparator 1 has detected the ADC value to be between 0 and 1000
   - Result: 960
4. As the potentiometer is turned, the "Result:" on the console shows the ADC converted value. Four digital comparators process the ADC converted value and generate an event. The conditions for digital comparator events are as follows:
   - Digital Comparator 1 generates an event when the ADC converted value is between 0 to 1000. All LEDs on the starter remain OFF.
   - Digital Comparator 2 generates an event when the ADC converted value is between 1100 to 2000. Also, LED D1 on the starter kit turns ON.
   - Digital Comparator 3 generates an event when the ADC converted value is between 2100 to 3000. Also, LED D1 and D2 on the starter kit turn ON.
   - Digital Comparator 4 generates an event when the ADC converted value is between 3100 to 4000. Also, all LEDs on the starter kit turn ON.
5. The following figure shows a working terminal emulator window.



adchs_sensor

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Description

This peripheral library example demonstrates the conversion of three Class 2 and one Class 3 analog inputs in Channel Scan mode, triggered by a Timer3 match. On the MEB II board, the chosen three Class 2 analog inputs are connected to the three axes of an accelerometer and the Class 3 analog input is connected to a temperature sensor. The demonstration application code uses the converted value of the three axes of the accelerometer, converts them into the tilt of the three axes, and displays the results on the serial port terminal (in radians). Also, the converted data from the temperature sensor is scaled to degrees Celsius and displayed on the serial port terminal.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the ADCHS Peripheral Library demonstration.

Description

To build this project, you must open the `adchs_sensor.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/examples/peripheral/adchs/adchs_sensor`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`adchs_sensor.X`	`<install-dir>/apps/examples/peripheral/adchs/adchs_sensor/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mz_ef_sk_meb2	pic32mz_ef_sk+meb2	Demonstrates the scan conversion feature with a timer trigger, while converting three Class 2 analog inputs (accelerometer) and one Class 3 analog input (temperature sensor) when connected to the PIC32MZ EF Starter Kit on the MEB II.
pic32mz_da_sk_meb2	pic32mz_da_sk+meb2	Demonstrates the scan conversion feature with a timer trigger, while converting three Class 2 analog inputs (accelerometer) and one Class 3 analog input (temperature sensor) when connected to the PIC32MZ DA Starter Kit on the MEB II.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32MZ EF Starter Kit connected to the MEB II

1. Mount the PIC32MZ EF Starter Kit on the MEB II.
2. Connect a mini-USB cable from a PC to the mini-USB connector J11 on the PIC32MZ EF Starter Kit.
3. Power the Starter Kit I/O Expansion Board with a 9V power supply on the MEB II or through the Debug connector (J3) on SK.

Note: The accelerometer y and z axes are connected to AN7 (RB12) and AN8 (RB13) on the PIC32MZ EF Starter kit. The same pins are also used for switch inputs, SW1 and SW2. During the application initialization, the ports are configured as analog. While running this demonstration care should be taken not to press SW1 or SW2. Otherwise, the converted ADC values will be incorrect.

PIC32MZ DA Starter Kit connected to the MEB II

1. Mount the PIC32MZ DA Starter Kit on the MEB II.
2. Connect a mini-USB cable from a PC to the mini-USB connector J11 on the PIC32MZ DA Starter Kit.
3. Power the Starter Kit I/O Expansion Board with a 9V power supply on the MEB II or through the Debug connector (J3) on SK.

Running the Demonstration

Provides instructions on how to build and run the ADCHS Peripheral Library demonstration.

Description

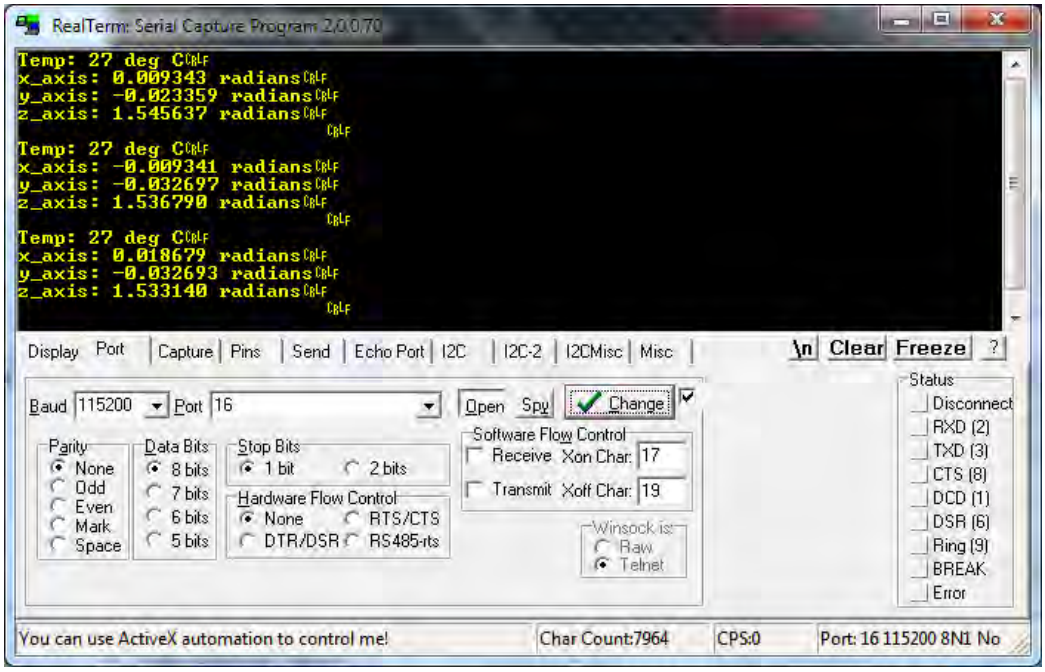
This demonstration reads the accelerometer and temperature sensor. Do the following to run the demonstration:

1. First compile and program the target device. While compiling, select the available configuration for the hardware in use.
2. Launch a terminal emulator (RealTerm/Tera Term, etc.,) and select the appropriate COM port and set the serial port settings to 115200-N-1.
3. Launch the demonstration. The following messages will appear in the console window:

- Temp: 27 deg C
- x-axis: 0.001 radians
- y-axis: 0.01 radians
- z-axis: 1.52 radians

4. As the MEB II board is tilted, the angles for each axis displayed on the console windows changes.
5. If the temperature sensor "U8" is heated (by touching), the displayed temperature on the console window changes.

The following figure shows a working terminal emulator window.



adchs_touchsense

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Description

This peripheral library example demonstrates the Capacitive Voltage Divider (CVD) feature of the ADCHS Peripheral Library and analog channel scan features using the PIC32MZ EF Starter Kit and the touch pad (B2) on the Multimedia Expansion Board II (MEB II).

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the ADCHS Peripheral Library demonstration.

Description

To build this project, you must open the `adchs_touchsense.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/examples/peripheral/adchs/adchs_touchsense`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`adchs_touchsense.X`	`<install-dir>/apps/examples/peripheral/adchs/adchs_touchsense/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mz_ef_sk_meb2	pic32mz_ef_sk+meb2	Demonstrates the CVD feature of ADCHS while converting a Class 3 analog input (AN28), in Scan mode when connected to the PIC32MZ EF Starter Kit on the MEB II.

pic32mz_da_sk_meb2	pic32mz_da_sk+meb2	Demonstrates the CVD feature of ADCHS while converting a Class 3 analog input (AN28), in Scan mode when connected to the PIC32MZ DA Starter Kit on the MEB II.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32MZ EF Starter Kit and MEB II

1. Mount the PIC32MZ EF Starter Kit on the MEB II.
2. Connect a mini-USB cable from a PC to the mini-USB connector J11 on the PIC32MZ EF Starter Kit.
3. Power the Starter Kit I/O Expansion Board with a 9V power supply on the MEB II or through the debug connector (J3) on the PIC32MZ EF Starter Kit.

PIC32MZ DA Starter Kit and MEB II

1. Mount the PIC32MZ DA Starter Kit on the MEB II.
2. Connect a mini-USB cable from a PC to the mini-USB connector J11 on the PIC32MZ DA Starter Kit.
3. Power the Starter Kit I/O Expansion Board with a 9V power supply on the MEB II or through the debug connector (J3) on the PIC32MZ DA Starter Kit.

Running the Demonstration

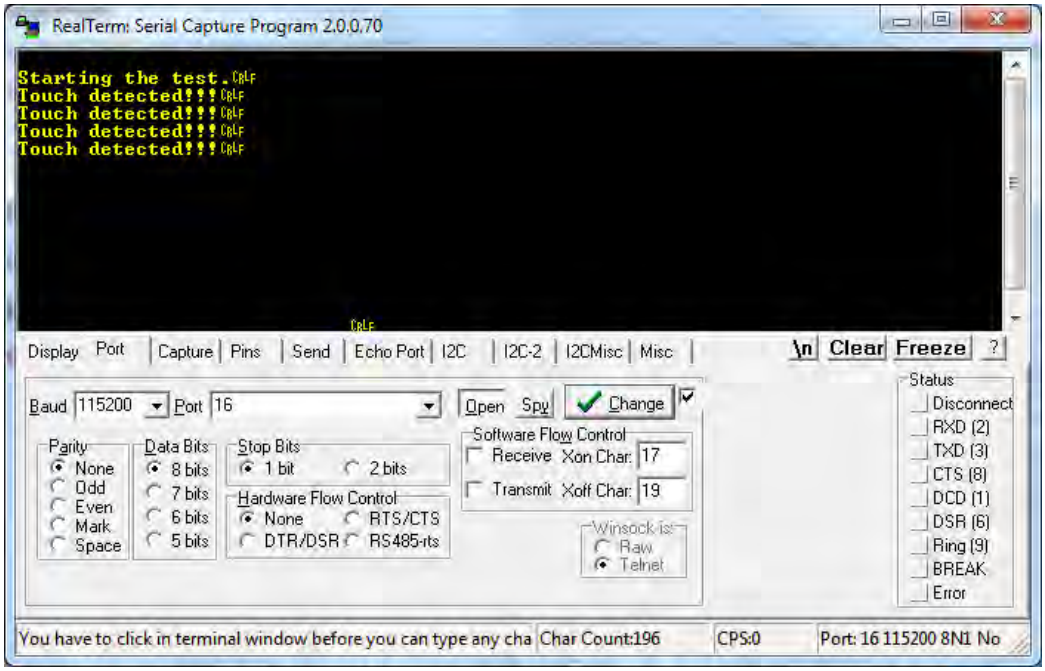
Provides instructions on how to build and run the ADCHS Peripheral Library demonstration.

Description

This example demonstrates the CVD feature of ADCHS and senses the touch event on the B2 touchpad of the MEB II.

1. First compile and program the target device. While compiling, select the available configuration for the hardware in use.
2. Launch a terminal emulator (RealTerm/Tera Term, etc.,) and select the appropriate COM port and set the serial port settings to 115200-N-1.
3. Launch the demonstration.
4. Touch the B2 touch pad on the MEB II. The B2 touch pad is located on the LCD side of the MEB II and not on the starter kit side of MEB II. Once touched, the LED D4 on the MEB II illuminates and "Touch Detected!!!" is displayed on the serial terminal program. This display repeats every 1 second, until B2 is no longer being touched.
5. Once B2 is not longer being touched, the LED D4 turns off and after a brief delay, LED D3 illuminates.

The following figure shows a working terminal emulator window.



Pipelined ADC (ADCP) Peripheral Library Examples

This topic provides descriptions of the Pipelined Analog-to-Digital Converter (ADCP) Peripheral Library examples.

Introduction

Pipelined ADC Peripheral Library Demonstration Applications Help

Description

This distribution package contains one ADC related firmware project that demonstrates the capabilities of the MPLAB Harmony Pipelined ADC Peripheral Library.

This section describes the hardware requirement and procedures to run this firmware project on Microchip demonstration and development boards.

To learn more about MPLAB Harmony stacks and libraries refer to the related documentation in Volume IV: MPLAB Harmony Framework Reference.

Demonstrations

This topic provides information on how to run the Pipelined ADC Peripheral Library demonstration applications included in this release.

adcp_cal

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Description

This example illustrates how to configure the Pipelined ADC prior to using it for normal operations. It also illustrates the required errata setup of channel, oversampling, and DMA transfer of data to achieve the best results.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the Pipelined ADC calibration demonstration.

Description

To build this project, you must open the `adcp_cal.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/examples/peripheral/adcp/adcp_cal`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`adcp_cal.X`	`<install-dir>/apps/examples/peripheral/adcp/adcp_cal/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mz_ec_pim_e16	pic32mz_ec_pim+e16	Using the PIC32MZ2048ECH100 Plug-in Module (PIM) connected to the Explorer 16 Development Board, this demonstration illustrates a software calibration step that is needed before using the Pipelined ADC. This calibration calculates the DC offset by sampling the internal voltage reference (IVREF) attached to the ADC.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32MZ2048ECH100 PIM, Explorer 16 Development Board, and Starter Kit I/O Expansion Board

The software is configured to use an external VREF+ and VREF- attached to pins 33 and 32, respectively, of the PIM. This can be accomplished through the Starter Kit I/O Expansion board or a PICtail™ Prototyping Daughter Board.

The VREF+ pin voltage needs to be applied either after, or at the same time as the main VDD power is applied. The software is set to accept 3.3V as the VREF+ voltage. The software is set to accept 0.0V as the VREF- voltage, so that pin may be connected to GND or AVSS.

If another voltage is used for VREF+ or VREF-, the corresponding setting in the software, in `adcp.h`, needs to be updated to make the calculations correct.

The potentiometer R6 on the Explorer 16 Development Board can be used to drive one of the inputs in the demonstration. Run a jumper between RB5 and RG8 on the PICtail prototyping daughter board, inserted into the PICtail slot. This board can also be used to set up the VREF+ and VREF- connections.

VREF+ can be set up by connecting RB9 on the PICtail prototyping daughter board to +3.3V. VREF- can be set up by connecting RB8 on the PICtail Prototyping Daughter Board.

Running the Demonstration

Provides instructions on how to build and run the Pipelined ADC demonstration.

Description

This demonstration shows how the Pipelined ADC module operates on PIC32MZ devices in accordance with the Errata and Data Sheet clarifications.

1. Connect and program the device using your debugger.
2. Set a breakpoint in `app.c`, near line 234, which reads:
   ```
   appData.state = APP_STATE_NORMALIZE_DATA;
   ```
3. Set a breakpoint in `app.c`, near line 241, which reads:
   ```
   appData.state = APP_STATE_DISPLAY_DATA;
   ```
4. Run the program.
5. When the program reaches the first breakpoint, you can use the debugger variables window to observe the data in `appData.ADC_Data1`.
6. Continue running the program from the breakpoint.
7. When the program reaches the second breakpoint, you can use the debugger variables window to observe the data in `appData.ADC_Data1`. This data has now been normalized, meaning that the values have been converted to 8-bit results. This would be the data an application would use.
8. Continue running the program to collect a new set of data, repeating Steps 5 through 7, as desired. If you have connected the jumper to allow potentiometer R6 operation, turn the potentiometer and observe the change in results.
9. The scale of the readings on the channel connected to the potentiometer is also reflected on the LEDs of the Explorer 16 Development Board.

Note: Timer3 is used to trigger the ADC scan automatically. If the number of channels to be used is changed, the Timer3 period needs to be adjusted accordingly.

Do the following to make the adjustment:

1. Open the Microchip Harmony Configurator.
2. Load the configuration for the adcp_cal project.
3. Navigate to *Harmony Framework Configuration* > *Drivers* > *Timer* > *Use Timer Driver?* and select *TMR Driver Instance 0*.
4. Change the Timer Period value according to this formula:
   - `Timer Period = 721 * APP_NUM_ANX_PINS` (where, `APP_NUM_ANX_PINS` is defined in `adcp_config.h` and represents the number of pins to sample)
5. Generate and run the demonstration again

BMX Peripheral Library Examples

This topic provides descriptions of the BMX Peripheral Library examples.

Introduction

BMX Peripheral Library Demonstration Applications Help

Description

This distribution package contains one BMX related firmware project that demonstrates the capabilities of the MPLAB Harmony BMX Peripheral Library.

This section describes the hardware requirement and procedures to run this firmware project on Microchip demonstration and development boards.

To learn more about MPLAB Harmony stacks and libraries refer to the related documentation in Volume IV: MPLAB Harmony Framework Reference.

Demonstrations

This topic provides information on how to run the BMX Peripheral Library demonstration applications included in this release.

mem_partition

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Description

This example sets up a memory partition in the PIC32MX device for Kernel and User segments. If the memory is set correctly, the LEDs on the Explorer 16 Development Board are lit.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the BMX Peripheral Library BMX Handler demonstration.

Description

To build this project, you must open the `mem_partition.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/examples/peripheral/bmx/mem_partition`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`mem_partition.X`	`<install-dir>/apps/examples/peripheral/bmx/mem_partition/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx795_pim_e16	pic32mx795_pim+e16	Demonstrates the BMX memory partition demonstration on the PIC32MX795F512L PIM and Explorer 16 Development Board.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32MX795F512L PIM and Explorer 16 Development Board

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

Provides instructions on how to build and run the BMX demonstration.

Description

This demonstration sets up Kernel and User memory partitions through the BMX Peripheral Library.

1. First compile and program the target device. While compiling, select the configuration suitable for the hardware in use.
2. Observe the status of the LEDs on the Explorer 16 Development Board. If the memory was correctly partitioned, the LEDs on the Explorer 16 Development Board are lit.

CAN Peripheral Library Examples

This topic provides descriptions of the CAN demonstrations.

Introduction

CAN Library Demonstration Applications Help.

Description

This distribution package contains one CAN-related firmware project that demonstrates the capabilities of the MPLAB Harmony CAN Library. This section describes the hardware requirement and procedures to run this firmware project on Microchip demonstration and development boards.

To learn more about MPLAB Harmony stacks and libraries, refer to the related documentation in Volume IV: MPLAB Harmony Framework Reference.

Demonstrations

This topic provides information on how to run the CAN Library demonstration applications included in this release.

echo_send

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Description

This demonstration shows how to use the CAN Peripheral Library and CAN peripheral on a device to send out a message over the CAN bus. This demonstration uses message filtering to echo back user data sent to its specific address. This demonstration does not use a CAN Driver or the CAN Stack.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the CAN Demonstration.

Description

To build this project, you must open the `echo_send.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/examples/peripheral/can/echo_send`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`echo_send.X`	`<install-dir>/apps/examples/peripheral/can/echo_send/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are within `./firmware/src/system_config`.

Project Configuration Name	BSP(s) Used	Description
pic32mx_125_sk	pic32mx_125_sk	Demonstrates sending a message over the CAN bus on the PIC32MX1/2/5 Starter Kit.
pic32mz_ec_sk_io_ebrd_can_pictail	pic32mz_ec_sk	Demonstrates sending a message over the CAN bus using the CAN/LIN PICtail Plus Daughter Board and the PIC32MZ EC Starter Kit connected to the PIC32MZ Starter Kit Adapter Board and Starter Kit I/O Expansion Board.
pic32mz_ef_sk_io_ebrd_can_pictail	pic32mz_ef_sk	Demonstrates sending a message over the CAN bus using the CAN/LIN PICtail Plus Daughter Board and the PIC32MZ EF Starter Kit connected to the PIC32MZ Starter Kit Adapter Board and Starter Kit I/O Expansion Board.
pic32mz_da_sk_io_ebrd_can_pictail	pic32mz_da_sk	Demonstrates sending a message over the CAN bus using the CAN/LIN PICtail Plus Daughter Board and the PIC32MZ DA Starter Kit connected to the PIC32MZ Starter Kit Adapter Board and Starter Kit I/O Expansion Board.
pic32mx_usb_sk2	pic32mx_usb_sk2	Demonstrates sending a message over the CAN bus using the combined CAN/LIN PICtail Plus Daughter Board and the PIC32 USB Starter Kit II.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32MX1/2/5 Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32 USB Starter Kit II

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ EC Starter Kit or PIC32MZ EF Starter Kit connected to the PIC32MZ Starter Kit Adapter Board

On the PIC32MZ Starter Kit Adapter Board, short pins 1 and 2 of JP1 and short pins 1 and 2 of JP3

PIC32MZ DA Starter Kit connected to the PIC32MZ Starter Kit Adapter Board and Starter Kit I/O Expansion Board

On the PIC32MZ Starter Kit Adapter Board, JP1 and JP3 should be open for this to work.

On the Starter Kit I/O Expansion Board configure the following jumpers:

- Set J11 pin 12 to J11 pin 7
- Set J11pin 9 to J11 pin 8

CAN/LIN PICtail Plus Daughter Board

- For CAN1, set J4 to 1 and J2 to 2-3
- For CAN2, use RE5 and RE4 by setting J15 and J16 to 1-2

Running the Demonstration

Provides instructions on how to build and run the CAN demonstration.

Description

The following are required to run this demonstration:

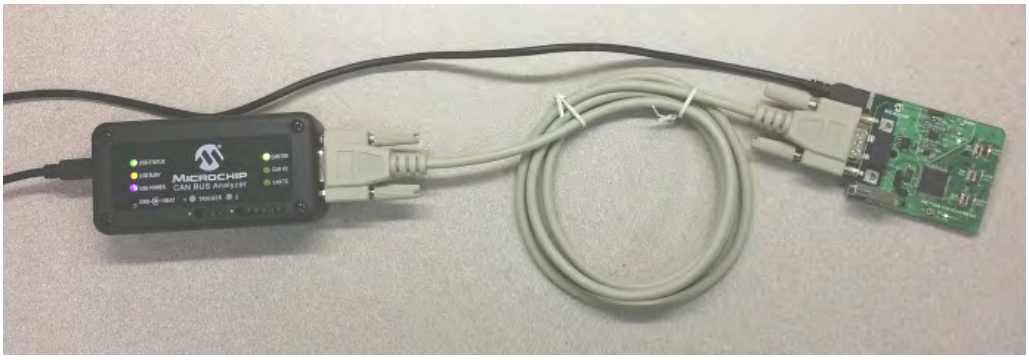
- MPLAB X IDE
- MPLAB XC32 C/C++ Compiler

Note: Prior to using this demonstration, it is recommended to review the MPLAB Harmony Release Notes for the specific versions. A PDF copy of the release notes is provided in the `<install-dir>/doc` folder of your installation.

- One of the following:
  - PIC32MX1/2/5 Starter Kit
  - CAN/LIN PICtail Plus Daughter Board and PIC32 USB Starter Kit II combination
  - PIC32MZ EC Starter Kit or PIC32MZ EF Starter Kit or PIC32MZ DA Starter Kit
- One Microchip CAN BUS Analyzer (APGDT002) or equivalent
- One DB9 cable
- Two USB A-to-B mini cables
- A personal computer

Hardware Example

The following figure illustrates the hardware setup for the PIC32MX1/2/5 Starter Kit.

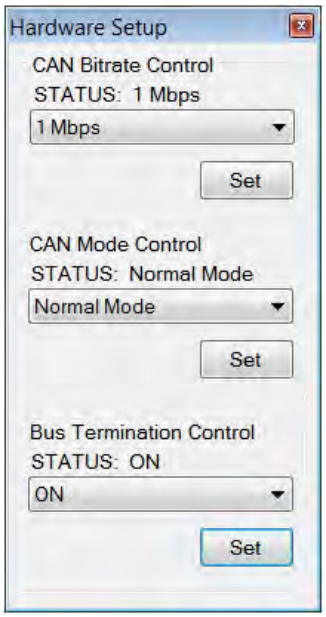


Refer to *"CAN BUS Analyzer User's Guide"* (DS50001848) for further operating instructions regarding the CAN BUS Analyzer.

For more information on the CAN Bus, visit: http://www.can-cia.org/

Do the following to run the demonstration:

1. Connect one end of the DB9 cable to the starter kit and the other end to the CAN BUS Analyzer.
2. Connect the USB cables to J3 on the starter kit and to the CAN BUS Analyzer.
3. Open the CAN BUS Analyzer software.
4. Configure the Analyzer for the Baud Rate Selected inside MHC (1 Mbps Typical), Normal Operation, Termination Resistor: ON.



5. Start MPLAB X IDE and open the project, `echo_send.X`.
6. Program the starter kit.
7. Open the Rolling Trace window in the CAN BUS Analyzer software.
8. Press the button(s) on the starter kit to see the output in the trace window.
9. Open the Transmit window.
10. To get a response from the starter kit, the following address must be used: ID = 0x201. Following the address, enter the DLC, which is the Data Length Code (the number of bytes to follow). For example, if 0x201, DLC, Byte1, Byte2, Byte3, Byte4 was entered, the starter kit will respond with: 0x102, DLC, Byte1, Byte2, Byte3, Byte4.

Demonstration Output

The following figure shows the Rolling Trace send/receive output from the CAN Bus Analyzer.

Rolling Trace

TRACE	ID	DLC	DATA	DATA	DATA	DATA	DATA	DATA	DATA	DATA	TIME STAMP (sec)	TIME DELTA (sec)
RX	0x102	4	0x44	0x33	0x22	0x11					759.7169	696.243
TX	0x201	4	0x11	0x22	0x33	0x44					63.4742	993.755

Button Press Mapping

SW1 Press **-** 0x12C, 2, 0x0B, 0x16.

The following figure shows the Rolling Trace output message.

File View Tools Setup Help

Rolling Trace

TRACE	ID	DLC	DATA	DATA	DATA	DATA	DATA	DATA	DATA	DATA	TIME STAMP (sec)	TIME DELTA (sec)
RX	0x12C	2	0x0B	0x16							876.5379	0.018
RX	0x55	4	0x11	0x22	0x33	0x44					873.5240	4.791
RX	0x100	4	0xDE	0xAD	0xBE	0xEF					868.6979	108.981

Comparator Peripheral Library Examples

This topic provides descriptions of the Comparator Peripheral Library examples.

Introduction

Comparator Peripheral Library Demonstration Applications Help

Description

This distribution package contains one Comparator related firmware project that demonstrates the capabilities of the MPLAB Harmony Comparator Peripheral Library.

This section describes the hardware requirement and procedures to run this firmware project on Microchip demonstration and development boards.

To learn more about MPLAB Harmony stacks and libraries refer to the related documentation in Volume IV: MPLAB Harmony Framework Reference.

Demonstrations

This topic provides information on how to run the Comparator Peripheral Library demonstration applications included in this release.

simple_comparator

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Description

This example sets up the Comparator in the PIC32MX device to compare the potentiometer input on inverting input to the reference voltage on non-inverting input. Depending on the comparison, one half of the LEDs on the Explorer 16 Development Board will be lit.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the Comparator Peripheral Library demonstration.

Description

To build this project, you must open the `simple_comparator.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/examples/peripheral/cmp/simple_comparator`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`simple_comparator.X`	`<install-dir>/apps/examples/peripheral/cmp/simple_comparator/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx795_pim_e16	pic32mx795_pim+e16	Simple comparator demonstration on the PIC32MX795F512L PIM and Explorer 16 Development Board.
pic32mx795_pim_e16_freertos	pic32mx795_pim+e16	FreeRTOS version of the simple comparator demonstration on the PIC32MX795F512L PIM and Explorer 16 Development Board.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32MX795F512L PIM and Explorer 16 Development Board

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

Provides instructions on how to build and run the Comparator demonstration.

Description

This demonstration sets up the analog comparator to trigger an interrupt when the inverting and non-inverting inputs change relative value.

1. First compile and program the target device. While compiling, select the configuration suitable for the hardware in use.
2. Observe the status of the LEDs on the Explorer 16 Development Board. Depending on the comparison between the inverting and non-inverting inputs, one half of the LEDs (D3-D6 or D7-D10) will be lit.

CVREF Peripheral Library Examples

This topic provides descriptions of the CVREF Peripheral Library examples.

Introduction

CVREF Peripheral Library Demonstration Applications Help.

Description

This distribution package contains one CVREF related firmware project that demonstrates the capabilities of the MPLAB Harmony CVREF Peripheral Library.

This section describes the hardware requirement and procedures to run this firmware project on Microchip demonstration and development boards.

To learn more about MPLAB Harmony stacks and libraries refer to the related documentation in Volume IV: MPLAB Harmony Framework Reference.

Demonstrations

This topic provides information on how to run the CVREF Peripheral Library demonstration applications included in this release.

triangle_wave

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Description

This example sets up the CVREF voltage divider in the PIC32 devices to create a triangle waveform that can be observed on an oscilloscope.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the CVREF Peripheral Library demonstration.

Description

To build this project, you must open the `triangle_wave.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/examples/peripheral/cvref/triangle_wave`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`triangle_wave.X`	`<install-dir>/apps/examples/peripheral/cvref/triangle_wave/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Configuration Name	BSP Used	Description
pic32mx795_pim_e16	pic32mx795_pim+e16	CVREF triangle wave demonstration on the PIC32MX795F512L PIM and Explorer 16 Development Board.
pic32mz_ec_pim_e16	pic32mz_ec_pim+e16	CVREF triangle wave demonstration on the PIC32MZ2048ECH100 PIM and Explorer 16 Development Board.
pic32mz_ef_pim_e16	pic32mz_ef_pim+e16	CVREF triangle wave demonstration on the PIC32MZ2048EFH100 PIM and Explorer 16 Development Board.
pic32mz_da_sk	pic32mz_da_sk	CVREF triangle wave demonstration on the PIC32MZ DA Starter Kit.
pic32mx795_pim_e16_freertos	pic32mx795_pim+e16	FreeRTOS version of the CVREF triangle wave demonstration on the PIC32MX795F512L PIM and Explorer 16 Development Board.
pic32mz_ef_pim_e16_freertos	pic32mz_ef_pim+e16	FreeRTOS version of the CVREF triangle wave demonstration on the PIC32MZ2048EFH100 PIM and Explorer 16 Development Board.
pic32mz_ef_sk_16b	pic32mz_ef_sk	microMIPS version of the CVREF triangle wave demonstration on the PIC32MZ EF Starter Kit.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32MX795F512L PIM and Explorer 16 Development Board

Attach an oscilloscope probe to RB10, which is the CVREFOUT pin.

PIC32MZ2048ECH100 PIM and Explorer 16 Development Board

Attach an oscilloscope probe to RB10, which is the CVREFOUT pin.

PIC32MZ2048EFH100 PIM and Explorer 16 Development Board

Attach an oscilloscope probe to RB10, which is the CVREFOUT pin.

PIC32MZ DA Starter Kit and Starter Kit I/O Expansion Board

Attach an oscilloscope probe to RB10, which is the CVREFOUT pin.

Running the Demonstration

Provides instructions on how to build and run the CVREF demonstration.

Description

This demonstration changes the voltage output on the CVREF pin to create a triangle waveform, which can be observed using an oscilloscope.

1. First compile and program the target device. While compiling, select the configuration suitable for the hardware in use.
2. Observe the output of the CVREFOUT pin using the oscilloscope. A triangle waveform of different voltage levels should be observed.

DDR Peripheral Library Examples

This topic provides descriptions of the DDR Peripheral Library examples.

Introduction

DDR Peripheral Library Demonstration Applications Help

Description

This distribution package contains one DDR related firmware project that demonstrates the capabilities of the MPLAB Harmony DDR Peripheral Library.

This section describes the hardware requirement and procedures to run this firmware project on Microchip demonstration and development boards.

To learn more about MPLAB Harmony stacks and libraries refer to the related documentation in Volume IV: MPLAB Harmony Framework Reference.

Demonstrations

This topic provides information on how to run the DDR Peripheral Library demonstration applications included in this release.

Description

This release contains one demonstration:

- write_read_ddr2

write_read_ddr2

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Description

This example demonstration tests the Micron MT47H64M16 device that is included on the PIC32MZ Graphics (DA) Family Starter Kit.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the DDR Peripheral Library demonstration.

Description

To build this project, you must open the `write_read_ddr2.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/examples/peripheral/ddr/write_read_ddr2`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`write_read_ddr2.X`	`<install-dir>/apps/examples/peripheral/ddr/write_read_ddr2/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mz_da_sk	pic32mz_da_sk	Demonstrates DDR functionality on the PIC32MZ Graphics (DA) Starter Kit.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32MZ DA Starter Kit

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

Provides instructions on how to build and run the DDR demonstration.

Description

This demonstration tests the functionality of the DDR SDRAM included on the PIC32MZ Graphics (DA) Family Starter Kit.

1. First compile and program the target device. While compiling, select the available configuration for the hardware in use.
2. Run the application. LED1 and LED2 (Red and Yellow) will flash as the DDR is being filled. LED2 and LED3 (Yellow and Green) will flash as the DDR is read and the pattern verified. LED3 (Green) will flash if all patterns match those written. LED1 (RED) will flash if any pattern does not match the one written.
3. Pressing Switch 1 at any time will restart the test.

DMA Peripheral Library Examples

This topic provides descriptions of the DMA Peripheral Library examples.

Introduction

DMA Peripheral Library Demonstration Applications Help

Description

This distribution package contains one DMA related firmware project that demonstrates the capabilities of the MPLAB Harmony DMA Peripheral Library.

This section describes the hardware requirement and procedures to run this firmware project on Microchip demonstration and development boards.

To learn more about MPLAB Harmony stacks and libraries refer to the related documentation in Volume IV: MPLAB Harmony Framework Reference.

Demonstrations

This topic provides information on how to run the DMA Peripheral Library demonstration applications included in this release.

dma_led_pattern

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the

demonstration.

Description

This demonstration displays a pattern stored in Flash on LEDs using DMA transfers (by exercising the DMA Peripheral Library), which are triggered by a Timer1 interrupt.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the DMA Peripheral Library DMA Handler demonstration.

Description

To build this project, you must open the `dma_led_pattern.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/examples/peripheral/dma/dma_led_pattern`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`dma_led_pattern.X`	`<install-dir>/apps/examples/peripheral/dma/dma_led_pattern/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
bootloader_pic32mx_eth_sk	pic32mx_eth_sk	This configuration is used and programmed by the Bootloader Demonstrations. Refer to those demonstrations for more information.
bootloader_pic32mz_ec_sk	pic32mz_ec_sk	This configuration is used and programmed by the Bootloader Demonstrations. Refer to those demonstrations for more information.
bootloader_pic32mz_da_sk	pic32mz_da_sk	This configuration is used and programmed by the Bootloader Demonstrations. Refer to those demonstrations for more information.
pic32mx795_pim_e16	pic32mx795_pim+e16	Demonstrates the DMA led pattern on PIC32MX795F512L PIM and Explorer 16 Development Board combination.
pic32mz_ec_sk	pic32mz_ec_sk	Demonstrates the DMA LED pattern on the PIC32MZ Embedded Connectivity (EC) Starter Kit.
pic32mz_ef_sk	pic32mz_ef_sk	Demonstrates the DMA LED pattern on the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit.
pic32mz_da_sk	pic32mz_da_sk	Demonstrates the DMA LED pattern on the PIC32MZ Graphics (DA) Starter Kit.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32MZ EC Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ EF Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ DA Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32MX795F512L PIM and Explorer 16 Development Board

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

Provides instructions on how to build and run the DMA demonstration.

Description

This demonstration triggers an interrupt based on the DMA alarm.

1. First compile and program the target device. While compiling, select the configuration for the hardware in use.
2. Observe the pattern on the LEDs upon successful execution. The pattern will repeat and continuously blink the LEDs in succession. If there is a failure, the LEDs will stop toggling.

EBI Peripheral Library Examples

This topic provides descriptions of the EBI Peripheral Library examples.

Introduction

External Bus Interface (EBI) Peripheral Library Demonstration Applications Help

Description

This distribution package contains an EBI SRAM read/write demonstration project that demonstrates the capabilities of the EBI and its ability to store data and access data that is attached to it.

This section describes the hardware requirement and procedures to run these firmware projects on Microchip demonstration and development boards.

To learn more about MPLAB Harmony stacks and libraries refer to the related documentation in Volume IV: MPLAB Harmony Framework Reference.

Demonstrations

This topic provides information on how to run the EBI Peripheral Library demonstration applications included in this release.

sram_read_write

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Building the Application

for the EBI Peripheral Library SRAM Read/Write Demonstration.

Description

To build this project, you must open the `sram_read_write.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/examples/peripheral/ebi/sram_read_write`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`sram_read_write.X`	`<install-dir>/apps/examples/peripheral/ebi/sram_read_write`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mz_ec_sk_meb2	pic32mz_ec_sk+meb2	Demonstrates SRAM read/write on the PIC32MZ EC Starter Kit with the MEB II.
pic32mz_ef_sk_meb2	pic32mz_ef_sk+meb2	Demonstrates SRAM read/write on the PIC32MZ EF Starter Kit with the MEB II.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32MZ EC Starter Kit and MEB II

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ EF Starter Kit and MEB II

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

Provides instructions on how to build and run the EBI basic demonstration.

Description

Please use the following procedure to run the demonstration:

1. Load the demonstration project into MPLAB X IDE.
2. Connect the PIC32MZ EC Starter Kit to the MEB II.
3. Connect the USB cable to the mini-B debugger port on the PIC32MZ EC Starter Kit and the other end to the computer.
4. Build, download, and run the demonstration project on the target board.

There are four states to the state machine in this demonstration, APP_STATE_WRITE, APP_STATE_READBACK, APP_STATE_DONE, and APP_STATE_FAIL.

The demonstration will initialize the EBI hardware module. After the hardware had been configured, the demonstration will write in a walking address to the entire memory array. After the demonstration has finished writing in data, it reads back the entire memory array and checks it against the expected data.

If the check PASSES, the demonstration will go to APP_STATE_DONE state where it will remain and indicate the demonstration success by turning ON LED3 (GREEN LED) of the PIC32MZ EC Starter Kit.

If the check FAILS, the demonstration will go to APP_STATE_FAIL state where it will remain and indicate the failure by turning ON LED1 (RED LED) of the PIC32MZ EC Starter Kit.

I2C Peripheral Library Examples

This topic provides descriptions of the I2C Peripheral Library examples.

Introduction

I2C Peripheral Library Demonstration Applications Help

Description

This distribution package contains I2C-related firmware projects that demonstrate the capabilities of the MPLAB Harmony I2C Peripheral Library.

This section describes the hardware requirement and procedures to run these firmware projects on Microchip demonstration and development boards.

To learn more about MPLAB Harmony stacks and libraries refer to the related documentation in Volume IV: MPLAB Harmony Framework Reference.

Demonstrations

This topic provides information on how to run the I2C Peripheral Library demonstration applications included in this release.

i2c_interrupt

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the I2C Peripheral Library example demonstration.

Description

To build this project, you must open the `i2c_interrupt.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/examples/peripheral/i2c/i2c_interrupt`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
i2c_interrupt.X	<install-dir>/apps/examples/peripheral/i2c/i2c_interrupt/firmware

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within ./firmware/src/system_config.

Project Configuration Name	BSP Used	Description
pic32mx795_pim_e16	pic32mx795_pim+e16	The purpose of this configuration is to demonstrate I2C Master mode transfer setup in Interrupt mode and static operation. The hardware used is the PIC32MX795F512L PIM connected to the Explorer 16 Development Board.
pic32mz_ec_sk_meb2	pic32mz_ec_sk+meb2	The purpose of this configuration is to demonstrate I2C Master mode transfer setup in Interrupt mode and static operation. The hardware used is the PIC32MZ EC Starter Kit connected to the MEB II.
pic32mz_da_sk_meb2_wvga	pic32mz_da_sk+meb2+wvga	The purpose of this configuration is to demonstrate I2C Master mode transfer setup in Interrupt mode and static operation. The hardware used is the PIC32MZ Graphics (DA) Starter Kit connected to the MEB II.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

Note: The i2c_interrupt demonstration was tested on the Microchip MCP7949N RTCC device. The address of this device is 0xDE.

Explorer 16 Development Board with the PIC32MX795F512L PIM

- Before attaching the PIC32MX795F512L PIM to the Explorer 16 Development Board, ensure that the processor select switch (S2) is in the PIM Position
- Short JP2 on the Explorer 16 Development Board to enable the LEDs

If a Starter Kit I/O Expansion Board is used, make the following connections:

- Jumper I/O Expansion board J11 pin 36 (SDA2) and J11 pin 38 (SCL2) should be pulled up to 3.3V through a 2.2k ohm resistor

If an external RTCC is used, make the following connections:

- Jumper I/O Expansion board J11 pin 36 (SDA2) and J11 pin 38 (SCL2) to the corresponding lines of an external I2C device
- If an external I2C device is connected, ensure that the Master and Slave device share a common ground.

If a PICtail Plus Daughter Board is used, make the following connections:

- PICtail Plus Daughter Board pins RA2 (SCL2) and RA3 (SDA2) should be pulled up to 3.3V through a 2.2k ohm resistor

If an external RTCC is used, make the following connections:

- Jumper PICtail Plus Daughter Board pins RA2 (SCL2) and pin RA3 (SDA2) to the corresponding SCL and SDA lines of an external I2C device
- If an external I2C device is connected, ensure that the Master and Slave device share a common ground

PIC32MZ EC Starter Kit, PIC32MZ EF Starter Kit, PIC32MZ Graphics (DA) Starter Kit connected to MEB II

The jumper JP2 on PIC32MZ EC/EF Starter Kit should be connected according to the debugger/programmer used, as follows:

- If PKOB is used, pins 1 and 3 and pins 2 and 4 should be shorted
- If MPLAB REAL ICE or MPLAB ICD 3 is being used, pins 1 and 3 and pins 2 and 4 should be left open

The connections pertaining to I2C are as follows:

- Connect MEB II J2 pin 3 (SCL2) to the corresponding SCL line of the external I2C device
- Connect MEB II J2 pin 5 (SDA2) to the corresponding SDA line of the external I2C device
- If an external I2C device is connected, ensure that the Master and Slave device share a common ground

Running the Demonstration

Provides instructions on how to build and run the I2C demonstration.

Description

1. This demonstration shows how to configure and make use of the I2C Driver APIs to support buffered operation of I2C in Interrupt mode. In this demonstration, the I2C is configured as single instance and single client.

Once the demonstration application is compiled successfully for the selected configuration, the firmware can be programmed into the target device.

To run the demonstration in Debug mode, perform the following steps:

1. Select the appropriate configuration from the MPLAB X IDE Project Properties based on the target hardware.
2. Select your device programmer from the Hardware Tool menu in MPLAB X IDE.

3. Select either *Debug* > *Debug Main Project* or click **Debug Main Project** in the toolbar.
4. Build the selected configuration in the MPLAB X IDE project and program the demonstration board.

The I2C Driver configures the I2C2 instance of the I2C peripheral in Master mode. The SDA and SCL lines are connected to the Microchip MCP7940N RTCC device as described in Configuring the Hardware. The Master writes to sequential memory locations in SRAM memory of the RTCC device. The Master then reads back the content from the same page.

The contents of the buffer variable can be checked to determine the result of the operation.

The expected results are shown in the following table.

Test Case	Contents of Buffer
I2C2 (Master)	`RXbuffer_6[] = "3RTCCSLAVE"` (data received from RTCC device)

Input Capture Peripheral Library Examples

This topic provides descriptions of the Input Capture Peripheral Library examples.

Introduction

Input Capture Peripheral Library Demonstration Applications Help

Description

This distribution package contains one Input Capture related firmware project that demonstrates the capabilities of the MPLAB Harmony Input Capture Peripheral Library.

This section describes the hardware requirement and procedures to run this firmware project on Microchip demonstration and development boards.

To learn more about MPLAB Harmony stacks and libraries refer to the related documentation in Volume IV: MPLAB Harmony Framework Reference.

Demonstrations

This topic provides information on how to run the Input Capture Peripheral Library demonstration applications included in this release.

ic_basic

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Description

This demonstration exercise the timer capture based on the rising edge of the Input Capture 1 pin (RD8). The timer capture value is stored in 'CaptureTime' variable.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the Input Capture Peripheral Library Input Capture Handler demonstration.

Description

To build this project, you must open the `ic_basic.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/examples/peripheral/ic/ic_basic`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`ic_basic.X`	`<install-dir>/apps/examples/peripheral/ic/ic_basic/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx_usb_sk2	pic32mx_usb_sk2	Demonstrates the Input Capture Peripheral Library on the PIC32 USB Starter Kit II and the I/O Expansion Board combination.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32 USB Starter Kit II and Starter Kit I/O Expansion Board

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

Provides instructions on how to build and run the IC demonstration.

Description

This demonstration triggers an interrupt.

1. First compile and program the target device. While compiling, select the configuration suitable for the hardware in use.
2. LED3 will turn ON once a successful input capture has been made.

NVM Peripheral Library Examples

This topic provides descriptions of the NVM Peripheral Library examples.

Introduction

NVM Peripheral Library Demonstration Applications Help

Description

This distribution package contains one Flash-related firmware project that demonstrates the capabilities of the MPLAB Harmony NVM Peripheral Library.

This section describes the hardware requirement and procedures to run this firmware project on Microchip demonstration and development boards.

To learn more about MPLAB Harmony stacks and libraries refer to the related documentation in Volume IV: MPLAB Harmony Framework Reference.

Demonstrations

This topic provides information on how to run the NVM Peripheral Library demonstration applications included in this release.

flash_modify

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Description

This demonstration does the following:

- Erases a page in the program Flash
- Writes a row of data into the program Flash
- Reads and verifies the written data
- Indicates the success or failure of the operation through on-board LEDs

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the NVM Peripheral Library demonstration.

Description

To build this project, you must open the `flash_modify.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is

`<install-dir>/apps/examples/peripheral/flash/flash_modify`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`flash_modify.X`	`<install-dir>/apps/examples/peripheral/flash/flash_modify/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx795_pim_e16	pic32mx795_pim+e16	Demonstrates the NVM Peripheral Library on the PIC32MX795F512L PIM and Explorer 16 Development Board combination.
pic32mz_ec_sk	pic32mz_ec_sk	Demonstrates the NVM Peripheral Library on the PIC32MZ Embedded Connectivity (EC) Starter Kit.
pic32mz_ef_sk	pic32mz_ef_sk	Demonstrates the NVM Peripheral Library on the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit.
pic32mz_da_sk	pic32mz_da_sk	Demonstrates the NVM Peripheral Library on the PIC32MZ Graphics (DA) Starter Kit.
pic32mz_ef_sk_16b	pic32mz_ef_sk	Demonstrates the NVM Peripheral Library with 16-bit configuration on the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit.
pic32mz795_pim_e16_freertos	pic32mx795_pim+e16	Demonstrates the NVM Peripheral Library on the PIC32MX795F512L PIM and Explorer 16 Development Board combination with FreeRTOS.
pic32mz_ef_sk_freertos	pic32mz_ef_sk	Demonstrates the NVM Peripheral Library on the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit with FreeRTOS.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32MX795F512L PIM and Explorer 16 Development Board

- Switch S2 should be set to PIM
- Jumper J2 should be in place

PIC32MZ EC Starter Kit

Remove Jumper JP1.

PIC32MZ EF Starter Kit

Remove Jumper JP1.

PIC32MZ DA Starter Kit

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

Provides instructions on how to build and run the NVM demonstration.

Description

This demonstration exercises internal Flash erase, write, and read operations through the NVM Peripheral Library.

1. First compile and program the target device. While compiling, select the configuration suitable for the hardware in use.
2. Upon successful execution of the demonstration, the LEDs on the respective hardware turn ON to indicate success or failure. Refer to the following table for the LED status for the different configurations.

Project Configuration	Success State	Failure State
pic32mx795_pim_e16	LED4 ON	LED3 ON

pic32mz_ec_sk pic32mz_ef_sk pic32mz_da_sk	LED3 ON	LED1 ON

Output Compare Peripheral Library Examples

This topic provides descriptions of the Output Compare Peripheral Library examples.

Introduction

Output Compare Peripheral Library Demonstration Applications Help.

Description

This distribution package contains one Output Compare related firmware project that demonstrates the capabilities of the MPLAB Harmony Output Compare Peripheral Library.

This section describes the hardware requirement and procedures to run this firmware project on Microchip demonstration and development boards.

To learn more about MPLAB Harmony stacks and libraries refer to the related documentation in Volume IV: MPLAB Harmony Framework Reference.

Demonstrations

This topic provides information on how to run the Output Compare Peripheral Library demonstration applications included in this release.

oc_pwm

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Description

This demonstration generates a 40 kHz PWM with a 25% duty cycle on the Output Compare 1 output pin.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the Output Compare Peripheral Library Output Compare Handler demonstration.

Description

To build this project, you must open the `oc_pwm.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/examples/peripheral/oc/oc_pwm`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`oc_pwm.X`	`<install-dir>/apps/examples/peripheral/oc/oc_pwm`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx_usb_sk2	pic32mx_usb_sk2	Demonstrates the Output Compare PWM on PIC32 USB Starter Kit II.
pic32mz_ec_sk	pic32mz_ec_sk+meb2	Demonstrates the Output Compare PWM on the PIC32MZ EC Starter Kit and MEB II combination.
pic32mz_ef_sk	pic32mz_ef_sk+meb2	Demonstrates the Output Compare PWM on the PIC32MZ EF Starter Kit and MEB II combination.

pic32mz_da_sk	pic32mz_da_sk+meb2	Demonstrates the Output Compare PWM on the PIC32MZ DA Starter Kit and MEB II combination.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32 USB Starter Kit II and Starter Kit I/O Expansion Board

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ EC Starter Kit and MEB II

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ EF Starter Kit and MEB II

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ DA Starter Kit and MEB II

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

Provides instructions on how to build and run the OC demonstration.

Description

This demonstration exhibits the generated PWM on the Output Compare pin.

1. First compile and program the target device. While compiling, select the configuration suitable for the hardware in use.
2. The user should see a 40 kHz signal with 25% duty cycle on the oscilloscope on the following pins for the respective configurations:
   - pic32mx_usb_sk2: Output Compare 1 output pin on the I/O Expansion Board
   - pic32mz_ec_sk or pic32mz_ef_sk: Output Compare 5 output pin (pin 22) on the PICtail connector of the MEB II

Oscillator Peripheral Library Examples

This topic provides descriptions of the Oscillator Peripheral Library examples.

Introduction

Oscillator Peripheral Library Demonstration Applications Help

Description

This distribution package contains one Oscillator related firmware project that demonstrates the capabilities of the MPLAB Harmony Oscillator Peripheral Library.

This section describes the hardware requirement and procedures to run this firmware project on Microchip demonstration and development boards.

To learn more about MPLAB Harmony stacks and libraries refer to the related documentation in Volume IV: MPLAB Harmony Framework Reference.

Demonstrations

This topic provides information on how to run the Oscillator Peripheral Library demonstration applications included in this release.

osc_config

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Description

This example demonstrates how to change the system clock source and PLL values during run-time.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the Oscillator Peripheral

Library.

Description

To build this project, you must open the `osc_config.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/examples/peripheral/osc/osc_config`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`osc_config.X`	`<install-dir>/apps/examples/peripheral/osc/osc_config/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx_usb_sk2	pic32mx_usb_sk2	Demonstrates the Timer3 interrupt on the PIC32 USB Starter Kit II.
pic32mz_ec_sk	pic32mz_ec_sk	Demonstrates the Timer3 interrupt on the PIC32MZ Embedded Connectivity (EC) Starter Kit.
pic32mz_ef_sk	pic32mz_ef_sk	Demonstrates the Timer3 interrupt on the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit.
pic32mz_da_sk	pic32mz_da_sk	Demonstrates the Timer3 interrupt on the PIC32MZ Graphics (DA) Starter Kit.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32MZ DA Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ EC Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ EF Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32 USB Starter Kit II

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

Provides instructions on how to build and run the Oscillator demonstration.

Description

This demonstration configures the Oscillator for different setups at run-time.

1. First compile and program the target device. While compiling, select the appropriate configuration for the hardware in use.
2. LED3 will turn ON if the clock settings have changed during run-time.

PMP Peripheral Library Examples

This topic provides descriptions of the PMP Peripheral Library examples.

Introduction

PMP Peripheral Library Demonstration Applications Help

Description

This distribution package contains one PMP related firmware project that demonstrates the capabilities of the MPLAB Harmony PMP Peripheral Library.

This section describes the hardware requirement and procedures to run this firmware project on Microchip demonstration and development boards.

To learn more about MPLAB Harmony stacks and libraries refer to the related documentation in Volume IV: MPLAB Harmony Framework Reference.

Demonstrations

This topic provides information on how to run the PMP Peripheral Library demonstration applications included in this release.

pmp_lcd

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Description

This example initializes the LCD on the Explorer 16 Development Board and a sends string of information to it using the PMP Peripheral Library.

Building the Application

for the PMP Peripheral Library PMP Alarm Demonstration.

Description

To build this project, you must open the `pmp_lcd.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/examples/peripheral/pmp/pmp_lcd`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`pmp_lcd.X`	`<install-dir>/apps/examples/peripheral/pmp/pmp_lcd/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx795_pim_e16	pic32mx795_pim+e16	Demonstrates the PMP LCD configuration on the Explorer 16 Development Board with the PIC32MX795F512L PIM.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32MX795F512L PIM and Explorer 16 Development Board

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

Provides instructions on how to build and run the PMP demonstration.

Description

This demonstration shows the PMP/counter capabilities using PMP peripheral library functions.

1. First compile and program the target device. While compiling, select the configuration suitable for the hardware in use.
2. Check the LCD of the Explorer 16 Development Board. The message, "Hello! Testing...", should appear on the display at run-time.

Ports Peripheral Library Examples

This topic provides descriptions of the PORTS Peripheral Library examples.

Introduction

Ports Peripheral Library Demonstration Applications Help.

Description

This distribution package contains two Ports related firmware projects that demonstrate the capabilities of the MPLAB Harmony Ports Peripheral Library.

This section describes the hardware requirement and procedures to run these firmware projects on Microchip demonstration and development boards.

To learn more about MPLAB Harmony stacks and libraries refer to the related documentation in Volume IV: MPLAB Harmony Framework Reference.

Demonstrations

This topic provides information on how to run the Ports Peripheral Library demonstration applications included in this release.

blinky_leds

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Description

This example blinks an LED with the selected frequency.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the Ports Peripheral Library.

Description

To build this project, you must open the `blinky_leds.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/examples/peripheral/ports/blinky_leds`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`blinky_leds.X`	`<install-dir>/apps/examples/peripheral/ports/blinky_leds/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx_eth_sk	pic32mx_eth_sk	Demonstrates the Ports Peripheral Library on the PIC32 Ethernet Starter Kit.
pic32mz_ec_sk	pic32mz_ec_sk	Demonstrates the Ports Peripheral Library on the PIC32MZ Embedded Connectivity (EC) Starter Kit.
pic32mz_ef_sk	pic32mz_ef_sk	Demonstrates the Ports Peripheral Library on the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit.
pic32mz_da_sk	pic32mz_da_sk	Demonstrates the Ports Peripheral Library on the PIC32MZ Graphics (DA) Starter Kit.
pic32mz_ef_sk_16b	pic32mz_ef_sk	Demonstrates the Ports Peripheral Library with 16-bit configuration on the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32 Ethernet Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ EC Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ EF Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ DA Starter Kit

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

Provides instructions on how to build and run the PORTS demonstration.

Description

This demonstration exercises the Ports Peripheral Library functionality.

1. First compile and program the target device. While compiling, select the configuration suitable for the hardware in use.
2. Observe that LED3 is blinking.
3. Change the value of APP_LED_BLINK_DELAY in `app.h`, and then compile and run the code. Observe the change in frequency of the blinking of the LED.

cn_interrupt

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Description

This example controls LED toggling using change notice interrupts associated with the peripheral libraries and specific hardware.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the Ports Peripheral Library.

Description

To build this project, you must open the `cn_interrupt.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/examples/peripheral/ports/cn_interrupt`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`cn_interrupt.X`	`<install-dir>/apps/examples/peripheral/ports/cn_interrupt/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx_eth_sk	pic32mx_eth_sk	Demonstrates the Ports Peripheral Library on the PIC32 Ethernet Starter Kit.
pic32mx_eth_sk_freertos	pic32mx_eth_sk	Demonstrates the Ports Peripheral Library on the PIC32 Ethernet Starter Kit with FreeRTOS enabled.
pic32mz_ec_sk	pic32mz_ec_sk	Demonstrates the Ports Peripheral Library on the PIC32MZ Embedded Connectivity (EC) Starter Kit.

pic32mz_ef_sk	pic32mz_ef_sk	Demonstrates the Ports Peripheral Library on the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit.
pic32mz_ef_sk_freertos	pic32mz_ef_sk	Demonstrates the Ports Peripheral Library on the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit with FreeRTOS enabled.
pic32mz_ef_sk_16b	pic32mz_ef_sk	Demonstrates the Ports Peripheral Library with 16-bit configuration on the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit.
pic32mz_da_sk	pic32mz_da_sk	Demonstrates the Ports Peripheral Library on the PIC32MZ Graphics (DA) Starter Kit.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32MZ EC Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ EF Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ DA Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32 Ethernet Starter Kit

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

Provides information on how to build and run the Change Notice Interrupt demonstration.

Description

This demonstration controls LED toggling using change notice interrupts. The on-board switch with debouncing logic is used for the change notice interrupt.

1. First compile and program the target device. While compiling, select the configuration suitable for the hardware in use.
2. Check the state of LED3, which should be blinking.
3. If you press Switch 1 on the starter kit once, LED3 stops blinking.
4. If you press Switch 1 again, LED3 resumes blinking.
5. Steps 3 and 4 can be repeated multiple times.

Power Peripheral Library Examples

This topic provides descriptions of the Power Peripheral Library examples.

Introduction

Power Peripheral Library Demonstration Applications Help.

Description

This distribution package contains two Power related firmware project that demonstrates the capabilities of the MPLAB Harmony Power Peripheral Library.

This section describes the hardware requirement and procedures to run this firmware project on Microchip demonstration and development boards.

To learn more about MPLAB Harmony stacks and libraries refer to the related documentation in Volume IV: MPLAB Harmony Framework Reference.

Demonstrations

This topic provides information on how to run the Power Peripheral Library demonstration applications included in this release.

deep_sleep_mode

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Description

This demonstration puts the device into Deep Sleep mode and uses the Deep Sleep Watchdog Timer (DSWDT) to wake the device. This example also demonstrates the use of the Deep Sleep General Purpose Registers (DSGPRs) to save the application-critical content.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the Power Peripheral Library Deep Sleep Mode demonstration.

Description

To build this project, you must open the `deep_sleep_mode.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/examples/peripheral/power/deep_sleep_mode`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`deep_sleep_mode.X`	`<install-dir>/apps/examples/peripheral/power/deep_sleep_mode/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mz_da_sk	pic32mz_da_sk	Demonstrates Deep Sleep mode on the PIC32MZ Graphics (DA) Family Starter Kit.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32MZ DA Starter Kit

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

Provides instructions on how to build and run the Power demonstration.

Description

This demonstration places the device into Deep Sleep mode and then wakes it up using the Deep Sleep Watchdog Timer (DSWDT).

1. Compile and program the target device. While compiling, select the configuration suitable for the hardware in use.
2. Check the state of the LEDs. Treat LED3, LED2, and LED1 as binary BIT2, BIT1, and BIT0, respectively. Observe the binary count from 000 to 111, which repeats.
3. Press Switch 2 at any count value to place the device into Deep Sleep mode. Observe that the counting stops and the device will be in Deep Sleep mode until the DSWDT times out (approximately 5 seconds).
4. After 5 seconds, the device wakes up from Deep Sleep and resumes counting.

Basic Operation

The application displays the binary count on LEDs. When Switch 2 is pressed, the application stores the count value into the Deep Sleep General Purpose Register (DSGPR0) and places the device into Deep Sleep mode.

Upon the DSWDT time-out event, the device wakes up and the application checks whether the device was in Deep Sleep mode. If it was, the count value in DSGPR0 is read and the device resumes the LED count from that value.

sleep_mode

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the

demonstration.

Description

This demonstration uses the Watchdog Timer to wake the device from Sleep mode and then toggle LEDs based on the status.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the Power Peripheral Library Sleep Mode demonstration.

Description

To build this project, you must open the `sleep_mode.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/examples/peripheral/power/sleep_mode`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`sleep_mode.X`	`<install-dir>/apps/examples/peripheral/power/sleep_mode/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx_eth_sk	pic32mx_eth_sk	Demonstrates Sleep mode on the PIC32 Ethernet Starter Kit.
pic32mz_ef_sk	pic32mz_ef_sk	Demonstrates Sleep mode on the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit.
pic32mz_da_sk	pic32mz_da_sk	Demonstrates Sleep mode on the PIC32MZ Graphics (DA) Starter Kit.
pic32mz_ef_sk_16b	pic32mz_ef_sk	Demonstrates Sleep mode with 16-bit configuration on the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32MZ EF Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ DA Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32 Ethernet Starter Kit

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

Provides instructions on how to build and run the Power demonstration.

Description

This demonstration puts the device in Sleep mode and than wakes it using the Watchdog Timer.

1. First compile and program the target device. While compiling, select the configuration suitable for the hardware in use.
2. Check the state of the LEDs. LED1 should glow for a few seconds and then turn off and then LED3 will begin toggling.

Reset Peripheral Library Examples

This topic provides descriptions of the Reset Peripheral Library examples.

Introduction

Reset Peripheral Library Demonstration Applications Help

Description

This distribution package contains one Reset related firmware project that demonstrates the capabilities of the MPLAB Harmony Reset Peripheral Library.

This section describes the hardware requirement and procedures to run this firmware project on Microchip demonstration and development boards.

To learn more about MPLAB Harmony stacks and libraries refer to the related documentation in Volume IV: MPLAB Harmony Framework Reference.

Demonstrations

This topic provides information on how to run the Reset Peripheral Library demonstration applications included in this release.

reset_handler

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Description

This example performs checks on various reset flags, assigning each one to an I/O port pin. If the flag is set, the corresponding LED is turned ON. All of the flags can then be cleared by pressing a switch on the board.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the Reset Peripheral Library Reset Handler demonstration.

Description

To build this project, you must open the `reset_handler.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/examples/peripheral/reset/reset_handler`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`reset_handler.X`	`<install-dir>/apps/examples/peripheral/reset/reset_handler/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx795_pim_e16	pic32mx795_pim+e16	Demonstrates the Reset Peripheral Library on the PIC32MX795F512L PIM and the Explorer 16 Development Board.
pic32mz_ec_sk	pic32mz_ec_sk	Demonstrates the Reset Peripheral Library on the PIC32MZ EC Starter Kit.
pic32mz_ef_sk	pic32mz_ef_sk	Demonstrates the Reset Peripheral Library on the PIC32MZ EF Starter Kit.
pic32mz_da_sk	pic32mz_da_sk	Demonstrates the Reset Peripheral Library on the PIC32MZ DA Starter Kit.
pic32mx795_pim_e16_16b	pic32mx795_pim+e16	microMIPS version of the demonstration, which demonstrates the Reset Peripheral Library on the PIC32MX795F512L PIM and the Explorer 16 Development Board.
pic32mz_ef_sk_16b	pic32mz_ef_sk	microMIPS version of the demonstration, which demonstrates the Reset Peripheral Library on the PIC32MZ EF Starter Kit.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32MX795F512L PIM and Explorer 16 Development Board

Jumper JP2 should be connected (shorted) for the LEDs to function.

PIC32MZ EC Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ EF Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ DA Starter Kit

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

Provides instructions on how to build and run the RESET demonstration.

Description

This demonstration finds the reason for a Reset and illuminates the LEDs accordingly.

First compile and program the target device. While compiling, select the configuration suitable for the hardware in use.

PIC32MX795F512L PIM with Explorer 16 Development Board:

Check the status of the LEDs to observe the different reasons for a Reset, as follows:

1. Press Switch S6 to clear all Reset flags, which turns all LEDs OFF.
2. Press the MCLR switch on the board to cause a Reset. LED D9 should turn ON.
3. Unplug the power and plug it again to cause a Power-on Reset (POR). LED D5 should turn ON.
4. Press the MCLR switch again. LED D5 and D9 should both turn ON.
5. Press Switch S6 again to clear all Resets, which turns all LEDs OFF.
6. Press Switch S4 to enable the Watchdog Timer. After a few seconds, LED 10 should turn ON indicating a WDT reset has occurred.

These steps can be repeated from the beginning.

PIC32MZ EC Starter Kit or PIC32MZ EF Starter or PIC32MZ DA Starter Kit:

1. Press Switch S3 to clear all Reset flags, which turns all LEDs OFF.
2. Press Switch S1 to enable the Watchdog Timer. After a few seconds, LED 1 should turn ON indicating a WDT reset has occurred.

Note: A POR clears all the other Reset flags, with the exception of a BOR and a POR flags.

RTCC Peripheral Library Examples

This topic provides descriptions of the RTCC Peripheral Library examples.

Introduction

RTCC Peripheral Library Demonstration Applications Help

Description

This distribution package contains one RTCC related firmware project that demonstrates the capabilities of the MPLAB Harmony RTCC Peripheral Library.

This section describes the hardware requirement and procedures to run this firmware project on Microchip demonstration and development boards.

To learn more about MPLAB Harmony stacks and libraries refer to the related documentation in Volume IV: MPLAB Harmony Framework Reference.

Demonstrations

This topic provides information on how to run the RTCC Peripheral Library demonstration applications included in this release.

rtcc_alarm

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Description

This demonstration sets up the RTCC module to function as an alarm, which goes off at 6:00 AM every morning. The time is set to 5:59:55, so the alarm will trigger 5 seconds after running the code.

Building the Application

for the RTCC Peripheral Library RTCC Alarm Demonstration.

Description

To build this project, you must open the `rtcc_alarm.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/examples/peripheral/rtcc/rtcc_alarm`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`rtcc_alarm.X`	`<install-dir>/apps/examples/peripheral/rtcc/rtcc_alarm/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx795_pim_e16	pic32mx795_pim+e16	Demonstrates the RTCC alarm on the PIC32MX795F512L PIM and Explorer 16 Development Board combination.
pic32mz_ec_sk	pic32mz_ec_sk	Demonstrates the RTCC alarm on PIC32MZ Embedded Connectivity (EC) Starter Kit.
pic32mz_ef_sk	pic32mz_ef_sk	Demonstrates the RTCC alarm on PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit.
pic32mz_da_sk	pic32mz_da_sk	Demonstrates the RTCC alarm on PIC32MZ Graphics (DA) Starter Kit.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32MZ EC Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ EF Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ DA Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32MX795F512L PIM and Explorer 16 Development Board

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

Provides instructions on how to build and run the RTCC Alarm demonstration.

Description

This demonstration triggers an interrupt based on the RTCC alarm.

1. First compile and program the target device. While compiling, select the configuration suitable for the hardware in use.
2. Check the state of the LEDs (D3 on the Explorer 16 Development Board or LED3 on the starter kit). The LED ON status indicates success and LED OFF status indicates failure.

SPI Peripheral Library Examples

This topic provides descriptions of the SPI Peripheral Library examples.

Introduction

SPI Peripheral Library Demonstration Applications Help

Description

This distribution package contains two SPI related firmware project that demonstrates the capabilities of the MPLAB Harmony SPI Peripheral Library.

This section describes the hardware requirement and procedures to run this firmware project on Microchip demonstration and development boards.

To learn more about MPLAB Harmony stacks and libraries refer to the related documentation in Volume IV: MPLAB Harmony Framework Reference.

Demonstrations

This topic provides information on how to run the SPI Peripheral Library demonstration applications included in this release.

spi_loopback

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Description

This demonstration loops back data transfer. This example assumes that the SPI SDO (output) is connected to the SDI (input).

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the SPI Peripheral Library Flash Read in PIO Mode Demonstration.

Description

To build this project, you must open the `spi_loopback.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/examples/peripheral/spi/spi_loopback`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`spi_loopback.X`	`<install-dir>/apps/examples/peripheral/spi/spi_loopback/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx_usb_sk2	pic32mx_usb_sk2	Demonstrates the SPI loopback on the PIC32 USB Starter Kit II and the Starter Kit I/O Expansion Board combination.
pic32mx795_pim_e16	pic32mx795_pim+e16	Demonstrates the SPI loopback on the PIC32MX795F512L PIM, Explorer 16 Development Board, and the Starter Kit I/O Expansion Board combination.
pic32mz_ec_sk	pic32mz_ec_sk	Demonstrates the SPI loopback on the PIC32MZ Embedded Connectivity (EC) Starter Kit and the Starter Kit I/O Expansion Board combination.
pic32mz_ef_sk	pic32mz_ef_sk	Demonstrates the SPI loopback on the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit and the Starter Kit I/O Expansion Board combination.

pic32mz_da_sk	pic32mz_da_sk	Demonstrates the SPI loopback on the PIC32MZ Graphics (DA) Starter Kit and the Starter Kit I/O Expansion Board combination.
pic32mz_ef_sk_16b	pic32mz_ef_sk	Demonstrates the SPI loopback on the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit and the Starter Kit I/O Expansion Board combination in microMIPS mode.
pic32mz_ef_sk_freertos	pic32mz_ef_sk	Demonstrates the SPI loopback on the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit and the Starter Kit I/O Expansion Board combination with FreeRTOS.
pic32mx795_pim_e16_freertos	pic32mx795_pim+e16	Demonstrates the SPI loopback on the PIC32MX795F512L PIM, Explorer 16 Development Board, and the Starter Kit I/O Expansion Board combination with FreeRTOS.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32MX795F512L PIM, Explorer 16 Development Board, and Starter Kit I/O Expansion Board

- Connect (using wires) the SDI1 and SDO1 pins on the Starter Kit I/O expansion board
- Connect the Starter Kit I/O Expansion Board to the Explorer 16 Development Board and mount the PIM on the development board

PIC32MZ EC Starter Kit and Starter Kit I/O Expansion Board

- Connect (using wires) the SDI2 pin (J11 pin 32) and SDO2 pin (J10 pin 35) on the Starter Kit I/O Expansion Board
- Connect the PIC32MZ EC Starter Kit with the adapter board to the Starter Kit I/O Expansion Board

PIC32MZ EF Starter Kit and Starter Kit I/O Expansion Board

- Connect (using wires) the SDI2 pin (J11 pin 32) and SDO2 pin (J10 pin 35) on the Starter Kit I/O Expansion Board
- Connect the PIC32MZ EF Starter Kit with the adapter board to the Starter Kit I/O Expansion Board

PIC32MZ DA Starter Kit and Starter Kit I/O Expansion Board

- Connect (using wires) the SDI1 pin (J11 pin 52) and SDO1 pin (J10 pin 44) on the Starter Kit I/O Expansion Board
- Connect the PIC32MZ DA Starter Kit with the adapter board to the Starter Kit I/O Expansion Board

PIC32 USB Starter Kit II and Starter Kit I/O Expansion Board

- Connect (using wires) the SDI1 and SDO1 pins on the Starter Kit I/O Expansion Board
- Connect the Starter Kit I/O Expansion Board to the PIC32 USB Starter Kit II

Running the Demonstration

Provides instructions on how to build and run the SPI PIO mode transfer demonstration.

Description

This demonstration loops back data on the SPI module (SPI1 and SPI2 when using the PIC32MZ EC Starter Kit or the PIC32MZ EF Starter Kit, and SPI1 and SPI3 when using the PIC32MZ DA Starter Kit.

1. First compile and program the target device. While compiling, select the configuration suitable for the hardware in use.
2. Check the state of LEDs:

- LED D4 and D5 on the Explorer 16 Development Board
- LED3 and LED2 on the PIC32 USB Starter Kit II, PIC32MZ EC Starter Kit, PIC32MZ EF Starter Kit, or PIC32MZ DA Starter Kit.

3. If the demonstration was successful, the LED D5 or LED3 illuminates. If the demonstration fails, LED D4 or LED2 illuminates.

SQI Peripheral Library Examples

This topic provides descriptions of the SQI Peripheral Library examples.

Introduction

SQI Peripheral Library Demonstration Applications Help

Description

This distribution package contains two SQI related firmware projects that demonstrate the capabilities of the MPLAB Harmony SQI peripheral libraries. This section describes the hardware requirement and procedures to run these firmware projects on Microchip demonstration and development boards.

To learn more about MPLAB Harmony stacks and libraries refer to the related documentation in Volume IV: MPLAB Harmony Framework Reference.

Demonstrations

This topic provides information on how to run the SQI Peripheral Library demonstration applications included in this release.

flash_read_dma_mode

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Description

This demonstration application exercises SQI module in DMA mode, by reading a page in the SQI Flash (SST26VF032/SST26VF032B) device on the PIC32MZ EC Starter Kit or the PIC32MZ EF Starter Kit. This demonstration uses PIO mode to write the Flash. Following steps describe the functionality per the calls during run time:

1. Sets up SQI to run at 25 MHz. (`system_init.c`:: SYS_Initialize, `app.c`:: APP_Initialize)
2. Once the clock frequency is programmed, the demonstration prepares the connected Serial Flash device for a write read transaction (`app.c`:: APP_Tasks:: APP_STATE_INIT_FLASH:: SQI_Flash_Setup).
3. Reads the device ID of the attached Flash device (`app.c`:: APP_Tasks:: APP_STATE_FLASH_ID_READ:: SQI_FlashID_Read).
4. Writes a page in Flash in PIO mode (`app.c`:: APP_Tasks:: APP_STATE_WRITE_FLASH:: SQI_PIO_PageWrite(FLASH_PAGE_ADDR)).
5. Reads the contents of the page in Flash using DMA mode and compares it to the data written to make sure the operation is successful (`app.c`:: APP_Tasks:: APP_STATE_READ_FLASH_DMA_MODE:: SQI_DMA_Read(FLASH_PAGE_ADDR)).
6. Indicates demonstration success using LED3 (Green LED) on the starter kit (`app.c`:: APP_Tasks:: APP_STATE_DONE:: BSP_SwitchONLED(LED_GRN)).
7. LED3 OFF, indicates demonstration FAILURE (stuck in one of the states).

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the SQI Peripheral Library Flash Read in DMA Mode Demonstration.

Description

To build this project, you must open the `flash_read_dma_mode.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/examples/peripheral/sqi/flash_read_dma_mode`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`flash_read_dma_mode.X`	`<install-dir>/apps/examples/peripheral/sqi/flash_read_dma_mode/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mz_ec_sk	pic32mz_ec_sk	Demonstrates the SQI DMA mode transfer on the PIC32MZ EC Starter Kit.
pic32mz_ef_sk	pic32mz_ef_sk	Demonstrates the SQI DMA mode transfer on the PIC32MZ EF Starter Kit.
pic32mz_da_sk	pic32mz_da_sk	Demonstrates the SQI DMA mode transfer on the PIC32MZ DA Starter Kit.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32MZ DA Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ EC Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ EF Starter Kit

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

Provides instructions on how to build and run the SQI DMA mode transfer demonstration.

Description

This demonstration allows page writes and reads to/from an SQI Flash device.

1. First compile and program the target device. While compiling, select the appropriate configuration for the starter kit in use.
2. Check the state of LED3 on the starter kit in use to determine the status of the demonstration (LED ON indicates success, LED OFF indicates failure).

flash_read_pio_mode

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Description

This demonstration application exercises the SQI module in PIO mode, by writing and reading a page in the SQI Flash (SST26VF032/SST26F032B) device on the PIC32MZ EC Starter Kit or PIC32MZ EF Starter Kit using the SQI Peripheral Library.

The following steps describe the functionality per the calls during run-time:

1. Sets up SQI to run at 25 MHz. (`system_init.c`:: SYS_Initialize, `app.c`:: APP_Initialize).
2. Once the clock frequency is programmed, the demonstration prepares the connected Serial Flash device for a write read transaction (`app.c`:: APP_Tasks:: APP_STATE_INIT_FLASH:: SQI_Flash_Setup).
3. Reads the device ID of the attached Flash device (`app.c`:: APP_Tasks:: APP_STATE_FLASH_ID_READ:: SQI_FlashID_Read)
4. Writes a page in Flash in PIO mode (`app.c`:: APP_Tasks:: APP_STATE_WRITE_FLASH:: SQI_PIO_PageWrite(FLASH_PAGE_ADDR)).
5. Reads the contents of the page in Flash and compares it to the data written to make sure the operation is successful (`app.c`:: APP_Tasks:: APP_STATE_READ_FLASH_PIO_MODE:: SQI_PIO_Read(FLASH_PAGE_ADDR)).
6. Indicates demonstration success using LED3 (Green LED) on the starter kit (`app.c`:: APP_Tasks:: APP_STATE_DONE:: BSP_SwitchONLED(LED_GRN)).
7. LED3 OFF, indicates demonstration FAILURE (stuck in one of the states).

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the SQI Peripheral Library Flash Read in PIO Mode Demonstration.

Description

To build this project, you must open the `flash_read_pio_mode.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/examples/peripheral/sqi/flash_read_pio_mode`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`flash_read_pio_mode.X`	`<install-dir>/apps/examples/peripheral/sqi/flash_read_pio_mode/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mz_ec_sk	pic32mz_ec_sk	Demonstrates the SQI PIO mode transfer on the PIC32MZ EC Starter Kit.
pic32mz_ef_sk	pic32mz_ef_sk	Demonstrates the SQI PIO mode transfer on the PIC32MZ EF Starter Kit.
pic32mz_da_sk	pic32mz_da_sk	Demonstrates the SQI PIO mode transfer on the PIC32MZ DA Starter Kit.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32MZ DA Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ EC Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ EF Starter Kit

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

Provides instructions on how to build and run the SQI PIO mode transfer demonstration.

Description

This demonstration allows page writes and reads to/from an SQI Flash device.

1. First compile and program the target device. While compiling, select the appropriate configuration for the starter kit in use.
2. Check the state of LED3 on the starter kit in use to determine the status of the demonstration (LED3 ON indicates success, LED3 OFF indicates failure).

flash_read_xip_mode

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Description

This demonstration application exercises the SQI module in XIP mode, by reading a page in the SQI Flash (SST26VF032/SST26VF032B) device on the PIC32MZ EC Starter Kit or the PIC32MZ EF Starter Kit. This demonstration uses PIO mode to write the Flash.

The following steps describe the functionality per the calls during run-time:

1. Sets up SQI to run at 25 MHz. (system_init.c:: SYS_Initialize, app.c:: APP_Initialize)
2. Once the clock frequency is programmed, the demonstration prepares the connected Serial Flash device for a write read transaction (app.c:: APP_Tasks:: APP_STATE_INIT_FLASH:: SQI_Flash_Setup).
3. Reads the device ID of the attached Flash device (app.c:: APP_Tasks:: APP_STATE_FLASH_ID_READ:: SQI_FlashID_Read).
4. Writes a page in Flash in PIO mode (app.c:: APP_Tasks:: APP_STATE_WRITE_FLASH:: SQI_PIO_PageWrite(FLASH_PAGE_ADDR)).
5. Reads the contents of the page in Flash using DMA mode and compares it to the data written to make sure the operation is successful (app.c:: APP_Tasks:: APP_STATE_READ_FLASH_DMA_MODE:: SQI_XIP_Read(FLASH_PAGE_ADDR)).
6. Indicates demonstration success using LED3 (Green LED) on the starter kit (app.c:: APP_Tasks:: APP_STATE_DONE:: BSP_SwitchONLED(LED_GRN)).
7. LED3 OFF, indicates demonstration FAILURE (stuck in one of the states).

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the SQI Peripheral Library Flash Read in XIP Mode Demonstration.

Description

To build this project, you must open the `flash_read_xip_mode.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/examples/peripheral/sqi/flash_read_pio_mode`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`flash_read_xip_mode.X`	`<install-dir>/apps/examples/peripheral/sqi/flash_read_xip_mode/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within ./firmware/src/system_config.

Project Configuration Name	BSP Used	Description
pic32mz_ef_sk	pic32mz_ef_sk	Demonstrates the SQI XIP mode transfer on the PIC32MZ EF Starter Kit.

pic32mz_da_sk	pic32mz_da_sk	Demonstrates the SQI XIP mode transfer on the PIC32MZ DA Starter Kit.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32MZ DA Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ EF Starter Kit

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

Provides instructions on how to build and run the SQI XIP mode transfer demonstration.

Description

This demonstration allows page writes and reads to/from an SQI Flash device.

1. First compile and program the target device. While compiling, select the appropriate configuration for the starter kit in use.
2. Check the state of LED3 on the starter kit to determine the status of the demonstration (LED3 ON indicates success, LED3 OFF indicates failure).

Timer Peripheral Library Examples

This topic provides descriptions of the TMR Peripheral Library examples.

Introduction

Timer Peripheral Library Demonstration Applications Help

Description

This distribution package contains one Timer related firmware project that demonstrates the capabilities of the MPLAB Harmony Timer Peripheral Library.

This section describes the hardware requirement and procedures to run this firmware project on Microchip demonstration and development boards.

To learn more about MPLAB Harmony stacks and libraries refer to the related documentation in Volume IV: MPLAB Harmony Framework Reference.

Demonstrations

This topic provides information on how to run the Timer Peripheral Library demonstration applications included in this release.

timer3_interrupt

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Description

This demonstration uses Timer3 in 32-bit mode to generate an interrupt based on the time-out (1 second).

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the TMR Peripheral Library TMR Alarm Demonstration.

Description

To build this project, you must open the `timer3_interrupt.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/examples/peripheral/tmr/timer3_interrupt`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
timer3_interrupt.X	<install-dir>/apps/examples/peripheral/tmr/timer3_interrupt/firmware

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within ./firmware/src/system_config.

Project Configuration Name	BSP Used	Description
pic32mx795_pim_e16	pic32mx795_pim+e16	Demonstrates the Timer3 interrupt on the PIC32MX795F512L PIM and Explorer 16 Development Board combination.
pic32mx_usb_sk2	pic32mx_usb_sk2	Demonstrates the Timer3 interrupt on the PIC32 USB Starter Kit II.
pic32mz_ec_sk	pic32mz_ec_sk	Demonstrates the Timer3 interrupt on the PIC32MZ Embedded Connectivity (EC) Starter Kit.
pic32mz_ef_sk	pic32mz_ef_sk	Demonstrates the Timer3 interrupt on the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit.
pic32mz_da_sk	pic32mz_da_sk	Demonstrates the Timer3 interrupt on the PIC32MZ Graphics (DA) Starter Kit.
pic32mz_ef_sk_16b	pic32mz_ef_sk	Demonstrates the Timer3 interrupt with 16-bit configuration on the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit.
pic32mx_usb_sk2_freertos	pic32mx_usb_sk2	Demonstrates the Timer3 interrupt on the PIC32 USB Starter Kit II with FreeRTOS running on the configuration.
pic32mz_ef_sk_freertos	pic32mz_ef_sk	Demonstrates the Timer3 interrupt on the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit with FreeRTOS running on the configuration.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32MX795F512L PIM and Explorer 16 Development Board

Jumper JP2 should be connected (shorted) for the LEDs to function.

PIC32MZ EC Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ EF Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ DA Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32 USB Starter Kit II

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

Provides instructions on how to build and run the TMR demonstration.

Description

This demonstration shows the timer/counter capabilities using TMR peripheral library functions.

1. First compile and program the target device. While compiling, select the configuration suitable for the hardware in use.
2. Check the state of the LEDs. LED3 ON status indicates success and LED3 OFF status indicates failure.

USART Peripheral Library Examples

This topic provides descriptions of the USART Peripheral Library examples.

Introduction

USART (USART) Peripheral Library Demonstration Applications Help

Description

This distribution package contains one USART related firmware project that demonstrates the capabilities of the MPLAB Harmony USART Peripheral Library.

This section describes the hardware requirement and procedures to run this firmware project on Microchip demonstration and development boards.

To learn more about MPLAB Harmony stacks and libraries refer to the related documentation in Volume IV: MPLAB Harmony Framework Reference.

Demonstrations

This topic provides information on how to run the USART Peripheral Library demonstration applications included in this release.

uart_basic

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Description

This demonstration uses USART2 in UART mode to transmit characters to the console and echo received characters on the console while turning on a LED.

Building the Application

for the USART Peripheral Library USART Alarm Demonstration.

Description

To build this project, you must open the `uart_basic.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/examples/peripheral/usart/uart_basic`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`uart_basic.X`	`<install-dir>/apps/examples/peripheral/usart/uart_basic/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Configuration Name	BSP Used	Description
pic32mx795_pim_e16	pic32mx795_pim+e16	Demonstrates the USART time-out function on the PIC32MX795F512L PIM and Explorer 16 Development Board combination.
pic32mx_usb_sk2	pic32mx_usb_sk2	Demonstrates the USART peripheral library on PIC32 USB Starter Kit II.
pic32mz_ec_sk	pic32mz_ec_sk	Demonstrates the USART peripheral library on PIC32MZ Embedded Connectivity (EC) Starter Kit.
pic32mz_ef_sk	pic32mz_ef_sk	Demonstrates the USART peripheral library on PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit.
pic32mz_da_sk	pic32mz_da_sk	Demonstrates the USART peripheral library on PIC32MZ Graphics (DA) Starter Kit.
pic32mx795_pim_e16_freertos	pic32mx795_pim+e16	FreeRTOS version of the demonstration, which demonstrates the USART time-out function on the PIC32MX795F512L PIM and Explorer 16 Development Board combination.
pic32mz_ef_sk_freertos	pic32mz_ef_sk	FreeRTOS version of the demonstration, which demonstrates the USART peripheral library on PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit.
pic32mz_ef_sk_16b	pic32mz_ef_sk	microMIPS version of the demonstration, which demonstrates the USART peripheral library on PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32MX795F512L PIM and Explorer 16 Development Board

Connect a standard serial cable or USB-to-RS-232 adapter cable between the personal computer and the Explorer 16 Development Board P1 (UART) port.

PIC32MZ EC Starter Kit or PIC32MZ EF Starter Kit

The optional MCP2200 Breakout Module (ADM00393), which is a USB-to-UART serial converter adapter board, may be used to run this demonstration. If the Breakout Module will be used, an additional interface is required. The acceptable interface is the Starter Kit I/O Expansion Board with the PIC32MZ Starter Kit Adapter Board (AC320006). Jumper from pins 58 and 23 of J10 header to RX and TX of the Breakout module, respectively. In addition, connect GND.

PIC32MZ DA Starter Kit

Connect a USB cable to the J5 Mini Type B connector on the PIC32MZ DA Starter Kit. Connect this USB cable to the computer running the terminal emulation program.

PIC32 USB Starter Kit II

The optional MCP2200 Breakout Module, which is a USB-to-UART serial converter adapter board, may be used to run this demonstration. If the Breakout Module will be used, an additional interface is required. The acceptable interface is the Starter Kit I/O Expansion Board. Jumper from pins 48 and 46 of J11 header to RX and TX of the Breakout Module, respectively. In addition, GND must be shorted.

Running the Demonstration

Provides instructions on how to build and run the USART demonstration.

Description

This demonstration shows the USART capabilities using the USART Peripheral Library functions.

1. First compile and program the target device. While compiling, select the configuration suitable for the hardware in use.
2. Launch a console client (OS native/Tera Term, etc.,) and set the serial port settings to 9600-N-1.
3. Launch the demonstration. The following messages will appear in the console window:
   *** UART Interrupt-driven Application Example ***
   *** Type some characters and observe the LED turn ON ***
4. As indicated in the message, notice the typed characters echoed on the console window and LED.
5. Turn on LED (D3 on Explorer 16 Development Board or LED3 on the PIC32 USB Starter Kit II, PIC32MZ EC Starter Kit, PIC32MZ EF Starter Kit, and PIC32MZ DA Starter Kit) indicating interrupt processing.

WDT Peripheral Library examples

This topic provides descriptions of the WDT Peripheral Library examples.

Introduction

Watchdog Timer (WDT) Peripheral Library Demonstration Applications Help

Description

This distribution package contains one WDT related firmware project that demonstrates the capabilities of the MPLAB Harmony Watchdog Timer Peripheral Library.

This section describes the hardware requirement and procedures to run this firmware project on Microchip demonstration and development boards.

To learn more about MPLAB Harmony stacks and libraries refer to the related documentation in Volume IV: MPLAB Harmony Framework Reference.

Demonstrations

This topic provides information on how to run the WDT Peripheral Library demonstration applications included in this release.

wdt_timeout

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the

demonstration.

Description

This demonstration exercises the watchdog time-out function using the WDT Peripheral Library.

Building the Application

for the WDT Peripheral Library WDT Alarm Demonstration.

Description

To build this project, you must open the `wdt_timeout.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/examples/peripheral/wdt/wdt_timeout`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`wdt_timeout.X`	`<install-dir>/apps/examples/peripheral/wdt/wdt_timeout/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Configuration Name	BSP Used	Description
pic32mx795_pim_e16	pic32mx795_pim+e16	Demonstrates the WDT time-out function on the PIC32MX795F512L PIM and Explorer 16 Development Board combination.
pic32mx_usb_sk2	pic32mx_usb_sk2	Demonstrates the WDT time-out function on the PIC32 USB Starter Kit II.
pic32mz_ec_sk	pic32mz_ec_sk	Demonstrates the WDT time-out function on the PIC32MZ Embedded Connectivity (EC) Starter Kit.
pic32mz_ef_sk	pic32mz_ef_sk	Demonstrates the WDT time-out function on the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit.
pic32mz_da_sk	pic32mz_da_sk	Demonstrates the WDT time-out function on the PIC32MZ Graphics (DA) Starter Kit.
pic32mx795_pim_e16_freertos	pic32mx795_pim+e16	FreeRTOS version of the demonstration, which demonstrates the WDT time-out function on the PIC32MX795F512L PIM and Explorer 16 Development Board combination.
pic32mz_ef_sk_freertos	pic32mz_ef_sk	FreeRTOS version of the demonstration, which demonstrates the WDT time-out function on the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit.
pic32mz_ef_sk_16b	pic32mz_ef_sk	microMIPS version of the demonstration, which demonstrates the WDT time-out function on the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32 USB Starter Kit II

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ EC Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ EF Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ DA Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32MX795F512L PIM and Explorer 16 Development Board

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

Provides instructions on how to build and run the WDT time-out demonstration.

Description

This demonstration exercises the WDT time-out function.

1. First compile and program the target device. While compiling, select the configuration suitable for the hardware in use.
2. The LEDs (LED1 on the PIC32 USB Starter Kit II, PIC32MZ EC Starter Kit, PIC32MZ EF Starter Kit and PIC32MZ DA Starter Kit, or LED D3 on the Explorer 16 Development Board) will blink during normal operation.
3. Press Switch 1 (PIC32 USB Starter Kit II, PIC32MZ EC Starter Kit, PIC32MZ EF Starter Kit and PIC32MZ DA Starter Kit) or Switch S3 (Explorer 16 Development Board) for the WDT time-out reset. If the demonstration is successful, LED3 (PIC32 USB Starter Kit II, PIC32MZ EC Starter Kit, PIC32MZ EF Starter Kit, and PIC32MZ DA Starter Kit) or LED D5 (Explorer 16 Development Board) will illuminate. If they do not, this indicates demonstration failure.

System Service Library Examples

Introduction

The example applications provide very simple single-purpose examples of how to use MPLAB Harmony system service libraries.

Description

System services have two primary types of implementations:

- System Service Libraries
- Low-Level Support

Most system service libraries follow the same basic model as a device driver (directly using a peripheral library to access hardware) or a middleware library (using a device driver to access hardware) as the rest of the system.

Command Processor System Service Examples

This topic provides descriptions of the Command Processor System Service examples.

Introduction

Command Processor System Service Library Demonstration Applications Help.

Description

This distribution package contains a firmware project that demonstrates the capabilities of the MPLAB Harmony Command Processor System Service. This section describes the hardware requirement and procedures to run this firmware project on Microchip demonstration and development boards.

To learn more about MPLAB Harmony stacks and libraries refer to the related documentation in Volume IV: MPLAB Harmony Framework Reference.

Demonstrations

This topic provides information on how to run the Command Processor System Service Library demonstration applications included in this release.

command_appio

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Description

This demonstration application exercises the Command Processor System Service by receiving user keyboard input and displaying the output string to the PIC AppIO window in MPLAB X IDE.

The demonstration application does the following:

1. Launches the application via MPLAB REAL ICE to a target device.
2. Displays "Ready to accept command input" in the PIC AppIO window in MPLAB X IDE at initialization.

3. Listens for user command input.
4. Supports two simple commands native to this application.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the Command Processor System Service Demonstration.

Description

To build this project, you must open the `command_appio.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/examples/system/command_appio`

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`command_appio.X`	`<install-dir>/apps/examples/system/command_appio/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx_usb_sk2	pic32mx_usb_sk2	Demonstrates application I/O using the PIC32 USB Starter Kit II, the Starter Kit I/O Expansion Board and the MPLAB REAL ICE in-circuit emulator.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32 USB Starter Kit II

This demonstration requires the MPLAB REAL ICE in-circuit emulator and the Starter Kit I/O Expansion Board.

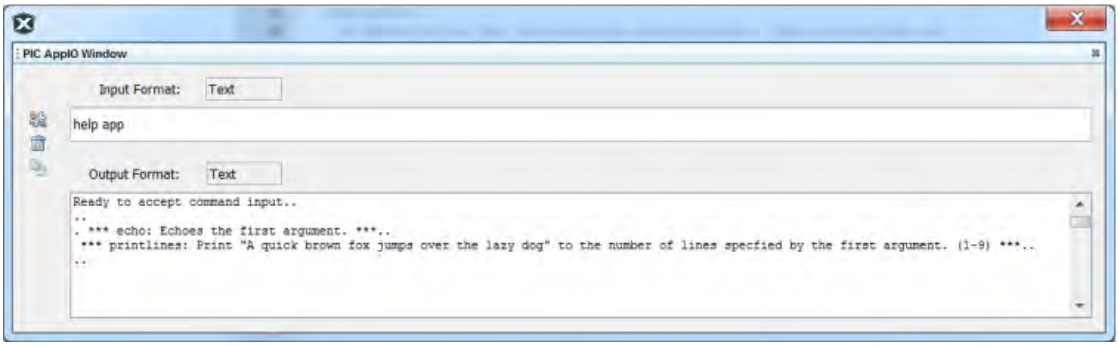
Running the Demonstration

Provides instructions on how to build and run the Command Processor System Service demonstration.

Description

Do the following to run the demonstration:

1. Ensure that the PIC32 USB Starter Kit II, the Starter Kit I/O Expansion Board, and the MPLAB REAL ICE in-circuit emulator are connected and ready.
2. Open the PIC AppIO window in MPLAB X IDE by selecting *Window* > *Debugging* > *PIC AppIO*.
3. Make sure the Output Format in PIC AppIO is set to "Text" (the default is 8-bit hex).
4. Debug the project.
5. Wait for "Ready to accept command input" to display in the Output Format section.
6. Type keyboard input into the Input Format bar and press <ENTER>.
7. Typing "help" will display the general help sections. Typing "help app" will display the commands unique to the application including a brief description.
8. Try the commands listed by "help app".



Console System Service Examples

This topic provides descriptions of the Console System Service examples.

Introduction

Console System Service Library Demonstration Applications Help.

Description

This distribution package contains a firmware project that demonstrates the capabilities of the MPLAB Harmony Console System Service. This section describes the hardware requirement and procedures to run this firmware project on Microchip demonstration and development boards.

To learn more about MPLAB Harmony stacks and libraries refer to the related documentation in Volume IV: MPLAB Harmony Framework Reference.

Demonstrations

This topic provides information on how to run the Console System Service Library demonstration applications included in this release.

multi_instance_console

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Description

This demonstration illustrates the read and write operation on the Console when multiple Console instances are running simultaneously. The project has three configurations, the first configuration demonstrates simultaneous operation of the UART Console and the USB CDC Console, the second configuration shows the UART Console and the AppIO Console and the third configuration shows the USB CDC Console and the AppIO Console.

The application perform the following tasks:

- Each instance of Console prints a welcome message and prompts the user to enter a string
- The string that is entered by the user is echoed back to the Console
- The read operation completion can be checked through both polling and by indication of a callback
- The application is designed so that the two Console instances can run independently of each other

Libraries Used

The Console System Service resides as the top layer. The UART and USB Drivers are used depending on the choice of Console selected. The UART and USB Drivers call their respective Peripheral Libraries (PLIBs) to interact with the hardware. If AppIO is selected as the Console choice, the AppIO service is used, which is provided with the MPLAB X IDE C/C++ XC32 Compiler.

The application interacts directly with the Console System Service Library. The Console System Service Library, depending upon the choice of console driver, makes calls to the UART, USB, or AppIO.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the Command Processor System Service Demonstration.

Description

To build this project, you must open the `multi_instance_console.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/examples/system/multi_instance_console`

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`multi_instance_console.X`	`<install-dir>/apps/examples/system/multi_instance_console/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx_usb_sk2	pic32mx_usb_sk2	Demonstrates USB CDC and AppIO Console instances running simultaneously on the PIC32 USB Starter Kit II.
pic32mx795_pim_e16	pic32mx795_pim+e16	Demonstrates UART and AppIO Console instances running simultaneously on the the PIC32MX795F512L PIM with the Explorer 16 Development Board.
pic32mz_ef_sk_meb2	pic32mz_ef_sk+meb2	Demonstrates UART and USB CDC Console instances running simultaneously on the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32 USB Starter Kit II

This demonstration requires the MPLAB REAL ICE in-circuit emulator for communication with AppIO and the Starter Kit I/O Expansion Board.

PIC32MX795F512L PIM with the Explorer 16 Development Board

This demonstration requires the MPLAB REAL ICE in-circuit emulator for communication with AppIO.

PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

Provides instructions on how to build and run the Console System Service demonstration.

Description

Depending on the hardware in use, use on the of the following three procedures to run the demonstration.

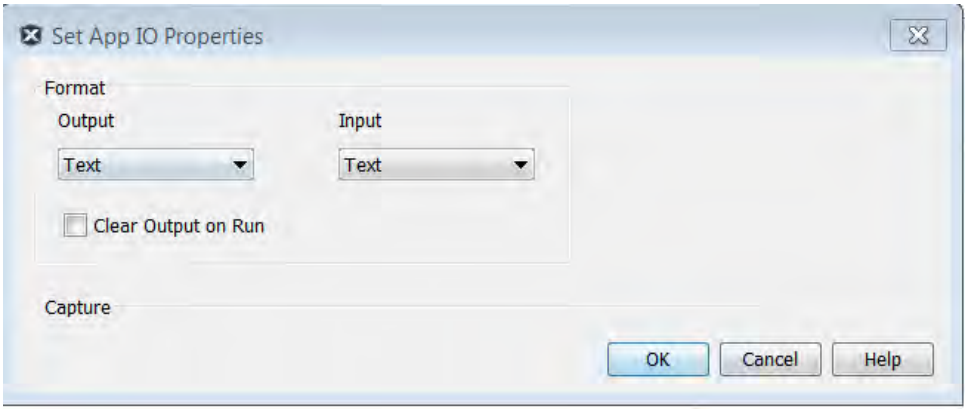
PIC32 USB Starter Kit II

This demonstration writes and reads to/from a terminal program running on a personal computer host and also from the AppIO interface in MPLAB X IDE.

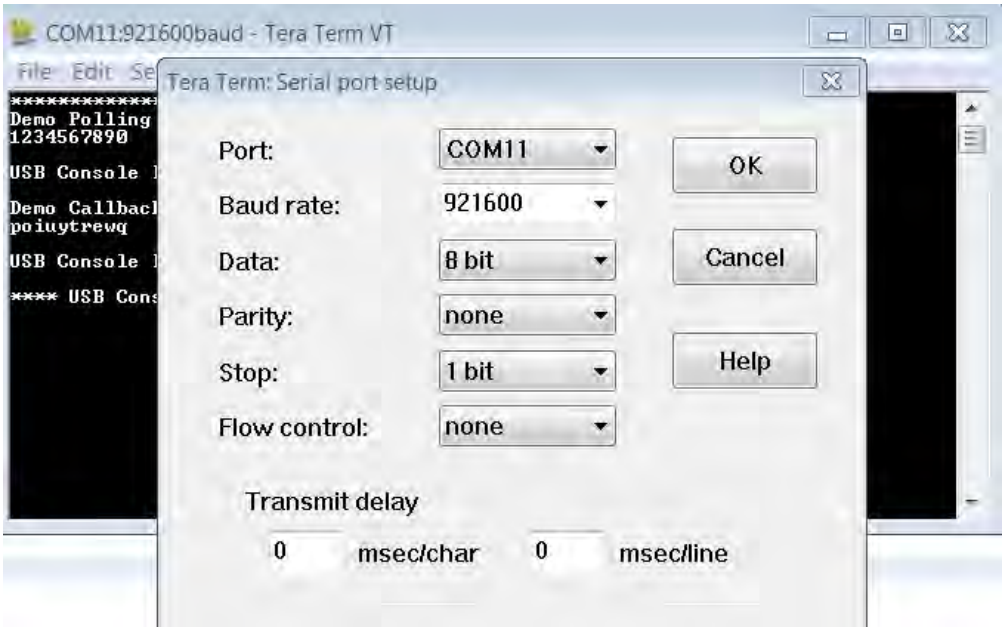
This demonstration utilizes the PIC32 USB Starter Kit II and requires the starter kit to be paired with the Starter Kit I/O Expansion Board.

Since AppIO uses the Debug interface, it also requires the MPLAB REAL ICE in-circuit emulator.

1. In MPLAB X IDE, select the hardware configuration to be used. Compile and program the target device in Debug mode with the selected configuration.
2. Open the AppIO window in MPLAB X IDE by selecting *Window* > *Debugging* > *PIC AppIO*.
3. Ensure that the Output Format in PIC AppIO is set to "Text" (the default is 8-bit hex), as shown in the following figure.

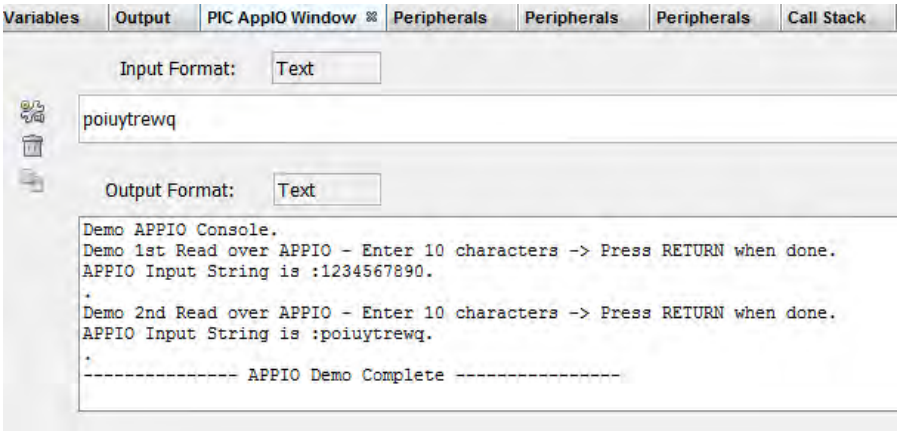


4. Before connecting the micro-USB cable to the host computer, the demonstration must be running for the terminal program to recognize the USB COM device. Once the demonstration is running, start a terminal emulator program (Tera Term shown) with serial port settings (921600 baud, 8 bit data, no parity, 1 bit stop, no flow control), as shown in the following figure.



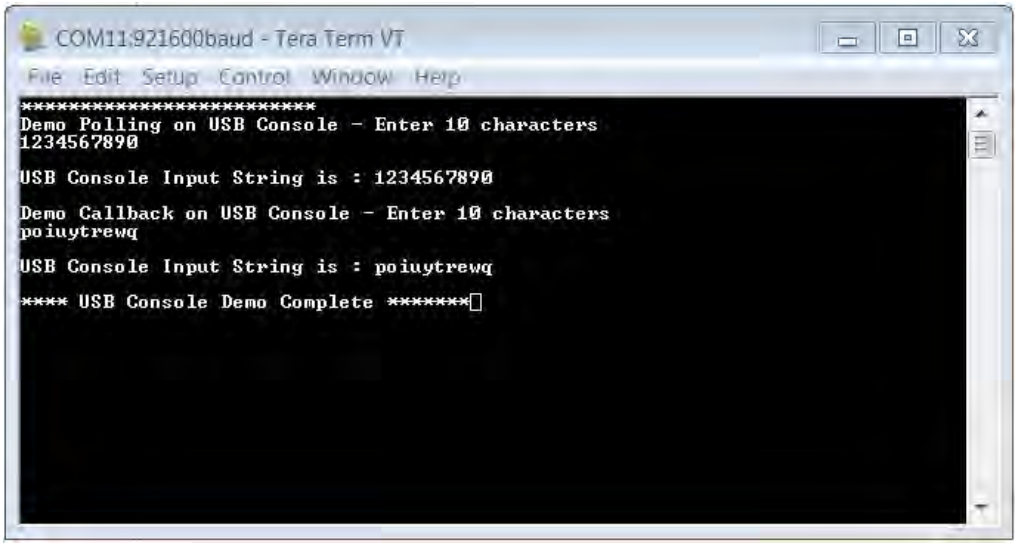
Demonstration Output

When running the program in debug mode, the AppIO interface will display messages, as shown in the following figure.



It is important to note that the AppIO interface implements a blocking read call expecting data from debug interface until the user enters a RETURN, so all of the necessary AppIO read operations should be executed first before proceeding with the USB Console.

USB can be executed only after the AppIO demonstration is complete. A display similar to the following figure can be expected after execution of the USB Console demonstration.

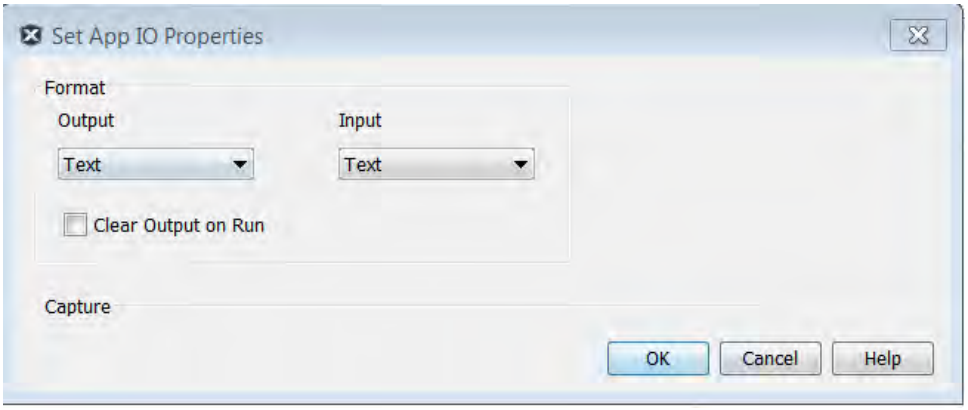


PIC32MX795F512 PIM and Explorer 16 Development Board

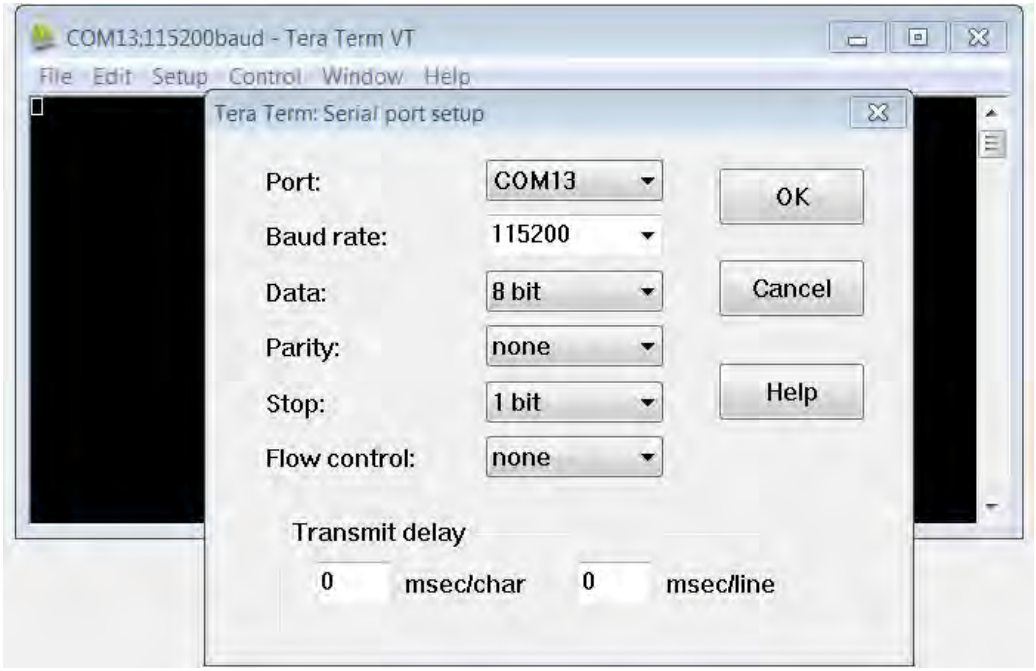
This demonstration reads and writes to a terminal program running on a personal computer host and also from the AppIO interface in MPLAB X IDE.

This demonstration utilizes the PIC32795F512L PIM paired with the Explorer 16 Development Board.

1. In MPLAB X IDE, select the hardware configuration to be used. Compile and program the target device in Debug mode with the selected configuration.
2. Open the AppIO window in MPLAB X IDE by selecting *Window > Debugging > PIC AppIO*.
3. Ensure that the Output Format in PIC AppIO is set to "Text" (the default is 8-bit hex), as shown in the following figure.

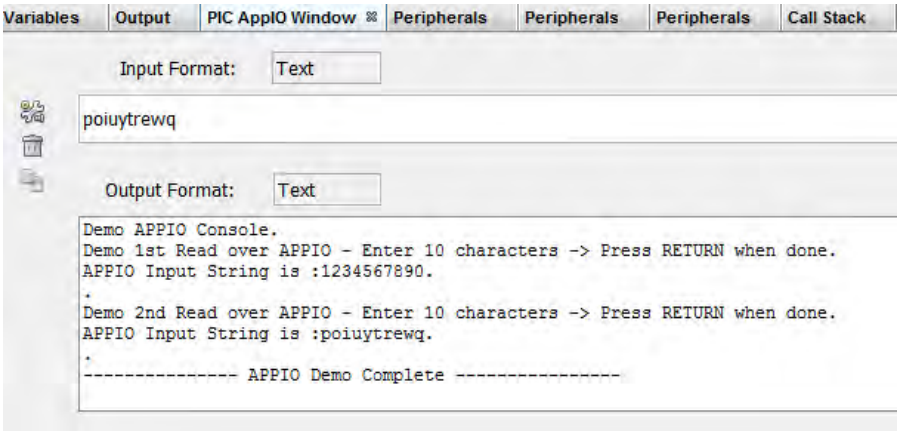


4. Connect the Explorer 16 Development Board to the host personal computer using a RS-232 UART connection.
5. A terminal program like Tera Term can be used with the settings shown in the following figure.



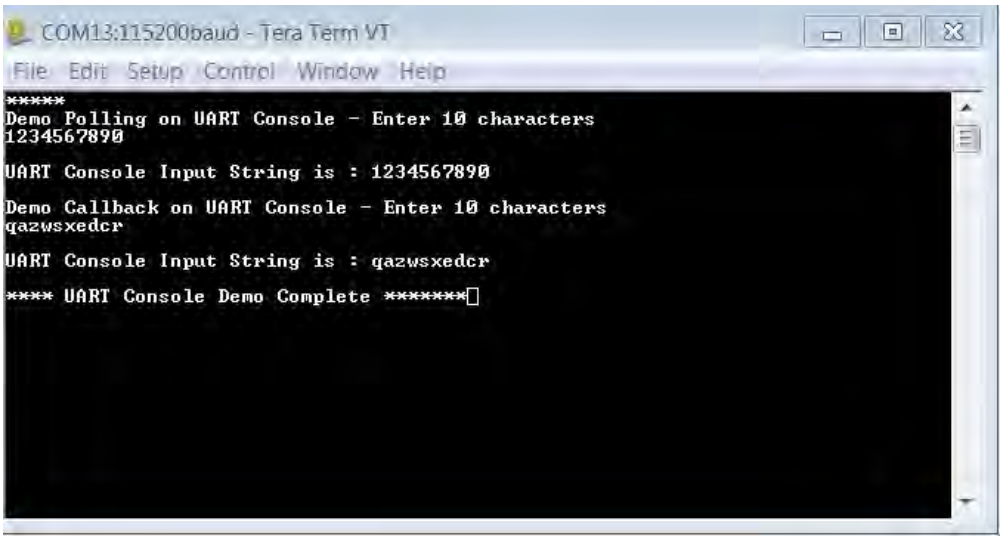
Demonstration Output

When running the program in debug mode, the AppIO interface will display messages, as shown in the following figure.



It is important to note that the AppIO interface implements a blocking read call, expecting data from debug interface until the user enters a RETURN, so all of the necessary AppIO read operations should be executed first before proceeding with the UART Console.

Once AppIO operation is complete, the UART Console can be executed. A display similar to the following figure can be expected.

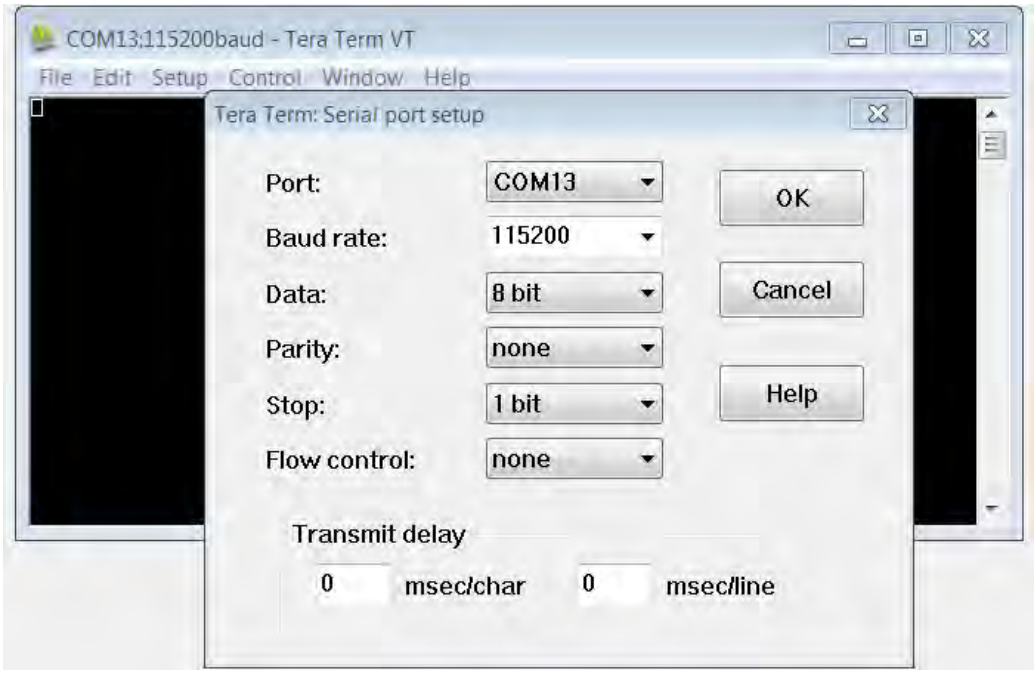


PIC32MZ EF Starter Kit

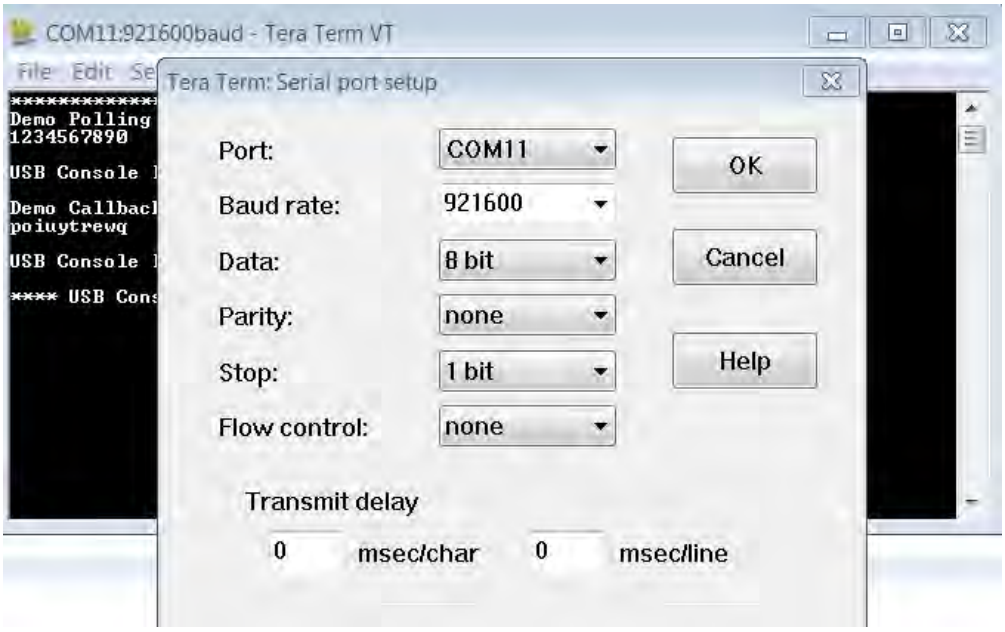
This demonstration reads and writes and to a terminal program running on a personal computer host that uses the UART and USB CDC 2 Console.

This demonstration utilizes the PIC32MZ EF Starter Kit.

1. In MPLAB X IDE, select the hardware configuration to be used. Compile and program the target device in Debug mode with the selected configuration.
2. Connect the PIC32MZ EF Starter Kit to the host personal computer using a mini-USB cable for the UART connection and a micro-USB cable for the USB connection.
3. A terminal program such as Tera Term can be used with the following UART settings.



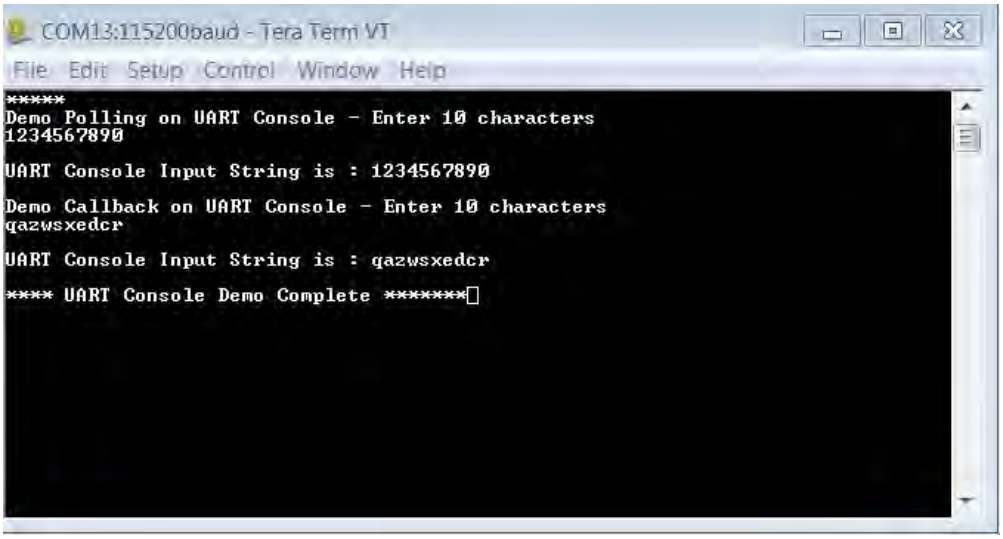
4. Before connecting the micro-USB cable to the host computer, the demonstration must be running for the terminal program to recognize the USB COM device. Once the demonstration is running, start a terminal emulator program (e.g., Tera Term) with serial port with the following USB settings: (921600 baud, 8 bit data, no parity, 1 bit stop, no flow control), as shown in the following figure.



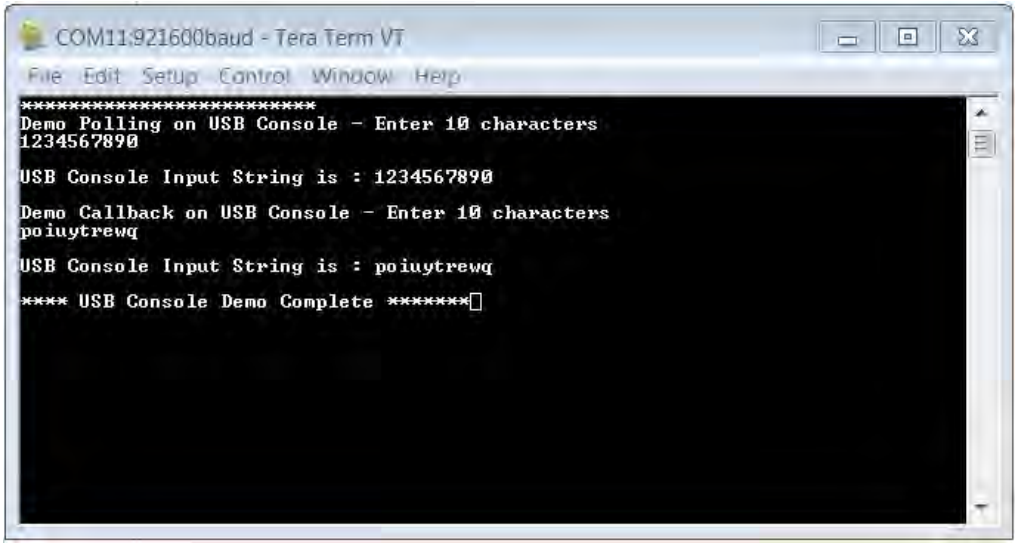
Demonstration Output

Since the UART and USB Console are running independently, the order in which the user interacts with each Console is irrelevant.

The UART Console should show an output similar to the following figure.



The USB Console should show an output similar to the following figure.



Debug System Service Examples

This topic provides descriptions of the Debug System Service examples.

Introduction

Debug System Service Library Demonstration Applications Help.

Description

This distribution package contains a firmware project that demonstrates the capabilities of the MPLAB Harmony Debug System Service. This section describes the hardware requirement and procedures to run this firmware project on Microchip demonstration and development boards.

To learn more about MPLAB Harmony stacks and libraries refer to the related documentation in Volume IV: MPLAB Harmony Framework Reference.

Demonstrations

This topic provides information on how to run the Debug System Service Library demonstration applications included in this release.

debug_uart

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Description

This demonstration application exercises the Debug and Console System Services by routing messages from the Debug System Service through the Console System Service to a terminal program running on a personal computer via the UART communications protocol.

The demonstration application does the following:

- Demonstrates a direct console write by outputting a string to the terminal
- Demonstrates formatted and unformatted message writes to the terminal
- Demonstrates the use of the global error level
- Demonstrates debug output messaging using both polling and callback notification of completion
- Demonstrates what happens when the write queue overflows
- Demonstrates console flush in reaction to an error condition
- Demonstrates console read using both polling and callback notification
- Demonstrates an echo function in which the characters are written back to the terminal as they are read

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the Debug System Service Demonstration.

Description

To build this project, you must open the `debug_uart.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/examples/system/debug_uart`

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`debug_uart.X`	`<install-dir>/apps/examples/system/debug_uart/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx795_pim_e16	pic32mx795_pim+e16	Demonstration console communication via UART RS-232 using the Explorer 16 Development Board and the PIC32MX795F512L PIM.
pic32mz_ef_sk	pic32mz_ef_sk	Demonstration console communication via UART RS-232 using using the PIC32MZ EF Starter Kit.
pic32mz_da_sk	pic32mz_da_sk	Demonstration console communication via UART RS-232 using the PIC32MZ DA Starter Kit.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32MX795F512L PIM combined with the Explorer 16 Development Board

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ DA Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ EF Starter Kit

No hardware related configuration or jumper setting changes are necessary.

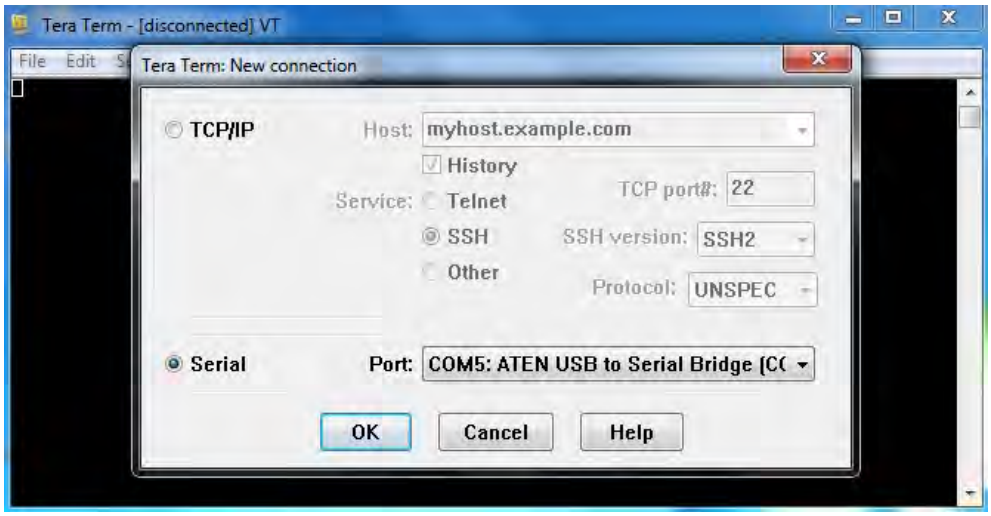
Running the Demonstration

Provides instructions on how to build and run the Debug System Service demonstration.

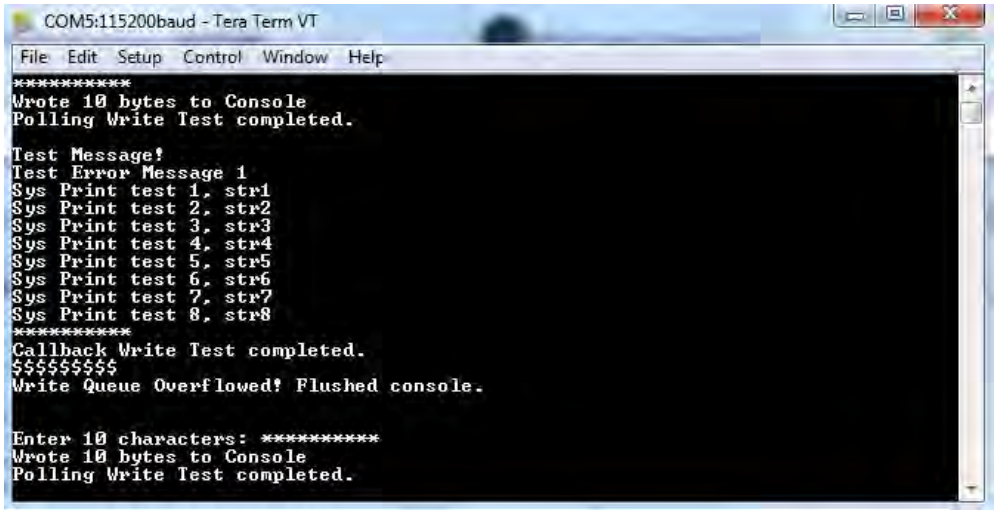
Description

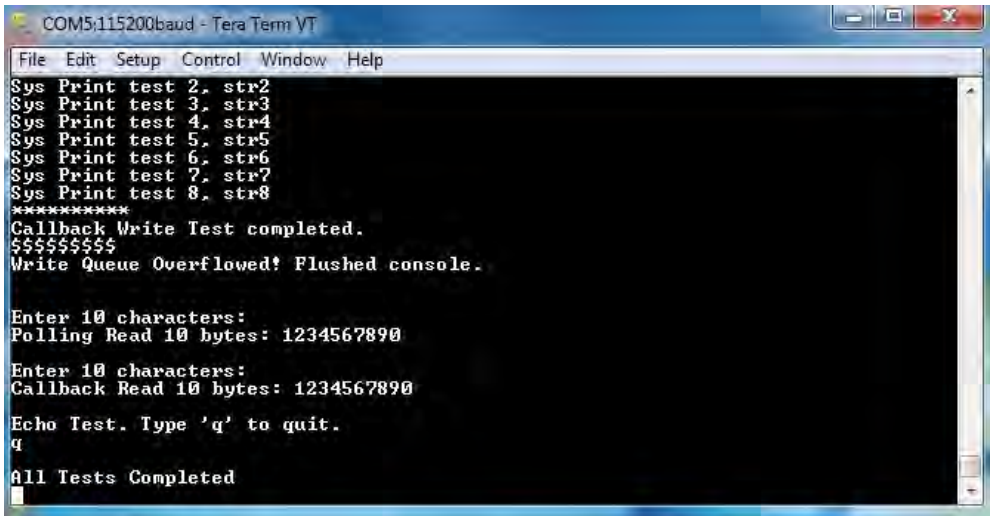
This demonstration writes and reads to/from a terminal program running on a personal computer host.

1. First compile and program the target device. While compiling, select the configuration for the hardware in use.
2. Connect the Explorer 16 Development Board to the host personal computer using a RS-232 UART connection.
3. The demonstration must be running for the terminal program to recognize the COM device. Start a terminal emulator program (Tera Term shown).



4. Press SW1 to start the demonstration.
5. Follow the instructions on the terminal.





debug_usb_cdc_2

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Description

This demonstration application exercises the Debug and Console System Services by routing messages from the Debug System Service through the Console System Service to a terminal program running on a personal computer via the USB-CDC communications protocol.

The demonstration application does the following:

- Demonstrates a direct console write by outputting a string to the terminal
- Demonstrates formatted and unformatted message writes to the terminal
- Demonstrates the use of the global error level
- Demonstrates debug output messaging using both polling and callback notification of completion
- Demonstrates what happens when the write queue overflows
- Demonstrates console flush in reaction to an error condition
- Demonstrates console read using both polling and callback notification
- Demonstrates an echo function in which the characters are written back to the terminal as they are read

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the Debug System Service Demonstration.

Description

To build this project, you must open the `debug_usb_cdc_2.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/examples/system/debug_usb_cdc_2`

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`debug_usb_cdc_2.X`	`<install-dir>/apps/examples/system/debug_usb_cdc_2/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx_usb_sk2	pic32mx_usb_sk2	Demonstrates console communication through USB with the PIC32 USB Starter Kit II.
pic32mz_ec_sk	pic32mz_ec_sk	Demonstrates console communication through USB with the PIC32MZ EC Starter Kit.
pic32mz_ef_sk	pic32mz_ef_sk	Demonstrates console communication through USB with the PIC32MZ EF Starter Kit.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32MZ EC Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ EF Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32 USB Starter Kit II

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

Provides instructions on how to build and run the Debug System Service demonstration.

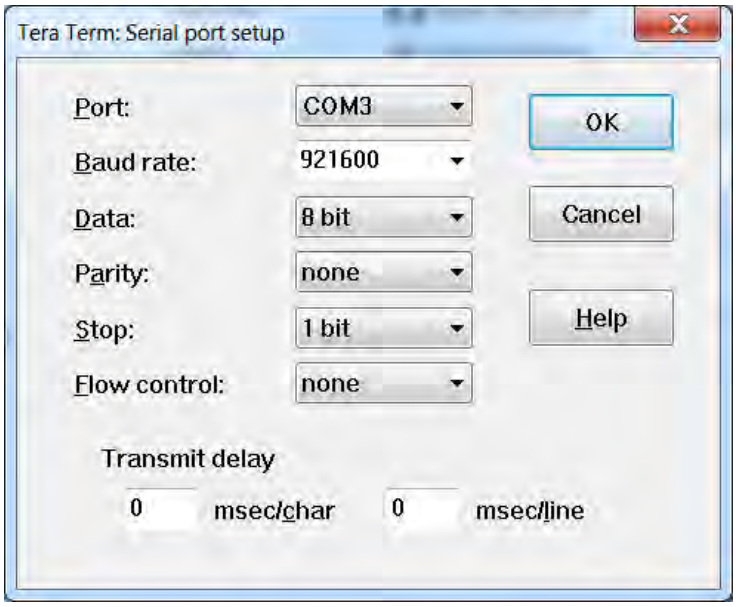
Description

This demonstration writes and reads to/from a terminal program running on a personal computer host.

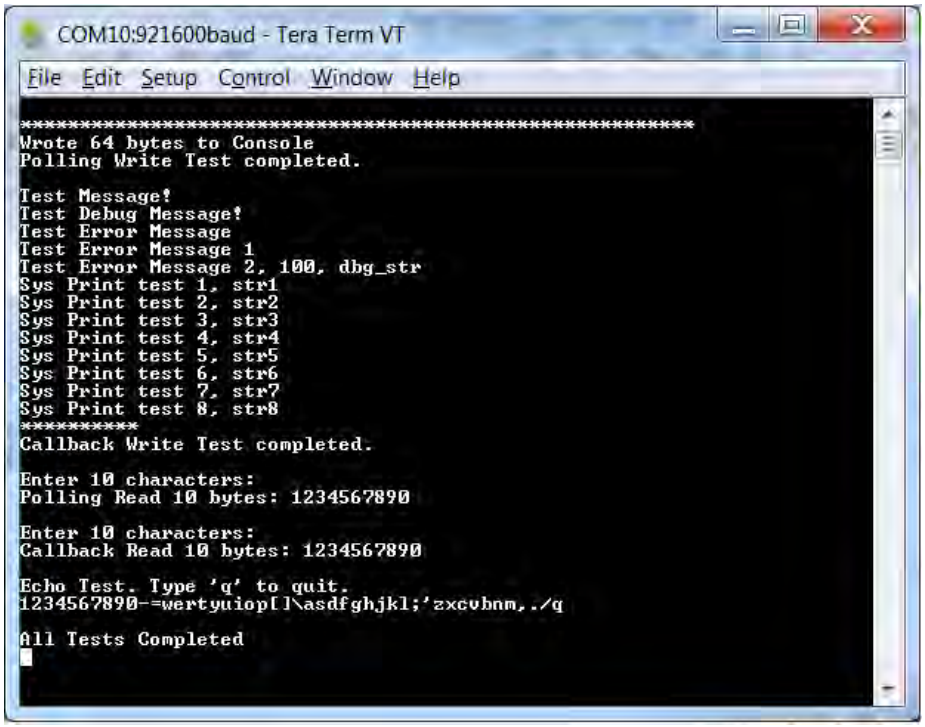
1. First compile and program the target device. While compiling, select the pic32mz_ec_sk configuration for the PIC32MZ EC Starter Kit, the

pic32mz_ef_sk configuration for the PIC32MZ EF Starter Kit, or the pic32mx_usb_sk2 configuration for the PIC32MX USB Starter Kit II.

2. Connect the starter kit to the host personal computer using an A to micro-A/B USB cable.
3. The demonstration must be running for the terminal program to recognize the COM device. Start a terminal emulator program (Tera Term shown) with serial port with the following settings: (921600 baud, 8 bit data, no parity, 1 bit stop, no flow control).



4. The terminal will indicate a successful connection. Press any key on the computer to start the demonstration.
5. Follow the instructions on the terminal.



Device Control System Service Examples

This topic provides descriptions of the Device Control System Service examples.

Introduction

Device Control System Service Library Demonstration Applications Help.

Description

This distribution package contains a firmware project that demonstrates the capabilities of the MPLAB Harmony Device Control System Service.

This section describes the hardware requirement and procedures to run this firmware project on Microchip demonstration and development boards.

To learn more about MPLAB Harmony stacks and libraries refer to the related documentation in Volume IV: MPLAB Harmony Framework Reference.

Demonstrations

This topic provides information on how to run the Device Control System Service Library demonstration applications included in this release.

devcon_cache_clean

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Description

This example application demonstrates how cache coherency issues arise when transferring data out of memory using DMA. The MPLAB Harmony Device Control System Service contains various cache functions, which are used in this example to resolve the problem.

The application first allocates two buffers, with the intention of copying the data in one buffer to the other using DMA. The source buffer is first loaded with data and then the DMA transfer is initiated. After the transfer is complete, it is clear that the two buffers contain different values. This is an issue relating to cache coherency. When data is written by the CPU, it is stored in the cache but it is not written back to RAM unless the line is evicted or an explicit cache write-back instruction is executed. The cache instructions are accessed through the Device Control System Service and serve as a wrapper to the underlying MIPS® cache operations.

In this specific example, the data in the source buffer was never written back to RAM before being transferred to the destination buffer using DMA. Data that is stored in cache but has not yet been written back to RAM is termed "dirty". In the second part of the application, the correct method of maintaining cache coherency is demonstrated. After writing data to the source buffer, the function SYS_DEVCON_DataCacheClean is executed, forcing the data to be written back to main memory. When the DMA transfer is initiated, it then pulls the data out of RAM and transfers it to the destination buffer – this time, the data in both buffers will match.

If the application runs as intended, the red and green LEDs will be lit. The yellow LED will only be lit if an error has occurred.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the Device Control System Service Cache Clean Demonstration.

Description

To build this project, you must open the `devcon_cache_clean.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/examples/system/devcon`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`devcon_cache_clean.X`	`<install-dir>/apps/examples/system/devcon/devcon_cache_clean/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mz_ec_sk	pic32mz_ec_sk	Demonstrates Device Control System Service cache functions using the PIC32MZ EC Starter Kit.
pic32mz_ef_sk	pic32mz_ef_sk	Demonstrates Device Control System Service cache functions using the PIC32MZ EF Starter Kit.
pic32mz_da_sk	pic32mz_da_sk	Demonstrates Device Control System Service cache functions using the PIC32MZ DA Starter Kit.
pic32mz_ef_sk_16b	pic32mz_ef_sk	Demonstrates Device Control System Service cache functions in microMIPS mode using the PIC32MZ EF Starter Kit.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32MZ EC Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ EF Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ DA Starter Kit

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

Provides instructions on how to build and run the demonstration.

Description

This application demonstrates the necessity and proper use of the SYS_DEVCON_DataCacheClean function.

1. First compile and program the target device. When compiling, select the correct configuration for the device.
2. Observe the LEDs on the starter kit development board. If the red and green LEDs are both lit, the application executed successfully. If the yellow LED is lit, an error has occurred.

devcon_cache_invalidate

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Description

This example application demonstrates how cache coherency issues arise when transferring data into memory using DMA. The MPLAB Harmony Device Control System Service contains various cache functions, which are used in this example to resolve the problem.

The application first allocates three buffers – two source buffers and one destination buffer. The two source buffers are filled with two different sets of data. The first buffer is copied to the destination buffer using DMA and the application checks to ensure they both contain the same data (which they do). The second source buffer is then copied to the destination buffer using DMA and once again the data is compared. This time the data does not match and once again, it is due to a cache coherency issue.

After the first DMA transfer and read of the destination buffer, the data is pulled into the cache. The second DMA transfer then updates the data contained in the destination buffer, but only the data contained in RAM. As far as the cache is aware, the stale data in the cache still matches the fresh data that is now in RAM. The cache simply sees that it is already storing a copy of the destination buffer, so it need not bother to pull the fresh data into itself when the CPU does the second set of reads. What we need is a way to tell the CPU to get rid of the stale cached data and pull in fresh data from main memory – this is known as an 'invalidate'. The example application demonstrates the proper technique for taking care of this issue. After the second DMA transfer, the destination buffer must be invalidated with the use of the function SYS_DEVCON_DataCacheInvalidate. This marks the data of interest in the cache as invalid. Now when the CPU performs a read on the destination buffer, fresh data is pulled out of main memory and into the cache, before being presented to the CPU.

If the application runs as intended, the red and green LEDs will be lit. The yellow LED will only be lit if an error has occurred.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the Device Control System Service Cache Invalidate Demonstration.

Description

To build this project, you must open the `devcon_cache_invalidate.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/examples/system/devcon`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`devcon_cache_invalidate.X`	`<install-dir>/apps/examples/system/devcon/devcon_cache_invalidate/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mz_ec_sk	pic32mz_ec_sk	Demonstrates Device Control System Service cache functions using the PIC32MZ EC Starter Kit.
pic32mz_ef_sk	pic32mz_ef_sk	Demonstrates Device Control System Service cache functions using the PIC32MZ EF Starter Kit.
pic32mz_da_sk	pic32mz_da_sk	Demonstrates Device Control System Service cache functions using the PIC32MZ DA Starter Kit.
pic32mz_ef_sk_16b	pic32mz_ef_sk	Demonstrates Device Control System Service cache functions in microMIPS mode using the PIC32MZ EF Starter Kit.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32MZ EC Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ EF Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ DA Starter Kit

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

Provides instructions on how to build and run the demonstration.

Description

This application demonstrates the necessity and proper use of the SYS_DEVCON_DataCacheInvalidate API.

1. First compile and program the target device. When compiling, select the correct configuration for the device.
2. Observe the LEDs on the starter kit development board. If the red and green LEDs are both lit, the application executed successfully. If the yellow LED is lit, an error has occurred.

devcon_sys_config_perf

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Description

This demonstration provides an example of how to initialize the service and configure optimum system performance using the SYS_DEVCON_PerformanceConfig API.

The demonstration application does the following:

- Initializes the Device Control System Service
- Calls the SYS_DEVCON_PerformanceConfig API
- Waits in a busy loop

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the Device Control System Service Demonstration.

Description

To build this project, you must open the `devcon_sys_config_perf.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/examples/system/devcon`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
devcon_sys_config_perf.X	<install-dir>/apps/examples/system/devcon/devcon_sys_config_perf/firmware

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within ./firmware/src/system_config.

Project Configuration Name	BSP Used	Description
pic32mx_eth_sk	pic32mx_eth_sk	Demonstrates various Device Control System Service cache functions using the PIC32 Ethernet Starter Kit.
pic32mz_ec_sk	pic32mz_ec_sk	Demonstrates Device Control System Service cache functions using the PIC32MZ EC Starter Kit.
pic32mz_ef_sk	pic32mz_ef_sk	Demonstrates Device Control System Service cache functions using the PIC32MZ EF Starter Kit.
pic32mz_da_sk	pic32mz_da_sk	Demonstrates Device Control System Service cache functions using the PIC32MZ DA Starter Kit.
pic32mz_ef_sk_16b	pic32mz_ef_sk	Demonstrates Device Control System Service cache functions in microMIPS mode using the PIC32MZ EF Starter Kit.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32MZ EC Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ EF Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ DA Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32 Ethernet Starter Kit

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

Provides instructions on how to build and run the Device Control System Service demonstration.

Description

This demonstration initializes the Device Control System Service and demonstrates the use of the SYS_DEVCON_PerformanceConfig API.

1. Select the desired MPLAB X IDE project configuration:
   - pic32mz_ec_sk (for PIC32MZ EC devices)
   - pic32mz_ef_sk (for PIC32MZ EF devices)
   - pic32mz_da_sk (for PIC32MZ DA devices)
   - pic32mx_eth_sk (for PIC32MX devices)
2. Build the selected configuration in the MPLAB X IDE project and program the demonstration board by selecting **Debug Main Project** from the Debug Menu. The program should build, download, and run.
3. Select **Pause** from the Debug menu. The program should pause in one of Tasks routines.
4. To verify that the device was initialized correctly, select *Window* > *PIC Memory Views* > *Peripherals* and check for the following:
   - for PIC32MZ, verify in the PRECON register
   - PFMWS is set to 2
   - PREFEN is set to 3
   - PIC32MX, verify in the CHECON register
   - PFMWS is set to 2
   - PREFEN is set to 3

DMA System Service Examples

This topic provides descriptions of the DMA System Service examples.

Introduction

DMA System Service Library Demonstration Applications Help.

Description

This distribution package contains a firmware project that demonstrates the capabilities of the MPLAB Harmony DMA System Service. This section describes the hardware requirement and procedures to run this firmware project on Microchip demonstration and development boards.

To learn more about MPLAB Harmony stacks and libraries refer to the related documentation in Volume IV: MPLAB Harmony Framework Reference.

Demonstrations

This topic provides information on how to run the DMA System Service Library demonstration applications included in this release.

dma_crc

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Description

This application demonstrates how to use the special function of CRC computation of the PIC32 DMA module by using the MPLAB Harmony DMA System Service Library. This section describes the hardware requirement and procedures to build and execute the demonstration project on Microchip development tools.

In this demonstration application, the DMA System Service sets up a memory to memory data transfer. It also enables the CRC engine to compute the CRC of the data being transferred from source location to destination location.

To know more about the MPLAB Harmony DMA System Service, configuring the DMA System Service and the APIs provided by the DMA System service, refer to the DMA System Service Library section of the help.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the DMA System Service Demonstration.

Description

To build this project, you must open the `dma_crc.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/examples/system/dma`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`dma_crc.X`	`<install-dir>/apps/examples/system/devcon/dma_crc/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mz_ef_sk	pic32mz_ef_sk	This demonstration runs on the PIC32MZ2048EFM144 device on-board the PIC32MZ EF starter kit. The configuration can be used for generating CRC using a 16-bit polynomial in background mode.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32MZ EF Starter Kit

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

Provides instructions on how to build and run the demonstration.

Description

1. Compile the demonstration application. While compiling, select the appropriate MPLAB X IDE project configuration based on the demonstration board. Refer to Building the Application for details.
2. Run the demonstration application in Debug mode by clicking **Debug** in MPLAB X IDE
3. The LED2 should illuminate. The illumination of LED2 indicates that the data is being transferred from the source to the destination and the CRC is computed as the data was transferred.
4. Click **Pause** in the MPLAB X IDE.
5. In the Variables window, observe the debug variable `blockCrc`. The `blockCrc` variable should have a value 0x31C3, which is the CRC value for 16-bit polynomial with an initial seed value of '`0`'.

Note on CRC Calculation: The CRC computation on the various websites usually uses the table approach method for CRC calculation. The table approach CRC calculation method generally pads the incoming message with extra 0 bits (16 bits in the case of a 16-bit polynomial, and 32 bits in the case of 32-bit polynomial). The PIC32 DMA CRC generation does not pad with any extra bits. The PIC32 DMA CRC calculation engine strictly calculates CRC of the input data buffer.

To obtain comparable results with the websites we have to append extra bits; 16 bits, or two zeros (bytes) for 16-bit polynomial computation. 32 bits or four zeros (bytes) for 32-bit polynomial computation. Therefore, the data transfer call in our DMA System Service CRC computation application has the size appended with polynomial length as shown in the following example:

```
SYS_DMA_ChannelTransferAdd(channelHandle, flashBuff,
        (APP_DMA_CRC_BUFFER_SIZE + (crc.polyLength/8)) ,
        ramBuff,(APP_DMA_CRC_BUFFER_SIZE + (crc.polyLength/8)),
        (APP_DMA_CRC_BUFFER_SIZE + (crc.polyLength/8)));
```

RTCC System Service Examples

This topic provides descriptions of the RTCC System Service examples.

Introduction

RTCC System Service Library Demonstration Applications Help.

Description

This distribution package contains a firmware project that demonstrates the capabilities of the MPLAB Harmony RTCC System Service. This section describes the hardware requirement and procedures to run this firmware project on Microchip demonstration and development boards.

To learn more about MPLAB Harmony stacks and libraries refer to the related documentation in Volume IV: MPLAB Harmony Framework Reference.

Demonstrations

This topic provides information on how to run the RTCC System Service Library demonstration applications included in this release.

rtcc_timestamps

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Description

This demonstration application shows how to use the RTCC System Service. A simple callback is registered with the RTCC System Service and the alarm causes the current time to be stored in an array. The RTCC System Service can be set to be interrupt-driven to increase efficiency in that it will only be called when the alarm interrupt occurs.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the Command Processor System Service Demonstration.

Description

To build this project, you must open the `rtcc_timestamps.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/examples/system/rtcc/rtcc_timestamps`

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`rtcc_timestamps.X`	`<install-dir>/apps/examples/system/rtcc/rtcc_timestamps/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mz_ef_sk	pic32mz_ef_sk	RTCC demonstration using the PIC32MZ EF Starter Kit.
pic32mz_ef_sk_freertos	pic32mz_ef_sk	FreeRTOS version of the RTCC demonstration using the PIC32MZ EF Starter Kit.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32MZ EF Starter Kit

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

Provides instructions on how to build and run the RTCC System Service demonstration.

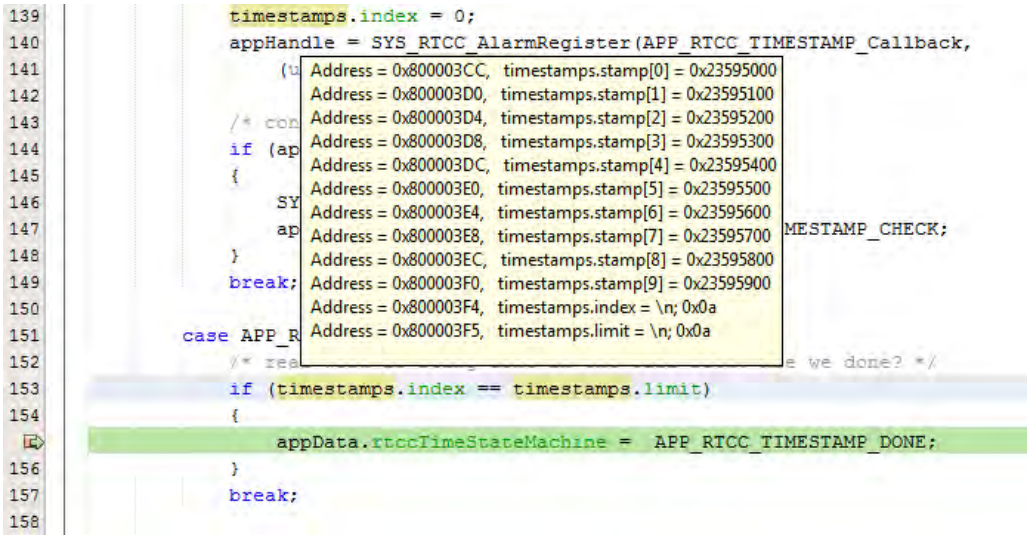
Description

Do the following to run the demonstration:

1. Compile the demonstration application. While compiling, select the appropriate MPLAB X IDE project configuration based on the hardware in use. Refer to Building the Application for details.
2. As shown in the following figure, create a breakpoint near line 155 with the following text:
   - `appData.rtccTimeStateMachine = APP_RTCC_TIMESTAMP_DONE;`

```
150
151             case APP_RTCC_TIMESTAMP_CHECK:
152                 /* real work is being done in the call back. Are we done? */
153                 if (timestamps.index == timestamps.limit)
154                 {
                        appData.rtccTimeStateMachine =  APP_RTCC_TIMESTAMP_DONE;
156                 }
157                 break;
158
159             case APP_RTCC_TIMESTAMP_DONE:
160                 break;
161         }
162     }
163
```

3. Run the demonstration application in Debug mode by clicking **Debug** in MPLAB X IDE.
4. When the debug session reaches the breakpoint (in approximately 10 seconds), the 'timestamps' array can be observed with the timestamps recorded at each second, as shown in the following figure.



External Memory Programmer Demonstrations

This section provides descriptions of the External Memory Programmer demonstrations.

Introduction

External Memory Programmer Demonstration Applications Help.

Description

This section describes the hardware requirement and procedures to run the External Memory Programmer firmware projects on Microchip demonstration and development boards.

To learn more about MPLAB Harmony stacks and libraries refer to the related documentation in Volume IV: MPLAB Harmony Framework Reference.

Demonstrations

This topic provides information on how to run the Programmer demonstration applications included in this release.

external_flash

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Description

This demonstration implements a bootloader that resides in boot Flash. With the bootloader operating on the target device, the device can then program an external SPI Flash memory device (SST25FV016B or similar). This can be useful in programming external SPI Flash memory on Graphics PICtail daughter boards.

The bootloader is, operationally, similar to the bootloader described in AN1388 *"PIC32 Bootloader"*, and will work with the personal computer application provided with the related source archive file. The application note and archive file are available for download from the Microchip web site (www.microchip.com).

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the External Flash Demonstration.

Description

To build this project, you must open the `external_flash.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/programmer/external_flash`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
external_flash.X	<install-dir>/apps/programmer/external_flash/firmware

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are within ./firmware/src/system_config.

Project Configuration Name	BSP(s) Used	Description
usbdevice_pic32mx_usb_sk2	pic32mx_usb_sk2	Demonstrates external SPI Flash programming capabilities on the PIC32 USB Starter Kit II, connected to a Graphics Controller PICtail Plus Epson S1D13517 board (AC164127).

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32 USB Starter Kit II

On the S1D13517 board, the jumpers need to be configured for operations using SPI 2 as the interface to the PIC32 device.

JP3 (SCK), JP4 (MOSI), JP5 (MISO), and JP6 (CS) should all be in the 2-3 (SPI 2) position.

Running the Demonstration

Provides instructions on how to build and run the External Flash demonstration.

Description

Personal Computer-based Host Demonstration

Do the following when using the configurations:

Operation

The bootloader is operated as follows:

1. Select the configuration suitable for the target hardware.
2. Compile and program the device.
3. Hold down SW3 on the starter kit to force bootloader operation.
4. LED1 will start blinking to indicate the bootloader is operating. If a program had previously been programmed, it may be necessary to hold down SW3 prior to applying power to the board or resetting the board.
5. Open the personal computer Host program from the AN1388 source archive file.
6. Select the appropriate communication path:
   - UART - Leave the baud rate at 115,200
   - UDP - Keep the IP address at 192.168.1.11 and the UDP port at 6234
   - USB Device - Keep the VID at 0x4D8 and the PID at 0x03C
7. Click **Connect** to connect to the bootloader and get the version.
8. If the bootloader connects, the personal computer Host application will indicate the version of the bootloader.

At this point, the bootloader is ready to accept a new application for programming into the program Flash. A demonstration application is provided, which is configured in a linker script to only operate in program Flash.

Setup

Create a hex file containing external SPI memory data (Graphics Resource Data is an example).

Programming the Device

With the demonstration application compiled, the generated hex file can now be programmed into the device using the bootloader.

To program the application into the device:

1. On the personal computer Host application described in AN1388, click **Load Hex File**.
2. Navigate to the data file meant to be programmed into external SPI flash (Graphics Resource Data is an example). Select the file and click **Open**.
3. Click **Erase-Program-Verify**.
4. The data will then be transferred to the bootloader, which will program the external SPI Flash.
5. Click **Disconnect** to release the Host Application.

sqi_flash

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Description

Applications that use large bitmap images or multiple page menu screens, which require several images or large or multiple font packages, etc., have a very large memory requirement for their graphics resources. In such applications, storing these graphics resources on-chip may result in insufficient memory or may be prohibitive to a possible cost benefit. A solution is to store the graphics resources to off-chip memory, such as non-volatile memory, thereby preserving the on-chip memory for program memory and allowing for more complex functional features. The pic32mz_ef_sk_meb2_gfx_ext_res configuration in the application can be used to store the external graphics resources onto external SQI Flash memory.

Another usage for external memory devices is for storing program routines and data. On PIC32MZ devices, the SQI peripheral can be configured to use the memory in eXecute-In-Place, or XIP, mode. When configured this way, the external memory appears in the memory space of the PIC32 device, and the running program can reference this memory the same as any other memory space, such as Program Flash and RAM. When the memory space in KSEG2 (cached) or KSEG3 (uncached) is referenced, the SQI peripheral automatically interfaces with the memory device and transfers the data in the appropriate direction without any further CPU intervention.

The current application, sqi_flash, serves as an external memory programmer to flash the off-chip non-volatile memory with the resources which can then be accessed by other applications saving on-chip memory for other programs and resources. The pic32mz_ef_sk_mebii_gfx_ext_res configuration of the sqi_flash application needs the resources to be stored externally in the form of a resource file that would be programmed into the external memory. An example resource file, `gfx_resources_ext.hex`, has already been generated and is available to the user within the `<install-dir>\apps\gfx\external_resources\firmware\src\system_config\pic32mz_ef_sk+meb2\` folder.

The MPLAB Harmony Graphics Composer, which is the primary tool used by the MPLAB Harmony application for configuring the graphic design for the application, has the ability to generate the required resource file containing the binary data for all of the graphics images to be stored on external memory. As previously mentioned, the default name for the file generated by MHGC is `gfx_resources_ext.hex`. Refer to the MPLAB X IDE online help and *Volume II: MPLAB Harmony Configurator (MHC)* > MPLAB Harmony Graphics Composer User's Guide section for usage information. For more information on creating the `gfx_resources_ext.hex` file, please refer to the *Applications Help* > *Graphics Demonstrations* > external_resources demonstration.

The sqi_flash application requires the resource file `gfx_resources_ext.hex` file to be copied from the computer to a USB Flash drive, which has a FAT32 file system installed. The USB Flash drive is then plugged into the development board and the application scans the USB Flash drive for the resource file. The sqi_flash application copies the resource file sector by sector and flashes the binary resource content onto the SQI Flash external memory.

The pic32_mz_ef_sk configuration needs an `image.hex` file containing the program and data information to be flashed onto the sqi_flash application. In addition, ensure that the Flash drive is connected to the development board prior to programming the PIC32 device.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the Programmer Demonstration.

Description

To build this project, you must open the `sqi_flash.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/programmer/sqi_flash`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`sqi_flash.X`	`<install-dir>/apps/programmer/sqi_flash/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are within `./firmware/src/system_config`.

Project Configuration Name	BSP(s) Used	Description
pic32mz_ef_sk_mebii_gfx_ext_res	pic32mz_ef_sk+meb2	SQI Flash demonstration for the Multimedia Expansion Board II (MEB II) connected to the PIC32MZ EF Starter Kit and the Graphics Display Powertip 4.3" 480x272 Board. The PIC32MZ EF Starter Kit has a 4 MB SQI Flash memory device, which is used as the external non-volatile memory for this application. This is the configuration used for flashing external graphics resources onto external SQI Flash memory.
pic32mz_ef_sk	pic32mz_ef_sk	SQI Flash demonstration for the PIC32MZ EF Starter Kit by itself with no other interface is required. However, the image name for the name of the file on the USB Flash drive, `image.hex`, is different.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32MZ EF Starter Kit and MEB II

The MEB II has two memory options External or Internal; however, this demonstration must be run in Internal mode. Configure the MEB II, as follows:

- EBIWE and LCD_PCLK (J9) must be closed (the jumper is located on the back of the MEB II board)
- Ensure that any MHC setting is defined to only use internal SRAM

The current internal/external memory setting for the application can be verified in MHC by selecting *Harmony Framework Configuration* > *Drivers* > *Graphics Controllers* > *LCC* > *Use LCC Driver* > *Memory Interface Mode*.

Configuring MHC

Provides information the MHC settings required for the demonstration application.

Description

PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit with pic32mz_ef_sk_mebii_gfx_ext_res Configuration

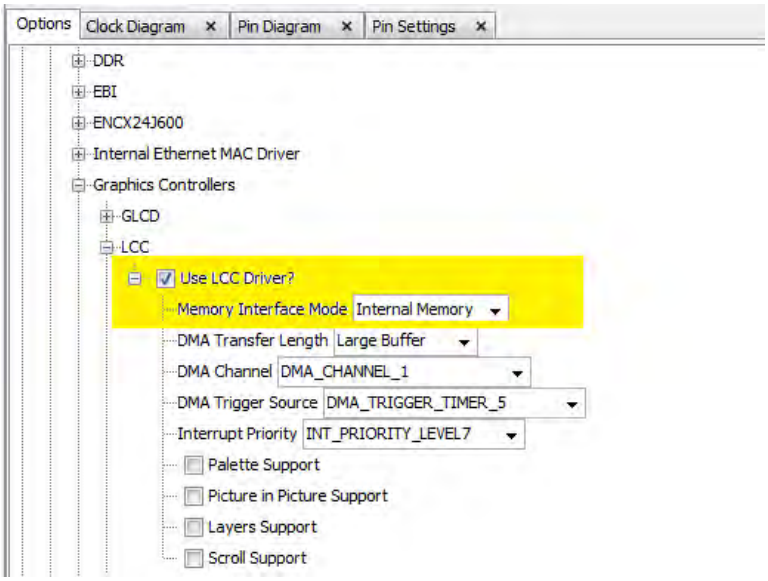
When using the PIC32MZ EF Starter Kit, and powering it from the Debug port (J3), please insert a jumper onto JP1 to ensure the USB Flash drive has the correct power.

Configuring the MHC

The following are MHC settings that were modified from the default values. Refer to Volume II: MPLAB Harmony Configurator (MHC) for information on using MHC.

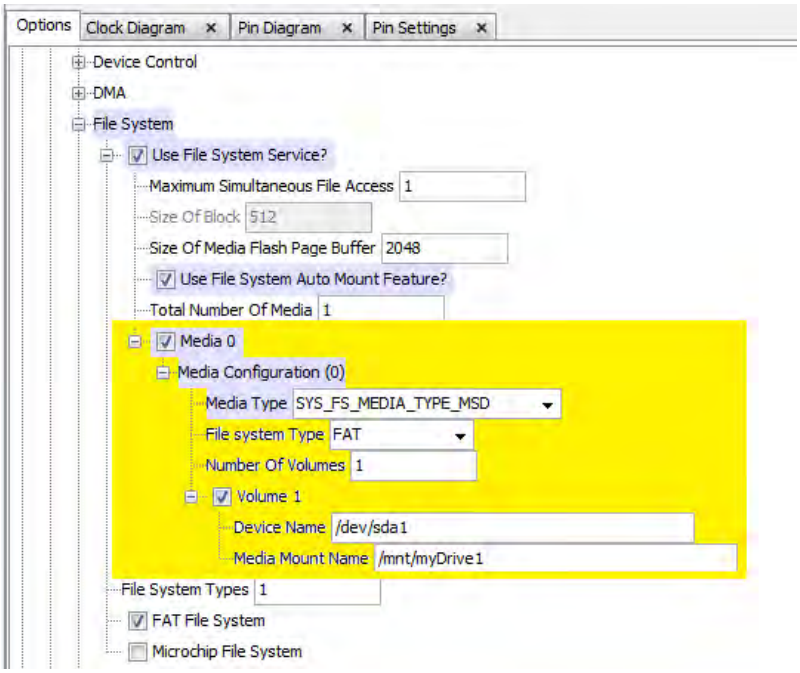
Drivers

The Graphics Controllers selection shows LCC was selected using the ‘Use LCC driver’ option. The Memory Interface Mode selected is Internal Memory. This is due to the fact that we want to load the program on internal memory and we are configuring the hardware with the jumper to match internal memory.



System Services

Select File System with the following settings:



BSP

The BSP selected for the supported configuration is PIC32MZ EF Starter Kit in combination w\Multimedia Expansion Board II - pic32mz_ef_sk_meb2.

Clock Diagram

Open the clock configurator section and make sure the following values are selected for the different clock settings as required for the pic32mz_sk_ef_meb2 configuration

- Primary Oscillator frequency: 24 MHz, EC mode
- USB PLL: 480 MHz
- System Clock: 200 MHz
- PB Clock: 100 MHz
- REFCLKO: The Reference Clock (REFCLK) uses the System Clock (SYSCLK) as the reference and generates the master clock for SPI modules at 200 MHz

Application-specific Software Setup

SQI external memory support: Since a formal SQI driver is not available in MPLAB Harmony, the external memory programmer uses the SQI Peripheral Library. Please note that the source and header file for SQI enabling have been manually included in the project.

`SourceFiles/drv_nvm_flash_sqi_sst26.c HeaderFiles/drv_nvm_flash_sqi_sst26.h`

Also note that, to refer to these files a preprocessor macro has been added to the application properties named `SST26VF_B`.

This application uses the `gfx_resources_ext.hex` file loaded on the USB Flash drive mentioned in the description.

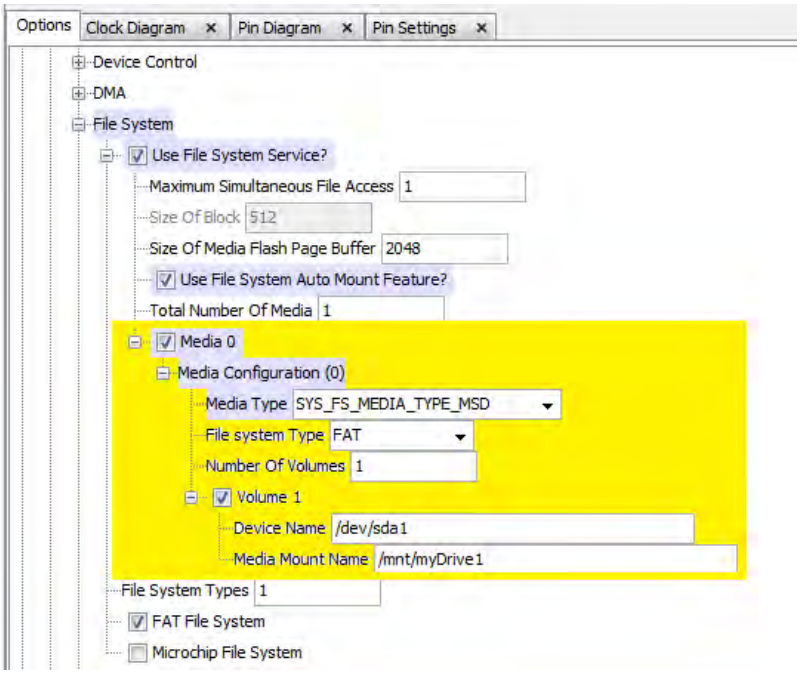
PIC32MZ EF Starter Kit with pic32mz_ef_sk Configuration

Configuring the MHC

The following are MHC settings that were modified from the default values. Refer to Volume II: MPLAB Harmony Configurator (MHC) for information on using MHC.

System Services

Select File System with the following settings:



BSP

The BSP selected for the supported configuration is PIC32MZ EF Starter Kit - pic32mz_ef_sk.

Clock Diagram

Open the clock configurator section and make sure the following values are selected for the different clock settings as required for the pic32mz_sk_ef configuration:

- Primary Oscillator frequency: 24 MHz, EC mode
- USB PLL: 480 MHz
- System Clock: 200 MHz
- PB Clock: 100 MHz
- REFCLKO: The Reference Clock (REFCLK) uses the System Clock (SYSCLK) as the reference and generates the master clock for SPI modules at 200 MHz

Application-specific Software Setup

SQI external memory support: Since a formal SQI driver is not available in MPLAB Harmony, the external memory programmer uses the SQI Peripheral Library. Please note that the source and header file for SQI enabling have been manually included in the project.

`SourceFiles/drv_nvm_flash_sqi_sst26.c HeaderFiles/drv_nvm_flash_sqi_sst26.h`

Also note that, to refer to these files a preprocessor macro has been added to the application properties named `SST26VF_B`.

This programmer also uses the same Intex HEX file processing that is used in the bootloader demonstrations, but it does not use the Bootloader Library, nor a bootloader linker script.

Running the Demonstration

Provides instructions on how to build and run the External Memory Programmer SQI Flash demonstration.

Description

The sqi_flash application loads the required `image.hex` file or the `gfx_resources_ext.hex` file to an off-chip external memory to facilitate large resource requirements, which would not be easily accommodated on on-chip internal memory. The external memory programmer is operated as follows:

pic32mz_ef_sk_mebii_gfx_ext_res Configuration:

1. The external resources to be flashed onto the external memory are required by the sqi_flash application in the form of a HEX text file with the default name `gfx_resources_ext.hex`. If you do not have the resource binary file, you can obtain it from the following MPLAB Harmony installation folder: `<install-dir>\apps\gfx\external_resources\firmware\src\system_config\pic32mz_ef_sk+meb2\`.
2. Connect a USB Flash drive to the computer port and copy the `gfx_resources_ext.hex` file from `<install-dir>\apps\gfx\external_resources\firmware\src\system_config\pic32mz_ef_sk+meb2\` to the USB Flash drive.
3. After the file has finished being copied to the USB Flash drive, remove the USB Flash drive from the computer and insert it into the USB host connector on the PIC32MZ EF Starter Kit board
4. Program the PIC32MZ device with the external memory programmer application, sqi_flash. This application flashes the `gfx_resources_ext.hex` file available on the USB Flash drive to the external SQI memory.
5. The display will convey the beginning of the flashing process to the user and also change the status to ‘Finished Writing’ once the flashing is complete. Also, the Green LED3 will light to indicate completion of the operation. Please make sure that the USB thumb drive is not unplugged while the program is actively flashing the memory.

pic32mz_ef_sk Configuration:

1. The program/data image to be programmed onto the external memory are required by sqi_flash in the form of a HEX text file with the default name `image.hex`.
2. Connect a USB Flash drive to the computer port and copy the `image.hex` file from the source directory onto the USB Flash drive.
3. After the file has finished being copied to the USB Flash drive, remove the USB Flash drive from the computer and insert it into the USB host connector on the PIC32MZ EF Starter Kit board.
4. Program the PIC32MZ device with the external memory programmer application, sqi_flash. This application flashes the `image.hex` file available on the USB Flash drive to the external SQI memory.
5. The green LED, LED3, will illuminate to indicate completion of the operation. Please make sure that the USB Flash drive is not disconnected while the program is actively flashing the memory.

File System Demonstrations

This section provides descriptions of the File System demonstrations.

Introduction

MPLAB Harmony File System Demonstration Help.

Description

This help file contains instructions and associated information about MPLAB Harmony File System demonstration applications, which are contained in the MPLAB Harmony Library distribution.

Demonstrations

Provides instructions on how to run the demonstration applications.

nvm_fat_single_disk

This demonstration uses a FAT12 image of a file on NVM Flash memory and demonstrates the working of all file system functions.

Description

This demonstration shows an example of implementing a FAT12 disk in device Flash memory. The demonstration contains a FAT12 disk image consisting of a Master Boot Record (MBR) sector, Logical Boot Sector, File Allocation Table, and Root Directory Area.

The demonstration opens an existing file named `FILE.TXT` and performs all file system related function calls on the file: SYS_FS_FileStat, SYS_FS_FileSize, SYS_FS_FileSeek, and SYS_FS_FileEOF. Finally, the string "Hello World" is written to this file. The string is then read and compared with the string that was written to the file. If the string compare is successful, LED indication is provided.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the NVM FAT Single Disk Demonstration.

Description

To build this project, you must open the `nvm_fat_single_disk.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/fs/nvm_fat_single_disk`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
nvm_fat_single_disk.X	<install-dir>/apps/fs/nvm_fat_single_disk/firmware

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within ./firmware/src/system_config.

Project Configuration Name	BSP Used	Description
pic32mx_bt_sk_int_dyn	pic32mx_bt_sk	This configuration runs on PIC32 Bluetooth Starter Kit. The media drivers are configured for Interrupt mode and dynamic operation.
pic32mx_usb_sk_int_dyn	pic32mx_usb_sk2	This configuration runs on the PIC32 USB Starter Kit II. The media drivers are configured for Interrupt mode and dynamic operation.
pic32mx_usb_sk_int_dyn_freertos	pic32mx_usb_sk2	This configuration runs on the PIC32 USB Starter Kit II and makes use of FreeRTOS as the underlying RTOS. The media drivers are configured for Interrupt mode and dynamic operation.
pic32mx_usb3_sk_int_dyn	pic32mx_usb_sk3	This configuration runs on PIC32 USB Starter Kit III. The media drivers are configured for Interrupt mode and dynamic operation.
pic32mz_ec_sk_int_dyn	pic32mz_ec_sk	This configuration runs on the PIC32MZ EC Starter Kit. The media drivers are configured for Interrupt mode and dynamic operation.
pic32mz_ef_sk_int_dyn	pic32mz_ef_sk	This configuration runs on the PIC32MZ EF Starter Kit. The media drivers are configured for Interrupt mode and dynamic operation.
pic32mz_ef_sk_int_dyn_freertos	pic32mz_ef_sk	This configuration runs on the PIC32MZ EF Starter Kit and makes use of FreeRTOS as the underlying RTOS. The media drivers are configured for Interrupt mode and dynamic operation.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32 USB Starter Kit II

No hardware related configuration or jumper setting changes are necessary.

PIC32 USB Starter Kit III

No hardware related configuration or jumper setting changes are necessary.

PIC32 Bluetooth Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ EC Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ EF Starter Kit

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

Provides instructions on how to build and run the NVM FAT single disk demonstration.

Description

Select the MPLAB X IDE project configuration:

- pic32mx_usb_sk2_int_dyn (for PIC32MX devices)
- pic32mx_usb_sk_int_dyn_freertos (for PIC32MX devices)
- pic32mx_bt_sk_int_dyn (for PIC32MX devices)
- pic32mx_usb_sk3_int_dyn (for PIC32MX devices)
- pic32mz_ec_sk_int_dyn (for PIC32MZ EC devices)

- pic32mz_ef_sk_int_dyn (for PIC32MZ EF devices)
- pic32mz_ef_sk_int_dyn_freertos (for PIC32MZ EF devices)

Build the selected configuration in the MPLAB X IDE project and program the demonstration board. The execution status (pass/fail) of the demonstration is indicated by LEDs on the demonstration board.

Demonstration Board	Demonstration Success	Demonstration Failure
PIC32 USB Starter Kit II	LED3	LED1
PIC32 Bluetooth Starter Kit	Green LED	Red LED
PIC32 USB Starter Kit III	LED3	LED1
PIC32MZ EC Starter Kit PIC32MZ EF Starter Kit	Green LED	Red LED

About the Demonstration:

This demonstration shows an example of:

- Implementing a FAT12 disk in device Flash memory
- Opening a file for read or write
- Implements file system functions
- Closing a file

The demonstration contains a FAT12 disk image consisting of a Master Boot Record (MBR) sector, Logical Boot Sector, File Allocation Table, and Root Directory Area. This image is implemented in the file `nvm_disk_images.c` (this is project configuration specific file and is contained in the `nvm_disk_images` logical folder in the MPLAB X IDE project). The image contains a single file named `FILE.TXT` which contains the string "Data".

The demonstration opens an existing file named `FILE.TXT` and performs all file system related function calls on the file: SYS_FS_FileStat, SYS_FS_FileSize, SYS_FS_FileSeek, and SYS_FS_FileEOF. Finally, the string "Hello World" is written to this file. The string is then read and compared with the string that was written to the file. If the string compare is successful, LED indication is provided.

The demonstration application logic is implemented as a state machine in the APP_Tasks function in the file `main.c`.

1. The disk is first mounted using the SYS_FS_Mount function. The `/dev/nvma1` path instructs the mount command to mount an internal Flash volume. The volume is mounted against a FAT type file system and mounted at `/mnt/myDrive/`.
2. If the mount is successful, the application opens a file `FILE.TXT` for reading and writing (SYS_FS_FILE_OPEN_READ_PLUS) with a SYS_FS_FileOpen function. The valid file handle is received once a successful opening of the file is performed.
3. If file open is successful, the status of file `FILE.TXT` is stored in the appData.fileStatus structure, using SYS_FS_FileStat function.
4. If the file status check is successful, the size of the `FILE.TXT` is checked by passing the file handle to the SYS_FS_FileSize function.
5. If the file size check is successful, the size of file is compared with the size element received earlier as a part of appData.fileStatus structure. If both values match, the code moves to the next step of file seek.
6. The file pointer is then moved by 4 bytes from the start of the file by calling the function SYS_FS_FileSeek and passing parameter as SYS_FS_SEEK_SET (seek from the beginning of the file).
7. If the file seek operation is successful, the file pointer should have reached the end of the file. This is because, the content of the `FILE.TXT` had only 4 byte string = "Data". The end of file is verified by calling the function SYS_FS_FileEOF. If the function returns "true" (end of file reached), the next step is performed.
8. In the next step, the file pointer is moved again by [(-1)*size of file], from the end of the file by calling the function SYS_FS_FileSeek and passing parameter SYS_FS_SEEK_END (seek from the end of the file).
9. If the file seek operation is successful, the file pointer should have reached the beginning of the file. Then, 4 Bytes are read from the file using SYS_FS_FileRead function (into a buffer).
10. If the read is successful, the content of file (present in the buffer) is compared with the "Data" string. If the comparison passed, the code moves to the next step.
11. In the next step, the file pointer is moved again by [(-1)*size of file], from the end of the file by calling the function SYS_FS_FileSeek() and passing parameter SYS_FS_SEEK_END (seek from the end of the file).
12. If the file seek operation is successful, the string "Hello World" is written to the file using SYS_FS_FileWrite function.
13. If the write operation is successful, the file pointer is moved to the beginning of the file.
14. If the file seek is successful, the contents of the file is read using SYS_FS_FileRead function (into a buffer).
15. If the read operation is successful, the content of the file (present in the buffer) is compared with the "Hello World" string using the strcmp function. A LED indicates the success of the demonstration.

nvm_mpfs_single_disk

This demonstration uses a MPFS image of two files on NVM Flash memory and demonstrates the working of all file system functions.

Description

This demonstration shows an example of implementing a MPFS disk in device Flash memory. The demonstration contains a MPFS disk image in the internal Flash memory. The disk image contains two files named:

- `FILE.txt`, Size = 11 Bytes. The content of the file is: "Hello World".

- TEST.txt, Size = 72 Bytes. The content of the file is: "This file contains a test string and it is meant for testing. 1234567890".

The demonstration performs all file system related function calls on the file: SYS_FS_FileRead, SYS_FS_FileStat, SYS_FS_FileSize, SYS_FS_FileSeek, SYS_FS_FileEOF. If all tests are successful, LED indication is provided.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the NVM MPFS Single Disk Demonstration.

Description

To build this project, you must open the `nvm_mpfs_single_disk.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/fs/nvm_mpfs_single_disk`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`nvm_mpfs_single_disk.X`	`<install-dir>/apps/fs/nvm_mpfs_single_disk/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx_bt_sk_int_dyn	pic32mx_bt_sk	This configuration runs on PIC32 Bluetooth Starter Kit. The media drivers are configured for Interrupt mode and dynamic operation.
pic32mx_usb_sk_int_dyn	pic32mx_usb_sk2	This configuration runs on the PIC32 USB Starter Kit II. The media drivers are configured for Interrupt mode and dynamic operation.
pic32mx_usb_sk_int_dyn_freertos	pic32mx_usb_sk2	This configuration runs on the PIC32 USB Starter Kit II and makes use of FreeRTOS as the underlying RTOS. The media drivers are configured for Interrupt mode and dynamic operation.
pic32mx_usb3_sk_int_dyn	pic32mx_usb_sk3	This configuration runs on PIC32 USB Starter Kit III. The media drivers are configured for Interrupt mode and dynamic operation.
pic32mz_ec_sk_int_dyn	pic32mz_ec_sk	This configuration runs on the PIC32MZ EC Starter Kit. The media drivers are configured for Interrupt mode and dynamic operation.
pic32mz_ef_sk_int_dyn	pic32mz_ef_sk	This configuration runs on the PIC32MZ EF Starter Kit. The media drivers are configured for Interrupt mode and dynamic operation.
pic32mz_ef_sk_int_dyn_freertos	pic32mz_ef_sk	This configuration runs on the PIC32MZ EF Starter Kit and makes use of FreeRTOS as the underlying RTOS. The media drivers are configured for Interrupt mode and dynamic operation.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32 USB Starter Kit II

No hardware related configuration or jumper setting changes are necessary.

PIC32 USB Starter Kit III

No hardware related configuration or jumper setting changes are necessary.

PIC32 Bluetooth Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ EC Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ EF Starter Kit

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

Provides instructions on how to build and run the NVM MPFS single disk demonstration.

Description

Select the MPLAB X IDE project configuration:

- pic32mx_usb_sk2_int_dyn (for PIC32MX devices)
- pic32mx_usb_sk_int_dyn_freertos (for PIC32MX devices)
- pic32mx_usb_sk3_int_dyn (for PIC32MX devices)
- pic32mx_bt_sk_int_dyn (for PIC32MX devices)
- pic32mz_ec_sk_int_dyn (for PIC32MZ EC devices)
- pic32mz_ef_sk_int_dyn (for PIC32MZ EF devices)
- pic32mz_ef_sk_int_dyn_freertos (for PIC32MZ EF devices)

Build the selected configuration in the MPLAB X IDE project and program the demonstration board. The execution status (pass/fail) of the demonstration is indicated by LEDs on the demonstration board.

Demonstration Board	Demonstration Success	Demonstration Failure
PIC32 USB Starter Kit II PIC32 USB Starter Kit III	LED3	LED1
PIC32 Bluetooth Starter Kit	Green LED	Red LED
PIC32MZ EC Starter Kit PIC32MZ EF Starter Kit	Green LED	Red LED

About the demonstration:

This demonstration shows an example of:

- Implementing a MPFS disk in device Flash memory
- Opening a file for read
- Implements all the file system functions
- Closing a file

This demonstration shows an example of implementing a MPFS disk in device Flash memory. The demonstration contains a MPFS disk image in the internal Flash memory. The disk image contains two files named:

- `FILE.txt`, Size = 11 bytes. The content of the file is: "Hello World".
- `TEST.txt`, Size = 72 bytes. The content of the file is: "This file contains a test string and it is meant for testing. 1234567890".

The demonstration application logic is implemented as a state machine in the APP_Tasks function in the file `main.c`.

1. The disk is first mounted using the SYS_FS_Mount function. The `/dev/nvma1` path instructs the mount command to mount an internal Flash volume. The volume is mounted against a MPFS2 type file system and mounted at `/mnt/myDrive/`.
2. If the mount is successful, the application opens a file `FILE.txt` for reading with a SYS_FS_FileOpen function.
3. If the open is successful, the application opens another file `TEST.txt` for reading with SYS_FS_FileOpen function.
4. If the open is successful, the application checks for size of file `FILE.txt`, by passing the handle obtained during file open, to the function SYS_FS_FileSize.
5. If the file size matches the known value of 11 bytes, the application moves the file pointer for the file `TEST.txt` 10 bytes from the end of file, using the function SYS_FS_FileSeek.
6. If file seek is successful, 10 bytes of content of the file `TEST.txt` is read into the application buffer, using the function SYS_FS_FileRead.
7. If read is successful, the application buffer content is compared with the known string of `1234567890` using the strncmp function.
8. If the comparison is successful, the application checks if the file pointer for file "`TEST.txt`" has reached the end of file using the SYS_FS_FileEOF function.
9. If end of file is reached, a LED indicates the success of the demonstration.

nvm_sdcard_fat_mpfs_multi_disk

This demonstration uses NVM and a Secure Digital (SD) Card with MPFS and FAT image of file and performs a read/write/verify operation from file of one media to another media.

Description

This demonstration shows an example of using the MPLAB Harmony File System to access files across multiple disks and multiple file system. The demonstration contains a MPFS disk image in the internal Flash memory. The disk image contains a file named `abc.txt` with content "Hello World". Another disk is a SD card, which is formatted to FAT (FAT16 or FAT32). The demonstration reads the contents of `abc.txt` from the disk implemented on internal Flash memory and writes the contents to `FILE.TXT` on the SD card. A successful write is indicated by an illuminated

LED.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the NVM SD Card FAT MPFS Multi-disk Demonstration

Description

To build this project, you must open the `nvm_sdcard_fat_mpfs_multi_disk.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/fs/nvm_sdcard_fat_mpfs_multi_disk`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`nvm_sdcard_fat_mpfs_multi_disk.X`	`<install-dir>/apps/fs/nvm_sdcard_fat_mpfs_multi_disk/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx795_pim_e16_int_dyn	pic32mx795_pim+e16	This configuration runs on the Explorer 16 Development Board using the PIC32MX795F512L PIM and PICtail Daughter Board for SD and MMC. The media drivers are configured for Interrupt mode and dynamic operation.
pic32mx795_pim_e16_int_dyn_freertos	pic32mx795_pim+e16	This configuration runs on the Explorer 16 Development Board using the PIC32MX795F512L PIM and PICtail Daughter Board for SD and MMC and makes use of FreeRTOS as the underlying RTOS. The media drivers are configured for Interrupt mode and dynamic operation.
pic32mx470_pim_e16_int_dyn	pic32mx470_pim+e16	This configuration runs on the Explorer 16 Development Board using the PIC32MX470F512L PIM and PICtail Daughter Board for SD and MMC. The media drivers are configured for Interrupt mode and dynamic operation.
pic32mz_ec_sk_int_dyn	pic32mz_ec_sk+meb2	This configuration runs on the PIC32MZ EC Starter Kit connected to the MEB II. The media drivers are configured for Interrupt mode and dynamic operation.
pic32mz_ef_sk_int_dyn	pic32mz_ef_sk+meb2	This configuration runs on the PIC32MZ EF Starter Kit connected to the MEB II. The media drivers are configured for Interrupt mode and dynamic operation.
pic32mz_ef_sk_int_dyn_freertos	pic32mz_ef_sk+meb2	This configuration runs on the PIC32MZ EF Starter Kit connected to the MEB II and makes use of FreeRTOS as the underlying RTOS. The media drivers are configured for Interrupt mode and dynamic operation.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

Explorer 16 Development Board, PIC32MX450/470F512L Plug-in Module (PIM) or PIC32MX795F512L Plug-in Module (PIM), and PICtail Daughter Board for SD and MMC

Use the following instructions for all Explorer 16 Development Board-based demonstration boards.

Since some peripheral functions are multiplexed through the Peripheral Pin Select (PPS) feature, the hardware on the following PIM must be modified by connecting the PIM pins, as follows:

PIC32MX470F512L PIM (MA320002-2) - PIM pin 99 to PIM pin 24 for CS

Refer to PIC32MX450/470F512L Plug-in Module (PIM) or PIC32MX795F512L Plug-in Module (PIM) for PIM pin locations.

Use the following general test setup for either PIM:

1. Insert the PIM into the Explorer 16 Development Board PIM connector.
2. Jumpers JP1, JP2 and JP3 on the PICtail Daughter Board for SD and MMC should connect to points 1 and 2 on their respective connectors (see PICtail Daughter Board for SD and MMC).
3. Insert the Daughter Board into the PICtail Plus connector on the Explorer 16 Development Board.

4. Insert a SD card into the SD card connector on the Daughter Board.
5. Power up the board.

PIC32MZ EC Starter Kit and MEB II

No hardware setting change is required. Insert the microSD card into the connector and power up the board.

PIC32MZ EF Starter Kit and MEB II

No hardware setting change is required. Insert the microSD card into the connector and power up the board.

Running the Demonstration

Provides instructions on how to build and run the NVM SD card FAT MPFS multi disk demonstration.

Description

Select the MPLAB X IDE project configuration:

- pic32mx795_pim_e16_int_dyn (for PIC32MX devices)
- pic32mx795_pim_e16_int_dyn_freertos (for PIC32MX devices)
- pic32mx470_pim_e16_int_dyn (for PIC32MX devices)
- pic32mz_ec_sk_int_dyn (for PIC32MZ EC devices)
- pic32mz_ef_sk_int_dyn (for PIC32MZ EF devices)
- pic32mz_ef_sk_int_dyn_freertos (for PIC32MZ EF devices)

Insert the SD card, which contains the file `FILE.TXT` (the file contains some arbitrary existing content).

Compile the selected configuration in the MPLAB X IDE project and run the code. After a few seconds, once the LED illuminates, remove the SD card from the SD Card PICtail Daughter Board and insert it into the SD card reader on a personal computer. Examine the contents of the file named `FILE.TXT`. The file should contain the string "Hello World".

Demonstration Board	Demonstration Success	Demonstration Failure
Explorer 16 Development Board	LED5 (D5)	LED6 (D6)
PIC32MZ EC Starter Kit PIC32MZ EF Starter Kit	Green LED	Red LED

About the Demonstration:

This demonstration shows an example of:

- Implementing a multi-disk demonstration with MPFS on internal Flash memory (NVM) and FAT File system (FAT16/ FAT32) on SD card
- Opening two files from two different disks and read the contents of the file from the first disk and write into the file of the second disk
- Closing the files

The demonstration contains a MPFS disk image in the internal Flash memory. The disk image contains a file named `abc.txt` with content "Hello World". Another disk is a SD card, which is formatted to FAT (FAT16 or FAT32). The demonstration reads the contents of `abc.txt` from the disk implemented on internal Flash memory and writes the contents to `FILE.TXT` on the SD card. A successful write is indicated by illumination of an LED.

The demonstration application logic is implemented as a state machine in the APP_Tasks function in the file `main.c`.

1. The first disk is mounted using the SYS_FS_Mount function. The `/dev/nvma1` path instructs the mount command to mount a internal Flash volume. The volume is mounted against a MPFS2 type file system and mounted at `/mnt/myDrive1/`.
2. If the mount is successful, the second disk is mounted using the SYS_FS_Mount function. The `/dev/mmcblka1` path instructs the mount command to mount a SD card volume. The volume is mounted against a FAT type file system and mounted at `/mnt/myDrive2/`.
3. If the mount is successful, the application opens the file `abc.txt` from `/mnt/myDrive1/` for reading and `FILE.TXT` from `/mnt/myDrive2/` for writing with the SYS_FS_FileOpen function.
4. If the file open is successful, the application reads 13 bytes from `abc.txt` of the internal Flash volume using SYS_FS_FileRead.
5. If the read is successful, the application closes `abc.txt` from the internal Flash volume, and then writes the 13 bytes into `FILE.TXT` of the SD card volume using the SYS_FS_FileWrite function. If the file write is successful, the application closes `FILE.TXT` from the SD card volume.
6. If file close is successful, a LED indicates the success of the operation.

nvm_sdcard_fat_multi_disk

This demonstration uses NVM and a Secure Digital (SD) card as media, searches a file from the NVM media, opens and reads the file, and then writes the data into another file in the SD card media.

Description

This demonstration shows an example of using the MPLAB Harmony File System to access files across multiple media. The demonstration contains a FAT12 disk image consisting of a Master Boot Record (MBR) sector, Logical Boot Sector, File Allocation Table, and Root Directory Area, placed in the internal Flash memory (NVM). Also, a SD card is used as another disk, which might have FAT16 or FAT32 implemented on it (dependent on the formatting of SD card). The demonstration searches the NVM media for a named `FILE.TXT`, opens and reads the contents of

the file in NVM and copies the contents to the file, `FILE.TXT`, in the SD card. Once the copy is successful, an addition string "Test is successful" is added to the file. If the write operation is successful, LED indication is provided.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the NVM SD Card FAT Multi-disk Demonstration.

Description

To build this project, you must open the `nvm_sdcard_fat_multi_disk.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/fs/nvm_sdcard_fat_multi_disk`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`nvm_sdcard_fat_multi_disk.X`	`<install-dir>/apps/fs/nvm_sdcard_fat_multi_disk/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx795_pim_e16_int_dyn	pic32mx795_pim+e16	This configuration runs on the Explorer 16 Development Board using the PIC32MX795F512L PIM and PICtail Daughter Board for SD and MMC. The media drivers are configured for Interrupt mode and dynamic operation.
pic32mx795_pim_e16_int_dyn_freertos	pic32mx795_pim+e16	This configuration runs on the Explorer 16 Development Board using the PIC32MX795F512L PIM and PICtail Daughter Board for SD and MMC and makes use of FreeRTOS as the underlying RTOS. The media drivers are configured for Interrupt mode and dynamic operation.
pic32mx470_pim_e16_int_dyn	pic32mx470_pim+e16	This configuration runs on the Explorer 16 Development Board using the PIC32MX470F512L PIM and PICtail Daughter Board for SD and MMC. The media drivers are configured for Interrupt mode and dynamic operation.
pic32mz_ec_sk_int_dyn	pic32mz_ec_sk+meb2	This configuration runs on the PIC32MZ EC Starter Kit connected to the MEB II. The media drivers are configured for Interrupt mode and dynamic operation.
pic32mz_ef_sk_int_dyn	pic32mz_ef_sk+meb2	This configuration runs on the PIC32MZ EF Starter Kit connected to the MEB II. The media drivers are configured for Interrupt mode and dynamic operation.
pic32mz_ef_sk_int_dyn_freertos	pic32mz_ef_sk+meb2	This configuration runs on the PIC32MZ EF Starter Kit connected to the MEB II and makes use of FreeRTOS as the underlying RTOS. The media drivers are configured for Interrupt mode and dynamic operation.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

Explorer 16 Development Board, PIC32MX450/470F512L Plug-in Module (PIM) or PIC32MX795F512L Plug-in Module (PIM), and PICtail Daughter Board for SD and MMC

Use the following instructions for all Explorer 16 Development Board-based demonstration boards.

Since some peripheral functions are multiplexed through the Peripheral Pin Select (PPS) feature, the hardware on the following PIM must be modified by connecting the PIM pins, as follows:

PIC32MX470F512L PIM (MA320002-2) - PIM pin 99 to PIM pin 24 for CS

Refer to PIC32MX450/470F512L Plug-in Module (PIM) or PIC32MX795F512L Plug-in Module (PIM) for PIM pin locations.

Use the following general test setup for either PIM:

1. Insert the PIM into the Explorer 16 Development Board PIM connector.
2. Jumpers JP1, JP2 and JP3 on the PICtail Daughter Board for SD and MMC should connect to points 1 and 2 on their respective connectors (see PICtail Daughter Board for SD and MMC).
3. Insert the Daughter Board into the PICtail Plus connector on the Explorer 16 Development Board.

4. Insert a SD card into the SD card connector on the Daughter Board.
5. Power up the board.

PIC32MZ EC Starter Kit and MEB II

No hardware setting change is required. Insert the microSD card into the connector and power up the board.

PIC32MZ EF Starter Kit and MEB II

No hardware setting change is required. Insert the microSD card into the connector and power up the board.

Running the Demonstration

Provides instructions on how to build and run the NVM SD card FAT multi-disk demonstration.

Description

Select the MPLAB X IDE project configuration:

- pic32mx795_pim_e16_int_dyn (for PIC32MX devices)
- pic32mx795_pim_e16_int_dyn_freertos (for PIC32MX devices)
- pic32mx470_pim_e16_int_dyn (for PIC32MX devices)
- pic32mz_ec_sk_int_dyn (for PIC32MZ EC devices)
- pic32mz_ef_sk_int_dyn (for PIC32MZ EF devices)
- pic32mz_ef_sk_int_dyn_freertos (for PIC32MZ EF devices)

Insert the SD card, which contains the file `FILE.TXT` and the file contains "abc" (some arbitrary existing content).

Compile the selected configuration in the MPLAB X IDE project and run the code. After a few seconds, once the LED is illuminated, remove the SD card from the Board and insert it into the SD card reader on a personal computer. Examine the contents of the file named `FILE.TXT`. The file should contain the string "This data from NVM Disk Test is successful".

Demonstration Board	Demonstration Success	Demonstration Failure
Explorer 16 Development Board	LED5 (D5)	LED6 (D6)
PIC32MZ EC Starter Kit PIC32MZ EF Starter Kit	Green LED	Red LED

About the demonstration:

This demonstration shows an example of:

- Implementing a multi-disk demonstration with FAT12 on internal Flash memory (NVM) and FAT File system (FAT16/FAT32) on a SD card
- Opening two files from two different disks, read content of file from first disk and write into the file of second disk
- Closing the files

The demonstration contains a FAT12 disk image consisting of a Master Boot Record (MBR) sector, Logical Boot Sector, File Allocation Table, Root Directory Area, placed in the internal Flash memory (NVM). Also, a SD card is used as another disk, which might have FAT16 or FAT32 implemented on it (depends on the formatting of SD card).The demonstration searches the NVM media for a file named `FILE.TXT`, opens and reads the contents of the file in NVM and copies the contents to `FILE.TXT` to the SD Card. Once the copy is successful, an additional string "Test is successful" is added to the file. If the write operation is successful, LED indication is provided.

The demonstration application logic is implemented as a state machine in the APP_Tasks function in the file `main.c`.

1. The first disk is mounted using the SYS_FS_Mount function. The `/dev/nvma1` path instructs the mount command to mount a internal Flash volume. The volume is mounted against a FAT type file system and mounted at `/mnt/myDrive1/`.
2. If the mount is successful, the second disk is mounted using the SYS_FS_Mount function. The `/dev/mmcblka1` path instructs the mount command to mount a SD card volume. The volume is mounted against a FAT type file system and mounted at `/mnt/myDrive2/`.
3. If the mount is successful, the application opens the root directory of `/mnt/myDrive1/` with the function SYS_FS_DirOpen.
4. If the directory open is successful, the application searches for the file, `FILE.TXT`, using the wildcard character `FIL*.*`. The function used for directory search is SYS_FS_DirSearch.
5. If the directory search returns a file found, the directory is closed with the function SYS_FS_DirClose. Also, the searched file name is compared with the `FILE.TXT` name.
6. If the file name matches successfully, the application opens the file, `FILE.TXT`, from `/mnt/myDrive1/` for reading and `FILE.TXT` from `/mnt/myDrive2/` for writing with a SYS_FS_FileOpen function.
7. If the file open is successful, the application reads 27 Bytes from `FILE.TXT` of internal Flash volume using SYS_FS_FileRead.
8. If the read is successful, the application closes `FILE.TXT` from internal Flash volume and then writes the 27 bytes into `FILE.TXT` of SD card volume using SYS_FS_FileWrite.
9. If the write is successful, a character and string are written to the file using SYS_FS_FileCharacterPut and SYS_FS_FileStringPut.
10. If the write is successful, the application closes `FILE.TXT` from the SD card volume.
11. If file close is successful, a LED indicates the success of the operation.

sdcard_fat_single_disk

This demonstration uses a Secure Digital (SD) card with a FAT file system as media, performs a read/write/verify operation on the files using long file names (LFN), and performs directory creation.

Description

This demonstration shows an example of using the MPLAB Harmony File System to access and modify the contents of a SD card. The demonstration opens a file named `FILE_TOO_LONG_NAME_EXAMPLE_123.JPG` on the SD card, reads the content of the file, creates a directory named `Dir1` and inside the directory, writes the content into another file `FILE_TOO_LONG_NAME_EXAMPLE_123_1.JPG` (creates a copy of one file into another file, inside a directory).

The input file `FILE_TOO_LONG_NAME_EXAMPLE_123.JPG` is not provided along with the release package. It could be any arbitrary JPEG (image) file chosen by the user and then renamed to `FILE_TOO_LONG_NAME_EXAMPLE_123.JPG`. The reason for choosing a JPEG file for test purposes is that the duplicate file, `FILE_TOO_LONG_NAME_EXAMPLE_123_1.JPG`, created by the FS demonstration could be easily verified for correctness by inserting the SD card into a computer and opening the `FILE_TOO_LONG_NAME_EXAMPLE_123_1.JPG` file. If the file opens for viewing on the computer, the test is deemed to have passed. Otherwise, if the file does not open (i.e., is corrupted), the test will be considered to have failed. Since the demonstration creates a directory named `Dir1`, it is important that the a folder with the same name does not exist on the SD card. If a directory named `Dir1` is already present on the SD card, the demonstration will fail.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the SD Card FAT Single Disk Demonstration.

Description

To build this project, you must open the `sdcard_fat_single_disk.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/fs/sdcard_fat_single_disk`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`sdcard_fat_single_disk.X`	`<install-dir>/apps/fs/sdcard_fat_single_disk/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx795_pim_e16_int_dyn	pic32mx795_pim+e16	This configuration runs on the Explorer 16 Development Board using the PIC32MX795F512L PIM and PICtail Daughter Board for SD and MMC. The media drivers are configured for Interrupt mode and dynamic operation.
pic32mx795_pim_e16_int_dyn_freertos	pic32mx795_pim+e16	This configuration runs on the Explorer 16 Development Board using the PIC32MX795F512L PIM and PICtail Daughter Board for SD and MMC and makes use of FreeRTOS as the underlying RTOS. The media drivers are configured for Interrupt mode and dynamic operation.
pic32mx470_pim_e16_int_dyn	pic32mx470_pim+e16	This configuration runs on the Explorer 16 Development Board using the PIC32MX470F512L PIM and PICtail Daughter Board for SD and MMC. The media drivers are configured for Interrupt mode and dynamic operation.
pic32mz_ec_sk_int_dyn	pic32mz_ec_sk+meb2	This configuration runs on the PIC32MZ EC Starter Kit connected to the MEB II. The media drivers are configured for Interrupt mode and dynamic operation.
pic32mz_ef_sk_int_dyn	pic32mz_ef_sk+meb2	This configuration runs on the PIC32MZ EF Starter Kit connected to the MEB II. The media drivers are configured for Interrupt mode and dynamic operation.
pic32mz_ef_sk_int_dyn_freertos	pic32mz_ef_sk+meb2	This configuration runs on the PIC32MZ EF Starter Kit connected to the MEB II and makes use of FreeRTOS as the underlying RTOS. The media drivers are configured for Interrupt mode and dynamic operation.
pic32mz_da_sk_adma	pic32mz_da_sk	This configuration runs on the PIC32MZ DA Starter Kit. The media driver is configured to use SD Host Controller ADMA2 Transfer mode operation.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

Explorer 16 Development Board, PIC32MX450/470F512L Plug-in Module (PIM) or PIC32MX795F512L Plug-in Module (PIM), and PICtail Daughter Board for SD and MMC

Use the following instructions for all Explorer 16 Development Board-based demonstration boards.

Since some peripheral functions are multiplexed through the Peripheral Pin Select (PPS) feature, the hardware on the following PIM must be modified by connecting the PIM pins, as follows:

PIC32MX470F512L PIM (MA320002-2) - PIM pin 99 to PIM pin 24 for CS

Refer to PIC32MX450/470F512L Plug-in Module (PIM) or PIC32MX795F512L Plug-in Module (PIM) for PIM pin locations.

Use the following general test setup for either PIM:

1. Insert the PIM into the Explorer 16 Development Board PIM connector.
2. Jumpers JP1, JP2 and JP3 on the PICtail Daughter Board for SD and MMC should connect to points 1 and 2 on their respective connectors (see PICtail Daughter Board for SD and MMC).
3. Insert the Daughter Board into the PICtail Plus connector on the Explorer 16 Development Board.
4. Insert a SD card into the SD card connector on the Daughter Board.
5. Power up the board.

PIC32MZ EC Starter Kit and MEB II

No hardware setting change is required. Insert the microSD card into the connector and power up the board.

PIC32MZ EF Starter Kit and MEB II

No hardware setting change is required. Insert the microSD card into the connector and power up the board.

PIC32MZ DA Starter Kit and MEB II

No hardware setting change is required.

Running the Demonstration

Provides instructions on how to build and run the SD card FAT single disk demonstration.

Description

Select the MPLAB X IDE project configuration:

- pic32mx795_pim_e16_int_dyn (for PIC32MX devices)
- pic32mx795_pim_e16_int_dyn_freertos (for PIC32MX devices)
- pic32mx470_pim_e16_int_dyn (for PIC32MX devices)
- pic32mz_ec_sk_int_dyn (for PIC32MZ EC devices)
- pic32mz_ef_sk_int_dyn (for PIC32MZ EF devices)
- pic32mz_ef_sk_int_dyn_freertos (for PIC32MZ EF devices)
- pic32mz_da_sk_adma (for PIC32MZ DA devices)

Insert the SD card, which contains the file named `FILE_TOO_LONG_NAME_EXAMPLE_123.JPG`. The file can be of any size.

Compile the selected configuration in the MPLAB X IDE project and run the code. After a few seconds, once the LED illuminates, remove the SD card from the SD Card PICtail Daughter Board (for PIC32MX) or MEB II (for PIC32MZ) and insert it into the SD card reader on a personal computer. Upon examining the contents of the SD card, a directory `Dir1` will have been created. Inside the `Dir1` folder, a file named `FILE_TOO_LONG_NAME_EXAMPLE_123_1.JPG` will be present. The file, `FILE_TOO_LONG_NAME_EXAMPLE_123_1.JPG`, will be a copy of `FILE_TOO_LONG_NAME_EXAMPLE_123.JPG`. Verify that both files open for viewing on a personal computer.

Demonstration Board	Demonstration Success	Demonstration Failure
Explorer 16 Development Board	LED5 (D5)	LED6 (D6)
PIC32MZ Embedded Connectivity (EC) Starter Kit	Green LED	Red LED

About the Demonstration:

This demonstration shows an example of:

- Implementing a FAT File system (FAT16/ FAT32) on a SD card
- Implementing long file name (LFN)
- Opening a file for read or write
- Closing a file

The demonstration opens a file named `FILE_TOO_LONG_NAME_EXAMPLE_123.JPG` on the SD Card, reads the content of the file, creates a

directory named `Dir1` and inside the directory, writes the content into another file `FILE_TOO_LONG_NAME_EXAMPLE_123_1.JPG` (creates a copy of one file into another file, inside a directory).

The demonstration application logic is implemented as a state machine in the APP_Tasks function in the file `main.c`.

1. The disk is first mounted using the SYS_FS_Mount function. The `/dev/mmcblka1` path instructs the mount command to mount a SD card volume. The volume is mounted against a FAT type file system and mounted at `/mnt/myDrive/`.
2. If the mount is successful, the volume is unmounted by passing the mount name `/mnt/myDrive` to SYS_FS_Unmount function. This unmounting is done for demonstration purposes only. Real applications do not need to unmount unless it is required for the application.
3. If the unmount is successful, the mounting process is repeated.
4. If the mount is successful, the application opens the file `FILE_TOO_LONG_NAME_EXAMPLE_123.JPG` for reading with the SYS_FS_FileOpen function.
5. If the file open is successful,the application creates a directory named `Dir1`, with the SYS_FS_DirectoryMake function.
6. If the directory creation is successful, the application opens the file, `FILE_TOO_LONG_NAME_EXAMPLE_123_1.JPG`, inside the directory `Dir1` for writing with the SYS_FS_FileOpen function. The attributes for file write is selected as "SYS_FS_FILE_OPEN_WRITE". Therefore, if the file does not exist, the file is created.
7. If the file open is successful, 512 bytes from the file `FILE_TOO_LONG_NAME_EXAMPLE_123.JPG` is read into application buffer using the SYS_FS_FileRead function.
8. If the file read successful, the 512 bytes is written from the application buffer to the `FILE_TOO_LONG_NAME_EXAMPLE_123_1.JPG` file using the SYS_FS_FileWrite function.
9. If the write operation is successful, the end of file for `FILE_TOO_LONG_NAME_EXAMPLE_123.JPG` is checked. If the end of file is not reached, the process of reading and writing continues (step 7 and step 8).
10. Once the end of the file is reached, both files are closed with the SYS_FS_FileClose function.
11. Finally, a LED indicates the success of the demonstration.

sdcard_msd_fat_multi_disk

This demonstration uses a USB Flash drive and a Secure Digital (SD) card as media. The application searches for a file on the USB Flash drive, opens and reads the file, and then writes the data into another file in the SD card media.

Description

This demonstration searches for a file using wildcard characters "`mch*.*`", reads the content of the file, and then writes the contents of the file to the SD card.

The demonstration application logic is implemented as a state machine in the APP_USB_MSDTasks and APP_SDCardTasks functions in the file `app.c`.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the SD Card MSD FAT Multi-disk Demonstration.

Description

To build this project, you must open the `sdcard_msd_fat_multi_disk`.X project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/fs/sdcard_msd_fat_multi_disk`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`sdcard_msd_fat_multi_disk.X`	`<install-dir>/apps/fs/sdcard_msd_fat_multi_disk/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mz_ec_sk_meb2	pic32mz_ec_sk+meb2	This configuration runs on PIC32MZ EC Starter Kit with the MEB II. The media drivers are configured for Interrupt mode and dynamic operation.
pic32mz_ef_sk_meb2	pic32mz_ef_sk+meb2	This configuration runs on PIC32MZ EF Starter Kit with the MEB II. The media drivers are configured for Interrupt mode and dynamic operation.
pic32mz_ef_sk_meb2_freertos	pic32mz_ef_sk+meb2	This configuration runs on the PIC32MZ EF Starter Kit connected to the MEB II and makes use of FreeRTOS as the underlying RTOS. The media drivers are configured for Interrupt mode and dynamic operation.

pic32mz_da_sk_meb2	pic32mz_da_sk+meb2	This configuration runs on PIC32MZ DA Starter Kit with the MEB II. The media drivers are configured for Interrupt mode and dynamic operation.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32MZ EC Starter Kit and MEB II

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ EF Starter Kit and MEB II

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ DA Starter Kit and MEB II

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

Provides instructions on how to build and run the SD card MSD FAT multi-disk demonstration.

Description

This demonstration shows an example of:

- Implementing a FAT File System on a SD card and a USB Flash drive
- Opening a file for read or write
- Searching for a file
- Checking for end of the file
- Closing a file

Do the following to run the demonstration:

1. Select the desired MPLAB X IDE project configuration for the hardware in use.
2. Copy the `mchpLogo.bmp` file from `<install-dir>/apps/fs/sdcard_msd_fat_multi_disk/firmware/src` to the USB Flash drive.
3. Insert the SD card into the MEB II.
4. Inset the USB Flash drive card into the starter kit.
5. Compile the selected configuration in the MPLAB X IDE project and run the code.
6. The demonstration searches for the `mchpLogo.bmp` on the USB Flash drive and copies it from the USB Flash drive to the SD card. The Green LED indicates the file has been successfully copied from the USB Flash drive to SD card.
7. Remove the SD card from the MEB II board and connect it to a personal computer to verify that the `mchpLogo.bmp` file is available on SD card.

Demonstration Board	Demonstration Success	Demonstration Failure
PIC32MZ EC Starter Kit PIC32MZ EF Starter Kit PIC32MZ DA Starter Kit	Green LED ON	Red LED ON

This demonstration searches for a file using wildcard characters "`mch*.*`", reads the content of the file, and then writes the contents of the file to the SD card.

The demonstration application logic is implemented as a state machine in the APP_USB_MSDTasks and APP_SDCardTasks functions in the file `app.c`.

The demonstration process is as follows:

1. The SD card is mounted using the SYS_FS_Mount function. The `/dev/mmcblka1` path instructs the mount function to mount a SD card volume. The volume is mounted with a FAT file system and mounted as `/mnt/sdDrive/`.
2. If the mount is successful, the SD card state machine waits until the USB Flash drive is connected and mounted.
3. The USB MSD task function opens an instance of the USB Host stack and enables the USB Host operations before mounting the USB Flash drive.
4. The USB Flash drive is mounted once it is connected using the SYS_FS_Mount function. The `/dev/sda1` path instructs the mount function to mount a SD USB Flash drive volume. The volume is mounted with the FAT file system as `/mnt/msdDrive/`.
5. If the USB Flash drive is mounted successfully, the application opens the root directory on the USB Flash drive and searches for the file using the wildcard characters "`mch*.*`" using SYS_FS_DirSearch.
6. If the search operation is successful, the application opens the file in read mode using SYS_FS_FileOpen.
7. If the file open is successful, the application sets the current working directory as `sdDrive` using SYS_FS_CurrentDriveSet and creates a new

file on the SD card in write mode. The name of the new file is the same as was returned from SYS_FS_DirSearch.

8. If the file is created successfully, the application reads the data from the file on the USB Flash drive using SYS_FS_FileRead and writes it to the file on the SD card using SYS_FS_FileWrite until the end of file is reached.
9. Once the end of the file is reached, both files are closed with the SYS_FS_FileClose function.
10. Green LED indicates successful operation.

sst25_fat

This application demonstrates the use of the MPLAB Harmony File System with SST25 Flash media.

Description

This application demonstrates the use of the MPLAB Harmony File System with SST25 Flash media. The application formats the SST25 Flash media, opens a file named “newFile.txt”, and writes the string “Hello World” to the file. The string is then read and compared with the string that was written to the file. If the string comparison is successful, LED indication is provided.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the SST25 Flash Demonstration.

Description

To build this project, you must open `sst25_fat.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/fs/sst25_fat`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`sst25_fat.X`	`<install-dir>/apps/fs/sst25_fat/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
bt_audio_dk_int_dyn	bt_audio_dk	This configuration runs on PIC32 Bluetooth Audio Development Kit.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32 Bluetooth Audio Development Kit

Ensure that switch S1 is set to PIC32_MCLR.

Running the Demonstration

Provides instructions on how to build and run the SST25 Flash demonstration.

Description

This demonstration illustrates the how the MPLAB Harmony File System works with the SST25VF SPI Flash media. The application does the following:

- Formats the SPI Flash media
- Opens a file named “newFile.txt”
- Writes the string “Hello World” to the file and then flushes the data onto the disk using the Sync operation
- Performs a file size check using the Stat operation, does a seek to the end of the file. The end of file is verified by using the EOF check operation.
- Another seek to the beginning of the file is done. The file data is read and compared. If the comparison is successful, the file is closed.
- The application then enters an Idle state and LED D9 is turned ON to indicate the demonstration was successful

- If an error occurs at any stage of the demonstration, LED D8 is turned ON to indicate the demonstration failed

Graphics Demonstrations

This section provides descriptions of the Graphics demonstrations.

Introduction

Graphics Library demonstrations applications Help.

Description

This distribution package contains a variety of Graphics-related firmware projects that demonstrate the capabilities of the MPLAB Harmony Graphics library. This help file describes the hardware requirement and procedures to run these firmware projects on Microchip graphics boards.

This help file contains instructions and associated information about MPLAB Harmony Graphics Demonstration applications, which are contained in the MPLAB Harmony Library distribution.

Prior to using this demonstration, it is recommended to review the MPLAB Harmony Release Notes for any known issues. A PDF copy of the release notes is provided in the `<install-dir>/doc` folder of your installation.

To know more about MPLAB Harmony Graphics, configuring the library and the APIs provided; refer to the Graphics Library documentation.

Graphic Demonstration	Description
basic_image_motion	Demonstrates the ability of the Graphics Library to depict motion by rapid display of a sequence of static images that differ from each other.
emwin_quickstart	Demonstrates integration of SEGGER emWin GUI application code with MPLAB Harmony.
external_resources	Demonstrates access of graphics resources stored on external memory.
graphics_showcase	Demonstrates advanced graphics features offered by MPLAB Harmony.
lcc	Demonstrates alpha blending, performance, images, and animation when using the on-board software-based graphics controller.
media_image_viewer	Demonstrates real-time image decoding via FAT32 File System stored on external media.
object	Demonstrates various user-interface widgets supported by the Graphics Library. The demonstration is constructed using the MPLAB Harmony Graphics Composer.
primitive	Demonstrates the types of primitive lines, rectangles, circles, and shapes as well as images on multiple screens as constructed using the MPLAB Harmony Graphics Composer. The user observes each screen through cyclical iteration.
resistive_touch_calibrate	Demonstrates a steady-state solution for calibrating through on-screen calibration prompts.
s1d13517	Demonstrates a slideshow, speed test, gradients, and alpha blending.
ssd1926	Demonstrates decoding and displaying of JPEG images utilizing the Solomon Systech SSD1926 graphics controller.
wvga_glcd	Demonstrates using Graphics LCD (GLCD) controller with the WVGA display.

Demonstrations

This topic provides information on how to run the Graphics Library demonstration applications included in this release.

basic_image_motion

The Basic Image Motion demonstration shows the ability of the Graphics Library to depict motion by rapid display of a sequence of static images that differ from each other.

Description

This application demonstrates how the Graphics Library and tools can be used to depict simple motion on the screen with displaying slightly different static images in quick succession. The ‘double buffering’ feature allows the application to use two framebuffers stored on Flash memory to enhance the display quality and demonstrate smooth motion. The double buffering feature is turned on as a part of the settings in MPLAB Harmony Configurator (MHC), which is picked up by the Graphics Library and the framebuffer is accordingly updated. The double buffering rate sets an upper limit on how fast the images can be changed to depict motion. This fastest achievable speed also varies with the size of the images to be redrawn, bigger the images, slower the fastest achievable motion.

The image formats used are JPEG and BMP. All image resources are stored on the Flash memory.

The demonstration provides the following features:

- The application loads with a PIC32 logo flash screen that brings the logo into focus and fades away
- The home screen loads with two selection options: one for a thermostat screen and another for a 3D icon spin demonstration
- The thermostat menu shows a rotating fan that changes speed with the temperature setting, which can be increased or decreased in predetermined finite jumps
- The 3D icon spin menu shows a spinning Microchip logo. A slider offers five spinning speeds and the rotations per minute (rpm) is displayed for each selected speed

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the Basic Image Motion Demonstration.

Description

To build this project, you must open the `basic_image_motion.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/gfx/basic_image_motion`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`basic_image_motion.X`	`<install-dir>/apps/gfx/basic_image_motion/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
basic_image_motion	pic32mz_ef_sk+meb2	Demonstration for the Multimedia Expansion Board II (MEB II) connected to the PIC32MZ EF Starter Kit.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32MZ EF Starter Kit and MEB II

EBIOE and LCD_PCLK (J9) must be closed. The jumper (J9) is available on the bottom side of the MEB II board.

Configuring the MHC

Provides information on MPLAB Harmony Configurator settings required for the demonstration.

Description

Drivers

Graphics Controller

The Graphics Controller selection shows the LCC Driver being selected using ‘Use LCC driver’. The Memory Interface mode selected is External Memory. This loads the program with all the resources on the 2 MB Flash memory available on the starter kit as opposed to the 512 KB RAM. External memory with its larger memory capacity is required for the application for the use of the double buffering feature, which uses two framebuffers. The hardware is accordingly configured with the jumper to match external memory setting of EBIOE and LCD_PCLK (J9) closed. Refer to the Graphics Driver Library for additional information.

I2C

The I2C Driver is selected automatically with the selection of LCC. For I2C, the software implementation of I2C is selected, which uses the bit-banged approach, as opposed to the hardware I2C. This is specific to the PIC32MZ EF Starter Kit. Refer to the I2C Driver Library for additional information.

Display

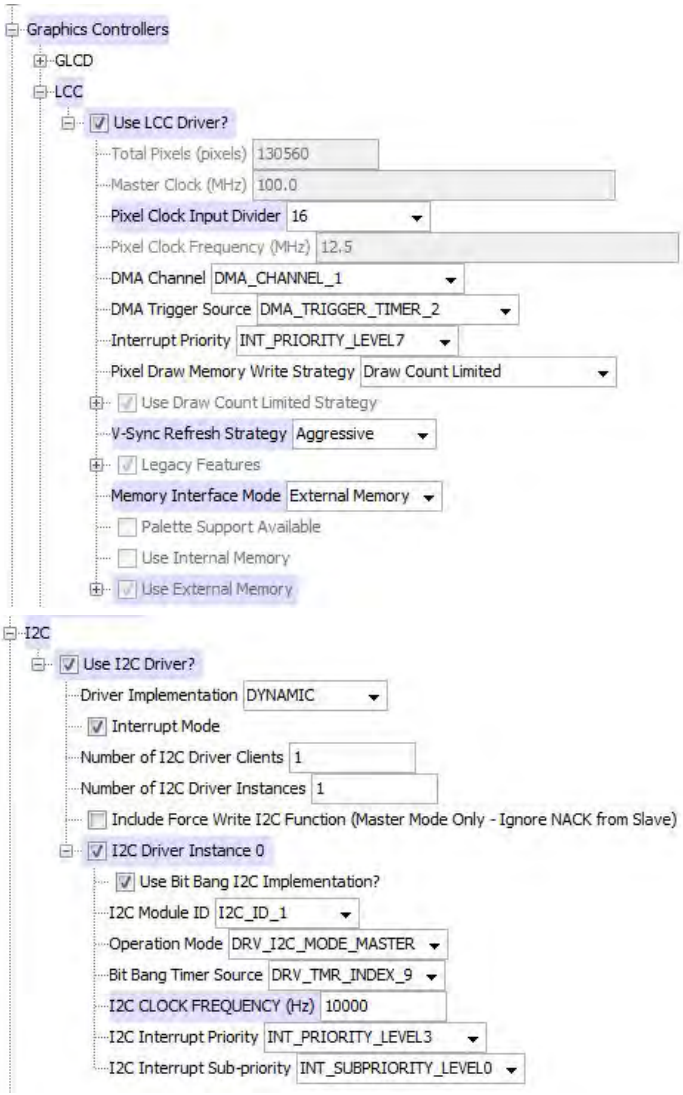
The Display Driver setting is selected to be the NewHaven 4.3"' PCAP WQVGA display. Refer to the MPLAB Harmony Display Manager User's Guide for additional information.

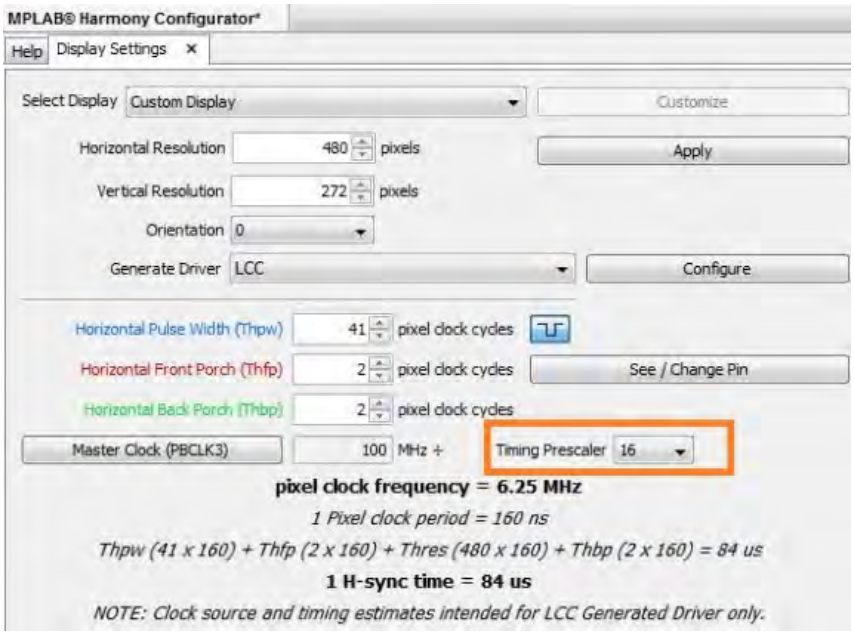
Touch Sensitivity Issue and Related Setting

With the current I2C, Touch, and Display Drivers, there is increased touch sensitivity being observed with the default settings of these drivers. This sensitivity could result in multiple interrupts being registered for a single touch and different touch location being fired non-deterministically. To work around this issue, it is necessary to change some of the I2C and Display Driver settings.

- The I2C Driver clock frequency was changed from 50 kHz to 10 kHz
- The display driver Master clock timing prescaler was changed from 8 to 16. This changes the pixel clock and the H-Sync timing, slowing the refresh rate

These settings can be observed in the following three images:





Interrupts

The option ‘Use External Interrupts’ is selected to accept touch input as the external interrupt for button actions and slideshow transitions in the application.

BSP

The BSP selected for the supported configuration is PIC32MZ EF Starter Kit in combination with the MEB II: pic32mz_ef_sk_meb2. Refer to the Configuring the Oscillator Module Using the MHC Clock Configurator for additional information.

Clock Diagram

Open the clock configurator section and make sure the following values are selected for the different clock settings as required for the pic32mz_sk_ef_meb2 configuration:

- Primary Oscillator Frequency: 24 MHz
- USB PLL: 48 MHz
- System Clock: 200 MHz
- Peripheral Bus Clock: 100 MHz
- REFCLKO: The Reference Clock (REFCLK) uses the System Clock (SYSCLK) as the reference and generates the master clock for SPI modules at 200 MHz. Refer to the Configuring the Oscillator Module Using the MHC Clock Configurator for additional information.

Pin Table

The clock, debug, and power pins will be selected as per the BSP. Pin selection specific to the application to be noted is for touch:port/pin RE8 must be selected as INT1. Refer to the MPLAB Harmony Graphical Pin Manager for additional information.

Running the Demonstration

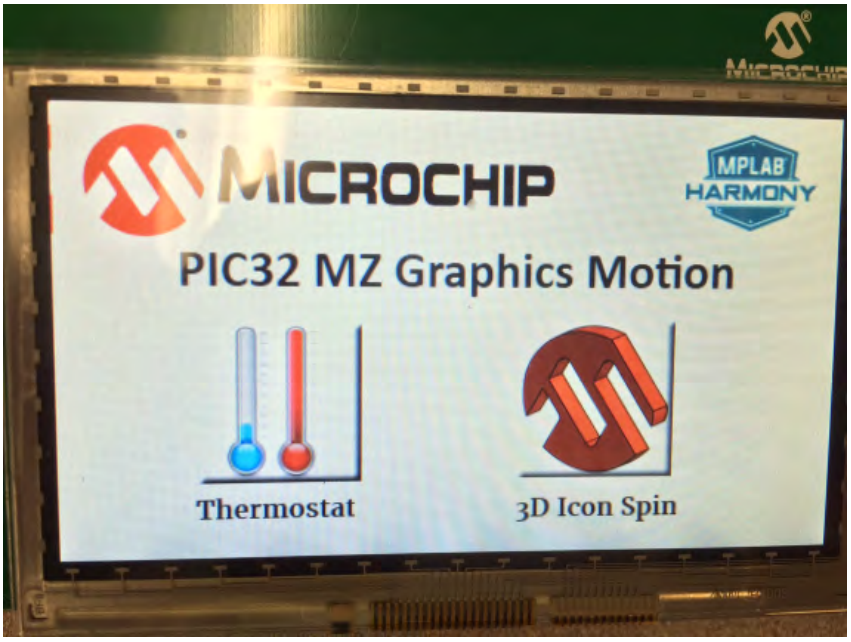
Provides instructions on how to build and run the Basic Image Motion demonstration.

Description

Perform the following steps to run the demonstration:

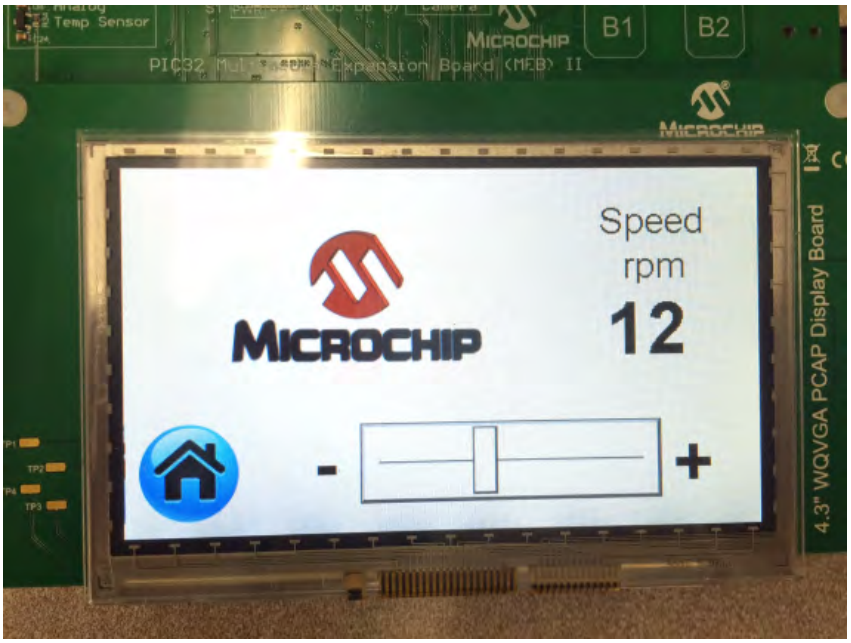
1. The application boots with a flash screen displaying a PIC32 logo coming into focus and then fading out.

2. The flash screen clears to display the main menu. The main menu shows two selection options: one for a thermostat menu and one for the 3D icon spin menu.



3. The thermostat menu displays a rotating fan and a thermometer with four settings of speed available. The speed of the fan increases as temperature decreases and vice versa, which are both being changed in finite and predetermined increments or decrements by the up and down arrow buttons. The value displayed on screen as a dummy temperature value, is in fact the timer value in milliseconds for the delay used to move through the static images to depict motion. Note that the upper and lower limits on speed and temperature setting are indicated by the buttons being grayed out.

4. The 3D icon spin menu shows the Microchip logo spinning around a slightly moving vertical axis. A slider at the bottom of the screen allows the user to change the spinning speed. There are five predetermined speed settings and the rotations per minute (rpm) for each of the speed settings are displayed on the side.



5. The transitions from the thermostat or the 3D icon spin menu to the Main menu using the Home button are accompanied with the flash screen briefly displaying the PIC32 logo coming into focus and fading out.

emwin_quickstart

Demonstrates integration of SEGGER emWin GUI application code with MPLAB Harmony.

Description

Demonstration Screens

The demonstration consists of three screens created using the SEGGER emWin GUIBuilder utility:

- Home
- Number Churning
- Text Alignment

Each screen uses different widgets from the SEGGER emWin Graphics Library. The Home screen uses the following widgets:

- Framewin : Home Screen

- Image : MPLAB Harmony Logo and SEGGER logo
- Text: *Powered by* and *emWin*
- Button: Next

Demonstration Screens

Press the **Next** button to navigate from the Home screen to the Number Churning screen. The Number Churning screen uses the following widgets:

- Framewin : Number Churning
- Slider : Single Slider with 10 divisions. The Slider position is updated by both touch input and spinbox.
- Spinbox : Three-digit spinbox with value updated by both arrow buttons and slider
- Button: Previous and Next
- Text: Move the slider or press up/down arrow button to change the number

Press the **Next** button to navigate from Number Churning Screen to Text Alignment screen. Similarly, press the **Previous** button to navigate from Number Churning Screen back to the Home screen. The Text Alignment screen consists of the following widgets:

- Framewin: Text Alignment
- Radio: Six radio buttons with each radio button affecting the alignment of the Alignment text
- Text: *Horizontal Alignment*, *Vertical Alignment*, *center*, *left*, *top*, *right*, *bottom*, and *Change text alignment by pressing the radio button*

Press the **Previous** button to navigate from Text Alignment screen back to the Number Churning screen.

SEGGER emWin and MPLAB Harmony Integration

C File Integration

The SEGGER emWin GUIBuilder utility has generated three C files with one file per screen. All files are added to the project within the logical folder `app\emwin_gui`. To integrate the generated files with MPLAB Harmony, the application uses the emWin GUI Wrapper. On selection of the emWin GUI Wrapper within MHC, the MHC code generation tool will generate the required wrapper library. Similarly, for Touch integration, an emWin Touch Wrapper Library is also available. The appropriate emWin GUI Wrapper and emWin Touch Wrapper APIs need to be called under the application code. Refer to GUI and Touch Wrapper Library for SEGGER emWIN for more information.

Display Controller Integration

Another important part is the integration of the display controller. This demonstration uses the PIC32MZ EF Starter Kit and the Multimedia Expansion Board II (MEB II). The display controller driver selected is LCC with internal memory configuration. The appropriate display controller driver APIs are called by the `LCDConf.c` file. This file will be generated by the emWin GUI Wrapper and will be added within the project logical folder `system_config\third_party\gfx\emwin\config`.

Please note that to run the demonstration using the LCC driver with the internal memory configuration, a jumper setting is required. If the jumper setting is not properly configured, the demonstration may fail to run with the display. See Configuring the Hardware for more details on the appropriate jumper settings.

Include Files

There are few include files referenced by the emWin application code. These files, which must be added manually to the project include path are located in the following folders of your installation of MPLAB Harmony:

- `<install-dir>\bin\framework\gfx\segger_emwin\inc`
- `<install-dir>\apps\gfx\emwin_quickstart\firmware\src\system_config\pic32mz_ef_sk_meb2\third_party\gfx\emwin\config`

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the emWin Quick Start Demonstration.

Description

To build this project, you must open the `emwin_quickstart.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/gfx/emwin_quickstart`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`emwin_quickstart.X`	`<install-dir>/apps/gfx/emwin_quickstart/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mz_ef_sk_meb2	pic32mz_ef_sk+meb2	SEGGER emWin GUI demonstration for the Multimedia Expansion Board II (MEB II) connected to the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32MZ EF Starter Kit and MEB II

The MEB II uses LCC as the display controller driver. LCC can be configured to use internal or external RAM for the frame buffer. This demonstration uses the LCC driver with internal RAM as frame buffer. To configure the MEB II to use internal RAM, EBIWE and LCD_PCLK (J9) must be closed.

Running the Demonstration

Provides instructions on how to build and run the emWin Quick Start demonstration.

Description

Perform the following steps to run the demonstration:

1. Open the emwin_quickstart project in MPLAB X IDE. The project file, `emwin_quickstart.X`, is located in the `<install-dir>\apps\gfx\emwin_quickstart\firmware` of your installation.
2. From the Project tab of MPLAB X IDE, right click the project and select **Set as Main Project**. This will ensure that the correct project is built and run in case multiple projects are open at the same time. By default. the pic32mz_ef_sk_meb2 configuration will be selected as current project configuration.
3. To clean and build the project, right click the project and select **Clean and Build**.
4. To run the application, connect the demonstration platform to the host computer and select the Make and Program Device tab in MPLAB X IDE. This will program the device with the newly build project hex file and run the demonstration.

external_resources

Demonstrates access of graphics resources stored on external memory.

Description

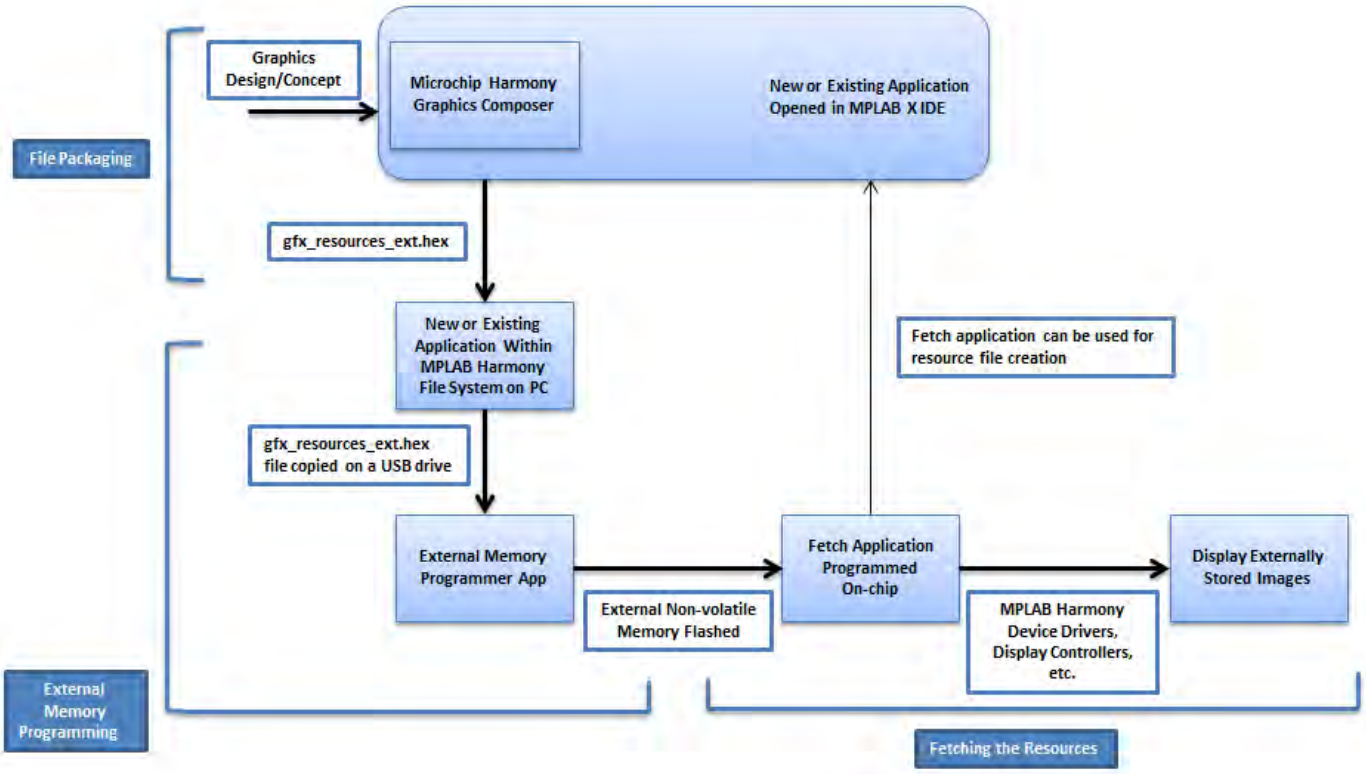
This demonstration provides information on how to access graphics resources that are stored on external memory.

This capability is useful for applications that have large graphics resource requirements, such as storing large bitmap files or multiple page menu screens that require several images or large or multiple font packages, etc. In these instances, storing these graphics resources on-chip may result in insufficient memory or may be prohibitive to a possible cost benefit. A solution is to store the graphics resources to off-chip memory, such as non-volatile memory, thereby preserving the on-chip memory for program memory and allowing for more complex functional features.

To demonstrate how to access graphics resources stored on an external memory device, three components are needed:

- File Packaging
- Bootloader Application
- Fetch Application

Figure 1: External Resources Process Diagram



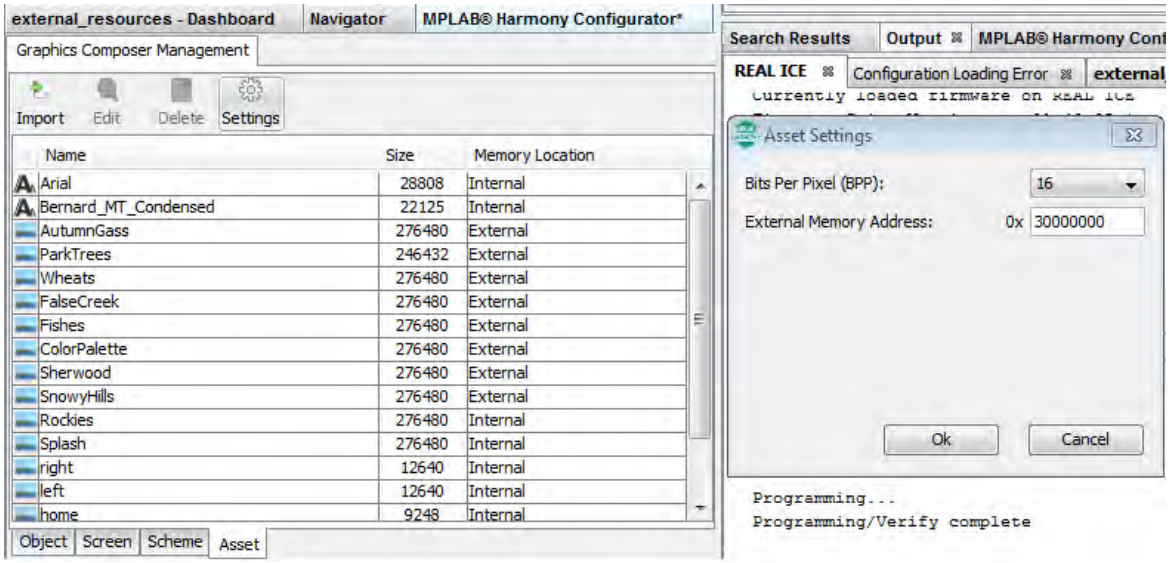
File Packaging

The resources to be stored externally need to be packaged into a resource file that would be flashed into the external memory. The MPLAB Harmony Graphics Composer, which is the primary tool used by the MPLAB Harmony application for configuring the graphic design for the application, has the ability to generate the required resource file containing the binary data for all of the graphics images to be stored on external memory.

Refer to the MPLAB X IDE online help and *Volume II: MPLAB Harmony Configurator (MHC)* > MPLAB Harmony Graphics Composer User's Guide for usage information.

The graphics composer has the capability to manage the application assets by importing different resources including images, fonts, etc., into an application. The Graphics Composer Management window in Figure 2 shows the selection of the storage location for each graphics resource, as either external or internal memory. Generating the graphics composer configuration creates the `gfx_resources_ext.hex` file. In future versions of the MPLAB Harmony Graphics Composer it is planned to include the ability to store different resources on different external memories and specify which external memory (e.g., SQI, SPI, etc.) is targeted for each individual resource. At present, the specific external memory chosen to store the resources is indicated with the starting address for the external memory. The Settings tab in the Asset window as shown in Figure 2 has a field for entering the External memory address. In this project as we are using SQI flash, the starting address of 0x30000000 has been specified. This information is incorporated into the `gfx_resources_ext.hex` file.

Figure 2: Graphics Composer Management Window



Memory Writer Application

A memory writer application is required to flash the `gfx_resources_ext.hex` file containing the binary data of the external graphics resources into the desired external non-volatile memory. The memory writer application, sqi_flash, uses a USB Flash drive, which has a FAT32 file system installed, in the Host mode as the source for the `gfx_resources_ext.hex` file. The USB Flash drive in the Host mode is scanned by the memory writer for this file and it is flashed onto the SQI Flash external memory. Refer to *External Memory Programmer Demonstrations*> sqi_flash for usage information.

Fetch Application

The third component is the application that actually fetches the stored external graphics resources and uses or processes these resources.

The external_resources application will demonstrate the fetching of the externally stored graphics images and using the MPLAB Harmony framework drivers, display controllers, etc., and display those resources on the screen. This application has been created to have a large memory requirement for its graphics resources that are larger than the available on-chip memory space. The graphics resources used are large bitmap images displayed as a slideshow with touch input to transition between the slides. Using the MPLAB Harmony Graphics Composer, the external_resources application generates the graphic design and configuration of the bitmap images on the screen and this also generates the `gfx_resources_ext.hex` file that the external memory programmer application uses to flash the external memory.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the External Resources Demonstration.

Description

To build this project, you must open the `external_resources.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/gfx/external_resources`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`external_resources.X`	`<install-dir>/apps/gfx/external_resources/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mz_ef_sk_meb2	pic32mz_ef_sk+meb2	External Resource demonstration for the Multimedia Expansion Board II (MEB II) connected to the PIC32MZ EF Starter Kit and the Graphics Display Powertip 4.3" 480x272 Board. The daughter board in the PIC32MZ EF Starter Kit has a 4 MB SQI Flash memory device, which is used as the external non-volatile memory for this application.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32MZ EF Starter Kit and MEB II with Graphics Display Powertip 4.3" 480x272 Board

The MEB II has two memory options External or Internal; however, this demonstration must be run in Internal mode. Configure the MEB II, as follows:

- EBIWE and LCD_PCLK (J9) must be closed (the jumper is located on the back of the MEB II board)
- Ensure that any MHC setting is defined to only use internal SRAM

The current internal/external memory setting for the application can be verified in MHC by selecting *Harmony Framework Configuration* > *Drivers* > *Graphics Controllers* > *LCC* > *Use LCC Driver* > *Memory Interface Mode*.

Configuring the MHC

Provides information on MPLAB Harmony Configurator settings required for the demonstration.

Description

The following are some of the MHC settings that were modified from the default values.

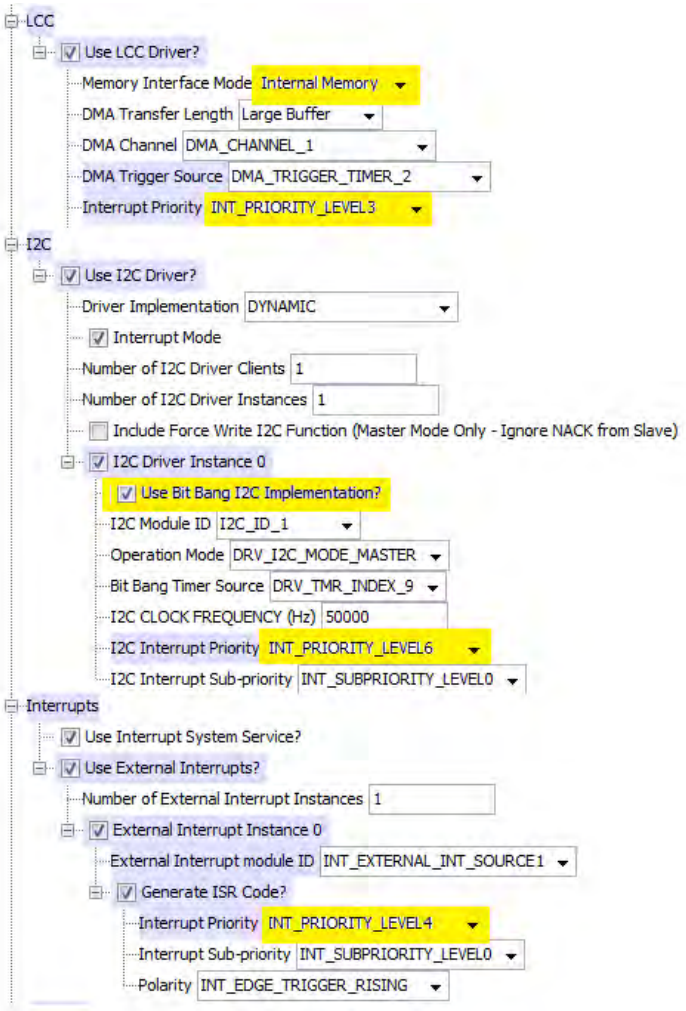
Drivers

The Graphics Controller selection shows the LCC Driver being selected using 'Use LCC driver'. The Memory Interface Mode selected is Internal Memory. This is due to the fact that we want to load the program on internal memory and we are configuring the hardware with the jumper to match internal memory.

I2C is selected in addition to LCC. For I2C we are selecting the software implementation of I2C which uses the bit-banged approach as opposed to the hardware I2C. This is specific to the PIC32MZ EF Starter Kit. Also important to note is that the bit-banged I2C implementation requires that the interrupt priority be changed.

The interrupt priorities for the modules in use must be arranged from high to low in the following order (see the following figure for details):

- I2C interrupt has the highest priority (e.g., priority 6)
- MTCH6301 interrupt (external interrupt) lower than I2C, but higher than LCC DMA (e.g., priority 5)
- LCC DMA interrupt lower than the MTCH6301 interrupt (e.g., priority 4)

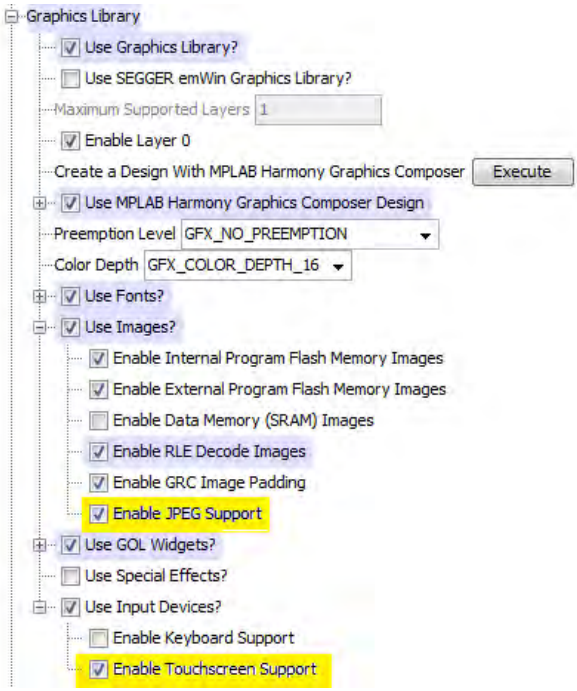


Graphics Library

This selection enables all of the Graphics Object Library (GOL) features required by the application. It also enables the graphics design features through the MPLAB Harmony Graphics Composer. Designing in the graphics composer automatically selects the different GOL components such as buttons, widgets, images, screens, etc., as used on the graphics composer design windows.

Specifically selected options are:

- Use Input devices > Enable Touch Support
- Use Images > Enable JPEG Support



Interrupts

The option 'Use External Interrupts' is selected to accept touch input as the external interrupt for button actions and slideshow transitions in the application.

BSP

The BSP selected for the supported configuration is PIC32MZ EF Starter Kit in combination with the MEB II: pic32mz_ef_sk_meb2.

Clock Diagram

Open the clock configurator section and make sure the following values are selected for the different clock settings as required for the pic32mz_sk_ef_meb2 configuration:

- Primary Oscillator frequency: 24 MHz
- USB PLL: 48 MHz
- System Clock: 200 MHz
- Peripheral Bus Clock: 100 MHz
- REFCLKO: The Reference Clock (REFCLK) uses the System Clock (SYSCLK) as the reference and generates the master clock for SPI modules at 200 MHz

Pin Table

The clock, debug, and power pins will be selected as per the BSP. Pin selection specific to the application to be noted is for touch:port/pin RE8 must be selected as INT1.

Application-specific Software Setup

SQI external memory support: A formal SQI driver is not available in MPLAB Harmony. Therefore, the SQI Peripheral Library in MPLAB Harmony is used. Please note that the source and header files for SQI enabling have been manually included in the project:

- `SourceFiles/framework/sqi_flash/drv_nvm_flash_sqi_sst26.c`
- `HeaderFiles/framework/drv_nvm_flash_sqi_sst26.h`

Also note that to refer to these files, a preprocessor macro has been added to the application properties named SST26VF_B.

Running the Demonstration

Provides instructions on how to build and run the External Resources demonstration.

Description

1. In this step we are using the MPLAB Harmony Graphics Composer portion of the external_resources application to create the `gfx_resources_ext.hex` file. Open the `<install-dir>\apps\gfx\external_resourcesexternal_resources` folder on the computer. The external resources to be stored on the external non-volatile memory are available in the `gfx_resources_ext.hex` file. In this demonstration, the file has already been generated and is available in the `<install-dir>\apps\gfx\external_resources\firmware\src\system_config\pic32mz_ef_sk+meb2\` folder. This file will be

required by the external memory programmer application to flash the SQI memory. If the user chooses to change the graphics design or external resources, the project external_resources should be opened using MPLAB X IDE and the graphics should be changed using the graphics composer. Any change to the graphics would require regenerating the configuration and regenerating the `gfx_resources_ext.hex` file before being used by the external memory programmer application. This process requires both MPLAB X IDe and MPLAB Harmony. Refer to the MPLAB X IDE online help and *Volume II: MPLAB Harmony Configurator (MHC)* > MPLAB Harmony Graphics Composer User's Guide for usage information.

2. Connect a USB Flash drive, which is mounted with a FAT32 file system, into the computer port and copy the `gfx_resources_ext.hex` file from `apps\gfx\external_resources\firmware\src\system_config\pic32mz_ef_sk+meb2\` onto the Flash drive.
3. Next, connect the USB Flash drive to the Host connector on the PIC32MZ EF Starter Kit daughter board.
4. Program the board with the programmer/sqi_flash application using the pic32mz_ef_sk_meb2_gfx_ext_res configuration. This application flashes the `gfx_resources_ext.hex` file available on the USB Flash drive into the external SQI memory. Refer to *External Memory Programmer Demonstrations*> sqi_flash for usage information.
5. The external_resources application is the third component that actually fetches and displays the external resources stored in external SQI memory. Program the external_resources application onto the device. The application demonstrates both internal and external resources being used together by distributing the images between internal and external memory. The first menu screen has two buttons, one for external and one for internal resources. Selecting one starts a slideshow, which accepts touch input to transition between slides and displays either the prestored external images or the internal images on screen. The internal images consist of bitmaps, as well as JPEG images, to demonstrate JPEG support and run-time JPEG decode for internal resources. The menu also has a third button that briefly describes the demonstration.
6. Please note that once the external resources have been flashed into the SQI memory, it is not required to re-flash the resources every time while using the external_resources application. However if the user changes the graphics design in the external_resources demonstration, the configuration needs to be regenerated and the new `gfx_resources_ext.hex` file needs to be reflashed to external memory using Step 2. This is to ensure that the external graphics resources being flashed on external memory are in sync with the new graphics composer design utilizing the resources. Failure to do so will result in externally stored graphics images not being displayed correctly on screen.

Note: Currently, JPEG decode support has been enabled for internal storage. During the demonstration it can be observed that latency fetching the images from external off-chip memory causes slow population of the display while rendering the images on screen memory. A similar latency is also seen while displaying JPEG images on screen due to the delay caused by JPEG run-time decoding.

graphics_showcase

Provides information on the demonstration.

Description

Demonstrates a sub-set of capabilities offered by the Graphics Library utilizing Low-Cost Controllerless features and the MTCH6303 PCAP Touch Controller with the 5" WVGA PCAP Display Board (see **Note**). Additional configurations supporting the 4.3" WQVGA PCAP Display Board that comes standard with the MEB II are also included as reference.

Note: Please contact your local Microchip sales office for information on obtaining the 5" WVGA PCAP Display Board.

The demonstration includes the following features:

- WVGA display
- Integrated MTCH6303 PCAP touch input
- Low-Cost Controllerless (LCC) Graphics driver
- 16-bit color depth support (65535 unique colors)
- JPEG and BMP images stored on internal Flash
- Real-time JPEG decode and rendering
- 16-bit Unicode character font support
- Multi-lingual localized menu (Chinese Traditional and Chinese Simplified)
- Console output debugging

Building the Application

This topic identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the Graphics Showcase Demonstration.

Description

To build this project, you must open the `graphics_showcase.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/gfx/graphics_showcase`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
graphics_showcase.X	<install-dir>/apps/gfx/graphics_showcase/firmware

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mz_ef_sk	pic32mz_ef_sk+meb2	Demonstration for the Multimedia Expansion Board II (MEB II) connected to the PIC32MZ EF Starter Kit.
pic32mz_ef_sk_meb2_wvga	pic32mz_ef_sk+meb2+wvga	Demonstration for the Multimedia Expansion Board II (MEB II) connected to the PIC32MZ EF Starter Kit utilizing the 5" WVGA PCAP Display Board.

Configuring the Hardware

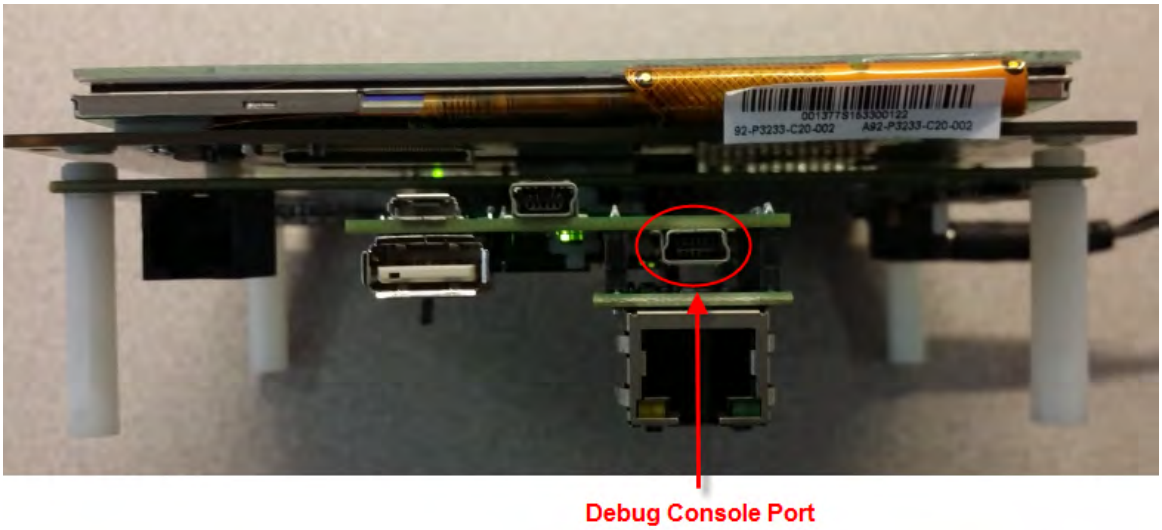
Describes how to configure the supported hardware.

Description

PIC32MZ EF Starter Kit and MEB II

EBIOE and LCD_PCLK (J9) must be closed. The jumper (J9) is available on the bottom side of the MEB II board.

This demonstration also has a Debug Console enabled via UART over USB. You will need a USB Type-A to USB Type-B cable. Connect the cable to the port as shown in the following figure. Also configure the terminal emulator software with the serial port settings of: 8-bit, Non-parity, 1 Stop bit, and No Flow Control.



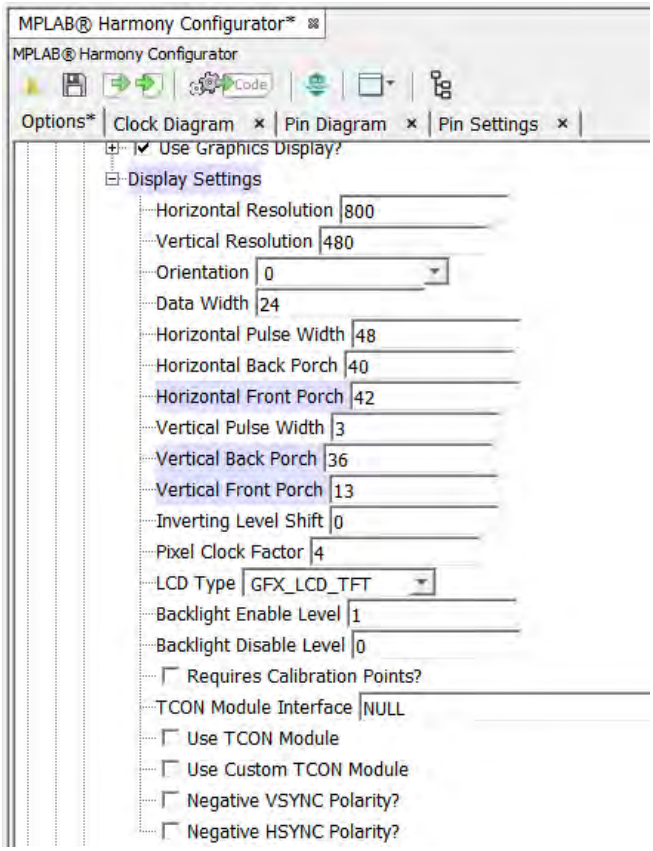
Configuring the MHC

Provides information on MPLAB Harmony Configurator settings required for the demonstration.

Description

The following figure shows the MHC Driver settings that were modified from the default values:

- Horizontal Front Porch: 42
- Vertical Back Porch: 36
- Vertical Front Porch: 13



Running the Demonstration

Provides instructions on how to build and run the Graphics Showcase demonstration.

Description

On successful power-on, the demonstration will display a similar menu to that shown in the following figure:

The demonstration is separated into four parts:

1. The Slideshow mode consists of a series of JPEG images rendered at 16-bpp color depth. The demonstration will cycle to the next slide upon time-out via a timer, which can be configured through the Settings sub-menu. Tapping the image will skip to the next slide without the need to

wait for the timer. Press and hold to keep the image from cycling.

2. The Touch Test mode brings up a simple screen that tracks and records the touch location. The X and Y coordinates are displayed through the digital meter widgets on the right. The X/Y coordinates are also displayed through the debug console.
3. Under the Settings menu you may change the timing of the slides using a slider. The other feature is the multi-lingual support of this demonstration. Touching any of radio buttons will allow you to change the language displayed for the entire demonstration between English and either Traditional or Simplified Chinese.
4. The demonstrated Features can be displayed through the last selection on the main menu.

Application Functions and Prototypes

Functions

	Name	Description
	APP_ChangeMode	Changes the current application mode
	APP_GenerateSysMsgGet	Generate Sys Msg Touch Data
	APP_HandleLanguageSetting	Changes the current application language settings
	APP_HandleTouchTest	Sends current x/y touch values to the digital meter in the Touch Test screen
	APP_ProcessModeState	Changes the currnet application state base on the current selected mode
	APP_RedrawRectangle	Set the redraw the rectangle in the touch test screen
	APP_TouchMessageCallback	Touch event callback routine.
	APP_UpdateFeatureList	Updates the Feature List to be displayed, base on the language setting
	APP_UpdateLanguageTexts	Updates the Settings text to be displayed, base on the language setting
	APP_UpdateMainMenu	Updates the Main Menu text to be displayed, base on the language setting
	APP_UpdateSlideShowTips	Updates the Slideshow instructrion text to be displayed, base on the language setting

Description

Lists the functions and prototypes available for the demonstration, which are provided in the `app.h` header file.

Functions

APP_ChangeMode Function

Changes the current application mode

File

graphics_showcase_app.h

C

```
void APP_ChangeMode(APP_MODES mode);
```

Description

This is function is setup to be called on a release event by a screen button to help navigate between modes. When called, this function sets up any necessary steps to switch to the requested mode.

Function

void APP_ChangeMode(APP_MODES mode);

APP_GenerateSysMsgGet Function

Generate Sys Msg Touch Data

File

graphics_showcase_app.h

C

```
bool APP_GenerateSysMsgGet();
```

Returns

true if touch event is processed.

Remark: This function is here because the MTCH6303 driver has not been integrated to SYS Touch. This function is doing normally what SYS Touch should be doing

Description

This function is called in APP_Tasks() every cycle to determine press/still press/release situations and then send out the result via SYS MSG, the recipient of the message should be the GOL library where it uses the data to handle widget behavior.

Function

bool APP_GenerateSysMsgGet(void)

APP_HandleLanguageSetting Function

Changes the current application language settings

File

graphics_showcase_app.h

C

```
void APP_HandleLanguageSetting(APP_LANGUAGES language);
```

Description

This is function is setup to be called on a select event by a radio button to select the language. When called, this function sets up any necessary steps to switch to the requested language.

Function

void APP_HandleLanguageSetting(APP_LANGUAGES language);

APP_HandleTouchTest Function

Sends current x/y touch values to the digital meter in the Touch Test screen

File

graphics_showcase_app.h

C

```
void APP_HandleTouchTest();
```

Description

Handles the reporting of the euclidean coordinate values to the digital meter in the Touch Test screen

Function

void APP_HandleTouchTest(void);

APP_ProcessModeState Function

Changes the currnet application state base on the current selected mode

File

graphics_showcase_app.h

C

```
void APP_ProcessModeState();
```

Description

This is function is called to handle transitioning to a new state if a mode change has been requested by the user.

Function

void APP_ProcessModeState(void);

APP_RedrawRectangle Function

Set the redraw the rectangle in the touch test screen

File

graphics_showcase_app.h

C

```
void APP_RedrawRectangle();
```

Description

When called, this function clears the touch screen test area by repainting a rectangle in the test area.

Function

void APP_RedrawRectangle(void);

APP_TouchMessageCallback Function

Touch event callback routine.

File

graphics_showcase_app.h

C

```
void APP_TouchMessageCallback(SYS_MSG_OBJECT * pMsg);
```

Description

This is the callback from the GFX_HGC layer to inform the application of a touch event. pMsg includes the current touch behavior and the touch position is reported via the Touch System Service

Remarks

This function is registered via GFX_HGC_RegisterAppTouchCallback in APP_Initialize(). This function is only included in the build when not using MTCH6303 touch driver. This is because the Touch System Service is not supported by MTCH6303 touch driver for MPLAB Harmony v1.07.

Function

void APP_TouchMessageCallback (SYS_MSG_OBJECT *pMsg);

APP_UpdateFeatureList Function

Updates the Feature List to be displayed, base on the language setting

File

graphics_showcase_app.h

C

```
void APP_UpdateFeatureList();
```

Description

This is called in APP_Tasks() during the Feature List mode to draw the correct set of feature list to display, base on the language setting (English, Chinese Traditional, and Chinese Simplified)

Function

void APP_UpdateFeatureList(void);

APP_UpdateLanguageTexts Function

Updates the Settings text to be displayed, base on the language setting

File

graphics_showcase_app.h

C

```
void APP_UpdateLanguageTexts();
```

Description

This is called in APP_Tasks() during the Settings mode to draw the correct set of settings text to display, base on the language setting (English, Chinese Traditional, and Chinese Simplified)

Function

void APP_UpdateLanguageTexts(void);

APP_UpdateMainMenu Function

Updates the Main Menu text to be displayed, base on the language setting

File

graphics_showcase_app.h

C

```
void APP_UpdateMainMenu();
```

Description

This is called in APP_Tasks() during the Main Menu mode to draw the correct set of text to display, base on the language setting (English, Chinese Traditional, and Chinese Simplified)

Function

void APP_UpdateMainMenu(void);

APP_UpdateSlideShowTips Function

Updates the Slideshow instructrion text to be displayed, base on the language setting

File

graphics_showcase_app.h

C

```
void APP_UpdateSlideShowTips();
```

Description

This is called in APP_Tasks() during the Slideshow mode to draw the correct set of text to display, base on the language setting (English, Chinese Traditional, and Chinese Simplified)

Function

void APP_UpdateSlideShowTips(void);

Data Types and Constants

lcc

Demonstrates the advanced capabilities of the Graphics Library utilizing the software graphics controller.

Description

This demonstration provides the ability to display alpha blend and gradient colors through the software graphics controller. The demonstration renders four folders for alpha blend, gradient, picture-in-picture (PIP), and performance for all PIC32 devices.

For PIC32MX devices, the demonstration runs on the PICtail Plus Low-Cost Controllerless (LCC) Daughter Board, and on PIC32MZ devices, it runs on the Multimedia Expansion Board II (MEB II).

This demonstration requires the use of memory external to the microcontroller. The memory is provided on the board, but must be configured with a hardware jumper.

Important! To set up the external memory, a jumper setting on the board is required. Failure to configure this jumper setting will prevent the display from working, although the software may still run. See Configuring the Hardware for details on the appropriate jumper settings.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the Low-Cost Controllerless (LCC) Demonstration.

Description

To build this project, you must open the `lcc.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/gfx/lcc`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`lcc.X`	`<install-dir>/apps/gfx/lcc/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx_pcap_db	pic32mx_pcap_db	LCC demonstration for the Low-Cost Controllerless (LCC) Graphics using the PIC32 GUI Development Board with Projected Capacitive Touch.
pic32mx_usb_sk2_lcc_pictail_wqvga	pic32mx_usb_sk2+lcc_pictail+wqvga	LCC demonstration for the Low-Cost Controllerless (LCC) Graphics PICtail Plus Daughter Board with the Graphics Display Powertip 4.3" 480x272 Board connected to the PIC32 USB Starter Kit II.
pic32mz_ef_sk_meb2	pic32mz_ef_sk+meb2	LCC demonstration for the Multimedia Expansion Board II (MEB II) connected to the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32 USB Starter Kit II

No hardware related configuration or jumper setting changes are necessary.

PIC32 USB Starter Kit II and Low-Cost Controllerless (LCC) Graphics PICtail Plus Daughter Board

Make the following changes to the daughter board:

- Set J4 to 2-3 for external SRAM use. The jumper must be set to enable display operation. Ensure that any MHC setting defines external SRAM use only.
- Set jumpers J6-J19 to (2-3) for 16-bit (565) color mode

PIC32MZ EF Starter Kit and MEB II

The MEB II has two memory options External or Internal; however, this demonstration must be run in External mode; therefore, EBIOE and LCD_PCLK (J9) must be closed. The jumper is located on the bottom side of the MEB II board. Ensure that any MHC setting is defined to only use external SRAM.

The current internal/external memory setting for the application can be verified in MHC by selecting *Harmony Framework Configuration* > *Drivers* > *Graphics Controllers* > *LCC* > *Use LCC Driver* > *Memory Interface Mode*.

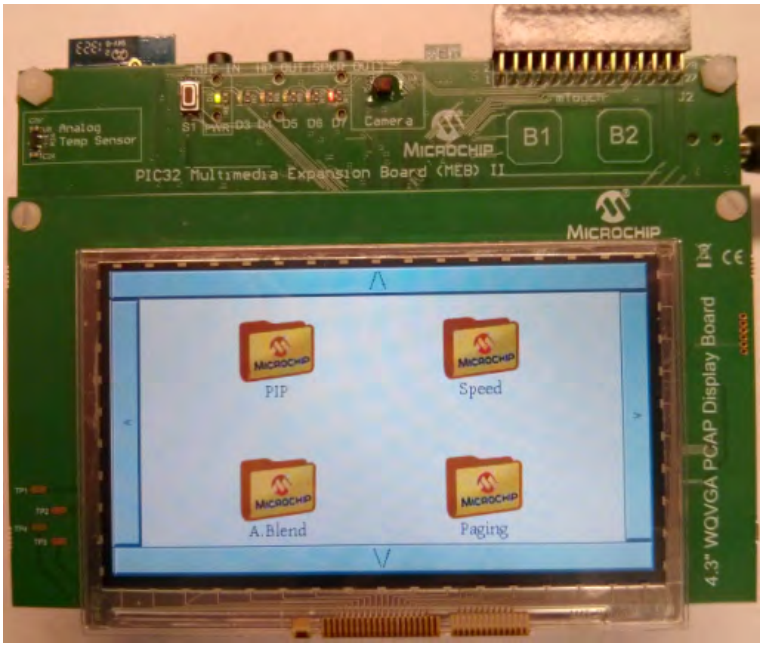
Running the Demonstration

Provides instructions on how to build and run the LCC demonstration.

Description

This demonstration shows the Graphics Library interfacing with the Low-Cost Controllerless (LCC) software display controller. It shows alpha blending, gradient, panning, and double buffering capabilities through the Graphics Library.

1. Load the demonstration project into MPLAB X IDE.
2. Build, Download, and Run the demonstration project on the target board.
3. Use the graphics buttons to navigate between screens.



Demonstration Output

The demonstration renders four folders for alpha blend, gradient, picture-in-picture (PIP), and performance. Touch one of the folders to activate the demonstration. Touching arrow buttons will move the screen in the arrow direction

- **PIP:** Demonstrates the moving cursor represented by different images and a bevel shape with gradient applied
- **Speed:** Draws random bars of random size at random locations demonstrating the speed of drawing bars
- **Alpha blend:** Demonstrates alpha blending feature applied to three buttons, which blends them with the background. The background is an image of MPLAB Harmony's "Integrate" and "Harmonize" logo
- **Paging:** Demonstrates background color changing effects using multiple surfaces. In this demonstration, the background color changes with the weather. The demonstration also draws a cloud image and includes text showing the date, time, and temperature.

Troubleshooting TIP! When executing the application, if the display is static and is either all bright or all dark, it is likely that the memory setting is incorrect. See Configuring the Hardware for additional information.

media_image_viewer

Demonstrates real-time image decoding via FAT32 File System stored on external media.

Description

This demonstration provides the ability to load and render image files via a FAT32 File System stored on external SD card media.

The image formats supported in this demonstration includes JPEG, BMP, static GIF, transparent GIF and animated GIF. The application also demonstrates the ability of the MPLAB Harmony Graphics Library to automatically perform best-fit to the screen by down-sizing images with a higher pixel resolution than the screen.

The auto-mount feature from the File System Service is utilized by the application such that the SD card media can be ejected and swapped at run-time.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the Media Image Viewer Demonstration.

Description

To build this project, you must open the `media_image_viewer.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/gfx/media_image_viewer`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
media_image_viewer.X	<install-dir>/apps/gfx/media_image_viewer/firmware

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within ./firmware/src/system_config.

Project Configuration Name	BSP Used	Description
pic32mz_ef_sk_meb2	pic32mz_ef_sk+meb2	Demonstration for the Multimedia Expansion Board II (MEB II) connected to the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit.
pic32mz_ef_sk_meb2_wvga	pic32mz_ef_sk+meb2+wvga	Demonstration for the Multimedia Expansion Board II (MEB II) connected to the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit with the WVGA display.

Application Header File

This table lists and describes the application header file used by the demonstration, which is located within ./firmware/src.

Project Configuration Name	Description
app.h	This header file provides function prototypes and data type definitions for the application. Some of these are required by the system (such as the APP_Initialize and APP_Tasks prototypes) and some of them are only used internally by the application (such as the APP_STATES definition). Both are defined in this file for convenience.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32MZ EF Starter Kit and MEB II

The MEB II has two memory options External or Internal; however, this demonstration must be run in External mode; therefore, EBIOE and LCD_PCLK (J9) must be closed. The jumper is located on the bottom side of the MEB II board. Ensure that any MHC setting is defined to only use external SRAM.

The current internal/external memory setting for the application can be verified in MHC by selecting *Harmony Framework Configuration* > *Drivers* > *Graphics Controllers* > *LCC* > *Use LCC Driver* > *Memory Interface Mode*.

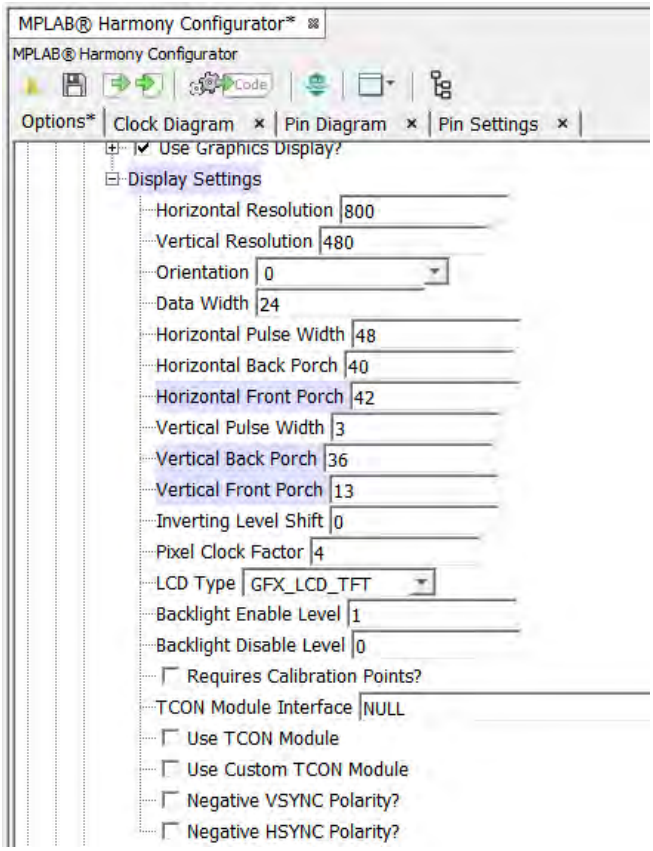
Configuring the MHC

Provides information on MPLAB Harmony Configurator settings required for the demonstration.

Description

The following figure shows the MHC Driver settings that were modified from the default values:

- Horizontal Front Porch: 42
- Vertical Back Porch: 36
- Vertical Front Porch: 13



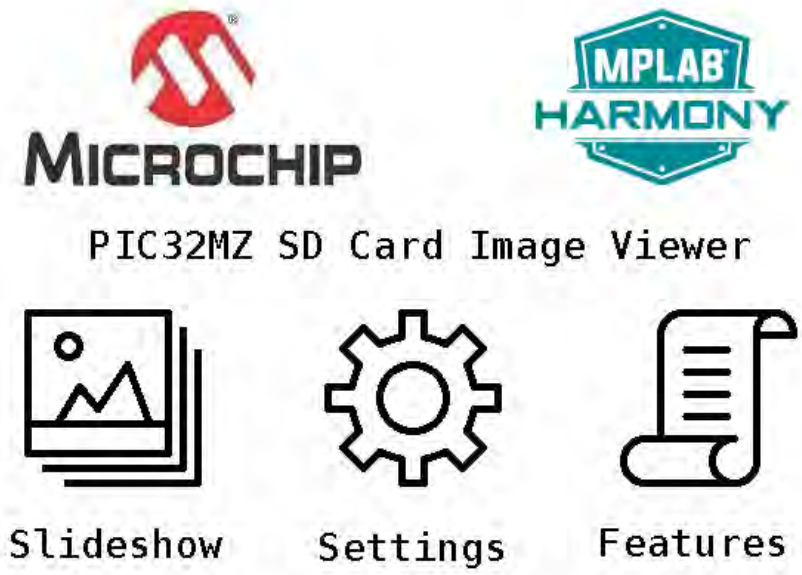
Running the Demonstration

Provides instructions on how to build and run the Media Image Viewer demonstration.

Description

Perform the following steps to run the demonstration.

1. Load the demonstration project into MPLAB X IDE.
2. Build, Download, and Run the demonstration project on the target board.
3. Insert a SD card (formatted for FAT or FAT32) with JPEG, BMP, and/or GIF images to the SD card socket, which is located on the back of the MEB II. The application is designed to allow the SD card to be ejected and swapped at run-time. However, there is a limitation to this feature. The application will not be able to recover if the SD card is ejected when an image is partially loaded on screen.
4. If a SD card is not present, or the application had problems reading the SD card, a screen will appear with the message "Please insert SD card".
5. When the application is able to detect the SD card, it will automatically proceed to search the card and discover all the images on the card. If the application detects a large number of images, a screen will appear with the message "Searching for images".
6. Once the SD card has been read by the application, the following menu is displayed.



7. Pressing the Slideshow virtual button on the screen will open a set of brief instructions on how to navigate between images during Slideshow mode. Tap anywhere on the screen and the application will proceed to render every image detected on the SD card. The image formats supported are JPEG, BMP and GIF (see **Note**). A limited amount of animated GIF and semi-transparent GIFs are also supported. Image rendering time may vary, depending on image resolution, file size (larger for BMP) and decoding time (JPEG and GIF). The application will perform a best-fit to the screen, automatically down-sizing for images with a resolution that is larger than the screen resolution.

Note: Progressive scan JPEG images are not supported.

8. The Settings button will direct you to the settings menu. The pause time between slides can be adjusted here. Also available for turning on/off is the image meta data that is displayed in the upper left corner. For the PIC32MZ EF Starter Kit plus MEB II configuration, the settings menu also includes the ability to enable and disable double buffering at run-time as an option to enhance display quality.
9. The Feature List button provides a list of the hardware and software features demonstrated in this application.

Application Functions and Prototypes

Functions

	Name	Description
	APP_DoubleBufferingEnable	API from the UI to application to enable/disable double buffering.
	APP_GoToNextSlide	Set the slideshow to the next slide.
	APP_IsSupportedFile	Callback handler to check if the file is supported.
	APP_MetaDataEnable	API from the UI to application to enable/disable meta data display.
	APP_ReadNextImageHeader	Read and prepare the next image header.
	APP_SetSlidePauseTime	Sets Slide Pause Interval Time.

Data Types and Constants

	Name	Description
	APP_DISK_FILE_NODE	This is type APP_DISK_FILE_NODE.
	APP_DISK_FILE_PATH	This is type APP_DISK_FILE_PATH.
	APP_DISK_MAX_DIRS	
	APP_DISK_MAX_FILES	This is macro APP_DISK_MAX_FILES.
	APP_LANGUAGES	Enumeration of the languages supported in this application

Description

Lists the functions and prototypes available for the demonstration, which are provided in the `app.h` header file.

Functions

APP_DoubleBufferingEnable Function

API from the UI to application to enable/disable double buffering.

File

media_image_viewer_app.h

C

```
void APP_DoubleBufferingEnable(bool enable);
```

Description

When called, this function updates the double buffering flag in the application.

Function

void APP_DoubleBufferingEnable(bool enable)

APP_GoToNextSlide Function

Set the slideshow to the next slide.

File

media_image_viewer_app.h

C

```
void APP_GoToNextSlide();
```

Description

When called, this function sets up any necessary steps to switch to the next slide.

Function

void APP_GoToNextSlide(void);

APP_IsSupportedFile Function

Callback handler to check if the file is supported.

File

media_image_viewer_app.h

C

```
bool APP_IsSupportedFile(char * name);
```

Description

This function confirms if the files are supported by the application.

Function

void APP_IsSupportedFile(char *name)

APP_MetaDataEnable Function

API from the UI to application to enable/disable meta data display.

File

media_image_viewer_app.h

C

```
void APP_MetaDataEnable(bool enable);
```

Description

When called, this function updates the meta data display flag in the application.

Function

void APP_MetaDataEnable(bool enable)

APP_ReadNextImageHeader Function

Read and prepare the next image header.

File

media_image_viewer_app.h

C

```
bool APP_ReadNextImageHeader();
```

Description

This function is set up to the next image resource header.

Function

bool APP_ReadNextImageHeader(void)

APP_SetSlidePauseTime Function

Sets Slide Pause Interval Time.

File

media_image_viewer_app.h

C

```
void APP_SetSlidePauseTime(int timeInSec);
```

Description

This function is set up to be called on a touch event by the slider bar in the Settings menu.

Function

void APP_SetSlidePauseTime(int timeInSec);

Data Types and Constants

APP_DISK_FILE_NODE Structure

File

media_image_viewer_app.h

C

```
typedef struct {
  SYS_FS_FSTAT fstat;
  char path[255];
} APP_DISK_FILE_NODE;
```

Description

This is type APP_DISK_FILE_NODE.

APP_DISK_FILE_PATH Structure

File

media_image_viewer_app.h

C

```
typedef struct {
  char path[255];
} APP_DISK_FILE_PATH;
```

Description

This is type APP_DISK_FILE_PATH.

APP_DISK_MAX_DIRS Macro

File

media_image_viewer_app.h

C

```
#define APP_DISK_MAX_DIRS 100
```

Section

Type Definitions

APP_DISK_MAX_FILES Macro

File

media_image_viewer_app.h

C

```
#define APP_DISK_MAX_FILES 1000
```

Description

This is macro APP_DISK_MAX_FILES.

APP_LANGUAGES Enumeration

Enumeration of the languages supported in this application

File

graphics_showcase_app.h

C

```
typedef enum {
  APP_LANG_ENGLISH,
  APP_LANG_CHINESE_TRAD,
  APP_LANG_CHINESE_SIMP
} APP_LANGUAGES;
```

Description

APP_LANGUAGES

This enum is to help track the three languages supported in this application: English, Chinese Traditional, and Chinese Simplified.

object

An example of standard user-interface widgets of the Graphics Library.

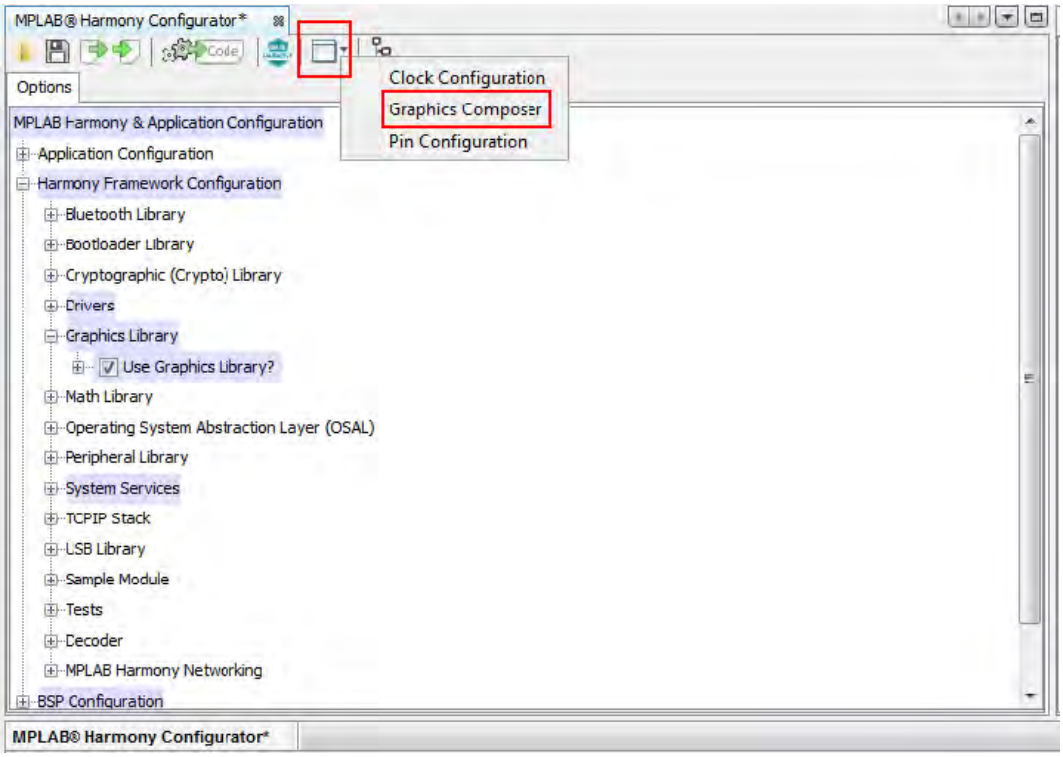
Description

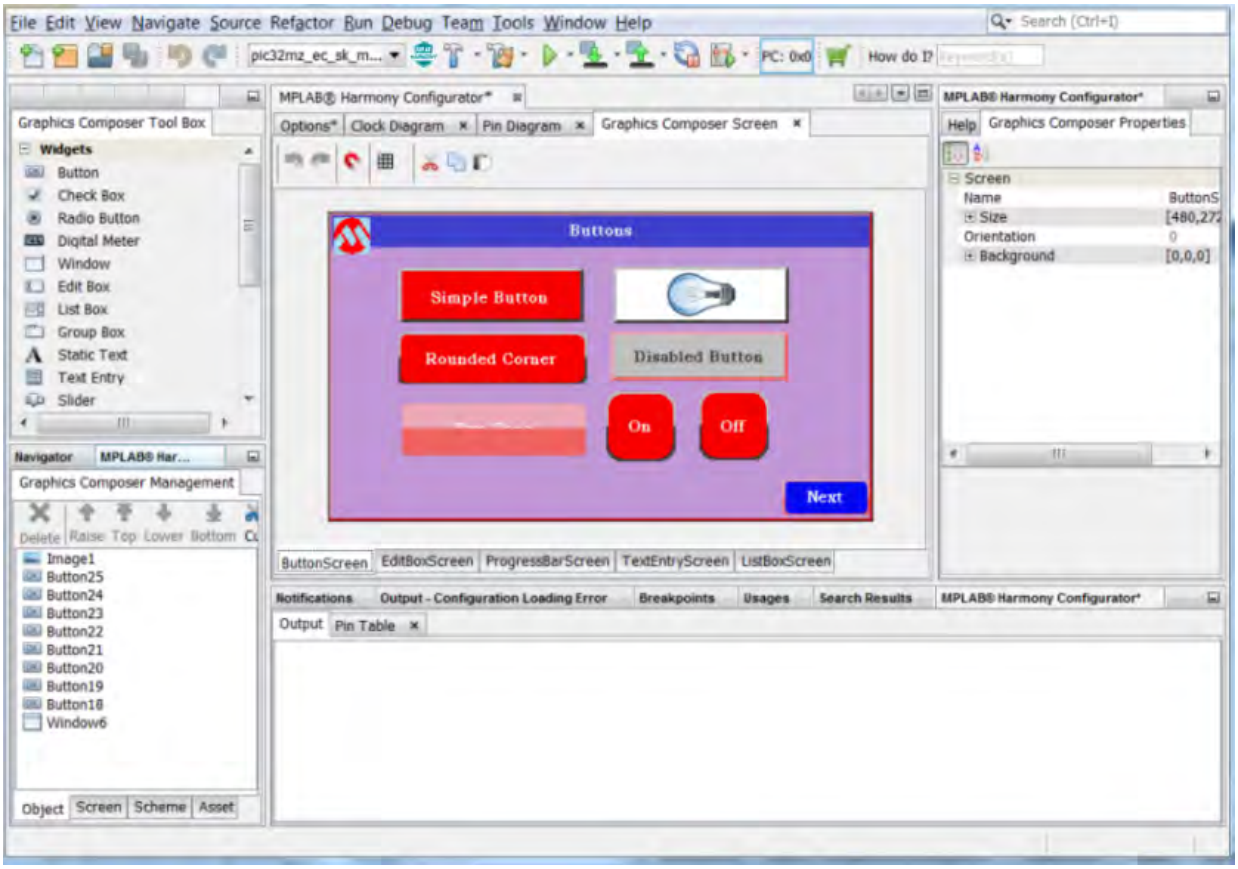
The object demonstration enables screen design using the MPLAB Harmony Graphics Composer through the standard types of objects/widgets that exist in the Graphics Object Layer (GOL) of the Graphics Library. The demonstration is composed of several pages of examples.

Important! This demonstration must be run in Internal Memory mode. See Configuring the Hardware for additional details on the setup of the available memory.

Viewing the Screen Designs

The screen designs can be viewed by activating the MPLAB Harmony Graphics Composer from within the MPLAB Harmony Configurator, by selecting **Graphics Composer** using the Launch Utility icon in the MPLAB Harmony Configurator toolbar. Refer to the MPLAB Harmony Graphics Composer User's Guide for more information.





Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the Graphics Object Library Demonstration.

Description

To build this project, you must open the `object.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/gfx/object`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`object.X`	`<install-dir>/apps/gfx/object/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx_usb_sk2_s1d_pictail_vga	pic32mx_usb_sk2+s1d_pictail+vga	Object demonstration for the Graphics LCD Controller PICtail Plus S1D13517 Daughter Board with Graphics Display Truly 5.7" 640x480 Board connected to the PIC32 USB Starter Kit II.
pic32mx_usb_sk2_s1d_pictail_wvga	pic32mx_usb_sk2+s1d_pictail+wvga	Object demonstration for the Graphics LCD Controller PICtail Plus S1D13517 Daughter Board with Graphics Display Truly 7" 800x480 Board connected to the PIC32 USB Starter Kit II.
pic32mz_ef_sk_meb2	pic32mz_ef_sk+meb2	Object demonstration for the Multimedia Expansion Board II (MEB II) connected to the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32 USB Starter Kit II

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ EF Starter Kit

No hardware related configuration or jumper setting changes are necessary.

Graphics LCD Controller PICtail Plus Epson S1D13517 Daughter Board

No hardware related configuration or jumper setting changes are necessary.

MEB II

The MEB II has two memory options External or Internal; however, this demonstration must be run in Internal mode. Configure the MEB II, as follows:

- EBIWE and LCD_PCLK (J9) must be closed (the jumper is located on the back of the MEB II board)
- Ensure that any MHC setting is defined to only use internal SRAM

The current internal/external memory setting for the application can be verified in MHC by selecting *Harmony Framework Configuration* > *Drivers* > *Graphics Controllers* > *LCC* > *Use LCC Driver* > *Memory Interface Mode*.

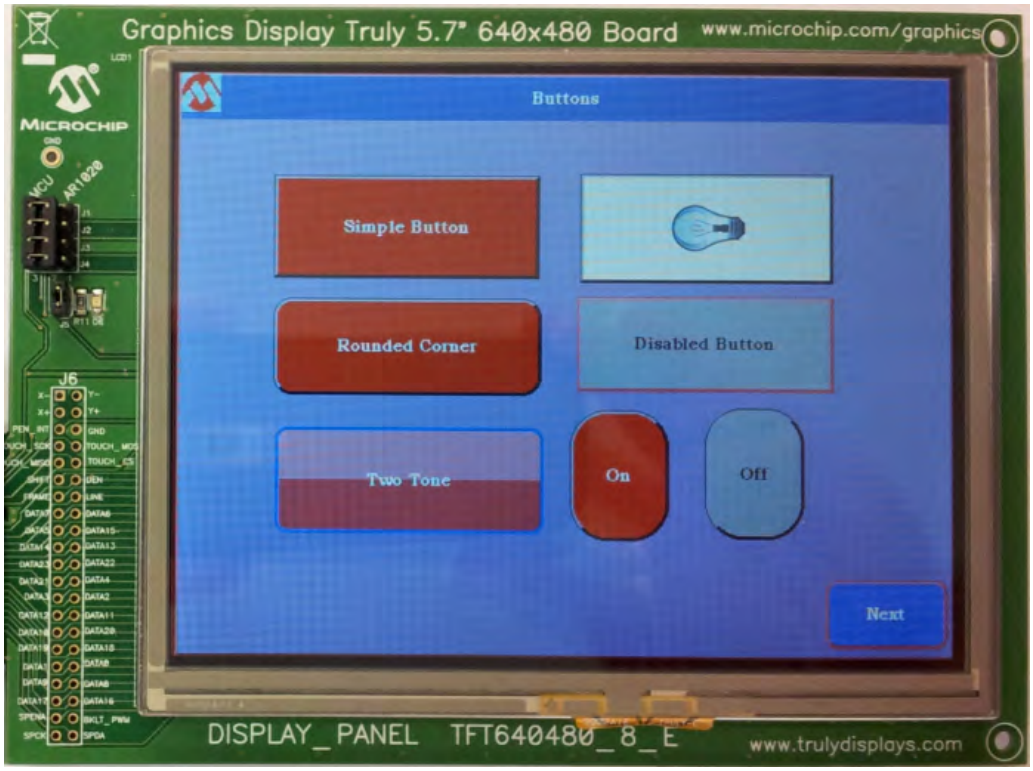
Running the Demonstration

Provides instructions on how to build and run the object demonstration.

Description

This demonstration shows screen designing using the MPLAB Harmony Graphics Composer by using pre-canned graphics object (widget) capabilities of the Object Layer (GOL) of the Graphics Library. Objects such as Button, Check Box, Edit Box, Group Box, Progress Bar, Radio Button, and Text Entry are rendered on several display screens.

1. Load the demonstration project into MPLAB X IDE.
2. Build, Download, and Run the demonstration project on the target board.
3. The initial screen should be similar to the following:



4. Sample the demonstration by touching various widgets on the screen.
5. Use the Next and Previous buttons to cycle through the demonstration.

Demonstration Output

The demonstration renders each object demonstration onto a window. To navigate from one window to another, arrow buttons are provided on the left and right of each rendered window. The available demonstrations are as follows:

- **Buttons:** A window with the title "Buttons" is rendered and multiple buttons with rectangle, bevel, and circular shapes are drawn. Each button demonstrates different states supported by the MPLAB Harmony Graphics Library.
- **Check box:** Demonstrates the change in text alignment of a button after a alignment is selected using a check box. In addition, different states supported by the check box widget are demonstrated.
- **Radio buttons:** Demonstrates the radio button feature and states supported by the feature
- **Group box:** Demonstrates the group box feature of the MPLAB Harmony Graphics library. The alignment of the text under group box is modified as per the selection of the state for the group box. In addition, a change in the window title string is demonstrated.
- **Progress bar:** Demonstrates the progress bar feature of the MPLAB Harmony Graphics Library by drawing a progress bar with its value updating run time and also demonstrates how fast the platform can update the value of progress bar
- **List box:** Demonstrates the list box feature of the MPLAB Harmony Graphics Library by selecting entries in the list box. The entries can be aligned to center by selecting the center alignment check box.
- **Digital Meter:** Demonstrates the digital meter widget of the MPLAB Harmony Graphics Library. The value displayed changes continuously by pressing the Accelerate/Deaccelerate button.
- **Meter:** Demonstrates the meter widget of the MPLAB Harmony Graphics Library. It is displayed as full round and quarter round dials and demonstrates the configurable display properties of the meter. The value displayed changes continuously by pressing the Accelerate/Deaccelerate button.

Troubleshooting TIP! When executing the application, if the display is static and is either all bright or all dark, it is likely that the memory setting is incorrect. See Configuring the Hardware for additional information.

primitive

An example of primitive drawing capabilities of the Graphics Library using the MPLAB Harmony Graphics Composer.

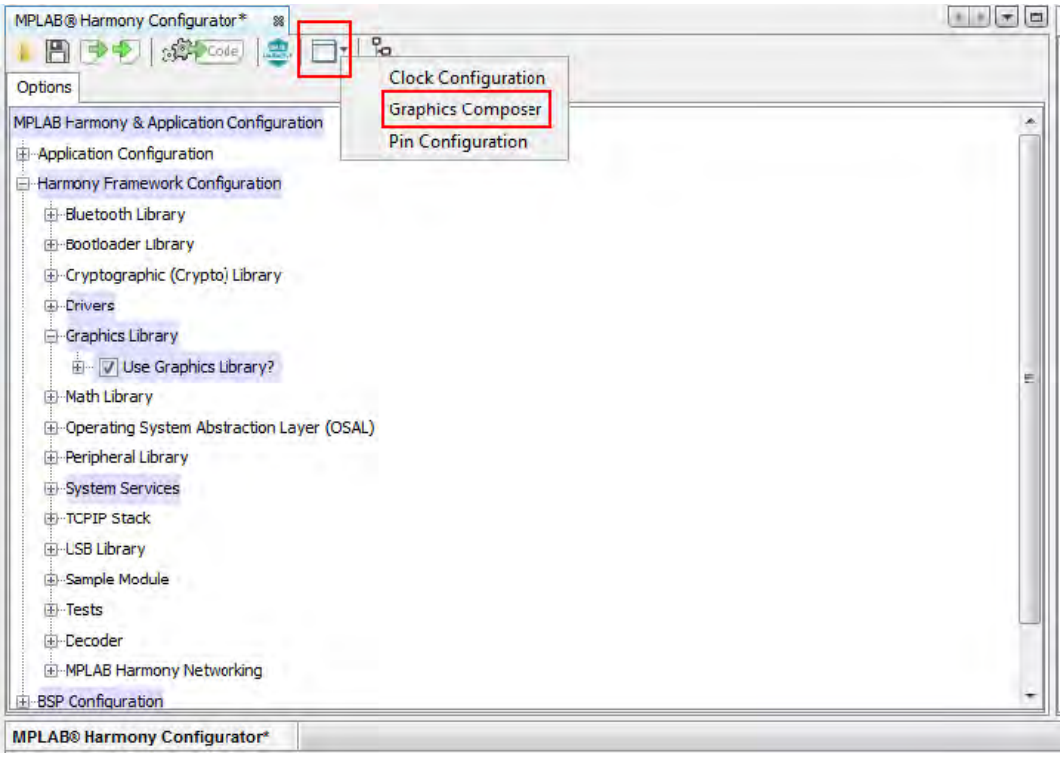
Description

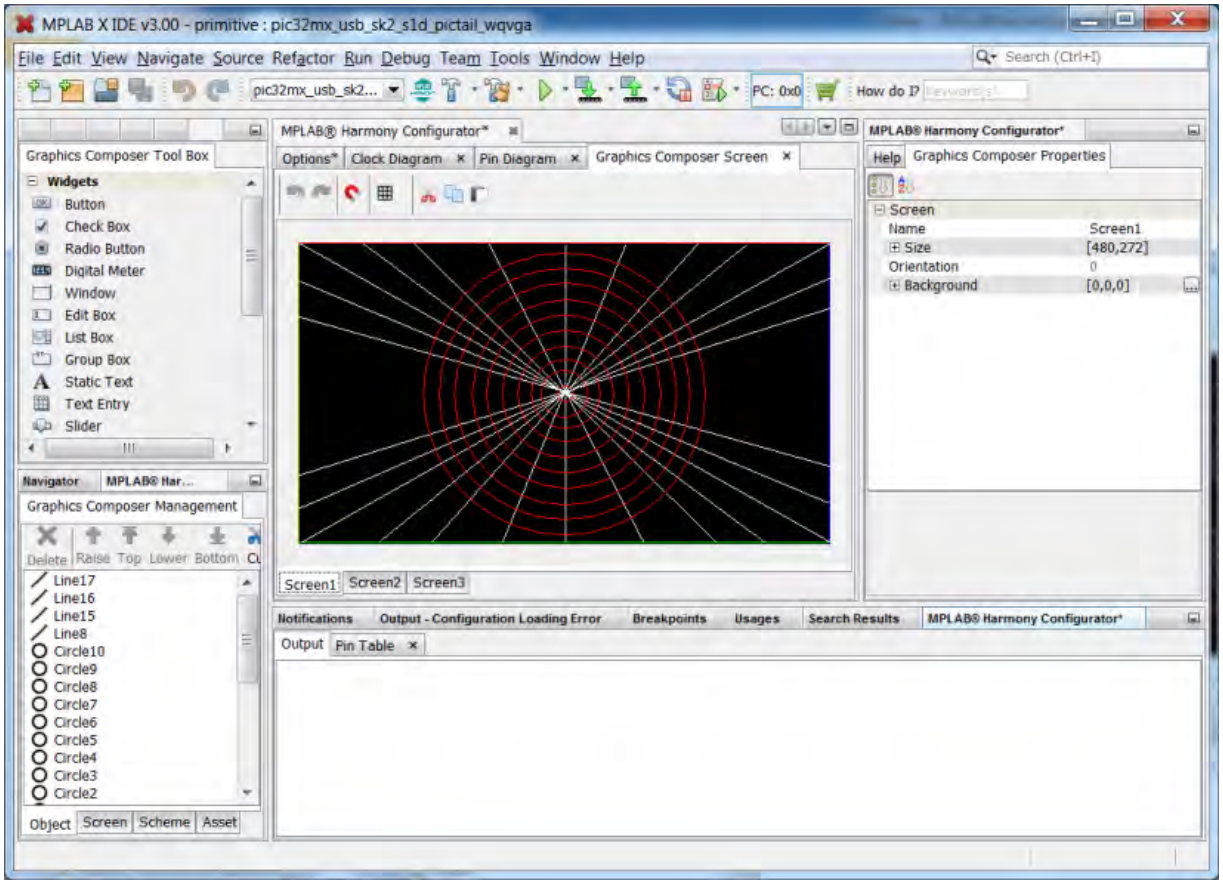
The Primitive example demonstrates primitive rendering of geometry, images, and fonts. The demonstration displays various circles, lines, rectangles, images depths, alias and non-aliased fonts.

This demonstration may run in either internal memory or external memory mode. The external memory is provided on the MEB II board. See Configuring the Hardware for additional details on setup of the available memory.

Viewing the Screen Designs

The screen designs can be viewed by activating the MPLAB Harmony Graphics Composer from within the MPLAB Harmony Configurator, by clicking **Execute** within *Graphics Library* > *Create a Design With MPLAB Harmony Graphics Composer*.





Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the Graphics Primitive Library Demonstration.

Description

To build this project, you must open the `primitive.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/gfx/primitive`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`primitive.X`	`<install-dir>/apps/gfx/primitive/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP used	Description
bt_audio_dk	bt_audio_dk	Primitive demonstration for the PIC32 Bluetooth Audio Development Kit.
pic32mx_125_sk_lcc_pictail_qvga	pic32mx_125_sk+lcc_pictail+qvga	Primitive demonstration for the Low-Cost Controllerless (LCC) Graphics PICtail Plus Daughter Board with the Graphics Display Truly 3.2" 320x240 Board connected to the PIC32MX1/2/5 Starter Kit.
pic32mx_usb_sk2_lcc_pictail_wqvga	pic32mx_usb_sk2+lcc_pictail+wqvga	Primitive demonstration for the Low-Cost Controllerless (LCC) Graphics PICtail Plus Daughter Board with the Graphics Display Powertip 4.3" 480x272 Board connected to the PIC32 USB Starter Kit II.
pic32mx_usb_sk2_meb	pic32mx_usb_sk2+meb	Primitive demonstration for the Multimedia Expansion Board (MEB) connected to the PIC32 USB Starter Kit II.
pic32mx_usb_sk2_s1d_pictail_wqvga	pic32mx_usb_sk2+s1d_pictail+wqvga	Primitive demonstration for the Graphics Controller PICtail Plus Epson S1D13517 Daughter Board with the Graphics Display Powertip 4.3" 480x272 Board connected to the PIC32 USB Starter Kit II.
pic32mx_usb_sk2_ssd_pictail_qvga	pic32mx_usb_sk2+ssd_pictail+qvga	Primitive demonstration for the Graphics LCD Controller PICtail Plus SSD1926 Daughter Board with Graphics Display Truly 3.2" 320x240 Board connected to the PIC32 USB Starter Kit II.
pic32mz_ef_sk_meb2	pic32mz_ef_sk_meb2	Primitive demonstration for the Multimedia Expansion Board II (MEB II) connected to the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit.
pic32mz_ef_sk_s1d_pictail_wqvga	pic32mz_ef_sk+s1d_pictail+wqvga	Primitive demonstration for the Graphics Controller PICtail Plus Epson S1D13517 Daughter Board with the Graphics Display Powertip 4.3" 480x272 Board connected to the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32 USB Starter Kit II and MEB

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ EF Starter Kit and MEB II

The MEB II has two memory options: External or Internal:

- When running a demonstration in External mode, EBIOE and LCD_PCLK (J9) must be closed. The jumper (J9) is available on the bottom side of the MEB II board.
- When running a demonstration in Internal mode EBIWE and LCD_PCLK (J9) must be closed. The jumper (J9) is available on the bottom side of the MEB II board.

The current internal/external memory setting for the application can be verified in MHC by selecting *Harmony Framework Configuration* > *Drivers* > *Graphics Controllers* > *LCC* > *Use LCC Driver* > *Memory Interface Mode*.

Graphics LCD Controller PICtail Plus SSD1926 Daughter Board

General set up:

The PIC32MZ Starter Kit Adapter Board is required to use a starter kit with the daughter board.

Set up the PMP interface:

The demonstration can only be run in 8-bit PMP mode; therefore, set JP2 to PARALLEL-8 bit. The setting for the PMP mode in MHC can be verified by selecting *Harmony Framework Configuration >Drivers* > *PMP* > *Transfer Size*. Ensure that this setting is PMP_DATA_SIZE_8_BITS.

Graphics LCD Controller PICtail Plus Epson S1D13517 Daughter Board

General set up:

PIC32MZ EF Starter Kit:

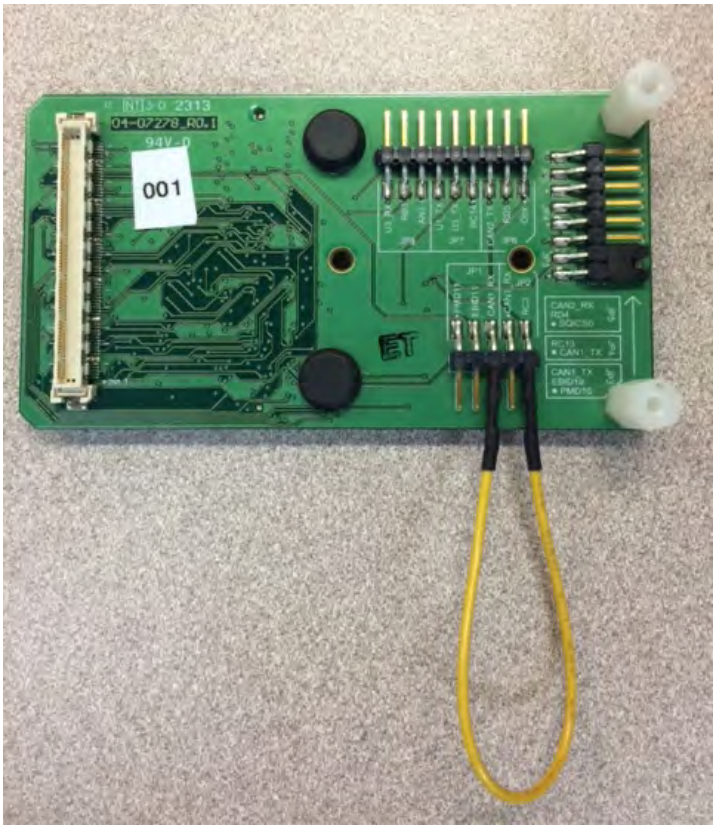
The PIC32MZ EF Starter Kit has a PKOB mode (JP2):

- When programming using PKOB, JP2 must be closed
- When programming using MPLAB REAL ICE, JP2 must be open

The PIC32MZ Starter Kit Adapter Board is required to use a starter kit with the daughter board.

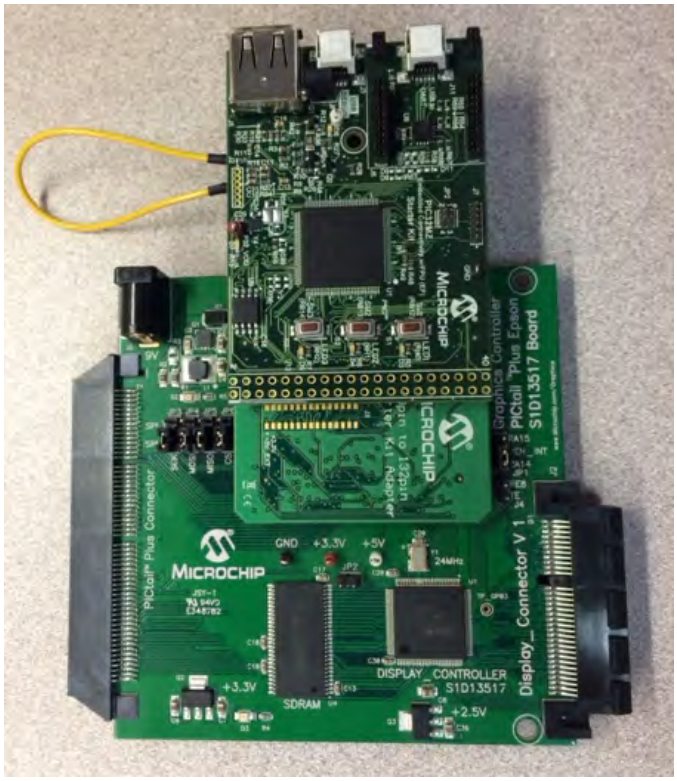
- Set jumpers JP1 (CAN_RX) and JP2 (RC3) for display output, as shown in the following figures:

Bottom Side of Adapter Board



PIC32MZ EF Starter Kit connected to the Adapter Board

PIC32MZ EF Starter Kit and Adapter Board connected to the Graphics Controller PICtail Plus Epson S1D13517 Daughter Board



PIC32MZ EF Starter Kit and Adapter Board connected to the Graphics Controller PICtail Plus Epson S1D13517 Daughter Board and the Graphics Display Truly 7" 800x480 Board

Note: To ensure correct demonstration display operation, this board configuration should remain flat and be kept away from obstructions that would cause a bend of the PICtail display connector that exists between the Graphics Controller PICtail Plus Epson S1D13517 Daughter Board and the Graphics Display Truly 5.7" and 7" boards.

Set up the PMP interface:

The demonstration can only be run in 8-bit PMP mode; therefore, open JP2. The setting for the PMP mode in MHC can be verified by selecting *Harmony Framework Configuration >Drivers > PMP > Transfer Size*. Ensure that this setting is PMP_DATA_SIZE_8_BITS.

- When running the demonstration in the 8-bit PMP interface mode, open JP2
- When running the demonstration in the 16-bit PMP interface mode, close JP2

Low-Cost Controllerless (LCC) Graphics PICtail Plus Daughter Board

- Set J4 to 2-3 for external SRAM use. Ensure the MHC settings are set to only use external SRAM.
- Set jumpers J6-J19 to (2-3) for 16-bit (565) color mode

The current internal/external memory setting for the application can be verified in MHC by selecting *Harmony Framework Configuration > Drivers > Graphics Controllers > LCC > Use LCC Driver > Memory Interface Mode*.

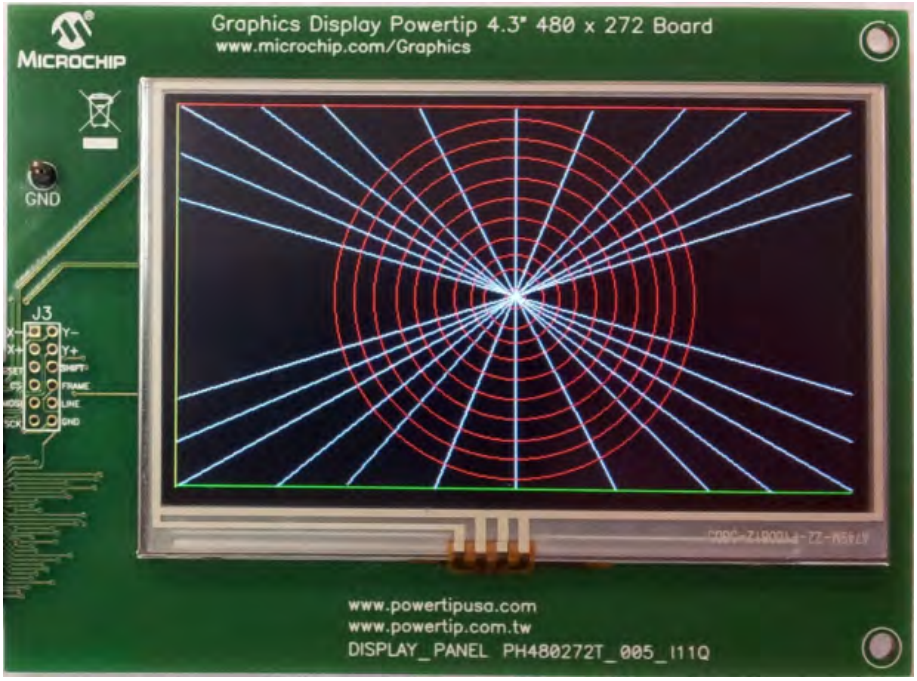
Running the Demonstration

Provides instructions on how to build and run the Primitive demonstration.

Description

This demonstration shows basic primitive capabilities of the Primitive Layer of Graphics Library by rendering 2D geometry, fonts, and images.

1. Load the demonstration project into MPLAB X IDE.
2. Build, Download, and Run the demonstration project on the target board.
3. The first screen should be similar to the following:



Demonstration Output

The output of this demonstration is as follows:

- Drawing rectangles
- Drawing color filled rectangles
- Drawing one 16 BPP image

Troubleshooting TIP! When executing the application, if the display is static and is either all bright or all dark, it is likely that the memory setting is incorrect. See Configuring the Hardware for additional information.

resistive_touch_calibrate

Demonstrates user-level application code to calibrate an AR1021 Resistive Touch Screen Controller.

Description

This application demonstrates a steady-state solution for calibrating through on-screen calibration prompts. Essentially, this demonstration presents displayed calibration targets as required by the AR1021 specification.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the Graphics Resistive Touch Calibration Demonstration.

Description

To build this project, you must open the `resistive_touch_calibrate.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/gfx/resistive_touch_calibrate`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`resistive_touch_calibrate.X`	`<install-dir>/apps/gfx/resistive_touch_calibrate/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within ./firmware/src/system_config.

Project Configuration Name	BSP used	Description
resistive_touch_calibrate	pic32mx_usb_sk2_s1d_pictail_vga	Graphics resistive touch calibration demonstration.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

Graphics Display Truly 5.7" 640 x 480 Board

- Set the AR1020 touch controller by setting the four AR1020 jumpers, J1, J2, J3, and J4, as shown in the following figure
- Leave the MCU row of pins open

Configuring the MHC

Provides information on MPLAB Harmony Configurator settings required for the demonstration.

Description

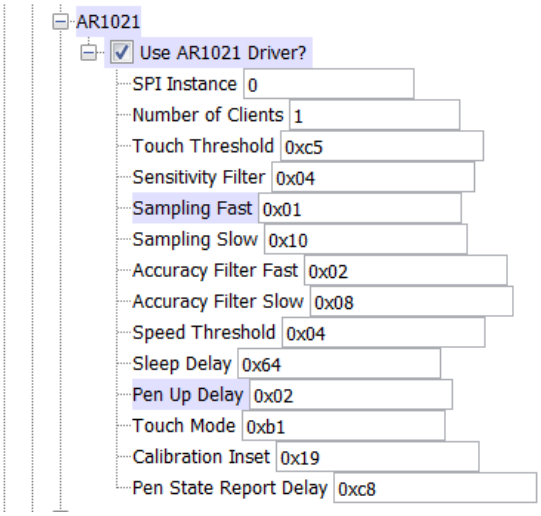
The following are some of the MHC settings that were modified from the default values.

Note: For additional value range information refer to the *"AR1000 Series Resistive Touch Screen Controller Data Sheet"* (DS41393), which is available for download from the Microchip web site (www.microchip.com).

Drivers

The AR1021 Touch Driver is automatically selected when the BSP is selected.

The SPI Driver is automatically selected when the AR1021 Driver is selected.



Graphics Library

The Graphics Library is automatically selected when the BSP is selected.

System Services

The Touch System Service is automatically selected with the BSP is selected.

BSP

The BSP selected for the configuration is pic32mx_usb_sk2_s1d_pictail_vga.

Pin Table

The AR1021 requires remapping. This is done through the Pin Table.

Running the Demonstration

Provides instructions on how to build and run the Resistive Touch Calibration demonstration.

Description

Perform the following steps to run the demonstration:

1. Power the development board using a USB-mini-B power connector.
2. Program the application onto the board using MPLAB X IDE or IPE.
3. The demonstration will display a main screen with Graphics Button widgets.
4. Touch the display to determine if calibration is required.
5. To calibrate, press Switch 1, to start the calibration routine.
6. The calibration routine will display four calibration targets (i.e., a red circle) in sequence. Touch each target as it appears on the display. The target will go from color “red” to color “green” on acceptance. After the last target is prompted, the user interface will redisplay the main screen to allow the user to test calibration.
7. To change calibration parameters, rerun the MHC configuration for the AR1021 Touch Driver.

s1d13517

Graphics Controller PICtail™ Plus Epson S1D13517 Board demonstration.

Description

This demonstration shows how gradients, scrolling, background drawing, speed testing, alpha-blending, and application capabilities using the Epson (S1D13517) graphics controller that resides on the Graphics Controller PICtail™ Plus Epson S1D13517 Board.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the S1D13517 Demonstration

Description

To build this project, you must open the `s1d13517.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/gfx/s1d13517`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`s1d13517.X`	`<install-dir>/apps/gfx/s1d13517/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx_usb_sk2_s1d_pictail_vga	pic32mx_usb_sk2+s1d_pictail+vga	S1D13517 demonstration for the Graphics Controller PICtail Plus Epson S1D13517 Daughter Board with the Graphics Display Truly 5.7" 640x480 Board connected to the PIC32 USB Starter Kit II.
pic32mx_usb_sk2_s1d_pictail_wvga	pic32mx_usb_sk2+s1d_pictail+wvga	S1D13517 demonstration for the Graphics Controller PICtail Plus Epson S1D13517 Daughter Board with Graphics Display Truly 7" 800x400 Board connected to the PIC32 USB Starter Kit II.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32 USB Starter Kit II

No hardware related configuration or jumper setting changes are necessary.

Graphics LCD Controller PICtail Plus Epson S1D13517 Daughter Board

General set up:

- Set the SPI Channel used by setting the four SPI1 or SPI2 jumpers
- Leave JP1 open

Set up the PMP interface:

- When running the demonstration in the 8-bit PMP interface mode, open JP2
- When running the demonstration in the 16-bit PMP interface mode, close JP2

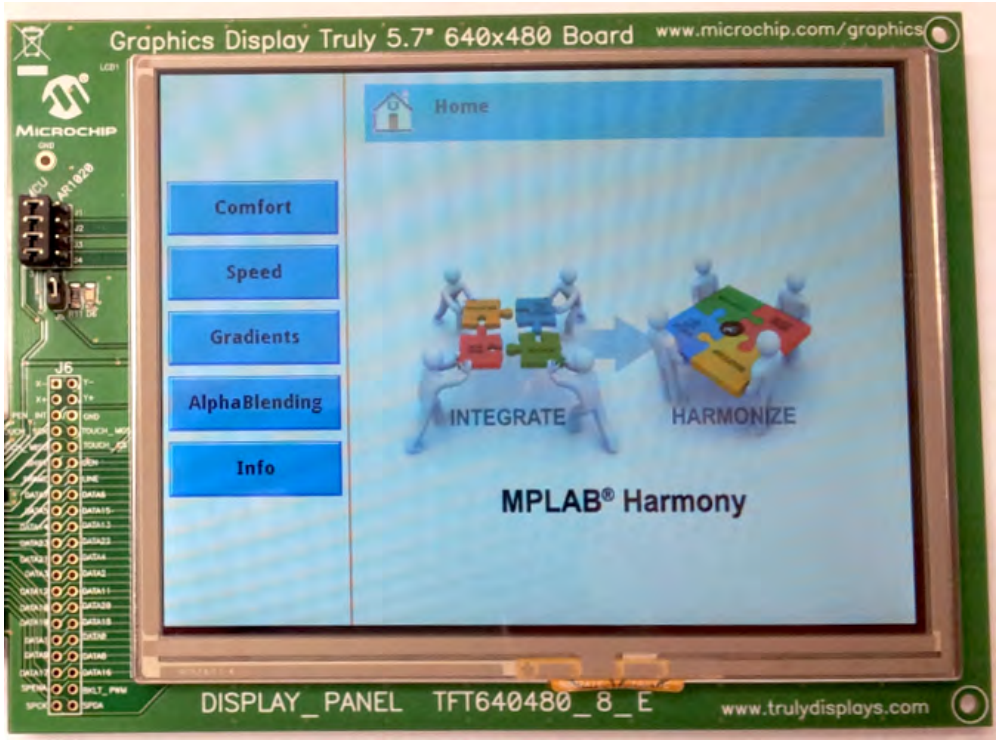
Running the Demonstration

Provides instructions on how to build and run the S1D13517 demonstration.

Description

This demonstration shows the Graphics Library interfacing with the Solomon Systech S1D13517 external display controller. It shows alpha-blending, gradient, panning, and double buffering capabilities through the Graphics Library.

1. Load the demonstration project into MPLAB X IDE.
2. Build, Download, and Run the demonstration project on the target board.
3. Use the touch buttons to navigate to various screens.



Demonstration Output

Demonstrates gradients, scrolling, background drawing, speed testing, alpha-blending, and application

capabilities using the Epson (S1D13517) graphics controller. Touch demonstration buttons on the left side of the display are used to run each demonstration.

- **Comfort:** Demonstrates the Air Conditioner control menu
- **Speed:** Demonstrates the speed at which the random shape and size of filled rectangles are drawn
- **Gradients:** Demonstrates the different modes of the gradient feature with start (red) and end (black) color
- **AlphaBlending:** Demonstrates how the background is blended with a color-shaded foreground with alpha of foreground changing run-time from maximum to minimum
- **Info:** Displays information about each demonstration

ssd1926

Shows how to display JPEG images using the Solomon Systech (SSD1926) graphics controller that resides on the PICtail™ Plus SSD1926 Daughter Board.

Description

The SSD1926 demonstration shows how to decode of JPEG images from an SD card utilizing the JPEG decoder capabilities of the Solomon Systech SSD1926 graphics controller.

This demonstration showcases hardware features that are unique to the LCD Controller Solomon Systech SSD1926. The two unique features are the hardware JPEG decoder and the hardware 4-bit SD card interface on the SSD1926.

This demonstration only runs with QVGA (320x240) displays and not the WQVGA (480x272). The reason begin there is only 256 Kbytes of RAM available on the SSD1926. If configured for a WQVGA display at 16 bpp color depth, 255 Kbytes of frame buffer space is required, and not enough RAM is left for the JPEG decoding. Therefore, this demonstration only runs on a QVGA setup.

The demonstration uses the Microchip Memory Disk Drive File System (MDDFS) Interface Library with the Microchip Graphics Library working on the Graphics LCD Controller PICtail™ Plus SSD1926 Board (AC164127-5) mounted with the SD Card receptacle.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the SSD1926 Demonstration.

Description

Note: By default, the project is configured to run in 8-bit PMP interface mode. 16-bit PMP mode is not supported at this time.

To build this project, you must open the `ssd1926.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/gfx/ssd1926`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`ssd1926.X`	`<install-dir>/apps/gfx/ssd1926/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx_usb_sk2_ssd_pictail_qvga	pic32mx_usb_sk2+ssd_pictail+qvga	SSD1926 demonstration for the Graphics LCD Controller PICtail Plus SSD1926 Daughter Board with Graphics Display Truly 3.2" 320x240 Board connected to the PIC32 USB Starter Kit II.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32 USB Starter Kit II

No hardware related configuration or jumper setting changes are necessary.

Graphics LCD Controller PICtail Plus SSD1926 Daughter Board

General set up:

- Set the SPI Flash Chip Select signal to use RD1 by setting JP3 to RD1-FLASH CS
- Leave JP1 open

Set up the PMP interface:

- This demonstration is only supported in 8-bit PMP interface mode. To run the demonstration, set JP2 to PARALLEL-8 bit

Running the Demonstration

Provides instructions on how to build and run the SSD1926 demonstration.

Description

This demonstration shows GFX Library interfacing with the Epson SSD1926 external display controller. It shows photo frames read from an SD Card interfaced to the display controller.

1. Insert a SD card and load the images from the demonstration `resources` folder.
2. Load the demonstration project into MPLAB X IDE.
3. Build, Download, and Run the demonstration project on the target board.
4. Observe a sequence of photo frames stored on the SD card.

Demonstration Output

With the SD card loaded with the images from the demonstration `resources` folder; the following is demonstrated:

- Microchip Logo
- Sample Video
- Scene 1
- Scene 2
- Scene 3
- Scene 4
- Scene 5

wvga_glcd

Provides information on the demonstration.

Description

Demonstrates the advanced capabilities of the Graphics Library utilizing the Graphics LCD (GLCD) controller and the MTCH6303 PCAP Touch Controller with the 5" WVGA PCAP Display Board (see **Note**).

Note: This demonstration is intended for PIC32MZ DA Early Adopters and is distributed separately from the official MPLAB Harmony 1.07 release. For information on obtaining the installer and/or the 5" WVGA PCAP Display Board, please contact your local Microchip sales office.

The goal of this application is to demonstrate the capability of the GLCD Controller to render four layers simultaneously (one base layer plus three layers with individual alpha and color modes), as well as to demonstrate basic functionality of the MTCH6303.

The demonstration also has Debug Console capability built-in to show the single-touch accuracy of the MTCH6303, as well as to demonstrate using the Console System Service as a screen calibration tool.

This demonstration was developed for PIC32MZ DA Early Adopters has only a subset of its graphics functionality supported by MPLAB Harmony Graphics Composer and the Graphics Object Library. It does not utilize the GPU peripheral. Since the Touch System Service does not support the MTCH6303 driver currently, the application accesses the driver directly.

The demonstration includes the following features:

- 24-bit true color (16.7M)
- Three simultaneous rendered graphical layers
- Per-pixel dynamic alpha blending
- Global-layer dynamic alpha blending
- Touch interactive circle at Layer 1 over image at Layer 0
- Persistent menu at Layer 2 hardware blended over Layers 1 and 0
- JPEG-compressed image stored on internal Flash
- Real-time JPEG decode and rendering
- DDR2 SDRAM memory utilization
- Non-synchronized double-buffered rendering
- WVGA display at 40+ Hz refresh rate
- Integrated MTCH6303 PCAP touch interface (non-gestured single-touch)

Building the Application

This topic identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the Graphics LCD (GLCD) Controller WVGA Demonstration.

Description

To build this project, you must open the `wvga_glcd.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/gfx/wvga_glcd`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`wvga_glcd.X`	`<install-dir>/apps/gfx/wvga_glcd/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mz_da_sk_meb2_wvga	pic32mz_da_sk+meb2+wvga	GLCD demonstration for the Multimedia Expansion Board II (MEB II) connected to the PIC32MZ Graphics (DA) Starter Kit.

Application Header File

This table lists and describes the application header file used by the demonstration, which is located within `./firmware/src`.

Project Configuration Name	Description
app.h	This header file provides function prototypes and data type definitions for the application. Some of these are required by the system (such as the APP_Initialize and APP_Tasks prototypes) and some of them are only used internally by the application (such as the APP_STATES definition). Both are defined in this file for convenience.

Configuring the Hardware

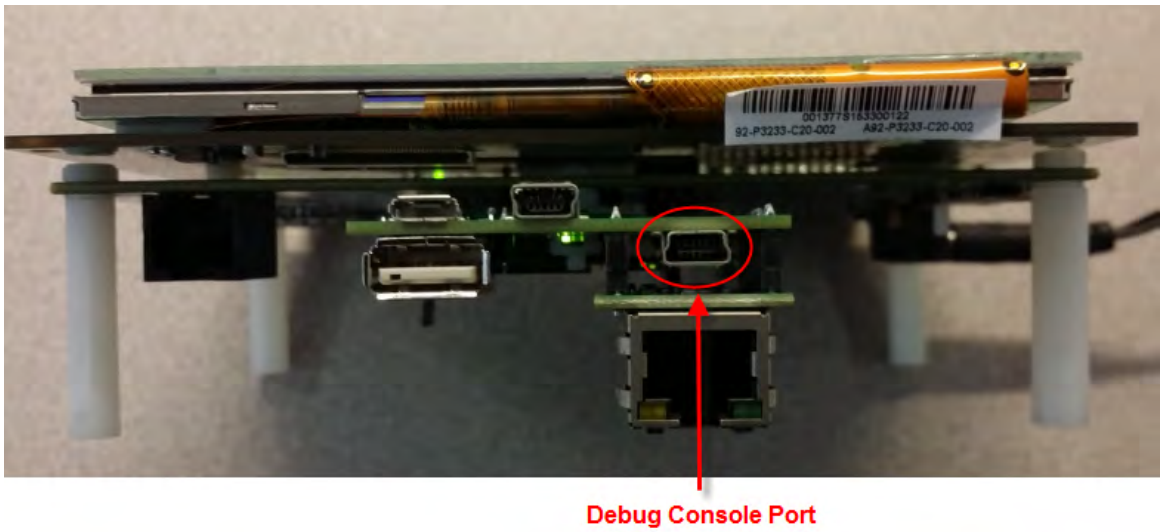
Describes how to configure the supported hardware.

Description

PIC32MZ DA Starter Kit and MEB II

EBIOE and LCD_PCLK (J9) must be closed. The jumper (J9) is available on the bottom side of the MEB II board.

This demonstration also has a Debug Console enabled via UART over USB. You will need a USB Type-A to USB Type-B cable. Connect the cable to the port as shown in the following figure. Also configure the terminal emulator software with the serial port settings of: 8-bit, Non-parity, 1 Stop bit, and No Flow Control.



Running the Demonstration

Provides instructions on how to build and run the GLCD WVGA demonstration.

Description

The demonstration has three modes:

- Home mode
- Full Screen Slide Show mode
- Touch Responsive Bubble mode

The side menu is rendered on the top layer, which is real-time alpha blending over two layers.

Home Mode

This mode contains a list of features that is demonstrated by the application, while demonstrating global-layer alpha blending at the same time.

Home Mode Example

Application Functions and Prototypes

a) Functions

	Name	Description
	APP_DrawBubble	Draws the bubble during Touch Responsive Bubble mode
	APP_DrawMenu	Draws the menu on Layer2 base on current state of the application

	APP_FillMenuBackBuffer	Pre-cache Menu Image Assets in a back buffer
	APP_Initialize	MPLAB Harmony application initialization routine.
	APP_IsCircle	Checks if a point (x,y) is part of the bubble or not
	APP_MoveBubble	Performs the bubble movement in Touch Responsive Bubble mode
	APP_ProcessMenu	Process touch events to the menu and handles mode transitions
	APP_SelectNewSlide	Selects a new slide
	APP_Tasks	MPLAB Harmony Demo application tasks function
	APP_TouchEventHandler	Touch event callback routine.
	APP_HandleHomeSlide	Changes transparency and images during Home Mode
	APP_PrepareHomeMode	Prepares buffers and layers in the application for Home Mode
	APP_ReceiveMenuTouch	Receives and records the touch menu event

b) Data Types and Constants

	Name	Description
	APP_DATA	Holds application data
	APP_MODES	Application modes enumeration
	APP_STATES	Application states enumeration
	APP_GLCD_LAYER0_BUFFER_ADDR	Defines the base memory address for the secondary buffer for GLCD Layer 0
	APP_GLCD_LAYER1_BUFFER_ADDR	Defines the base memory address for the secondary buffer for GLCD Layer 1
	APP_GLCD_LAYER2_BUFFER_ADDR	Defines the base memory address for the secondary buffer for GLCD Layer 2
	APP_GLCD_LAYER2_HOR_RES	The horizontal resolution of GLCD Layer 2
	APP_GLCD_LAYER1_ALPHA_RESOLUTION	Determines the smoothness of the fading and showing of the Microchip and Harmony logos
	APP_HOME_MODE_SEMI_TRANSPARENT_ALPHA_VALUE	Home mode uses this value to keep the Microchip and Harmony logos at semi-transparent levels
	APP_TRANSPARENT_ALPHA_VALUE	Value the GLCD driver accepts as 100% transparent
	APP_MENU_STATES	Application menu states enumeration

Description

Lists the functions and prototypes available for the demonstration, which are provided in the `app.h` header file.

a) Functions

APP_DrawBubble Function

Draws the bubble during Touch Responsive Bubble mode

File

wvga_glcd_app.h

C

```
void APP_DrawBubble();
```

Returns

None.

Description

This function is called every SYS_TASK cycle to render the bubble on Layer 1. Location to draw the bubble is based on the most recent touch location as reported by the MTCH6303 touch driver.

The function manages a double buffering scheme locally to improve visual quality. This function is responsible for rendering the entire Layer 1. This means it "brute force" color and alpha value to every single pixel of the entire 800x480 surface. Various optimization schemes were tried, none provided visual satisfactory results.

Function

void APP_DrawBubble (void)

APP_DrawMenu Function

Draws the menu on Layer2 base on current state of the application

File

wvga_glcd_app.h

C

```
void APP_DrawMenu();
```

Returns

None.

Description

This function is called constructs the menu at runtime based on appData.mode and appData.menuMode. It handles drawing the transition movement of the menu.

It performs all these by references to the pre-cached menu assets in the back buffer (see APP_FillMenuBackBuffer).

Function

void APP_DrawMenu (void)

APP_FillMenuBackBuffer Function

Pre-cache Menu Image Assets in a back buffer

File

wvga_glcd_app.h

C

```
void APP_FillMenuBackBuffer();
```

Returns

None.

Description

This function is called to pre-cache JPEG image assets to a memory location. The starting address for the location of where each image is cached is stored in appData, to be used later for drawing the menu.

The function also applies full transparent alpha value by using a ranged mask (RGB 000000 to D0D0D0) to create the smooth curved front part of the menu.

Lastly, semi-transparent alpha values is applied to every pixel of the image assets such the when the resulting menu is semi-transparent on render.

Function

void APP_FillMenuBackBuffer (void)

APP_Initialize Function

MPLAB Harmony application initialization routine.

File

wvga_glcd_app.h

C

```
void APP_Initialize();
```

Returns

None.

Description

This function initializes the Harmony application. It places the application in its initial state and prepares it to run so that its APP_Tasks function can be called.

Remarks

This routine must be called from the SYS_Initialize function.

Preconditions

All other system initialization routines should be called before calling this routine (in "SYS_Initialize").

Function

void APP_Initialize (void)

APP_IsCircle Function

Checks if a point (x,y) is part of the bubble or not

File

wvga_glcd_app.h

C

```
bool APP_IsCircle(uint32_t centerX, uint32_t centerY, uint32_t x, uint32_t y);
```

Returns

true if in the circle

Description

Uses a radius checking scheme to determine whether the point is part of the circle or not

Parameters

Parameters	Description
uint32_t centerX, uint32_t centerY	cartesian coordinates of the center of the circle
uint32_t x, uint32_t y	cartesian coordinates of the point to check

Function

bool APP_IsCircle(uint32_t centerX, uint32_t centerY, uint32_t x, uint32_t y)

APP_MoveBubble Function

Performs the bubble movement in Touch Responsive Bubble mode

File

wvga_glcd_app.h

C

```
void APP_MoveBubble();
```

Returns

None.

Description

This function is called every APP_TASK cycle to reposition the bubble's current position based on the most recent touch position. Instead of rendering the bubble exactly at the touch point, this function performs linear interpolation between the most recent touch position with the current bubble position. This creates a pleasant movement/follow effect.

Function

void APP_MoveBubble (void)

APP_ProcessMenu Function

Process touch events to the menu and handles mode transitions

File

wvga_glcd_app.h

C

```
void APP_ProcessMenu();
```

Returns

None.

Description

This function is called every APP_TASK cycle to detect if a touch menu event has occurred. It handles all the initial setup required when it detects a user request to transition between modes.

Function

void APP_ProcessMenu (void)

APP_SelectNewSlide Function

Selects a new slide

File

wvga_glcd_app.h

C

```
void APP_SelectNewSlide();
```

Returns

None.

Description

This function is called during Slide Mode to initiate a GFX_HGC_ChangeScreen call. This triggers the code generated by Harmony Composer to change screen. The JPEG image selected for the slide is decoded in runtime in a double buffering scheme. Where the decode occurs to a draw buffer, that is swapped with the render buffer at completion of the decode. Wihtout this scheme, the image would be rendered with a curtain effect, due to the block-by-block decoding algorithm of the JPEG decoder.

Double buffering is handled automatically by the GFX_Primitive layer.

Function

void APP_SelectNewSlide (void)

APP_Tasks Function

MPLAB Harmony Demo application tasks function

File

wvga_glcd_app.h

C

```
void APP_Tasks();
```

Returns

None.

Description

This routine is the Harmony Demo application's tasks function. It defines the application's state machine and core logic.

Remarks

This routine must be called from SYS_Tasks() routine.

Preconditions

The system and application initialization ("SYS_Initialize") should be called before calling this.

Function

void APP_Tasks (void)

APP_TouchEventHandler Function

Touch event callback routine.

File

wvga_glcd_app.h

C

```
void APP_TouchEventHandler(DRV_MTCH6303_BUFFER_EVENT event, DRV_MTCH6303_BUFFER_HANDLE bufferHandle,
uintptr_t context);
```

Returns

None.

Description

This function is a callback function for the MTCH6303 driver to call when a touch event has occured. The data of the touch event is cached in appData.touchData. If the application is in Touch Responsive Bubble mode, the application converts the raw value from the touch driver to cartesian coordinates calibrated to 800x480 WVGA resolution. It then stores the coordinates in appData.targetX and targetY as the most recent touch data.

If the touch event is in the region of the menu, it will call APP_ReceiveMenuTouch to forward the menu procession portion.

Function

void APP_TouchEventHandler(

DRV_MTCH6303_BUFFER_EVENT event,

DRV_MTCH6303_BUFFER_HANDLE bufferHandle,

uintptr_t context);

APP_HandleHomeSlide Function

Changes transparency and images during Home Mode

File

wvga_glcd_app.h

C

```
void APP_HandleHomeSlide();
```

Returns

None.

Description

This function fluctuates the global-layer alpha value of Layer 1. It changes the Layer 1 image between the Harmony and Microchip Logo by pointing the GLCD to render seperate buffers where the JPEG images are pre-cached.

Function

void APP_HandleHomeSlide (void)

APP_PrepareHomeMode Function

Prepares buffers and layers in the application for Home Mode

File

wvga_glcd_app.h

C

```
void APP_PrepareHomeMode();
```

Returns

None.

Description

This function pre-caches two JPEG images (Harmony & Microchip Logos) on seperate buffers to be rendered on Layer 1. It sets Layer 1's blend function to be controlled by the global-layer alpha value. It sets Layer 1's global-layer global value to 0 (full opacity).

It then points the GLCD to render the Feature list on Layer 0 and the Harmony logo on Layer 1.

Function

void APP_PrepareHomeMode (void)

APP_ReceiveMenuTouch Function

Receives and records the touch menu event

File

wvga_glcd_app.h

C

```
void APP_ReceiveMenuTouch();
```

Returns

None.

Description

This function handles incoming touch event and records it as for processing by the application later in APP_ProcessMenu

Function

void APP_ReceiveMenuTouch (void)

b) Data Types and Constants

APP_DATA Structure

Holds application data

File

wvga_glcd_app.h

C

```
typedef struct {
  uint8_t bufferIndex1;
  APP_STATES state;
  APP_MENU_STATES menuMode;
  APP_MODES mode;
  APP_MODES menuButtonMode;
  GFX_COLOR* pixelBuffer0A;
  GFX_COLOR* pixelBuffer0B;
  GFX_COLOR* pixelBuffer1A;
  GFX_COLOR* pixelBuffer1B;
  GFX_COLOR* pixelBuffer2A;
  GFX_COLOR* pixelBuffer2B;
  uint16_t targetX;
  uint16_t targetY;
  uint16_t currentX;
  uint16_t currentY;
  uint16_t menuCollapsedX;
  uint16_t menuExpandedX;
  uint32_t menuTipFrontX;
  int16_t menuTouchX;
  int16_t menuTouchY;
  bool touchContact;
  SYS_TMR_HANDLE sysTmrHandle;
  DRV_HANDLE hDrvMTCH6303;
  DRV_MTCH6303_BUFFER_HANDLE hTouchDataBuff;
  DRV_MTCH6303_TOUCH_DATA touchData;
  GFX_COLOR* backBufferMenuTip;
  GFX_COLOR* backBufferMenuTipPressed;
  GFX_COLOR* backBufferMenuTipExpanded;
  GFX_COLOR* backBufferMenuButtonHome;
  GFX_COLOR* backBufferMenuButtonSlides;
  GFX_COLOR* backBufferMenuButtonBubble;
  GFX_COLOR* backBufferMenuButtonSetting;
  int backBufferWidth;
  bool fadeLayer1;
  int32_t layerAlpha;
  GFX_RESOURCE_HDR* currentLayer1Image;
} APP_DATA;
```

Members

Members	Description
uint8_t bufferIndex1;	Index to keep track of layer1 buffers, this is use exclusively for the Touch Responsive Bubble mode
APP_STATES state;	The application's current state
APP_MENU_STATES menuMode;	The menu's current state

APP_MODES mode;	The application's current mode
APP_MODES menuButtonMode;	This is used to help track button behavior on the semi-transparent sliding menu
GFX_COLOR* pixelBuffer0A;	layer 0
GFX_COLOR* pixelBuffer0B;	Pointer to base memory address of one of the double buffers for Layer 0
GFX_COLOR* pixelBuffer1A;	Pointer to base memory address of one of the double buffers for Layer 1
GFX_COLOR* pixelBuffer1B;	Pointer to base memory address of one of the double buffers for Layer 1
GFX_COLOR* pixelBuffer2A;	Pointer to base memory address of the rendering buffer for Layer 2
GFX_COLOR* pixelBuffer2B;	Pointer to base memory address of the asset pre-cache buffer for Layer 2
uint16_t targetX;	X-coordinate for a valid touch event
uint16_t targetY;	Y-coordinate for a valid touch event
uint16_t currentX;	X-coordinate for the current location of the Touch Responsive Bubble
uint16_t currentY;	Y-coordinate for the current location of the Touch Responsive Bubble
uint16_t menuCollapsedX;	Used to store the X-coordinate location for the menu when collapsed. This value is calculated at start-up, using the resolution of Layer 2 and the width of the menu art asset.
uint16_t menuExpandedX;	Used to store the X-coordinate location for the menu when expanded. This value is calculated at start-up, using the resolution of Layer 2 and the width of the menu art assets.
uint32_t menuTipFrontX;	Used to store the X-coordinate location for the menu while the menu is in one of the transition states. This value is calculated at runtime, using the resolution of Layer 2 and the width of the menu art assets.
int16_t menuTouchX;	X-coordinate for a valid menu touch event
int16_t menuTouchY;	Y-coordinate for a valid menu touch event
bool touchContact;	Used to track if the user has stopped touching the screen Normally, this behavior can be tracked by the Touch System Service
SYS_TMR_HANDLE sysTmrHandle;	Timer System Service handle, used to track the delay between slides while the application is in the Fullscreen Slideshow mode
DRV_HANDLE hDrvMTCH6303;	MTCH6303 Driver Handle
DRV_MTCH6303_BUFFER_HANDLE hTouchDataBuff;	MTCH6303 Buffer handle
DRV_MTCH6303_TOUCH_DATA touchData;	MTCH6303 Touch Data, we are using single touch only
GFX_COLOR* backBufferMenuTip;	Pointer used to keep track of pre-cached art asset of the menu tip with the arrow un-lit
GFX_COLOR* backBufferMenuTipPressed;	Pointer used to keep track of pre-cached art asset of the menu tip with the arrow lit
GFX_COLOR* backBufferMenuTipExpanded;	Pointer used to keep track of pre-cached art asset of the menu tip with the arrow lit and pointing to the right
GFX_COLOR* backBufferMenuButtonHome;	Pointer used to keep track of pre-cached art asset of the menu buttons with the Home mode button lit
GFX_COLOR* backBufferMenuButtonSlides;	Pointer used to keep track of pre-cached art asset of the menu buttons with the Fullscreen Slideshow mode button lit
GFX_COLOR* backBufferMenuButtonBubble;	Pointer used to keep track of pre-cached art asset of the menu buttons with the Touch Responsive Bubble mode button lit
GFX_COLOR* backBufferMenuButtonSetting;	Pointer used to keep track of pre-cached art asset of the menu buttons with the Settings button lit
int backBufferWidth;	Keeps track of the total width of the back buffer
bool fadeLayer1;	If true, fades layer 1, if false, reveals layer 1
int32_t layerAlpha;	Keeps track of global alpha of layer 1
GFX_RESOURCE_HDR* currentLayer1Image;	Keeps track of the current layer 1 image

Description

Application Data

This structure holds the application's data.

Remarks

See inline comments for specifics.

APP_MODES Enumeration

Application modes enumeration

File

wvga_glcd_app.h

C

```
typedef enum {
  APP_MODE_HOME,
  APP_MODE_BUBBLE,
  APP_MODE_SLIDES
} APP_MODES;
```

Members

Members	Description
APP_MODE_HOME	Home mode: Microchip/ MPLAB Harmony image rendered at Layer 0 Layer 1 is disabled Layer 2 renders the semi-transparent sliding menu
APP_MODE_BUBBLE	Touch Responsive Bubble mode: Last image from previous mode rendered at Layer 0 Layer 1 renders the touch responsive dynamic alpha-blended bubble Layer 2 renders the semi-transparent sliding menu
APP_MODE_SLIDES	Full Screen Slideshow mode: Slideshow images rendered at Layer 0, cycles every 2000 msecs Layer 1 is disabled Layer 2 renders the semi-transparent sliding menu

Description

APP_MODES

This enumeration defines the valid application modes enumerations. There are three modes supported: Home, Touch Responsive Bubble and Full Screen Slideshow

Remarks

See inline comments for specifics.

APP_STATES Enumeration

Application states enumeration

File

wvga_glcd_app.h

C

```
typedef enum {
  APP_STATE_INIT = 0,
  APP_STATE_TOUCH_INIT,
  APP_STATE_TOUCH_EVENT_REGISTER,
  APP_STATE_IDLE,
  APP_STATE_MANAGE_SLIDES,
  APP_STATE_MANAGE_BUBBLE,
  APP_STATE_MANAGE_HOME
} APP_STATES;
```

Members

Members	Description
APP_STATE_INIT = 0	Application's state machine's initial state.
APP_STATE_TOUCH_INIT	MTCH6303 driver client initialize
APP_STATE_TOUCH_EVENT_REGISTER	MTCH6303 event handler set
APP_STATE_IDLE	Processes touches to the menu, handles mode switches, redraws menu if needed
APP_STATE_MANAGE_SLIDES	Manages the Full Screen Slideshow mode
APP_STATE_MANAGE_BUBBLE	Manages the Touch Responsive Bubble mode
APP_STATE_MANAGE_HOME	Manages the Home mode

Description

APP_STATES

This enumeration defines the valid application states. These states determine the behavior of the application at various times.

APP_GLCD_LAYER0_BUFFER_ADDR Macro

Defines the base memory address for the secondary buffer for GLCD Layer 0

File

wvga_glcd_app.h

C

```
#define APP_GLCD_LAYER0_BUFFER_ADDR GFX_GLCD_LAYER0_DBL_BASEADDR
```

Description

APP_GLCD_LAYER0_BUFFER_ADDR

This memory address location is defined to support a double buffer rendering scheme for layer 0.

Remarks

The address space chosen is in the DDR2 address space (0xA8000000 - 0xA9FFFFFF) unique to the PIC32MZ2048DAB288 device.

APP_GLCD_LAYER1_BUFFER_ADDR Macro

Defines the base memory address for the secondary buffer for GLCD Layer 1

File

wvga_glcd_app.h

C

```
#define APP_GLCD_LAYER1_BUFFER_ADDR GFX_GLCD_LAYER1_DBL_BASEADDR
```

Description

APP_GLCD_LAYER1_BUFFER_ADDR

This memory address location is defined to support a double buffer rendering scheme for layer 1.

Remarks

The address space chosen is in the DDR2 address space (0xA8000000 - 0xA9FFFFFF) unique to the PIC32MZ2048DAB288 device.

APP_GLCD_LAYER2_BUFFER_ADDR Macro

Defines the base memory address for the secondary buffer for GLCD Layer 2

File

wvga_glcd_app.h

C

```
#define APP_GLCD_LAYER2_BUFFER_ADDR GFX_GLCD_LAYER2_DBL_BASEADDR
```

Description

APP_GLCD_LAYER2_BUFFER_ADDR

This memory address location is defined to support a asset pre-load back buffer rendering scheme for layer 2.

Remarks

The address space chosen is in the DDR2 address space (0xA8000000 - 0xA9FFFFFF) unique to the PIC32MZ2048DAB288 device.

APP_GLCD_LAYER2_HOR_RES Macro

The horizontal resolution of GLCD Layer 2

File

wvga_glcd_app.h

C

```
#define APP_GLCD_LAYER2_HOR_RES GFX_GLCD_LAYER2_RES_X
```

Description

APP_GLCD_LAYER2_HOR_RES

This is needed for various positional cross-mapping of line buffer with screen pixel.

Remarks

The address space chosen is in the DDR2 address space (0xA8000000 - 0xA9FFFFFF) unique to the PIC32MZ2048DAB288 device.

APP_GLCD_LAYER1_ALPHA_RESOLUTION Macro

Determines the smoothness of the fading and showing of the Microchip and Harmony logos

File

wvga_glcd_app.h

C

```
#define APP_GLCD_LAYER1_ALPHA_RESOLUTION 7500
```

Description

APP_GLCD_LAYER1_ALPHA_RESOLUTION

Increases the resolution of 0 to 255 alpha value range

Remarks

Tuned to for build optimization O3 and Os

APP_HOME_MODE_SEMI_TRANSPARENT_ALPHA_VALUE Macro

Home mode uses this value to keep the Microchip and Harmony logos at semi-transparent levels

File

wvga_glcd_app.h

C

```
#define APP_HOME_MODE_SEMI_TRANSPARENT_ALPHA_VALUE 180
```

Description

APP_HOME_MODE_SEMI_TRANSPARENT_ALPHA_VALUE

This value represents watermark-like semi-transparent in RGBA8888 color scheme

APP_TRANSPARENT_ALPHA_VALUE Macro

Value the GLCD driver accepts as 100% transparent

File

wvga_glcd_app.h

C

```
#define APP_TRANSPARENT_ALPHA_VALUE 255
```

Description

APP_TRANSPARENT_ALPHA_VALUE

This value represents 100% transparent in RGBA8888 color scheme

APP_MENU_STATES Enumeration

Application menu states enumeration

File

wvga_glcd_app.h

C

```
typedef enum {
  APP_MENU_STATE_INIT,
  APP_MENU_STATE_COLLAPSED,
  APP_MENU_STATE_COLLAPSED_PRESSED,
  APP_MENU_STATE_EXPANDED,
  APP_MENU_STATE_EXPAND_TRANSITION,
  APP_MENU_STATE_COLLAPSE_TRANSITION
} APP_MENU_STATES;
```

Members

Members	Description
APP_MENU_STATE_INIT	Initial state, the menu will only be in this mode at launch
APP_MENU_STATE_COLLAPSED	State when the menu is collapsed, renders the asset showing the arrow button un-lit
APP_MENU_STATE_COLLAPSED_PRESSED	State when the menu is collapsed, renders the asset showing the arrow button lit
APP_MENU_STATE_EXPANDED	State when the menu is expanded, composes two assets to form the menu, the tip and the bar with the buttons

APP_MENU_STATE_EXPAND_TRANSITION	Transition state from collapsed to expanded
APP_MENU_STATE_COLLAPSE_TRANSITION	Transition state from expanded to collasped

Description

APP_MENU_MODES

This enumeration defines the valid application menu states enumerations. These states determine the behavior of the sliding menu at various times.

Remarks

See inline comments for specifics.

MEB II Demonstrations

This section provides descriptions of the MEB II demonstrations.

Introduction

MEB II Demonstration Applications Help

Description

This help file describes the hardware requirements and procedures to run the MEB II-related firmware projects.

To learn more about MPLAB Harmony stacks and libraries refer to the related documentation in Volume IV: MPLAB Harmony Framework Reference.

Demonstrations

This topic provides information on how to run the MEB II demonstration applications included in this release.

gfx_camera

Provides information on the gfx_camera demonstration and application requirements.

Description

The gfx_camera demo (`apps/meb_ii/gfx_camera/firmware/gfx_camera.X`) exercises the Omnivision camera sensor running on the MEB II. It utilizes LCC graphics with the DMA of the PIC32 to bring graphics from a camera sensor to an LCD without the need of a graphics controller.

Application Process

Prior to running the demonstration, an application needs to perform the following steps:

1. The system should have completed necessary setup initializations.
2. The I2C driver object should have been initialized by calling DRV_I2C_Initialize.
3. The Timer driver object should have been initialized by calling DRV_Timer_Initialize.
4. The Output Control driver object should have been initialized by calling DRV_OC_Initialize.
5. The Camera OVM7690 driver object should have been initialized by calling DRV_CAMERA_OVM7690_Initialize.
6. Open the Camera OVM7690 driver client by calling DRV_CAMERA_OVM7690_Open.
7. Pass the Graphics Frame buffer address to Camera OVM7690 Driver by calling DRV_CAMERA_OVM7690_FrameBufferAddressSet.
8. Set the Frame Rectangle area by calling DRV_CAMERA_OVM7690_FrameRectSet.
9. Set Other Camera settings such as: soft reset, enabling pclk, enabling href, enabling vsync, output color format, reversing HREF polarity, gating clock to the HREF, pixel clock frequency, sub-sampling mode by calling DRV_CAMERA_OVM7690_RegisterSet.
10. Start the Camera OVM7690 by calling DRV_CAMERA_OVM7690_Start.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the Graphics Library Demonstration.

Description

To build this project, you must open the `gfx_camera.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/meb_ii/gfx_camera`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
gfx_camera.X	<install-dir>/apps/meb_ii/gfx_camera/firmware

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mz_ef_sk_meb2	pic32mz_ef_sk+meb2	Select this MPLAB X IDE project configuration to run the demonstration on the Multimedia Expansion Board II (MEB II) connected to the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32MZ EF Starter Kit and MEB II

Jumper J9 on the MEB II should be set to (EBIWE – LCD_PCLK).

Running the Demonstration

Provides instructions on how to build and run demonstration.

Description

Use the following procedure to run the demonstration:

1. Load demonstration project into MPLAB X IDE.
2. Connect the mini-B debugger port on-board the starter kit to a USB port on the Development computer using the USB cable provided in the kit.
3. Build, Download, and Run demonstration project on the target board.
4. An image should appear on the WQVGA LCD displaying the information from the camera sensor.

gfx_cdc_com_port_single

This demonstration application creates a GFX USB CDC Device that enumerates as a single COM port on the host personal computer. The application demonstrates two-way communication between the USB device and the personal computer host. The application allows the user to enter keypad digits and a backspace from a PC host USB/Serial program to the GFX UI keypad edit box display.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the Graphics Library Demonstration.

Description

To build this project, you must open the `gfx_cdc_com_port_single.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/meb_ii/gfx_cdc_com_port_single`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`gfx_cdc_com_port_single.X`	`<install-dir>/apps/meb_ii/gfx_cdc_com_port_single/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mz_ef_sk_meb2	pic32mz_ef_sk+meb2	Select this MPLAB X IDE project configuration to run the demonstration on the Multimedia Expansion Board II (MEB II) connected to the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32MZ EF Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ EF Starter Kit and MEB II

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

Provides instructions on how to build and run the demonstration.

Description

This demonstration allows the device to appear like a serial (COM) port to the host.

1. To run this demonstration first compile and program the target device. While compiling, select the pic32mz_ef_sk_meb2 configuration. Attach the device to the host. If the host is a personal computer and this is the first time you have connected this device to the computer, you may be asked for an `.inf` file.
2. Select the Install from a list or specific location (Advanced) option. Point to the `<install_dir>/apps/usb/cdc_com_port_single/inf` directory.
3. Once the device is successfully installed, open up a terminal program, such as HyperTerminal. Select the appropriate COM port. On most machines this will be COM4 or higher.
4. Once connected to the device, there are two ways to run this example project. Typing a numerical key in the terminal window will result in the device echoing the key pressed onto the terminal and in the text box displayed onto the MEB II board display.

Note: Some terminal programs, such as HyperTerminal, require users to click the disconnect button before removing the device from the computer. Failing to do so may result in having to close and open the program again to reconnect to the device.

gfx_photo_frame

This demonstration application shows the capabilities of GFX, USB middleware, and the SQI. In this demonstration, off-chip SQI Flash memory (SST26VF032) is used as a medium to store images through the USB-CDC, XMODEM protocol, and then render those images on the MEB II display through the GFX Stack.

The demonstration includes four example WQVGA-aligned images, which are downloaded onto the SQI Flash at different locations, and then displayed on the screen through COM port commands and also rendered as slides through push button.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the Graphics Photo Frame Demonstration.

Description

To build this project, you must open the `gfx_photo_frame.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/meb_ii/gfx_photo_frame`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
gfx_photo_frame.X	<install-dir>/apps/meb_ii/gfx_photo_frame/firmware

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within ./firmware/src/system_config.

Project Configuration Name	BSP Used	Description
pic32mz_ef_sk_meb2	pic32mz_ef_sk+meb2	Select this MPLAB X IDE project configuration to run the demonstration on the Multimedia Expansion Board II (MEB II) connected to the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32MZ EF Starter Kit and MEB II

The MEB II has two memory options: External or Internal. This demonstration is supported in Internal mode only. Before running the demonstration, ensure that the EBIWE and LCD_PCLK (J9) pins on the MEB II are closed.

Running the Demonstration

Provides instructions on how to build and run demonstration.

Description

Use the following procedure to run the demonstration:

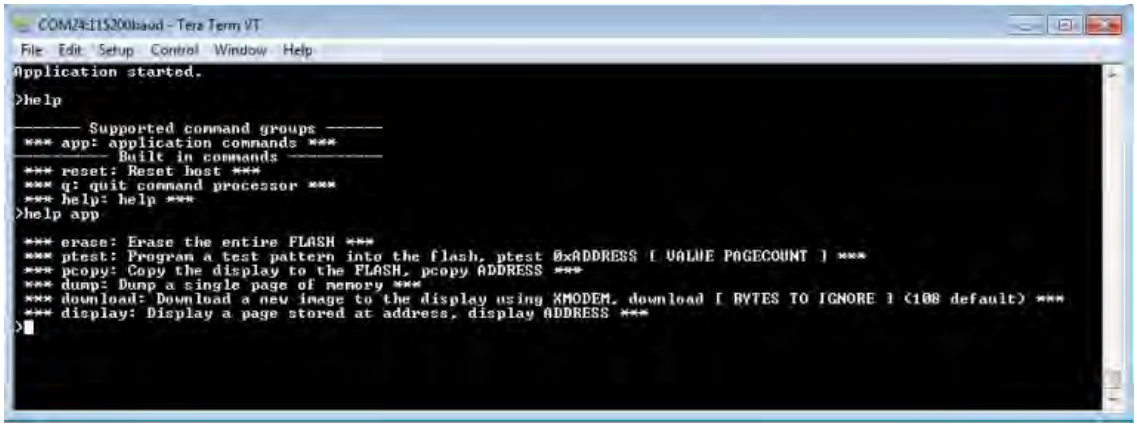
1. Load the demonstration project into MPLAB X IDE.
2. Connect the MEB II to the PIC32MZ EF Starter Kit.
3. Connect the mini-B debugger port on-board the starter kit to a USB port on the development computer using the USB cable provided in the kit. In addition, connect the micro-B USB connector on the bottom of the starter kit. This will create a USB CDC device on the USB bus. To communicate with the software, connect to this device though a standard terminal program and set the baud rate to 921,600 baud.

Note: In case the USB driver is not automatically recognized by the development computer, please use the driver support files provided in <install-dir>/apps/meb_ii/gfx_photo_frame/inf to update the driver.

4. Build, Download, and Run the demonstration project on the target board.
5. Once the MEB II display goes blank, launch a console client (OS native/Tera Term, etc.), select the serial port, and set the serial port settings to 115200-N-1

Note: Focusing in console client and pressing the Enter key should show the 'Application started' string in the console indicating proper start of application.

6. Press Enter again in the console client to see the '>' prompt, indicating the demonstration is ready to take commands.
7. Send a 'help' command to see the list of commands supported by the demonstration.



8. Send an ‘erase' command to erase the entire SQI Flash. The console will return ‘Erasing FLASH’ followed by ‘Erase complete' to indicate

completion of erase operation.

9. Send a ‘display 0x00000000’ command (which will display a frame at address ‘0’ of SQI Flash) and notice that the MEB II display turns white, as in the erased state, the SQI Flash has all 'F' characters, which will be loaded into the frame buffer.
10. Send a ‘ptest 0x00000000 0xf800 0x20' command to load a test pattern into the SQI Flash, which writes the first 32 pages in Flash with 0x20 (RED) pattern. The console will return ‘Programming test pattern complete', once the test pattern is loaded into the SQI Flash.
11. Send a ‘display 0x00000000' command and notice the first couple of lines on the display turn RED.
12. Send an ‘erase' command to erase the entire SQI Flash.
13. To download the images provided with the demonstration into the Flash, repeat the following steps:

- Send a `download [ignore bytes]` command

Note: The argument, ignore bytes, is not required. By default, the demonstration will use the value: 108. Well known values to ignore are 108, 124, and 188. The first, third, and fourth images in this demonstration use = 188. The second image will use the default and will not require an ignore. Each image in the demonstration takes 0x3FC00 of Flash.

- Send a download [ignore bytes] command. Console will return ‘Start XMODEM download' indicating XMODEM ready
- Select *File* >*Transfer* > *XMODEM-Send* and use a traditional checksum XMODEM transfer and select the image to send by browsing to `<install-dir>/apps/meb_ii/gfx_photo_frame` and press **send**. This will load the image directly into the GFX frame buffer and show the image on display.

Note: XMODEM sometimes is erratic, in which case this step would have to be repeated.

- Send a ‘pcopy <ADDRESS>' command to copy the image into SQI Flash at the <ADDRESS> location. The console returns the following to indicate the status:

‘.....

.....

.....

.....

.....

.....

Copy complete'

Note: ADDRESS = 0x00000000 for first image, 0x0003FC00 for second image, 0x0007F800 for third image, and 0x000BF400 for fourth image.

14. Once all of the images are copied into the SQI Flash, send a ‘display <ADDRESS>' command to load the stored images onto the display.
15. The ‘S1' switch on the MEB II can be pressed to view the images in a slide show.
16. Refer to the following console window capture for a summary of commands described in the previous steps:

gfx_web_server_nvm_mpfs

The GFX TCP/IP NVM MPFS web server demonstration (`apps\meb_ii\gfx_web_server_nvm_mpfs\firmware\pic32_eth_web_server.X`) exercises the HTTP web server running on PIC32 devices. The Non-Volatile Memory (NVM) Microchip Proprietary File System (MPFS) web server demonstration has the web pages stored in internal Flash and accessed through the MPFS API. The IP Address of the IP address of the Web server is displayed on the Graphical UI.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the Graphics Web Server NVM MPFS Demonstration.

Description

To build this project, you must open the `pic32_eth_web_server.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/meb_ii/gfx_web_server_nvm_mpfs`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`pic32_eth_web_server.X`	`<install-dir>/apps/meb_ii/gfx_web_server_nvm_mpfs/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mz_ef_sk_meb2	pic32mz_ef_sk+meb2	Select this MPLAB X IDE project configuration to run the demonstration on the Multimedia Expansion Board II (MEB II) connected to the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32MZ EF Starter Kit and MEB II

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

Provides instructions on how to build and run demonstration.

Description

To view the web page hosted by the demonstration application, open a web browser and direct it to the board running the HTTP server by typing the URL in the address bar (for example, http://mchpboard_e), and then pressing **Enter**.

Note: The NetBIOS name of the TCP/IP application is specified at the time the TCP/IP stack is initialized, which is usually in the hostName member of the tcpip_stack_init.c:: TCPIP_HOSTS_CONFIGURATION structure. The NetBIOS service must be enabled for the PIC32 demonstration to respond to NetBIOS queries. Alternatively, you can use the IPv4 or IPv6 address (if IPv6 is enabled) of the board directly, for example, http://192.168.1.131 or http://[fdfe:dcba:9876:1:204:a3ff:fe12:128e].

Please use the following procedure to run the demonstration:

1. Load the demonstration project into MPLAB X IDE.
2. Connect the mini-B debugger port on-board the starter kit to a USB port on the development computer using the USB cable provided in the kit.
3. Connect the RJ-45 Ethernet port on the starter kit to a network hub or an Ethernet port on the development computer using the Ethernet patch cord provided in the kit.
4. Build, Download, and Run the demonstration project on the target board.
5. A HTTP server is hosted by the demonstration application. Open a web browser and type `http://<ip address>`. The IP address is displayed on the graphical user interface.
   - *Real-time hardware control and Dynamic Variables* - On the Overview page the LEDs can be clicked to toggle LEDs on the starter kit. The buttons on the board can be pressed to see the buttons on the web page toggle. The dynamic variables can be updated in real time on the HTTP server.

Note: LED functionality part of the demonstration is somewhat limited due to errata items related to the functional multiplexing on GPIO and Ethernet pins.

- *Form Processing* - Input can be handled from the client by using GET and POST methods.
- *Authentication* - Shows an example to restricted access feature commonly used.
- *Cookies* - Shows the example of storing small text stings on the client side.

- *File Uploads* - Shows an example of file upload using POST method. The HTTP server can accept a user defined MPFS/MPFS2 image file for web pages.
- *Send E-mail* - Shows a simple SMTP POST methods.
- *Dynamic DNS* - Exercise Dynamic DNS capabilities.
- *Network Configuration* - MAC address, host name and IP address of the PIC32 EF Starter Kit board can be viewed in the Network Configuration page and some configuration can be updated.

segger_emwin

This demonstration shows basic and advanced capabilities of the SEGGER emWin Graphics Library utilizing the software graphics controller on a LCD display.

Description

The segger_emwin demonstration provides the ability to display some of the many features supported by the SEGGER emWin Graphics Library as a simple Graphical User Interface (GUI) demonstration.

SEGGER emWin is designed to provide an efficient, processor and LCD controller-independent GUI for any application that operates with a graphical LCD. Some of the features demonstrated in the application include GUIs showing alpha blending, sprites, radial menu operations, listing and tree widget features, multiple layer and drawing on the layers, use of different image formats, coloring features provided by the library, etc.

Currently, the demonstration includes the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit on a Multimedia Expansion Board II (MEB II), which has controllerless graphics on a WQVGA LCD display.

This demonstration requires the use of internal memory (SRAM). The memory setting must be configured with a hardware jumper and corresponding MHC setting needs to be selected.

Important! ☆	To set up the internal memory, a jumper setting on the board is required. Failure to configure this jumper setting will prevent the display from working, although the software may still run. See Configuring the Hardware for details on the appropriate jumper settings.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the SEGGER emWin MEB II Demonstration.

Description

To build this project, you must open the `segger_emwin.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/meb_ii/segger_emwin`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`segger_emwin.X`	`<install-dir>/apps/meb_ii/segger_emwin/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mz_ef_sk_meb2	pic32mz_ef_sk+meb2	Select this MPLAB X IDE project configuration to run the demonstration on the Multimedia Expansion Board II (MEB II) connected to the PIC32MZ EF Starter Kit.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32MZ EF Starter Kit and MEB II

The MEB II has two memory options, External or Internal; however, this demonstration must be run in Internal mode by implementing the following settings:

- EBIWE and LCD_PCLK (J9) must be closed. This jumper is located on the bottom of the MEB II

- Ensure that any MHC setting is defined to only use internal SRAM. The current internal/external memory setting for the application can be verified in MHC by selecting *Harmony Framework Configuration > Drivers > Graphics Controllers > LCC > Use LCC Driver > Memory Interface Mode*

Running the Demonstration

Provides instructions on how to build and run demonstration.

Description

This demonstration shows the Graphics Library interfacing with the Low-Cost Controllerless (LCC) software display controller. The demonstration displays some of the many features supported by the SEGGER emWin graphics library as a simple GUI demonstration.

Use the following procedure to run the demonstration:

1. Load the demonstration project into MPLAB X IDE.
2. Build, Download, and Run the demonstration project on the target board (see **Note**).
3. This is a GUI only demonstration; there is no touch input being processed.

Note: Upon building, the pic32mz_ef_sk_meb2 configuration warnings related to the Floating Point Unit. This is due to the fact that emWin does not support floating point even though the PIC32MZ EF Starter Kit has a floating point unit.

Demonstration Screens

The following are the different screens that demonstrate the various graphics features:

- **Radial menu** - Select an icon from a radial menu. Changing the selection is done using emWin motion support.
- **Bargraph demo** - Shows a bar graph using alpha blending
- **Antialiased text** - Shows anti-aliased text with different anti-aliasing qualities. Outputs anti-aliased text on different backgrounds (2 bpp, 4 bpp)
- **Transparent dialog** – Uses alpha blending for transparency effect on moving background
- **Washing machine** - Shows a washing machine demonstration with blue dolphin sprites moving on top of the application
- **Iconview demo** - Uses the ICONVIEW widget for showing an icon-based menu, which is often required in hand held devices. Shows the change of selection and change of icon text alignment.
- **Treeview widget** - Shows a customized TREEVIEW widget. Demonstrates hierarchical view of items in a directory and some sprites, show/hide lines, moving cursor, open/close nodes, change selection modes, setting images, show/hide lines.
- **Listview widget** - Shows the use of a LISTVIEW widget. Demonstrates changing order, enable sorting, using reverse/normal sorting order, moving rows, coloring row/column individual elements in the list.
- **Drawing a graph** - Uses the GRAPH widget to visualize a function graph (e.g., heartbeat, sine waves)
- **High speed** – Demonstrates multi-layer clipping and highly optimized drivers
- **Pixels speed** – Demonstrates pixel speed as pixels per seconds
- **Bitmaps** - Demonstrates `*.BMP` files by displaying all bitmaps of the Windows directory. Palette-based bitmaps, changing the pallete, bmp, gif, jpeg, 12, 16, 24 bpp formats, alpha bitmaps, changing color, grayscale bitmaps.
- **Color bar** - Shows a color bar with gradient bars (Black > Color, White > Color). Integrated color management, which finds the optimized color for any logical color.

RTOS Demonstrations

This section provides descriptions of the RTOS demonstrations.

Introduction

RTOS Demonstration Applications Help

Description

This distribution package contains a variety of RTOS-based firmware projects that demonstrate the capabilities of the MPLAB Harmony services and stacks integrated with RTOS running on PIC32 devices. This section describes the hardware requirement and procedures to run these firmware projects on Microchip demonstration and development boards.

To learn more about MPLAB Harmony stacks and libraries refer to the related documentation in Volume IV: MPLAB Harmony Framework Reference.

Source Code Disclaimers

OPENRTOS

The OPENRTOS demonstrations provided in MPLAB Harmony use the OPENRTOS evaluation license, which is meant for demonstration purposes only. Customers desiring development and production on OPENRTOS must procure a suitable license. Please refer to one of the following documents, which are located in the `third-party` folder of the MPLAB Harmony installation, for information on obtaining an evaluation

license for your device:

- `OpenRTOS Click Thru Eval License PIC32MXxx.pdf`
- `OpenRTOS Click Thru Eval License PIC32MZxx.pdf`

Micriμm

All μC/OS-III demonstrations have added the `crt0.S` "C" run-time library start-up file to the project. The demonstration sets the linker option "do not link startup code". This is necessary for μC/OS-III to work correctly with PIC32 devices as the general exception vector is located in `crt0.S`. μC/OS-III overrides this interrupt source (general exception handler) to perform OS-specific functionality.

If the user wants to implement their own application using μC/OS-III and a PIC32 device, they must add the `crt0.S` file to their project and override the general exception interrupt vector. See the current RTOS examples for this implementation.

A `crt0.S` template file can be found in the MPLAB XC32 C/C++ Compiler installation directory: `..\Microchip\xc32\<version>\pic32-libs\libpic32`.

Important! The Micriμm μC/OS-II and μC/OS-III source code that is distributed with MPLAB Harmony is for FREE short-term evaluation, for educational use, or peaceful research. If you plan or intend to use μC/OS-II and μC/OS-III in a commercial application/product, you need to contact Micriμm to properly license μC/OS-II and μC/OS-III for its use in your application/product. The source code is provided for your convenience and to help you experience μC/OS-II and μC/OS-III. The fact the source is provided does NOT mean that you can use it commercially without paying a licensing fee. Knowledge of the source code may NOT be used to develop a similar product. If you are unsure about whether you need to obtain a license for your application, please contact Micriμm and discuss the intended use with a sales representative (www.micrium.com).

Express Logic ThreadX

The source code for the ThreadX RTOS is not freely distributed. To obtain source code and the proper licensing agreement go to the Express Logic ThreadX website: http://rtos.com/products/threadx/.

SEGGER embOS

The source code for the SEGGER embOS RTOS is not freely distributed. To obtain source code and the proper licensing agreement go to the SEGGER embOS website: https://www.segger.com/license-models.html.

Express Logic ThreadX Demonstrations

basic

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Description

Source Code Disclaimer

The source code for this ThreadX RTOS demonstration is not freely distributed. To obtain source code and the proper licensing agreement go to the Express Logic ThreadX website: http://rtos.com/products/threadx/. So that ThreadX can work with the applicable MPLAB Harmony demonstrations, install the source in the following location: `<install-dir>/third_party/rtos/ThreadX/`.

The demonstrations will not compile unless the source code is provided and installed in the correct location.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the ThreadX Basic Demonstration.

Description

To build this project, you must open the `basic_threadx.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/rtos/threadx/basic`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`basic_threadx.X`	`<install-dir>/apps/rtos/threadx/basic`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mz_ef_sk	pic32mz_ef_sk	This configuration runs on the PIC32MZ EF Starter Kit.
pic32mz_ef_sk_microMIPS	pic32mz_ef_sk	This configuration runs on the PIC32MZ EF Starter Kit in microMIPS™ mode.
pic32mx_sk	pic32mx_usb_sk2, pic32mx_usb_sk3, pic32mx_eth_sk, and pic32mx_eth_sk2	This configuration runs on PIC32MX-based starter kits: PIC32 Ethernet Starter Kit, PIC32 Ethernet Starter Kit II, PIC32 USB Starter Kit II, PIC32 USB Starter Kit III.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32 Ethernet Starter Kit, PIC32 Ethernet Starter Kit II, PIC32 USB Starter Kit II, and PIC32 USB Starter Kit III

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ EF Starter Kit

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

Provides instructions on how to build and run the ThreadX basic demonstration.

Description

Once the demonstration is up and running an LED will toggle every 500 ms. This demonstration will show the RTOS running with the selected hardware.

gfx

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Description

Source Code Disclaimer

The source code for this ThreadX RTOS demonstration is not freely distributed. To obtain source code and the proper licensing agreement go to the Express Logic ThreadX website: http://rtos.com/products/threadx/. So that ThreadX can work with the applicable MPLAB Harmony demonstrations, install the source in the following location: `<install-dir>/third_party/rtos/ThreadX/`.

The demonstrations will not compile unless the source code is provided and installed in the correct location.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the ThreadX and MPLAB Harmony Graphics Library Demonstration.

Description

To build this project, you must open the `gfx_threadx.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/rtos/threadx/gfx`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`gfx_threadx.X`	`<install-dir>/apps/rtos/threadx/gfx`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx_usb_sk2_meb	pic32mx_usb_sk2+meb	This configuration runs on the PIC32 USB Starter Kit II and the MEB.
pic32mz_ef_sk_meb2	pic32mz_ef_sk+meb2	This configuration runs on the PIC32MZ EF Starter Kit and the MEB II.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32MZ EF Starter Kit with MEB II

No hardware related configuration or jumper setting changes are necessary.

PIC32 USB Starter Kit II with MEB

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

Provides instructions on how to build and run the ThreadX and MPLAB Harmony Graphics Library Demonstration.

Description

Power the board, open the demonstration with MPLAB X IDE, and then build and load the demonstration. The LCD screen color will change every 500 ms, and user LEDs will toggle every 500 ms.

There are two tasks in the application, and three interrupts in this application/system.

The lowest priority task, LEDblinkTask, controls toggling of the LEDs. The highest priority task, DisplayTask, changes the color of the LCD screen by calling the appropriate MPLAB Harmony Graphics Library function.

The CPU core timer hardware interrupt is used by the RTOS to source the RTOS Tick. DMA channel 1 interrupt is used to call the appropriate MPLAB Harmony graphics driver function, which takes all graphics work queued up by the application and physically writes it out to the LCD display. SYSCALL general exception is invoked by the RTOS and is used to process the task context switch routine

gfx_usb

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Description

Source Code Disclaimer

The source code for this ThreadX RTOS demonstration is not freely distributed. To obtain source code and the proper licensing agreement go to the Express Logic ThreadX website: http://rtos.com/products/threadx/. So that ThreadX can work with the applicable MPLAB Harmony demonstrations, install the source in the following location: `<install-dir>/third_party/rtos/ThreadX/`.

The demonstrations will not compile unless the source code is provided and installed in the correct location.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the ThreadX and MPLAB Harmony Graphics and USB Library Demonstration.

Description

To build this project, you must open the `gfx_usb_threadx.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/rtos/threadx`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`gfx_usb_threadx.X`	`<install-dir>/apps/rtos/threadx/gfx_usb`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mz_ef_sk_meb2	pic32mz_ef_sk+meb2	This configuration runs on the PIC32MZ EF Starter Kit and the MEB II.
pic32mx_usb_sk2_meb	pic32mx_usb_sk2+meb	This configuration runs on the PIC32 USB Starter Kit II and the MEB.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32MZ EF Starter Kit with MEB II

No hardware related configuration or jumper setting changes are necessary.

PIC32 USB Starter Kit II with MEB

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

Provides instructions on how to build and run the ThreadX and MPLAB Harmony Graphics plus USB Library.

Description

Power the board, open the demonstration with MPLAB X IDE, and then build and load the demonstration. A USB keyboard will be emulated when a micro USB cable is plugged into J4 on the PIC32MZ EC Starter Kit. Keystrokes, a-z and 1-9, will be sent when the push button SW3 is pressed. The LCD screen color will change every 500 ms, and the user LED, D3, will toggle every 500 ms.

There are four tasks and five interrupts used in this application/system.

SystemUSBDeviceTask is the highest priority task and is responsible for getting all USB data queued up by the application ready for sending over the USB by calling the appropriate MPLAB Harmony USB stack function. ApplicationUSBDeviceTask is the next highest priority task. ApplicationUSBDeviceTask emulates the keyboard key presses when it detects that the push button SW3 is being pressed. ApplicationDisplayTask changes the color of the entire LCD screen by calling the appropriate MPLAB Harmony Graphics Library function. ApplicationLEDblinkTask is the lowest priority task and toggles the user LED, D3, every 500 ms.

CPU core timer hardware interrupt is used by the RTOS to source the RTOS Tick. The Timer2 hardware interrupt is used to call the MPLAB Harmony Timer Driver function. This is a hardware requirement of the MPLAB Harmony USB stack. A DMA channel 1 interrupt is used to call the appropriate MPLAB Harmony graphics driver function, which takes all graphics work queued up the application and physically writes it out to the LCD display. A USB general event interrupt is used to call the appropriate MPLAB Harmony USB driver function, which takes all USB data queued up by the application and physically writes it out to the USB hardware. A SYSCALL general exception, is invoked by the RTOS and is used to process the task context switch routine.

usb

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Description

Source Code Disclaimer

The source code for this ThreadX RTOS demonstration is not freely distributed. To obtain source code and the proper licensing agreement go to the Express Logic ThreadX website: http://rtos.com/products/threadx/. So that ThreadX can work with the applicable MPLAB Harmony demonstrations, install the source in the following location: `<install-dir>/third_party/rtos/ThreadX/`.

The demonstrations will not compile unless the source code is provided and installed in the correct location.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the ThreadX and MPLAB Harmony Graphics plus USB Library Demonstration.

Description

To build this project, you must open the `usb_threadx.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/rtos/threadx/usb`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`usb_threadx.X`	`<install-dir>/apps/rtos/threadx/usb`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mz_ef_sk	pic32mz_ef_sk	This configuration runs on the PIC32MZ EF Starter Kit.
pic32mx_usb_sk2	pic32mx_usb_sk2	This configuration runs on the PIC32 USB Starter Kit II.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32MZ EF Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32 USB Starter Kit II

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

Provides instructions on how to build and run the ThreadX and MPLAB Harmony USB Library demonstration.

Description

Power the board, open the demonstration with MPLAB X IDE, and then build and load the demonstration. A USB keyboard will be emulated when a micro USB cable is plugged into J4 on the PIC32MZ EC Starter Kit. Keystrokes, a-z and 1-9, will be sent when the push button SW3 is pressed. The user LED, D3, will toggle every 500 ms.

There are three tasks and four interrupts used in this application/system.

SystemUSBDeviceTask is the highest priority task and is responsible for getting all USB data queued up by the application ready for sending over the USB by calling the appropriate MPLAB Harmony USB stack function. ApplicationUSBDeviceTask is the next highest priority task. ApplicationUSBDeviceTask emulates the keyboard key presses when it detects that the push button SW3 is being pressed. ApplicationLEDblinkTask is the lowest priority task and toggles the user LED, D3, every 500 ms.

CPU core timer hardware interrupt is used by the RTOS to source the RTOS Tick. The Timer2 hardware interrupt is used to call the MPLAB Harmony Timer Driver function. USB general event interrupt is used to call the appropriate MPLAB Harmony USB driver function, which takes all USB data queued up by the application and physically writes it out to the USB hardware. The SYSCALL general exception is invoked by the RTOS and is used to process the task context switch routine.

FreeRTOS Demonstrations

basic

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Description

The demonstration blinks the three user LEDs on a starter kit to show the RTOS threads that are running and to indicate status.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the FreeRTOS Basic

Demonstration.

Description

To build this project, you must open the `basic_freertos.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/rtos/freertos`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`basic_freertos.X`	`<install-dir>/apps/rtos/freertos/basic`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./src/system_config`.

Project Configuration Name	BSP(s) Used	Description
pic32mx_sk	pic32mx_usb_sk2, pic32mx_usb_sk3, pic32mx_eth_sk, and pic32mx_eth_sk2	This configuration runs on PIC32MX-based starter kits: PIC32 Ethernet Starter Kit, PIC32 Ethernet Starter Kit II, PIC32 USB Starter Kit II, PIC32 USB Starter Kit III.
pic32mx_sk_mips16	pic32mx_usb_sk2, pic32mx_usb_sk3, pic32mx_eth_sk, and pic32mx_eth_sk2	This configuration runs on PIC32MX-based starter kits in MIPS16 mode: PIC32 Ethernet Starter Kit, PIC32 Ethernet Starter Kit II, PIC32 USB Starter Kit II, PIC32 USB Starter Kit III.
pic32mz_sk	pic32mz_ec_sk	This configuration runs on the PIC32MZ EC Starter Kit.
pic32mz_ef_sk	pic32mz_ef_sk	This configuration runs on the PIC32MZ EF Starter Kit.
pic32mz_ef_sk_microMIPS	pic32mz_ef_sk	This configuration runs on the PIC32MZ EF Starter Kit in microMIPS™ mode

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32 Ethernet Starter Kit, PIC32 Ethernet Starter Kit II, PIC32 USB Starter Kit II, and PIC32 USB Starter Kit III

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ EC Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ EF Starter Kit

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

Provides instructions on how to build and run the FreeRTOS basic demonstration.

Description

Please use the following procedure to run the demonstration:

1. Load the demonstration project into MPLAB X IDE.
2. Connect the mini-B debugger port on-board either the PIC32MX or PIC32MZ target board to a USB port on the development computer using the USB cable provided in the kit.
3. Build, download, and run the demonstration project on the target board.

The demonstration application features the following:

- Application creates one queue and four tasks. One task that sends the data using the FreeRTOS queue to the two tasks that wait for the data in the queue. (QueueReceiveTask2 priority is higher than the QueueReceiveTask1 priority.)
- QueueReceiveTask2 receives the data first, toggles the LED, and then sleeps for the specified time
- QueueReceiveTask1 receives the next data since QueueReceiveTask2 is not in running state
- QueueReceiveTask1 receives the data, toggles the LED and waits for the data arrival

cdc_com_port_dual

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

This RTOS based demonstration application creates a USB CDC Device that enumerates as two serial ports on the USB Host personal computer. This application demonstrates the ability of the MPLAB Harmony USB Stack to operate in an Real-Time Operating System (this example uses FreeRTOS) and to support multiple instances of the same device class.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for this demonstration application.

Description

To build this project, you must open the `cdc_com_port_dual.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/rtos/freertos/cdc_com_port_dual`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`cdc_com_port_dual.X`	`<install-dir>/apps/rtos/freertos/cdc_com_port_dual/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx_usb_sk2_int_dyn	pic32mx_usb_sk2	Select this configuration to run the demonstration application on the PIC32 USB Starter Kit II in Interrupt mode and dynamic operation.
pic32mz_ec_sk_int_dyn	pic32mz_ec_sk	Select this configuration to run the demonstration application on the PIC32MZ Embedded Connectivity (EC) Starter Kit in Interrupt mode and dynamic operation.
pic32mz_ef_sk_int_dyn	pic32mz_ef_sk	Select this configuration to run the demonstration application on the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit in Interrupt mode and dynamic operation.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32 USB Starter Kit II

Remove jumper JP2.

PIC32MZ EC Starter Kit

Remove jumper JP1.

PIC32MZ EF Starter Kit

Remove jumper JP1.

Running the Demonstration

Provides instructions on how to build and run the cdc_com_port_dual demonstration.

Description

Refer to the Running the Demonstration topic for the bare-metal (non RTOS) version of the cdc_com_port_dual demonstration applications for running the demonstration.

The demonstration application contains six tasks. A description of these tasks is as follows:

- The FrameworkTasks task is created in the SYS_Tasks function. This task calls the USB Device Layer Tasks function (USB_DEVICE_Tasks). The priority of this task is designed to be the lowest when compared to the priorities of other tasks. Hence this tasks runs when all other tasks

are either in blocked state or not ready to run.

- The APP_USB_DEVICE_Open task is created in the APP_Tasks function. This task creates all the semaphores and message queues needed for the application. It creates 4 tasks which implement the application logic. It attempts to open the Device Layer and then blocks on the xSemaphoreBlockUsbConfigure semaphore. The xSemaphoreBlockUsbConfigure is given in the USB Device Layer Event Handler when the device is configured by the Host. The tasks then resumes the 4 application logic tasks and suspends itself.
- The APP_CDC1Read Task is created in the APP_USB_DEVICE_Open task. It schedules a read on the CDC1 instance and then blocks on the CDC1 instance xSemaphoreCDCReadComplete semaphore. This semaphore is given in the Read Complete event in the CDC Application Event Handler. The tasks will then post the data that it has received from the Host to the CDC 1 instance Message Queue.
- The APP_CDC2Read Task is created in the APP_USB_DEVICE_Open task. It schedules a read on the CDC2 instance and then blocks on the CDC2 instance xSemaphoreCDCReadComplete semaphore. This semaphore is given in the Read Complete event in the CDC Application Event Handler. The tasks will then post the data that it has received from the Host to the CDC 1 instance Message Queue.
- The APP_CDC1Write Task is created in the APP_USB_DEVICE_Open task. It blocks on the CDC 2 message queue. When APP_CDC2Read Task posts a message to this queue, the APP_CDC1Write gets ready to run and the writes the data (received on the queue) to the CDC 1. This data is then transferred to the Host.
- The APP_CDC2Write Task is created in the APP_USB_DEVICE_Open task. It blocks on the CDC 1 message queue. When APP_CDC1Read Task posts a message to this queue, the APP_CDC2Write gets ready to run and the writes the data (received on the queue) to the CDC 2. This data is then transferred to the Host.

cdc_msd_basic

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for this demonstration application.

Description

To build this project, you must open the `cdc_msd_basic.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/rtos/freertos/cdc_msd_basic`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`cdc_msd_basic.X`	`<install-dir>/apps/rtos/freertos/cdc_msd_basic/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx_usb_sk2_int_dyn	pic32mx_usb_sk2	Select this configuration to run the demonstration application on the PIC32 USB Starter Kit II in Interrupt mode and dynamic operation.
pic32mz_ec_sk_int_dyn	pic32mz_ec_sk	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32MZ Embedded Connectivity (EC) Starter Kit configured for Interrupt mode and dynamic operation.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32 USB Starter Kit II

JP2 should be in place if the attached USB device is bus-powered. It should be removed if the attached USB device is self-powered.

PIC32MZ Embedded Connectivity (EC) Starter Kit

Remove jumper JP1.

Running the Demonstration

Provides instructions on how to build and run the cdc_msd_basic demonstration.

Description

This USB Host demonstration application exercises the CDC and MSD interfaces on the attached composite USB device.

1. Open the project in MPLAB X IDE and select the desired project configuration.
2. Build the code and program the device.
3. Follow the directions for setting up and running the cdc_serial_emulator_msd USB device demonstration.
4. Connect the UART (P1) port on the Explorer 16 Development Board (running the cdc_serial_emulator_msd demonstration) to a USB Host personal computer via a commercially available Serial-to-USB Dongle.
5. Start a terminal program on the USB Host personal computer and select the Serial-to-USB Dongle as the communication port. Select the baud rate as 9600, no parity, 1 Stop bit and no flow control.
6. Connect the mini – B connector on the USB PICtail Plus Daughter Board, of the cdc_serial_emulator_msd demonstration setup, to the Type-A USB host connector on the starter kit.
7. A prompt (DATA :) will be displayed immediately on the terminal emulation program.
8. Type a string less than 12 characters and press the <Enter> key. The string entered here will be stored in the MSD device in a file named `file.txt`.
9. Step 8 can be repeated. Data entered in the prompt will be appended to the file.
10. Unplug the USB Device from the Host and connect it a personal computer host to examine the contents of the Mass Storage Device. This should contain a file named `file.txt` and this should contain the data that was entered at the terminal program prompt.

Tasks

This USB Host demonstration application contains four tasks. Descriptions of these tasks is as follows:

- The FrameworkTasks task is created in the SYS_Tasks function. This task calls the USB Host Layer Tasks function (USB_HOST_Tasks). The priority of this task is designed to be the lowest when compared to the priorities of other tasks. Hence this tasks runs when all other tasks are either in blocked state or not ready to run.
- The APP_USB_HOST_Open task is created in the APP_Tasks function. This task creates all the semaphores and message queues needed for the application. It creates two tasks that implement the application logic. It attempts to open the Host Layer and then enable USB Host Operation. The task then resumes the two application logic tasks and suspends itself.
- The APP_USBHostCDCTask Task is created in the APP_USB_HOST_Open task. It blocks on xSemaphoreUSBCDCAttach semaphore. This semaphore is given in the Application CDC Class Driver event handler when a CDC device is enumerated. The task then prints a prompt and schedules a read from the CDC interface of the attached USB device. When data is available, it posts the xSemaphoreCDCReadComplete semaphore.
- The APP_USBHostMSDTask Task is created in the APP_USB_HOST_Open task. It blocks on the xSemaphoreUSBMSDAttach semaphore. This semaphore is given in the Application MSD event Handler when a MSD device is enumerated. The task then mounts the attached storage media and then blocks on the xSemaphoreCDCReadComplete semaphore. The xSemaphoreCDCReadComplete semaphore is given by the APP_USBHostCDCTask task when the CDC Host has received data. The APP_USBHostMSDTask Task will then open a file on the mounted drive and will append the data (received from CDC) in the file. It closes the file, and then appends on xSemaphoreCDCReadComplete semaphore again.

gfx

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the FreeRTOS and MPLAB Harmony Graphics Demonstration.

Description

To build this project, you must open the `gfx_freertos.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/rtos/freertos`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`gfx_freertos.X`	`<install-dir>/apps/rtos/freertos/gfx`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mz_ec_sk_meb2	pic32mz_ec_sk+meb2	This configuration runs on the PIC32MZ EC Starter Kit and the MEB II.
pic32mz_ef_sk_meb2	pic32mz_ef_sk+meb2	This configuration runs on the PIC32MZ EF Starter Kit and the MEB II.
pic32mx_usb_sk2_meb	pic32mx_usb_sk2+meb	This configuration runs on the PIC32 USB Starter Kit II and the MEB.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32MZ EC Starter Kit with the MEB II

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ EF Starter Kit with the MEB II

No hardware related configuration or jumper setting changes are necessary.

PIC32 USB Starter Kit II with the MEB

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

Provides instructions on how to build and run the FreeRTOS RTOS with Graphics demonstration.

Description

Power the board, open the demonstration with MPLAB X IDE, and then build and load the demonstration. The LCD screen color will change every 500 ms, and user LEDs will toggle every 500 ms.

There are two tasks in the application, and three interrupts in this application/system.

The lowest priority task, LEDblinkTask, controls toggling of the LEDs. The highest priority task, DisplayTask, changes the color of the LCD screen, by calling the appropriate MPLAB Harmony Graphics Library function.

The Timer1 hardware interrupt is used by the RTOS to source the RTOS Tick. DMA channel 1 interrupt is used to call the appropriate MPLAB Harmony graphics driver function, which takes all graphics work queued up the application and physically write it out to the LCD display. Software interrupt 0, is invoked by the RTOS and is used to process the task context switch routine.

tcpip_client_server

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Description

The TCP/IP Client Server application, tcpip_client_server, demonstrates how to run multiple TCP and UDP servers and clients using the TCP/IP Stack in an RTOS environment. The demonstration also has the HTTP Web server running using the Non-Volatile Memory (NVM) Microchip Proprietary File System (MPFS) to store the web pages in the internal PIC32 Flash.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the FreeRTOS and MPLAB Harmony TCP/IP Demonstration.

Description

To build this project, you must open the `tcpip_client_server.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/rtos/freertos`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`tcpip_client_server.X`	`<install-dir>/apps/rtos/freertos/tcpip_client_server/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within ./firmware/src/system_config.

Project Configuration Name	BSP Used	Description
pic32mz_ec_sk	pic32mz_ec_sk	This configuration runs on the PIC32MZ EC Starter Kit and the Starter Kit I/O Expansion Board.
pic32mx_eth_sk	pic32mx_eth_sk	This configuration runs on the PIC32 Ethernet Starter Kit and the Starter Kit I/O Expansion Board.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32MZ EC Starter Kit connected to the Starter Kit I/O Expansion Board

No jumper settings are required for this configuration.

The demonstration makes extensive use of the UART. To use the UART output, you will need to connect an RS-232 level-shifter to UART2 on the Starter Kit I/O Expansion Board. From J11, connect U2TX (48) to the level-shifter TX and connect U2RX (46) to the level-shifter RX. Use any +5V and GND to complete the wiring of the RS-232 level-shifter. The baud rate is 115.2 kBaud, N81.

PIC32 Ethernet Starter Kit connected to the Starter Kit I/O Expansion Board

No jumper settings are required for this configuration.

The demonstration makes extensive use of the UART. To use the UART output, you will need to connect an RS-232 level-shifter to UART2 on the Starter Kit I/O Expansion Board. From J11, connect U2TX (48) to the level-shifter TX and connect U2RX (46) to the level-shifter RX. Use any +5V and GND to complete the wiring of the RS-232 level-shifter. The baud rate is 115.2 kBaud, N81.

Running the Demonstration

Provides instructions on how to build and run the FreeRTOS RTOS with TCP/IP demonstration.

Description

The run the demonstration application, apply power to the board, open the demonstration with MPLAB X IDE, and then build and load the demonstration.

This demonstration runs IPv4 only on the Ethernet interface. To view the Web page hosted by the demonstration application, open a Web browser and direct it to the board running the HTTP server by typing the URL in the address bar (for example, http://mchpboard_e), and then pressing **Enter**.

Notes:

1. The NetBIOS name of the TCP/IP application is specified at the time the TCP/IP stack is initialized, which is usually in the hostName member of the tcpip_stack_init.c:: TCPIP_HOSTS_CONFIGURATION structure. The NetBIOS service must be enabled for the PIC32 demonstration to respond to NetBIOS queries (the NetBIOS service is enabled by default for this demo). Alternatively, you can use the IPv4 of the board directly, for example, http://192.168.1.131.
2. The IPv4 address can be obtained from running the TCP/IP Discovery application on the PC side. It requires that the TCP/IP Announce module is enabled when building the stack (the Announce module is enabled by default in this application).

Advanced Features

To use the advanced features of this demonstration, a system console must be enabled for the application. A serial console is preferred and is enabled by default for the demonstration. Alternatively, the application can be reconfigured using MHC to use the USB console.

The PIC32MZ configuration has Telnet enabled by default. A Telnet connection could be also used for delivering the commands needed by the application. On the PIC32MX configuration, the Telnet module is *not* enabled due to limited memory resources.

The PIC32MZ configuration is preferred for running this demonstration as the PIC32MX version may run out of memory at run-time.

TCP/IP Tasks

There are four TCP/IP tasks in the application that demonstrate the use of IPv4 TCP and UDP sockets in a multi-threaded system. Each of these tasks implements (and registers with the system command processor) specific commands. The commands allow the corresponding sockets to be opened and to start the communication with the remote hosts. On all hosts, the server sockets must first be opened, and then have the client sockets connect to them. There are also commands for configuring each socket/communication channel.

Following the model in this application, extra commands could be added for any of the tasks to achieve desired operation.

Each of these communication channels can be exercised simultaneously or in turn. For the purposes of the demonstration, at least two different communication channels should be opened simultaneously to put in evidence the multi-threaded behavior.

A common scenario listing the console commands and steps needed for running this demonstration would be:

1. Start app1 – TCP server:

- Start the PIC32 TCP server socket that listens on port 9760 by issuing the console command: `topen_s1<CR>`
- On the client side (PC, etc.) open a client that connects over TCP to the PIC32 server using port 9760. Use any network tools (netcat, etc.) or special applications, scripts (TCL, Python, etc.) to transmit and receive data files.

2. Start app2 – TCP client:
   - On the remote host side (PC, etc.) open a TCP server that listens for incoming connections on port 9761. Use any network tools (netcat, etc.) or special applications, scripts (TCL, Python, etc.) to receive (and transmit) data files.
   - Set the PIC32 client side address and port for the server to connect to, for example: `tsrv4_c1 192.168.100.101 9761<CR>`
   - Start the PIC32 TCP client socket by issuing the console command: `topen_c1<CR>`
3. Start app3 – UDP server:
   - Start the PIC32 UDP server socket that listens on port 32323 by issuing the console command: uopen_s1<CR>
   - On the client side (PC, etc.) open a client that connects over UDP to the PIC32 server using port 32323. Use any network tools (netcat, etc.) or special applications, scripts (TCL, Python, etc.) to transmit and receive data files.
4. Start app4 – UDP client:
   - On the remote host side (PC, etc.) open a UDP server that listens for incoming connections on port 32324. Use any network tools (netcat, etc.) or special applications, scripts (TCL, Python, etc.) to receive (and transmit) data files.
   - Set the PIC32 client side address and port for the server to connect to, for example: `usrv4_c1 192.168.100.101 32324<CR>`
   - Start the PIC32 UDP client socket by issuing the console command: `uopen_c1<CR>`
5. Now that you have the TCP/IP tasks running you can check the progress at run time. These commands give the RX and TX statistics showing the amount of data transferred by each task:
   - `tstat_s1<CR>`
   - `tstat_c1<CR>`
   - `ustat_s1<CR>`
   - `ustat_c1<CR>`
6. Once the data transfer is completed, close the TCP/IP sockets (if not already closed by the remote party):
   - `tclose_s1<CR>`
   - `tclose_c1<CR>`
   - `uclose_s1<CR>`
   - `uclose_c1<CR>`

TCP/IP Task Descriptions and Commands

app1.c::TCP server

This task uses a TCP server socket that listens by default on port 9760 to implement a simple relay server. Any message that is received on that TCP port will be relayed back to the originating socket. The following table lists and describes the available commands

Command	Description
`topen_s1`	Opens the listening TCP server socket.
`tmsg_s1`	Sends a short message using this socket to the remote client.
`tabort_s1`	Sends an abort/RST to the remote client and stops the communication.
`tclose_s1`	Closes the socket and stops the communication.
`ttxsize_s1`	Sets the TX buffer size of the server socket. The larger the buffer the more memory is used by the socket and the more efficient is the transfer. Default value is 2048 bytes.
`trxsize_s1`	Sets the RX buffer size of the server socket. The larger the buffer the more memory is used by the socket and the more efficient is the transfer. Default value is 2048 bytes.
`tdisplay_s1`	Enables displaying of the received messages locally to the system console.
`tstat_s1`	Displays/clears the current TX and RX statistics for the current connection.

app2.c::TCP client

This task uses a TCP client socket to connect to a remote server that listens by default on port 9761. Any message that is received by the socket can be optionally displayed locally. The client has the possibility of sending messages to the server. The following table lists and describes the available commands.

Command	Description
`topen_c1`	Opens the TCP client socket.
`tmsg_c1`	Sends a message to the remote server.
`tabort_c1`	Sends an abort/RST to the server and stops the communication.
`tclose_c1`	Closes the socket and stops the communication.
`tsrv4_c1`	Sets the server IPv4 address and port. The default values are 192.168.100.101 and 9761.

tasync_c1	Enables the continuous transmission of messages to the server.
tdisplay_c1	Enables displaying of the received messages locally to the system console.
tstat_c1	Displays/clears the current TX and RX statistics for the current connection.

app3.c::UDP server

This task uses a UDP server socket that listens by default on port 32323 to implement a simple relay server. Any message that is received on that UDP port will be relayed back to the originating socket. The following table lists and describes the available commands.

Command	Description
uopen_s1	Opens the listening UDP server socket.
uclose_s1	Closes the socket and stops the communication.
ustnet_s1	Selects the strict network option for the UDP socket (incoming connections from any network are allowed or only from the network that initiated the first connection).
ustport_s1	Selects the strict port option for the UDP socket (incoming connections from any host port are allowed or only from the port that was used when the connection was first initiated).
ustadd_s1	Selects the strict address option for the UDP socket (incoming connections from any host address are allowed or only from the address that was used when the connection was first initiated).
udisplay_s1	Enables displaying of the received messages locally to the system console.
ustat_s1	Displays/clears the current TX and RX statistics for the current connection.
utxsize_s1	Sets the TX buffer size of the server socket. The larger the buffer the more memory is used by the socket and the more efficient is the transfer. Default value is 1024 bytes. Note that this value should not be made larger than 1460 for an Ethernet network (to avoid packets larger than the link MTU).

app4.c::UDP client

This task uses a UDP client socket to connect to a remote server that listens by default on port 32324. Any message that is received by the socket can be optionally displayed locally. The client has the possibility of sending messages to the server. The following table lists and describes the available commands.

Command	Description
uopen_c1	Opens the UDP client socket.
umsg_c1	Sends a message to the remote server.
uclose_c	Closes the socket and stops the communication.
usrv4_c1	Sets the server IPv4 address and port. The default values are 192.168.100.101 and 32324.
uasync_c1	Enables the continuous transmission of messages to the server.
udisplay_c1	Enables displaying of the received messages locally to the system console.
ustat_c1	Displays/clears the current TX and RX statistics for the current connection.
utxsize_c1	Sets the TX buffer size of the server socket. The larger the buffer the more memory is used by the socket and the more efficient is the transfer. Default value is 1024 bytes. Note that this value should not be made larger than 1460 for an Ethernet network (to avoid packets larger than the link MTU).

Micrium uC_OS_II Demonstrations

basic

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Description

The demonstration blinks a user LED on a starter kit to show the RTOS threads that are running and to indicate status.

Legal Disclaimer

The source code for this demonstration is not freely distributed. To obtain the proper licensing agreement go to the Micriμm website: http://www.micrium.com. The Micriμm μC/OS-II source has been installed in the following location, `<install_dir>/third_party/rtos/MicriumOSII/Software`, so that the applicable MPLAB Harmony demonstrations can work.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the Micriμm μC/OS-II Basic Demonstration.

Description

To build this project, you must open the `basic_ucos_II.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/rtos/uC_OS_II`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`basic_ucos_II.X`	`<install-dir>/apps/rtos/uC_OS_II/basic`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx_usb_sk2	pic32mx_usb_sk2	This configuration runs on the PIC32 USB Starter Kit II.
pic32mz_ef_sk	pic32mz_ef_sk	This configuration runs on the PIC32MZ EF Starter Kit.
pic32mz_ef_sk_microMIPS	pic32mz_ef_sk	This configuration runs on the PIC32MZ EF Starter Kit in microMIPS mode.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32MZ EC Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ EF Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32 USB Starter Kit II

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

Provides instructions on how to build and run the Micriμm μC/OS-II basic demonstration.

Description

In this demonstration, there is one user task and one hardware interrupt. The one user task, LEDBlinkTask, is responsible for toggling the user LED to show that the RTOS and the application are up and running. The hardware interrupt is used by the RTOS to run the RTOS Tick. The internal core timer is used as the source for the hardware interrupt.

Once the demonstration is up and running an LED will toggle every 500 ms. This demonstration will show the RTOS running with the selected hardware.

Micrium uC/OS-III Demonstrations

basic

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Description

The demonstration blinks a user LED on a starter kit to show the RTOS threads that are running and to indicate status.

Legal Disclaimer

The source code for this demonstration is not freely distributed. To obtain the proper licensing agreement go to the Micriμm website: http://www.micrium.com. The Micriμm μC/OS-III source has been installed in the following location, `<install_dir>/third_party/rtos/MicriumOSIII/Software`, so that the applicable MPLAB Harmony demonstrations can work.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the Micriμm μC/OS-III Basic Demonstration.

Description

To build this project, you must open the `basic_ucos_III.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/rtos/uC_OS_III`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`basic_ucos_III.X`	`<install-dir>/apps/rtos/uC_OS_III/basic`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx_usb_sk2	pic32mx_usb_sk2	This configuration runs on the PIC32 USB Starter Kit II.
pic32mz_ef_sk	pic32mz_ef_sk	This configuration runs on the PIC32MZ EF Starter Kit.
pic32mz_ef_sk_microMIPS	pic32mz_ef_sk	This configuration runs on the PIC32MZ EF Starter Kit in microMIPS mode

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32MZ EF Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32 USB Starter Kit II

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

Provides instructions on how to build and run the Micriμm μC/OS-III basic demonstration.

Description

In this demonstration, there is one user task and one hardware interrupt. The one user task, LEDBlinkTask, is responsible for toggling the user LED to show that the RTOS and the application are up and running. The hardware interrupt is used by the RTOS to run the RTOS Tick. The internal core timer is used as the source for the hardware interrupt.

Once the demonstration is up and running an LED will toggle every 500 ms. This demonstration will show the RTOS running with the selected hardware.

gfx

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the

demonstration.

Description

Legal Disclaimer

The source code for this demonstration is not freely distributed. To obtain the proper licensing agreement go to the Micriμm website: http://www.micrium.com. The Micriμm μC/OS-III source has been installed in the following location, `<install_dir>/third_party/rtos/MicriumOSIII/Software`, so that the applicable MPLAB Harmony demonstrations can work.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the Micriμm μC/OS-III and MPLAB Harmony Graphics Library Demonstration.

Description

To build this project, you must open the `gfx_ucosIII.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/rtos/uC_OS_III/gfx`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`gfx_ucosIII.X`	`<install-dir>/apps/rtos/uC_OS_III/gfx`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx_usb_sk2_meb	pic32mx_usb_sk2+meb	This configuration runs on the PIC32 USB Starter Kit II and the MEB.
pic32mz_ef_sk_meb2	pic32mz_ef_sk+meb2	This configuration runs on the PIC32MZ EF Starter Kit and the MEB II.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32MZ EF Starter Kit with MEB II

No hardware related configuration or jumper setting changes are necessary.

PIC32 USB Starter Kit II with MEB

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

Provides instructions on how to build and run the Micriμm μC/OS-III and MPLAB Harmony Graphics Library Demonstration.

Description

Power the board, open the demonstration with MPLAB X IDE, and then build and load the demonstration. The LCD screen color will change every 500 ms, and user LEDs will toggle every 500 ms.

There are two tasks in the application, and three interrupts in this application/system.

The lowest priority task, LEDblinkTask, controls toggling of the LEDs. The highest priority task, DisplayTask, changes the color of the LCD screen by calling the appropriate MPLAB Harmony Graphics Library function.

The CPU core timer hardware interrupt is used by the RTOS to source the RTOS Tick. DMA channel 1 interrupt is used to call the appropriate MPLAB Harmony graphics driver function, which takes all graphics work queued up by the application and physically writes it out to the LCD display. SYSCALL general exception is invoked by the RTOS and is used to process the task context switch routine

gfx_usb

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Description

Legal Disclaimer

The source code for this demonstration is not freely distributed. To obtain the proper licensing agreement go to the Micriμm website: http://www.micrium.com. The Micriμm μC/OS-III source has been installed in the following location, `<install_dir>/third_party/rtos/MicriumOSIII/Software`, so that the applicable MPLAB Harmony demonstrations can work.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the Micriμm μC/OS-III and MPLAB Harmony Graphics and USB Library Demonstration.

Description

To build this project, you must open the `gfx_usb_ucos_III.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/rtos/uC_OS_III`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`gfx_usb_ucos_III.X`	`<install-dir>/apps/rtos/uC_OS_III/gfx_usb`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mz_ef_sk_meb2	pic32mz_ef_sk+meb2	This configuration runs on the PIC32MZ EF Starter Kit and the MEB II.
pic32mx_usb_sk2_meb	pic32mx_usb_sk2+meb	This configuration runs on the PIC32 USB Starter Kit II and the MEB.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32MZ EF Starter Kit with MEB II

No hardware related configuration or jumper setting changes are necessary.

PIC32 USB Starter Kit II with MEB

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

Provides instructions on how to build and run the Micriμm μC/OS-III and MPLAB Harmony Graphics plus USB Library.

Description

Power the board, open the demonstration with MPLAB X IDE, and then build and load the demonstration. A USB keyboard will be emulated when a micro USB cable is plugged in to the starter kit. Keystrokes, a-z and 1-9, will be sent when the push button SW3 is pressed. The LCD screen color will change every 500 ms, and the user LED, D3, will toggle every 500 ms.

There are four tasks and five interrupts used in this application/system.

SystemUSBDeviceTask is the highest priority task and is responsible for getting all USB data queued up by the application ready for sending over the USB by calling the appropriate MPLAB Harmony USB stack function. ApplicationUSBDeviceTask is the next highest priority task. ApplicationUSBDeviceTask emulates the keyboard key presses when it detects that the push button SW3 is being pressed. ApplicationDisplayTask changes the color of the entire LCD screen by calling the appropriate MPLAB Harmony Graphics Library function.

ApplicationLEDblinkTask is the lowest priority task and toggles the user LED, D3, every 500 ms.

CPU core timer hardware interrupt is used by the RTOS to source the RTOS Tick. The Timer2 hardware interrupt is used to call the MPLAB Harmony Timer Driver function. This is a hardware requirement of the MPLAB Harmony USB stack. A DMA channel 1 interrupt is used to call the appropriate MPLAB Harmony graphics driver function, which takes all graphics work queued up the application and physically writes it out to the LCD display. A USB general event interrupt is used to call the appropriate MPLAB Harmony USB driver function, which takes all USB data queued up by the application and physically writes it out to the USB hardware. A SYSCALL general exception, is invoked by the RTOS and is used to process the task context switch routine.

usb

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Description

Legal Disclaimer

The source code for this demonstration is not freely distributed. To obtain the proper licensing agreement go to the Micriμm website: http://www.micrium.com. The Micriμm μC/OS-III source has been installed in the following location, `<install_dir>/third_party/rtos/MicriumOSIII/Software`, so that the applicable MPLAB Harmony demonstrations can work.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the Micriμm μC/OS-III and MPLAB Harmony Graphics plus USB Library Demonstration.

Description

To build this project, you must open the `usb_ucos_III.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/rtos/uC_OS_III/usb`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`usb_ucos_III.X`	`<install-dir>/apps/rtos/uC_OS_III/usb`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mz_ef_sk	pic32mz_ef_sk	This configuration runs on the PIC32MZ EF Starter Kit.
pic32mx_usb_sk2	pic32mx_usb_sk2	This configuration runs on the PIC32 USB Starter Kit II.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32MZ EF Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32 USB Starter Kit II

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

Provides instructions on how to build and run the Micriμm μC/OS-III and MPLAB Harmony USB Library demonstration.

Description

Power the board, open the demonstration with MPLAB X IDE, and then build and load the demonstration. A USB keyboard will be emulated when a micro USB cable is plugged in to the starter kit. Keystrokes, a-z and 1-9, will be sent when the push button SW3 is pressed. The user LED, D3,

will toggle every 500 ms.

There are three tasks and four interrupts used in this application/system.

SystemUSBDeviceTask is the highest priority task and is responsible for getting all USB data queued up by the application ready for sending over the USB by calling the appropriate MPLAB Harmony USB stack function. ApplicationUSBDeviceTask is the next highest priority task. ApplicationUSBDeviceTask emulates the keyboard key presses when it detects that the push button SW3 is being pressed. ApplicationLEDblinkTask is the lowest priority task and toggles the user LED, D3, every 500 ms.

CPU core timer hardware interrupt is used by the RTOS to source the RTOS Tick. The Timer2 hardware interrupt is used to call the MPLAB Harmony Timer Driver function. USB general event interrupt is used to call the appropriate MPLAB Harmony USB driver function, which takes all USB data queued up by the application and physically writes it out to the USB hardware. The SYSCALL general exception is invoked by the RTOS and is used to process the task context switch routine.

OPENRTOS Demonstrations

basic

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Description

The demonstration blinks the three user LEDs on a starter kit to show the RTOS threads that are running and to indicate status.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the OPENRTOS Basic Demonstration.

Description

To build this project, you must open the `basic_openrtos.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/rtos/openrtos/basic`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`basic_openrtos.X`	`<install-dir>/apps/rtos/openrtos/basic`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mz_sk	pic32mz_ec_sk	This configuration runs on the PIC32MZ EC Starter Kit.
pic32mx_sk	pic32mx_usb_sk2, pic32mx_usb_sk3, pic32mx_eth_sk, and pic32mx_eth_sk2	This configuration runs on PIC32MX-based starter kits: PIC32 Ethernet Starter Kit, PIC32 Ethernet Starter Kit II, PIC32 USB Starter Kit II, and PIC32 USB Starter Kit III.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32 Ethernet Starter Kit, PIC32 Ethernet Starter Kit II, PIC32 USB Starter Kit II, and PIC32 USB Starter Kit III

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ EC Starter Kit

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

Provides instructions on how to build and run the OPENRTOS basic demonstration.

Description

Once the demonstration is up and running an LED will toggle every 500 ms. This demonstration will show the RTOS running with the selected hardware. The demonstration blinks the three user LEDs on a starter kit to show the RTOS threads that are running and to indicate status.

cdc_com_port_dual

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

This RTOS based demonstration application creates a USB CDC Device that enumerates as two serial ports on the USB Host personal computer. This application demonstrates the ability of the MPLAB Harmony USB Stack to operate in an Real-Time Operating System (this example uses OPENRTOS) and to support multiple instances of the same device class.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for this demonstration application.

Description

To build this project, you must open the `cdc_com_port_dual.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/rtos/openrtos/cdc_com_port_dual`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`cdc_com_port_dual.X`	`<install-dir>/apps/rtos/openrtos/cdc_com_port_dual/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx_usb_sk2_int_dyn	pic32mx_usb_sk2	Select this configuration to run the demonstration application on the PIC32 USB Starter Kit II in Interrupt mode and dynamic operation.
pic32mz_ec_sk_int_dyn	pic32mz_ec_sk	Select this configuration to run the demonstration application on the PIC32MZ Embedded Connectivity (EC) Starter Kit in Interrupt mode and dynamic operation.
pic32mz_ef_sk_int_dyn	pic32mz_ef_sk	Select this configuration to run the demonstration application on the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit in Interrupt mode and dynamic operation.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32 USB Starter Kit II

Remove jumper JP2.

PIC32MZ EC Starter Kit

Remove jumper JP1.

PIC32MZ EF Starter Kit

Remove jumper JP1.

Running the Demonstration

Provides instructions on how to build and run the cdc_com_port_dual demonstration.

Description

Refer to the Running the Demonstration topic for the bare-metal (non RTOS) version of the cdc_com_port_dual demonstration applications for running the demonstration.

The demonstration application contains six tasks. A description of these tasks is as follows:

- The FrameworkTasks task is created in the SYS_Tasks function. This task calls the USB Device Layer Tasks function (USB_DEVICE_Tasks). The priority of this task is designed to be the lowest when compared to the priorities of other tasks. Hence this tasks runs when all other tasks are either in blocked state or not ready to run.
- The APP_USB_DEVICE_Open task is created in the APP_Tasks function. This task creates all the semaphores and message queues needed for the application. It creates 4 tasks which implement the application logic. It attempts to open the Device Layer and then blocks on the xSemaphoreBlockUsbConfigure semaphore. The xSemaphoreBlockUsbConfigure is given in the USB Device Layer Event Handler when the device is configured by the Host. The tasks then resumes the 4 application logic tasks and suspends itself.
- The APP_CDC1Read Task is created in the APP_USB_DEVICE_Open task. It schedules a read on the CDC1 instance and then blocks on the CDC1 instance xSemaphoreCDCReadComplete semaphore. This semaphore is given in the Read Complete event in the CDC Application Event Handler. The tasks will then post the data that it has received from the Host to the CDC 1 instance Message Queue.
- The APP_CDC2Read Task is created in the APP_USB_DEVICE_Open task. It schedules a read on the CDC2 instance and then blocks on the CDC2 instance xSemaphoreCDCReadComplete semaphore. This semaphore is given in the Read Complete event in the CDC Application Event Handler. The tasks will then post the data that it has received from the Host to the CDC 1 instance Message Queue.
- The APP_CDC1Write Task is created in the APP_USB_DEVICE_Open task. It blocks on the CDC 2 message queue. When APP_CDC2Read Task posts a message to this queue, the APP_CDC1Write gets ready to run and the writes the data (received on the queue) to the CDC 1. This data is then transferred to the Host.
- The APP_CDC2Write Task is created in the APP_USB_DEVICE_Open task. It blocks on the CDC 1 message queue. When APP_CDC1Read Task posts a message to this queue, the APP_CDC2Write gets ready to run and the writes the data (received on the queue) to the CDC 2. This data is then transferred to the Host.

cdc_msd_basic

Demonstrates host support for a composite USB Device in a RTOS application.

Description

This demonstration application creates a USB Host application that demonstrates operation of composite USB Device. The Host application enumerates the CDC and MSD interfaces on the attached composite devices and then operates these in one application. The demonstration application uses a RTOS to create thread that manage the CDC and MSD aspects of the Host application.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for this demonstration application.

Description

To build this project, you must open the `cdc_msd_basic.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/rtos/openrtos/cdc_msd_basic`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`cdc_msd_basic.X`	`<install-dir>/apps/rtos/openrtos/cdc_msd_basic/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx_usb_sk2_int_dyn	pic32mx_usb_sk2	Select this configuration to run the demonstration application on the PIC32 USB Starter Kit II in Interrupt mode and dynamic operation.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32 USB Starter Kit II

JP2 should be in place if the attached USB device is bus-powered. It should be removed if the attached USB device is self-powered.

Running the Demonstration

Provides instructions on how to build and run the cdc_msd_basic demonstration.

Description

This USB Host demonstration application exercises the CDC and MSD interfaces on the attached composite USB device.

1. Open the project in MPLAB X IDE and select the desired project configuration.
2. Build the code and program the device.
3. Follow the directions for setting up and running the cdc_serial_emulator_msd USB device demonstration.
4. Connect the UART (P1) port on the Explorer 16 Development Board (running the cdc_serial_emulator_msd demonstration) to a USB Host personal computer via a commercially available Serial-to-USB Dongle.
5. Start a terminal program on the USB Host personal computer and select the Serial-to-USB Dongle as the communication port. Select the baud rate as 9600, no parity, 1 Stop bit and no flow control.
6. Connect the mini – B connector on the USB PICtail Plus Daughter Board, of the cdc_serial_emulator_msd demonstration setup, to the Type-A USB host connector on the starter kit.
7. A prompt (DATA :) will be displayed immediately on the terminal emulation program.
8. Type a string less than 12 characters and press the <Enter> key. The string entered here will be stored in the MSD device in a file named `file.txt`.
9. Step 8 can be repeated. Data entered in the prompt will be appended to the file.
10. Unplug the USB Device from the Host and connect it a personal computer host to examine the contents of the Mass Storage Device. This should contain a file named `file.txt` and this should contain the data that was entered at the terminal program prompt.

Tasks

This USB Host demonstration application contains four tasks. Descriptions of these tasks is as follows:

- The FrameworkTasks task is created in the SYS_Tasks function. This task calls the USB Host Layer Tasks function (USB_HOST_Tasks). The priority of this task is designed to be the lowest when compared to the priorities of other tasks. Hence this tasks runs when all other tasks are either in blocked state or not ready to run.
- The APP_USB_HOST_Open task is created in the APP_Tasks function. This task creates all the semaphores and message queues needed for the application. It creates two tasks that implement the application logic. It attempts to open the Host Layer and then enable USB Host Operation. The task then resumes the two application logic tasks and suspends itself.
- The APP_USBHostCDCTask Task is created in the APP_USB_HOST_Open task. It blocks on xSemaphoreUSBCDCAttach semaphore. This semaphore is given in the Application CDC Class Driver event handler when a CDC device is enumerated. The task then prints a prompt and schedules a read from the CDC interface of the attached USB device. When data is available, it posts the xSemaphoreCDCReadComplete semaphore.
- The APP_USBHostMSDTask Task is created in the APP_USB_HOST_Open task. It blocks on the xSemaphoreUSBMSDAttach semaphore. This semaphore is given in the Application MSD event Handler when a MSD device is enumerated. The task then mounts the attached storage media and then blocks on the xSemaphoreCDCReadComplete semaphore. The xSemaphoreCDCReadComplete semaphore is given by the APP_USBHostCDCTask task when the CDC Host has received data. The APP_USBHostMSDTask Task will then open a file on the mounted drive and will append the data (received from CDC) in the file. It closes the file, and then appends on xSemaphoreCDCReadComplete semaphore again.

gfx

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the OPENRTOS and MPLAB Harmony Graphics Library Demonstration.

Description

To build this project, you must open the `gfx_openrtos.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is

<install-dir>/apps/rtos/openrtos.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
gfx_openrtos.X	<install-dir>/apps/rtos/openrtos/gfx

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within ./src/system_config.

Project Configuration Name	BSP Used	Description
pic32mz_ec_sk_meb2	pic32mz_ec_sk+meb2	This configuration runs on the PIC32MZ EC Starter Kit and the MEB II.
pic32mx_usb_sk2_meb	pic32mx_usb_sk2+meb	This configuration runs on the PIC32 USB Starter Kit II and the MEB.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32MZ EC Starter Kit connected to the MEB II

No hardware related configuration or jumper setting changes are necessary.

PIC32 USB Starter Kit II connected to the MEB

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

Provides instructions on how to build and run the OPENRTOS and MPLAB Harmony Graphics Library demonstration.

Description

Power the board, open the demonstration with MPLAB X IDE, and then build and load the demonstration. The LCD screen color will change every 500 ms, and user LEDs will toggle every 500 ms.

There are two tasks in the application, and three interrupts in this application/system.

The lowest priority task, LEDblinkTask, controls toggling of the LEDs. The highest priority task, DisplayTask, changes the color of the LCD screen, by calling the appropriate MPLAB Harmony Graphics Library function.

The Timer1 hardware interrupt is used by the RTOS to source the RTOS Tick. DMA channel 1 interrupt is used to call the appropriate MPLAB Harmony graphics driver function, which takes all graphics work queued up the application and physically write it out to the LCD display. Software interrupt 0, is invoked by the RTOS and is used to process the task context switch routine.

SEGGER embOS Demonstrations

basic

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Description

The demonstration blinks the three user LEDs on a starter kit to show the RTOS threads that are running and to indicate status.

Legal Disclaimer

The source code for this SEGGER embOS RTOS demonstration is not freely distributed. To obtain source code and the proper licensing agreement go to the SEGGER embOS website: https://www.segger.com/license-models.html. The SEGGER embOS source must be installed in the following location: <install-dir>/third_party/rtos/embOS so that the applicable MPLAB Harmony demonstrations can work.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the SEGGER embOS Basic Demonstration.

Description

To build this project, you must open the `basic_embos.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/rtos/embos/basic`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`basic_embos.X`	`<install-dir>/apps/rtos/embos/basic/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx_usb_sk2	pic32mx_usb_sk2	This configuration runs on the PIC32 USB Starter Kit II.
pic32mz_ef_sk	pic32mz_ef_sk	This configuration runs on the PIC32MZ EF Starter Kit.
pic32mz_ef_sk_microMIPS	pic32mz_ef_sk	This configuration runs on the PIC32MZ EF Starter Kit in microMIPS™ mode

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32MZ EF Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32 USB Starter Kit II

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

Provides instructions on how to build and run the SEGGER embOS basic demonstration.

Description

In this demonstration, there is one user task and one hardware interrupt. A user task is responsible for toggling the user LEDs to show that the RTOS and the application are up and running. The hardware interrupt is used by the RTOS to run the RTOS Tick. The internal core timer is used as the source for the hardware interrupt.

Once the demonstration is up and running a LED will toggle every 500 ms. This demonstration will show the RTOS running with the selected hardware.

gfx

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Description

Legal Disclaimer

The source code for this SEGGER embOS RTOS demonstration is not freely distributed. To obtain source code and the proper licensing agreement go to the SEGGER embOS website: https://www.segger.com/license-models.html. The SEGGER embOS source must be installed in the following location: `<install-dir>/third_party/rtos/embOS` so that the applicable MPLAB Harmony demonstrations can work

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the SEGGER embOS and MPLAB Harmony Graphics Library Demonstration.

Description

To build this project, you must open the `gfx_embos.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/rtos/embos/gfx`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`gfx_embos.X`	`<install-dir>/apps/rtos/embos/gfx/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx_usb_sk2_meb	pic32mx_usb_sk2+meb	This configuration runs on the PIC32 USB Starter Kit II and the MEB.
pic32mz_ef_sk_meb2	pic32mz_ef_sk+meb2	This configuration runs on the PIC32MZ EF Starter Kit and the MEB II.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32MZ EF Starter Kit with MEB II

No hardware related configuration or jumper setting changes are necessary.

PIC32 USB Starter Kit II with MEB

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

Provides instructions on how to build and run the SEGGER embOS and MPLAB Harmony Graphics Library Demonstration.

Description

Power the board, open the demonstration with MPLAB X IDE, and then build and load the demonstration. The LCD screen color will change every 500 ms, and user LEDs will toggle every 500 ms.

There is one task in the application and three interrupts in this application/system.

The user task controls toggling of a user LED and changes the LCD screen color by calling the appropriate MPLAB Harmony Graphics Library function.

The CPU core timer hardware interrupt is used by the RTOS to source the RTOS Tick. DMA channel 1 interrupt is used to call the appropriate MPLAB Harmony graphics driver function, which takes all graphics work queued up by the application and physically writes it out to the LCD display. SYSCALL general exception is invoked by the RTOS and is used to process the task context switch routine

gfx_usb

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the demonstration.

Description

Legal Disclaimer

The source code for this SEGGER embOS RTOS demonstration is not freely distributed. To obtain source code and the proper licensing agreement go to the SEGGER embOS website: https://www.segger.com/license-models.html. The SEGGER embOS source must be installed in

the following location: `<install-dir>/third_party/rtos/embOS` so that the applicable MPLAB Harmony demonstrations can work

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the SEGGER embOS and MPLAB Harmony Graphics and USB Library Demonstration.

Description

To build this project, you must open the `gfx_usb_embos.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/rtos/embos/gfx_usb`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`gfx_usb_embos.X`	`<install-dir>/apps/rtos/embos/gfx_usb/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mz_ef_sk_meb2	pic32mz_ef_sk+meb2	This configuration runs on the PIC32MZ EF Starter Kit and the MEB II.
pic32mx_usb_sk2_meb	pic32mx_usb_sk2+meb	This configuration runs on the PIC32 USB Starter Kit II and the MEB.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32MZ EF Starter Kit with MEB II

No hardware related configuration or jumper setting changes are necessary.

PIC32 USB Starter Kit II with MEB

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

Provides instructions on how to build and run the SEGGER embOS and MPLAB Harmony Graphics plus USB Library.

Description

Power the board, open the demonstration with MPLAB X IDE, and then build and load the demonstration. A USB keyboard will be emulated when a micro USB cable is plugged in to the starter kit. Keystrokes, a-z and 1-9, will be sent when the push button SW3 is pressed. The LCD screen color will change every 500 ms, and the user LED (D3 on the MEB II), will toggle every 500 ms.

There are four tasks and five interrupts used in this application/system.

SystemUSBDeviceTask is the highest priority task and is responsible for getting all USB data queued up by the application ready for sending over the USB by calling the appropriate MPLAB Harmony USB stack function. ApplicationUSBDeviceTask is the next highest priority task. ApplicationUSBDeviceTask emulates the keyboard key presses when it detects that the push button SW3 is being pressed. ApplicationDisplayTask changes the color of the entire LCD screen by calling the appropriate MPLAB Harmony Graphics Library function. ApplicationLEDblinkTask is the lowest priority task and toggles the user LED (D3 on the MEB II) every 500 ms.

CPU core timer hardware interrupt is used by the RTOS to source the RTOS Tick. The Timer2 hardware interrupt is used to call the MPLAB Harmony Timer Driver function. This is a hardware requirement of the MPLAB Harmony USB stack. A DMA channel 1 interrupt is used to call the appropriate MPLAB Harmony graphics driver function, which takes all graphics work queued up the application and physically writes it out to the LCD display. A USB general event interrupt is used to call the appropriate MPLAB Harmony USB driver function, which takes all USB data queued up by the application and physically writes it out to the USB hardware. A SYSCALL general exception, is invoked by the RTOS and is used to process the task context switch routine.

usb

This section provides information on the supported demonstration boards, how to configure the hardware (if needed), and how to run the

demonstration.

Description

Legal Disclaimer

The source code for this SEGGER embOS RTOS demonstration is not freely distributed. To obtain source code and the proper licensing agreement go to the SEGGER embOS website: https://www.segger.com/license-models.html. The SEGGER embOS source must be installed in the following location: `<install-dir>/third_party/rtos/embOS` so that the applicable MPLAB Harmony demonstrations can work

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the SEGGER embOS and MPLAB Harmony Graphics plus USB Library Demonstration.

Description

To build this project, you must open the `usb_embos.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/rtos/embos/usb`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`usb_embos.X`	`<install-dir>/apps/rtos/embos/usb/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mz_ef_sk	pic32mz_ef_sk	This configuration runs on the PIC32MZ EF Starter Kit.
pic32mx_usb_sk2	pic32mx_usb_sk2	This configuration runs on the PIC32 USB Starter Kit II.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32MZ EF Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32 USB Starter Kit II

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

Provides instructions on how to build and run the SEGGER embOS and MPLAB Harmony USB Library demonstration.

Description

Power the board, open the demonstration with MPLAB X IDE, and then build and load the demonstration. A USB keyboard will be emulated when a micro USB cable is plugged in to the starter kit. Keystrokes, a-z and 1-9, will be sent when the push button SW3 is pressed. A user LED will toggle every 500 ms.

There are three tasks and four interrupts used in this application/system.

SystemUSBDeviceTask is the highest priority task and is responsible for getting all USB data queued up by the application ready for sending over the USB by calling the appropriate MPLAB Harmony USB stack function. ApplicationUSBDeviceTask is the next highest priority task. ApplicationUSBDeviceTask emulates the keyboard key presses when it detects that the push button SW3 is being pressed. ApplicationLEDblinkTask is the lowest priority task and toggles the user LED every 500 ms.

CPU core timer hardware interrupt is used by the RTOS to source the RTOS Tick. The Timer2 hardware interrupt is used to call the MPLAB Harmony Timer Driver function. USB general event interrupt is used to call the appropriate MPLAB Harmony USB driver function, which takes all USB data queued up by the application and physically writes it out to the USB hardware. The SYSCALL general exception is invoked by the RTOS and is used to process the task context switch routine.

TCP/IP Demonstrations

This section provides descriptions of the TCP/IP demonstrations.

Introduction

TCP/IP and Wi-Fi® Demonstration Applications Help

Description

TCP/IP Demonstrations

This section describes Microchip's TCP/IP Demonstration projects, including information about demonstration-hardware compatibility and also provides the information about how to configure and run the demonstrations.

Wi-Fi Demonstrations

This distribution package contains a variety of Wi-Fi-based firmware projects that demonstrate the capabilities of the MPLAB Harmony Wi-Fi services and TCP/IP Stack running on PIC32 devices. This section describes the hardware requirements and procedures to run these firmware projects on Microchip demonstration and development boards.

Refer to the Wi-Fi Demonstration Configuration Matrix for demonstration support information.

Wi-Fi Demonstration Configuration Matrix

Provides Wi-Fi demonstration support information.

Description

The following matrix provides information for the Wi-Fi demonstrations.

Wi-Fi Demonstation Matrix	Demonstration Projects					
	pic32_wifi_web_server	pic32_eth_wifi_web_server	wifi_easy_configuration	wifi_g_demo	wifi_wolfssl_tcp_client	wifi_wolfssl_tcp_server
Wi-Fi PICtail Module						
MRF24WG0MA Wi-Fi G PICTail/PICtail Plus Daughter Board	Yes	Yes	Yes	Yes	Yes	Yes
MRF24WN0MA Wi-Fi PICtail/PICtail Plus Daughter Board	Yes	Yes	Yes	N/A	N/A	N/A
BSP						
Wi-Fi G Demo Board	N/A	N/A	N/A	Yes	N/A	N/A
chipKIT WF32	Yes	N/A	N/A	N/A	N/A	N/A
PIC32MX795F512L PIM with Explorer 16 Development Board	Yes	N/A	N/A	N/A	N/A	N/A
PIC32MX Ethernet Starter Kit	N/A	Yes	Yes	N/A	Yes	Yes
PIC32MZ EC Starter Kit	N/A	Yes	Yes	N/A	Yes	Yes
PIC32MZ EC Starter Kit with MEB II	N/A	Yes	Yes	N/A	N/A	N/A
PIC32MZ EF Starter Kit	N/A	Yes	Yes	N/A	N/A	N/A
PIC32MZ EF Starter Kit with MEB II	N/A	Yes	Yes	N/A	N/A	N/A
Project Configuration						
chipkit_wf32	Yes	N/A	N/A	N/A	N/A	N/A
pic32mx795_pim+e16	Yes	N/A	Yes	N/A	N/A	N/A
pic32mx795_pim+e16+11n+freertos	Yes	N/A	Yes	N/A	N/A	N/A
pic32mx795_pim+e16+freertos	Yes	N/A	Yes	N/A	N/A	N/A
pic32mx_eth_sk+ioexp	N/A	Yes	Yes	N/A	Yes	Yes
pic32mx_eth_sk+ioexp+11n+freertos	N/A	Yes	Yes	N/A	N/A	N/A
pic32mx_eth_sk+ioexp+freertos	N/A	Yes	Yes	N/A	N/A	N/A
pic32mz_ec_sk+ioexp	N/A	Yes	Yes	N/A	Yes	Yes
pic32mz_ec_sk+ioexp+11n+freertos	N/A	Yes	Yes	N/A	N/A	N/A
pic32mz_ec_sk+ioexp+freertos	N/A	Yes	Yes	N/A	N/A	N/A
pic32mz_ec_sk+meb2	N/A	Yes	Yes	N/A	N/A	N/A
pic32mz_ec_sk+meb2+11n+freertos	N/A	Yes	Yes	N/A	N/A	N/A
pic32mz_ec_sk+meb2+freertos	N/A	Yes	Yes	N/A	N/A	N/A
pic32mz_ef_sk+ioexp	N/A	Yes	Yes	N/A	N/A	N/A
pic32mz_ef_sk+ioexp+11n+freertos	N/A	Yes	Yes	N/A	N/A	N/A
pic32mz_ef_sk+ioexp+freertos	N/A	Yes	Yes	N/A	N/A	N/A
pic32mz_ef_sk+meb2	N/A	Yes	Yes	N/A	N/A	N/A
pic32mz_ef_sk+meb2+11n+freertos	N/A	Yes	Yes	N/A	N/A	N/A
pic32mz_ef_sk+meb2+freertos	N/A	Yes	Yes	N/A	N/A	N/A
wifi_g_db	N/A	N/A	N/A	Yes	N/A	N/A
Console Command Interface						
UART Console	Yes	Optional	Optional	N/A	Optional	Optional
USB CDC Console	N/A	Yes	Yes	N/A	Yes	Yes
RTOS						
Non-RTOS	Yes	Yes	Yes	Yes	Yes	Yes
FreeRTOS	Yes	Yes	Yes	N/A	N/A	N/A
Device Configuration						
PIC32MX695F512L	Yes	N/A	N/A	N/A	N/A	N/A
PIC32MX695F512H	N/A	N/A	N/A	Yes	N/A	N/A
PIC32MX795F512L	Yes	Yes	Yes	N/A	Yes	Yes
PIC32MZ2048ECH144	N/A	Yes	Yes	N/A	Yes	Yes
PIC32MZ2048EFM144	N/A	Yes	Yes	N/A	N/A	N/A
Duo-Port Ethernet and Wi-Fi						
PIC32MX Ethernet Starter Kit	N/A	Yes	Yes	N/A	N/A	N/A
PIC32MZ EC Start Kit	N/A	Yes	Yes	N/A	N/A	N/A
PIC32MZ EC Starter Kit with MEB II - rework on MEB II board is Required	N/A	Yes	Yes	N/A	N/A	N/A
PIC32MZ EF Start Kit	N/A	Yes	Yes	N/A	N/A	N/A
PIC32MZ EF Starter Kit MEB II - rework on MEB II board is Required	N/A	Yes	Yes	N/A	N/A	N/A
Single-Port Wi-Fi or Wi-Fi Only						
PIC32MX795F512L PIM with Explorer 16 Development Board	Yes	N/A	Yes	N/A	N/A	N/A
Starter Kit I/O Expansion						
Add on-board UART/Serial 9-pin Connector (see Configuring the Hardware for details)	N/A	Optional	Optional	N/A	Optional	Optional
On-board Jumper: J10/pin 56 to J10/pin 37 Required for MRF24WG PICtail (see Configuring the Hardware for details)	N/A	Required	Required	N/A	Required	Required
On-board Jumper: J10/pin 12 to J10/pin 8 Required for MRF24WN PICtail (see Configuring the Hardware for details)	N/A	Required	Required	N/A	N/A	N/A
168-pin to 132-pin Starter Kit Adapter for PIC32MZ EC or PIC32MZ EF Starter Kit	N/A	Required	Required	N/A	N/A	N/A

Wi-Fi Console Commands

This section describes the demonstration support commands available for the Wi-Fi Web Server and EasyConfig demonstrations.

Description

Note: Refer to the following documentation, which is available for download from the Microchip website:

- Microchip MRF24W Getting Started Guide for MRF24WB0MA/A, MRF24WG0MA/B for MLA v5 (DS52108)
- Microchip Wi-Fi® G Demo Board User's Guide (DS50002147)

Please be sure to consult the website for the latest version of the documentation.

Both the Web Server and the EasyConfig demonstrations support Wi-FI Console commands, which enable control over the Wi-Fi settings. All of the following commands, with the exception of `rftest`, are available for both the MRF24WG and MRF24WN Wi-Fi Drivers. The `rftest` command is only available for use with the MRF24WN Wi-Fi Driver.

Command: eraseconf

Parameters	Description
None.	Wi-Fi console command to erase saved Wi-Fi configuration in memory.

Command: iwconfig

Parameters	Description
[ssid <name>]	name: Specifies the name of the SSID (1-32 ASCII characters).
[mode <idle | managed>]	idle: Disconnected from the current configuration. managed: Connects in infrastructure mode to the currently set SSID.
[power <enable | disable>]	enable: Enables all Power-Saving features (PS_POLL). Will wake up to check for all types of traffic (unicast, multicast, and broadcast). disable: Disables any Power-Saving features. Will always be in an active power state.

[security <mode>]	mode: open/wep40/wep104/wpa/wpa2/pin/pbc. For example:
	`iwconfig security open`
	`iwconfig security wep40 <key>`
	`iwconfig security wep104 <key>`
	`iwconfig security wpa <key>`
	`iwconfig security wpa2 <key>`
	`iwconfig security pin <pin>`
	`iwconfig security pbc`

[scan]	Starts a Wi-Fi scan.
[scanget <scan_index>]	scan_index: Retrieves the scan result after the scan completes (1 - n).

Command: mac

Parameters	Description
None.	Wi-Fi console command to retrieve the MAC address of the MRF24WN module.

Command: readconf

Parameters	Description
None.	Wi-Fi console command to read saved Wi-Fi configuration in memory.

Command: rftest *(for use with the MRF24WN Wi-Fi Driver only)*

Parameters	Description
[rate < packet_count | packet_size | channel header_type >]	Wi-Fi console command to perform regulatory test. rate (in Mbps): • 0 = 1 • 1 = 2 • 2 = 5.5 • 3 = 11 • 4 = 6 • 5 = 9 • 6 = 12 • 7 = 18 • 8 = 24 • 9 = 36 • 10 = 48 • 11 = 54 • 12 = 6.5 • 13 = 13 • 14 = 19.5 • 15 = 26 • 16 = 39 • 17 = 52 • 18 = 58.5 packet_count: Number of transmits (1 through 14). packet_size: Payload size (0 to 1400). channel: 1 through 14. header_type: 0 - Beacon frame; 1 - QoS data frame; 2 through 4 Address data frame.

Command: saveconf

Parameters	Description
None.	Wi-Fi console command to save Wi-Fi configuration to memory.

Demonstrations

Description of TCP/IP Stack Library Demonstration Application.

Description

PHY Driver Support

All of the PIC32MX and PIC32MZ projects that are part of the distribution and use the Microchip reference development boards are preconfigured with specific PHY Drivers. Where the board supports different PHY daughter boards, the default PHY could be changed. To use a different PHY for a specific board the following must be done:

1. Use the MHC to configure your project to use the correct PHY and make sure that both the correct PHY address and configuration flags are used for the particular PHY daughter board. The MII/RMII and I/O configuration flags for the PHY board should match the project configuration fuses.
2. Regenerate the project and make sure that the new PHY driver is selected for the configuration that you're using.

Alternatively, you can manually set up your project, as follows:

- The project should select the PHY driver that corresponds to the PHY Daughter Board (i.e, LAN8720, LAN8740, LAN9303, etc.) in use for the selected configuration
- Modify for the TCPIP_EMAC_PHY_ADDRESS and TCPIP_EMAC_PHY_CONFIG_FLAGS to have the correct PHY address (the PHY address for both the SMSC PHY Daughter Boards is usually zero, for example) and the configuration flags (MII/RMII, I/O pin configuration, etc.)
- Or update directly the tcpip_stack_init.c:: tcpipMACPIC32INTInitData structure to have the correct PHY address and the configuration flags
- Make sure that the configuration fuses are properly selected to match your hardware and PHY board
- Rebuild the project

berkeley_tcp_client

This configuration demonstrates creating an Internet client that uses the Berkeley API to create a TCP/IP connection to a web server.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the Berkeley TCP Client Demonstration.

Description

To build this project, you must open the `berkeley_tcp_client.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/tcpip/berkeley_tcp_client`.

Warning

When using the Microchip Harmony Configurator (MHC), care must be taken when generating the code to *not* erase the USB descriptors in the `system_init.c` file.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`berkeley_tcp_client.X`	`<install-dir>/apps/tcpip/berkeley_tcp_client/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx_eth_sk	pic32mx_eth_sk	Demonstrates the Berkeley TCP Client on the PIC32 Ethernet Starter Kit.
pic32mx_eth_sk2	pic32mx_eth_sk2	Demonstrates the Berkeley TCP Client on the PIC32 Ethernet Starter Kit II.
pic32mz_ec_sk	pic32mz_ec_sk	Demonstrates the Berkeley TCP Client on the PIC32MZ EC Starter Kit.
pic32mz_ef_sk	pic32mz_ef_sk	Demonstrates the Berkeley TCP Client on the PIC32MZ EF Starter Kit.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32 Ethernet Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32 Ethernet Starter Kit II

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ EC Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ EF Starter Kit

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

This section provides instructions on how to build and run the demonstration.

Description

To use this demonstration, a USB cable needs to be connected to the micro-B USB connector on the bottom of the starter kit in use. When the demonstration runs, it will create a USB CDC device on the USB bus. The demonstration can be executed once you have connected to this device though a standard terminal program, set the baud rate to 921,600 baud, and a valid IP address has been received by the device.

Establish a connection between the router or switch with the PIC32 Ethernet Starter Kit using the RJ45 connector. Ensure the router or switch is connected to the Internet.

There is only one command available in the demonstration from the serial port:

`openurl <url>` - The <url> argument must be a fully formed URL; for instance, http://www.microchip.com/

After that one command is input, the demonstration will make a DNS query, and then open a connection to the requested URL and perform a simple HTTP PUT command. The results will be sent to the serial port.

berkeley_tcp_server

This configuration demonstrates creating an Internet server that uses the Berkeley API to create a TCP/IP echo server on port 9764.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the Berkeley TCP Server Demonstration.

Description

To build this project, you must open the `berkeley_tcp_server.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/tcpip/berkeley_tcp_server`.

Warning

When using the Microchip Harmony Configurator (MHC), care must be taken when generating the code to *not* erase the USB descriptors in the `system_init.c` file.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`berkeley_tcp_server.X`	`<install-dir>/apps/tcpip/berkeley_tcp_server/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx_eth_sk	pic32mx_eth_sk	Demonstrates the Berkeley TCP Server on the PIC32 Ethernet Starter Kit.
pic32mx_eth_sk2	pic32mx_eth_sk2	Demonstrates the Berkeley TCP Server on the PIC32 Ethernet Starter Kit II.
pic32mz_ec_sk	pic32mz_ec_sk	Demonstrates the Berkeley TCP Server on the PIC32MZ EC Starter Kit.
pic32mz_ef_sk	pic32mz_ef_sk	Demonstrates the Berkeley TCP Server on the PIC32MZ EF Starter Kit.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32 Ethernet Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32 Ethernet Starter Kit II

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ EC Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ EF Starter Kit

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

This section provides instructions on how to build and run the demonstration.

Description

The demonstration does not offer any additional functionality through the serial port; however, the current IP can be checked. As soon as a valid IP has been assigned through DHCP to the demonstration, it is then ready to accept a TCP/IP connection on 9760. The demonstration will echo back everything it receives along the connection.

A USB cable can be connected to the micro-B USB connector on the bottom of the starter kit in use. This will create a USB CDC device on the USB bus. To communicate with the software, connect to this device though a standard terminal program and set the baud rate to 921,600 baud.

berkeley_udp_client

This configuration demonstrates creating an Internet client that uses the Berkeley API to create a UDP/IP connection to a specified port.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the Berkeley UDP Client Demonstration.

Description

To build this project, you must open the `berkeley_udp_client.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/tcpip/berkeley_udp_client`.

Warning

When using the Microchip Harmony Configurator (MHC), care must be taken when generating the code to *not* erase the USB descriptors in the `system_init.c` file.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`berkeley_udp_client.X`	`<install-dir>/apps/tcpip/berkeley_udp_client/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx_eth_sk	pic32mx_eth_sk	Demonstrates the Berkeley UDP Client on the PIC32 Ethernet Starter Kit.
pic32mx_eth_sk2	pic32mx_eth_sk2	Demonstrates the Berkeley UDP Client on the PIC32 Ethernet Starter Kit II.
pic32mz_ec_sk	pic32mz_ec_sk	Demonstrates the Berkeley UDP Client on the PIC32MZ EC Starter Kit.
pic32mz_ef_sk	pic32mz_ef_sk	Demonstrates the Berkeley UDP Client on the PIC32MZ EF Starter Kit.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32 Ethernet Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32 Ethernet Starter Kit II

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ EC Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ EF Starter Kit

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

This section provides instructions on how to build and run the demonstration.

Description

To use this demonstration, a USB cable needs to be connected to the micro-B USB connector on the bottom of the starter kit in use. When the demonstration runs, it will create a USB CDC device on the USB bus. The demonstration can be executed once you have connected to this device though a standard terminal program, set the baud rate to 921,600 baud, and a valid IP address has been received by the device.

There are three sequential commands that can be used from the console:

- `setudppacketoptions <hostname> <port> <message>` - This command specifies where to send the UDP packet and what to have in the message
- `getudppacketoptions` - This command displays the current options
- `sendudppacket` - This command sends a UDP packet

After the `sendudppacket` command is input, the demonstration will make a DNS query to look up the host name and send a UDP packet to that host.

The output message will be received by the UDP server and by the UDP port that is configured by the command setudppacketoptions.

berkeley_udp_relay

This application demonstrates the use of multiple sockets for both sending and receiving. There are three different sub-functions of this application:

- UDP Relay, which accepts UDP packets on one socket, and sends the packets out on a different socket
- UDP Relay Client, which generates UDP traffic that is compatible with the UDP Relay Server
- UDP Relay Server, which receives and checks traffic for a packet count and reports is any packets are dropped

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the Berkeley UDP Relay Demonstration.

Description

To build this project, you must open the `berkeley_udp_relay.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/tcpip/berkeley_udp_relay`.

Warning

When using the Microchip Harmony Configurator (MHC), care must be taken when generating the code to *not* erase the USB descriptors in the `system_init.c` file.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`berkeley_udp_relay.X`	`<install-dir>/apps/tcpip/berkeley_udp_relay/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx_eth_sk	pic32mx_eth_sk	Demonstrates the Berkeley UDP Relay on the PIC32 Ethernet Starter Kit.
pic32mx_eth_sk2	pic32mx_eth_sk2	Demonstrates the Berkeley UDP Relay on the PIC32 Ethernet Starter Kit II.
pic32mz_ec_sk	pic32mz_ec_sk	Demonstrates the Berkeley UDP Relay on the PIC32MZ EC Starter Kit.
pic32mz_ef_sk	pic32mz_ef_sk	Demonstrates the Berkeley UDP Relay on the PIC32MZ EF Starter Kit.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32 Ethernet Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32 Ethernet Starter Kit II

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ EC Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ EF Starter Kit

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

This section provides instructions on how to build and run the demonstration.

Description

To use this demonstration, a USB cable needs to be connected to the micro-B USB connector on the bottom of the starter kit in use.

When the demonstration runs, it will create a USB CDC device on the USB bus. The demonstration can be executed once you have connected to this device though a standard terminal program, set the baud rate to 921,600 baud, and a valid IP address has been received by the device.

Also, establish a connection between the router or switch with the PIC32 Ethernet Starter Kit using the RJ45 connector. Ensure the router or switch is connected to the Internet.

This application demonstrates a simple UDP packet relay. Functionality has also been put in place to generate packets and to receive packets on the same device. IPv6 has not been tested.

Demonstration Commands

There is are several different commands available in the demonstration from the console port:

General Application Commands:

- current - Displays the current configuration
- start - Starts the packet relay service
- stop - Stops the packet relay service
- reportinterval <seconds> - Sets the interval between reports to the console

Relay Service Configuration:

- relayhost <host name> - Sets the host to which packets are to be relayed
- relayport <port number> - Sets the port to which packets are to be relayed
- ipv4port <port number> - Sets the IPv4 port that the relay server will listen to for packets to relay
- ipv6port <port number> - Sets the IPv6 port that the relay server will listen to for packets to relay

Relay Client Configuration and Commands:

- relayclienthost <host name> - Sets the host to which packets are to be sent
- relayclientport <port number> - Sets the port to which packets are to be sent
- relayclientiter <number> - The number of packets to generate
- relayclientstart - Starts the relay client. This command must be used after the general application start. After a start is called, and the first packet is received by either the relay or the relay server, periodic updates will be sent to the console with information about the number of packets and bytes received.

berkeley_udp_server

This configuration demonstrates creating an Internet server that uses the Berkeley API to create a UDP/IP echo server on port 9764.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the Berkeley UDP Server Demonstration.

Description

To build this project, you must open the `berkeley_udp_server.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/tcpip/berkeley_udp_server`.

Warning

When using the Microchip Harmony Configurator (MHC), care must be taken when generating the code to *not* erase the USB descriptors in the `system_init.c` file.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`berkeley_udp_server.X`	`<install-dir>/apps/tcpip/berkeley_udp_server/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx_eth_sk	pic32mx_eth_sk	Demonstrates the Berkeley UDP Server on the PIC32 Ethernet Starter Kit.
pic32mx_eth_sk2	pic32mx_eth_sk2	Demonstrates the Berkeley UDP Server on the PIC32 Ethernet Starter Kit II.
pic32mz_ec_sk	pic32mz_ec_sk	Demonstrates the Berkeley UDP Server on the PIC32MZ EC Starter Kit.
pic32mz_ef_sk	pic32mz_ef_sk	Demonstrates the Berkeley UDP Server on the PIC32MZ EF Starter Kit.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32 Ethernet Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32 Ethernet Starter Kit II

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ EC Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ EF Starter Kit

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

This section provides instructions on how to build and run the demonstration.

Description

The demonstration does not offer any additional functionality through the serial port; however, the current IP can be checked. As soon as a valid IP has been assigned through DHCP to the demonstration, it is then ready to accept a UDP/IP connection on 9760. The demonstration will echo back everything it receives along the connection.

A USB cable can be connected to the micro-B USB connector on the bottom of the starter kit in use. This will create a USB CDC device on the USB bus. To communicate with the software, connect to this device though a standard terminal program and set the baud rate to 921,600 baud.

snmpv3_nvm_mpfs

SNMPv3 NVM MPFS demonstration.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the SNMPv3 NVM MPFS Demonstration.

Description

To build this project, you must open the `snmpv2_nvm_mpfs.X` project in MPLAB X IDE, and then select the desired configuration.

The Non-Volatile Memory (NVM) Microchip Proprietary File System (MPFS) has the `snmp.bib` file along with other web page files stored in internal Flash and are accessed through the MPFS API.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/tcpip/snmpv3_nvm_mpfs`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`snmpv3_nvm_mpfs.X`	`<install-dir>/apps/tcpip/snmpv3_nvm_mpfs/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32_eth_sk	pic32mx_eth_sk	Demonstrates the SNMPv3 NVM MPFS on the PIC32 Ethernet Starter Kit in Interrupt mode and dynamic operation.
pic32mz_ef_sk	pic32mz_ef_sk	Demonstrates the SNMPv3 NVM MPFS on the PIC32MZ EF Starter Kit in Interrupt mode and dynamic operation.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32MZ EF Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32 Ethernet Starter Kit

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

This section provides instructions on how to build and run the demonstration.

Description

Use the following procedure to run the demonstration:

1. Load the demonstration project into MPLAB X IDE.
2. Connect the mini-B debugger port on-board the starter kit in use to a USB port on the development computer using the USB cable provided in the kit.
3. Connect the RJ-45 Ethernet port on the starter kit board to a network hub or an Ethernet port on the development computer using the Ethernet patch cord provided in the kit.
4. Build, download, and run the demonstration project on the target board.
5. A SNMP and SNMPv3 server is hosted by the demonstration application.
6. Run tcpip_discoverer to get the IPv4 and IPv6 address for the board.
7. Open a SNMP manager (iREASONING SNMP manager is recommended) and configure the IPv4 or IPv6 address.

Note: Refer to the iREASONING Networks MIB Browser section in the Third-Party help for complete details on using and configuring the application using the iREASONING SNMP Manager.

8. Connect a USB cable to the micro-B USB connector on the bottom of the PIC32 Ethernet Starter Kit. When the demonstration runs, it will create a USB CDC device on the USB bus. Connect to this device though a standard terminal program, and set the baud rate to 921,600 baud. You can observe the IP address details and query the stack using the console interface.

SNMP MIB Browser

Several SNMP MIB browsers are available. Users can also install a customized MIB browser specific to their application.

SNMP Get, GetNext, GetBulk, Set request and response are working as expected for SNMP v1/v2/v3 versions.

- For SNMP v2c , the Agent is configured with three Read communities ("public", "read", " ") and three Write communities ("private","write","public").
- For SNMP v3, the Agent is configured as per the following table:

Type	USER 1	USER 2	USER 3
USM User	microchip	SnmpAdmin	root
Security Level	auth, priv	auth, no priv	no auth, no priv
Auth Algorithm	MD5	SHA1	N/A
Auth Password	auth12345	ChandlerUS	N/A
Privacy Algorithm	AES	N/A	N/A
Privacy Password	priv12345	N/A	N/A

The Microchip SNMP Stack supports both TRAP version 1 and TRAP version 2. This demonstration trap output is a multi-varbind SNMPv3 TRAP version 2. Users may be required to configure the Trap receiver as per the SNMP browser selection.

HTTP Configuration for SNMPv2c Community

It is possible to dynamically configure the Read and Write community names through the SNMP Configuration web page. Access the web page using http://mchpboard_e/mpfsupload or http://<Board IP address>(for IPv6 it should be http://<Ipv6 address>:80/index.html), and then access the SNMP Configuration web page through the navigation bar. Use "admin" for the username and "microchip" for the password.

Warning

When using the Microchip Harmony Configurator (MHC), care must be taken when generating the code to *not* erase the USB descriptors in the `system_init.c` file.

snmpv3_sdcard_fatfs

SNMPv3 SD Card FAT File System demonstration.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the SNMPv3 SD Card FAT FS Demonstration.

Description

To build this project, you must open the `snmpv3_sdcard_fatfs.X` project in MPLAB X IDE, and then select the desired configuration.

The SD Card FAT FS has the `snmp.bib` file with other web pages stored in an external SD card and is accessed through a FAT FS API.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/tcpip/snmpv3_sdcard_fatfs`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`snmpv3_sdcard_fatfs.X`	`<install-dir>/apps/tcpip/snmpv3_sdcard_fatfs/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32_eth_sk	pic32mx_eth_sk	Demonstrates the access of a SNMP file on a microSD card through the FAT file system on the PIC32 Ethernet Starter Kit using the Starter Kit I/O Expansion Board with the PICtail daughter board for SD and MMC cards. The demonstration runs in Interrupt mode and dynamic operation.
pic32mz_ef_sk	pic32mz_ef_sk+meb2	Demonstrates the access of a SNMP file on a microSD card through the FAT file system on the PIC32MZ EF Starter Kit and the MEB II board combination. The demonstration runs in Interrupt mode and dynamic operation.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32MZ EF Starter Kit with the MEB II

1. Connect the starter kit to the application board connector on the MEB II.
2. Make sure a microSD card is formatted and loaded with the `snmp.bib` file along with the web pages provided in the `<install-dir>/apps/tcpip/web_server_sdcard_fatfs/firmware/src/web_pages` folder.
3. Insert the microSD card with the web pages into the microSD card slot (J8) on the MEB II.

PIC32 Ethernet Starter Kit with the Starter Kit Expansion Board

1. Connect the PIC32 Ethernet Starter Kit to the I/O expansion board.
2. Make sure a SD card is formatted and loaded with the `snmp.bib` file along with the web pages provided within the `<install-dir>apps/tcpip/snmpv3_sdcard_fatfs/firmware/src/web_pages` folder.
3. Insert the SD card into the PICtail Daughter Board for SD and MMC cards with the `snmp.bib` file along with web pages into the SPI1 slot (J4 - starts slot count from 1) of the PIC32 I/O Expansion Board.

Note: The SD card on the PICtail daughter board should face the PIC32 Ethernet Starter Kit.

Running the Demonstration

This section provides instructions on how to build and run the demonstration.

Description

Please refer to the Running the Demonstration section for the snmpv3_nvm_mpfs configuration, as the process is the same for this configuration.

Note: Ensure that the SD card with the `snmp.bib` file and the Web pages is inserted as detailed in Configuring the Hardware.

tcpip_tcp_client

This configuration demonstrates creating an Internet client that uses the MPLAB Harmony TCP API to create a TCP/IP connection to a web server.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the TCP/IP TCP Client Demonstration.

Description

To build this project, you must open the `tcpip_tcp_client.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/tcpip/tcpip_tcp_client`.

Warning

When using the Microchip Harmony Configurator (MHC), care must be taken when generating the code to *not* erase the USB descriptors in the `system_init.c` file.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`tcpip_tcp_client.X`	`<install-dir>/apps/tcpip/tcpip_tcp_client/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx_eth_sk2	pic32mx_eth_sk2	Demonstrates the TCP/IP TCP Client on the PIC32 Ethernet Starter Kit II.
pic32mz_ef_sk	pic32mz_ef_sk	Demonstrates the TCP/IP TCP Client on the PIC32MZ EF Starter Kit.
pic32mx_eth_sk2_enc28j60	pic32mx_eth_sk2	Demonstrates the TCP/IP TCP Client on the PIC32 Ethernet Starter Kit II connected to the 10 Mbps Ethernet PICtail Plus Daughter Board and Starter Kit I/O Expansion Board using the ENC28J60 Driver Library.
pic32mx_eth_sk2_encx24j600	pic32mx_eth_sk2	Demonstrates the TCP/IP TCP Client on the PIC32 Ethernet Starter Kit II connected to the Fast 100Mbps Ethernet PICtail Plus Daughter Board and Starter Kit I/O Expansion Board using the ENCx24J600 Driver Library.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32 Ethernet Starter Kit II

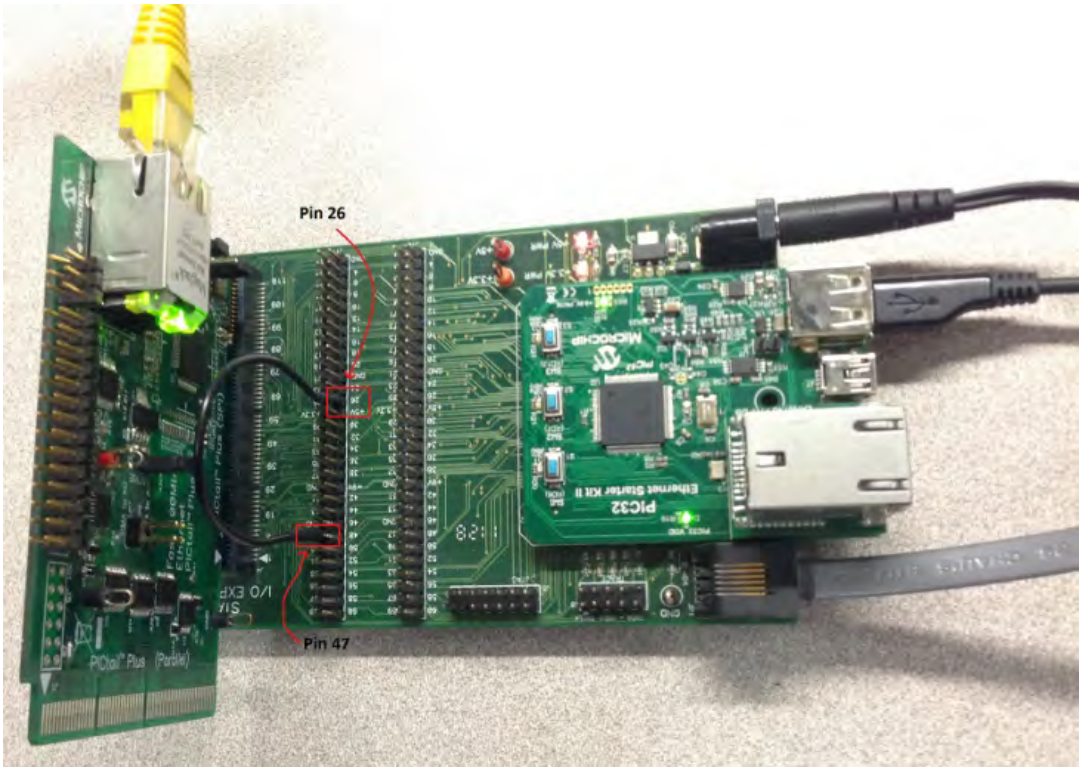
No hardware related configuration or jumper setting changes are necessary.

PIC32MZ EF Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32 Ethernet Starter Kit II, Fast 100Mbps Ethernet PICtail Plus Daughter Board, and Starter Kit I/O Expansion Board

The Fast 100Mbps Ethernet PICtail Plus Daughter Board is connected to J4 on the Starter Kit I/O Expansion Board board by sliding the J2 PICtail Plus (SPI) card edge into the top of the connector so that the white arrows on the two boards line up. The PICtail daughter board is inserted so that it uses SPI1. Pins 26 and 47 on J11 need to be jumpered to allow the CS line to be controlled by the PIC32. ThePIC32 Ethernet Starter Kit II is connected to J1 on the Starter Kit I/O Expansion board. Please refer to the following figure for more detail.



PIC32 Ethernet Starter Kit II, Ethernet PICtail Plus Daughter Board, and Starter Kit I/O Expansion Board

The 10 Mbps Ethernet PICtail Plus Daughter Board is connected to J4 on the Starter Kit I/O Expansion Board board by sliding the J2 PICtail Plus (SPI) card edge into the top of the connector. The PICtail daughter board is inserted so that it uses SPI1. Pins 26 and 47 on J11 need to be jumpered to allow the CS line to be controlled by the PIC32. The PIC32 Ethernet Starter kit II is connected to J1 on the Starter Kit I/O Expansion board.

Using the previous figures as a reference, replace the Fast 100 Mbps Ethernet PICtail Plus Daughter Board with the Ethernet PICtail Plus Daughter Board for this configuration. The RJ45 of the PICtail should be towards the edge connectors of the Starter Kit I/O Expansion Board.

Running the Demonstration

This section provides instructions on how to build and run the demonstration.

Description

To use this demonstration, a USB cable needs to be connected to the micro-B USB connector on the bottom of the starter kit in use. When the demonstration runs, it will create a USB CDC device on the USB bus. The demonstration can be executed once you have connected to this device though a standard terminal program, set the baud rate to 921,600 baud, and a valid IP address has been received by the device.

There is only one command available in the demonstration from the serial port:

`openurl <url>` - The <url> argument must be a fully formed URL; for instance, http://www.microchip.com/

After that one command is input, the demonstration will make a DNS query, and then open a connection to the requested URL and perform a simple HTTP PUT command. The results will be sent to the serial port.

tcpip_tcp_client_server

This configuration demonstrates creating an Internet client and an Internet server that uses the MPLAB Harmony TCP API. This demonstration shows how the TCP/IP loopback works, and is a combination of the TCP/IP Client and TCP/IP Server application.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the TCP/IP TCP Client Server Demonstration.

Description

To build this project, you must open the `tcpip_tcp_client_server.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/tcpip/tcpip_tcp_client_server`.

Warning

When using the Microchip Harmony Configurator (MHC), care must be taken when generating the code to *not* erase the USB descriptors in the `system_init.c` file.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`tcpip_tcp_client_server.X`	`<install-dir>/apps/tcpip/tcpip_tcp_client_server/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx_eth_sk2	pic32mx_eth_sk2	Demonstrates the TCP/IP TCP Client Server on the PIC32 Ethernet Starter Kit II.
pic32mz_ef_sk	pic32mz_ef_sk	Demonstrates the TCP/IP TCP Client Server on the PIC32MZ EF Starter Kit.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32 Ethernet Starter Kit II

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ EF Starter Kit

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

This section provides instructions on how to build and run the demonstration.

Description

To use this demonstration, a USB cable needs to be connected to the micro-B USB connector on the bottom of the starter kit in use. When the demonstration runs, it will create a USB CDC device on the USB bus. The demonstration can be executed once you have connected to this device though a standard terminal program, set the baud rate to 921,600 baud, and a valid IP address has been received by the device.

There is only one command available in the demonstration from the serial port:

`openurl <url>` - The <url> argument must be a fully formed URL; for instance, http://www.microchip.com/

After that one command is input, the demonstration will make a DNS query, and then open a connection to the requested URL and perform a simple HTTP PUT command. The results will be sent to the serial port.

tcpip_tcp_server

This configuration demonstrates creating an Internet server that uses the MPLAB Harmony TCP API to create a TCP/IP echo server on port 9764.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the TCP/IP TCP Server Demonstration.

Description

To build this project, you must open the `tcpip_tcp_server.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/tcpip/tcpip_tcp_server`.

Warning

When using the Microchip Harmony Configurator (MHC), care must be taken when generating the code to *not* erase the USB descriptors in the `system_init.c` file.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`tcpip_tcp_server.X`	`<install-dir>/apps/tcpip/tcpip_tcp_server/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx_eth_sk2	pic32mx_eth_sk2	Demonstrates the TCP/IP TCP Server on the PIC32 Ethernet Starter Kit II.
pic32mz_ef_sk	pic32mz_ef_sk	Demonstrates the TCP/IP TCP Server on the PIC32MZ EF Starter Kit.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32 Ethernet Starter Kit II

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ EF Starter Kit

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

This section provides instructions on how to build and run the demonstration.

Description

The demonstration does not offer any additional functionality through the serial port; however, the current IP can be checked. As soon as a valid IP has been assigned through DHCP to the demonstration, it is then ready to accept a TCP/IP connection on 9764. The demonstration will echo back everything it receives along the connection.

A USB cable can be connected to the micro-B USB connector on the bottom of the starter kit in use. This will create a USB CDC device on the USB bus. To communicate with the software, connect to this device though a standard terminal program and set the baud rate to 921,600 baud.

tcpip_udp_client

This configuration demonstrates creating an Internet client that uses the MPLAB Harmony UDP API to create a UDP/IP connection to a specified port.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the TCP/IP UDP Client Demonstration.

Description

To build this project, you must open the `tcpip_udp_client.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/tcpip/tcpip_udp_client`.

Warning

When using the Microchip Harmony Configurator (MHC), care must be taken when generating the code to *not* erase the USB descriptors in the `system_init.c` file.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`tcpip_udp_client.X`	`<install-dir>/apps/tcpip/tcpip_udp_client/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx_eth_sk2	pic32mx_eth_sk2	Demonstrates the TCP/IP UDP Client on the PIC32 Ethernet Starter Kit II.
pic32mz_ef_sk	pic32mz_ef_sk	Demonstrates the TCP/IP UDP Client on the PIC32MZ EF Starter Kit.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32 Ethernet Starter Kit II

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ EF Starter Kit

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

This section provides instructions on how to build and run the demonstration.

Description

To use this demonstration, a USB cable needs to be connected to the micro-B USB connector on the bottom of the starter kit in use. When the demonstration runs, it will create a USB CDC device on the USB bus. The demonstration can be executed once you have connected to this device though a standard terminal program, set the baud rate to 921,600 baud, and a valid IP address has been received by the device.

There are three commands that can be used from the console:

- `setudppacketoptions <hostname> <port> <message>` - This command specifies where to send the UDP packet and what to have in the message
- `getudppacketoptions` - This command displays the current options
- `sendudppacket` - This command sends a UDP packet

After the `sendudppacket` command is input, the demonstration will make a DNS query to look up the host name and send a UDP packet to that host.

tcpip_udp_client_server

This configuration demonstrates creating an Internet client and an Internet server that uses the MPLAB Harmony UDP API. This demonstration shows how the UDP/IP loopback works, and is a combination of the TCP/IP UDP Client and TCP/IP UDP Server application.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the TCP/IP UDP Client Server Demonstration.

Description

To build this project, you must open the `tcpip_udp_client_server.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/tcpip/tcpip_udp_client_server`.

Warning

When using the Microchip Harmony Configurator (MHC), care must be taken when generating the code to *not* erase the USB descriptors in the `system_init.c` file.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`tcpip_udp_client_server.X`	`<install-dir>/apps/tcpip/tcpip_udp_client_server/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx_eth_sk2	pic32mx_eth_sk2	Demonstrates the TCP/IP UDP Client Server on the PIC32 Ethernet Starter Kit II.
pic32mz_ef_sk	pic32mz_ef_sk	Demonstrates the TCP/IP UDP Client Server on the PIC32MZ EF Starter Kit.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32 Ethernet Starter Kit II

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ EF Starter Kit

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

This section provides instructions on how to build and run the demonstration.

Description

To use this demonstration, a USB cable needs to be connected to the micro-B USB connector on the bottom of the starter kit in use. When the demonstration runs, it will create a USB CDC device on the USB bus. The demonstration can be executed once you have connected to this device though a standard terminal program, set the baud rate to 921,600 baud, and a valid IP address has been received by the device.

There are three commands that can be used from the console:

- `setudppacketoptions <hostname> <port> <message>` - This command specifies where to send the UDP packet and what to have in the message
- `getudppacketoptions` - This command displays the current options
- `sendudppacket` - This command sends a UDP packet

After the `sendudppacket` command is input, the demonstration will make a DNS query to look up the host name and send a UDP packet to that host.

The UDP Client can be configured to send UDP data to the host, configured using the commands previously described.

The UDP server in this demonstration waits for the client connection and data at port 9760.

As the server receives the data from the external UDP client, the data is shared to the UDP Client to transmit back to the external UDP Server.

The data received over UDP by the server is looped backed using the UDP Client.

tcpip_udp_server

This configuration demonstrates creating an Internet server that uses the MPLAB Harmony UDP API to create a UDP/IP echo server on port 9760.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the TCP/IP UDP Server Demonstration.

Description

To build this project, you must open the `tcpip_udp_server.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/tcpip/tcpip_udp_server`.

Warning

When using the Microchip Harmony Configurator (MHC), care must be taken when generating the code to *not* erase the USB descriptors in the `system_init.c` file.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`tcpip_udp_server.X`	`<install-dir>/apps/tcpip/tcpip_udp_server/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx_eth_sk2	pic32mx_eth_sk2	Demonstrates the TCP/IP UDP Server on the PIC32 Ethernet Starter Kit II.
pic32mz_ef_sk	pic32mz_ef_sk	Demonstrates the TCP/IP UDP Server on the PIC32MZ EF Starter Kit.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32 Ethernet Starter Kit II

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ EF Starter Kit

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

This section provides instructions on how to build and run the demonstration.

Description

The demonstration does not offer any additional functionality through the serial port; however, the current IP can be checked. As soon as a valid IP has been assigned through DHCP to the demonstration, it is then ready to accept a UDP/IP connection on 9760. The demonstration will echo back everything it receives along the connection.

A USB cable can be connected to the micro-B USB connector on the bottom of the starter kit in use. This will create a USB CDC device on the USB bus. To communicate with the software, connect to this device though a standard terminal program and set the baud rate to 921,600 baud.

web_net_server_nvm_mpfs

Web Net Server Non-volatile Memory (NVM) MPFS TCP/IP demonstration.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the TCP/IP Web Net Server Demonstration.

Description

To build this project, you must open the `pic32_eth_web_server.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/tcpip/web_net_server_nvm_mpfs`.

Warning

When using the Microchip Harmony Configurator (MHC), care must be taken when generating the code to *not* erase the USB descriptors in the `system_init.c` file.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`pic32_eth_web_server.X`	`<install-dir>/apps/tcpip/web_net_server_nvm_mpfs/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx_eth_sk	pic32mx_eth_sk	Demonstrates the web server hosted on internal Flash through Microchip proprietary file system on the PIC32 Ethernet Starter Kit.
pic32mx_eth_sk2	pic32mx_eth_sk2	Demonstrates the web server hosted on internal Flash through Microchip proprietary file system on the PIC32 Ethernet Starter Kit II.
pic32mz_ec_sk	pic32mz_ec_sk	Demonstrates the web server hosted on internal Flash through Microchip proprietary file system on the PIC32MZ EC Starter Kit.
pic32mz_ef_sk	pic32mz_ef_sk	Demonstrates the web server hosted on internal Flash through Microchip proprietary file system on the PIC32MZ EF Starter Kit.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32 Ethernet Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32 Ethernet Starter Kit II

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ EC Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ EF Starter Kit

No hardware related configuration or jumper setting changes are necessary.

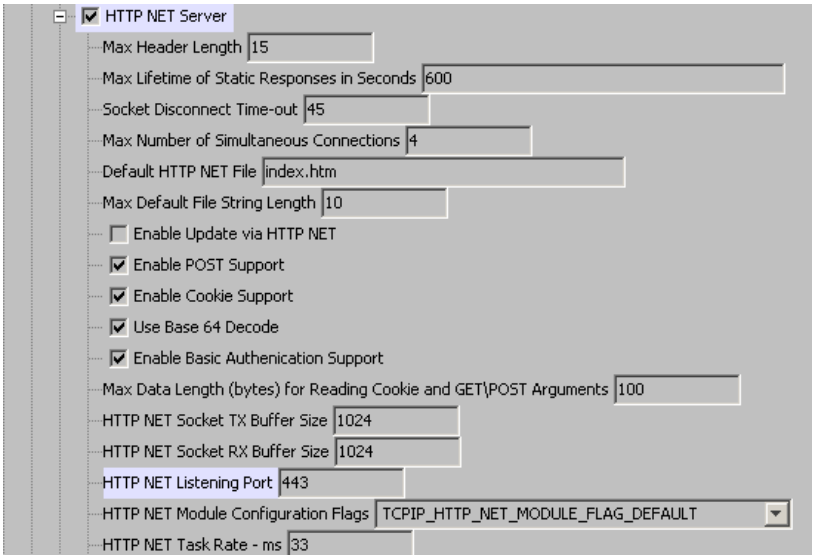
Configuring the MHC

Provides information on the MHC configuration for the demonstration.

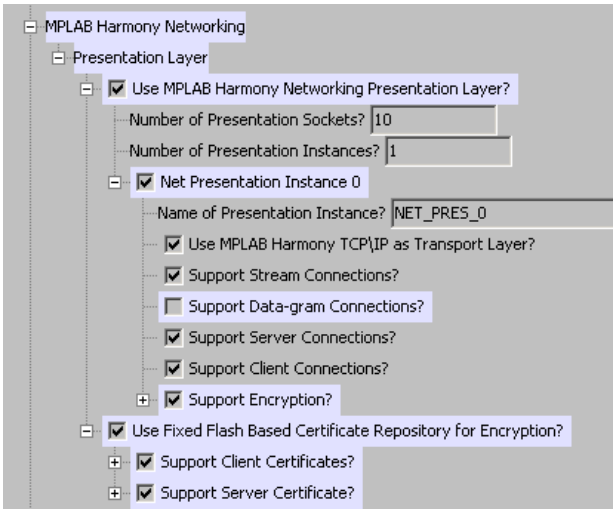
Description

MHC Configuration:

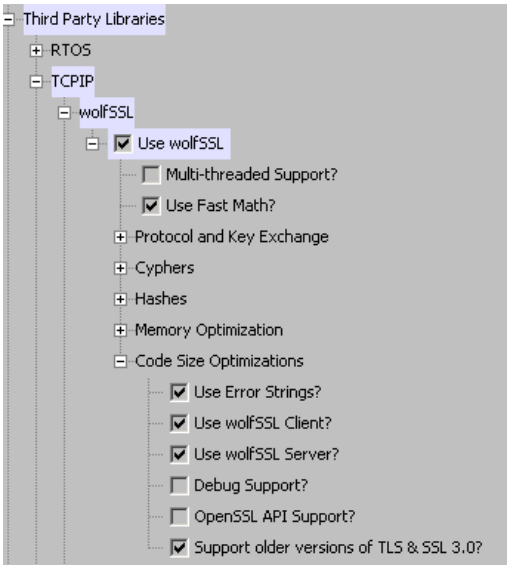
1. From *Harmony Framework Configuration* > *TCPIP Stack* select **HTTP NET Server**.
2. Leave the default settings. The HTTP server listening port should be already set to 443 for encrypted connections, as shown in the following figure; however, change this value to 80 if unencrypted connection is required:



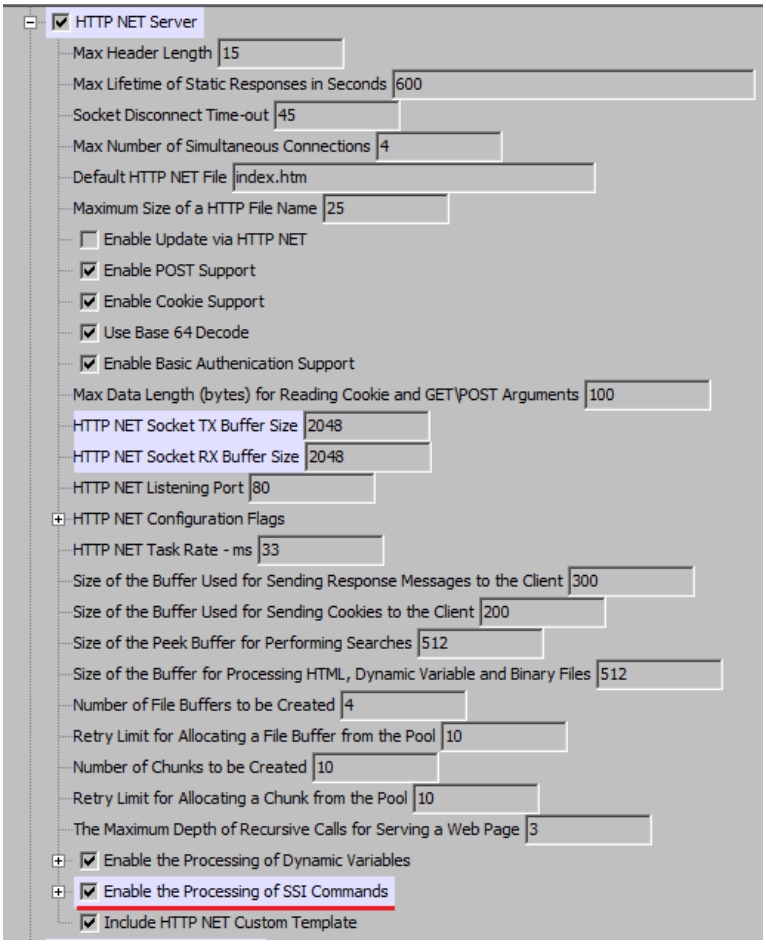
3. Enable the MPLAB Harmony Networking Presentation Layer, as follows:
   - Ensure that the TCP/IP stack is used as transport layer
   - Select **Support Stream Connections?** (for TCP support)
   - Select **Support Server Connections?** (for HTTPS support)
   - Select **Support Client Connections?** (for encrypted SMTP support)
   - Select **Support Client Certificate?** and **Support Server Certificate?** (as appropriate)



4. Enable *Third Party Libraries* > *TCPIP* > *wolfSSL* > *Use wolfSSL*. Ensure that the wolfSSL client and wolfSSL server are enabled depending on your HTTP and SMTP selection, as shown in the following figure:



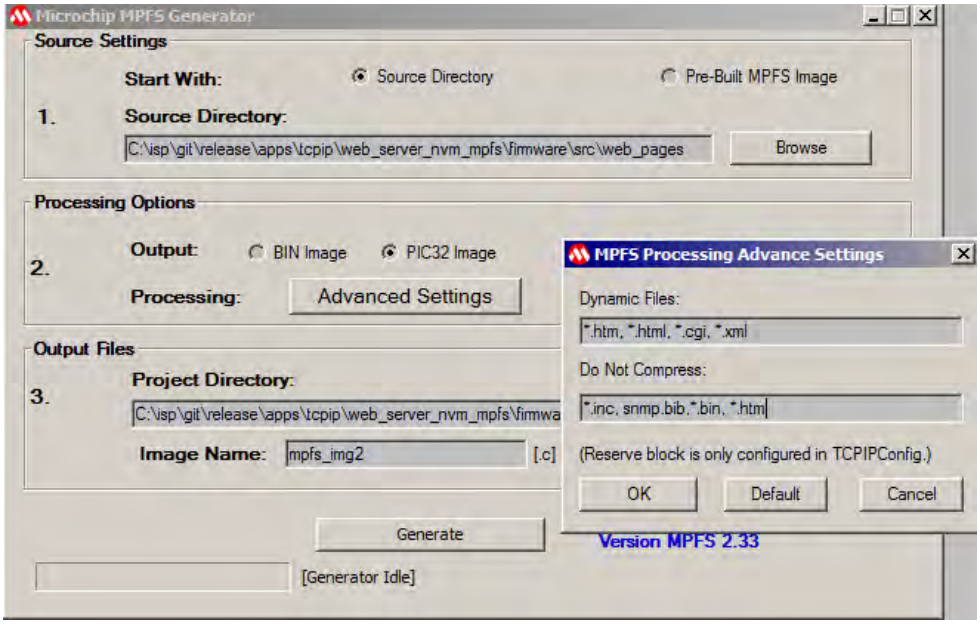
5. As shown in the following figure, select **HTTP Net Server** from *Harmony Framework Configuration >TCPIP Stack*. Ensure that the “Enable the Processing SSI Commands” is enabled. Leave the default settings or expand the item and adjust to your application needs.



6. This version of the HTTP Net MHC configuration allows for the explicit selection of the dynamic variables processing. Ensure that this option is also selected.

Note: For demonstrations that use SSI, the file inclusion is now done in a standard way using `.htm` files.

For example, `<!--#include virtual="header.htm">`. These files may contain dynamic variables, other SSI commands, or include other files. As shown in the following figure, ensure that when using the `mpfs2.jar` image generation tool that `*.htm` is added using *Advanced Settings > Do Not Compress.*



Running the Demonstration

This section provides instructions on how to build and run the PIC32 Ethernet Web Net Server demonstration.

Description

To view the web page hosted by the demonstration application, open a web browser and direct it to the board running the HTTP server by typing the URL in the address bar (for example, http://mchpboard_e), and then pressing **Enter**.

Notes:

1. The NetBIOS name of the TCP/IP application is specified at the time the TCP/IP stack is initialized, which is usually in the hostName member of the tcpip_stack_init.c:: TCPIP_HOSTS_CONFIGURATION structure. The NetBIOS service must be enabled for the PIC32 demonstration to respond to NetBIOS queries. Alternatively, you can use the IPv4 or IPv6 address (if IPv6 is enabled) of the board directly, for example, http://192.168.1.131 or http://[fdfe:dcba:9876:1:204:a3ff:fe12:128e].
2. The IPv4 and IPv6 addresses can be obtained from running the TCP/IP Discovery application on the PC side. It requires that the TCP/IP Announce module is enabled when building the stack.

Demonstration Process

Please use the following procedure to run the demonstration:

1. Load the demonstration project into MPLAB X IDE.
2. Connect the mini-B debugger port on-board the starter kit in use to a USB port on the Development computer using the USB cable provided in the kit.
3. Connect the RJ-45 Ethernet port on the starter kit board to a network hub or an Ethernet port on the development computer using the Ethernet patch cord provided in the kit.
4. Build, download, and run the demonstration project on the target board.
5. A HTTP server is hosted by the demonstration application. Open a web browser and direct it to the board running the HTTP server by typing the URL in the address bar (for example, http://mchpboard_e), and then pressing **Enter**.

The demonstration application features following:

- *Real-time Hardware Control and Dynamic Variables* - On the Overview page the LEDs can be clicked to toggle the LEDs on the PIC32 Ethernet Starter Kit board. The buttons on the PIC32 Ethernet Starter Kit board can be pressed to toggle the Buttons on the web page. The dynamic variables can be updated in real-time on the HTTP server.

Note: The LED functionality portion of the demonstration is somewhat limited due to issue related to the functional multiplexing on GPIO and Ethernet pins on different supported hardware.

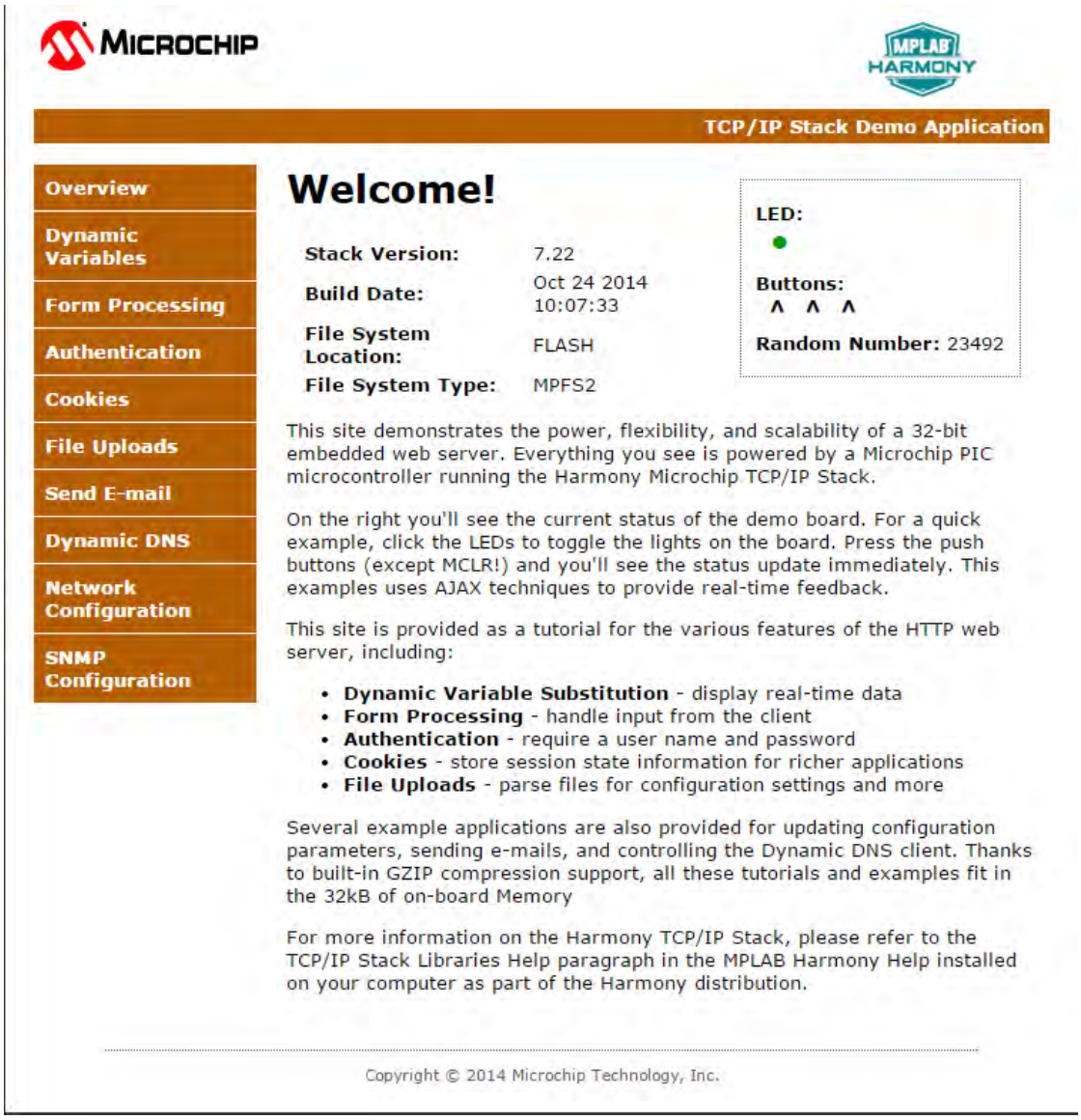
- *Form Processing* - Input can be handled from the client by using GET and POST methods (this functionality controls the on-board LEDs and will be operational only on Explorer 16 Development Board)
- *Authentication* - Shows an example of the commonly used restricted access feature
- *Cookies* - Shows an example of storing small text stings on the client side
- *File Uploads* - Shows an example of file upload using the POST method. The HTTP server can accept a user-defined MPFS/MPFS2 image file for web pages.
- *Send E-mail* - Shows simple SMTP POST methods
- *Dynamic DNS* - Exercises Dynamic DNS capabilities
- *Network Configuration* - The MAC address, host name, and IP address of the PIC32 Ethernet Starter Kit board can be viewed in the Network

Configuration page and some configurations can be updated

- *MPFS Upload* - A new set of web pages can be uploaded to the web server using this feature, which is accessed through http://mchpboard_e/mpfsupload.

Notes:

1. The location of the MPFS image is fixed at the beginning of the Flash page (aligned to the page boundary). The size of the MPFS upload is limited to 64K in the demonstration, which it can be expanded by changing NVM_MEDIA_SIZE to the desired size (restricted based on the available size) and overriding the EBASE address using the following linker command:
   - --defsym=_ebase_address=0x9D0xxxx (where, xxxx = 9D000000+NVM_MEDIA_SIZE)
2. The MPFS UPLOAD functionality has to be enabled when the project is built.



web_server_nvm_mpfs

This topic contains the Web Server Non-volatile Memory (NVM) MPFS TCP/IP demonstrations.

pic32_eth_web_server

This section describes the steps necessary to begin using the PIC32 Ethernet Web Server Demonstration Application.

Description

This demonstration exercises the HTTP web server running on PIC32 devices. The Non-Volatile Memory (NVM) Microchip Proprietary File System (MPFS) web server demonstration has the web pages stored in internal Flash and are accessed through the MPFS API.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the TCP/IP Web Server Demonstration.

Description

To build this project, you must open the `pic32_eth_web_server.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/tcpip/web_server_nvm_mpfs`.

Warning

When using the Microchip Harmony Configurator (MHC), care must be taken when generating the code to *not* erase the USB descriptors in the `system_init.c` file.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`pic32_eth_web_server.X`	`<install-dir>/apps/tcpip/web_server_nvm_mpfs/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx_eth_sk	pic32mx_eth_sk	Demonstrates the web server hosted on internal Flash through Microchip proprietary file system on the PIC32 Ethernet Starter Kit.
pic32mx_eth_sk2	pic32mx_eth_sk2	Demonstrates the web server hosted on internal Flash through Microchip proprietary file system on the PIC32 Ethernet Starter Kit II.
pic32mz_ec_sk	pic32mz_ec_sk	Demonstrates the web server hosted on internal Flash through Microchip proprietary file system on the PIC32MZ EC Starter Kit.
pic32mz_ef_sk	pic32mz_ef_sk	Demonstrates the web server hosted on internal Flash through Microchip proprietary file system on the PIC32MZ EF Starter Kit.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32 Ethernet Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32 Ethernet Starter Kit II

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ EC Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ EF Starter Kit

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

This section provides instructions on how to build and run the PIC32 Ethernet Web Server demonstration.

Description

To view the web page hosted by the demonstration application, open a web browser and direct it to the board running the HTTP server by typing

the URL in the address bar (for example, http://mchpboard_e), and then pressing **Enter**.

Notes:

1. The NetBIOS name of the TCP/IP application is specified at the time the TCP/IP stack is initialized, which is usually in the hostName member of the tcpip_stack_init.c:: TCPIP_HOSTS_CONFIGURATION structure. The NetBIOS service must be enabled for the PIC32 demonstration to respond to NetBIOS queries. Alternatively, you can use the IPv4 or IPv6 address (if IPv6 is enabled) of the board directly, for example, http://192.168.1.131 or http://[fdfe:dcba:9876:1:204:a3ff:fe12:128e].
2. The IPv4 and IPv6 addresses can be obtained from running the TCP/IP Discovery application on the PC side. It requires that the TCP/IP Announce module is enabled when building the stack.

Demonstration Process

Please use the following procedure to run the demonstration:

1. Load the demonstration project into MPLAB X IDE.
2. Connect the mini-B debugger port on-board the starter kit in use to a USB port on the Development computer using the USB cable provided in the kit.
3. Connect the RJ-45 Ethernet port on the starter kit board to a network hub or an Ethernet port on the development computer using the Ethernet patch cord provided in the kit.
4. Build, download, and run the demonstration project on the target board.
5. A HTTP server is hosted by the demonstration application. Open a web browser and direct it to the board running the HTTP server by typing the URL in the address bar (for example, http://mchpboard_e), and then pressing **Enter**.

The demonstration application features following:

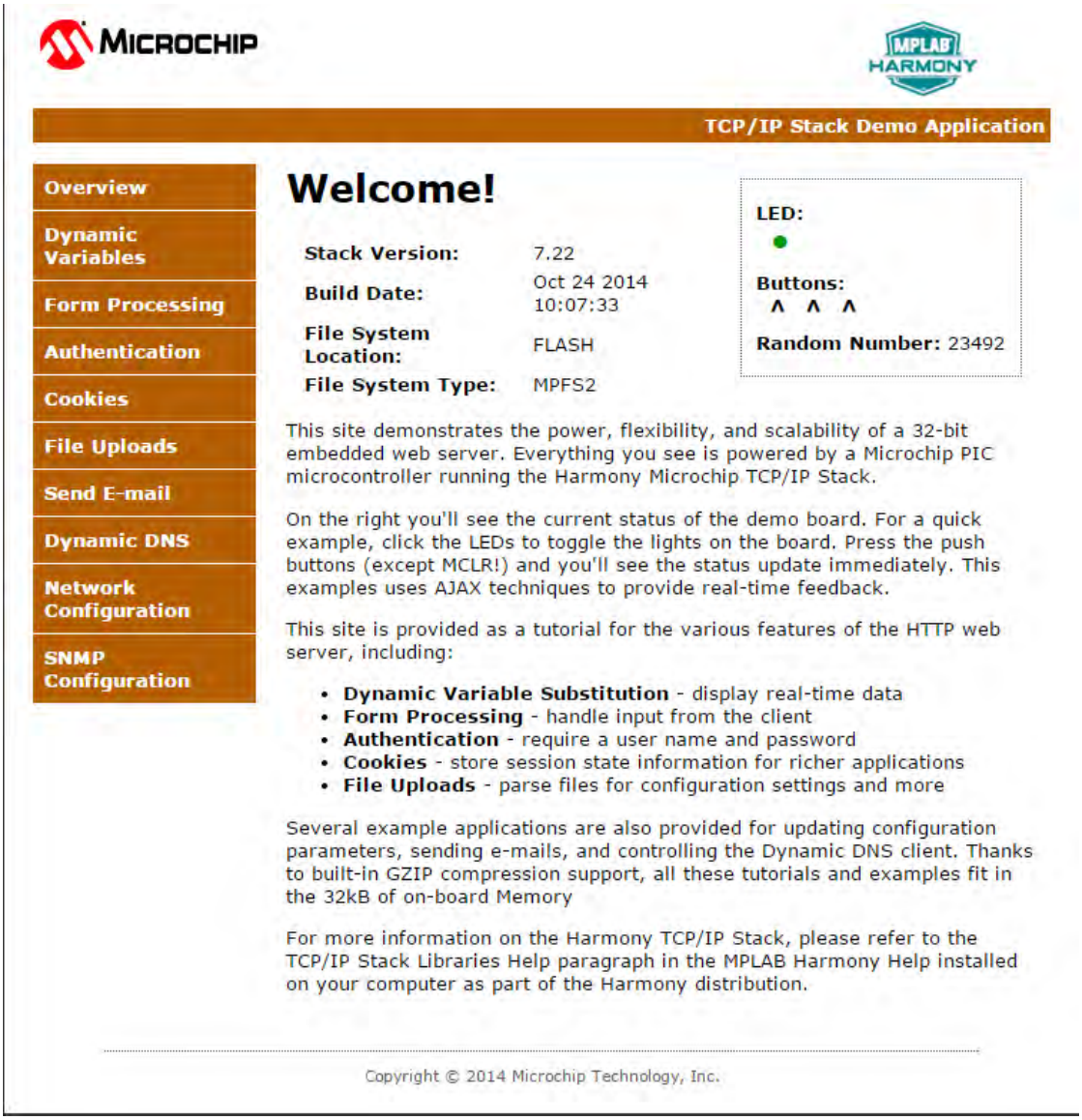
- *Real-time Hardware Control and Dynamic Variables* - On the Overview page the LEDs can be clicked to toggle the LEDs on the PIC32 Ethernet Starter Kit board. The buttons on the PIC32 Ethernet Starter Kit board can be pressed to toggle the Buttons on the web page. The dynamic variables can be updated in real-time on the HTTP server.

Note: The LED functionality portion of the demonstration is somewhat limited due to issue related to the functional multiplexing on GPIO and Ethernet pins on different supported hardware.

- *Form Processing* - Input can be handled from the client by using GET and POST methods (this functionality controls the on-board LEDs and will be operational only on Explorer 16 Development Board)
- *Authentication* - Shows an example of the commonly used restricted access feature
- *Cookies* - Shows an example of storing small text stings on the client side
- *File Uploads* - Shows an example of file upload using the POST method. The HTTP server can accept a user-defined MPFS/MPFS2 image file for web pages.
- *Send E-mail* - Shows simple SMTP POST methods
- *Dynamic DNS* - Exercises Dynamic DNS capabilities
- *Network Configuration* - The MAC address, host name, and IP address of the PIC32 Ethernet Starter Kit board can be viewed in the Network Configuration page and some configurations can be updated
- *MPFS Upload* - A new set of web pages can be uploaded to the web server using this feature, which is accessed through http://mchpboard_e/mpfsupload.

Notes:

1. The location of the MPFS image is fixed at the beginning of the Flash page (aligned to the page boundary). The size of the MPFS upload is limited to 64K in the demonstration, which it can be expanded by changing NVM_MEDIA_SIZE to the desired size (restricted based on the available size) and overriding the EBASE address using the following linker command:
   - --defsym=_ebase_address=0x9D0xxxx (where, xxxx = 9D000000+NVM_MEDIA_SIZE)
2. The MPFS UPLOAD functionality has to be enabled when the project is built.



pic32_eth_wifi_web_server

This section describes the steps necessary to begin using the PIC32 Ethernet Wi-Fi Web Server Demonstration Application.

Description

The Wi-Fi Web Server demonstration (`apps\tcpip\web_server_nvm_mpfs\firmware`) exercises the HTTP web server running on PIC32 devices. The Non-Volatile Memory (NVM) Microchip Proprietary File System (MPFS) web server demonstration has the web pages stored in internal Flash and are accessed through the MPFS API.

Wi-Fi Demonstration Matrix

Refer to Wi-Fi Demonstration Configuration Matrix for additional information.

Notes:

1. Due to a hardware limitation, the pic32mz_ec_sk+meb2 and pic32mz_ef_sk+meb2 configurations in the Ethernet and Wi-Fi Web server demonstration (pic32_eth_wifi_web_server), exercises a Web server through Wi-Fi only. The work around is explained in the Configuring the Hardware topic.
2. For the pic32mz_ec_sk+meb2 or pic32mz_ef_sk+meb2 configuration, either or both the MRF24WG Wi-Fi module and MRF24WN Wi-Fi PICtail may be installed, but only one Wi-Fi module will be active depending on the MHC selection of the MRF24W. If the MRF24WG Wi-Fi module is selected, it will not work if the MRF24WN Wi-Fi PICtail is installed.
3. For the Wi-Fi demonstration to function properly on the MEB II development board, the board should be powered with a 9V-15V DC power supply. Also on the PIC32MZ EC or PIC32MZ EF Starter Kit board, JP1 jumper should be Open (no jumper).

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the PIC32 Ethernet Wi-Fi Web Server Demonstration.

Description

To build this project, you must open the `pic32_eth_wifi_web_server.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/tcpip/web_server_nvm_mpfs`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`pic32_eth_wifi_web_server.X`	`<install-dir>/apps/tcpip/web_server_nvm_mpfs/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx_eth_sk+ioexp	pic32mx_eth_sk	Demonstration running on the PIC32 Ethernet Starter Kit connected to the Starter Kit I/O Expansion Board with the MRF24WG PICtail Daughter Board.
pic32mz_ec_sk+ioexp	pic32mz_ec_sk	Demonstration running on the PIC32MZ EC Starter Kit connected to the Starter Kit I/O Expansion Board with the MRF24WG PICtail Daughter Board.
pic32mz_ec_sk+meb2	pic32mz_ec_sk+meb2	Demonstration running on the PIC32MZ EC Starter Kit connected to the Multimedia Expansion Board II (MEB II) with the MRF24WG PICtail Daughter Board.
pic32mx_eth_sk+ioexp+freertos	pic32mx_eth_sk	FreeRTOS version of the demonstration running on the PIC32 Ethernet Starter Kit connected to the Starter Kit I/O Expansion Board with the MRF24WG PICtail Daughter Board.
pic32mx_eth_sk+ioexp+11n+freertos	pic32mx_eth_sk	FreeRTOS version of the demonstration running on the PIC32 Ethernet Starter Kit connected to the Starter Kit I/O Expansion Board with the MRF24WN PICtail Daughter Board.
pic32mz_ec_sk+ioexp+freertos	pic32mz_ec_sk	FreeRTOS version of the demonstration running on the PIC32MZ EC Starter Kit connected to the Starter Kit I/O Expansion Board with the MRF24WG PICtail Daughter Board.
pic32mz_ec_sk+ioexp+11n+freertos	pic32mz_ec_sk	FreeRTOS version of the demonstration running on the PIC32MZ EC Starter Kit connected to the Starter Kit I/O Expansion Board with the MRF24WN PICtail Daughter Board.
pic32mz_ec_sk+meb2+freertos	pic32mz_ec_sk+meb2	FreeRTOS version of the demonstration running on the PIC32MZ EC Starter Kit connected to the Multimedia Expansion Board II (MEB II) with the MRF24WG PICtail Daughter Board.
pic32mz_ec_sk+meb2+11n+freertos	pic32mz_ec_sk+meb2	FreeRTOS version of the demonstration running on the PIC32MZ EC Starter Kit connected to the Multimedia Expansion Board II (MEB II) with the MRF24WN PICtail Daughter Board.
pic32mz_ef_sk+ioexp	pic32mz_ef_sk	Demonstration running on the PIC32MZ EF Starter Kit connected to the I/O Expansion board with the MRF24WG PICtail Daughter Board.
pic32mz_ef_sk+ioexp+freertos	pic32mz_ef_sk	FreeRTOS version of the demonstration running on the PIC32MZ EF Starter Kit connected to the I/O Expansion board with the MRF24WG PICtail Daughter Board
pic32mz_ef_sk+meb2	pic32mz_ef_sk+meb2	Demonstration running on the PIC32MZ EF Starter Kit connected to the MEB II with the MRF24WG PICtail Daughter Board.
pic32mz_ef_sk+meb2+freertos	pic32mz_ef_sk+meb2	FreeRTOS version of the demonstration running on the PIC32MZ EF Starter Kit connected to the I/O Expansion board with the MRF24WG PICtail Daughter Board.
pic32mz_ef_sk+ioexp+11n+freertos	pic32mz_ef_sk	FreeRTOS version of the demonstration running on the PIC32MZ EF Starter Kit connected to the I/O Expansion board with the MRF24WN PICtail Daughter Board.
pic32mz_ef_sk+meb2+11n+freertos	pic32mz_ef_sk	FreeRTOS version of the demonstration running on the PIC32MZ EF Starter Kit connected to the MEB II with the MRF24WN PICtail Daughter Board.

Configuring the Hardware

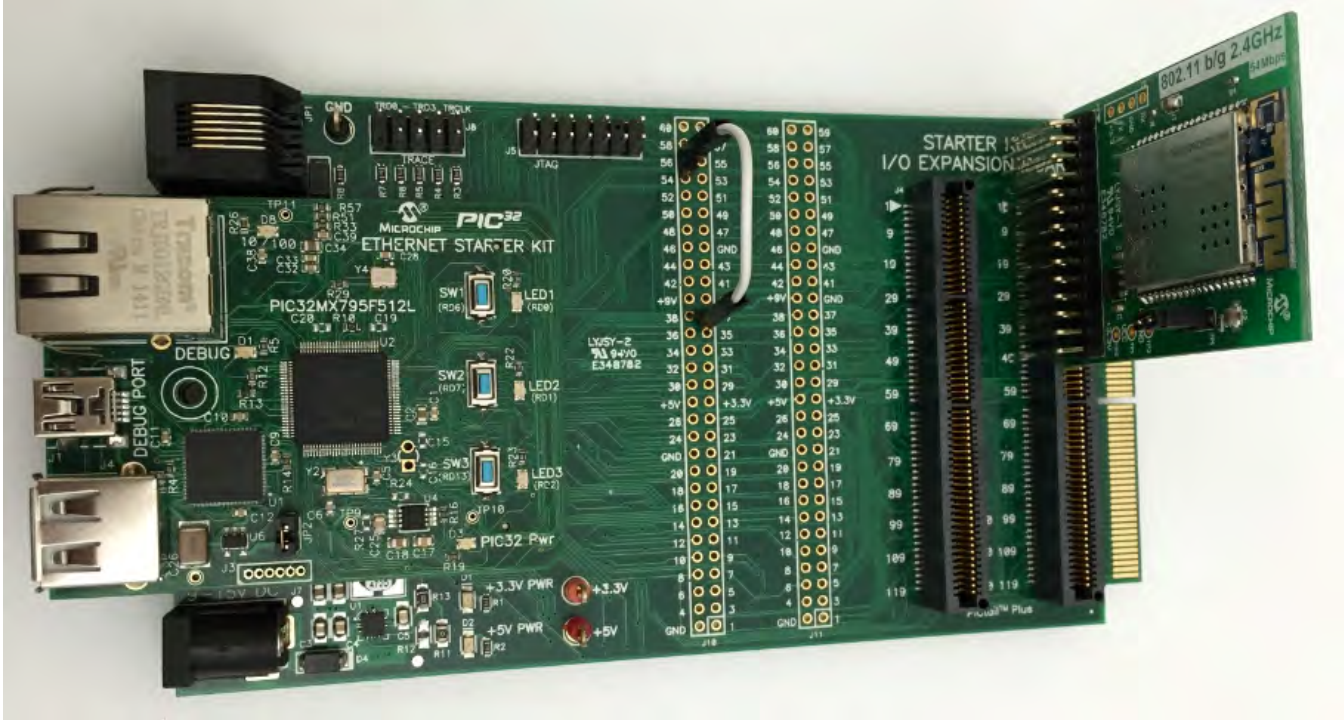
Describes how to configure the supported hardware.

Description

PIC32 Ethernet Starter Kit with PIC32MX795F512L, MRF24WG0MA Wi-Fi G PICtail/PICtail Plus Daughter Board, and Starter Kit I/O Expansion Board

Configure the Starter Kit I/O Expansion Board jumper modifications, as described in the following figure:

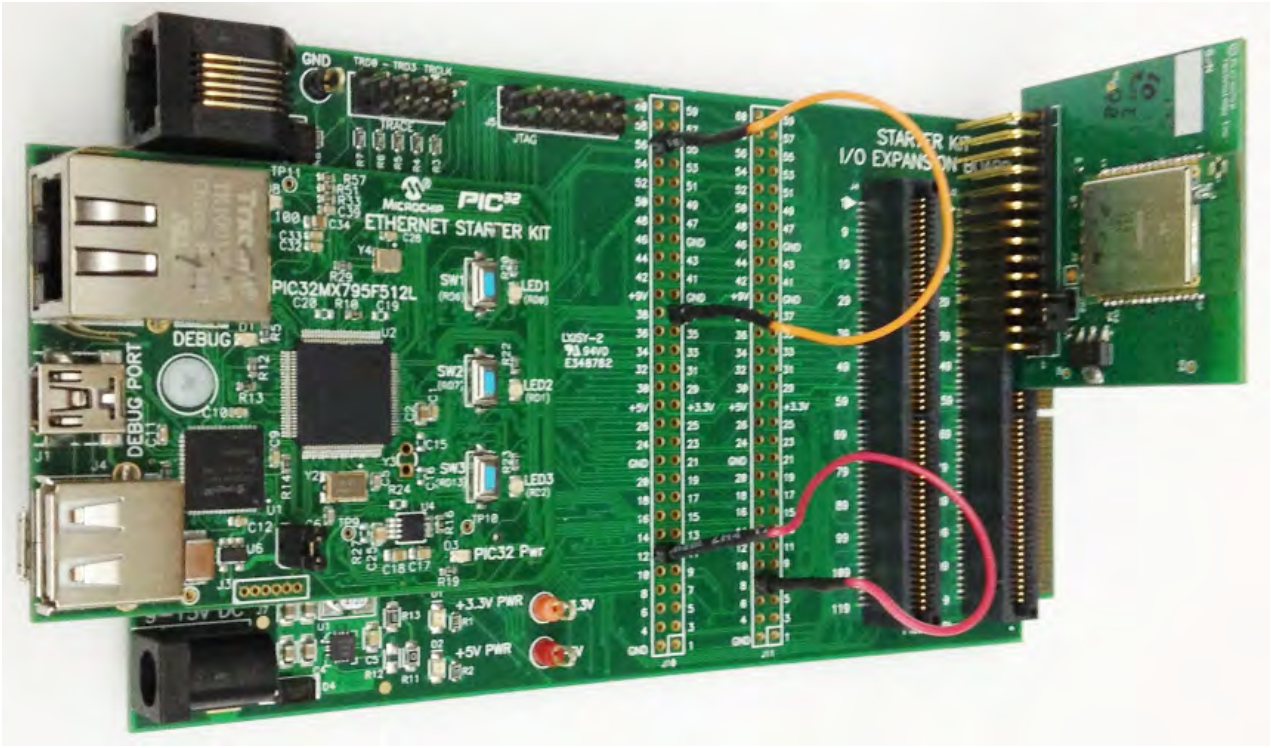
On-board Jumper: J10/pin 56 to J10/pin 37 (white jumper cable)



PIC32 Ethernet Starter Kit with PIC32MX795F512L, MRF24WN0MA Wi-Fi PICtail/PICtail Plus Daughter Board, and Starter Kit I/O Expansion Board

Configure the Starter Kit I/O Expansion Board jumper modifications, as described in the following figure:

On-board Jumpers: J10/pin 12 to J11/pin 8 (red jumper cable0, and J10/pin 56 to J10/pin 37 (orange jumper cable).

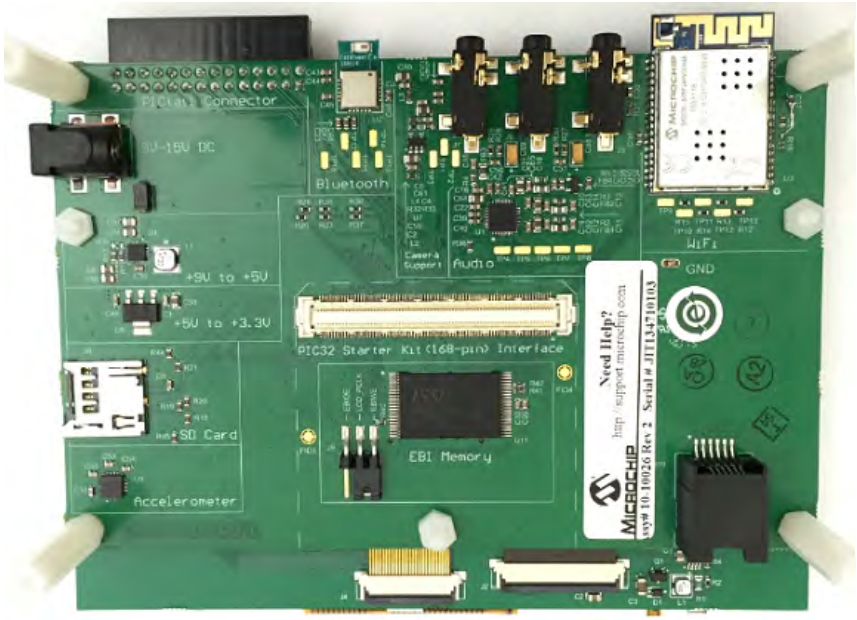


MRF24WG0MA Wi-Fi module, 4.3" WQVGA PCAP Display Board, and Multimedia Expansion Board II (MEB II)

Configure the hardware, as shown in the following figures:

Front Configuration

Back Configuration

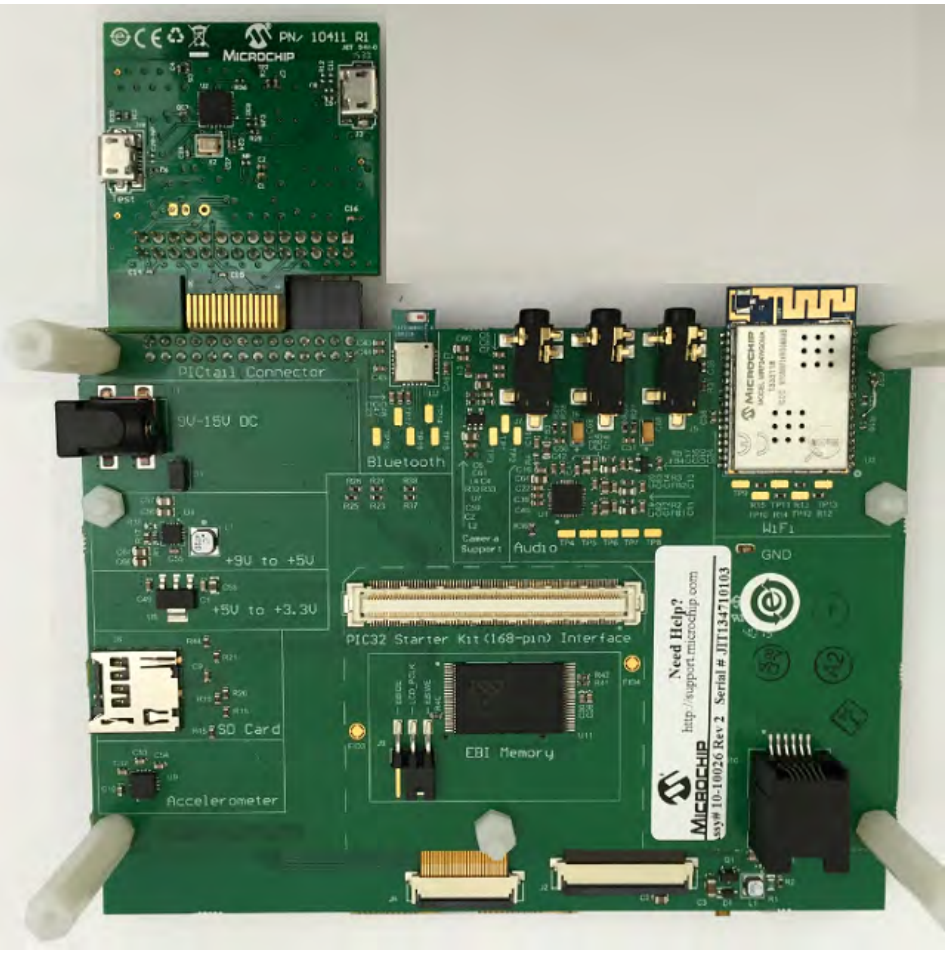


MRF24WG0MA Wi-Fi module, MRF24WN0MA Wi-Fi PICtail/PICtail Plus Daughter Board, 4.3" WQVGA PCAP Display Board, and Multimedia Expansion Board II (MEB II)

Configure the hardware, as shown in the following figures:

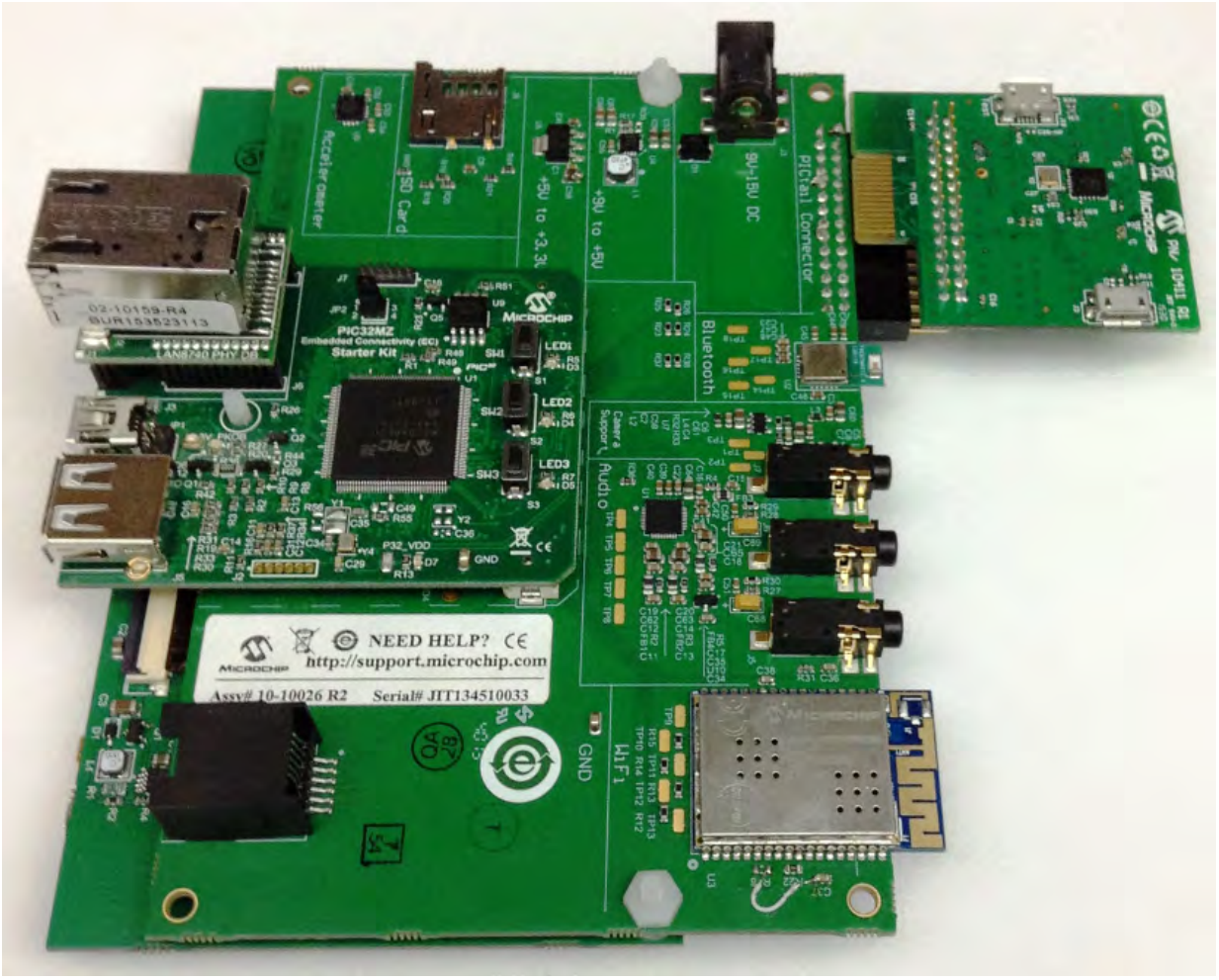
Front Configuration

Back Configuration



PIC32MZ EC Starter Kit with PIC32MZ2048ECH144, MRF24WG0MA Wi-Fi G module, MRF24WN0MA Wi-Fi PICtail/PICtail Plus Daughter Board, 4.3" WQVGA PCAP Display Board, and Multimedia Expansion Board II (MEB II)

Note: The PIC32MZ EC Starter Kit, shown in the following figure, can also be interchanged with the PIC32MZ EF Starter Kit with PIC32MZ2048EFM144.

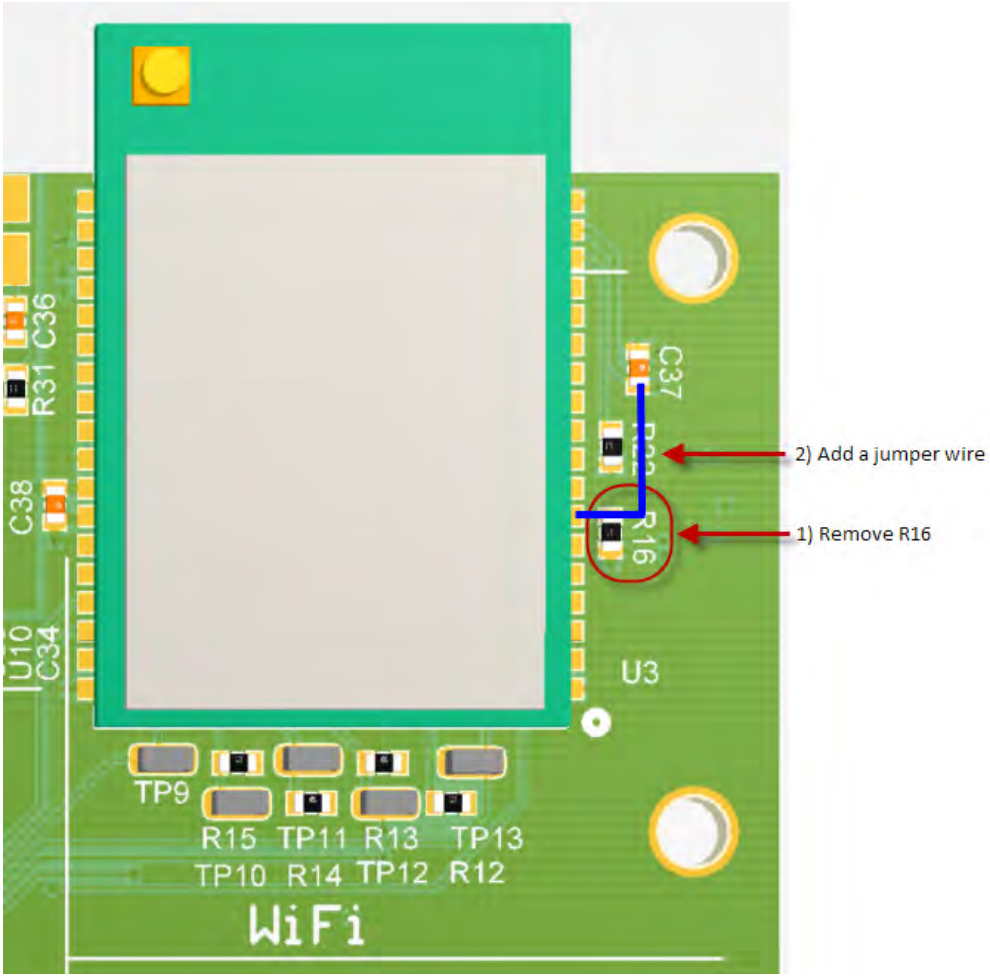


PIC32MZ EC Starter Kit or PIC32MZ EF Starter Kit and Multimedia Expansion Board II (MEB II)

Due to a hardware limitation, the pic32mz_ec_sk+meb2 configuration in the Ethernet and Wi-Fi Web server demonstration, exercises a Web server through Wi-Fi only. To enable Ethernet, use the following hardware work around and add the Ethernet interface in the project to run the Web server using both Ethernet and Wi-Fi connections. Refer to the following figure for details:

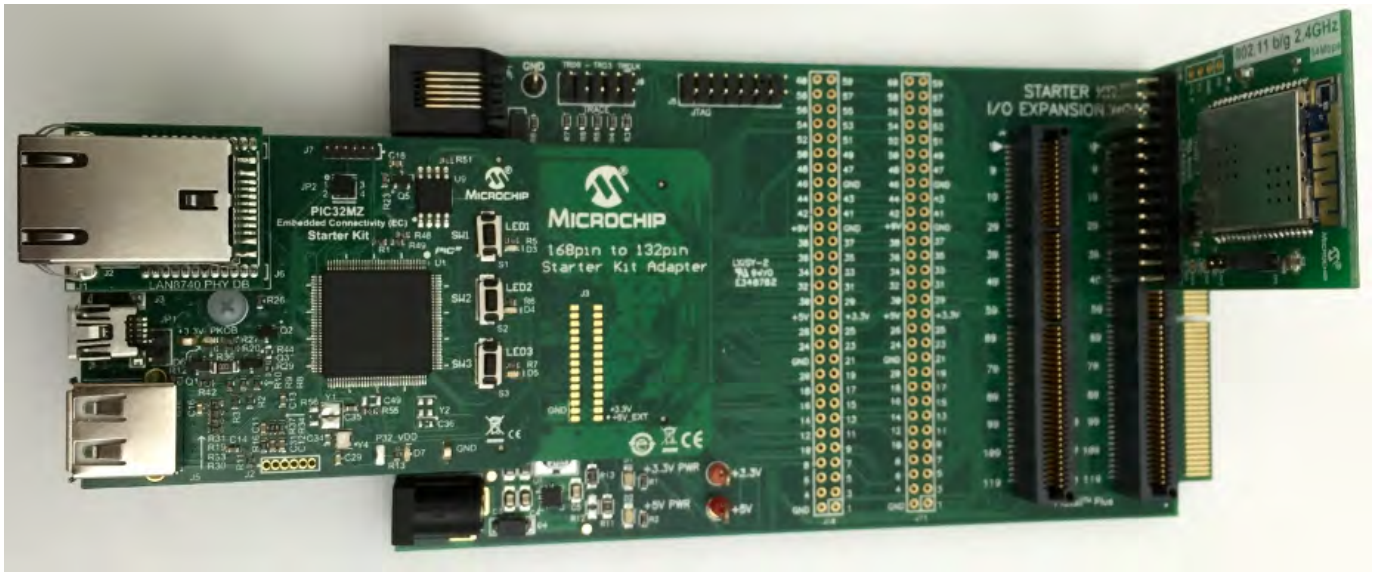
1. Remove R16, which is located near the Wi-Fi module of the MEB II,
2. Add a jumper wire from pin 7 of U3 to the lower pad of C37 (VCC).

Note: The MEB II development board should be powered with a 9V-15V DC power supply. The PIC32MZ EC or PIC32MZ EF Starter Kit board JP1 should be Open (no jumper).



PIC32MZ EC Starter Kit with PIC32MX2048ECH144, MRF24WG0MA Wi-Fi G PICtail/PICtail Plus Daughter Board, and Starter Kit I/O Expansion Board

Configure the hardware, as shown in the following figure:

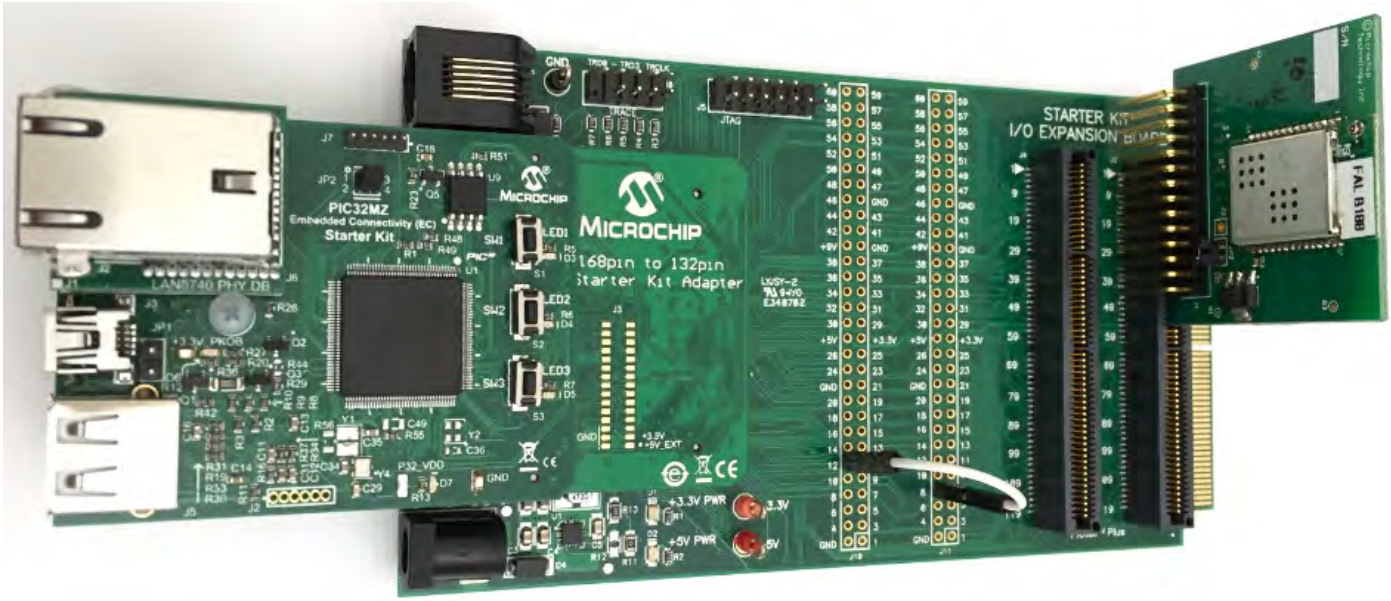


PIC32MZ EC Starter Kit, MRF24WN0MA Wi-Fi PICtail/PICtail Plus Daughter Board, and Starter Kit I/O Expansion Board

Note: The PIC32MZ EC Starter Kit, shown in the following figure, can also be interchanged with the PIC32MZ EF Starter Kit with PIC32MZ2048EFM144.

Configure the hardware, as shown in the following figure:

On-board Jumper: J10/pin 12 to J11/pin 8 (white jumper cable)



Running the Demonstration

This section provides instructions on how to build and run the PIC32 Ethernet Wi-Fi Web Server demonstration.

Description

To view the web page hosted by the demonstration application, open a web browser and direct it to the board running the HTTP server by typing the URL in the address bar (for example, http://mchpboard_w), and then pressing **Enter**.

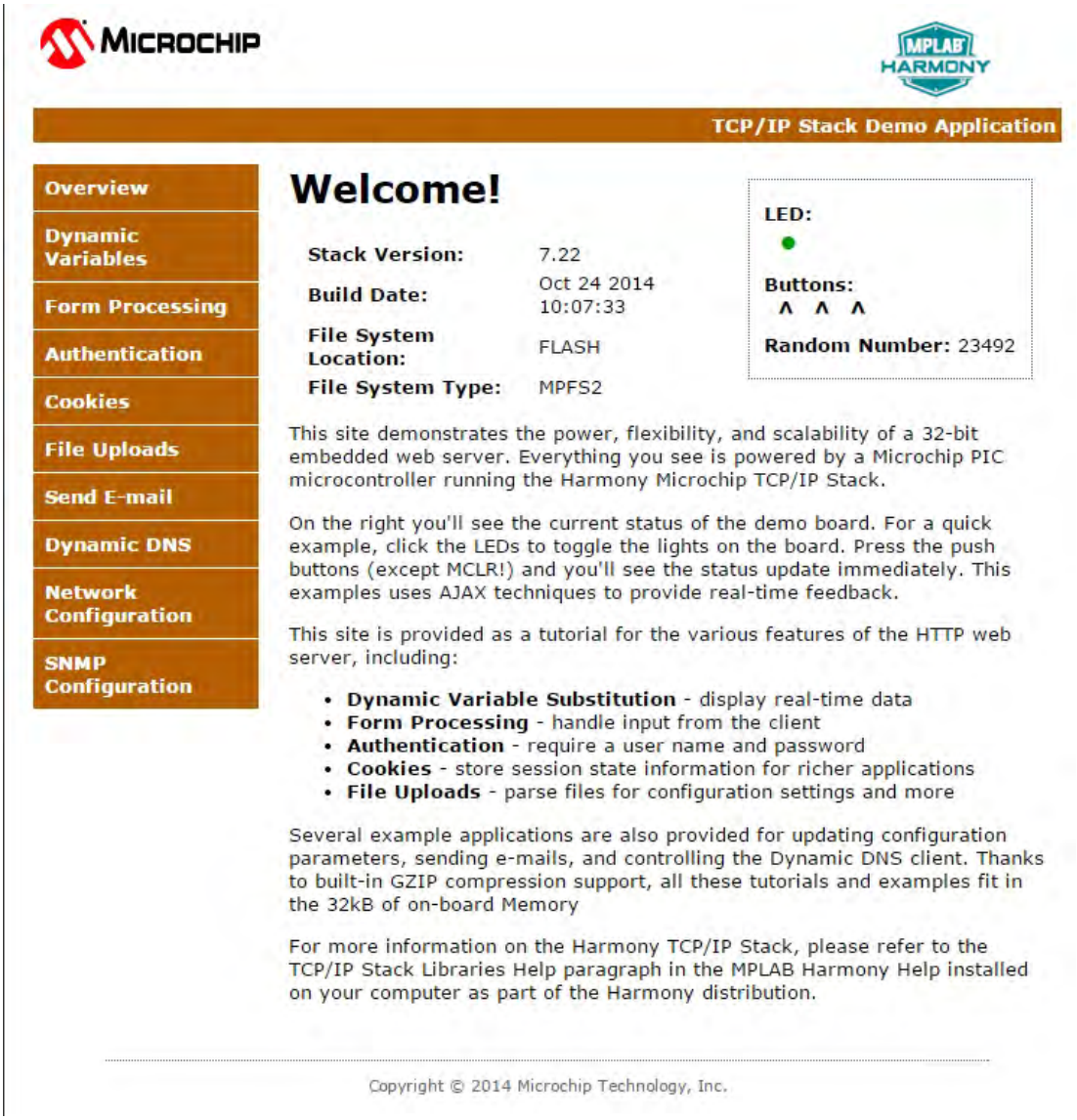
This demonstration runs on two interfaces, Ethernet and Wi-Fi. A second web browser tab could be opened pointing to the other interface (http://mchpboard_e) to have both interfaces running simultaneously.

Notes:

1. The NetBIOS name of the TCP/IP application is specified at the time the TCP/IP stack is initialized, which is usually in the hostName member of the tcpip_stack_init.c:: TCPIP_HOSTS_CONFIGURATION structure. The NetBIOS service must be enabled for the PIC32 demonstration to respond to NetBIOS queries. Alternatively, you can use the IPv4 or IPv6 address (if IPv6 is enabled) of the board directly, for example, http://192.168.1.131 or http://[fdfe:dcba:9876:1:204:a3ff:fe12:128e].
2. The IPv4 and IPv6 addresses can be obtained from running the TCP/IP Discovery application on the PC side. It requires that the TCP/IP Announce module is enabled when building the stack.
3. For the Wi-Fi demonstration to function properly on MEB2 development board, the board should be powered with a 9V-15V DC power supply. Also on the PIC32MZ EC or PIC32MZ EF Starter Kit board, JP1 jumper should be Open (no jumper).

Please refer to the **Demonstration Process** in the Running the Demonstration section for the pic32_eth_web_server configuration, as the process is the same for this configuration.

Note: Refer to Wi-Fi Console Commands for information on the commands that enable control over the Wi-Fi settings.



pic32_wifi_web_server

This section describes the steps necessary to begin using the PIC32 Wi-Fi Web Server Demonstration Application.

Description

The Wi-Fi Web Server demonstration (`<install-dir>\apps\tcpip\web_server_nvm_mpfs\firmware`) exercises the HTTP Web Server running on PIC32 devices. The Non-Volatile Memory (NVM) Microchip Proprietary File System (MPFS) Web Server demonstration has the Web pages stored in internal Flash and are accessed through the MPFS API.

Wi-Fi Demonstration Matrix

Refer to Wi-Fi Demonstration Configuration Matrix for additional information.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the PIC32 Wi-Fi Web Server Demonstration.

Description

To build this project, you must open the `pic32_wifi_web_server.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/tcpip/web_server_nvm_mpfs`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
pic32_wifi_web_server.X	<install-dir>/apps/tcpip/web_server_nvm_mpfs/firmware

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within ./firmware/src/system_config.

Project Configuration Name	BSP Used	Description
chipkit_wf32	chipkit_wf32	Demonstration running on the chipKIT™ WF32™ Wi-Fi Development Board with the PIC32MX695F512L and the MRF24WG PICtail module.
pic32mx795_pim+e16	pic32mx795_pim+e16	Demonstration running on the PIC32MX795F512L PIM and the Explorer 16 Development Board with the MRF24WG PICtail Daughter Board.
pic32mx795_pim+e16+freertos	pic32mx795_pim+e16	FreeRTOS version of the demonstration running on the PIC32MX795F512L PIM and the Explorer 16 Development Board with the MRF24WG PICtail Daughter Board.
pic32mx795_pim+e16+11n+freertos	pic32mx795_pim+e16	FreeRTOS version of the demonstration running on the PIC32MX795F512L PIM on the Explorer 16 Development Board with the MRF24WN PICtail Daughter Board.

Configuring the Hardware

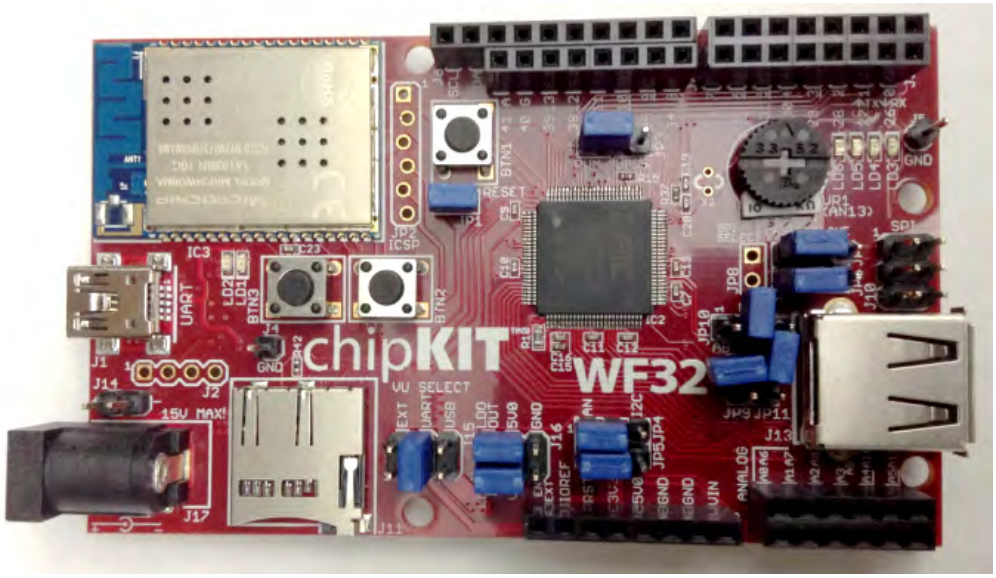
Describes how to configure the supported hardware.

Description

chipKIT™ WF32™ Wi-Fi Development Board with on-board MRF24WG PICtail and PIC32MX695F512L MCU

The console output uses the USB/Serial connector on the board at 115,200 baud, 8-bit data, No parity, 1 Stop bit, with No Flow control.

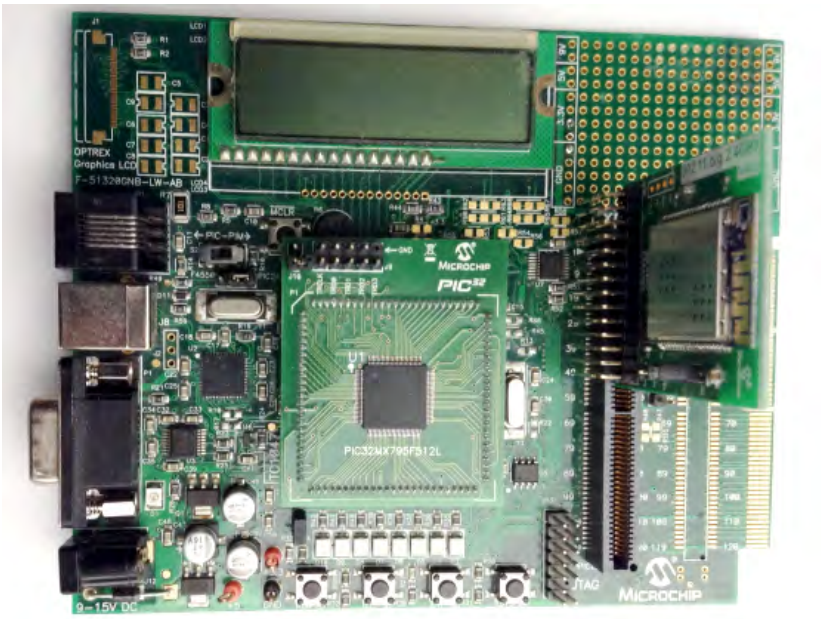
The following figure shows the hardware configuration.



PIC32MX795F512L PIM with the Explorer 16 Development Board and MRF24WG PICtail Daughter Board

- Connect the MRF24WG PICtail Daughter Board into the PICtail Plus slot closest to the MCU. The module should face into the board and be placed all the way to the end on the pin 1 side of the connector.
- The console output uses the DB9 connector on the board at 115200 baud, 8-bit data, No parity, 1 Stop bit, with No Flow Control

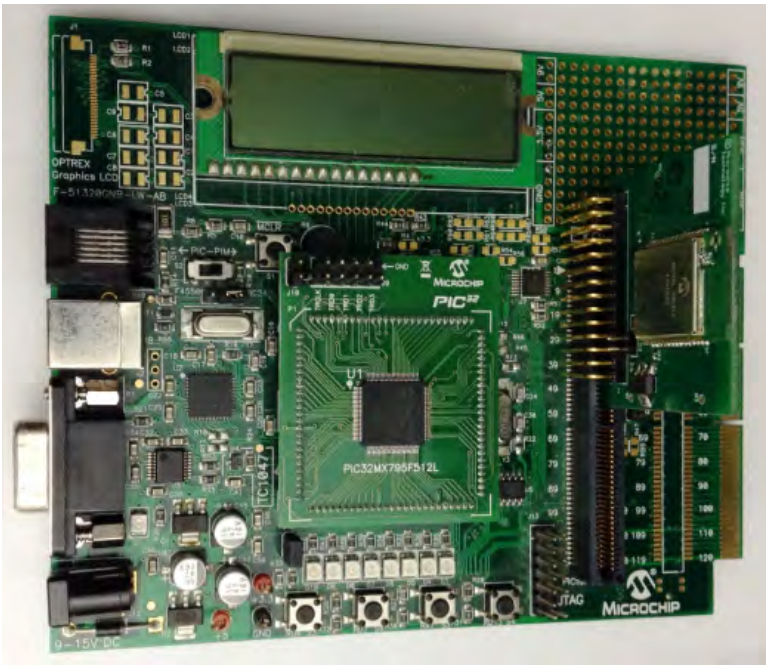
The following figure shows the hardware configuration.



PIC32MX795F512L PIM with the Explorer 16 Development Board and MRF24WN PICtail Daughter Board

- Connect the MRF24WN PICtail Daughter Board into the PICtail Plus slot closest to the MCU. The module should face into the board and be placed all the way to the end on the pin 1 side of the connector.
- The console output uses the DB9 connector on the board at 115200 baud, 8-bit data, No parity, 1 Stop bit, with No Flow Control

The following figure shows the hardware configuration.



Running the Demonstration

This section provides instructions on how to build and run the PIC32 Wi-Fi Web Server demonstration.

Description

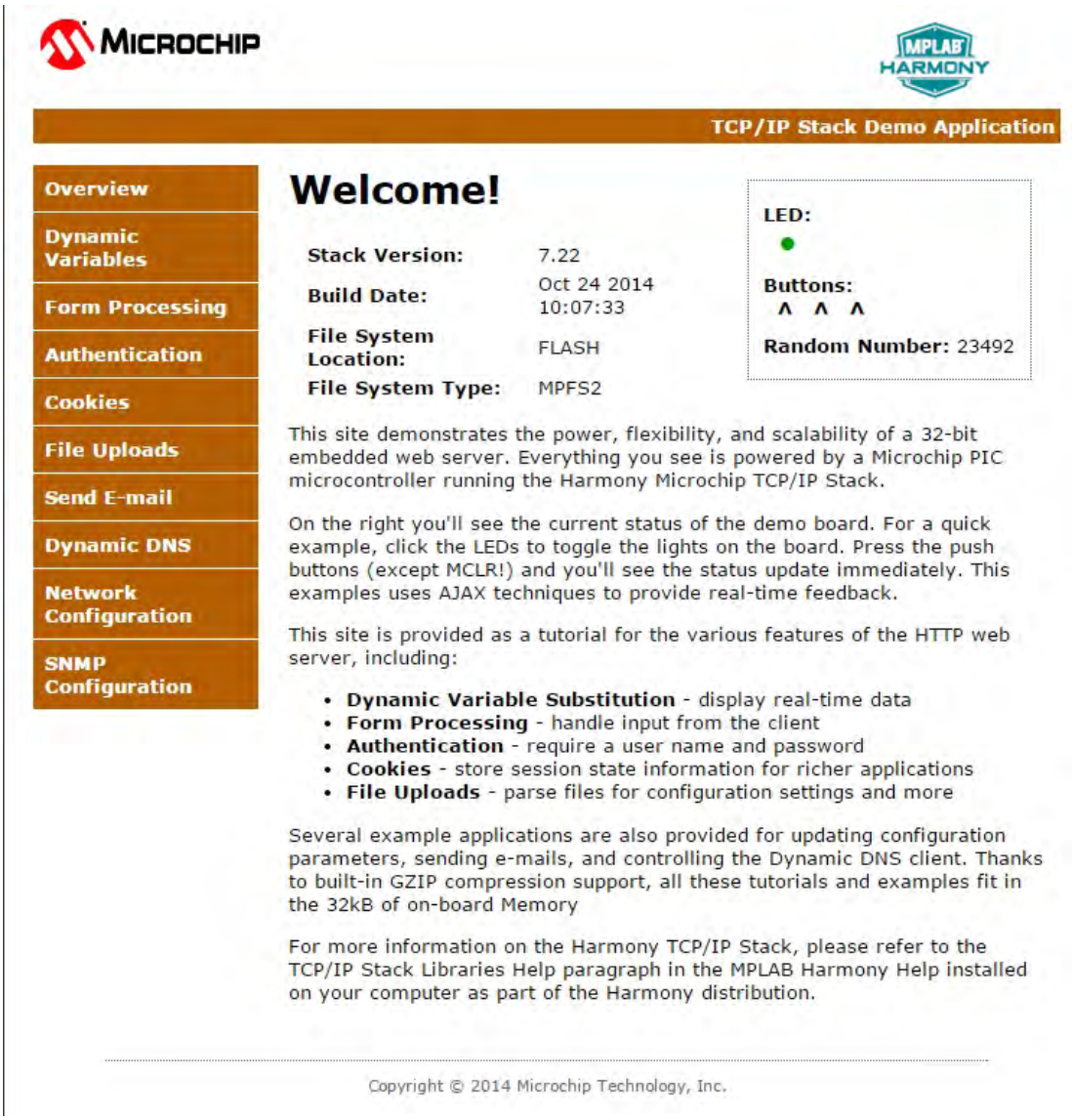
To view the web page hosted by the demonstration application, open a web browser and direct it to the board running the HTTP server by typing the URL in the address bar (for example, http://mchpboard_w), and then pressing **Enter**.

Notes:

1. The NetBIOS name of the TCP/IP application is specified at the time the TCP/IP stack is initialized, which is usually in the hostName member of the tcpip_stack_init.c:: TCPIP_HOSTS_CONFIGURATION structure. The NetBIOS service must be enabled for the PIC32 demonstration to respond to NetBIOS queries. Alternatively, you can use the IPv4 or IPv6 address (if IPv6 is enabled) of the board directly, for example, http://192.168.1.131 or http://[fdfe:dcba:9876:1:204:a3ff:fe12:128e].
2. The IPv4 and IPv6 addresses can be obtained from running the TCP/IP Discovery application on the PC side. It requires that the TCP/IP Announce module is enabled when building the stack.

Please refer to the **Demonstration Process** in the Running the Demonstration section for the pic32_eth_web_server configuration, as the process is the same for this configuration.

Note: Refer to Wi-Fi Console Commands for information on the commands that enable control over the Wi-Fi settings.



web_server_sdcard_fatfs

Web Server SD Card FAT File System TCP/IP demonstration.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the Web Server SD Card FAT FS Demonstration.

Description

To build this project, you must open the `pic32_eth_web_server.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/tcpip/web_server_sdcard_fatfs`.

Warning

When using the Microchip Harmony Configurator (MHC), care must be taken when generating the code to *not* erase the USB descriptors in the `system_init.c` file.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`pic32_eth_web_server.X`	`<install-dir>/apps/tcpip/web_server_sdcard_fatfs/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx_eth_sk2_sd_mmc_pictail	pic32mx_eth_sk2	Demonstrates the Web Server hosted on a microSD card through the FAT file system on the PIC32 Ethernet Starter Kit II and the PICtail Daughter Board for SD and MMC.
pic32mz_ef_sk_meb2	pic32mz_ef_sk+meb2	Demonstrates the Web Server hosted on a microSD card through the FAT file system on the PIC32MZ EF Starter Kit and the MEB II combination.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32 Ethernet Starter Kit with the Starter Kit I/O Expansion Board and PICtail Daughter Board for SD and MMC

- Plug the PIC32 Ethernet Starter Kit into application board connector (J1) on the Starter Kit I/O Expansion Board
- Plug the PICtail Daughter Board for SD and MMC into the PICtail connector (J4) on the Starter Kit I/O Expansion Board
- Make sure a SD card is formatted and loaded with the web pages provided within the `apps/tcpip/web_server_sdcard_fatfs/firmware/src/web_pages2_sdcard` folder
- Insert the SD card with the web pages into the SD card slot (J1) on the PICtail Daughter Board for SD and MMC into the PICtail connector
- Connect a USB cable to the micro-B USB connector on the bottom of the PIC32 Ethernet Starter Kit. When the demonstration runs, it will create a USB CDC device on the USB bus. Connect to this device though a standard terminal program, and set the baud rate to 921,600 baud. You can observe the IP address details and query the stack using the console interface.

PIC32 Ethernet Starter Kit II with the Starter Kit I/O Expansion Board and PICtail Daughter Board for SD and MMC

- Plug the PIC32 Ethernet Starter Kit II into application board connector (J1) on the Starter Kit I/O Expansion Board
- Plug the PICtail Daughter Board for SD and MMC into the PICtail connector (J4) on the Starter Kit I/O Expansion Board
- Make sure a SD card is formatted and loaded with the web pages provided within the `apps/tcpip/web_server_sdcard_fatfs/firmware/src/web_pages2_sdcard` folder
- Insert the SD card with the web pages into the SD card slot (J1) on the PICtail Daughter Board for SD and MMC into the PICtail connector
- Connect a USB cable to the micro-B USB connector on the bottom of the PIC32 Ethernet Starter Kit II. When the demonstration runs, it will create a USB CDC device on the USB bus. Connect to this device though a standard terminal program, and set the baud rate to 921,600 baud. You can observe the IP address details and query the stack using the console interface.

PIC32MZ EC Starter Kit or PIC32MZ EF Starter Kit with the MEB II

- Plug the desired starter kit into the application board connector on the MEB II
- Ensure a microSD card is formatted and loaded with the web pages provided within the `apps/tcpip/web_server_sdcard_fatfs/firmware/src/web_pages2_sdcard` directory.
- Insert the microSD card with the web pages into the microSD card slot (J8) on the MEB II
- Connect a USB cable to the micro-B USB connector on the bottom of the PIC32MZ EC Starter Kit
- When the demonstration runs, it will create a USB CDC device on the USB bus. Connect to this device though a standard terminal program, and set the baud rate to 921,600 baud. You can observe the IP address details and query the stack using the console interface.

Running the Demonstration

This section provides instructions on how to build and run the TCP/IP SD Card FAT FS Web Server demonstration.

Description

To view the web page hosted by the demonstration application, open a web browser and direct it to the board running the HTTP server by typing the URL in the address bar (for example, http://mchpboard_e), and then pressing **Enter**.

Notes:

1. The NetBIOS name of the TCP/IP application is specified at the time the TCP/IP stack is initialized, which is usually in the hostName member of the tcpip_stack_init.c:: TCPIP_HOSTS_CONFIGURATION structure. The NetBIOS service must be enabled for the PIC32 demonstration to respond to NetBIOS queries. Alternatively, you can use the IPv4 or IPv6 address (if IPv6 is enabled) of the board directly, for example, http://192.168.1.131 or http://[fdfe:dcba:9876:1:204:a3ff:fe12:128e].
2. The IPv4 and IPv6 addresses can be obtained from running the TCP/IP Discovery application on the PC side. It requires that the TCP/IP Announce module is enabled when building the stack.

Please refer to the **Demonstration Process** in the Running the Demonstration section for the pic32_eth_web_server configuration of the web_server_nvm_mpfs demonstration, as the process is the same for this configuration.

wifi_easy_configuration

This topic contains the Wi-Fi Easy Configuration TCP/IP demonstration.

Description

This demonstration shows how to connect a MRF24WG or MRF24WN Wi-Fi device with no keyboard or display to a wireless network.

Wi-Fi Demonstration Matrix

Refer to Wi-Fi Demonstration Configuration Matrix for additional information.

Notes:

1. For the pic32mz_ec_sk+meb2 or pic32mz_ef_sk+meb2 configuration, either or both the MRF24WG Wi-Fi module and MRF24WN Wi-Fi PICtail may be installed, but only one Wi-Fi module will be active depending on the MHC selection of the MRF24W. If the MRF24WG Wi-Fi module is selected, it will not work if the MRF24WN Wi-Fi PICtail is installed.
2. For the Wi-Fi demonstration to function properly on the MEB II development board, the board should be powered with a 9V-15V DC power supply. Also on the PIC32MZ EC or PIC32MZ EF Starter Kit board, JP1 jumper should be Open (no jumper).

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the PIC32 Wi-Fi Easy Configuration Demonstration.

Description

To build this project, you must open the `wifi_easy_configuration.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/tcpip/wifi_easy_configuration`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`wifi_easy_configuration.X`	`<install-dir>/apps/tcpip/wifi_easy_configuration/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx_eth_sk_ioexp	pic32mx_eth_sk	Demonstration running on the PIC32MZ EC Starter Kit using the I/O Expansion Board with the MRF24WG PICtail Daughter Board.
pic32mx_eth_sk_ioexp+freertos	pic32mx_eth_sk	FreeRTOS version of the demonstration running on the PIC32MZ EC Starter Kit connected to the I/O Expansion Board with the MRF24WG PICtail Daughter Board.
pic32mx795_pim+e16	pic32mx795_pim+e16	Demonstration running on the PIC32MX795F512L PIM on the Explorer 16 Development Board with the MRF24WG PICtail Daughter Board.

pic32mx795_pim+e16+freertos	pic32mx795_pim+e16	FreeRTOS version of the demonstration running on the PIC32MX795F512L PIM on the Explorer 16 Development Board with the MRF24WG PICtail Daughter Board.
pic32mz_ec_sk_ioexp	pic32mz_ec_sk	Demonstration running on the PIC32MZ EC Starter Kit connected to the I/O Expansion board with the MRF24WG PICtail Daughter Board.
pic32mz_ec_sk_ioexp+freertos	pic32mz_ec_sk	FreeRTOS version of the demonstration running on the PIC32MZ EC Starter Kit connected to the I/O Expansion board with the MRF24WG PICtail Daughter Board.
pic32mz_ec_sk+meb2	pic32mz_ec_sk+meb2	Demonstration running on the PIC32MZ EC Starter Kit connected to the MEB II with the MRF24WG PICtail Daughter Board.
pic32mz_ec_sk+meb2+freertos	pic32mz_ec_sk+meb2	FreeRTOS version of the demonstration running on the PIC32MZ EC Starter Kit connected to the MEB II with the MRF24WG PICtail Daughter Board.
pic32mx795_pim+e16+11n+freertos	pic32mx795_pim+e16	FreeRTOS version of the demonstration running on the PIC32MX795F512L PIM on the Explorer 16 Development Board with the MRF24WN PICtail Daughter Board.
pic32mx_eth_sk_ioexp+11n+freertos	pic32mx_eth_sk	Demonstration running FreeRTOS on the PIC32 Ethernet Starter Kit connected to the Starter Kit I/O Expansion Board with the MRF24WN PICtail Daughter Board.
pic32mz_ec_sk_ioexp+11n+freertos	pic32mz_ec_sk	Demonstration running FreeRTOS on the PIC32MZ EC Starter Kit connected to the Starter Kit I/O Expansion Board with the MRF24WN PICtail Daughter Board.
pic32mz_ec_sk_meb2+11n+freertos	pic32mz_ec_sk+meb2	Demonstration running FreeRTOS on the PIC32MZ EC Starter Kit and the MEB II.
pic32mz_ef_sk+ioexp	pic32mz_ef_sk	Demonstration running on the PIC32MZ EF Starter Kit connected to the I/O Expansion board with the MRF24WG PICtail Daughter Board
pic32mz_ef_sk+ioexp+freertos	pic32mz_ef_sk	FreeRTOS version of the demonstration running on the PIC32MZ EF Starter Kit connected to the I/O Expansion board with the MRF24WG PICtail Daughter Board.
pic32mz_ef_sk+meb2	pic32mz_ef_sk+meb2	Demonstration running on the PIC32MZ EF Starter Kit connected to the MEB II with the MRF24WG PICtail Daughter Board.
pic32mz_ef_sk+meb2+freertos	pic32mz_ef_sk+meb2	FreeRTOS version of the demonstration running on the PIC32MZ EF Starter Kit connected to the I/O Expansion board with the MRF24WG PICtail Daughter Board.
pic32mz_ef_sk+ioexp+11n+freertos	pic32mz_ef_sk	FreeRTOS version of the demonstration running on the PIC32MZ EF Starter Kit connected to the I/O Expansion board with the MRF24WN PICtail Daughter Board.
pic32mz_ef_sk+meb2+11n+freertos	pic32mz_ef_sk	FreeRTOS version of the demonstration running on the PIC32MZ EF Starter Kit connected to the MEB II with the MRF24WN PICtail Daughter Board.

Configuring the Hardware

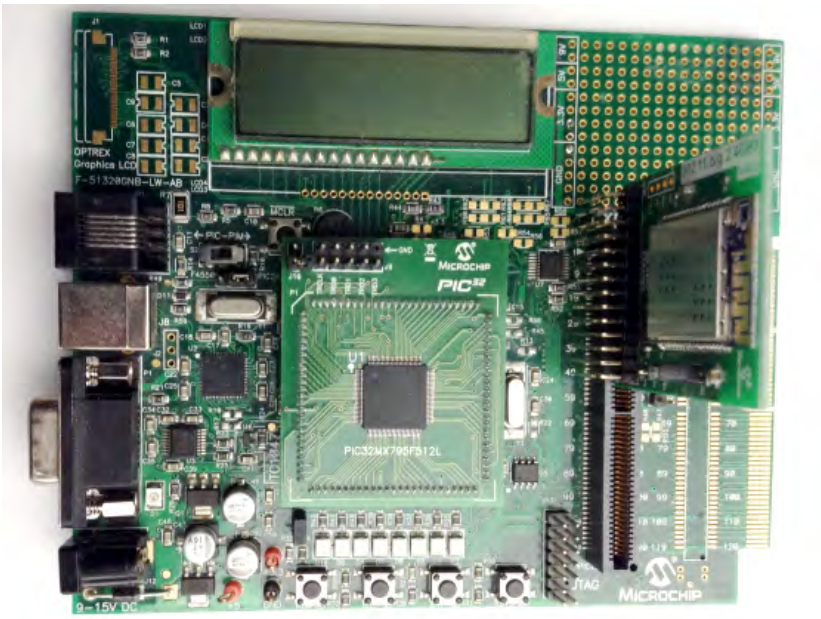
Describes how to configure the supported hardware.

Description

PIC32MX795F512L PIM with the Explorer 16 Development Board and MRF24WG PICtail Daughter Board

- Connect the MRF24WG PICtail Daughter Board into the PICtail Plus slot closest to the MCU. The module should face into the board and be placed all the way to the end on the pin 1 side of the connector.
- The console output uses the DB9 connector on the board at 115200 baud, 8-bit data, No parity, 1 Stop bit, with No Flow Control

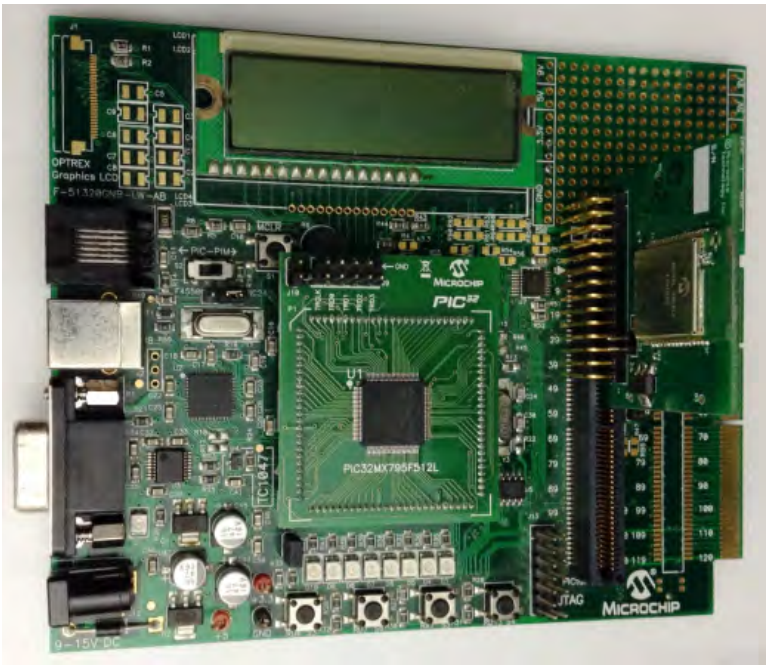
The following figure shows the hardware configuration.



PIC32MX795F512L PIM with the Explorer 16 Development Board and MRF24WN PICtail Daughter Board

- Connect the MRF24WN PICtail Daughter Board into the PICtail Plus slot closest to the MCU. The module should face into the board and be placed all the way to the end on the pin 1 side of the connector.
- The console output uses the DB9 connector on the board at 115200 baud, 8-bit data, No parity, 1 Stop bit, with No Flow Control

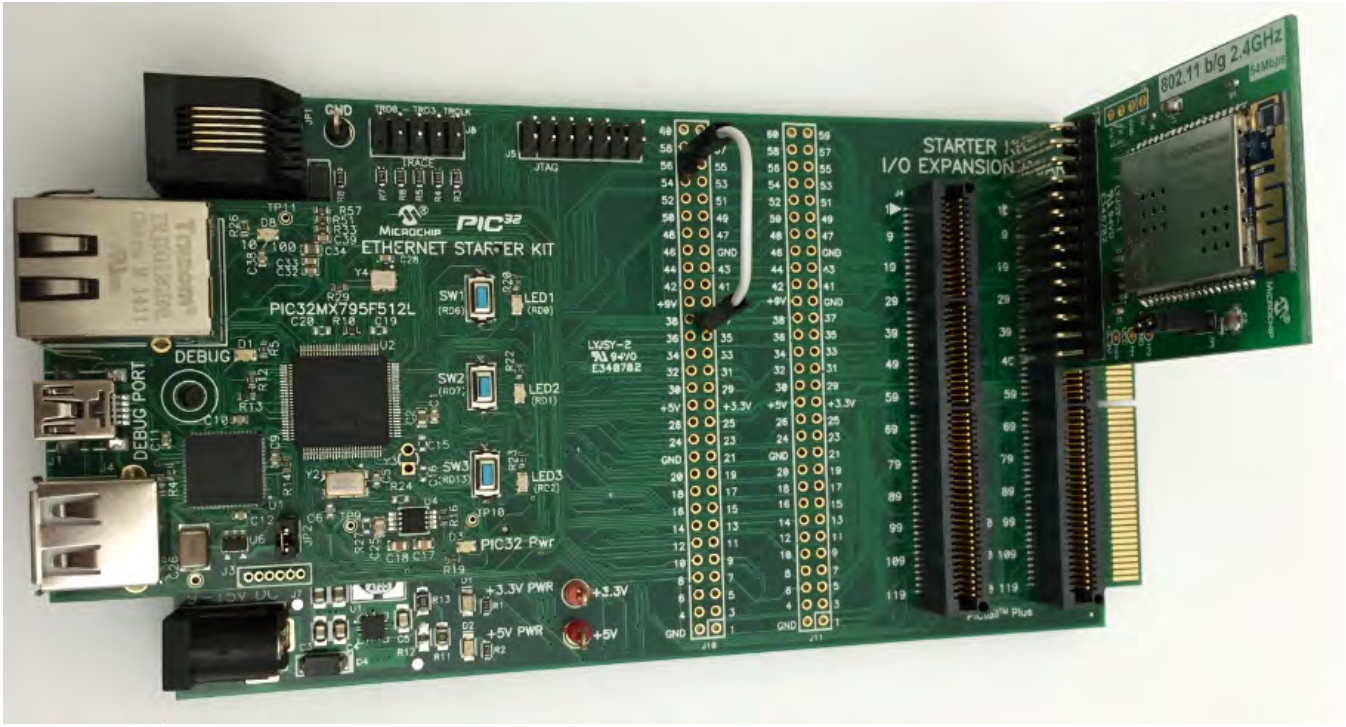
The following figure shows the hardware configuration.



PIC32 Ethernet Starter Kit, MRF24WG0MA Wi-Fi G PICtail/PICtail Plus Daughter Board, and Starter Kit I/O Expansion Board

Configure the Starter Kit I/O Expansion Board jumper modifications, as described in the following figure:

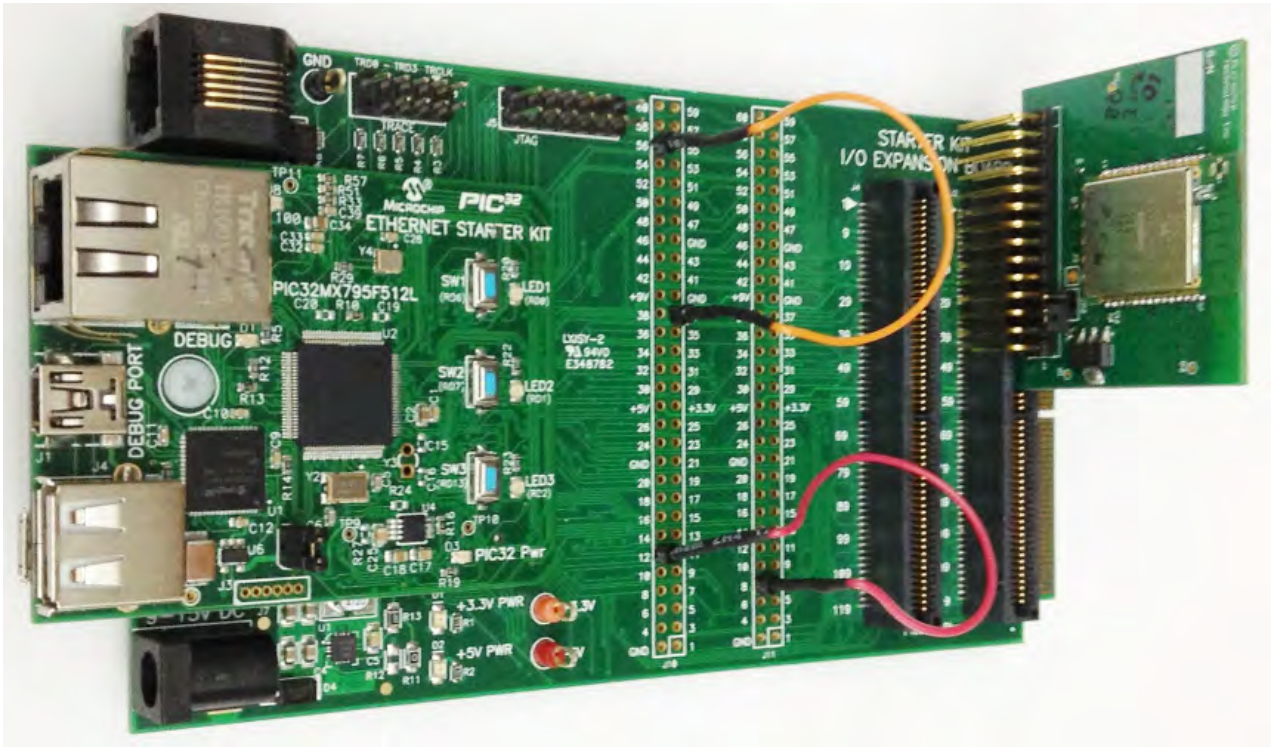
On-board Jumper: J10/pin 56 to J10/pin 37 (white jumper cable)



PIC32 Ethernet Starter Kit, MRF24WN0MA Wi-Fi PICtail/PICtail Plus Daughter Board, and Starter Kit I/O Expansion Board

Configure the Starter Kit I/O Expansion Board jumper modifications, as described in the following figure:

On-board Jumpers: J10/pin 12 to J11/pin 8 (red jumper cable), and J10/pin 56 to J10/pin 37 (orange jumper cable).

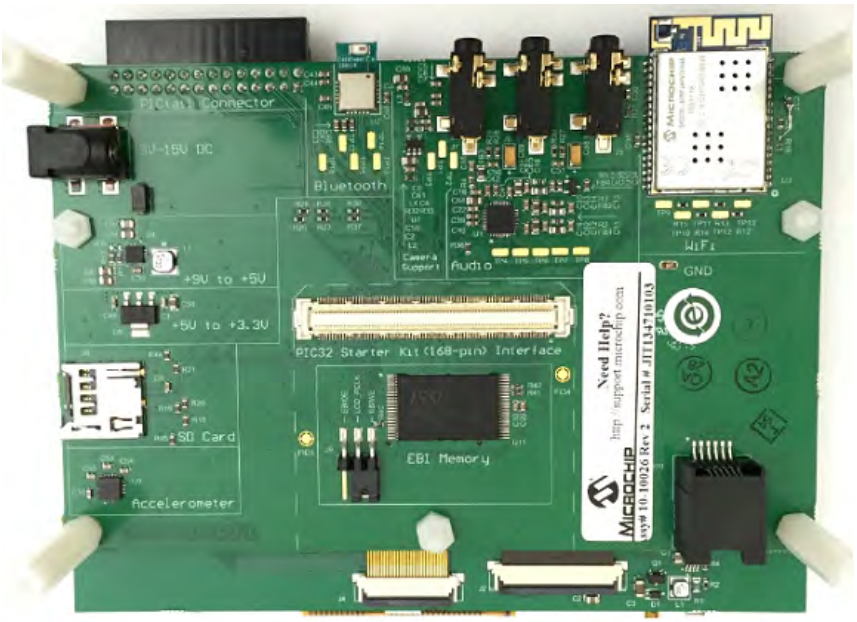


MRF24WG0MA Wi-Fi G module, 4.3" WQVGA PCAP Display Board, and Multimedia Expansion Board II (MEB II)

Configure the hardware, as shown in the following figures:

Front Configuration

Back Configuration

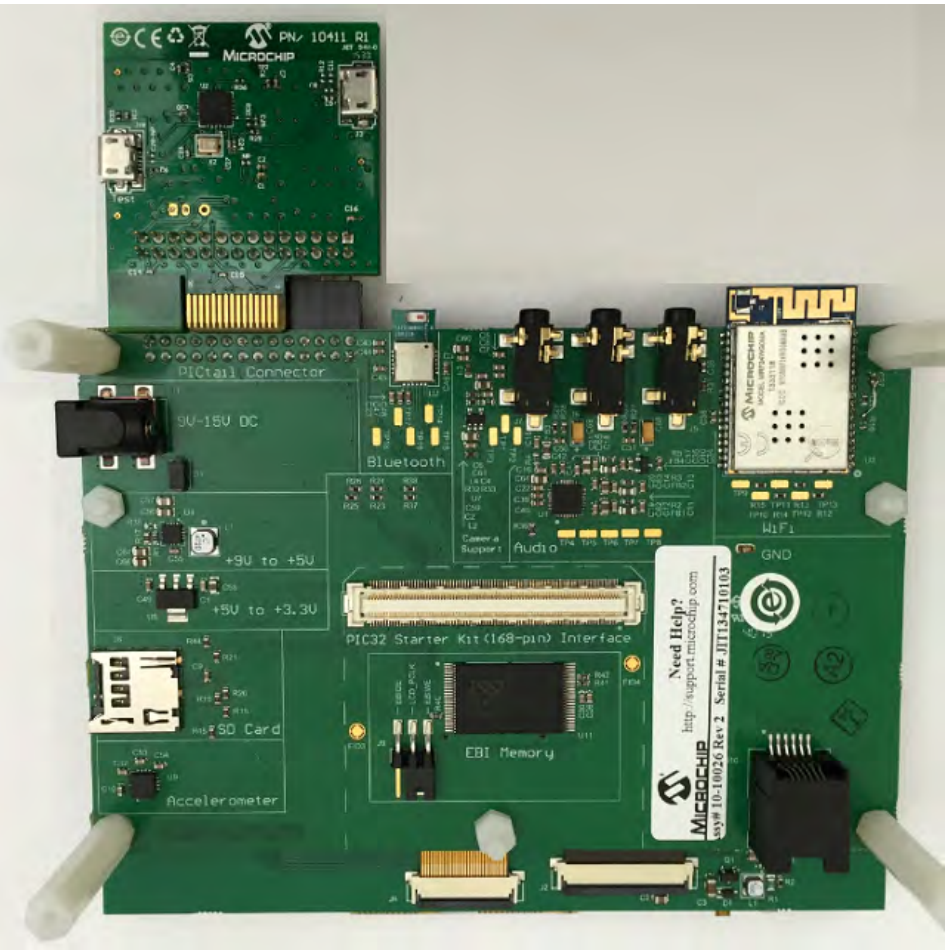


MRF24WF0MA Wi-Fi module, MRF24WN0MA Wi-Fi PICtail/PICtail Plus Daughter Board, 4.3" PCAP Display Board, and Multimedia Expansion Board II (MEB II)

Configure the hardware, as shown in the following figures:

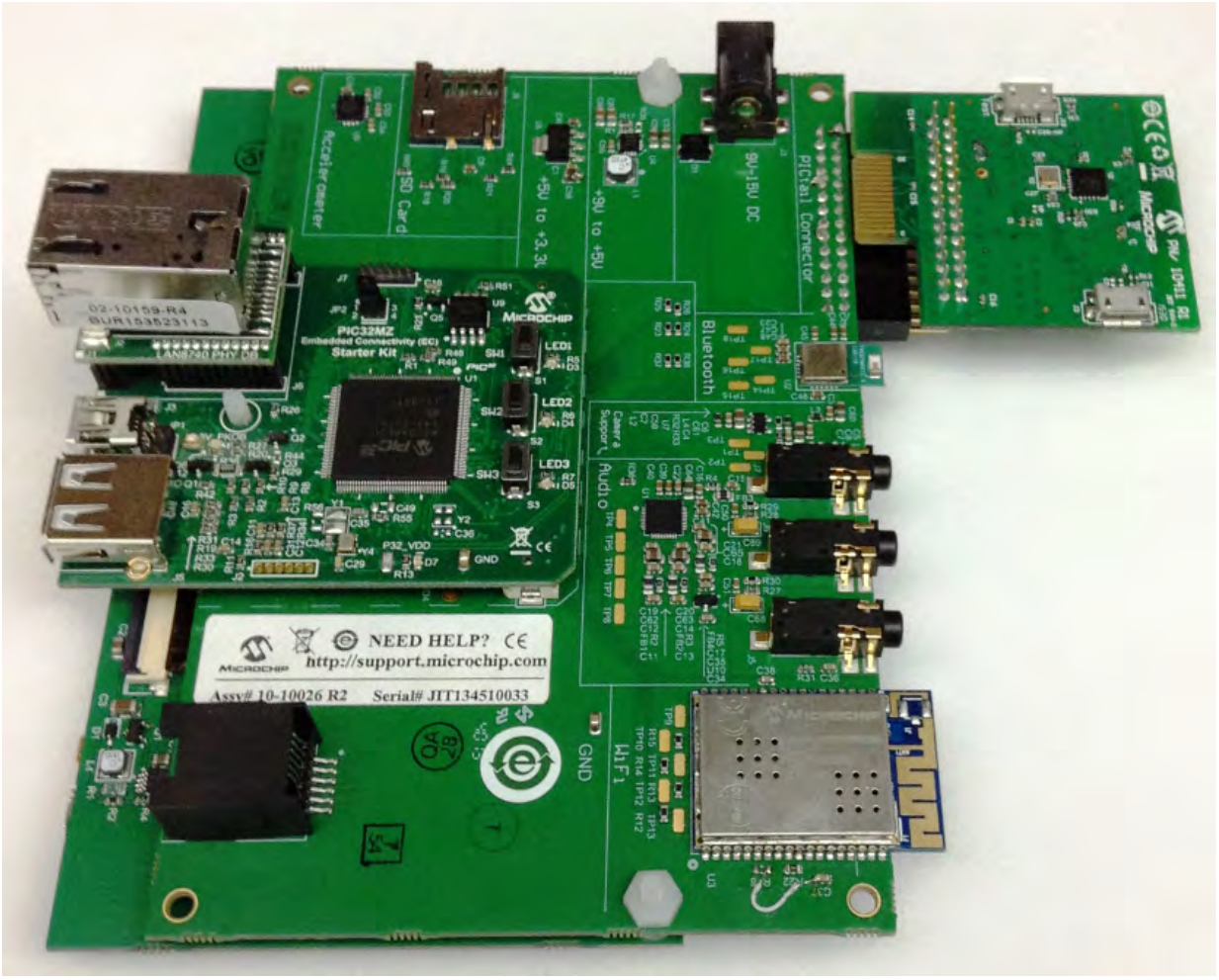
Front Configuration

Back Configuration



PIC32MZ EC Starter Kit with PIC32MZ2048ECH144, MRF24WG0MA Wi-Fi module, MRF24WN0MA Wi-Fi PICtail/PICtail Plus Daughter Board, 4.3" WQVGA PCAP Display Board, and Multimedia Expansion Board II (MEB II)

Note: The PIC32MZ EC Starter Kit, shown in the following figure, can also be interchanged with the PIC32MZ EF Starter Kit with PIC32MZ2048EFM144.

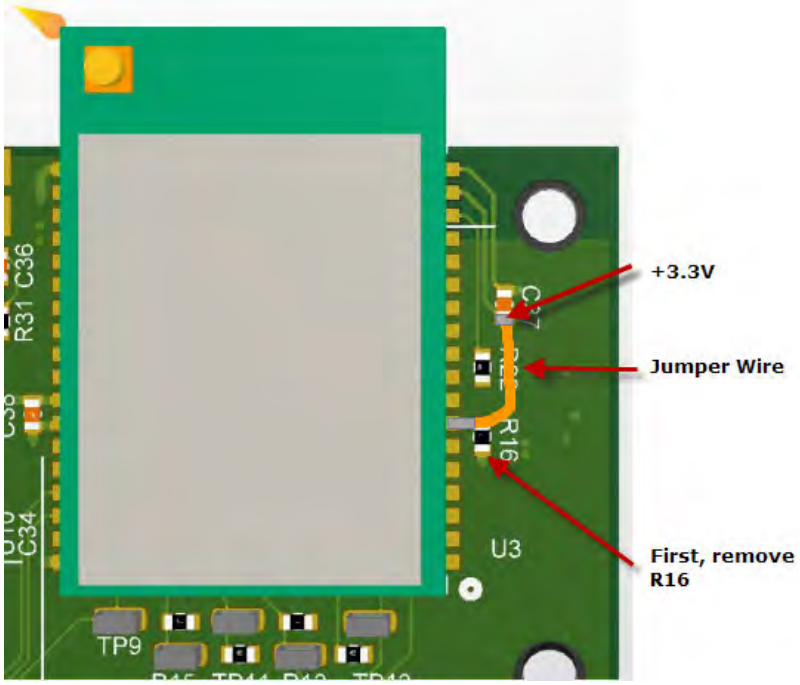


PIC32MZ EC Starter Kit or PIC32MZ EF Starter Kit and MEB II

Due to a hardware limitation, the pic32mz_ec_sk+meb2 configuration in the Ethernet and Wi-Fi Web server demonstration, exercises a Web server through Wi-Fi only. To enable Ethernet, use the following hardware work around and add the Ethernet interface in the project to run the Web server using both Ethernet and Wi-Fi connections. Refer to the following figure for details:

1. Remove R16, which is located near the Wi-Fi module of the MEB II.
2. Add a jumper wire from pin 7 of U3 to the lower pad of C37 (VCC).

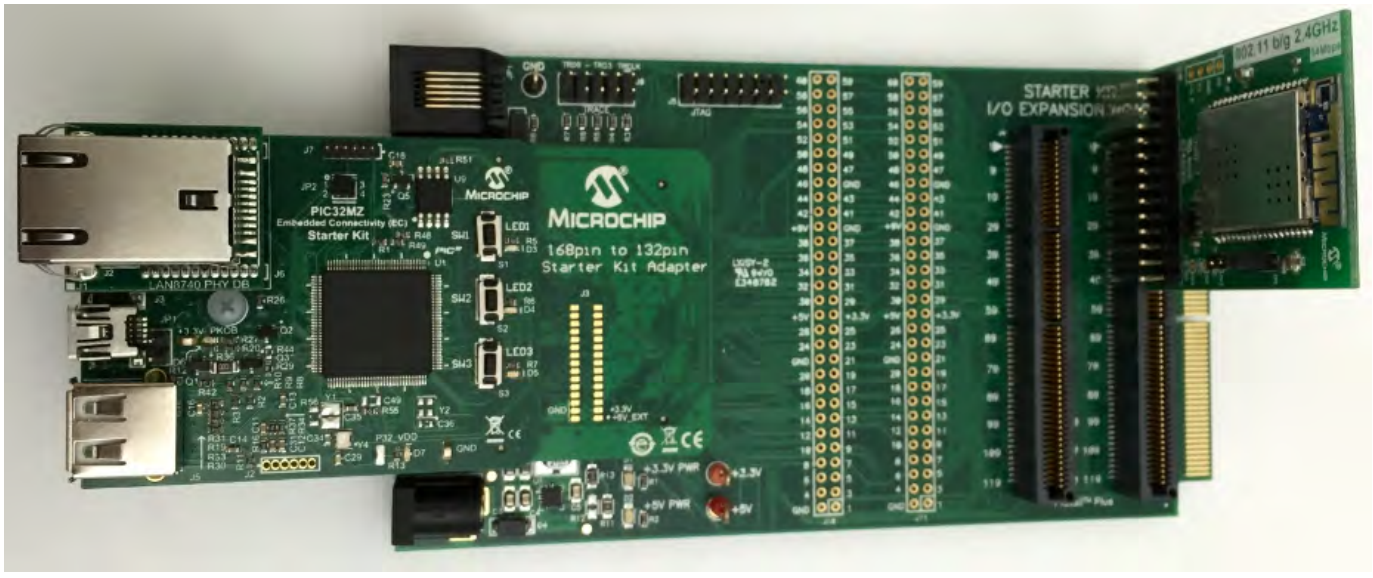
Note: The MEB II development board should be powered with a 9V-15V DC power supply. The PIC32MZ EC or PIC32MZ EF Starter Kit board JP1 should be Open (no jumper).



PIC32MZ EC Starter Kit with PIC32MZ2048ECH144, MRF24WG0MA Wi-Fi G PICtail/PICtail Plus Daughter Board, and Starter Kit I/O Expansion Board

Note: The PIC32MZ EC Starter Kit, shown in the following figure, can also be interchanged with the PIC32MZ EF Starter Kit with PIC32MZ2048EFM144.

Configure the hardware, as shown in the following figure:

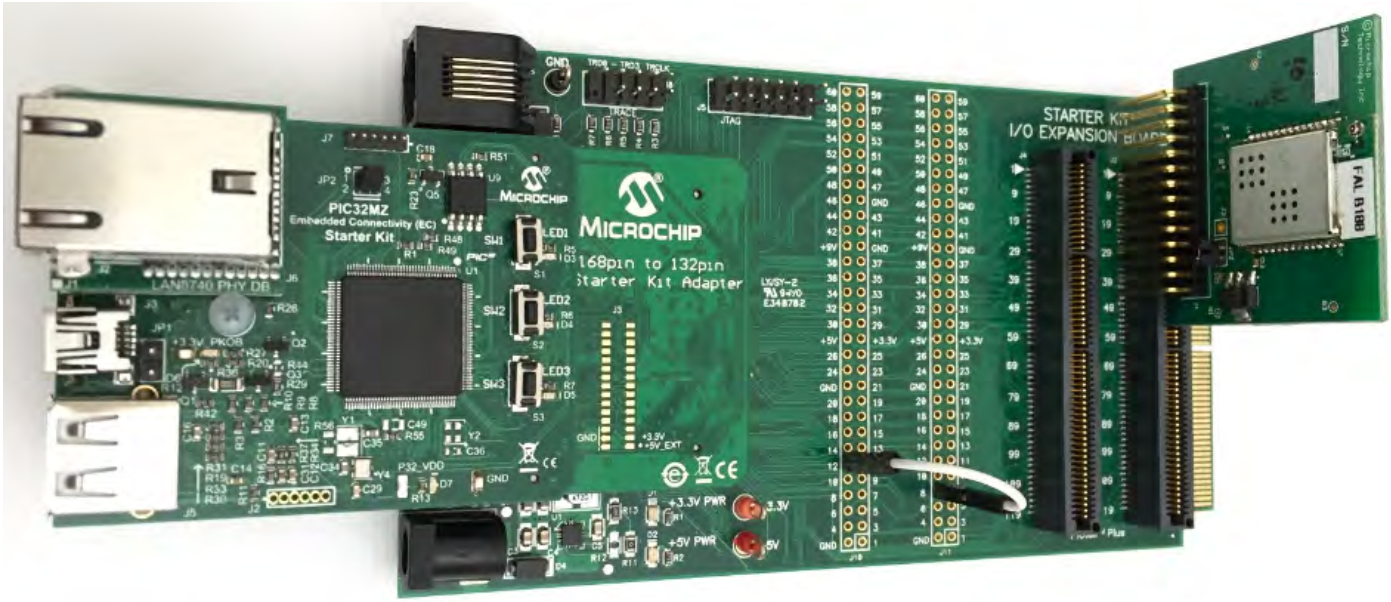


PIC32MZ EC Starter Kit with PIC32MZ2048ECH144, MRF24WN0MA Wi-Fi PICtail/PICtail Plus Daughter Board, and Starter Kit I/O Expansion Board

Note: The PIC32MZ EC Starter Kit, shown in the following figure, can also be interchanged with the PIC32MZ EF Starter Kit with PIC32MZ2048EFM144.

Configure the hardware, as shown in the following figure:

On-board Jumper: J10/pin 12 to J11/pin 8 (white jumper cable)



Running the Demonstration

This section provides instructions on how to build and run the Wi-Fi Easy Configuration demonstration with the MRF24WG or MRF24WN Wi-Fi module.

Description

Notes:

1. Refer to Wi-Fi Console Commands for information on the commands that enable control over the Wi-Fi settings.
2. For the Wi-Fi demonstration to function properly on MEB2 development board, the board should be powered with a 9V-15V DC power supply. Also on the PIC32MZ EC or PIC32MZ EF Starter Kit board, JP1 jumper should be Open (no jumper).

The demonstration does the following:

- Scans the area and stores the list of Access Points in memory
- Switches to SoftAP mode allowing another device to connect to it (smartphone or personal computer)
- After a smartphone or personal computer wirelessly connects to the MRF24WG or MRF24WN, a web page is served to it
- That web page will display the Access Point (AP) list (from step 1)
- From the smartphone you can select the desired AP and command the MRF24WG or MRF24WN to connect to that AP
- MRF24WG or MRF24WN will connect to the selected AP and store the configuration information in non-volatile memory

Use the following procedure to run the demonstration:

1. Load the demonstration project into MPLAB X IDE.

2. Connect the mini-B debugger port on-board the starter kit to a USB port on the development computer using the USB cable provided in the kit.

3. Build, download, and run the demonstration project on the board.

4. When the demonstration runs, it scans for local Access Points and outputs the results to the serial console. After the scan results, the MRF24WG or MRF24WN goes into SoftAP mode (where it behaves like an Access Point) and outputs the following to the serial console (MRF24WG output is shown):

```
=========================
*** Wi-Fi EZConfig Demo ***
=========================
Device:             MRF24WG (0x3108)
Domain:             FCC
MAC:                00 1E C0 10 20 32
SSID:               MCHPSoftAP
Network Type:       SoftAP
Scan Type:          Passive Scan
Channel List:       6
Beacon Timeout:     40
Retry Count:        3
Security:           Open
Security Key:
Tx Mode:            802.11bg mixed
Power Save:         disabled
IP Config:          dynamic
```

```
Start Wi-Fi Connect  . . .
MRF24W IP Address:  0.0.0.0
MRF24W IP Address:  192.168.1.25
MRF24W Event: Connection Successful
  Connected BSSID : 00:00:00:00:00:00
           Channel: 0
```

5. From a smartphone or personal computer, connect to the 'MCHPSoftAP' network, which is the SoftAP network started by the demonstration. Then, bring up a web page by entering the IP address of the SoftAP network into the smartphone browser. This is the IP address displayed in step 4 (e.g., 192.168.1.25). When the web page is displayed:

a. Select **Network Configuration**, and then **Scan for Wireless Networks**. The MRF24WG or MRF24WN will display the list of wireless networks on the web page.

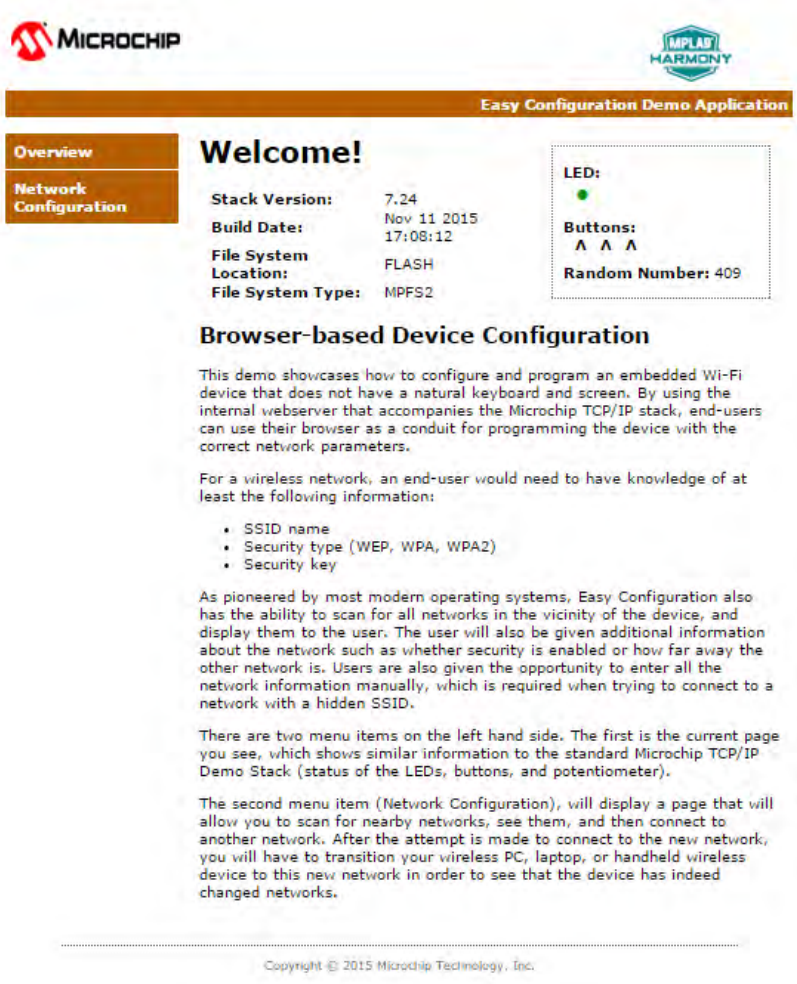
b. Select the desired AP to which the MRF24WG or MRF24WN should connect by clicking the name of the AP.

c. The MRF24WG or MRF24WN will then connect to that Access Point and write the configuration information to non-volatile memory.

d. The console output will show the new connection taking place

6. If you rerun the demonstration, it will automatically connect the selected AP as the configuration data stored in non-volatile memory will be used to reconnect to the desired AP.

7. To reset and run the demonstration from the beginning, erase the stored configuration by bringing up the demonstration, and at the command line type **iw_eraseconf**.



wifi_g_demo

Wi-Fi G Demo Board TCP/IP demonstration.

Description

This demonstration showcases a browser-based device configuration application to configure and program an embedded Wi-Fi device that does not have a natural keyboard and screen. By using the internal Web server that accompanies the Microchip TCP/IP Stack, end-users can use their browser as a conduit for programming the device with the correct network parameters.

Wi-Fi Demonstration Matrix

Refer to Wi-Fi Demonstration Configuration Matrix for additional information.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the PIC32 Wi-Fi G Demonstration.

Description

To build this project, you must open the `wifi_g_demo.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/tcpip/wifi_g_demo`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`wifi_g_demo.X`	`<install-dir>/apps/tcpip/wifi_g_demo/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within ./firmware/src/system_config.

Project Configuration Name	BSP Used	Description
wifi_g_demo	wifi_g_db	Demonstration running on the Wi-Fi G Demo Board.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

Wi-Fi G Demo Board with the PICkit™ 3 In-Circuit Debugger

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

This section provides instructions on how to build and run the Wi-Fi G demonstration.

Description

This demonstration showcases a browser-based device configuration application to configure and program an embedded Wi-Fi device that does not have a natural keyboard and screen. By using the internal Web server that accompanies the Microchip TCP/IP Stack, end-users can use their browser as a conduit for programming the device with the correct network parameters.

For a wireless network, an end-user would need to have knowledge of at least the following information:

- SSID
- Security Type (None, WEP, WPA-PSK, WPA2-PSK, WPA-PSK AUTO)
- Security PSK Key or Passphrase

The application also has the ability to scan for all networks in the vicinity of the device, and display them to the user. The user will also be given additional information about the network, such as whether security is enabled, or how far away the other network is. Users are also given the opportunity to enter all the network information manually, which is required when trying to connect to a network with a hidden SSID.

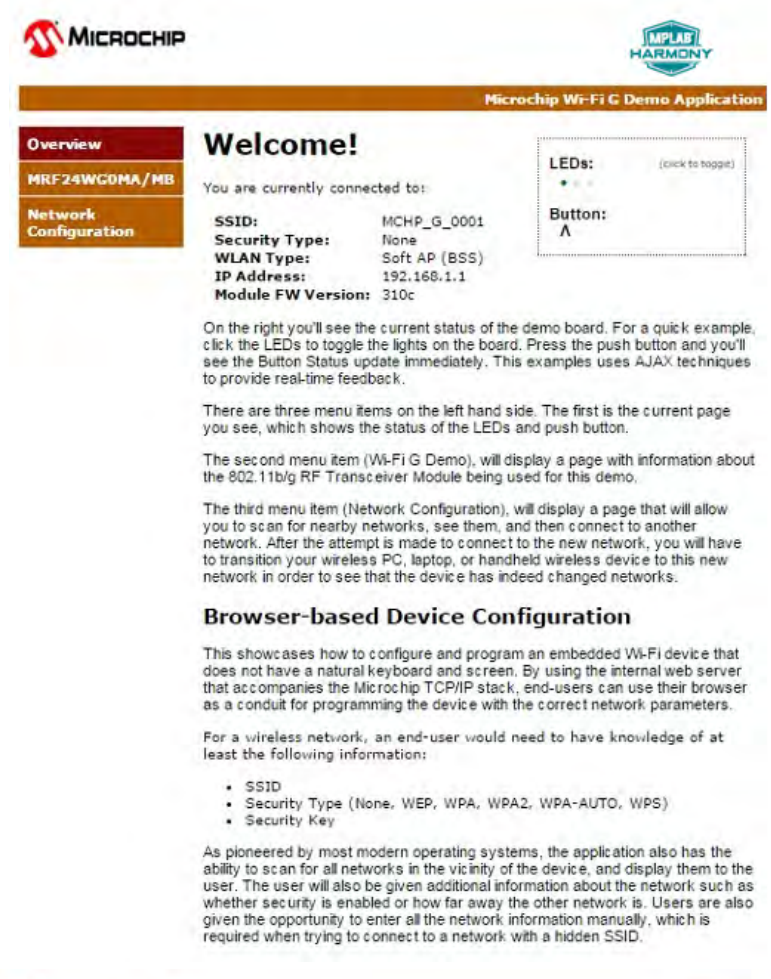
Running the Demonstration

This demonstration can be loaded and run on the Wi-Fi G Demo Board. In addition, a PICkit 3 In-Circuit Debugger is required for use with MPLAB X IDE to program the Wi-Fi G Demo Board.

Use the following procedure to run the demonstration:

1. Load the wifi_g_demo demonstration project into MPLAB X IDE.
2. Select **Run** to build and program the Wi-Fi G Demo Board with the demo Hex image.

Note: Refer to the *"Wi-Fi G Demo Board User's Guide"* (DS50002147) for additional information on using and programming the Wi-Fi Demo Board.



wifi_wolfssl_tcp_client

This configuration provides a Wi-Fi wolfSSL TCP/IP Client demonstration.

Description

Wi-Fi Demonstration Matrix

Refer to Wi-Fi Demonstration Configuration Matrix for additional information.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the TCP/IP Ethernet Wi-Fi wolfSSL TCP Client Demonstration.

Description

To build this project, you must open the `wifi_wolfssl_tcp_client.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/tcpip/wifi_wolfssl_tcp_client`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`wifi_wolfssl_tcp_client.X`	`<install-dir>/apps/tcpip/wifi_wolfssl_tcp_client/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx_eth_sk+ioexp	pic32mx_eth_sk	Wi-Fi wolfSSL TCP Client demonstration on the PIC32 Ethernet Starter Kit connected to the Starter Kit I/O Expansion Board with the MRF24WG PICtail Daughter Board.
pic32mz_ec_sk+ioexp	pic32mz_ec_sk	Wi-Fi wolfSSL TCP Client demonstration on the PIC32MZ EC Starter Kit connected to the Starter Kit I/O Expansion Board with the MRF24WG PICtail Daughter Board.

Configuring the Hardware

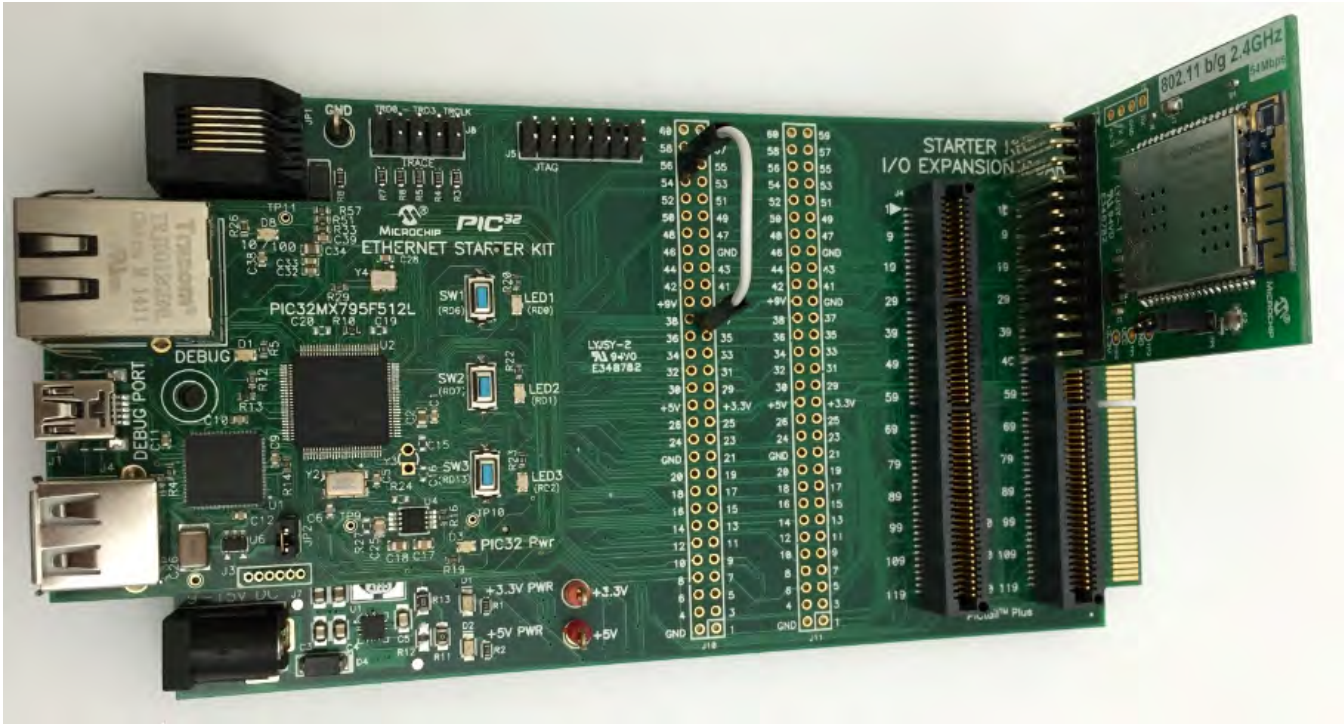
Describes how to configure the supported hardware.

Description

PIC32 Ethernet Starter Kit, MRF24WG0MA Wi-Fi G PICtail/PICtail Plus Daughter Board, and Starter Kit I/O Expansion Board

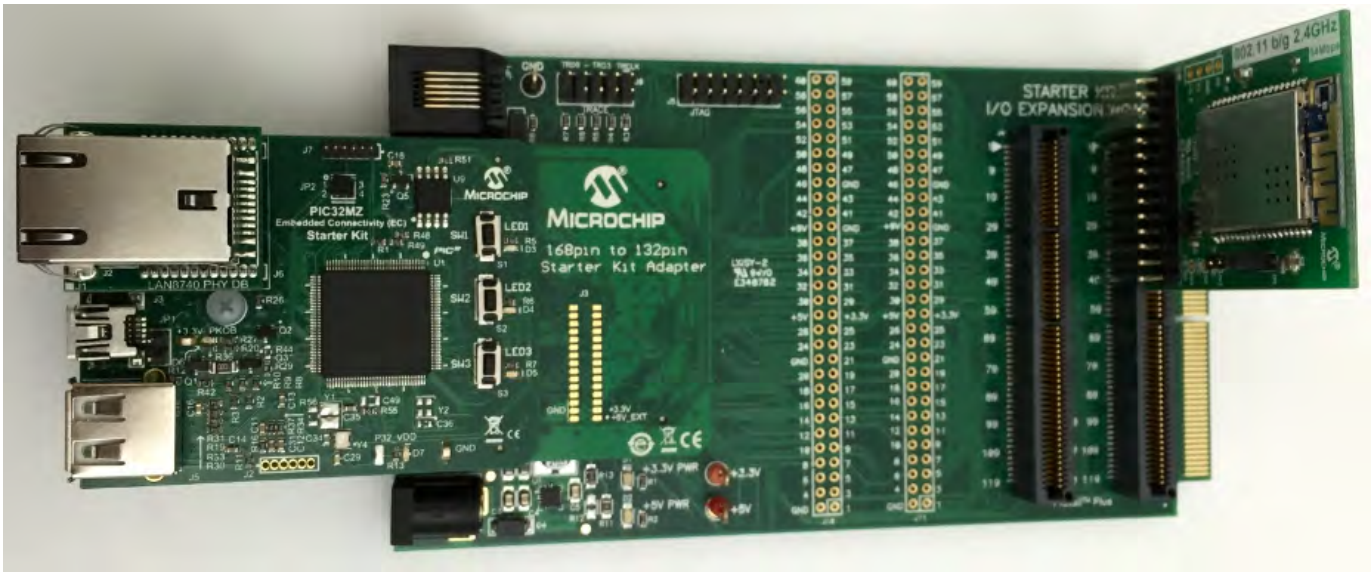
Configure the Starter Kit I/O Expansion Board jumper modifications, as described in the following figure:

On-board Jumper: J10/pin 56 to J10/pin 37 (white jumper cable)



PIC32MZ Embedded Connectivity (EC) Starter Kit, MRF24WG0MA Wi-Fi G PICtail/PICtail Plus Daughter Board, and Starter Kit I/O Expansion Board

For the PIC32MZ EC Starter Kit, the on-board jumper, J10/pin 56 to J10/pin 37 (white jumper cable) is not required. Configure the hardware as shown in the following figure:



Running the Demonstration

This section provides instructions on how to build and run the demonstration.

Description

This demonstration can be executed via Ethernet or Wi-Fi.

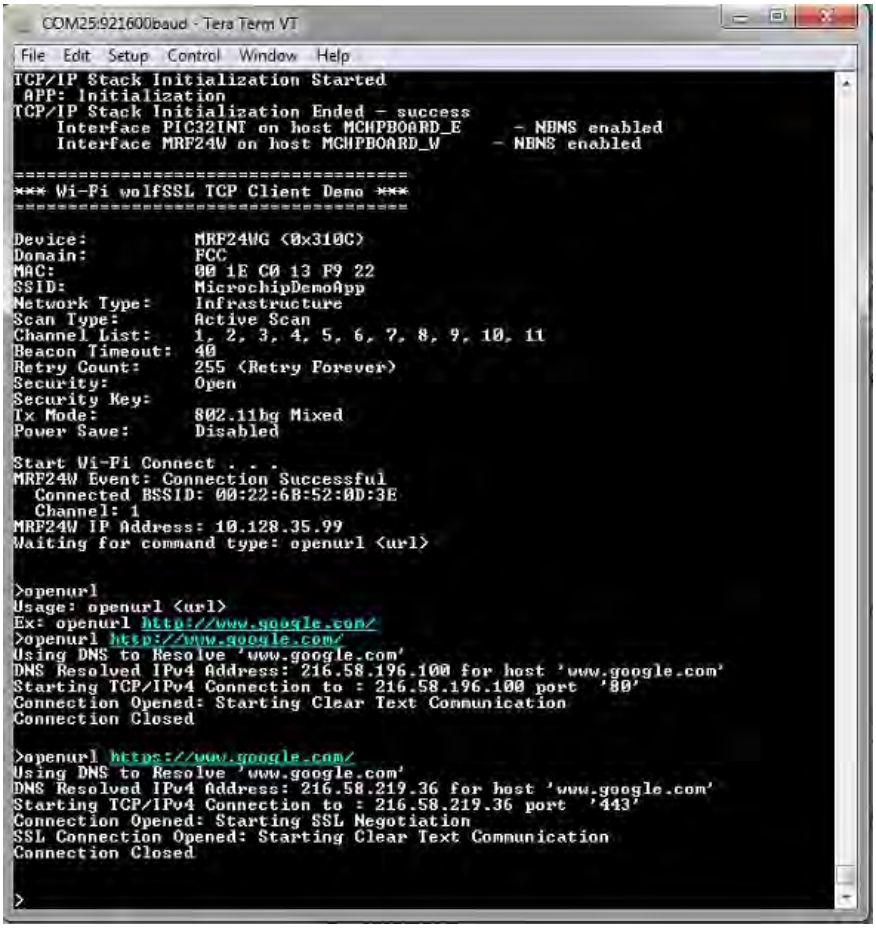
To use this demonstration, a USB cable needs to be connected to the micro-B USB connector on the bottom of the starter kit in use. When the demonstration runs, it will create a USB CDC device on the USB bus. The demonstration can be executed once you have connected to this device though a standard terminal program, set the baud rate to 921,600 baud, and a valid IP address has been received by the device.

There are three commands available in the demonstration from the serial port:

- openurl <url> - The <url> argument must be a fully formed URL; for instance, http://www.microchip.com/
- ipmode <mode> - The <mode> argument selects the IP version. 0 - Any IP version, 4 - IPv4 only, 6 - IPv6 only
- stats - Output the statistics of the previous openurl run. Statistics such as how long each phase of the connection took, and how many bytes were transferred.

After the openurl command is input, the demonstration will make a DNS query, and then open a connection to the requested URL and perform a simple HTTP PUT command. The results will be sent to the serial port. If a https URL is specified, the connection will first undergo SSL negotiation before sending the HTTP PUT command.

If ipmode is set to '0' (Any), the demonstration will favor IPv6 over IPv4, which means it will look for the IPv6 address before the IPv4 address.



wifi_wolfssl_tcp_server

This configuration provides a Wi-Fi wolfSSL TCP/IP Server demonstration.

Description

Wi-Fi Demonstration Matrix

Refer to Wi-Fi Demonstration Configuration Matrix for additional information.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the TCP/IP Ethernet Wi-Fi wolfSSL TCP Server Demonstration.

Description

To build this project, you must open the `wifi_wolfssl_tcp_server.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/tcpip/wifi_wolfssl_tcp_server`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`wifi_wolfssl_tcp_server.X`	`<install-dir>/apps/tcpip/wifi_wolfssl_tcp_server/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx_eth_sk+ioexp	pic32mx_eth_sk	Wi-Fi wolfSSL TCP Server demonstration on the PIC32 Ethernet Starter Kit connected to the Starter Kit I/O Expansion Boardwith the MRF24WG PICtail Daughter Board.
pic32mz_ec_sk+ioexp	pic32mz_ec_sk	Wi-Fi wolfSSL TCP Server demonstration on the PIC32MZ EC Starter Kit connected to the Starter Kit I/O Expansion Board with the MRF24WG PICtail Daughter Board.

Configuring the Hardware

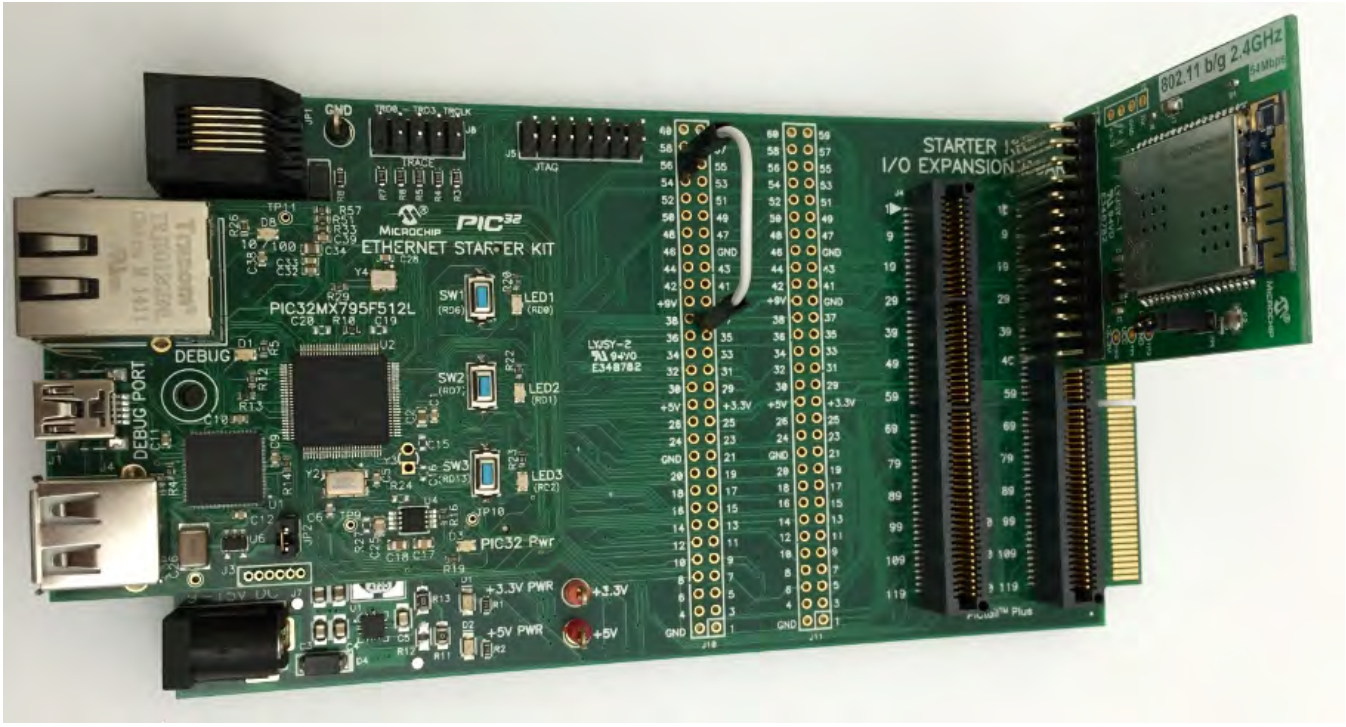
Describes how to configure the supported hardware.

Description

PIC32 Ethernet Starter Kit with PIC32MX795F512L, MRF24WG0MA Wi-Fi G PICtail/PICtail Plus Daughter Board, and Starter Kit I/O Expansion Board

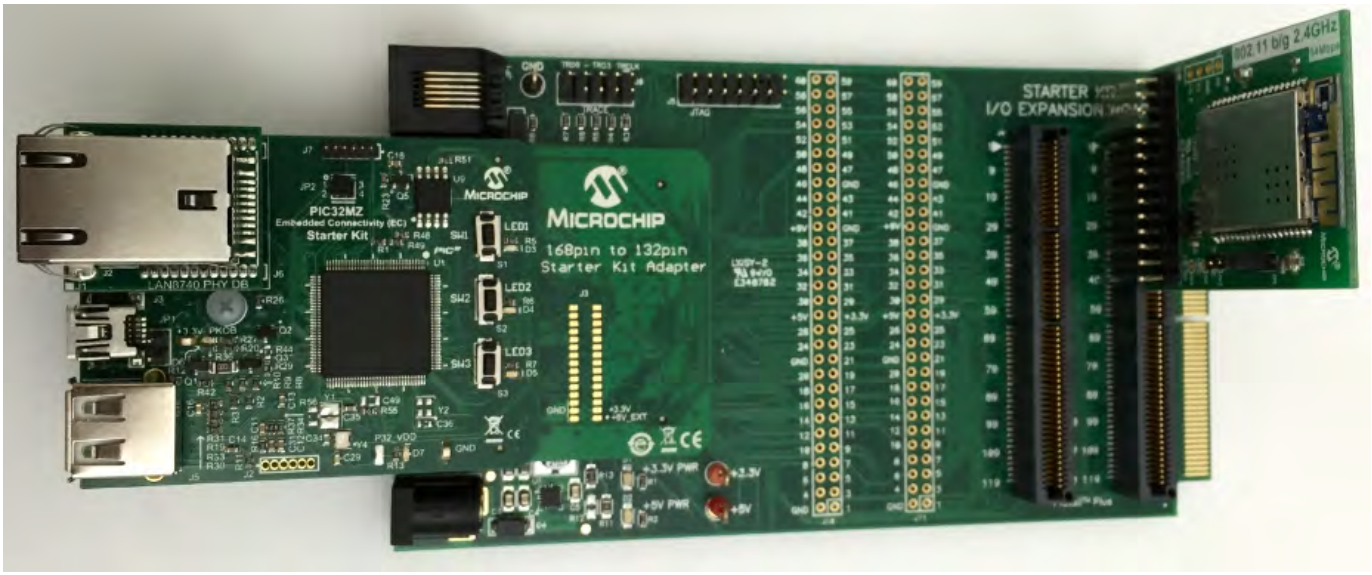
Configure the Starter Kit I/O Expansion Board jumper modifications, as described in the following figure:

On-board Jumper: J10/pin 56 to J10/pin 37 (white jumper cable)



PIC32MZ EC Starter Kit with PIC32MZ2048ECH144, MRF24WG0MA Wi-Fi G PICtail/PICtail Plus Daughter Board, and Starter Kit I/O Expansion Board

For the PIC32MZ EC Starter Kit, the on-board jumper, J10/pin 56 to J10/pin 37 (white jumper cable) is not required. Configure the hardware as shown in the following figure:



Running the Demonstration

This section provides instructions on how to build and run the demonstration.

Description

This demonstration can be executed via Ethernet or Wi-Fi.

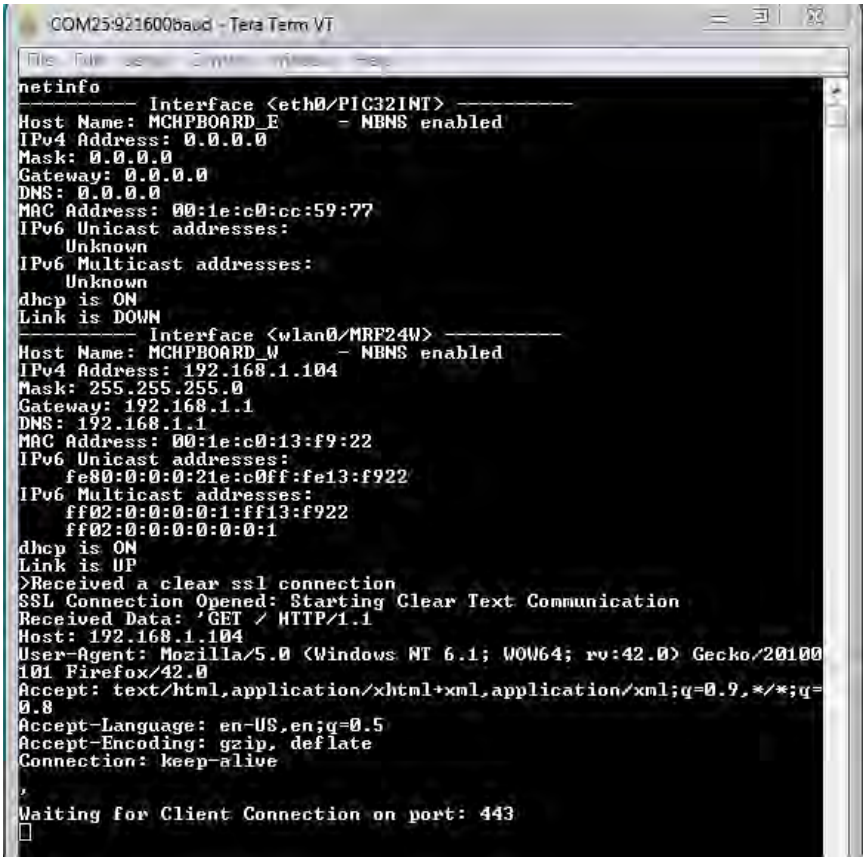
To use this demonstration, a USB cable needs to be connected to the micro-B USB connector on the bottom of the starter kit in use. When the demonstration runs, it will create a USB CDC device on the USB bus. The demonstration can be executed once you have connected to this device though a standard terminal program, set the baud rate to 921,600 baud, and a valid IP address has been received by the device.

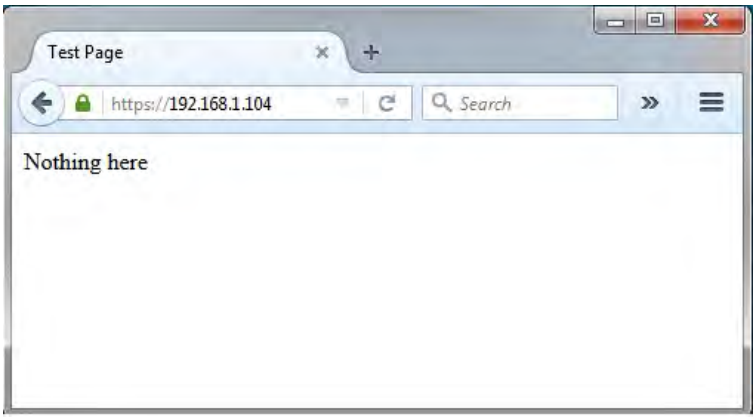
There are three commands available in the demonstration from the serial port:

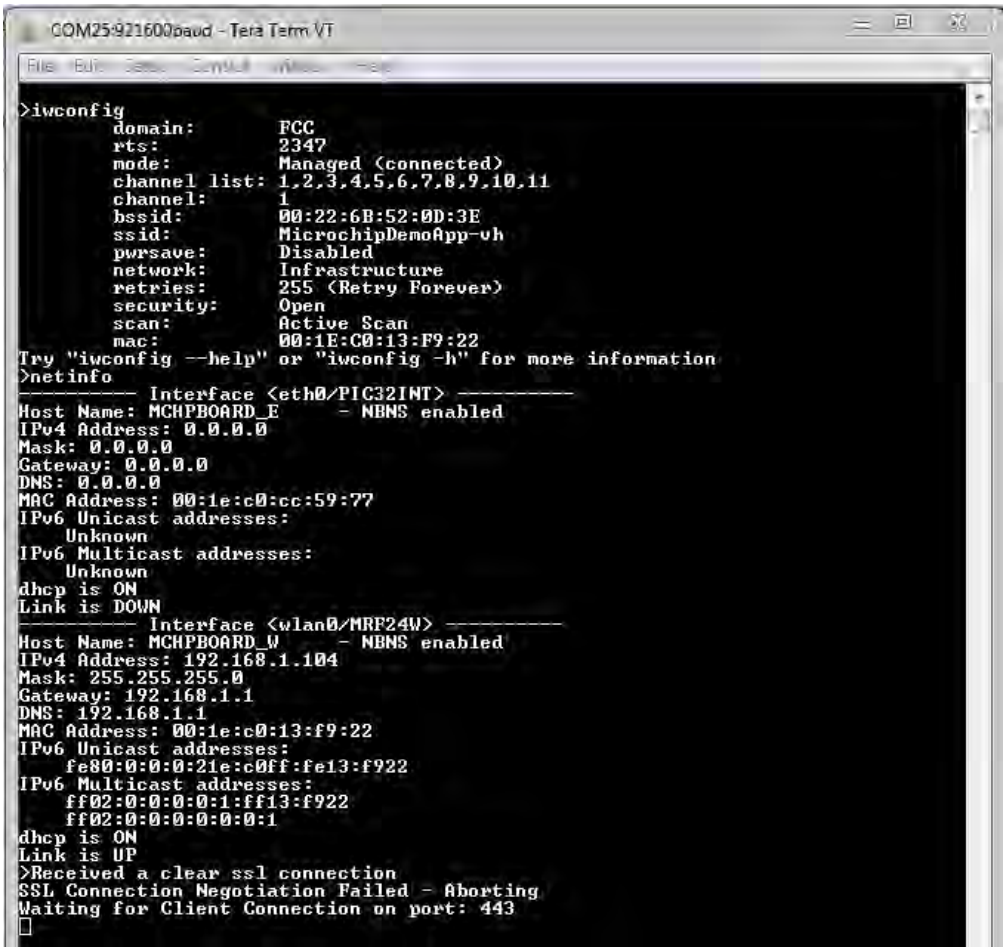
- openurl <url> - The <url> argument must be a fully formed URL; for instance, http://www.microchip.com/
- ipmode <mode> - The <mode> argument selects the IP version. 0 - Any IP version, 4 - IPv4 only, 6 - IPv6 only
- stats - Output the statistics of the previous openurl run. Statistics such as how long each phase of the connection took, and how many bytes were transferred.

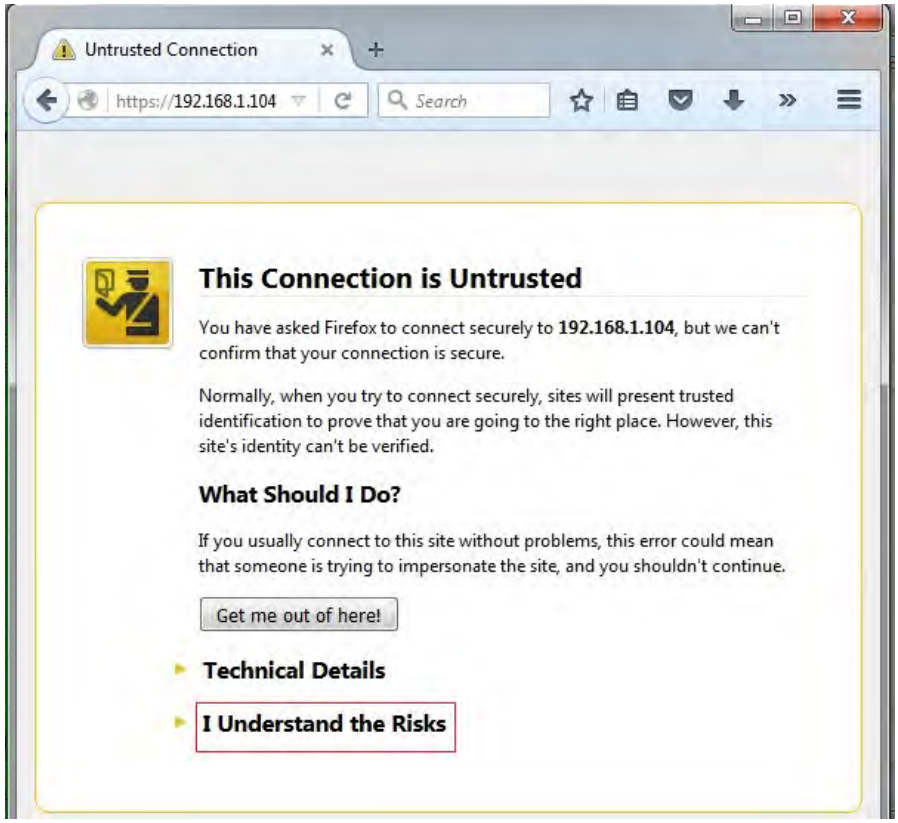
After the openurl command is input, the demonstration will make a DNS query, and then open a connection to the requested URL and perform a simple HTTP PUT command. The results will be sent to the serial port. If a https URL is specified, the connection will first undergo SSL negotiation before sending the HTTP PUT command.

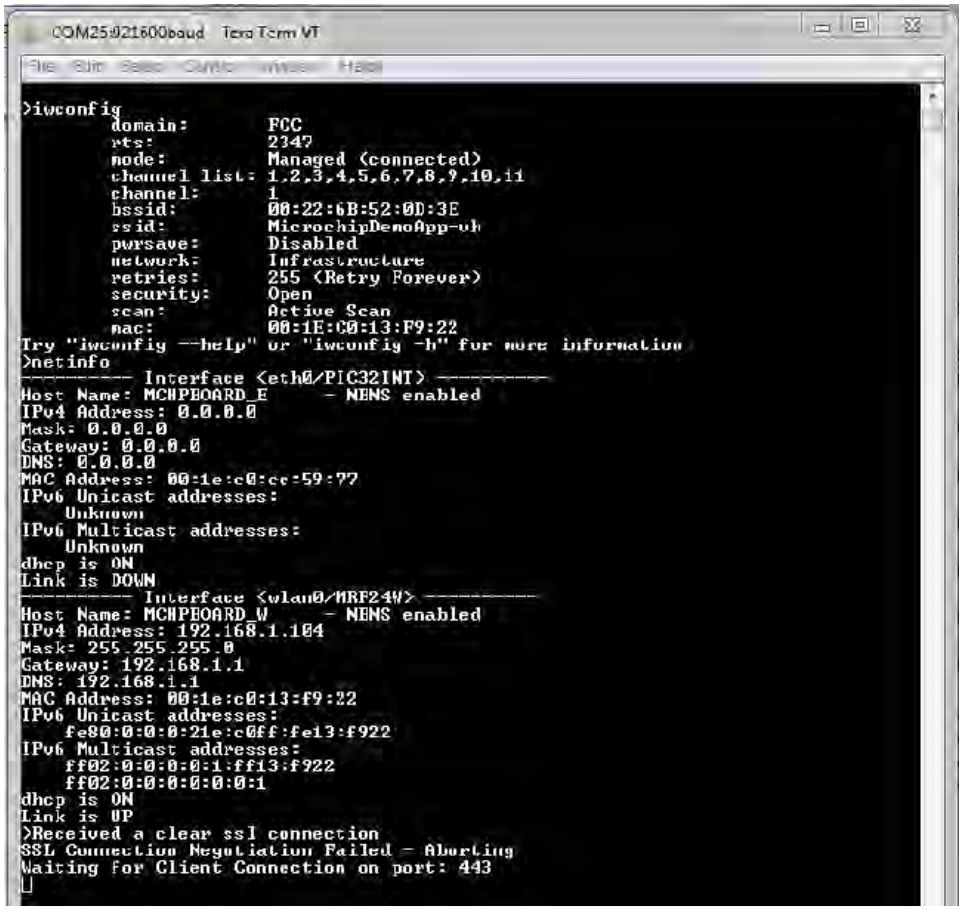
If ipmode is set to '0' (Any), the demonstration will favor IPv6 over IPv4, which means it will look for the IPv6 address before the IPv4 address.

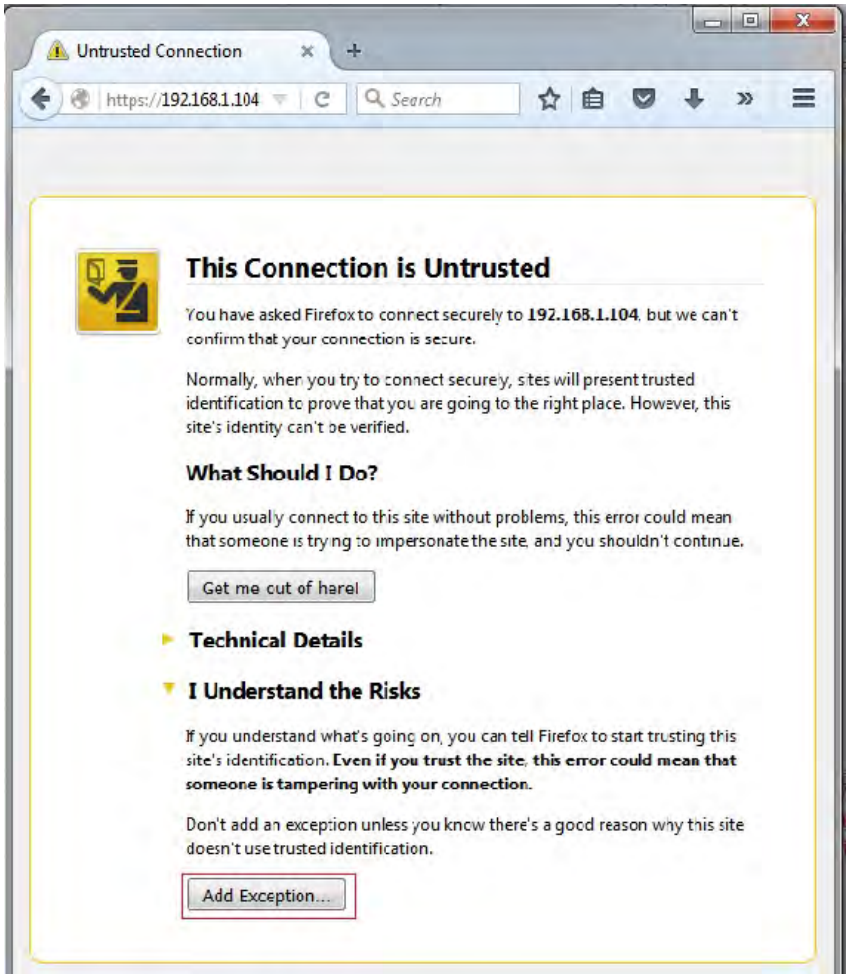

COM25:921600baud - Tera Term VT
netinfo
---------- Interface <eth0/PIC32INT> ----------
Host Name: MCHPBOARD_E - NBNS enabled
IPv4 Address: 0.0.0.0
Mask: 0.0.0.0
Gateway: 0.0.0.0
DNS: 0.0.0.0
MAC Address: 00:1e:c0:cc:59:77
IPv6 Unicast addresses:
Unknown
IPv6 Multicast addresses:
Unknown
dhcp is ON
Link is DOWN
---------- Interface <wlan0/MRF24W> ----------
Host Name: MCHPBOARD_W - NBNS enabled
IPv4 Address: 192.168.1.104
Mask: 255.255.255.0
Gateway: 192.168.1.1
DNS: 192.168.1.1
MAC Address: 00:1e:c0:13:f9:22
IPv6 Unicast addresses:
fe80:0:0:0:21e:c0ff:fe13:f922
IPv6 Multicast addresses:
ff02:0:0:0:0:1:ff13:f922
ff02:0:0:0:0:0:0:1
dhcp is ON
Link is UP
>Received a clear ssl connection
SSL Connection Opened: Starting Clear Text Communication
Received Data: 'GET / HTTP/1.1
Host: 192.168.1.104
User-Agent: Mozilla/5.0 (Windows NT 6.1; WOW64; rv:42.0) Gecko/20100
101 Firefox/42.0
Accept: text/html,application/xhtml+xml,application/xml;q=0.9,*/*;q=
0.8
Accept-Language: en-US,en;q=0.5
Accept-Encoding: gzip, deflate
Connection: keep-alive
'
Waiting for Client Connection on port: 443

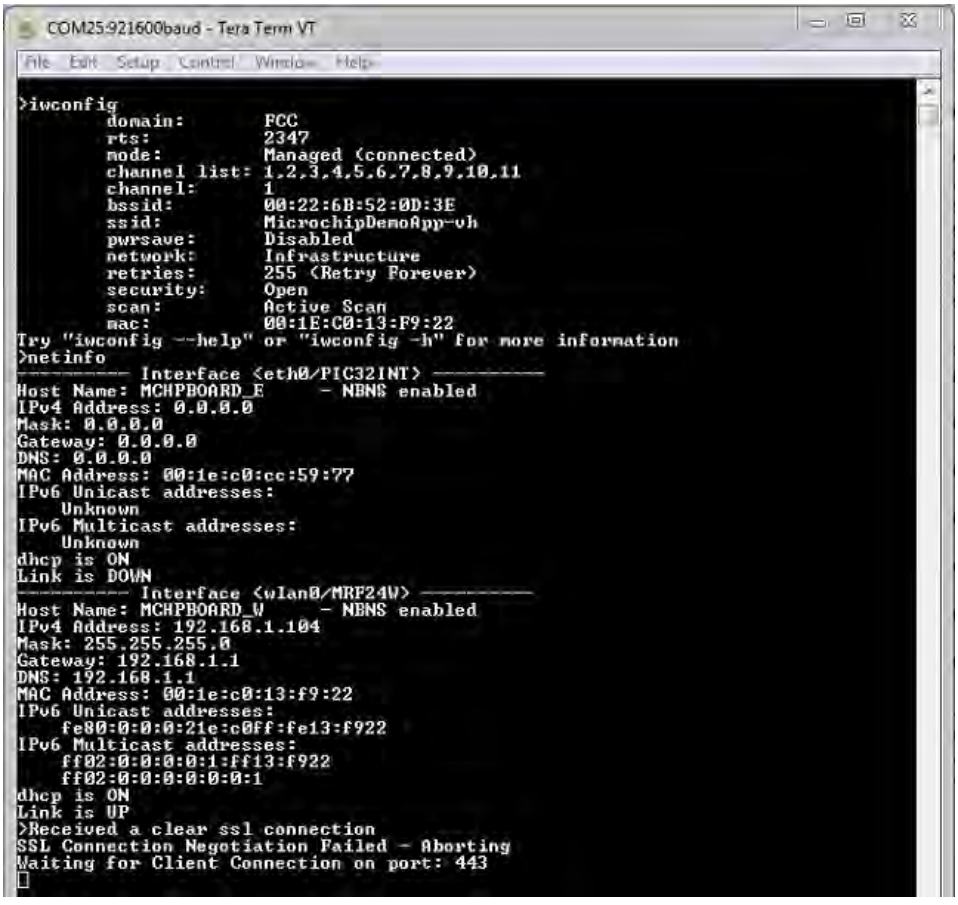

Test Page
https://192.168.1.104
Search
Nothing here

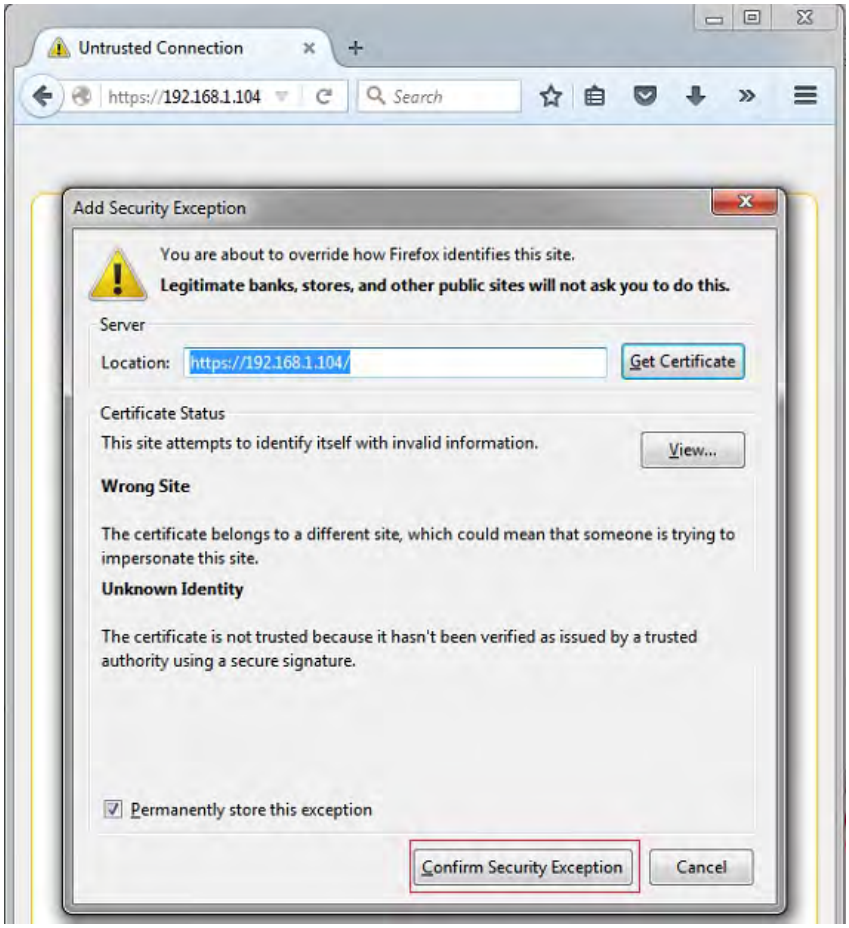

COM25:921600baud - Tera Term VT
>iwconfig
domain: FCC
rts: 2347
mode: Managed (connected)
channel list: 1,2,3,4,5,6,7,8,9,10,11
channel: 1
bssid: 00:22:6B:52:0D:3E
ssid: MicrochipDemoApp-vh
pwrsave: Disabled
network: Infrastructure
retries: 255 (Retry Forever)
security: Open
scan: Active Scan
mac: 00:1E:C0:13:F9:22
Try "iwconfig --help" or "iwconfig -h" for more information
>netinfo
---------- Interface <eth0/PIC32INT> ----------
Host Name: MCHPBOARD_E - NBNS enabled
IPv4 Address: 0.0.0.0
Mask: 0.0.0.0
Gateway: 0.0.0.0
DNS: 0.0.0.0
MAC Address: 00:1e:c0:cc:59:77
IPv6 Unicast addresses:
Unknown
IPv6 Multicast addresses:
Unknown
dhcp is ON
Link is DOWN
---------- Interface <wlan0/MRF24W> ----------
Host Name: MCHPBOARD_W - NBNS enabled
IPv4 Address: 192.168.1.104
Mask: 255.255.255.0
Gateway: 192.168.1.1
DNS: 192.168.1.1
MAC Address: 00:1e:c0:13:f9:22
IPv6 Unicast addresses:
fe80:0:0:0:21e:c0ff:fe13:f922
IPv6 Multicast addresses:
ff02:0:0:0:0:1:ff13:f922
ff02:0:0:0:0:0:0:1
dhcp is ON
Link is UP
>Received a clear ssl connection
SSL Connection Negotiation Failed - Aborting
Waiting for Client Connection on port: 443

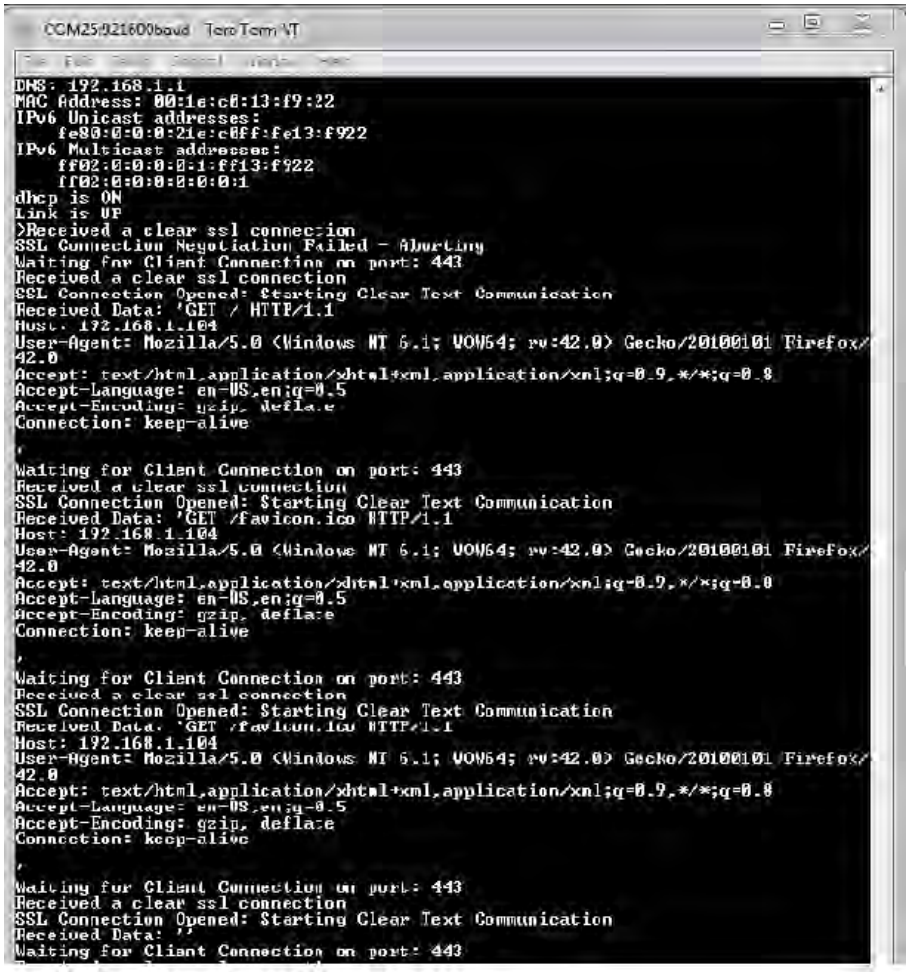

Untrusted Connection
https://192.168.1.104
Search
This Connection is Untrusted
You have asked Firefox to connect securely to 192.168.1.104, but we can't confirm that your connection is secure.
Normally, when you try to connect securely, sites will present trusted identification to prove that you are going to the right place. However, this site's identity can't be verified.
What Should I Do?
If you usually connect to this site without problems, this error could mean that someone is trying to impersonate the site, and you shouldn't continue.
Get me out of here!
Technical Details
I Understand the Risks

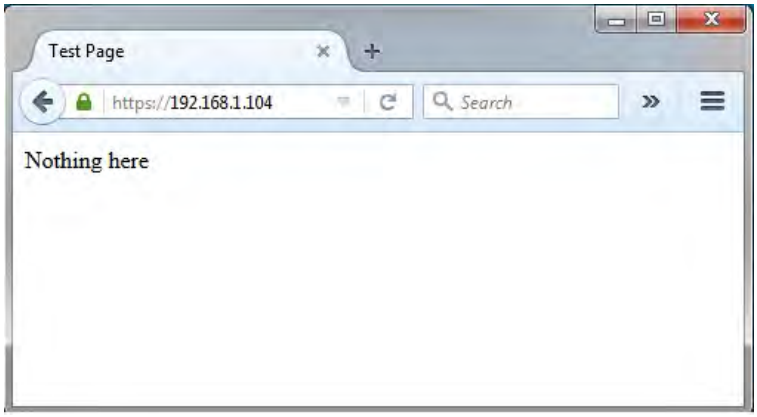

COM25@21600baud - Tera Term VT
File Edit Setup Control Window Help
>iwconfig
domain: FCC
rts: 2347
mode: Managed (connected)
channel list: 1,2,3,4,5,6,7,8,9,10,11
channel: 1
bssid: 00:22:6B:52:0D:3E
essid: MicrochipDemoApp-vh
pwrsave: Disabled
network: Infrastructure
retries: 255 (Retry Forever)
security: Open
scan: Active Scan
mac: 00:1E:C0:13:F9:22
Try "iwconfig --help" or "iwconfig -h" for more information
>netinfo
---------- Interface <eth0/PIC32INT> ----------
Host Name: MCHPBOARD_E - NBNS enabled
IPv4 Address: 0.0.0.0
Mask: 0.0.0.0
Gateway: 0.0.0.0
DNS: 0.0.0.0
MAC Address: 00:1e:c0:cc:59:77
IPv6 Unicast addresses:
Unknown
IPv6 Multicast addresses:
Unknown
dhcp is ON
Link is DOWN
---------- Interface <wlan0/MRF24W> ----------
Host Name: MCHPBOARD_W - NBNS enabled
IPv4 Address: 192.168.1.104
Mask: 255.255.255.0
Gateway: 192.168.1.1
DNS: 192.168.1.1
MAC Address: 00:1e:c0:13:f9:22
IPv6 Unicast addresses:
fe80:0:0:0:21e:c0ff:fe13:f922
IPv6 Multicast addresses:
ff02:0:0:0:0:1:ff13:f922
ff02:0:0:0:0:0:0:1
dhcp is ON
Link is UP
>Received a clear ssl connection
SSL Connection Negotiation Failed - Aborting
Waiting for Client Connection on port: 443


Untrusted Connection
https://192.168.1.104
Search
This Connection is Untrusted
You have asked Firefox to connect securely to 192.168.1.104, but we can't confirm that your connection is secure.
Normally, when you try to connect securely, sites will present trusted identification to prove that you are going to the right place. However, this site's identity can't be verified.
What Should I Do?
If you usually connect to this site without problems, this error could mean that someone is trying to impersonate the site, and you shouldn't continue.
Get me out of here!
Technical Details
I Understand the Risks
If you understand what's going on, you can tell Firefox to start trusting this site's identification. Even if you trust the site, this error could mean that someone is tampering with your connection.
Don't add an exception unless you know there's a good reason why this site doesn't use trusted identification.
Add Exception...


COM25:921600baud - Tera Term VT
File Edit Setup Control Window Help
>iwconfig
domain: FCC
rts: 2347
mode: Managed (connected)
channel list: 1,2,3,4,5,6,7,8,9,10,11
channel: 1
bssid: 00:22:6B:52:0D:3E
ssid: MicrochipDemoApp-vh
pwrsave: Disabled
network: Infrastructure
retries: 255 (Retry Forever)
security: Open
scan: Active Scan
mac: 00:1E:C0:13:F9:22
Try "iwconfig --help" or "iwconfig -h" for more information
>netinfo
---------- Interface <etH0/PIC32INT> ----------
Host Name: MCHPBOARD_E - NBNS enabled
IPv4 Address: 0.0.0.0
Mask: 0.0.0.0
Gateway: 0.0.0.0
DNS: 0.0.0.0
MAC Address: 00:1e:c0:cc:59:77
IPv6 Unicast addresses:
Unknown
IPv6 Multicast addresses:
Unknown
dhcp is ON
Link is DOWN
---------- Interface <wlan0/MRF24W> ----------
Host Name: MCHPBOARD_W - NBNS enabled
IPv4 Address: 192.168.1.104
Mask: 255.255.255.0
Gateway: 192.168.1.1
DNS: 192.168.1.1
MAC Address: 00:1e:c0:13:f9:22
IPv6 Unicast addresses:
fe80:0:0:0:21e:c0ff:fe13:f922
IPv6 Multicast addresses:
ff02:0:0:0:0:1:ff13:f922
ff02:0:0:0:0:0:0:1
dhcp is ON
Link is UP
>Received a clear ssl connection
SSL Connection Negotiation Failed - Aborting
Waiting for Client Connection on port: 443


Untrusted Connection
https://192.168.1.104
Search
Add Security Exception
You are about to override how Firefox identifies this site.
Legitimate banks, stores, and other public sites will not ask you to do this.
Server
Location:
https://192.168.1.104/
Get Certificate
Certificate Status
This site attempts to identify itself with invalid information.
View...
Wrong Site
The certificate belongs to a different site, which could mean that someone is trying to impersonate this site.
Unknown Identity
The certificate is not trusted because it hasn't been verified as issued by a trusted authority using a secure signature.
Permanently store this exception
Confirm Security Exception
Cancel





wolfssl_tcp_client

wolfSSL TCP Client demonstration.

Description

This configuration demonstrates creating an Internet client that uses the MPLAB Harmony TCP API to create a TCP/IP connection to a Web server. The connection can either be clear text, or it can use SSL to encrypt the connection with wolfSSL. The demonstration can use either IPv4 or IPv6.

Wi-Fi Demonstration Matrix

Refer to Wi-Fi Demonstration Configuration Matrix for additional information.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the wolfSSL TCP Client Demonstration.

Description

To build this project, you must open the wolfssl_tcp_client.X project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is <install-dir>/apps/tcpip/wolfssl_tcp_client.

Warning

When using the Microchip Harmony Configurator (MHC), care must be taken when generating the code to *not* erase the USB descriptors in the system_init.c file.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
wolfssl_tcp_client.X	<install-dir>/apps/tcpip/wolfssl_tcp_client/firmware

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within ./firmware/src/system_config.

Project Configuration Name	BSP Used	Description
pic32mx_eth_sk	pic32mx_eth_sk	Demonstrates the wolfSSL TCP Client on the PIC32 Ethernet Starter Kit.
pic32mx_eth_sk2	pic32mx_eth_sk2	Demonstrates the wolfSSL TCP Client on the PIC32 Ethernet Starter Kit II.
pic32mz_ec_sk	pic32mz_ec_sk	Demonstrates the wolfSSL TCP Client on the PIC32MZ EC Starter Kit.
pic32mz_ef_sk	pic32mz_ef_sk	Demonstrates the wolfSSL TCP Client on the PIC32MZ EF Starter Kit.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32 Ethernet Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32 Ethernet Starter Kit II

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ EC Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ EF Starter Kit

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

This section provides instructions on how to build and run the demonstration.

Description

To use this demonstration, a USB cable needs to be connected to the micro-B USB connector on the bottom of the starter kit in use. When the demonstration runs, it will create a USB CDC device on the USB bus. The demonstration can be executed once you have connected to this device though a standard terminal program, set the baud rate to 921,600 baud, and a valid IP address has been received by the device.

There are three commands available in the demonstration from the serial port:

- openurl <url> - The <url> argument must be a fully formed URL; for instance, http://www.microchip.com/
- ipmode <mode> - The <mode> argument selects the IP version. 0 - Any IP version, 4 - IPv4 only, 6 - IPv6 only
- stats - Output the statistics of the previous openurl run. Statistics such as how long each phase of the connection took, and how many bytes were transferred.

After the `openurl` command is input, the demonstration will make a DNS query, and then open a connection to the requested URL and perform a simple HTTP PUT command. The results will be sent to the serial port. If a https URL is specified, the connection will first undergo SSL negotiation before sending the HTTP PUT command.

If `ipmode` is set to '`0`' (Any), the demonstration will favor IPv6 over IPv4, which means it will look for the IPv6 address before the IPv4 address.

wolfssl_tcp_server

wolfSSL TCP Server demonstration.

Description

This configuration demonstrates creating a simple Internet Web server, that operates with clear text (TCP Port 80), and with encrypted text (TCP Port 443). If IPv6 is enabled than the demonstration also serves both types of connections on IPv6. The Web server only serves one page with the text 'Nothing Here' to all Web clients.

Wi-Fi Demonstration Matrix

Refer to Wi-Fi Demonstration Configuration Matrix for additional information.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the wolfSSL TCP Client Demonstration.

Description

To build this project, you must open the wolf`ssl_tcp_server.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/tcpip/wolfssl_tcp_server`.

Warning

When using the Microchip Harmony Configurator (MHC), care must be taken when generating the code to *not* erase the USB descriptors in the `system_init.c` file.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`wolfssl_tcp_server.X`	`<install-dir>/apps/tcpip/wolfssl_tcp_server/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx_eth_sk	pic32mx_eth_sk	Demonstrates the wolfSSL TCP Server on the PIC32 Ethernet Starter Kit.
pic32mx_eth_sk2	pic32mx_eth_sk2	Demonstrates the wolfSSL TCP Server on the PIC32 Ethernet Starter Kit II.
pic32mz_ec_sk	pic32mz_ec_sk	Demonstrates the wolfSSL TCP Server on the PIC32MZ EC Starter Kit.
pic32mz_ef_sk	pic32mz_ef_sk	Demonstrates the wolfSSL TCP Server on the PIC32MZ EF Starter Kit.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32 Ethernet Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32 Ethernet Starter Kit II

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ EC Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ EF Starter Kit

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

This section provides instructions on how to build and run the demonstration.

Description

The demonstration does not offer any additional functionality through the serial port; however, the current IP can be checked. As soon as a valid IP has been assigned through DHCP to the demonstration, it is ready to serve Web pages. Use any Web browser (i.e., Chrome, Internet Explorer, Firefox, etc.) to connect to the Web server with either http:// or https://.

A USB cable can be connected to the micro-B USB connector on the bottom of the starter kit in use. This will create a USB CDC device on the USB bus. To communicate with the software, connect to this device though a standard terminal program and set the baud rate to 921,600 baud.

Test Applications

Test applications demonstrate the use of the MPLAB Harmony Test Harness and predefined test libraries.

Introduction

Test Applications Help

Description

This help file contains instructions and associated information about MPLAB Harmony Test applications, which are contained in the MPLAB Harmony distribution.

Applications

Provides instructions on how to run the Test applications.

test_sample

The MPLAB Harmony Test Sample demonstrates the use of the Test Harness to validate a sample library module.

Description

The Test Harness controls initialization and execution of each test, as well as the library it tests. The Test Harness accumulates results given to it by the test and determines an over-all pass or fail result. If debug system output is supported and configured, which, in this demonstration is not, these results will be displayed textually on the terminal display in use. Otherwise, as demonstrated in this application, a debugger must be used to determine the results.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the Test Sample application.

Description

To build this project, you must open the `test_sample.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/tests/test_sample`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`test_sample.X`	`<install-dir>/apps/tests/test_sample/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within ./firmware/src/system_config.

Project Configuration Name	BSP Used	Description
e16mx795f512_freertos_interrupt	None.	This configuration runs on the Explorer 16 Development Board with the PIC32MX795F512L PIM. It executes the included test in a FreeRTOS thread and runs the associated library in interrupt-driven mode.
e16mx795f512_freertos_polled	None.	This configuration runs on the Explorer 16 Development Board with the PIC32MX795F512L PIM. It executes the included test in a FreeRTOS thread and runs the associated library in a polled mode in a different thread.
e16mx795f512_interrupt	None.	This configuration runs on the Explorer 16 Development Board with the PIC32MX795F512L PIM. It executes the included test in a bare-metal (no-RTOS) "super" loop environment and runs the associated library in an interrupt-driven mode.
e16mx795f512_polled	None.	This configuration runs on the Explorer 16 Development Board with the PIC32MX795F512L PIM. It executes the included test and the library under test in a bare-metal (no-RTOS) "super" loop environment.
pic32mz_ec_sk_freertos_polled	None.	This configuration runs on the PIC32MZ EC Starter Kit. It executes the included test in a FreeRTOS thread and runs the associated library in a polled mode in a different thread.
pic32mz_ec_sk_freertos_interrupt	None.	This configuration runs on the PIC32MZ EC Starter Kit. It executes the included test in a bare-metal (no-RTOS) "super" loop environment and runs the associated library in an interrupt-driven mode.
pic32mz_ec_sk_interrupt	None.	This configuration runs on the PIC32MZ EC Starter Kit. It executes the included test in a bare-metal (no-RTOS) "super" loop environment and runs the associated library in an interrupt-driven mode.
pic32mz_ec_sk_polled	None.	This configuration runs on the PIC32MZ EC Starter Kit. It executes the included test and the library under test in a bare-metal (no-RTOS) "super" loop environment.
pic32mz_ef_sk_freertos_polled	None.	This configuration runs on the PIC32MZ EF Starter Kit. It executes the included test in a FreeRTOS thread and runs the associated library in a polled mode in a different thread.
pic32mz_ef_sk_freertos_interrupt	None.	This configuration runs on the PIC32MZ EF Starter Kit. It executes the included test in a bare-metal (no-RTOS) "super" loop environment and runs the associated library in an interrupt-driven mode.
pic32mz_ef_sk_interrupt	None.	This configuration runs on the PIC32MZ EF Starter Kit. It executes the included test and the library under test in a bare-metal (no-RTOS) "super" loop environment.
pic32mz_ef_sk_polled	None.	This configuration runs on the PIC32MZ EF Starter Kit. It executes the included test and the library under test in a bare-metal (no-RTOS) "super" loop environment.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

Explorer 16 Development Board with the PIC32MX795F512L PIM

Before attaching the PIC32MX795F512L PIM to the Explorer 16 Development Board, ensure that the processor select switch (S2) is in the PIM Position.

No hardware related configuration or jumper setting changes are necessary for the PIM itself.

PIC32MZ EC Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ EF Starter Kit

No hardware related configuration or jumper setting changes are necessary.

Running the Application

Provides instructions on how to build and run the Test Sample application.

Description

To run the Test Sample application, select the desired configuration, build the application in Debug mode, program it to the associated hardware, and execute it under control of a debugger.

As the demonstration runs, the Test Harness Library accumulates results provided to it by the test. If System Debug output were supported and configured, the results would be displayed textually on the debug terminal display in use. However, depending upon the testing needs or the hardware used, it may not be possible to support a debug output method and none is supported in any of the configurations included in this demonstration. Therefore, it is necessary to utilize the debugger to analyze the TEST_HARNESS_DATA structure to determine the results of the test. When all tests are complete (or when a failure occurs), the Test Harness will execute a hard-coded breakpoint and stop. At that time, you may use the debugger to obtain the results.

The following members of this structure give the overall results once the test harness enters its Idle state:

- testsCount - This is the total number of tests executed
- testsPassed - This is the number of tests that reported no sub-test failures, resulting in an overall passing result
- result - This is the final result, which is true (1) if all sub-tests in all tests passed; otherwise, it is false (0).

USB Demonstrations

This section provides descriptions of the USB demonstrations.

Introduction

USB Library Demonstration Applications Help

Description

This distribution package contains a variety of USB-related firmware projects that demonstrate the capabilities of the MPLAB Harmony USB stack. This section describes the hardware requirement and procedures to run these firmware projects on Microchip demonstration and development boards.

To know more about the MPLAB Harmony USB stack and configuring the USB stack and the APIs provided by the USB stack, refer to the USB Library documentation.

Program, Data Memory, and Stack Component Memory

Refer to USB Device Stack Demonstration Application Program and Data Memory Requirements and USB Device Stack Component Memory Requirements for important memory information.

Pen Drive Tests

Refer to USB MSD Host USB Pen Drive Tests for information on the tests conducted on USB Flash devices.

USB Device Stack Demonstration Application Program and Data Memory Requirements

Provides information on program and data memory requirements, as well as pen drive test specifications.

Description

Program Memory and Data Memory Requirements with -O1 Optimization

The following table shows the program memory and data memory requirements of the USB Device Stack demonstration applications. All size figures are in bytes. Demonstration applications were compiled with the MPLAB XC32 C/C++ Compiler, v1.40, with –O1 optimization.

Demonstration Name		Program Memory Components			Data Memory Components	
-O1 Optimization		USB Stack	Other Drivers	System and Application	USB Stack	Others
cdc_com_port_single	PIC32MX	14048	0	5880	262	718
	PIC32MZ	18924	4328	11632	318	1410
cdc_com_port_dual	PIC32MX	13980	0	5776	262	1250
	PIC32MZ	18856	4328	10908	318	2166
cdc_serial_emulator	PIC32MX	13976	9100	5916	262	858
	PIC32MZ	N/A	N/A	N/A	N/A	N/A
cdc_serial_emulator_msd	PIC32MX	20380	12560	39540	438	1950
	PIC32MZ	NA	NA	NA	NA	NA
cdc_msd_basic	PIC32MX	20392	3460	39444	494	1810
	PIC32MZ	25264	7788	45404	494	20438
hid_basic	PIC32MX	13988	0	5440	263	601
	PIC32MZ	18764	4328	10460	319	893
hid_joystick	PIC32MX	13432	0	5332	263	485
	PIC32MZ	18208	4328	10368	319	777
hid_keyboard	PIC32MX	14016	0	6196	263	581
	PIC32MZ	18792	4328	11048	319	873
hid_mouse	PIC32MX	13460	0	5972	263	497
	PIC32MZ	18236	4328	10964	319	793
hid_msd_basic	PIC32MX	20352	3460	39172	495	1861
	PIC32MZ	25232	7788	44216	495	20445
msd_basic	PIC32MX	17848	3460	38108	492	1348
	PIC32MZ	22632	7788	43996	492	20068
vendor	PIC32MX	12560	0	5660	324	560
	PIC32MZ	17356	4328	12080	324	1748

Note: The msd_basic, cdc_msd_basic, and the hid_msd_basic demonstrations use the PIC32 program Flash memory as the MSD storage media. The difference in Data Memory requirements between the PIC32MX and PIC32MZ microcontrollers for these demonstration examples, is due to an application demonstration buffer whose size is equal to the erase page size of the PIC32 microcontroller. On the PIC32MX795F512L, this size is 4096 bytes. On the PIC32MZ2048ECH144, the erase page size is 16 KB.

Program Memory and Data Memory Requirements with -Os Optimization

The following table shows the program memory and data memory requirements of the USB Device Stack demonstration applications. All size figures are in bytes. Demonstration applications were compiled with the MPLAB XC32 C/C++ Compiler, v1.40, with –Os optimization.

Demonstration Name		Program Memory Components			Data Memory Components	
Optimization -Os		USB Stack	Other Drivers	System and Application	USB Stack	Others
cdc_com_port_single	PIC32MX	12556	0	5656	262	718
	PIC32MZ	16840	4144	11076	318	1410
cdc_com_port_dual	PIC32MX	12548	0	5620	262	1250
	PIC32MZ	16832	4144	10448	318	2166
cdc_serial_emulator	PIC32MX	12504	7744	5880	262	858
	PIC32MZ	N/A	N/A	N/A	N/A	N/A
cdc_serial_emulator_msd	PIC32MX	20380	12560	35080	438	1950
	PIC32MZ	N/A	N/A	N/A	N/A	N/A
cdc_msd_basic	PIC32MX	17896	2884	39232	494	1810
	PIC32MZ	22172	7012	44868	494	20438
hid_basic	PIC32MX	12656	0	5344	263	601
	PIC32MZ	16784	4144	10060	319	893
hid_joystick	PIC32MX	12144	0	5304	263	485
	PIC32MZ	16272	4144	10040	319	777
hid_keyboard	PIC32MX	12664	0	6060	263	581
	PIC32MZ	16792	4144	10604	319	873
hid_mouse	PIC32MX	12152	0	5820	263	497
	PIC32MZ	16280	4144	10512	319	793
hid_msd_basic	PIC32MX	18060	2884	39068	495	1861
	PIC32MZ	20352	7012	45788	495	20445
msd_basic	PIC32MX	15776	2884	38044	492	1348
	PIC32MZ	19090	7012	44426	492	20068
vendor	PIC32MX	11452	0	5540	324	560
	PIC32MZ	15584	4144	10948	324	1748

USB Device Stack Component Memory Requirements

Provides memory requirements.

Description

The following table shows the Program and Data Memory requirements for individual components in the MPLAB Harmony USB Device Stack.

Device Stack Component	Program Memory	Data Memory
Device Layer	5688	184
CDC Function Driver	2420	64 + (36 * Queue Size)
MSD Function Driver	5352	217
HID Function Driver	2376	40 + (36 * Queue Size)
Vendor	912	8 + (36 * Queue Size)
PIC32MX USB Driver	5636	144 + (32 * Number of Endpoints)
PIC32MZ USB Driver	10244	192 + (32 * Number of Endpoints)

Notes:

1. Memory requirements (in bytes) for a single instance.
2. Size measured for USB Device Stack Components in MPLAB Harmony.
3. Data Memory does not include function call stack memory size.

USB MSD Host USB Pen Drive Tests

Provides pen drive test specifications.

Description

USB MSD Host USB Pen Drive Tests

The following table lists the commercially available USB pen drives, which have been tested to successfully enumerate with the MSD Host Driver

in the MPLAB Harmony USB Host. Note that if the USB pen drive you are using in not included in the table, this indicates that this USB pen drive has not been tested with the MSD Host Driver. However, the USB pen drive could still potentially work with MSD Host Driver. Some USB pen drives in this table did not have their manufacturer or model data available. The USB Pen drives were tested with the msd_basic USB Host demonstration in the latest version of the MPLAB Harmony USB Host Stack.

VID	PID	Manufacturer	Model/Drive Capacity
0x1B1C	0x1A0F	Corsair Components	Flash Voyager Go 8 GB
0x03F0	0x0AB7	Hewlett-Packard	64 GB
0xABCD	0x1234	Microchip Technology Inc.	4 GB
0x125F	0xCB10	Adata	Dashdrive UV100 8 GB
0x8644	0x8003	Verico	T Series 16 GB
0x8564	0x1000	Transcend	USB 3.0 32 GB
0x0951	0x16A7	Dell	Kingston Technology 16 GB
0x0718	0x0704	Imation	16 GB Pen Drive
0x048D	0x1168	iBall	Jaldi 16 GB Pen Drive
0x058F	0x6366	Alcor	Micro AXL 32 GB
0x154B	0x005B	PNY	Cube 16 GB
0x0930	0x6544	Toshiba	Hatabusa Pen Drive 8 GB
0x058F	0x6387	Alcor	ZipMem 16 GB
0x090C	0x1000	Silicon Motion Inc.	Axl 8GB
0x18A5	0x0245	Verbatim	Store N Go Audio USB 8 GB
0x05DC	0xC75C	Lexar	USB Pen Drive 8 GB
0x1005	0xb113	Apacer	8 GB (AH233)
0x054C	0x06B0	Sony	8 GB
0x054C	0x0862	Sony	Micro Vault USM-V 8 GB
0x0781	0x557c	SanDisk	8 GB
0x1E4E	0x3257	Etron	iBall 16 GB
0x1EC9	0x0101	Moserbaer	Swivel 16 GB Pen Drive
0x0BDA	0x0109	SanDisk	Standard A and Mini-B connector 16 GB
0x1908	0x1320	ZBEL	Wrist Band Flash Drive 4 GB
0x0951	0x1665	Kingston	Data Traveler SE9 16 GB

USB HID Host Keyboard and Mouse Tests

Description

The following table lists the commercially available USB keyboards and mouse, which have been tested to successfully enumerate with the HID Host Driver in the MPLAB Harmony USB Host. Note that if the USB HID device you are using in not included in the table, this indicates that this USB HID device has not been tested, but could still potentially work with the HID Host Driver.

Type	Manufacturer	VID	PID	Device Details
Keyboard	Microsoft	0x045E	0x07B9	Microsoft wired 200.
	ProHT	0x1A2C	0x0C21	110 keys.
	HP	0x04D9	0x1702	K1500 standard keyboard.
	Zebronics	0x1A2C	0x0027	Standard keyboard.
	Logitech	0x046D	0xC31D	112 keys.
	Gear Head	0x04D9	0x2BA0	82 key, mini-USB keyboard plus integrated mouse.
	Intex	0x1C4F	0x0002	122 keys.
Mouse	HP	0x0461	0x4D0F	Three button mouse.
	Intex	0x1BCF	0x0007	Three button mouse.
	Anker	0x1BCF	0x0005	Five button mouse.
	TeraByte	0x10C4	0x8103	Three button mouse.
	Kensington	0x1BCF	0x0002	Five button mouse.
	Logitech	0x046D	0xC069	Five button mouse.
	Microsoft	0x045E	0x0797	Optical mouse 200, three buttons.
	Logitech	0x046D	0xC246	Nine button mouse.
	HP	0x03F0	0x0941	Three button mouse.
	Lenovo	0x1BCF	0x000A	Five button mouse.

Demonstration Application Configurations

This topic provides information on the available USB demonstration project configurations.

Description

The available USB Demonstration application MPLAB X IDE projects feature support for multiple configurations. Selecting these configurations allow for the demonstration projects to run across different PIC32 microcontrollers and development boards. The following project configurations are available:

Configuration name	Description
pic32mx_usb_sk2_int_dyn	Selecting this configuration will set up the demonstration application to run on the PIC32 USB Starter Kit II development board, with the PIC32MX795F512L microcontroller. The USB Stack will be configured for Interrupt mode operation and the USB Driver will be configured for Dynamic operation mode.
pic32mx_usb_sk2_poll_dyn	Selecting this configuration will set up the demonstration application to run on the PIC32 USB Starter Kit II development board, with the PIC32MX795F512L microcontroller. The USB Stack will be configured for Polled mode operation and the USB driver will be configured for Dynamic operation mode.
pic32mx_usb_sk3_int_dyn	Selecting this configuration will set up the demonstration application to run on the PIC32 USB Starter Kit III development board, with the PIC32MX470F512L microcontroller. The USB Stack will be configured for Interrupt mode operation and the USB Driver will be configured for Dynamic operation mode.
pic32mx_usb_sk2_int_sta	Selecting this configuration will set up the demonstration application to run on the PIC32 USB Starter Kit II development board, with the PIC32MX795F512L microcontroller. The USB Stack will be configured for interrupt mode operation and the USB Driver will be configured for Static operation mode.
pic32mz_bt_audio_int_dyn	Selecting this configuration will setup the demonstration application to run on the PIC32 Bluetooth Audio Development Kit along with the a PIC32MZ20148ECH144 microcontroller. The USB Device stack will be configured for Interrupt mode of operation and the USB Driver will be configured for dynamic operation mode.
pic32mx_bt_sk_int_dyn	Selecting this configuration will set up the demonstration application to run on the PIC32 Bluetooth Starter Kit development board, with the PIC32MX270F256D microcontroller. The USB Stack will be configured for Interrupt mode operation and the USB Driver will be configured for dynamic operation mode.
pic32mz_da_sk_int_dyn	Selecting this configuration will set up the demonstration application to run on the PIC32MZ DA Starter Kit development board, with the PIC32MZ2064DAB288 microcontroller. The USB Stack will be configured for Interrupt mode operation and the USB Driver will be configured for Dynamic operation mode.
pic32mz_ec_sk_int_dyn	Selecting this configuration will set up the demonstration application to run on the PIC32MZ EC Starter Kit development board, with the PIC32MZ2048ECH144 microcontroller. The USB Stack will be configured for Interrupt mode operation and the USB Driver will be configured for Dynamic operation mode.
pic32mz_ec_sk_poll_dyn	Selecting this configuration will set up the demonstration application to run on the PIC32MZ EC Starter Kit development board, with the PIC32MC2048ECH144 microcontroller. The USB Stack will be configured for Polled mode operation and the USB Driver will be configured for Dynamic operation mode.
pic32mz_ec_sk_meb2_int_dyn	Selecting this configuration will set up the demonstration application to run on the PIC32MZ EC Starter Kit, with the PIC32MZ2048ECH144 microcontroller board attached to the MEB II. The USB Stack will be configured for Interrupt mode operation and the USB Driver will be configured for Dynamic operation mode.

pic32mz_ef_sk_int_dyn	Selecting this configuration will set up the demonstration application to run on the PIC32MZ EF Starter Kit, with the PIC32MZ2048EFM144 microcontroller. The USB Stack will be configured for Interrupt mode operation and the USB Driver will be configured for Dynamic operation mode.
pic32mz_ef_sk_poll_dyn	Selecting this configuration will set up the demonstration application to run on the PIC32MZ EF Starter Kit development board, with the PIC32MZ2048EFM144 microcontroller. The USB Stack will be configured for Polled mode operation and the USB Driver will be configured for Dynamic operation mode.
pic32mx795_pim_e16_int_dyn	Selecting this configuration will set up the demonstration application to run on the Explorer 16 Development Board along with the PIC32MX795F512L microcontroller Plug In Module and USB PICtail Plus Daughter Board. The USB Stack will be configured for Interrupt mode operation and the USB Driver will be configured for Dynamic operation mode.
pic32mx460_pim_e16_int_dyn	Selecting this configuration will set up the demonstration application to run on the Explorer 16 Development Board along with the PIC32MX460F512L microcontroller Plug In Module and USB PICtail Plus Daughter Board. The USB Stack will be configured for Interrupt mode operation and the USB Driver will be configured for Dynamic operation mode.
pic32mx470_curiosity	Selecting this configuration will set up the demonstration application to run on the PIC32MX470 Curiosity Development Board, with the PIC32MX470F512H microcontroller. The USB Stack will be configured for Interrupt mode operation and the USB Driver will be configured for Dynamic operation mode.
pic32mz_ef_curiosity	Selecting this configuration will set up the demonstration application to run on the PIC32MZ EF Curiosity Development Board, with the PIC32MZ2048EFM100 microcontroller. The USB Stack will be configured for Interrupt mode operation and the USB Driver will be configured for Dynamic operation mode.

The following figure shows how a configuration can be selected in MPLAB X IDE.

Alternatively, the active configuration can be selected in the Project Properties.

USB Device Demonstrations Matrix

The following table shows the availability of a configuration across available USB Device demonstration applications. **Green** indicates support. Red indicates no support.

Demo Apps \ Configurations	pic32mx_usb_sk2_int_dyn	pic32mz_ec_sk_int_dyn	pic32mx795_pim_e16_int_dyn	pic32mx_bt_sk_int_dyn	pic32mz_ec_sk_meb2_int_dyn	pic32mx_usb_sk2_poll_dyn	pic32mz_ec_sk_poll_dyn	pic32mx460_pim_e16_int_dyn	pic32mx_usb_sk2_int_sta	pic32mx_usb_sk3_int_dyn	pic32mz_bt_audio_int_dyn	pic32mz_ef_sk_poll_dyn	pic32mz_ef_sk_int_dyn	pic32mx_125_sk_int_dyn	chipkit_wf32	chipkit_wifire
cdc_com_port_single																
cdc_com_port_dual																
cdc_serial_emulator																
hid_basic																
hid_mouse																
hid_keyboard																
hid_joystick																
msd_basic																
vendor																
hid_msd_basic																
cdc_serial_emulator_msd																
cdc_msd_basic																
msd_sdcard																

USB Host Demonstration Matrix

The following table shows the availability of a configuration across available USB Host demonstration applications. Green indicates support. Red indicates no support.

Demo Apps \ Configurations	pic32mx_usb_sk2_int_dyn	pic32mz_ec_sk_int_dyn	pic32mz_ec_sk_meb2_int_dyn	pic32mz_ef_sk_int_dyn	pic32mz_ef_sk_meb2_int_dyn	pic32mx795_pim_e16_int_dyn	chipkit_wf32	chipkit_wifire
cdc_basic								
msd_basic								
cdc_msd								
hid_basic_mouse								
audio_speaker								
hub_msd								
hub_cdc_hid								
hid_basic_keyboard								

Demonstrations

The USB Demonstrations are grouped into USB Device Stack and USB Host Stack Demonstrations.

Device

This section describes the USB Device demonstrations.

Description

The MPLAB Harmony USB Device Stack demonstration applications uses LEDs on the development board to indicate the USB state of the device. The following table provides details on the development board specific LEDs and the USB Device State these indicate when active. This indication scheme is implemented by all USB Device Stack Demonstration applications.

USB Device State and LED Indication

Demonstration Board	Reset State	Configured State	Suspended State
Explorer 16 Development Board and PIM	D3, D4	D5	D4, D5
PIC32 USB Starter Kit II	LED1, LED2	LED3	LED2, LED3
PIC32MZ Embedded Connectivity (EC) Starter Kit	LED1, LED2	LED3	LED2, LED3
PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit	LED1, LED2	LED3	LED2, LED3
PIC32 USB Starter Kit III	LED1, LED2	LED3	LED2, LED3
PIC32 Bluetooth Starter Kit	Red LED, Green LED	Blue LED	Green LED, Blue LED
PIC32MX470 Curiosity Development Board	LED1, LED2	LED3	LED2, LED3
PIC32MZ EF Curiosity Development Board	LED1, LED2	LED3	LED2, LED3

cdc_com_port_dual

Demonstrates a USB CDC device, emulating dual serial COM ports - one looping back into the other.

Description

This demonstration application creates a USB CDC Device that enumerates as two serial ports on the USB Host personal computer. This application demonstrates the ability of the MPLAB Harmony USB Device Stack to support multiple instances of the same Device class.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the USB CDC Device

Dual COM Port Demonstration.

Description

To build this project, you must open the `cdc_com_port_dual.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/usb/device/cdc_com_port_dual`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`cdc_com_port_dual.X`	`<install-dir>/apps/usb/device/cdc_com_port_dual/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx460_pim_e16_int_dyn	pic32mx460_pim+e16	Select this MPLAB X IDE project configuration to run the demonstration on the Explorer 16 Development Board configured for Interrupt mode and dynamic operation. This configuration also requires PIC32MX460F512L Plug-In Module (PIM) and the USB PICtail Plus Daughter Board.
pic32mx_bt_sk_int_dyn	pic32mx_bt_sk	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32 Bluetooth Starter Kit configured for Interrupt mode and dynamic operation.
pic32mx_usb_sk3_int_dyn	pic32mx_usb_sk3	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32 USB Starter Kit III configured for Interrupt mode and dynamic operation.
pic32mx_usb_sk2_int_sta	pic32mx_usb_sk2	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32 USB Starter Kit II with the USB Driver configured for a static build configured for Interrupt mode and static operation.
pic32mx_usb_sk2_int_dyn	pic32mx_usb_sk2	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32 USB Starter Kit II configured for Interrupt mode and dynamic operation.
pic32mz_ec_sk_int_dyn	pic32mz_ec_sk	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32MZ Embedded Connectivity (EC) Starter Kit configured for Interrupt mode and dynamic operation.
pic32mz_ef_sk_int_dyn	pic32mz_ef_sk	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit configured for Interrupt mode and dynamic operation.
pic32mx470_curiosity	pic32mx470_curiosity	Select this MPLAB X IDE project configuration to run the demonstration application to run on the PIC32MX470 Curiosity Development Board, with the PIC32MX470F512H microcontroller. The USB Stack will be configured for Interrupt mode operation and the USB Driver will be configured for Dynamic operation mode.
pic32mz_ef_curiosity	pic32mz_ef_curiosity	Select this MPLAB X IDE project configuration to run the demonstration application to run on the PIC32MZ EF Curiosity Development Board, with the PIC32MZ2048EFM100 microcontroller. The USB Stack will be configured for Interrupt mode operation and the USB Driver will be configured for Dynamic operation mode.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32 USB Starter Kit II

Remove jumper JP2.

PIC32MZ EC Starter Kit

Remove jumper JP1.

PIC32MZ EF Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32 USB Starter Kit III

Remove jumper JP1.

PIC32 Bluetooth Starter Kit

Jumper J8 should either be shorted between pins 2 and 3 or should be completely open.

PIC32MX460F512L PIM

Jumper J10 should be removed. This plug-in module should be used along with the Explorer 16 Development Board and the USB PICtail Plus daughter board. The microcontroller PIM should be plugged into the PIM socket on the board. The USB PICtail Plus daughter board should be connected to the edge connector J9.

On the Explorer 16 Development Board:

- Switch S2 should be set to PIM
- Jumper JP2 should be in place

On the USB PICtail Plus Daughter Board:

- Jumper JP1 should be in place
- Jumper JP2 and JP4 should be removed

On the PIC32MX460F512L PIM:

- Keep jumper J10 open
- Keep all jumpers in J9 open

PIC32MX470 Curiosity Development Board

Ensure that a jumper is placed at 4-3 on J8.

PIC32MZ EF Curiosity Development Board

Ensure that a jumper is placed at 4-3 on J8.

Running the Demonstration

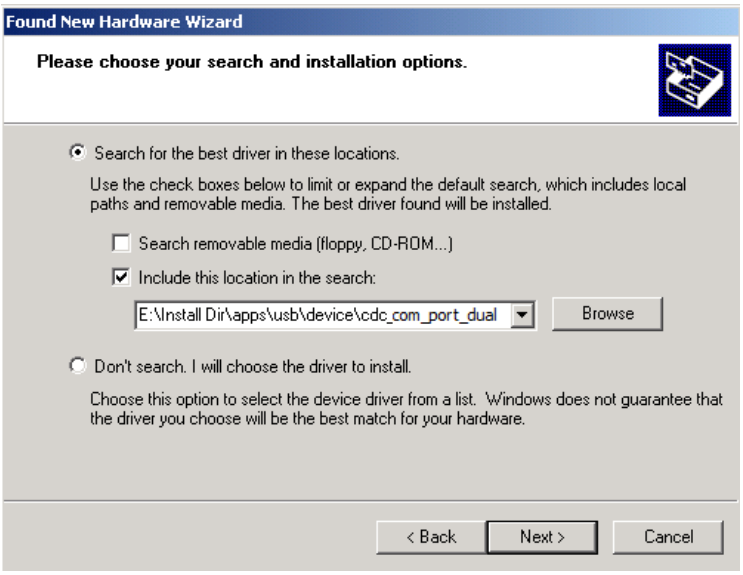
Provides instructions on how to build and run the CDC Dual COM Port demonstration.

Description

This demonstration allows the device to appear like dual serial (COM) ports to the host. Do the following to run this demonstration:

1. First compile and program the target device. While compiling, select the appropriate MPLAB X IDE project configuration based on the demonstration board. Refer to Building the Application for details.
2. Attach the device to the host. If the host is a personal computer and this is the first time you have plugged this device into the computer you may be prompted for a `.inf` file.

3. Select the "Install from a list or specific location (Advanced)" option. Specify the `<install-dir>/apps/usb/device/cdc_com_port_dual/inf` directory.



4. Once the device is successfully installed, open up two instances of a terminal program, such as HyperTerminal. Select the appropriate COM port for each of these terminal instance.
5. The LEDs on the demonstration board will indicate the USB state of the device, as described in the USB Device State and LED Indication Table in the Device section.
6. To run the demonstration, type a character or string in one terminal window. The same character or string appears on the second terminal window. Similarly, any character typed in the second window appears in the first window.

Note: Some terminal programs, like HyperTerminal, require users to click the disconnect button before removing the device from the computer. Failing to do so may result in having to close and open the program again to reconnect to the device.

cdc_com_port_single

Demonstrates a USB CDC device, emulating a serial COM port.

Description

This demonstration application creates a USB CDC Device that enumerates as a single COM port on the host personal computer. The application demonstrates two-way communication between the USB device and the personal computer host.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the USB CDC Device Single COM Port Demonstration.

Description

To build this project, you must open the `cdc_com_port_single.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/usb/device/cdc_com_port_single`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`cdc_com_port_single.X`	`<install-dir>/apps/usb/device/cdc_com_port_single/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx460_pim_e16_int_dyn	pic32mx460_pim+e16	Select this MPLAB X IDE project configuration to run the demonstration on the Explorer 16 Development Board configured for Interrupt mode and dynamic operation. This configuration also requires PIC32MX460F512L Plug-In Module (PIM) and the USB PICtail Plus Daughter Board.
pic32mx_usb_sk2_poll_dyn	pic32mx_bt_sk	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32 USB Starter Kit II with the USB Device Stack configured for Polled mode and dynamic operation.
pic32mx_usb_sk3_int_dyn	pic32mx_usb_sk3	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32 USB Starter Kit III configured for Interrupt mode and dynamic operation.
pic32mx_usb_sk2_int_sta	pic32mx_usb_sk2	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32 USB Starter Kit II with the USB Driver configured for Interrupt mode and static operation.
pic32mx_usb_sk2_int_dyn	pic32mx_usb_sk2	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32 USB Starter Kit II configured for Interrupt mode and dynamic operation.
pic32mz_da_sk_int_dyn	pic32mz_da_sk	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32MZ Graphics (DA) Starter Kit configured for Interrupt mode and dynamic operation.
pic32mz_ec_sk_int_dyn	pic32mz_ec_sk	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32MZ Embedded Connectivity (EC) Starter Kit configured for Interrupt mode and dynamic operation.
pic32mz_ec_sk_poll_dyn	pic32mz_ec_sk	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32MZ Embedded Connectivity (EC) Starter Kit with the USB Device Stack configured for Polled mode and dynamic operation.
pic32mz_ef_sk_int_dyn_micromips	pic32mz_ef_sk	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit configured in microMIPS mode for Interrupt mode and dynamic operation.
pic32mz_ef_sk_int_dyn	pic32mz_ef_sk	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit configured for Interrupt mode and dynamic operation.
pic32mz_ef_sk_poll_dyn	pic32mz_ef_sk	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit with the USB Device Stack configured for Polled mode and dynamic operation.
pic32mx_125_sk_int_dyn	pic32mx_125_sk	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32MX1/2/5 Starter Kit with the USB Device Stack configured for Interrupt mode and dynamic operation.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32 USB Starter Kit II

Remove jumper JP2.

PIC32MZ DA Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ EC Starter Kit

Remove jumper JP1.

PIC32MZ EF Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32 USB Starter Kit III

Remove jumper JP1.

PIC32MX460F512L PIM

Jumper J10 should be removed. This plug-in module should be used along with the Explorer 16 Development Board and the USB PICtail Plus daughter board. The microcontroller PIM should be plugged into the PIM socket on the board. The USB PICtail Plus daughter board should be connected to the edge connector J9.

On the Explorer 16 Development Board:

- Switch S2 should be set to PIM
- Jumper JP2 should be in place

On the USB PICtail Plus Daughter Board:

- Jumper JP1 should be in place
- Jumper JP2 and JP4 should be removed

On the PIC32MX460F512L PIM:

- Keep jumper J10 open
- Keep all jumpers in J9 open

Running the Demonstration

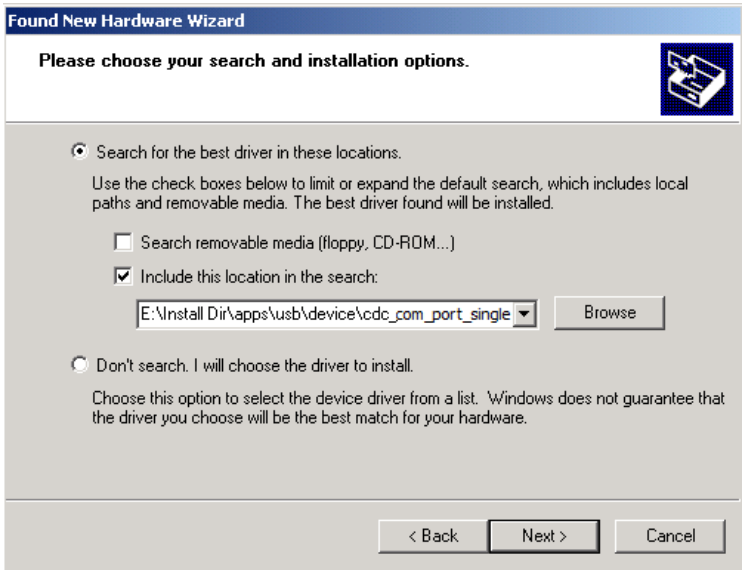
Provides instructions on how to build and run the CDC Single COM Port demonstration.

Description

This demonstration allows the device to appear like a serial (COM) port to the host. Do the following to run this demonstration:

1. First compile and program the target device. While compiling, select the appropriate MPLAB X IDE project configuration based on the demonstration board. Refer to Building the Application for details.
2. Attach the device to the host. If the host is a personal computer and this is the first time you have plugged this device into the computer, you may be prompted for a `.inf` file.

3. Select the "Install from a list or specific location (Advanced)" option. Specify the `<install-dir>/apps/usb/device/cdc_com_port_single/inf` directory.



4. Once the device is successfully installed, open up a terminal program, such as HyperTerminal and select the appropriate COM port. On most machines this will be COM5 or higher. Set the communication properties to 9600 baud, 1 Stop bit and No parity, with Flow Control set to None.

5. The LEDs on the demonstration board will indicate the USB state of the device, as described in the USB Device State and LED Indication Table in the Device section.
6. Once connected to the device, there are two ways to run this example project:
   - a) Typing a key in the terminal window will result in the attached device echoing the next letter. Therefore, if the letter 'b' is pressed, the device will echo 'c'.
   - b) If the push button is pressed, the device will echo "PUSH BUTTON PRESSED" to the terminal window.

The following table shows the switch buttons to be pressed for different demonstration boards.

Demonstration Board	Button
PIC32 USB Starter Kit II PIC32 USB Starter Kit III PIC32MZ Graphics (DA) Starter Kit PIC32MZ Embedded Connectivity (EC) Starter Kit PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit	SW1
Explorer 16 Development Board	S3

Note: Some terminal programs, like HyperTerminal, require users to click the disconnect button before removing the device from the computer. Failing to do so may result in having to close and open the program again to reconnect to the device.

cdc_msd_basic

Demonstrates a composite USB device emulating a COM port and Flash drive.

Description

This demonstration application creates a composite USB Device that enumerates as a COM port and as Flash drive simultaneously.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the USB CDC MSD Composite Device Demonstration.

Description

To build this project, you must open the `cdc_msd_basic.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/usb/device/cdc_msd_basic`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`cdc_msd_basic.X`	`<install-dir>/apps/usb/device/cdc_msd_basic/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx_usb_sk2_int_dyn	pic32mx_usb_sk2	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32 USB Starter Kit II configured for Interrupt mode and dynamic operation.
pic32mz_ec_sk_int_dyn	pic32mz_ec_sk	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32MZ Embedded Connectivity (EC) Starter Kit configured for Interrupt mode and dynamic operation.
pic32mz_ef_sk_int_dyn	pic32mz_ef_sk	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit configured for Interrupt mode and dynamic operation.

Configuring the Hardware

Description

PIC32 USB Starter Kit II

Remove jumper JP2.

PIC32MZ EC Starter Kit

Remove jumper JP1.

PIC32MZ EF Starter Kit

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

Provides instructions on how to build and run the USB CDC MSD Composite Device demonstration.

Description

This demonstration application creates a composite USB Device that works simultaneously as a CDC and as a MSD device. This application combines the functionality of the cdc_com_port_single and msd_basic demonstration applications into one device.

Refer to Running the Demonstration section of the cdc_com_port_single demonstration and the Running the Demonstration section of the msd_basic demonstration for details on exercising the CDC and MSD device features, respectively.

The LEDs on the demonstration board will indicate the USB state of the device, as described in the USB Device State and LED Indication Table in the Device section.

cdc_serial_emulator

This application demonstrates the use of the CDC device class in implementing a USB-to-Serial Dongle.

Description

This application demonstrates the use of the CDC device class in implementing a USB-to-Serial Dongle. The application enumerates a COM port on the personal computer. Data received through the CDC USB interface is forwarded to a UART. Data received on the UART is forwarded to the CDC USB interface. This emulates a USB-to-Serial Dongle.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the USB CDC Device USB-to-Serial Demonstration.

Description

To build this project, you must open the `cdc_serial_emulator.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/usb/device/cdc_serial_emulator`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`cdc_serial_emulator.X`	`<install-dir>/apps/usb/device/cdc_serial_emulator/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx795_pim_e16_int_dyn	pic32mx795_pim+e16	Select this MPLAB X IDE project configuration to run the demonstration on the Explorer 16 Development Board configured for Interrupt mode and dynamic operation. This configuration also requires the PIC32MX795F512L Plug-In Module (PIM) and the USB PICtail Plus Daughter Board.

pic32mz_ef_sk_int_dyn	pic32mz_ef_sk	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32MZ EF Starter Kit configured for Interrupt mode and dynamic operation.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32MZ EF Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32MX795F512L PIM)

Jumper J10 should be removed. Jumper J1 and J2 should connect to positions 1 and 2. This PIM should be used along with the Explorer 16 Development Board and the USB PICtail Plus daughter board. The microcontroller PIM should be plugged into the PIM socket on the board. The USB PICtail Plus daughter board should be connected to the edge connector J9.

On the Explorer 16 Development Board:

- Switch S2 should be set to PIM
- Jumper JP2 should be in place

On the USB PICtail Plus Daughter Board:

- Jumper JP1 should be in place
- Jumper JP2 and JP4 should be removed

On the PIC32MX795F512L PIM:

- Keep jumper J10 open
- Keep all jumpers in J9 open
- Jumper J1 should be shorted between positions 1 and 2. This configuration is only applicable for the PIC32MX795F512L USB CAN PIM (MA320003), and not the PIC32MX795F512L USB PIM (MA320002).
- Jumper J2 should be shorted between positions 1 and 2. This configuration is only applicable for the PIC32MX795F512L USB CAN PIM (MA320003) and not the PIC32MX795F512L USB PIM (MA320002).

Running the Demonstration

Provides instructions on how to build and run the CDC Serial Emulator Demonstration.

Prior to using this demonstration, it is recommended to review the MPLAB Harmony Release Notes for any known issues. A PDF copy of the release notes is provided in the `<install-dir>/doc` folder of your installation.

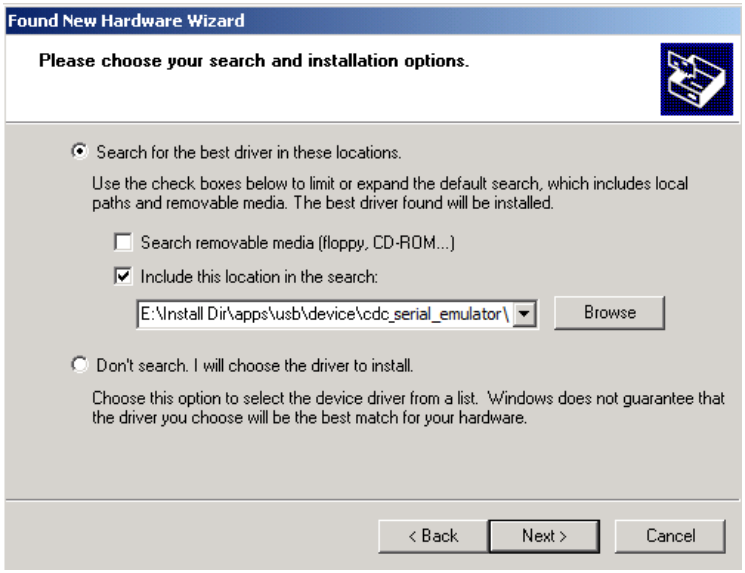
Description

This application demonstrates the use of the CDC Device class in implementing a USB-to-Serial Dongle. The application enumerates a COM port on the personal computer. Data received through the CDC USB interface is forwarded to a UART. Data received on the UART is forwarded to the CDC USB interface. This emulates a USB-to-Serial Dongle.

1. Open the project in MPLAB X IDE and select the desired configuration.
2. Build the code and program the device.
3. Depending on the hardware in use, do one of the following:

- If you are using the Explorer 16 board, connect the mini-B device connector on the USB PICtail Plus Daughter Board to the personal computer
- If you a are using the PIC32MZ EF starter kit, connect the micro-USB device connector to the personal computer

7. Select the "Install from a list or specific location (Advanced)" option. Specify the `<install-dir>/apps/usb/device/cdc_serial_emulator/inf` directory.



The LEDs on the demonstration board will indicate the USB state of the device, as described in the USB Device State and LED Indication Table in the Device section.

8. Open a terminal emulation program of your choice and select the enumerated USB COM port.

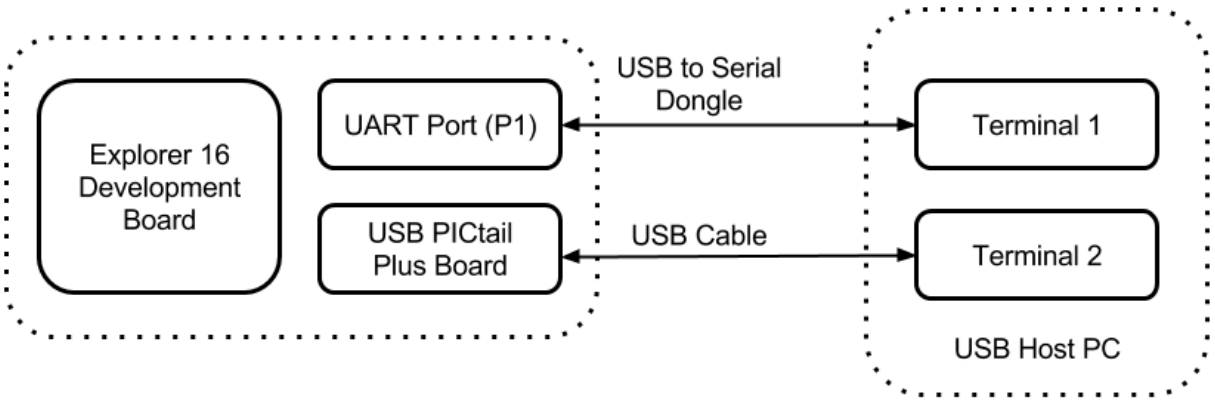
9. Connect the USB-to-Serial Dongle to the same personal computer.

10. Open another instance of the terminal emulation program and select the USB-to-Serial Dongle.

11. Connect the serial connector of the USB-to-Serial Dongle to the UART connector (P1) on the Explorer 16 Development Board.

12. Choose a baud rate of 9600, 1 Stop bit and no parity while opening both of the terminal emulation programs.

The setup should be similar to the following diagram.



Any text entered into the terminal 1 program will be echoed on terminal 2 and vice versa.

cdc_serial_emulator_msd

Demonstrates a USB to Serial Dongle combined with a MSD class.

Description

This demonstration application creates a USB Device that combines the functionality of the cdc_serial_emulator and msd_basic demonstration applications.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the this demonstration application.

Description

To build this project, you must open the `cdc_serial_emulator_msd.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/usb/cdc_serial_emulator_msd`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`cdc_serial_emulator_msd.X`	`<install-dir>/apps/usb/device/cdc_serial_emulator_msd/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx795_pim_e16_int_dyn	pic32mx795_pim+e16	Select this MPLAB X IDE project configuration to run the demonstration on the Explorer 16 Development Board configured for Interrupt mode and dynamic operation. This configuration also requires the PIC32MX795F512L Plug-In Module (PIM) and the USB PICtail Plus Daughter Board.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32MX795F512L PIM

Jumper J10 should be removed. Jumper J1 and J2 should connect to positions 1 and 2. This PIM should be used along with the Explorer 16 Development Board and the USB PICtail Plus daughter board. The microcontroller PIM should be plugged into the PIM socket on the board. The USB PICtail Plus daughter board should be connected to the edge connector J9.

On the Explorer 16 Development Board:

- Switch S2 should be set to PIM
- Jumper JP2 should be in place

On the USB PICtail Plus Daughter Board:

- Jumper JP1 should be in place
- Jumper JP2 and JP4 should be removed

On the PIC32MX795F512L PIM:

- Keep jumper J10 open.
- Keep all jumpers in J9 open
- Jumper J1 should be shorted between positions 1 and 2
- Jumper J2 should be shorted between positions 1 and 2

Running the Demonstration

Provides instructions on how to build and run the demonstration.

Description

This demonstration functions as a composite USB Device that combines the features of the devices created by the cdc_serial_emulator and the msd_basic demonstration applications. Refer to Running the Demonstration section of the cdc_serial_emulator demonstration and Running the Demonstration section of the msd_basic demonstration for details on exercising the CDC and MSD functions, respectively.

The LEDs on the demonstration board will indicate the USB state of the device, as described in the USB Device State and LED Indication Table in the Device section.

hid_basic

This demonstration application creates a custom HID device that can be controlled by a personal computer-based utility.

Description

This application creates a custom HID device that can be controlled by a personal computer-based utility. The device allows the USB Host utility to control the LEDs on the board and query the status of a switch.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the USB HID Basic Demonstration.

Description

To build this project, you must open the `hid_basic.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/usb/device/hid_basic`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`hid_basic.X`	`<install-dir>/apps/usb/device/hid_basic/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx460_pim_e16_int_dyn	pic32mx460_pim+e16	Select this MPLAB X IDE project configuration to run the demonstration on the Explorer 16 Development Board configured for Interrupt mode and dynamic operation. This configuration also requires the PIC32MX460F512L Plug-In Module (PIM) and the USB PICtail Plus Daughter Board.
pic32mx_usb_sk3_int_dyn	pic32mx_usb_sk3	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32 USB Starter Kit III configured for Interrupt mode and dynamic operation.
pic32mx_usb_sk2_int_dyn	pic32mx_usb_sk2	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32 USB Starter Kit II configured for Interrupt mode and dynamic operation.

pic32mz_ec_sk_int_dyn	pic32mz_ec_sk	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32MZ Embedded Connectivity (EC) Starter Kit configured for Interrupt mode and dynamic operation.
pic32mz_ef_sk_int_dyn	pic32mz_ef_sk	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit configured for Interrupt mode and dynamic operation.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32 USB Starter Kit II

Remove jumper JP2.

PIC32MZ EC Starter Kit

Remove jumper JP1.

PIC32MZ EF Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32 USB Starter Kit III

Remove jumper JP1.

PIC32MX460F512L PIM

Jumper J10 should be removed. This plug-in module should be used along with the Explorer 16 Development Board and the USB PICtail Plus daughter board. The microcontroller PIM should be plugged into the PIM socket on the board. The USB PICtail Plus daughter board should be connected to the edge connector J9.

On the Explorer 16 Development Board:

- Switch S2 should be set to PIM
- Jumper JP2 should be in place

On the USB PICtail Plus Daughter Board:

- Jumper JP1 should be in place
- Jumper JP2 and JP4 should be removed

On the PIC32MX460F512L PIM:

- Keep jumper J10 open
- Keep all jumpers in J9 open

Running the Demonstration

Provides instructions on how to build and run the HID Basic demonstration.

Description

This demonstration uses the selected hardware platform as a HID class USB device, but uses the HID class for general purpose I/O operations. While compiling, select the appropriate MPLAB X IDE project configuration based on the demonstration board. Refer to Building the Application for details.

Typically, the HID class is used to implement human interface products, such as mice and keyboards. The HID protocol, is however, quite flexible, and can be adapted and used to send/receive general purpose data to/from a USB device. Using the HID class for general purpose I/O operations is quite advantageous, in that it does not require any kind of custom driver installation process. HID class drivers are already provided by and are distributed with common operating systems. Therefore, upon plugging in a HID class device into a typical computer system, no user installation of drivers is required, the installation is fully automatic.

The LEDs on the demonstration board will indicate the USB state of the device, as described in the USB Device State and LED Indication Table in the Device section.

HID devices primarily communicate through one interrupt IN endpoint and one interrupt OUT endpoint. In most applications, this effectively limits the maximum achievable bandwidth for full speed HID devices to 64 kBytes/s of IN traffic, and 64 kBytes/s of OUT traffic (64 kB/s, but effectively "full duplex").

The `GenericHIDSimpleDemo.exe` program, and the associated firmware demonstrate how to use the HID protocol for basic general purpose USB data transfer.

Before you can run the `GenericHIDSimpleDemo.exe` executable, you will need to have the Microsoft® .NET Framework Version 2.0 Redistributable Package (later versions are probably acceptable, but have not been tested) installed on your computer. Programs that were built in the Visual Studio® .NET languages require the .NET redistributable package. The redistributable package can be freely downloaded from Microsoft's website. Users of Windows Vista® operating systems will not need to install the .NET framework, as it comes preinstalled as part of the operating system.

Launching the Application

To launch the application, simply double click the executable `GenericHIDSimpleDemo.exe` in the `<install-dir>\apps\usb\device\hid_basic\bin` directory. A property sheet similar to the following should appear:

Note: If instead of this window, an error message appears while trying to launch the application, it is likely the Microsoft .NET Framework Version 2.0 Redistributable Package has not yet been installed. Please install it and try again.

Send/Receive Packets

To begin sending/receiving packets to the device, you must first find and connect to the device. As configured by default, the application is looking for HID class USB devices with VID = 0x04D8 and PID = 0x003F. The device descriptor in the firmware project meant to be used with this demonstration uses the same VID/PID. If you plug in a USB device programmed with the correct precompiled `.hex` file, and click **Connect**, the other push buttons should become enabled. If clicking **Connect** has no effect, it is likely the USB device is either not connected, or has not been programmed with the correct firmware.

Clicking **Toggle LED(s)** should send a single packet of general purpose generic data to the HID class USB peripheral device. The data will arrive on the interrupt OUT endpoint. The firmware has been configured to receive this generic data packet, parse the packet looking for the Toggle LED(s) command, and should respond appropriately by controlling the LED(s) on the demonstration board.

The Get Pushbutton State option will send one packet of data over the USB to the peripheral device (to the interrupt OUT endpoint) requesting the current push button state. The firmware will process the received Get Pushbutton State command, and will prepare an appropriate response packet depending upon the pushbutton state.

The following table shows the button that has to be pressed on the demonstration board to see the change in the push button state.

Demonstration Board	Button
PIC32 USB Starter Kit II PIC32 USB Starter Kit III PIC32MZ Embedded Connectivity (EC) Starter Kit PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit	SW1
Explorer 16 Development Board	S3

hid_joystick

Demonstrates a USB HID device emulating a joystick.

Description

This demonstration application creates a custom HID joystick. This application is only intended to demonstrate creation of Joystick HID Report descriptors and may not be a definite end solution. The end application requirements may need the report descriptor to be modified.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the USB HID Joystick Demonstration.

Description

To build this project, you must open the `hid_joystick.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/usb/device/hid_joystick`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`hid_joystick.X`	`<install-dir>/apps/usb/device/hid_joystick/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx460_pim_e16_int_dyn	pic32mx460_pim+e16	Select this MPLAB X IDE project configuration to run the demonstration on the Explorer 16 Development Board configured for Interrupt mode and dynamic operation. This configuration also requires the PIC32MX460F512L Plug-In Module (PIM) and the USB PICtail Plus Daughter Board.
pic32mx_usb_sk3_int_dyn	pic32mx_usb_sk3	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32 USB Starter Kit III configured for Interrupt mode and dynamic operation.
pic32mx_usb_sk2_int_dyn	pic32mx_usb_sk2	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32 USB Starter Kit II configured for Interrupt mode and dynamic operation.
pic32mz_ec_sk_int_dyn	pic32mz_ec_sk	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32MZ Embedded Connectivity (EC) Starter Kit configured for Interrupt mode and dynamic operation.
pic32mz_ef_sk_int_dyn	pic32mz_ef_sk	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit configured for Interrupt mode and dynamic operation.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32 USB Starter Kit II

Remove jumper JP2.

PIC32MZ EC Starter Kit

Remove jumper JP1.

PIC32MZ EF Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32 USB Starter Kit III

Remove jumper JP1.

PIC32MX460F512L PIM

Jumper J10 should be removed. This plug-in module should be used along with the Explorer 16 Development Board and the USB PICtail Plus daughter board. The microcontroller PIM should be plugged into the PIM socket on the board. The USB PICtail Plus daughter board should be connected to the edge connector J9.

On the Explorer 16 Development Board:

- Switch S2 should be set to PIM
- Jumper JP2 should be in place

On the USB PICtail Plus Daughter Board:

- Jumper JP1 should be in place
- Jumper JP2 and JP4 should be removed

On the PIC32MX460F512L PIM:

- Keep jumper J10 open
- Keep all jumpers in J9 open

Running the Demonstration

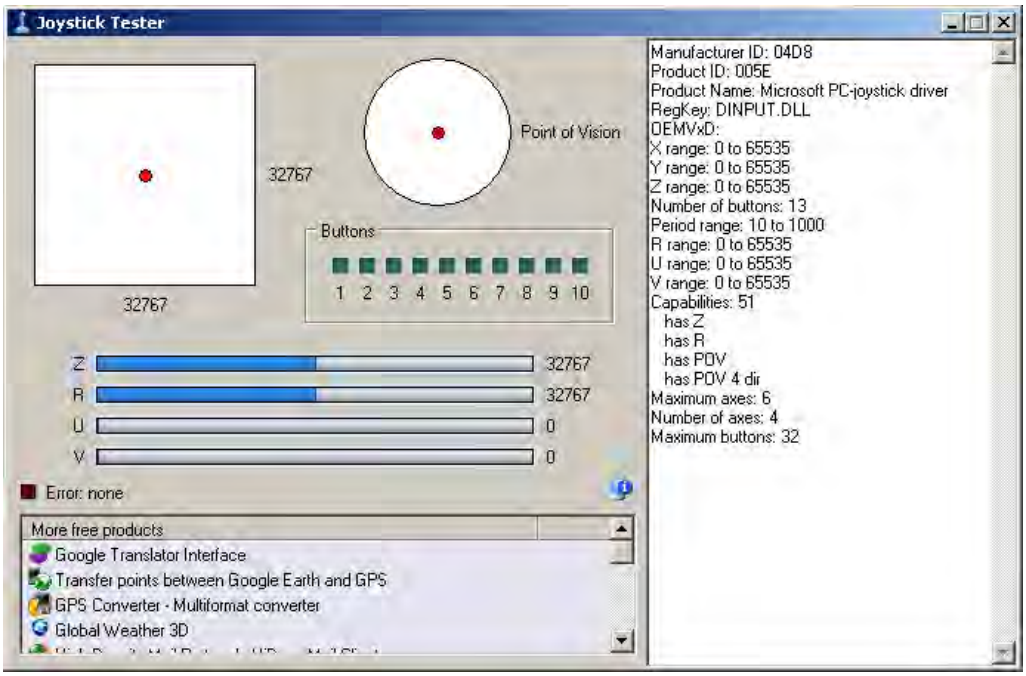
Provides instructions on how to build and run the USB HID Joystick demonstration.

Description

This demonstration uses the selected hardware platform as a USB Joystick. Select the appropriate MPLAB X IDE project configuration based on the demonstration board. Refer to Building the Application for details.

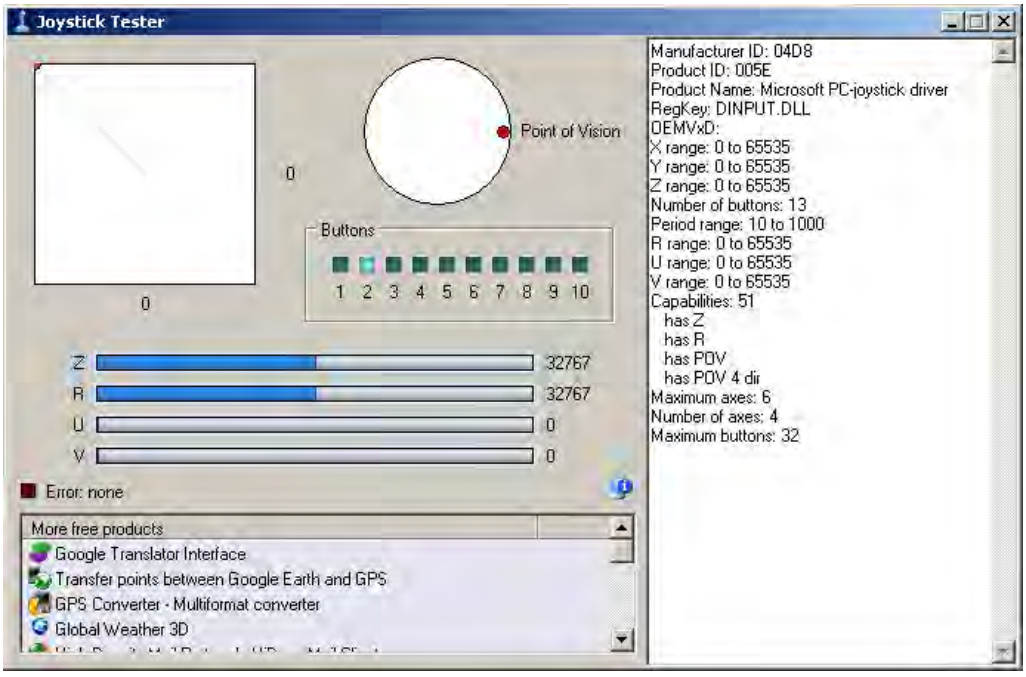
The LEDs on the demonstration board will indicate the USB state of the device, as described in the USB Device State and LED Indication Table in the Device section.

To test the joystick feature, navigate to the `<install-dir>/apps/usb/device/hid_joystick/bin` directory and open `JoystickTester.exe`:



Pressing the button will cause the device to:

- Indicate that the "x" button is pressed, but no others
- Move the hat switch to the "east" position
- Move the X and Y coordinates to their extreme values



The Following table shows the button that has to be pressed on the demonstration board to emulate the joystick.

Demonstration Board	Button
PIC32 USB Starter Kit II PIC32 USB Starter Kit III PIC32MZ Embedded Connectivity (EC) Starter Kit PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit	SW1
Explorer 16 Development Board	S3

hid_keyboard

Demonstrates a USB HID device, emulating a keyboard.

Description

This demonstration application creates a Generic HID keyboard. Pressing a key on the board emulates a keyboard key press.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the USB HID Keyboard Demonstration.

Description

To build this project, you must open the `hid_keyboard.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/usb/device/hid_keyboard`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`hid_keyboard.X`	`<install-dir>/apps/usb/device/hid_keyboard/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx460_pim_e16_int_dyn	pic32mx460_pim+e16	Select this MPLAB X IDE project configuration to run the demonstration on the Explorer 16 Development Board configured for Interrupt mode and dynamic operation. This configuration also requires the PIC32MX460F512L Plug-In Module (PIM) and the USB PICtail Plus Daughter Board.
pic32mx_usb_sk3_int_dyn	pic32mx_usb_sk3	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32 USB Starter Kit III configured for Interrupt mode and dynamic operation.
pic32mx_usb_sk2_int_dyn	pic32mx_usb_sk2	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32 USB Starter Kit II configured for Interrupt mode and dynamic operation.
pic32mz_ec_sk_int_dyn	pic32mz_ec_sk	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32MZ Embedded Connectivity (EC) Starter Kit configured for Interrupt mode and dynamic operation.
pic32mz_ef_sk_int_dyn	pic32mz_ef_sk	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit configured for Interrupt mode and dynamic operation.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32 USB Starter Kit II

Remove jumper JP2.

PIC32MZ EC Starter Kit

Remove jumper JP1.

PIC32MZ EF Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32 USB Starter Kit III

Remove jumper JP1.

PIC32MX460F512L PIM

Jumper J10 should be removed. This plug-in module should be used along with the Explorer 16 Development Board and the USB PICtail Plus daughter board. The microcontroller PIM should be plugged into the PIM socket on the board. The USB PICtail Plus daughter board should be connected to the edge connector J9.

On the Explorer 16 Development Board:

- Switch S2 should be set to PIM
- Jumper JP2 should be in place

On the USB PICtail Plus Daughter Board:

- Jumper JP1 should be in place
- Jumper JP2 and JP4 should be removed

On the PIC32MX460F512L PIM:

- Keep jumper J10 open
- Keep all jumpers in J9 open

Running the Demonstration

Provides instructions on how to build and run the USB HID Keyboard demonstration.

Description

This demonstration uses the selected hardware platform as a USB keyboard. While compiling, select the appropriate MPLAB X IDE project configuration based on the demonstration board. Refer to Building the Application for details.

The LEDs on the demonstration board will indicate the USB state of the device, as described in the USB Device State and LED Indication Table in the Device section.

Before pressing the button, select a window in which it is safe to type text freely. Pressing the button on the demonstration board will cause the device to print a character on the screen.

The following table shows the button that has to be pressed on the demonstration board to print a character.

Demonstration Board	Button
PIC32 USB Starter Kit II PIC32 USB Starter Kit III PIC32MZ Embedded Connectivity (EC) Starter Kit PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit	SW1
Explorer 16 Development Board	S3

hid_mouse

Demonstrates a USB HID device, emulating a mouse pointing device.

Description

This demonstration application creates a USB HID based two-button mouse device. When connected, the device emulates mouse operation by moving the cursor in a circular pattern.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the USB HID Mouse Demonstration.

Description

To build this project, you must open the `hid_mouse.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/usb/device/hid_mouse`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`hid_mouse.X`	`<install-dir>/apps/usb/device/hid_mouse/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx460_pim_e16_int_dyn	pic32mx460_pim+e16	Select this MPLAB X IDE project configuration to run the demonstration on the Explorer 16 Development Board configured for Interrupt mode and dynamic operation. This configuration also requires the PIC32MX460F512L Plug-In Module (PIM) and the USB PICtail Plus Daughter Board.
pic32mx_usb_sk3_int_dyn	pic32mx_usb_sk3	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32 USB Starter Kit III configured for Interrupt mode and dynamic operation.
pic32mx_usb_sk2_int_dyn	pic32mx_usb_sk2	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32 USB Starter Kit II configured for Interrupt mode and dynamic operation.
pic32mz_da_sk_int_dyn	pic32mz_da_sk	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32MZ Graphics (DA) Starter Kit configured for Interrupt mode and dynamic operation.
pic32mz_ec_sk_int_dyn	pic32mz_ec_sk	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32MZ Embedded Connectivity (EC) Starter Kit configured for Interrupt mode and dynamic operation.
pic32mz_ef_sk_int_dyn	pic32mz_ef_sk	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit configured for Interrupt mode and dynamic operation.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32 USB Starter Kit II

Remove jumper JP2.

PIC32MZ DA Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ EC Starter Kit

Remove jumper JP1.

PIC32MZ EF Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32 USB Starter Kit III

Remove jumper JP1.

PIC32MX460F512L PIM

Jumper J10 should be removed. This plug-in module should be used along with the Explorer 16 Development Board and the USB PICtail Plus daughter board. The microcontroller PIM should be plugged into the PIM socket on the board. The USB PICtail Plus daughter board should be connected to the edge connector J9.

On the Explorer 16 Development Board:

- Switch S2 should be set to PIM
- Jumper JP2 should be in place

On the USB PICtail Plus Daughter Board:

- Jumper JP1 should be in place
- Jumper JP2 and JP4 should be removed

On the PIC32MX460F512L PIM:

- Keep jumper J10 open
- Keep all jumpers in J9 open

Running the Demonstration

Provides instructions on how to build and run the HID Mouse Demonstration.

Description

This demonstration uses the selected hardware platform as a USB mouse. While compiling, select the appropriate MPLAB X IDE project configuration based on the demonstration board. Refer to Building the Application for details.

The LEDs on the demonstration board will indicate the USB state of the device, as described in the USB Device State and LED Indication Table in the Device section.

Before connecting the board to the computer through the USB cable please be aware that the device will begin moving the mouse cursor on the computer. There are two ways to stop the device from allowing the cursor to continue to move. The first way is to disconnect the device from the computer. The second is to press the correct button on the hardware platform. Pressing the button again will cause the mouse cursor to start moving in a circle again.

The following table shows the button that has to be pressed on the demonstration board to stop the circular motion:

Demonstration Board	Button
PIC32 USB Starter Kit II PIC32 USB Starter Kit III PIC32MZ Graphics (DA) Starter Kit PIC32MZ Embedded Connectivity (EC) Starter Kit PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit	SW1
Explorer 16 Development Board	S3

hid_msd_basic

Demonstrates a HID Device Class and MSD class composite USB Device.

Description

This demonstration application creates a USB Device that combines the functionality of the hid_basic and msd_basic demonstration applications.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the this demonstration application.

Description

To build this project, you must open the `hid_msd_basic.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/usb/device/hid_msd_basic`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`hid_msd_basic.X`	`<install-dir>/apps/usb/device/hid_msd_basic/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx_usb_sk2_int_dyn	pic32mx_usb_sk2	Select this configuration to run the demonstration application on the PIC32 USB Starter Kit II configured for Interrupt mode and dynamic operation.
pic32mz_ec_sk_int_dyn	pic32mz_ec_sk	Select this configuration to run the demonstration application on the PIC32MZ Embedded Connectivity (EC) Starter Kit configured for Interrupt mode and dynamic operation.
pic32mz_ef_sk_int_dyn	pic32mz_ef_sk	Select this configuration to run the demonstration application on the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit configured for Interrupt mode and dynamic operation.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32 USB Starter Kit II

Remove jumper JP2.

PIC32MZ EC Starter Kit

Remove jumper JP1.

PIC32MZ EF Starter Kit

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

Provides instructions on how to build and run the demonstration.

Description

This demonstration functions as composite USB Device that combines the features of the devices created by the hid_basic and the msd_basic demonstration applications. Refer to Running the Demonstration section of the hid_basic demonstration and Running the Demonstration section of the msd_basic demonstration for details on exercising the HID and MSD functions, respectively.

The LEDs on the demonstration board will indicate the USB state of the device, as described in the USB Device State and LED Indication Table in the Device section.

msd_basic

Demonstrates a USB MSD Device emulating a Flash Drive.

Description

This demonstration application creates a Flash drive using the Mass Storage Device Class.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the USB MSD Basic Demonstration.

Description

To build this project, you must open the `msd_basic.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/usb/device/msd_basic`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`msd_basic.X`	`<install-dir>/apps/usb/device/msd_basic/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx_bt_sk_int_dyn	pic32mx_bt_sk	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32 Bluetooth Starter Kit configured for Interrupt mode and dynamic operation.
pic32mx_usb_sk2_poll_dyn	pic32mx_usb_sk2	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32 USB Starter Kit II with the USB Device Stack configured for Polled mode and dynamic operation..
pic32mx_usb_sk2_int_dyn	pic32mx_usb_sk2	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32 USB Starter Kit II configured for Interrupt mode and dynamic operation.

pic32mx_usb_sk3_int_dyn	pic32mx_usb_sk3	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32 USB Starter Kit III configured for Interrupt mode and dynamic operation.
pic32mz_ec_sk_poll_dyn	pic32mz_ec_sk	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32MZ Embedded Connectivity (EC)Starter Kit with the USB Device Stack configured for Polled mode and dynamic operation.
pic32mz_ec_sk_int_dyn	pic32mz_ec_sk	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32MZ Embedded Connectivity (EC) Starter Kit configured for Interrupt mode and dynamic operation.
pic32mz_ef_sk_int_dyn	pic32mz_ef_sk	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit configured for Interrupt mode and dynamic operation.
pic32mz_ef_sk_poll_dyn	pic32mz_ef_sk	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit configured for Polled mode and dynamic operation.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32 USB Starter Kit II

Remove jumper JP2.

PIC32MZ EC Starter Kit

Remove jumper JP1.

PIC32MZ EF Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32 USB Starter Kit III

Remove jumper JP1.

PIC32 Bluetooth Starter Kit

No hardware related configuration or jumper settings required.

PIC32MX460F512L PIM

Jumper J10 should be removed. This plug-in module should be used along with the Explorer 16 Development Board and the USB PICtail Plus daughter board. The microcontroller PIM should be plugged into the PIM socket on the board. The USB PICtail Plus daughter board should be connected to the edge connector J9.

On the Explorer 16 Development Board:

- Switch S2 should be set to PIM
- Jumper JP2 should be in place

On the USB PICtail Plus Daughter Board:

- Jumper JP1 should be in place
- Jumper JP2 and JP4 should be removed

Running the Demonstration

Provides instructions on how to build and run the USB MSD Basic demonstration.

Description

This demonstration uses the selected hardware platform as a logical drive on the computer using the internal Flash of the device as the drive storage media. Connect the hardware platform to a computer through a USB cable. The device should appear as a new drive on the computer named "Drive Name". The drive can used to store files.

The LEDs on the demonstration board will indicate the USB state of the device, as described in the USB Device State and LED Indication Table in the Device section.

Note: Reprogramming the development board will cause any stored files to be erased.

msd_fs_spiflash

This application demonstrates accessing the SPI Flash connected to the PIC32 device as a media by multiple clients.

Description

This application demonstrates accessing the SPI Flash connected to the PIC32 device as a media by multiple clients. When connected via USB to the Host Computer, the SPI Flash is shown as the storage media. The Host writes files to the media, which is later accessed by the application running on the PIC32 device using the File System.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the USB MSD File System SPI Flash Demonstration.

Description

To build this project, you must open the `msd_fs_spiflash.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/usb/device/msd_fs_spiflash`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`msd_fs_spiflash.X`	`<install-dir>/apps/usb/device/msd_fs_spiflash/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
bt_audio_dk_int_dyn	bt_audio_dk	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32 Bluetooth Audio Development Kit.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32 Bluetooth Audio Develoment Kit

Ensure that switch S1 is set to PIC32_MCLR.

Running the Demonstration

Provides instructions on how to build and run the USB MSD File System SPI Flash demonstration.

Description

This demonstration shows an example of:

- Accessing the media attached to PIC32 by multiple clients
- Application running on the PIC32 firmware accesses the media using the MPLAB Harmony File System

When connected to the USB Host the very first time, the user is expected to format the media and create a file named `FILE.TXT` in the root directory of the media. The user can update the file to provide input for the application to glow the LEDs present on the development kit. The application running on the PIC32 reads and interprets the data present in the file and accordingly turns ON or OFF the LEDs LED8 and LED9 of the development kit. The format of input in the file `FILE.TXT` should be as follows:

- For turning ON an LED:
  - LED8:1
  - LED9:1
- For turning OFF an LED:
  - LED8:0
  - LED9:0

After having set the appropriate values in the file, the user can then press and release the wwitch SW1 located on the development kit for the MPLAB Harmony File System running on the PIC32 to act upon the contents of the file.

The FS state machine of the demonstration is only triggered by the switch SW1. When the user presses and releases SW1 the following occurs:

- LED5 is turned ON to indicate that the FS state machine is running
- The USB is detached
- The file system on the SPI Flash is mounted
- The contents of `FILE.TXT` is read and acted upon. Depending on the values set in the file, the LEDs are either turned ON or OFF.
- Next, the file system is unmounted and the USB is reattached
- LED5 is turned OFF to indicate that FS state machine is no longer running
- If LED6 is turned ON during any part of the demonstration, this indicates the demonstration has failed

msd_sdcard

Demonstrates data transfer from a SD card and a computer through USB MSD.

Description

This application demonstrates the usage of a SD card reader through the USB Mass Storage Device (MSD) class to transfer data between a computer and SD card. High-Speed USB is used for communication between the Host computer and the PIC32 device, while a SD card is used as the storage medium.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the USB MSD SD Card Demonstration.

Description

To build this project, you must open the `msd_sdcard.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/usb/device/msd_sdcard`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`msd_sdcard.X`	`<install-dir>/apps/usb/device/msd_sdcard/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mz_ec_sk_int_dyn	pic32mz_ec_sk+meb2	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32MZ EC Starter Kit connected to the MEB II. The media drivers are configured for Interrupt mode and dynamic operation.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32MZ Embedded Connectivity (EC) Starter Kit and Multimedia Expansion Board II (MEB II)

No hardware related configuration or jumper settings required.

Running the Demonstration

Provides instructions on how to build and run the USB MSD SD Card demonstration.

Description

This demonstration uses the selected hardware platform as a logical drive on the computer using the SD card as the drive storage media. Connect the hardware platform to a computer through a USB cable. The device should appear as a new drive on the computer named "Drive Name". The drive can then be used to store files.

The LEDs on the demonstration board will indicate the USB state of the device, as described in the USB Device State and LED Indication Table in

the Device section.

vendor

Demonstrates a custom USB Device created by using the USB Device Layer Endpoint functions.

Description

This demonstration application creates a custom USB device using the USB Device Layer Endpoint functions.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the Vendor USB Device Demonstration.

Description

To build this project, you must open the `vendor.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/usb/device/vendor`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`vendor.X`	`<install-dir>/apps/usb/device/vendor/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx460_pim_e16_int_dyn	pic32mx460_pim+e16	Select this MPLAB X IDE project configuration to run the demonstration on the Explorer 16 Development Board configured for Interrupt mode and dynamic operation. This configuration also requires the PIC32MX460F512L Plug-In Module (PIM) and the USB PICtail Plus Daughter Board.
pic32mx_usb_sk3_int_dyn	pic32mx_usb_sk3	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32 USB Starter Kit III configured for Interrupt mode and dynamic operation.
pic32mx_usb_sk2_int_dyn	pic32mx_usb_sk2	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32 USB Starter Kit II configured for Interrupt mode and dynamic operation.
pic32mz_ec_sk_int_dyn	pic32mz_ec_sk	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32MZ Embedded Connectivity (EC) Starter Kit configured for Interrupt mode and dynamic operation.
pic32mz_ef_sk_int_dyn	pic32mz_ef_sk	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit configured for Interrupt mode and dynamic operation.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32 USB Starter Kit II

Remove jumper JP2.

PIC32MZ EC Starter Kit

Remove jumper JP1.

PIC32MZ EF Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32 USB Starter Kit III

Remove jumper JP1.

PIC32MX460F512L PIM

Jumper J10 should be removed. This plug-in module should be used along with the Explorer 16 Development Board and the USB PICtail Plus daughter board. The microcontroller PIM should be plugged into the PIM socket on the board. The USB PICtail Plus daughter board should be connected to the edge connector J9.

On the Explorer 16 Development Board:

- Switch S2 should be set to PIM
- Jumper JP2 should be in place

On the USB PICtail Plus Daughter Board:

- Jumper JP1 should be in place
- Jumper JP2 and JP4 should be removed

On the PIC32MX460F512L PIM:

- Keep jumper J10 open
- Keep all jumpers in J9 open

Running the Demonstration

Provides instructions on how to build and run the Vendor USB Device demonstration.

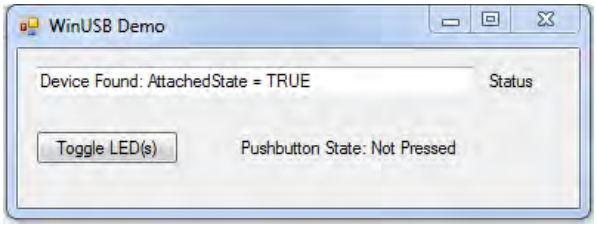
Description

The Vendor device can be exercised by using the WinUSB PnP Demonstration application, which is provided in your installation of MPLAB Harmony.

The LEDs on the demonstration board will indicate the USB state of the device, as described in the USB Device State and LED Indication Table in the Device section.

This application allows the state of the LEDs on the board to be toggled and indicates the state of a switch (pressed/released) on the board.

To launch the application, double click `WinUSB PnP Demo.exe` located in `<install dir>/apps/usb/device/vendor/bin`. A dialog box similar to the following should appear:



Pressing the Toggle LED button will cause the LED on the board to toggle. The Pushbutton State field in the application indicates the state of a button on connected USB Device. Pressing the switch on the development board will update the Pressed/Not Pressed status of the Pushbutton State field.

Demonstration Board	Button
PIC32 USB Starter Kit II PIC32 USB Starter Kit III PIC32MZ Embedded Connectivity (EC) Starter Kit PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit	SW1
Explorer 16 Development Board	S3

Host

This section describes the USB Host demonstrations.

audio_speaker

This application demonstrates the use of the Audio v1.0 Host Class Driver to enumerate and operate an audio speaker device.

Description

This application demonstrates the use of the Audio v1.0Host Class Driver to enumerate and an audio speaker device. The application uses the USB Host Layer and Audio 1.0 class driver to enumerate an Audio v1.0 USB device. The demonstration host application then operates and uses the functionality of the attached audio speaker device.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the USB Device Audio Speaker Demonstration.

Description

To build this project, you must open the `audio_speaker.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/usb/host/audio_speaker`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`audio_speaker.X`	`<install-dir>/apps/usb/host/audio_speaker/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx_usb_sk2_int_dyn	pic32mx_usb_sk2	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32 USB Starter Kit II configured for Interrupt mode and dynamic operation.
pic32mz_ec_sk_int_dyn	pic32mz_ec_sk	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32MZ Embedded Connectivity (EC) Starter Kit configured for Interrupt mode and dynamic operation.
pic32mz_ef_sk_int_dyn	pic32mz_ef_sk	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit configured for Interrupt mode and dynamic operation.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32 USB Starter Kit II

JP2 should be in place.

PIC32MZ EC Starter Kit

JP1 should be in place and the Ethernet plug-in board should be removed.

PIC32MZ EF Starter Kit

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

Provides instructions on how to build and run the USB Host Audio v1.0 Basic Demo.

Description

This application demonstrates the use of the Audio v1.0 Host Class Driver to enumerate and operate an Audio v1.0 Device. The application uses the USB Host layer and Audio v1.0 class driver to enumerate a Audio v1.0 USB device. The demonstration host application then operates and uses the functionality of the attached Audio v1.0 Device.

Prior to using this demonstration, it is recommended to review the MPLAB Harmony Release Notes for any known issues. A PDF copy of the release notes is provided in the `<install-dir>/doc` folder of your installation.

1. Open the project in MPLAB X IDE and select the desired project configuration.
2. Build the code and program the device.
3. Attach a commercially available USB speaker to the board.
4. LED1 is turned ON if the attached device is accepted by the Audio 1.0 class driver.
5. The speaker should produce a 1 kHz sine wave.
6. LED2 will continue blinking if the demonstration application cannot accept the device.

7. Press switch SW1 to mute the audio.
8. Press switch SW2 to unmute the audio

cdc_basic

This application demonstrates the use of the CDC Host Class Driver to enumerate and operate a CDC Device.

Description

This application demonstrates the use of the CDC Host Class Driver to enumerate and operate a CDC Device. The application uses the USB Host layer and CDC class driver to enumerate a CDC USB device. The demonstration host application then operates and uses the functionality of the attached CDC Device.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the USB CDC Host Basic Demonstration.

Description

To build this project, you must open the `cdc_basic.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/usb/host/cdc_basic`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`cdc_basic.X`	`<install-dir>/apps/usb/host/cdc_basic/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx_usb_sk2_int_dyn	pic32mx_usb_sk2	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32 USB Starter Kit II configured for Interrupt mode and dynamic operation.
pic32mx_usb_sk2_poll_dyn	pic32mx_usb_sk2	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32 USB Starter Kit II configured for Polled mode and dynamic operation.
pic32mz_ec_sk_int_dyn	pic32mz_ec_sk	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32MZ Embedded Connectivity (EC) Starter Kit configured for Interrupt mode and dynamic operation.
pic32mz_ec_sk_poll_dyn	pic32mz_ec_sk	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32MZ Embedded Connectivity (EC) Starter Kit configured for Polled mode and dynamic operation.
pic32mz_ef_sk_int_dyn	pic32mz_ef_sk	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit configured for Interrupt mode and dynamic operation.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32 USB Starter Kit II

JP2 should be in place.

PIC32MZ EC Starter Kit

JP1 should be in place and the Ethernet plug-in board should be removed.

PIC32MZ EF Starter Kit

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

Provides instructions on how to build and run the USB Host CDC Basic Demo.

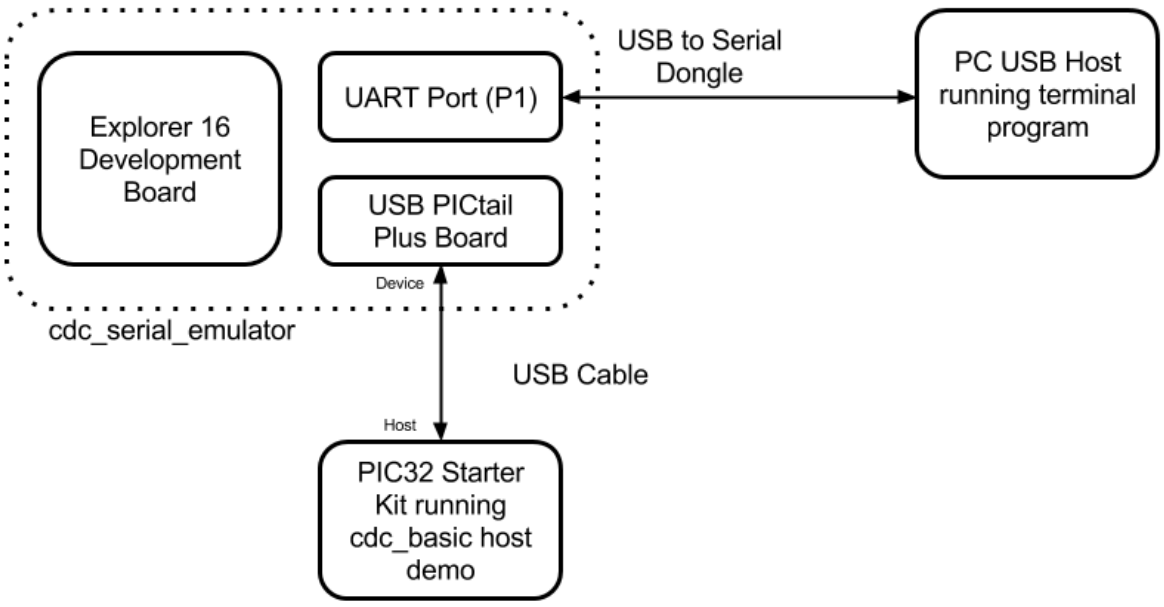
Description

This application demonstrates the use of the CDC Host Class Driver to enumerate and operate a CDC Device. The application uses the USB Host layer and CDC class driver to enumerate a CDC USB device. The demonstration host application then operates and uses the functionality of the attached CDC Device.

Prior to using this demonstration, it is recommended to review the MPLAB Harmony Release Notes for any known issues. A PDF copy of the release notes is provided in the `<install-dir>/doc` folder of your installation.

1. Open the project in MPLAB X IDE and select the desired project configuration.
2. Build the code and program the device.
3. Follow the directions for setting up and running the cdc_serial_emulator USB device demonstration.
4. Connect the UART (P1) port on the Explorer 16 Development Board (running the cdc_serial_emulator demonstration) to a USB Host personal computer via a commercially available Serial-to-USB Dongle.
5. Start a terminal program on the USB Host personal computer and select the Serial-to-USB Dongle as the communication port. Select the baud rate as 9600, no parity, 1 Stop bit and no flow control.
6. Connect the mini – B connector on the USB PICtail Plus Daughter Board, of the cdc_serial_emulator demonstration setup, to the Type-A USB host connector on the starter kit.
7. A prompt (LED :) will be displayed immediately on the terminal emulation program.
8. Pressing either the 1, 2, or 3 key on the USB Host keyboard will cause LED 1, 2, or 3 on the PIC32 Starter kit (running the USB CDC Host application) to switch on, respectively.
9. The prompt will again be displayed on terminal emulation program, and step 8 can be repeated.

The setup should be similar to the following diagram.



The cdc_serial_emulator demonstration emulates a USB-to-Serial Dongle. The CDC Host (running the cdc_basic demonstration application) sends the prompt message to the CDC device. The CDC device forwards the prompt to the UART port from where it is transmitted to the personal computer USB Host through the USB-to-Serial Dongle. A key press on the personal computer USB Host is transmitted to the CDC device, which in turn presents the key press data to the CDC host. The cdc_basic demonstration then analyzes the key press data and switches on the respective LED.

cdc_msd

Demonstrates host support for multiple device classes.

Description

This demonstration application creates a USB Host that can support different device classes in one application.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for this USB CDC MSD Host Demonstration.

Description

To build this project, you must open the `cdc_msd.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/usb/host/cdc_msd`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`cdc_msd.X`	`<install-dir>/apps/usb/host/cdc_msd/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx_usb_sk2_int_dyn	pic32mx_usb_sk2	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32 USB Starter Kit II configured for Interrupt mode and dynamic operation.
pic32mz_ec_sk_int_dyn	pic32mz_ec_sk	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32MZ Embedded Connectivity (EC) Starter Kit configured for Interrupt mode and dynamic operation.
pic32mz_ef_sk_int_dyn	pic32mz_ef_sk	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit configured for Interrupt mode and dynamic operation.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32 USB Starter Kit II

JP2 should be in place.

PIC32MZ EC Starter Kit

JP1 should be in place and the Ethernet plug-in board should be removed.

PIC32MZ EF Starter Kit

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

Provides instructions on how to build and run the USB CDC MSD demonstration.

Description

This demonstration application creates a USB Host application that enumerates a CDC and a MSD device. This application combines the functionality of the Host cdc_basic and msd_basic demonstration applications into one application. If a CDC device is connected, the demonstration application behaves like the cdc_basic host application. If a MSD device is connected, the demonstration application behaves like the msd_basic host application.

Refer to Running the Demonstration section of the host cdc_basic demonstration and the Running the Demonstrationsection of the host msd_basic demonstration for details on exercising the CDC and MSD host aspects of the demonstration.

hid_basic_keyboard

Demonstrates using the USB HID Host Client driver with the Keyboard Usage driver to facilitate the use of a USB HID Keyboard with a PIC32 USB Host.

Description

This application demonstrates the use of the USB HID Host Client Driver to enumerate and operate a HID keyboard device. The application uses the USB Host layer, HID Client driver and HID Keyboard Usage driver to enumerates a USB keyboard and understand keyboard press release events.

The keyboard events are displayed using a terminal emulator on a personal computer.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the USB HID Basic Keyboard Demonstration.

Description

To build this project, you must open the `hid_basic_keyboard.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/usb/host/hid_basic_keyboard`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`hid_basic_keyboard.X`	`<install-dir>/apps/usb/host/hid_basic_keyboard/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx795_pim_e16_int_dyn	pic32mx795_pim+e16	Select this MPLAB X IDE project configuration to run the demonstration configured for Interrupt mode and dynamic operation on the PIC32MX795F512L PIM connected to the Explorer 16 Development Board with the USB PICtail Plus Daughter Board attached.
pic32mz_ef_sk_int_dyn	pic32mz_ef_sk	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit configured for Interrupt mode and dynamic operation.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit

No hardware related configuration or jumper setting changes are necessary.

Explorer 16 Development Board:

- Switch S2 should be set to PIM

USB PICtail Plus Daughter Board:

- Jumper the Host Enable pins
- Device Enable and OTG Enable should be open

PIC32MX795F512L Plug-in Module (PIM):

- Keep jumper J10 open
- Keep all jumpers in J9 open
- Jumper J1 should be shorted between positions 1 and 2. This configuration is only applicable for the PIC32MX795F512L USB CAN PIM (MA320003), and not the PIC32MX795F512L USB PIM (MA320002).
- Jumper J2 should be shorted between positions 1 and 2. This configuration is only applicable for the PIC32MX795F512L USB CAN PIM (MA320003) and not the PIC32MX795F512L USB PIM (MA320002).

For the pic32mx795_pim_e16_int_dyn configuration:

1. Ensure that the PIC32MX795F512L PIM is connected properly to the PIM socket on the Explorer 16 Development Board.
2. Connect the Serial Port connector on the Explorer 16 Development Board to a PC using a Serial-to-USB converter cable.
3. Connect the USB PICtail Plus Daughter Board to the horizontal edge connector (J9) of the Explorer 16 Development Board.

For the pic32mz_ef_sk_int_dyn configuration:

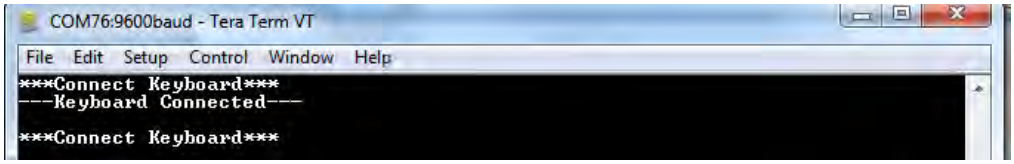
Connect the USB to the UART connector (J11) on the PIC32MZ EF Starter Kit to a PC using a USB micro cable.

Running the Demonstration

Provides instructions on how to build and run the USB HID Basic Keyboard demonstration.

Description

1. Open the project in MPLAB X IDE and select the project configuration.
2. Build the code and program the device.
3. Launch a terminal emulator, such as Tera Term, and select the appropriate COM port and set the serial port settings to 115200-N-1.
4. If a USB keyboard is not connected to the Host connector using J4 on the USB PICtail Plus Daughter Board, the terminal emulator window will show the *Connect Keyboard* prompt.
5. Attach a USB keyboard to the Host connector of the target hardware. The message, *Keyboard Connected*, will appear in the terminal emulator window.
6. Begin typing on the keyboard and the appropriate keys should be displayed on the serial terminal. Subsequent press and release of modifier keys (i.e., CAPS LOCK, NUM LOCK, etc.) will result in the appropriate keyboard LEDs to turning ON and OFF.
7. Disconnecting the keyboard will result in the message, *Connect Keyboard*.



hid_basic_mouse

Demonstrates USB Host application support for a USB HID mouse.

Description

This application demonstrates the use of the USB HID Host Client Driver to enumerate and operate a HID mouse device. The application uses the USB Host layer, HID Client driver and HID Mouse Usage driver to enumerates USB mouse and understand mouse generated data.

Mouse-specific events are demonstrated by cursor movements on the MEB II display screen. Mouse button clicks are indicated by LEDs.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the USB Host HID Basic Mouse Demonstration.

Description

To build this project, you must open the `hid_basic_mouse.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/usb/host/hid_basic_mouse`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`hid_basic_mouse.X`	`<install-dir>/apps/usb/host/hid_basic_mouse/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mz_ec_sk_meb2	pic32mz_ec_sk+meb2	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32MZ EC Starter Kit and the MEB II.
pic32mz_ef_sk_meb2	pic32mz_ef_sk+meb2	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32MZ EF Starter Kit and the MEB II.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32MZ EC Starter Kit and MEB II

1. Ensure that the PIC32MZ EC Starter Kit is securely fastened into the MEB II expansion board.
2. JP1 on the PIC32MZ EC Starter Kit should be in place.
3. The Ethernet plug-in module on the PIC32MZ EC Starter Kit should be removed.

PIC32MZ EF Starter Kit and MEB II

Ensure that the PIC32MZ EC Starter Kit is securely fastened into the MEB II expansion board.

Running the Demonstration

Provides instructions on how to build and run the USB Host HID Basic Mouse demonstration.

Description

This application demonstrates the use of the HID Host Client Driver to enumerate USB HID mouse and establish communication with the mouse. The application uses the USB Host layer, HID client driver and the MPLAB Harmony Graphics Library to enumerate a USB HID mouse and capture mouse-specific events on the USB Host side.

Prior to using this demonstration, it is recommended to review the MPLAB Harmony Release Notes for any known issues. A PDF copy of the release notes is provided in the `<install-dir>/doc` folder of your installation.

1. Open the project in MPLAB X IDE and select the desired project configuration.
2. Build the code and program the device.
3. If a USB mouse is not connected to the USB Host connector on the PIC32MZ EC/EF Starter Kit, the display on the MEB II will show a “Connect Mouse” prompt on a red background.
4. Attach a USB mouse to the Host connector on the PIC32MZ EC/EF Starter Kit. The “Connect Mouse” prompt will disappear and the cursor (a small white dot) will appear on the screen.
5. Moving the mouse will move the cursor. Mouse button clicks will toggle LEDs on the MEB II.

Refer to the following table for LED indication details.

Mouse Click	MEB II
Left	D3
Right	D4
Middle	D5
Lower Left	D6
Lower Right	D7

6. Disconnecting the mouse will cause the "Connect Mouse" prompt to reappear.

hub_cdc_hid

Demonstrates the enumeration of a HID mouse and CDC emulator device via an external hub.

Description

This application demonstrates the capability of the USB Host Stack to access and manage multiple USB Devices through a Hub. The demonstration application enumerates a HID mouse and CDC emulator device via an external hub. The host will demonstrate the communication from the CDC emulator device and the HID mouse.

Building the Application

This topic identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the USB Host HUB CDC HID Demonstration.

Description

To build this project, you must open the `hub_cdc_hid.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/usb/host/hub_cdc_hid`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
hub_cdc_hid.X	<install-dir>/apps/usb/host/hub_cdc_hid/firmware

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within ./firmware/src/system_config.

Project Configuration Name	BSP Used	Description
pic32mx_usb_sk2_int_dyn	pic32mx_usb_sk2	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32 USB Starter Kit II configured for Interrupt mode and dynamic operation.
pic32mz_ec_sk_int_dyn	pic32mz_ec_sk	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32MZ EC Starter Kit configured for Interrupt mode and dynamic operation.
pic32mz_ef_sk_int_dyn	pic32mz_ef_sk	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32MZ EF Starter Kit configured for Interrupt mode and dynamic operation.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32 USB Starter Kit II

JP2 should be in place.

PIC32MZ EC Starter Kit

JP1 should be in place and the Ethernet plug-in board should be removed.

PIC32MZ EF Starter Kit

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

Provides instructions on how to build and run the USB Host HUB CDC HID demonstration.

Description

This application demonstrates the capability of the USB Host Stack to access and manage multiple USB Devices through a Hub. The demonstration application enumerates a HID mouse and CDC emulator device via an external hub. The host will demonstrate the communication from the CDC emulator device and the HID mouse.

1. Open the project in MPLAB X IDE and select the desired project configuration.
2. Build the code and program the device.
3. Connect a hub to the Type A Host connector on the desired board.
4. Connect a mouse to a spare port on the hub.
5. Connect the CDC emulator device to another spare port on the hub.
6. Click the mouse to toggle LEDs on the starter kit.
7. On the personal computer, open a terminal emulator. At the prompt, (LED:), enter 1, 2, or 3 to toggle the LEDs on the starter kit.

hub_msd

This application demonstrates the capability of the USB Host stack to support multiple MSD device through a hub.

Description

This application demonstrates the use of the Hub Driver and the MSD Host Client Driver, with File System, to support multiple MSD devices and Hub. The demonstration application copies a file from one pen driver into another pen drive.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the USB Host Hub MSD Demonstration.

Description

To build this project, you must open the `hub_msd.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/usb/host/hub_msd`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`hub_msd.X`	`<install-dir>/apps/usb/host/hub_msd/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
pic32mx_usb_sk2_int_dyn	pic32mx_usb_sk2	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32 USB Starter Kit II configured for Interrupt mode and dynamic operation.
pic32mz_ec_sk_int_dyn	pic32mz_ec_sk	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32MZ Embedded Connectivity (EC) Starter Kit configured for Interrupt mode and dynamic operation.
pic32mz_ef_sk_int_dyn	pic32mz_ef_sk	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit configured for Interrupt mode and dynamic operation.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32 USB Starter Kit II

JP2 should be in place.

PIC32MZ EC Starter Kit

JP1 should be in place and the Ethernet plug-in board should be removed.

PIC32MZ EF Starter Kit

No hardware related configuration or jumper setting changes are necessary.

Running the Demonstration

Provides instructions on how to build and run the USB Host Hub MSD demonstration.

Description

This application demonstrates the capability of the USB Host Stack to access and manage multiple USB Devices through a Hub. The demonstration application copies a file from one USB pen drive (i.e., a USB Flash storage device) to another USB pen drive, where these pen drives are attached to a hub.

Note: The demonstration will search for a file named `file.txt` on any of the connected pen drives. Such a file should be created on one of the pen drives through any suitable method.

1. Open the project in MPLAB X IDE and select the desired project configuration.
2. Build the code and program the device.
3. Connect a hub to the Type A Host connector on the desired board.
4. Connect a USB Pen drive containing an arbitrary file named `file.txt` to a spare port on the hub.
5. Connect another USB pen drive to another spare port on the hub.
6. The application will copy the file `file.txt` from the drive containing this file to the other drive. The copied file will be renamed as

`newfile.txt`. LED 2 on the demonstration board will illuminate to indicate completion of the file transfer.

7. Disconnect the drives and confirm demonstration success by inserting them into a personal computer and verifying the file transfer completed as expected.

The demonstration application will always be in state where it waits for two pen drives to be connected to the hub and at least one of these pen drives contains a file named `file.txt`.

msd_basic

This application demonstrates the use of the MSD Host Class Driver to write a file to USB Flash Drive.

Description

This application demonstrates the use of the MSD Host Class Driver to write a file to a USB Flash drive. The application uses the USB Host layer , MSD class driver and the MPLAB Harmony File System Framework to enumerate a USB Flash drive and to write a file to it.

Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the USB MSD Host Class Driver Demonstration.

Description

To build this project, you must open the `msd_basic.X` project in MPLAB X IDE, and then select the desired configuration.

The following tables list and describe the project and supported configurations. The parent folder for these files is `<install-dir>/apps/usb/host/msd_basic`.

MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

Project Name	Location
`msd_basic.X`	`<install-dir>/apps/usb/host/msd_basic/firmware`

MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/system_config`.

Project Configuration Name	BSP Used	Description
chipkit_wf32	chipkit_wf32	Demonstration running on the chipKIT WF32 Development Board.
chipkit_wifire	chipkit_wifire	Demonstration running on the chipKIT Wi-FIRE Development Board.
pic32mx_usb_sk2_int_dyn	pic32mx_usb_sk2	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32 USB Starter Kit II configured for Interrupt mode and dynamic operation.
pic32mx_usb_sk3_int_dyn	pic32mx_usb_sk3	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32 USB Starter Kit III with the PIC32MX470F512L microcontroller configured for Interrupt mode and dynamic operation.
pic32mz_da_sk_int_dyn	pic32mz_da_sk	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32MZ Graphics (DA) Starter Kit configured for Interrupt mode and dynamic operation.
pic32mz_ec_sk_int_dyn	pic32mz_ec_sk	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32MZ Embedded Connectivity (EC) Starter Kit configured for Interrupt mode and dynamic operation.
pic32mz_ef_sk_int_dyn	pic32mz_ef_sk	Select this MPLAB X IDE project configuration to run the demonstration on the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit configured for Interrupt mode and dynamic operation.
pic32mx470_curiosity	pic32mx470_curiosity	Select this MPLAB X IDE project configuration to run the demonstration application to run on the PIC32MX470 Curiosity Development Board, with the PIC32MX470F512H microcontroller. The USB Stack will be configured for Interrupt mode operation and the USB Driver will be configured for Dynamic operation mode.
pic32mz_ef_curiosity	pic32mz_ef_curiosity	Select this MPLAB X IDE project configuration to run the demonstration application to run on the PIC32MZ EF Curiosity Development Board, with the PIC32MZ2048EFM100 microcontroller. The USB Stack will be configured for Interrupt mode operation and the USB Driver will be configured for Dynamic operation mode.

Configuring the Hardware

Describes how to configure the supported hardware.

Description

PIC32 USB Starter Kit II

JP2 should be in place.

PIC32 USB Starter Kit III

JP1 should be in place.

PIC32MZ DA Starter Kit

No hardware related configuration or jumper setting changes are necessary.

PIC32MZ EC Starter Kit

JP1 should be in place and the Ethernet plug-in board should be removed.

PIC32MZ EF Starter Kit

No hardware related configuration or jumper setting changes are necessary.

chipKIT WF32 Wi-Fi Development Board

No hardware related configuration or jumper setting changes are necessary.

chipKIT Wi-FIRE Development Board

No hardware related configuration or jumper setting changes are necessary.

PIC32MX470 Curiosity Development Board

- Ensure that a jumper is placed at 4-3 on J8
- Place a jumper on J13 to drive VBUS in Host mode

PIC32MZ EF Curiosity Development Board

- Ensure that a jumper is placed at 4-3 on J8
- Place a jumper on J13 to drive VBUS in Host mode

Running the Demonstration

Provides instructions on how to build and run the USB Host MSD Basic demonstration.

Description

This application demonstrates the use of the MSD Host Class Driver to write a file to USB Flash drive. The application uses the USB Host layer, MSD class driver and the MPLAB Harmony File System Framework to enumerate a USB Flash drive and to write a file to it.

Prior to using this demonstration, it is recommended to review the MPLAB Harmony Release Notes for any known issues. A PDF copy of the release notes is provided in the `<install-dir>/doc` folder of your installation.

1. Open the project in MPLAB X IDE and select the desired project configuration.
2. Build the code and program the device.
3. With the code running, attach a USB Flash drive to the Host connector on the desired starter kit.
4. The demonstration application will then create a file named `file.txt`. It will then write the text "Hello World" to this file, and then close the file.
5. The demonstration will then move to Idle mode, which is indicated when LED2 on the starter kit illuminates.
6. The USB Flash drive can then be attached to a USB Host personal computer to verify the demonstration application operation.
7. Steps 3 through 6 can be repeated.
8. If the USB Flash drive already contains a file with the name `file.txt`, the demonstration application will append the text "Hello World" to the end of the file contents.
9. LED1 on the starter kit illuminates if the file creation or write failed.

Board Support Packages Help

This section describes the Board Support Packages (BSP) that are available in MPLAB Harmony.

Introduction

This topic provides information for the Board Support Package (BSP) in MPLAB Harmony.

Description

A Board Support Package (BSP) provides code and configuration items necessary to support board-specific hardware. A BSP may be provided for Microchip development or demonstration boards or may be defined by customers for their own boards, which is recommended to make it easy to support multiple boards in the future, even if only a single board exists when a project is first created (see **Developing a New BSP** for more information).

A BSP may contain a board-specific configuration header (`bsp_config.h` and possibly others), a board-specific system initialization file (`bsp_sys_init.c`), a file containing board-specific ISR implementations (`bsp_sys_int.c`), a board-specific system "tasks" routine (implemented in a `bsp_sys_tasks.c` file), and even board-specific driver implementations (each with its own directory).

Everything that is contained within a BSP can be either used by or replaced by application specific items if desired. For example, the application may configure the system initialization routine (`SYS_Initialize`) to directly call a board-specific initialization routine (`BSP_Initialize`) or it can use the BSP-specific initialization routine as an example from which to start developing application-specific board initialization code. Normally, Microchip demonstration applications will use the BSP code directly to avoid duplication of board-specific code.

Developing a New BSP

Customers who want to develop their own BSPs can use an existing Microchip BSP as a starting point. To do this, simply copy an existing BSP folder, rename it to something appropriate for the board, and then make any changes necessary to define the board-specific items that application configurations may use. Then, add the BSP to the MPLAB Harmony Configurator (MHC) and it will be available for any new applications developed for that board.

To add a new BSP to the MHC, refer to the instructions in Adding New BSPs in the MPLAB Harmony Configurator Developer's Guide, which is located within *Utilities Help > MPLAB Harmony Configurator Help*.

Locating Demonstrations

Within the individual demonstration board topics in the Development Tools section, you will find part numbers, product links, and a list of demonstrations that are available for each board.

Using the BSP

This sections provides information on using a BSP.

Description

A BSP configuration header defines configuration options that are "fixed" by the board. That is, any option that cannot be changed unless the hardware on the board is changed may be defined in a BSP's `bsp_config.h` file (or in a file included by it). This will normally include board parameters such as the oscillator frequency for a fixed-frequency oscillator or convenient names by which board-specific features may be identified (such as which pins connect to switches or LEDs). It may also include options for libraries and drivers that can be used by an application running on that board that are "fixed" by the hardware on the board. However, it may not define all options necessary for a library, only the board-specific options. Application-specific headers may include BSP-specific headers to define the board-hardware-specific options or it may define them itself, thus overriding a BSP's options.

System Initialization

This topic describes BSP system initialization.

Description

Normally, an application will define or configure the `SYS_Initialize` routine in any way that is necessary to initialize the system as desired. However, board-specific initialization may be necessary. When it is, a BSP must implement a board-specific initialization routine named `BSP_Initialize` that performs any necessary low-level board initialization necessary to support normal system operation. The `BSP_Initialize` routine may have an associated "initialization" structure, a pointer to which may be passed in as a parameter, to define any application-specific parameters necessary to initialize any low-level board hardware. Low-level board hardware may be things like power subsystems, bus enable signals, or other items necessary for basic board operations. It should not include the initialization of board-specific drivers as that is done separately. However, a BSP may define initialization data used to initialize board-specific drivers if that data is "fixed" by the board.

Board Drivers

This topic describes the board drivers of the BSP.

Description

Some peripheral hardware may not be directly built into the microcontroller. For example, devices such as external Codecs, EEPROMs, etc., may be built onto a board and will not be available as peripherals in the microcontroller. Devices such as these still need device drivers and these drivers still need to follow the MPLAB harmony driver architecture. However, they will not normally be provided as part of the standard MPLAB Harmony driver set for Microchip microcontrollers. Instead, all files related to drivers for devices mounted on Microchip development boards will be contained within the `bsp/drivers` directory. Otherwise, they follow the same rules as all other MPLAB Harmony device drivers.

Interrupt Service Routine (ISR) Implementation

This topic describes BSP Interrupt Service Routine (ISR) implementation.

Description

Like the `SYS_Initialize` routine, an ISR may be implemented by an application in any way necessary to support the desired system behavior. Unlike the initialization support, a BSP-specific ISR implementation should never be called by the application-specific ISR implementation. It must either be used exactly as defined by the BSP or the application's system interrupt support must define its own ISR implementation. If the application defines its own implementation, the BSP ISR can be used as an example.

Building the BSP

This topic describes the files necessary to build a BSP.

Description

Board Support Package (BSP) Files

The BSP files are provided in the `<install-dir>/bsp` folder of your MPLAB Harmony installation. Within the `bsp` folder are the individual Board Support Package folders, each of which contain the files to be included. See Board Support Packages for the complete list of available BSPs.

Interface Files

This table lists and describes the header and C files that must be included (i.e., using `#include`) by any application that uses a BSP.

Source Folder Name: <install-dir>/bsp/<bsp_name>/	Description
`bsp_config.h`	This file contains the data types, constants, and function prototypes for initialization and control of the selected BSP.
`bsp_sys_init.c`	This file contains initialization and control functions for the selected BSP.

Board Support Packages

Provides information on the individual board support packages provide in the installation of MPLAB Harmony.

bt_audio_dk

PIC32 Bluetooth Audio Development Kit BSP.

Description

This BSP is intended for the PIC32 Bluetooth Audio Development Kit.

The following figure illustrates the hardware configuration.

chipkit_wf32

chipKIT™ WF32™ Wi-Fi Development Board BSP.

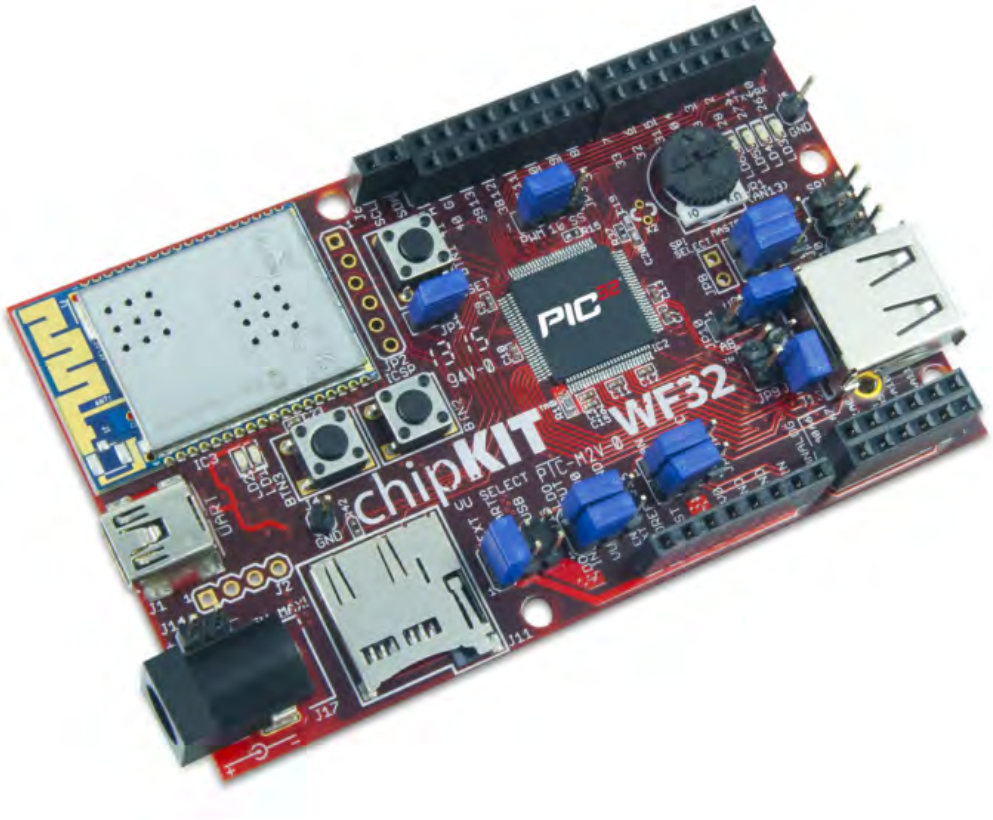
Description

This BSP is intended for the chipKIT™ WF32™ Wi-Fi Development Board.

Note: If a USB Host application is used, the board *will not* be able to power the USB device without one of the following:
Using an external power supply (9V or greater) connected to J17
- or -
Bypassing the on-board voltage regulator by removing the jumpers on J16 and only connecting VU to 5V0.

Warning: Do not connect an external power supply in this configuration, or the 5V rail on the board will be supplied with the external voltage directly, which could result in damage to the board.

The following figure illustrates the hardware configuration.



chipkit_wifire

chipKIT™ Wi-FIRE Development Board BSP.

Description

This BSP is intended for the chipKIT Wi-FIRE Development Board.

Note: If a USB Host application is used, the board *will not* be able to power the USB device without one of the following:
Using an external power supply (9V or greater) connected to J15
- or -
Bypassing the on-board voltage regulator by removing the jumpers on J17 and only connecting VU to 5V0.

Warning: Do not connect an external power supply in this configuration, or the 5V rail on the board will be supplied with the external voltage directly, which could result in damage to the board.

The following figure illustrates the hardware configuration.

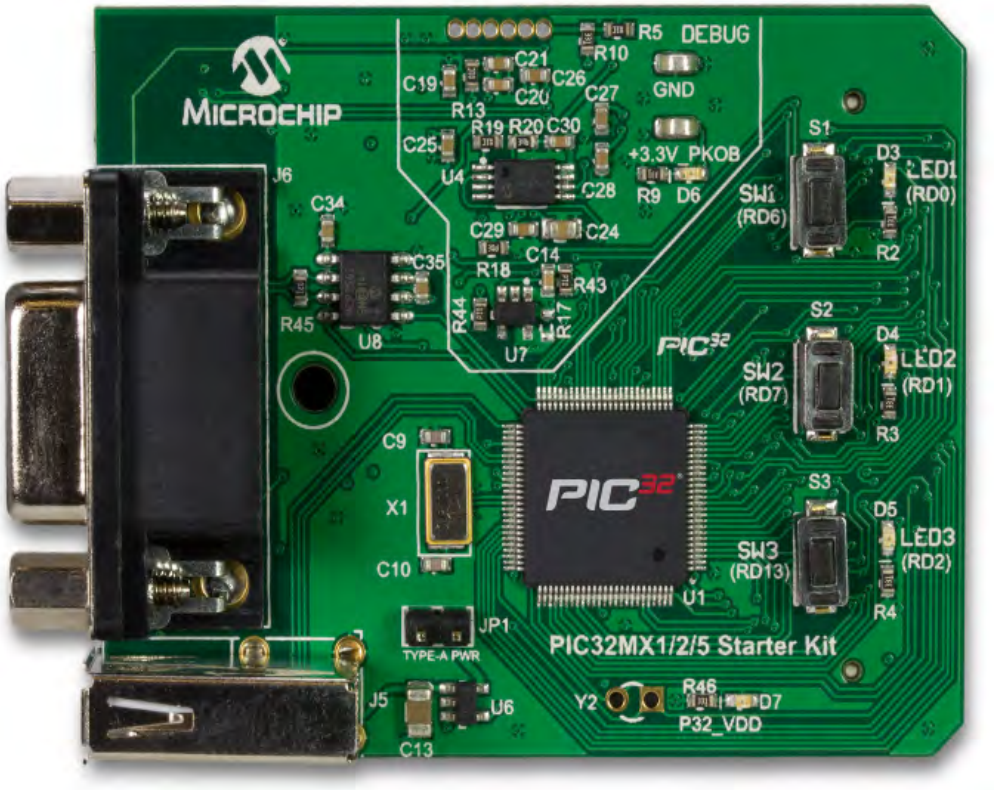
pic32mx_125_sk

PIC32MX1/2/5 Starter Kit BSP.

Description

This BSP is intended for the PIC32MX1/2/5 Starter Kit.

The following figure illustrates the hardware configuration.



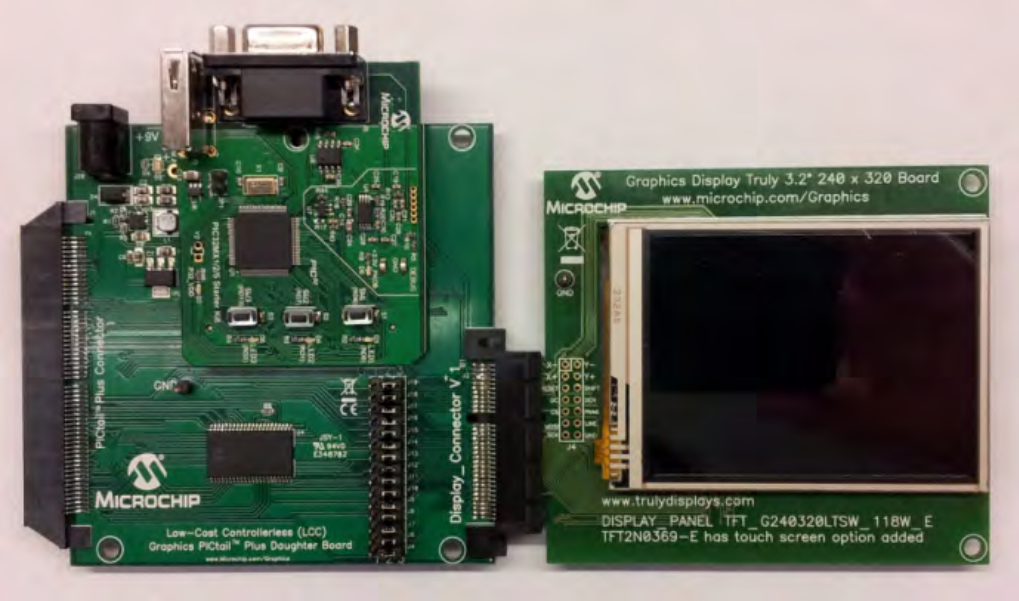
pic32mx_125_sk+lcc_pictail+qvga

PIC32MX1/2/5 Starter Kit plus the Low-Cost Controllerless (LCC) Graphics PICtail Plus Daughter Board with the Graphics Display Truly 3.2" 320x240 Board BSP.

Description

This BSP is intended for the Low-Cost Controllerless (LCC) Graphics PICtail Plus Daughter Board with the Graphics Display Truly 3.2" 320x240 Board connected to the PIC32MX1/2/5 Starter Kit.

The following figure illustrates the hardware configuration.



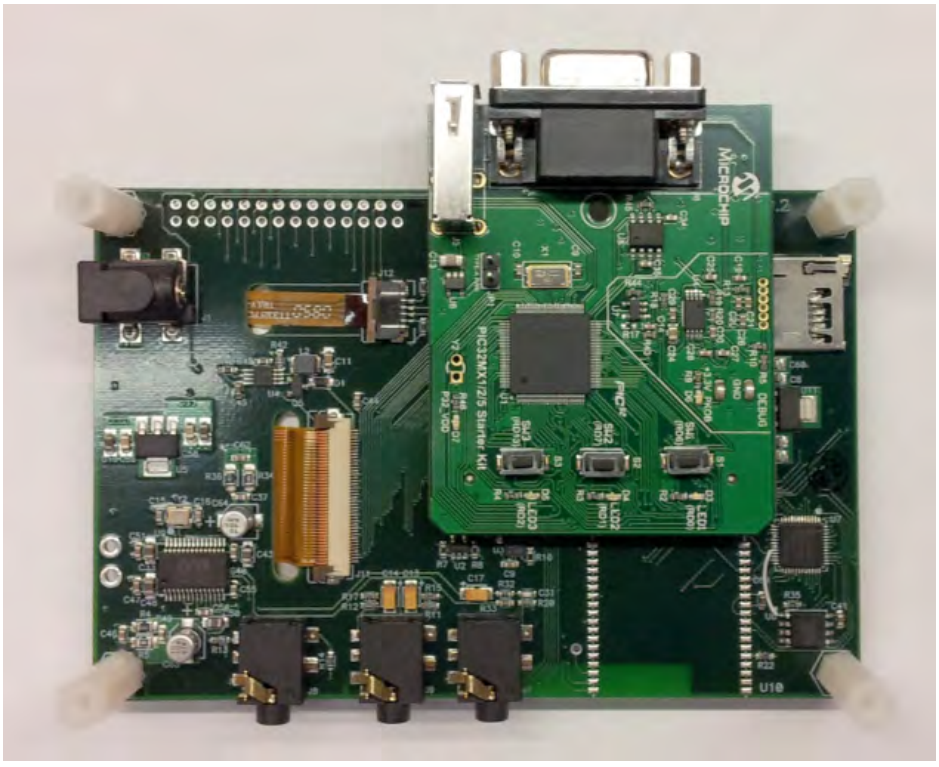
pic32mx_125_sk+meb

PIC32MX1/2/5 Starter Kit plus MEB BSP.

Description

This BSP is intended for the Multimedia Expansion Board (MEB) connected to the PIC32MX1/2/5 Starter Kit.

The following figure illustrates the hardware configuration.



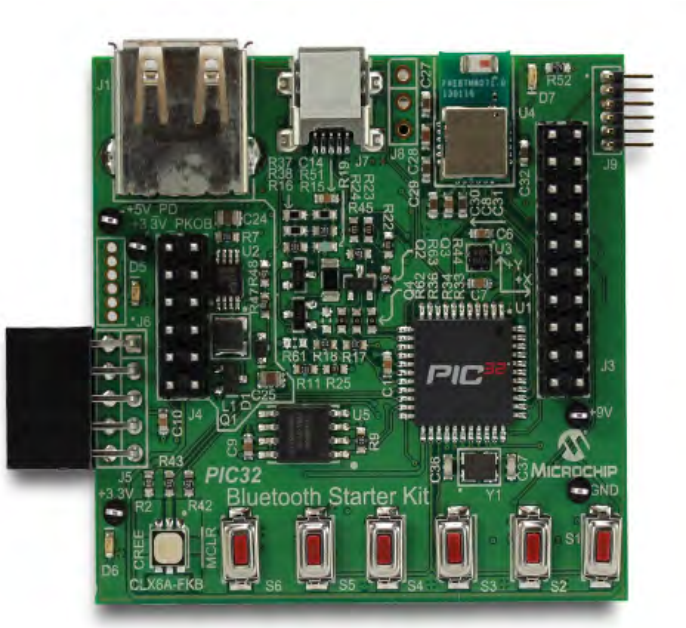
pic32mx_bt_sk

PIC32 Bluetooth Starter Kit BSP.

Description

This BSP is intended for the PIC32 Bluetooth Starter Kit.

The following figure illustrates the hardware configuration.



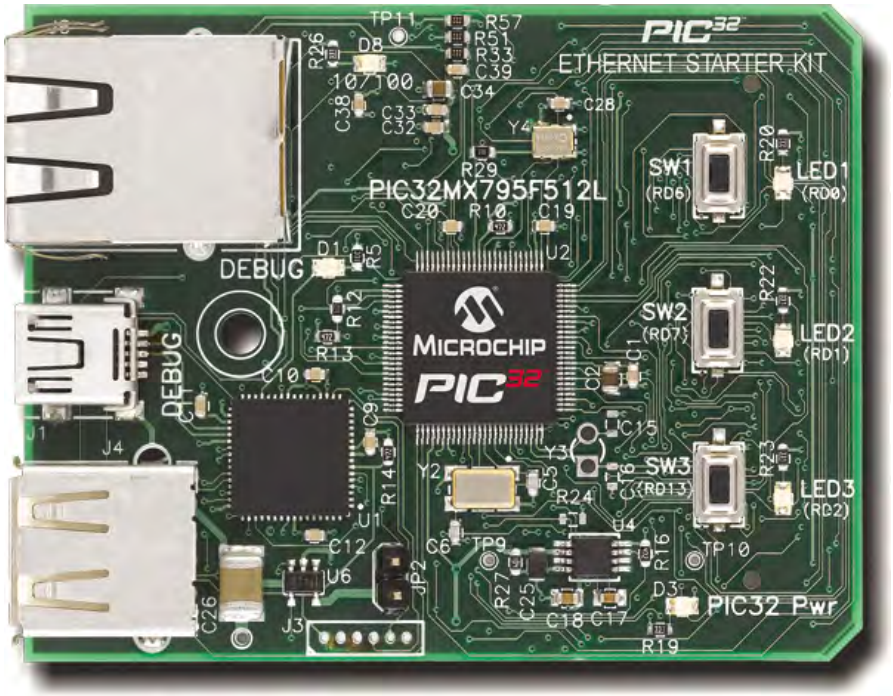
pic32mx_eth_sk

PIC32 Ethernet Starter Kit BSP.

Description

This BSP is intended for the PIC32 Ethernet Starter Kit.

The following figure illustrates the hardware configuration.



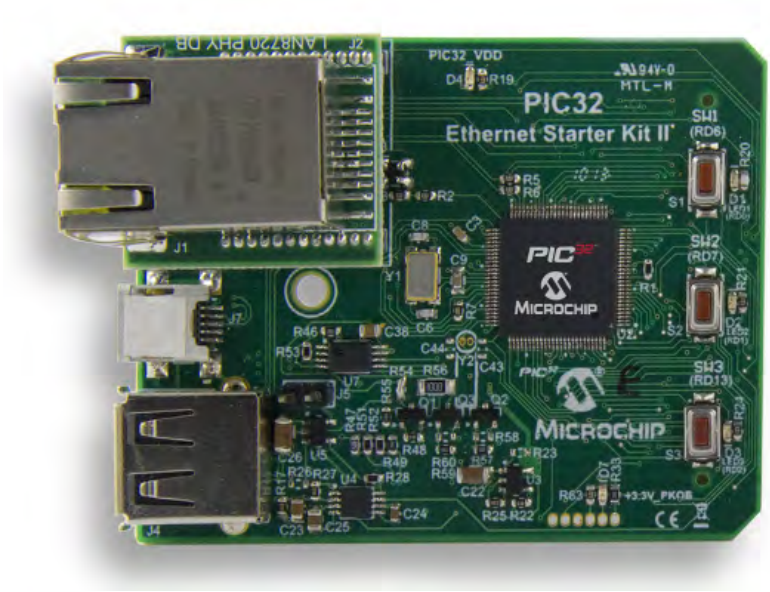
pic32mx_eth_sk2

PIC32 Ethernet Starter Kit II BSP.

Description

This BSP is intended for the PIC32 Ethernet Starter Kit II.

The following figure illustrates the hardware configuration.



pic32mx_pcap_db

PIC32 GUI Development Board with Projected Capacitive Touch BSP.

Description

This BSP is intended for the PIC32 GUI Development Board with Projected Capacitive Touch.

The following figure illustrates the hardware configuration.

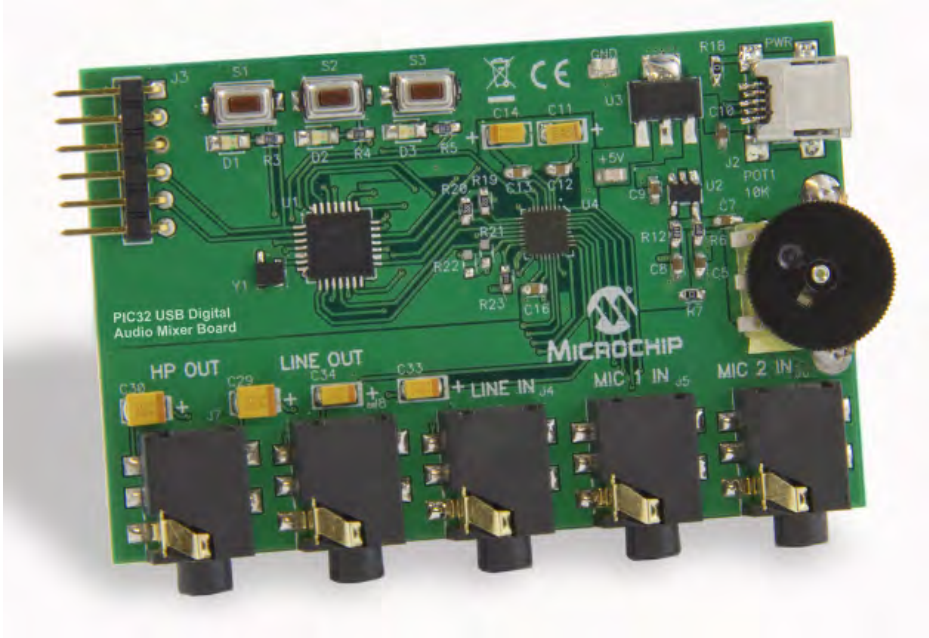
pic32mx_usb_digital_audio_ab

PIC32 USB Digital Audio Accessory Board BSP.

Description

This BSP is intended for the PIC32 USB Digital Audio Accessory Board.

The following figure illustrates the hardware configuration.



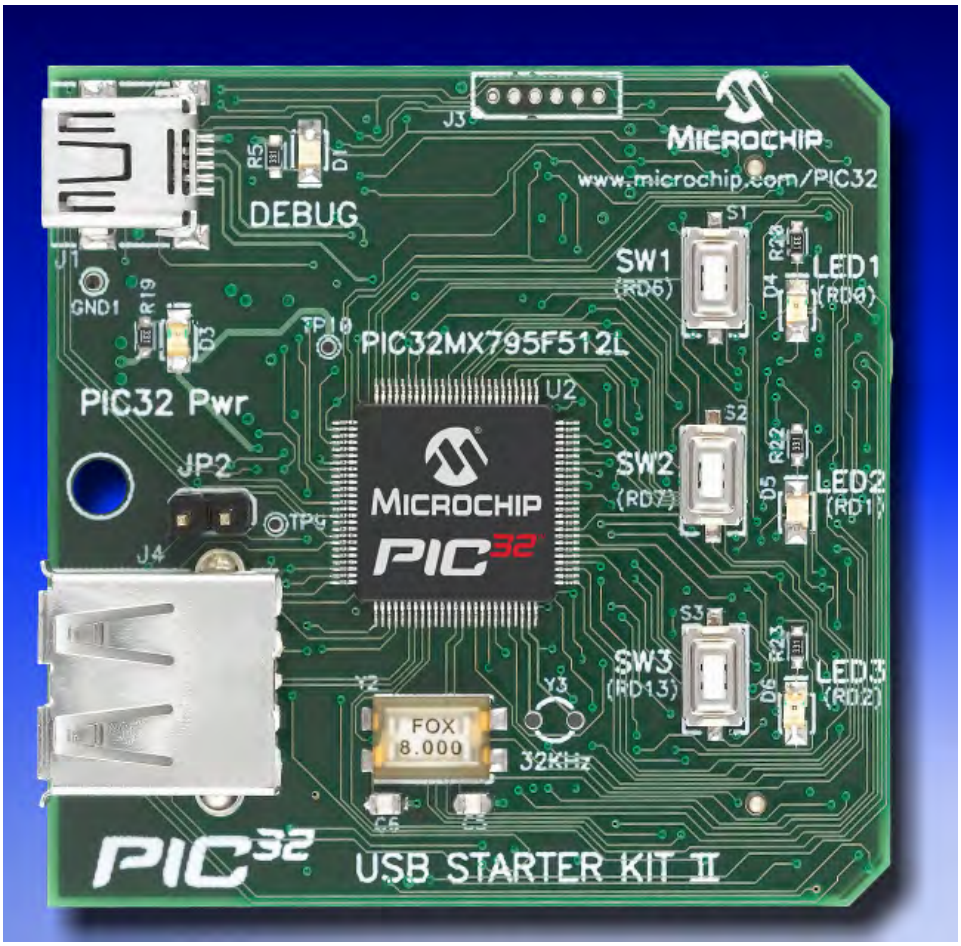
pic32mx_usb_sk2

PIC32 USB Starter Kit II BSP.

Description

This BSP is intended for the PIC32 USB Starter Kit II.

The following figure illustrates the hardware configuration.



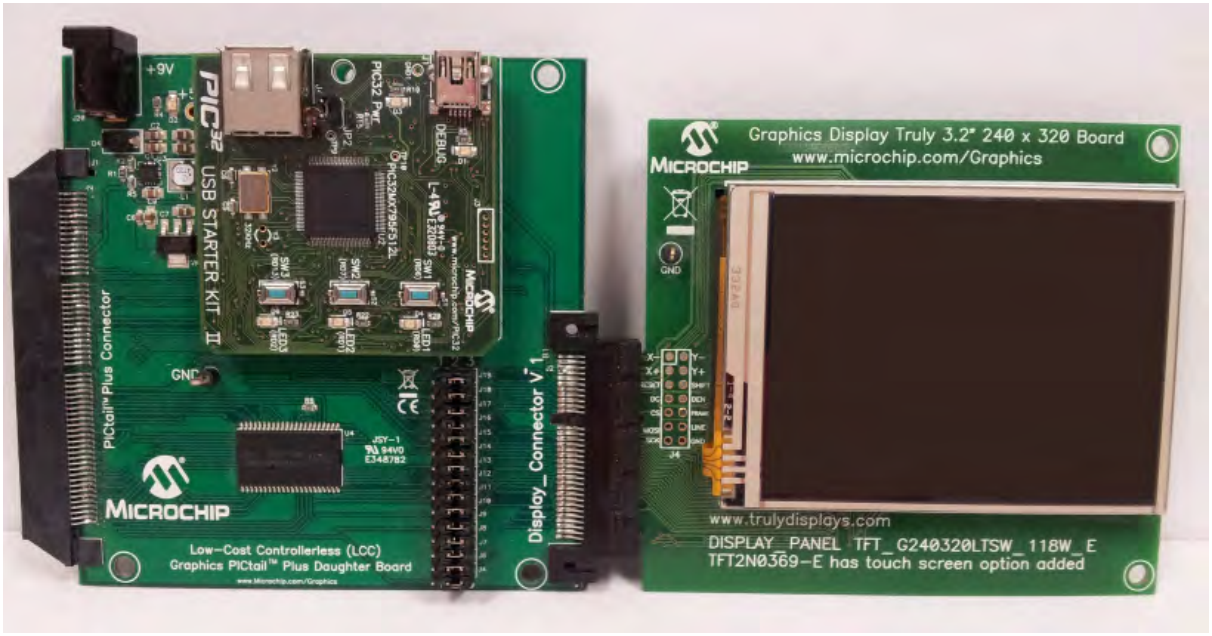
pic32mx_usb_sk2+lcc_pictail+qvga

PIC32 USB Starter Kit II plus the Low-Cost Controllerless (LCC) Graphics PICtail Plus Daughter Board with the Graphics Display Truly 3.2" 320x240 Board BSP.

Description

This BSP is intended for the Low-Cost Controllerless (LCC) Graphics PICtail Plus Daughter Board with the Graphics Display Truly 3.2" 320x240 Board connected to the PIC32 USB Starter Kit II.

The following figure illustrates the hardware configuration.



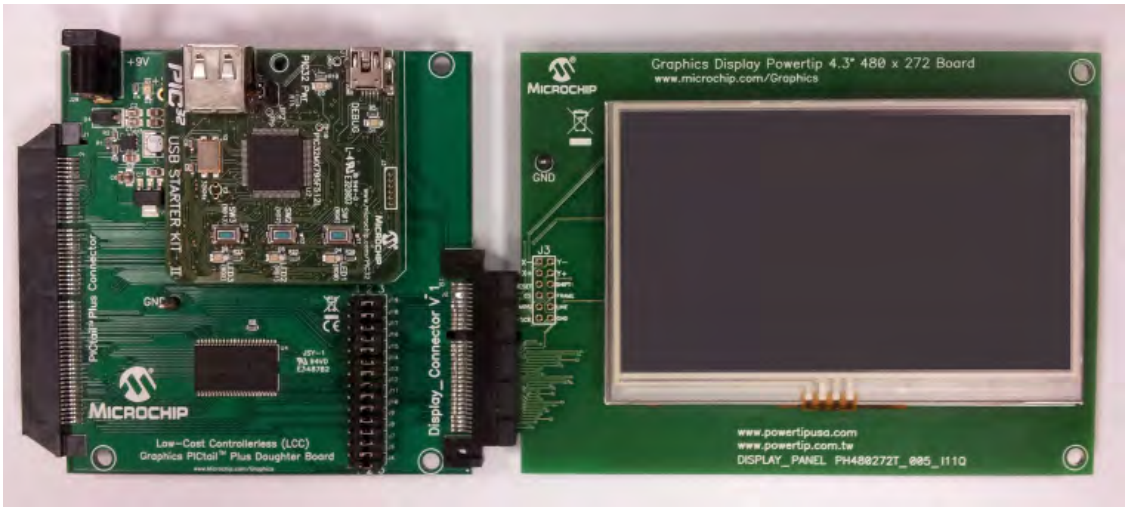
pic32mx_usb_sk2+lcc_pictail+wqvga

PIC32 USB Starter Kit II plus the Low-Cost Controllerless (LCC) Graphics PICtail Plus Daughter Board with Graphics Display Powertip 4.3" 480x272 Board BSP.

Description

This BSP is intended for the Low-Cost Controllerless (LCC) Graphics PICtail Plus Daughter Board with the Graphics Display Powertip 4.3" 480x272 Board connected to the PIC32 USB Starter Kit II.

The following figure illustrates the hardware configuration.



pic32mx_usb_sk2+meb

PIC32 USB Starter Kit II plus MEB BSP.

Description

This BSP is intended for the Multimedia Expansion Board (MEB) connected to the PIC32 USB Starter Kit II.

The following figure illustrates the hardware configuration.

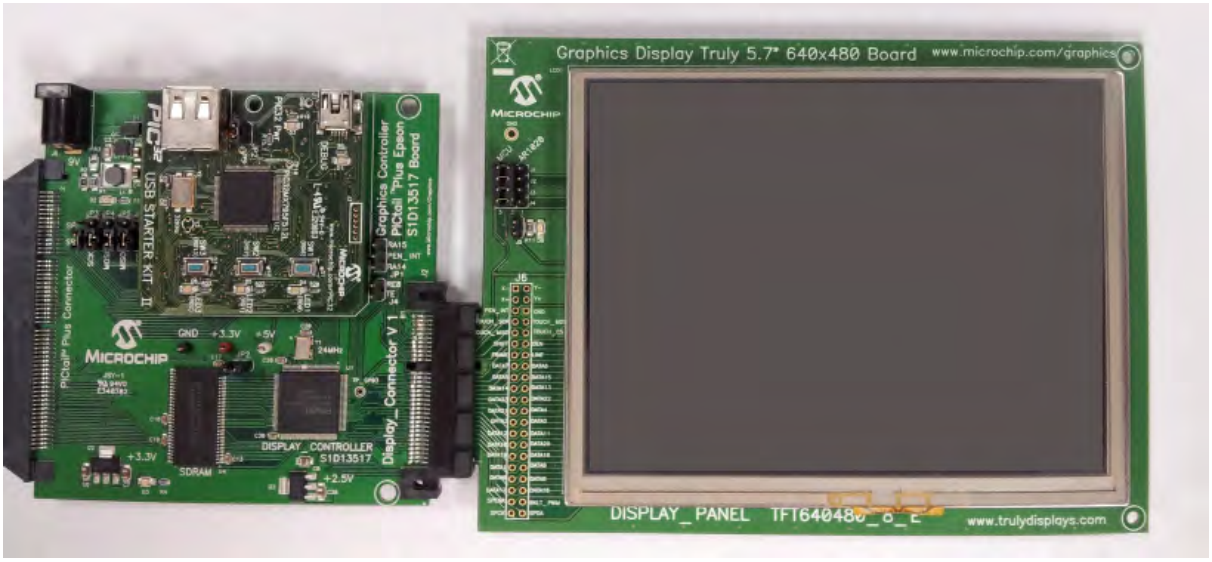
pic32mx_usb_sk2+s1d_pictail+vga

PIC32 USB Starter Kit II plus the Graphics Controller PICtail Plus Epson S1D13517 Daughter Board with Graphics Display Truly 5.7" 640x480 Board BSP.

Description

This BSP is intended for the Graphics Controller PICtail Plus Epson S1D13517 Daughter Board with the Graphics Display Truly 5.7" 640x480 Board connected to the PIC32 USB Starter Kit II.

The following figure illustrates the hardware configuration.



pic32mx_usb_sk2+s1d_pictail+wqvga

PIC32 USB Starter Kit II plus the Graphics Controller PICtail Plus Epson S1D13517 Daughter Board with the Graphics Display Powertip 4.3" 480x272 Board BSP.

Description

This BSP is intended for the Graphics Controller PICtail Plus Epson S1D13517 Daughter Board with the Graphics Display Powertip 4.3" 480x272 Board connected to the PIC32 USB Starter Kit II.

The following figure illustrates the hardware configuration.

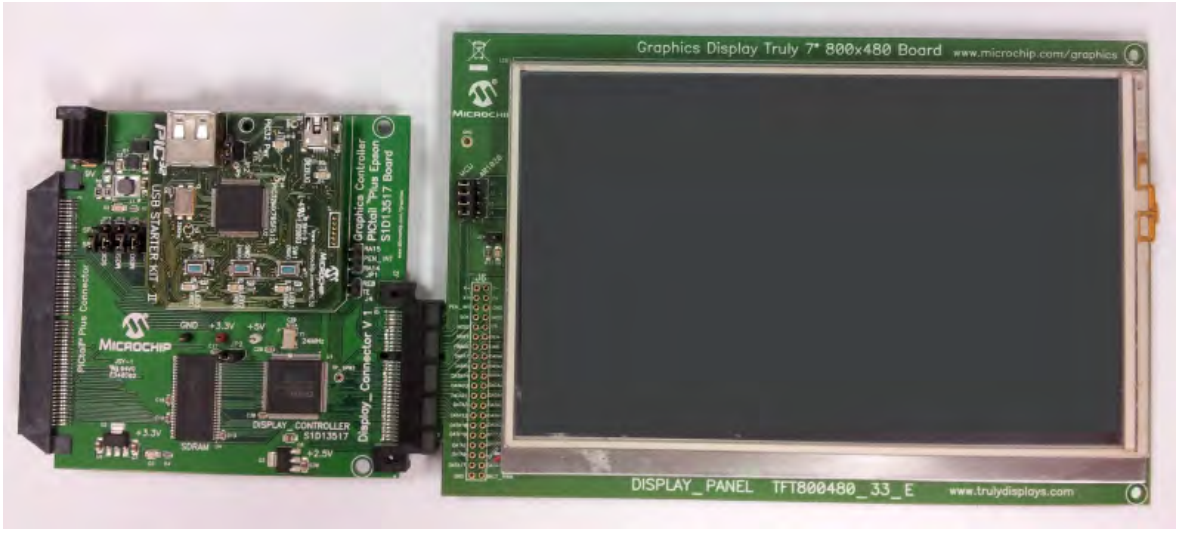
pic32mx_usb_sk2+s1d_pictail+wvga

PIC32 USB Starter Kit II plus the Graphics Controller PICtail Plus Epson S1D13517 Daughter Board with Graphics Display Truly 7" 800x400 Board BSP.

Description

This BSP is intended for the Graphics Controller PICtail Plus Epson S1D13517 Daughter Board with Graphics Display Truly 7" 800x400 Board connected to the PIC32 USB Starter Kit II.

The following figure illustrates the hardware configuration.



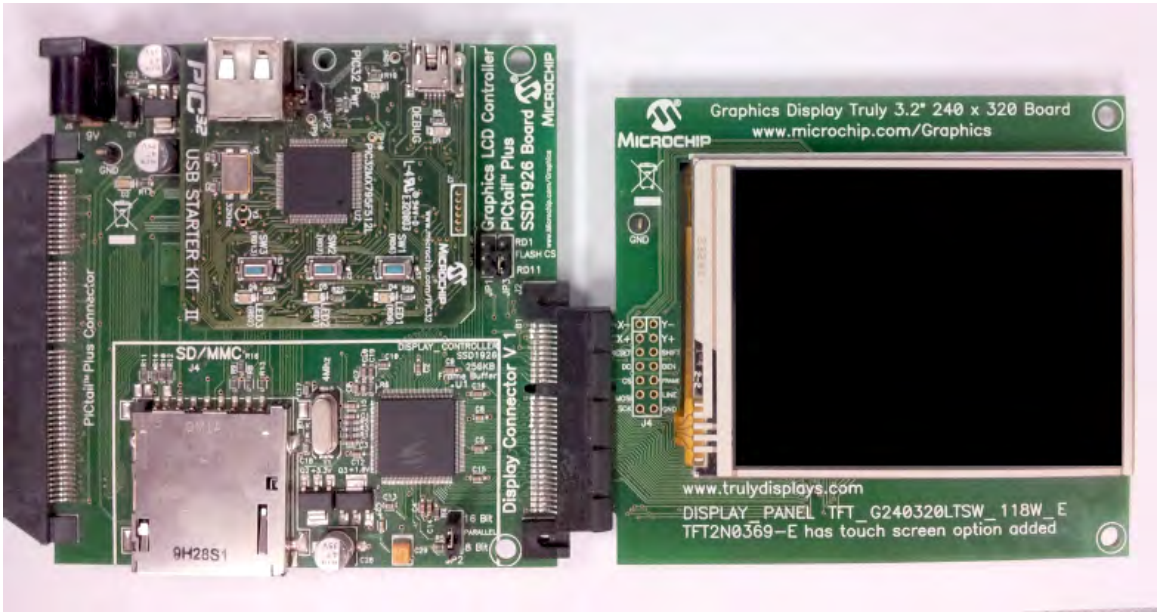
pic32mx_usb_sk2+ssd_pictail+qvga

PIC32 USB Starter Kit II plus the Graphics LCD Controller PICtail Plus SSD1926 Daughter Board with Graphics Display Truly 3.2" 320x240 Board BSP.

Description

This BSP is intended for the Graphics LCD Controller PICtail Plus SSD1926 Daughter Board with Graphics Display Truly 3.2" 320x240 Board connected to the PIC32 USB Starter Kit II.

The following figure illustrates the hardware configuration.



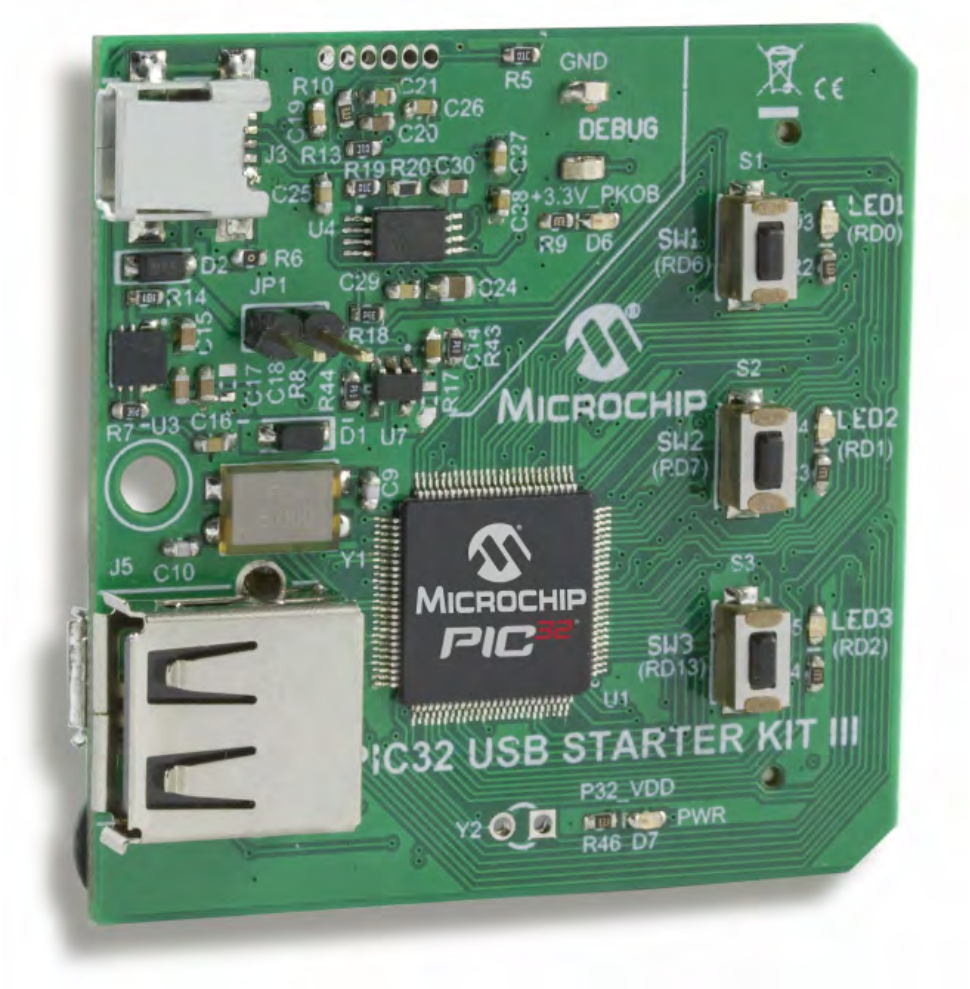
pic32mx_usb_sk3

PIC32 USB Starter Kit III BSP.

Description

This BSP is intended for the PIC32 USB Starter Kit III.

The following figure illustrates the hardware configuration.



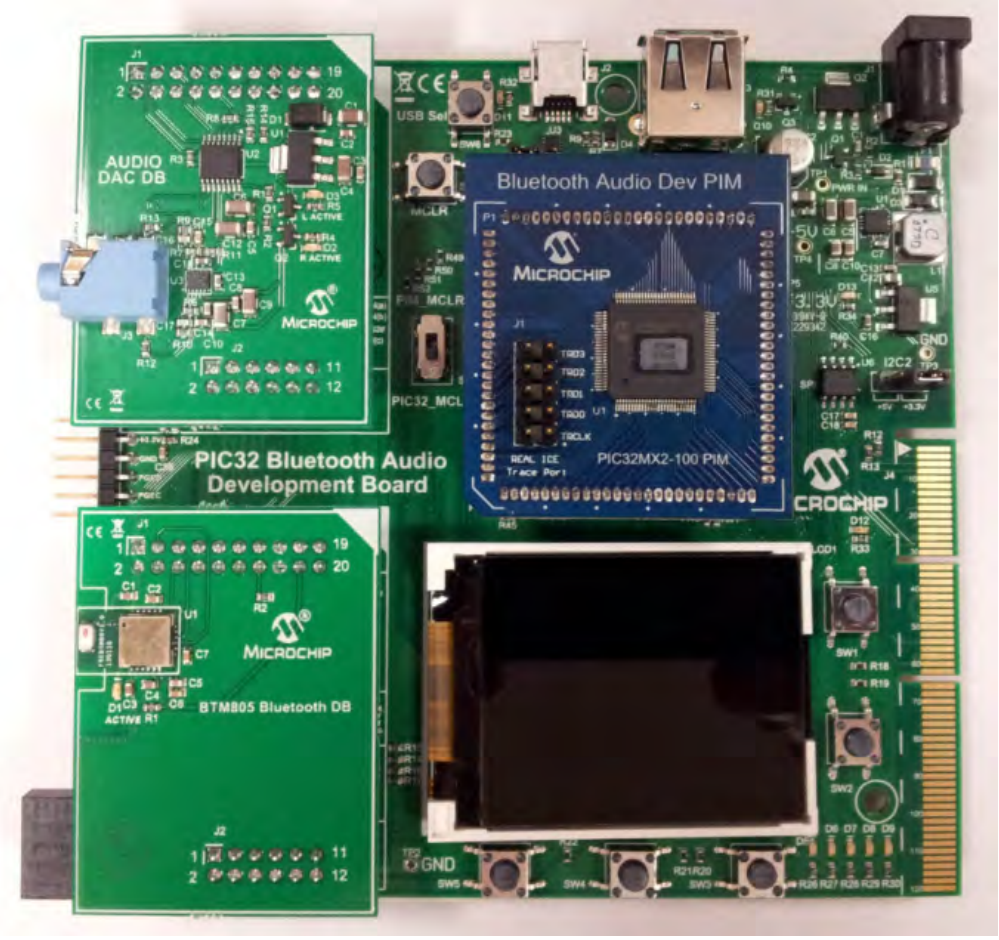
pic32mx270f512l_pim+bt_audio_dk

PIC32MX270F512L Plug-in Module (PIM) plus PIC32 Bluetooth Audio Development Kit.

Description

This BSP is intended for the PIC32MX270F512L Plug-in Module (PIM) connected to the PIC32 Bluetooth Audio Development Kit.

The following figure illustrates the hardware configuration.



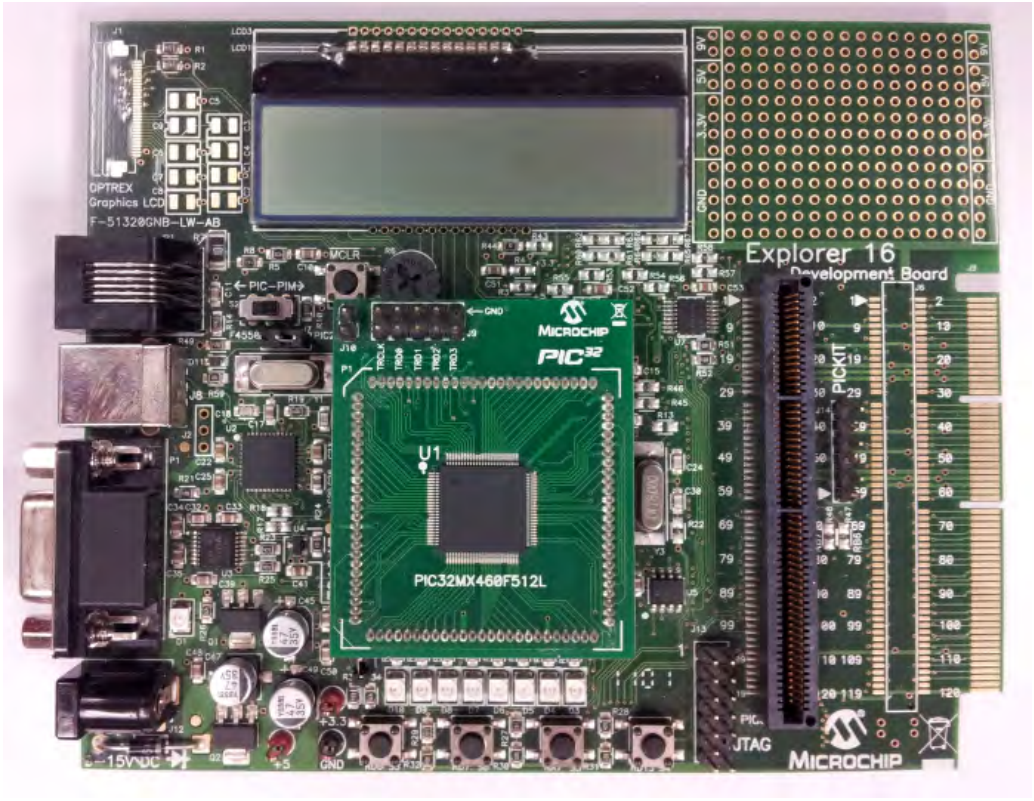
pic32mx460_pim+e16

PIC32MX460F512L Plug-in Module (PIM) plus Explorer 16 Development Board BSP.

Description

This BSP is intended for the PIC32MX460F512L Plug-in Module (PIM) connected to the Explorer 16 Development Board.

The following figure illustrates the hardware configuration.



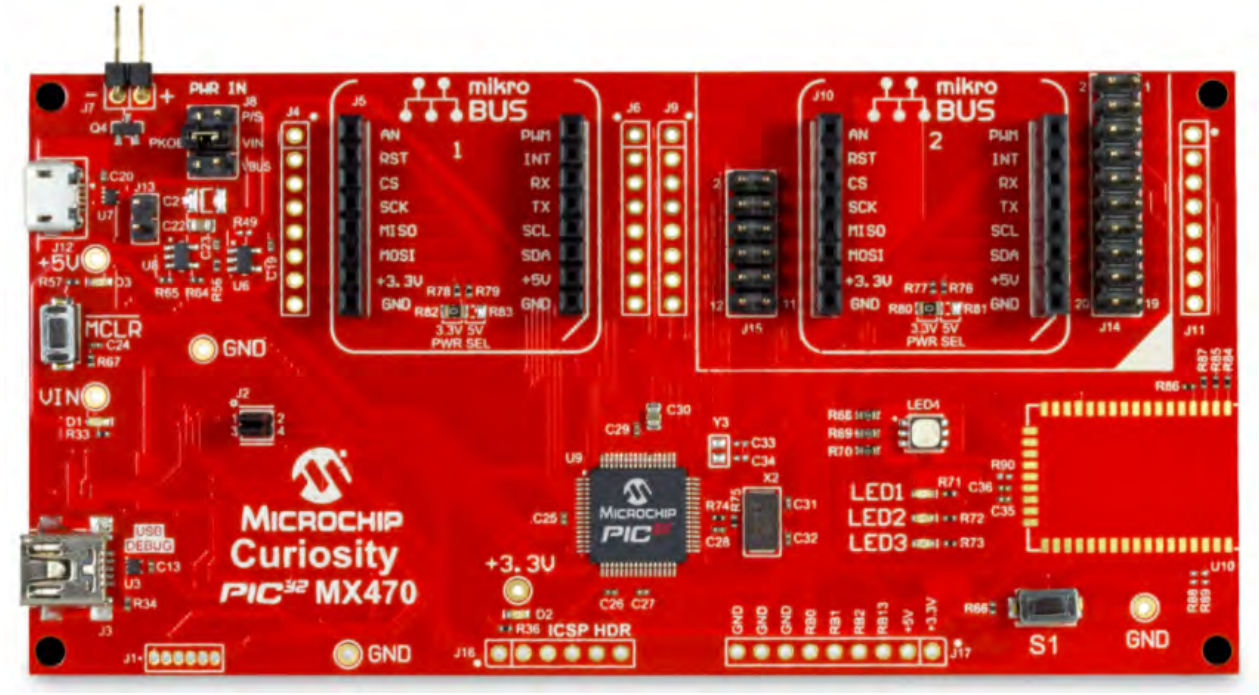
pic32mx470_curiosity

PIC32MX470 Curiosity Development Board BSP.

Description

This BSP is intended for the PIC32MX470 Curiosity Development Board.

The following figure illustrates the hardware configuration.



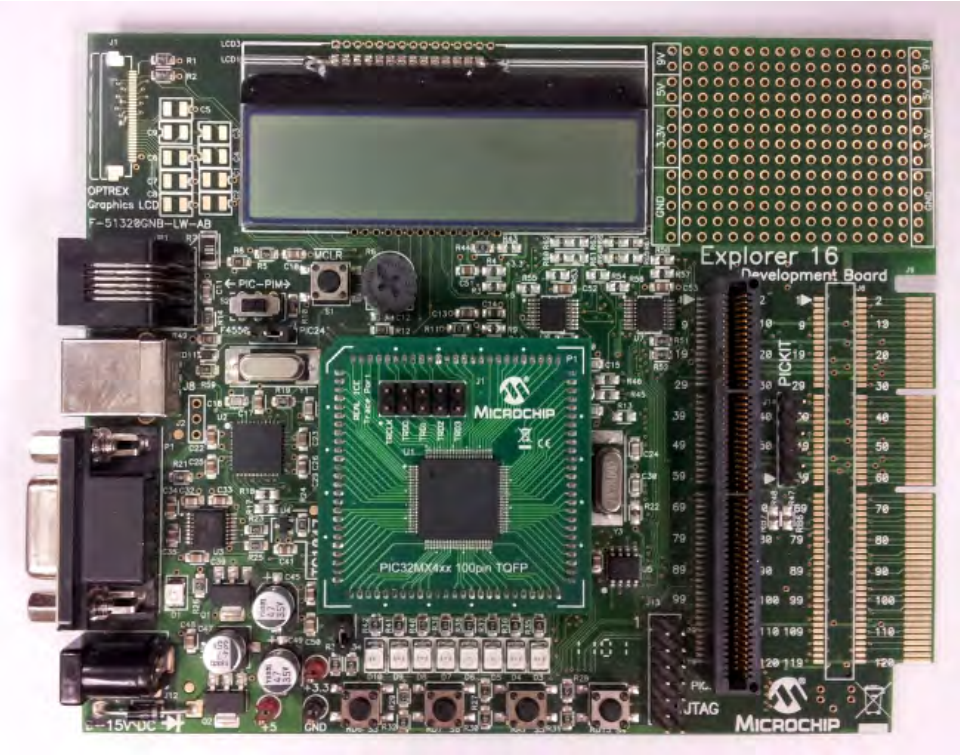
pic32mx470_pim+e16

PIC32MX450/470F512L Plug-in Module (PIM) plus Explorer 16 Development Board BSP.

Description

This BSP is intended for the PIC32MX450/470F512L Plug-in Module (PIM) connected to the Explorer 16 Development Board.

The following figure illustrates the hardware configuration.



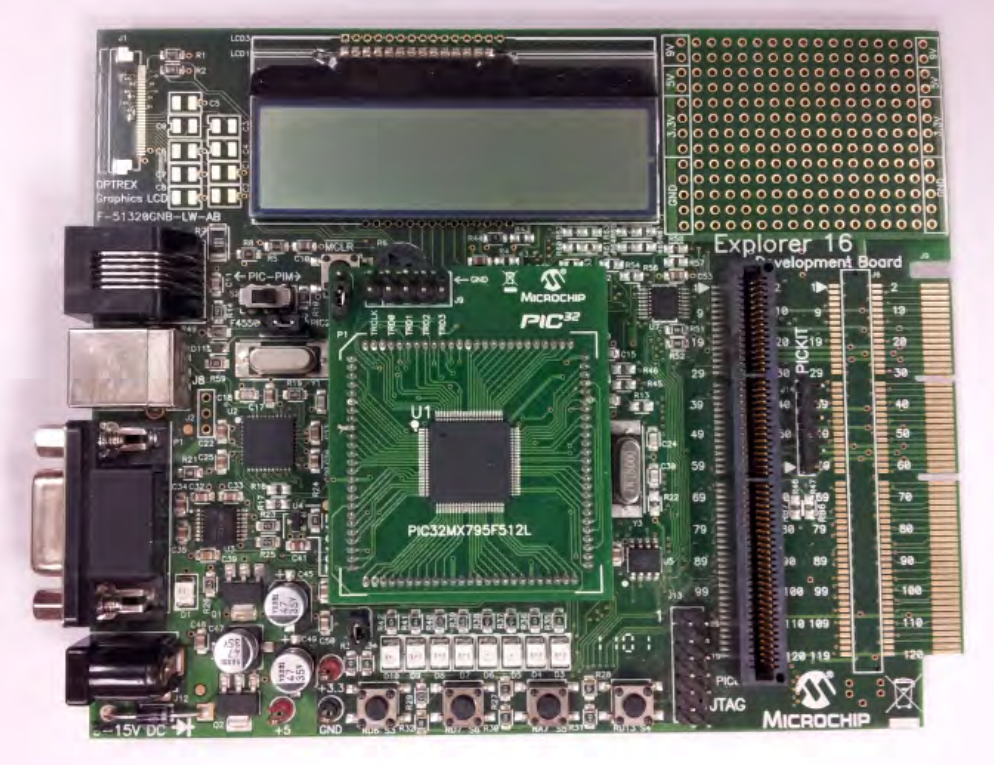
pic32mx795_pim+e16

PIC32MX795F512L Plug-in Module (PIM) plus Explorer 16 Development Board BSP.

Description

This BSP is intended for the PIC32MX795F512L Plug-in Module (PIM) connected to the Explorer 16 Development Board.

The following figure illustrates the hardware configuration.



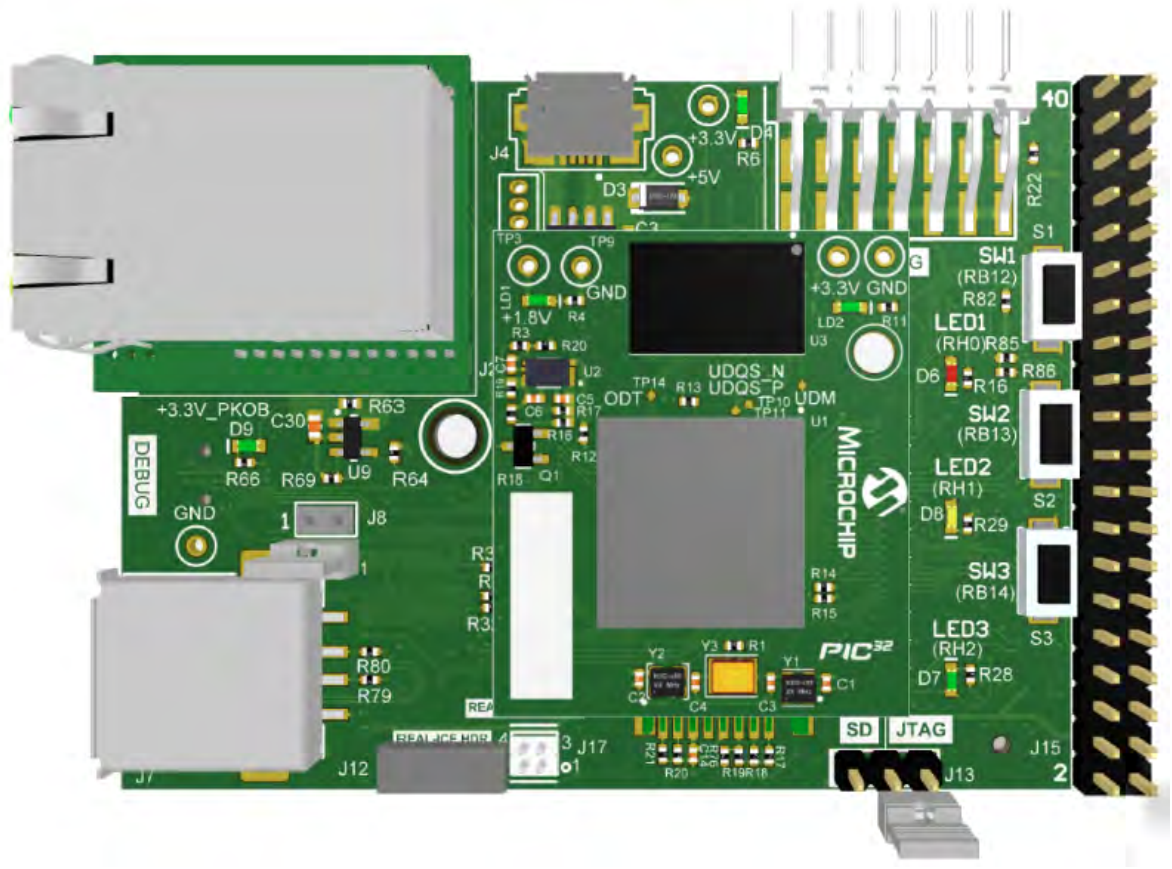
pic32mz_da_sk

PIC32MZ Graphics (DA) Starter Kit BSP.

Description

This BSP is intended for the PIC32MZ Graphics (DA) Starter Kit.

The following figure illustrates the hardware configuration.



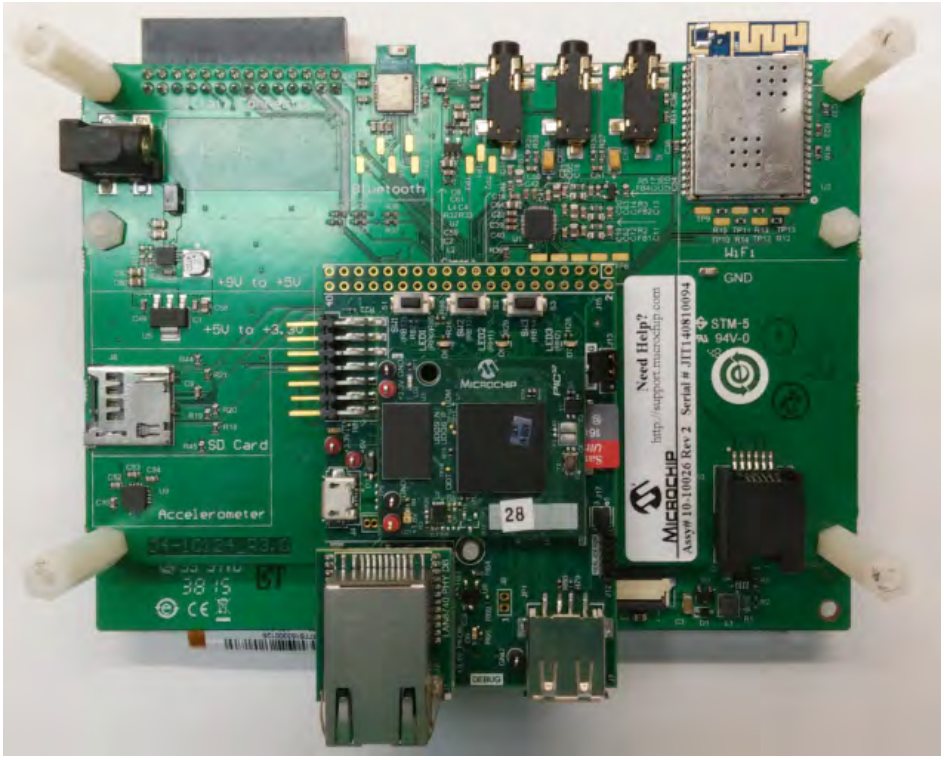
pic32mz_da_sk+meb2

PIC32MZ Graphics (DA) Starter Kit plus MEB II BSP.

Description

This BSP is intended for the Multimedia Expansion Board II (MEB II) connected to the PIC32MZ Graphics (DA) Starter Kit.

The following figure illustrates the hardware configuration.



pic32mz_da_sk+meb2+wvga

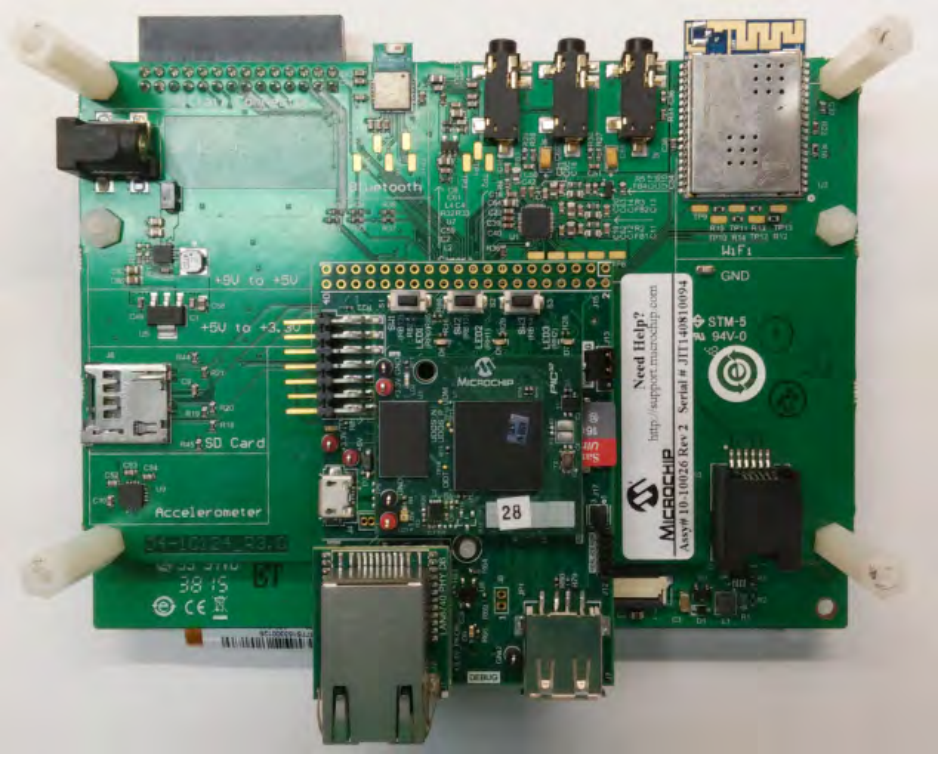
PIC32MZ Graphics (DA) Starter Kit plus MEB II and 5" WVGA PCAP Display Board BSP.

Description

This BSP is intended for the Multimedia Expansion Board II (MEB II) with the 5" WVGA PCAP Display Board (see **Note 1**) connected to the PIC32MZ Graphics (DA) Starter Kit.

Note: Please contact your local Microchip sales office for information on obtaining the 5" WVGA PCAP Display Board.

The following figure illustrates the hardware configuration.



pic32mz_ec_pim+bt_audio_dk

PIC32MZ2048ECH144 Audio Plug-in Module (PIM) plus PIC32 Bluetooth Audio Development Kit BSP.

Description

This BSP is intended for the PIC32MZ2048ECH144 Audio Plug-in Module (PIM) connected to the PIC32 Bluetooth Audio Development Kit.

The following figure illustrates the hardware configuration.

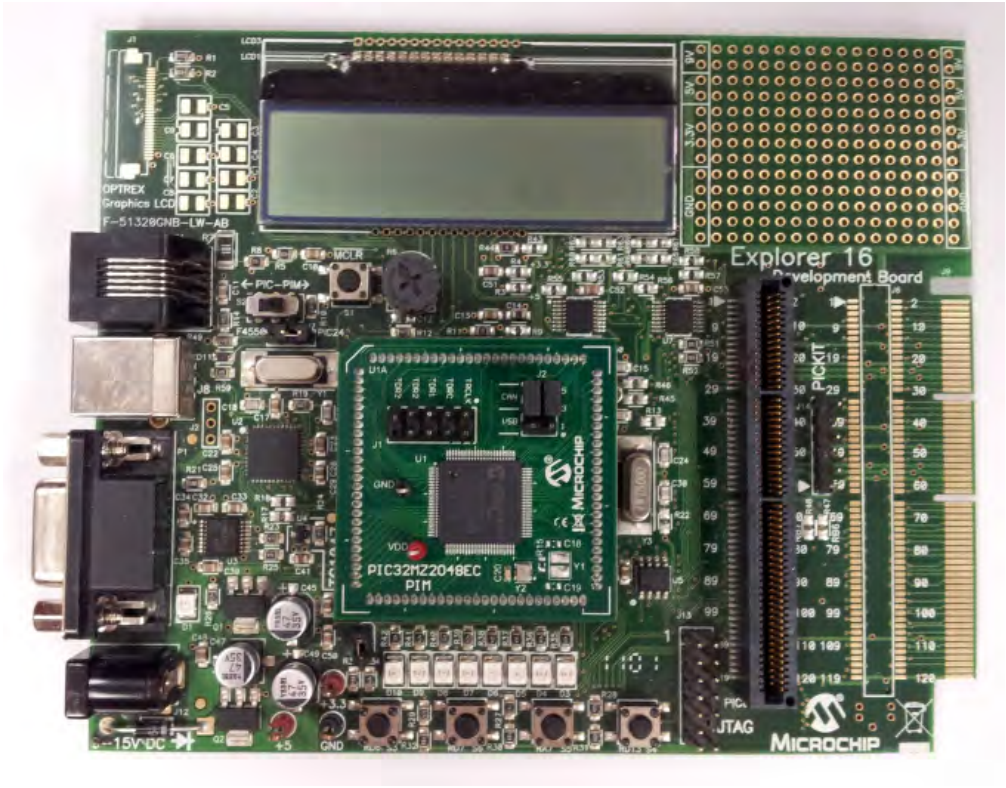
pic32mz_ec_pim+e16

PIC32MZ2048ECH100 Plug-in Module (PIM) plus Explorer 16 Development Board BSP.

Description

This BSP is intended for the PIC32MZ2048ECH100 Plug-in Module (PIM) connected to the Explorer 16 Development Board.

The following figure illustrates the hardware configuration.



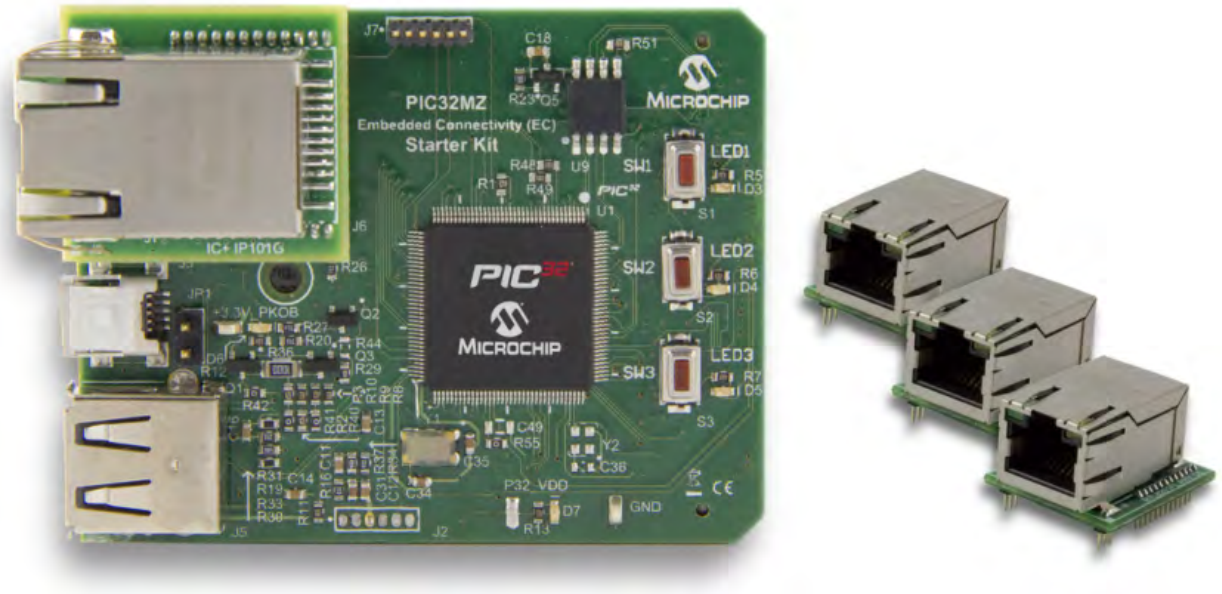
pic32mz_ec_sk

PIC32MZ EC Starter Kit BSP.

Description

This BSP is intended for the PIC32MZ Embedded Connectivity (EC) Starter Kit.

The following figure illustrates the hardware configuration.



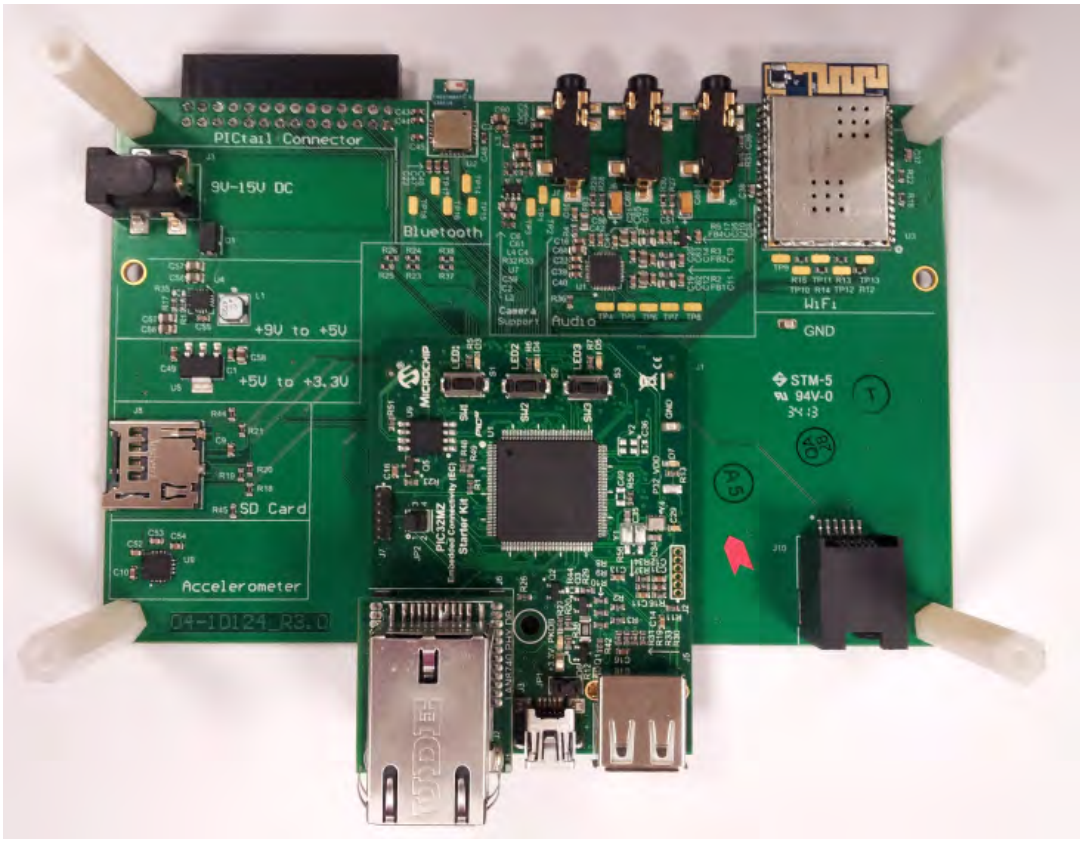
pic32mz_ec_sk+meb2

PIC32MZ EC Starter Kit plus MEB II BSP.

Description

This BSP is intended for the Multimedia Expansion Board II (MEB II) connected to the PIC32MZ Embedded Connectivity (EC) Starter Kit.

The following figure illustrates the hardware configuration.



pic32mz_ec_sk+meb2+wvga

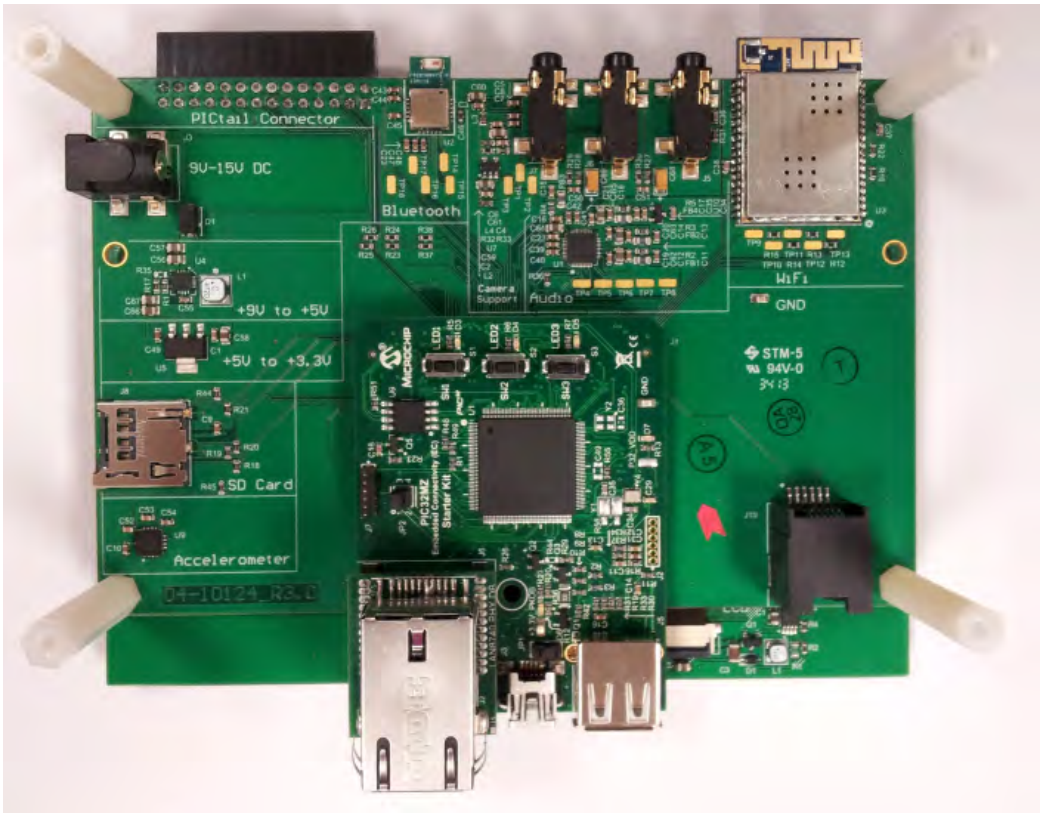
PIC32MZ EC Starter Kit plus MEB II and 5" WVGA PCAP Display Board BSP.

Description

This BSP is intended for the Multimedia Expansion Board II (MEB II) with the 5" WVGA PCAP Display Board (see the following **Note**) connected to the PIC32MZ Embedded Connectivity (EC) Starter Kit.

Note: Please contact your local Microchip sales office for information on obtaining the 5" WVGA PCAP Display Board.

The following figure illustrates the hardware configuration.



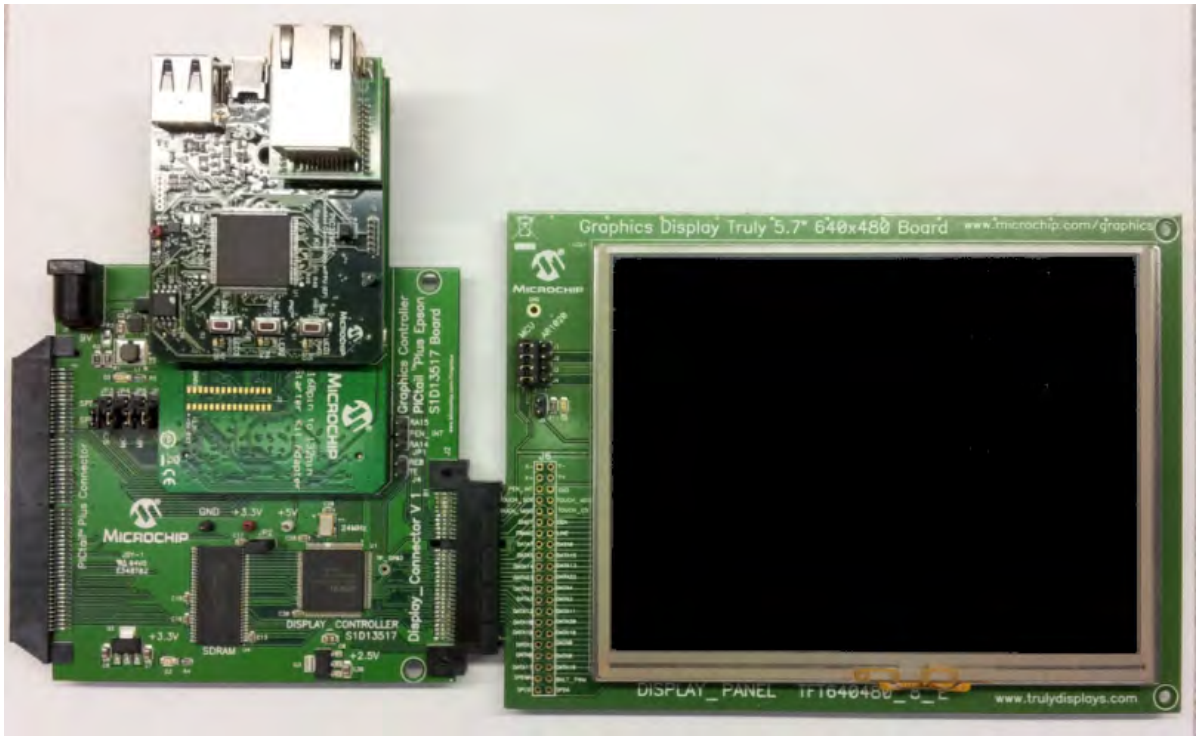
pic32mz_ec_sk+s1d_pictail+vga

PIC32MZ EC Starter Kit plus Graphics Controller PICtail Plus Epson S1D13517 Daughter Board with Graphics Display Powertip 4.3" 480x272 Board BSP.

Description

This BSP is intended for the Graphics Controller PICtail Plus Epson S1D13517 Daughter Board with the Graphics Display Truly 5.7" 640x480 Board connected to the PIC32MZ Embedded Connectivity (EC) Starter Kit.

Note: The starter kit shown in the following figure is the PIC32MZ EF Starter Kit. The PIC32MZ EC and PIC32MZ EF starter kits are identical with the exception of the on-board device, so the hardware configuration is the same regardless of which starter kit is used.



pic32mz_ec_sk+s1d_pictail+wqvga

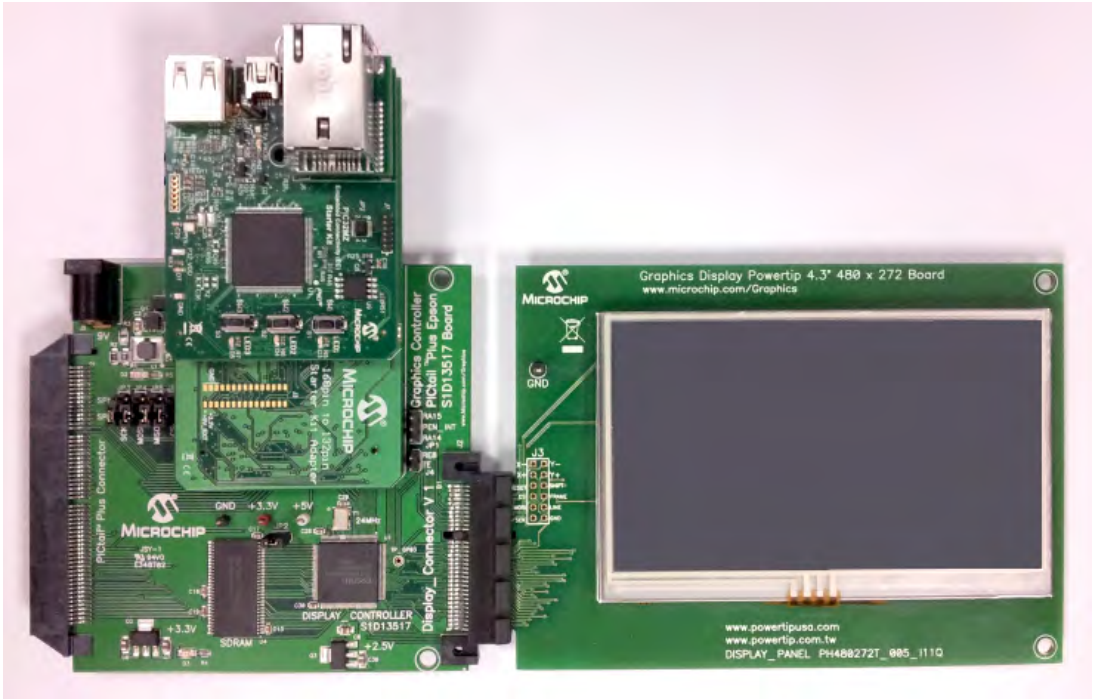
PIC32MZ EC Starter Kit plus Graphics Controller PICtail Plus Epson S1D13517 Daughter Board with Graphics Display Powertip 4.3" 480x272 Board BSP.

Description

This BSP is intended for the Graphics Controller PICtail Plus Epson S1D13517 Daughter Board with the Graphics Display Powertip 4.3" 480x272 Board connected to the PIC32MZ Embedded Connectivity (EC) Starter Kit with the PIC32MZ Starter Kit Adapter Board.

Note: The PIC32MZ EC Adapter Board is required when using the Graphics Controller PICtail Plus Epson S1D13517 Daughter Board with the PIC32MZ EC Starter Kit.

The following figure illustrates the hardware configuration.

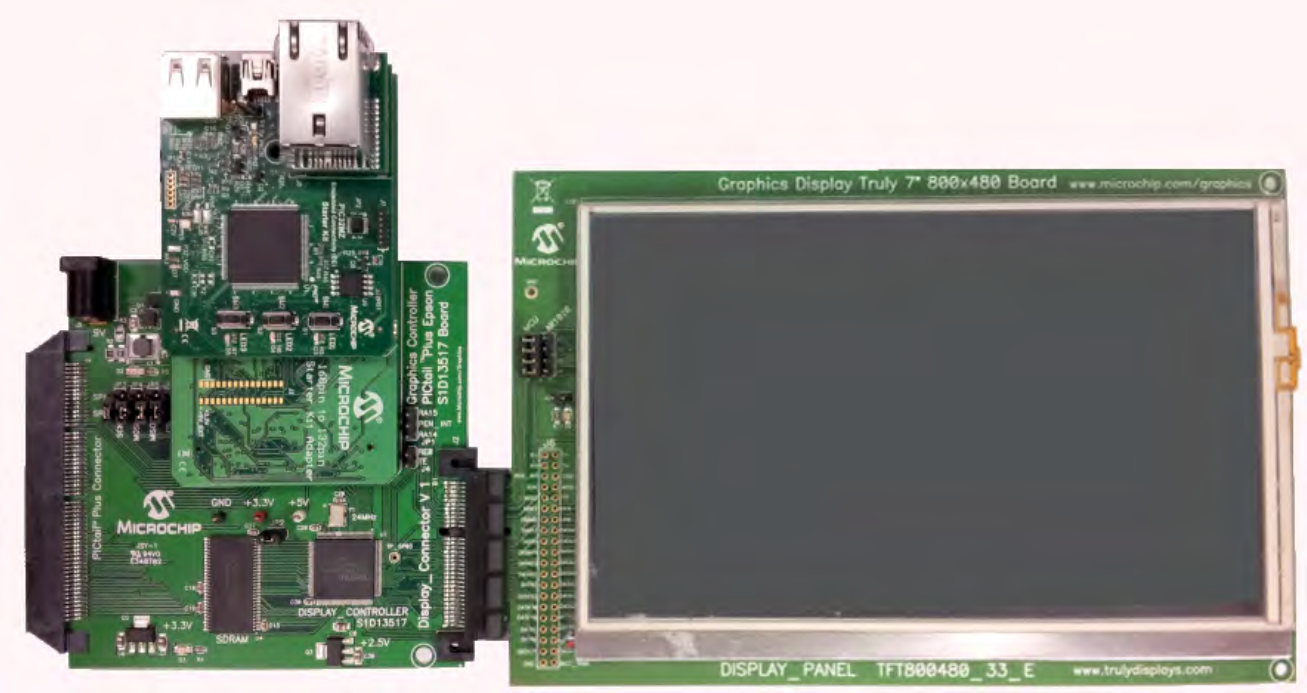


pic32mz_ec_sk+s1d_pictail+wvga

PIC32MZ EC Starter Kit plus Graphics Controller PICtail Plus Epson S1D13517 Daughter Board and Graphics Display Truly 7" 800x400 Board BSP.

Description

This BSP is intended for the Graphics Controller PICtail Plus Epson S1D13517 Daughter Board with Graphics Display Truly 7" 800x400 Board connected to the PIC32MZ Embedded Connectivity (EC) Starter Kit.



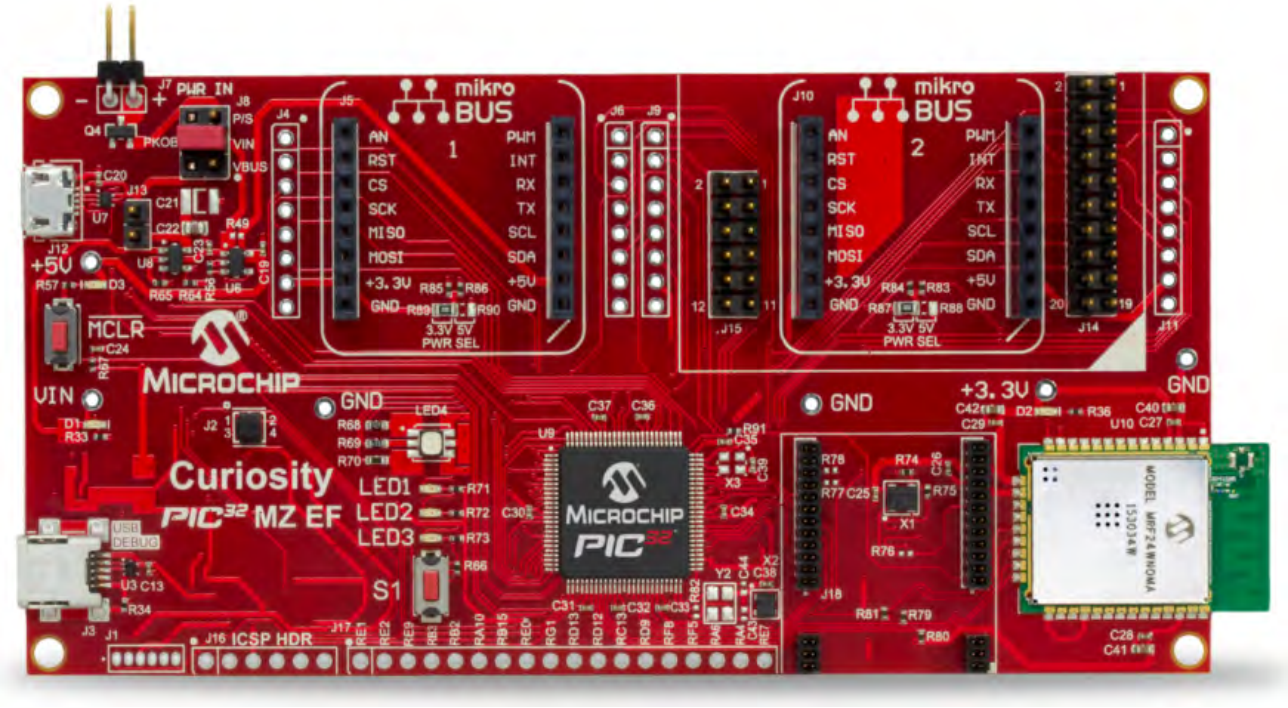
pic32mz_ef_curiosity

PIC32MZ EF Curiosity Development Board BSP.

Description

This BSP is intended for the PIC32MZ EF Curiosity Development Board.

The following figure illustrates the hardware configuration.



pic32mz_ef_pim+bt_audio_dk

PIC32MZ2048EFH144 Audio Plug-in Module (PIM) plus PIC32 Bluetooth Audio Development Kit BSP.

Description

This BSP is intended for the PIC32MZ2048EFH144 Audio Plug-in Module (PIM) connected to the PIC32 Bluetooth Audio Development Kit.

Note: The PIM shown in the following figure is the PIC32MZEC2048. The PIC32MZ EC and PIC32MZ EF PIMs are identical with the exception of the on-board device, so the hardware configuration is the same regardless of which PIM is used.

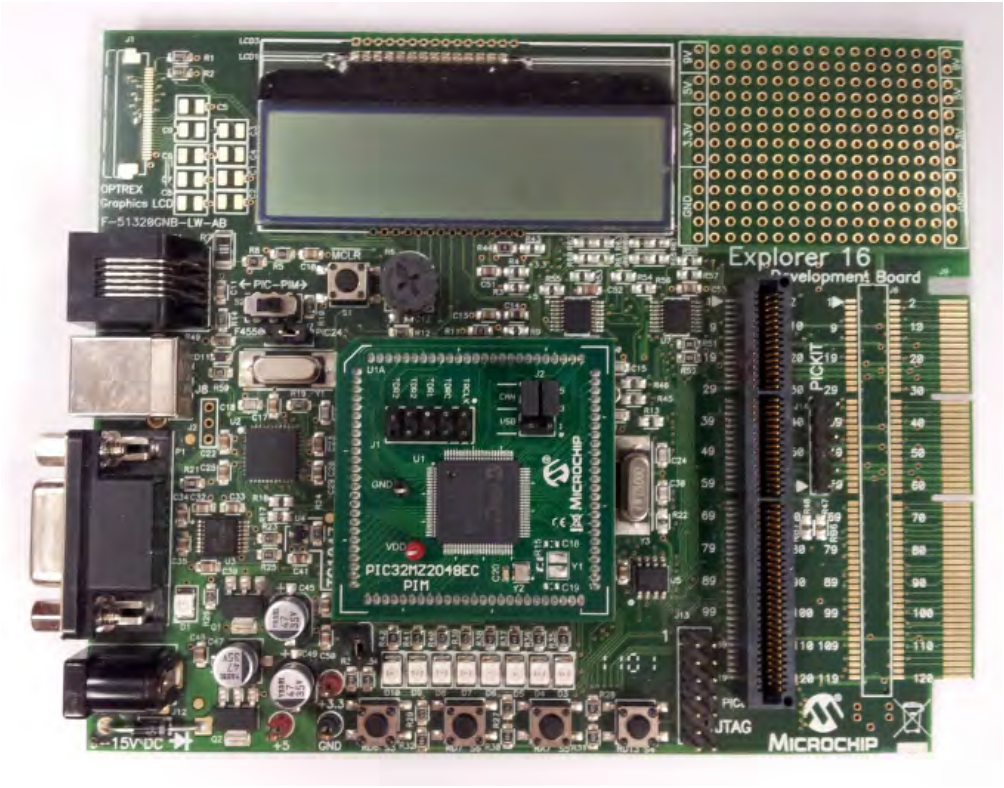
pic32mz_ef_pim+e16

PIC32MZ2048EFH100 Plug-in Module (PIM) plus Explorer 16 Development Board BSP.

Description

This BSP is intended for the PIC32MZ2048EFH100 Plug-in Module (PIM) connected to the Explorer 16 Development Board.

Note: The PIM shown in the following figure is the PIC32MZEC2048. The PIC32MZ EC and PIC32MZ EF PIMs are identical with the exception of the on-board device, so the hardware configuration is the same regardless of which PIM is used.



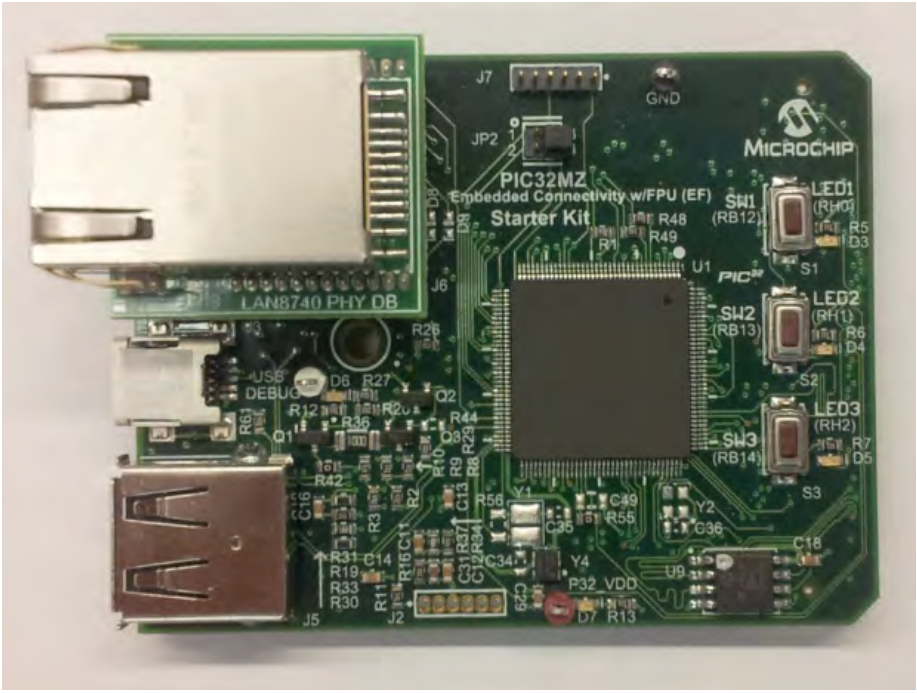
pic32mz_ef_sk

PIC32MZ EF Starter Kit BSP.

Description

This BSP is intended for the PIC32MZ Embedded Connectivity (EF) Starter Kit.

The following figure illustrates the hardware configuration.



pic32mz_ef_sk+meb2

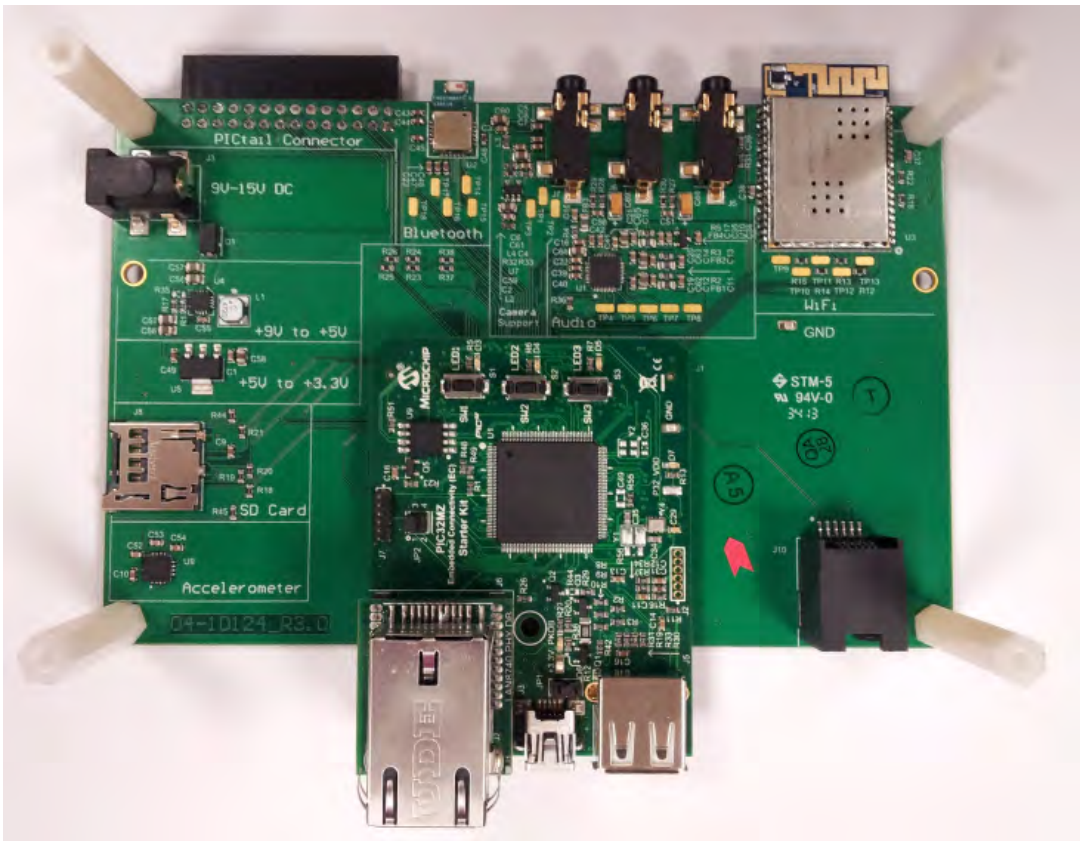
PIC32MZ EF Starter Kit plus MEB II BSP.

Description

This BSP is intended for the Multimedia Expansion Board II (MEB II) connected to the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit.

Note: The starter kit shown in the following figure is the PIC32MZ EC Starter Kit. The PIC32MZ EC and PIC32MZ EF starter kits are identical with the exception of the on-board device, so the hardware configuration is the same regardless of which starter kit is used.

The following figure illustrates the hardware configuration.



pic32mz_ef_sk+meb2+wvga

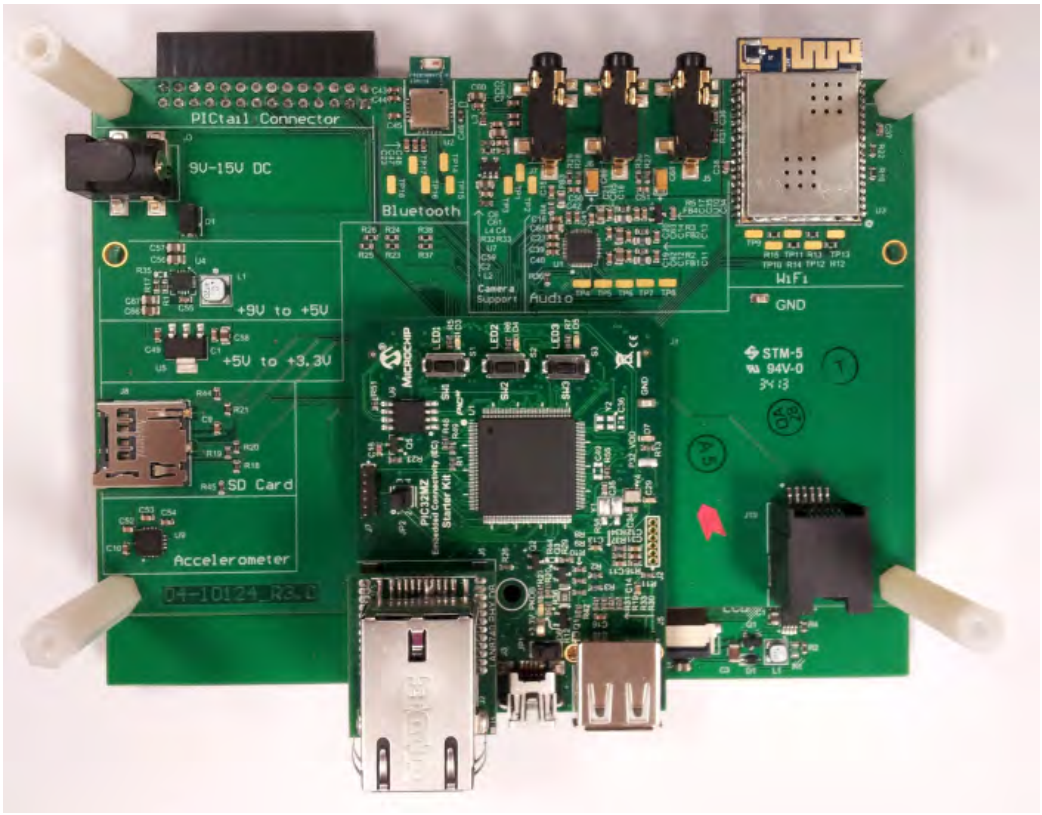
PIC32MZ EF Starter Kit plus MEB II and 5" WVGA PCAP Display Board BSP.

Description

This BSP is intended for the Multimedia Expansion Board II (MEB II) with the 5" WVGA PCAP Display Board (see **Note 1**) connected to the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit.

Notes:

1. Please contact your local Microchip sales office for information on obtaining the 5" WVGA PCAP Display Board.
2. The starter kit shown in the following figure is the PIC32MZ EC Starter Kit. The PIC32MZ EC and PIC32MZ EF starter kits are identical with the exception of the on-board device, so the hardware configuration is the same regardless of which starter kit is used.



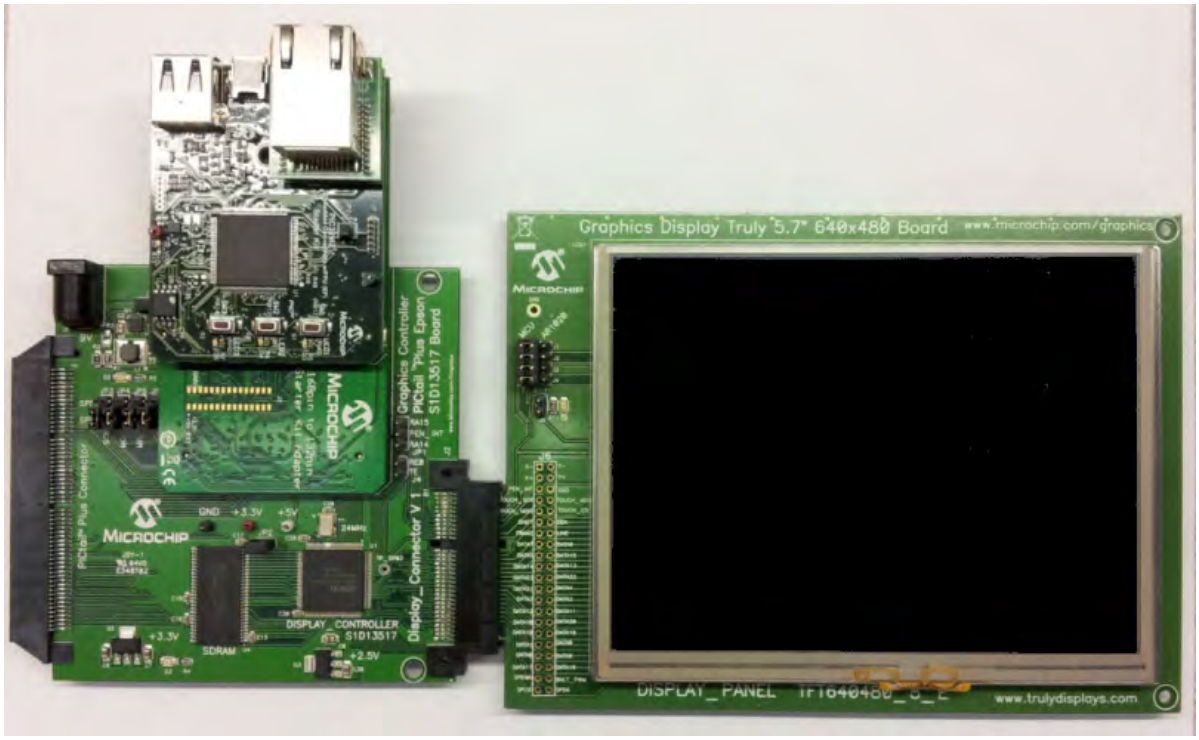
pic32mz_ef_sk+s1d_pictail+vga

PIC32MZ EF Starter Kit plus Graphics Controller PICtail Plus Epson S1D13517 Daughter Board with Graphics Display Powertip 4.3" 480x272 Board BSP.

Description

This BSP is intended for the Graphics Controller PICtail Plus Epson S1D13517 Daughter Board with the Graphics Display Truly 5.7" 640x480 Board connected to the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit.

The following figure illustrates the hardware configuration.



pic32mz_ef_sk+s1d_pictail+wqvga

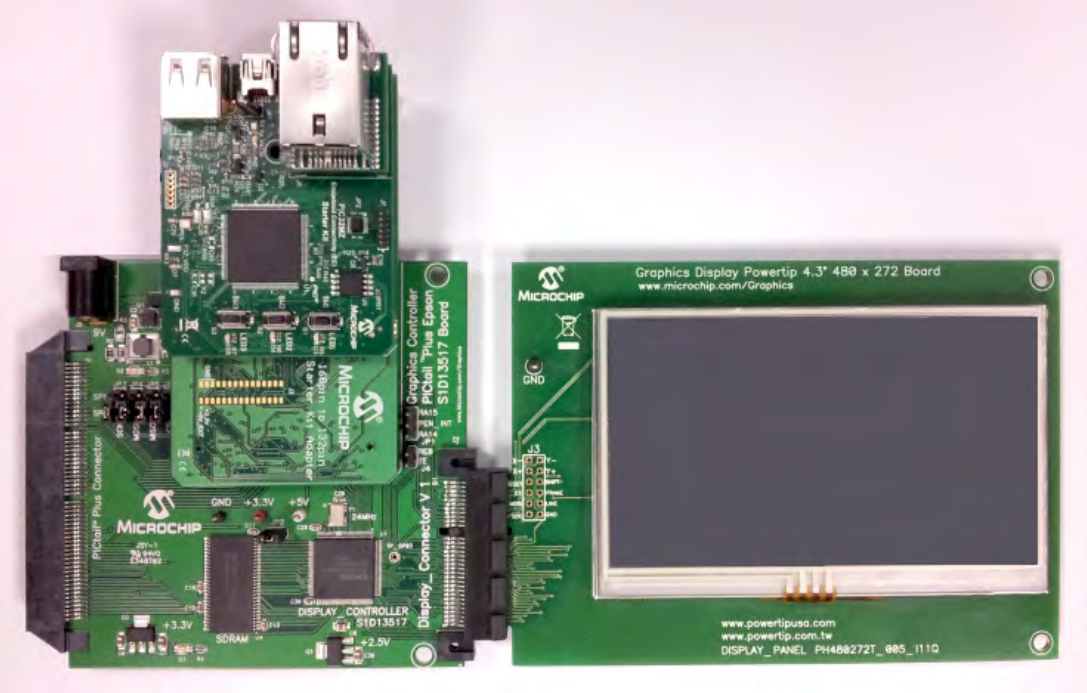
PIC32MZ EF Starter Kit plus Graphics Controller PICtail Plus Epson S1D13517 Daughter Board with Graphics Display Powertip 4.3" 480x272 Board BSP.

Description

This BSP is intended for the Graphics Controller PICtail Plus Epson S1D13517 Daughter Board with the Graphics Display Powertip 4.3" 480x272 Board connected to the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit with the PIC32MZ Starter Kit Adapter Board.

Note: The starter kit shown in the following figure is the PIC32MZ EC Starter Kit. The PIC32MZ EC and PIC32MZ EF starter kits are identical with the exception of the on-board device, so the hardware configuration is the same regardless of which starter kit is used.

The following figure illustrates the hardware configuration.



wifi_g_db

Wi-Fi® G Demo Board BSP.

Description

This BSP is intended for the Wi-Fi G Demo Board.

The following figure illustrates the hardware configuration.

Library Interface

Provides information on BSP functions, structs, types, and macros.

Data Types and Constants

	Name	Description
	BSP_LED	Defines the LEDs available on this board.
	BSP_SWITCH_STATE	Defines possible states of the switches on this board.
	BSP_LED_STATE	Enumerates the supported LED states.
	BSP_SWITCH	Defines the switches available on this board.
	BSP_OSC_FREQUENCY	Defines the frequency value of crystal/oscillator used on the board

Initialization Functions

	Name	Description
	BSP_Initialize	Performs the necessary actions to initialize a board.

LED Control Functions

	Name	Description
	BSP_LEDOff	Switches OFF the specified LED.
	BSP_LEDOn	Switches ON the specified LED.
	BSP_LEDStateGet	Returns the present state of the LED.
	BSP_LEDStateSet	Controls the state of the LED.
	BSP_LEDToggle	Toggles the state of the LED between BSP_LED_STATE_ON and BSP_LED_STATE_OFF.

Other Functions

	Name	Description
	BSP_SwitchStateGet	Returns the present state (pressed or not pressed) of the specified switch.

Description

The header file for each BSP library uses the file named `bsp_config.h`.

Initialization Functions

BSP_Initialize Function

Performs the necessary actions to initialize a board.

File

bsp_config_template.h

C

```
void BSP_Initialize();
```

Returns

None.

Description

This function initializes the LED and Switch ports on the board. This function must be called by the user before using any APIs present on this BSP.

Remarks

None.

Preconditions

None.

Example

```
//Initialize the BSP
BSP_Initialize();
```

Function

void BSP_Initialize(void)

LED Control Functions

BSP_LEDOff Function

Switches OFF the specified LED.

File

bsp_config_template.h

C

```
void BSP_LEDOff(BSP_LED led);
```

Returns

None.

Description

This function switches OFF the specified LED.

Remarks

None.

Preconditions

BSP_Initialize() should have been called.

Example

```
// Initialize the BSP
BSP_Initialize();
```

```
// Switch off LED1 on the board
BSP_LEDOff(BSP_LED_1);
```

Parameters

Parameters	Description
led	The LED to switch off

Function

void BSP_LEDOff(BSP_LED led);

BSP_LEDOn Function

Switches ON the specified LED.

File

bsp_config_template.h

C

```
void BSP_LEDOn(BSP_LED led);
```

Returns

None.

Description

This function switches ON the specified LED.

Remarks

None.

Preconditions

BSP_Initialize() should have been called.

Example

```
// Initialize the BSP
BSP_Initialize();

// Switch on LED1 on the board
BSP_LEDOn(BSP_LED_1);
```

Parameters

Parameters	Description
led	The LED to switch on

Function

void BSP_LEDOn(BSP_LED led);

BSP_LEDStateGet Function

Returns the present state of the LED.

File

bsp_config_template.h

C

```
BSP_LED_STATE BSP_LEDStateGet(BSP_LED led);
```

Returns

The ON/OFF state of the LED.

Description

This function returns the present state of the LED.

Remarks

None.

Preconditions

BSP_Initialize() should have been called.

Example

```
// Initialize the BSP
BSP_Initialize();

// Check if LED2 is off
if(BSP_LED_STATE_OFF == BSP_LEDStateGet(BSP_LED_2)
{
    // Switch on the LED.
    BSP_LEDStateSet(BSP_LED_2, BSP_LED_STATE_ON);
}
```

Parameters

Parameters	Description
led	The LED to whose status needs to be obtained

Function

BSP_LED_STATE BSP_LEDStateGet(BSP_LED led);

BSP_LEDStateSet Function

Controls the state of the LED.

File

bsp_config_template.h

C

```
void BSP_LEDStateSet(BSP_LED led, BSP_LED_STATE state);
```

Returns

None.

Description

This function allows the application to specify the state of the LED.

Remarks

None.

Preconditions

BSP_Initialize() should have been called.

Example

```
// Initialize the BSP
BSP_Initialize();

// Switch on LED1 on the board
BSP_LEDStateSet(BSP_LED_1, BSP_LED_STATE_ON);

// Switch off LED2 on the board
BSP_LEDStateSet(BSP_LED_2, BSP_LED_STATE_OFF);
```

Parameters

Parameters	Description
led	The LED to operate on
state	The state to be set

Function

void BSP_LEDStateSet(BSP_LED led, BSP_LED_STATE state);

BSP_LEDToggle Function

Toggles the state of the LED between BSP_LED_STATE_ON and BSP_LED_STATE_OFF.

File

bsp_config_template.h

C

```
void BSP_LEDToggle(BSP_LED led);
```

Returns

None.

Description

This function toggles the state of the LED between BSP_LED_STATE_ON and BSP_LED_STATE_OFF.

Remarks

None.

Preconditions

BSP_Initialize() should have been called.

Example

```
// Initialize the BSP
BSP_Initialize();

// Switch on LED1 on the board
BSP_LEDStateSet(BSP_LED_1, BSP_LED_STATE_ON);

// Switch off LED2 on the board
BSP_LEDStateSet(BSP_LED_2, BSP_LED_STATE_OFF);

// Toggle state of LED3
BSP_LEDToggle(BSP_LED_3);
```

Parameters

Parameters	Description
led	The LED to toggle

Function

void BSP_LEDToggle(BSP_LED led);

Other Functions

BSP_SwitchStateGet Function

Returns the present state (pressed or not pressed) of the specified switch.

File

bsp_config_template.h

C

```
BSP_SWITCH_STATE BSP_SwitchStateGet(BSP_SWITCH bspSwitch);
```

Returns

The pressed released state of the switch.

Description

This function returns the present state (pressed or not pressed) of the specified switch.

Remarks

None.

Preconditions

BSP_Initialize() should have been called.

Example

```
// Initialize the BSP
BSP_Initialize();

// Check the state of the switch.
if(BSP_SWITCH_STATE_PRESSED == BSP_SwitchStateGet(BSP_SWITCH_1))
{
    // This means that Switch 1 on the board is pressed.
}
```

Parameters

Parameters	Description
switch	The switch whose state needs to be obtained

Function

BSP_SWITCH_STATE BSP_SwitchStateGet(BSP_SWITCH switch);

Data Types and Constants

BSP_LED Enumeration

Defines the LEDs available on this board.

File

bsp_config_template.h

C

```
typedef enum {
  BSP_LED_1,
  BSP_LED_2,
  BSP_LED_3
} BSP_LED;
```

Members

Members	Description
BSP_LED_1	LED 1
BSP_LED_2	LED 2
BSP_LED_3	LED 3

Description

LED Number.

This enumeration defines the LEDs available on this board.

Remarks

None.

BSP_SWITCH_STATE Enumeration

Defines possible states of the switches on this board.

File

bsp_config_template.h

C

```
typedef enum {
  BSP_SWITCH_STATE_PRESSED,
  BSP_SWITCH_STATE_RELEASED
} BSP_SWITCH_STATE;
```

Members

Members	Description
BSP_SWITCH_STATE_PRESSED	Switch pressed
BSP_SWITCH_STATE_RELEASED	Switch not pressed

Description

BSP Switch state.

This enumeration defines the possible states of the switches on this board.

Remarks

None.

BSP_LED_STATE Enumeration

Enumerates the supported LED states.

File

bsp_config_template.h

C

```
typedef enum {
  BSP_LED_STATE_OFF,
  BSP_LED_STATE_ON
} BSP_LED_STATE;
```

Members

Members	Description
BSP_LED_STATE_OFF	LED State is on
BSP_LED_STATE_ON	LED State is off

Description

LED State

This enumeration defines the supported LED states.

Remarks

None.

BSP_SWITCH Enumeration

Defines the switches available on this board.

File

bsp_config_template.h

C

```
typedef enum {
  BSP_SWITCH_1,
  BSP_SWITCH_2,
  BSP_SWITCH_3
} BSP_SWITCH;
```

Members

Members	Description
BSP_SWITCH_1	SWITCH 1
BSP_SWITCH_2	SWITCH 2
BSP_SWITCH_3	SWITCH 3

Description

BSP Switch.

This enumeration defines the switches available on this board.

Remarks

None.

BSP_OSC_FREQUENCY Macro

Defines the frequency value of crystal/oscillator used on the board

File

bsp_config_template.h

C

```
#define BSP_OSC_FREQUENCY
```

Description

Oscillator Frequency

This macro defines the frequency value of the crystal/oscillator used on the board.

Files

Files

Name	Description
bsp_config_template.h	Board Support Package configuration file.

Description

This section lists the files associated with the Board Support Packages.

bsp_config_template.h

Board Support Package configuration file.

Enumerations

	Name	Description
	BSP_LED	Defines the LEDs available on this board.
	BSP_LED_STATE	Enumerates the supported LED states.
	BSP_SWITCH	Defines the switches available on this board.
	BSP_SWITCH_STATE	Defines possible states of the switches on this board.

Functions

	Name	Description
	BSP_Initialize	Performs the necessary actions to initialize a board.
	BSP_LEDOff	Switches OFF the specified LED.
	BSP_LEDOn	Switches ON the specified LED.
	BSP_LEDStateGet	Returns the present state of the LED.
	BSP_LEDStateSet	Controls the state of the LED.
	BSP_LEDToggle	Toggles the state of the LED between BSP_LED_STATE_ON and BSP_LED_STATE_OFF.
	BSP_SwitchStateGet	Returns the present state (pressed or not pressed) of the specified switch.

Macros

	Name	Description
	BSP_OSC_FREQUENCY	Defines the frequency value of crystal/oscillator used on the board

Description

Board Support Package Configuration File.

This file contains the configuration APIs for use with Board Support Packages.

File Name

bsp_config.h

Company

Microchip Technology Inc.

Supported Development Boards

Information on the development tools (i.e., hardware) used by the MPLAB Harmony Board Support Packages and demonstration applications.

Description

This section provides details on the development tools that are used by the board support packages and demonstration applications.

169-pin LFBGA CPU Daughter Board

Provides information on the 169-pin LFBGA CPU Daughter Board.

Description

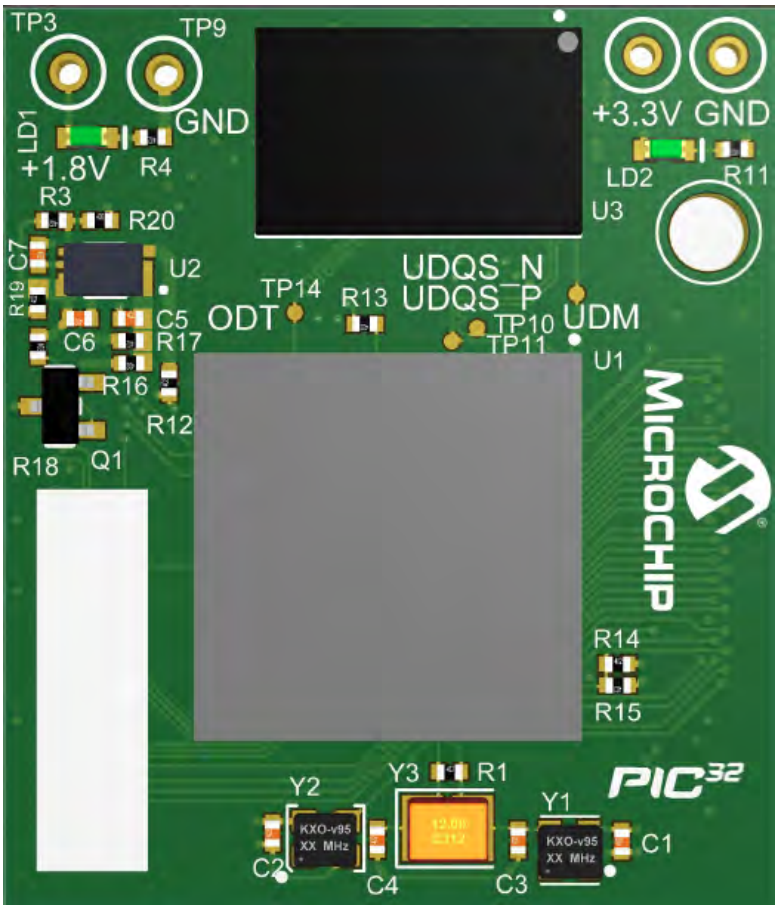
Microchip Part Number:

Please contact your local Microchip sales office for information on obtaining this daughter board.

Available Demonstrations

Feature	Demonstrations
Peripheral Library Examples	• dma_led_pattern

Hardware Layout



Audio Codec Daughter Board AK4642EN

Provides information on the Audio Codec AK4642EN Daughter Board.

Description

Microchip Part Number:

AC320100

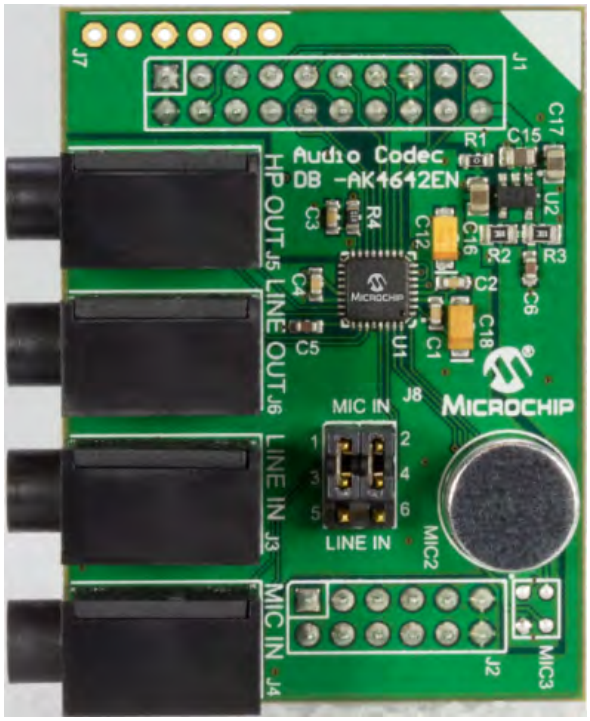
Product Page:

http://www.microchip.com/AC320100

Available Demonstrations

Feature	Demonstrations
Audio	• audio_microphone_loopback

Hardware Layout



CAN/LIN PICtail Plus Daughter Board

Provides information on the CAN/LIN PICtail Plus Daughter Board.

Description

Microchip Part Number:

AC164130-2

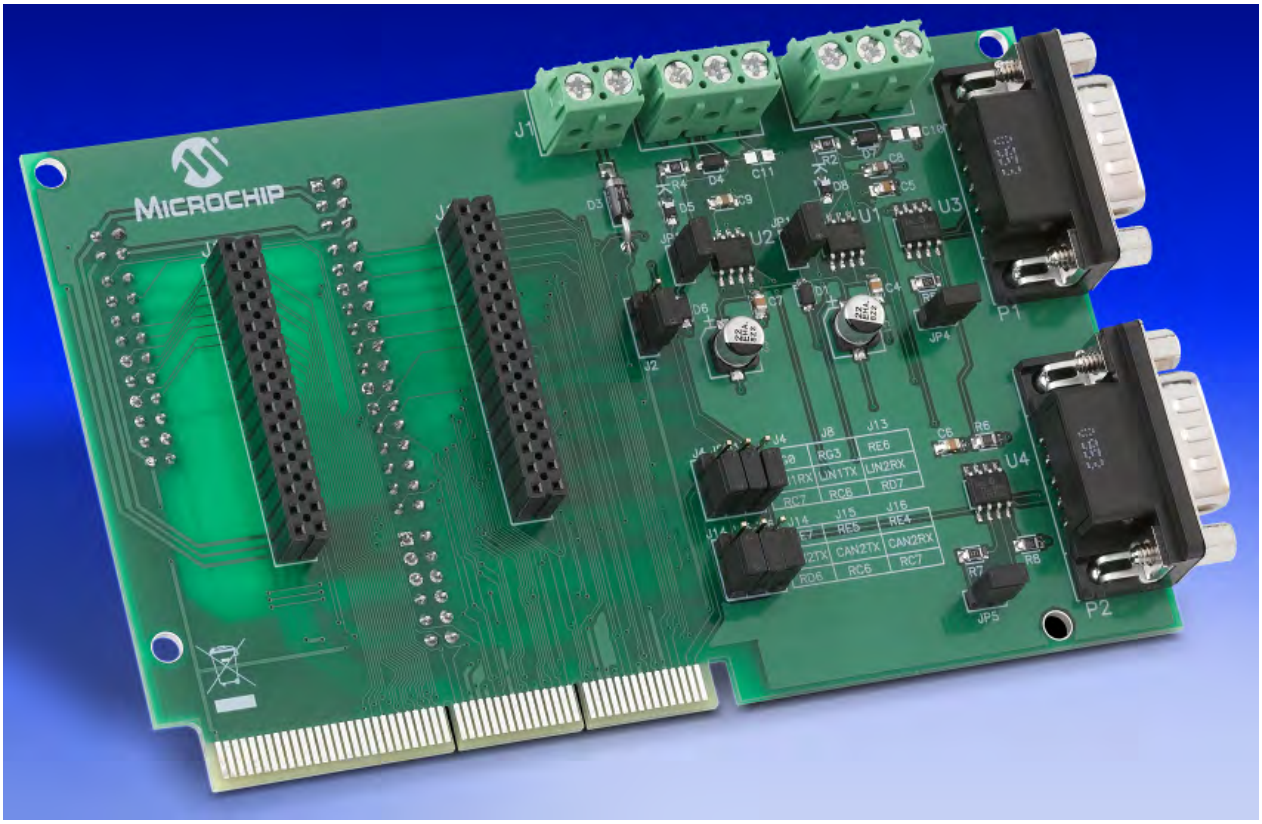
Product Page:

http://www.microchip.com/DevelopmentTools/ProductDetails.aspx?PartNO=ac164130-2

Available Demonstrations

Feature	Demonstrations
CAN	• echo_send

Hardware Layout



chipKIT WF32 Wi-Fi Development Board

Provides information on the chipKIT™ WF32™ Wi-Fi Development Board.

Description

Microchip Part Number:

TDGL021

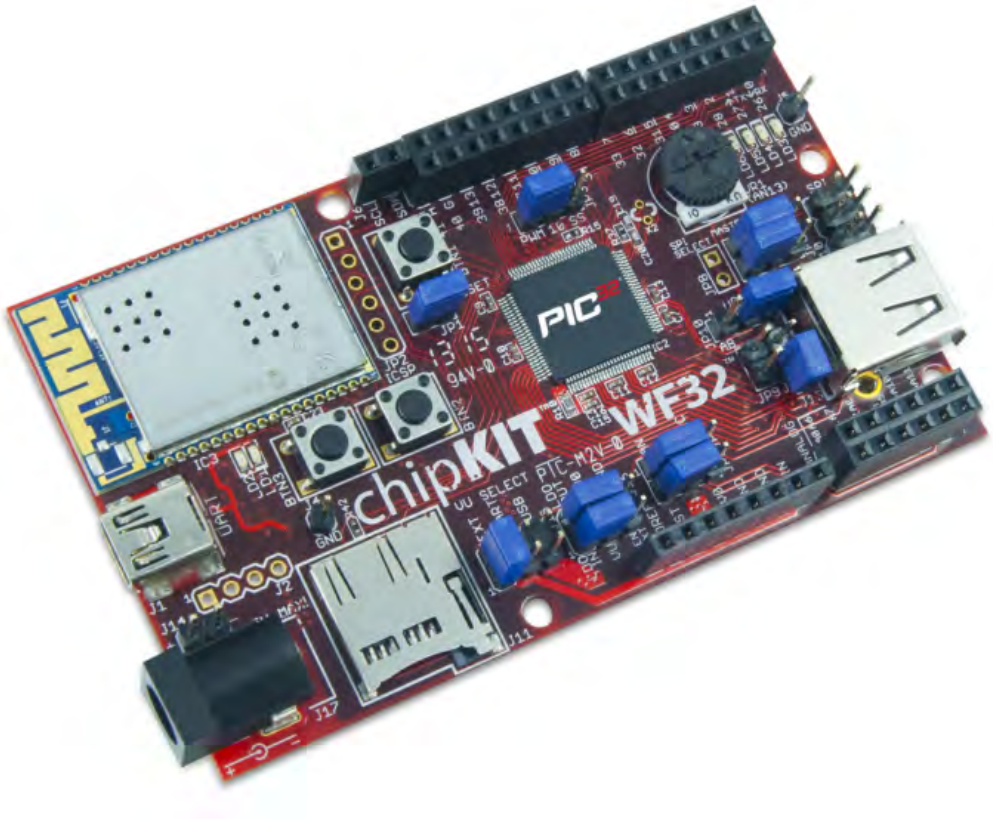
Product Page:

http://www.microchip.com/DevelopmentTools/ProductDetails.aspx?PartNO=TDGL021

Available Demonstrations

Feature	Demonstrations
TCP/IP	• pic32_wifi_web_server
USB Device	• hid_mouse
USB Host	• msd_basic

Hardware Layout



chipKIT Wi-FIRE Development Board

Provides information on the chipKIT™ Wi-FIRE Development Board.

Description

Microchip Part Number:

TDGL021-2

Product Page:

http://www.microchip.com/Developmenttools/ProductDetails.aspx?PartNO=TDGL021-2

Available Demonstrations

Feature	Demonstrations
USB Device	• cdc_com_port_single
USB Host	• msd_basic

Hardware Layout

Explorer 16 Development Board

Provides information on the Explorer 16 Development Board.

Description

Microchip Part Number:

DM240001

Product Page:

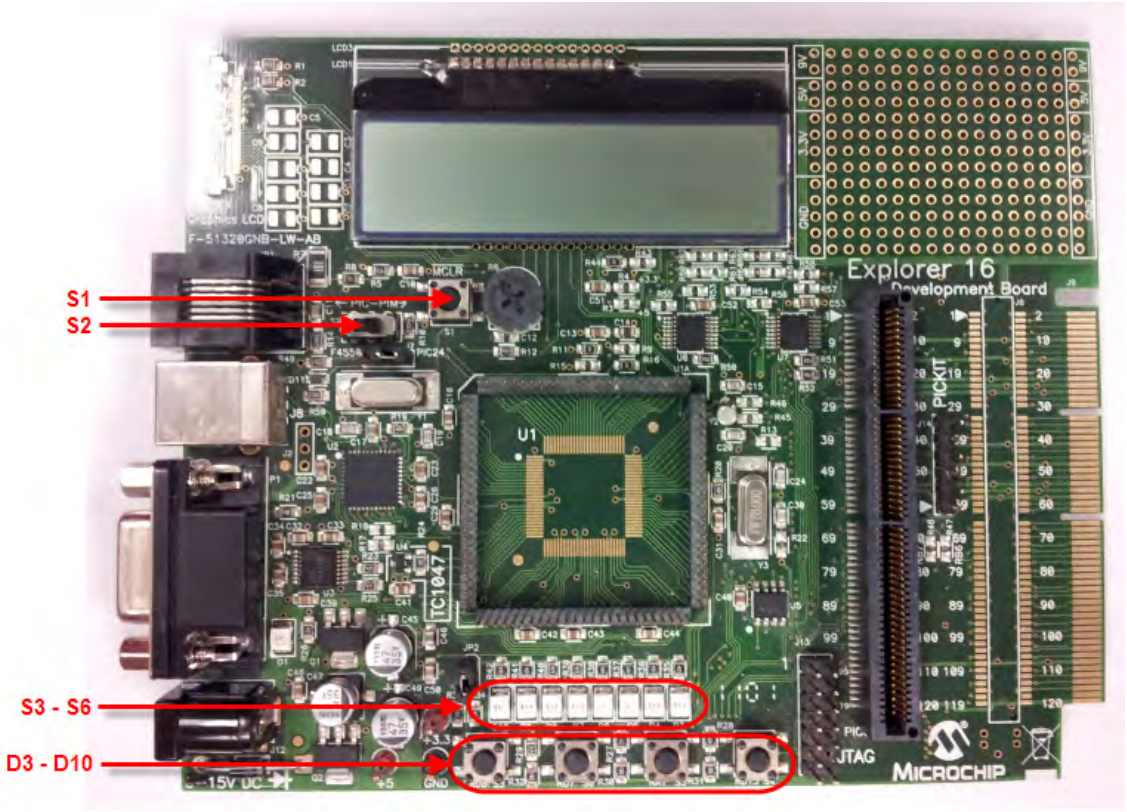
http://www.microchip.com/stellent/idcplg?IdcService=SS_GET_PAGE&nodeId=1406&dDocName=en024858&part=DM240001

Available Demonstrations

Feature	Demonstrations
Drivers	• i2c_eeprom • serial_eeprom
File System	• nvm_sdcard_fat_mpfs_multi_disk • sdcard_fat_single_disk
Peripheral Library Examples	• adc_pot • adcp_cal • flash_modify • i2c_eeprom_rw • i2c_loopback • mem_partition • pmp_lcd • reset_handler • rtcc_alarm • simple_comparator • spi_loopback • timer3_interrupt • triangle_wave • uart_basic • wdt_timeout
System Service Examples	• debug_uart
TCP/IP	• wifi_easy_configuration • web_server_nvm_mpfs

Test	• harness
USB Device	• cdc_com_port_dual • cdc_com_port_single • cdc_serial_emulator • cdc_serial_emulator_msd • hid_basic • hid_joystick • hid_keyboard • hid_mouse • msd_basic • vendor

Hardware Layout



Switch/Button Descriptions

1. S1 - Reset button (MCLR)/
2. S2 - Processor switch. This switch determines which processor is running, the processor on the board or the processor on the Plug-In-Module (PIM).
3. S3, S4, S5, and S6 - Application switches. For information about which pin is connected to this switch, please refer to the Information Sheet for the PIM in use.
4. D3 through D10 - Application LEDs. For information about which pin is connected to this LED, please refer to the Information Sheet for the PIM in use.

Ethernet PICtail Plus Daughter Board

Provides information on the Ethernet PICtail Plus Daughter Board.

Description

Microchip Part Number:

AC164123

Product Page:

http://www.microchip.com/AC164123

Available Demonstrations

Feature	Demonstrations
TCP/IP	• tcpip_tcp_client

Hardware Layout

Fast 100Mbps Ethernet PICtail Plus Daughter Board

Provides information on the Fast 100Mbps Ethernet PICtail Plus Daughter Board.

Description

Microchip Part Number:

AC164132

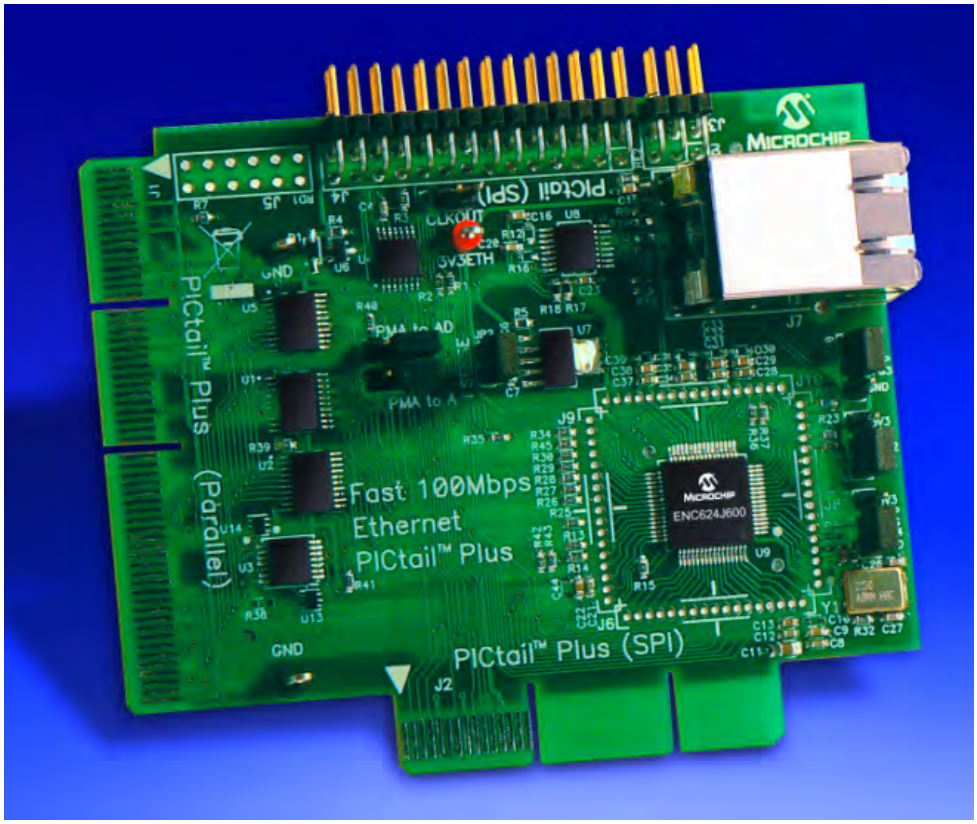
Product Page:

http://www.microchip.com/AC164132

Available Demonstrations

Feature	Demonstrations
TCP/IP	• tcpip_tcp_client

Hardware Layout



Graphics Controller PICtail Plus Epson S1D13517 Daughter Board

Provides information about the Graphics LCD Controller PICtail Plus Epson S1D13517 Daughter Board.

Description

Microchip Part Number:

AC164127-7

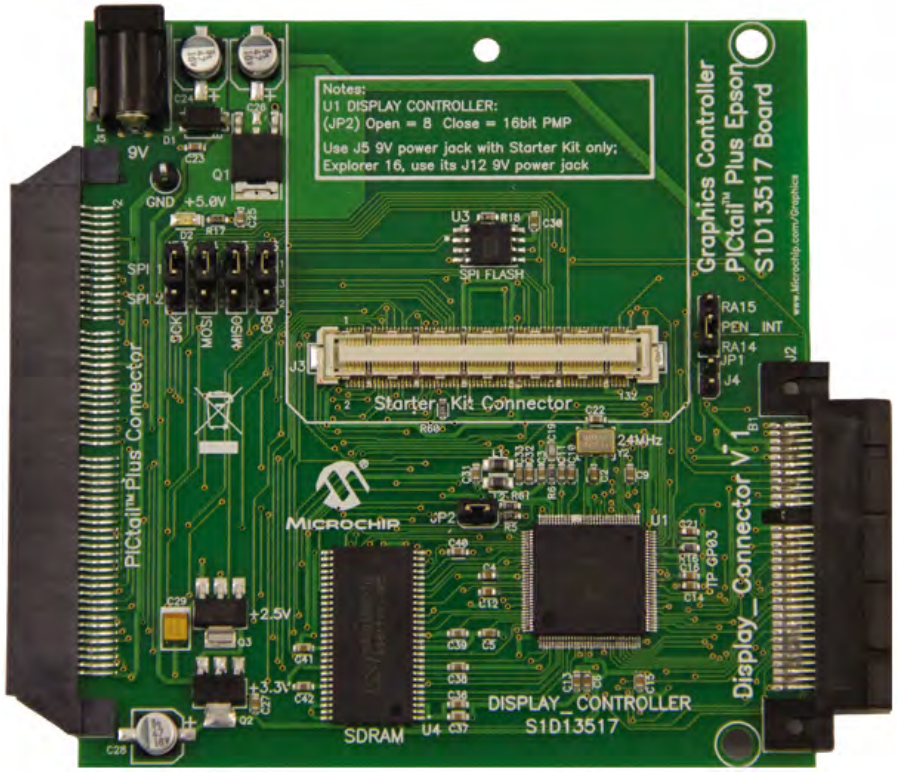
Product Page:

http://www.microchip.com/DevelopmentTools/ProductDetails.aspx?PartNO=ac164127-7

Available Demonstrations

Feature	Demonstrations
Graphics	• primitive • s1d13517

Hardware Layout



Graphics Display Truly 3.2" 320x240 Board

Provides information on the Graphics Display Truly 3.2" 320x240 Board.

Description

The Graphics Display Truly 3.2 240x320 Board is a demonstration board for evaluating Microchip graphic display solutions and the Graphics Library for 16- and 32-bit microcontrollers.

Microchip Part Number

AC164127-4

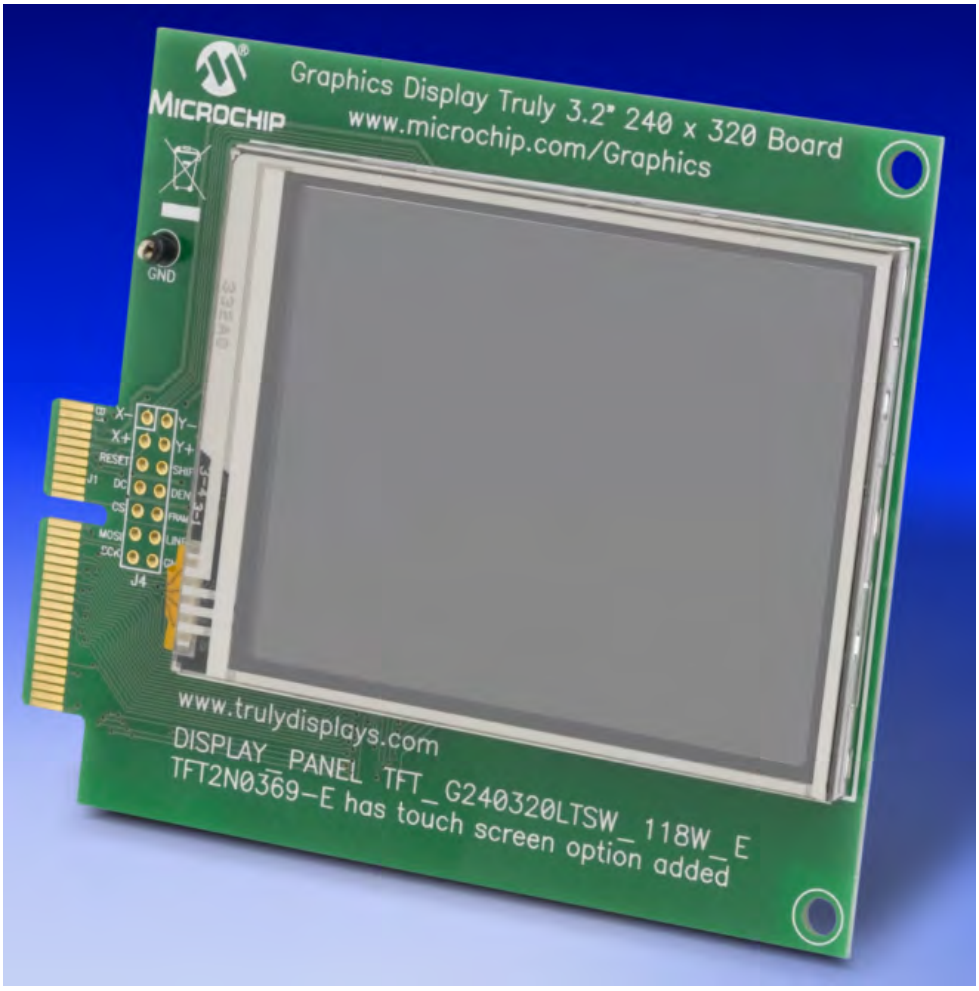
Product Page

http://www.microchip.com/Developmenttools/ProductDetails.aspx?PartNO=AC164127-4

Available Demonstrations

Feature	Demonstrations
Graphics	• object • primitive • ssd1926

Hardware Layout



Graphics Display Powertip 4.3" 480x272 Board

Provides information on the Graphics Display Powertip 4.3" 480x272 Board.

Description

The Graphics Display Powertip 4.3" 480x272 Board is a demonstration board for evaluating Microchip's graphic display solutions and the Graphics Library for 16- and 32- bit microcontrollers.

Microchip Part Number

AC164127-6

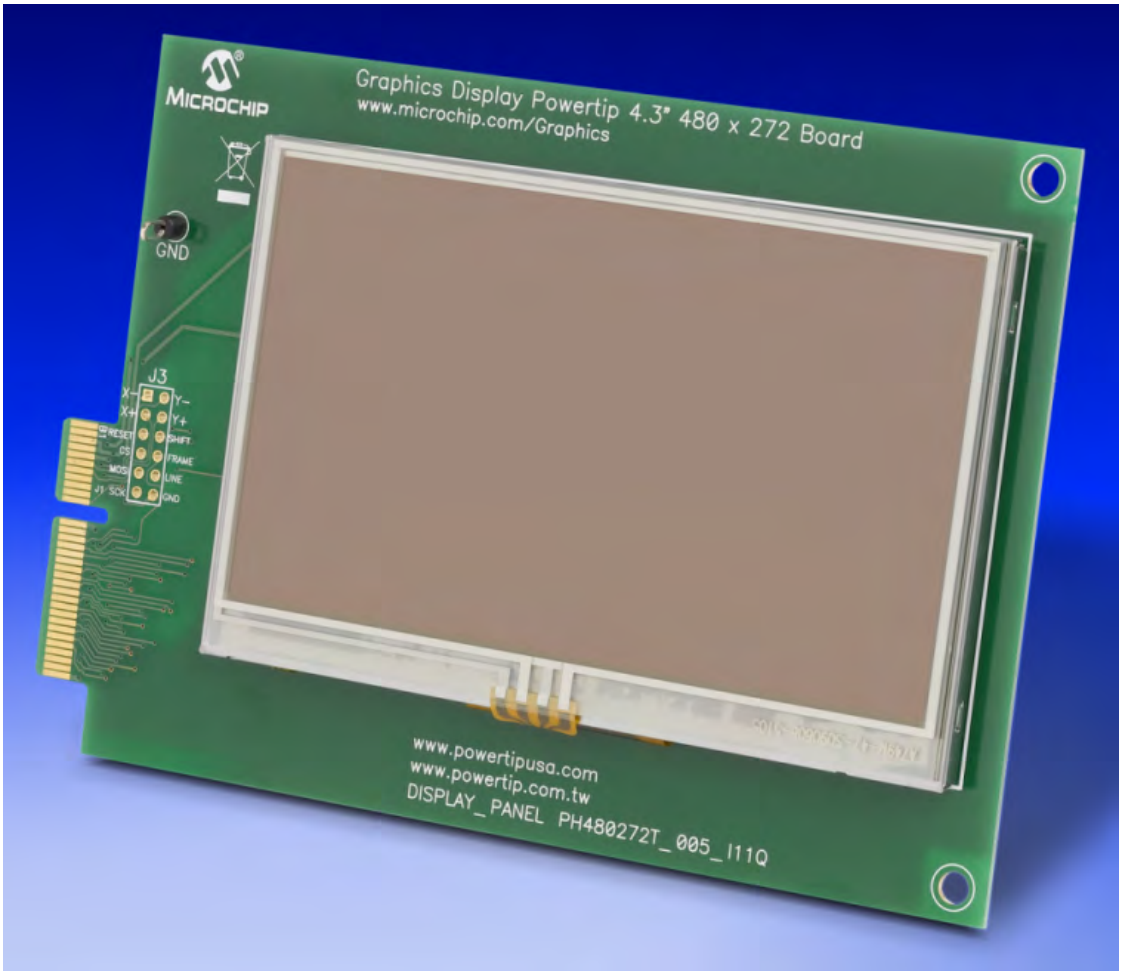
Product Page

http://www.microchip.com/Developmenttools/ProductDetails.aspx?PartNO=AC164127-6

Available Demonstrations

Feature	Demonstrations
Graphics	• lcc • primitive

Hardware Layout



Graphics Display Truly 5.7" 640x480 Board

Provides information on the Graphics Display Truly 5.7" 640x480 Board.

Description

The Graphics Display Truly 5.7" 640x480 Board is a demonstration board for evaluating Microchip's graphic display solution and Graphics Library for 16- and 32-bit microcontrollers

Microchip Part Number

AC164127-8

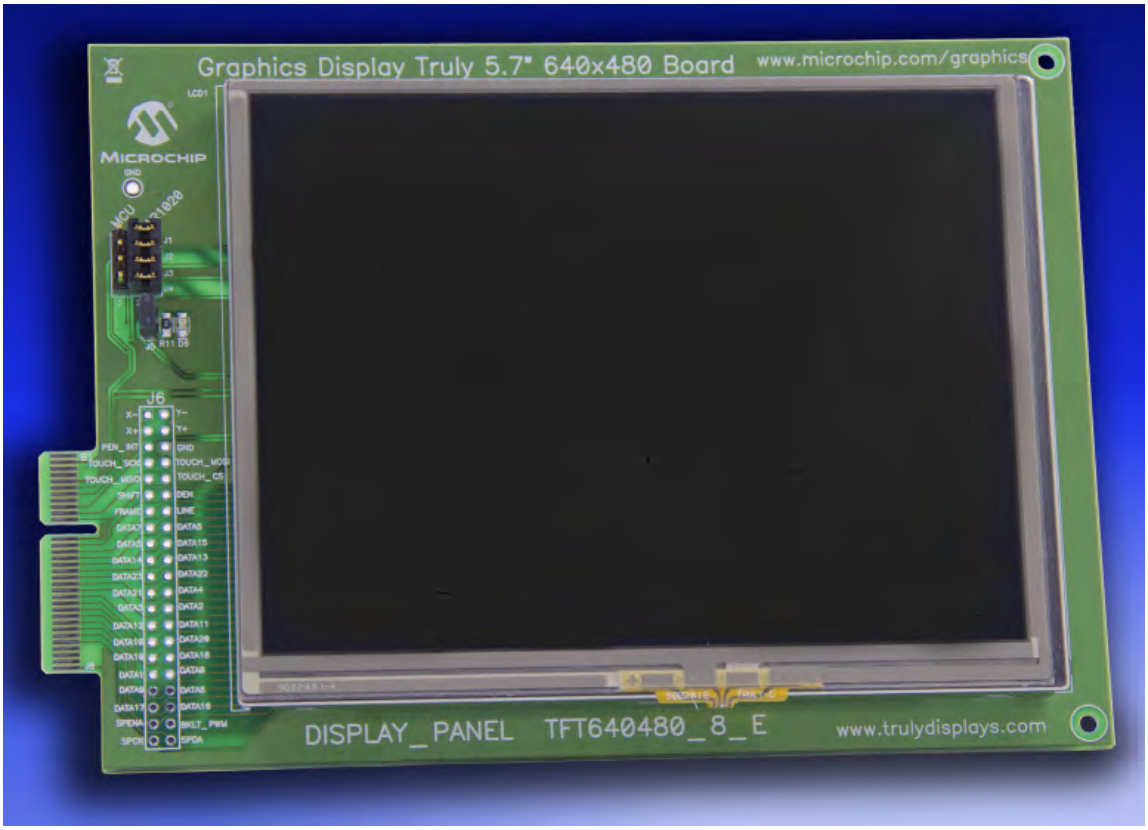
Product Page

http://www.microchip.com/Developmenttools/ProductDetails.aspx?PartNO=AC164127-8

Available Demonstrations

Feature	Demonstrations
Graphics	• s1d13517

Hardware Layout



Graphics Display Truly 7" 800x480 Board

Provides information on the Graphics Display Truly 7" 800x480 Board.

Description

The Graphics Display Truly 7" 800x480 Board is a demonstration board for evaluating Microchip's graphic display solution and Graphics Library for 16- and 32-bit microcontrollers.

Microchip Part Number

AC164127-9

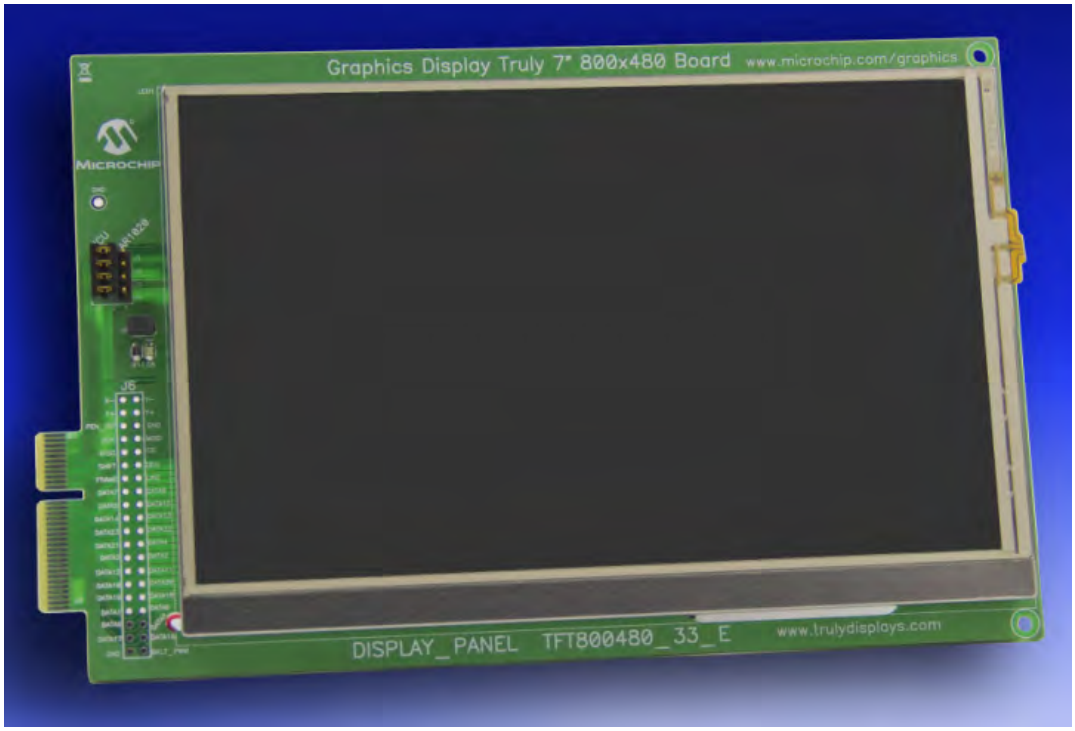
Product Page

http://www.microchip.com/DevelopmentTools/ProductDetails.aspx?PartNO=ac164127-9

Available Demonstrations

Feature	Demonstrations
Graphics	• s1d13517

Hardware Layout



Graphics LCD Controller PICtail Plus SSD1926 Daughter Board

Provides information on the Graphics LCD Controller PICtail Plus SSD1926 Daughter Board.

Description

Microchip Part Number:

AC164127-5

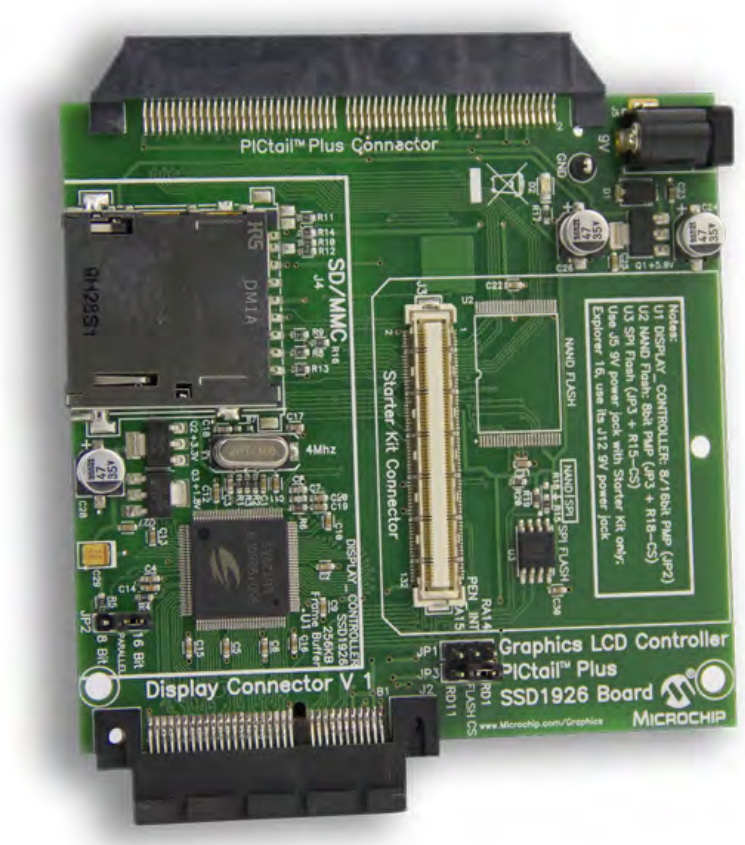
Product Page:

http://www.microchip.com/DevelopmentTools/ProductDetails.aspx?PartNO=ac164127-5

Available Demonstrations

Feature	Demonstrations
Graphics	• object • primitive • ssd1926

Hardware Layout



Low-Cost Controllerless (LCC) Graphics PICtail Plus Daughter Board

Provides information on the Low-Cost Controllerless (LCC) Graphics PICtail Plus Daughter Board.

Description

Microchip Part Number:

AC164144

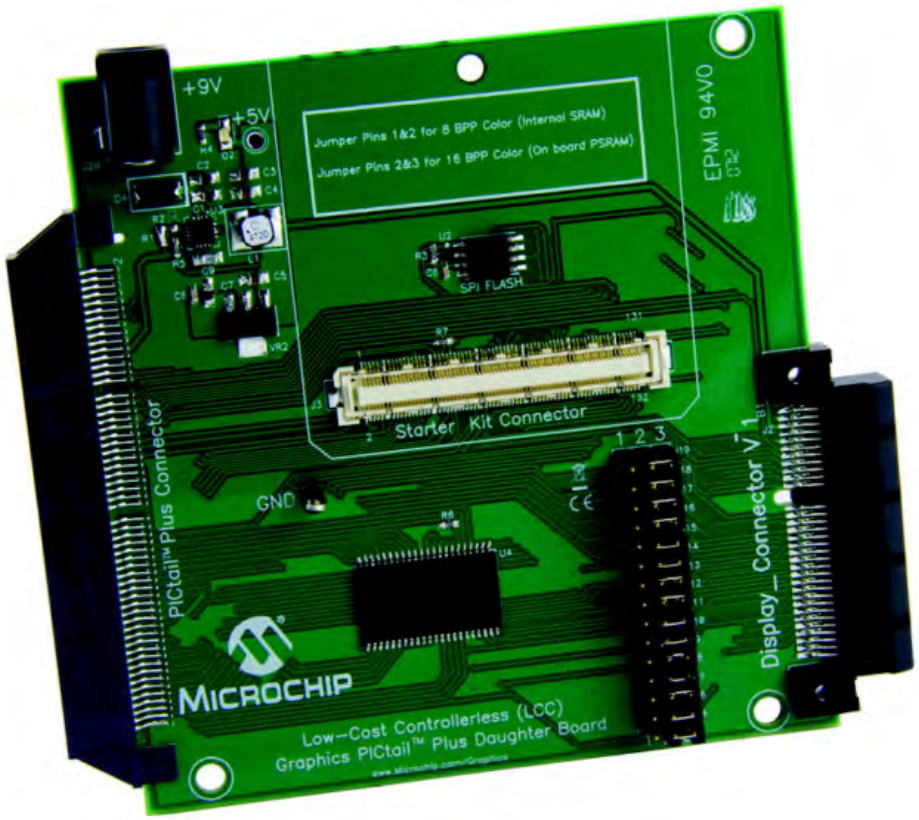
Product Page:

http://www.microchip.com/DevelopmentTools/ProductDetails.aspx?PartNO=ac164144

Available Demonstrations

Feature	Demonstrations
Graphics	• lcc • primitive

Hardware Layout



MCP2200 Breakout Module

Provides information on the MCP2200 Breakout Module.

Description

The MCP2200 Breakout Module is a development and evaluation platform for the USB-to-UART serial converter MCP2200 device. The module is comprised of a single Dual In-Line Package (DIP) form-factor board.

Microchip Part Number:

ADM00393

Product Page:

http://www.microchip.com/DevelopmentTools/ProductDetails.aspx?PartNO=ADM00393

Available Demonstrations

Feature	Demonstrations
Crypto	• large_hash
Bootloader	• LiveUpdate
Peripheral Library Examples	• uart_basic

Hardware Layout

MPLAB REAL ICE

Provides information on the MPLAB REAL ICE In-Circuit Emulator.

Description

Microchip Part Number:

DV244005

Product Page:

http://www.microchip.com/DevelopmentTools/ProductDetails.aspx?PartNO=dv244005

MRF24WG0MA Wi-Fi G PICtail/PICtail Plus Daughter Board

Provides information on the MRF24WG0MA Wi-Fi G PICtail/PICtail Plus Daughter Board.

Description

Microchip Part Number:

AC164149

Microchip Product Page:

http://www.microchip.com/Developmenttools/ProductDetails.aspx?PartNO=AC164149

Available Demonstrations

Feature	Demonstrations
TCP/IP	• pic32_eth_wifi_web_server • wifi_easy_configuration • wifi_wolfssl_tcp_client • wifi_wolfssl_tcp_server

Hardware Layout

MRF24WN0MA Wi-Fi PICtail/PICtail Plus Daughter Board

Provides information on the MRF24WN0MA Wi-Fi PICtail/PICtail Plus Daughter Board.

Description

Microchip Part Number:

AC164153

Microchip Product Page:

http://www.microchip.com/Developmenttools/ProductDetails.aspx?PartNO=AC164153

Available Demonstrations

Feature	Demonstrations
TCP/IP	• pic32_eth_wifi_web_server • wifi_easy_configuration

Hardware Layout

Multimedia Expansion Board (MEB)

Provides information on the Multimedia Expansion Board (MEB).

Description

Microchip Part Number:

DM320005

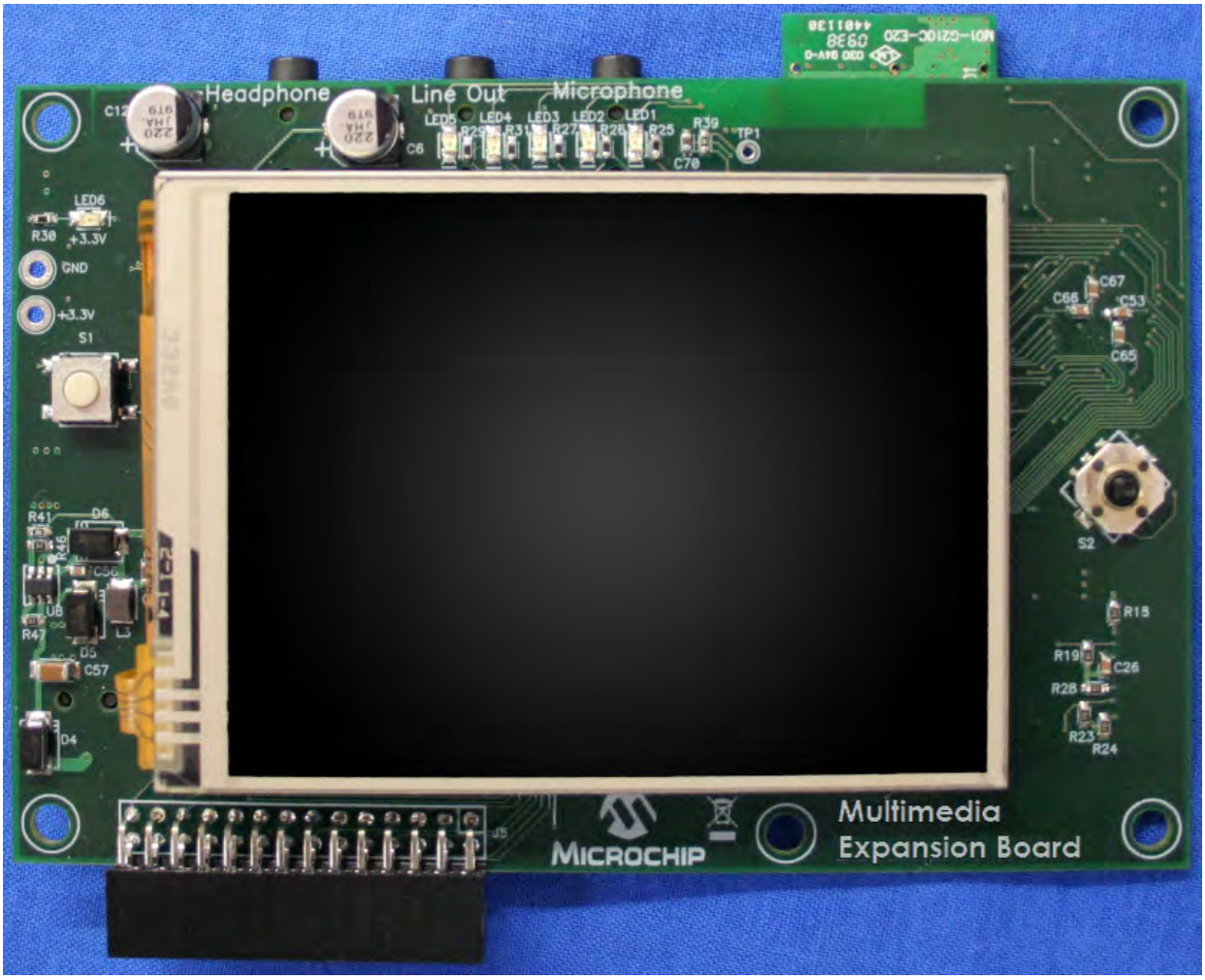
Product Page:

http://www.microchip.com/Developmenttools/ProductDetails.aspx?PartNO=DM320005

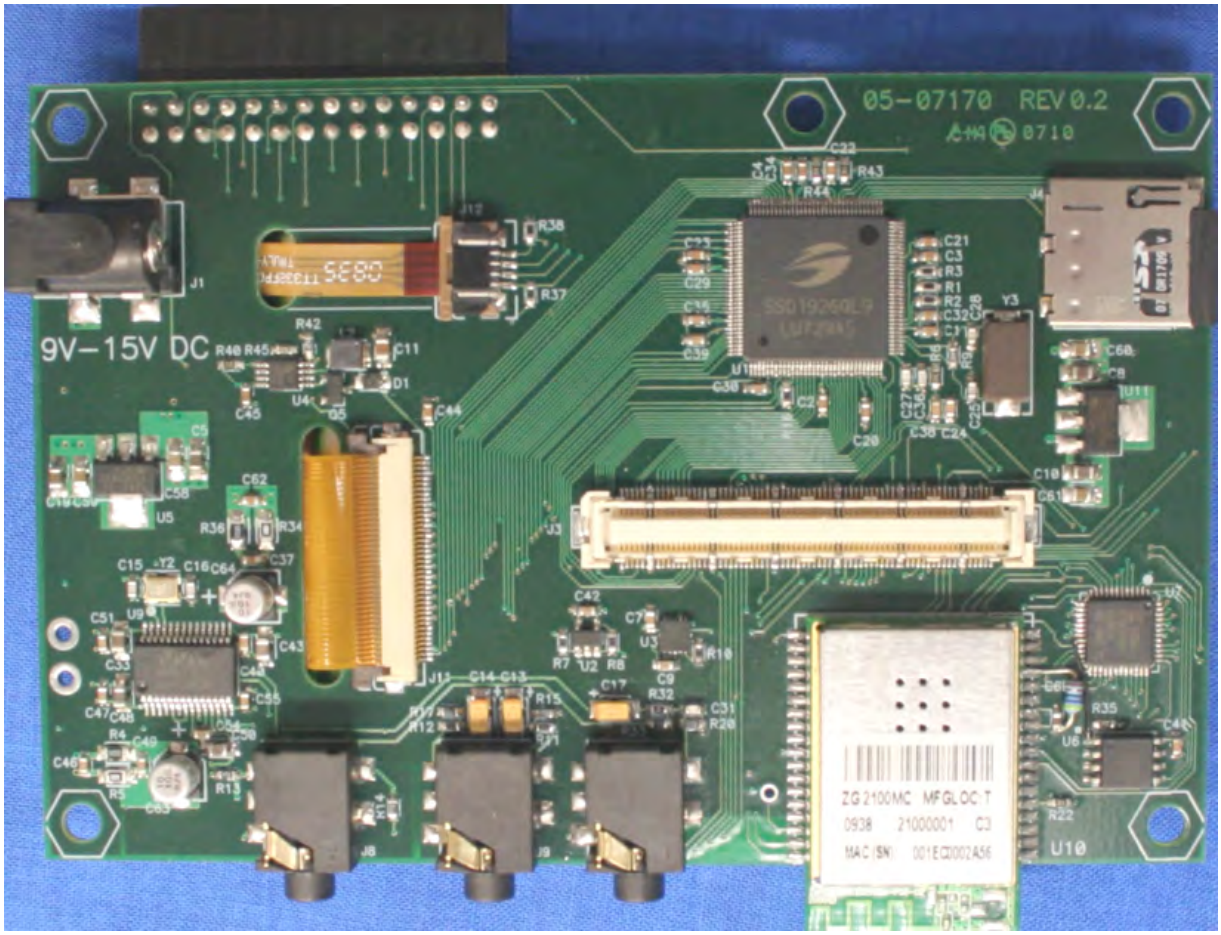
Available Demonstrations

Feature	Demonstrations
Graphics	• primitive

Hardware Layout (Front)



Hardware Layout (Back)



Multimedia Expansion Board II (MEB II)

Provides information on the Multimedia Expansion Board II (MEB II).

Description

Microchip Part Number

DM320005-2

Product Page

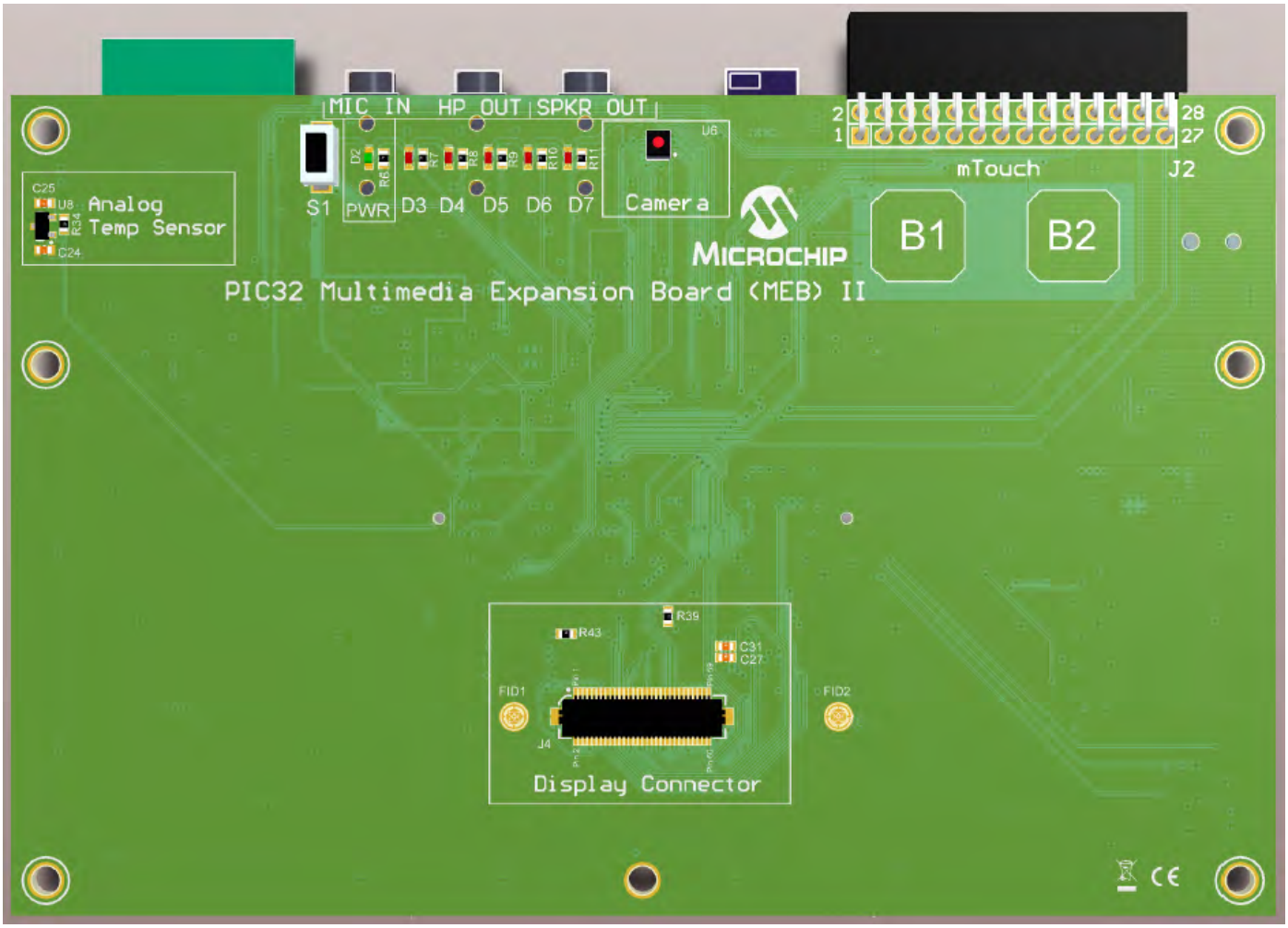
http://www.microchip.com/DevelopmentTools/ProductDetails.aspx?PartNO=dm320005-2

Available Demonstrations

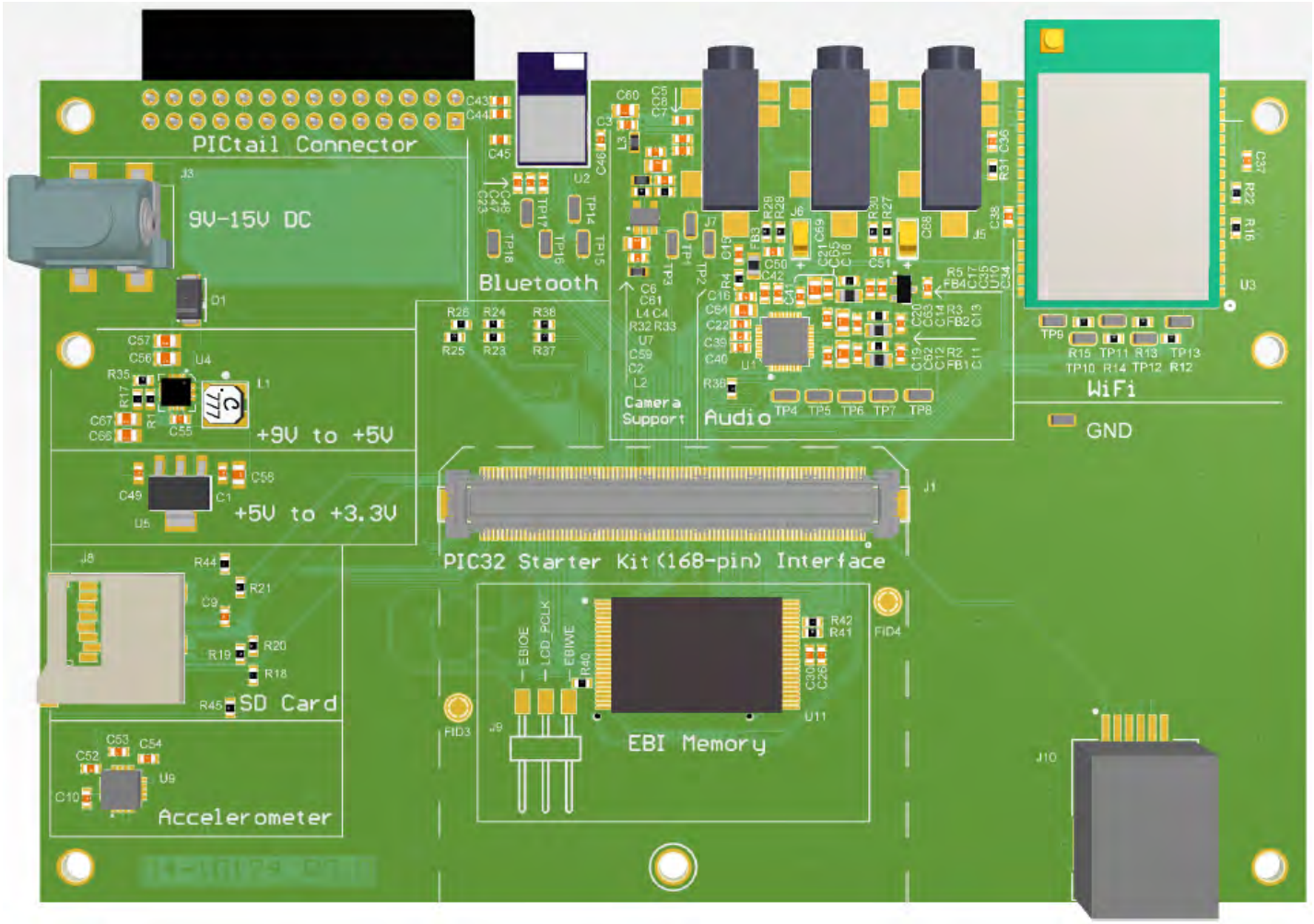
Feature	Demonstrations
Audio	• audio_tone
Bluetooth	• a2dp_avrcp • data_basic
Crypto	• large_hash
External Memory Programmer	• sqi_flash
Graphics	• lcc • object • primitive
MEB II	• gfx_cdc_com_port_single • gfx_photo_frame • gfx_web_server_nvm_mpfs
TCP/IP	• web_server_nvm_mpfs

USB Device	• audio_speaker • msd_sdcard

Hardware Layout (Front)



Hardware Layout (Back)



PIC32 Audio DAC Daughter Board

Provides information on the PIC32 Audio DAC Daughter Board (AK4384VT).

Description

Microchip Part Number:

AC320032-2

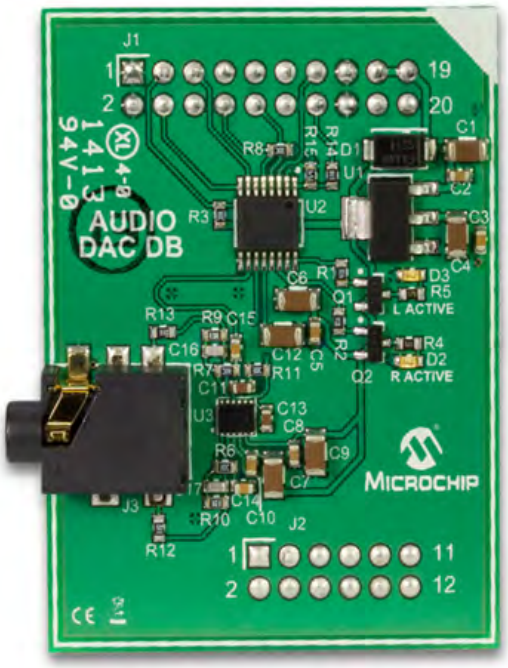
Product Page:

http://www.microchip.com/Developmenttools/ProductDetails.aspx?PartNO=AC320032-2

Available Demonstrations

Feature	Demonstrations
Audio	• audio_tone • mac_audio_hi_res • usb_headset • universal_audio_decoders

Hardware Layout



PIC32 Bluetooth Audio Development Kit

Provides information on the PIC32 Bluetooth Audio Development Kit.

Description

Microchip Part Number:

DV320032

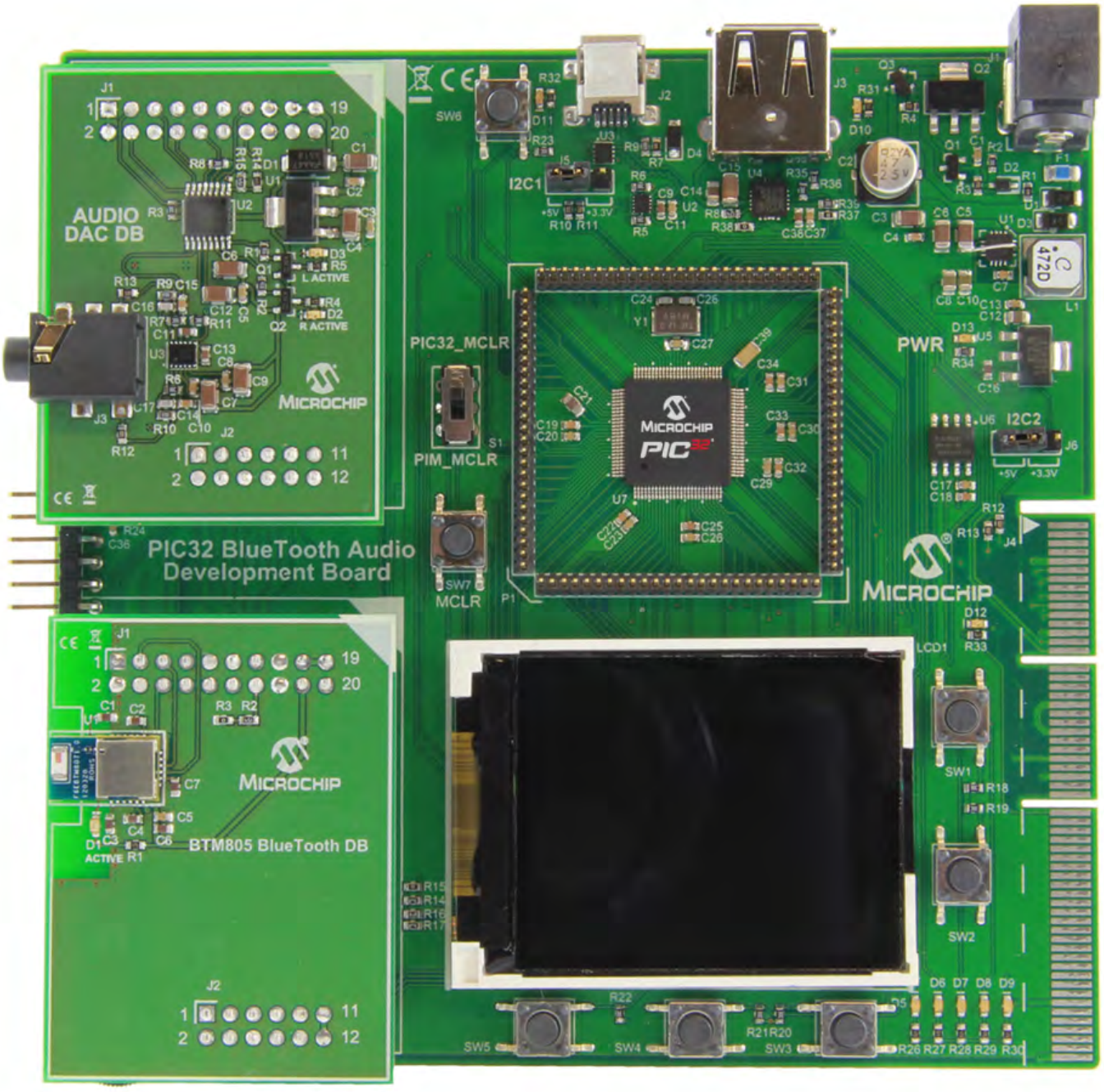
Product Page:

http://www.microchip.com/Developmenttools/ProductDetails.aspx?PartNO=DV320032

Available Demonstrations

Feature	Demonstrations
Audio	• audio_microphone_loopback • audio_tone • mac_audio_hi_res • usb_headset • universal_audio_decoders
Bluetooth	• 2dp_avrcp • data_basic
Graphics	• primitive

Hardware Layout



PIC32 Bluetooth Starter Kit

Provides information on the PIC32 Bluetooth Starter Kit.

Description

Microchip Part Number:

DM320018

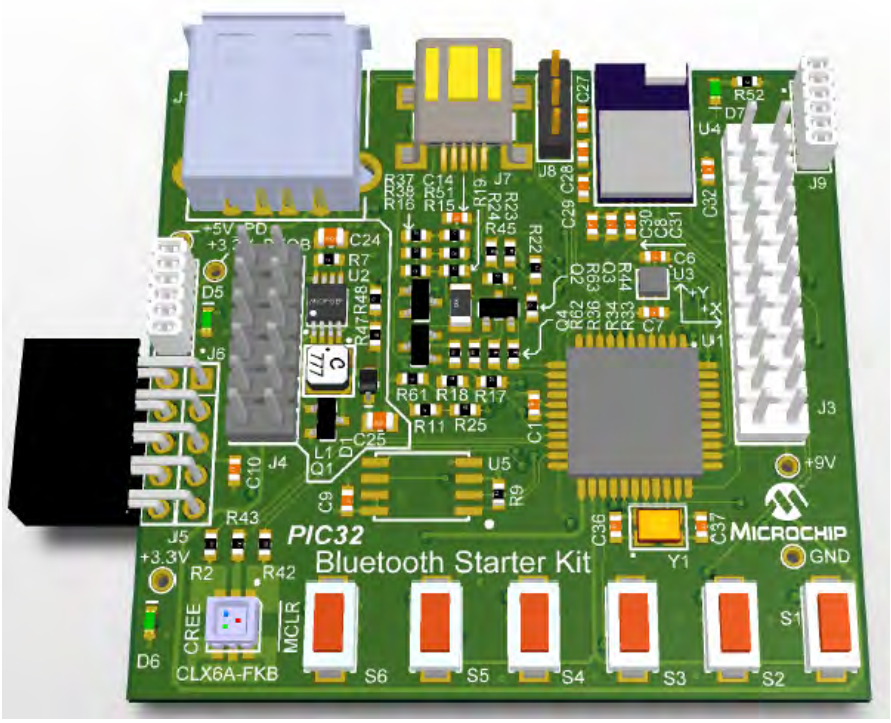
Product Page:

http://www.microchip.com/Developmenttools/ProductDetails.aspx?PartNO=DM320018

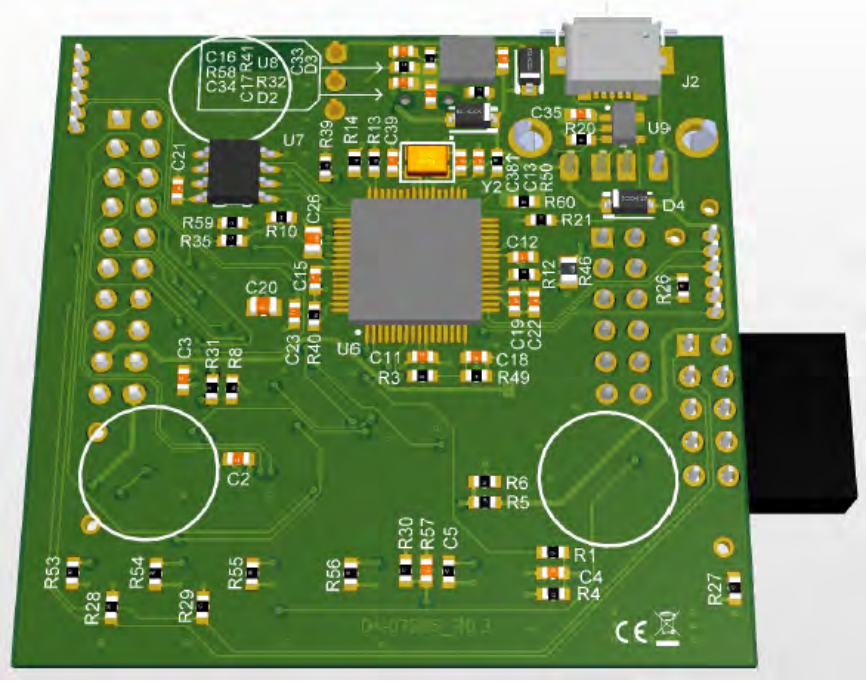
Available Demonstrations

Feature	Demonstrations
Audio	• universal_audio_decoders • usb_headset
Bluetooth	• a2dp_avrcp • data_basic • data_temp_sens_rgb
File System	• nvm_fat_single_disk • nvm_mpfs_single_disk
Graphics	• primitive
USB Device	• cdc_com_port_dual • msd_basic

Hardware Layout (Front)



Hardware Layout (Back)



PIC32 Ethernet Starter Kit

Provides information on the PIC32 Ethernet Starter Kit.

Description

Microchip Part Number:

DM320004

Product Page:

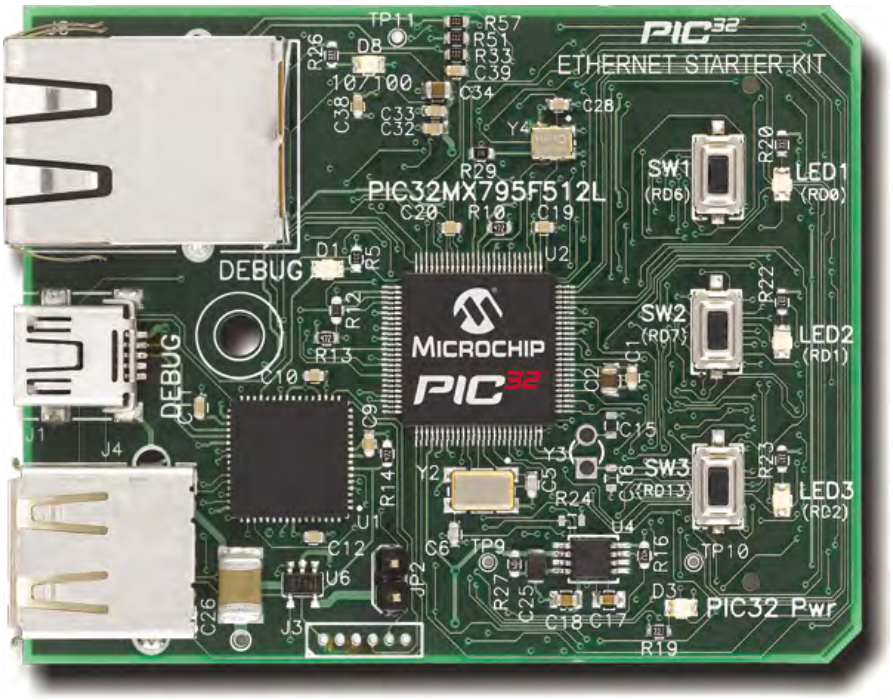
http://www.microchip.com/DevelopmentTools/ProductDetails.aspx?PartNO=dm320004

Available Demonstrations

Feature	Demonstrations
RTOS	• basic (FreeRTOS) • basic (OPENRTOS) • basic (ThreadX)

TCP/IP	• berkeley_tcp_client • berkeley_tcp_server • berkeley_udp_client • berkeley_udp_relay • berkeley_udp_server • snmpv3_nvm_mpfs • snmpv3_sdcard_fatfs • tcpip_tcp_client • tcpip_tcp_client_server • tcpip_tcp_server • tcpip_udp_client • tcpip_udp_client_server • tcpip_udp_server • web_server_nvm_mpfs • web_server_sdcard_fatfs • wifi_easy_configuration • wifi_wolfssl_tcp_client • wolfssl_tcp_client • wolfssl_tcp_server

Hardware Layout



PIC32 Ethernet Starter Kit II

Provides information on the PIC32 Ethernet Starter Kit II.

Description

Microchip Part Number:

DM320004-2

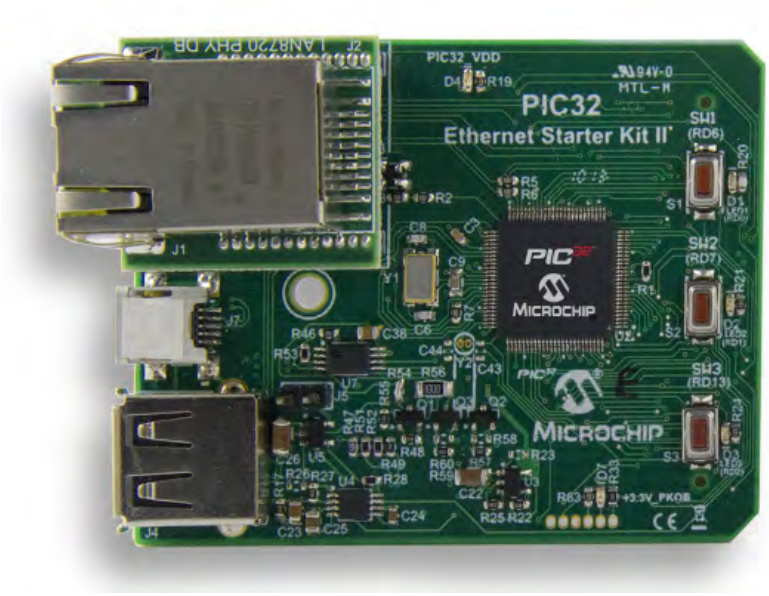
Product Page:

http://www.microchip.com/DevelopmentTools/ProductDetails.aspx?PartNO=DM320004-2

Available Demonstrations

Feature	Demonstrations
RTOS	• basic (FreeRTOS) • basic (OPENRTOS) • basic (ThreadX)
TCP/IP	• berkeley_tcp_client • berkeley_tcp_server • berkeley_udp_client • berkeley_udp_relay • berkeley_udp_server • tcpip_tcp_client • tcpip_tcp_client_server • tcpip_tcp_server • tcpip_udp_client • tcpip_udp_client_server • tcpip_udp_server • web_server_nvm_mpfs • web_server_sdcard_fatfs • wifi_easy_configuration • wolfssl_tcp_client • wolfssl_tcp_server

Hardware Layout



PIC32 GUI Development Board with Projected Capacitive Touch

Provides information on the PIC32 GUI Development Board with Projected Capacitive Touch.

Description

Microchip Part Number:

DM320015

Product Page:

http://www.microchip.com/DevelopmentTools/ProductDetails.aspx?PartNO=dm320015

Available Demonstrations

Feature	Demonstrations
Graphics	• lcc

Hardware Layout

PIC32 USB Digital Audio Accessory Board

Provides information on the PIC32 USB Digital Audio Board.

Description

Microchip Part Number:

DM320014

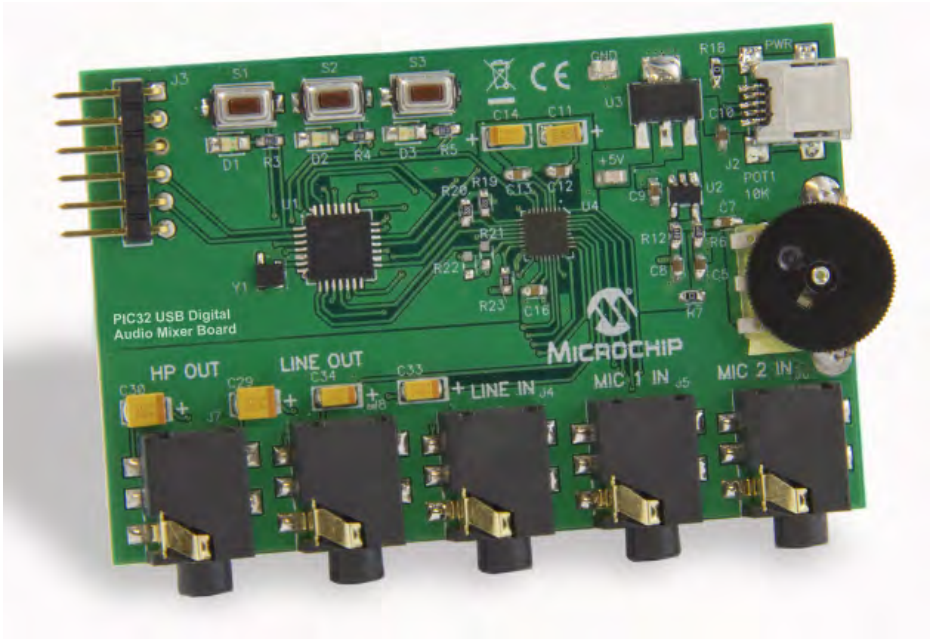
microchipDIRECT Product Page:

http://www.microchip.com/DevelopmentTools/ProductDetails.aspx?PartNO=dm320014

Available Demonstrations

Feature	Demonstrations
Audio	• audio_tone

Hardware Layout



PIC32 USB Starter Kit II

Provides information on the PIC32 USB Starter Kit II.

Description

Microchip Part Number:

DM320003-2

Product Page:

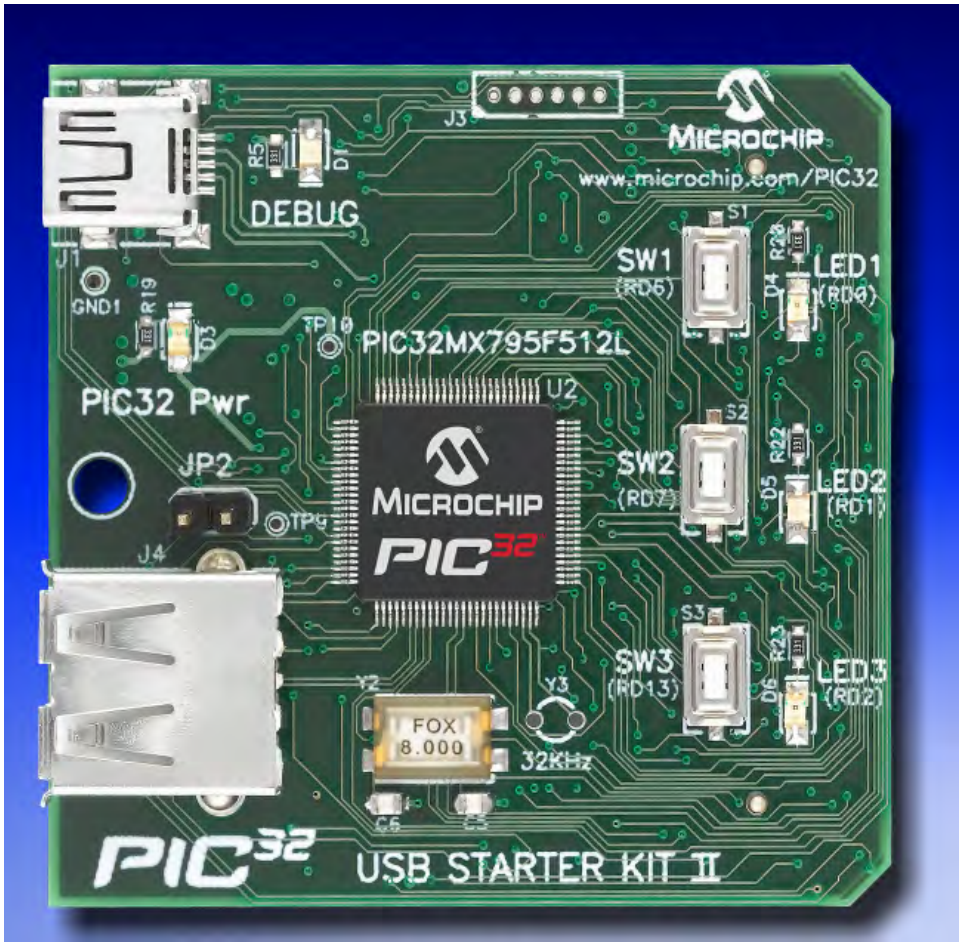
http://www.microchip.com/DevelopmentTools/ProductDetails.aspx?PartNO=dm320003-2

Available Demonstrations

Feature	Demonstrations
Drivers	• nvm_read_write
External Memory Programmer	• external_flash
File System	• nvm_fat_single_disk • nvm_mpfs_single_disk
FreeRTOS	• basic • cdc_com_port_dual • cdc_msd_basic • gfx
Graphics	• lcc • object • primitive • s1d13517 • ssd1926
OPENRTOS	• basic • gfx • cdc_com_port_dual • cdc_msd_basic
Micrium	Micriμm μC/OS-II • basic Micriμm μC/OS-III • gfx • gfx_usb • usb
SEGGER embOS	• gfx • gfx_usb • usb
System Services	• command_appio • debug_usb_cdc_2
ThreadX	• basic • gfx • gfx_usb • usb

TCP/IP	• berkeley_tcp_client • berkeley_tcp_server • berkeley_udp_client • berkeley_udp_relay • berkeley_udp_server • tcpip_tcp_client • tcpip_tcp_client_server • tcpip_tcp_server • tcpip_udp_client • tcpip_udp_client_server • tcpip_udp_server • web_server_nvm_mpfs • wifi_easy_configuration • wolfssl_tcp_client • wolfssl_tcp_server
Peripheral Library Example Applications	• echo_send • ic_basic • i2c_eeprom_rw • oc_pwm • osc_config • spi_loopback • timer3_interrupt • uart_basic • usart_loopback • wdt_timeout
USB	• cdc_com_port_dual • cdc_com_port_single • cdc_basic • cdc_msd_basic • cdc_msd • hid_basic • hid_msd_basic • hid_joystick • hid_keyboard • hid_mouse • msd_basic • msd_basic (Host) • vendor

Hardware Layout



PIC32 USB Starter Kit III

Provides information on the PIC32 USB Starter Kit III.

Description

Microchip Part Number:

DM320003-2

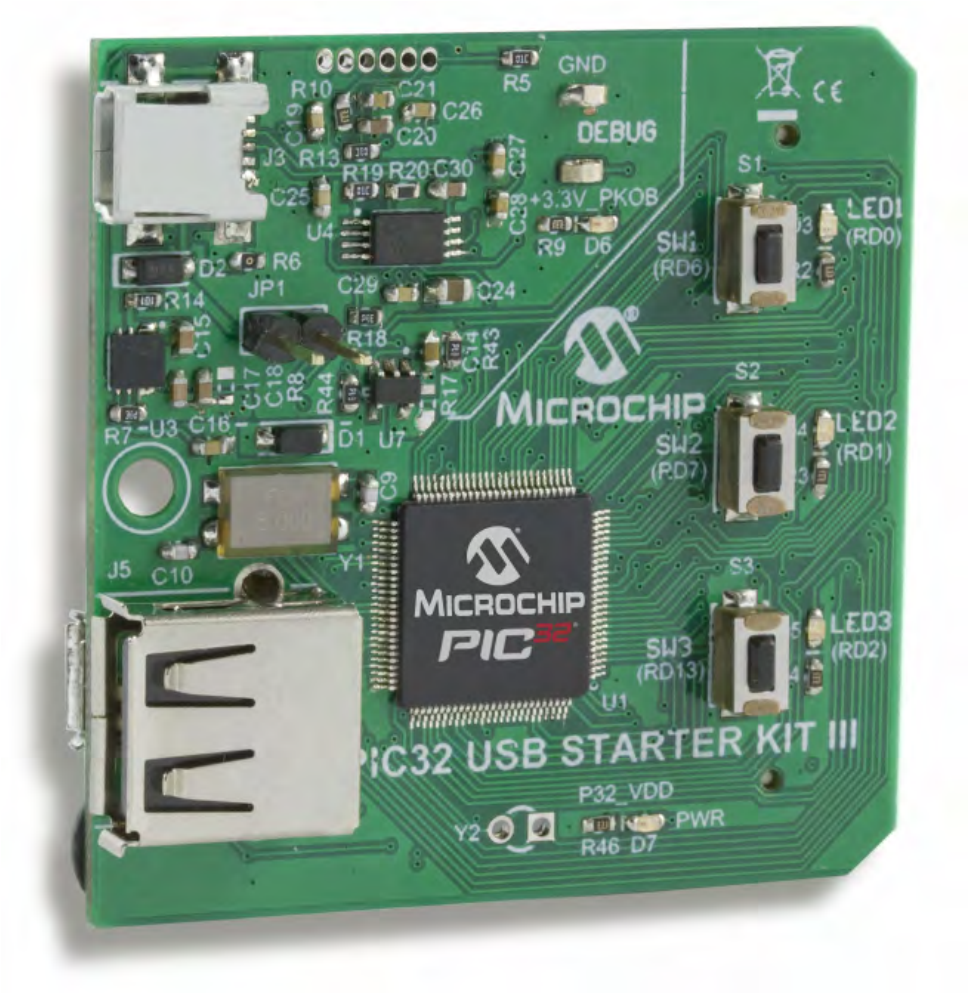
Product Page:

http://www.microchip.com/Developmenttools/ProductDetails.aspx?PartNO=DM320003-3

Available Demonstrations

Feature	Demonstrations
File System	• nvm_fat_single_disk • nvm_mpfs_single_disk
RTOS	• basic (FreeRTOS) • basic (OPENRTOS) • basic (ThreadX)
USB	• cdc_basic • cdc_com_port_dual • cdc_com_port_single • hid_basic • hid_joystick • hid_keyboard • hid_mouse • msd_basic • vendor

Hardware Layout



PIC32MX1/2/5 Starter Kit

Provides information on the PIC32MX1/2/5 Starter Kit.

Description

Microchip Part Number:

DM320100

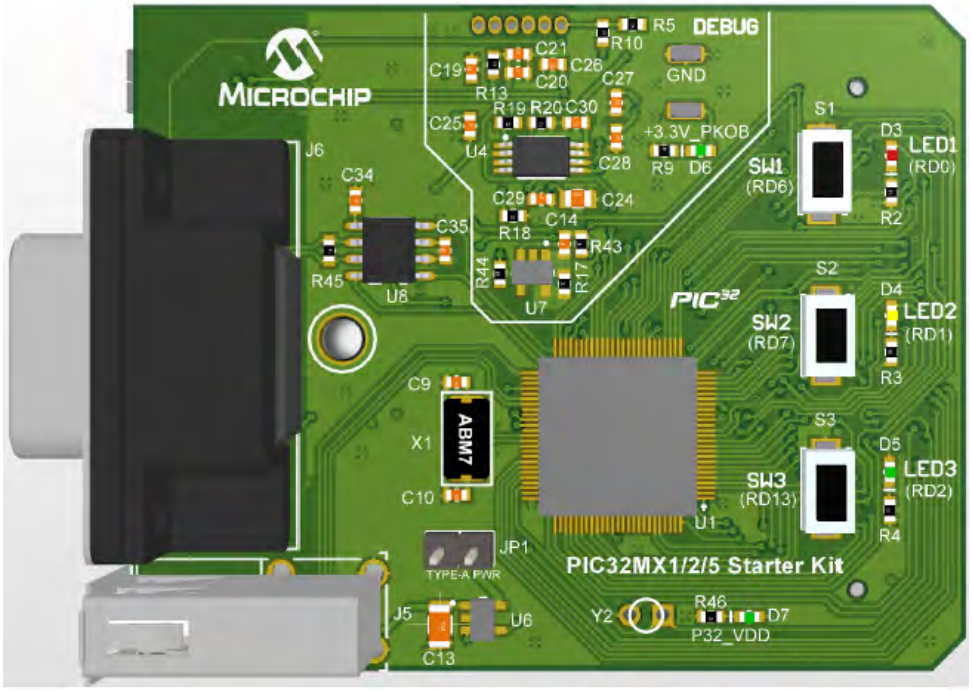
Product Page:

http://www.microchip.com/Developmenttools/ProductDetails.aspx?PartNO=DM320100

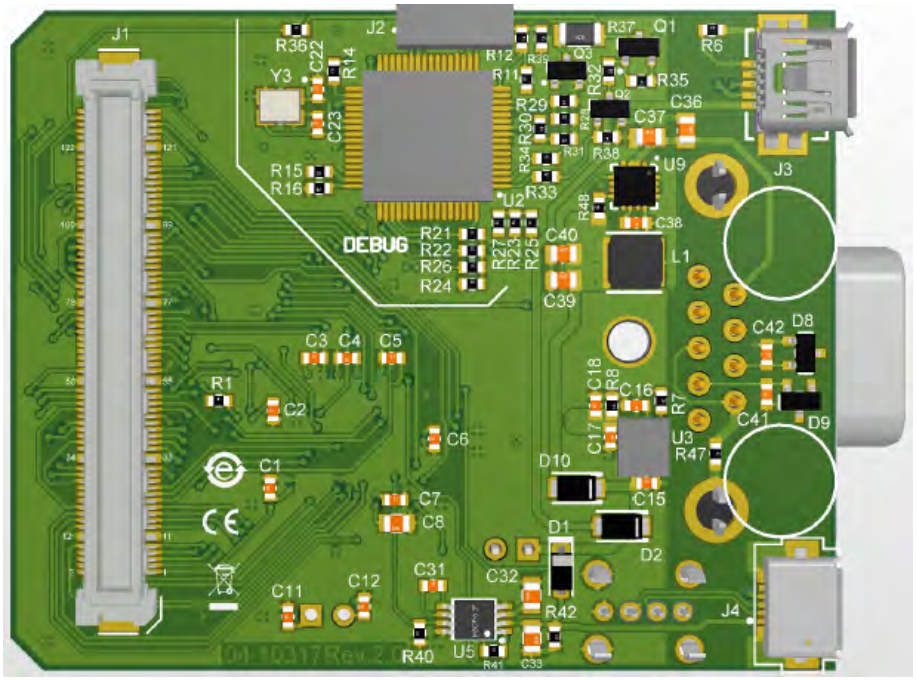
Available Demonstrations

Feature	Demonstrations
CAN	echo_send
USB Device	cdc_com_port_single

Hardware Layout (Front)



Hardware Layout (Back)



PIC32MX270F256D Plug-in Module (PIM)

Provides information on the PIC32MX270F256D Plug-in Module (PIM).

Description

Two PIC32MX270F256D PIMs are available, one for use with the PIC32 Bluetooth Audio Development Kit, and one for use with the Explorer 16 Development Board.

Microchip Part Number:

MA320013

This PIM is required while using the PIC32 Bluetooth Audio Development Kit

microchipDIRECT Product Page:

http://www.microchip.com/Developmenttools/ProductDetails.aspx?PartNO=MA320013

Available Demonstrations

Feature	Demonstrations
USB Device	• cdc_com_port_dual • msd_basic

Hardware Layout

Microchip Part Number:

MA320014

This PIM is required while using the Explorer 16 Development Board.

microchipDIRECT Product Page:

http://www.microchip.com/DevelopmentTools/ProductDetails.aspx?PartNO=MA320014

PIC32MX270F512L Plug-in Module (PIM)

Provides information on the PIC32MX270F512L Plug-in Module (PIM).

Description

Microchip Part Number:

MA320017

This PIM is for use with the PIC32 Bluetooth Audio Development Kit.

microchipDIRECT Product Page:

http://www.microchip.com/Developmenttools/ProductDetails.aspx?PartNO=MA320017

Available Demonstrations

Feature	Demonstrations
Audio	• universal_audio_decoders • usb_headset

Hardware Layout

PIC32MX360F512L Plug-in Module (PIM)

Provides information on the PIC32MX360F512L Plug-in Module (PIM).

Description

Microchip Part Number:

MA320001

microchipDIRECT Product Page:

http://www.microchip.com/Developmenttools/ProductDetails.aspx?PartNO=MA320001

Available Demonstrations

Feature	Demonstrations
SPI Driver	• spi_eeprom

Hardware Layout

PIC32MX460F512L Plug-in Module (PIM)

Provides information on the PIC32MX460F512L Plug-in Module (PIM).

Description

Microchip Part Number:

MA320002

microchipDIRECT Product Page:

http://www.microchip.com/Developmenttools/ProductDetails.aspx?PartNO=MA320002

Available Demonstrations

Feature	Demonstrations
USB Device	• cdc_com_port_dual • cdc_com_port_single • hid_basic • hid_joystick • hid_keyboard • hid_mouse • vendor

Hardware Layout

PIC32MX450/470F512L Plug-in Module (PIM)

Provides information on the PIC32MX450/470F512L Plug-in Module (PIM).

Description

Microchip Part Number:

MA320002-2

microchipDIRECT Product Page:

http://www.microchipdirect.com/ProductSearch.aspx?Keywords=MA320002-2

Available Demonstrations

Feature	Demonstrations
File System	• nvm_sdcard_fat_mpfs_multi_disk • sdcard_fat_single_disk

Hardware Layout

PIC32MX470 Curiosity Development Board

Provides information on the PIC32MX470 Curiosity Development Board.

Description

Microchip Part Numbers:

DM320103

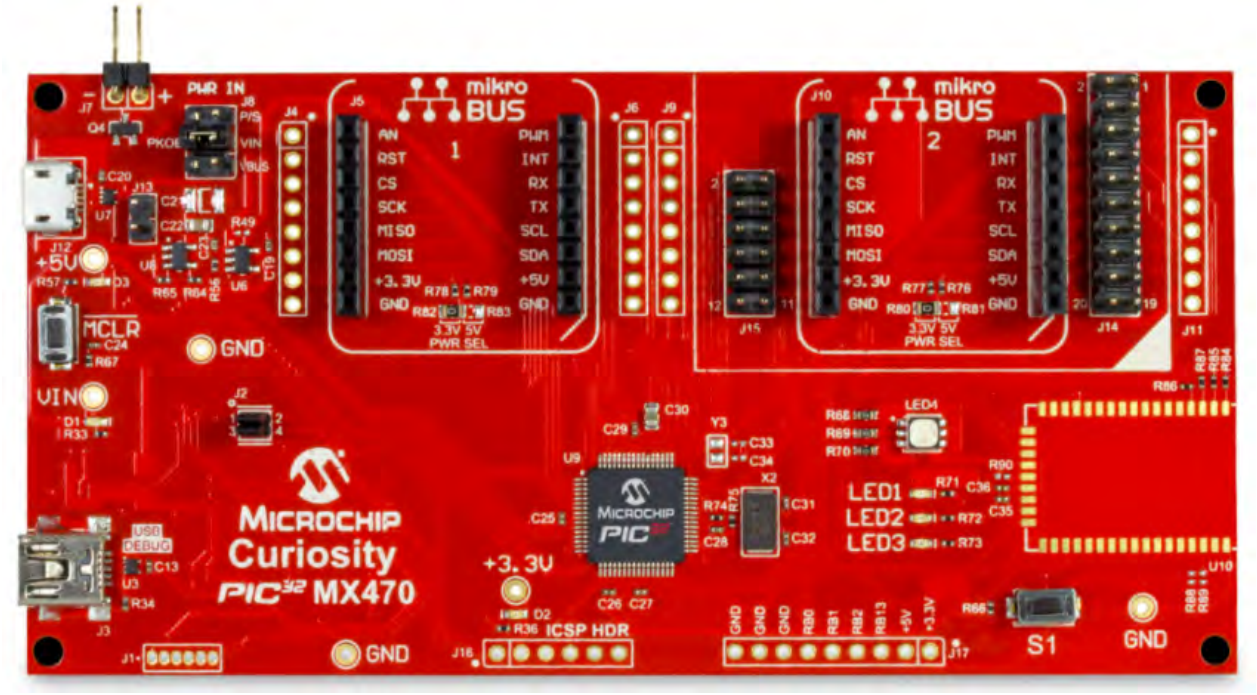
Microchip Product Pages:

http://www.microchip.com/Developmenttools/ProductDetails.aspx?PartNO=DM320103

Available Demonstrations

Feature	Demonstrations
USB Device	cdc_com_port_dual
USB Host	msd_basic

Hardware Layout



PIC32MX570F512L Plug-in Module (PIM)

Provides information on the PIC32MX570F512L Plug-in Module (PIM).

Description

Microchip Part Number:

MA320015

microchipDIRECT Product Page:

http://www.microchipdirect.com/ProductSearch.aspx?Keywords=MA320015

Available Demonstrations

Feature	Demonstrations
File System	• nvm_sdcard_fat_mpfs_multi_disk • nvm_sdcard_fat_multi_disk • sdcard_fat_single_disk

Hardware Layout

PIC32MX795F512L Plug-in Module (PIM)

Provides information on the PIC32MX795F512L Plug-in Module (PIM).

Description

This PIM is required while using the Explorer 16 Development Board.

Microchip Part Number:

MA320003

microchipDIRECT Product Page:

http://www.microchipdirect.com/productsearch.aspx?keywords=MA320003

Available Demonstrations

Feature	Demonstrations
Crypto	• encrypt_decrypt
Drivers	• i2c_eeprom • i2c_eeprom_rw • i2c_loopback • serial_eeprom • spi_loopback • uart_basic • usart_echo • usart_loopback
File System	• nvm_sdcard_fat_mpfs_multi_disk • sdcard_fat_single_disk
Peripheral Library Example Applications	• adc_pot • mem_partition • simple_comparator • triangle_wave • dma_led_pattern • flash_modify • pmp_lcd • rtcc_alarm • timer3_interrupt • wdt_timeout
System Services	• debug_uart
Test	• harness
TCP/IP	• web_server_nvm_mpfs • wifi_easy_configuration
USB	• cdc_serial_emulator • cdc_serial_emulator_msd

Hardware Layout

PIC32MZ2048ECH100 Plug-in Module (PIM)

Provides information on the PIC32MZ2048ECH100 Plug-in Module (PIM).

Description

Microchip Part Number:

MA320012

microchipDIRECT Product Page:

http://www.microchipdirect.com/productsearch.aspx?keywords=MA320012

Available Demonstrations

Feature	Demonstrations
Peripheral Library Examples	• adcp_cal • triangle_wave
System Services	• debug_uart

Hardware Layout

PIC32MZ2048EFH100 Plug-in Module (PIM)

Provides information on the PIC32MZ2048EFH100 Plug-in Module (PIM).

Description

Microchip Part Number:

MA320019

Microchip Product Page:

http://www.microchip.com

Available Demonstrations

Feature	Demonstrations
Peripheral Library Examples	• triangle_wave

Hardware Layout

PIC32MZ2048ECH144 Audio Plug-in Module (PIM)

Provides information on the PIC32MZ2048ECH144 Audio Plug-in Module (PIM).

Description

Microchip Part Number:

MA320016

microchipDIRECT Product Page:

http://www.microchipdirect.com/productsearch.aspx?keywords=MA320016

Available Demonstrations

Feature	Demonstrations
Audio Demonstrations	• audio_tone • mac_audio_hi_res

Hardware Layout

PIC32MZ2048EFH144 Audio Plug-in Module (PIM)

Provides information on the PIC32MZ2048EFH144 Audio Plug-in Module (PIM).

Description

Microchip Part Number:

MA320018

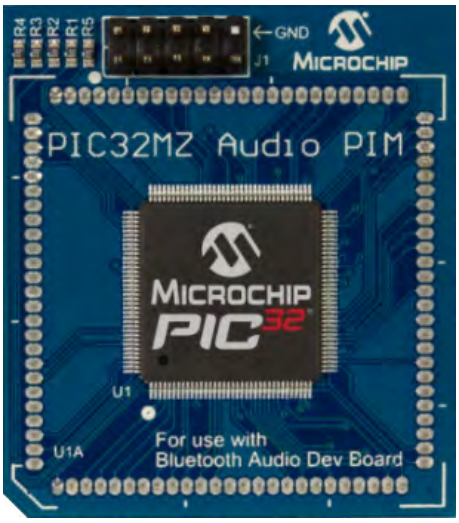
microchipDIRECT Product Page:

http://www.microchipdirect.com/productsearch.aspx?keywords=MA320018

Available Demonstrations

Feature	Demonstrations
Audio Demonstrations	• audio_tone • mac_audio_hi_res

Hardware Layout



PIC32MZ Audio PIM

Provides information on the PIC32MZ Audio PIM.

Description

Microchip Part Number:

MA320016

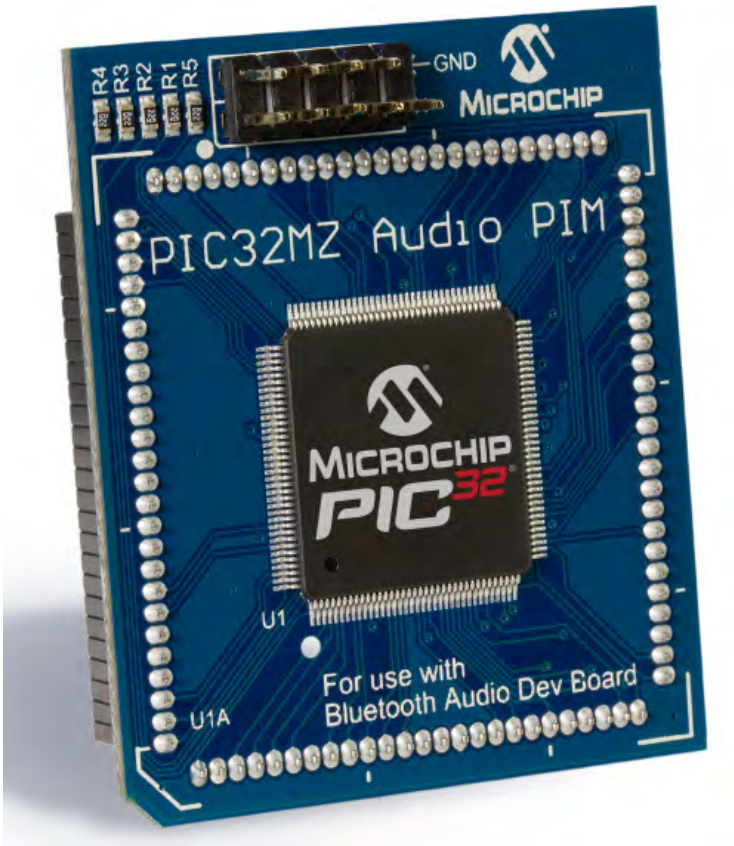
Microchip Product Page:

http://www.microchip.com/Developmenttools/ProductDetails.aspx?PartNO=MA320016

Available Demonstrations

Feature	Demonstrations
Audio	• mac_audio_hi_res • universal_audio_decoders • usb_headset

Hardware Layout



PIC32MZ EF Curiosity Development Board

Provides information on the PIC32MZ EF Curiosity Development Board.

Description

Microchip Part Numbers:

DM320104

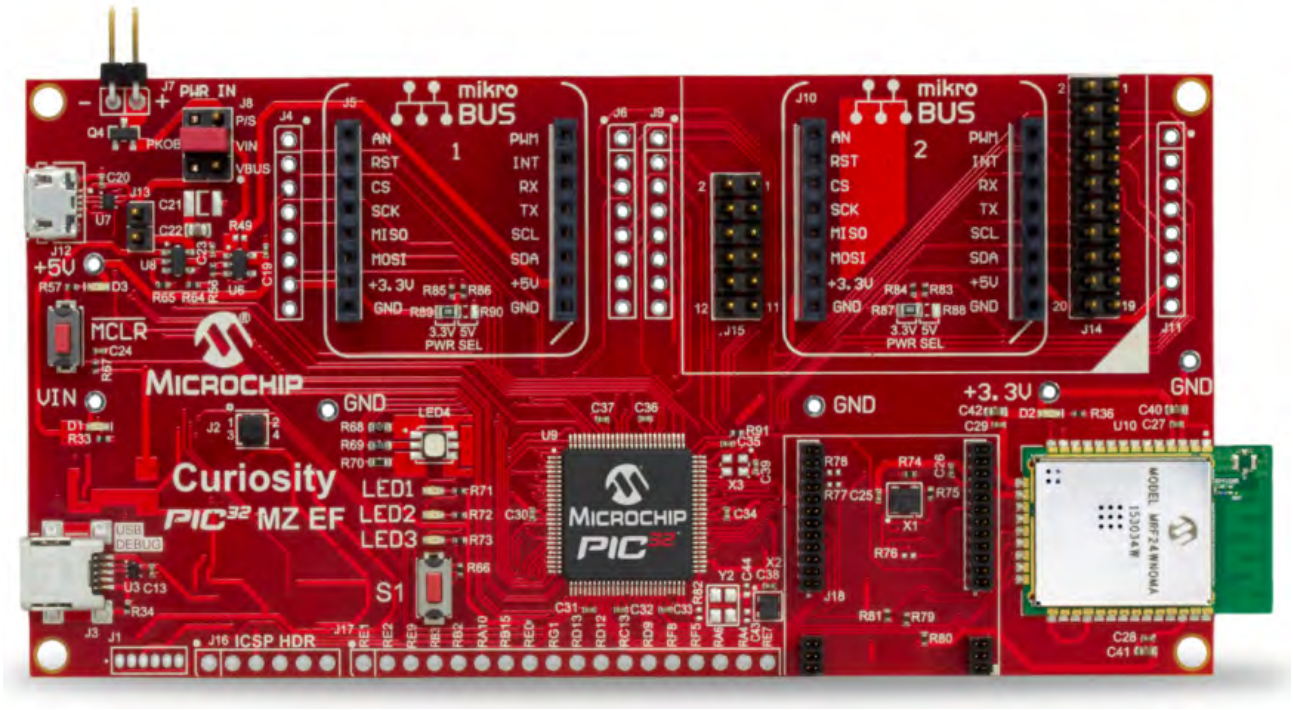
Microchip Product Pages:

http://www.microchip.com/Developmenttools/ProductDetails.aspx?PartNO=DM320104

Available Demonstrations

Feature	Demonstrations
USB Device	cdc_com_port_dual
USB Host	msd_basic

Hardware Layout



PIC32MZ Embedded Connectivity (EC) Starter Kit

Provides information on the PIC32MZ Embedded Connectivity (EC) Starter Kit.

Description

Microchip Part Numbers:

DM320006

DM320006-C (with Crypto Engine)

Microchip Product Pages:

http://www.microchip.com/Developmenttools/ProductDetails.aspx?PartNO=DM320006

http://www.microchip.com/Developmenttools/ProductDetails.aspx?PartNO=DM320006-C

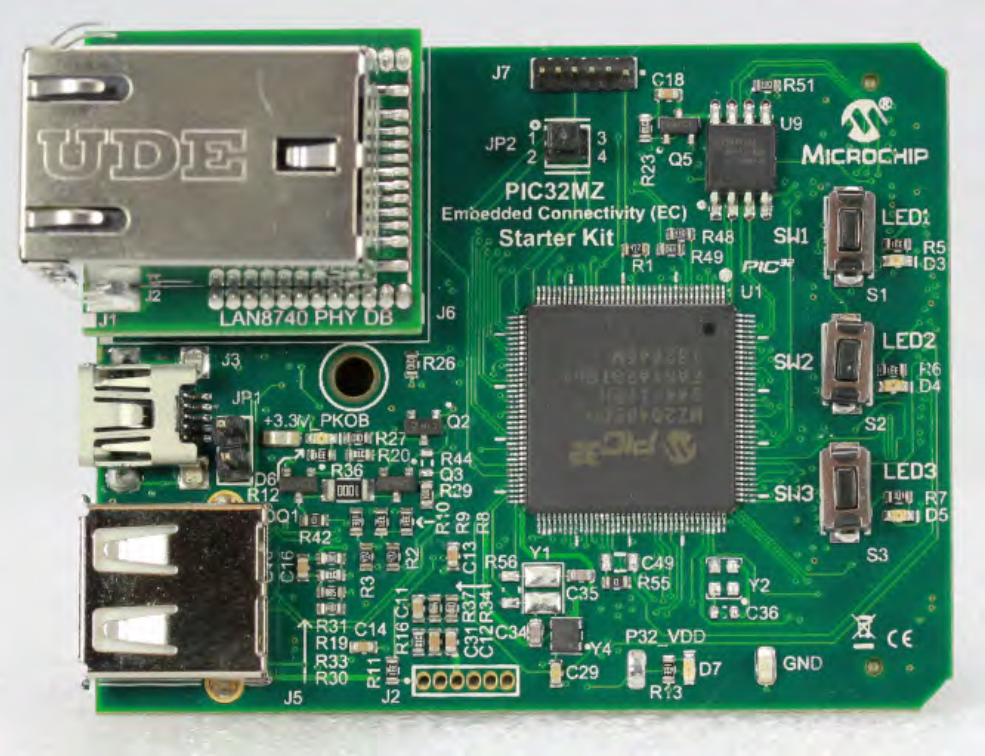
Available Demonstrations

Feature	Demonstrations
Audio	• audio_tone • universal_audio_decoders • usb_headset
Bluetooth	• data_basic • a2dp_avrcp
Bootloader	• basic • LiveUpdate_application • LiveUpdate
Crypto	• encrypt_decrypt • large_hash
Drivers	• i2c_eeprom • nvm_read_write • spi_loopback • spi_multislave • usart_loopback

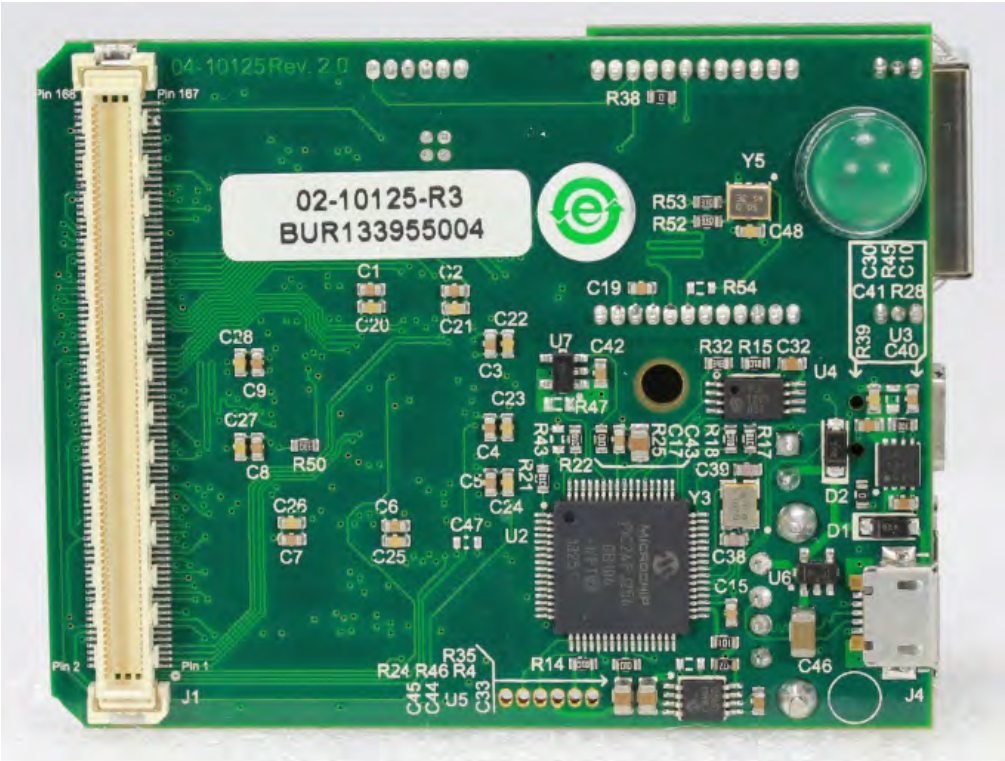
File System	• nvm_fat_single_disk • nvm_mpfs_single_disk • nvm_sdcard_fat_mpfs_multi_disk • nvm_sdcard_fat_multi_disk • sdcard_fat_single_disk • sdcard_msd_fat_multi_disk
Graphics	• lcc • object • primitive
MEB II	• gfx_cdc_com_port_single • gfx_photo_frame • gfx_web_server_nvm_mpfs • segger_emwin
Peripheral Library Examples	• echo_send • dma_led_pattern • sram_read_write • flash_modify • oc_pwm • osc_config • blinky_leds • sleep_mode • reset_handler • rtcc_alarm • spi_loopback • flash_read_pio_mode • flash_read_dma_mode • timer3_interrupt • uart_basic • wdt_timeout
RTOS	ThreadX: • gfx • gfx_usb • usb FreeRTOS: • basic • cdc_com_port_dual • gfx Micriμm μC/OS-II • basic Micriμm μC/OS-III • basic • gfx • gfx_usb • usb OPENRTOS: • basic • cdc_com_port_dual • gfx SEGGER embOS: • basic • gfx • gfx_usb • usb
System Service Examples	• debug_usb_cdc_2 • devcon_cache_clean • devcon_sys_config_perf

TCP/IP	• berkeley_tcp_client • berkeley_tcp_server • berkeley_udp_client • berkeley_udp_relay • berkeley_udp_server • snmpv3_nvm_mpfs • snmpv3_sdcard_fatfs • tcpip_tcp_client • tcpip_tcp_client_server • tcpip_tcp_server • tcpip_udp_client • tcpip_udp_client_server • tcpip_udp_server • web_server_nvm_mpfs • web_server_sdcard_fatfs • wifi_wolfssl_tcp_client • wifi_easy_configuration • wolfssl_tcp_client • wolfssl_tcp_server
USB Device	• audio_speaker • cdc_com_port_dual • cdc_com_port_single • cdc_msd_basic • hid_basic • hid_joystick • hid_keyboard • hid_mouse • hid_msd_basic • msd_basic • vendor
USB Host	• cdc_basic • cdc_msd • hid_basic_mouse • msd_basic • msd_sdcard

Hardware Layout (Front)



Hardware Layout (Back)



PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit

Provides information on the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit.

Description

Microchip Part Numbers:

DM320007 (without Crypto)

DM320007-C (with Crypto)

Microchip Product Page:

http://www.microchip.com/Developmenttools/ProductDetails.aspx?PartNO=DM320007

http://www.microchip.com/Developmenttools/ProductDetails.aspx?PartNO=DM320007-C

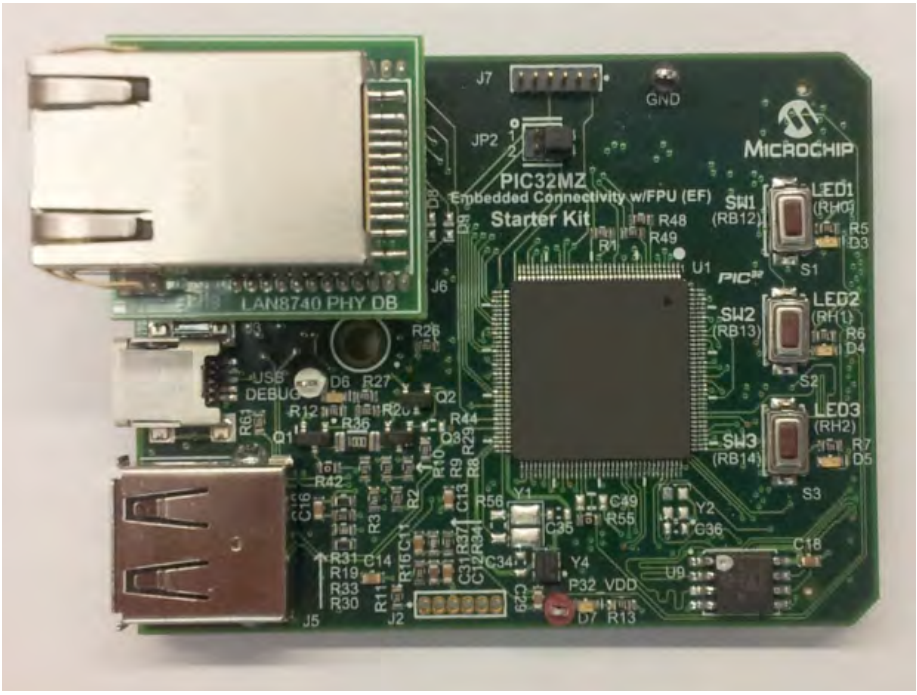
Available Demonstrations

Feature	Demonstrations
Audio	• audio_tone • universal_audio_decoders • usb_headset
Bluetooth	• data_basic • a2dp_avrcp
Bootloader	• basic • LiveUpdate_application • LiveUpdate
Crypto	• encrypt_decrypt • large_hash
Drivers	• i2c_rtcc • nvm_read_write • spi_loopback • spi_multislave • usart_loopback
External Memory Programmer	• sqi_flash
File System	• nvm_fat_single_disk • nvm_mpfs_single_disk • nvm_sdcard_fat_mpfs_multi_disk • nvm_sdcard_fat_multi_disk • sdcard_fat_single_disk • sdcard_msd_fat_multi_disk
Graphics	• lcc • object • primitive
MEB II	• gfx_cdc_com_port_single • gfx_photo_frame • gfx_web_server_nvm_mpfs • segger_emwin
Peripheral Library Examples	• echo_send • dma_led_pattern • sram_read_write • flash_modify • oc_pwm • osc_config • blinky_leds • sleep_mode • reset_handler • rtcc_alarm • spi_loopback • flash_read_pio_mode • flash_read_dma_mode • timer3_interrupt • uart_basic • wdt_timeout

RTOS	ThreadX: • gfx • gfx_usb • usb FreeRTOS: • basic • cdc_com_port_dual • gfx Micriμm μC/OS-II • basic Micriμm μC/OS-III • basic • gfx • gfx_usb • usb OPENRTOS: • basic • cdc_com_port_dual • gfx SEGGER embOS: • basic • gfx • gfx_usb • usb
System Service Examples	• debug_usb_cdc_2 • devcon_cache_clean • devcon_sys_config_perf
TCP/IP	• berkeley_tcp_client • berkeley_tcp_server • berkeley_udp_client • berkeley_udp_relay • berkeley_udp_server • snmpv3_nvm_mpfs • snmpv3_sdcard_fatfs • tcpip_tcp_client • tcpip_tcp_client_server • tcpip_tcp_server • tcpip_udp_client • tcpip_udp_client_server • tcpip_udp_server • web_server_nvm_mpfs • web_server_sdcard_fatfs • wifi_wolfssl_tcp_client • wifi_easy_configuration • wolfssl_tcp_client • wolfssl_tcp_server
USB Device	• audio_speaker • cdc_com_port_dual • cdc_com_port_single • cdc_msd_basic • hid_basic • hid_joystick • hid_keyboard • hid_mouse • hid_msd_basic • msd_basic • vendor

USB Host	• cdc_basic • cdc_msd • hid_basic_mouse • msd_basic

Hardware Layout



Note: The hardware layout is subject to change and my differ from the photograph provided.

PIC32MZ Graphics (DA) Starter Kit

Provides information on the PIC32MZ Graphics (DA) Starter Kit.

Description

Microchip Part Numbers:

DM320008 (without Crypto)

DM320008-C (with Crypto)

Microchip Product Page:

http://www.microchip.com/Developmenttools/ProductDetails.aspx?PartNO=DM320008

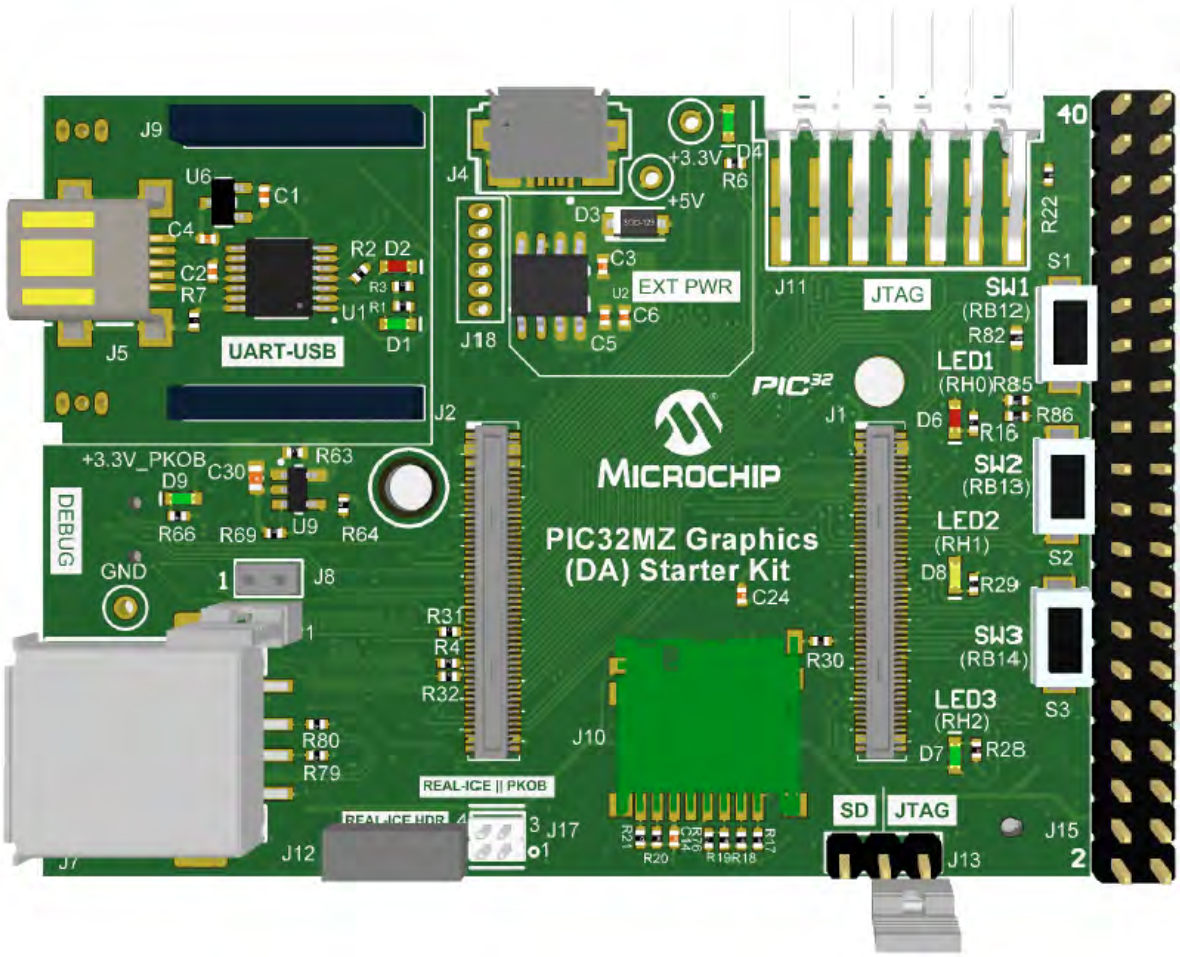
http://www.microchip.com/Developmenttools/ProductDetails.aspx?PartNO=DM320008-C

Available Demonstrations

Feature	Demonstrations
Audio	• audio_tone • universal_audio_decoders
Bluetooth	• a2dp_avrcp
Bootloader	• basic • LiveUpdate
Crypto	• encrypt_decrypt • large_hash
Drivers	• i2c_rtcc • nvm_read_write • spi_loopback • usart_loopback

Graphics	• wvga_glcd
MEB II	• gfx_cdc_com_port_single • gfx_photo_frame • gfx_web_server_nvm_mpfs
Peripheral Library Examples	• adchs_3ch_dma • adchs_oversample • adchs_pot • adchs_sensor • adchs_touchsense • echo_send • triangle_wave • dma_led_pattern • i2c_interrupt • i2c_polling • flash_modify • oc_pwm • osc_config • blinky_leds • deep_sleep_mode • sleep_mode • reset_handler • rtcc_alarm • spi_loopback • flash_read_dma_mode • flash_read_pio_mode • flash_read_xip_mode • timer3_interrupt • uart_basic • wdt_timeout
RTOS	ThreadX: • basic FreeRTOS: • basic Micriμm μC/OS-II • basic Micriμm μC/OS-III • basic OPENRTOS: • basic SEGGER embOS: • basic
System Service Examples	• debug_uart • devcon_cache_clean • devcon_cache_invalidate • devcon_sys_config_perf
TCP/IP	• tcpip_tcp_client • web_server_nvm_mpfs
USB Device	• cdc_com_port_dual • hid_mouse
USB Host	• msd_basic

Hardware Layout



PIC32MZ Starter Kit Adapter Board

Provides information on the PIC32MZ Starter Kit Adapter Board.

Description

Microchip Part Number:

AC320006

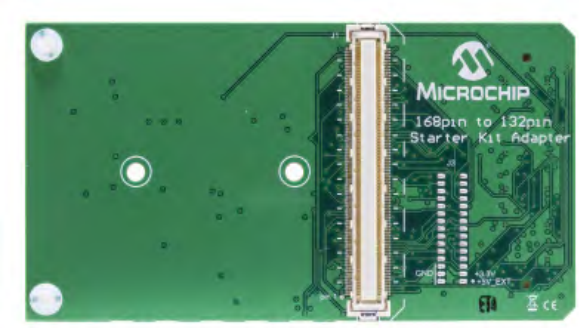
Microchip Product Page:

http://www.microchip.com/Developmenttools/ProductDetails.aspx?PartNO=AC320006

Available Demonstrations

Feature	Demonstrations
Crypto	• large_hash
Drivers	• spi_loopback • usart_loopback
USB Device	• hid_basic

Hardware Layout



PICkit 3 In-Circuit Debugger

Provides information on the PICkit™ 3 In-Circuit Debugger.

Description

Microchip Part Number:

PG164130

Microchip Product Page:

http://www.microchip.com/Developmenttools/ProductDetails.aspx?PartNO=PG164130

Available Demonstrations

Feature	Demonstrations
TCP/IP Demonstrations	• wifi_g_demo

Hardware Layout

PICtail Daughter Board for SD and MMC

Provides information on the PICtail Daughter Board for SD and MMC.

Description

Microchip Part Number:

AC164122

Microchip Product Page:

http://www.microchip.com/Developmenttools/ProductDetails.aspx?PartNO=AC164122

Available Demonstrations

Feature	Demonstrations
File System	• sdcard_fat_single_disk • nvm_sdcard_fat_mpfs_multi_disk • nvm_sdcard_fat_multi_disk
TCP/IP	• snmpv3_sdcard_fatfs • web_server_sdcard_fatfs

Hardware Layout

Prototype PICtail Plus Daughter Board

Provides information on the Prototype PICtail Plus Daughter Board.

Description

Microchip Part Number:

AC164126

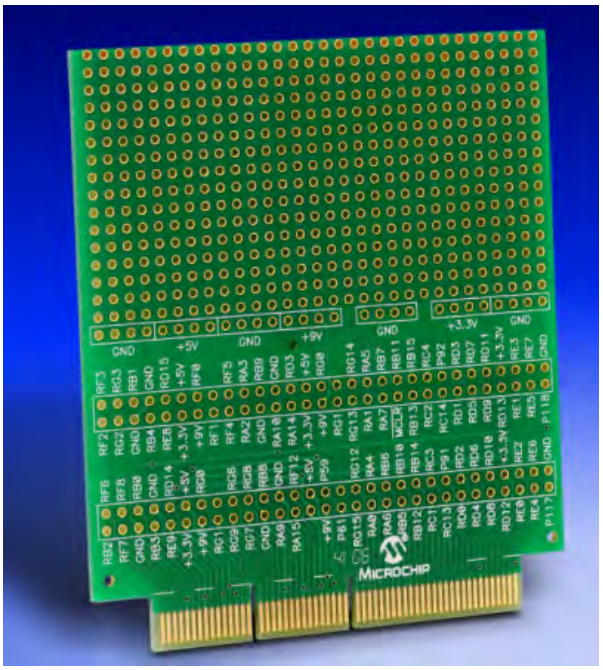
Microchip Product Page:

http://www.microchip.com/Developmenttools/ProductDetails.aspx?PartNO=AC164126

Available Demonstrations

Feature	Demonstrations
Drivers	• i2c_loopback

Hardware Layout



Starter Kit I/O Expansion Board

Provides information on the Starter Kit I/O Expansion Board.

Description

Microchip Part Number:

DM320002

Microchip Product Page:

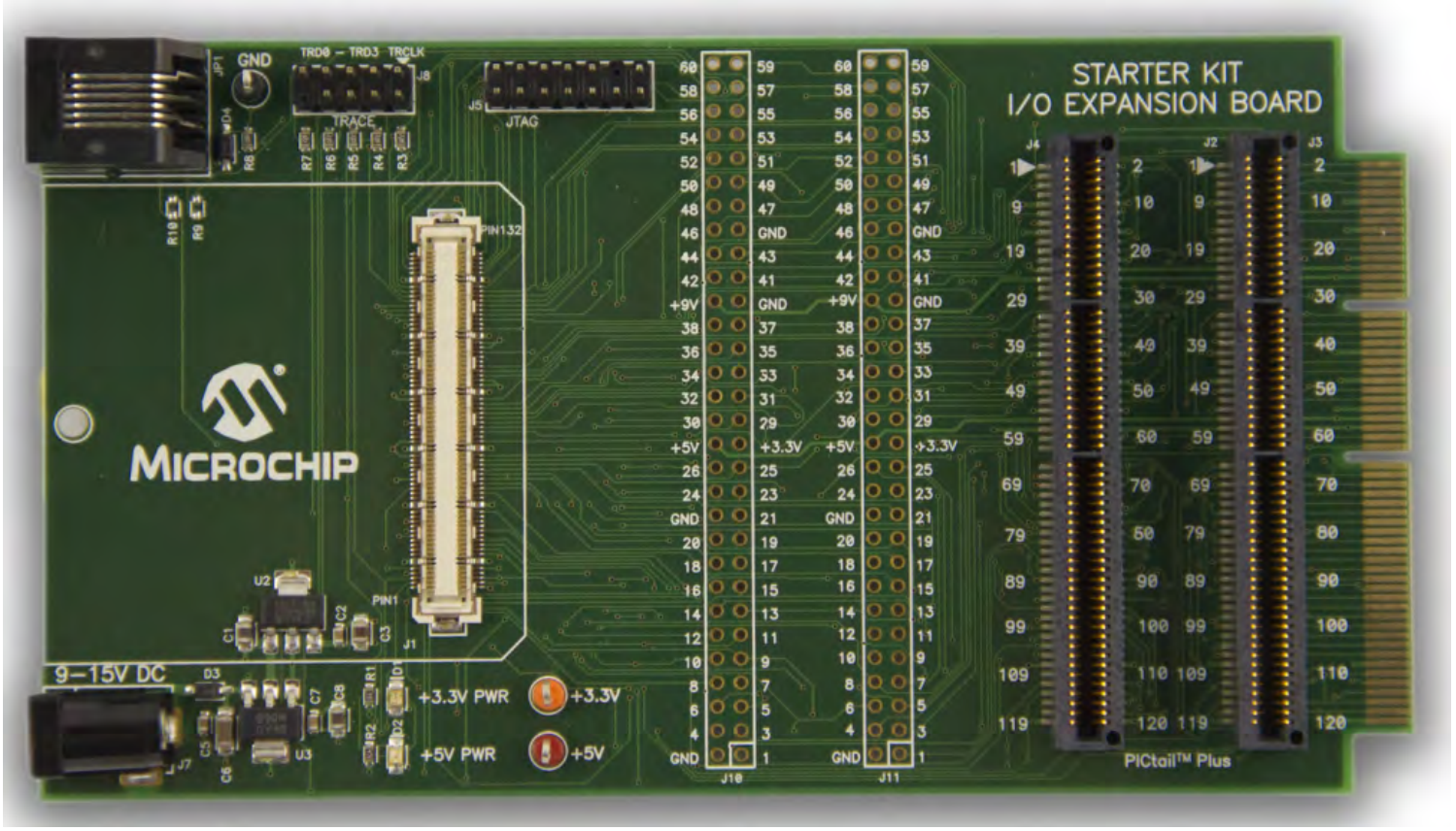
http://www.microchip.com/DevelopmentTools/ProductDetails.aspx?PartNO=DM320002

Available Demonstrations

Feature	Demonstrations
Bootloader	• basic • LiveUpdate_application • LiveUpdate
Crypto	• large_hash
Drivers	• spi_loopback • usart_loopback
Peripheral Library Examples	• adc_pot • adcp_cal • i2c_eeprom_rw • ic_basic • spi_loopback • uart_basic
System Services	• command_appio

TCP/IP	• snmpv3_sdcard_fatfs • tcpip_tcp_client • web_server_nvm_mpfs • web_server_sdcard_fatfs • wifi_wolfssl_tcp_client

Hardware Layout



USB PICtail Plus Daughter Board

Provides information on the USB PICtail Plus Daughter Board.

Description

Microchip Part Number:

AC164131

Microchip Product Page:

http://www.microchip.com/Developmenttools/ProductDetails.aspx?PartNO=AC164131

Available Demonstrations

Feature	Demonstrations
FreeRTOS	• cdc_msd_basic

USB Device	• audio_speaker • cdc_com_port_dual • cdc_com_port_single • cdc_serial_emulator • cdc_serial_emulator_msd • hid_basic • hid_joystick • hid_keyboard • hid_mouse • vendor
USB Host	• cdc_basic

Hardware Layout

Wi-Fi G Demo Board

Provides information on the Wi-Fi G Demo Board.

Description

Microchip Part Number:

DV102412

Microchip Product Page:

http://www.microchip.com/Developmenttools/ProductDetails.aspx?PartNO=dv102412

Available Demonstrations

Feature	Demonstrations
TCP/IP	• wifi_g_demo

Hardware Layout


MICROCHIP
MRF24WG0MA
Wi-Fi G Demo Board
SW0
LED0 LED1 LED2
OFF
ON
DEBUG PORT
MICROCHIP
PIC

Creating Your First Project

This tutorial guides you through the process of using the MPLAB Harmony Configurator (MHC) and MPLAB Harmony libraries to develop your first MPLAB Harmony project.

Overview

Lists the basic steps necessary to create a MPLAB Harmony application using the MHC.

Description

MPLAB Harmony provides a convenient MPLAB X IDE plug-in configuration utility, the MPLAB Harmony Configurator (MHC), which you can use to easily create MPLAB Harmony-based projects. This tutorial will show you how to use the MHC to quickly create your first MPLAB Harmony application using the following steps:

- Step 1: Create a New Project
- Step 2: Configure the Processor Clock
- Step 3: Configure Key Device Settings
- Step 4: Configure the I/O Pins
- Step 5: Add and Configure Libraries
- Step 6: Generate the Project's Starter Files
- Step 7: Develop the Application

Your first application should be extremely simple. The example used in this tutorial blinks an LED on the selected platform to provide an application heartbeat health indicator. For guidance on using MPLAB Harmony to develop more capable applications, please refer the Help documentation listed in the Summary section.

Prerequisites and Assumptions

Describes the prerequisites for starting this tutorial and the assumptions made when it was written.

Description

Before beginning this tutorial, ensure that you have installed the MPLAB X IDE and necessary language tools as described in Volume I: Getting Started With MPLAB Harmony > Prerequisites. In addition, an appropriate hardware platform is required.

The example project in this tutorial utilizes the PIC32MZ Embedded Connectivity (EC) Starter Kit. In the event you do not have this development hardware, refer to the Supported Development Boards section for a list of available development boards that you could use to complete this tutorial.

To complete this tutorial you will need to know the following about your selected hardware platform:

- The name of the PIC32 device it uses
- The Primary Oscillator input clock frequency and desired processor clock frequency
- The debugger interface settings
- The I/O Port and Pin that connect to the desired indicator LED
- The input clock source and frequency for the timer selected to blink the indicator LED

Please refer to the documentation for the selected hardware platform and PIC32 device for this information, as described in *Volume I: Getting Started With MPLAB Harmony > Guided Tour >* Documentation.

Finally, this tutorial assumes that you have some familiarity with the following; however, you should be able to follow the directions in this tutorial with very little experience:

- MPLAB X IDE development and debugging fundamentals
- C language programming
- PIC32 product family and supported development boards

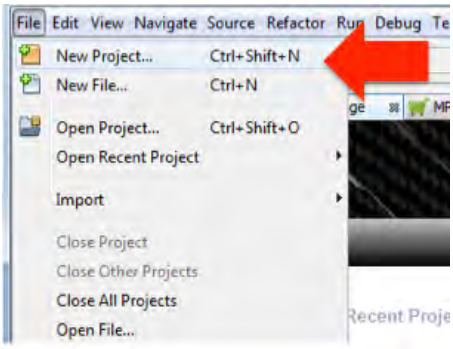
Step 1: Create a New Project

Provides directions for creating a new empty MPLAB Harmony project.

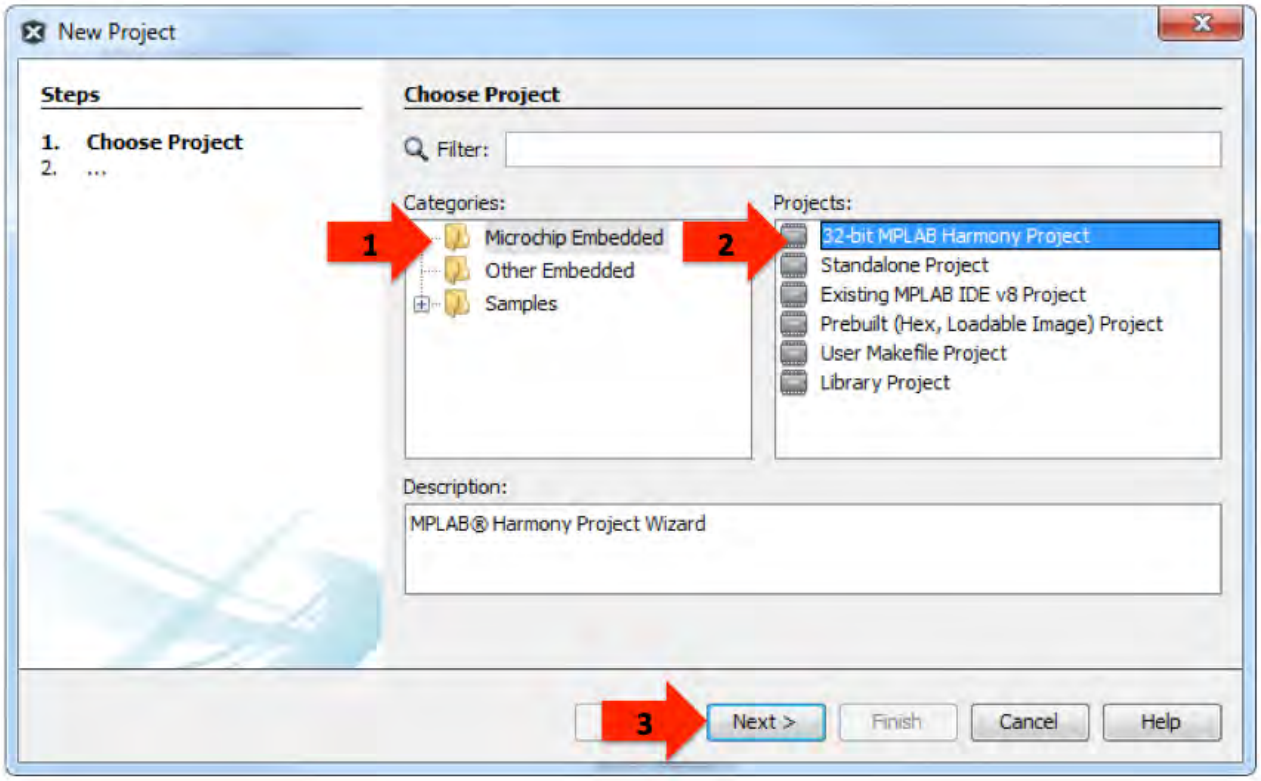
Description

After launching MPLAB X IDE and ensuring that the MHC plug-in is properly installed, you can create a new MPLAB Harmony project using the following the directions.

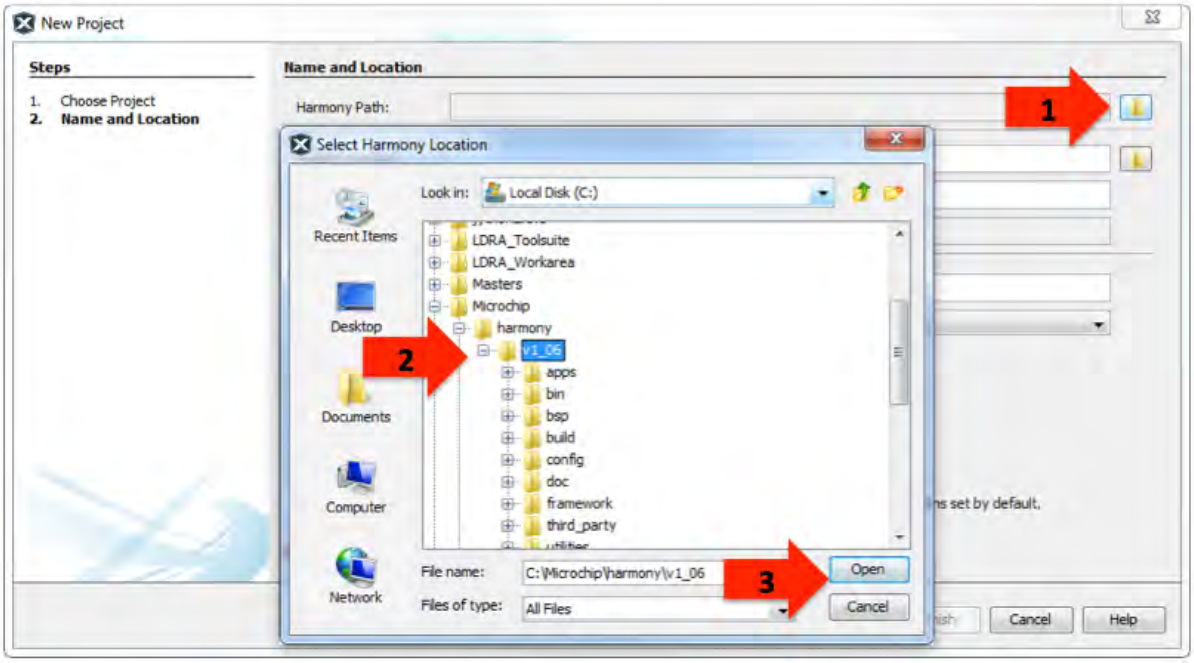
1. Select New Project from the MPLAB X IDE File menu (shown by the red arrow in the following figure), which opens the New Project dialog and launches the New Project wizard.



2. In the Choose Project pane of the New Project window, 1) select **Microchip Embedded**, 2) select **32-bit MPLAB Harmony** Project, 3) and then click **Next**, which opens the Name and Location pane in the New Project dialog window.



3. Select the desired MPLAB Harmony installation by 1) clicking the folder icon next to the Harmony Path display box, 2) navigating to and selecting the folder for the desired MPLAB Harmony distribution (by default, this is the folder matching the installation's version number), and 3) clicking **Open**, as shown in the following figure. The path to the desired MPLAB Harmony installation should now be displayed.

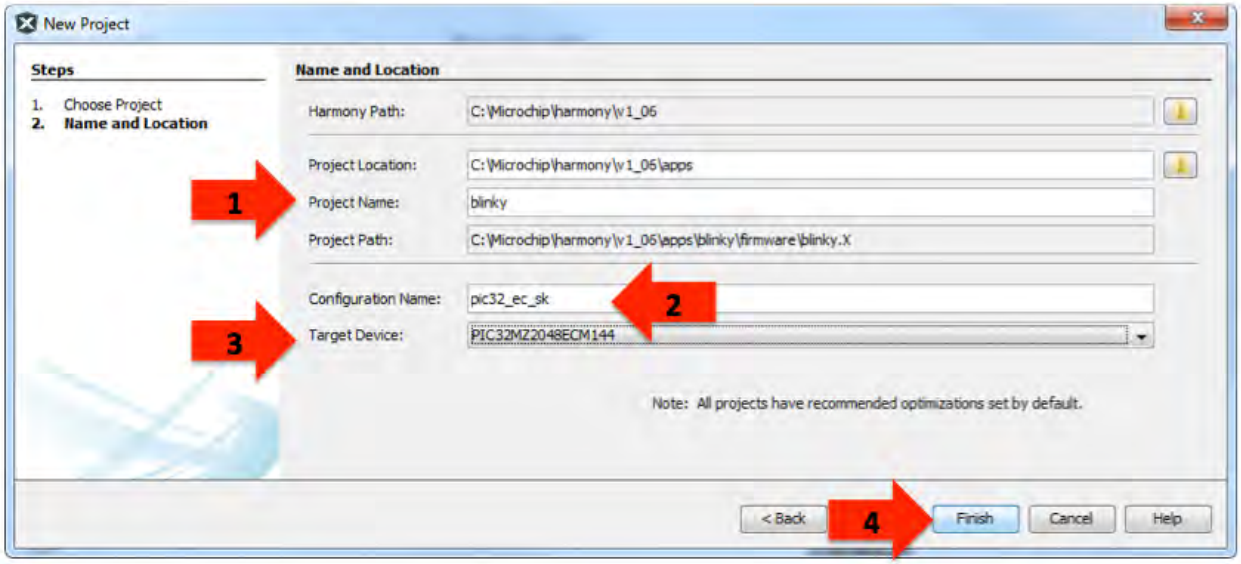


4. As shown in the following figure, choose your project location, name, and initial configuration name by 1) entering the new project name, “blinky” in this example (by default, the MHC will locate this in the `apps` folder of the selected MPLAB Harmony installation), 2) entering a new configuration name, `pic32_ec_sk` in this example, as shown in the following figure (a configuration is commonly named after the board it uses, but you can use any name that meaningfully identifies the configuration), 3) selecting the target device on the PIC32MZ EC Starter Kit in use (see the following **Note**), and 4) click **Finish**.

Note: There are two versions of the PIC32MZ EC Starter Kit, which use different microcontrollers:

- DM320006-C (with Crypto Engine) uses the PIC32MZ2048ECM144
- DM320006 (without Crypto Engine) uses the PIC32MZ2048ECH144

Depending on the starter kit in use, you will need to select the appropriate device.



After clicking Finish, the New Project wizard will create several new folders on disk within the project location folder and an empty MPLAB X IDE project (i.e., no source files exist within the folder).

Generated Folders:

```
<project-location>/<project-name>
   firmware
     <project-name>.X
     src
       system_config
         <configuration-name>
```

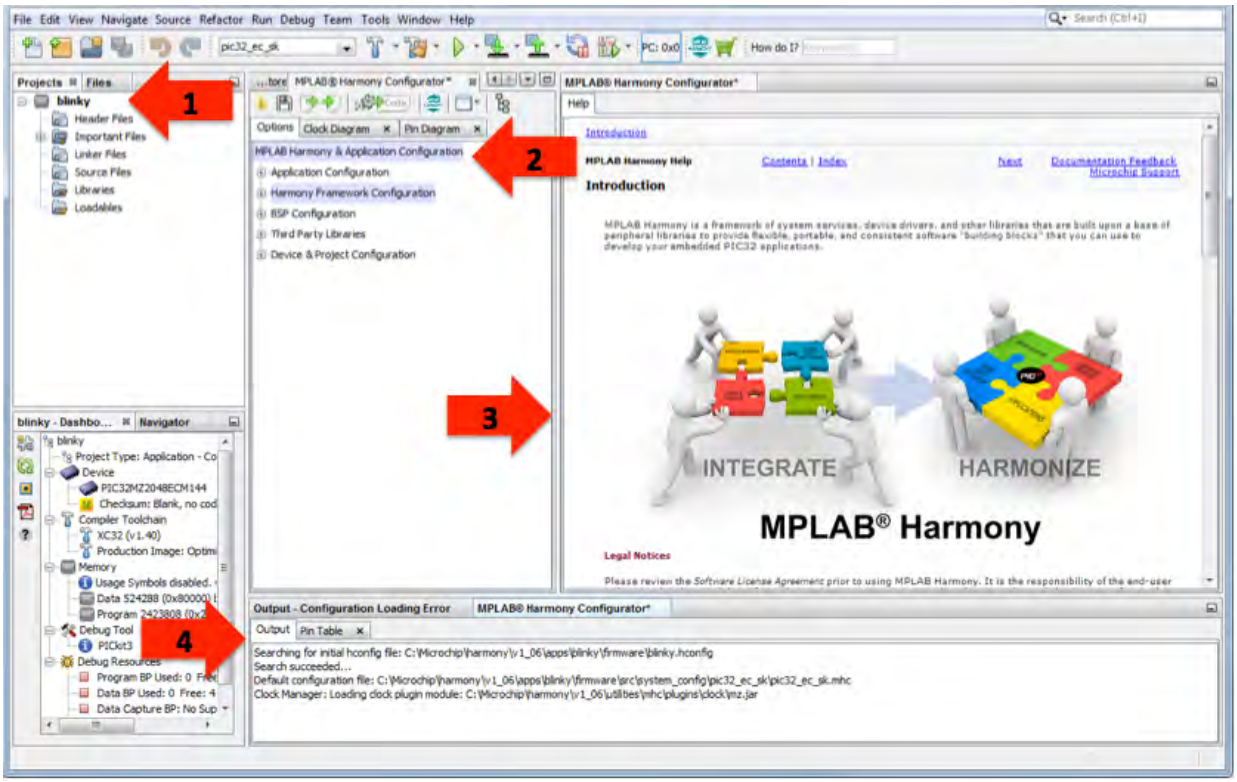
Where `<project-location>`, `<project-name>`, and `<configuration-name>` match the values provided in the New Project Name and Location window (in this example, `C:\microchip\harmony\v1_06`, `blinky`, and `pic32_ec_sk`).

After creating the empty project, the New Project wizard will launch the MHC plug-in so that you may configure the project.

From within MPLAB X IDE, depending on the current layout of the MPLAB X IDE panes, you should see something similar to the following figure, which should display the following items:

1. The empty project (with no files).
2. The MPLAB Harmony configuration tree.
3. The MPLAB Harmony Help system.
4. The MPLAB Harmony Configurator (MHC) output window.

Note: The MPLAB Harmony new project wizard will automatically set the new project as the *main* project in MPLAB X IDE. This is required because the MHC will not launch if there is no currently selected main project open within the MPLAB X IDE.



The project you have just created (see arrow 1, in the previous figure) is empty, meaning it does not yet contain any source files. In later steps, you will use the MHC to generate an initial set of source files for the initial configuration of your project. You will use the MPLAB Harmony configuration tree (see arrow 2) to make the selections for your initial configuration. As you select items in the configuration tree, you will see help for that item appear in the help window (see arrow 3). As you use the MHC, it will display activity, warning, and possibly error messages in the output window (see arrow 4), depending on the level of output for which it is set. By default, it only displays key activity and error messages.

Step 2: Configure the Processor Clock

Provides instructions on how to use the MHC to configure the processor clock.

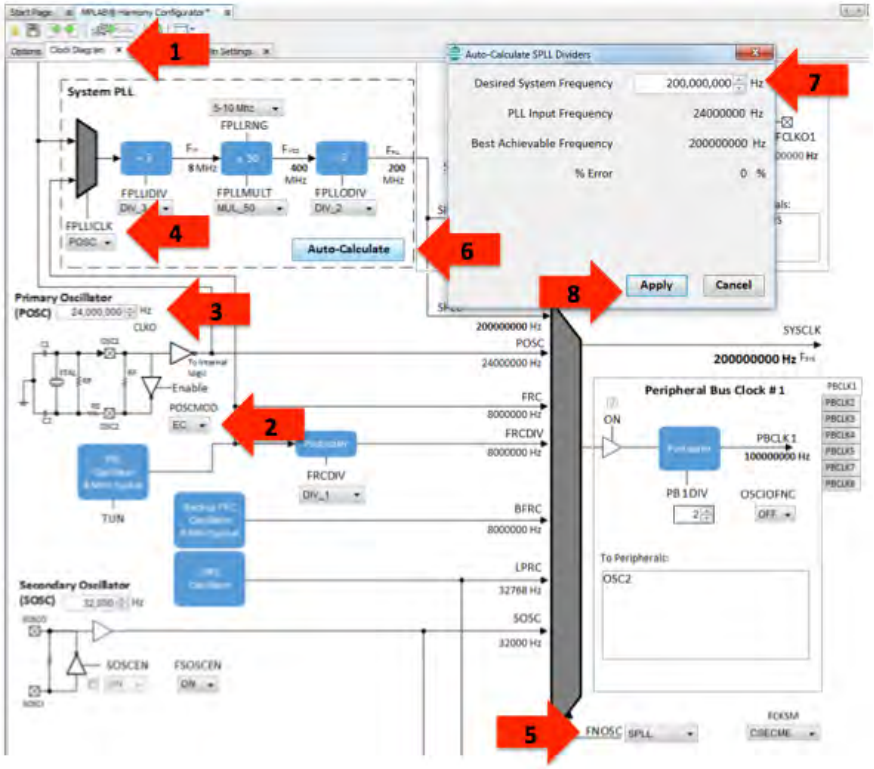
Description

After creating a new blank MPLAB Harmony project, the next step is to use the interactive clock diagram in the MHC to configure the processor clock. To do this, use the following process. The numbered red arrows in the following clock diagram show the location of each step in the process.

1. Select the clock diagram in the MPLAB Harmony Configurator pane.
2. Select the External Clock (EC) mode for the primary oscillator.
3. Enter the primary oscillator input clock frequency (24 MHz for the PIC32MZ EC Starter Kit).
4. Select the primary oscillator (POSC) as the system PLL input clock.

Note: Values that are not supported on the selected device appear in red and must be changed to a supported value

5. Select the system PLL (SPLL) from the oscillator multiplexer (FNOSC).
6. Click **Auto-Calculate**.
7. Enter the desired system frequency (200 MHz for the PIC32MZ EC Starter Kit).
8. Click **Apply**.



The exact settings will vary for different Microchip development boards. Most Microchip PIC32 development boards will utilize a primary oscillator input at a frequency that allows running the processor at its highest rate. Refer to the documentation for the development board in use for information on the crystal or oscillator used. You may also find the settings used by MPLAB Harmony demonstration applications helpful as examples.

Use of a Board Support Package (BSP), such as the ones provided for Microchip development boards in the `<install-dir>/bsp` folder, will automatically set the clock configuration for maximum performance. BSPs are used by most demonstration applications provided in the MPLAB Harmony installation, but they are not required for your own applications. Also, do not worry if you decide to change frequencies later. It is easy to return to the clock diagram at any time and change the processor's clock settings.

Step 3: Configure Key Device Settings

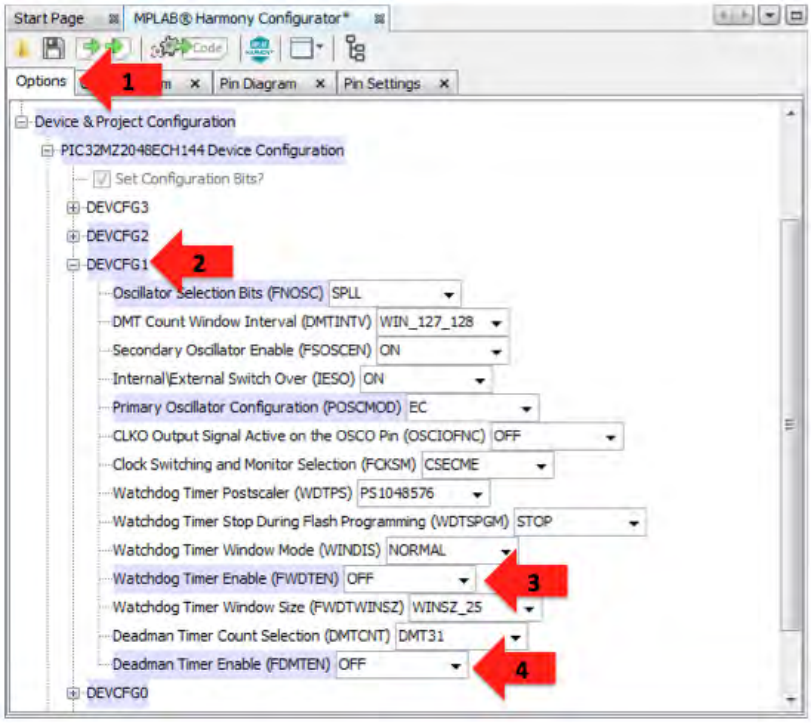
Explains how to configure key device settings to program, debug, and run firmware.

Description

There are a few key device configuration settings for most processors that must be correct to effectively run and debug the firmware. Exactly which settings are important depends on which processor is in use and what you are currently doing.

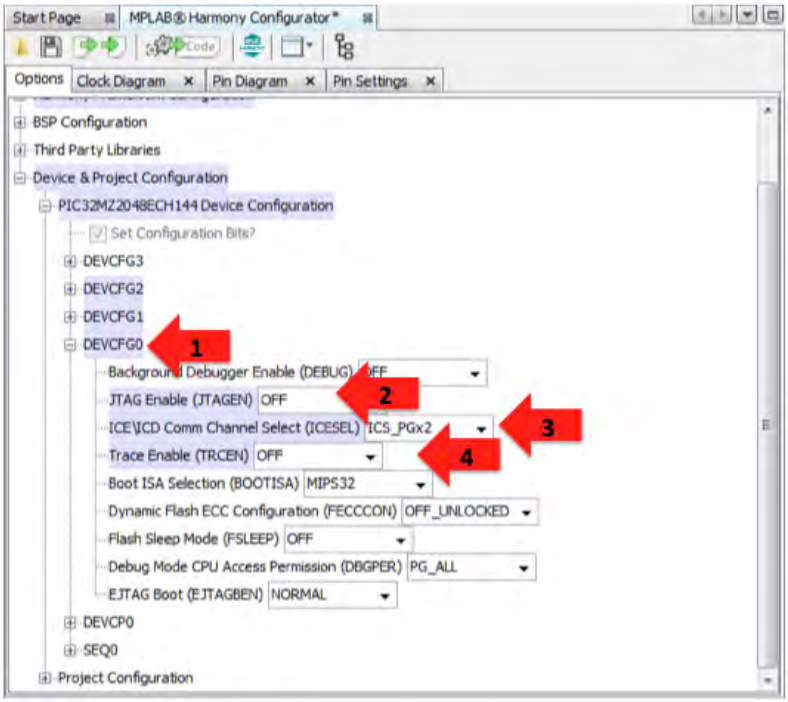
To get started, it is usually necessary to disable all Watchdog and Deadman Timers to avoid having the timer expire and reset the processor before the firmware has been implemented to support that functionality. To do this for the PIC32MZ2048ECM144 device used by this example, perform the following steps, which are also shown by numbered red arrows in the next figure:

1. Select the Options pane in the MPLAB Harmony Configurator Window.
2. Expand the Device Configuration 1 (DEVCFG1) register settings tree.
3. Change the Watchdog Timer Enable (FWDTEN) flag to OFF.
4. Change the Deadman Timer Enable (FDMTEN) flag to OFF.



Additionally, it is often necessary to ensure that the in-circuit emulator interface and other debugging capabilities like instruction trace (for devices that support it) are properly configured. Most PIC32 starter kits do not utilize JTAG, so it will need to be disabled, and instruction trace is not required for this tutorial and will need to be disabled. To do this for the PIC32MZ2048ECM144 device used by this demonstration, perform the following steps.

1. Expand the Device Configuration 0 (DEVCFG0) register settings tree.
2. Change the JTAG Enable (JTAGEN) setting to OFF.
3. Change the In-circuit Emulator Communication Channel Select (ICESEL) setting to ICSxPGx2. The ICSxPG setting must match the debug channel used on the physical hardware.
4. Change the Trace Enable (TRCEN) setting to OFF.



When you select the *<device name>* Device Configuration item within the MHC Options tree, the MHC Help window will show information describing the device configuration settings for the processor selected for the main project's currently selected configuration. You may also reference information about the device's configuration settings in the compiler's user guide and in the device's data sheet. If your hardware and debugger connections are correct and you are unable to program, debug, or run code on the device, it is very likely that one of these key device configuration settings is incorrect. You must ensure that these settings are correct before continuing.

Step 4: Configure the I/O Pins

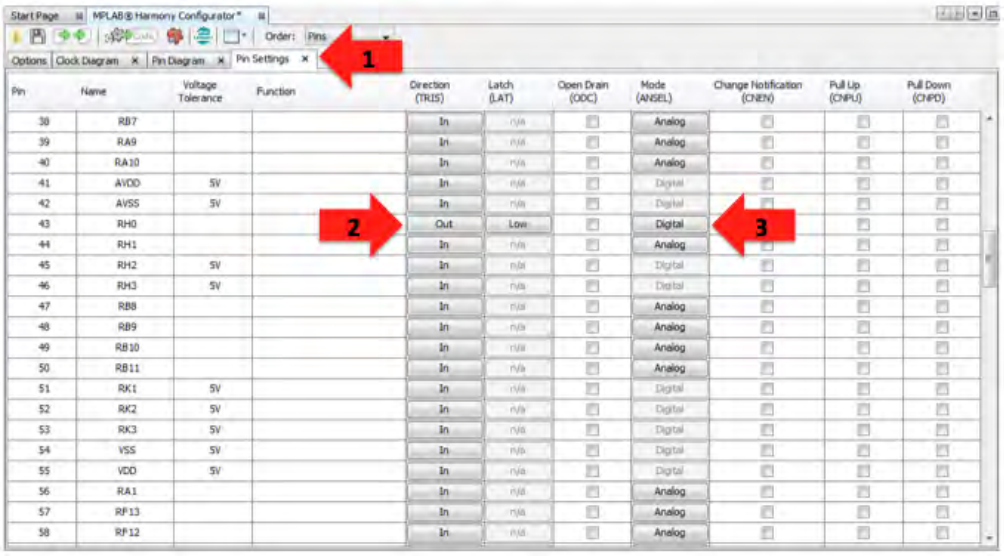
Provides an example of how to use the MHC to configure I/O pins.

Description

After configuring the processor clock and key settings, configure any general purpose I/O pins required by your project using the interactive Pin Diagram and Pin Settings panes provided by the MHC.

For example, the PIC32MZ EC Starter Kit has LED1 connected to port pin RH0. Therefore, that pin will need to be set as an output to blink the heartbeat indicator LED, by performing the following actions.

1. Select the Pin Settings tab in the MHC pane.
2. Scroll to pin 43, RH0 and select it as a digital output pin by clicking the **Out** Direction (TRIS) button. (You can accept the default Low initial output level.)
3. Select **Digital** mode.



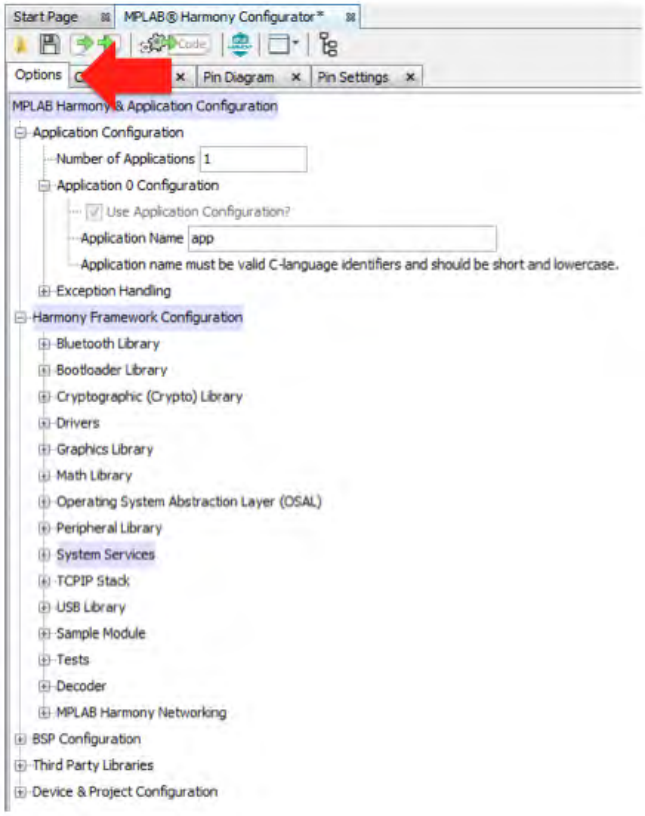
Often, boards will have switches and LEDs and it is a good idea to provide some sort of *heartbeat* indicator to show that the application is running, particularly during development. Therefore, you will normally configure a few general purpose I/O pins when you first create a project. However, do not worry about configuring all of your I/O pins when you first create a new project. Predefined BSPs will automatically configure the I/O pins for LEDs and switches for supported Microchip development boards. (Refer to Board Support Packages Help for more information on BSPs.) And, you can return to the Pin Settings and Pin Diagram tabs in the MHC at any time to update your I/O port settings.

Step 5: Add and Configure Libraries

Demonstrates how to add and configure a library required by an application.

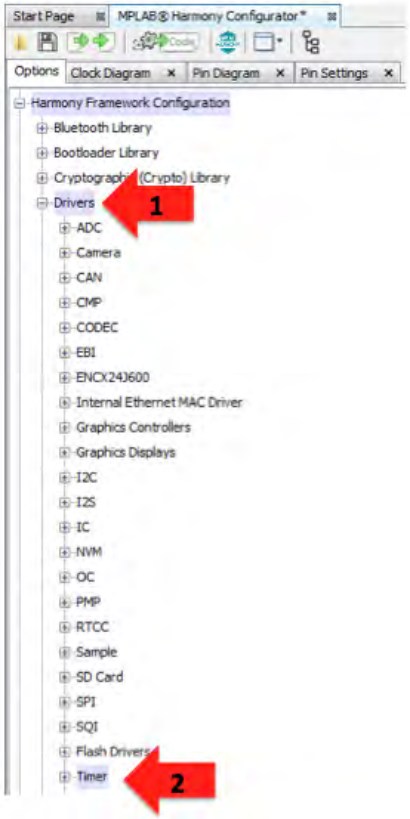
Description

The MHC allows you to configure basic application features and select and configure the desired MPLAB Harmony libraries. Click the Options tab to select this pane, as shown by the red arrow in the following figure.



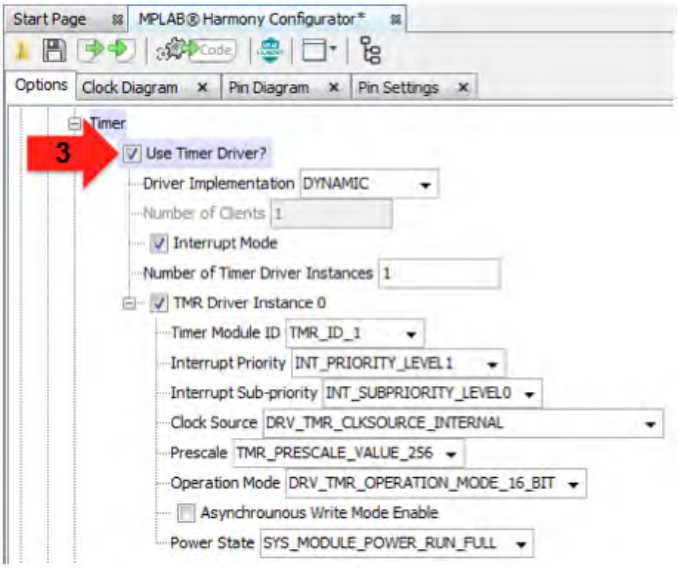
In this example, you can accept the default application configuration settings, but you will need to utilize the Timer Driver. To access the Timer Driver configuration options, you must expand the Harmony Framework configuration tree by clicking the plus (+) icons next to Drivers and Timer.

1. Expand the Drivers tree.
2. Expand the Timer driver's configuration tree.

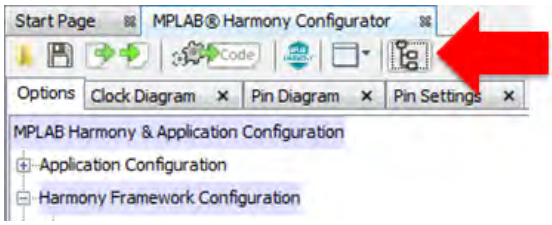


3. Enable use of the Timer Driver, by selecting the check box next to *Use Timer Driver*, as shown in the following figure. This will expand the Timer Driver configuration options. For this example, you can accept all of the default options. This will configure the Timer Driver to use a single interrupt-driven dynamic implementation as instance 0 (DRV_TMR_INDEX_0). That instance will utilize hardware Timer Peripheral 1

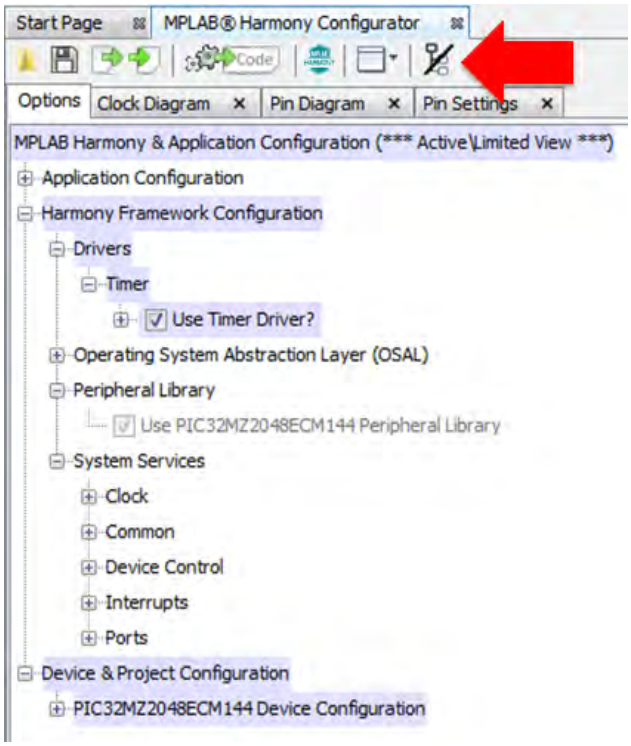
(TMR_ID_1) in 16-bit mode with a maximum prescale divisor of 256, using the internal peripheral bus clock as the timer's clock source.



The blinky example application used in this tutorial will also utilize the Ports System Service (SYS_PORTS). However, that service is enabled by default and you have already configured it previously, using the Pin Settings pane. Also, the SYS CLOCK service (previously configured using the interactive clock diagram) is enabled by default. To see which libraries are enabled and how they're configured, select the Options Tree icon to see the limited view of the options tree that shows only the active libraries, as shown in the following figure.



When viewing the limited Options Tree and showing only the active libraries, the Tree View icon shows a black slash through it and only the currently enabled libraries are shown in the MHC configuration tree, as shown in the following figure. Click the Tree View icon again to return to the full view.

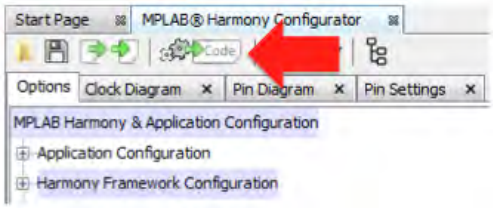


Step 6: Generate the Project's Starter Files

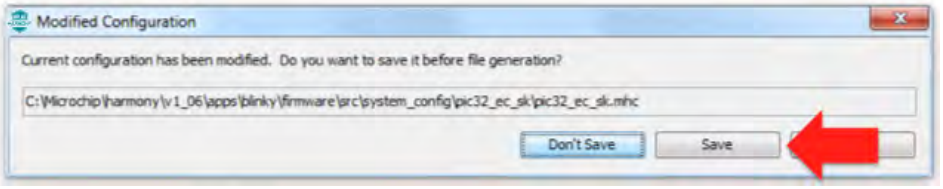
Describes how to generate the project's starter files.

Description

Once the initial configuration options have been selected in the MHC, click the Generate Code icon, as shown in the following figure to generate the initial set of source files for your application.



Accept the default location for the configuration setting's (`.mhc`) file and click **Save** in the Modified Configuration dialog (see the following figure), unless you have previously saved the current configuration settings. This file stores the selections made in the MHC window.



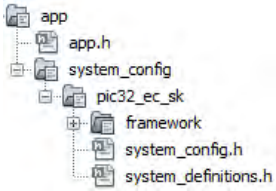
Accept the default settings and click Generate in the File Generation dialog, as shown in the next figure.

Notes:

1. Selecting 'Overwrite any local changes automatically' will cause the MHC to overwrite the existing configuration fields with the newly generated versions. If this option is not selected, the MHC will identify when configuration files have been changed and when it does it will open a diff/merge utility so that you can choose which changes to keep. By default, this option is not selected.
2. If the 'Create a backup of the current project state' option is selected (enabled by default), the MHC will generate a back-up of the current configuration settings before updating them. Refer to the MPLAB Harmony Configurator User's Guide for details on using and restoring configurations.
3. If the 'Enable recommended compiler optimizations' option is selected (enabled by default), the MHC will automatically enable a minimal level of optimization (equivalent to `-O1` on the XC32 command line) in the project settings. To change this setting, refer to the MPLAB X IDE project Properties window.

This will cause the MHC to generate an initial set of project source files, based on your current configuration selections. This set of files will include the following application files, as shown in the MPLAB X IDE Project window.

Generated Header Files



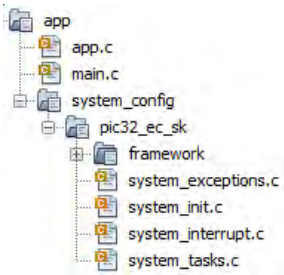
The `app.h` header file contains definitions and prototypes required by the application or by other modules that use the application.

The `system_config.h` header file defines build options and is included by all other files that require any configuration options.

The `system_definitions.h` header file provides definitions required by the system configuration files.

These files implement a configuration of an MPLAB Harmony firmware system. They are generated in a configuration-specific folder (`pic32_ec_sk` folder in this example, as follows).

Generated Source Files



The `main.c` source file contains a standard MPLAB Harmony C-language main function.

The `app.c` source file contains the application logic state machine.

The system files (`system_*.c`) implement the (`pic32_ec_sk`) configuration of the system.

The `system_init.c` file contains the standard MPLAB Harmony SYS_Initialize function (and supporting code) that is called by main to initialize all modules in the system.

The `system_tasks.c` file implements the standard MPLAB Harmony SYS_Tasks function that is called in a loop by main to keep the state machines of all non-interrupt-driven modules running in the system.

The `system_interrupt.c` file implements the Interrupt Service Routine (ISR) functions for any interrupt-driven modules in the system.

Finally, the `system_exceptions.c` file implements any exception-handling functions required by the system.

The MHC generates some MPLAB Harmony libraries, either wholly or in part, using knowledge of configuration selections made by the user, which makes them configuration specific. The `app/system_config/<configuration>/framework` folder contains these configuration-specific files that are conceptually part of the MPLAB Harmony framework, not the application.

Refer to the Project Layout section for additional information on the files generated by the MHC.

Notes:

1. The `app` folder, as displayed in MPLAB X IDE, corresponds to the `src` folder on disk.
2. The top-level (non-configuration-specific) `<install-dir>/framework` folder corresponds to the top-level `framework` folder in the MPLAB Harmony installation directory. Files in this folder are referenced and used by your project, but are not copied into the project-specific folders.

Step 7: Develop the Application

Describes how to develop MPLAB Harmony application logic, using the Blinky Heartbeat Indicator project as an example.

Description

Once the initial set of application and configuration files have been generated, you're ready to begin developing your application logic. To do this, you will modify some of the generated files, adding your own custom code. Some of these files, such as `app.h` and `app.c`, are only generated once, when the project is initially created. These are starter files where you are intended to do most of your development. Other files (like the system configuration files) are under control of the MHC. You can, and will occasionally need to modify these files; however, you need not worry about losing your changes if you regenerate the project files. The MHC will open a *diff* tool when it detects that you have modified a file and allow you to choose which changes you want to keep and which ones you want to update.

Note: A default *diff* tool is included in MPLAB X IDE. However, you can replace this tool with one of your own preference. Refer to the MPLAB X IDE documentation for details on how to use a custom *diff* tool.

Heartbeat Indicator

For this example, you will develop a heartbeat indicator. The heartbeat indicator is an LED that blinks at a regular pace (a rate of about one-half Hz) as long as your application's main tasks function (APP_Tasks) is running properly. If your APP_Tasks function is called too slowly or becomes blocked, the heartbeat indicator will slow down or stop blinking. This functionality is a good thing to have in most projects (particularly during development), so this example is a good place to start most new applications.

The state variables that belong to an application are usually managed in a data structure called APP_DATA. To implement the heartbeat indicator, add the following variables to this structure in `app.h`, as follows.

Heartbeat Variables:

- heartbeatTimer – Heartbeat timer driver handle
- heartbeatCount – Count of heartbeat timer driver alarms
- heartbeatToggle – A flag indicating when to toggle the heartbeat LED

Updated APP_DATA Structure in app.h

```
typedef struct
{
    /* The application's current state */
    APP_STATES      state;

    /* Heartbeat driver timer handle. */
```

```
    DRV_HANDLE      heartbeatTimer;

    /* Heartbeat timer timeout count. */
    unsigned int    heartbeatCount;

    /* Heartbeat LED toggle flag. */
    bool            heartbeatToggle;

} APP_DATA;
```

You will also need to add an idle state to the application's state machine so that the application has a state to which it can transition after its initial state has started the heartbeat timer running. To do this, add the APP_STATE_IDLE entry to the APP_STATES enumeration, also defined in the following `app.h` header file

Updated APP_STATES Enumeration in app.h

```
typedef enum
{
    /* Application's state machine's initial state. */
    APP_STATE_INIT=0,

    /* Application state machine's idle state. */
    APP_STATE_IDLE,
    APP_STATE_SERVICE_TASKS,

} APP_STATES;
```

While you're editing the `app.h` file, this would be a good time to add include statements for the Timer Driver and Ports System Service header files (`drv_tmr.h` and `sys_ports.h`, respectively) to `app.h` to provide the prototypes that the application's heartbeat code will require, as follows.

Included Files in app.h

```
#include <stdint.h>
#include <stdbool.h>
#include <stddef.h>
#include <stdlib.h>
#include "system_config.h"
#include "system_definitions.h"
#include "driver/tmr/drv_tmr.h"
#include "system/ports/sys_ports.h"
```

There are several application-specific configuration constants that are used in place of hard-coded values. There will also be a few other constants needed to identify things such as the indicator LED port and pin numbers, the timer alarm period, and maxim alarm counts, as follows.

Application-Specific Configuration Constants

- APP_HEARTBEAT_TMR
- APP_HEARTBEAT_TMR_IS_PERIODIC
- APP_HEARTBEAT_TMR_PERIOD
- APP_HEARTBEAT_COUNT_MAX
- APP_HEARTBEAT_PORT
- APP_HEARTBEAT_PIN

These macros are best defined in the `system_config.h` header file. Defining them as application-specific configuration options in the `system_config.h` header allows the heartbeat logic to be easily changed to use a different timer instance or a different indicator port pin in different configurations of the application, if desired.

Application-Specific Configuration Macros in system_config.h

```
#define APP_HEARTBEAT_TMR               DRV_TMR_INDEX_0
#define APP_HEARTBEAT_TMR_IS_PERIODIC   true
#define APP_HEARTBEAT_TMR_PERIOD        0xFE51
#define APP_HEARTBEAT_COUNT_MAX         6
#define APP_HEARTBEAT_PORT              PORT_CHANNEL_H
#define APP_HEARTBEAT_PIN               PORTS_BIT_POS_0
```

The usage of these items will be discussed in more detail in the following sections, but first, the application should initialize these new variables to ensure that they will have appropriate initial values when the application's state machine function (APP_Tasks) is called at a later time. To do this, update the APP_Initialize function in the `app.c` file, as follows.

Updated APP_Initialize Funciton in app.c

```
void APP_Initialize ( void )
{
    /* Place the App state machine in its initial state. */
    appData.state           = APP_STATE_INIT;
    appData.heartbeatTimer  = DRV_HANDLE_INVALID;
    appData.heartbeatCount  = 0;
    appData.heartbeatToggle = false;
}
```

To use the Timer Driver, it must first be opened and a handle to it obtained from the driver's *Open* function (DRV_TMR_Open). This must be done in the application's state machine (in the APP_STATE_INIT state) before the application can call any other Timer Driver functions. If a valid handle is returned from the driver's *Open* function, an alarm callback (to a function to be defined later by the application) can be registered with the driver by calling DRV_TMR_AlarmRegister and the timer can be started by calling DRV_TMR_Start function.

If the handle returned from the driver's *Open* function is invalid, the application should stay in its initial state (APP_STATE_INIT) and try again next time its state-machine function is called. Once the application has successfully opened the Timer Driver, registered a callback, and started the timer, it can move to the next state (APP_STATE_IDLE) by assigning a new value to the appData.state variable.

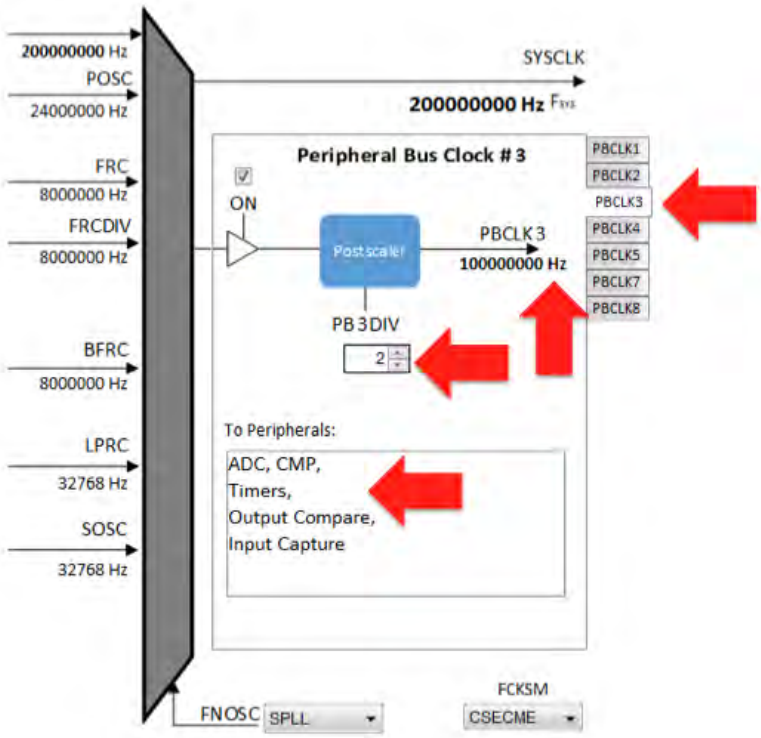
The following updated code shows how to implement the logic previously described.

Updated APP_Tasks Switch Statement in app.c

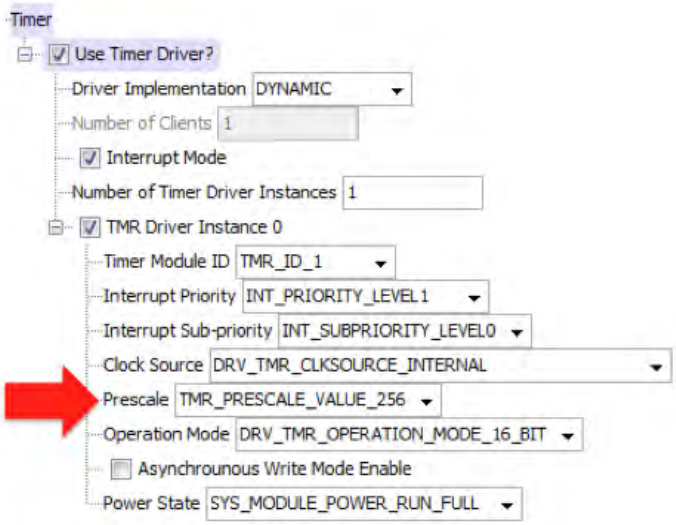
```
switch ( appData.state )
{
    case APP_STATE_INIT:
    {
        appData.heartbeatTimer = DRV_TMR_Open( APP_HEARTBEAT_TMR,
            DRV_IO_INTENT_EXCLUSIVE);
        if ( DRV_HANDLE_INVALID != appData.heartbeatTimer )
        {
            DRV_TMR_AlarmRegister(appData.heartbeatTimer,
                APP_HEARTBEAT_TMR_PERIOD,
                APP_HEARTBEAT_TMR_IS_PERIODIC,
                (uintptr_t)&appData,
                APP_TimerCallback);
            DRV_TMR_Start(appData.heartbeatTimer);
            appData.state = APP_STATE_IDLE;
        }
        break;
    }

    case APP_STATE_IDLE:
    {
        break;
    }

    default:
    {
        break;
    }
}
```

The APP_HEARTBEAT_TMR macro identifies which instance of the Timer Driver was configured for its use. The APP_HEARTBEAT_TMR_IS_PERIODIC macro is mostly provided as documentation (heartbeat timer would always have to be periodic, so that value could be hard-coded), but it does help make the call to DRV_TMR_AlarmRegister easier to read and understand. The APP_HEARTBEAT_PORT and APP_HEARTBEAT_PIN macros define the I/O port pin that will be used to toggle the heartbeat indicator LED.

The APP_HEARTBEAT_TMR_PERIOD macro defines the counter period used to divide down the timer *alarm* (a.k.a., interrupt or match) period (which must be 16 bits to match the timer) and the APP_HEARTBEAT_COUNT_MAX macro defines how many times the heartbeat logic (which you will implement shortly) will count that alarm occurrence before it toggles the indicator LED. These macros are used, in combination with the system clock and timer prescale divisor settings, to define the indicator blink rate. The timers in the PIC32MZ2048ECM144 device receive their input clocks from peripheral bus clock 3 (PBCLK3). You can see this from the MHC's interactive clock diagram by looking at the PBCLK3 tab in the following diagram.

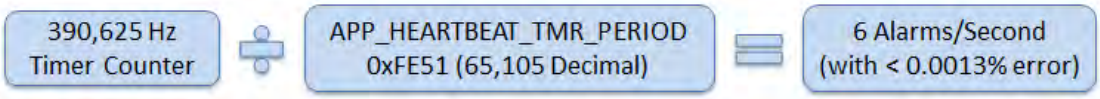


PBCLK3 was configured (by default) with a divisor of 2 from the system clock, and providing a 100 MHz input clock to the timers (based on the previously selected clock configuration settings). Next, observe that the timer prescale divisor was configured with a value of 256, as selected (again by default) in the Timer Driver instance 0 configuration settings, as shown in the following diagram.

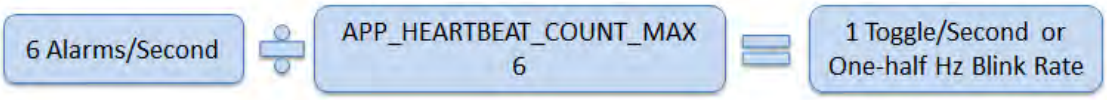


This allows you to calculate the timer counter rate as shown in the next diagram.

With this information and the knowledge that the alarm period must be 16 bits (to match the timer counter) as required by the parameter data type for the DRV_TMR_AlarmRegister function, you can determine (with a little trial and error) a large timer alarm period to minimize the number of alarm interrupts required while still giving a very small error, as shown in the following diagram.



With six alarms per second, you simply need to count alarm occurrences before toggling the indicator LED to give a nice leisurely heartbeat indicator blink rate.



The logic to count the heartbeat alarms must be implemented in the `app.c` file in the APP_TimerCallback function (as follows) because that is the function that was registered with the Timer Driver by the DRV_TMR_AlarmRegister function.

Timer Callback Function in app.c

```
static void APP_TimerCallback (  uintptr_t context, uint32_t  alarmCount )
{
    appData.heartbeatCount++;
    if (appData.heartbeatCount >= APP_HEARTBEAT_COUNT_MAX)
    {
        appData.heartbeatCount  = 0;
        appData.heartbeatToggle = true;
    }
}
```

In an interrupt-driven configuration of the Timer Driver (as was previously selected in the Timer Driver configuration options), this function will be called from an ISR context. Therefore, it must do a minimal amount of work and it must have no possibility of corrupting any data shared by the rest of the application. For this reason, the appData.HeartBeatCount variable (once initialized) must only be updated by this callback function. So, to signal that the application needs to toggle the heartbeat indicator LED, the callback function sets a Boolean flag (appData.heartbeatToggle) using an atomic (single-instruction) assignment statement, allowing the count variable to be ignored by the rest of the application logic.

With the heartbeat indicator's toggle rate managed independently by the timer driver, the APPS_Tasks function only needs to check the appData.heartbeatToggle flag and use the PORTS system service SYS_PORTS_PinToggle function to toggle the indicator LED pin (identified by the APP_HEARTBEAT_PORT and APP_HEARTBEAT_PIN macros).

Once the appData.heartbeatToggle flag is set, this logic will toggle the indicator pin and reset the flag (also done with an atomic single-instruction assignment). This could be done within the application's main switch statement, but that would complicate it unnecessarily once other states were added and the heartbeat indicator should run independently as a parallel (if extremely simple) state machine. Therefore, it is far better to implement this logic outside of the switch statement, but still within the APP_Tasks function, as shown in the following complete APP_Tasks function implementation.

Complete APP_Tasks Implementation in app.c

```
void APP_Tasks ( void )
{
    /* Signal the application's heartbeat. */
    if (appData.heartbeatToggle == true)
    {
        SYS_PORTS_PinToggle(PORTS_ID_0, APP_HEARTBEAT_PORT,
                            APP_HEARTBEAT_PIN);
        appData.heartbeatToggle = false;
    }

    /* Check the application's current state. */
    switch ( appData.state )
    {
        /* Application's initial state. */
        case APP_STATE_INIT:
        {
            appData.heartbeatTimer = DRV_TMR_Open( APP_HEARTBEAT_TMR,
                                                   DRV_IO_INTENT_EXCLUSIVE);
            if ( DRV_HANDLE_INVALID != appData.heartbeatTimer )
            {
                DRV_TMR_AlarmRegister(appData.heartbeatTimer,
                                      APP_HEARTBEAT_TMR_PERIOD,
                                      APP_HEARTBEAT_TMR_IS_PERIODIC,
                                      (uintptr_t)&appData,
                                      APP_TimerCallback);
                DRV_TMR_Start(appData.heartbeatTimer);

                appData.state = APP_STATE_IDLE;
            }
            break;
        }

        case APP_STATE_IDLE:
        {
            break;
        }
```

```
            default:
            {
                break;
            }
        }
    }
```

This implementation ensures that the heartbeat indicator blinks correctly when the APP_Tasks function is being called at a sufficient rate. However, if the main loop becomes blocked and the function is not called often enough, the heartbeat indicator will blink more slowly, change its duty cycle, or stop entirely even though the timer interrupts may continue to occur at the normal rate. This behavior makes it useful as an indicator of the health of the application's state machine.

As you develop the application logic, build, run, and test the project each time you add a new bit of functionality. If it does not behave as you expect, use the debugging capabilities supported by the MPLAB X IDE and the debugger interface you have to determine what the logic actually does, and then you can fix any incorrect behavior. Once you have a working heartbeat indicator, you have successfully created your first MPLAB Harmony project.

Summary

Summarizes the teachings of this tutorial and describes where to find additional help.

Description

This tutorial has demonstrated how to create a new MPLAB Harmony project, use the MHC to configure the processor clocks, ports, and other settings, and to enable and configure MPLAB Harmony libraries. It has also provided a good starting point for your own custom applications by providing an application health *heartbeat* indicator.

Although this tutorial performs only one pass through these steps, it is generally best to build up an application module-by-module, making multiple passes through this process as needed for each new library, module, or feature you add to your system. This allows you to build up your application one piece at a time and to test each new feature as your project develops into a complete solution.

Additional Information

You are now ready to begin developing your own MPLAB Harmony applications. Please refer to the following MPLAB Harmony Help volumes for additional information:

- Volume II: MPLAB Harmony Configurator (MHC) - For details on how to use and develop the MHC
- Volume III: MPLAB Harmony Development - For a better understanding of key concepts of MPLAB Harmony and additional information on how to develop your own libraries, drivers and other items for MPLAB Harmony
- Volume IV: MPLAB Harmony Framework Reference - For interface details and information on how to use the libraries provided in the MPLAB Harmony installation
- Volume V: Third-Party Products - For information on third party products provided with the MPLAB Harmony installation
- Volume VI: Utilities - For information on utilities (used during development and testing) that are provided with the MPLAB Harmony installation

Enjoy!

Using MHC Application Templates to Create an Application

This tutorial guides you through the process of using the MPLAB Harmony Configurator (MHC) application templates to develop a MPLAB Harmony application.

Description

The MHC provides Application Templates that can be used to create a baseline working project (i.e., application).

In this tutorial, the project will be minimal, but will be able to perform a high-level function (e.g., transmit a string with a fully configured USART) without a lot of peripheral configuration and connecting code together.

The software module connections are made by the precoded application templates. These templates generate one (or more) specific applications based on the module(s) chosen (i.e., USART, SPI).

This tutorial will describe the process for using MHC to choose 'Application Templates', choose a function (e.g., USART transmit) and generate the code in less than a minute and be running 'Hello World'.

- Step 1: Select Your Application Template
- Step 2: Save the Configuration
- Step 3: Generate the Code
- Step 4: Build the Code
- Step 5: Building on the Application Template
- Step 6: Integrating Multiple Modules
- Step 7: Creating Multiple Applications
- Step 8: Application Peripheral Integrity

Once you have a working application, you can modify it further to provide a more specific application to suit your needs.

Prerequisites and Assumptions

Describes the prerequisites for starting this tutorial and the assumptions made when it was written.

Description

Before beginning this tutorial, ensure that you have installed the MPLAB X IDE and necessary language tools as described in *Volume I: Getting Started With MPLAB Harmony* > *Prerequisites*. In addition, an appropriate hardware platform is required.

The example project in this tutorial utilizes the PIC32MZ Embedded Connectivity (EC) Starter Kit. In the event you do not have this development hardware, refer to the *Volume I: Getting Started With MPLAB Harmony* > *Supported Development Boards* section for a list of available development boards that you could use to complete this tutorial.

To complete this tutorial you will need to know the following about your selected hardware platform:

- The name of the PIC32 device it uses
- The Primary Oscillator input clock frequency and desired processor clock frequency
- The debugger interface settings
- The input clock source and frequency for the timer selected to blink the indicator LED

Please refer to the documentation for the selected hardware platform and PIC32 device for this information, as described in *Volume I: Getting Started With MPLAB Harmony* > *Guided Tour* > *Documentation*.

Finally, this tutorial assumes that you have some familiarity with the following; however, you should be able to follow the directions in this tutorial with very little experience:

- MPLAB X IDE development and debugging fundamentals
- C language programming
- PIC32 product family and supported development boards

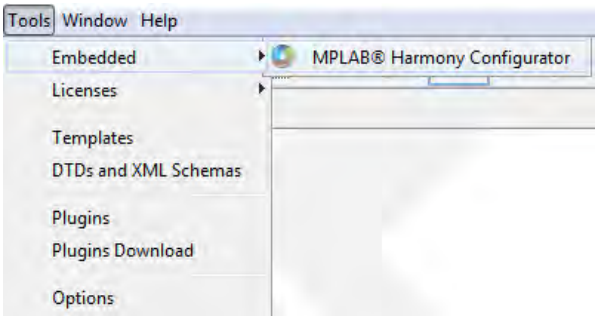
Step 1: Select Your Application Template

Describes opening MHC and selecting your application.

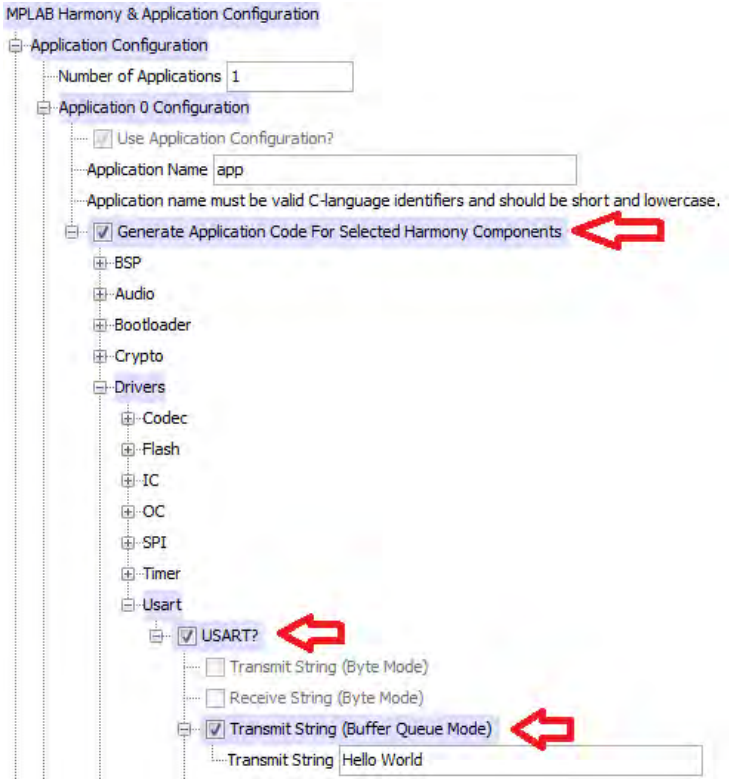
Description

Perform the following steps to select your application template:

1. In MPLAB X IDE, start the MPLAB Harmony Configurator (MHC) by selecting *Tools* > *Embedded* > *MPLAB Harmony Configurator*.



2. Within MPLAB Harmony & Application Configuration, expand *Application Configuration* > *Application 0 Configuration* and make the selections shown in the following figure.

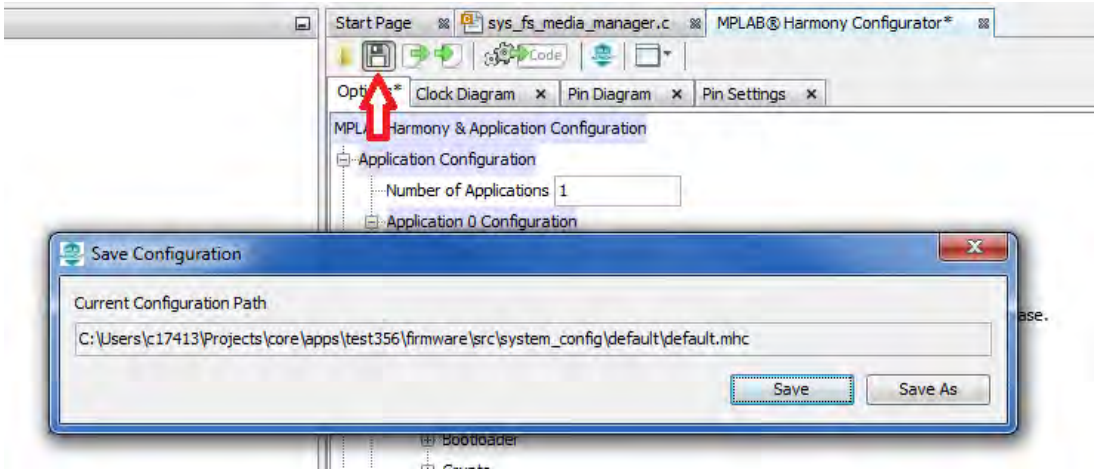


Step 2: Save the Configuration

Describes saving the application.

Description

After making the initial selections, save the configuration by clicking the Save icon, and then clicking **Save**, as shown in the following figure.

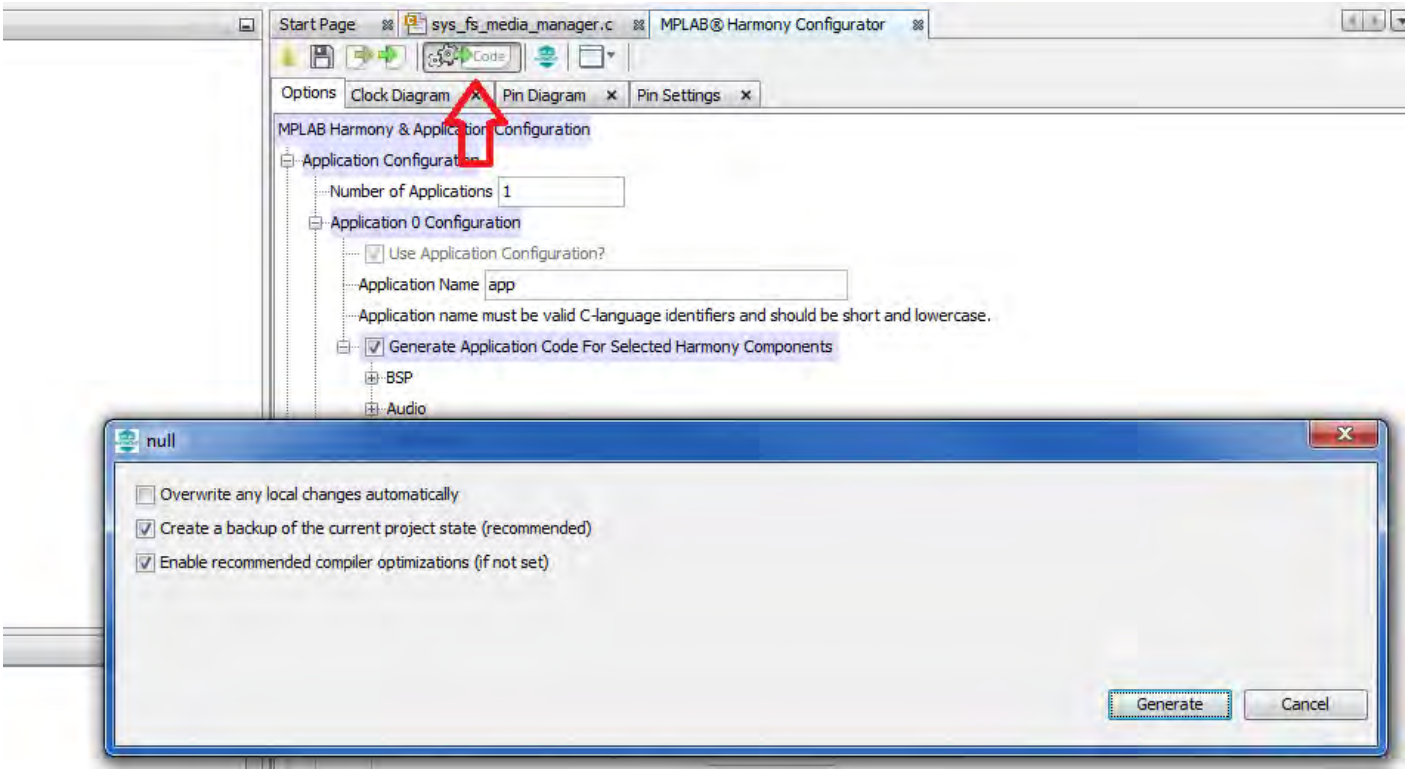


Step 3: Generate the Code

Describes how to generate the code for the new application.

Description

Next, generate the application code by clicking the Generate Code icon, and then clicking **Generate**, as shown in the following figure. Code generation should complete without errors. You now have a code base that is ready to be built.

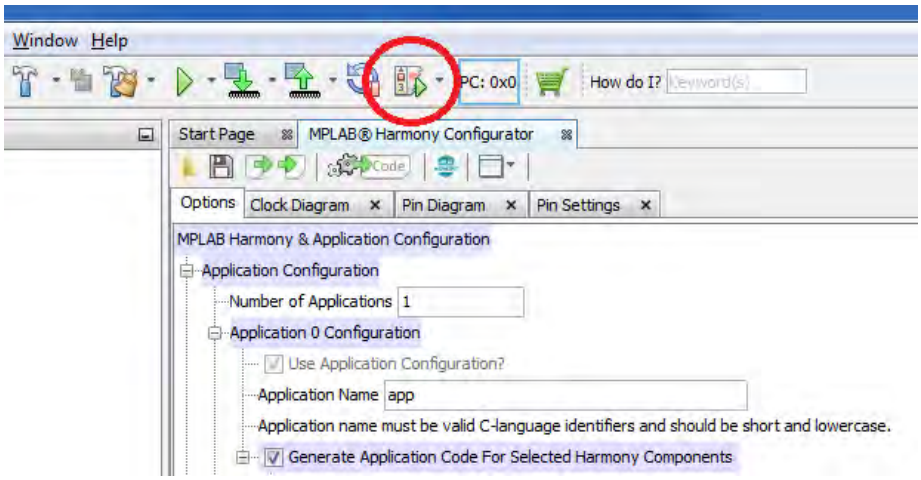


Step 4: Build the Code

Describes how to build and debug the application code.

Description

The next step is the build and start a debug session by clicking the Debug icon, as shown in the following figure. Once the application is running, refer to the Help for the specific application template to see the results.



Step 5: Building on the Application Template

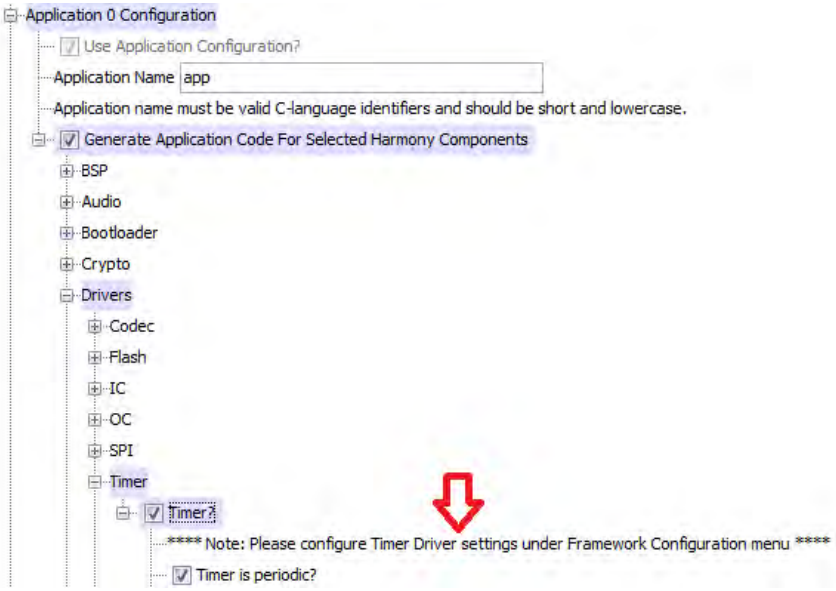
Describes how to build on the existing application template by modifying the configuration and template parameters.

Description

Modifying Configurations

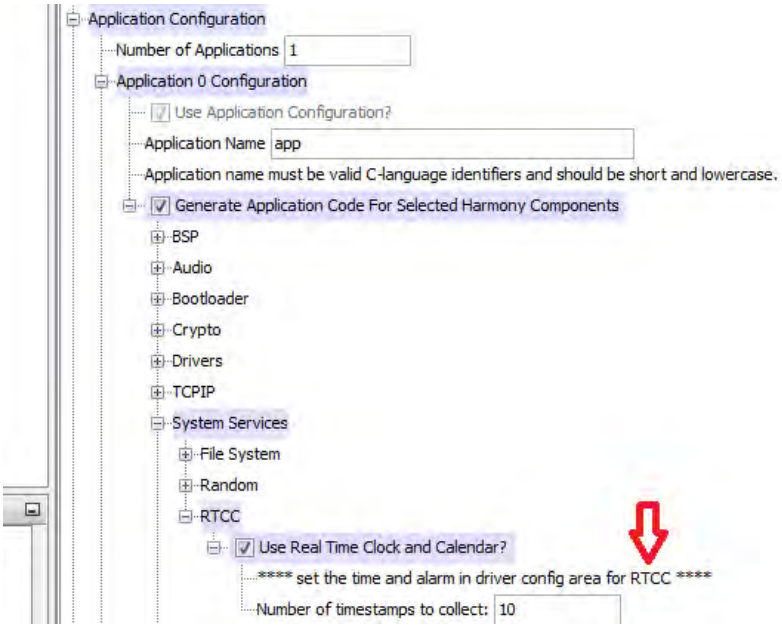
The configuration for supporting peripherals can be changed to new values, and then new code can be generated. For example, change the baud rate for the USART or change the alarm time mask for the RTCC.

Some application templates require that supporting modules be modified to be used. These templates will have a comment in the configuration menu that will state where the configuration change should be made, as shown in the following figure.



Changing Template Parameters

Some templates have parameters that can be changed, as shown in the following figure.



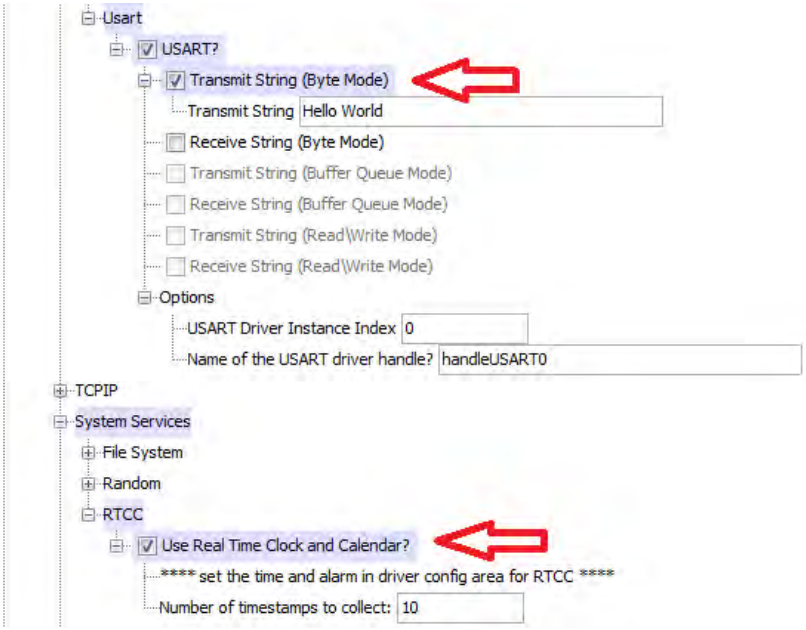
Step 6: Integrating Mutiple Modules

Describes how to integrate multiple modules into your application.

Description

When building an application, it is possible to select more than one module. For example, you can choose the SPI and USART modules in one application and modify the code with multiple modules to communicate with each other as producers and consumers.

As an example, the RTCC System Service can be added to the project as a producer, as shown in the following figure.



After regenerating the code, modify the APP_RTCC_TIMESTAMP_Callback function to make it a 'producer'. This function will put data into the array that the USART task checks. Then, modify the USART task to be the 'consumer'. Note that the RTCC state machine will never quit because the code that increments the index for the timestamp array has been abandoned.

```
void APP_RTCC_TIMESTAMP_Callback(SYS_RTCC_ALARM_HANDLE handle, uintptr_t context)
{
    /* save typing and help readability */
    timestampsT *times = (timestampsT *)context;

    /* the handle will tell us it is our handle – check data sent */
    if ((handle == appHandle) && times && !appData.tx_count)
    {
        SYS_RTCC_BCD_TIME timestamp;
        SYS_RTCC_STATUS status = SYS_RTCC_TimeGet(&timestamp);
        if (SYS_RTCC_STATUS_OK == status)
        {
            /* get the seconds out that is in BDC and set the flag */
            app_tx_buf[0]= ((timestamp >> 8) & 0xF) + '0';
            appData.tx_count = 1;
        }
    }
}
```

Modify the USART_Task so that it watches the tx_count, which is now just a flag for data present. If there is data, it will be sent out the USART and tx_count will be marked as clear. By default, the RTCC System Service is only running once per second.

```
static void USART_Task (void)
{
   if (appData.tx_count)
       {
           if(!DRV_USART_TransmitBufferIsFull(appData.handleUSART0))
           {
            DRV_USART_WriteByte(appData.handleUSART0, app_tx_buf[0]);
            appData.tx_count = 0;
        }
       }
}
```

Now the USART will output 0-9 at each second.

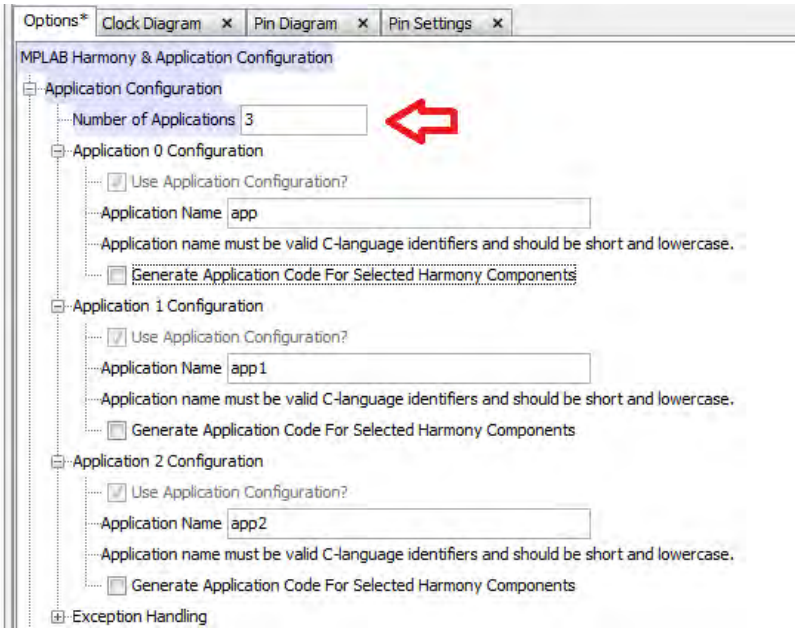
Step 7: Creating Multiple Applications

Provides information on creating multiple applications.

Description

With MHC, it is possible to create up to 10 applications. Using multiple applications allows you to perform multiple operations at the same time. For example, you can have one application read from the file system and another application can write to the file system.

Each application has its own state machine and variables with independent data scope of each other. The state machines of the individual applications run ‘concurrently’ with one state machine being called, and then the next instead of having one state machine to do all the work. This allows separating the work into more logical and understandable ‘chunks’.

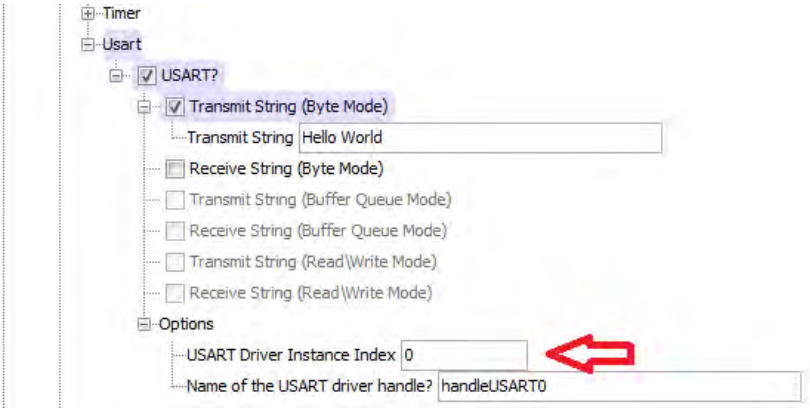


Step 8: Application Peripheral Integrity

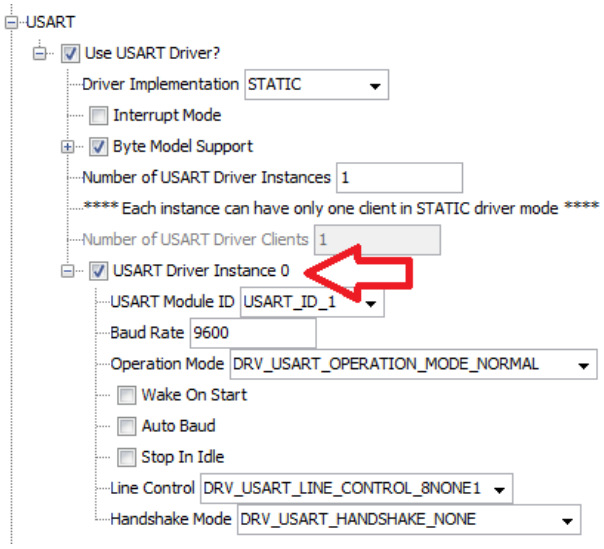
Describes application templates that have peripherals associated by 'instances'.

Description

Some of the application templates have peripherals associated by ‘instances’. These peripheral instances need to be configured in their respective section of the configuration tool. Make sure the peripheral instance specified in the application template configuration matches the instance number in the peripheral configuration. For the USART Application Template section the following option should be set:



Next, connect to USART driver configuration:



Summary

Summarizes the teachings of this tutorial and describes where to find additional help.

Description

The application templates described in this tutorial are no substitute for good engineering and design in a large project, but are a valuable start to a project by providing configuration, initialization, ‘glue’ and an execution loop.

Break up your application into logical parts and select which parts need to be together (consume and produce) and which may benefit from being separate. Use multiple applications to support separate, unrelated functionality and combine both for a complex solution.

Additional Information

Please refer to the following MPLAB Harmony Help volumes for additional information:

- Volume II: MPLAB Harmony Configurator (MHC) - For details on how to use and develop the MHC
- Volume III: MPLAB Harmony Development - For a better understanding of key concepts of MPLAB Harmony and additional information on how to develop your own libraries, drivers and other items for MPLAB Harmony
- Volume IV: MPLAB Harmony Framework Reference - For interface details and information on how to use the libraries provided in the MPLAB Harmony installation
- Volume V: Third-Party Products - For information on third party products provided with the MPLAB Harmony installation
- Volume VI: Utilities - For information on utilities (used during development and testing) that are provided with the MPLAB Harmony installation

Enjoy!

Quick Start Guides

This section provides brief user material to enable users to get started quickly with a process or procedure.

Graphics and Touch Quick Start Guides

Provides information on how to create a new touch input-enabled project using the MPLAB Harmony Graphics Composer.

PIC32MX USB Starter Kit II Plus MEB

Provides information on how to create a new touch input-enabled project for the PIC32MZ USB Starter Kit II and the Multimedia Expansion Board (MEB) using the MPLAB Harmony Graphics Composer.

Description

Use the following steps to create a new MPLAB Harmony project with touch input capability for your MPLAB Harmony graphics.

1. Create a new MPLAB Harmony project using the instructions provided in Step 1: Create the New Project and select the PIC32MX795F512L as the device.
2. Perform the following configuration changes in the MHC Tree:
   - Use BSP, selecting PIC32MX USB Starter Kit 2 w\Multimedia Expansion Board
   - Graphics Library > Harmony Graphics Library > Use Graphics Library > set to enable
   - Graphics Library > Harmony Graphics Library > Use Graphics Library > Use MPLAB Harmony Graphics Composer Design > set to enable
   - Graphics Library > Harmony Graphics Library > Use Graphics Library > Use Input Devices? > set to enable
   - Graphics Library > Harmony Graphics Library > Use Graphics Library > Use Input Devices? > Enable Touchscreen Support > set to enable
3. You are now ready to use the MPLAB Harmony Graphics Composer to design your touch-enabled graphics user interface. See the Getting Started section in the *MPLAB Harmony Graphics Composer User's Guide* for additional information.

Additional Details

To provide this level of ease-of-use, the MHC Tree is built-in with some auto-configuration features. The following provides a detailed explanation of what exactly is going on "under-the-hood".

This section involves some basic knowledge of the workings of HConfig. See *Volume I: MPLAB Harmony Configurator (MHC > MPLAB Harmony Configurator Developer's Guide* > hconfig Files for additional information.

To see how the auto-configuration logic is setup, you may want to review the file `bsp\config\DS60001156.hconfig`, specifically at the definition for the hconfig Boolean variable, `BSP_PIC32MX_USB_SK2_MEB`.

```
config BSP_PIC32MX_USB_SK2_MEB
    depends on USE_BSP
    depends on DS60001156
    select BSP_TRIGGER
    select BSP_JTAG
    select BSP_POSC_8MHz
    select USE_GFX_TRULY_32_240X320_NEEDED if BSP_GRAPHICS_NEEDED
    select USE_DRV_GFX_SSD1926_NEEDED if BSP_GRAPHICS_NEEDED
    select USE_DRV_TOUCH_ADC10BIT_NEEDED if BSP_TOUCH_INPUT_NEEDED
    bool "PIC32MX USB Starter Kit 2 w/ Multimedia Expansion Board (MEB)"
```

Focusing on the bold lines in the previous code example, when the BSP selection for the PIC32MX USB Starter Kit II with the Multimedia Expansion Board is made, the LCD performance specification and touch driver technology requirement can be inferred by the MHC Tree.

When the 'Use Graphics Library' option is enabled, the MHC Tree enables the Truly 3.2-inch 240x320 (QVGA) display support (*Drivers > Graphics Display*). For the display controller driver, the SSD1926 and SSD1289 are enabled (*Drivers > Graphics Controller*).

The MPLAB Harmony Graphics Composer also updates its display screen size to match.

When 'Enable Touchscreen' is enabled, the MHC Tree enables the 10-bit ADC Resistive Touch driver (*Driver -> Touch -> ADC10BIT*).

Three system services are needed to support the 10-bit ADC Touch driver. These are the Touch System Service, the Message System Service and the Interrupt System Service, which are also enabled automatically because they are a dependency for the ADC 10-bit Resistive Touch Driver. To review the logic, you may want to review the files under `framework\system\touch\config\sys_touch.hconfig`, `framework\system\msg\config\sys_msg.hconfig`, and `framework\system\int\config\sys_int.hconfig`.

PIC32MZ Plus MEB II

Provides information on how to create a new touch input-enabled project for the PIC32MZ Embedded Connectivity with Floating Point Unit (EF) Starter Kit and the Multimedia Expansion Board II (MEB II) with the 4.3" WVQGA PCAP Display using the MPLAB Harmony Graphics Composer.

Description

Use the following steps to create a new MPLAB Harmony project with touch input capability for your MPLAB Harmony Graphics Composer design.

1. Create a new MPLAB Harmony project using the instructions provided in *MPLAB Harmony Configurator User's Guide* > *Using MHC to Create a New Application* > Step 1: Create the New Project and select the PIC32MZ2048ECM144 as the device.
2. Perform the following configuration changes in the MHC Tree:
   - Use BSP, selecting PIC32MZ EC Starter Kit w/Multimedia Expansion Board (MEB) II
   - Graphics Library > Use Graphics Library > set to enable
   - Graphics Library > Use Graphics Library > Use MPLAB Harmony Graphics Composer Design > set to enable
3. Next, set Pin Manager > Map External Interrupt 1 (INT1) to Pin 23 (RE8). Refer to the *MPLAB Harmony Configurator User's Guide* > MPLAB Harmony Graphical Pin Manager section for assistance.
4. You are now ready to use the MPLAB Harmony Graphics Composer to design your touch-enabled graphics user interface. See the Getting Started section in the *MPLAB Harmony Graphics Composer User's Guide* for additional information.

Additional Details

To provide this level of ease-of-use, the MHC Tree is built-in with some auto-configuration features. The following provides a detailed explanation of what takes place "under the hood".

This section involves some basic knowledge of the workings of HConfig. See *Volume I: MPLAB Harmony Configurator (MHC* > *MPLAB Harmony Configurator Developer's Guide* > hconfig Files for additional information.

To see how the auto-configuration logic is setup, you may want to review the file `bsp\config\DS60001320.hconfig`, specifically at the definition for the hconfig Boolean variable BSP_PIC32MZ_EF_SK_MEB2.

```
config BSP_PIC32MZ_EF_SK_MEB2
    depends on USE_BSP
    depends on DS60001320
    select BSP_TRIGGER
    select BSP_POSC_24MHz
    select BSP_USE_USBSWITCH
    select USE_GFX_NEWHAVEN_43_480X272_PCAP_NEEDED if BSP_GRAPHICS_NEEDED
    select USE_DRV_GFX_LCC_NEEDED if BSP_GRAPHICS_NEEDED
    select USE_DRV_TOUCH_MTCH6301_NEEDED if BSP_TOUCH_INPUT_NEEDED
    select DRV_I2C_BIT_BANG_NEEDED if BSP_TOUCH_INPUT_NEEDED
    set DRV_TOUCH_MTCH6301_INTERRUPT_SOURCE to "INT_SOURCE_EXTERNAL_1" if BSP_TOUCH_INPUT_NEEDED &&
      BSP_PIC32MZ_EF_SK_MEB2_WVGA
    set EXT_INT_PERIPHERAL_ID_IDX0 to "INT_EXTERNAL_INT_SOURCE1" if BSP_TOUCH_INPUT_NEEDED &&
      BSP_PIC32MZ_EF_SK_MEB2
    set EXT_INT_PRIORITY_IDX0 to "INT_PRIORITY_LEVEL5" if BSP_TOUCH_INPUT_NEEDED &&
      BSP_PIC32MZ_EF_SK_MEB2
    set EXT_INT_POLARITY_IDX0 to "INT_EDGE_TRIGGER_RISING" if BSP_TOUCH_INPUT_NEEDED &&
      BSP_PIC32MZ_EF_SK_MEB2
    bool "PIC32MZ EF Starter Kit w/ Multimedia Expansion Board (MEB) II"
```

Focusing on the bold lines in the previous code example, when the BSP selection for the PIC32MZ EF Starter Kit with the Multimedia Expansion Board II is made, the LCD performance specification and touch driver technology requirement can be inferred by the MHC Tree.

When the 'Use Graphics Library' option is enabled, the MHC Tree enables the NewHaven 4.3-inch 480x272 (WQVGA) with PCAP display support (*Drivers* > *Graphics Display*). For the display controller driver, the Low-Cost Controllerless (LCC) driver is enabled (*Drivers* > *Graphics Controller*).

MPLAB Harmony Graphics Composer also updates its display screen size to match.

When 'Enable Touchscreen' is enabled, the MHC Tree enables the MTCH6301 Touch driver (*Driver* > *Touch* > *MTCH6301*). The MTCH6301 Touch Driver has a dependency on the I2C peripheral operating in bit-bang interrupt mode. Therefore, these options are also enabled.

Three system services are needed to support the touch input stack. These are the Touch System Service, the Message System Service and the Interrupt System Service (*System Service* > *Touch, System Service* > *Message, System Service* > *Interrupt*). Since the interrupt for the PCAP touch is external, the external interrupt option is required. All of these are also enabled automatically because they are a dependency for the MTCH6301Touch Driver. To review the logic, you may want to review the files within `framework\system\touch\config\sys_touch.hconfig`, `framework\system\msg\config\sys_msg.hconfig`, and `framework\system\int\config\sys_int.hconfig`.

Note the use of the 'set' command to establish values for some of the hconfig variables.

External Interrupt Source 1 is set because the EXT1 module provides a means to map the PCAP touch interrupt to pin 23 via PPS.

The priority levels of the touch interrupt and the LCC DMA interrupt are set at their values respective to ensure the I2C bit-bang driver (default interrupt priority level 6) can receive adequate processing time.

Each component has various configuration settings that default to our suggested settings. They are made available for you to configure if needed.

The intent here is for this to serve as a template for setting up the BSP for your own board.

Display Manager Quick Start Guide

Provides information on how to use the MPLAB Harmony Display Manager plug-in to configure graphics display and graphics controller settings.

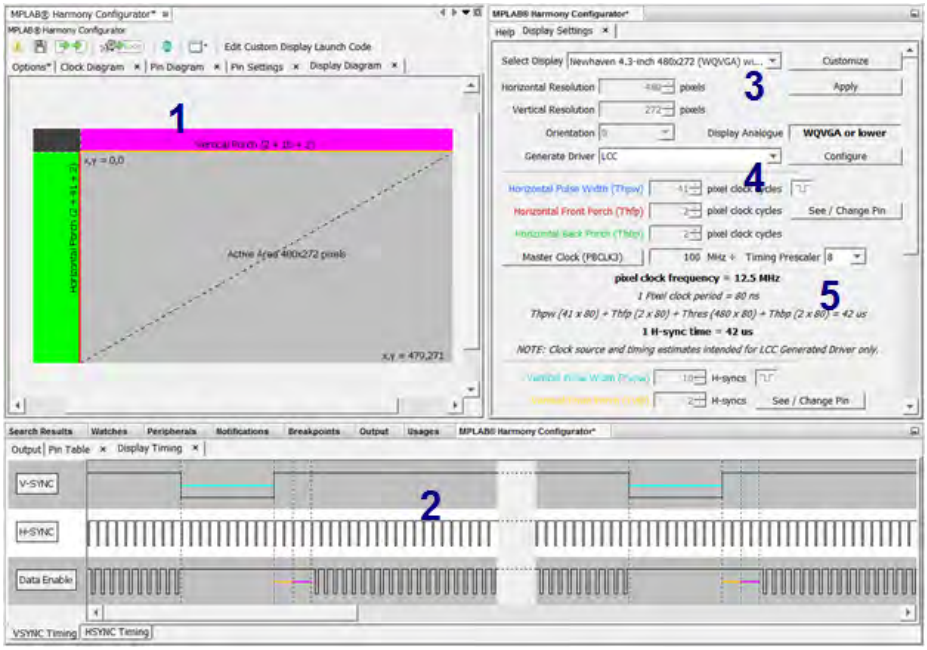
Features

Provides a brief overview of the various features of the MPLAB Harmony Display Manager plug-in.

Description

For detailed information on the Display Manager, please refer to *Volume II: MPLAB Harmony Configurator (MHC) > MPLAB Harmony Display Manager User's Guide*.

The following figure illustrates the Display Manager screen. Descriptions for each numbered area follow the figure.



1. **Active Area / Hidden Area Diagram** – This mimics the display active area transposed over the hidden area as often shown in display data sheets. It also provides a simulation of how the display behaves on the hardware.
2. **Display Timing Simulation** – These timing diagrams simulate the display timing and can be used as a reference to the timing diagrams often shown in display data sheets. It also provides a simulation of the behavior of the graphics controller (**Note:** Currently, the only graphics controller supported is the LCC).
3. **Display Selection** – This is the area to select a display currently supported by the Harmony framework. To set up your own display, select **Customize**.
4. **Generate Controller Driver Selection** – Select the desired graphics controller for generating a driver (**Note:** For the current release, only the LCC driver is supported).
5. **Display / Graphics Controller Settings** – The goal of the Display Manager is to abstract the essential settings needed to support a new graphics display. The settings shown in the Display Settings window reflect the timing characteristics that allow the graphics controller to support the display. For a detailed walk-through of these settings, please refer to the MPLAB Harmony Display Manager User's Guide.

Support

This section provides support information for MPLAB Harmony.

Using the Help

This topic contains general information that is useful to know to maximize using the MPLAB Harmony help.

Description

Help Formats

MPLAB Harmony Help is provided in three formats:

- Stand-alone HyperText Markup Language (HTML)
- Microsoft Compiled HTML Help (CHM)
- Adobe® Portable Document Format (PDF)

TIP! When using the MPLAB Harmony Help PDF, be sure to open the "bookmarks" if they are not already visible to assist in document navigation. See Using the Help for additional information.

Help File Locations

Each of these help files are included in your installation of MPLAB Harmony in the following locations:

- HTML - `<install-dir>/doc/html/index.html`
- CHM - `<install-dir>/doc/help_harmony.chm`
- PDF - `<install-dir>/doc/help_harmony.pdf`

Refer to Help Features for more information on using each output format.

Where to Begin With the Help

The help documentation provides a comprehensive source of information on how to use and understand MPLAB Harmony. However, you don't need to read the entire document before you start working with MPLAB Harmony.

Prior to using MPLAB Harmony, it is recommended to review the Release Notes for any known issues. A PDF copy of the release notes is provided in the `<install-dir>/doc` folder of your installation.

New Users

If you are completely new to MPLAB Harmony, it is best to follow the Guided Tour provided in *Volume I: Getting Started With MPLAB Harmony*.

Experienced Users

If you are already somewhat familiar with the MPLAB Harmony installation and online resources and you want to jump right into a specific topic, you can follow the links provided in the table in *Volume 1: Getting Started With MPLAB Harmony* > *Guided Tour*.

Trademarks

Provides information on trademarks used in this documentation.

Description

Trademarks

01/25/2016

Typographic Conventions

This topic describes the typographic conventions used in the MPLAB Harmony Help.

Description

The MPLAB Harmony Help uses the following typographic conventions:

Convention	Represents	Example
TIP!	Provides helpful information to assist the user.	**TIP!** Throughout this documentation, occurrences of `<install-dir>` refer to the default MPLAB Harmony installation path, which is: `C:/microchip/harmony/<version>`.
Note:	Provides useful information to the user.	**Note:** Refer to the individual Release Notes for the libraries and demonstrations for details on changes from the previous release of MPLAB Harmony.
Important!	Provides important information to the user.	**Important!** This tutorial is based on the PIC32MZ Embedded Connectivity (EC) Starter Kit. If you are using a different hardware platform, you may need to change some of the settings used in the tutorial (such as timer selection and clock rates) to appropriate values for your platform.
Warning	Warns the user of a potentially harmful issue.	**Warning** The cause of the interrupt must be removed before clearing the interrupt source or the interrupt may reoccur immediately after the source is cleared potentially causing an infinite loop. An infinite loop may also occur if the source is not cleared before the interrupt-handler returns.
MHC Followed by ***Green italicized*** text	Indicates a process step that is automated by the MPLAB Harmony Configurator (MHC).	**MHC** ***Throughout the documentation, when you see this icon, it indicates that the MHC automates the associated task(s).***
Italic Characters	Referenced documentation and emphasized text.	• *MPLAB X IDE User's Guide* • ...is the *only* option.
Initial Capitalization	• A window • A dialog • A menu selection	• the Output window • the SaveAs dialog • the Enable Programmer menu
Quotation Marks	A field name in a window or dialog.	"Save project before build"
Italic text with right angle bracket	A menu path.	*File > Save*
Bold Characters	• Topic headings • A dialog button	• **Prerequisites** • Click **OK**
Courier New text enclosed in angle brackets	A key on the keyboard.	Press `<Ctrl><V>`.
Courier New text	• Sample source code • File names • File paths	• `#define START` • `system_config.h` • `<install-dir>/apps/examples`
Square Brackets	Optional arguments.	`command [options] file [options]`
Curly Braces and Pipe Character	Choice of mutually exclusive arguments; an OR selection.	`errorlevel {0|1}`

Recommended Reading

The following Microchip documents are available and recommended as supplemental reference resources.

Description

Using the MPLAB Harmony Help Documentation

If you are new to MPLAB Harmony, read the Understanding MPLAB Harmony section and follow the Creating Your First Project tutorial to create your first MPLAB Harmony application.

For an overview of the libraries, demonstration projects, and other resources provided in the MPLAB Harmony installation, review the tables in the **Release Contents** section of the MPLAB Harmony Release Notes. A PDF copy of the Release Notes is provided in the `<install-dir>/doc`

folder of your installation.

Refer to the Applications Help section for more information on the demonstration projects and the Framework Reference section for more information on the libraries that make up the MPLAB Harmony framework. There are also help sections available for the third-party material, board support packages, and prebuilt libraries that you should review for more information on each of those items.

The help documentation for each MPLAB Harmony library is organized into common topics:

- **Introduction** - This section provides a brief description of the library for those who are new to it
- **Using the Library** - Read this section to understand the library's usage model and see examples of how to use the library's interface functions to create the solutions you need
- **Files**, **Building the Library**, and **Configuring the Library** - These sections describe how to add the library to your project and configure it for your desired usage
- **Library Interface** - This section provides a convenient programmer's reference dictionary of the library's interface functions, data types, and constants with a convenient hyper-linked summary table. Use it while you are developing your own applications.

PIC32 Family Reference Manual Sections

PIC32 Family Reference Manual sections are available, which explain the operation of the PIC32 microcontroller family architecture and peripheral modules. The specifics of each device family are discussed in the individual family's device data sheet.

To access this documentation, please visit, http://www.microchip.com/pic32/ and click **Documentation**. Then, expand **Reference Manual** to see the list of available sections.

PIC32 Device Data Sheets

Refer to the appropriate device data sheet for device-specific information and specifications.

Reference information found in these data sheets includes:

- Device memory maps
- Device pin out and packaging details
- Device electrical specifications
- List of peripherals included on the devices

To access this documentation, please visit, http://www.microchip.com/pic32/ and click **Documentation**. Then, expand **Data Sheets** to see the list of available documents.

MPLAB® XC32 C/C++ Compiler User's Guide (DS50001686)

This document details the use of Microchip's MPLAB XC32 Compiler for PIC32 microcontrollers to develop 32-bit applications. Please visit the Microchip website to access the latest version of this document.

MPLAB® X IDE User's Guide (DS50002027)

Consult this document for more information pertaining to the installation and implementation of the MPLAB X IDE software. Please visit the Microchip website to access the latest version of this document.

Documentation Feedback

This topic includes information on how to provide feedback on this documentation.

Description

Your valuable feedback can be provided to Microchip in several ways. Regardless of the method you use to provide feedback, please include the following information whenever possible:

- The Help platform you are viewing:
  - Adobe® Portable Document Format (PDF)
  - Windows® Compiled Help (CHM)
  - HyperText Markup Language (HTML)
- The title of the topic and the section in which it resides
- A clear description of the issue or improvement

How To Send Your Feedback

It is preferred that you use one of the following two methods to provide your feedback:

- Through the Documentation Feedback link, which is available in the header and footer of each topic when viewing compiled Help (CHM) or HTML Help
- By email at: docerrors@microchip.com

If either of the two previous methods are inconvenient, you may also provide your feedback by:

- Contacting your local Field Applications Engineer
- Contacting Customer Support at: http://support.microchip.com

Help Features

Describes the features available in the Help files provided in MPLAB Harmony.

Description

Cross-document Linking

The six MPLAB Harmony PDF volumes that are available for separate download from the MPLAB Harmony website provide cross-document links. To ensure that the cross-document links resolve correctly, all six volumes must reside in the same folder. If you choose to copy the files to another location, all volumes must exist in that same folder to enable the cross-document linking.

Refer to PDF Help Features for additional information on cross-document linking and PDF page navigation.

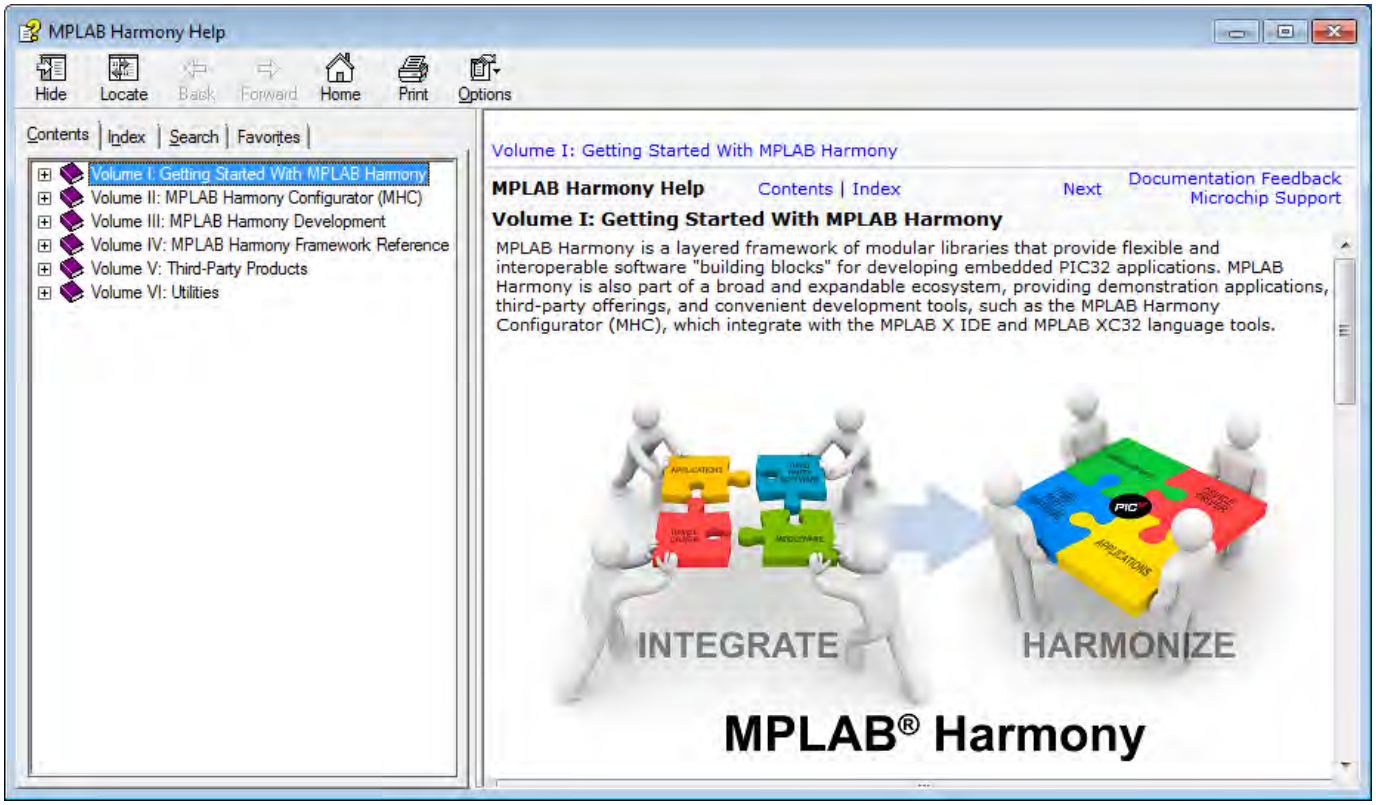
CHM Help Features

Provides detailed information on the features available in the CHM Help file.

Description

The MPLAB Harmony CHM file (`<install-dir>/doc/help_harmony.chm`) provides many useful features for accessing Help content. Figure 1 shows the initial Help window.

Figure 1: Initial CHM Help View



Help Icons

Several icons are provided in the interface of the Help, which aid in accessing the Help content.

Table 1: Help Icon Features

Help Icon	Description
Hide Show	Use the Hide icon to turn off the left Help pane. Once the Hide icon is selected, it is replaced with the Show icon. Clicking the Show icon restores the left Help pane.
Locate	Use the Locate icon to visually locate the Help topic you are viewing in the Contents. Clicking the Locate icon causes the current topic to be highlighted in blue in the Contents pane.
Back	Use the Back icon to move back through the previously viewed topics in the order in which they were viewed.

Forward	Use the Forward icon to move forward through the previously viewed topics in the order in which they were viewed.
Home	Use the Home icon to return to the first topic in the Help.
Print	Use the Print icon to print the current topic or the selected heading and all subtopics.
Options	Use the Options icon to: • Hide tabs • Locate a topic • Go Back, Forward, and Home • Stop • Refresh • Set Internet Explorer options • Print topics • Turn Search Highlight Off and On

Topic Window

The Topic Window displays the current topic. In addition to the Help content, special links are provided in the upper portion of the window, as shown in Figure 2. Table 2 lists and describes the different links by their category

Figure 2: Help Links

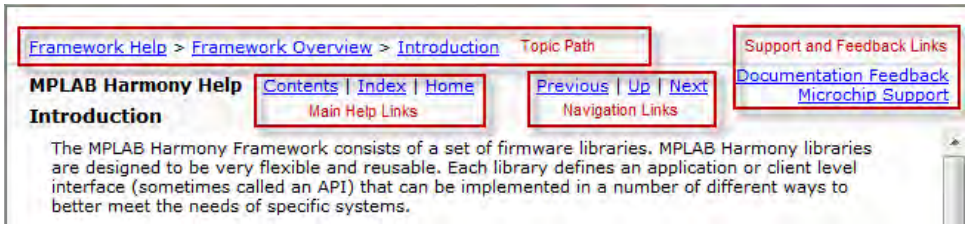


Table 2: Help Links

Link Category	Description
Topic Path	The full path of the current topic is provided at the top and bottom of each topic, beginning with the top-level section name.
Support and Feedback Links: • Documentation Feedback • Microchip Support	 Click this link to send feedback in the form of an email (see **Note 1**). Click this link to open the Microchip Support Web page.
Main Help Links: • Contents • Index • Home	 Click this link to open the Contents in the left pane. Click this link to open the Index in the left pane (see **Note 2**). Click this link to go to the initial Help topic (see **Note 2**).
Navigation Links: • Previous • Up • Next	 Click this link to go back to the previously viewed topic. Click this link to go to the parent section of the topic. Click this link to go to the next topic.

Notes:

1. To use the *Documentation Feedback* link, you must have an email system, such as Outlook configured. Clicking the link automatically opens a new email window and populates the recipient and subject lines.
2. The *Home* and *Index* links do not appear initially. Once you begin traversing the topics, they dynamically appear.

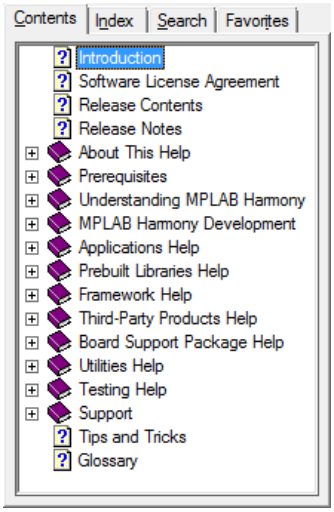
Tabs

The CHM Help provides four Tabbed windows: *Contents*, *Index*, *Search*, and *Favorites*.

Contents

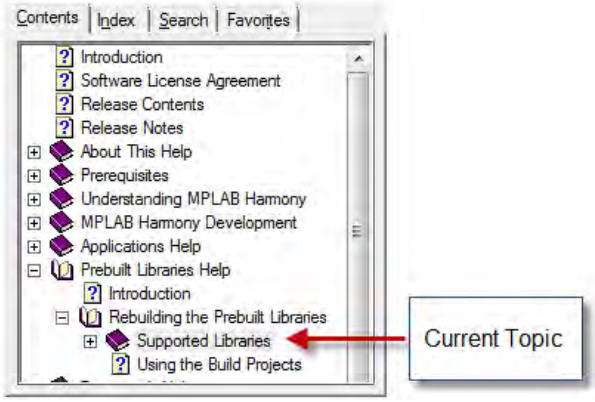
The Contents tab displays the top-level topics/sections. Figure 3 shows the initial view when the CHM Help is first opened.

Figure 3: Initial Contents Tab View



As topics are explored, the information in the Contents tab dynamically updates. For example, by clicking **Prebuilt Libraries Help** and using the Next link in the current topic to traverse through this section, the collapsed section automatically expands and the current topic is highlighted in light gray, as shown in Figure 4.

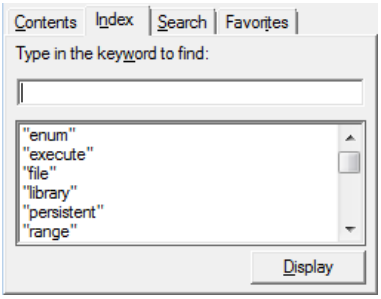
Figure 4: Current Topic Highlighting



Index

Clicking the Index tab results in an alphabetic list of all Help index entries. Figure 5 shows the default Index interface.

Figure 5: Default Index Interface

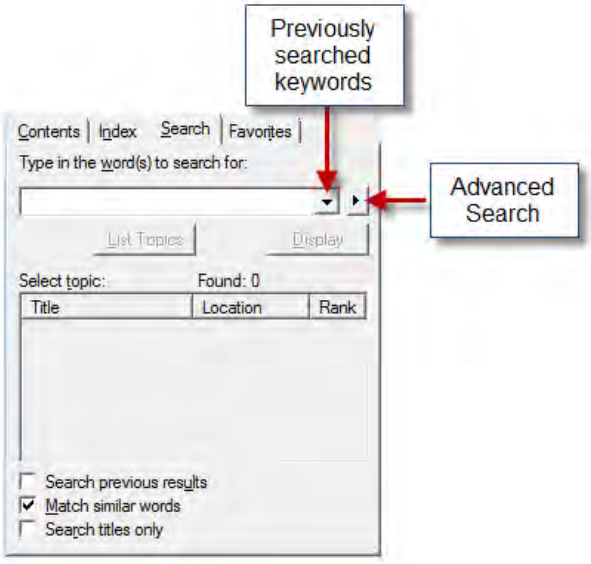


- To locate a specific entry, enter the keyword in the *Type in the keyword to find:* box. As you type, the index list dynamically updates.
- To display the desired item in the list, select the item and click **Display**, or double-click the desired item. The related content appears in the Help window.

Search

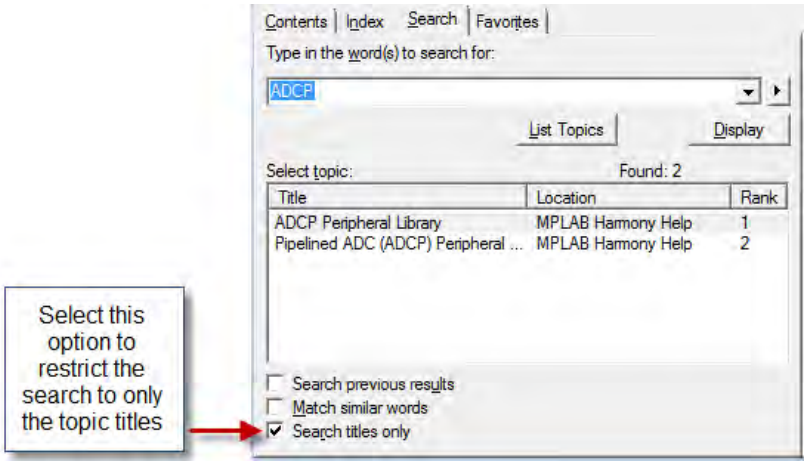
Clicking the Search tab provides an efficient way to find specific information. Figure 6 shows the default Search interface.

Figure 6: Default Search Interface



- Enter the specific word or words in the *Type in the word(s) to search for:* box
- Clicking the drop-down arrow provides the list of previously searched words
- The right arrow provides Advanced Search options: AND, OR, NEAR, and NOT
- Located at the bottom left of the Search window, three options are provided to narrow-down your search. By default, *Match similar words is selected*. To reduce the number of returned words, clear this box and select *Search titles only*, which restricts the search to only the topic titles in the Help, as shown in Figure 7.

Figure 7: Search Titles Only



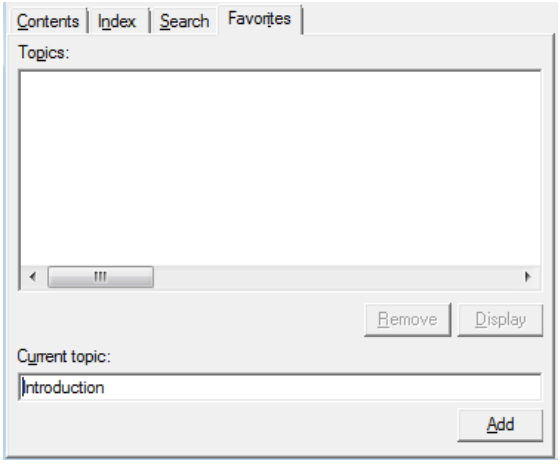
- The *Title* column provides the list of related topics
- The *Location* column lists in which Help system the topic was found (see **Note**)
- The *Rank* column determines to search result that most closely matches the specified word

Note: The *Location* column is automatically included in the CHM Help when the Advanced Search features are implemented and cannot be excluded. Its purpose is to provide the name of the Help system in which the topic is located for Help output that is generated from multiple sources. Since the MPLAB Harmony Help is contained within a single Help system, this information is the same for all searches. Do not confuse this column to mean the actual topic location.

Favorites

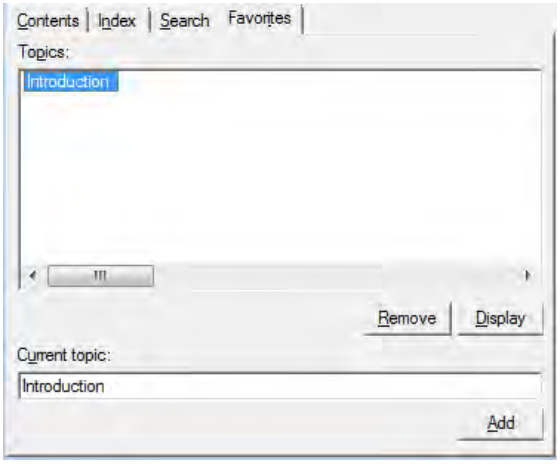
Use the Favorites tab to create a custom list of topics that you may want to repeatedly access. Figure 8 shows the default Favorites interface.

Figure 8: Default Favorites Interface



- The title of the current topic is shown in the *Current topic:* box.
- Click **Add** to add the topic to the *Topics:* list, as shown in Figure 9.
- Click **Display** to view the selected topic.
- Click **Remove** to remove the selected topic from the list of favorites.

Figure 9: Adding a Favorite Topic



HTML Help Features

Provides detailed information on the features available in the stand-alone HTML Help.

Description

The HTML Help output for MPLAB Harmony has two purposes. First, it can be used as "stand-alone" Help. Second, the HTML files are used by the MPLAB Harmony Configurator (MHC) when using MHC in MPLAB X IDE.

Stand-alone HTML Help

To use the HTML Help in a "stand-alone" manner, open the file, `<install-dir>/doc/index.html`, in your browser of choice. Click **Allow blocked content** if a message appears regarding ActiveX controls.

The following figure shows the initial view after opening the HTML Help.

The following links are provided:

- *Table of Contents* - Located at the top left, clicking this link opens the Table of Contents in the right frame
- *Topic Path* - At the top and bottom of each topic, the full path to the current topic is listed
- *Microchip Logo* - Clicking this image opens a new browser tab and displays the Microchip website (www.microchip.com)
- *Contents* - The Contents topic is a static file, which displays and lists the major sections available in the Help in the left frame. Due to a restriction with the Help browser used by the MHC, a dynamic Contents topic cannot be used.
- *Home* - This link returns to the Introduction topic (see **Note 1**)
- *Previous* and *Next* navigation links - Use these links to traverse through the Help topics
- *Documentation Feedback* - Use this link to provide feedback in the form of an email (see **Note 2**)
- *Microchip Support* - Use this link to open the Support page of the Microchip website

Notes:

1. The *Home* link does not appear initially. Once you begin traversing the topics, it dynamically appears.
2. To use the *Documentation Feedback* link, you must have an email system such as Outlook configured. Clicking the link automatically opens a new email message and populates the recipient and subject lines.

PDF Help Features

Provides detailed information on the features available in the PDF version of the Help.

Description

The MPLAB Harmony Help provided in Portable Document Format (PDF) provides many useful features. By default, PDF bookmarks should be visible when opening the file. If PDF bookmarks are not visible, click the PDF Bookmark icon, which is located near the top of the left navigation pane or by selecting *View* > *Show/Hide* > *Navigation Panes* > *Bookmarks.*

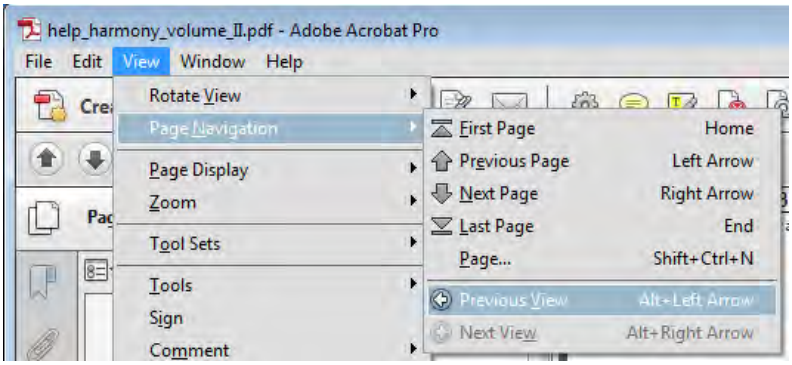
To make full use of the PDF features, it is recommended that Adobe products be used to view the documentation (see **Note**).

Help on how to use the PDF features is available through your copy of Acrobat (or Acrobat Reader) by clicking **Help** in the main menu.

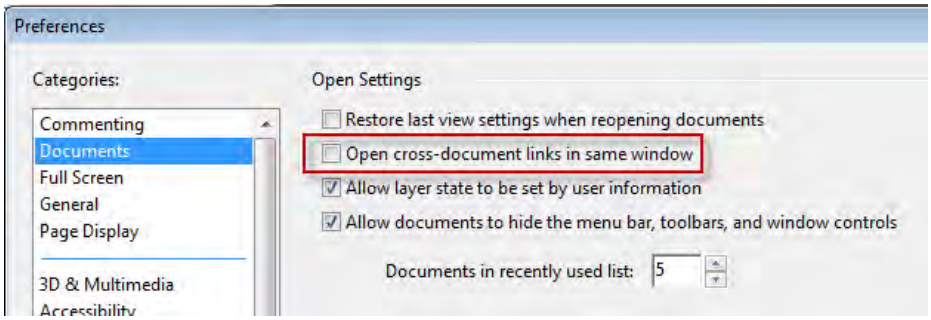
Note: The MPLAB Harmony Help PDF files can be viewed using a PDF viewer or reader that is compatible with Adobe PDF Version 7.0 or later.

Cross-document Linking

The six MPLAB Harmony PDF volumes that are available for separate download from the MPLAB Harmony website, provide cross-document links. By default, Adobe Acrobat specifies that cross-document links be opened in the same window. If this option is set, you will need to use the PDF Navigation features to return to the original topic. You can navigate pages by either using the menu by selecting *View* > *Page Navigation* > *Previous View; Next View*, as shown in the following figure, or by using the <Alt> plus <Left Arrow> or <Right Arrow> keys.



To change the default setting so that a cross-linked PDF is to open in a new window, edit your Adobe Acrobat Preferences by selecting *Edit* > *Preferences* and clear the **Open cross-document links in same window** option, as shown in the following figure. Once you have changed this option, it will remain set for all PDFs until you change it back to the default.



Microchip Website

This topic provides general information on the Microchip website.

Description

The Microchip website can be accessed online at: http://www.microchip.com

Accessible by most Internet browsers, the following information is available:

Product Support

- Data sheets
- Silicon errata
- Application notes and sample programs
- Design resources
- User's guides
- Hardware support documents
- Latest software releases and archived software

General Technical Support

- Frequently Asked Questions (FAQs)
- Technical support requests
- Online discussion groups
- Microchip consultant program member listings

Business of Microchip

- Product selector and ordering guides
- Latest Microchip press releases
- Listings of seminars and events
- Listings of Microchip sales offices, distributors, and factory representatives

Microchip Forums

This topic provides information on the Microchip Web Forums.

Description

The Microchip Web Forums can be accessed online at: http://www.microchip.com/forums

Microchip provides additional online support via our web forums.

The Development Tools Forum is where the MPLAB Harmony forum discussion group is located. This forum handles questions and discussions concerning the MPLAB Harmony Integrated Software Framework and all associated libraries and components.

Additional Development Tool discussion groups include, but are not limited to:

- MPLAB X IDE - This forum handles questions and discussions concerning the released versions of the MPLAB X Integrated Development Environment (IDE)
- MPLAB XC32 - This forum handles questions and discussions concerning Microchip's 32-bit compilers, assemblers, linkers, and related tools for PIC32 microcontrollers
- Tips and Tricks - This forum provides shortcuts and quick workarounds for Microchip's development tools
- FAQs - This forum includes Frequently Asked Questions

Additional forums are also available.

Customer Support

This topic provides information for obtaining support from Microchip.

Description

Users of Microchip products can receive assistance through several channels:

- Distributor or Representative
- Local Sales Office (see Contact Microchip Technology to locate your local sales office)
- Field Application Engineer (FAE)
- Technical Support (http://support.microchip.com)

Contact Microchip Technology

Worldwide sales and service contact information for Microchip Technology Inc.

Description

The following table provides worldwide sales and service contact information.

Americas	Asia/Pacific	Asia/Pacific (Continued)	Europe
Corporate Office 2355 West Chandler Blvd. Chandler, AZ 85224-6199 Tel: 480-792-7200 **Atlanta** Duluth, GA Tel: 678-957-9614 **Austin, TX** Tel: 512-257-3370 **Boston** Westborough, MA Tel: 774-760-0087 **Chicago** Itasca, IL Tel: 630-285-0071 **Cleveland** Independence, OH Tel: 216-447-0464 **Dallas** Addison, TX Tel: 972-818-7423 **Detroit** Novi, MI Tel: 248-848-4000 **Houston, TX** Tel: 281-894-5983 **Indianapolis** Noblesville, IN Tel: 317-773-8323 **Los Angeles** Mission Viejo, CA Tel: 949-462-9523 **New York, NY** Tel: 631-435-6000 **San Jose, CA** Tel: 408-735-9110 **Canada - Toronto** Tel: 905-673-0699	**Asia Pacific Office** Suites 3707-14, 37th Floor Tower 6, The Gateway Harbour City, Kowloon **Hong Kong** Tel: 852-2943-5100 **Australia - Sydney** Tel: 61-2-9868-6733 **China - Beijing** Tel: 86-10-8569-7000 **China - Chengdu** Tel: 86-28-8665-5511 **China - Chongqing** Tel: 86-23-8980-9588 **China - Dongguan** Tel: 86-769-8702-9880 **China - Hangzhou** Tel: 86-571-8792-8115 **China - Hong Kong SAR** Tel: 852-2943-5100 **China - Nanjing** Tel: 86-25-8473-2460 **China - Qingdao** Tel: 86-532-8502-7355 **China - Shanghai** Tel: 86-21-5407-5533 **China - Shenyang** Tel: 86-24-2334-2829 **China - Shenzhen** Tel: 86-755-8864-2200 **China - Wuhan** Tel: 86-27-5980-5300 **China - Xian** Tel: 86-29-8833-7252	**China - Xiamen** Tel: 86-592-2388138 **China - Zhuhai** Tel: 86-756-3210040 **India - Bangalore** Tel: 91-80-3090-4444 **India - New Delhi** Tel: 91-11-4160-8631 **India - Pune** Tel: 91-20-3019-1500 **Japan - Osaka** Tel: 81-6-6152-7160 **Japan - Tokyo** Tel: 81-3-6880- 3770 **Korea - Daegu** Tel: 82-53-744-4301 **Korea - Seoul** Tel: 82-2-554-7200 **Malaysia - Kuala Lumpur** Tel: 60-3-6201-9857 **Malaysia - Penang** Tel: 60-4-227-8870 **Philippines - Manila** Tel: 63-2-634-9065 **Singapore** Tel: 65-6334-8870 **Taiwan - Hsin Chu** Tel: 886-3-5778-366 **Taiwan - Kaohsiung** Tel: 886-7-213-7828 **Taiwan - Taipei** Tel: 886-2-2508-8600 **Thailand - Bangkok** Tel: 66-2-694-1351	**Austria - Wels** Tel: 43-7242-2244-39 **Denmark - Copenhagen** Tel: 45-4450-2828 **France - Paris** Tel: 33-1-69-53-63-20 **Germany - Dusseldorf** Tel: 49-2129-3766400 **Germany - Karlsruhe** Tel: 49-721-625370 **Germany - Munich** Tel: 49-89-627-144-0 **Germany - Pforzheim** Tel: 49-7231-424750 **Italy - Milan** Tel: 39-0331-742611 **Italy - Venice** Tel: 39-049-7625286 **Netherlands - Drunen** Tel: 31-416-690399 **Poland - Warsaw** Tel: 48-22-3325737 **Spain - Madrid** Tel: 34-91-708-08-90 **Sweden - Stockholm** Tel: 46-8-5090-4654 **UK - Wokingham** Tel: 44-118-921-5800

07/14/2015

Glossary

This topic contains a glossary of general MPLAB Harmony terms.

Description

Glossary of MPLAB Harmony Terms

Term	Definition
Application	One or more application modules define the overall behavior of a MPLAB Harmony system. Applications are either demonstrations or examples provided with the installation or are implemented by you, using MPLAB Harmony libraries to accomplish a desired task.
Client	A client module is any module that uses the services (calls the interface functions) of another module.

Configuration	A MPLAB Harmony configuration consists of static definitions (C language #define statements), executable source code, and other definitions in a set of files that are necessary to create a working MPLAB Harmony system. (See the System Configurations section for additional information.)
Configuration Options	Configuration options are the specific set of #define statements that are required by any specific MPLAB Harmony library to specify certain parameters (such as buffer sizes, minimum and maximum values, etc.) build that library. Configuration options are defined in the system_config.h system-wide configuration header.
Driver	A "driver" (or device driver) is a MPLAB Harmony software module designed to control and provide access to a specific peripheral, either built into or external to the microcontroller.
Driver Index	Dynamic MPLAB Harmony drivers (and other dynamic modules) can manage the more than one instance of the peripheral (and other resources) that they control. The "driver index" is a static index number (0, 1, 2,...) that identifies which instance of the driver is to be used. **Note:** The driver index is not necessarily identical to the peripheral index. The association between these two is made when the driver is initialized.
Driver Instance	An instance of a driver (or other module) consists of a complete set of the memory (and other resources) controlled by the driver's code. Selection of which set of resources to control is made using a driver index. **Note:** Even though there may be multiple instances of the resources managed by a dynamic driver, there is only ever one instance of the actual object code. However, static drivers always maintain a 1:1 relationship between resource and code instances.
Framework	The MPLAB Harmony framework consists of a set of libraries (and the rules and conventions used to create those libraries) that can be used to create MPLAB Harmony systems.
Handle	A handle is a value that allows one software module to "hold" onto a specific instance of some object owned by another software module (analogous to the way a valet holds the handle of a suitcase), creating a link between the two software modules. A handle is an "opaque" value, meaning that the "client" module (the module that receives and holds the handle) must not attempt to interpret the contents or meaning of the handle value. The value of the handle is only meaningful to the "server" module (the module that provides the handle). Internal to the server module, the handle may represent a memory address or it may represent a zero-based index or any other value, as required by the "server" module to identify the "object" to which the client is linked by the handle.
Initialization Overrides	Initialization overrides are configuration options that can be defined to statically override (at build time) parameters that are normally passed into the "Initialize" function of a driver or other MPLAB Harmony module. This mechanism allows you to statically initialize a module, instead of dynamically initializing the module.
Interface	The interface to a module is the set of functions, data types, and other definitions that must be used to interact with that module.
Middleware	The term "middleware" is used to describe any software that fits between the application and the device drivers within a MPLAB Harmony system. This term is used to describe libraries that use drivers to access a peripheral, and then implement communication protocols (such as TCP/IP, USB protocols, and graphics image processing), as well as other more complex processing, which is required to use certain peripherals, but is not actually part of controlling the peripheral itself.
Module	A MPLAB Harmony software module is a closely related group of functions controlling a related set of resources (memory and registers) that can be initialized and maintained by the system. Most MPLAB Harmony modules provide an interface for client interaction. However, "headless" modules with no interface are possible.
Peripheral Index	A peripheral index is a static label (usually an C language "enum" value) that is used to identify a specific instance of a peripheral. **Note:** Unlike a driver index, which always starts at '0', a peripheral index may be internally represented as any number, letter, or even a base address and the user should not rely on the value itself, but only the label.
Peripheral Instance	An instance of a peripheral is a complete set of the registers (and internal physical resources) necessary to provide the core functionality of a given type of peripheral (either built into or external to the microcontroller). **Note:** A specific peripheral instance is identified using a peripheral index.
System	A MPLAB Harmony system is a complete set of libraries, applications, and configuration items loaded and executing on a specific hardware platform (microcontroller, board, and external peripherals) or the source items necessary to build such a system. **Note:** Since a system can multiple configurations, one MPLAB Harmony project may support multiple systems through multiple supported configurations. See the demonstration applications included in the installation for examples.
System Service	A system service is a MPLAB Harmony module that provides access to and/or control of common system resources (memory and registers) with which other modules (drivers, middleware, libraries and application) may interact. **Note:** System services, much like drivers, manage sharing of resources so as to avoid conflicts between modules that would otherwise occur if each module attempted to manage the share resource itself. But, unlike drivers, system services do not normally need to be "opened" to use them.

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