



# AN1160 Demonstration Readme

## AN1160 Demonstration Readme for the dsPICDEM™ MCLV-2 Development Board with the dsPIC33CK256MP508 External Op Amp Motor Control PIM (MPLAB® X IDE)

### 1.0 INTRODUCTION

This document describes the setup requirements for running the Sensorless BLDC Motor Control Algorithm, which is referenced in AN1160, “*Sensorless BLDC Control with Back-EMF Filtering Using a Majority Function*”, using a dsPICDEM™ MCLV-2 Development Board in the external op amp configuration.

The demonstration is configured to run on the dsPICDEM MCLV-2 Development Board (DM330021-2) in external op amp configuration with the dsPIC33CK256MP508 External Op Amp Motor Control Plug-In Module (PIM) (MA330041-1).

### 2.0 SUGGESTED DEMONSTRATION REQUIREMENTS

#### 2.1 Motor Control Application Firmware Required for the Demonstration

- AN1160\_dsPIC33CK256MP508\_EXT\_MCLV\_MCHV.zip

**Note:** In this document, hereinafter this firmware package is referred to as firmware.

#### 2.2 Software Tools Used for Testing the Firmware

- MPLAB® X IDE v5.50
- MPLAB XC16 Compiler v1.41
- MPLAB X IDE Plug-In: X2C Scope v1.3.0 or later

**Note:** The software used for testing the firmware prior to release is listed above. It is recommended to use the version listed above or later versions for building the firmware.

#### 2.3 Hardware Tools Required for the Demonstration

- dsPICDEM MCLV-2 Development Board (DM330021-2)
- 24V Power Supply (AC002013)
- 24V Three-Phase Brushless DC Motor (AC300020)
- dsPIC33CK256MP508 External Op Amp Motor Control Plug-In Module (MA330041-1)
- Microchip Programmer Tools, such as MPLAB REAL ICE™ In-Circuit Emulator (DV244005) or MPLAB ICD 3 (DV164035), etc.

**Note:** All items listed under [Section 2.3 “Hardware Tools Required for the Demonstration”](#) are available at [microchipDIRECT](#).

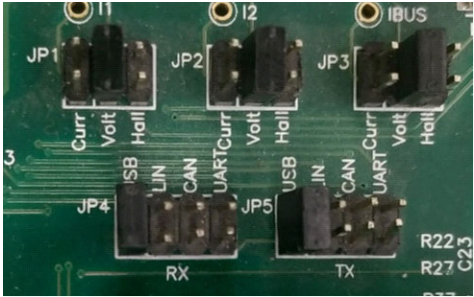
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## 3.0 HARDWARE SETUP

This section describes the hardware setup required for the demonstration. Bus current feedback needed by the firmware is amplified by the operational amplifier provided on the Development Board. This is referred as 'external amplifier configuration'.

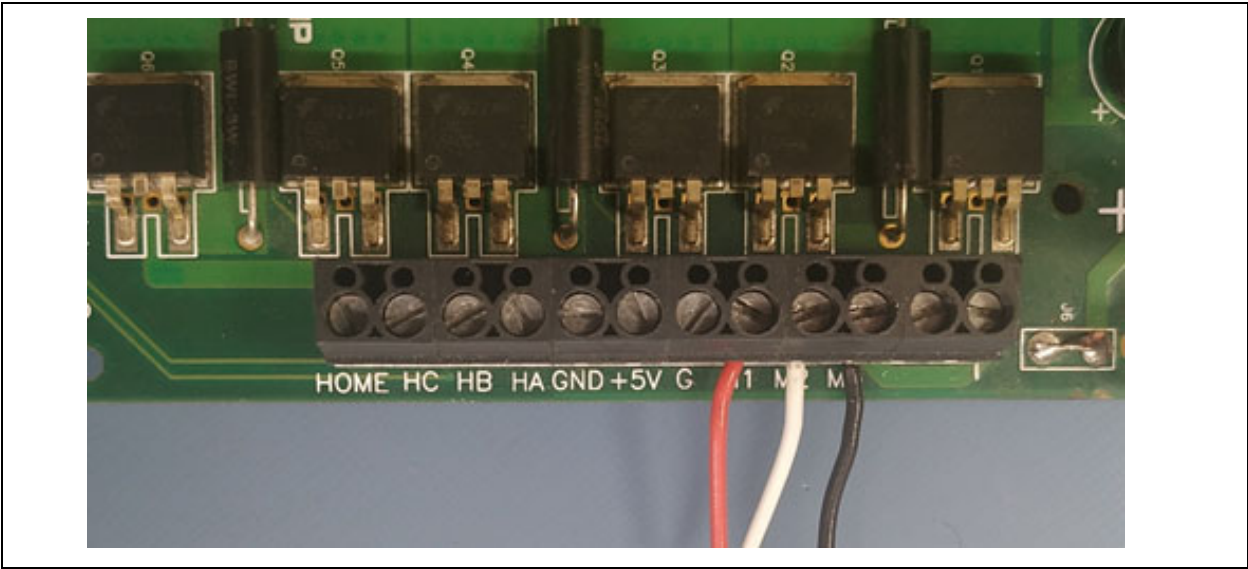
Refer to the “dsPICDEM™ MCLV-2 Development Board User’s Guide” for any clarification while setting up the hardware.

1. Disconnect power to the dsPICDEM MCLV-2 Development Board and set up the following jumpers:

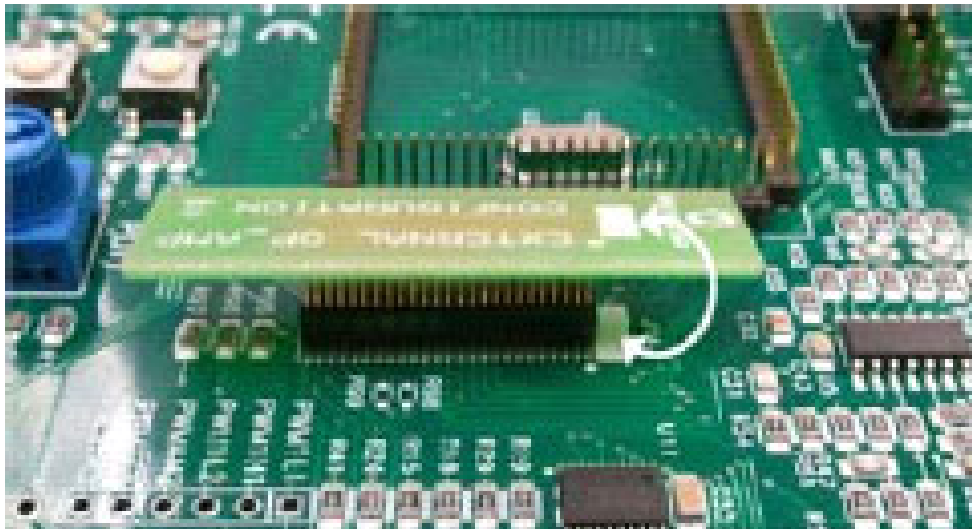
Jumper	Pins to Short	Board Reference
JP1	Volt Position	
JP2	Volt Position	
JP3	Volt Position	
JP4	USB Position	
JP5	USB Position	

2. Connect the three phase wires from the motor to the M1, M2 and M3 terminals of connector J7 provided on the Development Board, as mentioned in the below table.

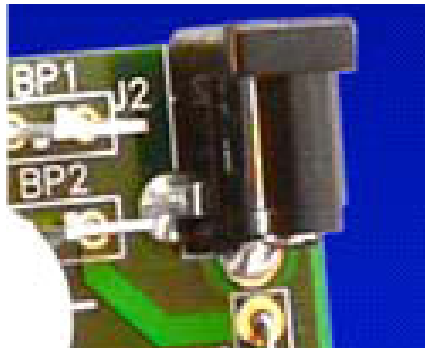
MCLV Board	Hurst® 075 Motor	
	Winding Terminals (Color as per image below)	Molex® 39-01-2040 (Mating Connector)
M1	Red	1
M2	White	2
M3	Black	3



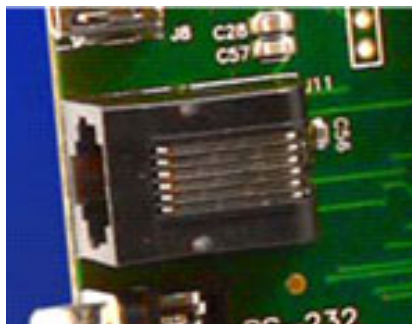
3. Connect the 'External Op Amp Configuration Matrix Board' to matrix board header J14. Ensure the matrix board is correctly oriented before proceeding.



4. Insert the dsPIC33CK256MP508 External Op Amp Motor Control PIM into the PIM Socket U9 provided on the dsPICDEM MCLV-2 Development Board. Make sure the PIM is correctly placed and oriented before proceeding.
5. Plug in the 24V power supply to connector J2 provided on the dsPICDEM MCLV-2 Development Board.



6. Connect the Microchip programmer/debugger tools, such as MPLAB REAL ICE or MPLAB ICD 3 to the connector J11 of the dsPICDEM MCLV-2 Development Board and to the Host PC used for programming the device.



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## 4.0 SOFTWARE SETUP AND RUN

### 4.1 Setup: MPLAB X IDE and MPLAB XC16 Compiler

Install the MPLAB X IDE and MPLAB XC16 Compiler versions that support the dsPIC33CK256MP508 device assembled on the Plug-In Module (PIM). The versions of the MPLAB X IDE, MPLAB XC16 Compiler and X2C plug-in used for testing the firmware are mentioned in [Section 2.1 “Motor Control Application Firmware Required for the Demonstration”](#). To get help on:

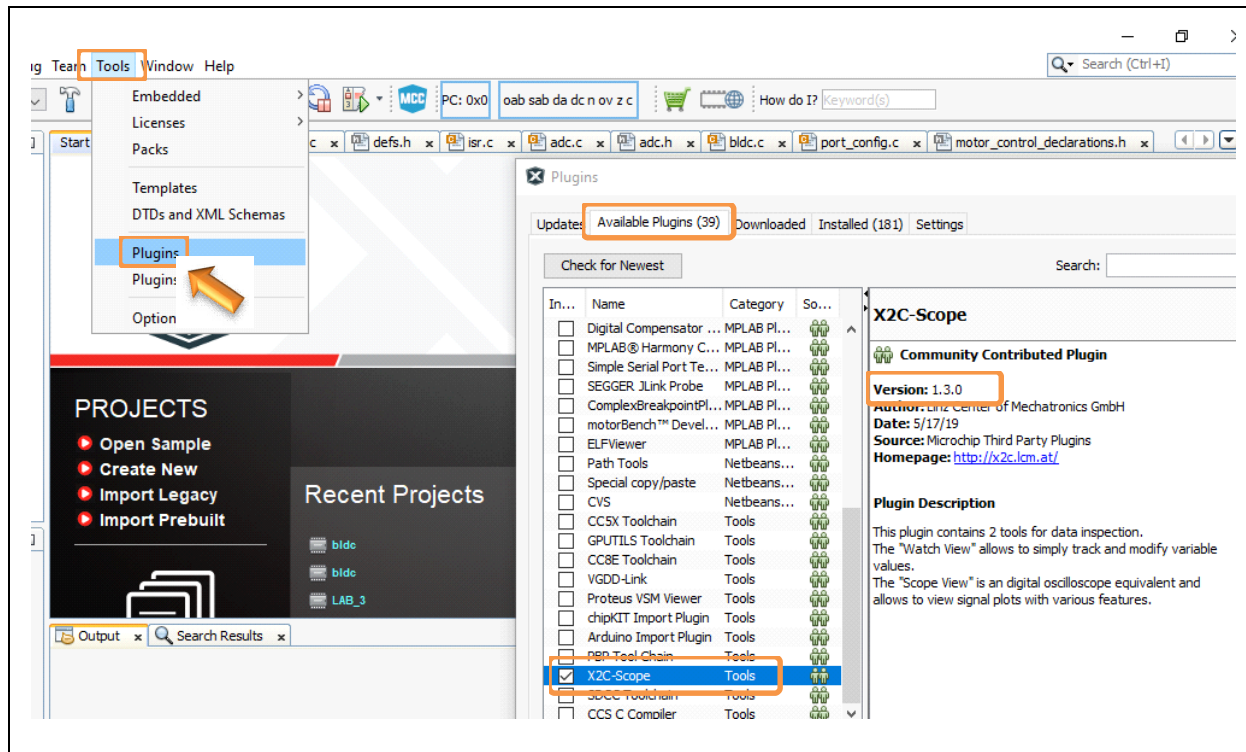
- [MPLAB X IDE](#) installation
- [MPLAB XC16](#) Compiler installation steps

If MPLAB X IDE v8 or earlier is already installed on your computer, then run the MPLAB driver switcher (it is installed when MPLAB X IDE is installed) to switch from MPLAB IDE v8 drivers to MPLAB X IDE drivers. If you have Windows® 7 or 8, you must run the MPLAB driver switcher in 'Administrator Mode'. To run the Device Driver Switcher GUI application as administrator, right click on the executable (or desktop icon) and select 'Run as Administrator'. For additional details, refer to MPLAB X IDE help topic: *“Before You Begin: Install the USB Device Drivers (For Hardware Tools): USB Driver Installation for Windows Operating Systems”*.

### 4.2 Setup: X2C Scope

X2C Scope is an MPLAB X IDE plug-in that allows a developer to interact with an application while the application program is running. X2C Scope enables you to read, write and plot global variables (for motor control) in real time. It communicates with the target using the UART. To use X2C, the plug-in must be installed:

- In MPLAB X IDE, select *Tools>Plugins* and click on the **Available Plugins** tab.
- Select X2C Scope plug-in by checking its check box and then click **Install**.
- Look for tool X2C Scope under *Tools>Embedded*.



## 5.0 BASIC DEMONSTRATION

### 5.1 Firmware Description

The firmware version required for the demonstration is mentioned under [Section 2.1 “Motor Control Application Firmware Required for the Demonstration”](#).

This firmware is implemented to work on Microchip's 16-bit Digital Signal Controller (dsPIC® DSC), dsPIC33CK256MP508. For more information, see the “*dsPIC33CK256MP508 Family Data Sheet*” (DS70005349).

The Motor Control Demo application uses a push button to start or stop the motor and a potentiometer to vary the speed of the motor.

For more details, refer to Microchip Application Note: AN1160, “*Sensorless BLDC Control with Back-EMF Filtering Using a Majority Function*”, available on the [Microchip website](#).

**Note:** The project may not build correctly in Windows OS if the maximum path length of any source file in the project is more than 260 characters. In case an absolute path is exceeding or nearing the maximum length, do any (or both) of the following:

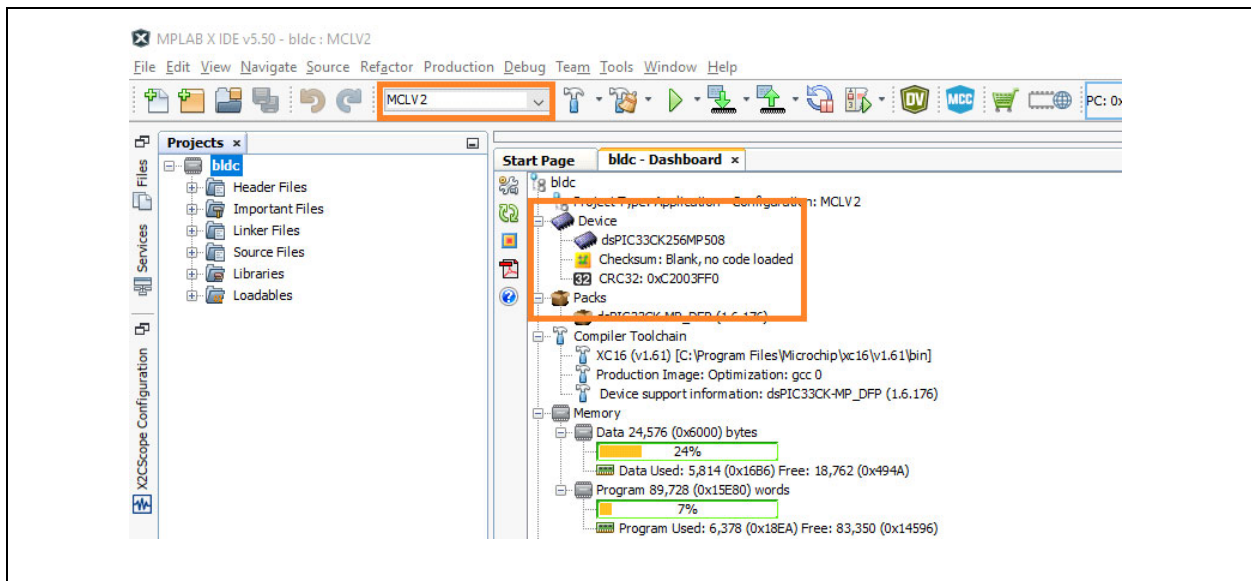
- Shorten the name of the directory containing the firmware used in this demonstration. In this case, rename directory, AN1160\_dsPIC33CK256MP508\_EXT\_MCLV\_MCHV, to a more appropriate shorter name. In case you renamed the directory, consider the new name while reading instructions provided in the upcoming sections of the document.
- Place firmware in a location, such that the absolute path length of each file included in the projects does not exceed the maximum path length specified.

For details, refer to the MPLAB X IDE help topic, “*Path, File and Folder Name Restrictions*”.

### 5.2 Basic Demonstration

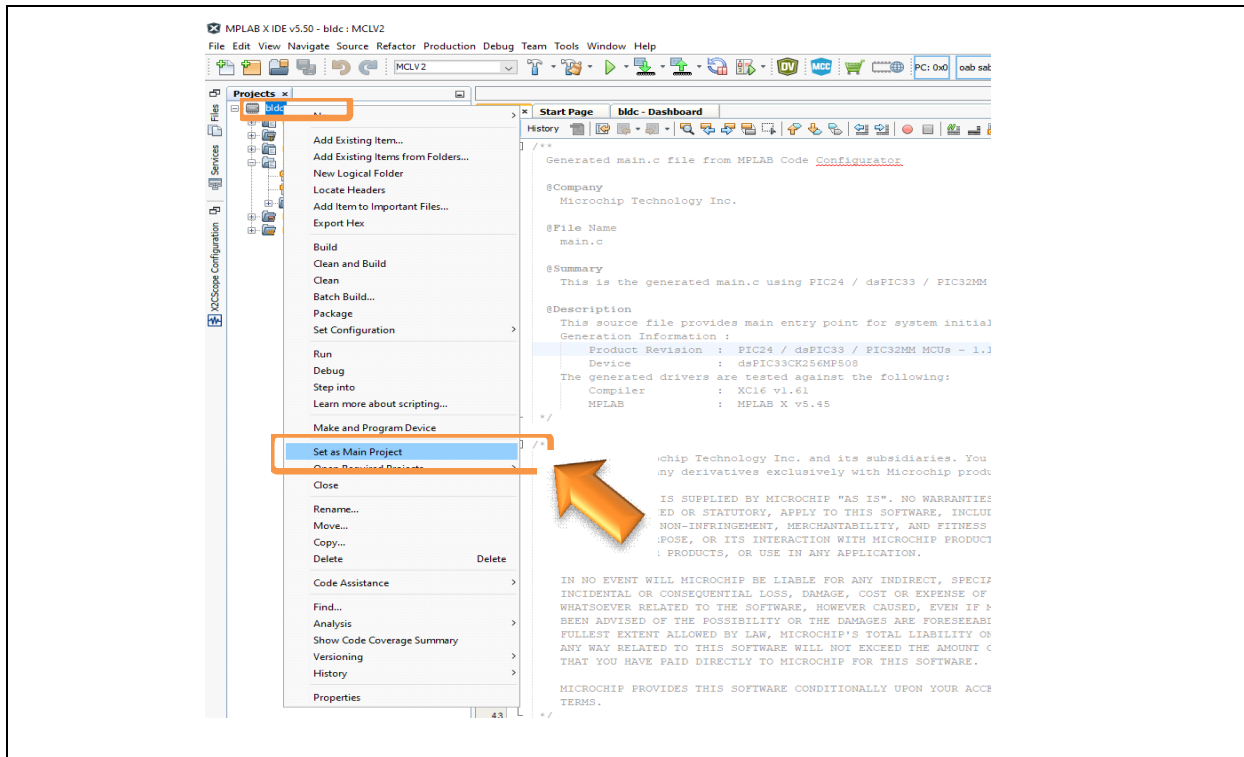
Follow below instructions step-by-step to set up and run the motor control demo application:

1. Start MPLAB X IDE and open (*File>Open Project*) the project, bldc.X (..\AN1160\_dsPIC33CK256MP508\_EXT\_MCLV\_MCHV\bldc.X) with device selection, dsPIC33CK256MP508.

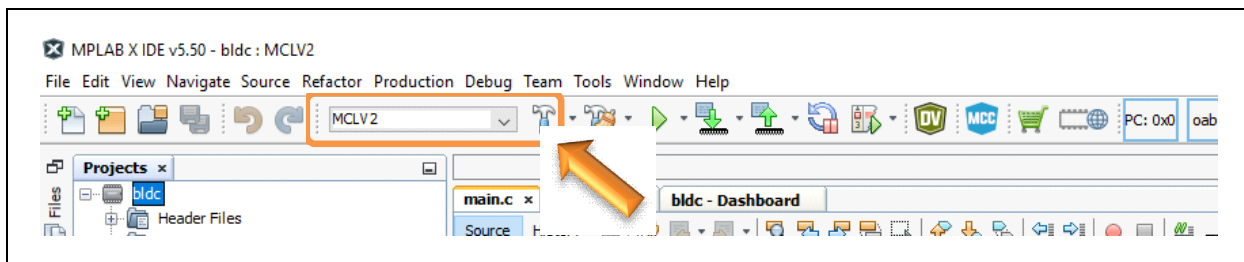


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2. Set the project `bldc.X` as the main project by right clicking on the project name and selecting “Set as Main Project” as shown. The project “**bldc**” will then appear in **bold**.



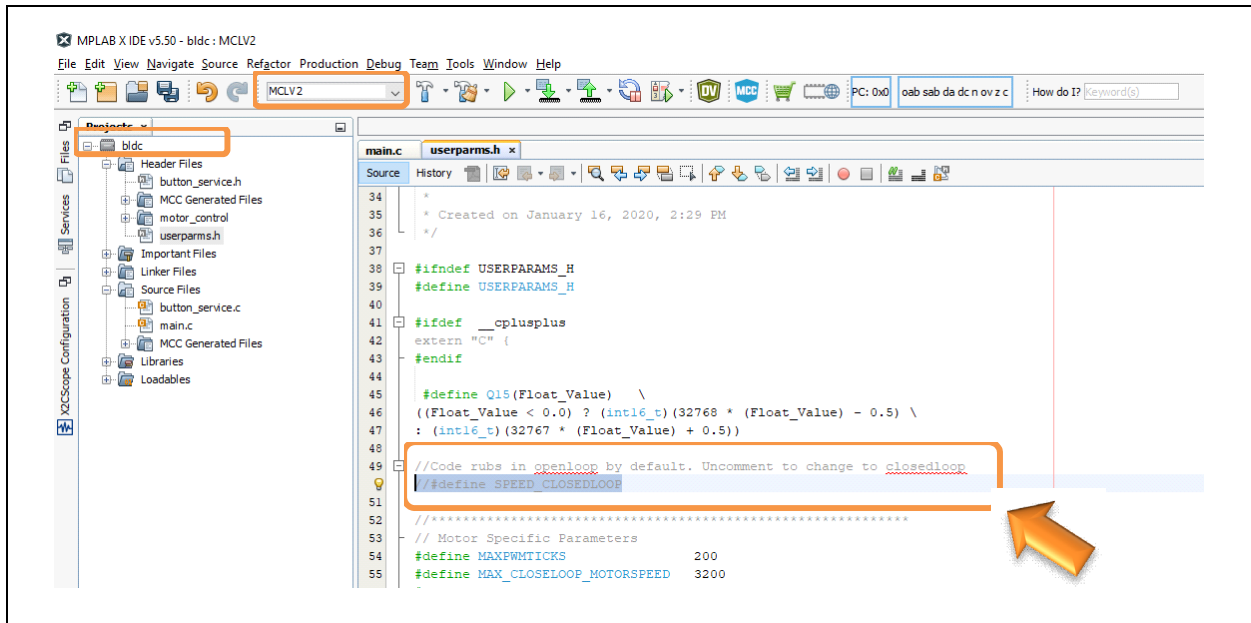
3. Select project configuration as “MCLV2” from the Project Configuration drop down box on the toolbar as shown:



There may be multiple project configurations available for `bldc.X`.



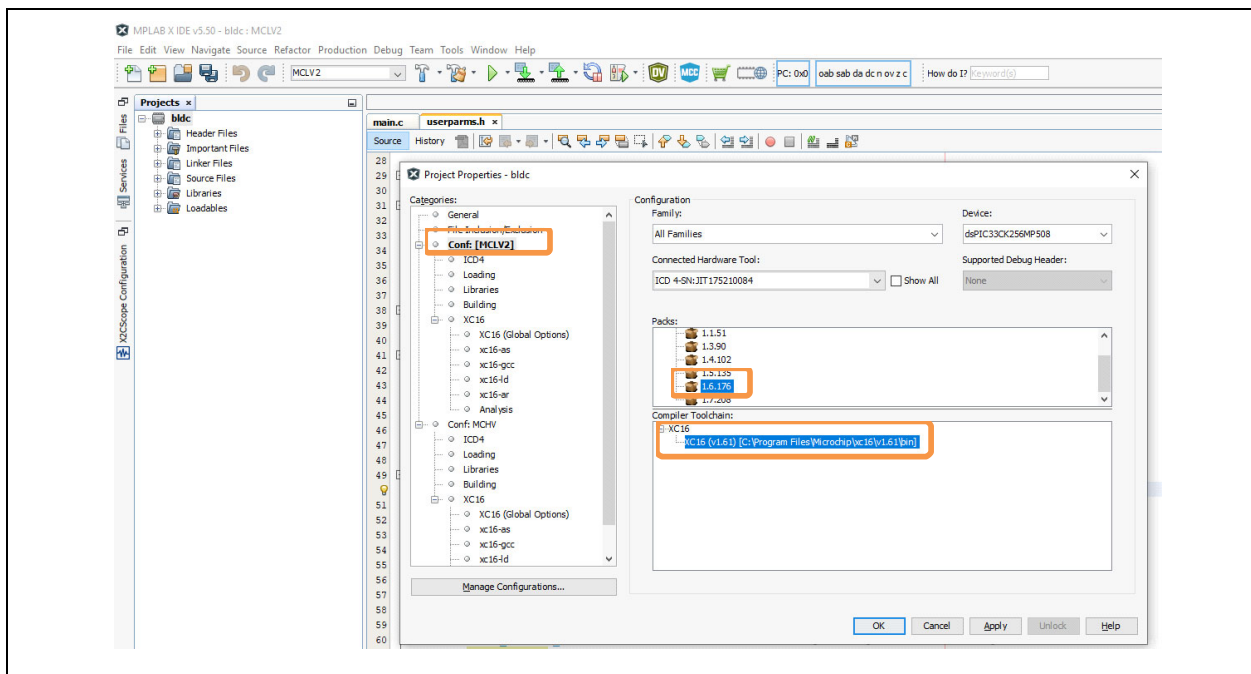
- Open `userparams.h` (under `bldc.X` -> `headerfiles`) in the project `bldc.X` and ensure any one of the modes of operation is defined. The user may enable or disable the open-loop control.



- Right click on the project `bldc.X` and select "Properties" to open its Project Properties dialog. Click the "Conf: [MCLV2]" category to reveal the general project configuration information.

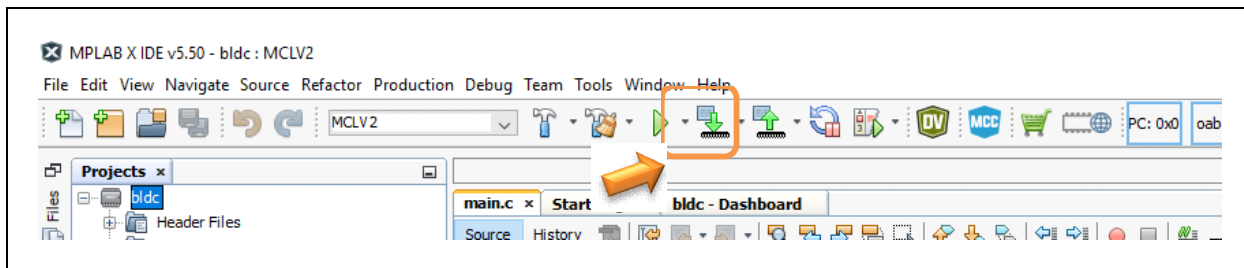
In the Conf-MCLV2 category window:

- Select the specific Compiler Toolchain from the available list of compilers. Please ensure MPLAB XC16 Compiler supports the device `dsPIC33CK256MP508`. In this case, "XC16(v1.41)" is selected. The compiler used for testing the firmware is listed in [Section 2.2 "Software Tools Used for Testing the Firmware"](#).
- Select the Hardware Tool to be used for programming and debugging. In this case, "ICD 3" is the selected programmer.
- After selecting Hardware Tool and Compiler Toolchain, click button **Apply**.

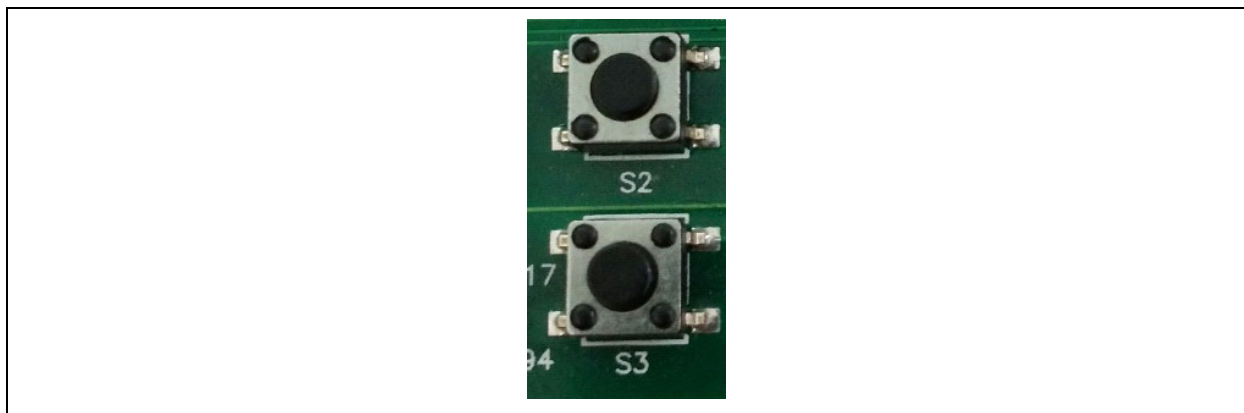


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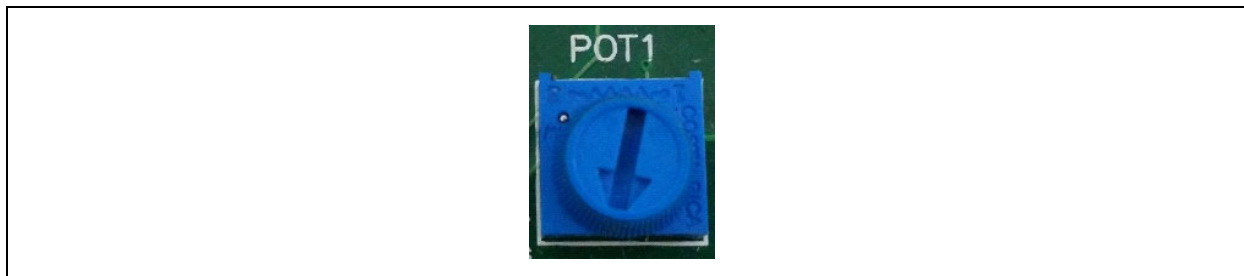
- To build the project (in this case, `bldc.X`) and program the device `dsPIC33CK256MP508`, click **Make and Program Device Main project** on the toolbar.



- If the device is successfully programmed, **LED D17** will be turned on, indicating that the `dsPIC DSC` is enabled.
- Run or stop the motor by pressing the push button **S2**. The function of the push button **S2** (run/stop of the motor) is indicated by turning on or off the **LED D2**.



- If desired, the motor speed can be varied using the potentiometer (labeled "POT1").



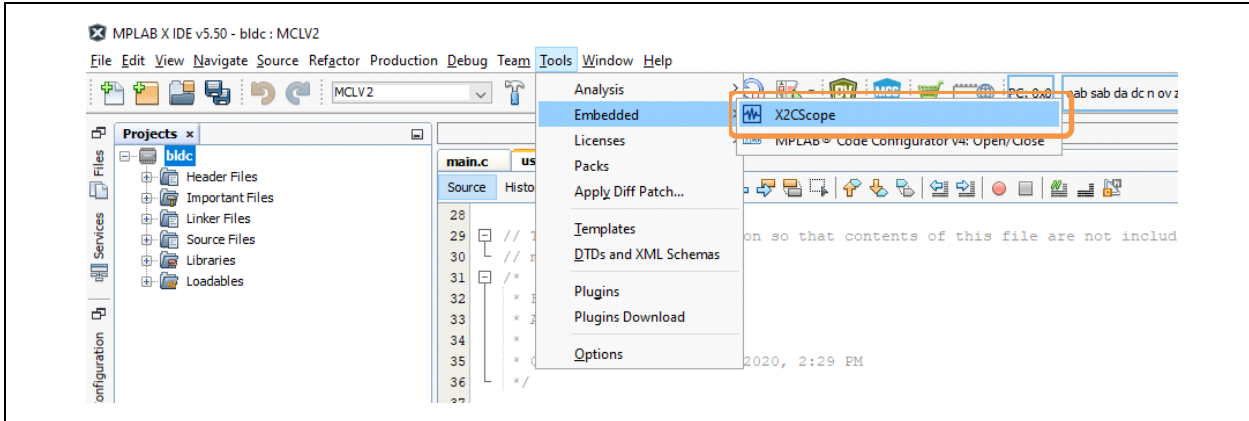
- To reverse the direction of rotation, press the push button **S3**.
- Press the push button **S2** to stop the motor.



## 6.0 DATA VISUALIZATION THROUGH X2C SCOPE PLUG-IN OF MPLAB X IDE

The application firmware comes with initialization required to interface the controller with the Host PC to enable data visualization through the X2C Scope plug-in. X2C Scope is a third-party plug-in for MPLAB X IDE, which facilitates real-time diagnostics.

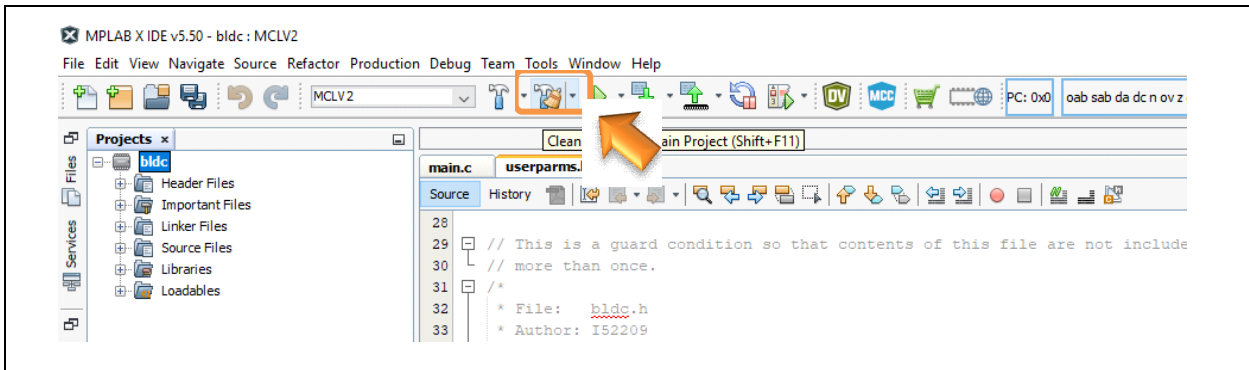
1. Ensure the X2C Scope plug-in is installed. For additional information on how to set up a plug-in, refer to <https://microchipdeveloper.com/mplabx:tools-plugins-available>.



2. To utilize X2C communication for this demonstration, a mini-USB connection is required between the Host PC and the dsPICDEM MCLV-2 Development Board. Connect a mini-USB cable from your computer to the J8 connector of the dsPICDEM MCLV-2 Development Board and install USB drivers if necessary.

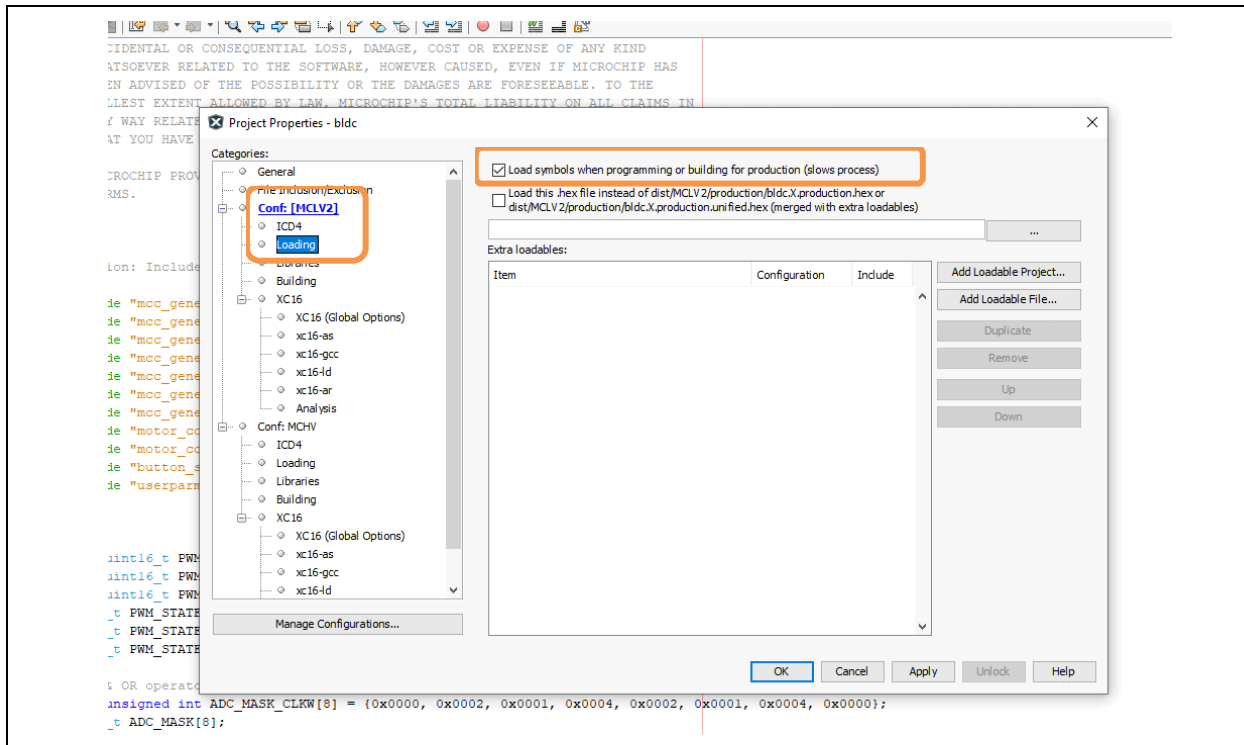


3. Ensure the application is configured and running as described under [Section 5.2 “Basic Demonstration”](#) by following Steps 1 through 11.
4. Build the project `bldc.X`. To do that, right click on the project `bldc.X` and select “Clean and Build”.

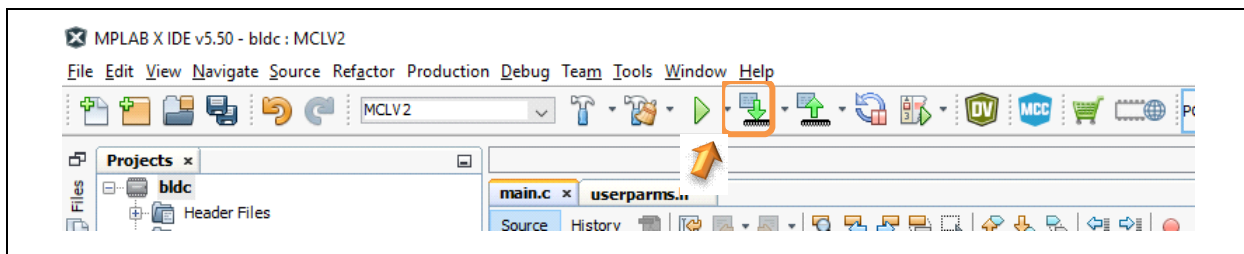


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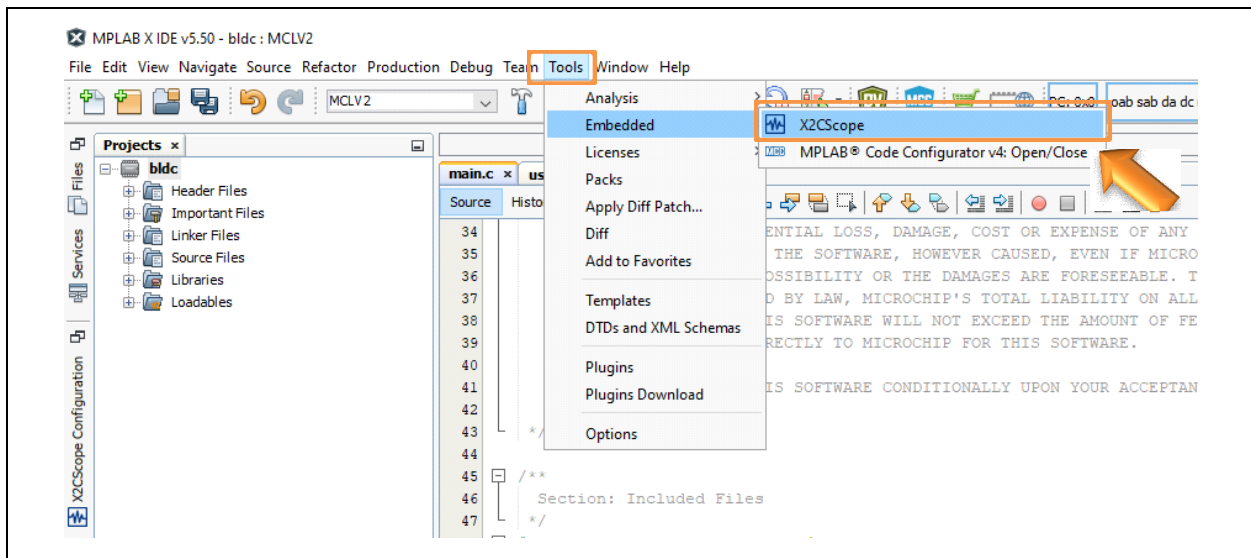
- Please ensure that the checkbox “Load symbols when programming or building for production (slows process)” is checked, which is under the “Loading” category of the Project Property dialog.



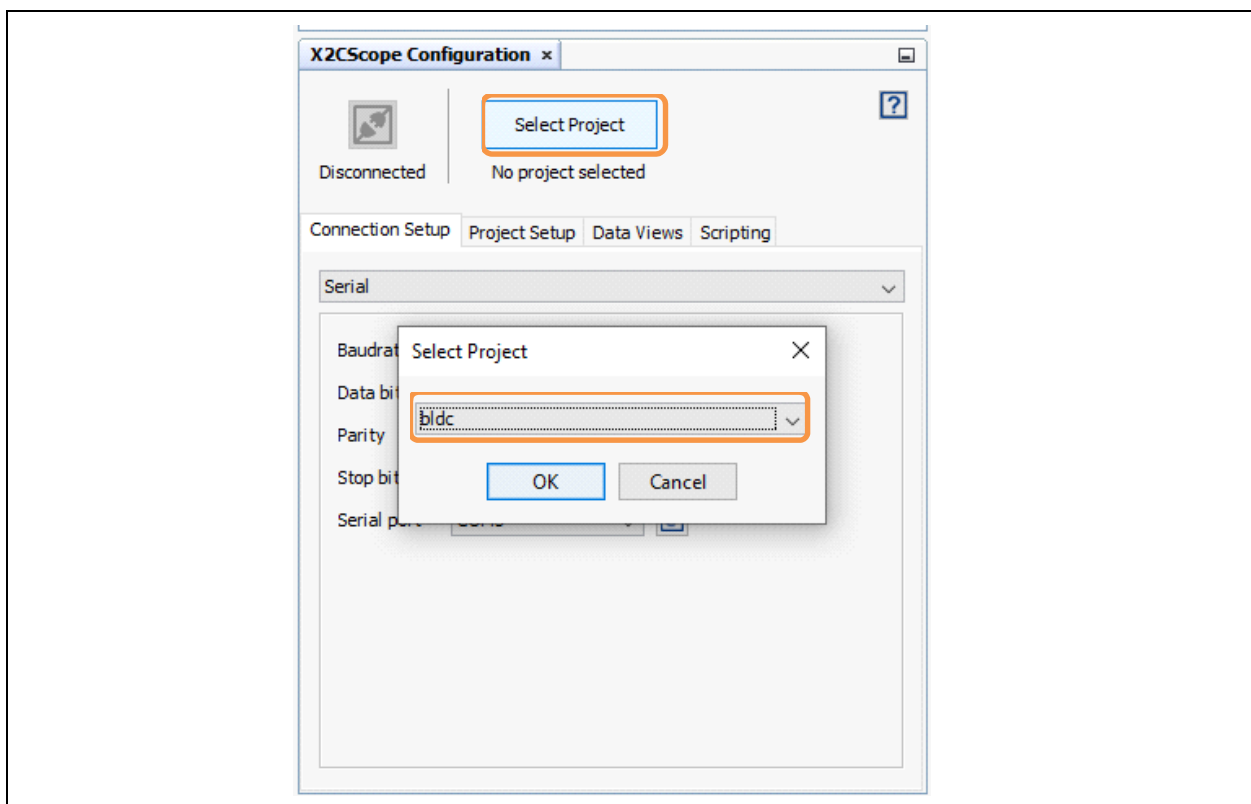
- To build the project (in this case, `blcdc.X`) and program the device `dsPIC33CK256MP508`, click “Make and Program Device Main project” on the toolbar.



7. Open the X2C window by selecting *Tools>Embedded>X2CScope*.

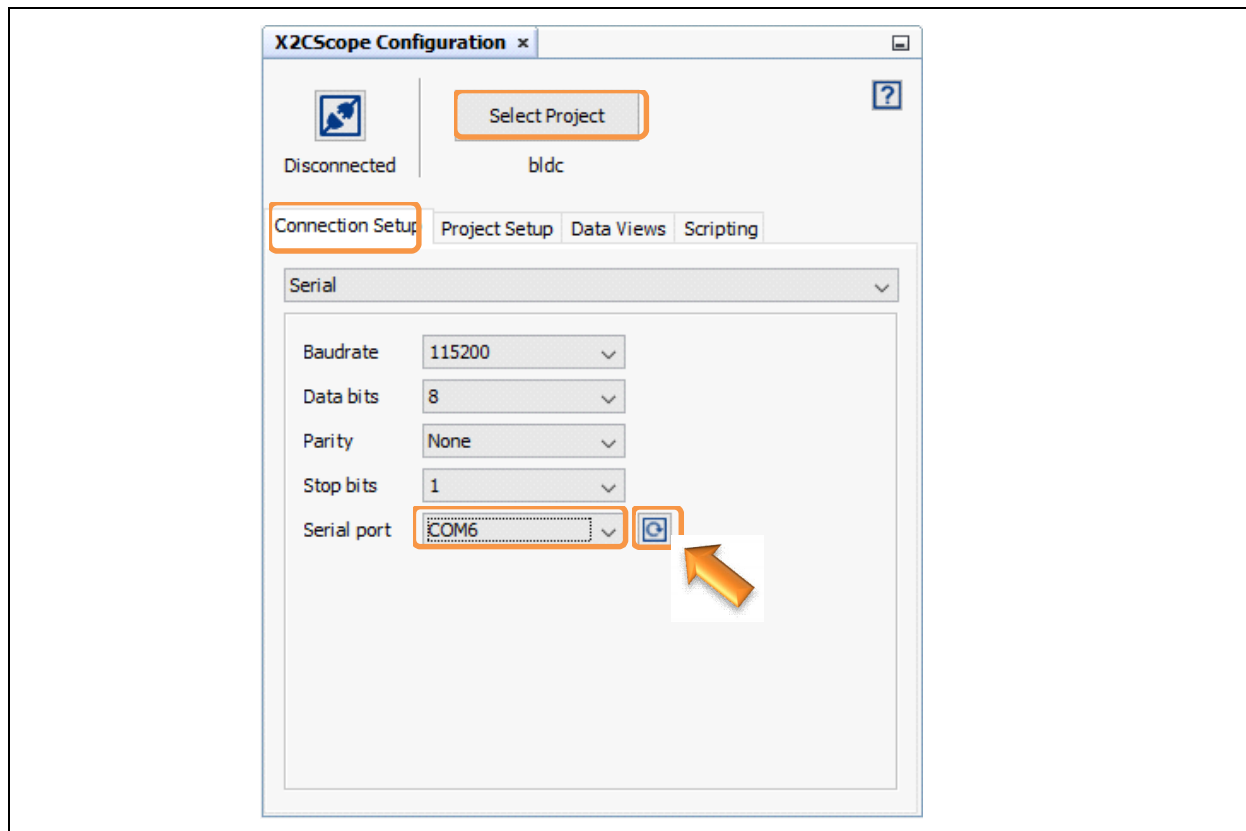


8. Open the X2C Scope Configuration window and in the “Select project” menu, select bldc project as shown.

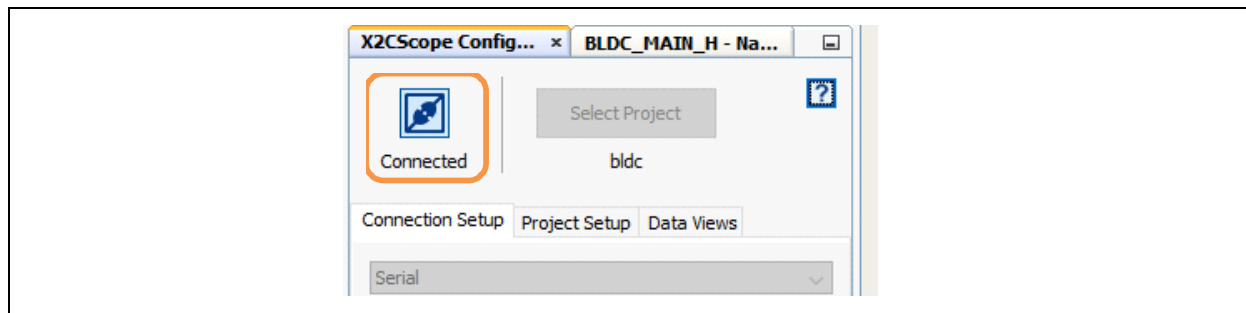


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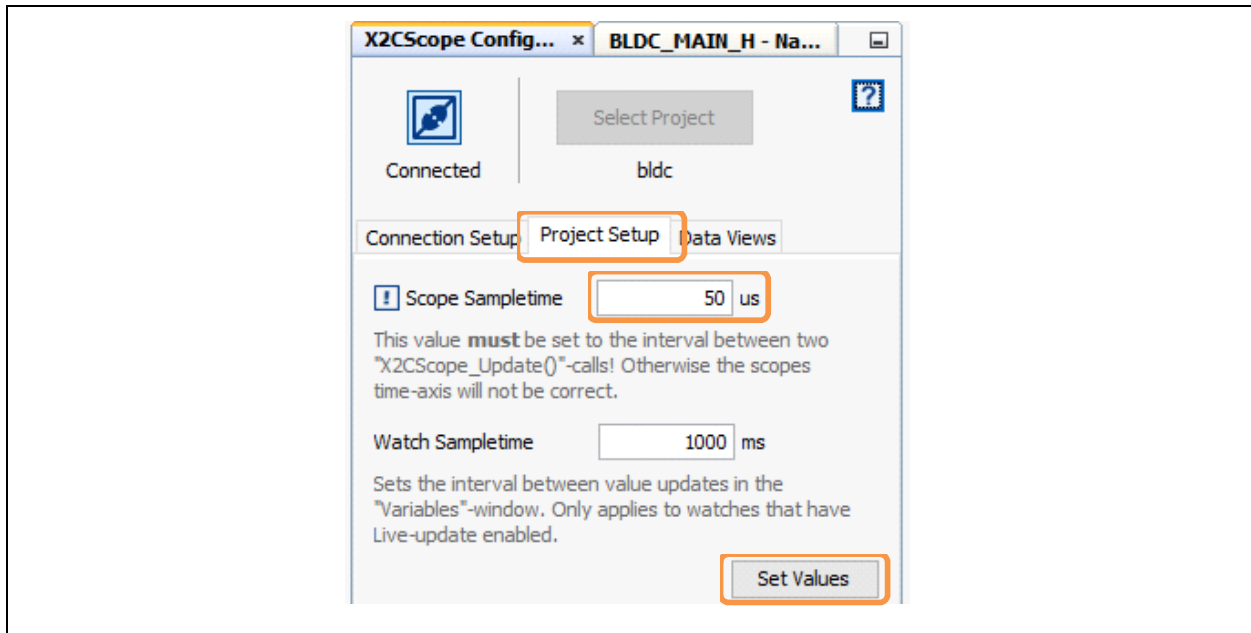
9. Remote communication needs to be established, as indicated in the following figure. Ensure the communication baud rate is set to 115200, as the same is set in the application firmware, while the COM port used depends on the system settings. The **Refresh** button lists the available COM ports. Select the COM port as per the connection.



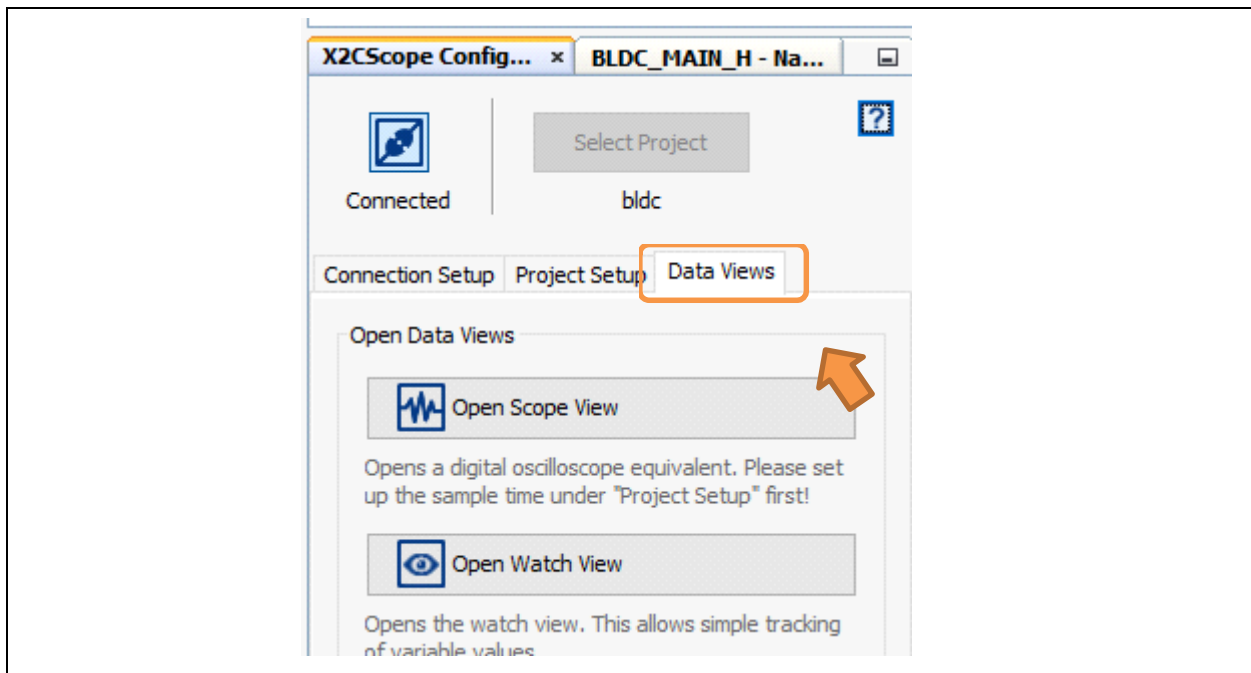
10. Once the COM port detected, click on **Disconnected**, and it will be turn into **Connected** if the link is established as programmed.



11. Set the "Project Setup" as shown below and click "Set Values". Set Scope sample time as interval at which X2CScopeUpdate() is called. In this application, it is every 20 kHz (50  $\mu$ s).

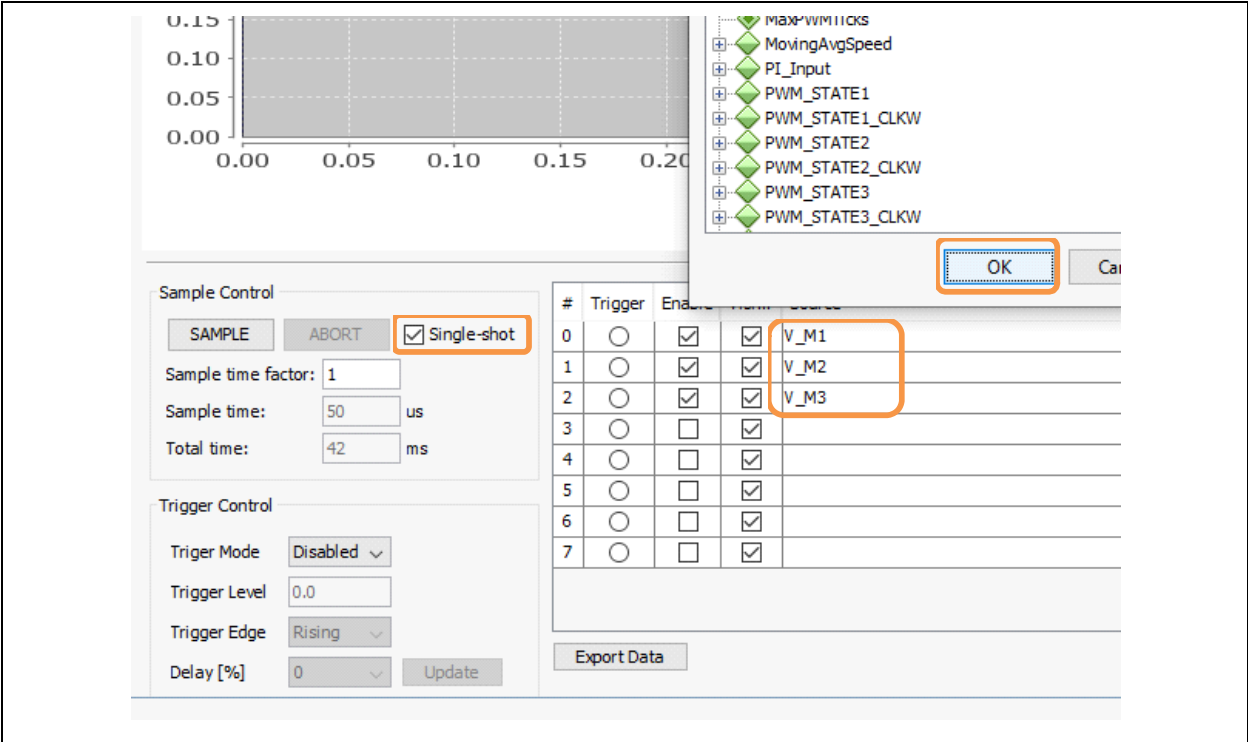


12. When the setup is established, click on "Open Scope View" (under sub-window "Data Views"); this opens the Scope window.

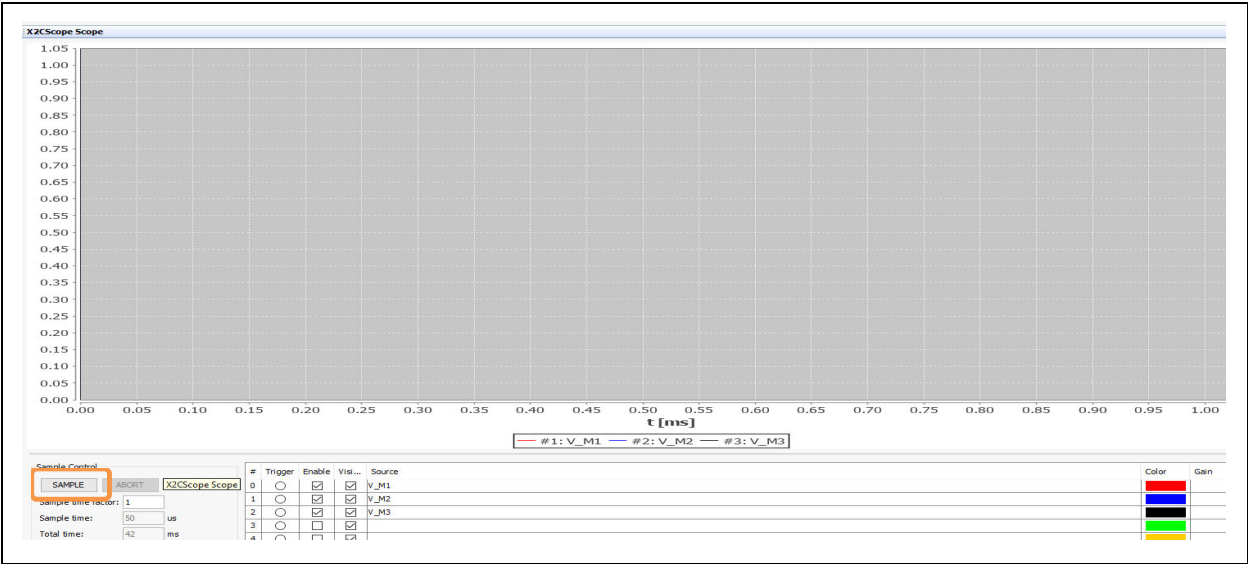


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13. In this window, select the variables that need to be monitored. To do this, click on the source against each channel, a Select Variables window opens upon the screen. From the available list, the required variable can be chosen. Ensure check boxes, Enable and Visible, are checked for the variables to be plotted.
- To view data plots continuously, uncheck Single-Shot. When Single-Shot is checked, it captures the data once and stops. The sample time factor value multiplied with the sample time determines the time difference between any two consecutive data points on the plot.

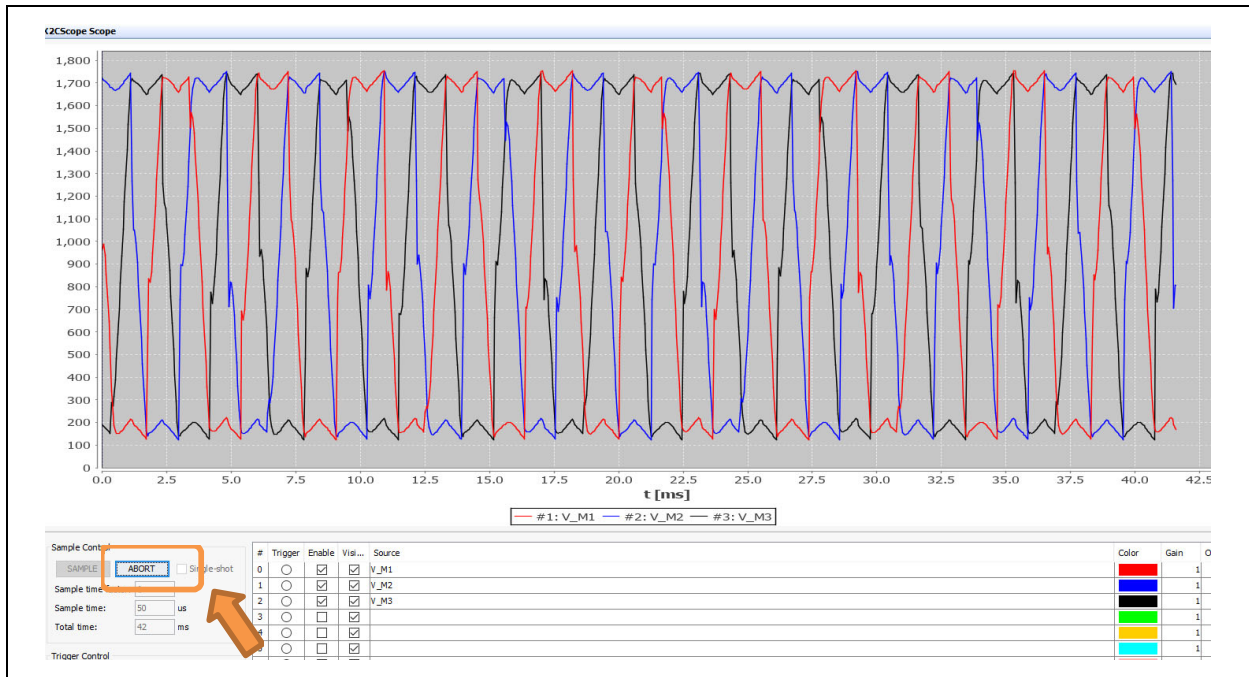


14. Click on SAMPLE, then the X2C Scope window shows the variables in real time, which is updated automatically.





15. Click on ABORT to stop.



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## 7.0 dsPIC DSC RESOURCE USAGE SUMMARY

### 7.1 Device Pin Mapping and Its Functionality in the Firmware

The following table summarizes the device pins configured and used in the AN1160 motor control application firmware, demonstrated using the Development Board and the dsPIC33CK256MP508 External Op Amp Motor Control PIM (MA330041-1). Refer to “dsPIC33CK256MP508 External Op Amp Motor Control Plug-in-Module (PIM) Information Sheet” (DS50002757) for more information.

Functional Description	PIM Pin Number	Device Pin Number	Device Pin Name	Signal Type	Remarks
<b>Motor Control PWMs and Fault Input</b>					
PWM1H	PIM:94	1	RP46/ <b>PWM1H</b> /PMD5/ <b>RB14</b>	PWM Output	Controls Hex Bridge MOSFET Q5
PWM1L	PIM:93	3	RP47/ <b>PWM1L</b> /PMD6/ <b>RB15</b>	PWM Output	Controls Hex Bridge MOSFET Q6
PWM2H	PIM:99	78	TDI/RP44/ <b>PWM2H</b> /PMD3/ <b>RB12</b>	PWM Output	Controls Hex Bridge MOSFET Q3
PWM2L	PIM:98	80	RP45/ <b>PWM2L</b> /PMD4/ <b>RB13</b>	PWM Output	Controls Hex Bridge MOSFET Q4
PWM3H	PIM:03	75	TMS/RP42/ <b>PWM3H</b> /PMD1/ <b>RB10</b>	PWM Output	Controls Hex Bridge MOSFET Q1
PWM3L	PIM:100	76	TCK/RP43/ <b>PWM3L</b> /PMD2/ <b>RB11</b>	PWM Output	Controls Hex Bridge MOSFET Q2
<b>Analog Inputs – Phase Currents, Speed Reference</b>					
POT	PIM:32	36	<b>AN19</b> /CMP2C/RP75/PMA0/PMALL/PSA0/ <b>RD11</b>	Analog Input	Speed Reference Connected to Potentiometer POT1
IBUS	PIM:23	33	<b>AN15</b> /CMP2A/IBIAS2/RP51/PMD11/PMA11/ <b>RC3</b>	Analog Input	Connected to Bus Current through External Op Amp Matrix Board
V_M1	PIM:22	2	<b>AN20</b> /RE0	Analog Input	Connected to Phase Voltage Monitor 1 through External Op Amp Matrix Board and Jumper JP1
V_M2	PIM:21	4	<b>AN21</b> /RE1	Analog Input	Connected to Phase Voltage Monitor 2 through External Op Amp Matrix Board and Jumper JP2
V_M3	PIM:20	17	<b>AN22</b> /RE2	Analog Input	Connected to Phase Voltage Monitor 3 through External Op Amp Matrix Board and Jumper JP3
<b>Miscellaneous Signals</b>					
BTN_1	PIM:83	54	RP69/PMA15/PMCS2/ <b>RD5</b>	Digital Input	Connected to Push Button S2
BTN_2	PIM:84	39	<b>RE7</b>	Digital Input	Connected to Push Button S3
Debug LED1	PIM:60	42	<b>RE8</b>	Digital Output	Connected to LED D17
Debug LED2	PIM:01	44	<b>RE9</b>	Digital Output	Connected to LED D2
RX (UART)	PIM:49	52	<b>RP71</b> /PMD15/ <b>RD7</b>	UART1 Input	Connected to UART-USB Converter to establish Serial Communication Interface between Host PC and the dsPIC® DSC
TX (UART)	PIM:50	53	<b>RP70</b> /PMD14/ <b>RD6</b>	UART1 Output	Connected to UART-USB Converter to establish Serial Communication Interface between Host PC and the dsPIC® DSC

## 8.0 REFERENCES

For additional information, refer to the following documents or links.

1. AN1160, “Sensorless BLDC Control with Back-EMF Filtering Using a Majority Function” Application Note.
2. “dsPICDEM™ MCLV-2 Development Board User’s Guide” (DS52080).
3. “dsPIC33CK256MP508 External Op Amp Motor Control Plug-In Module (PIM) Information Sheet” (DS50002757).
4. “dsPIC33CK256MP508 Family Data Sheet” (DS70005349).
5. Family Reference Manuals (FRMs) of the dsPIC33CK256MP508 family.
6. “MPLAB® X IDE User’s Guide” (DS50002027) or MPLAB® X IDE help.
7. [MPLAB X IDE](#) installation.
8. [MPLAB XC16](#) Compiler installation.

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NOTES: