

Getting Started with the MPLAB[®] Mindi[™] Analog Simulator

Note the following details of the code protection feature on Microchip devices:

- Microchip products meet the specification contained in their particular Microchip Data Sheet.
- Microchip believes that its family of products is one of the most secure families of its kind on the market today, when used in the intended manner and under normal conditions.
- There are dishonest and possibly illegal methods used to breach the code protection feature. All of these methods, to our knowledge, require using the Microchip products in a manner outside the operating specifications contained in Microchip's Data Sheets. Most likely, the person doing so is engaged in theft of intellectual property.
- Microchip is willing to work with the customer who is concerned about the integrity of their code.
- Neither Microchip nor any other semiconductor manufacturer can guarantee the security of their code. Code protection does not mean that we are guaranteeing the product as "unbreakable."

Code protection is constantly evolving. We at Microchip are committed to continuously improving the code protection features of our products. Attempts to break Microchip's code protection feature may be a violation of the Digital Millennium Copyright Act. If such acts allow unauthorized access to your software or other copyrighted work, you may have a right to sue for relief under that Act.

Information contained in this publication regarding device applications and the like is provided only for your convenience and may be superseded by updates. It is your responsibility to ensure that your application meets with your specifications. MICROCHIP MAKES NO REPRESENTATIONS OR WARRANTIES OF ANY KIND WHETHER EXPRESS OR IMPLIED, WRITTEN OR ORAL, STATUTORY OR OTHERWISE, RELATED TO THE INFORMATION, INCLUDING BUT NOT LIMITED TO ITS CONDITION, QUALITY, PERFORMANCE, MERCHANTABILITY OR FITNESS FOR PURPOSE. Microchip disclaims all liability arising from this information and its use. Use of Microchip devices in life support and/or safety applications is entirely at the buyer's risk, and the buyer agrees to defend, indemnify and hold harmless Microchip from any and all damages, claims, suits, or expenses resulting from such use. No licenses are conveyed, implicitly or otherwise, under any Microchip intellectual property rights unless otherwise stated.

Microchip received ISO/TS-16949:2009 certification for its worldwide headquarters, design and wafer fabrication facilities in Chandler and Tempe, Arizona; Gresham, Oregon and design centers in California and India. The Company's quality system processes and procedures are for its PIC® MCUs and dsPIC® DSCs, KEELOQ® code hopping devices, Serial EEPROMs, microperipherals, nonvolatile memory and analog products. In addition, Microchip's quality system for the design and manufacture of development systems is ISO 9001:2000 certified.

QUALITY MANAGEMENT SYSTEM CERTIFIED BY DNV = ISO/TS 16949=

Trademarks

The Microchip name and logo, the Microchip logo, AnyRate, AVR, AVR logo, AVR Freaks, BitCloud, chipKIT, chipKIT logo, CryptoMemory, CryptoRF, dsPIC, FlashFlex, flexPWR, Heldo, JukeBlox, KeeLoq, Kleer, LANCheck, LINK MD, maXStylus, maXTouch, MediaLB, megaAVR, MOST, MOST logo, MPLAB, OptoLyzer, PIC, picoPower, PICSTART, PIC32 logo, Prochip Designer, QTouch, SAM-BA, SpyNIC, SST, SST Logo, SuperFlash, tinyAVR, UNI/O, and XMEGA are registered trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

ClockWorks, The Embedded Control Solutions Company, EtherSynch, Hyper Speed Control, HyperLight Load, IntelliMOS, mTouch, Precision Edge, and Quiet-Wire are registered trademarks of Microchip Technology Incorporated in the U.S.A. Adjacent Key Suppression, AKS, Analog-for-the-Digital Age, Any Capacitor, AnyIn, AnyOut, BodyCom, CodeGuard, CryptoAuthentication, CryptoAutomotive, CryptoCompanion, CryptoController, dsPICDEM, dsPICDEM.net, Dynamic Average Matching, DAM, ECAN, EtherGREEN, In-Circuit Serial Programming, ICSP, INICnet, Inter-Chip Connectivity, JitterBlocker, KleerNet, KleerNet logo, memBrain, Mindi, MiWi, motorBench, MPASM, MPF, MPLAB Certified logo, MPLIB, MPLINK, MultiTRAK, NetDetach, Omniscient Code Generation, PICDEM, PICDEM.net, PICkit, PICtail, PowerSmart, PureSilicon, QMatrix, REAL ICE, Ripple Blocker, SAM-ICE, Serial Quad I/O, SMART-I.S., SQI, SuperSwitcher, SuperSwitcher II, Total Endurance, TSHARC, USBCheck, VariSense, ViewSpan, WiperLock, Wireless DNA, and ZENA are trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

 $\ensuremath{\mathsf{SQTP}}$ is a service mark of Microchip Technology Incorporated in the U.S.A.

Silicon Storage Technology is a registered trademark of Microchip Technology Inc. in other countries.

GestIC is a registered trademark of Microchip Technology Germany II GmbH & Co. KG, a subsidiary of Microchip Technology Inc., in other countries.

All other trademarks mentioned herein are property of their respective companies.

© 2019, Microchip Technology Incorporated, All Rights Reserved. ISBN: 978-1-5224-4210-3



Table of Contents

Preface	4
Chapter 1. Introduction	7
• 1.1 What Is the MPLAB® Mindi™ Analog Simulator?	7
1.2 What Is This User's Guide For?	7
Chapter 2. Running the MPLAB [®] Mindi™ Analog Simulator	8
2.1 Starting the MPLAB [®] Mindi™ Simulator	8
2.2 Setting the Update Schedule	9
2.3 PSpice and HSpice Compatibility	10
2.4 Welcome Page Overview and Navigation	11
2.5 Working with the Provided Application Schematics	12
2.6 Creating a New Schematic	13
2.7 The Design Analyzer	14
Chapter 3. Running a Simulation	16
3.1 Running a Simulation	16
3.2 Simulation Results	17
Chapter 4. Simulation Terms and Concepts	19
• • • • • • • • • • • • • • • • • • •	19
4.2 Start-up from ENABLE	20
4.3 Load Transient Response	20
4.4 Power Supply Rejection Ratio (PSRR)	21
4.5 Continuous and Discontinuous Conduction	21
4.6 Pulse Width and Pulse Frequency Modulation	22
4.7 HyperLight Load [®]	22
4.8 Soft Start	23
4.9 Power Good	23
Worldwide Sales and Service	24



Preface

NOTICE TO CUSTOMERS

All documentation becomes dated, and this manual is no exception. Microchip tools and documentation are constantly evolving to meet customer needs, so some actual dialogs and/or tool descriptions may differ from those in this document. Please refer to our website (www.microchip.com) to obtain the latest documentation available.

Documents are identified with a "DS" number. This number is located on the bottom of each page, in front of the page number. The numbering convention for the DS number is "DSXXXXXXA", where "XXXXXXX" is the document number and "A" is the revision level of the document.

For the most up-to-date information on development tools, see the MPLAB[®] IDE online help. Select the Help menu, and then Topics, to open a list of available online help files.

INTRODUCTION

This chapter contains general information that will be useful to know before using the MPLAB[®] Mindi[™] Analog Simulator. Items discussed in this chapter include:

- Document Layout
- Conventions Used in this Guide
- Recommended Resources
- The Microchip Website
- Product Change Notification Service
- Customer Support
- Document Revision History

DOCUMENT LAYOUT

This document describes how to use the MPLAB[®] Mindi[™] Analog Simulator as a comprehensive tool for analog circuit design and analysis. The manual layout is as follows:

- Preface
- Introduction
- Running the MPLAB® Mindi™ Analog Simulator
- Running a Simulation
- Simulation Terms and Concepts
- Worldwide Sales and Service

CONVENTIONS USED IN THIS GUIDE

This manual uses the following documentation conventions:

DOCUMENTATION CONVENTIONS

Description	Represents	Examples
Arial font:		
Italic characters	Referenced books	MPLAB [®] IDE User's Guide
	Emphasized text	is the only compiler
Initial caps	A window	the Output window
	A dialog	the Settings dialog
	A menu selection	select Enable Programmer
Quotes	A field name in a window or dialog	"Save project before build"
Underlined, italic text with right angle bracket	A menu path	<u>File>Save</u>
Bold characters	A dialog button	Click OK
	A tab	Click the Power tab
N'Rnnnn	A number in verilog format, where N is the total number of digits, R is the radix and n is a digit.	4'b0010, 2'hF1
Text in angle brackets < >	A key on the keyboard	Press <enter>, <f1></f1></enter>
Courier New font:		
Plain Courier New	Sample source code	#define START
	Filenames	autoexec.bat
	File paths	c:\mcc18\h
	Keywords	_asm, _endasm, static
	Command-line options	-Opa+, -Opa-
	Bit values	0, 1
	Constants	OxFF, 'A'
Italic Courier New	A variable argument	<i>file.</i> o, where <i>file</i> can be any valid filename
Square brackets []	Optional arguments	mcc18 [options] file [options]
Curly brackets and pipe character: { }	Choice of mutually exclusive arguments; an OR selection	errorlevel {0 1}
Ellipses	Replaces repeated text	<pre>var_name [, var_name]</pre>
	Represents code supplied by user	<pre>void main (void) { }</pre>

RECOMMENDED RESOURCES

• This user's guide provides information on how to use the MPLAB[®] Mindi™ Analog Simulator. For more in-depth, hands-on training, visit http://microchipdeveloper.com/mindi:hands-on-workbook.

THE MICROCHIP WEBSITE

Microchip provides online support via our website at www.microchip.com. This website is used as a means to make files and information easily available to customers. Accessible by using your favorite Internet browser, the website contains the following information:

- **Product Support** Data sheets and errata, application notes and sample programs, design resources, user's guides and 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 listing
- Business of Microchip Product selector and ordering guides, latest Microchip press releases, listing of seminars and events, listings of Microchip sales offices, distributors and factory representatives

PRODUCT CHANGE NOTIFICATION SERVICE

Microchip's customer notification service helps keep customers current on Microchip products. Subscribers will receive e-mail notifications whenever there are changes, updates, revisions or errata related to a specified product family or development tool of interest.

To register, access the Microchip website at www.microchip.com, click **Product Change Notification** and follow the registration instructions.

CUSTOMER SUPPORT

Users of Microchip products can receive assistance through several channels:

- Distributor or Representative
- · Local Sales Office
- Field Application Engineer (FAE)
- Technical Support

Customers should contact their distributor, representative or field application engineer (FAE) for support. Local sales offices are also available to help customers. A listing of sales offices and locations is included in the back of this document.

Technical support is available through the website at: http://www.microchip.com/support.

DOCUMENT REVISION HISTORY

Revision B (February 2019)

- Updated to current template.
- · Divided the document into several chapters.
- Added new chapter Simulation Terms and Concepts.
- Edited text for clarity.
- Updated figures throughout the document.

Revision A (January 2017)

• Initial release of this document.



Chapter 1. Introduction

1.1 WHAT IS THE MPLAB[®] MINDI[™] ANALOG SIMULATOR?

The MPLAB[®] Mindi[™] Analog Simulator is a comprehensive tool for analog circuit design and analysis. It contains two simulation engines: SIMetrix (SPICE) and SIMulation of Piecewise Linear Systems (SIMPLIS).

1.2 WHAT IS THIS USER'S GUIDE FOR?

This document is just a quick starting guide to help you use the MPLAB[®] MindiTM Analog Simulator. It is not intended to replace the documentation and tutorials provided for the SIMetrix and SIMPLIS tools, which can be accessed from the **Help** menu in MPLAB[®] MindiTM.



Chapter 2. Running the MPLAB[®] Mindi[™] Analog Simulator

2.1 STARTING THE MPLAB[®] MINDI[™] SIMULATOR

To start the MPLAB[®] Mindi[™] Analog Simulator, double-click the desktop shortcut after installation or select MPLAB[®] Mindi[™] 8.20 from the Start Menu. A splash screen will display the MPLAB[®] Mindi[™] Analog Simulator logo and brief licensing terms.



FIGURE 2-1: MPLAB[®] Mindi[™] Simulator Splash Screen.

After clicking **OK** on the splash screen, the MPLAB[®] Mindi™ Analog Simulator graphical user interface (GUI) will load and display the Welcome page.



FIGURE 2-2:

MPLAB[®] Mindi[™] Simulator Welcome Page.

2.2 SETTING THE UPDATE SCHEDULE

We strongly recommend you to allow the MPLAB[®] Mindi[™] Analog Simulator to check for regular updates automatically in order to ensure that the tool will always offer the latest patches, models and example application schematics.

To set the update schedule when opening the MPLAB[®] Mindi[™] Analog Simulator for the first time, click "here" in the red text area.



FIGURE 2-3:

MPLAB[®] Mindi[™] Initial Update Settings Window.

You can also set the desired update schedule later on. To do this, click <u>Help>Check</u> <u>Updates Now</u> and change the "Automatic Update Schedule" to Daily, Weekly, or Monthly.

🖌 Update Settings 🛛 🗙 🗡
Check Updates Now Automatic Update Schedule Weekly
Ok Cancel

FIGURE 2-4: MPLAB[®] Mindi[™] Update Settings Window.

2.3 PSPICE AND HSPICE COMPATIBILITY

With the release of version 8.2, the MPLAB[®]Mindi[™] Analog Simulator implemented global PSpice and HSpice compatibility options for SIMetrix. You can set these options in <u>Options>General>Miscellaneous>PSpice/HSpice compatibility level</u>.

imulator compatibility	
Spice compatibility level 0	•
Ispice compatibility level 0	\$

FIGURE 2-5: MPLAB[®] Mindi[™] Compatibility Options Menu.

If the compatibility level is not set at the time of the simulation, SIMetrix will automatically use the default level, which is 2. Several simulation issues can be resolved by setting this option to 0. Also, this option can be set directly into the schematic by adding the line options initcondmode=0 below the analysis directives (.TRAN, .DC, .AC, etc.) but above the .simulator DEFAULT line in the schematic editor's command window. Also known as the F11 window, it can be displayed by pressing the <F11> key.





MPLAB[®] Mindi™ Compatibility Options - initcondmode.

The initcondmode directive sets the behavior of capacitors and inductors when given an initial condition parameter (IC) and may have these values:

- 0 Berkeley SPICE compatible mode
- 1 SIMPLIS compatible mode. Forces hard initial condition
- 2 Spice compatible mode. Forces soft initial condition

2.4 WELCOME PAGE OVERVIEW AND NAVIGATION

The Welcome page has quick links for the following actions:

- By clicking the menu button \blacksquare you can browse application schematics by category using the searchable navigation tree;
- Create New/Open: Open or create a new schematic or symbol for SIMPLIS or SIMetrix from scratch;
- *MPLAB[®] Mindi*[™] *Support*: Get help or more application schematics from Microchip;
- Recent Schematics: Open recent schematics.

You can browse for the available example schematics in the navigation tree by going through the product categories. The navigation tree also has a search bar where you can search by IC part name as well as a a **Close** button in the top right corner.

mcp163	x Q	×
- MCP1630		
⁶ (MCP1630))) Boost example, start up	
⁶ (MCP1630))) Boost example, transient load step	
⁶ (MCP1630))) Boost example, AC response	
- MCP1630V		
(MCP1630)	V) Boost example, start up	
(MCP1630)	V) Boost example, transient load step	
(MCP1630)	V) Boost example, AC response	
- MCP1631		
Voltage loo	op, peak current mode control, start up and tra	ansient
S Voltage loo	op, peak current mode control, AC response	
S Current loo	op, start up and transient	
S Current loo	op, AC response	
- MCP1632		

FIGURE 2-7: MPLAB[®] Mindi[™] - Navigation Menu.

To search through the navigation tree, you can type a fragment or the whole IC part name and then press the <Enter> key or the **Search** button to display the results that match the search input.

To clear the search results, you can press the <Esc> key while the search input is focused or click the **x** button that will be displayed in the search input field.

If you press the <Esc> key twice while the search input is focused, the navigation tree will close. You can also close the navigation menu by clicking the **(Close) x** button in the top right corner.

Some navigation elements have a pop-up window that will display a brief description when the mouse hovers over that node.



FIGURE 2-8: MPLAB[®] Mindi[™] Popup Window.

The application schematics are preceded by icons that indicate which simulator engine is being used for that particular schematic.

You can also access the application schematics from the **File View** tab by navigating to the Microchip folder under SIMetrix or SIMPLIS.

SIMetrix files are marked with the *I* icon, whereas SIMPLIS files are indicated by the <> icon.



FIGURE 2-9: MPLAB[®] Mindi[™] Directory Structure - File View Tab.

2.5 WORKING WITH THE PROVIDED APPLICATION SCHEMATICS

All application schematics are copied to your local documents folder when you run the simulator for the first time.

When modifying any of these schematics, we highly recommend you to save a copy of the file (using *File>Save Schematic As*) right after opening the schematic in order to avoid overwriting the default version.

If you overwrite your local default schematics by mistake, you can find copies of the provided schematics in the simulator installation folder, which is typically located at C:\Program Files (x86)\MPLAB Mindi 820\support\examples.

2.6 CREATING A NEW SCHEMATIC

You can create a new schematic from *File>New>SIMetrix/SIMPLIS Schematic*, or by using the Create New/Open quick link from the Welcome page. If you want to start from scratch, you can use Microchip's models from the *Place>From Microchip Library* menu.

The model list is organized according to product category, and only those models compatible with the currently selected simulator (SIMetrix or SIMPLIS) will be shown.

Repeat Last Place Alt+F	K 🔍 🔍 🥒 🕨 II 👗 🕴	≑ ~ ÷ ⊙ θ ≭ ≭ ·	-K-K⊐E⊐E∓TT≯-K
From Model Library Ctrl+	G		
From Symbol Library			
From Microchip Library	 Comparators 		
Select by Specification	Amplifiers		
Search Part	High-Voltage Interface		
	MOSEET and Motor Drivers		
Hierarchy	Bower Management	C	
Create Model	+ Fower management	Controllers •	MCP1632-AA_SIMETRIX
Magnetics		LED Drivers	MCP1632-BA_SIMETRIX
magnetics		Linear Regulators	MCP19035-AAAA
Passives		Power Switches	MCP19035-BAAA
Connectors	• • • • • • • • • • • • • • • • • • • •	System Supervisors •	
Probe	• • • • • • • • • • • • • • • •		••••••
Voltage Sources	•		
Current Sources	•		
Controlled Sources	• []]]]]]]]]]]]]]]]]]		
Bias Annotation			
Semiconductors	• Los la la la la cal la la		
Digital	,		
Digital Generic	•		
Analog Behavioural			
Analog Eunstions			
Analog runctions			

FIGURE 2-10: MPLAB[®] Mindi[™] - New Schematic Menu.

Many common components or measuring devices can be selected from the toolbar at the top or from the Place menu.

For example you can choose fixed probes from the Place menu or interactive probes from the toolbar.

The probes 🥢 💒 will ensure that waveforms will be displayed during simulation.

You can access all installed models from the <u>*Place>From Model Library*</u> menu, or by pressing the <Ctrl+G> key combination.



FIGURE 2-11: MPLAB[®] Mindi[™] - Model Library.

2.7 THE DESIGN ANALYZER

The Design Analyzer is an integral part of the simulation environment of the MPLAB[®]Mindi[™] Analog Simulator. It allows you to alter system requirements quickly, while observing key converter characteristics, such as loop stability via Bode plots. By employing input parameter range constrains, the Design Analyzer reduces circuit design time and design risk prior to simulation and hardware prototyping.

The Design Analyzer interface has two panels. The left panel contains parameters that can be modified by the user and suggested values based on the system requirements. The right panel contains the schematic of the part which is being analyzed, a closed-loop Bode plot, and estimated efficiency plots.



FIGURE 2-12: MPLAB[®] Mindi™ Design Analyzer Panels.

Some inputs can have specific validation criteria and suggested values attached to the left of the editable input.



FIGURE 2-13: MPLAB[®] Mindi[™] Design Analyzer - Suggested Values.

If the range validation of an input fails, an orange or red notification will pop up in the bottom right corner of the screen.



FIGURE 2-14: MPLAB[®] Mindi™ Design Analyzer - Invalid Input Notifications.

Some inputs take part in the calculation of the suggested values. If such an input value is changed, you will see the following pop-up notification:



After changing the values, if you click the bottom left **Calculate Data/Plots** button, the tool will calculate the Bode and estimated efficiency plots. The results output from each tab and the following notification will pop up:





Chapter 3. Running a Simulation

3.1 RUNNING A SIMULATION

After opening a Microchip application schematic, you can run the default analysis by pressing the <F9> key or by clicking <u>Simulator>Run Schematic.</u>

🖌 MPLAB Mindi	Main Window		
File Edit View	Simulator Place Probe Probe AC/Noise	Hierarchy Mor	nte Ca
🗋 🗕 🚞 🗙 🖬	Choose Analysis	F8	
File View	Run Schematic	F9	MPLA
Add Directory	Abort Show SIMPLIS Status Window	Ctrl+Space	
V 📕 Example	Initial Conditions	•	11 H
> SIMe	Setup Multi-step Run Multi-step		
>] 4 >] 4 >] 6	Find Smallest Time Constant Graph Time Constants Debug Simulation		
	Manage Data Groups		L.
	Edit Netlist (before preprocess) Edit Netlist (after preprocess)		
>	Open/Close Command (F11) Window	F11	171
×.	Enable/Disable Simulation Health Report		
	Switch to SIMetrix Mode		1

FIGURE 3-1: $MPLAB^{\textcircled{R}}$ MindiTM - Running the Simulation.

The default analysis type is highlighted in the application schematic's file name (for example MCP1623_AC_Load_Transient). To set its parameters you can open the Choose Analysis window under the Simulator tab or press the <F8> key.

If you want to run your own schematic, you must first choose the analysis type and its parameters.

Periodic Operating Point AC Transient Analysis parameters POP AC Y Transient Save options All Voltages Only Probes Only Probes Only Advanced No Forced Output Data ✓ Force New Analysis Advanced
Advanced No Forced Output Data

FIGURE 3-2:

MPLAB[®] Mindi[™] - Custom Schematic.

The analysis options for SIMPLIS and SIMetrix are different, and the models are generally not compatible from one tool to the other. If you try to run a SIMPLIS schematic using the SIMetrix tool (or vice versa), the MPLAB[®] Mindi[™] Analog Simulator will issue a warning and highlight the incompatible components.



FIGURE 3-3: MPLAB[®] Mindi[™] - Incompatibility Warning.

3.2 SIMULATION RESULTS

You can monitor the status of the simulation and analysis in the simulation status window, as shown below. During simulation, incremental waveform results will be displayed if they have been previously enabled. Please note that not all stimulus components or probes are functional with every simulation/analysis type. For each analysis type selected, it is important to add the proper probes and sources to the schematic.

SIMPLIS St	tatus			
Analysis statu	15			
Analysis A	AC	Data	Group simplis_ac1	
Run status F	inished	Step		
Run Progress				100%
POP Status	Pass	4	Convergence	1.763248277e-12%
	Frequency	100k	Topologies	New topology #30
Elapsed Time	Current	0 hr 0 min 1 sec	Total	0 hr 0 min 3 sec
CPU time	Current	0 hr 0 min 0.28 sec	Total	0 hr 0 min 0.44 sec
Writing per Leaving SIN	rtinent data file MPLIS. ** For additional	Analyzed fr s nk you for trying M support, please vi	eq. : 1.0000000 PLAB Mindi **** sit www.microch	00000e+05 Hz
Abort	Clear Messages	Close		Close on complet

FIGURE 3-4: MPLAB[®] Mindi[™] - Simulation Status.

The MPLAB[®] Mindi[™] Analog Simulator can perform time domain (waveforms) and frequency domain (Bode plot) analyses. A time domain simulation shows multiple characteristics such as response time and overshoot.



FIGURE 3-5: MPLAB[®] Mindi[™] - Time Domain Simulation.

While the time domain analysis shows how a signal changes over time, the frequency domain analysis shows how the signal's energy is distributed over a range of frequencies.



FIGURE 3-6: MPLAB[®] Mindi[™] - Frequency Domain Analysis.

This frequency domain analysis produces the Bode plots. These plots include critical information regarding the circuit's closed-loop stability, such as gain and phase margins.



Chapter 4. Simulation Terms and Concepts

This chapter is a list of key terms and concepts used in describing and analyzing the characteristics of a circuit simulation. Please note that specific terms may vary slightly depending on the device that is being used.

4.1 START-UP FROM VIN

Start-up from V_{IN} refers to the behavior of a device or circuit when first powered on. The assertion of the enable pin must be done before applying V_{IN}. The start-up time, in this case, is typically measured from the rising or the falling edge of the enable signal (depending on the required logic level) to 90% of the steady-state output value of the device, as shown in the waveform below.



FIGURE 4-1: Start-Up from V_{IN} Waveform.

4.2 START-UP FROM ENABLE

Start-up from ENABLE is the response of a circuit or device when an enable signal is asserted. It is assumed that the system has been properly biased and any settling times have been met before the assertion of the enable signal. The start-up time, in this case, is typically measured from the rising or the falling edge of the enable signal (depending on the required logic level) to 90% of the steady-state output value of the device, as shown in the waveform below.



FIGURE 4-2:

Start-up from Enable Waveform.

4.3 LOAD TRANSIENT RESPONSE

Load transient response describes the capability of a converter to maintain its output voltage during a change in the load. Typically, this is specified by the output voltage undershoot and overshoot during a load step, as shown below.



FIGURE 4-3: Load Transient Response.

4.4 POWER SUPPLY REJECTION RATIO (PSRR)

Power Supply Rejection Ratio (PSRR) describes the capability of an electronic circuit to suppress any power supply variations to its output signal. This capability is often expressed in decibels.



FIGURE 4-4:

Power Supply Rejection Ratio.

4.5 CONTINUOUS AND DISCONTINUOUS CONDUCTION

In power supplies, the Continuous Conduction Mode (CCM) is the operating mode in which current flows through the inductor throughout the switching cycle.

In Discontinuous Conduction Mode (DCM), the inductor current falls to zero for some portion of the switching cycle. The first half of the figure below depicts CCM. After the load current drops in the second half, the converter transitions to DCM operation.





Continuous and Discontinuous Conduction Modes.

4.6 PULSE WIDTH AND PULSE FREQUENCY MODULATION

The Pulse Frequency Modulation (PFM) mode offers a higher efficiency over all load ranges. Devices run in PFM mode for light load conditions and for large input-to-output voltage ratios.

However, devices will switch into Pulse-Width Modulation (PWM) mode at higher load currents and lower input-to-output voltage ratios. PWM only operation is recommended for noise-sensitive applications in order to exhibit a much lower output voltage ripple.



FIGURE 4-6:

Pulse Width Modulation and Pulse Frequency Modulation.

4.7 HYPERLIGHT LOAD®

HyperLight Load (HLL) is a proprietary tool that controls load cycles through automatic switching between the ON and OFF modes. After the (constant) ON-time duration has expired, HLL turns the high side switch OFF until the output drops below the threshold. Once the output drops below the threshold a new cycle begins.

Using an NMOS low side switch instead of a diode allows for lower voltage drop across the switching device when it is on.

In discontinuous mode, HyperLight Load is used to regulate the output and to improve the efficiency of the regulators during light load currents by switching to the ON mode only when it is needed.

4.8 SOFT START

Soft start reduces the power supply input surge current at start-up by controlling the output voltage rise time. The input surge takes place while the output capacitor is being charged up. A slower output rise time will draw a lower input surge current.



FIGURE 4-7: Soft start.

4.9 POWER GOOD

The Power Good (PG) output provides an indication of the output state of the device and is typically implemented as a comparator that trips when V_{OUT} is below 90% of regulation voltage.

The PG pin is generally an open-drain output that should be pulled up by the device that is measuring the PG state.

The PG delay time is measured from the point at which V_{OUT} reaches 90% of the regulation value and the rising edge of the PG output. The PG response time is measured from the point at which V_{OUT} drops below 90% of the regulation value to the falling edge of the PG output.



Worldwide Sales and Service

AMERICAS

Corporate Office 2355 West Chandler Blvd. Chandler, AZ 85224-6199 Tel: 480-792-7200 Fax: 480-792-7277 Technical Support: http://www.microchip.com/ support

Web Address: www.microchip.com

Atlanta Duluth, GA Tel: 678-957-9614 Fax: 678-957-1455

Austin, TX Tel: 512-257-3370

Boston Westborough, MA Tel: 774-760-0087 Fax: 774-760-0088

Chicago Itasca, IL Tel: 630-285-0071 Fax: 630-285-0075

Dallas Addison, TX Tel: 972-818-7423 Fax: 972-818-2924

Detroit Novi, MI Tel: 248-848-4000

Houston, TX Tel: 281-894-5983

Indianapolis Noblesville, IN Tel: 317-773-8323 Fax: 317-773-5453 Tel: 317-536-2380

Los Angeles Mission Viejo, CA Tel: 949-462-9523 Fax: 949-462-9608 Tel: 951-273-7800

Raleigh, NC Tel: 919-844-7510

New York NY Tel: 631-435-6000

San Jose, CA Tel: 408-735-9110 Tel: 408-436-4270

Canada - Toronto Tel: 905-695-1980 Fax: 905-695-2078

ASIA/PACIFIC

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 - Guangzhou Tel: 86-20-8755-8029

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: 86-21-3326-8000

China - Shenyang Tel: 86-24-2334-2829

China - Shenzhen Tel: 86-755-8864-2200

China - Suzhou Tel: 86-186-6233-1526

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

ASIA/PACIFIC

India - Bangalore Tel: 91-80-3090-4444

India - New Delhi Tel: 91-11-4160-8631 India - Pune

Tel: 91-20-4121-0141

Tel: 81-3-6880- 3770

Tel: 82-53-744-4301

Tel: 82-2-554-7200

Tel: 60-3-7651-7906

Tel: 60-4-227-8870

Tel: 63-2-634-9065

Tel: 65-6334-8870

Taiwan - Kaohsiung

Tel: 886-2-2508-8600

Vietnam - Ho Chi Minh Tel: 84-28-5448-2100

Netherlands - Drunen

EUROPE

Austria - Wels

Tel: 43-7242-2244-39

Tel: 45-4450-2828

Fax: 45-4485-2829

Tel: 358-9-4520-820

Tel: 33-1-69-53-63-20

Fax: 33-1-69-30-90-79

Germany - Garching

Tel: 49-2129-3766400

Germany - Heilbronn

Germany - Karlsruhe

Tel: 49-721-625370

Germany - Munich

Tel: 49-89-627-144-0

Fax: 49-89-627-144-44

Germany - Rosenheim

Tel: 49-8031-354-560

Israel - Ra'anana

Italy - Milan

Italy - Padova

Tel: 972-9-744-7705

Tel: 39-0331-742611

Fax: 39-0331-466781

Tel: 39-049-7625286

Tel: 49-7131-67-3636

Tel: 49-8931-9700

Germany - Haan

Finland - Espoo

France - Paris

Fax: 43-7242-2244-393

Denmark - Copenhagen

Tel: 31-416-690399 Fax: 31-416-690340

Norway - Trondheim Tel: 47-7288-4388

Poland - Warsaw Tel: 48-22-3325737

Romania - Bucharest Tel: 40-21-407-87-50

Spain - Madrid Tel: 34-91-708-08-90 Fax: 34-91-708-08-91

Sweden - Gothenberg Tel: 46-31-704-60-40

Sweden - Stockholm Tel: 46-8-5090-4654

UK - Wokingham Tel: 44-118-921-5800 Fax: 44-118-921-5820

Japan - Osaka Tel: 81-6-6152-7160 Japan - Tokyo

Korea - Daegu

Korea - Seoul

Malaysia - Kuala Lumpur

Malaysia - Penang

Philippines - Manila

Singapore

Taiwan - Hsin Chu Tel: 886-3-577-8366

Tel: 886-7-213-7830

Taiwan - Taipei

Thailand - Bangkok

Tel: 66-2-694-1351