MCP16502
Evaluation Board
User's Guide

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MCP16502 EVALUATION BOARD USER'S GUIDE

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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 "DSXXXXXXXXA", where "XXXXXXXX" 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 MCP16502 Evaluation Board. Items discussed in this chapter include:

• Document Layout
• Conventions Used in this Guide
• Recommended Reading
• The Microchip WebSite
• Customer Support
• Document Revision History

DOCUMENT LAYOUT

This document describes how to use the MCP16502 Evaluation Board as a development tool. The manual layout is as follows:

• **Chapter 1. "Product Overview"** – Important information about the MCP16502 Evaluation Board.
• **Chapter 2. "Installation and Operation"** – Includes instructions on how to get started with the MCP16502 Evaluation Board and a description of each function.
• **Chapter 3. "GUI Installation and Operation"** – Includes instructions on how to install the Graphical User Interface.
• **Chapter 4. "GUI Description"** – Describes the items in the Graphical User Interface.
• **Appendix A. "Schematic and Layouts"** – Shows the schematic and layout diagrams for the MCP16502 Evaluation Board.
• **Appendix B. "Bill of Materials (BOM)"** – Lists the parts used to build the MCP16502 Evaluation Board.

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	*File>Save*
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>
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	`0xFF, 'A'`
Italic Courier New	A variable argument	`file`.o, where `file` 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	`var_name [, var_name...]`

	Represents code supplied by user	`void main (void)`
		`{ ...`
		`}`

RECOMMENDED READING

This user's guide describes how to use the MCP16502 Evaluation Board. Another useful document is listed below. The following Microchip document is available and recommended as a supplemental reference resource.

- **MCP16502 Data Sheet** – *"High-Performance PMIC for SAMA5DX/SAM9x6 MPUs"* **(DS20006275)**

THE MICROCHIP WEBSITE

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- **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

CUSTOMER SUPPORT

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- 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 C (December 2019)

- Revised data sheet title.

Revision B (November 2019)

- Remove AEC-Q100 reference.

Revision A (November 2019)

- Initial Release of this Document.

NOTES:

Chapter 1. Product Overview

1.1 INTRODUCTION

This chapter provides an overview of the MCP16502 Evaluation Board and covers the following topics:

- MCP16502 Short Overview
- MCP16502 Evaluation Board Overview
- Contents of the MCP16502 Evaluation Board Kit

1.2 MCP16502 SHORT OVERVIEW

The MCP16502 is an optimally integrated PMIC compatible with Microchip's eMPUs (embedded microprocessor units), requiring Dynamic Voltage Scaling (DVS), with the use of High-Performance mode (HPM). It is compatible with SAMA5DX and SAM9x6 MPUs, supported by dedicated device variants which optimize the solution BOM.

The MCP16502 integrates four DC-DC buck regulators and two auxiliary LDOs and provides a comprehensive interfacing to the MPU, which includes an interrupt flag and a 1 MHz I^{2}C interface.

All buck channels can support loads up to 1A. All bucks are 100% duty cycle capable.

Two 300 mA LDOs are provided such that sensitive analog loads can be supported.

The DDR memory voltage (Buck2) is selectable by means of a tri-state input pin. This method allows greater precision in the output voltage setting by eliminating inaccuracies due to external feedback resistors, while minimizing external component count. The voltages selection set allows easy migration across different generations of memories.

The default power channel sequencing is built-in, according to the requirements of the MPU. A dedicated pin (LPM) facilitates the transition to low-power modes and the implementation of the Backup mode with DDR in self-refresh (Hibernate mode).

The MCP16502 features a low, no-load operational quiescent current and it draws less than 10 µA in full shutdown.

Active discharge resistors are provided on each output. All buck channels support safe start-up into pre-biased outputs.

The MCP16502 is available in a 32-pin 5 mm x 5 mm VQFN package, with an operating junction temperature range from -40°C to +125°C.
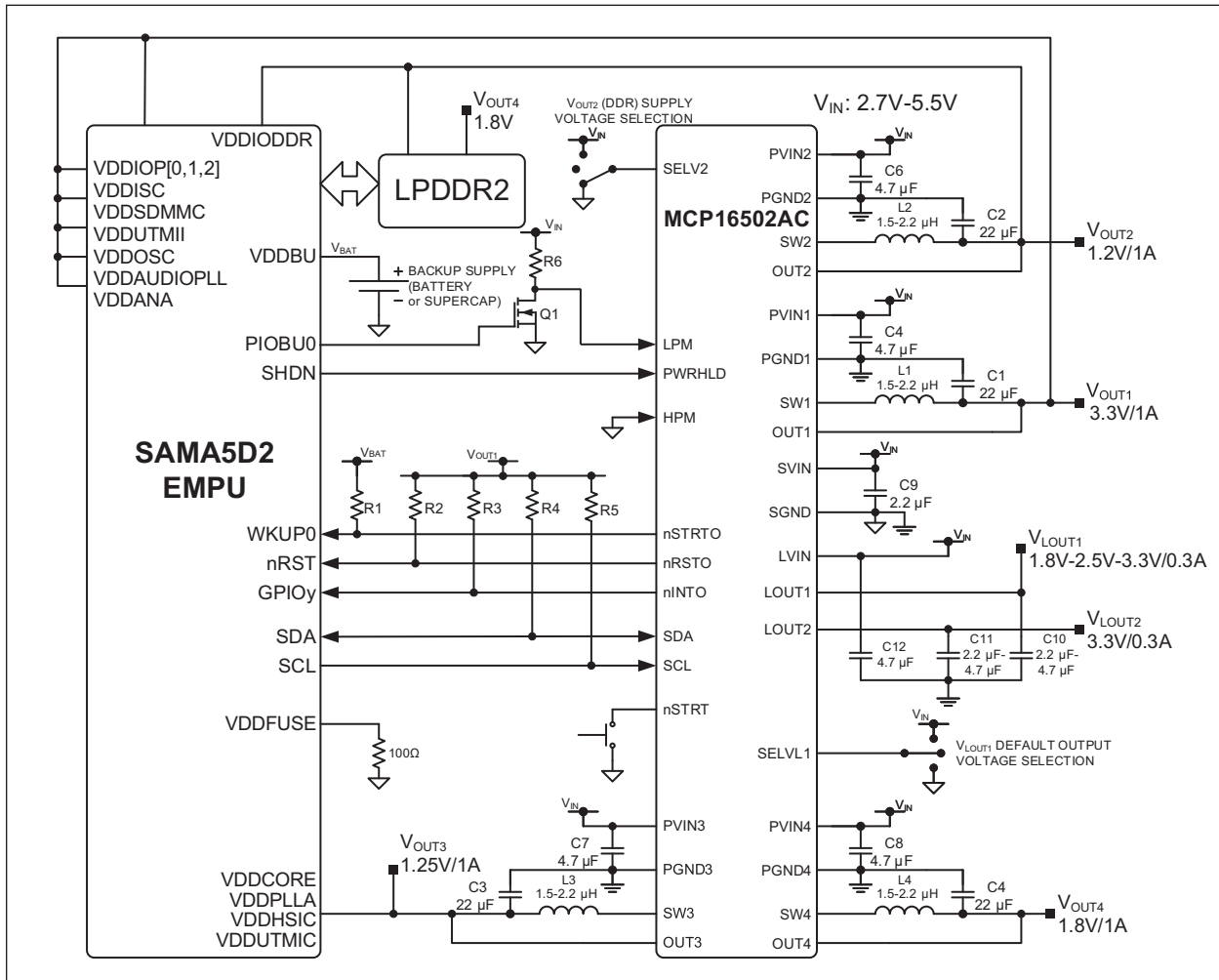
FIGURE 1-1: *Typical MCP16502AC with SAMA5D2 and LPDDR2 Application.*

1.3 MCP16502 EVALUATION BOARD OVERVIEW

The MCP16502 Evaluation Board is designed to simplify the evaluation and testing of all the MCP16502 capabilities. The V_{IN} supply has a 2.7V-5.5V range and V_{OUT} has a 1.2V-3.7V range for Buck1 and the two LDOs and 0.6-1.85V for Buck2, Buck3 and Buck4.

An on-board MCP2221, which is a USB 2.0 to I^{2}C/UART Protocol Converter with GPIO, is placed on the board to simplify the configuration of the MCP16502.

The application allows for both manual control of power state pins through 3-pin jumpers on PWRHLD, LPM and HPM pins and software control using the I^{2}C Monitor GUI.

Additionally, an on-board load transient generator circuit is provided to evaluate the load step response of some of the buck channels.

1.4 CONTENTS OF THE MCP16502 EVALUATION BOARD KIT

The MCP16502 Evaluation Board kit includes:

- MCP16502 Evaluation Board (DT100105)
- USB-to-Micro-USB Cable
- Important Information Sheet

Chapter 2. Installation and Operation

2.1 INTRODUCTION

The MCP16502 Evaluation Board has been developed to test the MCP16502's capabilities, control and monitor through the USB interface (via the I^{2}C Monitor GUI).
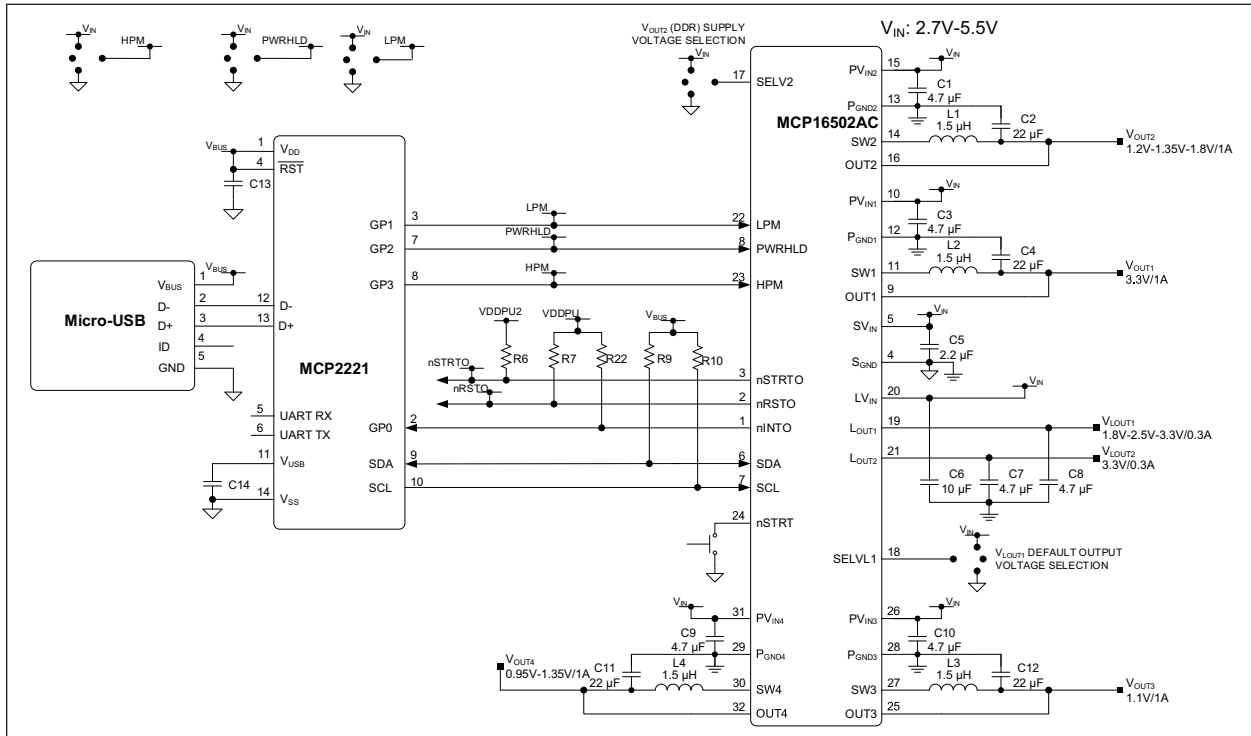
FIGURE 2-1: *MCP16502 Evaluation Board with MCP2221 I^{2}C Bridge.*

2.2 FEATURES

The MCP16502 Evaluation Board has the following features:

- Input Voltage Range: 2.7V to 5.5V
- Four 1A Buck DC-DC Channels with 100% Maximum Duty Cycle Capability
- 2 MHz Buck Channels PWM Operation
- Two Auxiliary 300 mA LDOs
- ±1% Voltage Accuracy for DDR (Buck2), Core (Buck3) and CPU (Buck4)
- Pin-Selectable Output Voltages for DDR Buck: 1.2V, 1.35V, 1.8V
- MPU-Specific Built-In Default Channel Sequencing and nRSTO Assertion Delay
- Support of Hibernate, Low-Power and High-Performance Modes with DVS
- 1 MHz I^{2}C Interface for Programming and Diagnostics
- Low-Noise Forced PWM (FPWM) and Low Quiescent Current Light Load High-Efficiency Mode
- Leakage-Free Interfacing to MPU in any Operating Condition through Optimized ESD Protection
- Less than 300 µA Low-Power Mode Typical Quiescent Current (Bucks and LDO1 on, no load)
- 10 µA Maximum Shutdown Current (V_{IN} = 4.5V, T_J = +105°C)
- Cost and Size-Optimized BOM
- Thermal Shutdown and Current-Limit Protection
- User-Programmable Overcurrent Fault Response
- 32-pin 5 mm × 5 mm VQFN Package
- -40°C to +125°C Junction Temperature Range

2.3 GETTING STARTED

The MCP16502 Evaluation Board is fully assembled and tested to evaluate and demonstrate the MCP16502 product.

This board requires a single power supply with at least 3A current capability if multiple channels are tested under load. The MCP16502 Evaluation Board can be powered directly from the USB connector by connecting jumper J1. Note that in this configuration, the amount of power which can be supplied at the outputs is limited by the USB connection. This is only meant for testing using the GUI of the sequencing and different register settings.

The MCP16502 is available in five different product options, depending on the default settings at power-up, prior to any I^{2}C write operation. The differences among the various product options are described in the MCP16502 data sheet. The Evaluation Board carries the AC option, which is intended for an efficiency-optimized, high-performance (i.e., 500 MHz) SAMA5D2 application, equipped with LPDDR2 memories.

2.3.1   Power Input and Output Connections

To power up the MCP16502 Evaluation Board, follow the steps below:

1. Connect a power supply to the MAIN and PGND terminals. An ammeter may be placed between the input supply and the MAIN terminal to the Evaluation Board. Ensure that the supply voltage is monitored at the MAIN terminal. The ammeter and/or power lead resistance can reduce the voltage supplied to the input. Keep the power supply disabled; do not apply power before Step 5.

2. Connect the loads to the VOUTx for buck converters or LDOx for LDO regulators and PGND terminals. The load can be either passive (resistive) or active (electronic load). An ammeter can be placed between the load and each output terminal. Ensure that the output voltage is monitored at the output terminals. Alternatively, for high-speed load transient testing at low output voltages, the on-board load transient generator can be used (see **Section 2.4 "On-Board Load Transient Generator"**).

3. Make sure the jumpers are connected as in Figure 2-2 (PWRHLD = HPM = LPM = SELVL1 = SELV2 = HIGH and optionally VDDPU2 = VIN). If experimenting with the connection VDDPU2 = VDDBAT, make sure to remove R3 prior to that.

4. If changing the PMIC parameters is required or simply to monitor the part, make sure to connect the Micro-USB cable between the Evaluation Board and the PC.
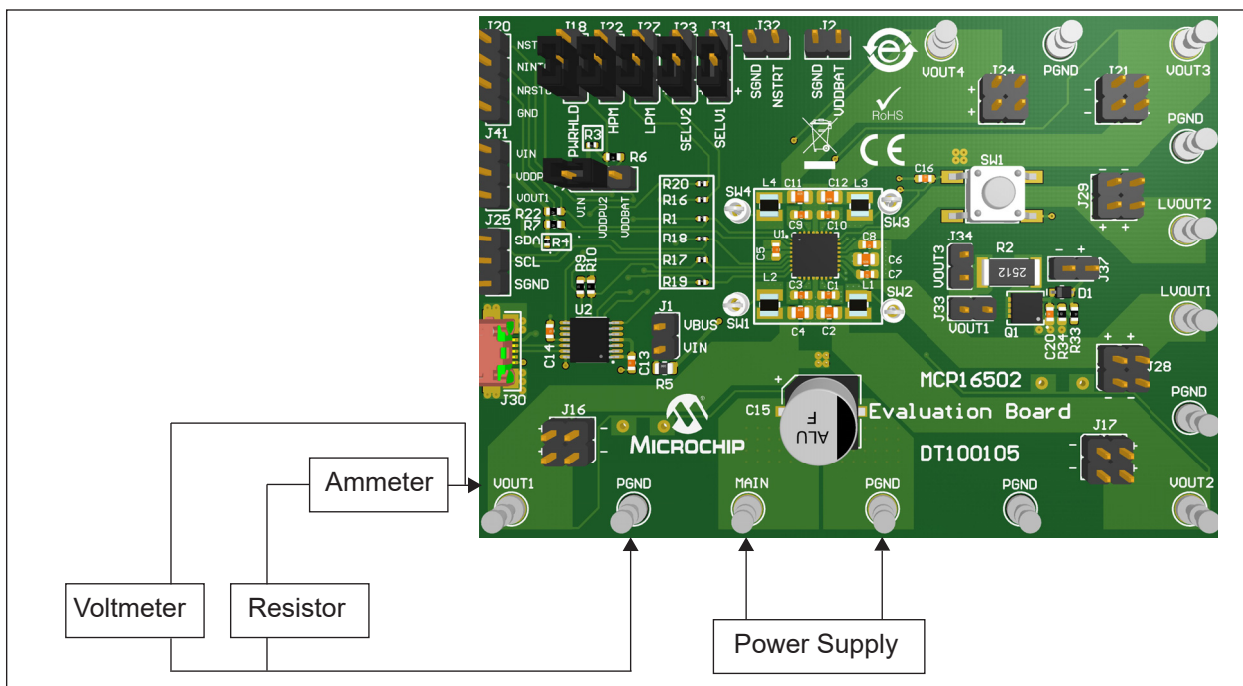
FIGURE 2-2:   *MCP16502 Evaluation Board Connection.*

5. Set the power supply to 5V and turn it on. Alternatively, if no power supply is available, a jumper can be connected to J1, such that the board is powered from the USB connection.

6. Press the **SW1** button.

7. Verify that the output voltages are regulated to the desired VOUT setting for each channel.

8. The PMIC settings can be modified using the GUI. For details on how to use the I^{2}C Monitor, see **Section 3.3 "I2C Monitor Graphical User Interface Uninstall"**.

2.4   ON-BOARD LOAD TRANSIENT GENERATOR

The MCP16502 Evaluation Board provides circuitry to enable load transient testing with fast current rise time and fast, yet controlled, fall time. This is done by a fast turn-on, controlled turn-off MOSFET switch (Q1). MOSFET Q1 must be driven by an external signal generator, connected at J37, using a square wave (the suggested low level is 0V, the high level is 5V-6V). Drive levels can be adjusted to modify the switching speed of Q1, but should always ensure complete turn-on and turn-off of Q1 after settling, while not exceeding its V_{GS} ratings. By default, the R2 resistor is 4.7Ω, with a power dissipation rating of 1W. It is very important not to exceed the power dissipation limit of R2. When using the 2512 resistor (1W rating), the constraint is:

EQUATION 2-1:

$$D \times \frac{V_{OUT}^{2}}{R2} < 1W$$

Where:

$\quad$ D $\quad$ = $\quad$ The on-time duty cycle of Q1

$\quad V_{OUT} \quad$ = $\quad$ The selected output voltage

The on-board load transients generator can be used to test either Buck1, by connecting a jumper to J33, or Buck3, by connecting a jumper to J34.

The on-board load transient generator is especially useful when testing at very low output voltages, since not many active loads can perform well under those conditions, while current rise times achievable with external load boards are limited by stray inductance.

2.5   LAYOUT CONSIDERATIONS

The MCP16502 PMIC requires at least nine vias from the ICs Exposed Pad to the ground (GND) plane, in order to dissipate the generated heat. The GND plane can be increased or decreased based on the ambient temperature, air flow or other devices that generate heat. The rule of thumb is that the GND plane must be as big as possible.

The MCP16502 also features power ground (PGND) pins that must be connected to the power components (power input and output capacitors) and to a low-impedance return path, such as a dedicated plane or copper pour. It is also recommended to connect the input and output capacitor GND connections, as well as the PGND pins on the same layer (thus avoiding vias inductance) and the same continuous copper plane for optimal performance.

The PGND pins and GND planes should be connected together at the Exposed Pad. See **Appendix A. "Schematic and Layouts"** for a PCB layout example.

For low EMI (Electromagnetic Interference) emissions, the switching node of the Buck regulators should be routed on an internal plane, surrounded/enclosed by input supply voltage distribution or GND planes.

Chapter 3. GUI Installation and Operation

3.1 GETTING STARTED

In order to install, use and evaluate the product, several software and hardware tools are required.

3.1.1 Required Software

- I^2C Monitor Graphical User Interface 5.0 or higher
- Microsoft[®].NET Framework 4.5 or higher
- Adobe[®] Reader[®]
- Windows[®] 7 or 10

3.1.2 Required Hardware

- MCP16502 Evaluation Board
- USB-to-Micro-USB Cable

3.2 GRAPHICAL USER INTERFACE INSTALLATION

The following steps describe how to install the I^2C Monitor Graphical User Interface:

1. If Microsoft .NET Framework is already installed, go to Step 3. If not, download Microsoft .NET Framework from www.microsoft.com and follow the installation instructions.
2. If Adobe Reader is already installed, go to Step 3. If not, download Adobe Reader from http://get.adobe.com/reader/ and follow the installation instructions.
3. Download the I^2C Monitor Graphical User Interface archive from the product web page under "Documentation".
4. Unzip the I^2C Monitor Graphical User Interface archive, which contains the `setup.exe` file.

> **Note:** If an older version or a corrupted version of the current I^2C Monitor Graphical User Interface is already installed on the computer, see
> **Section 3.3 "I2C Monitor Graphical User Interface Uninstall"** before proceeding with the installation.

5. Double click the `setup.exe` file to open the Install Shield Wizard window and wait for the extraction to complete. If required, the installation can be stopped by pressing the **Cancel** button.

6. In the Welcome to the InstallShield Wizard for I2CMonitor window, click the **Next** button to start the installation.
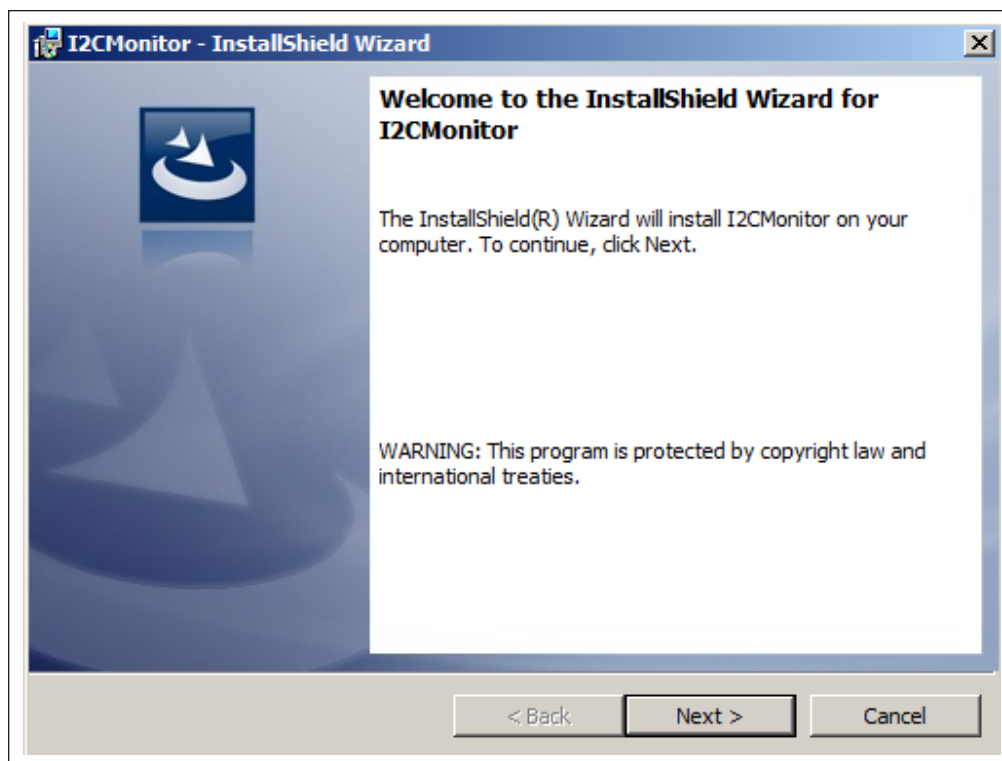
FIGURE 3-1: *Starting the I²C Monitor Graphical User Interface Installation.*

7. The installation path can be changed, although it is recommended to keep the default path. Click **Next** to continue.
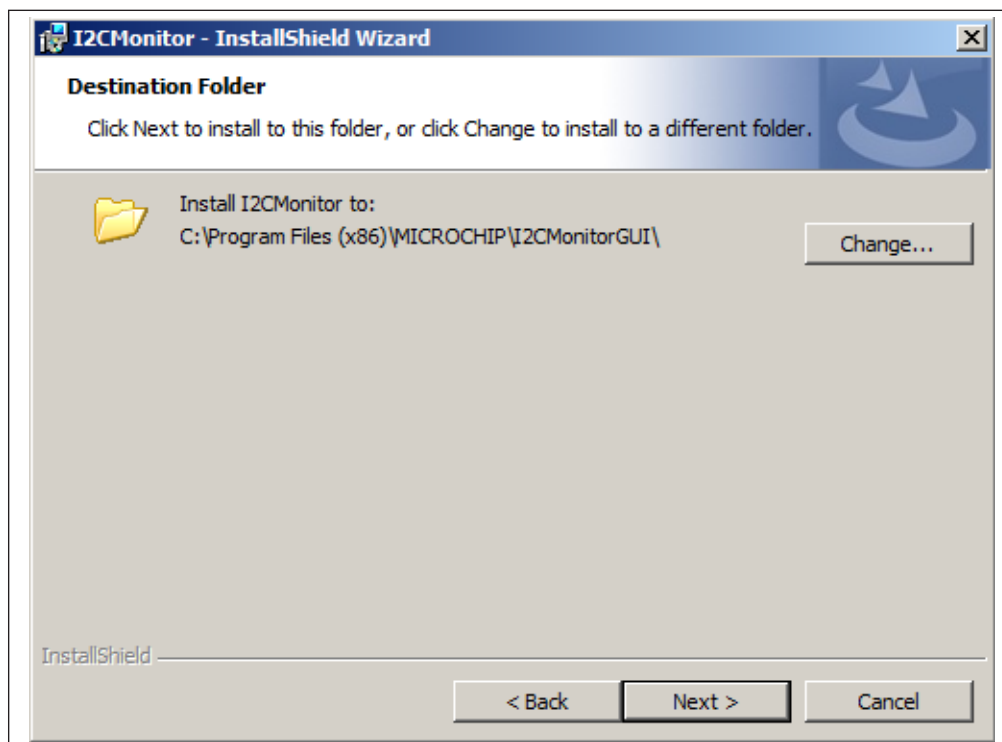
FIGURE 3-2: *Selecting the Destination Folder.*

8. In the Ready to Install the Program window, click the **Install** button and wait for the application to proceed with the installation.
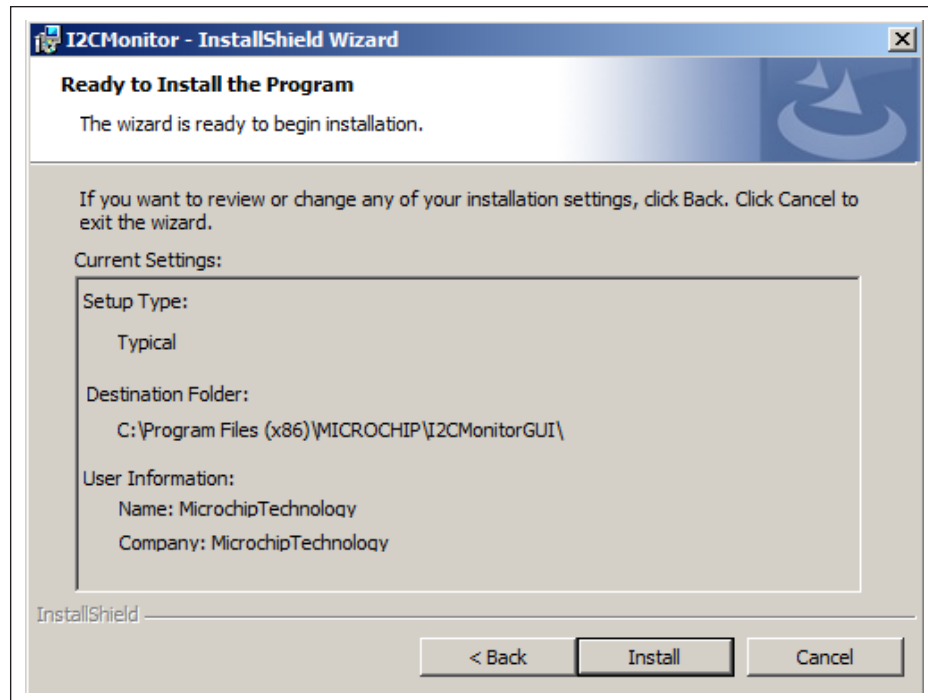
FIGURE 3-3: *Installing the I^{2}C Monitor Graphical User Interface.*

9. Once the installation is complete, click **Finish** to end the installation. To start the GUI, either click the desktop icon or browse to *Windows Start>All Programs>Microchip>I2C Monitor*.
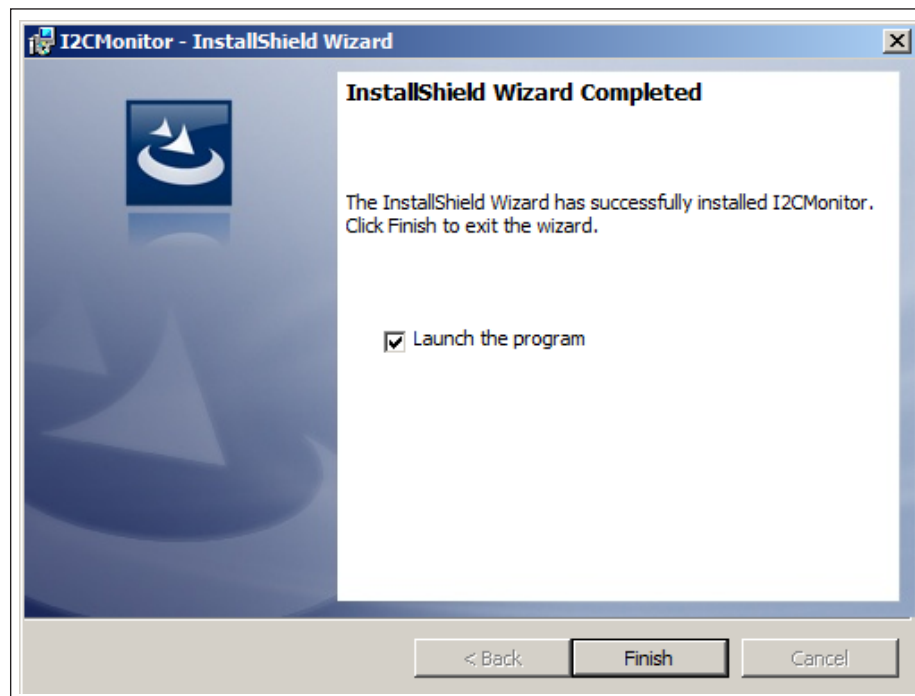
FIGURE 3-4: *InstallShield Wizard Completed Window.*

3.3   I^{2}C MONITOR GRAPHICAL USER INTERFACE UNINSTALL

In order to install a new version of the I^{2}C Monitor Graphical User Interface, any previous or corrupted version must be removed from the computer.

To uninstall, go to *Windows Start>Control Panel>Uninstall a program>I2C Monitor*.

The I^{2}C Monitor will automatically close once the process is complete.
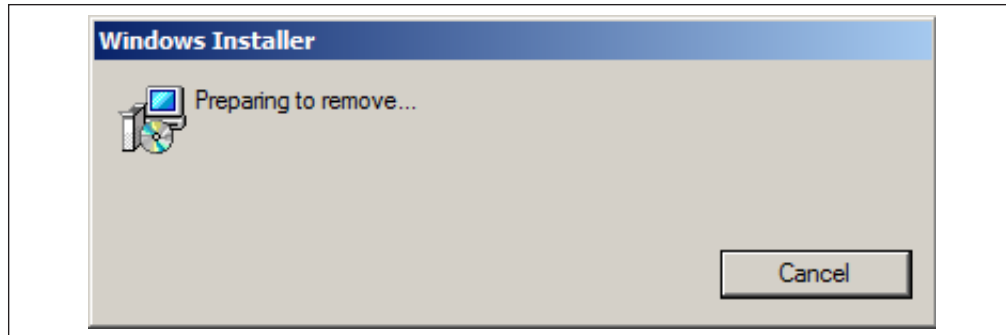
FIGURE 3-5:   *Uninstalling the I^{2}C Monitor Graphical User Interface.*

Chapter 4. GUI Description

4.1 INTRODUCTION

This chapter describes how to use the I^{2}C Monitor Graphical User Interface using the MCP16502 Evaluation Board.

NOTICE
This chapter provides information regarding the use of the GUI in the case of the MCP16502. For other devices using the I^{2}C Monitor Graphical User Interface, see their specific Data Sheets and User's Guides.
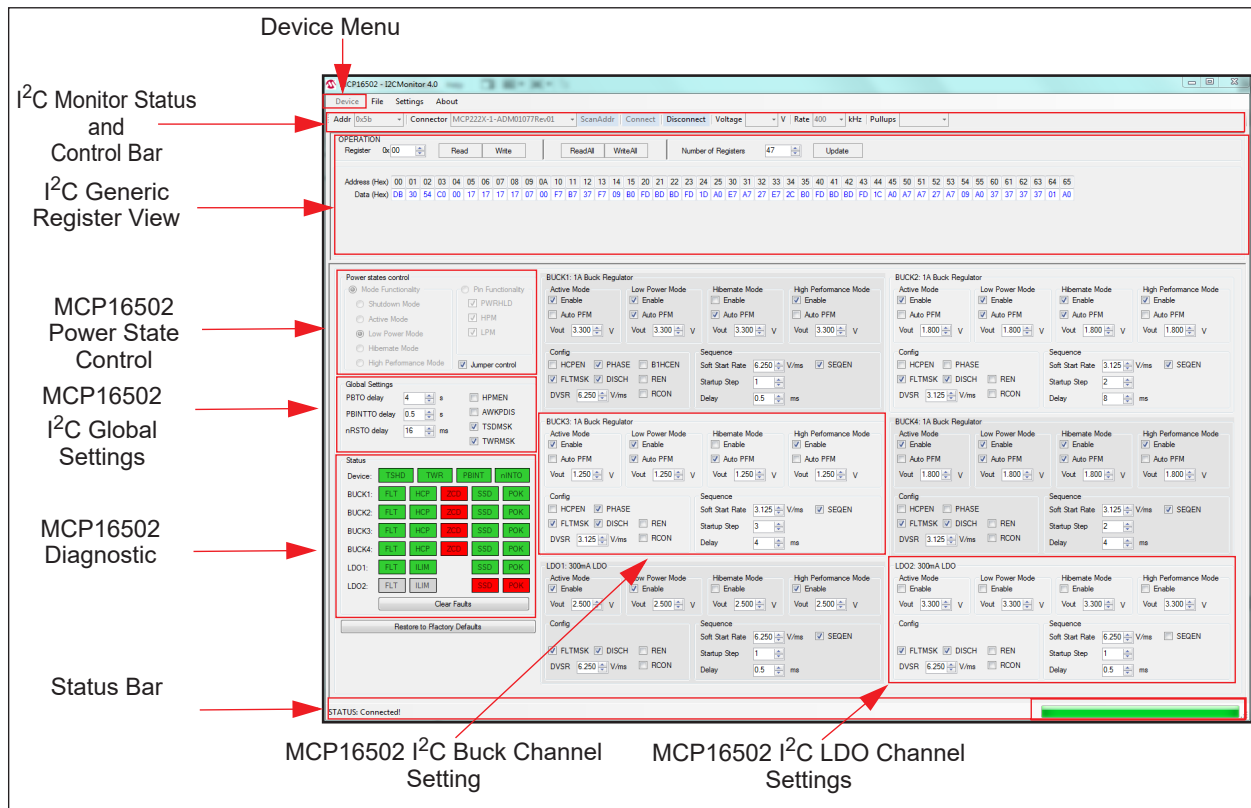
FIGURE 4-1: *I^{2}C Monitor Graphical User Interface Main Window - MCP16502 View.*

4.2   GRAPHICAL USER INTERFACE

4.2.1   Device Menu

The Device drop-down menu allows the user to select the device to be evaluated.

4.2.2   I^{2}C Monitor Status and Control

The "Status and Control" bar contains the items described in Table 4-1

FIGURE 4-2:   *I^{2}C Monitor Status and Control Bar.*

TABLE 4-1:   MONITOR STATUS AND CONTROL BAR

Item	Description
Addr	This drop-down menu shows the address of the available devices.
Connector	This drop-down menu shows the type of connector used to connect the board.
ScanAddr	This button is used to scan for a valid address.
Connect/Disconnect	These buttons are used to connect/disconnect the current selected device.
Voltage	This drop-down menu is used to select the voltage level of the communication when using the PICkit™ Serial Analyzer.
Rate	This drop-down menu is used to select the corresponding communication rate for the device.
Pull-ups	This drop-down menu is used to activate the internal pull-ups from the PICkit™ Serial Analyzer.

In the "Status and Control" bar, the user can select the hardware tool for communicating with the device and the setting it should allow.

In order to connect to a device, the user must first follow the first three steps described in **Section 2.3 "Getting Started"**. After connecting the Micro-USB cable, the user must scan for a valid address. Once a valid address is detected, clicking the **Connect** button initializes the connection with the device and the registers are available for read and write operations.

4.2.3   I^{2}C Generic Register View

The I^{2}C Generic Register View area contains the items described in Table 4-2. This section of the I^{2}C Monitor GUI is common for any device evaluated.
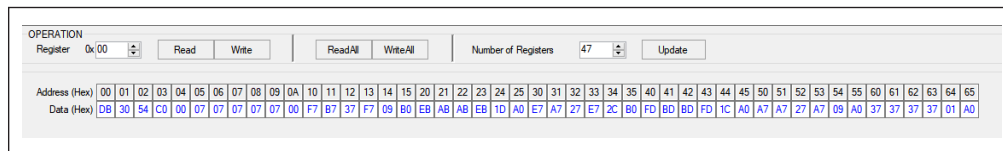
FIGURE 4-3:   *Generic Register View Area.*

TABLE 4-2: I²C GENERIC REGISTER VIEW ITEMS

Panel	Item	Description
Operation	Register	This section shows the registers available for read/write operations.
	Read/Write	These buttons are used for single register read/write operations.
	ReadAll/WriteAll	These buttons are used for reading/writing all the available registers.
	Number of Registers	In this section, the user can set the number of available registers for read/write operations.
	Update	This button sets the number of available registers for read/write operations in the Register Area.
Register Area		This section shows the current status of the registers address and the content.

The MCP16502 specific registers are described in the MCP16502 data sheet.

4.2.4   MCP16502 Power State Control

The MCP16502 Power states control area of the GUI allows the visualization or control of the device's power states.
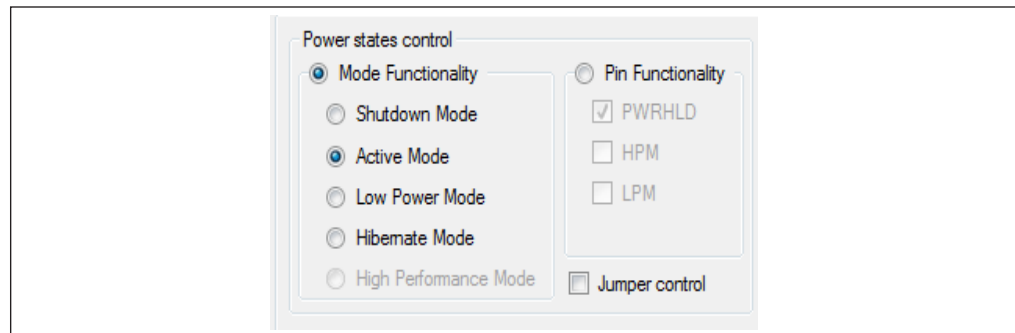
FIGURE 4-4:   *Power States Control Area.*

The GUI allows the visualization of the control pins state (PWRHLD, HPM, LPM) and the associated power state if "Jumper control" is activated, or to set the actual mode if "Jumper control" is not activated.

For the relation between each pin status and the corresponding mode, refer to the data sheet.

4.2.5   MCP16502 I²C Global Settings

This region of the GUI allows the user to modify the device global features.
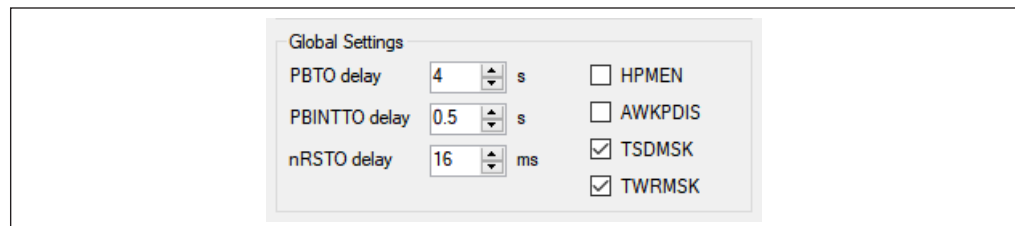
FIGURE 4-5:   *Global Settings.*

4.2.6 MCP16502 I^{2}C Diagnostic

The MCP16502 I^{2}C Diagnostic part of the GUI resumes the information contained in the STATUS register.
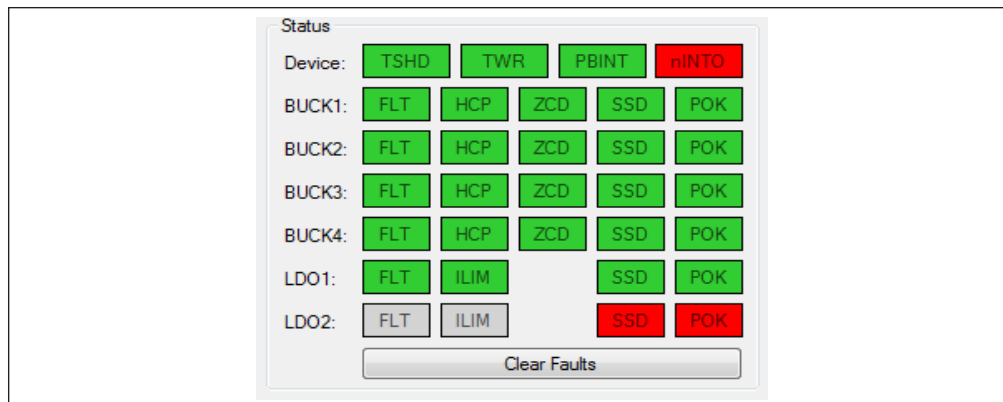
FIGURE 4-6: *I^{2}C Diagnostic Area.*

This region marks the status and faults of each corresponding bits in the registers. In the case of the SSD and POK status flags, green signals a '1' condition and red signals a '0' condition. In the case of the TSHD, TWR, PBINT, nINTO, FLT, HCP, ZCD and ILIM Fault flags, green signals a '0' condition and red signals a '1' condition or an active Fault.

This information is refreshed once every two seconds. All Fault flags are reset on read, so the GUI memorizes the apparition of a Fault. In order to clear them from the GUI, the **Clear Faults** button must be clicked.

4.2.7 MCP16502 I^{2}C Buck Channel Settings

This area of the GUI allows the user to modify the buck related features individually for each of the four buck channels.
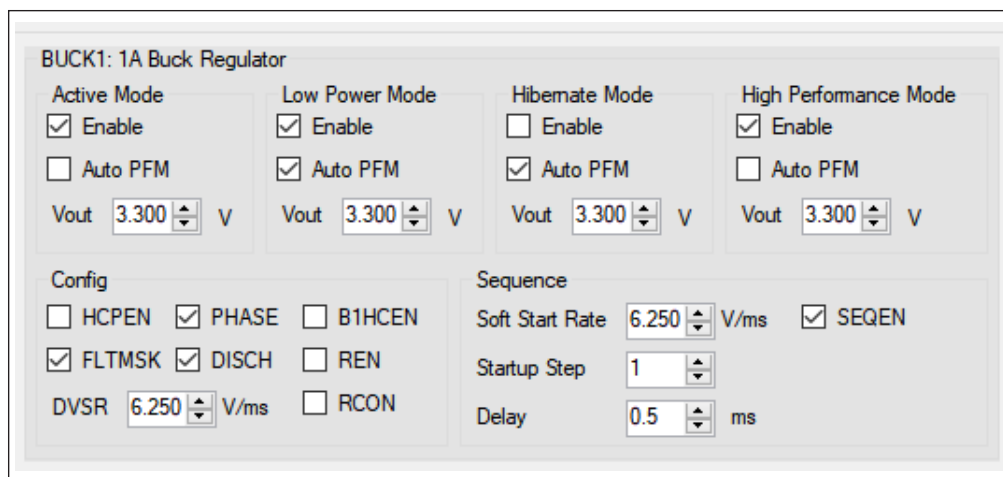
FIGURE 4-7: *I^{2}C Buck Channel Settings.*

4.2.8   MCP16502 I²C LDO Channel Settings

This area of the GUI allows the user to modify the buck related features individually for each of the two LDO channels.
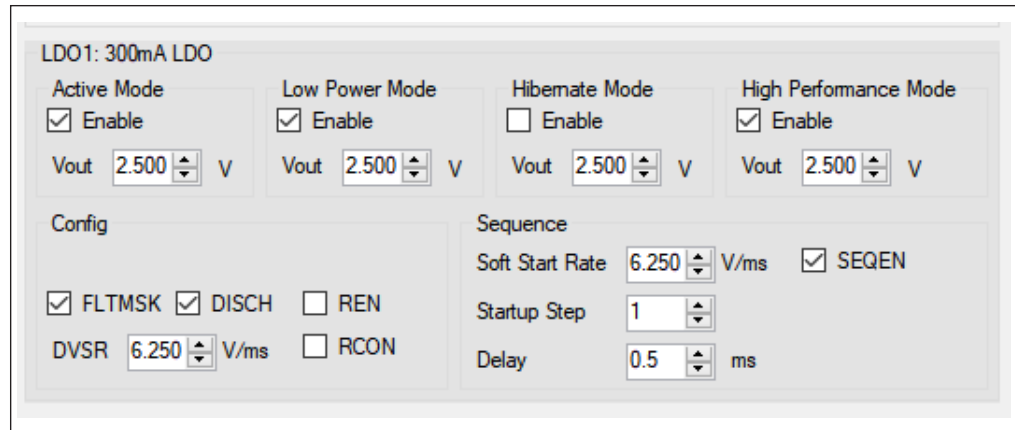
FIGURE 4-8:   *I²C LDO Channel Settings.*

4.2.9   Status Bar

The status bar provides information on the status of the device connected to the PC.

FIGURE 4-9:   *Status Bar.*

TABLE 4-3:   STATUS BAR ITEMS

Item	Description
Status Label	The label shows if there is any device connected to the board. Refer to Table 4-4 for a list of possible labels.
Progress Bar	This bar shows the level of completion for a given command.

TABLE 4-4:   STATUS LABELS

Status Label	Description
STATUS: Connected!	This message is shown when the GUI connects to a device.
STATUS: Disconnected!	This message is shown when the GUI does not detect a connected device.

The specific settings for all control areas are detailed in the register map available in the MCP16502 data sheet.

NOTES:

Appendix A. Schematic and Layouts

A.1 INTRODUCTION

This appendix contains the following schematic and layouts for the MCP16502 Evaluation Board:

- Board – Schematic
- Board – Top Copper and Silk
- Board – Mid-Layer 1
- Board – Mid-Layer 2
- Board – Bottom Copper and Silk

A.2 BOARD – SCHEMATIC

Individual Power Lines

Main Input Power Line

VOUT1 TP15 J16 TP16
TP Turret   TP Turret
DNP
PGND

VOUT2 TP17 J17 TP18
TP Turret   TP Turret
DNP
PGND

VOUT3 TP19 J21
TP Turret
DNP
PGND

VOUT4 TP22 J24 TP21
TP Turret   TP Turret
DNP
PGND

LVOUT1 TP23 J28 TP24
TP Turret   TP Turret
DNP
PGND

LVOUT2 TP25 J29 TP26
TP Turret   TP Turret
DNP
PGND

TP3 VIN   TP4
TP Turret   TP Turret
C15
330uF
25V
AL-F
PGND   PGND

JP6 VIN
Shunt 2.54mm 1x2
J42   R3
0R
VDDPU2

VDDCAL
VDDBAT
J2
SGND

JP1 VIN   JP2 VIN
Shunt 2.54mm 1x2   Shunt 2.54mm 1x2
nSTRT   J31 VIN   J23 VIN
J32   SELVL1   SELV2
SGND   SGND   SGND

JP5
Shunt 2.54mm 1x2
J22   VDDPU
HPM

JP3   JP4
Shunt 2.54mm 1x2   Shunt 2.54mm 1x2
J27   J18
LPM   PWRHLD
SGND   SGND

J41   R4
0R
VDDPU
VIN

VOLT1

J20   J25
nSTRTO   SDA
nINTO   SCL
nRSTO
HDR-2.54 Male 1x4   SGND
SGND

SW1
TACT SPST   nSTRT
0.1uF   DNP
16V   C16
0603
SGND

U1
SELV2 17 SELV2   PVIN2 15
PGND2 13 TP27
LPM 21 LPM   SW2 14
PWRHLD 8 PWRHLD   OUT2 16
HPM 23 HPM   PVIN1 10
PGND1 12 TP28
R6 100k 0603 1%   nSTRTO 7 nSTRTO   SW1 11
R7 10k 0603 1%   nRSTO 2 nRSTO   OUT1 9
R22 10k 0603 1%   nINTO 1 nINTO   SVIN
SGND 3
SDA 5 SDA   LVIN 20
SCL 6 SCL   LOUT1 19
LOUT2 18
nSTRT 24 nSTRT   SELVL1 18
VIN   PVIN3 26
4.7uF 10V C9 0603   PVIN4 31 PVIN4   PGND3 28
PGND 0603   PGND4 29 PGND4   TP30
C11 22uF 0805 10V   SW4 30 SW4   SW3 27
VOUT4   L4 1.5uH   OUT4 32 OUT4   OUT3 25
TP29   EP 33   MCP16502
SGND

R33 0603
1k 5%
D1
1N4148WS
J37   DNP 10000pF
C20
0603 25V

J1
VBUS 2 1   R5   VIN
4.7R

VBUS   VBUS   VBUS
J30   U2
VBUS 1   VDD 1   GP0 GP0
D- 2   VUSB 11   GP1 GP1
D+ 3   D- 12   GP2 GP2
ID 4   D+ 13   GP3 GP3
GND 5   4   GP1   R16 100R   LPM
USB2.0 MICRO-B FEMALE   RST   UART RX   GP2   R19 100R   PWRHLD
MCP2221   UART TX   GP3   R20 100R   HPM
C13 0.1uF 16V 0603   VSS 14   SDA   R17 0R   SCL   GP0   R1 0R   nINTO
C14 0.47uF 6.3V 0603   SCL   R18 0R   SDA
R9 2.2k 0603   R10 2.2k 0603
SGND   SGND   SGND   SGND

PAD1   PAD3
Rubber Pad Cyl D7.9H5.3   Rubber Pad Cyl D7.9H5.3
PAD2   PAD4
Rubber Pad Cyl D7.9H5.3   Rubber Pad Cyl D7.9H5.3

LABEL1
02-   -R1
JIT
LABEL Need Help Small

A.3   BOARD – TOP COPPER AND SILK

A.4   BOARD – MID-LAYER 1

A.5   BOARD – MID-LAYER 2

A.6   BOARD – BOTTOM COPPER AND SILK

04-11018 -R1

Appendix B. Bill of Materials (BOM)

TABLE B-1:   BILL OF MATERIALS (BOM)

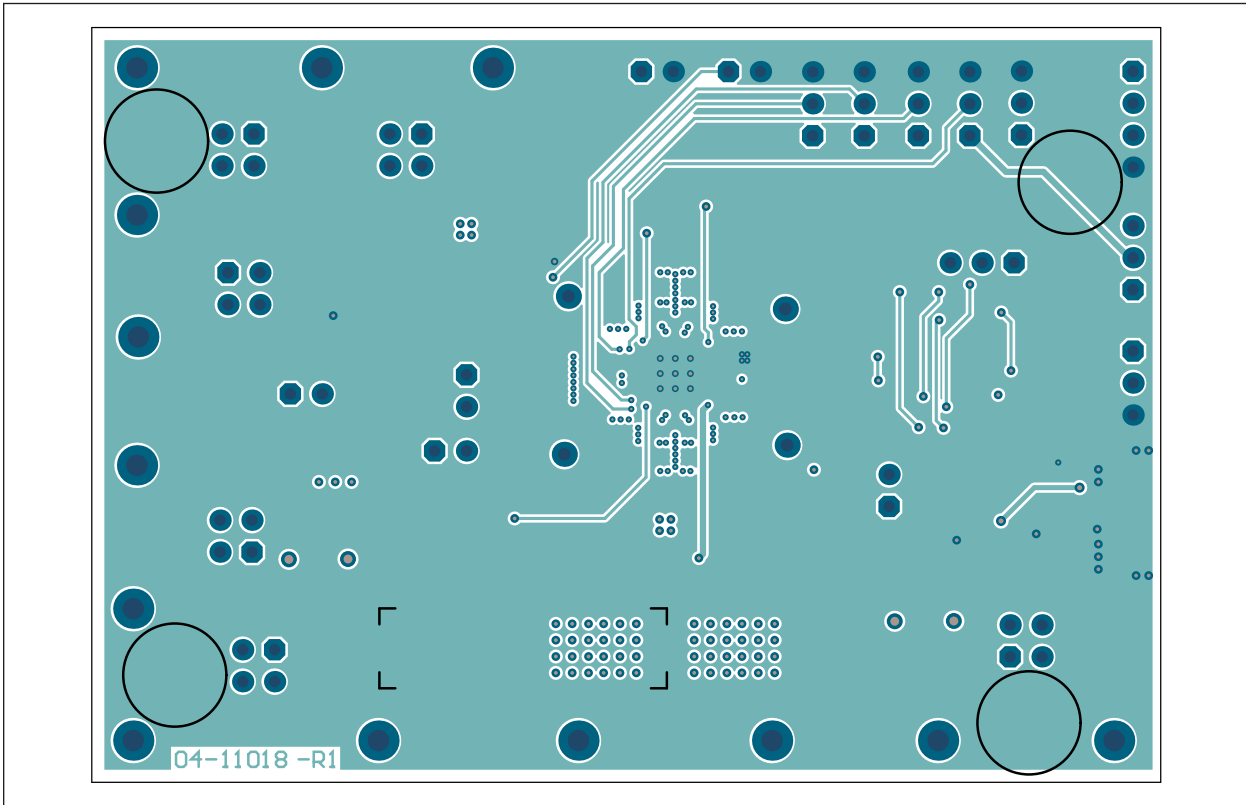| Qty.	Reference	Description	Manufacturer	Part Number
6	C1, C3, C7, C8, C9, C10	Ceramic Capacitor, 4.7 µF, 10V, 10%, X7S, SMD, 0603	TDK Corporation	C1608X7S1A475K080AC
4	C2, C4, C11, C12	Ceramic Capacitor, 22 µF, 10V, 20%, X7S, SMD, 0805	TDK Corporation	C2012X7S1A226M125AC
1	C5	Ceramic Capacitor, 2.2 µF, 10V, 10%, X7R, SMD, 0603	Taiyo Yuden Co., Ltd.	LMK107B7225KA-T
1	C6	Ceramic Capacitor, 10 µF, 10V, 10%, X7R, SMD, 0805	Samsung Electro-Mechanics America, Inc.	CL21B106KPQNFNE
1	C13	Ceramic Capacitor, 0.1 µF, 16V, 10%, X7R, SMD, 0603	Taiyo Yuden Co., Ltd.	EMK107B7104KA-T
1	C14	Ceramic Capacitor, 0.47 µF, 6.3V, 10%, X5R, SMD, 0603	Murata Electronics North America, Inc.	GRM188R60J474KA01D
1	C15	Aluminum Capacitor, 330 µF, 25V, 20%, SMD F	Nichicon Corporation	UWT1E331MNL1GS
1	D1	Diode Rectifier, 1.25V, 150 mA, 75V, SOD-323	Diodes Incorporated®	1N4148WS-7-F
6	J1, J2, J32, J33, J34, J37	Connector Header, 2.54 Male, 1x2, Gold, 5.84 MH, TH, Vertical	Amphenol Commercial	77311-118-02LF
8	J18, J22, J23, J25, J27, J31, J41, J42	Connector Header, 2.54 Male, 1x3, Tin, 5.84 MH, TH, Vertical	Samtec, Inc.	TSW-103-07-T-S
1	J20	Connector Header, 2.54 Male, 1x4, Gold, 5.84 MH, TH, Vertical	Wurth Elektronik	61300411121
1	J30	Connector USB, 2.0, Micro-B, Female, SMD, R/A	Amphenol Commercial	10118192-0001LF
4	L1, L2, L3, L4	Inductor, 1.5 µH, 3.5A, 20%, SMD, 1008	Murata Electronics North America, Inc.	DFE252012P-1R5M=P2
1	PCB1	MCP16502 Evaluation Board – Printed Circuit Board	Microchip Technology Inc.	**04-11018-R1**
1	Q1	Transistor MOSFET N-Channel, 40V, 40A, 0.0028R, 71W, TDSON-8, AEC-Q101	Infineon Technologies AG	IPZ40N04S5L2R8ATMA1
5	R1, R3, R4, R17, R18	Resistor, TKF, 0R, SMD, 0402, AEC-Q200	Panasonic® - ECG	ERJ-2GE0R00X
1	R2	Resistor, TKF, 4.7R, 5%, 1W, SMD, 2512	Stackpole Electronics, Inc.	RPC2512JT4R70
1	R5	Resistor, TKF, 4.7R, 1%, 1/10W, SMD, 0805	Panasonic - ECG	ERJ-B3BF4R7V
1	R6	Resistor, TF, 100k, 1%, 1/8W, SMD, 0603	Vishay Beyschlag	MCT06030C1003FP500

Note 1:   The components listed in this Bill of Materials are representative of the PCB assembly. The released BOM used in manufacturing uses all RoHS-compliant components.

TABLE B-1: BILL OF MATERIALS (BOM) (CONTINUED)

Qty.	Reference	Description	Manufacturer	Part Number
2	R7, R22	Resistor, TF, 10k, 1%, 1/16W, SMD, 0603	TE Connectivity, Ltd.	CPF0603F10KC1
2	R9, R10	Resistor, TKF, 2.2k, 1%, 1/10W, SMD, 0603	Panasonic - ECG	ERJ3EKF2201V
3	R16, R19, R20	Resistor, TKF, 100R, 1%, 1/10W, SMD, 0402	Panasonic - ECG	ERJ2RKF1000X
1	R33	Resistor, TKF, 1k, 5%, 1/10W, SMD, 0603	Panasonic - ECG	ERJ3GEYJ102V
1	R34	Resistor, TKF, 20k, 5%, 1/10W, SMD, 0603	Panasonic - ECG	ERJ-3GEYJ203V
1	SW1	Tactile Switch, SPST, 12V, 50 mA, SMD	E-Switch®, Inc.	TL3301NF260QG
13	TP3, TP4, TP15, TP16, TP17, TP18, TP19, TP21, TP22, TP23, TP24, TP25, TP26	Connector TP PIN, Tin, TH	Harwin Plc.	H2121-01
4	TP27, TP28, TP29, TP30	Miscellaneous, Test Point, Multi-Purpose, Miniature, White	Permabond®	5002
1	U1	Microchip Analog PMIC Switcher Buck ADJ, QFN-32	Microchip Technology Inc.	MCP16502AC-I/S8B
1	U2	Microchip Interface USB I^{2}C UART, TSSOP-14	Microchip Technology Inc.	MCP2221-I/ST

Note 1: The components listed in this Bill of Materials are representative of the PCB assembly. The released BOM used in manufacturing uses all RoHS-compliant components.

TABLE B-2: BILL OF MATERIALS (BOM) – MECHANICAL PARTS

Qty.	Reference	Description	Manufacturer	Part Number
6	JP1, JP2, JP3, JP4, JP5, JP6	Mechanical Headers and Wire Jumper, 2.54 mm, 1x2	3M	969102-0000-DA
4	PAD1, PAD2, PAD3, PAD4	Mechanical HW Rubber Pad, Cylindrical, D7.9, H5.3, Black	3M	70006431483

Note 1: The components listed in this Bill of Materials are representative of the PCB assembly. The released BOM used in manufacturing uses all RoHS-compliant components.

TABLE B-3: BILL OF MATERIALS (BOM) – DO NOT POPULATE PARTS

Qty.	Reference	Description	Manufacturer	Part Number
1	C16	Ceramic Capacitor, 0.1 µF, 16V, 10%, X7R, SMD, 0603	Taiyo Yuden Co., Ltd.	EMK107B7104KA-T
1	C20	Ceramic Capacitor, 10000 pF, 25V, 10%, X7R, SMD, 0603	Panasonic - ECG	ECJ-1VB1E103K
6	J16, J17, J21, J24, J28, J29	Connector Header, 2.54, Male, 2x2, Gold, 5.84 MH, TH, Vertical	Wurth Elektronik	61300421121

Note 1: The components listed in this Bill of Materials are representative of the PCB assembly. The released BOM used in manufacturing uses all RoHS-compliant components.

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