MIC33M356 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 on-line help. Select the Help menu, and then Topics to open a list of available on-line help files.

INTRODUCTION

This chapter contains general information that will be useful to know before using the MIC33M356 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 MIC33M356 Evaluation Board as a development tool. The manual layout is as follows:

- **Chapter 1. "Product Overview"** – Important information about the MIC33M356.
- **Chapter 2. "Installation and Operation"** – Includes instructions on how to get started with the MIC33M356 Evaluation Board and a description of each function.
- **Chapter 3. "GUI Installation and Operation"** – Includes instructions on how to install the Graphical User Interface (GUI).
- **Chapter 4. "GUI Description"** – Describes the items in the Graphical User Interface.
- **Appendix A. "Schematic and Layouts"** – Shows the schematic and PCB layout for the MIC33M356.
- **Appendix B. "Bill of Materials (BOM)"** – Lists the parts used to build the MIC33M356 Evaluation Board.
- **Appendix C. "MIC33M356 Internal Registers"** – Describes the device's internal registers.

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>
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 MIC33M356 Evaluation Board. Another useful document is the following Microchip document listed below, which is available and recommended as a supplemental reference resource:

- **MIC33M356 Data Sheet – *"3A, Power Module Converter with HyperLight Load® Mode and I^{2}C Interface"* (DS20006349)**

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

CUSTOMER SUPPORT

Users of Microchip products can receive assistance through several channels:

- Distributor or Representative
- Local Sales Office
- Field Application Engineer (FAE)
- Subject Matter Expert Engineers (SMEs)
- Technical Support

Customers should contact their distributor, representative, field application engineer (FAE) or Subject Matter Expert Engineers (SME) 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 A (May 2020)

- Initial release of this document.

NOTES:

Chapter 1. Product Overview

1.1 INTRODUCTION

This chapter provides an overview of the MIC33M356 Evaluation Board and covers the following topics:

- MIC33M356 Short Overview
- What is the MIC33M356 Evaluation Board?
- Contents of the MIC33M356 Evaluation Board Kit

1.2 MIC33M356 SHORT OVERVIEW

The MIC33M356 is an I^2C programmable, high-efficiency, low-voltage input, 3A current, synchronous step-down regulator power module with integrated inductor. The Constant On-Time (COT) control architecture with HyperLight Load® (HLL) mode provides very high efficiency at light loads, while still having ultra-fast transient response. The I^2C interface allows programming various parameters, such as output voltage, on-time, soft start slope, high-side current limit, HLL or Forced PWM mode of operation. The 2.4V to 5.5V input voltage range, low shutdown and quiescent currents make the MIC33M356 ideal for single-cell, Li-Ion, battery-powered applications.

An open-drain Power Good (PG) output is provided to indicate when the output voltage is within 9% of regulation and facilitates output voltage monitoring and sequencing. When set in Shutdown mode (EN = GND), the MIC33M356 typically draws 1.5 µA.

The MIC33M356 is available in a thermally efficient, 24-Lead, 3 mm x 4.5 mm x 1.8 mm QFN package, with an operating junction temperature range from -40°C to +125°C. More detailed information regarding the capabilities of the MIC33M356 are available in the data sheet.

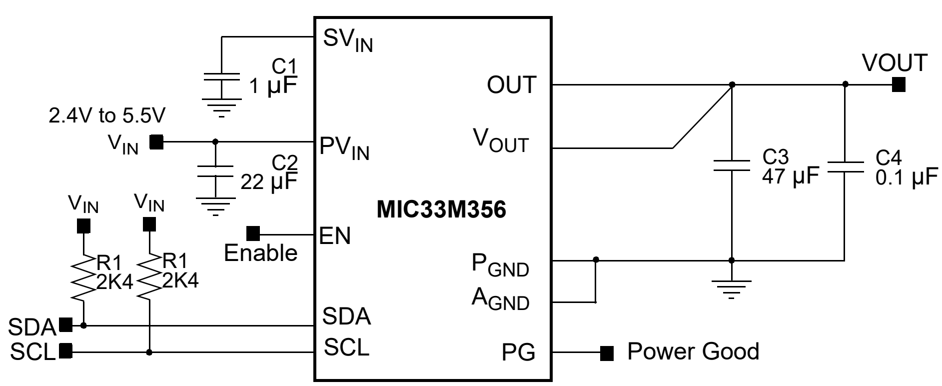


FIGURE 1-1: *Typical MIC33M356 Step-Down Application.*

1.3 WHAT IS THE MIC33M356 EVALUATION BOARD?

The MIC33M356 Evaluation Board is used to evaluate and demonstrate Microchip Technology's MIC33M356 module. This board demonstrates the MIC33M356 in a buck converter application supplied from an external voltage source (2.4V-5.5V), with I^2C programmed regulated output. The I^2C Monitor GUI allows comprehensive control and status reporting with the MIC33M356.

1.4 CONTENTS OF THE MIC33M356 EVALUATION BOARD KIT

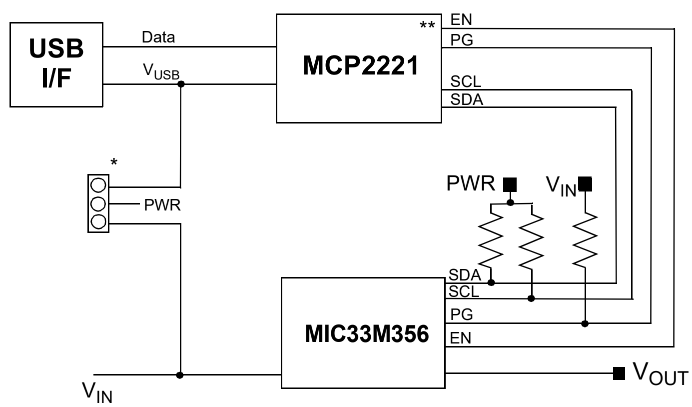
The MIC33M356 Evaluation Board kit includes:

- MIC33M356 Evaluation Board (ADM00855)
- Important Information Sheet

Chapter 2. Installation and Operation

2.1 INTRODUCTION

The MIC33M356 Evaluation Board has been developed to test the MIC33M356 capabilities, including loading up to a 3A control and monitor through the USB interface (via I^2C monitor GUI). Pin headers are also fitted for Bode analysis and external I^2C communication.



*Three-way jumper fitted for selection of I^2C pull-up voltage.

**I^2C bus (SDA, SCL), EN control and PG status via MCP2221 USB bridge.

FIGURE 2-1: *MIC33M356 Step-Down Regulator with MCP2221 I^2C Bridge.*

2.2 FEATURES

The MIC33M356 Evaluation Board has the following features:

- 2.4V to 5.5V Input Voltage Range
- 3A (maximum) Continuous Output Current
- Multiple Faults Indication through I^2C
- I^2C Programmable:
  - Output voltage: 0.6-1.28V, 5 mV resolution
  - Slew rate: 0.2-3.2 ms/V
  - Switching frequency: Up to 2.5 MHz
  - High-side current limit: 3.5A or 5A
  - Enable delay: 0.25-3 ms
  - Output discharge when disabled
- High Efficiency (up to 95%)
- ±1.5% Output Voltage Accuracy Over Line/Load/Temperature Range
- Safe Start-up with Pre-Biased Output
- Typical 1.5 µA Shutdown Supply Current
- Low Dropout (100% Duty Cycle) Operation
- Ultra-Fast Transient Response
- Latch-Off Thermal Shutdown Protection
- Latch-Off Current Limit Protection
- Power Good Open-Drain Output

2.3 GETTING STARTED

The MIC33M356 Evaluation Board is fully assembled and tested to evaluate and demonstrate the MIC33M356 module. This board requires the use of external lab supplies and a PC. The MIC33M356 is offered in four different product options, depending on the default settings at power-up, prior to any I^2C write operation. The differences among the various product options are described in the *"MIC33M356 Data Sheet"*. The Evaluation Board carries the -HAYFT option, whose default output voltage is 1.0V. All the device options may be fitted on the board, as is.

2.3.1 Power Input and Output Connection

2.3.1.1 POWERING THE MIC33M356 EVALUATION BOARD

When the board is ready for evaluation, apply positive input voltage to the "VIN" terminal and the corresponding return to the "GND_IN" terminal. The maximum input voltage should not exceed 5.5V. An electronic load or resistive load can be used for evaluation. Some electronic loads can sink the programmed current, starting from very low output voltage levels, during start-up. For a more realistic start-up behavior evaluation, a resistive load or Constant Resistance mode for electronic load is recommended. Connect the positive voltage terminal of the load to the "VOUT" terminal on the Evaluation Board and connect the negative or return side of the load to the "GND_OUT" terminal. If changing the regulator parameters is required, or simply to monitor the part, make sure to connect the Micro-USB cable between the Evaluation Board and the PC. Then, install the GUI according to **Chapter 3. "GUI Installation and Operation"** and follow the indications in **Chapter 2. "Installation and Operation"** for more extensive evaluation.

Note:	The inductance associated with long wires on the board input may cause voltage spikes at load stepping or start-up into heavy load. If the spikes exceed the 5.5V maximum input voltage rating, the MIC33M356 may fail. This can be prevented by populating a 470 µF electrolytic capacitor on C8 footprint.

2.3.1.2 BOARD POWER-UP PROCEDURE

For the power-up procedure, follow the steps below:

1. Connect the PC, input supply, voltmeter and ammeter, and load as shown in Figure 2-2. Set the ammeter on a 10A range.
2. Fit a jumper on the EN position across the J5 header, as marked on the silkscreen.
3. Once the input voltage is greater than 2.35V typ. at the board input (VIN), the device begins to switch.
4. The voltmeter should now indicate an output voltage according to the preset register values.
5. Set the input voltage and the load to the desired values, with a maximum of 5.5V on the input voltage and a maximum load of 3A.
6. Adjust the regulator output and monitor the STATUS registers, as described in **Chapter 4. “GUI Description”**.
7. Optionally, for more advanced readings, place Oscilloscope Probe 1 in “SW” test point to monitor the switching waveforms and Probe 2 on the output header to measure the AC ripple of the output voltage. Please note that for a more accurate output voltage ripple measurement, probing is facilitated by the availability of test points for probe tip and ground spring connections close to the output capacitor.

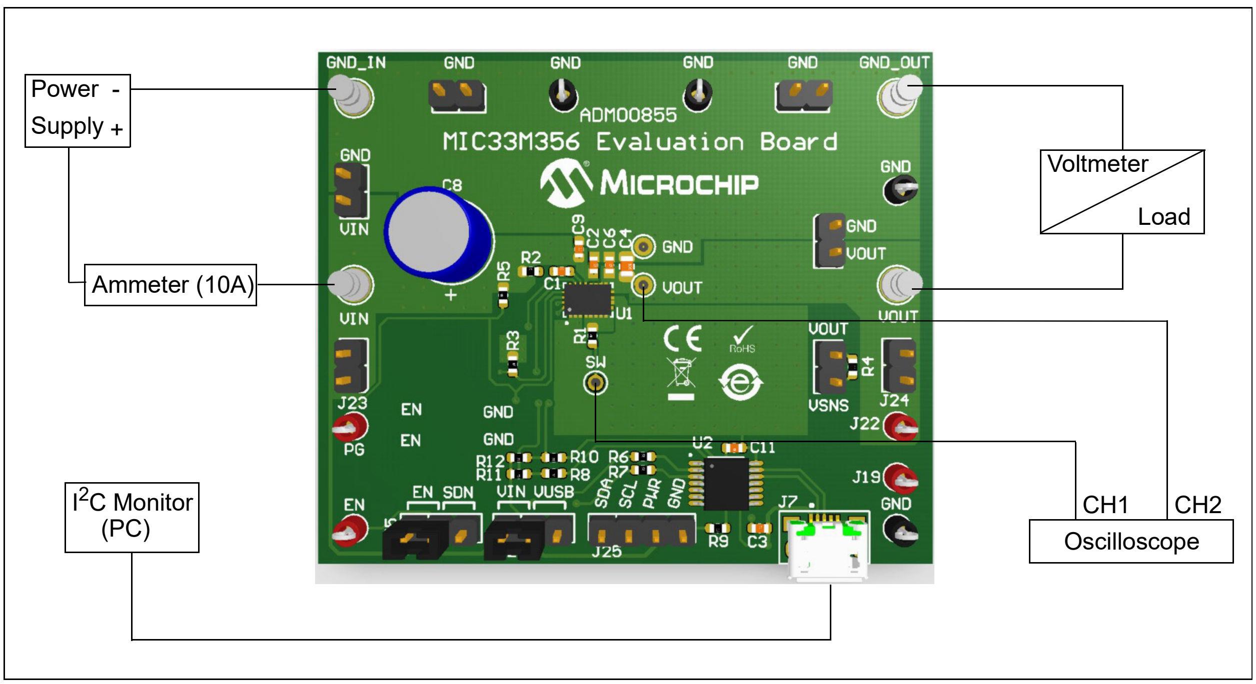


FIGURE 2-2: *MIC33M356 Evaluation Board Test Setup.*

2.3.1.3 PERFORMANCE EVALUATION

The oscilloscope screen capture in Figure 2-3 displays the MIC33M356 switching waveforms, during normal operation, when supplied from 5V input at full load (3A).

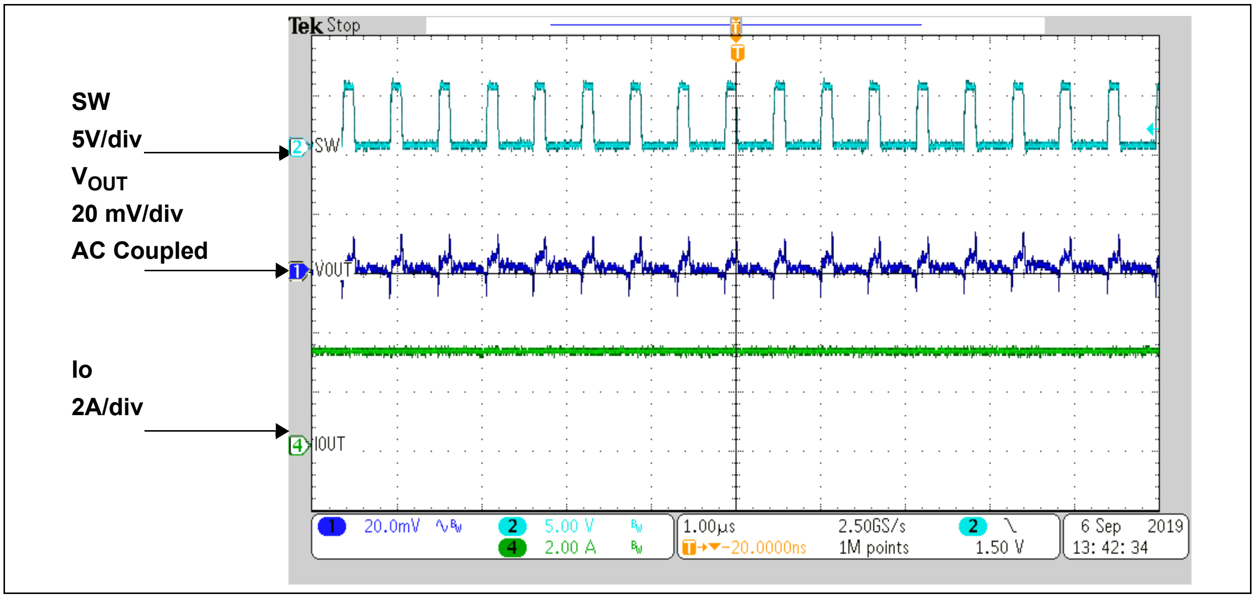


FIGURE 2-3: *Normal Operation at 1V Output, 3A Load.*

2.3.1.4 LOOP GAIN MEASUREMENT

The MIC33M356 Evaluation Board provides injection points and a termination resistor (R4) for AC loop gain measurements. If needed, the value of R4 can be changed to optimize the injection signal level. Inject the oscillator at J6 through the insulation transformer (i.e., across resistor R4, and connect the A (CH1) and B (CH2) channels to J6 Pin 1 and J6 Pin 2, respectively, or as indicated by the operating instructions of the particular loop gain analyzer in use).

2.3.1.5 I^{2}C PULL-UP VOLTAGE SELECTION

The MIC33M356 Evaluation Board is equipped with a jumper for selecting the I^{2}C pull-up supply voltage. The J12 header can be used to select the I^{2}C pull-up voltage to either V_{USB} or V_{IN}.

2.3.1.6 USING THE MIC33M356 EVALUATION BOARD WITH THE EXTERNAL I^{2}C MASTER

In order to use the MIC33M356 with an external I^{2}C master (e.g., a microcontroller, microprocessor or another I^{2}C master), the on-board MCP2221 must be disabled. To accomplish this, the pull-down resistor R9 must be populated to avoid any interference between the MCP2221 and the external I^{2}C master. If the MCP2221 is not powered (e.g., by disconnecting the USB cable), resistors R8 and R10 must be removed and then the desired I^{2}C master can be connected to J25. If the external I^{2}C master already provides pull-up resistors for the SDA and SCL lines, the I^{2}C pull-up resistors, R11 and R12, present on the MIC33M356 Evaluation Board, are not needed and must be removed to prevent pull-up voltage conflicts.

2.3.1.7 STARTING THE MIC33M356 WITH A CUSTOM OUTPUT VOLTAGE

To power up the MIC33M356 with a custom output voltage, the MIC33M356 Evaluation Board must be first powered up with the MIC33M356 disabled (either by placing the EN jumper on the J5 header, SDN position, or applying a logic '0' voltage on the EN test point). Program it via the I^2C interface (using the PC GUI interface) to the desired output voltage and then start it by placing the EN jumper on J5, EN position (or by applying a logic '1' voltage on the EN test point). The MIC33M356 does not retain the set voltage and returns to the default configuration after a power cycle.

2.3.1.8 MIC33M356 EVALUATION BOARD ENABLE OPTIONS

In order to enable the MIC33M356 on the Evaluation Board, three options are provided:

1. The EN jumper placed on the J5 header – By placing a jumper on the EN position, as described by the silkscreen, and by having bit 1 of register CTRL1 (address 0x00) set to '1', the MIC33M356 is enabled. By placing a jumper on the SDN position, the MIC33M356 is disabled. The MIC33M356 Evaluation Board features a pull-down resistor R3 connected to the EN pin, so by default, without any jumper connected, the regulator will be disabled.
2. Software controlled – By setting EN_INT (bit 1) of register CTRL1 (address 0x00), the MIC33M356 status is controlled by EN_CON (bit 0) of the CTRL1 register and the EN pin status is ignored. By setting the EN_CON bit, the MIC33M356 is enabled and by clearing the EN_CON bit, the MIC33M356 is disabled.
3. MCP2221 GPIO control – By checking "Enable GP0 Control" in the I^2C Monitor GUI, the EN pin is controlled by the GP0 output of the MCP2221 and by using the **"GP0 active"** button, the MIC33M356 is enabled or disabled.

> **Note:** When using MCP2221 GPIO control, remove any low-impedance connection between the EN pin and V_{IN} or GND (e.g., a jumper on the J5 header) as this may cause undefined behavior.

2.3.1.9 PCB LAYOUT CONSIDERATIONS WHEN DESIGNING WITH MIC33M356

For the best performance with the minimum occupied board space, some proper layout techniques should be applied. First, the input and output capacitors should be placed as close to the MIC33M356 as possible and on the same layer as the IC. This will ensure low ripple and lower switching noise. Then, vias must be used under the MIC33M356, from its exposed pad to the GND plane, in order to improve heat dissipation.

2.3.1.10 BENCH TESTING AT HIGH CURRENTS

When testing the MIC33M356 device at high load currents, or when checking the overcurrent protection behavior, it may be necessary to remove the series ammeter shown in Figure 2-2 or to replace it with a very low value shunt resistor. This is because the internal resistance of many Digital Multimeters (DMMs) used for current measurements is generally too high.

2.3.1.11 THERMAL CONSIDERATIONS

The MIC33M356 Junction-to-Ambient Thermal Resistance (θ_{JA}), as measured on the Evaluation Board, is approximately +36°C/W. Depending on the loading conditions, ambient temperature and device settings, the junction temperature might exceed the rated operating limit of +125°C due to internal power dissipation. Continuous operation above the maximum operating limits stated in the data sheet should be avoided.

NOTES:

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 (minimum v.6.0)
- Microsoft.NET Framework 4.5 or higher
- Adobe® Acrobat® Reader

3.1.2 Required Hardware

- MIC33M356 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 Acrobat Reader is already installed, go to Step 3. If not, download Adobe Acrobat Reader from http://get.adobe.com/reader/ and follow the installation instructions.
3. Download the I^2C Monitor Graphical User Interface (v.6.0) archive from https://www.microchip.com/MIC33M356, under "Documents".
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, please see **Section 3.3 "I^2C Monitor Graphical User Interface Uninstall"** before proceeding with the installation.

5. Double click the `setup.exe` file to open the InstallShield 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.

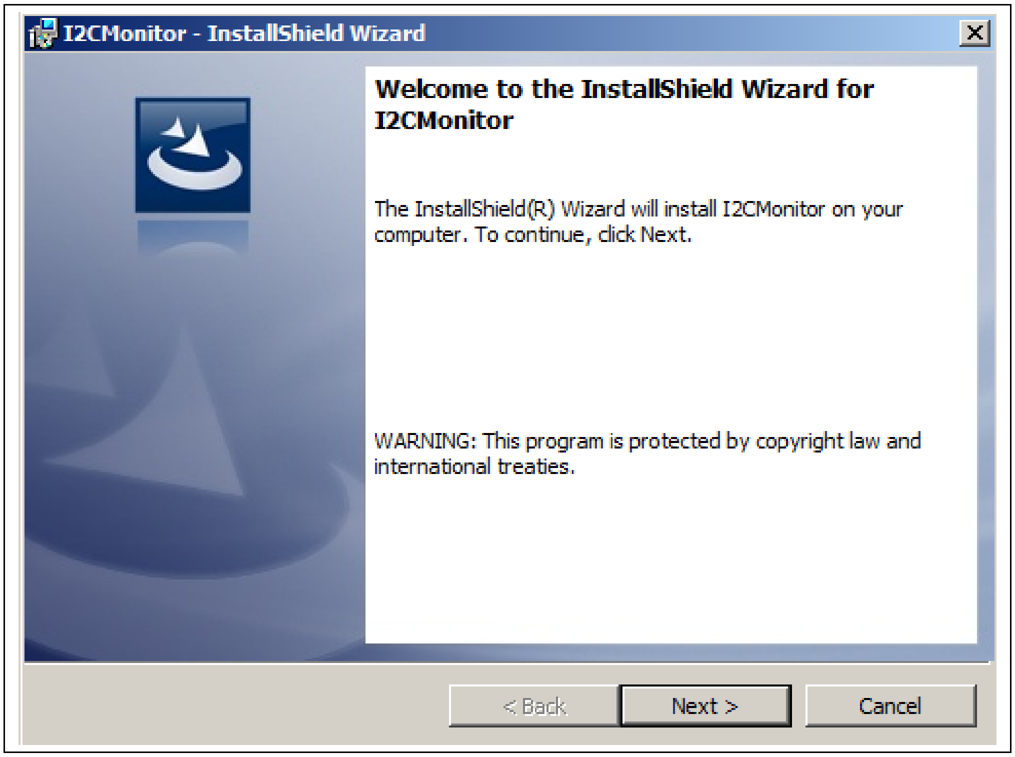


FIGURE 3-1: *Starting the I^2C Monitor Graphical User Interface Installation.*

7. The installation path can be changed, although it is recommended to keep the default path. Click **Next** to continue.

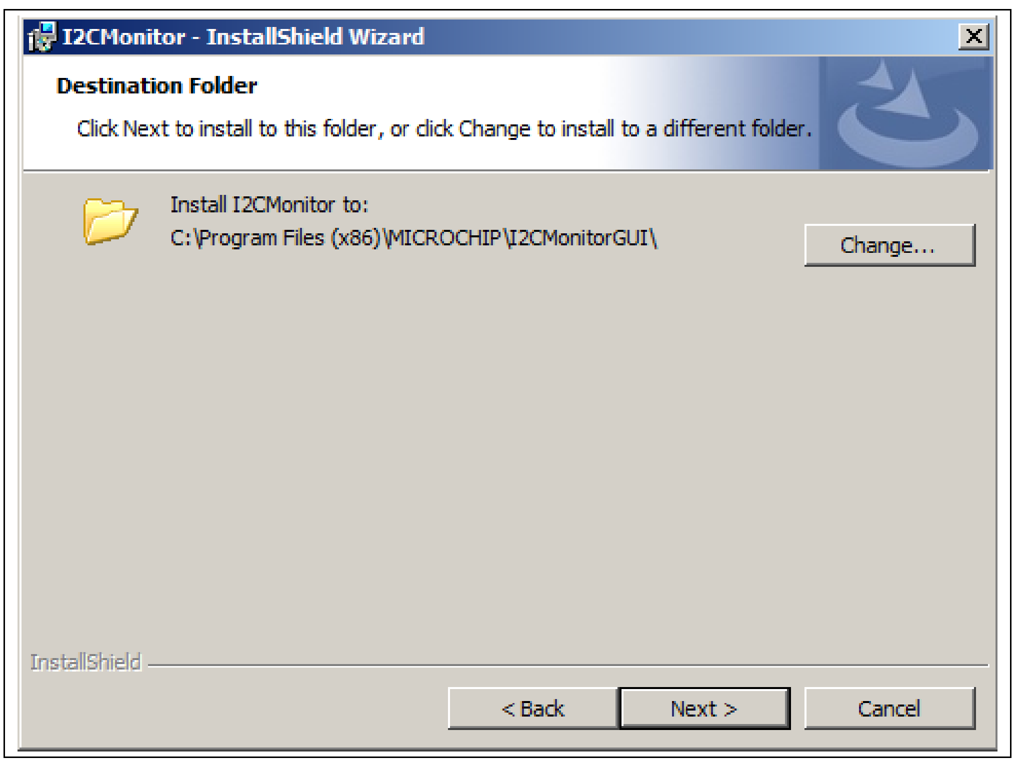


FIGURE 3-2: *Selecting the Destination Folder.*

8. In the Ready to Install the Program window, click the **Install** button and wait for the application to proceed with the installation. The progress can be observed in the “Status” bar.

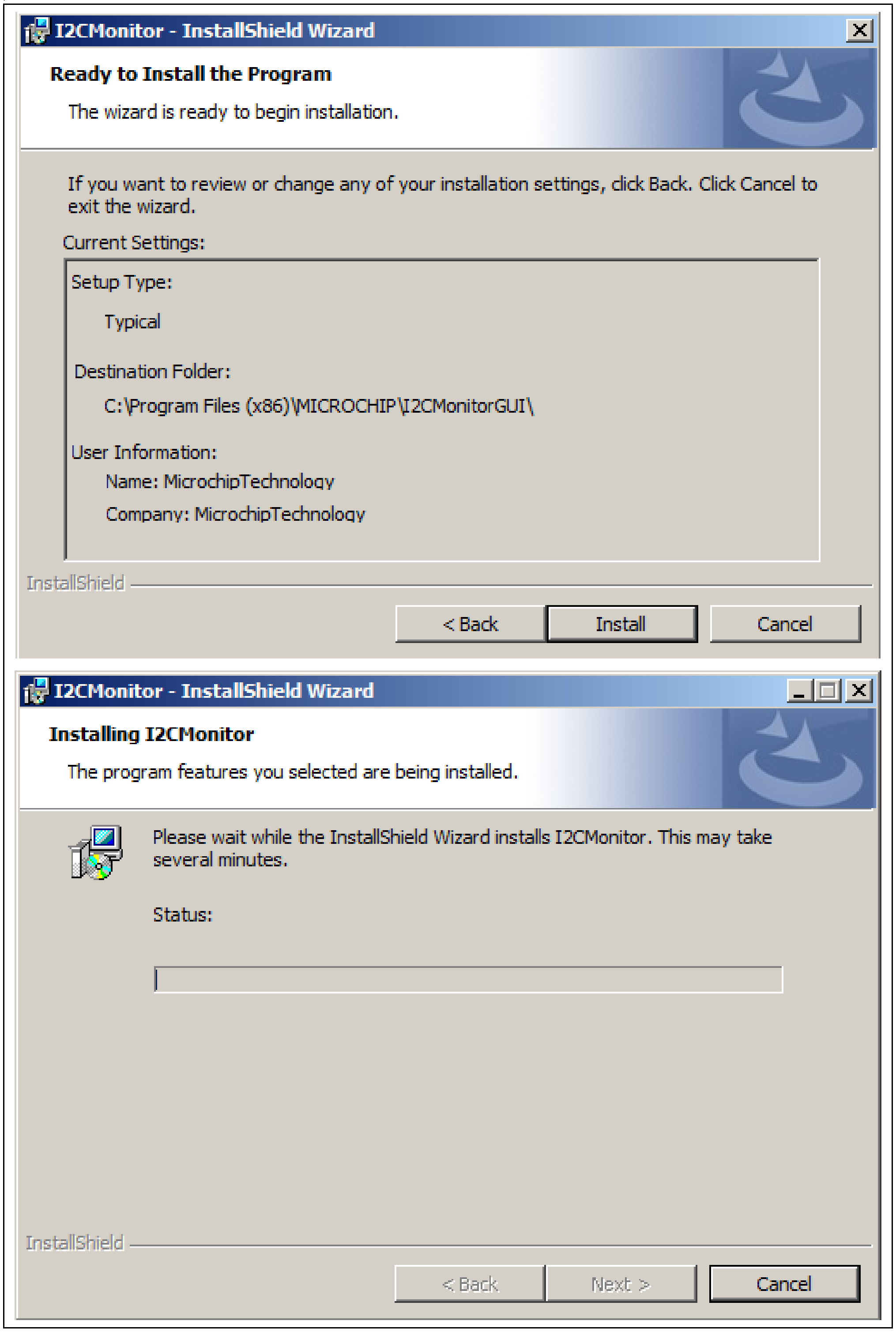


FIGURE 3-3: *Installing the I^2C Monitor Graphical User Interface.*

9. Once the installation is complete, leave the "Launch the program" box checked to automatically start the I²C Monitor GUI, or deselect this check box to start the GUI at a later stage. Click **Finish** to end the installation.

   To start the GUI at a later stage, either click the desktop icon or browse to *Windows Start>All Programs>Microchip>I2C Monitor*.

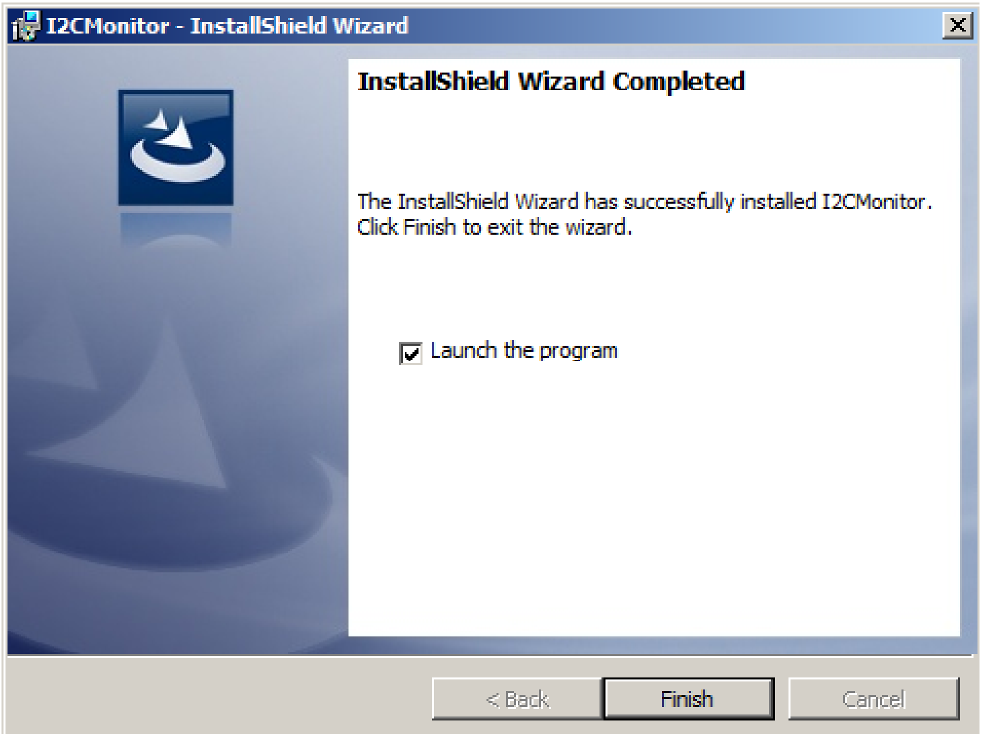


FIGURE 3-4: *The Installation Complete Window.*

3.3 I²C MONITOR GRAPHICAL USER INTERFACE UNINSTALL

In order to install a new version of the I²C Monitor Graphical User Interface, any previous version or corrupted version should be removed from the computer.

To uninstall, go to *Windows Start>Control Panel>Uninstall a program>I2CMonitor*. The I²C Monitor GUI will automatically close once the uninstallation process is complete.

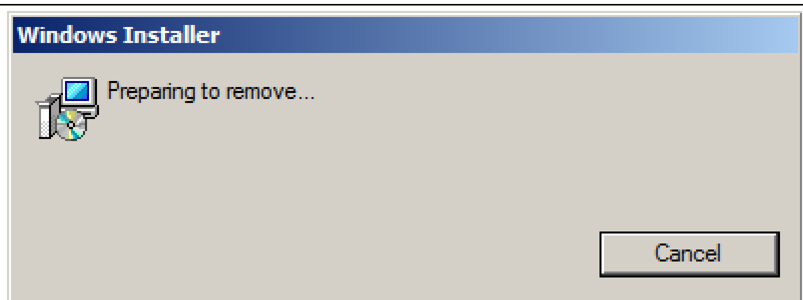


FIGURE 3-5: *Uninstalling the I²C Monitor Graphical User Interface.*

Chapter 4. GUI Description

4.1 INTRODUCTION

This chapter describes how to use the I^{2}C Monitor Graphical User Interface, using the MIC33M356 Evaluation Board included in the kit.

NOTICE

This chapter provides information regarding the use of the GUI only in the case of the MIC33M356 device. For other devices using the I^{2}C Monitor Graphical User Interface, see their specific Data Sheets and User's Guides.

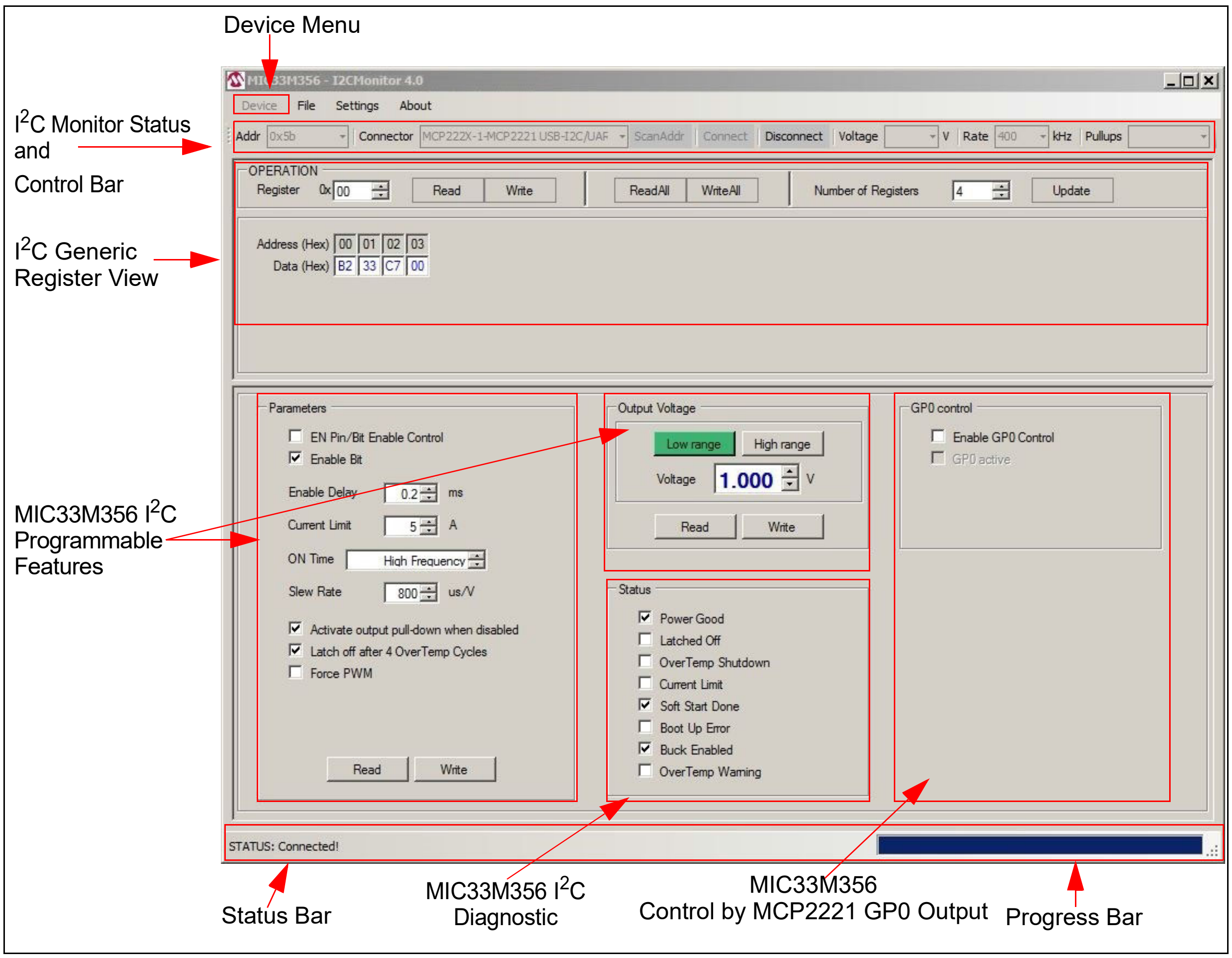


FIGURE 4-1: *I^{2}C Monitor Graphical User Interface Main Window – MIC33M356 View.*

4.2 THE GRAPHICAL USER INTERFACE

The following sections describe the items in the Graphical User Interface.

4.2.1 Device Menu

The Device drop-down menu allows the user to select the device to be evaluated. If an evaluation (or added custom) board is used, the profile will automatically change to the preselected profile.

4.2.2 File Menu

The File menu allows the user to save (Save registers to file) the registers of the currently selected device to a file that can then be loaded into the GUI by using the **Load registers from file** button. The saved file can also be edited (open it with a text editor).

FIGURE 4-2: *File Menu.*

4.2.3 Settings Menu

From the Settings menu, add a new custom board to be automatically detected and switch to its profile. To do this, go to *Settings>Device* descriptors and in the Descriptors window, add the desired "Board" descriptor and select the desired "Device" profile.

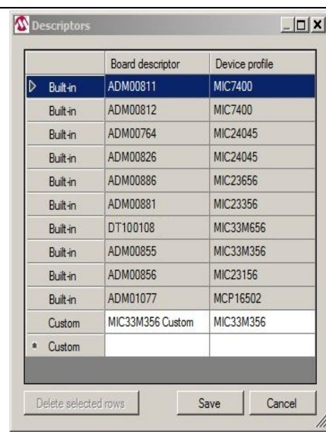


FIGURE 4-3: *Custom Board Menu.*

4.2.4 I^{2}C Monitor Status and Control Bar

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

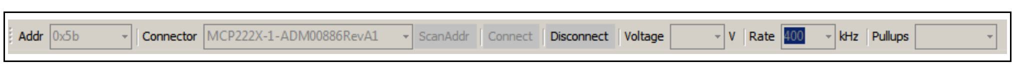


FIGURE 4-4: *I^{2}C Monitor Status and Control Bar.*

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 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.

Note: Optional. PICkit Serial Analyzer should first be connected on the I^2C pin header, on the MIC33M356 Evaluation Board.

In the "Status and Control" bar, the user can choose the hardware tool for the communication with the device and the settings it should allow.

In order to connect to a device, the user must follow the 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 will initialize the connection with the device and the registers will be available for read and write operations.

4.2.5 I^2C Generic Register View

The I^2C Generic Register View area contains the items in Table 4-2. This section of the I^2C Monitor GUI is common for any device evaluated.

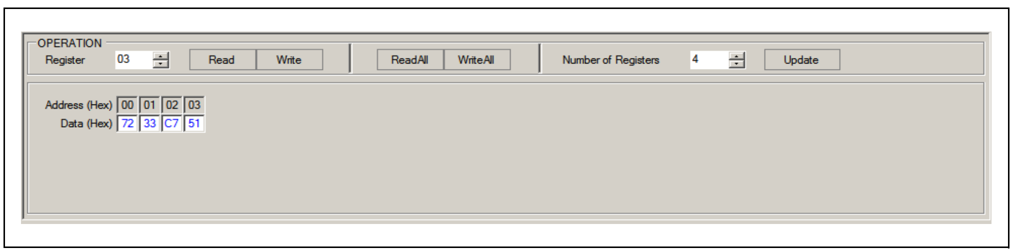


FIGURE 4-5: Generic Register View Area.

TABLE 4-2: I^2C 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 their content.

The specific registers for MIC33M356 are described in **Appendix C. "MIC33M356 Internal Registers"**.

4.2.6 MIC33M356 I²C Programmable Features

The MIC33M356 I²C "Programmable Features" area contains the items in Table 4-3.

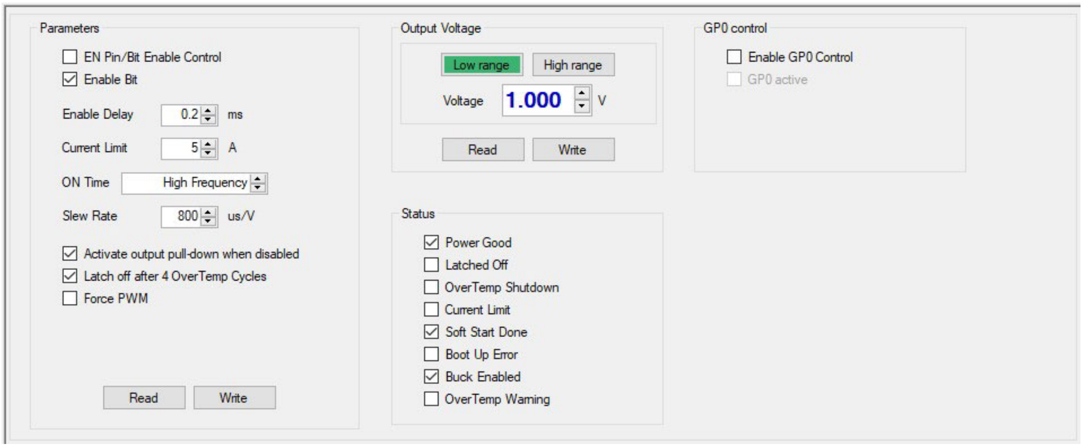


FIGURE 4-6: *MIC33M356 I²C Programmable Features Area.*

TABLE 4-3: MIC33M356 I^2C Programmable Features

Panel/Button	Items	Description
Parameters	EN Pin/Bit Enable Control	This check box allows switching between the I^2C controlled device enable (checked) and pin controlled enable (unchecked). Leave this box unchecked to enable by jumper or MCP2221 GP0.
	Enable Bit	This check box sets the MIC33M356 Enable Bit register. Check the box for regulator enabling, uncheck for disabling. This bit value is considered only if EN Pin/Bit Enable Control is checked.
	Enable Delay	This spin box allows setting the available start time delays.
	Current Limit	This spin box allows setting the available high-side current limits in order to obtain the nominal load currents.
	On-Time	This spin box allows setting the available on-time values that determine slower (high T_{ON}) or faster (lower T_{ON}) switching frequencies.
	Slew Rate	This spin box allows setting the available output slew rates.
	Activate Output Pull-Down when Disabled	This check box activates automatic output pull-down resistor when the MIC33M356 is disabled.
	Latch Off after 4 OverTemp Cycles	This check box sets the latch-off after four overtemperature (thermal shutdown) cycles.
	Force PWM	This check box sets Forced PWM mode, regardless of output loading.
	Disable 100% Duty Cycle	This check box disables 100% duty cycle operation on high side when V_{IN} is close to V_{OUT}. This feature is available only in High Range mode (option MIC33M356-SAYFT).
	Read/Write	These buttons are used to read/write the registers that contain the information described above.
Output Voltage	Voltage	This spin box allows setting the available output voltages. If the evaluated chip option is MIC33M356-YFT, MIC33M356-HAYFT or MIC33M356-FAYFT, the Low Range mode option must be selected. If the evaluated chip is MIC33M356-SAYFT, High Range mode must be selected.
	Read/Write	These buttons are used to read/write the registers that contain the information described above.
GP0 control	Enable GP0 Control	This check box allows enable control from the MCP2221 GP0 pin. If unchecked, pin GP0 is tri-state. To enable access to this feature and allow pin enable control, uncheck EN Pin/Bit Enable Control. The enable jumper must first be removed to prevent short-circuiting GP0 with the jumper.
	GP0 active	This check box sets the state of the MCP2221 GP0 pin. Leave unchecked to disable the MIC33M356 through the Enable pin or check the box to enable the MIC33M356 regulator.

This area of the GUI allows the user to modify the device features. For additional information on the part, refer to the data sheet.

4.2.7 MIC33M356 I²C Diagnostic

The MIC33M356 Diagnostic area contains the items in Table 4-4.

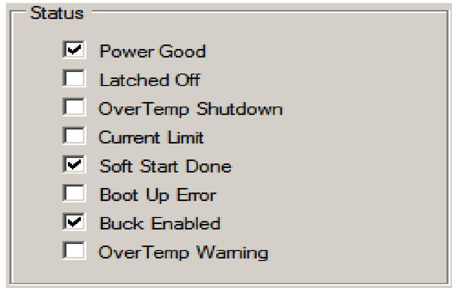


FIGURE 4-7: *MIC33M356 I²C Diagnostic Area.*

TABLE 4-4: MIC33M356 I²C DIAGNOSTIC AREA ITEMS

Panel	Items	Description
Status	Power Good	This box is checked if the output voltage reaches 91% of its set value.
	Latched Off	This box is checked if the regulator output is latched off due to four consecutive hiccup events or thermal shutdown.
	OverTemp Shutdown	This box is checked if the MIC33M356 enters thermal shutdown (Typ., T_J = +165°C).
	Current Limit	This box is checked if the high-side sensed current reaches the value set in the "Current Limit" spin box.
	Soft Start Done	This box is checked after successful regulator soft start ramp.
	Boot Up Error	This box is checked if an error occurs while loading the trim and configuration data into the digital core. At successful start-up, this box remains unchecked (clear).
	Buck Enabled	This box indicates the internal state of the regulator, determined by enable commands (via EN pin or I²C).
	OverTemp Warning	This box is checked if the MIC33M356 junction temperature exceeds +118°C. This does not affect the normal operation of the device.

The MIC33M356 I²C Diagnostic area resumes the information contained in the STATUS register. The STATUS register contains latched (Flag) or non-latched (Status) bits. Flag bits are set when the corresponding Fault condition occurs and they do not return to zero once the Fault condition ceases. If such a Fault occurs, the user can clear the Faults by toggling the enable function or power cycling the device. Status bits are set when the corresponding Fault condition has occurred and return to zero automatically once the Fault condition has ceased. This information is refreshed once every two seconds.

Because of this refresh traffic, when using a logic analyzer it is more difficult to synchronize the exact moment of a certain command. In order to simplify this, an auxiliary trigger signal is provided on pin GP2 of the MCP2221. This signal is triggered for each user Read/Write command.

TABLE 4-5: STATUS BAR ITEMS

Item	Description
Status Label	The status label shows if there is any device connected to the board. Refer to Table 4-6 for a list of possible labels.
Progress Bar	This bar shows the level of completion for a given command.

TABLE 4-6: 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.

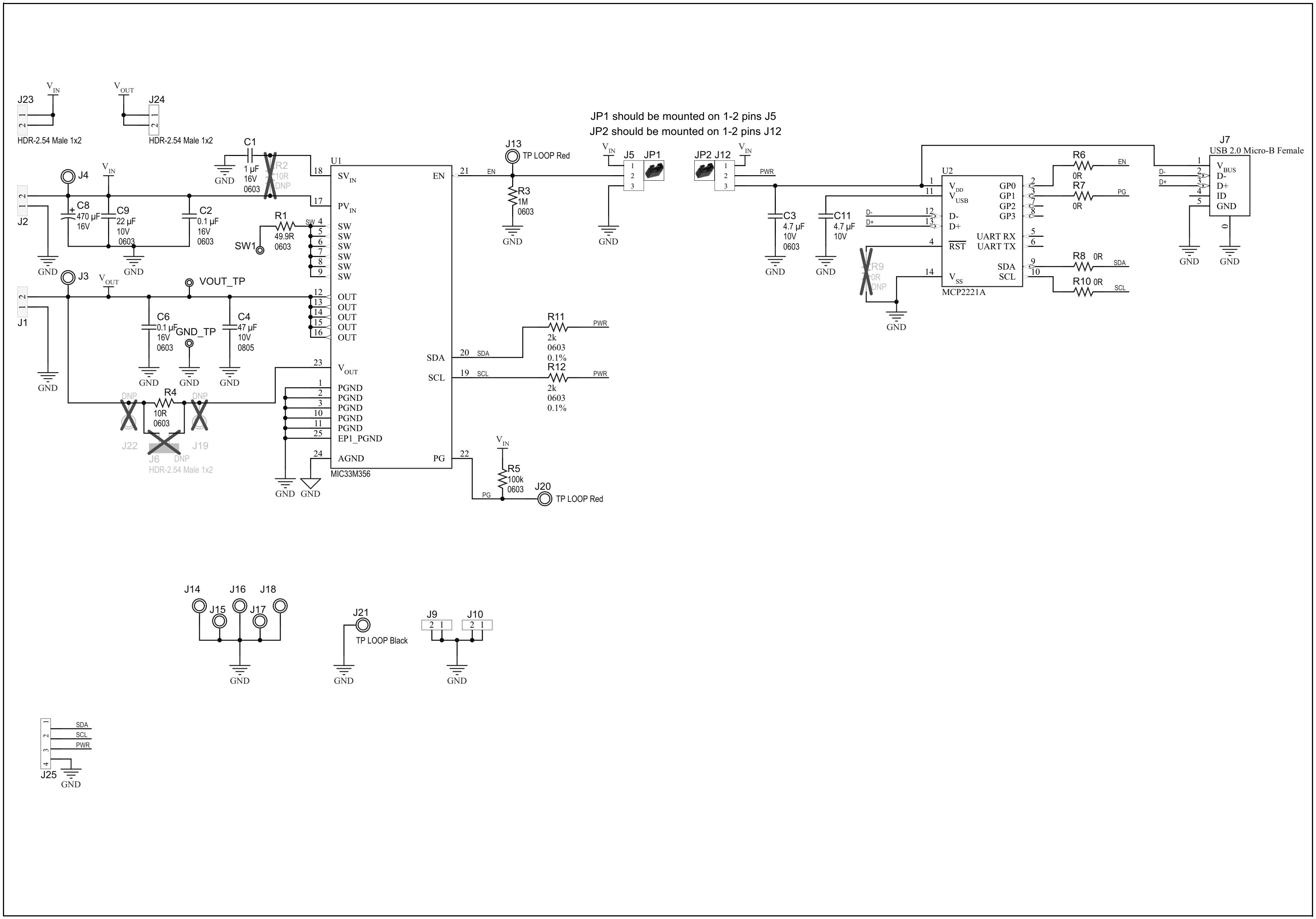
NOTES:

Appendix A. Schematic and Layouts

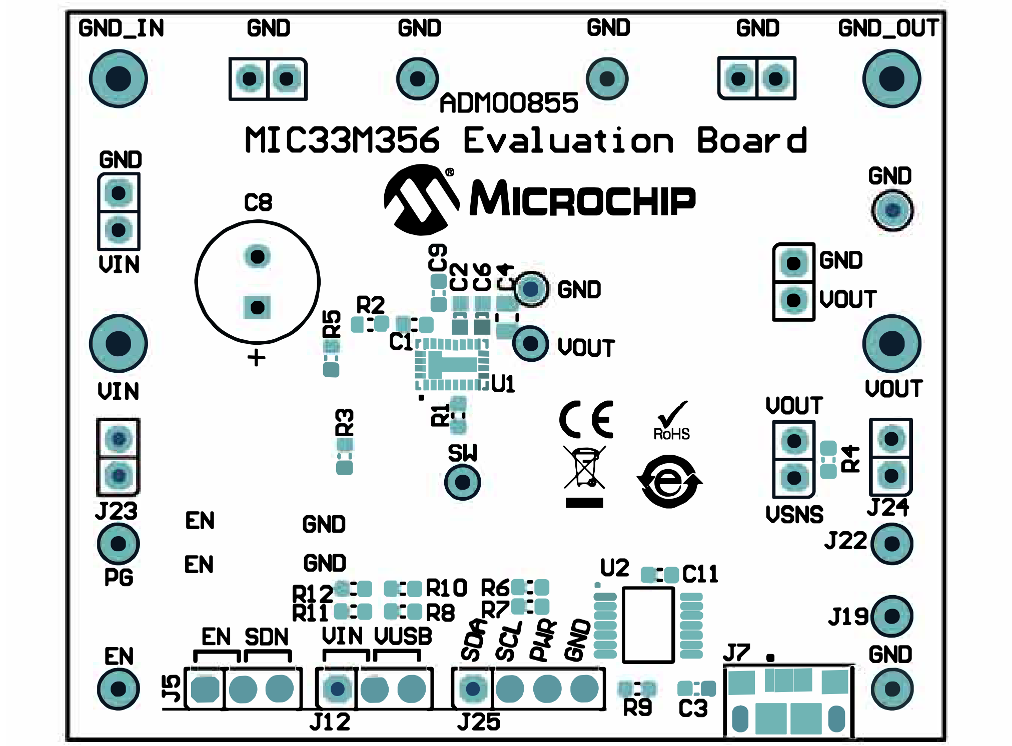
A.1 INTRODUCTION

This appendix contains the following schematic and layouts for the MIC33M356 Evaluation Board:

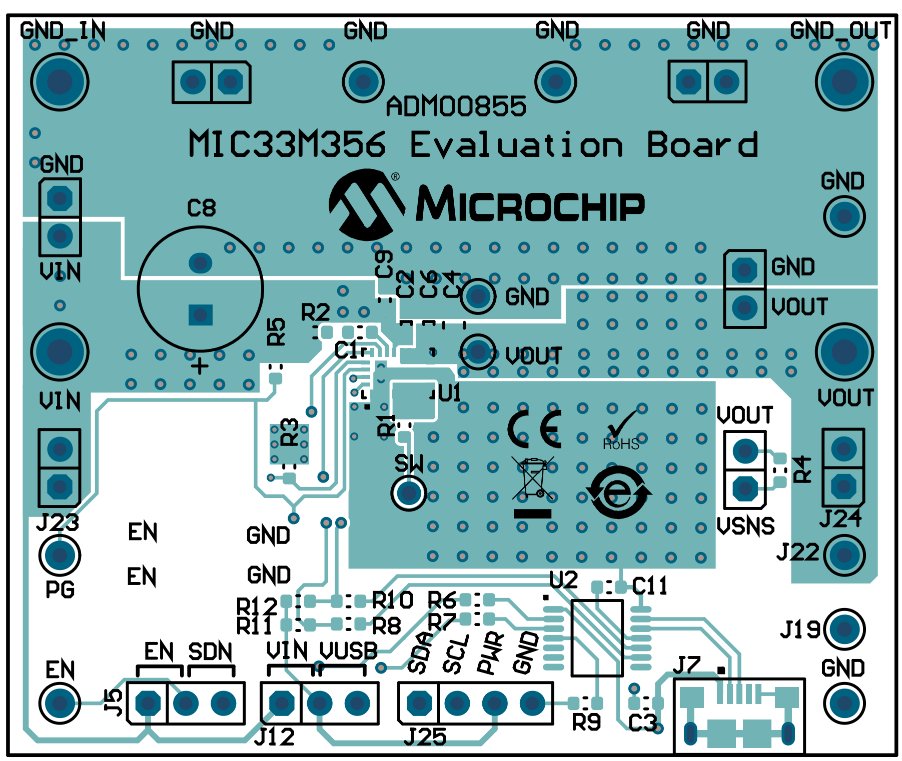
A.2 BOARD – SCHEMATIC



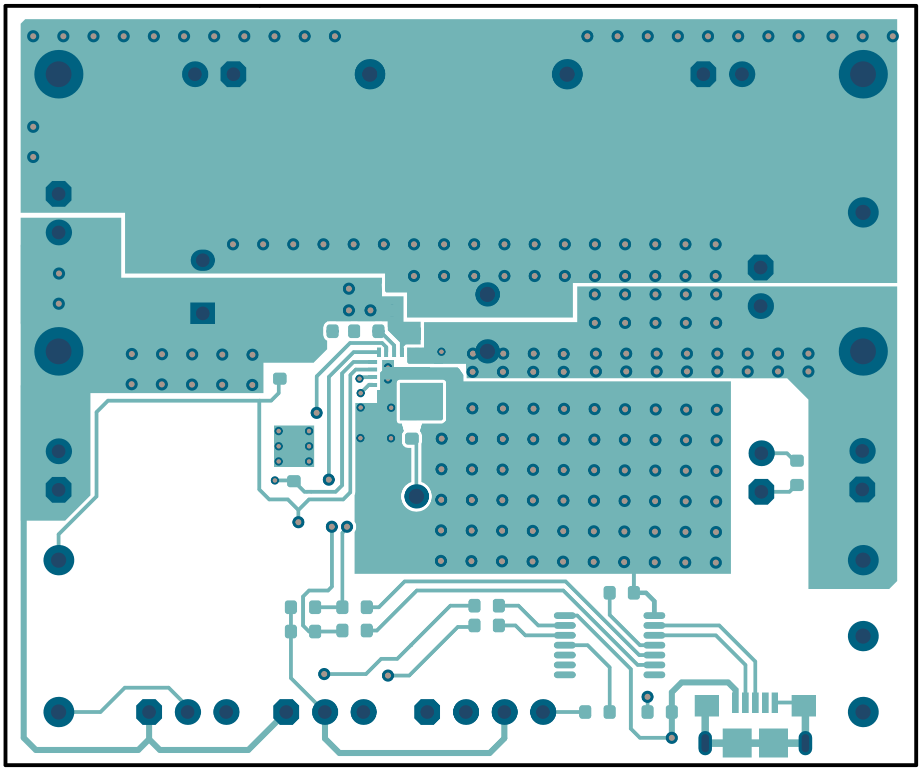
A.3 BOARD – TOP SILK



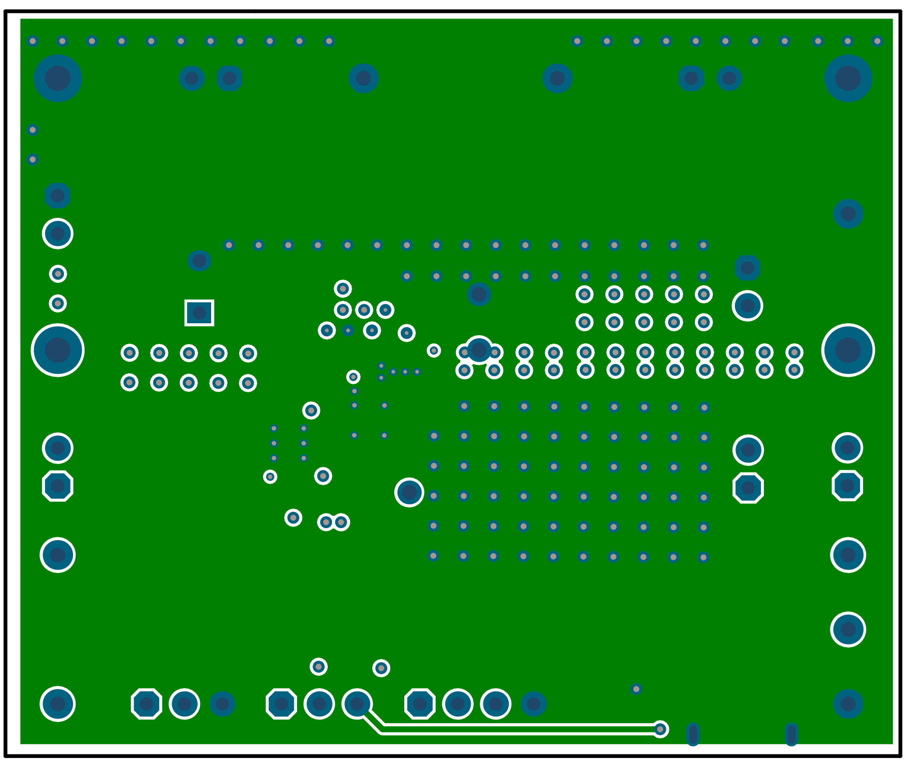
A.4 BOARD – TOP COPPER AND SILK



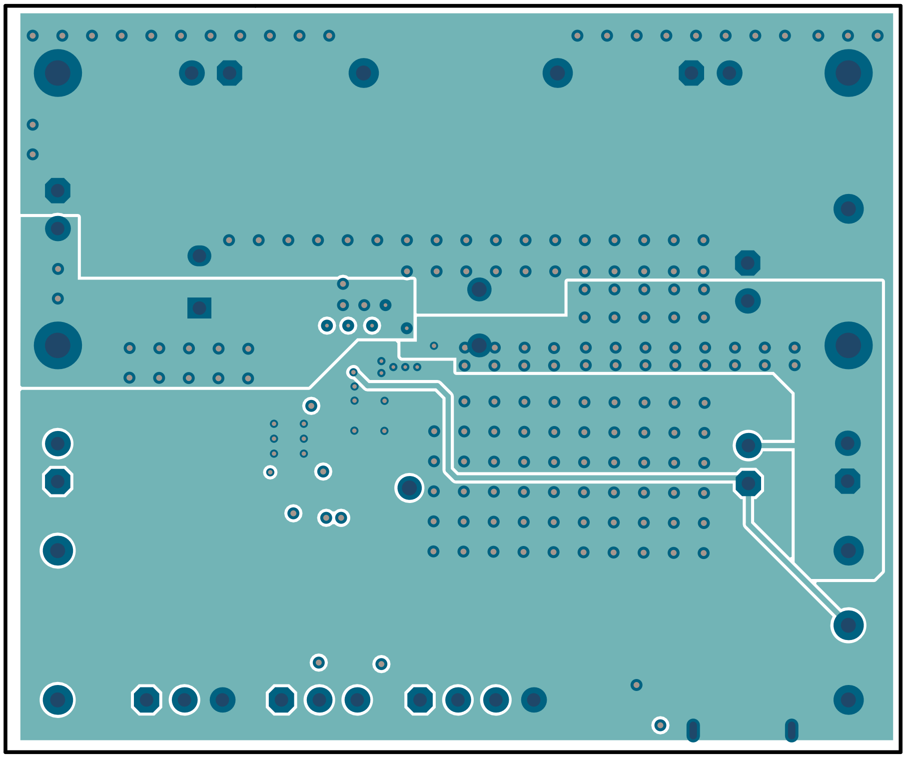
A.5 BOARD – TOP COPPER



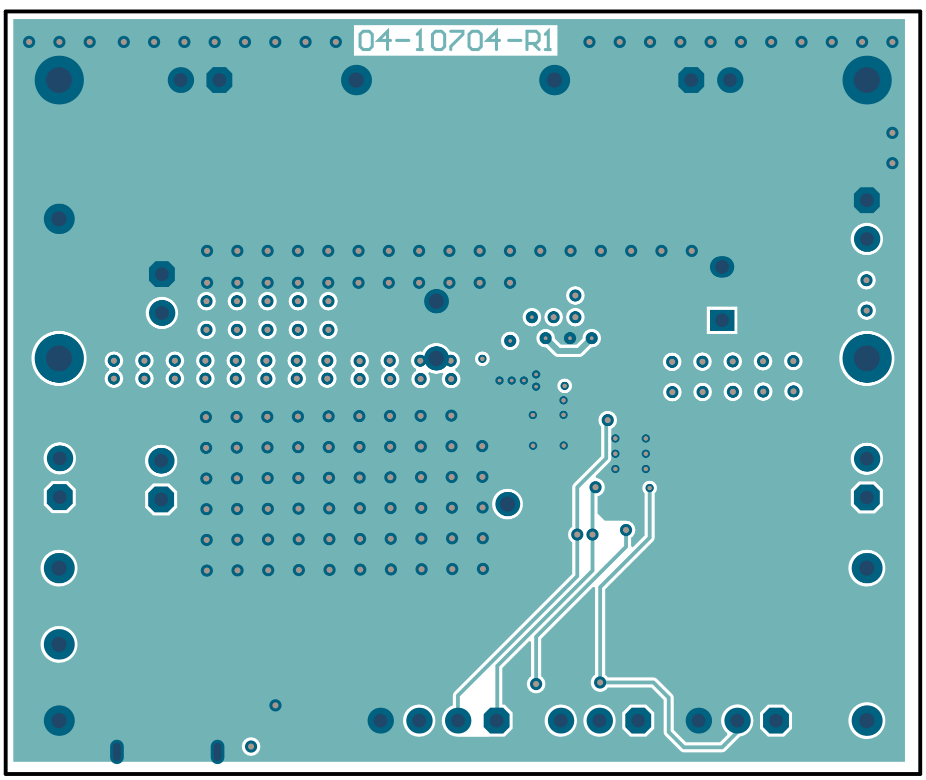
A.6 BOARD – SIGNAL LAYER 1



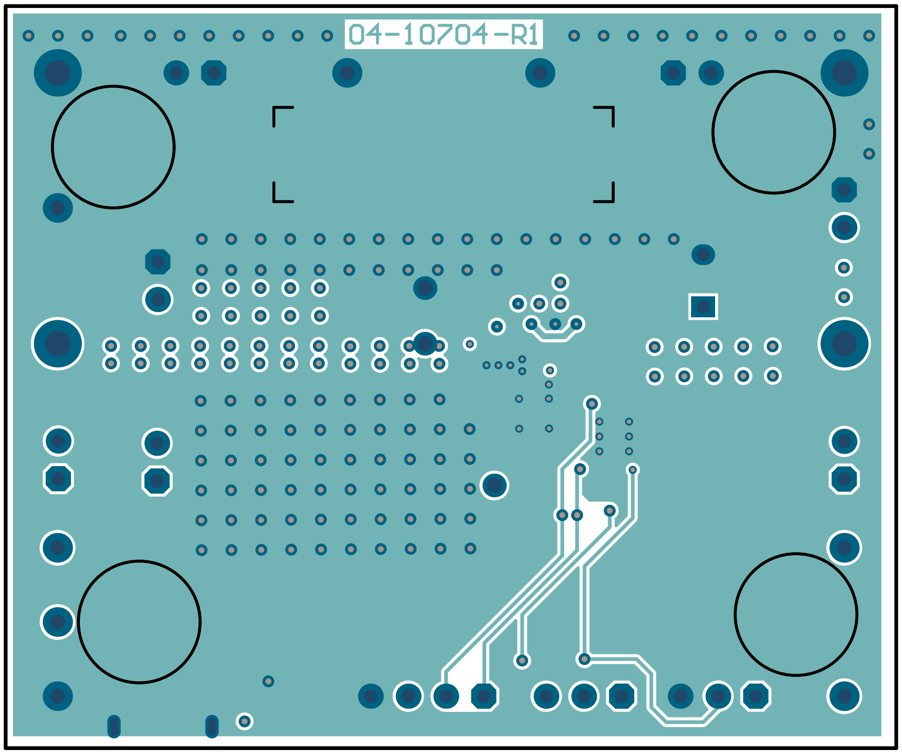
A.7 BOARD – SIGNAL LAYER 2



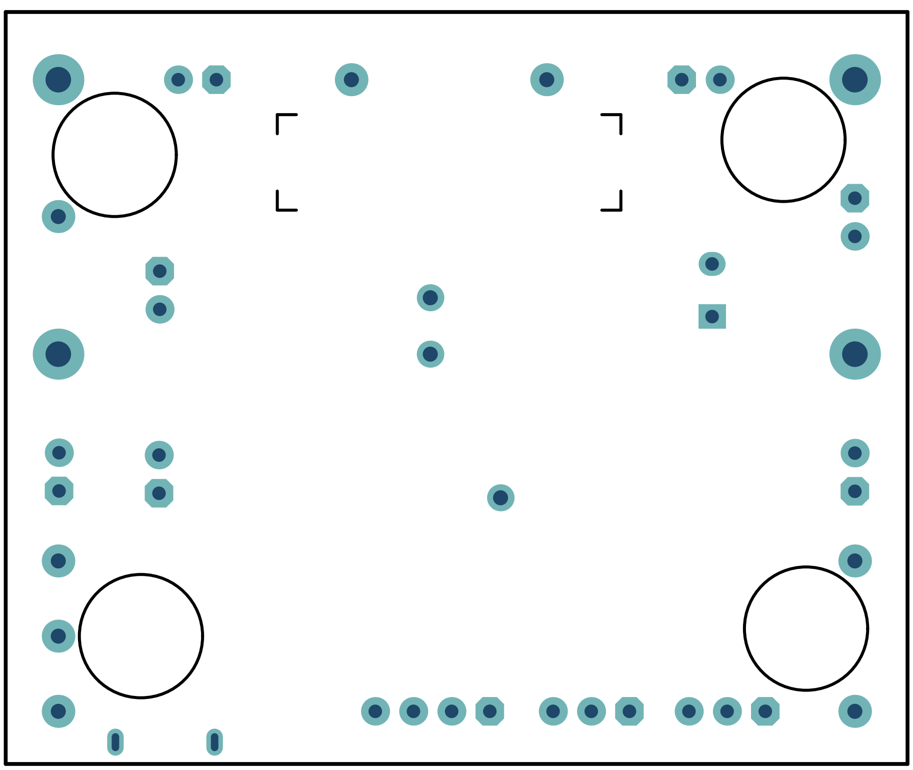
A.8 BOARD – BOTTOM COPPER



A.9 BOARD – BOTTOM COPPER AND SILK



A.10 BOARD – BOTTOM SILK



Appendix B. Bill of Materials (BOM)

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

Qty.	Reference	Description	Manufacturer	Part Number
1	C1	Capacitor Ceramic, 1 µF, 16V, 10%, X5R, SMD, 0603	AVX Corporation/Kyocera	0603YD105KAT2A
2	C2, C6	Capacitor Ceramic, 0.1 µF, 16V, 10%, X7R, SMD, 0603	Samsung	CL10B104KO8NNNC
2	C3, C11	Capacitor Ceramic, 4.7 µF, 10V, 10%, X5R, SMD, 0603	KEMET	C0603C475K8PACTU
1	C4	Capacitor Ceramic, 47 µF, 10V, 20%, X5R, SMD, 0805	TDK Corporation	C2012X5R1A476M125AC
1	C8	Capacitor Aluminum, 470 µF, 16V, 20%, RAD, P3.5, D8, H11.5	Nichicon Corporation	UVZ1C471MPD
1	C9	Capacitor Ceramic, 22 µF, 10V, 20%, X5R, SMD, 0603	TDK Corporation	C1608X5R1A226M080AC
6	J1, J2, J9, J10, J23, J24	Connector Header, 2.54, Male 1x2, Gold, 5.84MH, TH, Vertical	Amphenol ICC	77311-118-02LF
4	J3, J4, J14, J18	Connector, Pin, Tin, TH	Harwin Plc.	H2121-01
2	J5, J12	Connector Header, 2.54, Male, 1x3, Tin, 5.84MH, TH, Vertical	Samtec, Inc.	TSW-103-07-T-S
0	J6	Connector Header, 2.54, Male, 1x2, Gold, 5.84MH, TH, Vertical **DO NOT POPULATE**	Amphenol ICC	77311-118-02LF
1	J7	Connector, USB 2.0, Micro-B, Female, SMD, R/A	Amphenol FCI	10118193-0001LF
2	J13, J20	Test Point Multipurpose, Mini, Red	Keystone Electronics Corp.	5000
4	J15, J16, J17, J21	Test Point Multipurpose, Mini, Black	Keystone Electronics Corp.	5001
0	J19, J22	Test Point Multipurpose, Mini, Red **DO NOT POPULATE**	Keystone Electronics Corp.	5000
1	J25	Connector Header, 2.54, Male, 1x4, Tin, 5.84MH, TH, Vertical	Amphenol FCI	68002-404HLF
2	JP1, JP2	Mechanical HW Jumper, 2.54 mm, 1x2	3M	969102-0000-DA
1	LABEL1	Label, Assembly w/Rev Level (Small Modules) per MTS-0002	—	—
4	PAD1, PAD2, PAD3, PAD4	Mechanical, Hardware, Rubber Pad, Cylindrical, D7.9, H5.3, Black	3M	70006431483
1	PCB1	MIC33M356 Evaluation Board – Printed Circuit Board	Microchip Technology Inc.	**04-10704-R1**

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)[1] (CONTINUED)

Qty.	Reference	Description	Manufacturer	Part Number
1	R1	Resistor, TKF, 49.9R,1%, 1/10W, SMD, 0603	Panasonic®	ERJ3EKF49R9V
0	R2	Resistor, TKF, 10R, 1%, 1/10W, SMD, 0603 **DO NOT POPULATE**	Panasonic	ERJ3EKF10R0V
1	R3	Resistor, TKF, 1M, 1%, 1/10W, SMD, 0603	Panasonic	ERJ-3EKF1004V
1	R4	Resistor, TKF, 10R, 1%, 1/10W, SMD, 0603	Panasonic	ERJ3EKF10R0V
1	R5	Resistor, TKF, 100k, 1%, 1/10W, SMD, 0603	TE Connectivity	1622827-1
4	R6, R7, R8, R10	Resistor, TKF, 0R, 1/10W, SMD, 0603	Panasonic	ERJ-3GEY0R00V
0	R9	Resistor, TKF, 0R, 1/10W, SMD, 0603 **DO NOT POPULATE**	Panasonic	ERJ-3GEY0R00V
2	R11, R12	Resistor, TF, 2k, 0.1%, 1/10W, SMD, 0603	Yageo Corporation	RT0603BRD072KL
1	U1	Microchip Analog Switcher Buck, 0.6V to 3.3V, MIC33M356, 24-Lead QFN	Microchip Technology Inc.	**MIC33M356-HAYMP**
1	U2	Microchip Interface, USB, I^2C/UART, MCP2221A-I/ST, 14-Lead TSSOP	Microchip Technology Inc.	**MCP2221A-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.

Appendix C. MIC33M356 Internal Registers

C.1 REGISTER MAP AND I²C PROGRAMMABILITY

The MIC33M356 internal registers are summarized in Table C-1.

TABLE C-1: MIC33M356 REGISTER MAP

Address	Register Name							
0x00	Output Control Register 1 (CTRL1)							
	TON[1:0]		Reserved	ILIM	EN_DELAY[1:0]		EN_INT	EN_CON
0x01	Output Control Register 2 (CTRL2)							
	DIS_100PCT	FPWM	OT_LATCH	PULL_DN	SLEW_RATE[3:0]			
0x02	Output Voltage Control Register (VOUT)							
	VO[7:0]							
0x03	STATUS and Fault Register (FAULT)							
	OT_WARN	EN_STAT	BOOT_ERR	SSD	HICCUP	OT	LATCH_OFF	PG

REGISTER C-1: CTRL1: OUTPUT CONTROL REGISTER 1 (ADDRESS 0x00)

R/W-0	R/W-0	r-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
TON[1:0]		—	ILIM	EN_DELAY[1:0]		EN_INT	EN_CON
bit 7							bit 0

Legend:	r = Reserved bit		
R = Readable bit	W = Writable bit	U = Unimplemented bit, read as '0'	
-n = Value at POR	'1' = Bit is set	'0' = Bit is cleared	x = Bit is unknown

bit 7-6 **TON[1:0]:** On Time
00 = Low Frequency
01 = Medium Frequency
10 = High Frequency
11 = Very Fast Frequency

bit 5 **Reserved**

bit 4 **ILIM:** High-Side Peak Current Limit
0 = 3.5A
1 = 5A

bit 3-2 **EN_DELAY[1:0]:** Enable Delay
00 = 250 µs
01 = 1 ms
10 = 2 ms
11 = 3 ms

bit 1 **EN_INT:** Enable Bit Register Control
0 = Register controlled
1 = Enable controlled

bit 0 **EN_CON:** Enable Control
0 = Off
1 = On

REGISTER C-2: CTRL2: OUTPUT CONTROL REGISTER 2 (ADDRESS 0x01)

R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
DIS_100PCT	FPWM	OT_LATCH	PULLDN	SLEW_RATE[3:0]			
bit 7							bit 0

Legend:			
R = Readable bit	W = Writable bit	U = Unimplemented bit, read as '0'	
-n = Value at POR	'1' = Bit is set	'0' = Bit is cleared	x = Bit is unknown

bit 7 **DIS_100PCT:** Disable 100% Duty Cycle
0 = 100% DC
1 = Disable 100% DC

bit 6 **FPWM:** Force PWM
0 = HLL
1 = FPWM

bit 5 **OT_LATCH:** Overtemperature Latch
0 = Latch off immediately
1 = Latch off after four OT cycles

bit 4 **PULLDN:** Enable/Disable Regulator Pull-Down when Power-Down
0 = No pull-down
1 = Pull-down

bit 3-0 **SLEW_RATE[3:0]:** Step Slew Rate Time in µs/V
0000 = 200
0001 = 400
0010 = 600
0011 = 800
0100 = 1000
0101 = 1200
0110 = 1400
0111 = 1600
1000 = 1800
1001 = 2000
1010 = 2200
1011 = 2400
1100 = 2600
1101 = 2800
1110 = 3000
1111 = 3200

REGISTER C-3: VOUT: OUTPUT VOLTAGE CONTROL REGISTER (ADDRESS 0x02)

R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
VO[7:0]							
bit 7							bit 0

Legend:			
R = Readable bit	W = Writable bit	U = Unimplemented bit, read as ‘0’	
-n = Value at POR	‘1’ = Bit is set	‘0’ = Bit is cleared	x = Bit is unknown

bit 7-0 **VO[7:0]:** Output Voltage Control, Options: YFT, --HAYFT, -FAYFT

0x00-0x76 = 0.6V	0x80 = 0.645	0xA0 = 0.805V	0xC0 = 0.965	0xE0 = 1.125V
	0x81 = 0.65V	0xA1 = 0.81V	0xC1 = 0.97V	0xE1 = 1.13V
	0x82 = 0.655V	0xA2 = 0.815V	0xC2 = 0.975V	0xE2 = 1.135V
	0x83 = 0.66V	0xA3 = 0.82V	0xC3 = 0.98V	0xE3 = 1.14V
	0x84 = 0.665V	0xA4 = 0.825V	0xC4 = 0.985V	0xE4 = 1.145V
	0x85 = 0.67V	0xA5 = 0.83V	0xC5 = 0.99V	0xE5 = 1.15V
	0x86 = 0.675V	0xA6 = 0.835V	0xC6 = 0.995V	0xE6 = 1.155V
	0x87 = 0.68V	0xA7 = 0.84V	0xC7 = 1V	0xE7 = 1.16V
	0x88 = 0.685V	0xA8 = 0.845V	0xC8 = 1.005V	0xE8 = 1.165V
	0x89 = 0.69V	0xA9 = 0.85V	0xC9 = 1.01V	0xE9 = 1.17V
	0x8A = 0.695V	0xAA = 0.855V	0xCA = 1.015V	0xEA = 1.175V
	0x8B = 0.7V	0xAB = 0.86V	0xCB = 1.02V	0xEB = 1.18V
	0x8C = 0.705V	0xAC = 0.865V	0xCC = 1.025V	0xEC = 1.185V
	0x8D = 0.71V	0xAD = 0.87V	0xCD = 1.03V	0xED = 1.19V
	0x8E = 0.715V	0xAE = 0.875V	0xCE = 1.035V	0xEE = 1.195V
	0x8F = 0.72V	0xAF = 0.88V	0xCF = 1.04V	0xEF = 1.2V
	0x90 = 0.725V	0xB0 = 0.885V	0xD0 = 1.045V	0xF0 = 1.205V
	0x91 = 0.73V	0xB1 = 0.89V	0xD1 = 1.05V	0xF1 = 1.21V
	0x92 = 0.735V	0xB2 = 0.895V	0xD2 = 1.055V	0xF2 = 1.215V
	0x93 = 0.74V	0xB3 = 0.9V	0xD3 = 1.06V	0xF3 = 1.22V
	0x94 = 0.745V	0xB4 = 0.905V	0xD4 = 1.065V	0xF4 = 1.225V
	0x95 = 0.75V	0xB5 = 0.91V	0xD5 = 1.07V	0xF5 = 1.23V
	0x96 = 0.755V	0xB6 = 0.915V	0xD6 = 1.075V	0xF6 = 1.235V
0x77 = 0.6V	0x97 = 0.76V	0xB7 = 0.92V	0xD7 = 1.08V	0xF7 = 1.24V
0x78 = 0.605V	0x98 = 0.765V	0xB8 = 0.925V	0xD8 = 1.085V	0xF8 = 1.245V
0x79 = 0.61V	0x99 = 0.77V	0xB9 = 0.93V	0xD9 = 1.09V	0xF9 = 1.25V
0x7A = 0.615V	0x9A = 0.775V	0xBA = 0.935V	0xDA = 1.095V	0xFA = 1.255V
0x7B = 0.62V	0x9B = 0.78V	0xBB = 0.94V	0xDB = 1.1V	0xFB = 1.26V
0x7C = 0.625V	0x9C = 0.785V	0xBC = 0.945V	0xDC = 1.105V	0xFC = 1.265V
0x7D = 0.63V	0x9D = 0.79V	0xBD = 0.95V	0xDD = 1.11V	0xFD = 1.27V
0x7E = 0.635V	0x9E = 0.795V	0xBE = 0.955V	0xDE = 1.115V	0xFE = 1.275V
0x7F = 0.64V	0x9F = 0.8V	0xBF = 0.96V	0xDF = 1.12V	0xFF = 1.28V

REGISTER C-3: VOUT: OUTPUT VOLTAGE CONTROL REGISTER (ADDRESS 0x02)

bit 7-0 **VO[7:0]:** Output Voltage Control, Option: -SAYFT

0x00-0x3B = 0.6V	0x40 = 0.65V	0x60 = 0.97V	0x80 = 1.3V	0xA0 = 1.94V	0xC0 = 2.58V	0xE0 = 3.22V
	0x41 = 0.66V	0x61 = 0.98V	0x81=1.32V	0xA1 = 1.96V	0xC1 = 2.6V	0xE1 = 3.24V
	0x42 = 0.67V	0x62 = 0.99V	0x82 = 1.34V	0xA2 = 1.98V	0xC2 = 2.62V	0xE2 = 3.26V
	0x43 = 0.68V	0x63 = 1V	0x83 = 1.36V	0xA3 = 2V	0xC3 = 2.64V	0xE3 = 3.28V
	0x44 = 0.69V	0x64 = 1.01V	0x84 = 1.38V	0xA4 = 2.02V	0xC4 = 2.66V	0xE4 = 3.3V
	0x45 = 0.7V	0x65 = 1.02V	0x85 = 1.4V	0xA5 = 2.04V	0xC5 = 2.68V	0xE5 = 3.32V
	0x46 = 0.71V	0x66 = 1.03V	0x86 = 1.42V	0xA6 = 2.06V	0xC6 = 2.7V	0xE6 = 3.34V
	0x47 = 0.72V	0x67 = 1.04V	0x87 = 1.44V	0xA7 = 2.08V	0xC7 = 2.72V	0xE7 = 3.36V
	0x48 = 0.73V	0x68 = 1.05V	0x88 = 1.46V	0xA8 = 2.1V	0xC8 = 2.74V	0xE8 = 3.38V
	0x49 = 0.74V	0x69 = 1.06V	0x89 = 1.48V	0xA9 = 2.12V	0xC9 = 2.76V	0xE9 = 3.4V
	0x4A = 0.75V	0x6A = 1.07V	0x8A = 1.5V	0xAA = 2.14V	0xCA = 2.78V	0xEA = 3.42V
	0x4B = 0.76V	0x6B = 1.08V	0x8B = 1.52V	0xAB = 2.16V	0xCB = 2.8V	0xEB = 3.44V
	0x4C = 0.77V	0x6C = 1.09V	0x8C = 1.54V	0xAC = 2.18V	0xCC = 2.82V	0xEC = 3.46V
	0x4D = 0.78V	0x6D = 1.1V	0x8D = 1.56V	0xAD = 2.2V	0xCD = 2.84V	0xED = 3.48V
	0x4E = 0.79V	0x6E = 1.11V	0x8E = 1.58V	0xAE = 2.22V	0xCE = 2.86V	0xEE = 3.5V
	0x4F = 0.8V	0x6F=1.12V	0x8F = 1.6V	0xAF = 2.24V	0xCF = 2.88V	0xEF = 3.52V
	0x50 = 0.81V	0x70 = 1.13V	0x90 = 1.62V	0xB0 = 2.26V	0xD0 = 2.9V	0xF0 = 3.54V
	0x51 = 0.82V	0x71 = 1.14V	0x91 = 1.64V	0xB1 = 2.28V	0xD1 = 2.92V	0xF1 = 3.56V
	0x52 = 0.83V	0x72 = 1.15V	0x92 = 1.66V	0xB2 = 2.3V	0xD2 = 2.94V	0xF2 = 3.58V
	0x53 = 0.84V	0x73 = 1.16V	0x93 = 1.68V	0xB3 = 2.32V	0xD3 = 2.96V	0xF3 = 3.6V
	0x54 = 0.85V	0x74 = 1.17V	0x94 = 1.7V	0xB4 = 2.34V	0xD4 = 2.98V	0xF4 = 3.62V
	0x55 = 0.86V	0x75 = 1.18V	0x95 = 1.72V	0xB5 = 2.36V	0xD5 = 3V	0xF5 = 3.64V
	0x56 = 0.87V	0x76=1.19V	0x96 = 1.74V	0xB6 = 2.38V	0xD6 = 3.02V	0xF6 = 3.66V
	0x57 = 0.88V	0x77 = 1.2V	0x97 = 1.76V	0xB7 = 2.4V	0xD7 = 3.04V	0xF7 = 3.68V
	0x58 = 0.89V	0x78 = 1.21V	0x98 = 1.78V	0xB8 = 2.42V	0xD8 = 3.06V	0xF8 = 3.7V
	0x59 = 0.9V	0x79 = 1.22V	0x99 = 1.8V	0xB9 = 2.44V	0xD9 = 3.08V	0xF9 = 3.72V
	0x5A = 0.91V	0x7A = 1.23V	0x9A = 1.82V	0xBA = 2.46V	0xDA = 3.1V	0xFA = 3.74V
0x3B = 0.6V	0x5B = 0.92V	0x7B = 1.24V	0x98 = 1.84V	0xBB = 2.48V	0xDB = 3.12V	0xFB = 3.76V
0x3C = 0.61V	0x5C = 0.93V	0x7C = 1.25V	0x9C = 1.86V	0xBC = 2.5V	0xDC = 3.14V	0xFC = 3.78V
0x3D = 0.62V	0x5D = 0.94V	0x7D = 1.26V	0x9D = 1.88V	0xBD = 2.52V	0xDD = 3.16V	0xFD = 3.8V
0x3E = 0.63V	0x5E = 0.95V	0x7E = 1.27V	0x9E = 1.9V	0xBE = 2.54V	0xDE = 3.18V	0xFE = 3.82V
0x3F = 0.64V	0x5F = 0.96V	0x7F = 1.28V	0x9F = 1.92V	0xBF = 2.56V	0xDF = 3.2V	0xFF = 3.84V

REGISTER C-4: STATUS AND FAULT REGISTER (ADDRESS 0x03)

R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0
OT_WARN	EN_STAT	BOOT_ERR	SSD	HICCUP	OT	LATCH_OFF	PG
bit 7							bit 0

Legend:			
R = Readable bit	W = Writable bit	U = Unimplemented bit, read as ‘0’	
-n = Value at POR	‘1’ = Bit is set	‘0’ = Bit is cleared	x = Bit is unknown

bit 7 **OT_WARN:** Overtemperature Warning
0 = No Fault
1 = Fault

bit 6 **EN_STAT:** Buck On/Off Control
0 = Off
1 = On

bit 5 **BOOT_ERR:** Boot-up Error
0 = No Fault
1 = Fault

bit 4 **SSD:** Soft Start Done
0 = Ramp not done
1 = Ramp done

bit 3 **HICCUP:** Current Limit Hiccup
0 = Not in hiccup
1 = In hiccup

bit 2 **OT:** Overtemperature
0 = No Fault
1 = Fault

bit 1 **LATCH_OFF:** Overcurrent or Overtemperature Output Latch Off
0 = No Fault
1 = Fault

bit 0 **PG:** Power Good
0 = Power not good
1 = Power good

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