MIC24045 Evaluation Board User's Guide

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ISBN: 978-1-5224-1721-7

Object of Declaration: MIC24045 Evaluation Board

EU Declaration of Conformity

This declaration of conformity is issued by the manufacturer.
The development/evaluation tool is designed to be used for research and development in a laboratory environment. This development/evaluation tool is not a Finished Appliance, nor is it intended for incorporation into Finished Appliances that are made commercially available as single functional units to end users under EU EMC Directive 2004/108/EC and as supported by the European Commission's Guide for the EMC Directive 2004/108/EC (8th February 2010).
This development/evaluation tool complies with EU RoHS2 Directive 2011/65/EU.
This development/evaluation tool, when incorporating wireless and radio-telecom functionality, is in compliance with the essential requirement and other relevant provisions of the R&TTE Directive 1999/5/EC and the FCC rules as stated in the declaration of conformity provided in the module datasheet and the module product page available at www.microchip.com.
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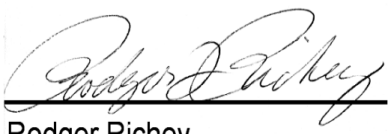

Rodger Richey
Director of Development Tools

4/4/17

Date

NOTES:

MIC24045 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 MIC24045 Evaluation Board. Items discussed in this chapter include:

- Document Layout
- Conventions Used in this Guide
- Recommended Reading
- The Microchip Web Site
- Customer Support
- Document Revision History

DOCUMENT LAYOUT

This document describes how to use the MIC24045 Evaluation Board as a development tool. The manual layout is as follows:

- **Chapter 1. "Product Overview"** – Important information about the MIC24045 Evaluation Board.
- **Chapter 2. "Installation and Operation"** – Includes description and instructions on how to use the MIC24045 Evaluation Board.
- **Chapter 3. "GUI Installation and Operation"** – Includes Instructions on how to install the I^2C Monitor Graphical User Interface.
- **Chapter 4. "GUI Description"** – Includes the description for I^2C Monitor Graphical User Interface.
- **Appendix A. "Schematic and Layouts"** – Shows the schematic and layout diagrams for the MIC24045 Evaluation Board.
- **Appendix B. "Bill of Materials (BOM)"** – Lists the parts used to build the MIC24045 Evaluation Board.
- **Appendix C. "MIC24045 Internal Registers"** – Includes a detailed description of the available registers in the MIC24045 device.

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 MIC24045 Evaluation Board. Another useful document is listed below. The following Microchip document is available and recommended as a supplemental reference resource:

- **MIC24045 Data Sheet – *"I^2C Programmable, 4.5V-19V Input, 5A Step-Down Converter" (DS20005568).***

THE MICROCHIP WEB SITE

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
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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 A (May 2017)

- Initial Release of this Document.

NOTES:

Chapter 1. Product Overview

1.1 INTRODUCTION

This chapter provides an overview of the MIC24045 Evaluation Board (ADM00826) and covers the following topics:

- MIC24045 Device Short Overview
- MIC24045 Evaluation Board Overview
- What the MIC24045 Evaluation Board User's Guide Contains

1.2 MIC24045 DEVICE SHORT OVERVIEW

The MIC24045 is a I^2C programmable, high-efficiency, wide-input range, 5A synchronous step-down regulator. The MIC24045 is perfectly suited for multiple voltage rail application environments found in enterprise computing and telecommunication systems. For the MIC24045 device, the user can program, via I^2C, various parameters such as Output Voltage, Switching Frequency, Soft-Start slope, Margining, Current Limit values and Start-up Delay. The MIC24045 wide switching frequency adjustment range, valley current-mode control technique, high-performance error amplifier and external compensation allow the best trade-offs between high-efficiency and small solution size. The MIC24045 device supports extensive diagnostics and status information through I^2C. Programmable cycle-by-cycle current limit value helps optimize the size of the inductor in each particular application.

The MIC24045 is available in thermally-efficient, space-saving 20-pin 3 mm x 3 mm FQFN package, with an operating junction temperature range from –40°C to +125°C.

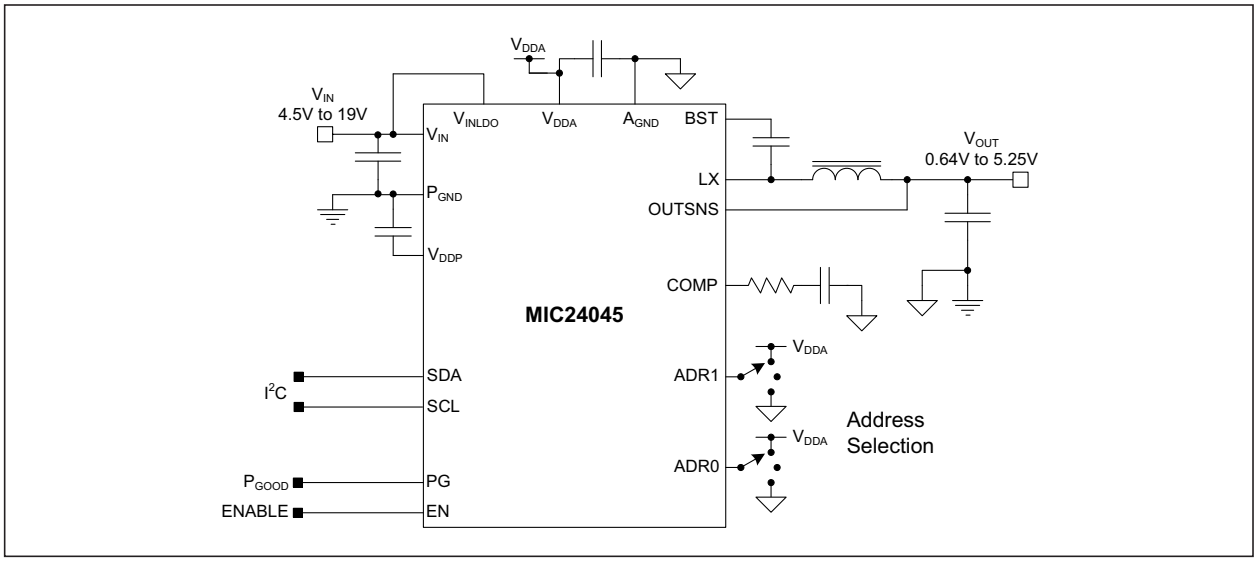


FIGURE 1-1: *MIC24045 Typical Application.*

1.3 MIC24045 EVALUATION BOARD OVERVIEW

For the evaluation of the MIC24045 device, the V_{IN} supply ranges from 4.5V to 19V and output voltage from 0.64V to 5.25V in 5 mV, 10 mV, 30 mV and 50 mV steps at 5A. Additionally, an on-board load transient generator circuit and connections for loop gain measurements are provided. A micro-USB connector is available on the board and is used to connect to the I^2C Monitor, which allows the user to control the output voltage, switching frequency, current limit and soft start of the MIC24045.

1.4 WHAT THE MIC24045 EVALUATION BOARD USER'S GUIDE CONTAINS

The MIC24045 Evaluation Board includes:

- MIC24045 Evaluation Board
- USB-to-Micro-USB Cable
- Important Information Sheet

Chapter 2. Installation and Operation

2.1 INTRODUCTION

The MIC24045 Evaluation Board requires only a single power supply with at least 5A current capability. The MIC24045 has an internal V_{DDA} LDO, so no external linear regulator is required to power the internal biasing of the device.

2.2 GETTING STARTED

To power up the MIC24045 Evaluation Board, the following steps must be completed:

1. Connect a power supply to the V_{IN} and G_{ND} terminals. An ammeter may be placed between the input supply and the V_{IN} terminal of the evaluation board. Ensure that the supply voltage is monitored at the V_{IN} terminal (TP2 or J6). The ammeter and/or power lead resistance can reduce the voltage supplied to the input. Keep the power supply disabled; do not apply power until Step 5.
2. Connect the load to the V_{OUT} and G_{ND} terminals.The load can be either passive (resistive) or active (electronic load). An ammeter can be placed between the load and the V_{OUT} terminal. Ensure that the output voltage is monitored at the V_{OUT} terminal (TP3 or J7). Alternatively, for high-speed load transient testing at low output voltages, the on-board load transient generator can be used (see **Section 2.3 "On-Board Load Transient Generator"**).
3. Make sure that a jumper is connected on J19, between V_{BUS} and PWR, and another jumper on J1, between V_{IN} and V_{INLDO}.
4. Connect the USB to Micro USB Cable (see Figure 2-1).

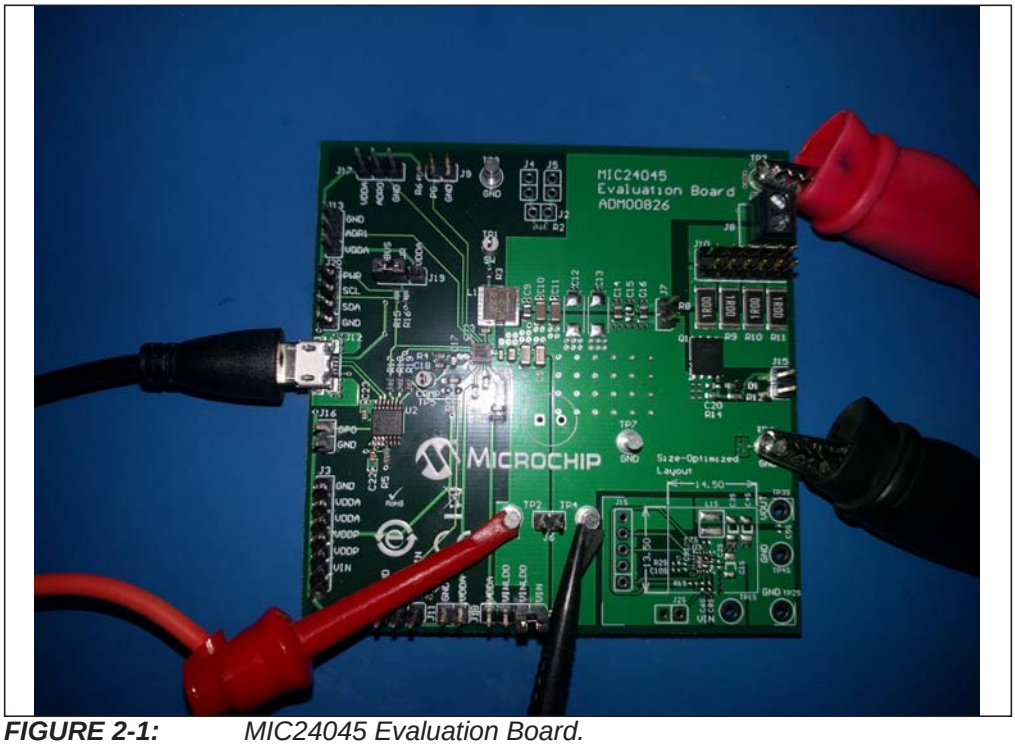


FIGURE 2-1: *MIC24045 Evaluation Board.*

5. Turn on the power supply.
6. To modify the Current Limit, Switching Frequency, Output Voltage, Soft Start time and other features of the part, use the I^2C Monitor Graphical User Interface (for more details, see **Chapter 3. "GUI Installation and Operation"** and **Chapter 4. "GUI Description"**).
7. Using the **Enable** button in the GUI, turn on the converter.
8. Once **Enable** is turned on, the voltage set using the GUI should be present at the output of the converter.

2.3 ON-BOARD LOAD TRANSIENT GENERATOR

The MIC24045 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). Resistive loads (R8 to R11) can be selectively connected by means of header J10. MOSFET Q1 must be driven by an external signal generator, connected at J15, using a square wave (suggested low level = 0V, high level = 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. It is very important not to exceed the power dissipation limit of R8 to R11. Using 2512 resistors (1W rating), the constraint is as shown in Equation 2-1 (R_{LOAD} takes the values of R8 to R11):

EQUATION 2-1:

$$D \cdot \frac{V_{OUT}^{\ 2}}{R_{LOAD}} < 1W$$

Where:

D	= on time duty cycle of Q1
V_{OUT}	= selected output voltage
R_{LOAD}	= the value of resistors R8 to R11 (default board value is 1Ω)

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.

2.4 LOOP GAIN MEASUREMENT

The MIC24045 Evaluation Board provides injection points and a termination resistor for AC loop gain measurements. Inject the oscillator at J2 through the insulation transformer and connect the A (CH1) and B (CH2) channels at J4 and J5, respectively, or as indicated by the operating instructions of the particular loop gain analyzer in use.

Chapter 3. GUI Installation and Operation

3.1 GETTING STARTED

In order to install, use and evaluate the product, there are several software and hardware tools required to be installed and/or set.

3.1.1 Required Software

- I^2C Monitor Graphical User Interface (v.1.0.0)
- Microsoft®.NET Framework 4.5 or Higher
- Adobe® Acrobat Reader
- Microsoft Windows® 7

3.1.2 Required Hardware

- MIC24045 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 (v.1.0.0) archive from www.microchip.com/MIC24045, under "Documentation& Software".
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 on 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 on the **Next** button to start the installation.

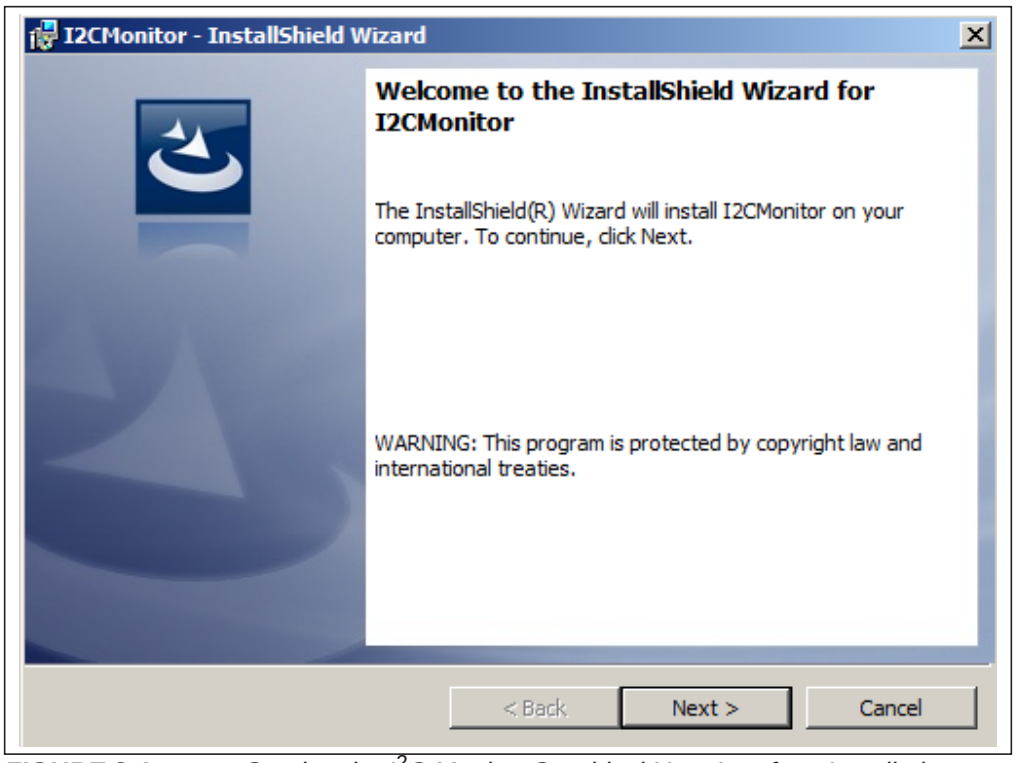


FIGURE 3-1: *Starting the I²C Monitor Graphical User Interface Installation.*

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

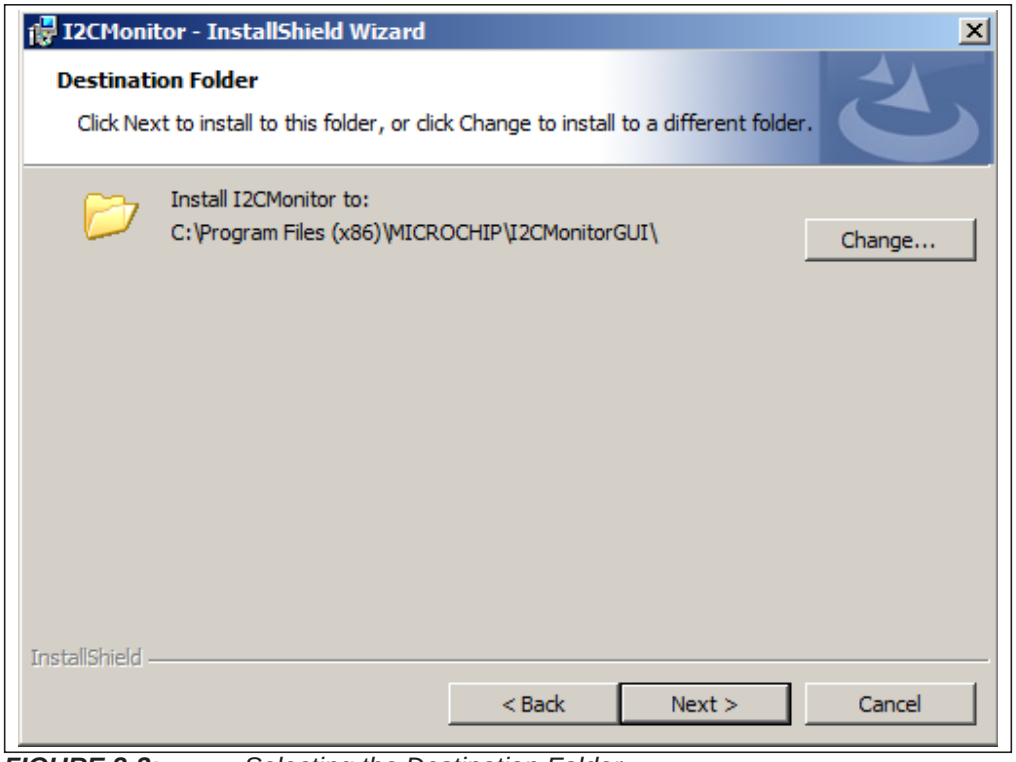


FIGURE 3-2: *Selecting the Destination Folder.*

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

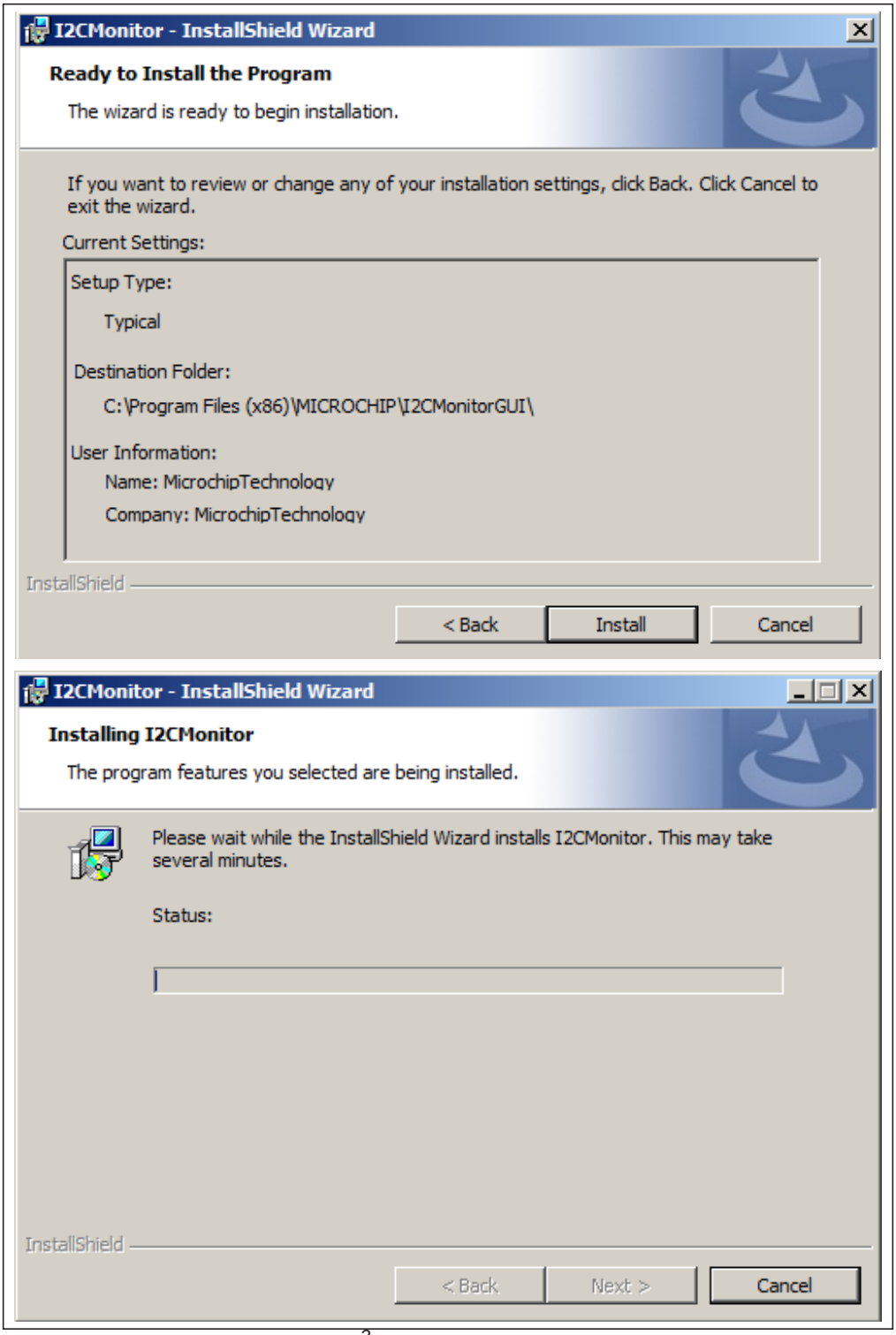


FIGURE 3-3: *Installing the I²C Monitor Graphical User Interface.*

9. Once the installation completes, 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 on the desktop icon or browse to *Windows Start>All Programs>Microchip>I2C Monitor*.

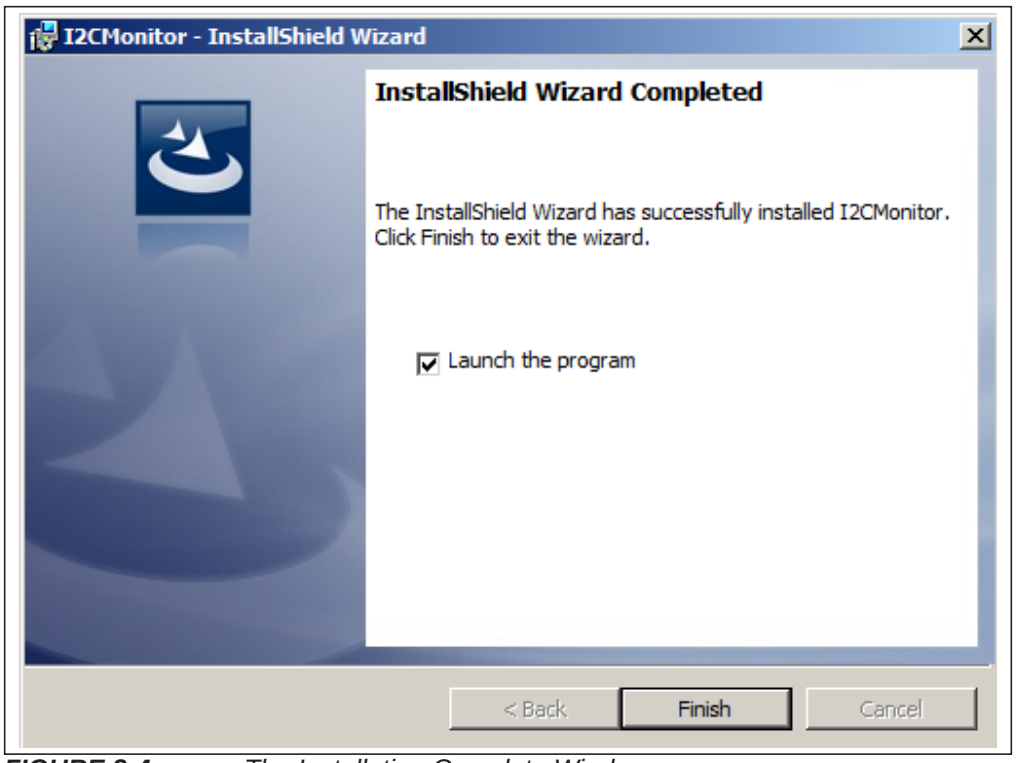


FIGURE 3-4: *The Installation Complete Window.*

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.

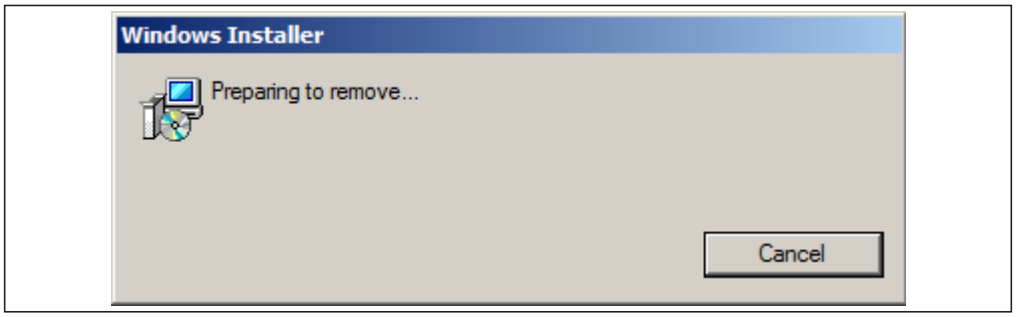


FIGURE 3-5: *Uninstalling the I²C Monitor Graphical User Interface.*

Chapter 4. GUI Description

4.1 INTRODUCTION

This chapter describes how to use the I²C Monitor Graphical User Interface, using the MIC24045 Evaluation Board included in the kit.

NOTICE

This chapter provides information regarding the use of the GUI only in the case of the MIC24045 device. For other devices using the I²C Monitor Graphical User Interface, see their specific Data Sheets and User's Guides.

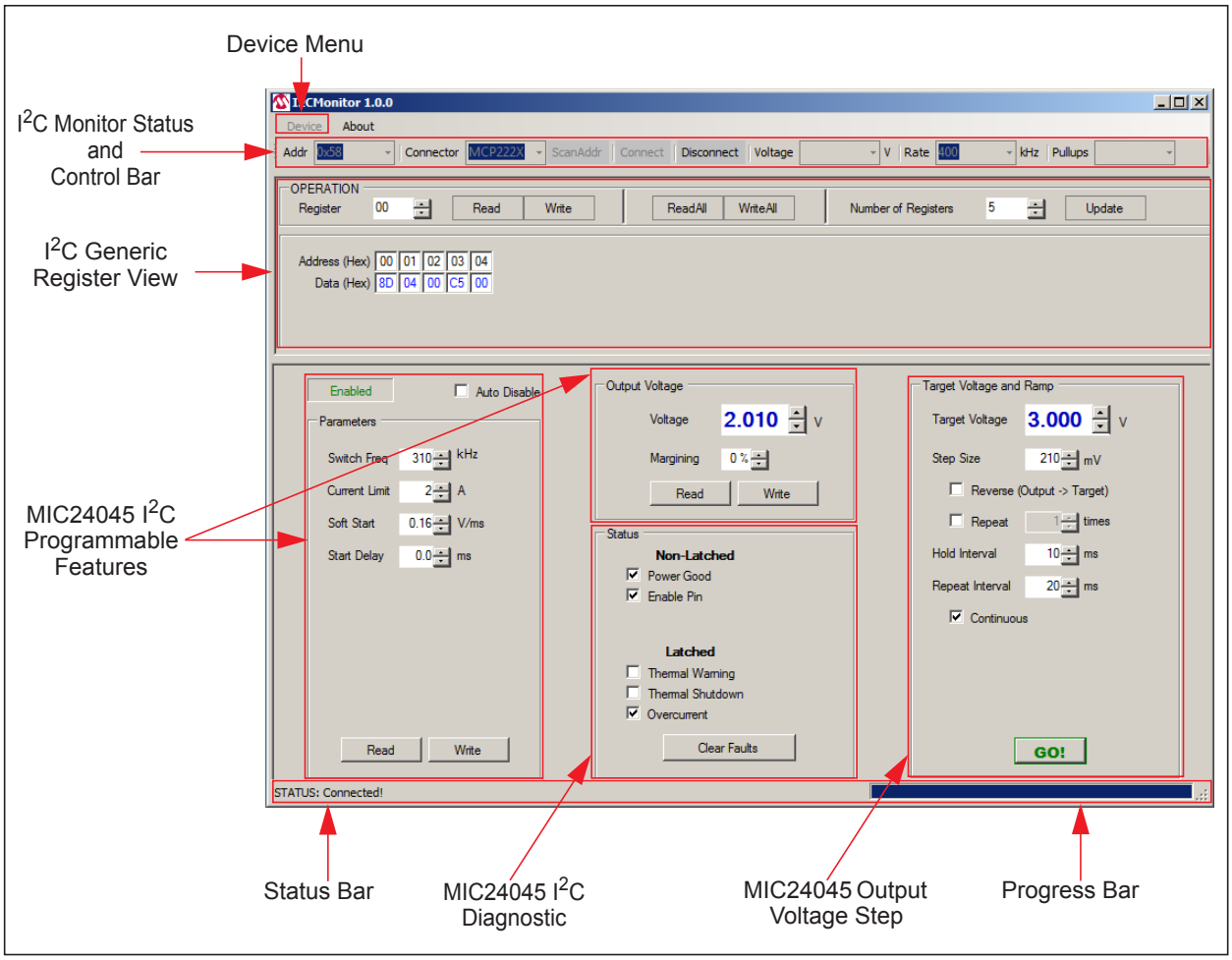


FIGURE 4-1: *I²C Monitor Graphical User Interface Main Window - **MIC24045** View.*

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.

4.2.2 I²C Monitor Status and Control Bar

The status and control bar contains the items in Table 4-1.

FIGURE 4-2: *I²C 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.
Pullups	This drop-down menu is used to activate the internal pullups from the Pickit Serial Analyzer.

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 Steps 1-3 as described in **Section 2.2 "Getting Started"**. After connecting the USB-to-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.

4.2.3 I²C Generic Register View

The I²C Generic Register View area contains the items in Table 4-2. This section of the I²C Monitor GUI is common for any device evaluated.

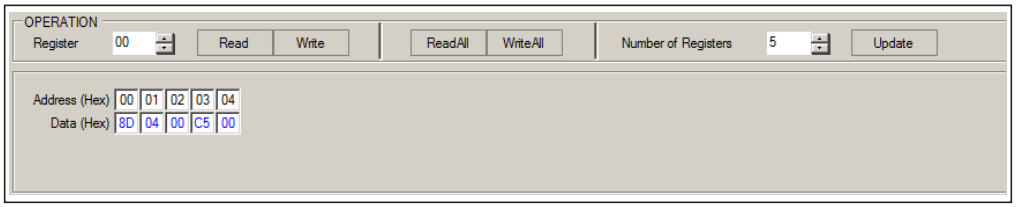


FIGURE 4-3: *Generic Register View Area.*

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 address of the registers and their content.

The specific registers for MIC24045 device are described in **Appendix C. "MIC24045 Internal Registers"**.

4.2.4 MIC24045 I²C Programmable Features

The MIC24045 I²C Programmable Features area contains the items in Table 4-3.

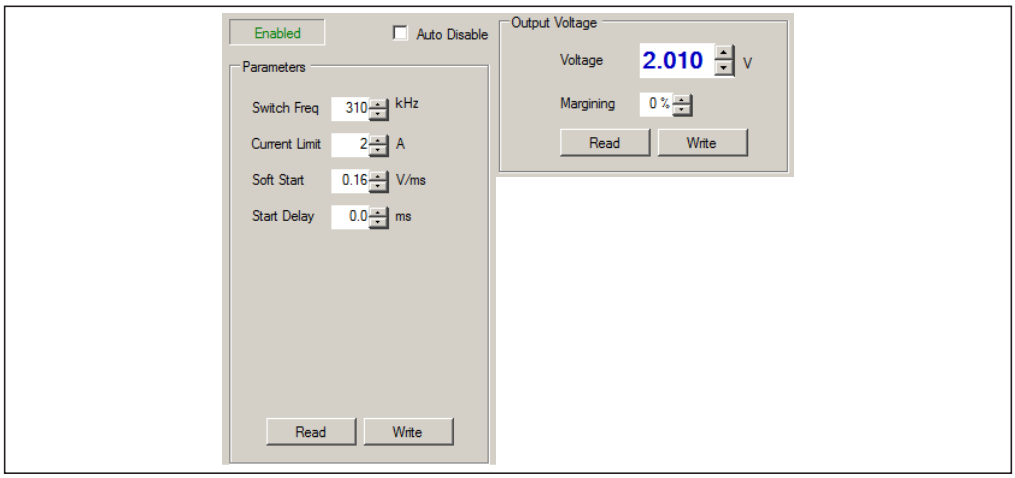


FIGURE 4-4: *MIC24045 I²C Programmable Features Area.*

TABLE 4-3: MIC24045 I²C Programmable Features

Panel/Button	Items	Description
Enable		This button controls the Enable pin of the MIC24045. The red color of this button marks the Off state and green marks the On state.
Auto Disable		If this option is checked, the GUI automatically disables the part using the Enable when critical parameters for the MIC24045 are changed.
Parameters	Switch Freq	This spin box allows setting the available switching frequencies.
	Current Limit	This spin box allows setting the available low-side current limits in order to obtain the nominal load currents.
	Soft Start	This spin box allows setting the available soft-start times.
	Start Delay	This spin box allows setting the available start time delays.
	Read/Write	These buttons are used to write the registers that contain the information described above.
Output Voltage	Voltage	This spin box allows setting the available output voltages.
	Margining	This spin box allows setting the available margining options.
	Read/Write	These buttons are used to write the registers that contain the output voltage and the margining information.

This area of the GUI allows the user to modify the device features. For the MIC24045 device, the features which can be modified trough I^2C are the switching frequency, the current limit, the soft-start time, the startup-delay, the output voltage and the output voltage margining. For the limitations and permissible settings of the MIC24045, refer to the device datasheet.

Note that the **Enable** button does not control the device trough I^2C, but through a direct hardware connection to the MIC24045 EN pin.

4.2.5 MIC24045 I^2C Diagnostic

The MIC24045 Diagnostic area contains the items in Table 4-4.

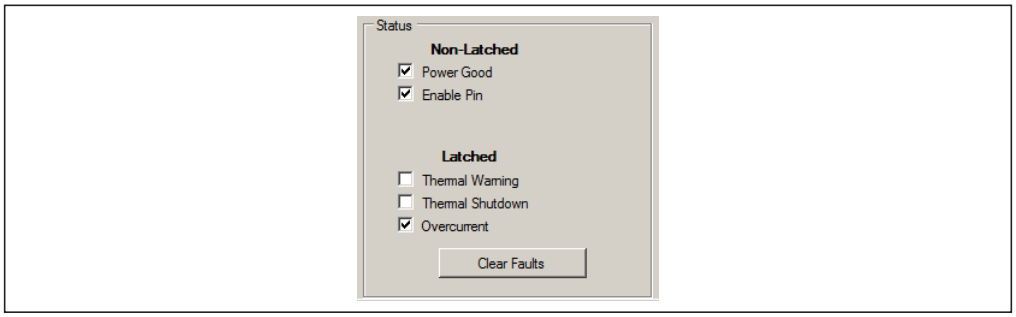


FIGURE 4-5: *MIC24045 I^2C Diagnostic Area.*

TABLE 4-4: MIC24045 I^2C DIAGNOSTIC AREA ITEMS

Panel	Items	Description
Status	Non-Latched	Power Good, Enable Pin bits logic values (ticked = '1', blank = '0')
	Latched	Thermal Warning, Thermal Shutdown, Overcurrent (ticked = '1', blank = '0')
	Clear Faults	This button allows the user to clear the faults.

The MIC24045 I^2C 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 do not return to zero once the fault conditions ceases. If such a fault occurs, it is the user's responsibility to clear it trough the **Clear Faults** button. 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 used on pin GP0 of the MCP2221 and is routed on an external Test Point. This signal is triggered for each user read/write command.

4.2.6 MIC24045 Output Voltage Step

The MIC24045 Output Voltage Step area contains the items in Table 4-5.

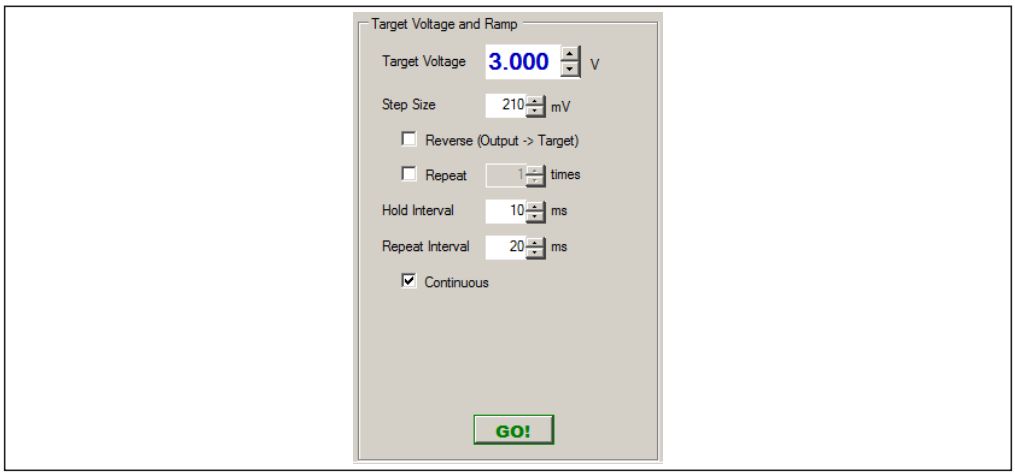


FIGURE 4-6: *MIC24045 Output Voltage Ramp Area.*

TABLE 4-5: MIC24045 OUTPUT VOLTAGE STEP ITEMS

Panel	Item	Description
Target Voltage and Ramp	Target Voltage	This spin box allows the user to set the voltage for output ramp up.
	Step Size	This spin box allows the user to set the value of the steps to ramp up/down the voltage.
	Hold Interval	This spin box allows the user to define the settling time between subsequent ramp ups.
	Reverse (Output → Target)	If the Reverse (Output → Target) box is checked, once the GO! button is pressed, the GUI will ramp down from the Target Voltage to the Output Voltage and vice-versa if it is not checked.
	Repeat	In the Repeat box, the user can select the number of ramps up/down.
	Repeat Interval	This spin box allows the user to set the repeat time between subsequent ramp up/downs, between the Output Voltage and Target Voltage.
	Continuous	If the Continuous box is checked, continuous ramp up/down will be done until stopped by the user.
	GO!	Initiates all voltage ramps.

The MIC24045 Output Voltage Ramp area allows the user to ramp up or down the output voltage in a controlled approach, by setting the voltage steps and the settling time between ramping up/down sequences.

By setting the Target Voltage, the GUI will issue commands to the MIC24045 in order to reach the respective value. In order to control the ramp up/down of the output voltage, the user can select the voltage step. To facilitate the reverse jump, the "Reverse (Output → Target)" check box has to be checked. Also, if a continuous jump between the two values is required, just check the "Continuous" box.

All voltage jumps are initiated by clicking the **GO!** button. If the Continuous box is checked and the **GO!** button is clicked, the **GO!** button will turn into a **STOP** button and its purpose is to stop the continuous ramp up/down.

Figure 4-7 represents a scope shot of the output voltage waveform detailing the settings in the GUI, during a ramp up/down procedure.

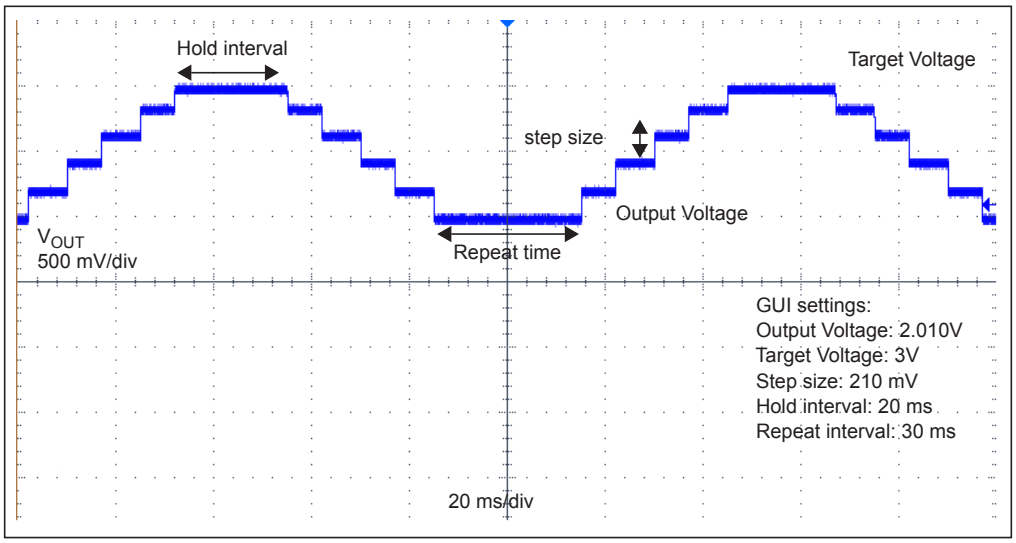


FIGURE 4-7: *Output Voltage Ramp Up/Down.*

4.2.7 Status Bar

The status bar provides information on the status of the device connected to the PC. The items available in the status bar are shown in Table 4-6.

FIGURE 4-8: *Status Bar.*

TABLE 4-6: STATUS BAR ITEMS

Item	Description
Status Label	The status label shows if there is any device connected to the board. Refer to Table 4-7 for a list of possible labels.
Progress Bar	This bar shows the level of completion for a given command.

TABLE 4-7: 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 device connected.

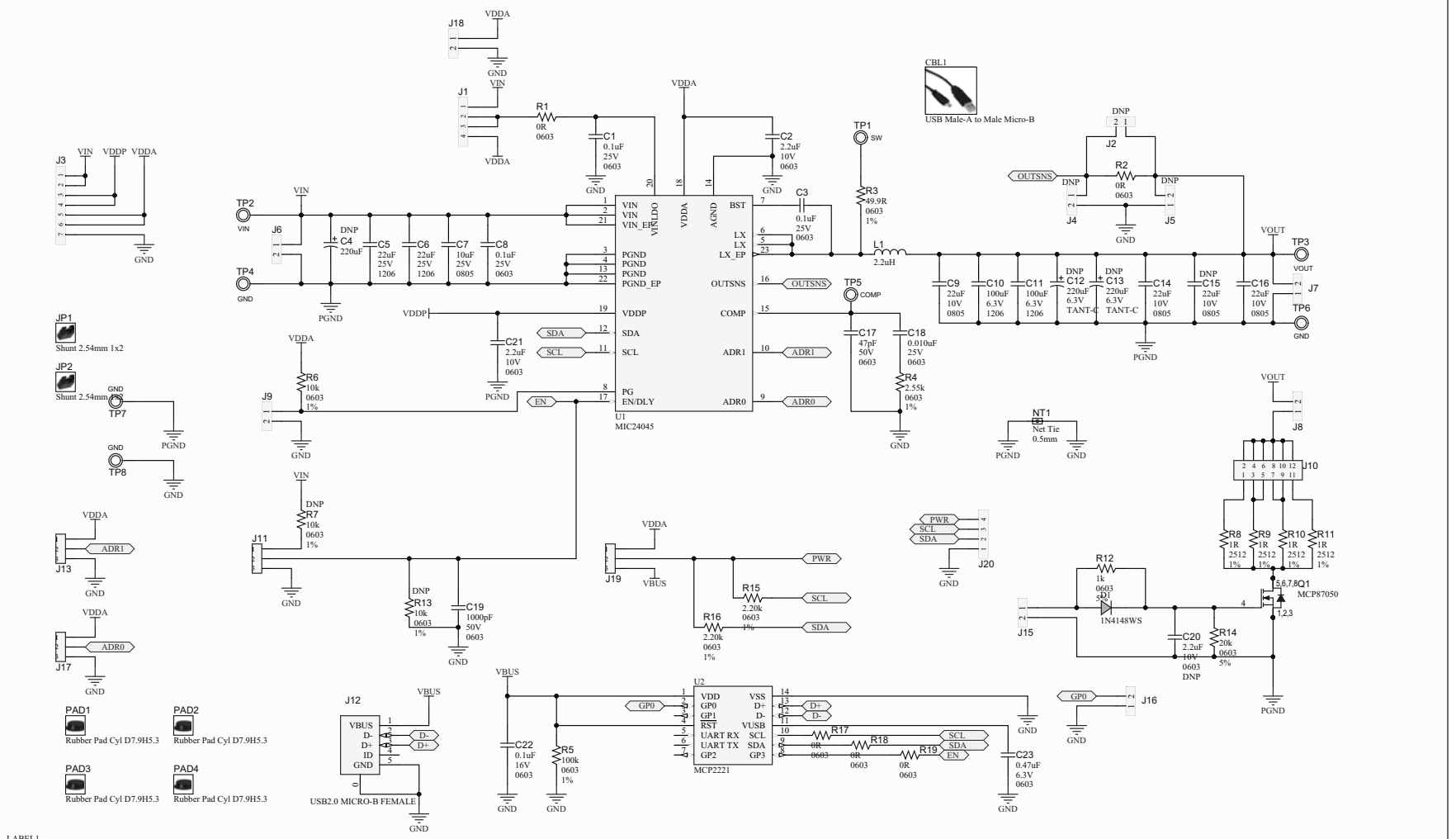
Appendix A. Schematic and Layouts

A.1 INTRODUCTION

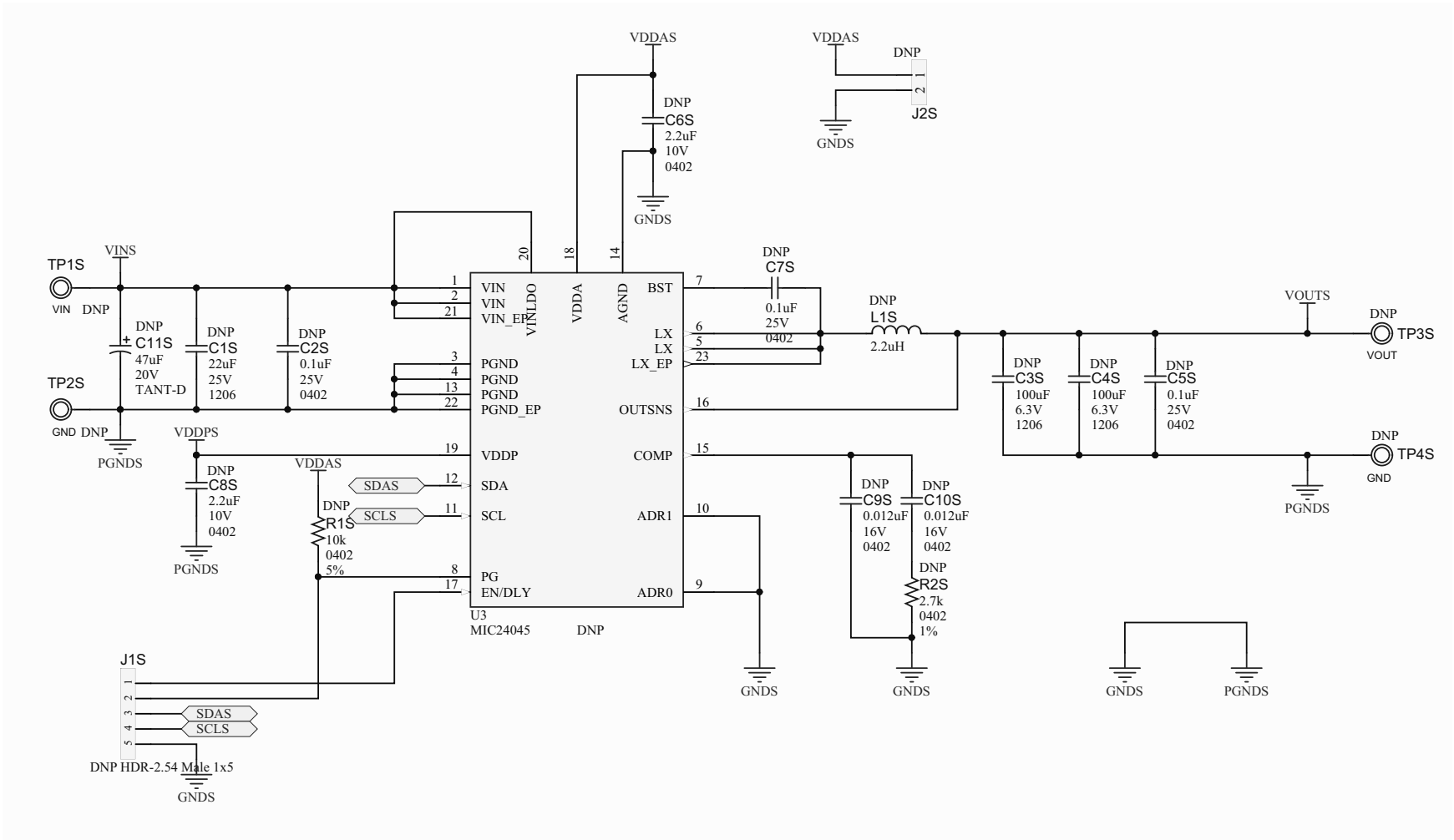
This appendix contains the following schematics and layouts for the MIC24045 Evaluation Board:

- Board – Schematic 1
- Board – Schematic 2
- Board – Top Silk
- Board – Top Copper and Silk
- Board – MID-LAYER 1
- Board – MID-LAYER 2
- Board – Bottom Copper

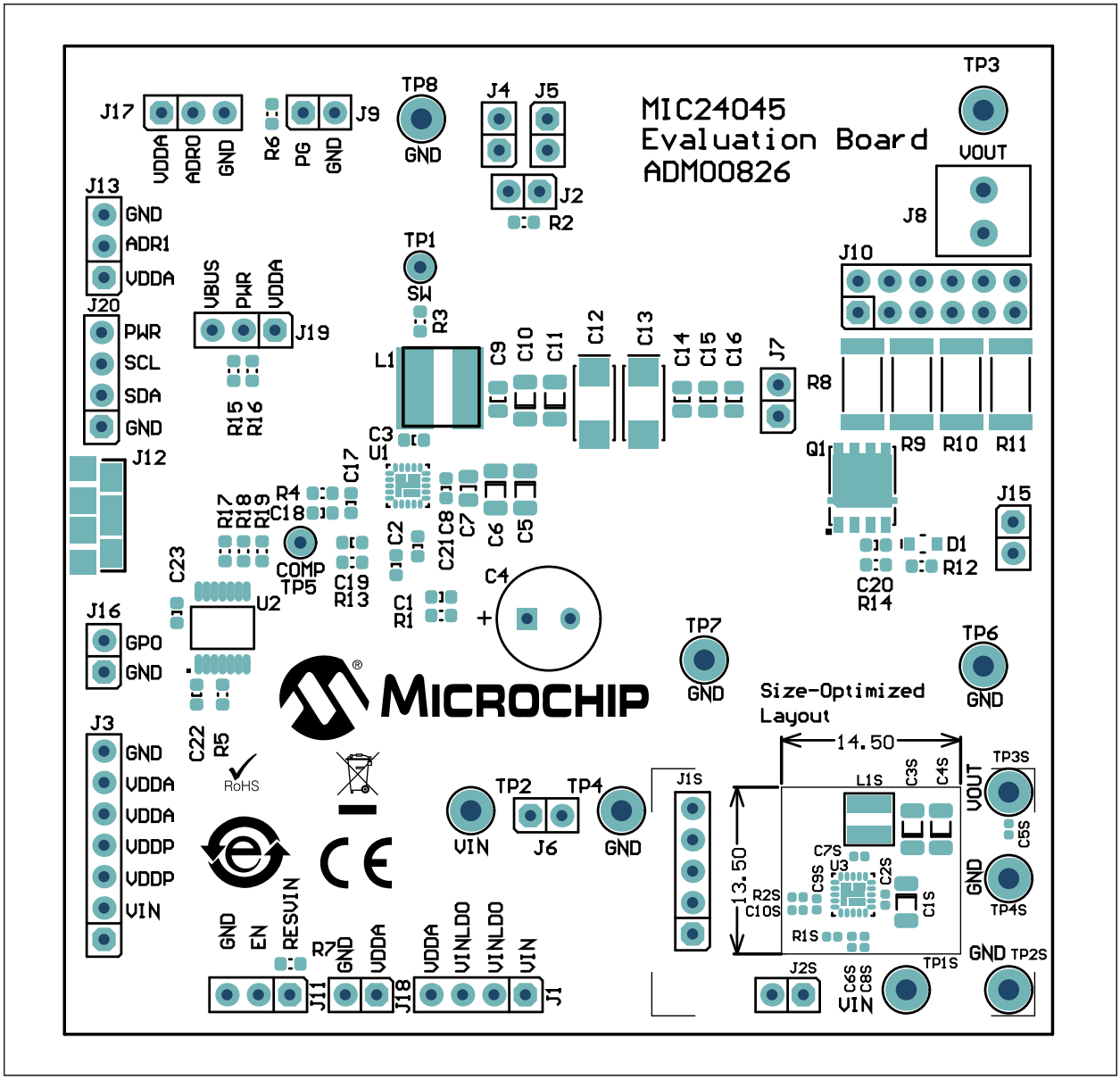
A.2 BOARD – SCHEMATIC 1



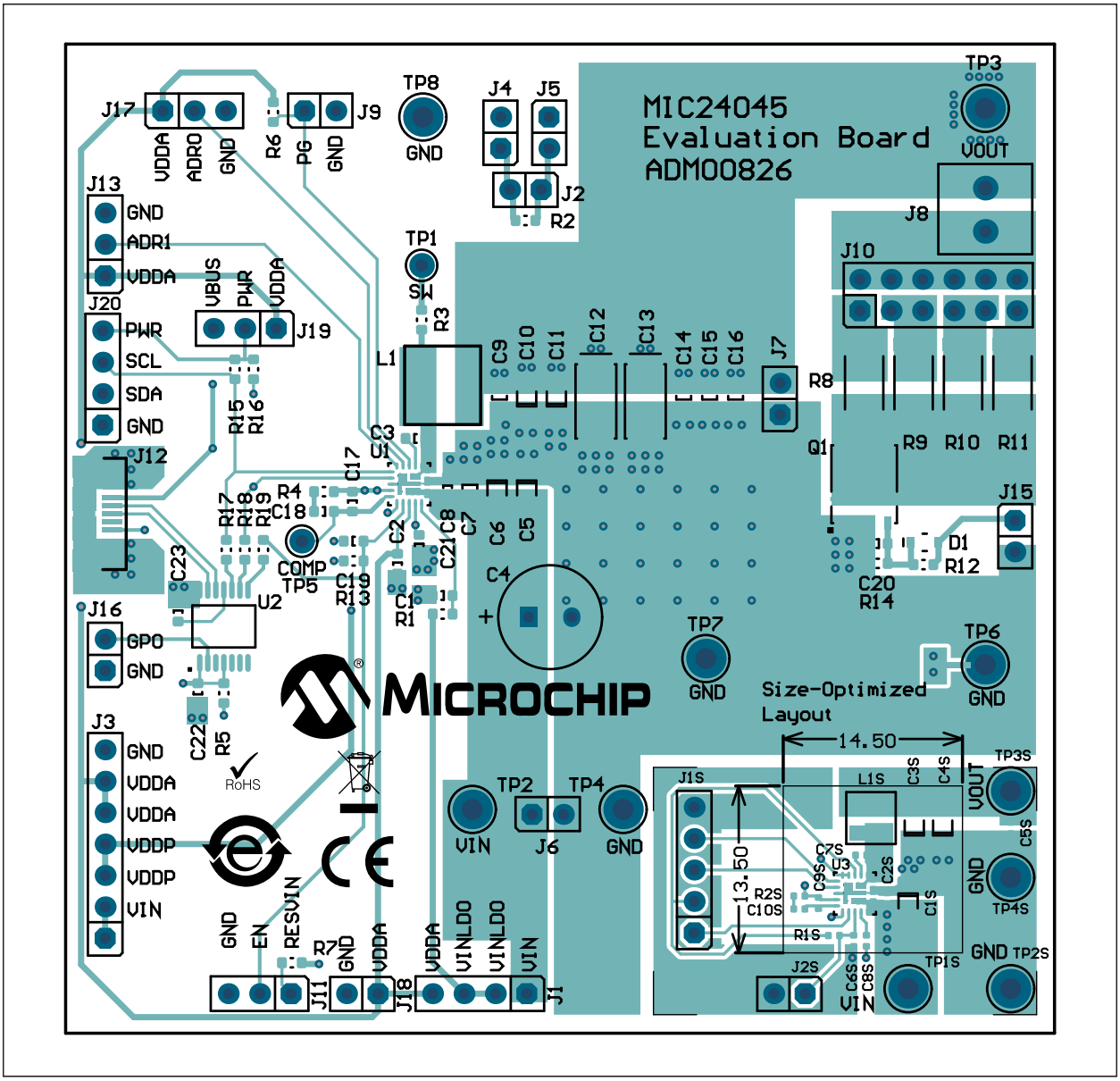
A.3 BOARD – SCHEMATIC 2



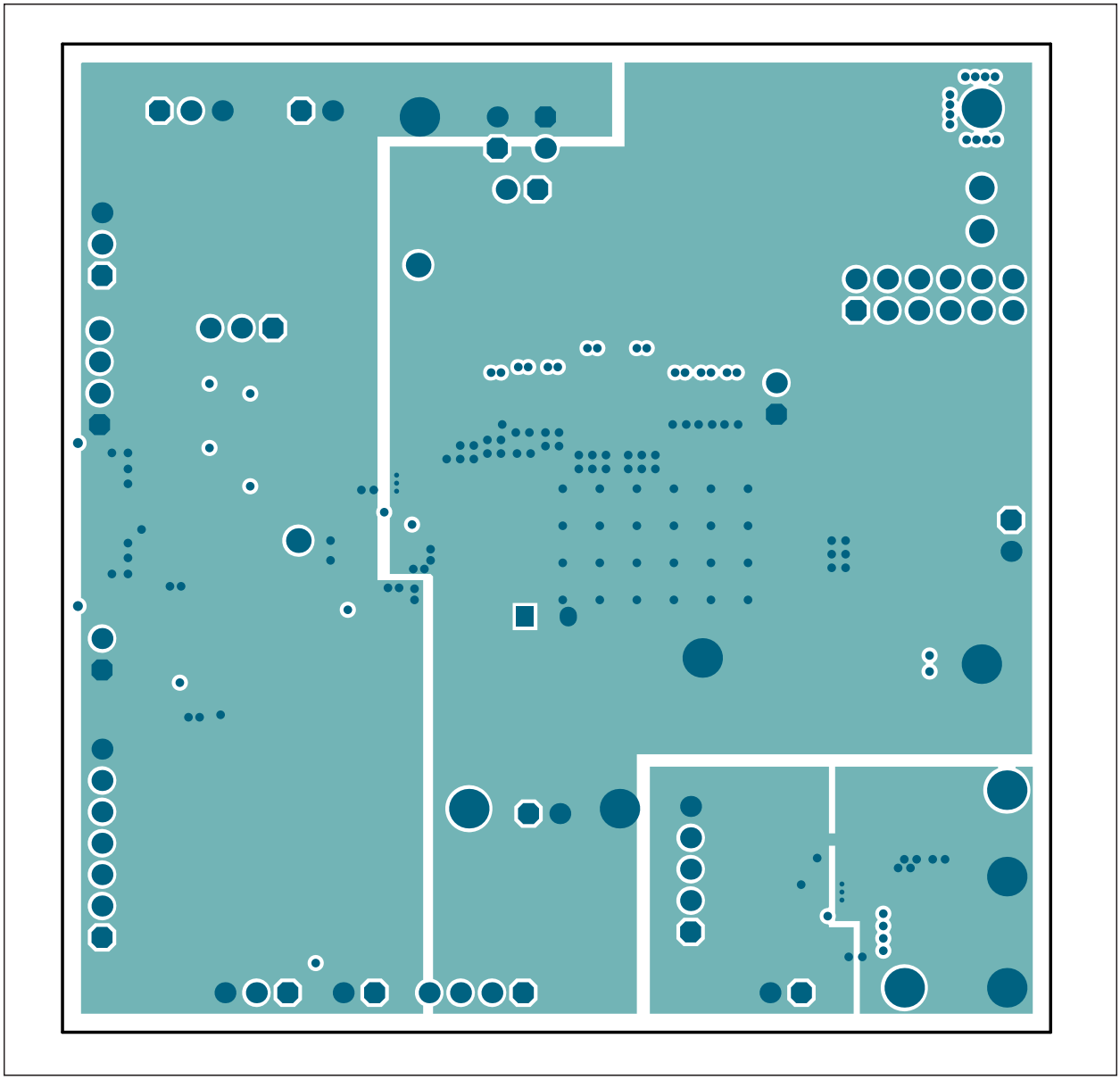
A.4 BOARD – TOP SILK



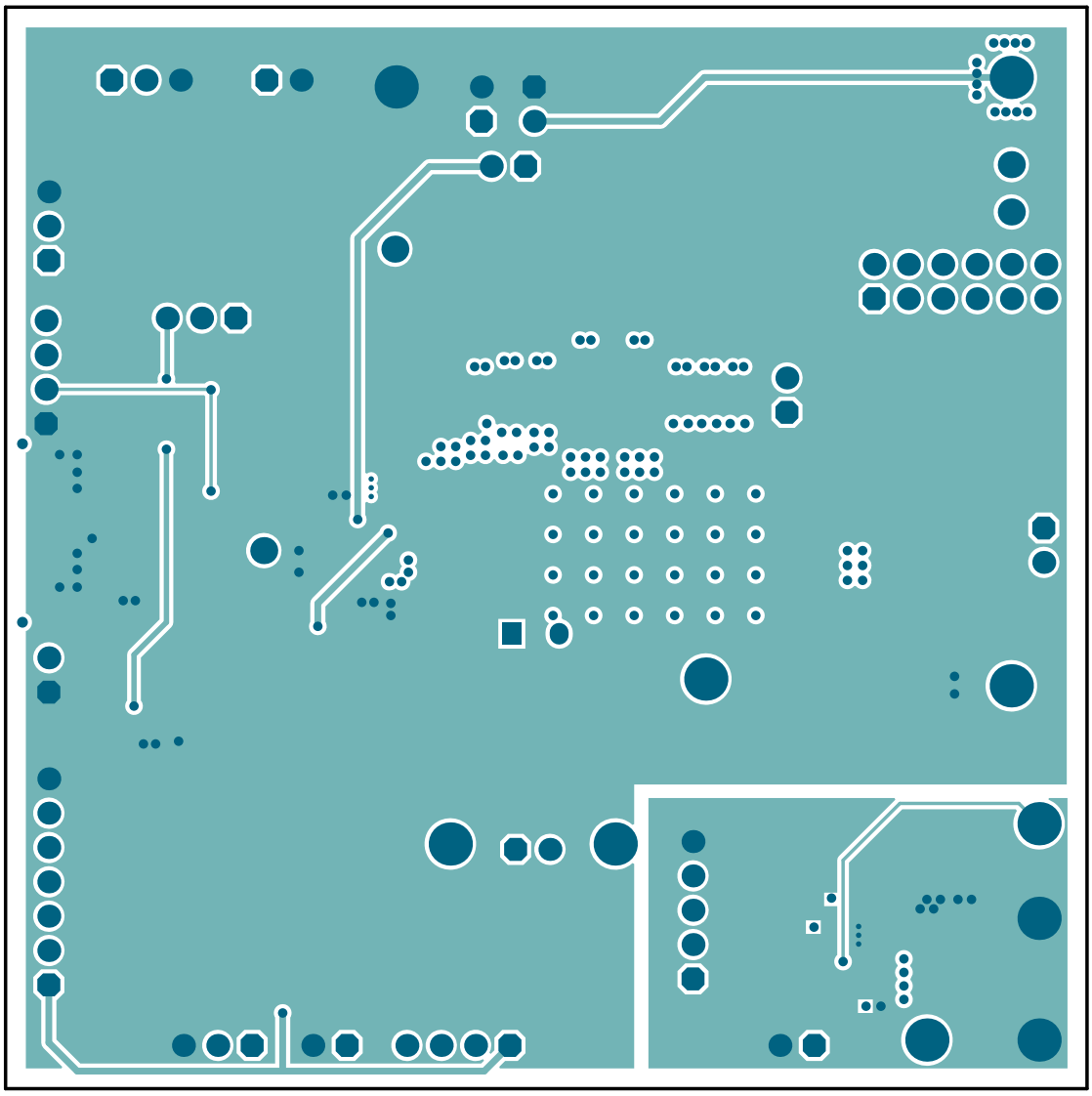
A.5 BOARD – TOP COPPER AND SILK



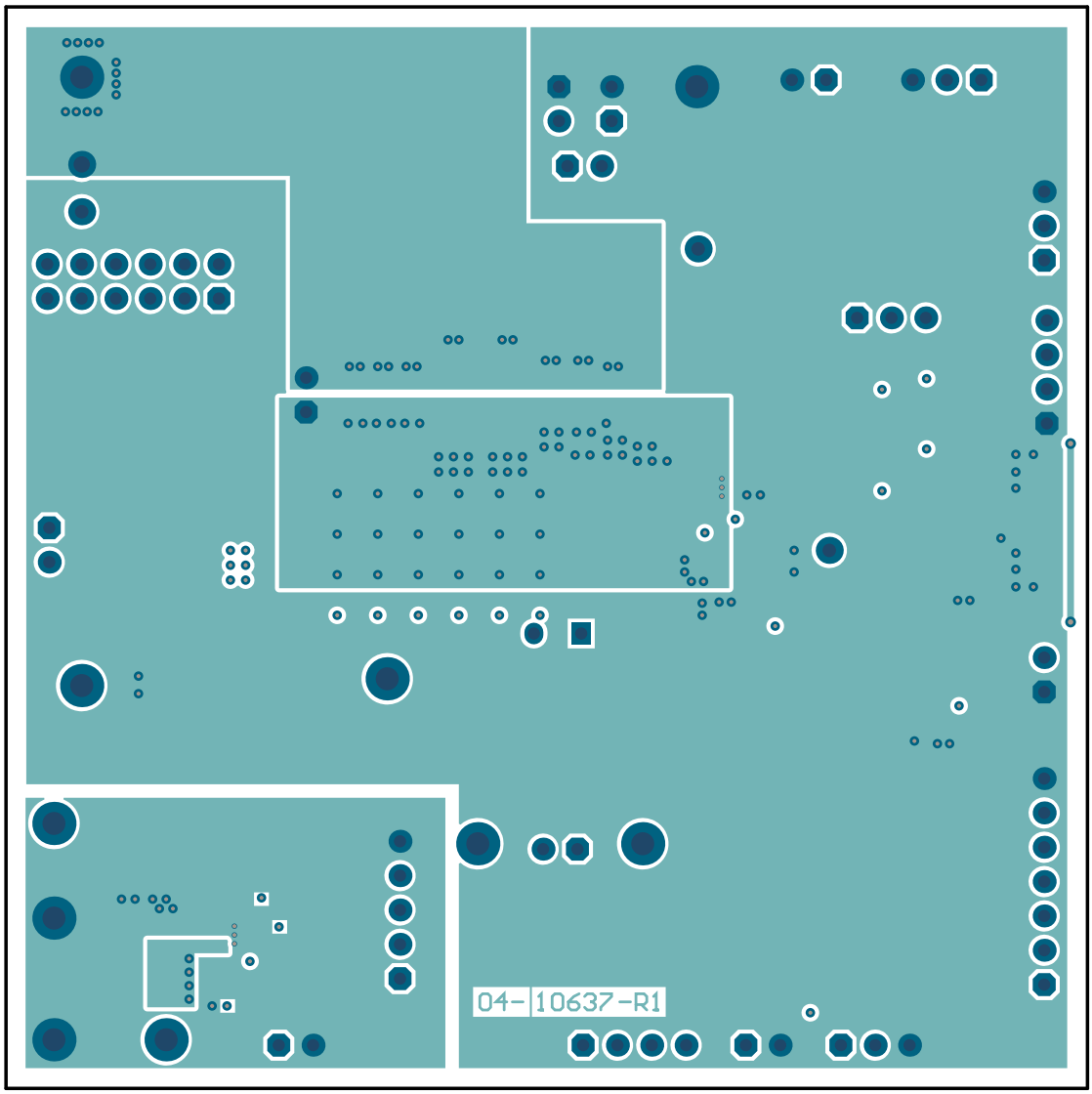
A.6 BOARD – MID-LAYER 1



A.7 BOARD – MID-LAYER 2



A.8 BOARD – BOTTOM COPPER



Appendix B. Bill of Materials (BOM)

TABLE B-1: BILL OF MATERIALS (BOM)

Qty.	Reference	Description	Manufacturer	Part Number
3	C1, C3, C8	CAP CER 0.1 µF 25V 10% X7R SMD 0603	Murata Electronics®	GRM188R71E104KA01D
1	C1S	DO NOT POPULATE - CAP CER 22 µF 25V 10% X5R SMD 1206	Murata Electronics®	GRM31CR61E226KE15L
2	C2, C21	CAP CER 2.2 µF 10V 10% X7R SMD 0603	Murata Electronics®	GRM188R71A225KE15D
3	C2S, C5S, C7S	DO NOT POPULATE - CAP CER 0.1 µF 25V 10% X7R SMD 0402	TDK Corporation	C1005X7R1E104K050BB
2	C3S, C4S	DO NOT POPULATE - CAP CER 100 µF 6.3V 20% X5R SMD 1206	Murata Electronics®	GRM31CR60J107ME39L
1	C4	DO NOT POPULATE - CAP ALU 220 µF 16V 20% 0.015R RAD P3.5D8H8	Wurth Electronik	870025374003
2	C5, C6	CAP CER 22 µF 25V 10% X5R SMD 1206	Murata Electronics®	GRM31CR61E226KE15L
2	C6S, C8S	DO NOT POPULATE - CAP CER 2.2 µF 10V 10% X7S SMD 0402	TDK Corporation	C1005X7S1A225K050BC
1	C7	CAP CER 10u µF 25V 10% X5R SMD 0805	Murata Electronics®	GRM21BR61E106KA73L
3	C9, C14, C16	CAP CER 22 µF 10V 20% X7S SMD 0805	TDK Corporation	C2012X7S1A226M125AC
2	C9S, C10S	DO NOT POPULATE - CAP CER 0.012 µF 16V 10% X7R SMD 0402	Murata Electronics®	GRM155R71C123KA01D
2	C10, C11	CAP CER 100 µF 6.3V 20% X5R SMD 1206	Murata Electronics®	GRM31CR60J107ME39L
1	C11S	DO NOT POPULATE - CAP TANT 47 µF 20V 10% 700mOhm SMD D	KEMET	T491D476K020AS
2	C12, C13	DO NOT POPULATE - CAP TANT 220 µF 6.3V 10% 225mOhm SMD C	AVX Corporation	TPSC227K006R0125
1	C15	DO NOT POPULATE - CAP CER 22 µF 10V 20% X7S SMD 0805	TDK Corporation	C2012X7S1A226M125AC
1	C17	CAP CER 47 pF 50V 5% NP0 SMD 0603	KEMET	C0603C470J5GACTU
1	C18	CAP CER 0.010 µF 25V 10% X7R SMD 0603	Yageo Corporation	CC0603KRX7R8BB103
1	C19	CAP CER 1000 pF 50V 20% X7R SMD 0603	TDK Corporation	C1608X7R2A102K080AA
1	C20	DO NOT POPULATE - CAP CER 2.2 µF 10V 10% X7R SMD 0603	Murata Electronics®	GRM188R71A225KE15D

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
1	C22	CAP CER 0.1 µF 16V 10% X7R SMD 0603	Wurth Electronik	885012206046
1	C23	CAP CER 0.47 µF 6.3V 10% X5R SMD 0603	Murata Electronics®	GRM188R60J474KA01D
1	D1	DIO RECT 1N4148WS 1.25V 150 mA 75V SOD-323	Diodes Incorporated®	1N4148WS-7-F
2	J1, J20	CON HDR-2.54 Male 1x4 Gold 5.84MH TH VERT	Wurth Electronik	61300411121
1	J1S	DO NOT POPULATE - CON HDR-2.54 Male 1x5 Gold 5.84MH TH VERT	Samtec®, Inc.	TSW-105-07-S-S
4	J2, J2S, J4, J5	DO NOT POPULATE - CON HDR-2.54 Male 1x2 Gold 5.84MH TH VERT	FCI	77311-118-02LF
1	J3	CON HDR-2.54 Male 1x7 Gold 5.84MH TH VERT	Wurth Electronik	61300711121
6	J6, J7, J9, J15, J16, J18	CON HDR-2.54 Male 1x2 Gold 5.84MH TH VERT	FCI	77311-118-02LF
1	J8	CON TERMINAL 3.5mm 1x2 Female 16-28AWG 6A TH R/A	On-Shore Technology, Inc.	ED555/2DS
1	J10	CON HDR-2.54 Male 2x6 Gold 5.84MH TH VERT	Samtec, Inc.	TSW-106-07-G-D
4	J11, J13, J17, J19	CON HDR-2.54 Male 1x3 Tin 6.75MH TH VERT	Molex Inc	90120-0123
1	J12	CON USB2.0 MICRO-B FEMALE SMD R/A	FCI	10118192-0001LF
1	L1	INDUCTOR 2.2 µH 9.7A 20% SMD L5.28W5.48H3.1	Coilcraft	XAL5030-222MEC
1	L1S	DO NOT POPULATE - INDUCTOR 2.2 µH 5.5A 20% SMD L4W4H2.1	Coilcraft	XAL4020-222MEC
1	PCB1	Printed Circuit Board	Microchip Technology Inc.	**04-10637-R1**
1	Q1	MCHP ANALOG MOSFET N-CH 25V 100A 0.006R MCP87050-U/MF PDFN-8	Microchip Technology Inc.	**MCP87050T-U/MF**
5	R1, R2, R17, R18, R19	RES TKF 0R 1/10W SMD 0603	Panasonic	ERJ-3GSY0R00V
1	R1S	DO NOT POPULATE - RES TKF 10k 5% 1/16W SMD 0402	Vishay	CRCW040210K0JNED
1	R2S	DO NOT POPULATE - RES TKF 2.7k 1% 1/10W SMD 0402	Panasonic® - BSG	ERJ-2RKF2701X
1	R3	RES TKF 49.9R 1% 1/10W SMD 0603	Panasonic® - BSG	ERJ-3EKF49R9V
1	R4	RES TKF 2.55k 1% 1/10W SMD 0603	Yageo Corporation	RC0603FR-072K55L
1	R5	RES TF 100k 1% 1/8W SMD 0603	Vishay	MCT06030C1003FP500
1	R6	RES TF 10k 1% 1/16W SMD 0603	TE Connectivity	5-1879337-9
2	R7, R13	DO NOT POPULATE - RES TF 10k 1% 1/16W SMD 0603	TE Connectivity	5-1879337-9
4	R8, R9, R10, R11	RES TKF 1R 1% 2W SMD 2512	Bourns®, Inc.	CRM2512-FX-1R00ELF
1	R12	RES TKF 1k 5% 1/10W SMD 0603	Panasonic® - BSG	ERJ-3GEYJ102V

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
1	R14	RES TKF 20k 5% 1/10W SMD 0603	Panasonic® - BSG	ERJ-3GSYJ203
2	R15, R16	RES TF 2.20k 1% 1/8W SMD 0603	Vishay Beyschlag	MCT06030C2201FP500
2	TP1, TP5	MISC, TEST POINT MULTI PURPOSE MINI WHITE	Keystone Electronics Corp.	5002
4	TP1S, TP2S, TP3S, TP4S	DO NOT POPULATE - CON TP PIN Tin TH	Harwin Plc.	H2121-01
6	TP2, TP3, TP4, TP6, TP7, TP8	CON TP PIN Tin TH	Harwin Plc.	H2121-01
1	U1	MCHP ANALOG SWITCHER Buck 0.64V MIC24045-2ZYFL-TR VFQFN-20	Microchip Technology Inc.	**MIC24045-2ZYFL-TR**
1	U2	MCHP INTERFACE USB I2C UART MCP2221-I/ST TSSOP-14	Microchip Technology Inc.	**MCP2221-I/ST**
1	U3	DO NOT POPULATE - MCHP ANALOG SWITCHER Buck 0.64V MIC24045-2ZYFL-TR VFQFN-20	Microchip Technology Inc.	**MIC24045-2ZYFL-TR**

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
1	CBL1	MECH HW CABLE USB Male-A to Male Micro-B	DongGuan ZhanXin	A006ZX027
2	JP1, JP2	MECH HW JUMPER 2.54mm 1x2	3M	969102-0000-DA
1	LABEL1	LABEL, NEED HELP WITH ASSY/SERIAL		
4	PAD1, PAD2, PAD3, PAD4	MECH HW RUBBER PAD CYLINDRICAL D7.9 H5.3 BLACK	3M	SJ61A11

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.

NOTES:

Appendix C. MIC24045 Internal Registers

C.1 REGISTERS MAPS AND I²C PROGRAMMABILITY

The MIC24045 internal registers are summarized in Table C-1, below.

TABLE C-1: MIC24045 REGISTER MAP

Register Address	Register Name	Type	B7	B6	B5	B4	B3	B2	B1	B0
0h	Status	RO	OCF	ThSDF	ThWrnF	Reserved	EnS	Reserved	Reserved	PGS
1h	Setting 1	RW	ILIM1	ILIM0	Freq2	Freq1	Freq0	Reserved	Reserved	Reserved
2h	Setting 2	RW	Reserved	SUDly2	SUDly1	SUDly0	Mrg1	Mrg0	SS1	SS0
3h	VOUT	RW	VOUT7	VOUT6	VOUT5	VOUT4	VOUT3	VOUT2	VOUT1	VOUT0
4h	Com-mand	RW	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	ClFF

C.1.1 Status Register

In the read-only Status registers, diagnostic information is provided. Bits can be F = latched (Flag) or S = non-latched (Status).

Flag bits are set when the corresponding fault condition has occurred and do not return to zero once the fault condition has ceased. Flags can only be cleared by writing '1' in Bit 0 of the Command Register 4h, or by power cycling. Status bits are set when the corresponding fault condition has occurred and return to zero automatically once the fault condition has ceased.

Default bits value at power-up is zero, except for Bit2 (which will always be read as '1') and Bit1 (QHS), which is '1' if no fault conditions are detected.

REGISTER C-1: STATUS: STATUS REGISTER (ADDRESS 0H)

R-0	R-0	R-0	R'0'	R-0	R'1'	R-1	R-0
OCF	ThSDF	ThWrnF	Reserved	EnS	Reserved	Reserved	PGS
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
RC = Read-then-clear bit			

bit 7 **OCF:** Over-Current Flag bit. OCF is set high whenever an overcurrent event occurs. Latched.

bit 6 **ThSDF:** Thermal Shutdown Flag bit. ThSDF is set high whenever a Thermal Shutdown occurs. Latched.

bit 5 **ThWrnF:** Thermal Warning Flag bit. ThWrnF is set high whenever a Thermal Warning occurs. Latched.

bit 4 **Reserved:** Flag bit. Always read as zero.

bit 3 **EnS:** Enable Pin Status bit. EnS reflects the logic value present on pin EN. Nonlatched.

bit 2 **Reserved:** Status bit. Always read as '1'.

bit 1 **Reserved:** Default status at POR is '1' (no faults detected).

bit 0 **PGS:** Power-Good Status bit. PGS reflects the logic value present on pin PG. Nonlatched.

REGISTER 3-1: SETTING 1 – SETTING 1 REGISTER (ADDRESS 1H)

RW-V	RW-V	RW-V	RW-V	RW-V	U-0	U-0	U-0
ILIM1	ILIM0	Freq2	Freq1	Freq0	Reserved	Reserved	Reserved
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
RC = Read-then-clear bit	V = factory-programmed POR value(1)		

bit 7-6 **ILIM<1:0>:** MOSFET Current Limit bit. See the Current Limit selection in table below**:**

ILIM1	ILIM0	Typ. Low-Side Current Limit (A)	Typ. High-Side Current Limit (A)	Nominal Load Current (A)
0	0	3.25	4.7	2
0	1	4.3	6.2	3
1	0	5.6	8.6	4
1	1	6.2	9.4	5

bit 5-3 **Freq0 (Switching Frequency):** See the Switching Frequency selection in table below:

Freq2	Freq1	Freq0	Frequency (kHz)
0	0	0	310
0	0	1	400
0	1	0	500
0	1	1	570
1	0	0	660
1	0	1	780
1	1	0	970
1	1	1	1200

bit 2-0 **Reserved:** Unimplemented bit. Read as '0'.

Note 1: Default Status settings at power-up can be changed at the factory. Standard selections are described in **Section 6.0 "MIC24045 Default Settings Values at Power-Up"** in the data sheet. Overwriting default settings by I^2C has no permanent effect and values will return to factory default values upon power cycling.

2: Changing Setting 1 Register values while power delivery is enabled is not recommended. To change settings by I^2C, set EN pin low first, then write the new configuration, and finally set EN pin high again to resume power delivery.

REGISTER C-2: SETTING 2: SETTING 2 REGISTER (ADDRESS 2H)

U-0	RW-V	RW-V	RW-V	RW-0	RW-0	RW-V	RW-V
Reserved	SUDly2	SUDly1	SUDly0	Mrg1	Mrg0	SS1	SS0
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
RC = Read-then-clear bit	V = factory-programmed POR value(1)		

bit 7 **Reserved:** Unimplemented bit. Read as '0'. Writing to this bit has no effect.

bit 6-4 **SUDly<2:0>:** Start-Up Delay bit. Delay to start power delivery from the rising edge of the EN signal. See the Start-up Delay selection in table below:

SUDly2	SUDly1	SUDly0	Start-Up Delay (ms)
0	0	0	0
0	0	1	0.5
0	1	0	1
0	1	1	2
1	0	0	4
1	0	1	6
1	1	0	8
1	1	1	10

bit 3-2 **Mrg<1:0>:** Voltage Margins bit. These bits can be changed at any time during power delivery. See the Voltage Margining selection in table below:

Mrg1	Mrg0	Change to nominal V_{OUT} Setting (%)
0	0	0%
0	1	-5%
1	0	+5%
1	1	+5%

Default at power-up is <0:0>

bit 1-0 **SS1<1:0>:** Soft-Start Ramp Rate bit. See the Soft-Start Tamp Rates selection in table below:

SS1	SS0	Soft-Start Slope (V/ms)
0	0	0.16
0	1	0.38
1	0	0.76
1	1	1.5

Note 1: With the exception of Margining Bits Mrg<1:0>, changing Setting 2 register values while power delivery is enabled is not recommended. To change settings by I^2C, set EN pin low first, then write the new configuration, and finally set EN pin high again to resume power delivery

2: With the exception of Margining Bits Mrg<1:0>, changing Setting 2 register values while power delivery is enabled is not recommended. To change settings by I^2C, set EN pin low first, then write the new configuration, and finally, set EN pin high again to resume power deliver.

REGISTER C-3: VOUT: VOUT REGISTER (ADDRESS 3H)

RW-V	RW-V	RW-V	RW-V	RW-V	RW-V	RW-V	RW-V
VOUT7	VOUT6	VOUT5	VOUT4	VOUT3	VOUT2	VOUT1	VOUT0
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
RC = Read-then-clear bit	V = factory-programmed POR value(1)		

bit 7-0 **VOUT<7:0>:** VOUT register bits can be changed at any time during power delivery, provided that transitions from one code to another:

- are done step-by-step, by small VOUT increments. The speed of the transition is left to the user and limited by the I^2C writing interface speed.
- code transition shall take place only within the same VOUT Range. Crossing boundaries of resolution ranges may cause VOUT glitches and it is not recommended.

See VOUT selection in table below:

VOUT Range	Step Size	Codes-decimal (hex)
0.640V to 1.280V	5 mV	0 (00h) to 128 (80h)
1.290V to 1.950V	10 mV	129 (81h) to 195 (C3h)
1.980V to 3.420V	30 mV	196 (C4h) to 244 (F4h)
4.750V to 5.250V	50 mV	245 (F5h) to 255 (FFh)

Note 1: Default Status settings at power-up can be changed at the factory. Standard selections are described in **Section 6.0 "MIC24045 Default Settings Values at Power-Up"** in the data sheet. Overwriting default settings by I^2C has no permanent effect and values will return to factory default values upon power cycling.

2: The functionality of the MIC24045 at any output voltage selection is subject to limitations described in **Section 7.0 "Application Information"**, in the data sheet.

REGISTER C-4: COMMAND: COMMAND REGISTER (ADDRESS 4H)

RW-0	RW-0	RW-0	RW-0	RW-0	RW-0	RW-0	RW-0
Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	CIFF
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
RC = Read-then-clear bit			

bit 7-1 **Reserved<7:1>:** Writing to these bits has no effect on the device operation.

bit 0 **CIFF:** Clear Fault Flags bit. Writing '1' to bit 0 will clear all Fault Flags. The CIFF bit is self-clearing and it returns to '0' as soon as the Fault Flags have been cleared.

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