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# MIC24045 Evaluation Kit User's Guide

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Manufacturer: Microchip Technology Inc.
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Chandler, Arizona, 85224-6199
USA

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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Signed for and on behalf of Microchip Technology Inc. at Chandler, Arizona, USA

Derek Carlson
VP Development Tools

12-Sep-14
Date

**NOTES:**

# MIC24045 EVALUATION KIT USER'S GUIDE

## Table of Contents

# 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 Kit. 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 MIC24045 Evaluation Kit as a development tool. The manual layout is as follows:

- **Chapter 1. "Product Overview"** – Important information about the MIC24045 Evaluation Kit.
- **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 Kit. Another useful document is listed below. The following Microchip document is available and recommended as a supplemental reference resource:

- **MIC24045 Data Sheet – *"I²C Programmable, 4.5V-19V Input, 5A Step-Down Converter" (DS20005568).***

## 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
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## 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 A (June 2016)

- Initial release of this document.

**NOTES:**

# Chapter 1. Product Overview

## 1.1 INTRODUCTION

This chapter provides an overview of the MIC24045 Evaluation Kit (ADM00764) and covers the following topics:

- MIC24045 Device Short Overview
- MIC24045 Evaluation Board Overview
- What the MIC24045 Evaluation Kit 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 optimizing the size of the inductor in each particular application.

The MIC24045 pin-out is compatible with the MIC24046 pin-strapping programmable regulators pin-out, such that $I^2C$-based implementations can be seamlessly converted into pin-programmable ones.

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.

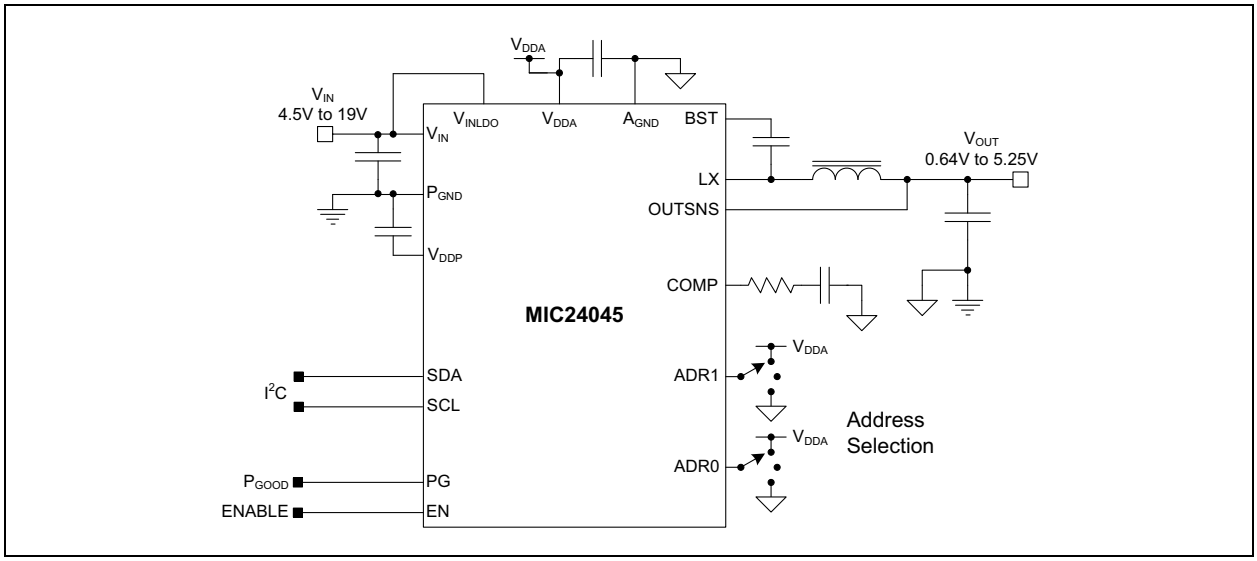


***FIGURE 1-1:*** *MIC24045 Typical Application.*

## 1.3 MIC24045 EVALUATION BOARD OVERVIEW

The MIC24045 Evaluation Board is designed to serve all of the devices that make up Microchip's MIC2404x family of parts. As a result, only a subset of its features is needed for the MIC24045 evaluation.

Specific 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 connector (J10) matching the MCP2221 Breakout Module $I^2C$ interface is provided for board compatibility with $I^2C$.

## 1.4 WHAT THE MIC24045 EVALUATION KIT USER'S GUIDE CONTAINS

The MIC24045 Evaluation Kit includes:

- MIC24045 Evaluation Board
- MCP2221 Breakout Module
- USB-to-mini-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 VIN and GND_IN terminals. An ammeter may be placed between the input supply and the VIN terminal of the evaluation board. Ensure that the supply voltage is monitored at the VIN terminal (CON1 or J2). 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 VOUT and GND_OUT terminals.The load can be either passive (resistive) or active (electronic load). An ammeter can be placed between the load and the VOUT terminal. Ensure that the output voltage is monitored at the VOUT terminal (CON5 or J1). 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 J18 and another jumper on J3, between VIN and VINLDO.
4. Connect the MCP2221 Breakout Module to the MIC24045 Evaluation Board (see Figure 2-1).


***FIGURE 2-1:*** *MIC24045 with MCP2221 Board Connection.*

5. Turn on the power supply.
6. Make sure a jumper is connected on JP1 on the MCP2221 Breakout Module, on the 3.3V side.
7. 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"**).
8. Using the **Enable** button in the GUI, turn on the converter.
9. 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 (Q2). Resistive loads (R10 to R13) can be selectively connected by means of header J14. MOSFET Q2 must be driven by an external signal generator, connected at J21, using a square wave (suggested low level = 0V, high level = 5V-6V). Drive levels can be adjusted to modify the switching speed of Q2, but should always ensure complete turn-on and turn-off of Q2 after settling, while not exceeding its $V_{GS}$ ratings. It is very important not to exceed the power dissipation limit of R10 to R13. Using 2512 resistors (1W rating), the constraint is ($_{RLOAD}$ takes the values of R10 to R13):

**EQUATION 2-1:**

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

Where:

| | |
|---|---|
| D | = on time duty cycle of Q2 |
| $V_{OUT}$ | = selected output voltage |
| $R_{LOAD}$ | = the value of resistors R10 to R13 (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 J15 through the insulation transformer and connect the A (CH1) and B (CH2) channels at J17 and J16, 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
- MCP2221 Breakout Module
- USB-to-mini-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 $I^2C$ 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.

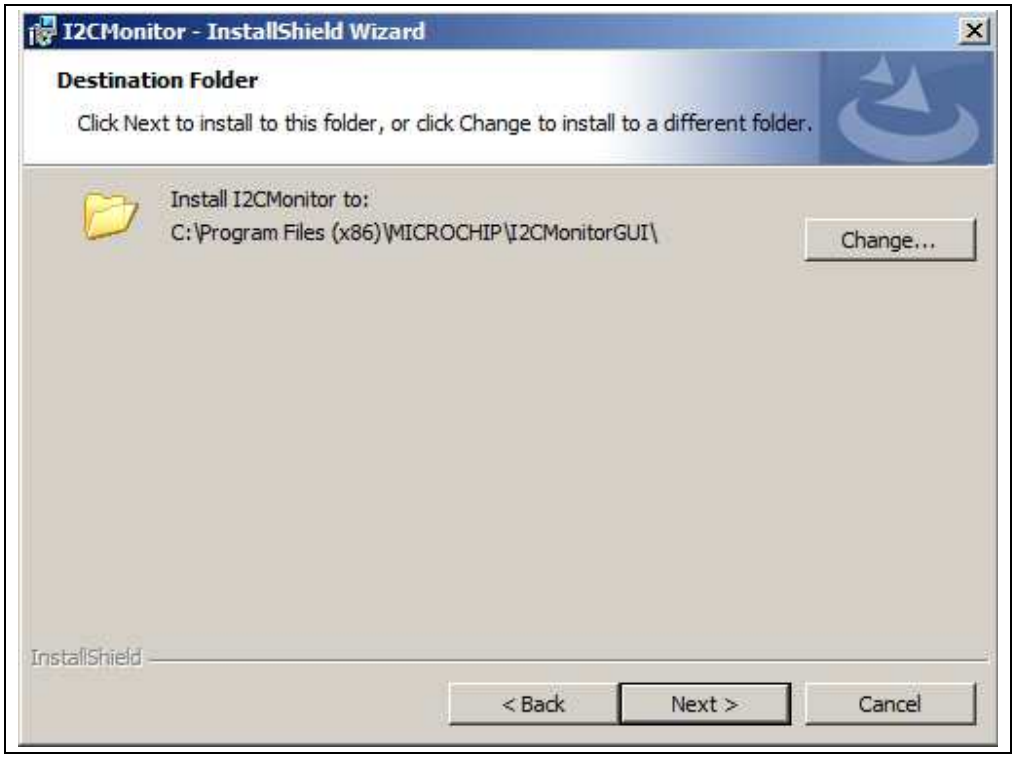


***FIGURE 3-2:*** *Selecting the Destination Folder.*

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.

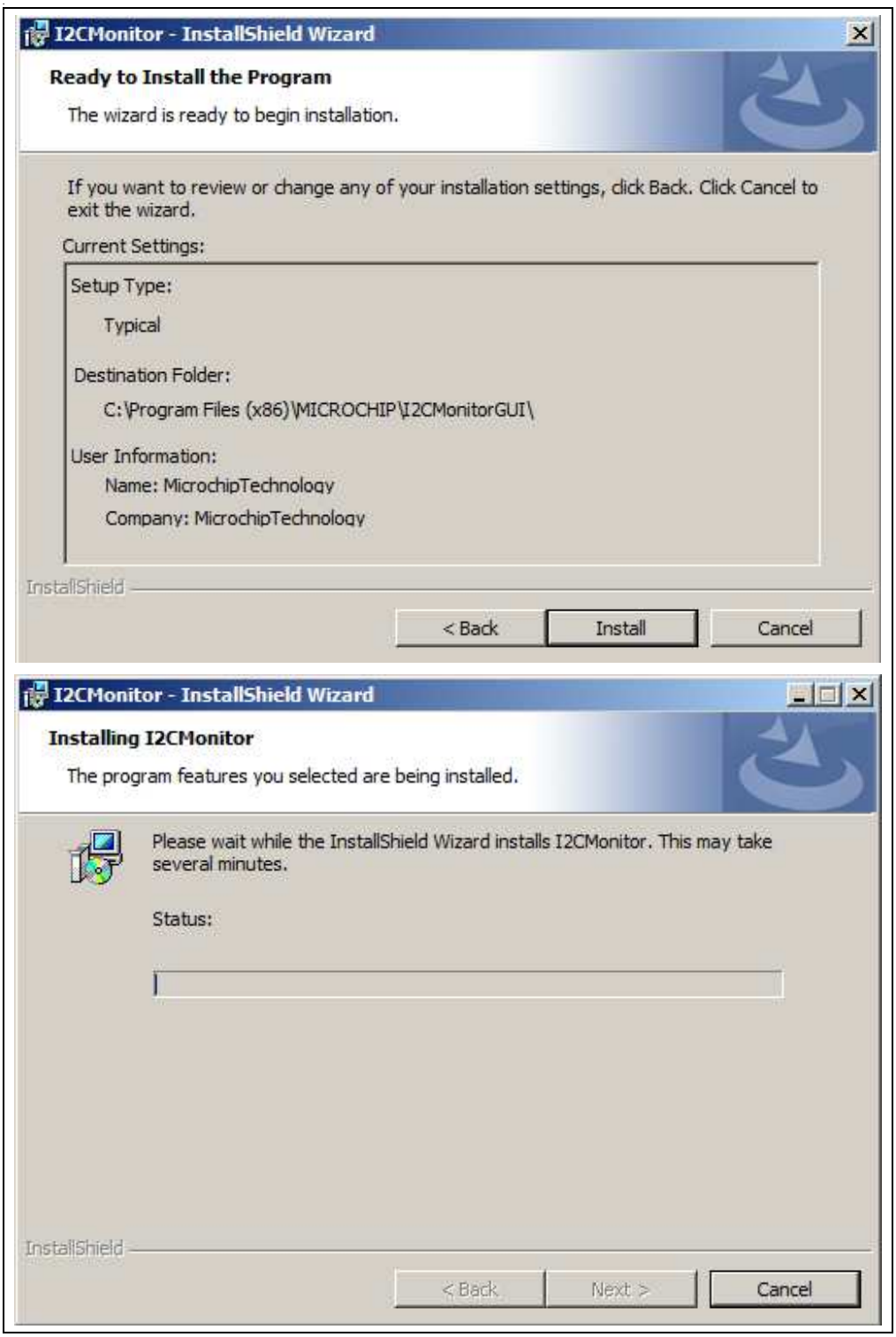


***FIGURE 3-3:*** *Installing the I²C Monitor Graphical User Interface.*

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*.

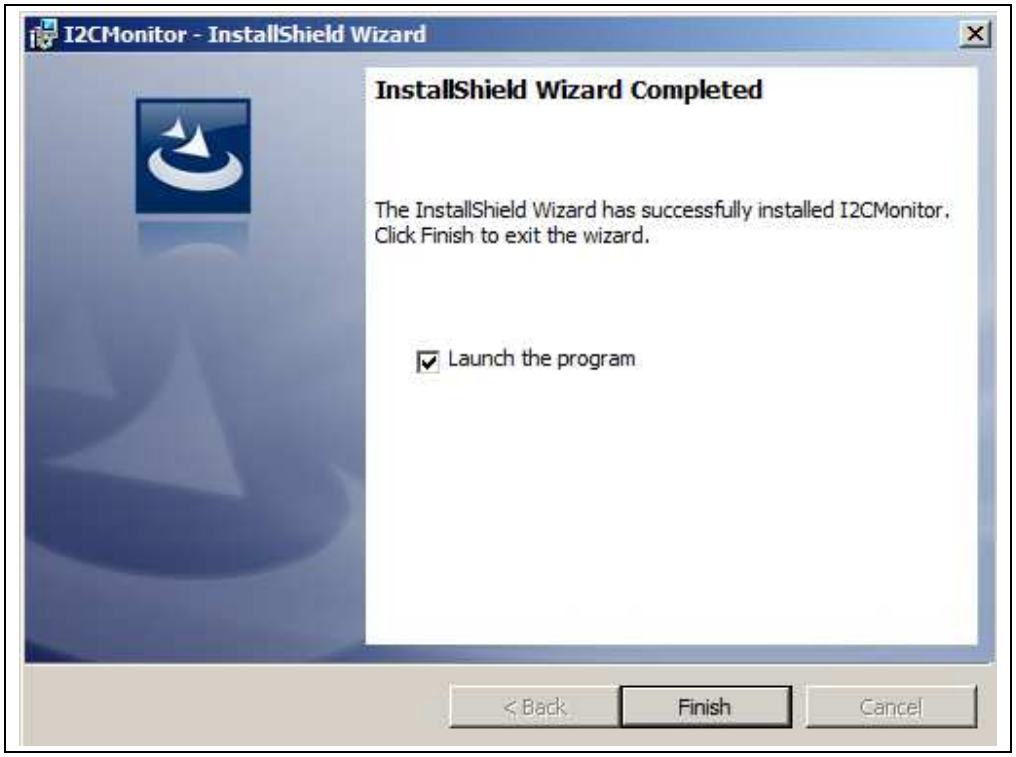


***FIGURE 3-4:*** *The Installation Complete Window.*

## 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.

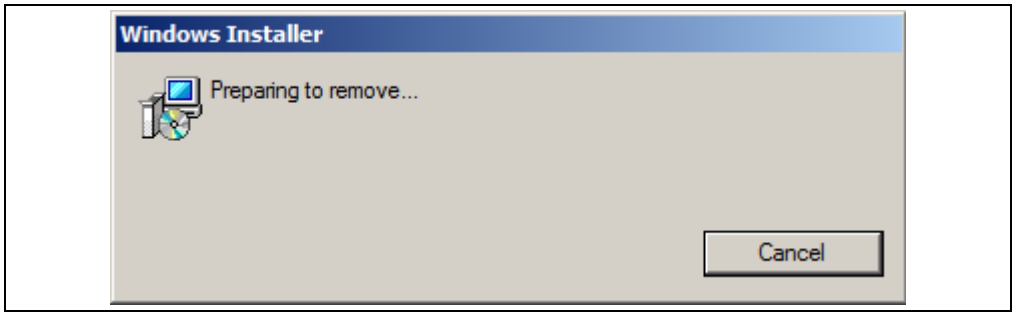


***FIGURE 3-5:*** *Uninstalling the I²C Monitor Graphical User Interface.*

# 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.**

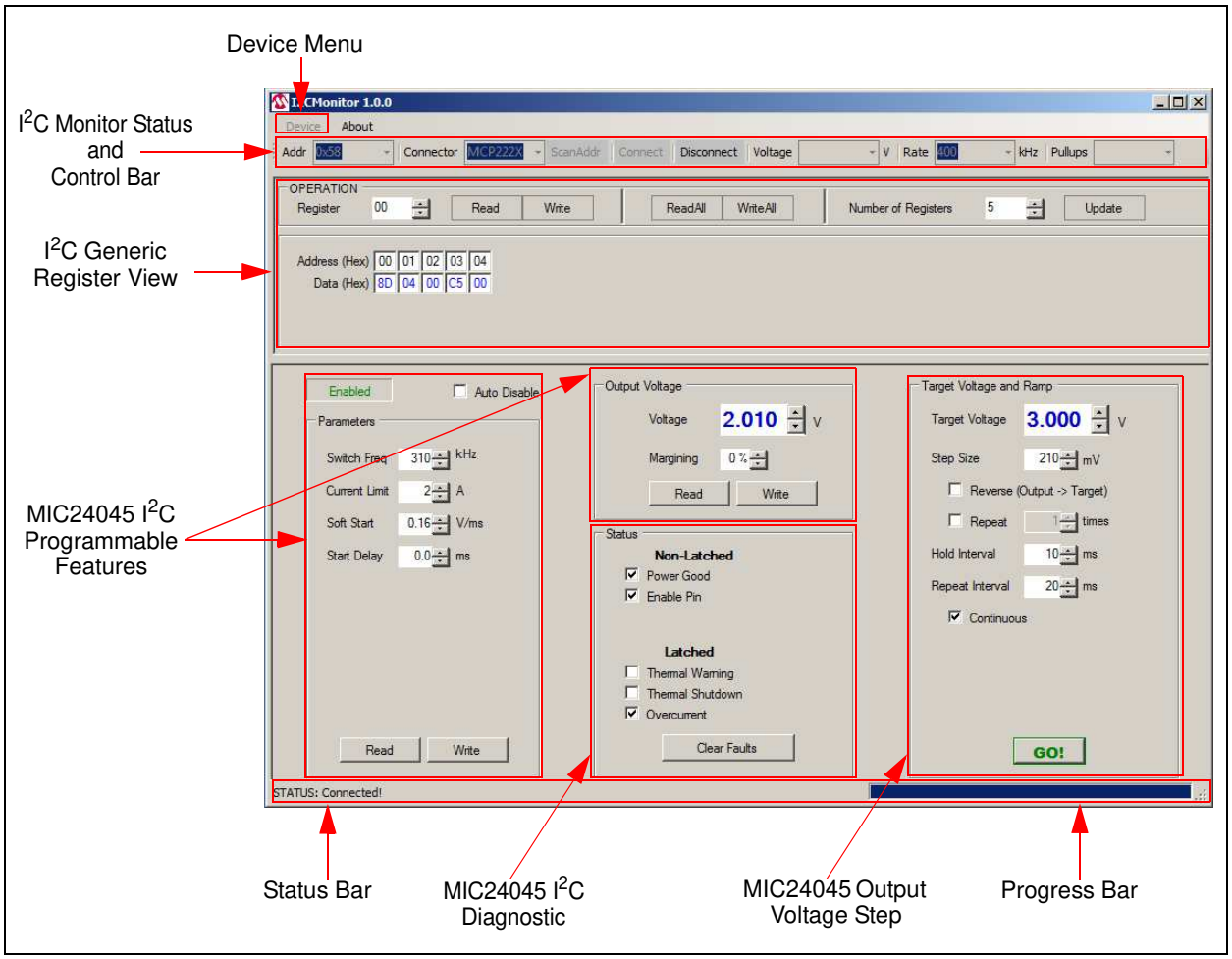


***FIGURE 4-1:*** *I²C Monitor Graphical User Interface Main Window - **MIC24045** View.*

## 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 MCP2221 Breakout Module, 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.

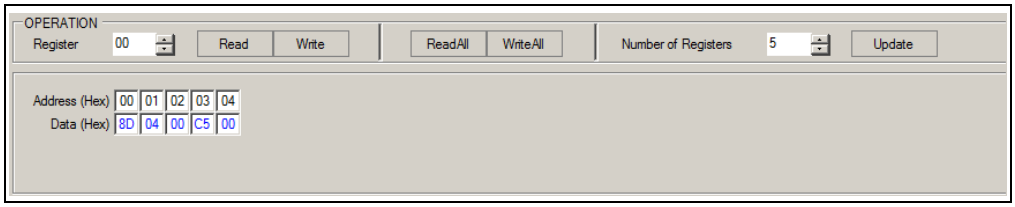


***FIGURE 4-3:*** *Generic Register View Area.*

**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 button 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.

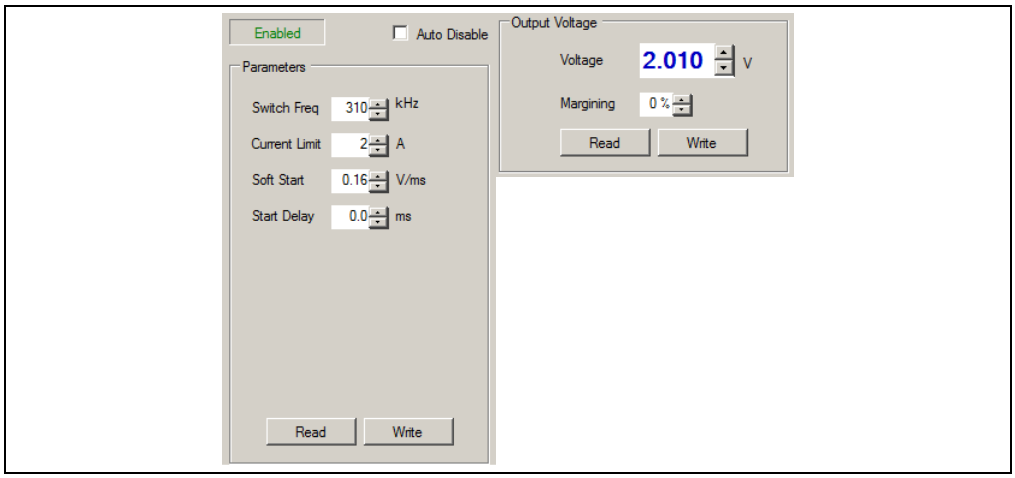


***FIGURE 4-4:*** *MIC24045 I²C Programmable Features Area.*

**TABLE 4-3: MIC24045 I²C Programmable Features**

| Panel/Button | Items | Description |
|---|---|---|
| **Enable** | | This button controls the Enable pin of the MIC24045 when a header is connected on J18. 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.

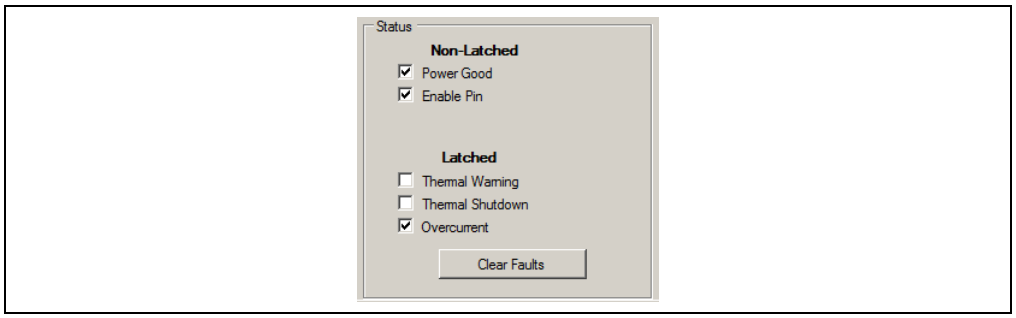


***FIGURE 4-5:*** *MIC24045 $I^2C$ Diagnostic Area.*

**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 Breakout Module. 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.

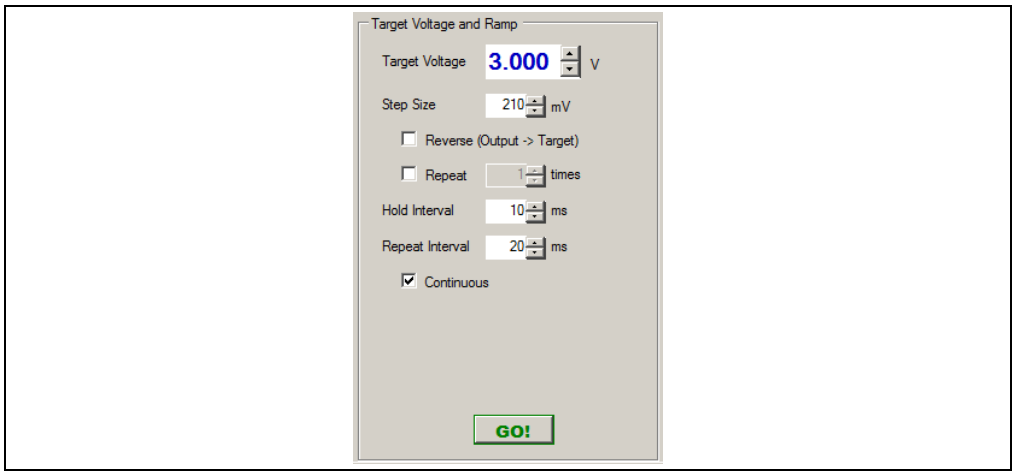


***FIGURE 4-6:*** *MIC24045 Output Voltage Ramp Area.*

**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.

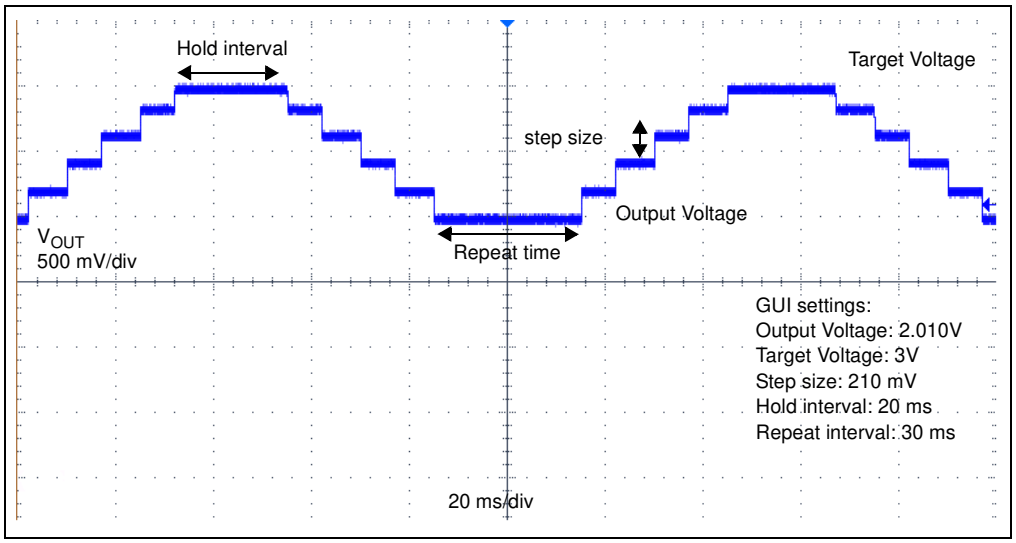


***FIGURE 4-7:*** *Output Voltage Ramp Up/Down.*

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