MCP2221
I^{2}C Demonstration Board
User's Guide

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Object of Declaration: MCP2221 I^{2}C Demonstration Board User's Guide

EU Declaration of Conformity

Manufacturer: Microchip Technology Inc.
2355 W. Chandler Blvd.
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:

MCP2221 I²C DEMONSTRATION BOARD USER'S GUIDE

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MCP2221 I^{2}C DEMONSTRATION BOARD USER'S GUIDE

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 web site (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 MCP2221 I^{2}C Demonstration 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 MCP2221 I^{2}C Demonstration Board as an evaluation tool to debug a target motor system. The manual layout is as follows:

- **Chapter 1. "Product Overview"** – Important information on the board.
- **Chapter 2. "Installation and Operation"** – Covers the initial setup of this board and the Graphical User Interface (GUI).
- **Chapter 3. "Testing Board Features"** – Describes how to use the board's capabilities.
- **Chapter 4. "Creating Custom I^{2}C Software Applications"** – Provides information for the custom usage of the board.
- **Chapter 5. "Troubleshooting"** – Provides procedures for troubleshooting the most common problems encountered when installing and operating the board.
- **Appendix A. "Schematics and Layouts"** – Shows the schematic and layout diagrams for the board.
- **Appendix B. "Bill of Materials (BOM)"** – Lists the parts used to build the board.

MCP2221 I²C Demonstration Board User's Guide

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 MCP2221 I^{2}C Demonstration Board. Other useful documents are listed below. The following Microchip documents are available and recommended as a supplemental reference resource.

- **MCP2221 Data Sheet** – *"USB 2.0 to I^{2}C™/UART/Protocol Converter with GPIO" (*DS20005292*)*
- **PAC1710/20 Data Sheet** – *"Single and Dual High-Side Current-Sense Monitor with Power Calculation"* (DS20005386)
- **MCP3221 Data Sheet** – *"Low-Power 12-Bit A/D Converter With I^{2}C™ Interface"* (DS21732)
- **MCP9808 Data Sheet** – *"±0.5°C Maximum Accuracy Digital Temperature Sensor"* (DS25095)
- **PIC16(L)F1508/9 Data Sheet** – *"20-Pin Flash, 8-Bit Microcontrollers with XLP Technology"* (DS40001609)
- **MCP4706/4716/4726 Data Sheet** – *"8-/10-/12-Bit Voltage Output Digital-to-Analog Converter with EEPROM and I^{2}C™ Interface"* (DS22272)
- **MCP23008/MCP23S08 Data Sheet** – *"8-Bit I/O Expander with Serial Interface"* (DS21919)

THE MICROCHIP WEB SITE

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- **Product Support** – Data sheets and errata, application notes and sample programs, design resources, user's guides and hardware support documents, latest software releases and archived software
- **General Technical Support** – Frequently Asked Questions (FAQs), technical support requests, online discussion groups, Microchip consultant program member listing
- **Business of Microchip** – Product selector and ordering guides, latest Microchip press releases, listing of seminars and events, listings of Microchip sales offices, distributors and factory representatives

CUSTOMER SUPPORT

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 web site at: http://www.microchip.com/support.

DOCUMENT REVISION HISTORY

Revision A (April 2016)

- Initial release of this document.

NOTES:

Chapter 1. Product Overview

1.1 INTRODUCTION

This chapter provides an overview of the MCP2221 I^{2}C Demonstration Board and covers the following topics:

- **MCP2221 I^{2}C Demonstration Board Description**
- **What the MCP2221 I^{2}C Demonstration Board Kit Includes**

1.2 MCP2221 I^{2}C DEMONSTRATION BOARD DESCRIPTION

The MCP2221 I^{2}C Demonstration Board allows the user to communicate through a PC application to I^{2}C slave devices by using the MCP2221 device as a USB to I^{2}C master converter (bridge). Additionally, it can create a USB to RS-232 (UART) bridge using the same MCP2221 board.

1.2.1 Board Features Controlled through PC Application

Here are the main features of the demonstration board when used with its dedicated PC application:

- Users can perform measurements for resistors (above 10Ω) or capacitors (above 40 nF), using the MCP2221 device's Analog-to-Digital Converter (ADC) and General Purpose Input/Output (GPIO) pins
- Real-time monitoring and logging of the current, and power consumptions of a USB device using the PAC1710 current, voltage and power sensor
- Real-time monitoring and logging of the ambient temperature using the MCP9808 temperature sensor
- Real-time monitoring and logging of the voltage level recorded by the MCP3221 device's 12-bit ADC
- Configuration and control of up to 8 GPIOs, available from the MCP23008 I/O expander, as well as continuously monitoring the state of the pins (when used as digital inputs)
- PIC16F1509 configuration to issue multiple warnings through an RGB LED when any of the featured readings are outside of user settable conditions (such as "measured USB current is above 50 mA")
- Storing the above mentioned configuration, as well as other random data, in a 24LC128 128-Kbit Electrically Erasable Programmable Read-Only Memory (EEPROM)
- Output voltage level control of the MCP4726 Digital-to-Analog Converter (DAC)
- Creating a USB to RS-232 bridge, based on the MCP2221 device and a Texas Instrument's MAX3232 transceiver; alternately creating a USB to UART bridge to the PIC16F1509 microcontroller

1.2.2   Other Hardware Features

The board also provides features that are independent of the software application:

- 5V or 3.3V user-selectable V$_{DD}$, up to 500 mA operating capability for the demonstration board and all on-board devices.
- I^{2}C female socket (similar to the PICkit™ Serial Analyzer) for connectivity to external slaves, as well as test points for the I^{2}C lines, and the option to disconnect the on-board, 4.7 kΩ pull-up resistors for the I^{2}C data and clock lines.
- In-Circuit Serial Programming™ (ICSP™) male connector to debug or program the PIC16F1509 using a PICkit 3 programmer or another compatible tool.
- The option to connect the PIC16F1509 device's Universal Asynchronous Receiver/Transmitter (UART) to the board's RS-232 connector (through the MAX3232 transceiver).
- A small prototyping area which includes extensions of the board's power (V$_{DD}$) and ground (GND) lines.
- Test points to measure the current, voltage or power of non-USB devices (as well as receive configurable interrupts) using the PAC1710 current-sensing chip.
- Option to connect the interrupt pin of the MCP23008 I/O expander to an external interrupt pin of the PIC16F1509 for custom applications.

1.2.3   I^{2}C Devices Available on the Board

Table 1-1 identifies the I^{2}C devices (master and slaves) available on the MCP2221 I^{2}C Demonstration Board.

TABLE 1-1:   I^{2}C DEVICES AVAILABLE ON THE MCP2221 BOARD

Device Name	I^{2}C Master/Slave	Description
MCP2221	Master	USB to I^{2}C/UART/SMBus Protocol Converter with GPIO (Master Mode)
PAC1710	Slave	Single High-Side Current Sense Monitor with Power Calculation
24LC128	Slave	128-Kbit EEPROM
MCP9808	Slave	Temperature Sensor
MCP3221	Slave	1-Channel, 12-Bit Analog-to-Digital Converter (ADC)
MCP4726	Slave	12-Bit Digital-to-Analog Converter (DAC)
MCP23008	Slave	8-Bit I/O Expander
PIC16F1509	Slave	8-Bit Microcontroller (preprogrammed to perform as I^{2}C slave)

Figure 1-1 illustrates the components on the top view.

FIGURE 1-1: **MCP2221 TOP VIEW – I²C DEVICES ON THE BOARD**
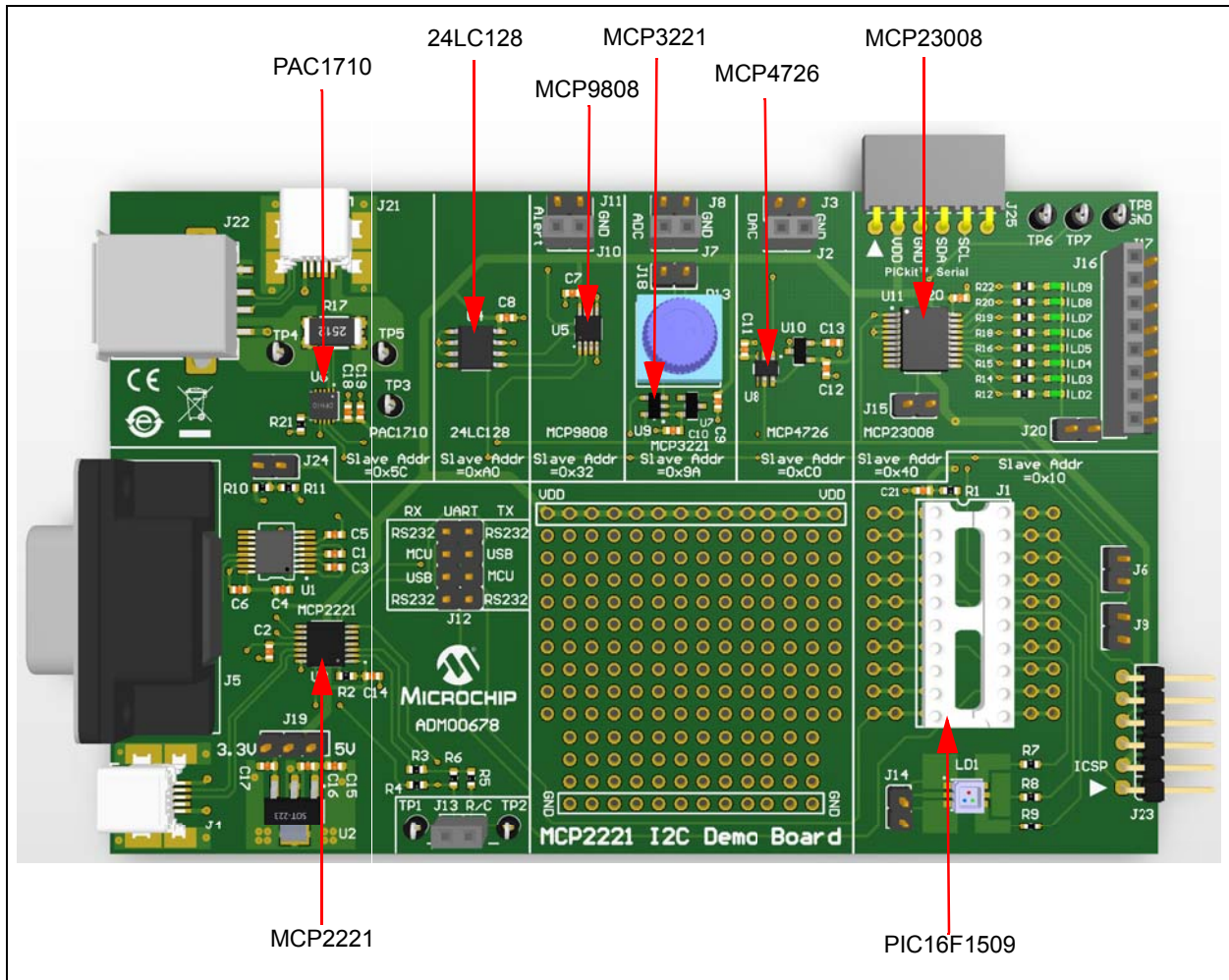
1.3   WHAT THE MCP2221 I²C DEMONSTRATION BOARD KIT INCLUDES

The MCP2221 I²C Demonstration Board Kit (ADM00678) includes:

- MCP2221 I²C Demonstration Board
- Preprogrammed PIC16F1509 Microcontroller
- Two Mini-USB Cables
- Important Information Sheet

NOTES:

Chapter 2. Installation and Operation

2.1 MINIMUM SYSTEM REQUIREMENTS

The MCP2221 I^{2}C Demonstration Board is designed to be used in a Microsoft® Windows® XP (SP3 or later) environment, based on the Microsoft.NET Framework 4 (client profile). Users can utilize the Microsoft.NET Framework 4 web installer package to download and install the Microsoft.NET Framework 4 components.

For USB connectivity, the minimal physical requirement for the PC is a standard USB 2.0 port. The board connects to the PC via the mini-USB connector (J4). In case the board connects to the PC through a USB hub, use a self-powered hub.

2.2 BOARD SETUP

Before the MCP2221 I^{2}C Demonstration Board can be used, a few steps must be performed to install the PC software and configure the board's hardware.

2.2.1 Software Installation

Follow these steps to install the required software:

1. Download the support material (PC application) that can be found on the board's page at www.microchip.com.
2. Unzip the archive and install the `.exe` file. The setup process should also perform the USB driver installation, if needed. If there are driver-related issues, refer to **Section 5.2 "USB Driver Installation Issues"**.

2.2.2 Hardware Setup

Follow these steps to set up the hardware:

1. Check if the board is properly powered from USB by setting jumper J19 to either 5V or 3.3V; by default, it is set to 5V.
2. Connect the MCP2221 I^{2}C Demonstration Board to a PC through the mini-USB port (J4).

2.3   JUMPERS AND CONNECTORS DESCRIPTION

Refer to Figure 2-1 to view the default settings for the jumpers and connectors.

FIGURE 2-1:   DEFAULT JUMPERS AND CONNECTORS CONFIGURATIONS
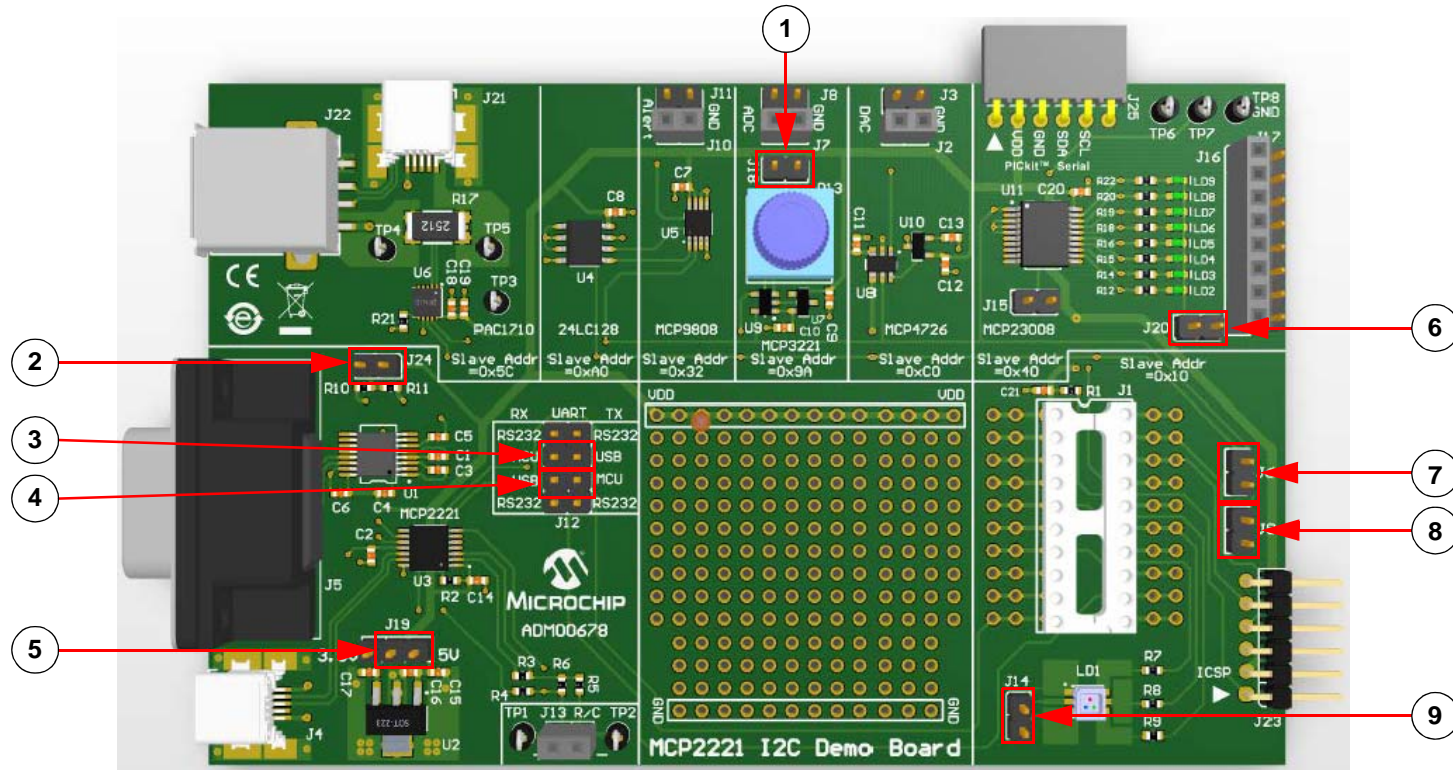
Legend:

1 = Enable potentiometer R13 for MCP3221 ADC

2 = Enable board's I²C pull-up resistors, R10 and R11

3 = Connect UART RX of PIC16F1509 to UART TX of MCP2221

4 = Connect UART RX of MCP2221 to UART TX of PIC16F1509

5 = Set board voltage (V$_{DD}$) to 5V

6 = Enable LEDs, LD2-LD9, for MCP23008 GPIO expander

7 = Enable SDA (data) line of PIC16F1509 for I²C connectivity

8 = Enable SCL (clock) line of PIC16F1509 for I²C connectivity

9 = Enable RGB LED (connect to PIC16F1509)

Table 2-1 describes the functions of all the board's jumpers and connectors.

TABLE 2-1:   **MCP2221 BOARD JUMPERS CONFIGURATION**

Jumper Designator	Function Description
J1	PDIP socket for PIC16F1509 microcontroller.
J2	Female connector to the MCP4726 Digital-to-Analog Converter; one pin is the DAC output and the other connects to the ground.
J3	Male connector to the MCP4726 Digital-to-Analog Converter; one pin is the DAC output and the other connects to the ground.
J4	Mini-B type USB female connector for power and connectivity for MCP2221 from the PC.
J5	RS-232 female connector.
J6	Jumper connecting the I^2C SDA (data) pin of the PIC16F1509 to the board's SDA line. This jumper is connected by **default**.
J7	Female connector to the MCP3221 Analog-to-Digital Converter; one pin is the ADC custom input and the other connects to the ground; for custom input, disconnect jumper J18.
J8	Male connector to the MCP3221 Analog-to-Digital Converter; one pin is the ADC custom input and the other connects to the ground; for custom input, disconnect jumper J18.
J9	Jumper connecting the I^2C SCL (clock) pin of the PIC16F1509 to the board's SCL line. This jumper is connected by **default**.
J10	Female connector for the MCP9808 temperature sensor. One pin connects to the sensor's $\overline{ALERT}$ pin and the other to the ground.
J11	Male connector for the MCP9808 temperature sensor. One pin connects to the sensor's $\overline{ALERT}$ pin and the other to the ground.
J12	Jumper for configuring the UART/RS-232 traffic directions: • <u>MCP2221 to PIC16F1509</u>: Short-circuit (RX MCU) with (TX USB), then (TX MCU) with (RX USB). This is the **default** setting. • <u>MCP2221 to RS232</u>: Short-circuit (RX RS-232) with (RX USB), then (TX RS-232) with (TX USB). • <u>PIC16F1509 to RS232:</u> Short-circuit (RX RS-232) with (RX MCU), then (TX RS-232) with (TX MCU).
J13	Female connector for measuring resistances and capacitances. The '–' (minus) sign indicates the ground pin in case of measuring polarized capacitors.
J14	Jumper enabling the RGB LED LD1 that connects to the PIC16F1509. The jumper is connected by default.
J15	Jumper allowing the possibility to connect the interrupt pin of the MCP23008 I/O expander to pin RA2 of the PIC16F1509. The jumper is not connected by **default** (not populated).
J16	Female connector to the eight I/O pins of the MCP23008 I/O expander. When using the connector, consider disabling the LEDs connected to the I/O pins by removing jumper J20.
J17	Male connector to the eight I/O pins of the MCP23008 I/O expander. When using the connector, consider disabling the LEDs connected to the I/O pins by removing jumper J20.
J18	Jumper connecting the potentiometer R13 to the ADC input pin of the MCP3221 DAC. Disconnect jumper to allow custom voltage measurements via connectors J7/J8. The jumper is connected by **default**.
J19	Jumper for selecting the voltage level (V_{DD}) of the board: connect left hand side and middle pins for 3.3V or middle and right hand side pins for 5V. The default setting is for 5V.
J20	Jumper enabling LEDs LD2-LD9 that are connected to the I/O pins of the MCP23008 I/O expander; consider removing it if using connectors J16 and J17. The jumper is connected by **default**.
J21	Mini-B type USB female connector used for measuring current, voltage and power with the PAC1710. This side goes towards the USB voltage source, such as a PC.
J22	A type USB female connector used for measuring current/voltage/power with the PAC1710. Connect the USB device (load) through this jumper.
J23	In-Circuit Serial Programming™ (ICSP™) connector for the PIC16F1509, compatible with the PICkit™ 3 debugger/programmer; the white triangle indicates the first pin ($\overline{MCLR}/V_{PP}$).

TABLE 2-1: **MCP2221 BOARD JUMPERS CONFIGURATION (CONTINUED)**

Jumper Designator	Function Description
J24	Jumper enabling the 4.7Ω pull-up resistors for the I^{2}C data (SDA) and clock (SCL) lines on the board. Consider removing it if the demonstration board connects to an external I^{2}C slave circuit which already has I^{2}C pull-up resistors. The jumper is connected by **default**.
J25	I^{2}C female connector; similar to the PICkit™ Serial Analyzer connector; however, this one only has the power and I^{2}C lines (V$_{DD}$, GND, SDA, SCL). The white triangle indicates the first pin. Pins 1 and 6 are not connected.

2.4   TEST POINTS DESCRIPTION

Table 2-2 describes the board's test points.

TABLE 2-2: **MCP2221 BOARD TEST POINTS CONFIGURATION**

Test Point Designator	Description
TP1	Test point for measuring resistance or capacitance. If required, connect the positive pin of the polarized capacitor to this test point.
TP2	Test point (connected to ground) for measuring resistance or capacitance. If required, connect the negative pin of the polarized capacitor to this test point.
TP3	Test point for the $\overline{\text{ALERT}}$ pin of the PAC1710. This test point is not used by the demonstration board's application.
TP4	Test point for the load side (target USB device) of the PAC1710 measuring circuit.
TP5	Test point for the source side (USB Host/PC) of the PAC1710 measuring circuit.
TP6	Test point for the I^{2}C SDA line of the board.
TP7	Test point for the I^{2}C SCL line of the board.
TP8	Test point connected to ground.

Chapter 3. Testing Board Features

This section describes the working principles and limitations that should be taken into account when using the board with the dedicated PC application, as well as the actual steps to use all of the demonstration kit's features.

It is assumed that the user has already successfully run the installation process described in **Section 2.2 "Board Setup"**.

3.1 ABOUT THE MPC2221 I²C DEMO BOARD APPLICATION

The PC application for the device is named the MCP2221 I²C Demo Board Application. The three main sections that can be observed in Figure 3-1 are the Feature tabs, General Information panel and Setup area.

FIGURE 3-1: THE MCP2221 I²C DEMO BOARD APPLICATION – INITIAL VIEW
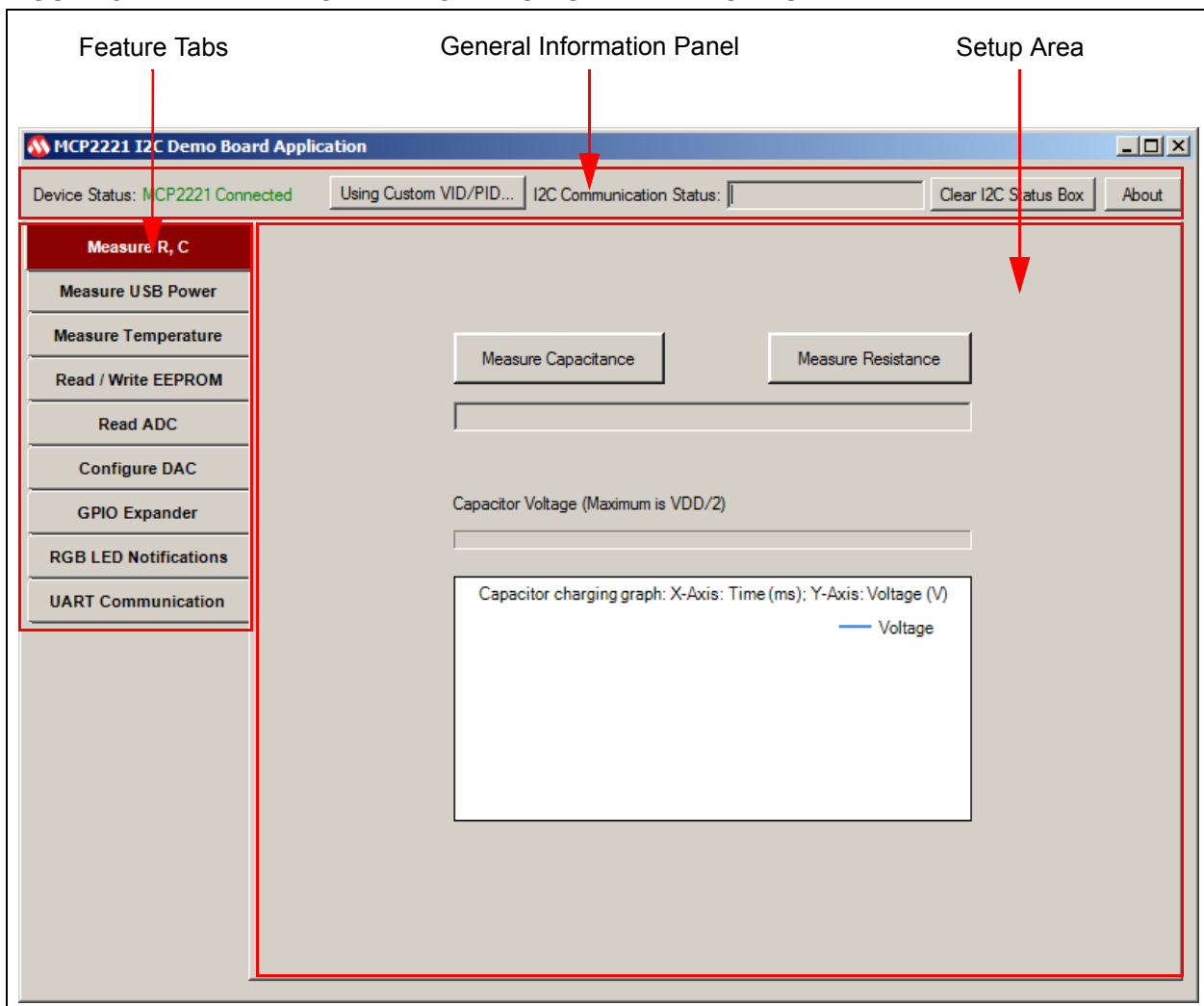
For more information on the General Information panel, see **Section 3.2 "General Information Panel Description"**.

The Feature tabs determine the content of the Setup area. For more information, see **Section 3.3 "Feature Tabs"**.

3.2   GENERAL INFORMATION PANEL DESCRIPTION

3.2.1   The Device Status Label

The Device status label displays whether the board is connected to the PC. One of the following messages is generated by the system:

• MCP2221 Connected
• MCP2221 not Connected

3.2.2   The Using Custom VID/PID... Button

When clicking the **Using Custom VID/PID...** button, the Select VID & PID window is displayed. The window contains information on the VID/PID combination to find the drivers that are to be used for the USB device.

FIGURE 3-2:   THE SELECT VID & PID WINDOW
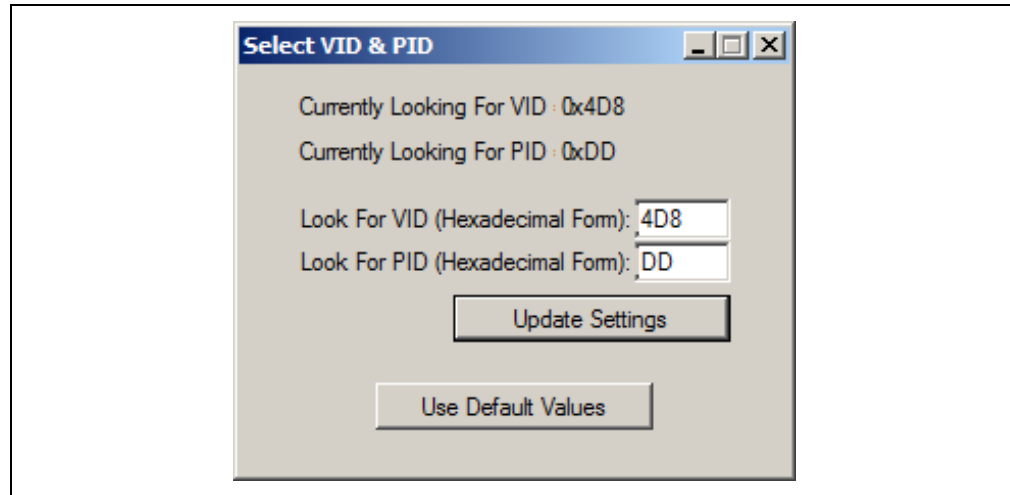
By default, the values are 0x4D8 for the VID and 0xDD for the PID. New values can be inserted in the "Look for VID (Hexadecimal Form)" and the "Look for PID (Hexadecimal Form)" fields. After inserting the new values, click the **Update Settings** button. Users can return to the default values by clicking the **Use Default Values** button.

3.2.3   The I2C Communication Status Box

By default, the "I2C Communication Status" text box is blank. It is populated when actions are performed in the Feature tabs. The information is system-generated and read-only.

Message examples include: "EEPROM write successful", "Pins states updated", "Settings saved" and others. If errors are displayed, see **Section 5.4 "PC Application Reports I^{2C} Errors"**.

3.2.4   The Clear I2C Status Box Button

Click the **Clear I2C Status Box** button to clear the I2C Communication Status box. Note that clearing the text in the box does not cancel or revert any previously performed action.

3.2.5 The About Button

Click the **About** button to open a window that contains information on the application's version and legal disclaimers. Click the **OK** button to close the window.

FIGURE 3-3: THE ABOUT WINDOW
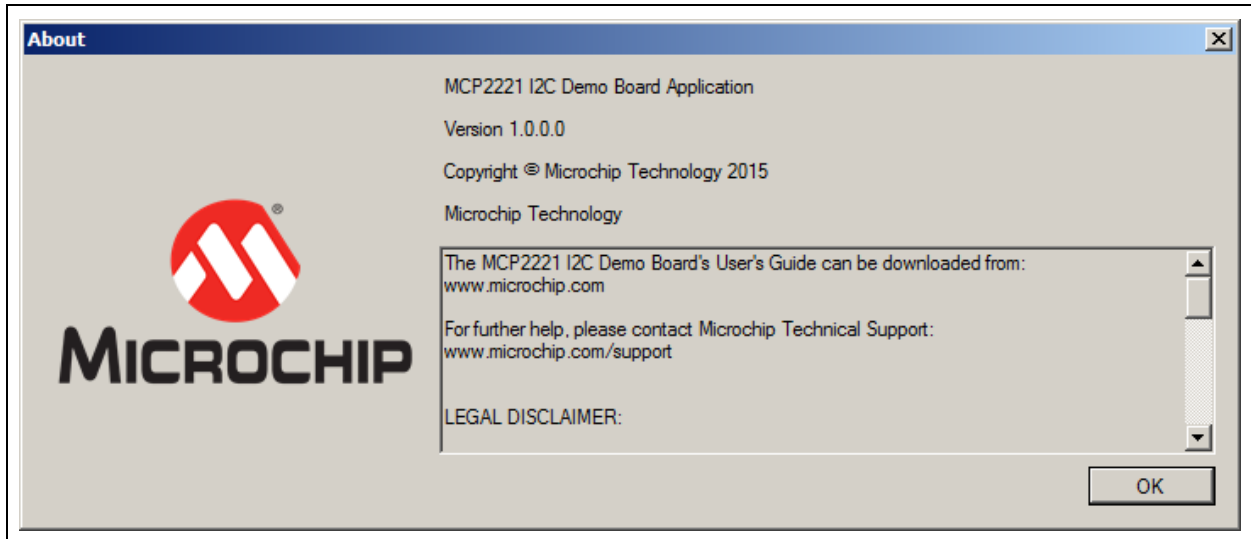
3.3 FEATURE TABS

The left panel of the application contains nine tabs that allow the user to explore all the board's features:

- **Measure R, C**
- **Measure USB Power**
- **Measure Temperature**
- **Read/Write EEPROM**
- **Read ADC**
- **Configure DAC**
- **GPIO Expander**
- **RGB LED Notifications**
- **UART Communication**

Each tab displays a dedicated setting area when selected.

3.3.1 Measure R, C Tab

Capacitance is determined by measuring the capacitor's charging time. In case of large capacitors, the charging time is software limited to 10 seconds, after which, a mathematical formula is applied to determine the approximate capacitance. The charging current is provided by a digital output pin of the MCP2221 board and limited by a 470 kΩ resistor. The **Measure R, C** tab also generates a charging graph for the capacitor, as well as an indicator of its voltage.

Resistance is determined by placing the unknown resistor in series with another known one, thus creating a voltage divider where relative voltage values are sufficient to calculate the resistance.

Prior to performing measurements, the pins must be correctly placed in the connector marked with J13 or use the test points, TP1 and TP2.

3.3.1.1 TAB OPERATION

To measure a resistor or capacitor, select the **Measure R, C** tab.

- Click the **Measure Resistance** button to measure the resistance. The system displays the approximate resistance and a capacitor charging graph.
- Click the **Measure Capacitance** button to measure capacitance. The system displays the approximate capacitance and a capacitor charging graph.

> **Note:** In case of a polarized capacitor, make sure the pins are correctly placed – the '+' (plus) and '–' (minus) signs on the board must be next to connectors, J13 and TP2.

Figure 3-4 shows an example of measuring resistance.

FIGURE 3-4: MEASURING RESISTANCE
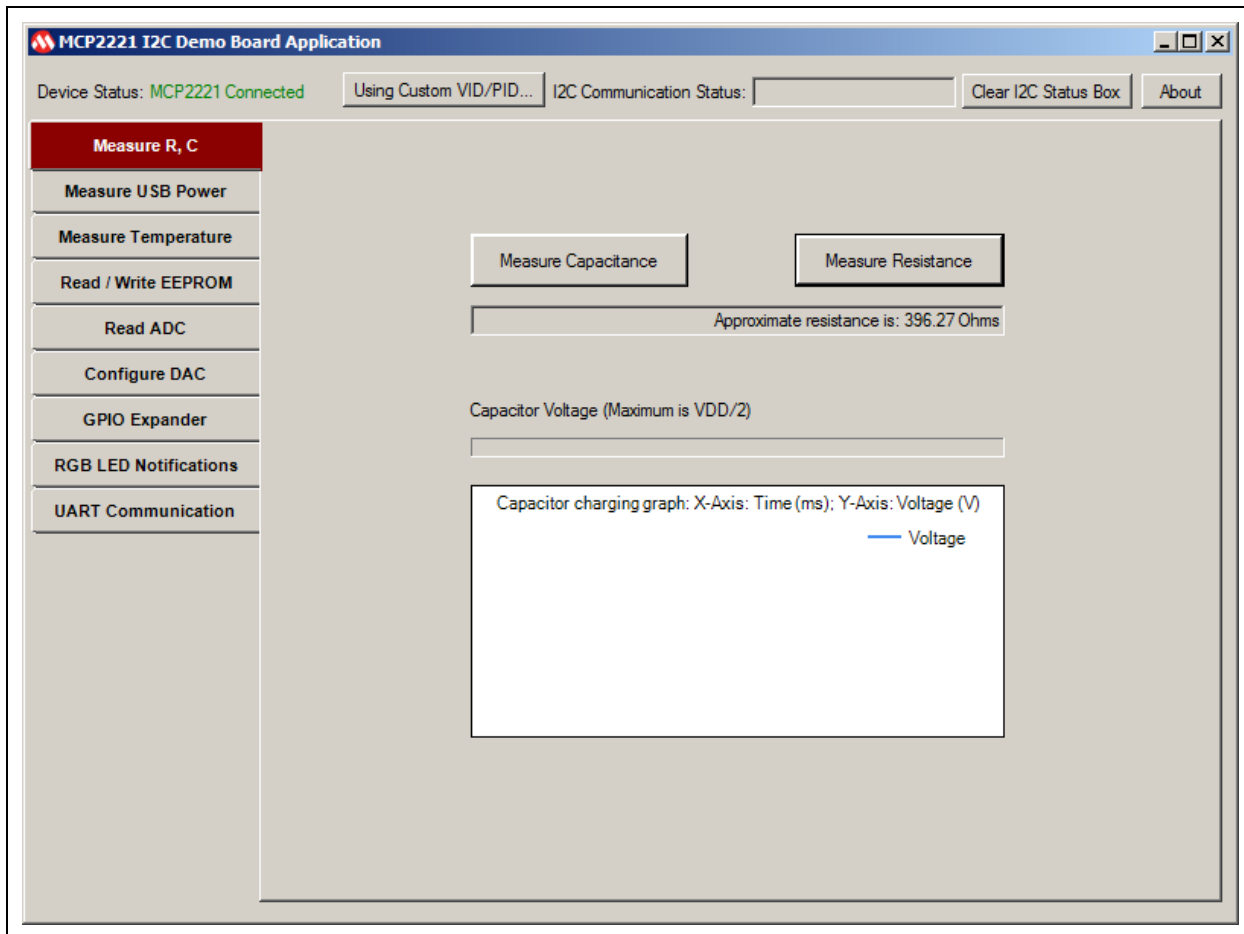
3.3.1.2 CONSIDERATIONS AND WARNINGS

- The minimum supported values are around 10Ω for resistors and 40 nF for capacitors.
- To maintain a certain level of accuracy, the maximum recommended values to measure are ~1 MΩ for resistors and 470 µF for capacitors.
- The measurement accuracy may be, in some cases, of about ±10%, therefore the MCP2221 I²C Demonstration Board Kit is not recommended for precision measurements.
- For both capacitor and resistance measurements, voltages are generated by digital output pins and measured using the analog input pins of the MCP2221 I²C Demonstration Board.

3.3.2 Measure USB Power Tab

The **Measure USB Power** tab allows users to perform current, voltage or power measurements of a USB device.

Prior to measuring the current/power of the USB device, make sure that:

- The load to be measured (for example a USB mouse) is connected to the MCP2221 board's USB socket marked with J22
- The power source (such as the PC) is connected to the mini-USB socket marked with J21

3.3.2.1 TAB OPERATION

Users can determine what measurements the system should perform by selecting at least one of the following check boxes: "Chart Voltage", "Chart Current" or "Chart Power".

The "Show Numbers" check box determines whether numerical values for voltage, current and power will also be indicated in real time inside its corresponding text box. If the check box is selected, current and power will be indicated in real time.

Generated data can be saved using the "Log into .CSV File …" check box. When the check box is selected, the Open window opens to allow users to select the `.csv` file or create a new document, where the measured data can be logged. Figure 3-5 depicts this action.

FIGURE 3-5: SELECTING A `.csv` FILE
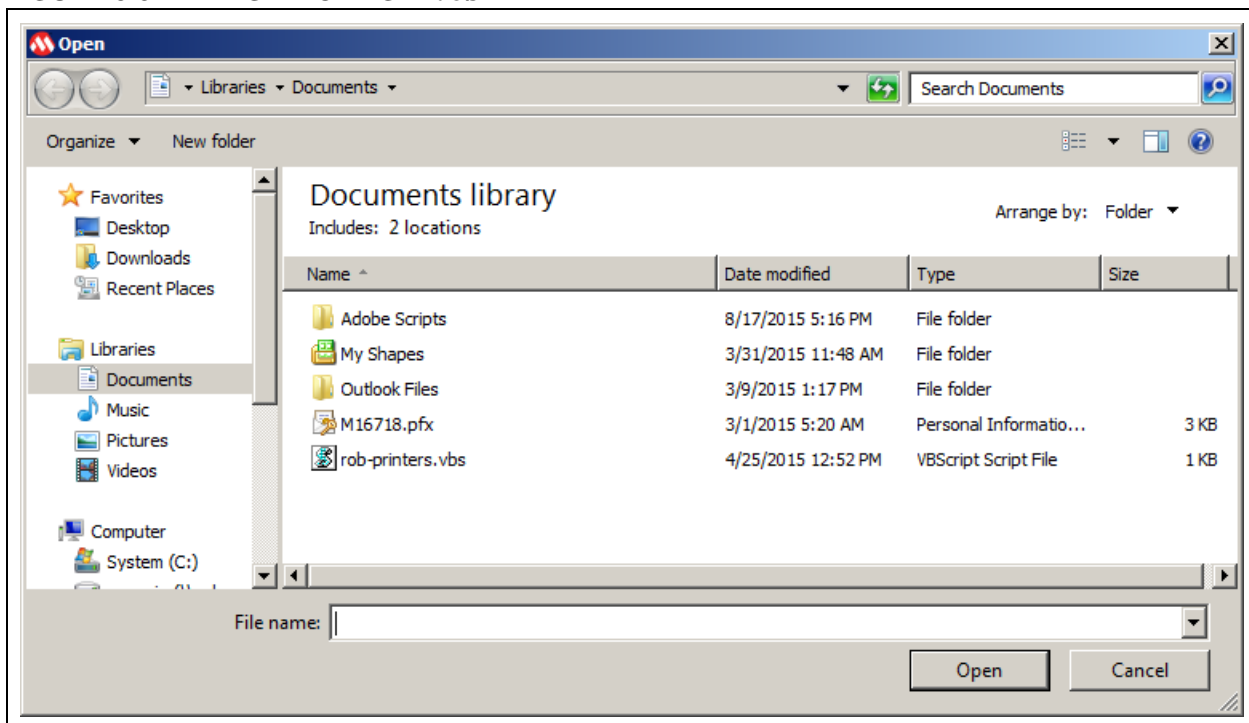
It is advisable to use comma separated values for the `.csv` file type to be Microsoft® Excel® compatible.The `.csv` file is generated by the application, with four columns, and each set of readings is placed on a row. The columns are: Data entry index, Voltage (in Volts), Current (in Amps), Power (in Watts). Logging can be turned off by clearing the check box.

Click the **Start Measurement** button for the system to start performing measurements. Pressing the **Stop Measurement** button interrupts the measurements. The **Reset Measurement** button clears all the previously generated data and prepares the system for new measurements.

The **Measure All One Time** button is for the application to retrieve, in real time, just one set of numeric values (for voltage, current and power) and to write them in the corresponding text box below it. This can be used as an alternate solution to **Start Measurement** in order to save system resources.

Figure 3-6 shows an example for measuring the current, voltage and power of a USB Flash drive when connected to the PC via the measuring circuit.

FIGURE 3-6: **MEASURING CURRENT, VOLTAGE AND POWER OF A USB DEVICE**
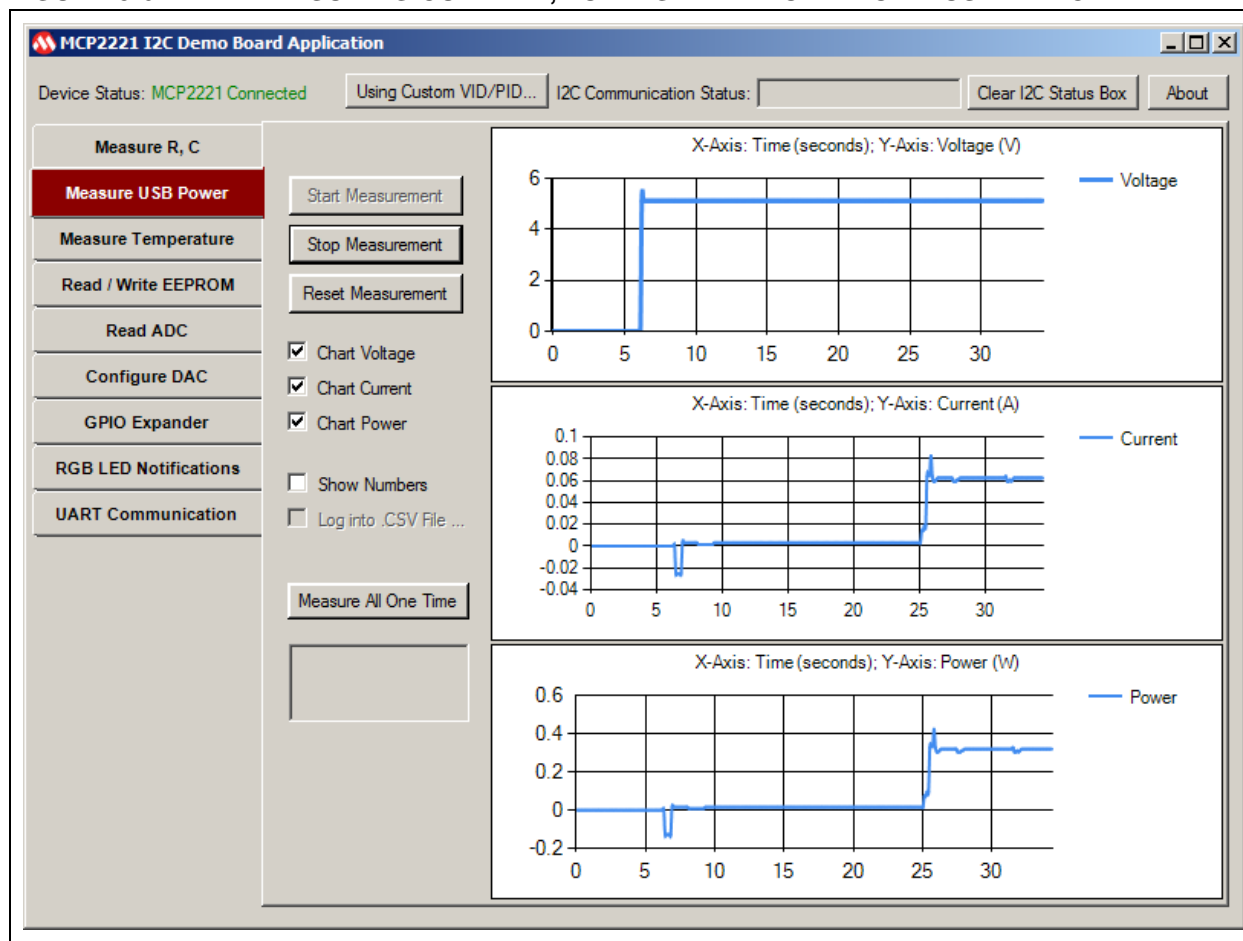
3.3.2.2   WARNINGS AND CONSIDERATIONS

- When measuring the current/power consumption, it is recommended to connect the loads (devices) that do not draw a current above ~2.5A.
- A shunt resistor of 0.025Ω is used, which sets the PAC1710 chip's full-scale current value to 3.2A. However, current limitations are also imposed by the MCP2221 board's design.
- In case of continuous measurement, samples are taken once every 100 milliseconds, so higher frequency variations may not be noticed by the application.
- The software provides the option not to display specific variations (such as populating the voltage graph, for example) to reduce the amount of tasks that the PC must perform. This is especially useful when the PC is running low on system resources (like processor usage or memory filling).
- Even when switching to a different tab (such as measuring resistors), if the monitoring is enabled, then it will not be automatically halted unless the board is physically disconnected from the PC. Therefore, it is recommended to stop performing the measurements when they are no longer required.

3.3.2.3   NOTIFICATIONS FUNCTIONALITY

The MCP2221 board also provides three access points (TP3, TP4 and TP5), described in **Section 2.3 "Jumpers and Connectors Description"**.

The PAC1710 chip can be configured to signal notifications via the $\overline{\text{ALERT}}$ pin that's connected to the TP3 test point of the MCP2221 I²C Demonstration Board.

For custom measurements, it's highly recommended to read the data sheet for the PAC1710 chip, as well as view the schematic and layouts of the board, available in **Appendix A. "Schematics and Layouts"** of this document.

3.3.3   Measure Temperature Tab

The temperature sensor is built into the MCP9808 chip. The sensor's accuracy depends on the temperature value intervals, as seen in the following table:

Temperature Value Intervals	Accuracy
-40°C to +125°C	±0.25° (typical)
-20°C to +100°C	±0.5°C (maximum)
-40°C to +125°C	±1°C (maximum)

In the case of continuous monitoring, samples are taken once every 100 milliseconds, so higher frequency variations may not be noticed by the software.

The software provides the option not to display specific variations (for example, populating the temperature graph) to reduce the amount of tasks that the PC must perform. This is especially useful when the PC is running low on system resources (such as processor usage or memory filling).

Even when switching to a different application tab, if the monitoring is enabled, then it will not be automatically halted unless the board is physically disconnected from the PC. Therefore, it is recommended to stop performing the measurements when they are no longer required.

3.3.3.1 TAB OPERATION

The **Measure Temperature** tab allows users to perform temperature measurements. The "Show in Chart" check box determines if a graph is displayed during the real-time measurements. Users can choose the measuring unit (Fahrenheit or Celsius) inside the "Unit" radio button group.

The functionalities of the "Show Numbers" and the "Log into .CSV File..." check boxes are similar to the ones described in **Section 3.3.2 "Measure USB Power Tab"**. However, the `.csv` file contains two columns and each set of readings is placed on a row. The columns are: Data entry index and Temperature.

The functionalities of the **Start Measurement**, **Stop Measurement** and **Reset Measurement** buttons are similar to the ones described in **Section 3.3.2 "Measure USB Power Tab"**.

Click the **Measure Temperature Once** button for the application to retrieve, in real time, just one set of numeric values (for temperature) and to write them in the corresponding text box below it. This can be used as an alternate solution to **Measure Temperature**, in order to save system resources.

For example, the application can be set so that temperatures exceeding 26°C will result in an orange LED blinking on the board. Custom LED notifications are described in **Section 3.3.8 "RGB LED Notifications Tab"**.

Figure 3-7 shows an example for measuring the temperature in °C.

FIGURE 3-7: **TEMPERATURE MEASUREMENT**
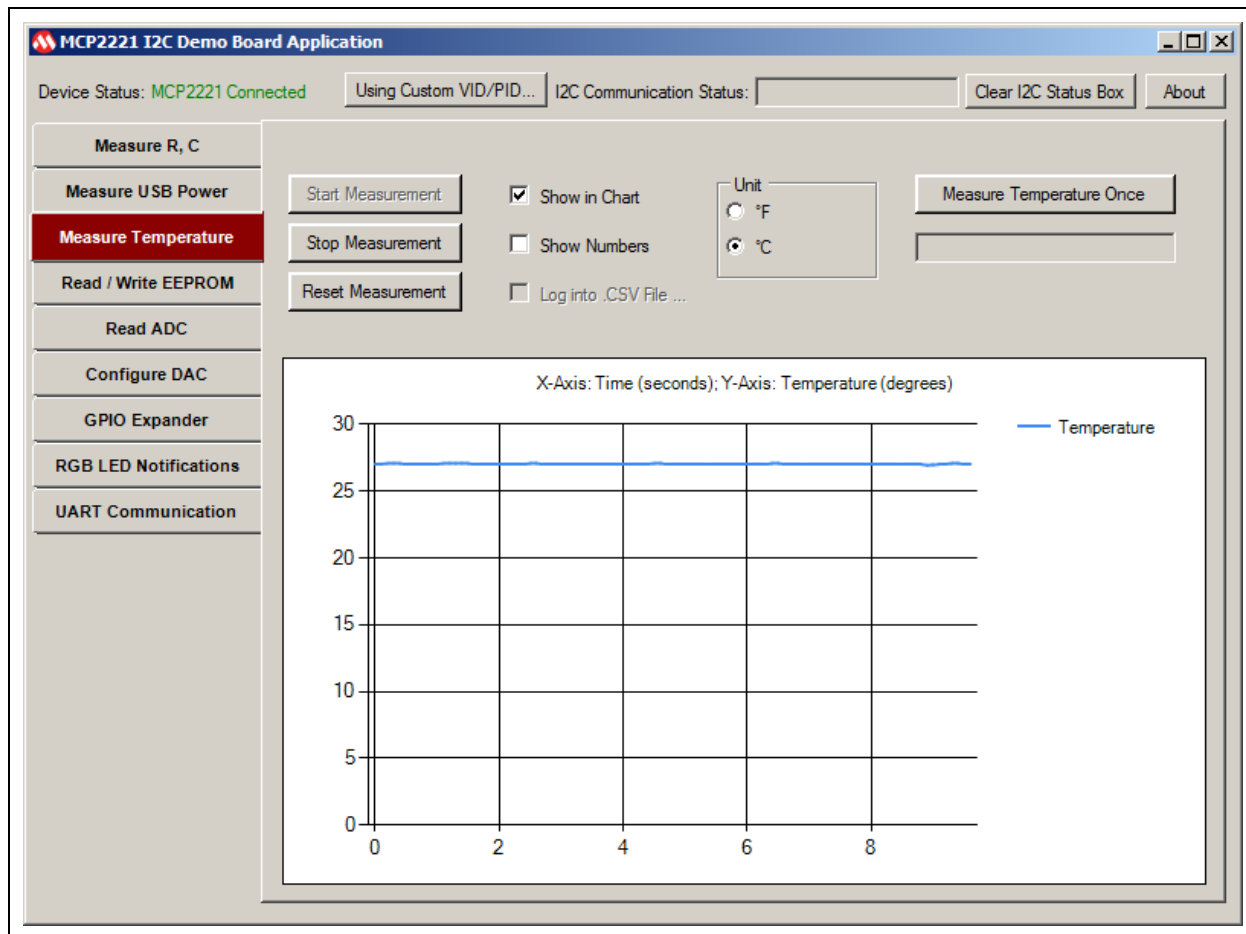
3.3.3.2 NOTIFICATIONS FUNCTIONALITY

The MCP9808 temperature sensor can be configured to output an alert signal when the temperature changes beyond the specified boundary limits. The signal can be read on the MCP2221 board through the pin extensions marked with J10 and J11. More information is available in **Section 2.3 "Jumpers and Connectors Description"**.

3.3.4 Read/Write EEPROM Tab

The 24LC128 EEPROM is organized into 256 pages of memory (numbered from 0 to 255), each containing 64 bytes of data. The MCP2221 I^{2}C Demo Board Application displays the memory content per page, organized in a matrix of 16 rows and 4 columns. Data and addresses are displayed in hexadecimal form.

The last page of the EEPROM, page 255, is also used to store the LED notifications configuration that is described in **Section 3.3.8 "RGB LED Notifications Tab"**.

By default, all the memory bytes are set as 0xFF.

Writing to a data cell will cause the EEPROM to rewrite the cell's entire page.

3.3.4.1 TAB OPERATION

Follow these steps to write to a specific cell or page of the EEPROM:

1. Select the **Read/Write EEPROM** tab.
2. From the "Select Page" drop-down, choose the EEPROM memory page you want to read or write.
3. The address of the cell can be determined by adding the column and row indexes in the matrix table below. Edit a cell by double-clicking on it and entering the 8-bit value in hexadecimal form (example: for 0x1C, write 1C). Users must enter a valid number in hexadecimal form, between 0x00 and 0xFF.
4. To update the EEPROM content, click the **Write Page** button. Figure 3-8 shows an example of writing the 0x1A value to address 0x1D0 (Memory Page Number 7).

FIGURE 3-8: **WRITING INTO THE EEPROM**
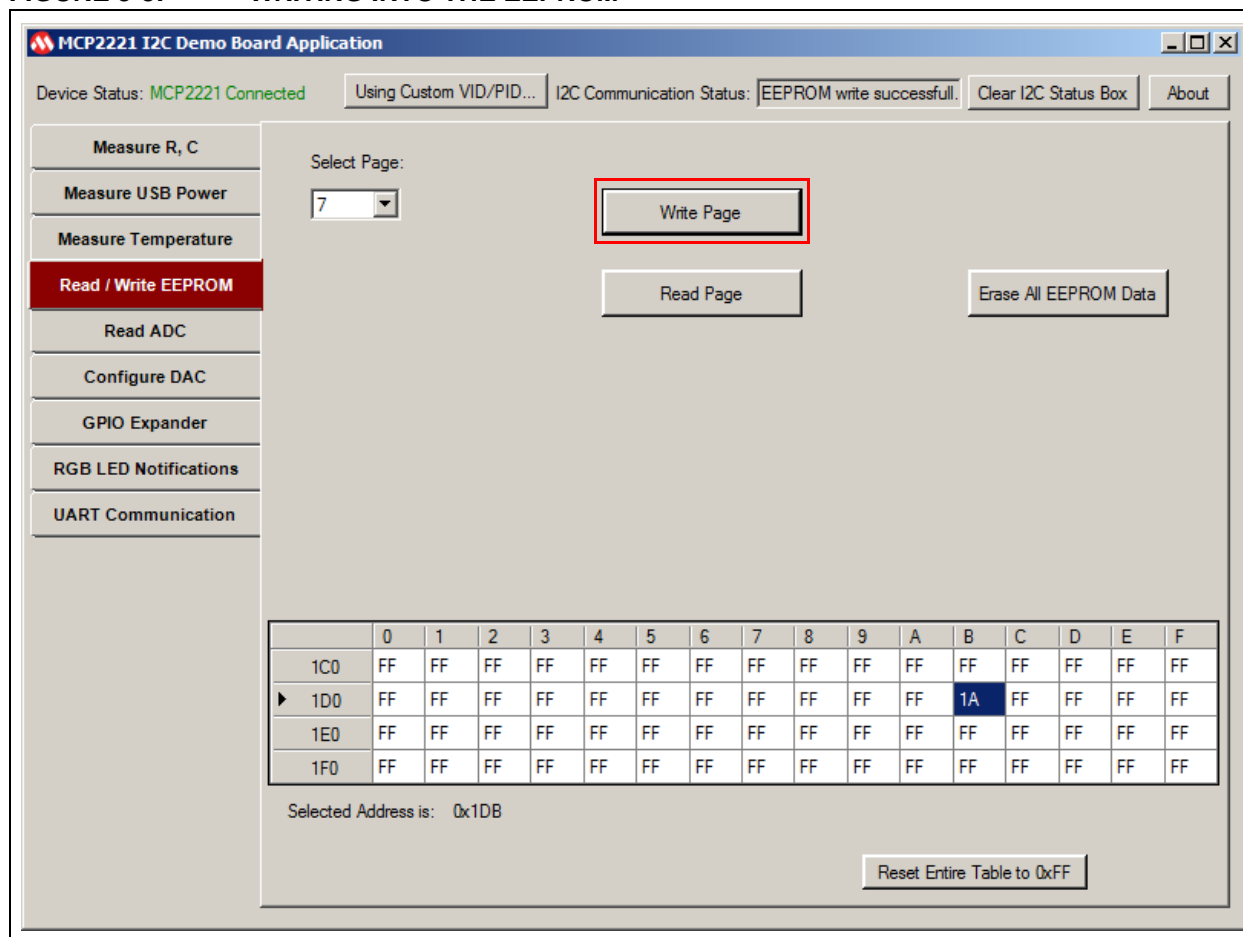
To read an EEPROM page:

1. Select the desired page number from the "Select Page" drop-down.
2. Click the **Read Page** button.

The **Erase All EEPROM Data** button resets the entire content of the EEPROM to 0xFF.

The **Reset Entire Table to 0xFF** button only affects the displayed matrix, not the actual EEPROM memory.

3.3.5 Read ADC Tab

The MCP3221 Analog-to-Digital Converter uses both a fixed 2.5V voltage reference and the power supply from an MCP1525 voltage reference chip, which allows the conversion to be independent of the demo board's power line: 3.3V/5V.

Therefore, the analog voltage to be measured must be between 0 and 2.5V. The board can be used to measure the voltage from:

- Potentiometer R13, from the 2.5V supply that's also powering the MCP3221 if jumper J18 is connected (the default setting);

    or

- An external source (via J7 and J8) if jumper J18 is disconnected.

In case of continuous monitoring, samples are taken once per 100 milliseconds, so higher frequency variations may not be noticed by the PC application.

The software provides the option not to display specific variations (such as populating the ADC graph) to reduce the amount of tasks that the PC must perform. This is especially useful when the PC is running low on system resources (such as processor usage or memory filling). Even when switching to a different application tab, if the monitoring is enabled, then it will not be automatically halted unless the board is physically disconnected from the PC. Therefore, it is recommended to stop performing the measurements when they are no longer required. Prior to performing measurements, make sure to select the analog voltage source by connecting or removing jumper J18. See Table 2-1 for more information.

3.3.5.1 TAB OPERATION

Select the **Read ADC** tab to perform ADC measurements.

The "Show in Chart" check box determines whether a chart is generated by the system to illustrate the measured values.

The functionalities of the "Show numbers" and the "Log into .CSV File..." check boxes are similar to the ones described in **Section 3.3.2 "Measure USB Power Tab"**. However, the `.csv` file contains two columns and each set of readings is placed on a row. The columns are: Data entry index, Voltage (in Volts).

The functionalities of the S**tart Measurement, Stop Measurement** and **Reset Measurement** buttons are similar to the ones described in **Section 3.3.2 "Measure USB Power Tab"**.

The **Measure ADC Voltage Once** button is for the application to retrieve, in real time, just one set of numeric values (for voltage) and to write them inside the text box below it. This can be used as an alternate solution to **Start Measurement** in order to save system resources.

Custom LED notifications (for example: voltage readings above 2.31V results in a green LED blinking on the board) are described in **Section 3.3.8 "RGB LED Notifications Tab"**.

Figure 3-9 shows an example for measuring the voltage:

FIGURE 3-9: **VOLTAGE MEASUREMENT**
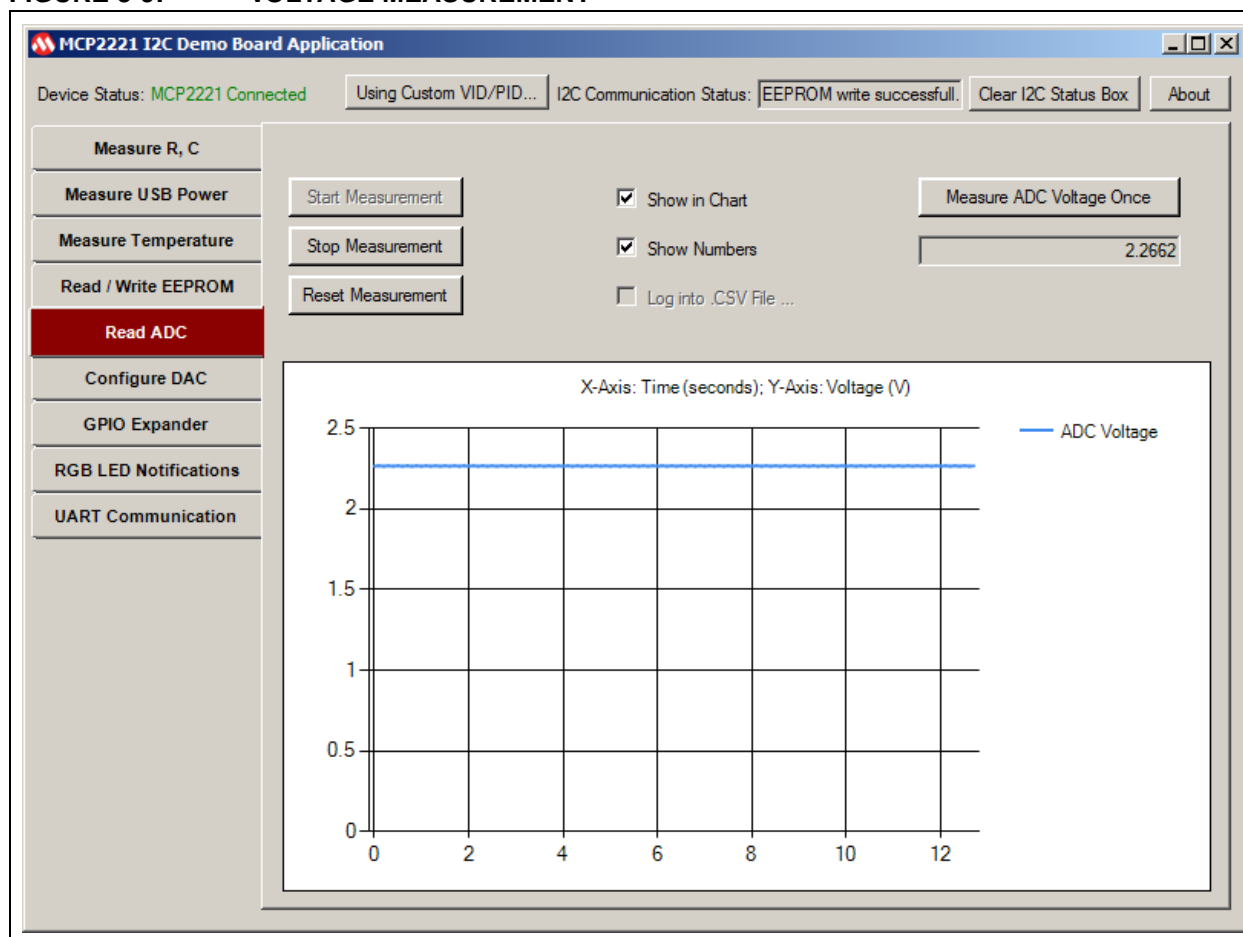
3.3.6   Configure DAC Tab

The MCP4726 DAC (Digital-to-Analog Converter) uses an MCP1525 as a 2.5V voltage reference, thus allowing it to generate a fixed voltage no matter if the board's power (V_{DD}) is set to 3.3V or 5V.

The MCP4726 also has the option to set a 2x reference gain, which means that only if the MCP2221 I^{2}C Demonstration Board works at 5V (jumper J19 is set to 5V), then the analog voltage output can be as high as 5V. This option can be enabled from the PC application.

3.3.6.1   TAB OPERATION

Follow these steps to set the voltage value for the DAC:

1. Select the **Configure DAC** tab.
2. From the **Select Reference Voltage** radio button group, choose the preferred voltage. The default value is 2.5V. Note that users should only select 5V if the V_{DD} value is 5V.
3. To set the output voltage, use one of the following formats:
    - Inside the text box corresponding to the "Write Value in Volts" text box, type in the numeric value;

      or
    - Select the "Set Voltage in Real Time" check box, then adjust the slider. The resulting values will be shown in the text box corresponding to "Write Value in Volts (Example: 2.35)" label. Use a period (.) and not a comma (,) to write the value.
4. Regardless of the method used to set the output voltage, the voltages are only submitted to the board after the user clicks the **Set Voltage** button. The value is also displayed below the "Current Voltage" label, inside the corresponding read-only text box.
5. To read the output voltage value back from the chip's register, click the **Read Voltage Data** button. The value is displayed in the read-only text box, below the "Current Voltage" label.

Figure 3-10 shows how to configure the DAC to output 1.45V.

FIGURE 3-10: CONFIGURING THE DIGITAL-TO-ANALOG CONVERTER
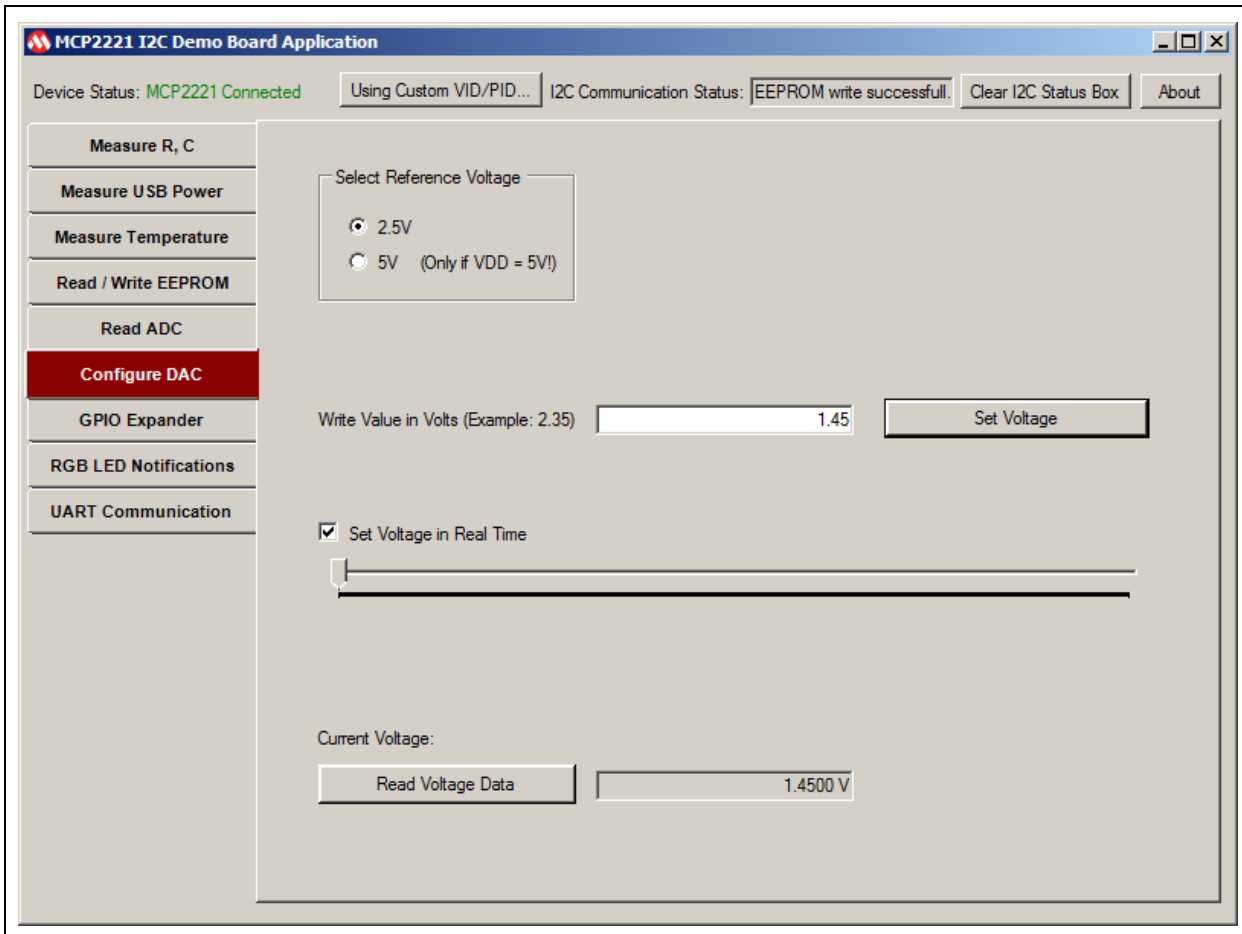
3.3.7 Digital I/O Pins Tab

The MCP23008 pin expander provides access to eight configurable digital input/output pins. Short-circuiting jumper J20 connects LEDs, LD2, LD3,…,LD9, to the eight pins. The eight general purpose pins are also accessible via connectors J16 and J17. For example, if a pin is configured as an output and intended to be connected to an external circuit or component via J16 or J17, it may help to remove jumper J20 in order to preserve the pin's current driving strength.

In case a pin is used as a digital input, a logical high input signal should match the demonstration board's power level (3.3V or 5V, determined via jumper J19). For more information on voltage tolerances, see the *"MCP23008/MCP23S08 Data Sheet"* (DS21919).

Even when switching to a different application tab (such as for measuring resistors), if the pin state monitoring (auto-read) is enabled, then it will not be automatically halted unless the board is physically disconnected from the PC. Therefore, it is recommended to stop performing the readings when they are no longer required.

Custom LED notifications for pin GP0 (for example: the pin having a logical high state results in a yellow LED blinking on the board) are described in **Section 3.3.8 "RGB LED Notifications Tab"**.

3.3.7.1 TAB OPERATION

To control the digital I/O pins, follow these steps:

1. Select the **GPIO Expander** tab.
2. Configure the pin directions (input or output) under the "Set GPIO Direction" section. The configuration only becomes active after the user clicks the **Submit Pin Directions** button.
3. For the pins that are set as outputs, the "Configure Pin State (if Output)" section allows the user to change their state in one of the following ways:
   - All at once, if the "Instant Command" check box is cleared and when clicking the **Submit Pin States** button;
     or
   - Individually (real-time state toggling), the "Instant Command" check box is selected.

In case a pin is configured as an input, these pin state control commands are ignored.

Reading the states for all eight general purpose pins can be done by either:

• Automatically (continuously, every 100 milliseconds), in case the "Auto Read Every 100ms" check box is selected;
or
• Manually, by clicking on the **Read Pin States** button.

Figure 3-11 shows an example of using the **GPIO Expander** tab.

FIGURE 3-11: INTERFACING THE GPIO EXPANDER
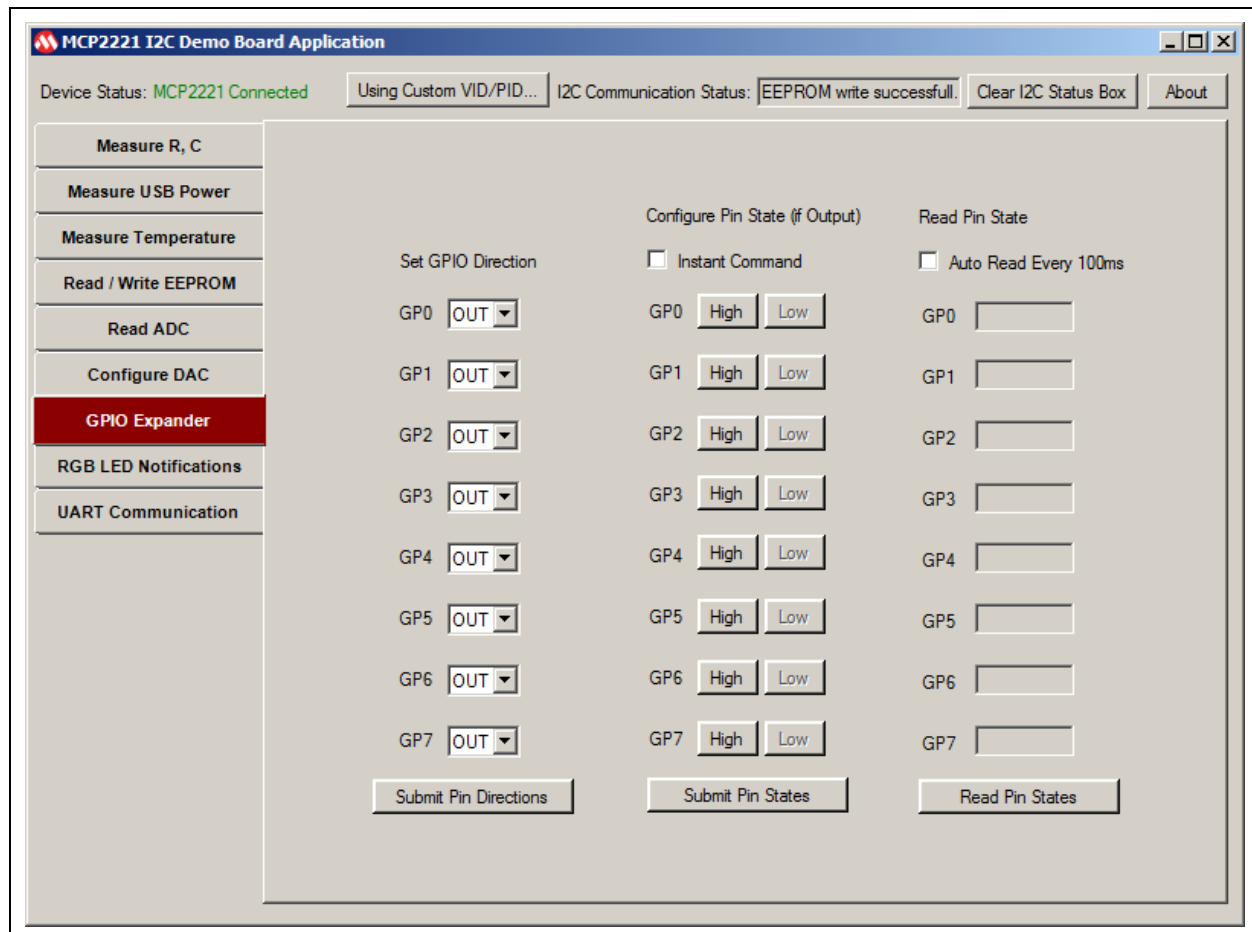
3.3.7.2   UNIMPLEMENTED FEATURES

The MCP23008 also has a separate interrupt output pin which can be used to signal to the I^{2}C master, a logical state change of one of its input pins.

By default, the interrupt pin is not connected to the MCP3221. It can be connected to the RA2 pin of the PIC16F1509 by short-circuiting jumper J15, in case of a custom application, where, for example, the PIC16F1509 is programmed to perform as an I^{2}C master.

3.3.8   RGB LED Notifications Tab

LED notifications can be configured to indicate certain events related to the readings described in the previous sections.

The LED can indicate events every 500 milliseconds (including 100 milliseconds of specific color) allocated per I^{2}C device:

• PAC1710 USB voltage, current or power consumption
• MCP9808 temperature sensor
• MCP3221 analog voltage value
• MCP23008 GP0 pin state change

In the remaining 100 milliseconds from one time period, the LED will be powered off.

In case a device does not have notifications enabled for its corresponding time interval, the LED will also be powered off.

As a general observation, higher frequency events may not be noticed in time to be signaled by the LED.

Notifications are done using the RGB LED LD1, that is fully controlled by three Pulse-Width Modulation (PWM) pins of the PIC16F1509, which receives commands (as I^{2}C slave) from the MCP2221 DLL through the MCP2221 board. The LED color and brightness are configured from the PC application. It is recommended to avoid light color tones, because they can translate into very intense LED brightness.

Prior to attempting to configure the LED notifications, make sure that:

• The PIC16F1509 microcontroller is present in socket J1 and that it can communicate via I^{2}C (jumpers J6 and J9 must be connected)
• Jumper 14 is connected to enable the RGB LED LD1

3.3.8.1 TAB OPERATION

Follow these steps to enable a notification:

1. Open the **RGB LED Notifications** tab.
2. The **Preview Color…** button brings up the Color window, allowing users to choose colors.

FIGURE 3-12:   COLOR WINDOW
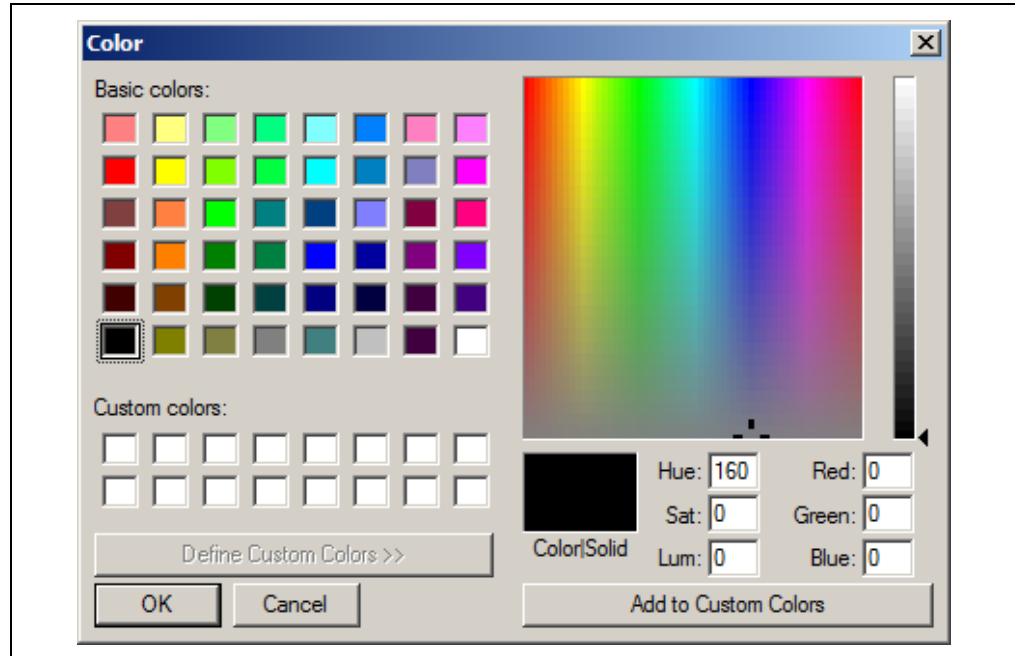
3. After selecting the desired colors, click the **OK** button and the system changes the LED color accordingly.
4. To enable a specific notification, select the color you want in the "Blink" radio button group corresponding to the notification. You can either:
   - Select the default color (blue, red, green or white) available for each of the four notifications;

     or

   - Set any color by selecting the "custom color..." radio button. In the Color window (Figure 3-12), choose one of the basic colors or define a new color and click **OK**.
5. Set the notification conditions, including the numeric value for comparison, if applicable.
6. Click the corresponding "Enable" check box.
7. Optional. Users can also click the **Save Preferences into EERPROM** button to save the current created configuration inside the 24LC128 EEPROM that's on the MCP2221 board (data is stored inside its last memory page, 255). Also, the **Load Preferences from EEPROM** button can be used to restore configurations from the EEPROM.

Note: Changing a numeric value used for the comparison will clear the "Enable" check box.

Figure 3-13 shows how the LED is configured to blink (blue color) in case the measured USB current exceeds 85 mA.

FIGURE 3-13:   CONFIGURING LED NOTIFICATIONS
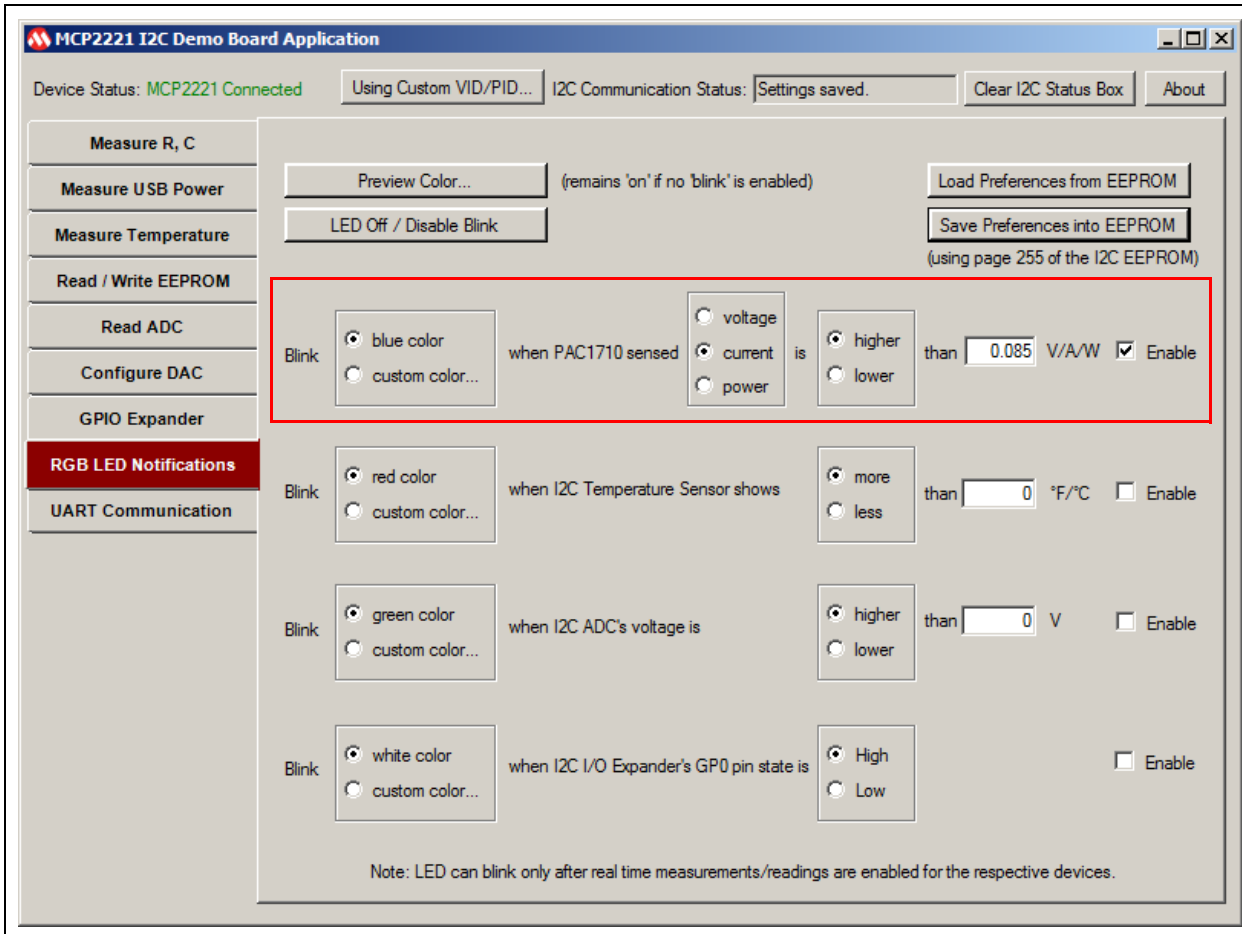
3.3.9   UART Communication Tab

There are several combinations of connectivity, which are determined through jumper J12:

- (Default Setting): MCP2221 (from PC) to PIC16F1509. Every time the PIC® microcontroller receives a character from the MCP2221, it increments its value and sends it back.
- MCP2221 (from PC) to RS-232 connector.
- PIC16F1509 to RS-232. Unless the PIC microcontroller is reprogrammed, it will behave the same as in Case 1 described above.

For the first two cases, data loss (sent or received) may be noticed inside the PC application's text box due to the nature of the .NET Framework that is used by the application. A work around is to use a third-party PC application for COM port bridging.

3.3.9.1   TAB OPERATION

To receive information on the COM ports present in the system, follow these steps:

1. Open the **UART Communication** tab.
2. Click the **Get COM Ports Info** button for the system to display information (in the text box below it) about the COM ports present in the system; this can be used to determine the COM port number of the MCP2221 USB to I²C/UART converter from the demonstration board.
3. Select the COM port number from the drop-down box. The system will populate the "Baud:", "Data Bits:" and "Stop Bits:" fields. For example, the settings in the case of communication between MCP2221 and PIC16F1509 (determined through jumper J12) are: Baud: 9600, Data Bits: 8, Stop Bits: 1.
4. Open the COM port by clicking the **Open Port** button.
5. Received data is automatically added inside the read-only text box on the right-hand side as red colored text.

To send data, follow these steps:

1. Open the **UART Communication** tab.
2. Enter the information you want to communicate in the text boxes corresponding to the **Text 1, Text Line 2** and **Text Line 3** buttons, under the "Send data:" section.
3. "Sent data:" can be seen inside the read-only text box on the right-hand side (combined with the received data) if the "Show Sent Data" check box is selected.
4. The buttons, **Text Line 2** and T**ext Line 3**, place the sent/received data on a new line inside the text box.
5. To clear the text box, click the **Clear Serial Data Box** button.

Figure 3-14 shows an example of sending the text '12' to the PIC microcontroller and receiving '23' back.

FIGURE 3-14: UART COMMUNICATION WITH THE PIC16F1509
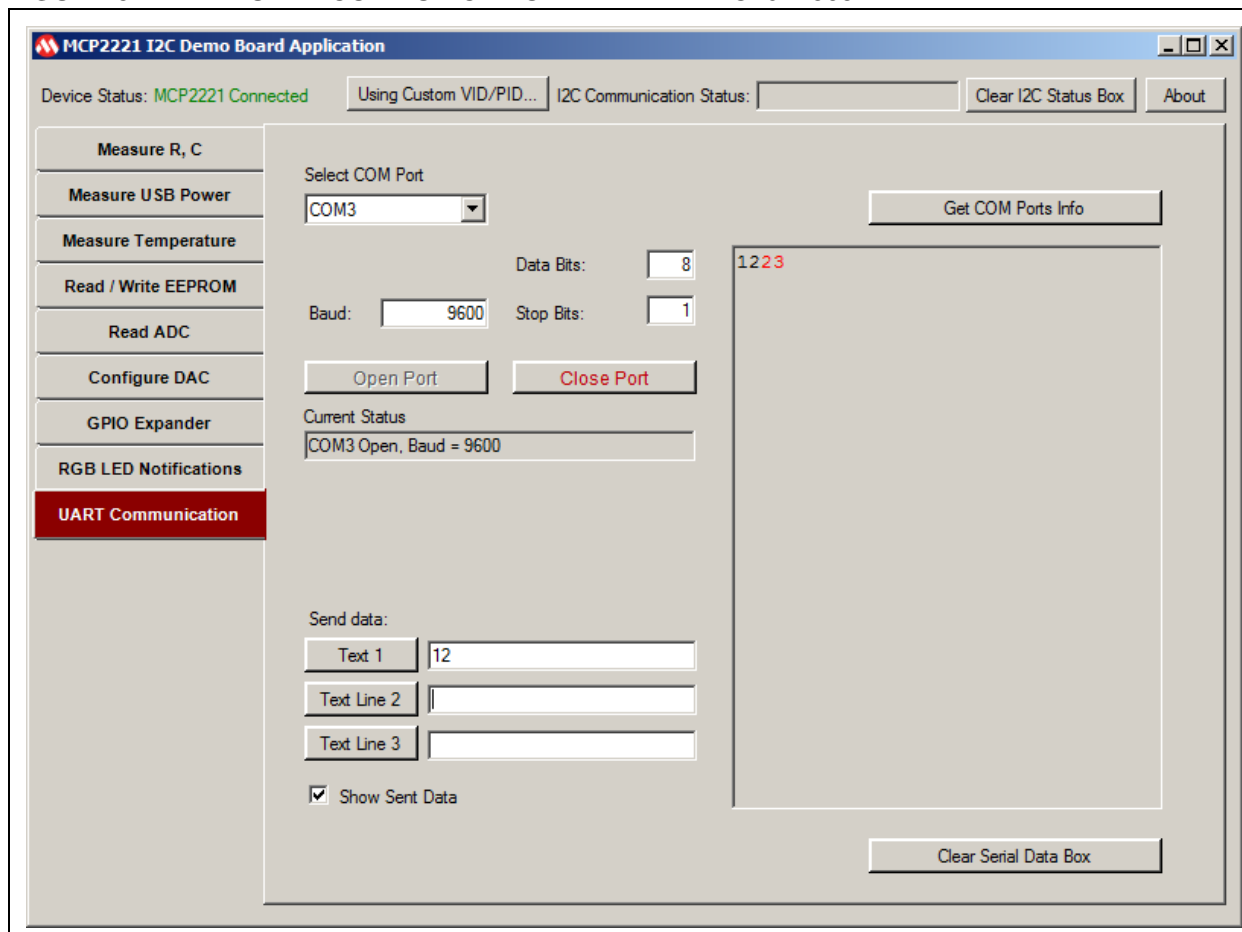
Chapter 4. Creating Custom I^{2}C Software Applications

This chapter provides a few suggestions on how to get started in developing custom applications that involve I^{2}C communication, using the MCP2221 I^{2}C Demonstration Board.

Section 4.1 "USB to I^{2}C": The MCP2221 is the I^{2}C master and the Graphical User Interface (GUI) lies on a USB Host (such as a PC or Android device).

Section 4.2 "PIC16F1509 as I^{2}C Master": The PIC16F1509 which is available on the board (or a pin-compatible PIC$^®$ microcontroller) is presumed to be the I^{2}C master, while also using (or not) the MCP2221.

Section 4.3 "I^{2}C Slave Addresses": Lists the I^{2}C slave addresses of the devices found on the demonstration board.

4.1   USB TO I^{2}C

This section discusses two aspects of a USB to I^{2}C custom application:

• Interfacing the MCP2221 I^{2}C Demonstration Board from a different PC application, or even, an operating system.
• Connecting external I^{2}C slaves to the MCP2221 I^{2}C Demonstration Board.

4.1.1   Using a Different Operating System or Application

The MCP2221 can be accessed via USB from several types of operating systems: Windows$^®$, Linux$^®$, Mac$^®$ or Android. The required USB drivers and related information are available on the MCP2221 official web site.

Also available for download are several applications that can be used for I^{2}C transfer and for GPIO pin configuration, such as the MCP2221 I^{2}C/SMBus Terminal for Windows or the MCP2221 Terminal Android Application for Android.

In order to create a custom application (GUI), the user can call the MCP2221 associated functions (for its configuration or actual data transfer) through the DLL files that can be downloaded from the same location.

For Android, the source code for the application and the available libraries can be used as a basis for developing a new application.

See the **"Recommended Reading"** section for more information on the I^{2}C slave devices.

4.1.2   Connecting External I^{2}C Slaves to the Board

The MCP2221 I^{2}C Demonstration Board also provides the possibility to connect external I^{2}C slave devices using the female connector J25. This is same as the one from the PICkit™ Serial Analyzer in terms of I^{2}C connectivity. The white colored triangle indicates the first pin of the socket.

These are the pin designations:

- Pin 1: Not connected
- Pin 2: V$_{DD}$ (power) must be provided by the I^{2}C demonstration board and it is user-selectable (3.3V or 5V via jumper J19)
- Pin 3: GND (ground connection)
- Pin 4: SDA (I^{2}C data line)
- Pin 5: SCL (I^{2}C clock line)
- Pin 6: Not connected

Additional test points are available in the case, for example, of connecting a logical analyzer to the demo board's I^{2}C bus:

- TP6: Test point connected to the I^{2}C data line
- TP7: Test point connected to the I^{2}C clock line
- TP8: Test point connected to ground

> **Note:** If the externally connected I^{2}C slave already has its own pull-up resistors connected to the I^{2}C data and clock lines, the ones available on the demo board can be disconnected by removing jumper J24.

4.2   PIC16F1509 AS I^{2}C MASTER

There may be the case where it is desirable to have the PIC16F1509 microcontroller as the I^{2}C master with no required USB communication. This section contains information related to the hardware connectivity (power supply and I^{2}C communication), as well as programming the PIC16F1509.

4.2.1   Hardware Connectivity

For powering the board, there are two possibilities:

1. From the PC, via the mini-USB connector J4 (USB Host) or a from a USB charger adapter that provides a constant 5V (DC) and at a recommended minimum of 200 mA. In this case, the board's voltage level can be set to either 3.3V or 5V, depending on how jumper J19 is connected.
2. By connecting an external power supply (between 3.3V and 5V) to the board's V$_{DD}$ power line, ideally through:
    - The V$_{DD}$ pin that is available on the ICSP™ (In-Circuit Serial Programming™) connector marked with J23;

        or

    - The V$_{DD}$ pin that is available on the female connector J25.

> **Note:** In case a power supply is connected directly to the V$_{DD}$ line, jumper J19 should be completely disconnected to avoid unwanted current flow. This flow could affect the board's MCP1825 voltage regulator or the USB connector marked with J4.

To enable I^{2}C communication, make sure that:

- The PIC16F1509 connects to the I^{2}C bus by short-circuiting jumpers J6 and J9.
- The I^{2}C data and clock lines' pull-up resistors are connected; if no pull-up resistors are externally connected to the board, then jumper J24 must be connected.

4.2.2 Programming the PIC16F1509

The PIC16F1509 can be programmed via the ICSP (In-Circuit Serial Programming) connector marked with J23, with tools such as the PICkit™ 3 or compatible debuggers/programmers. In case there are programming issues, consult **Chapter 5. "Troubleshooting"** in this document.

The source code for the PIC microcontroller can be written using MPLAB® X IDE and the XC8 C compiler that are available for download at http://www.microchip.com. Part of the code, including for the I^{2}C master, can be generated automatically using the MPLAB Code Configurator plug-in.

4.3 I^{2}C SLAVE ADDRESSES

This section lists the addresses of the I^{2}C slave devices that are available on the demonstration board. The values displayed in Table 4-1 are in the 8-bit form and can be used directly as parameters during application development when calling the `MCP2221.DLL` functions.

The 8-bit equivalent (write address) of a 7-bit I^{2}C address is the result of a left-shift-once (or multiplication by 2) of the 7-bit address.

TABLE 4-1: LIST OF I^{2}C SLAVE ADDRESSES

Device	I^{2}C Write 8-Bit Address	I^{2}C Read 8-Bit Address
24LC128	0xA0	0xA1
MCP23008	0x40	0x41
MCP3221	0x9A	0x9B
MCP4726	0xC0	0xC1
MCP9808	0x32	0x33
PAC1710	0x5C	0x5D
PIC16F1509	0x10	0x11

NOTES:

Chapter 5. Troubleshooting

This chapter handles a number of possible scenarios that may occur when the MCP2221 I²C Demonstration Board does not function as expected.

5.1 BOARD NOT DETECTED BY PC

In case the PC does not signal, either visually or acoustically, that the MCP2221 board has been connected, perform the following actions:

- Check the board's power selection jumper. Make sure jumper J19 is connected and that its default position is for 5V operation.
- Connect the PC to the correct on-board mini-USB socket. The board communicates with the PC and it is also powered using the mini-USB connector marked with J4, not J21.
- Verify that enough power is provided to the board. If the board connects through a USB hub, then the hub should be self-powered.

5.2 USB DRIVER INSTALLATION ISSUES

When connecting the MCP2221 board to a PC running a Windows® operating system, the USB driver should install automatically. In case the process is not successful, the driver can be downloaded from http://www.microchip.com/mcp2221, extracted to a folder on the local drive and then installed manually, as described below.

1. From the Start menu, select *Control Panel>Device Manager*. Connect the board to the PC and see what device is added to the list under Ports.
2. Right-click on the device and click the **Update Driver Software…** button.
3. Manually select the folder where the driver has been extracted.
4. Click **OK**.

After the driver installs, a system restart may be required.

5.3 PC APPLICATION REPORTS "MCP2221 NOT CONNECTED"

When a USB device (such as the MCP2221) connects to the USB Host (such as the PC), the host will ask for the device's Product and Vendor IDs (VID & PID).

The default values for the MCP2221 are 0x4D8 and 0xDD. In case any of these values has been changed by the user, and the USB.inf driver file has been customized accordingly and has been installed properly, then the PC application will report the "MCP2221 not connected" error message. In such a case, the application can be configured to look for a device with custom values by clicking the **Using Custom VID/PID…** button.

> **Note:** The MCP2221 I²C Demo Board Application does not rewrite the VID & PID inside the MCP2221 board. This can be done using the MCP2221 Utility which can be downloaded from http://www.microchip.com. However, extra knowledge in terms of legal and technical implications is required.

5.4 PC APPLICATION REPORTS I^{2}C ERRORS

If the text box corresponding to the **I^{2}C Communication Status** label indicates an error followed by a number, then the physical and logical setup of the I^{2}C bus should be checked. Perform the following verifications:

- Check the pull-up resistors. External I^{2}C circuits connected to the MCP2221 I^{2}C Demonstration Board may have their own pull-up resistors for the I^{2}C data and clock lines, in which case, jumper J24 should be removed depending on the resulting resistances; otherwise, J24 must be connected.

- Check for slave address conflicts. In case there are external I^{2}C slaves connected to the board, make sure there are no overlapping addresses. The list of addresses of the devices available on the board is detailed in **Section 4.3 "I^{2}C Slave Addresses** of this document.

- Check the I^{2}C error codes. The codes are available inside the *"MCP2221 Breakout Module User's Guide"* (DS50002282, package version 06/17/2015) available at www.microchip.com.

5.5 ISSUES PROGRAMMING THE PIC$^®$ MICROCONTROLLER

In case the PICkit™ 3 (or another Microchip debugger/programmer compatible to the PIC microcontroller) is configured to provide power to the target device, but reports that PIC16F1509 cannot be programmed, the cause may be that the PICkit 3 cannot provide enough power to the PIC device.

In such a case, it is recommended to power the MCP2221 board externally through:

- The mini-USB connector marked as J19 (as opposed to powering from the PICkit 3) from the PC;
  or

- A USB charger that provides a constant 5V (DC) at a recommended minimum of 200 mA if the microcontroller supports this voltage level.

Appendix A. Schematics and Layouts

A.1   INTRODUCTION

This appendix contains the schematics and layouts for the following devices which are included in the MCP2221 I^{2}C Demonstration Board Kit (ADM00678):

- **Board – Interface Schematic**
- **Board – Slaves Schematic**
- **Board – Top Silk**
- **Board – Top Copper and Silk**
- **Board – Top Copper**
- **Board – Bottom Copper**
- **Board – Bottom Copper and Silk**
- **Board – Bottom Silk**

A.2   BOARD – INTERFACE SCHEMATIC

MCP2221 and R/C measurement circuit

VDD
VDD
R2 10k 0603 5%
C14 0.1uF 16V 0603
GND

U3
VDD GP0 GP1 RST UART RX UART TX GP2
VSS D+ D- VUSB SCL SDA GP3
MCP2221

GP0
GP1
RESET
RX_MCP
TX_MCP
GP2
D_P
D_N
VUSB
SCL
SDA
GP3
GND
C2 0.47uF 6.3V 0603
GND

R3 10k 0603 1%
R4 10k 0603 1%
R5 10k 0603 1%
R6 470k 0603 1%
GND

TP1 TP LOOP Black
TP2 TP LOOP Black

J13 HDR-2.54 Female 1x2
GND

USB connector for MCP2221

5V
D_N
D_P
J4
VBUS D- D+ ID GND
USB Mini-B
GND

Power module

5V
U2 MCP1825
VIN VOUT GND
VUSB
VDD
5V
C15 4.7uF 10V 0603
C16 0.1uF 16V 0603
C17 4.7uF 10V 0603
J19 HDR-2.54 Male 1x3
GND GND GND GND

I2C bus pinouts

TP8 TP LOOP Black
GND
TP7 TP LOOP Black
SCL
TP6 TP LOOP Black
SDA

VDD
J25
SCL SDA
HDR-2.54 Female 1x6
GND

I2C Pull-Up Resistors

VDD
J24
HDR-2.54 Male 1x2
R10 4.7k 0603 5% SCL
R11 4.7k 0603 5% SDA

PIC16F1509 microcontroller

VDD
C21 0.1uF 16V 0603
R1 10k 0603 5%
GND

J1
VDD RA5 RA4 MCLR/RA3 RC5 RC4 RC3 RC6 RC7 TX_PIC/RB7
VSS RA0/ICSPDAT RA1/ICSPCLK RA2 RC0 RC1 RC2 RB4 RX_PIC/RB5 RB6

GND
SDA
J6 HDR-2.54 Male 1x2
SCL
J9 HDR-2.54 Male 1x2

R7 1.5k 0603 5%
R8 3.3k 0603 5%
R9 2.7k 0603 5%
BLUE GREEN RED
LD1 LED_RGB CLX6A-FKB-CK1P1G1BB7R3R3
J14 HDR-2.54 Male 1x2
GND

ICSP connector

J23
MCLR/RA3 VDD VSS RA0/ICSPDAT RA1/ICSPCLK
HDR-2.54 Male 1x6

MCP23008 interrupt pin to PIC

IO_INT
RA2
J15 HDR-2.54 Male 1x2

MAX3232 UART adapter and RS-232 connector

VDD
VDD
C4 0.1uF 16V 0603
C3 0.1uF 16V 0603
C6 0.1uF 16V 0603
C1 0.1uF 16V 0603

U1
C1+ V+ C1- C2+ C2- V- DOUT2 RIN2
VCC GND DOUT1 RIN1 ROUT1 DIN1 DIN2 ROUT2
MAX3232

C5 0.1uF 16V 0603
GND

GND
RX_MAX
TX_MAX
J5 DE-9 Female
GND

UART connectivity selection jumpers

J12
RX_PIC/RB5 RX_MCP RX_MAX
TX_MCP TX_PIC/RB7 TX_MAX
HDR-2.54 Male 2x4

A.3   BOARD – SLAVES SCHEMATIC

PAC1710 USB current and power measurer

24LC128 EEPROM

MCP9808 Temperature sensor

MCP3221 ADC

MCP4726 DAC

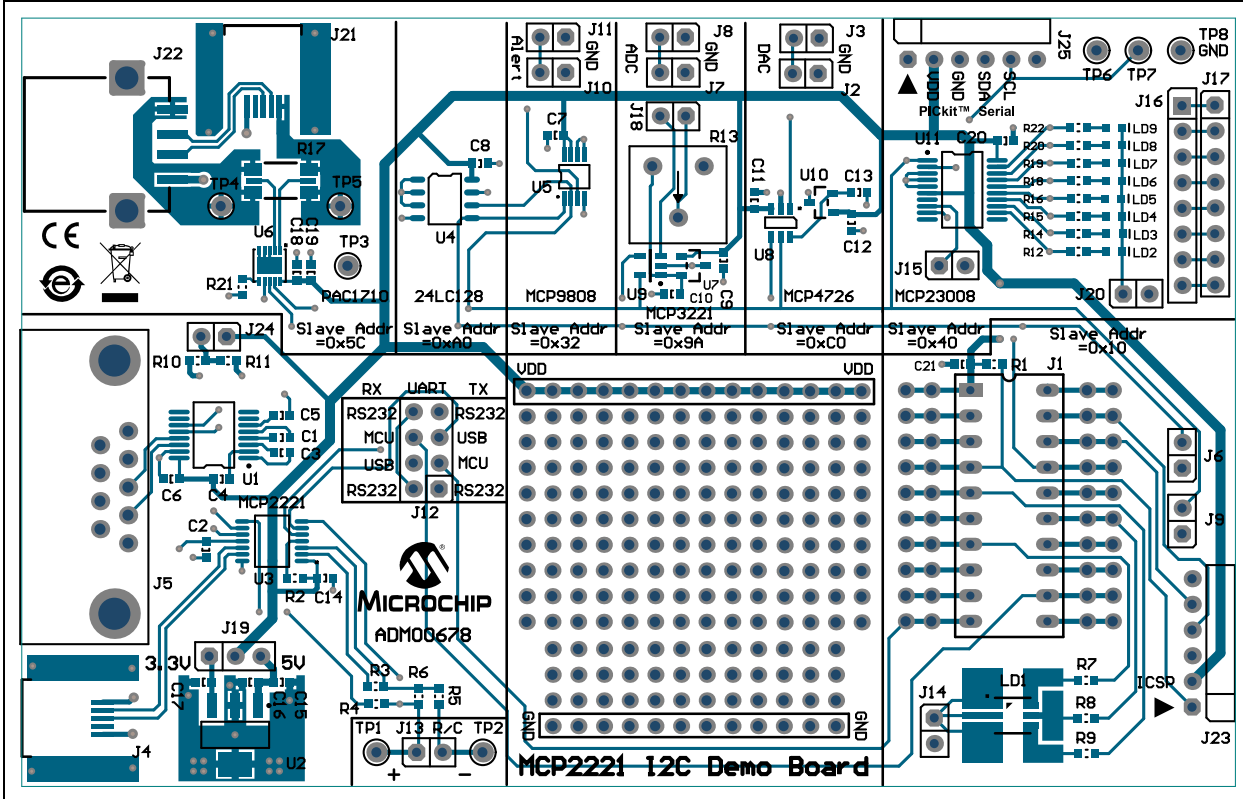**MCP23008 GPIO Expander**

MCP2221 I²C Demonstration Board User's Guide
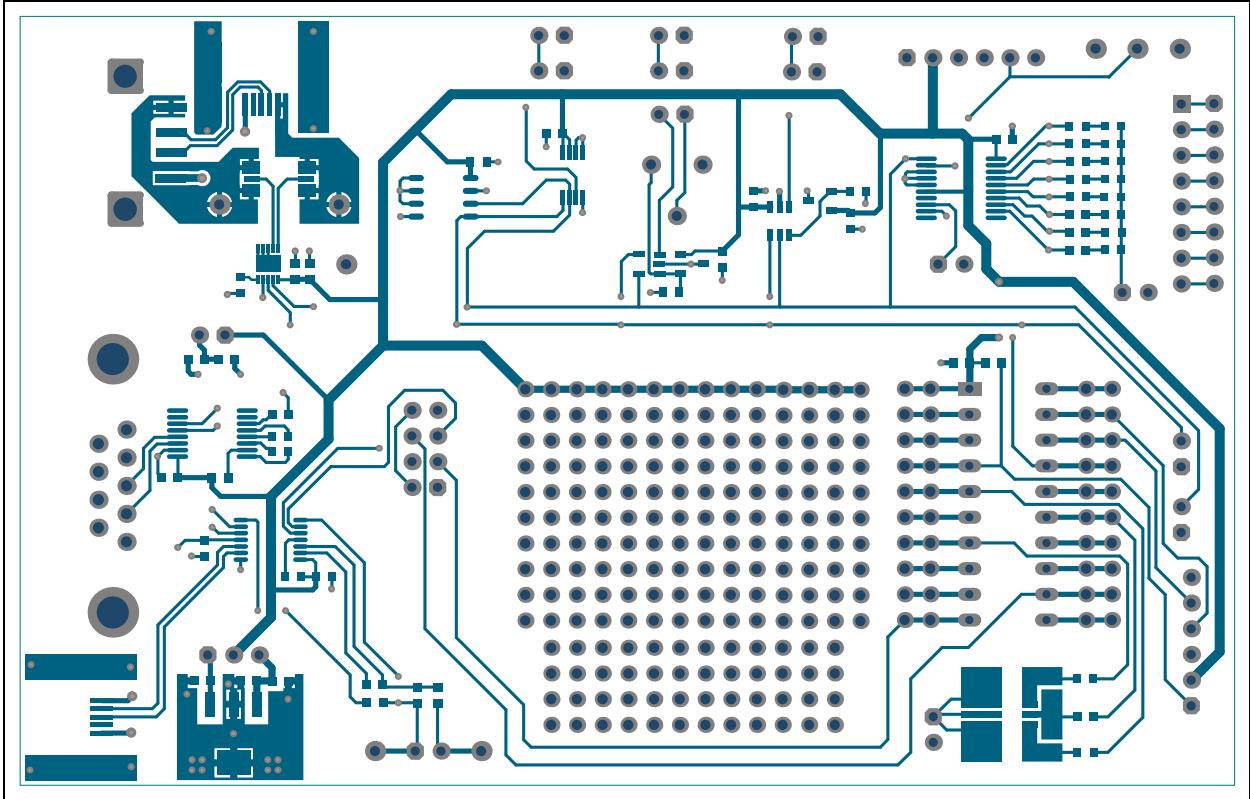
A.4   BOARD – TOP SILK
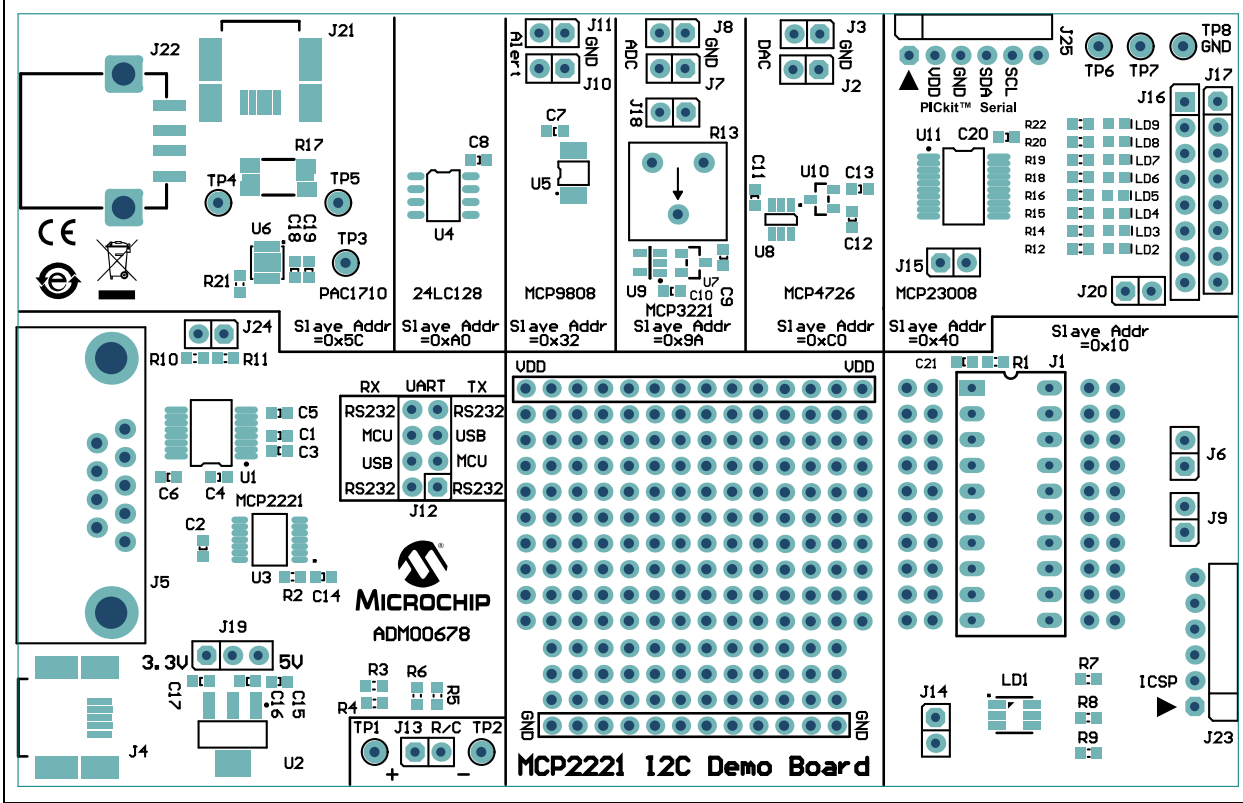
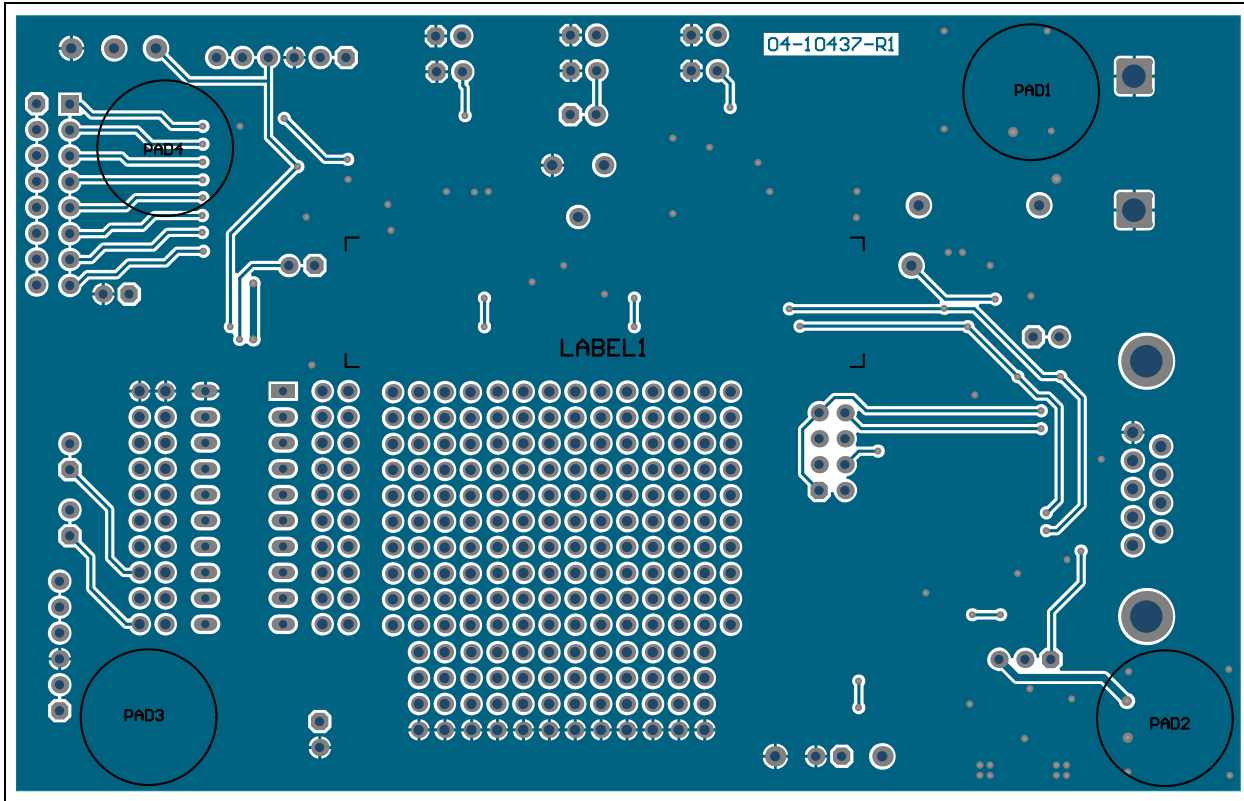## A.5   BOARD – TOP COPPER AND SILK

A.6   BOARD – TOP COPPER

A.7   BOARD – BOTTOM COPPER
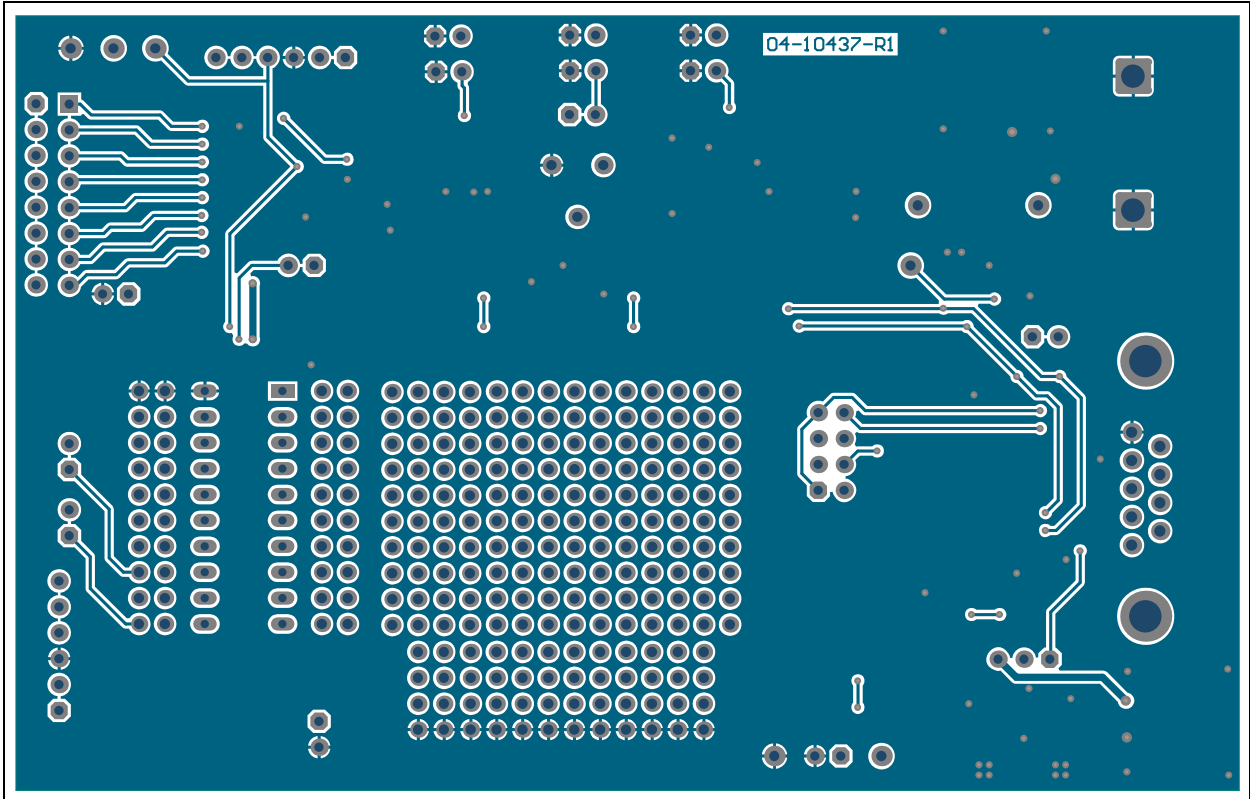
A.8   BOARD – BOTTOM COPPER AND SILK

A.9   BOARD – BOTTOM SILK
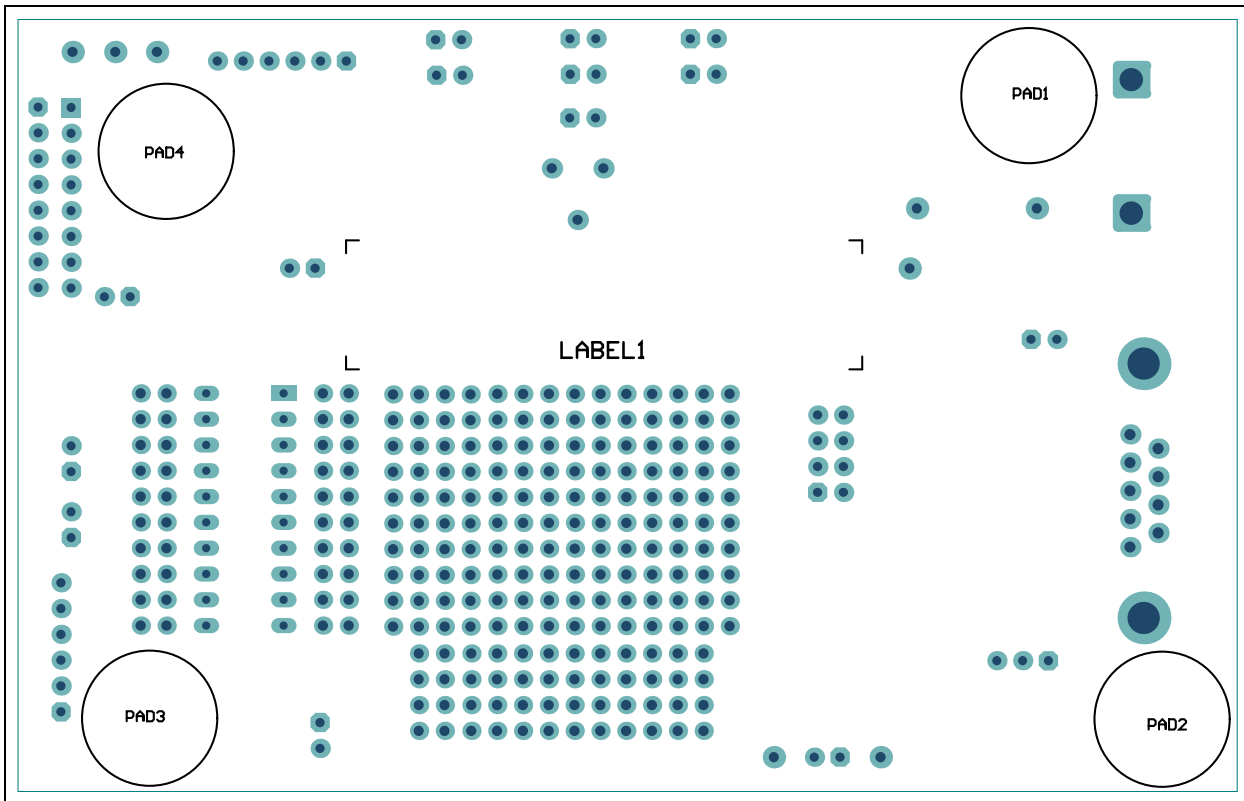
Appendix B. Bill of Materials (BOM)

TABLE B-1: **BILL OF MATERIALS (BOM)**[1]

Qty	Reference	Description	Manufacturer	Part Number
15	C1, C3, C4, C5, C6, C7, C8, C9, C11, C12, C14, C16, C18, C20, C21	Cap. Ceramic, 0.1 µF, 16V, 10%, X7R SMD, 0603	AVX Corporation	0603YC104KAT2A
1	C2	Cap. Ceramic, 0.47 µF, 6.3V, 10%, X5R SMD, 0603	Murata Electronics®	GRM188R60J474KA01D
3	C10, C13, C19	Cap. Ceramic, 1 µF, 10V, 20%, Y5V SMD, 0603	Murata Electronics	GRM188F51A105ZA01D
2	C15, C17	Cap. Ceramic, 4.7 µF, 10V, 10%, X5R SMD, 0603	Taiyo Yuden Co., Ltd.	LMK107BJ475KA-T
1	J1	Socket IC, Push, DIP 20, TH	Mill-Max Mfg. Corporation	110-99-320-41-001
4	J2, J7, J10, J13	Conn. Header-2.54, Female, 1x2, Gold, TH, Vertical	Samtec, Inc.	SSW-102-01-T-S
10	J3, J6, J8, J9, J11, J14, J15, J18, J20, J24	Conn. Header-2.54, Male, 1x2, Gold, 5.84 MH TH, Vertical	FCI	77311-118-02LF
2	J4, J21	Conn. USB Mini-B, Female, SMD, R/A	Molex®	0548190572
1	J5	Conn. DSUB DE-9, Female, TH, R/A	Fuk Hing Industries Co., Ltd	DR-9S
1	J12	Conn. Header-2.54, Male, 2x4, Tin, 5.84 MH TH, Vertical	FCI	67996-408HLF
1	J16	Conn. Header-2.54, Female, 1x8, Tin, TH, Vertical	Sullins Connector Solutions	PPTC081LFBN-RC
1	J17	Conn. Header-2.54, Male, 1x8, Gold, 5.84 MH TH	FCI	68001-108HLF
1	J19	Conn. Header-2.54, Male, 1x3, Gold, 5.84 MH TH, Vertical	FCI	68000-103HLF
1	J22	Conn. USB, USB-A, Female, SMD, R/A	Assmann Electronics Inc.	AU-Y1006-R
1	J23	Conn. Header-2.54, Male, 1x6, Gold, 5.84 MH TH, R/A	FCI	68016-106HLF
1	J25	Conn. Header-2.54, Female, 1x6, Gold, TH, R/A	Sullins Connector Solutions	PPPC061LGBN-RC
1	LD1	LED, RGB, 3.5x3.4 MM, 6PLCC	Cree, Inc.	CLX6A-FKB-CJNN-RFJBB7A363
8	LD2, LD3, LD4, LD5, LD6, LD7, LD8, LD9	Diode LED, Green, 2.2V, 25 mA, 15 mcd, Clear, SMD, 0603	Kingbright Corp.	APT1608SGC

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
4	PAD1, PAD2, PAD3, PAD4	Mechanical HW, Rubber Pad, Cylindrical, D12.7, H3.5, Gray	3M	SJ-5012
1	PCB	MCP2221 Printed Circuit Board	—	04-10437-R2
2	R1, R2	Resistor TKF, 10k, 5%, 1/10W, SMD, 0603	Panasonic®	ERJ-3GEYJ103V
3	R3, R4, R5	Resistor TF, 10k, 1%, 1/8W, SMD, 0603	Vishay Intertechnology, Inc.	MCT06030C1002FP500
1	R6	Resistor TKF, 470k, 1%, 1/10W, SMD, 0603	Vishay Intertechnology, Inc.	CRCW0603470KFKEA
1	R7	Resistor TKF, 1.5k, 5%, 1/10W, SMD, 0603	Panasonic	ERJ-3GEYJ152V
1	R8	Resistor TKF, 3.3k, 5%, 1/10W, SMD, 0603	Panasonic	ERJ-3GSYJ332V
1	R9	Resistor TKF, 3.3k, 5%, 1/10W, SMD, 0603	Panasonic	ERJ-3GSYJ272V
2	R10, R11	Resistor TKF, 4.7k, 5%, 1/10W, SMD, 0603	Yageo Corporation	RC0603JR-074K7L
8	R12, R14, R15, R16, R18, R19, R20, R22	Resistor TKF, 1k, 5%, 1/10W, SMD, 0603	Panasonic	ERJ-3GEYJ102V
1	R13	Resistor Trimmer Cermet, 10k, 10%, 500 mΩ, TH, 3386F	Bourns®, Inc.	3386F-1-103TLF
1	R17	Resistor Ceramic, 0.025R, 1%, 2W, SMD, 2512	TT Electronics Plc.	LRF2512-R025FW
1	R21	Resistor TKF, 20k, 5%, 1/10W, SMD, 0603	Yageo Corporation	RC0603JR-0720KL
8	TP1, TP2, TP3, TP4, TP5, TP6, TP7, TP8	Misc, Test Point, Multi-Purpose, Mini, Black	Keystone Electronics Corp.	5001
1	U1	In-Circuit Transceiver, MAX3232, SSOP-16	Texas Instruments	MAX3232CDBR
1	U2	Microchip Analog LDO, 3.3V, MCP1825ST-3302E/DB, SOT-223-3	Microchip Technology Inc	**MCP1825S-3302E/DB**
1	U3	Microchip Interface, USB, I^{2}C, UART, MCP2221-I/ST, TSSOP-14	Microchip Technology Inc	**MCP2221-I/ST**
1	U4	Microchip Memory Serial EEPROM, 128k, I^{2}C, 24LC128-I/SN, SOIC-8	Microchip Technology Inc	**24LC128T-I/SN**
1	U5	Microchip Analog Temperature Sensor, -40°C to +125°C, MCP9808-E/MS, MSOP-8	Microchip Technology Inc	**MCP9808-E/MS**
1	U6	Microchip Analog Current Sense Monitor, PAC1710-1-AIA-TR, DFN-10	Microchip Technology Inc	**PAC1710-1-AIA-TR**
2	U7, U10	Microchip Analog V$_{REF}$, 2.5V, MCP1525-I/TTG, SOT-23-3	Microchip Technology Inc	**MCP1525T-I/TT**
1	U8	Microchip Analog DAC, 1-Ch, 12-Bit, MCP4726A0T-E/CH, SOT-23-6	Microchip Technology Inc	**MCP4726A0T-E/CH**
1	U9	Microchip Analog ADC-SAR, 12-Bit, MCP3221A5T-E/OT, SOT-23-5	Microchip Technology Inc	**MCP3221A5T-E/OT**
1	U11	Microchip Interface GPIO-Port, Expand, I^{2}C, 8-Port, MCP23008T-E/SS, SSOP-20	Microchip Technology Inc	**MCP23008T-E/SS**

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**[1]

Qty	Reference	Description	Manufacturer	Part Number
1	CBL1, CBL2	Mech. HW Cable, USB-A Male to USB Mini-B Male, 3 ft, Black	Katerno	10UM-02103BK
2	JP6, JP9, JP12a, JP12b, JP14, JP18, JP19, JP20, JP24	Mech. HW Jumper, 2.54 mm, 1x2, Handle, Gold	TE Connectivity, Ltd.	881545-2

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

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Fax: 34-91-708-08-91

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