PAC1944 Evaluation Board User's Guide

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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 PAC1944 Evaluation Board. Items discussed in this chapter include:

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

DOCUMENT LAYOUT

This document describes how to use the PAC1944 Evaluation Board as a development tool to emulate and debug firmware on a target board. The manual layout is as follows:

- Chapter 1. "Product Overview" – Important information about the PAC1944 Evaluation Board.
- Chapter 2. "GUI Installation" – Includes instructions on installing and starting the PAC194x Demo Application.
- Chapter 3. "GUI Description and Operation" – Includes details about the PAC194x Demo Application.
- Chapter 4. "Hardware Description" – Includes hardware details about the PAC1944 Evaluation Board.
- **Appendix A. "Schematic and Layouts"** – Shows the schematic and layout diagrams for the PAC1944 Evaluation Board.
- **Appendix B. "Bill of Materials (BOM)"** – Lists the parts used to build the PAC1944 Evaluation Board.

CONVENTIONS USED IN THIS GUIDE

This manual uses the following documentation conventions:

DOCUMENTATION CONVENTIONS

Description	Represents	Examples
Arial font:		
Italic characters	Referenced books	*MPLAB® IDE User's Guide*
	Emphasized text	...is the *only* compiler...
Initial caps	A window	the Output window
	A dialog	the Settings dialog
	A menu selection	select Enable Programmer
Quotes	A field name in a window or dialog	"Save project before build"
Underlined, italic text with right angle bracket	A menu path	*File>Save*
Bold characters	A dialog button	Click **OK**
	A tab	Click the **Power** tab
N'Rnnnn	A number in verilog format, where N is the total number of digits, R is the radix and n is a digit.	4'b0010, 2'hF1
Text in angle brackets < >	A key on the keyboard	Press <Enter>, <F1>
Courier New font:		
Plain Courier New	Sample source code	`#define START`
	Filenames	`autoexec.bat`
	File paths	`c:\mcc18\h`
	Keywords	`_asm, _endasm, static`
	Command-line options	`-Opa+, -Opa-`
	Bit values	`0, 1`
	Constants	`0xFF, 'A'`
Italic Courier New	A variable argument	*`file`*`.o`, where *`file`* can be any valid filename
Square brackets [ ]	Optional arguments	`mcc18 [options]` *`file`* `[options]`
Curly brackets and pipe character: { | }	Choice of mutually exclusive arguments; an OR selection	`errorlevel {0|1}`
Ellipses...	Replaces repeated text	`var_name [, var_name...]`
	Represents code supplied by user	`void main (void) { ... }`

RECOMMENDED READING

This user's guide describes how to use the PAC1944 Evaluation Board. Another useful document is listed below. The following Microchip document is available and recommended as a supplemental reference resource:

- **PAC194X Data Sheet – *"DC Power/Energy Monitor with Accumulator"* (DS20006543)**

THE MICROCHIP WEBSITE

Microchip provides online support via our website at www.microchip.com. This website is used as a means to make files and information easily available to customers. Accessible by using your favorite Internet browser, the website contains the following information:

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

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To register, access the Microchip website at www.microchip.com, click on **Product Change Notification** and follow the registration instructions.

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 website at:
https://www.microchip.com/support.

DOCUMENT REVISION HISTORY

Revision A (August 2022)

- Initial release of this document.

NOTES:

Chapter 1. Product Overview

1.1 INTRODUCTION

This chapter provides general information about the PAC1944 Evaluation Board and the PAC1944 device. Items discussed in this chapter include:

- PAC1944 Device Overview
- PAC1944 Evaluation Board Hardware Overview
- Software and System Control Overview
- PAC1944 Evaluation Board Kit Contents

1.2 PAC1944 DEVICE OVERVIEW

The PAC1944 device is a four-channel DC Power/Energy Monitor with Accumulator. The 16-bit ADC is used for monitoring power rail voltages connected by a multiplexer to the positive (+) input pin of each channel and produces results named V_{BUS}. There is a second 16-bit ADC for measuring the voltage across a current sense resistor. This ADC is connected by a differential multiplexer to the positive and negative input pins for each channel, producing results V_{SENSE}. Channel selection for the multiplexers is controlled in sequential fashion to scan all four channels up to 1024 samples per second (sps).

The PAC1944 device also computes V_{POWER} by multiplying V_{BUS} by V_{SENSE} and accumulates these power results in an Accumulator. The device registers also hold eight times averaged V_{BUS} and V_{SENSE} results for very accurate low-noise voltage and current measurements. All the results are stored in registers. The values in the Results Registers only change when a `REFRESH` or a `REFRESH_V` command is sent. A software application is available for plotting, displaying and logging data. This application calculates energy based on the accumulated power and accumulated time and controls all the registers and alerts.

1.3 PAC1944 EVALUATION BOARD HARDWARE OVERVIEW

The PAC1944 Evaluation Board (EV40S84A) provides a flexible platform for evaluating the PAC1944 device and demonstrating its feature set. The mounted PAC1944 device enables direct control of all device pins and easy measurements of on-board or external voltages and currents.

The PAC1944 Evaluation Board is equipped with a USB port for direct communication with a computer. The PAC1944 device can be powered directly by V_{BUS} from the USB port or by an external connection for V_{DD}.

I^2C™ communication is provided over USB using the on-board MCP2221A USB to I^2C Bridge. Direct I^2C communication can also be obtained by connecting the VIO, Ground, SLOW, ALERT2, SDA and SCL to an external source, such as a PC motherboard, Linux® system or a SAM E54 Curiosity Ultra Board (DM320210). The I^2C address is connected as 0x20 (8-bit) by default. Multiple addresses can be obtained by removing resistors in the ADDR Select area on the PCB (see **Section 4.6 "Address Selection"**). The default sampling rate is 1024 sps with adaptive accumulation. Pressing the **SLOW** button results in a slow sampling rate of 8 sps.

The shorting shunts and the switches on the PAC1944 Evaluation Board facilitate simple demonstration of the device functions, by using the on-board current sources. Detailed evaluation of function and performance can be done by using external current loads to prototype the user's system.

An on-board Digital-to-Analog Converter (DAC) provides for various current signals for functionality testing and demonstration purposes. There are also on-board current sense resistors, provisions for external sources and loads and provisions for both USB control and direct I^2C connection. See Chapter 4. "Hardware Description" for more details.

1.4 SOFTWARE AND SYSTEM CONTROL OVERVIEW

The PAC194x Demo Application provides USB control over the PAC1944 device with the PAC1944 Evaluation Board. The application provides an easy way to control the registers and read the results for the PAC1944 device.

To use the PAC194x Demo Application with the PAC1944 Evaluation Board, download the software and launch the application. Then, connect the provided USB cable to the computer and ensure that the USB/I^2C switch SW301 is set to Bridge. See Chapter 2. "GUI Installation" for details on getting started.

1.5 PAC1944 EVALUATION BOARD KIT CONTENTS

The PAC1944 Evaluation Board Kit contains:

- PAC1944 Evaluation Board (EV40S84A)
- USB Cable
- Load Resistor and Wire
- Important Information Sheet

Chapter 2. GUI Installation

2.1 INTRODUCTION

This chapter describes how to download and install thePAC194x Demo Application. Items discussed in this chapter include:

- System Requirements
- Getting Started
- Installing the PAC194x Demo Application

2.2 SYSTEM REQUIREMENTS

The PAC1944 Evaluation Board is designed to be used with a personal computer (desktop or laptop) running Microsoft® Windows® 7 or later. For USB connectivity, the minimal physical requirement for the PC is a standard type-A USB 2.0 port.

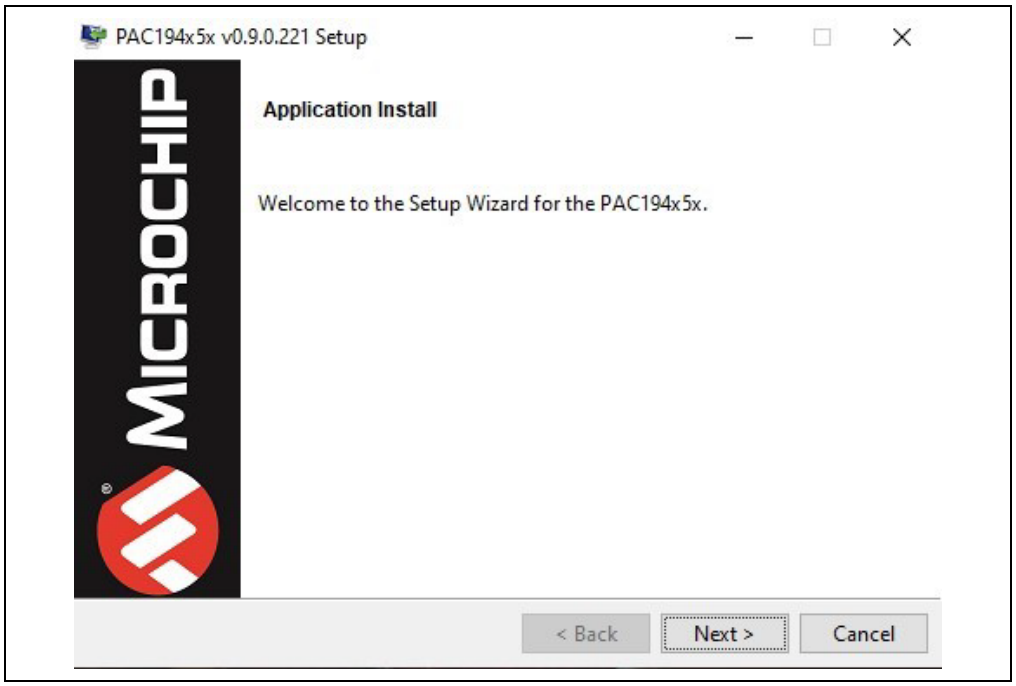
2.3 GETTING STARTED

1. Download the PAC194x Demo Application installer from the Microchip website.
2. If a previous version of the PAC194x Demo Application is already installed on the PC, uninstall it before proceeding.
3. Connect the PAC1944 Evaluation Board to the PC with the provided USB cable.

2.4 INSTALLING THE PAC194X DEMO APPLICATION

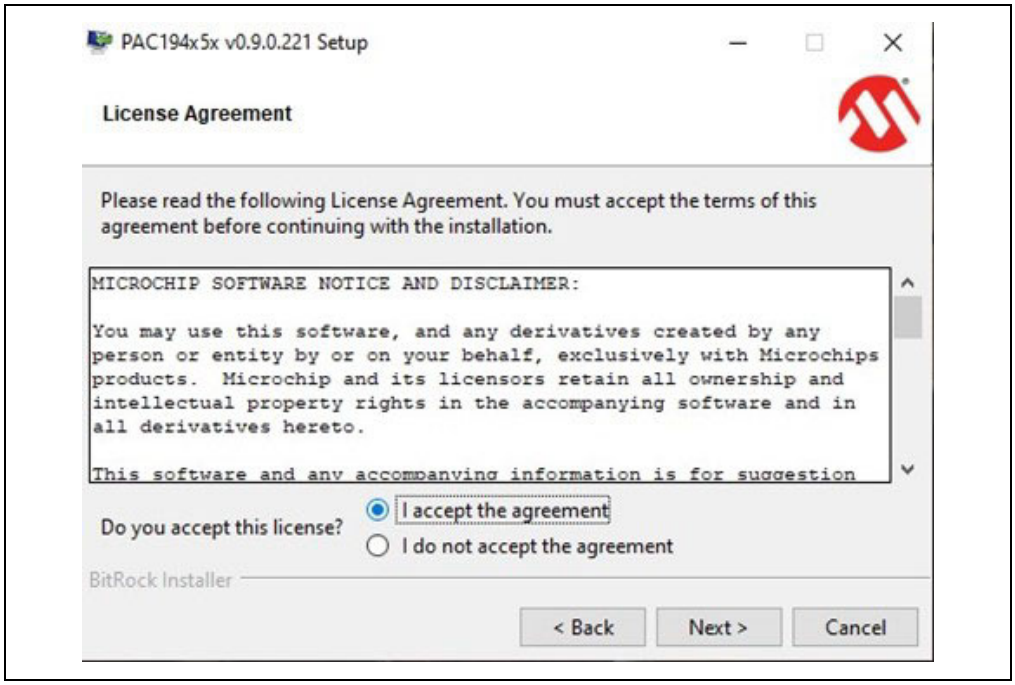
1. Double-click the installer.
2. An alert pops up, informing the user to uninstall any previous version of the application. Click **OK** to continue.
3. In the Installation screen (Figure 2-1), click the **Next** button to continue.

FIGURE 2-1: PAC194X DEMO APPLICATION – INSTALLATION SCREEN



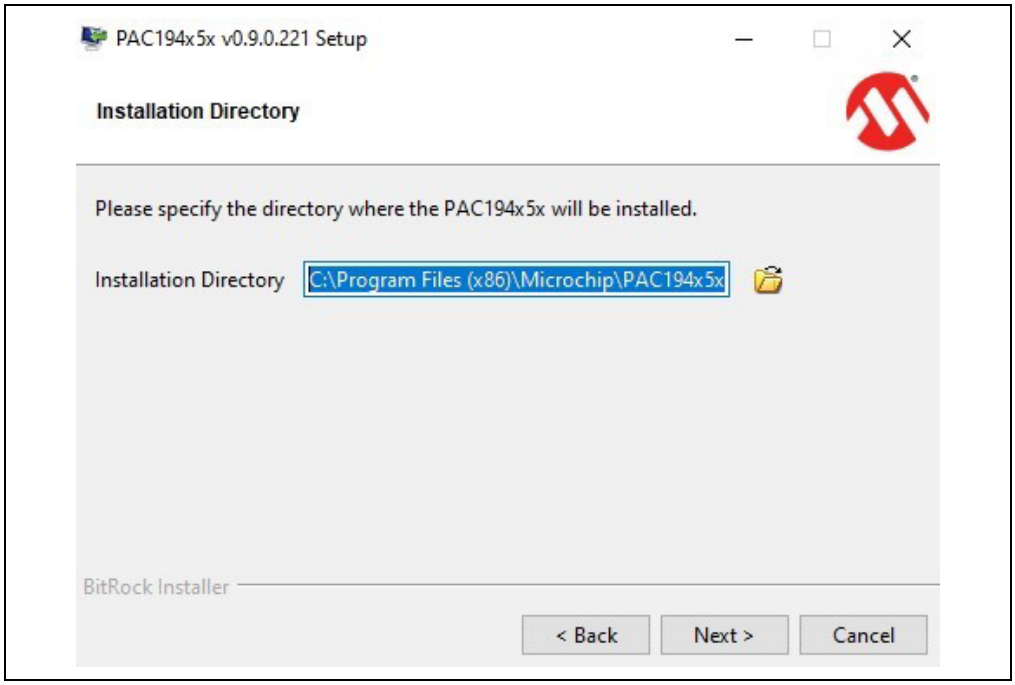
4. Read the License Agreement (Figure 2-2).
5. Select the **I accept the agreement** radio button, then click **Next** to proceed. Note that selecting the **I do not accept the agreement** radio button aborts the installation process.

FIGURE 2-2: PAC194X DEMO APPLICATION – LICENSE AGREEMENT SCREEN



6. Choose the installation directory (Figure 2-3), then click **Next** to continue.

FIGURE 2-3: PAC194X DEMO APPLICATION – INSTALLATION DIRECTORY SCREEN



7. The setup is now ready (Figure 2-4). Click **Next** to being installing the application. A green progress bar indicates the completion percentage (Figure 2-5).

FIGURE 2-4: PAC194X DEMO APPLICATION – READY TO INSTALL SCREEN

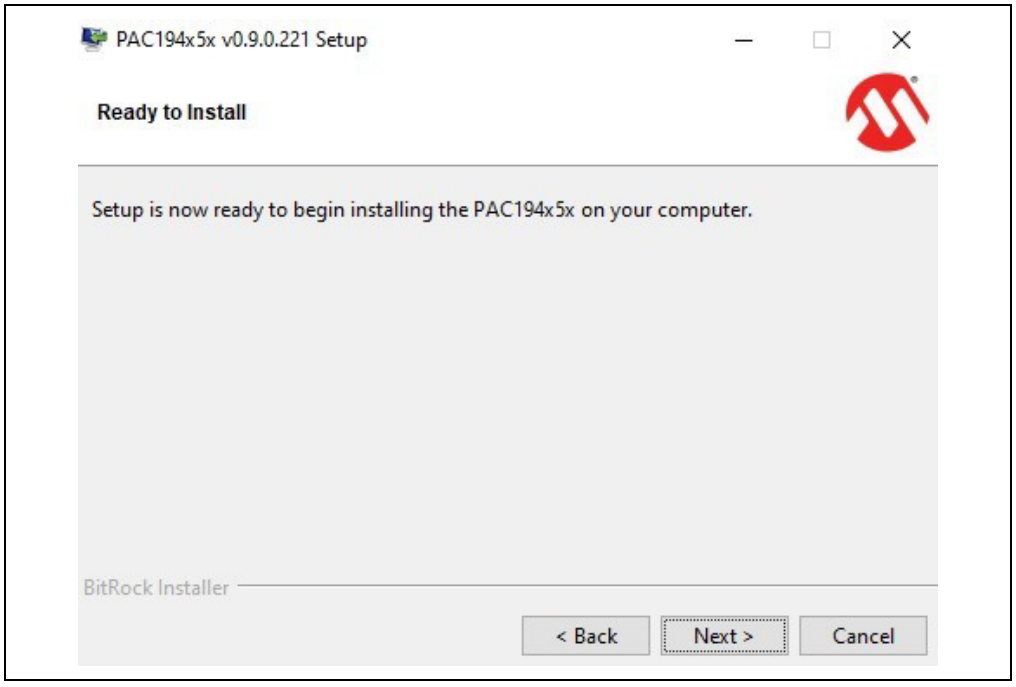
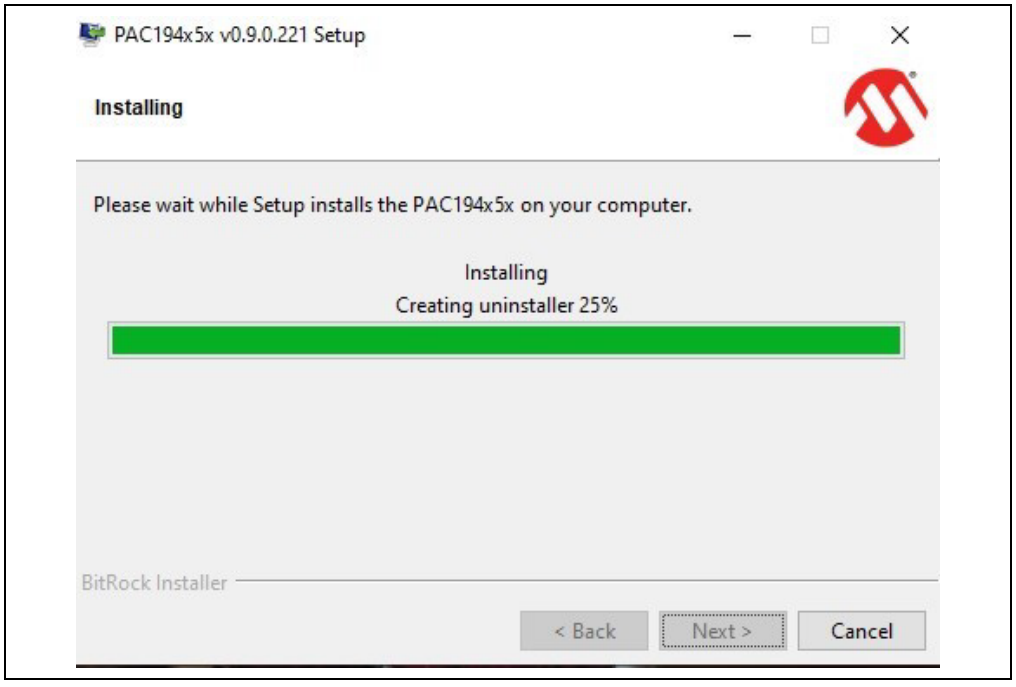
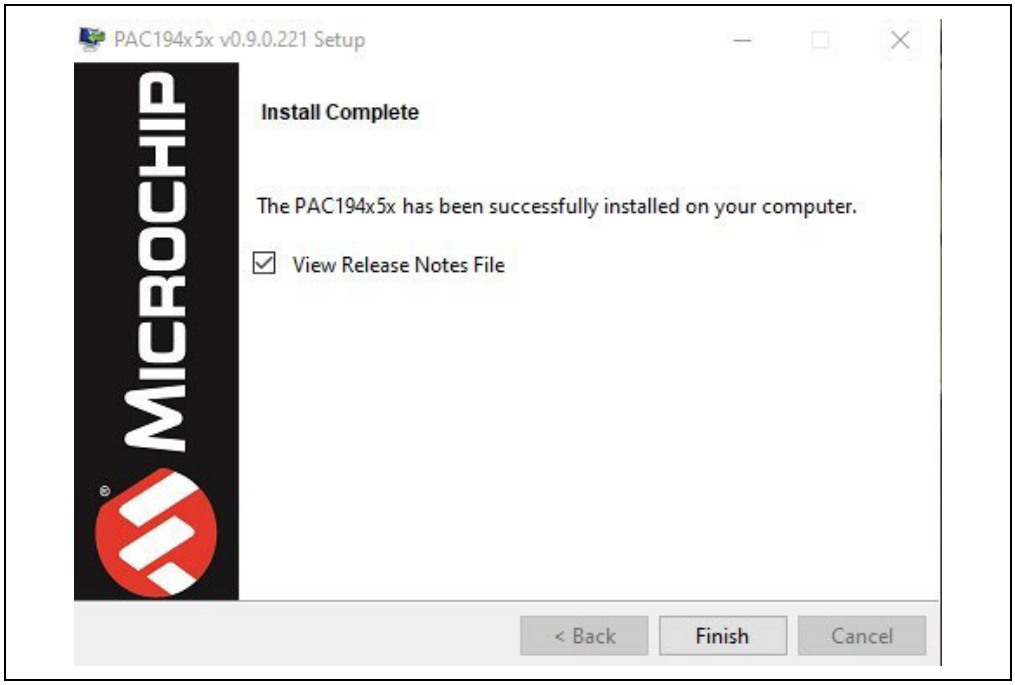


FIGURE 2-5: PAC194X DEMO APPLICATION – INSTALLATION PROGRESS SCREEN



8. As soon as the setup finishes installing, the Installation Complete screen appears (Figure 2-6). The PAC194x Demo Application is now installed and ready to use. Click **Finish** to exit the setup.

FIGURE 2-6: PAC194X DEMO APPLICATION – INSTALLATION COMPLETE SCREEN



NOTES:

Chapter 3. GUI Description and Operation

3.1 INTRODUCTION

This chapter describes how to operate the PAC194x Demo Application. Items discussed in this chapter include:

- First Launch
- PAC194x Demo Application GUI Description
- PAC194x Demo Application GUI Operation

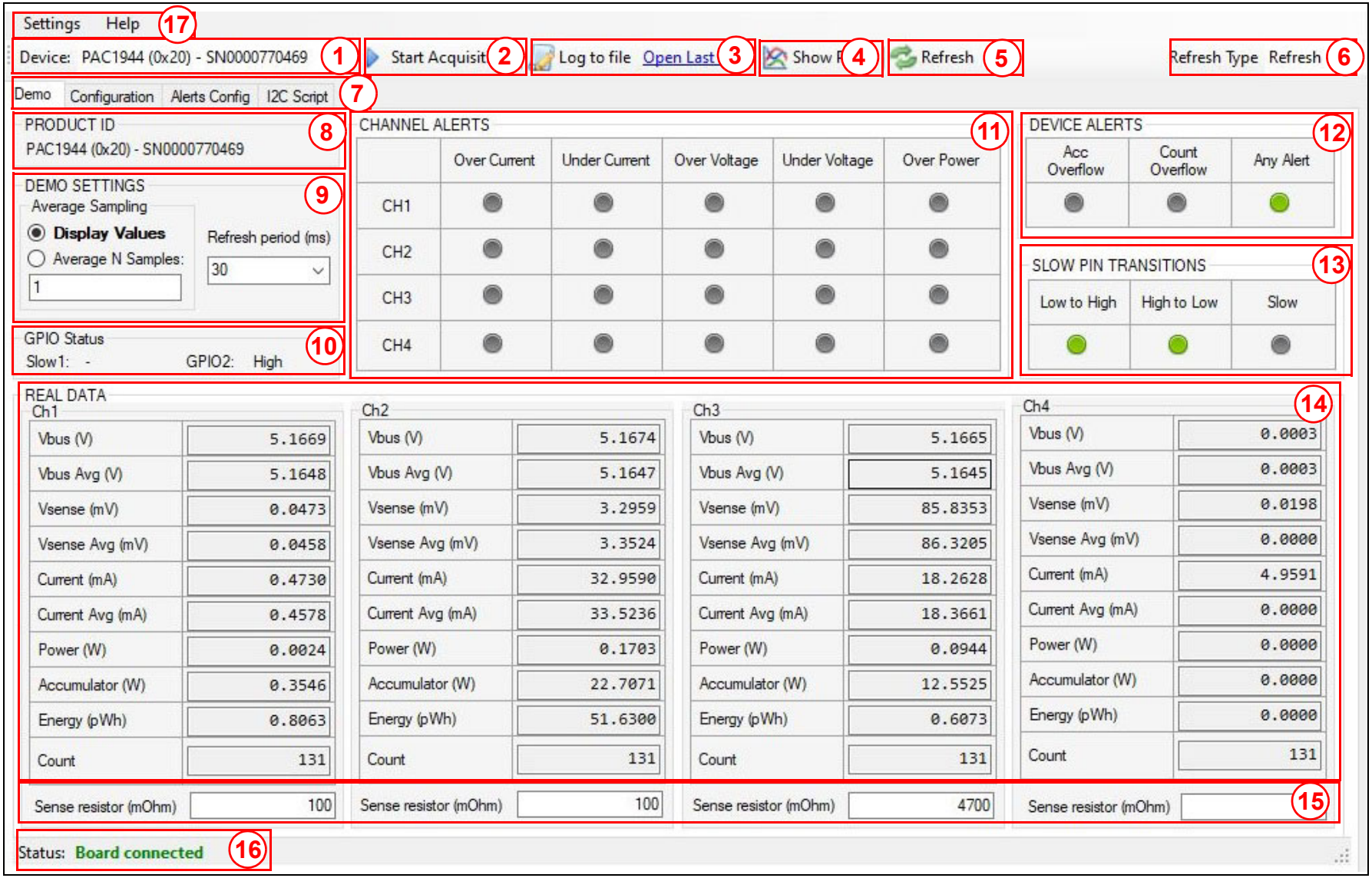
3.2 FIRST LAUNCH

Launch the PAC194x Demo Application. Connect the PAC1944 Evaluation Board to the computer with the provided USB cable and ensure that the Jumper 101 is shorted (I_{VDD} jumper) and that the SW300 is switched to Bridge, while SW302 is switched to Extern. Once everything is connected, LED activity can be seen on the board:

- D301: Red LED for +5V USB power from the USB connection
- D300: Green LED shows I^2C activity from the USB bridge

3.3 PAC194X DEMO APPLICATION GUI DESCRIPTION

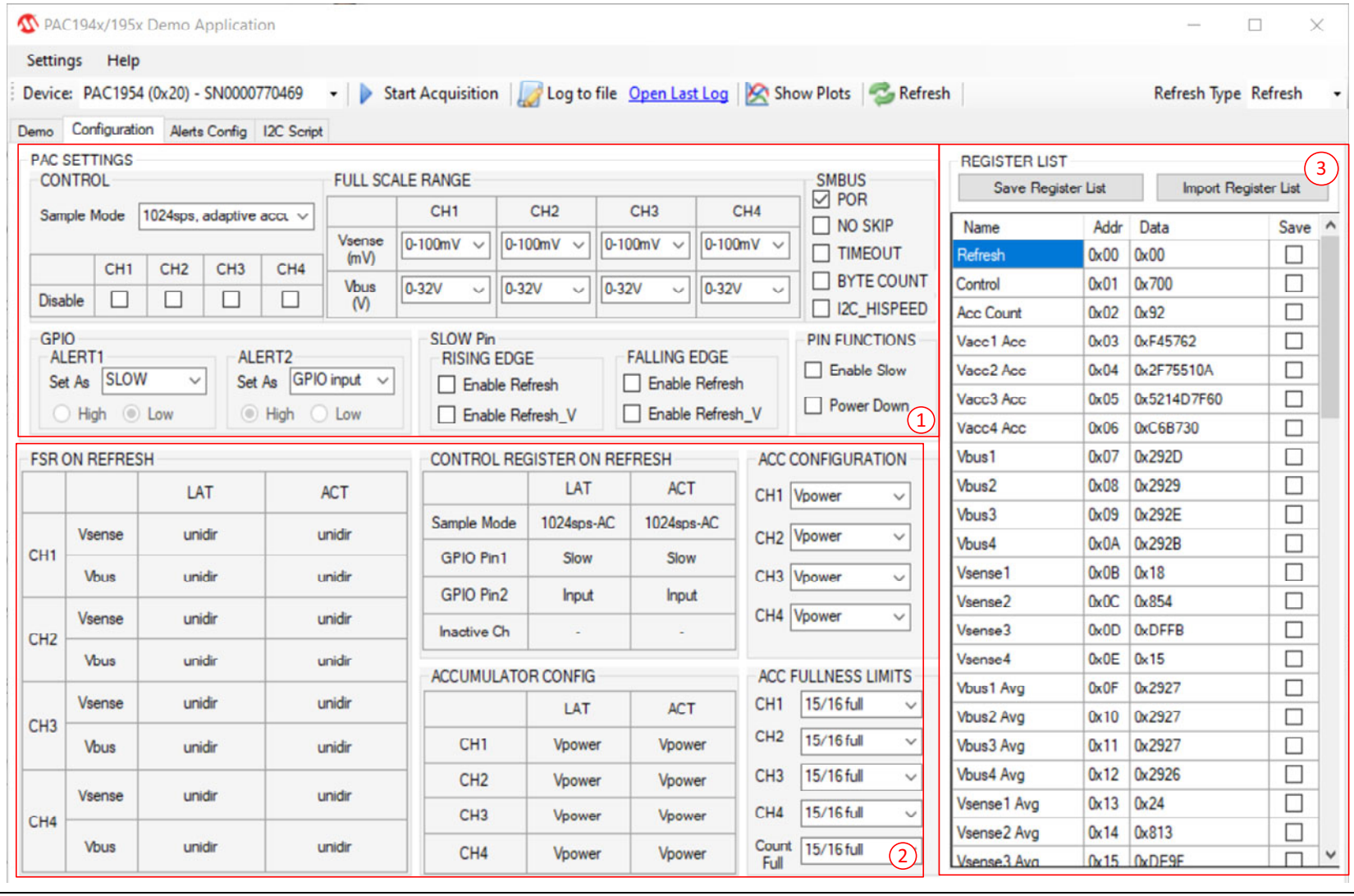
FIGURE 3-1: PAC194X DEMO APPLICATION GUI – MAIN PAGE (DEMO TAB)



All the sections of the PAC194x Demo Application's Main Page (Demo tab) are identified with a number in Figure 3-1 and are detailed below.

1. Device: shows the device currently connected to the PC. If multiple devices are connected, the GUI reads all of them and the user can control each one via the Demo screen. The user can choose the device from this section.
2. **Start Acquisition** button: clicking it starts the data logging function. Once started, the button changes to **Stop Acquisition** and clicking it ceases the data logging process.
3. **Log to File** / **Open Last Log** button: clicking **Log to File** saves the logging to a CSV file. Data is only collected while the Acquisition process is running. Clicking **Open Last Log** opens the last saved CSV file, as configured in the user's system.
   The user can stop the logging process at any time.
4. **Show Plots** button: clicking it opens the Visualization window. The user can have more than one window open at the same time, with different registers selected.
5. **Refresh** button: clicking it refreshes based on the selected Refresh Type from the drop-down menu (6).
6. Refresh Type drop-down menu: the user can choose between the three refresh types (Regular, Global and V). The change can be made during the Acquisitions process.
7. Tabs for various setups, including current data values, register setup, alert setup or manual I^2C commands.
8. Product ID section: displays device information, I^2C address and the serial number for the MCP2221A device.
9. Demo Settings: this section controls how fast the SW requests data and how long the data in Plots is displayed.
   The user can use the **Display Values** radio button to show the 8x averaged values in the V_{SENSE} Avg and V_{BUS} Avg fields from section 14.
   The user can also select the **Average N Samples** radio button and change its value in order to use software averaging.
10. GPIO Status: this section shows the status of the selected GPIO pins as Input or Output. It also displays the configuration for Alerts or Slow functionality.
11. Channel Alerts: this section is the visual display of the status of all the channel-specific alerts, set up in the Alerts Configuration tab (Figure 3-3).
12. Device Alerts: this section is the visual display of the accumulator alerts and global alerts.
13. Slow Pin Transitions section: shows the status of the Slow pin and if it has been asserted or not
14. Real Data: this section displays all the data associated with each channel.
15. Sense Resistor section: displays the values of the resistors used for calculating current.
16. Status: this section displays if any board is connected to the PC.
17. Settings and Help pull-down menus. The Settings menu contains the Demo Board Settings, the Channel Renaming option and the Voltage Ratios configuration. The Help menu provides the software version number and the terms of compliance. See Figure 3-5 for more details.

FIGURE 3-2: PAC194X DEMO APPLICATION GUI – CONFIGURATION TAB



All the sections of the PAC194x Demo Application's Configuration tab are identified with a number in Figure 3-2 and are detailed below.

1. PAC Settings: this section displays various settings such as I/O type, Disable Channels, Unidirectional or Bidirectional, etc. Consult the PAC194x/PAC195x Data Sheet for the operations.
   a) Pin Functions selectors are used to control the MCP2221A GPIO that are connected to both the Slow pin and the Power Down pin. Checking the box on either sets the MCP2221A to assert logic high on the pins. Unchecked GPIOs are set as inputs.
2. This section provides settings for Latch, Actual status and Accumulator configuration.
3. Register List: this section contains the current setting for each register. The registers can be saved to a CSV file and reloaded at a later time.
   a) Right-clicking the **Save Register List** button allows the user to Select All or Deselect All registers.
   b) Each writable register can be modified by clicking the data text field of that register and changing the value.

Note: The GUI loads the register values from the device when connected via USB. The customized settings from the Register List section (3) overwrite the default GUI ones. A reload of the registers is necessary for a specific setup of the registers.

Disabling channels in the Configuration tab and then choosing Fast or Burst speeds up the device operation on the enabled channels. However, the MCP2221A device cannot support the data rate, so, while the chip is operating at a higher speed, the user is not able to get each sample out with the on-board bridge. Microchip intends to develop a hardware solution that allows for higher speed communication to support the Fast and Burst mode options.

While in the Configuration tab, an automatic Refresh occurs after any selection. The user can see the GUI change the LAT/ACT values after applying any setting.

FIGURE 3-3: PAC194X DEMO APPLICATION GUI – ALERTS CONFIGURATION TAB

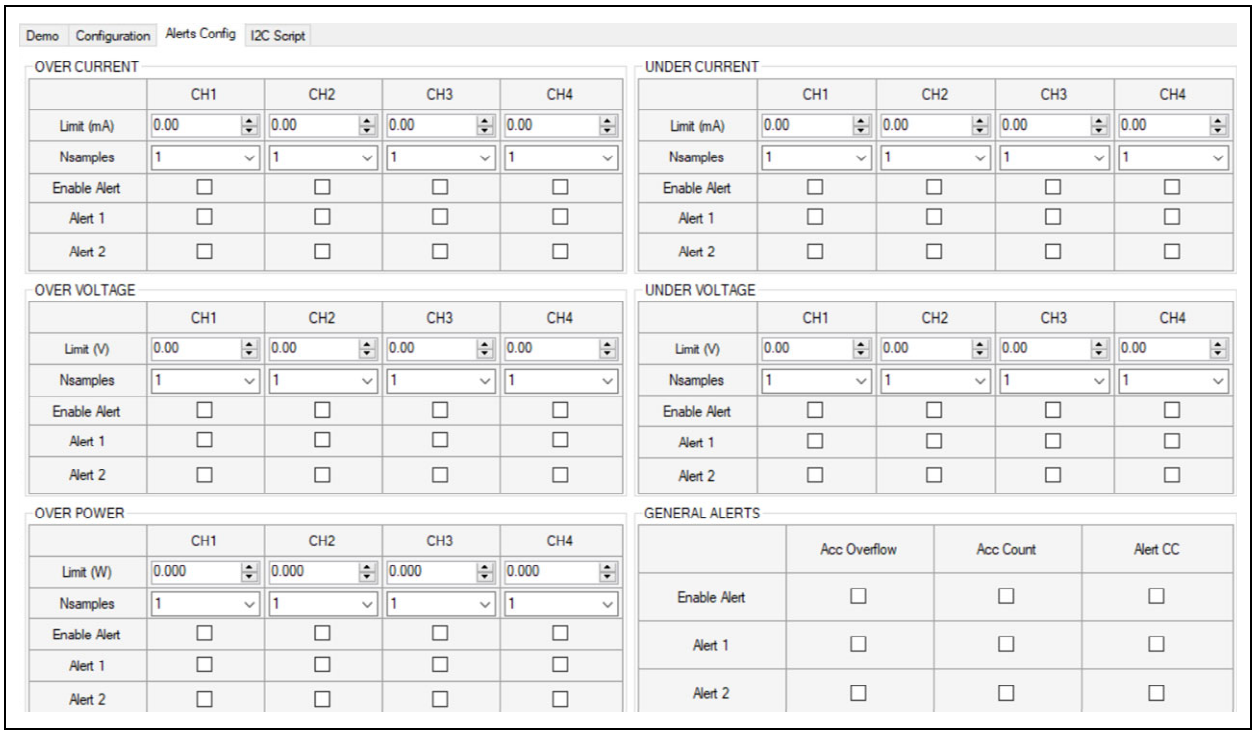


Figure 3-3 displays the Alerts Configuration tab. The user can set the limit for the desired alert in this section. The limits are measured in milliamperes for Current, volts for V_{BUS} and watts for Power. The user can also select the number of consecutive failures before the alert occurs (1,4, 8 or 16).

When the alert is enabled, the light on the Demo tab (Figure 3-1) turns green. The light turns red when the limit is exceeded. By selecting the Alert 1 or Alert 2 check boxes, the user can choose the pin the alert appears on. Any combination is allowed. The alert is still noted in the Alerts Status register even if no alert pins are selected.

The general alerts for Accumulator Overflow, Count and Conversion Complete can also be enabled from this tab.

FIGURE 3-4: PAC194X DEMO APPLICATION – I²C SCRIPT TAB

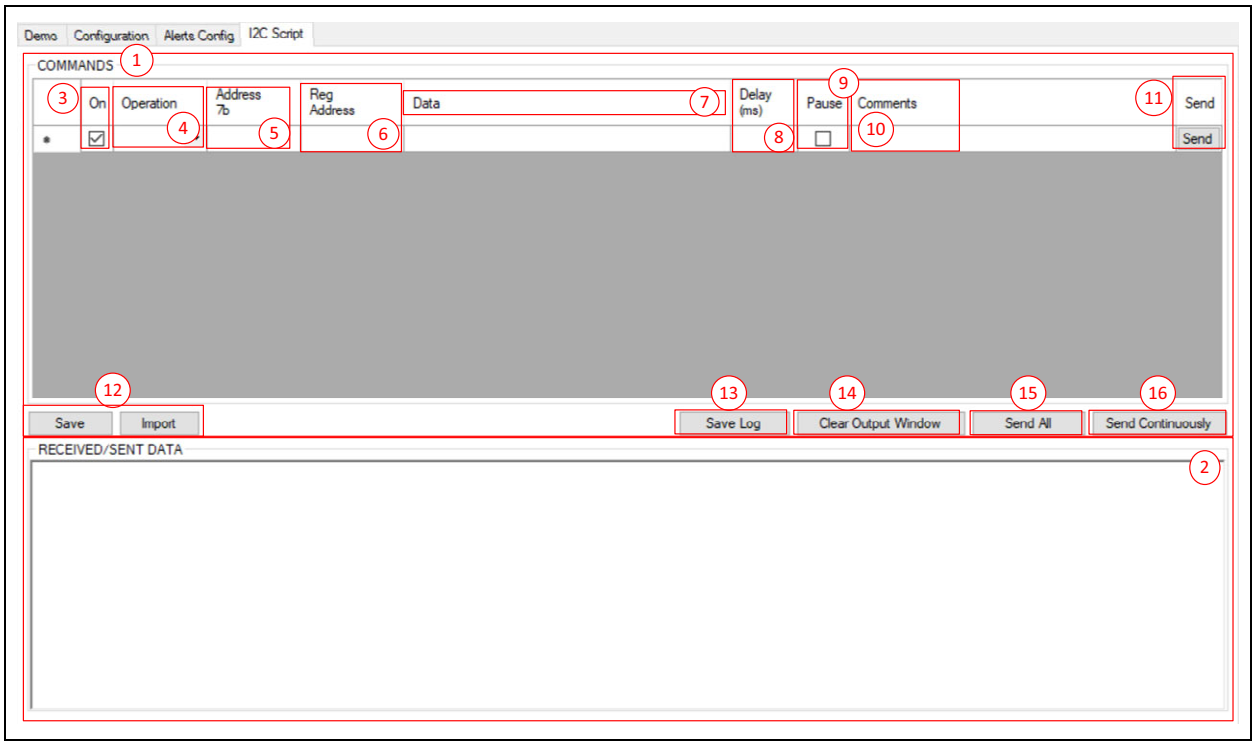
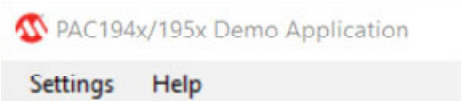


Figure 3-4 shows the sections of the I²C Tab, each marked by a number. They are detailed below.

1. Commands: this section contains all the commands to be sent to the device.
2. Received/Sent Data: displays the sent and received data from the IC.
3. ON check box: when the box is checked, a command is sent to the device. When the box is cleared, no commands are sent.
4. Operation: this can be either Read or Write. A Send option is available when the Data section (7) is clear.
5. Address 7b: I²C address is in 7-bit format.
6. Reg Address: displays the device register address.
7. Data: for Read, it contains the number of bytes that are returned; for Write, it contains the data to be written. The user must add a comma between bytes for multi-Write byte sequence.
8. Delay: this is displayed in milliseconds (delays are approximated).
9. Pause check box: when the box is checked, a dialog box pops up and commands are paused until the **OK** button is clicked.
10. Comments: the user can manually input comments.
11. **Send** button: when clicked, a single line is sent.
12. **Save/Import** buttons: clicking the **Save** button saves the commands from the Command section above it (1). Clicking the **Import** button opens a previously-saved set of commands.
13. **Save Log** button: clicking this button saves the data from the Received/Sent Data section (2).
14. **Clear Output Window** button: clears the Received/Sent Data section.
15. **Send All** button: sends all the commands from the Commands section (1) in consecutive order.
16. **Send Continuously** button: clicking this button sends all the commands from the Commands section continuously, until manually stopped.

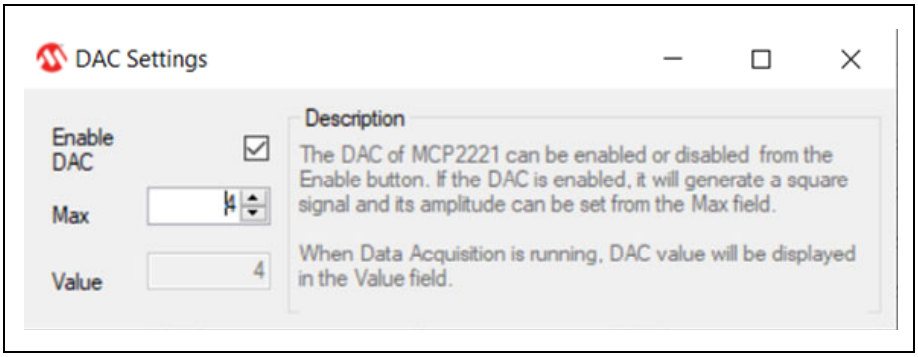
FIGURE 3-5: PAC194X DEMO APPLICATION – TOP MENU BAR



The Settings and Help menus can be accessed from the top-left corner of the PAC194x Demo Application GUI (noted in Figure 3-1 with the number 17). Clicking either Settings or Help displays a pull-down menu with various options.

1. **Settings Pull-Down Menu**
   a) DAC Settings: selecting this option opens a pop-up window. This window is used while in Demo Configuration tab (Figure 3-2), in order to control an on-board field-effect transistor (FET). The FET produces a pulsed-current waveform. The DAC Settings window provides the user with the option to enable or disable the DAC output on the MCP2221A device; the amplitude is determined by the value in the Max text field (see Figure 3-6).
   b) Rename Channels: selecting this option opens a pop-up window, in which the user can change the name of a channel from "Ch1" to "Ch1 - *Text*". The new name becomes visible in the Demo tab along with the plots.
2. **Help Pull-Down Menu**
   a) About: contains the software version number and the Microchip base warranty information.
   b) User's Guides: opens up this document to provide easy access to this guide.

FIGURE 3-6: PAC194X DEMO APPLICATION – DAC SETTINGS POP-UP WINDOW



3.4 PAC194X DEMO APPLICATION GUI OPERATION

3.4.1 Demo Plots

Click the **Show Plots** button (marked in Figure 3-1 by the number **4**) to open the Demo Plots Menu Window.

FIGURE 3-7: DEMO PLOT WINDOW – SINGLE CHART, SINGLE PLOT

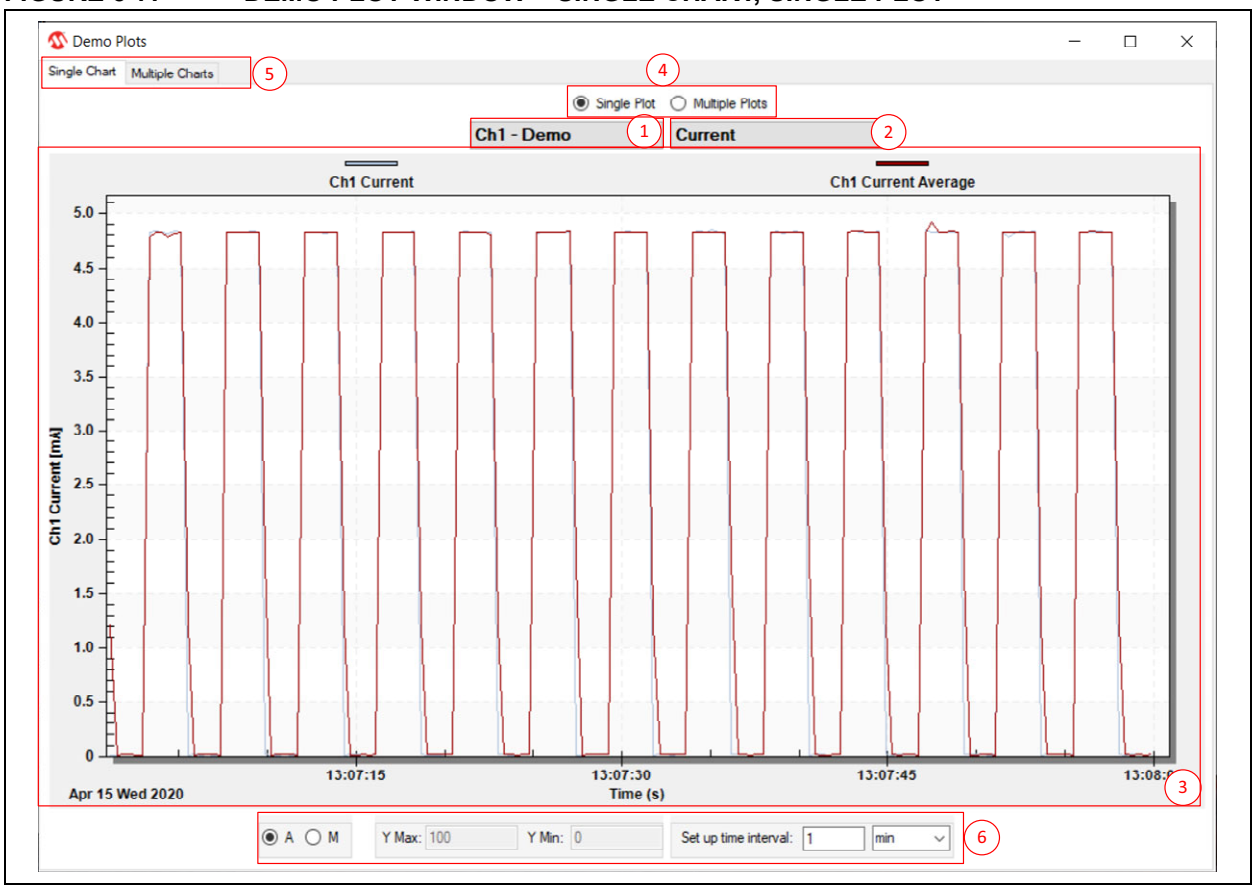


Figure 3-7 represents an example of what a single chart with a single plot looks like. Each section in Figure 3-7 is marked by a number and is explained below.

1. Channel Selection: this drop-down menu allows the user to choose between Ch1 through Ch4.
2. Register Selection: this drop-down menu allows the user to choose between Count, V_{BUS}, V_{SENSE}, Current, Power, Accumulator and Energy.
3. Data Display: this section is the visual representation of the chosen data.
4. Plot Style Selection: by clicking the radio buttons, the user can select between Single Plot style or Multiple Plot style (multiple channels on each plot).
5. Chart Selection tab: by selecting each tab, the user can switch between one chart or multiple charts in one window.
6. Plot Controls: this section provides the user with the option to choose between manual and automatic, set Y-axis values and set the time base from seconds to hours.

FIGURE 3-8: DEMO PLOT WINDOW – SINGLE CHART, MULTIPLE PLOTS

Figure 3-8 represents an example of what a single chart with multiple plots looks like. Each section in Figure 3-8 is marked by a number and is explained below.

1. Register Selection: this drop-down menu allows the user to choose between Count, V_{BUS}, V_{SENSE}, Current, Power, Accumulator and Energy.
2. Data Display: this section is the visual representation of the chosen data.

FIGURE 3-9: DEMO PLOT WINDOW – MULTIPLE CHART, SINGLE PLOT

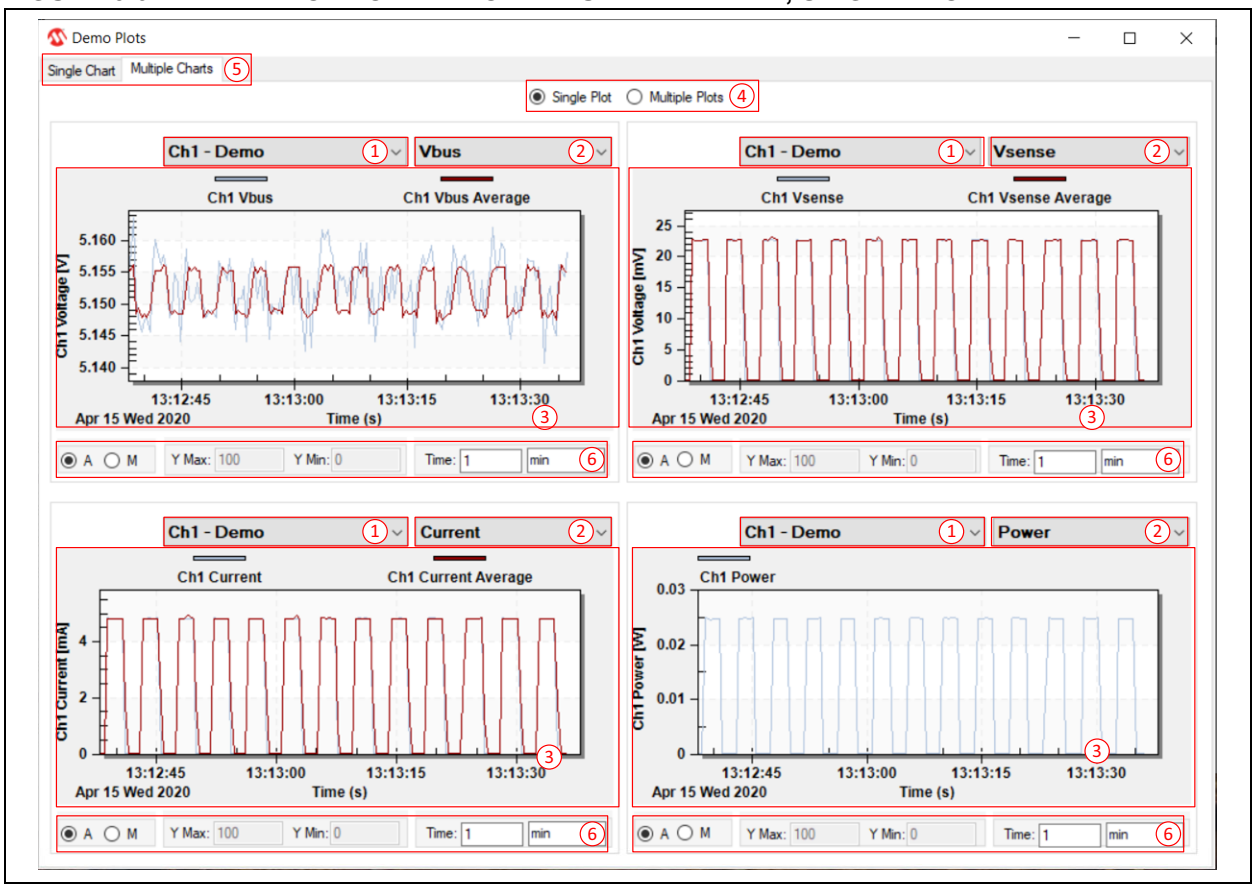


Figure 3-9 represents an example of what multiple charts with a single plot look like. Each section in Figure 3-9 is marked by a number and is explained below.

1. Channel Selection: this drop-down menu allows the user to choose between Ch1 through Ch4.
2. Register Selection: this drop-down menu allows the user to choose between Count, V_{BUS}, V_{SENSE}, Current, Power, Accumulator and Energy.
3. Data Display: this section is the visual representation of the chosen data.
4. Plot Style Selection: by clicking the radio buttons, the user can select between Single Plot style or Multiple Plot style (multiple channels on each plot).
5. Chart Selection tab: by selecting each tab, the user can switch between one chart or multiple charts in one window.
6. Plot Controls: this section provides the user with the option to choose between manual and automatic, set Y-axis values and set the time base from seconds to hours.

FIGURE 3-10: DEMO PLOT WINDOW – MULTIPLE CHART, MULTIPLE PLOTS

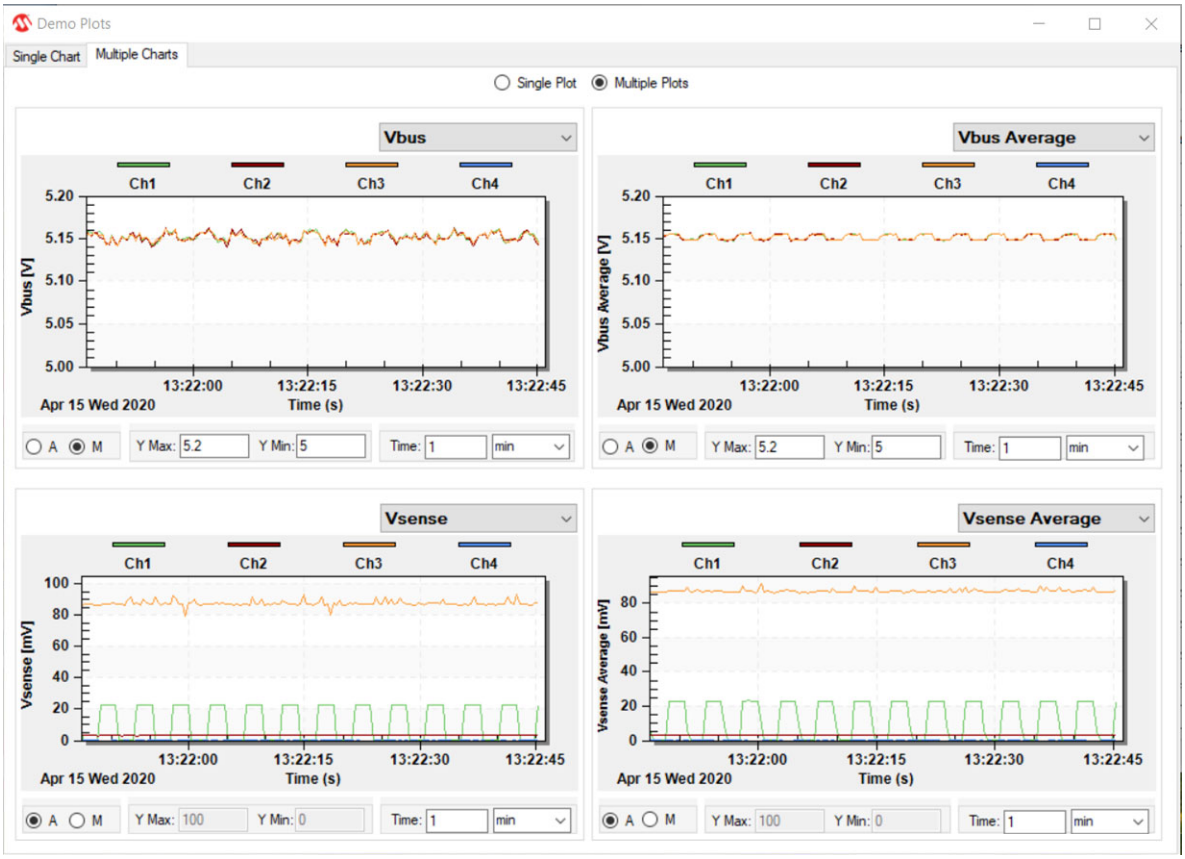


Figure 3-10 represents an example of what multiple charts with multiple plots look like. Sections in Figure 3-10 have the same functions as in Figure 3-9.

3.4.2 Operation Scenarios

3.4.2.1 SCENARIO 1: CHANGING THE SAMPLING RATE/MODE

The PAC1944 device supports multiple sampling rates (8, 64, 256 and 1024 sps) along with variations on accumulation. This scenario covers the changing of the sampling rate settings.

1. In the Configuration tab (Figure 3-2), go to the Sample Mode drop-down menu and select the eighth element, labeled “8 sps”. This triggers a refresh and the ACT register for the Control Register On Refresh now displays 8 sps, while the LAT continues to display the previous setting of 1 ksps.
2. Go back to the Demo tab (Figure 3-1).
3. Click the **Start Acquisition** button to start collecting data at the new rate.

The update can be seen in the count register, as it now has a lower value. The MCP2221A device and GUI collect data approximately 2 times per second. This means that the register now displays a count of 3, as the device is doing 3 samples in the time that the GUI sends the next Refresh command.

3.4.2.2 SCENARIO 2: CHANGING THE TYPE OF REFRESH FROM REGULAR TO REFRESH_V

The PAC1944 device supports 3 Refresh options:

1. Refresh (Regular): this type causes the device to load all changes and become the active setup.
2. REFRESH_G: this type does the same thing as the Regular refresh, but is also a Global Refresh for the bus.
3. REFRESH_V: this type does not reset the count or load registers. Instead, this type of refresh moves the data to the I^2C domain for reading. Changing the refresh type to V allows for the counting to continue upward, while still allowing the user to read out the latest data.

To change the refresh type, access the Refresh Type drop-down menu (Figure 3-1) and select the new option.

Go back to the Demo tab (Figure 3-1) and click the **Start Acquisition** button to start collecting data using the Refresh_V method. This change can also be done while the GUI acquisition is running.

3.4.2.3 SCENARIO 3: SETTING LIMITS AND ALERTS

The PAC1944 device allows for an extended alert functionality. This includes setting limits for Over Current, Under Current, Over Voltage, Under Voltage and Over Power. Each limit can be set per channel and each channel allows the selection of 2 Alert pins (Figure 3-3).

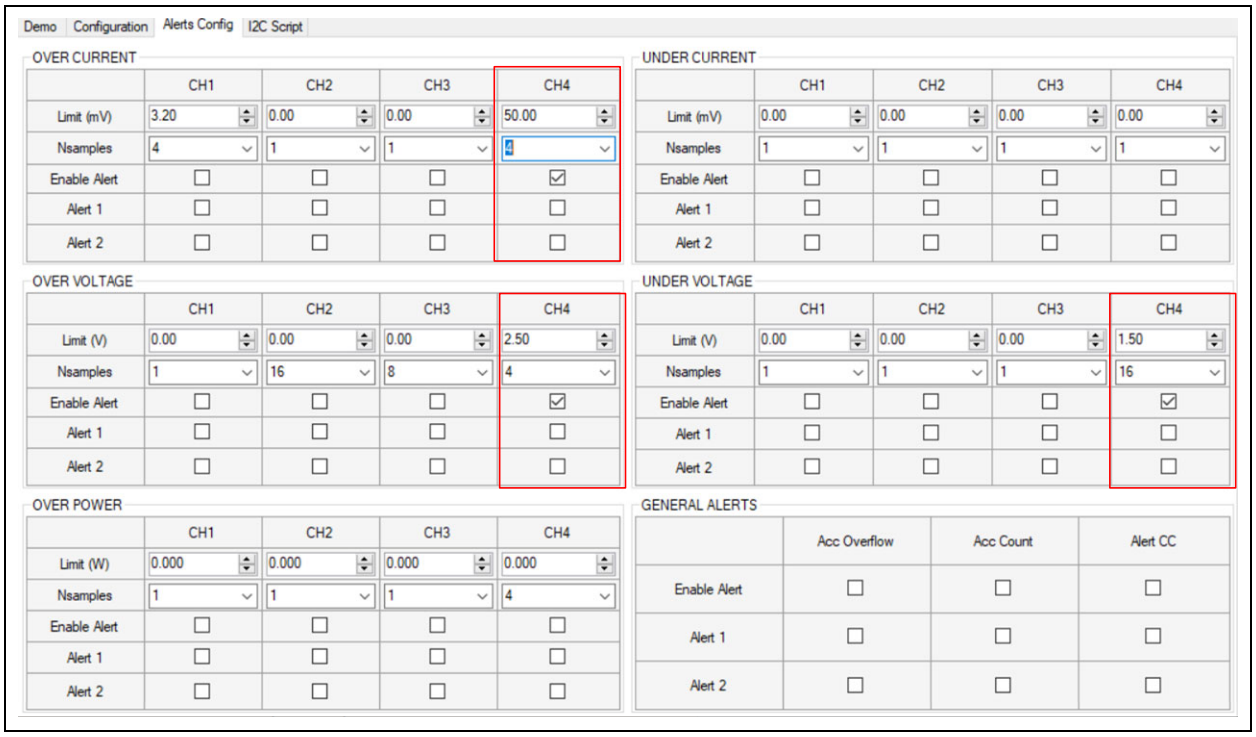
This section covers the process of setting alert limits and demonstrates what happens when one of the channels fails a limit check.

1. Go to the Alerts Configuration tab (Figure 3-3).
2. Modify the variables for Channel 4, following the next example:

- **Over Current**
  - Limit: 50 mV
  - $N_{SAMPLES}$: 4
  - Enable Alert: tick the check box
- **Over Voltage**
  - Limit: 2.5 mV
  - $N_{SAMPLES}$: 4
  - Enable Alert: tick the check box
- **Under Voltage**
  - Limit: 1.5 mV
  - $N_{SAMPLES}$: 16
  - Enable Alert: tick the check box

Check Figure 3-11 for the visual representation.

FIGURE 3-11: ALERTS CONFIGURATION DEMONSTRATION



3. Return to the Demo tab.
4. Apply a voltage of 2V on the SENSE4+ pin.
5. Click the **Start Acquisition** button.
6. Notice that the light for each enabled Channel is now illuminated. If the value of the new data is within the parameters, the color of the light is green (see Figure 3-12).
7. The light under the Any Alert section is also green. This signifies that no alerts are sensed (Figure 3-12).
8. Lower the voltage that is applied to the SENSE4+ to 0.9V. The limit now fails and the lights for Under Voltage and Any Alert turn red (Figure 3-13).

FIGURE 3-12: ALERTS LIGHTS DEMONSTRATION – GREEN

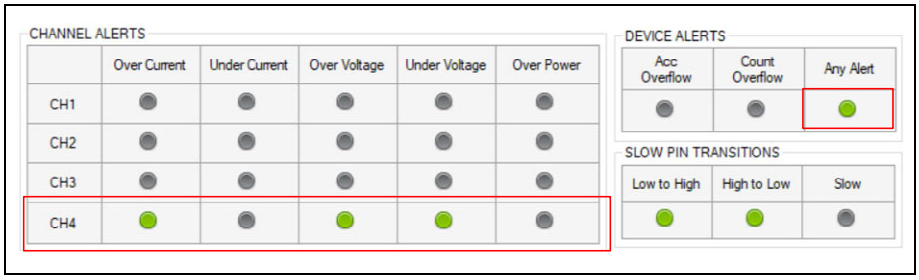
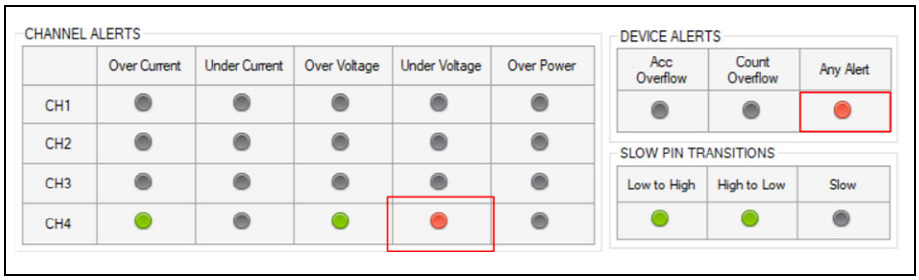


FIGURE 3-13: ALERTS LIGHTS DEMONSTRATION – RED



3.4.2.4 SCENARIO 4: FAST AND BURST OPTIONS

The default sampling rate for the PAC1944 devices is 1024 sps. PAC1944 can sample all 4 channels (and offset correction) at that rate. Reducing the number of channels sampled leads to an increase in the sampling speed for the remaining channels, up to 5120 sps (see the Data Sheet for detailed explanation). However, the MCP2221A cannot support the communication speeds necessary to capture all the data, so an alternative host is required to actually capture it.

To access faster sampling rates and bypass the need for an alternative hosting device, the user can access the Fast and Burst commands by following the next steps:

1. Go to the Configuration tab (Figure 3-2).
2. Click the Sampling Mode drop-down menu and select Fast.
3. Disable Ch2, Ch3 and Ch4.
4. This enables the sampling rate to run at 2560 sps.
5. Select the Burst option from the Sampling Mode drop-down menu, in order to sample at the full 5120 sps rate.
6. Click the Start Acquisition button when ready to begin sampling at the new rate.

NOTES:

Chapter 4. Hardware Description

4.1 INTRODUCTION

The PAC1944 device (U1) is placed at the center of the PAC1944 Evaluation Board, in a quad flat no-lead package (QFN), with wettable flanks. It is surrounded by probe points with labeled pin names. A provision for input filter for each pair exists on input pins, but they are not populated. Other pieces of hardware on the board are described in this chapter.

4.2 DEFAULT CONNECTIONS

The USB port is at the top, marked by J301 in Figure 4-1. The default (as shipped) position of the shorting shunts connecting the different pin pairs is marked by J101. SW301 must be set to the Bridge position for USB communication to work properly. SW302 must be switched to Extern for initial evaluation. A jumper should be on J101 for operation.

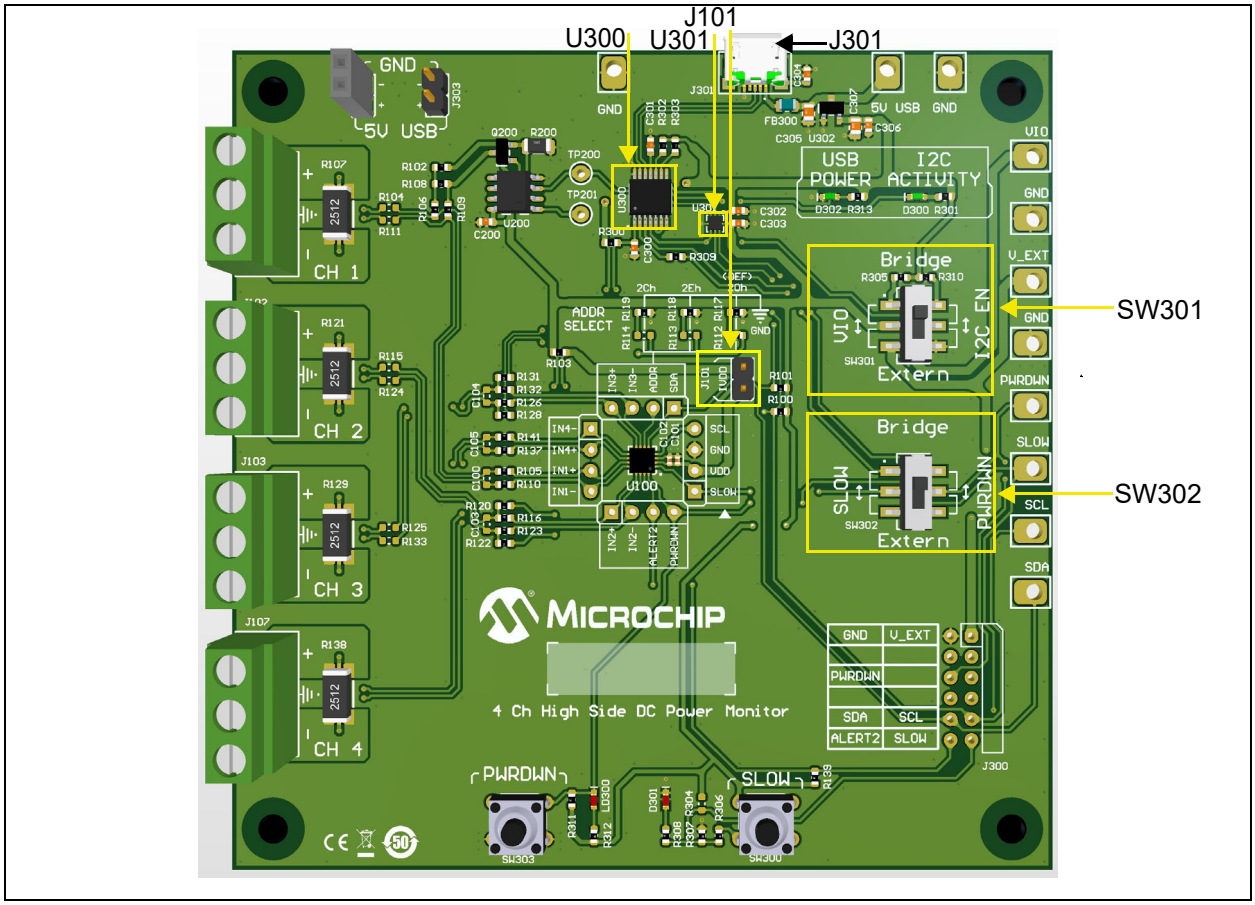


FIGURE 4-1: *PAC1944 Evaluation Board – Top View.*

4.3 HARDWARE FOR I²C/SMBUS COMMUNICATION OVER USB OR EXTERNAL I²C CONNECTION

The MCP2221A is a USB-2 to I²C bridge chip that translates the USB communications into I²C read/write commands and is marked in Figure 4-1 by U300. U300 is used to configure the PAC1944 device and to capture status and data results. To the left of U300 is U301, a level shifter that matches the I²C signals from the MCP2221A to the VIO voltage.

The SW301 switch and J302 connector (Figure 4-1) are both used when attaching an external I²C bridge directly to the PAC1944 Evaluation Board instead of using the USB port. J302 allows the user to connect the external VIO, SCA and SCL signals directly to the PAC1944 device. SW301 disables the USB bridge and level shifter and connects the pull-up resistors on SCA and SCL pins to the external VIO voltage.

The SW302 switch is used to select the SLOW and POWERDOWN pins to either the MCP2221A (bridge selection) or the J302 (extern selection).

4.4 DEMO MODE AND EVB MODE

The PAC1944 Evaluation Board is designed for easy demonstration or evaluation of the 4 channel inputs. In Demo mode, the inputs are connected to different Sense resistors, compared to the EVB mode.

Table 4-1 shows the channel configuration for each mode.

TABLE 4-1: DEMO VS. EVB SENSE RESISTOR VALUES

Channel	Demo	EVB (Headers)
1	R108 = 4.7Ω (Demo signal)	R107 = 4 mΩ
2	R103 = 10Ω (IVDD PAC device)	R121 = 4 mΩ
3	R300 = 10Ω (IVDD MCP2221 device)	R129 = 4 mΩ
4	R138 = 4 mΩ	R138 = 4 mΩ

The Sense resistors are connected to the Headers at the edge of the board, labeled Ch1 (J100), Ch2 (J102), Ch3 (J103) and Ch4 (J107). Ch4 is connected to the Header in both the Demo and EVB configurations. Note that the center pin for each Header is Ground to allow easy testing but it is not required to be used.

To switch between Demo mode and EVB mode, 0Ω resistors should be populated as presented in Table 4-2.

TABLE 4-2: DEMO VS. EVB SETUP PER CHANNEL

Channel	Demo	EVB
1	R106 and R109 populated	R106 and R109 not populated
	R104 and R111 not populated	R104 and R111 populated
2	R120 and R122 populated	R120 and R122 not populated
	R115 and R124 not populated	R115 and R124 populated
3	R128 and R131 populated	R128 and R131 not populated
	R125 and R133 not populated	R125 and R133 populated
4	No Change	No Change

Figure 4-2 and Figure 4-3 show the configurations for the Demo and EVB setups.

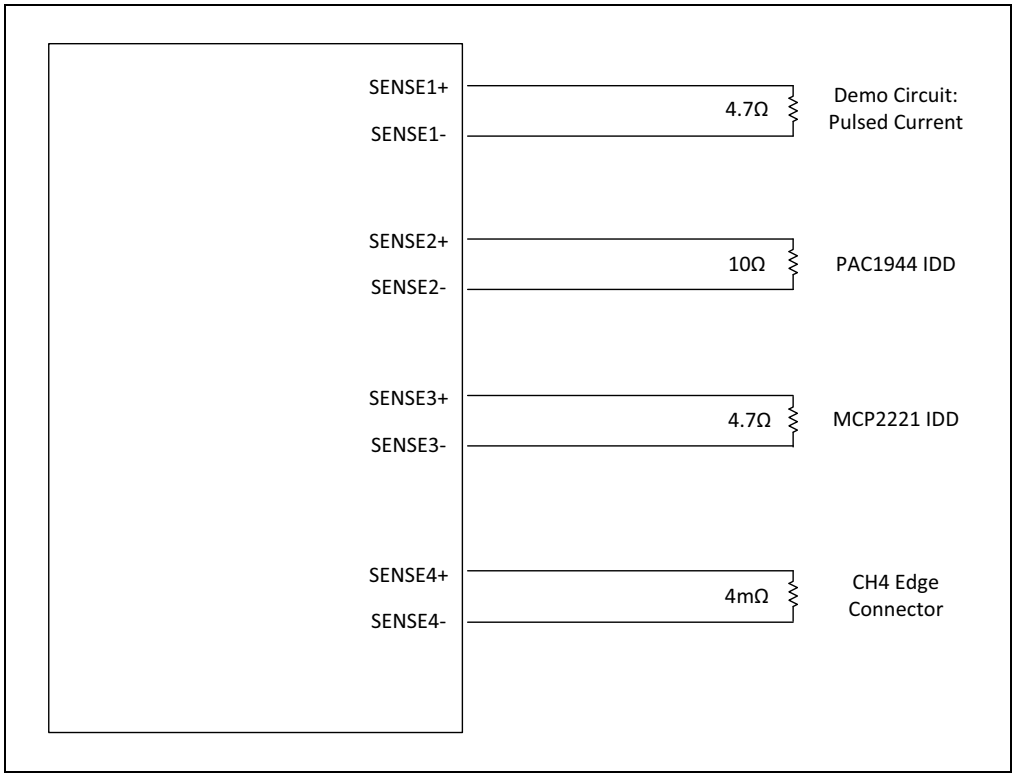


FIGURE 4-2: *Demo Configuration.*

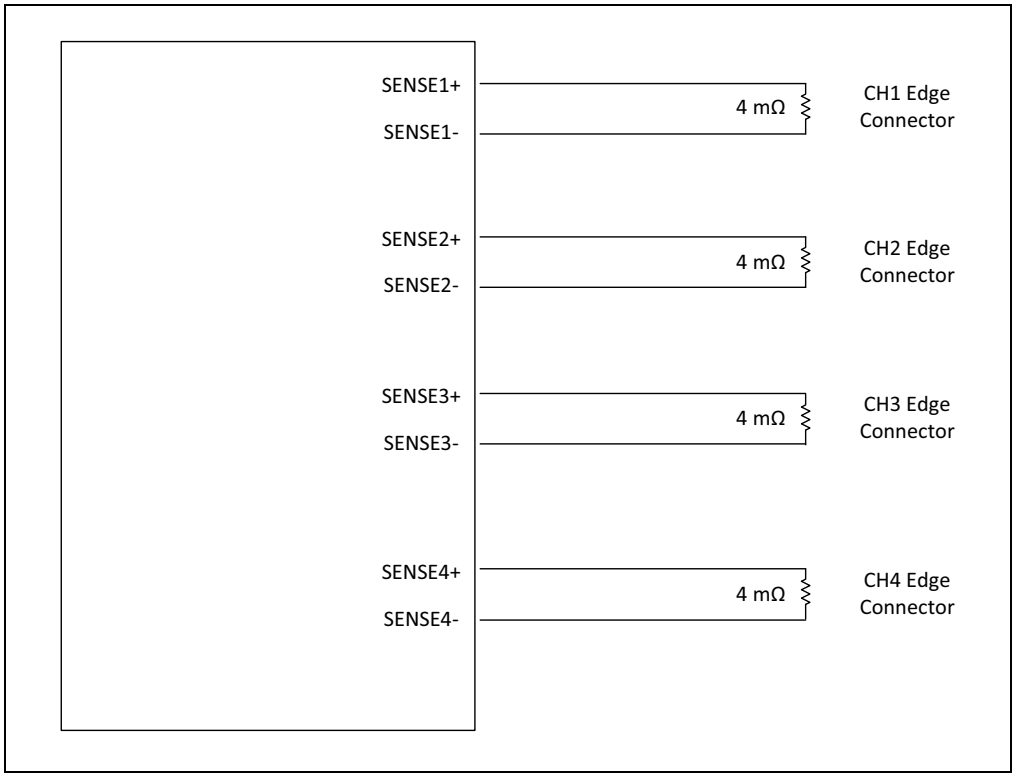


FIGURE 4-3: *EVB Configuration.*

4.5 V_{BUS} AND V_{SENSE} CONNECTIONS – USING EXTERNAL SOURCES FOR SYSTEM MODE

To use external sources for V_{BUS} with an external load, the PAC1944 Evaluation Board needs to be in EVB mode. The center terminal of each connector is attached to Ground for a convenient return load. Each PAC1944 channel has an on-board current Sense resistor of 4 mΩ connected between the positive (+) input and negative (-) input pins, which gives 25A for the full-scale current (V_{SENSE} FSR is fixed at 100 mV).

The 4 mΩ Sense resistors can be unsoldered and replaced with a different value at any time. The 4 mΩ Sense resistors have a very wide metal piece at each end connected to the 1 and 3 terminals of the connector block. This makes it is challenging to remove them cleanly. Removing them reveals a layout that facilitates the soldering of the metal end of the Sense resistor to a kelvin connection of the PAC1944 device. Both the wide metal piece of the connector block and the kelvin connection need to be soldered to the new Sense resistor.

4.6 ADDRESS SELECTION

The PAC1944 device can have up to 16 different I^2C addresses based on the resistor connected to the ADDR_SEL pin (see the PAC194x/PAC195x Data Sheet) to select up to 4 different addresses. The default resistor setup is grounded, which results in an address of 20h (10h for 7-bit address). Table 4-3 is used to determine which hardware setting results in which address.

TABLE 4-3: ADDR_SEL PIN SETTINGS

Setup	R112	R113	R114	8-bit Address
1	POP	DNP	DNP	20h (Default)
2	DNP	POP	DNP	2Eh
3	DNP	DNP	POP	2Ch
4	DNP	POP	POP	2Ah
Generic	DNP	DNP	DNP	Various: Connect desired resistor to ADDRSEL test point, then connect to Ground.

4.7 SIGNAL DESCRIPTION IN DEMO MODE

In DEMO mode, the signals measured are:

1. Channel 1: Demo signal – 4.7Ω Shunt
   a) A pulsed waveform using the DAC to control the current level.
   b) Enable the DAC and change the value to 1.0, 2.0,3.0 to see different current levels.
2. Channel 2: PAC1944 IDD – 10Ω
3. Channel 3: MCP2221AA IDD – 4.7Ω
4. Channel 4: External Load – 4 mΩ

All of the plots in Chapter 3. "GUI Description and Operation" are made in the default Demo mode configuration using varied DAC settings.

4.8 ADDITIONAL HARDWARE DETAILS

The J101 jumper can be used with an external meter to measure the IDD. This provides a place to remove the short and insert a current meter to measure the current in the PAC1944 IDD.

4.9 DIRECT EXTERNAL I^2C CONNECTION

The PAC1944 Evaluation Board can be used with direct I^2C control from a PC running Windows, Linux or other digital controller. VIO can require a different voltage for external I^2C use, than the default settings for USB control. This is easily resolved by moving SW301 from the Bridge position (used for USB control) to the Extern position (used for external I^2C control). Connecting the external SCA and SCL signals with the Power (VIO) and Ground is also necessary. PAC194x Demo Application cannot be used with direct I^2C connection.

NOTES:

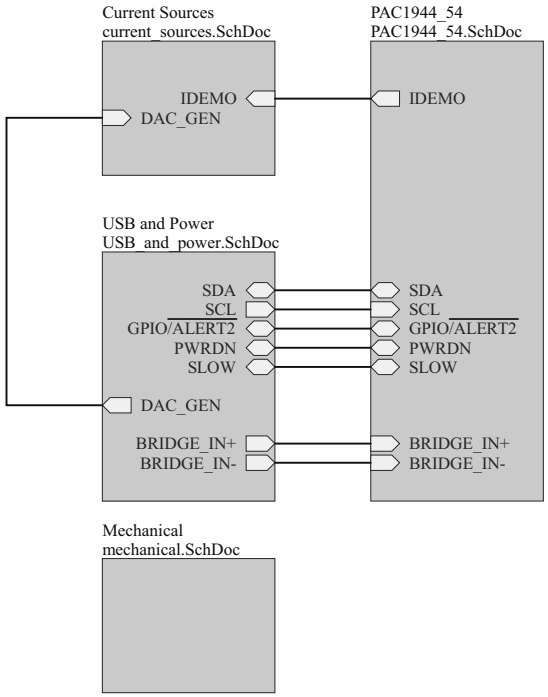
Appendix A. Schematic and Layouts

A.1 INTRODUCTION

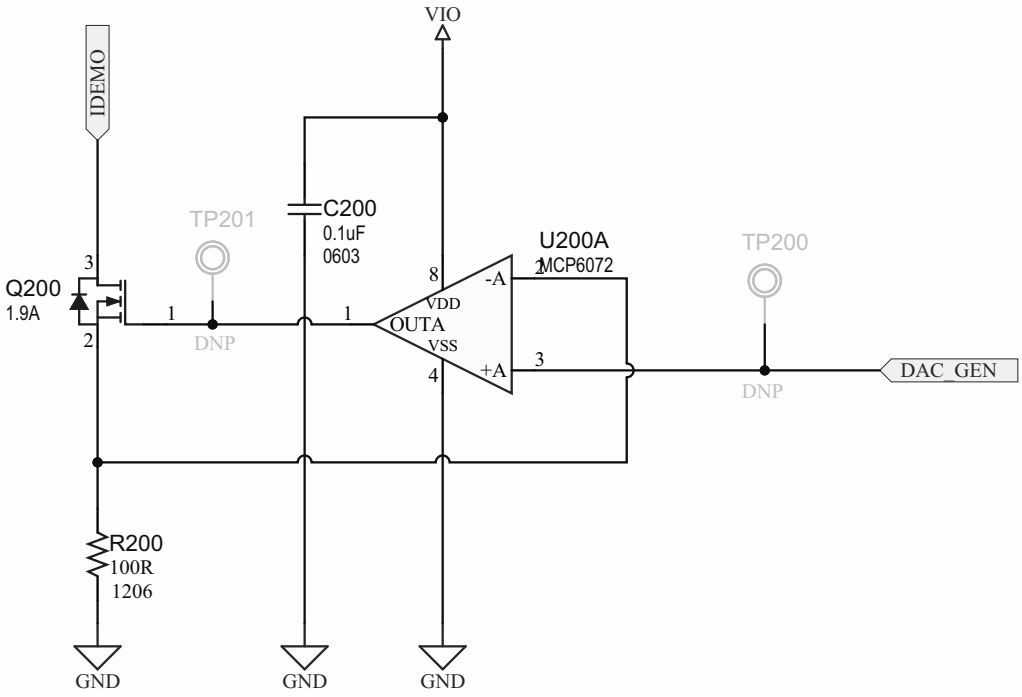
This appendix contains the following schematics and layouts for the PAC1944 Evaluation Board:

- Board – Schematic 1 (Current Sources)
- Board – Schematic 2 (DAC-Controlled Current Generator)
- Board – Schematic 3 (PAC Channel Connections)
- Board – Schematic 4 (PAC IC and Power)
- Board – Schematic 5 (External IC, I2C Pull-Ups and Address Selection)
- Board – Schematic 6 (USB – i2C Bridge)
- Board – Schematic 7 (Bridge/External Selection)
- Board – Schematic 8 (USB Connector With Filtering and Communication Buffering Circuit)
- Board – Schematic 9 (SLOW and PWRDN Stimulation)
- Board – Schematic 10 (External Board Connections and Test Points)
- Board – Top Silk
- Board – Top Copper and Silk
- Board – Top Copper
- Board – Bottom Copper
- Board – Bottom Copper and Silk
- Board – Bottom Silk

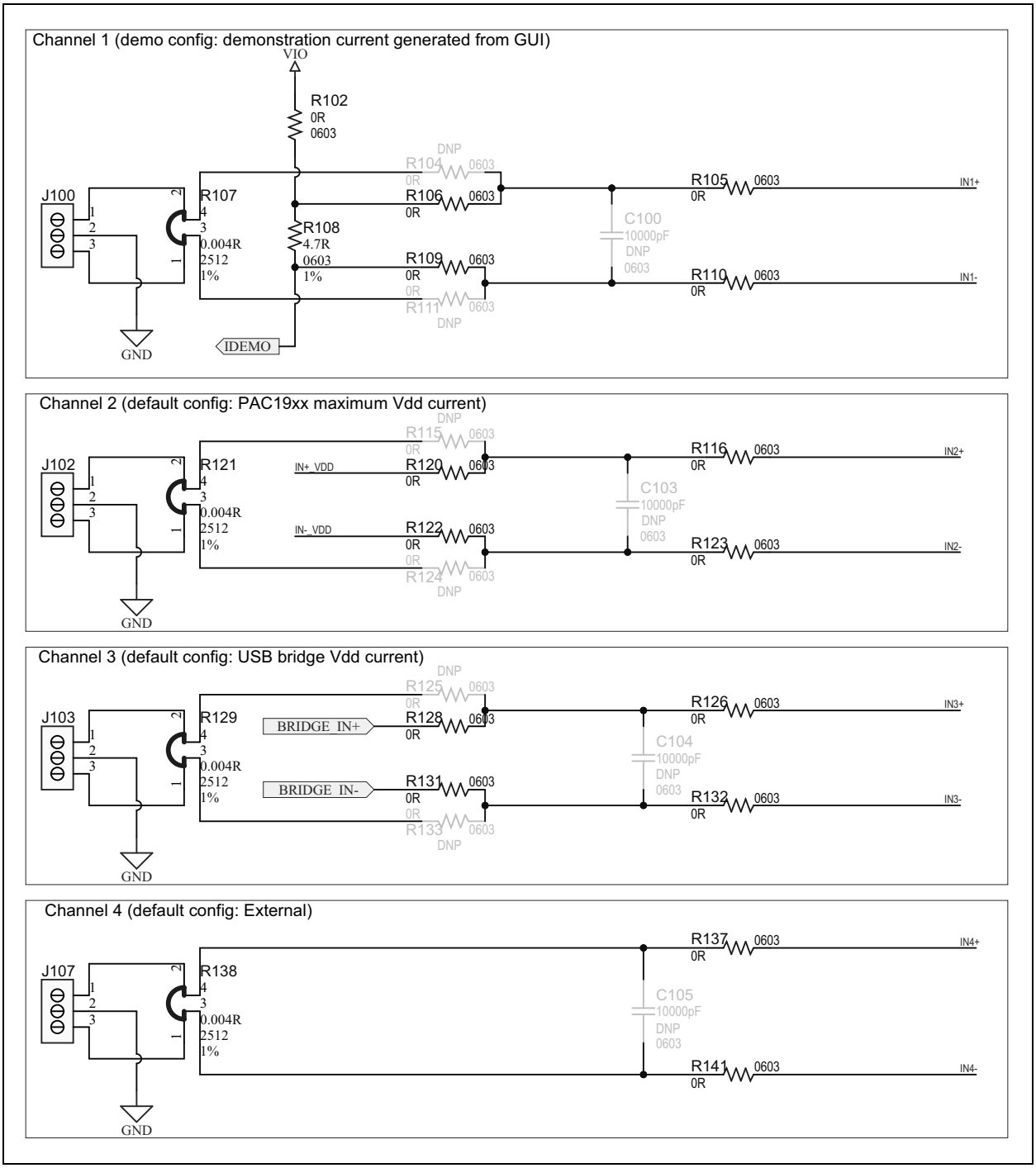
A.2 BOARD – SCHEMATIC 1 (CURRENT SOURCES)



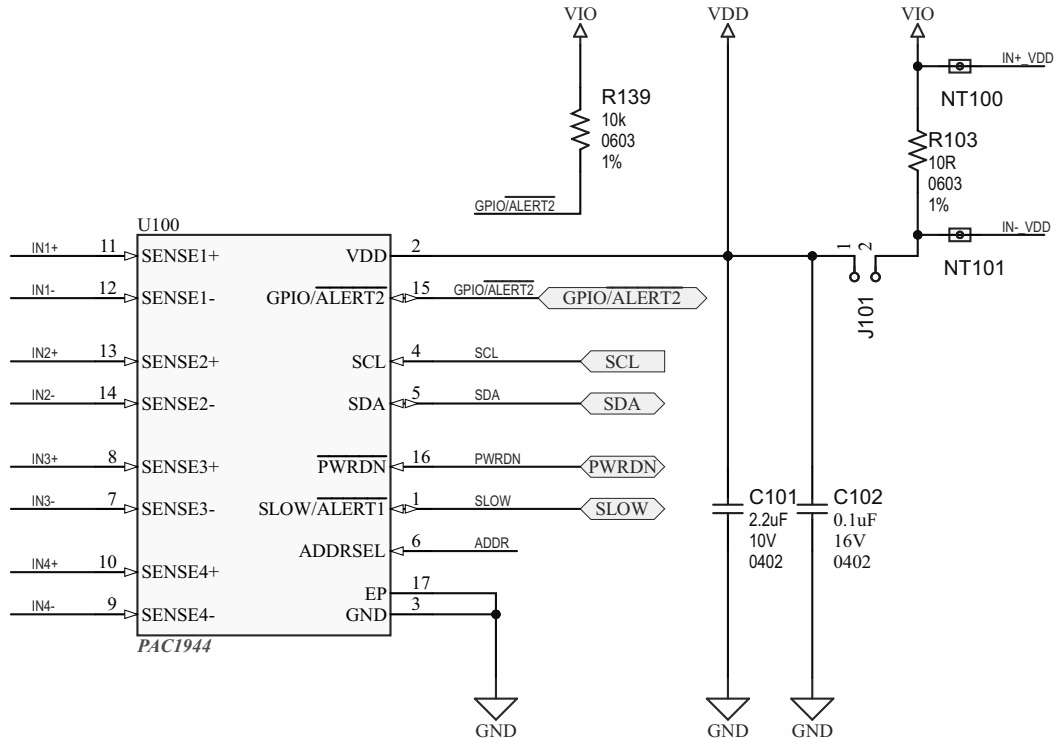
A.3 BOARD – SCHEMATIC 2 (DAC-CONTROLLED CURRENT GENERATOR)



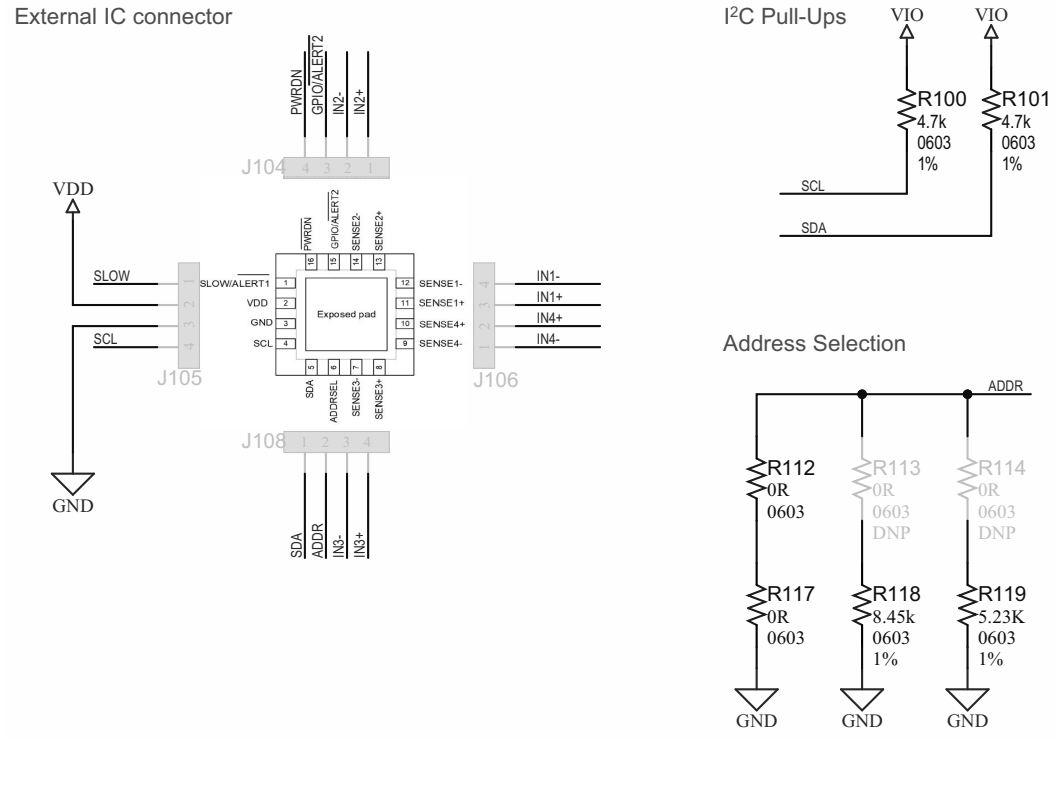
A.4 BOARD – SCHEMATIC 3 (PAC CHANNEL CONNECTIONS)



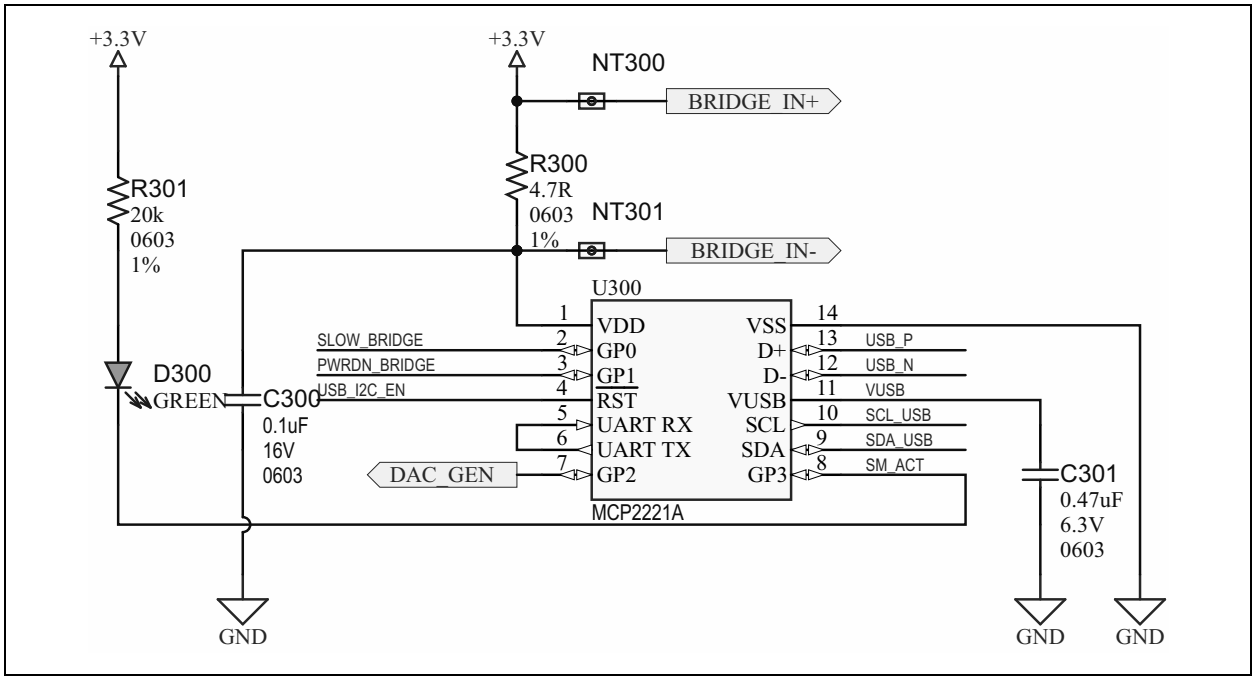
A.5 BOARD – SCHEMATIC 4 (PAC IC AND POWER)



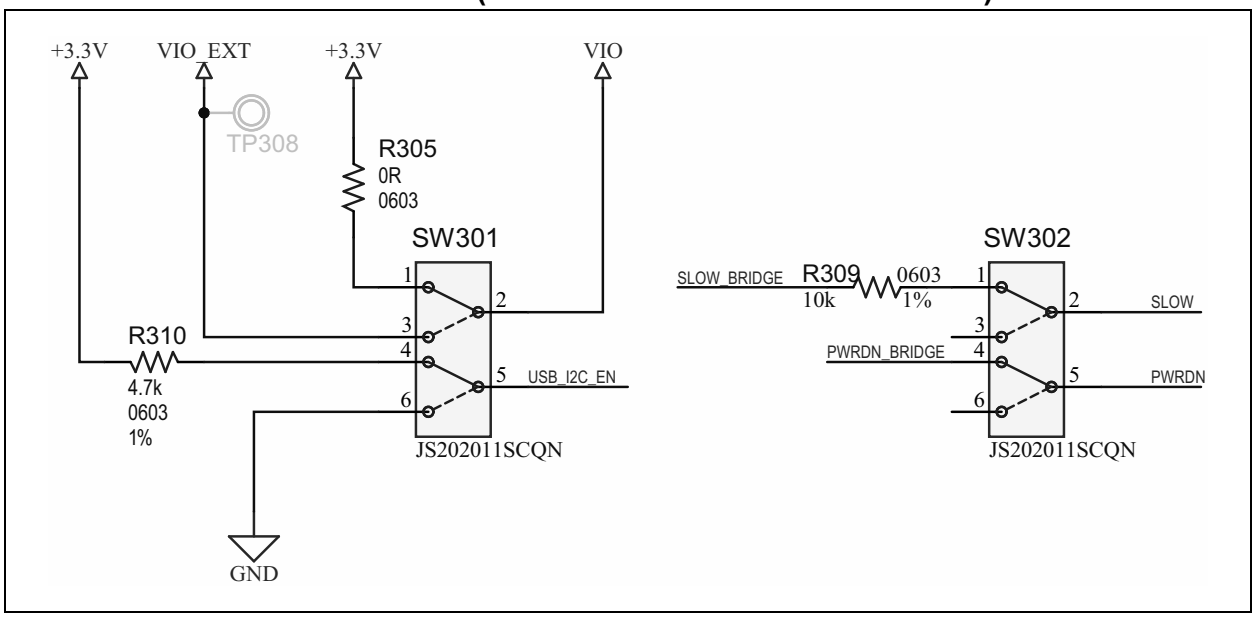
A.6 BOARD – SCHEMATIC 5 (EXTERNAL IC, I²C PULL-UPS AND ADDRESS SELECTION)



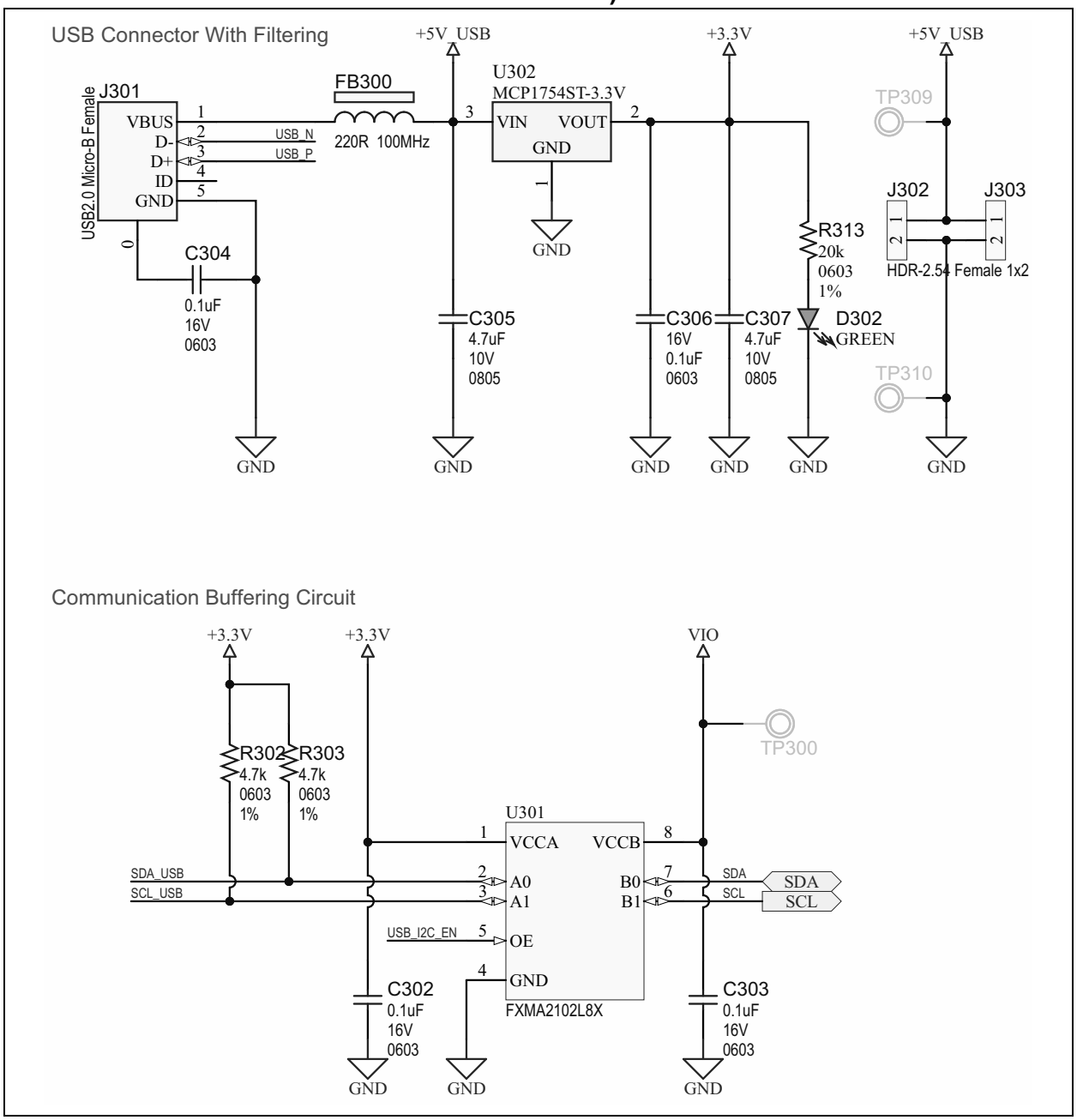
A.7 BOARD – SCHEMATIC 6 (USB – I²C BRIDGE)



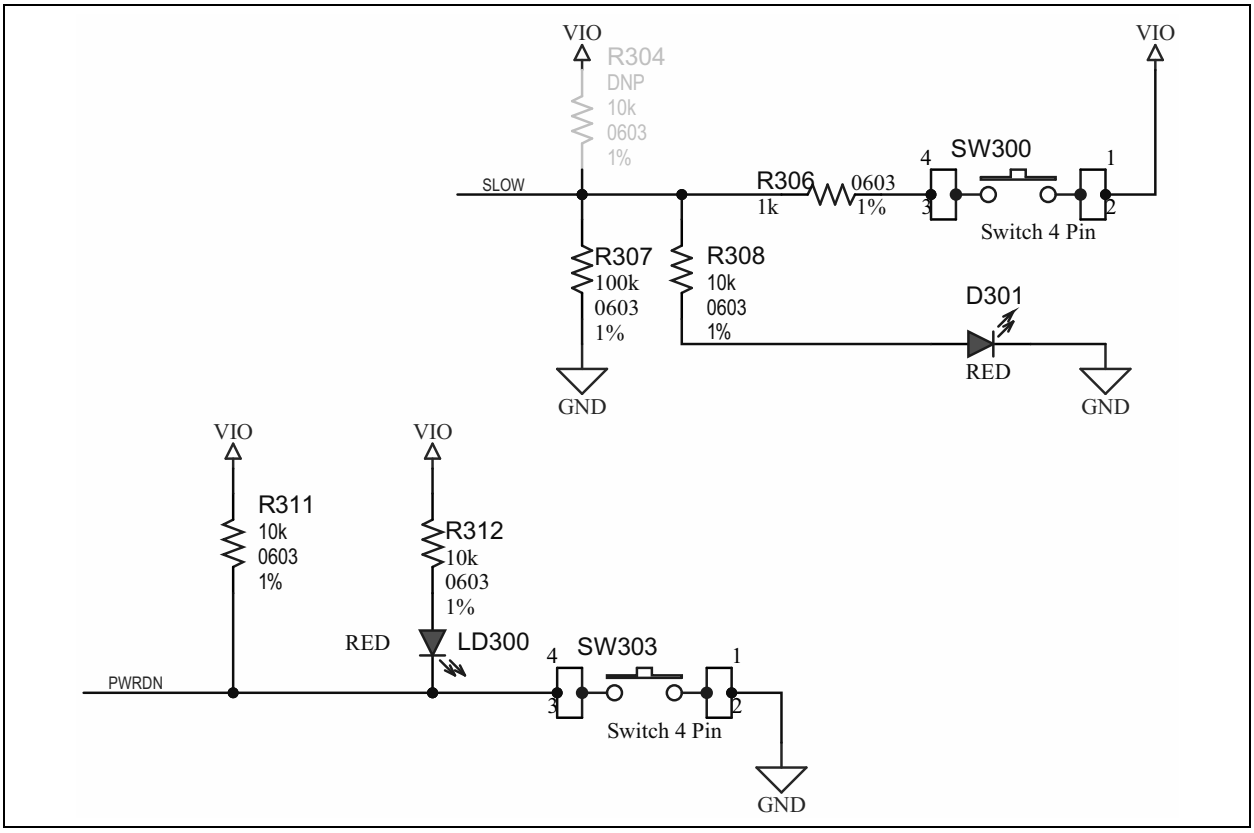
A.8 BOARD – SCHEMATIC 7 (BRIDGE/EXTERNAL SELECTION)



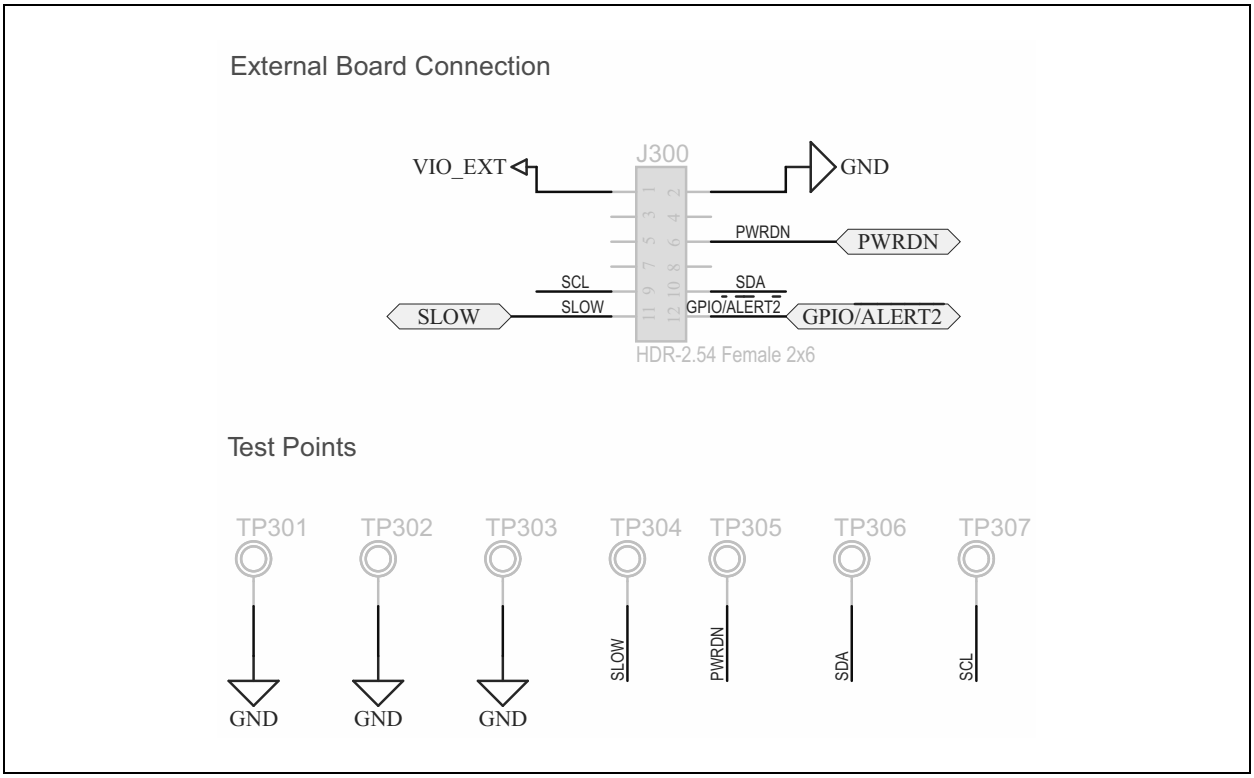
A.9 BOARD – SCHEMATIC 8 (USB CONNECTOR WITH FILTERING AND COMMUNICATION BUFFERING CIRCUIT)



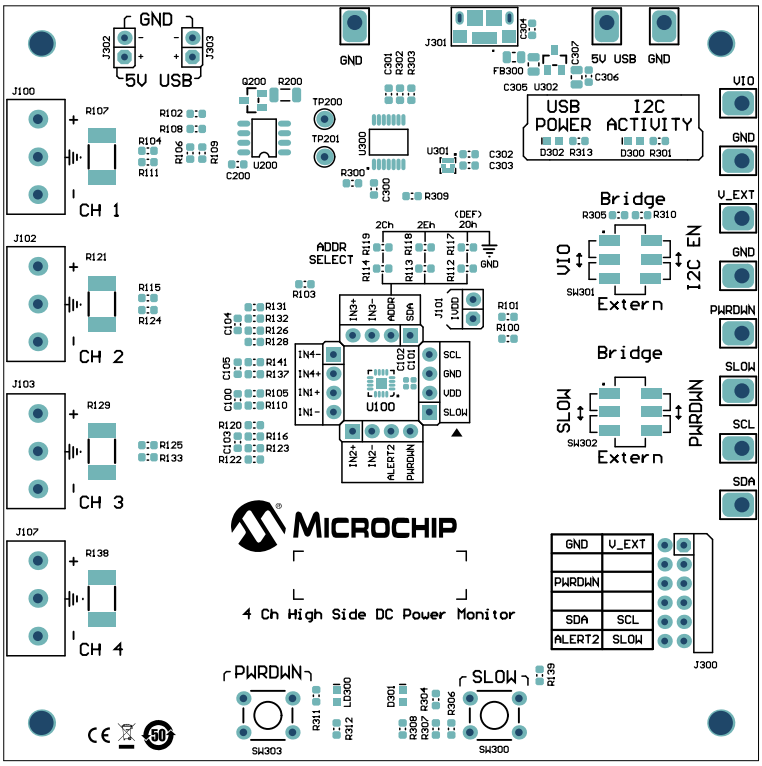
A.10 BOARD – SCHEMATIC 9 (SLOW AND PWRDN STIMULATION)



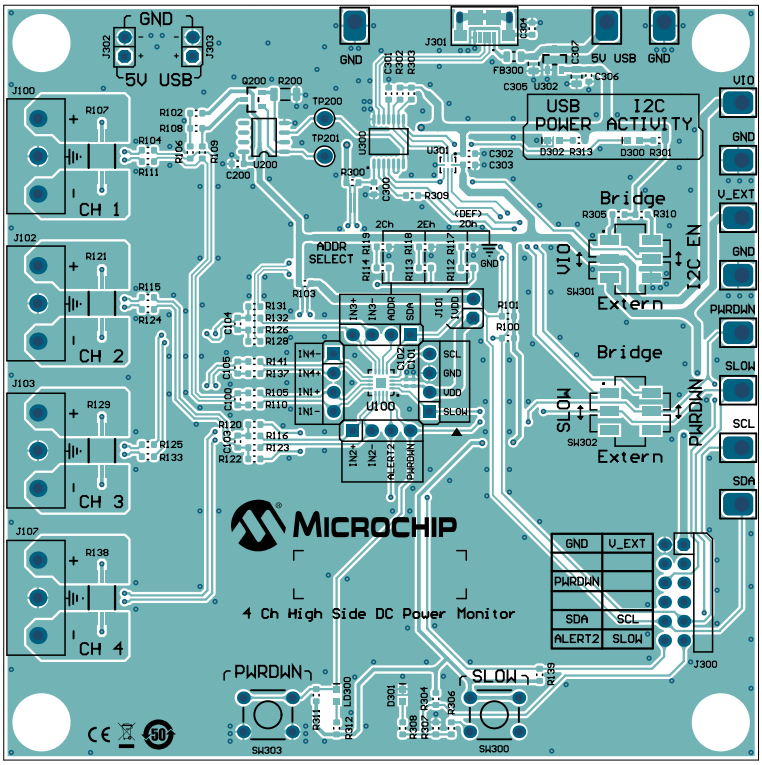
A.11 BOARD – SCHEMATIC 10 (EXTERNAL BOARD CONNECTIONS AND TEST POINTS)



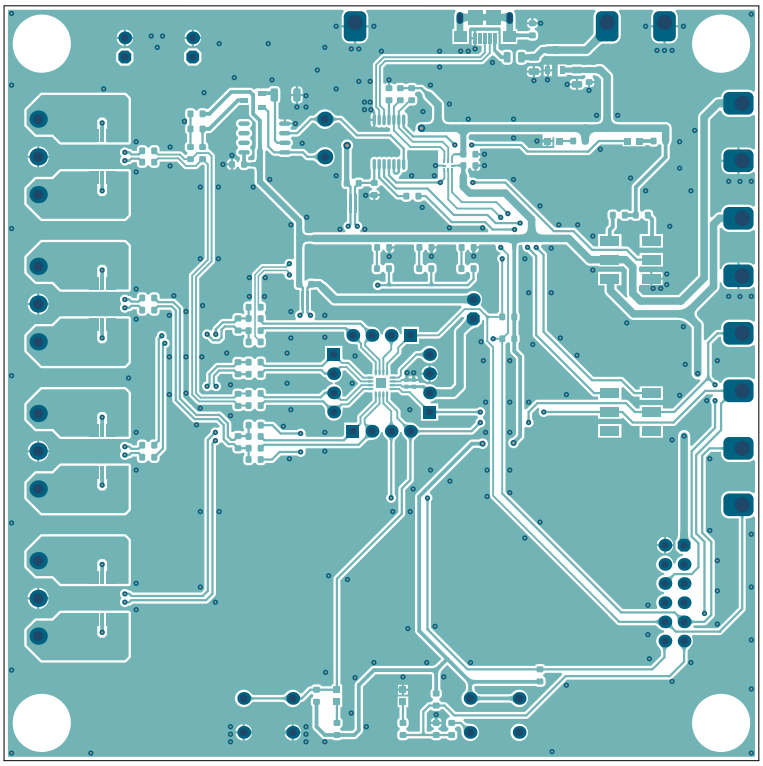
A.12 BOARD – TOP SILK



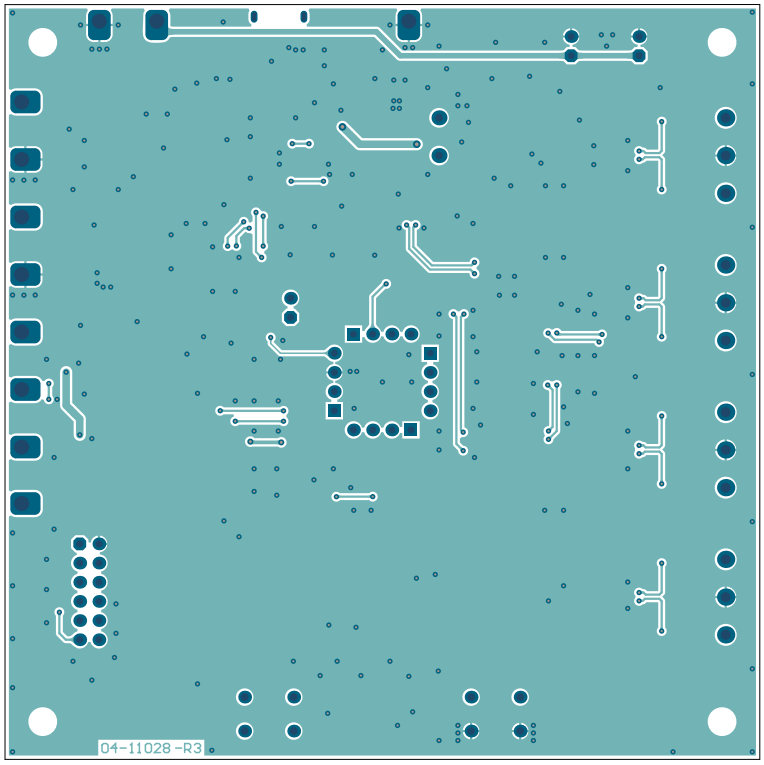
A.13 BOARD – TOP COPPER AND SILK



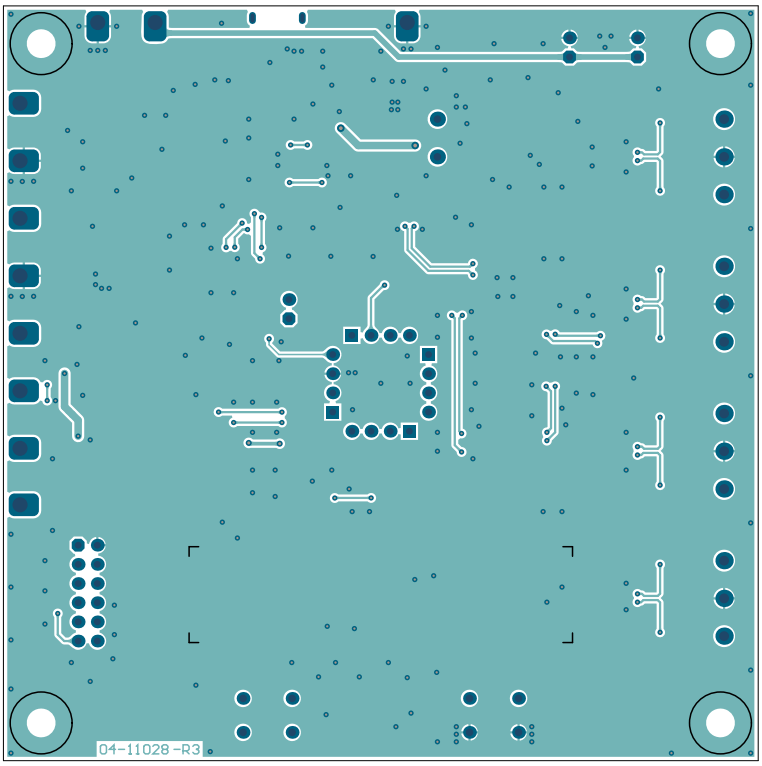
A.14 BOARD – TOP COPPER



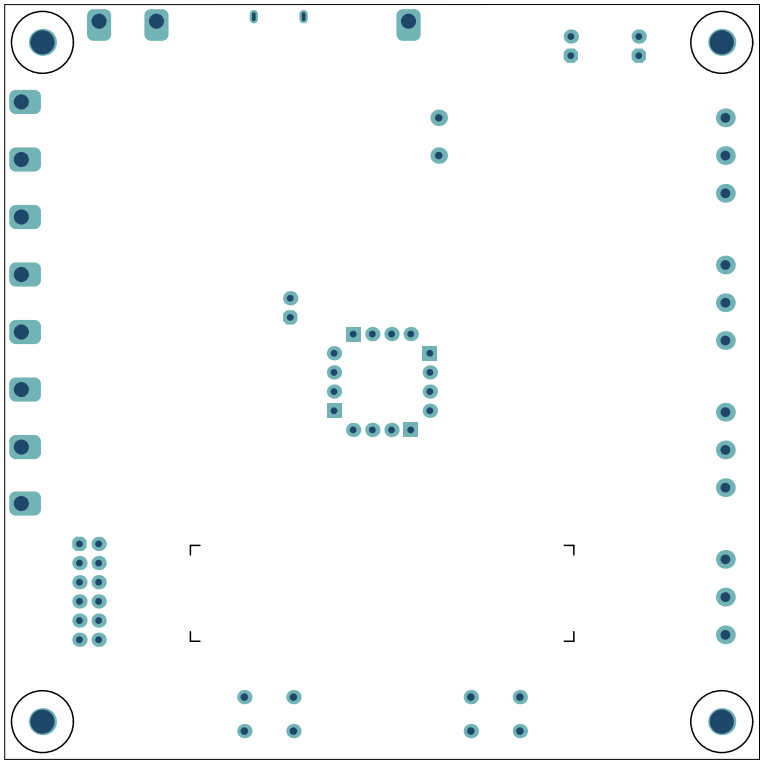
A.15 BOARD – BOTTOM COPPER



A.16 BOARD – BOTTOM COPPER AND SILK



A.17 BOARD – BOTTOM SILK



Appendix B. Bill of Materials (BOM)

B.1 PAC1944 EVALUATION BOARD – BILL OF MATERIALS (BOM)

TABLE B-1: PAC1944 EVALUATION BOARD – BILL OF MATERIALS (BOM)

Qty.	Reference	Description	Manufacturer	Part Number
1	C101	Capacitor, ceramic, 2.2 µF, 10V, 10%, X7S, SMD, 0402	TDK Corporation	C1005X7S1A225K050BC
1	C102	Capacitor, ceramic, 0.1 µF, 16V, 10%, X7R, SMD, 0402	Murata Electronics®	GRM155R71C104KA88D
6	C200, C300, C302, C303, C304, C306	Capacitor, ceramic, 0.1 µF, 16V, 10%, X7R, SMD, 0603	Wurth Elektronik	885012206046
1	C301	Capacitor, ceramic, 0.47 µF, 6.3V, 10%, X5R, SMD 0603	Wurth Elektronik	885012106001
2	C305, C307	Capacitor, ceramic, 4.7 µF, 10V, 10%, X5R, SMD, 0805	Wurth Elektronik	885012107009
2	D300, D302	Diode, LED, Green, 3.2V, 20 mA, 430mcd, Clear, SMD, 0603	Wurth Elektronik	150060GS75000
2	D301, LD300	Diode, LED, Red, 2V, 20 mA, 250mcd, Clear, SMD, 0603	Wurth Elektronik	150060RS75000
1	FB300	Ferrite, 2A, 220R, SMD, 0805	Wurth Elektronik	742792022
4	J100, J102, J103, J107	Connector, Terminal, 5 mm, 1x3, Female, 12-30AWG, 16A, TH, R/A	Wurth Elektronik	691137710003
2	J101, J303	Connector, Header-2.54, Male, 1x2, Gold, 5.84MH, TH, Vertical	Wurth Elektronik	61300211121
1	J301	Connector, USB2.0, Micro-B, Female, SMD, R/A	Amphenol Commercial	10118193-0001LF
1	J302	Connector, Header-2.54, Female, 1x2, Gold, TH, vertical	Samtec, Inc.	SSW-102-01-T-S
1	PCB1	PAC1944 Evaluation Board - Printed Circuit Board	Microchip Technology Inc.	**04-11028-R3**
1	Q200	Transistor, FET, N-Channel, ZXMN2A01F, 20V, 1.9A, 625mW, SOT-23-3	Diodes Incorporated®	ZXMN2A01FTA
5	R100, R101, R302, R303, R310	Resistor, TKF, 4.7k, 1%, 1/10W, SMD, 0603	Vishay/Dale	CRCW0603-4K70FKEA
18	R102, R105, R106, R109, R110, R112, R116, R117, R120, R122, R123, R126, R128, R131, R132, R137, R141, R305	Resistor, TKF, 0R, 1/10W, SMD, 0603	Stackpole Electronics, Inc.	RMCF0603ZT0R00
1	R103	Resistor, TKF, 10R, 1%, 1/10W, SMD, 0603	Panasonic® - ECG	ERJ3EKF10R0V

TABLE B-1: PAC1944 EVALUATION BOARD – BILL OF MATERIALS (BOM) (CONTINUED)

Qty.	Reference	Description	Manufacturer	Part Number
4	R107, R121, R129, R138	Resistor, Shunt, MF, 0.004R, 1%, 2W, 2512	Stackpole Electronics, Inc.	CSNL2512FT4L00
2	R108, R300	Resistor, TKF, 4.7R, 1%, 1/10W, SMD, 0603	Vishay/Dale	CRCW06034R70FNEA
1	R118	Resistor, TKF, 8.45k, 1%, 1/10W, SMD, 0603	Yageo Corporation	RC0603FR-078K45L
1	R119	Resistor, TKF, 5.23K, 1%, 1/10W, SMD, 0603	Panasonic - ECG	ERJ-3EKF5231V
5	R139, R308, R309, R311, R312	Resistor, TKF, 10k, 1%, 1/10W, SMD, 0603	NIC Components Corp.	NRC06F1002TRF
1	R200	Resistor, TKF, 100R, 1%, 1/4W, SMD, 1206	Yageo Corporation	RC1206FR-07100RL
2	R301, R313	Resistor, TKF, 20k, 1%, 1/10W, SMD, 0603	Yageo Corporation	RC0603FR-0720KL
1	R306	Resistor, TKF, 1k, 1%, 1/10W, SMD, 0603	Stackpole Electronics, Inc.	RMCF0603FT1K00
1	R307	Resistor, TKF, 100k, 1%, 1/10W, SMD, 0603	Vishay/Dale	CRCW0603-100KFKEA
2	SW300, SW303	Switch, Tactical, SPST, 15V, 20mA, TH, L6W6H5	Wurth Elektronik	430186050716
2	SW301, SW302	Switch, Slide, DPDT, 6V, 300mA, JS202011SCQN, SMD	C&K Components	JS202011SCQN
1	U100	Microchip, Analog, Power Current Sense Monitor, PAC1954-E/4MX, QFN-16	Microchip Technology Inc.	**PAC1944-E/4MX**
1	U200	Microchip, Analog, Op Amp, 2-Channel, 1.2MHz, MCP6072-E/SN, SOIC-8	Microchip Technology Inc.	**MCP6072-E/SN**
1	U300	Microchip, Interface USB, I2C, UART, MCP2221A-I/ST, TSSOP-14	Microchip Technology Inc.	**MCP2221A-I/ST**
1	U301	IC, Interface, FXMA2102L8X, 2-Bit Voltage Translator/Buffer, Micropak-8	ON Semiconductor®	FXMA2102L8X
1	U302	Microchip, Analog, LDO, 3.3V, MCP1754ST-3302E/CB, SOT-23A-3	Microchip Technology Inc.	**MCP1754ST-3302E/CB**

TABLE B-2: PAC1944 EVALUATION BOARD – MECHANICAL PARTS

Qty.	Reference	Description	Manufacturer	Part Number
1	CBL400	Mechnical, Hardware, Cable, USB, Male-A to Male Micro-B, Clear,4	DongGuan ZhanXin	A006ZX027
0.1	CBL401	Mechnical, Hardware, Jumper, Wire, Male to Male, 11.81 inch, Pack of 10	Bud Industries, Inc.	BC-32670
1	JP400	Mechnical, Hardware, Jumper, 2.54mm, 1x2, Handle, Gold	TE Connectivity Alcoswitch	881545-2
1	LABEL400	Label, NEED HELP WITH ASSY/SERIAL???	—	—
1	LABEL401	Label, Assembly, with Rev level, (Small Modules) per MTS-0002	—	—
4	PAD400, PAD401, PAD402, PAD403	Mechnical, Hardware, Rubber Pad, Cylindrical, D7.9, H5.3, Black	3M	70006431483
1	R400	Resistor, 50R, 1W, 1% AX, P17.8L11D4.3	Vishay Beyschlag	PAC100005009FA1000

TABLE B-3: PAC1944 EVALUATION BOARD – NOT POPULATED

Qty.	Reference	Description	Manufacturer	Part Number
0	C100, C103, C104, C105	Capacitor, Ceramic, 10000pF, 50V, 20%, X7R, SMD, 0603	AVX Corporation	06035C103KAT2A\4K
0	J104, J105, J106, J108	Connector, Header-2.54, Female, 1x4, Gold, TH, Vertical	Samtec, Inc.	SSW-104-01-G-S
0	J301	Connector, ON, Header-2.54, Female, 2x6, Gold, TH, RA	Sullins Connector Solutions	PPPC062LJBN-RC
0	R104, R111, R113, R114, R115, R124, R125, R133	Resistor, TKF, 0R, 1/10W, SMD, 0603	Yageo Corporation	RC0603JR-070RL
0	R304	Resistor, TKF, 10k, 1%, 1/10W, SMD, 0603	Yageo Corporation	RC0603FR-0710KL
0	TP200, TP201, TP300, TP301, TP302, TP303, TP304, TP305, TP306, TP307, TP308, TP309, TP310	Misc., Test Point, Multi Purpose, Mini, Black	Keystone Electronics Corp.	5001

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