# PAC1952-2 Evaluation Board User's Guide

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# Preface

## NOTICE TO CUSTOMERS

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**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 PAC1952-2 Evaluation Board. Items discussed in this chapter include:

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

## DOCUMENT LAYOUT

This document describes how to use the PAC1952-2 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 PAC1952-2 Evaluation Board.
- **Chapter 2. "Installation and Operation"** – Includes instructions on installing the application.
- **Chapter 3. "Software GUI Description"** – Includes details about the Graphical User Interface.
- **Chapter 4. "Hardware Description"** – Includes hardware details about the PAC1952-2 Evaluation Board.
- **Appendix A. "Schematic and Layouts"** – Shows the schematic and layout diagrams for the PAC1952-2 Evaluation Board.
- **Appendix B. "Bill of Materials (BOM)"** – Lists the parts used to build the PAC1952-2 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 PAC1952-2 Evaluation Board. Another useful document is listed below. The following Microchip document is available and recommended as a supplemental reference resource:

**PAC195X Data Sheet – *"Single/Multi-Channel Power Monitor with Accumulator, 32V Full-Scale Range"* (DS20006539)**

## 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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- Distributor or Representative
- Local Sales Office
- Field Application Engineer (FAE)
- Technical Support

Customers should contact their distributor, representative or field application engineer (FAE) for support. Local sales offices are also available to help customers. A listing of sales offices and locations is included in the back of this document.

Technical support is available through the website at:
http://www.microchip.com/support.

## DOCUMENT REVISION HISTORY

### Revision A (March 2023)

- Initial release of this document.

**NOTES:**

# Chapter 1. Product Overview

## 1.1 INTRODUCTION

The PAC1952-2 Evaluation Board (EV99K19A) provides a flexible platform for evaluating the PAC1952-2 device and demonstrating the feature set.

The PAC1952-2 Evaluation Board is provided with a USB connector for computer-to-device communication. The PAC1952-2 device can be powered directly by $V_{BUS}$ from the USB connector or by an external connection for $V_{DD}$.

$I^2C$ communication can be provided over USB by using the on-board MCP2221A USB to the $I^2C$ bridge. There is also a header that facilitates direct $I^2C$ communication by connecting the $V_{IO}$, Ground, SLOW, ALERT2, SDA and SCL to an external source such as a PC motherboard, a Linux® system or a SAM E54 Curiosity Ultra Development Board (DM320210).

The shorting shunts and the switch on the board facilitate either simple demonstration of the device functions using on-board current sources or detailed evaluation of function and performance with external sources to prototype the user's system.

## 1.2 PAC1952-2 DEVICE FEATURES

The PAC1952-2 is a two-channel DC power/energy monitor with accumulator. There is a 16-bit ADC for monitoring power rail voltages connected by a multiplexer to the $V_{BUS}$ input pins, producing 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 $V_{SENSE+}$ and $V_{SENSE-}$ pins for each channel, producing $V_{SENSE}$ results. Channel selection for the multiplexers is controlled in sequential fashion to scan both channels up to 1024 SPS.

The device also computes $V_{POWER}$ by multiplying $V_{BUS}$ by $V_{SENSE}$ and accumulates these power results in an accumulator. The device registers 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 value in the results registers only changes when a REFRESH or a REFRESH_V command is sent. A software application is available for plotting, displaying and logging data. This application also calculates energy based on the accumulated power and accumulation time, as well as controlling all the registers and alerts.

## 1.3 PAC1952-2 EVALUATION BOARD (EV99K19A)

### 1.3.1 Hardware Overview

The EV99K19A evaluation board has a PAC1952-2 device and enables direct control of all device pins and easy measurements of on-board or external voltages and currents. The $I^2C$ address is connected as 0x20 (8-bit) by default. Multiple addresses can be done simply by removing resistors in the ADDR Selection area on the PCB (see **Section 4.5 "Address Selection"**). The sampling rate is 1024 SPS with adaptive accumulation by default. Pressing the **SLOW** button results in SLOW sampling rate of 8 SPS, while pressing the **PWRDWN** button will do a hardware reset.

An on-board DAC will provide for various current signals for functionality testing and demo 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/5X demo application, described in detail in **Chapter 2. "Installation and Operation"**, provides USB control of the PAC1952-2 with the EV99K19A evaluation board.

The application provides an easy way to control the registers and read out the results for the device. To use this software application with the PAC1952-2 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 SW300 is set to bridge (see **Chapter 2. "Installation and Operation"**).

## 1.5 CONTENTS OF THE PAC1952-2 EVALUATION BOARD KIT

The PAC1952-2 Evaluation Board kit includes:

- PAC1952-2 Evaluation Board (EV99K19A)
- USB Cable
- Load Resistor and Wire
- Important Information Sheet

# Chapter 2. Installation and Operation

## 2.1 INTRODUCTION

This section describes how to power-up and interface with the PAC1952-2 Evaluation Board. Items discussed in this chapter include:

- System requirements
- Downloading and installing the software.

## 2.2 SYSTEM REQUIREMENTS

The PAC1952-2 Evaluation Board is designed to be used with a personal computer (desktop or laptop), running Microsoft® Windows® 7 or later. For USB connectivity, the minimum physical requirement for the PC is a standard Type-A USB 2.0 port.

## 2.3 INSTALLING THE SOFTWARE

To install the software, follow the steps below:

1. Double click the installer and you will be alerted to uninstall any previous versions of the software before the new version is installed.

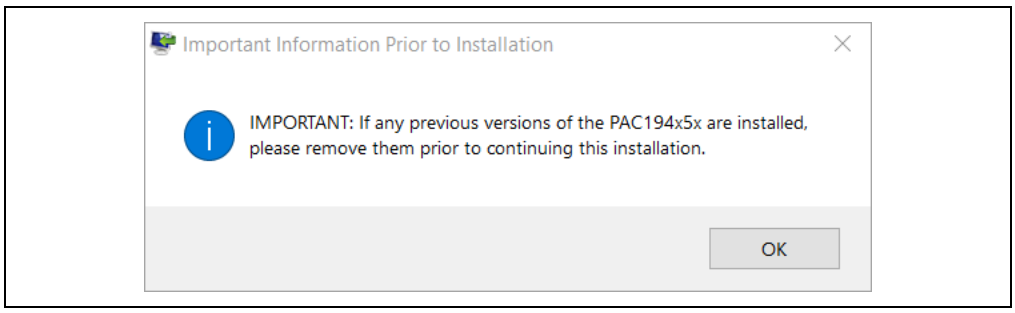



***FIGURE 2-1:*** *Prior Installation Alert.*

Click **OK** to start the installation process.

2. Click the **Next** button and the License Agreement window will appear.

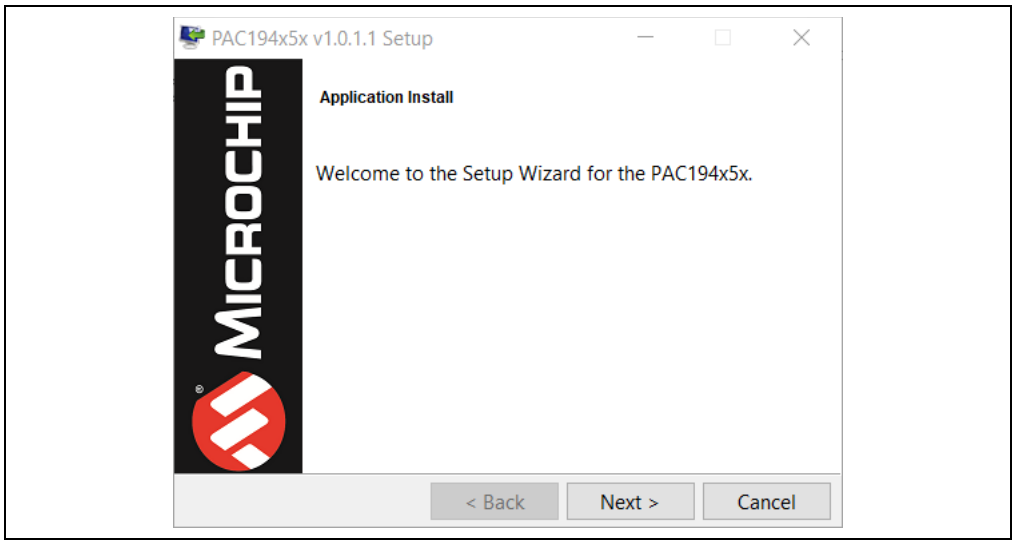



***FIGURE 2-2:*** *Installation Window.*

3. Read the agreement and select "I accept the agreement" when you are ready to proceed. Selecting "I do not accept the agreement" will stop the installation. Click **Next**.


***FIGURE 2-3:*** *License Agreement.*

4. Verify the installation directory and click **Next**.

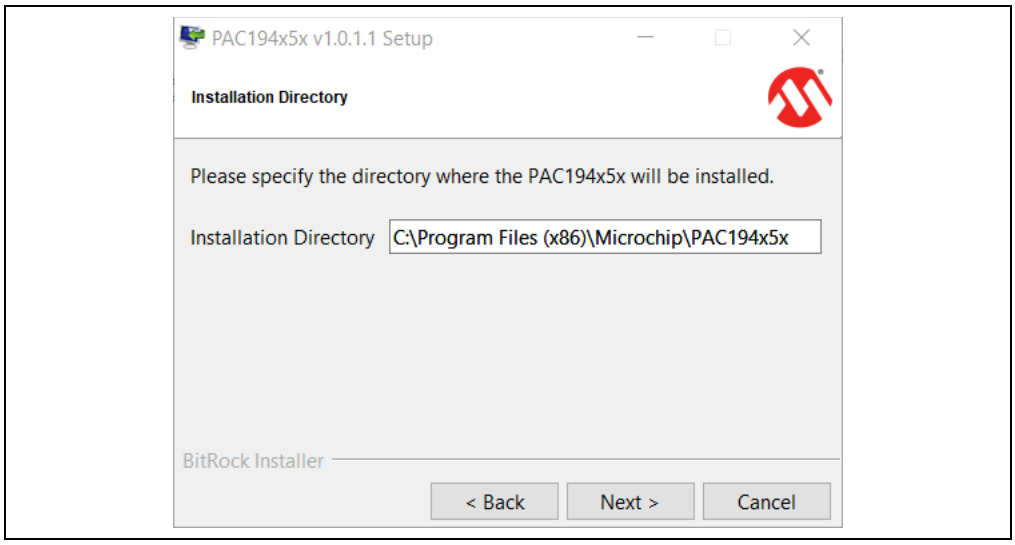



***FIGURE 2-4:*** *Installation Directory.*

5. The setup is now ready. Click **Next** to install the application. A green progress bar indicates when the installation is complete.

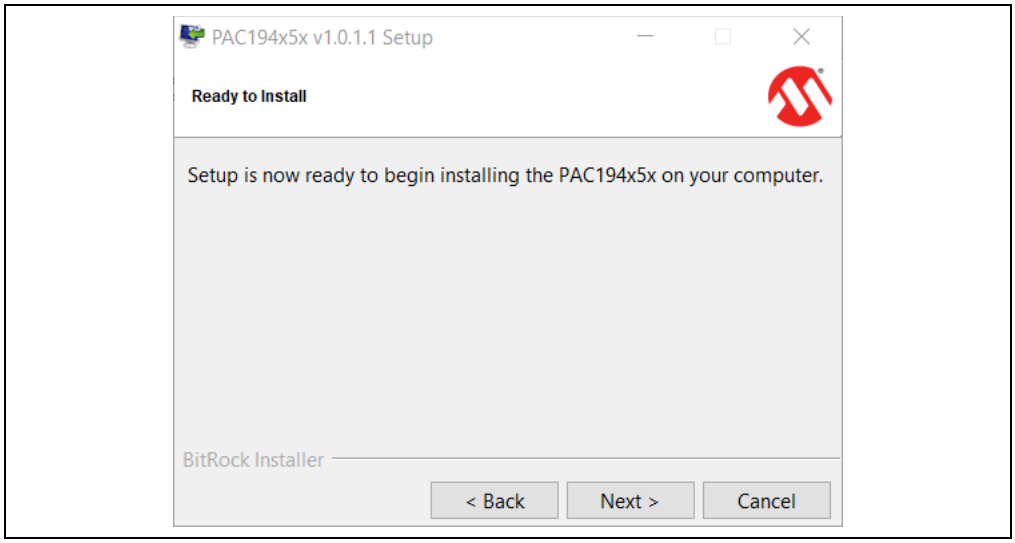



***FIGURE 2-5:*** *Ready to Install.*

6. In the Install Complete window, click **Finish**. The program is now installed and is ready to use. A shortcut on the Windows Start menu is created under the Microchip menu and is called PAC194x5x. Software builds are available from local Sales and ESE contacts.

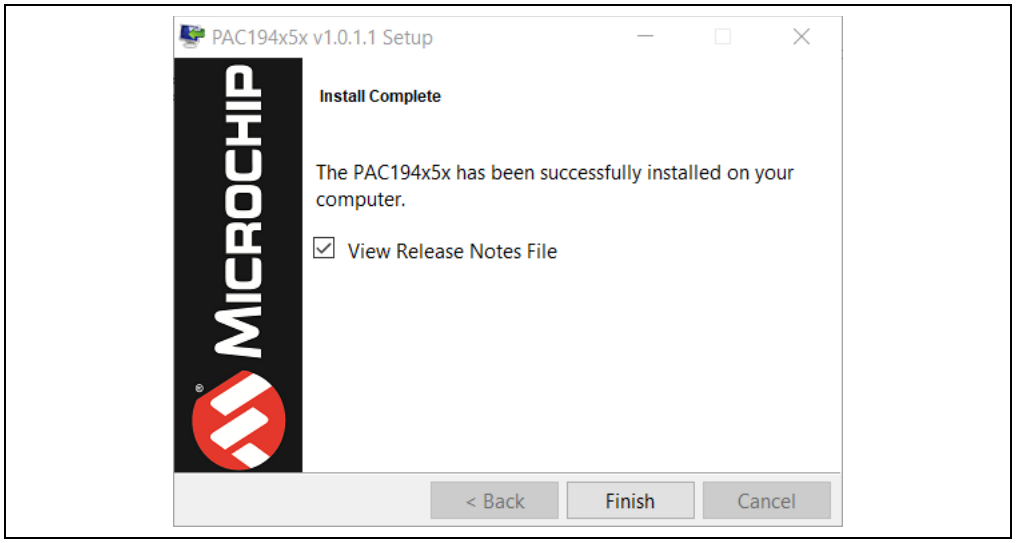



***FIGURE 2-6:*** *Install Complete.*

# Chapter 3. Software GUI Description

## 3.1 FIRST LAUNCH

When the installation is complete, go to Start and double click the PAC194x5x icon in order to launch the PAC194x/PAC195x Demo Application.

1. Connect the board to the PC with the provided USB cable and ensure Jumper 112 is shorted (IVDD jumper) and the SW300 is switched to bridge while SW301 is switched to Extern. The J112 jumper is located near the IC and the two switches are on the right side of the board. Once they are connected, LED activity can be seen on the board – D300: Green LED for +5V USB power from the USB connection. Figure 3-1 shows the GUI for the PAC194x/PAC195x Demo Application.

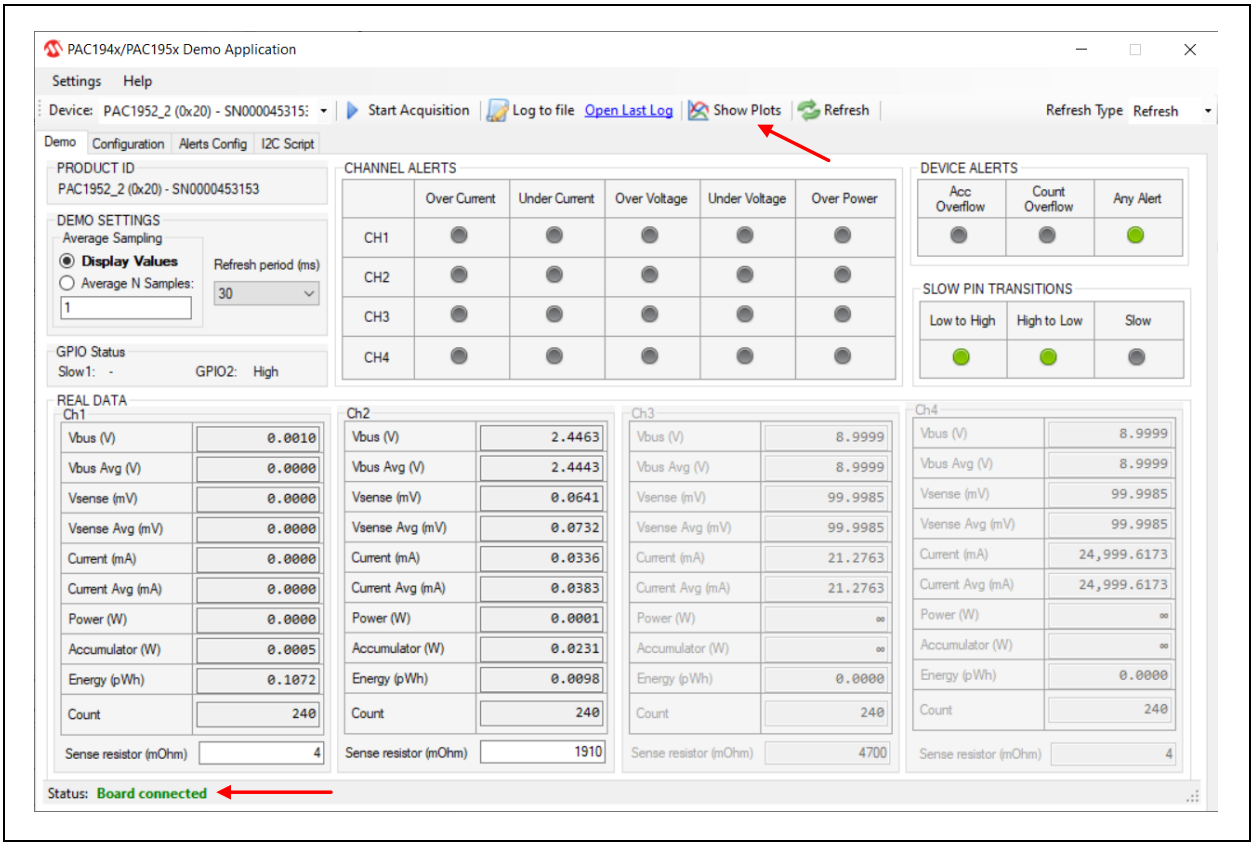
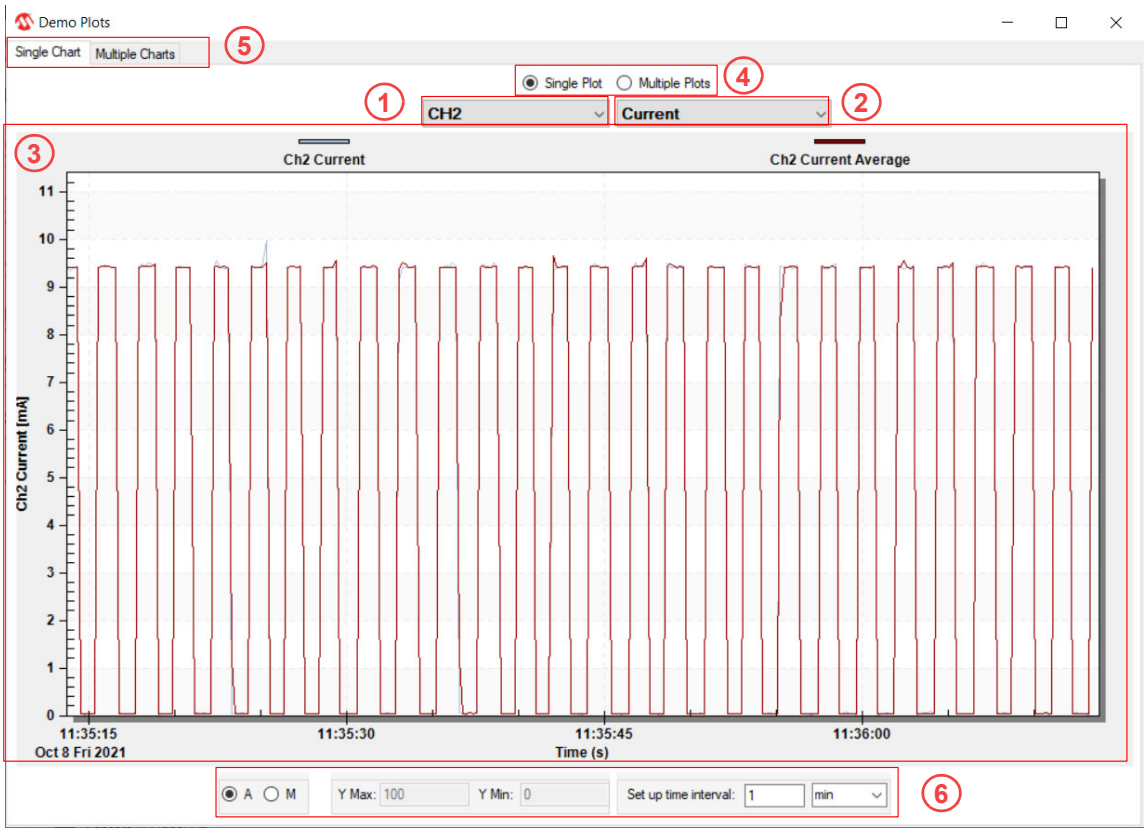



***FIGURE 3-1:*** *Software GUI Main Window.*

On the bottom left side of the window, there is a field called "Status". If the board is connected and the device installed, the status will be "Board connected". The Product ID will contain the part type, the $I^2C$ address and the serial number on the left top of the window, under **Device**.

2. Click **Show Plots** to open the Demo Plots window.




**Note 1:** Channel selection – Choose between CH1 and CH2.

**2:** Register selection – Select Count (ACCUM), $V_{BUS}$, $V_{SENSE}$, Current, Power, Accumulator or Energy.

**3:** Display of the chosen data.

**4:** Plot style – Choose between Single Plot and Multiple Plots (multiple channels on each plot).

**5:** Option to display one plot or multiple plots in one window.

**6:** Plot control – Choose between manual and automatic Y-axis values, select the time interval from seconds to hours.

***FIGURE 3-2:*** *Demo Plots Window.*

Four plot instances may run at the same time.

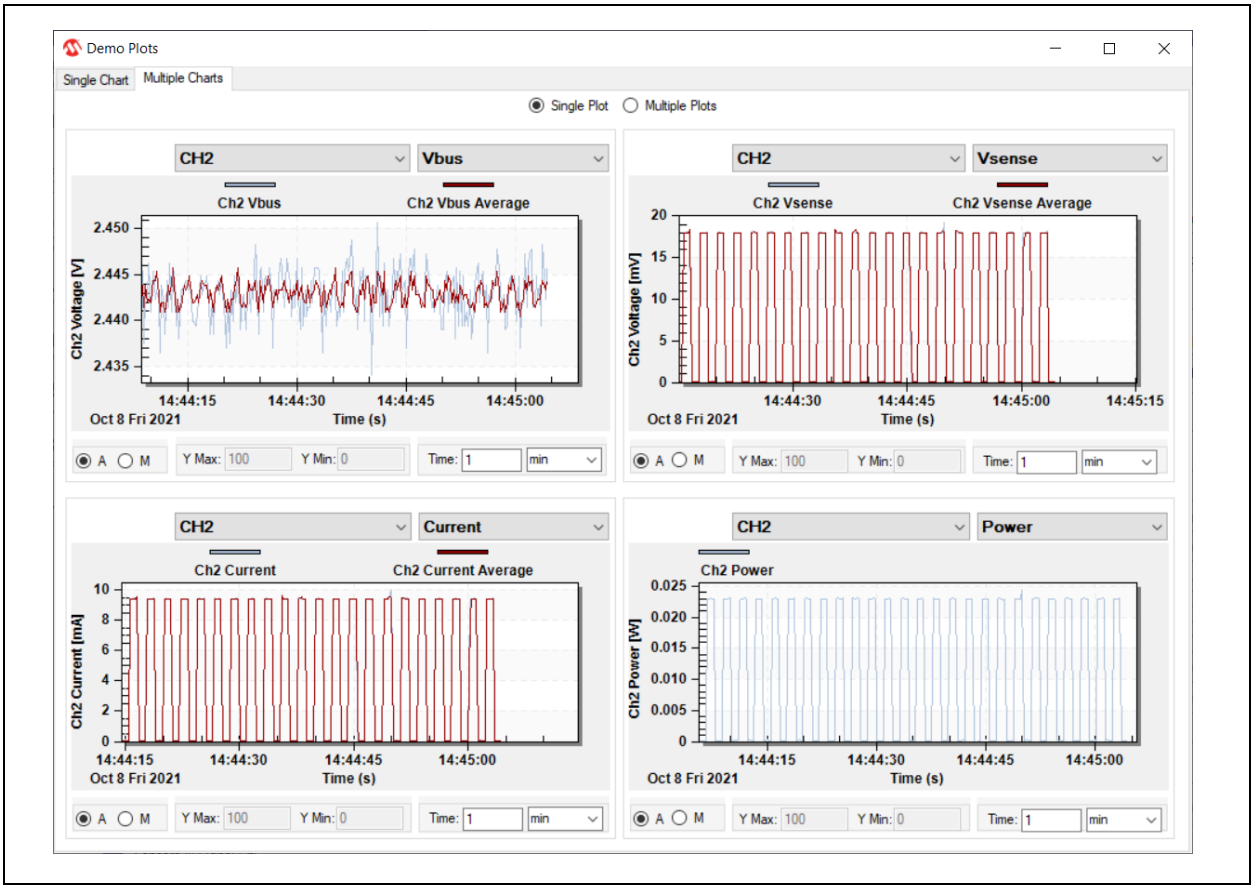
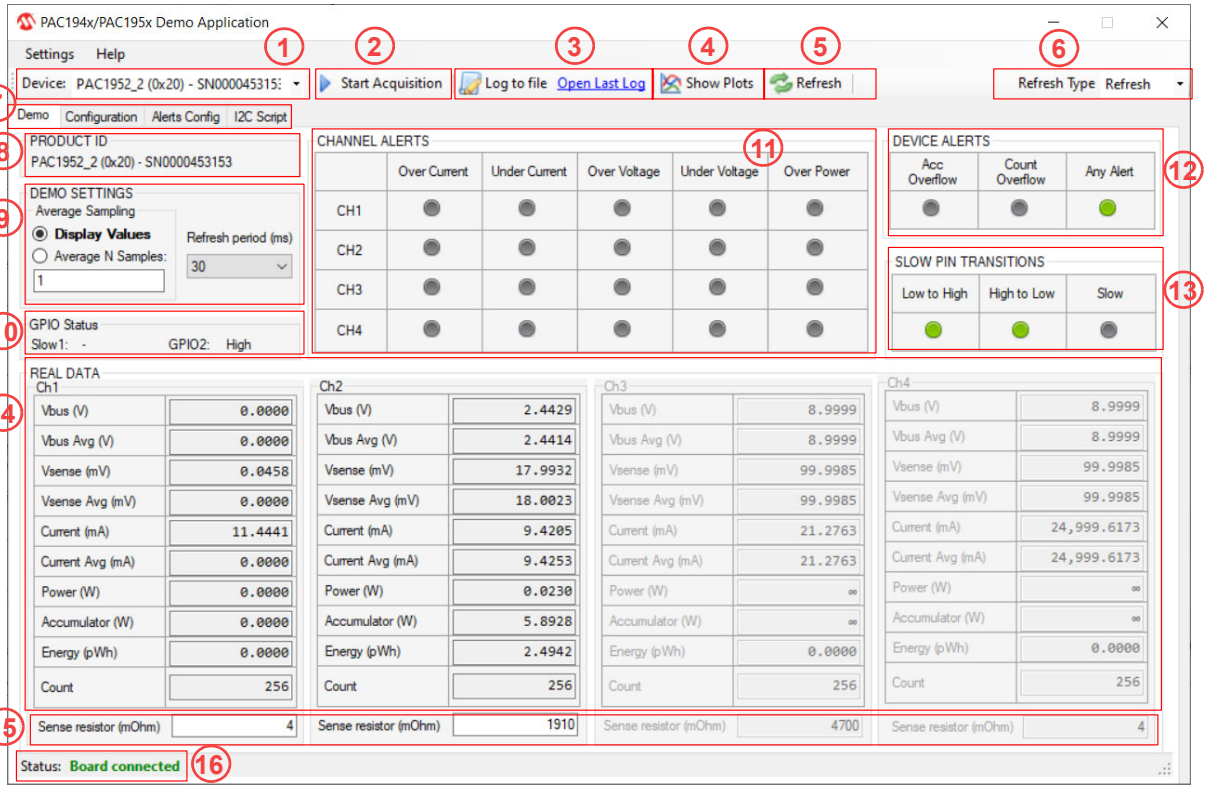



***FIGURE 3-3:*** *Multiple Plots.*

1. The first time the GUI is run, the resistor values near the bottom on the Demo Application window must be populated. See Figure 3-5 to determine where to enter the resistor values.
2. Click **Start Acquisition** to start generating the default waveforms. After 10 seconds, click the tab again to stop the acquisition and freeze the waveforms. The waveforms above were generated using the Demo software with the DAC enabled and set to various voltages (thus the CH1 current peak changing).

## 3.2 DETAILED GUI DESCRIPTION

This section provides a detailed description of the GUI and a few scenarios that explain how to change various settings and see the results.




**Note 1:** Current device (may have more than one connected).

**2:** **Start Acquisition** – Starts the data logging function. When started, the tab will display **Stop Acquisition** to stop the function.

**3:** **Log to file**/**Open Last Log** – Clicking **Log to file** starts the logging to a CSV file (see Figure 3-5). The user can stop the logging at any time. Data are collected only while the **Start Acquisition** is running. The files are saved to `PAC194x5x Files` in the user's `Documents` folder. Click **Open Last Log** to open the last CSV file as configured on the user's system.

**4:** **Show Plots** – Enables the visualization window; more than one may be open at a time with different registers selected.

**5:** **Refresh** – Manual refresh which is based on the type of refresh selected in the **Refresh Type** drop-down menu.

**6:** **Refresh Type** – The user can select one of the three refresh types (Regular, Global and V). Changes can be made while acquisitions are made.

**7:** Tabs for various setup including current data values, register setup, alert setup or manual $I^2C$ commands.

**8:** PRODUCT ID – Displays device information, the $I^2C$ address and the MCP2221A serial number.

**9:** DEMO SETTINGS – Displays how fast the SW requests data and for how long the data are shown in the plots. Select Display Values to show the 8x averaged values in the $V_{SENSE}$ Avg and $V_{BUS}$ Avg area (as well as plots). Click the Average N Samples and change the value to use software averaging using the application.

**10:** GPIO Status – Shows the status of the GPIO pins when selected to be an Input or an Output. Notes configuration if it is set for Alerts or Slow functionality.

**11:** CHANNEL ALERTS – Status of all the channel specific alerts (set the alerts in the **Alters Config** tab).

**12:** DEVICE ALERTS – Accumulator alerts and global Any Alert.

**13:** SLOW PIN TRAINSITIONS – Shows if the SLOW pin is asserted/deasserted and if SLOW is currently asserted.

**14:** REAL DATA – All the data associated with each channel.

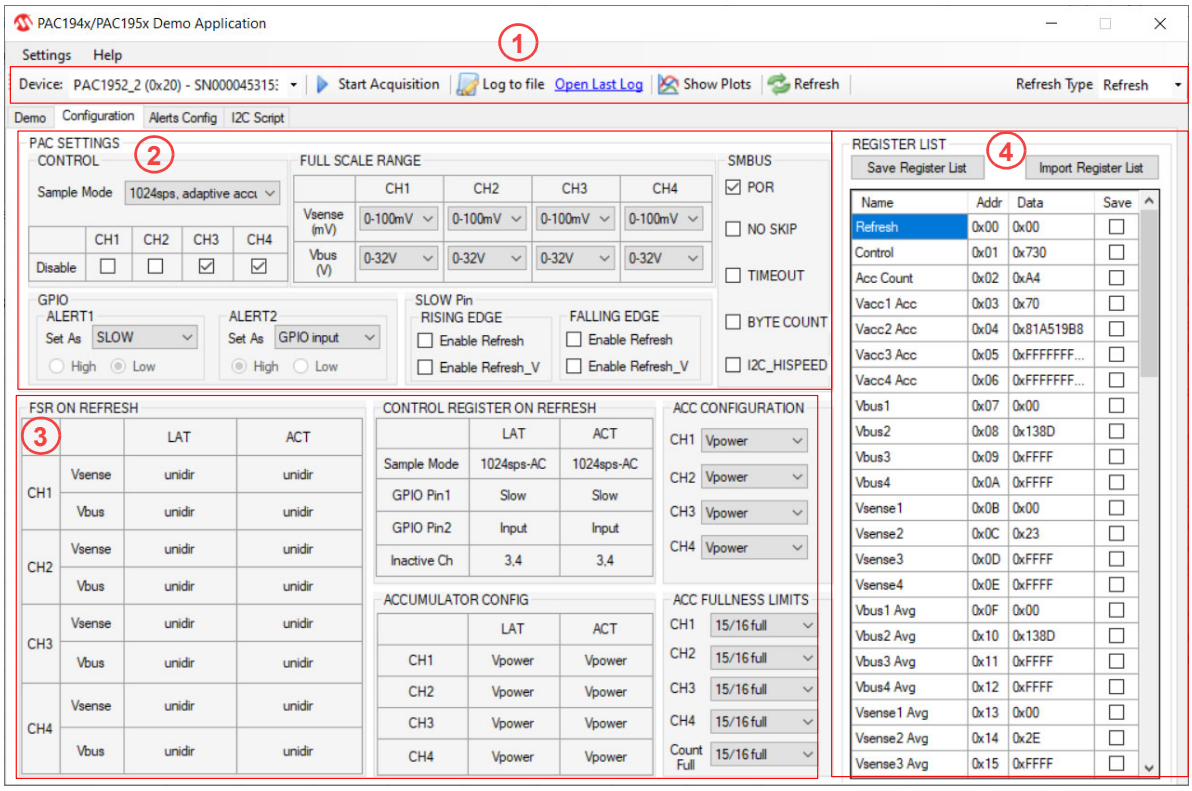
**15:** Sense resistor – Resistor used to calculate current based on the $V_{SENSE}$ value.

**16:** Status: Board connected – Displays if the SW senses the device correctly or not.

***FIGURE 3-4:*** *Main GUI Tab.*

| | A | B | C | D | E | F | G | H | I | J |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Count | Vbus_Ch1 | VbusAve_Ch1 | Vsense_Ch1 | VsenseAve_Ch1 | Current_Ch1 | CurrentAve_Ch1 | Power_Ch1 | Acc_Ch1 | Energy_Ch1 |
| 2 | [N] | [V] | [V] | [mV] | [mV] | [mA] | [mA] | [W] | [W] | [mWh] |
| 3 | 35126 | 5.159317 | 5.160965 | 0.03204346 | 0.04119873 | 0.006817757 | 0.008765687 | 3.52E-05 | 8.473948456 | 5.90E-12 |
| 4 | 461 | 5.159729 | 5.161789 | 0.05340576 | 0.04577637 | 0.011362928 | 0.009739653 | 5.86E-05 | 0.123873655 | 8.63E-14 |
| 5 | 407 | 5.164261 | 5.163025 | 0.05645752 | 0.0579834 | 0.012012238 | 0.012336893 | 6.20E-05 | 0.105746821 | 7.37E-14 |
| 6 | 404 | 5.161789 | 5.163025 | 0.06256104 | 0.06256104 | 0.013310859 | 0.013310859 | 6.87E-05 | 0.108764314 | 7.58E-14 |
| 7 | 407 | 5.162338 | 5.161514 | 0.04272461 | 0.05187988 | 0.009090342 | 0.011038273 | 4.69E-05 | 0.108678308 | 7.57E-14 |
| 8 | 401 | 5.158905 | 5.16124 | 0.03509521 | 0.04882813 | 0.007467067 | 0.010388963 | 3.85E-05 | 0.10423998 | 7.26E-14 |
| 9 | 399 | 5.162476 | 5.161926 | 0.06866455 | 0.05493164 | 0.014609479 | 0.011687583 | 7.54E-05 | 0.11035761 | 7.69E-14 |
| 10 | 426 | 5.161789 | 5.161789 | 0.04272461 | 0.05493164 | 0.009090342 | 0.011687583 | 4.69E-05 | 0.114062923 | 7.95E-14 |
| 11 | 411 | 5.162613 | 5.161514 | 0.08392334 | 0.06408691 | 0.01785603 | 0.013635514 | 9.22E-05 | 0.112372222 | 7.83E-14 |

***FIGURE 3-5:*** *Portion of the CSV LOG File.*



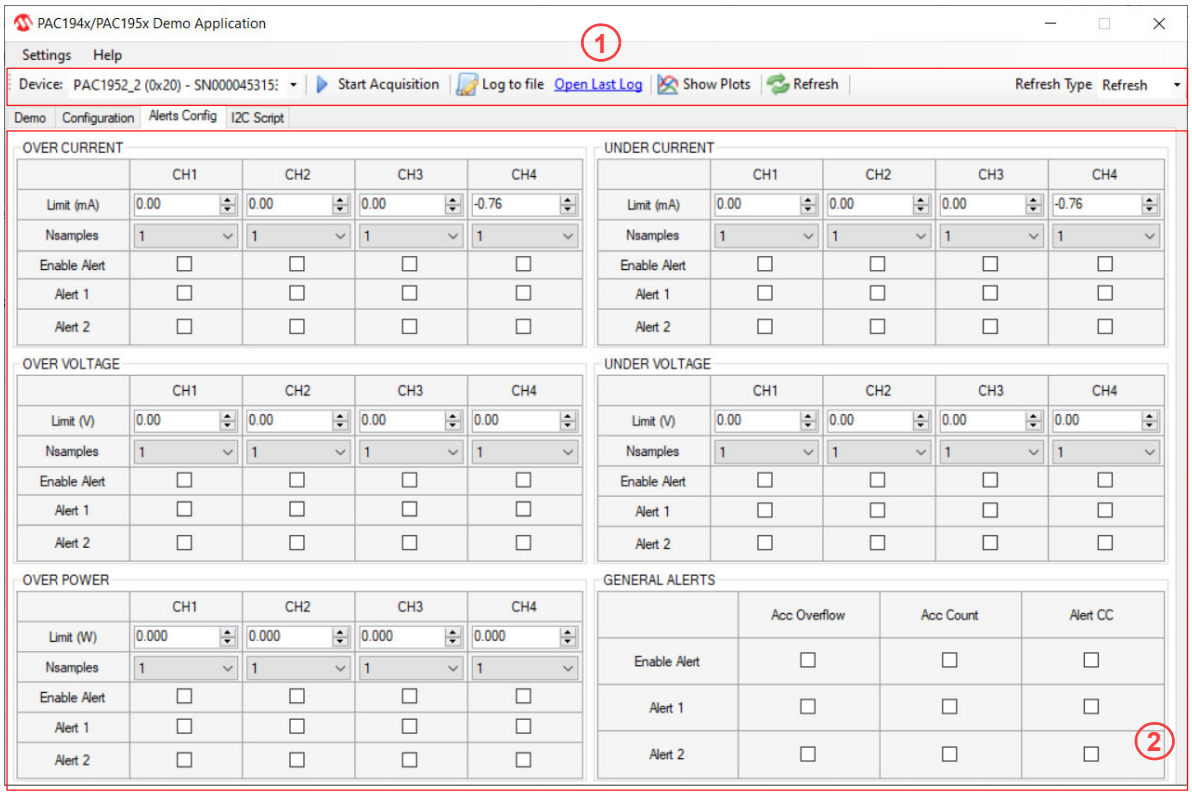

**Note 1:** See Figure 3-4.

**2:** Various settings for I/O type, disabling channels, unidirectional or bidirectional, etc. See the data sheet for the various operations. Pin functions selectors are used to control the MCP2221A GPIOs that are connected to both the SLOW pin and the PowerDown pin. Activating the box for either one of them will set the MCP2221A to assert the logic high on these pins. Unchecked GPIOs are set as inputs.

**3:** Latch and actual status, as well as accumulator configuration settings.

**4:** REGISTER LIST – Contains the current settings for each register. The registers can be saved to a CSV file and reloaded at a later time. The GUI loads the register values from the device when connected to the USB bridge. This overwrites what was previously in the GUI. A reload of the registers is necessary if the user wants a specific setup for the registers.

***FIGURE 3-6:*** ***Configuration*** *Tab.*




**Note 1:** See Figure 3-4.

**2:** Alert settings including enable and limits:

a) Set the limit for the desired alert. For current, use mA (mV for $V_{SENSE}$ for initial builds), $V_{BUS}$ in V and power in W.

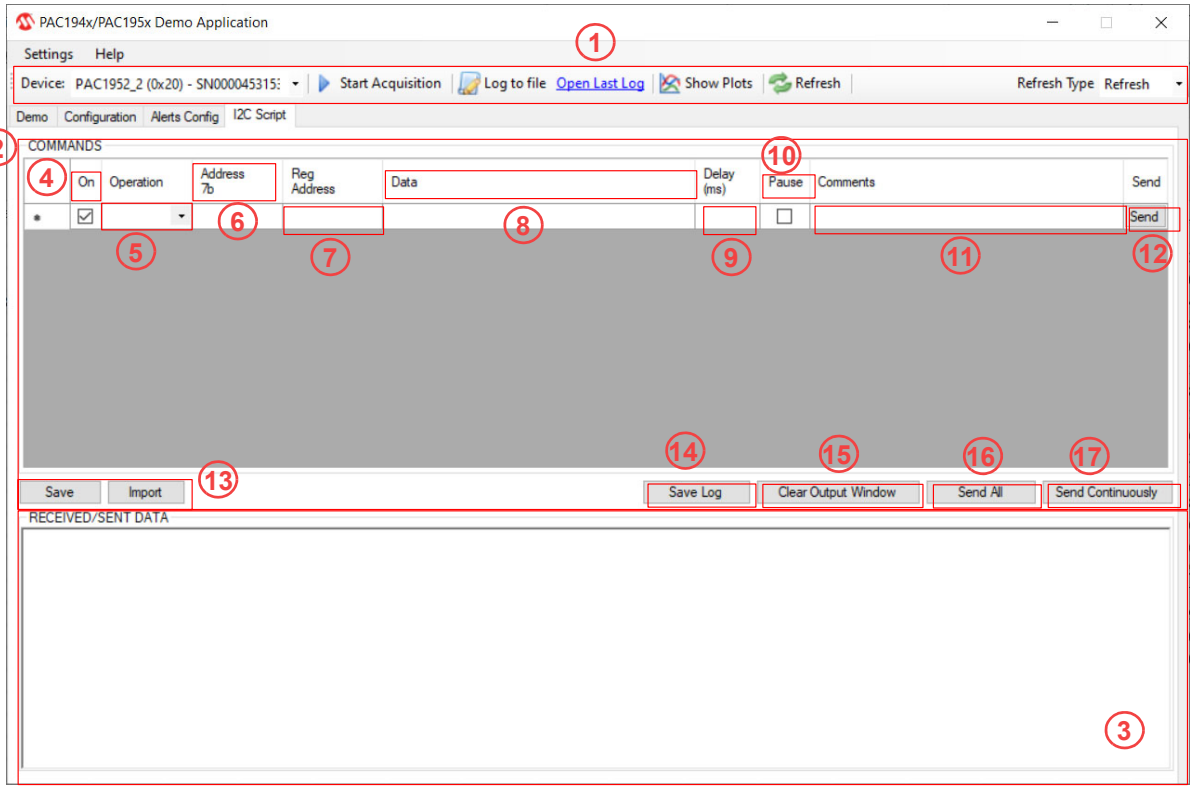
b) Select the number of consecutive failures before the alert occurs (1,4, 8 or 16).

c) Enable the alert. When enabled, the light on the Demo window turns green (enabled and no alert) and it turns red when limit is exceeded.

d) Select which $\overline{\text{ALERT}}$ pin (1 or 2) the alert should appear on. Any combination is allowed, as well as not setting the $\overline{\text{ALERT}}$ pins at all. The alert is still noted in the Alerts Status register (26h).

e) The GENERAL ALERTS for Acc Overflow, Acc Count and Alert CC (Conversion Complete) are also enabled here.

***FIGURE 3-7:*** ***Alerts Config*** *Tab.*




**Note:** All values are hexadecimal.

**Note 1:** See Figure 3-4.

**2:** COMMANDS section – Contains all the commands to manually send to device.

**3:** RECEIVED/SENT DATA – Contains the sent and received data from the IC on a per command basis.

**4:** On – If the check box is activated, the command will be sent. If not, the command will not be sent.

**5:** Operation – The Operation is to read or write (Send option when nothing is provided in the Data section).

**6:** Address 7b – $I^2C$ address in 7-bit.

**7:** Reg Address – Device register address.

**8:** Data – For read, it contains the number of bytes returned. For write, it contains the data to be written. For multibyte writes, use a comma between bytes.

**9:** Delay – In ms (Windows® is not a real-time OS, so delays are approximate).

**10:** Pause – If activated, a dialog box will open and commands will be paused until **OK** is clicked.

**11:** Comments – Manual comments.

**12:** **Send** – Single send. When clicked, that line (and only that line) will be done.

**13:** **Save/Import** – Save the commands above or import a set of commands previously saved.

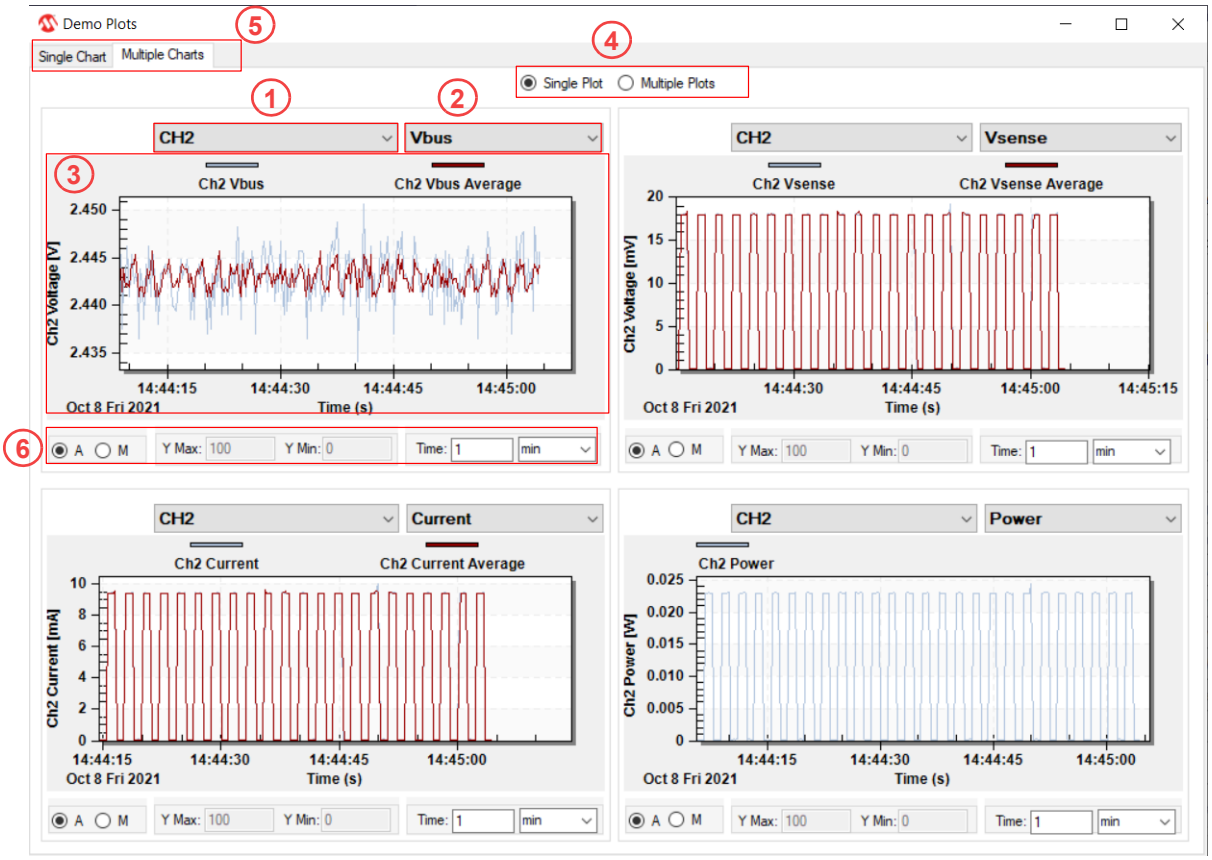
**14:** **Save Log** – Save the data in the RECEIVED/SENT DATA below.

**15:** **Clear Output Window** – Clear the RECEIVED/SENT DATA below.

**16:** **Send All** – Send all the commands in the COMMANDS section, one after another.

**17:** **Send Continuously** – Same as **Send All**, but repeats continuously until stopped.

***FIGURE 3-8:*** ***I2C Script** Tab.*




**Note 1:** Channel selection – Choose between CH1 and CH2.

**2:** Register selection – Select Count (ACCUM), $V_{BUS}$, $V_{SENSE}$, Current, Power, Accumulator or Energy.

**3:** Display of the chosen data.

**4:** Plot style – Choose between Single Plot or Multiple Plots (multiple channels on each plot).

**5:** Option to display one plot or multiple plots in one window.

**6:** Plot controls – Choose between manual and automatic Y-axis values, select the time interval from seconds to hours.

***FIGURE 3-9:*** *Demo Plots – Multiple Charts, Single Plot Option.*

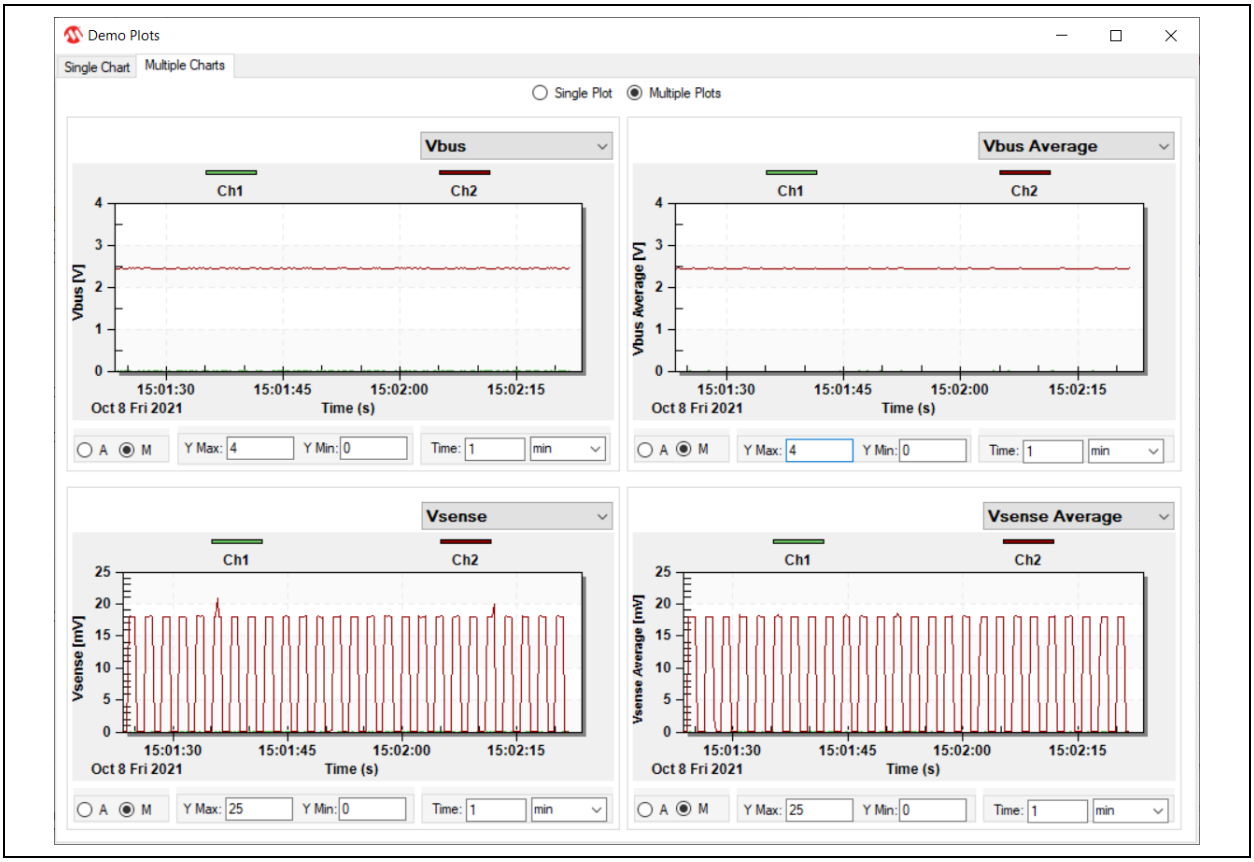



***FIGURE 3-10:*** *Demo Plots – Multiple Charts, Multiple Plots Option.*

### 3.2.1 Settings

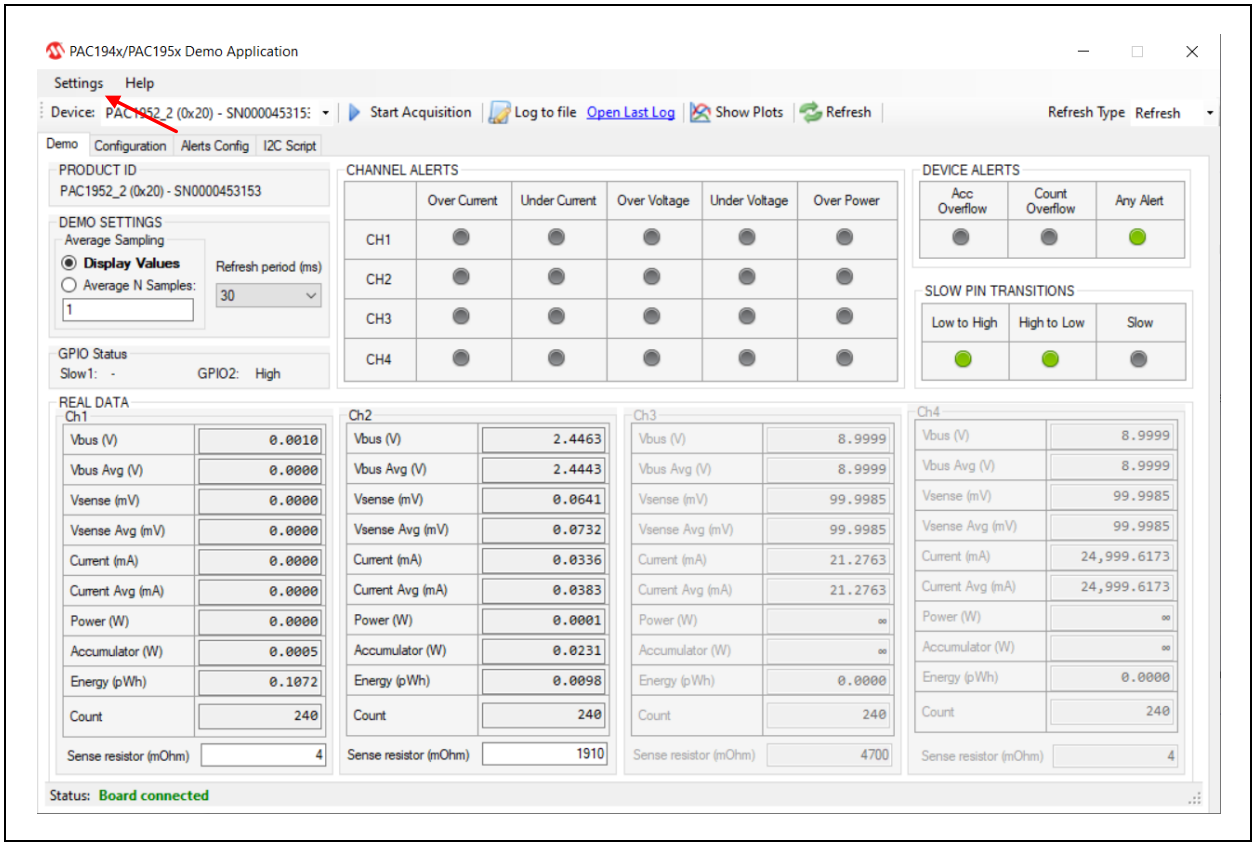



***FIGURE 3-11:*** *Settings.*

The Settings drop-down menu contains three items:

- Demo Board Settings
- Rename Channels
- Voltage Ratios

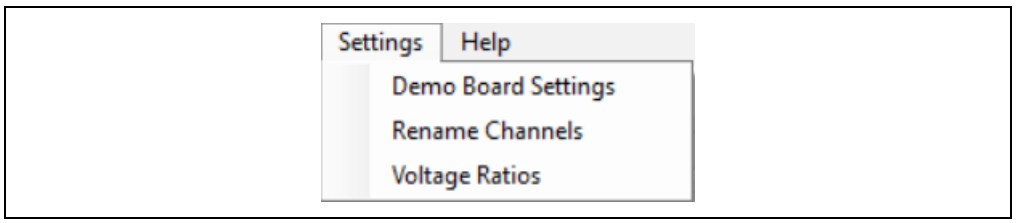



***FIGURE 3-12:*** *Settings Options.*

1. Demo Board Settings – This is used in Demo configuration to control an on-board FET. It currently produces a pulsed current waveform, as seen in Figure 3-10. The DAC Settings enable the DAC output on the MCP2221A and the amplitude is determined by the value entered in “Max”.

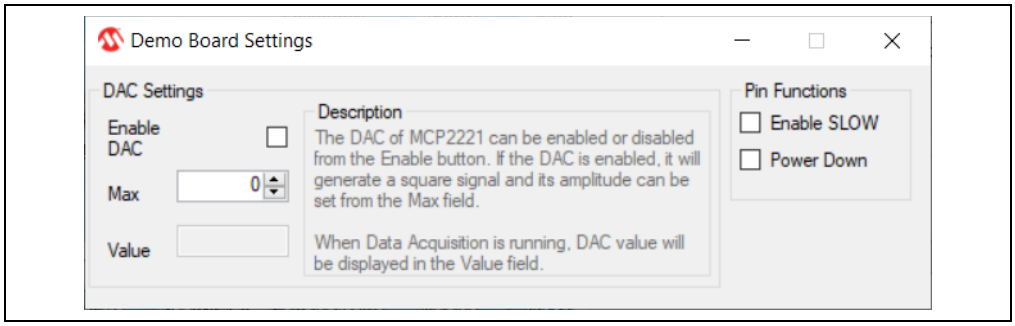



***FIGURE 3-13:*** *Demo Board Settings.*

2. Rename Channels – This setting allows the user to change the name of a channel from CH1 to “Ch1 - Text”. The new name will be visible in the Demo Application window, as well as the Demo Plots (see Figure 3-16 and Figure 3-17).

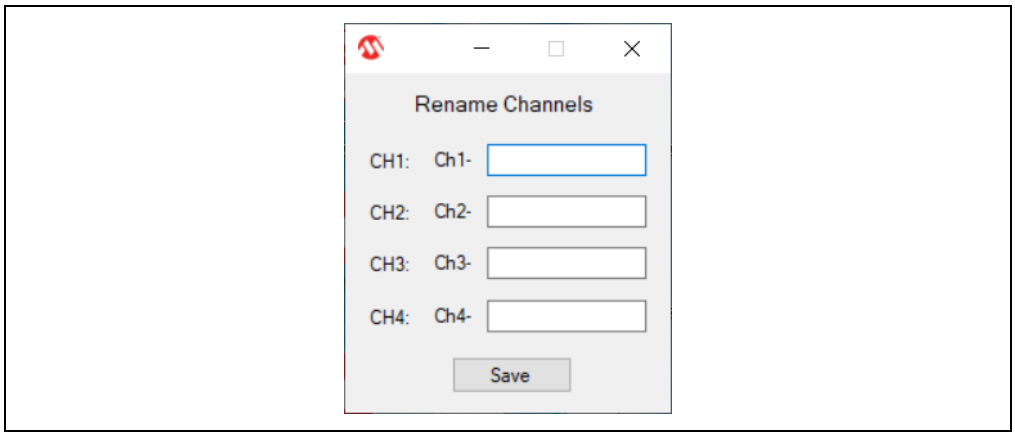



***FIGURE 3-14:*** *Rename Channels.*

3. Voltage Ratios – This setting allows the user to set the resistor divider ratio (when selected with J106 or J104). The GUI will translate the measured voltage to the value before the divider.

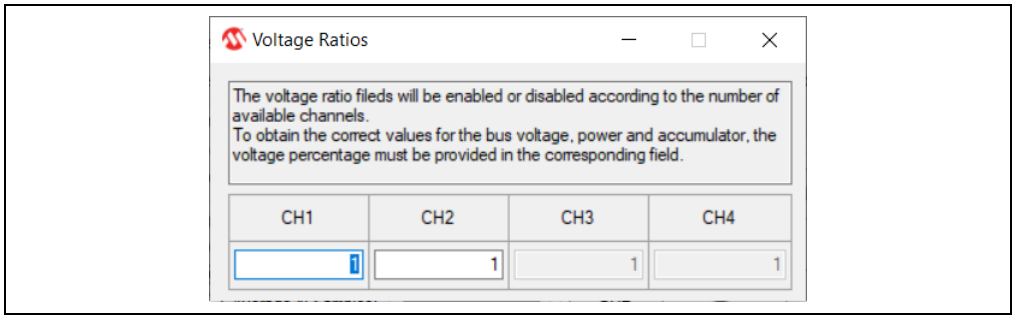



***FIGURE 3-15:*** *Voltage Ratios.*

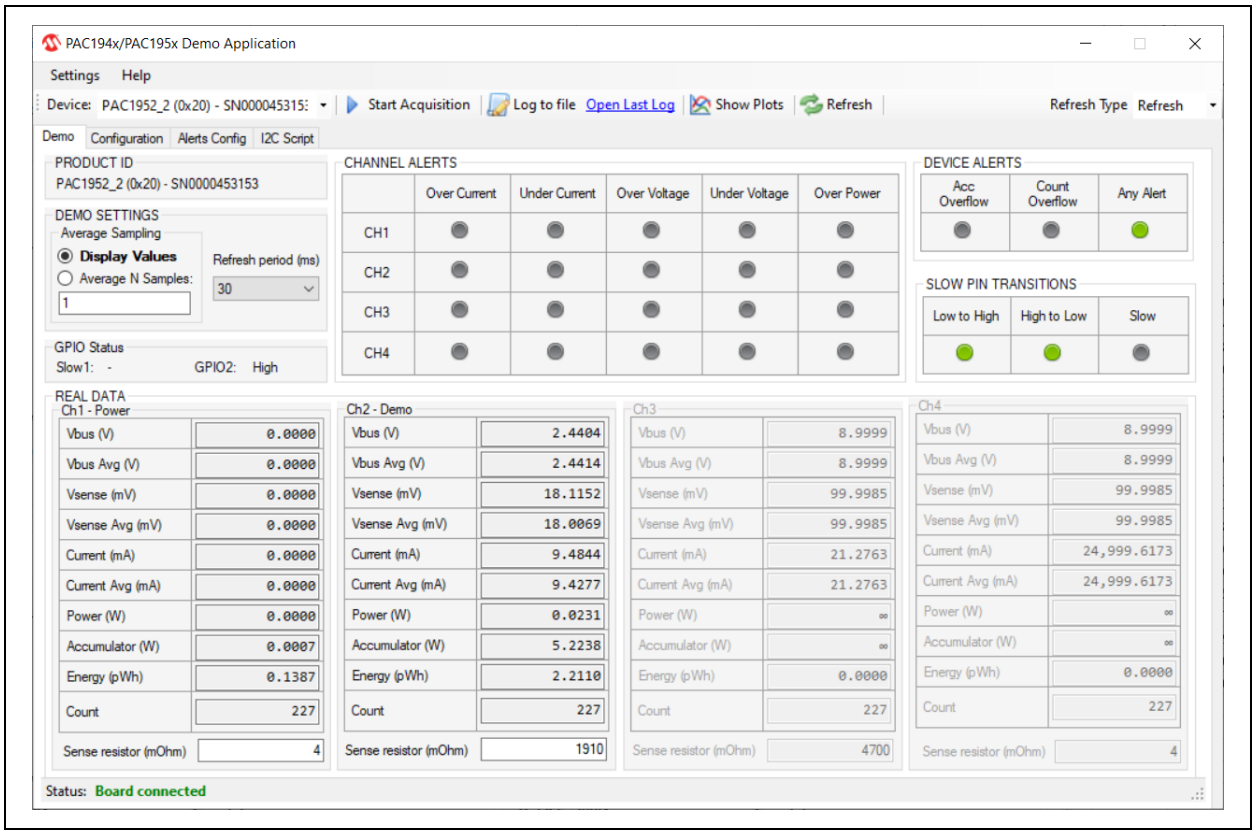



***FIGURE 3-16:*** *Channel Renaming Example.*

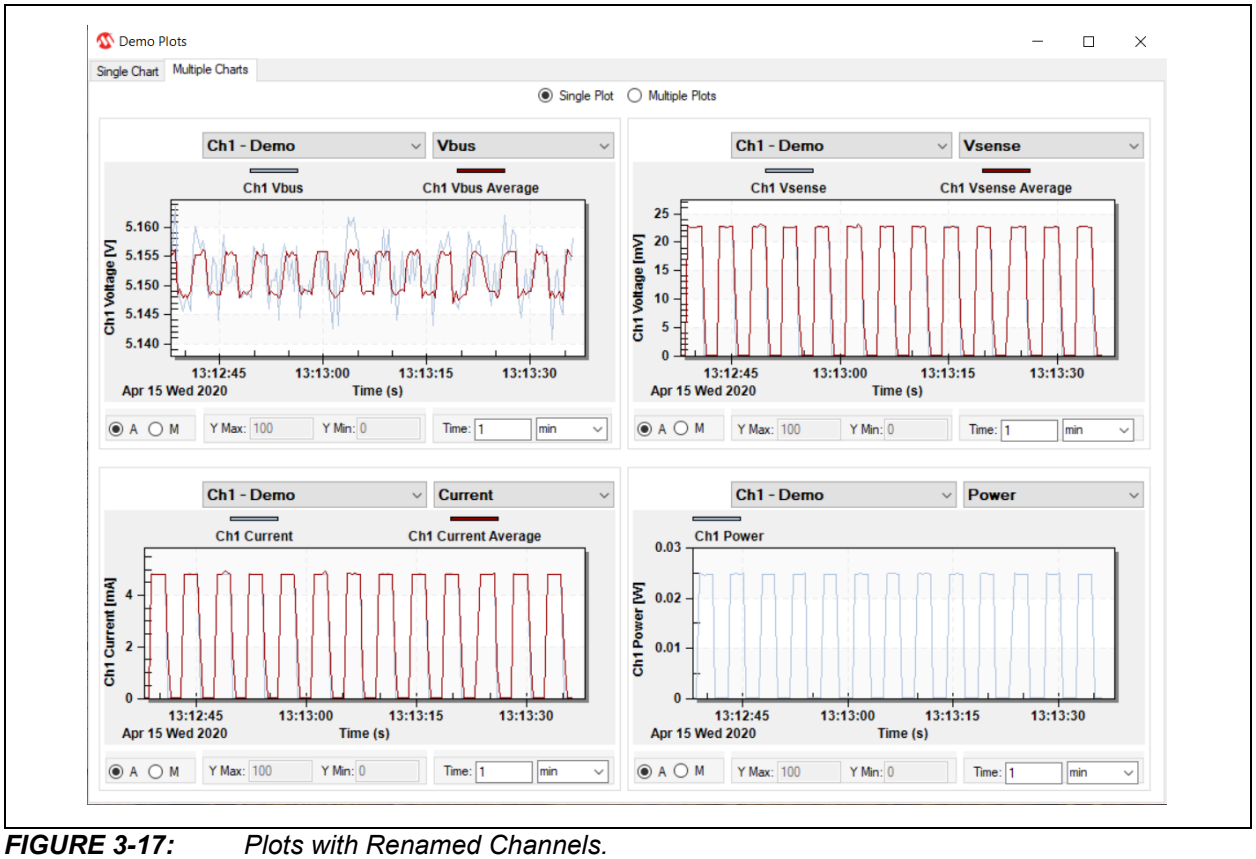



***FIGURE 3-17:*** *Plots with Renamed Channels.*

### 3.2.2 Help

The Help drop-down menu contains one item:

- About – Contains the software revision number and the Microchip base warranty information.

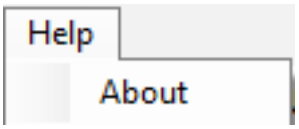



***FIGURE 3-18:*** *Help.*

### 3.2.3 Other GUI Descriptions

Here are some general hints and tricks to improve the usability of the GUI:

1. If the user has multiple PAC1952-2 devices connected to the $I^2C$ bus, the GUI will see them and the user can control them via *PAC194x/PAC195x Demo Application>Device*.
2. Disabling channels in the **Configuration** tab and then choosing Fast or Burst will speed up the device operation on the enabled channels. The MCP2221A cannot support the data rate, so while the chip is operating at a higher speed, the user will not be able to get each sample out with the on-board bridge.
3. On the **Configuration** tab, a REFESH is done after any selection. The user will see the GUI change the LAT/ACT values after selecting the setting for this reason.
4. Right click **Save** in the REGISTER LIST to select or deselect all registers.

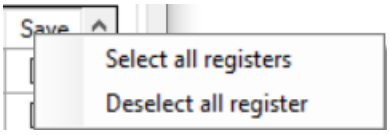



***FIGURE 3-19:*** *Registers Selection.*

5. Each writable register can be changed by clicking Data for that register and changing the value. This only works for writable registers.
6. Change the color of the trace:

- right click on the plot (anywhere) to get the menu below:

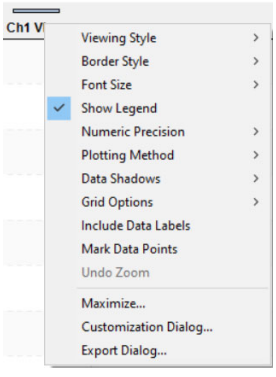



***FIGURE 3-20:*** *Changing Colors.*

- Select Customization Dialog and then select **Style**.

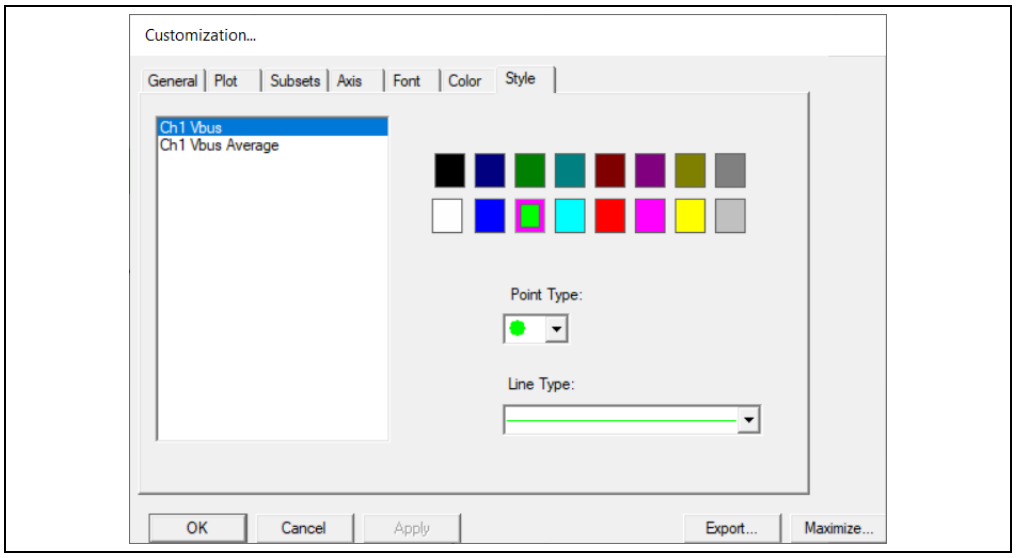



***FIGURE 3-21:*** *Customization.*

- Change the color to one of the 16 options and set the "Point Type" and "Line Type".

7. Choose between hardware averaging, 8x (Display Values) and software averaging (Average N Samples). See Figure 3-4. If the user selects Average N Samples, the values in the REAL DATA section for average $V_{BUS}$ Avg and $V_{SENSE}$ Avg, as well as the Plot data will be the software averaged value.

### 3.2.4 Scenario 1: Changing the Sampling Rate/Mode

The PAC1952-2 supports several sampling rates (8, 64, 256 and 1024 SPS) along with variations on accumulation. This scenario describes how to change the settings for a couple of different options.

The first selection moves from the default sampling speed of 1024 SPS to 8 SPS, as well as from the sampling mode Adaptive Accumulation to the regular Accumulation Method (see the data sheet for differences).

Under the **Configuration** tab, go to *CONTROL>Sample Mode* and select the eighth element, labeled “8sps”. This triggers a Refresh and the ACT register for the CONTROL REGISTER ON REFRESH will show 8 SPS while the LAT will show the previous setting of 1 ksps.

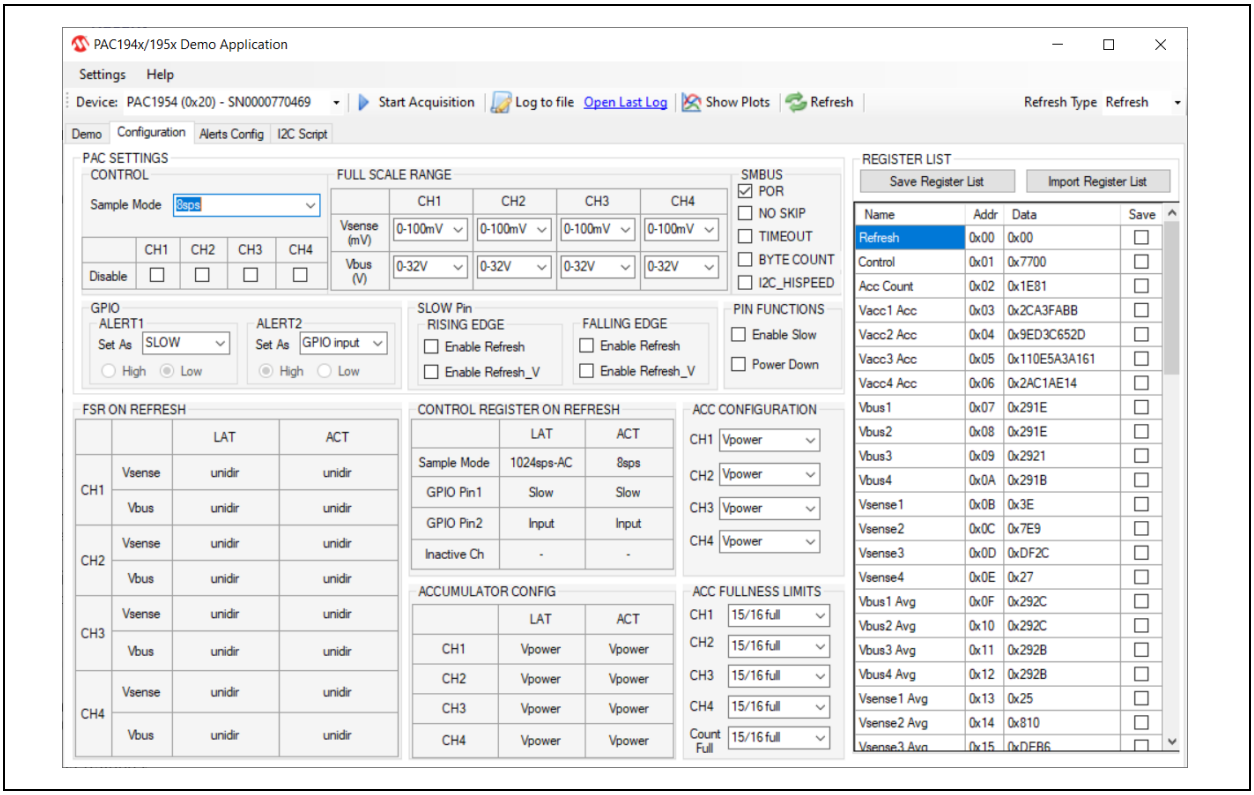



***FIGURE 3-22:*** *Changing Sample Mode to 8 SPS.*

In the PAC194x/PAC195x Demo Application window, click **Start Acquisition** and the data will be collected at the new rate. This can be seen in the Acc Count register, as a much lower rate. The MCP2221A and the GUI collect data a little over two times per second. Thus the user will see a count of 3 as the device does 3 samples during the time the GUI sends the next Refresh command.

### 3.2.5 Scenario 2: Changing the Refresh Type to Refresh_V

The PAC1952-2 supports three Refresh options:

- Refresh (regular) – This Refresh causes the device to load all changes and become the active setup.
- Refresh_G – This is the same as a regular Refresh but it is a Global Refresh for the bus.
- Refresh_V – This does not reset the Acc Count or Load registers, it simply moves the data to the $I^2C$ domain for reading.

Changing the Refresh Type to Refresh_V allows the Count to continue to go up while still allowing the user to read the latest data.

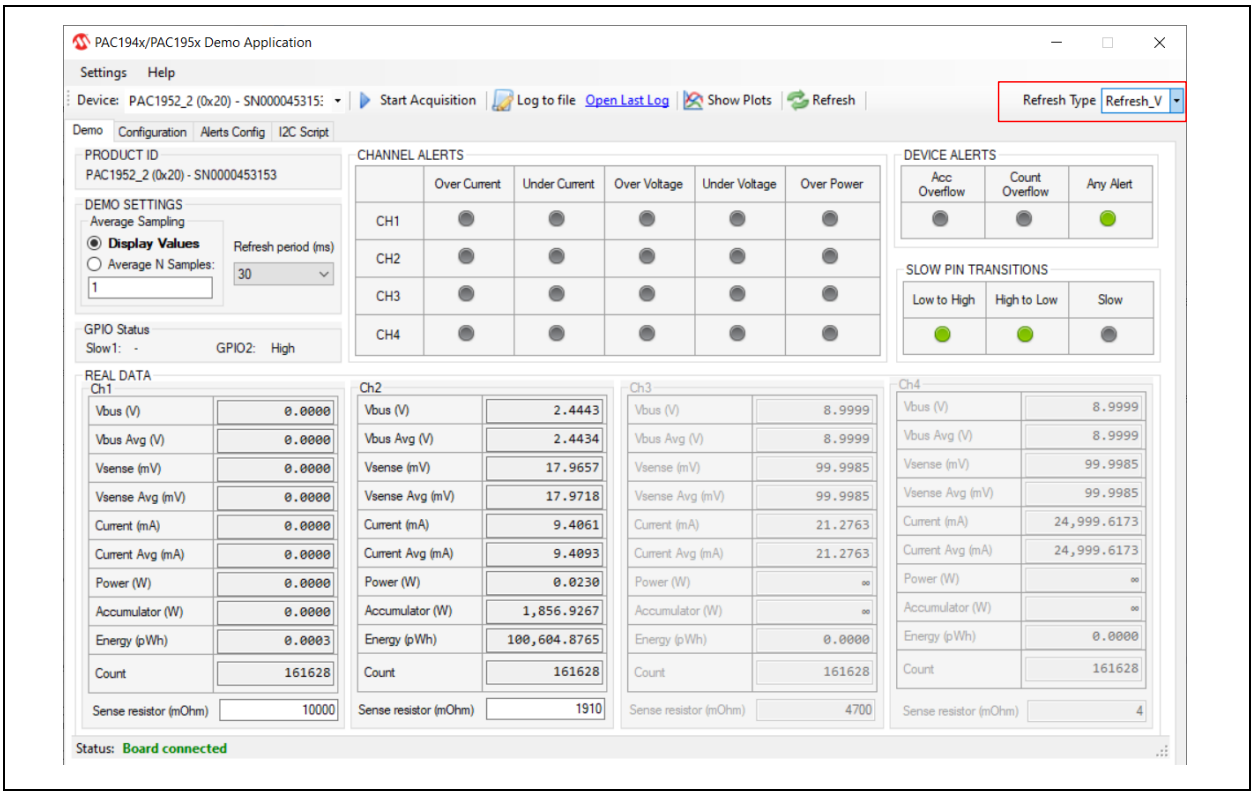



***FIGURE 3-23:*** *Refresh Type.*

Click the drop-down menu and select Refresh_V.

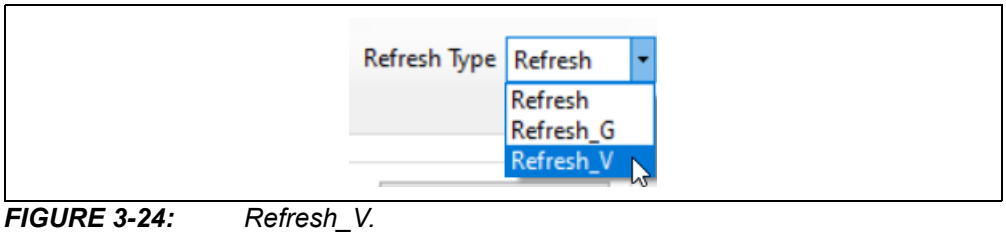



***FIGURE 3-24:*** *Refresh_V.*

Click **Start Acquisition** and the data will be collected using the Refresh_V method. This option is available while the GUI collects data. With the GUI still running, use the drop-down to select the Refresh and see the Count being reset regularly.

### 3.2.6 Scenario 3: Setting Limits and Alerts

A new feature of the PAC1952-2 is the additional alert functionality, including limits for overcurrent, undercurrent, overvoltage, undervoltage and overpower. These limits are selectable per channel and able to drive one of the two ALERT pins.

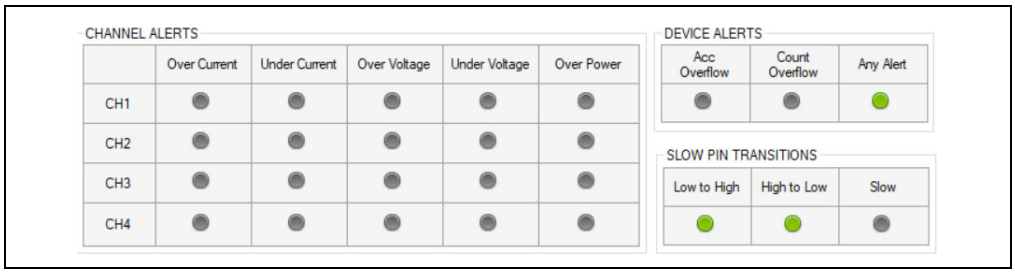



***FIGURE 3-25:*** *Channel Alerts.*

The alert is green when the limit is enabled. If the data value is within the limits (or condition), the alert is green. If the data value is outside the limit, the alert turns red.

**EXAMPLE 3-1: SETTING LIMITS**

Select the **Alerts Config** tab and note the options for the various limits. Limits are set on CH4 and Limit, Nsamples and Enable Alert are modified. The user may also select the Alert to be visible on one of the two ALERT pins.

Below, Over Current ($V_{SENSE}$), Over Voltage ($V_{BUS}$) and Under Voltage ($V_{BUS}$) are set, limits are set and the Alert is enabled for those limits (see Figure 3-27). 2.0V are applied on the SENSE4+ pin.

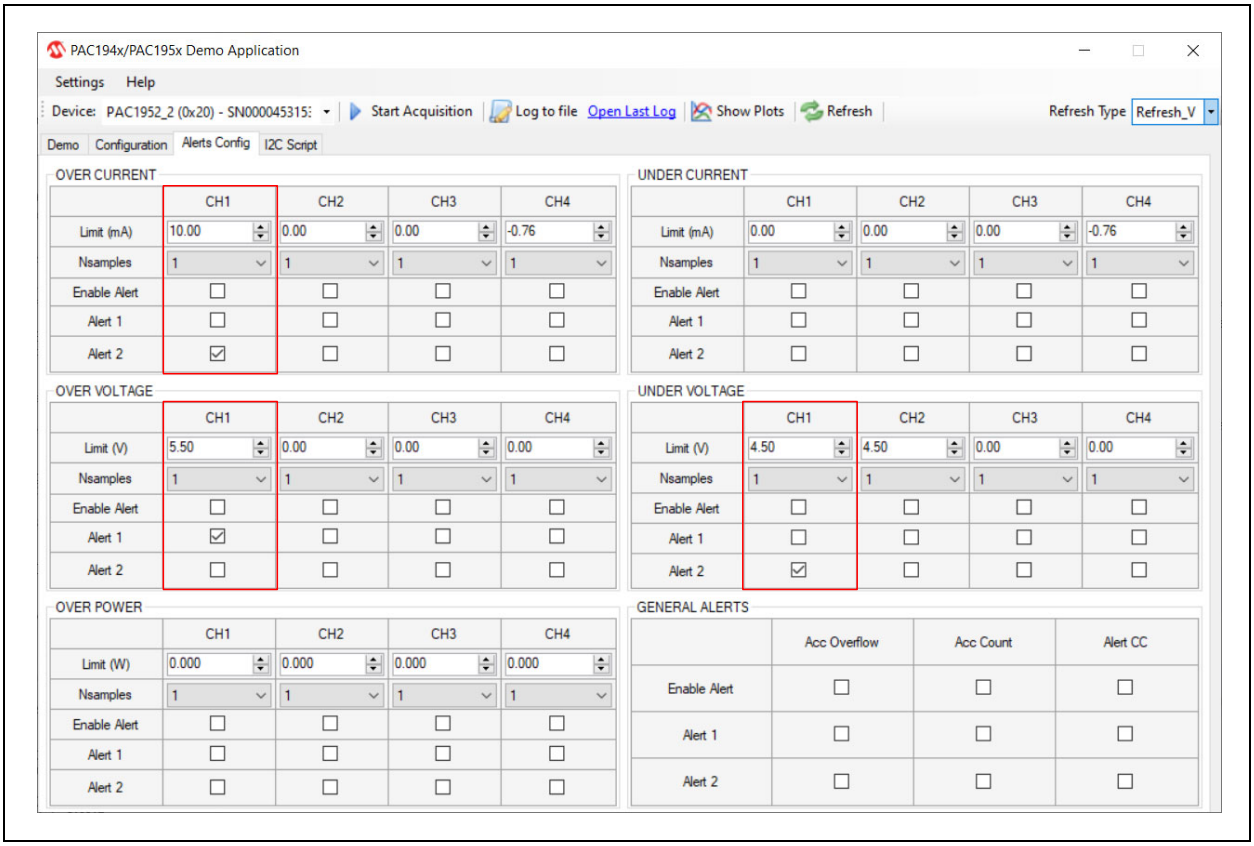



***FIGURE 3-26:*** ***Alerts Config*** *Tab.*

In the PAC194x/PAC195x Demo Application window, click **Start Acquisition**. The CHANNEL ALERTS are set based on the setup in the **Alerts Config** tab and will be green when the calculated values are within the limits, and red when the values exceed the limits.

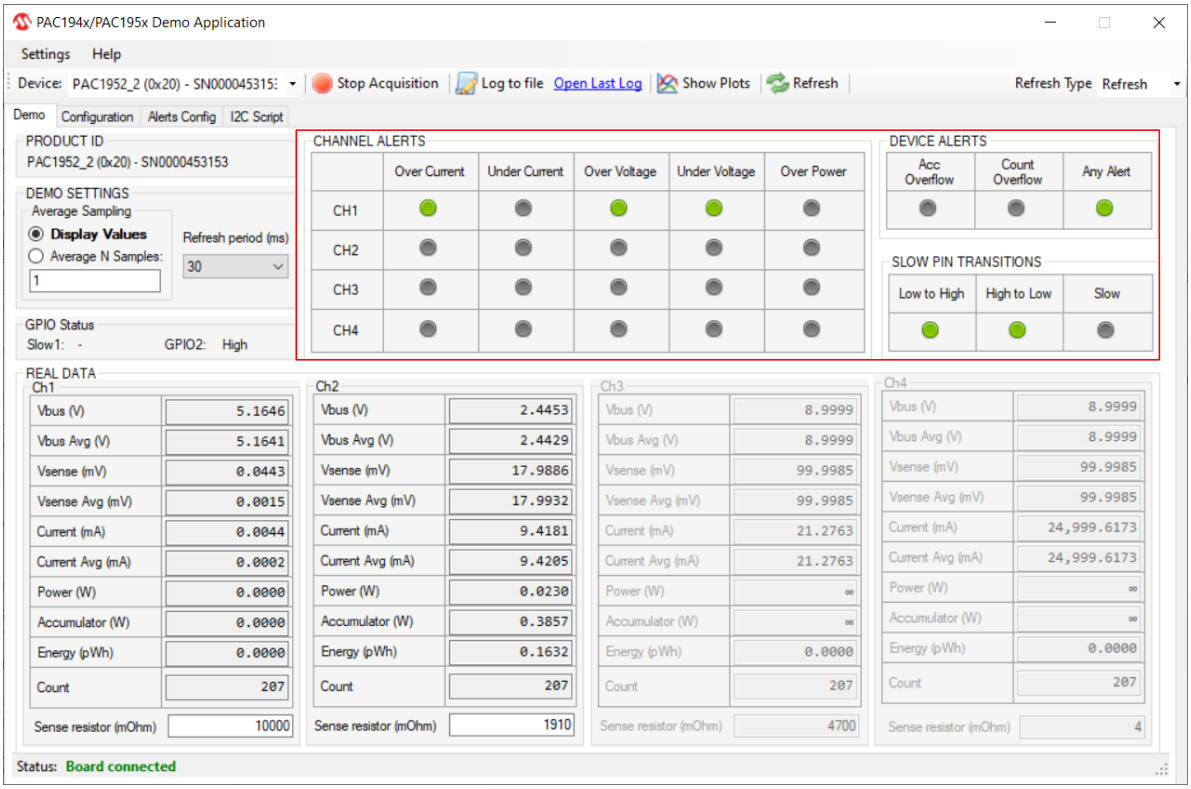



***FIGURE 3-27:*** *Limits Set.*

Note that Any Alert (top right corner) is also green. This signifies that alerts are not sensed. If you lower the voltage that is applied to the SENSE1+ to 0.0V (under the previous limit of 4.5V), the limit fails and the Under Voltage alert is red, as well as Any Alert. The $V_{SENSE}$ value in the REAL DATA section will show 0.0V. See Figure 3-28.

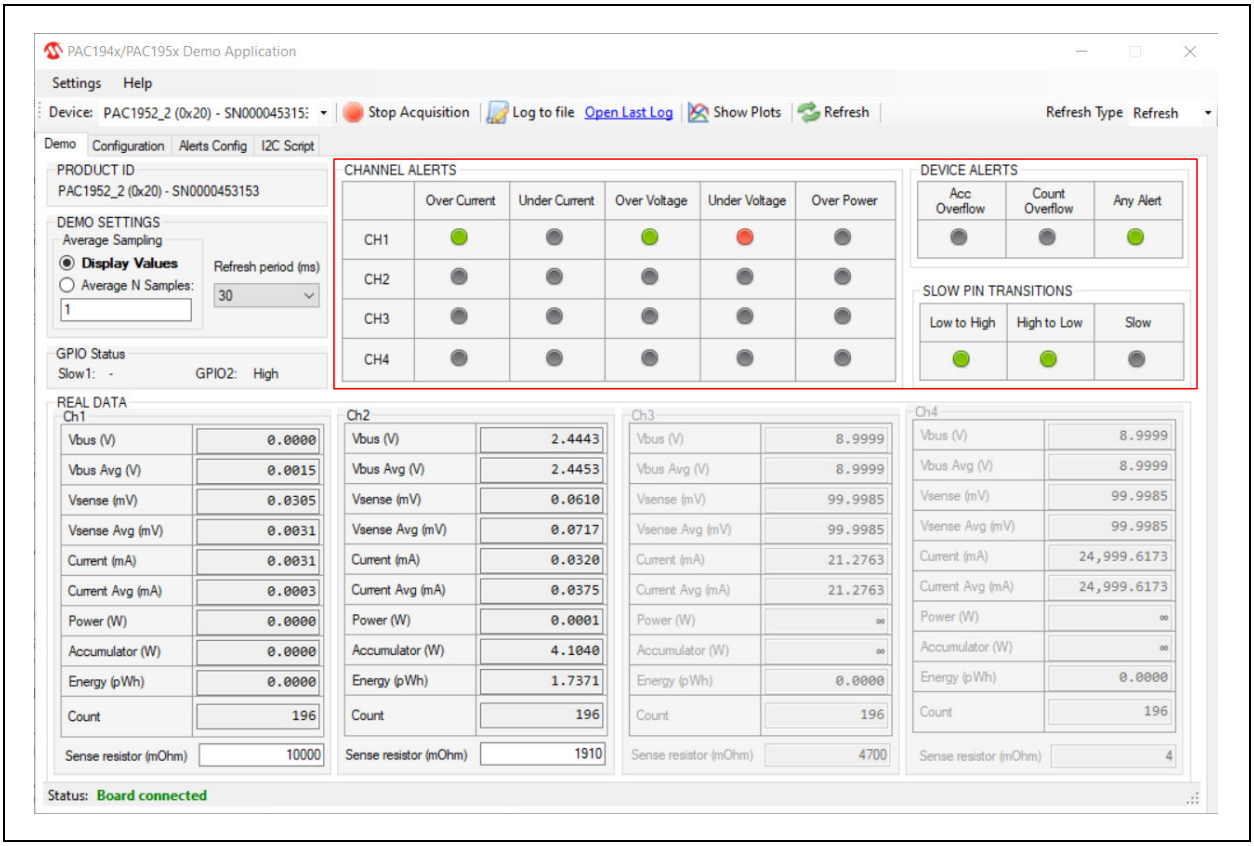



***FIGURE 3-28:*** *Limits Failing.*

### 3.2.7 Scenario 4: Go Fast

The PAC1952-2 default sampling rate is 1024 SPS and it can sample all channels (and offset correction) at that rate. In order to sample faster than that rate, the Fast and Burst options are available. 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 a detailed explanation). The MCP2221A cannot support the communication speeds necessary to capture all the data, so an alternative Host is required to capture the data.

Select the **Configuration** tab, set the Sample Mode to Fast and disable CH2. You can see the results in the CONTROL REGISTER ON REFRESH section. Sample at a Fast rate of 2560 SPS (because you are still doing offset correction). To go to the full 5120 SPS, select Burst from the Sample Mode drop-down menu.

The chip is now in that mode, the GUI is not capturing/refreshing the data until you **Start Acquisition**. When you **Start Acquisition**, you can see the count going up faster than the previous settings.

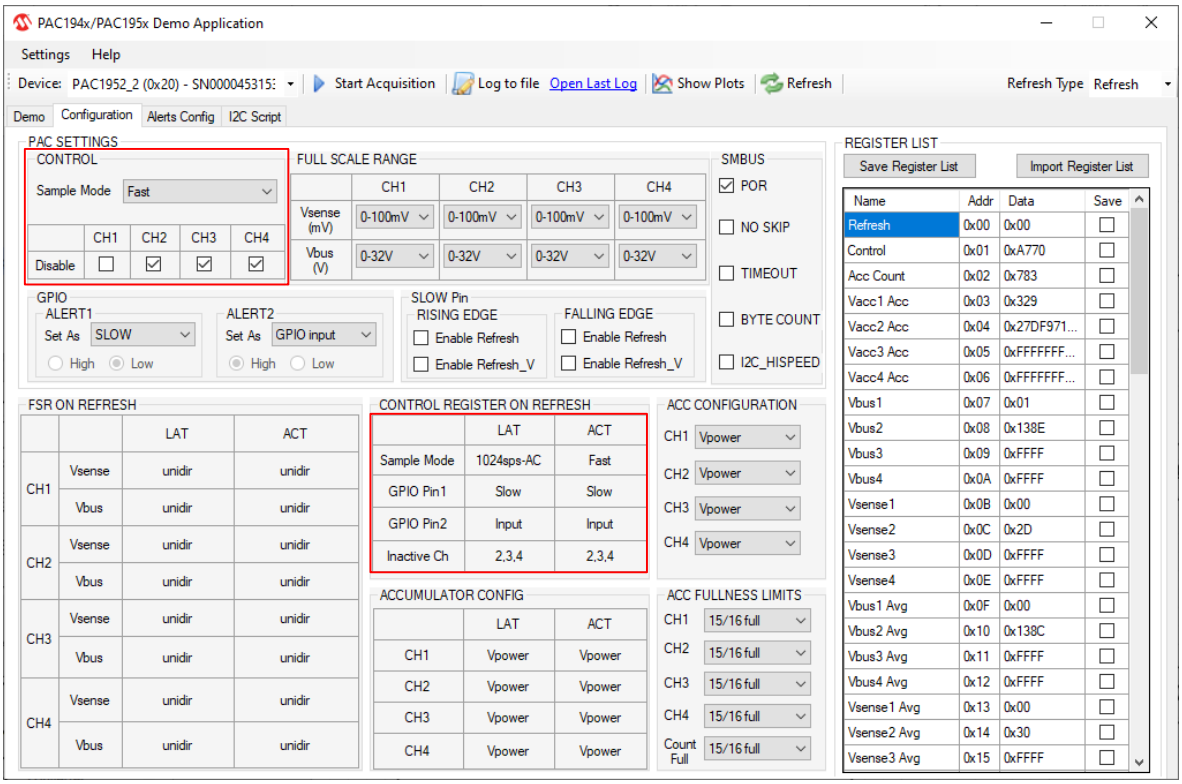



***FIGURE 3-29:*** *Sample Mode: Fast.*

# Chapter 4. Hardware Description

## 4.1 INTRODUCTION

The PAC1952-2 is placed at the center of the board, in a quad flat no-lead package (QFN) with wettable flanks; U1. It is surrounded by probe points with the pin names labeled. There is a provision for an input filter for each pair on the input pins, but these are not populated. The other hardware on the board is described below.

Initial samples will be provided with a Plug-In Module (PIM) that allows easy changing of parts and the update of parts as needed.

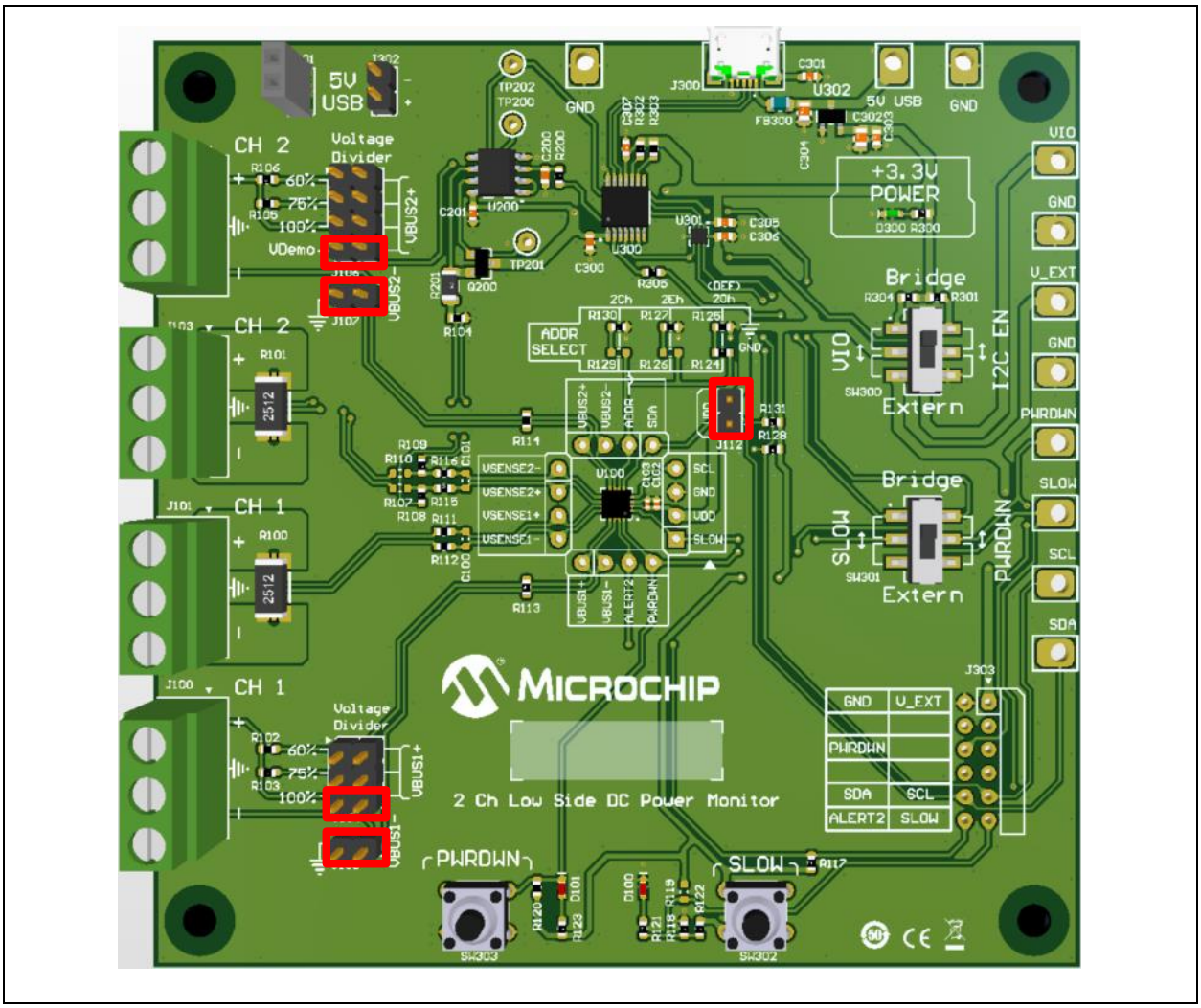



***FIGURE 4-1:*** *PAC1952-2 Evaluation Board.*

## 4.2 DEMO MODE AND EVB MODE

The EVB mode is designed to allow an easy demonstration of the board or to be used in a normal evaluation of the four channel inputs. In Demo mode, the inputs are connections to different sense resistors, compared to the EVB mode. They are configured as in Table 4-1.

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

| Channel | Demo | EVB (Headers) |
|---|---|---|
| 1 | R100 = 4 mΩ | R100 = 4 mΩ |
| 2 | R104 = 1.9Ω (Demo signal) | R101 = 4 mΩ |

The EVB sense resistors are connected to the headers on the edge of the board labeled CH1 (J100), CH2 (J102), CH3 (J103) and CH4 (J107). CH4 is connected to the header in the Demo and EVB configuration. The center pin for each header is Ground to allow easy testing but it is not required to use it.

To change from Demo mode to EVB mode (and back), the following 0Ω resistors must be populated as per Table 4-2.

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

| Channel | Demo | EVB |
|---|---|---|
| 1 | No Change | No Change |
| 2 | R108 and R109 populated<br>R107 and R110 not populated | R108 and R109 not populated<br>R107 and R110 populated |

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

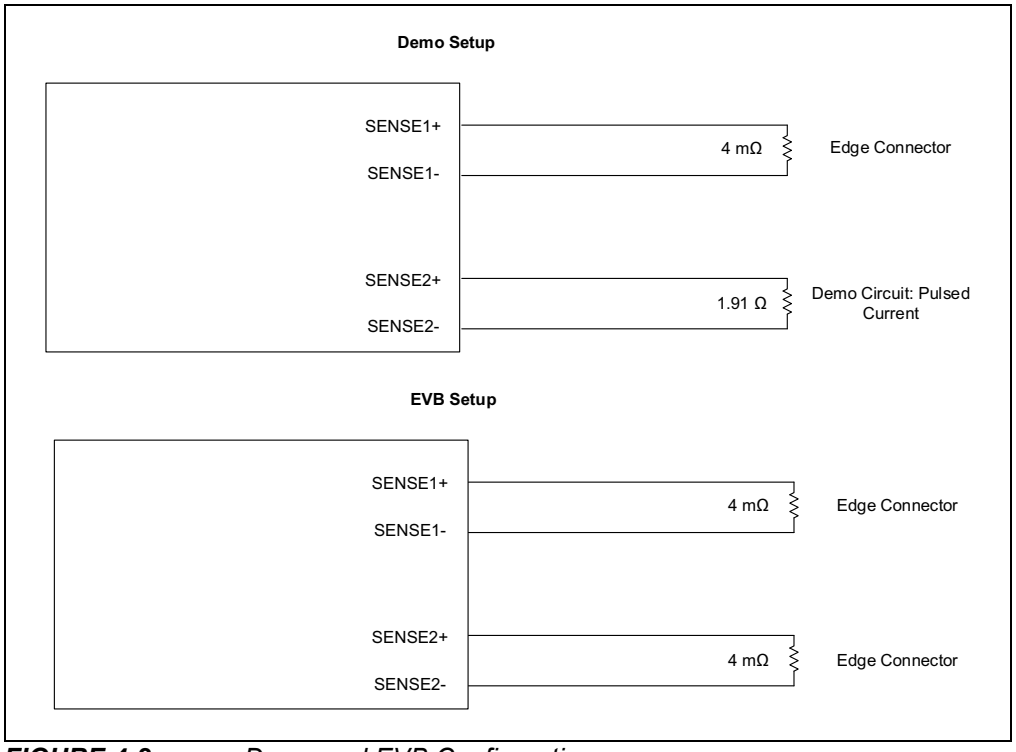



***FIGURE 4-2:*** *Demo and EVB Configuration.*

## 4.3 DEFAULT CONNECTIONS

In **Section A.2 "Board – Schematic 1"**, the USB connector is at the top. This is the default (as shipped) position of the shorting shunts that connect the different pin pairs. SW300 must be set to the bridge position for the USB communication to work properly. SW301 must be switched to Extern for the initial evaluation. A jumper must be on J112 to operate.

## 4.4 $V_{BUS}$ AND $V_{SENSE}$ CONNECTIONS – USING EXTERNAL SOURCES FOR SYSTEM MODE

To use external sources for $V_{BUS}$ with an external load, the board must be used in the EVB configuration discussed above. The center terminal of each connector is connected to ground for a convenient return connection for the load. Each PAC1952-2 channel has an on-board current sense resistor of 4 mΩ connected between the positive (+) input and the negative (-) input pins, which gives 25A for the full-scale current.

The 4 mΩ resistors can be unsoldered and replaced with a different value at the discretion of the user. The 4 mΩ resistors have very wide metal connecting each end to terminals 1 and 3 of the connector block and it is challenging to remove them cleanly. If they are removed, they will reveal a layout that facilitates soldering this wide metal connection to each end of the new sense resistor and a Kelvin connection for each end that goes to the inputs of the PAC1952-2. Both the wide metal to the connector block and the Kelvin connection need to be soldered to the new sense resistor.

## 4.5 ADDRESS SELECTION

The PAC194X/5X devices can have up to 16 different $I^2C$ addresses based on the resistor connected to the ADDR_SEL pin (see the data sheet). The EVB has resistors on board that allow the user to select up to four different addresses based on the resistors on board. The default resistor setup is grounded which results in an address of 20h (10h for a 7-bit address). Table 4-3 shows the hardware setting for each address.

**TABLE 4-3: ADDR_SEL PIN OPTIONS**

| Setup | R125 | R127 | R129 | 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 the desired resistor to the ADDR PIM connection and connect to ground. |

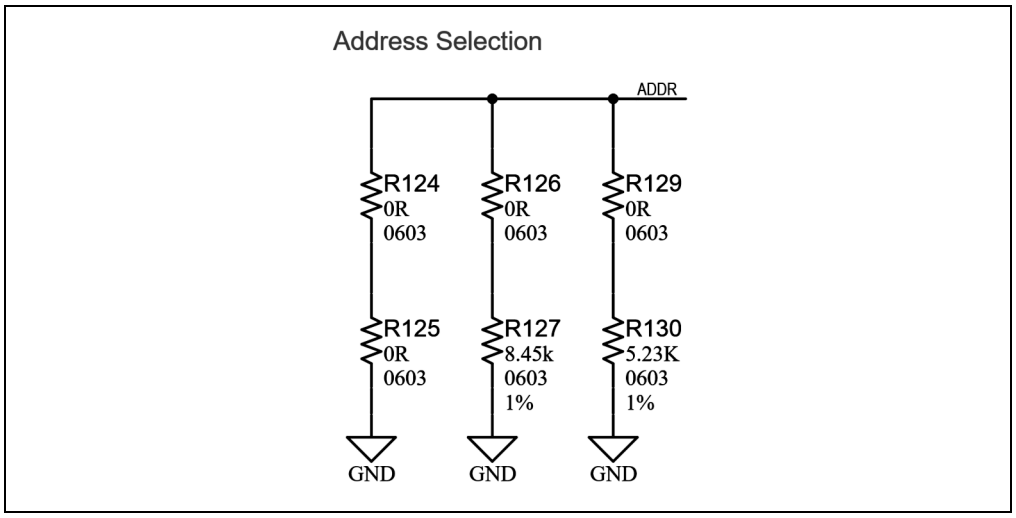



***FIGURE 4-3:*** *ADDR_SEL Circuit.*

## 4.6 HARDWARE FOR I²C/SMBUS COMMUNICATION OVER USB OR EXTERNAL I²C CONNECTION

U300 is an MCP2221 USB-2 to $I^2C$ bridge chip that translates the USB communications into $I^2C$ read/write commands to configure the PAC1952-2 and to capture status and results data. To the left of U300 there is U301, a level shifter that matches the $I^2C$ signals from the MCP2221 to the $V_{IO}$ voltage used for the PAC1952-2 $V_{DD}$. On the far right side of the board, there is a SW300 switch and a J303 connector. These are both used when connecting an external $I^2C$ connection directly to the board instead of using the USB connection. J303 allows the user to connect the external $V_{IO}$, SCA and SCL signals directly to the PAC1952-2. SW300 disables the USB bridge and level shifter and connects the pull-up resistors on the SCA and SCL pins to the external $V_{IO}$ voltage.

SW301 is used to select the SLOW and POWER-DOWN pins to either the MCP2221A (bridge selection) or the J303 (external selection).

## 4.7 SIGNAL DESCRIPTION IN DEMO MODE

In Demo mode, the signals measured are:

- Channel 1: Edge Connector
- Channel 2: PAC1952-2 Demo signal – 1.91Ω
    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.

All the plots in the GUI description above are made in the default Demo mode configuration using varied DAC settings.

## 4.8 ADDITIONAL HARDWARE DETAILS

The J112 jumper is available for the use of an external meter to measure the $I_{DD}$. This provides a place to remove the short and insert a current meter to measure the current in the PAC1952-2 $I_{DD}$.

## 4.9 DIRECT EXTERNAL I²C CONNECTION

The EV99K19A can be used with direct $I^2C$ control from a PC running Windows®, Linux® or other digital controller. For external $I^2C$ use, $V_{DD}$ may need a voltage that is different from the default settings for USB control. This is easily implemented by moving SW300 from the bridge position used for USB control to the external position used for external $I^2C$ control. Connecting the external SCA and SCL signals is then required, along with the power ($V_{IO}$) and ground used for these $I^2C$ signals. The PAC194x5x Demo Application cannot be used with direct $I^2C$ connection.

**NOTES:**

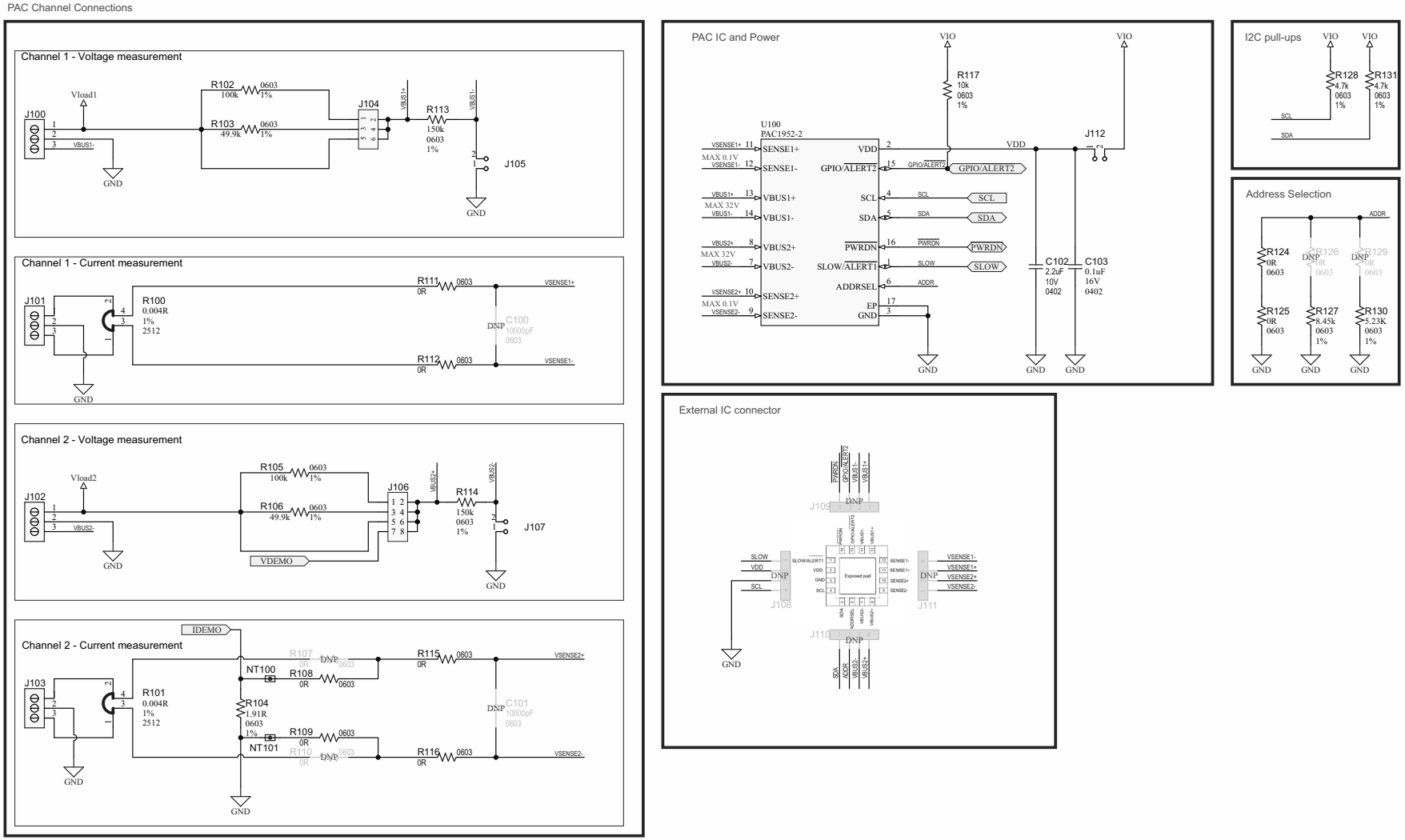
# Appendix A. Schematic and Layouts

## A.1 INTRODUCTION

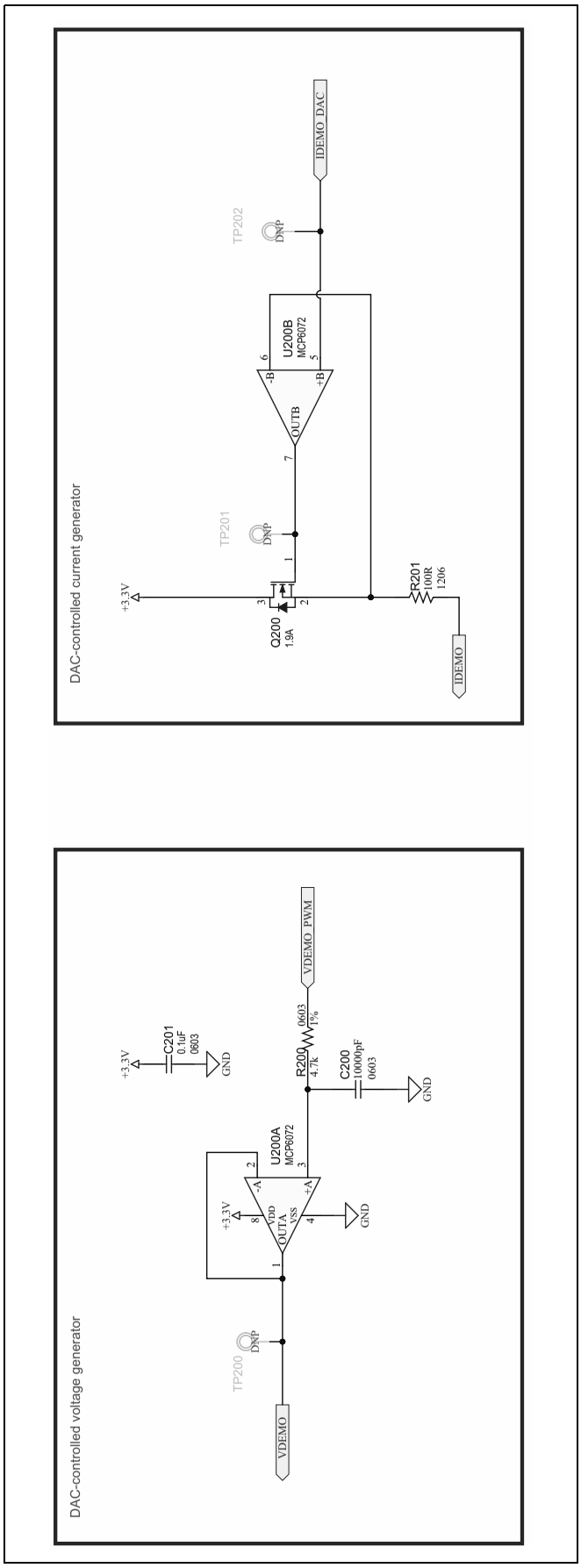
This appendix contains the following schematics and layouts for the PAC1952-2 Evaluation Board:

- **Board – Schematic 1**
- **Board – Schematic 2**
- **Board – Schematic 3**
- **Board – Top Silk**
- **Board – Top Copper and Silk**
- **Board – Top Copper**
- **Board – Bottom Silk**
- **Board – Bottom Copper and Silk**

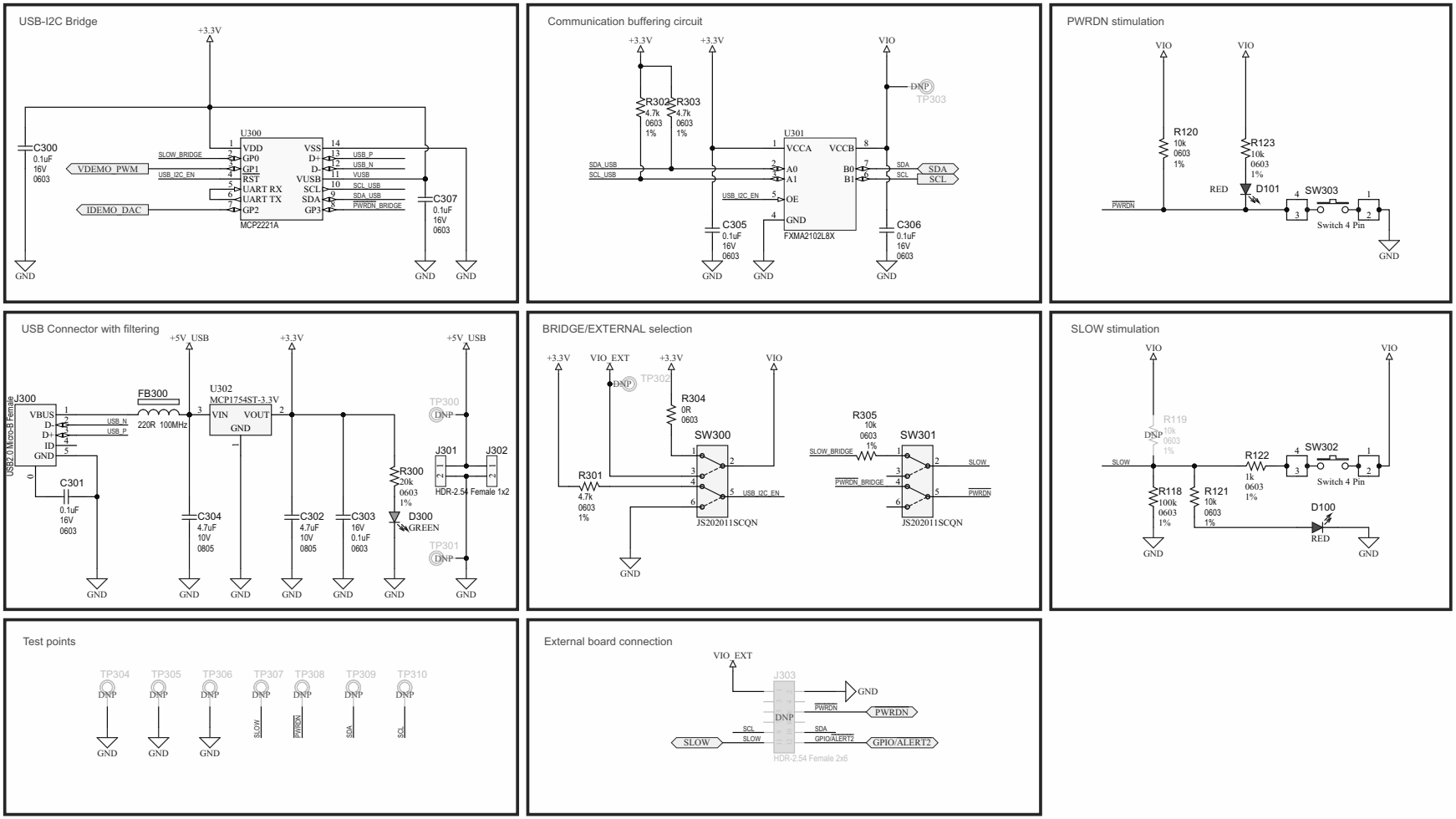
## A.2 BOARD – SCHEMATIC 1



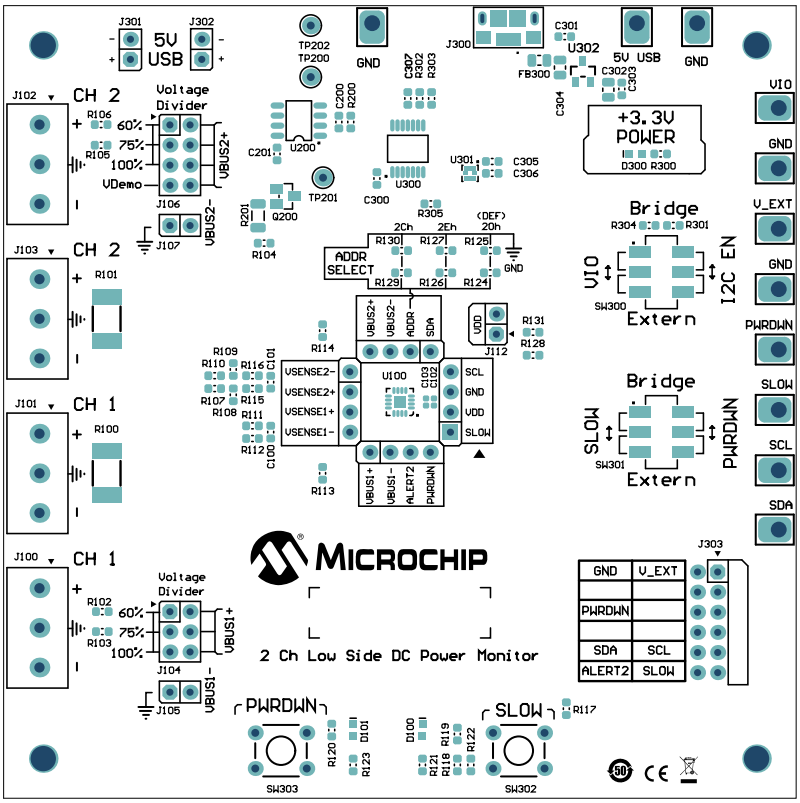
## A.3 BOARD – SCHEMATIC 2



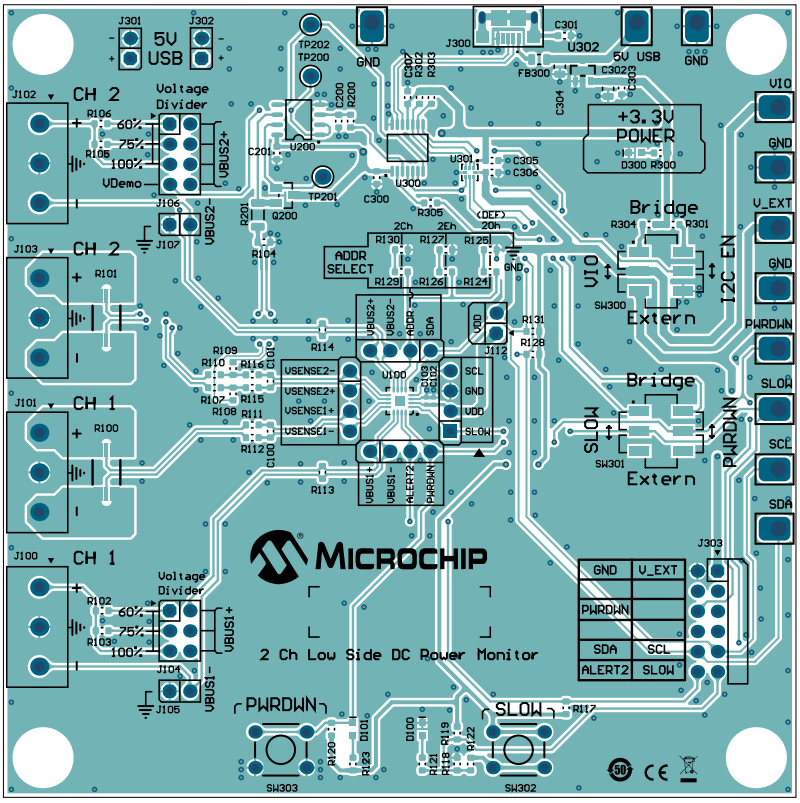
## A.4 BOARD – SCHEMATIC 3



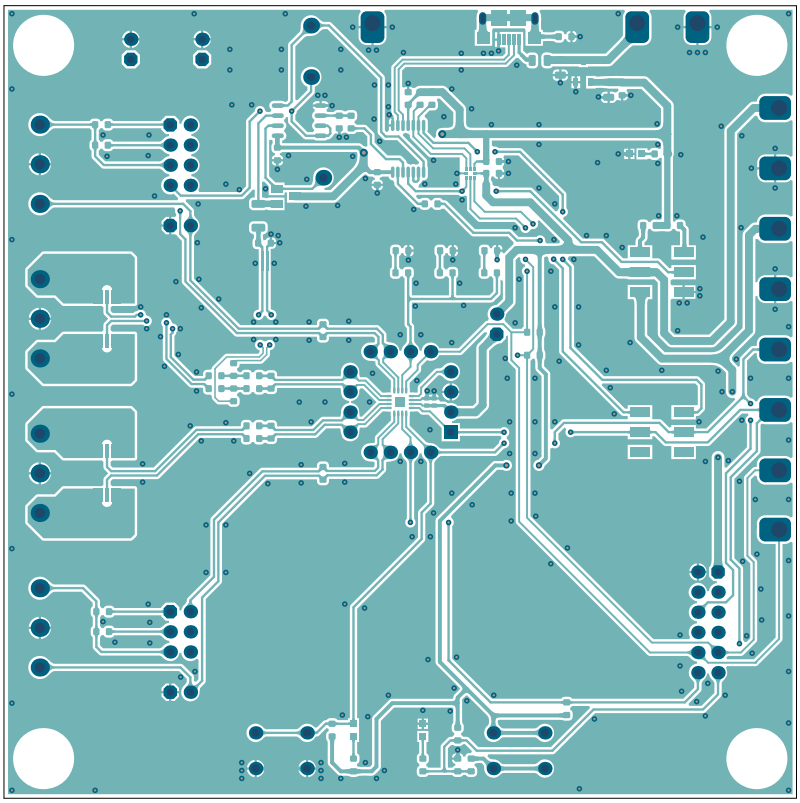
## A.5 BOARD – TOP SILK



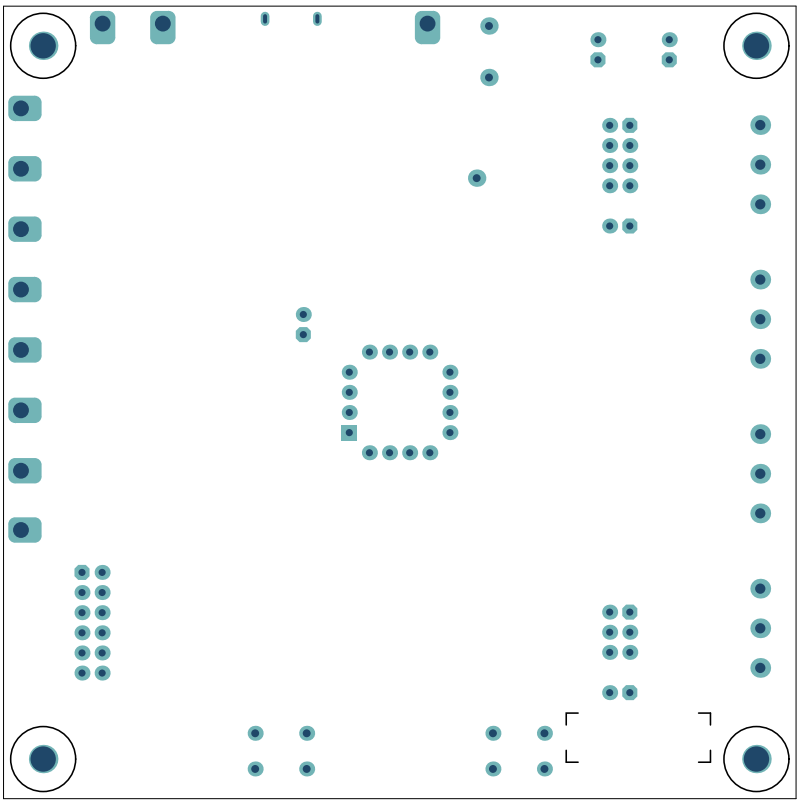

## A.6 BOARD – TOP COPPER AND SILK



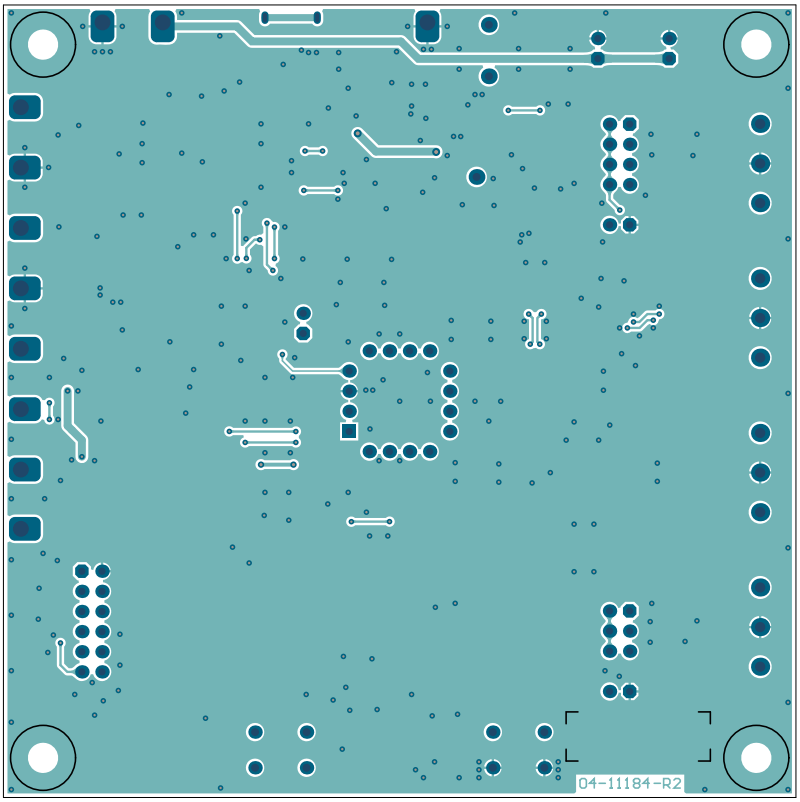
## A.7 BOARD – TOP COPPER



## A.8 BOARD – BOTTOM SILK



## A.9 BOARD – BOTTOM COPPER AND SILK



**NOTES:**

# Appendix B. Bill of Materials (BOM)

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

| Qty. | Reference | Description | Manufacturer | Part Number |
|---|---|---|---|---|
| 0 | C100, C101 | **DO NOT POPULATE**, Ceramic capacitor, 10000 pF, 50V, 20%, X7R, SMD, 0603 | Kyocera AVX | 06035C103KAT2A |
| 1 | C102 | Ceramic capacitor, 2.2 µF, 10V, 10%, X7S, SMD, 0402 | TDK Corporation | C1005X7S1A225K050BC |
| 1 | C103 | Ceramic capacitor, 0.1 µF, 16V, 10%, X7R, SMD, 0402 | Wurth Elektronik | 885012205037 |
| 1 | C200 | Ceramic capacitor, 10000 pF, 25V, 10%, X7R, SMD, 0603 | Samsung Electro-Mechanics America, Inc. | CL10B103KA8NNNC |
| 7 | C201, C300, C301, C303, C305, C306, C307 | Ceramic capacitor, 0.1 µF, 16V, 10%, X7R, SMD, 0603 | Taiyo Yuden Co., Ltd. | EMK107B7104KA-T |
| 2 | C302, C304 | Ceramic capacitor, 4.7 µF, 10V, 10%, X5R, SMD, 0805 | Samsung Electro-Mechanics America, Inc. | CL21A475KPFNNNE |
| 1 | CBL1 | Mechanical, hardware, cable USB, Male-A to Male Micro-B, clear 4 | Dongguan ZhanXin Electronic Technology Co., Ltd. | A006ZX027 |
| 2 | D100, D101 | Diode, red LED, 2V, 20 mA, 25 mcd, clear, SMD, 0603 | Wurth Elektronik | 150060RS75000 |
| 1 | D300 | Diode, green LED, 3.2V, 20 mA, 430 mcd, clear, SMD, 0603 | Wurth Elektronik | 150060GS75000 |
| 1 | FB300 | Ferrite, 2A, 220R, SMD, 0805 | Murata Manufacturing Co., Ltd. | BLM21PG221SN1D |
| 4 | J100, J101, J102, J103 | Connector, terminal, 5 mm, 1x3, Female, 12-30AWG, 16A, Through-Hole, R/A | Wurth Elektronik | 691137710003 |
| 1 | J104 | Connector, header-2.54, Male, 2x3, gold, 5.84 MH, Through-Hole, vertical | Samtec, Inc. | TSW-103-07-G-D |
| 4 | J105, J107, J112, J302 | Connector, header-2.54, Male, 1x2, Gold, 5.84 MH, Through-Hole, vertical | Multicomp Inc. | SPC20481 |
| 1 | J106 | Connector, header-2.54, Male, 2x4, gold, 5.84 MH, Through-Hole, vertical | Wurth Elektronik | 61300821121 |
| 0 | J108, J109, J110, J111 | **DO NOT POPULATE**, Connector, header-2.54, Female, 1x4, gold, Through-Hole, vertical | Samtec, Inc. | SSW-104-01-G-S |
| 1 | J300 | Connector, USB 2.0, Micro-B, Female, SMD, R/A | Amphenol ICC (FCI) | 10118193-0001LF |

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

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

| Qty. | Reference | Description | Manufacturer | Part Number |
|---|---|---|---|---|
| 1 | J301 | Connector, header-2.54, Female, 1x2, gold, Through-Hole, vertical | Samtec, Inc. | SSW-102-01-T-S |
| 0 | J303 | **DO NOT POPULATE**, Connector, header-2.54, Female, 2x6, gold, Through-Hole, R/A | Sullins Connector Solutions | PPPC062LJBN-RC |
| 5 | JP1, JP2, JP3, JP4, JP5 | Mechanical, hardware, jumper, 2.54 mm, 1x2 handle, gold | TE Connectivity, Ltd. | 881545-2 |
| 1 | LABEL1 | Label, PCBA, 18x6 mm, Datamatrix Assy#/Rev/Serial/Date | ACT Logimark AS | 505462 |
| 1 | LABEL2 | Label, assy. with rev level (Small Modules) per MTS-0002 | | |
| 4 | PAD1, PAD2, PAD3, PAD4 | Mechanical, hardware, rubber pad, cylindrical, D7.9, H5.3, black | 3M | 70006431483 |
| 1 | PCB1 | PAC1952-2 Evaluation Board – Printed Circuit Board | Microchip Technology Inc. | **04-11184-R2** |
| 1 | Q200 | Transistor FET N-Channel, 20V, 1.9A, 625 mW, SOT-23-3 | Diodes Incorporated® | ZXMN2A01FTA |
| 2 | R100, R101 | Resistor, Shunt MF, 0.004R, 1%, 2W, 2512 | Stackpole Electronics, Inc. | CSNL2512FT4L00 |
| 3 | R102, R105, R118 | Resistor, Thick Film, 100 kΩ, 1%, 1/10W, SMD, 0603 | TE Connectivity, Ltd. | 1622827-1 |
| 2 | R103, R106 | Resistor, Thick Film, 49.9 kΩ, 1%, 1/10W, SMD, 0603 | Panasonic® - ECG | ERJ-3EKF4992V |
| 1 | R104 | Resistor, Thick Film, 1.91R, 1%, 1/10W, SMD, 0603, AEC-Q200 | Stackpole Electronics, Inc. | RMCF0603FT1R91 |
| 0 | R107, R110, R126, R129 | **DO NOT POPULATE**, Resistor, Thick Film, 0R, 1/10W, SMD, 0603 | Stackpole Electronics, Inc. | RMCF0603ZT0R00 |
| 9 | R108, R109, R111, R112, R115, R116, R124, R125, R304 | Resistor, Thick Film, 0R, 1/10W, SMD, 0603 | Stackpole Electronics, Inc. | RMCF0603ZT0R00 |
| 2 | R113, R114 | Resistor, Thick Film, 150 kΩ, 1%, 1/8W, SMD, 0603 | KOA Speer Electronics, Inc. | SG73S1JTTD1503F |
| 5 | R117, R120, R121, R123, R305 | Resistor, Thick Film, 10 kΩ, 1%, 1/10W, SMD, 0603 | Yageo Corporation | RC0603FR-0710KL |
| 0 | R119 | **DO NOT POPULATE**, Resistor, Thick Film, 10 kΩ, 1%, 1/10W, SMD, 0603 | Yageo Corporation | RC0603FR-0710KL |
| 1 | R122 | Resistor, Thick Film, 1 kΩ, 1%, 1/10W, SMD, 0603 | Stackpole Electronics, Inc. | RMCF0603FT1K00 |
| 1 | R127 | Resistor, Thick Film, 8.45 kΩ, 1%, 1/10W, SMD, 0603 | Yageo Corporation | RC0603FR-078K45L |
| 6 | R128, R131, R200, R301, R302, R303 | Resistor, Thick Film, 4.7 kΩ, 1%, 1/10W, SMD, 0603 | Vishay/Dale | CRCW06034K70FKEA |

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

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

| Qty. | Reference | Description | Manufacturer | Part Number |
|---|---|---|---|---|
| 1 | R130 | Resistor, Thick Film, 5.23 kΩ, 1%, 1/10W, SMD, 0603 | Panasonic - ECG | ERJ-3EKF5231V |
| 1 | R201 | Resistor, Thick Film, 100R, 1%, 1/4W, SMD, 1206 | Yageo Corporation | RC1206FR-07100RL |
| 1 | R300 | Resistor, Thick Film, 20 kΩ, 1%, 1/10W, SMD, 0603 | Yageo Corporation | RC0603FR-0720KL |
| 2 | SW300, SW301 | Switch, Slide DPDT, 6V, 300 mA, SMD | C&K Components | JS202011SCQN |
| 2 | SW302, SW303 | Switch, tactile, SPST, 15V, 20 mA | Panasonic - ECG | EVQ-PAC05R |
| 1 | U100 | Microchip Analog Power Current Sense Monitor, PAC1952-2, QFN-16 | Microchip Technology Inc. | **PAC1952T-2E/4MX** |
| 1 | U200 | Microchip Analog Op Amp, 2-Ch, 1.2 MHz, SOIC-8 | Microchip Technology Inc. | **MCP6072-E/SN** |
| 1 | U300 | Microchip Interface USB $I^2C$, UART, TSSOP-14 | Microchip Technology Inc. | **MCP2221A-I/ST** |
| 1 | U301 | IC Interface, 2-bit Voltage Translator/Buffer Micropak-8 | ON Semiconductor®/Fairchild Semiconductor® | FXMA2102L8X |
| 1 | U302 | Microchip Analog LDO, 3.3V, SOT-23A-3 | Microchip Technology Inc. | **MCP1754ST-3302E/CB** |

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

**NOTES:**

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