PAC1710 and PAC1720 High-Side Current Sensors Evaluation Board User's Guide

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Object of Declaration: PAC17X0 High-Side Current Sensors Evaluation Board

EU Declaration of Conformity

Manufacturer: Microchip Technology Inc.
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USA

This declaration of conformity is issued by the manufacturer.

The development/evaluation tool is designed to be used for research and development in a laboratory environment. This development/evaluation tool is not a Finished Appliance, nor is it intended for incorporation into Finished Appliances that are made commercially available as single functional units to end users under EU EMC Directive 2004/108/EC and as supported by the European Commission's Guide for the EMC Directive 2004/108/EC (8th February 2010).

This development/evaluation tool complies with EU RoHS2 Directive 2011/65/EU.

This development/evaluation tool, when incorporating wireless and radio-telecom functionality, is in compliance with the essential requirement and other relevant provisions of the R&TTE Directive 1999/5/EC and the FCC rules as stated in the declaration of conformity provided in the module datasheet and the module product page available at www.microchip.com.

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

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VP Development Tools

12-Sep-14
Date

NOTES:

PAC17X0 HIGH-SIDE CURRENT SENSORS EVALUATION BOARD USER'S GUIDE

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Preface

NOTICE TO CUSTOMERS

All documentation becomes dated, and this manual is no exception. Microchip tools and documentation are constantly evolving to meet customer needs, so some actual dialogs and/or tool descriptions may differ from those in this document. Please refer to our website (www.microchip.com) to obtain the latest documentation available.

Documents are identified with a "DS" number. This number is located on the bottom of each page, in front of the page number. The numbering convention for the DS number is "DSXXXXXXXXA", where "XXXXXXXX" is the document number and "A" is the revision level of the document.

For the most up-to-date information on development tools, see the MPLAB® IDE online help. Select the Help menu, and then Topics, to open a list of available online help files.

INTRODUCTION

This chapter contains general information that will be useful to know before using the PAC17X0 High-Side Current Sensors Evaluation Board. Items discussed in this chapter include:

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

DOCUMENT LAYOUT

This document describes how to use the PAC17X0 High-Side Current Sensors 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 PAC17X0 High-Side Current Sensors Evaluation Board.
- **Chapter 2. "Installation and Operation"** – Includes instructions on installing and starting the Microchip Chip Manager application.
- **Chapter 3. "Hardware Description"** – Shows hardware details of the PAC17X0 High-Side Current Sensors Evaluation Board.
- **Chapter 4. "Software Description"** – Describes the main operations in the Microchip Chip Manager software.
- **Chapter 5. "Evaluation Board Demonstration"** – Highlights several experiments with the PAC17X0 High-Side Current Sensors Evaluation Board.
- **Appendix A. "Schematic and Layouts"** – Shows the schematic and layout diagrams for the PAC17X0 High-Side Current Sensors Evaluation Board.
- **Appendix B. "Bill of Materials (BOM)"** – Lists the parts used to build the PAC17X0 High-Side Current Sensors 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) { ... }`

WARRANTY REGISTRATION

Please complete the enclosed Warranty Registration Card and mail it promptly. Sending in the Warranty Registration Card entitles users to receive new product updates. Interim software releases are available at the Microchip website.

RECOMMENDED READING

This user's guide describes how to use the PAC17X0 High-Side Current Sensors Evaluation Board. Other useful documents are listed below. The following Microchip document is available and recommended as a supplemental reference resource:

PAC1710/20 Data Sheet (DS20005386)

This data sheet describes the operation and features of the PAC1710/20 devices which have a single and dual high-side current-sense monitor with power calculation.

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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 B (May 2016)

The following is the list of modifications:

- Updated the Steady-State Current Consumption table header in section **Section 3.6.1 "Steady-State Current Source"**.

Revision A (July 2015)

- Initial Release of this Document.

Chapter 1. Product Overview

1.1 INTRODUCTION

The PAC17X0 High-Side Current Sensors Evaluation Board provides an easily-accessible platform to test the various features of the PAC17X0. The System Management Bus (SMBus) communication is accomplished using a Universal Serial Bus (USB) bridge, which provides a standard interface for the application code interface. The evaluation board supports communication with both the PAC1710 and PAC1720 devices that are populated on the board. The SMBus address of the PAC1710 is set by R4 and the PAC1720 SMBus address is selectable with the J12 jumper.

1.2 PAC17X0 DEVICE FEATURES

The PAC1710 and PAC1720 are I^2C/SMBus devices that provide high-side, bidirectional current sensing with precision voltage measurement capabilities. The devices are similar, except that the PAC1710 contains one current sensing circuit and the PAC1720 contains two. Both devices measure the voltage developed across an external sense resistor to represent the high-side current of a battery or voltage regulator. They also measure the SENSE+ pin voltage and use these measured values to present a proportional average power calculation. Current sensing includes Fault protection. During a Fault, the $\overline{\text{ALERT}}$ pin can be asserted or masked.

The PAC17X0 High-Side Current Sensors Evaluation Board provides users with the means to exercise device functionality while connected either to target systems (Sys mode) or while utilizing on-board sources (Demo mode). On-board sources include bus power, selectable steady-state current, adjustable low-frequency square wave current signal, and a test current pulse with selectable amplitude and duration.

1.3 WHAT IS THE PAC17X0 HIGH-SIDE CURRENT SENSORS EVALUATION BOARD?

All functions of the PAC17X0 devices can be tested and observed using the USB-based PAC17X0 High-Side Current Sensors Evaluation Board. Figure 1-1 shows the block diagram of this board.

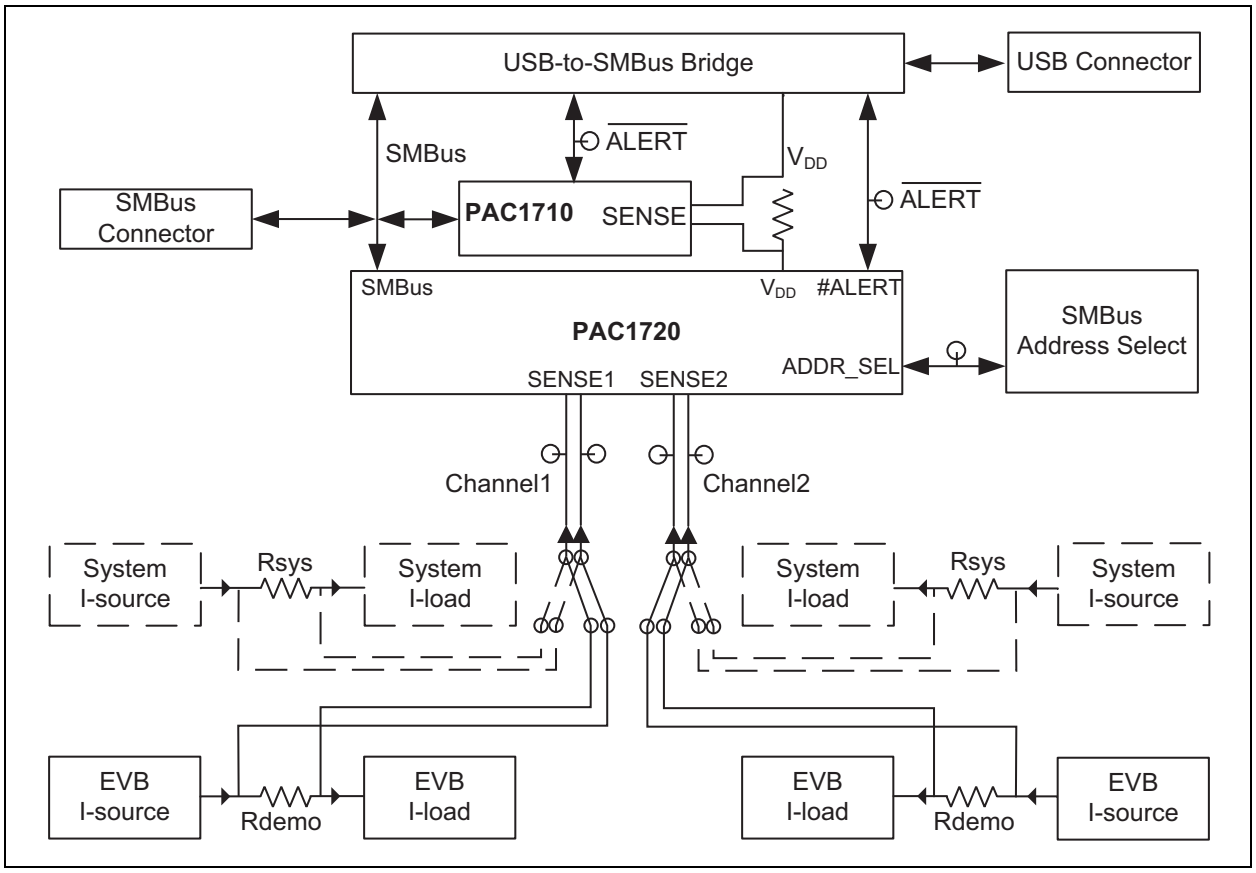


FIGURE 1-1: *PAC17X0 High-Side Current Sensors Evaluation Board Block Diagram.*

The evaluation system is comprised of the PAC17X0 High-Side Current Sensors Evaluation Board and the Microchip Chip Manager application. The PAC17X0 High-Side Current Sensors Evaluation Board has the following features:

- Test points and LEDs for monitoring on-board function
- Screw terminal connections for monitoring external system current up to 20A
- Multiple on-board adjustable current sources (steady state, square wave, test pulse)
- USB-to-SMBus bridge for power and communications
- Capability to connect directly to external SMBus master

The user can perform the following operations using the Chip Manager application:

- Viewing and changing register values
- Saving settings of all registers, allowing for quick configuration at a later time
- Graphing of any register

The evaluation board is designed for ease of use and experimentation purposes. Figure 1-2 shows the top silk screen of the PAC17X0 High-Side Current Sensors Evaluation Board.

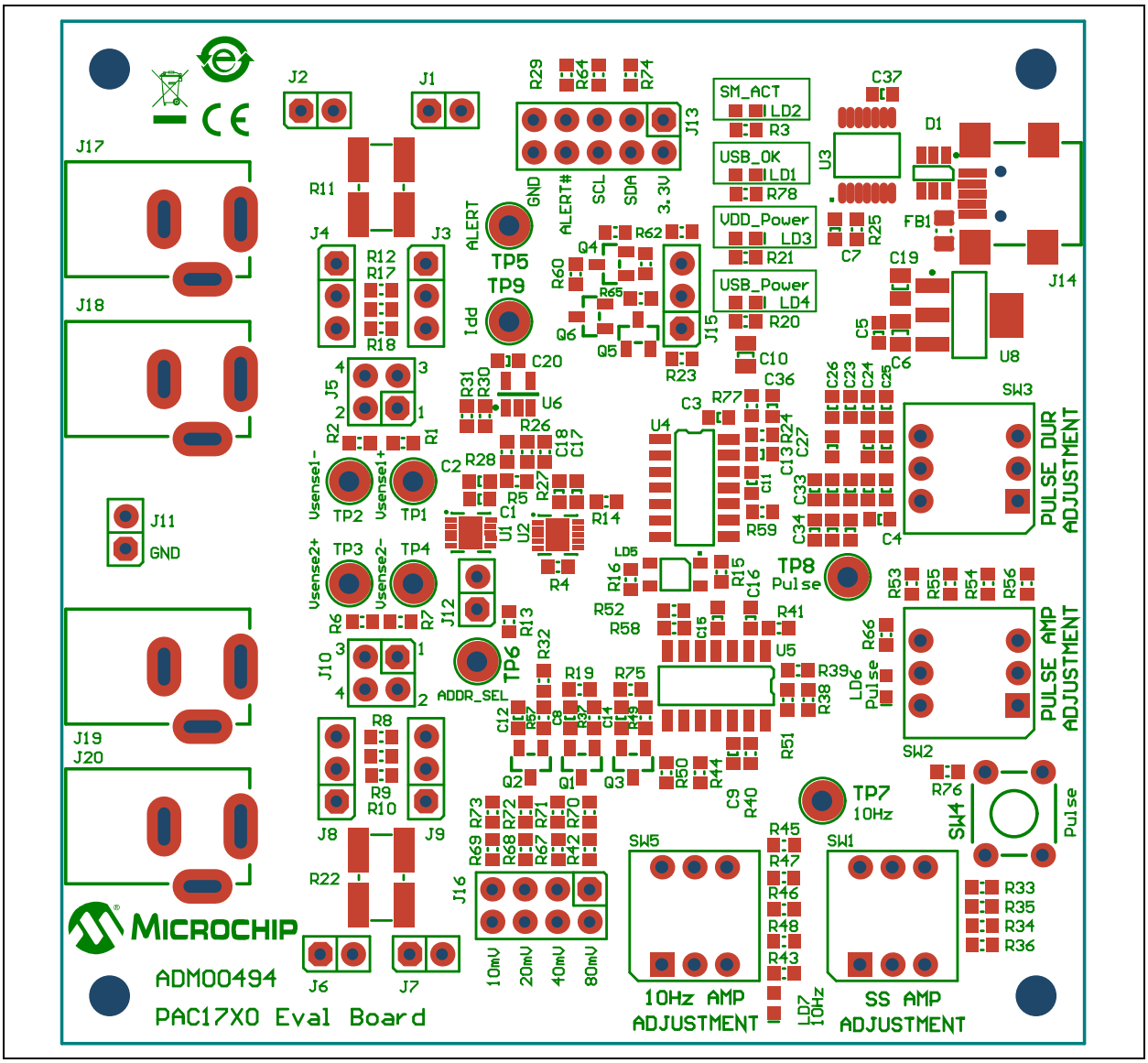


FIGURE 1-2: *PAC17X0 High-Side Current Sensors Evaluation Board – Top Silk Screen.*

1.4 WHAT THE PAC17X0 HIGH-SIDE CURRENT SENSORS EVALUATION BOARD KIT CONTAINS?

This PAC17X0 High-Side Current Sensors Evaluation Board kit includes:

- PAC17X0 High-Side Current Sensors Evaluation Board (ADM00494)
- Supplied USB-A Male to Mini USB-B Male Cable
- Information Sheet

NOTES:

Chapter 2. Installation and Operation

2.1 GETTING STARTED

2.1.1 System Requirements

To use the PAC17X0 High-Side Current Sensors Evaluation Board, the following are required:

- A PC running Microsoft® Windows® operating system
- A display resolution of 800x600 or larger, for viewing several windows simultaneously
- An available USB port

2.1.2 Installing the Evaluation Board

Follow the next steps to install the Microchip Chip Manager application:

1. Before installing and running the Chip Manager, install the "MCP2200/MCP2221 Windows Driver & Installer" on the local machine. If the driver and installer package has already been installed, skip this step. The "MCP2200/MCP2221 Windows Driver & Installer" can be downloaded from: http://www.microchip.com/wwwproducts/Devices.aspx?product=MCP2221. Follow the on-screen instructions to complete the installation process.
2. Download the zip file for the ChipMan program from www.microchip.com (search for "ChipMan" in the search box and choose version v4.16.7). Unzip the archive. The application's revision history and install/uninstall notes may be found in the `readme.txt` file.
3. To install the Chip Manager application and the device driver on the PC, run `ChipMan-v4.16.7-windows-installer.exe`.
4. Connect the supplied USB cable to an available USB port on the PC. Plug the mini-B end of the USB cable into the board connector, J14. The LEDs for VDD_Power, USB_Power, USB_OK and ALERT (LD5) should illuminate, and the 10 Hz LED (LD7) will blink. For a description of the LEDs, see **Section 3.3 "LED Indicators"**.
5. If the USB bridge driver has not previously been installed on the selected USB port, the Driver Software Installation window pops up, prompting for the driver install (see Figure 2-1).

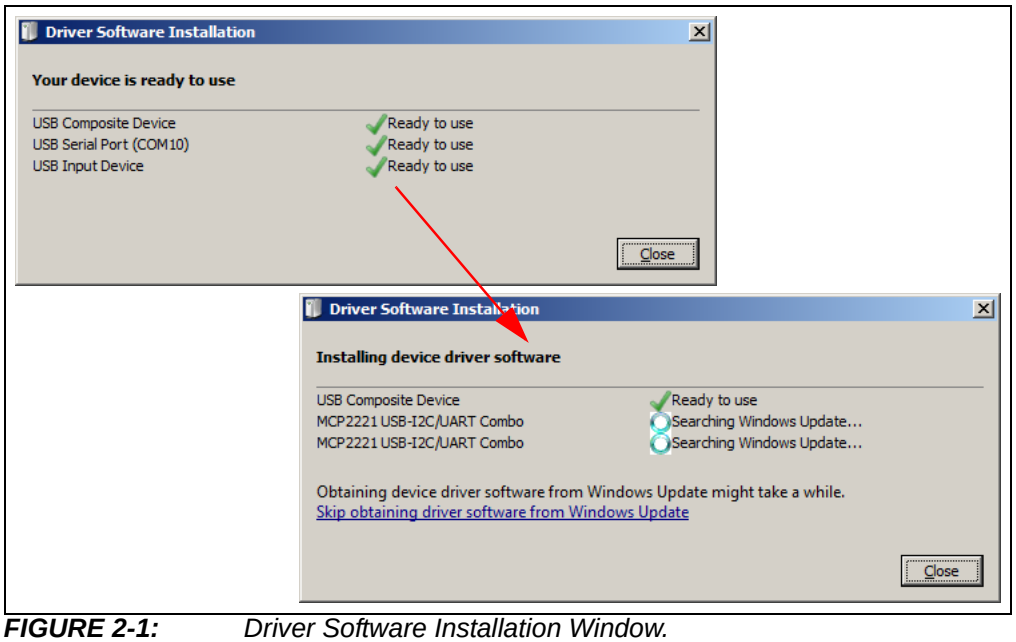


FIGURE 2-1: *Driver Software Installation Window.*

6. After the driver installation is complete, the initial setup screen for the Chip Manager application appears (see Figure 2-2). Click **Next** to start the installation.

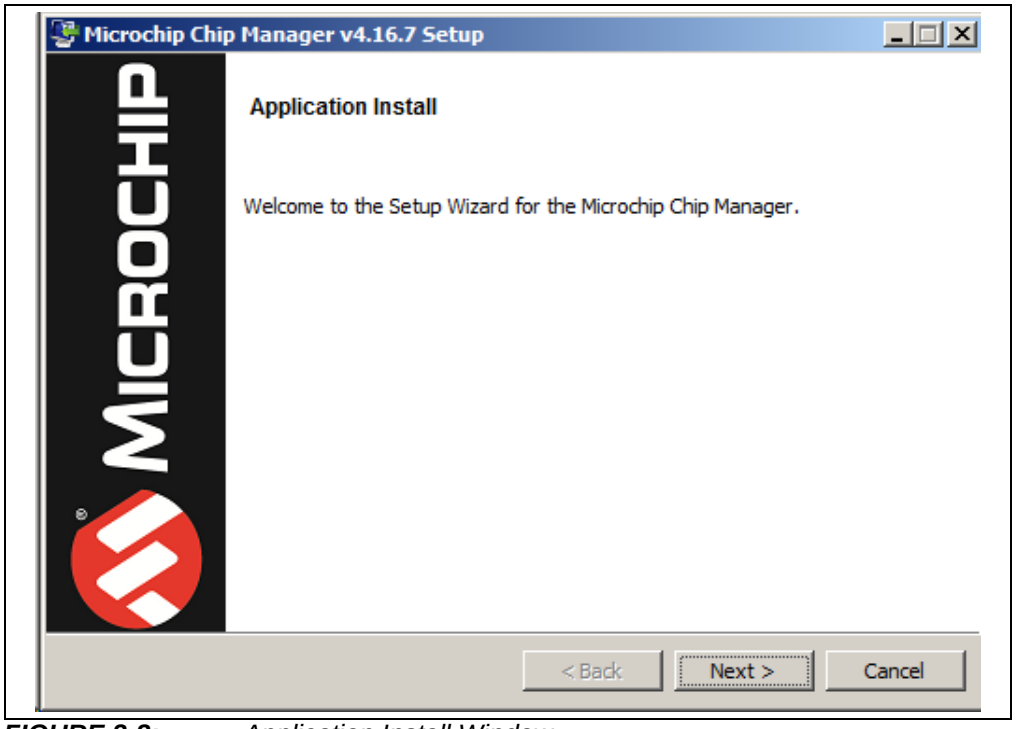


FIGURE 2-2: *Application Install Window.*

7. To proceed with the installation, read the License Agreement and accept by clicking the radio button corresponding to “I accept the agreement”. Then click **Next**.

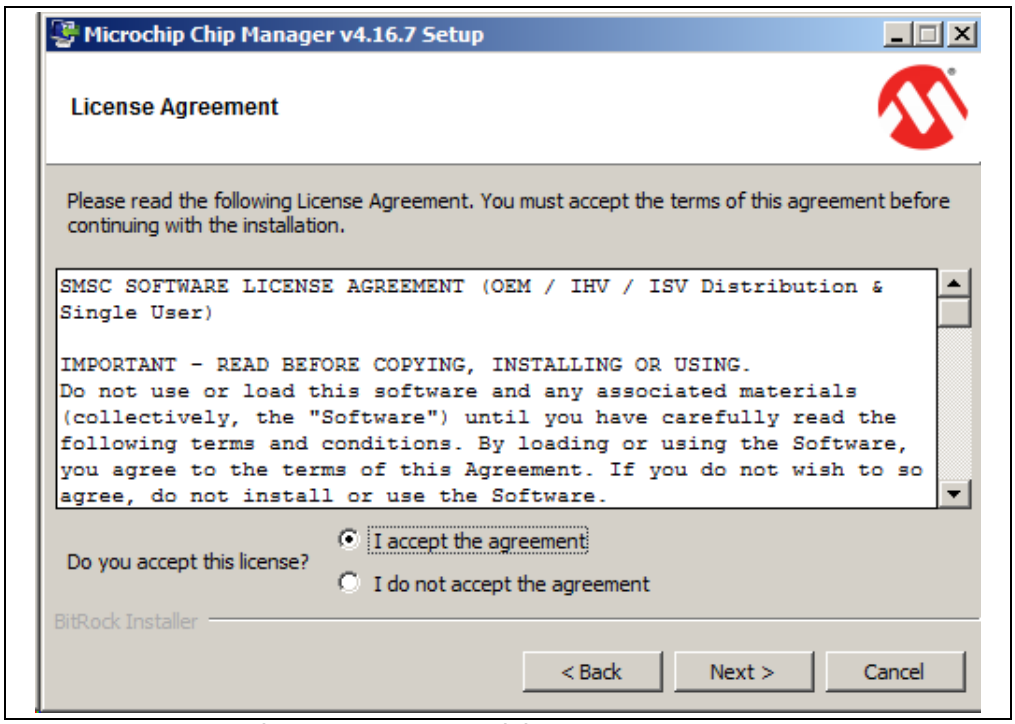


FIGURE 2-3: *License Agreement Dialog.*

8. On the Installation Directory dialog, browse for the desired location or click **Next** to install in the default location (see Figure 2-4).

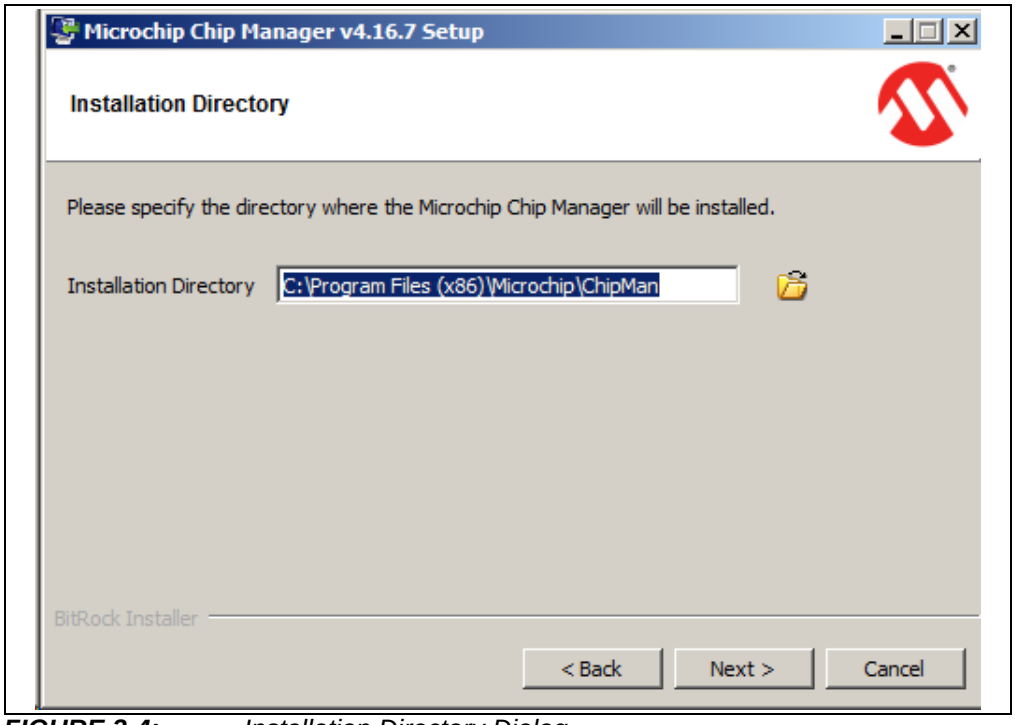


FIGURE 2-4: *Installation Directory Dialog.*

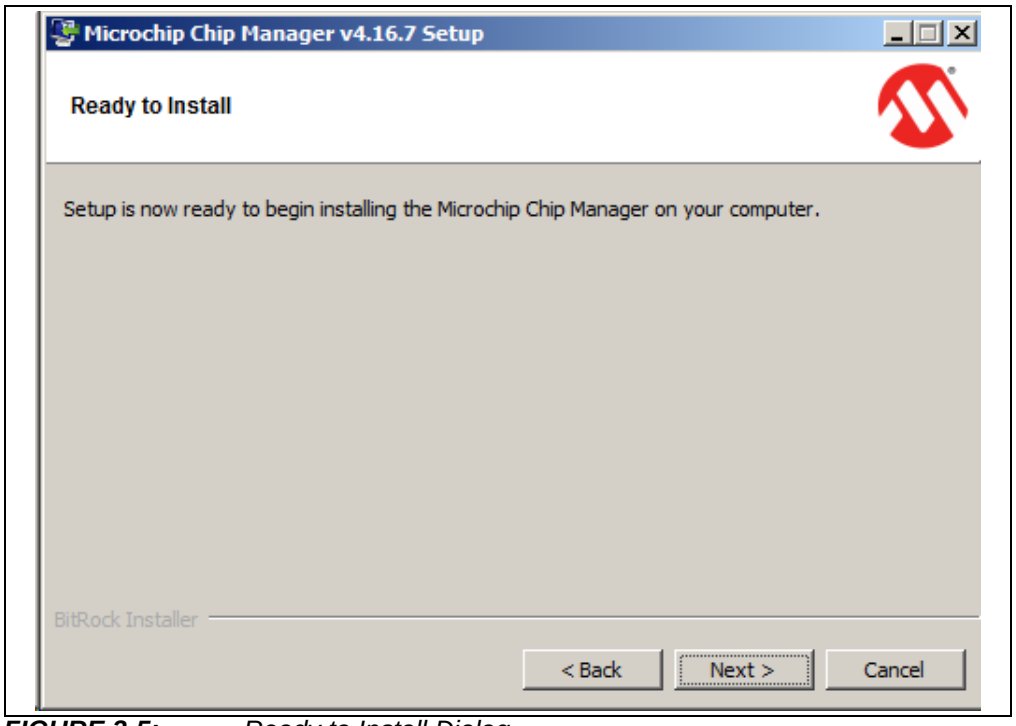


FIGURE 2-5: *Ready to Install Dialog.*

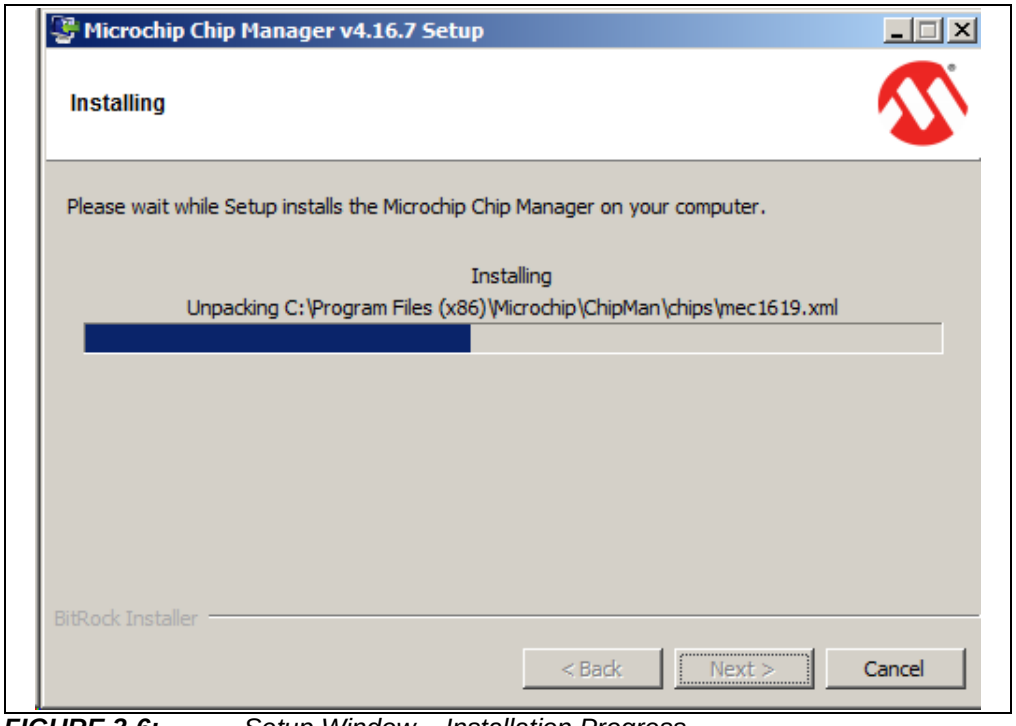


FIGURE 2-6: *Setup Window – Installation Progress.*

9. After the setup is complete, the MSXML Parser used by the Chip Manager software is installed, as shown in Figure 2-7. Once the setup completes successfully, press **Finish** to exit the install.

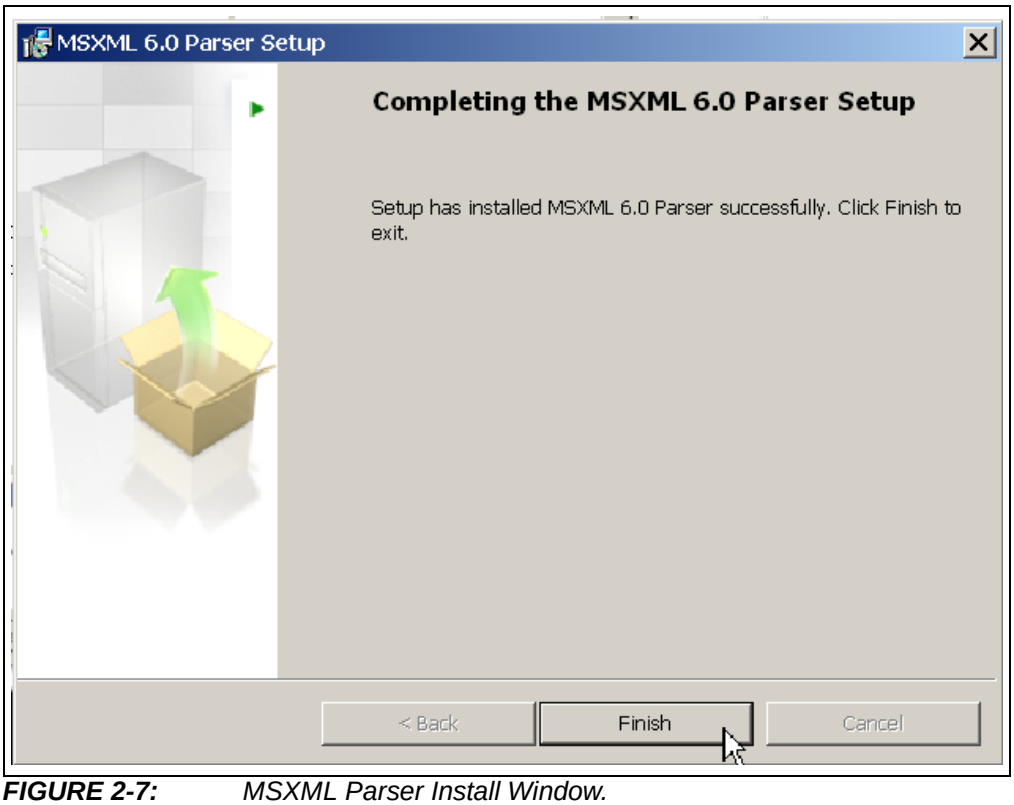


FIGURE 2-7: *MSXML Parser Install Window.*

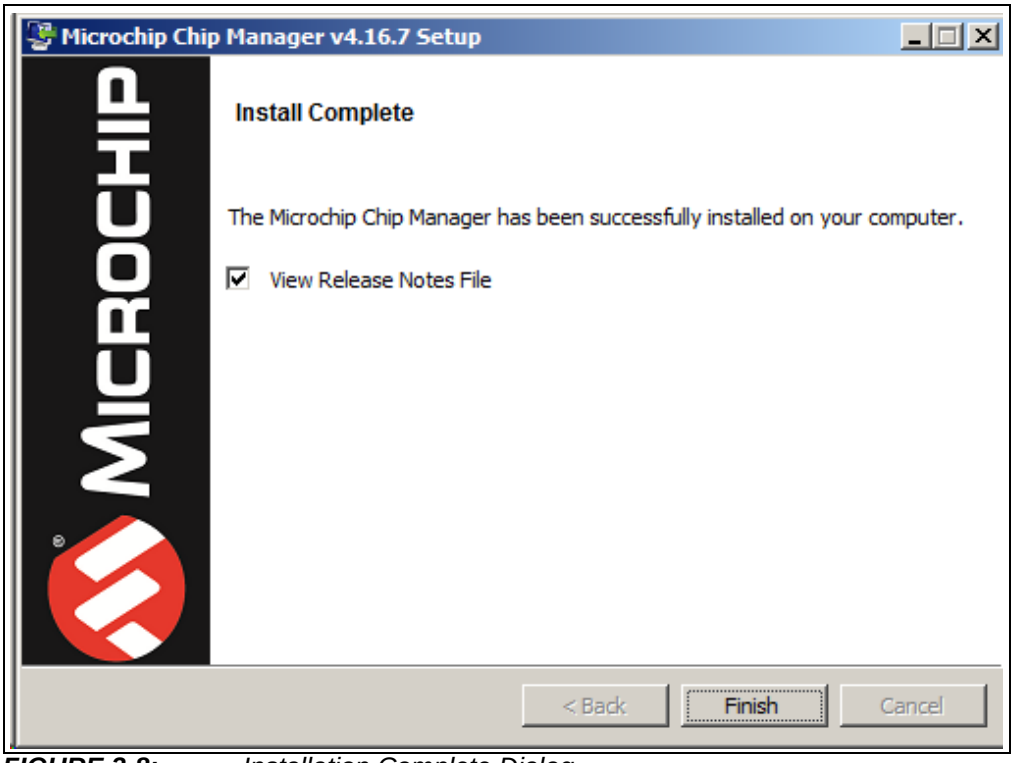


FIGURE 2-8: *Installation Complete Dialog.*

10. Start the software by either going to Windows *Start button > All Programs > Microchip > Microchip Chip Manager* or by double-clicking the software icon ( ) on the desktop. The evaluation board software will initialize and the Microchip Chip Manager with the Quick Help screen appears (see Figure 2-9).

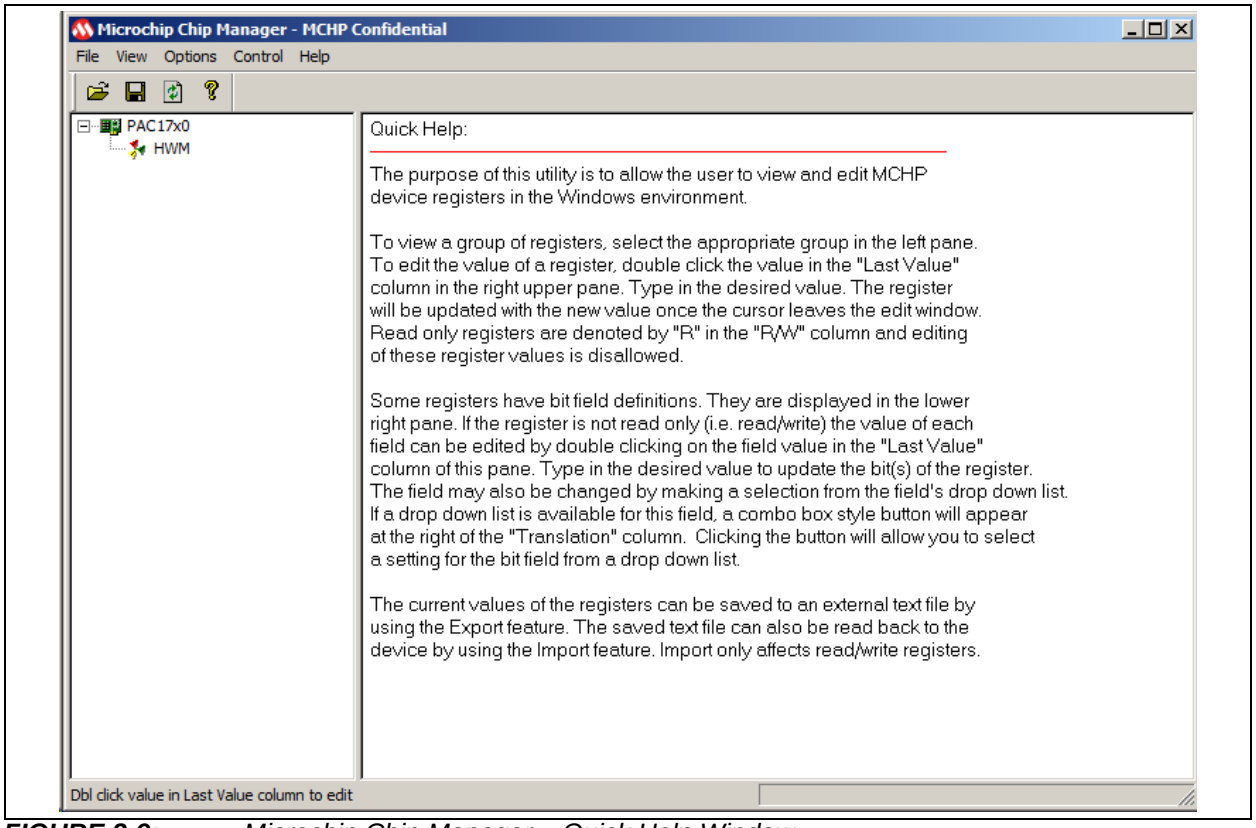


FIGURE 2-9: *Microchip Chip Manager – Quick Help Window.*

11. If a message stating that no device has been selected appears, click **Yes** to select a device. Alternatively, go to the Chip Manager's main menu, select *Options > Select Device*. In either case, the Select Microchip Device window displays, as shown in Figure 2-10.

    In the "Device" list, choose PAC17X0. The "Master Controller" drop-down list should highlight "USB SMBus Bridge". Click **OK** to complete the device selection.

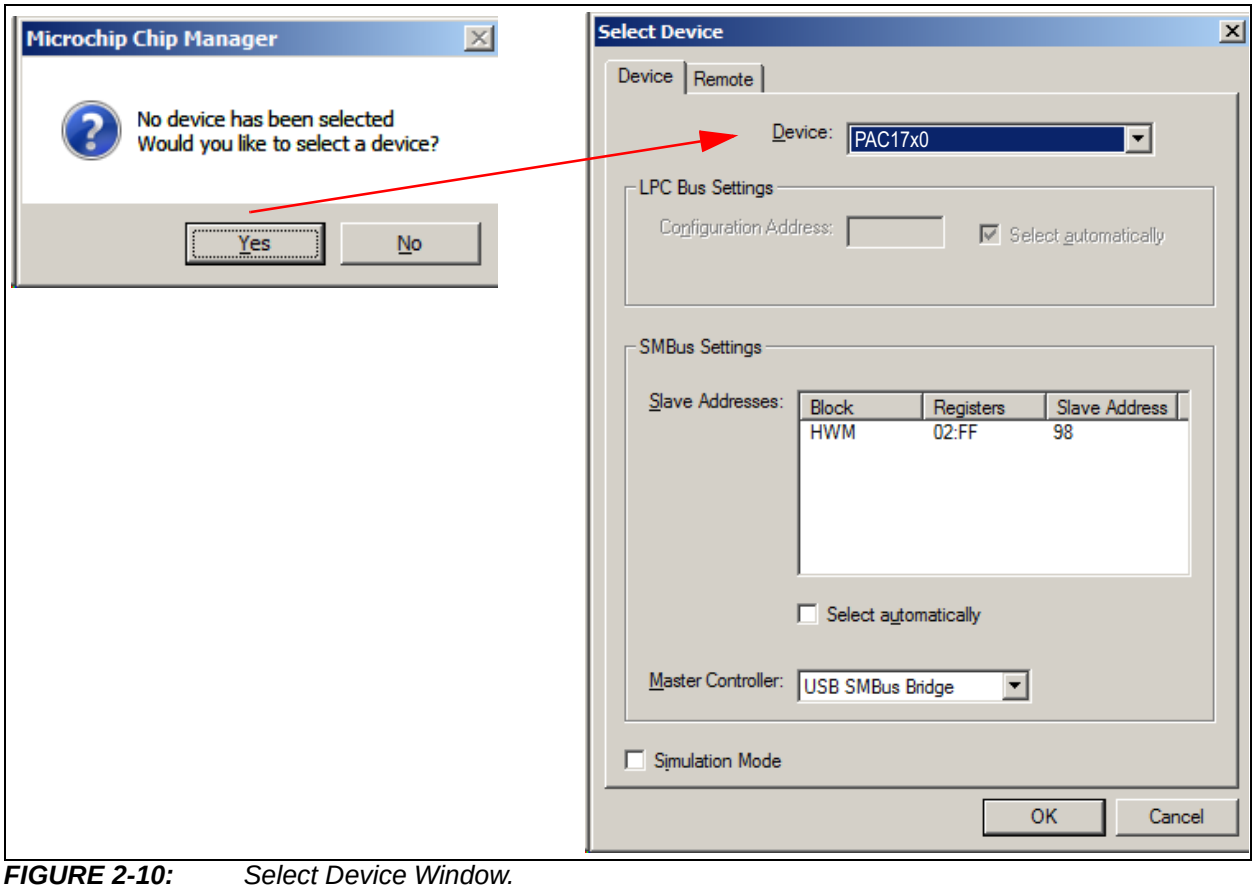


FIGURE 2-10: *Select Device Window.*

12. From the Chip Manager main menu, ensure that *Options > Auto refresh Registers* is checked. In the left panel, click the Hardware Monitor (HWM) to expand the content, then select any of the register groups, as shown in Figure 2-11. The SM_ACT LED on the board starts blinking when any of the register groups are selected. The register values are automatically updated every second when the Auto Refresh option is on.

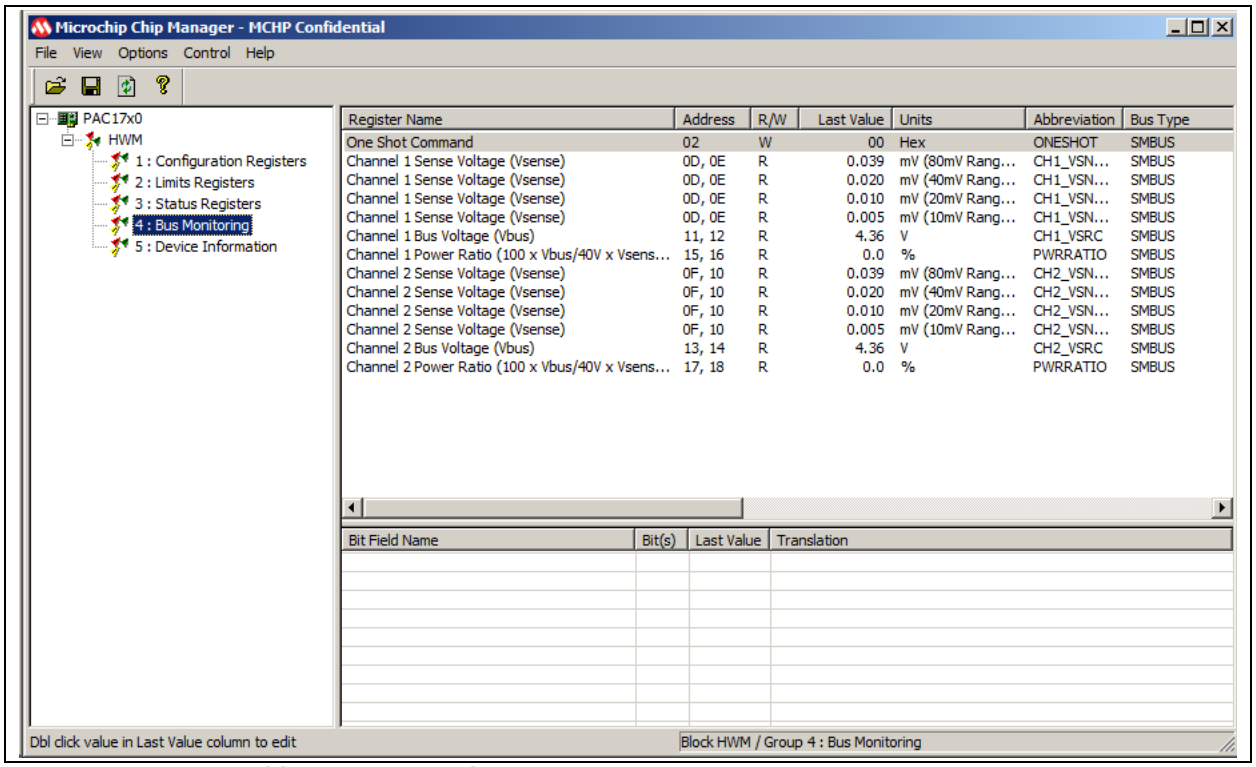


FIGURE 2-11: *Chip Manager Register Groups.*

Devices supported with PAC17X0 are listed in Table 2-1.

TABLE 2-1: PAC17X0 SUPPORTED DEVICES

Address	J12 State	Device
58h	N/A	PAC1710
98h	Installed	PAC1720
9Ah	Open	PAC1720

Chapter 3. Hardware Description

3.1 INTRODUCTION

The PAC17X0 High-Side Current Sensors Evaluation Board provides the means to evaluate features and to view and modify registers. There are two modes of evaluation board current monitoring operation:

- Demo mode: Monitors an on-board current source
- Sys mode: Monitors an external current source

LEDs indicate status information and test points are included to monitor system voltages with a user-provided voltmeter or oscilloscope.

3.1.1 PAC1710 and PAC1720

The PAC1710 and PAC1720 devices are SMBus-compliant, high-side, bidirectional current-sense monitors in a 10-pin, 3 mm x 3 mm DFN package. Communications with the sensor are via the SMBus. For details regarding the PAC1710 and PAC1720, refer to the device data sheet.

3.1.2 Power Source

This evaluation board only requires a single USB cable to operate. USB bus voltage is provided to the on-board test current sources and the USB-SMBus bridge. The USB-SMBus bridge regulates the +5V USB power to +3.3V used by the PAC1710, PAC1720 and other evaluation board circuitry.

3.2 USB-TO-SMBus BRIDGE

The communication bridge on the PAC17X0 evaluation board is based on the MCP2221 protocol converter. The MCP2221 enables USB connectivity in applications that have UART and/or I^2C and SMBus interfaces.

The MCP2221 USB bridge requires a driver to be installed on the computer for proper communication with the PAC17X0 devices. Please refer to **Section 2.1.1 "System Requirements"** to review the installation process of the MCP2221 communication driver.

3.2.1 Direct SMBus Connect Option

It is also possible to connect an external communication master to the PAC17X0:

- Remove the jumpers on J13 and connect the SMBus master to the SDA, SCL and ALERT pins, as well as an external supply for +3.3V. Note that a return is also provided on this header for convenience (GND).
- The +3.3V can be supplied by the communication bridge by leaving the +3.3V jumper in place and retaining the USB connection.

3.3 LED INDICATORS

Figure 3-1 identifies the location of the LEDs.

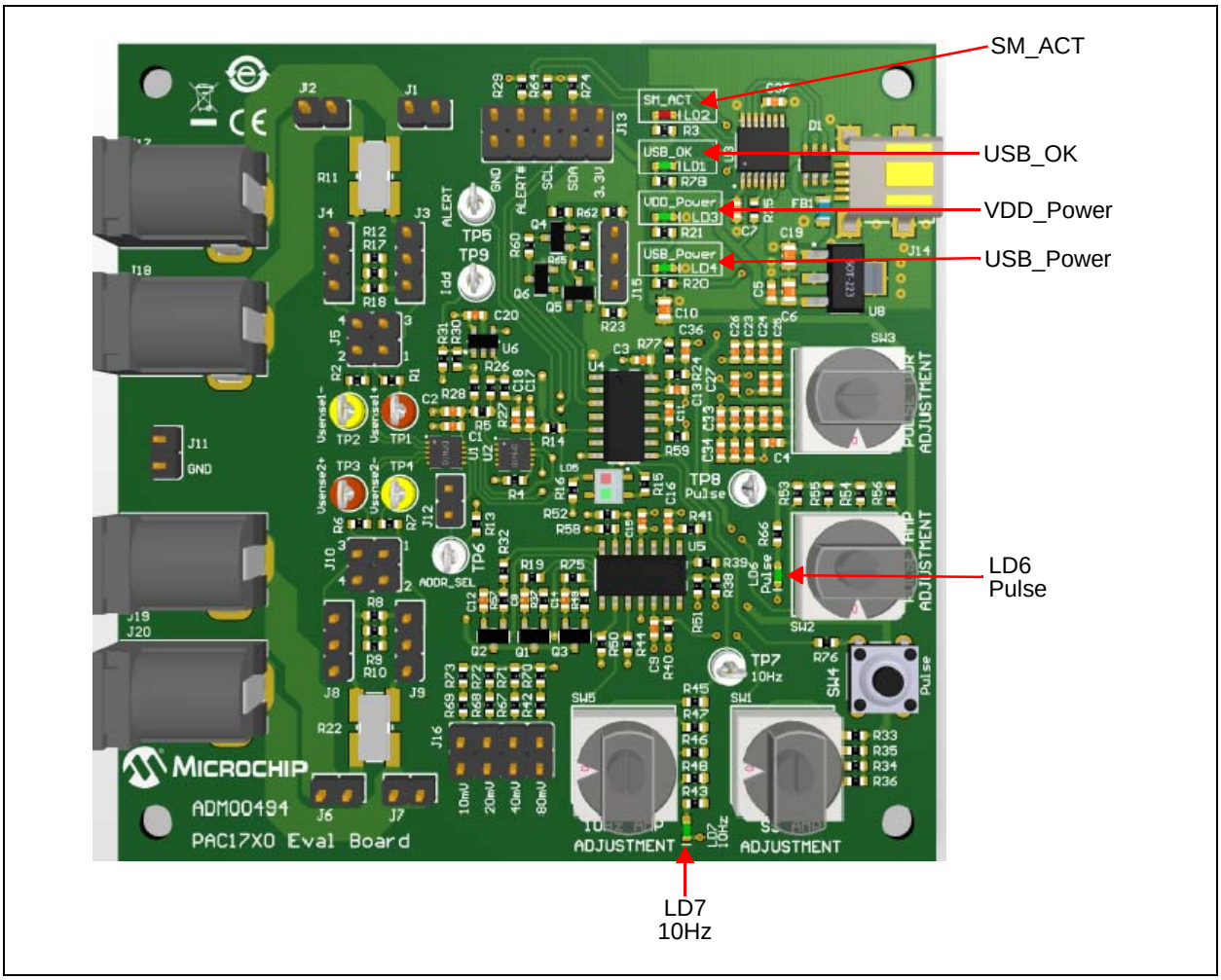


FIGURE 3-1: *LED Locations.*

Table 3-1 details the LED status of the following signals:

TABLE 3-1: LED STATUS INDICATORS

LED #	Signal	LED Status		
		OFF	GREEN	RED
1	USB Activity	No activity on USB port	Activity on USB port	N/A
2	SMBus Activity	No activity within USB-SMBus bridge	N/A	Activity within USB-SMBus bridge
3	V_{DD} Power	V_{DD} is not present	V_{DD} is present	V_{DD} is present
4	USB Power	USB power is not present	USB power is present	N/A
5	Alert	N/A	$\overline{\text{ALERT}}$ is not asserted	$\overline{\text{ALERT}}$ is asserted
6	Pulse	SW4 pulse trigger is not pressed	SW4 pulse trigger is pressed	N/A
7	10 Hz	(Blinking) 10 Hz test square wave source is operating		N/A

3.4 JUMPER SETTINGS

Figure 3-2 identifies the jumper locations on the evaluation board.

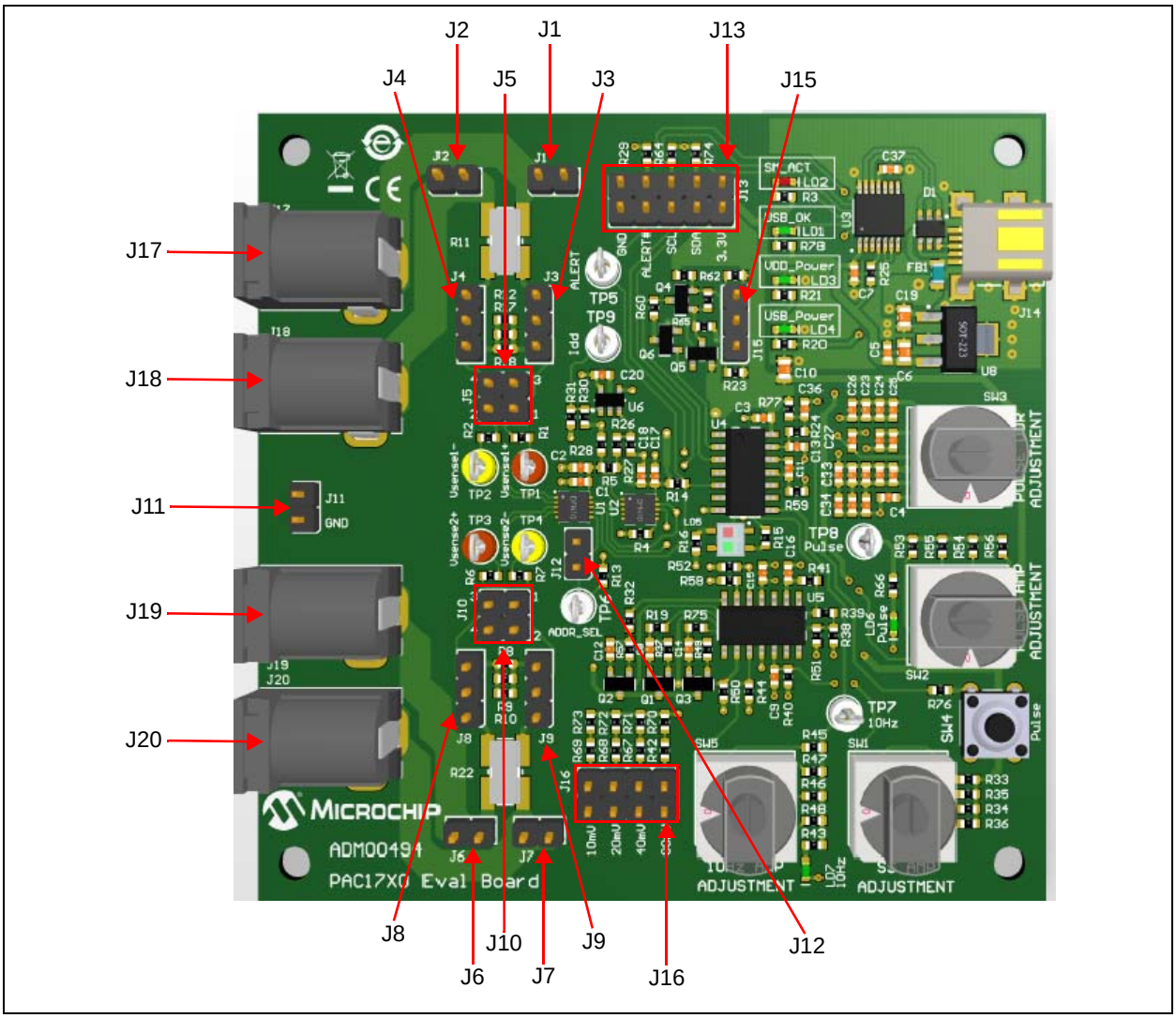


FIGURE 3-2: *Jumper Locations.*

This evaluation board has pin headers and jumper configurations to evaluate the features of the PAC1710 and PAC1720 devices. Jumper settings are described in Table 3-2.

TABLE 3-2: JUMPER SETTINGS

Pin Header	Label	Default Position	Alternate Position(s)
J1, J2	$V_{SOURCE}1+$, $V_{SOURCE}1-$	External power source terminals. See **Section 3.7.2 "Load Connection"**.	
J3, J4	DEMO SYS (1)	Select Demo mode $R_{SENSE}1+/-$. Positions 3-2 are jumpered on both jumpers. See **Section 3.6 "Demo Mode Setup and Operation"**.	Select Sys mode $R_{SENSE}1+/-$. Positions 1-2 are jumpered on both jumpers. See **Section 3.7 "Sys Mode Setup and Operation"**.
J5	Polarity	Normal polarity of $V_{SOURCE}1$. Positions 2-4 and 1-3 are jumpered.	Reversed polarity of $V_{SOURCE}1$. Positions 1-2 and 3-4 are jumpered.
J6, J7	$V_{SOURCE}2+$, $V_{SOURCE}2-$	External power source terminals. See **Section 3.7.2 "Load Connection"**.	
J8, J9	DEMO SYS (2)	Select Demo mode $R_{SENSE}2+/-$. Positions 3-2 are jumpered on both jumpers. PAC1720 only. See **Section 3.6 "Demo Mode Setup and Operation"**.	Select Sys mode $R_{SENSE}2+/-$. Positions 1-2 are jumpered on both jumpers. PAC1720 only. See **Section 3.7 "Sys Mode Setup and Operation"**.
J10	Polarity	Normal polarity of $V_{SOURCE}2$. Positions 2-4 and 1-3 are jumpered.	Reversed polarity of $V_{SOURCE}2$. Positions 1-2 and 3-4 are jumpered.
J11	GND		Connect ground from external source for Sys mode.
J12	J12 (ADDR_SEL)	Set SMBus address at power-up to `1001_100b` – 98h. Jumper in place (closed).	Set SMBus address at power-up to `1001_101b` – 9Ah. Jumper off (open).
J13	GND, $\overline{\text{ALERT}}$, SCL, SDA, 3.3V	USB bridge generates on-board 3.3V and provides SMBus host. Positions 1-2, 3-4, 5-6, 7-8, 9-10 are all jumpered.	See **Section 3.2.1 "Direct SMBus Connect Option"**.
J14	USB Connection	USB connection for Chip Manager control and monitoring.	
J15	Pulse Dur Range	See **Section 3.6.3 "Pulse Current Source"**	
J16	Demo Current Range Sel	80 mV range. Positions 1-2 are jumpered. See **Section 3.6.1 "Steady-State Current Source"**.	40 mV range. Positions 3-4 are jumpered. 20 mV range. Positions 5-6 are jumpered. 10 mV range. Positions 7-8 are jumpered.
J17	$V_{SOURCE}1+$	Power jacks. See **Section 3.7.2 "Load Connection"**.	
J18	$V_{SOURCE}1-$		
J19	$V_{SOURCE}2+$		
J20	$V_{SOURCE}2-$		

3.5 PAC17X0 TEST POINTS

The PAC17X0 High-Side Current Sensors Evaluation Board provides test points for ground reference and signal access. Table 3-3 summarizes these test points.

TABLE 3-3: TEST POINT LOCATION

Test Point #	Marking	Monitored Signal Function
1	$V_{SENSE}1+$ (orange)	SENSE+
2	$V_{SENSE}1-$ (yellow)	SENSE-
3	$V_{SENSE}2+$ (orange)	SENSE+
4	$V_{SENSE}2-$ (yellow)	SENSE-
5	ALERT (white)	ALERT
6	ADDR_SEL (white)	SMBus Address Select (at power-up)
7	10 Hz (white)	Square Wave Current Output
8	PULSE (white)	Momentary Pulse (SW4 pushed)
9	I_{DD} (white)	Current Monitor with 2.5V/mA Sensitivity

3.6 DEMO MODE SETUP AND OPERATION

Demo mode uses three on-board current sources to exercise and demonstrate the features of the PAC1710 and PAC1720 devices. Jumpers J3, J4, J8 and J9 are initially set for Demo mode (see **Section 3.4 "Jumper Settings"**).

3.6.1 Steady-State Current Source

A constant current source is provided using +5V USB as the supply. This current is adjustable from zero to approximately 85 mA (80 mV range) using rotary switch, SW1 SS Amp Adjust. Parallel sense resistors are provided for a combined value of one ohm, with accuracy less than or equal to 0.3%. This is used to convert the current to a corresponding voltage for the PAC1720 to read at the SENSE+ and SENSE- inputs. The steady-state current consumption for the rotary switch SW3 Pulse Duration settings, in conjunction with the J16 jumper position which sets the range, are shown in Table 3-4.

TABLE 3-4: STEADY-STATE CURRENT CONSUMPTION

SW1 Position	J16 Jumper Position			
	Pins 1-2 (80 mV Range)	Pins 3-4 (40 mV Range)	Pins 5-6 (20 mV Range)	Pins 7-8 (10 mV Range)
0	0 mA	0 mA	0 mA	0 mA
1	~6.6 mA	~3.3 mA	~1.6 mA	~0.8 mA
2	~13.2 mA	~6.6 mA	~3.2 mA	~1.7 mA
3	~19.4 mA	~9.6 mA	~4.6 mA	~2.4 mA
4	~26.8 mA	~13.3 mA	~6.4 mA	~3.4 mA
5	~32.4 mA	~16.0 mA	~7.8 mA	~4.1 mA
6	~38.1 mA	~18.9 mA	~9.1 mA	~4.8 mA
7	~43.4 mA	~21.5 mA	~10.4 mA	~5.5 mA
8	~53.2 mA	~26.3 mA	~12.8 mA	~6.7 mA
9	~57.9 mA	~28.7 mA	~13.9 mA	~7.3 mA
A	~62.8 mA	~31.1 mA	~15.1 mA	~7.9 mA
B	~67.2 mA	~33.3 mA	~16.1 mA	~8.4 mA
C	~72.7 mA	~36.0 mA	~17.4 mA	~9.1 mA
D	~76.9 mA	~38.0 mA	~18.4 mA	~9.7 mA
E	~81.1 mA	~40.1 mA	~19.4 mA	~10.2 mA
F	~85.0 mA	~42.1 mA	~20.4 mA	~10.7 mA

3.6.2 10 Hertz Current Source

Rotary switch SW5 10 Hz Amp Adjust injects a 10 Hz square wave signal into the current-sense measurement circuit. This function is provided to demonstrate the PAC1710 and PAC1720 devices' ability to attenuate circuit noise. The steady-state current consumption for the rotary switch SW1 Steady-State settings, in conjunction with the J16 jumper position which sets the range, are shown in Table 3-4. The square wave amplitude is adjustable by rotary switch SW5 to obtain the pulse consumption shown in Table 3-5.

TABLE 3-5: 10 Hz PULSE CURRENT CONSUMPTION

SW5 Position	10 Hz Pulse Consumption (mA)
0	0 mA
1	~0.7 mA
2	~1.4 mA
3	~2.0 mA
4	~2.8 mA
5	~3.4 mA
6	~4.0 mA
7	~4.6 mA
8	~5.6 mA
9	~6.1 mA
A	~6.6 mA
B	~7.1 mA
C	~7.6 mA
D	~8.1 mA
E	~8.5 mA
F	~8.9 mA

3.6.3 Pulse Current Source

The pulse current source is provided to demonstrate the PAC1710 and PAC1720 devices' ability to detect current spikes of varying amplitude and duration. The current source is activated using momentary switch SW4 Pulse Trigger. Rotary switch SW2 Pulse Amp Adjust, in conjunction with the J15 jumper position which increases the dynamic range of the pulse width, sets the pulse duration as shown in Table 3-6. Single pulse current consumption is shown in Table 3-7.

TABLE 3-6: SINGLE PULSE DURATION

SW2 Position	J15 Jumper Position		
	Pins 1-2	Pins 2-3	Open
0	~1.38 ms	~14.68 ms	~0.176s
1	~2.45 ms	~28.60 ms	~0.347s
2	~3.53 ms	~42.55 ms	~0.517s
3	~4.58 ms	~56.00 ms	~0.683s
4	~5.73 ms	~70.60 ms	~0.862s
5	~6.76 ms	~83.70 ms	~1.03s
6	~7.79 ms	~96.80 ms	~1.19s
7	~8.79 ms	~109.4 ms	~1.35s
8	~9.74 ms	~121.6 ms	~1.50s
9	~10.70 ms	~133.8 ms	~1.66s
A	~11.64 ms	~145.6 ms	~1.81s
B	~12.52 ms	~156.8 ms	~1.95s
C	~13.44 ms	~168.8 ms	~2.10s
D	~14.26 ms	~179.0 ms	~2.23s
E	~15.04 ms	~189.0 ms	~2.36s
F	~15.7 ms	~190.0 ms	~2.47s

TABLE 3-7: SINGLE PULSE CURRENT CONSUMPTION

SW5 Position	Single Pulse Consumption (mA)
0	0 mA
1	~2.8 mA
2	~5.6 mA
3	~8.2 mA
4	~11.3 mA
5	~13.7 mA
6	~16.1 mA
7	~18.4 mA
8	~22.4 mA
9	~24.5 mA
A	~26.5 mA
B	~28.4 mA
C	~30.7 mA
D	~32.5 mA
E	~34.3 mA
F	~35.9 mA

3.7 SYS MODE SETUP AND OPERATION

Sys mode uses external current sources, such as 12 V_{DC}, to exercise and demonstrate the features of the PAC1710 and PAC1720.

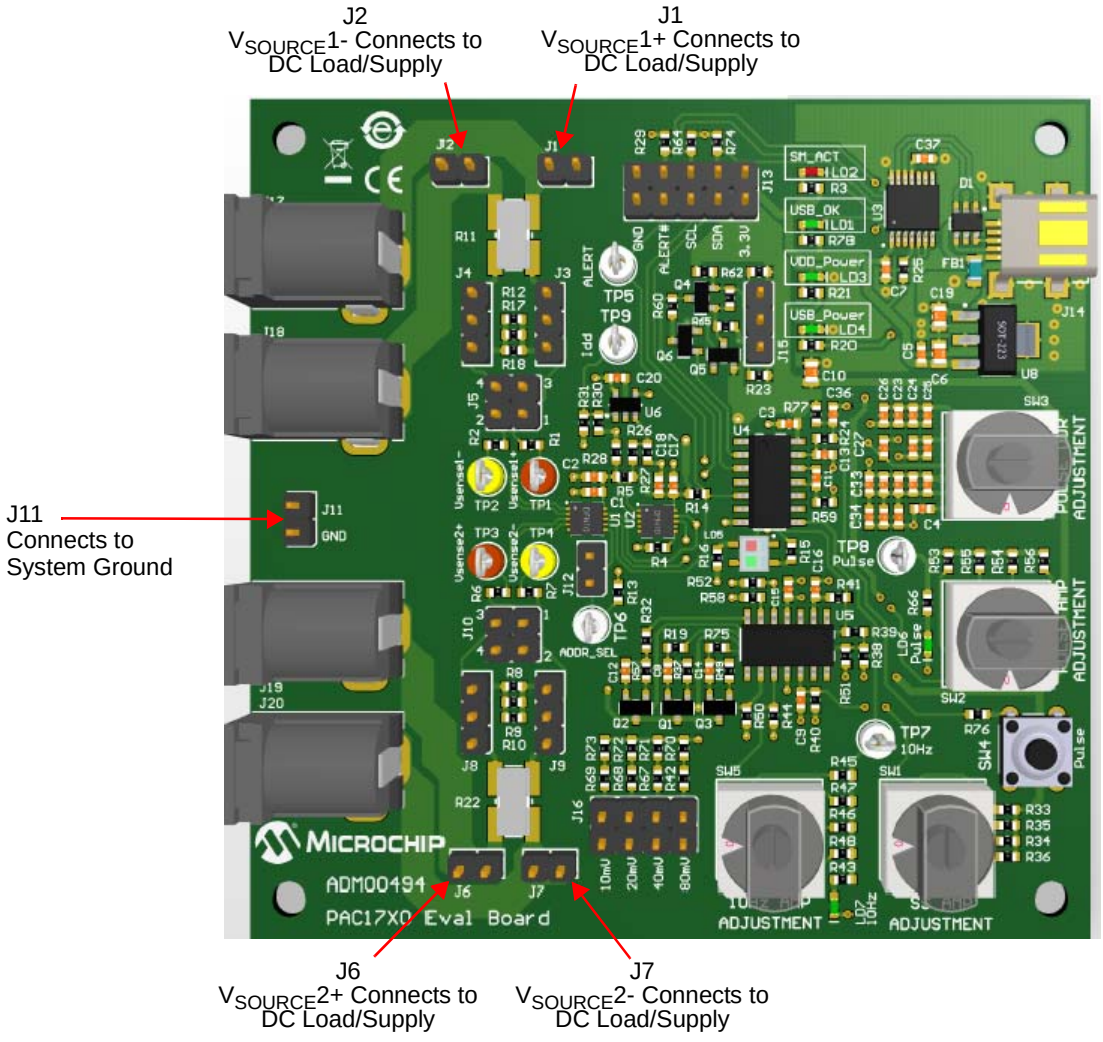
3.7.1 Jumper Positions

To use Sys mode, adjust jumpers J3, J4, J8 and J9 (see Table 3-2) to disconnect the on-board demonstration current sources.

3.7.2 Load Connection

A 3 mΩ (1% tolerance) sense resistor is provided on-board the PAC17X0 High-Side Current Sensors Evaluation Board to measure system current. For $V_{SOURCE}1$, this sense resistor is connected between J17 and J18 if using these power jacks, or between J1 and J2 if using wire terminals. For $V_{SOURCE}2$, this sense resistor is connected between J19 and J20 if using these power jacks, or between J6 and J7 if using wire terminals.

When using wire terminals, connections to the system can be established as shown in Figure 3-3.



Note: J17/J18 are alternate connections for $V_{SOURCE}1$ and J19/J20 are alternate connections for $V_{SOURCE}2$.

FIGURE 3-3: *External Load Connection Using Wire Terminals.*

3.8 MEASUREMENT POLARITY

Measurement polarity can be reversed using jumpers provided in J5 for $V_{SOURCE}1$ and J10 for $V_{SOURCE}2$. For normal polarity measurements, jumpers are placed in locations 1-3 and 2-4 (default). For measurement polarity reversal, jumpers are positioned in locations 1-2 and 3-4.

Chapter 4. Software Description

4.1 CHIP MANAGER APPLICATION OVERVIEW

The Chip Manager application enables the user to display voltage readings, set bus voltage and current-sense limits and read/write Configuration register values. The Chip Manager initially displays a Quick Help screen (see Figure 2-9). For detailed information on application features and usage, select *Help > Contents* to display the HTML-based Help document, as shown in Figure 4-1.

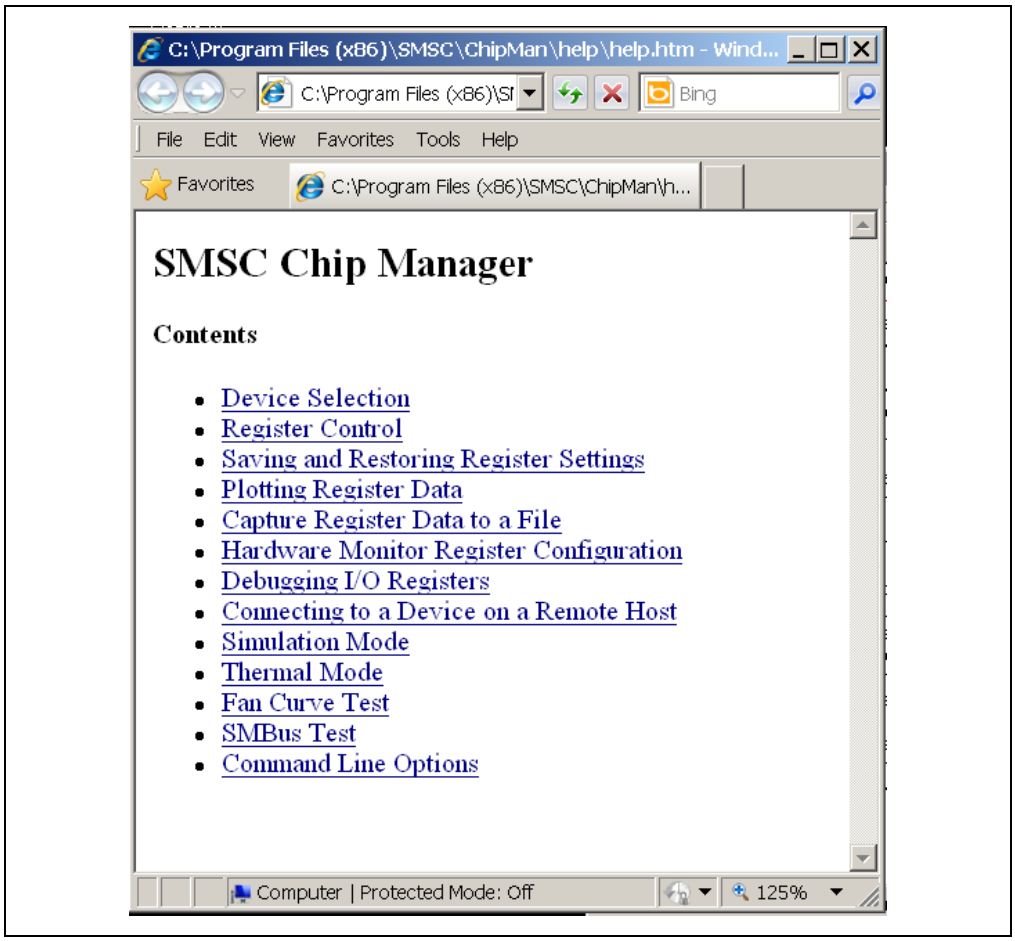


FIGURE 4-1: *Chip Manager Help Screen.*

4.1.1 Real-Time Register Graphs

The Chip Manager software has the ability to plot register values in real time, up to a 4 Hz continuous rate.

4.1.2 Selecting Registers to Plot

1. To plot a register, right-click the desired register name or value. Select the "Add Register(s) to Plot" from the context menu (see Figure 4-2) to add the register or value to the plot list.

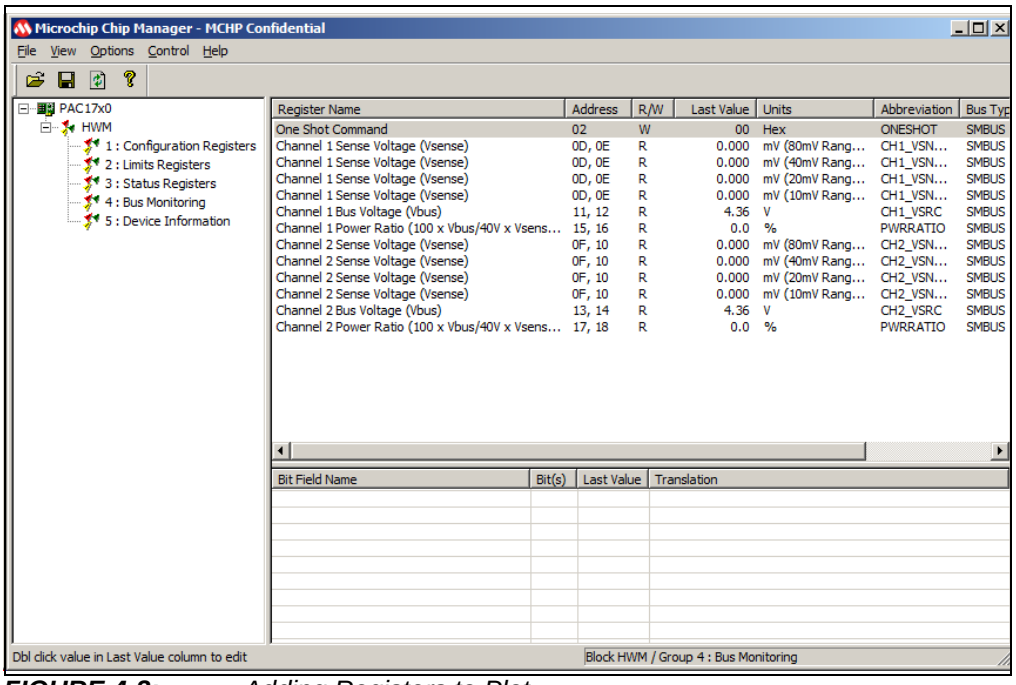


FIGURE 4-2: *Adding Registers to Plot.*

2. Once the desired register is added to be plotted, a graphic plot window will appear with a legend on top, as shown in Figure 4-3. The two windows can be rearranged independently.

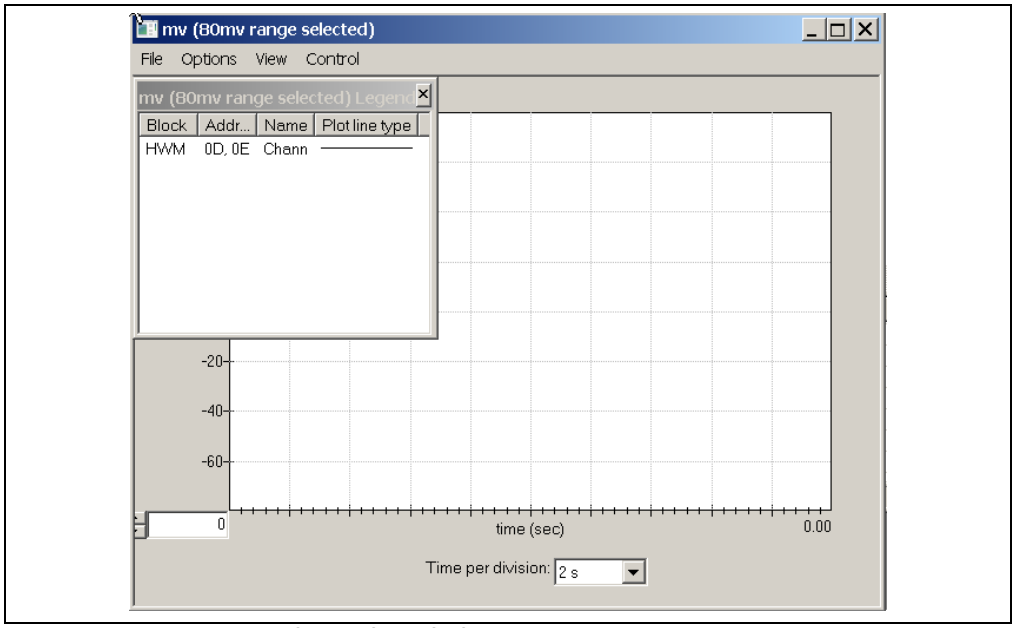


FIGURE 4-3: *Register Plot Window.*

3. To plot additional registers, go back to the Chip Manager main window and repeat Step 1.

4.1.3 Starting the Plots

Note:	Before starting the plots, it is important to disable the register's auto refresh. On the Chip Manager main menu, ensure that *Options > Auto Refresh Registers* is not checked.

All plots can be started simultaneously by selecting *Control > Plots > Start All Plots* from the menu in the Main Application window. Multiple plots will be in sync if they are started simultaneously.

Individual plots may be paused at any time by clicking *Control > Pause* in the Plot window. This will not cause loss of captured data on the other Plot windows.

For a better view of the plot, select a different "Time per division" value in the drop-down menu at the bottom of the Plotting window. This scale change affects both the Real-Time mode and the Playback mode, while the rate at which data is recorded is unaffected.

4.1.4 Exporting and Importing the Plot Data

The data on each plot window may be stored in a semicolon-separated text file. To save the data, follow the steps:

1. Stop the plotting by selecting *Control > Stop* from the Plot window or *Control > Plots > Stop All Plots* from the Chip Manager main window.
2. Select *File > Export* from the Plot window to save the data.

To review saved data:

1. Select *File > Import* from an open Plot window and then select the file name to open.

Note:	Importing a saved data file into a Plot window with a different data type is not allowed by the Chip Manager application. In this case, a warning message will display. It is recommended to choose a file name that reflects the data type when exporting the plot data.

NOTES:

Chapter 5. Evaluation Board Demonstration

5.1 INTRODUCTION

This chapter provides insight to the PAC17X0 High-Side Current Sensors Evaluation Board capabilities.

5.2 STEADY-STATE CURRENT SOURCE – ROTARY SWITCH 1

Rotary Switch 1 provides a means to control the current level through the on-board 1Ω sense resistor in fifteen discrete steps (see **Section 3.6.1 "Steady-State Current Source"**). To demonstrate this, complete the following steps:

1. In the Chip Manager application, select Bus Monitoring from the left pane to show registers. Right-click a V_{SENSE} range and add it to the registers to plot (see Figure 5-1 and **Section 4.1.2 "Selecting Registers to Plot"**).

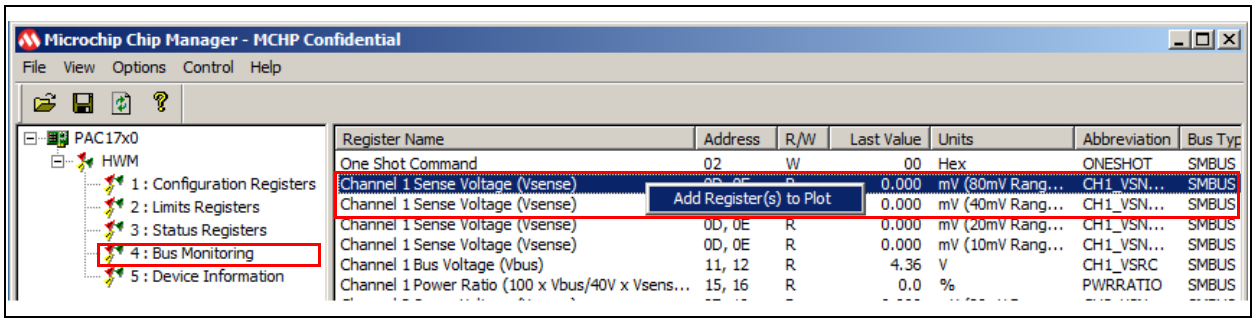


FIGURE 5-1: *Selecting Register to Plot.*

2. Turn all rotary switches to the "0" position.
3. Go to the Control menu and start the plot. Figure 5-2 shows a plot of current with all switches off.

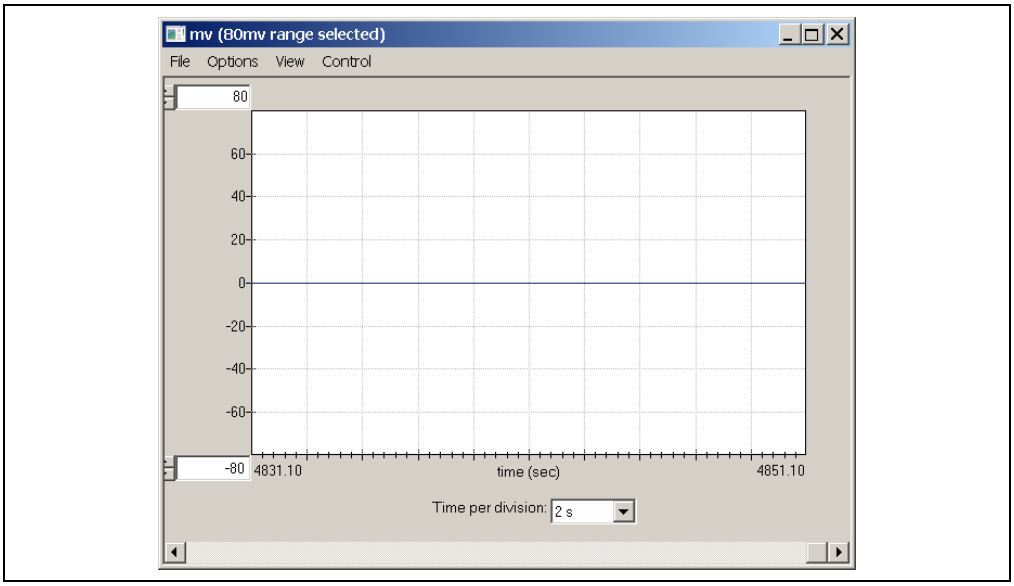


FIGURE 5-2: *All Current Sources Off Plot.*

4. Turn the Rotary Switch 1 to move through positions "1" through "F" and observe the plot (Figure 5-3).

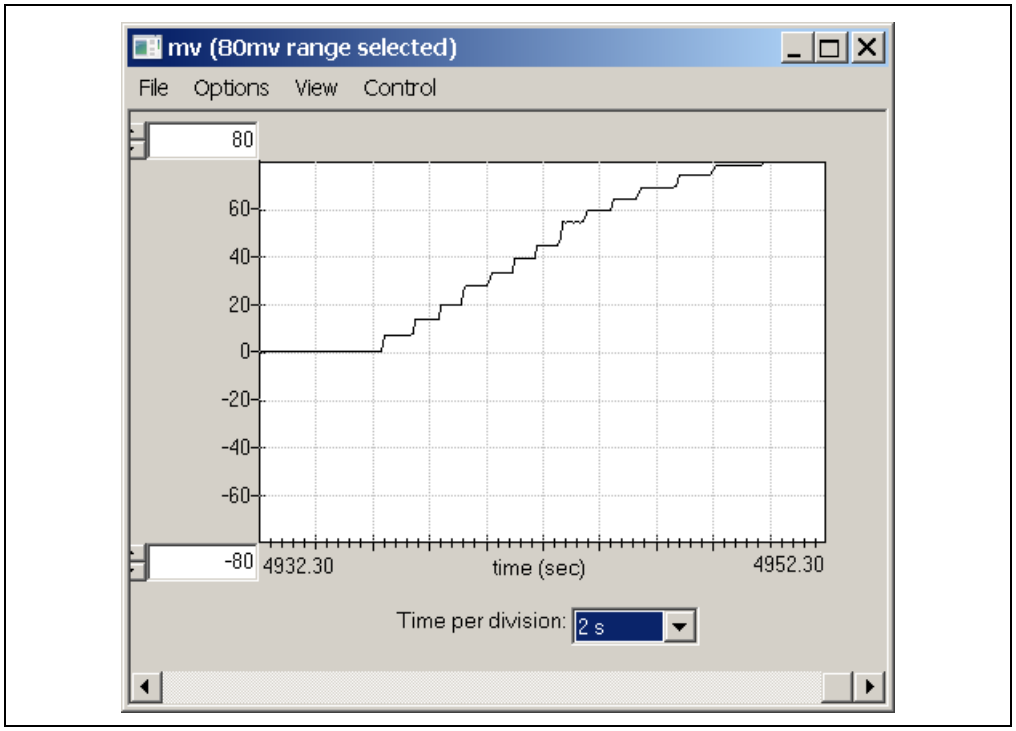


FIGURE 5-3: *Steady-State Current Plot.*

5. After experimenting, you can stop the plot and export the data (see **Section 4.1.4 "Exporting and Importing the Plot Data"**) or leave it running for the next demonstration.

5.3 MOMENTARY PULSE CURRENT SOURCE (AMPLITUDE) – ROTARY SWITCH 2

Rotary Switches 2 and 3 can be used to generate current spikes of varying amplitude and duration (see **Section 3.6.3 "Pulse Current Source"**). To demonstrate amplitude changes, complete the following steps:

1. Turn all rotary switches to the "0" position.
2. Ensure J15 is open. This increases pulse width so the demonstration is easier to see.
3. Start the V_{SENSE} range plot used in the previous demonstration.
4. Turn Rotary Switch 3 to position "4".
5. Turn Rotary Switch 2 to position "1" and press Switch 4 (Pulse Trigger button).
6. Turn Rotary Switch 2 to position "2" and press Switch 4 (Pulse Trigger button).
7. Continue turning Rotary Switch 2, one position at a time, and pressing Switch 4. Observe the plot (Figure 5-4).

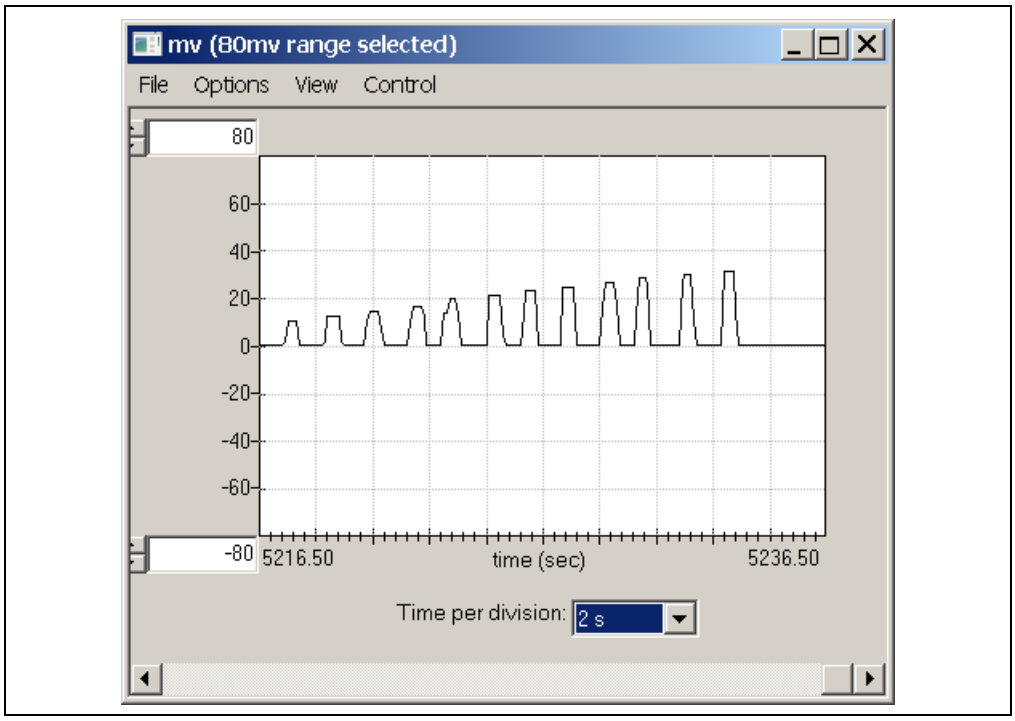


FIGURE 5-4: *Momentary Pulse Amplitude Plot.*

8. After experimenting, you can stop the plot and export the data (see **Section 4.1.4 "Exporting and Importing the Plot Data"**) or leave it running for the next demonstration.

5.4 MOMENTARY PULSE CURRENT SOURCE (DURATION) – ROTARY SWITCH 2

Rotary Switches 2 and 3 can be used to generate current spikes of varying amplitude and duration. To demonstrate duration changes, complete the following steps:

1. Turn all rotary switches to the "0" position.
2. Ensure J15 is open. This increases pulse width so the demonstration is easier to see.
3. Start the V_{SENSE} range plot used in the previous demonstration.
4. Turn Rotary Switch 2 to position "F" (highest level of pulse).
5. Turn Rotary Switch 3 to position "F" and press Switch 4 (Pulse Trigger button) to send the pulse.
6. Turn Rotary Switch 3 to position "E" and press Switch 4 (Pulse Trigger button) to send the pulse.
7. Continue turning Rotary Switch 3, one position at a time, and pressing Switch 4. Observe the plot (Figure 5-5).

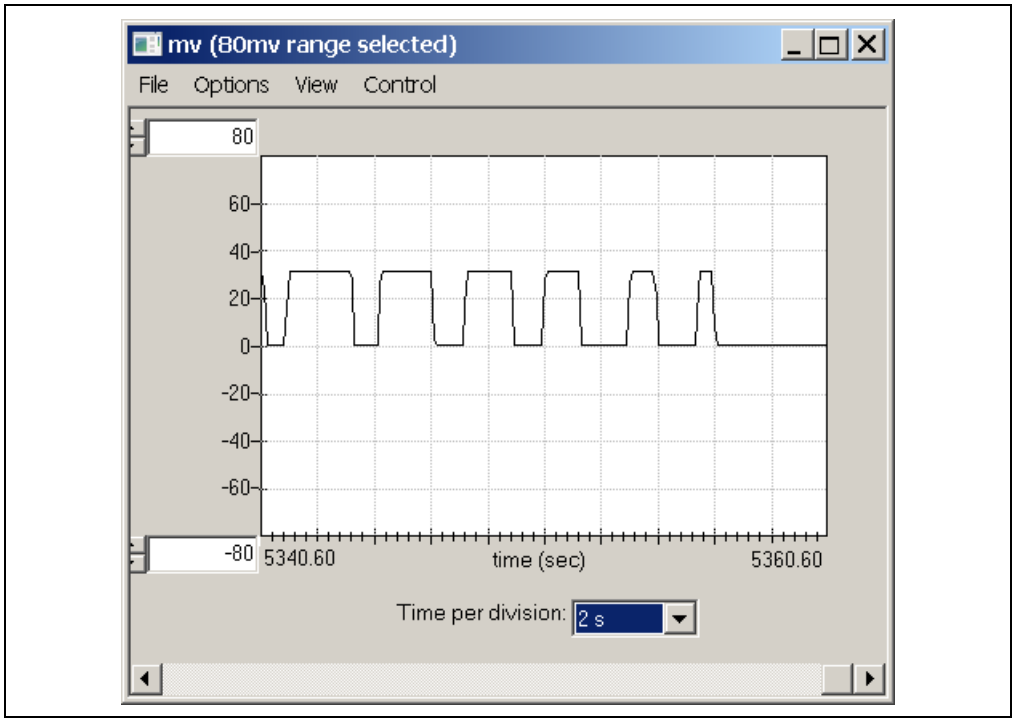


FIGURE 5-5: *Momentary Pulse Duration Plot.*

8. After experimenting, stop the plot.

5.5 10 Hz PULSE TRAIN CURRENT SOURCE – ROTARY SWITCH 5

Rotary Switch 5 can be used to introduce noise (see **Section 3.6.2 "10 Hertz Current Source"**). The evaluation board with the Chip Manager tool does not demonstrate the PAC1710 and PAC1720 devices' ability to attenuate circuit noise because the maximum update rate of the Chip Manager is limited to 4 Hz. To see this feature, connect an external SMBus master to read the device quickly enough to properly see the results of the injected 4 Hz noise.

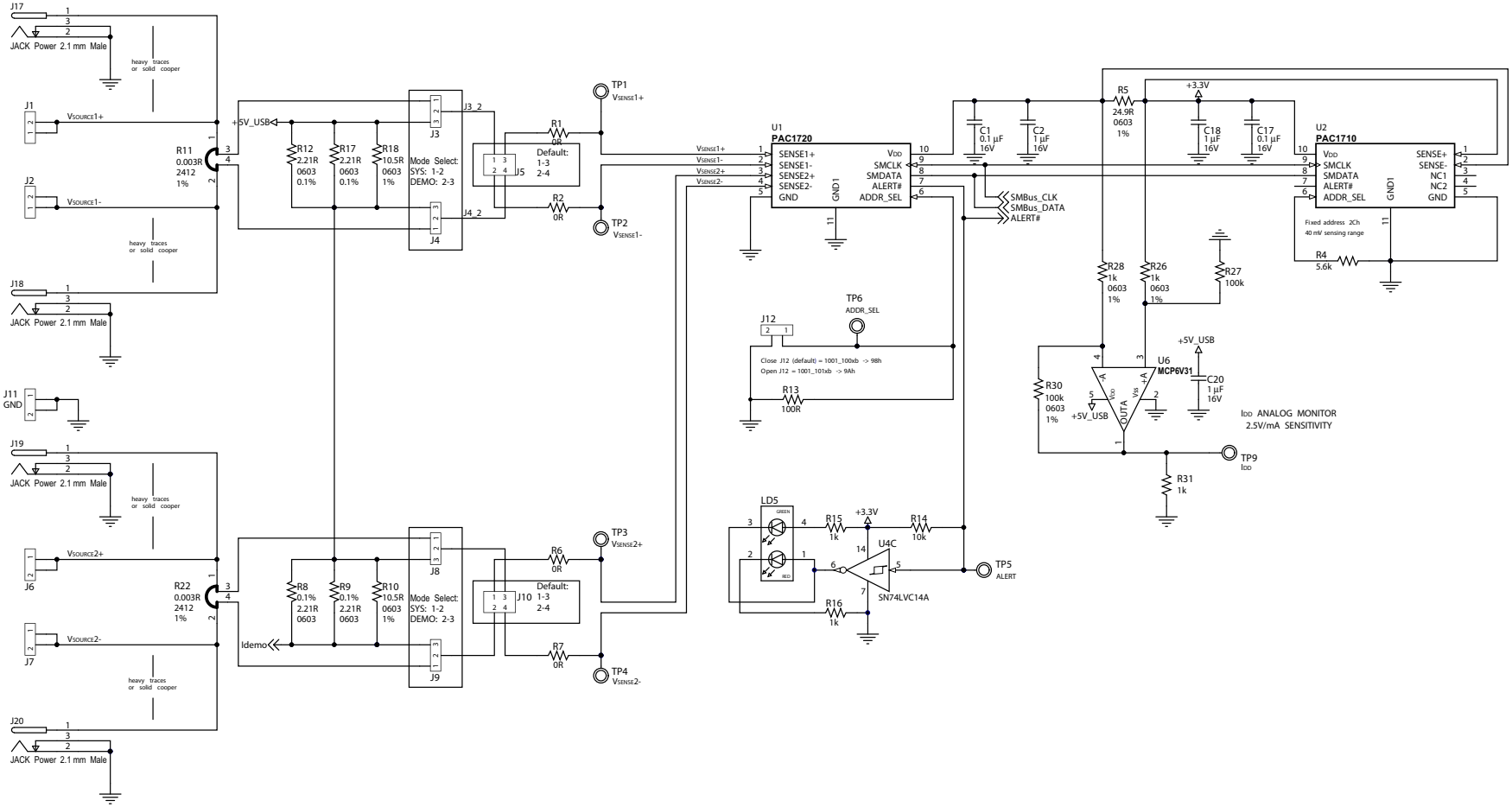
Appendix A. Schematic and Layouts

A.1 INTRODUCTION

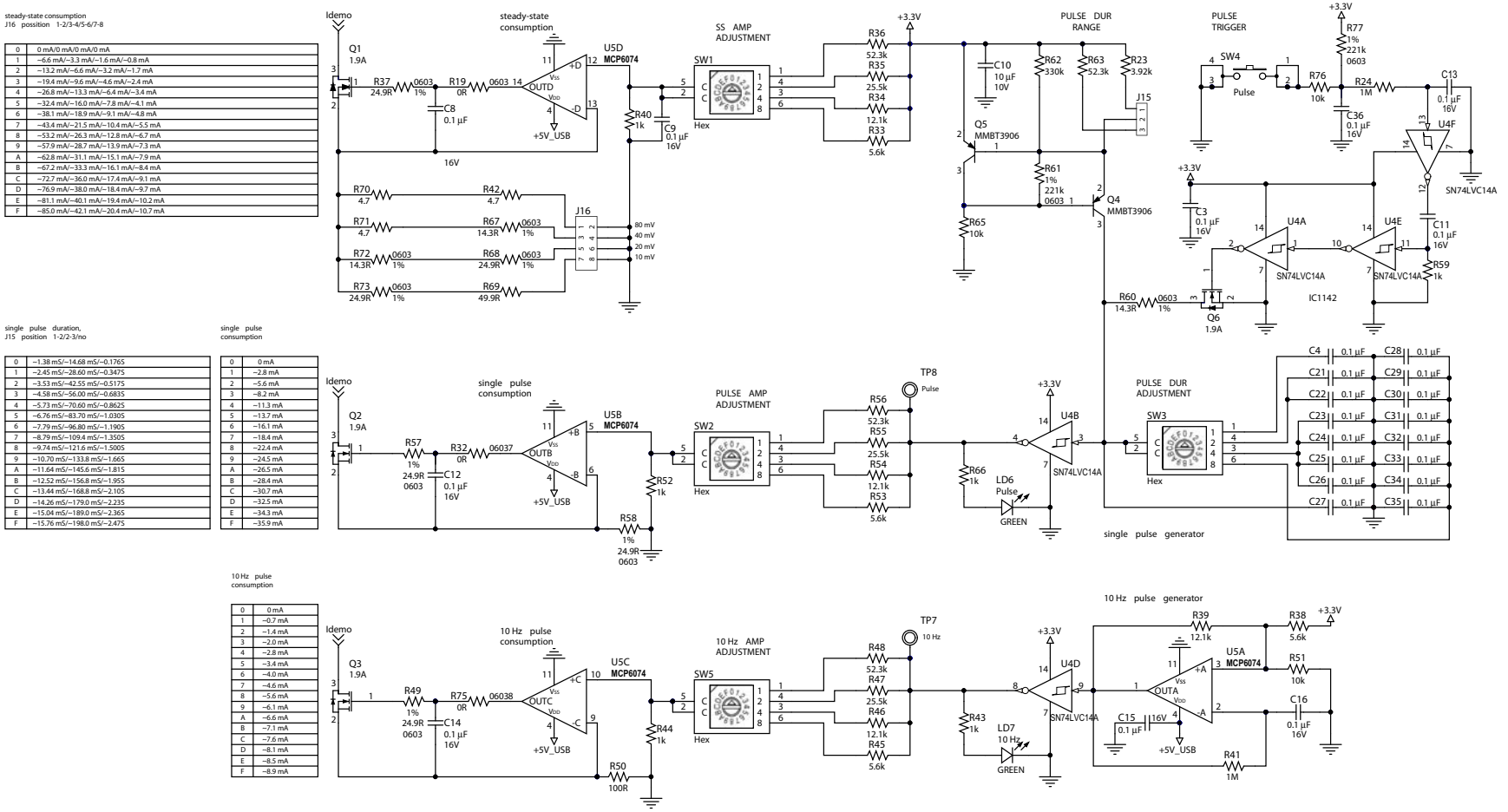
This appendix contains the following schematics and layouts for the PAC17X0 High-Side Current Sensors Evaluation Board:

- Board – Schematic: Current Sensors
- Board – Schematic: Current Sources
- Board – Schematic: MCP2221 USB Bridge
- Board – Top Silk
- Board – Top Copper and Silk
- Board – Top Copper
- Board – Bottom Copper
- Board – Bottom Copper and Silk
- Board – Bottom Silk

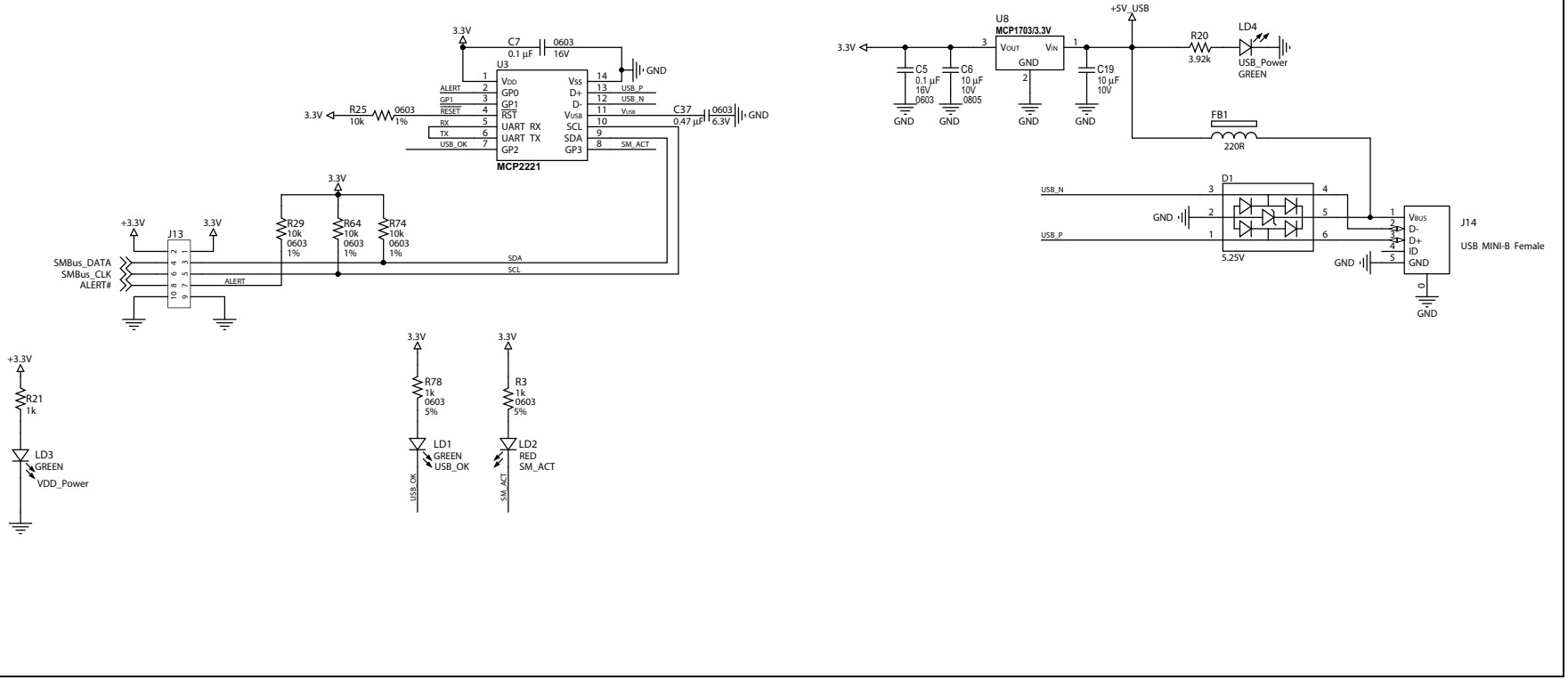
A.2 BOARD – SCHEMATIC: CURRENT SENSORS



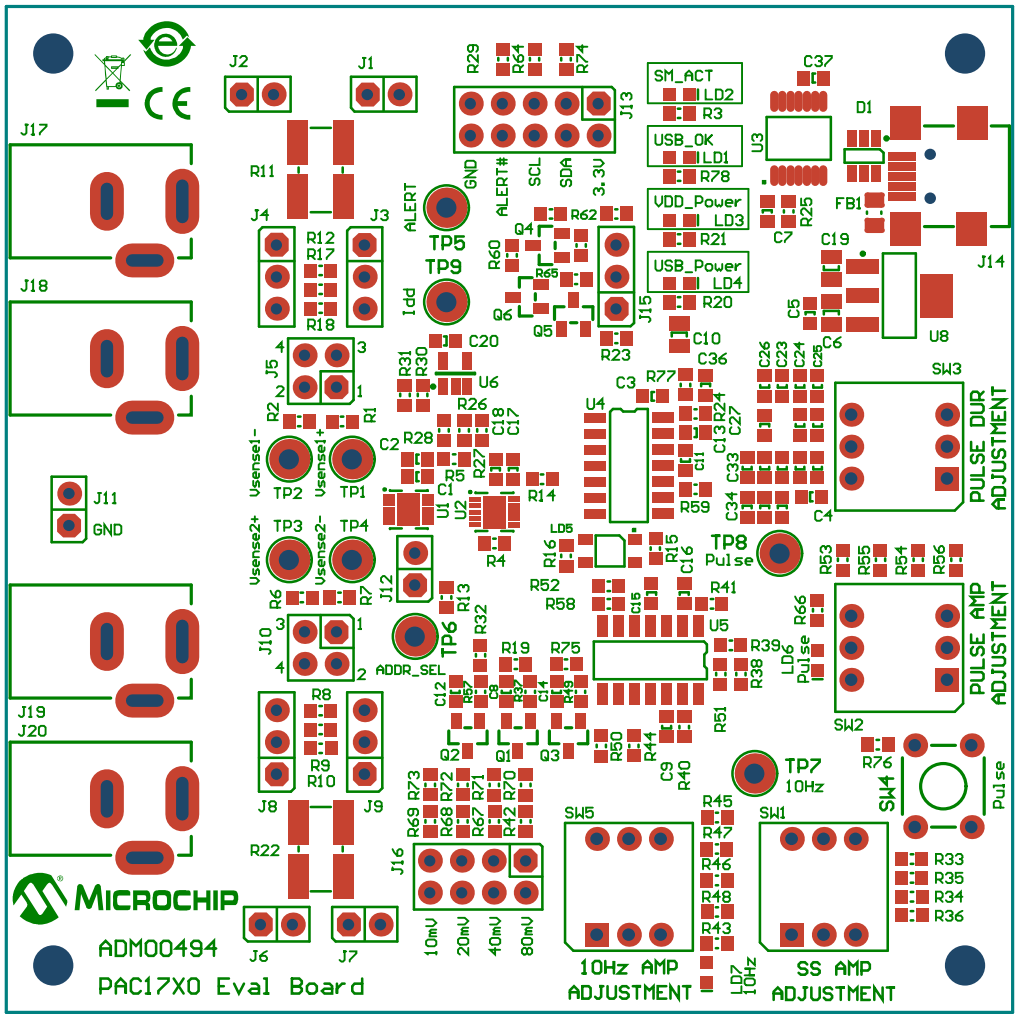
A.3 BOARD – SCHEMATIC: CURRENT SOURCES



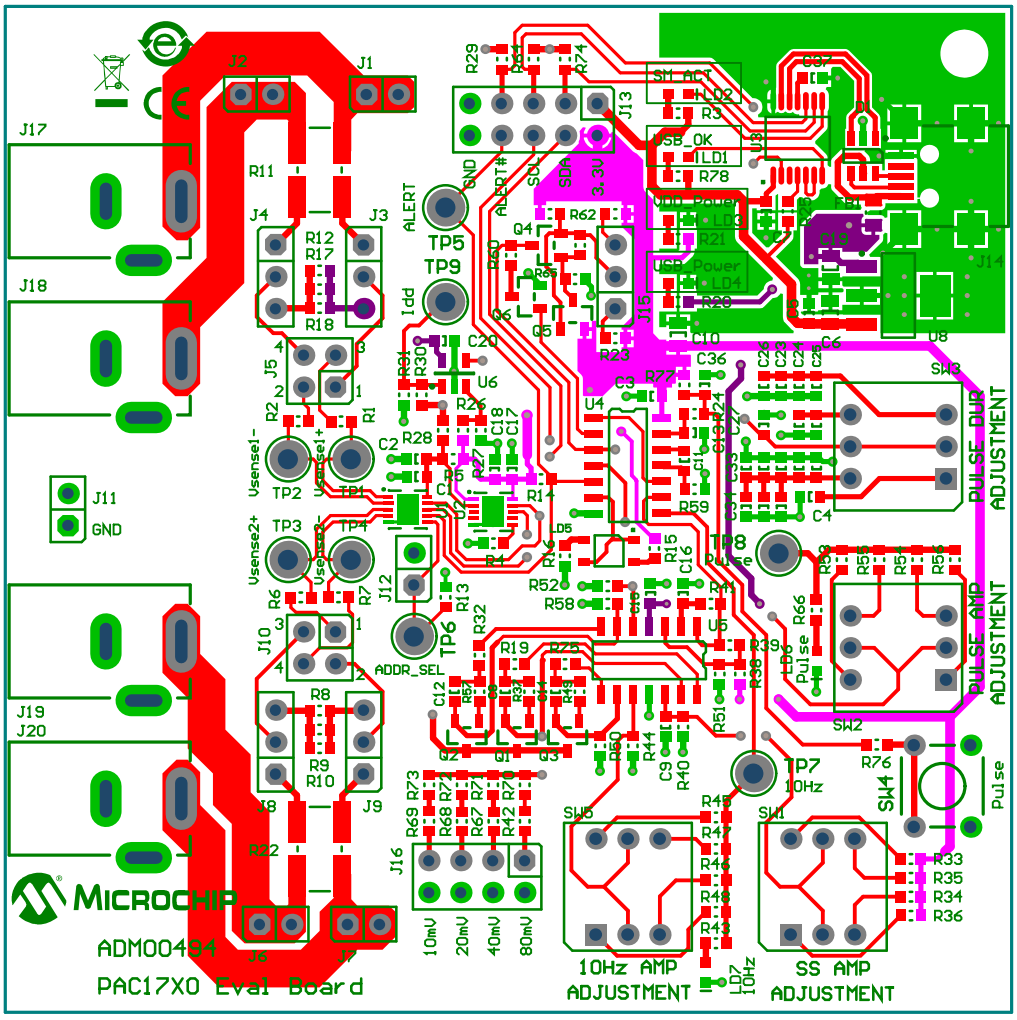
A.4 BOARD – SCHEMATIC: MCP2221 USB BRIDGE



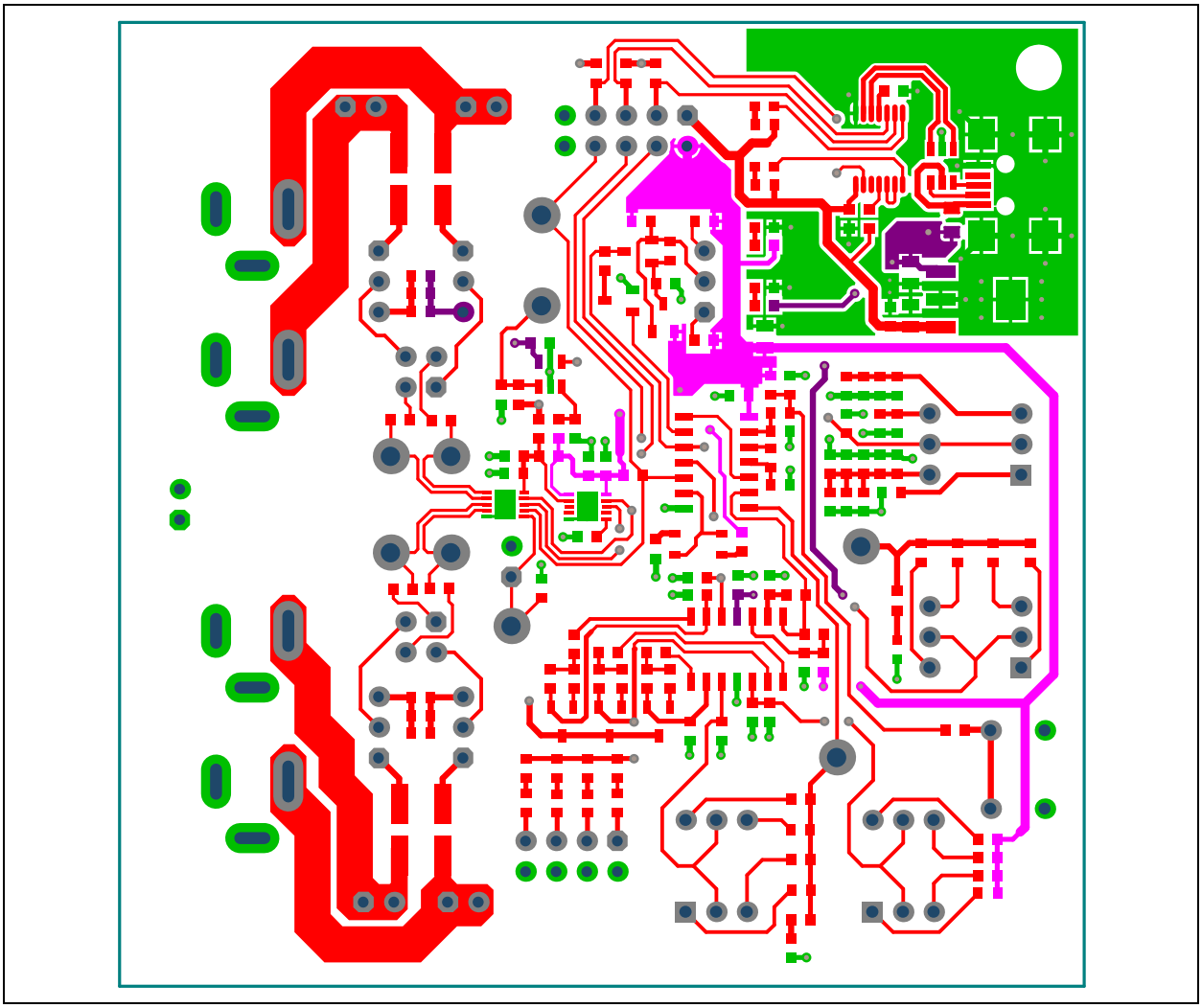
A.5 BOARD – TOP SILK



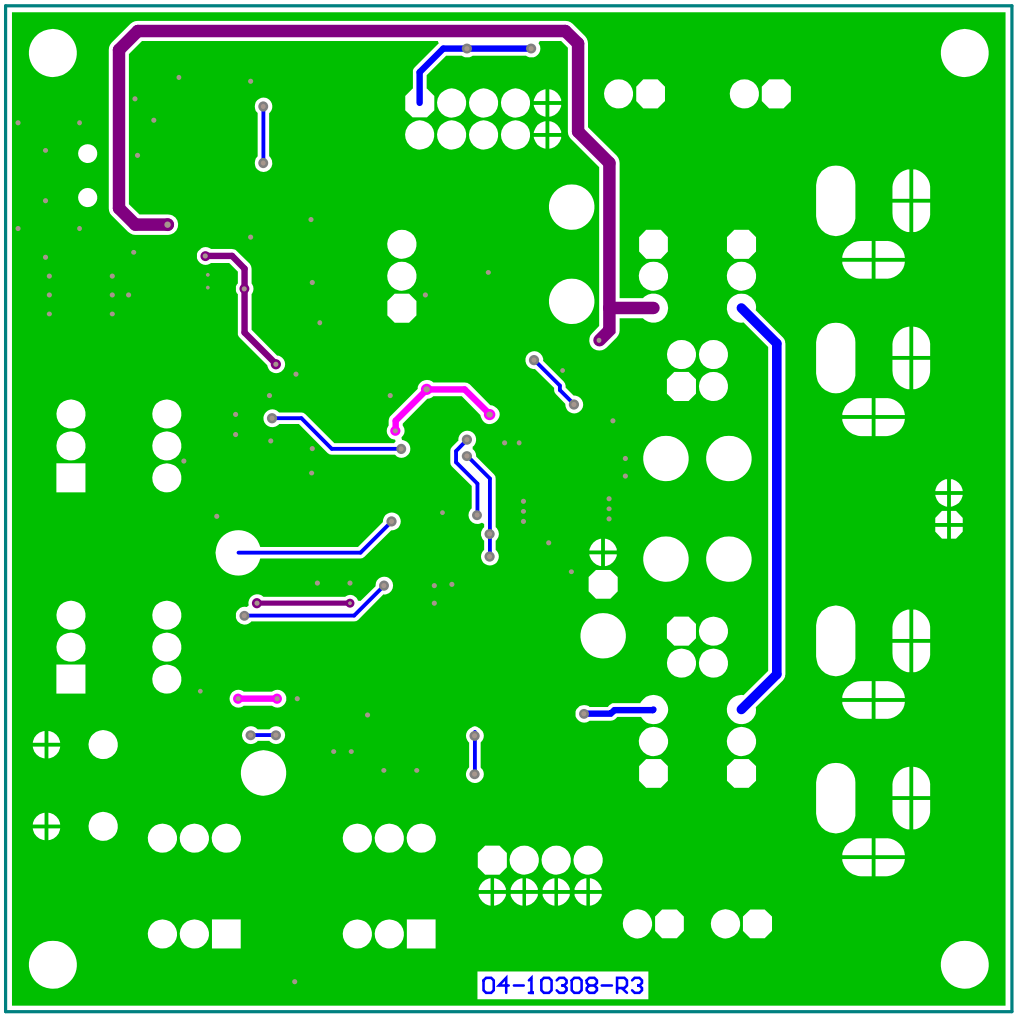
A.6 BOARD – TOP COPPER AND SILK



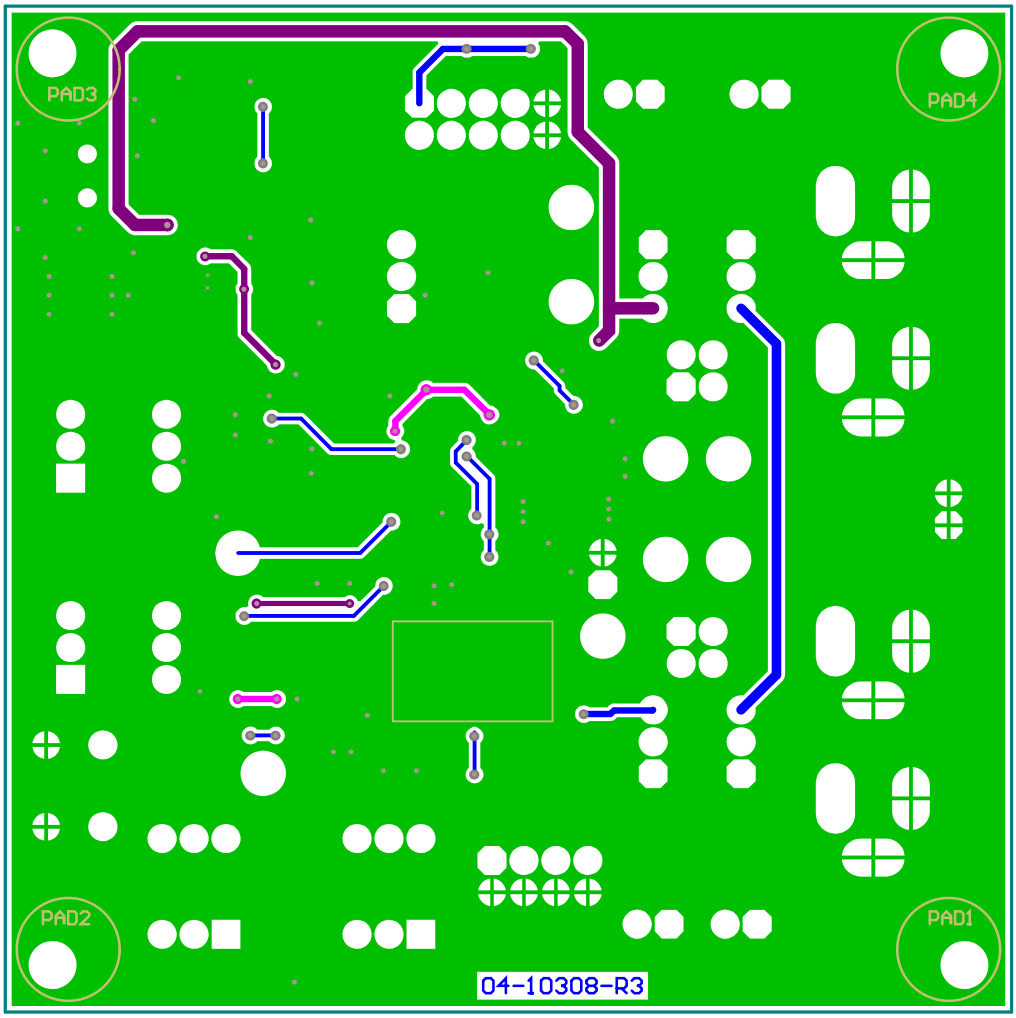
A.7 BOARD – TOP COPPER



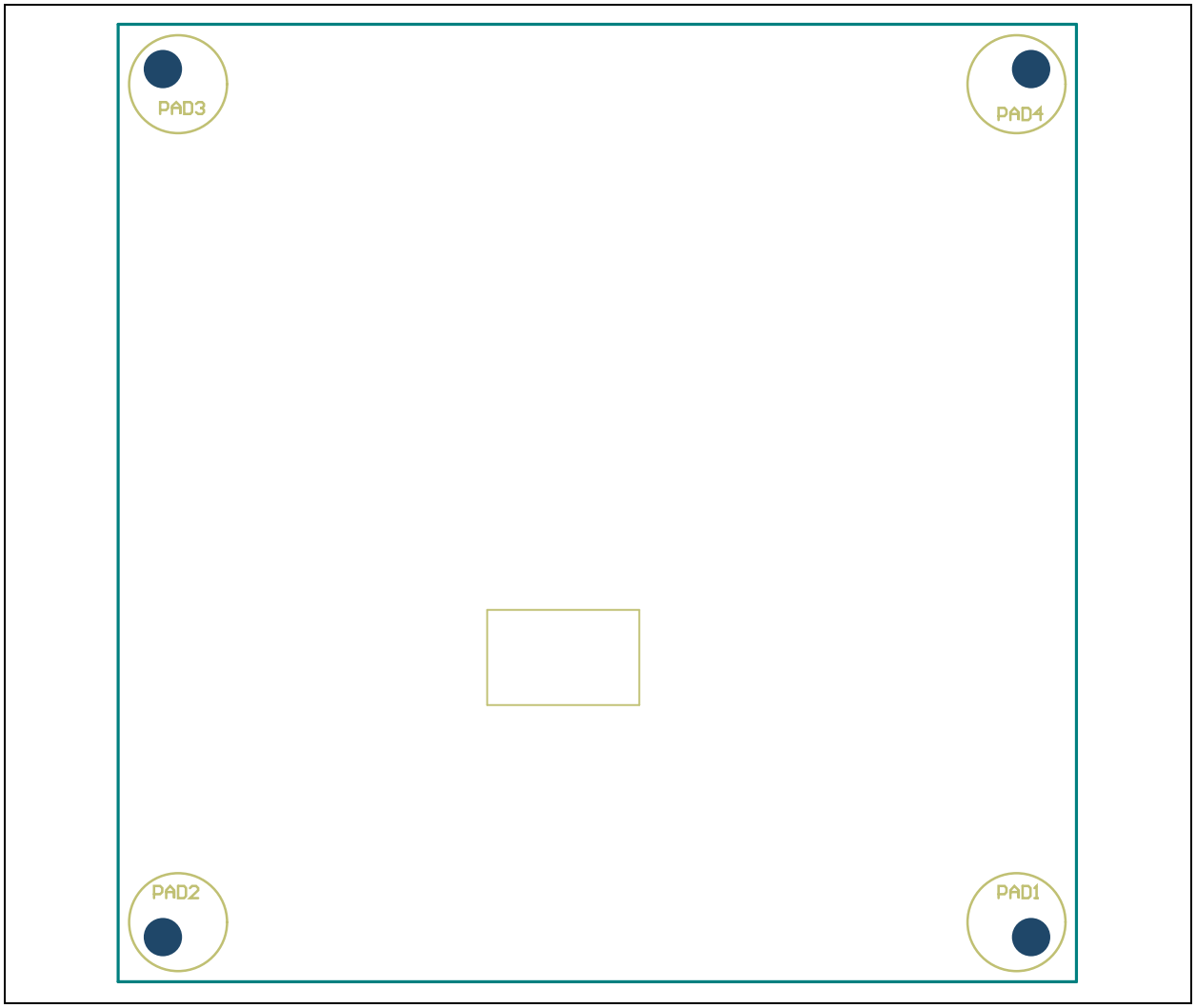
A.8 BOARD – BOTTOM COPPER



A.9 BOARD – BOTTOM COPPER AND SILK



A.10 BOARD – BOTTOM SILK



Appendix B. Bill of Materials (BOM)

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

Qty.	Reference	Description	Manufacturer	Part Number
30	C1, C3, C4, C5, C7, C8, C9, C11-C17, C21-C36	Cap. ceramic, 0.1 µF, 16V, 10%, X7R, SMD, 0603	KEMET	C0603C104M3RACTU
3	C2, C18, C20	Cap. ceramic, 1 µF, 16V, 10%, X7R, SMD, 0603	Samsung Electro-Mechanics America, Inc.	CL10B105KO8NNNC
3	C6, C10, C19	Cap. ceramic, 10 µF, 10V, 20%, Y5V, SMD, 0805	TDK Corporation	C1608X5R1C106M080AB
1	C37	Cap. ceramic, 0.47 µF, 6.3V, 10%, X5R, SMD, 0603	Murata Electronics®	GRM188R60J474KA01D
1	CBL1	Mech. HW cable, USB-A male to Mini USB-B male, 3 ft., black	Katerno	10UM-02103BK
1	D1	Diode TVS array, USBLC6-2SC6, 5.25V, SMD, SOT-23-6	STMicroelectronics™	USBLC6-2SC6
1	FB1	Ferrite, 2A, 220R, SMD, 0805	Murata Electronics	BLM21PG221SN1D
6	J1, J2, J6, J7, J11, J12	Connector header-2.54, male, 1x2, gold, 5.84 MH, TH vert.	FCI Electronics	68001-202HLF
5	J3, J4, J8, J9, J15	Connector header-2.54, male, 1x3, gold, 5.84 MH, thin vert.	FCI Electronics	68000-103HLF
2	J5, J10	Connector header-2.54, male, 2x2, gold, 5.84 MH, thin vert.	FCI Electronics	67997-104HLF
1	J13	Connector header-2.54, male, 2x5, gold, 5.84 MH, thin vert.	FCI Electronics	67997-110HLF
1	J14	Connector USB Mini-B female, SMD, R/A	Hirose Electric Co., Ltd.	UX60-MB-5ST
1	J16	Connector header-2.54, male, 2x4, tin, 5.84 MH, thin vert.	FCI Electronics	67996-408HLF
4	J17, J18, J19, J20	Connector jack power, 2.1 mm, 24V, 5A, male, thin R/A	CUI Inc.	PJ-002AH
14	JP1	Mech. HW jumper, 2.54 mm, 1x2, handle gold	TE Connectivity, Ltd.	881545-2
4	KNOB1	Actuator knob black	Grayhill Inc.	947705-021
5	LD1, LD3, LD4, LD6, LD7	Diode LED green, 2.2V, 25 mA, 15 mcd, clear, SMD, 0603	Kingbright Corp.	APT1608SGC
1	LD2	Diode LED red, 1.95V, 30 mA, 700 mcd, clear, SMD, 0603	Kingbright Corp.	APTD1608SURCK
1	LD5	Diode LED blue, red, green, 2V, 2.2V, 30 mA, 25 mA, 4-SMD	Lumex® Inc.	SSL-LXA3025IGC-TR
4	PAD1, PAD2, PAD3, PAD4	Mech. HW rubber pad, cylindrical, D7.9, H5.3, black	3M	SJ61A11

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

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

Qty.	Reference	Description	Manufacturer	Part Number
0	PCB	PAC17x0 High-Side Current Sensors Evaluation Board – Printed Circuit Board	—	104-10308
4	Q1, Q2, Q3, Q6	Transistor FET N-Ch., ZXMN2A01F, 20V, 1.9A, 625 mW, SOT-23-3	Diodes® Incorporated	ZXMN2A01FTA
2	Q4, Q5	Transistor BJT, PNP, MMBT3906, -40V, -200 mA, 300 mW, SOT-23-3	Central™ Semiconductor Corp.	CMPT3906-PST-LEAD-FREE
7	R1, R2, R6, R7, R19, R32, R75	Resistor TKF, 0R, 1/10W, SMD, 0603	NIC Components Corp.	NRC06Z0TRF
2	R3, R78	Resistor TKF, 1k, 5%, 1/10W, SMD, 0603	Panasonic® - ECG	ERJ-3GEYJ102V
5	R4, R33, R38, R45, R53	Resistor TKF, 5.6k, 1%, 1/10W, SMD, 0603	Yageo Corporation	RC0603FR-075K6L
7	R5, R37, R49, R57, R58, R68, R73	Resistor TKF, 24.9R, 1%, 1/10W, SMD, 0603	Vishay/Dale	CRCW060324R9FKEA
4	R8, R9, R12, R17	Resistor TF, 2.21R, 0.1%, 1/16W, SMD, 0603	Stackpole Electronics, Inc.	RNCF0603BKC2R21
2	R10, R18	Resistor TKF, 10.5R, 1%, 1/10W, SMD, 0603	Yageo Corporation	RC0603FR-0710R5L
2	R11, R22	Resistor 0.003R, 1%, 2W, 1%, 2412	Ohmite® Manufacturing	LVK25R003FER
2	R13, R50	Resistor TKF, 100R, 1%, 1/10W, SMD, 0603	Panasonic - ECG	ERJ-3EKF1000V
8	R14, R25, R29, R51, R64, R65, R74, R76	Resistor TKF, 10k, 1%, 1/10W, SMD, 0603	Vishay/Dale	CRCW060310K0FKEA
12	R15, R16, R21, R26, R28, R31, R40, R43, R44, R52, R59, R66	Resistor TKF, 1k, 1%, 1/10W, SMD, 0603	Panasonic - ECG	ERJ-3EKF1001V
2	R20, R23	Resistor TKF, 3.92k, 1%, 1/10W, SMD, 0603	Panasonic - ECG	ERJ-3EKF3921V
2	R24, R41	Resistor TKF, 1M, 1%, 1/10W, SMD, 0603	Panasonic - ECG	ERJ-3EKF1004V
2	R27, R30	Resistor TKF, 100k, 1%, 1/4W, SMD, 0603	Stackpole Electronics, Inc.	RMCF0603FT100K
4	R34, R39, R46, R54	Resistor TKF, 12.1k, 1%, 1/10W, SMD, 0603	Yageo Corporation	RC0603FR-0712K1L
3	R35, R47, R55	Resistor TKF, 25.5k, 1%, 1/10W, SMD, 0603	Panasonic - ECG	ERJ-3EKF2552V
4	R36, R48, R56, R63	Resistor TKF, 52.3k, 1%, 1/10W, SMD, 0603	Panasonic - ECG	ERJ-3EKF5232
3	R42, R70, R71	Resistor TKF, 4.7k, 1%, 1/10W, SMD, 0603	Panasonic - ECG	ERJ-3RQF4R7V
3	R60, R67, R72	Resistor TKF, 14.3R, 1%, 1/10W, SMD, 0603	Panasonic - ECG	ERJ-3EKF14R3V
2	R61, R77	Resistor TKF, 221k, 1%, 1/10W, SMD, 0603	Panasonic - ECG	ERJ-3EKF2213V

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

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

Qty.	Reference	Description	Manufacturer	Part Number
1	R62	Resistor TKF, 330k, 1%, 1/10W, SMD, 0603	Panasonic - ECG	ERJ-3EKF3303V
1	R69	Resistor TKF, 49.9R, 1%, 1/10W, SMD, 0603	Panasonic - ECG	ERJ-3EKF49R9V
4	SW1, SW2, SW3, SW5	Switch, Rotary HEX, 50V, 0.1A, 94HBB16T, thin, DIP-8	Grayhill Inc.	94HBB16T
1	SW4	Switch, Tact. SPST, 15V, 20 mA, EVQ-PAC05R	Panasonic - ECG	EVQ-PAC05R
2	TP1, TP3	Conn. TP loop, orange, thin	Keystone Electronics Corp.	5013
2	TP2, TP4	Conn. TP loop, yellow, thin	Keystone Electronics Corp.	5014
5	TP5, TP6, TP7, TP8, TP9	Conn. TP loop, white, thin	Keystone Electronics Corp.	5012
1	U1	Microchip Analog Current-Sense Monitor, PAC1720-1-AIA-TR, DFN-10	Microchip Technology Inc.	PAC1720-1-AIA-TR
1	U2	Microchip Analog Current-Sense Monitor, PAC1710-1-AIA-TR, DFN-10	Microchip Technology Inc.	PAC1710-1-AIA-TR
1	U3	Microchip Interface USB I^2C UART, MCP2221-I/ST, TSSOP-14	Microchip Technology Inc.	MCP2221-I/ST
1	U4	IC buffer inverter, SN74LVC14ADR, SOIC-14	Texas Instruments	SN74LVC14ADR
1	U5	Microchip Analog Op Amp, 4-Ch., 1.2 MHz, MCP6074-E/SL, SOIC-14	Microchip Technology Inc.	MCP6074-E/SL
1	U6	IC Analog op amp, 1-Ch., 300 kHz, MCP6V31UT-E/OT, SOT-23-5	Microchip Technology Inc.	MCP6V31UT-E/OT
1	U8	Microchip Analog LDO, 3.3V, MCP1703T-3302E/DB, SOT-223-3	Microchip Technology Inc.	MCP1703-3302E/DB

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

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