MCP9904 Temperature Sensor Evaluation Board User's Guide

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VP Development Tools

11-NOV-16
Date

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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 web site (www.microchip.com) to obtain the latest documentation available.

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

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

INTRODUCTION

This chapter contains general information that will be useful to know before using the MCP9904 Temperature Sensor Evaluation Board. Items discussed in this chapter include:

- Document Layout
- Conventions Used in This Guide
- Recommended Reading
- The Microchip Web Site
- Customer Support
- Document Revision History

DOCUMENT LAYOUT

This document describes how to use the MCP9904 Temperature Sensor 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 MCP9904 Temperature Sensor Evaluation Board.
- **Chapter 2. "Installation and Operation"** – Includes instructions on installing and starting the Microchip Technology Incorporated Chip Manager application.
- **Chapter 3. "Hardware Description"** – Shows hardware details of the MCP9904 Temperature Sensor Evaluation Board.
- **Chapter 4. "Software Description"** – Describes the main operations in the Microchip Chip Manager software.
- **Appendix A. "Schematic and Layouts"** – Shows the schematic and layout diagrams for the MCP9904 Temperature Sensor Evaluation Board.
- **Appendix B. "Bill of Materials (BOM)"** – Lists the parts used to build the MCP9904 Temperature Sensor 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 MCP9904 Temperature Sensor Evaluation Board. Other useful documents are listed below. The following Microchip documents are available and recommended as supplemental reference resources:

- **MCP990X Data Sheet – *"MCP990X Multi-Channel Low-Temperature Remote Diode Sensor"* (DS20005382)**
- **AN10.14 – *"Using Temperature-Sensing Diodes with Remote Thermal Sensors"* (DS00001839)**
- **AN12.14 – *"Remote Thermal Sensing Diode Selection Guide"* (DS00001838)**
- **AN13.19 – *"Resistance Error Correction"* (DS00001852)**
- **AN14.0 – *"Microchip Dedicated Slave Devices in I^2C Systems"* (DS00001853)**
- **AN16.4 – "*Using Anti-Parallel Diodes (APD) with Microchip's Remote Temperature Sensing Devices"* (DS00001828)**

THE MICROCHIP WEB SITE

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

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To register, access the Microchip web site at http://www.microchip.com, click on **Product Change Notification** and follow the registration instructions.

CUSTOMER SUPPORT

Users of Microchip products can receive assistance through several channels:

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

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

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

DOCUMENT REVISION HISTORY

Revision A (January 2017)

- Initial Release of this Document.

Chapter 1. Product Overview

1.1 INTRODUCTION

The MCP9904 Temperature Sensor Evaluation Board provides an easily-accessible platform to test the various features of the MCP9904. The System Management Bus (SMBus) communication is accomplished using a Universal Serial Bus (USB) bridge, providing a standard interface for the application code interface. The board is populated with an 10-Lead 3x3 VDFN version of the MCP9904 device.

1.2 MCP9904 DEVICE FEATURES

The MCP9904 device is a four-channel SMBus temperature sensor featuring both pin-selectable and fixed SMBus address capability. The communications bus is also compatible with I^2C communication protocol.

Note: Refer to Microchip application note AN14.0 - "Microchip Dedicated Slave Devices in I2C Systems" (DS00001853) for details on the differences between the Microchip SMBus implementation and standard I2C/SMBus.

Three externally connected temperature diodes and one internal diode are available for temperature sensing. $\overline{\text{THERM}}$ and $\overline{\text{ALERT}}$ outputs have programmable temperature limits.

1.3 WHAT IS THE MCP9904 TEMPERATURE SENSOR EVALUATION BOARD?

All functions of the MCP9904 device can be tested and observed using the USB-based MCP9904 Temperature Sensor Evaluation Board. Figure 1-1 shows the block diagram of this board.

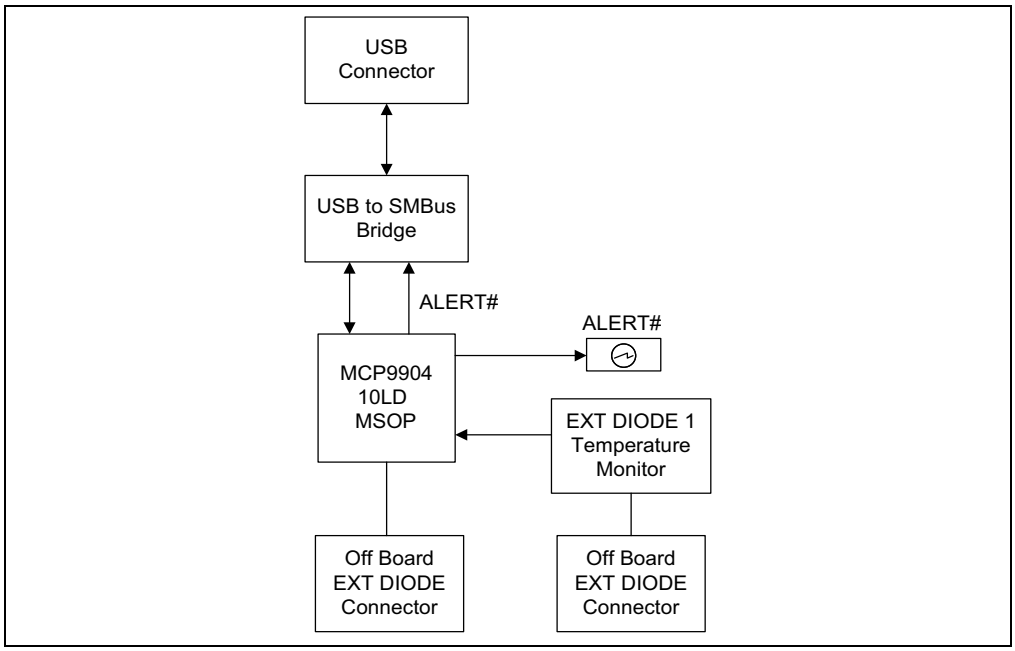


FIGURE 1-1: *MCP9904 Temperature Sensor Evaluation Board Block Diagram.*

The evaluation system is composed of the MCP9904 Temperature Sensor Evaluation Board and the Microchip Chip Manager application. The MCP9904 Temperature Sensor Evaluation Board has the following features:

- Two headers for connecting an external diode or CPU/GPU
- USB-to-SMBus bridge for power and communications

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

- 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 was designed for ease of use and experimentation purposes. Figure 1-2 shows the top silk screen of the MCP9904 Temperature Sensor Evaluation Board.

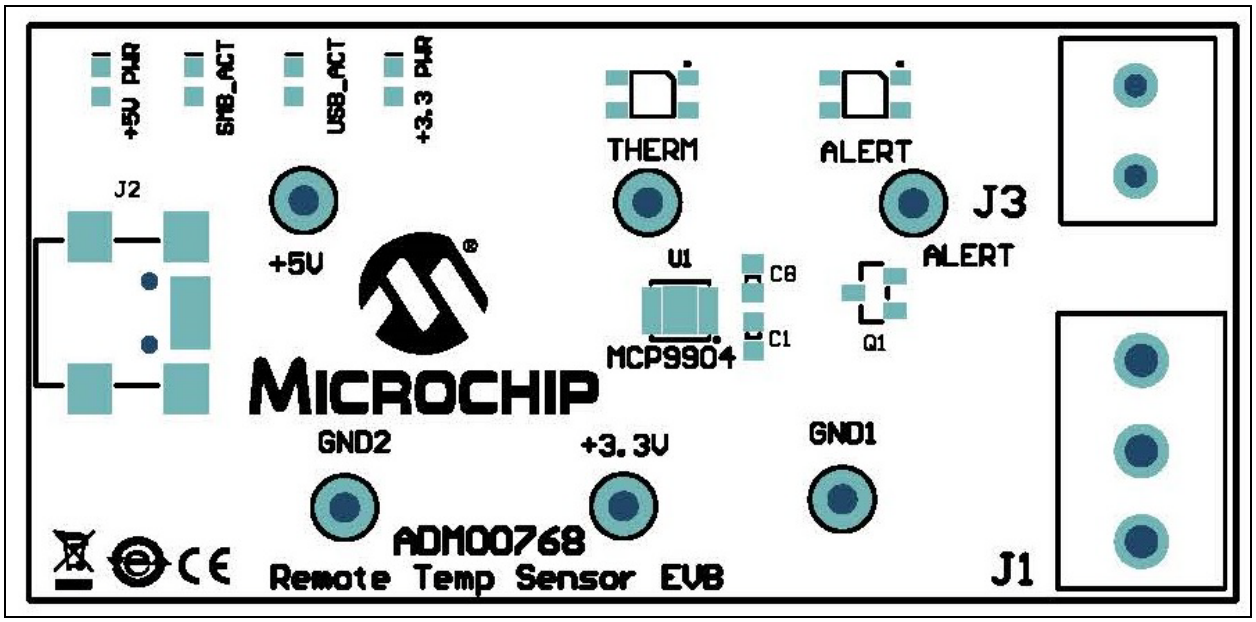


FIGURE 1-2: *MCP9904 Temperature Sensor Evaluation Board – Top Silk Screen.*

1.4 WHAT DOES THE MCP9904 TEMPERATURE SENSOR EVALUATION BOARD KIT CONTAIN?

This MCP9904 Temperature Sensor Evaluation Board kit includes:

- MCP9904 Temperature Sensor Evaluation Board (ADM00768)
- USB to Micro-USB Cable
- Important Information Sheet
- 2N3904 for remote diode temperature sensing.
- TO-92 BJT.

Chapter 2. Installation and Operation

2.1 GETTING STARTED

2.1.1 System Requirements

To use the MCP9904 Temperature Sensor Evaluation Board, the following are required:

- A PC running the 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 these steps to install the Microchip Chip Manager:

1. Before installing and running Chip Manager, the MCP2221 driver and utility package needs to be installed on the local machine. If the driver and utility package have already been installed, this step may be skipped. The MCP2221 driver and utility package are located at: http://www.microchip.com/wwwproducts/Devices.aspx?product=MCP2221, under "Documentation & Software". Follow the on-screen instructions to complete the installation process for the appropriate OS.
2. Download the Chip Manager from the board web page. 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-windows-installer.exe` file.
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 J2. The +5V PWR, +3.3V PWR and USB_ACT LEDs should illuminate.
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).

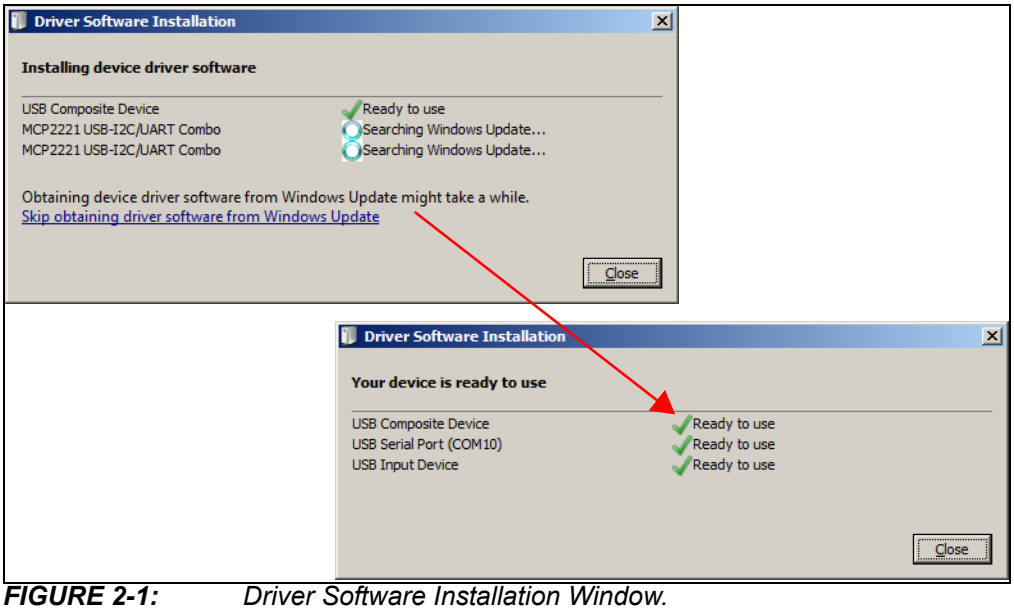


FIGURE 2-1: *Driver Software Installation Window.*

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.

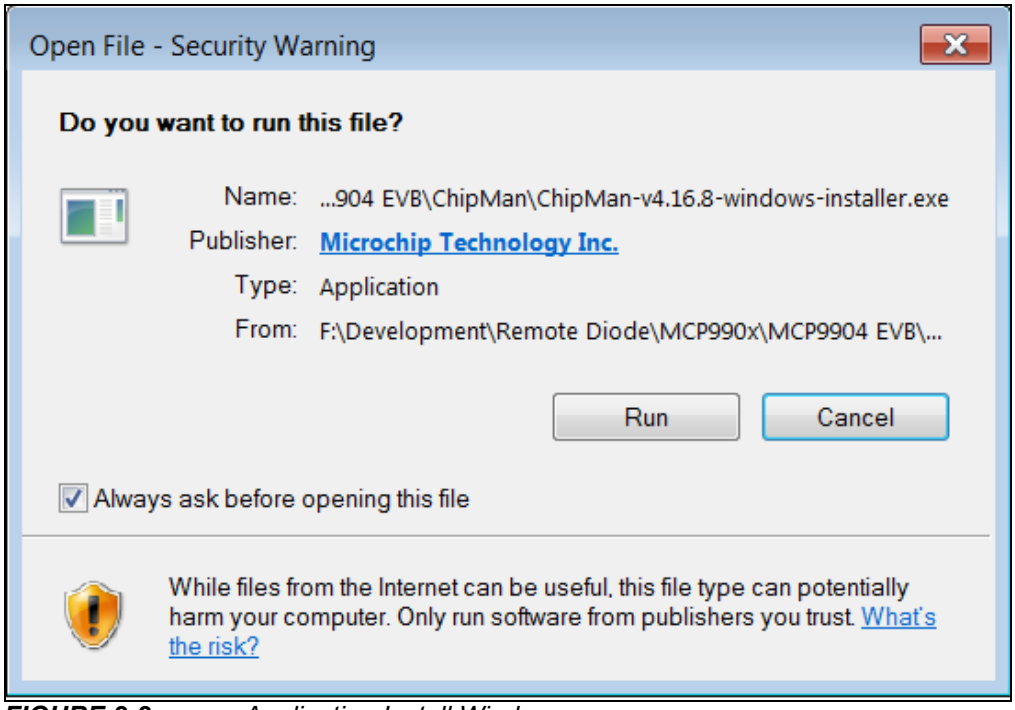


FIGURE 2-2: *Application Install Window.*

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**.

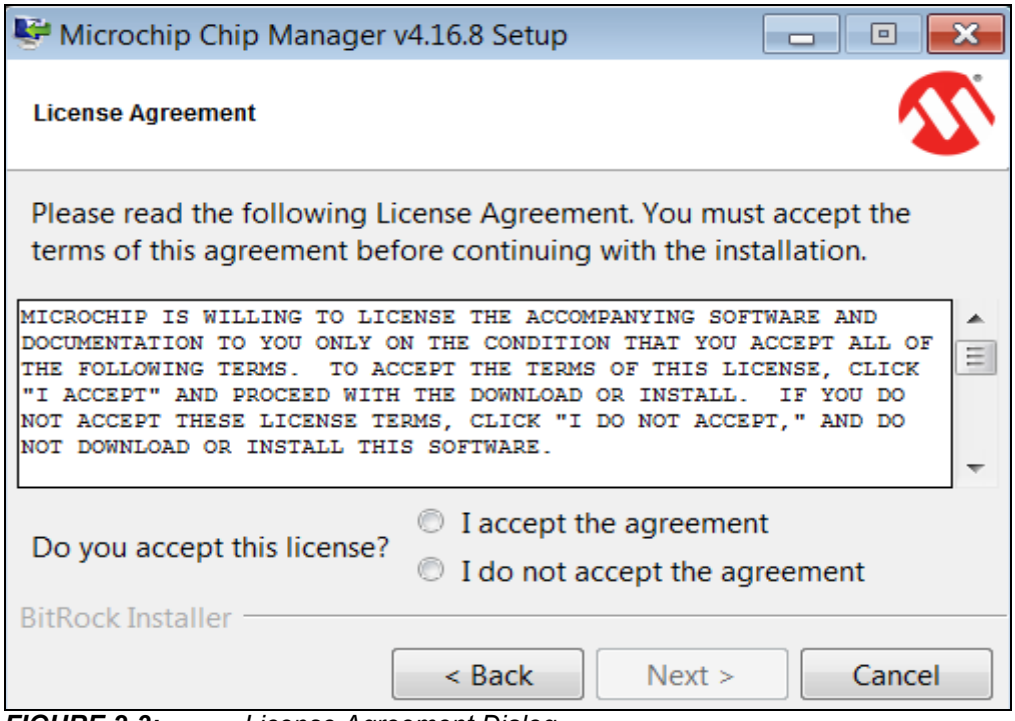


FIGURE 2-3: *License Agreement Dialog.*

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

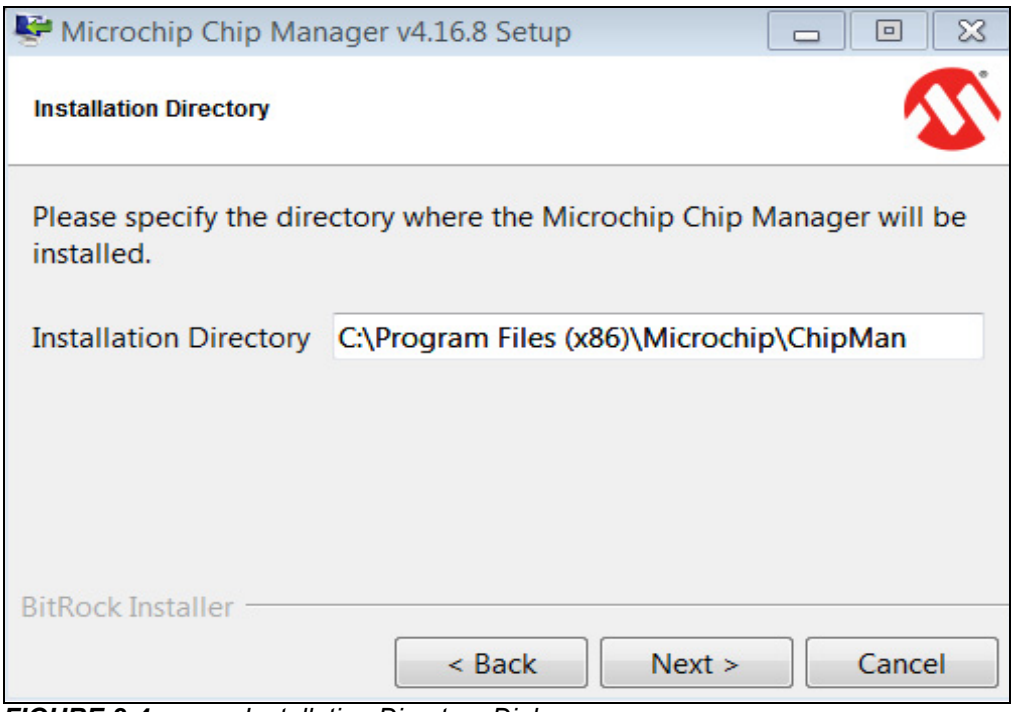


FIGURE 2-4: *Installation Directory Dialog.*

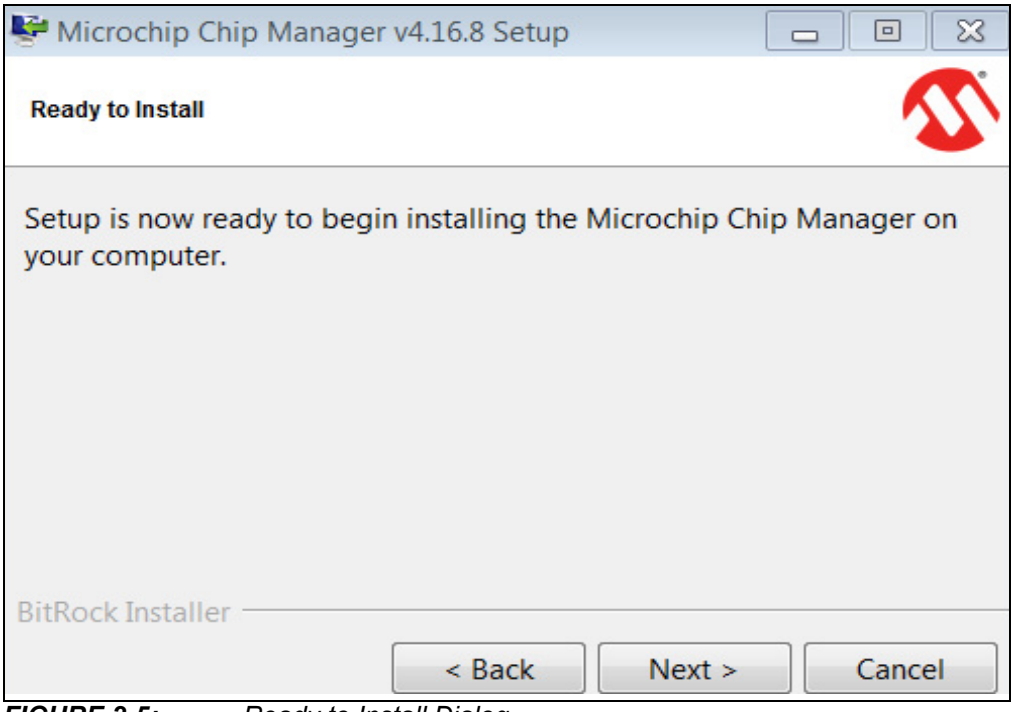


FIGURE 2-5: *Ready to Install Dialog.*

9. The application setup window appears, showing the installation progress (see Figure 2-6).

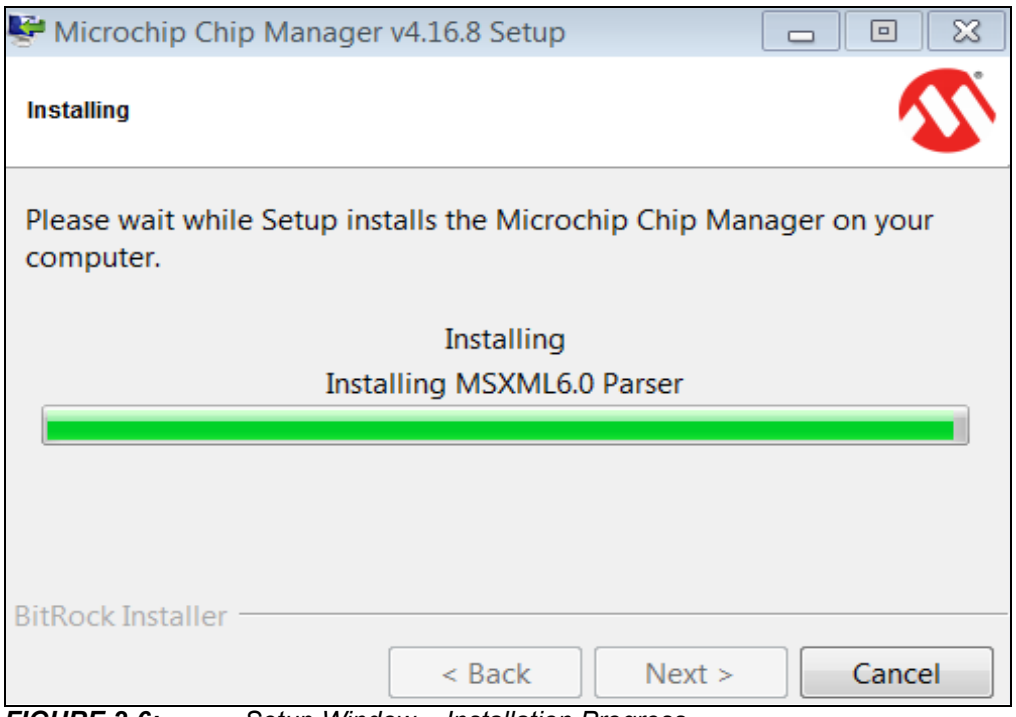


FIGURE 2-6: *Setup Window – Installation Progress.*

10. After the setup is complete, the MSXML Parser used by the Chip Manager software is installed, as shown in Figure 2-7.

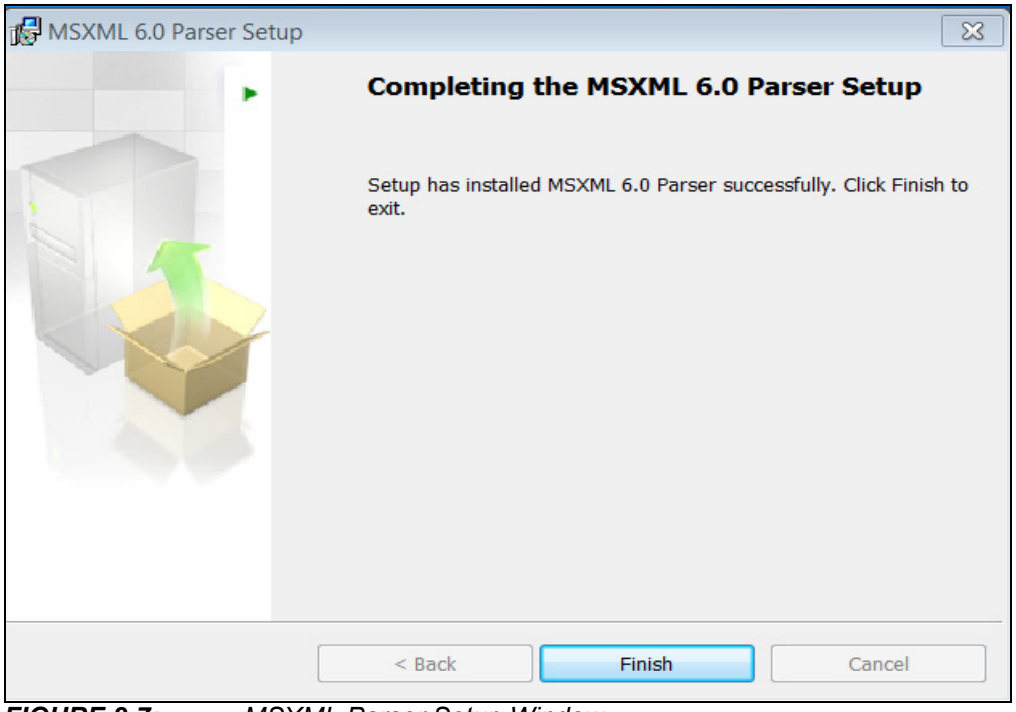


FIGURE 2-7: *MSXML Parser Setup Window.*

11. Once the setup completes successfully, press **Finish** to exit the installer (see Figure 2-8).

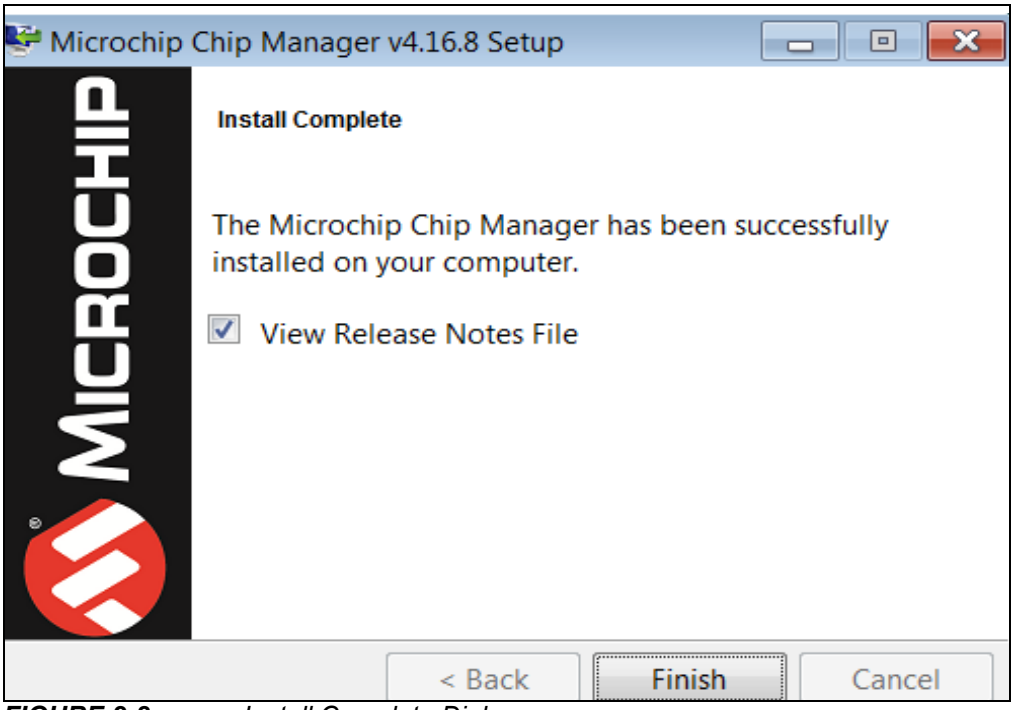


FIGURE 2-8: *Install Complete Dialog.*

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

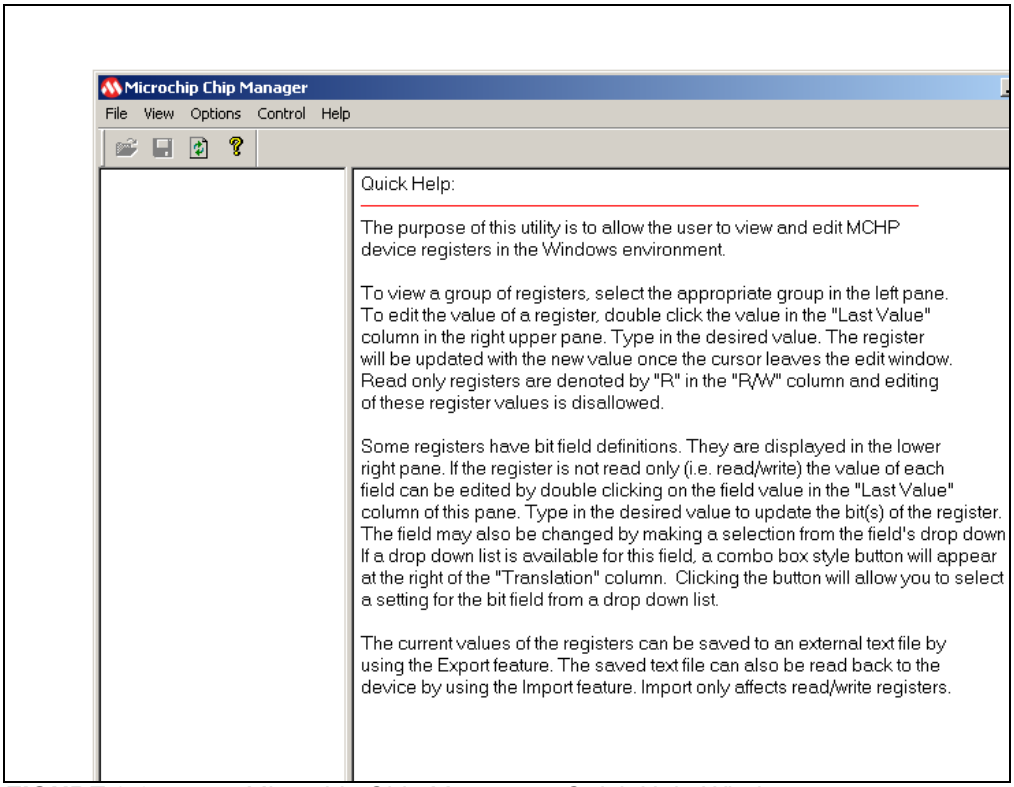


FIGURE 2-9: *Microchip Chip Manager – Quick Help Window.*

13. 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 Device window displays, as shown in Figure 2-10.

    In the "Device" list of the "Select Device" window, choose "MCP9904". The "Master Controller" drop-down list should highlight "USB SMBus Bridge". Click **OK** to complete the device selection.

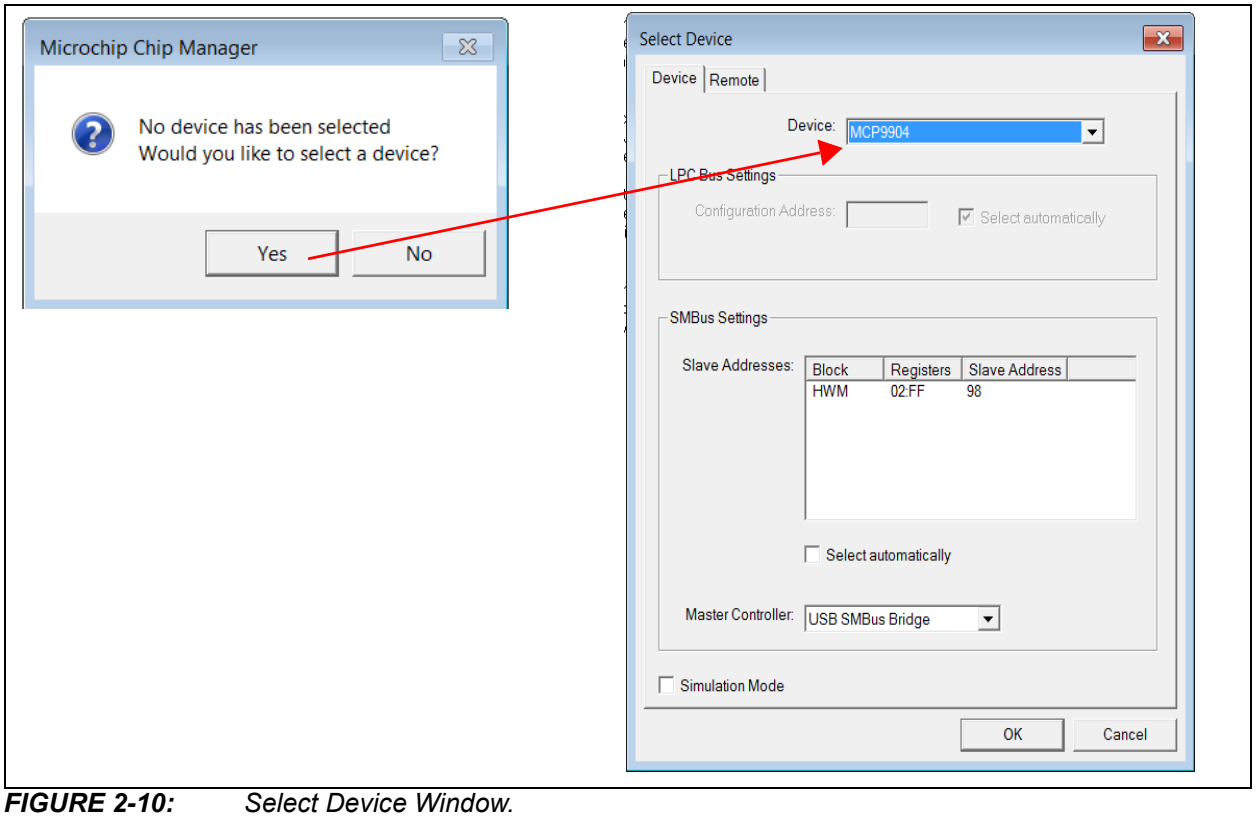


FIGURE 2-10: *Select Device Window.*

14. 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 SMB_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.

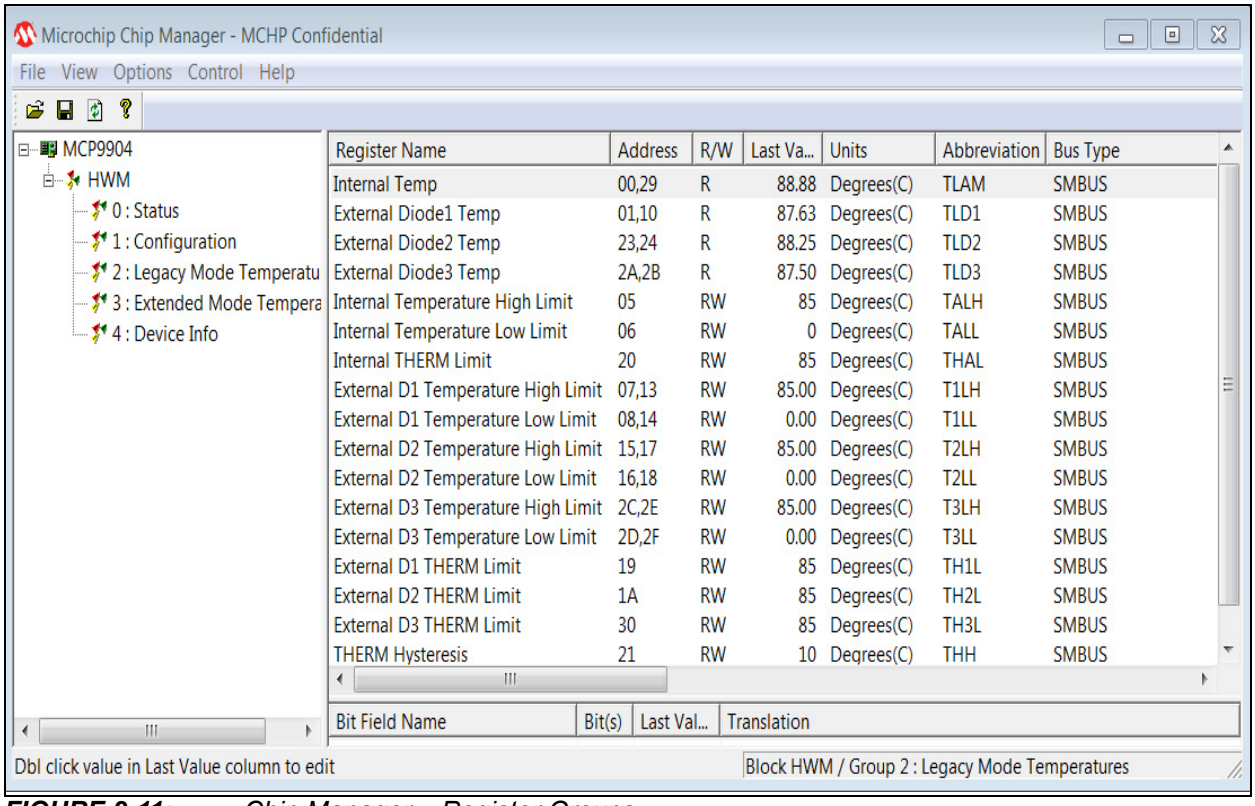


FIGURE 2-11: *Chip Manager – Register Groups.*

15. To reveal the register descriptions in Chip Manager, highlight "Configuration" as shown in Figure 2-12. The "Bit Field Name" and "Translation" will be shown in the Chip Manager window. For a detailed description of each register, please refer to the MCP990X Data Sheet.

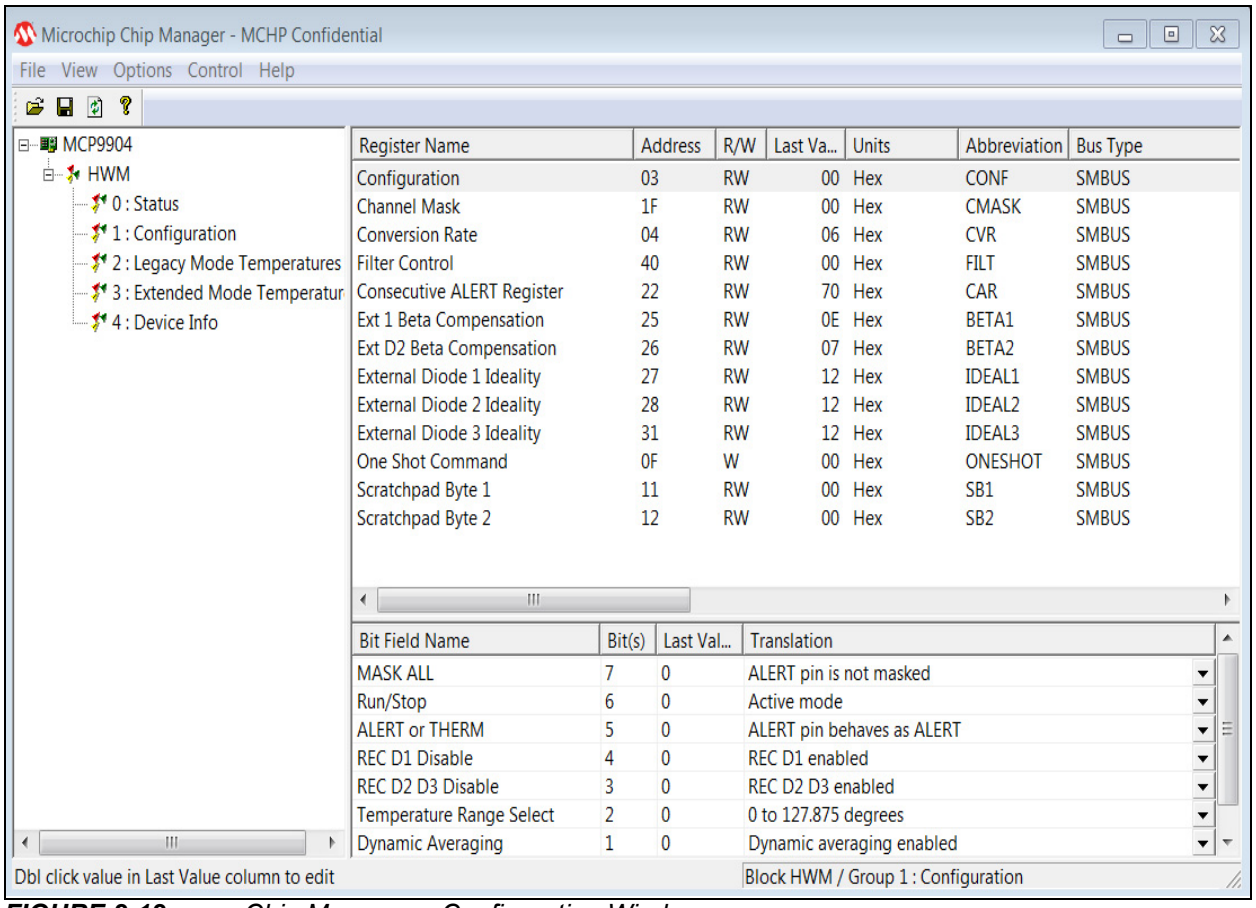


FIGURE 2-12: *Chip Manager – Configuration Window.*

Chapter 3. Hardware Description

3.1 INTRODUCTION

The MCP9904 Temperature Sensor Evaluation Board (EVB) provides the means to demonstrate all features of the MCP9904 device, and allows the registers to be viewed and modified. LEDs indicating status information and test points are included to enable system voltage monitoring using a voltmeter or an oscilloscope.

3.1.1 Power Source

The MCP9904 EVB requires only one universal serial bus (USB) connection for power. An on-board LDO regulates the +5V USB power to +3.3V required by the MCP9904 and other evaluation board circuitry.

3.2 USB-TO-I^{2}C/SMBUS BRIDGE

The MCP9904 EVB implements Microchip's MCP2221 protocol converter to ensure communication from USB to I^{2}C. Power is delivered to the bridge from the on-board LDO.

3.3 TEST POINTS

The MCP9904 Temperature Sensor Evaluation Board includes test points for the following signals:

- $\overline{\text{ALERT}}$ output
- $\overline{\text{THERM}}$ output
- +5V USB supply
- +3.3V analog supply
- GND

3.4 LED INDICATORS

Table 3-1 details the status of the LEDs for the following signals:

TABLE 3-1: LED STATUS INDICATORS

Signal	When LED is OFF	When LED is ON
$\overline{\text{ALERT}}$	$\overline{\text{ALERT}}$ is not active - GREEN	$\overline{\text{ALERT}}$ is active – RED
$\overline{\text{THERM}}$	$\overline{\text{THERM}}$ is not active - GREEN	$\overline{\text{THERM}}$ is active – RED
+3.3V PWR	+3.3V analog voltage is not available	+3.3V analog voltage is available – GREEN
+5V PWR	USB +5V is not available	USB +5V is available – GREEN
USB_ACT	No Activity on USB port	Activity on USB port – GREEN
SMB_ACT	No Activity on SMBus	Activity on SMBus – GREEN

3.5 REMOTE DIODES

The MCP9904 EVB is populated with an on-board transistor (Q1) with the base terminal shorted to the collector terminal. This type of connection is known as a diode-connected transistor. The headers J1 and J3 allow for an off-board connections to a remote diode, a remote CPU or GPU attached with a cable assembly (see Table 3-2).

To connect to an off-board CPU, GPU or cable assembly, remove the on-board transistor, Q1, and refer to Table 3-2 for the proper connections. Ensure a common ground exists between the off-board diode (GPU, etc.) and the evaluation board by connecting to the ground of the EVB via pin 2 of J1. The off-board diode of a CPU or GPU requires proper biasing, so it is recommended to consult the CPU manufacturer's data sheet for guidance on interfacing to the thermal diode.

Please refer to the MCP9904 Temperature Sensor Evaluation Board schematic in **Appendix A. "Schematic and Layouts"** for details on the evaluation board header connections.

TABLE 3-2: REMOTE DIODE CONFIGURATIONS

Header	Configuration	Pin 1	Pin 2	Pin 3
J1/J3	On-board diode (Q1)	Collector/Base Shorted	N/A	Emitter
	Diode with Shielded Cable Assembly	Collector/Base Shorted	Shield Ground	Emitter
	Diode without Shielded Cable Assembly	Collector/Base Shorted	N/A	Emitter
	CPU/GPU Diode	Emitter	Ground	Base

3.6 OTHER SENSOR FEATURES

Other features, such as conversion rate, dynamic averaging and digital filtering, can be controlled with the MCP9904 registers. For details on the register description, refer to the MCP9902/3/4 Data Sheet.

Chapter 4. Software Description

4.1 CHIP MANAGER APPLICATION OVERVIEW

Chip Manager is a Microchip Technology Inc. application that enables the user to display temperature readings, set temperature limits and read/write configuration register values. Chip Manager initially displays a Quick Help screen. For detailed information on application features and usage, select *Help > Contents* to display the HTML-based Help document.

4.1.1 Real-Time Register Graphs

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

4.1.2 Selecting Registers to Plot

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

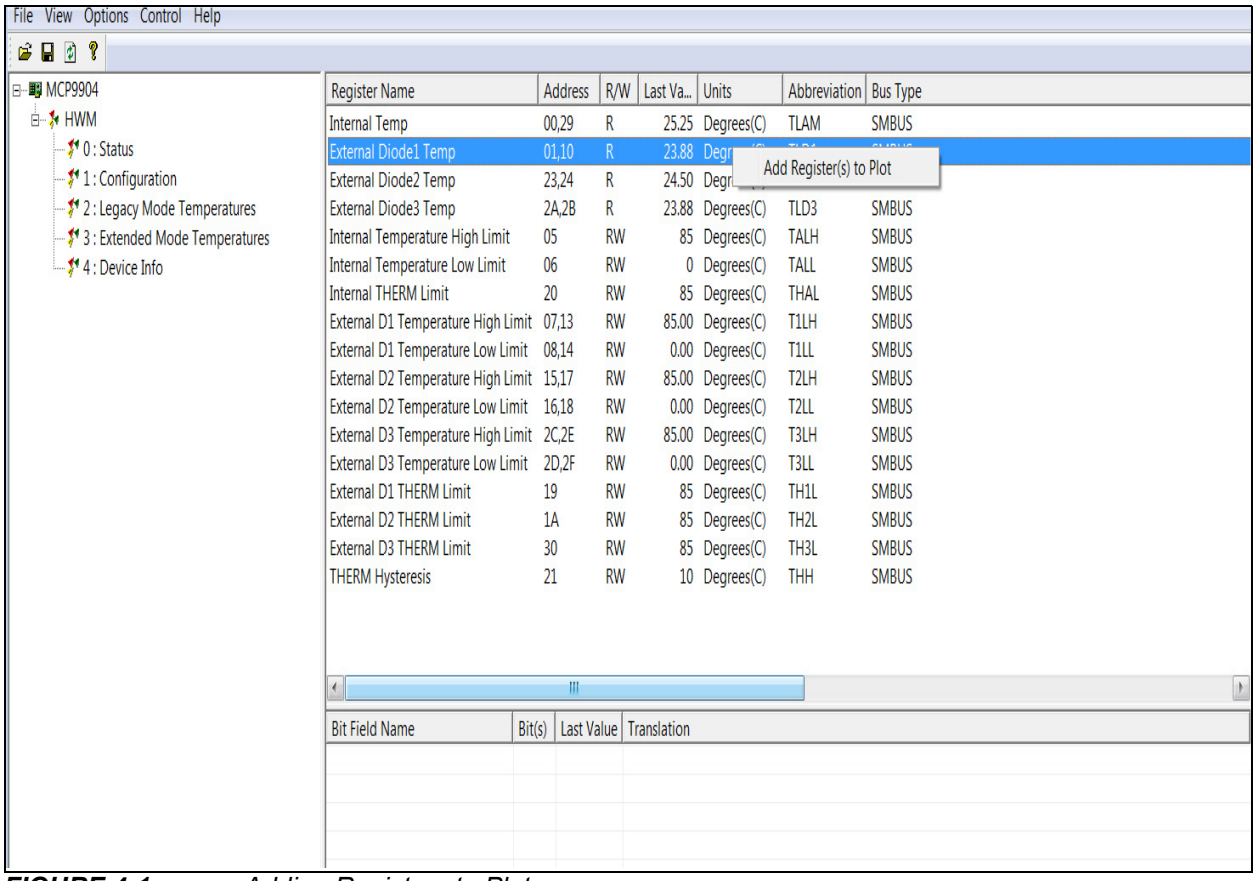


FIGURE 4-1: *Adding Registers to Plot.*

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

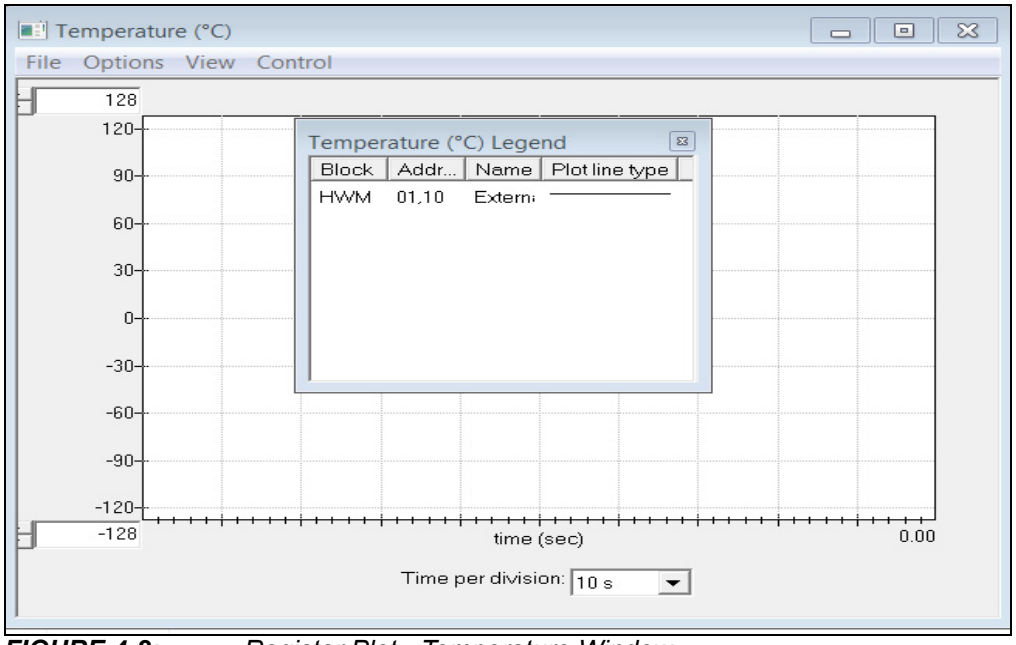


FIGURE 4-2: *Register Plot - Temperature Window.*

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

4.1.3 Starting the Plots

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 active 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 remains unaffected.

4.1.4 Sampling a Plot

Figure 4-3 is an example of temperature history. Internal Temperature, External Diode 1 Temperature and External Diode 1 High Limit are selected for plotting. The results after starting the plot are that the External Diode Temperature High Limit is reduced, and the External Diode 1 starts at room temperature and is then heated by simply placing a finger on the external diode Q1.

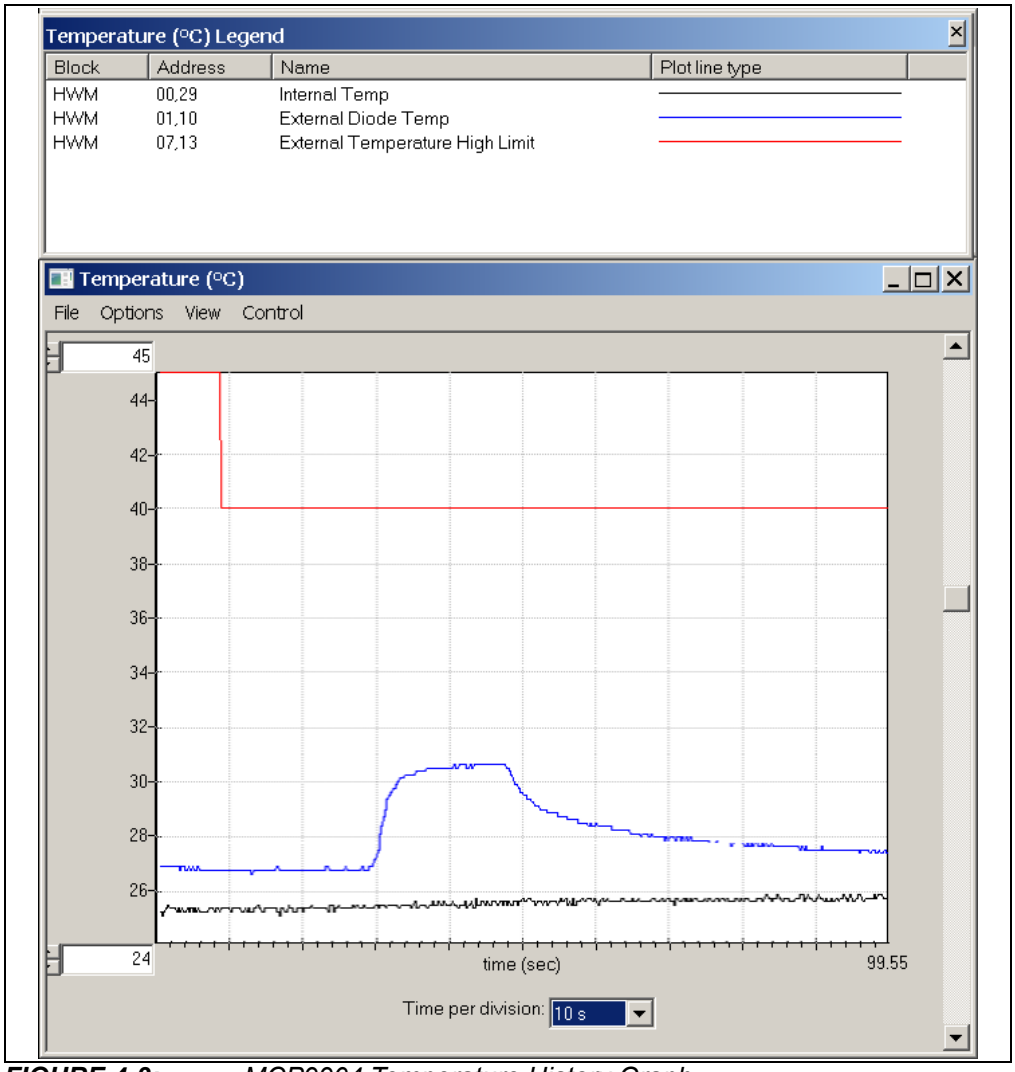


FIGURE 4-3: *MCP9904 Temperature History Graph.*

4.1.5 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, 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 best describes the data type when exporting the plot data.

NOTES:

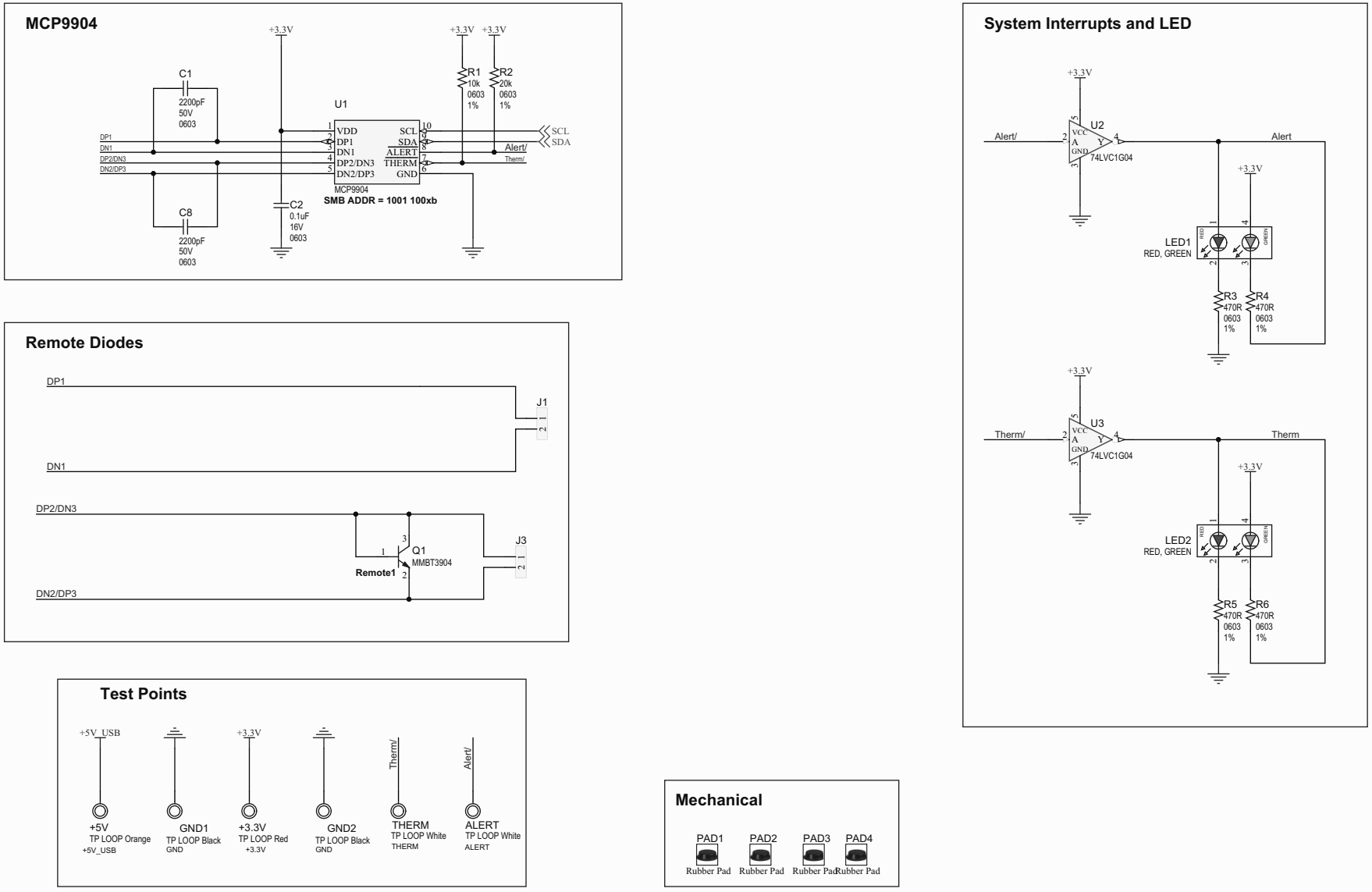
Appendix A. Schematic and Layouts

A.1 INTRODUCTION

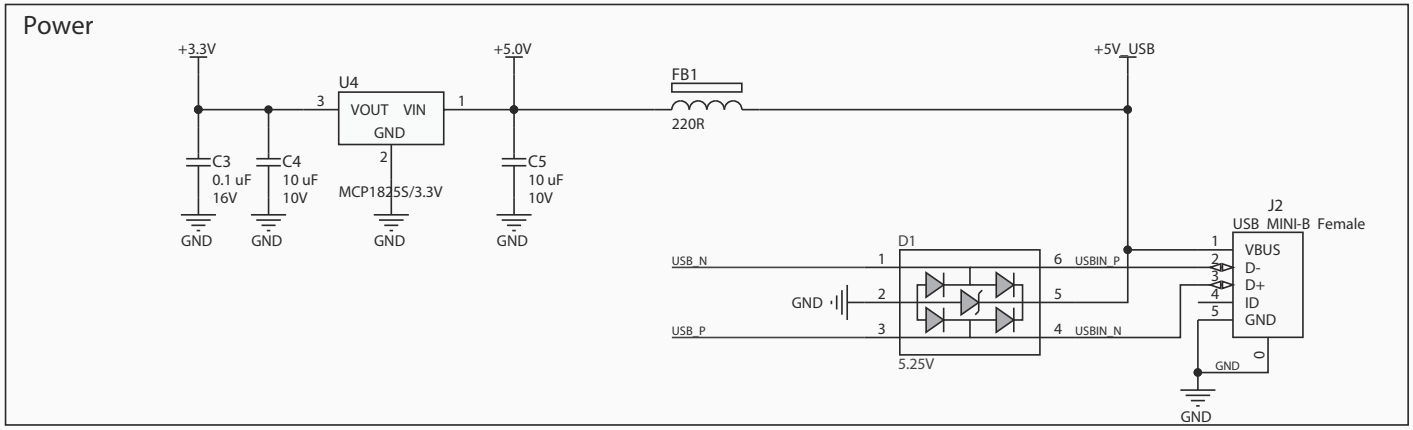
This appendix contains the following schematics and layouts for the MCP9904 Temperature Sensor Evaluation Board:

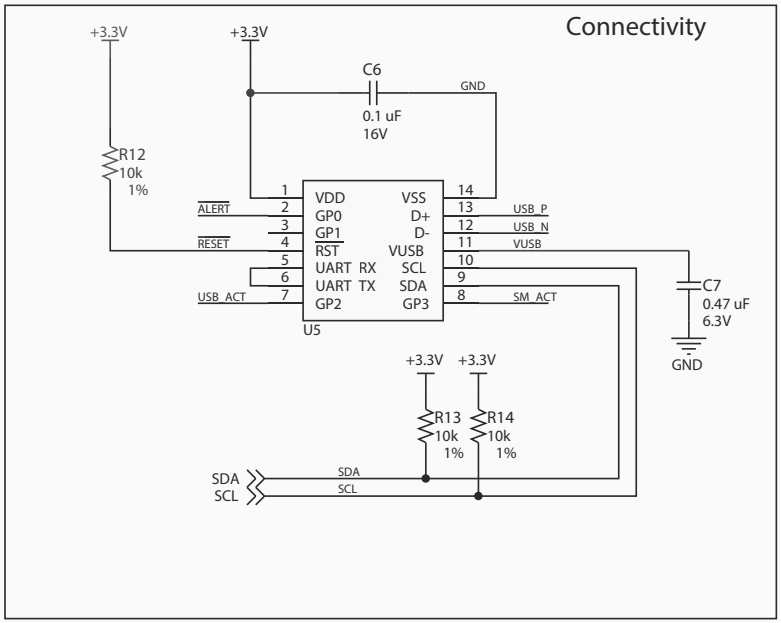
- Board – MCP9904 and Interface Schematic
- Board – USB-to-SMBus Bridge Schematic
- Board – Top Silk
- Board – Top Copper and Silk
- Board – Top Copper
- Board – Bottom Copper
- Board – Bottom Copper and Silk
- Board – Bottom Silk

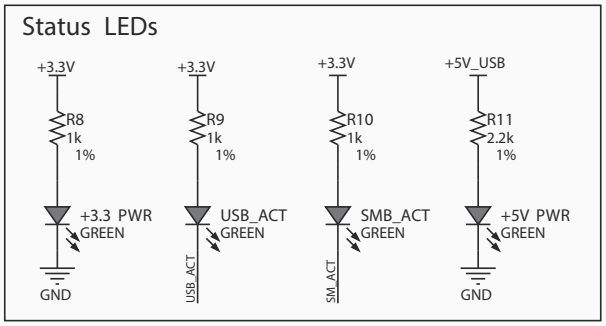
A.2 BOARD – MCP9904 AND INTERFACE SCHEMATIC



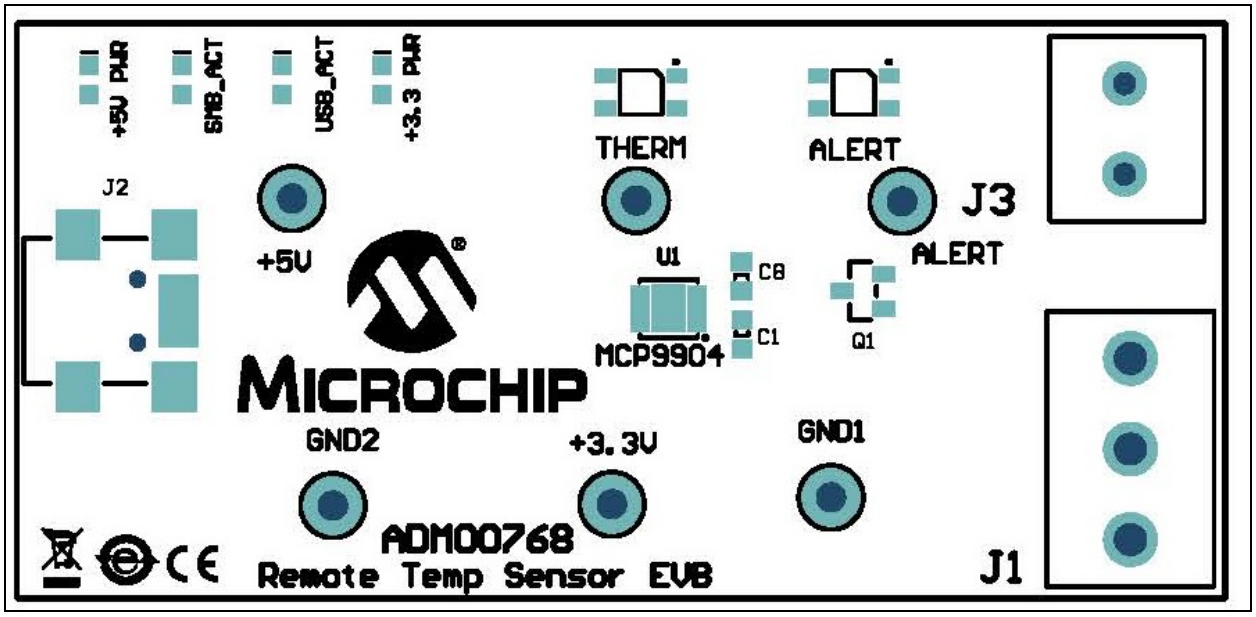
A.3 BOARD – USB-TO-SMBUS BRIDGE SCHEMATIC



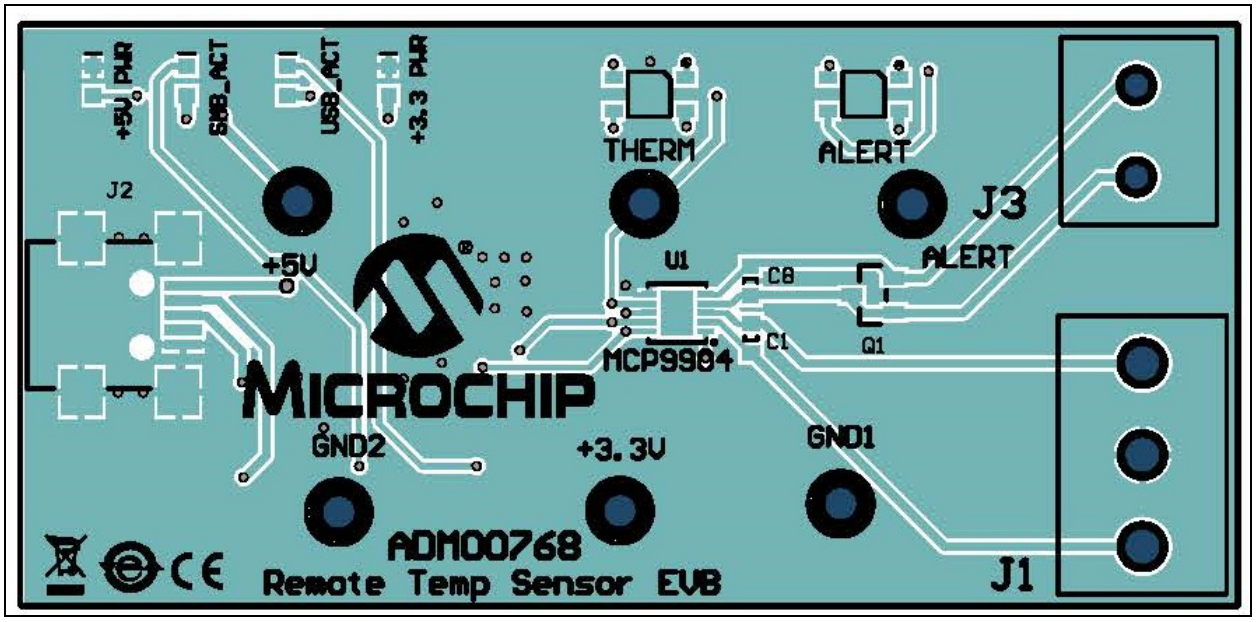




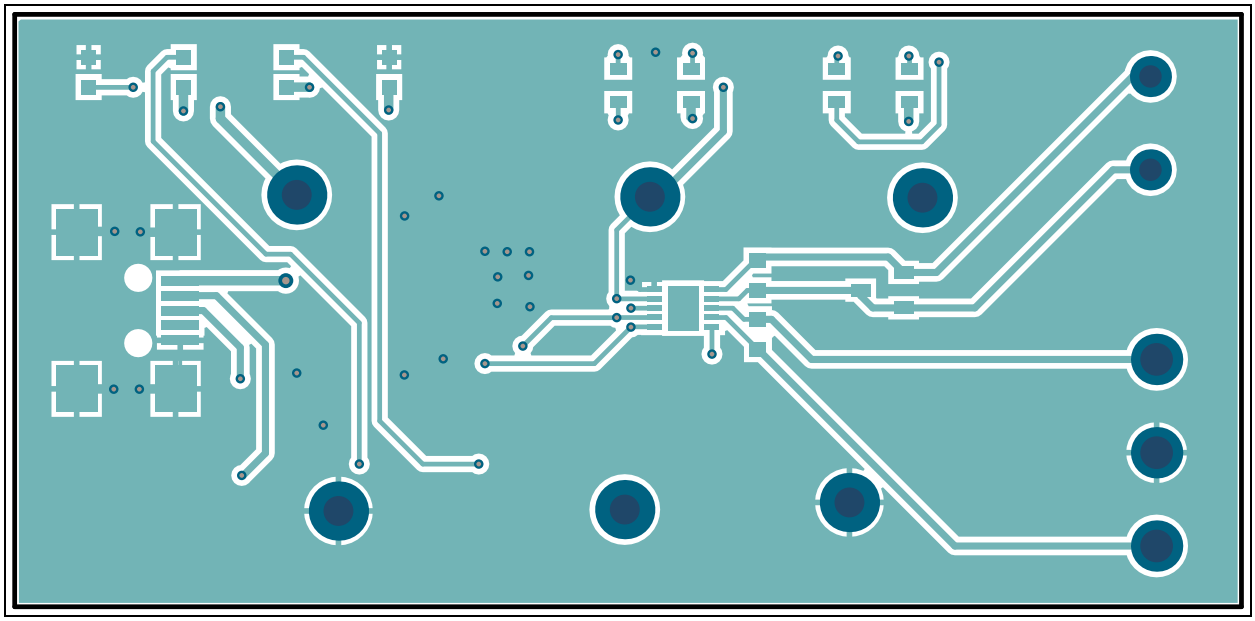
A.4 BOARD – TOP SILK



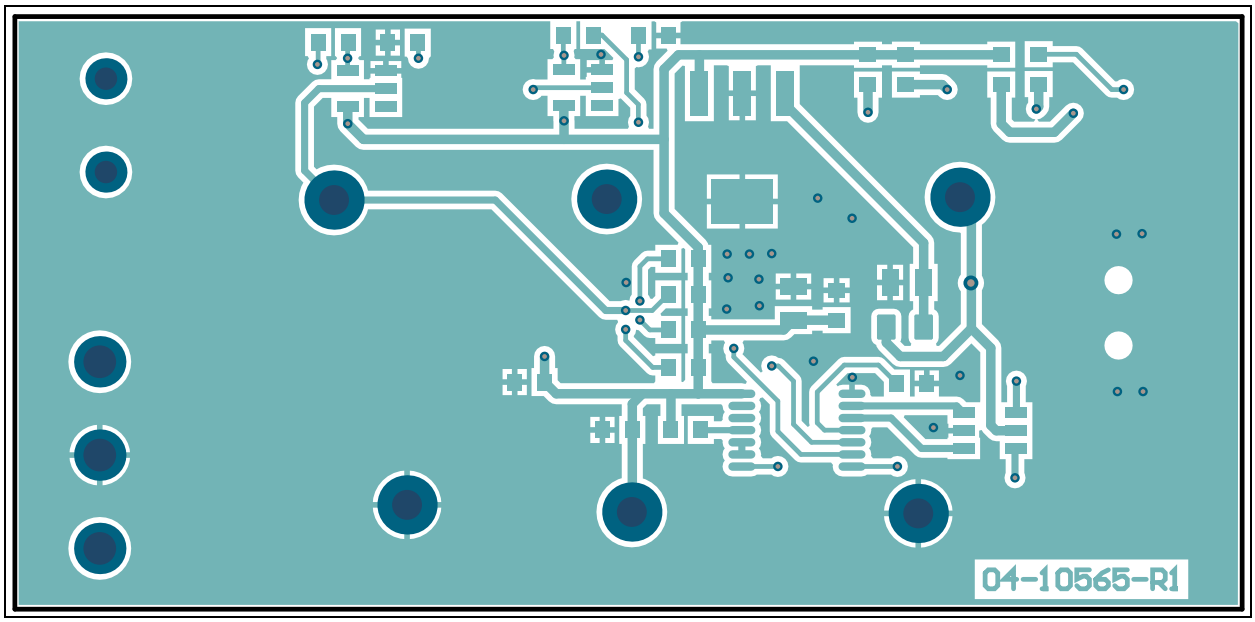
A.5 BOARD – TOP COPPER AND SILK



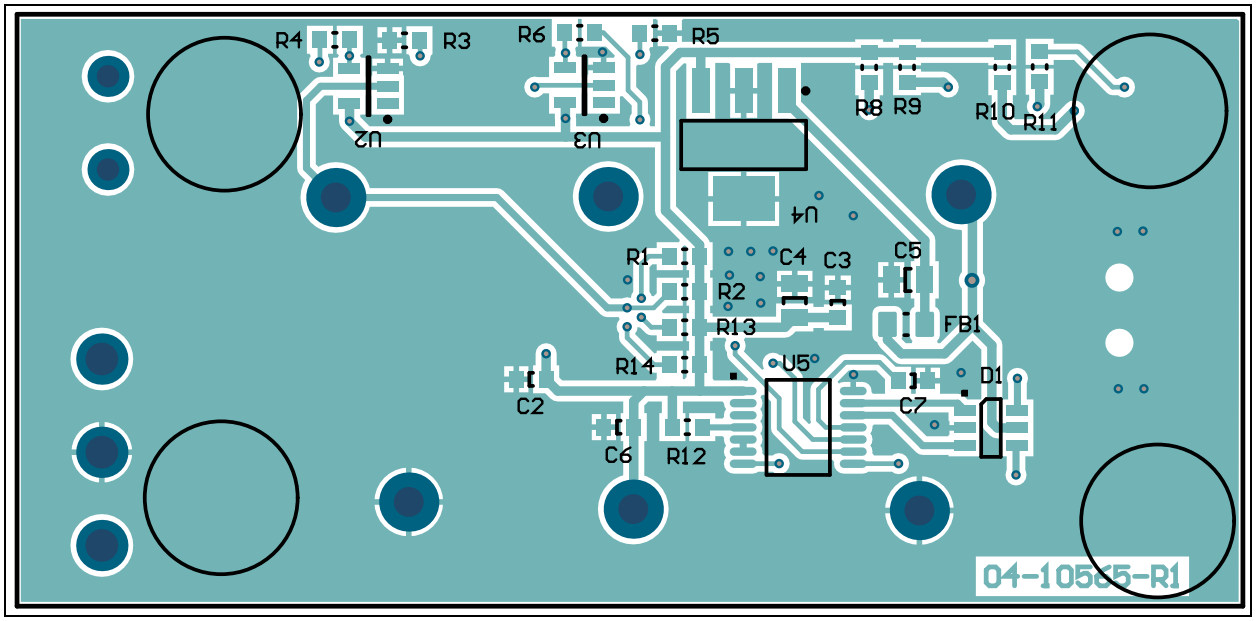
A.6 BOARD – TOP COPPER



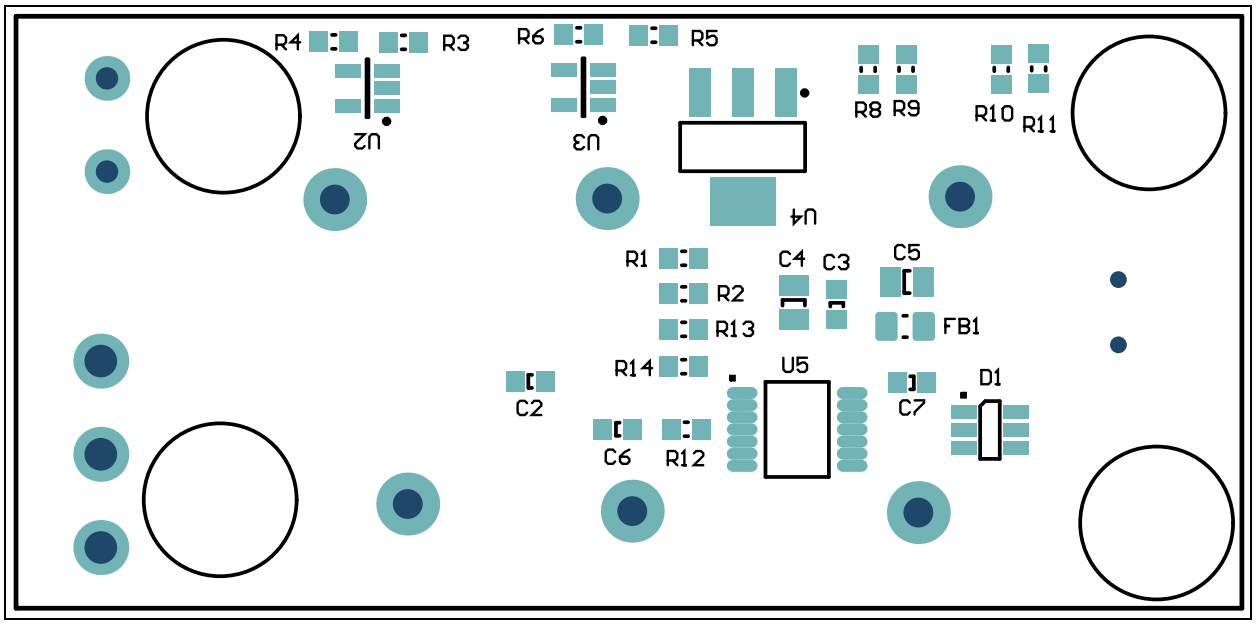
A.7 BOARD – BOTTOM COPPER



A.8 BOARD – BOTTOM COPPER AND SILK



A.9 BOARD – BOTTOM SILK



Appendix B. Bill of Materials (BOM)

TABLE B-1: BILL OF MATERIALS (BOM)

Qty.	Reference	Description	Manufacturer	Part Number
4	+3.3 PWR, +5V PWR, SMB_ACT, USB_ACT	Diode LED green 2.2V 25 mA 15 mcd Clear SMD 0603	Kingbright Corp.	APT1608SGC
1	+3.3V	Conn. TP Loop Red TH	Keystone Electronics Corp.	5010
1	+5V	Conn. TP Loop Orange TH	Keystone Electronics Corp.	5013
2	ALERT, THERM	Conn. TP Loop White TH	Keystone Electronics Corp.	5012
2	C1, C8	Cap. ceramic 2200 pF 50V 10% X7R SMD 0603	KEMET®	C0603C222K5RACTU
3	C2, C3, C6	Cap. ceramic 0.1 µF 16V 10% X7R SMD 0603	NIC Components Corp.	NMC0603X7R104K16TRPF
2	C4, C5	Cap. ceramic 10 µF 10V 10% X5R SMD 0805	Taiyo Yuden Co., Ltd.	LMK212BJ106KD-T
1	C7	Cap. ceramic 0.47 µF 6.3V 10% X5R SMD 0603	Murata Electronics®	GRM188R60J474KA01D
1	D1	Diode TVSARR USBLC6-2SC6 5.25V SMD SOT-23-6	STMicroelectronics	USBLC6-2SC6
1	FB1	Ferrite 2A 220R SMD 0805	Murata Electronics	BLM21PG221SN1D
2	GND1, GND2	Conn. TP Loop Black TH	Keystone Electronics Corp.	5011
1	J1	Conn. Term Block 5 mm 3POS GRN	PHOENIX CONTACT	1792876
1	J2	Conn. USB MINI-B female SMD R/A	Hirose Electric Co., Ltd.	UX60-MB-5ST
1	J3	Conn. term Block 5 mm 2POS GRN	PHOENIX CONTACT	1792863
2	LED1, LED2	Diode LED bi 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
1	PCB	MCP9904 Temperature Sensor Evaluation Board – Printed Circuit Board	Microchip Technology Inc.	04-10565
1	Q1	Trans. BJT NPN MMBT3904 40V 200 mA 310 mW SOT-23-3	Diodes® Incorporated	MMBT3904-7
1	R1	Res. TKF 10 kΩ 1% 1/10W SMD 0603	NIC Components Corp.	NRC06F1002TRF

Note: 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	R2	Res. TKF 20 kΩ 1% 1/10W SMD 0603	Yageo Corporation	9C06031A2002FKHFT
4	R3, R4, R5, R6	Res. TKF 470R 1% 1/10W SMD 0603	Yageo Corporation	RC0603FR-07470RL
3	R8, R9, R10	Res. TKF 1 kΩ 1% 1/10W SMD 0603	Panasonic® – ECG	ERJ-3EKF1001V
1	R11	Res. TKF 2.2 kΩ 1% 1/10W SMD 0603	Panasonic – ECG	ERJ-3EKF2201V
3	R12, R13, R14	Res. TF 10 kΩ 1% 1/8W SMD 0603	Vishay Intertechnology, Inc.	MCT06030C1002FP500
1	U1	Microchip Analog Temperature Sensor -40°C to +125°C MCP9904T-1E/RW DFN-10	Microchip Technology Inc.	**MCP9904T-1E/9Q**
2	U2, U3	IC LOGIC 74LVC1G04 SOT-23-5	Texas Instruments	SN74LVC1G04DBVR
1	U4	MCHP ANALOG LDO 3.3V MCP1825ST-3302E/DB SOT-223-3	Microchip Technology Inc.	**MCP1825S-3302E/DB**
1	U5	USB-to-I^2C/UART SMBus Protocol Converter with GPIO	Microchip Technology Inc.	**MCP2221-I/ST**

Note: 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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