



# **MCP9700 Thermistor Demo Board User's Guide**

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# MCP9700 THERMISTOR DEMO BOARD USER'S GUIDE

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# MCP9700 Thermistor Demo Board User's Guide

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## Preface

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### 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](http://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 “DSXXXXXA”, where “XXXXX” 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 on-line help. Select the Help menu, and then Topics to open a list of available on-line help files.

## INTRODUCTION

This chapter contains general information that will be useful to know before using the MCP9700 Thermistor Demo 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 MCP9700 Thermistor Demo Board as a development tool. The manual layout is as follows:

- **Chapter 1. “Product Overview”** – Important information about the MCP9700 Thermistor Demo Board.
- **Chapter 2. “Installation and Operation”** – This chapter includes a detailed description of each function of the demo board and instructions for how to begin using the board.
- **Appendix A. “Schematic and Layouts”** – Shows the schematic and layout diagrams for the MCP9700 Thermistor Demo Board.
- **Appendix B. “Bill Of Materials (BOM)”** – Lists the parts used to build the MCP9700 Thermistor Demo Board.

## CONVENTIONS USED IN THIS GUIDE

This manual uses the following documentation conventions:

### DOCUMENTATION CONVENTIONS

| Description                                      | Represents                                                                                          | Examples                                                    |
|--------------------------------------------------|-----------------------------------------------------------------------------------------------------|-------------------------------------------------------------|
| <b>Arial font:</b>                               |                                                                                                     |                                                             |
| Italic characters                                | Referenced books                                                                                    | <i>MPLAB<sup>®</sup> IDE User's Guide</i>                   |
|                                                  | Emphasized text                                                                                     | ...is the <i>only</i> 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                                                                                         | <u><i>File&gt;Save</i></u>                                  |
| Bold characters                                  | A dialog button                                                                                     | Click <b>OK</b>                                             |
|                                                  | A tab                                                                                               | Click the <b>Power</b> 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>                                         |
| <b>Courier New font:</b>                         |                                                                                                     |                                                             |
| 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                                                                                 | <i>file.o</i> , where <i>file</i> can be any valid filename |
| Square brackets [ ]                              | Optional arguments                                                                                  | mcc18 [options] <i>file</i> [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)<br>{ ...<br>}                              |

## RECOMMENDED READING

This user's guide describes how to use the MCP9700 Thermistor Demo Board. The following Microchip documents are available on our web site ([www.microchip.com](http://www.microchip.com)) and recommended as supplemental reference resources.

**AN897, “Thermistor Temperature Sensing with MCP6SX2 PGAs”, DS00897**

Explains the functionality and design of this board's circuit. Contains measurement results.

**MCP9700 Data Sheet, “Low-Power Linear Active Thermistor™”, DS21942**

This data sheet provides detailed information regarding the MCP9700 product family.

**MCP6S21/2/6/8 Data Sheet, “Single-Ended, Rail-to-Rail I/O, Low Gain PGA”, DS21117**

Gives detailed information on the MCP6S21/2/3/6/8 Programmable Gain Amplifiers (PGA).

**MCP6S91/2/3 Data Sheet, “Single-Ended, Rail-to-Rail I/O, Low Gain PGA”, DS21908**

Gives detailed information on the MCP6S91/2/3 PGAs.

**PIC18F2455/2550/4455/4550 Data Sheet, “28/40/44-Pin, High-Performance, Enhanced Flash, USB Microcontrollers with nanoWatt Technology”, DS39632**

This data sheet provides detailed information regarding the PIC18F2455/2550/4455/4550 devices.

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

## CUSTOMER SUPPORT

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- Distributor or Representative
- Local Sales Office
- Field Application Engineer (FAE)
- Technical Support
- Development Systems Information Line

Customers should contact their distributor, representative or field application engineer 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://support.microchip.com>

## DOCUMENT REVISION HISTORY

### Revision A (August 2008)

- Initial Release of this Document



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## Chapter 1. Product Overview

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### 1.1 INTRODUCTION

The following name and assembly number are found on the MCP9700 Thermistor Demo Board's Printed Circuit Board (PCB):

- 102-00156

This PCB goes by the following title:

- MCP9700 Thermistor Demo Board

This board is supported by AN897, "*Thermistor Temperature-Sensing with MCP6SX2 PGAs*", (DS00897). It uses a BC Components® 2322 640 55103 NTC thermistor to detect temperature. The circuit also includes a voltage divider and a MCP6S22 Programmable Gain Amplifier (PGA) and the MCP9700 Linear Active Thermistor.

- Kit Contents
- MCP9700 Thermistor Demo Board
- Associated Tools
- Initial Set-up

### 1.2 WHAT IS THE MCP9700 THERMISTOR DEMO BOARD?

The MCP9700 Thermistor Demo Board contains the analog circuitry to measure temperature. It uses BC Components' 2322 640 55103 NTC thermistor to convert temperature to resistance. The thermistor is placed in a voltage divider which converts resistance to voltage. This voltage is filtered and placed at the MCP6S22 Programmable Gain Amplifier's (PGA) CH0 input. The PGA gains and buffers the thermistor.

In addition, the board includes the MCP9700 Linear Active Thermistor. The MCP9700 outputs voltage proportional to temperature. A PIC18F2550 is used to both measure the voltage output of the MCP9700 and the MCP6S22 using an integrated 10-bit Analog to Digital Converter and communicate to a PC via USB interface.

Temperature can be datalogged using Microchip Thermal Management Software Graphical User Interface (GUI).

### 1.3 WHAT THE MCP9700 THERMISTOR DEMO BOARD KIT INCLUDES

- MCP9700 Thermistor Demo Board – An assembled and tested PCB (102-00156)
- Microchip Thermal Management Graphical User Interface
- Analog and Interface Products Demonstration Boards CD-ROM (DS21912)
  - MCP9700 Thermistor Demo Board User's Guide, (DS51753)

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## Chapter 2. Installation and Operation

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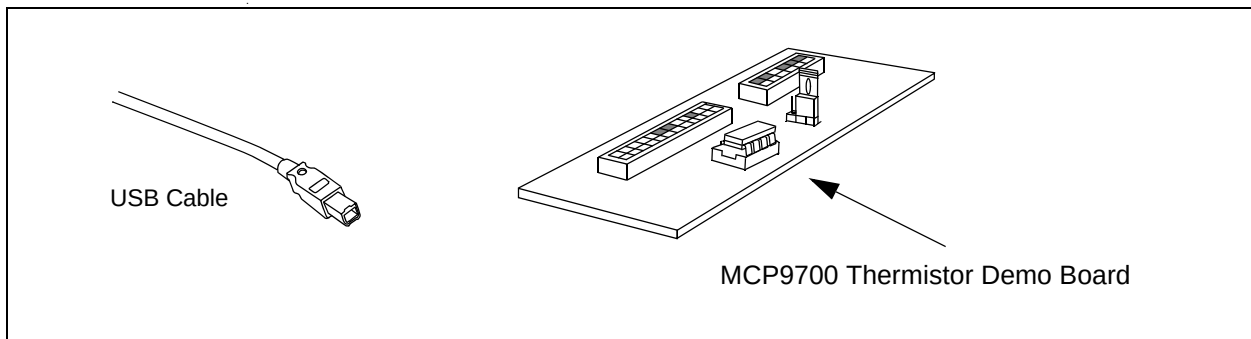
### 2.1 INTRODUCTION

The MCP9700 Thermistor Demo Board makes it easy to explore the operation of two thermistor applications using the MCP6S22 PGA and the MCP9700 Linear Active Thermistor. Items discussed in this chapter include:

- Configuring the MCP9700 Thermistor Demo Board
- Using the MCP9700 Thermistor Demo Board
- Using the Microchip Thermal Management GUI

### 2.2 GETTING STARTED

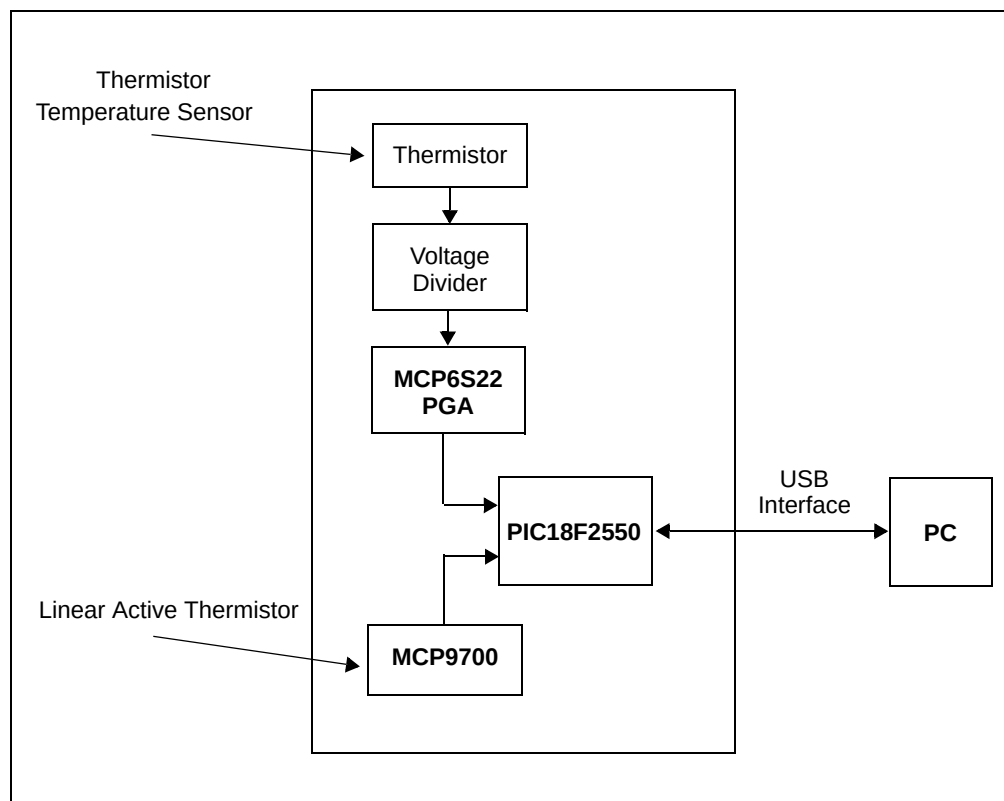
This section describes how to power up and interface with the MCP9700 Thermistor Demo Board, [Figure 2-1](#).



**FIGURE 2-1:** MCP9700 Thermistor Demo Board Block Diagram.

#### 2.2.1 Hardware Setup

1. The MCP9700 Thermistor Demo Board has a mini-USB connector for a PC interface. Connect the USB cable from the MCP9700 Thermistor Demo Board to a PC. The MCP9700 Thermistor Demo Board is fully powered and temperature can be measured.
2. Start the Thermal Management Software GUI for data logging or to evaluate the MCP9700 Thermistor Demo Board features.



**FIGURE 2-2:** MCP9700 Thermistor Demo Board Circuit Block Diagram.

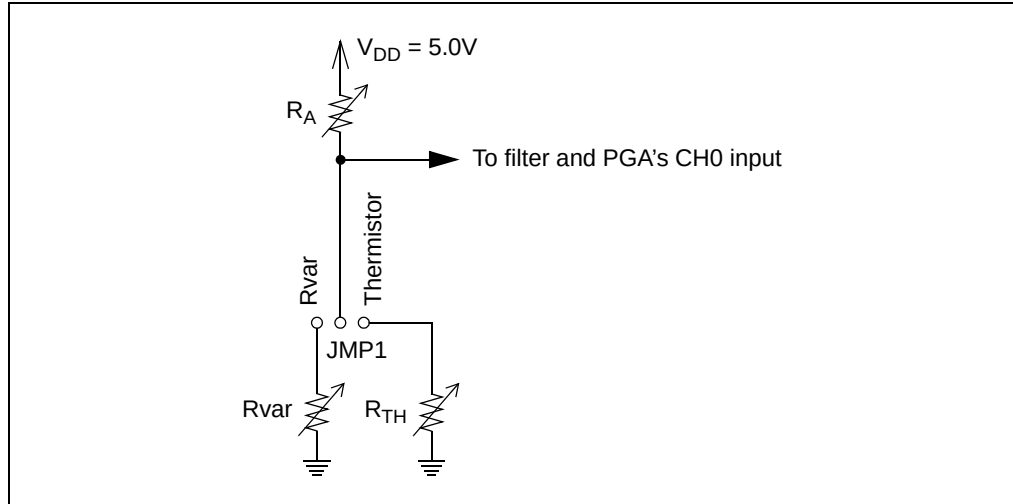
The MCP9700 Thermistor Demo Board includes a Thermistor and Microchip's MCP9700 Linear Active Thermistor temperature sensors. The thermistor is biased using a resistive stack which can be adjusted using the user settable dip switches. The voltage across the thermistor is proportional to change in temperature. The thermistor output is gained and buffered using Microchip's MCP6S22 Programmable Gain Amplifier (PGA). The output of the PGA is directly connected to an Analog to Digital Converter. The MCP9700 output voltage is also directly connected to an ADC. The data from the ADC is sent to the PC using the USB interface.

The user can compare and evaluate both the standard thermistor solution and Microchip's Linear Active Thermistor solution using this MCP9700 Thermistor Demo Board.

## 2.3 CONFIGURING BOARD

### 2.3.1 Configuring Jumper JMP1 (select Thermistor or Rvar)

Figure 2-3 shows how jumper JMP1 configures the circuit. When the shorting bar is on the right side of jumper JMP1, the thermistor  $R_{TH}$  is connected to the circuit. When it is on the left side of jumper JMP1, the thermistor emulator  $R_{var}$  is connected to the circuit. Refer to Figure A.3 for the complete schematic.

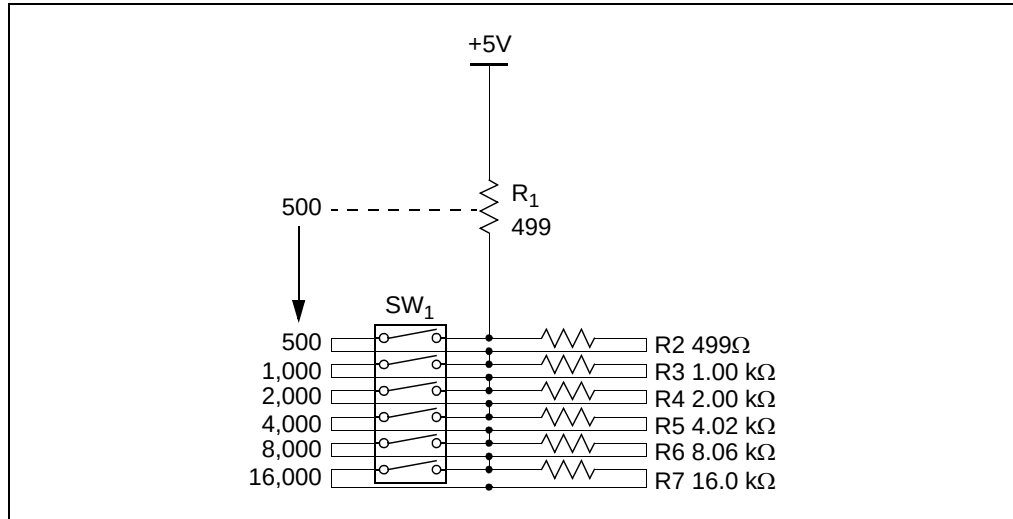


**FIGURE 2-3:** Simplified Jumper Circuit.

### 2.3.2 Configuring DIP Switch SW<sub>1</sub> ( $R_A$ )

DIP switch SW<sub>1</sub> and resistors  $R_1 - R_7$  in Figure 2-4 emulate the voltage divider resistor ( $R_A$  in Figure 2-3).  $R_1$  is placed in series with the others to prevent shorting the supplies together. These resistors produce a binary sequence of values between 0.5 k $\Omega$  and 32.0 k $\Omega$ .

Refer to Figure A.3 for the complete schematic.



**FIGURE 2-4:**  $R_A$  Emulator.

Each resistor with its switch (in SW1) pointing to the right, away from the silk screen resistor values, is not added into the total for  $R_A$  (it shorts that resistor).

Each resistor with its switch (in SW1) pointing to the left, towards the silk screen resistor values, is added into the total for  $R_A$ .

As an example, if the top four switches are to the right, and the bottom two are to the left, then  $R_A$  is calculated as  $500 + 0 + 0 + 0 + 0 + 8,000 + 16,000 = 24,500\Omega$ .

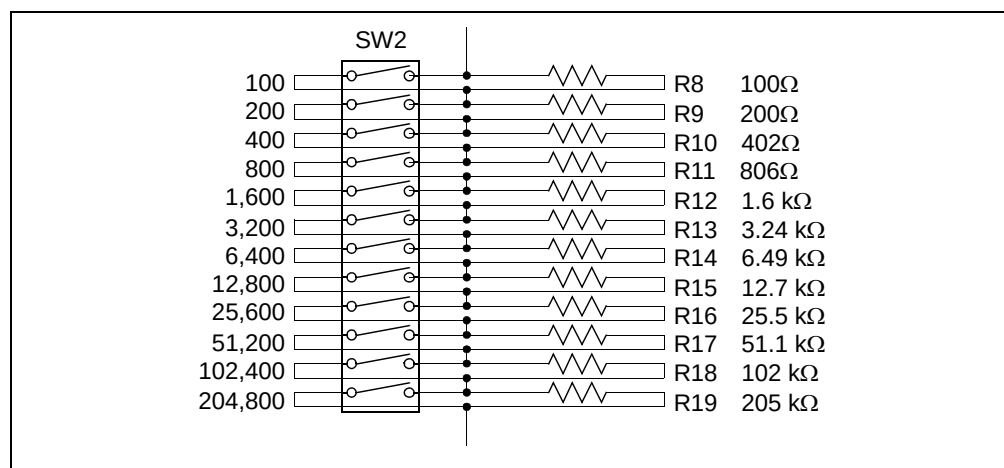
## 2.3.3 Using the Thermistor ( $R_{TH}$ )

In **Appendix A. "Schematic and Layouts"**,  $R_{21}$  is the thermistor ( $R_{TH}$  in [Figure 2-3](#)). The resistance changes depending on temperature; see AN897, "Thermistor Temperature Sensing with MCP6SX2 PGAs" (DS00897).

## 2.3.4 Configuring DIP Switch SW2 ( $R_{TH}$ Emulator, $R_{var}$ )

DIP switch SW2 and resistors  $R_8 - R_{19}$  in [Figure 2-5](#) comprise the thermistor emulator ( $R_{var}$  in [Figure 2-3](#)).  $R_{var}$  produces a binary sequence of resistances between  $0\Omega$  and  $409.5\text{ k}\Omega$ .

Refer to [Figure A.3](#) for the complete schematic.



**FIGURE 2-5:**  $R_{TH}$  Emulator ( $R_{var}$ ).

Each resistor with its switch (in SW2) pointing to the right, away from the silk screen resistor values, is not added into the total for  $R_A$  (it shorts that resistor).

Each resistor with its switch (in SW) pointing to the left, towards the silk screen resistor values, is added into the total for  $R_A$ .

As an example, if the top ten switches are to the right, and the bottom two are to the left, then  $R_{var}$  is calculated as  $0 + 0 + \dots + 0 + 102,400 + 204,800 = 307,200\Omega$ .

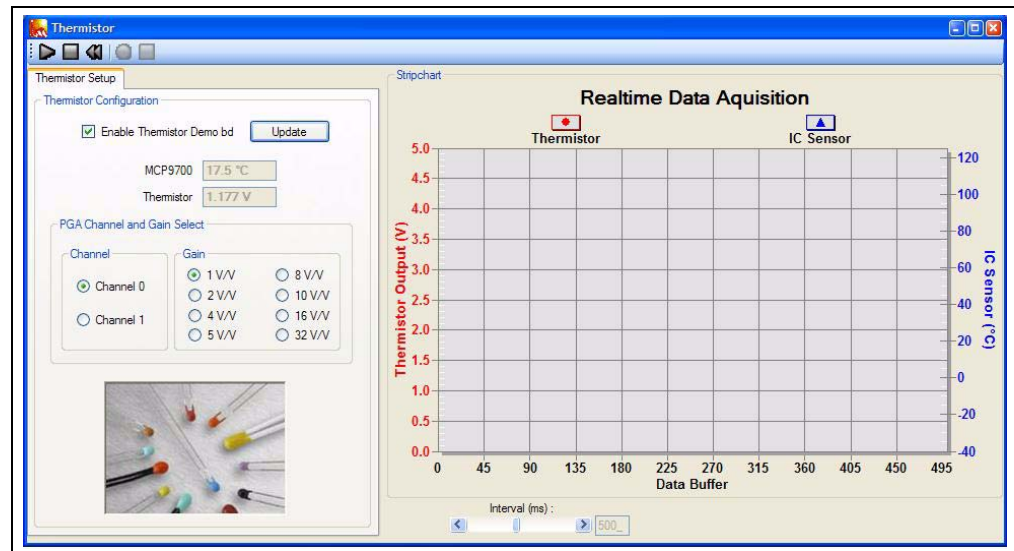
AN897, "Thermistor Temperature Sensing with MCP6SX2 PGAs" (DS00897) contains information on converting this resistance to the equivalent, nominal thermistor temperature, and vice versa.

## 2.3.5 Using the MCP9700

The MCP9700 Linear Active Thermistor is a temperature sensor which outputs voltage directly proportional to change in temperature. This sensor provides a 10 mV per degree Celsius temperature coefficient and it measures temperature from  $-40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ , see datasheet (DS21942) for details.

## 2.3.6 Microchip Thermal Management GUI

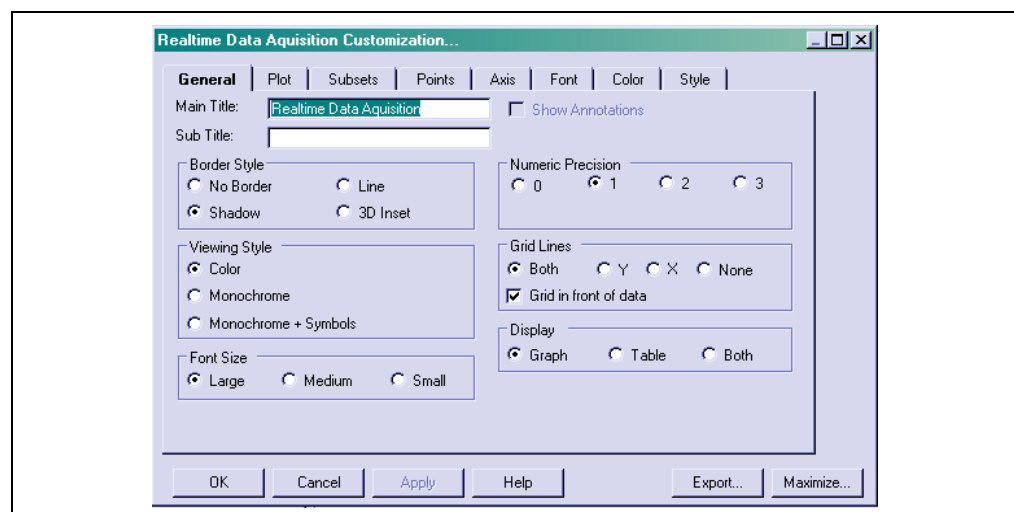
The Microchip Thermal Management Graphical User Interface is an easy to use software tool which allows users to evaluate the MCP9700 Thermistor Demo Board and sensor features, as displayed in [Figure 2-6](#).



**FIGURE 2-6:** Microchip Thermal Management GUI.

Once the hardware is connected, the software recognizes the device ID and displays the corresponding GUI for the MCP9700 Thermistor Demo Board. This tool enables the user to evaluate the demo board features and perform temperature datalog. The black “Play”, “Stop”, and “Reset” icons can be used to perform continuous datalog. And the red “Record” icon enables the user to datalog to an external file. The logging interval can be adjusted using the Interval Scroll bar from 100 ms to 1000 ms.

The Real-time Data Acquisition charting tool can be customized by double clicking the chart, as shown in [Figure 2-7](#). Additional options are available by right clicking the chart. The users can also zoom into a specific plot range by clicking and dragging the section.



**FIGURE 2-7:** Chart Setup Options.

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## **Appendix A. Schematic and Layouts**

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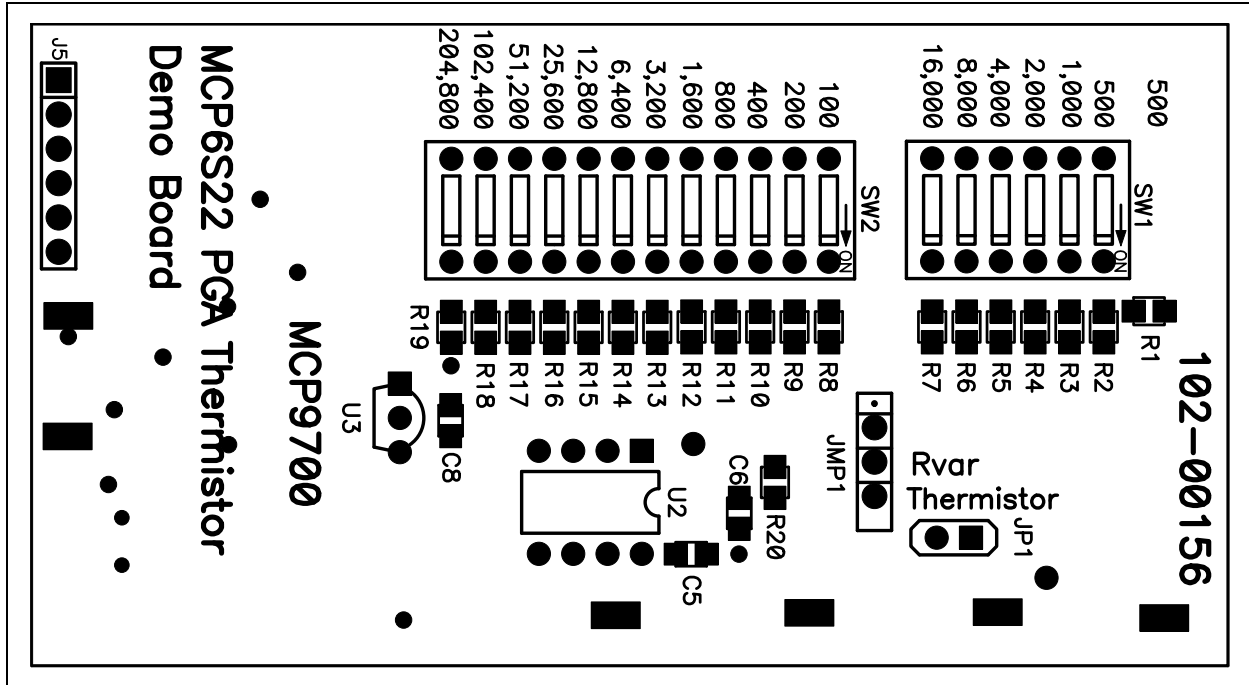
### **A.1 INTRODUCTION**

This appendix contains the following schematics and layouts for the MCP9700 Thermistor Demo Board:

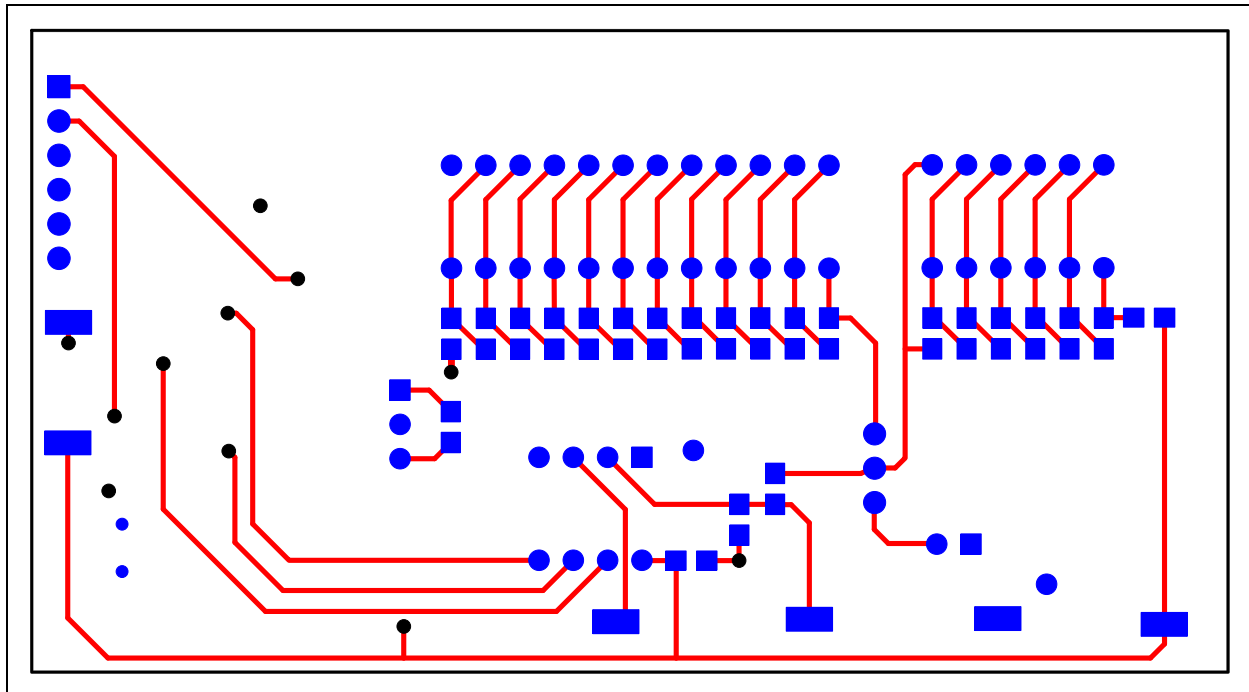
- Board Schematic
- Board - Top Layer
- Board - Silk-screen Layer
- Board - Bottom Layer



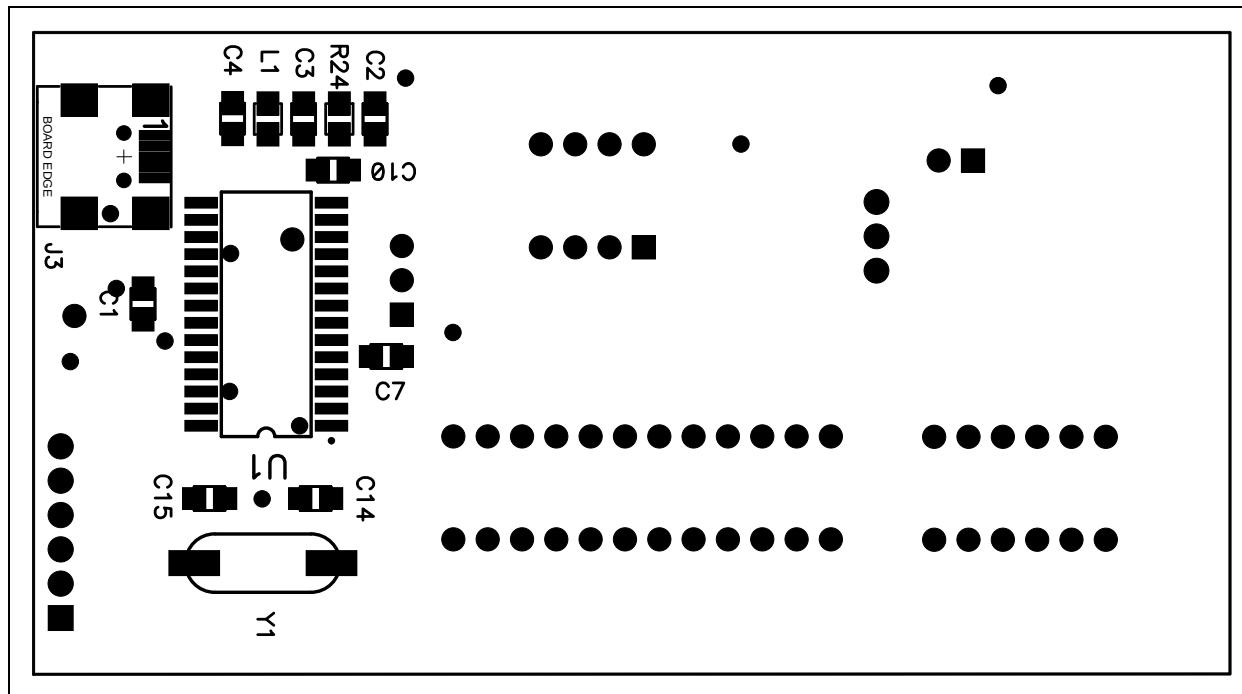
## A.3 BOARD - TOP SILK-SCREEN LAYER



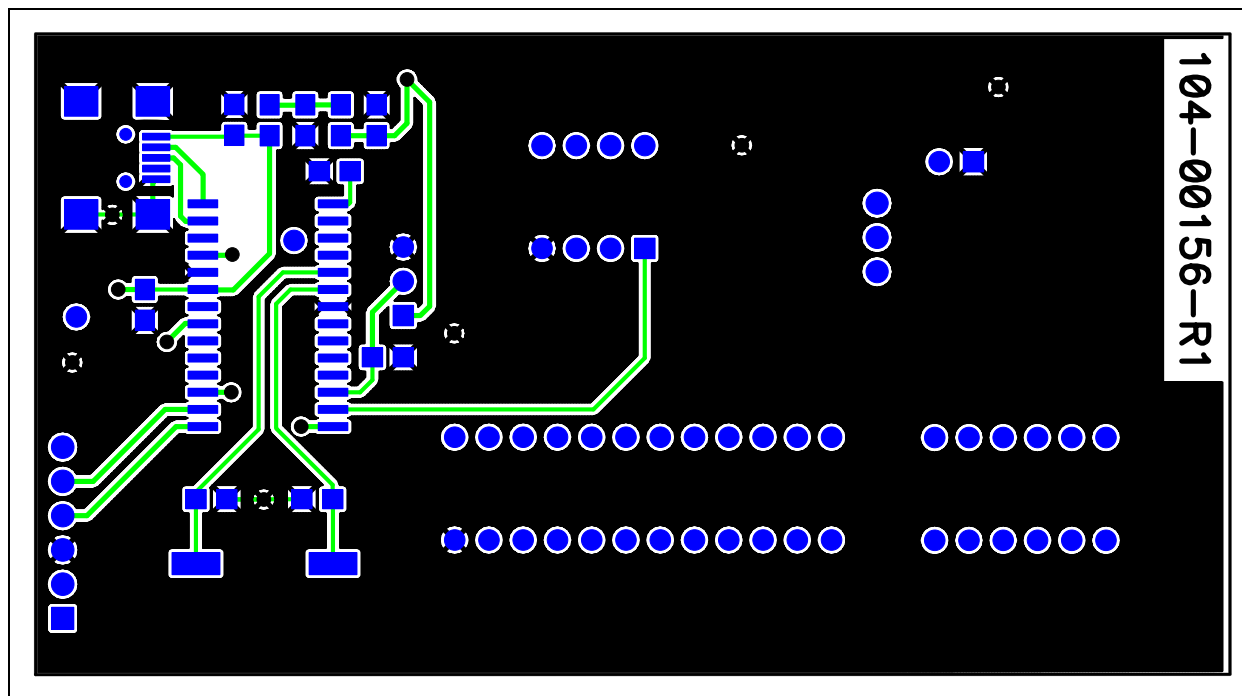
## A.4 BOARD - TOP LAYER



## A.5 BOARD - BOTTOM SILK



## A.6 BOARD - BOTTOM LAYER



## Appendix B. Bill Of Materials (BOM)

**TABLE B-1: BILL OF MATERIALS**

| Qty | Reference        | Description                                                        | Manufacturer                        | Part Number      |
|-----|------------------|--------------------------------------------------------------------|-------------------------------------|------------------|
| 1   | (for JMP1)       | Shunt - SOCKET, SHORT BLKS W TAB BLK                               | AMP®/Tyco Electronics               | 881545-2         |
| 1   | (for U1)         | CONN IC SOCKET 8POS DIP TIN                                        | AMP/Tyco Electronics                | 2-641260-1       |
| 4   | C1,C5,C7,C8      | CAP .1UF 25V CERAMIC X7R 0805                                      | Panasonic® - ECG                    | ECJ-2VB1E104K    |
| 1   | C10              | CAP .47UF 16V CERAMIC X7R 0805                                     | Panasonic - ECG                     | ECJ-2YB1C474K    |
| 2   | C14,C15          | CAP 22PF 50V CERM CHIP 0805 SMD                                    | Panasonic - ECG                     | ECJ-2VC1H220J    |
| 2   | C2,C6            | CAP 1.0UF 16V CERAMIC X7R 0805                                     | Kemet® Electronics Corp             | C0805C105K4RACTU |
| 2   | C3,C4            | CAP 10UF 10V CERAMIC F 0805                                        | Panasonic - ECG                     | ECJ-2FF1A106Z    |
| 6   | CH0,CH1,GND, VDD | PC TEST POINT COMPACT SMT                                          | Keystone Electronics®               | 5016             |
| 4   | EA. Corner       | BUMPON TALL TAPER SQ .50X.23 BK (Package comes in 64pcs per unit ) | 3M                                  | SJ-5518 (BLACK)  |
| 1   | J3               | CONN RECEPT MINI USB2.0 5POS (mini USB)                            | Hirose Electronic Co Ltd            | UX60-MB-5ST      |
|     | J5               | "DO NOT POPULATE" CONN HEADER VERT 6POS .100 TIN                   | Tyco® Electronics/Amp               | 3-644695-6       |
| 1   | JMP1             | CONN HEADER 3POS 0.100 VERT TIN                                    | AMP/Tyco Electronics                | 3-644456-3       |
| 1   | JP1              | THERMISTOR 10K OHM NTC LEADED                                      | BC Components                       | 2381 640 55103   |
| 1   | L1               | INDUCTOR 10UH 100MA 0805                                           | Murata Electronics® - North America | LQM21FN100M70L   |
| 1   | PCB              | MCP9700 Thermistor Demo Board                                      | Microchip Technology Inc.           | 113-00156        |
| 2   | R1,R2            | RES 499 OHM 1/8W 1% 0805 SMD                                       | Panasonic - ECG                     | ERJ-6ENF4990V    |
| 1   | R10              | RES 402 OHM 1/8W 1% 0805 SMD                                       | Panasonic - ECG                     | ERJ-6ENF4020V    |
| 1   | R11              | RES 806 OHM 1/8W 1% 0805 SMD                                       | Panasonic - ECG                     | ERJ-6ENF8060V    |
| 1   | R12              | RES 1.62K OHM 1/8W 1% 0805 SMD                                     | Panasonic - ECG                     | ERJ-6ENF1621V    |
| 1   | R13              | RES 3.24K OHM 1/8W 1% 0805 SMD                                     | Panasonic - ECG                     | ERJ-6ENF3241V    |
| 1   | R14.             | RES 6.49K OHM 1/8W 1% 0805 SMD                                     | Panasonic - ECG                     | ERJ-6ENF6491V    |
| 1   | R15              | RES 12.7K OHM 1/8W 1% 0805 SMD                                     | Panasonic - ECG                     | ERJ-6ENF1272V    |
| 1   | R16              | RES 25.5K OHM 1/8W 1% 0805 SMD                                     | Panasonic - ECG                     | ERJ-6ENF2552V    |
| 1   | R17              | RES 51.1K OHM 1/8W 1% 0805 SMD                                     | Panasonic - ECG                     | ERJ-6ENF5112V    |
| 1   | R18              | RES 102K OHM 1/8W 1% 0805 SMD                                      | Panasonic - ECG                     | ERJ-6ENF1023V    |
| 1   | R19              | RES 205K OHM 1/8W 1% 0805 SMD                                      | Panasonic - ECG                     | ERJ-6ENF2053V    |
| 1   | R20              | RES 100K OHM 1/8W 1% 0805 SMD                                      | Panasonic - ECG                     | ERJ-6ENF1003V    |
| 1   | R24              | RES 10.0 OHM 1/8W 1% 0805 SMD                                      | Panasonic - ECG                     | ERJ-6ENF10R0V    |

**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.

# MCP9700 Thermistor Demo Board User's Guide

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

| Qty | Reference | Description                                                                                   | Manufacturer              | Part Number     |
|-----|-----------|-----------------------------------------------------------------------------------------------|---------------------------|-----------------|
| 1   | R3        | RES 1.00K OHM 1/8W 1% 0805 SMD                                                                | Panasonic - ECG           | ERJ-6ENF1001V   |
| 1   | R4        | RES 2.00K OHM 1/8W 1% 0805 SMD                                                                | Panasonic - ECG           | ERJ-6ENF2001V   |
| 1   | R5        | RES 4.02K OHM 1/8W 1% 0805 SMD                                                                | Panasonic - ECG           | ERJ-6ENF4021V   |
| 1   | R6        | RES 8.06K OHM 1/8W 1% 0805 SMD                                                                | Panasonic - ECG           | ERJ-6ENF8061V   |
| 1   | R7        | RES 16.2K OHM 1/8W 1% 0805 SMD                                                                | Panasonic - ECG           | ERJ-6ENF1622V   |
| 1   | R8        | RES 100 OHM 1/8W 1% 0805 SMD                                                                  | Panasonic - ECG           | ERJ-6ENF1000V   |
| 1   | R9        | RES 200 OHM 1/8W 1% 0805 SMD                                                                  | Panasonic - ECG           | ERJ-6ENF2000V   |
| 1   | SW1       | SWITCH 6 POS DIP EXTENDED SEALED                                                              | Grayhill, Inc             | 78B06ST         |
| 1   | SW2       | SWITCH 12 POS DIP EXTENDED UNSLD                                                              | Grayhill, Inc             | 78B12ST         |
| 1   | U1        | 28/40/44-Pin, High-Performance, Enhanced Flash, USB Microcontrollers with nanoWatt Technology | Microchip Technology Inc. | PIC18F2550-I/SO |
| 1   | U2        | PGA, Rail-to-Rail I/O, Digital control                                                        | Microchip Technology Inc. | MCP6S22-I/P     |
| 1   | U3        | Low-Power Linear Active Thermistor™ Ics                                                       | Microchip Technology Inc. | MCP9700-E/TO    |
| 1   | Y1        | CRYSTAL 20.0000 MHZ SERIES SMT                                                                | CTS-Frequency Controls    | ATS200SM        |

**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.

# Bill Of Materials (BOM)

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NOTES:



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