MCP9800 Thermal Sensor PICtail™ Demo Board User's Guide

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MCP9800 THERMAL SENSOR PICtail™ DEMO 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 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 "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 MCP9800 Thermal Sensor PICtail™ 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 MCP9800 Thermal Sensor PICtail™ Demo Board. The manual layout is as follows:

- **Chapter 1. "Product Overview"** – Important information about the MCP9800 Thermal Sensor PICtail™ Demo Board.
- **Chapter 2. "Installation and Operation"** – Includes a detailed description of each function of the demo board and instructions on how to begin using the board.
- **Appendix A. "Schematic and Layouts"** – Shows the schematic and layout diagrams for the MCP9800 Thermal Sensor PICtail™ Demo Board.
- **Appendix B. "Bill Of Materials (BOM)"** – Lists the parts used to build the MCP9800 Thermal Sensor PICtail™ Demo 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

The following Microchip documents are available and recommended as supplemental reference resources.

MCP9800 Data Sheet, *"2-Wire High-Accuracy Temperature Sensor"* (DS21909)

This data sheet provides detailed information regarding the MCP9800 device.

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- Development Systems Information Line

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

DOCUMENT REVISION HISTORY

Revision B (May 2006)

- Updated Bill of Materials (BOM) to show RoHS-compliant part numbers

Revision A (January 2005)

- Initial Release of this Document.

NOTES:

Chapter 1. Product Overview

1.1 INTRODUCTION

This chapter provides an overview of the MCP9800 Thermal Sensor PICtail™ Demo Board and covers the following topics:

- What is the MCP9800 Thermal Sensor PICtail™ Demo Board?
- What the MCP9800 Thermal Sensor PICtail™ Demo Board Kit includes

1.2 WHAT IS THE MCP9800 THERMAL SENSOR PICTAIL™ DEMO BOARD?

The MCP9800 Thermal Sensor PICtail™ Demo Board demonstrates how to interface the MCP9800 to a PICmicro® microcontroller using the PICkit™ 1 Flash Starter Kit as a platform. A PIC16F684 14-pin, Flash-based, 8-bit CMOS microcontroller device is included with the demo board and can be used with the PICkit 1 Flash Starter Kit. Also included is firmware that provides the I^{2}C™ interface and temperature conversion routines to communicate with the MCP9800 and convert the serial data to temperature.

The MCP9800 Thermal Sensor PICtail™ Demo Board can also be used as a "stand-alone" module to quickly add thermal-sensing capability to any existing application. This basic sensor functionality is implemented on a small Printed Circuit Board (PCB) and an interface via a standard 100 mil header.

1.3 WHAT THE MCP9800 THERMAL SENSOR PICTAIL™ DEMO BOARD KIT INCLUDES

This MCP9800 Thermal Sensor PICtail™ Demo Board Kit includes:

- The MCP9800 Thermal Sensor PICtail™ Demo Board
- MCP9800 Thermal Sensor PICtail™ Demo Board User's Guide (DS51528)
- MCP9800 Data Sheet, *"2-Wire High-Accuracy Temperature Sensor"* (DS21909)
- PIC16F684 14-pin, Flash-based, 8-bit, CMOS Microcontroller
- PIC16F684 Firmware

NOTES:

Chapter 2. Installation and Operation

2.1 INTRODUCTION

The MCP9800 Thermal Sensor PICtail™ Demo Board demonstrates how to interface the MCP9800 to a microcontroller for use by the system designer as an example of how to integrate a digital temperature sensor into a system. In addition, the designer can serially transmit the temperature data to the on board, 7-segment LED display to show the temperature.

2.2 FEATURES

The MCP9800 Thermal Sensor PICtail™ Demo Board has the following features:

• Small PCB layout
• Standard 100 mil 14-pin header (J2) for easy interface to the PICkit 1 Flash Starter Kit or custom application
• 7-segment LED display to display temperature in °C or °F
• Temperature alert-indicating LED

2.3 GETTING STARTED

This section describes how to quickly configure the MCP9800 Thermal Sensor PICtail™ Demo Board and PICkit 1 Flash Starter Kit. A block diagram of the configuration is shown in Figure 2-1.
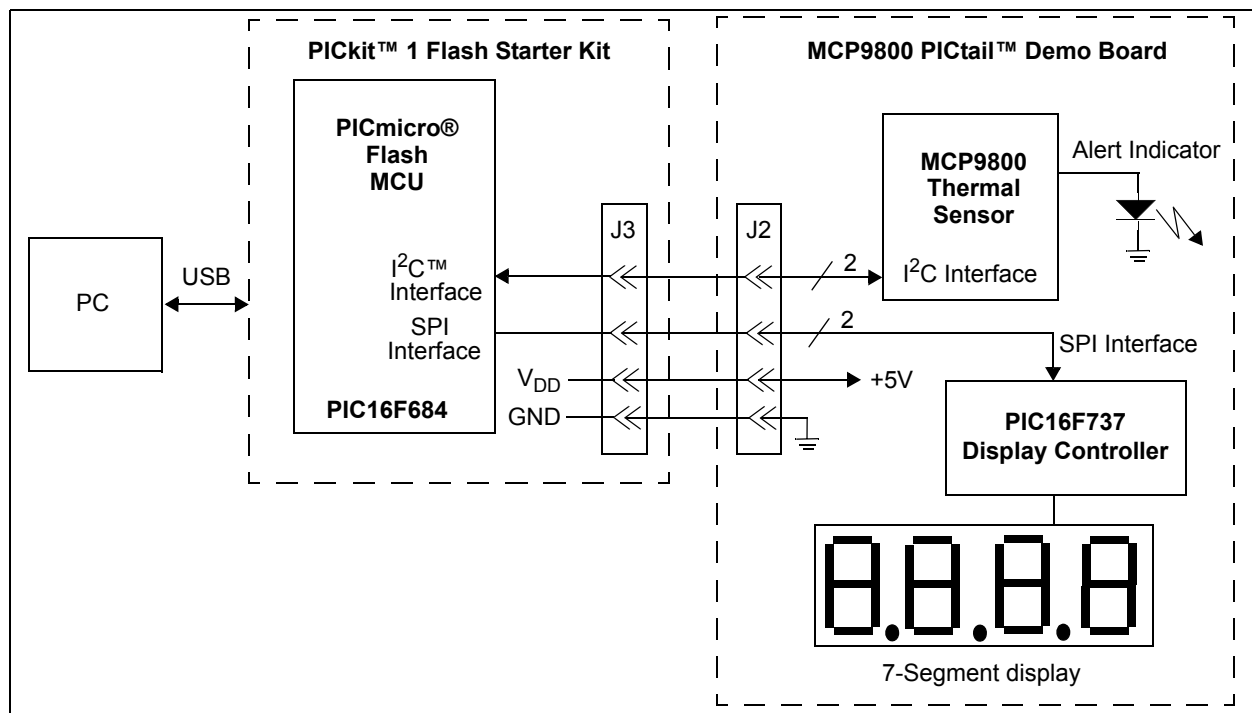
FIGURE 2-1: *MCP9800 Thermal Sensor PICtail™ Demo Board Block Diagram.*

2.3.1 Hardware Setup

1. Connect the J2 header of the MCP9800 Thermal Sensor PICtail Demo Board to the J3 connector on the PICkit 1 Flash Starter Kit. Refer to Figure 2-2 for proper orientation of the MCP9800 Thermal Sensor PICtail™ Demo Board and Figure 2-3 for a simplified board schematic.

2. Insert the PIC16F684 into the evaluation socket of the PICkit 1 Flash Starter Kit.

3. Connect the PICkit 1 Flash Starter Kit USB cable from the USB port of the PC to the USB port (J1) on the PICkit 1 Flash Starter Kit. +5V of power is supplied to the PICkit 1 Flash Starter Kit via the USB cable. The green power LED and the red busy LED will turn on, indicating that power is being supplied to the board.

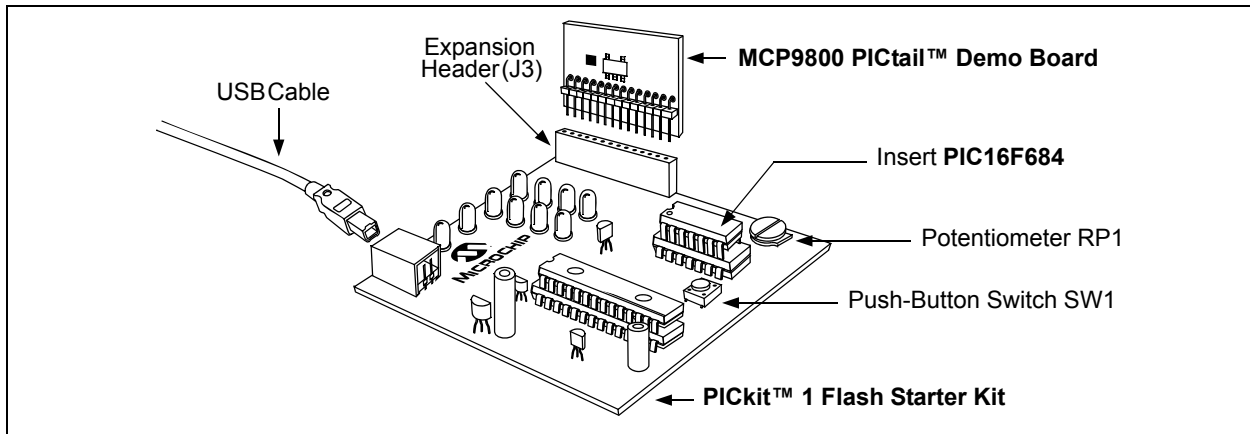| WARNING |
| --- |
| **Do not hot-swap the MCP9800 PICtail™ Demo Board.** |

FIGURE 2-2: *MCP9800 Thermal Sensor PICtail™ Demo Board and PICkit™1 Flash Starter Kit.*
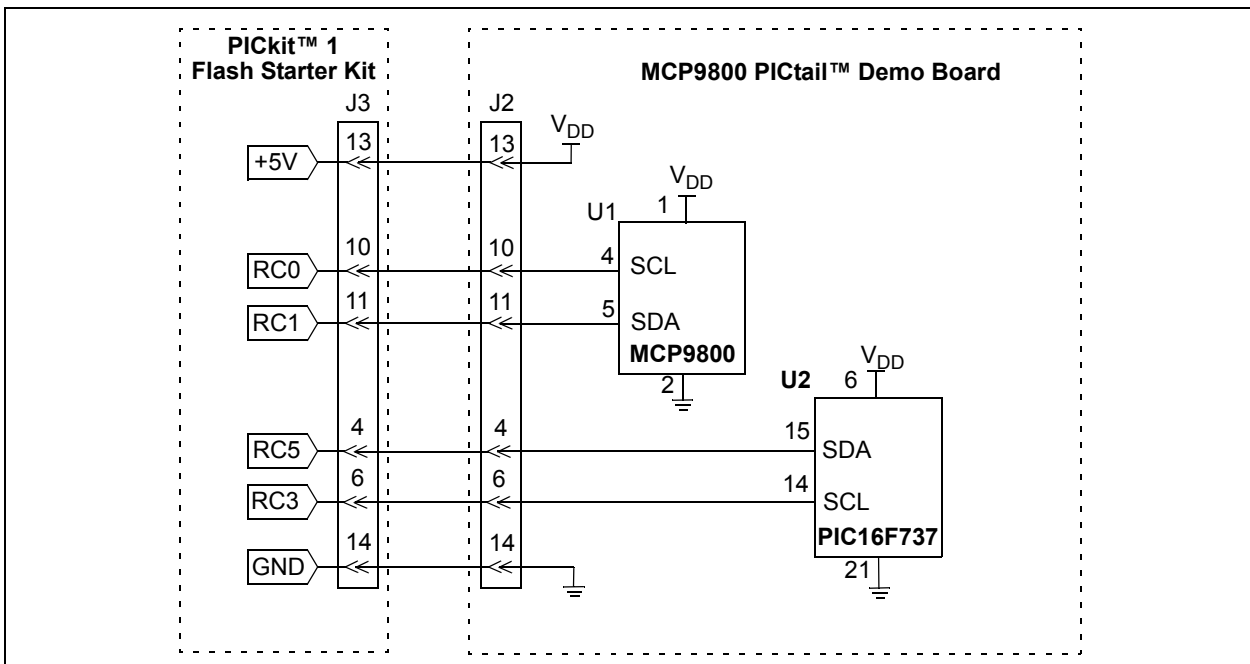

FIGURE 2-3: *Simplified MCP9800 Thermal Sensor PICtail™ Demo Board Schematic.*

2.3.2   Programming the PIC16F684

1. Download and install the PICkit 1 Flash Starter Kit software onto your PC.
2. Copy the `00031R1-1.HEX` file (supplied on the CD that came with this kit) onto your PC.
3. When the PICkit 1 Flash Starter Kit is started, the main window will be displayed on the PC, as indicated in Figure 2-4.
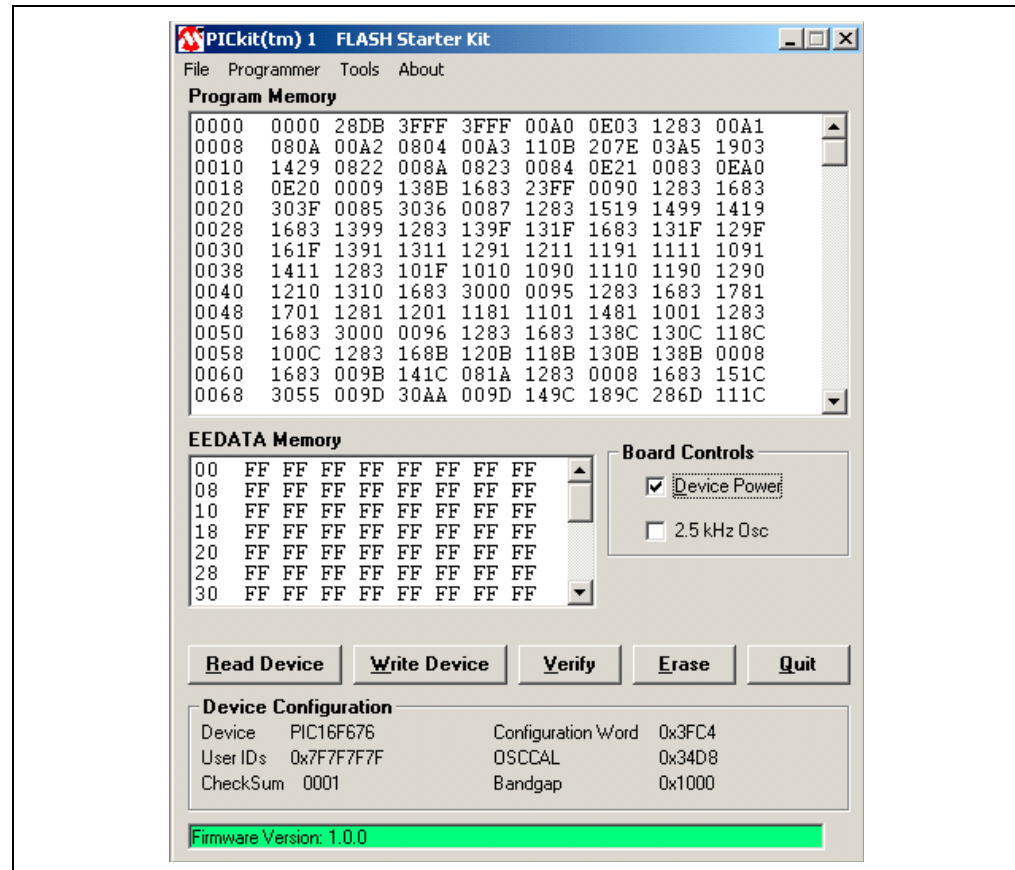

FIGURE 2-4:   *PICkit™ 1 Flash Starter Kit GUI Window on the PC.*

4. Switch off the device power by unchecking the **Device Power** box under **Board Controls** in the PICkit 1 Flash Starter Kit window (Figure 2-4). The busy LED on the PICkit 1 Flash Starter Kit will switch off when the device power is switched off.
5. Click on the **Erase** button in the window to ensure that the PIC16F684 device has been erased.
6. From the **File** pull-down menu, select **Import HEX**. A file window will appear. Select and open `00031R1-1.HEX`.
7. Click on the **Write Device** button in the PICkit 1 Flash Starter Kit window. The PIC16F684 device will be written to with the `00031R1-1.HEX` firmware. Once completed, the status bar at the bottom of the window will indicate **`Write Successful`**.
8. Switch on the device power by checking the **Device Power** box under **Board Controls** in the PICkit 1 Flash Starter Kit window. The busy LED on the PICkit 1 Flash Starter Kit will turn on when the device power is switched on.
9. The 7-segment display on the MCP9800 Thermal Sensor PICtail™ Demo Board will show ambient temperature (°C).

2.4 FUNCTIONAL DESCRIPTION

2.4.1 The MCP9800 Thermal Sensor PICtail™ Demo Board

This demo board has the MCP9800 temperature sensor device and a 7-segment LED display circuit. The user can read the ambient temperature data from the MCP9800 using the PICkit 1 Flash Starter Kit and display the data using the 7-segment display on the MCP9800 Thermal Sensor PICtail™ Demo Board. It's also possible to transmit the data to a PC for a display using the PICkit 1 Flash Starter Kit software strip-chart display tool.

This demo board has a 14-pin header that connects to the PICkit 1 Flash Starter Kit. The header connects the +5V supply, ground and all serial I/O pins to the MCP9800 Thermal Sensor PICtail™ Demo Board. There are four serial I/O lines used to communicate with the MCP9800 and the 7-segment display circuit. The MCP9800 uses two I/O lines for the I^{2}C™ interface to transmit temperature data, while the 7-segment display circuit uses two I/O lines for the SPI interface to display temperature data.

The user can develop custom firmware to communicate with the MCP9800 and the 7-segment display using most 14-pin PICmicro® microcontrollers and the PICkit 1 Flash Starter Kit. In addition, Microchip provides a demo firmware that uses the PIC16F684 microcontroller. This firmware will be referenced throughout the user's guide to show the various functions of the demo board.

2.4.2 The MCP9800

The MCP9800 comes with user-programmable registers that provide flexibility for temperature-sensing applications. The register settings allow user-selectable 9-bit to 12-bit temperature measurement resolution, configuration of the power-saving Shutdown and One-Shot (single conversion on command while in Shutdown) modes and the specification of both temperature alert output and hysteresis limits. When the temperature changes beyond the specified limits, the MCP9800 outputs an alert signal. The user has the option of setting the alert output signal polarity as an active-low or active-high comparator output for thermostat operation, or as a temperature event interrupt output for microprocessor-based systems

This device has I^{2}C/SMBus-compatible serial interface (refer to the MCP9800 data sheet (DS21909) for further details).

2.4.3   User-Selectable Features

The demo firmware programs the Temperature Limit and Hysteresis Limit registers (T_{SET} and T_{HYST}, respectively) according to the position of the RP1 potentiometer, located on the PICkit 1 Flash Starter Kit. The potentiometer is connected to the PIC16F684 analog input pin. The voltage across the potentiometer wiper terminal determines T_{SET}. The wiper position provides 15 possible T_{SET} limits from 10°C to 55°C, in 3°C increments. T_{HYST} is programmed 5°C below T_{SET} (5°C hysteresis).

When the ambient temperature exceeds the programmed T_{SET} limit, the MCP9800 outputs an alert signal using the ALERT output pin. This pin is an open-drain output that is configured as an active-high output. When this pin is high, the D_1 diode lights up and remains lit until the temperature drifts beyond the hysteresis limit (T_{HYST}).

This firmware also converts degree Celsius to degree Fahrenheit using the SW1 switch located on the PICkit 1 Flash Starter Kit. When the user presses the momentary push-button switch, the 7-segment display shows the ambient temperature in degree Fahrenheit.

In addition, the user has the option of changing the MCP9800 temperature measurement resolution (default resolution is 10-bit). However, this requires modifying a firmware variable and recompiling the firmware. The `00031R1-1.asm` firmware can be edited and compiled using Microchip's MPLAB® IDE, which can be downloaded from Microchip's web site at www.microchip.com. This particular variable is identified in text within the firmware, with an instruction provided about how to change the variable to select a resolution. Once the variable is changed according to the instruction given in the `00031R1-1.asm` firmware, the user can recompile the firmware and program the PIC16F684 with the `00031R1-1.HEX` file, as shown in **Section 2.3.2 "Programming the PIC16F684"**.

This demo board and demo firmware provides a platform to easily develop a custom firmware and evaluate the various features of the MCP9800.

2.4.4 Displaying the Temperature Data

2.4.4.1 THE 7-SEGMENT LED DISPLAY

The PIC16F684 microcontroller firmware, located on the PICkit 1 Flash Starter Kit, reads the ambient temperature from the MCP9800 temperature sensor and sends the data to the 7-segment LED display.

The 7-segment LED display is controlled using another PICmicro microcontroller that is located on the MCP9800 Thermal Sensor PICtail™ Demo Board. This PICmicro microcontroller controls the LED segments and display frequency. It receives data from the PICkit 1 Flash Starter Kit using ports RC3 and RC5, via the SPI protocol. Once the data is successfully received, the PICmicro microcontroller displays the corresponding LED segments.

The temperature data from the PICkit 1 Flash Starter Kit has to be formatted to Binary Code Decimal (BCD) before transmission. A 4-bit instruction and a 4-bit BCD has to be transmitted for each of the four digits on the 7-segment display. The location and definition of the instruction bits and BCD bits are shown in Table 2-1.

TABLE 2-1: SERIAL DATA FORMAT

Instruction				BCD	
Start	Dot	No display	Dash	MSb	LSb
bit 7					bit 0

bit 7   **START:** Start-of-display bit
             1 = This BCD is the first digit
             0 = This BCD is not the first digit

bit 6   **DOT:** Display dot bit
             1 = Display dot after this BCD, which indicates that the next BCD is a decimal point
             0 = No dot displayed

bit 5   **NO DISPLAY:** No digit to be displayed
             1 = Digit not displayed
             0 = Digit displayed

bit 4   **DASH:** Display dash for negative number bit
             1 = Display dash (—) to indicate negative number
             0 = Dash not displayed

bit 3 - 0   **BCD:** BCD bits MSb first

This format requires that a 32-bit data (8 bits at a time) needs to be transmitted in order to display four-digit temperature data on the 7-segment display.

Table 2-2 shows examples on displaying temperature data.

TABLE 2-2: TEMPERATURE DATA FORMAT FOR DISPLAY

Temperature	1st byte	2nd byte	3rd byte	4th byte
125.5	1000 0001	0000 0010	0100 0101	0000 0101
25.25	1000 0010	0100 0101	0000 0010	0000 0101
5.25	1010 0000	0100 0101	0000 0010	0000 0101
-5.25	1001 0000	0100 0101	0000 0010	0000 0101
-55.5	1001 0000	0000 0101	0100 0101	0000 0101

This format ensures proper protocol between the microcontrollers on the PICkit 1 Flash Starter Kit and the MCP9800 Thermal Sensor PICtail™ Demo Board. In addition, this display protocol makes the 7-segment display circuit generic for use in applications other than temperature data display.

The 7-segment display controller firmware (`00031R1-2.HEX`) can be customized using Microchip's MPLAB® ICD 2 programming tool. A header can be soldered on the MCP9800 Thermal Sensor PICtail Demo Board for the MPLAB ICD 2 programmer. The PIC16F737 microcontroller cannot be programmed using the PICkit 1 Flash Starter Kit.

2.4.4.2   STRIP-CHART DISPLAY ON PC

Once the hardware is connected to the PICkit 1 Flash Starter Kit, as shown in **Section 2.3.1 "Hardware Setup"**, and the PIC16F684 MCU is programmed as indicated in **Section 2.3.2 "Programming the PIC16F684"**, the user can use the strip-chart tool available on the PICkit 1 Flash Starter Kit software. This is done by selecting the stripchart tool on the software and clicking **GO**.

The strip-chart display shows the ambient temperature data from the MCP9800. This display does not support negative numbers. Therefore, the data is offset by 1024. In addition, the tool does not support 11-bit and 12-bit data.
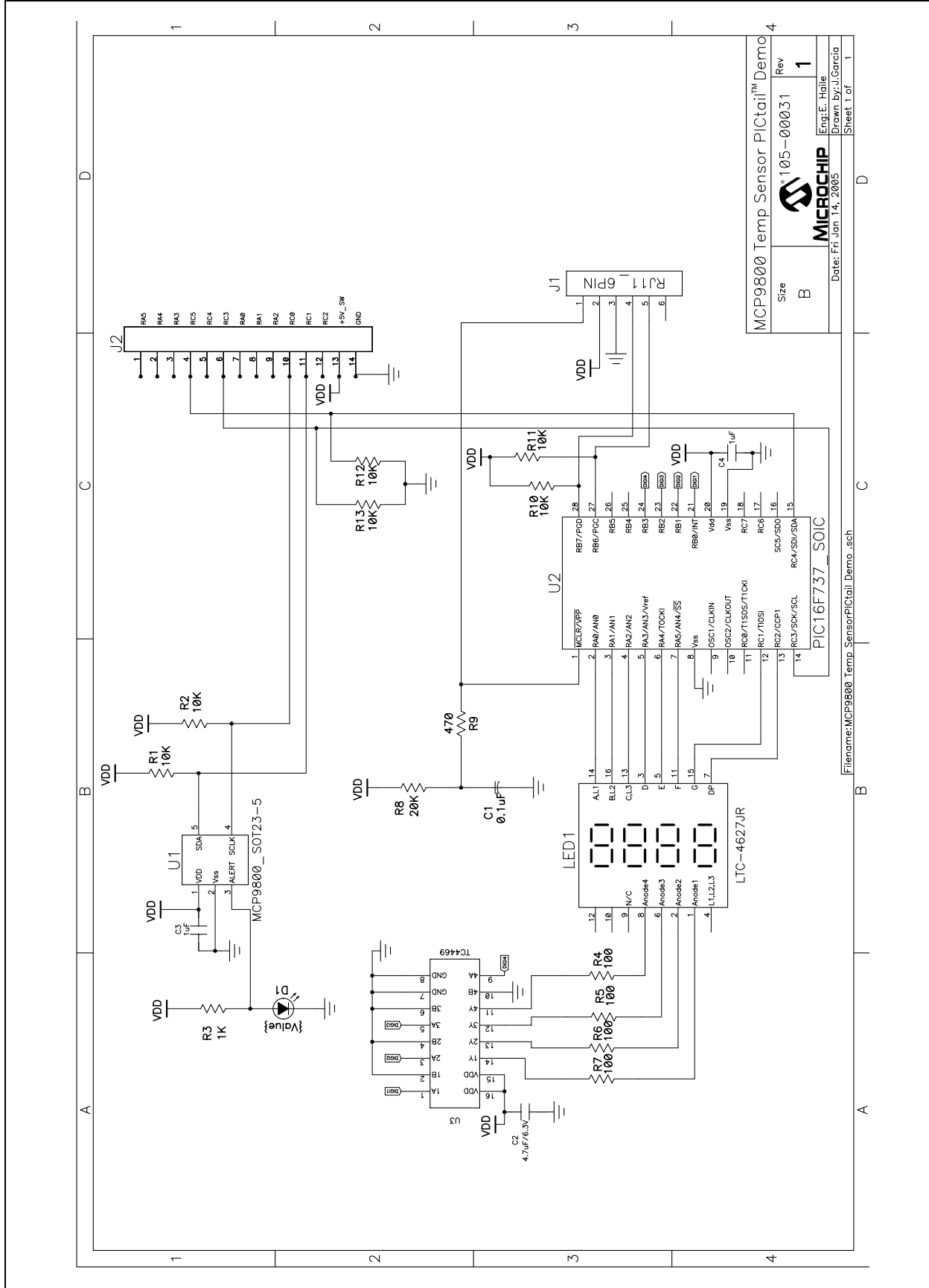
NOTES:

Appendix A. Schematic and Layouts

A.1 INTRODUCTION

This appendix contains the following schematics and layouts for the MCP9800 Thermal Sensor PICtail™ Demo Board:
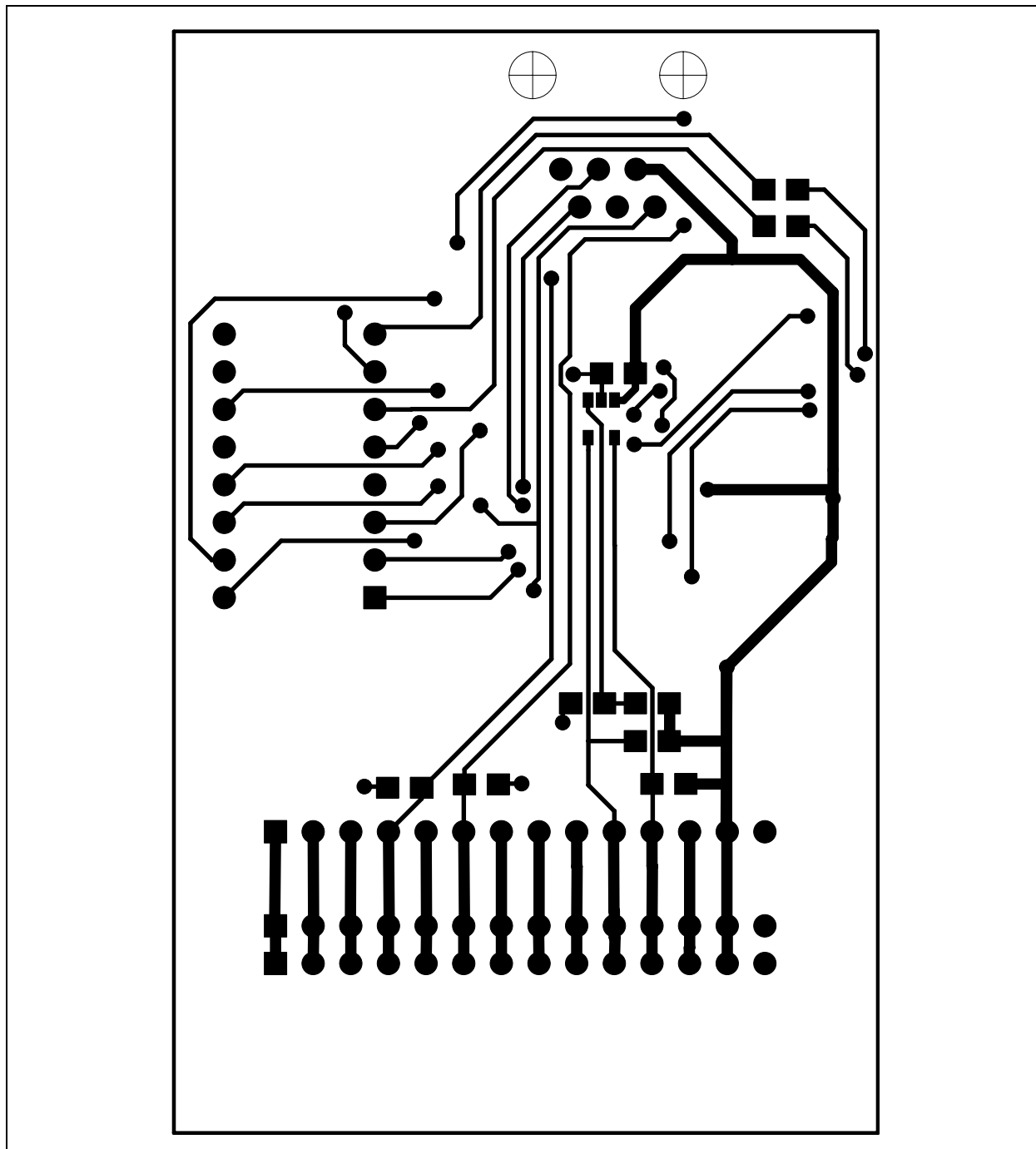
- Board Schematic
- Board - Top Layer
- Board - Silk-Screen Layer
- Board - Bottom Layer

A.2   BOARD SCHEMATIC

A.3 BOARD - TOP LAYER

A.4   BOARD - SILK SCREEN LAYER
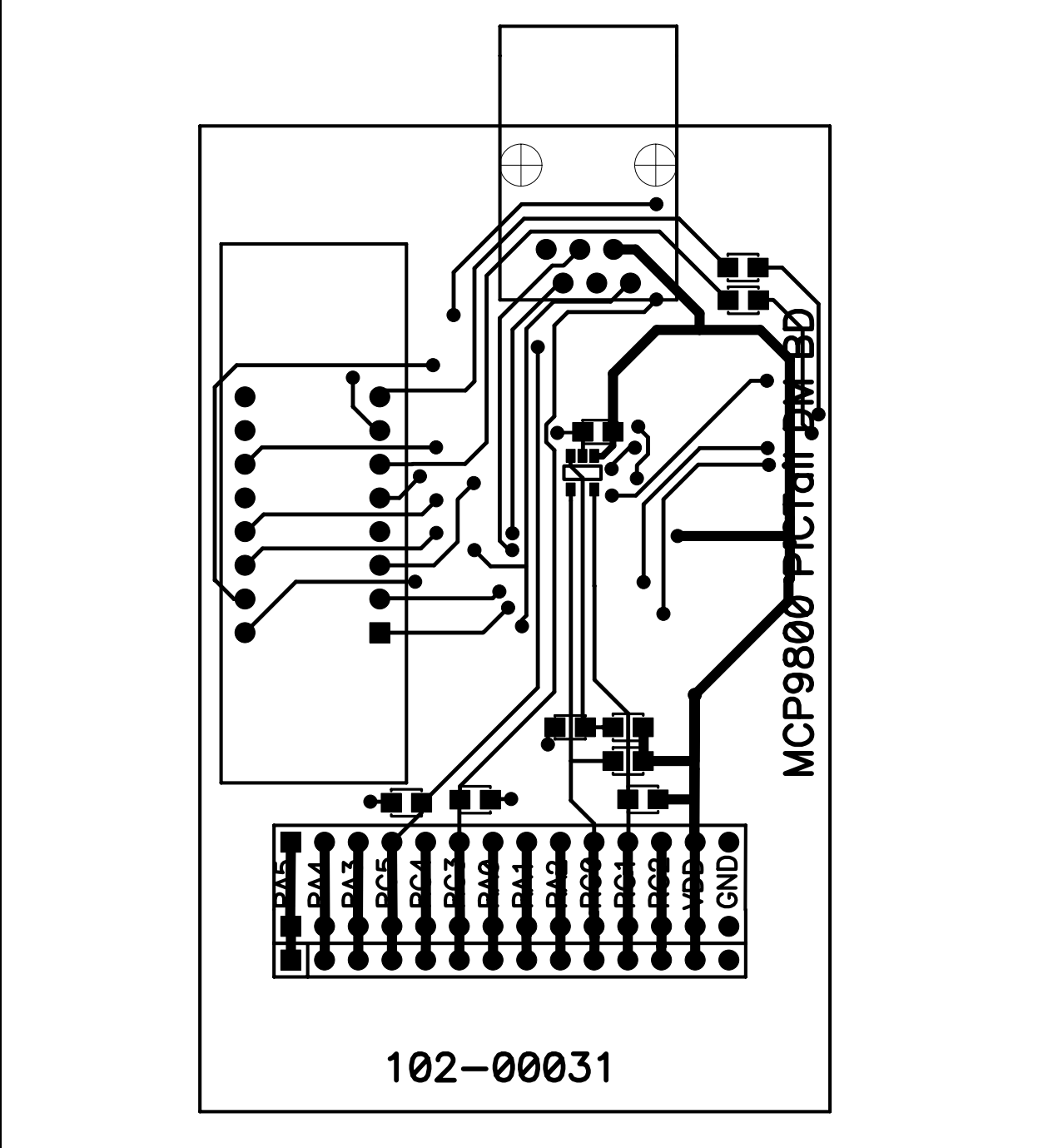
A.5   BOARD - BOTTOM LAYER
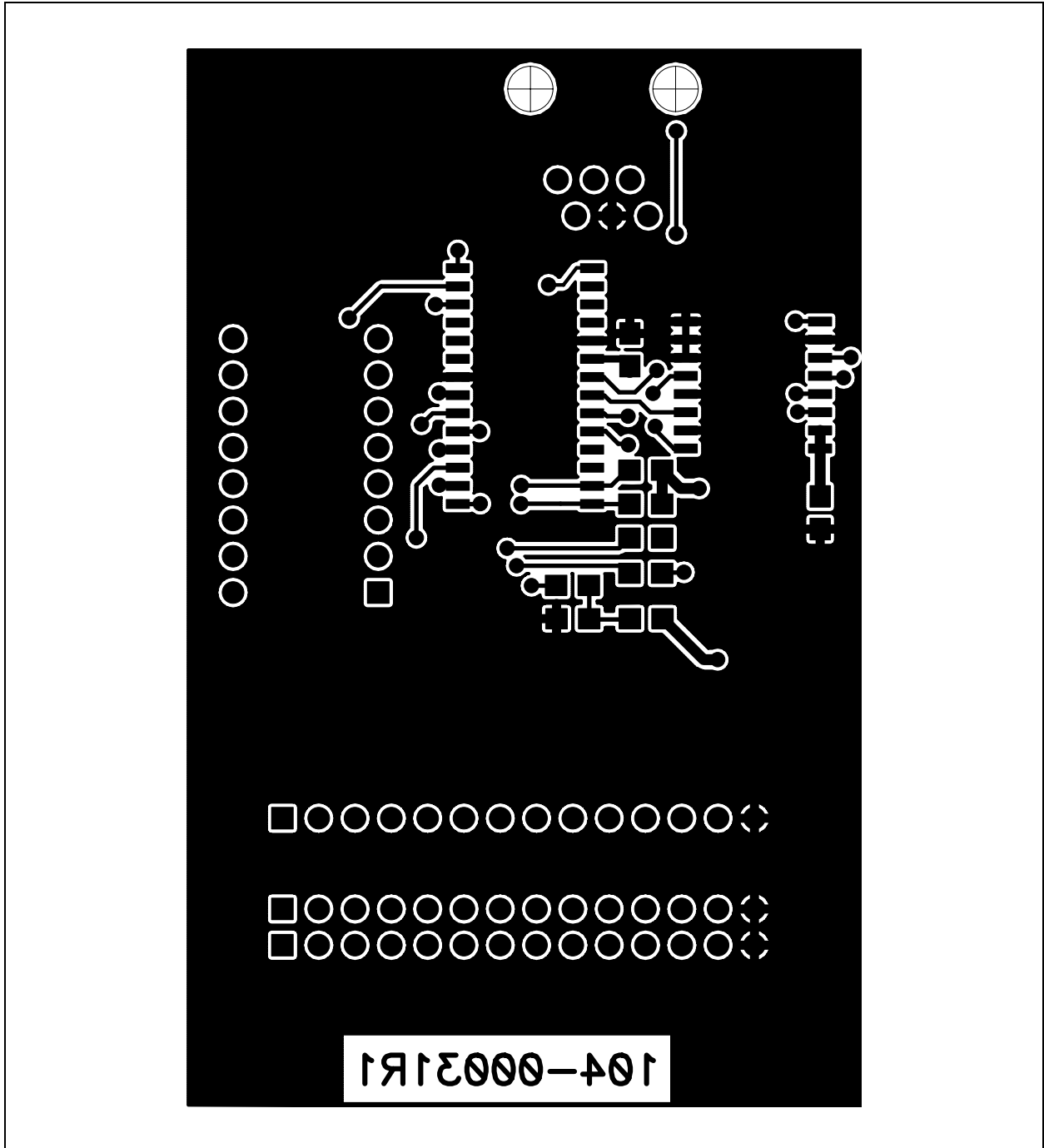
NOTES:

Appendix B. Bill Of Materials (BOM)

TABLE B-1:   BILL OF MATERIALS (BOM)

Qty	Reference	Description	Manufacturer	Part Number
4	C1, C2, C3, C4	CAP .1UF 16V CERAMIC X7R 0805	Panasonic® - ECG	ECJ-2VB1C104K
1	D1	LED RED CLEAR 0805 SMD	Lite-On Trading USA Inc	LTST-C170CKT
1	LED1	LED 7 Segment .4" 4DGT SUPER RED CA	Panasonic - ECG	LTC-4627JR
1	J1	**"NOT POPULATED"** CONN MOD JACK 6-6 R/A PCB 50AU	AMP®/Tyco® Electronics	5520470-3
1	J2	CONN HEADER VERT 14POS .100 TIN	AMP/Tyco Electronics	1-640454-4
6	R1, R2, R10, R11, R12, R13	RES 10.0K OHM 1/10W 1% 0805 SMD	Panasonic - ECG	ERJ-6ENF1002V
5	R3, R4, R5, R6, R7	RES 100 OHM 1/10W 1% 0805 SMD	Panasonic - ECG	ERJ-6ENF1000V
1	R8	RES 20.0K OHM 1/10W 1% 0805 SMD	Panasonic - ECG	ERJ-6ENF2002V
1	R9	RES 475 OHM 1/10W 1% 0805 SMD	Yageo® America	RC0805FR-07475RL
1	U1	2-wire High-Accuracy Temperature Sensor	Microchip Technology, Inc.	MCP9800AOT-M/TOG
1	U2	8-bit CMOS Flash Microcontroller	Microchip Technology, Inc.	PIC16F737-I/SO
1	U3	Logic-Input CMOS Quad Drivers	Microchip Technology, Inc.	TC4469COE

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02/16/06