



# **Humidity Sensor PICtail™ 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.

## INTRODUCTION

This chapter contains general information that will be useful to know before using the Humidity 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 Humidity Sensor PICTail™ Demo Board as a development tool to emulate and debug firmware on a target board. The manual layout is as follows:

- **Chapter 1. “Product Overview”** – This is an introduction to the Humidity Sensor PICTail™ Demo Board. It covers the kit contents, associated tools and how they work together.
- **Chapter 2. “Setup and Installation”** – Covers the initial set-up of the Humidity Sensor PICTail™ Demo Board. It lists the required tools, shows how to connect this board and demonstrates how to verify the set-up.
- **Chapter 3. “Operation”** – This chapter discusses using the humidity sensor on the PCB and using the software PC Application.
- **Chapter 4. “Modified Circuit”** – Gives the modifications necessary to increase measurement resolution by a factor of 100 (see AN1016 for details)
- **Appendix A. “Schematic and Layouts”** – Gives detailed information on the Humidity Sensor PICTail™ Demo Board. Includes detailed circuit explanation, schematic and board layouts.
- **Appendix B. “Bill Of Materials (BOM)”** – Gives detailed information on the Humidity Sensor PICTail™ Demo Board's firmware.

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## 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® 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) { ... }

## RECOMMENDED READING

This user's guide describes how to use Humidity Sensor PICtail™ Demo Board. Other useful documents are listed below and are recommended as supplemental reference resources.

**PICkit™ 2 Microcontroller Programmer User's Guide (DS51553)**

Contains instructions on how to use the PICkit 2 Microcontroller Programmer hardware and software.

**PICkit™ 1 Flash Starter Kit User's Guide (DS40051)**

Contains instructions on how to use the PICkit 1 Flash Starter Kit hardware and software.

**MPLAB® ICD 2 In-Circuit Debugger User's Guide (DS51331)**

This user's guide covers Microchip's low cost, real-time debugger and programmer for selected PICmicro® Microcontrollers (MCUs) and dsPIC® Digital Signal Controllers (DSCs).

**AN1016, "Detecting Small Capacitive Sensors Using the MCP6291 and PIC16F690 Devices" (DS01016)**

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

**MCP6291/2/3/4/5 Data Sheet (DS21812)**

Gives detailed information on the MCP6291/2/3/4/5 Op Amps.

**PIC16F685/687/689/690 Data Sheet (DS41262)**

Gives detailed information on the microcontroller used on the Humidity Sensor PICtail™ Demo Board.

**PIC16C745/765 Data Sheet (DS41124)**

Gives detailed information on the PICmicro microcontroller used on the PICkit 1 Flash Starter Kit.

The following document is available on the internet from the company listed, and is recommended as a supplemental reference resource.

**Humirel, "Relative Humidity Sensor HS1100LF / HS1101LF," Data Sheet, Rev. C, Sept. 2004.**

Gives detailed information on Humirel's ([www.humirel.com](http://www.humirel.com)) HS1101LF capacitive relative humidity sensor.

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## 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
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- Field Application Engineer (FAE)
- Technical Support
- Development Systems Information Line

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://support.microchip.com>

## DOCUMENT REVISION HISTORY

### Revision A (December 2005)

- Initial Release of this Document.



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## Chapter 1. Product Overview

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### 1.1 INTRODUCTION

The Printed Circuit Board (PCB) discussed in this user's guide is described as follows:

- Order Number: PIC16F690DM-PCTLHS
- Assembly Number: 102-00084R1
- Board Name: Humidity Sensor PICTail™ Demo Board

This board supports the capacitive humidity sensor application note AN1016. It measures the capacitance of a relative humidity sensor (or capacitor) plugged into the board. The on-board microcontroller sends the measured and calculated data to a PC (Personal Computer) for display.

Items discussed in this chapter include:

- Kit Contents
- Humidity Sensor PICTail™ Demo Board
- Associated Tools
- Initial Set-up

### 1.2 KIT CONTENTS

- Humidity Sensor PICTail™ Demo Board – This is an assembled and tested Printed Circuit Board (PCB).
- CD-ROM – Provided separately in the shipping box; it contains the files and literature mentioned in this user's guide.
- Humidity Sensor (HS1101LF) – Provided separately in the shipping box.
- Bag of Capacitors – Provided separately in the shipping box. These capacitors are provided for the user's convenience; they make it easy to try out this board's functionality, and to verify its accuracy.

### 1.3 HUMIDITY SENSOR PICTAIL™ DEMO BOARD

The circuit operation is detailed in AN1016, *"Detecting Small Capacitive Sensors Using the MCP6291 and PIC16F690 Devices"* (DS01016)

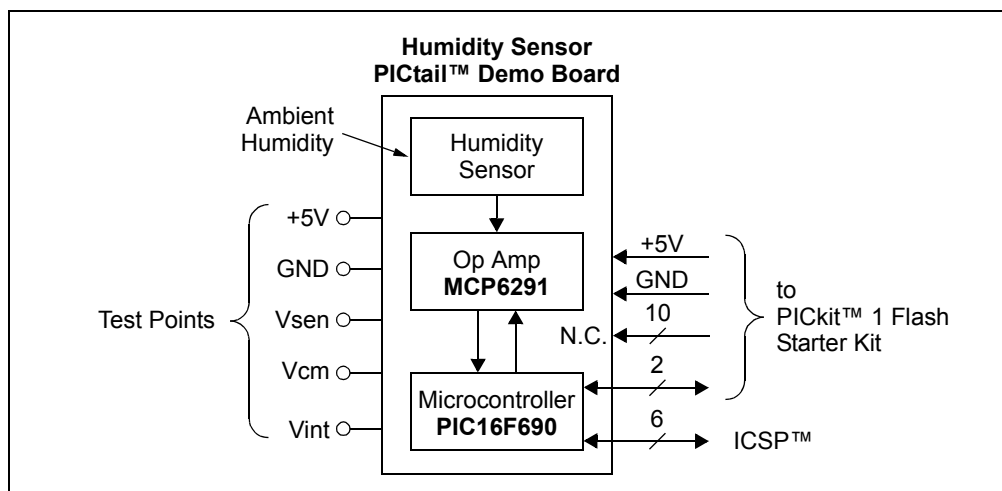
The Humidity Sensor PICTail™ Demo Board contains the circuitry represented in Figure 1-1. The ambient relative humidity changes the capacitance of the humidity sensor (HS1101LF from Humirel). This sensor is connected to a MCP6291 op amp and a resistor to form an inverting (Miller) integrator. The PIC16F690 microcontroller sends a square wave to the input of the integrator, which the integrator converts to a triangle wave at its output. The firmware controls the magnitude of the triangle wave and measures the integration time. The microcontroller measures the time it takes for the triangle wave to rise and fall. These times are converted to a capacitance value.

A 14-pin header is provided for connecting to the PICKit™ 1 Flash Starter Kit, which acts like a docking station. It includes a two-wire serial bus that transfers the data, and two more wires for board power (+5V and GND inputs). This interface also supports programming of the on-board PIC16F690.

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The +5V single supply voltage from the PICkit™ 1 Flash Starter Kit board is bypassed with two bulk 1  $\mu$ F capacitors near the header, and two local 0.1  $\mu$ F capacitors (one for each Integrated Circuit (IC)).

A 6-pin header for ICSP™ (In-Circuit Serial Programming™) is available as an alternate interface for programming the on-board PIC16F690. This allows the user to modify the program that comes with the Humidity Sensor PICtail™ Demo Board (with the MPLAB® ICD 2 or PICkit™ 2 microcontroller programmer).



**FIGURE 1-1:** Humidity Sensor PICtail™ Demo Board Block Diagram.

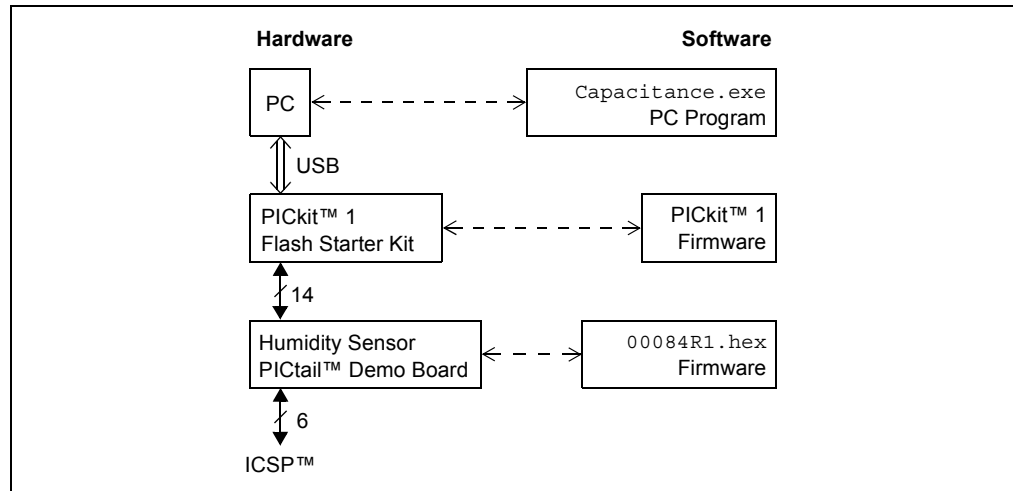
The test points make it easier to test key points in the circuit using common lab equipment. The test points are:

- GND – Is connected to ground plane, and is for any lab equipment
- +5V – Positive supply voltage (at board edge); it provides a means to power this board with a laboratory power supply (when not connected to the PICkit™ 1 Flash Starter Kit)
- VINT – Integrator's input (a square wave during measurements)
- VCM – Op amp's common mode voltage (at its inverting input)
- VSEN – Integrator's output of the integrator (a triangle wave during measurements)

More details on the circuit and on its design can be found in **Appendix A. "Schematic and Layouts"** and AN1016, "Detecting Small Capacitive Sensors Using the MCP6291 and PIC16F690 Devices" (DS01016).

## 1.4 ASSOCIATED TOOLS

Figure 1-2 shows the block diagram of the hardware and software tools that the Humidity Sensor PICtail™ Demo Board is designed to work with. More information on these tools can be found in the “**Recommended Reading**” section.



**FIGURE 1-2:** Measurement Set-up Block Diagram.

### 1.4.1 Humidity Sensor PICtail™ Demo Board

This board is described in **Section 1.3 “Humidity Sensor PICtail™ Demo Board”**.

### 1.4.2 Firmware for the Humidity Sensor PICtail™ Demo Board

00084R1.hex is the firmware file that supports the Humidity Sensor PICtail™ Demo Board application. It implements the measurement routines and the data communications with the PICkit™ 1 Flash Starter Kit.

### 1.4.3 ICSP™ Header

The ICSP header provides a means to program the PIC16F690. It is intended for connection to devices that program the on board PIC16F690, such as the MPLAB® ICD 2 (DV164005) and the PICkit™ 2 Microcontroller Programmer (DV164120).

### 1.4.4 PICkit™ 1 Flash Starter Kit

The PICkit 1 Flash Starter Kit (DV164101) programs PICmicro® microcontrollers. It is used to program the PIC16F690, and provides a communications link with the PC. The PICkit™ 1 Flash Starter Kit's PIC16C745 has a USB port that communicates with the Humidity Sensor PC Program. It also connects to the Humidity Sensor PICtail™ Demo Board (the on-board PIC16F690) via a header (see Figure 2-1).

This board provides a single +5V supply voltage for the daughter board. It can drive up to 5 µF on the supply; a larger capacitance may interfere with program timing.

### 1.4.5 PICkit™ 1 Firmware

This software resides on the PICkit™ 1 Flash Starter Kit's PIC16C745 microcontroller. Use version 2.0.2 or later.

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## 1.4.6 PC Platform

The Personal Computer (PC) shown in Figure 1-2 needs to run on Windows® 98 SE or later. It provides a convenient interface for the user, communicates with the other boards and provides power through the USB connection.

## 1.4.7 Humidity Sensor PC Program

The `capacitance.exe` PC Program communicates with the PIC16F690 MCU on the Humidity Sensor PICtail™ Demo Board through the USB port on the PICKit™ 1 Flash Starter Kit. It also imports data through the same connections and displays them.

The user inputs the board configuration, and can select to view either capacitance or relative humidity (assuming the HS1101LF sensor is plugged in).

## 1.5 ASSEMBLY CODE MODULES

The following assembly code modules (for the PIC16F690) make up the Humidity Sensor project:

- `main.inc` - contains I/O port and global defines used throughout the project
- `main.asm` - contains the main executive routine including configuration bit assignments
- `initialize_f690.asm` - initializes the PIC16F690 to known initial values
- `capacitance.asm` - reads capacitance using a dual slope integration technique
- `humidity.inc` - contains PwLI table segment values
- `humidity.asm` - contains PwLI routine to convert capacitance to %RH humidity
- `ssc.asm` - contains Synchronous Serial Communications (SSC), which is a synchronous serial communications protocol between a target PICmicro® microcontroller (MCU) and the PICKit™ 1 Flash Starter Kit or PICKit™ 2 Starter Kit
- `16f690.lkr` - linker script for Humidity Sensor project

These files can be downloaded from the Microchip web site ([www.microchip.com](http://www.microchip.com)) and are contained in the "00084R1.zip" file.

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## Chapter 2. Setup and Installation

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### 2.1 INTRODUCTION

This chapter shows how to set up the Humidity Sensor PICTail™ Demo Board. Items discussed in this chapter include:

- Required Tools
- Connecting the Humidity Sensor PICTail™ Demo Board
- Set-up Verification

### 2.2 REQUIRED TOOLS

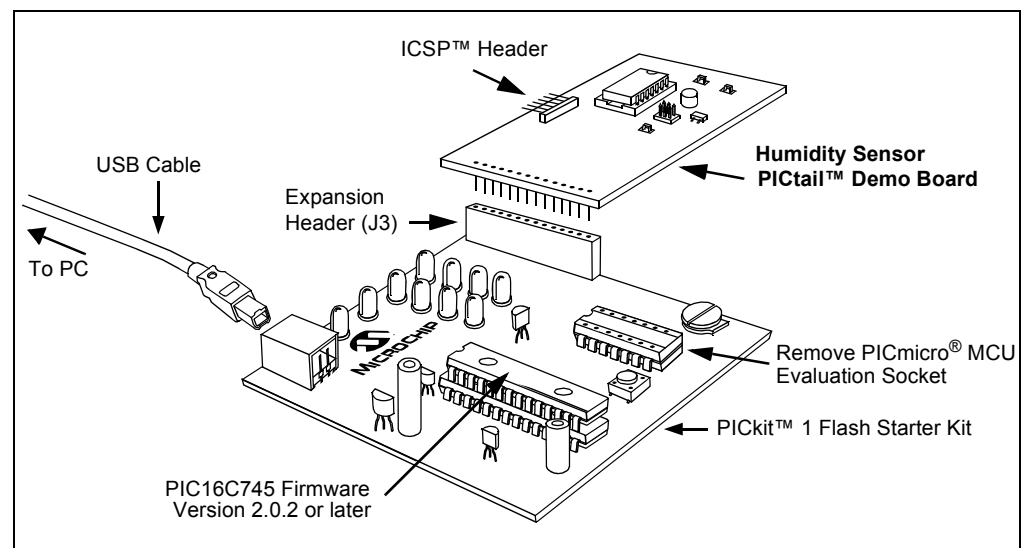
The PICKit™ 1 Flash Starter Kit User's Guide explains how to set up the PC and the PICKit™ 1 Flash Starter Kit. Use firmware version 2.0.2 or later.

The PICKit™ 1 Flash Starter Kit CD-ROM (DS40049) contains many of the necessary files.

The `capacitance.exe` PC program comes with the Humidity Sensor PICTail™ Demo Board CD-ROM (Version v1.07.01 or later).

### 2.3 SETTING UP THE HUMIDITY SENSOR PICTAIL™ DEMO BOARD

This section discusses the primary method for setting up the Humidity Sensor PICTail™ Demo Board. An exploded view of how the different boards connect is shown in Figure 2-1.



**FIGURE 2-1:** Board Connections for PICKit™ 1 Flash Starter Kit.

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## 2.3.1 PICKit™ 1 Flash Starter Kit

1. Remove any PICmicro microcontroller that may be in the Evaluation Socket.
2. Connect the USB cable to the PC and to the PICKit™ 1 Flash Starter Kit board. The status LEDs (green POWER and yellow BUSY in the LED array) should light up.

It is easiest to use this board when it lays directly on a bench top.

## 2.3.2 Humidity Sensor PICtail™ Demo Board

1. Setup Board (first time only); connect shunt to jumper JP1 at the 0.1 pF / position (0.1 pF / count).
2. Plug this board into the PICKit 1 Flash Starter Kit's expansion header J3 (as shown in Figure 2-1) without covering the LED array. There should be no change in the status LEDs on the PICKit™ 1 Flash Starter Kit board after it is plugged in.

The PIC16F690 comes with the 00084R1.hex file already programmed.

## 2.3.3 Humidity Sensor PC Program

1. Run the installer program, AN1016 install.exe (which places the executable file capacitance.exe in the desired directory).
2. Run the capacitance.exe PC Program to start the Graphical User Interface (GUI).

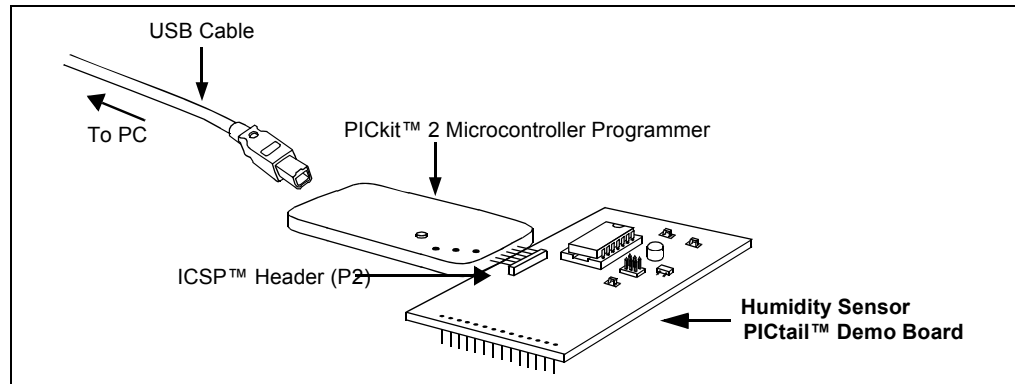
## 2.3.4 Set-up Verification

1. Check Basic Functionality.
  - a) Place one of the capacitors that came in the shipping box (nominal values of 10 pF, 180 pF, 1.0 nF and 100 nF) into the Csen socket.
  - b) Follow the steps 1.a. through 1.g. in **Section 3.3 “Using the Humidity Sensor PC Program”**.
  - c) The reading should be within  $\pm 5\%$  (for 10 pF, 180 pF, and 1.0 nF capacitors), or  $\pm 10\%$  (for the 100 nF capacitor only), of the nominal value.
2. Check HS1101LF Sensor.
  - a) Place the HS1101LF sensor into the Csen socket.
  - b) Follow the steps 2.a. through 2.f. in **Section 3.3 “Using the Humidity Sensor PC Program”**.
  - c) The reading should be similar to that of a calibrated relative humidity sensor placed nearby.

## 2.4 CONNECTING TO ALTERNATE TOOLS

### 2.4.1 PICkit™ 2 Microcontroller Programmer

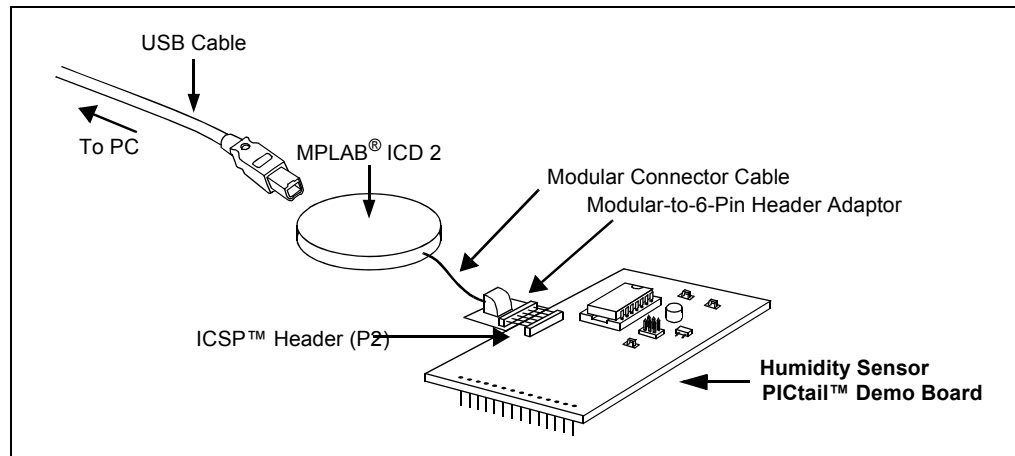
An exploded view of how the PICkit™ 2 microcontroller programmer connects to the Humidity Sensor PICtail™ Demo Board is shown in Figure 2-2. This setup is an alternative way to reprogram the PIC16F690 on the Humidity Sensor PICtail™ Demo Board.



**FIGURE 2-2:** Board Connections for PICkit™ 2 Microcontroller Programmer.

### 2.4.2 MPLAB® ICD 2

An exploded view of how the MPLAB® ICD 2 connects to the Humidity Sensor PICtail™ Demo Board is shown in Figure 2-3. This setup is an alternative way to reprogram the PIC16F690 on the Humidity Sensor PICtail™ Demo Board.



**FIGURE 2-3:** Board Connections for MPLAB® ICD 2.

# Humidity Sensor PICtail™ Demo Board User's Guide

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NOTES:



## Chapter 3. Operation

### 3.1 INTRODUCTION

This demonstration board makes it easy to explore the operation of a humidity sensor application. Items discussed in this chapter include:

- Configuring the Humidity Sensor PICTail™ Demo Board
- Using the Humidity Sensor PC Program
- Programming the PIC16F690
- Humidity Sensor Calibration

### 3.2 CONFIGURING THE HUMIDITY SENSOR PICTAIL™ DEMO BOARD

1. Setup the board as explained in **Chapter 2. “Setup and Installation”**.
2. Place a humidity sensor or capacitor in the C<sub>SEN</sub> socket.
  - a) Humirel's HS1101LF capacitive humidity sensor.
  - b) A capacitor of known value.
3. Connect the shunt to jumpers JP1 – JP3 according to the measurement resolution and capacitance values desired; see Table 3-1.
4. Allow sufficient time for the humidity sensor to respond to changes in the environment (about 30 seconds for the HS1101LF).

**TABLE 3-1: JUMPER SELECTION – MODIFIED CIRCUIT**

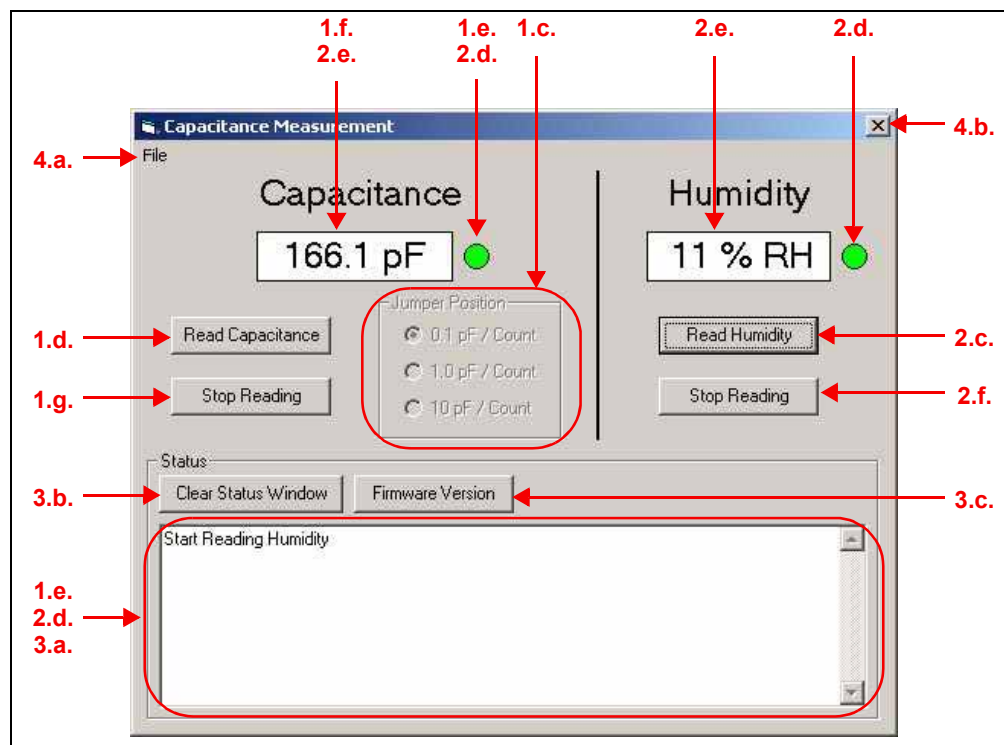
Jumper Selected	Measurement Resolution (pF / count)	C <sub>SEN</sub> Range	R <sub>INT</sub> (Ω)	Comments
JP1	0.1	0.6 pF to 6.5 nF	6.65 M	Use for HS1101LF sensor
JP2	1	6 pF to 65 nF	665 k	
JP3	10	60 pF to 650 nF	66.5 k	

### 3.3 USING THE HUMIDITY SENSOR PC PROGRAM

The `capacitance.exe` PC Program Graphical User Interface (GUI) is displayed in Figure 3-1. It is a simple program that helps the user to control the functionality of the Humidity Sensor PICTail™ Demo Board and to view the results sent back from that board.

**Note:** This program is intended as an evaluation tool; it does not check for all possible errors. It is the user's responsibility to make sure the GUI and demo board are used under reasonable conditions.

# Humidity Sensor PICtail™ Demo Board User's Guide



**FIGURE 3-1:** "Humidity Sensor PC Program" GUI.

The following steps will help familiarize the user with this GUI. The step numbers are displayed in Figure 3-1.

1. Measure Capacitance ( $C_{SEN}$ ).
  - a) Put capacitor in  $C_{SEN}$ 's socket on the board.
  - b) Select desired resolution on the board (set by shunt and JP1 – JP3).
  - c) Input the resolution.
  - d) Click on the **READ CAPACITANCE** button.
  - e) The green light turns on and the status window is updated.
  - f) Read the current capacitance value (which is updated about once a second).
  - g) Click on the **STOP READING** button.
2. Measure Humidity (RH).
  - a) Put the HS1101LF sensor in  $C_{SEN}$ 's socket on the board.
  - b) Select the 0.1 pF / count resolution on the board (put shunt across JP1).
  - c) Click on the **READ HUMIDITY** button (a resolution of 0.1 pF / count is assumed by the GUI).
  - d) The green lights turn on and the status window is updated.
  - e) Read the current capacitance value and relative humidity (which are updated about once a second).
  - f) Click on the **STOP READING** button.
3. Check Program Status.
  - a) Read the status history in the status window.
  - b) Click the **CLEAR STATUS WINDOW** button to clear the status history.
  - c) Click the **FIRMWARE VERSION** button to see the version displayed in the status window.
4. Quit the Program.
  - a) Click the **FILE** button, then the **EXIT** button that pops up. Or click on the **WINDOWS' EXIT** button.

## 3.4 HUMIDITY SENSOR CALIBRATION

If desired, the capacitive humidity sensor used on this board can be calibrated. Manufacturing tolerances, aging and changes in circuit operating conditions (i.e., supply voltage and temperature) may cause errors larger than desired. Many reputable companies provide humidity calibration equipment and/or services.

There are two common approaches to calibrating these sensors:

1. Put sensor in an atmosphere with well controlled RH.
2. Use another, more accurate sensor to measure the RH.

In both cases, there are two areas of concern. First, the RH can change rapidly across time and position, making an accurate calibration difficult to do. Second, it takes time for humidity sensors to settle to an accurate value. Some can take many minutes to settle properly.

# Humidity Sensor PICtail™ Demo Board User's Guide

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NOTES:

## Chapter 4. Modified Circuit

### 4.1 INTRODUCTION

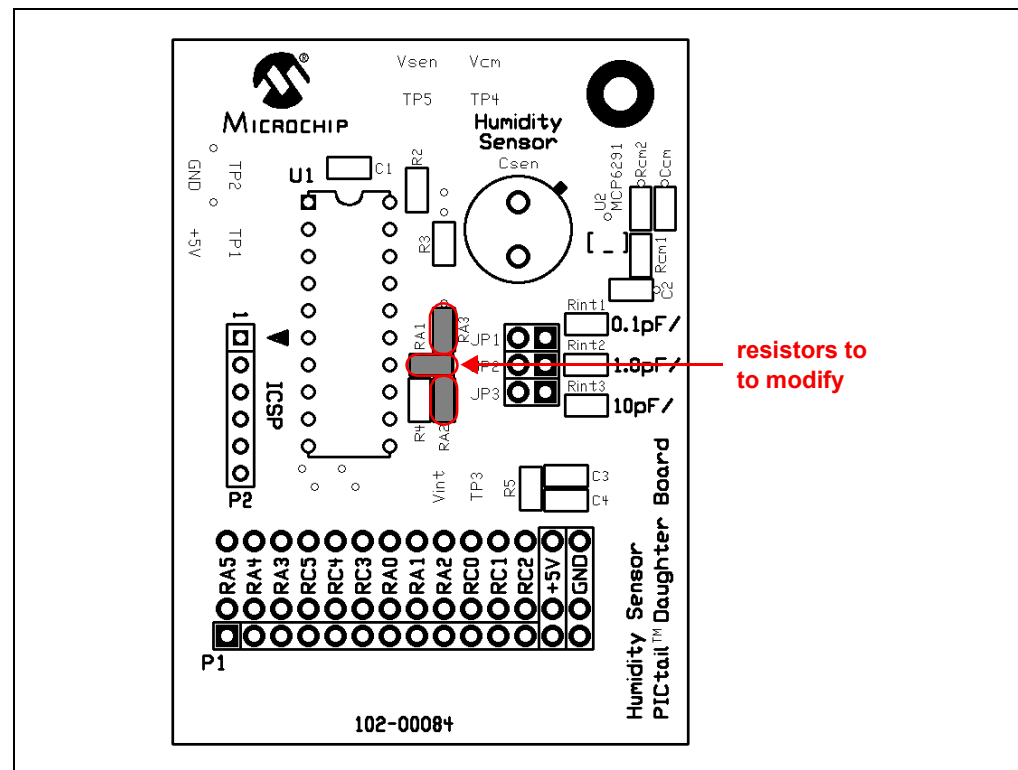
The modifications described here will reduce the current going into the integrator ( $I_{INT}$ ) by a factor of 100 ×, so the measurement resolution increases by the same factor. These modifications are intended for measuring small capacitances. See AN1016 for more details on this modified circuit's performance.

### 4.2 THE “REDUCED CURRENT” CIRCUIT

#### 4.2.1 Modifications

Figure 4-1 shows the Humidity Sensor PICTail™ Demo Board top silk-screen. Figure 4-1 also shows the locations of the resistors that need to be modified to implement the “Reduced Current” circuit discussed in application note AN1016:

1. Remove (de-solder) the 1Ω resistor, RA1, already on the board.
2. Refer to **Appendix B. “Bill Of Materials (BOM)”**, **Section B.3** for the BOM for the three resistors (provided by the user) that need to be soldered onto the board.
  - RA1 = 1 MΩ
  - RA2 = RA3 = 20 kΩ
3. Solder RA1, RA2 and RA3 onto the board.



**FIGURE 4-1:** Resistor Modifications.

# Humidity Sensor PICtail™ Demo Board User's Guide

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## 4.2.2 Modified Configuration

Configure the Humidity Sensor PICtail™ Demo Board as follows:

1. Start with the configuration in **Section 3.2**.
2. Connect the shunt to jumpers JP1 – JP3 according to the modified measurement resolutions and capacitance values desired; see Table 4-1.

**TABLE 4-1: JUMPER SELECTION – MODIFIED CIRCUIT**

Jumper Selected	Measurement Resolution (pF / count)	C <sub>SEN</sub> Range	R <sub>INT</sub> (Ω)
JP1	0.001	0.6 pF to 65 pF	6.65 M
JP2	0.01	6 pF to 650 pF	665 k
JP3	0.1	60 pF to 6.5 nF	66.5 k

## 4.2.3 Interpreting the Output from the Humidity Sensor PC Program

The `capacitance.exe` PC program displays measured capacitance values assuming the Humidity Sensor PICtail™ Demo Board has not been modified. To correct the displayed values, move the displayed decimal point to the left two places (e.g., 321.0 pF is actually 3.210 pF).

**Note:** The decimal point *must* be moved two places to the left by the user for the modified circuit.

The RH numbers make no sense for measurements produced by the modified board; they are based on another circuit configuration (see **Section 3.2**).

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## Appendix A. Schematic and Layouts

---

### A.1 INTRODUCTION

This appendix contains the schematics and layouts for the Humidity Sensor PICTail™ Demo Board.

### A.2 HIGHLIGHTS

The Humidity Sensor PICTail™ Demo Board is constructed using a two-layer Printed Circuit Board (PCB). The top layer is for components and traces. The bottom layer is the ground plane.

Information on this board includes:

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

### A.3 DEMONSTRATION BOARD DESCRIPTION

A schematic is shown in Figure A-1 and Figure A-2. Csen is the humidity sensor or capacitor. Op amp, U2, and the components, Csen and  $R_{INT}$  (Rint1, Rint2 or Rint3), form an inverting (Miller) integrator. The jumpers, JP1 – JP3, select the  $R_{INT}$  value of choice (6.65 M $\Omega$ , 665 k $\Omega$  or 66.5 k $\Omega$ ), which sets the measurement resolution (0.1 pF / count, 1 pF / count or 10 pF / count). The microcontroller, U1, sends a square wave at its pin 14 to the input of the integrator. The integrator converts it to a triangle wave, which is seen at the microcontroller's pin 15. There is a comparator internal to U1 which compares the voltage at pin 15 to one of two reference levels;  $V_{RL} = 0.125 V_{DD}$  or  $V_{RH} = 0.500 V_{DD}$ . The microcontroller changes the logic value output at pin 14 each time the triangle wave exceeds one of these two limits.

The microcontroller (U1) measures the time between changes in logic values at pin 14 ("integration times"), and calculates a capacitance value for Csen. This capacitance value ( $C_{SEN}$ ) is converted to Relative Humidity (RH) for Humirel's HS1101LF humidity sensor.  $C_{SEN}$  and RH are then sent to the PICkit™ 1 Flash Starter Kit, which sends them to the `capacitance.exe` PC program on the PC via the USB cable.

<p><b>Note:</b> Converting Csen to RH for other humidity sensors must be done either manually or by modifying the PIC16F690 firmware (i.e., the linear interpolation table).</p>
--

RA1 – RA3 are used for the "Op Amp Integrator with Reduced Current" described in AN1016 and **Chapter 4. "Modified Circuit"**. Rcm1, Rcm2 and Ccm provide a mid-supply reference voltage for the op amp, U2.

# Humidity Sensor PICtail™ Demo Board User's Guide

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The test points, TP3 – TP5, have 10 k $\Omega$  placed in series to isolate the circuit from external measurement equipment. This will help prevent over-voltage events, and will help the op amp, U2, operate in a stable condition.

- a) This is a two-layer board. It has a solid ground plane on the bottom layer to minimize EMC issues, and routes the traces in the top layer. The complete schematic is in Figure A-1 and Figure A-2, the board layer plots in Figure A-3, Figure A-4 and Figure A-5. The Bill of Materials (BOM) is in **Appendix B. “Bill Of Materials (BOM)”**. The Gerber files for this board are available on the Microchip web site ([www.microchip.com](http://www.microchip.com)) and are contained in the zip file 00084R1.zip.

## A.4 THE “REDUCED CURRENT” MODIFICATION

Figure A-1 shows the Humidity Sensor PICtail™ Demo Board as it comes from Microchip. This board can be modified by the user to implement the “Reduced Current” circuit discussed in application note AN1016 and **Chapter 4. “Modified Circuit”**.

## A.5 ADDITIONAL COMMENTS

The demonstration board includes test points for convenience on the bench. The “+5V” and “GND” test points (TP1 and TP2) connect to the board's supply voltages.

<p><b>Note:</b> Do <b>NOT</b> connect a power supply to the “+5V” and “GND” test points, unless the board is <b>NOT</b> connected to the PICkit™ 1 Flash Starter Kit (i.e., it stands alone).</p>
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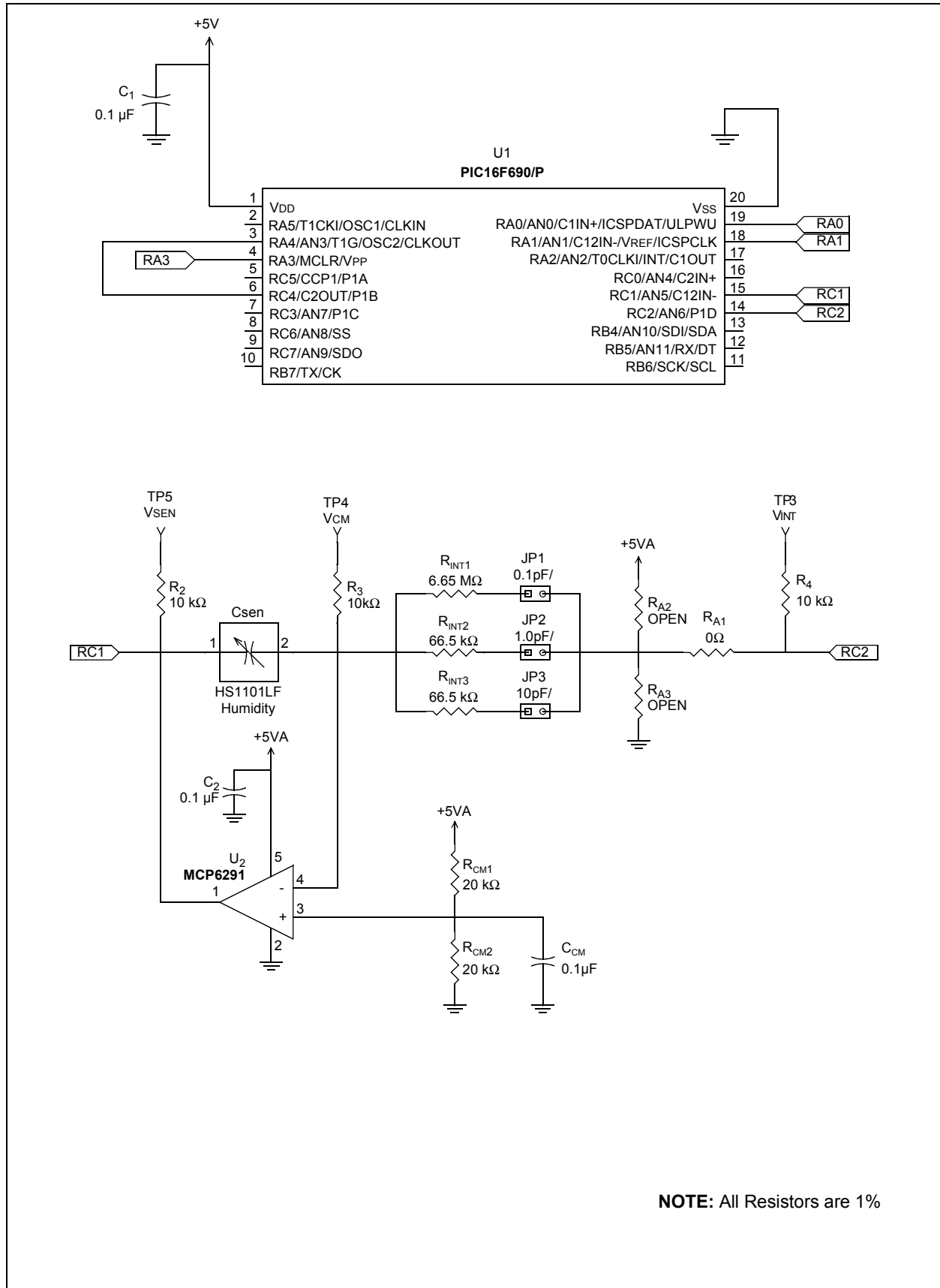
The “VINT” test point (TP3) connects to U1's pin 14 to allow the user to monitor the square wave into the integrator. The “VCM” test point (TP4) allows the user to measure the op amp's common mode input voltage. The “VSEN” test point (TP5) allows connection to the op amps output to allow the user to monitor the triangle wave at the integrator's output.

The PICkit™ 1 Flash Starter Kit provides a +5V single supply voltage. It can drive up to 5  $\mu$ F on the supply; a larger capacitive load causes current loading and timing issues. This demonstration board also uses the +5V single supply voltage. It has two 1  $\mu$ F bulk bypass capacitors and two 0.1  $\mu$ F local bypass capacitors.

High frequency design practices are used to minimize digital interference:

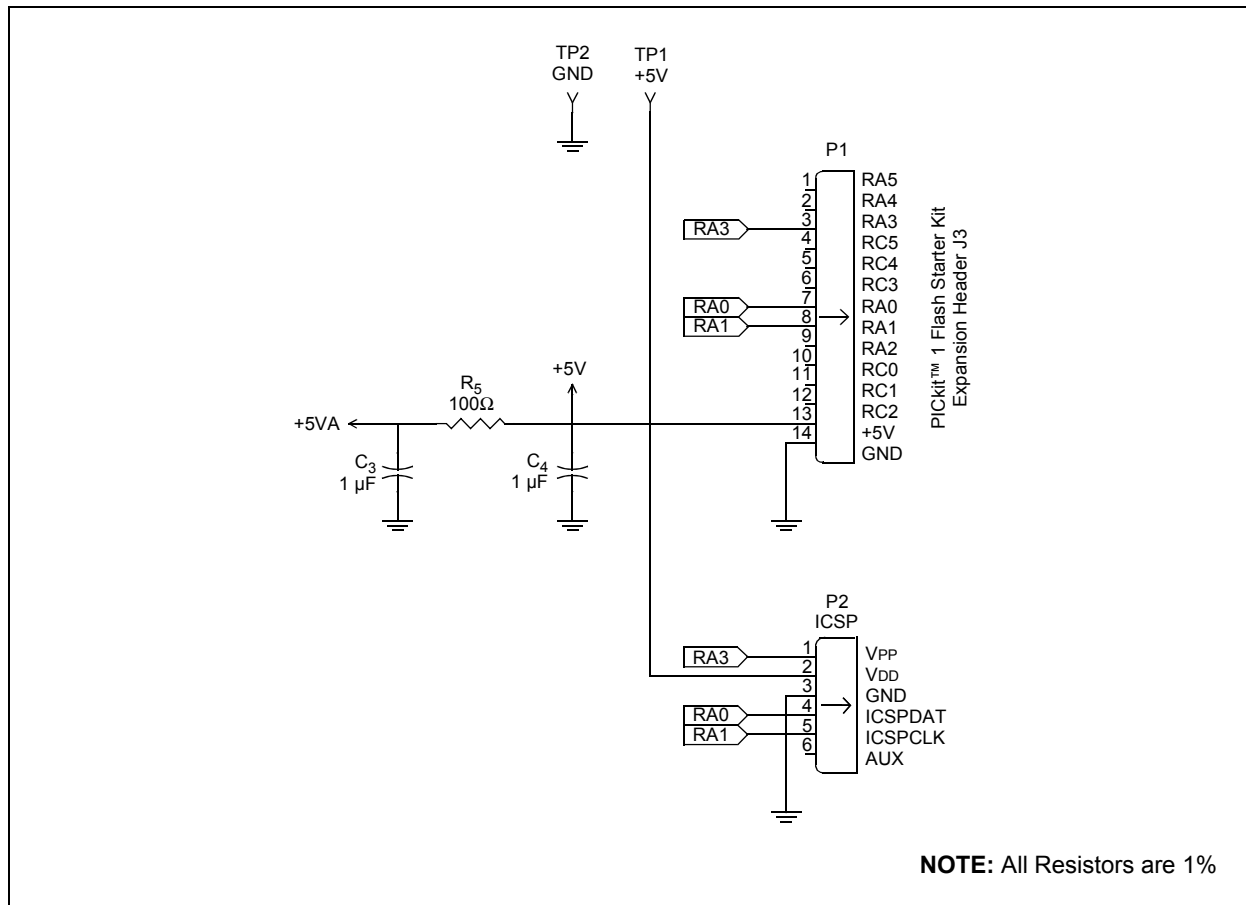
- Solid ground plane
- Surface mount devices for the analog circuitry
- Separate digital and analog lines and sections



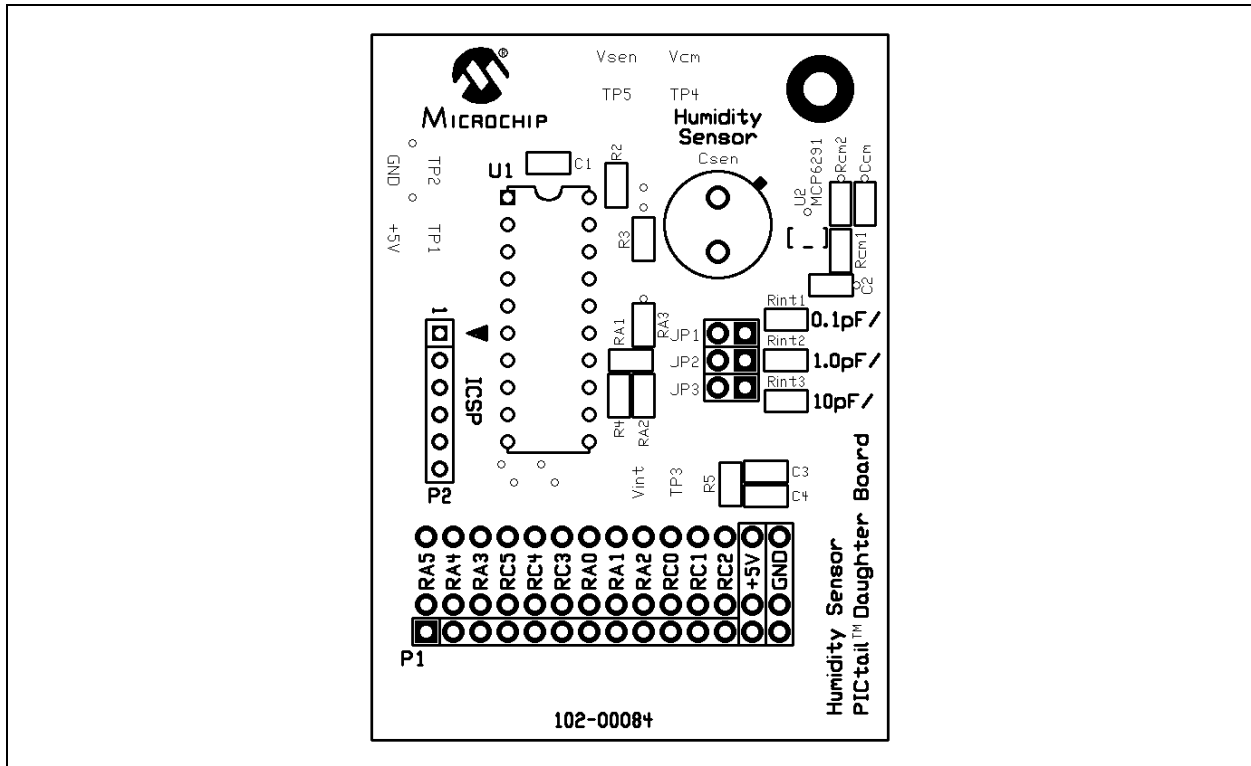


**FIGURE A-1:** Board – Schematic.

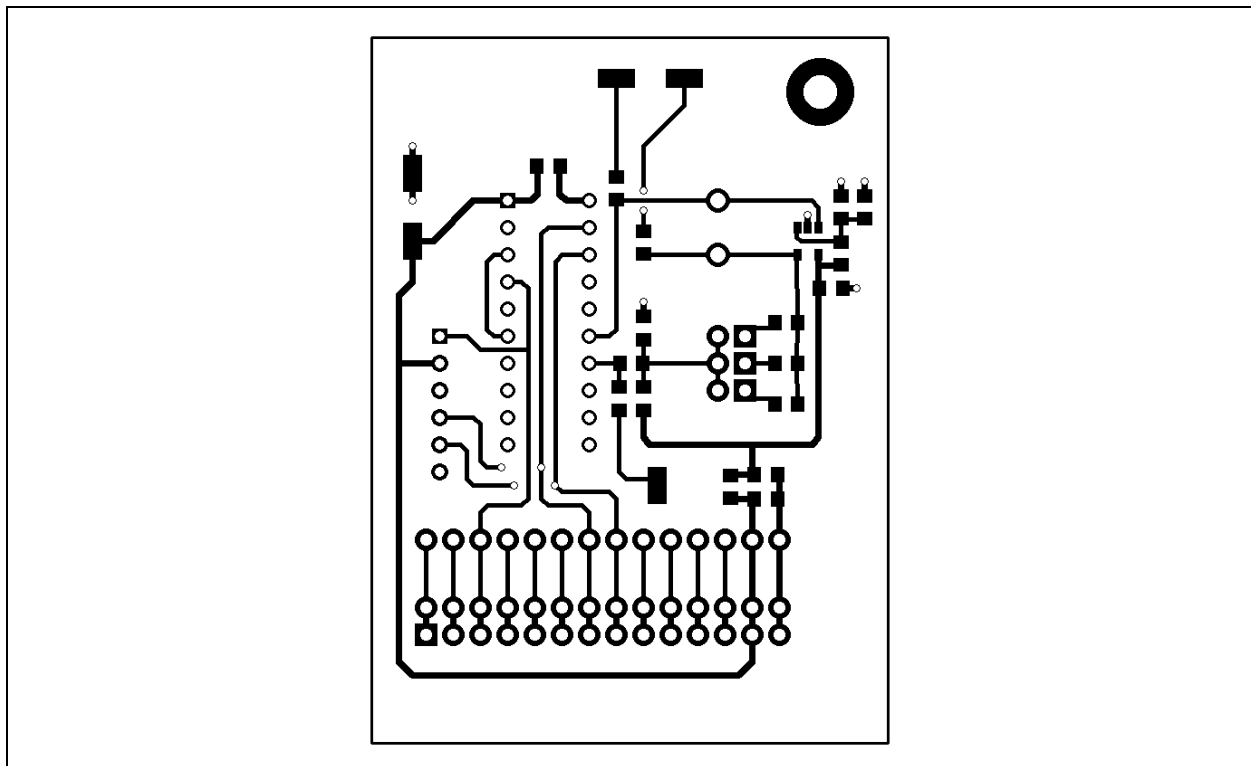
# Humidity Sensor PICtail™ Demo Board User's Guide



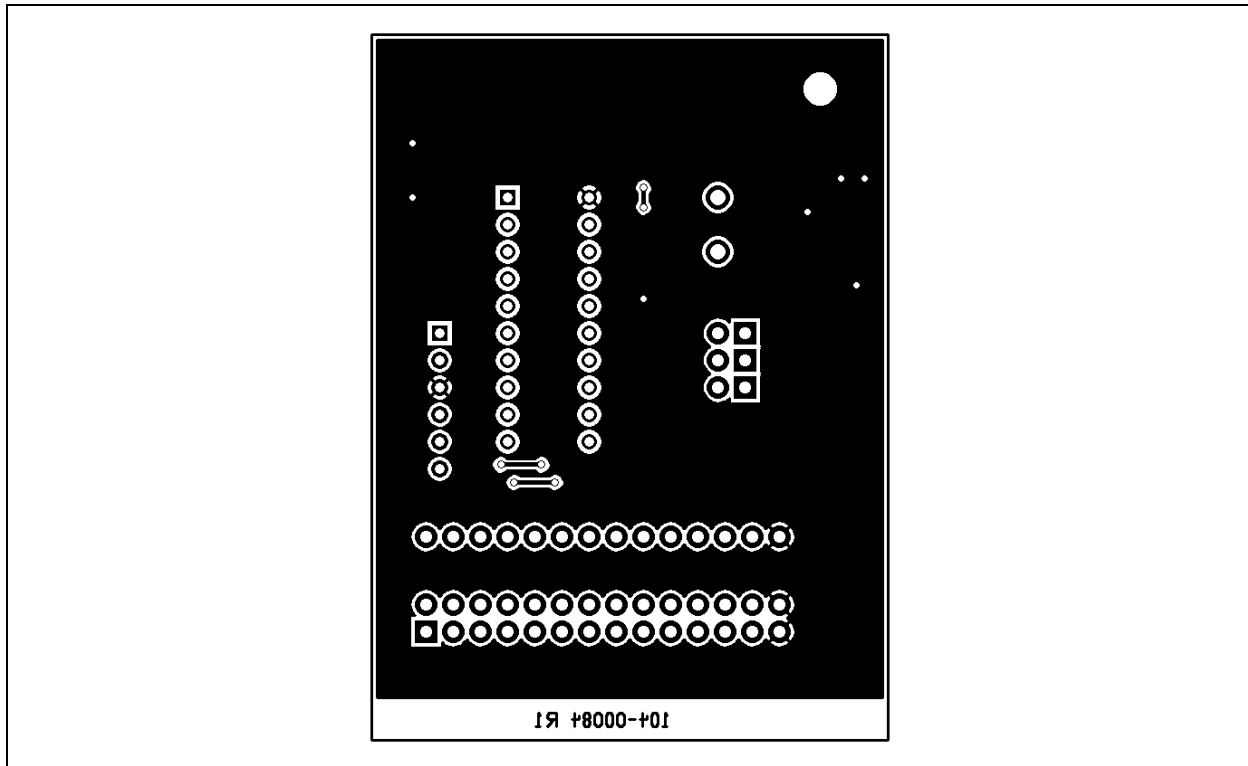
**FIGURE A-2:** Board – Schematic. (Continued)



**FIGURE A-3:** Board – Top Silk-Screen.



**FIGURE A-4:** Board – Top Metal Layer.



**FIGURE A-5:** Board – Bottom Metal Layer.

## Appendix B. Bill Of Materials (BOM)

### B.1 HUMIDITY SENSOR PICTAIL™ DEMO BOARD BOM

Table B-1 shows the BOM for the Humidity Sensor PICTail™ Demo Board as it comes from Microchip.

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

Qty	Reference	Description	Manufacturer	Part Number
1	CSEN	Ceramic Capacitor, Monolithic, 180 pF, 50V, 5%, C0G, Radial 0.2"	EPCOS Inc.	B37979N5181J051
3	C1, C2, CCM	Ceramic Capacitor, 100 nF, 50V, 10%, X7R, 0805 SMD	Kemet	C0805C104K5RACTU
2	C3, C4	Ceramic Capacitor, 1.0 $\mu$ F, 16V, 10%, X7R, 0805 SMD	Kemet	C0805C105K4RACTU
1	P1	Header, 1 $\times$ 14, 0.100" Pitch, Vertical, Gold	Molex/Waldom Electronics	22-28-4143
1	P2	Header, 1 $\times$ 6, 0.100" Pitch, Right Angle, Gold	Molex/Waldom Electronics	22-28-8062
1	JP1 – JP3	Header, 2 $\times$ 3, 0.100" Pitch, Vertical, Gold	Molex/Waldom Electronics	10-89-1061
1	(for JP1 – JP3)	Shunt, 1 $\times$ 2, With Handle, Gold	AMP/Tyco Electronics	881545-2
1	RA1	Chip Resistor, 1.00 $\Omega$ , 1/8W, 5%, 0805 SMD ( <b>Note 1</b> )	Yageo America	RC0805FR-071RL
0	RA2, RA3	(not used; left open) ( <b>Note 1</b> )	—	—
1	R5	Chip Resistor, 100 $\Omega$ , 1/8W, 1%, 0805 SMD	Yageo America	RC0805FR-07100RL
3	R2 – R4	Chip Resistor, 10.0 k $\Omega$ , 1/8W, 1%, 0805 SMD	Yageo America	RC0805FR-0710KL
2	RCM1, RCM2	Chip Resistor, 20.0 k $\Omega$ , 1/8W, 1%, 0805 SMD	Yageo America	RC0805FR-0720KL
1	RINT3	Chip Resistor, 66.5 k $\Omega$ , 1/8W, 1%, 0805 SMD	Yageo America	RC0805FR-0766K5L
1	RINT2	Chip Resistor, 665 k $\Omega$ , 1/8W, 1%, 0805 SMD	Yageo America	RC0805FR-07665KL
1	RINT1	Chip Resistor, 6.65 M $\Omega$ , 1/8W, 1%, 0805 SMD	Yageo America	RC0805FR-076M65L
5	TP1 – TP5	PCB Test Point, Compact, SMT	Keystone Electronics	5016
1	U1	PIC16F690, PICmicro® Microcontroller, 20-pin, 20 MHz, PDIP-20	Microchip	PIC16F690-I/P
1	U2	MCP6291, Single Op Amp, 10 MHz, $V_{OS} \leq \pm 3$ mV, SOT-23-5	Microchip	MCP6291-E/OT
2	(for CSEN)	Pin Recepticle, 0.015" to 0.025" dia., 0.060" hole dia.	Mill-Max®	0669-0-15-15-30-27-10-0
1	(for U1)	IC Socket, 20-pin DIP, Gold Plated, 0.400"	Mill-Max®	110-13-420-41-001000
1	(for PCB mounting)	Stand-off, Hex, 1.000", 4 $\times$ 40 Thread, Nylon, 0.285" max. O.D	Keystone Electronics	1902C
1	(for PCB mounting)	Machine Screw, Phillips, 4 $\times$ 40 Thread, 1/4 in long, Nylon	Digi-Key	H542-ND
1	PCB	Bare Printed Circuit Board	—	—

**Note 1:** These resistors are intended for the "Reduced Current" circuit modifications detailed in Table B-3.

# Humidity Sensor PICtail™ Demo Board User's Guide

## B.2 BOM FOR HUMIDITY SENSOR AND OTHER CAPACITORS IN BOX

Table B-2 lists capacitors included separately in the Humidity Sensor PICtail™ Demo Board's shipping box. These capacitors or the HS1101LF sensor will fit in the Csen pin receptacles. The capacitors provide a means for quickly evaluating circuit operation.

**TABLE B-2: BILL OF MATERIALS FOR HUMIDITY SENSOR AND OTHER CAPACITORS**

Qty	Reference	Description	Manufacturer	Part Number
1	CSEN	Relative Humidity Sensor, Capacitive Cell, 180 pF, 5V, 1% to 99% RH, -40°C to +140°C	Humirel	HS1101LF
1	CSEN	Ceramic Capacitor, Monolithic, 100 pF, 50V, 5%, C0G, Radial 0.2"	EPCOS Inc.	B37979N5101J000
1	CSEN	Ceramic Capacitor, Monolithic, 1.0 nF, 50V, 5%, C0G, Radial 0.2"	EPCOS Inc.	B37979G5102J000
1	CSEN	Ceramic Capacitor, Monolithic, 100 nF, 50V, 10%, X7R, Radial 0.2"	EPCOS Inc.	B37987F5104K000

## B.3 BOM FOR “REDUCED CURRENT” MODIFICATIONS

Table B-3 shows the components for the “Reduced Current” circuit modifications discussed in application note AN1016 and **Chapter 4. “Modified Circuit”**.

**TABLE B-3: BILL OF MATERIALS FOR “REDUCED CURRENT” MODIFICATIONS**

Qty	Reference	Description	Manufacturer	Part Number
2	RA2, RA3	Chip Resistor, 20.0 kΩ, 1/8W, 1%, 0805 SMD	Yageo America	RC0805FR-0720KL
1	RA1	Chip Resistor, 1.00 MΩ, 1/8W, 1%, 0805 SMD	Yageo America	RC0805FR-071ML

# Bill Of Materials (BOM)

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NOTES:



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