



PICDEM™ Touch Sense 2 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 “DSXXXXA”, where “XXXX” 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 you use the PICDEM Touch Sense 2 Demo Board. Items discussed in this chapter include:

- Document Layout
- Conventions Used in this Guide
- Warranty Registration
- Recommended Reading
- The Microchip Web Site
- Development Systems Customer Change Notification Service
- Customer Support
- Document Revision History

DOCUMENT LAYOUT

This document describes how to use the Touch Sense 2 Demo Board as a development and demonstrative tool for PIC24F MCU device capabilities and features. The manual layout is as follows:

- **Chapter 1. Introduction to the Demo Board** – This chapter introduces the Touch Sense 2 Demo Board and provides an overview of its features.
- **Chapter 2. The Demonstration Application** – This chapter describes the preprogrammed capacitive touch sense demo application.
- **Chapter 3. Using the mTouch™ Sensing Solution** – This chapter describes the diagnostic software and how to use it with the Touch Sense 2 Demo Board.
- **Chapter 4. Demo Board Hardware** – This chapter provides a functional overview of the Touch Sense 2 Demo Board and identifies the major hardware components.
- **Chapter 5. Troubleshooting** – This chapter provides troubleshooting tips for commonly encountered issues.
- **Appendix A. Demo Board Schematics** – This appendix provides detailed schematic diagrams of the demo board.

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CONVENTIONS USED IN THIS GUIDE

This manual uses the following documentation conventions:

DOCUMENTATION CONVENTIONS

Description	Represents	Examples
Arial font:		
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>Save</i></u>
Bold characters	A dialog button	Click OK
	A tab	Click the Power tab
Text in angle brackets < >	A key on the keyboard	Press <Enter>, <F1>
Courier New font:		
Plain Courier New	Sample source code	<code>#define START</code>
	Filenames	<code>autoexec.bat</code>
	File paths	<code>c:\mcc18\h</code>
	Keywords	<code>_asm, _endasm, static</code>
	Command-line options	<code>-Opa+, -Opa-</code>
	Bit values	<code>0, 1</code>
	Constants	<code>0xFF, 'A'</code>
Italic Courier New	A variable argument	<i>file.o</i> , where <i>file</i> can be any valid filename
Square brackets []	Optional arguments	<code>mcc18 [options] file [options]</code>
Curly brackets and pipe character: { }	Choice of mutually exclusive arguments; an OR selection	<code>errorlevel {0 1}</code>
Ellipses...	Replaces repeated text	<code>var_name [, var_name...]</code>
	Represents code supplied by user	<code>void main (void) { ... }</code>

WARRANTY REGISTRATION

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

RECOMMENDED READING

This user's guide describes how to use the PICDEM Touch Sense 2 Demo Board. Other useful documents are listed below. The following Microchip documents are available and recommended as supplemental reference resources.

Readme Files

For the latest information on using other tools, read the tool-specific Readme files in the Readmes subdirectory of the MPLAB® IDE installation directory. The Readme files contain update information and known issues that may not be included in this user's guide.

PIC24F Family Reference Manual

This reference manual explains the operation of the PIC24F microcontroller family architecture and peripheral modules. The specifics of each device family are discussed in the individual family's device data sheet. Users are specifically directed to **Section 11. "Charge Time Measurement Unit (CTMU)"** (available individually as DS39724) for a detailed discussion of this module, which is at the heart of the capacitive touch sense demonstration.

This useful manual is on-line in sections at the Technical Documentation section of the Microchip web site. Refer to these for detailed information on PIC24F device operation.

Device Data Sheets and Flash Programming Specifications

Refer to the appropriate device data sheet for device-specific information and specifications. Also, refer to the appropriate device Flash Programming Specification for information on instruction sets and firmware development. These files may be found on the Microchip web site or from your local sales office.

User may want to specifically refer to the "*PIC24FJ256GB110 Family Device Data Sheet*" (DS39897) for information on the PIC24F microcontroller used in this application.

MPLAB® ASM30, MPLAB® LINK30 and Utilities User's Guide (DS51317)

This document helps you use Microchip Technology's language tools for PIC24F devices based on GNU technology. The language tools discussed are the MPLAB ASM30 Assembler, MPLAB LINK30 Linker, MPLAB LIB30 Archiver/Librarian and other 16-bit device utilities.

MPLAB® C30 C Compiler User's Guide and Libraries (DS51284)

This document helps you use Microchip's MPLAB C30 C compiler to develop your application. MPLAB C30 is a GNU-based language tool, based on source code from the Free Software Foundation (FSF). For more information about FSF, see www.fsf.org.

MPLAB® IDE User's Guide (DS51519)

This document describes how to use the MPLAB IDE integrated development environment, as well as the MPLAB project manager, MPLAB editor and MPLAB SIM simulator. Use these development tools to help you develop and debug application code.

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THE MICROCHIP WEB SITE

Microchip provides online support via our web site at www.microchip.com. This web site is used as a means to make files and information easily available to customers. Accessible by using your favorite Internet browser, the web site contains the following information:

- **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

DEVELOPMENT SYSTEMS CUSTOMER CHANGE NOTIFICATION SERVICE

Microchip's customer notification service helps keep customers current on Microchip products. Subscribers will receive e-mail notification whenever there are changes, updates, revisions or errata related to a specified product family or development tool of interest.

To register, access the Microchip web site at www.microchip.com, click on Customer Change Notification and follow the registration instructions.

The Development Systems product group categories are:

- **Compilers** – The latest information on Microchip C compilers and other language tools. These include the MPLAB C18 and MPLAB C30 C compilers; MPASM™ and MPLAB ASM30 assemblers; MPLINK™ and MPLAB LINK30 object linkers; and MPLIB™ and MPLAB LIB30 object librarians.
- **In-Circuit Emulators** – The latest information on Microchip in-circuit emulators. These include the MPLAB REAL ICE™ and MPLAB ICE 2000 in-circuit emulators.
- **In-Circuit Debuggers** – The latest information on Microchip in-circuit debuggers. These include MPLAB ICD 2 and PICKit™ 2.
- **MPLAB IDE** – The latest information on Microchip MPLAB IDE, the Windows® Integrated Development Environment for development systems tools. This list is focused on the MPLAB IDE, MPLAB IDE project manager, MPLAB editor and MPLAB SIM simulator, as well as general editing and debugging features.
- **Programmers** – The latest information on Microchip programmers. These include the MPLAB PM3 device programmer and the PICSTART® Plus and PICKit 1 and 2 development programmers.

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://support.microchip.com>

DOCUMENT REVISION HISTORY

Revision A (June 2008)

- Initial Release of this Document

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Chapter 1. Introduction to the Demo Board

Thank you for purchasing Microchip Technology's PICDEM Touch Sense 2 Demo Board. This board is intended to introduce and demonstrate the possibilities for capacitive touch sense applications on the PIC24F microcontroller platform.

This chapter introduces the starter kit and provides an overview of its features. Topics covered include:

- Overview
- Operational Requirements
- Initial Board Setup

1.1 OVERVIEW

The PICDEM Touch Sense 2 Demo Board provides a simple platform for developing a variety of capacitive touch sense applications. Despite a simple and low part-count design, the Touch Sense 2 board shows how to implement USB-enabled touch applications with multiple outputs using a single microcontroller.

The USB connection supplies both communications and power to the board; no additional external power supply is needed. For independent operation, the demo board may be disconnected from the PC and powered at test points for independent functionality.

The PC side application that accompanies the demo board allows users to monitor the performance of the touch sensors and calibrate their response. A separate, 6-wire programming interface allows users to replace the pre-programmed demo firmware with their own applications, using Microchip's MPLAB Integrated Development Environment and In-Circuit Serial Programming™ (ICSP™). This allows the board to also be used as a test bed for capacitive touch sense solutions.

1.2 OPERATIONAL REQUIREMENTS

To communicate with and program the Touch Sense 2 Demo Board, the following hardware and software requirements must be met:

- PC compatible system with CD-ROM drive
- One available USB port on the PC, or a powered USB hub
- Microsoft® Windows® XP SP2, or Windows Vista (32-bit)

<p>Note: Only initial testing has been performed on 32-bit Windows Vista for this release. The 64-bit version is not supported at this time.</p>

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1.3 INITIAL BOARD SETUP

With its pre-installed demo application, the PICDEM Touch Sense 2 Demo Board is designed to be used straight out of the box. Except for a single connection to a computer, no additional hardware or configuration is necessary.

1.3.1 Installing the Software

Before connecting the demo board to any computer for the first time, it is important to install the accompanying software on the accompanying CD first. This ensures that the proper USB drivers for communicating with the demo board are installed and ready to recognize the board.

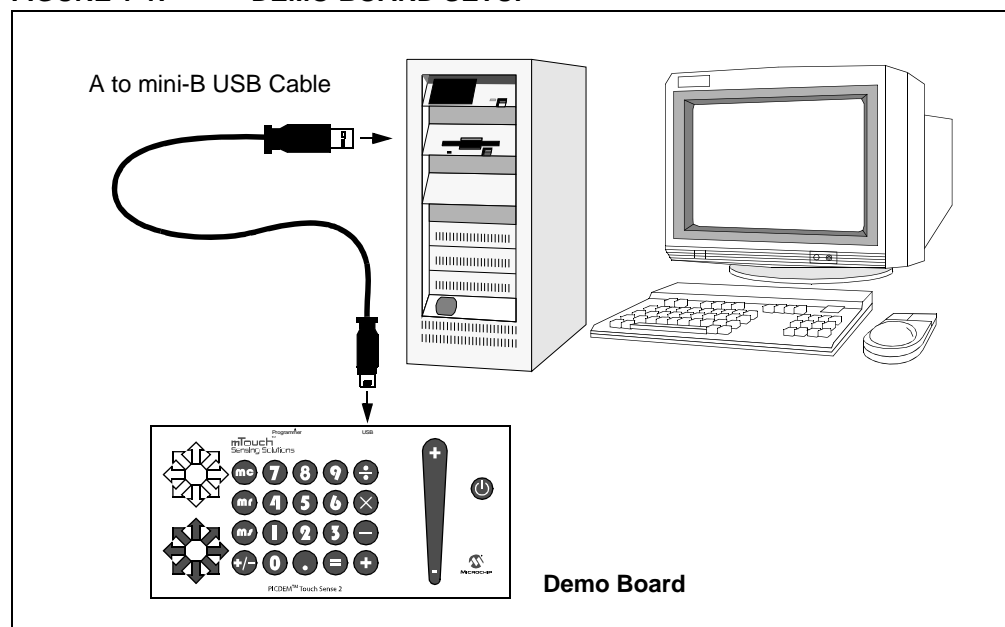
To install the software and driver, insert the demo board CD into the CD-ROM drive. The installation process starts automatically. The process pauses for user responses to accept the Microchip software licenses and to confirm the installation directories; respond appropriately.

1.3.2 Connecting the Hardware

Prior to connection, place the Touch Sense 2 Demo Board on a flat surface near the computer. Check to make sure that there are no objects underneath the board. Once the demo board software is installed, connect the provided USB cable (A to mini-B) to any available USB port on the PC or powered hub, then to the board at the mini-B receptacle (Figure 1-1). The PC USB connection provides communication and power to the board.

Note: Do not touch the underside of the demo board, particularly while it is connected to the computer. Doing so may introduce stray capacitance and affect the board's operation.

FIGURE 1-1: DEMO BOARD SETUP



Introduction to the Demo Board

If the cable is connected correctly, the LEDs for the touch slider on the right side of the demo board run through an animated “chaser” sequence, running from bottom to top and back again. No other LEDs should be lit. At the same time, a sequence of pop-up balloons in the system tray (lower right of desktop) should appear, stating that (1) new hardware has been found, (2) drivers are being installed, and (3) the new hardware is ready for use. If you do not see these messages and the demo board does not work, try unplugging and reconnecting the USB cable. If this does not work, refer to **Chapter 5. “Troubleshooting”**.

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Chapter 2. The Demonstration Application

This chapter describes the demo touch sense application that is preprogrammed on the PIC24F microcontroller and its general principles of operation. Highlights include:

- Introduction to the Touch Interface
- Individual Touch Sense Demonstrations

2.1 INTRODUCTION TO THE TOUCH INTERFACE

Control of the touch sense features are built on the PIC24F microcontroller's on-chip Charge Time Measurement Unit (CTMU) module. The CTMU consists of a constant current source that charges the touch circuit to a fixed voltage level. When any additional capacitance is added to the circuit (from the touch of a fingertip, for example), the fixed current source will now charge the circuit to a lower voltage. This change is how the microcontroller detects a touch event. A more detailed description of the CTMU's operation is provided **Section 11. "Charge Time Measurement Unit (CTMU)"** of the *"PIC24F Family Reference Manual"* (DS39724).

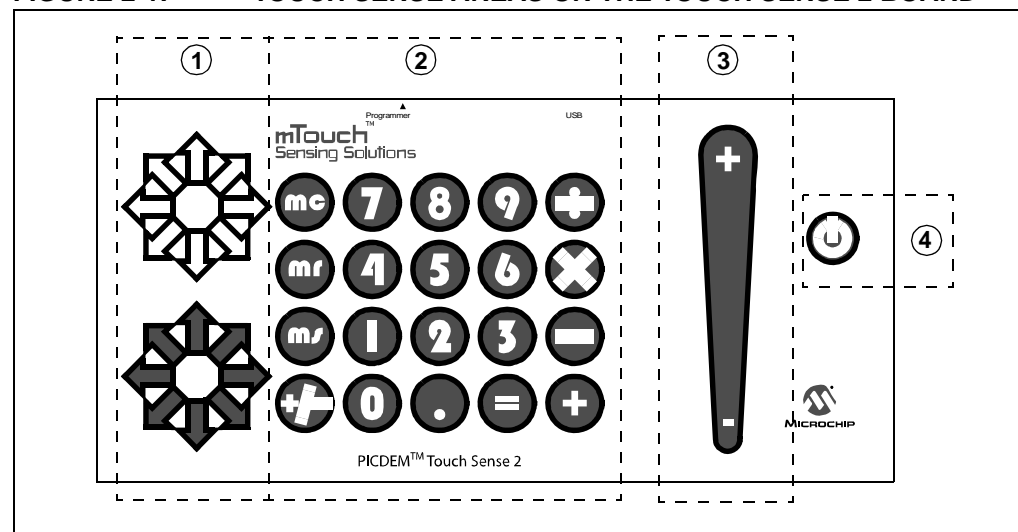
The microcontroller uses the CTMU to monitor its analog input channels, which are in turn, connected to capacitive touch pad sensors on the top layer of the circuit board. The acrylic top layer protects the top layer of the PCB from direct contact, as well as visual cues of where to touch.

The Touch Sense 2 Demo Board has four different sensor demonstration areas:

1. Directional Keypad (bottom) and Display (top)
2. Numeric Keypad
3. Touch Slider
4. "Soft" Power Control

A more detailed description of the Touch Sense 2 Demo Board's operation is provided in **Chapter 4. "Demo Board Hardware"**.

FIGURE 2-1: TOUCH SENSE AREAS ON THE TOUCH SENSE 2 BOARD



2.1.1 Touch Sensitivity

The response of the sensor to fingertip touch is influenced by many factors: touch areas, voltage and current levels, ambient humidity, static buildup, and so on. Most of these factors have been accounted for in designing the demo application firmware, and are based on typical environmental values, as well as certain assumed constants (e.g., the use of the top acrylic layer as a dielectric). In this respect, the demo application is not adjustable.

The PC side application accompanying the Touch Sense 2 Demo Board can also be used to change the sensitivity of the sensors by writing trip point information back to the board. This is discussed in more detail in **Section 3.2.2.1 “Global Diagnostic Window Settings”**.

2.1.2 Sensor Persistence

By design, the demo application is designed to respond to a state change event on any sensor. More simply, they respond to a touch, and not to a touch and release. This behavior, along with the firmware's slow averaging algorithm that accounts for constant changes in the demo board's environment, causes a continuous touch on one or more sensors to yield a continuous response for a few seconds, followed by no response at all. Removing the touch stimulus from the sensor resets the algorithm and restores the sensor's responsiveness.

Note: Do not touch the bottom side of the Touch Sense 2 Demo Board. This will affect the board's overall capacitance and cause unpredictable operation.
--

2.2 INDIVIDUAL TOUCH SENSE DEMONSTRATIONS

2.2.1 Directional Keypad

Located at the bottom left side of the demo board, the directional keypad takes the form of an 8-point compass rose of red arrows surrounding a white circle. Above this is a second compass rose with white arrows instead of red. Touching any one of the arrows in the keypad causes the corresponding arrow in the upper compass rose to light up. Similarly, touching the center circle of the keypad causes the circle in the upper compass rose to light up.

2.2.2 Numeric Keypad

By board area, the largest application on the demo board is the numeric keypad. This is an array of 20 touch-sensitive keys arranged in a 4x5 arbitrarily labelled, simple four-function calculator. Touching any one of the keypads causes it to be lit in its upper left corner and from beneath, accompanied by an audible tone.

2.2.3 Touch Slider

Located on the right side of the board, the touch slider resembles the upper portion of a large exclamation point. Touching the slider anywhere along its length causes it to be lit at that point. The light follows your finger as it moves up and down the slider and remains at the last position on the slider when you remove your finger.

2.2.4 “Soft” Power Control

At the far right side of the board is a touch control marked with the universal power switch symbol. Touching the control lights the pad and turns the demo board on and off. When the demo board is off, only a brief touch is required to turn it on. When the demo board is on, it is necessary to touch and hold the power control for 3 seconds to turn the board off.

When the demo board is powered on, the touch slider performs a “chaser” display, with the light moving rapidly from the bottom to top and back again.

Chapter 3. Using the mTouch™ Sensing Solution

This chapter describes the mTouch sensing solution that accompanies the PICDEM Touch Sense 2 Demo Board, and how it can be used in developing and troubleshooting touch sense applications. Highlights include:

- About the mTouch Sensing Solution
- Using the mTouch Sensing Solution

3.1 ABOUT THE mTOUCH SENSING SOLUTION

The mTouch sensing solution is a multi-purpose application that has been designed for use with many of Microchip's touch sense demonstrations. The software provides a useful tool for viewing, adjusting and debugging various aspects of the demonstration software preloaded on the PICDEM Touch Sense 2 Demo Board. The mTouch sensing solution can also be used for development of custom applications.

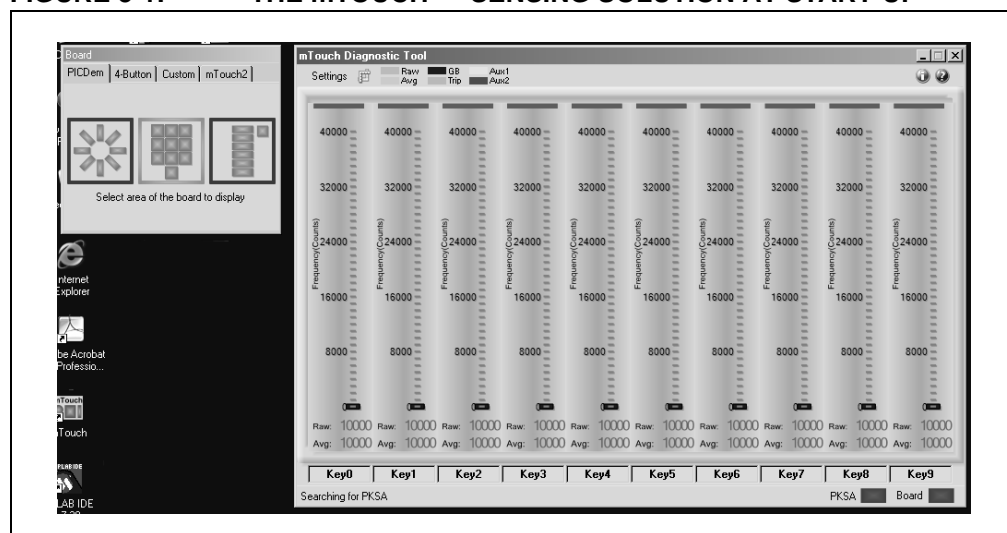
The operation of the mTouch sensing solution described here is specific to its use with the Touch Sense 2 Demo Board. For use with other Microchip applications, refer to that application's user's guide.

3.2 USING THE mTOUCH SENSING SOLUTION

Before starting the mTouch sensing solution, be sure that the PICDEM Touch Sense 2 Demo Board is connected to a USB port on a personal computer (or a USB hub connected to the computer), and that the demo board is operating normally.

To start the mTouch sensing solution, double-click on the mTouch sensing solution shortcut icon on the desktop. Alternatively, the program may be launched by clicking on the **Start** button, then *Programs > Microchip > mTouch*. The application launches with two windows The Board window and Diagnostic Tool window, as shown in Figure 3-1.

FIGURE 3-1: THE mTOUCH™ SENSING SOLUTION AT START-UP

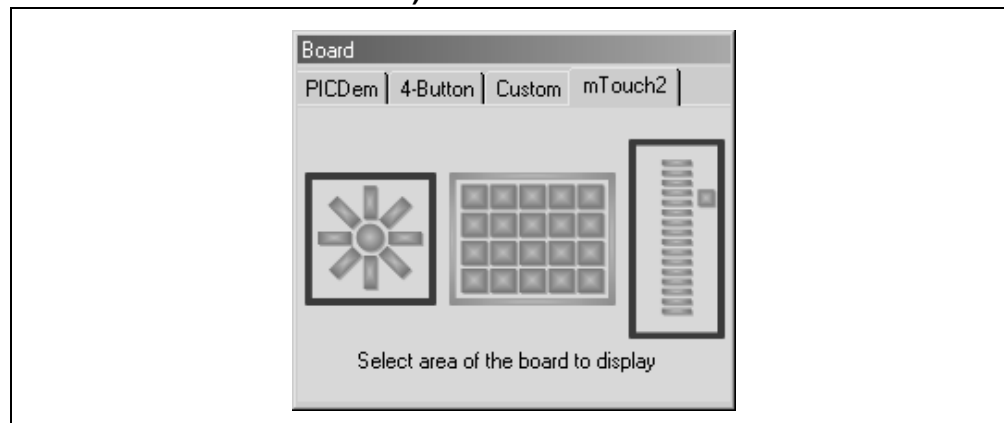


3.2.1 The Board Window

The smaller of the two windows is the Board window. This window is used to select the Microchip hardware application to be used with the diagnostic tool, and which subsystem is to be examined.

By default, the application starts up configured for Microchip's PICDEM Touch Sense 1 Demo Board (**PICDem** tab). To configure for the Touch Sense 2 Demo Board, select the **mTouch sensing solution 2** tab (Figure 3-2), then select one of the three areas of the board for diagnostic testing by clicking on the appropriate graphic.

FIGURE 3-2: THE BOARD WINDOW (mTOUCH™ SENSING SOLUTION 2 TAB SHOWN)



3.2.2 The Diagnostic Tool Window

The larger window is used to display the status of the individual sensors or channels for the hardware and subsystem selected in the Board window. When the application is configured for the Touch Sense 2 Demo Board, the Diagnostic Tool window changes. Depending on the sensor area selected, the board shows status displays corresponding to the number of sensor channels used for that area. Figure 3-3 shows the window for the numeric keypad, with displays for the 4 rows (R1 through R4) and 5 columns (C1 through C5). When the directional keypad is selected, four status displays are shown (north, south, east and west). For the touch slide sensor, three displays are shown (top, bottom and power). An indicator, labelled "Board", is also provided; this shows a successful connection to the board.

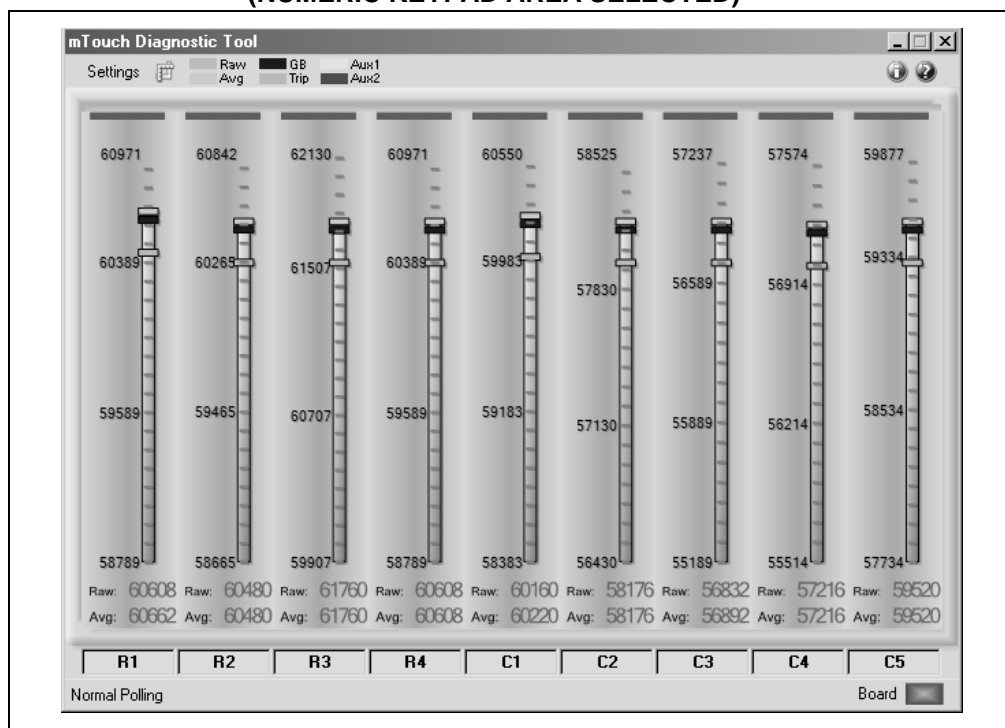
The status display for each of the sensors takes the form of a bar graph. Above each bar graph display is an indicator; this lights up (changes from dark green to light green) when the software detects a touch event. The bar graph shows the sensor's current state in terms of the A/D conversion value of its channel. Values shown are scaled to a range of 0 to 65,535 and are dimensionless. Each bar graph has the following information:

- A constantly moving vertical bar that indicates the instantaneous conversion value
- An orange horizontal indicator across the bar that indicates the moving average of the touch sensor
- A dark blue horizontal indicator showing the hysteresis value for the touch sensor (the level the sensor must return to after an active or pressed level to change state to inactive or unpressed)
- A light green horizontal indicator that shows the trip level that the touch channel must reach to become pressed or activated.
- The average and raw conversion values, displayed numerically at the bottom of the bar graph

A color key for the indicators is provided at the top of the Diagnostic Tool window.

Using the mTouch™ Sensing Solution

FIGURE 3-3: DIAGNOSTIC TOOL WINDOW FOR mTOUCH™ SENSING SOLUTION WITH SUCCESSFUL USB CONNECTION (NUMERIC KEYPAD AREA SELECTED)

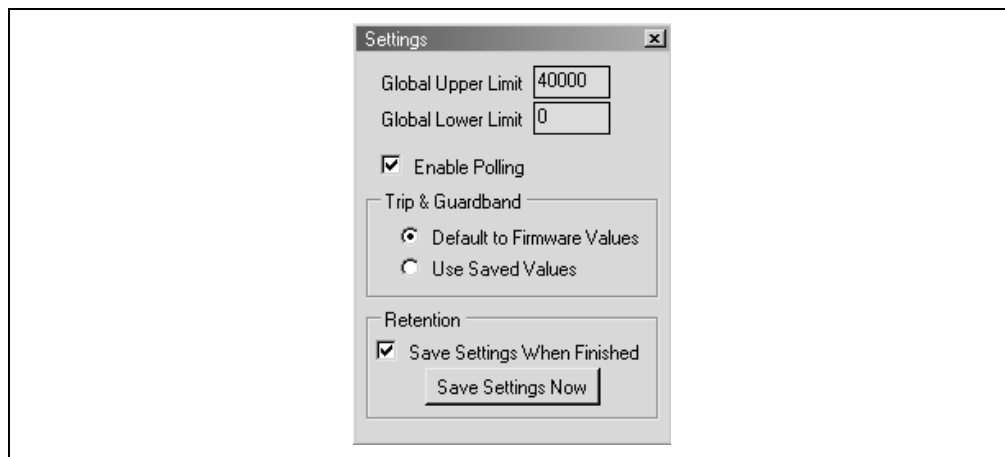


The A/D converter produces values of up to 1023 (10 bits). The PICDEM Touch Sense 2 Demo Board contains software algorithms that use scaled values of the raw A/D reading to improve averaging and overall performance of the hardware.

3.2.2.1 GLOBAL DIAGNOSTIC WINDOW SETTINGS

In the Diagnostic Tool window, users can change certain global settings for all sensors, as well as the way the demo board and the diagnostic software interact. These features are available through the Settings dialog box, which opens when **Settings** in the mTouch Sensing Solution Diagnostic Tool window is selected (Figure 3-4).

FIGURE 3-4: GLOBAL SETTINGS DIALOG BOX



The global limit area allows the minimum and maximum values for all of the bar graphs to be globally set manually. The values must be in the range from 0 to 65535. Enter a value in the text box and press <Enter> for the value to take effect. Notice that changing this setting overrides any auto-scaling that has been performed.

The **Enable Polling** checkbox enables communication with the PICDEM Touch Sense 2 Demo Board and the real-time display of sensor information. The USB portion of the mTouch sensing solution remains operational and communicating with the demo board even when the box is unchecked. If the checkbox is unselected, the last polled values from the board remain on the bar graphs until **Enable Polling** is selected again; the latest data is displayed at that time, and normal polling resumes. This makes the checkbox useful as a “Freeze” or pause button.

The “Trip & Guardband” section configures the interaction between the mTouch sensing solution and Touch Sense 2 Demo Board with regards to guardband and trip point settings. There are two option buttons:

- **Default to Firmware Values** enables the trip and guardband values to be calculated by the demo board's firmware, using an algorithm that calculates the optimum trip and guardband values based on the average value. These values are sent to the mTouch sensing solution tool via the USB connection, and are constantly updated and displayed on the bar graphs; this is enabled by default.
- **Use Saved Values** enables the values entered into the mTouch sensing solution to be sent to and used by the demo board via USB. The trip and guardband values set by the mTouch sensing solution by user input are static, and only change when the user changes them.

The “Retention” area of the Settings subwindow determines how these settings of the mTouch sensing solution are saved:

- Global minimum and maximum limits for bar graphs
- Auto-scaling settings
- Trip and guardband settings
- Aux1 and Aux2 settings

When the **Save Settings When Finished** checkbox is selected (default), all of the above settings are saved to permanent storage on the PC when the mTouch sensing solution is closed. Clicking the **Save Settings Now** button immediately saves all of the above values to permanent storage on the PC. In both cases, all settings are restored when the application is restarted.

Leaving **Save Settings When Finished** unselected allows users to save working configurations at their discretion by using the **Save Settings Now** button. This allows for experimentation with the ability to return to “known good” settings by quitting the mTouch sensing solution and restarting it.

3.2.2.2 INDIVIDUAL SENSOR DISPLAY SETUP

In addition to global display settings, each of the sensor channels can be individually configured to adjust its behavior, as well as specific display properties. To do this, left-click directly on top of any channel's bar graph; the Setup dialog box for that channel appears (Figure 3-5).

Clicking on another channel while a Setup dialog is open does not close the original window or open a second Setup dialog. Instead, the dialog box becomes the Setup dialog for the channel most recently selected.

Using the mTouch™ Sensing Solution

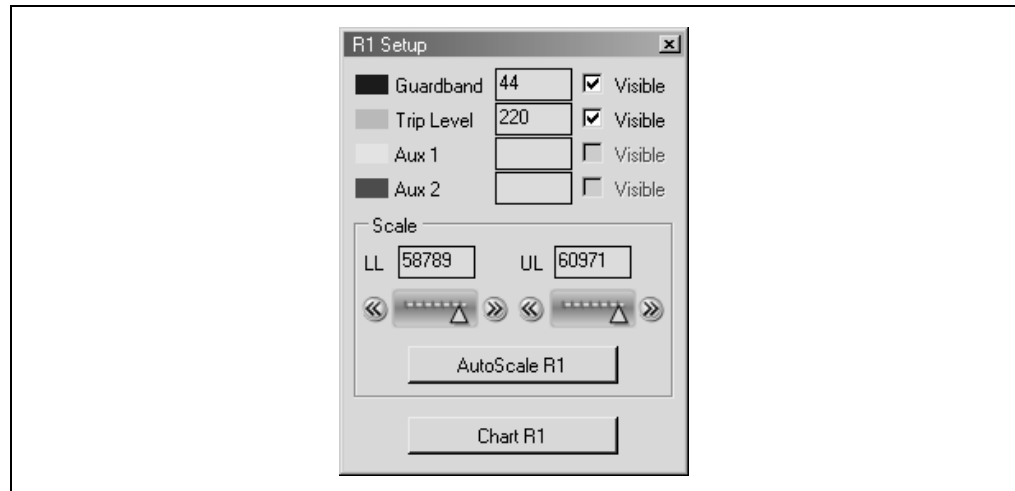
The upper portion of the Setup dialog allows the user to set individual values for the Guardband and Trip Point for each sensor channel. Users may optionally set additional reference points, labelled “Aux1” and “Aux2”. All four variables have a valid range of 0 to 65535. Each point has an additional “Visible” checkbox that determines if the value is to be displayed on the bar graph.

Note 1: The **Use Saved Values** option button must be set for these values to be valid and used by the demo board. See **Section 3.2.2.1 “Global Diagnostic Window Settings”** for further information.

2: “Aux1” and “Aux2” are not available on the initial version of the mTouch sensing solution.

The “Scale” area of the dialog is used to manually scale the bar graph. Values for the lower limit (LL) and upper limit (UL) of the bar graph may be directly entered in the text boxes provided; they may be set using the slider and/or bump arrow under the boxes. As with the other set points, values for LL and UL are valid from 0 to 65,535 (provided, of course, that UL is always greater than LL). The **Autoscale R1** button automatically selects the minimum and maximum values to be displayed for the bar graph.

FIGURE 3-5: SENSOR DISPLAY SETUP DIALOG BOX



3.2.2.3 SENSOR DATA CHARTING AND LOGGING

Within the Setup window, the **Chart R1** button enables data recording from any sensor channel. Clicking on **Chart R1** opens an additional window (Figure 3-6) that displays a plot of the channel's conversion value versus time. Plotting of data begins immediately when the **Chart R1** is pressed, and continues to plot as long as the **Run** checkbox in the Plot window is selected; pressing the **Clear** button erases the plot and begins a new plot in the same window.

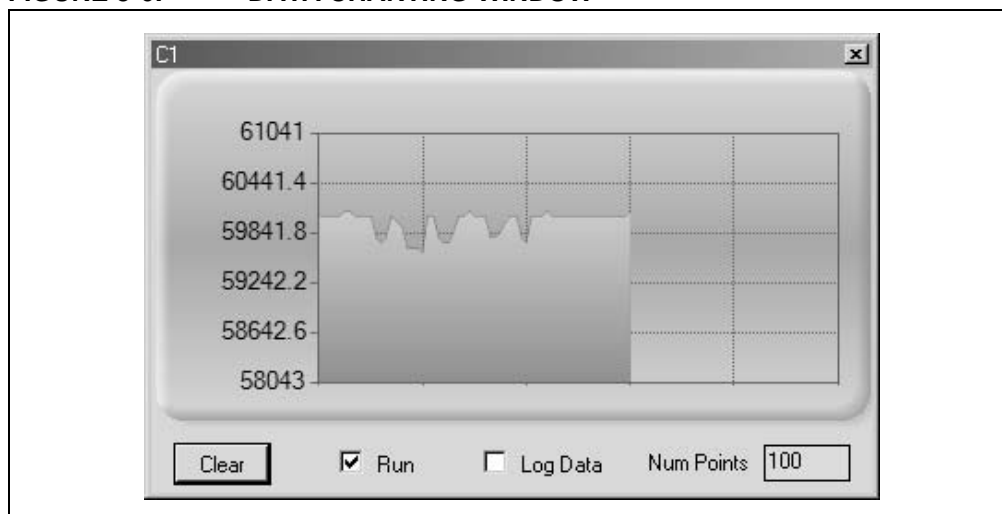
The range of the touch sensor values on the chart are equal to the minimum and maximum values set for the bar graph. Data for the plot window is sampled and displayed at a minimum rate of 10 samples per second. The amount of data displayed (and effectively, the scale of the time axis) is changed by changing the value in the **Num Points** text box. By default, the number of data points is 500.

The **Log Data** checkbox enables automatic logging of the channel's data to a text file (.txt extension). The filename is the touch sensor channel name with the .txt extension. When the checkbox is selected, a dialog pop-up appears to confirm the file name (generally, <channel-name>.txt) and working directory (C:\Program Files\ Microchip\mTouch2). Data is logged to the file at the same rate as it is plotted (5 samples per second).

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Just like the sensor Setup dialog boxes, clicking on another channel while a Data Charting window is open, does not close the original window or open a second Charting window. Instead, the window becomes the Charting window for the channel most recently selected.

FIGURE 3-6: DATA CHARTING WINDOW



Chapter 4. Demo Board Hardware

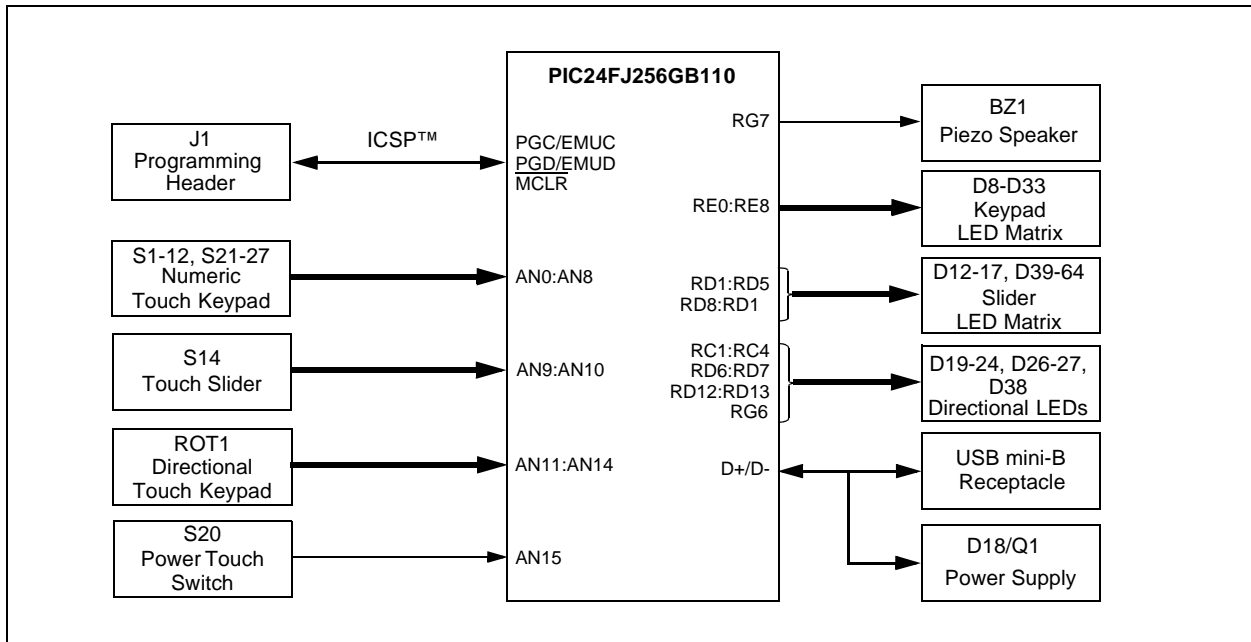
This chapter provides a functional overview of the PICDEM Touch Sense 2 Demo Board and identifies the major hardware components. Topics covered include:

- Application Functional Overview
- Board Components

4.1 APPLICATION FUNCTIONAL OVERVIEW

Figure 4-1 illustrates the main functions of the Touch Sense 2 Demo Board:

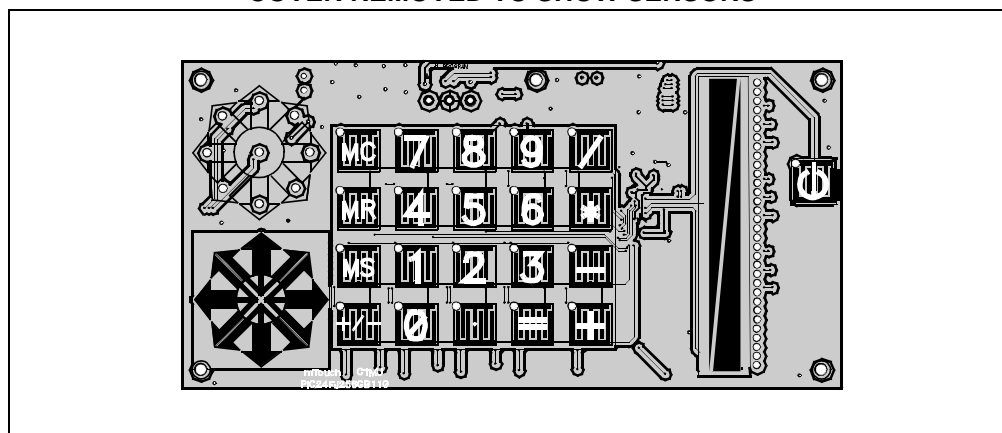
FIGURE 4-1: APPLICATION SIDE BLOCK DIAGRAM



The operation of the demo board is managed by the PIC24FJ256GB110 microcontroller, which requires very little additional hardware to perform its tasks. In addition to the Touch Sense demo application code, the preloaded demo uses substantial parts of the Microchip USB Stack Library to provide a hardware interface to the PC-based interface application.

The Touch Sense application uses the microcontroller's Charge Time Measurement Unit (CTMU) and all 16 of the microcontroller's A/D input channels to monitor the touch interfaces. The CTMU functions by sensing small changes in capacitance on its inputs, such as those occurring when a person touches the copper pad electrodes. By continuously monitoring for these changes, the CTMU can determine when a touch event occurs. The sensors on the Touch 2 Demo Board are comprised of carefully placed circuit traces and capacitive touch pads, shown in Figure 4-2.

FIGURE 4-2: TOUCH SENSE 2 DEMO BOARD, WITH TOP ACRYLIC COVER REMOVED TO SHOW SENSORS



Nine of the A/D channels are used to monitor the numeric keypad switches (S1 through S12 and S21 through S27), arranged in a 4x5 array. Each “switch” is composed of interleaved conductors from two channels. The location of the touched key is determined by a simultaneous capacitance change on any two channels.

Four channels are used to monitor the directional keypad. The sensor consists of four arrow shaped, dual capacitive touch pads, oriented at the four cardinal compass points (N, E, S and W), with capacitive touch pads at the adjacent four compass points (NE, SE, SW and NW) and in the center. Touch events on the cardinal points causes a capacitance change in the corresponding channel. Touches between the cardinal points, or in the center, are interpolated from simultaneous changes on two adjacent channels, or all four channels, respectively.

Two channels are used to monitor the touch slider, S14. The slider is composed of two large and adjacent capacitive touch pads, tapering from one side to the other and in opposite directions. The location of a touch event on the slider is determined by the differential change in capacitance between the channels.

The remaining A/D channel is used to monitor the demo board’s “soft” power switch, S20; this is an interleaved capacitive touch pad similar to those in the numeric keypad. When power is applied to the Touch Sense 2 Demo Board, the microcontroller immediately initializes the demo application and starts in Full-Power mode. When the power switch is pressed and held for approximately 3 seconds, the microcontroller goes into Low-Power Sleep mode, monitoring S20 at intervals of 50 milliseconds. A touch event on S20 causes the application to wake again to full-power operation.

When an event occurs, the application firmware also provides feedback by activating one or more LEDs at that location. A total of 61 LEDs are driven directly by the microcontroller through pins on PORTC, PORTD, PORTE and PORTG. The LEDs for the numeric keypad are driven as a 4x5 matrix from PORTE, using 5 lines to source current and four to sink current. Individual LEDs are used for the directional keypad and the power switch.

The linear LED display on the touch slider is driven in a method similar to those of the numeric keypad, using a 4x4 matrix on PORTD. Each node has two LEDs, connected in forward and reverse-biased pairs. To light a specific diode in each pair, the row and column ports are toggled to act as current sources or sinks, causing one diode or the other to be properly biased.

In addition to visual feedback, the demo board also provides audible feedback for each touch event on the numeric keypad. An audio signal is generated using one of the microcontroller’s PWM module, and directly drives the piezo speaker BZ1 through pin RG7.

The microcontroller uses its on-chip USB engine and transceiver to communicate the PC side interface application, using the USB mini-B receptacle. The demo board also uses the USB receptacle for application power as a bus-powered device. Microcontroller and LED power is provided from the VBUS by Q1, an MCP1702 voltage regulator. Provisions on the board allow for users to add components and create an externally powered application.

For users interested in using the Touch Sense 2 Demo Board as an experimental platform, the microcontroller can be reprogrammed through a standard interface. A six-pin header is provided for connecting the demo board to any MPLAB ICD 2 compatible programmer. Since the ICD interface shares some input lines with the numeric keypad interface, a separate switch (S13, not shown in the figure) allows users to connect or disconnect the ICD lines from the scan lines. While this is not strictly necessary, it does help to reduce the overall capacitance of the touch pads.

4.2 BOARD COMPONENTS

Figure 4-3 identifies the key hardware components for the demo board. Note that the active components are mounted to the bottom side of the board; only the touch sensors are on the front side.

FIGURE 4-3: TOUCH SENSE 2 DEMO BOARD COMPONENT LAYOUT (BOTTOM SIDE)

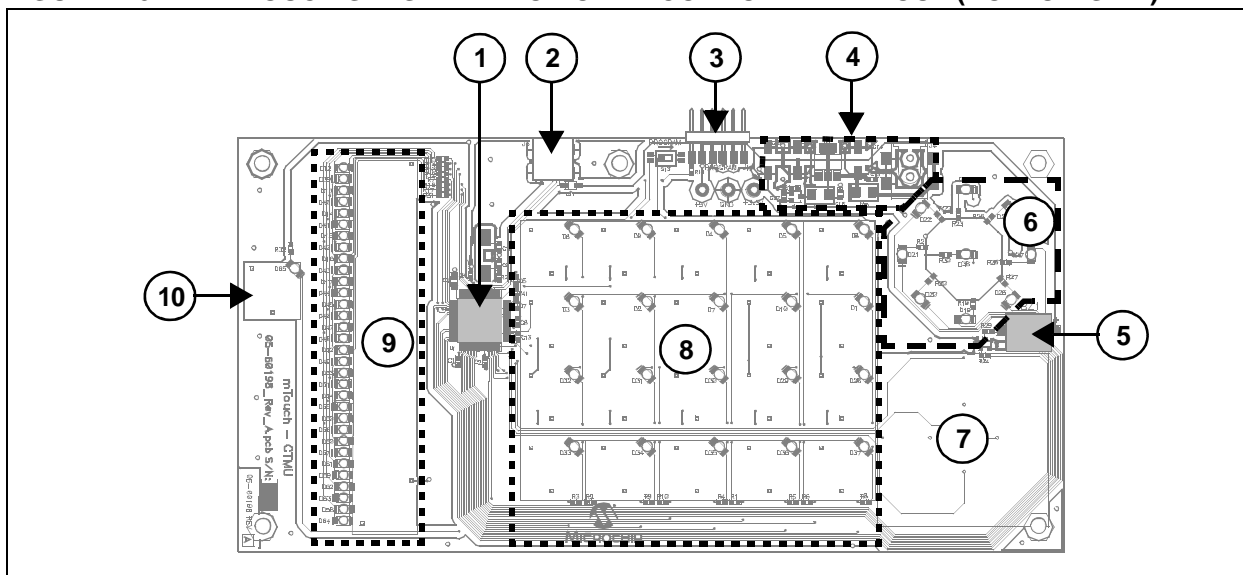


TABLE 4-1: BOARD COMPONENTS

Ref	Component
1	PIC24FJ256GB110 Microcontroller (U1)
2	USB mini-B Receptacle (J3)
3	ICSP™ Programming Header (J1)
4	Power Supply (D18, Q1)
5	Piezo Speaker (BZ1)
6	Directional Touch Sensor LEDs (D19-24, D26-27, D38)
7	Directional Touch Sensor Area – Front of Board (ROT1)
8	Numeric Keypad Area – Sensors on Front of Board (S1-12, S21-28, D1-10, D28-37)
9	Touch Slider Area – Sensor on Front of Board (S14, D12-17, D39-64)
10	Power Touch Switch – Sensor on Front of Board (S20, D65)

4.2.1 Components

The components listed here (in order of their reference tags in Figure 4-3) are the key components of the application side of the Touch Sense 2 Demo Board:

1. **PIC24FJ256GB110 Microcontroller (U1):** This provides the processing power for the Touch Sense demo applications. The microcontroller features 256 Kbytes of Flash program memory and 16 Kbytes RAM, allowing sufficient space for the development of more complex touch sense applications.
The demo application uses an 8 MHz signal to create the 48 MHz USB clock, as well as the application's 32 MHz clock. Crystal, Y1, and associated components are used by the microcontroller's internal oscillator to maintain the frequency tolerances required by the USB specifications.
2. **USB mini-B Receptacle (J3):** This provides a convenient interface to the PC-side of the demo application. As the Touch Sense 2 Demo Board functions as a bus-powered device, this connection also provides power to the board.
3. **ICSP Header Interface (J1):** This provides a standard Microchip ICD interface for programming and debugging applications on the Touch Sense 2 Demo Board; it is designed to connect directly with Microchip's PICkit™ Serial Programmer. Pin 1 (N/C) is located on the right side of the interface, as viewed from the front of the board, and is marked with an arrow.
An optional RJ-11 adapter (Microchip Part # AC164110, included with the Touch Sense 2 Demo Board kit) can also be used for modular cable connections to both the MPLAB ICD 2 Programmer/Debugger module and the MPLAB REAL ICE™ module. Switch S11 (to the left of the header) connects the PGD and PGC lines of the interface with columns 3 and 4 of the keypad, which are also used as the PGD and PGC pins of the microcontroller.
4. **Power Supply (D18/Q1):** This converts the +5 VDC from VBUS to the regulated +3.3 VDC required by the demo board.
Circuit traces in this area are also provided to create a non-USB power supply for self-powered (freestanding) use. This power supply is designed to convert 9 VAC to a regulated +3.3 VDC and +5 VDC. To implement, the user will need to populate the indicated locations with diode, D25, and voltage regulator, U5, as well as capacitors, C14, C15, C16 and C17, and receptacle, J4. Specifications for these components are provided in **Appendix A. "Demo Board Schematics"**.
5. **Piezo Speaker (BZ1):** This small form factor component provides audible feedback in the demo application.
6. **Directional Sensor LEDs (D19-24, D26-27, D38):** These provide visual feedback for touch events on the directional sensor pad.
7. **Directional Touch Sensor (ROT1):** The capacitive sensors are located in this area on the front side of the board (see Figure 4-2).
8. **Numeric Keypad (S1-12, S21-28, D1-10, D28-37):** This area contains the sensors and LEDs associated with the touch keypad. The capacitive touch sensors are located on the front of the board (see Figure 4-2).
9. **Touch Slide (S14, D12-17, D39-64):** This area contains the sensors for the touch slide and the 32 LEDs comprising the continuous bar display. The capacitive touch sensors are located on the front of the board (see Figure 4-2).
10. **Power Touch Switch (S20, D65):** This area contains the LED and sensor for the demo board's "soft" power switch. The sensor is located in this area on the front side of the board (see Figure 4-2).

Chapter 5. Troubleshooting

5.1 HIGHLIGHTS

This chapter discusses common operational issues and how to resolve them.

5.2 COMMON ISSUES

1. The demo board does not respond to inputs (i.e., no lights when a keypad or touch sensor is touched)

Check the Touch Sense 2 Demo Board board for power:

- Verify that USB power (V_{USB}, +5 VDC) is present on the USB connection.
- If the demo board is connected to a computer through a USB hub, verify the hub is powered and capable of providing power to downstream devices.
- If the demo board is directly connected to a computer, verify that the USB port used is active; try switching to another port.

The demo board may have been placed into Standby mode. Briefly press the power control; if the board was in Standby mode, the power control LED will light up and a touch slider bar graph will respond with a “chaser” display”.

2. The touch sensors are abnormally sensitive or insensitive (generally insensitive) to inputs

The top acrylic surface of the Touch Sense 2 Demo Board has become dirty. Gently clean the surface with a moistened (not wet) soft cloth. Only use water for cleaning; do not use glass cleaner or commercial solvents.

Check the bar graph settings for the sensors in the mTouch sensing solution software. The demo board's trip point and other settings may have been changed to values that interfere with default operation. To correct:

- In the Settings dialog box, verify that the **Use Firmware Settings** option is selected.
- If the **Use Saved Value** option is selected instead, change the trip point values for each affected channel to a value that produces an appropriate response

3. The Demo Board and the mTouch sensing solution are installed and operating properly, but are not communicating with each other

The USB host controller may not have enumerated the demo board correctly upon connection. To correct, try the following:

- If the board is connected through an external USB hub, try connecting it directly to a USB port on the host computer.
- Disconnect the board, wait for 5 to 10 seconds, then reconnect the board.

It is also possible that the USB host controller has dropped the communication channel; this happens occasionally when the demo board is placed into Standby mode and then powered up using the power control. In this case, disconnect the board and reconnect after 5 to 10 seconds.

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NOTES:

Appendix A. Demo Board Schematics

The following schematic diagrams are included in this appendix:

Programmer/Debugger:

- Figure A-1: Microcontroller and Associated Components
- Figure A-2: Keypad and Slider Touch Switches, and Associated LEDs
- Figure A-3: Directional Touch Sensor and LEDs, External Connections and Power Supply

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FIGURE A-1: TOUCH SENSE 2 DEMO BOARD SCHEMATIC, SHEET 1: MICROCONTROLLER AND ASSOCIATED COMPONENTS

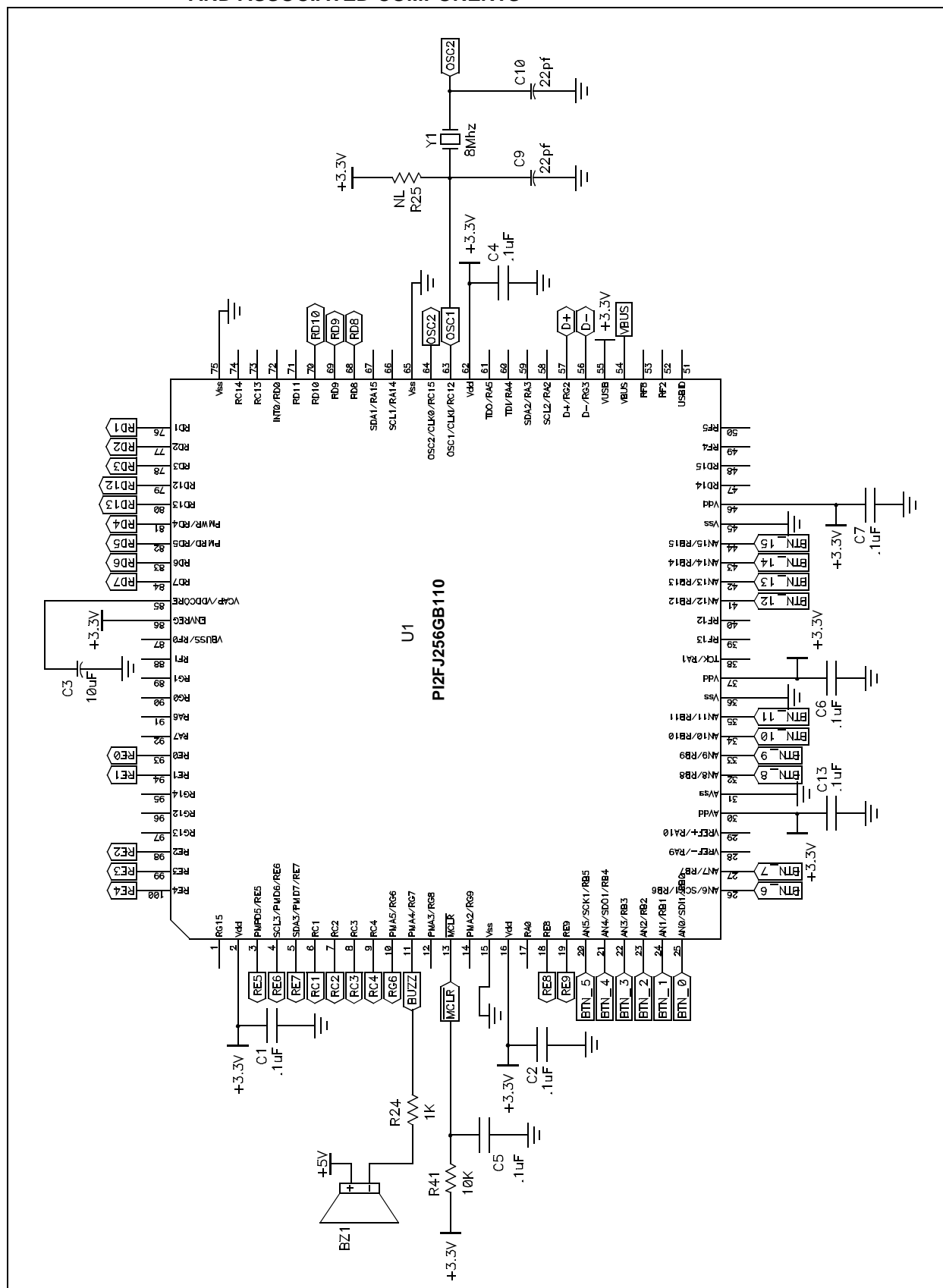
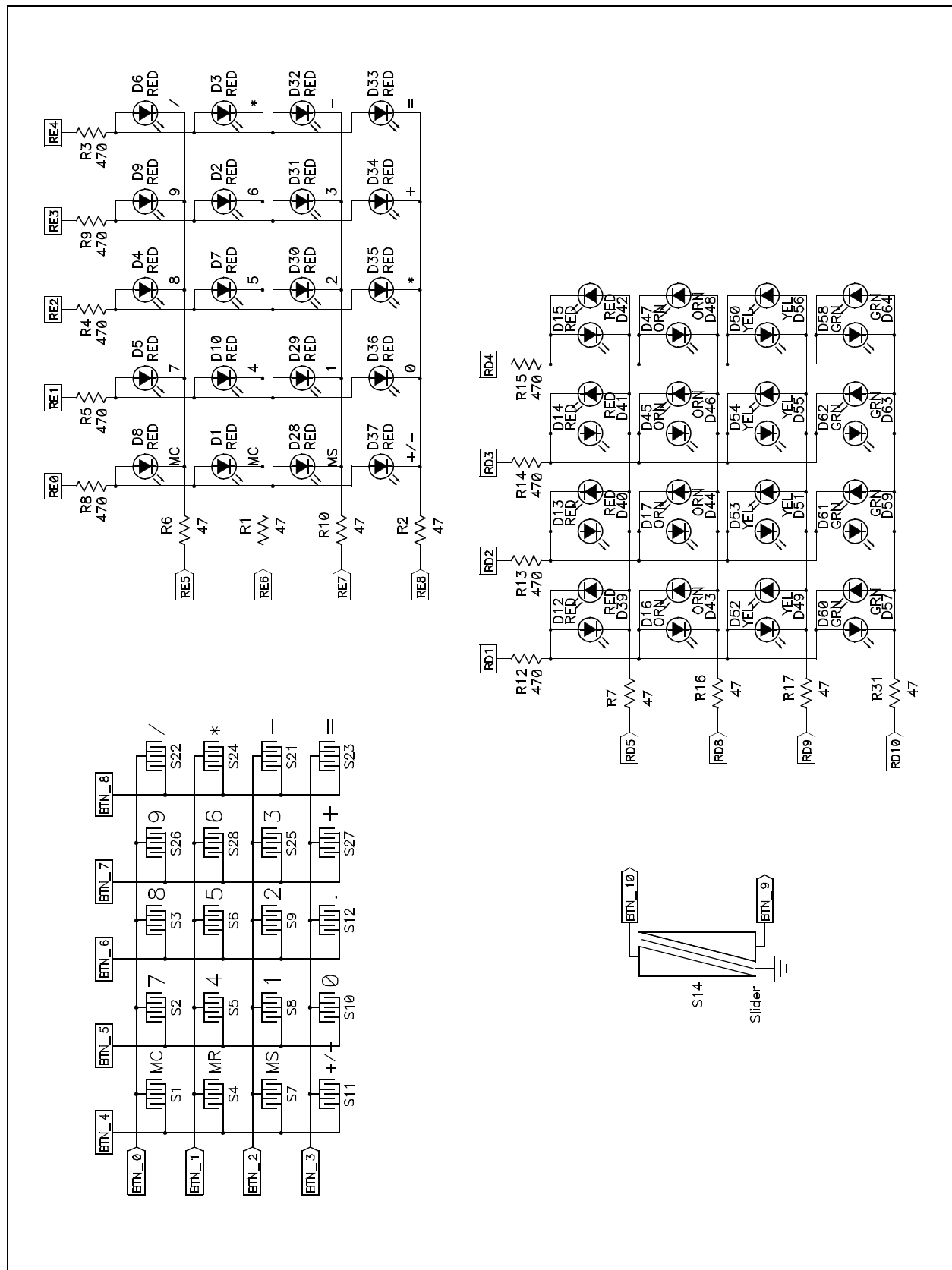
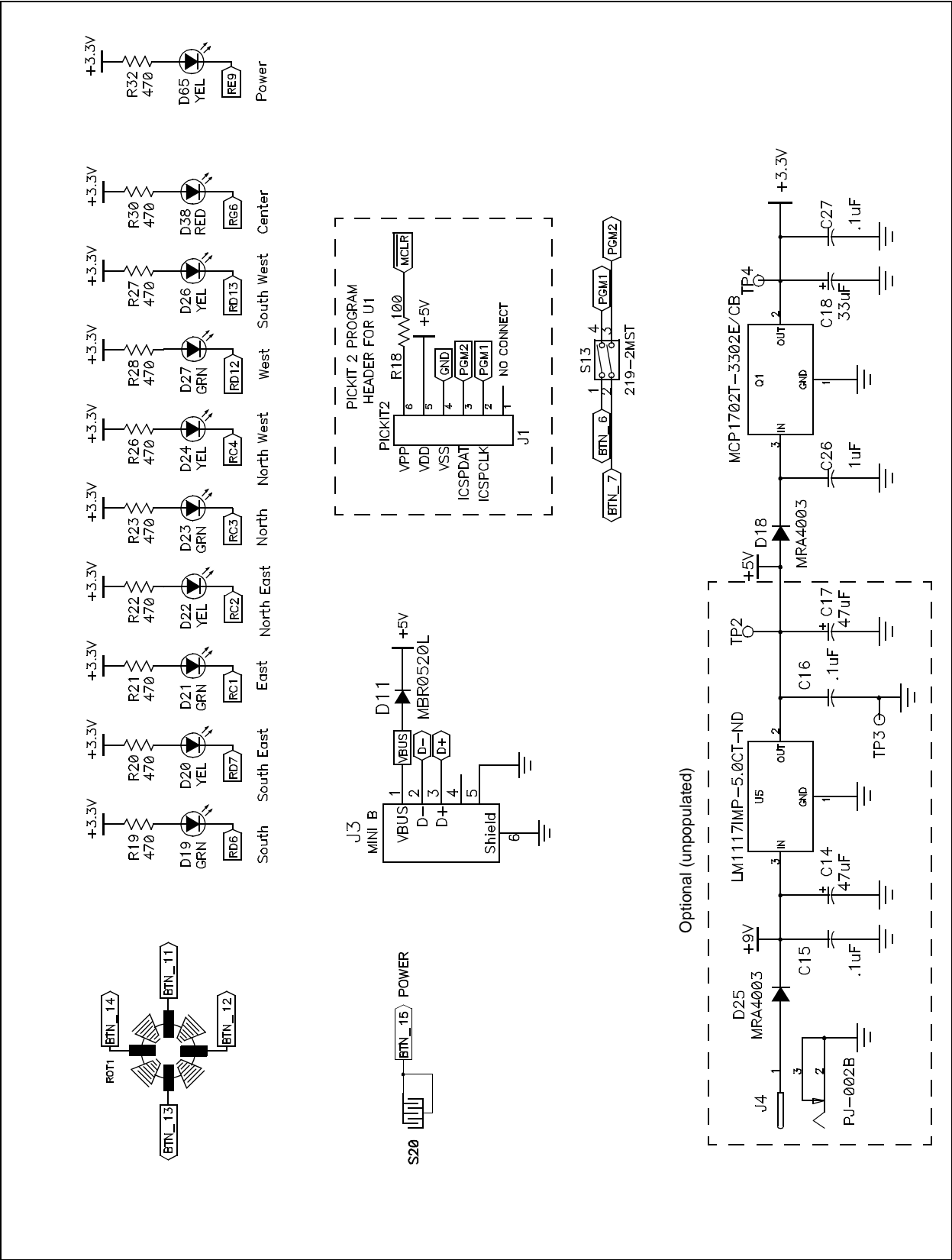


FIGURE A-2: TOUCH SENSE 2 DEMO BOARD SCHEMATIC, SHEET 2: KEYPAD AND SLIDER TOUCH SWITCHES AND ASSOCIATED LEDs



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FIGURE A-3: TOUCH SENSE 2 DEMO BOARD SCHEMATIC, SHEET 3: DIRECTIONAL TOUCH SENSOR AND LEDs, EXTERNAL CONNECTIONS AND POWER SUPPLY



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