



mTouchTM Inductive Touch User's Guide

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INDUCTIVE TOUCH 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 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 Inductive Touch 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 Inductive Touch Demo Board as a development tool to emulate and debug firmware on a target board. The manual layout is as follows:

- **Chapter 1. “Introduction”** – Introduces the Inductive Touch Demo Board and provides a brief description of the system.
- **Chapter 2. “Getting Started”** – Goes through a basic step-by-step process for getting your Inductive Touch Demo Board up and running as a stand-alone board or with the mTouch™ GUI.
- **Chapter 3. “Theory of Operation”** – Provides an overview of how the Inductive Touch system operates.
- **Appendix A. “System Detail”** – Describes in detail the operation of the Demo Board hardware and software.

Inductive Touch Demo Board User's Guide

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
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	<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) { ... }

WARRANTY REGISTRATION

Please complete the enclosed Warranty Registration Card and mail it promptly. Sending in the Warranty Registration Card entitles users 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 Inductive Touch Demo Board. Other useful documents are listed below. The following Microchip documents are available and recommended as supplemental reference resources.

Readme for Inductive Touch Demo Board

For the latest information on using Inductive Touch Demo Board, read the "Readme for Inductive Touch Demo Board.txt" file (an ASCII text file) in the Readmes subdirectory of the MPLAB IDE installation directory. The Readme file contains update information and known issues that may not be included in this user's guide.

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.

Reference Documents

Reference documents may be obtained by contacting your nearest Microchip sales office (listed in the back of this document) or by downloading via the Microchip web site (www.microchip.com). Recommended documents include:

- Individual data sheets and reference manuals:
 - *PIC16F1936 Data Sheet* (DS41364)
 - *MPLAB[®] IDE Simulator, Editor User's Guide* (DS51025)
 - *MPASM[™] Assembler, MPLINK[™] Object Linker, MPLIB[™] Object Librarian User's Guide* (DS33014)
 - *MPLAB REAL ICE[™] In-Circuit Emulator User's Guide* (DS51616)
 - *PICKit[™] Serial Analyzer User's Guide* (DS51647)
 - *mTouch[™] Sensing Solution User's Guide* (DS41328)
 - *PICKit[™] 3 Programmer/Debugger User's Guide* (DS51795)
 - *MPLAB[®] ICD 3 In-Circuit Debugger User's Guide* (DS51766)

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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

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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.
- **Emulators** – The latest information on Microchip in-circuit emulators. This includes the PICKit 3, MPLAB ICD 3, and MPLAB REAL ICE™.
- **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 SIM simulator, MPLAB IDE Project Manager and general editing and debugging features.

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 (November 2009)

- Initial Release of this Document.

Inductive Touch Demo Board User's Guide

NOTES:

Chapter 1. Introduction

1.1 INTRODUCTION

Thank you for purchasing the mTouch™ Inductive Touch demonstration board from Microchip Technology Incorporated. The mTouch Inductive Touch is a simple board that demonstrates the capabilities of Microchip's Inductive Touch Technology.

The Inductive Touch Demo Board can be used stand-alone or with an in-circuit debugger (for example, MPLAB® ICE). The demo board can also be used with the PICkit™ Serial and the mTouch GUI.

1.2 DEVELOPMENT KIT CONTENTS

The Inductive Touch Demo Board comes with the following:

- Inductive Touch demonstration board (Figure 1-1)
- CD-ROM that contains:
 - Sample code
 - Source files
 - Inductive Touch Demo Board User's Guide
 - Application Notes

If you are missing any part of the kit, please contact your nearest Microchip sales office listed in the back of this publication for help.

1.3 INDUCTIVE TOUCH DEMONSTRATION BOARD

The Inductive Touch demonstration board has the following hardware features:

- 4 touch sensor buttons
- 4 indicator LEDs
- Variable frequency tone generator
- 5V power supply
- ICSP™ header
- PICkit™ Serial header

Inductive Touch Demo Board User's Guide

FIGURE 1-1: INDUCTIVE TOUCH HARDWARE



1.4 SAMPLE CODE

The Inductive Touch Demo Board comes preprogrammed with working Inductive Touch software.

The CD-ROM also includes the software hex file, and the source code for the software. This program may be used as-is in the demo board, with the REAL ICE™ In-Circuit Emulator (ICE) or with either the PICKit™ 3 or the ICD 3 In-Circuit Debugger.

Chapter 2. Getting Started

The Inductive Touch Demonstration Board may be used as a stand-alone board, with an in-circuit emulator (for example, MPLAB[®] REAL ICE[™]) or with the PICKit[™] Serial and the mTouch GUI.

2.1 INDUCTIVE TOUCH DEMO BOARD AS A STAND-ALONE BOARD – PREPROGRAMMED DEVICE

The Inductive Touch Demonstration Board may be demonstrated immediately by following the steps listed below:

- Apply power to the Inductive Touch Demo Board. For information on acceptable power sources, see Appendix A.
- Apply pressure to any of the 4 buttons, the associated LED should light, and a tone should sound.

To reprogram the demo board microcontroller, the following will be necessary:

- Program source code – user source code may be used to program the device, or if this previously has been done, the sample program may be restored from the file on the included CD-ROM.
- A compiler, such as the HITECH C[®] compiler, or equivalent third party compiler, must be used to compile the source code into a hex file before it can be programmed into the device.

Other compilers may be used. For a list of these PIC[®] MCU compatible language tools, see the Microchip web site (www.microcip.com).

Once the sample program is in hex file format, a programmer can program the Flash device.

- A device programmer, such as PICKit 3, MPLAB[®] ICD 3, or REAL ICE[™] (programmer functionality available with MPLAB[®] IDE v8.40 or greater)
If the code protection bit(s) have not been programmed, the on-chip program memory can be read out for verification purposes.

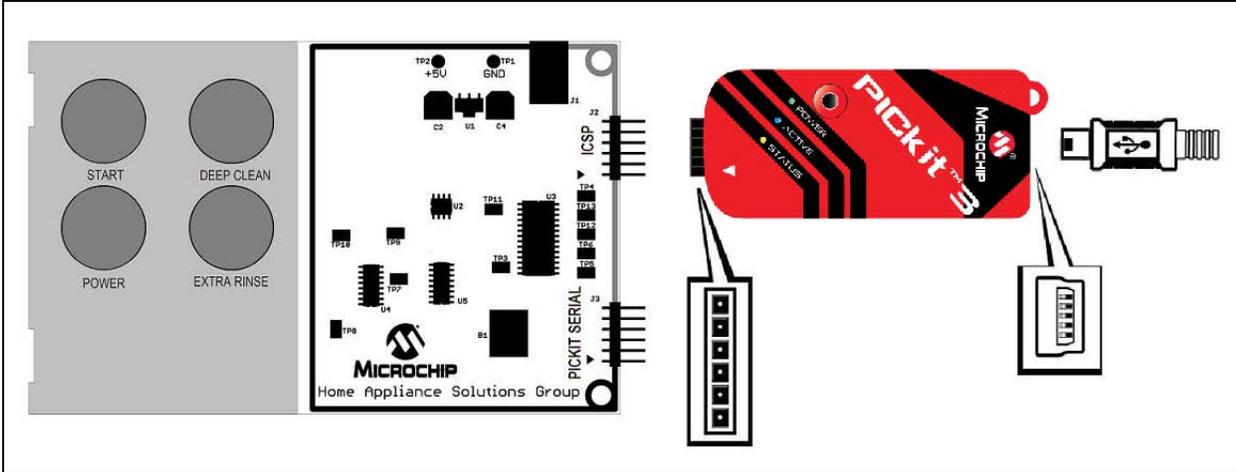
2.2 INDUCTIVE TOUCH DEMO BOARD USED WITH AN IN-CIRCUIT DEBUGGER

To use the Inductive Touch Demonstration Board with an In-Circuit Debugger (ICD), refer to the tool's user guide for instructions to learn how to:

- Power-up and configure the ICD
- Connect to target boards (such as in Figure 2-1)
- Program and debug the microcontroller on the demo board.

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FIGURE 2-1: INDUCTIVE TOUCH DEMO BOARD CONNECTED TO PICKIT™3 USING USB

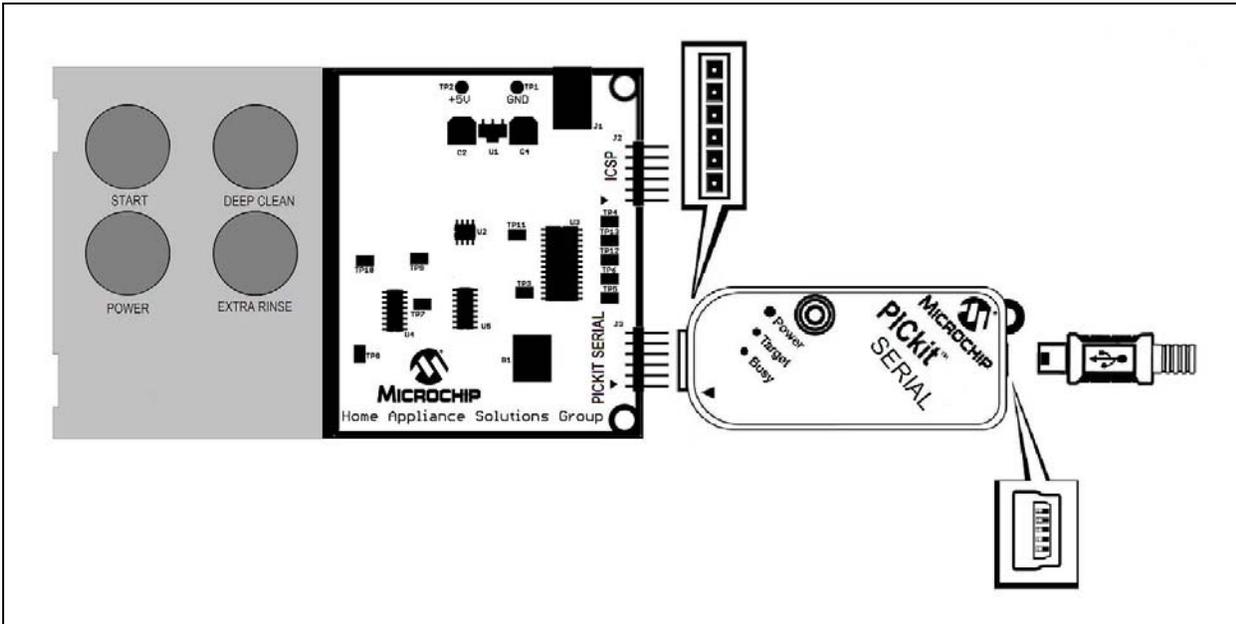


2.3 INDUCTIVE TOUCH DEMO BOARD CONNECTION TO THE mTOUCH™ GUI

The Inductive Touch Demonstration Board can be used with the mTouch GUI to demonstrate the operation of the system.

- Connect the Inductive Touch Demonstration Board to a PICKIT™ Serial Analyzer as shown in Figure 2-2.

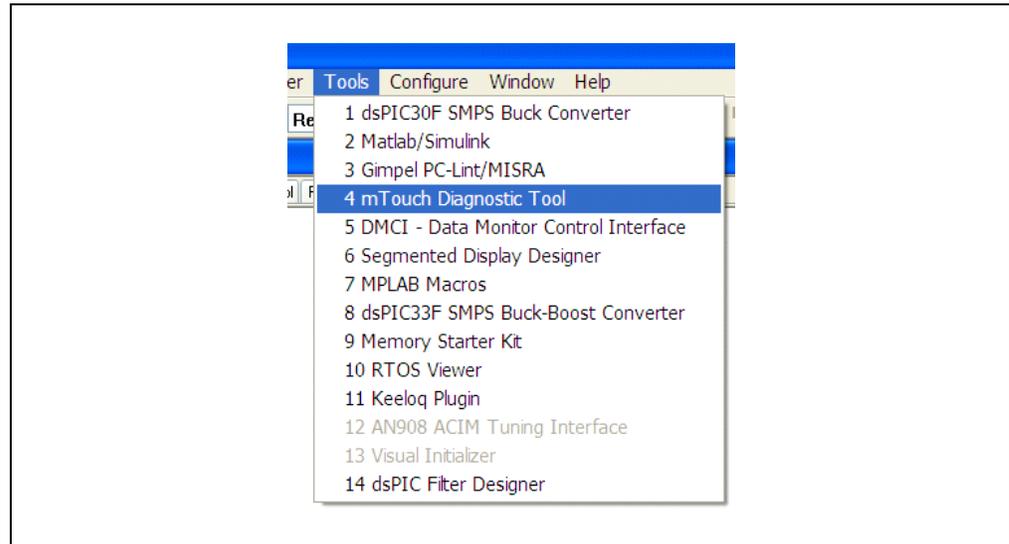
FIGURE 2-2: CONNECTION TO A PICKIT™ SERIAL ANALYZER



- Apply power to the Inductive Touch Demonstration Board. For information on acceptable power sources, see **Appendix A. "System Detail"**.

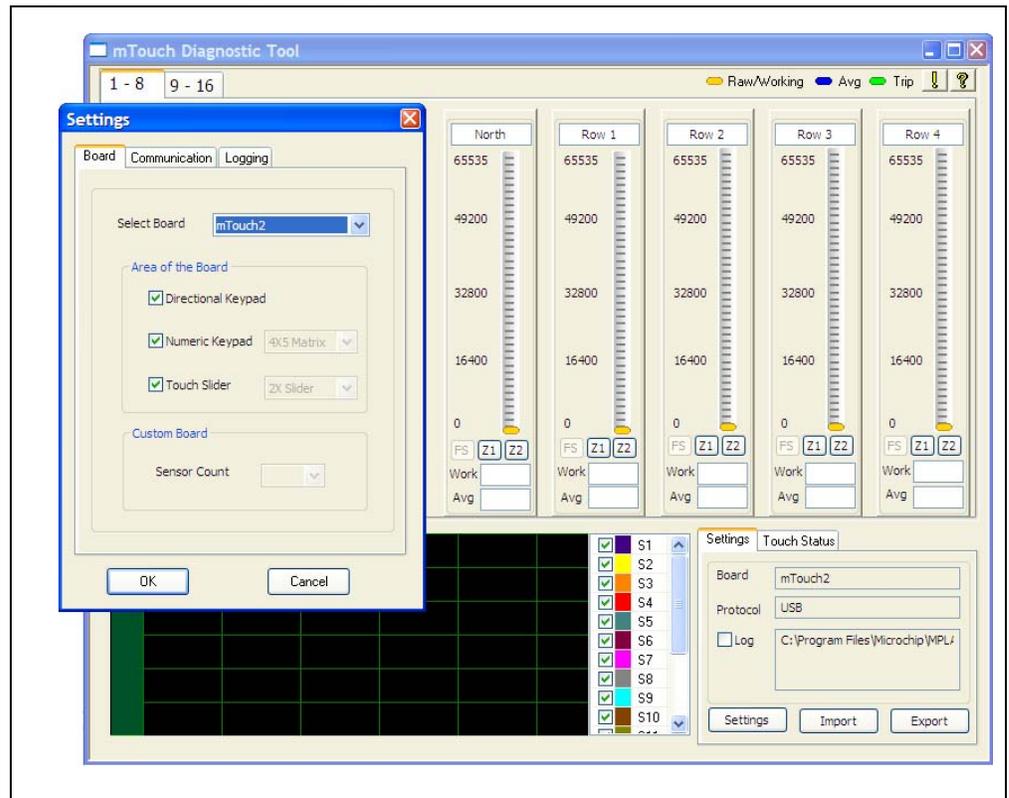
In MPLAB (version 8.4 or later), select the mTouch Diagnostic Tool under the *Tools* menu (as shown in Figure 2-3).

FIGURE 2-3: mTOUCH DIAGNOSTIC TOOL



When the Diagnostic Tool is loaded, select the **Settings** tab to access the tool configuration menu (Figure 2-4).

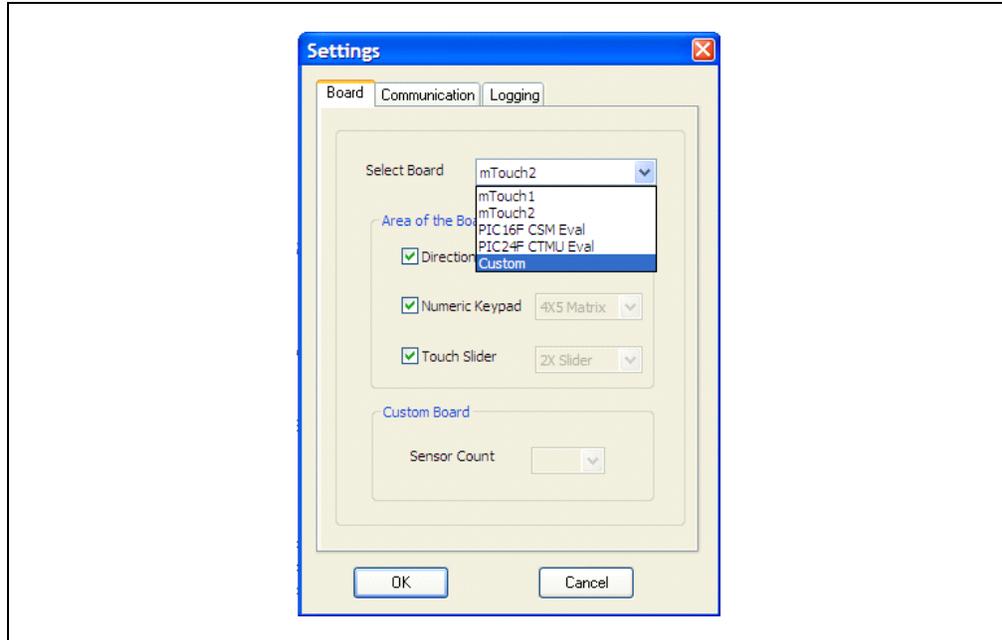
FIGURE 2-4: SETTINGS



Under the Settings menu select the Custom option (Figure 2-5).

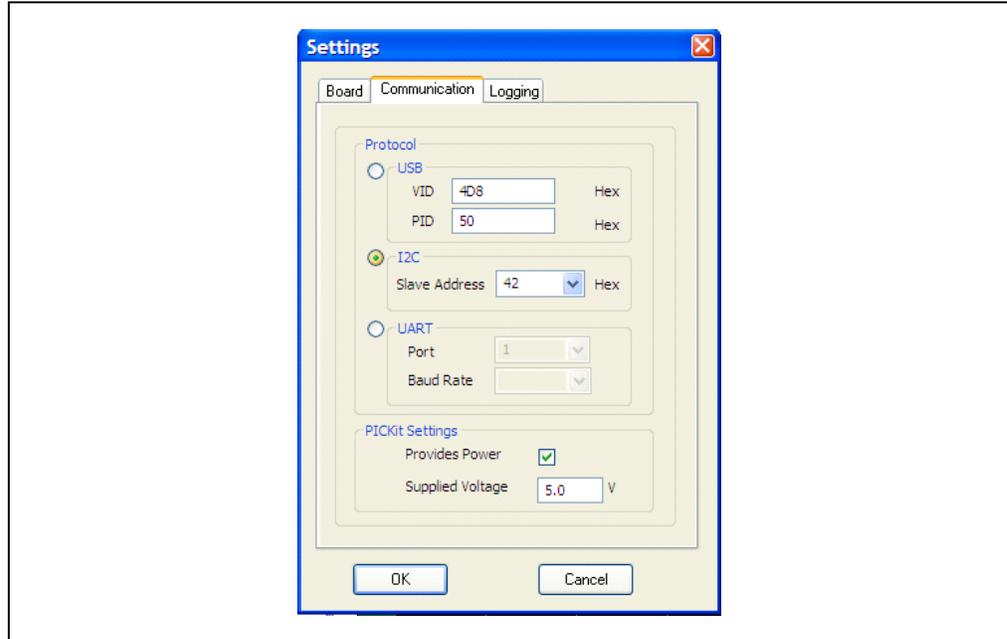
Inductive Touch Demo Board User's Guide

FIGURE 2-5: SELECT BOARD



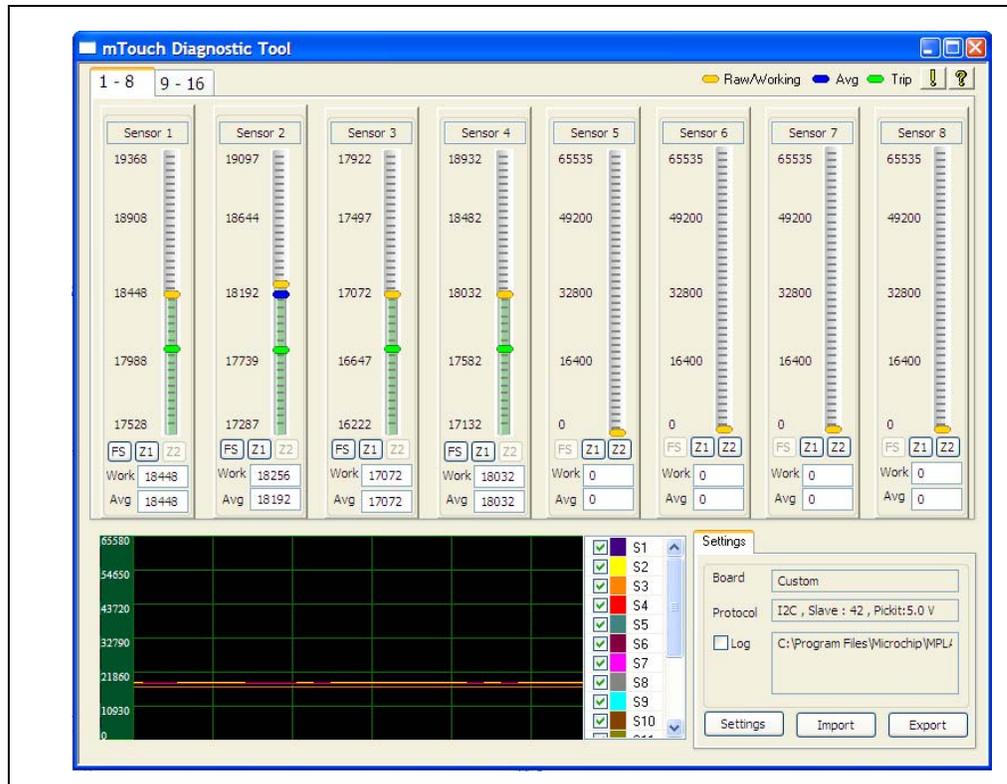
Under the **Communication** tab, select the *I2C* option and enter an address of 42 (Figure 2-6).

FIGURE 2-6: COMMUNICATION



The *Diagnostic Tool* should now display the readings for the first 4 sensors on the display (Figure 2-7).

FIGURE 2-7: FIRST 4 SENSORS READINGS



For more information concerning the diagnostic tools, please check the Microchip web page at www.microchip.com and the MPLAB help files.

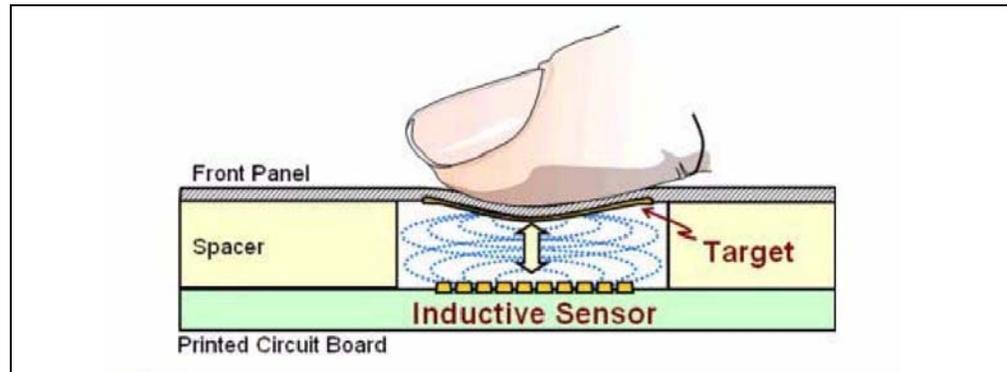
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Chapter 3. Theory of Operation

An Inductive Touch system uses the magnetic coupling between a solid metal target and an inductive sensing coil. If a user presses on the front panel, then the coupling between the target and sense coil will increase due to the minute shift in the target's position toward the sensor coil, as shown in Figure 3-1. The result is a change in the impedance of the sensing coil.

FIGURE 3-1: CROSS SECTION OF AN INDUCTIVE TOUCH SENSOR



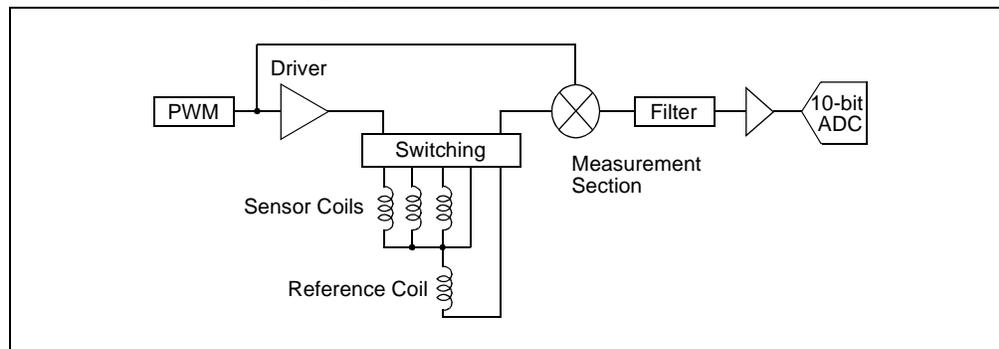
3.1 SENSOR COIL IMPEDANCE MEASUREMENT SYSTEM

To sense this change in the inductive sensing coil, an impedance measurement system and a microcontroller are required. The impedance measurement system operates by exciting the sensor coil with a pulsed current. This produces a pulsed voltage across the coil that is proportional to both the current and the impedance of the coil. The impedance measurement system then converts the pulsed voltage into a DC voltage proportional to the amplitude of the pulsed voltage using a frequency mixer, low pass filter, and amplifier. The resulting DC value is converted to a binary number using an ADC.

To assist in maintaining consistency in the readings, a reference coil has been added to remove variations in the readings due to long term variations in the current and due to temperature shifts. The reference coil is in series with the sensor coil, and is measured as part of the conversion process. The resulting value for the reference coil is divided into the sensor coil, resulting in a "normalized value" for the coil. By using the impedance ratio of the two coils, any variation in the impedances due to temperature or long term drive current variation fall out and we are left with a temperature and voltage compensated value. Figure 3-2 shows a block diagram of a typical impedance measurement system.

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FIGURE 3-2: BLOCK DIAGRAM OF THE IMPEDANCE MEASUREMENT SYSTEM

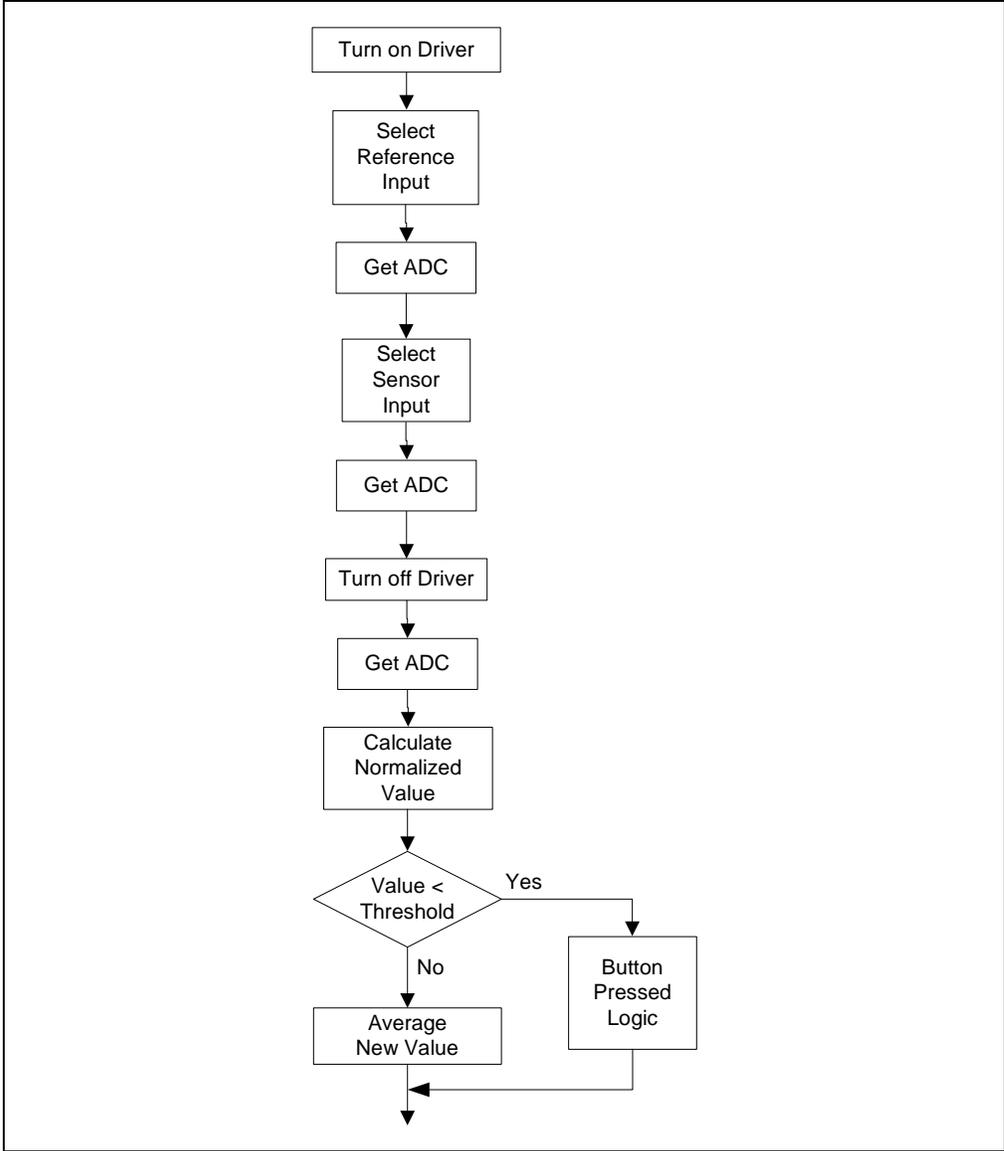


3.2 POLLING SOFTWARE

The microcontroller periodically polls the various sensors by measuring impedance of the individual sensing coils. If the impedance of the sense coil has changed from the store average for each coil, then the microcontroller determines if the shift in impedance is sufficient to qualify as a user's press.

Figure 3-3 is a flowchart of the system software. The polling process includes the measurement of the voltage across both coils, just the reference coil, and the virtual ground of the system. Subtracting the various values from one another produces voltages for both coil. Dividing the sensor coil voltage by the reference coil voltage, then gives a normalized value in which temperature and drive variations have been removed. The software then compares the normalized value against a running average to determine if the shift is sufficient for a valid press by the user.

FIGURE 3-3: SYSTEM FLOWCHART



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Appendix A. System Detail

A.1 SENSOR DESIGN

An inductive touch system uses the magnetic coupling between a solid metal target and an inductive sensing coil. If a user presses on the front panel, then the coupling between the target and sense coil will change due to the minute shift in the target's position, as shown in Figure A-1.

FIGURE A-1: TYPICAL SENSOR/TARGET SANDWICH

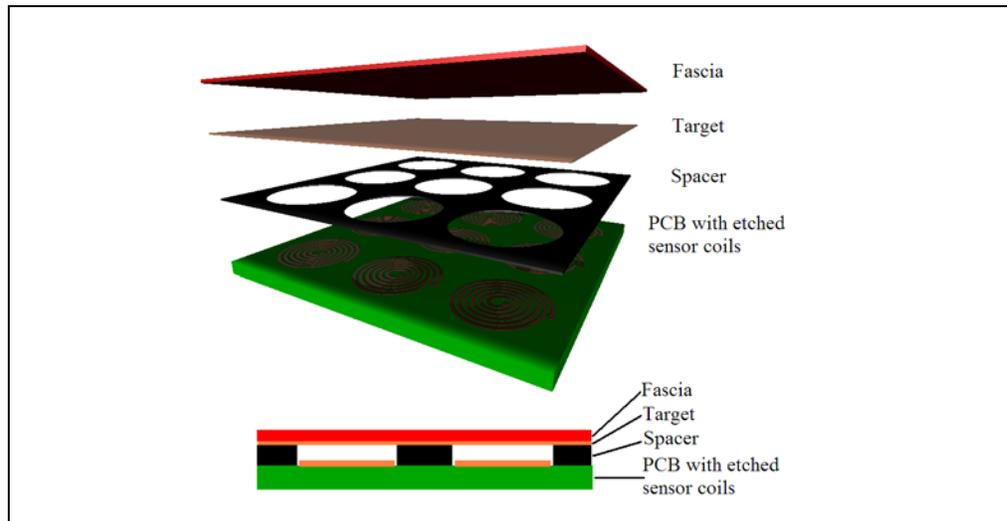
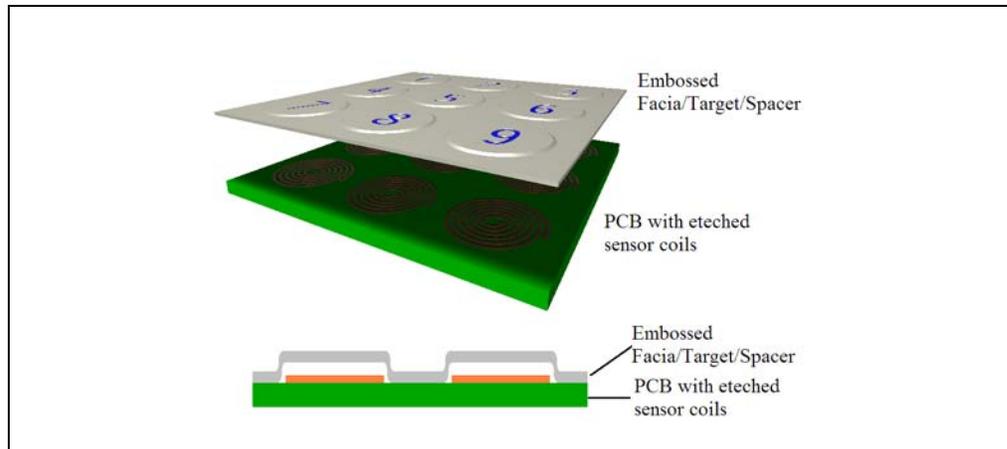


FIGURE A-2: SENSOR/TARGET SANDWICH OF DEMO BOARD



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A.1.1 Fascia

The fascia is typically the top layer of the sensor sandwich. It is the plastic panel or metal sheet that the user presses on and usually carries the labeling that identifies the button's location and function. The fascia can also be combined with the target if it is conductive, and can be sufficiently deformed by the user's press to cause the required minimum change in inductance (the Inductive Touch Demo Board uses a combined Fascia and Target). The material of the fascia can, in theory, be made from any material – so long as it elastically deforms under the range of expected pressures that will be applied by the user.

The fascia used in the Inductive Touch Demo Board is 0.018 inches thick aluminum. With a button diameter of 0.8 inches, that means a press force of only 5½ oz. is required to generate the minimum deflection required for a user press.

Other common fascia constructions include plastic injection moldings, plastic sheet, sheet or formed metal. Other materials can also be used by the user, provided they elastically deform under pressure.

A.1.2 Targets

The target is a passive, electrically conductive layer which is arranged to displace or deform along the measurement axis relative to the coil. If a separate fascia layer is used, then the target is mechanically bonded to the fascia, so it will deform with pressure on the fascia. While magnetically permeable materials such as ferrites can be used for the target, highly conductive materials are preferable, due to their good conductivity and lower cost. In a typical application, the target is made from a copper lamination, but it could also be made from any other highly conductive materials such as aluminum, gold, silver or steel. The target layer in the Inductive Touch Demo Board is aluminum, and approximately 0.018 inches thick.

Only a thin layer of conductive material is actually required for a target (typically <100 microns) and can be produced, for example, using 3 ounce copper cladding on a PCB substrate. The diameter target should be the same size and shape as the coil.

A.1.3 Spacer

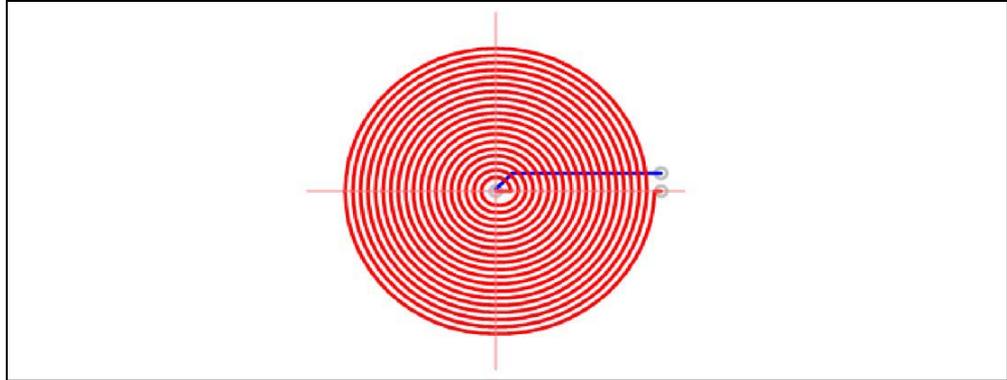
Most – but not all – inductive touch constructions use a spacer layer to provide the separation between the target and the coils. Constructions which use an injection molded fascia do not typically require a spacer layer since the separation distance can be molded as an integral feature of the plastic. A spacer layer can also be built into the target layer through embossing (creating a raised 'bump' in the target material). The embossed area of the target (immediately above the sensor coil) provides the necessary displacement that will allow the target to move.

The thickness of the spacer should be approximately 1%-3% of the diameter of the coil. The spacer layer can be made from a wide range of materials but should be a mechanically stiff and electrically insulating material such as FR4, FR2, resin bonded paper, ABS or other plastic. The depth of embossing on the Inductive Touch Demo Board is approximately 0.010 inch for a 0.8 inch diameter button, or approximately 1.2%.

A.1.4 Sensor Coils

The sensor coils are one or more inductors, preferably implemented as flat spiral coils, etched into the copper layer of a PCB, as shown in Figure A-3.

FIGURE A-3: SPIRAL INDUCTOR PCB PATTERN



The inductance of the coil is determined by the number of turns and the dimensions of the pattern etched into the PCB. Note that the calculated inductance of the coil is not particularly important as the target will change the impedance of the coil due to its proximity. The coils in the Inductive Touch Demo Board are approximately 0.8 inches in diameter, with 24 turns. This works out to a trace width of 0.010 inch with 0.010 inch spacing (0.008 width with 0.008 spacing is also typically used). The uncovered inductance is, therefore, nominally 12 μH .

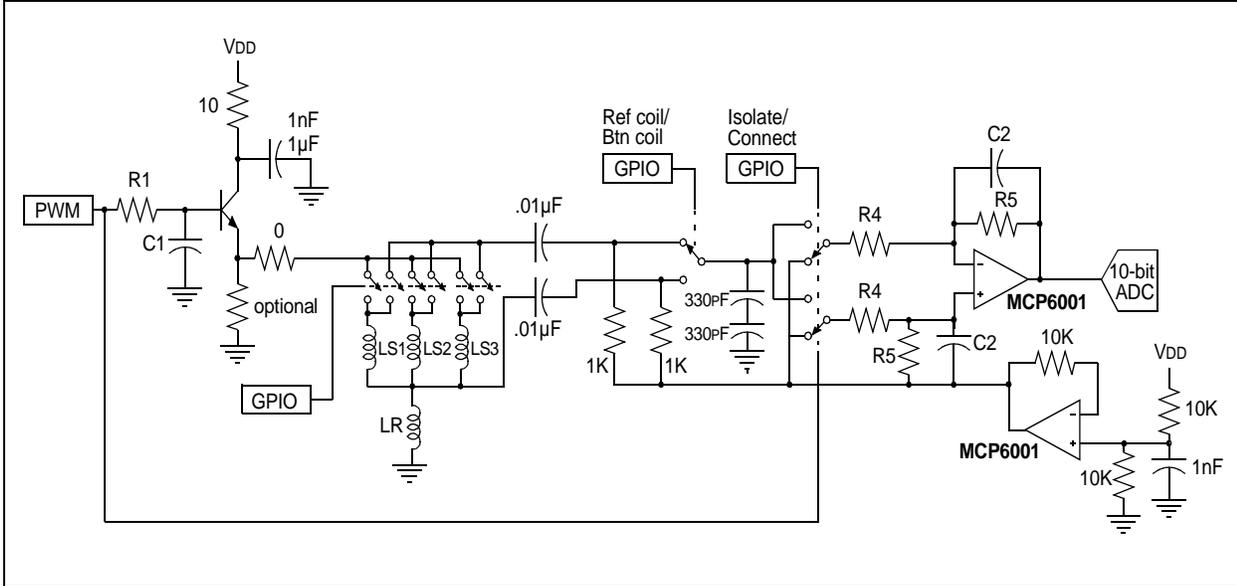
A.2 HARDWARE DESIGN

To measure the impedance of a sensor coil, the measurement system must first excite the coil with a pulsed current. This produces a pulsed voltage across the coil that is proportional to both the current and the impedance of the coil. The impedance system then converts the pulsed voltage into a DC voltage proportional to the amplitude of the pulsed voltage. The resulting DC value is converted to a binary number using an ADC, and software in the system then decides if the shift in impedance is indicative of a user's touch.

To assist in maintaining consistency in the readings, a reference coil has been added to remove variations in the readings due to long term variations in the current and due to temperature shifts. The reference coil is in series with the sensor coil, and is measured as part of the conversion process. The resulting value for the reference coil is divided into the sensor coil, resulting in a "normalized value" for the coil. By using the impedance ratio of the two coils, any variation in the impedances due to temperature or long term drive current variation fall out and we are left with a temperature and voltage compensated value. Figure A-4 shows a simplified schematic diagram of the Inductive Touch Demo Board's impedance measurement circuitry.

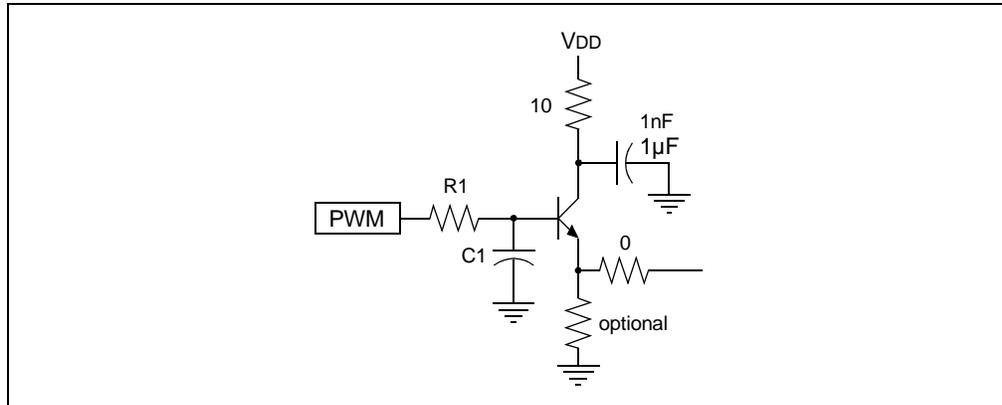
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FIGURE A-4: SIMPLIFIED MEASUREMENT CIRCUITRY



The first section of the design is the current driver, shown in Figure A-5.

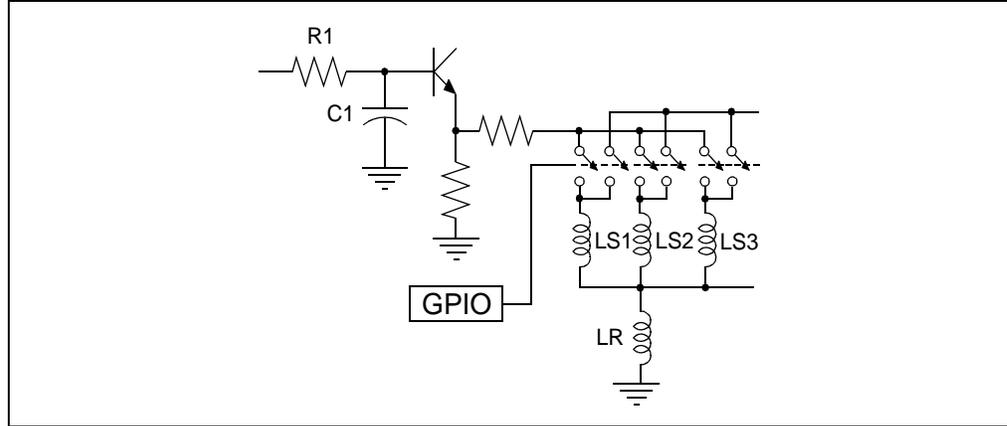
FIGURE A-5: CURRENT DRIVER CIRCUIT



R1 and C1 form a low pass filter which rounds off the edges of the PWM square wave, to produce a more sine-like waveform for driving the coil. In the Inductive Touch Demo Board, R1 is 1K and C1 is 150pF, this puts the corner frequency at 1MHz which is the frequency of the PWM drive.

The next section of the design is the switching circuitry for selecting individual sensor coils. Figure A-6 shows the section of the design.

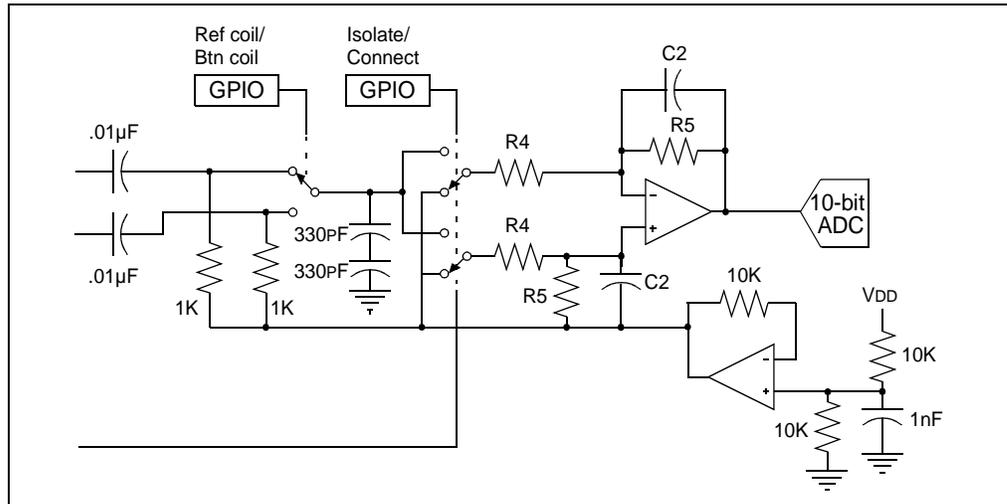
FIGURE A-6: COIL SELECTION MULTIPLEXERS



The analog multiplexer used in the Inductive Touch Demo Board is a MM74HC4052 from Fairchild Semiconductor. It was chosen for its extremely low on resistance of 30-50 Ohms, which significantly increases the current drive to the coils. The multiplexers are also doubled, one on the drive side and one on the measurement side, to eliminate offset voltages that are generated across the on resistance of the drive side multiplexers.

After the switching section is the detector circuit. Figure A-7 shows the schematic for this section.

FIGURE A-7: SCHEMATIC OF THE DETECTOR SECTION



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The detector operates by switching the filter/amplifier circuit between an inverting and non-inverting configuration, in time with the drive waveform of the coils. This allows the detector to flip the negative side of the waveform, resulting in a positive signal – similar to the output of a full wave rectifier. The capacitors in the feedback path of the amplifier/filter, average out the peaks and valleys to produce a DC level proportional to the AC signal's amplitude. The detector in the Inductive Touch Demo Board uses parallel combination of 100K and 330 pF to place the corner frequency at 5 kHz. With a value of 10K for R4, this also gives a gain of 10 for the system.

The multiplexer used for multiplexing the button/reference inputs, and the switching of the amplifier is an MM74HC4053, also from Fairchild. The second op amp at the bottom of the diagram provides a virtual ground at $V_{DD}/2$ for the single supply circuit. In the demo board, both amps are part of an MCP6002 op amp device.

The detector also uses two inputs from the microcontroller to control which waveforms are detected. The first selects between the button coil and the reference coil. The second, disables the multiplexer in the detector, to isolate the detector from the sensor coils. This is necessary to obtain a clean measurement of the detector $V_{DD}/2$ virtual ground. All three measurements are required to convert the button coil impedance into a normalized value in the software.

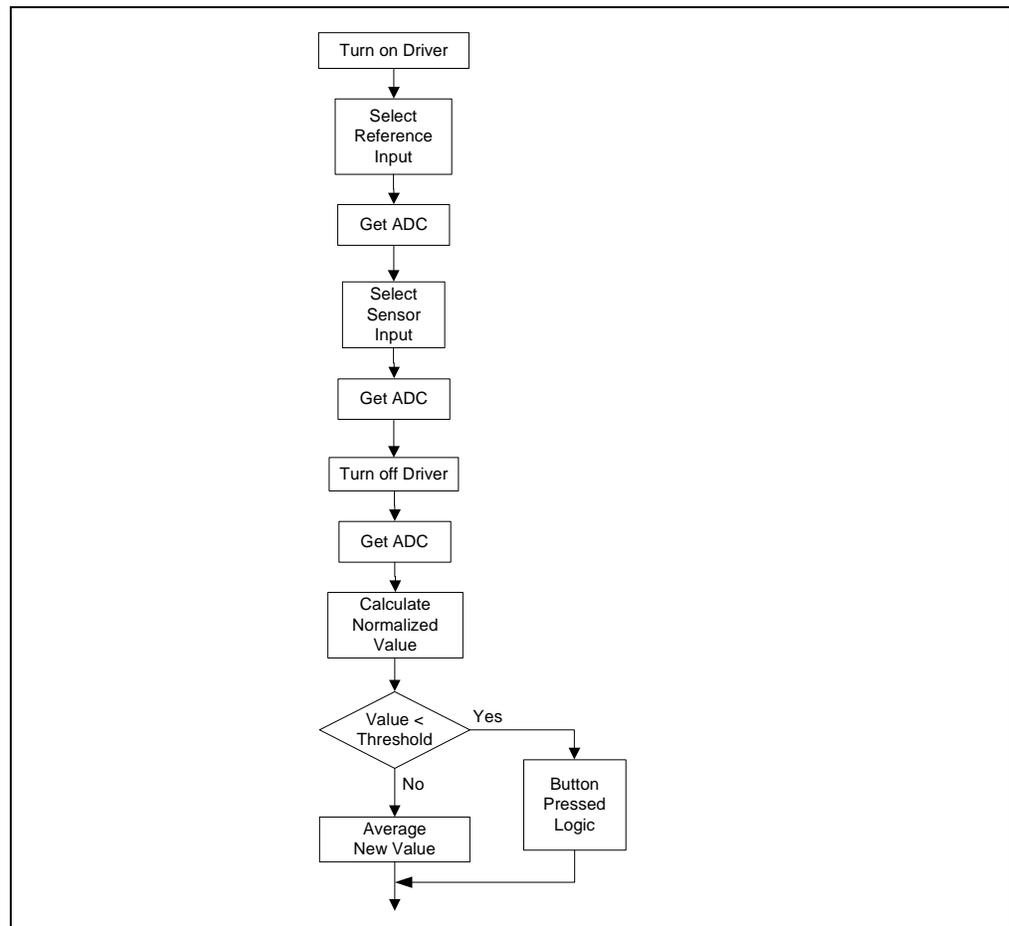
A.3 POWER SUPPLY

The power supply of the Inductive Touch Demo Board requires a 9 VDC source, capable of supplying a minimum of 50 mA. Power is supplied to the demo board through a barrel connector at the top right corner of the board. Any standard Microchip 9 VDC power supply will work, which has the appropriate mating connector.

A.4 SOFTWARE DESIGN

The flowchart for the system software is shown in Figure A-8.

FIGURE A-8: SYSTEM FLOWCHART



A timer interrupt driven function scanning is responsible for scanning and interpreting the impedance values from the buttons.

The scanning function first selects a specific coil and turns on the PWM. It then measures both the combined impedance of the button and reference coils:

```

MUX_ENABLE = ENABLE;           // Enable the 4053 mux
RX_SEL = BUTTON_COIL;          // Make sure to select button
PWM_OUTPUT = PWM_ON;
delay = STABILITY_TIME;        // Delay for stability
while(delay--);                // Delay

Pad_Value = get_adc_value();     // Read ADC
  
```

Next, it measures the impedance of just the reference coils:

```

RX_SEL = REF_COIL;             // Make sure to select button
delay = STABILITY_TIME;        // Delay for stability
while(delay--);                // Delay

Ref_Value = get_adc_value();    // Read ADC
  
```

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Then, after turning off the PWM and isolating the detector, it determines a value for the virtual ground of the system:

```
MUX_ENABLE = NOT_ENABLE;           // Enable the 4053 mux
PWM_OUTPUT = PWM_OFF;
delay = STABILITY_TIME;             // Delay for stability
while(delay--);                     // Delay

Vref_Value = get_adc_value();        // Read ADC
```

Using this information, the function then generates a normalized value for the sensor coil:

```
pressValue = Pad_Value - Ref_Value; // Get just button value
pressValue <= 10;                   // Multiply by 1024
pressValue = pressValue / (Ref_Value - Vref_Value); // Key pad reading
```

It then compares the value against a trip threshold based on the coil's running average and the trip value specified for the coil:

```
smallAvg = averageData[button]>>4;
threshold = smallAvg - (tripData[button]>>4);

if(pressValue < threshold)
{
    _KeyPressed = TRUE;           // Set flag for key pressed
}
```

And, finally, it averages the new value into the running average if the button is not pressed:

```
else if (pressValue >= (threshold - 5))
{
    _KeyPressed = FALSE;         // Set flag for no key pressed
    if (averageCtr[button]++ > AVG_DELAY)
    {
        averageData[button] -= smallAvg;
        averageData[button] += pressValue;
        averageCtr[button] = 0;
    }
}
```

The actual conversion of a value out of the detector is performed by the `get_adc_value(void)` function. It performs 4 conversions of each value and adds the results together to obtain a 12-bit value from the 10 bit ADC. This increase in resolution is possible due to the random noise present at the output of the detector.

```

WORD get_adc_value(void)
{
    BYTE Tacq;
    BYTE i;
    WORD ADC_Val = 0;
    DWORD ADC_Avg = 0;

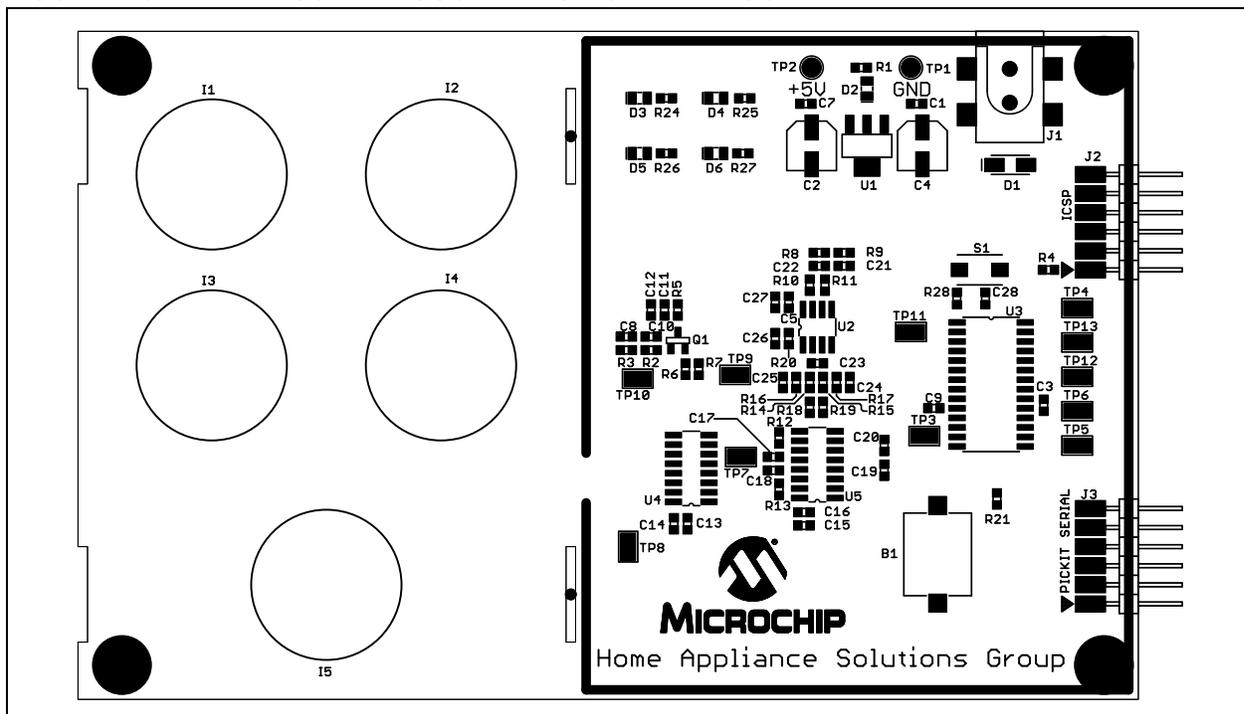
    while(ADGO == 1); // Wait until done

    for (i=0; i<4; i++) // Do 4 samples and average
    {
        Tacq = ACQ_TIME; // Wait the needed acq time
        while(Tacq--);
        ADGO = 1; // Start ADC conversion
        while(ADGO == 1); // Wait until done
        ADC_Val = (unsigned int)ADRESH<<8; // Read high byte value
        ADC_Val |= (unsigned int)ADRESL; // Read high byte value
        ADC_Avg += ADC_Val;
    }
    return((WORD)ADC_Avg); // Return the average value
}
    
```

The main line program then interprets the button press, lights the appropriate LED, and generates the appropriate tone.

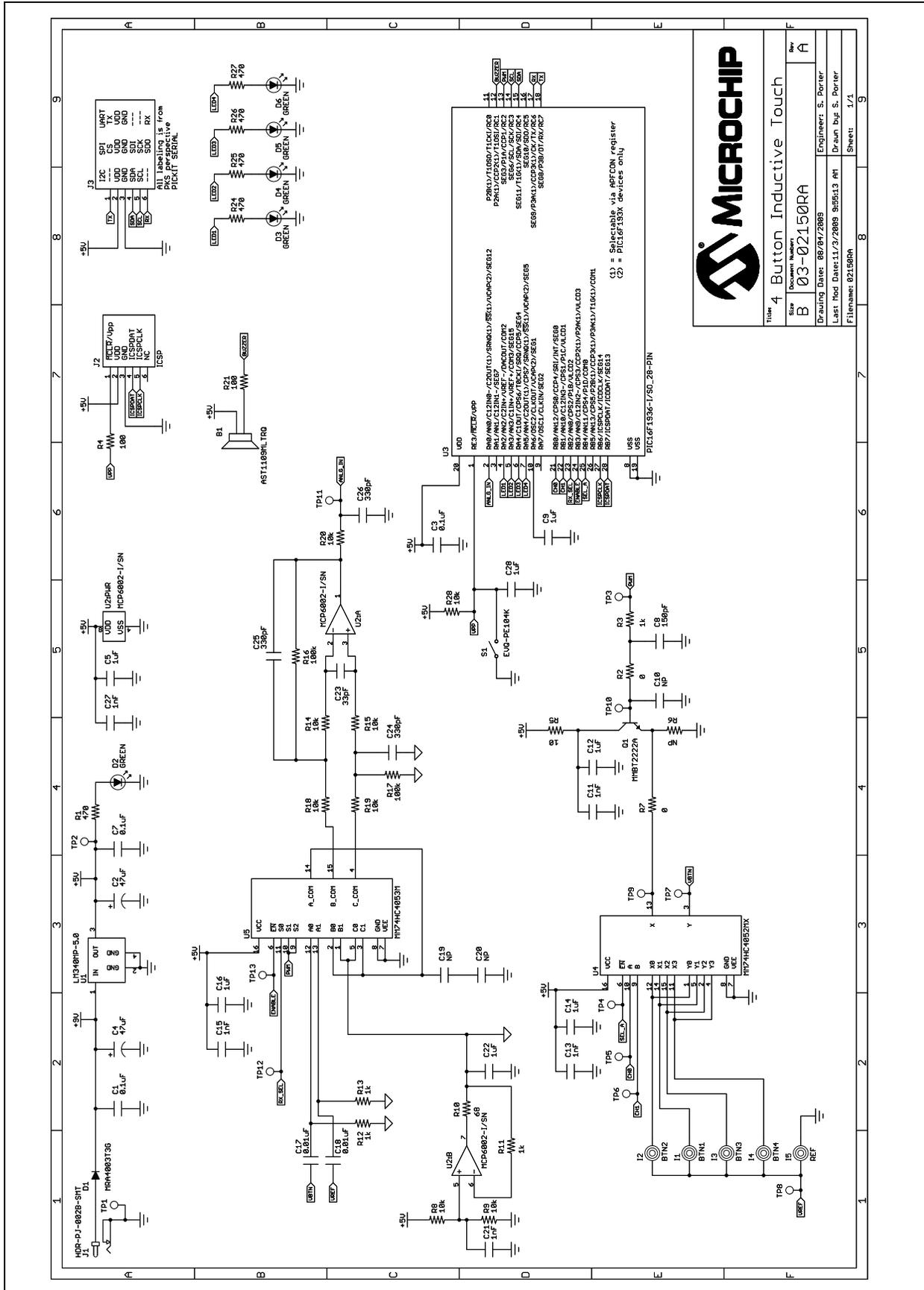
A.5 BOARD LAYOUT AND SCHEMATIC

FIGURE A-9: INDUCTIVE TOUCH DEMO BOARD LAYOUT



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FIGURE A-10: INDUCTIVE TOUCH DEMO BOARD SCHEMATIC



Title	4 Button Inductive Touch		
Doc. Number	B 03-02150RA		
Rev	A		
Engineer	S. Dorier		
Drawn by	S. Dorier		
Checked by			
Date	11/2/2009 9:55:13 AM		
Filename	02150RA		
Sheet	1/1		

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