

mTouch™ Capacitive Evaluation Kit User's Guide

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Preface

NOTICE TO CUSTOMERS

All documentation becomes dated, and this manual is no exception. Microchip tools and documentation are constantly evolving to meet customer needs, so some actual dialogs and/or tool descriptions may differ from those in this document. Please refer to our web site (www.microchip.com) to obtain the latest documentation available.

Documents are identified with a "DS" number. This number is located on the bottom of each page, in front of the page number. The numbering convention for the DS number is "DSXXXXXA", where "XXXXX" is the document number and "A" is the revision level of the document.

For the most up-to-date information on development tools, see the MPLAB® IDE 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 mTouch™ Capacitive Evaluation Kit. 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 mTouch Capacitive Evaluation Kit as a development and demonstrative tool for PIC24F MCU device capabilities and features. The manual layout is as follows:

- **Chapter 1. Introduction to the Evaluation Board –** This chapter introduces the mTouch Capacitive Evaluation Kit 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 mTouch Capacitive Evaluation Kit.
- **Chapter 4. Evaluation Board Hardware** – This chapter provides a functional overview of the mTouch Capacitive Evaluation Kit and identifies the major hardware components.
- **Chapter 5. Troubleshooting** – This chapter provides troubleshooting tips for commonly encountered issues.
- **Appendix A. "Evaluation Board Schematics"** – This appendix provides detailed schematic diagrams of the evaluation 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	*MPLAB® IDE User's Guide*
	Emphasized text	...is the *only* compiler...
Initial caps	A window	the Output window
	A dialog	the Settings dialog
	A menu selection	select Enable Programmer
Quotes	A field name in a window or dialog	"Save project before build"
Underlined, italic text with right angle bracket	A menu path	*File>Save*
Bold characters	A dialog button	Click **OK**
	A tab	Click the **Power** tab
Text in angle brackets < >	A key on the keyboard	Press <Enter>, <F1>
Courier New font:		
Plain Courier New	Sample source code	`#define START`
	Filenames	`autoexec.bat`
	File paths	`c:\mcc18\h`
	Keywords	`_asm, _endasm, static`
	Command-line options	`-Opa+, -Opa-`
	Bit values	`0, 1`
	Constants	`0xFF, 'A'`
Italic Courier New	A variable argument	*`file`*`.o`, where *`file`* can be any valid filename
Square brackets [ ]	Optional arguments	`mcc18 [options]` *`file`* `[options]`
Curly brackets and pipe character: { | }	Choice of mutually exclusive arguments; an OR selection	`errorlevel {0|1}`
Ellipses...	Replaces repeated text	var_name [, var_name...]
	Represents code supplied by user	void main (void) { ... }

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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.

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RECOMMENDED READING

This user's guide describes how to use the mTouch Capacitive Evaluation Kit. 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 Readme 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 sections 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 Data Sheet*" (DS39897) for information on the PIC24F microcontroller used in this application.

MPLAB® Assembler, Linker and Utilities for PIC24 MCUs and dsPIC® DSCs 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® C Compiler for PIC24 MCUs and dsPIC® DSCs 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 (IDE), 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.

Application Notes

There are several Application Notes available from Microchip that help in understanding capacitive touch applications. These include:

- *AN1101, "Introduction to Capacitive Sensing"*
- *AN1102, "Layout and Physical Design Guidelines for Capacitive Sensing"*
- *AN1103, "Software Handling for Capacitive Sensing"*
- *AN1104, "Capacitive Multibutton Configurations"*

- *AN1171, "Using Capacitive Sensing Module with PIC16F72X"*
- *AN1202, "Capacitive Sensing with PIC10F"*
- *AN1250, "Microchip CTMU for Capacitive Touch Applications"*

Microchip mTouch™ Sensing Solutions Webinars

Currently, there are three online Webinars available:

- Introduction to mTouch™ Capacitive Touch Sensing
- Capacitive mTouch™ Sensing Solutions: Design Guidelines
- Overview of Charge Time Measurement Unit (CTMU)

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.

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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 (April 2009)

- Initial Release of this Document

NOTES:

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Chapter 1. Introduction to the Evaluation Board

Thank you for purchasing Microchip Technology's mTouch™ Capacitive Evaluation Kit. These evaluation boards are intended to introduce and demonstrate the possibilities for capacitive touch sense applications on the PIC16F and PIC24F microcontroller platforms.

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

- Overview
- Operational Requirements
- Initial Board Setup

1.1 OVERVIEW

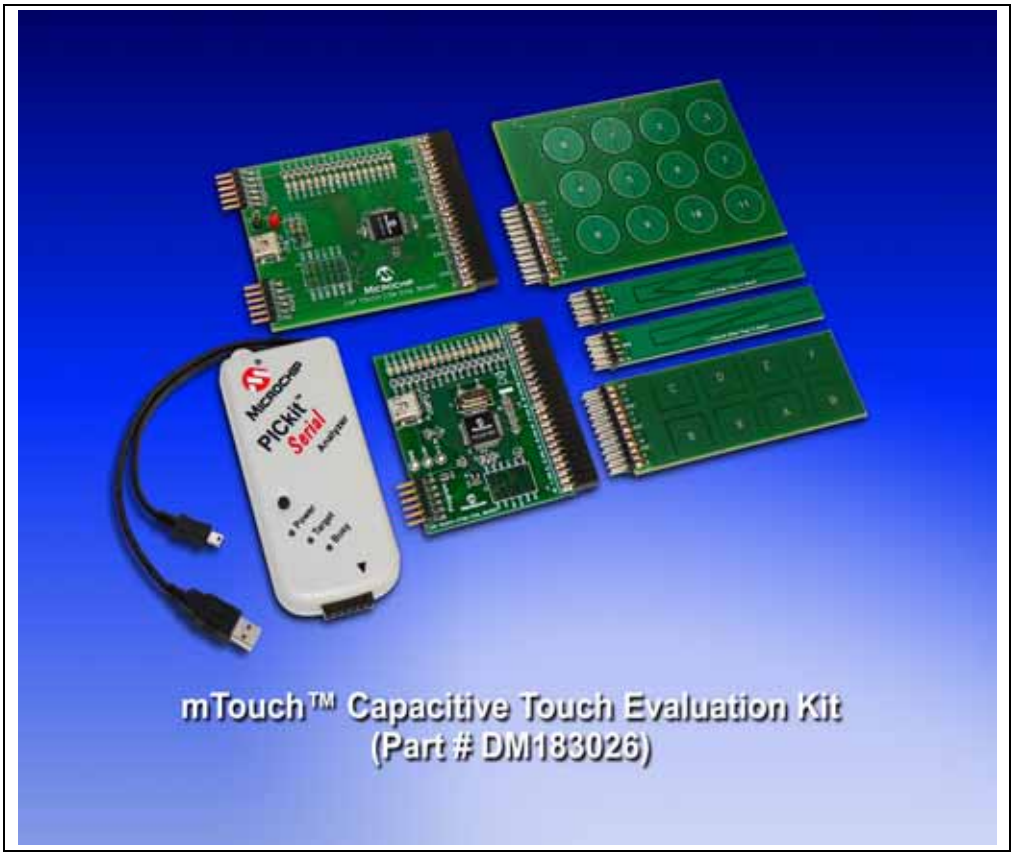
The mTouch Capacitive Evaluation Kit provides a simple platform for developing a variety of capacitive touch sense applications. Two motherboards are included in the kit, which connect to the 4 sensor boards, as shown in Figure 1-1 below.

This Capacitive Evaluation Kit is intended to be used to develop sensors and software using Microchip's mTouch technologies. It is used by first connecting a sensor board, and then supplying power to the board via USB, Pickit™ 2, or Pickit Serial Analyzer. The connector on the right side, with numbers 0 to 15, is the connector for sensing channels. The number, from 0 to 15, represents the microcontroller's sensing channel. The vertical 2-row header is for debugging, to give easy access to some of the microcontroller pins. Debugging may also be done by Microchip Programmers, or by I^2C™ or USB with the mTouch Diagnostic Tool.

When using the evaluation kit out of the box, the LEDs default function is to illuminate on a key press. All functionalities may be reprogrammed by using a Microchip programmer, and reprogramming the firmware in the device. The firmware supplied with the evaluation kit has been written to use the four sensor boards supplied.

The USB connection supplies power to the board; no additional external power supply is needed. For independent operation, the evaluation board may be disconnected from the PC and powered at test points for independent functionality. For the PIC24F board, the USB also provides communications. The PIC16F board uses the PICkit Serial Analyzer to communicate via I^2C to the PC. The PC side application that accompanies the evaluation kit 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 preprogrammed 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.

FIGURE 1-1: KIT CONTENTS



KIT CONTENTS:

- PIC16F727 CSM Motherboard
- PIC24FJ64GB106 Motherboard
- Direct 8 Key Board
- 12-Key Matrix Sensor Board
- 4-Channel Slider Sensor Board
- 2-Channel Slider Sensor Board
- PICKit Serial Analyzer
- USB Cable

1.2 OPERATIONAL REQUIREMENTS

To communicate with and program the mTouch Capacitive Evaluation Kit Boards, 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)

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1.3 INITIAL BOARD SETUP

With its pre-installed demo application, the mTouch Capacitive Evaluation Kit Boards are 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 evaluation board to any computer for the first time, it is important to install the PC software found on the accompanying CD first. This ensures that the proper USB drivers for communicating with the evaluation board are installed and ready to recognize the board.

To install the software and driver, insert the evaluation 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; you must accept the license to use the software.

1.3.2 Connecting the Hardware

Prior to connection, place the mTouch Evaluation Board on a flat surface near the computer. Check to make sure that there are no objects underneath the board. Once the evaluation 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. The PC USB connection provides power to the board.

The CSM Evaluation Board uses the PICkit Serial Analyzer to communicate to the PC. Connect the USB cable to the PICkit Serial Analyzer, and connect it to connector J2 on the board and the PC's USB port. The default code uses the 8-button board.

The CTMU board will have 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 evaluation board does not work, try unplugging and reconnecting the USB cable. If this does not work, refer to **Chapter 5. "Troubleshooting"**.

NOTES:

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Chapter 2. The Demonstration Application

This chapter describes the touch sense application that is preprogrammed on the PIC24F and PIC16F microcontrollers, and its general principles of operation. Topics included are:

- Introduction to the Touch Interface
- Individual Touch Sense Demonstrations

2.1 INTRODUCTION TO THE TOUCH INTERFACE

On the PIC16F727 Motherboard, the on-chip Cap Sense Module (CSM) creates a relaxation oscillator to perform touch sensing. The period or frequency of the relaxation oscillator can be measured, and when the sensor is touched, the frequency will drop and the period will increase, indicating a touched condition.

Control of the touch sense features is built on the PIC24F microcontroller's on-chip Charge Time Measurement Unit (CTMU) module. The CTMU consists of a constant current source that charges each 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 in **Section 11, "Charge Time Measurement Unit (CTMU)"** (DS39724) of the "*PIC24F Family Reference Manual*".

The microcontrollers use the CTMU or CSM 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 evaluation board has four different sensor demonstration boards:

1. Direct 8 Key Plug-in Board
2. Matrix Key Plug-in Board
3. 2-Channel Slider Plug-in Board
4. 4-Channel Slider Plug-in Board

A more detailed description of the CAP TOUCH – CTMU Evaluation Board's operation is provided in **Chapter 4. "Evaluation Board Hardware"**.

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, and certain assumed constants. The demo application is very flexible in the sense that it can be modified by the user.

The PC side application accompanying the mTouch Capacitive Evaluation Kit can 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 an affirmative response for a few seconds, followed eventually by no response at all. Removing the touch stimulus from the sensor resets the algorithm and restores the sensor's responsiveness.

2.2 INDIVIDUAL TOUCH SENSE DEMONSTRATIONS

2.2.1 Direct 8 Key Plug-in Board

The Direct Key Plug-in board is an 8-channel plug-in board with one key directly mapped to one channel. This can be interfaced with any of the 8 channels of the 16 channels provided in the mTouch Capacitive Evaluation Kit. Touching any one of the keys on the plug-in board will light up the corresponding LED in the evaluation board.

The LEDs, D8 to D15 of the evaluation board, correspond to the direct keys numbered from '8' to 'F', respectively, in the Direct Key Plug-in board.

The default firmware loaded in the mTouch Capacitive Evaluation Kit is configured for channels 8 to 15.

When the key numbered '8' is pressed, the LED D8 will be lit. Similarly, when keys '9' through 'F' are pressed, the LEDs D9 through D15 will be lit. Here, one LED will be lit for every press key on the plug-in board (see Figure 2-1).

FIGURE 2-1: DEFAULT PLUG-IN CHANNELS FOR 8-KEY PLUG-IN BOARD



2.2.2 Matrix Key Plug-in Board

The Matrix Key Plug-in board is an array of 12 touch-sensitive keys arranged in a 4x3 matrix. Touching any one of the keys will light up one of the LEDs. Here, the Matrix Key Plug-in board is numbered 0 to 11, which corresponds to LEDs D1 to D12, respectively.

The default firmware loaded in the mTouch Capacitive Evaluation Kit for the Matrix Key Plug-in board is configured for channels 8 to 15.

When the key numbered '0' is pressed, the LED D1 will be lit. Similarly, when the keys numbered '1' to '11' are pressed, the LEDs D2 through D12 will be lit, respectively. Here, one LED will be lit for every press of the key on the plug-in board.

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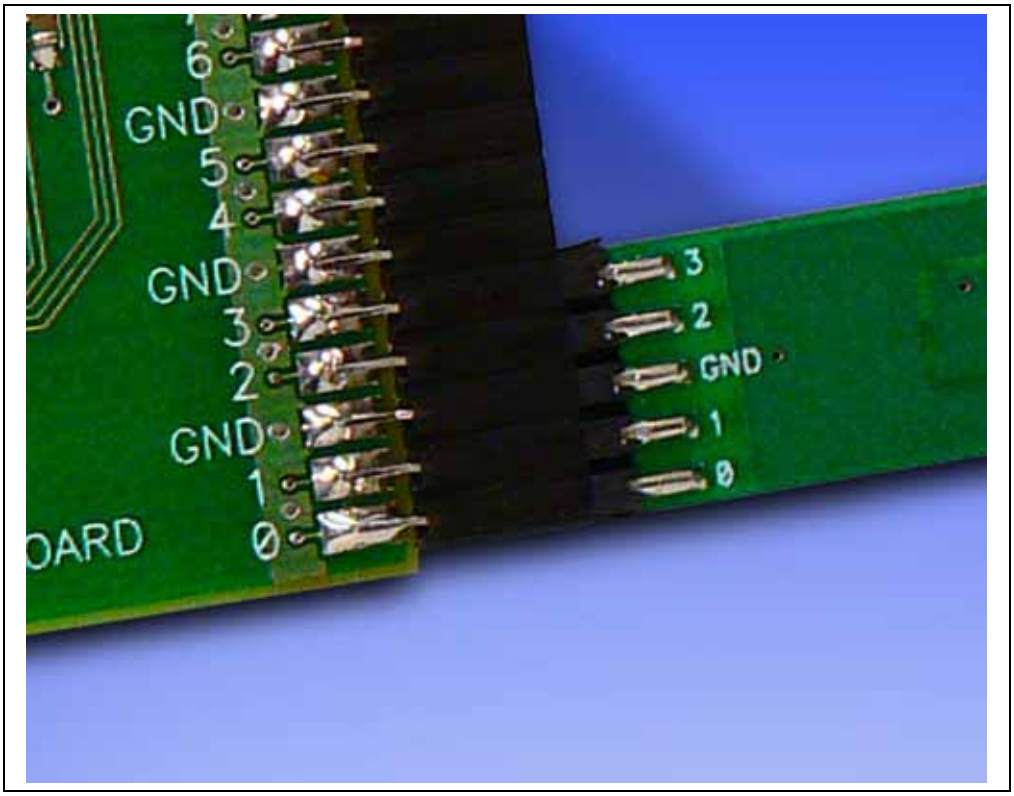
2.2.3 2-Channel and 4-Channel Slider Plug-in Board

Touching anywhere along the length of the slider causes all the LEDs to light up as a bar graph that is representative to the position of the touch. The LED bar graph follows the finger as it moves up and down along the length of the slider, and remains at the last position on the slider when the finger is removed.

The default firmware for the 2-Channel Slider Plug-in, loaded in the mTouch Capacitive Evaluation Kit, is configured such that, the channels 0 and 1 of connector J4 in the mTouch Capacitive Evaluation Kit are connected to the 2-Channel Slider Plug-in board.

The default firmware for the 4-Channel Slider Plug-in, loaded in the mTouch Capacitive Evaluation Kit, is configured such that, channels 0, 1, 2 and 3 of connector J4 in the main evaluation board are connected to the 4 channels in the 4-Channel Slider Plug-in board (see Figure 2-2).

FIGURE 2-2: DEFAULT PLUG-IN CHANNELS FOR 4-CHANNEL SLIDER PLUG-IN BOARD



Note: The plug-in boards can be interfaced to any of the channels in the mTouch Capacitive Evaluation Kit by changing the configuration settings. The details of the configuration settings are explained in the `Readme.txt` file.

Note: Plugging a sensor board in, while a motherboard is running, may require resetting the touch algorithm, most easily done by cycling power.

FIGURE 2-3: PLUG IN THE SENSORS BEFORE POWERING BOARD

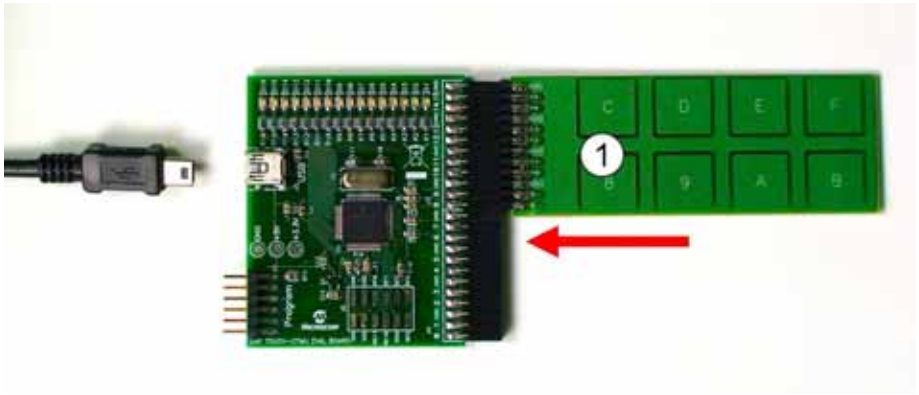
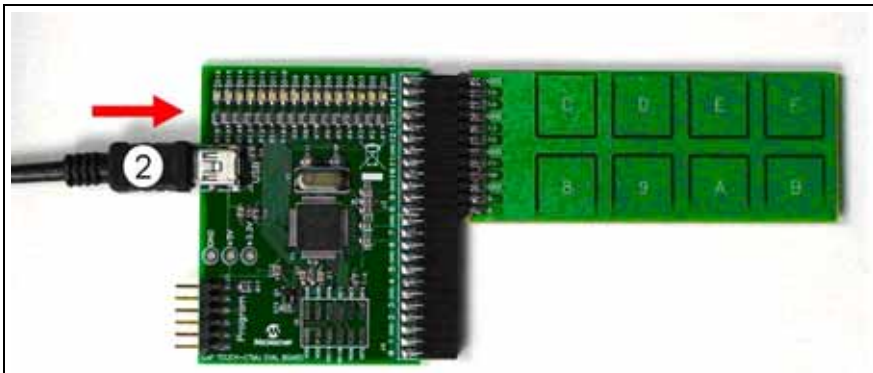


FIGURE 2-4: PLUG IN POWER AFTER SYSTEM IS CONFIGURED



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Chapter 3. Using the mTouch™ Sensing Solution

This chapter describes the Graphical User Interface (GUI) diagnostic tool, mTouch™ sensing solution, that accompanies the mTouch Capacitive Evaluation Kit Boards, and how it can be used in developing and troubleshooting touch sense applications. Highlights include:

- About the mTouch™ Sensing Solution Diagnostic Tool
- Using the mTouch™ Sensing Solution Diagnostic Tool

3.1 ABOUT THE mTouch™ SENSING SOLUTION DIAGNOSTIC TOOL

The touch 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 mTouch Capacitive Evaluation Kit Boards. The touch sensing solution can also be used for developing customized applications.

The operation of the touch sensing solution described here is specific to its use with the mTouch Capacitive Evaluation Kit Boards. For use with other Microchip applications, refer to the specific application's user's guide.

3.2 USING THE mTouch™ SENSING SOLUTION DIAGNOSTIC TOOL

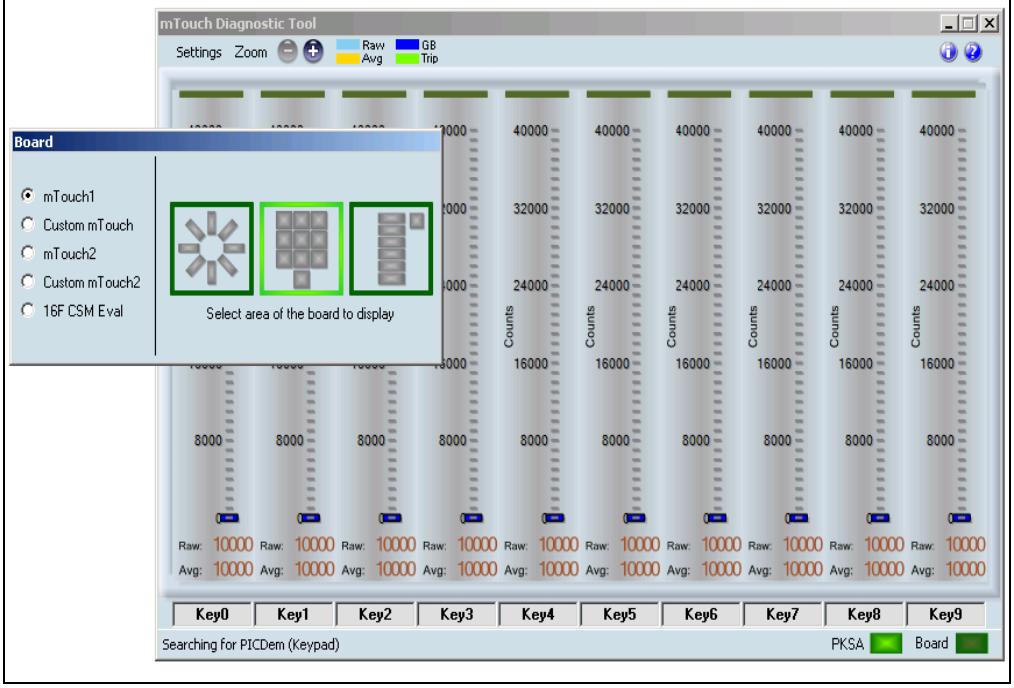
Before starting the mTouch sensing solution diagnostic tool, ensure that the evaluation board is connected to a USB port on a personal computer (or a USB hub connected to the computer) and that the demo board is operating normally.

To start the mTouch sensing solution diagnostic tool:

1. Double-click the mTouch sensing solution diagnostic tool shortcut icon on the desktop.
2. Alternatively, the program may be launched by clicking on the **Start** button and then *Programs > Microchip > mTouch*.

   The application launches with two windows, the Board Selection window and Main Bar Graph Diagnostic Tool window, as shown in Figure 3-1.

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

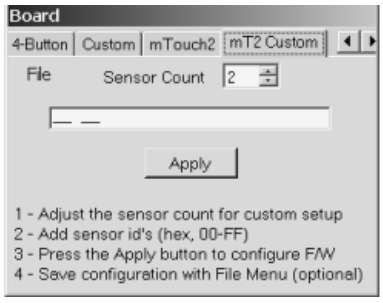


3.2.1 The Board Window

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

By default, the application starts configured for Microchip's mTouch PICDEM™ 1 board, an earlier demo board. The boards in this evaluation kit may use the custom tabs for custom mTouch (PIC16F), or custom mTouch 2 (PIC24F). For the PIC16F custom, the hex address 42 must be supplied for an I^2C address. For the PIC24F mTouch custom 2, select the number of channels appropriate and it will communicate via USB (see Figure 3-2).

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



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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 CAP TOUCH – CTMU Evaluation Board, the Diagnostic Tool window changes, as shown in Figure 3-3. Depending on the sensor area selected, the board shows status displays corresponding to the number of sensor channels used for that area.

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 may be in the 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.

The A/D converter produces values of up to 1023 (10 bits). The CAP TOUCH – CTMU Evaluation 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, certain global settings can be changed for all sensors, and the way the evaluation 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 3-3).

FIGURE 3-3: DIAGNOSTIC TOOL WINDOW FOR mTouch™ SENSING SOLUTION WITH SUCCESSFUL USB CONNECTION (MATRIX KEY PLUG-IN BOARD AREA SELECTED)

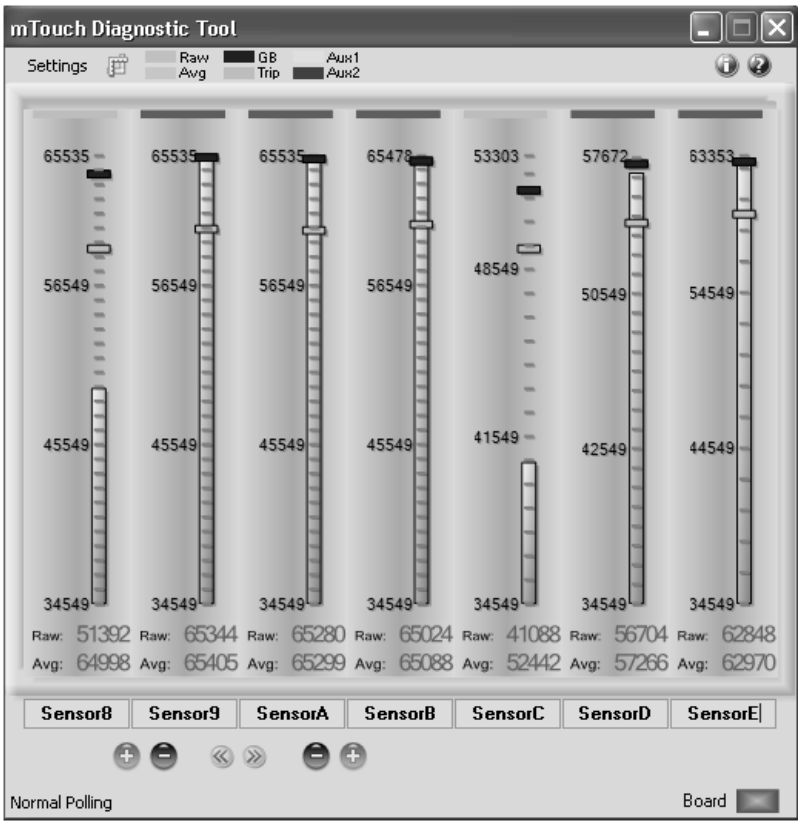
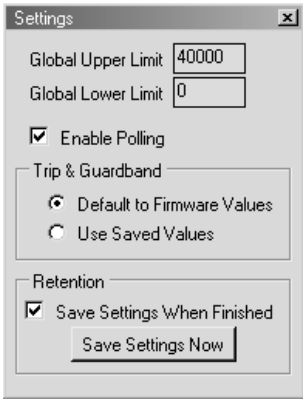


FIGURE 3-4: GLOBAL SETTINGS DIALOG BOX



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 of 0 to 65535. Enter a value in the text box and press **Enter** for the value to take effect. Note that changing this setting overrides any auto-scaling that has been performed.

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The **Enable Polling** checkbox enables communication with the evaluation boards and the real-time display of sensor information. The USB portion of the mTouch sensing solution remains operational and communicates 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** configures the interaction between the mTouch sensing solution and the evaluation boards 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 evaluation 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

When the **Save Settings When Finished** default checkbox is selected, 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 and 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).

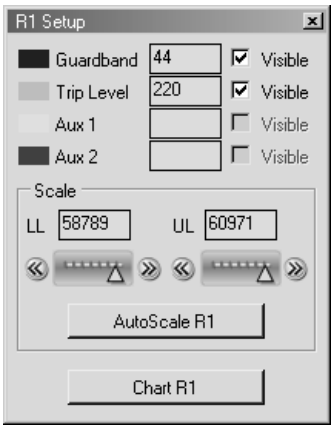
Clicking on another channel while a **Setup** dialog box is open does not close the original window or open a second **Setup** dialog box. Instead, the dialog box becomes the **Setup** dialog box for the channel most recently selected.

The upper portion of the **Setup** dialog box allows the user to set individual values for the **Guardband** and **Trip Level** for each sensor channel. Both 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** radio button must be set for these values to be valid and used by the evaluation board. See **Section 3.2.2.1 “Global Diagnostic Window Settings”** for more information.

The **Scale** area of the dialog box 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



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3.2.2.3 SENSOR DATA CHARTING AND LOGGING

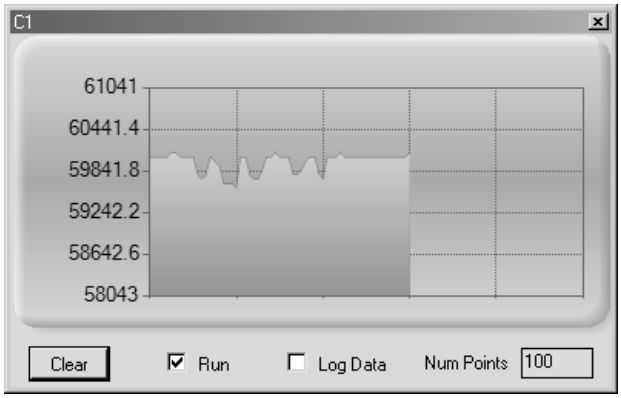
In Figure 3-6, the channel selected is named R1. The **Autoscale** button will have the channel name it is associated with. Within the Setup window, the **Chart R1** button enables data recording from any sensor channel. Clicking on **Chart R1** opens an additional window (Figure 3-6) that displays a 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 is 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 box pops up 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 (10 samples per second).

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 Data Charting window. Instead, the window becomes the Data Charting window for the channel most recently selected.

FIGURE 3-6: DATA CHARTING WINDOW



NOTES:

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Chapter 4. Evaluation Board Hardware

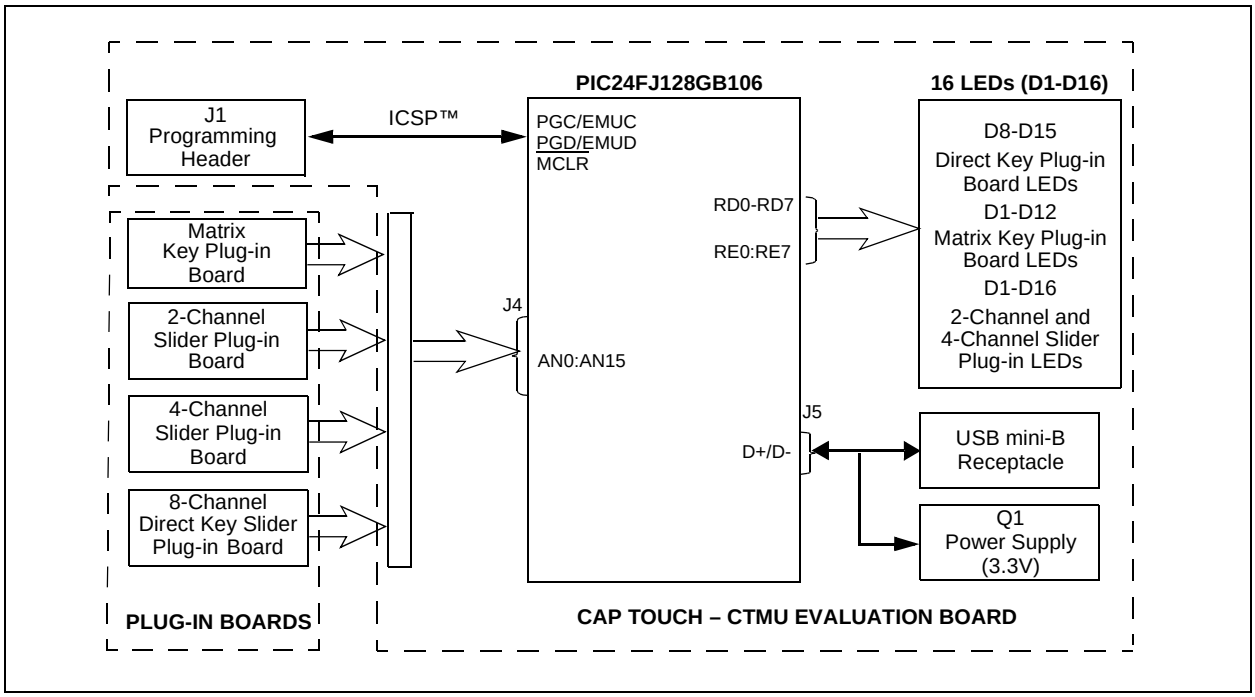
This chapter provides a functional overview of the CAP TOUCH – CTMU Evaluation Board and identifies the major hardware components. Topics covered include:

- Application Functional Overview
- Board Components

4.1 APPLICATION FUNCTIONAL OVERVIEW

Block Diagrams for the CSM and CTMU Boards are shown in Figure 4-1 and Figure 4-2.

FIGURE 4-1: APPLICATION SIDE BLOCK DIAGRAM FOR THE CTMU BOARD



The operation of the demo board is managed by the PIC24F 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 mTouch™ sensing solution diagnostic tool.

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 CAP TOUCH – CTMU Evaluation Board comprise carefully placed circuit traces and capacitive touch pads.

The CAP TOUCH – CTMU Evaluation Board comprises 16 A/D channels of the PIC24F microcontroller connected to connector, J4. This connector is used to interface the plug-in boards to the evaluation board.

The plug-in boards can be connected to any of the 16 channels of the connector (14) by changing the configuration settings, which is explained in the `Readme.txt` file.

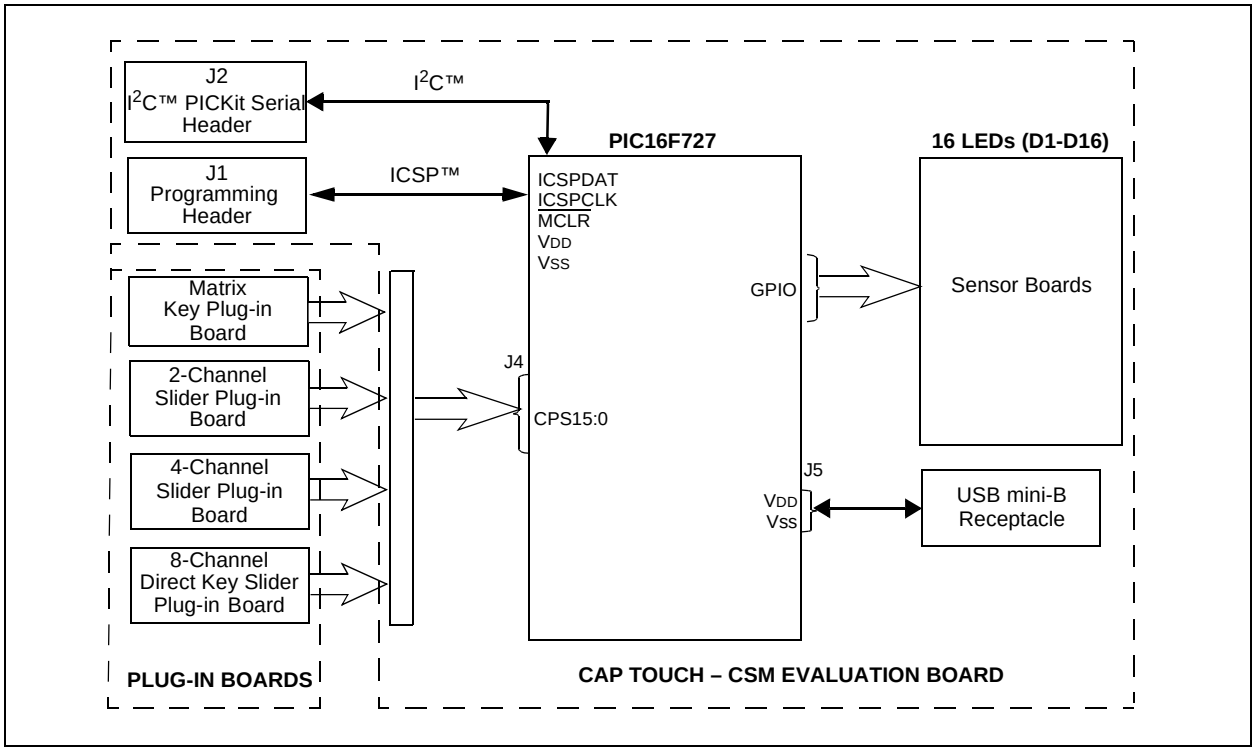
A total of 16 LEDs are provided in the CAP TOUCH – CTMU Evaluation Board. These LEDs are driven directly by the microcontroller through pins on PORTD and PORTE. When an event occurs, the application firmware also provides feedback by activating one or more LEDs at that location. The sequence for the activation of the LEDs depends on the type of touch pads that is interfaced to the evaluation board.

The microcontroller uses its on-chip USB engine and transceiver to communicate to 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 are provided from the V_{BUS} 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 CAP TOUCH – CTMU Evaluation Board as an experimental platform, the microcontroller can be reprogrammed using the ICSP™ connector. A 6-pin header is provided for connecting the demo board to any MPLAB ICD 2 compatible programmer. Since the ICD interface (PGD and PGC) shares some input channels of the connector J4 (channel 6 and 7), necessary care should be taken when the debugger is enabled.

The firmware in the CAP TOUCH-CTMU Evaluation Board will have the default plug-in board channel configurations, which is explained in the `Readme.txt` file. The user can reconfigure the channels based on his application by referring to the `Readme.txt` file.

FIGURE 4-2: APPLICATION SIDE BLOCK DIAGRAM FOR THE CSM BOARD



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The CSM Evaluation Board shares many of the same core features of the PIC24F board. In-circuit Serial Programming lines are provided via a PICkit 2 header, a Mini-B USB adaptor is available for power, and the PICkit Serial Analyzer may be used to communicate to the mTouch GUI via I^2C (transferred through USB by the PICkit Serial Analyzer). For this board, do not use both USB and a PICkit to power the board. The USB has a 3.3V regulator afterwards to regulate the USB power, and the PICkit tools have their own regulator straight to the device V_{DD}. So, choose one or the other.

4.2 BOARD COMPONENTS

Figure 4-3 identifies the key hardware components for the evaluation board. There is one motherboard and 4 plug-in boards. The 4 plug-in boards are identified as direct keys, matrix keys, 2-channel slider and 4-channel slider (see also Figure 4-4).

FIGURE 4-3: CAP TOUCH – CTMU EVALUATION BOARD COMPONENT LAYOUT (TOP SIDE)

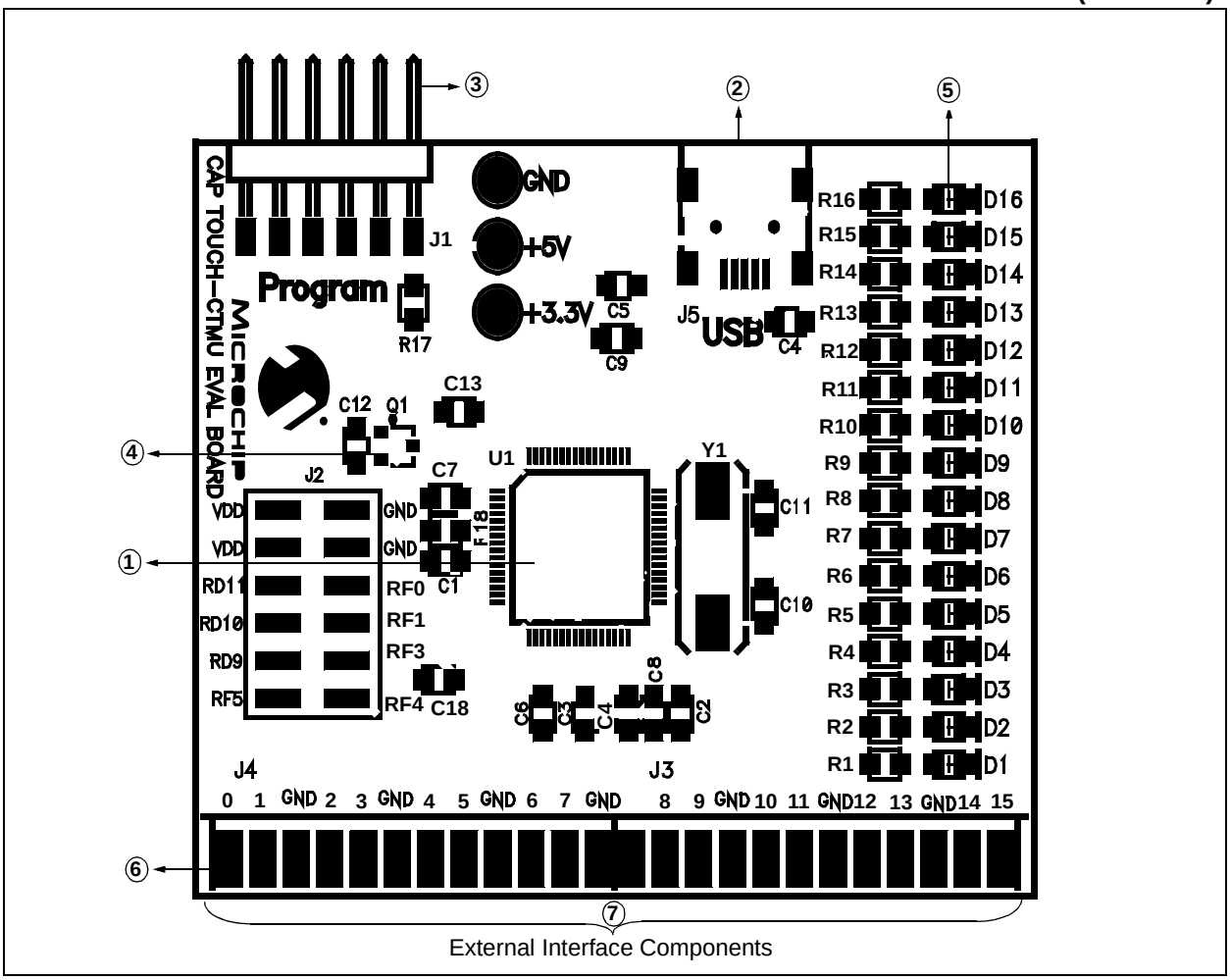


TABLE 4-1: BOARD COMPONENTS

Ref.	Component
1	PIC24FJ128GB106 Microcontroller (U1)
2	USB mini-B Receptacle (J3)
3	ICSP™ Programming Header (J1)
4	Power Supply (Q1) to provide the V_{DD} to the Evaluation Board
5	Plug-in Sensor LEDs (D1-D16)
6	Plug-in Interface Connector (J4)
7	External Plug-in Components (Matrix Key Plug-in Board, Direct Key Plug-in Board, 2-Channel and 4-Channel Slider Plug-in Boards)

4.2.1 Components

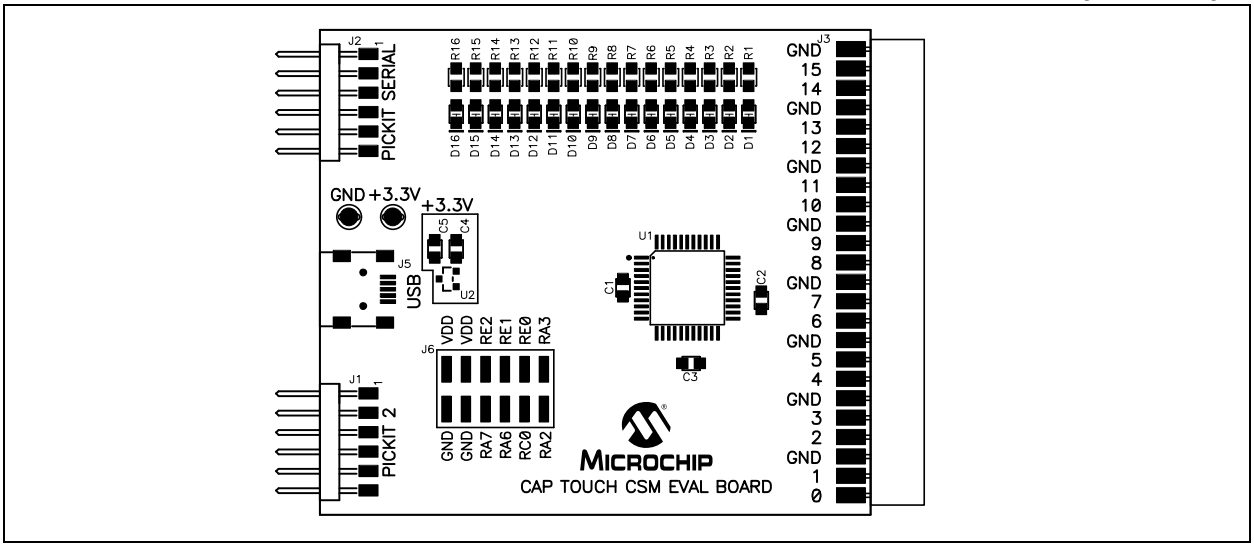
The components listed here (in order of their reference tags in Figure 4-3) are the key components of the application side of the CAP TOUCH – CTMU Evaluation Board:

1. **PIC24FJ128GB106 Microcontroller (U1):** This provides the processing power for the touch sense demo applications. The microcontroller features 64 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 CAP TOUCH – CTMU Evaluation Board functions as a bus-powered device, this connection also provides power to the board.
3. **ICSP™ Programming Header (J1):** This provides a standard Microchip ICD interface for programming and debugging applications on the CAP TOUCH – CTMU Evaluation Board. It is designed to connect directly with Microchip's PICkit™ Starter Kit. 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.
4. **Power Supply (Q1):** This converts the +5 V_{DC} from V_{BUS} to the regulated +3.3 V_{DC} required by the demo board.
5. **Plug-in Sensor LEDs (D1-D16):** Sixteen LEDs (D1 through D16) are connected to PORTD and PORTE of the PIC® microcontroller. These LEDs are lit based on the need of the application.
6. **Plug-in Interface Connector (J4):** This is a 48-pin connector, which is used to interface the different plug-in boards to the microcontroller. This connector is interfaced to 16 analog channels of the microcontroller and the remaining pins are connected to ground of the CAP TOUCH – CTMU Evaluation Board.
7. **External Plug-in Components:**
   - **Matrix Key Plug-in Board:** The Matrix Key Plug-in board is an array of 12 touch-sensitive keys arranged in a 4x3 matrix. The plug-in also comprises a 24-pin connector (12-pin x 2) to connect to the evaluation boards.
   - **Direct Key Plug-in Board:** The Direct Key Plug-in board comprises 8 touch-sensitive keys and a 24-pin connector (12-pin x 2), which can be interfaced to any of the 8 channels of the connector (J4) provided in the evaluation boards.

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- **2-Channel Slider Plug-in Board:** The 2-Channel Slider Plug-in board comprises two triangular shaped touch-sensitive pads and a 10-pin connector (5-pin x 2). The 2-Channel Slider Plug-in board can be connected to any two adjacent channels from the 16 channels provided by the J4 connector in the evaluation boards.
- **4-Channel Slider Plug-in Board:** The 4-Channel Slider Plug-in board comprises 4 touch-sensitive pads and it has a 10-pin connector (5-pin x 2). The 4-Channel Slider Plug-in board can be connected to any 4 channels from the 16 channels that are provided by the J4 connector in the evaluation boards.

FIGURE 4-4: CAP TOUCH – CSM EVALUATION BOARD COMPONENT LAYOUT (TOP SIDE)

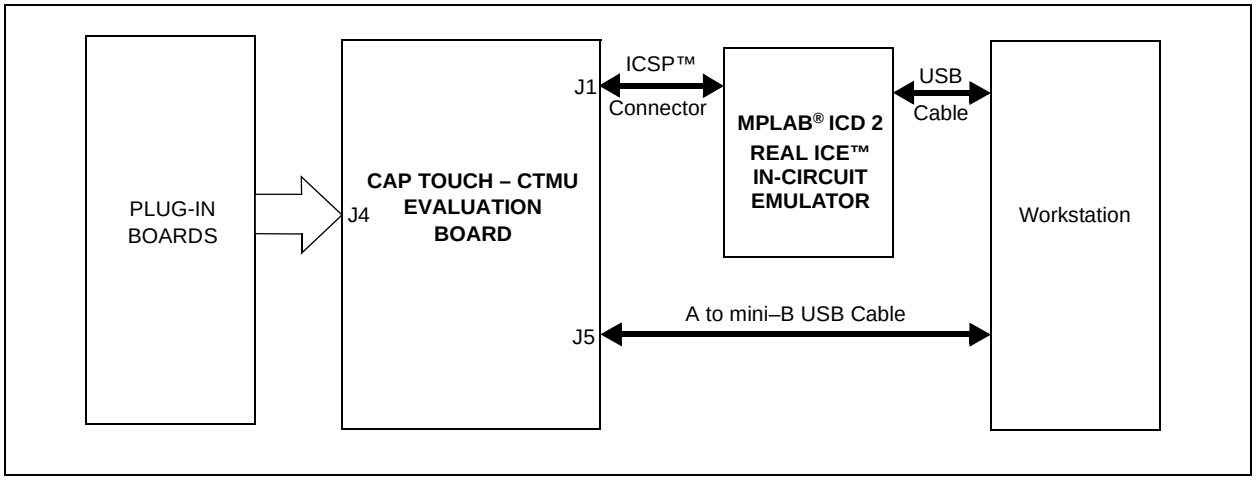


4.3 INTERFACING THE PLUG-IN BOARDS TO THE CAP TOUCH EVALUATION BOARDS

To interface the plug-in boards to the mTouch Capacitive Evaluation Kit Boards:

1. Connect the evaluation board to the MPLAB® ICD programmer interface through the ICSP™ connector, J1.
2. Connect the USB receptacle from the workstation to connector J5 of the evaluation board. This is also used to power-up the evaluation board. For the CTMU board, it is also used to interface to the PC.
3. Connect any of the 4 plug-in boards to the evaluation board through the J4 connector (48-pin).
4. After the hardware connections are done, open the working project in the MPLAB IDE and make the required changes for the corresponding plug-in board, which is explained in the `Readme.txt` file. However, the default values of the channel settings of the corresponding header files are mentioned in **Section 2.2 “Individual Touch Sense Demonstrations”**. The default settings of the configured channels are also explained in the `Readme.txt` file.
5. Download the Hex file onto the evaluation board using the MPLAB ICD 2 interface.
6. Check the working of the respective plug-in boards and view their output through the 16 LEDs on the evaluation board.

FIGURE 4-5: CAP TOUCH – CTMU EVALUATION BOARD BLOCK DIAGRAM



Note: The number of Plug-in boards that can be interfaced with the evaluation board simultaneously is limited by the number of channels in the evaluation board. Since the ICD interface (PGD and PGC) shares two of the input channels of the connector, J4 (channel 6 and channel 7), the operation might fail if any of the plug-in boards is connected to these 2 channels when the Debugger mode is enabled in the MPLAB® IDE.

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Chapter 5. Troubleshooting

5.1 HIGHLIGHTS

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

5.2 COMMON ISSUES

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

   Check the CAP TOUCH – CTMU Evaluation Board board for power:

   - Verify that USB power (V_{USB}, +5 V_{DC}) 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.

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

   Check to make sure that the plug-in boards are connected to the channels that are mentioned in the `Readme.txt` file.

   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 the 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 evaluation board and the mTouch sensing solution diagnostic tool are installed and operating properly, but are not communicating with each other**

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

   - If the evaluation 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 evaluation board and reconnect after 5 to 10 seconds.

4. **The board's edge connector will add some additional parasitic capacitance to the system.**
5. **Touching the solder connections can create a very strong coupling to the sensor and trigger buttons.**

NOTES:

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Appendix A. Evaluation Board Schematics

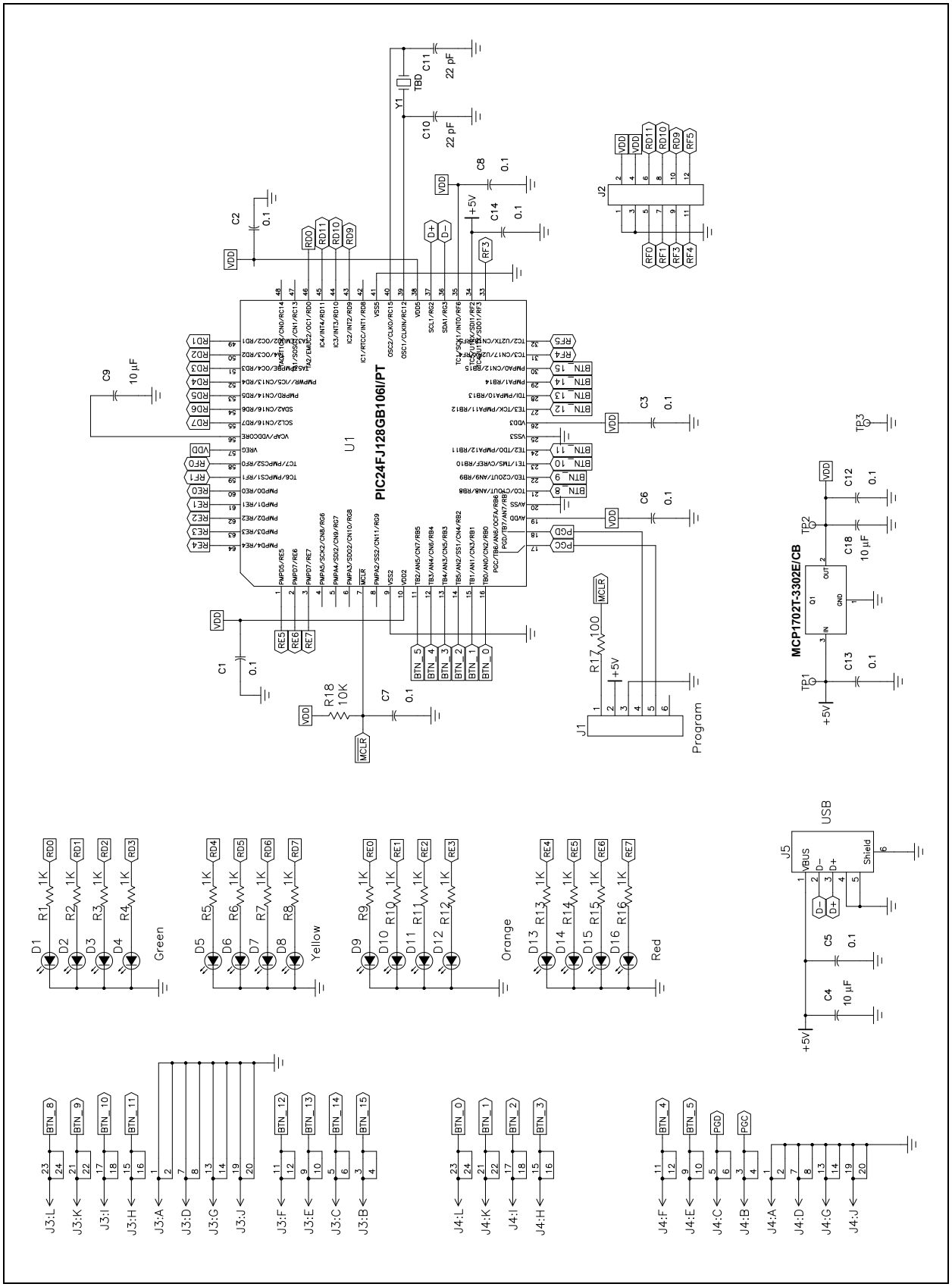
The CAP TOUCH – CTMU Evaluation Board schematic is included in this appendix.

Programmer/Debugger:

- **Figure A-1: "mTouch™ – CTMU Evaluation Board Schematic"** – Microcontroller, Touch Key Plug-in LEDs and Associated Components
- **Figure A-2: "mTouch™ – CSM Evaluation Board schematic"** – Microcontroller, Touch Key Plug-in LEDs and Associated Components

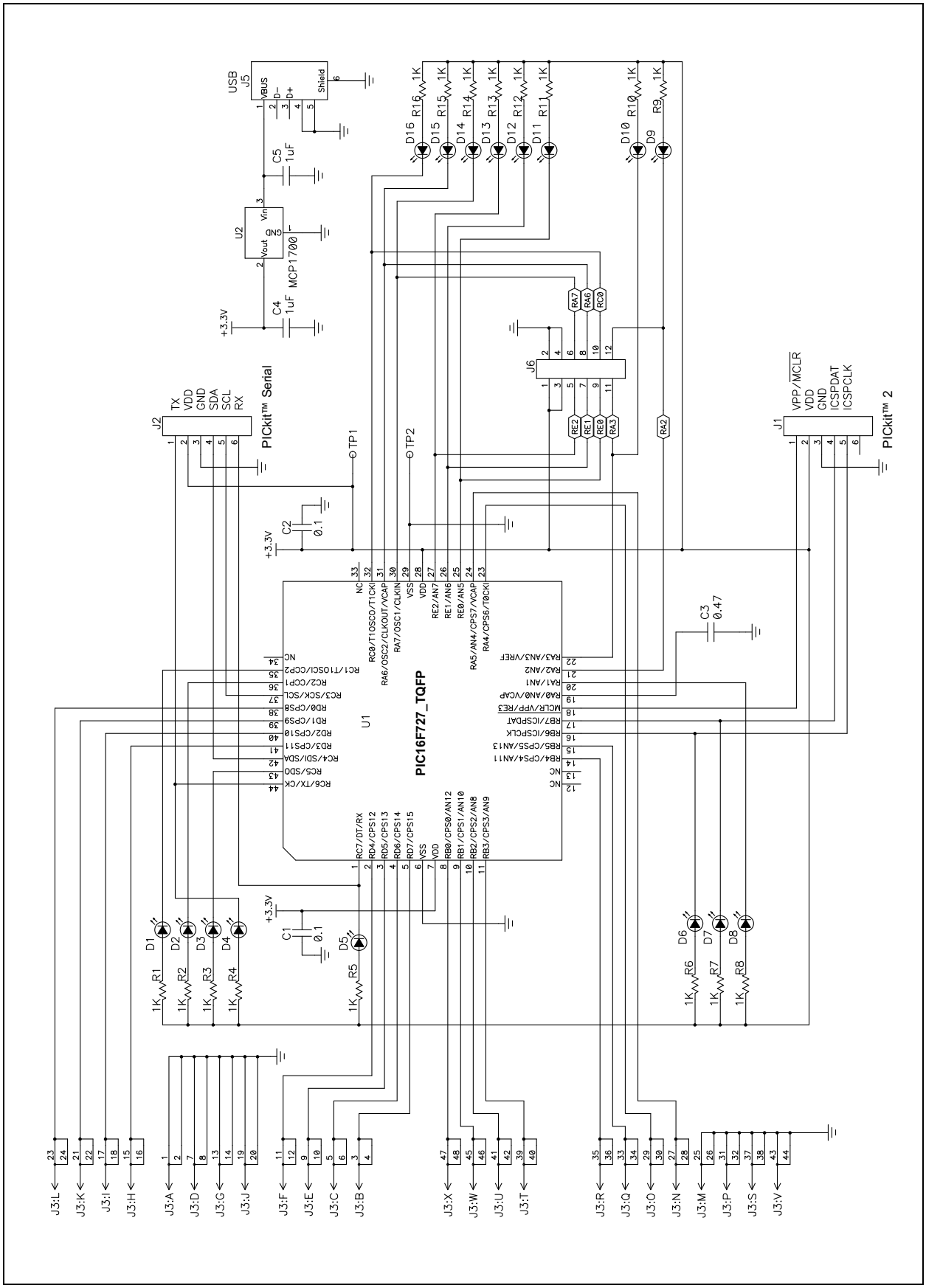
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FIGURE A-1: mTouch™ – CTMU EVALUATION BOARD SCHEMATIC



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FIGURE A-2: mTouch™ – CSM EVALUATION BOARD SCHEMATIC

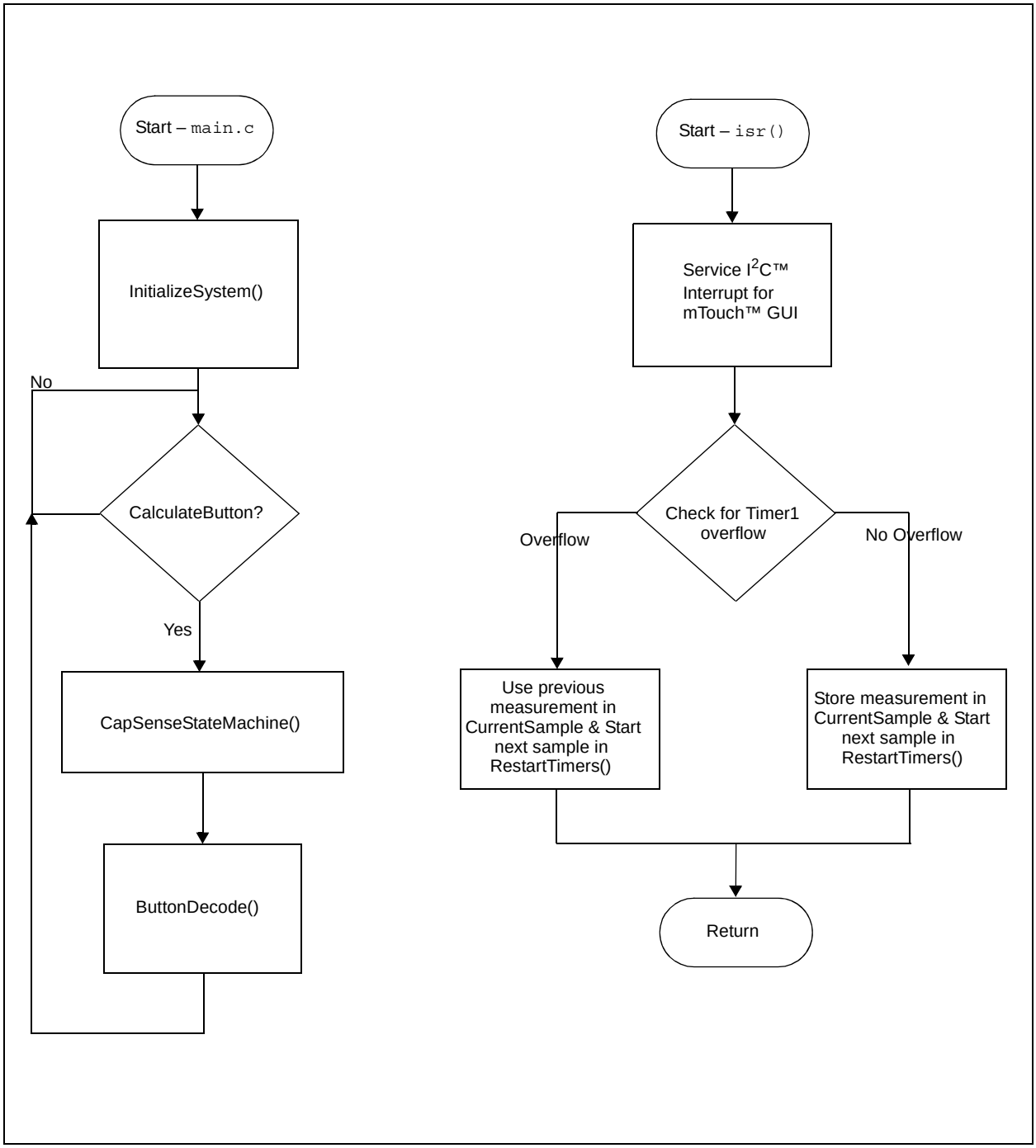


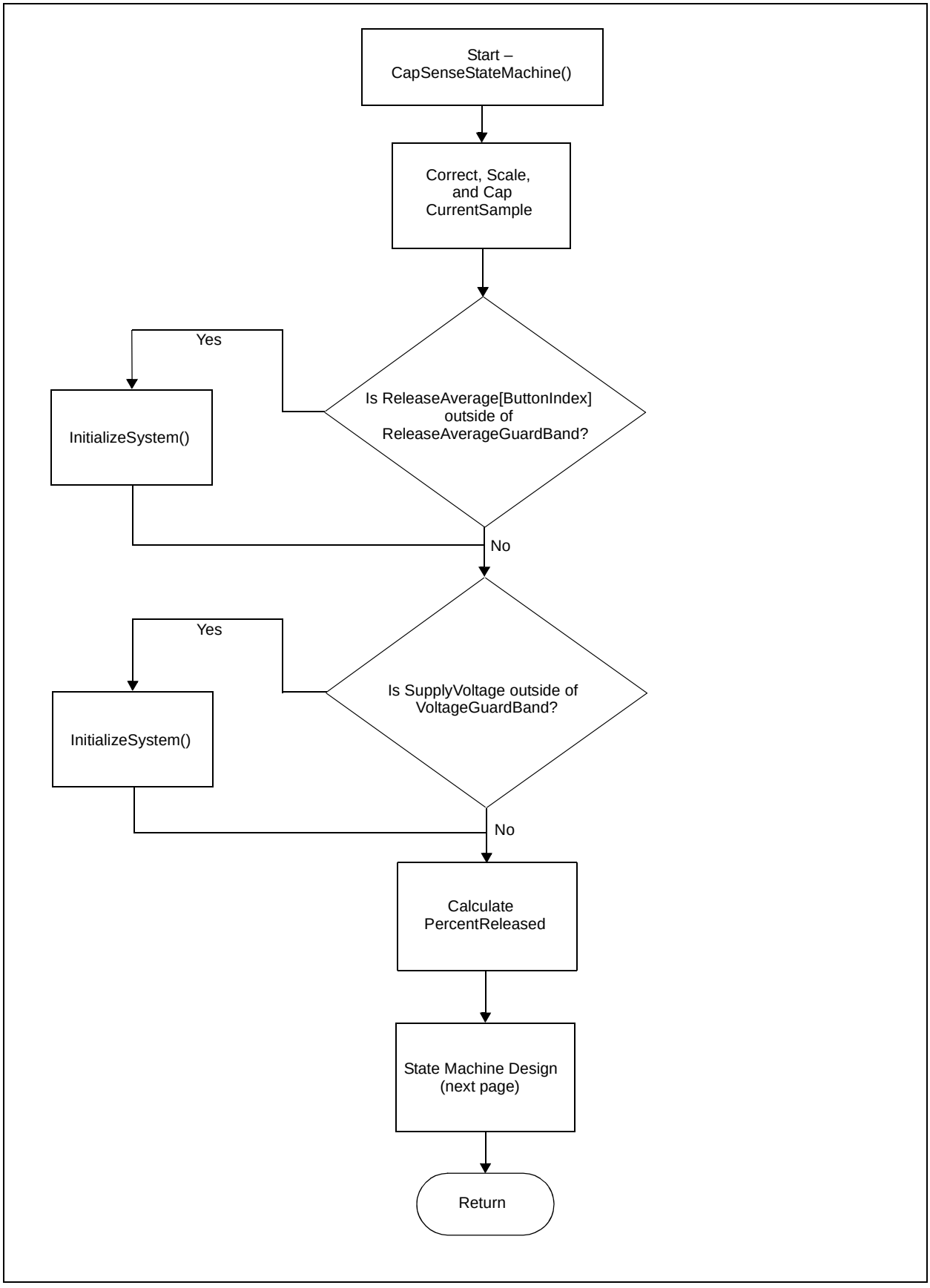
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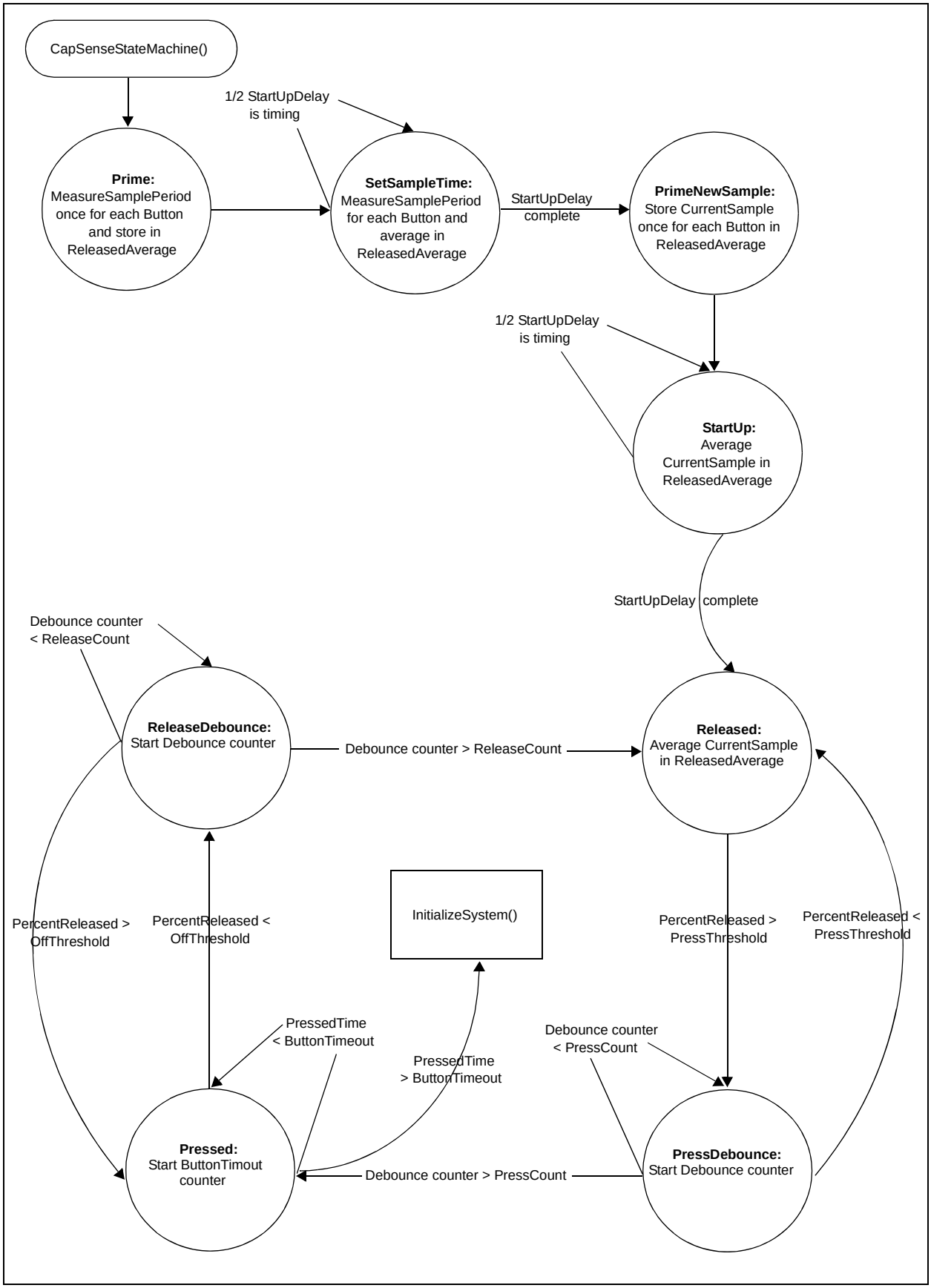
Appendix B: mTouch™ CSM State Diagrams

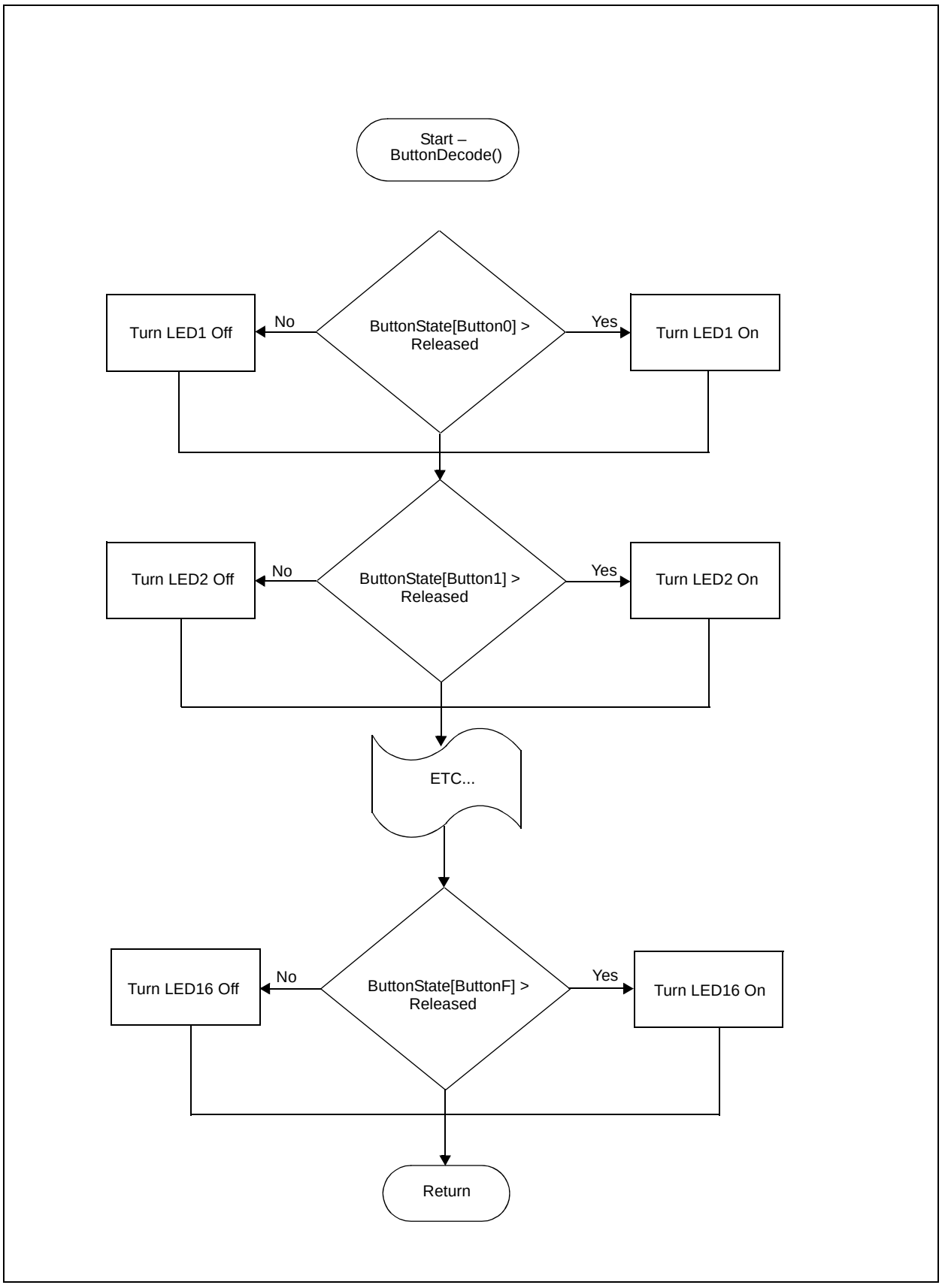
FIGURE B-1: mTouch™ – CSM STATE DIAGRAMS





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CapSenseStateMachine()
1/2 StartUpDelay is timing
Prime: MeasureSamplePeriod once for each Button and store in ReleasedAverage
SetSampleTime: MeasureSamplePeriod for each Button and average in ReleasedAverage
StartUpDelay complete
PrimeNewSample: Store CurrentSample once for each Button in ReleasedAverage
1/2 StartUpDelay is timing
StartUp: Average CurrentSample in ReleasedAverage
StartUpDelay complete
Debounce counter < ReleaseCount
ReleaseDebounce: Start Debounce counter
Debounce counter > ReleaseCount
Released: Average CurrentSample in ReleasedAverage
InitializeSystem()
PercentReleased > OffThreshold
PercentReleased < OffThreshold
PercentReleased > PressThreshold
PercentReleased < PressThreshold
PressedTime < ButtonTimeout
PressedTime > ButtonTimeout
Debounce counter < PressCount
Pressed: Start ButtonTimout counter
Debounce counter > PressCount
PressDebounce: Start Debounce counter



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