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**MICROCHIP**

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**Enhanced mTouch™ Capacitive  
Touch Evaluation Kit and  
Accessory Boards  
User's Guide**

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# ENHANCED mTouch™ CAPACITIVE TOUCH EVALUATION KIT AND ACCESSORY BOARDS USER'S GUIDE

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# ENHANCED mTouch™ CAPACITIVE TOUCH EVALUATION KIT AND ACCESSORY BOARDS USER'S GUIDE

## 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](http://www.microchip.com)) to obtain the latest documentation available.

Documents are identified with a “DS” number. This number is located on the bottom of each page, in front of the page number. The numbering convention for the DS number is “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 an Enhanced mTouch Capacitive Touch Evaluation Kit and Accessory Boards. 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 Enhanced mTouch Capacitive Touch Evaluation Kit and Accessory Boards as a development and demonstration tool for PIC16F, PIC18F, PIC24F, PIC24H, and PIC32 MCU device capabilities and features. The document layout is as follows:

- **Chapter 1. Introduction** – This chapter introduces the Enhanced mTouch Capacitive Touch Evaluation Kit and Accessory Boards and provides an overview of their features.
- **Chapter 2. Demonstration Application** – This chapter describes the preprogrammed capacitive touch sense demonstration application.
- **Chapter 3. ProfiLab-Expert™ Graphical User Interface for Real-Time Debugging** – This chapter describes the diagnostic software and how to use it with the Enhanced mTouch Capacitive Touch Evaluation Kit and Accessory Boards.
- **Chapter 4. Evaluation Board Hardware** – This chapter provides a functional overview of the Enhanced mTouch Capacitive Touch Evaluation Kit and Accessory Boards 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 boards.
- **Appendix B. “Adding Features to a ProfiLab-Expert™ GUI”** – This appendix provides for more information on ProfiLab-Expert and how to extend the GUI by adding new features.

## CONVENTIONS USED IN THIS GUIDE

This manual uses the following documentation conventions:

### DOCUMENTATION CONVENTIONS

Description	Represents	Examples
<b>Arial font:</b>		
Italic characters	Referenced books	<i>MPLAB® IDE User's Guide</i>
	Emphasized text	...is the <i>only</i> compiler...
Initial caps	A window	the Output window
	A dialog	the Settings dialog
	A menu selection	select Enable Programmer
Quotes	A field name in a window or dialog	"Save project before build"
Underlined, italic text with right angle bracket	A menu path	<u><i>File&gt;Save</i></u>
Bold characters	A dialog button	Click <b>OK</b>
	A tab	Click the <b>Power</b> tab
Text in angle brackets < >	A key on the keyboard	Press <Enter>, <F1>
<b>Courier New font:</b>		
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 Enhanced mTouch Capacitive Touch Evaluation Kit and Accessory Boards. Other useful documents are listed below. The following Microchip documents are available and recommended as supplemental reference resources. The latest documentation is available from the mTouch Sensing Solutions web page ([www.microchip.com/mtouch](http://www.microchip.com/mtouch)).

### Readme Files

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

### Family Reference Manual Sections

Family Reference Manual sections are available, which explain the operation of the PIC<sup>®</sup> 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 the “**Charge Time Measurement Unit (CTMU)**” Family Reference Manual sections for a detailed discussion of this module, which is at the heart of the capacitive touch sense demonstration. Please refer to the Microchip web site for the latest version of these documents.

### 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 documents may be obtained from the Microchip web site or your local sales office.

### 16-bit MCU and DSC Programmer's Reference Manual (DS70157)

This manual is a software developer's reference for the 16-bit PIC24F and PIC24H MCU, and 16-bit dsPIC30F and dsPIC33F DSC families of devices. It describes the instruction set in detail and also provides general information to assist in developing software for these device families.

**Note:** Refer to “*MIPS32<sup>®</sup> Architecture for Programmers Volume II: The MIPS32<sup>®</sup> Instruction Set*” at [www.mips.com](http://www.mips.com) for related information on PIC32 MCUs.

### MPLAB<sup>®</sup> Assembler Linker and Utilities for PIC24 MCUs and dsPIC<sup>®</sup> DSCs User's Guide (DS51317)

This document details Microchip Technology's language tools for dsPIC DSC devices based on GNU technology. The language tools discussed are:

- MPLAB Assembler PIC24 MCUs and dsPIC DSCs
- MPLAB Linker PIC24 MCUs and dsPIC DSCs
- MPLAB Archiver/Librarian PIC24 MCUs and dsPIC DSCs
- Other utilities



### **MPLAB® Assembler Linker and Utilities for PIC32 MCUs User's Guide (DS51833)**

This document details Microchip Technology's language tools for PIC32 MCU devices based on GNU technology. The language tools discussed are:

- MPLAB Assembler PIC32 MCUs
- MPLAB Linker PIC32 MCUs
- MPLAB Archiver/Librarian PIC32 MCUs
- Other utilities

### **HI-TECH C® for PIC10/12/16 User's Guide (DS51865)**

This document details the use of Microchip's HI-TECH C Compiler for PIC10/12/16 MCUs, which is a free-standing, optimizing ANSI C compiler. It supports all PIC10, PIC12 and PIC16 series devices, as well as the PIC14000 device and the enhanced Mid-Range PIC® MCU architecture.

### **MPLAB® C Compiler for PIC18 MCUs User's Guide (DS51288)**

This document details the use of Microchip's MPLAB C Compiler for PIC18 MCU devices to develop an application. The MPLAB C Compiler is a GNU-based language tool, based on source code from the Free Software Foundation (FSF). For more information about the FSF, see [www.fsf.org](http://www.fsf.org).

### **MPLAB® C Compiler for PIC24 MCUs and dsPIC® DSCs User's Guide (DS51284)**

This document details the use of Microchip's MPLAB C Compiler for PIC24 MCUs and dsPIC DSC devices to develop an application. The MPLAB C Compiler is a GNU-based language tool, based on source code from the Free Software Foundation (FSF). For more information about the FSF, see [www.fsf.org](http://www.fsf.org).

### **MPLAB® C Compiler for PIC32 MCUs User's Guide (DS51686)**

This document details the use of Microchip's MPLAB C Compiler for PIC32 MCU devices to develop an application. The MPLAB C Compiler is a GNU-based language tool, based on source code from the Free Software Foundation (FSF). For more information about the FSF, see [www.fsf.org](http://www.fsf.org).

### **MPLAB® REAL ICE™ In-Circuit Emulator User's Guide (DS51616)**

This document describes how to use the MPLAB REAL ICE in-circuit emulator as a development tool to emulate and debug firmware on a target board, as well as how to program devices.

### **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.

### **PICKit™ Serial Analyzer User's Guide (DS51647)**

This document details the PICKit™ Serial Analyzer development system, which enables a personal computer (PC) to communicate with embedded development systems via serial protocols such as I<sup>2</sup>C™, SPI, and asynchronous and synchronous USART. The PC program uses a graphical interface to enter data and commands to communicate to the target device. Data and commands can be entered using basic or scripting commands. The PICKit Serial Analyzer connects to the embedded development system using a 6-pin header.

## 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”*
- AN1250 *“Microchip CTMU for Capacitive Touch Applications”*
- AN1298 *“Capacitive Touch Using Only an ADC (“CVD”)”*
- AN1317 *“mTouch™ Conducted Noise Immunity Techniques for the CTMU”*
- AN1325 *“mTouch™ Metal Over Cap Technology”*
- AN1334 *“Techniques for Robust Touch Sensing Design”*

## Microchip mTouch™ Sensing Solutions Webinars

Currently, there are three online Webinars available from the Microchip web site ([www.microchip.com/mtouch](http://www.microchip.com/mtouch)) for mTouch Sensing Solutions:

- 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 through our web site at [www.microchip.com](http://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 <http://www.microchip.com>, click **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® C compiler; MPASM™ and MPLAB 16-bit assemblers; MPLINK™ and MPLAB 16-bit object linkers; and MPLIB™ and MPLAB 16-bit object librarians.
- **Emulators** – The latest information on the Microchip MPLAB REAL ICE™ in-circuit emulator.
- **In-Circuit Debuggers** – The latest information on the Microchip in-circuit debugger, MPLAB ICD 3.
- **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.
- **Programmers** – The latest information on Microchip programmers. These include the MPLAB PM3 device programmer and the PICKit™ 3 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 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 our web site at: <http://support.microchip.com>

## DOCUMENT REVISION HISTORY

### Revision A (April 2009)

This is the initial released version of the document.

### Revision B (September 2009)

- Added reference to PIC18F MCU
- Added PIC18F CTMU Evaluation Board Schematic
- Added PIC18F Block Diagram for the CTMU Board
- Modified the Kit Contents list

### Revision C (June 2010)

This version of the document includes the following updates:

- Added references to PIC24H and PIC32 MCUs throughout the document
- Modified the Kit Contents list
- Added the PIC32 CVD Touch Evaluation Board
- Added block diagrams for the PIC24H CVD and PIC32 CVD Evaluation Boards
- Updated PIC16F CSM/CVD Evaluation Board schematic and layout

### Revision D (August 2011)

- Removed references to CSM
- Added references to new PIC16F CVD Evaluation Board
- Replaced “CVD/CSM schematic” with “CVD schematic”
- Updated all references to CVD/CSM, to CVD only
- Changed document’s title to *“Enhanced mTouch™ Capacitive Touch Evaluation Kit User’s Guide”*

### Revision E (February 2012)

This revision of the document includes the following updates:

- The document title has been updated to *“Enhanced mTouch™ Capacitive Touch Evaluation Kit and Accessory Boards User’s Guide”*
- Added the *“PICKit™ Serial Analyzer User’s Guide”* (DS51647) and AN1325 *“mTouch™ Metal Over Cap Technology”* to **“Recommended Reading”**
- Updated the Enhanced mTouch™ Capacitive Touch Evaluation Kit Contents (see [Figure 1-1](#))
- Updated **Section 1.1.2.1 “PIC24H Capacitive Touch Evaluation Board”**
- Added **Section 1.1.2.2 “PIC32 CTMU Capacitive Touch Evaluation Board”**
- Added **Chapter 3. “ProfiLab-Expert™ Graphical User Interface for Real-Time Debugging”**
- Added **Section 4.1.6 “PIC32 CTMU Evaluation Board”**
- Updated the PIC16 CVD Evaluation Board Components (see [Figure 4-7](#), [Table 4-1](#), and [Section 4.2.1.1](#))
- Added **Section 4.1.6 “PIC32 CTMU Evaluation Board”**
- Added the PIC32 CTMU Evaluation Board to [Section 4.2.2](#), [Figure 4-8](#), [Table 4-2](#), and [Section 4.2.2.1](#)
- Added the PIC32 CTMU Evaluation Board schematic (see [Figure A-6](#))
- Added **Appendix B. “Adding Features to a ProfiLab-Expert™ GUI”**
- Formatting updates and minor typographical changes have been incorporated throughout the document

**Revision F (May 2012)**

This revision of the document includes the following updates:

- All references to VDDCORE were removed
- Minor updates to text and formatting were incorporated throughout the document





# ENHANCED mTouch™ CAPACITIVE TOUCH EVALUATION KIT AND ACCESSORY BOARDS USER'S GUIDE

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## Chapter 1. Introduction

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Thank you for purchasing a Microchip Technology Enhanced mTouch Capacitive Touch Evaluation Kit and/or Accessory Board. Depending on your purchase, up to four individual evaluation boards are provided. These evaluation boards are intended to introduce and demonstrate the possibilities for capacitive touch sense applications on the PIC16F, PIC18F, PIC24F, PIC24H, and PIC32 microcontroller platforms.

**Note:** This evaluation kit (and the accessory boards) are intended as a functional evaluation of Microchip's mTouch™ Sensing Solutions. The kit and boards have not been designed for use in noisy or production-level testing environments. Please refer to the Microchip application notes listed in the [Recommended Reading](#) section of the [Preface](#) for guidelines when attempting to design a product to be used or deployed in such environments.

This chapter introduces the evaluation kit and the separate accessory boards and provides an overview of their features. Topics covered include:

- [Overview](#)
- [Operational Requirements](#)
- [Initial Board Setup](#)

### 1.1 OVERVIEW

The Enhanced mTouch Capacitive Touch Evaluation Kit and Accessory Boards provide a simple platform for developing a variety of capacitive touch sense applications. Depending on the kit or board purchased, up to four evaluation boards are included with PIC16F, PIC18F, PIC24F, PIC24H, and PIC32 microcontrollers, with four sensor daughter boards, as shown in [Figure 1-1](#), [Figure 1-2](#), and [Figure 1-3](#).

These evaluation boards are intended to be used to develop a capacitive touch sense application using Microchip's mTouch Sensing Solution technologies. A board is used by first connecting a sensor daughter board, and then supplying power to the board via USB, a PICkit™ 3 In-Circuit Programmer/Debugger, or the PICkit Serial Analyzer. The J3/J4 connector, with numbers from 0 to 15, is the connector for the sensor channels. The numbers, from 0 to 13 for PIC16F, from 0 to 12 for PIC18F, and from 0 to 15 for PIC24F, PIC24H, and PIC32, represent the microcontroller's sensor channels.

When using an evaluation board out of the box, the default function of the LEDs 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 board has been optimized for use with the four sensor daughter boards. This firmware is also available for download from the Microchip web site.

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.

A separate, 6-wire programming interface on connector J1 allows users to replace the preprogrammed demonstration firmware with their own applications using Microchip's MPLAB Integrated Development Environment (IDE) and In-Circuit Serial Programming™ (ICSP™). This allows the board to also be used as a test platform for capacitive touch sense applications.

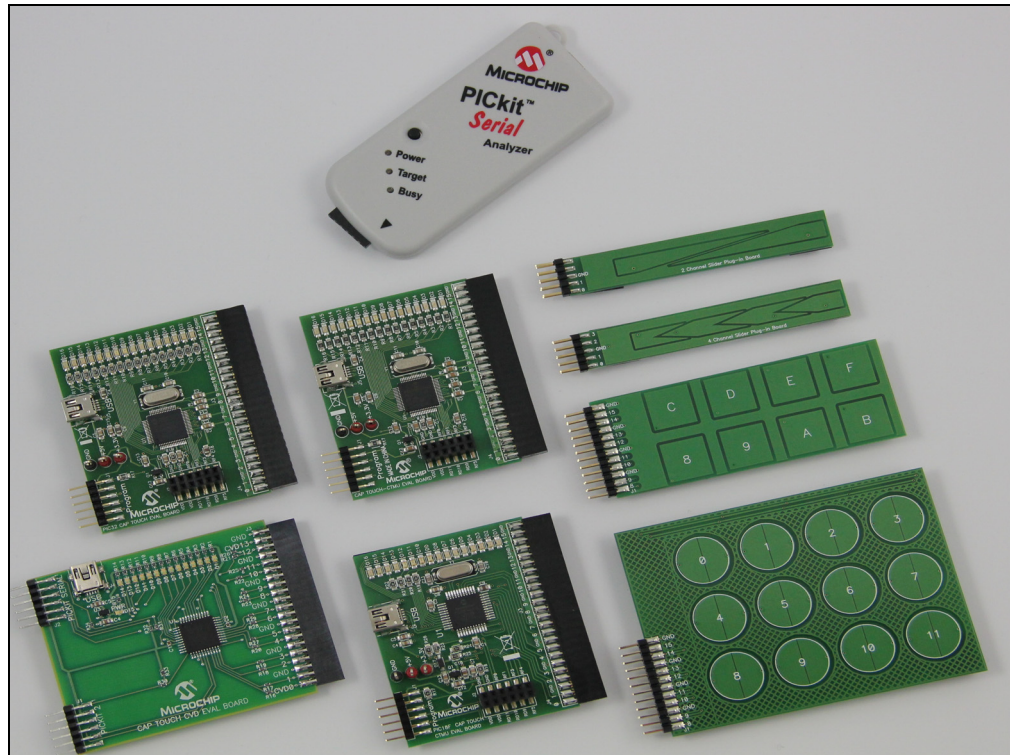
Any of the in-circuit debugger/programmers listed in [Section 1.2 “Operational Requirements”](#) can be used to debug the application from MPLAB. Real-time diagnostic output on the J2 connector can be captured with the PICkit Serial Analyzer.

### 1.1.1 Enhanced mTouch Capacitive Touch Evaluation Kit Contents

The Enhanced mTouch Capacitive Touch Evaluation Kit (DM183026-2), shown in [Figure 1-1](#), contains the following items:

- Four evaluation boards:
  - PIC16F CVD Evaluation Board
  - PIC18F CTMU Evaluation Board
  - PIC24F CTMU Evaluation Board
  - PIC32 CVD Evaluation Board
- Four sensor daughter boards
  - 2-Channel Slider Sensor Daughter Board
  - 4-Channel Slider Sensor Daughter Board
  - 8-Key Direct Sensor Daughter Board
  - 12-Key Matrix Sensor Daughter Board
- PICkit Serial Analyzer
- Two accessory cables (not shown in [Figure 1-1](#)):
  - PICkit Serial Analyzer to evaluation board J2 adaptor cable (future upgrade)
  - USB cable

**FIGURE 1-1: ENHANCED mTouch™ CAPACITIVE TOUCH EVALUATION KIT CONTENTS**



## 1.1.2 Additional Evaluation Boards

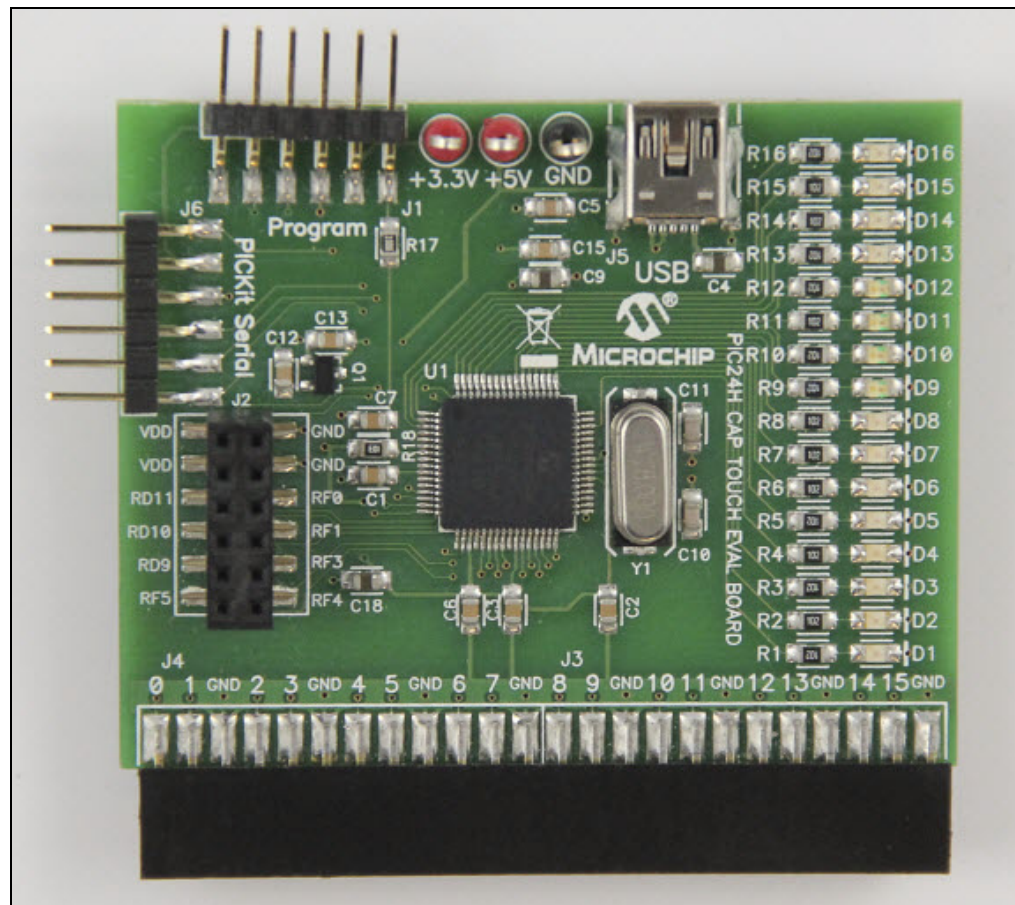
Two additional evaluation boards (PIC24H and PIC32 CTMU) are available for use with the four sensor daughter boards, the PICKit Serial Analyzer, and the accessory cables provided in the Enhanced mTouch Capacitive Touch Evaluation Kit. Both of these boards are described in the following sections.

### 1.1.2.1 PIC24H CAPACITIVE TOUCH EVALUATION BOARD

The PIC24H Capacitive Touch Evaluation Board (AC243026) is designed to facilitate the development of capacitive touch-based applications using PIC24H-series microcontrollers. This board is intended to supplement the Enhanced mTouch Capacitive Touch Evaluation Kit and uses the same sensor daughter boards listed in [Section 1.1.1 “Enhanced mTouch Capacitive Touch Evaluation Kit Contents”](#).

This evaluation board includes an onboard PICKit serial interface, an ICSP header, a USB connector (for power only), and a 16-bit LED display. The 24-pin header (J3/J4) connects to the sensor daughter boards that are included in the Enhanced mTouch Capacitive Touch Evaluation Kit (sold separately, DM183026-2).

**FIGURE 1-2: PIC24H CAPACITIVE TOUCH EVALUATION BOARD**



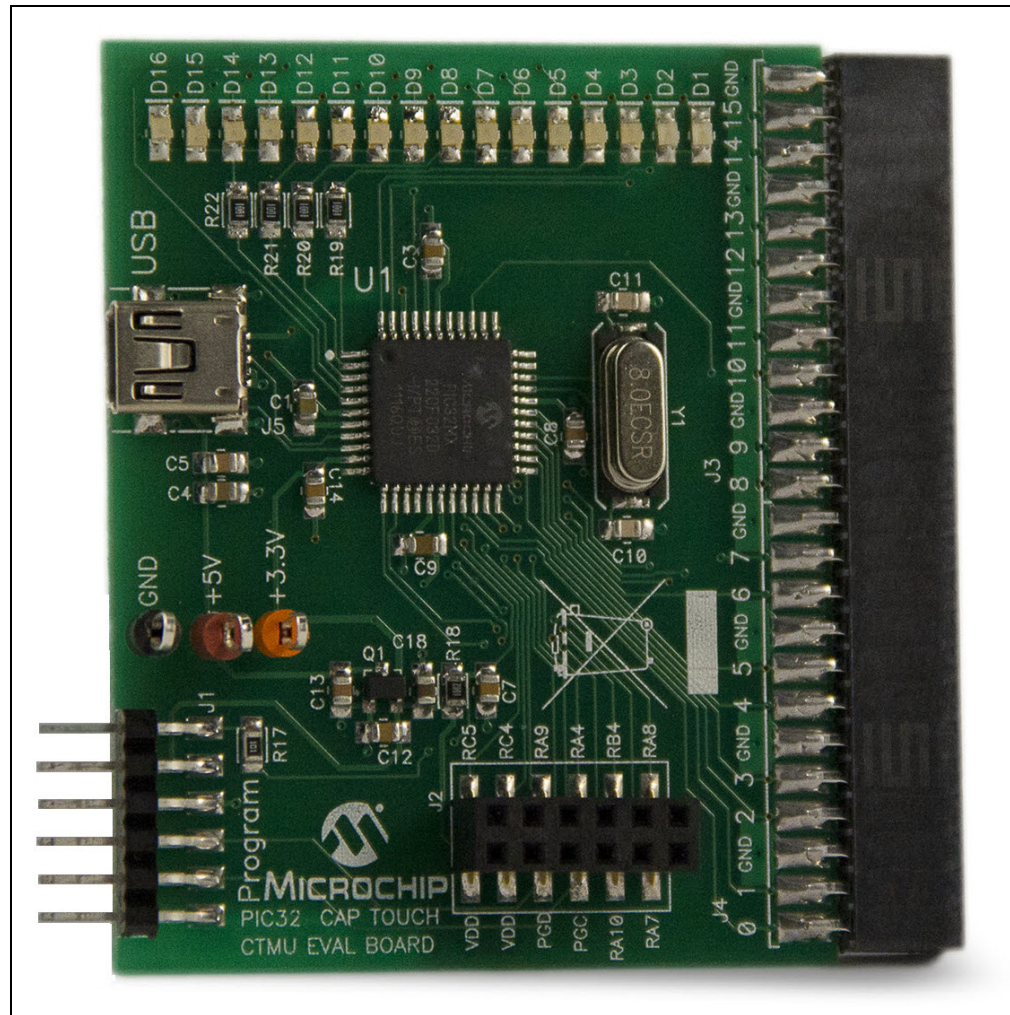


1.1.2.2 PIC32 CTMU CAPACITIVE TOUCH EVALUATION BOARD

The PIC32 CTMU Capacitive Touch Evaluation Board (AC323027) is designed to facilitate the development of capacitive touch-based applications using PIC32-series microcontrollers with a Charge Time Measurement Unit (CTMU) module. This board is intended to supplement the Enhanced mTouch Capacitive Touch Evaluation Kit and uses the same sensor daughter boards listed in [Section 1.1.1 “Enhanced mTouch Capacitive Touch Evaluation Kit Contents”](#).

This evaluation board includes an ICSP header, a USB connector (for power only), and a 16-bit LED display. The 24-pin header (J3/J4) connects to the sensor daughter boards that are included in the Enhanced mTouch Capacitive Touch Evaluation Kit (sold separately, DM183026-2).

FIGURE 1-3: PIC32 CTMU EVALUATION BOARD



## 1.2 OPERATIONAL REQUIREMENTS

To communicate with, and to program an evaluation board, the following hardware and software are needed:

- PC-compatible system with a CD-ROM drive
- One available USB port on the PC or a powered USB hub
- An additional USB port for the PICkit Serial Analyzer (optional)
- Microsoft® Windows® XP SP2, Windows Vista (32-bit), or Windows 7
- One of the following debugging/programming development tools:
  - PICkit 3 In-Circuit Programmer/Debugger (PG164130), or
  - MPLAB ICD 3 In-Circuit Debugger (DV164035), or
  - MPLAB REAL ICE™ In-Circuit Emulator (DV244005) with the RJ-11 to ICSP™ Adaptor (AC164110)

## 1.3 INITIAL BOARD SETUP

With its preinstalled demonstration application, an evaluation board is designed to be used right out of the box. Except for a single USB connection to a computer for power, no additional hardware or configuration is necessary.

### 1.3.1 Installing the Software

Before you use the evaluation kit or an accessory board, it is important that you have installed the Microchip MPLAB Integrated Development Environment (IDE). MPLAB IDE provides the assembler tools you will use for development. You will also need a C compiler for the demonstration code. The MPLAB C Compiler seamlessly integrates into MPLAB IDE. Both the MPLAB IDE and C Compiler are free (see the note below) and are available for download from the Microchip web site at:

[www.microchip.com/MPLAB](http://www.microchip.com/MPLAB) and [www.microchip.com/compilers](http://www.microchip.com/compilers), respectively.

<p><b>Note:</b> The Standard Evaluation (Free) Version supports all optimization levels for 60 days, but then reverts to optimization level 0, or 1 only.</p>
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### 1.3.2 Connecting the Hardware

Prior to connection, place the evaluation board on a flat surface near the computer. Check to make sure that there are no objects between the board and the surface upon which it is sitting. Once the evaluation kit software is installed, connect the provided USB cable (A to mini-B) to any available USB port on the PC or powered hub, and then to the board at the mini-B receptacle. The PC USB connection provides power to the board.

The default code uses the 8-button board. Refer to [Section 2.2.1 “8-Key Direct Plug-in Daughter Board”](#) for more information on connecting this daughter board to an evaluation board.

After connecting the daughter board to the evaluation board and applying power, the firmware application will illuminate all of the LEDs on the board at start-up. Any finger presses on the daughter board will cause the associate LED to illuminate. If this does not occur, refer to [Chapter 5. “Troubleshooting”](#).



**NOTES:**

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## Chapter 2. Demonstration Application

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This chapter describes the touch sense application that is preprogrammed on the PIC16F, PIC18F, PIC24F, PIC24H and PIC32 microcontrollers, and its general principles of operation. Topics included in this chapter are:

- [Introduction to the Touch Interface](#)
- [Individual Touch Sense Demonstrations](#)

### 2.1 INTRODUCTION TO THE TOUCH INTERFACE

Microchip's mTouch capacitive touch sensing techniques are voltage-based scanning methods that detect whether a key or button is pressed or not pressed (asserted/unasserted) using the change in the capacitance of a key or button, which is caused by contact with the user's finger. The change in capacitance creates a change in voltage that is measured by an on-chip Analog-to-Digital converter (ADC) module.

PIC16F, PIC24H, and PIC32 microcontrollers without a CTMU module use the Sample and Hold (S&H) capacitor of an on-chip ADC to move the charge to or from each key or button. When two capacitors at different voltages are connected, a voltage divider is formed, which explains why the technique is known as Capacitive Voltage Divider (CVD).

To charge a key or button, the ADC module is connected to an output pin that is pulled high, and is then switched to the pin of the key/button circuit. This process is repeated up to four times. The ADC module is then used to measure the resulting voltage.

Discharging a key/button circuit with the ADC module also involves switching the ADC module between the key/button pin and an output pin; however, in this case, the output pin is low (i.e., grounded) and the key/button circuit has been previously charged. The key/button circuit is brought to  $V_{DD}$  by converting the key/button pin on the device to an output pin that is pulled high before changing the pin back to an input pin. With the key/button circuit charged, the ADC module can then begin to discharge the circuit one S&H capacitor value at a time.

Since the ADC module can source or sink a charge to or from the key/button circuit, it can be used to provide a differential touch measurement. If  $V_{POS}$  is the voltage measurement when the ADC module sources current, and  $V_{NEG}$  is the voltage measurement when the ADC module sinks current, this would result in  $V_{DIF} = V_{POS} - V_{NEG}$ . Differential measurements provide greater noise immunity compared to just using  $V_{POS}$  or  $V_{NEG}$ .

**Note:** Please refer to the Microchip application note AN1298 "*Capacitive Touch Using Only an ADC ("CVD")*" for more details on capacitive touch measurements without a CTMU module.

PIC18F, PIC24F, and some PIC32 microcontrollers use an on-chip Charge Time Measurement Unit (CTMU) module to charge each button and an on-chip ADC module to measure the resulting voltage. The CTMU consists of a constant current source that provides a highly repeatable charge to each key or button. When any additional capacitance is added to the key/button circuit (from the touch of a fingertip, for example), this charge results in a lower voltage compared to the voltage seen on the circuit without the additional capacitance. This change in voltage is how the microcontroller with an on-chip ADC module detects a touch event.

**Note:** Please refer to Microchip application note AN1250 *“Microchip CTMU for Capacitive Touch Applications”* for more details on how the CTMU and ADC modules work together to measure capacitive touch.

For detailed information on the CTMU module, please refer to the related **“Charge Time Measurement Unit (CTMU)”** Family Reference Manual section, which is available from the Microchip web site.

Each evaluation board can be used with these sensor daughter boards:

- 2-Channel Slider Plug-in Daughter Board
- 4-Channel Slider Plug-in Daughter Board
- 8-Key Direct Plug-in Daughter Board
- 12-Key Matrix Plug-in Daughter Board

A more detailed description of evaluation board operation is provided in [Chapter 4. “Evaluation Board Hardware”](#).

The response of the sensor to fingertip touch is influenced by many factors, such as touch areas, voltage and current levels, ambient humidity, static buildup, and so on. The capacitive touch sensing is done by a relative shift in the capacitance due to the addition of the finger capacitance to the touch sensor. The demonstration code supplied takes most of the typical environmental factors into consideration. The demonstration application is very flexible in the sense that it can be modified by the user.

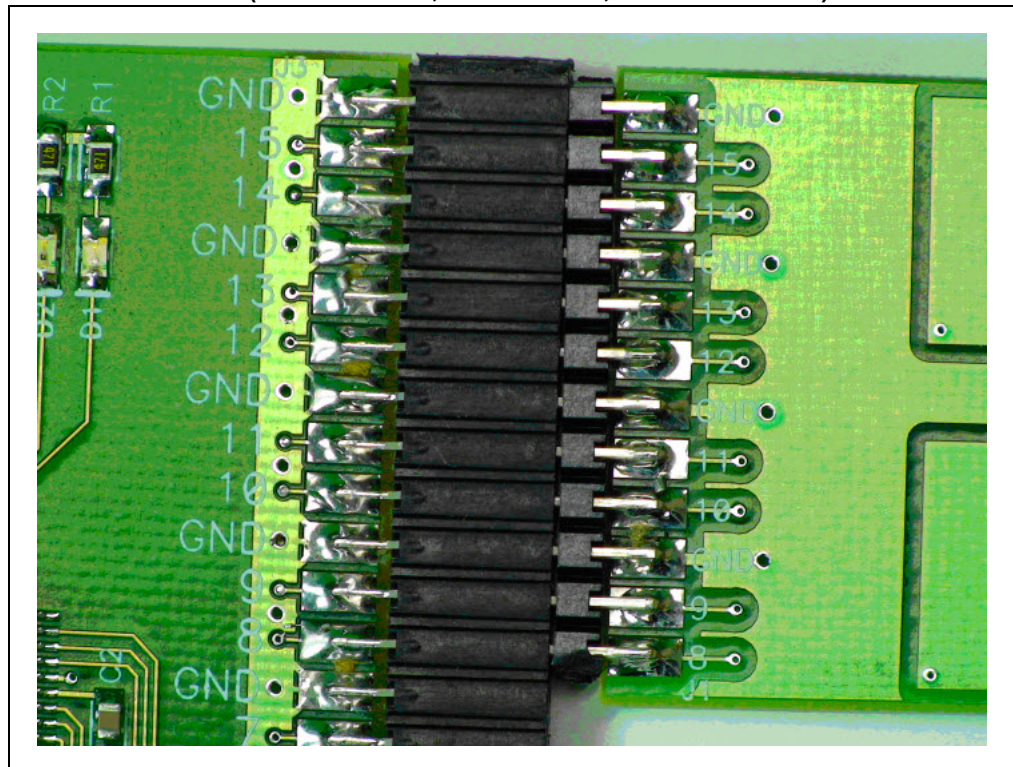
## 2.2 INDIVIDUAL TOUCH SENSE DEMONSTRATIONS

### 2.2.1 8-Key Direct Plug-in Daughter Board

The 8-Key Direct Plug-in Daughter Board is an 8-channel plug-in board with each key directly mapped to a sensor channel. This board can be interfaced with eight channels out of the 16 channels provided in the Enhanced mTouch Capacitive Touch Evaluation Kit and Accessory Boards. Touching any one of the keys on the plug-in board will illuminate the corresponding LED on the evaluation board.

Figure 2-1 shows the default plug-in channels of the 8-Key Direct Plug-in Daughter Board for the PIC24F CTMU, PIC24H CVD, and PIC32 CVD Evaluation Boards.

**FIGURE 2-1: DEFAULT PLUG-IN CHANNELS FOR 8-KEY PLUG-IN BOARD (PIC24F CTMU, PIC24H CVD, AND PIC32 CVD)**



The default firmware for all evaluation boards uses the 8-Key Direct Key Plug-in Daughter Board. Refer to Table 2-1 for the J3/J4 sensor channels that are used for the specific evaluation board.

**TABLE 2-1: DEFAULT J3/J4 CONNECTOR PLUG-IN CHANNELS**

Evaluation Board	Sensor Daughter Board			
	8-Key Direct	12-Key Matrix	4-Channel Slider	2-Channel Slider
PIC16F CVD	0-7	0-6	0-3	0-1
PIC18F CTMU	0-7	6-12	0-3	0-1
PIC24F CTMU	8-15	8-14	0-3	0-1
PIC24H CVD	8-15	8-14	0-3	0-1
PIC32 CTMU	0-7	0-6	0-3	0-1
PIC32 CVD	8-15	8-14	0-3	0-1

### 2.2.2 12-Key Matrix Plug-in Daughter Board

The 12-Key Matrix Plug-in Daughter Board is an array of 12 touch-sensitive keys arranged in a 4x3 matrix (required 3 + 4 = 7 sensor inputs). Touching any one of the keys will illuminate one of the LEDs. The 12-Key Matrix Plug-in Daughter Board is numbered from 0 to 11, which corresponds to LEDs D1 to D12, respectively.

Refer to [Table 2-1](#) for the J3/J4 sensor channels that are used by each evaluation board when connected to the 12-Key Matrix Plug-in Daughter Board.

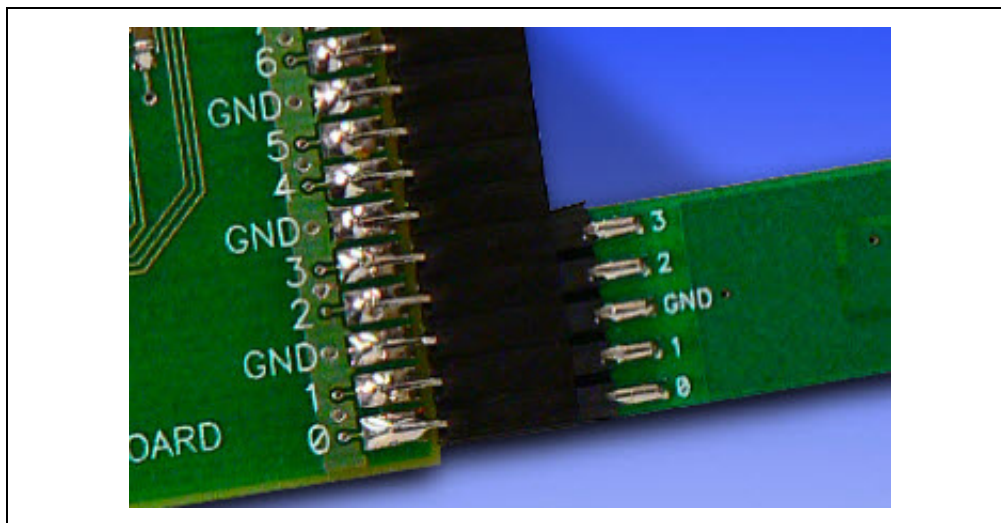
### 2.2.3 2-Channel and 4-Channel Slider Plug-in Daughter Boards

Touching anywhere along the length of the slider causes all the LEDs to illuminate 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 loaded in the 2-Channel Slider Plug-in Daughter Board, is configured such that, channels 0 and 1 of connector J4/J3 in the evaluation kit are connected to the two channels in the 2-Channel Slider Plug-in Daughter Board.

The default firmware for the 4-Channel Slider Plug-in Daughter Board, is configured such that, channels 0, 1, 2, and 3 of connector J4/J3 in the main evaluation board are connected to the four channels in the 4-Channel Slider Plug-in Daughter Board (see [Figure 2-2](#)).

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



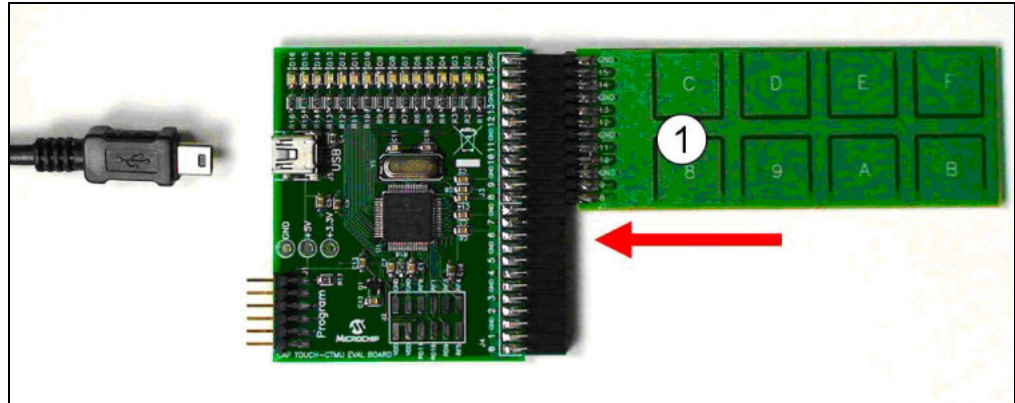
- Note 1:** The plug-in daughter boards can be interfaced to any of the channels in the evaluation kit by changing the configuration settings. The details of the configuration settings are explained in the `Readme.txt` file, which is distributed in each demonstration.
- 2:** Plugging in a sensor board while an evaluation board is running, may require resetting the touch algorithm, most easily done by cycling power.



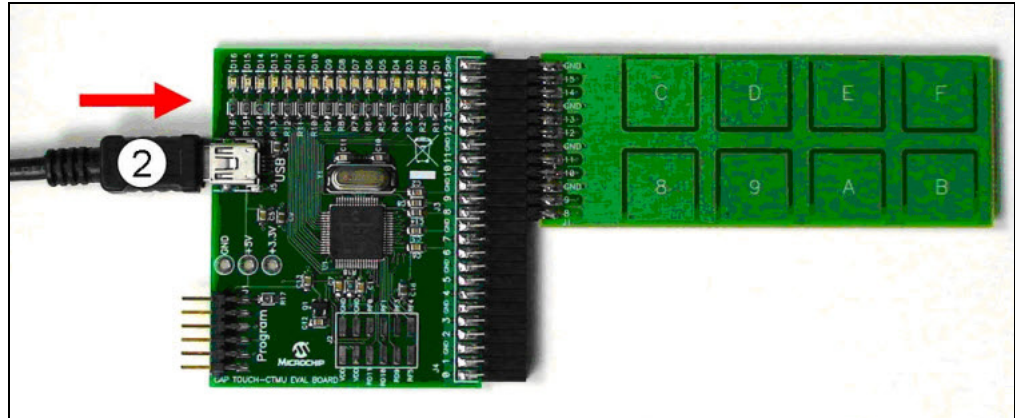
# Demonstration Application

The recommended approach, as shown in [Figure 2-3](#) and [Figure 2-4](#), is to first connect the sensor daughter board, and then apply power to the evaluation board by connecting the USB cable to the evaluation board.

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



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



**NOTES:**

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## Chapter 3. ProfiLab-Expert™ Graphical User Interface for Real-Time Debugging

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This chapter describes the ProfiLab-Expert™ Graphical User Interface (GUI), which can be used for real-time debugging of the Enhanced mTouch Capacitive Touch Evaluation Kit and Accessory Boards.

### 3.1 OVERVIEW

Real-time debugging support for mTouch software on the mTouch evaluation boards is supported by a stand-alone Windows® executable, `mTouch GUI.exe`, and an associated ProfiLab-Expert project, both of which are provided in the MPLAB mTouch projects for these boards. It is important to note that it is not necessary to purchase ProfiLab-Expert to make use of these project and executable files.

ABACOM's ProfiLab-Expert supports the development of Windows GUIs using a graphical programming paradigm. Optionally, users can purchase ProfiLab-Expert and adapt or extend the projects provided to support real-time debugging needs for most mTouch projects. For more information on ProfiLab-Expert, visit the ABACOM web site at: <http://www.abacom-online.de/uk/html/profilab-expert.html>

**Note:** Refer to [Appendix B. “Adding Features to a ProfiLab-Expert™ GUI”](#) for more information on ProfiLab-Expert and how to extend the GUI by adding new features.

### 3.2 GUI SETUP

#### 3.2.1 Operation Principles and Benchtop Setup

The basic principle of operation is for the mTouch application to format a text string of five-digit decimal numbers that are separated by commas, and output this data through the UART transmit (TX) pin on the device. Using a PICKit™ Serial Analyzer running special firmware, a ProfiLab-Expert GUI can display this data in real-time on a PC. The button status, button asserts, slider values, and button voltage measurements are displayed by the GUI, while the UART data can be captured in ASCII text files for later analysis.

In fact, once the UART TX pin is active, the same data can be captured by a simple COM-port application, such as HyperTerminal (or equivalent) for later analysis using Excel® or Matlab®, or GNU Octave.

A typical benchtop setup is shown in [Figure 3-1](#). The UART receive (RX) pin of the PICKit Serial Analyzer is connected to a UART TX pin on connector J2. Refer to the ReadMe file (`1st Read Me.txt`) of each mTouch application to determine which pins of the J2 connector are used. A summary PICKit Serial Analyzer to evaluation board pin assignment is provided in [Table 3-1](#).