
PIC16F18446 Sensor Board User's Guide

Preface

**Important: 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 website (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 document describes the features and operation of the PIC16F18446 Sensor Board. The PIC16F18446 Sensor Board was created to provide examples of how to use the PIC16F18446 MCU to interface with various sensor elements. It also shows how the MPLAB® Xpress PIC16F18446 evaluation board can be connected to a target board to create a rapid prototype of an application.

Recommended Reading

This user's guide describes the hardware and software component of the PIC16F18446 Sensor Board, as well as how the user is able to interact with it. Other useful documents are listed below. The following Microchip documents are available and recommended as supplemental reference resources.

- PIC16(L)F18426/46 14/20-Pin Full-Featured, Low Pin Count Microcontrollers with XLP (DS40001985A)

For the latest information on using the device, read the “`Readme for Device #.htm`” file (an HTML file) in the Readmes subdirectory of the MPLAB IDE installation directory. The release notes (Readme) contains update information and known issues that may not be included in this user's guide.

Table of Contents

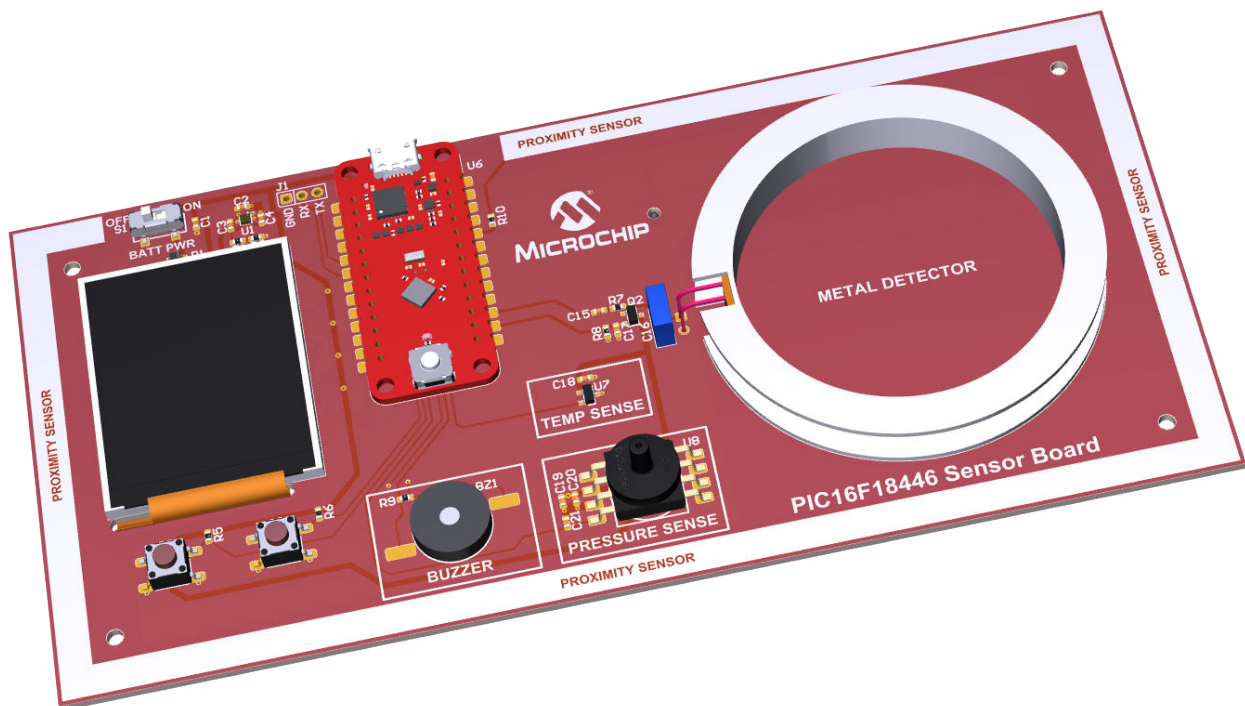
Preface.....	1
1. Introduction.....	3
1.1. Prerequisites.....	3
2. Overview.....	4
2.1. Block Diagram.....	5
2.2. Operation Guide.....	6
3. Software Details.....	7
3.1. Splash Page.....	8
3.2. Battery Level Measurement.....	8
3.3. Temperature Measurement.....	9
3.4. Pressure Measurement.....	10
3.5. Proximity Detection and Measurement.....	10
3.6. Metal Detection.....	11
3.7. Firmware Programming.....	12
4. Hardware Details.....	13
4.1. MPLAB Xpress PIC16F18446.....	13
4.2. Battery Measurement.....	13
4.3. Temperature Sensing.....	13
4.4. Pressure Sensing.....	14
4.5. Proximity Sensing.....	15
4.6. Metal Detection.....	16
4.7. User Interface.....	16
5. Revision History.....	19
The Microchip Web Site.....	20
Customer Change Notification Service.....	20
Customer Support.....	20
Microchip Devices Code Protection Feature.....	20
Legal Notice.....	21
Trademarks.....	21
Quality Management System Certified by DNV.....	22
Worldwide Sales and Service.....	23

1. Introduction

This is the user's guide for the PIC16F18446 Sensor Board, based on the MPLAB® Xpress PIC16F18446 evaluation board.

The purpose of the PIC16F18446 Sensor Board is to show the implementation of various sensor interfacing the 12-bit Analog-to-Digital Converter with Computation (ADC²). This peripheral automates Capacitive Voltage Divider (CVD) techniques for advanced touch sensing, averaging, filtering, oversampling and automatic threshold comparison. The ADC² is used in the context of several applications that make use of its features along with other peripherals and Core Independent Peripherals (CIPs).

Figure 1-1. PIC16F18446 Sensor Board



1.1 Prerequisites

In order to get started with the demo, the user needs the following:

- Hardware:
 - PIC16F18446 Sensor Board with the MPLAB Xpress PIC16F18446 attached;
 - Two AA batteries to power the PIC16F18446 Sensor Board **or** USB cable to power the MPLAB Xpress PIC16F18446 board.
- Software:
 - MPLAB Xpress environment **or** MPLAB X IDE version 4.10 or higher, to compile the firmware;
 - PIC16F18446 Sensor Board firmware.

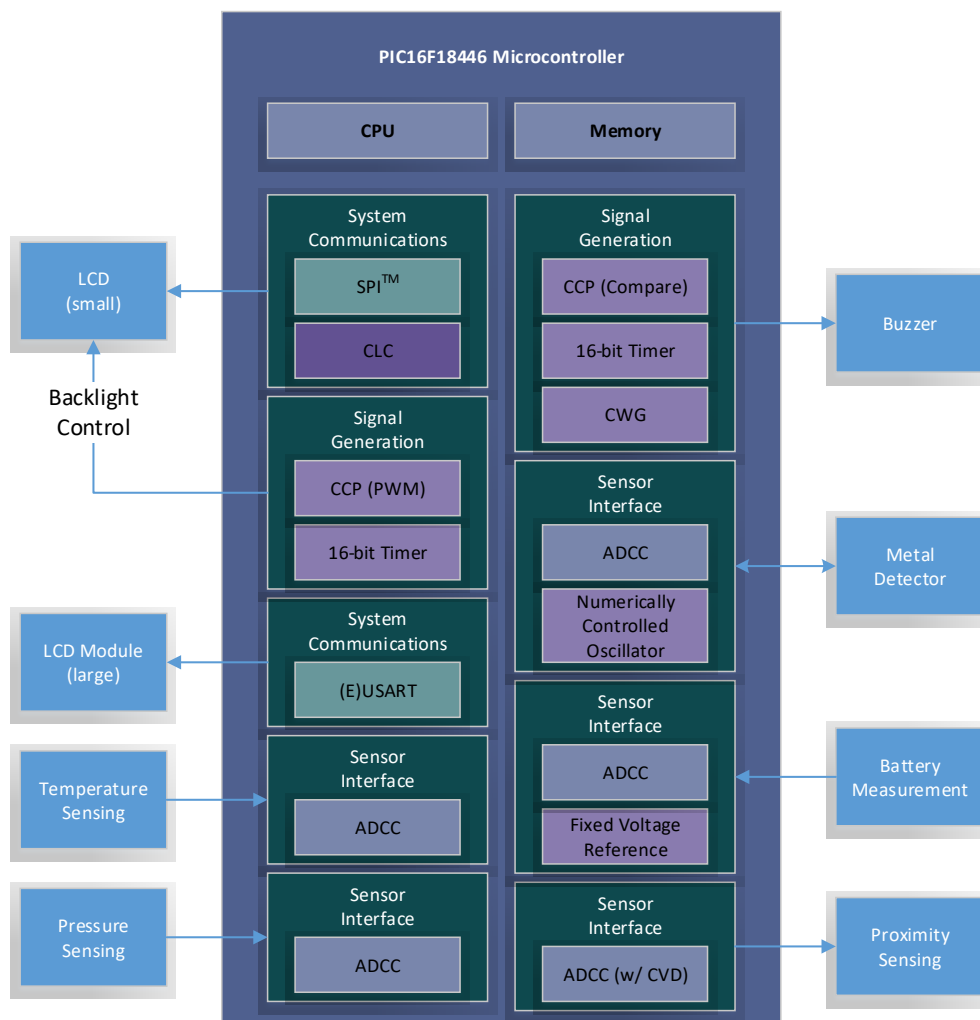
2. Overview

The board includes:

- MPLAB Xpress PIC16F18446
- Temperature Sensor Microchip MCP9701
- Pressure Sensor NXP MP3V5050GP
- Proximity Sensing PCB Trace
- Metal Detector Coil
- 128*160 Pixels TFT LCD
- Push Buttons
- Piezo Audio Transducer
- Two AA Batteries as power

2.1 Block Diagram

Figure 2-1. PIC16F18446 Sensor Board Block Diagram



2.2 Operation Guide

There are two ways of powering the board: from two AA batteries, or from USB. If the two batteries are inserted in the battery sockets, then the ON/OFF switch is used to turn the board ON and OFF. If an USB cable is used, then the board gets power as soon as the USB cable is inserted into the MPLAB Xpress PIC16F18446. If both power sources are present, the board gets its power from USB.

The first screen is the splash screen: Microchip logo appears on the LCD. The proximity sensor is used to detect user presence. If the user does not interact with the board or if the proximity measurement falls below the detection threshold for 60 seconds, the backlight of the LCD turns OFF.

The user can navigate between the screens using the two push buttons. Right button (S3) switches to the next screen, and left button (S2) switches to the previous screen. If the current screen is the last one, pressing S3 will switch to the first screen. If the current screen is first one, pressing S2 will switch to last screen. For details, see [Figure 3-1](#).

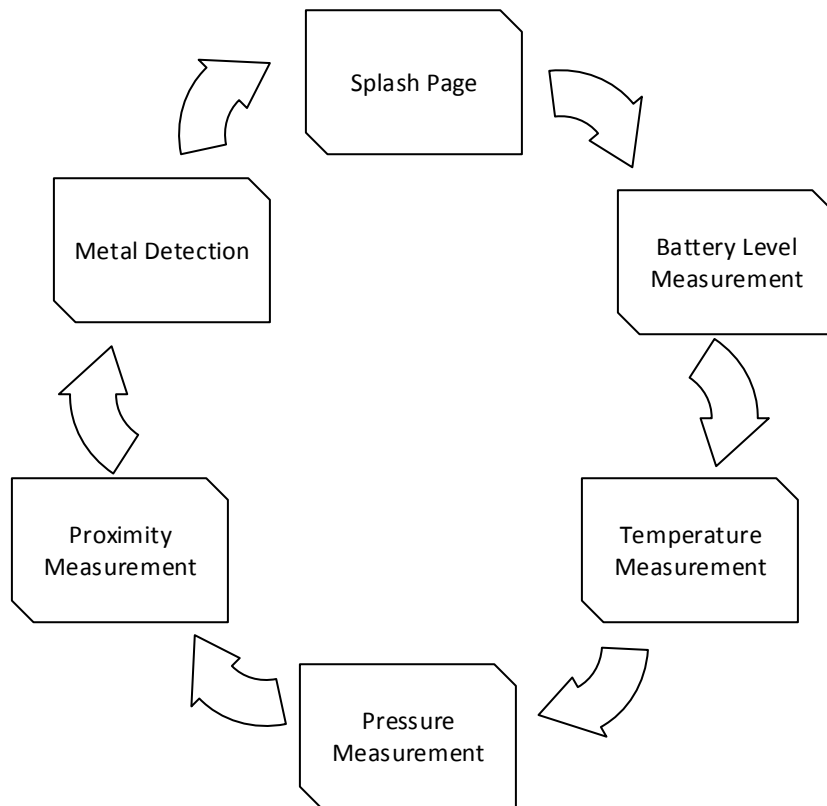
3. Software Details

The demo contains sub-modules for each of the different analog sensors and displays what is happening in close to real time, presenting a visual comparison between 12-bit resolution signal acquisition and 10-bit result without the computational functions. The following analog measurements are performed:

- Battery level measurement
- Temperature measurement
- Pressure measurement
- Proximity detection and measurement
- Metal detection

For all these measurements, separate views are used. Switching through these views is done with the use of the two on-board push buttons (left and right buttons), in the order described by the following state machine:

Figure 3-1. Demo Application



The two last measurements (proximity and metal) are repeated before looping back to the splash page, but their representation also makes use of the buzzer:

- Proximity buzz: buzzer generates a tone with variable pitch according to the sensor reading;
- Metal detector beep: buzzer generates beeps at a variable interval, according to the sensor reading. So, the closer a metal object to the coil, the higher the beeping frequency.

For these two last views, the demo does not provide a graphical representative difference between 12-bit and 10-bit resolution in data acquisition.

3.1 Splash Page

This page displays an image of the Microchip logo, which is stored in the Flash memory.

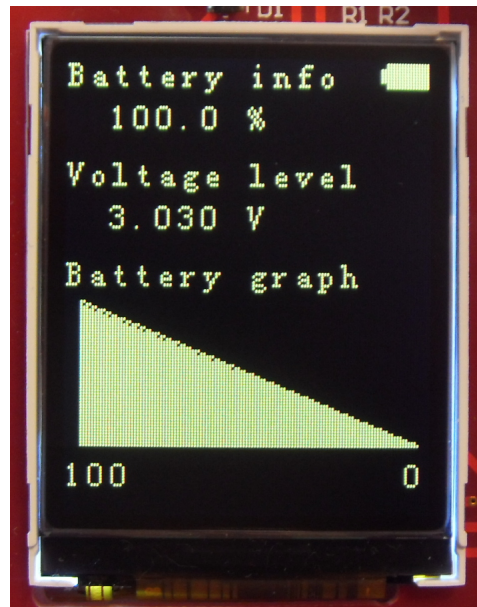
Figure 3-2. Splash Page View



3.2 Battery Level Measurement

Battery level measurement is performed while the display is turned on and the board is operating in one of the following: Battery Measurement, Temperature Measurement and Pressure Measurement views. In these three views, the percentage level of the remaining charge in the batteries is shown as a battery icon with proportional filling in the top-right corner of the display. Additionally, in the Battery Measurement view, the battery voltage in **Volts** and percentage graph are displayed.

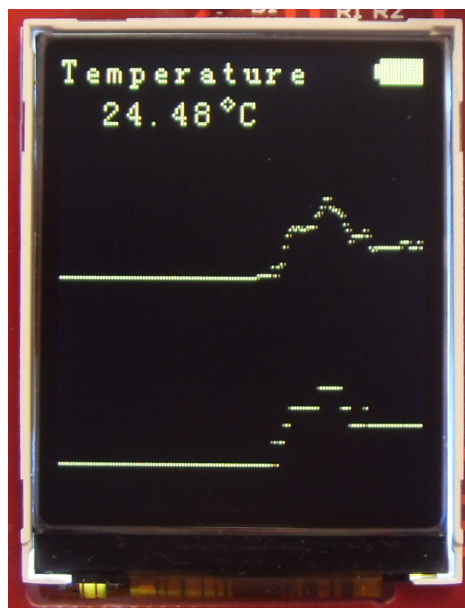
Figure 3-3. Battery Measurement View



3.3 Temperature Measurement

In this view, the current temperature is displayed (in **Celsius**). Also, two graphs display the variations of the 12-bit and 10-bit temperature values in real time.

Figure 3-4. Temperature Measurement View



3.4 Pressure Measurement

In this view, the current air pressure is displayed in **Pascal** units. Also, two graphs display the variations of the 12-bit and 10-bit pressure values in real time. This view is similar to the temperature view.

Figure 3-5. Pressure Measurement View



3.5 Proximity Detection and Measurement

When the board displays the Splash Page or Proximity Measurement View and is powered from batteries, the proximity sensor is used to detect human activity around the device. If no activity is detected for 60 seconds, the display backlight turns OFF, and turns back ON if the user approaches.

In Proximity Measurement View, a dynamic interpretation of the user's hand distance to the sensor is displayed as in the figure below:

Figure 3-6. Proximity Measurement View



In the Proximity Buzz View, the board generates a sound through the buzzer with a frequency variable according to the hand distance with respect to the board. In this mode, the LCD backlight stays always ON.

3.6 Metal Detection

When this view is entered for the first time, the board scans the metal detector LC circuit in order to find the peak (resonant) frequency. Then it supplies a signal with that frequency using the NCO, and reads the ADC². When a metal object approaches, it shifts the resonant frequency, and the ADC² value changes. The 12-bit and 10-bit values are plotted in real time. When entering this mode, the first ADC² reading is used as an offset for the plots. The LCD backlight turns OFF after 60 seconds of inactivity, and turns back ON when the user presses a button.

Figure 3-7. Metal Detection View



In the Metal Buzz View, the board generates a beep at a variable interval. The beep interval changes according to the metal detector reading. In this mode, the LCD backlight stays always ON.

3.7 Firmware Programming

The project source code can be downloaded from the website. After opening it in the MPLAB X IDE and compiling, the HEX file is generated in the `\dist\default\production` folder - path relative to the project directory. Attach the board to the PC via USB cable, and after the Mass Storage Device is detected program the MPLAB Xpress PIC16F18446 by copying the HEX file to the drive.

4. Hardware Details

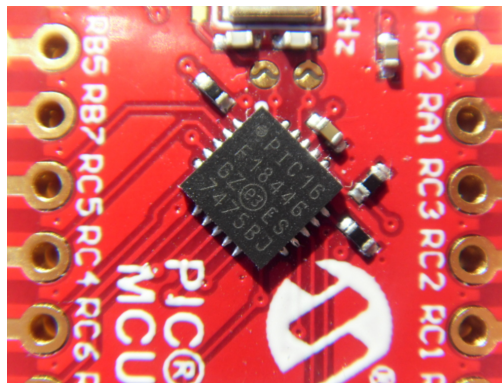
4.1 MPLAB Xpress PIC16F18446

The MPLAB Xpress PIC16F18446 evaluation kit is a hardware platform to evaluate the PIC16F18446 microcontroller. The kit provides an easy way to develop prototype hardware and firmware using the PIC16F18446. It includes an on-board Nano Embedded Debugger (nEDBG), and no external tools are necessary to program it. When plugged to a PC's USB port, it appears as mass storage device, and the user can program it by copying the HEX file to the drive.

4.1.1 PIC16F18446 Microcontroller

The MPLAB Xpress PIC16F18446 board uses, as the name implies, a PIC16F18446 microcontroller. It features Intelligent Analog, CIPs and communication peripherals, combined with eXtreme Low-Power (XLP) to simplify the design of sensor end-nodes and other applications. Features such as a 12-bit ADC², Memory Access Partitioning (MAP), the Device Information Area (DIA), Power-Saving Operating modes and Peripheral Pin Select (PPS) offer flexibility for interfacing to many different sensors and creating customized functions in hardware.

Figure 4-1. PIC16F18446



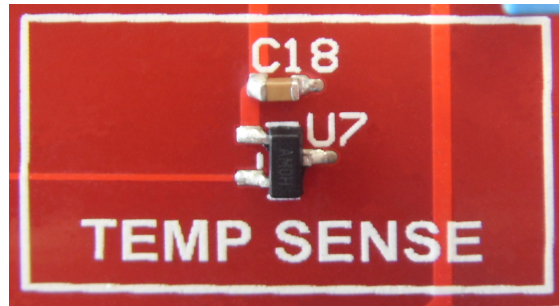
4.2 Battery Measurement

As the batteries drain, the V_{DD} voltage decreases. In order to measure the battery voltage, it must be compared to a fixed voltage. The PIC16F18446 has an internal Fixed Voltage Reference (FVR) that can be internally measured with the ADC², or used as positive reference. To get the battery voltage, ADC² is used to measure the FVR (which is configured to 1.024V) with V_{DD} as positive reference. Then the user obtains the V_{DD} (in mV) using the following formula: $V_{DD} = (2^{12}) * V_{FVR} / ADC_{Reading}$.

4.3 Temperature Sensing

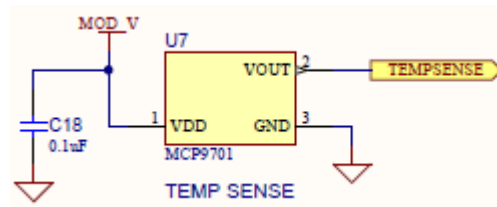
The temperature sensor is the Microchip MCP9701.

Figure 4-2. HW Temperature Sensor



The sensor has a temperature coefficient of 19.5 mV/°C. It is sensitive enough to detect the heat of the user's hand from a distance of 1 cm.

Figure 4-3. Temperature Sensor Schematic



4.4 Pressure Sensing

The pressure sensor used is the NXP MP3V5050GP. It has a sensitivity of 54 mV/kPa.

Figure 4-4. HW Pressure Sensor

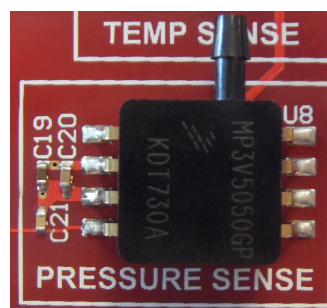
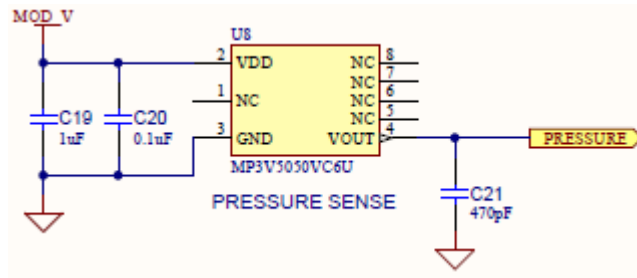


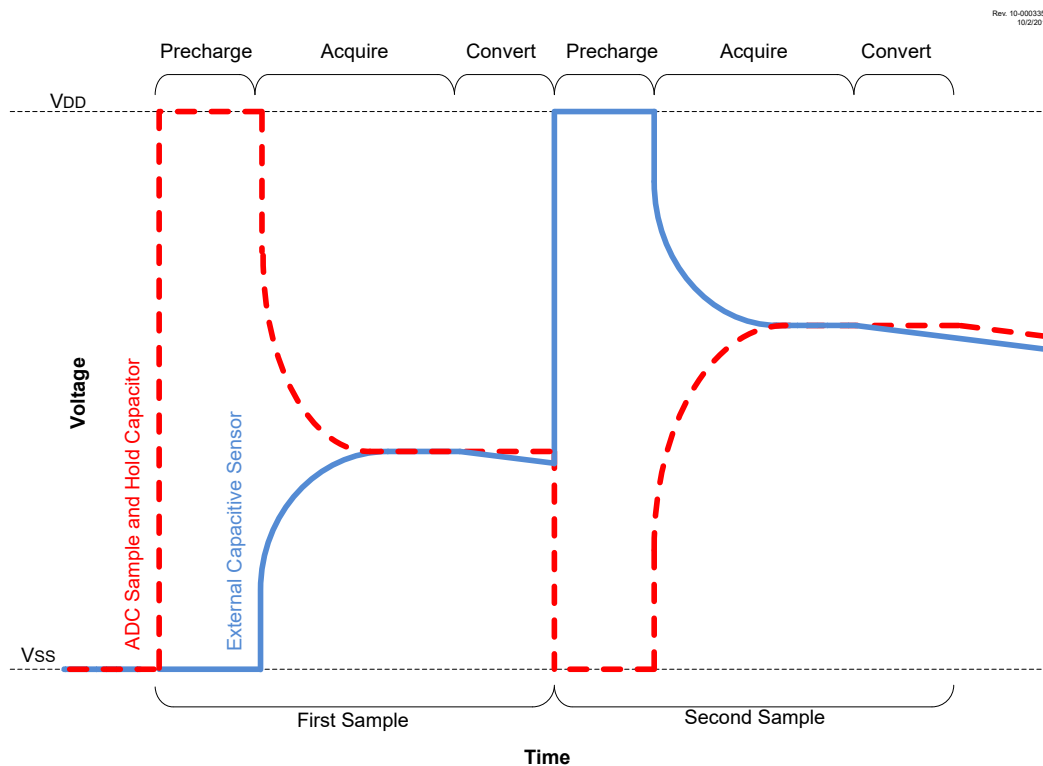
Figure 4-5. Pressure Sensor Schematic



4.5 Proximity Sensing

The sensor board has a PCB trace on its perimeter, which acts as a proximity sensor. To read this sensor, the PIC® MCU uses the ADC² in CVD mode. In this mode, the ADC² first precharges the C_{HOLD} to V_{DD} or V_{SS} , and the sensor to V_{SS} or V_{DD} , respectively. After the precharge phase, the pin is reconnected to ADC² and the charge of the two capacitors redistributes. The CVD operation principle is described in the figure below. For more details, refer to the [PIC16F18446 data sheet](#).

Figure 4-6. Differential CVD Measurement Waveform

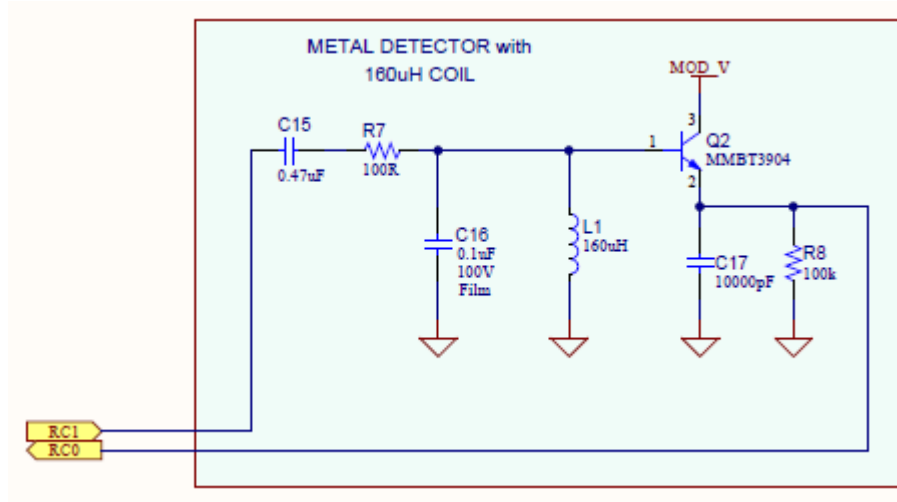


The figure displays differential CVD measurement, however the sensor board uses Non-Differential mode, since this mode is better fitted to this specific situation.

4.6 Metal Detection

The metal detection circuit is built around an MCD-L 160UH coil.

Figure 4-7. Metal Detector Schematic



The output of the Numerically Controlled Oscillator (NCO) is connected to RC1. That signal is applied to the resonant circuit composed of L1 and C16. The amplitude of the signal reaches its peak when the NCO frequency equals the resonant frequency of the circuit. When the Metal Detector mode is accessed for the first time after power-up, the firmware performs frequency scanning to detect the resonant frequency of the LC circuit. It then keeps the NCO on that frequency.

The Q2 transistor works in Repeater mode. The C17 charges at the peak amplitude. The value of R8 is large enough to not discharge the C17 during the period of the signal, so the ADC² connected to RC0 will read the peak amplitude of the signal.

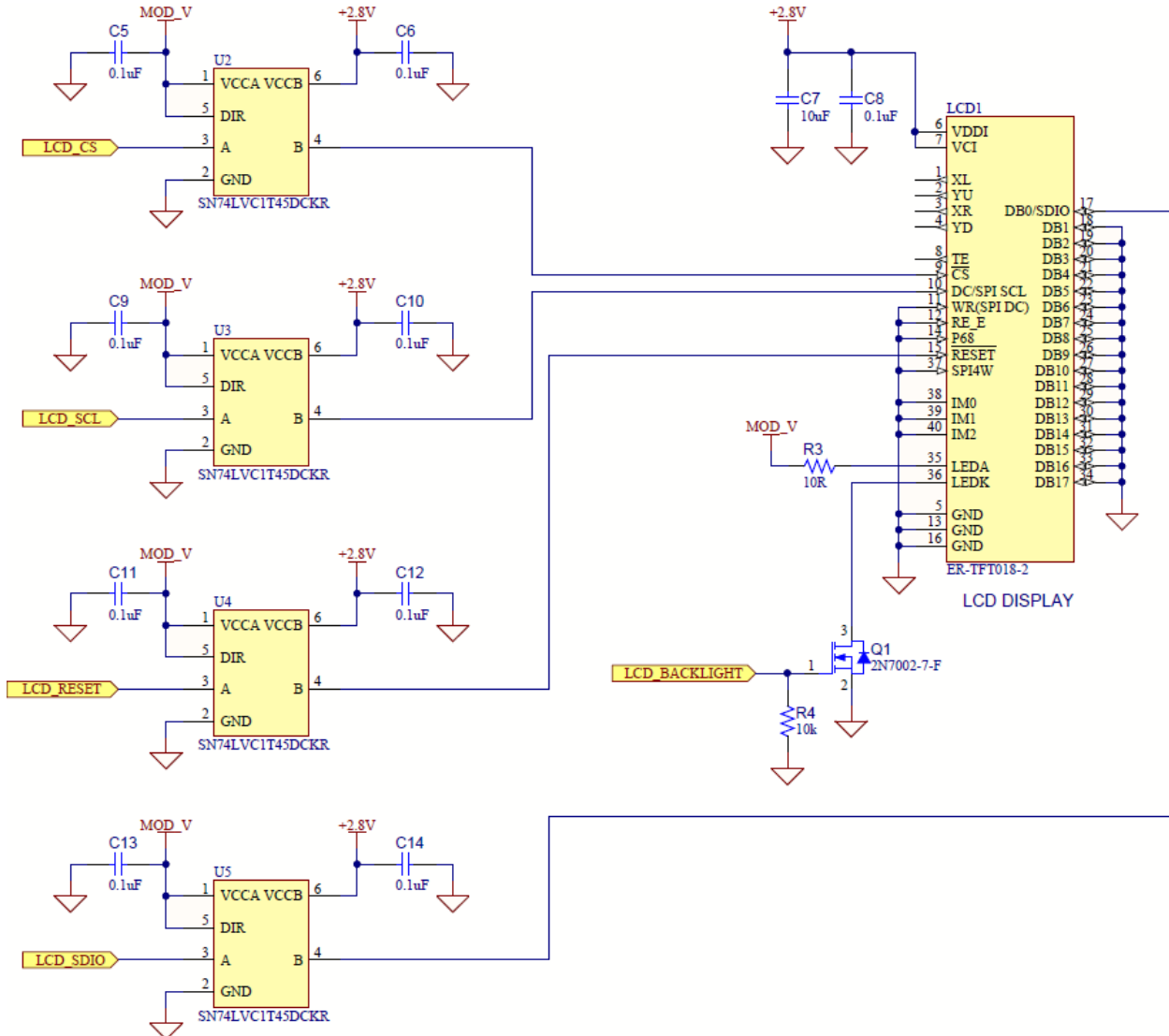
When a metal object approaches the coil L1, it changes its inductance and causes a shift in the resonant frequency, which moves away from the NCO frequency, and the amplitude decreases. The reading of the ADC² is then subtracted from a constant value, so that the plot will display an increase in value when a metal object approaches.

4.7 User Interface

4.7.1 LCD Display

The board features the **ER-TFT018-2** LCD, which is a 1.8" TFT LCD module display in 128x160 resolution with parallel and serial SPI interface. It is connected to the PIC16F18446 via 3-wire SPI. On the board, the LCD is used to display the graphical representation of the data acquired from the sensors, in a comparative manner between the 12-bit and 10-bit resolution.

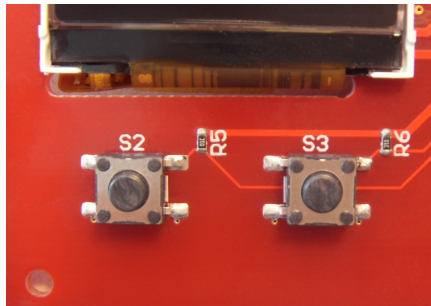
Figure 4-8. LCD Schematic



4.7.2 Buttons

There are two push buttons on the board: S2 and S3. They are used to switch between the Display modes. See [Figure 4-9](#).

Figure 4-9. HW Buttons



The PIC MCU has Interrupt on Change (IOC) enabled for the two pins, so a button press event is detected even if occurred during display redraw.

5. Revision History

Doc.Rev.	Date	Comments
A	03/2018	Initial document release.

The Microchip Web Site

Microchip provides online support via our web site at <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 (FAQ), 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

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/>. Under "Support", click on "Customer Change Notification" and follow the registration instructions.

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://www.microchip.com/support>

Microchip Devices Code Protection Feature

Note the following details of the code protection feature on Microchip devices:

- Microchip products meet the specification contained in their particular Microchip Data Sheet.
- Microchip believes that its family of products is one of the most secure families of its kind on the market today, when used in the intended manner and under normal conditions.
- There are dishonest and possibly illegal methods used to breach the code protection feature. All of these methods, to our knowledge, require using the Microchip products in a manner outside the operating specifications contained in Microchip's Data Sheets. Most likely, the person doing so is engaged in theft of intellectual property.
- Microchip is willing to work with the customer who is concerned about the integrity of their code.

- Neither Microchip nor any other semiconductor manufacturer can guarantee the security of their code. Code protection does not mean that we are guaranteeing the product as “unbreakable.”

Code protection is constantly evolving. We at Microchip are committed to continuously improving the code protection features of our products. Attempts to break Microchip's code protection feature may be a violation of the Digital Millennium Copyright Act. If such acts allow unauthorized access to your software or other copyrighted work, you may have a right to sue for relief under that Act.

Legal Notice

Information contained in this publication regarding device applications and the like is provided only for your convenience and may be superseded by updates. It is your responsibility to ensure that your application meets with your specifications. MICROCHIP MAKES NO REPRESENTATIONS OR WARRANTIES OF ANY KIND WHETHER EXPRESS OR IMPLIED, WRITTEN OR ORAL, STATUTORY OR OTHERWISE, RELATED TO THE INFORMATION, INCLUDING BUT NOT LIMITED TO ITS CONDITION, QUALITY, PERFORMANCE, MERCHANTABILITY OR FITNESS FOR PURPOSE. Microchip disclaims all liability arising from this information and its use. Use of Microchip devices in life support and/or safety applications is entirely at the buyer's risk, and the buyer agrees to defend, indemnify and hold harmless Microchip from any and all damages, claims, suits, or expenses resulting from such use. No licenses are conveyed, implicitly or otherwise, under any Microchip intellectual property rights unless otherwise stated.

Trademarks

The Microchip name and logo, the Microchip logo, AnyRate, AVR, AVR logo, AVR Freaks, BeaconThings, BitCloud, CryptoMemory, CryptoRF, dsPIC, FlashFlex, flexPWR, Helder, JukeBlox, KeeLoq, KeeLoq logo, Kleer, LANCheck, LINK MD, maXStylus, maXTouch, MediaLB, megaAVR, MOST, MOST logo, MPLAB, OptoLyzer, PIC, picoPower, PICSTART, PIC32 logo, Prochip Designer, QTouch, RightTouch, SAM-BA, SpyNIC, SST, SST Logo, SuperFlash, tinyAVR, UNI/O, and XMEGA are registered trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

ClockWorks, The Embedded Control Solutions Company, EtherSynch, Hyper Speed Control, HyperLight Load, IntelliMOS, mTouch, Precision Edge, and Quiet-Wire are registered trademarks of Microchip Technology Incorporated in the U.S.A.

Adjacent Key Suppression, AKS, Analog-for-the-Digital Age, Any Capacitor, AnyIn, AnyOut, BodyCom, chipKIT, chipKIT logo, CodeGuard, CryptoAuthentication, CryptoCompanion, CryptoController, dsPICDEM, dsPICDEM.net, Dynamic Average Matching, DAM, ECAN, EtherGREEN, In-Circuit Serial Programming, ICSP, Inter-Chip Connectivity, JitterBlocker, KleerNet, KleerNet logo, Mindi, MiWi, motorBench, MPASM, MPF, MPLAB Certified logo, MPLIB, MPLINK, MultiTRAK, NetDetach, Omniscient Code Generation, PICDEM, PICDEM.net, PICkit, PICtail, PureSilicon, QMatrix, RightTouch logo, REAL ICE, Ripple Blocker, SAM-ICE, Serial Quad I/O, SMART-I.S., SQI, SuperSwitcher, SuperSwitcher II, Total Endurance, TSHARC, USBCheck, VariSense, ViewSpan, WiperLock, Wireless DNA, and ZENA are trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

SQTP is a service mark of Microchip Technology Incorporated in the U.S.A.

Silicon Storage Technology is a registered trademark of Microchip Technology Inc. in other countries.

GestIC is a registered trademark of Microchip Technology Germany II GmbH & Co. KG, a subsidiary of Microchip Technology Inc., in other countries.

All other trademarks mentioned herein are property of their respective companies.

© 2018, Microchip Technology Incorporated, Printed in the U.S.A., All Rights Reserved.

ISBN: 978-1-5224-2832-9

Quality Management System Certified by DNV

ISO/TS 16949

Microchip received ISO/TS-16949:2009 certification for its worldwide headquarters, design and wafer fabrication facilities in Chandler and Tempe, Arizona; Gresham, Oregon and design centers in California and India. The Company's quality system processes and procedures are for its PIC[®] MCUs and dsPIC[®] DSCs, KEELOQ[®] code hopping devices, Serial EEPROMs, microperipherals, nonvolatile memory and analog products. In addition, Microchip's quality system for the design and manufacture of development systems is ISO 9001:2000 certified.

Worldwide Sales and Service

AMERICAS	ASIA/PACIFIC	ASIA/PACIFIC	EUROPE
Corporate Office 2355 West Chandler Blvd. Chandler, AZ 85224-6199 Tel: 480-792-7200 Fax: 480-792-7277 Technical Support: http://www.microchip.com/support Web Address: www.microchip.com	Australia - Sydney Tel: 61-2-9868-6733 China - Beijing Tel: 86-10-8569-7000 China - Chengdu Tel: 86-28-8665-5511 China - Chongqing Tel: 86-23-8980-9588 China - Dongguan Tel: 86-769-8702-9880 China - Guangzhou Tel: 86-20-8755-8029 China - Hangzhou Tel: 86-571-8792-8115 China - Hong Kong SAR Tel: 852-2943-5100 China - Nanjing Tel: 86-25-8473-2460 China - Qingdao Tel: 86-532-8502-7355 China - Shanghai Tel: 86-21-3326-8000 China - Shenyang Tel: 86-24-2334-2829 China - Shenzhen Tel: 86-755-8864-2200 China - Suzhou Tel: 86-186-6233-1526 China - Wuhan Tel: 86-27-5980-5300 China - Xian Tel: 86-29-8833-7252 China - Xiamen Tel: 86-592-2388138 China - Zhuhai Tel: 86-756-3210040	India - Bangalore Tel: 91-80-3090-4444 India - New Delhi Tel: 91-11-4160-8631 India - Pune Tel: 91-20-4121-0141 Japan - Osaka Tel: 81-6-6152-7160 Japan - Tokyo Tel: 81-3-6880-3770 Korea - Daegu Tel: 82-53-744-4301 Korea - Seoul Tel: 82-2-554-7200 Malaysia - Kuala Lumpur Tel: 60-3-7651-7906 Malaysia - Penang Tel: 60-4-227-8870 Philippines - Manila Tel: 63-2-634-9065 Singapore Tel: 65-6334-8870 Taiwan - Hsin Chu Tel: 886-3-577-8366 Taiwan - Kaohsiung Tel: 886-7-213-7830 Taiwan - Taipei Tel: 886-2-2508-8600 Thailand - Bangkok Tel: 66-2-694-1351 Vietnam - Ho Chi Minh Tel: 84-28-5448-2100	Austria - Wels Tel: 43-7242-2244-39 Fax: 43-7242-2244-393 Denmark - Copenhagen Tel: 45-4450-2828 Fax: 45-4485-2829 Finland - Espoo Tel: 358-9-4520-820 France - Paris Tel: 33-1-69-53-63-20 Fax: 33-1-69-30-90-79 Germany - Garching Tel: 49-8931-9700 Germany - Haan Tel: 49-2129-3766400 Germany - Heilbronn Tel: 49-7131-67-3636 Germany - Karlsruhe Tel: 49-721-625370 Germany - Munich Tel: 49-89-627-144-0 Fax: 49-89-627-144-44 Germany - Rosenheim Tel: 49-8031-354-560 Israel - Ra'anana Tel: 972-9-744-7705 Italy - Milan Tel: 39-0331-742611 Fax: 39-0331-466781 Italy - Padova Tel: 39-049-7625286 Netherlands - Drunen Tel: 31-416-690399 Fax: 31-416-690340 Norway - Trondheim Tel: 47-7289-7561 Poland - Warsaw Tel: 48-22-3325737 Romania - Bucharest Tel: 40-21-407-87-50 Spain - Madrid Tel: 34-91-708-08-90 Fax: 34-91-708-08-91 Sweden - Gothenberg Tel: 46-31-704-60-40 Sweden - Stockholm Tel: 46-8-5090-4654 UK - Wokingham Tel: 44-118-921-5800 Fax: 44-118-921-5820