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MCP3903 ADC Evaluation Board for 16-Bit MCUs User's Guide

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MCP3903 ADC EVALUATION BOARD FOR 16-BIT MCUs USER'S GUIDE

Table of Contents

MCP3903 ADC EVALUATION BOARD FOR 16-BIT MCUs 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) 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 on-line help. Select the Help menu, and then Topics to open a list of available on-line help files.**

INTRODUCTION

This chapter contains general information that will be useful to know before using the MCP3903 ADC Evaluation Board for 16-Bit MCUs. Items discussed in this chapter include:

- Document Layout
- Conventions Used in this Guide
- Recommended Reading
- The Microchip Web Site
- Customer Support
- Document Revision History

DOCUMENT LAYOUT

This document describes how to use the MCP3903 ADC Evaluation Board for 16-Bit MCUs as a development tool to emulate and debug firmware on a target board. The manual layout is as follows:

- **Chapter 1. "Hardware Description"**– Provides important information about the hardware.
- **Chapter 2. "Code example"**– Describes the firmware.
- **Appendix A. "Schematics and Layouts"**– Shows the schematic and board layouts.
- **Appendix B. "Bill of Materials (BOM)"** – Lists the parts used to build the MCP3903 ADC Evaluation Board for 16-Bit MCUs.

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	<u>*File>Save*</u>
Bold characters	A dialog button	Click **OK**
	A tab	Click the **Power** tab
N'Rnnnn	A number in verilog format, where N is the total number of digits, R is the radix and n is a digit.	4'b0010, 2'hF1
Text in angle brackets < >	A key on the keyboard	Press <Enter>, <F1>
Courier New font:		
Plain Courier New	Sample source code	`#define START`
	Filenames	`autoexec.bat`
	File paths	`c:\mcc18\h`
	Keywords	`_asm, _endasm, static`
	Command-line options	`-Opa+, -Opa-`
	Bit values	`0, 1`
	Constants	`0xFF, 'A'`
Italic Courier New	A variable argument	*`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)`
		`{ ...`
		`}`

RECOMMENDED READING

This User's Guide describes how to use MCP3903 ADC Evaluation Board for 16-Bit MCUs. Other useful documents are listed below. The following Microchip document is available and recommended as a supplemental reference resource:

- **MCP3903 Data Sheet -** ***"Six Channel Delta Sigma A/D Converter"*** **(DS25048B)**

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- **General Technical Support** – Frequently Asked Questions (FAQs), technical support requests, online discussion groups, Microchip consultant program member listing
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- 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 (July 2011)

- Initial Release of this Document.

NOTES:

Chapter 1. Hardware Description

1.1 OVERVIEW

The MCP3903 ADC Evaluation Board for 16-Bit MCUs system lets users evaluate the performance of the MCP3903 six-channel ADC. It also provides a development platform for 16-bit PIC® MCU-based applications, using existing 100-pin PIM systems, compatible with the Explorer-16 and other high pincount PIC demo boards. The system comes with programmed PIC24FJ128GA010 PIM modules that communicate with the LabView GUI for data exchange and ADC setup.

1.1.1 Feature Highlights

- Six-channel ADC MCP3903 output display using serial communication to the PC Software Interface and LCD
- Simultaneous 4 ksps at 91 dB Signal-to-Noise and Distortion Ratio (SINAD) performance. The ADC can run up to 64 ksps.
- System and ADC performance analysis through graphical PC tools showing Time domain scope plot, Frequency Domain (FFT), and statistical numerical analysis.
- Robust hardware design with analog grounding and analog/digital separation, allowing low noise evaluation of the MCP3903 devices. Separate power supplies and power planes - 4 layer board.
- Pigtail Plus connectors for Explorer-16 daughter board compatibility.

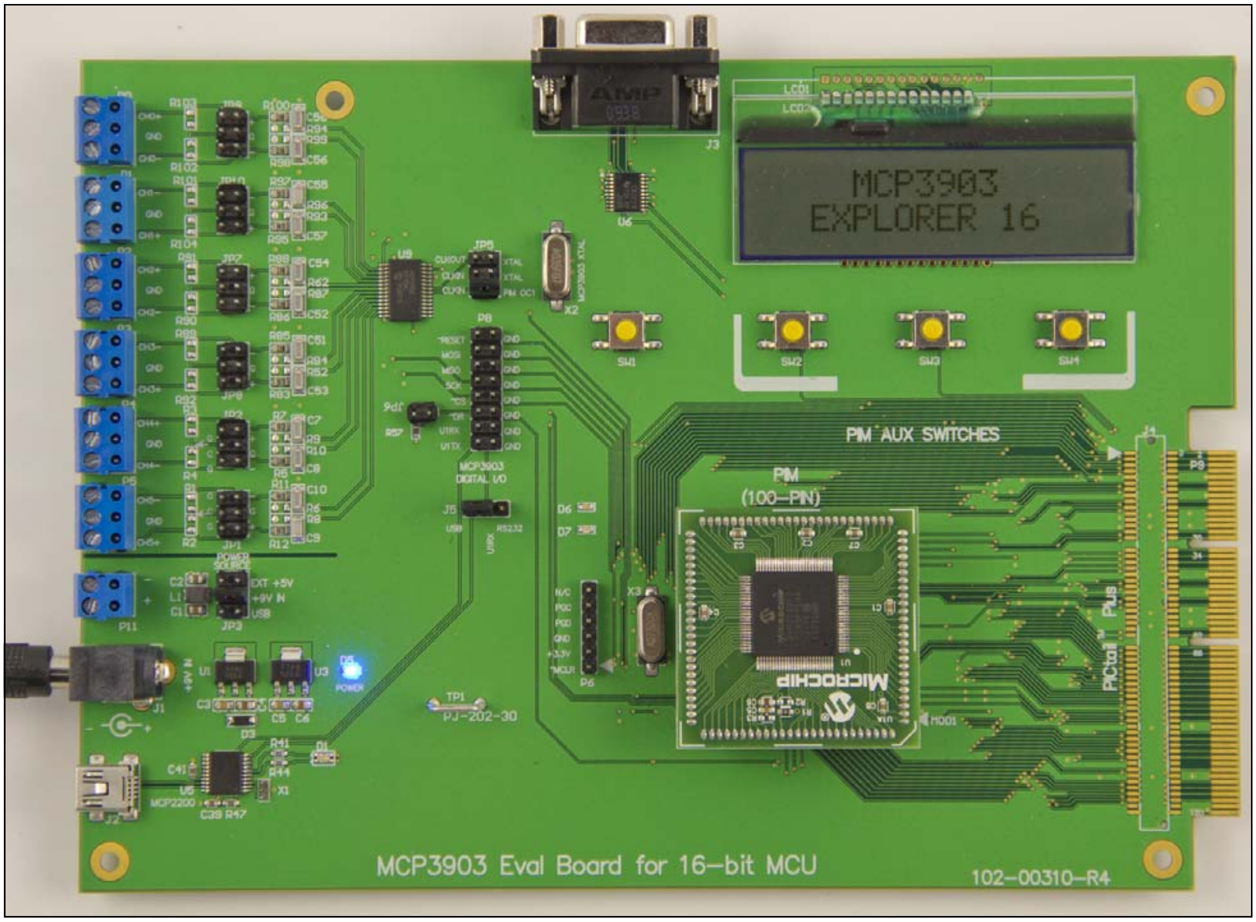


FIGURE 1-1: *MCP3903 ADC Evaluation Board for 16-Bit MCUs.*

1.2 PIM MODULE / MCP3903 CONNECTION AND PERIPHERAL USAGE OVERVIEW

The MCP3903 ADC Evaluation Board for 16-Bit MCUs contains a 100-pin PIM socket, compatible with Microchip's PIM modules. The system comes with a PIM module: the PIC24FJ128GA010.

For a complete description of the firmware programmed with these two modules, see **Chapter 1. "Hardware Description"**.

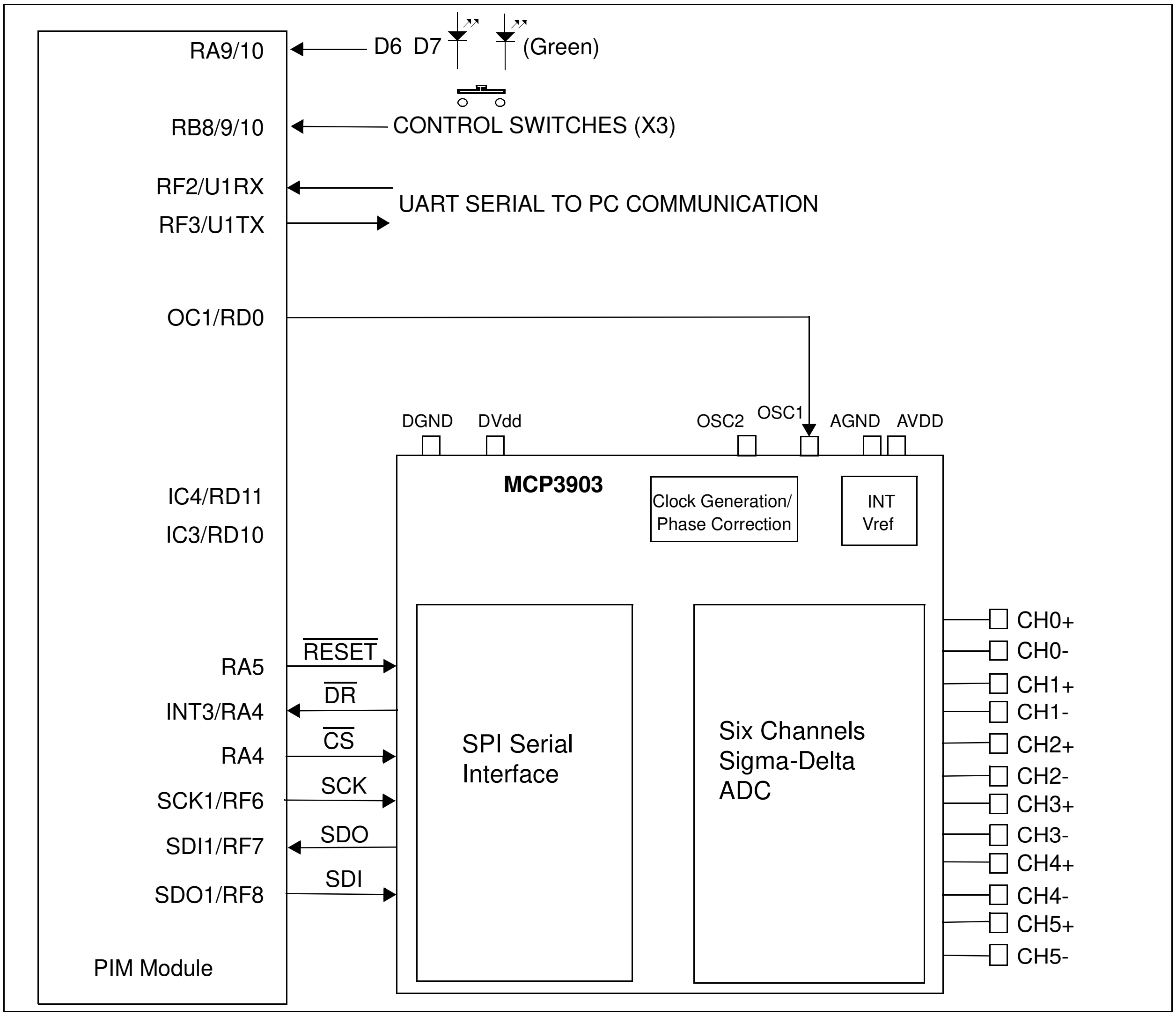


FIGURE 1-2: *Digital Connection Overview PIM/MCP3903 Connections.*

Ports A, B, and D are used for signals such as push buttons, output LEDs, $\overline{CS}$ and $\overline{MCLR}$ (for MCP3903 data mode setting). Output Capture 1 is used for MCP3903's clock generation. Serial communication is achieved through the MSSP module 1.

The MCP3903 device is an ADC with a second order modulator and a third order sync filter. This Delta-Sigma A/D converter has an adjustable oversampling ratio. The CLKIN pin of the MCP3903 is the ADC's clock (MCLK) input. The MCP3903 ADC Evaluation Board for 16-Bit MCUs offers two different options for the MCP3903 master clock (MCLK).

1.2.1 Using the Crystal X2

The MCP3903 ADC Evaluation Board for 16-Bit MCUs is populated with a 3.58 MHz crystal, being used as a clock source, by placing jumpers in the following position on the MCP3903 Digital I/O header block:

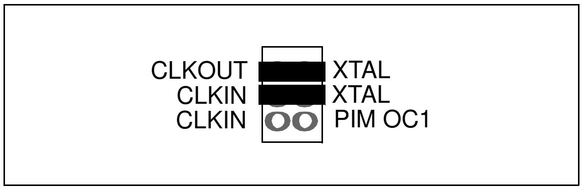


FIGURE 1-3: *ADC Clock Selection Jumpers - External Crystal.*

1.2.2 Driving the Clock with the PIM Module

The PIC® MCU can be used to generate the CLKIN (MCLK) signal for the MCP3903, setting the ADC sample rate through the use of the output compare module OC1. To use this, make the following jumper change to the MCP3903 Digital I/O header block:

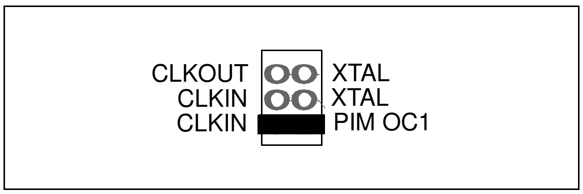


FIGURE 1-4: *ADC Clock Selection Jumpers - Clock from MCU.*

The signal frequency from OC1 can be changed by the user from the PC software by changing the value in the **Sampling Speed Control** box from the **Edit** menu. A low number will generate a high frequency signal. The value of the sampling rate, which is directly proportional to the clock frequency from OC1, is indicated in the sampling speed indicator box in the PC software (see Figure 2-3) for the dsPIC33 example. In the PIC24F example, the sampling speed is constant at 4.8 ksps, regardless of the OSR value.

1.3 ANALOG INPUT STRUCTURE

Two differential input paths allow external signal sources to be easily connected to the MCP3903 input. Edge connectors JP1 and JP2 are 3-pin connectors that act both as crew-type and clip-on post connectors.

> **Note:** To use an edge connector as a post connector, pull up the blue plastic top to access the posts.

JP1 and JP2 can be used to force either channel from a differential to a single-ended configuration. R3 and R4 (on CH0), and R1 and R2 (on CH2) act as locations for burden resistor connectors for any current transformer inputs.

1.4 USB TO SERIAL CONVERTER

The MCP3903 ADC Evaluation Board for 16-Bit MCUs also contains a USB connection for connecting the evaluation board to a PC. On the board, there is an MCP2200 USB to UART converter that creates a virtual COM port on the PC. The MCP3903 ADC Evaluation Board for 16-Bit MCUs also features a RS232 connector just in case it is required. The RS232 Line driver is connected to the same UART pins of the MCU. For this reason, a 3-pin jumper (J5) is present on the evaluation board to select which serial communication will be used: USB or RS232. The following figure summarizes the connections between the ADC, MCU, USB to serial converter and RS232 line driver.

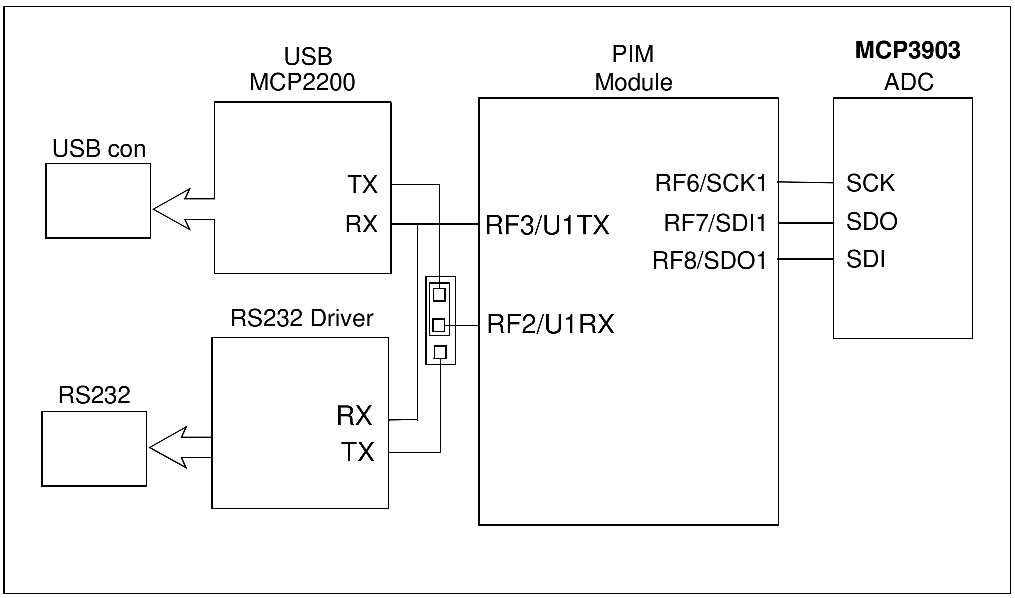


FIGURE 1-5: *Serial Communication Block Diagram.*

NOTES:

Chapter 2. Code Example

2.1 DSPIC33 EXAMPLE DESCRIPTION

If the user needs to evaluate the ADC on a system that uses dsPIC33 microcontrollers, then a PIM connector with a dsPIC33FJ256GA710A can be used on the evaluation board.

Using this example, the user can modify all MCP3903 internal registers from the PC software "MCP390x Data VIEW". The UART communication speed is at 115.2 kbps.

2.1.1 SPI Communication

To transfer data from the ADC to the MCU, the SPI communication is controlled by DMA1. DMA1 channel is set up to use nul data write to read the MCP3903 register correctly. The DMA1 reads 7 bytes, but the first byte is not used. Before a new DMA read takes place, the CS pin must be controlled in the software and the MCU must wait for a new external interrupt 3 that indicates a new acquisition.

After the DMA1 transfer is finished, the DMA buffer content is moved into the Vch0 and Vch1 buffers. The loop is repeated until Vch0 and Vch1 are filled.

Timer 8 and Timer 9 are configured to work as a 32-bit timer. This timer starts when the acquisition is started and stopped when data buffers are full. The value indicated by this timer will be used to evaluate the sampling speed of the ADC on the PC interface.

After the buffers are filled with the samples, the internal registers of MCP3903 are read also using DMA1, now configured to read 16 bytes. The state of the MCP3903 internal registers will be stored into the MCU, since later they will be sent to the PC GUI.

To set the MCP3903 configuration registers, MCU must write on the SPI bus. For this purpose, the DMA0 channel is used and is set to do a thirteen bytes transfer from MCU to MCP3903.

2.1.2 UART Communication

To send the acquired samples from the MCU to the PC, the UART peripheral is used. On the board, the user can use the RS232 DB9 connector to connect to a serial port on PC side, or it can use the USB port that creates a virtual serial port on the PC, thanks to the MCP2200 USB to TTL converter that is connected to the MCU.

The RX pins of the MAX2323 and the MCP2200 are tightened together with the TX pin of the UART2 from the MCU. The user needs to select from jumperJ5 if the MCU receives data from MCP2200 or MAX2323. In firmware, the MCU is using DMA2 to do the transfer from MCU to the PC. To receive data from the PC through UART, the RX interrupt is used.

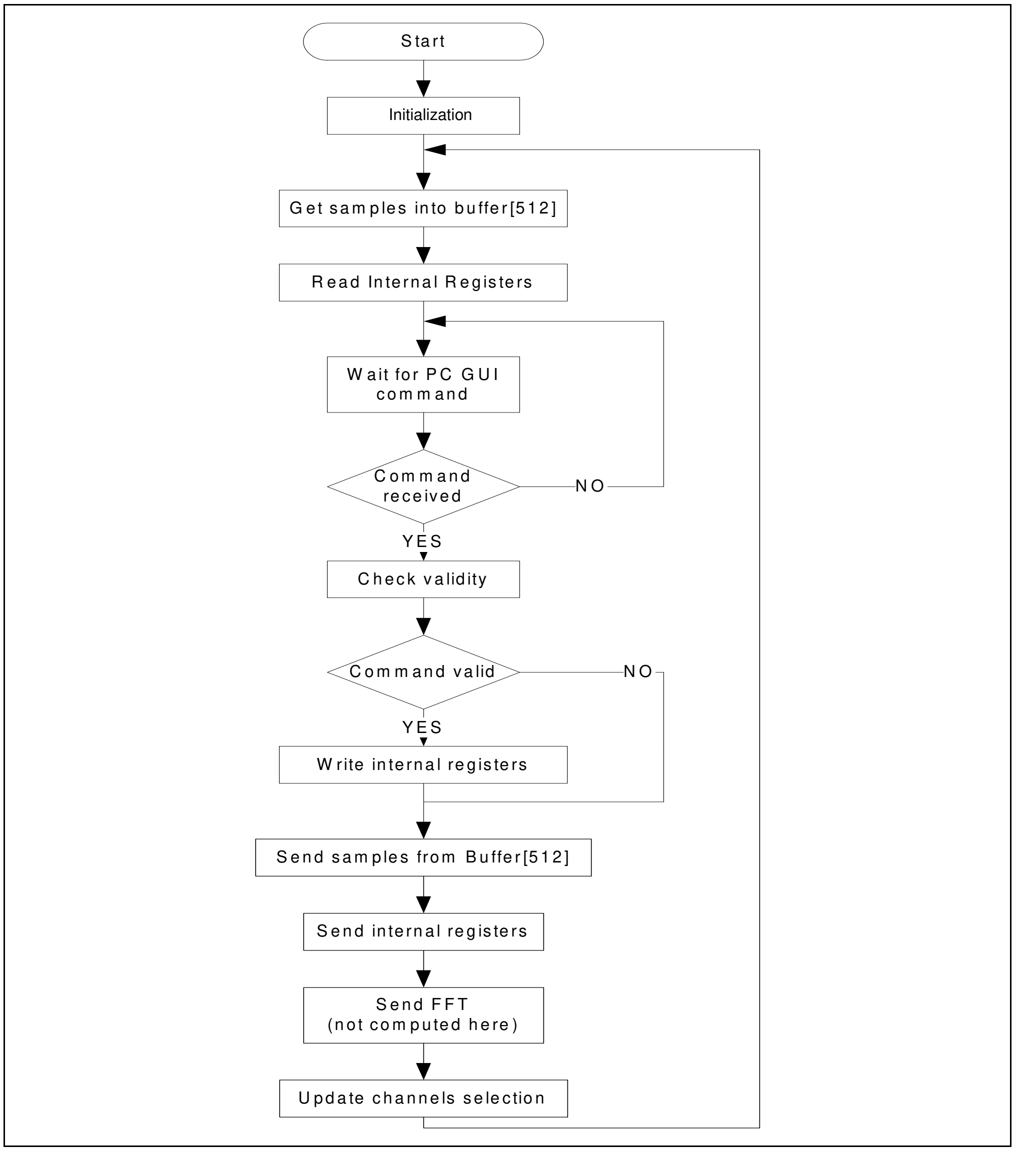


FIGURE 2-1: *dsPIC33 Example Flow Chart.*

2.1.3 PC Software

The PC receives the data and displays it on the MCP390x Data View. The program can display and process only two channels at the same time. To select the desired channels, the SW4 (RD13) must be pressed.

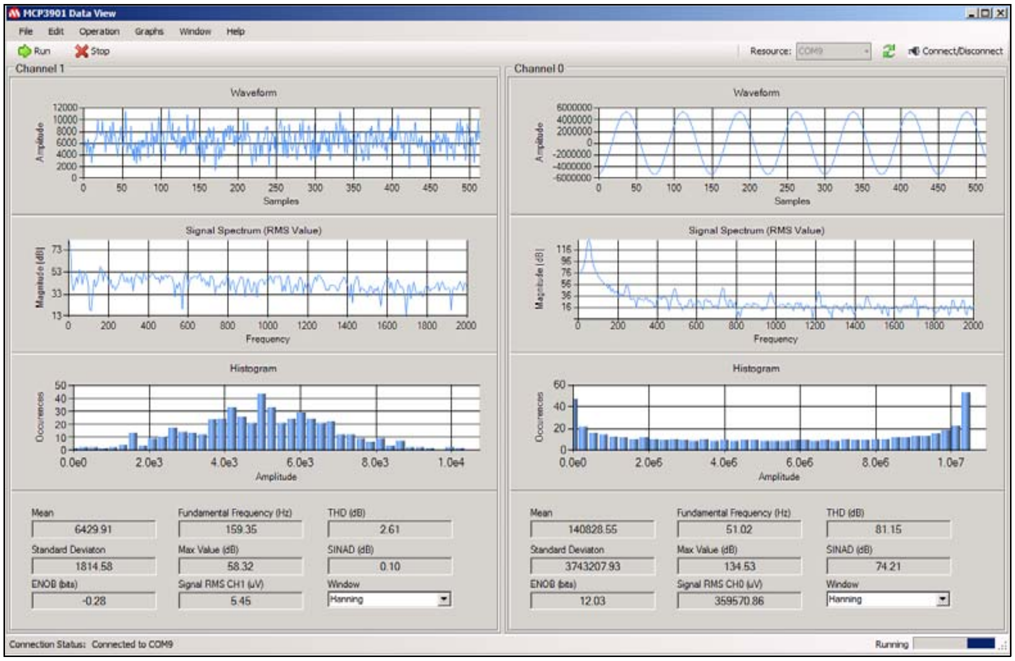


FIGURE 2-2: MCP3903 Data View Software - Main Screen.

Connectivity is done through the serial port. First, the user must identify the com port number from **My computer** > **Manage** > **Device Manager**. After this, in “VISA resource names”, users must find and select the correct com port number. Only after this, can the START button be pressed to begin the data acquisition.

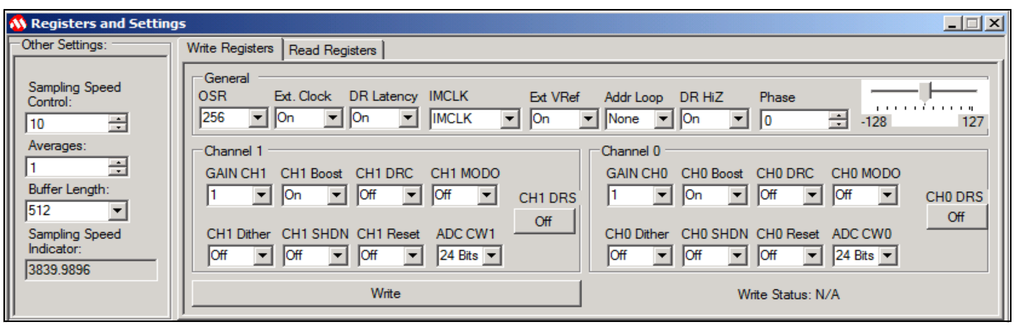


FIGURE 2-3: MCP3903 Data View Software - Registers and Settings Screen.

From the **Edit** menu, the user can open the **Registers and Settings** window to control the internal registers of the MCP3903, the sampling speed of the ADC or if any averaging should be done on the acquired samples.

From the buffer length, the user can select the amount of data that will be processed. The maximum length is 512. From the Sampling Speed Control, the user can change the sampling speed of the ADC. By writing a lower value, the sampling speed is increased, and for higher values it is decreased. The accurate value of the sampling speed is indicated in the Sampling speed indicator.

If the user wants to investigate the effect of averaging on the performance indicator, the desired value can be written in the “Averages” control. It must be noted that the processed buffer will decrease by a factor equal to the value of the average.

The **Write Register** and **Read Registe**r tabs are used to set the internal registers of the MCP3903. With the **Write Register** tab they are written and with the **Read Register** tab, the user can check the settings of the registers.

The Waveform Graphs will show the signal in Time domain, while the Signal Spectrum graphs shows the signal in Frequency domain. From the **Graphs** menu, under the **Signal Spectrum** option, the user can find the **Switch Y-axis scale** option. From here, it is possible to change the Y axis of the Signal Spectrum in linear scale or in logarithmic scale. The spectrum signal information is obtained by performing a Fast Fourier transformation over the Time domain signal. This Fourier transformation can be done after the signal has been windowed. For this, the user must select the type of window from the **Window** control on the lower area of the main window.

The Histogram Graph can be used to investigate the distribution of the codes. This is especially helpful to check if a DC signal distribution is Gaussian. From the **Graphs** menu, under the **Histogram** option, the user can **Change the number of bits**, with the default being 40.

The indicators from the lower area of the program indicate other performance parameters of the ADC. The main one is SINAD and related to it is Effective Number of Bits (ENOB), used to indicate the AC signal performance. The ENOB value is computed according to the formula below:

EQUATION 2-1:

$$ENOB = \frac{\mathrm{SINAD} - 1.76}{6.02}$$

For DC signals, the Noise RMS signal in µV is displayed. For AC signals, the indicator will show the RMS value of the signal.

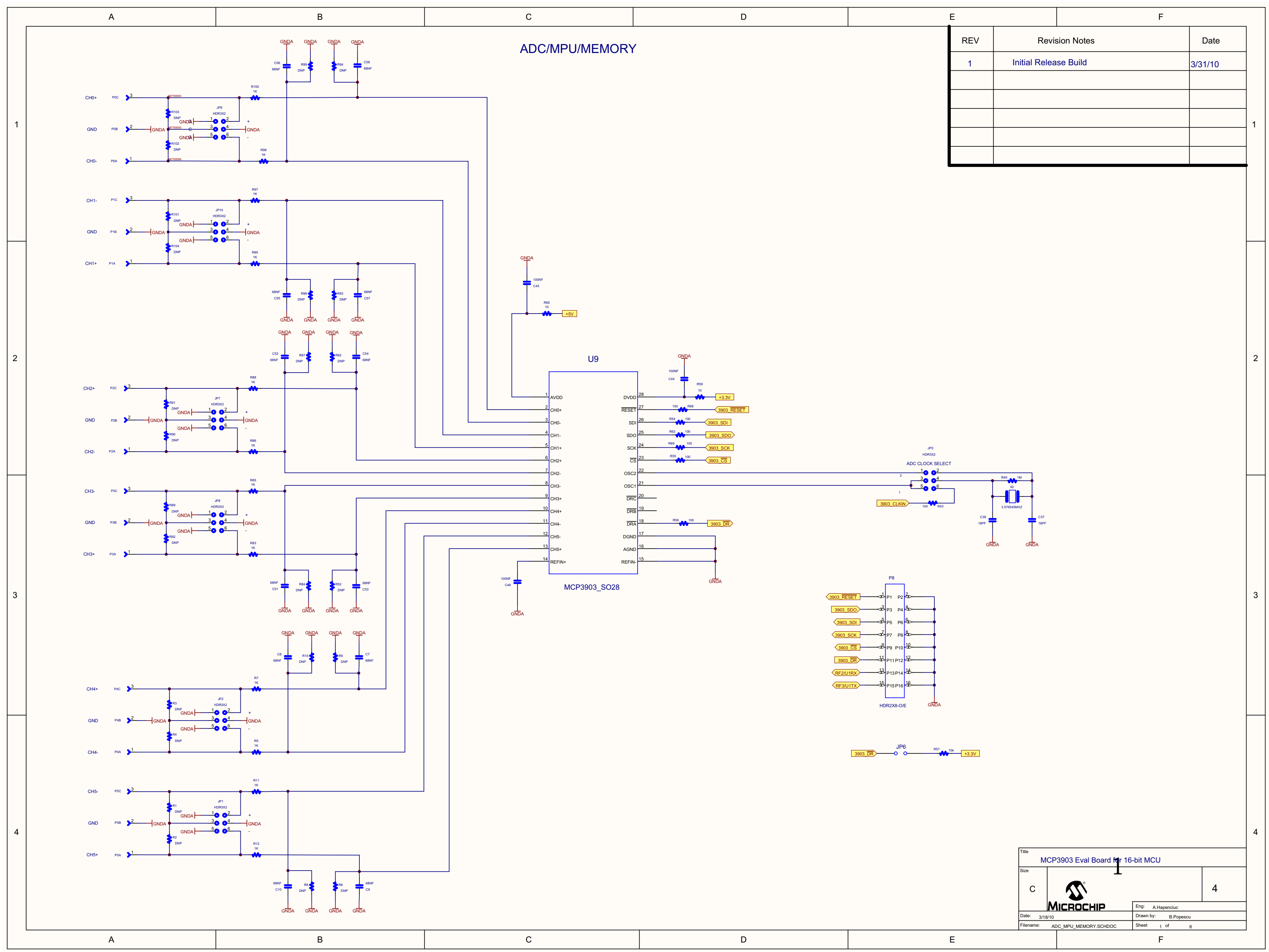
Appendix A. Schematics and Layouts

A.1 INTRODUCTION

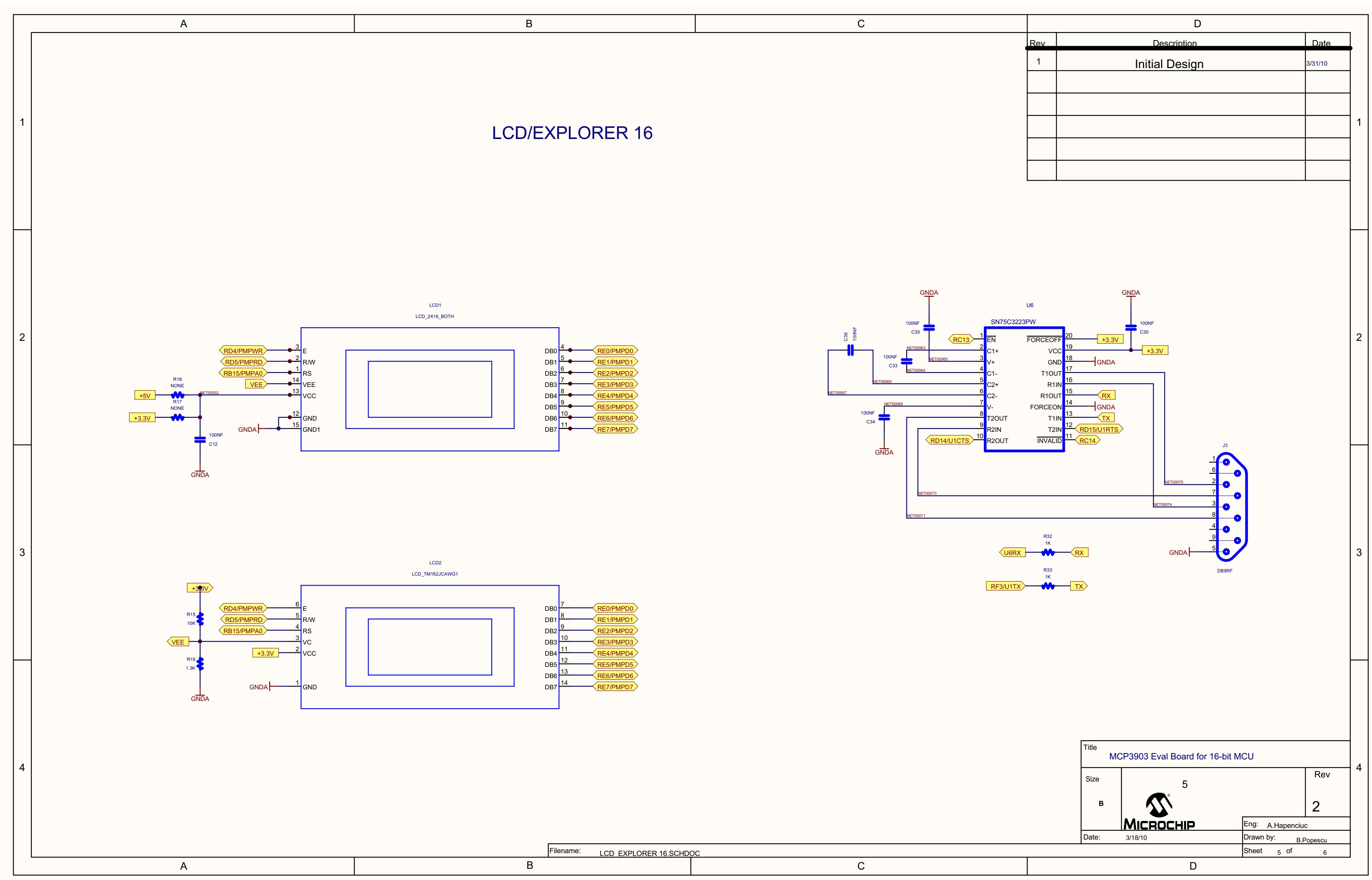
This appendix contains the following schematics of the MCP3903 ADC Evaluation Board for 16-Bit MCUs.

- Schematic - Analog
- Schematic - LCD and UART
- Schematic - USB and Memory
- Schematic - Microcontroller (MCU)
- Schematic - PIM Module
- Schematic - Power
- Board - Top Trace and Top Silk
- Board - Bottom Trace and Bottom Silk
- Board - Layer #2 V_{DD}
- Board - Layer #3 GND
- Board - Top Silk and Pads
- Board - Bottom Silk and Pads

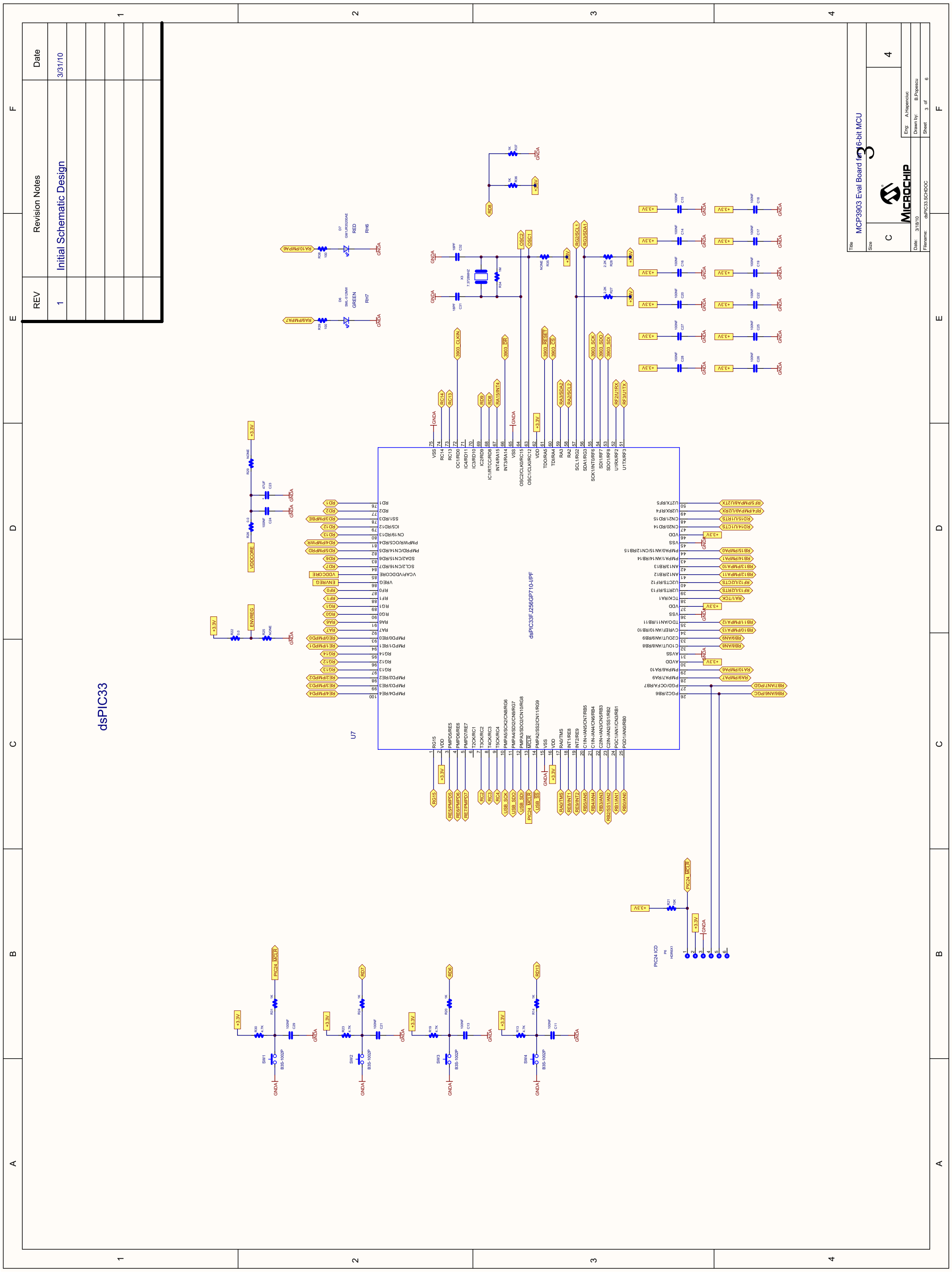
A.2 SCHEMATIC - ANALOG



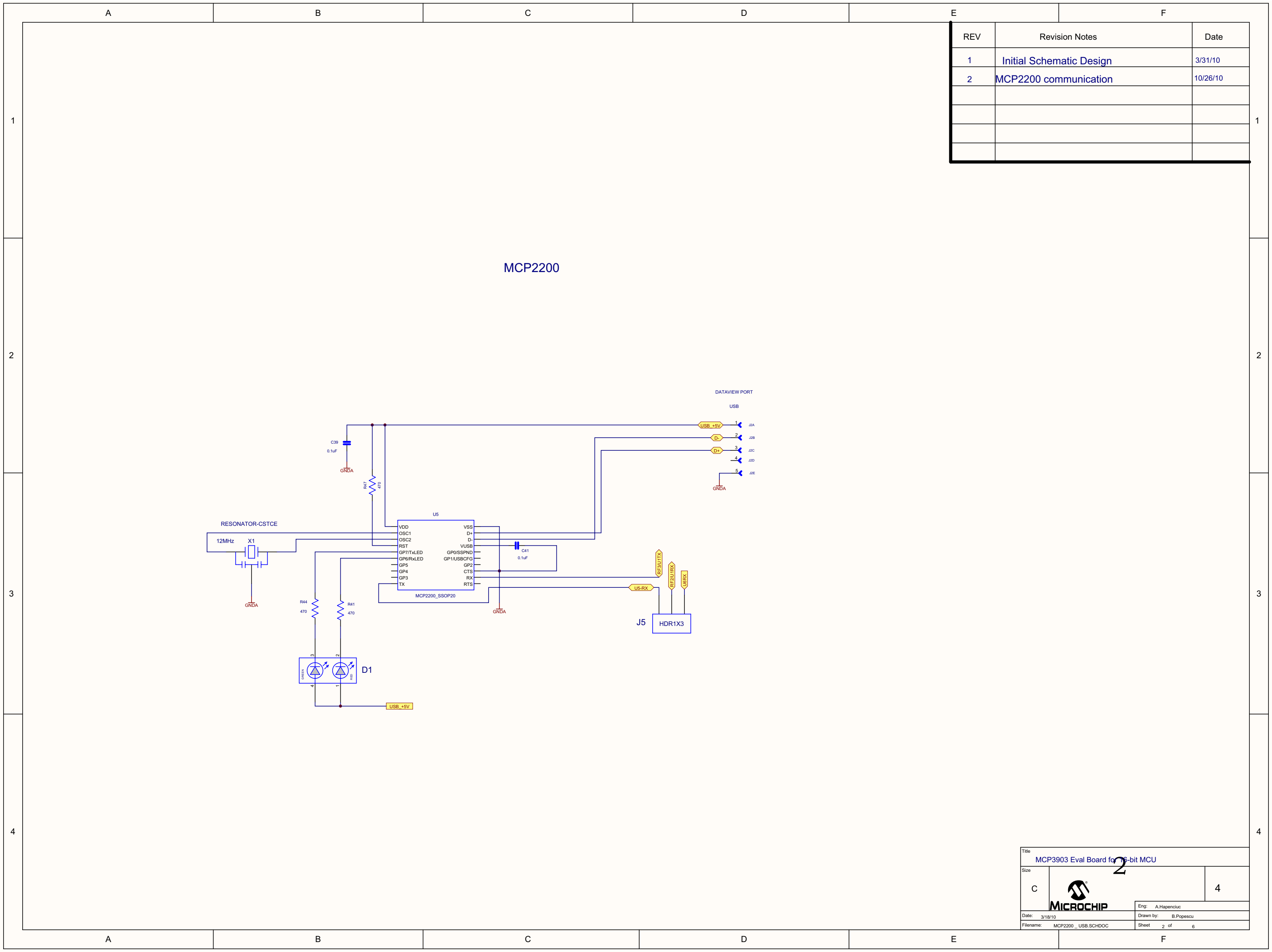
A.3 SCHEMATIC - LCD AND UART



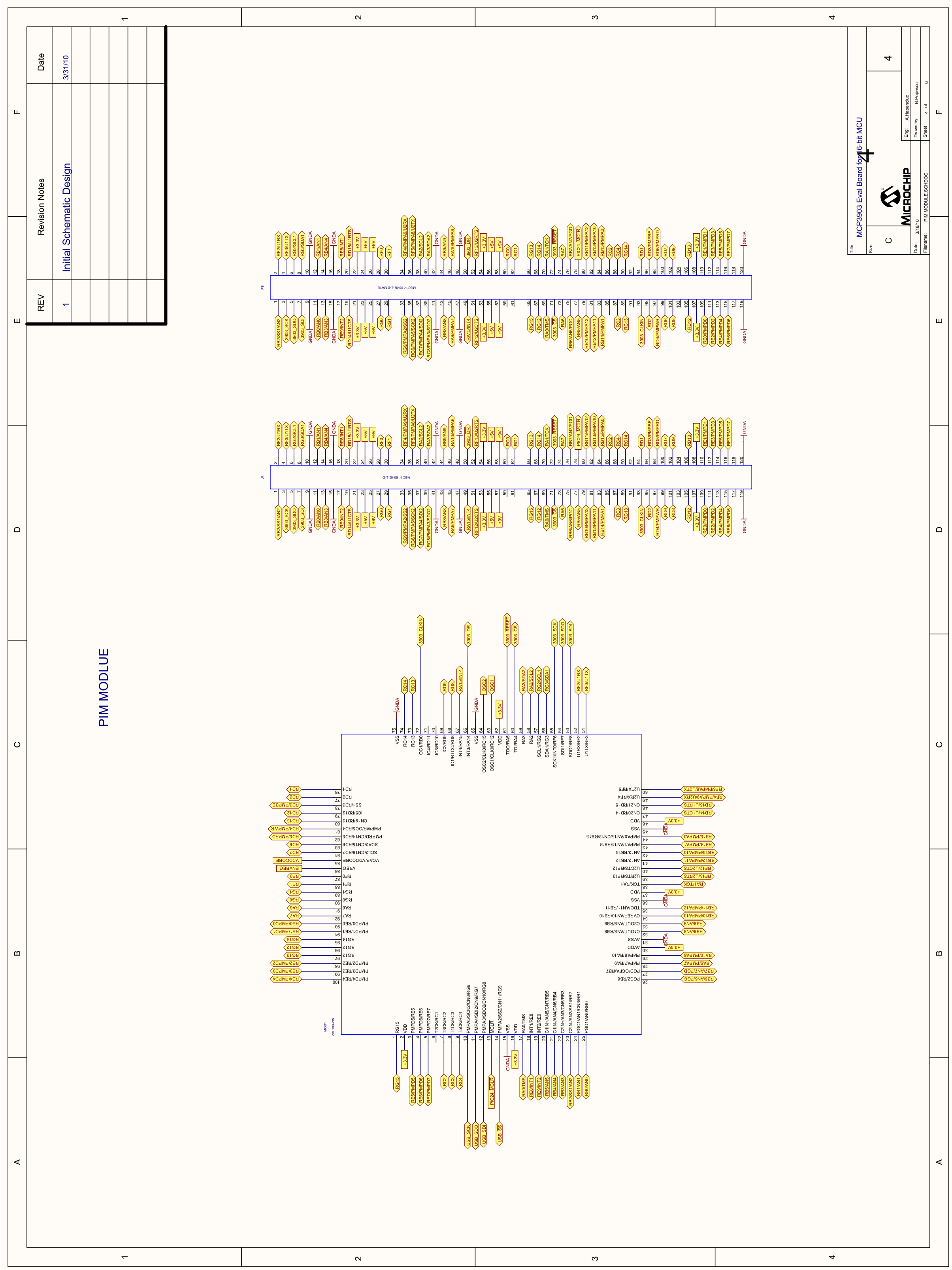
A.4 SCHEMATIC - USB AND MEMORY



A.5 SCHEMATIC - MICROCONTROLLER (MCU)



A.6 SCHEMATIC - PIM MODULE



A.7 SCHEMATIC - POWER