



MCP3914
ADC Evaluation Board
for 16-Bit MCUs
User's Guide

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EU Declaration of Conformity

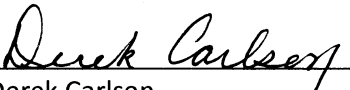
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Signed for and on behalf of Microchip Technology Inc. at Chandler, Arizona, USA


Derek Carlson
VP Development Tools

16-July-2013
Date

MCP3914 ADC Evaluation Board for 16-Bit MCUs User's Guide

NOTES:



MCP3914 ADC EVALUATION BOARD FOR 16-BIT MCUs USER'S GUIDE

Table of Contents

Preface	7
Introduction	7
Document Layout	7
Conventions Used in this Guide	8
Recommended Reading	9
The Microchip Web Site	9
Customer Support	9
Document Revision History	9
Chapter 1. Product Overview	
1.1 Overview	11
1.2 What the MCP3914 ADC Evaluation Board for 16-Bit MCUs Contains	12
Chapter 2. Hardware Description	
2.1 PIM Module/MCP3914 Connection and Peripheral Usage Overview	13
2.2 Analog Input Structure	14
2.3 Universal Serial Bus (USB)	15
Chapter 3. Firmware	
3.1 PIC24FJ256GA110 Firmware Description	17
3.2 Data Acquisition	17
3.3 UART Communication Protocol	18
Appendix A. Schematics and Layouts	
A.1 Introduction	19
A.2 Schematic – Power	20
A.3 Schematic – ADC	21
A.4 Schematic – Microcontroller (MCU)	22
A.5 Schematic – PIM Module	23
A.6 Schematic – LCD and UART	24
A.7 Board – Top Trace and Top Silk	25
A.8 Board – Bottom Trace and Bottom Silk	25
A.9 Board – Layer #2 GND	26
A.10 Board – Layer #3 VDD	26
A.11 Board – Top Silk and Pads	27
A.12 Board – Bottom Silk and Pads	27
Appendix B. Bill of Materials (BOM)	
Worldwide Sales and Service	32

MCP3914 ADC Evaluation Board for 16-Bit MCUs User's Guide

NOTES:



MCP3914 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 “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 using the MCP3914 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 MCP3914 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. “Product Overview”** – Provides important information about the MCP3914 ADC Evaluation Board for 16-Bit MCUs hardware.
- **Chapter 2. “Hardware Description”** – Provides information about the evaluation board software.
- **Chapter 3. “Firmware”** – Describes the MCP3914 ADC Evaluation Board for 16-Bit MCUs firmware.
- **Appendix A. “Schematics and Layouts”** – Shows the schematic and board layouts for the MCP3914 ADC Evaluation Board for 16-Bit MCUs.
- **Appendix B. “Bill of Materials (BOM)”** – Lists the parts used to build the MCP3914 ADC Evaluation Board for 16-Bit MCUs.

MCP3914 ADC Evaluation Board for 16-Bit MCUs User's Guide

CONVENTIONS USED IN THIS GUIDE

This manual uses the following documentation conventions:

DOCUMENTATION CONVENTIONS

Description	Represents	Examples
Arial font:		
Italic characters	Referenced books	<i>MPLAB® IDE User's Guide</i>
	Emphasized text	...is the <i>only</i> compiler...
Initial caps	A window	the Output window
	A dialog	the Settings dialog
	A menu selection	select Enable Programmer
Quotes	A field name in a window or dialog	"Save project before build"
Underlined, italic text with right angle bracket	A menu path	<u><i>File>Save</i></u>
Bold characters	A dialog button	Click OK
	A tab	Click the Power tab
N'Rnnnn	A number in verilog format, where N is the total number of digits, R is the radix and n is a digit.	4'b0010, 2'hF1
Text in angle brackets < >	A key on the keyboard	Press <Enter>, <F1>
Courier New font:		
Plain Courier New	Sample source code	<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	<code>file.o</code> , 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>

RECOMMENDED READING

This user's guide describes how to use MCP3914 ADC Evaluation Board for 16-Bit MCUs. Another useful document is listed below. The following Microchip document is available and recommended as a supplemental reference resource:

- **MCP3914 Data Sheet – “3V Eight-Channel Analog Front End” (DS20005216)**

THE MICROCHIP WEB SITE

Microchip provides online support via our web site at www.microchip.com. This web site is used as a means to make files and information easily available to customers. Accessible by using your favorite Internet browser, the web site contains the following information:

- **Product Support** – Data sheets and errata, application notes and sample programs, design resources, user's guides and hardware support documents, latest software releases and archived software
- **General Technical Support** – Frequently Asked Questions (FAQs), technical support requests, online discussion groups, Microchip consultant program member listing
- **Business of Microchip** – Product selector and ordering guides, latest Microchip press releases, listing of seminars and events, listings of Microchip sales offices, distributors and factory representatives

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- 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 (October 2013)

- Initial release of this document.

MCP3914 ADC Evaluation Board for 16-Bit MCUs User's Guide

NOTES:



MCP3914 ADC EVALUATION BOARD FOR 16-BIT MCUs USER'S GUIDE

Chapter 1. Product Overview

1.1 OVERVIEW

The MCP3914 ADC Evaluation Board for 16-Bit MCUs system provides the opportunity to evaluate the performance of the MCP3914 eight-channel AFE. It also provides a development platform for 16-bit PIC[®] device-based applications, using existing 100-pin PIC microcontroller Plug-in Module (PIM) systems that are compatible with the Explorer 16 and other high pin count PIC device-based demo boards. The system comes with a programmed PIC24FJ256GA110 PIM module that communicates with the Energy Management Utility software for data exchange and ADC setup.

The MCP3914 ADC Evaluation Board for 16-Bit MCUs uses the Energy Management Utility software for evaluation of the MCP3914 via a USB connection to the board. A download link for this software can be found on the evaluation board's web page. For instructions on the use of this software, refer to the supporting documentation included within the application install package.

1.1.1 Feature Highlights

- Eight-channel ADC MCP3914 output display using serial communication to the PC software interface.
- Simultaneous 57 ksps at OSR32 address loop ALL or 95 dB SINAD at OSR512 performance on MCP3914.
- System and ADC performance analysis through graphical PC tools showing noise histogram, frequency domain (FFT), time domain scope plot, and statistical numerical analysis.
- Robust hardware design with analog grounding and analog/digital separation, allowing low noise evaluation of the MCP3914 device; includes separate power supplies and power planes on a 4-layer board.
- PICTail[™] Plus connectors for Explorer 16 daughter board compatibility.

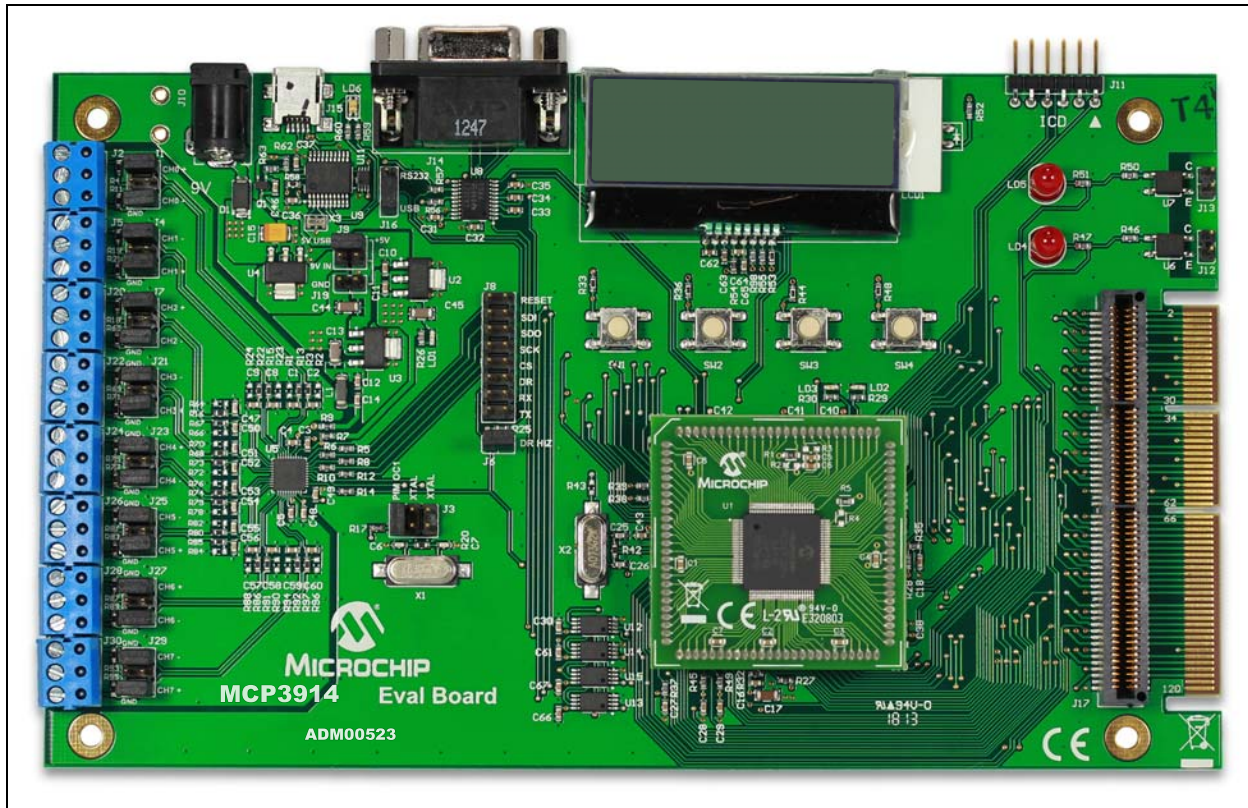


FIGURE 1-1: MCP3914 Evaluation Board.

1.2 WHAT THE MCP3914 ADC EVALUATION BOARD FOR 16-BIT MCUS CONTAINS

This MCP3914 ADC Evaluation Board for 16-Bit MCUs kit includes:

- MCP3914 ADC Evaluation Board for 16-Bit MCUs (ADM00523)
- PIC24FJ256GA110 PIM
- USB Cable
- Important Information Sheet

Chapter 2. Hardware Description

2.1 PIM MODULE/MCP3914 CONNECTION AND PERIPHERAL USAGE OVERVIEW

The MCP3914 ADC Evaluation Board for 16-Bit MCUs contains a 100-pin PIM socket compatible with Microchip's PIM modules. The system comes with one PIM module, the PIC24FJ256GA110.

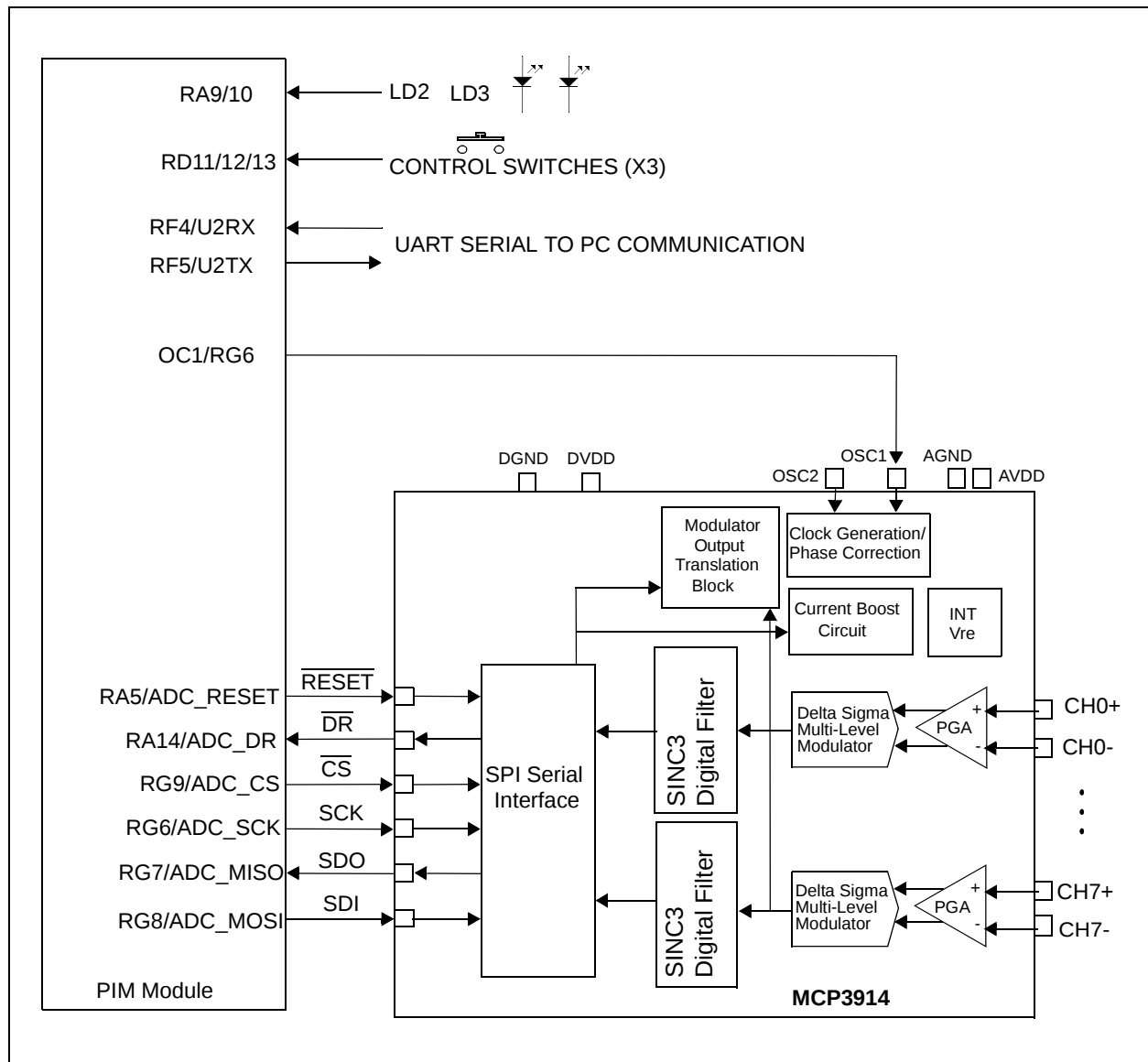


FIGURE 2-1: Digital Connection Overview PIM/MCP3914 Connections.

Ports A, D, and G are used for signals such as push buttons, output LEDs, $\overline{CS}$ and MCLR (for MCP3914 data mode setting). Output Compare 1 is used for clock generation in the MCP3914. Serial communication is achieved through the MSSP module 1.

The MCP3914 device is an AFE with eight ADCs featuring a second order modulator and a third order sinc filter, plus a first order sinc filter used for higher OSR's values. The delta-sigma A/D converters have an adjustable oversampling ratio. The CLKIN pin of the MCP3914 is the oversampling clock (MCLK) input. The MCP3914 ADC Evaluation Board for 16-Bit MCUs offers two different options for the MCP3914 master clock (MCLK). The default setting for the ADC internal clock is external clock driven by the MCU.

2.1.1 Using the Crystal X1

The MCP3914 ADC Evaluation Board for 16-Bit MCUs is populated with a 10 MHz crystal, used as a clock source, by placing jumpers in the following position on the MCP3914 Digital I/O header block:

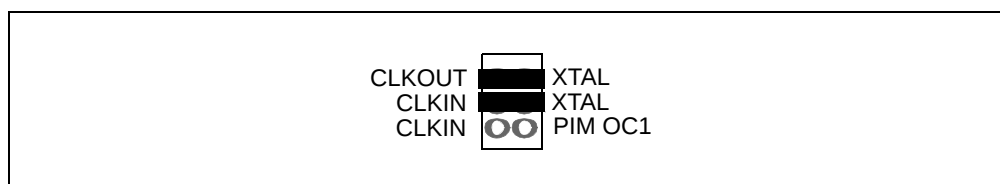


FIGURE 2-2: ADC Clock Selection Jumpers – External Crystal.

2.1.2 Driving the Clock with the PIM Module

The PIC[®] MCU can be used to generate the CLKIN (MCLK) signal for the MCP3914, setting the ADC sample rate through the use of the output compare module OC1. To use this feature, make the following jumper change to the MCP3914 Digital I/O header block:

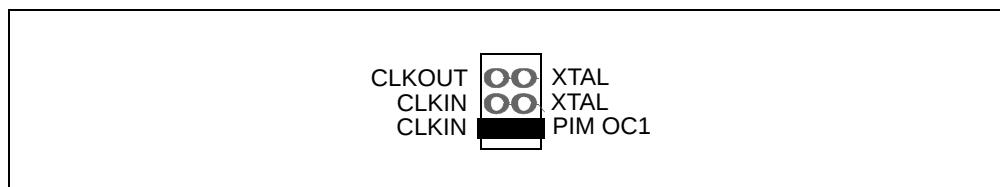


FIGURE 2-3: ADC Clock Selection Jumpers – Clock from MCU.

The frequency of the OC1 output is based on the PR1 bit settings in the firmware.

2.2 ANALOG INPUT STRUCTURE

Eight differential input paths allow external signal sources to be easily connected to the MCP3914 inputs. Screw-terminal connectors J1, J4, J7, J21, J23, J25, J27 and J29 are 3-pin connectors that act as both screw-type and clip-on post connectors.

Note: To use a screw-terminal connector as a post connector, pull up the blue plastic top to access the posts.

The connectors J1, J4, J7, J21, J23, J25, J27 and J29 can be used to force either channel from a differential to single-ended configuration. R4 and R11 (on CH0), R19 and R21 (on CH1) R18 and R65 (on CH2), R69 and R71 (on CH3), R75 and R77 (on CH4), R81 and RR83 (on CH5), R87 and R89 (on CH6) and R93 and R95 (on CH7) act as locations for burden resistor connectors for any current transformer inputs.

2.3 UNIVERSAL SERIAL BUS (USB)

The MCP3914 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 COMM port on the PC. The MCP3914 ADC Evaluation Board for 16-Bit MCUs also features a RS-232 connector, just in case it is required. The RS-232 line driver is connected to the same UART pins of the MCU. For this reason, a 3-pin jumper (J16) is present on the evaluation board to select which serial communication will be used: USB or RS-232. The following figure summarizes the connections between the ADC, MCU, USB to serial converter and the RS-232 line driver.

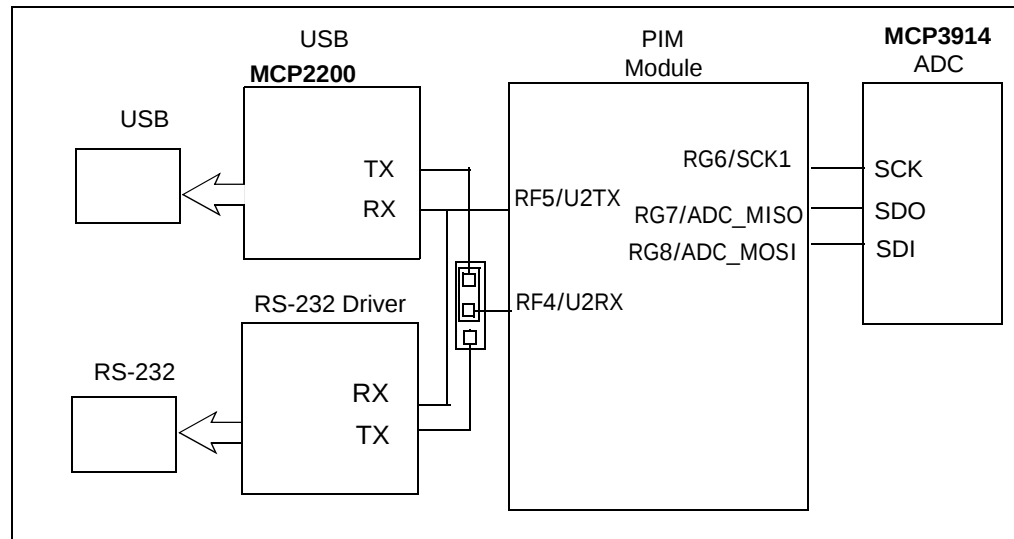


FIGURE 2-4: USB Block Diagram.

The MCP2200 is powered from the USB with 5V. The Q1 transistor (see [Appendix A.](#)) is used to disconnect the board from the PC when it is powered down to avoid power consumption. By changing the jumper J9 setting, the user can select the source of the power supply for the board to be either +5V derived from USB or an external +9V power supply.

Since the PIC24F runs at 3.3V, a level shifter was used to modify the signal level to 5V as required by the MCP2200; this is done with U11 (see [Appendix A.](#)).

The 7.3728 MHz value of the crystal is required to achieve the correct baud rate values for higher speed. This design uses a baud rate of 921.6 kbaud and for this baud rate, the register (U1BRG) value is 3 (decimal).

MCP3914 ADC Evaluation Board for 16-Bit MCUs User's Guide

NOTES:

Chapter 3. Firmware

3.1 PIC24FJ256GA110 FIRMWARE DESCRIPTION

3.1.1 MCU Initialization

The microcontroller used for the code example is the 16-bit XLP with 16 MIPS PIC24FJ256GA110. The MCU has remappable pins and output compare with a dedicated time base.

The MCU uses a 7.3278 MHz crystal for the clock and the internal PLL to increase the frequency by four times. The uncommon crystal value was chosen to obtain the correct baud rate, even for high baud rates. The remappable pins are configured to make the PIM compatible with the Explorer 16 development board. The MCP3914 is linked with the MCU through the SPI1 port. The ADC clock is given by OC1. The DR pin of the MCP3914 is tied to external Interrupt 2.

Serial data transmission is carried out through the UART2 module. For transmission, OC2 interrupt is used; for receiving, the _U1RX Interrupt is used. The UART communication speed is 921.6 kbaud. OC2 is used for the serial transmission to create short bursts of data that can be processed by the MCP2200. Sending too many characters, with no time between them at the current baud rate, will cause the MCP2200 to lose data.

Note: The PIC24FJ256GA110 must be Rev. A5 or newer, in order for this code example to work.

3.2 DATA ACQUISITION

External Interrupt 2 is used for detecting the end of conversion on the MCP3914. In the INT2 Interrupt, the data samples are read from the ADC using SPI.

When a new buffer begins to be read, Timer4 is started. This is set as a 32-bit timer together with Timer5. It will be stopped when the buffer is full and it is used to measure the sampling speed.

Before reading the data samples, the MCU investigates the address loop setting (READ <1:0> bits) in the STATUSCOM register and adjusts the read sequence accordingly (when the address is not incremented automatically in hardware, the MCU has to do that in firmware, leading to a longer read sequence). The acquired samples are written in six long vectors created in the RAM of the MCU. The six vectors hold the first, second and third byte from both channels.

The vectors have a length of 2048. The value of Timer 4, and the values of the other registers inside the ADC, are stored in a vector called "internal_registers[26]".

3.3 UART COMMUNICATION PROTOCOL

The serial connection is used to send the acquired data to the PC at a speed of 921.6 kbaud, and the MCP2200 is used for the UART-to-USB conversion.

The communication uses handshaking, meaning that the board will not send data to the PC unless the board receives a command from the PC.

The UART transmission is triggered by the output compare module OC2. This allows the data to be transmitted to the PC in short bursts that are separated by a dead time. This way of sending data allows the MCP2200 to handle the high throughput. If the entire amount of data is sent continuously to the PC at the current baud rate, the MCP2200 will not be able to process the data for correct USB transfer.

After a complete transmission, the UART RX interrupt is enabled by increasing its priority, while all other interrupts have lower priorities. In this interrupt, the MCU needs to receive the values of the internal registers as the user is setting them in the PC GUI.



MCP3914 ADC EVALUATION BOARD FOR 16-BIT MCUs USER'S GUIDE

Appendix A. Schematics and Layouts

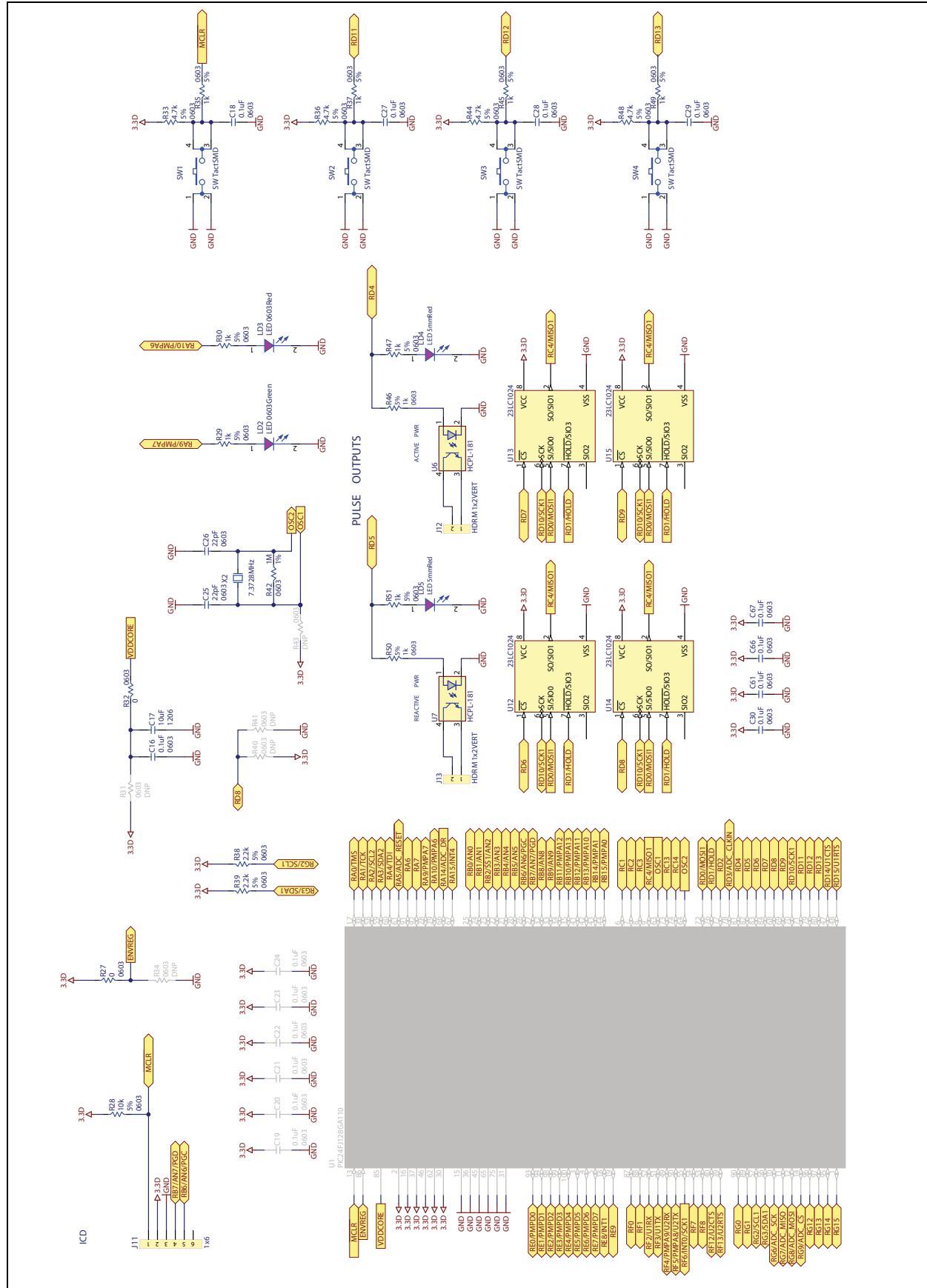
A.1 INTRODUCTION

This appendix contains the following schematics of the MCP3914 ADC Evaluation Board for 16-Bit MCUs:

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

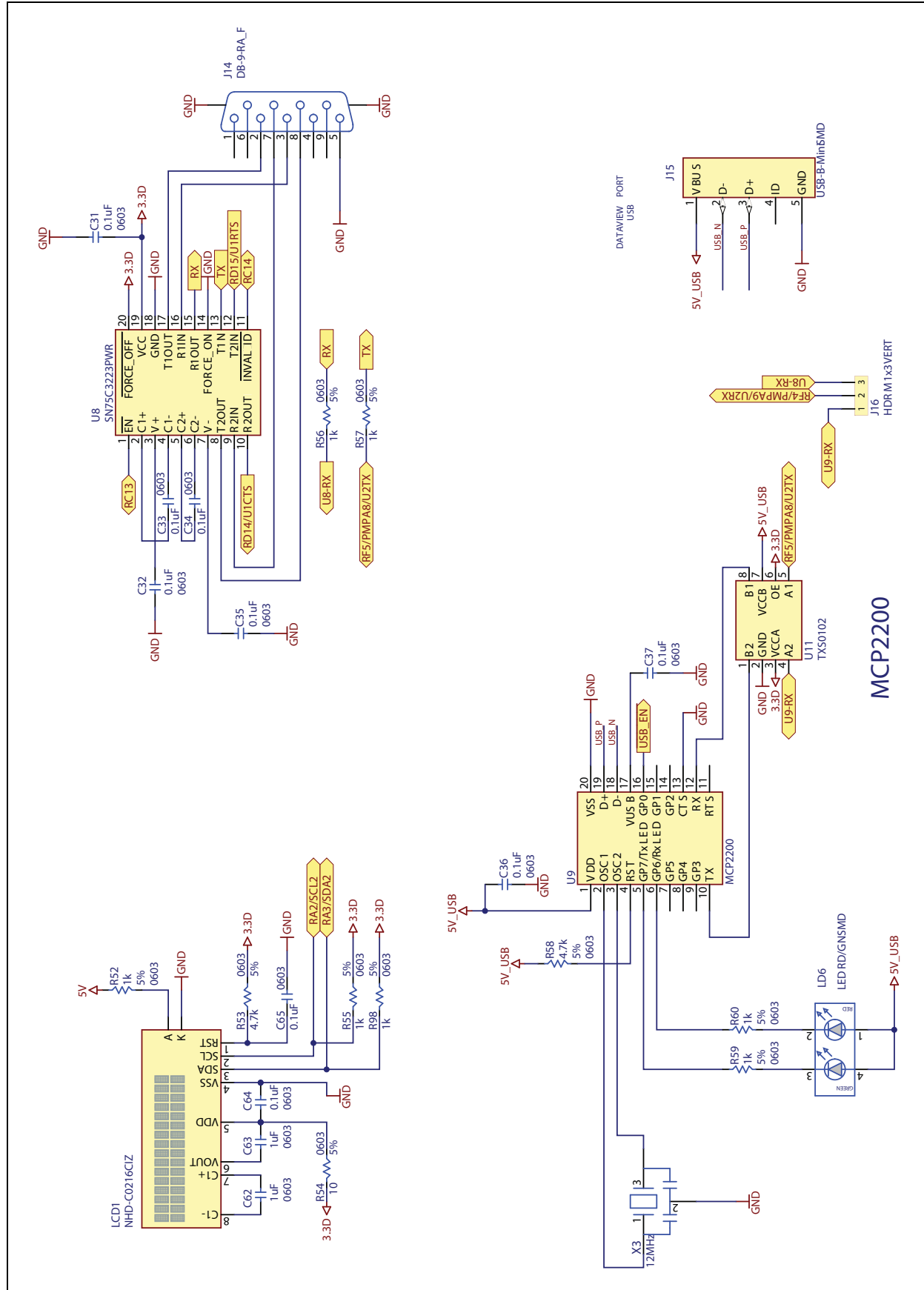
MCP3914 ADC Evaluation Board for 16-Bit MCUs User's Guide

A.4 SCHEMATIC – MICROCONTROLLER (MCU)

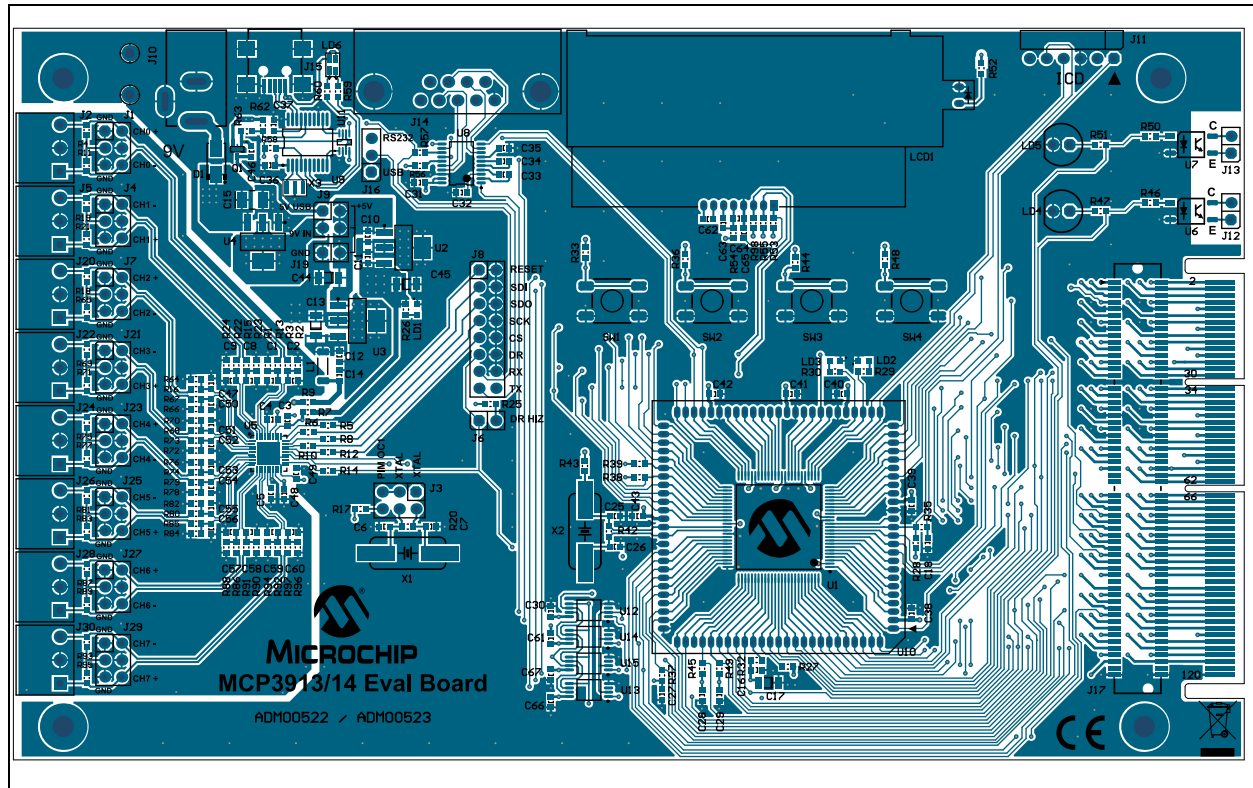


MCP3914 ADC Evaluation Board for 16-Bit MCUs User's Guide

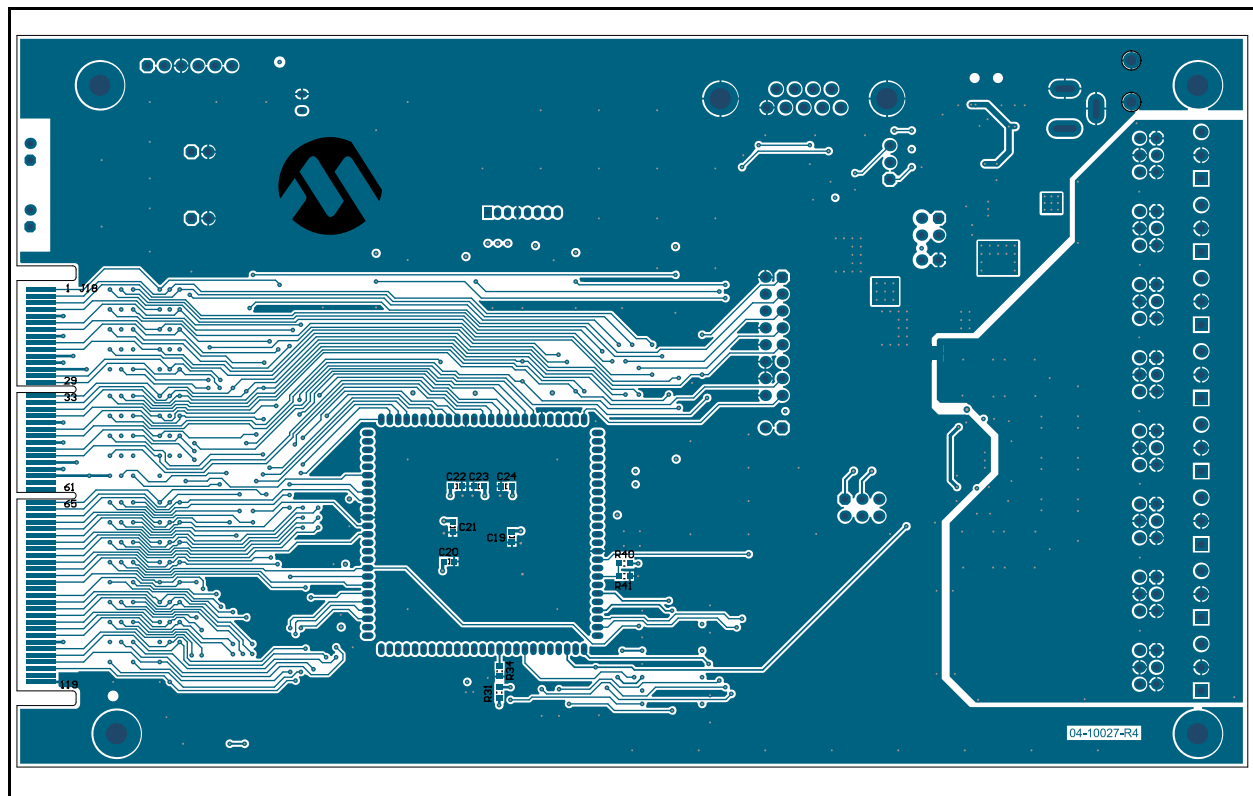
A.6 SCHEMATIC – LCD AND UART



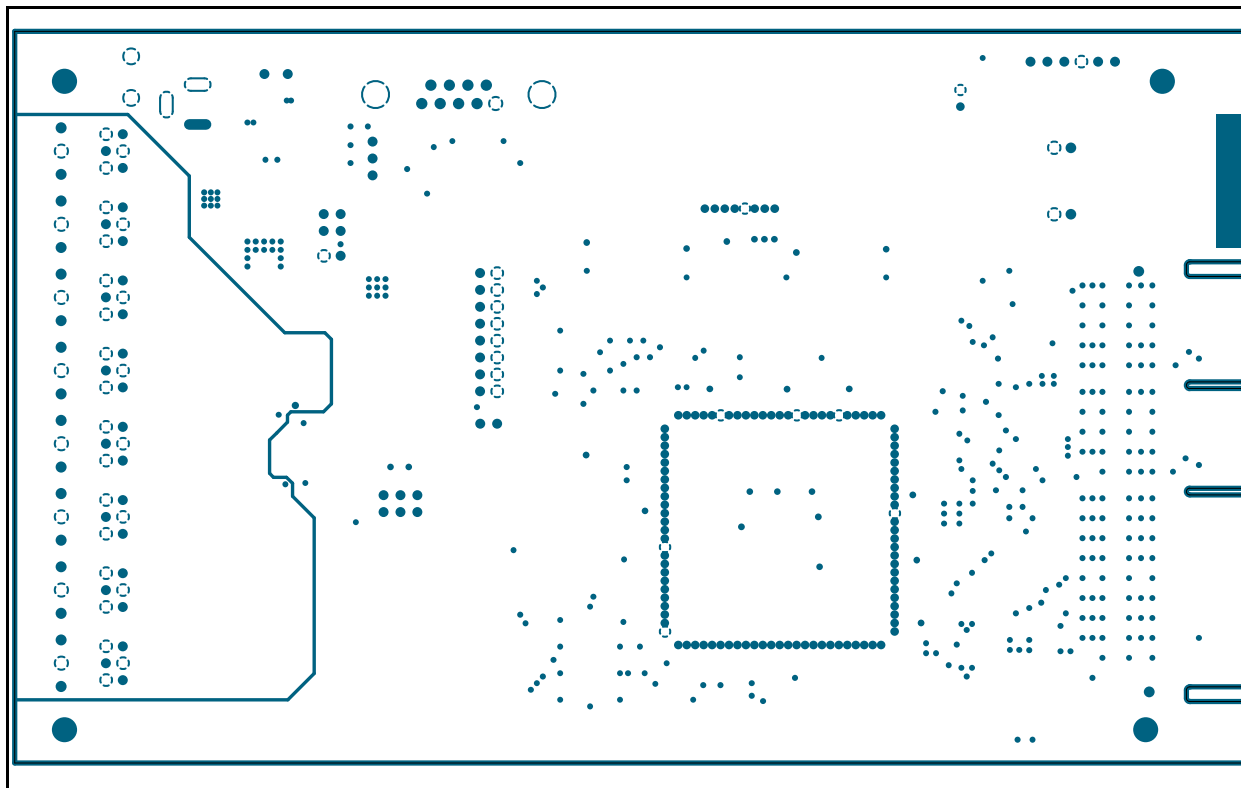
A.7 BOARD – TOP TRACE AND TOP SILK



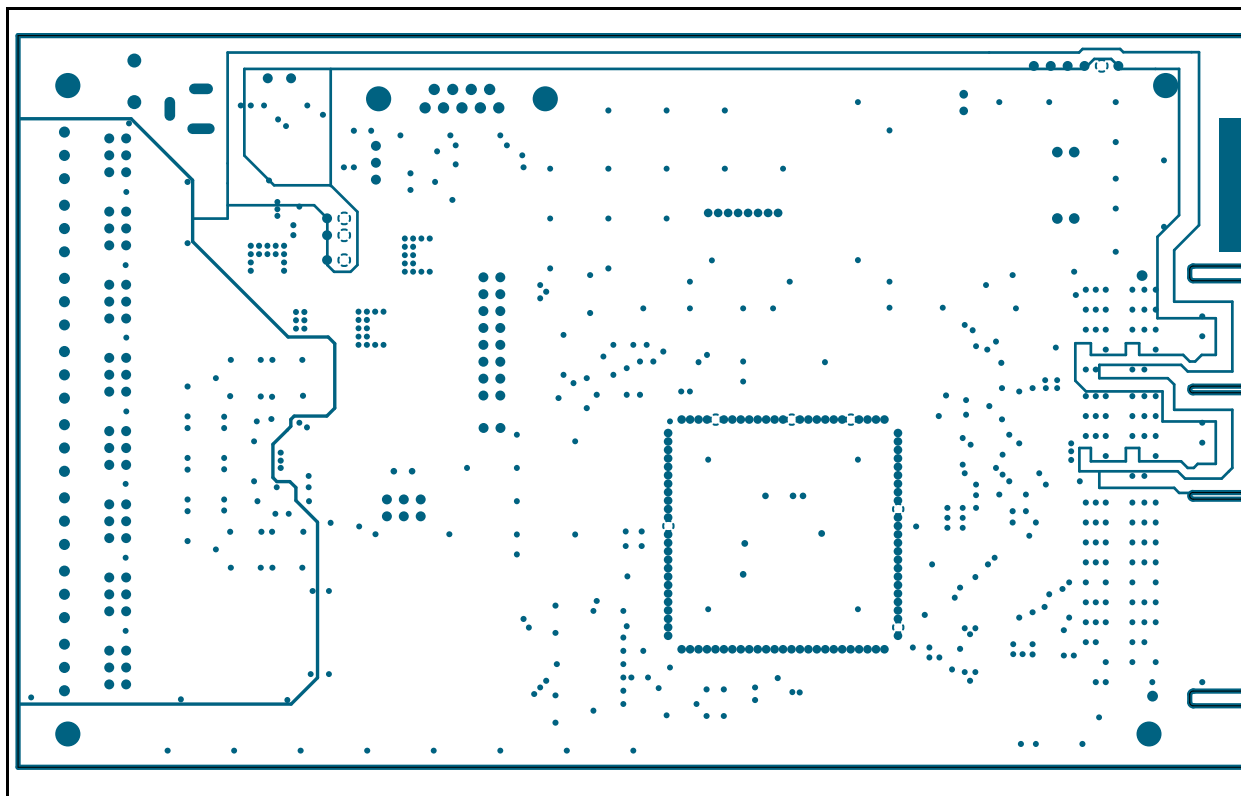
A.8 BOARD – BOTTOM TRACE AND BOTTOM SILK



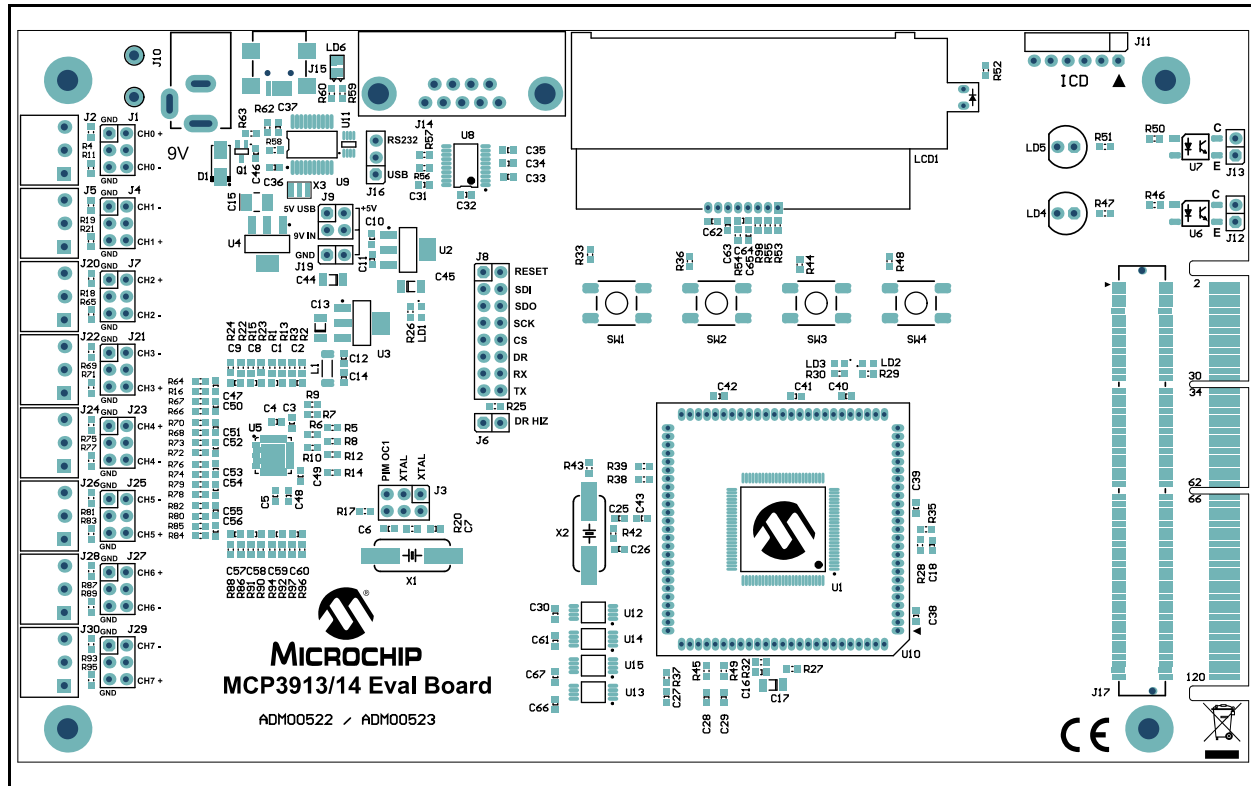
A.9 BOARD – LAYER #2 GND



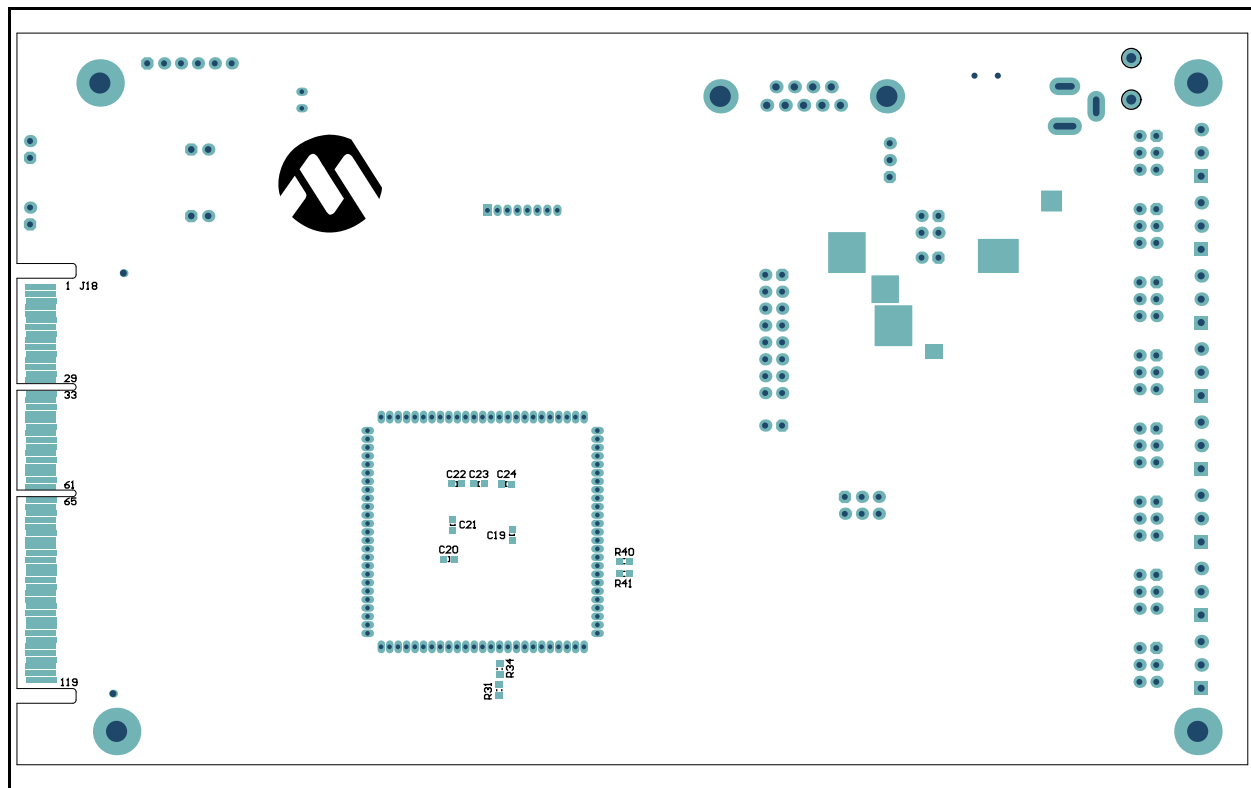
A.10 BOARD – LAYER #3 VDD



A.11 BOARD – TOP SILK AND PADS



A.12 BOARD – BOTTOM SILK AND PADS



MCP3914 ADC Evaluation Board for 16-Bit MCUs User's Guide

NOTES:

Appendix B. Bill of Materials (BOM)

TABLE B-1: BILL OF MATERIALS (BOM)

Qty	Reference	Description	Manufacturer	Part Number
50	C1, C2, C3, C4, C5, C8, C9, C10, C11, C12, C14, C16, C18, C27, C28, C29, C30, C31, C32, C33, C34, C35, C36, C37, C38, C39, C40, C41, C42, C43, C46, C47, C48, C49, C50, C51, C52, C53, C54, C55, C56, C57, C58, C59, C60, C61, C64, C65, C66, C67	Cap. ceramic 0.1uF 16V 10% X7R 0603	TDK Corporation	C1608X7R1C104K
3	C13, C44, C45	Cap. ceramic 10uF 10V 20% X7R SMD 1206	TDK Corporation	C3216X7R1A106M
1	C15	Cap. Tant. 10uF 20V 10% 2.1 Ohm Size B	AVX Corporation	TAJB106K020RNJ
1	C17	Cap. ceramic 10uF 10V X7R 20% 1206	TDK Corporation	C3216X7R1A106M
0	C19, C20, C21, C22, C23, C24	DO NOT POPULATE – Cap. ceramic 0.1uF 16V 10% X7R 0603	TDK Corporation	C1608X7R1C104K
2	C25, C26	Cap. ceramic 22pF 50V 5% C0G 0603	TDK Corporation	C1608C0G1H220J
2	C6, C7	Cap. ceramic 15pF 50V 5% NP0 SMD 0603	Yageo Corporation	CC0603JRNPO9BN150
2	C62, C63	Cap. ceramic 1uF 10V X7R 20% 0603	TDK Corporation	C1608X7R1A105M
1	D1	Diode std. rec. 1A 600V SMA	ON Semiconductor	MRA4005T3G
9	J1, J3, J4, J7, J21, J23, J25, J27, J29	Conn. header male 100 2x3 POS VERT	FCI	67996-206HLF
1	J10	Conn. power jack male 2.5 MM CLSD	CUI Inc.	PJ-002B
1	J11	Conn. header-2.54 male 1x6 TH R/A	FCI	68016-106HLF
1	J14	Conn. D-sub Rcpt. R/A 9 POS 15 GOLD	TE Connectivity	1734354-2
1	J15	Conn. Recept. mini SMD R/A 5 POS	Hirose Electric Co., Ltd.	UX60-MB-5ST
1	J16	Conn. header male 100 1x3 POS vert.	FCI	68000-103HLF
1	J17	Mini edge card socket 1 mm pitch vertical	Samtec, Inc.	MEC1-160-02-L-D-A
8	J2, J5, J20, J22, J24, J26, J28, J30	Conn. terminal blk. plug 6A 3.5MM 3 POS (mates with 8724 HDR-24 pin)	Keystone Electronics Corp.	8723

Note 1: The components listed in this Bill of Materials are representative of the PCB assembly. The released BOM used in manufacturing uses all RoHS-compliant components.

MCP3914 ADC Evaluation Board for 16-Bit MCUs User's Guide

TABLE B-1: BILL OF MATERIALS (BOM) (CONTINUED)

Qty	Reference	Description	Manufacturer	Part Number
4	J6, J12, J13, J19	Conn. HDR Male .100 1x2POS Vert.	FCI	77311-118-02LF
1	J8	Conn. HDR Male .100 2x8 Pos Vert.	FCI	68602-116HLF
1	J9	Conn. HDR Male .100 2x2 Pos Vert.	FCI	68602-204HLF
1	L1	Ferrite 300 MA 500 m Ohm 1806 SMD	Laird Technologies®	LI1806C151R-10
1	LCD1	LCD cog. char. 2X16 TRANSFL	Shenzhen Multisight Display Co., Ltd.	NHD-C0216-CIZ-FSW-FBW-3V3
2	LD1, LD2	LED SMARTLED green 570 nm 0603	OSRAM Opto Semiconductors GmbH.	LG L29K-G2J1-24-Z
1	LD3	LED SMARTLED red 630 nm 0603	OSRAM Opto Semiconductors GmbH.	LS L29K-G1J2-1-0-2-R18-Z
2	LD4, LD5	LED 5 mm red 640nm 20 mcd 2 mA	Kingbright Corp.	WP7113LSRD
1	LD6	LED 2X1.2 mm rd/gn wtr. clr. SMD	Kingbright Corp.	APHBM2012SURKCGKC
5	PAD1	Mech. HW rubber pad Bumpon Hemisphere 0.44" x 0.20" Black	3M	SJ-5003 (BLACK)
1	Q1	MOSFET P 12V 850 mA 290 mW SC-70-3	Vishay Siliconix	SI1307EDL-T1-GE3
0	R1, R2, R23, R24, R64, R66, R70, R72, R76, R78, R82, R84, R88, R90, R94, R96	DO NOT POPULATE – Res. TKF 1k 1% 1/10W SMD 0603	Panasonic	ERJ-3EKF1001V
2	R20, R42	Res. 1M Ohm 1/10W 1% 0603 SMD	Panasonic – ECG	ERJ-3EKF1004V
20	R25, R26, R29, R30, R35, R37, R45, R46, R47, R49, R50, R51, R52, R55, R56, R57, R59, R60, R63, R98	Res. 1k Ohm 1/10W 5% 0603 SMD	Panasonic – ECG	ERJ-3GEYJ102V
2	R27, R32	Res. 0 Ohm 1/10W 0603 SMD	Panasonic – ECG	ERJ-3GEY0R00V
2	R28, R62	Res. 10k Ohm 1/10W 5% 0603 SMD	Panasonic – ECG	ERJ-3GEYJ103V
32	R3, R4, R11, R13, R15, R16, R18, R19, R21, R22, R65, R67, R68, R69, R71, R73, R74, R75, R77, R79, R80, R81, R83, R85, R86, R87, R89, R91, R92, R93, R95, R97	Res. TKF 1k 1% 1/10W SMD 0603	Panasonic	ERJ-3EKF1001V
0	R31, R34	DO NOT POPULATE – Res. 10 Ohm 1/10W 5% 0603 SMD	Panasonic – ECG	ERJ-3GEYJ100V

Note 1: The components listed in this Bill of Materials are representative of the PCB assembly. The released BOM used in manufacturing uses all RoHS-compliant components.

Bill of Materials (BOM)

TABLE B-1: BILL OF MATERIALS (BOM) (CONTINUED)

Qty	Reference	Description	Manufacturer	Part Number
6	R33, R36, R44, R48, R53, R58	Res. 4.7k Ohm 1/10W 5% 0603 SMD	Panasonic – ECG	ERJ-3GEYJ472V
2	R38, R39	Res. 2.2k Ohm 1/10W 5% 0603 SMD	Panasonic – ECG	ERJ-3GEYJ222V
0	R40, R41	DO NOT POPULATE – Res. 1k Ohm 1/10W 5% 0603 SMD	Panasonic – ECG	ERJ-3GEYJ102V
0	R43	DO NOT POPULATE – Res. 1M Ohm 1/10W 1% 0603 SMD	Panasonic – ECG	ERJ-3EKF1004V
1	R5	Res. 100 Ohm 1/10W 5% 0603 SMD	Panasonic – ECG	ERJ-3GEYJ101V
9	R6, R7, R8, R9, R10, R12, R14, R17, R54	Res. 10 Ohm 1/10W 5% 0603 SMD	Panasonic – ECG	ERJ-3GEYJ100V
4	SW1, SW2, SW3, SW4	Switch tact. 6 MM 160GF H=4.3 MM	Omron Electronics LLC - EMC Division	B3S-1000P
0	U1	DO NOT POPULATE – PIC24FJXXX-GA110	Microchip Technology Inc.	PIC24FJ256GA110
1	U10	Four 25 X 1 Header 1.27 mm pitch (100 pin socket)	Samtec, Inc.	MTMS-125-01-G-S-230
1	U11	IC volt-level translator US-8	Texas Instruments	TXS0102DCUR
4	U12, U13, U14, U15	IC SRAM SPI 1024K 2.5V TSSOP-8	Microchip Technology Inc.	23LC1024-I/ST
1	U2	IC LDO reg. 500 MA 3.3V SOT-223-3	Microchip Technology Inc.	MCP1825S-3302E/DB
1	U3	IC reg. LDO 150 mA 3.3V SOT-223-3	Microchip Technology Inc.	MCP1754ST-3302E/DB
1	U4	IC reg. LDO 800 MA 5V SOT-223	National Semiconductor	LM1117MPX-5.0/NOPB
1	U5	IC 8-Ch AFE QFN-40	Microchip Technology Inc.	MCP3914
2	U6, U7	Photocoupler trans. out 4-minipak	Avago Technologies	HCPL-181-00CE
1	U8	IC line drvrr/rcvr RS-232 20-TSSOP	Texas Instruments	SN75C3223PWR
1	U9	IC USB to UART SSOP-20	Microchip Technology Inc.	MCP2200-I/SS
1	X1	Crystal 10 MHz 18 pF HC49-SMD-B	Abracon® Corporation	ABLS-10.000MHZ-B4-T
1	X2	Crystal 7.3728 MHz 18 pF HC49-SMD-B	Abracon Corporation	ABLS-7.3728MHZ-B4-T
1	X3	Resonator 12 MHz 0.1% SMD CSTCE-G	Murata	CSTCE12M0G15L99-R0

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