MCP3919
ADC Evaluation Board for 16-Bit MCUs User's Guide

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Object of Declaration: MCP3919 ADC Evaluation Board for 16-Bit MCUs

EU Declaration of Conformity

Manufacturer: Microchip Technology Inc.
2355 W. Chandler Blvd.
Chandler, Arizona, 85224-6199
USA

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Derek Carlson
VP Development Tools

12-Sep-14
Date

MCP3919 ADC EVALUATION BOARD FOR 16-BIT MCUs USER'S GUIDE

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MCP3919 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 "DSXXXXXXXXA", where "XXXXXXXX" 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 MCP3919 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 MCP3919 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 MCP3919 ADC Evaluation Board for 16-Bit MCUs hardware.
- **Chapter 2. "Hardware Description"** – Provides information about the evaluation board software.
- **Chapter 3. "Firmware"** – Describes the MCP3919 ADC Evaluation Board for 16-Bit MCUs firmware.
- **Appendix A. "Schematics and Layouts"**– Shows the schematic and board layouts for the MCP3919 ADC Evaluation Board for 16-Bit MCUs.
- **Appendix B. "Bill of Materials (BOM)"** – Lists the parts used to build the MCP3919 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	*File>Save*
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) { ... }

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RECOMMENDED READING

This user's guide describes how to use MCP3919 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:

- **MCP3919 Data Sheet –** ***"3V Three-Channel Analog Front End"*** **(DS20005347A)**

THE MICROCHIP WEB SITE

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Technical support is available through the web site at: http://support.microchip.com.

DOCUMENT REVISION HISTORY

Revision A (September 2014)

- Initial release of this document.

Chapter 1. Product Overview

1.1 OVERVIEW

The MCP3919 ADC Evaluation Board for 16-Bit MCUs system provides the opportunity to evaluate the performance of the MCP3919 three-channel Analog Front End (AFE). It also provides a development platform for 16-bit microcontroller-based applications, using the existing 100-pin PIC® microcontroller Plug-in Module (PIM) systems that are compatible with the Explorer 16 Evaluation Board (DM240001) 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 MCP3919 ADC Evaluation Board for 16-Bit MCUs uses the Energy Management Utility software for evaluation of the MCP3919 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

- Three-channel ADC MCP3919 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 MCP3919.
- 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 MCP3919 device; includes separate power supplies and power planes on a four-layer board.
- PICtail™ Plus connectors for Explorer 16 daughter board compatibility.

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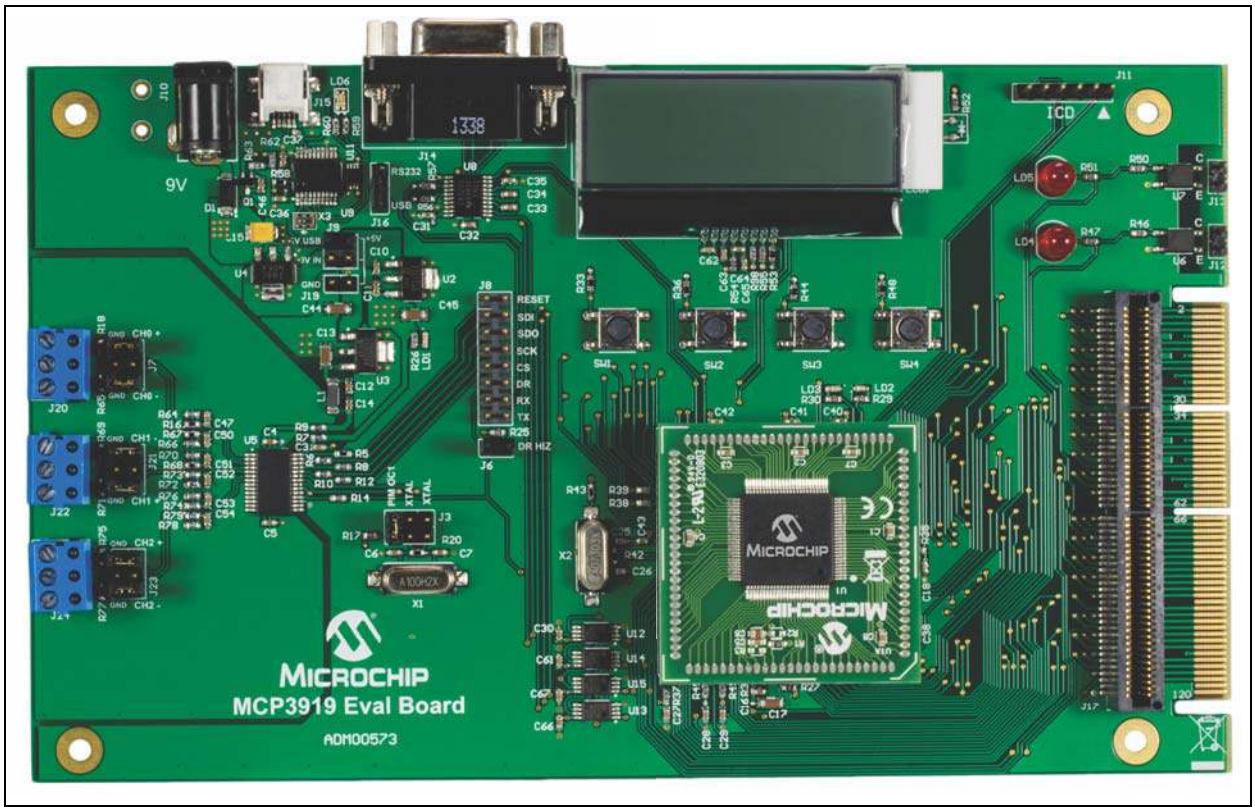

FIGURE 1-1: *MCP3919 Evaluation Board.*

1.2 WHAT THE MCP3919 ADC EVALUATION BOARD FOR 16-BIT MCUS CONTAINS

This MCP3919 ADC Evaluation Board for 16-Bit MCUs kit includes:

- MCP3919 ADC Evaluation Board for 16-Bit MCUs (Part number ADM00573)
- PIC24FJ256GA110 PIM
- USB Cable
- Important Information Sheet

Chapter 2. Hardware Description

2.1 PIM MODULE/MCP3919 CONNECTION AND PERIPHERAL USAGE OVERVIEW

The MCP3919 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.

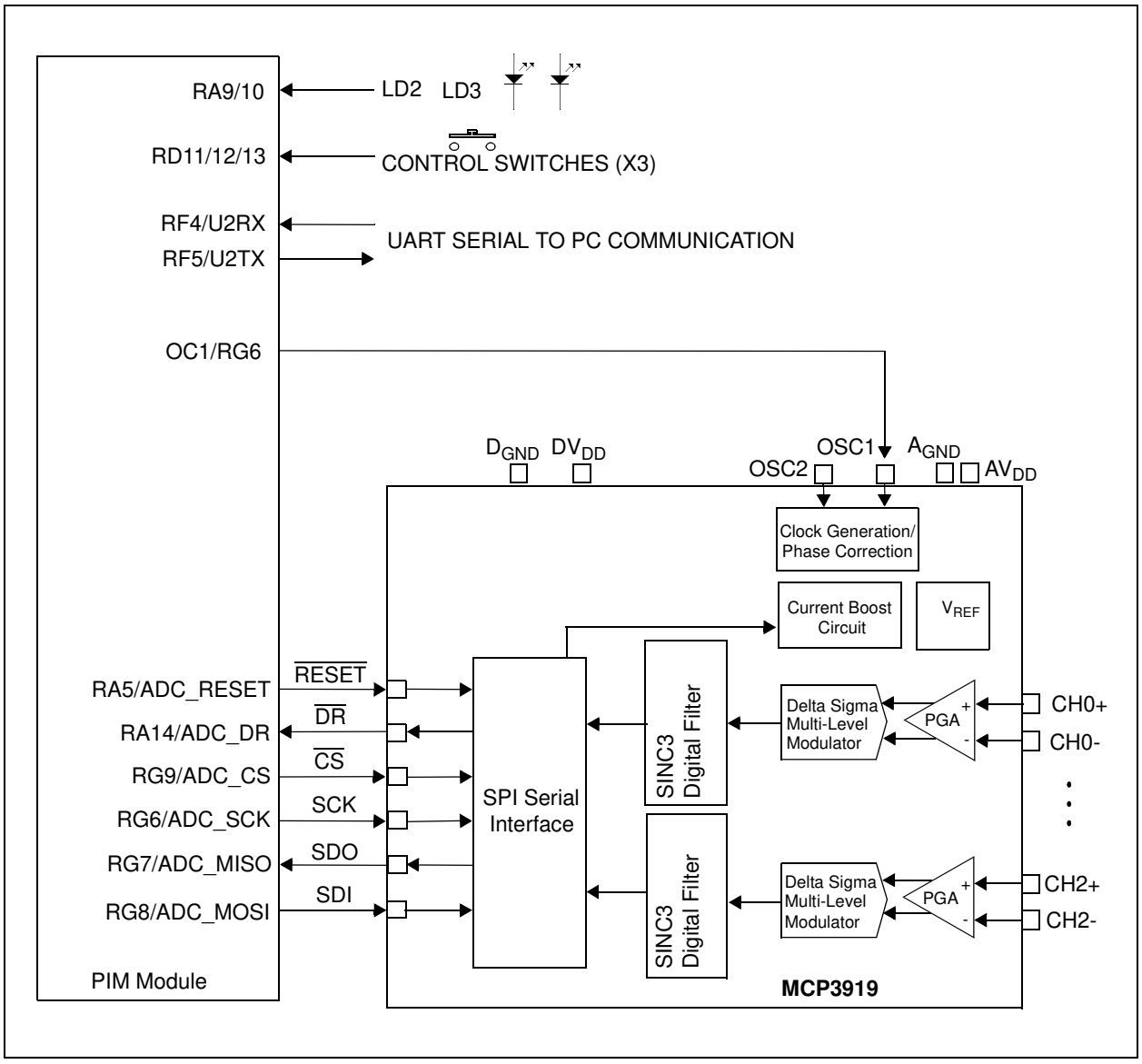

FIGURE 2-1: *Digital Connection Overview PIM/MCP3919 Connections.*

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Ports A, D and G are used for signals such as push buttons, output LEDs, $\overline{CS}$ and $\overline{MCLR}$ (for the MCP3919 data mode setting). Output Compare 1 is used for clock generation in the MCP3919. Serial communication is achieved through the MSSP module 1.

The MCP3919 device is an Analog Front End (AFE) with three ADCs featuring a second order modulator and a third order sinc filter, plus a first order sinc filter used for higher OSR values. The delta-sigma A/D converters have an adjustable oversampling ratio. The CLKIN pin of the MCP3919 is the oversampling clock (MCLK) input. The MCP3919 ADC Evaluation Board for 16-Bit MCUs offers two different options for the MCP3919 master clock (MCLK). The default setting for the ADC internal clock is an external clock driven by the MCU.

2.1.1 Using the Crystal X1

The MCP3919 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 MCP3919 Digital I/O header block:

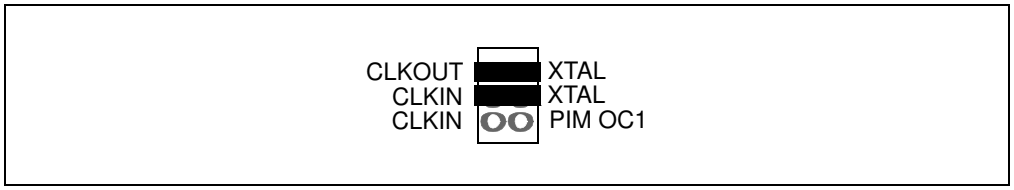

FIGURE 2-2: *ADC Clock Selection Jumpers – External Crystal.*

2.1.2 Driving the Clock with the PIM Module

The PIC MCU can be used to generate the CLKIN (MCLK) signal for the MCP3919, 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 MCP3919 Digital I/O header block:

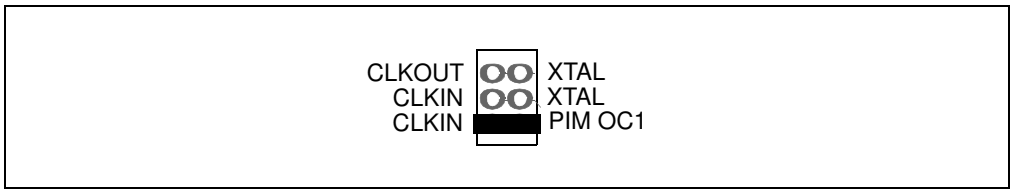

FIGURE 2-3: *ADC Clock Selection Jumpers – Clock from MCU.*

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

2.2 ANALOG INPUT STRUCTURE

Three differential input paths allow external signal sources to be easily connected to the MCP3919 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 and J25 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) and R81 and RR83 (on CH5) act as locations for burden resistor connectors for any current transformer inputs.

2.3 UNIVERSAL SERIAL BUS (USB)

The MCP3919 ADC Evaluation Board for 16-Bit MCUs also contains a USB connection for connecting the evaluation board to a PC. There is an MCP2200 USB to UART converter on the board which creates a virtual COMM port on the PC. The MCP3919 ADC Evaluation Board for 16-Bit MCUs also features an 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.

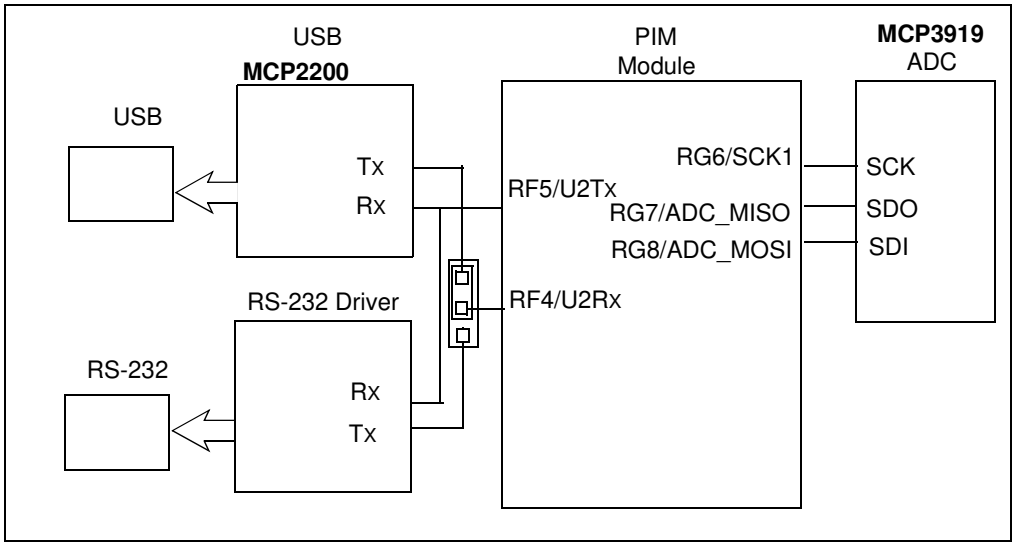

FIGURE 2-4: *USB Block Diagram.*

The MCP2200 is powered from the USB with 5V. The Q1 transistor (see **Appendix A. "Schematics and Layouts"**) 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 the 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. "Schematics and Layouts"**).

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).

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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 MCP3919 is linked with the MCU through the SPI1 port. The ADC clock is given by OC1. The $\overline{DR}$ pin of the MCP3919 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 MCP3919. In the INT2 Interrupt, the data samples are read from the ADC using SPI.

When a new buffer begins to be read, Timer 4 is started. This is set as a 32-bit timer together with Timer 5. It will be stopped when the buffer is full and is used to measure the sampling speed.

Before reading the date 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 three long vectors created in the RAM of the MCU. The three 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 method 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 relative to all other interrupts. In this interrupt, the MCU needs to receive the values of the internal registers as the user is setting them in the PC GUI.

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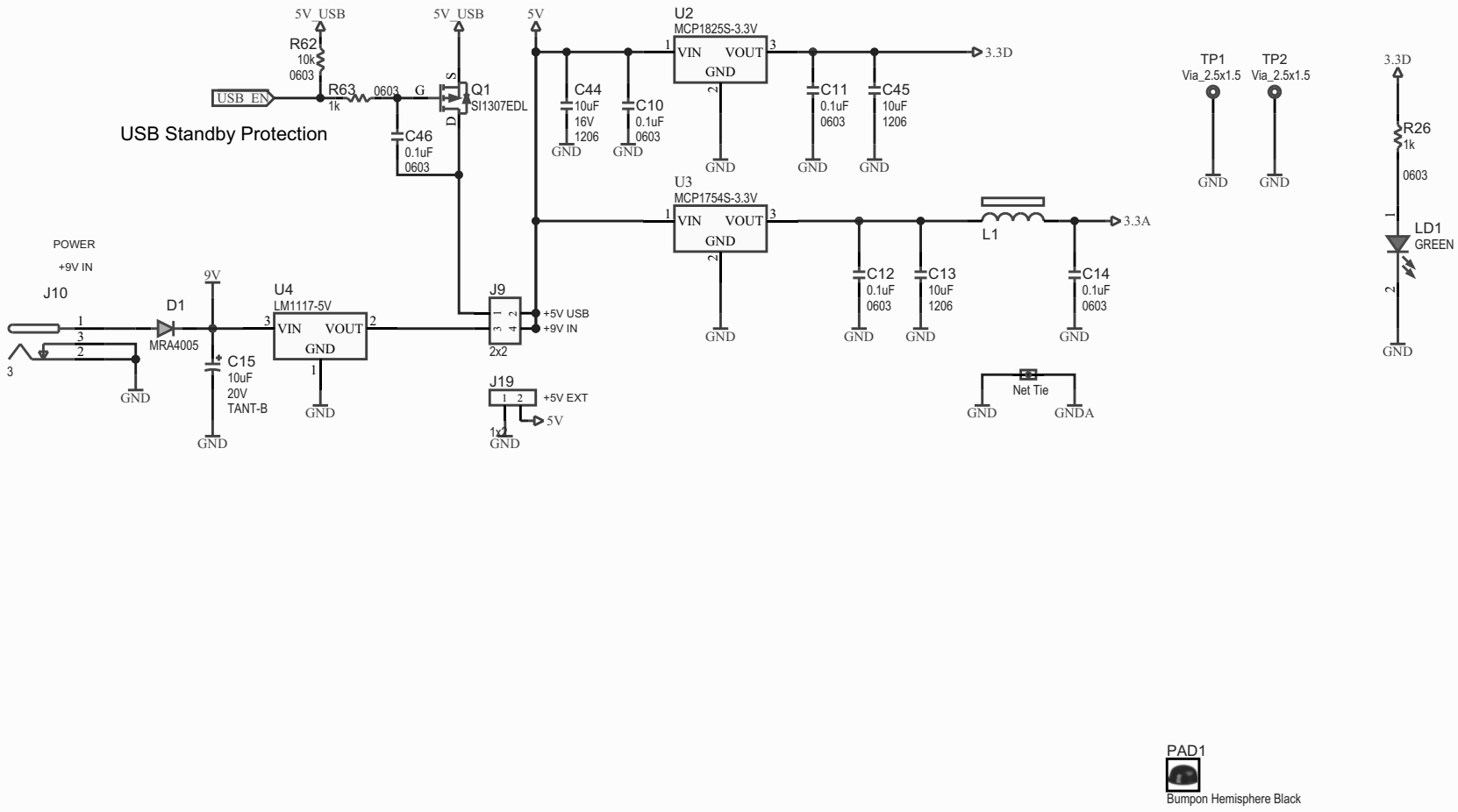
Appendix A. Schematics and Layouts

A.1 INTRODUCTION

This appendix contains the following schematics of the MCP3919 ADC Evaluation Board for 16-Bit MCUs:

- Board – Power Schematic
- Board – ADC Schematic
- Board – Microcontroller (MCU) Schematic
- Board – PIM Module Schematic
- Board – Top Silk
- Board – Top Copper and Silk
- Board – Top Copper
- Board – Internal Plane 1 and Assembly Top
- Board – Internal Plane 2 and Assembly Top
- Board – Bottom Copper
- Board – Bottom Copper and SILK
- Board – Bottom Silk

A.2 BOARD – POWER SCHEMATIC



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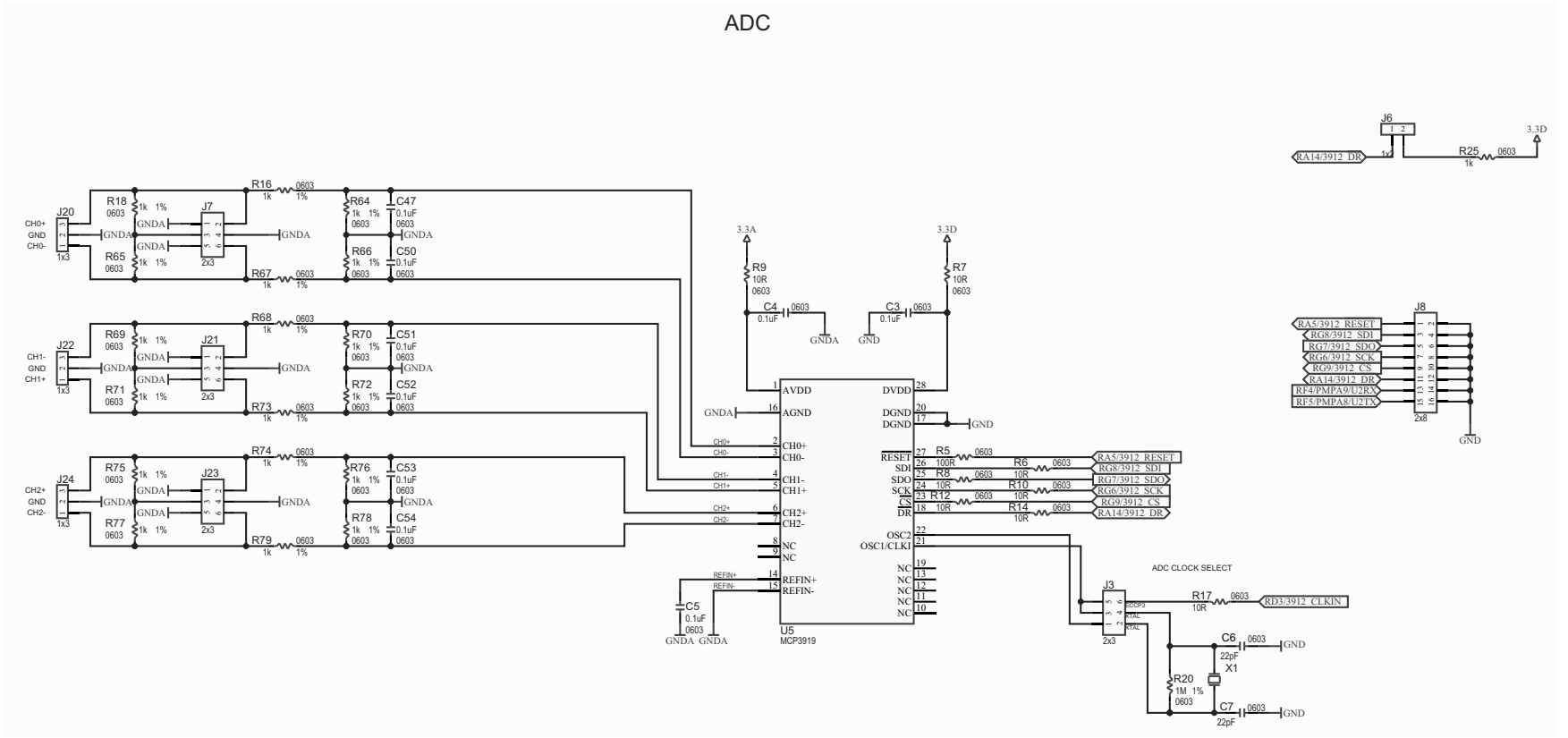
A.3 BOARD – ADC SCHEMATIC



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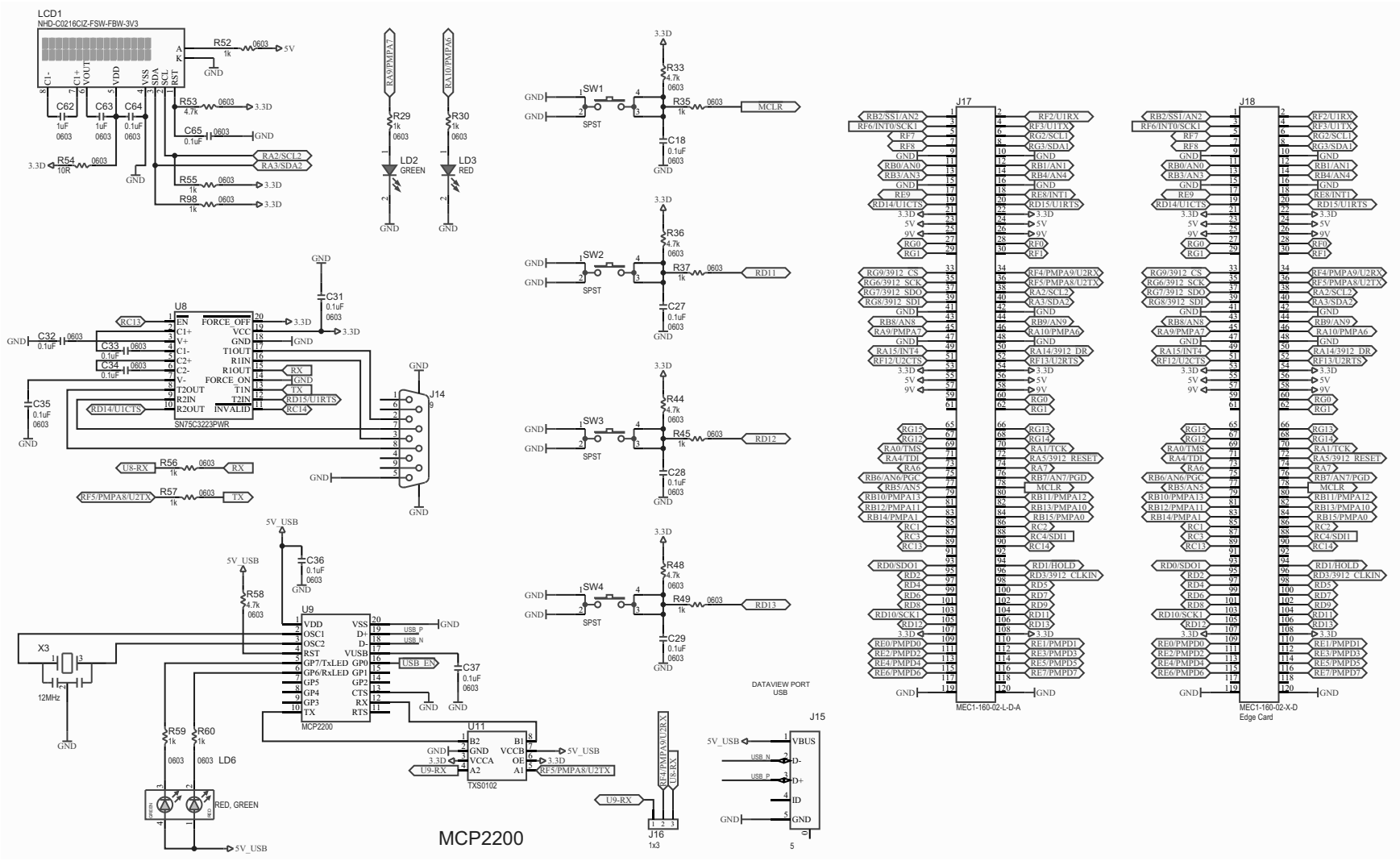
A.4 BOARD – MICROCONTROLLER (MCU) SCHEMATIC



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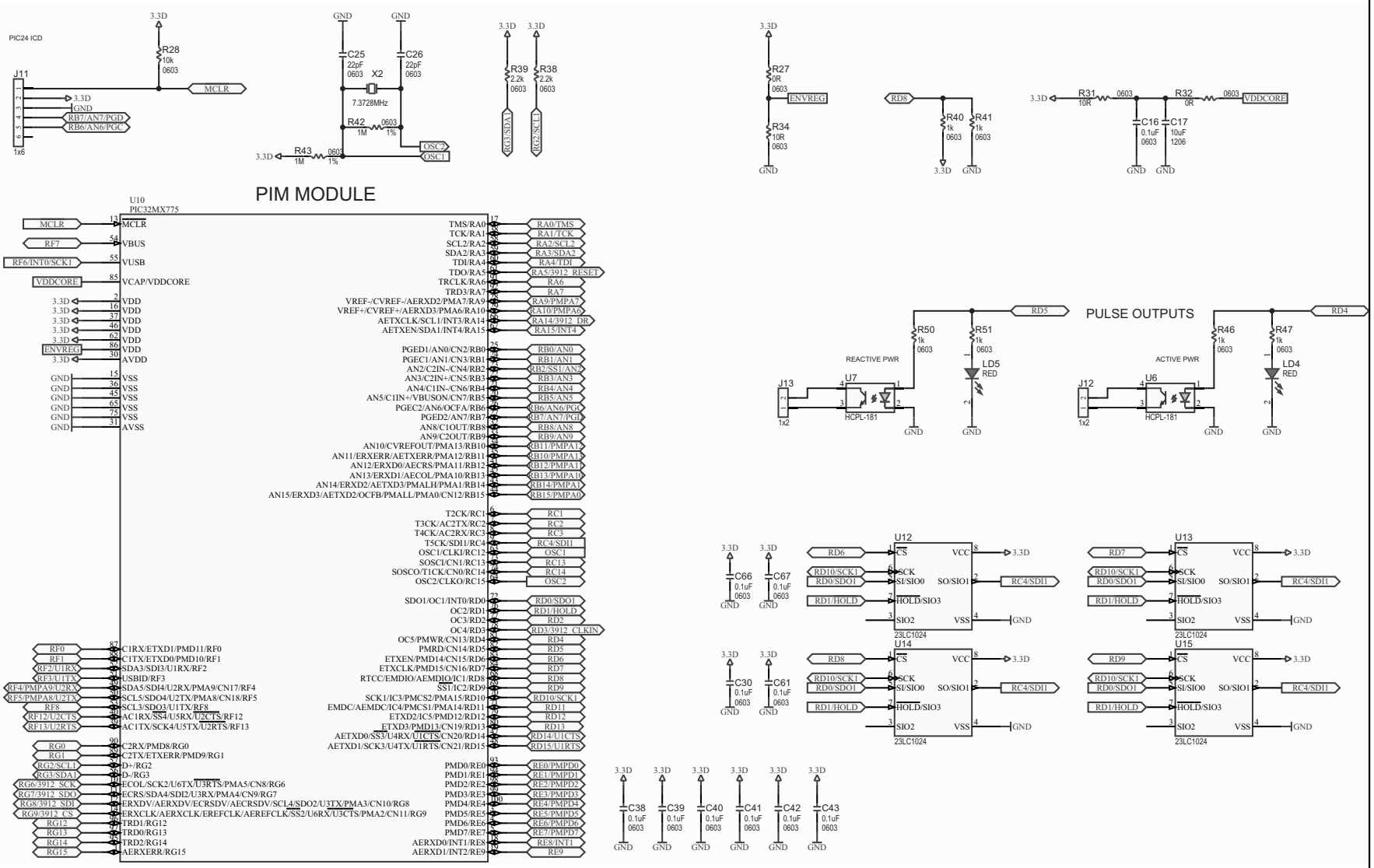
A.5 BOARD – PIM MODULE SCHEMATIC



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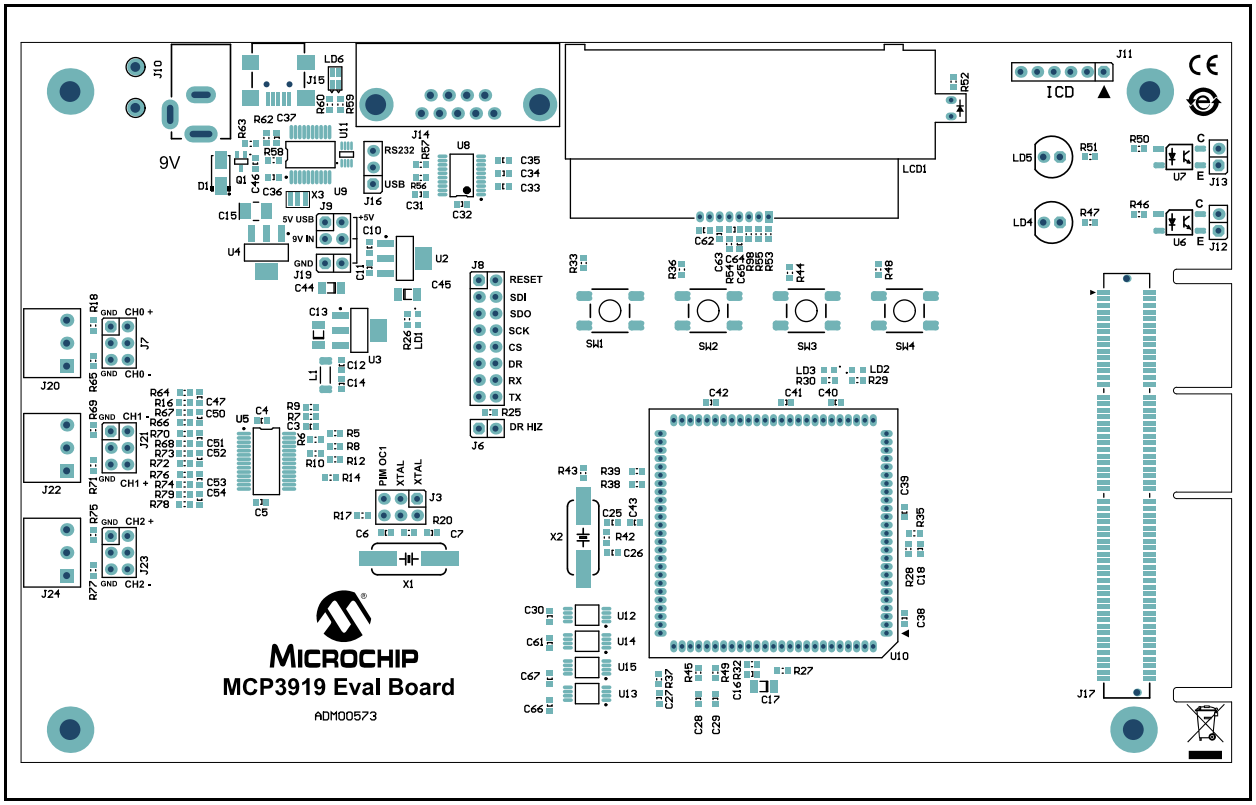
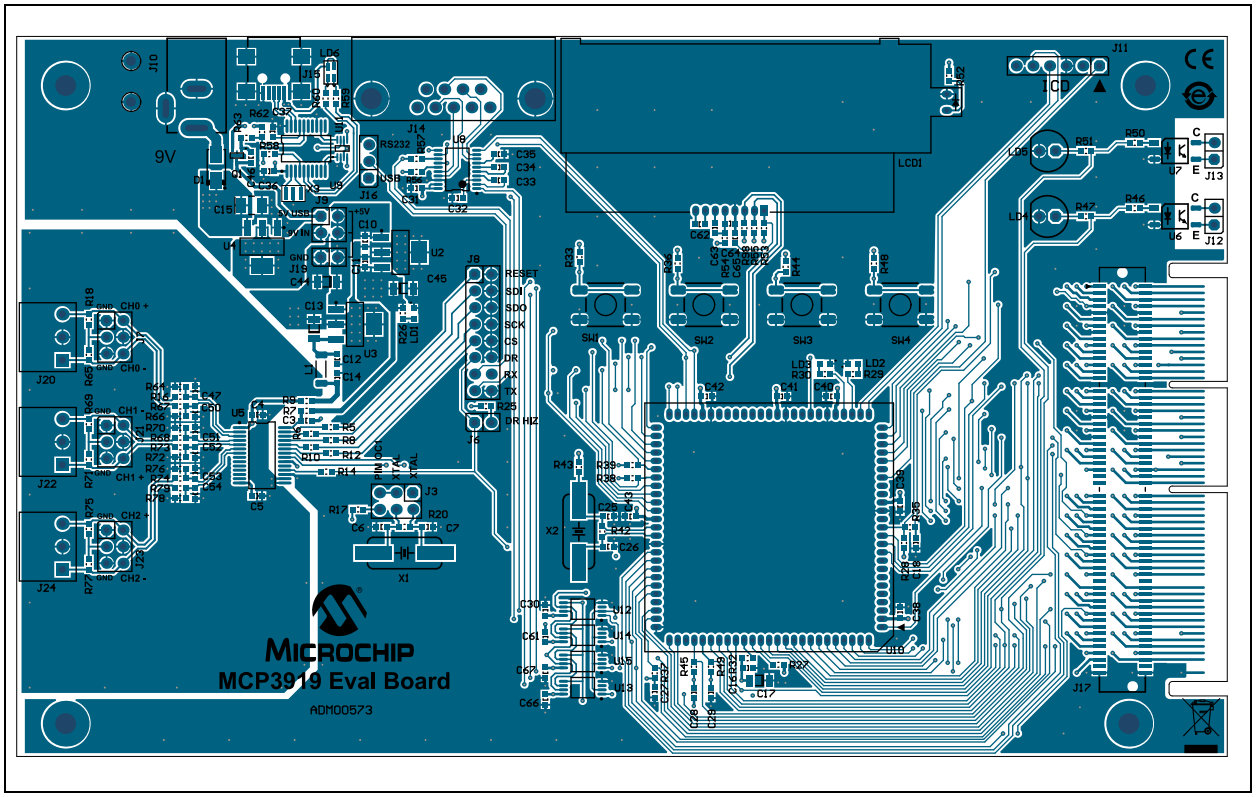
A.6 BOARD – TOP SILK



A.7 BOARD – TOP COPPER AND SILK



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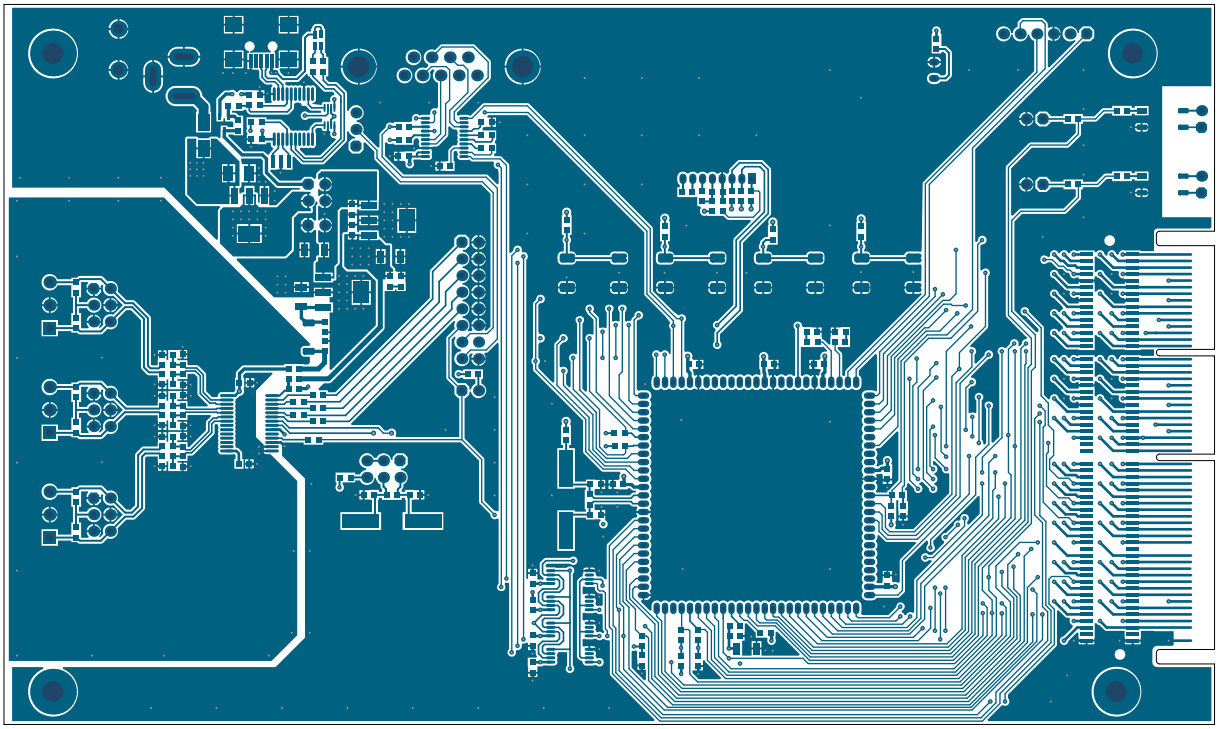
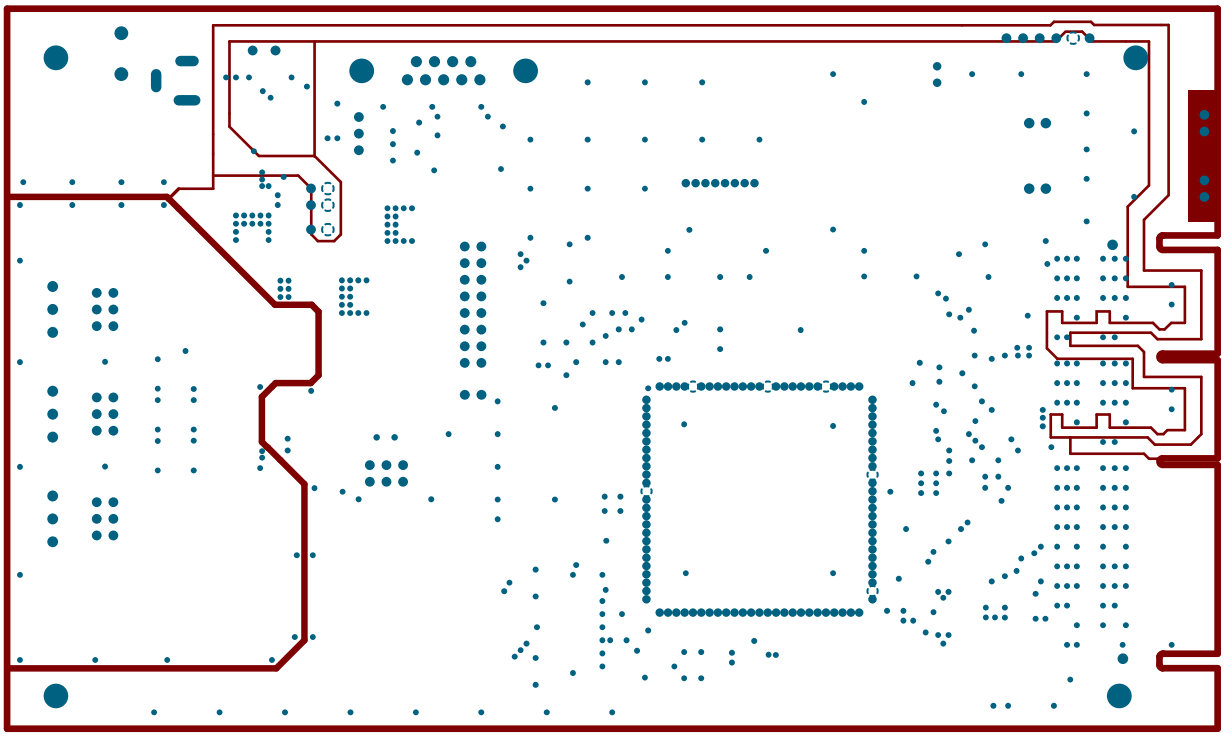
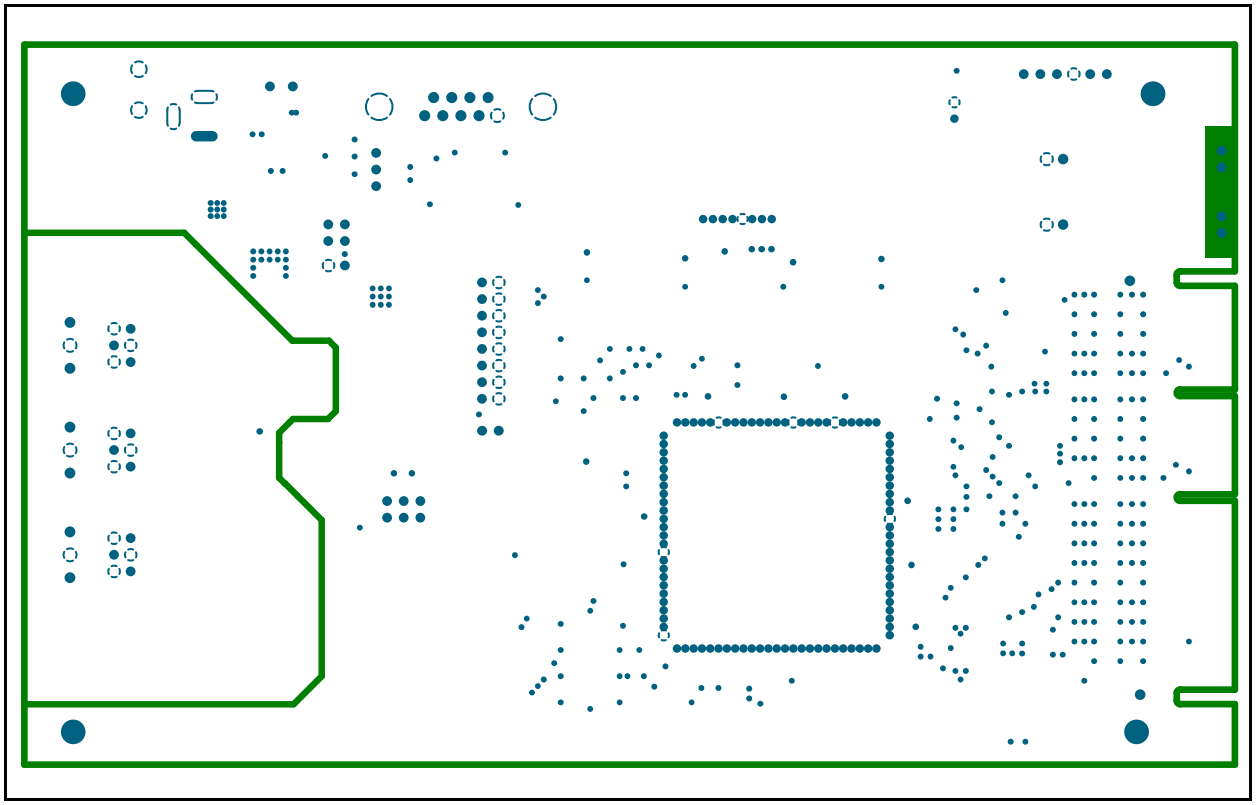
A.8 BOARD – TOP COPPER



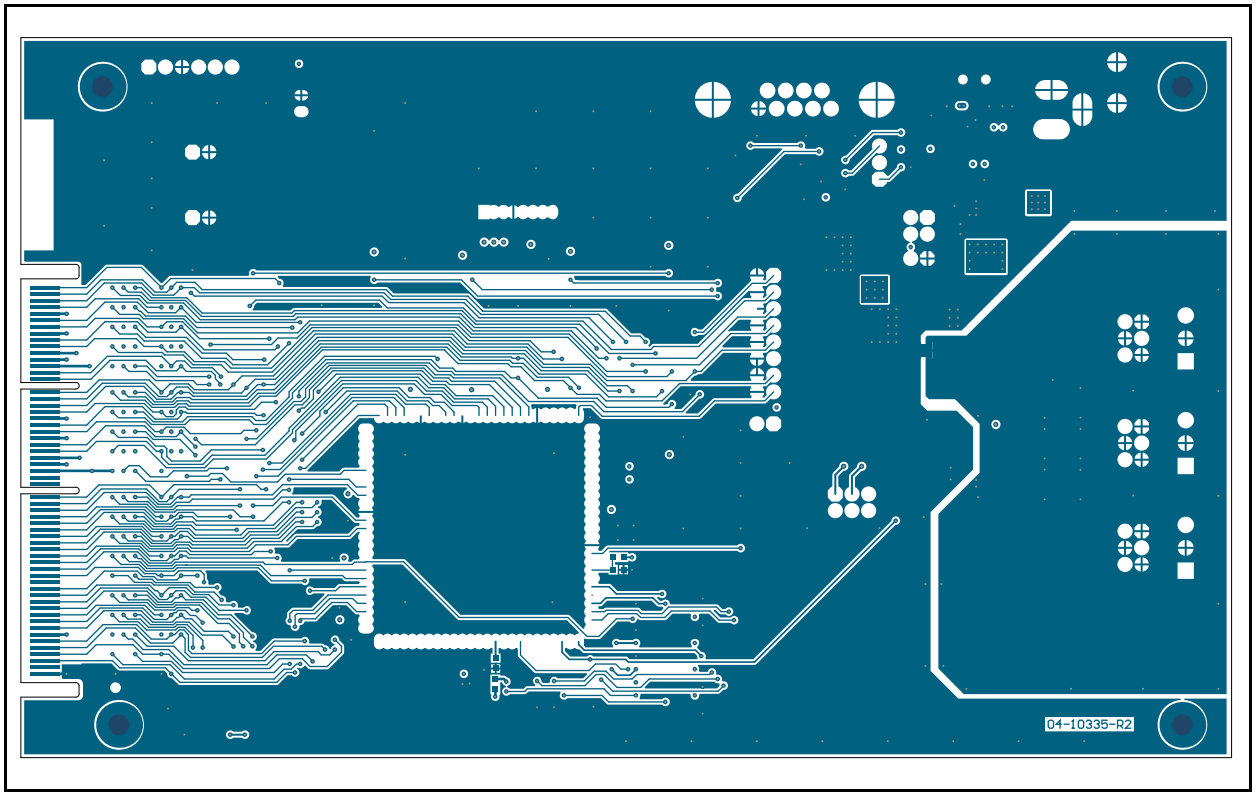
A.9 BOARD – INTERNAL PLANE 1 AND ASSEMBLY TOP



A.10 BOARD – INTERNAL PLANE 2 AND ASSEMBLY TOP



A.11 BOARD – BOTTOM COPPER



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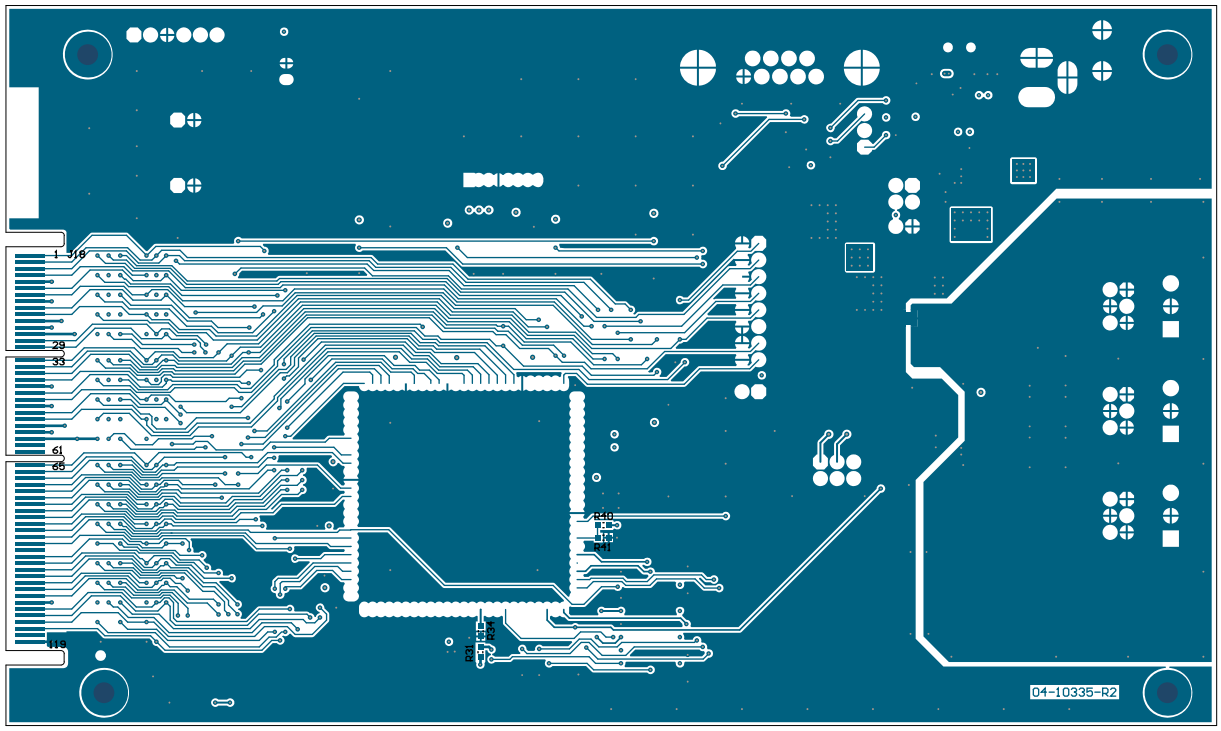
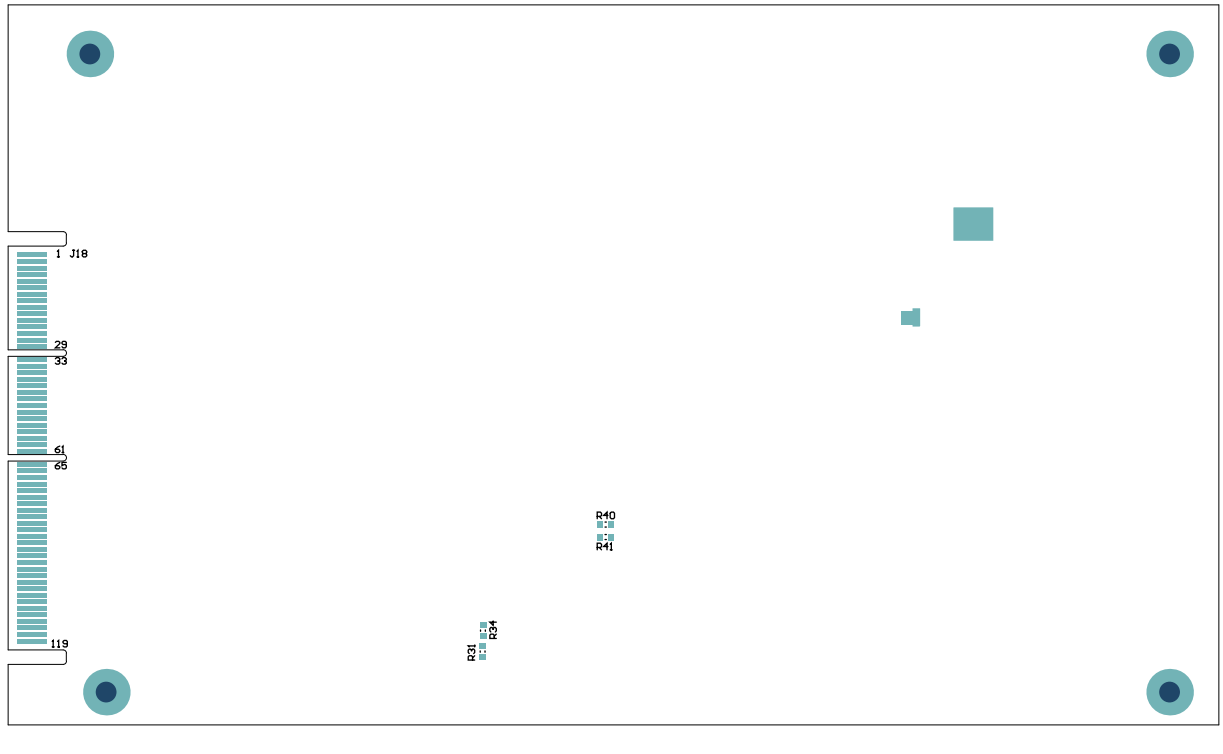
A.12 BOARD – BOTTOM COPPER AND SILK



A.13 BOARD – BOTTOM SILK



NOTES:

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Appendix B. Bill of Materials (BOM)

TABLE B-1: BILL OF MATERIALS (BOM)

Qty	Reference	Description	Manufacturer	Part Number
3	C13, C44, C45	Cap. ceramic 10 µF 16V 10% X5R SMD 1206	TDK Corporation	C3216X5R1C106K
1	C15	Cap. Tant. 10 µF 20V 10% 2.1Ohm SMD B	AVX Corporation	TAJB106K020RNJ
1	C17	Cap. ceramic 10 µF 10V 20% X7R SMD 1206	TDK Corporation	C3216X7R1A106M
38	C3, C4, C5, 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, C50, C51, C52, C53, C54, C61, C64, C65, C66, C67	Cap. ceramic 0.1 µF 16V 10% X7R 0603	TDK Corporation	C1608X7R1C104K
4	C6, C7, C25, C26	Cap. ceramic 22 pF 50V 10% C0G SMD 0603	TDK Corporation	C1608C0G1H220J
2	C62, C63	Cap. ceramic 1 µF 10V 20% X7R SMD 0603	TDK Corporation	C1608X7R1A105M
1	D1	Diode Rect. MRA4005 1.1V 1A 600V DO-214AC_SMA	ON Semiconductor®	MRA4005T3G
1	J10	Conn. power jack 2.5mm	CUI Inc.	PJ-002B
1	J11	Conn. header-2.54 Male 1x6 TH vert.	FCI	68001-106HLF
1	J14	Conn. DSUB 250V 2A DB-9-RA_F	TE Connectivity	1734354-2
1	J15	Conn. USB Mini USB-B Female SMD R/A	Hirose Electric Co., Ltd.	UX60-MB-5ST
1	J16	Conn. header-2.54 Male 1x3 TH vert.	Molex®	90120-0763
1	J17	Conn. Mini Edge Card MEC1 1 mm Female 2x60 SMD vert.	Samtec, Inc.	MEC1-160-02-L-D-A
3	J20, J22, J24	Conn. Terminal Female 1x3 TH R/A	Keystone Electronics Corp.	8723
4	J3, J7, J21, J23	Conn. header-2.54 Male 2x3 TH vert.	Samtec, Inc.	TSW-103-08-L-D
4	J6, J12, J13, J19	Conn. header-2.54 Male 1x2 TH vert.	FCI	77311-118-02LF
1	J8	Conn. header-2.54 Male 2x8 TH vert.	FCI	68602-116HLF
1	J9	Conn. header-2.54 100V 2A Male 2x2 TH vert.	3M	961204-6404-AR
1	L1	Ferrite 300 mA 0.5R SMD 1806	Laird Technologies®	LI1806C151R-10

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.

TABLE B-1: BILL OF MATERIALS (BOM)

Qty	Reference	Description	Manufacturer	Part Number
1	LCD1	Display LCD NHD-C0216-CIZ-FSW-FBW-3V3 16x2 Alpha 3.3V TH	Newhaven Display	NHD-C0216-CIZ-FSW-FBW-3V3
2	LD1, LD2	Diode LED green 1.7V 20 mA 0603	OSRAM Opto Semiconductors GmbH.	LG L29K-G2J1-24-Z
1	LD3	Diode LED red 2V 25 mA 0603	OSRAM Opto Semiconductors GmbH.	LS Q976-NR-1-0-20-R18
2	LD4, LD5	Diode LED red 1.65V 30 mA RAD T-1_3/4	Kingbright Corp.	WP7113LSRD
1	LD6	Diode LED bi red, green 1.95V, 2.1V 30 mA 0805	Kingbright Corp.	APHBM2012SURKC-GKC
5	PAD1	Mech. HW Rubber Pad Bumpon Hemisphere 0.44" x 0.20" Black	3M	SJ-5003 (BLACK)
1	Q1	Trans. Fet. P-CH SI1307EDL -12V -850 mA 290 mW SOT-323-3	Vishay Siliconix	SI1307EDL-T1-GE3
18	R16, R18, R64, R65, R66, R67, R68, R69, R70, R71, R72, R73, R74, R75, R76, R77, R78, R79	Res. TKF 1k 1% 1/10W SMD 0603	Panasonic®	ERJ-3EKF1001V
3	R20, R42, R43	Res. TKF 1M 1% 1/10W SMD 0603	Panasonic	ERJ-3EKF1004V
22	R25, R26, R29, R30, R35, R37, R40, R41, R45, R46, R47, R49, R50, R51, R52, R55, R56, R57, R59, R60, R63, R98	Res. TKF 1k 5% 1/10W SMD 0603	Panasonic	ERJ-3GEYJ102V
1	R27	Res. TKF 0R 1/10W SMD 0603	NIC Components Corp.	NRC06Z0TRF
2	R28, R62	Res. TKF 10k 5% 1/10W SMD 0603	Panasonic	ERJ-3GEYJ103V
1	R32	Res. TKF 0R 1/10W SMD 0603	Panasonic	ERJ-3GEY0R00V
6	R33, R36, R44, R48, R53, R58	Res. TKF 4.7k 5% 1/10W SMD 0603	Yageo Corporation	RC0603JR-074K7L
2	R38, R39	Res. TKF 2.2k 5% 1/10W SMD 0603	Panasonic	ERJ-3GEYJ222V
1	R5	Res. TKF 100R 5% 1/10W SMD 0603	NIC Components Corp.	NRC06J101TRF
11	R6, R7, R8, R9, R10, R12, R14, R17, R31, R34, R54	Res. TKF 10R 5% 1/10W SMD 0603	Yageo Corporation	RC0603JR-0710RL
4	SW1, SW2, SW3, SW4	Switch SPST 12V 50mA TL3301NF160QG/TR SMD	E-Switch®, Inc.	TL3301NF160QG/TR
4	U10	Socket PIM 100 Pin Female TH	Oupiin	2246-1X25G00SU
1	U11	IC Transceiver TXS0102 US-8	Texas Instruments	TXS0102DCUR
4	U12, U13, U14, U15	MCHP Mem. SRAM 23LC1024 TSSOP-8	Microchip Technology Inc.	23LC1024-I/ST
1	U2	MCHP Ana. LDO MCP1825S-3.3V SOT-223-3	Microchip Technology Inc.	MCP1825S-3302E/DB
1	U3	MCHP Ana. LDO MCP1754ST-3302E/DB SOT-223-3	Microchip Technology Inc.	MCP1754ST-3302E/DB

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.

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TABLE B-1: BILL OF MATERIALS (BOM)

Qty	Reference	Description	Manufacturer	Part Number
1	U4	IC Power LM1117-5V SOT-223-3	National Semiconductor	LM1117MPX-5.0/NOPB
1	U5	IC ADC 3 Ch Delta Sigma SSOP-28	Microchip Technology Inc.	MCP3919
2	U6, U7	IC Photo HCPL-181 4-SMD	Avago Technologies	HCPL-181-00CE
1	U8	IC Transceiver SN75C3223PWR TSSOP-20	Texas Instruments	SN75C3223PWR
1	U9	MCHP Int. USB MCP2200 SSOP-20	Microchip Technology Inc.	MCP2200-I/SS
1	X1	Crystal 10 MHz 18pF SMD HC49/US	Abracon® Corporation	ABLS-10.000MHZ-B4-T
1	X2	Crystal 7.3728 MHz 18pF SMD HC49/US	Abracon Corporation	ABLS-7.3728MHZ-B4-T
1	X3	Resonator 12 MHz 0.1% SMD CSTCE-G	Murata Electronics®	CSTCE12M0G15L99-R0

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.

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