MCP39F511 Power Monitor Demonstration Board User's Guide

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Object of Declaration: MCP39F511 Power Monitor Demonstration Board

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Manufacturer: Microchip Technology Inc.
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USA

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Derek Carlson
VP Development Tools

12-Sep-14
Date

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MCP39F511 POWER MONITOR DEMONSTRATION BOARD USER'S GUIDE

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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 MCP39F511 Power Monitor Demonstration Board. 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 MCP39F511 Power Monitor Demonstration Board as a demonstration board to evaluate the MCP39F511 device. The manual layout is as follows:

- **Chapter 1. "Product Overview"** – Provides important information about the MCP39F511 Power Monitor Demonstration Board
- **Chapter 2. "Installation and Operation"** – Provides information on using the MCP39F511 Power Monitor Demonstration Board, including **Section 2.1.1 "Step 1: Wiring connections"** that describes wiring the line and load connections
- **Chapter 3. "Hardware Description"** – Provides details on the functional blocks of the power monitor, including the analog front-end design and power supply design
- **Appendix A. "Schematic and Layouts"** – Shows the schematic and layout diagrams
- **Appendix B. "Bill of Materials (BOM)"** – Lists the parts used to build the MCP39F511 Power Monitor Demonstration Board

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 MCP39F511 Power Monitor Demonstration Board. Another useful document is listed below. The following Microchip document is available and recommended as a supplemental reference resource.

MCP39F511 Data Sheet – *"Power-Monitoring IC with Calculation with Energy Accumulation"* (DS20005393)

This data sheet provides detailed information regarding the MCP39F511 device.

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:

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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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- Technical Support

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

DOCUMENT REVISION HISTORY

Revision A (March 2015)

- Initial Release of this Document.

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Chapter 1. Product Overview

1.1 INTRODUCTION

The MCP39F511 Power Monitor Demonstration Board is a fully functional single-phase power and energy monitor. The system calculates active power, reactive power, RMS current, RMS voltage, active energy, (both import and export), reactive energy and other typical power quantities, as defined in the MCP39F511 data sheet.

The "MCP39F511 Power Monitor Utility" software is used to calibrate and monitor the system, and can be used to create custom calibration setups. For most accuracy requirements, only a single-point calibration is needed. The energy meter software offers an automated step-by-step calibration process that can be used to quickly calibrate energy meters.

This demonstration board uses the MCP39F511 Power Monitor Utility software for evaluation 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 how to use the software, refer to the software's supporting documentation included within the application install package.

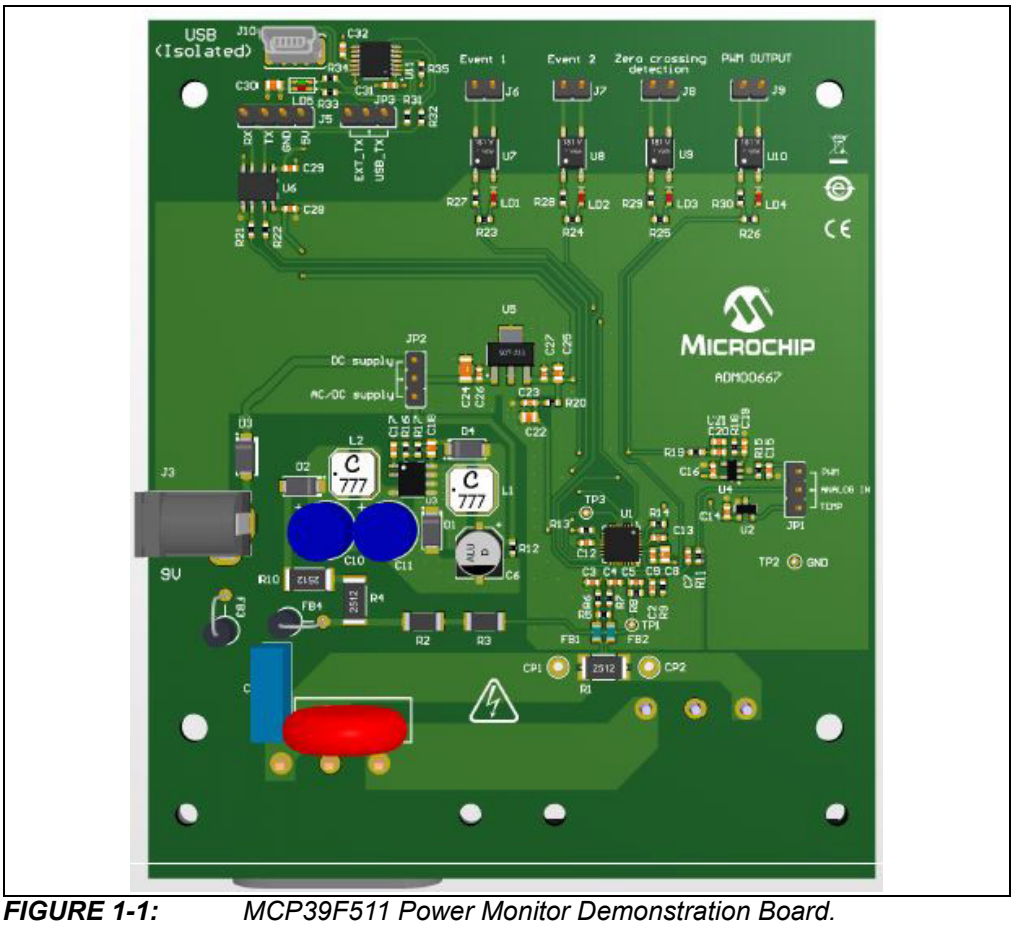

FIGURE 1-1: *MCP39F511 Power Monitor Demonstration Board.*

1.2 WHAT DOES THE MCP39F511 POWER MONITOR DEMONSTRATION BOARD KIT INCLUDE?

This MCP39F511 Power Monitor Demonstration Board kit includes:

- MCP39F511 Power Monitor Demonstration Board (ADM00667)
- AC Line Cable
- IEC to Female AC Load Cable
- Mini-USB Cable
- Important Information Sheet

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Chapter 2. Installation and Operation

2.1 GETTING STARTED

To use the MCP39F511 Power Monitor Demonstration Board, follow the steps described in the sections below. The meter design uses a 5A load for calibration current and a maximum current (I_{MAX}) of 15A.

It is not recommended to put more than 15A through the AC plugs mounted on the Printed Circuit Board (PCB).

To test the calibrated meter, the following connections can be made:

2.1.1 Step 1: Wiring connections

Figure 2-1 identifies the line and load connections of the MCP39F511 Power Monitor Demonstration Board.

FIGURE 2-1: *Connecting the MCP39F511 Power Monitor Demonstration Board.*

2.1.2 Step 2: Turn on line/load power to the meter (power the meter)

The meter will turn on when the line connection has between 90V to 220V connected.

2.1.3 Step 3: Connect the USB cable to a PC with the installed "MCP39F511 Power Monitor Utility" software

Select the appropriate COM port. If the meter is connected correctly, the connection status in the bottom-left corner of the software will display "Meter Connected". If no meter is found, the status will be "Meter Disconnected". Check that the correct COM port was selected and try again. Press the "Start" Icon to begin showing output data and UART transmission between the PC and the MCP39F511

Note:	For instructions on using the software GUI, please refer to the help file located in the program installation directory and also on the website: MCP39F511 Power Monitor Software User Manual.pdf

NOTES:

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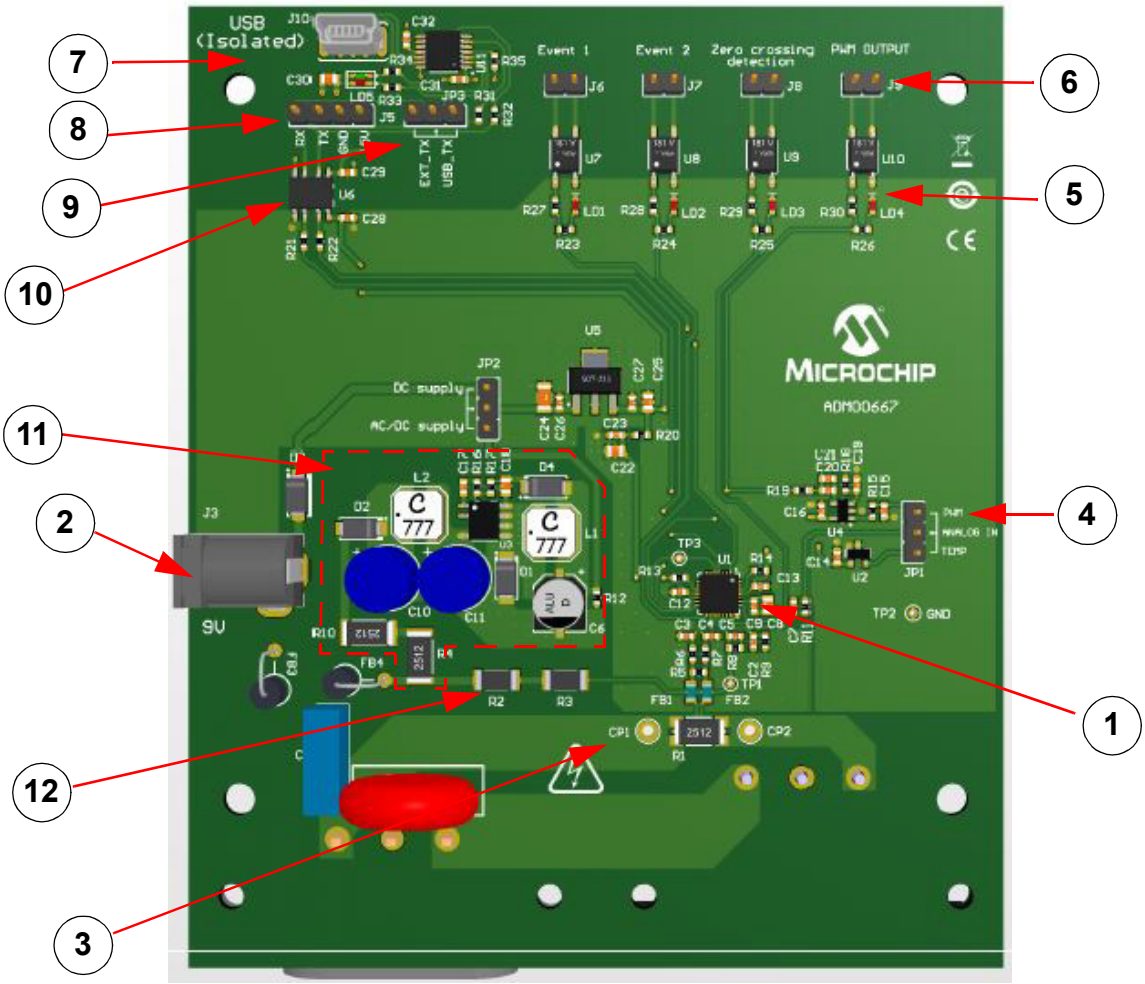
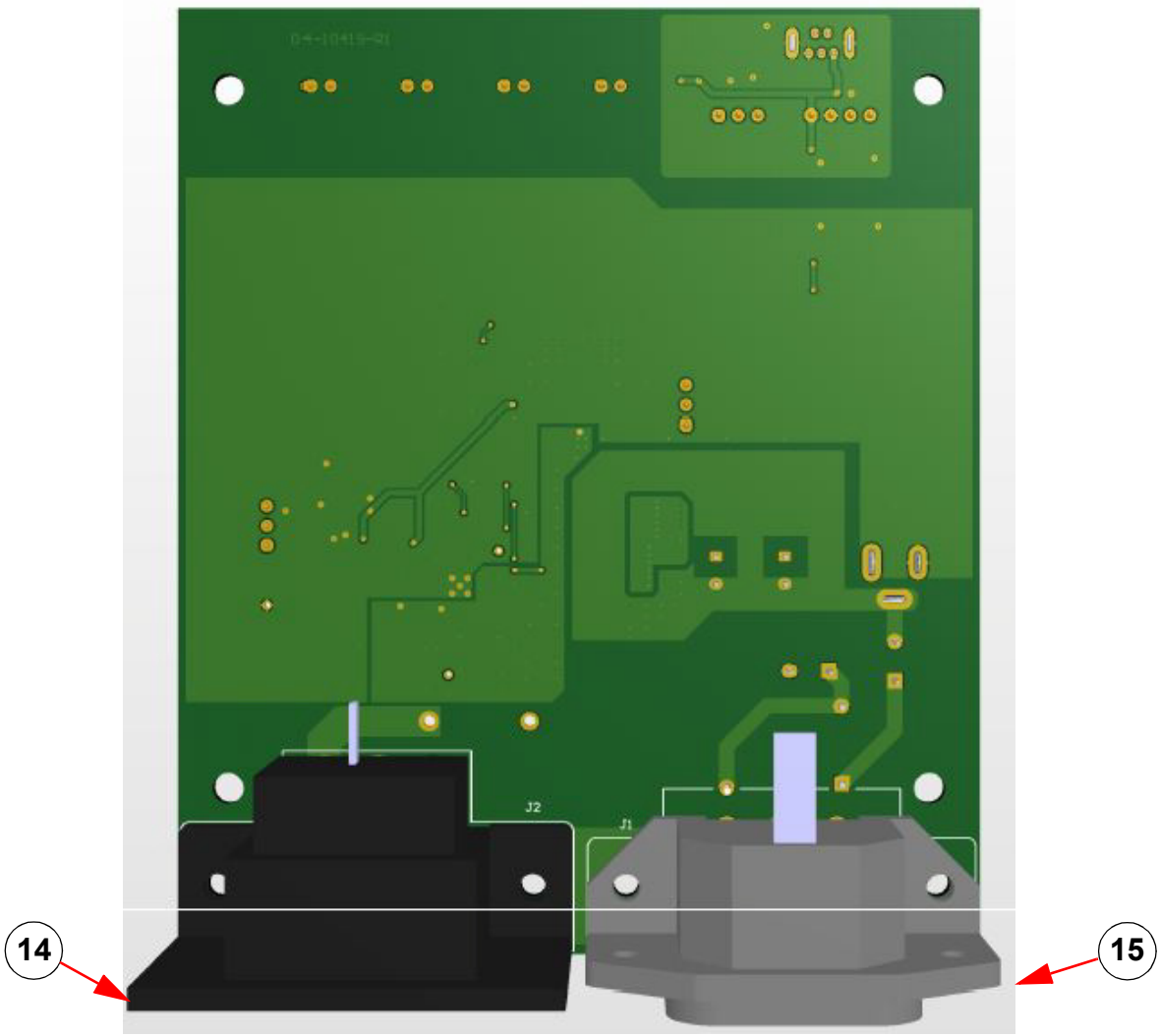
Chapter 3. Hardware Description



Legend:

1 = MCP39F511
2 = +9V DC Input (non-isolated)
3 = Connections to external shunt current sensing resistor
4 = Configuration jumper for analog input
5 = Output LEDs for digital I/O
6 = Headers for pulse testing (isolated)
7 = USB Connection (isolated)
8 = Header for connection to external master MCU (isolated)
9 = Jumper selection for external MCU or USB (GUI) operation
10 = Isolation IC
11 = Switching AC/DC Power Supply
12 = 1000:1 Voltage Divider for Voltage Input
13 = Jumper for DC or Switching AC/DC Supply

FIGURE 3-1: *MCP39F511 Power Monitor Demonstration Board Top View.*



Legend:

14	=	Line connection AC supply (90 – 230V)
15	=	Load connection (15A maximum recommended current)

FIGURE 3-2: *MCP39F511 Power Monitor Demonstration Board Bottom View.*

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3.1 INPUT AND ANALOG FRONT END

The MCP39F511 Power Monitor Demonstration Board will operate from 90V to 230V. At the bottom of the main board, there are the high-voltage line and neutral connections. The shunt sits on the neutral or low side of a two-wire system. The board comes populated with a surface mount 2 mΩ shunt. If a lower value external shunt is to be used, the wires going from the external shunt to the CP1 and CP2 connections should be twisted together.

The neutral side of the two-wire system goes into a resistor divider on the voltage channel input, along with a DC offset added from V_{DD}. Anti-aliasing low-pass filters are included. The voltage channel uses two 499 kΩ resistors to achieve a divider ratio of 1000:1. For a line voltage of 220 V_{RMS}, the channel 1 input signal size will be 220 mV_{RMS}.

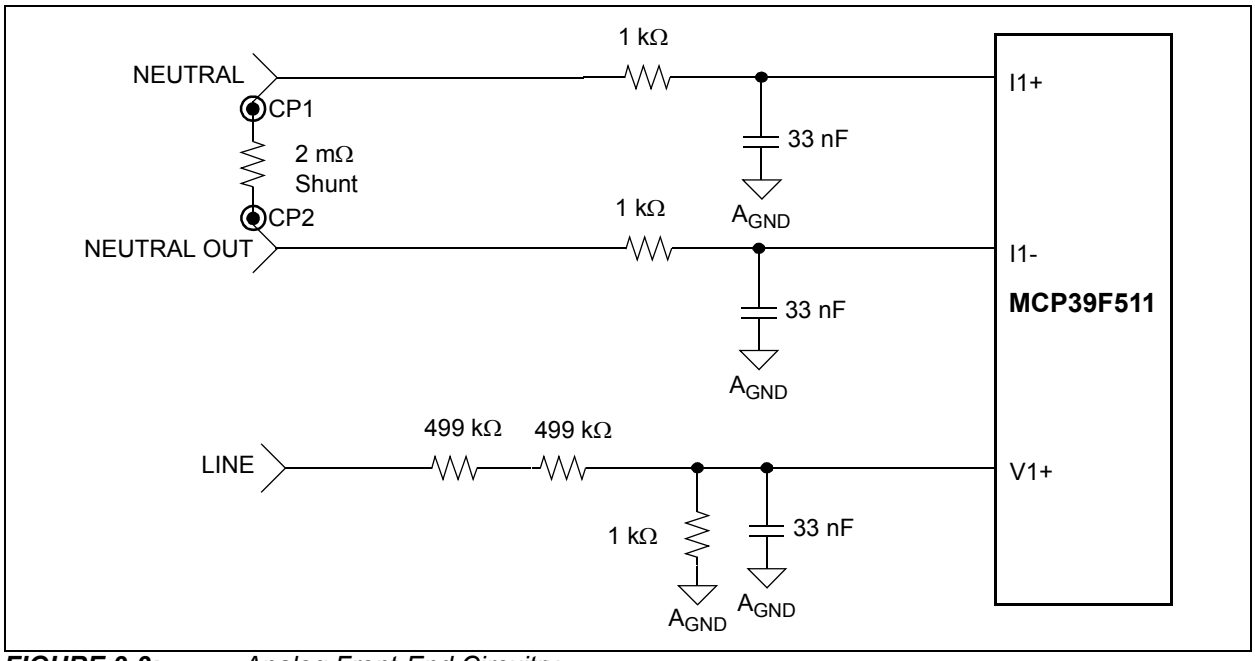

FIGURE 3-3: *Analog Front-End Circuitry.*

Note that all of the analog circuitry associated with this part of the circuit is connected to the analog ground plane (A_{GND}).

3.2 POWER SUPPLY CIRCUIT

The power supply circuit for the MCP39F511 Power Monitor Demonstration Board is shown in Figure 3-4.

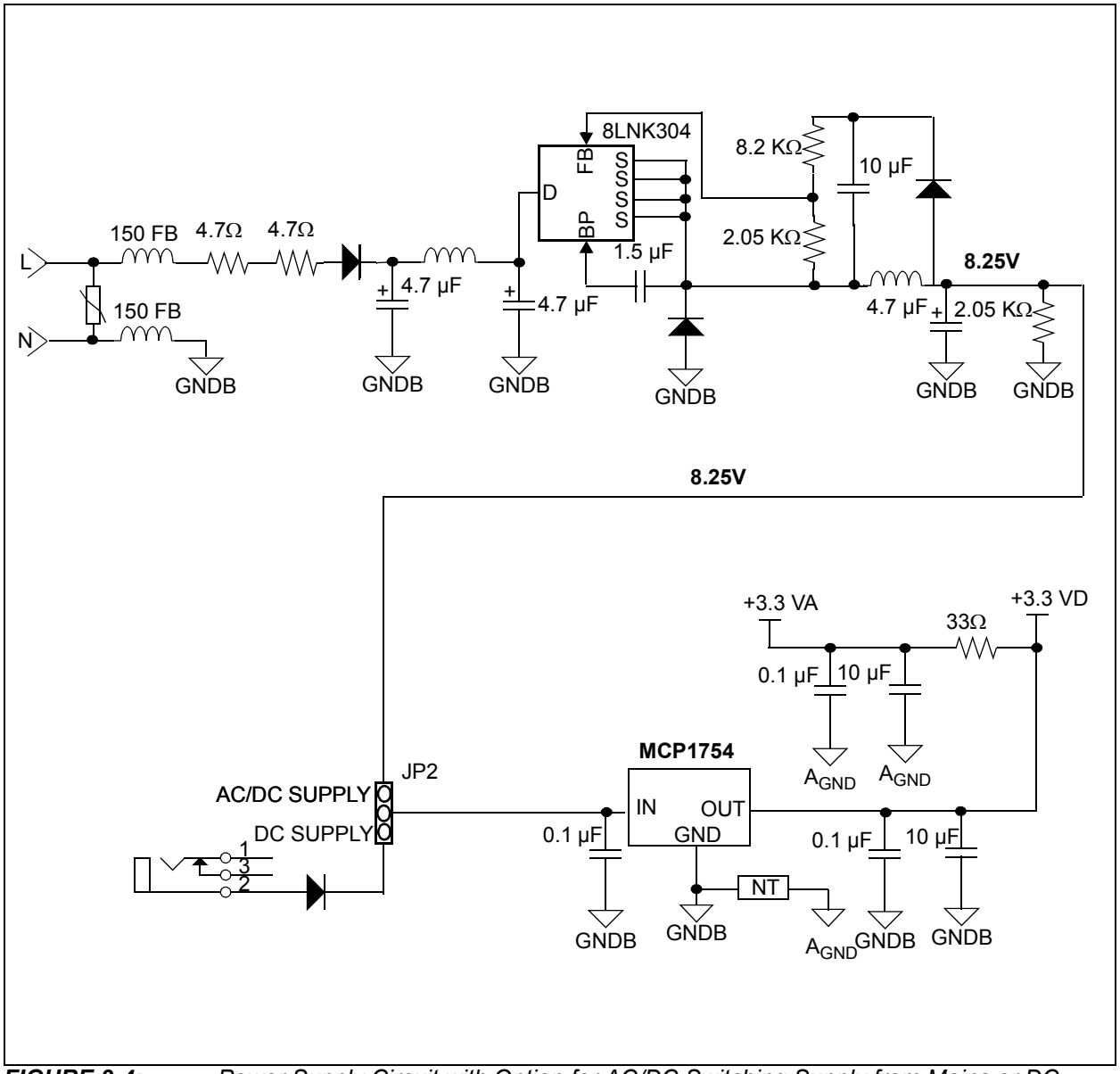

FIGURE 3-4: *Power Supply Circuit with Option for AC/DC Switching Supply from Mains or DC Supply.*

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Appendix A. Schematic and Layouts

A.1 INTRODUCTION

This appendix contains the following schematics and layouts for the MCP39F511 Power Monitor Demonstration Board:

- Board – Schematic
- Board – Schematic (Continued)
- Board – Top Silk
- Board – Top Copper and Silk
- Board – Top Copper
- Board – Bottom Copper
- Board – Bottom Copper and Silk

A.2 SCHEMATICS AND PCB LAYOUT

The layer order is shown in Figure A-1.

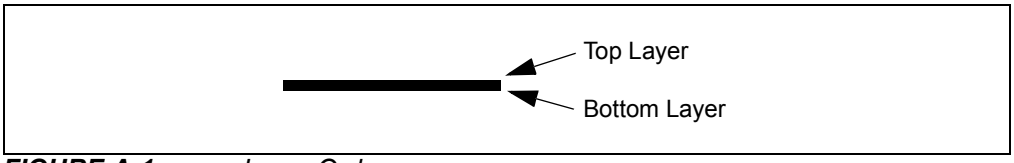
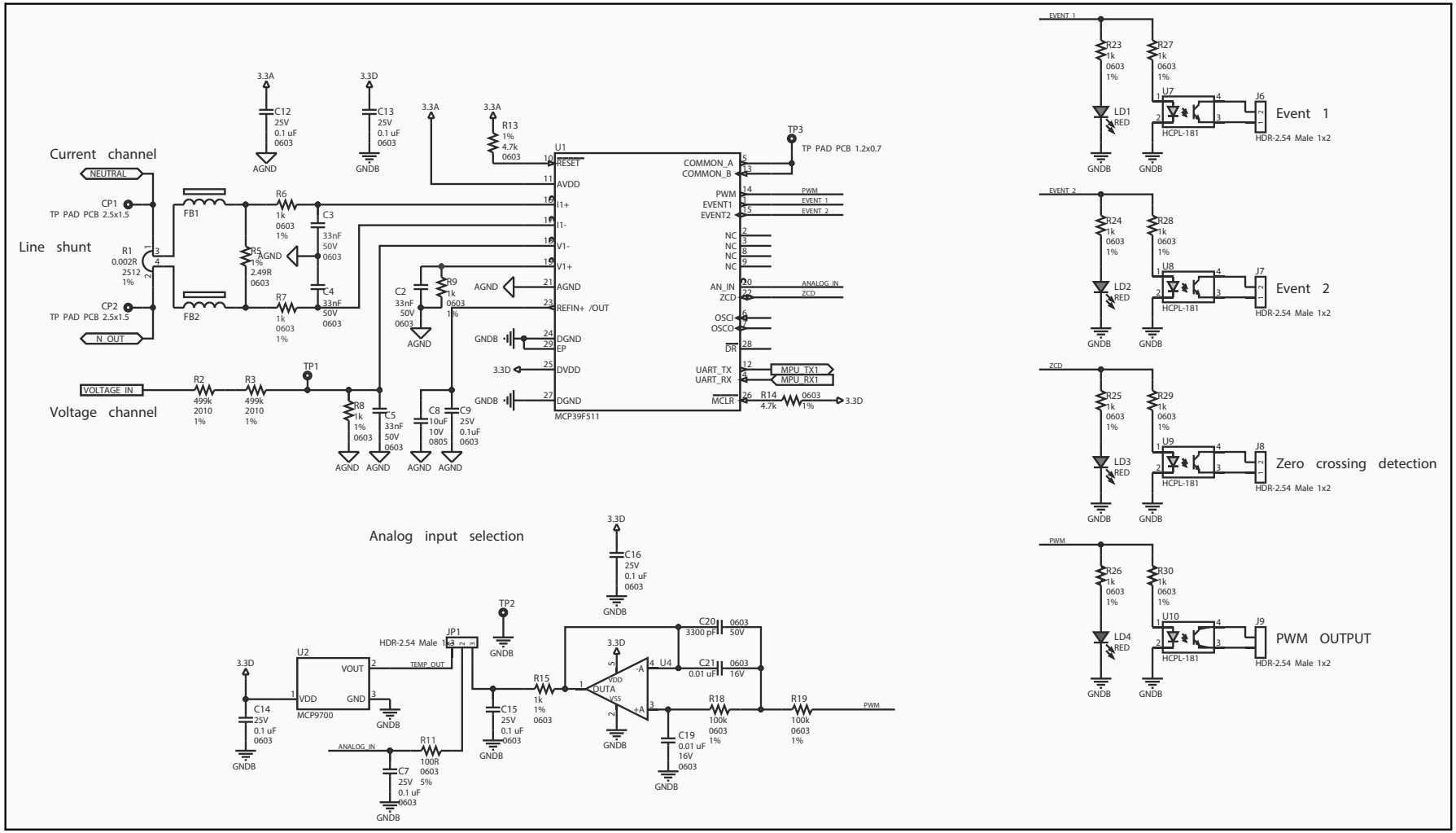


FIGURE A-1: *Layer Order.*

A.3 BOARD – SCHEMATIC



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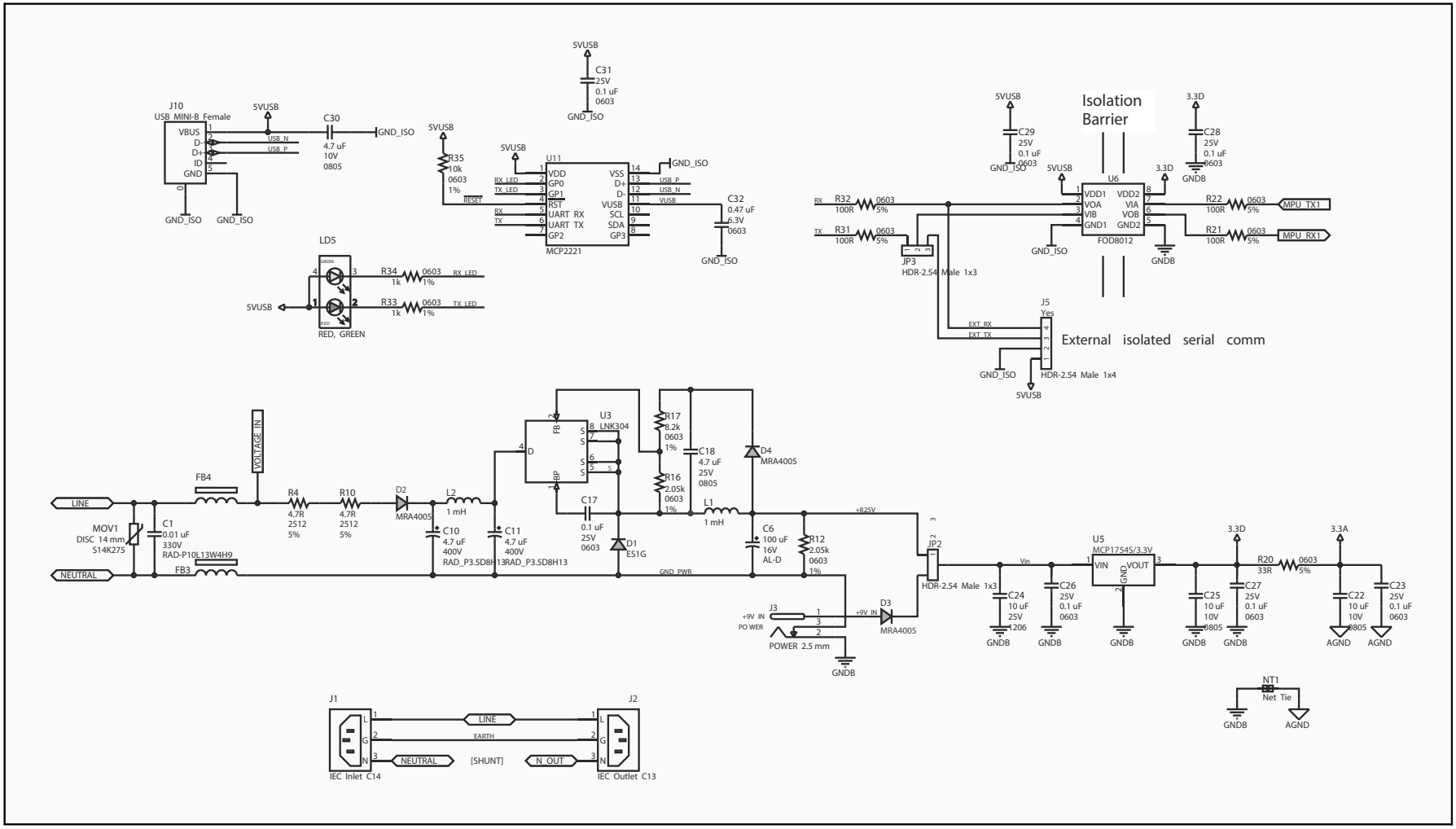
A.3 BOARD – SCHEMATIC (CONTINUED)



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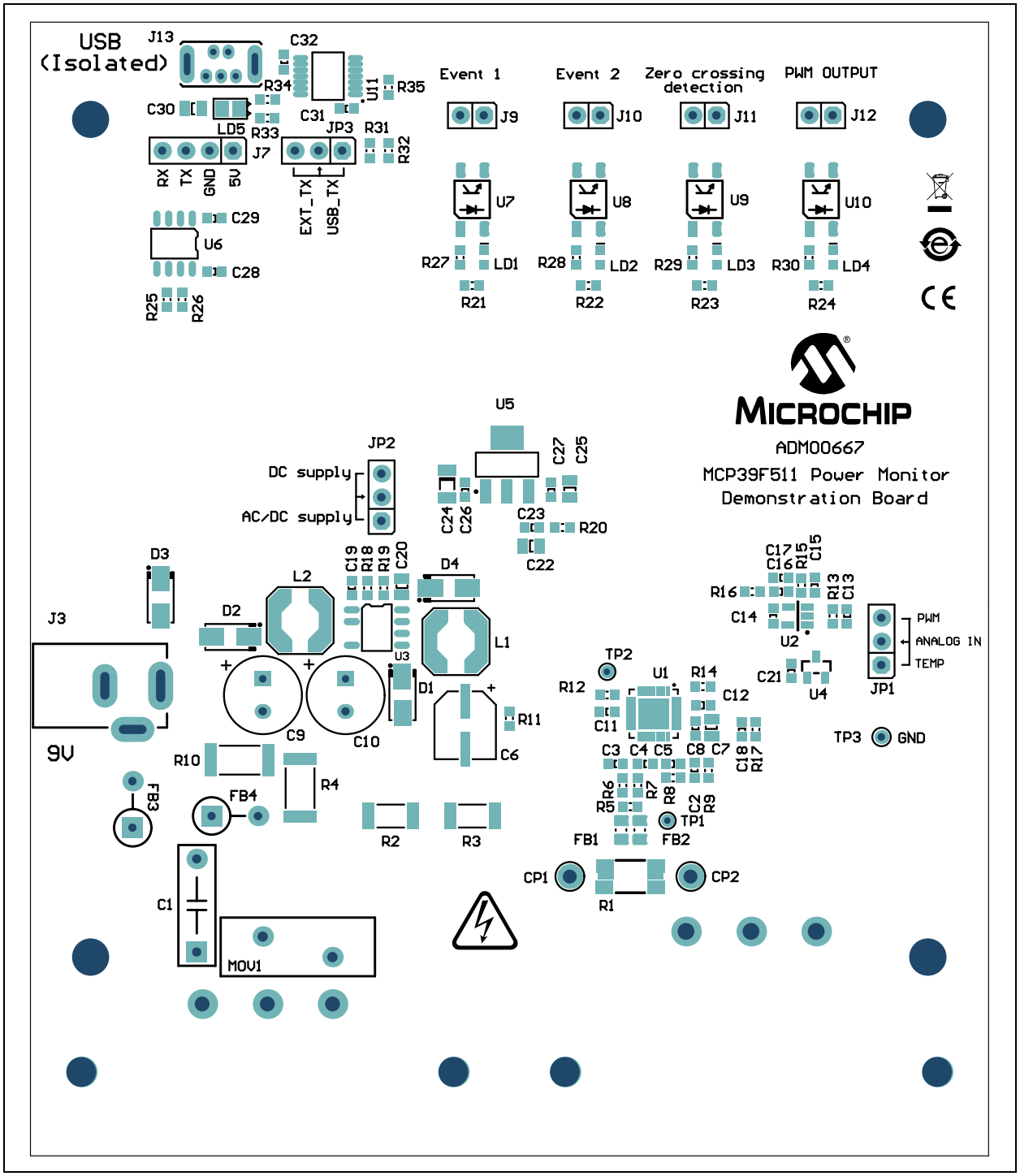
A.4 BOARD – TOP SILK



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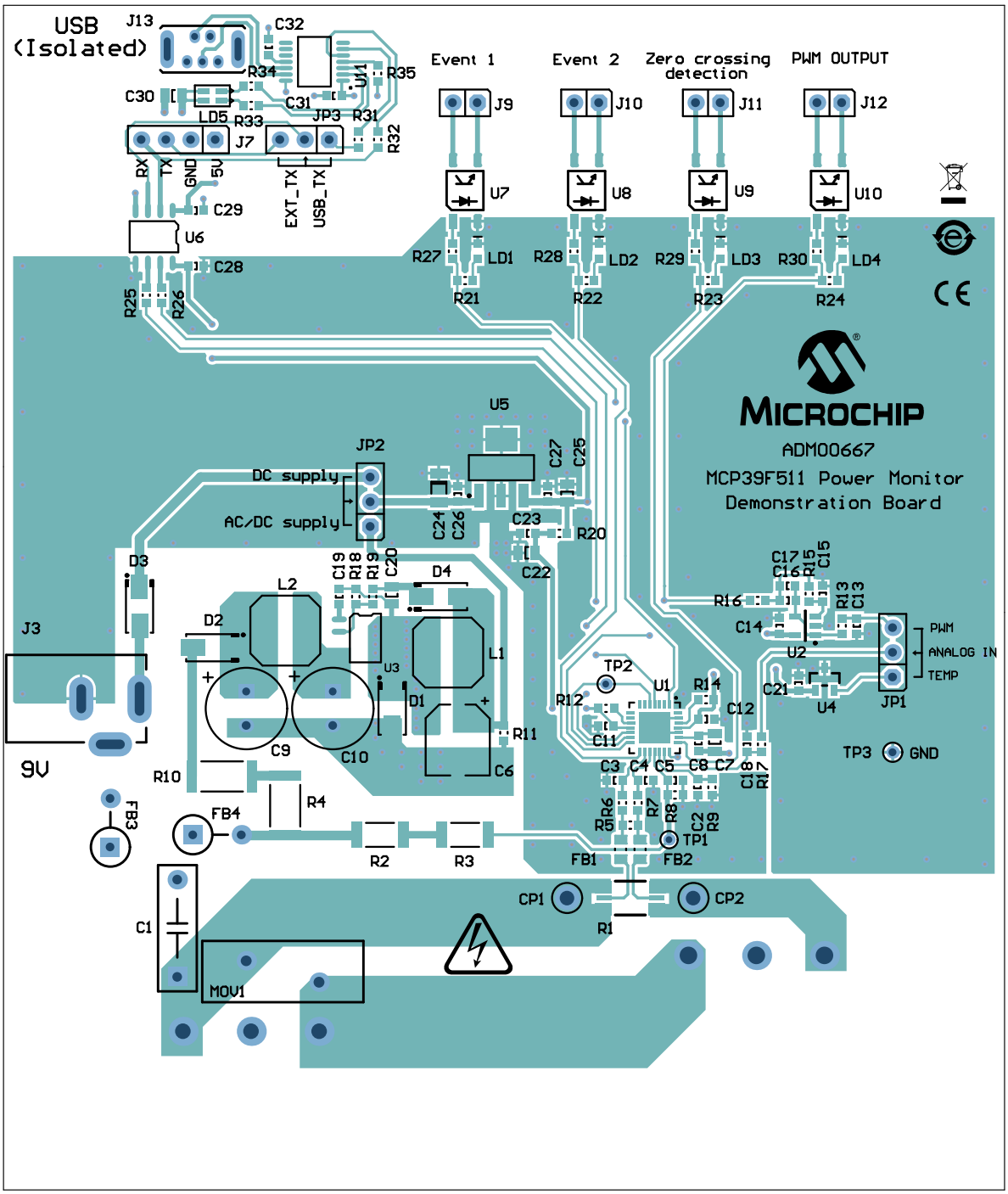
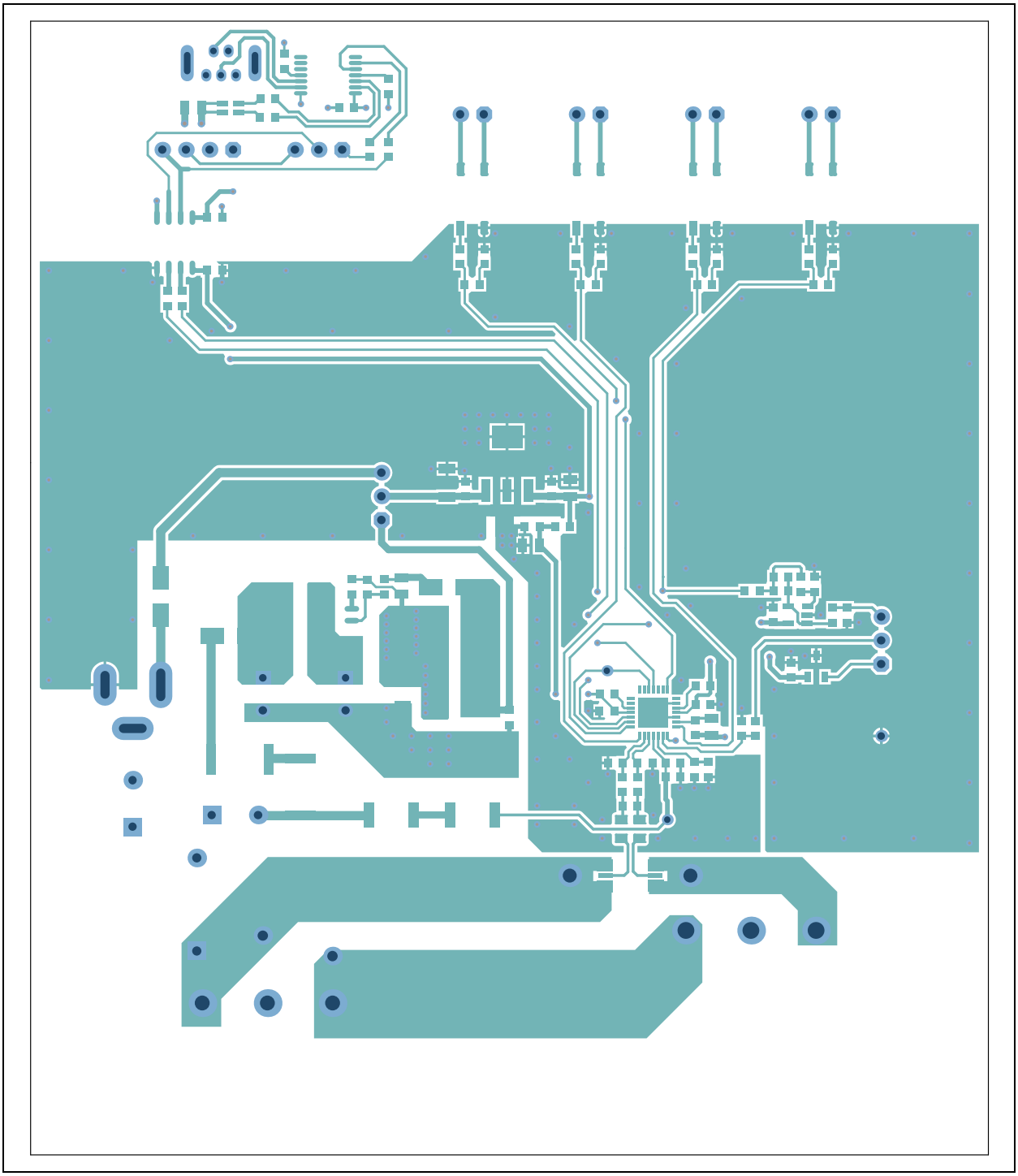
A.5 BOARD – TOP COPPER AND SILK



A.6 BOARD – TOP COPPER



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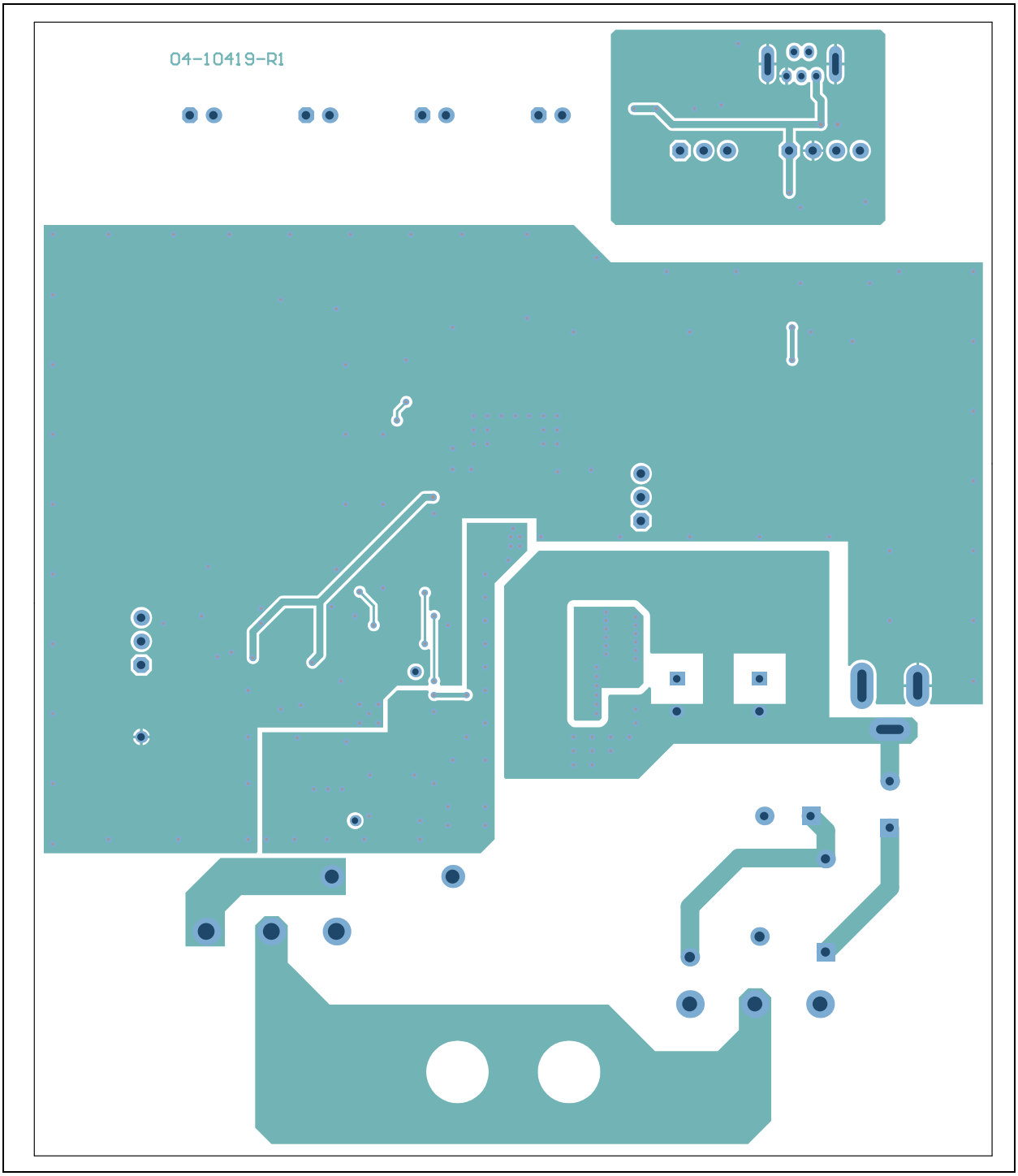
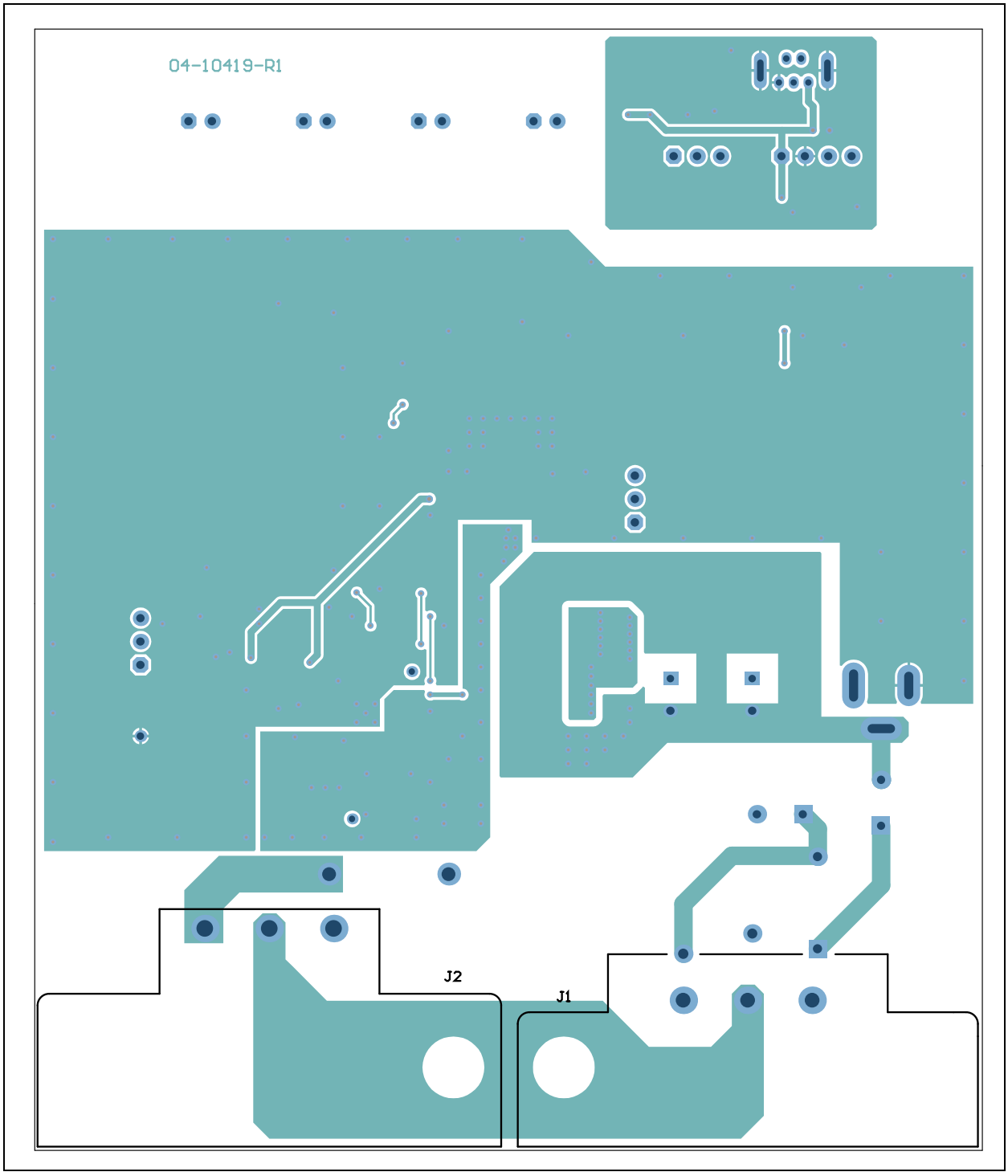
A.7 BOARD – BOTTOM COPPER



A.8 BOARD – BOTTOM COPPER AND SILK



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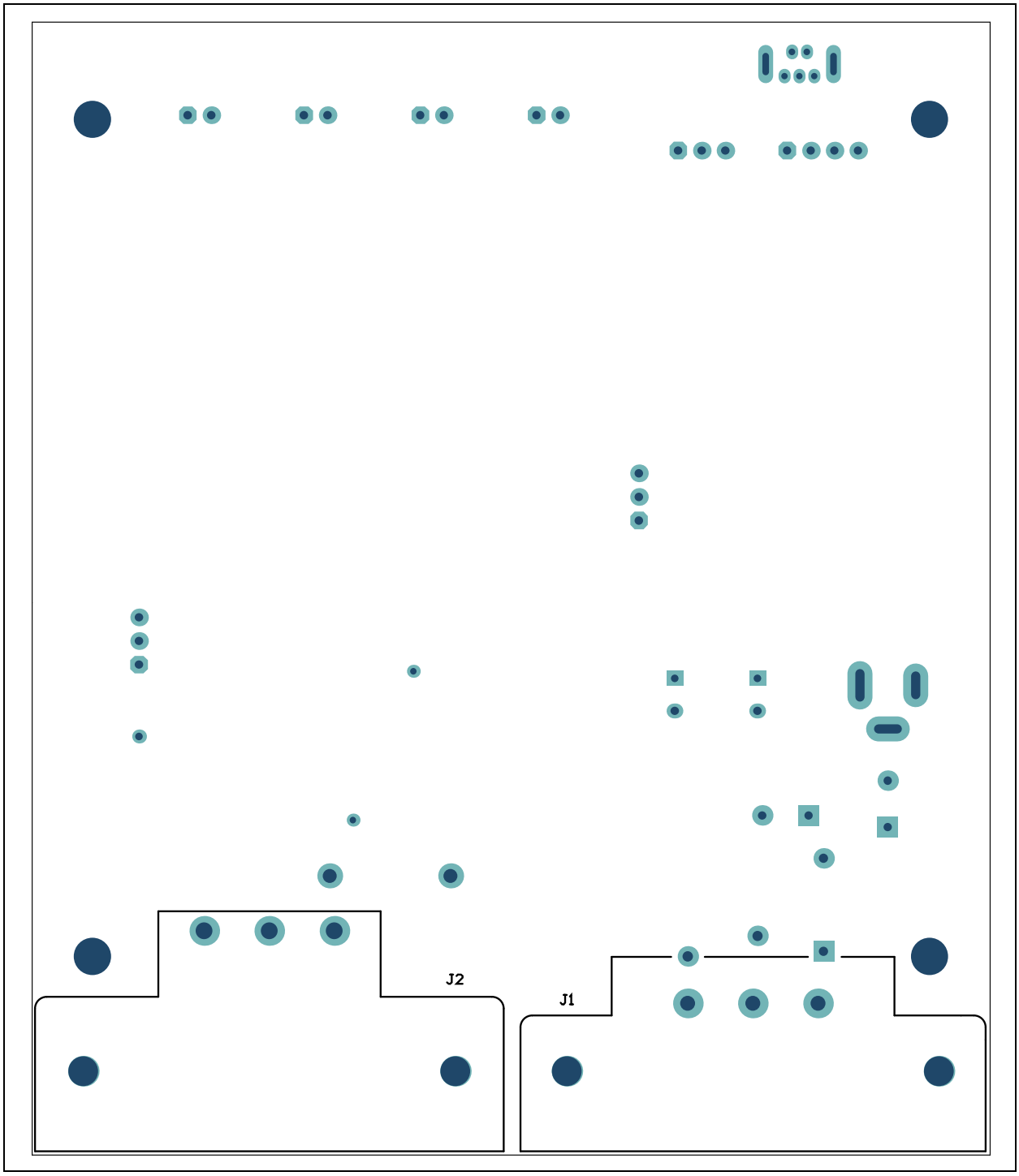
A.9 BOARD – BOTTOM SILK



NOTES:

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Appendix B. Bill of Materials (BOM)

TABLE B-1: BILL OF MATERIALS (BOM)

Qty.	Reference	Description	Manufacturer	Part Number
1	C1	Cap. film 0.01 µF 330V 20% RAD P10L13W4H9	EPCOS AG	B32911A3103M
4	C2, C3, C4, C5	Cap. ceramic 33 nF 50V 10% X7R SMD 0603	TDK Corporation®	C1608X7R1H333K
1	C6	Cap. aluminum 100 µF 16V 20% SMD D	Nichicon Corporation®	UWX1C101MCL1GB
14	C7, C9, C12, C13, C14, C15, C16, C17, C23, C26, C27, C28, C29, C31	Cap. ceramic 0.1µF 25V 10% X7R SMD 0603	Murata Electronics®	GRM188R71E104KA01D
3	C8, C22, C25	Cap. ceramic 10 µF 10V 10% X7R SMD 0805	TDK Corporation	C2012X7R1A106K125AC
2	C10, C11	Cap. aluminum 4.7 µF 400V 20% RAD_P3.5D8H13	Nichicon Corporation	UVC2G4R7MPD1TD
1	C18	Cap. ceramic 4.7 µF 25V 10% X7R SMD 0805	TDK Corporation	C2012X7R1E475K125AB
2	C19, C21	Cap. ceramic 0.01 µF 16V 5% SMD 0603	Taiyo Yuden Co., Ltd.®	EMK107SD103JA-T
1	C20	Cap. ceramic 3300 pF 50V 10% X7R SMD 0603	ROHM Semiconductor®	C0603C332K5RACTU
1	C24	Cap. ceramic 10 µF 25V 10% X7R SMD 1206	Taiyo Yuden Co., Ltd.	TMK316B7106KL-TD
1	C30	Cap. ceramic 4.7µF 10V 10% X5R SMD 0805	Taiyo Yuden Co., Ltd.	LMK212BJ475KD-T
1	C32	Cap. ceramic 0.47 µF 6.3V 10% X5R SMD 0603	Murata Electronics	GRM188R60J474KA01D
1	D1	Diode rec. ES1G 1.25V 1A 400V SMD DO-214AC_SMA	Diodes Incorporated®	ES1G-13-F
3	D2, D3, D4	Diode rec. MRA4005 1.1V 1A 600V DO-214AC_SMA	ON Semiconductor®	MRA4005T3G
2	FB1, FB2	Ferrite 800 mA 0.15R SMD 0805	Laird Technologies	LI0805H151R-10
2	FB3, FB4	Ferrite 7A 0.01R RAD P5L5.3D3.8	Panasonic® – ECG	EXC-ELSR35S
1	J1	Conn. IEC 250V 15A Inlet C14 TH R/A	SCHURTER Inc.	GSP1.9103.1
1	J2	Conn. IEC 250V 15A Outlet C13 TH R/A	SCHURTER Inc.	6182.0033
1	J3	Conn. power 2.5 mm 5.5 mm Switch TH R/A	CUI Inc.	PJ-002B

Note: 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) (CONTINUED)

Qty.	Reference	Description	Manufacturer	Part Number
1	J5	Conn. header-2.54 Male 1x4 Tin 5.84MH TH vert.	FCI	68002-404HLF
4	J6, J7, J8, J9	Conn. header-2.54 Male 1x2 Tin 6.10MH TH vert.	Molex®	0022284020
1	J10	Conn. USB Mini-B Female TH vert.	Molex	500075-1517
3	JP1, JP2, JP3	Conn. header-2.54 Male 1x3 Gold 5.84MH TH vert.	FCI	68000-103HLF
2	L1, L2	Inductor 1 mH 240 mA 20% SMD L6W6H2.4	Coilcraft®	LPS6225-105MLB
4	LD1, LD2, LD3, LD4	Diode LED red 1.95V 30 mA 700 mcd Clear SMD 0603	Kingbright Corp.®	APTD1608SURCK
1	LD5	Diode LED bi red, green 1.95V, 2.1V 30mA 0805	Kingbright Corp.	APHBM2012SURKCGKC
1	MOV1	Res. Varistor 275V 130J TH DISC 14 mm	EPCOS AG	S14K275E2K1
1	PCB	Printed Circuit Board – MCP39F501 Power Monitor Demonstration Board	Microchip Technology Inc.®	04-10419
1	R1	Res. Shunt MF 0.002R 1% 2W 2512	Stackpole Electronics, Inc.	CSNL2512FT2L00
2	R2, R3	Res. TKF 499 kΩ 1% 3/4W SMD 2010	Vishay/Dale	CRCW2010499KFKEF
2	R4, R10	Res. TKF 4.7R 5% 1W SMD 2512	Stackpole Electronics, Inc.	RPC2512JT4R70
1	R5	Res. TKF 2.49R 1% 1/10W SMD 0603	Vishay/Dale	CRCW06032R49FKEA
15	R6, R7, R8, R9, R15, R23, R24, R25, R26, R27, R28, R29, R30, R33, R34	Res. TKF 1 kΩ 1% 1/10W SMD 0603	Panasonic – ECG	ERJ-3EKF1001V
5	R11, R21, R22, R31, R32	Res. TKF 100R 5% 1/10W SMD 0603	Vishay/Dale	CRCW0603100RJNEA
2	R12, R16	Res. TKF 2.05 kΩ 1% 1/10W SMD 0603	Yageo Corporation	RC0603FR-072K05L
2	R13, R14	Res. TKF 4.7 kΩ 1% 1/10W SMD 0603	Panasonic – ECG	ERJ-3EKF4701V
1	R17	Res. TKF 8.2 kΩ 1% 1/10W SMD 0603	Panasonic – ECG	ERJ-3EKF8201V
2	R18, R19	Res. TF 100 kΩ 1% 1/8W SMD 0603	Vishay/Dale	MCT06030C1003FP500
1	R20	Res. TKF 33R 5% 1/10W SMD 0603	Yageo Corporation	9C06031A33R0JLHFT
1	R35	Res. TKF 10 kΩ 1% 1/10W SMD 0603	Panasonic – ECG	ERJ-3EKF1002V
1	U3	IC Switcher LNK304 SO-8C	Power Integrations™	LNK304DG-TL
1	U6	IC Photo FOD8012 Bi-Dir 3.3V and 5V SOIC-8	Fairchild Semiconductor®	FOD8012
4	U7, U8, U9, U10	IC Photo HCPL-181 4-SMD	Avago Technologies	HCPL-181-00CE

Note: 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-2: BILL OF MATERIALS – MICROCHIP CONSIGNED PARTS

Qty.	Reference	Description	Manufacturer	Part Number
1	U1	MCHP Analog Energy Measurement 4000:1 MCP39F511-E/MQ QFN-28	Microchip Technology Inc.	**MCP39F511-E/MQ**
1	U2	MCHP Analog Temperature Sensor -40°C to +150°C MCP9700T-E/TT SOT-23-3	Microchip Technology Inc.	**MCP9700T-E/TT**
1	U4	MCHP Analog OPAMP 1-Ch 10 MHz MCP6021T-E/OT SOT-23-5	Microchip Technology Inc.	**MCP6021T-E/OT**
1	U5	MCHP Analog LDO 3.3V MCP1754ST-3302E/DB SOT-223-3	Microchip Technology Inc.	**MCP1754ST-3302E/DB**
1	U11	MCHP Interface USB I^2C UART MCP2221-I/ST TSSOP-14	Microchip Technology Inc.	**MCP2221-I/ST**

Note: 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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