MCP39F521 Power Monitor Demonstration Board User's Guide

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Object of Declaration: MCP39F521 Power Monitor Demonstration Board

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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

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MCP39F521 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 MCP39F521 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 MCP39F521 Power Monitor Demonstration Board to evaluate the MCP39F521 device. The manual layout is as follows:

- **Chapter 1. "Product Overview"** – Provides important information about the MCP39F521 Power Monitor Demonstration Board
- **Chapter 2. "Installation and Operation"** – Provides information on using the MCP39F521 Power Monitor Demonstration Board, including **Section 2.1.1** 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 MCP39F521 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 the MCP39F521 Power Monitor Demonstration Board. Other useful documents are listed below. The following Microchip documents are available and recommended as supplemental reference resources.

MCP39F521 Data Sheet – *"I²C Single Phase Energy and Power Monitoring IC with Calculation"* (DS20005442)

This data sheet provides detailed information regarding the MCP39F521 device.

THE MICROCHIP WEB SITE

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

DOCUMENT REVISION HISTORY

Revision A (September 2015)

- Initial release of this document.

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Chapter 1. Product Overview

1.1 INTRODUCTION

The MCP39F521 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 MCP39F521 data sheet.

The "MCP39F521 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 MCP39F521 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 the use of this software, refer to the software's supporting documentation included within the application install package.

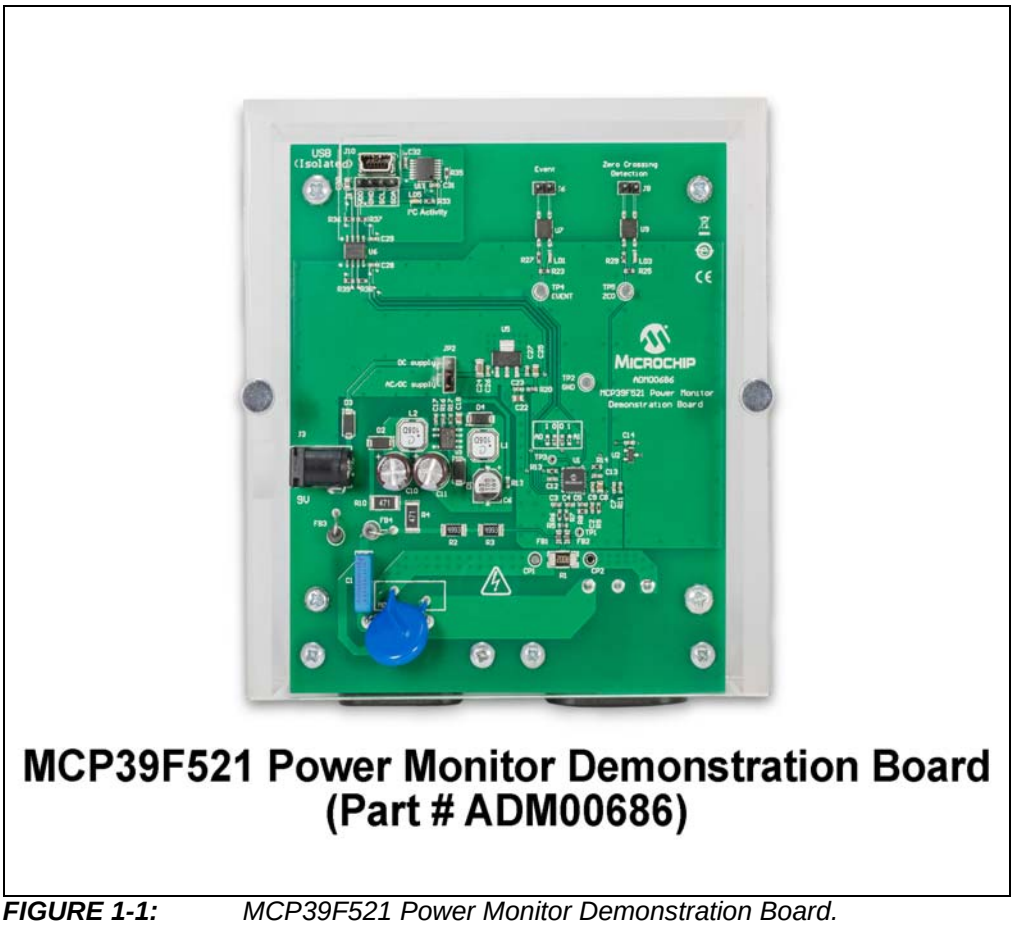

FIGURE 1-1: *MCP39F521 Power Monitor Demonstration Board.*

1.2 WHAT THE MCP39F521 POWER MONITOR DEMONSTRATION BOARD KIT INCLUDES

This MCP39F521 Power Monitor Demonstration Board kit includes:

- MCP39F521 Power Monitor Demonstration Board (ADM00686)
- 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 MCP39F521 Power Monitor Demonstration Board, follow the steps described in the following sections. 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 MCP39F521 Power Monitor Demonstration Board.

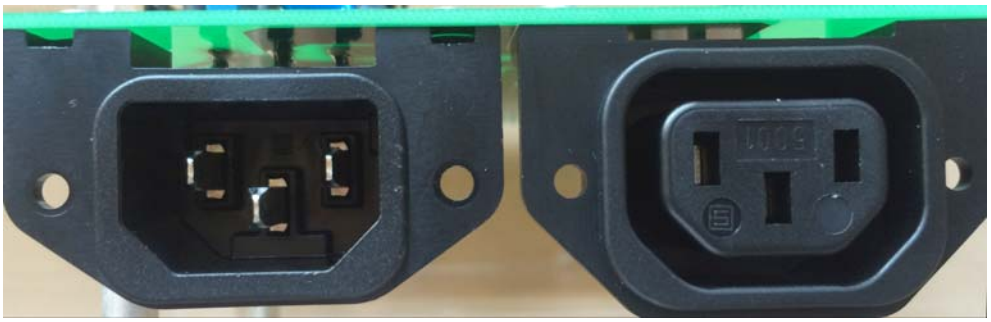

FIGURE 2-1: *Connecting the MCP39F521 Power Monitor Demonstration Board.*

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 is powered by 90V to 220V.

2.1.3 Step 3: Connect the USB cable to a PC with the installed "MCP39F521 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 MCP39F521.

NOTES:

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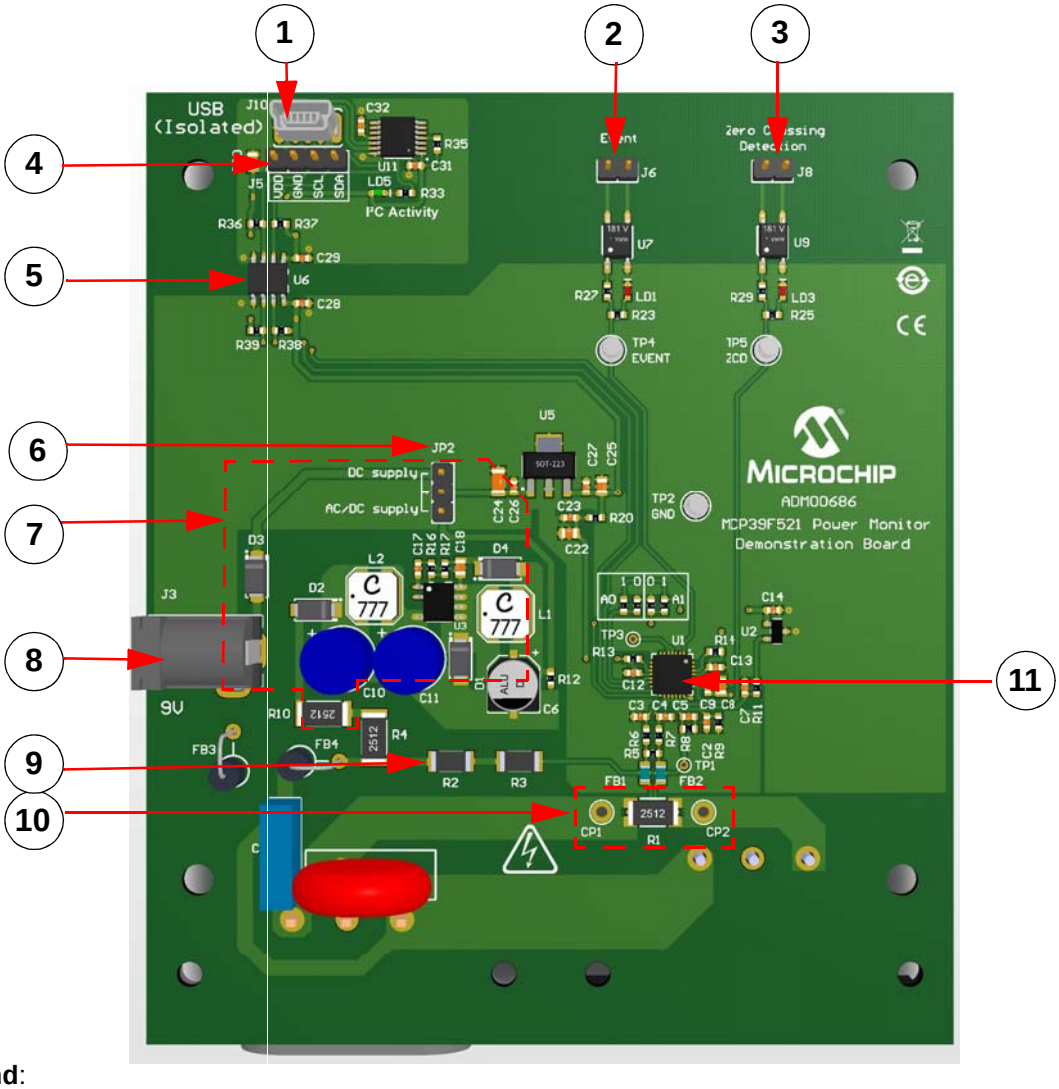
Chapter 3. Hardware Description

This chapter identifies the main features of the MCP39F521 board and describes the circuits. Figure 3-1 illustrates the components on the top view.

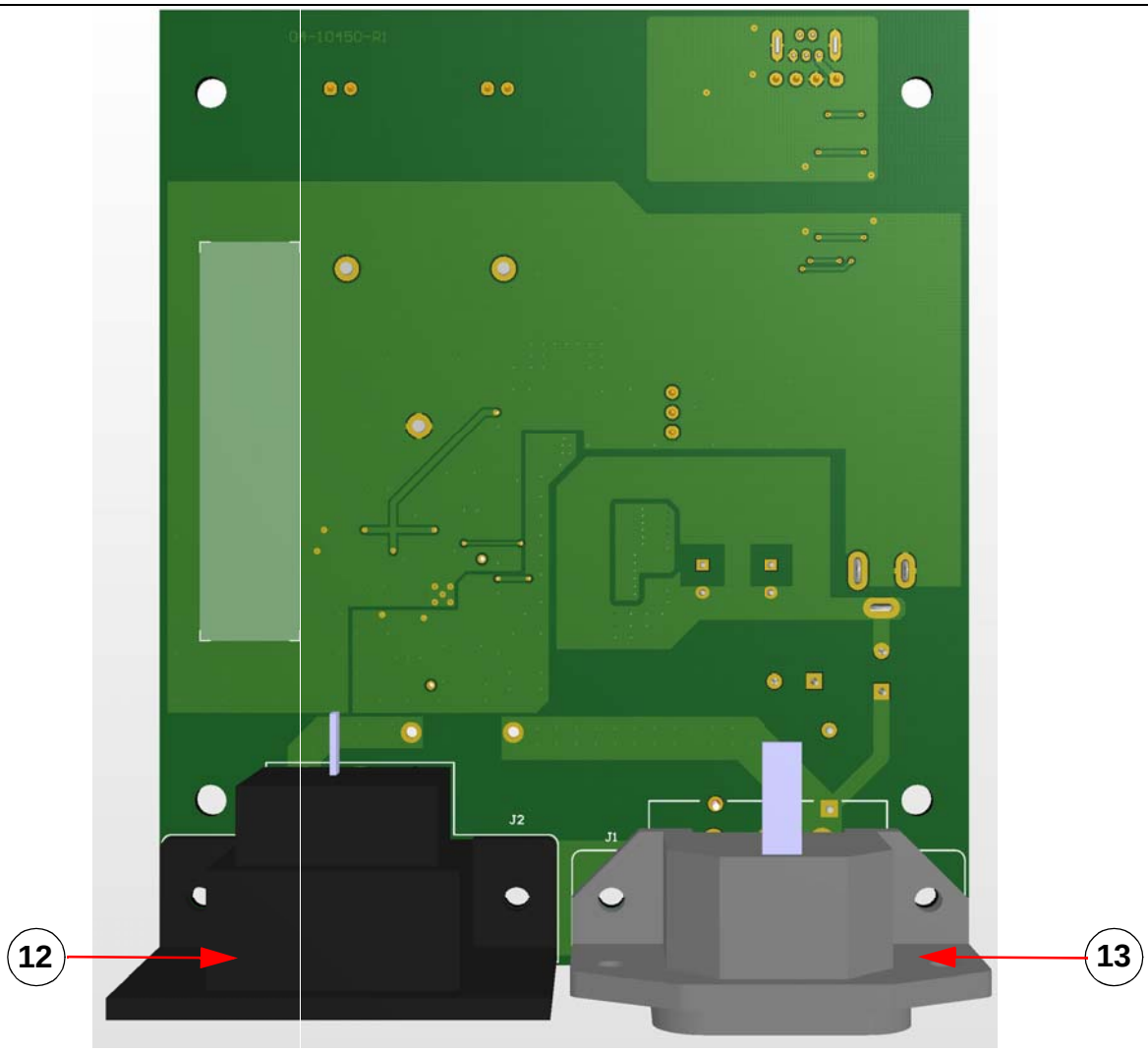


Legend:

1 = USB Connection (isolated)
2 = Event Digital Output
3 = Zero Cross Digital Output
4 = Header for connection to external master MCU (isolated)
5 = Isolation IC
6 = Jumper for DC or Switching AC/DC Supply
7 = Switching AC/DC Power Supply
8 = +9V DC Input (non-isolated)
9 = 1000:1 Voltage Divider for Voltage Input
10 = Connections to external shunt current sensing resistor
11 = MCP39F521

FIGURE 3-1: *MCP39F521 Power Monitor Demonstration Board Top View.*

Figure 3-2 illustrates the components on the board's bottom view.



Legend:

12	=	Load connection (15A maximum recommended current)
13	=	Line connection AC supply (90-230V)

FIGURE 3-2: *MCP39F521 Power Monitor Demonstration Board Bottom View.*

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3.1 INPUT AND ANALOG FRONT END

The MCP39F521 Power Monitor Demonstration Board will operate from 90V to 230V. At the bottom of the main board are the high-voltage line and neutral connections. The shunt sits on the neutral side, 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 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}.

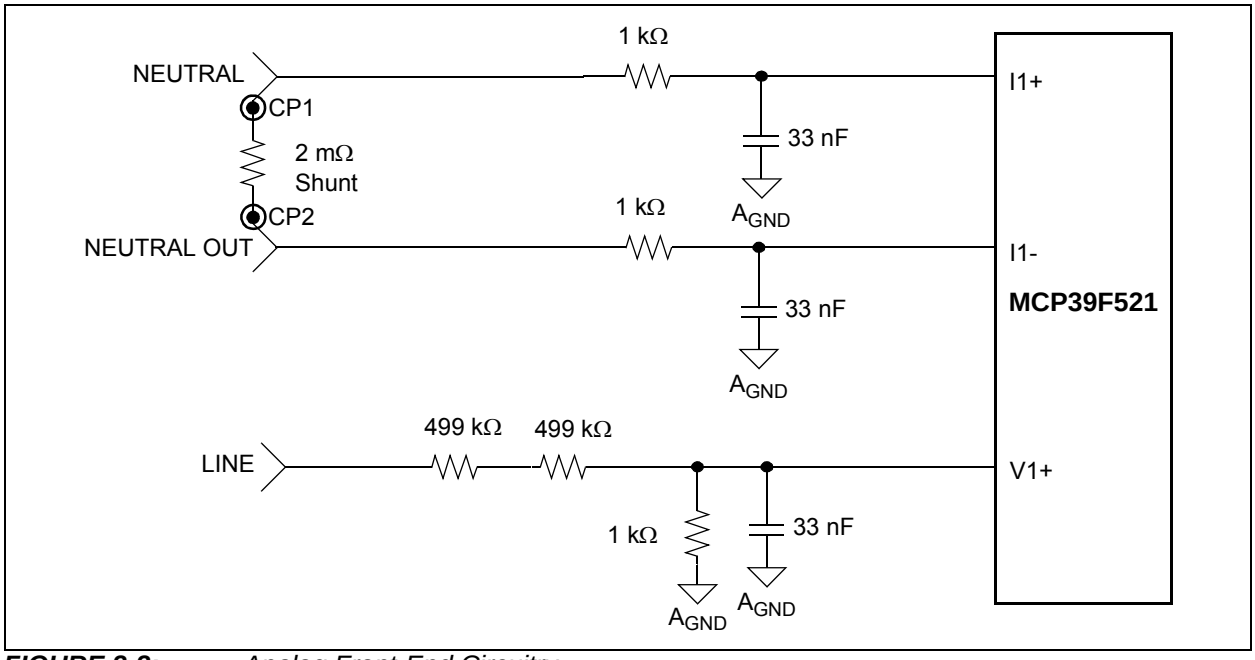

FIGURE 3-3: *Analog Front-End Circuitry.*

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 MCP39F521 Power Monitor Demonstration Board is shown in Figure 3-4.

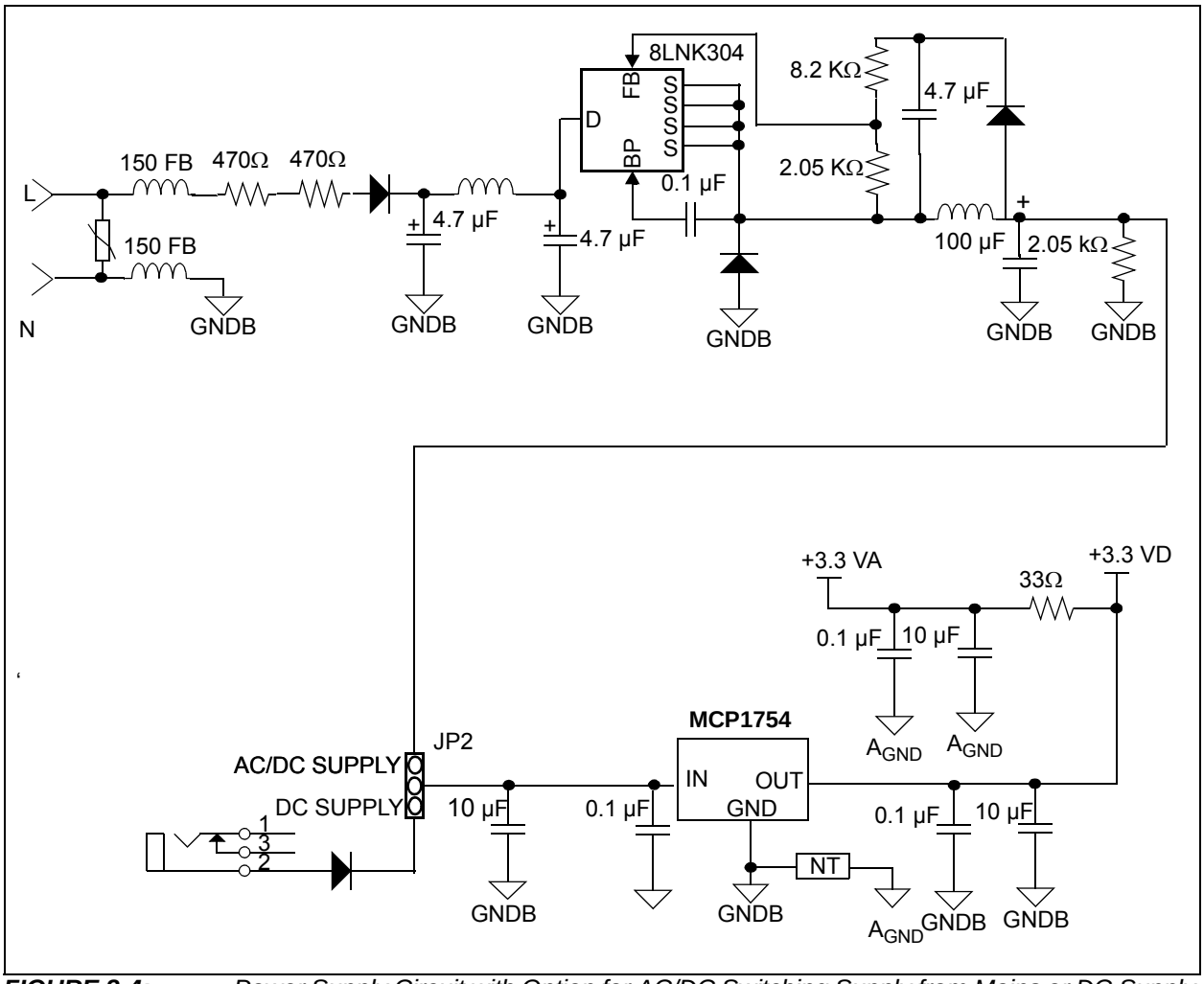

FIGURE 3-4: *Power Supply Circuit with Option for AC/DC Switching Supply from Mains or DC Supply.*

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Appendix A. Schematic and Layouts

A.1 INTRODUCTION

This appendix contains the following schematics and layouts for of the MCP39F521 Power Monitor Demonstration Board:

- Board – MCP39F521 Schematic
- Board – Power and USB Schematic
- Board – Top Silk
- Board – Top Copper and Silk
- Board – Top Copper
- Board – Bottom Copper
- Board – Bottom Copper and Silk
- Board – Bottom Silk

A.2 SCHEMATICS AND PCB LAYOUT

The layer order is shown in Figure A-1.

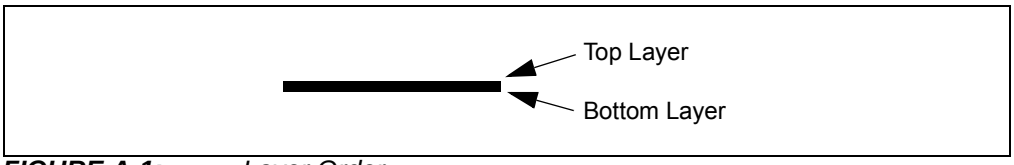
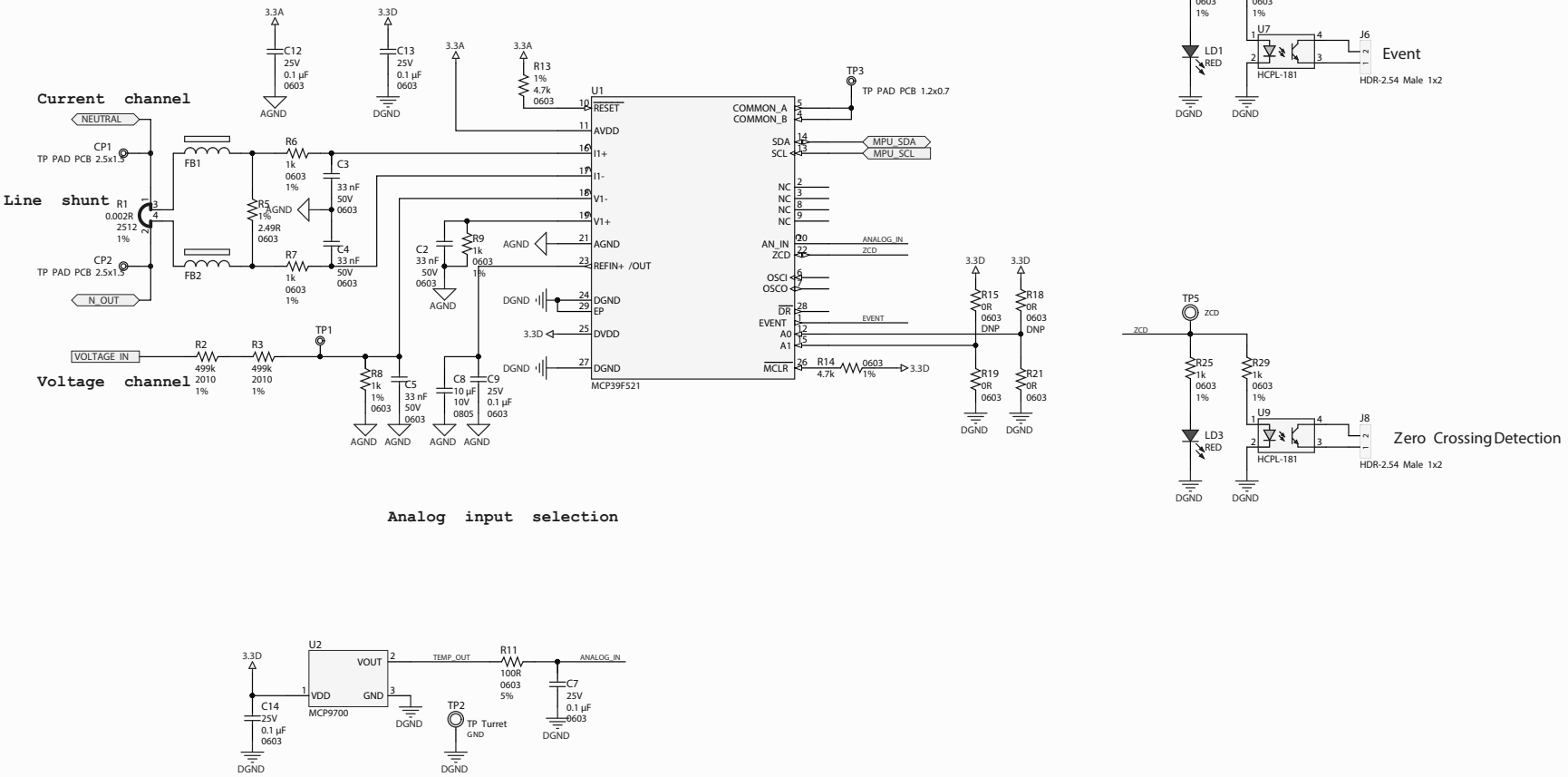


FIGURE A-1: *Layer Order.*

A.3 BOARD – MCP39F521 SCHEMATIC



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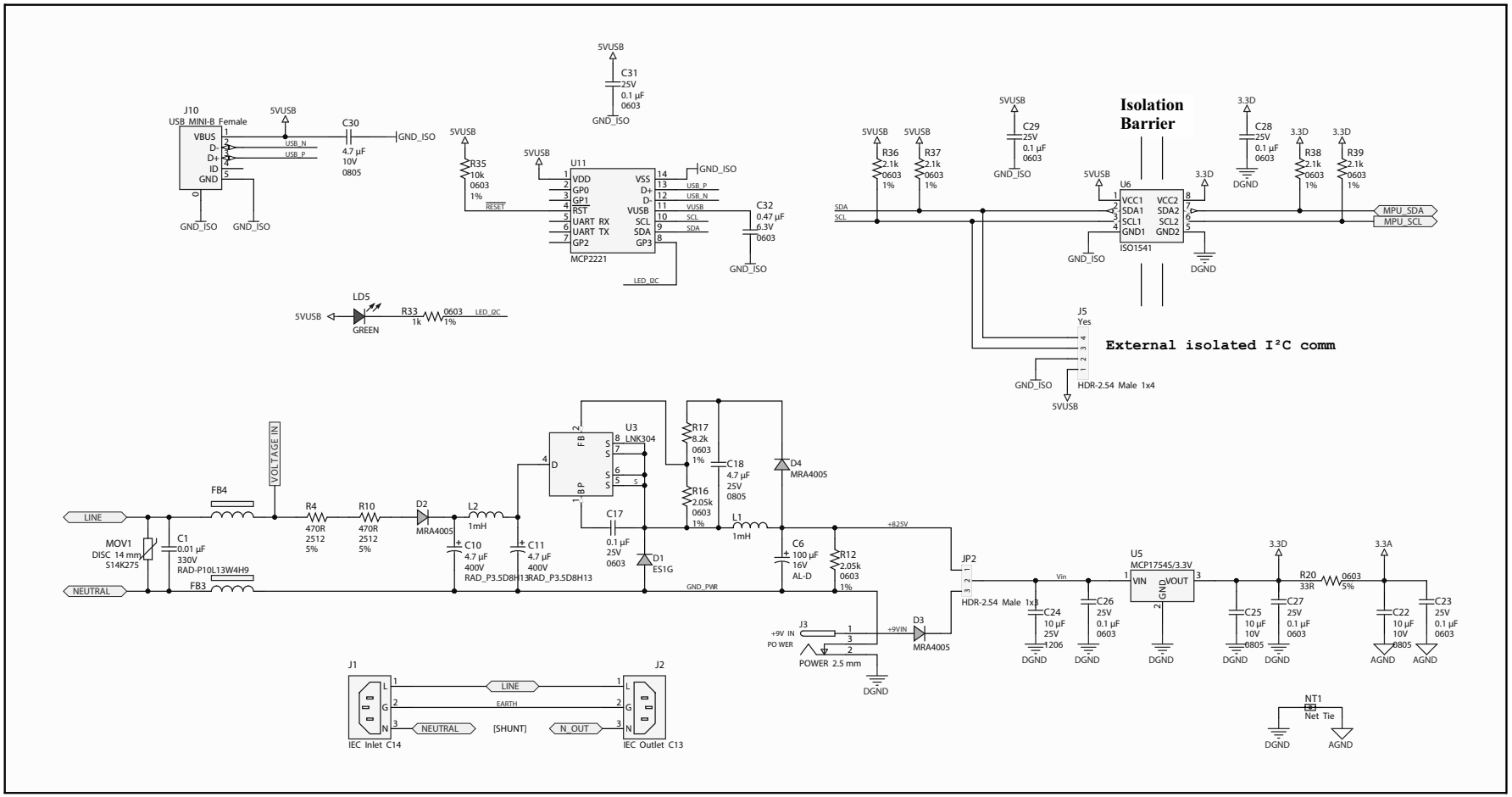
A.4 BOARD – POWER AND USB SCHEMATIC



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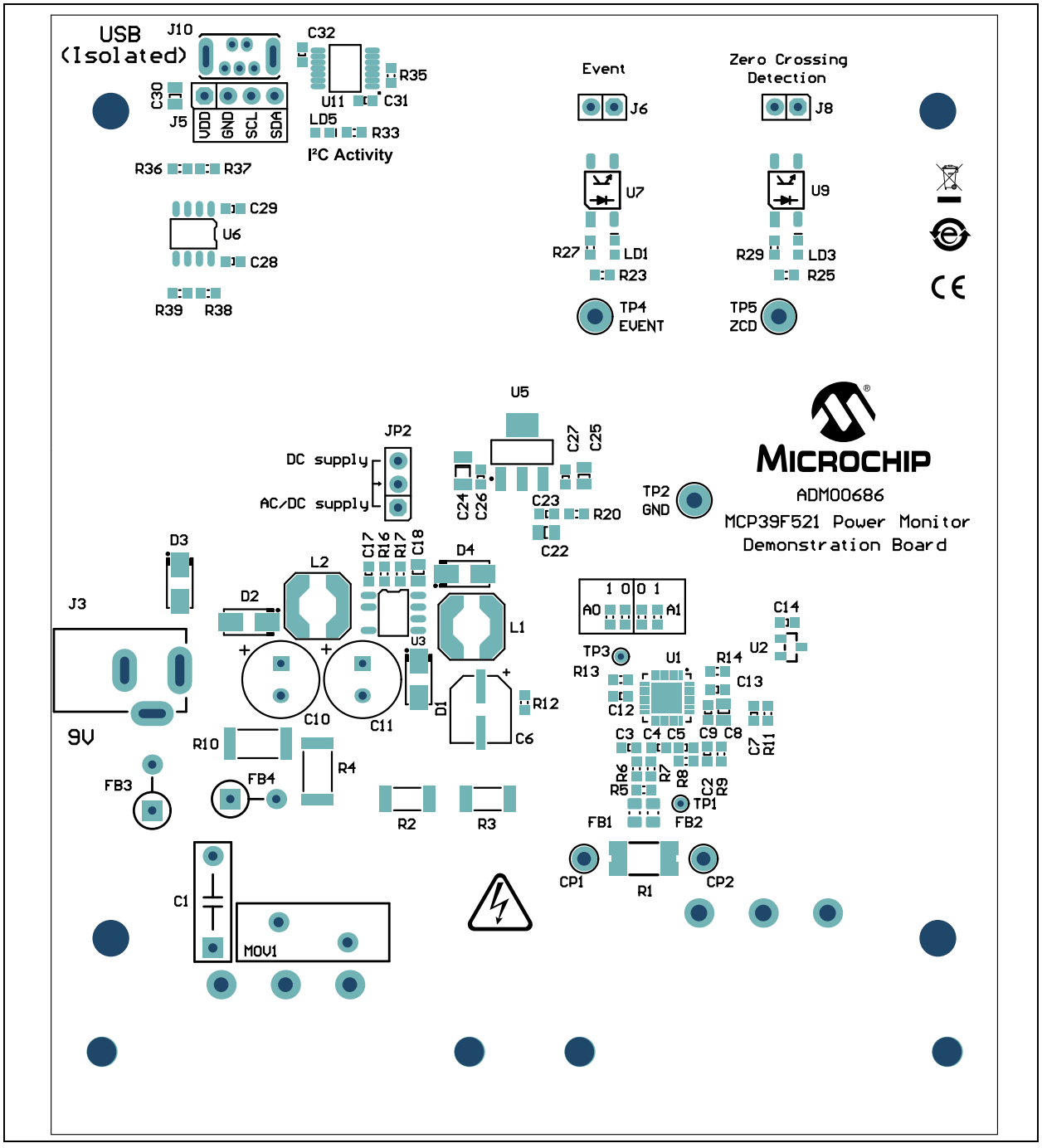
A.5 BOARD – TOP SILK



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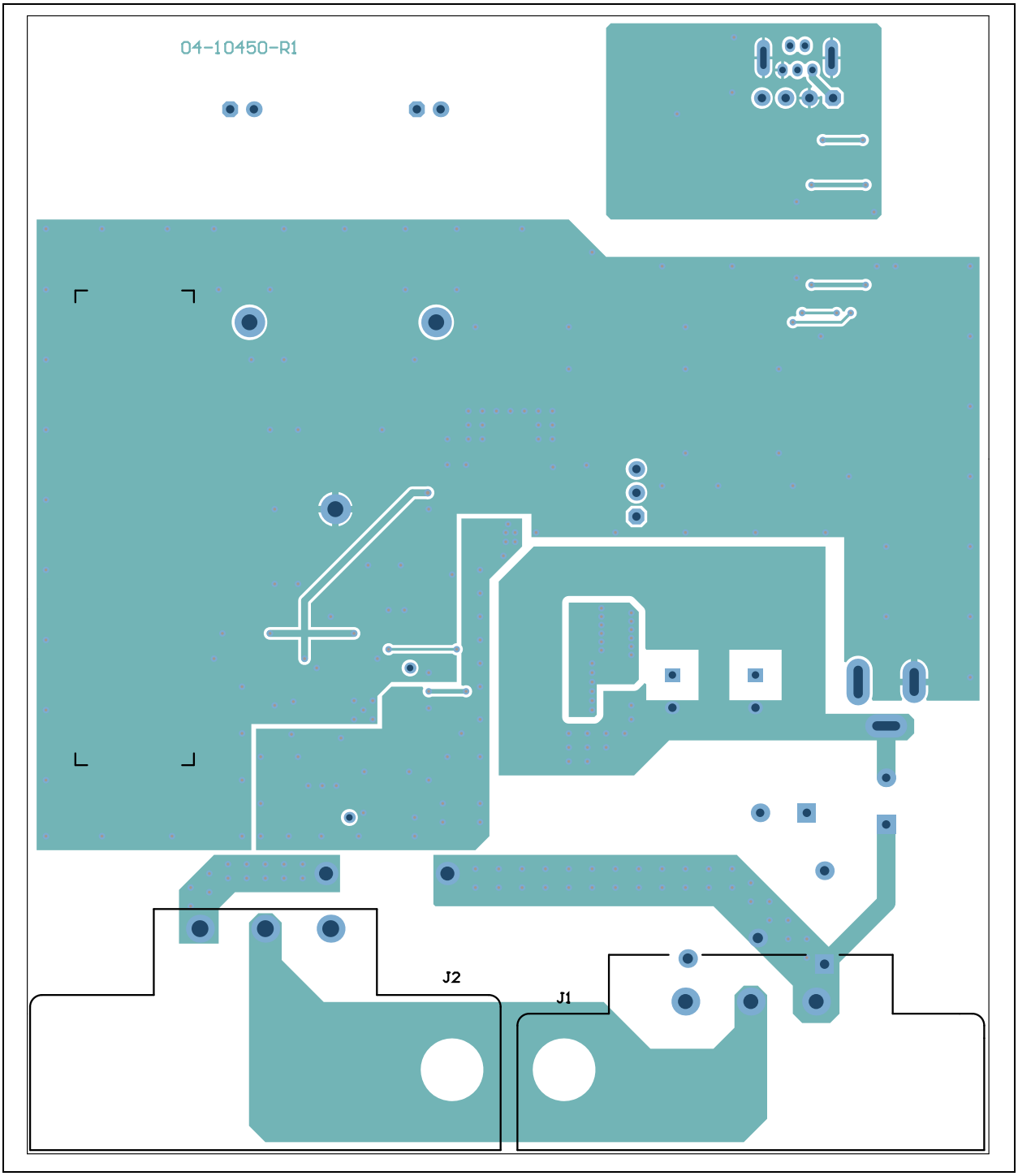
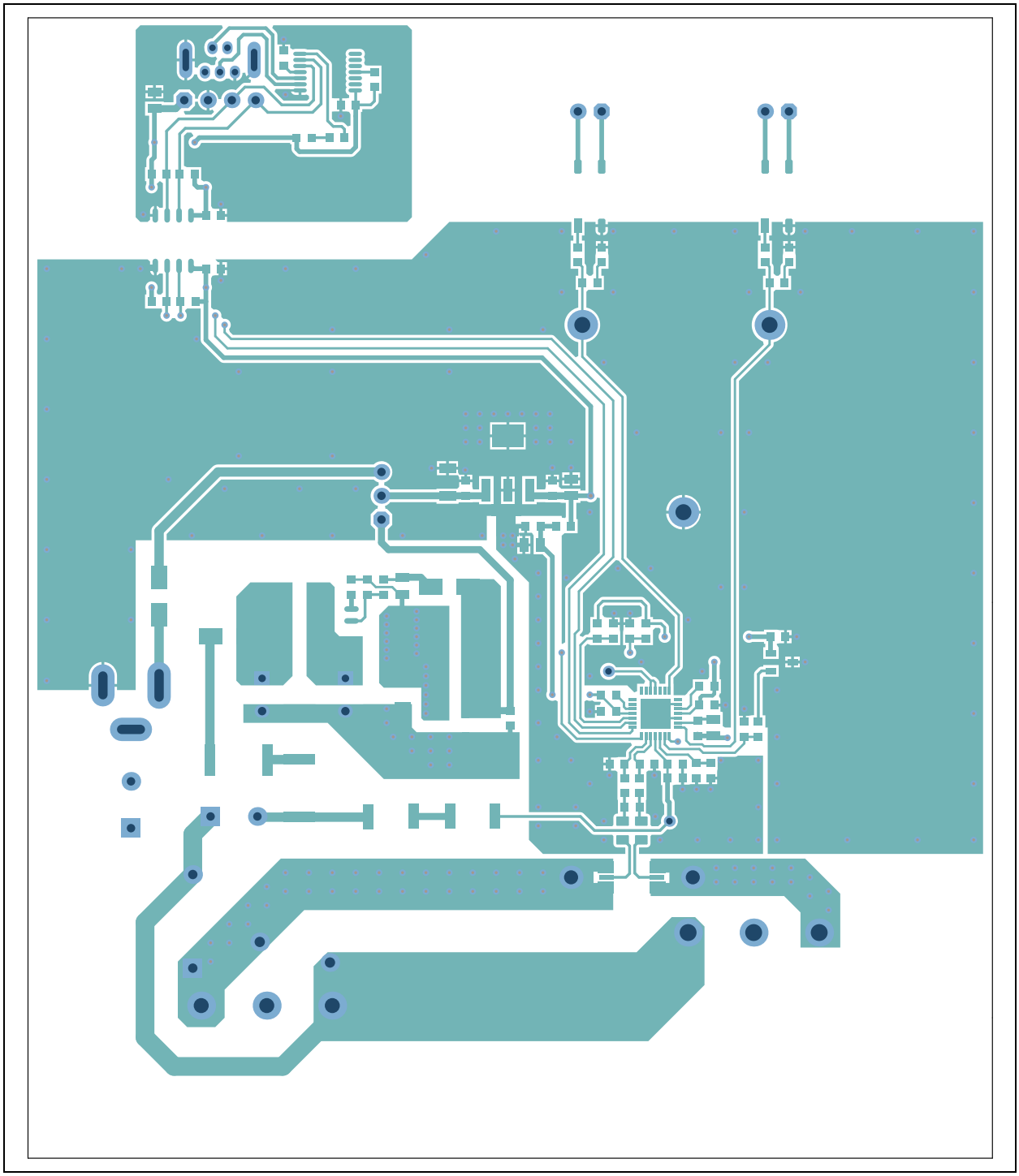
A.6 BOARD – TOP COPPER AND SILK



A.7 BOARD – TOP COPPER



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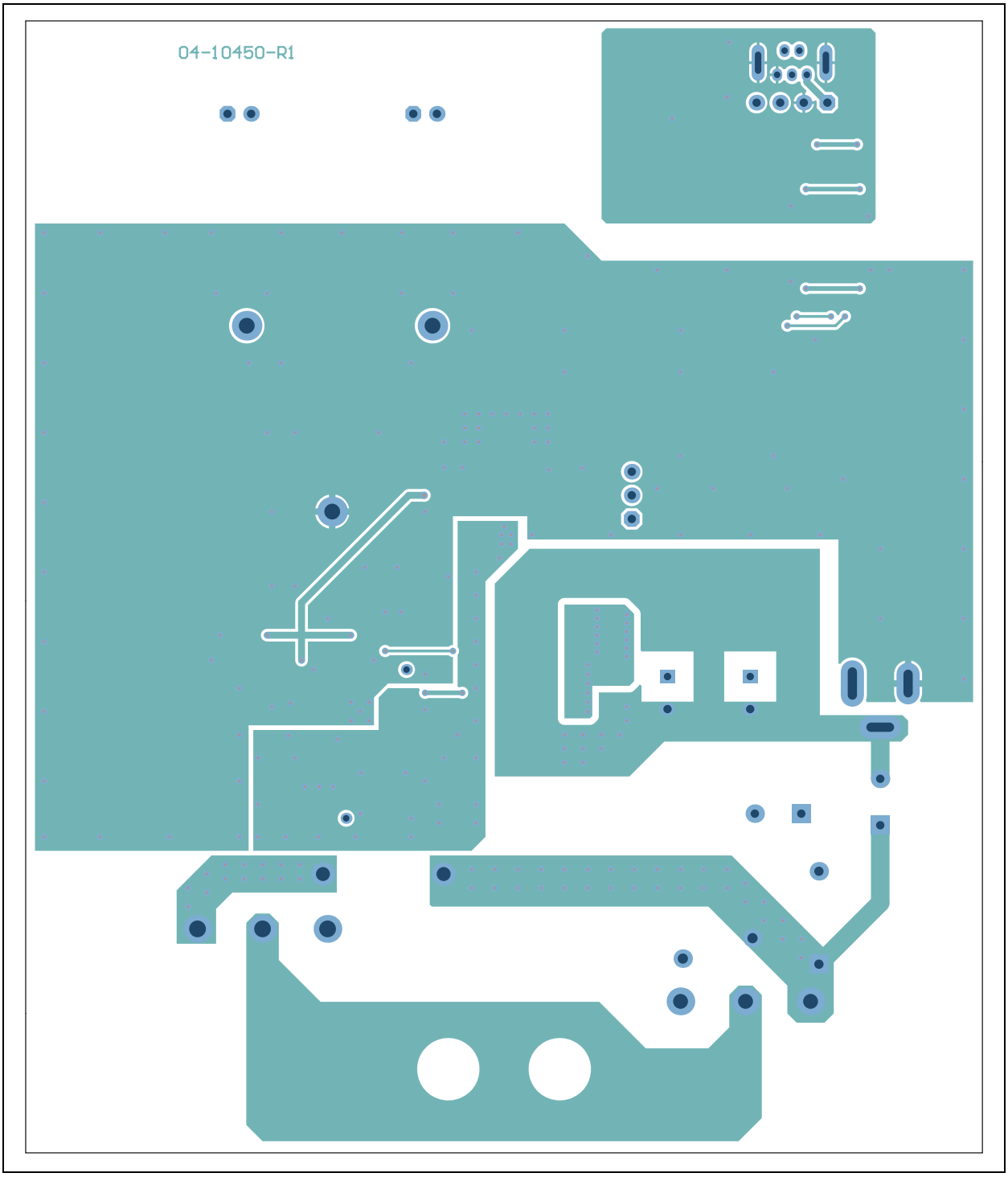
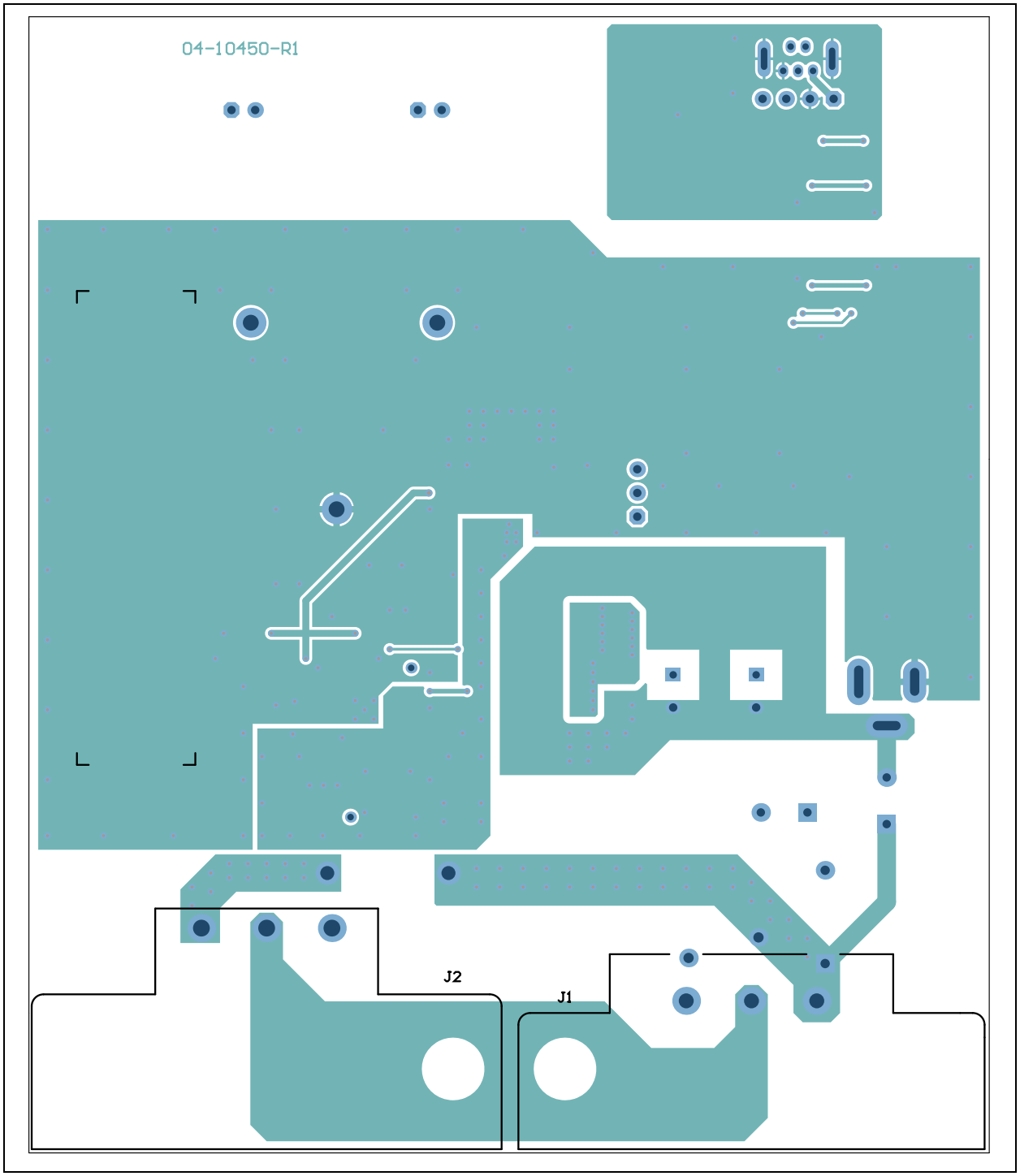
A.8 BOARD – BOTTOM COPPER



A.9 BOARD – BOTTOM COPPER AND SILK



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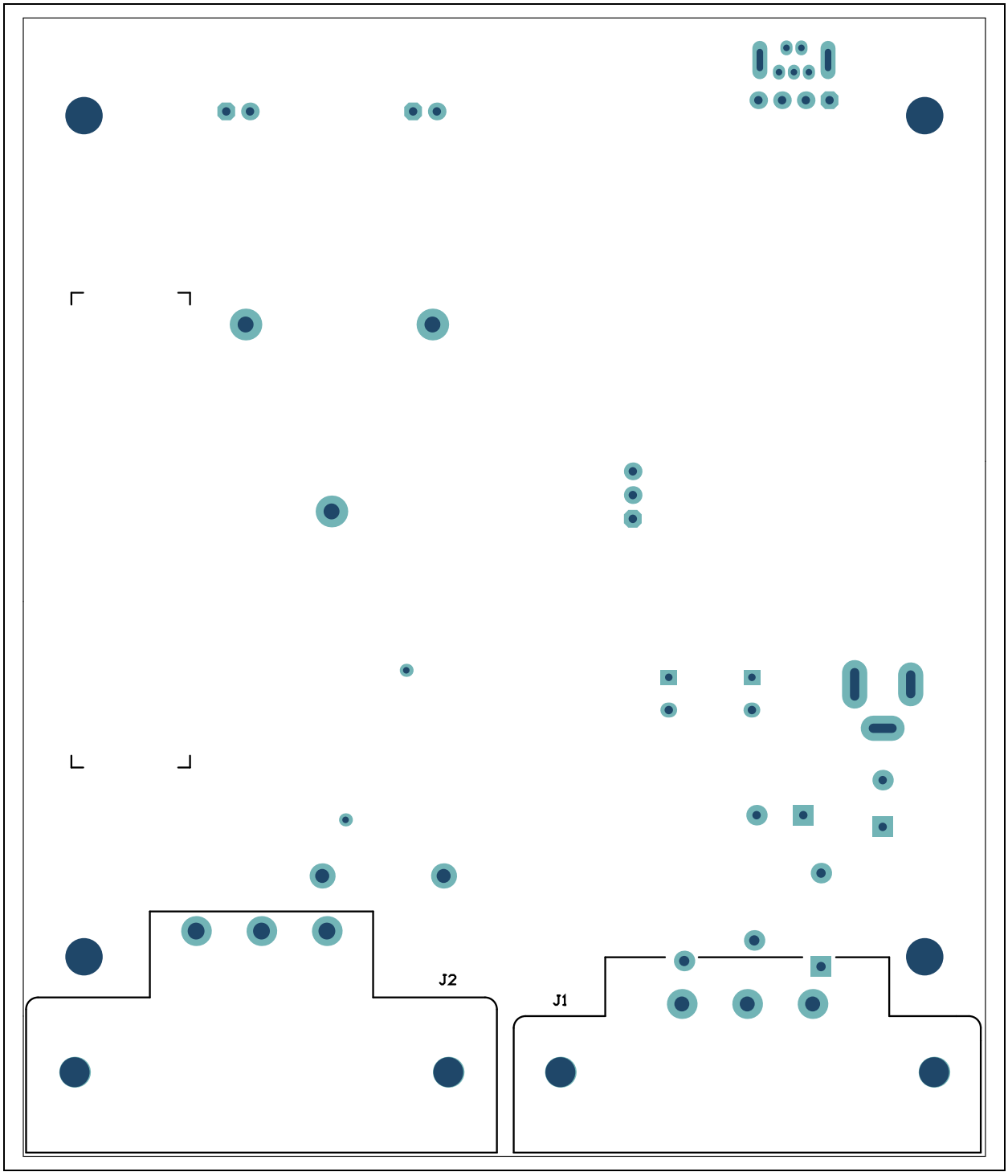
A.10 BOARD – BOTTOM SILK



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Appendix B. Bill of Materials (BOM)

TABLE B-1: BILL OF MATERIALS (BOM)

Qty.	Designator	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
12	C7, C9, C12, C13, C14, C17, C23, C26, C27, C28, C29, C31	Cap. ceramic 0.1 µF 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
1	C24	Cap. ceramic 10 µF 25V 10% X7R SMD 1206	Taiyo Yuden Co., Ltd.	MK316B7106KL-TD
1	C30	Cap. ceramic 4.7 µF 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
1	J5	Conn. Header-2.54 Male 1x4 Tin 5.84 MH TH Vert.	FCI	68002-404HLF
2	J6, J8	Conn. Header-2.54 Male 1x2 Tin 6.10 MH TH Vert.	Molex®	0022284020
1	J10	Conn. Header-2.54 Male 1x2 Tin 6.10 MH TH Vert.	Molex	500075-1517
1	JP2	Conn. Header-2.54 Male 1x3 Gold 5.84 MH TH Vert.	FCI	68000-103HLF

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) (CONTINUED)

Qty.	Designator	Description	Manufacturer	Part Number
3	JP4	Mech. HW Jumper 2.54 mm 1x2 Handle Gold	TE Connectivity, Ltd.	881545-2
2	L1, L2	Inductor 1 mH 240 mA 20% SMD L6W6H2.4	Coilcraft	LPS6225-105MLB
2	LD1, LD3	Diode LED red 1.95V 30 mA 700 mcd Clear SMD 0603	Kingbright Corp.	APTD1608SURCK
1	LD5	Diode LED green 2V 30 mA 35 mcd Clear SMD 0603	Lite-On® Technology Corporation	LTST-C190KGKT
1	MOV1	Res. Varistor 275V 130J TH DISC 14 mm	EPCOS AG	S14K275E2K1
1	PCB	MCP39F521 Printed Circuit Board	—	04-00686-R1
1	R1	Res. Shunt MF 0.002R 1% 2W 2512	Stackpole Electronics, Inc.	CSNL2512FT2L00
2	R2, R3	Res. TKF 499k 1% 3/4W SMD 2010	Vishay/Dale	CRCW2010499KFKEF
2	R4, R10	Res. TKF 470R 5% 1W SMD 2512	Panasonic - ECG	ERJ-1TYJ471U
1	R5	Res. TKF 2.49R 1% 1/10W SMD 0603	Vishay Intertechnology, Inc.	CRCW06032R49FKEA
9	R6, R7, R8, R9, R23, R25, R27, R29, R33	Res. TKF 1k 1% 1/10W SMD 0603	Panasonic - ECG	ERJ-3EKF1001V
1	R11	Res. TKF 100R 5% 1/10W SMD 0603	Vishay Intertechnology, Inc.	CRCW0603100RJNEA
2	R12, R16	Res. TKF 2.05k 1% 1/10W SMD 0603	Yageo Corporation	RC0603FR-072K05L
2	R13, R14	Res. TKF 4.7k 1% 1/10W SMD 0603	Panasonic - ECG	ERJ-3EKF4701V
2	R15, R18	Res. TKF 0R 1/10W SMD 0603	NIC Components Corp.	NRC06Z0TRF
1	R17	Res. TKF 8.2k 1% 1/10W SMD 0603	Panasonic - ECG	ERJ-3EKF8201V
2	R19, R21	Res. TKF 0R 1/10W SMD 0603	NIC Components Corp.	NRC06Z0TRF
1	R20	Res. TKF 33R 5% 1/10W SMD 0603	Yageo Corporation	9C06031A33R0JLHFT
1	R35	Res. TKF 10k 1% 1/10W SMD 0603	Panasonic - ECG	ERJ-3EKF1002V
4	R36, R37, R38, R39	Res. TKF 2.1k 1% 1/10W SMD 0603	Panasonic - ECG	ERJ-3EKF2101V
3	TP2, TP4, TP5	Conn. TP Pin Tin TH	Harwin Plc.	H2121-01
1	U1	MCHP Analog Energy Measurement 4000:1 MCP39F521-E/MQ QFN-28	Microchip Technology, Inc.	**MCP39F521-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	U3	IC Switcher LNK304 SO-8C	Power Integrations™	LNK304DG-TL
1	U5	MCHP Analog LDO 3.3V MCP1754ST-3302E/DB SOT-223-3	Microchip Technology Inc.	**MCP1754ST-3302E/DB**
1	U6	IC Isolator ISO1541DR Bidirectional I2C SOIC-8	Texas Instruments	SO1541DR
2	U7, U9	IC Photo HCPL-181 4-SMD	Avago Technologies	HCPL-181-00CE
1	U11	MCHP Interface USB I2C UART MCP2221-I/ST TSSOP-14	Microchip Technology Inc.	**MCP2221-I/ST**

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-2: BILL OF MATERIALS (BOM) — MECHANICAL PARTS

Qty.	Designator	Description	Manufacturer	Par Number
4	NUT1	Hex Nut 5/16" 6-32	B&F™ Fasteners Supply	HNZ 632
4	SCR1	Machine Screw Pan Phillips 6-32	B&F Fasteners Supply	PMS 632 0038 PH

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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