



**MCP39F511**  
**Power Monitor**  
**Demonstration Board**  
**User's Guide**

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USA

This declaration of conformity is issued by the manufacturer.

The development/evaluation tool is designed to be used for research and development in a laboratory environment. This development/evaluation tool is not intended to be a finished appliance, nor is it intended for incorporation into finished appliances that are made commercially available as single functional units to end users. This development/evaluation tool complies with EU EMC Directive 2004/108/EC and as supported by the European Commission's Guide for the EMC Directive 2004/108/EC (8<sup>th</sup> February 2010).

This development/evaluation tool complies with EU RoHS2 Directive 2011/65/EU.

This development/evaluation tool, when incorporating wireless and radio-telecom functionality, is in compliance with the essential requirement and other relevant provisions of the R&TTE Directive 1999/5/EC and the FCC rules as stated in the declaration of conformity provided in the module datasheet and the module product page available at [www.microchip.com](http://www.microchip.com).

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

  
Derek Carlson  
VP Development Tools

12-Sep-14  
Date

NOTES:



# MCP39F511 POWER MONITOR DEMONSTRATION BOARD USER'S GUIDE

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## Preface

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### 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](http://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 “DSXXXXXXA”, where “XXXXXXX” 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                                                    |
|--------------------------------------------------|-----------------------------------------------------------------------------------------------------|-------------------------------------------------------------|
| <b>Arial font:</b>                               |                                                                                                     |                                                             |
| Italic characters                                | Referenced books                                                                                    | <i>MPLAB<sup>®</sup> 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&gt;Save</i></u>                                  |
| Bold characters                                  | A dialog button                                                                                     | Click <b>OK</b>                                             |
|                                                  | A tab                                                                                               | Click the <b>Power</b> 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>                                         |
| <b>Courier New font:</b>                         |                                                                                                     |                                                             |
| 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                                                                                 | <i>file.o</i> , where <i>file</i> can be any valid filename |
| Square brackets [ ]                              | Optional arguments                                                                                  | mcc18 [options] <i>file</i> [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)<br>{ ...<br>}                              |

## 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](http://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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Users of Microchip products can receive assistance through several channels:

- 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 (March 2015)

- Initial Release of this Document.

NOTES:

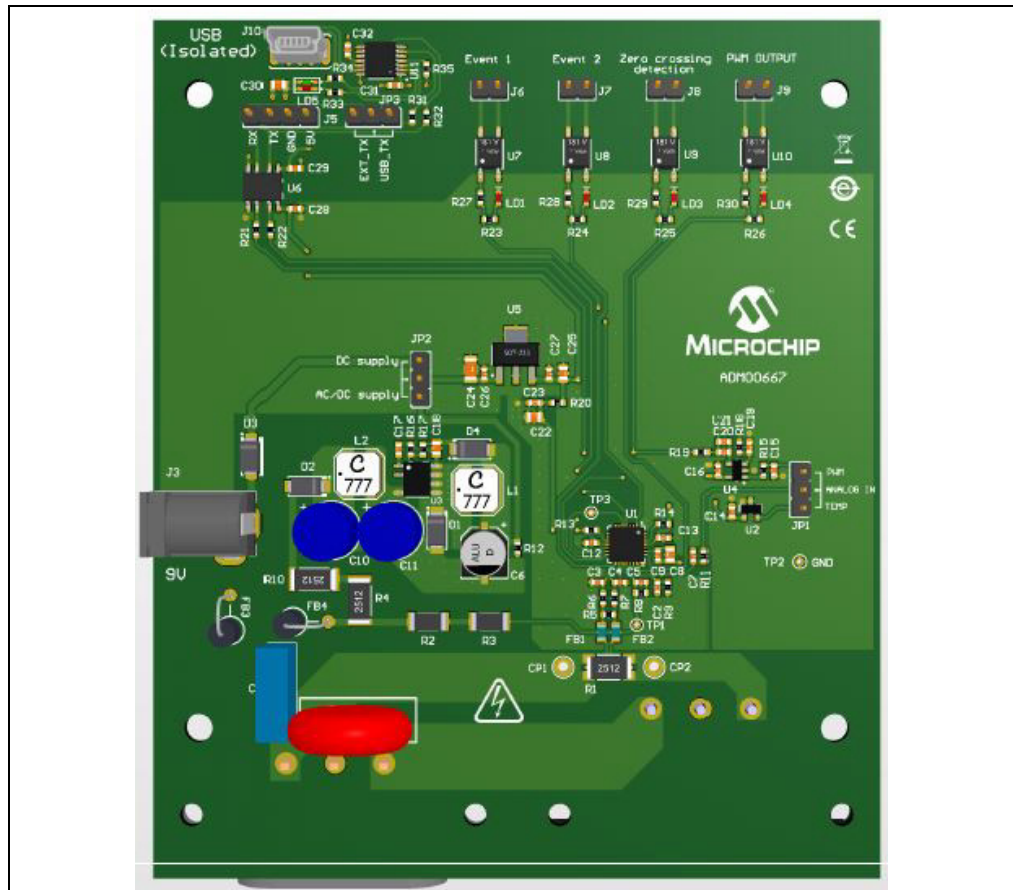
## Chapter 1. Product Overview

### 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

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### 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.

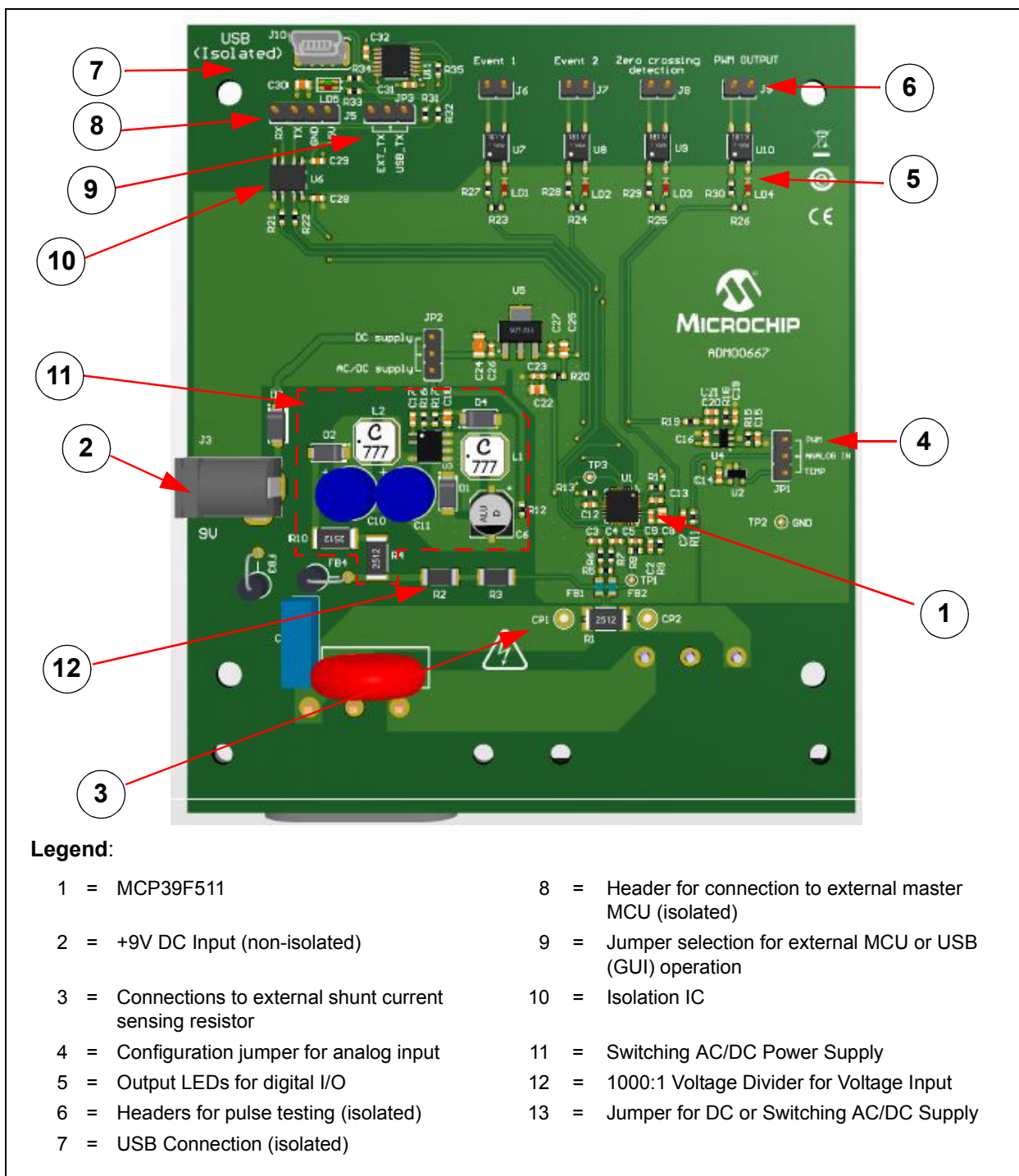
#### 2.1.3 Step 3: Connect the USB cable to a PC with the installed “MCP39F511 Power Monitor Utility” software

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

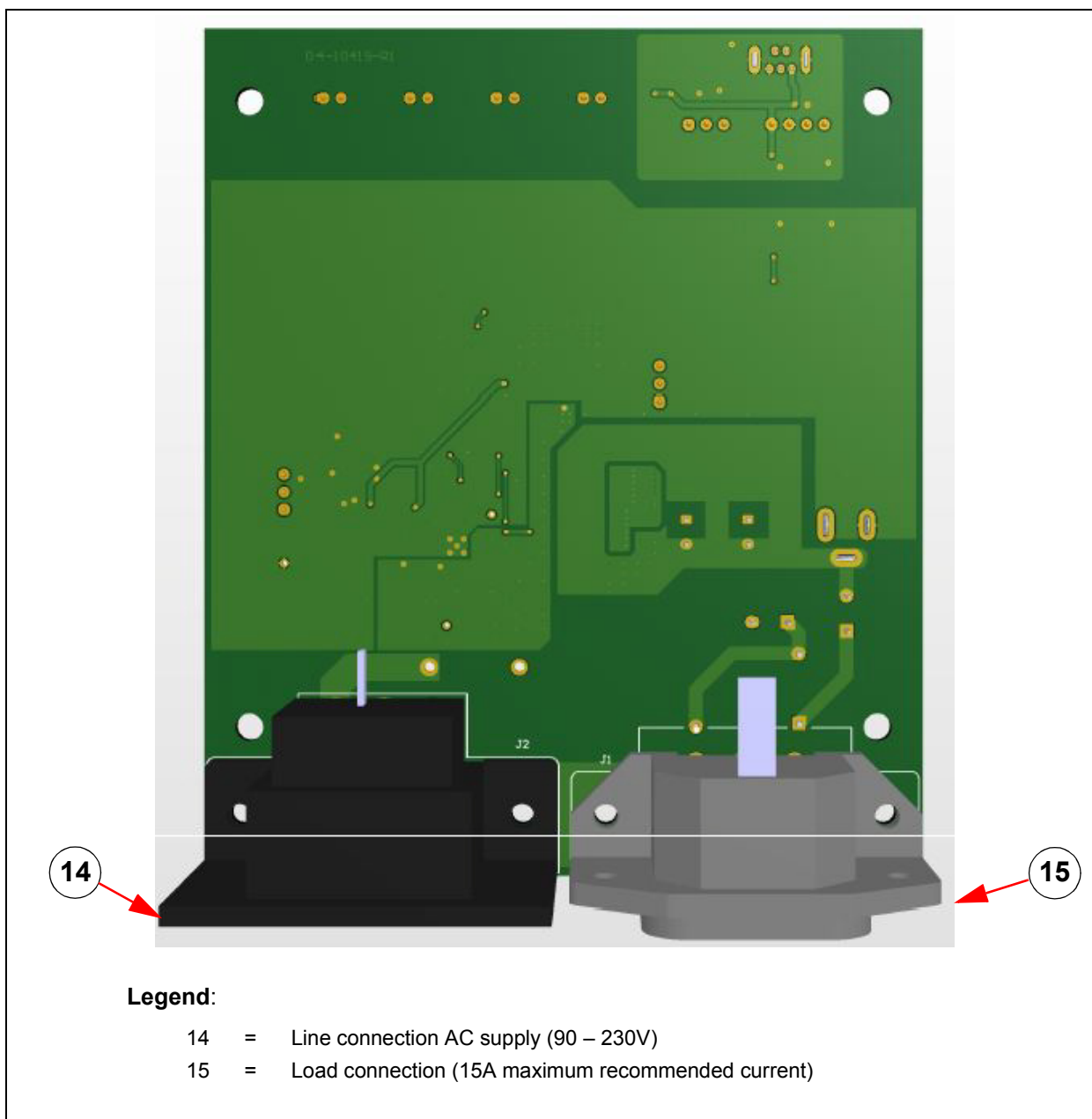
**Note:** For instructions on using the software GUI, please refer to the help file located in the program installation directory and also on the website: MCP39F511 Power Monitor Software User Manual.pdf

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## Chapter 3. Hardware Description



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

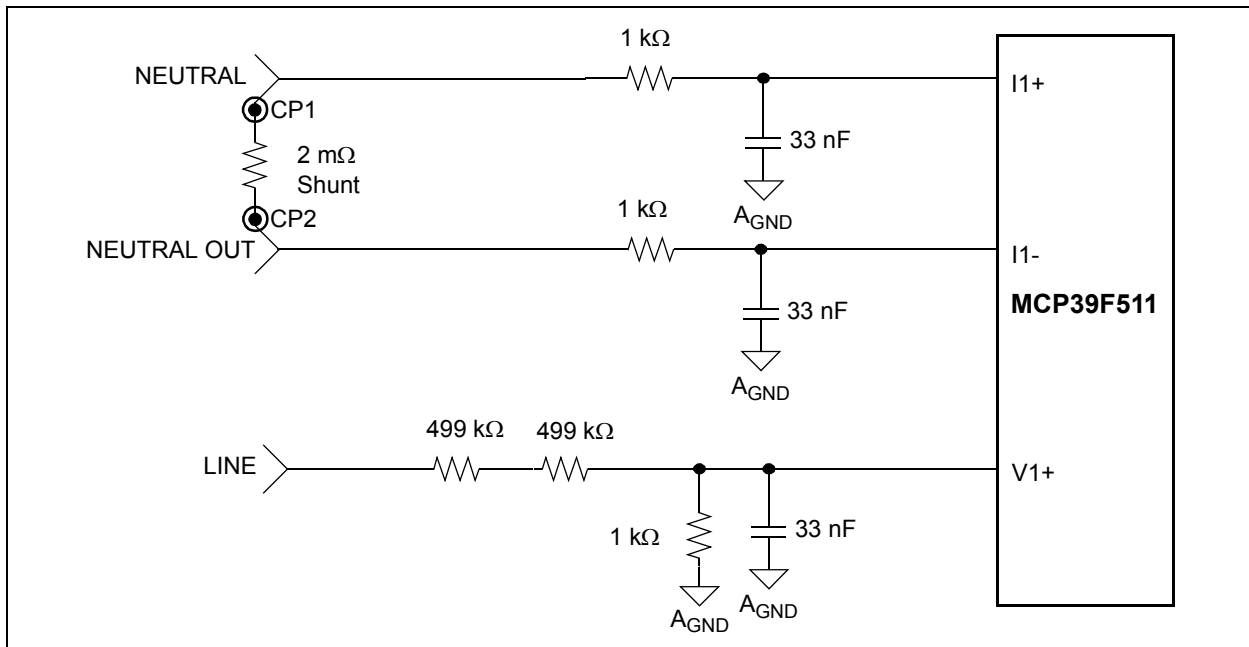


**FIGURE 3-2:** MCP39F511 Power Monitor Demonstration Board Bottom View.

## 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<sub>RMS</sub>.

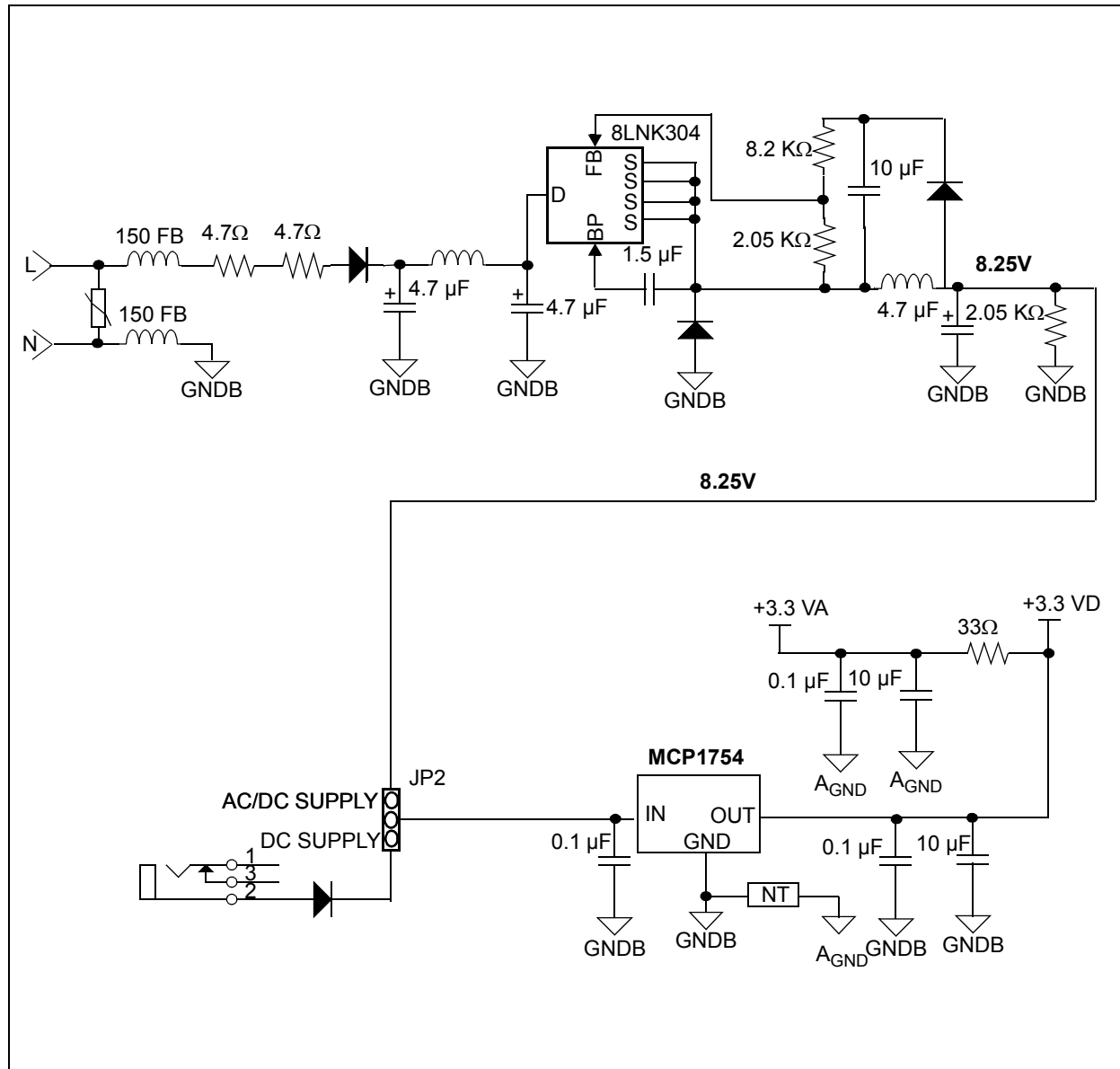


**FIGURE 3-3:** Analog Front-End Circuitry.

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

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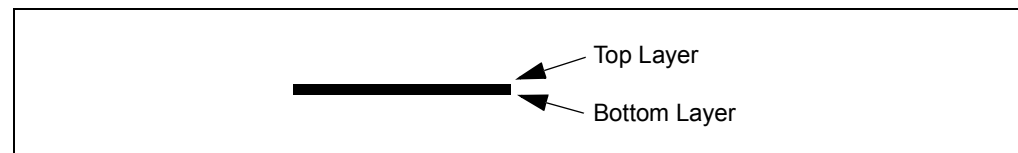
### A.1 INTRODUCTION

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

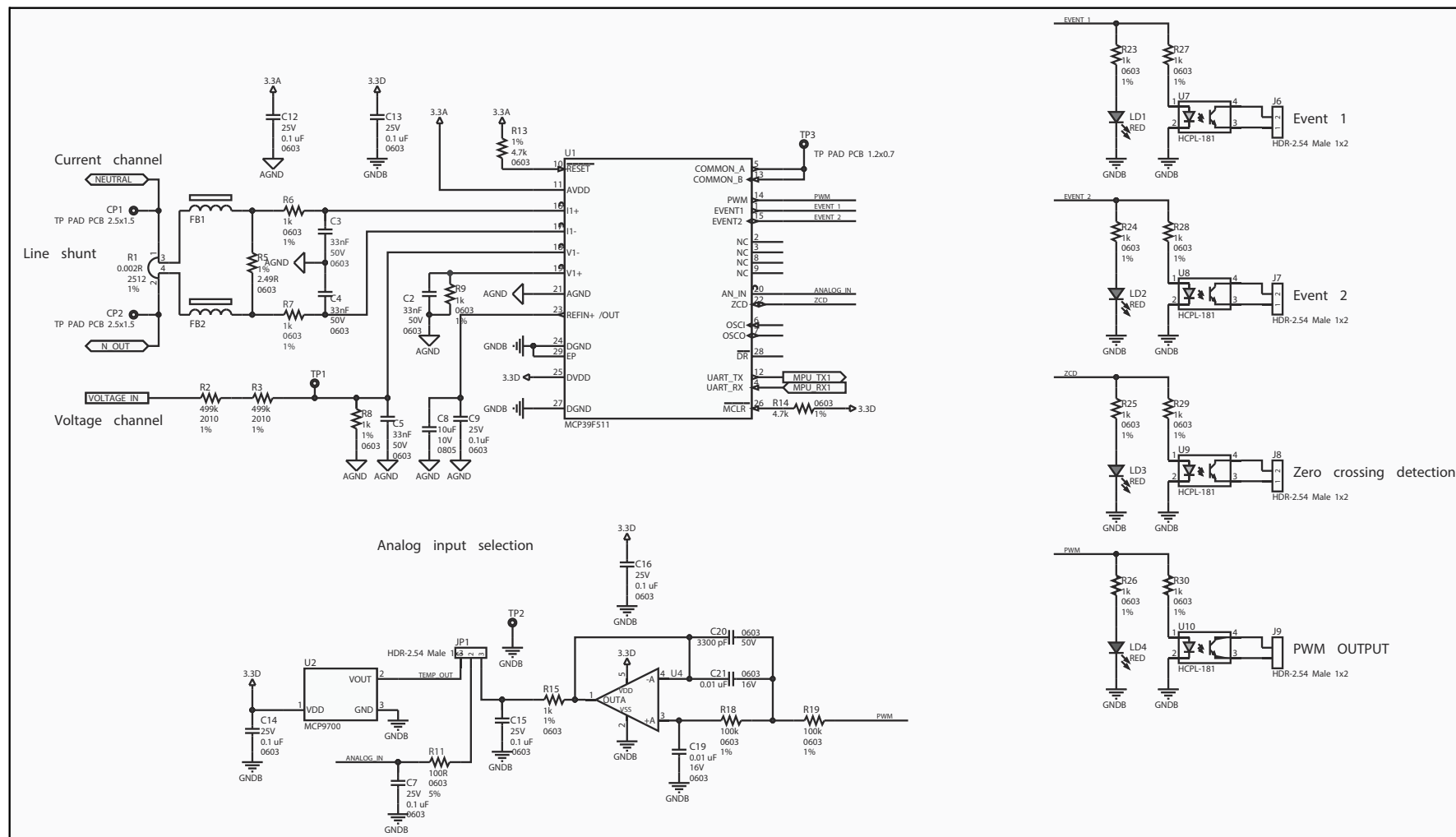
### A.2 SCHEMATICS AND PCB LAYOUT

The layer order is shown in [Figure A-1](#).

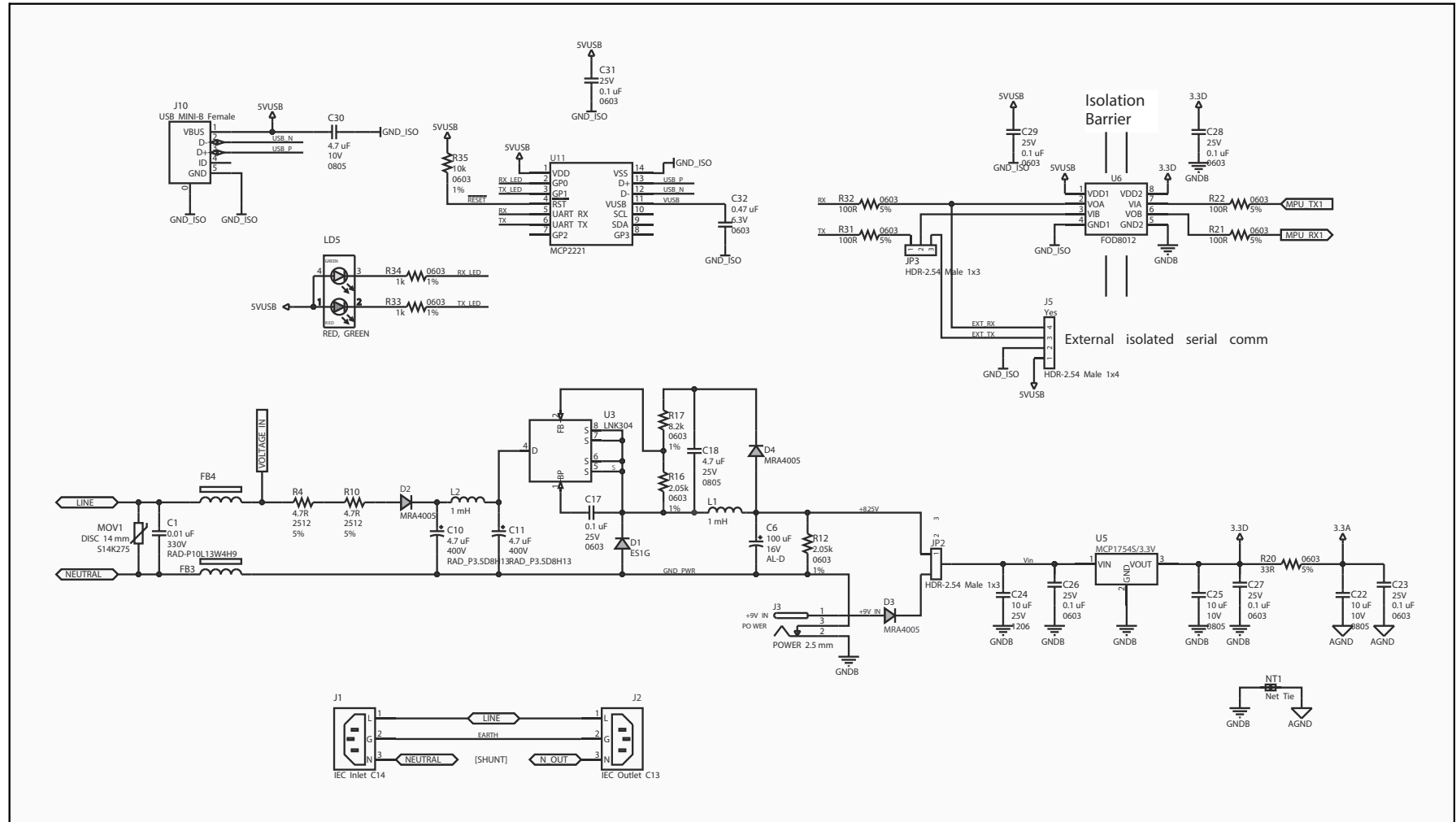


**FIGURE A-1:** Layer Order.

## A.3 BOARD – SCHEMATIC

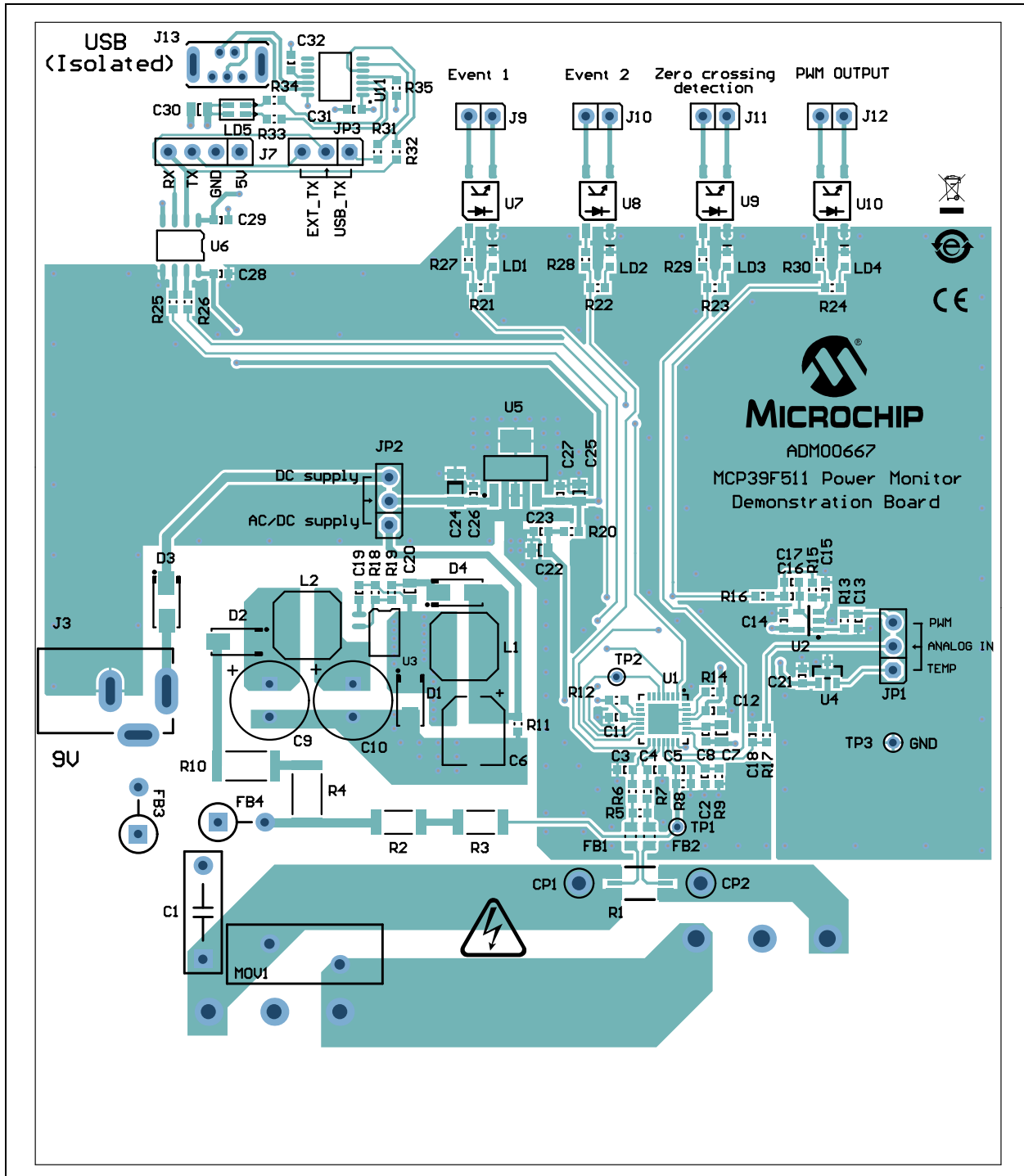


## A.3 BOARD – SCHEMATIC (CONTINUED)

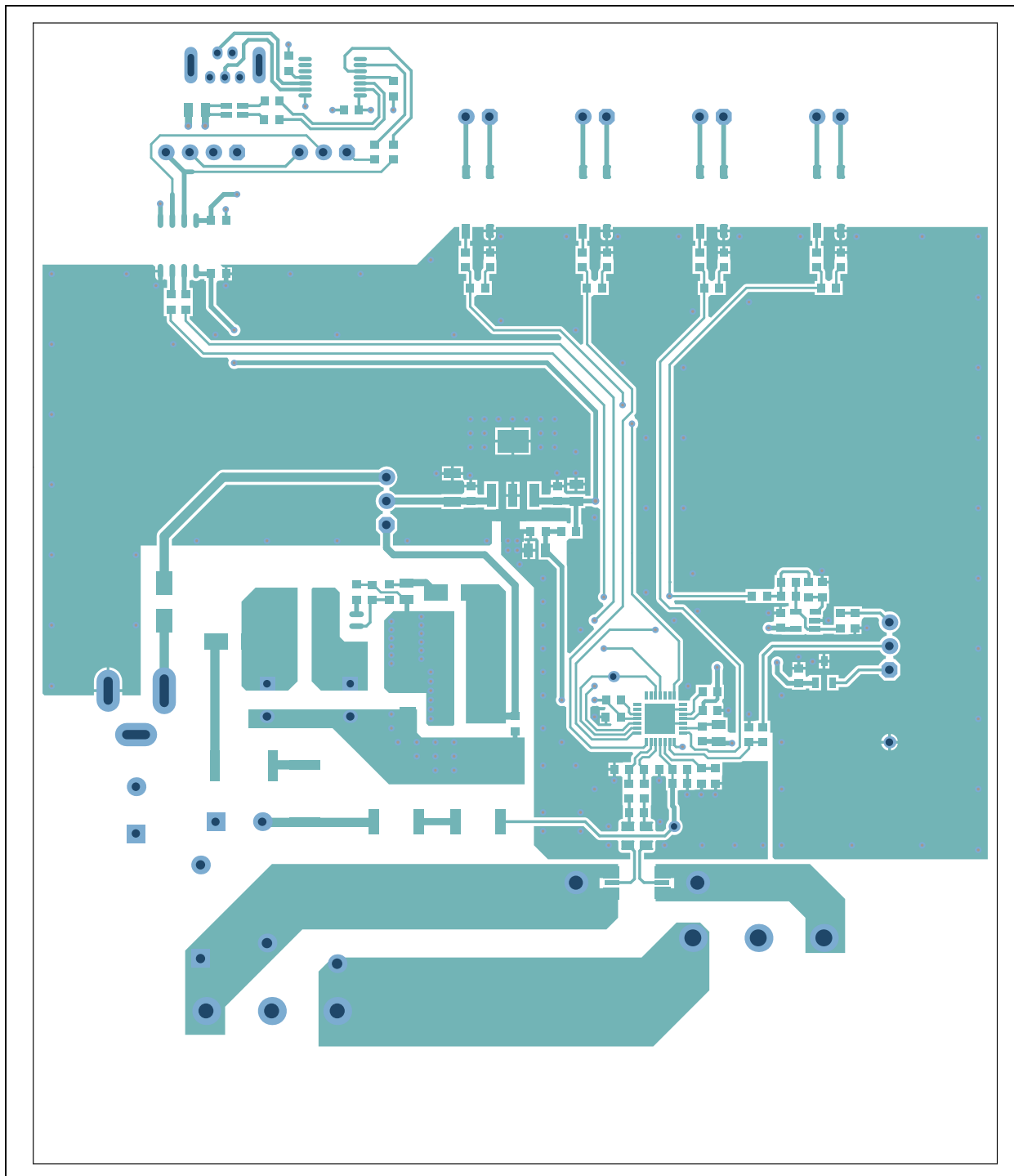




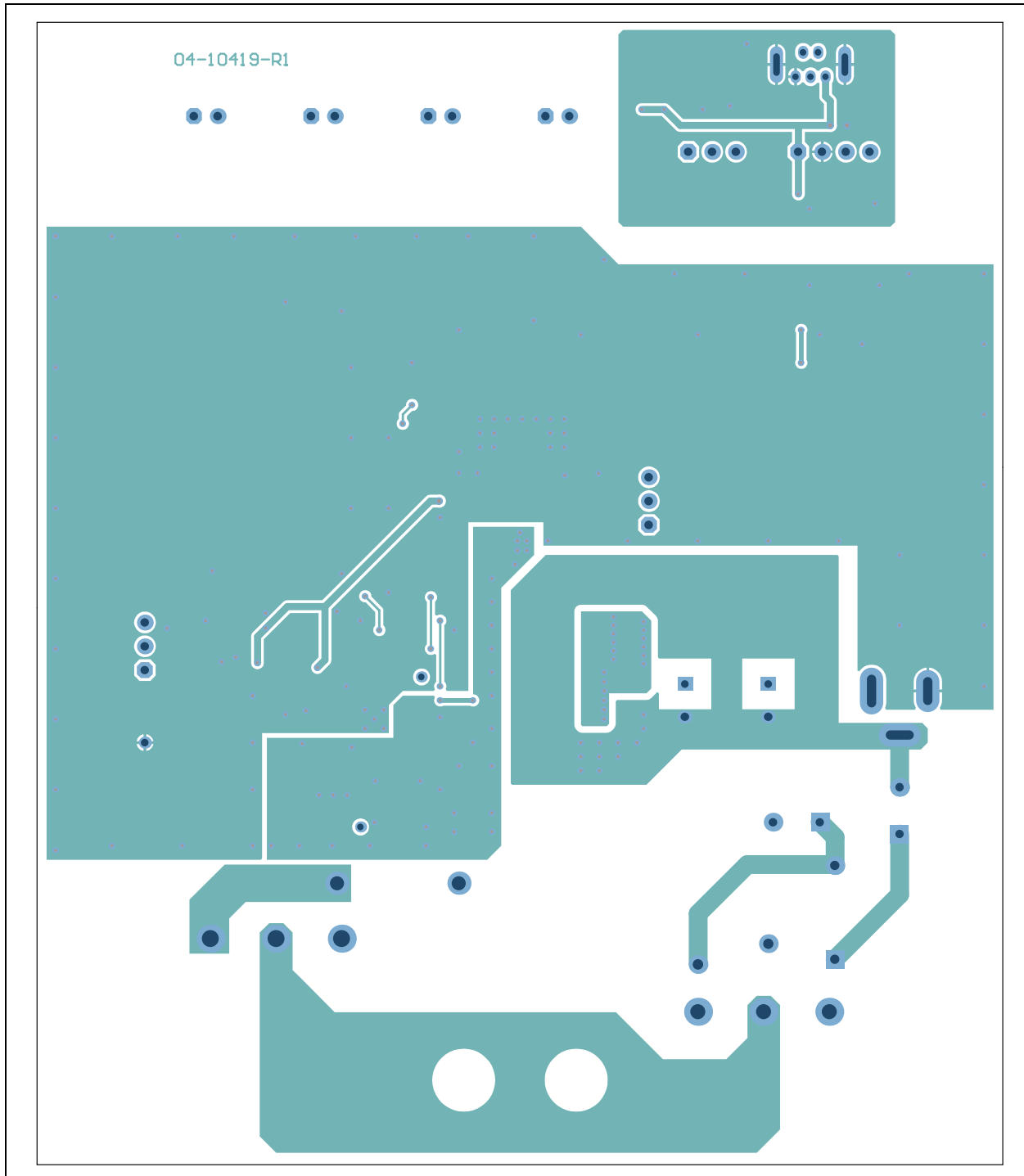
## A.5 BOARD – TOP COPPER AND SILK



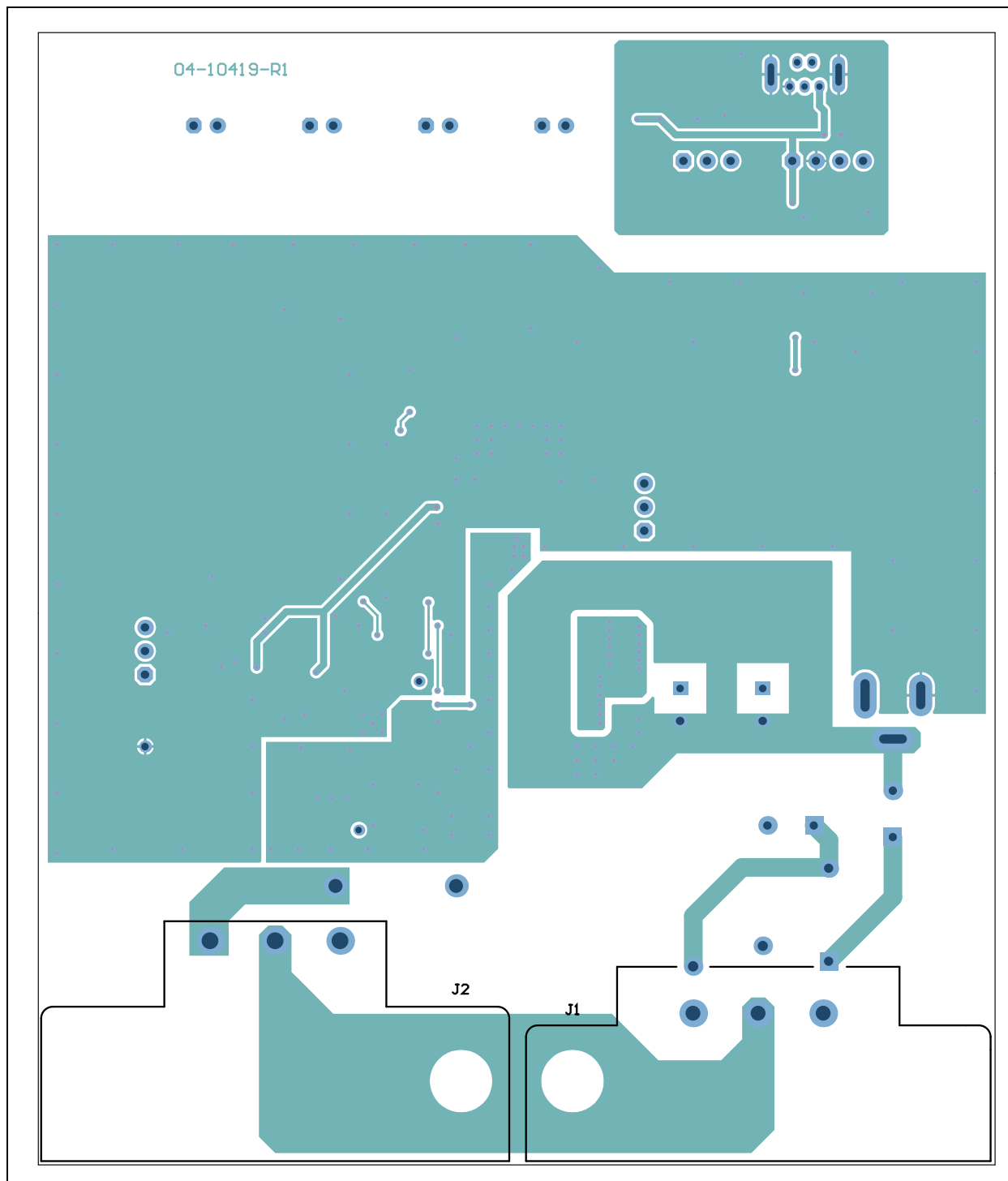
## A.6 BOARD – TOP COPPER



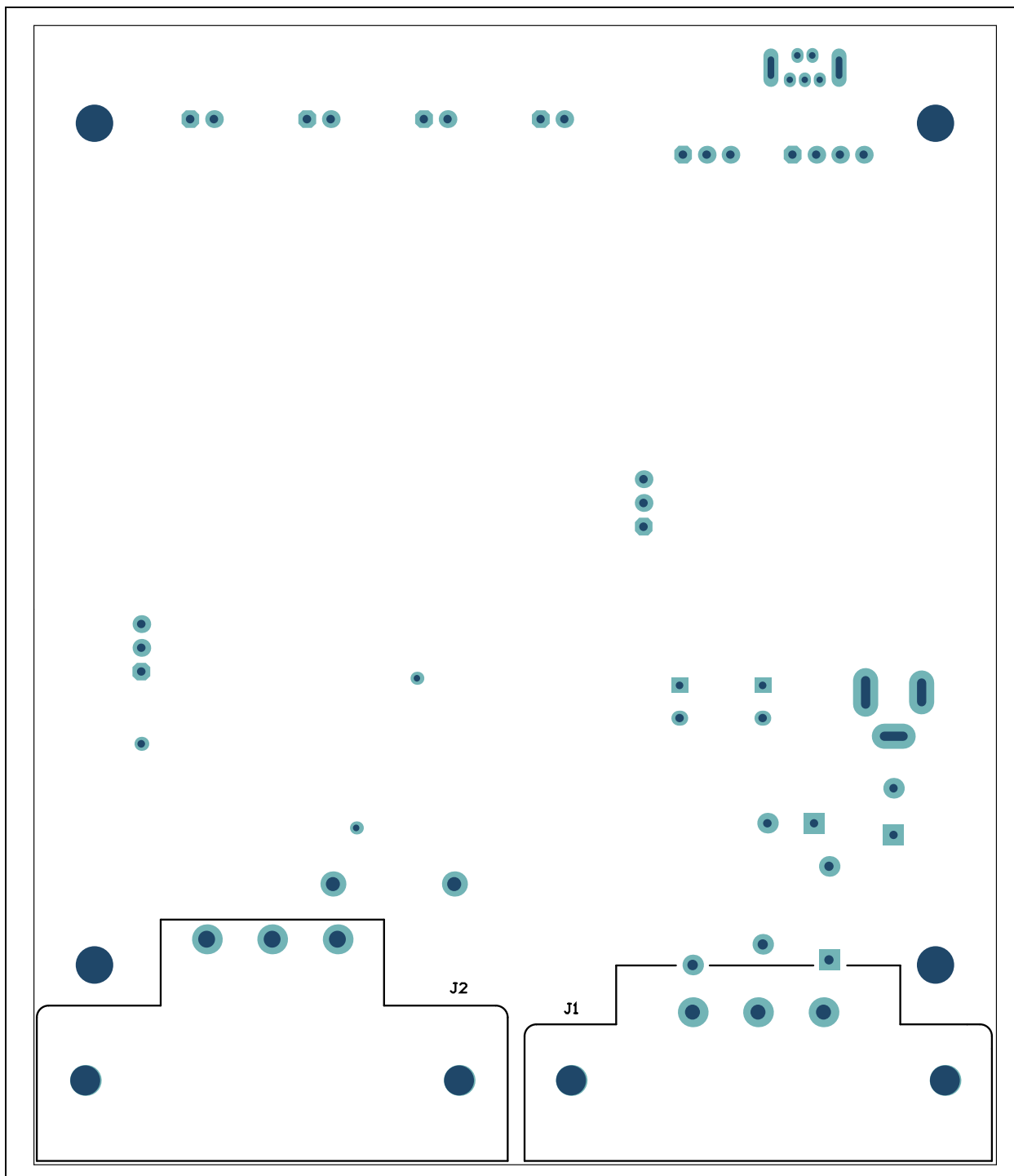
## A.7 BOARD – BOTTOM COPPER



## A.8 BOARD – BOTTOM COPPER AND SILK



## A.9 BOARD – BOTTOM SILK



NOTES:

## 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 $\mu$ F 330V 20%<br>RAD P10L13W4H9   | EPCOS AG               | B32911A3103M        |
| 4    | C2, C3, C4, C5                                                              | Cap. ceramic 33 nF 50V 10%<br>X7R SMD 0603          | TDK Corporation®       | C1608X7R1H333K      |
| 1    | C6                                                                          | Cap. aluminum 100 $\mu$ F 16V 20%<br>SMD D          | Nichicon Corporation®  | UWX1C101MCL1GB      |
| 14   | C7, C9, C12, C13,<br>C14, C15, C16, C17,<br>C23, C26, C27, C28,<br>C29, C31 | Cap. ceramic 0.1 $\mu$ F 25V 10%<br>X7R SMD 0603    | Murata Electronics®    | GRM188R71E104KA01D  |
| 3    | C8, C22, C25                                                                | Cap. ceramic 10 $\mu$ F 10V 10%<br>X7R SMD 0805     | TDK Corporation        | C2012X7R1A106K125AC |
| 2    | C10, C11                                                                    | Cap. aluminum 4.7 $\mu$ F 400V<br>20% RAD_P3.5D8H13 | Nichicon Corporation   | UVC2G4R7MPD1TD      |
| 1    | C18                                                                         | Cap. ceramic 4.7 $\mu$ F 25V 10%<br>X7R SMD 0805    | TDK Corporation        | C2012X7R1E475K125AB |
| 2    | C19, C21                                                                    | Cap. ceramic 0.01 $\mu$ F 16V 5%<br>SMD 0603        | Taiyo Yuden Co., Ltd.® | EMK107SD103JA-T     |
| 1    | C20                                                                         | Cap. ceramic 3300 pF 50V 10%<br>X7R SMD 0603        | ROHM Semiconductor®    | C0603C332K5RACTU    |
| 1    | C24                                                                         | Cap. ceramic 10 $\mu$ F 25V 10%<br>X7R SMD 1206     | Taiyo Yuden Co., Ltd.  | TMK316B7106KL-TD    |
| 1    | C30                                                                         | Cap. ceramic 4.7 $\mu$ F 10V 10%<br>X5R SMD 0805    | Taiyo Yuden Co., Ltd.  | LMK212BJ475KD-T     |
| 1    | C32                                                                         | Cap. ceramic 0.47 $\mu$ F 6.3V 10%<br>X5R SMD 0603  | Murata Electronics     | GRM188R60J474KA01D  |
| 1    | D1                                                                          | Diode rec. ES1G 1.25V 1A 400V<br>SMD DO-214AC_SMA   | Diodes Incorporated®   | ES1G-13-F           |
| 3    | D2, D3, D4                                                                  | Diode rec. MRA4005 1.1V 1A<br>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<br>P5L5.3D3.8                  | Panasonic® – ECG       | EXC-ELSR35S         |
| 1    | J1                                                                          | Conn. IEC 250V 15A Inlet C14<br>TH R/A              | SCHURTER Inc.          | GSP1.9103.1         |
| 1    | J2                                                                          | Conn. IEC 250V 15A Outlet C13<br>TH R/A             | SCHURTER Inc.          | 6182.0033           |
| 1    | J3                                                                          | Conn. power 2.5 mm 5.5 mm<br>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.

# MCP39F511 Power Monitor Demonstration Board Us-

**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.

# Bill of Materials (BOM)

**TABLE B-2: BILL OF MATERIALS – MICROCHIP CONSIGNED PARTS**

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

**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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