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**MCP39F521  
Power Monitor  
Demonstration Board  
User's Guide**

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ISBN: 978-1-63277-821-5

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**Object of Declaration: MCP39F521 Power Monitor Demonstration Board**

EU Declaration of Conformity

Manufacturer: Microchip Technology Inc.  
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Chandler, Arizona, 85224-6199  
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

# MCP39F521 Power Monitor Demonstration Board User's Guide

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# MCP39F521 POWER MONITOR DEMONSTRATION BOARD USER'S GUIDE

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## Table of Contents

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|   |           |
|---|-----------|
| <b>Preface</b> .....  | <b>7</b>  |
| Introduction.....   | 7         |
| Document Layout .....   | 7         |
| Conventions Used in this Guide .....                                      | 8         |
| Recommended Reading.....  | 9         |
| The Microchip Web Site .....  | 9         |
| Customer Support .....  | 9         |
| Document Revision History .....   | 9         |
| <b>Chapter 1. Product Overview</b>  |           |
| 1.1 Introduction .....  | 11        |
| 1.2 What the MCP39F521 Power Monitor Demonstration Board Kit Includes ... | 12        |
| <b>Chapter 2. Installation and Operation</b>                              |           |
| 2.1 Getting Started .....   | 13        |
| <b>Chapter 3. Hardware Description</b>                                    |           |
| 3.1 Input and Analog Front End .....                                      | 17        |
| 3.2 Power Supply Circuit .....  | 18        |
| <b>Appendix A. Schematic and Layouts</b>                                  |           |
| A.1 Introduction .....  | 19        |
| A.2 Schematics and PCB Layout .....                                       | 19        |
| A.3 Board – MCP39F521 Schematic .....                                     | 20        |
| A.4 Board – Power and USB Schematic .....                                 | 21        |
| A.5 Board – Top Silk .....  | 22        |
| A.6 Board – Top Copper and Silk .....                                     | 23        |
| A.7 Board – Top Copper .....  | 24        |
| A.8 Board – Bottom Copper .....   | 25        |
| A.9 Board – Bottom Copper and Silk .....                                  | 26        |
| A.10 Board – Bottom Silk .....  | 27        |
| <b>Appendix B. Bill of Materials (BOM)</b>                                |           |
| <b>Worldwide Sales and Service</b> .....                                  | <b>32</b> |

# MCP39F521 Power Monitor Demonstration Board User's Guide

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NOTES:



# MCP39F521 POWER MONITOR DEMONSTRATION BOARD 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](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 “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  |
|--|---|---|
| <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</i></u> >Save                                    |
| 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 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 – “ $I^2C$  Single Phase Energy and Power Monitoring IC with Calculation” (DS20005442)**

This data sheet provides detailed information regarding the MCP39F521 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

## CUSTOMER SUPPORT

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 (September 2015)**

- Initial release of this document.

# MCP39F521 Power Monitor Demonstration Board User's Guide

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# MCP39F521 POWER MONITOR DEMONSTRATION BOARD USER'S GUIDE

## 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.



**MCP39F521 Power Monitor Demonstration Board  
(Part # ADM00686)**

**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

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### 2.1 GETTING STARTED

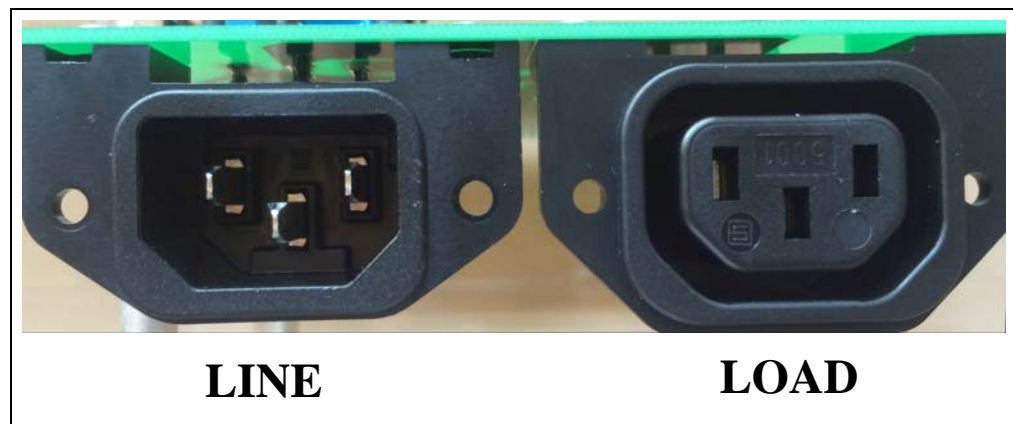
To use the MCP39F521 Power Monitor Demonstration Board, follow the steps described in the following sections. The meter design uses a 5A load for calibration current and a maximum current ( $I_{MAX}$ ) of 15A.

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.

# MCP39F521 Power Monitor Demonstration Board User's Guide

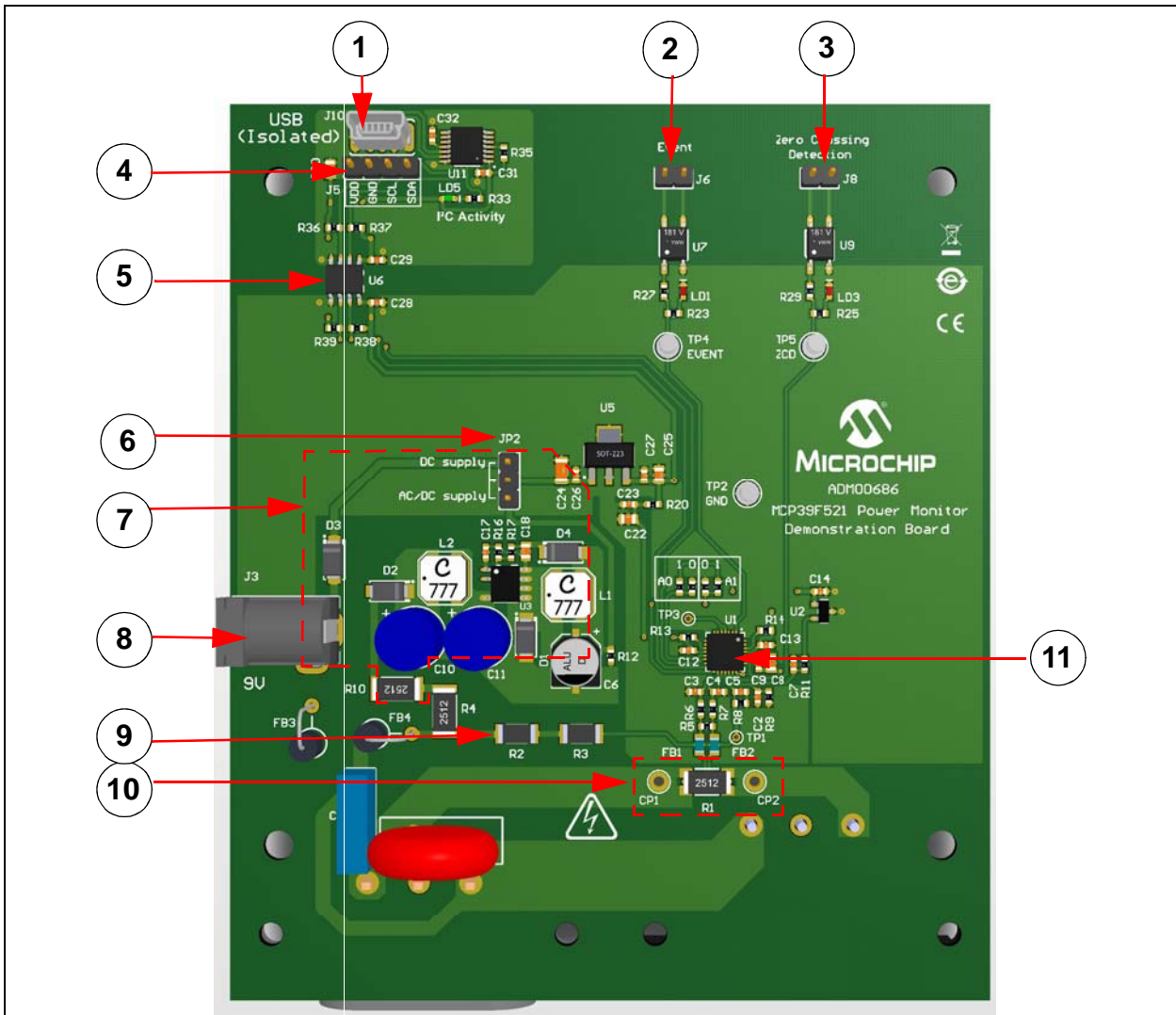
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**Chapter 3. Hardware Description**

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

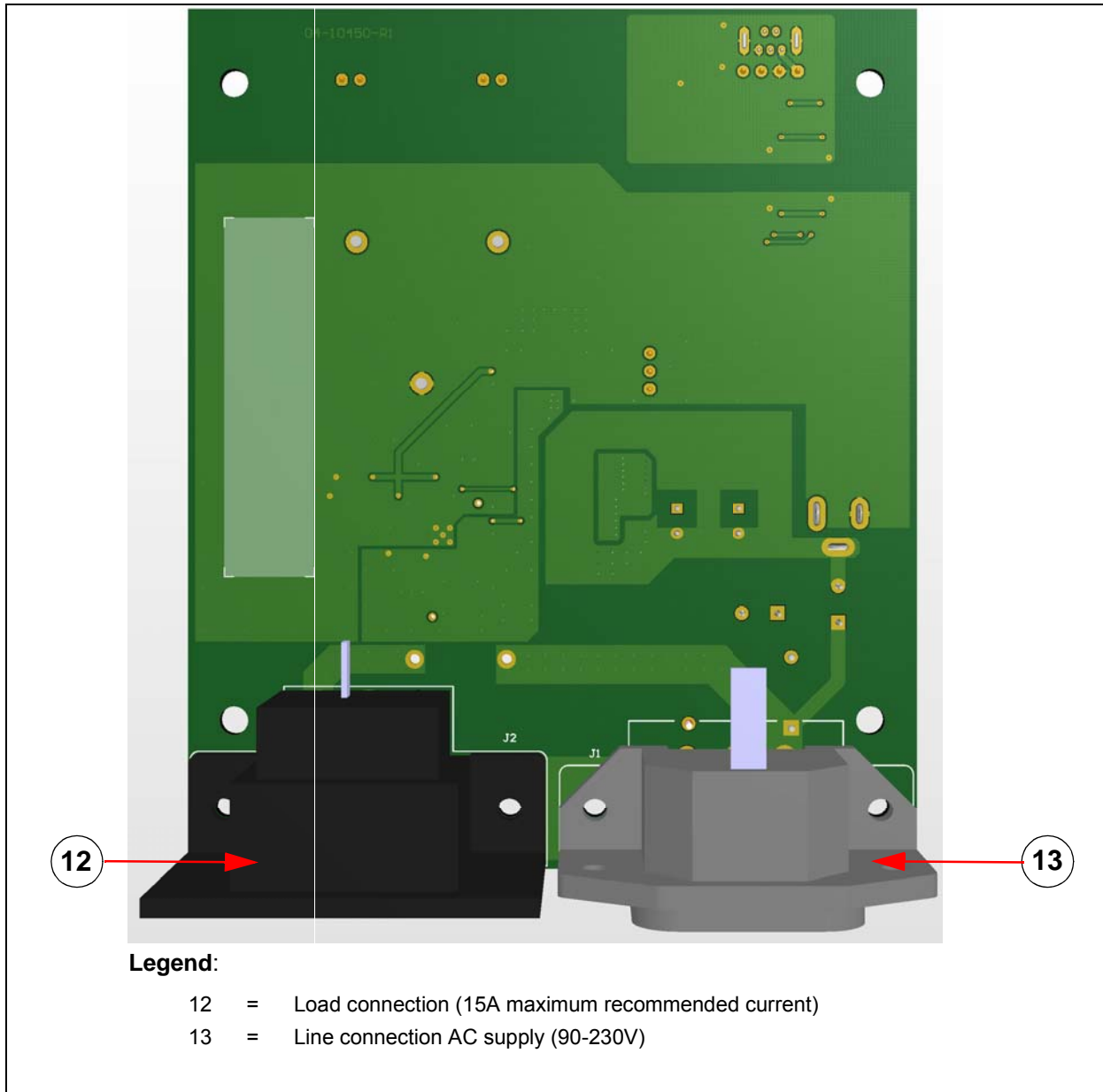


**Legend:**

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

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

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



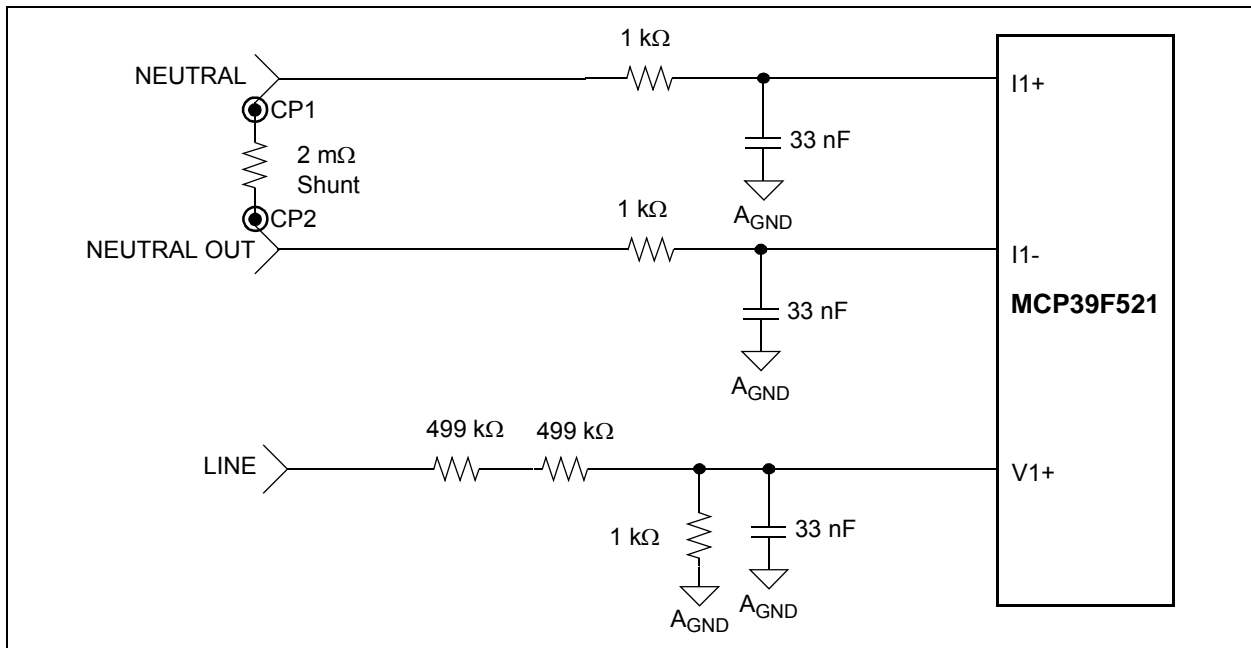
**FIGURE 3-2:** MCP39F521 Power Monitor Demonstration Board Bottom View.



## 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 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>.

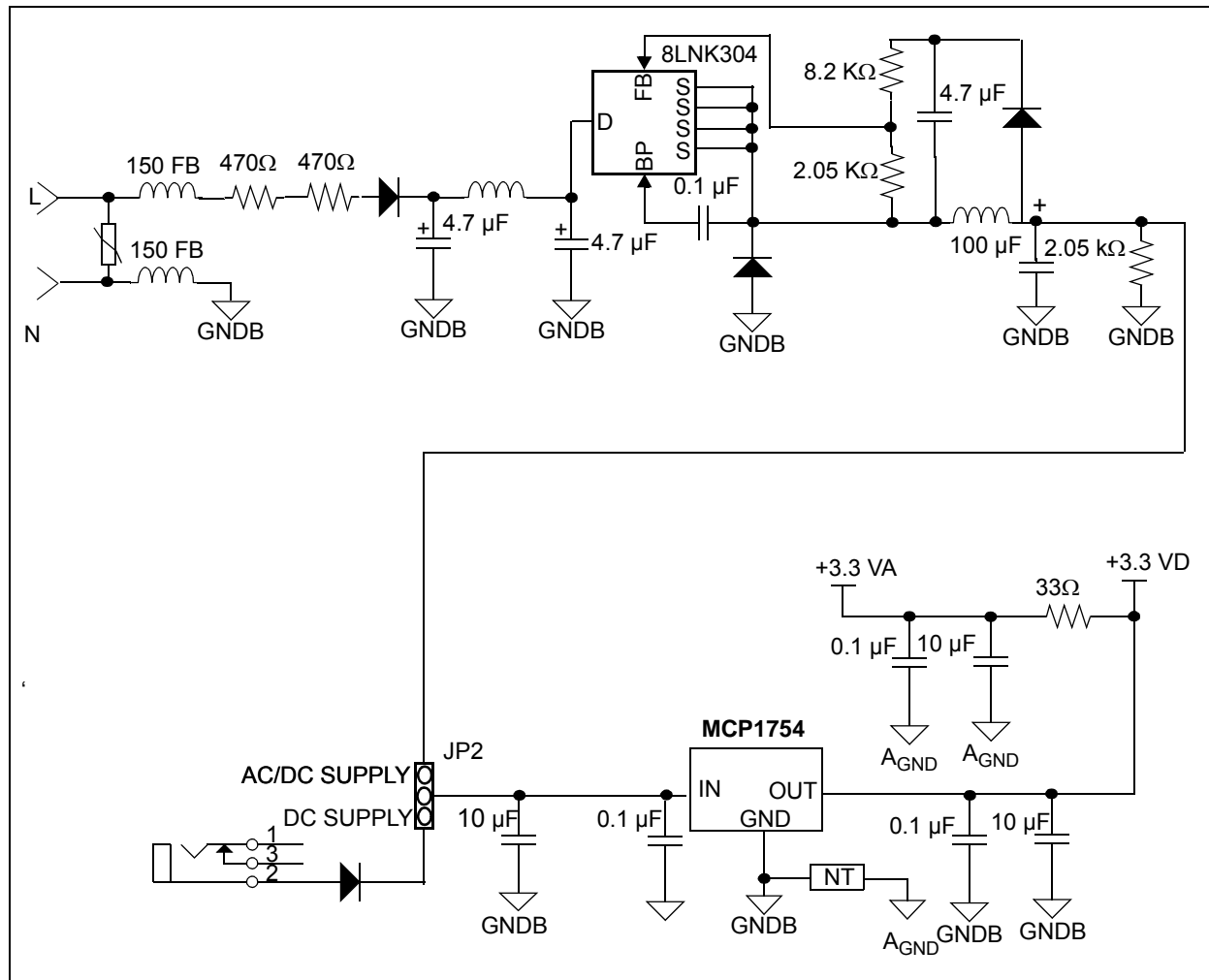


**FIGURE 3-3:** Analog Front-End Circuitry.

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 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.



## Appendix A. Schematic and Layouts

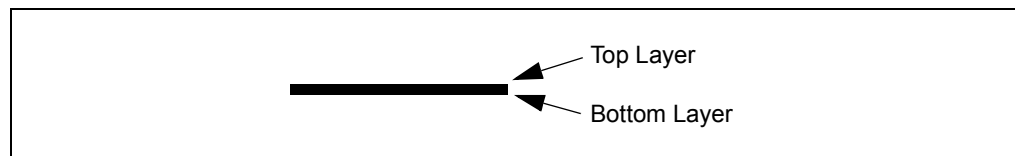
### A.1 INTRODUCTION

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

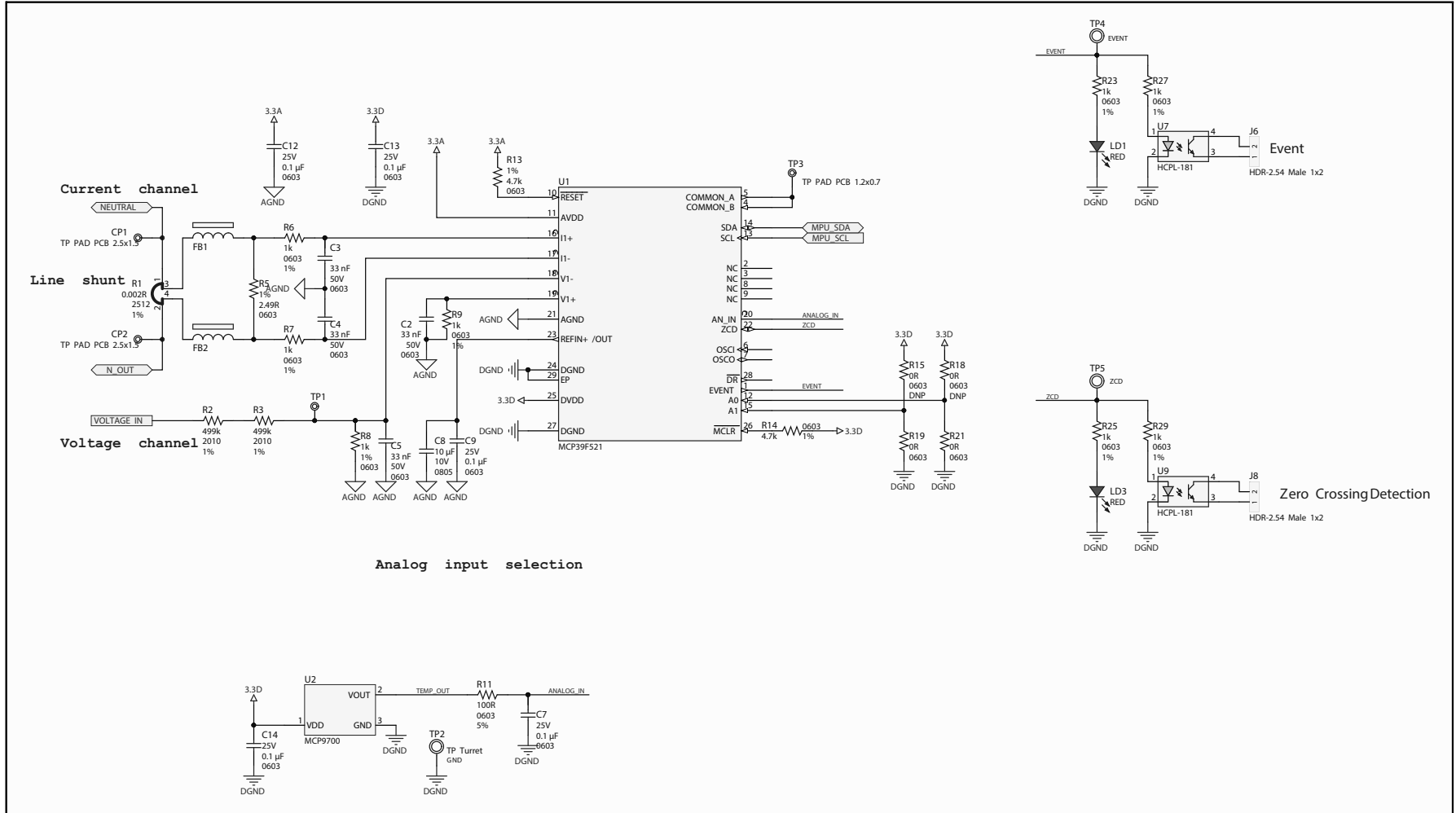
### A.2 SCHEMATICS AND PCB LAYOUT

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

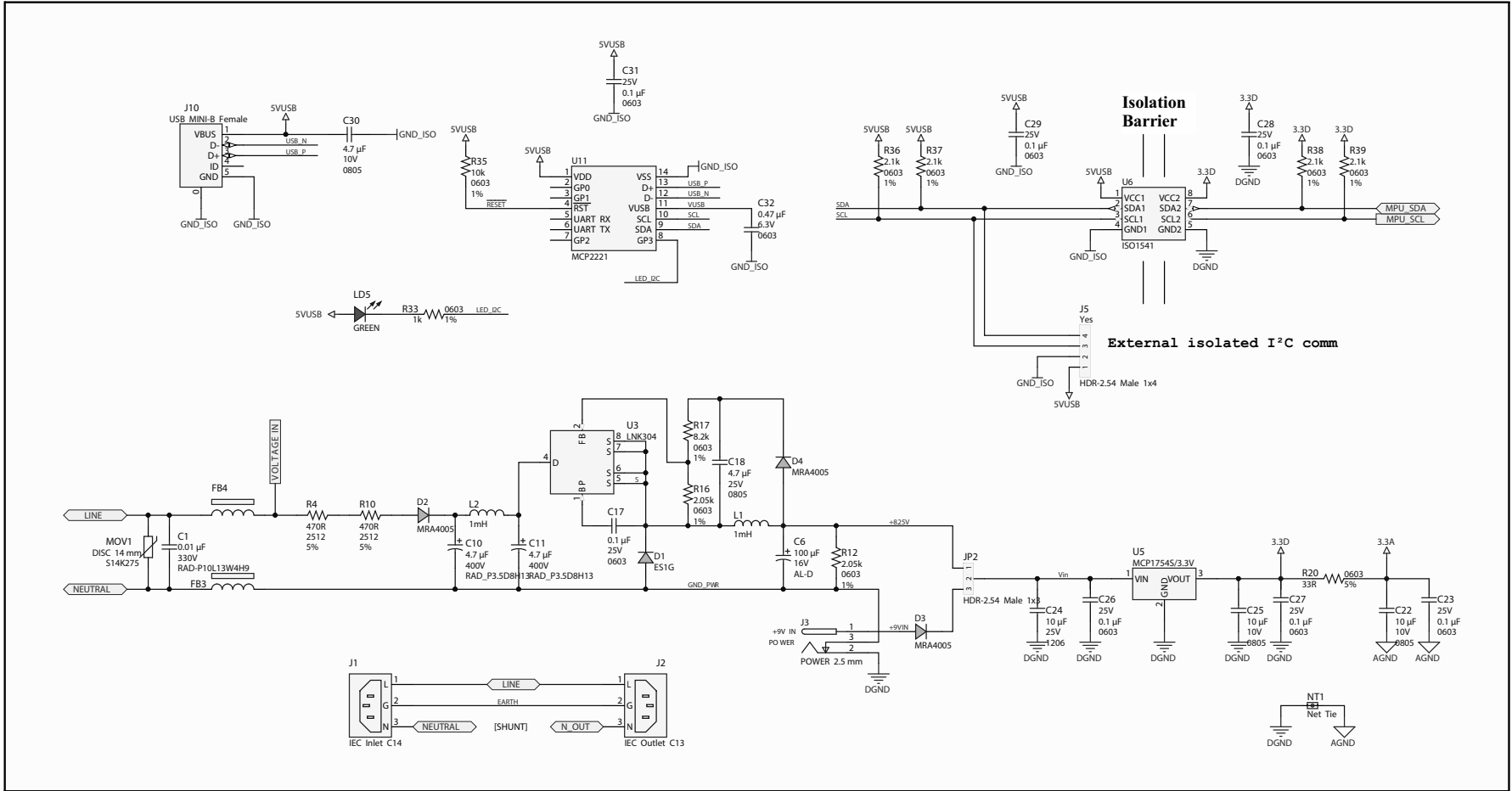


**FIGURE A-1:** Layer Order.

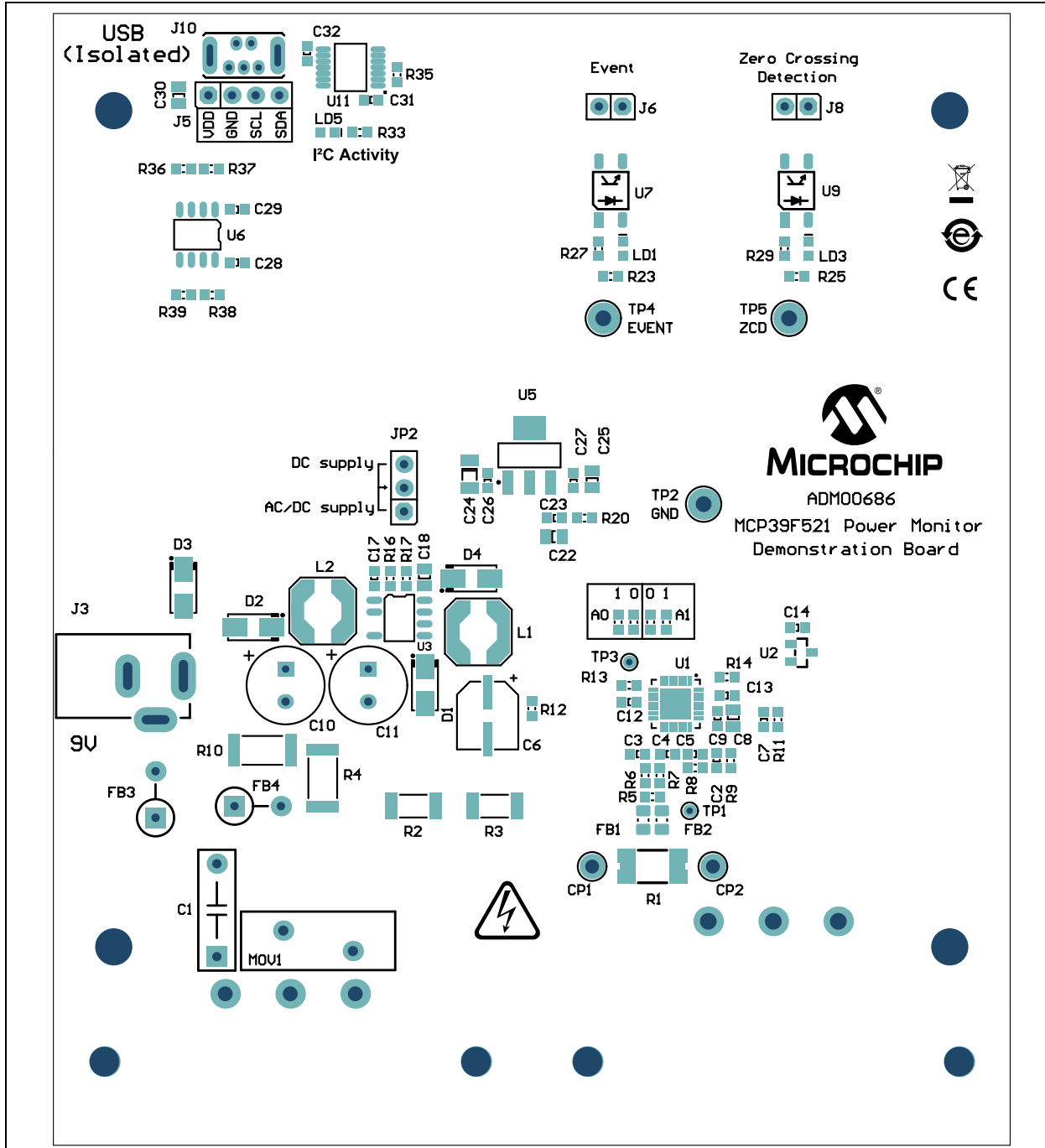
A.3 BOARD – MCP39F521 SCHEMATIC



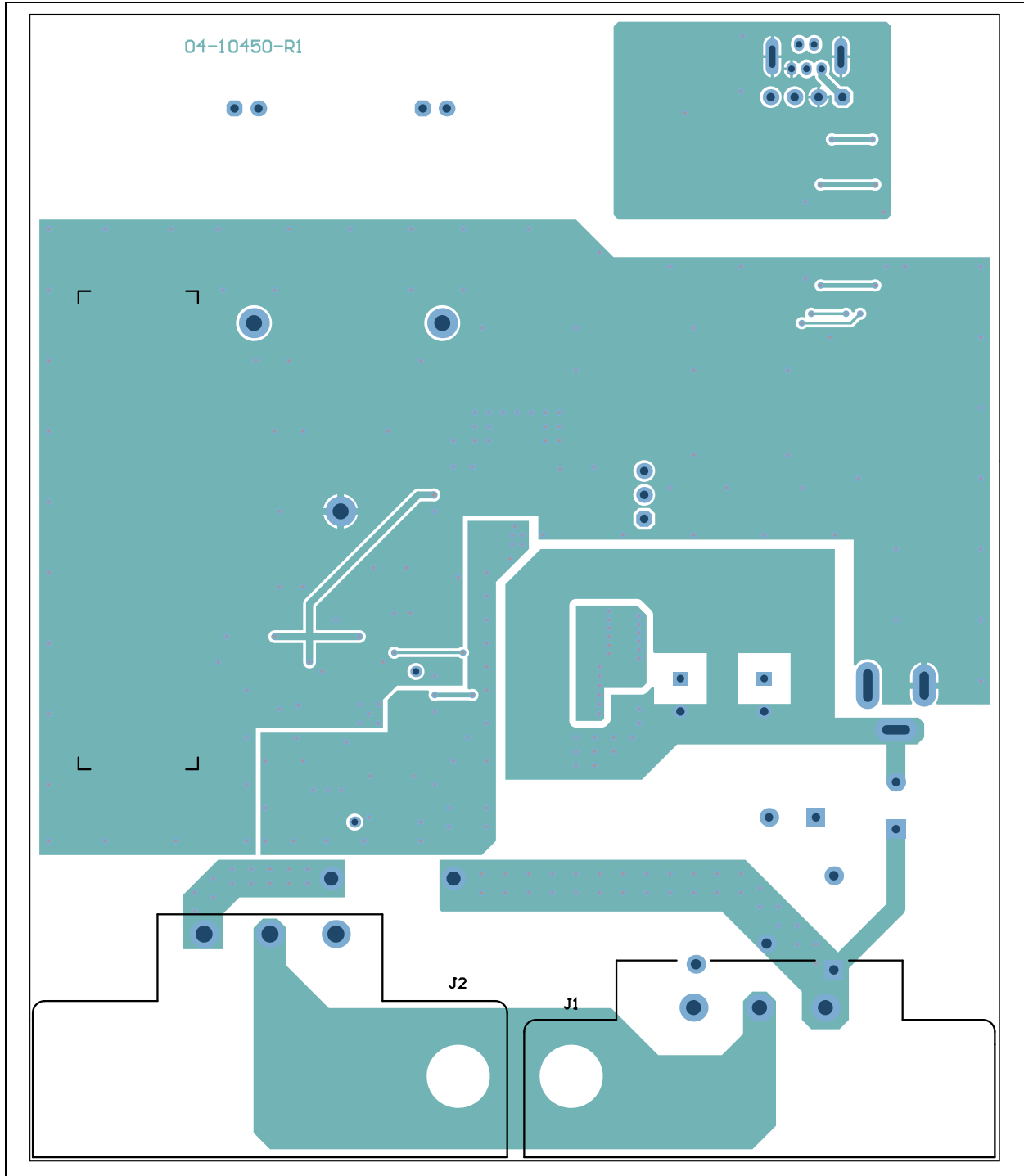
### A.4 BOARD – POWER AND USB SCHEMATIC



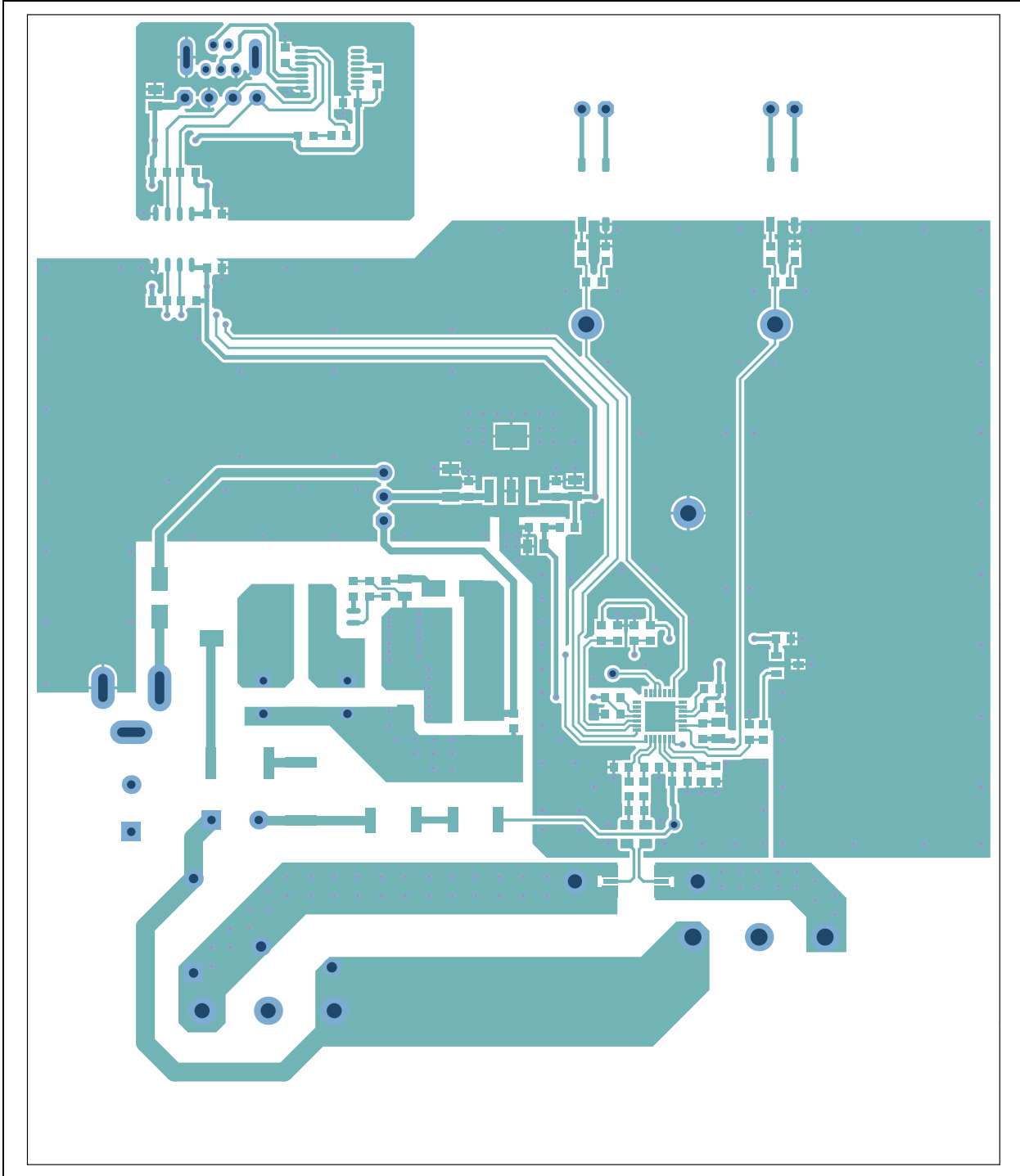
## A.5 BOARD – TOP SILK



## A.6 BOARD – TOP COPPER AND SILK

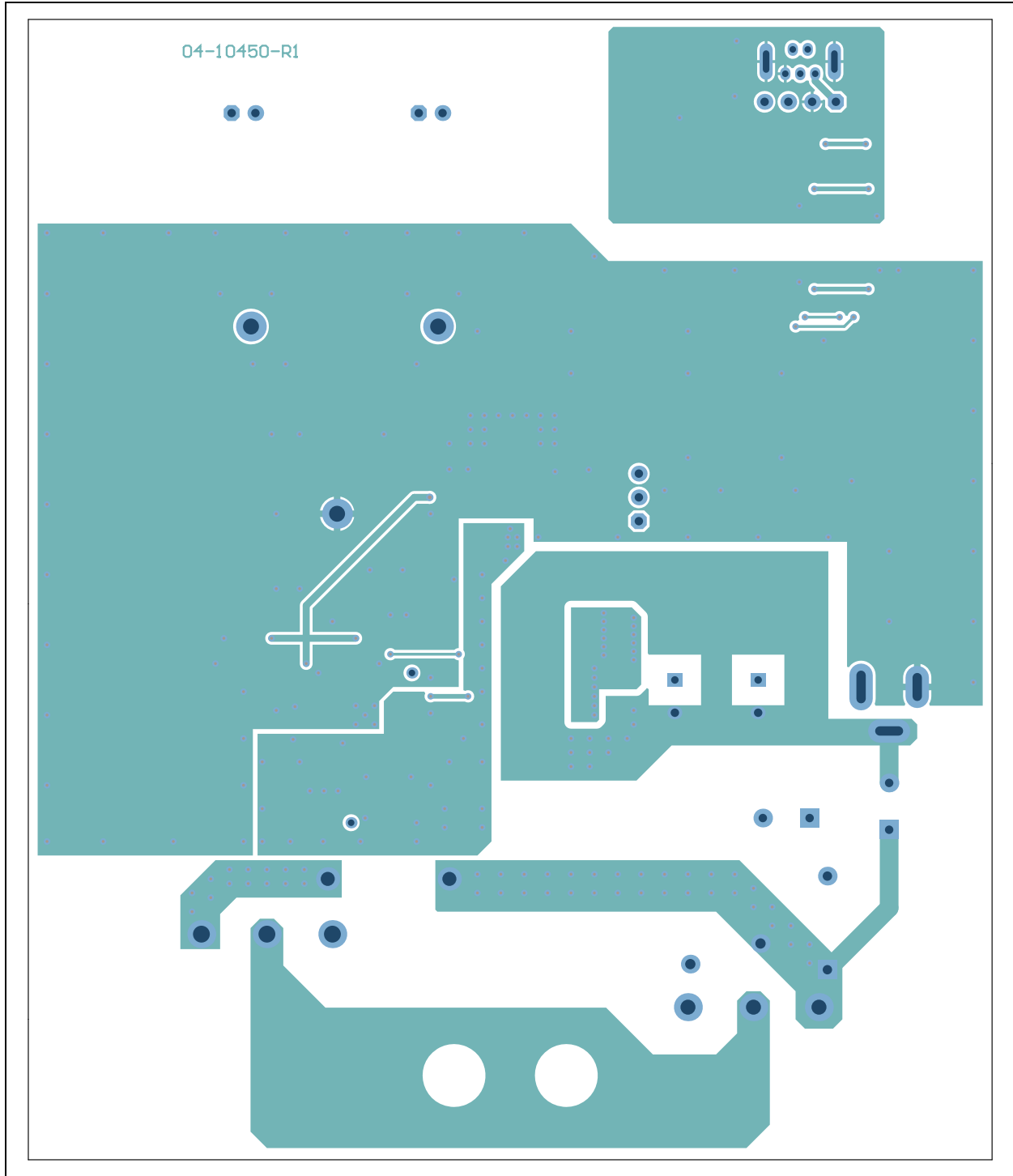


## A.7 BOARD – TOP COPPER

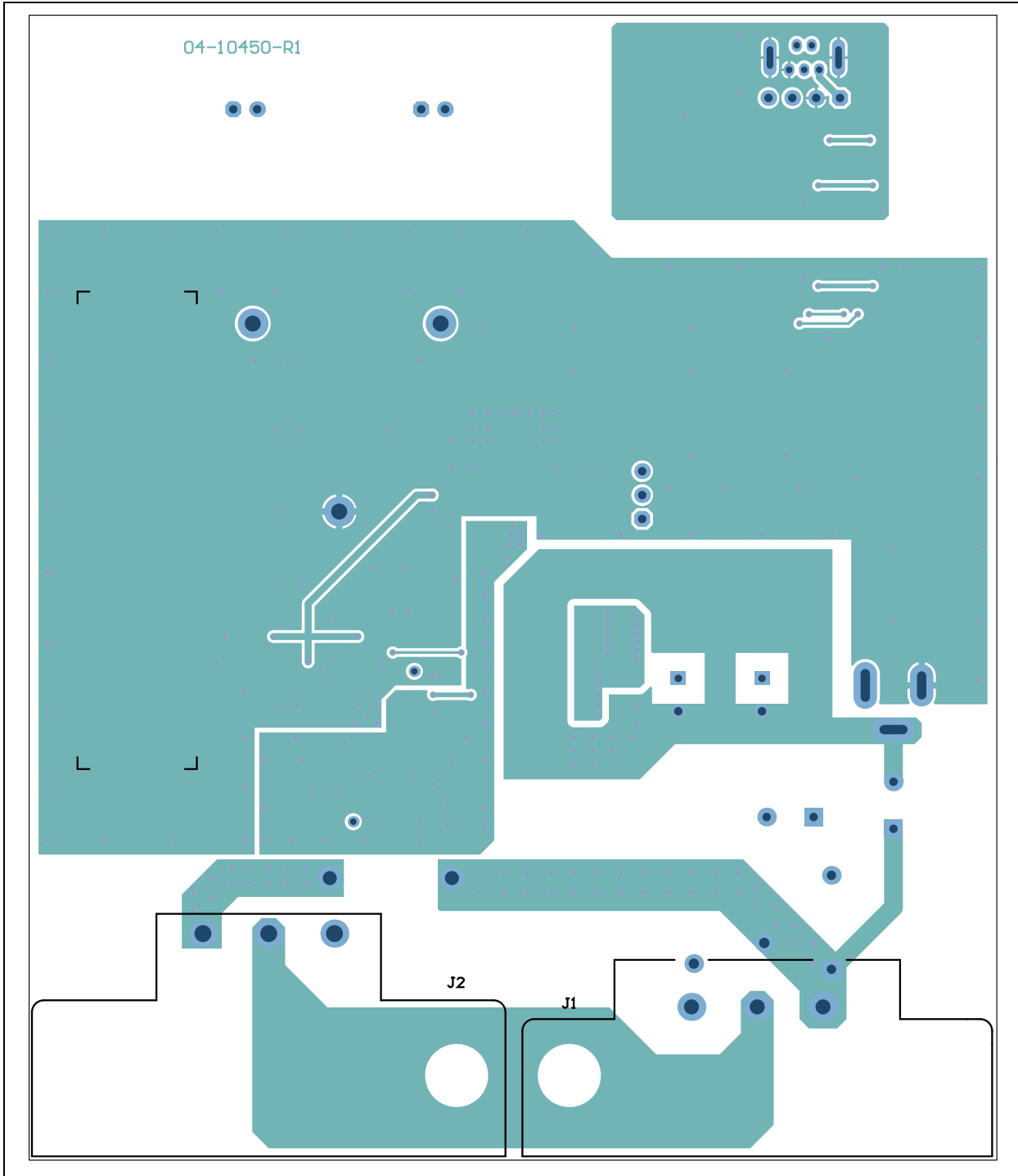




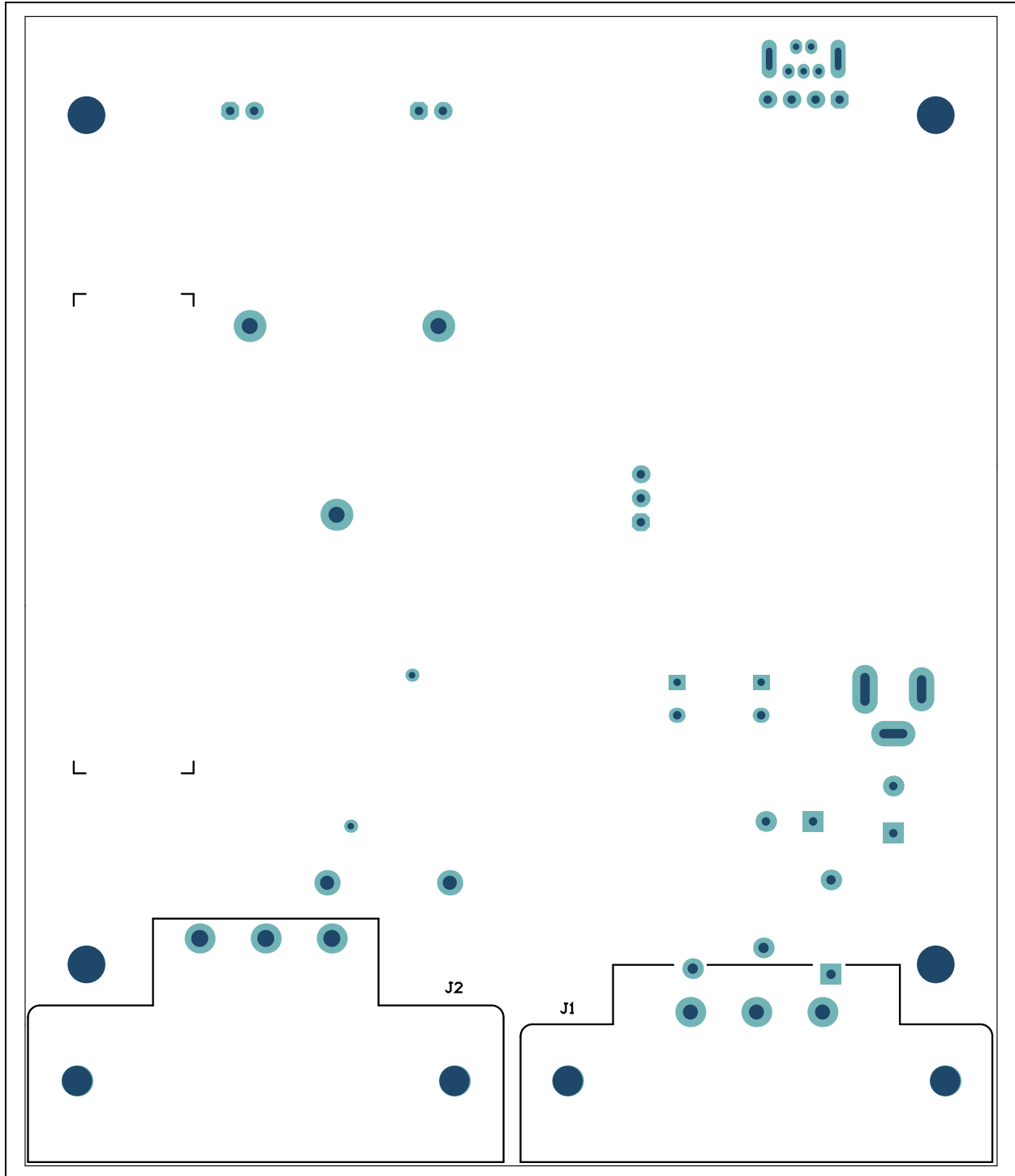
## A.8 BOARD – BOTTOM COPPER



## A.9 BOARD – BOTTOM COPPER AND SILK



## A.10 BOARD – BOTTOM SILK



# MCP39F521 Power Monitor Demonstration Board User's Guide

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NOTES:



# MCP39F521 POWER MONITOR DEMONSTRATION BOARD USER'S GUIDE

## 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 $\mu$ F 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 $\mu$ F 16V 20% SMD D          | Nichicon Corporation             | UWX1C101MCL1GB      |
| 12   | C7, C9, C12, C13, C14, C17, C23, C26, C27, C28, C29, C31 | Cap. ceramic 0.1 $\mu$ F 25V 10% X7R SMD 0603    | Murata Electronics <sup>®</sup>  | GRM188R71E104KA01D  |
| 3    | C8, C22, C25   | Cap. ceramic 10 $\mu$ F 10V 10% X7R SMD 0805     | TDK Corporation                  | C2012X7R1A106K125AC |
| 2    | C10, C11   | Cap. aluminum 4.7 $\mu$ F 400V 20% RAD_P3.5D8H13 | Nichicon Corporation             | 'UVC2G4R7MPD1TD     |
| 1    | C18  | Cap. ceramic 4.7 $\mu$ F 25V 10% X7R SMD 0805    | TDK Corporation                  | C2012X7R1E475K125AB |
| 1    | C24  | Cap. ceramic 10 $\mu$ F 25V 10% X7R SMD 1206     | Taiyo Yuden Co., Ltd.            | MK316B7106KL-TD     |
| 1    | C30  | Cap. ceramic 4.7 $\mu$ F 10V 10% X5R SMD 0805    | Taiyo Yuden Co., Ltd.            | LMK212BJ475KD-T     |
| 1    | C32  | Cap. ceramic 0.47 $\mu$ F 6.3V 10% X5R SMD 0603  | Murata Electronics               | GRM188R60J474KA01D  |
| 1    | D1   | Diode rec. ES1G 1.25V 1A 400V SMD DO-214AC_SMA   | Diodes <sup>®</sup> Incorporated | ES1G-13-F           |
| 3    | D2, D3, D4   | Diode rec. MRA4005 1.1V 1A 600V DO-214AC_SMA     | ON Semiconductor <sup>®</sup>    | MRA4005T3G          |
| 2    | FB1, FB2   | Ferrite 800 mA 0.15R SMD 0805                    | Laird Technologies <sup>®</sup>  | LI0805H151R-10      |
| 2    | FB3, FB4   | Ferrite 7A 0.01R RAD P5L5.3D3.8                  | Panasonic <sup>®</sup> - 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 <sup>®</sup>               | 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.

# MCP39F521 Power Monitor Demonstration Board User's Guide

**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.      | <b>MCP39F521-E/MQ</b>     |
| 1    | U2                                      | MCHP Analog Temperature Sensor -40°C to +150°C MCP9700T-E/TT SOT-23-3 | Microchip Technology Inc.       | <b>MCP9700T-E/TT</b>      |
| 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.       | <b>MCP1754ST-3302E/DB</b> |
| 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.       | <b>MCP2221-I/ST</b>       |

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

# Bill of Materials (BOM)

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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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