



**MCP39F511N  
Power Monitor  
Demonstration Board  
User's Guide**

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**Object of Declaration: MCP39F511N Power Monitor Demonstration Board**

**EU Declaration of Conformity**

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

This declaration of conformity is issued by the manufacturer.

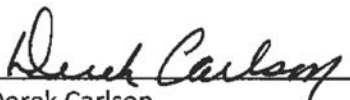
The development/evaluation tool is designed to be used for research and development in a laboratory environment. This development/evaluation tool is not intended to be a finished appliance, nor is it intended for incorporation into finished appliances that are made commercially available as single functional 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).

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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

# MCP39F511N Power Monitor Demonstration Board User's Guide

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# MCP39F511N POWER MONITOR DEMONSTRATION BOARD USER'S GUIDE

## Table of Contents

|                                                                                 |           |
|---------------------------------------------------------------------------------|-----------|
| <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 MCP39F511N Power Monitor Demonstration Board Kit<br>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 – Schematic .....                                                     | 20        |
| A.4 Board – Schematic (Continued) .....                                         | 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>29</b> |
| <b>Worldwide Sales and Service</b> .....                                        | <b>32</b> |

# MCP39F511N Power Monitor Demonstration Board User's Guide

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NOTES:



# MCP39F511N 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 “DSXXXXXXA”, where “XXXXXX” 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 MCP39F511N 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 MCP39F511N Power Monitor Demonstration Board as a demonstration board to evaluate the MCP39F511N device. The manual layout is as follows:

- **Chapter 1. “Product Overview”** – Provides important information about the MCP39F511N Power Monitor Demonstration Board
- **Chapter 2. “Installation and Operation”** – Provides information on using the MCP39F511N 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 MCP39F511N Power Monitor Demonstration Board

# MCP39F511N Power Monitor Demonstration Board User's Guide

## 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 MCP39F511N Power Monitor Demonstration Board. Another useful document is listed below. The following Microchip document is available and recommended as a supplemental reference resource:

**MCP39F511N Data Sheet – “Dual-Channel, Single-Phase Power-Monitoring IC with Calculation” (DS20005473)**

This data sheet provides detailed information regarding the MCP39F511N device.

## THE MICROCHIP WEB SITE

Microchip provides on-line 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, on-line discussion groups, Microchip consultant program member listing
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- 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 (December 2015)

- Initial Release of this Document.

# MCP39F511N Power Monitor Demonstration Board User's Guide

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## Chapter 1. Product Overview

### 1.1 INTRODUCTION

The MCP39F511N Power Monitor Demonstration Board is a fully functional dual-channel single-phase power and energy monitor. For each channel, the system calculates active power, reactive power, RMS current, RMS voltage, active energy, (both import and export), reactive energy and other typical power quantities for two separate loads, as defined in the MCP39F511N 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 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:** MCP39F511N Power Monitor Demonstration Board.

## 1.2 WHAT THE MCP39F511N POWER MONITOR DEMONSTRATION BOARD KIT INCLUDES

This MCP39F511N Power Monitor Demonstration Board kit includes:

- MCP39F511N Power Monitor Demonstration Board (ADM00706)
- AC Line Cable
- Two IEC-to-Female AC Load Cables
- Mini-USB Cable
- Important Information Sheet

## Chapter 2. Installation and Operation

### 2.1 GETTING STARTED

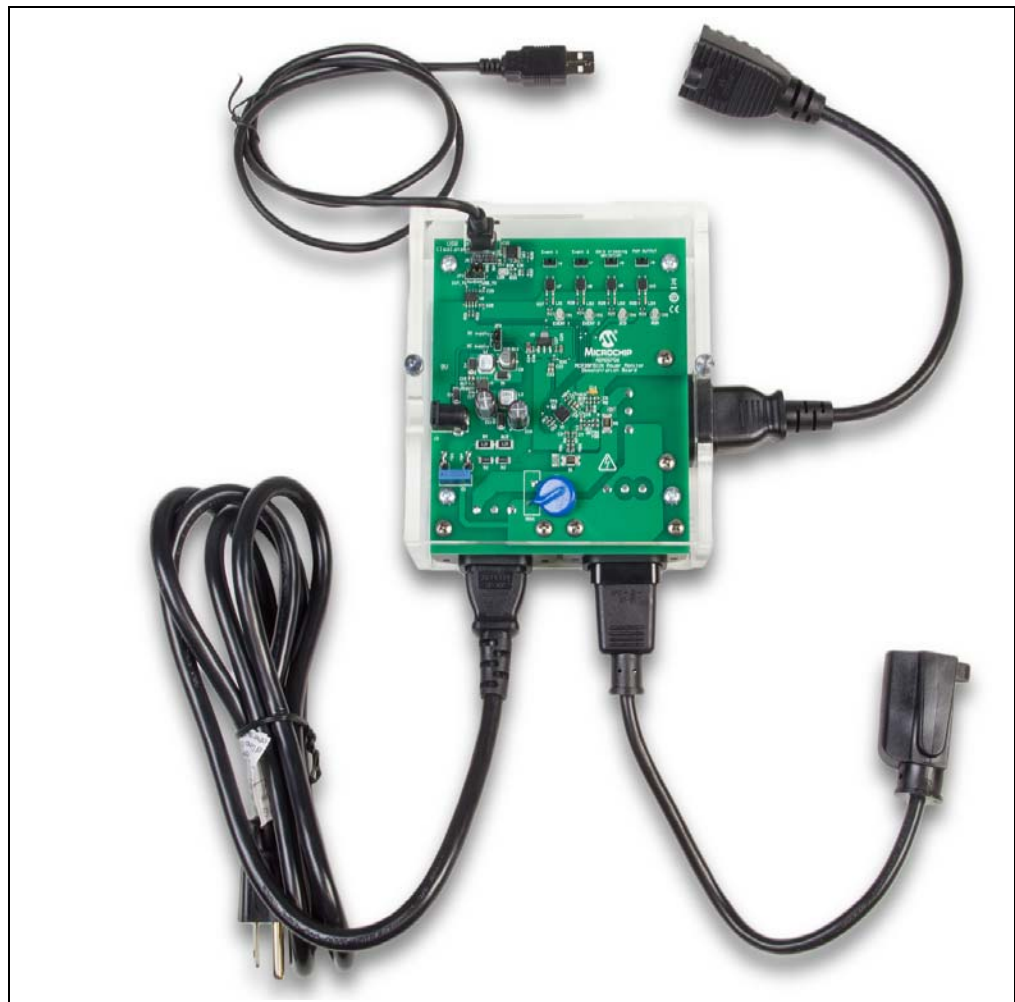
To use the MCP39F511N Power Monitor Demonstration Board, follow the steps described in the sections below. The meter design uses a 5A load for calibration current and a maximum current ( $I_{MAX}$ ) of 15A.

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 two load connections of the MCP39F511N Power Monitor Demonstration Board.



**FIGURE 2-1:** Connecting the MCP39F511N Power Monitor Demonstration Board.

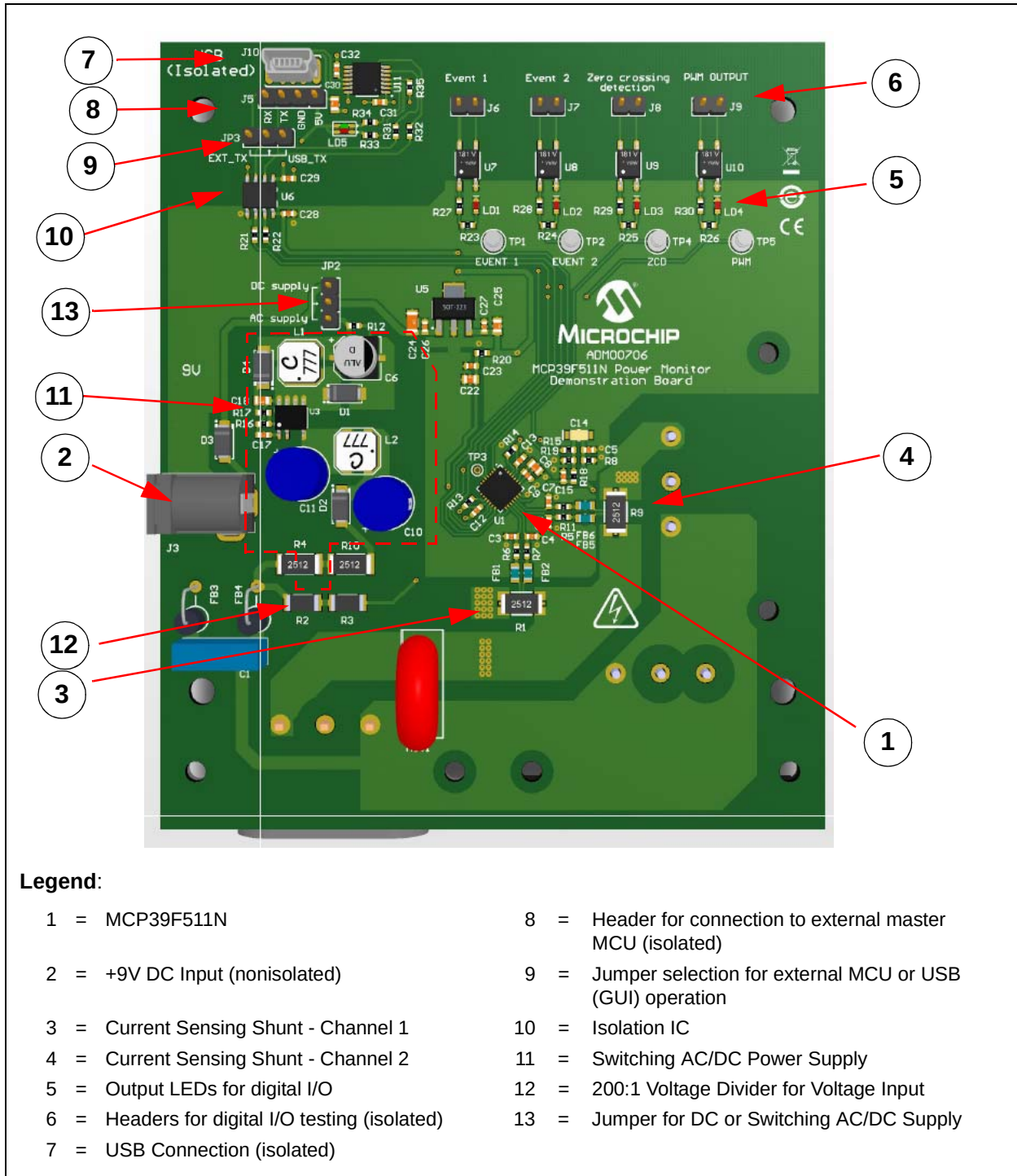
## 2.1.2 Step 2: Connect line/load power to the meter (power the meter)

The meter will turn on when the line connection has between 90V to 220V connected. One or two loads can be connected to the meter.

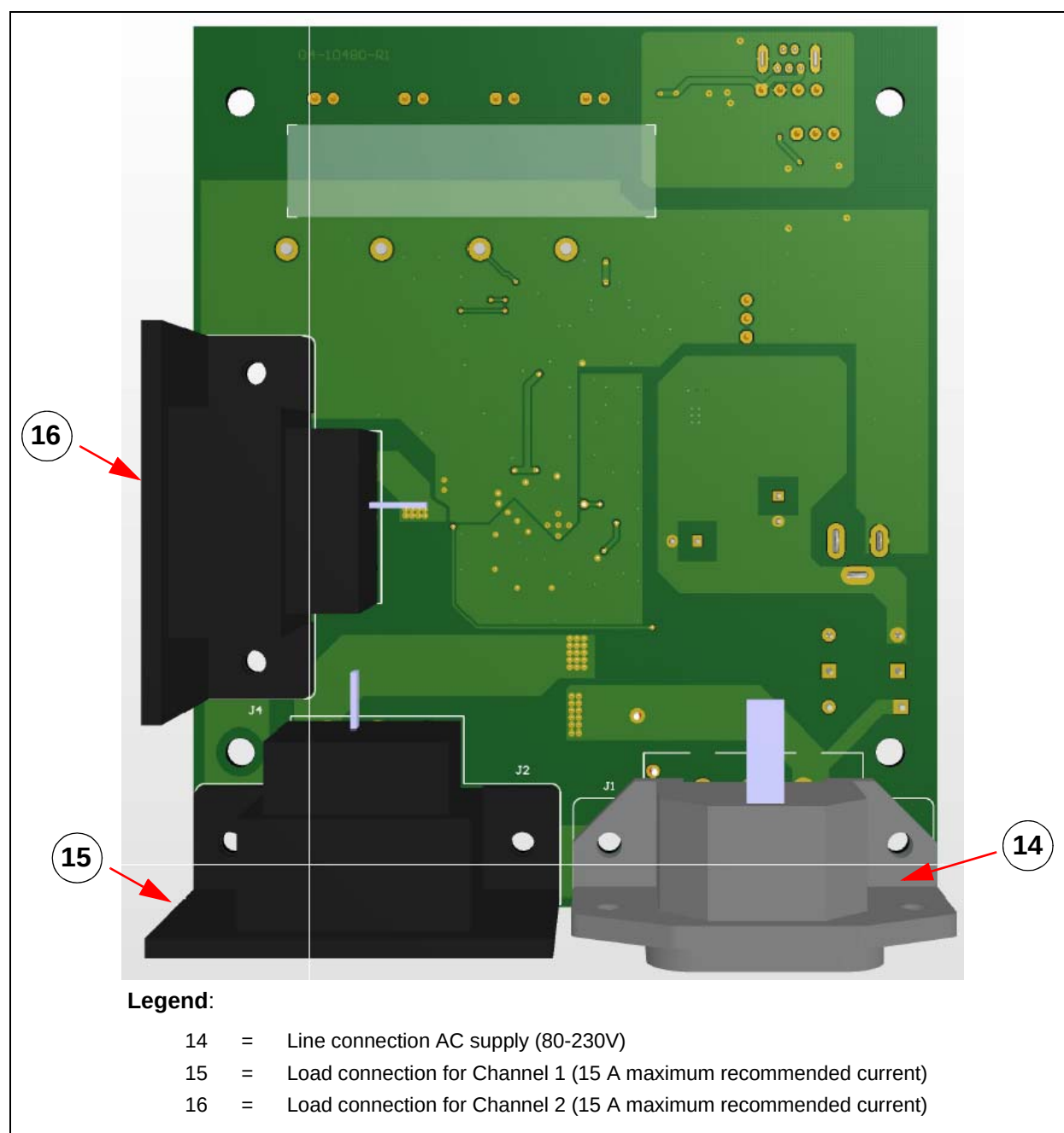
## 2.1.3 Step 3: Connect the USB cable to a PC with the installed MCP39F511N Power Monitor Utility software

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 MCP39F511N.

## Chapter 3. Hardware Description



**FIGURE 3-1:** MCP39F511N Power Monitor Demonstration Board Top View.



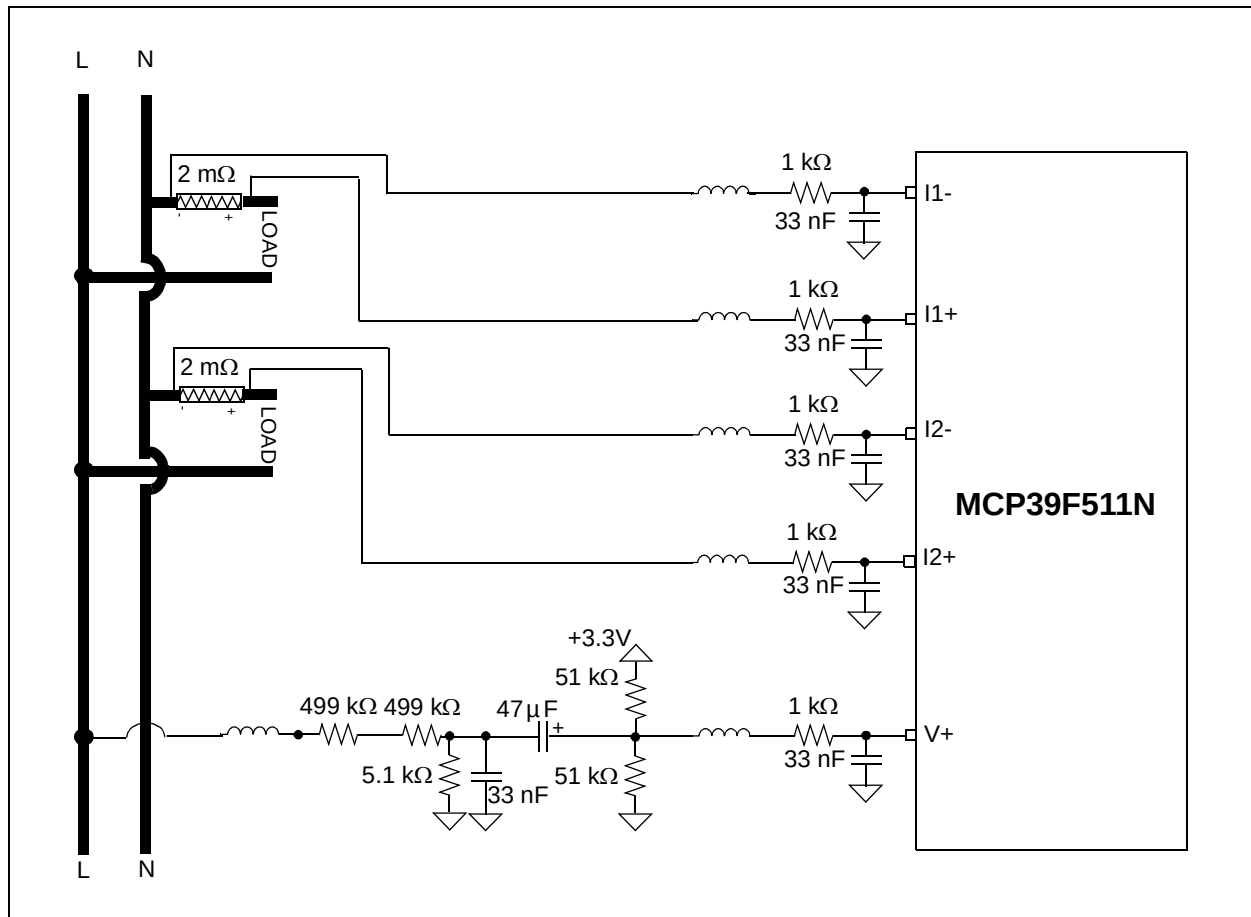
**FIGURE 3-2:** MCP39F511N Power Monitor Demonstration Board Bottom View.



### 3.1 INPUT AND ANALOG FRONT END

The MCP39F511N Power Monitor Demonstration Board will operate from 80V to 230V. At the bottom of the main board, there are the high-voltage line and neutral connections. The shunts sit on the neutral or low-side of a two-wire system. The board comes populated with two surface mount 2 mΩ shunts.

The line side of the two-wire system goes into a resistive 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 and the additional components to achieve a divider ratio of approximately 236:1. For a line voltage of 236 V<sub>RMS</sub>, the channel 1 input signal size will be 1V<sub>RMS</sub> with a DC offset voltage of  $DV_{DD}/2$  per the schematic snippet below.



**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 ( $A_{GND}$ ).



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## Appendix A. Schematic and Layouts

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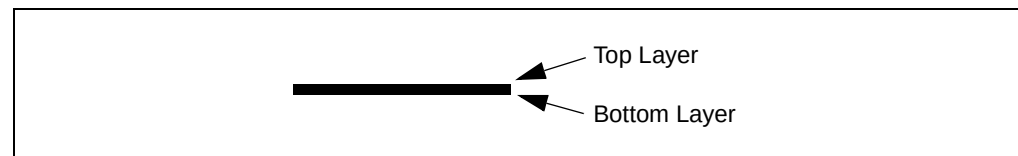
### A.1 INTRODUCTION

This appendix contains the following schematics and layouts for of the MCP39F511N 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
- Board – Bottom Silk

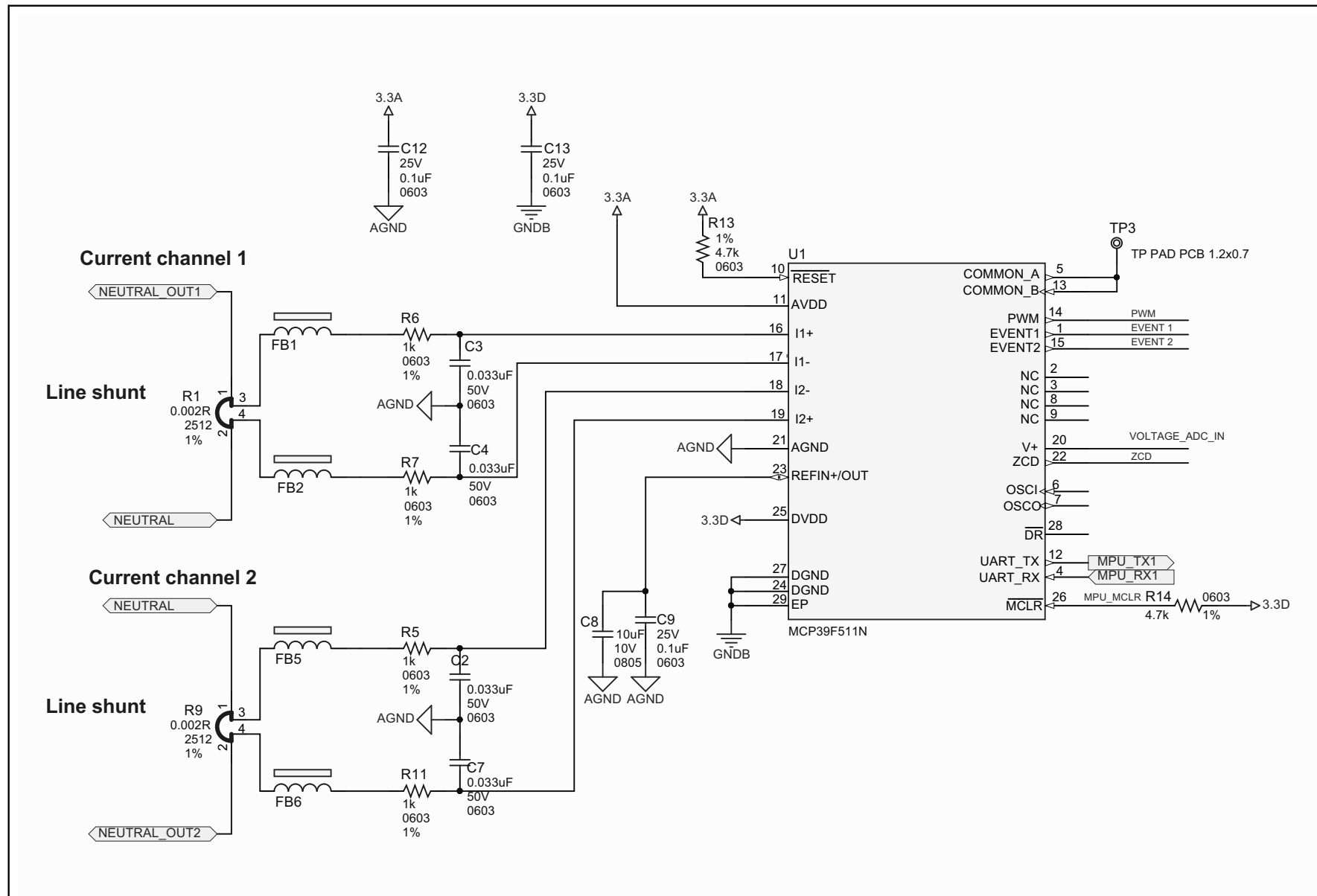
### A.2 SCHEMATICS AND PCB LAYOUT

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

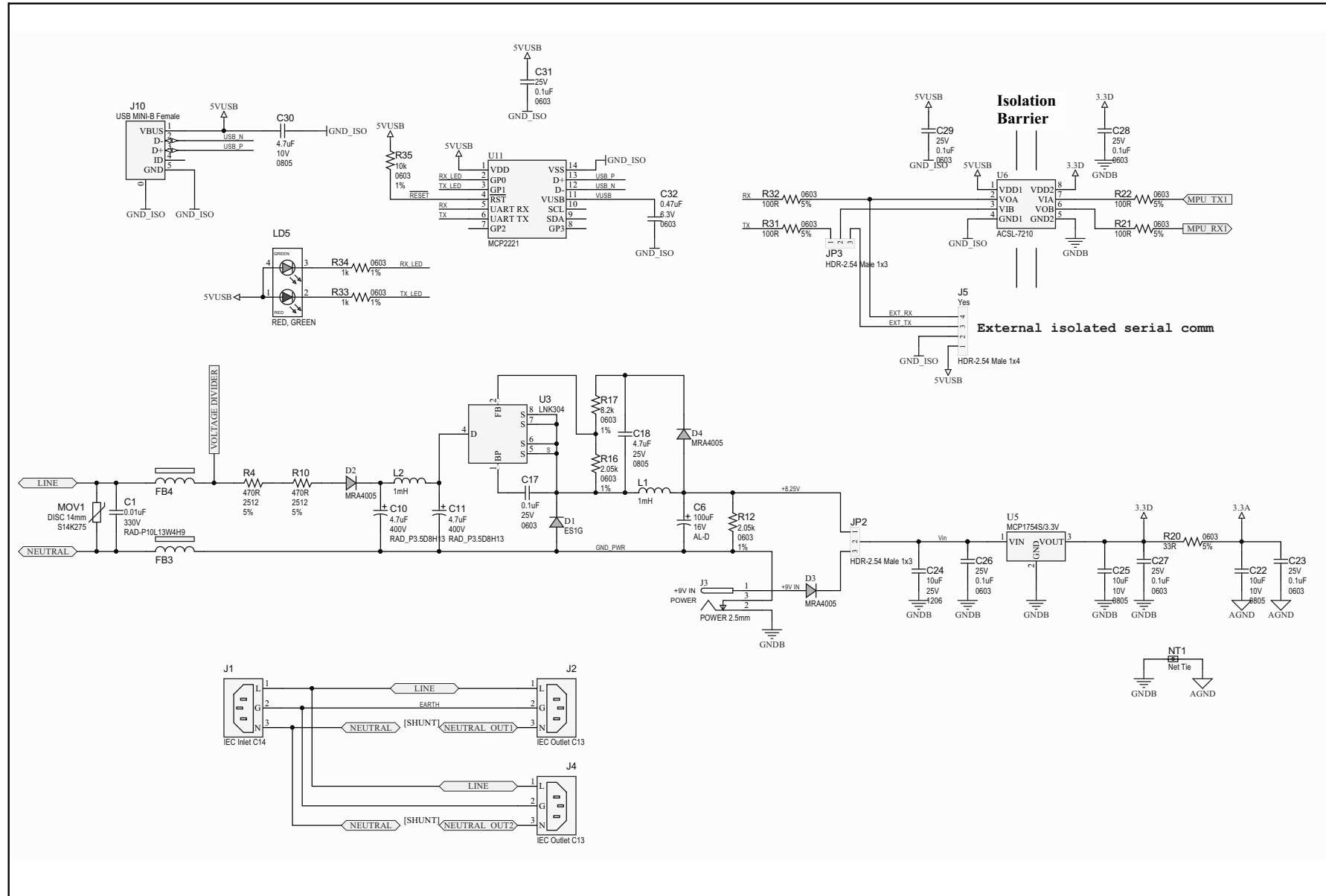


**FIGURE A-1:** Layer Order.

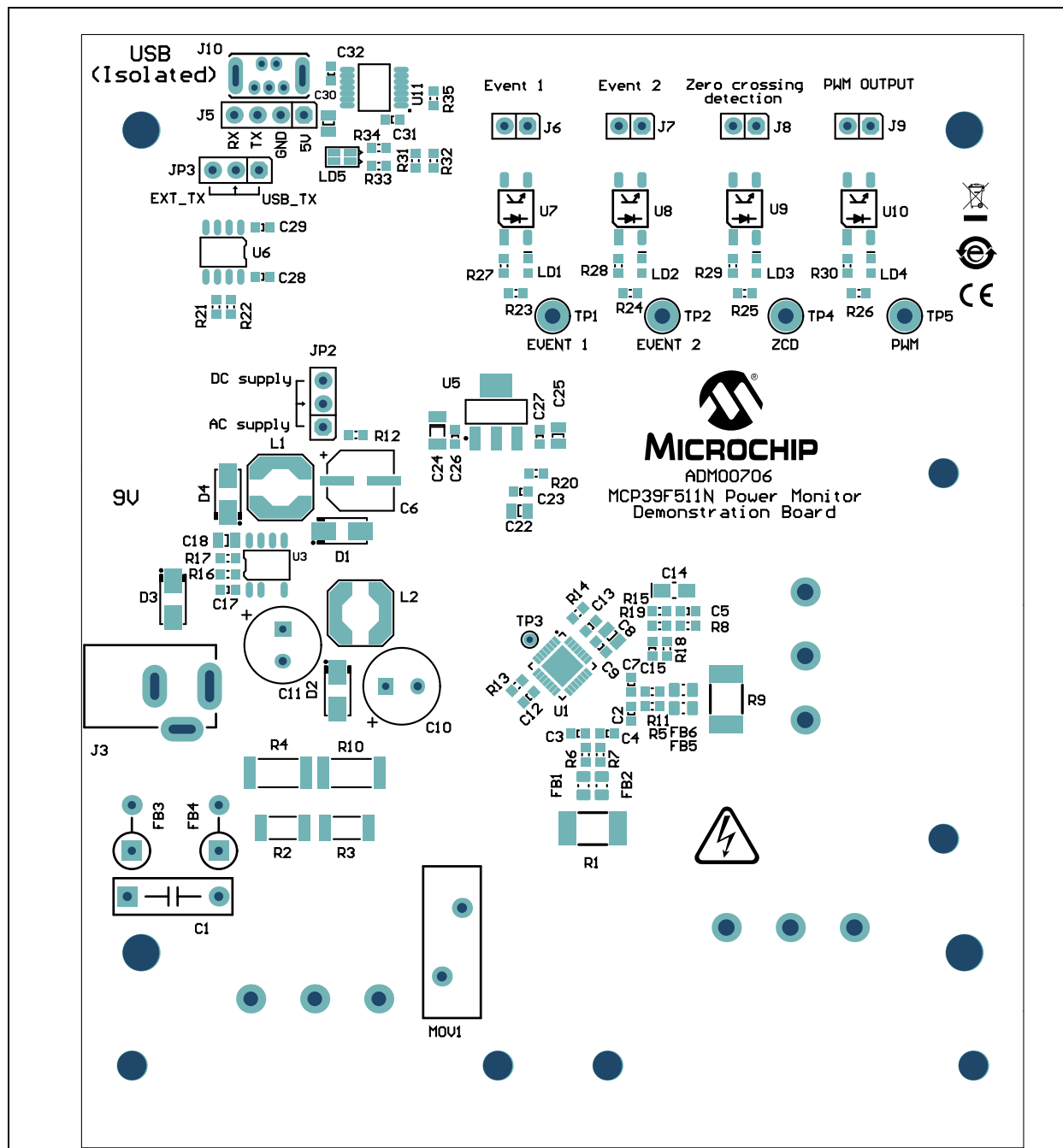
## A.3 BOARD - SCHEMATIC



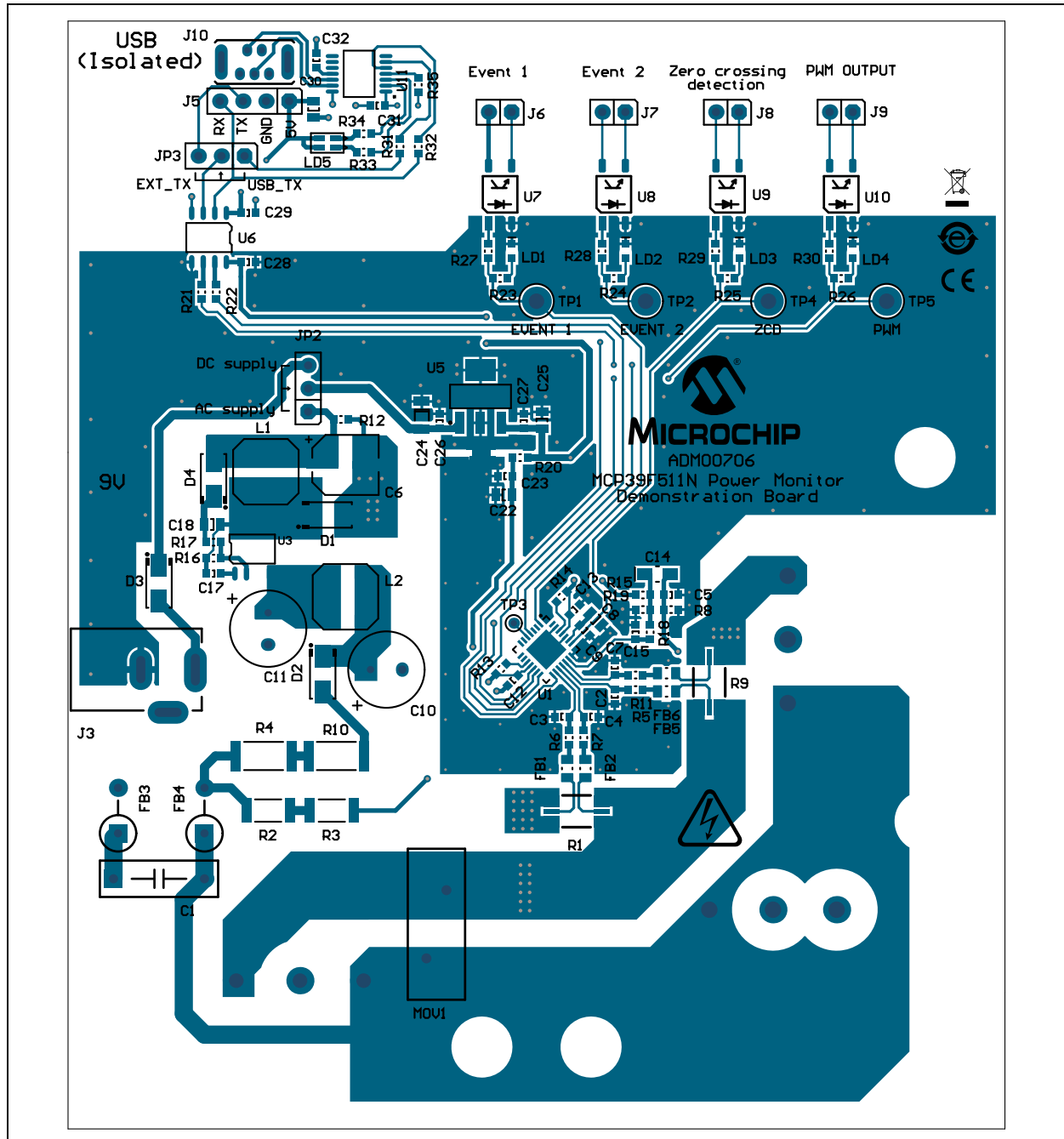
## A.4 BOARD – SCHEMATIC (CONTINUED)



## A.5 BOARD – TOP SILK



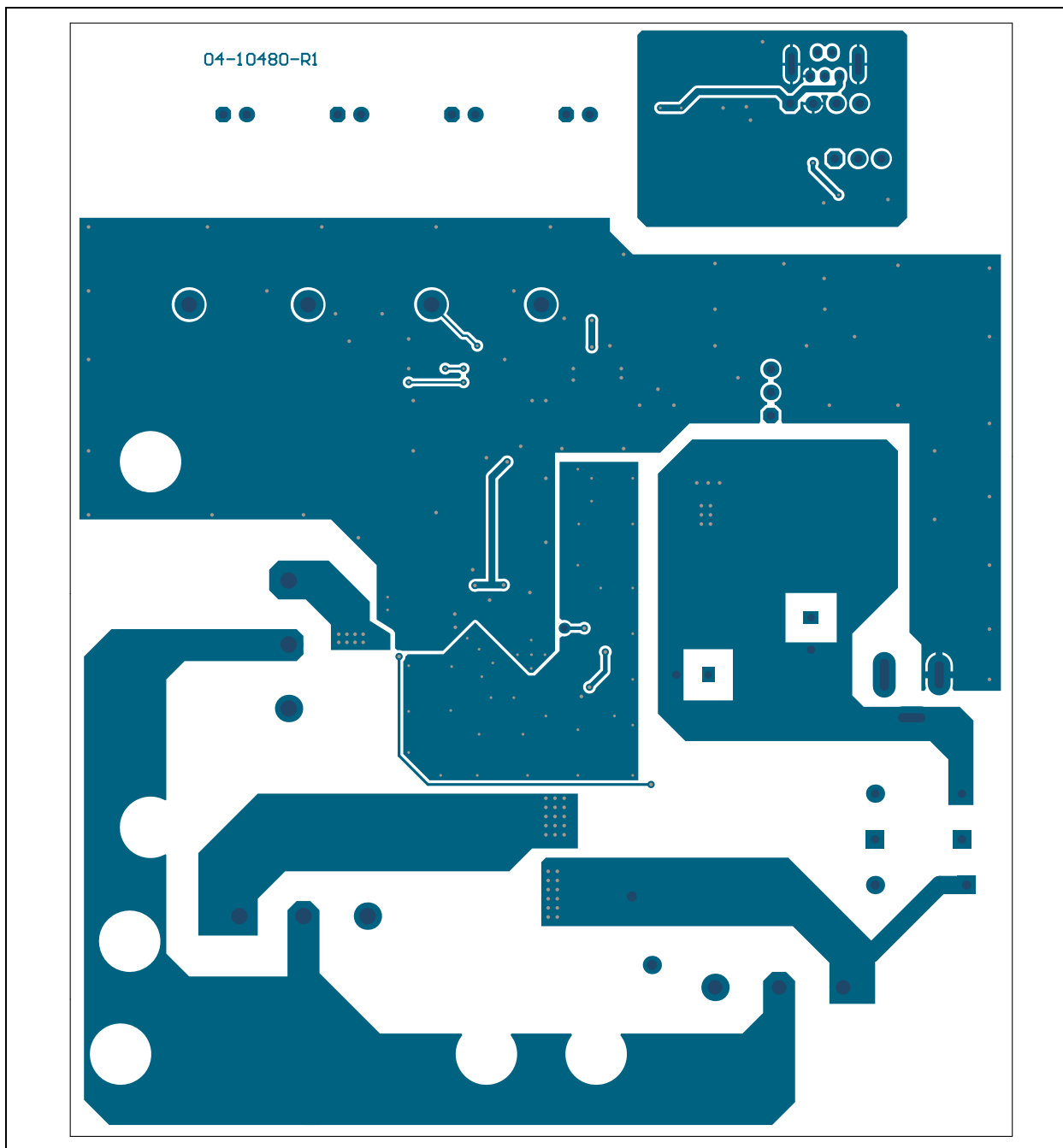
## A.6 BOARD – TOP COPPER AND SILK



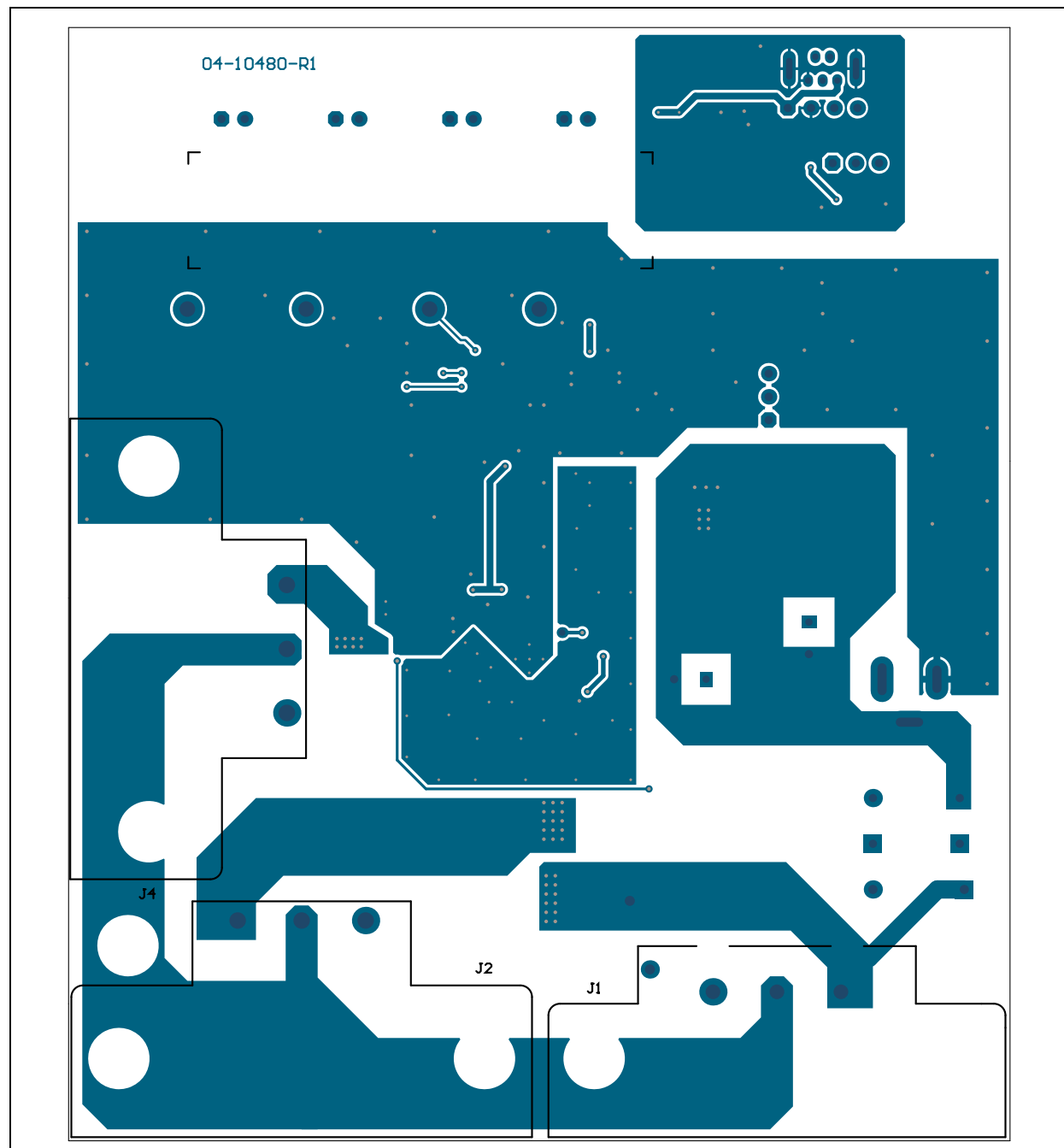
\_\_\_\_\_



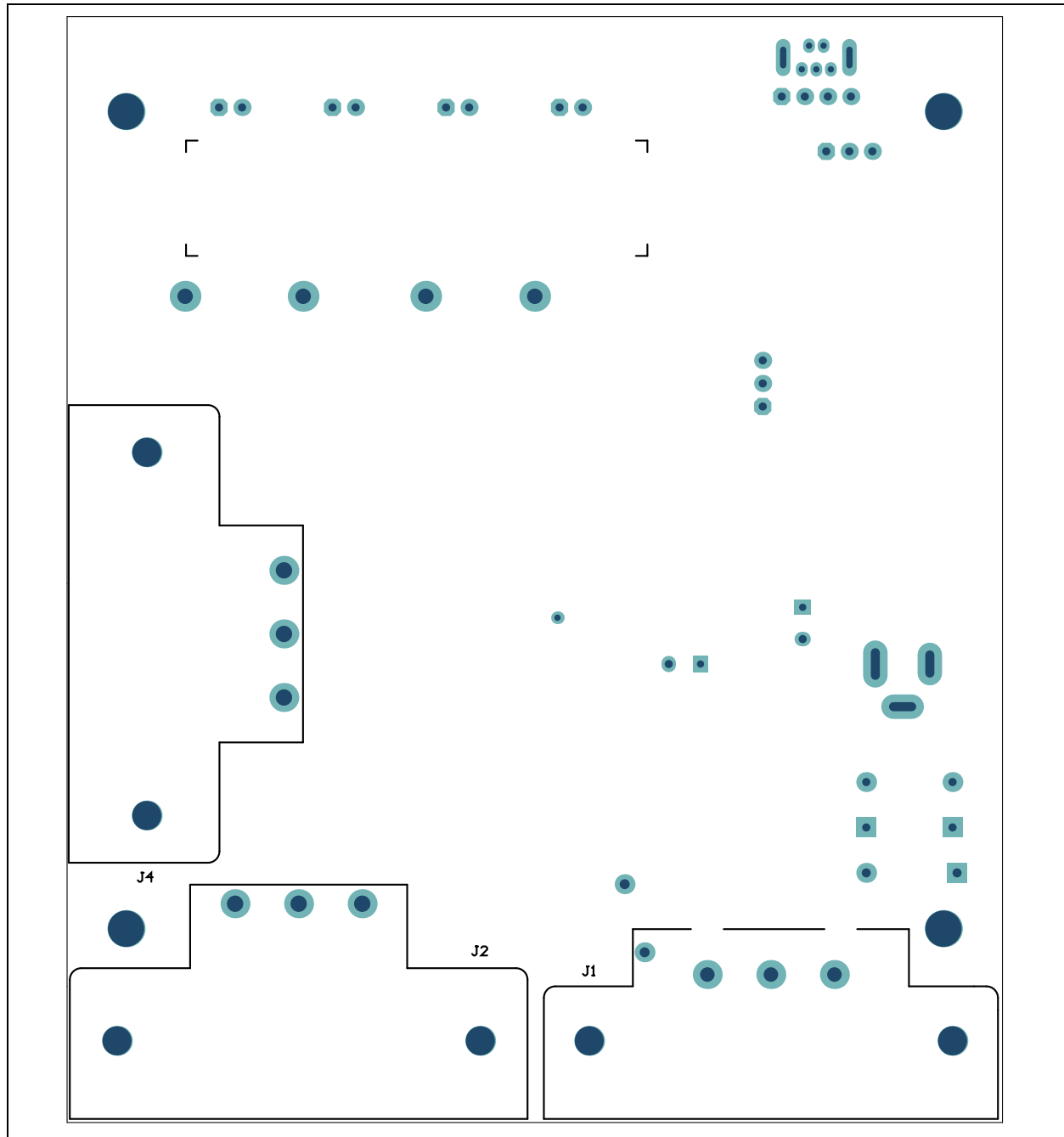
## A.8 BOARD – BOTTOM COPPER



## A.9 BOARD – BOTTOM COPPER AND SILK



## A.10 BOARD – BOTTOM SILK



# MCP39F511N Power Monitor Demonstration Board User's Guide

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NOTES:

## Appendix B. Bill of Materials (BOM)

**TABLE B-1: BILL OF MATERIALS (BOM)**

| Qty. | Reference                                       | Description                                                              | Manufacturer                           | Part Number         |
|------|-------------------------------------------------|--------------------------------------------------------------------------|----------------------------------------|---------------------|
| 1    | C1                                              | Capacitor film 0.01 $\mu$ F 330V 20% RAD P10L13W4H9                      | EPCOS AG                               | B32911A3103M        |
| 6    | C2, C3, C4, C5, C7, C15                         | Capacitor ceramic 0.033 $\mu$ F 50V 10% X7R SMD 0603                     | TDK Corporation                        | C1608X7R1H333K      |
| 1    | C6                                              | Capacitor alum. 100 $\mu$ F 16V 20% SMD D                                | Nichicon Corporation                   | UWX1C101MCL1GB      |
| 3    | C8, C22, C25                                    | Capacitor ceramic 10 $\mu$ F 10V 10% X7R SMD 0805                        | TDK Corporation                        | C2012X7R1A106K125AC |
| 10   | C9, C12, C13, C17, C23, C26, C27, C28, C29, C31 | Capacitor ceramic 0.1 $\mu$ F 25V 10% X7R SMD 0603                       | Murata Electronics                     | GRM188R71E104KA01D  |
| 2    | C10, C11                                        | Capacitor alum. 4.7 $\mu$ F 400V 20% RAD_P3.5D8H13                       | Nichicon Corporation                   | UVC2G4R7MPD1TD      |
| 1    | C14                                             | Capacitor tantalum 47 $\mu$ F 4V 10% 2.6Ohm SMD A                        | AVX Corporation                        | TAJA476K004RNJ      |
| 1    | C18                                             | Capacitor ceramic 4.7 $\mu$ F 25V 10% X7R SMD 0805                       | TDK Corporation                        | C2012X7R1E475K125AB |
| 1    | C24                                             | Capacitor ceramic 10 $\mu$ F 25V 10% X7R SMD 1206                        | Taiyo Yuden Co., Ltd.                  | TMK316B7106KL-TD    |
| 1    | C30                                             | Capacitor ceramic 4.7 $\mu$ F 10V 10% X5R SMD 0805                       | Taiyo Yuden Co., Ltd.                  | LMK212BJ475KD-T     |
| 1    | C32                                             | Capacitor ceramic 0.47 $\mu$ F 6.3V 10% X5R SMD 0603                     | Murata Electronics®                    | GRM188R60J474KA01D  |
| 1    | CBL1                                            | Mech. HW cable USB-A male-to-mini USB-B male 3 ft black                  | Katerno                                | 10UM-02103BK        |
| 2    | CBL2, CBL3                                      | Mech. HW 1ft 18 AWG monitor power adapter cord (NEMA 5-15R to IEC320C14) | Katerno                                | 152360              |
| 1    | CBL4                                            | Mech. HW 6 ft 16 AWG universal power cord (IEC320C13 to NEMA 5-15P)      | Katerno                                | 153879              |
| 1    | D1                                              | Diode rectifier ES1G 1.25V 1A 400V SMD DO-214AC_SMA                      | Diodes® Incorporated                   | ES1G-13-F           |
| 3    | D2, D3, D4                                      | Diode rectifier MRA4005 1.1V 1A 600V DO-214AC_SMA                        | ON Semiconductor®                      | MRA4005T3G          |
| 1    | ENCLOSURE1                                      | Mech. enclosure slim ref. side port meter                                | Tech-Demos.com                         | TD03-0102R0         |
| 4    | FB1, FB2, FB5, FB6                              | Ferrite 800mA 0.15R SMD 0805                                             | Laird Technologies®                    | LI0805H151R-10      |
| 2    | FB3, FB4                                        | Ferrite 7A RAD P5L5.3D3.8                                                | Murata Electronics North America, Inc. | BL02RN1R2M2B        |

**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)

**TABLE B-1: BILL OF MATERIALS (BOM) (CONTINUED)**

| Qty. | Reference                                                              | Description                                                         | Manufacturer                    | Part Number       |
|------|------------------------------------------------------------------------|---------------------------------------------------------------------|---------------------------------|-------------------|
| 1    | J1                                                                     | Conn. IEC 250V 15A inlet C14 TH R/A                                 | SCHURTER Inc.                   | GSP1.9103.1       |
| 2    | J2, J4                                                                 | Conn. IEC 250V 15A outlet C13 TH R/A                                | SCHURTER Inc.                   | 6182.0033         |
| 1    | J3                                                                     | Conn. pwr. 2.5mm 5.5mm 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      |
| 4    | J6, J7, J8, J9                                                         | Conn. header-2.54 male 1x2 tin 6.10 MH TH vert.                     | Molex®                          | 0022284020        |
| 1    | J10                                                                    | Conn. USB mini-B female TH vert.                                    | Molex® Connector Corporation    | 500075-1517       |
| 2    | JP2, JP3                                                               | Conn. header-2.54 male 1x3 gold 5.84 MH TH vert.                    | FCI                             | 68000-103HLF      |
| 2    | JP4, JP5                                                               | 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®                      | LPS6225-105MRB    |
| 1    | LABEL1                                                                 | Label, NEED HELP WITH ASSY/SERIAL                                   |                                 |                   |
| 1    | LABEL2                                                                 | Mech. HW LABEL HIGH VOLTAGE                                         | Panduit Corp.                   | PLD-56            |
| 4    | LD1, LD2, LD3, LD4                                                     | Diode LED red 1.95V 30 mA 700 MCD clear SMD 0603                    | Kingbright Electronic Co., Ltd. | APTD1608SURCK     |
| 1    | LD5                                                                    | Diode LED bi. red, green 1.95V, 2.1V 30 mA 0805                     | Kingbright Corp.                | APHBM2012SURKCGKC |
| 1    | MOV1                                                                   | Resistor varistor 275V 130J TH disc 14 mm                           | EPCOS AG                        | S14K275E2K1       |
| 6    | NUT1, NUT2, NUT3, NUT4, NUT5, NUT6                                     | Hex. nut 0.217" steel M3                                            | Keystone Electronics Corp.      | 4708              |
| 1    | PCB1                                                                   | Printed Circuit Board – MCP39F501 Power Monitor Demonstration Board | Microchip Technology Inc.       | 04-10480-1        |
| 2    | R1, R9                                                                 | Resistor 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      |
| 15   | R5, R6, R7, R11, R18, R23, R24, R25, R26, R27, R28, R29, R30, R33, R34 | Res. TKF 1k 1% 1/10W SMD 0603                                       | Panasonic - ECG                 | ERJ-3EKF1001V     |
| 1    | R8                                                                     | Res. TKF 5.1k 1% 1/10W SMD 0603                                     | Panasonic - ECG                 | ERJ-3EKF5101V     |
| 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, R19                                                               | Res. TKF 51k 1% 1/10W SMD 0603                                      | Panasonic - ECG                 | ERJ-3EKF5102V     |
| 1    | R17                                                                    | Res. TKF 8.2k 1% 1/10W SMD 0603                                     | Panasonic - ECG                 | ERJ-3EKF8201V     |
| 1    | R20                                                                    | Res. TKF 33R 5% 1/10W SMD 0603                                      | Yageo Corporation               | 9C06031A33R0JLHFT |
| 4    | R21, R22, R31, R32                                                     | Res. TKF 100R 5% 1/10W SMD 0603                                     | Vishay/Dale                     | CRCW0603100RJNEA  |

**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. | Reference                                      | Description                                                          | Manufacturer                 | Part Number               |
|------|------------------------------------------------|----------------------------------------------------------------------|------------------------------|---------------------------|
| 1    | R35                                            | Resistor TKF 10k 1% 1/10W SMD 0603                                   | Panasonic - ECG              | ERJ-3EKF1002V             |
| 6    | SCR1,<br>SCR2,<br>SCR3,<br>SCR4,<br>SCR5, SCR6 | Machine screw pan Phillips M3                                        | Digi-Key® Electronics        | 335-1156-ND               |
| 4    | TP1, TP2,<br>TP4, TP5                          | Conn. TP pin tin TH                                                  | Harwin Plc.                  | H2121-01                  |
| 1    | U1                                             | Microchip Analog Energy Measurement<br>4000:1 MCP39F511N-E/MQ QFN-28 | Microchip Technology<br>Inc. | <b>MCP39F511N-E/MQ</b>    |
| 1    | U3                                             | IC switcher LNK304 SO-8C                                             | Power Integrations™          | LNK304DG-TL               |
| 1    | U5                                             | Microchip Analog LDO 3.3V<br>MCP1754ST-3302E/DB SOT-223-3            | Microchip Technology<br>Inc. | <b>MCP1754ST-3302E/DB</b> |
| 1    | U6                                             | IC photo ACSL-7210-06RE Bi-Dir. 3.3V<br>and 5V SOIC-8                | Avago Technologies           | ACSL-7210-06RE            |
| 4    | U7, U8, U9,<br>U10                             | IC Photo HCPL-181 4-SMD                                              | Avago Technologies           | HCPL-181-00CE             |
| 1    | U11                                            | Microchip interface USB I2C UART<br>MCP2221-I/ST TSSOP-14            | Microchip Technology<br>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.

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