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MCP39F501
Power Monitor PICtail™
Evaluation Board
User's Guide

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Object of Declaration: MCP39F501 Power Monitor PICtail™ Evaluation Board

EU Declaration of Conformity


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 (8th February 2010).

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

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


Derek Carlson
VP Development Tools


Date

MCP39F501 Power Monitor PICtail™ Evaluation Board User's Guide

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MCP39F501 POWER MONITOR PICTAIL™ EVALUATION BOARD USER'S GUIDE

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Preface

NOTICE TO CUSTOMERS

All documentation becomes dated, and this manual is no exception. Microchip tools and documentation are constantly evolving to meet customer needs, so some actual dialogs and/or tool descriptions may differ from those in this document. Please refer to our web site (www.microchip.com) to obtain the latest documentation available.

Documents are identified with a “DS” number. This number is located on the bottom of each page, in front of the page number. The numbering convention for the DS number is “DSXXXXXXXXA”, where “XXXXXXXX” is the document number and “A” is the revision level of the document.

For the most up-to-date information on development tools, see the MPLAB® IDE online help. Select the Help menu, and then Topics to open a list of available online help files.

INTRODUCTION

This chapter contains general information that will be useful to know before using the MCP39F501 Power Monitor PICTail™ Evaluation 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 MCP39F501 Power Monitor PICTail™ Evaluation Board as a development board for the MCP39F501 device. The manual layout is as follows:

- **Chapter 1. “Product Overview”** – Provides important information about the MCP39F501 Power Monitor PICTail™ Evaluation Board.
- **Chapter 2. “Installation and Operation”** – Provides important information on using the MCP39F501 Power Monitor PICTail™ Evaluation Board including a getting started section that describes wiring the line and load connections.
- **Chapter 3. “Hardware”** – Includes details on the function 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 MCP39F501 Power Monitor PICTail™ Evaluation Board.

CONVENTIONS USED IN THIS GUIDE

This manual uses the following documentation conventions:

DOCUMENTATION CONVENTIONS

| Description | Represents | Examples |
|--|---|---|
| Arial font: | | |
| Italic characters | Referenced books | <i>MPLAB® 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>Save</i></u> |
| Bold characters | A dialog button | Click OK |
| | A tab | Click the Power tab |
| N'Rnnnn | A number in verilog format, where N is the total number of digits, R is the radix and n is a digit. | 4'b0010, 2'hF1 |
| Text in angle brackets < > | A key on the keyboard | Press <Enter>, <F1> |
| Courier New font: | | |
| Plain Courier New | Sample source code | #define START |
| | Filenames | autoexec.bat |
| | File paths | c:\mcc18\h |
| | Keywords | _asm, _endasm, static |
| | Command-line options | -Opa+, -Opa- |
| | Bit values | 0, 1 |
| | Constants | 0xFF, 'A' |
| Italic Courier New | A variable argument | <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) { ... } |

RECOMMENDED READING

This user's guide describes how to use MCP39F501 Power Monitor PICtail™ Evaluation Board. Another useful documents is listed below. The following Microchip document is available and recommended as a supplemental reference resource.

MCP39F501 Data Sheet – “Single-Phase Power-Monitoring IC with Calculation and Event Detection” (DS20005256)

This data sheet provides detailed information regarding the MCP39F501 device.

THE MICROCHIP WEB SITE

Microchip provides online support via our web site at www.microchip.com. This web site is used as a means to make files and information easily available to customers. Accessible by using your favorite Internet browser, the web site contains the following information:

- **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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- 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://www.microchip.com/support>.

DOCUMENT REVISION HISTORY

Revision A (August 2014)

- Initial Release of this Document.

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Chapter 1. Product Overview

1.1 INTRODUCTION

The MCP39F501 Power Monitor PICTail™ Evaluation Board provides the option of a fully functional single-phase power monitor, along with a development platform. This low-cost design does not use any transformers and requires few external components. The device calculates active power, reactive power, RMS current, RMS voltage, power factor, line frequency and other typical power quantities as defined in the MCP39F501 data sheet.

The *MCP39F501 Power Monitor Utility* software is used to calibrate and monitor the system, and can be used to create custom calibration setups. For some accuracy requirements, only a single point calibration may be needed.

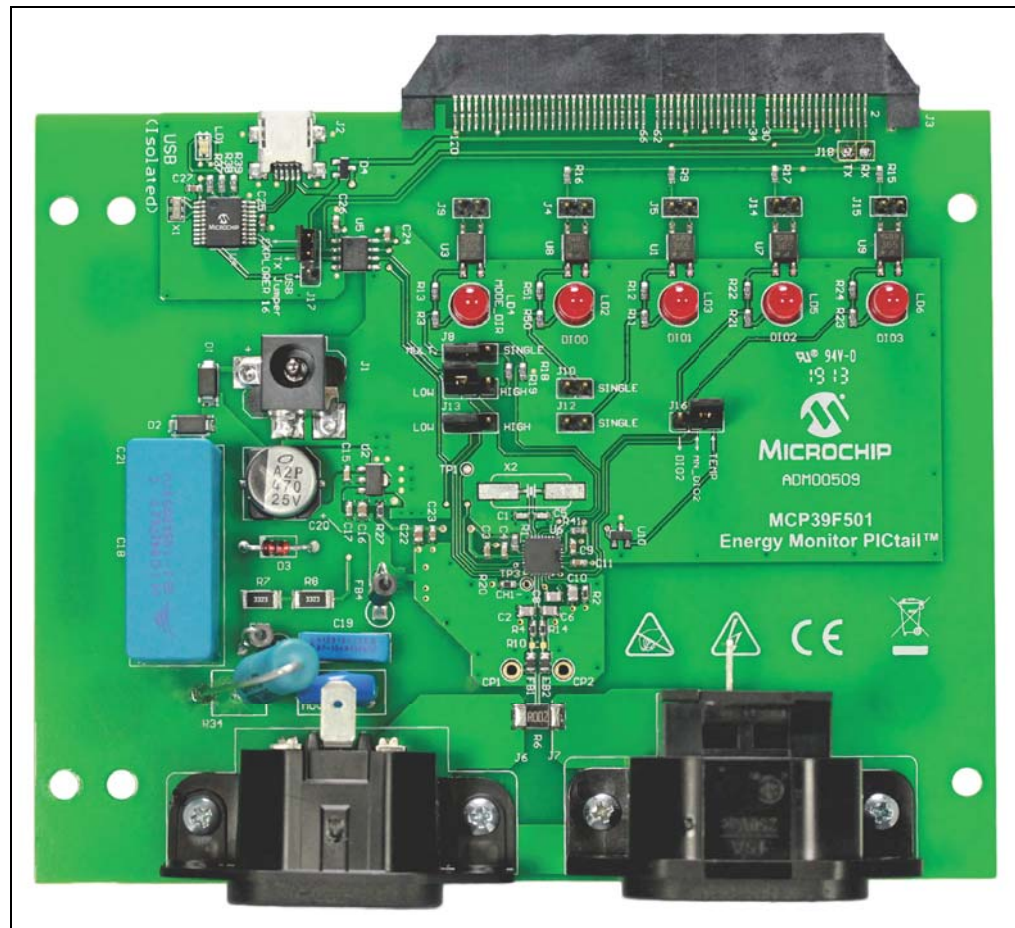


FIGURE 1-1: MCP39F501 Power Monitor PICTail™ Evaluation Board.

1.2 WHAT THE MCP39F501 POWER MONITOR PICTAIL™ EVALUATION BOARD KIT INCLUDES

This MCP39F501 Power Monitor PICtail™ Evaluation Board kit includes:

- MCP39F501 Power Monitor PICtail™ Evaluation Board and Case (ADM00509)
- Line Cable
- Load Cable
- USB Cable
- Important Information Sheet

Chapter 2. Installation and Operation

2.1 GETTING STARTED

To use the MCP39F501 Power Monitor PICTail™ Evaluation Board, follow the steps described below. The meter design uses a 5A load for nominal current and a maximum current (I_{MAX}) of 15A. It is not recommended to draw more than 15A through the AC plugs mounted on the Printed Circuit Board (PCB).

To get started, follow the next steps.

2.1.1 Step 1: Wiring connections

Figure 2-1 identifies the line and load connections of the MCP39F501 Power Monitor PICTail™ Evaluation Board.

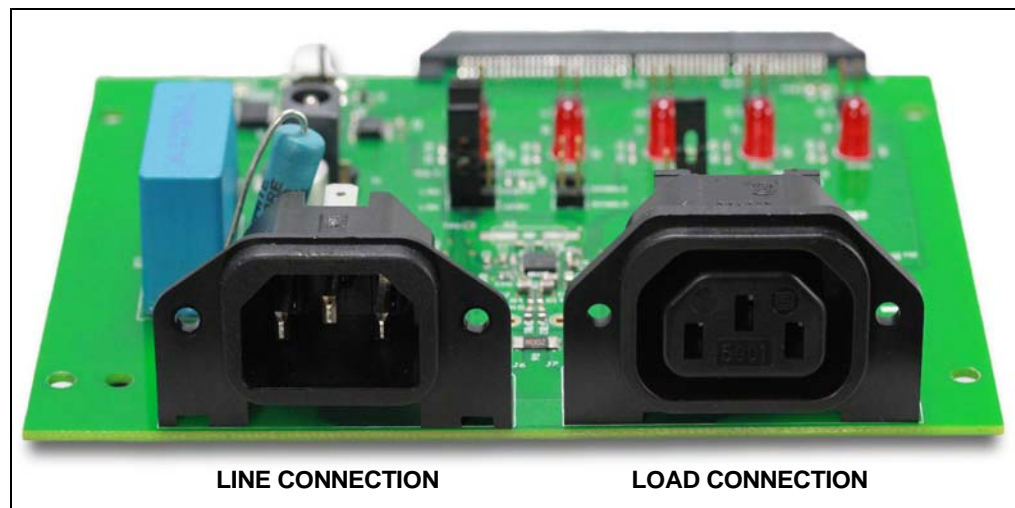


FIGURE 2-1: Connecting the MCP39F501 Power Monitor PICTail™ Evaluation Board.

2.1.2 Step 2: Connect the Line Cable to the Meter and plug into appropriate power plug

The meter will turn on when the line connection has between 90V to 230V.

2.1.3 Step 3: Connect the USB cable to a PC with the installed “MCP39F501 Power Monitor Utility” software

Select the correct COMM port and the following message should appear:

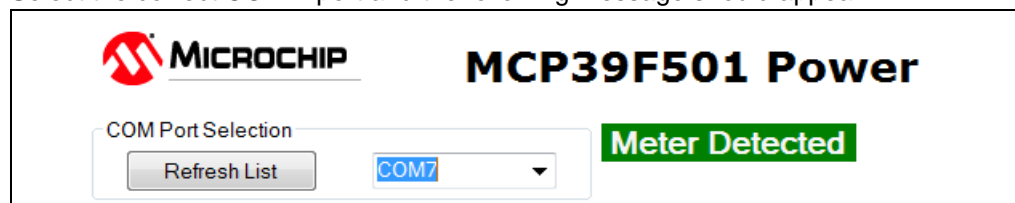


FIGURE 2-2: Successful Connection Between PC and Evaluation Board.

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Chapter 3. Hardware

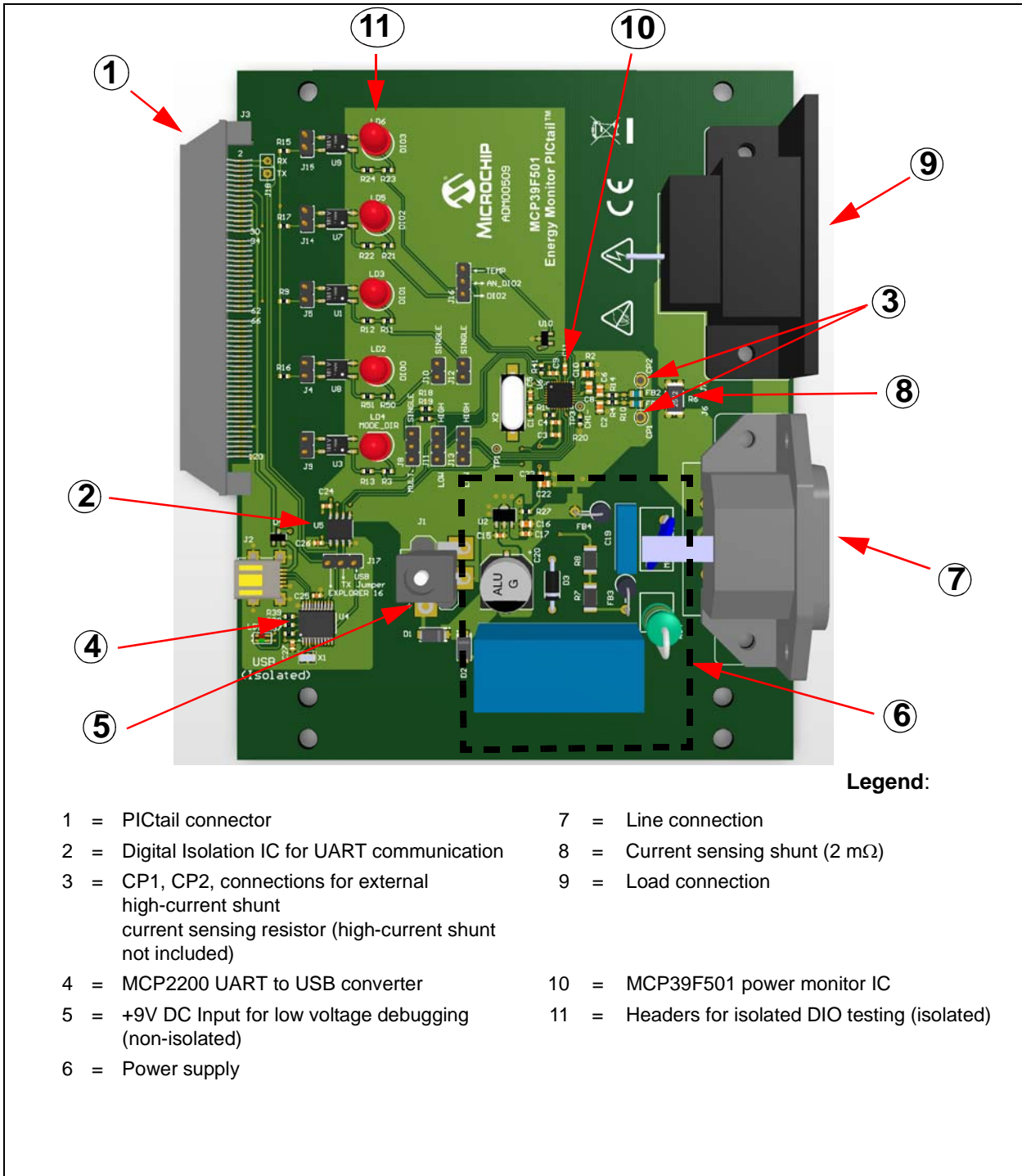


FIGURE 3-1: Top View – Hardware Components.

3.1 INPUT AND ANALOG FRONT END

The MCP39F501 Power Monitor PICtail™ Evaluation Board comes populated with components designed for 90V to 230V line voltage. The neutral side of the phase goes through a 2 mΩ shunt connected directly to the MCP39F501 for current measurement. The line side of the phase goes through a 1000:1 voltage divider and into the device for voltage measurement.

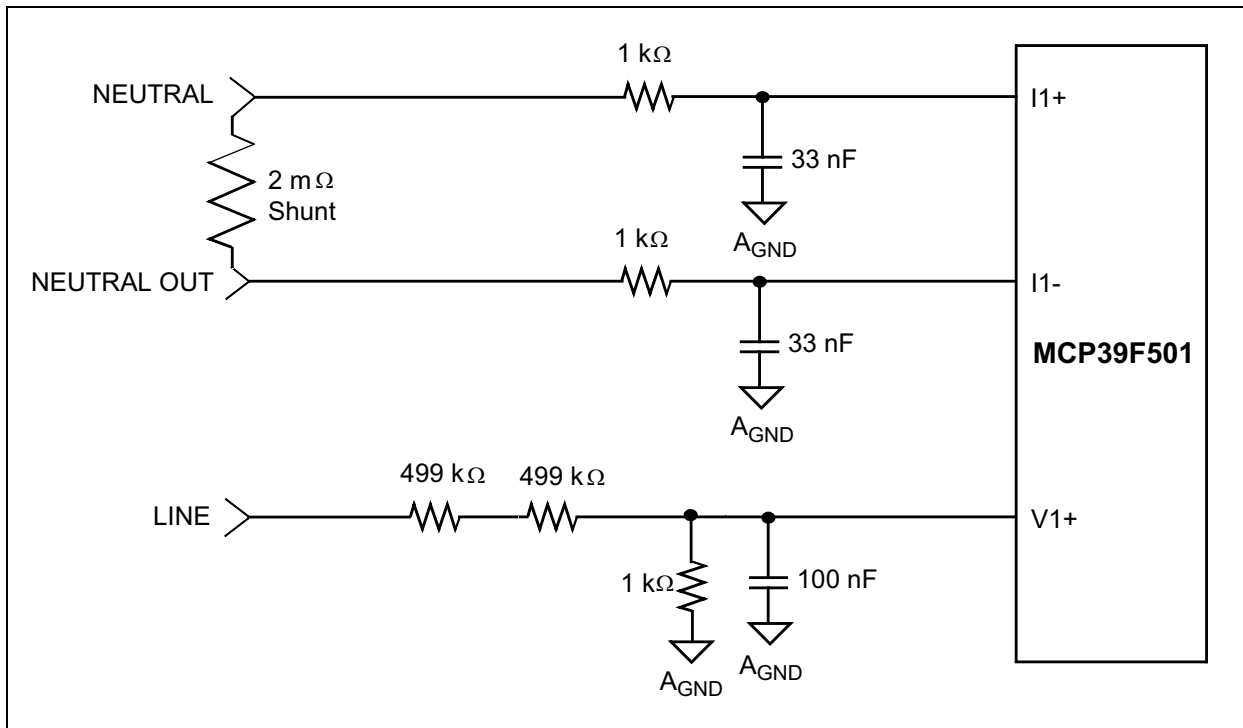


FIGURE 3-2: Analog Front End Circuitry.

Note: All of the analog circuitry associated with this part of the circuit is connected to the analog ground plane, AGND. Similar grounding and layout approaches should be used in all MCP39F501 applications. For complete schematic and PCB layout information, see [Appendix A. “Schematic and Layouts”](#) and [Appendix B. “Bill of Materials \(BOM\)”](#).

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Appendix A. Schematic and Layouts

A.1 INTRODUCTION

This appendix contains the following schematics and layouts for of the MCP39F501 Power Monitor PICtail™ Evaluation Board:

- Board – Schematic 1
- Board – Schematic 2
- Board – Assembly Top
- Board – Top Silk
- Board – Top Copper and Silk
- Board – Top Copper
- Board – Bottom Copper

A.2 SCHEMATICS AND PCB LAYOUT

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

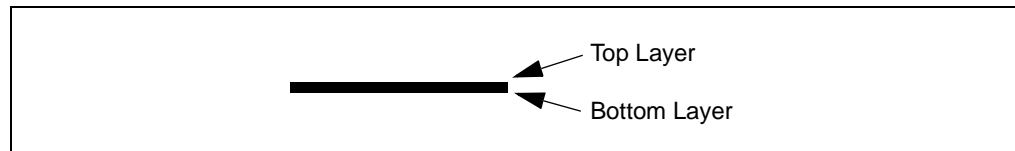
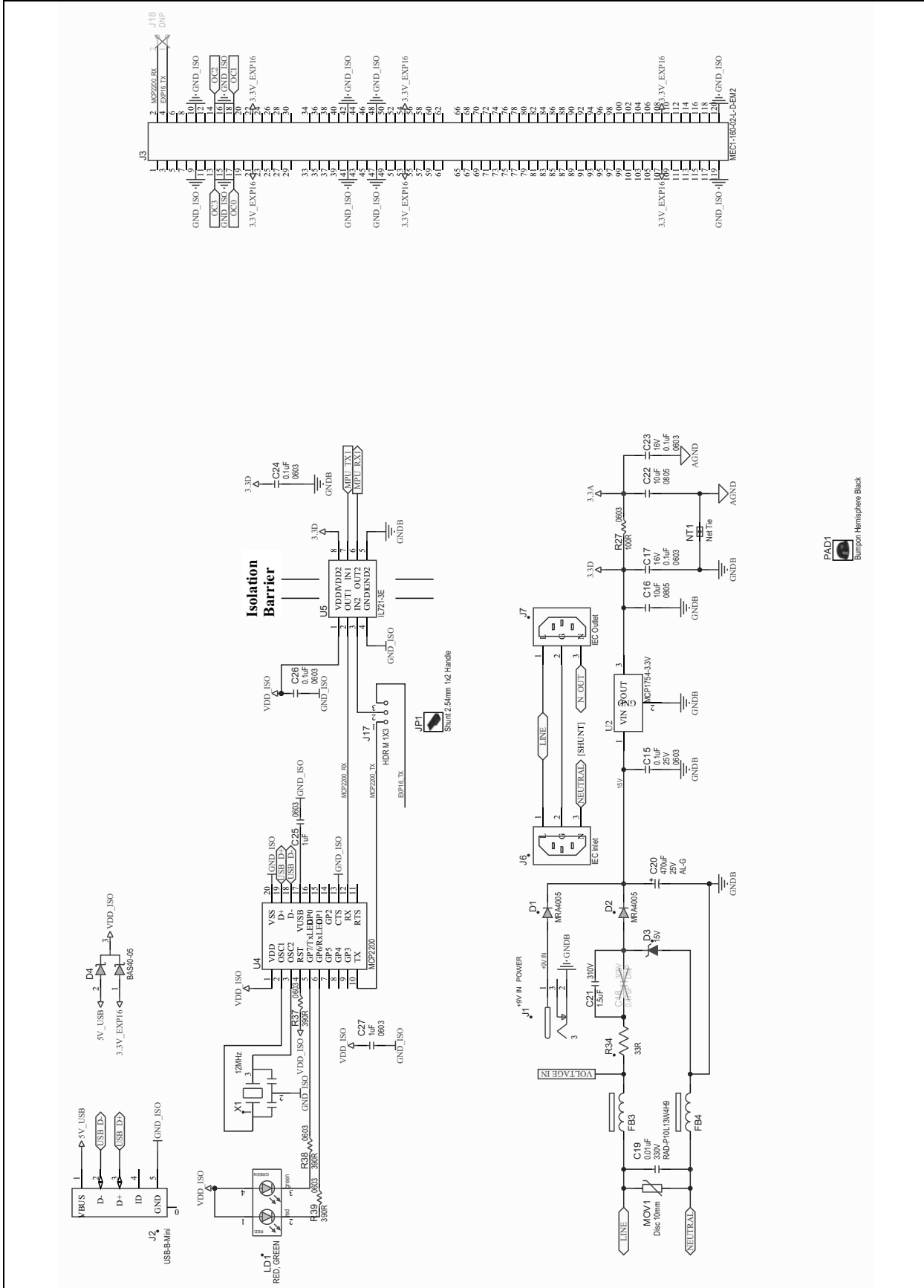
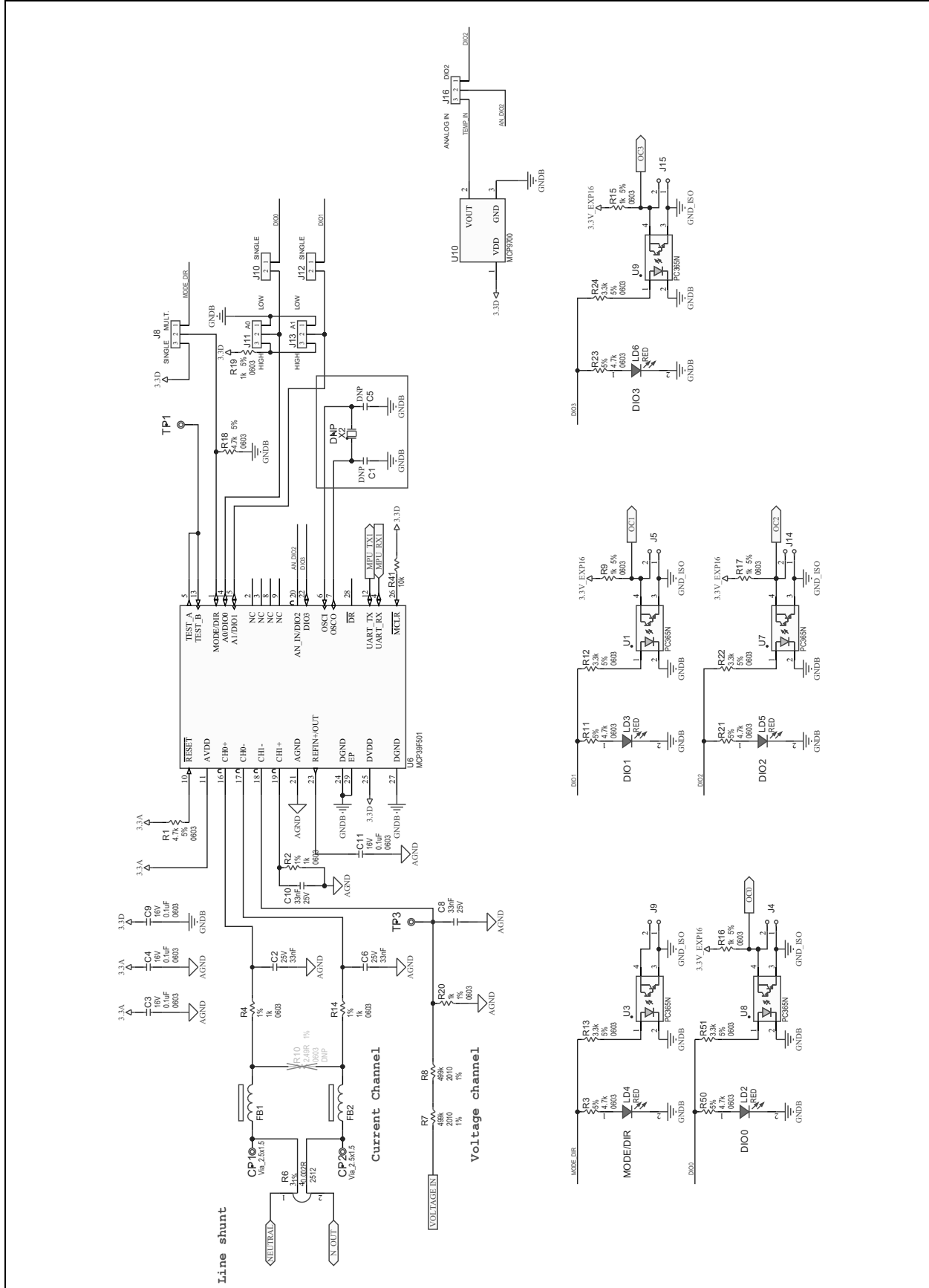


FIGURE A-1: Layer Order.

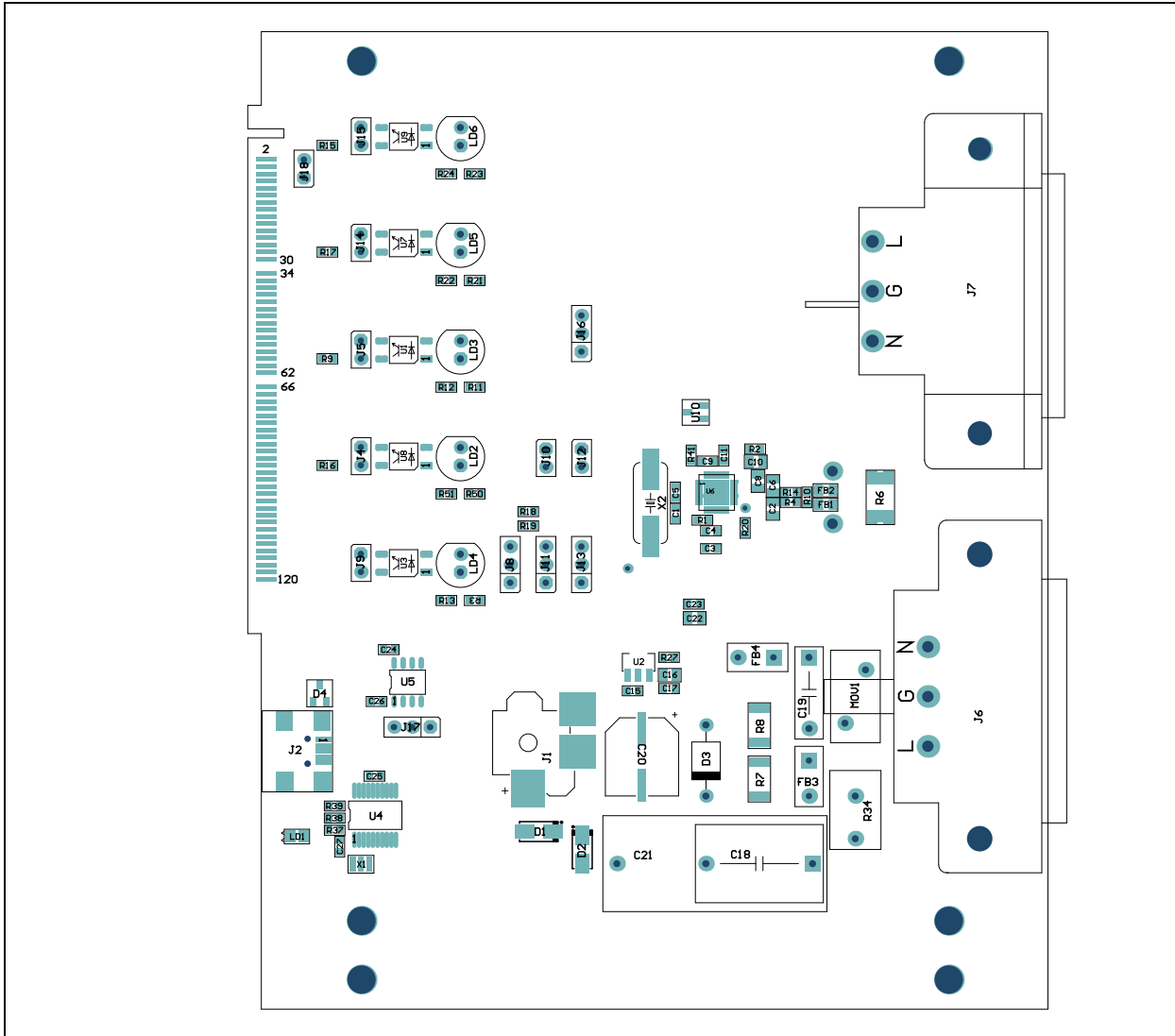
A.3 BOARD – SCHEMATIC 1



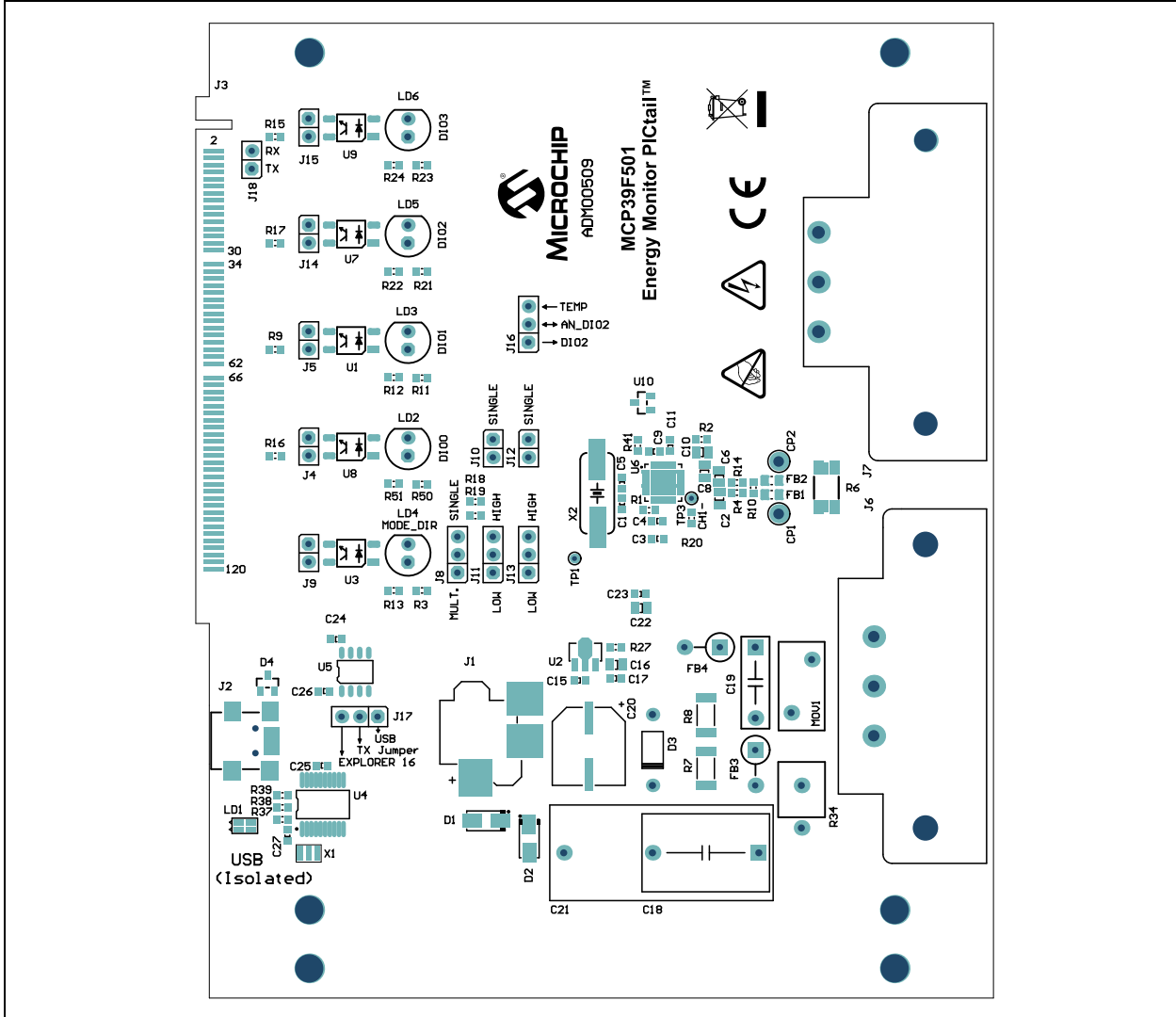
A.4 BOARD – SCHEMATIC 2



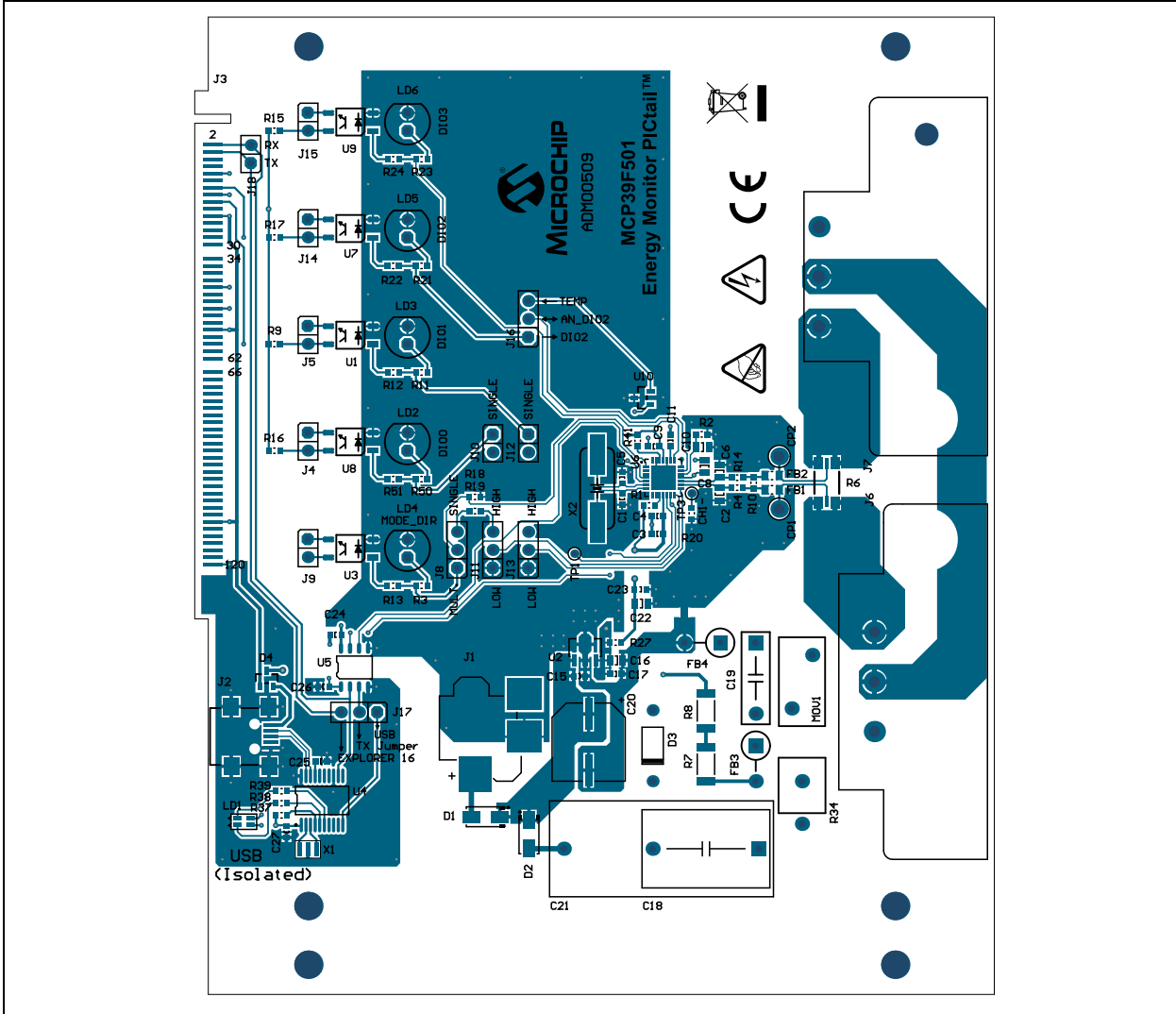
A.5 BOARD – ASSEMBLY TOP



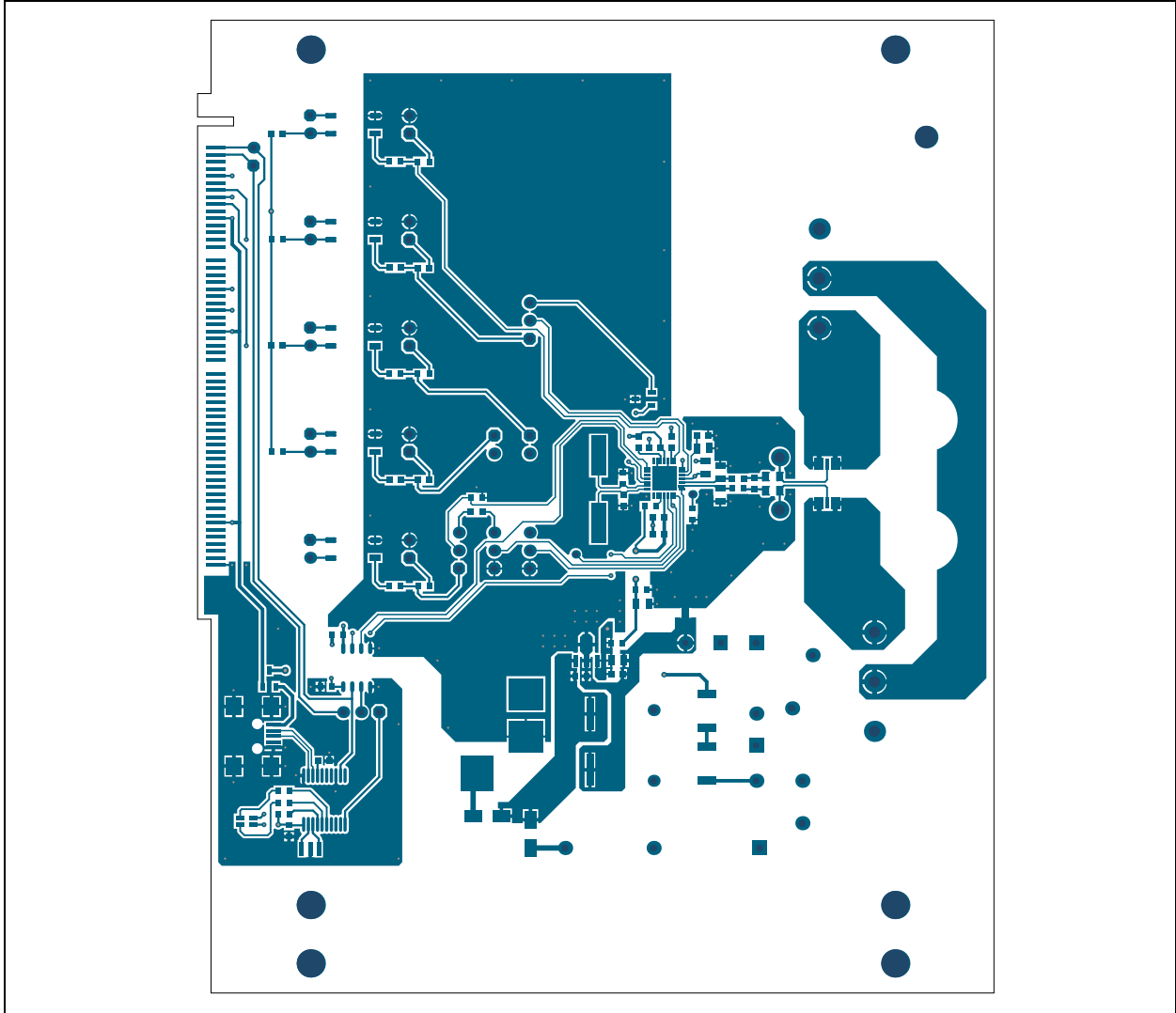
A.6 BOARD – TOP SILK



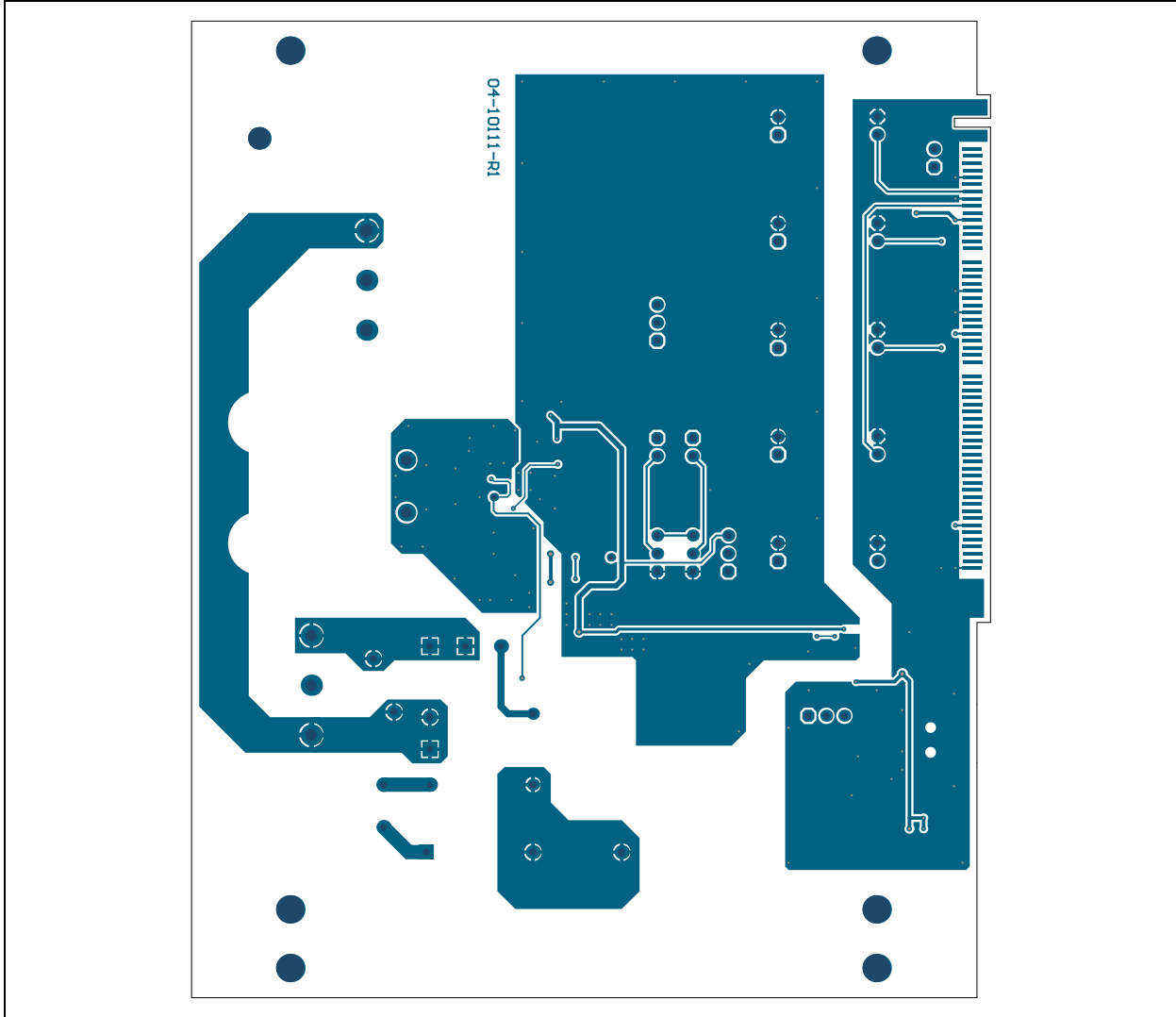
A.7 BOARD – TOP COPPER AND SILK



A.8 BOARD – TOP COPPER



A.9 BOARD – BOTTOM COPPER



Appendix B. Bill of Materials (BOM)

TABLE B-1: BILL OF MATERIALS (BOM)

| Qty | Reference | Description | Manufacturer | Part Number |
|-----|---|---|--------------------------|--------------------|
| 2 | C1, C5 | Cap. ceramic 18 pF 50V 5% NP0 SMD 0603 - DO NOT POPULATE | Panasonic® - ECG | ECJ-1VC1H180J |
| 1 | C15 | Cap. ceramic 0.1 µF 25V 5% X7R SMD 0603 | AVX Corporation | 06033C104JAT2A |
| 2 | C16, C22 | Cap. ceramic 10 µF 10V 20% Y5V SMD 0805 | TDK Corporation | C2012Y5V1A106Z |
| 0 | C18 | Cap. film 0.47 µF 305V 20% RAD P15L18W11H18.5 - DO NOT POPULATE | EPCOS AG | B32932A3474M |
| 1 | C19 | Cap. film 0.01 µF 330V 20% RAD P10L13W4H9 | EPCOS AG | B32911A3103M |
| 4 | C2, C6, C8, C10 | Cap. ceramic 33 nF 25V 5% C0G, NP0 SMD 0805 | TDK Corporation | C2012C0G1E333J |
| 1 | C20 | Cap. alum. 470 µF 25V 20% SMD G | Nichicon Corporation | UWT1E471MNL1GS |
| 1 | C21 | Cap. film 1.5 µF 310V 20% RAD P27.5L31.5W13.5H23 | EPCOS AG | B32924A2155M |
| 2 | C25, C27 | Cap. ceramic 1 µF 10V 20% X7R SMD 0603 | TDK Corporation | C1608X7R1A105M |
| 8 | C3, C4, C9, C11, C17, C23, C24, C26 | Cap. ceramic 0.1 µF 16V 10% X7R 0603 | TDK Corporation | C1608X7R1C104K |
| 2 | D1, D2 | Diode rect. MRA4005 1.1V 1A 600V DO-214AC_SMA | ON Semiconductor® | MRA4005T3G |
| 1 | D3 | Diode zener 1N4744A 15V 1W DO-41 | Fairchild Semiconductor® | 1N4744A |
| 1 | D4 | Diode Sctky. Arr. bas. 40-05 1V 200 mA 40V SOT-23-3 | Vishay | BAS40-05-V-GS08 |
| 4 | Fasten J6 & J7 to PCB at four locations | Machine screw pan Phillips 6-32 | B&F™ Fasteners Supply | NY PMS 632 0038 PH |
| 4 | Fasten J6 & J7 to PCB at four locations | Hex nut 5/16" nylon 6-32 | B&F™ Fasteners Supply | NY HN 632 |
| 2 | FB1, FB2 | Ferrite 800 mA 0.15R SMD 0805 | Laird Technologies® | LI0805H151R-10 |
| 2 | FB3, FB4 | Ferrite 7A 0.01R RAD P5L5.3D3.8 | Panasonic® - ECG | EXC-ELSR35S |
| 1 | Included in Box at time of packing | USB a male to mini USB B 5 pin cable - 3 foot (distributor Katerno.com) | Katerno.com | 10UM-02103BK |
| 1 | Included in Box at time of packing | 6 foot 16 AWG universal power cord (IEC320C13 to NEMA 5-15P) | Katerno.com | 25545_c2g |

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 | Included in Box at time of packing | 1 foot 18 AWG monitor power adapter cord (NEMA 5-15R to IEC320C14) | Katerno.com | 03147_c2g |
| 1 | J1 | Conn. jack power jack 2.5 mm | CUI Inc. | PJ-006B-SMT |
| 0 | J18 | Conn. header-2.54 male 1x2 th. vert. - DO NOT POPULATE | FCI | 77311-118-02LF |
| 1 | J2 | Conn. USB mini USB-B female SMD R/A | Hirose Electric Co., Ltd. | UX60-MB-5ST |
| 1 | J3 | Conn. edge mini edge card MEC1-EM 1mm female 2x60 SMD R/A | Samtec, Inc. | MEC1-160-02-L-D-EM2 |
| 7 | J4, J5, J9, J10, J12, J14, J15 | Conn. header-2.54 male 1x2 th. vert. | FCI | 77311-118-02LF |
| 1 | J6 | Conn. IEC 250V 15A Inlet th. R/A | SCHURTER Inc. | GSP1.9103.1 |
| 1 | J7 | Conn. IEC 250V 15A Outlet th. R/A | SCHURTER Inc. | 6182.0033 |
| 5 | J8, J11, J13, J16, J17 | Conn. header-2.54 male 1x3 th. vert. | FCI | 68000-103HLF |
| 1 | JP1 | Mech. hw. jumper 2.54 mm 1x2 handle gold | TE Connectivity, Ltd. | 881545-2 |
| 1 | LD1 | Diode LED bi. red, green 1.95V, 2.1V 30 mA 0805 | Kingbright Corp. | APHBM2012SURKCGKC |
| 5 | LD2, LD3, LD4, LD5, LD6 | Diode LED red 1.65V 30 mA RAD T-1_3/4 | Kingbright Corp. | WP7113LSRD |
| 1 | Meter Enclosure | Clear acrylic enclosure | Tech-Demos.com | 072612 R6 |
| 1 | MOV1 | Resistor varistor mo. 420V 45J disc 10 mm | EPCOS AG | S10K420 |
| 4 | PAD1 | Mech. hw. rubber pad Bumpon Hemisphere 0.44" x 0.20" Black | 3M | SJ-5003 (BLACK) |
| 7 | R1, R3, R11, R18, R21, R23, R50 | Resistor tkf. 4.7k 5% 1/10W SMD 0603 | Panasonic - ECG | ERJ-3GEYJ472V |
| 0 | R10 | Resistor tkf. 2.49R 1% 1/10W SMD 0603 - DO NOT POPULATE | Vishay | CRCW06032R49FKEA |
| 5 | R12, R13, R22, R24, R51 | Resistor tkf. 3.3k 5% 1/10W SMD 0603 | Panasonic - ECG | ERJ-3GEYJ332V |
| 4 | R2, R4, R14, R20 | Resistor tkf. 1k 1% 1/10W SMD 0603 | Panasonic - ECG | ERJ-3EKF1001V |
| 1 | R27 | Res. tkf. 100R 1% 1/10W SMD 0603 | Panasonic - ECG | ERJ-3EKF1000V |
| 1 | R34 | Res. 33 ohm 5W 1% AXIAL | Ohmite [®] Manufacturing | 45F33RE |
| 3 | R37, R38, R39 | Res. tkf. 390R 5% 1/10W SMD 0603 | Panasonic - ECG | ERJ-3GEYJ391V |
| 1 | R41 | Res. tkf. 10k 5% 1/10W SMD 0603 | Panasonic - ECG | ERJ-3GEYJ103V |
| 1 | R6 | Res. shunt MF 0.002R 1% 2W 2512 | Stackpole Electronics, Inc. | CSNL2512FT2L00 |
| 2 | R7, R8 | Res. 499K ohm 3/4W 1% 2010 SMD | Vishay Dale | CRCW2010499KFKEF |
| 5 | R9, R15, R16, R17, R19 | Resistor tkf. 1k 5% 1/10W SMD 0603 | Panasonic - ECG | ERJ-3GEYJ102V |
| 5 | U1, U3, U7, U8, U9 | IC photo PC365N 4-SMD | Sharp Microelectronics | PC365NJ0000F |

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 | U10 | Microchip Analog Temperature Sensor MCP9700 SOT-23-3 | Microchip Technology Inc. | MCP9700T-E/TT |
| 1 | U2 | Microchip Analog LDO MCP1754ST-3302E/MB SOT-89-3 | Microchip Technology Inc. | MCP1754ST-3302E/MB |
| 1 | U4 | Microchip int. USB MCP2200 SSOP-20 | Microchip Technology Inc. | MCP2200-I/SS |
| 1 | U5 | IC isolator IL721-3E SOIC-8 | NVE Corp./Isolation Products | IL721-3E |
| 1 | U6 | MCP39F501 QFN-28 | Microchip Technology Inc. | MCP39F501-E/MQ |
| 1 | X1 | Resonator 12MHz 0.1% SMD CSTCE-G | Murata Manufacturing Co., Ltd. | CSTCE12M0G15L99-R0 |
| 1 | X2 | Crystal 4MHz 18pF SMD HC49/US - DO NOT POPULATE | Abracon® Corporation | ABLS-4.000MHZ-B4-T |

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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