MCP39F501 Power Monitor Demonstration Board User's Guide

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

Derek Carlson
VP Development Tools

16-July-2013
Date

NOTES:

MCP39F501 POWER MONITOR DEMONSTRATION BOARD USER'S GUIDE

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Preface

NOTICE TO CUSTOMERS

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

Documents are identified with a "DS" number. This number is located on the bottom of each page, in front of the page number. The numbering convention for the DS number is "DSXXXXXA", where "XXXXX" 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 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 MCP39F501 Power Monitor Demonstration Board as a demonstration board to evaluate the MCP39F501 device. The manual layout is as follows:

- **Chapter 1. "Product Overview"** – Provides important information about the MCP39F501 Power Monitor Demonstration Board
- **Chapter 2. "Installation and Operation"** – Provides information on using the MCP39F501 Power Monitor Demonstration Board, including **Section 2.1.3 "Step 3: Connect the USB cable to a PC with the installed "MCP39F501 Power Monitor Utility" software"** that describes wiring the line and load connections
- **Chapter 3. "Hardware Description"** – Provides 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 Demonstration Board

CONVENTIONS USED IN THIS GUIDE

This manual uses the following documentation conventions:

DOCUMENTATION CONVENTIONS

Description	Represents	Examples
Arial font:		
Italic characters	Referenced books	*MPLAB® IDE User's Guide*
	Emphasized text	...is the *only* compiler...
Initial caps	A window	the Output window
	A dialog	the Settings dialog
	A menu selection	select Enable Programmer
Quotes	A field name in a window or dialog	"Save project before build"
Underlined, italic text with right angle bracket	A menu path	*File>Save*
Bold characters	A dialog button	Click **OK**
	A tab	Click the **Power** tab
N'Rnnnn	A number in verilog format, where N is the total number of digits, R is the radix and n is a digit.	4'b0010, 2'hF1
Text in angle brackets < >	A key on the keyboard	Press <Enter>, <F1>
Courier New font:		
Plain Courier New	Sample source code	`#define START`
	Filenames	`autoexec.bat`
	File paths	`c:\mcc18\h`
	Keywords	`_asm, _endasm, static`
	Command-line options	`-Opa+, -Opa-`
	Bit values	`0, 1`
	Constants	`0xFF, 'A'`
Italic Courier New	A variable argument	*`file`*`.o`, where *`file`* can be any valid filename
Square brackets [ ]	Optional arguments	`mcc18 [options]` *`file`* `[options]`
Curly brackets and pipe character: { | }	Choice of mutually exclusive arguments; an OR selection	`errorlevel {0|1}`
Ellipses...	Replaces repeated text	`var_name [, var_name...]`
	Represents code supplied by user	`void main (void) { ... }`

RECOMMENDED READING

This user's guide describes how to use MCP39F501 Power Monitor Demonstration 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 Energy and Power Monitoring IC with Calculation"* (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:

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- **General Technical Support** – Frequently Asked Questions (FAQs), technical support requests, online discussion groups, Microchip consultant program member listing
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- Field Application Engineer (FAE)
- Technical Support

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

DOCUMENT REVISION HISTORY

Revision A (February 2014)

- Initial Release of this Document.

NOTES:

Chapter 1. Product Overview

1.1 INTRODUCTION

The MCP39F501 Power Monitor Demonstration Board is a fully functional single-phase power monitor. This low-cost design does not use any transformers and requires few external components. The system calculates active power, reactive power, RMS current, RMS voltage and other typical power quantities, as defined in the MCP39F501 data sheet.

The Microchip Energy Meter 1-Phase 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. 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 MCP39F501 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: *MCP39F501 Power Monitor Demonstration Board.*

1.2 WHAT THE MCP39F501 POWER MONITOR DEMONSTRATION BOARD KIT INCLUDES

This MCP39F501 Power Monitor Demonstration Board kit includes:

- MCP39F501 Power Monitor Demonstration Board (ARD00455)
- Important Information Sheet
- Mini USB cable
- AC Line cable
- AC Load cable
- Plastic enclosure

Chapter 2. Installation and Operation

2.1 GETTING STARTED

To use the MCP39F501 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 MCP39F501 Power Monitor Demonstration Board.

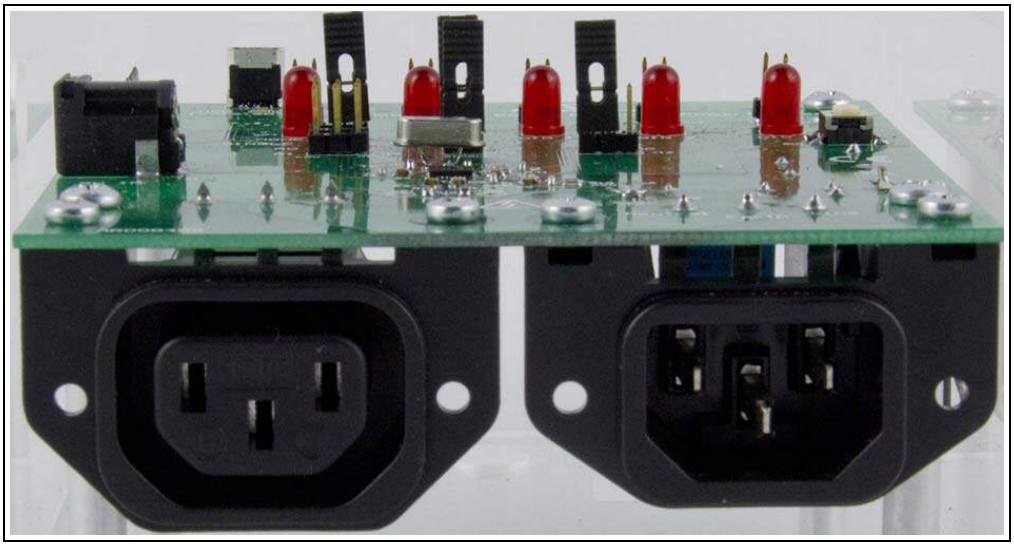


FIGURE 2-1: *Connecting the MCP39F501 Power Monitor Demonstration Board.*

2.1.2 Step 2: Turn on line/load power to the meter (power the meter)

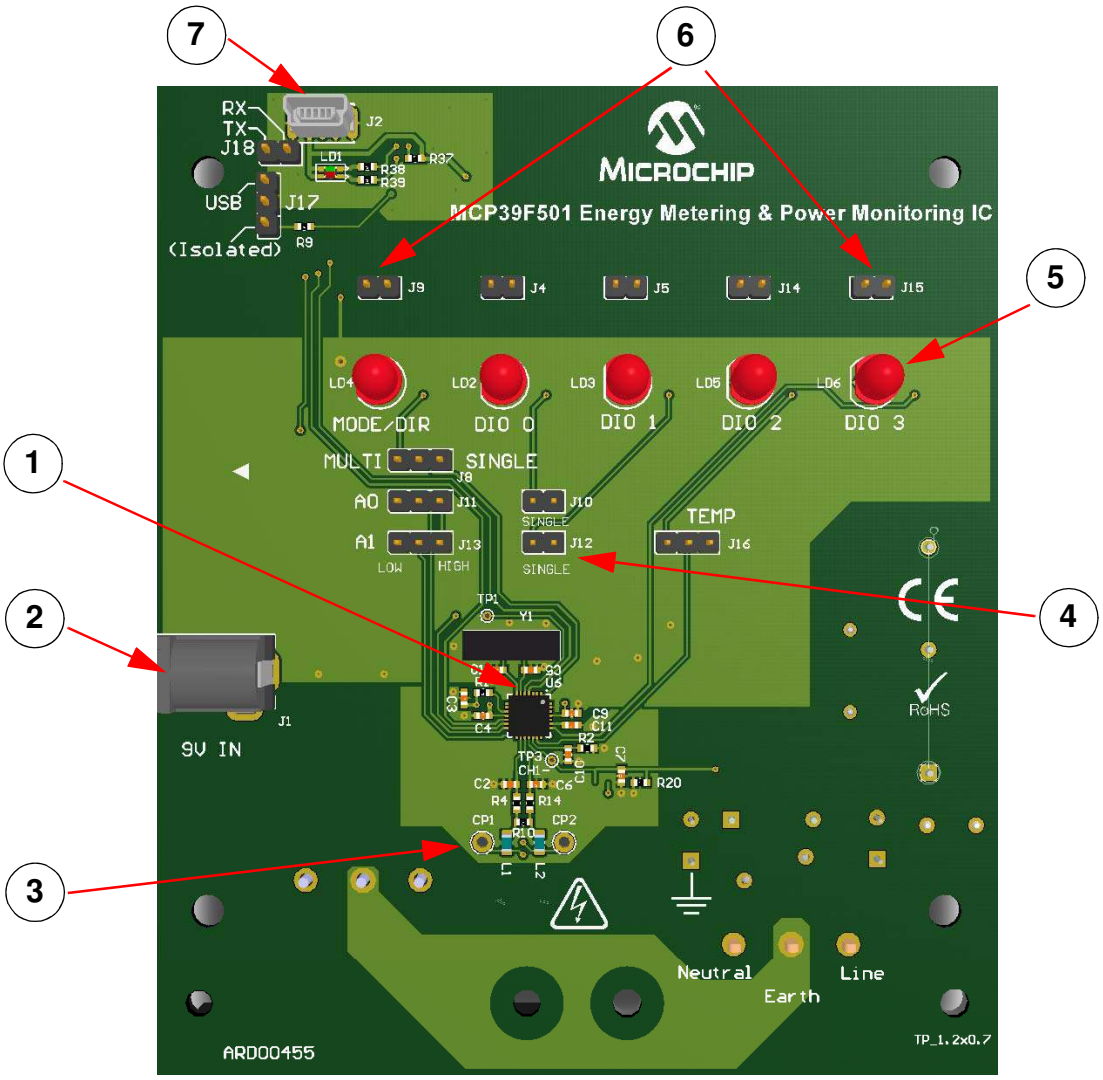
The meter will turn on when the line connection has between 90V to 220V connected.

2.1.3 Step 3: Connect the USB cable to a PC with the installed "MCP39F501 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.

NOTES:

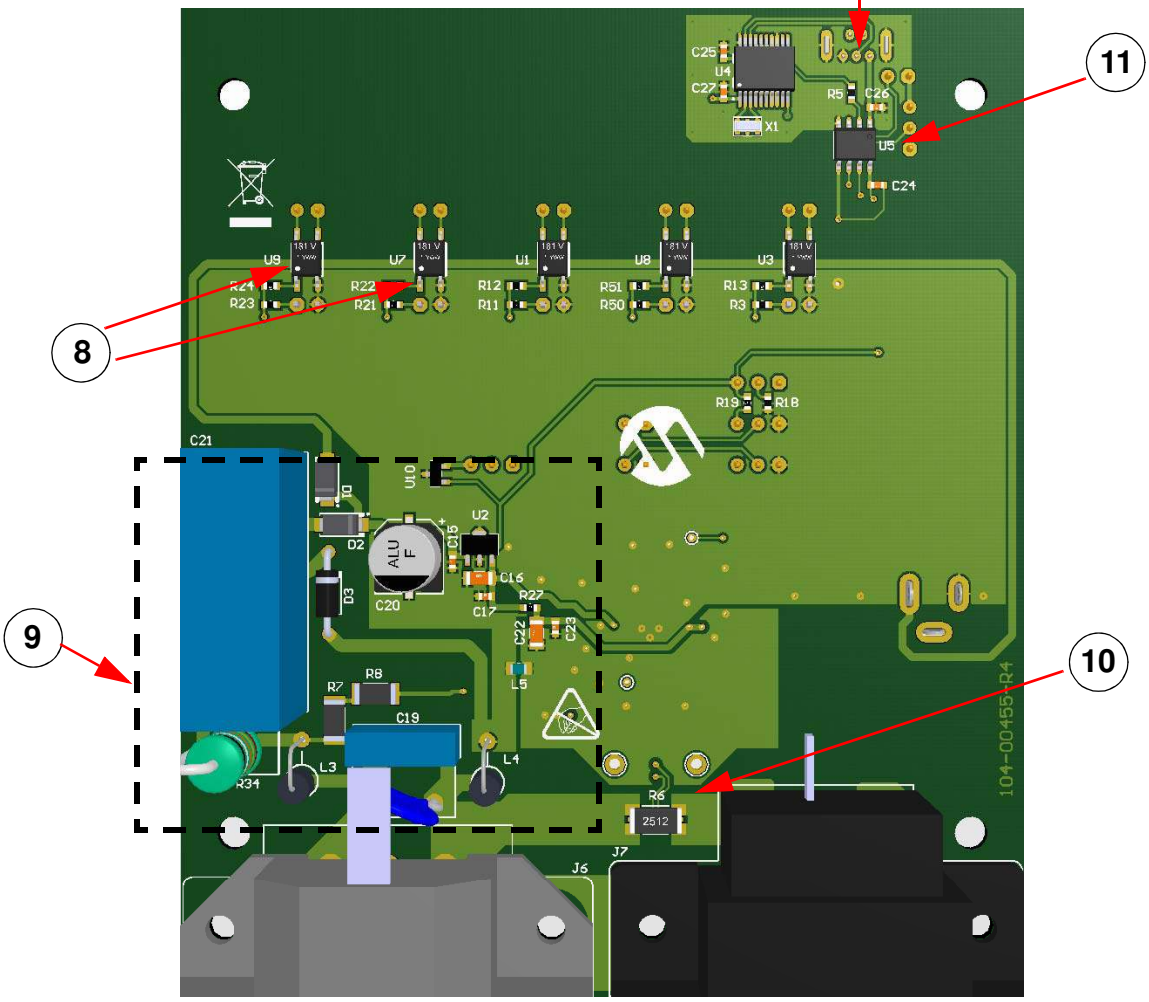
Chapter 3. Hardware Description



Legend:

1 = MCP39F501
2 = +9V DC Input (non-isolated)
3 = Connections to external shunt current sensing resistor
4 = Configuration jumpers
5 = Output LEDs for digital I/O
6 = Headers for pulse testing (isolated)
7 = USB Connection (isolated)

FIGURE 3-1: *MCP39F501 Power Monitor Demonstration Board Top View – Hardware Components.*



Legend:

8	=	Opto-isolators
9	=	Power supply
10	=	Current sensing shunt (2 mΩ)
11	=	Isolation IC
12	=	MCP2200 for USB connection

FIGURE 3-2: *MCP39F501 Power Monitor Demonstration Board Bottom View – Hardware Components.*

3.1 INPUT AND ANALOG FRONT END

The MCP39F501 Power Monitor Demonstration Board comes populated with components designed for 220V line voltage. However, it will work from 90V to 230V. At the bottom of the main board, there are the high-voltage line and neutral connections. There are four connections from the PCB to the meter casing. They are labeled LINE, NEUTRAL, SHUNT1 and SHUNT2. The shunt sits on the high- or line-side of a two-wire system and the meter employs a hot or “live” ground. The wires going into the shunt to SHUNT1 and SHUNT2 should be twisted together. The wires going into the LINE and NEUTRAL side of the meter should be twisted together, and also kept away from the SHUNT1 and SHUNT2 wires, if possible.

The neutral side of the two-wire system goes into a resistor divider on the voltage channel input. 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 230 V_{RMS}, the channel 1 input signal size will be 230 mV_{RMS}.

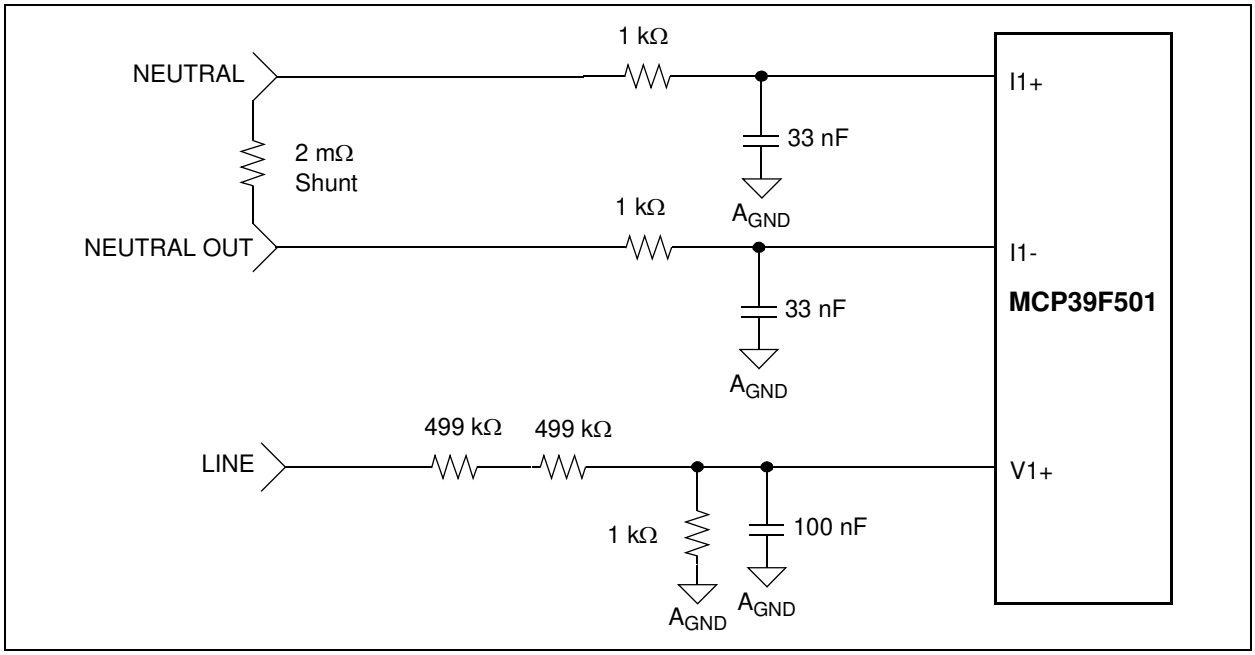


FIGURE 3-3: *Analog Front-End Circuitry.*

Note that all of the analog circuitry associated with this part of the circuit is connected to the analog ground plane (A_{GND}).

3.2 POWER SUPPLY CIRCUIT

The power supply circuit for the MCP39F501 Power Monitor Demonstration Board uses a half-wave rectified signal and a +3.3V voltage regulator.

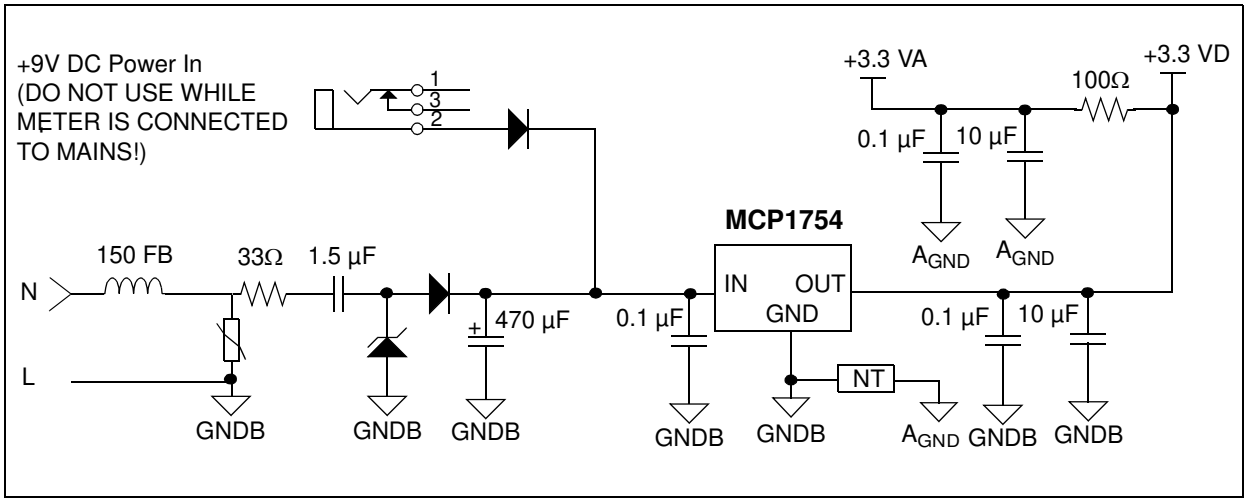


FIGURE 3-4: *Low-Cost Power Supply Circuit.*

Appendix A. Schematic and Layouts

A.1 INTRODUCTION

This appendix contains the following schematics and layouts for of the MCP39F501 Power Monitor Demonstration Board:

- Board – 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.

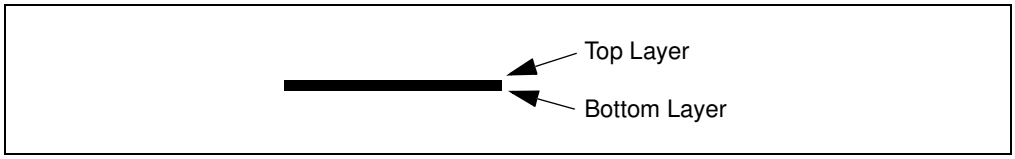
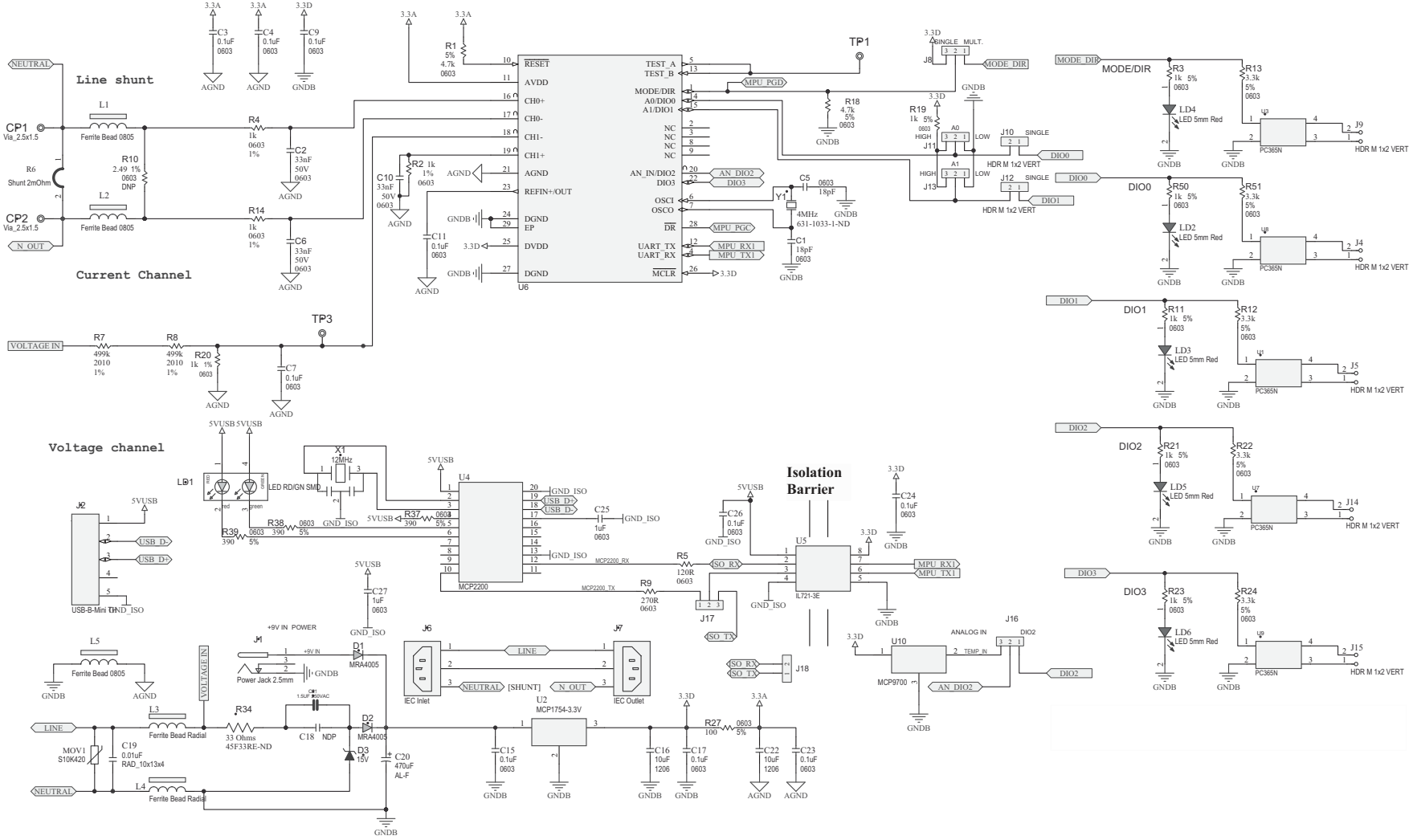
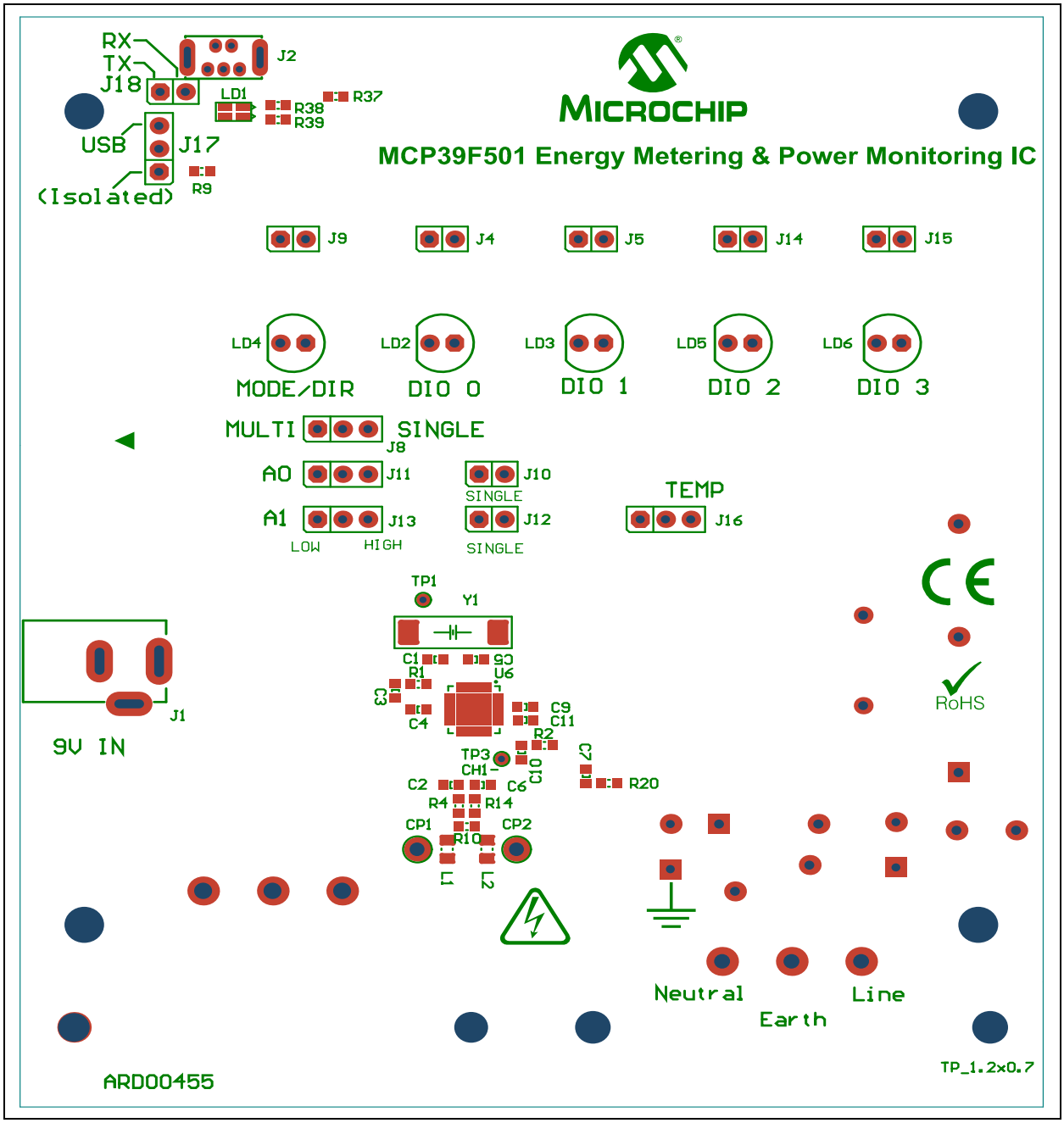


FIGURE A-1: *Layer Order.*

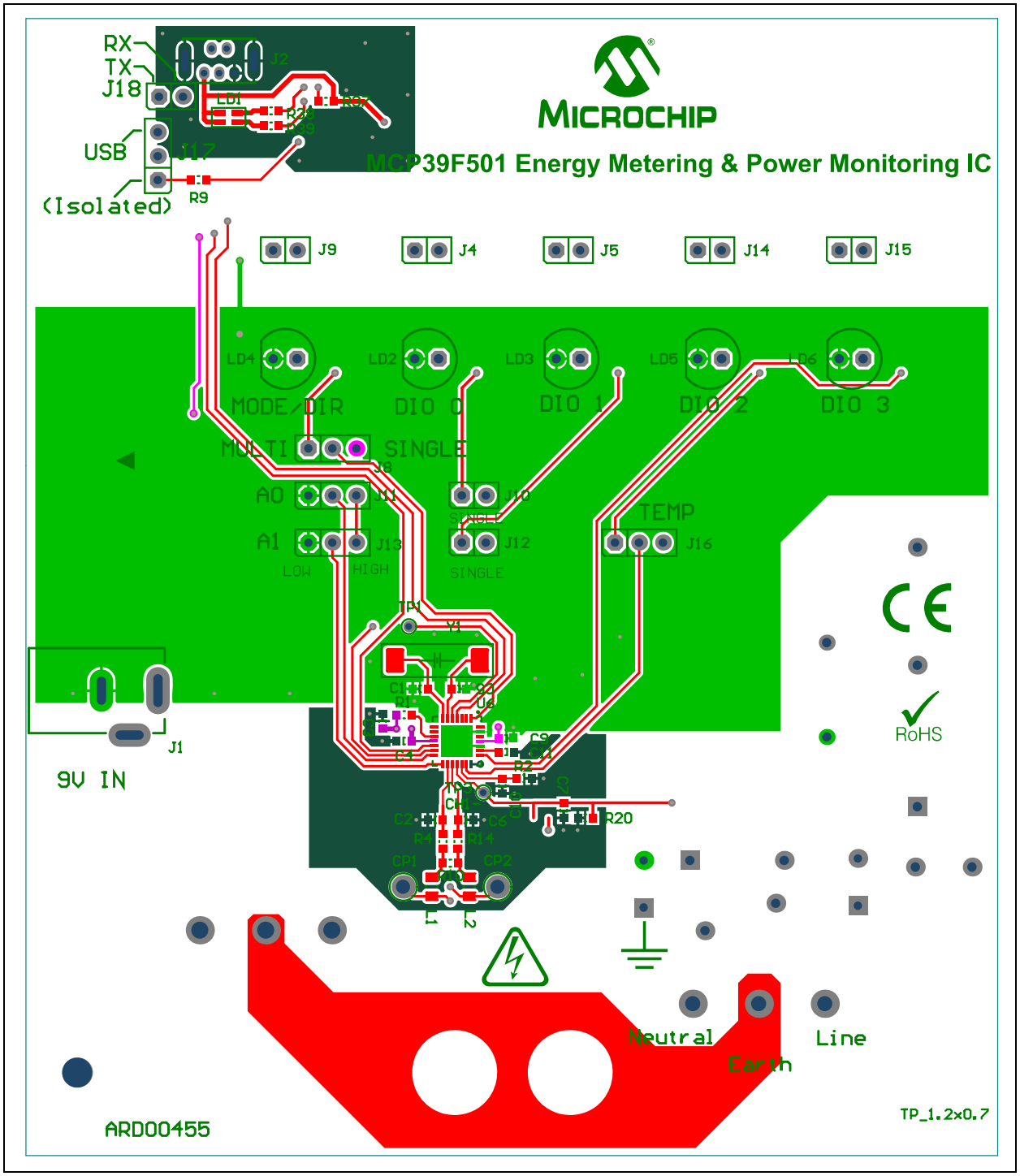
A.3 BOARD – SCHEMATIC



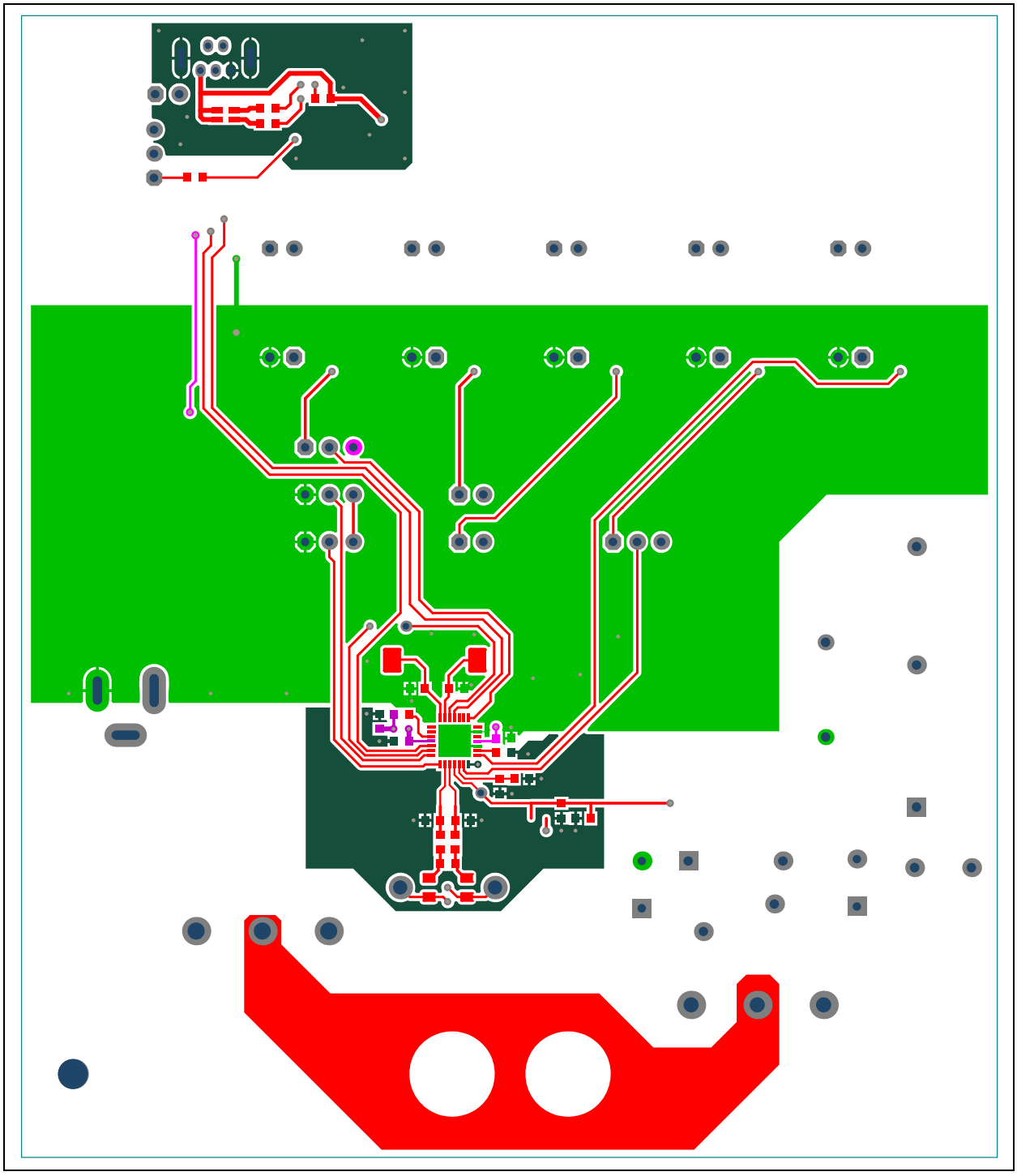
A.4 BOARD – TOP SILK



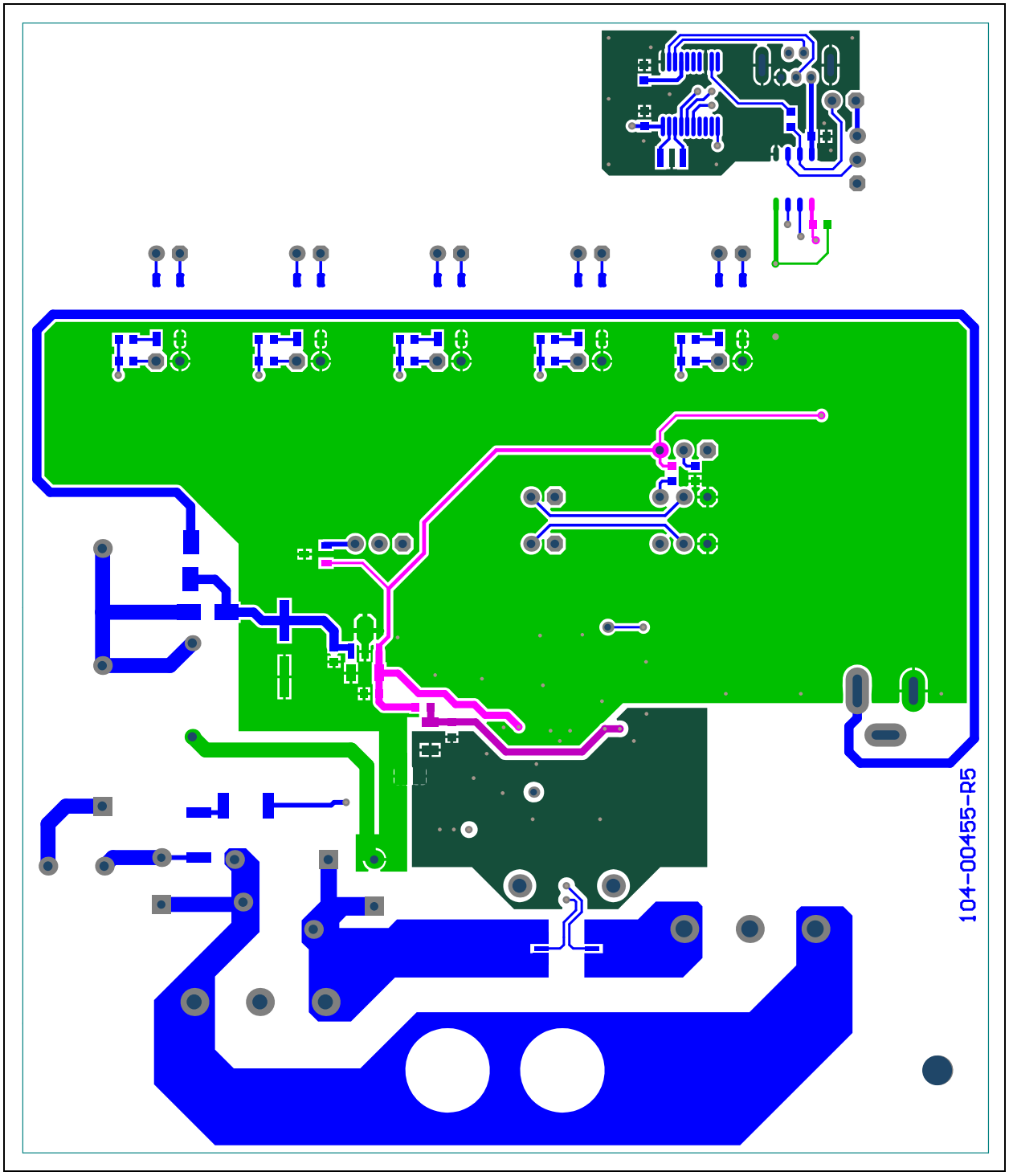
A.5 BOARD – TOP COPPER AND SILK



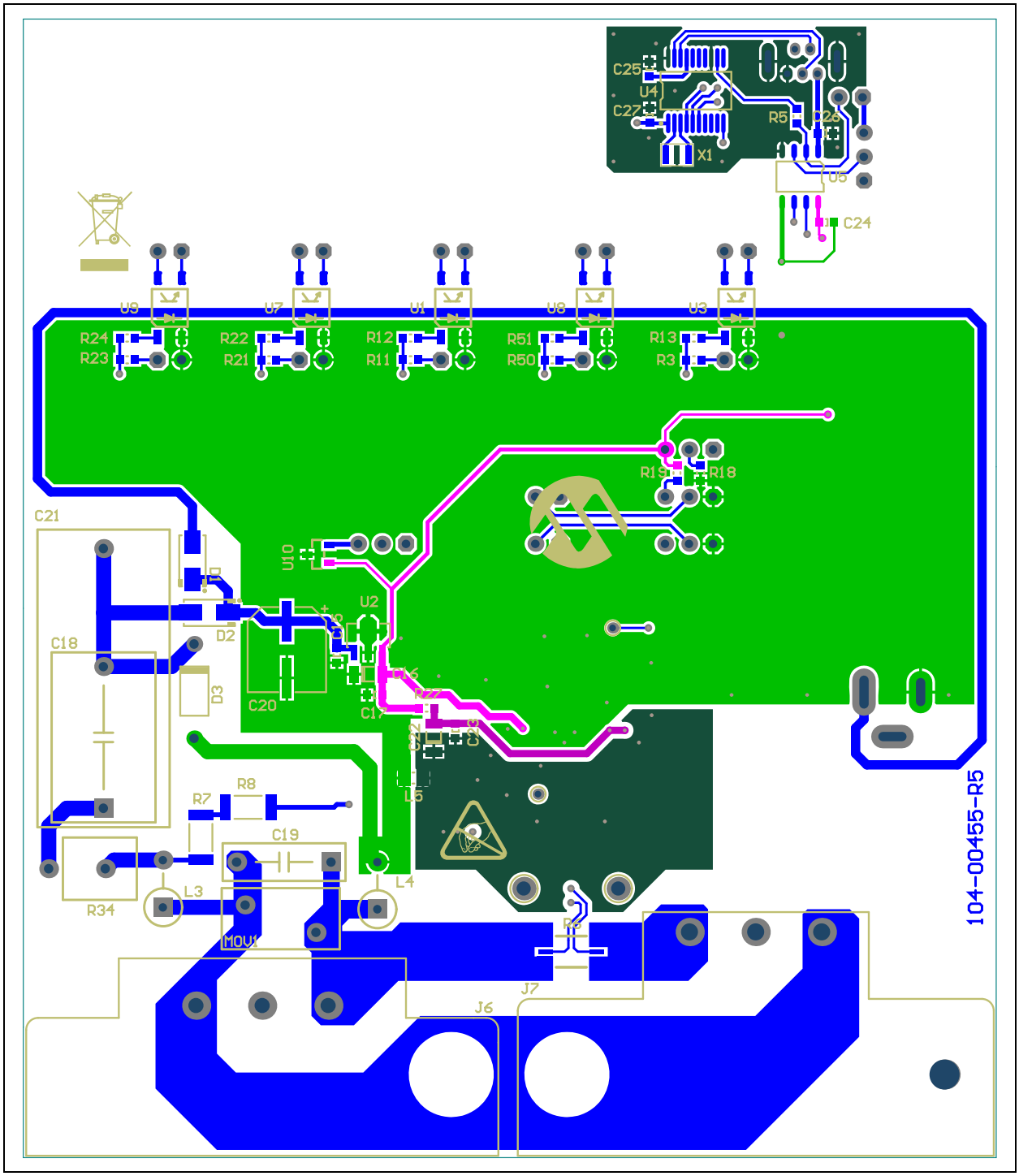
A.6 BOARD – TOP COPPER



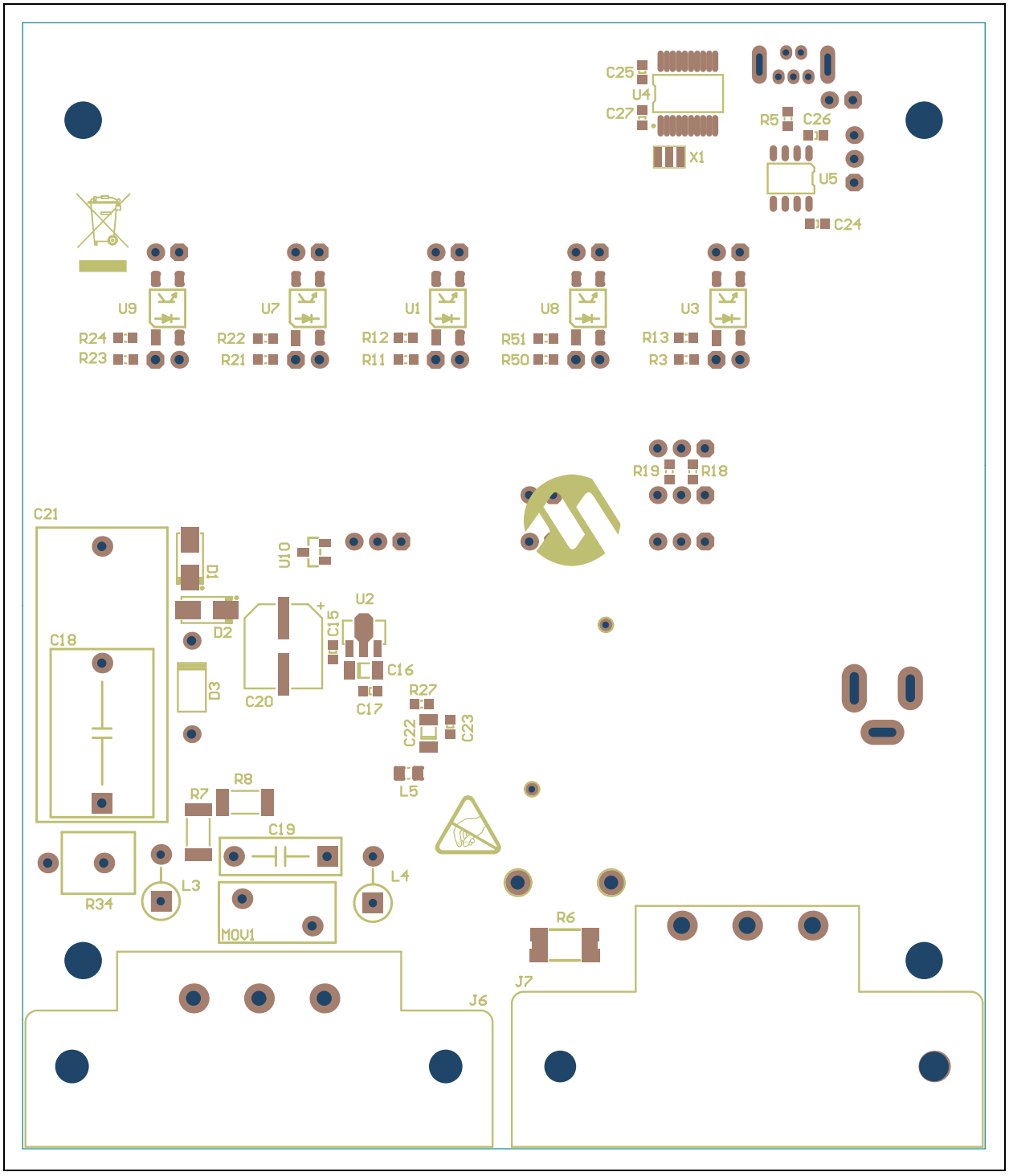
A.7 BOARD – BOTTOM COPPER



A.8 BOARD – BOTTOM COPPER AND SILK



A.9 BOARD – BOTTOM SILK



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 C0G 5% 0603	TDK Corporation	C1608C0G1H180J
3	C2, C6, C10	Cap. ceramic 33 nF 50V 10% X7R SMD 0603	TDK Corporation	C1608X7R1H333K
10	C3 – C4, C7, C9, C11, C15, C17, C23 – C24, C26	Cap. ceramic 0.1 µF 16V 10% X7R 0603	TDK Corporation	C1608X7R1C104K
2	C16, C22	Cap. ceramic 10 µF 10V X7R 20% 1206	TDK Corporation	C3216X7R1A106M
1	C18	Cap. film 0.47 µF 305 VAC Power Supply – **DO NOT POPULATE**	EPCOS AG	B32932A3474M
1	C19	Cap. film 0.01 µF 330 VAC Suppress	EPCOS AG	B32911A3103M
1	C20	Cap. elect. 470 µF 16V 20% vs size F	Panasonic® - ECG	EEE-1CA471UP
1	C21	Cap. film 1.5 µF 275 VAC radial	Panasonic - ECG	ECQ-U2A155ML
2	C25, C27	Cap. ceramic 1 µF 10V X7R 20% 0603	TDK Corporation	C1608X7R1A105M
1	C36	Cap. ceramic 0.1 µF 16V 10% X7R 0603 – **DO NOT POPULATE**	TDK Corporation	C1608X7R1C104K
2	D1 – D2	Diode std. rec. 1A 600V SMA	ON Semiconductor®	MRA4005T3G
1	D3	Diode Zener 15V 1W DO-41	Fairchild Semiconductor®	1N4744A
1	J1	Conn. power jack male 2.5 mm CLSD	CUI Inc.	PJ-002B
1	J2	Conn. recept. USB TH vert. 5 pos.	Molex® Connector Corporation	500075-1517
1	J3	Conn. hdr. male 0.100 1x6 pos. vert.	Tyco Electronics	68001-106HLF
5	J4 – J5, J9, J14 – J15	Conn. hdr. male 0.100 1x2 pos. vert.	FCI	77311-118-02LF
1	J6	Module inlet. ang. GND W/M3 hole PCB	SCHURTER Inc.	GSP1.9103.1
1	J7	Module outlet F screw-on PCB	SCHURTER Inc.	6182.0033
5	J8, J11, J13, J16 – J17	Conn. hdr. male 0.100 1x3 pos. vert.	Tyco Electronics	HDR M 1x3 Vertical
3	J10, J12, J18	Conn. hdr. male 0.100 1x2 pos. vert.	FCI	77311-118-02LF
3	L1 – L2, L5	Ferrite 800 mA 150 mΩ 0805 SMD	Laird Technologies®	LI0805H151R-10
2	L3 – L4	Bead core single 3.8 x 5.3 mm Radial	Panasonic - ECG	EXC-ELSR35S
1	LD1	LED 2 x 1.2 mm RD/GN wtr. clr. SMD	Kingbright Corp.	APHBM2012SURKCGKC

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
5	LD2 – LD6	LED 5 mm red 640 nm 20 mcd 2 mA	Kingbright Corp.	WP7113LSRD
1	MOV1	Varistor 420 VRMS 10 mm Radial	EPCOS AG	S10K420
	PCB	Printed Circuit Board – MCP39F501 Power Monitor Demonstration Board	—	104-00455
1	R1	Res. 4.7 kΩ 1/10W 5% 0603 SMD	Panasonic - ECG	ERJ-3GEYJ472V
4	R2, R4, R14, R20	Res. 1 kΩ 1/10W 1% 0603 SMD	Panasonic - ECG	ERJ-3EKF1001V
6	R3, R11, R19, R21, R23, R50	Res. 1 kΩ 1/10W 5% 0603 SMD	Panasonic - ECG	ERJ-3GEYJ102V
1	R5	Res. TKF 120R 5% 1/10W SMD 0603	Panasonic - ECG	ERJ-3GEYJ121V
1	R6	Current sense resistor 2 mΩ 2W 1% 2512 SMD	Stackpole Electronics, Inc.	CSNL2512FT2L00
2	R7 – R8	Res. 499 kΩ 3/4W 1% 2010 SMD	Vishay/Dale	CRCW2010499KFKEF
1	R9	Res. TKF 270R 5% 1/10W SMD 0603	KOA Speer Electronics, Inc.	RK73B1JTTD271J
1	R10	Res. 2.49Ω 1/10W 1% 0603 SMD	Vishay/Dale	CRCW06032R49FKEA
5	R12 – R13, R22, R24, R51	Res. 3.3 kΩ 1/10W 5% 0603 SMD	Panasonic - ECG	ERJ-3GEYJ332V
1	R18	Res. 4.7 kΩ 1/10W 5% 0603 SMD	Panasonic - ECG	ERJ-3GEYJ472V
1	R27	Res. 100Ω 1/10W 5% 0603 SMD	Panasonic - ECG	ERJ-3GEYJ101V
1	R34	Res. 33Ω 5W 1% AXIAL	Ohmite® Manufacturing	45F33RE
3	R37 – R39	Res. 390Ω 1/10W 5% 0603 SMD	Panasonic - ECG	ERJ-3GEYJ391V
1	R40	Res. 1 kΩ 1/10W 5% 0603 SMD – **DO NOT POPULATE**	Panasonic - ECG	ERJ-3GEYJ102V
1	R41	Res. 10 kΩ 1/10W 5% 0603 SMD – **DO NOT POPULATE**	Panasonic - ECG	ERJ-3GEYJ103V
1	SW1	Switch Tact. 6 mm 160GF H = 4.3 mm – **DO NOT POPULATE**	Omron Electronics LLC – EMC Division	B3S-1000P
5	U1, U3, U7 – U9	Photocoupler Darl. Out 4-SMD	Sharp Corporation	PC365NJ0000F
1	U5	Isolator HS dual digital SOIC-8	NVE Corporation/ Isolation Products	IL721-3E
1	X1	Resonator ceramic 12.0 MHz CST-CE_G	Murata Electronics®	CSTCE12M0G55-R0
1	Y1	Crystal 4.0 MHz 20 pF SMD	Fox Electronics®	FQ1045A-4
5	Jumpers – See Test procedure for locations	Conn. jumper shorting TIN	Sullins Connector Solutions	STC02SYAN

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-2: BILL OF MATERIALS – MICROCHIP CONSIGNED PARTS

Qty	Reference	Description	Manufacturer	Part Number
1	U2	IC reg. LDO 150 mA 3.3V SOT-89-3	Microchip Technology Inc.	**MCP1754ST-3302E/MB**
1	U4	IC USB TO UART SSOP-20	Microchip Technology Inc.	**MCP2200-I/SS**
1	U6	MCP39F501 QFN-28	Microchip Technology Inc.	**MCP39F501-E/MQ**
1	U10	IC Sensor Thermal 2.3V SOT-23-3	Microchip Technology Inc.	**MCP9700T-E/TT**

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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