MCP39F511A CT Power Meter User's Guide

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MCP39F511A CT POWER METER 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 website (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 MCP39F511A CT Power Meter. Items discussed in this chapter include:

- Document Layout
- Conventions Used in this Guide
- Recommended Reading
- The Microchip Website
- Product Change Notification Service
- Customer Support
- Document Revision History

DOCUMENT LAYOUT

This document describes how to use the MCP39F511A CT Power Meter as a development tool. The manual layout is as follows:

- **Chapter 1. "Product Overview"** – Important information about the MCP39F511A CT Power Meter.
- **Chapter 2. "Installation and Operation"** – Includes instructions on how to get started with the MCP39F511A CT Power Meter.
- **Chapter 3. "Hardware Description"** – Includes hardware details about the MCP39F511A CT Power Meter.
- **Chapter 4. "Test Results"** – Includes data samples taken during board validation.
- **Appendix A. "Schematics and Layouts"** – Shows the schematics and layout diagrams for the MCP39F511A CT Power Meter.
- **Appendix B. "Bill of Materials (BOM)"** – Lists the parts used to build the MCP39F511A CT Power Meter.

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 the MCP39F511A CT Power Meter. Another useful document is listed below.

- **MCP39F511A Data Sheet – *"AC/DC Dual-Mode Power-Monitoring IC with Calculation and Energy Accumulation"* (DS20006044)**

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- **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
- Embedded System Engineer (ESE)
- 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 website at:
https://www.microchip.com/support.

DOCUMENT REVISION HISTORY

Revision A (October 2022)

- Initial release of this document.

NOTES:

Chapter 1. Product Overview

1.1 INTRODUCTION

The MCP39F511A Current Transformer (CT) Power Meter is a single-phase evaluation board demonstrating current measurement using a split-core current transformer. The system calculates the active/reactive power, RMS current, RMS voltage, active energy (both import and export), reactive energy and other typical power quantities, as defined in the MCP39F511A data sheet.

Note: Boards are not shipped calibrated and must be calibrated using standard calibration equipment and the Power Monitor Utility user interface software included with the board. For most accuracy requirements, only a single-point calibration is needed. The software offers an automated step-by-step calibration process that can be used to quickly calibrate measurements.

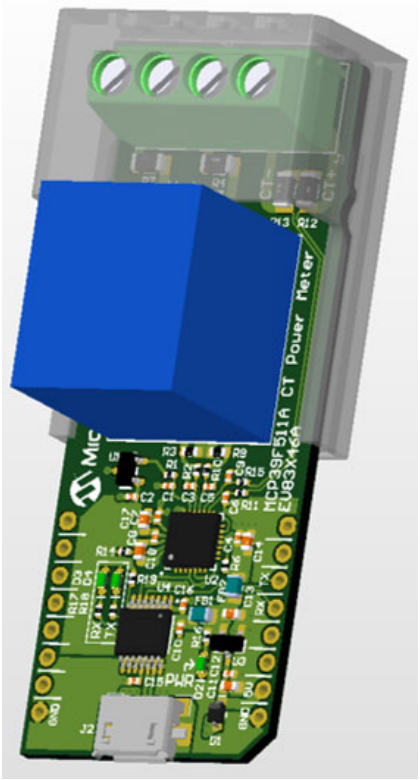


FIGURE 1-1: *MCP39F511A CT Power Meter.*

Communication between the MCP39F511A CT Power Meter and the Power Monitor Utility user interface is established via the MCP2221A USB 2.0 to I^2C/UART Protocol Converter. The Power Monitor Utility software can be found on the demonstration board's product webpage.

1.2 MCP39F511A CT POWER METER FEATURES

- MCP39F511A 24-bit Single-Phase AC/DC Power Monitoring IC
- ZMPT101L Current-Type Voltage Transformer
- MCP9700 Low-Power Linear Active Thermistor IC
- MCP2221A USB 2.0 to I^2C/UART Protocol Converter with GPIO
- MCP1754 16V, High PSRR, 150 mA LDO w/V_{OUT} = 3.3V
- mikroBUS™ Header Interface
- 4-Position Screw Block Terminal
- Micro-USB 2.0 Connector

1.3 MCP39F511A CT POWER METER KIT CONTENTS

The MCP39F511A CT Power Meter kit includes:

- MCP39F511A CT Power Meter (EV83X46A)
- SCT013-000 100A to 50 mA Split-Core Transformer with 1% Accuracy and Linearity
- Micro-USB Cable
- Important Information Sheet

1.4 NOT INCLUDED IN THE KIT

The MCP39F511A CT Power Meter kit **does not** include the following:

- AC Line Cable (see Figure 2-1 and Figure 2-2).

Chapter 2. Installation and Operation

2.1 GETTING STARTED

The MCP39F511A CT Power Meter uses four connections, two connections for L and N of the mains voltage (120 VAC to 240 VAC) and two connections for C+ and C- of the current transformer. The MCP39F511A CT Power Meter is supplied with a 100A to 50 mA (1:2000) split-core transformer from PowerUC Electronics Co., Ltd. (YHDC®) as the current sensing component.

Note: All color-coded connections described in this section are based on the connections for the PowerUC Electronics Co., Ltd. SCT013-000 Split-Core Current Transformer. If an alternate current transformer is used, refer to the manufacturer's documentation for proper connections.

2.1.1 MCP39F511A CT Power Meter Wiring Connections

2.1.1.1 STEP 1: CURRENT TRANSFORMER WIRING CONNECTIONS

Connect the SCT013-000 transformer to the MCP39F511A CT Power Meter by connecting the white wire to the C+ input at the J1 terminal block and the red wire to the C- input at the J1 terminal block (see Figure 2-1).

2.1.1.2 STEP 2: MAINS VOLTAGE WIRING CONNECTIONS

Connect the mains line and neutral voltage sources to the L and N inputs of the J1 terminal block (Figure 2-1).

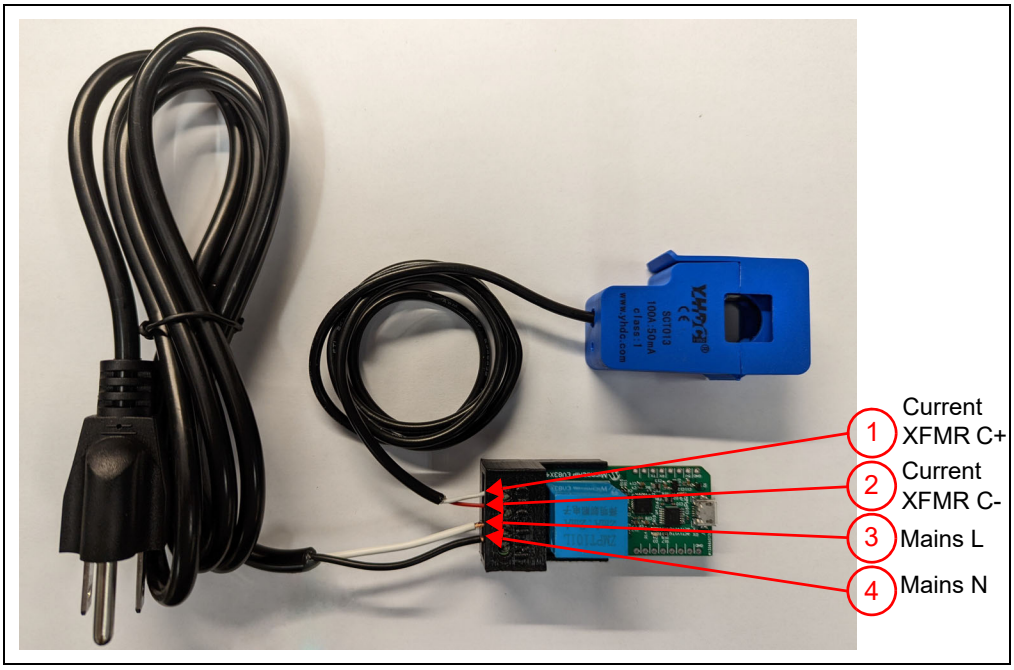


FIGURE 2-1: *Wiring Connections.*

2.1.2 Applying Power and Connecting the Current Transformer

2.1.2.1 STEP 1: APPLYING MAINS POWER TO THE BOARD

Apply mains power to the board via the power supply cable connected to the L and N sockets of the J1 terminal block.

2.1.2.2 STEP 2: CURRENT TRANSFORMER CONNECTION

Connect the SCT013-000 CT to a load current carrying wire, as shown in Figure 2-2. The CT is connected around the white L wire of the AC line cable (not supplied). Connecting the CT around the black N wire provides the same results. However, simply connecting the CT around the entire cable will result in a near-zero current measurement due to the current in the L and N wires flowing in the opposite direction within the cable.

FIGURE 2-2: *Current Transformer Connection.*

2.1.3 Power Monitor Utility

2.1.3.1 STEP 1: CONNECT THE MCP39F511A CT POWER METER TO THE COMPUTER

Connect the Micro-USB connector of the supplied USB cable to the MCP39F511A CT Power Meter and connect the standard USB connector to a PC.

2.1.3.2 STEP 2: LAUNCH THE POWER MONITOR UTILITY SOFTWARE

Launch the Power Monitor Utility software and select the MCP39F511A from the drop-down menu.

2.1.3.3 STEP 3: VERIFY COMMUNICATIONS

Verify communications are properly established by checking the "Connection Status" in the tray of the software. If communications are not immediately established, the "Connection Status" will display "Meter Disconnected". In this event, try selecting a different COM port via the **COM Port** drop-down menu in the top-right window corner. The **COM Port** initialized by connecting the MCP39F511A CT Power Meter to a PC USB port can be found in the PC Device Manager. See Figure 2-3.

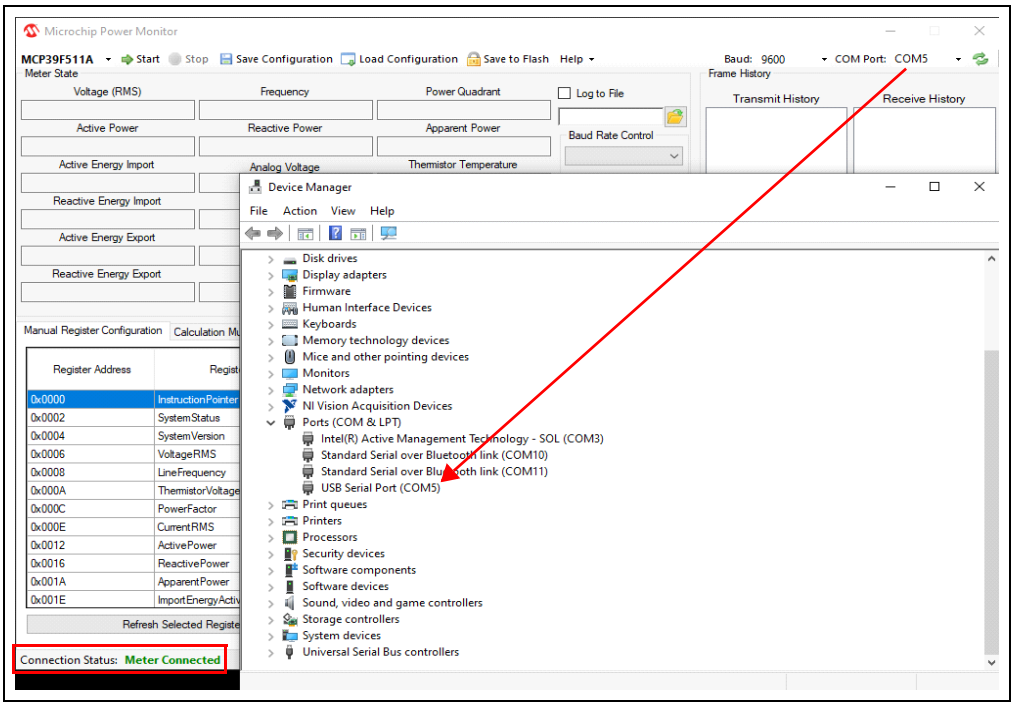


FIGURE 2-3: *Meter Connection Status.*

2.1.3.4 STEP 4: START METERING

To start collecting power measurements, click the **Start** button to begin data acquisition (see Figure 2-4).

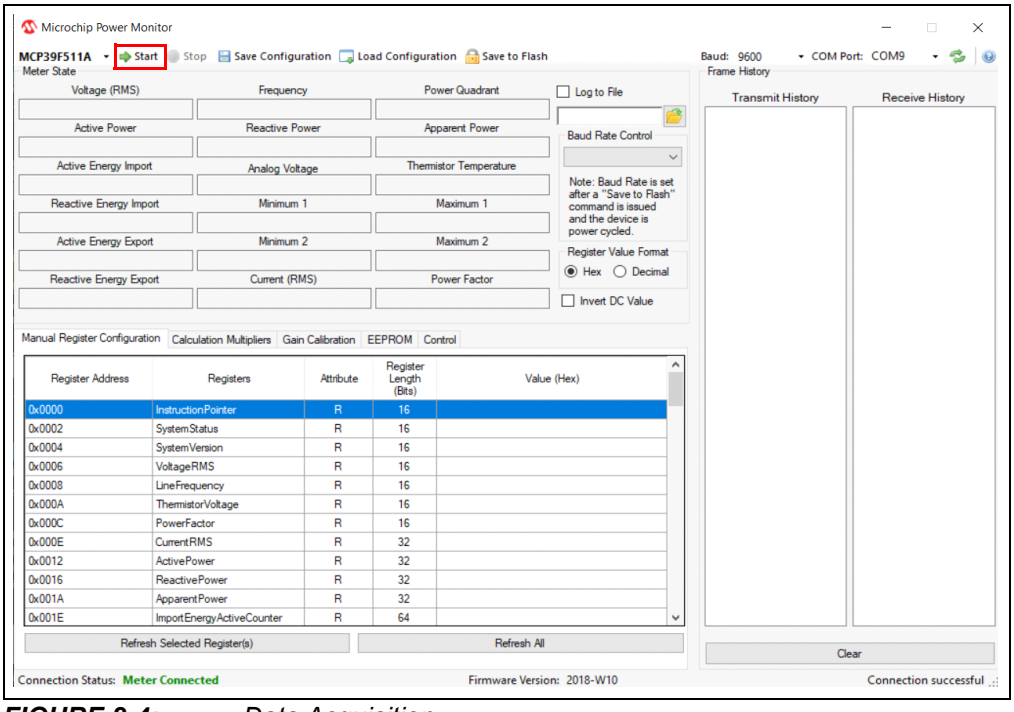


FIGURE 2-4: *Data Acquisition.*

2.1.3.5 STEP 5: VERIFY DATA ACQUISITION

Once metering has started, the **Start** button turns gray and the user can see data populating the fields of the software (see Figure 2-5).

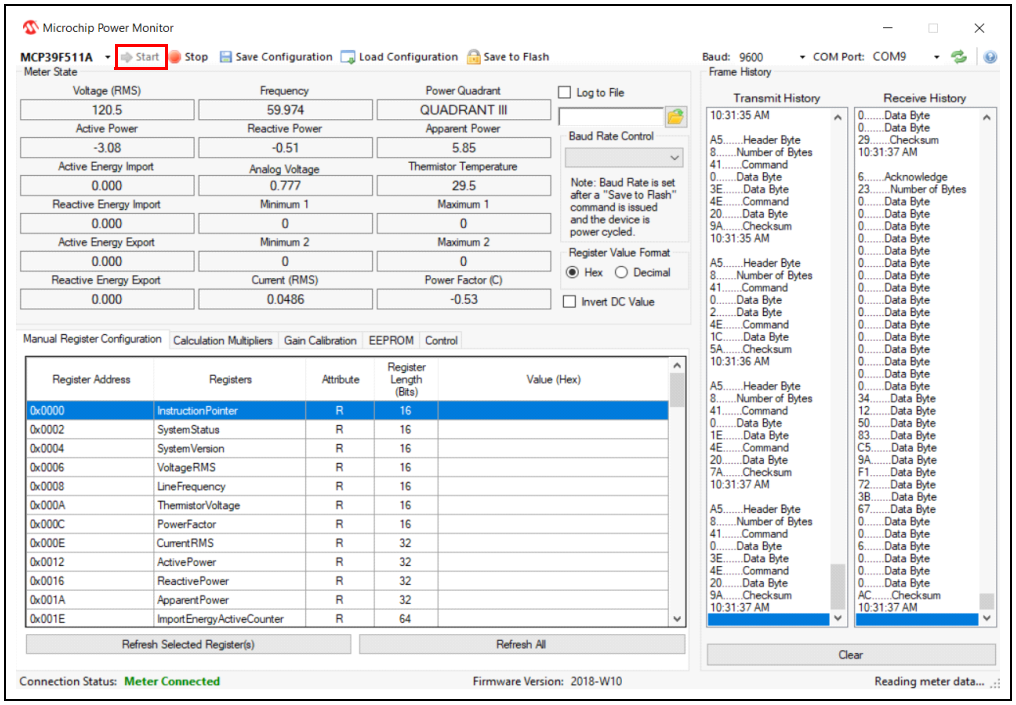
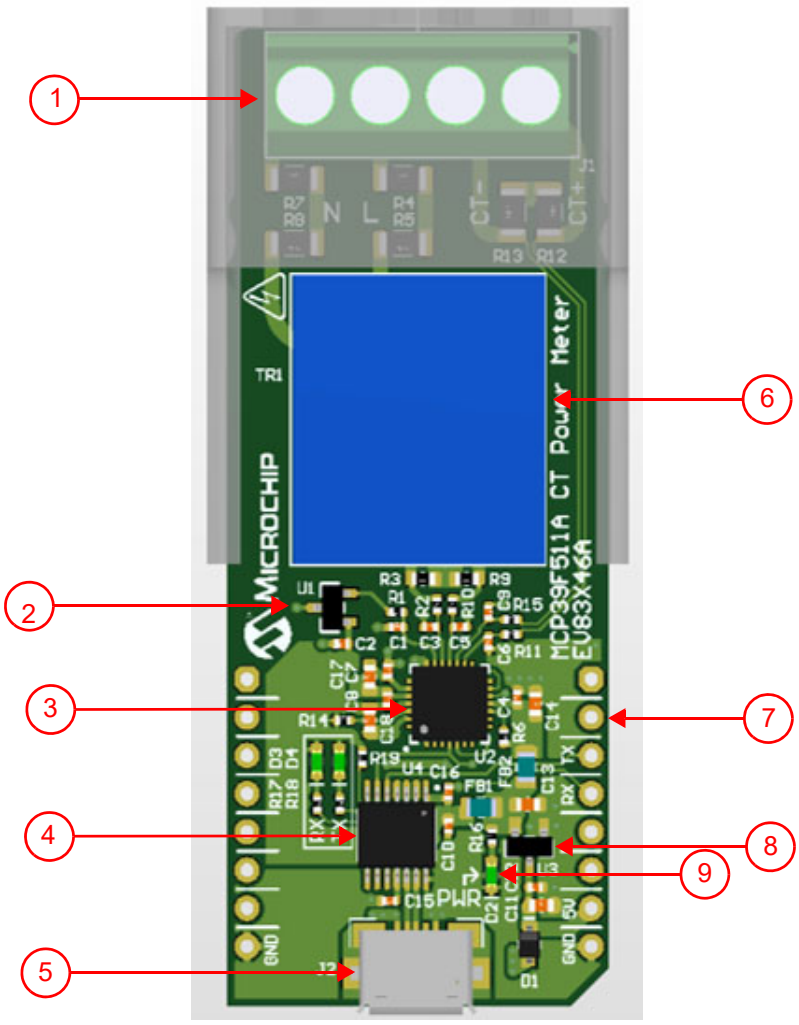


FIGURE 2-5: *Measurement Output.*

> **Note:** The *"Power Monitor Utility Software User Manual"* can be found under the Help menu of the utility software.

Chapter 3. Hardware Description

3.1 BOARD DESIGN



Where:

1. Four-Position Screw Block Terminal
2. MCP9700 Low-Power Linear Active Thermistor IC
3. MCP39F511A 24-bit Single-Phase AC/DC Power Monitoring IC
4. MCP2221A USB 2.0 to I^2C/UART Protocol Converter with GPIO
5. Micro-USB 2.0 Connector
6. ZMPT101L Current-Type Voltage Transformer
7. mikroBUS™ Header Interface
8. MCP1754 16V, High PSRR, 150 mA LDO w/V_{OUT} = 3.3V
9. Power-On/Off LED

FIGURE 3-1: *MCP39F511A CT Power Meter (Top View).*

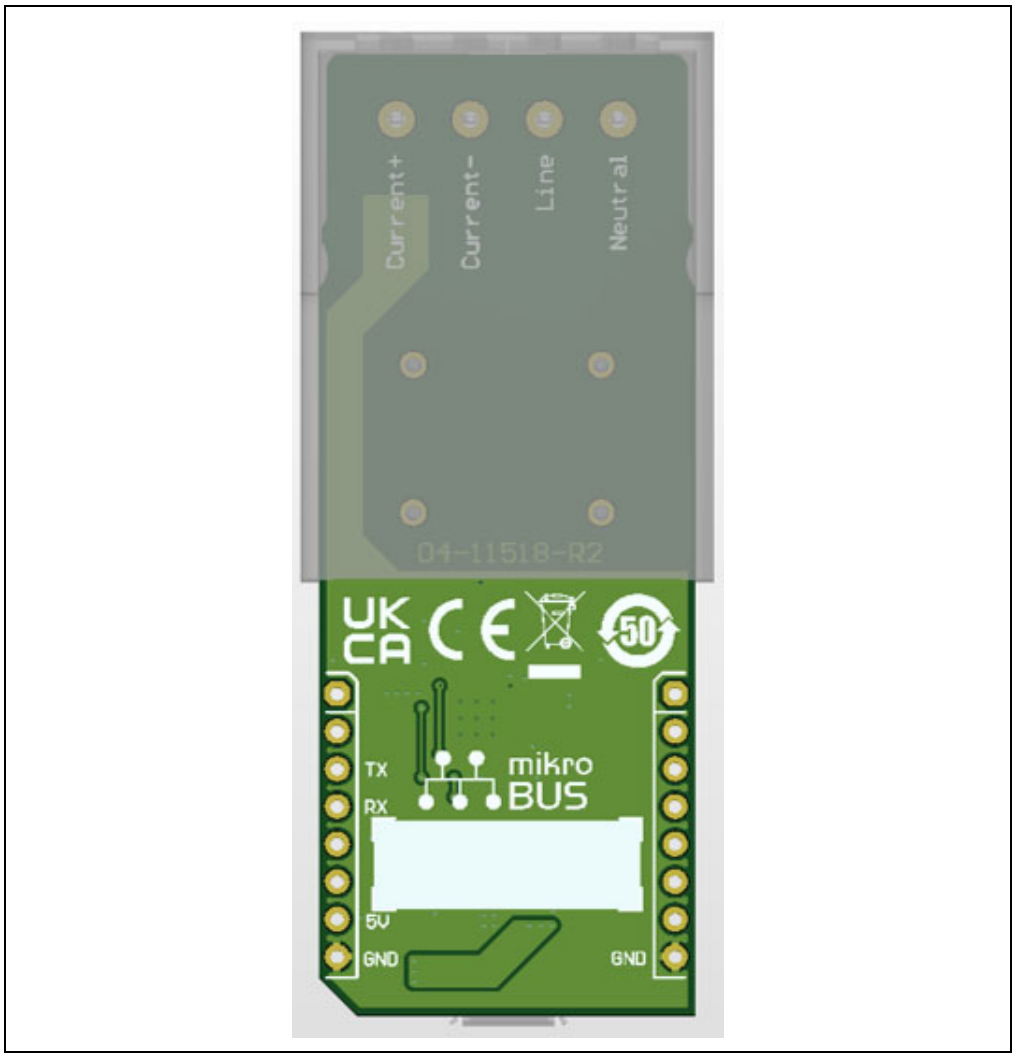


FIGURE 3-2: *MCP39F511A CT Power Meter (Bottom View).*

3.1.1 Power Supply

The MCP39F511A CT Power Meter is powered from a USB bus via the Micro-USB connector located at J2. The USB bus feeds an MCP1754 LDO to provide the analog (3.3V VA) and digital (3.3V VD) power supplies (see Figure 3-3).

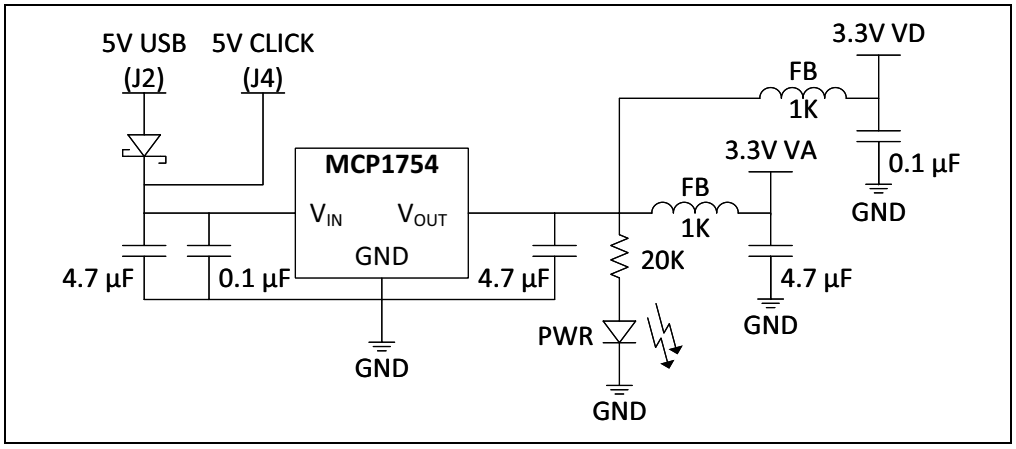


FIGURE 3-3: *Power Supply Circuitry.*

3.1.2 Analog Input and Front-End

3.1.2.1 MAINS VOLTAGE MEASUREMENT

The mains line (L) and neutral (N) connections are located at the J1 terminal block of the MCP39F511A CT Power Meter. Measurement and isolation of the mains voltage are achieved with a 1000:1000 current-type voltage transformer (ZMPT101L). The input current to the ZMPT101L is limited to a maximum of 0.7 mA (RMS) through four 100 kΩ resistors. The output current of the ZMPT101L is then converted to a voltage through a 240Ω resistor and measured by the MCP39F511A. The maximum mains voltage supported by the MCP39F511A CT Power Meter is 395 VAC (peak, i.e., 280 VAC RMS), with a maximum output current of 0.7 mA (RMS).

Anti-Aliasing low-pass filters are inserted on each input pin of the MCP39F511A (see Figure 3-4).

3.1.2.2 CURRENT MEASUREMENT

The current transformers C+ (CT+) and C- (CT-) are located at the J1 terminal block of the MCP39F511A CT Power Meter. Measurement of the load current is achieved with a 100A:50 mA split-core current transformer (SCT013-000) supplied with the MCP39F511A CT Power Meter kit.

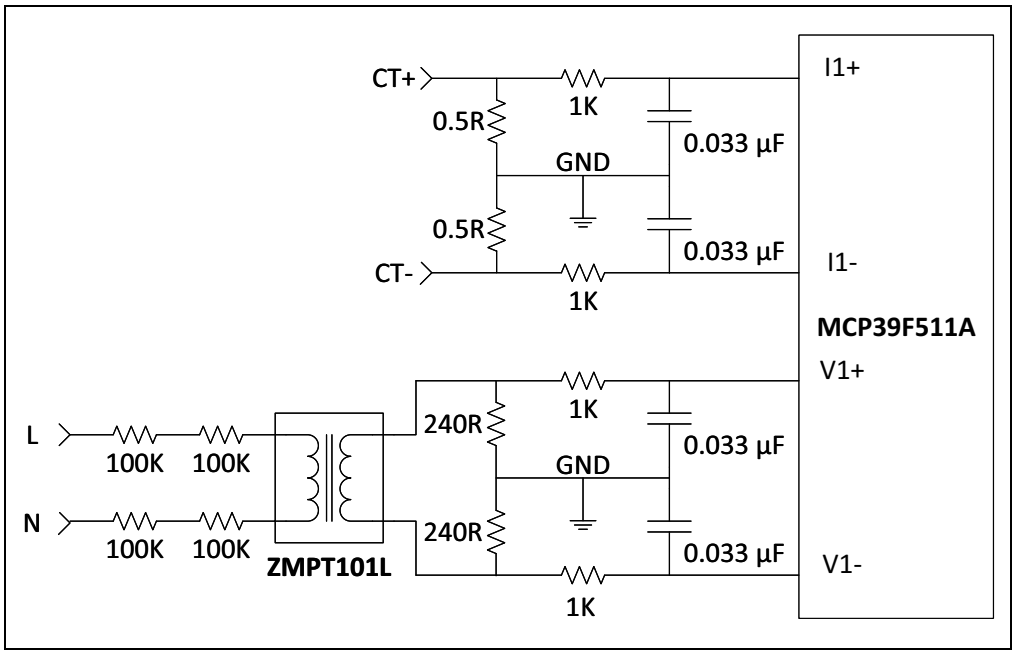


FIGURE 3-4: *Analog Front-End Circuitry.*

NOTES:

Chapter 4. Test Results

4.1 TEST SETUP – FLUKE 6100A ELECTRICAL POWER STANDARD

During validation of the MCP39F511A CT Power Meter, the following test data were collected on boards calibrated using a Fluke 6100A Electrical Power Standard unit.

Note: The results presented in this section are not to be considered an exhaustive characterization of PowerUC Electronics Co., Ltd. (YHDC) SCT013-000 Current Transformers.

4.1.1 Current and Power Measurements

The data in this section were collected with the SCT013-000 current transformer and the MCP39F511A CT Power Meter was calibrated at 220V, 50 Hz, 20A.

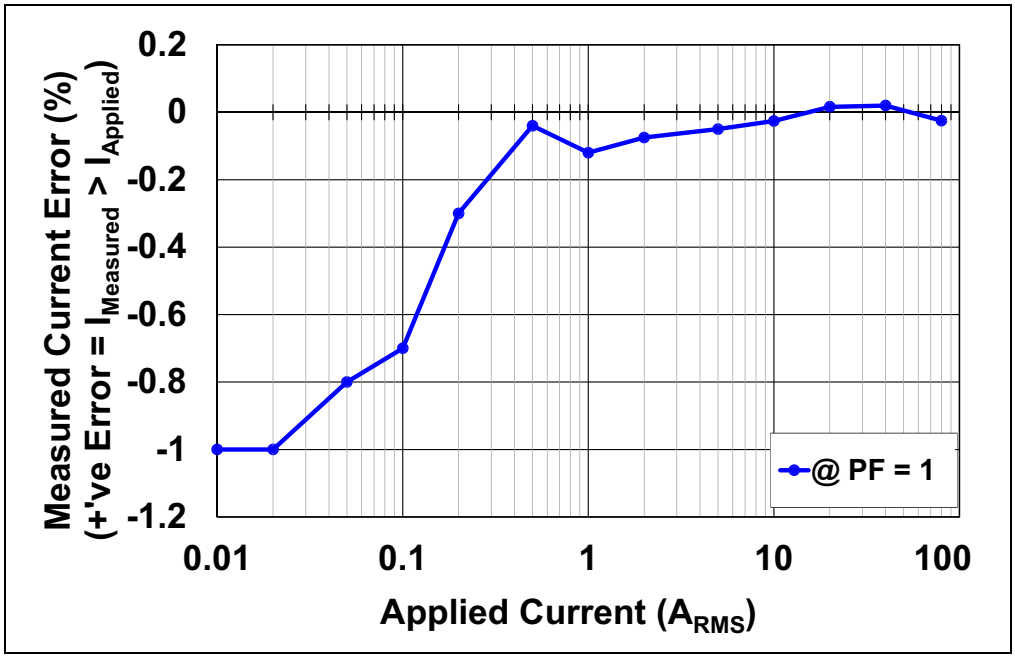


FIGURE 4-1: *Current Measurement Error (%).*

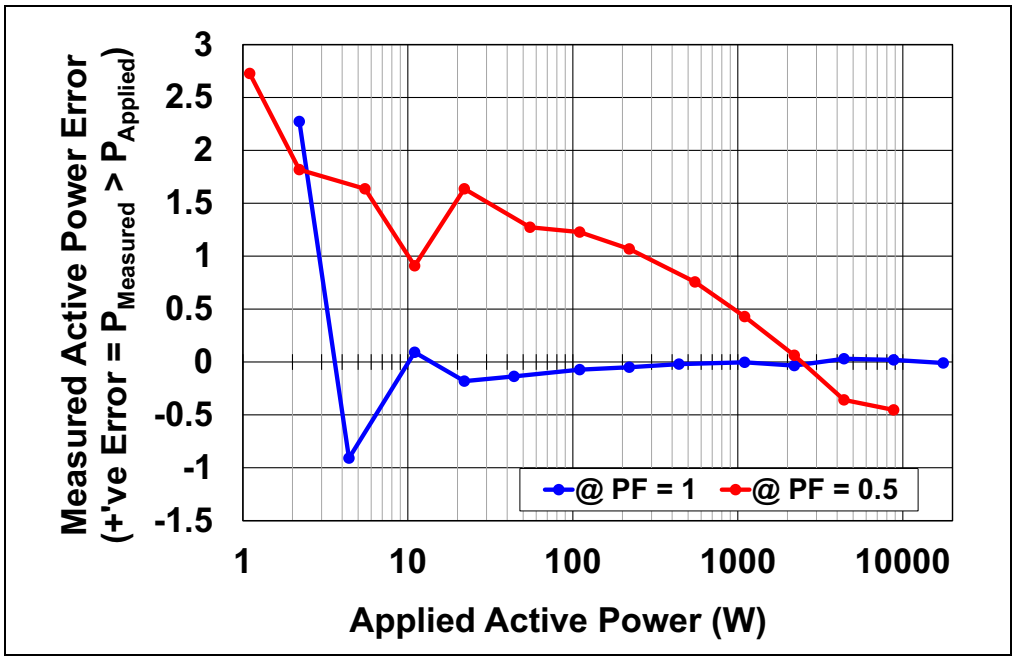


FIGURE 4-2: *Active Power Measurement Error (%).*

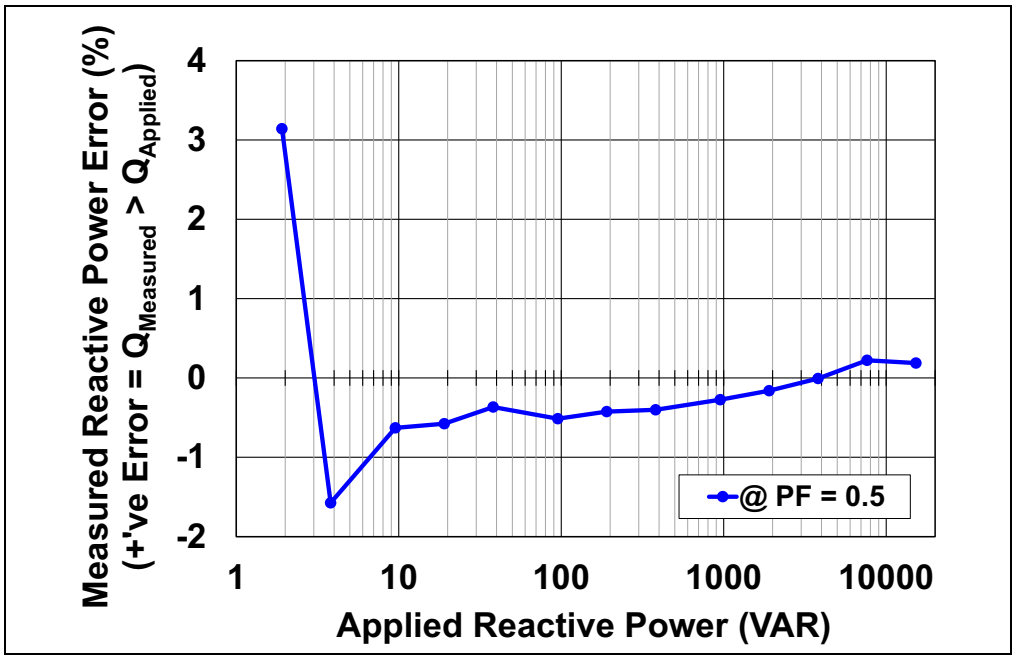


FIGURE 4-3: *Reactive Power Measurement Error (%).*

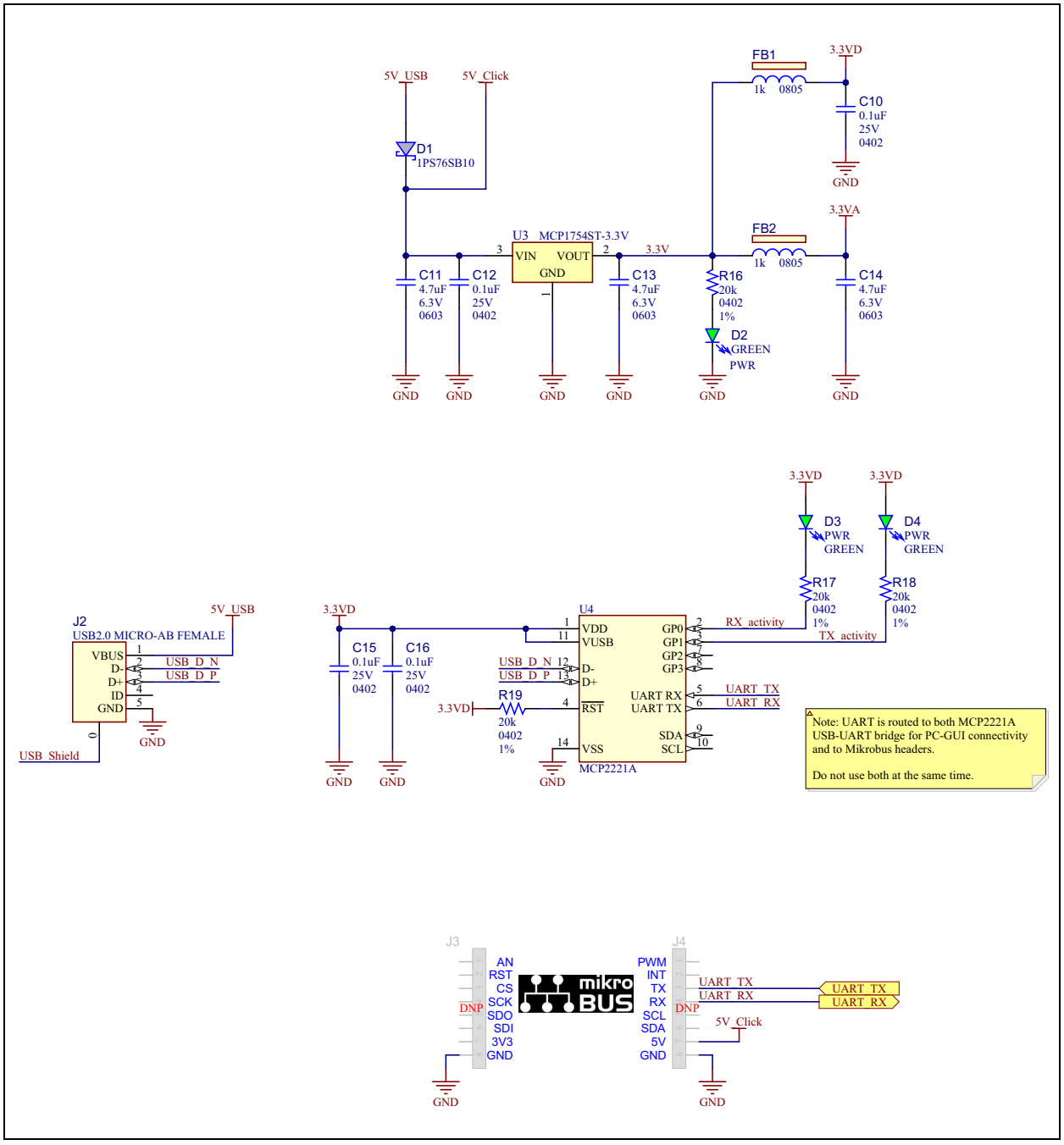
Appendix A. Schematics and Layouts

A.1 INTRODUCTION

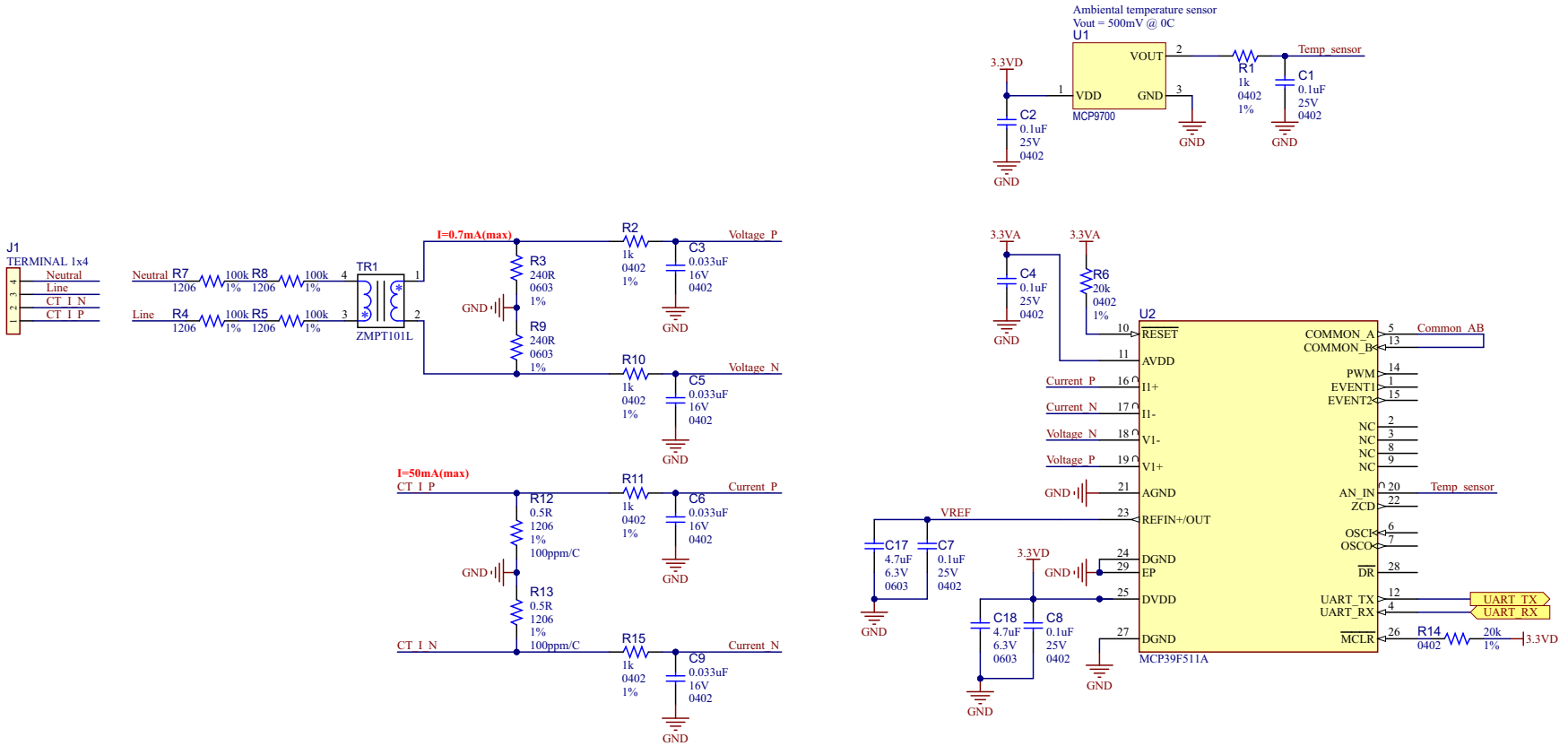
This appendix contains the following schematic and layouts for the MCP39F511A CT Power Meter:

- Board – Schematic (Power + USB)
- Board – Schematic (MCP39F511A)
- Board – Schematic (Mechanical)
- Board – Top Silk
- Board – Top Copper and Silk
- Board – Top Copper
- Board – Bottom Copper
- Board – Bottom Copper and Silk
- Board – Bottom Silk

A.2 BOARD – SCHEMATIC (POWER + USB)

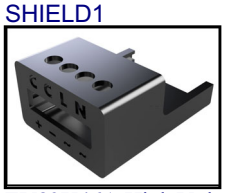


A.3 BOARD – SCHEMATIC (MCP39F511A)



A.4 BOARD – SCHEMATIC (MECHANICAL)

SHIELD1



EV83X46A High Voltage Shield

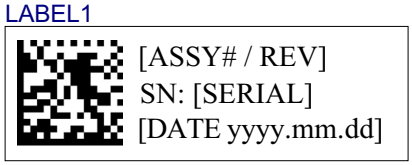
CT1

SCT013-B84

CBL1

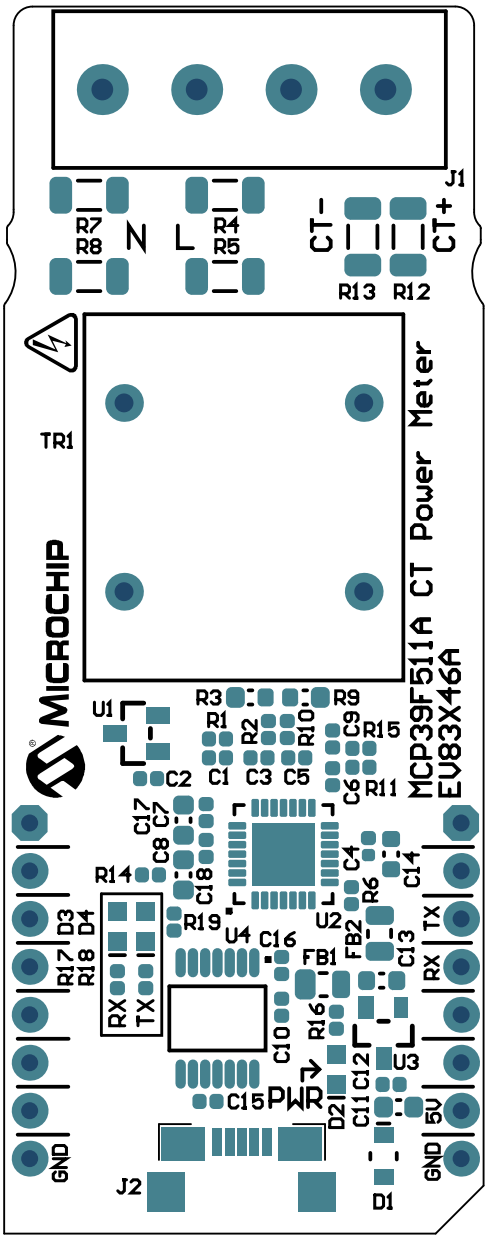
USB A to USB Micro-B Cable

LABEL1

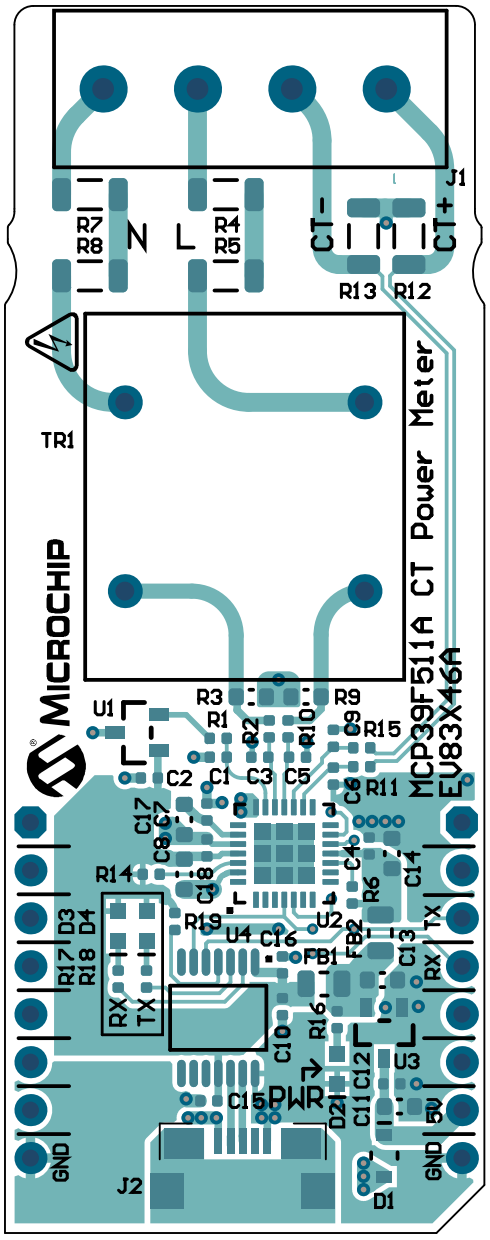


PCBA LABEL 18X6mm

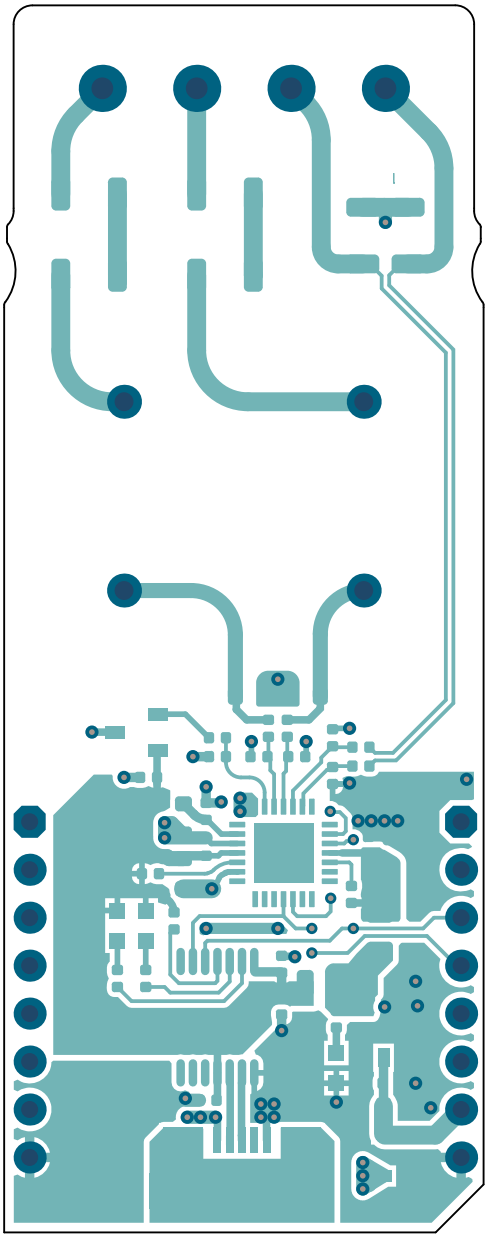
A.5 BOARD – TOP SILK



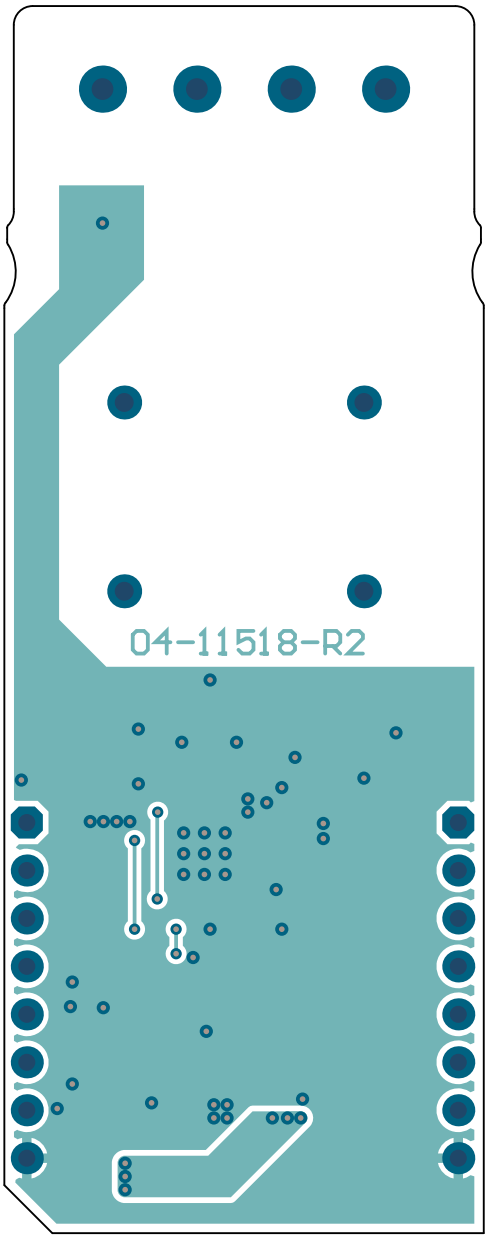
A.6 BOARD – TOP COPPER AND SILK



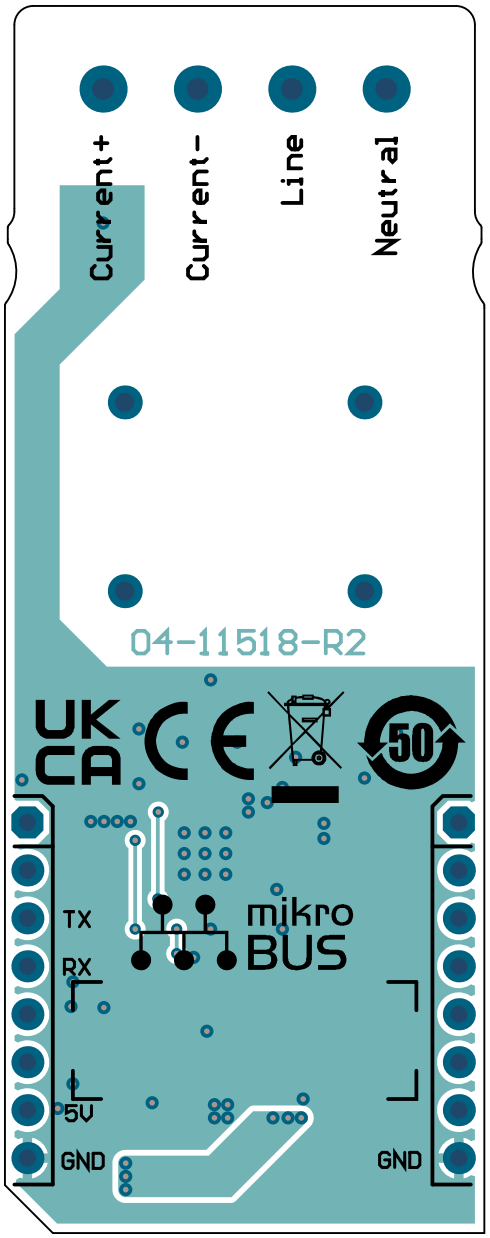
A.7 BOARD – TOP COPPER



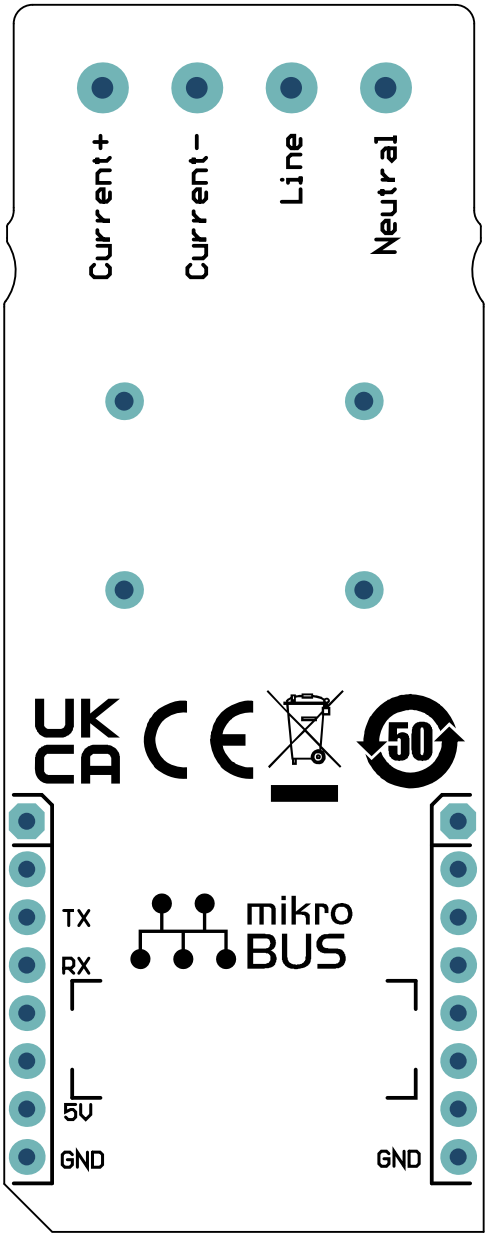
A.8 BOARD – BOTTOM COPPER



A.9 BOARD – BOTTOM COPPER AND SILK



A.10 BOARD – BOTTOM SILK



Appendix B. Bill of Materials (BOM)

TABLE B-1: BILL OF MATERIALS (BOM)

Qty.	Reference	Description	Manufacturer	Part Number
9	C1, C2, C4, C7, C8, C10, C12, C15, C16	Ceramic capacitor, 0.1 µF, 25V, 10%, X7R, SMD, 0402	TDK Corporation	C1005X7R1E104K050BB
4	C3, C5, C6, C9	Ceramic capacitor, 0.033 µF, 16V, 10%, X7R, SMD, 0402	Wurth Elektronik	885012205034
5	C11, C13, C14, C17, C18	Ceramic capacitor, 4.7 µF, 6.3V, 10%, X5R, SMD, 0603	KEMET	C0603C475K9PACTU
1	CBL1	Mechanical HW Cable USB, Male, A to USB Male, Micro-B, 0.91M	Qualtek Electronics Corp.	3025030-03
1	CT1	Split Core Current Transformer, 100A to 50 mA, 50 Hz-1 kHz, 1:2000, 1% Wire to Board	Seeed Technology Co., Ltd.	SCT013-B84
1	D1	Schottky diode, 800 mV, 200 mA, 30V, SOD-323	NXP Semiconductors	1PS76SB10,115
3	D2, D3, D4	Green, LED diode, 3.2V, 20 mA, 430 mcd, Clear SMD 0603	Wurth Elektronik	150060GS75000
2	FB1, FB2	Ferrite, 1K at 100 MHz, 1.5A, SMD, 0805	TDK Corporation	MPZ2012S102AT000
1	J1	Connector Terminal, 5 mm, 1x4, Female, 14-30AWG, 10A, Through-Hole, R/A	Phoenix Contact	1729034
1	J2	Connector, USB 2.0 Micro-AB, Female, SMD, R/A	Hirose Electric Co., Ltd.	ZX62-AB-5PA(31)
0	J3, J4	Connector, Header-2.54, Male, 1x8, Gold, 5.84 MH, Through-Hole	Amphenol ICC (FCI)	68001-108HLF
1	LABEL1	Label, PCBA, 18x6 mm, Datamatrix Assy#/Rev/Serial/Date	ACT Logimark AS	505462
1	PCB1	MCP39F511A CT Power Meter – Printed Circuit Board	Microchip Technology Inc.	**04-11518-R2**
5	R1, R2, R10, R11, R15	Resistor, Thick Film, 1 kΩ, 1%, 1/10W, SMD, 0402	Panasonic Industry Co., Ltd.	ERJ-2RKF1001X
2	R3, R9	Resistor, Thick Film, 240R, 1%, 1/10W, SMD, 0603	Yageo Corporation	RC0603FR-07240RL
4	R4, R5, R7, R8	Resistor, Thick Film, 100 kΩ, 1%, 1/4W, SMD, 1206	Panasonic Industry Co., Ltd.	ERJ-8ENF1003V
6	R6, R14, R16, R17, R18, R19	Resistor, Thick Film, 20 kΩ, 1%, 1/16W, SMD, 0402	Yageo Corporation	RC0402FR-0720KL

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
2	R12, R13	Resistor, Thick Film, 0.5R, 1%, 1/2W, SMD, 1206	Stackpole Electronics, Inc.	CSR1206FKR500
1	SHIELD1	Mechanical HW 3D Printed Shield for EV83X46A	Microchip Technology Inc.	**MECH0468**
1	TR1	Transformer, Voltage Metering 50-400Hz, 1000:1000, 2 mA/2 mA, Through-Hole, L19.2W16.7H18.6	Qingxian Zeming Langxi Electronic Devices Co., Ltd.	ZMPT101L
1	U1	Microchip Analog Temperature Sensor, -40°C to +150°C, SOT-23-3	Microchip Technology Inc.	**MCP9700T-E/TT**
1	U2	Microchip Analog Energy Measurement, 4000:1, QFN-28	Microchip Technology Inc.	**MCP39F511A-E/MQ**
1	U3	Microchip Analog LDO, 3.3V, SOT-23A-3	Microchip Technology Inc.	**MCP1754ST-3302E/CB**
1	U4	Microchip Interface USB I^2C UART, TSSOP-14	Microchip Technology Inc.	**MCP2221A-I/ST**

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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