

UCS1002 and PIC16F1503 Reference Design

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Object of Declaration: UCS1002 and PIC16F1503 Reference Design

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.

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

This development/evaluation tool, when incorporating wireless and radio-telecom functionality, is in compliance with the essential requirement and other relevant provisions of the R&TTE Directive 1999/5/EC and the FCC rules as stated in the declaration of conformity provided in the module datasheet and the module product page available at www.microchip.com.

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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

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Preface

NOTICE TO CUSTOMERS

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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 UCS1002 and PIC16F1503 Reference Design. 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 UCS1002 and PIC16F1503 Reference Design. The manual layout is as follows:

- **Chapter 1. "Product Overview"** – Important information about the UCS1002 and PIC16F1503 Reference Design. Includes a Getting Started section that describes the connections to the power supply and the Portable Device.
- **Chapter 2. "Hardware Description"** – Includes details about the components of the USB charger.
- **Appendix A. "Schematic and Layouts"** – Shows the schematic and layout diagrams.
- **Appendix B. "Bill of Materials (BOM)"** – Lists the parts used to build the UCS1002 and PIC16F1503 Reference Design.

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) { ... }`

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RECOMMENDED READING

This user's guide describes how to use the UCS1002 and PIC16F1503 Reference Design. Other useful documents are listed below. The following Microchip documents are available and recommended as supplemental reference resources.

- **UCS1002-2 Data Sheet - *"Programmable USB Port Power Controller with Charger Emulation"* (Rev.1.4 - 7-16-2013)**

This data sheet provides detailed information regarding the UCS1002 device.

- **PIC16F1503 Data Sheet - *"14-Pin Flash, 8-bit Microcontroller"* (DS40001607)**

This data sheet provides detailed information regarding the PIC16F1503 device.

- **AN1827 – *"UCS1002 Highest Current Algorithm Using a PIC® Microcontroller"* (DS20001827A)**

This application note provides information on the firmware programmed in PIC16F1503.

THE MICROCHIP WEB SITE

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- **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 (September 2014)

- Initial Release of this Document.

Chapter 1. Product Overview

1.1 INTRODUCTION

This UCS1002 and PIC16F1503 Reference Design is a fully functional universal serial bus (USB) charger compatible with a large variety of portable devices.

The UCS1002 programmable port-power controller can deliver up to 2.5A charging current. Features like current monitoring and programmable charger emulation profiles make it a good candidate to be used with a PIC® Microcontroller for intelligent USB charging solutions.

The algorithm implemented in the PIC microcontroller applies multiple charger emulation profiles and selects the one that provides the highest current to the attached device. For more information regarding the code, refer to AN1827 – "UCS1002 Highest Current Algorithm Using a PIC® Microcontroller" (DS20001827A).

The board can be powered from 5V directly or through the MCP16323 Synchronous Buck Regulator that allows 6-18V input.

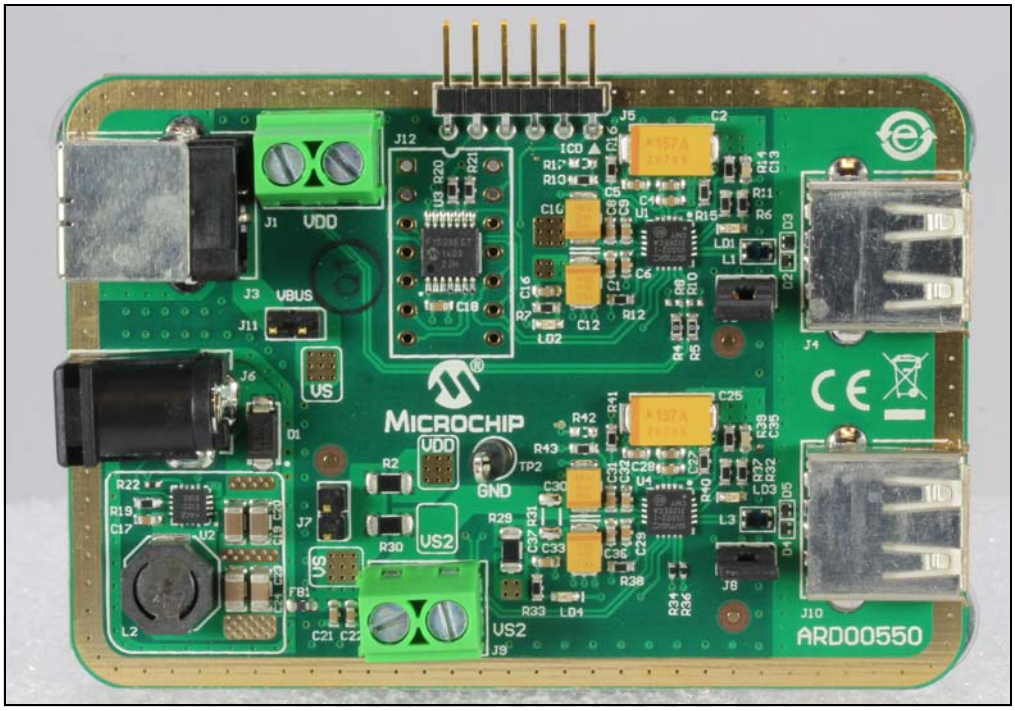


FIGURE 1-1: *UCS1002 and PIC16F1503 Reference Design.*

1.2 WHAT DOES THE UCS1002 AND PIC16F1503 REFERENCE DESIGN KIT INCLUDE?

This UCS1002 and PIC16F1503 Reference Design kit includes:

- UCS1002 and PIC16F1503 Reference Design (ARD00550)
- AC Power Adapter (AC cable not included), 12V DC output
- Important Information Sheet

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1.3 GETTING STARTED

Depending on the available DC supply, the board has a variety of powering options. One of the following options can be used:

- External power supply 6-18V DC on J6 jack connector. J11 must be unpopulated.
- External power supply 5V DC on J9, J1 or J7. J11 must be unpopulated.
- If the USB host can supply enough current for charging, then the external power supply is not required and J11 must be populated.

J2 jumper must be populated to provide power to the corresponding USB connector (J4). A current probe or a multimeter can be connected to J2 header for monitoring the charging current and the voltage close to the USB connector.

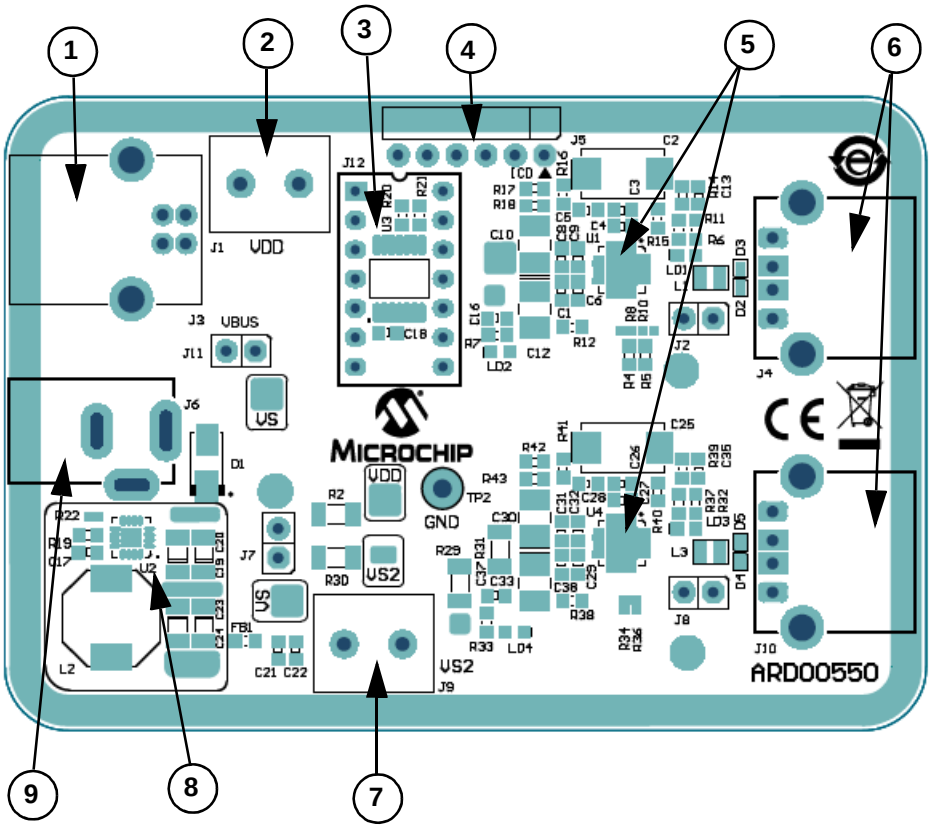
After the proper jumper configurations are set and power is turned on, the portable device to be charged can be plugged into the USB connector J4. The green LED (LD1) turns on, confirming the attach detection.

The board comes with the PIC16F1503 microcontroller programmed with a firmware version that communicates with only one of the two UCS1002 devices on the board (U1 on the schematic, with the corresponding USB connector J4). The other path available on the board (containing the components U4, J8 and J10) can be enabled by changing the I^2C™ address of the UCS1002 in the firmware and reprogramming the MCU via the J5 ICSP connector.

Chapter 2. Hardware Description

2.1 OVERVIEW

Figure 2-1 and Figure 2-2 show the main hardware components and the block diagram of the UCS1002 and PIC16F1503 Reference Design.



Legend:

1 = USB connector (to host)
2 = VDD 5V input option
3 = PIC16F1503
4 = ICSP connector
5 = UCS1002
6 = USB connector (to portable device)
7 = VS2 5V input option
8 = MCP16323 Synchronous Buck Regulator
9 = DC Input Jack 6-18V

FIGURE 2-1: *Top View - Main Hardware Components.*

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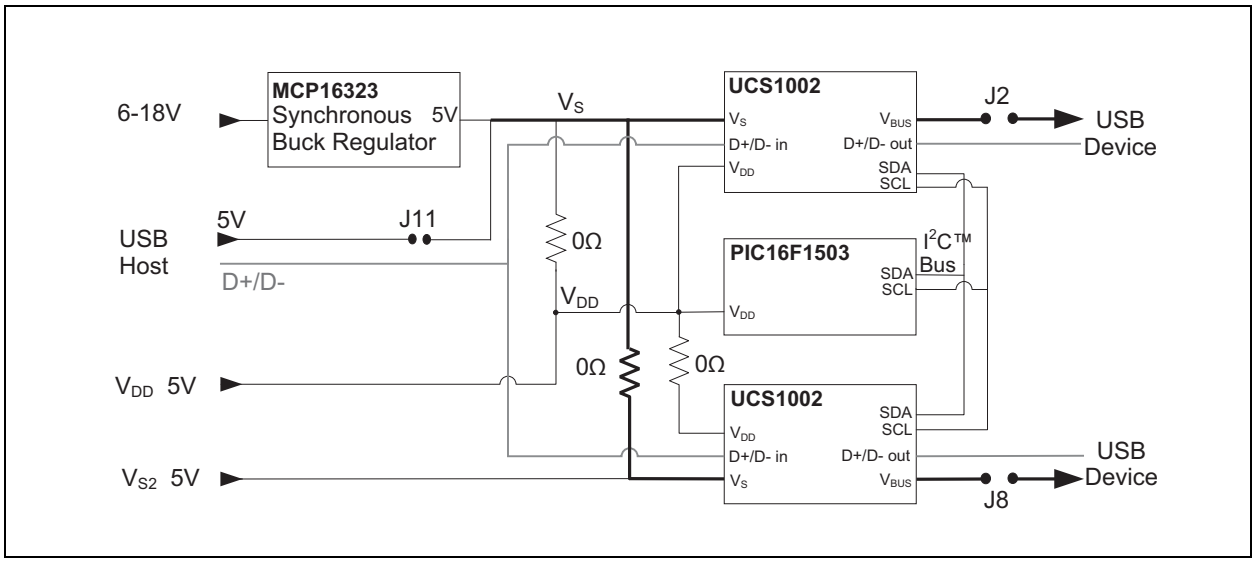


FIGURE 2-2: *Block Diagram.*

2.2 POWER SUPPLY

The board can be powered directly from a 5V DC supply or via the MCP16323 High-Efficiency Synchronous Buck Regulator, allowing input voltages from 6V to 18V DC and output currents up to 3A at 5V.

Note:	Because of the space constraints, the power dissipation is limited, and the maximum output current is lower than 3A.

The UCS1002 and PIC16F1503 Reference Design is designed with a split 5V supply:

- V_S is input for the Power Switch of the UCS1002 device
- V_{DD} is the main power supply to the PIC MCU and to UCS1002 (chip functionality)

The board comes with the R2, R29 and R30 (all with 0Ω values) populated, so V_{DD} and V_S traces for the two UCS1002 are connected.

2.3 PIC16F1503 DEBUG SUPPORT (OPTIONAL)

The PIC16F1503 has no built-in debug circuitry. It requires the AC244051 external header for debug support.

In order to use the in-circuit debug feature provided by the external header, these steps must be followed:

1. Remove the PIC16F1503 from the board.
2. Populate the 14-pin DIP socket on the board (J12). The DIP socket is not included in the UCS1002 and PIC16F1503 Reference Design kit.
3. Connect the external debug header to the DIP socket through the gold pins headers provided in the AC244051 kit.

For more information on AC244051 debug header, refer to the latest *"Processor Extension Pack and Header Specification"* (DS51292) document.

2.4 UCS1002 PIN CONFIGURATION

The UCS1002 device is configured to work in SMBus mode, with maximum hardware current limit setting (2500 mA). The proper value pull-down resistor connected to COMM_SEL/I_{LIM} pin can be drawn from **Section 4.1 - "Operating Mode"** in the UCS1002 data sheet. In this case, the value is 33 kΩ.

PWR_EN polarity is set to active high and the SMBus addresses for the two UCS1002 devices on the board are the following (refer to Table 4.2 - "SEL Pin Decode" in the data sheet):

- U1 - Address 33h: pull-down resistor value of 47 kΩ
- U4 - Address 30h: pull-down resistor value of 82 kΩ

The addresses specified above represent the hexadecimal value of the seven bits shown in the table (without the RD/$\overline{WR}$ indicator bit).

The UCS1002 device is configured in Dedicated Charger Emulation by setting the following logic states on M1, M2 and EM_EN pins (see Table 9.1 - "Active Mode Selection" in the data sheet):

M1	M2	EM_EN	Active Mode
0	0	1	Dedicated Charger Emulation Cycle

The PWR_EN pin that controls the port power switch in Active state is set to a logic-high state (active). When the board is powered up, the microcontroller sets the PIN_IGNORE configuration bit in the UCS1002. This determines the PWR_EN to be controlled by the microcontroller via SMBus communication. As a result, the status of the PWR_EN pin is ignored by the UCS1002 device.

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Appendix A. Schematic and Layouts

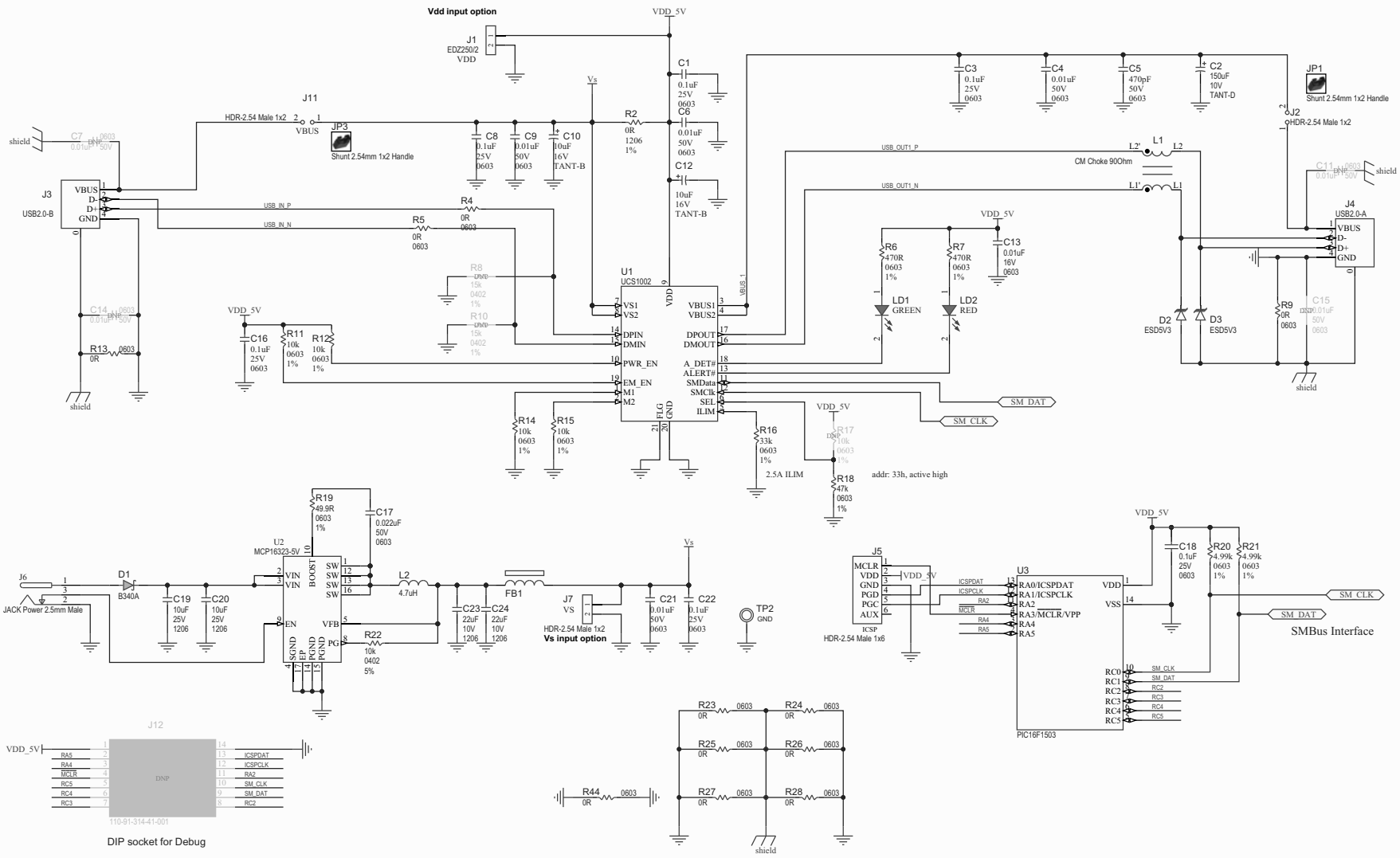
A.1 INTRODUCTION

This appendix contains the following schematics and layouts for the UCS1002 and PIC16F1503 Reference Design:

- Board – Schematic – UCS1002, PIC16F1503 and Power Supply
- Board – Schematic – Second Charging Path with UCS1002 (optional)
- Board – Top Silk
- Board – Top Silk and Copper
- Board – Top Copper
- Board – Inner Plane 1 – GROUND
- Board – Inner Plane 2 – POWER
- Board – Bottom Copper
- Board – Bottom Copper and Silk
- Board – Bottom Silk

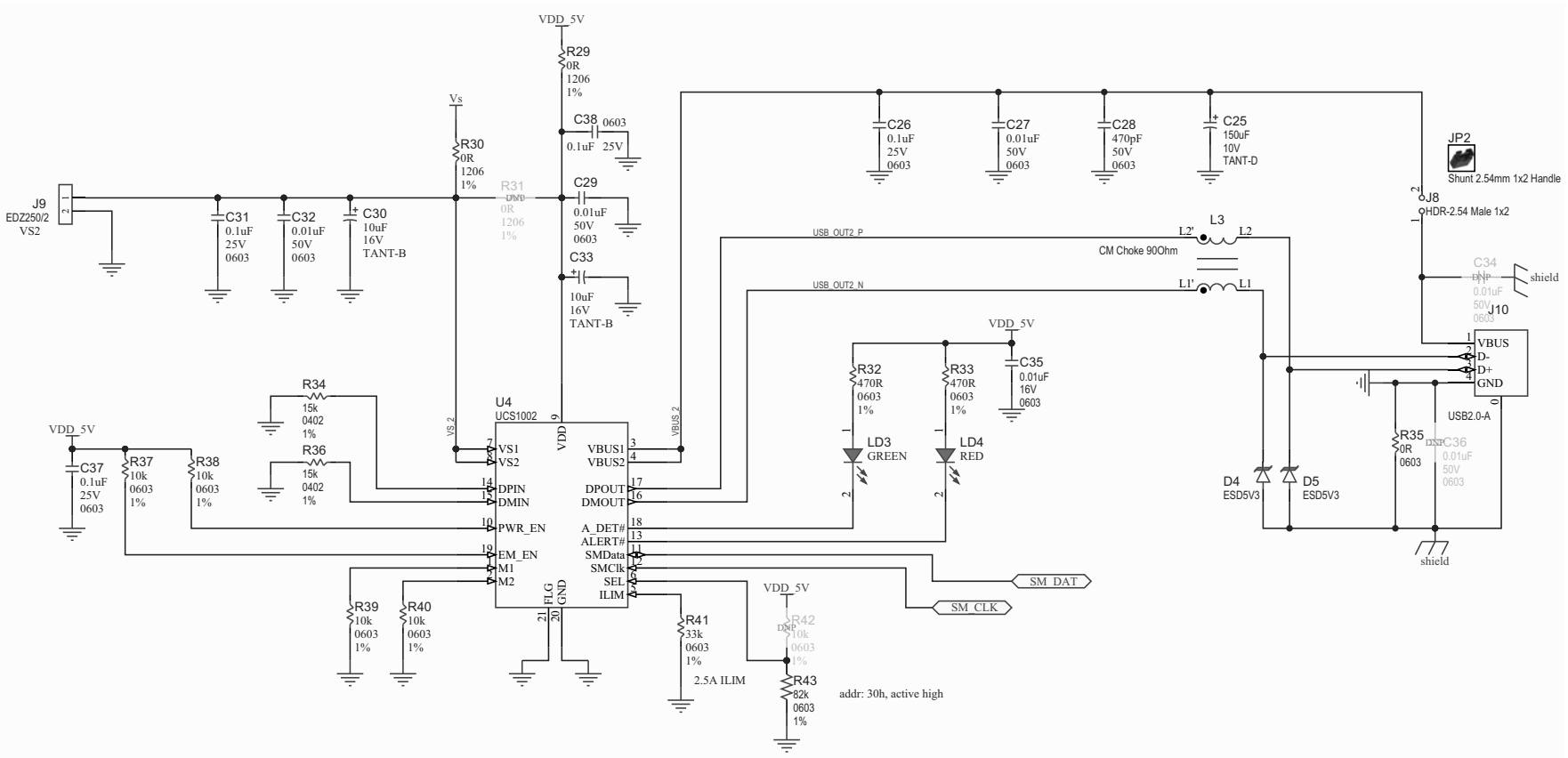
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A.2 BOARD – SCHEMATIC – UCS1002, PIC16F1503 AND POWER SUPPLY



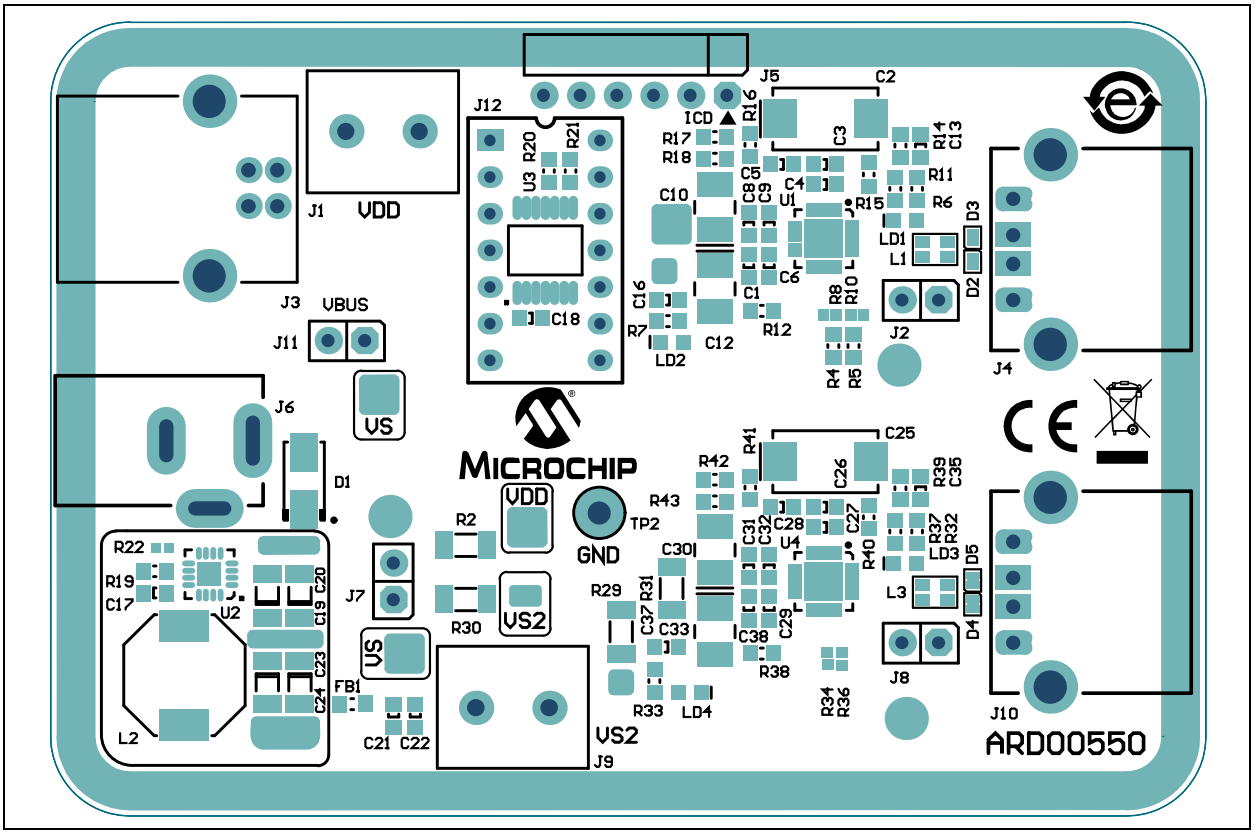
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A.3 BOARD – SCHEMATIC – SECOND CHARGING PATH WITH UCS1002 (OPTIONAL)

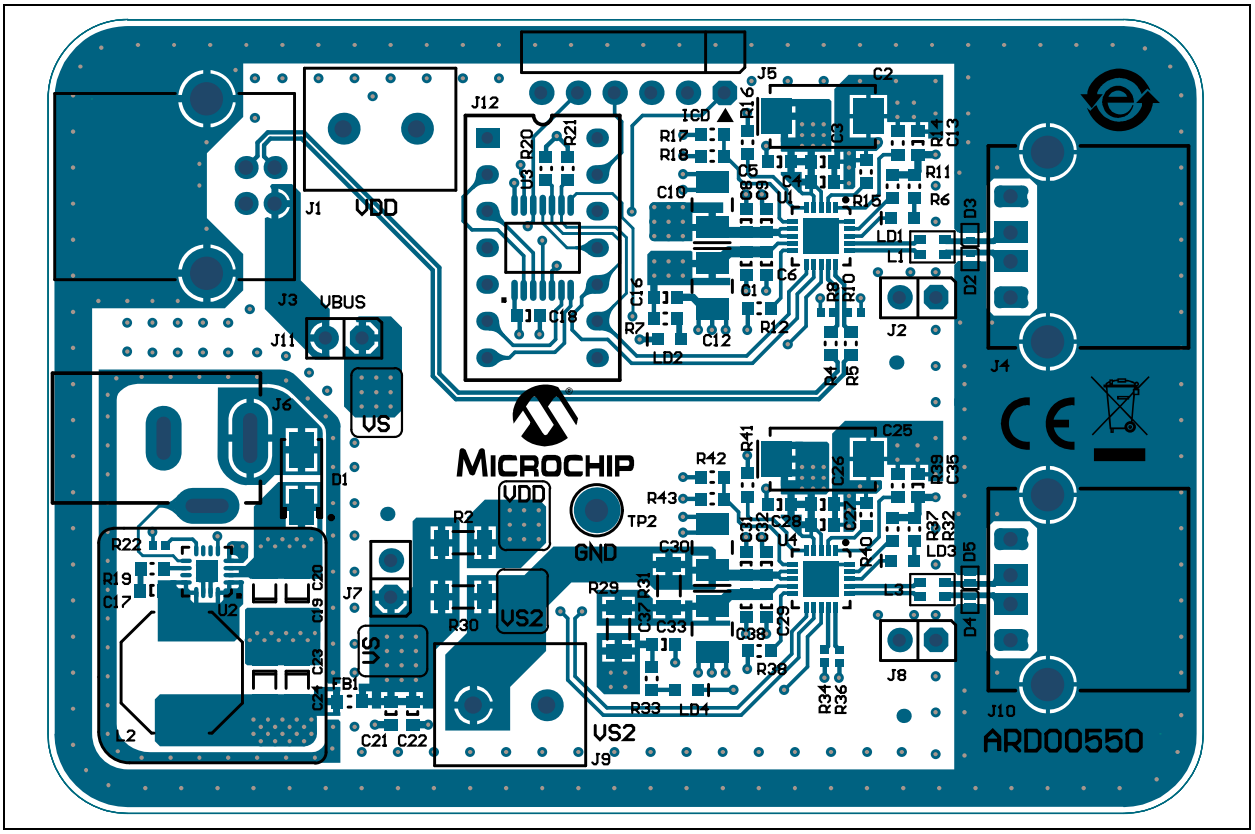


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A.4 BOARD – TOP SILK

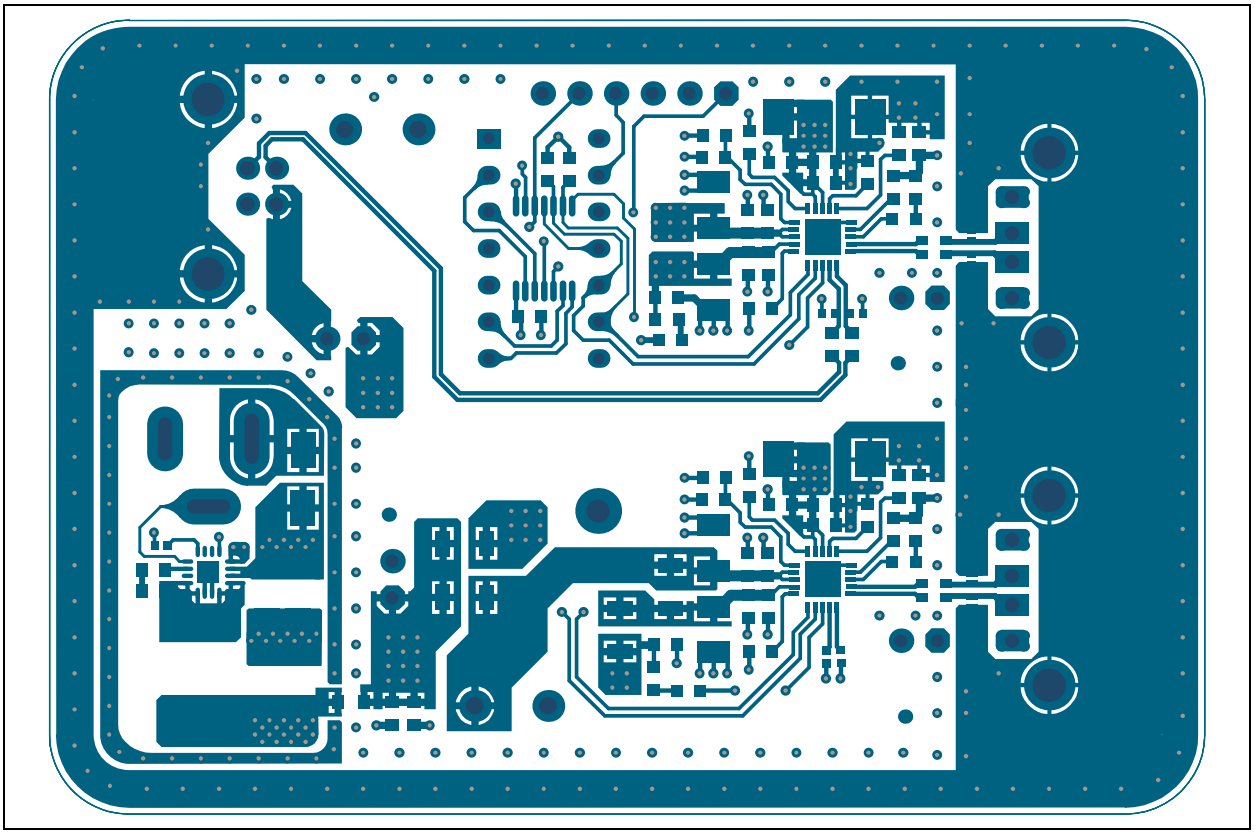


A.5 BOARD – TOP SILK AND COPPER

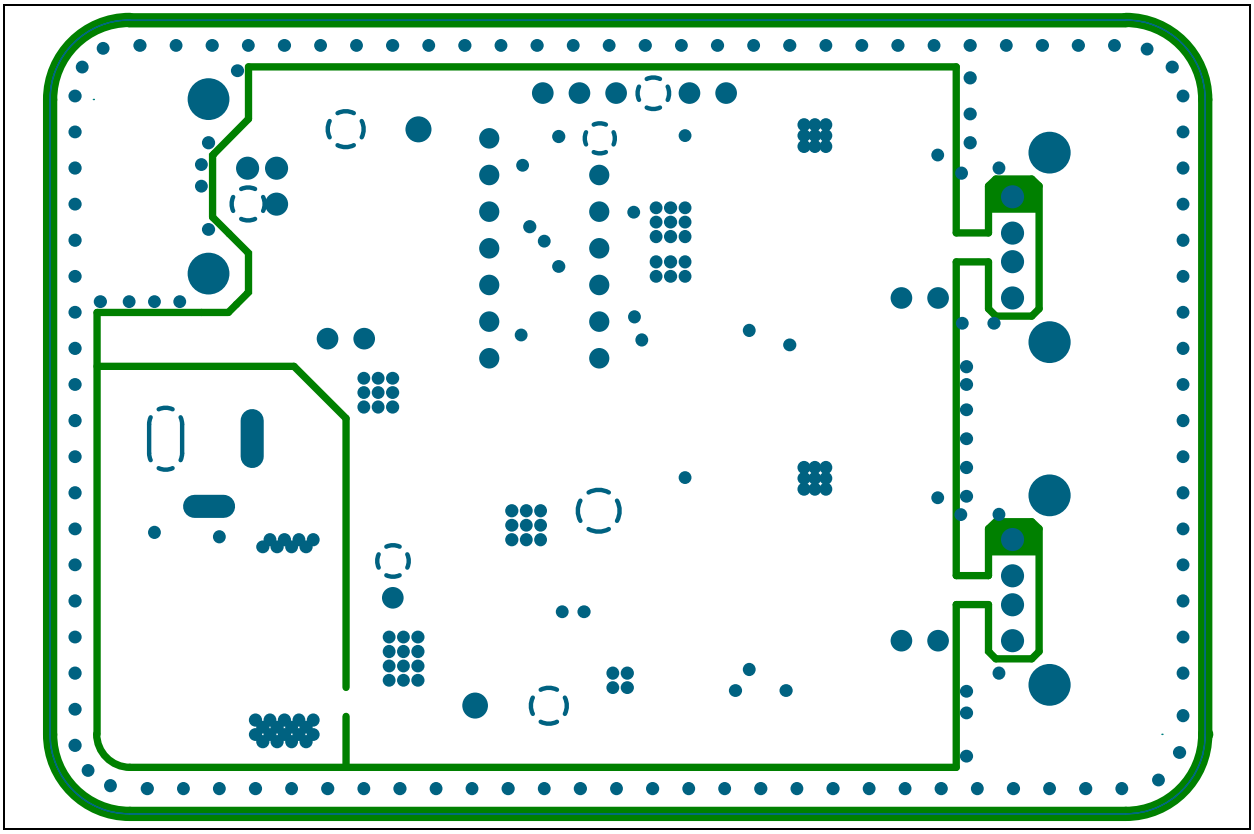


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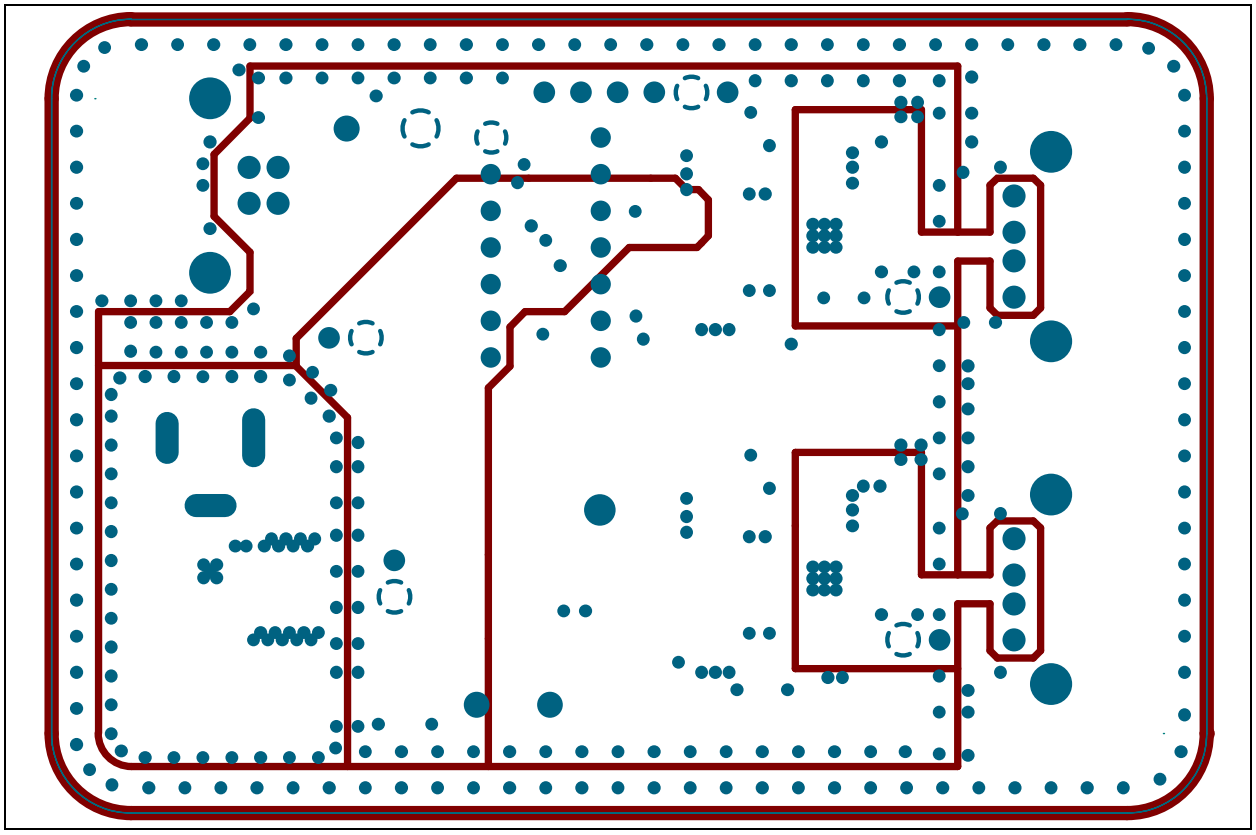
A.6 BOARD – TOP COPPER



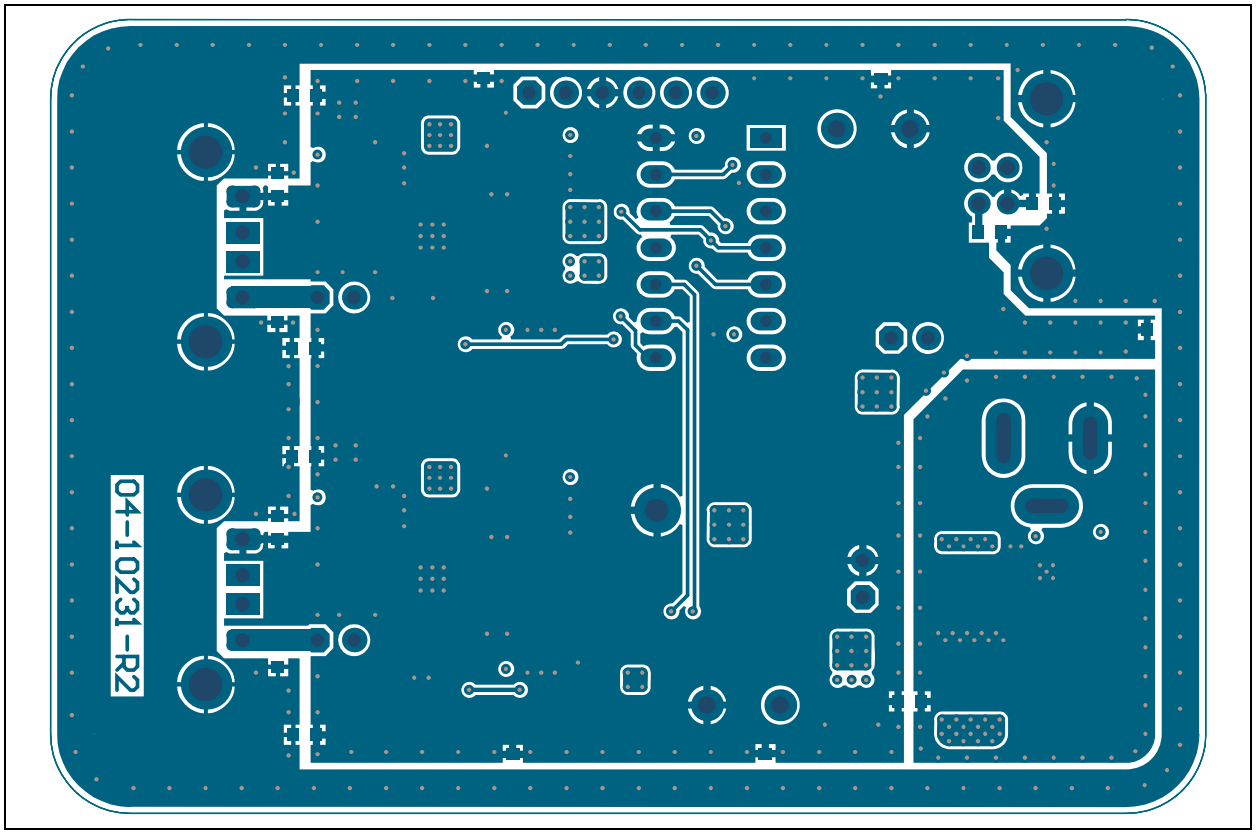
A.7 BOARD – INNER PLANE 1 – GROUND



A.8 BOARD – INNER PLANE 2 – POWER

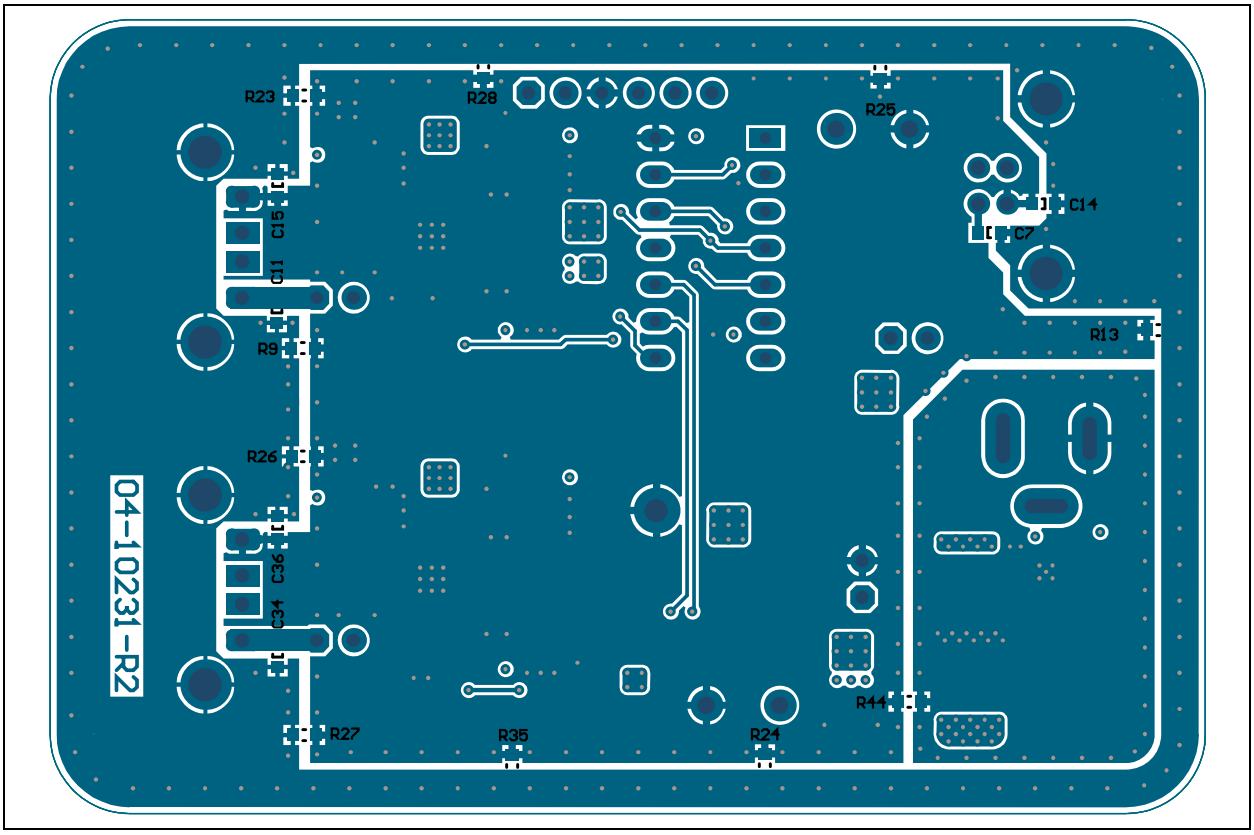


A.9 BOARD – BOTTOM COPPER

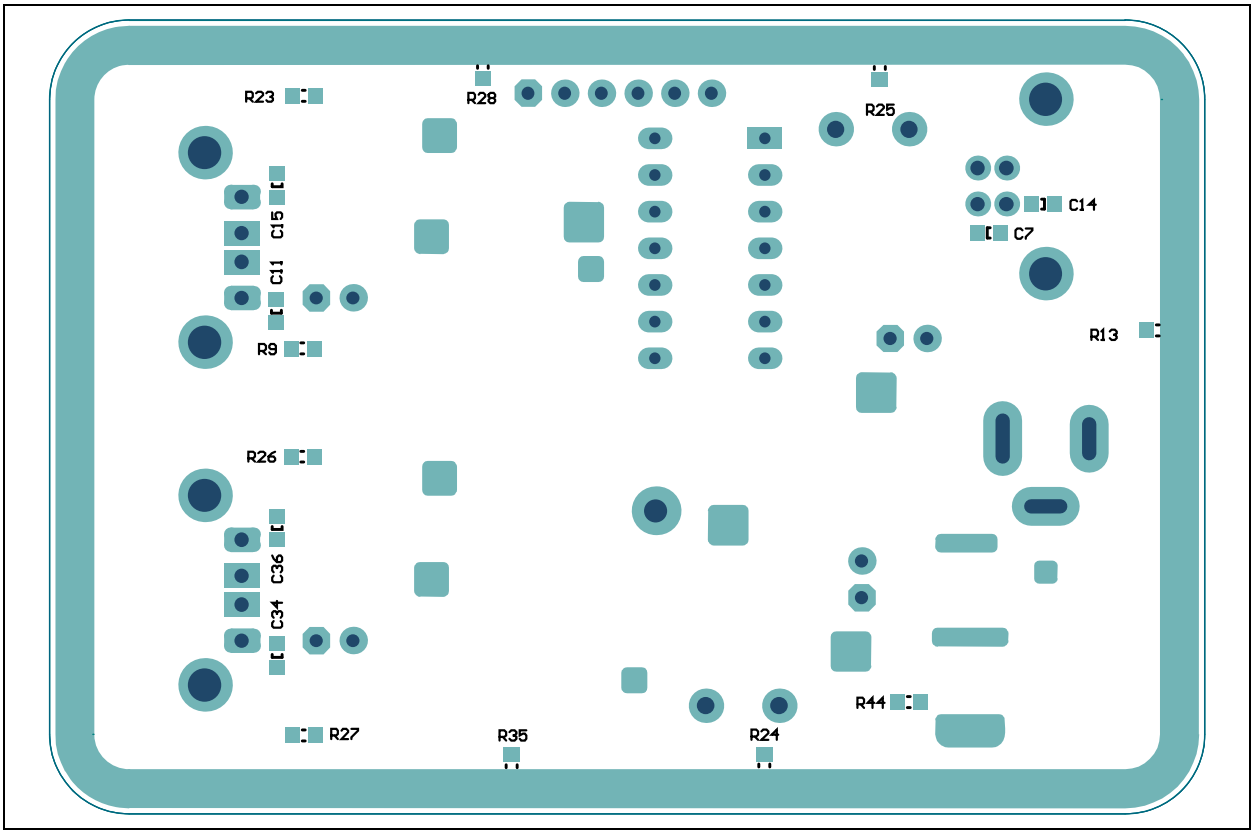


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A.10 BOARD – BOTTOM COPPER AND SILK



A.11 BOARD – BOTTOM SILK



Appendix B. Bill of Materials (BOM)

TABLE B-1: BILL OF MATERIALS (BOM)

Qty.	Reference	Description	Manufacturer	Part Number
10	C1, C3, C8, C16, C18, C22, C26, C31, C37, C38	Cap. ceramic 0.1 µF 25V 20% X7R SMD 0603	KEMET®	C0603C104M3RACTU
2	C2, C25	Cap. Tant. 150 µF 10V 10% 100 mOhm SMD D	AVX Corporation	TPSD157K010R0100
7	C4, C6, C9, C21, C27, C29, C32	Cap. ceramic 0.01 µF 50V 20% X7R SMD 0603	KEMET	C0603C103M5RAC
2	C5, C28	Cap. ceramic 470 pF 50V 10% X7R SMD 0603	Johanson Dielectrics	500R14W471KV4T
0	C7, C11, C14, C15, C34, C36	Cap. ceramic 0.01 µF 50V 20% X7R SMD 0603 – **DO NOT POPULATE**	KEMET	C0603C103M5RAC
4	C10, C12, C30, C33	Cap. ceramic 10 µF 16V 10% 2.8 Ohm SMD B	KEMET	T491B106K016AS
2	C13, C35	Cap. ceramic 0.01 µF 16V 10% X7R SMD 0603	Panasonic® - ECG	ECJ-1VB1C103K
1	C17	Cap. ceramic 0.022 µF 50V 10% X7R SMD 0603	TDK Corporation	C1608X7R1H223K
2	C19, C20	Cap. ceramic 10 µF 25V 10% X7R SMD 1206	Taiyo Yuden Co., Ltd.	TMK316B7106KL-TD
2	C23, C24	Cap. ceramic 22 µF 10V 10% X7R SMD 1206	Samsung Electro-Mechanics America, Inc.	CL31B226KPHNNNE
1	D1	Diode Sctky B340A 500 mV 3A 40V DO-214AC_SMA	Diodes® Incorporated	B340A-13-F
4	D2, D3, D4, D5	Diode TVS Unidir. ESD5V3U1U 5.3V SMD SOD-882	Infineon Technologies AG	ESD5V3U1U-02LRH E6327
1	FB1	Ferrite 6A 0.007R SMD 0603	Murata Electronics®	BLM18KG260TN1D
2	J1, J9	Conn. terminal 5.08 mm 15A Female 1x2 TH R/A	On-Shore Technology, Inc.	EDZ250/2
4	J2, J7, J8, J11	Conn. header 2.54 Male 1x2 Gold 5.84MH TH VERT	FCI	68001-202HLF
1	J3	Conn. USB 2.0 STD-B Female TH R/A	Tyco Electronics (TE Connectivity)	292304-1
2	J4, J10	Conn. USB 2.0 STD-A Female TH R/A	FCI	87520-0010BLF
1	J5	Conn. header 2.54 Male 1x6 Gold 5.84MH TH R/A	FCI	68016-106HLF
1	J6	Conn. power jack male 2.5 mm 16V 2.5A TH R/A	CUI Inc	PJ-002B

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

Qty.	Reference	Description	Manufacturer	Part Number
0	J12	Socket IC Push Dip 14 TH – **DO NOT POPULATE**	Mill-Max Mfg. Corporation	110-93-314-41-001
2	JP1=J2, JP2=J8	Mech. HW Jumper 2.54mm 1x2 Handle Gold	TE Connectivity, Ltd.	881545-2
0	JP3	Jumper 2.54 mm 1x2 Handle Gold – **DO NOT POPULATE**	TE Connectivity, Ltd.	881545-2
2	L1, L3	Inductor Choke Common Mode 90 Ohm 0805	Murata Electronics	DLW21HN900SQ2L
1	L2	Inductor 4.7 µH 4.6A SMD L8W8H4.3	Bourns®, Inc.	SRU8043-4R7Y
2	LD1, LD3	Diode LED Green 2.1V 30 mA 6mcd Clear SMD 0603	Lite-On® Technology Corporation	LTST-C190GKT
2	LD2, LD4	Diode LED Red 1.8V 40 mA 10mcd Clear SMD 0603	Lite-On Technology Corporation	LTST-C190KRKT
	PCB	Printed Circuit Board – UCS1002 and PIC16F1503 Reference Design	—	104-00231
1	Plugs onto J6	AC Power Adapter Transformer Desktop 12V 18W	SL Power Electronics	MENB1020A1203F01
3	R2, R29, R30	Res. 0R 1% 1/4W SMD 1206	TT Electronics Plc.	WCR1206-R005JI
12	R4, R5, R9, R13, R23, R24, R25, R26, R27, R28, R35, R44	Res. TKF 0R 1/10W SMD 0603	NIC Components Corp.	NRC06Z0TRF
4	R6, R7, R32, R33	Res. TKF 470R 1% 1/10W SMD 0603	Yageo Corporation	RC0603FR-07470RL
0	R8, R10	Res. TKF 15k 1% 1/10W SMD 0402 – **DO NOT POPULATE**	Panasonic - ECG	ERJ-2RKF1502X
8	R11, R12, R14, R15, R37, R38, R39, R40	Res. TKF 10k 1% 1/10W SMD 0603	Vishay Intertechnology, Inc.	CRCW060310K0FKEA
2	R16, R41	Res. TKF 33k 1% 1/10W SMD 0603	Stackpole Electronics, Inc.	RMCF0603FT33K0
0	R17, R42	Res. TKF 10k 1% 1/10W SMD 0603 – **DO NOT POPULATE**	Vishay Intertechnology, Inc.	CRCW060310K0FKEA
1	R18	Res. TKF 47k 1% 1/10W SMD 0603	Stackpole Electronics, Inc.	RMCF 1/16 47K 1% R
1	R19	Res. TKF 49.9R 1% 1/10W SMD 0603	Panasonic - ECG	ERJ-3EKF49R9V
2	R20, R21	Res. TKF 4.99k 1% 1/10W SMD 0603	Yageo Corporation	9C06031A4991FKHFT
1	R22	Res. TKF 10k 5% 1/10W SMD 0402	Panasonic - ECG	ERJ-2GEJ103X
0	R31	Res. 0R 1% 1/4W SMD 1206 – **DO NOT POPULATE**	TT Electronics Plc.	WCR1206-R005JI
2	R34, R36	Res. TKF 15k 1% 1/10W SMD 0402	Panasonic - ECG	ERJ-2RKF1502X
1	R43	Res. 82K OHM 1/10W 1% 0603 SMD	Panasonic - ECG	ERJ-3EKF8202V
1	TP2	Conn. TP Loop Black TH	Keystone Electronics Corp.	5011

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	U1, U4	IC USB Port Power Controller UCS1002 QFN-20	Microchip Technology Inc.	**UCS1002-2-BP-TR**
1	U2	Analog Switcher 3A Buck 5V MCP16323T-500E/NG QFN-16	Microchip Technology Inc.	**MCP16323T-500E/NG**
1	U3	MCU 8-BIT 20 MHz 3.5 kB 128B PIC16F1503T-E/ST TSSOP-14	Microchip Technology Inc.	**PIC16F1503T-E/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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