MCP19061 Dual Charge Port Board User's Guide

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MCP19061 DUAL CHARGE PORT 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 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 MCP19061 Dual Charge Port Board. Items discussed in this chapter include:

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

DOCUMENT LAYOUT

This document describes how to use the MCP19061 Dual Charge Port Board as a development tool. The manual layout is as follows:

- **Chapter 1. "Product Overview"** – Important information about the MCP19061 Dual Charge Port Board.
- **Chapter 2. "Installation and Operation"** – Covers the initial setup and operation of the MCP19061 Dual Charge Port Board.
- **Chapter 3. "Graphical User Interface"** – Provides detailed information on the Graphical User Interface (GUI).
- **Chapter 4. "Firmware Update"** – Provides information on updating the firmware.
- **Appendix A. "Schematic and Layouts"** – Shows the schematic and layout diagrams for the MCP19061 Dual Charge Port Board.
- **Appendix B. "Bill of Materials (BOM)"** – Lists the parts used to build the MCP19061 Dual Charge Port 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) { ... }`

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RECOMMENDED READING

This user's guide describes how to use the MCP19061 Dual Charge Port Board. The following Microchip documents are available and recommended as supplementary reference resources.

- **MCP19061 Data Sheet –** ***"Synchronous Four Switch Buck-Boost Analog Front End" (DS20006888)***
- **MCP22350 Data Sheet –** ***"Highly Integrated Small Form Factor USB Type-C® Power Delivery 3.1 Port Controller" (DS20006885)***
- **MCP22301 Data Sheet –** ***"Stand-Alone USB Type-C™ Power Delivery 3.1 Controller" (DS20006887)***
- **UCS4002 Data Sheet –** ***"UCS4002 - USB Type-C Port Protector with Integrated VCONN FETs" (DS20006892)***

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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
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- Local Sales Office
- Field Application Engineer (FAE)
- Technical Support

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Technical support is available through the website at:
https://www.microchip.com/support.

DOCUMENT REVISION HISTORY

Revision A (March 2024)

- Initial release of this document.

Revision B (November 2024)

- Added **Chapter 4. "Firmware Update"**.
- Updated **Chapter 2. "Installation and Operation"**.
- Updated **Chapter 3. "Graphical User Interface"**.
- Updated Board – Block Diagram and Board – Schematic 1 and 2.

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Chapter 1. Product Overview

1.1 INTRODUCTION

This chapter provides an overview of the MCP19061 Dual Charge Port Board and covers the following topics:

- MCP19061 Analog Front End Power Controller Short Overview
- What is the MCP19061 Dual Charge Port (DCP) Board?
- Contents of the MCP19061 Dual Charge Port Board Kit

1.2 MCP19061 ANALOG FRONT END POWER CONTROLLER SHORT OVERVIEW

The MCP19061 device is a highly integrated, mixed-signal, digitally controlled, 4-switch Buck-Boost controller with an I^2C interface. It can provide output voltages that are lower, same, or higher than the input voltage. It includes a Nonvolatile Memory that can be used to store running parameters and a proprietary state-machine that supervises operating parameters, protection levels and Fault handling procedures.

1.3 WHAT IS THE MCP19061 DUAL CHARGE PORT (DCP) BOARD?

The MCP19061 DCP Board is intended to demonstrate how the MCP19061 device operates in a 4-switch buck-boost topology for the purpose of supplying USB loads and charging them with any required voltage, regardless of the input voltage value, within the permitted range. The board is able to regulate the amount of output voltage and current independently for the two USB channels, while simultaneously communicating with the USB-C connected loads using the USB-PD stack protocols.

The board is delivered preprogrammed. To benefit from the latest features implemented in the Microchip Power Delivery Stack (PDS), it is recommend to reprogram the board with the firmware from the latest PDS release or the .hex file available on the board's webpage as described in **Chapter 4. "Firmware Update"**.

The board communicates with a PC running a Graphical User Interface (GUI) through the UART interface and MCP2221A USB-C Breakout Board. The usage of the GUI is optional and is only necessary if the user wants to see information about the connected devices or configure parameters in real time.

The board is equipped with headers for In-Circuit Serial Programming™ (ICSP™), as well as UART communication.

1.4 CONTENTS OF THE MCP19061 DUAL CHARGE PORT BOARD KIT

The MCP19061 DCP Board kit includes:

- MCP19061 Dual Charge Port Board
- Important Information Sheet
- MCP2221A USB-C Breakout Board (BB62Z76A)

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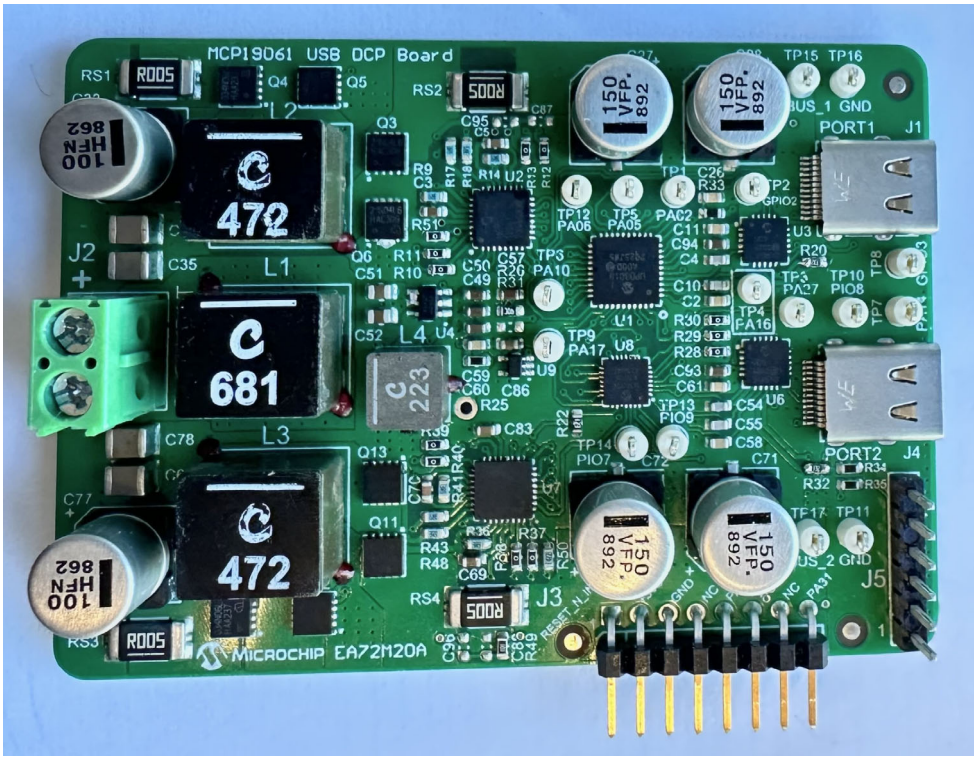

FIGURE 1-1: *MCP19061 USB DCP Board (Top).*

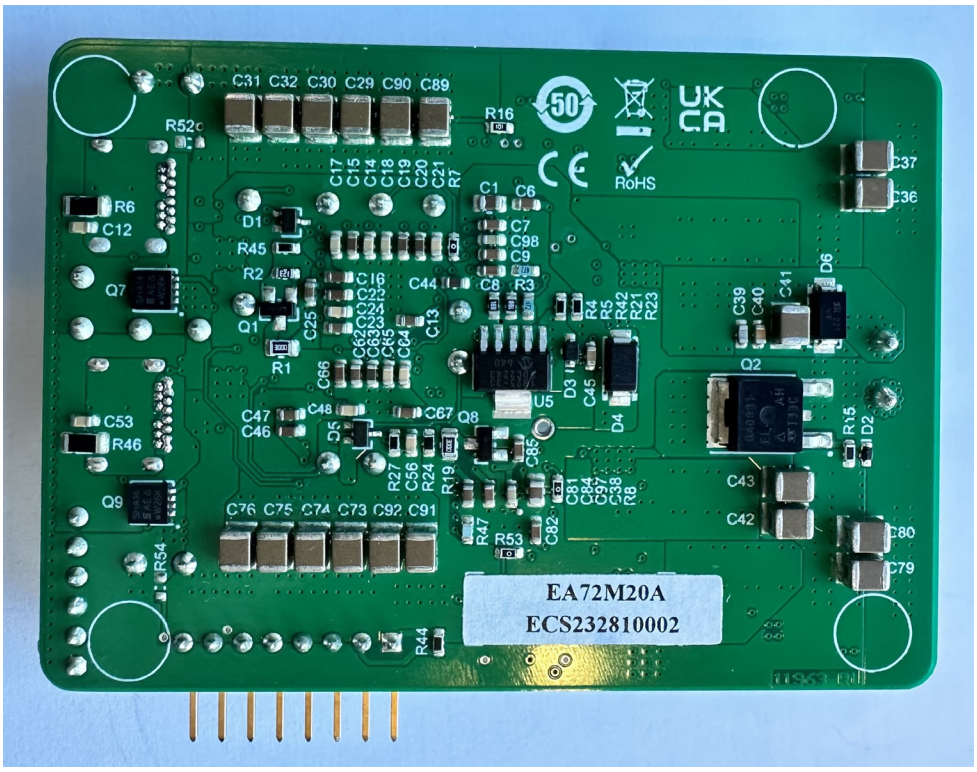

FIGURE 1-2: *MCP19061 USB DCP Board (Bottom).*

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Chapter 2. Installation and Operation

2.1 INTRODUCTION

2.1.1 MCP19061 Dual Charge Port Board Features

The MCP19061 DCP Board is used for charging USB-PD connected devices. It provides output voltages from 5V up to 21V and output currents up to 3A to the USB-C ports. The maximum input voltage range for the DCP Board is from 8 to 16V, with 12V being the recommended value. The board supports a total output power of more than 100W in room ambient temperature.

The board contains two independent USB-PD channels, each one utilizing the following Microchip ICs:

- One MCP19061 4-switch buck-boost converter controlling 4 NMOS Power switches
- One USB-PD controller (MCP22301-1 USB Type-C Power Delivery (PD) Port Controller for Channel 1 and MCP22350-2 for Channel 2)
- One UCS4002 USB Type-C Port Protector

The DCP Board includes an auxiliary supply based on the MCP16301 Integrated Step-down switch-mode regulator providing the +5V voltage, and an MCP1825 LDO linear regulator providing the +3.3V auxiliary voltage. The board's input rail is labeled VBATT and includes a PMOS switch for reverse polarity protection, and a CLC EMI filter. The board's temperature is monitored using an MCP9700 temperature sensor.

The MCP22301 and MCP22350 are responsible for the USB Type-C connection detection and USB Power Delivery communication for the two USB ports.

The SAMD20E16 microcontroller integrated in the MCP22301 runs the Microchip Power Delivery Stack (PDS) and communicates with all Microchip ICs on the board: the two MCP19061 devices, the two MCP22350 devices (one external and one integrated in MCP22301), the two UCS4002 devices and the PC running the Graphical User's Interface (GUI).

The two MCP19061 DC/DC converters use the current and voltage control loops to monitor and regulate the load voltage and current. The board automatically detects the connection and the removal of a USB-PD compliant load on each port independently.

The USB-PD charger board may optionally be connected to a computer running the MCP19061 Dual PD Demo GUI to provide information on the input and output voltages, output currents and the USB Power Delivery profiles used by the connected devices. The GUI also allows the configuration of the Power Balancing and Power Throttling parameters. The communication with the GUI is done by connecting a USB-to-UART bridge, such as the MCP2221A Breakout Board USB (BB62Z76A).

The MCP19061 DCP Board is offered fully assembled, programmed, and tested to evaluate and demonstrate the MCP19061 operating performance in digitally controlled, "smart charging" applications for various USB-PD loads. The interconnection of the devices and the interfaces are visible in **A.2 "Board – Block Diagram"**.

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2.2 GETTING STARTED

2.2.1 Configuration Requirements

The MCP19061 Dual Charge Port Board GUI requires a computer with Microsoft® Windows® 7/8/10/11 operating system and a USB port. To run the software, follow the steps described in this section.

To power-up and run the MCP19061 Dual Charge Port Board with the GUI, the following are required:

- MCP19061 Dual Charge Port Board
- MCP19061 Dual PD Demo GUI
- MCP2221A USB-to-serial bridge and USB cable
- Input Power Supply with cables sized to supply enough current (able to support the maximum board power at the minimum voltage tested)
- USB-PD compliant load
- USB-C cable capable of the maximum load current to be tested.

2.2.2 Installing the MCP19061 Dual PD Demo GUI

Follow the steps below to download and install the MCP19061 Dual PD Demo GUI:

1. Download the GUI from the board's webpage or from Microchip Power Delivery Stack (PDS) on the path "\Demo\dual_port_19061_301_350\PC GUI". The GUI is designed to work only with its corresponding firmware version, so the user should update the firmware too, as described in **Chapter 4. "Firmware Update"**.
2. After downloading and unzipping the archive, open the GUI folder and locate the `MCP19061_Dual_PD_Demo_GUI.exe` file.
3. Double-click the file. In the Security Warning dialog box, press the Run Anyway button.

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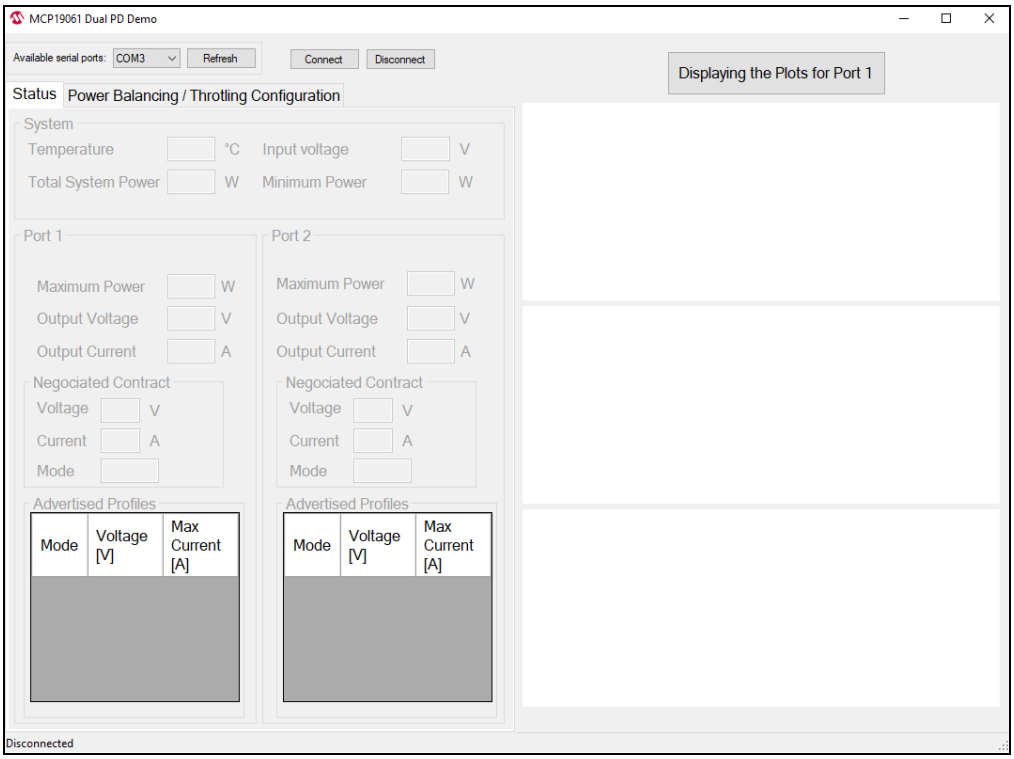

FIGURE 2-1: *Starting the MCP19061 Dual PD Demo GUI.*

4. Once the GUI is started and visible, press the Refresh button and select the COM port assigned to the MCP2221 USB-to-serial bridge from the Available serial ports list, and press Connect.

NOTES:

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Chapter 3. Graphical User Interface

3.1 RUNNING THE MCP19061 DUAL CHARGE PORT BOARD

3.1.1 Setting up the GUI and the Board

1. Connect the two power cables from the power supply to the VIN terminal block J2 on the left-side of the DCP Board. VIN Positive (+) terminal is the upper one. Input voltage should be between 8 and 16V DC.
2. Attach the MCP2221 USB-to-serial bridge to the J5 header on the right-side of the board (pin 1 is the closest to the board corner) and connect it to the computer via USB.
3. Make sure the MCP19061 Dual PD Demo GUI is installed on the computer. Apply DC power to the board and open the GUI.

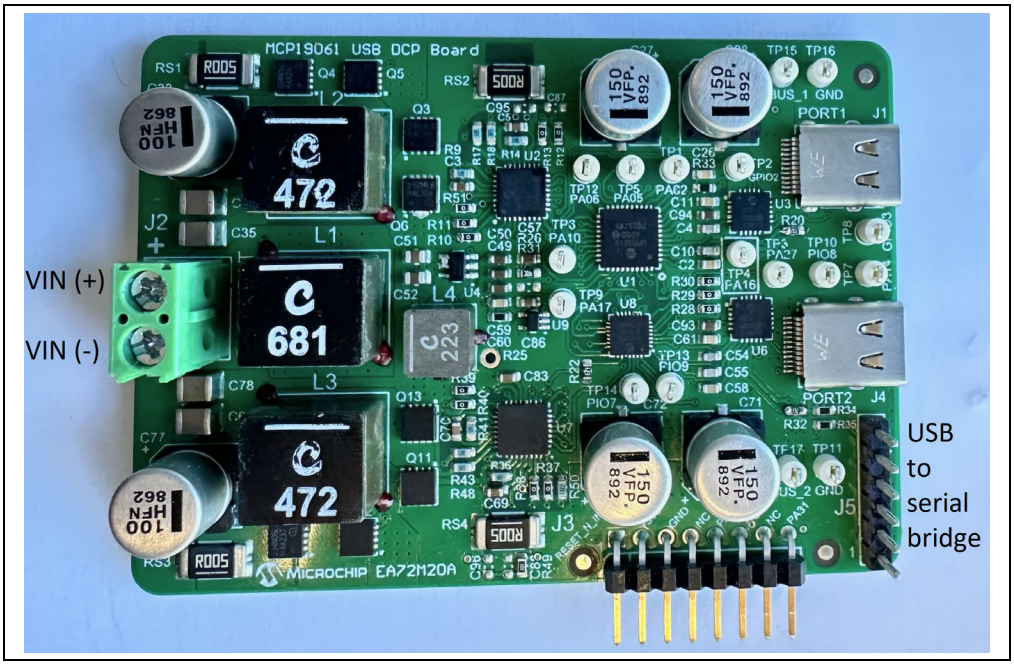

FIGURE 3-1: *Setting Up the Board.*

3.1.2 GUI Status Tab

Once the board is powered and connected to the GUI, the first tab in the GUI will display the System Temperature (Celsius), Total System Power capability (W), the Input Voltage (V) and the Minimum Power guaranteed by USB-PD profile. The GUI status is now Connected and is visible at the bottom of the window.

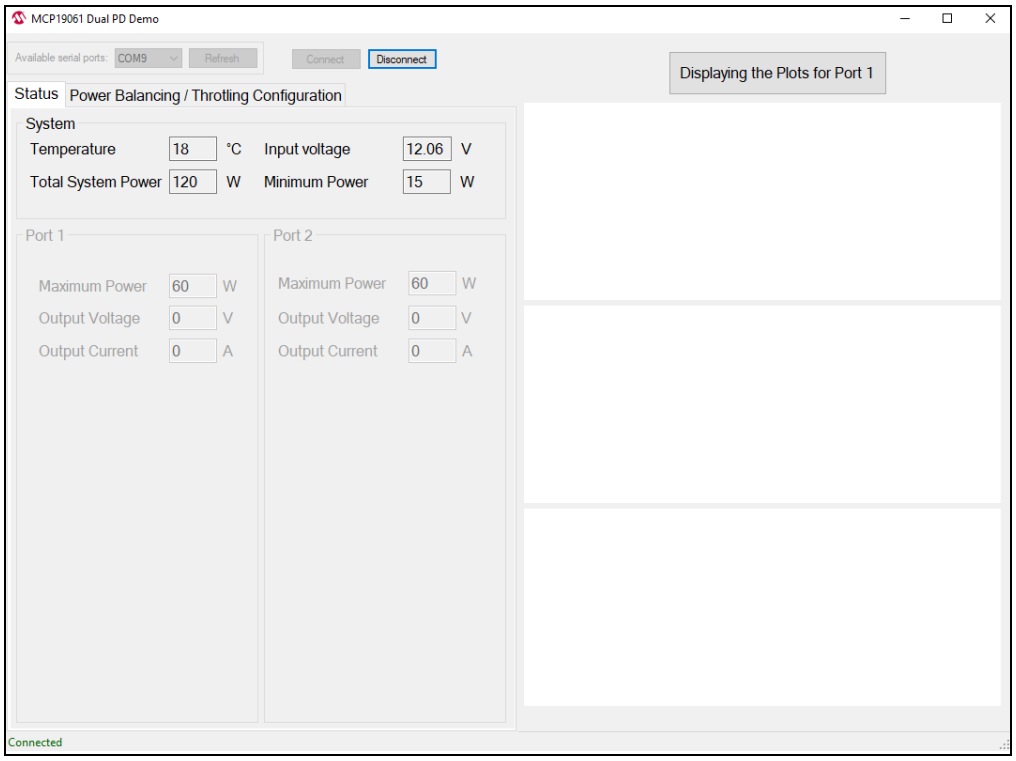

FIGURE 3-2: *GUI Status Tab with No USB Load Connected.*

When a USB-PD compliant load is connected to the USB-C Port 1 (on the PCB right-side, this is the higher one), the USB communication starts and the MCP19061 DCP Board advertises its charging profiles under the Port 1 window.

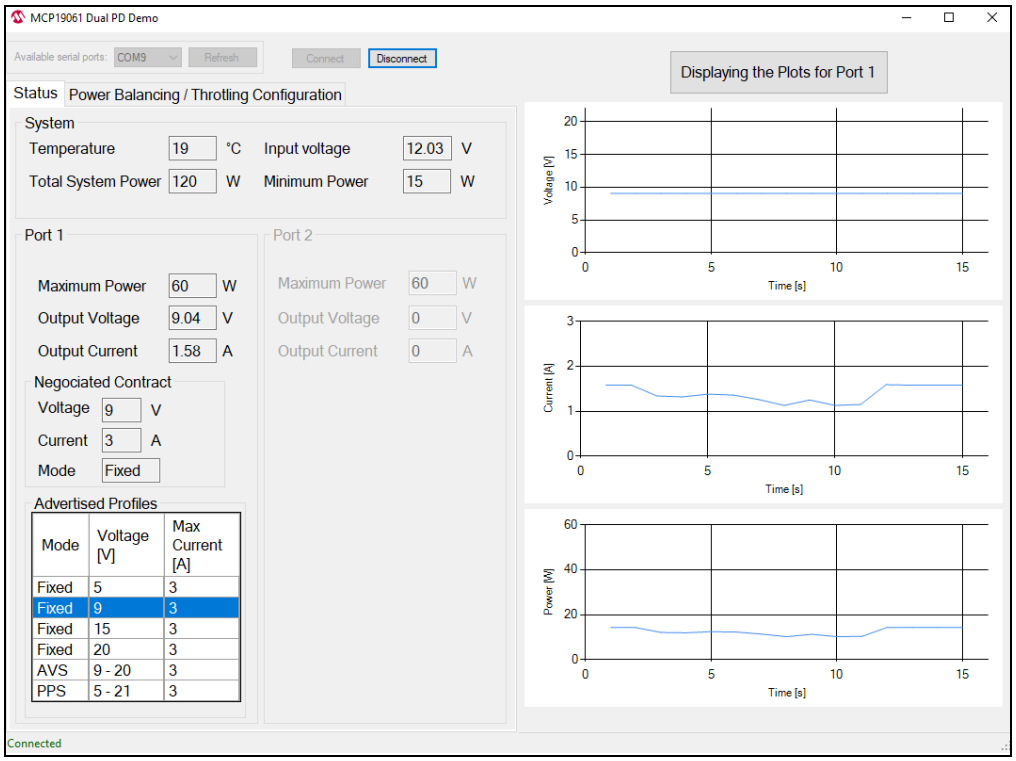

FIGURE 3-3: *USB-PD Load Connected to Port 1.*

If another USB-PD load is connected to the USB-C Port 2, the Port 2 window gets populated the same way.

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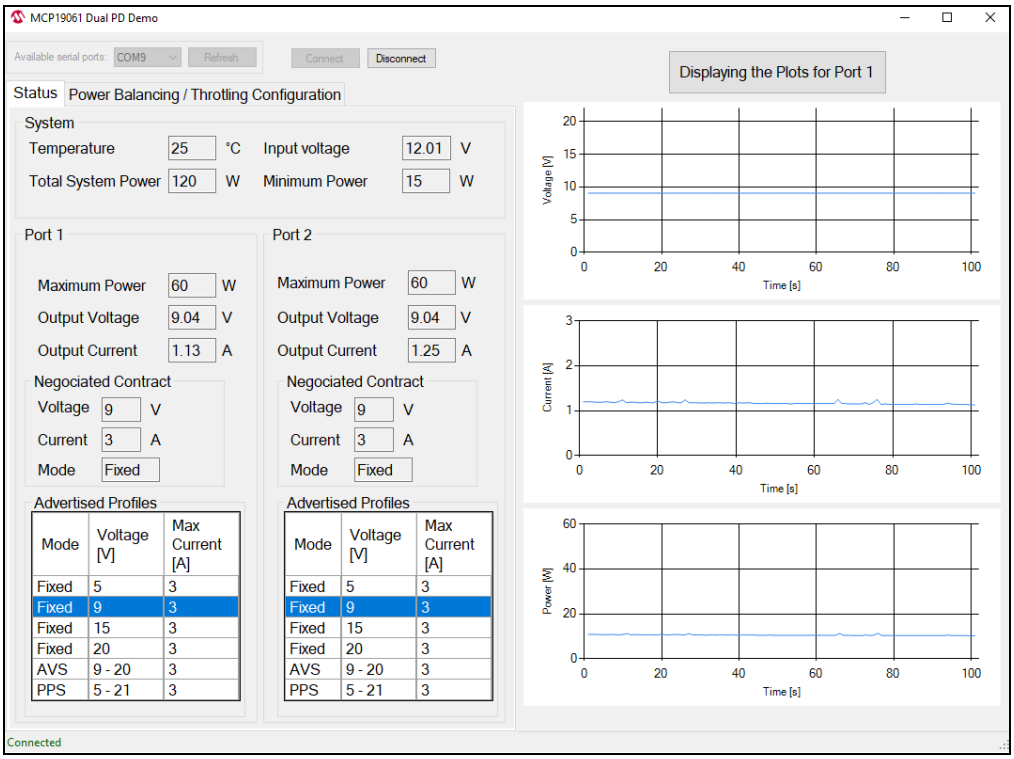

FIGURE 3-4: *USB-PD Load Connected to Both Ports.*

The status window on the right displays the Voltage, Current and Power graphs for Port 1. By clicking the “Displaying the Plots for Port 1” button, the graphs will switch to reflect Port 2. Clicking the button again will revert to Port 1 graphs.

3.1.3 GUI Power Balancing/Throttling Configuration Tab

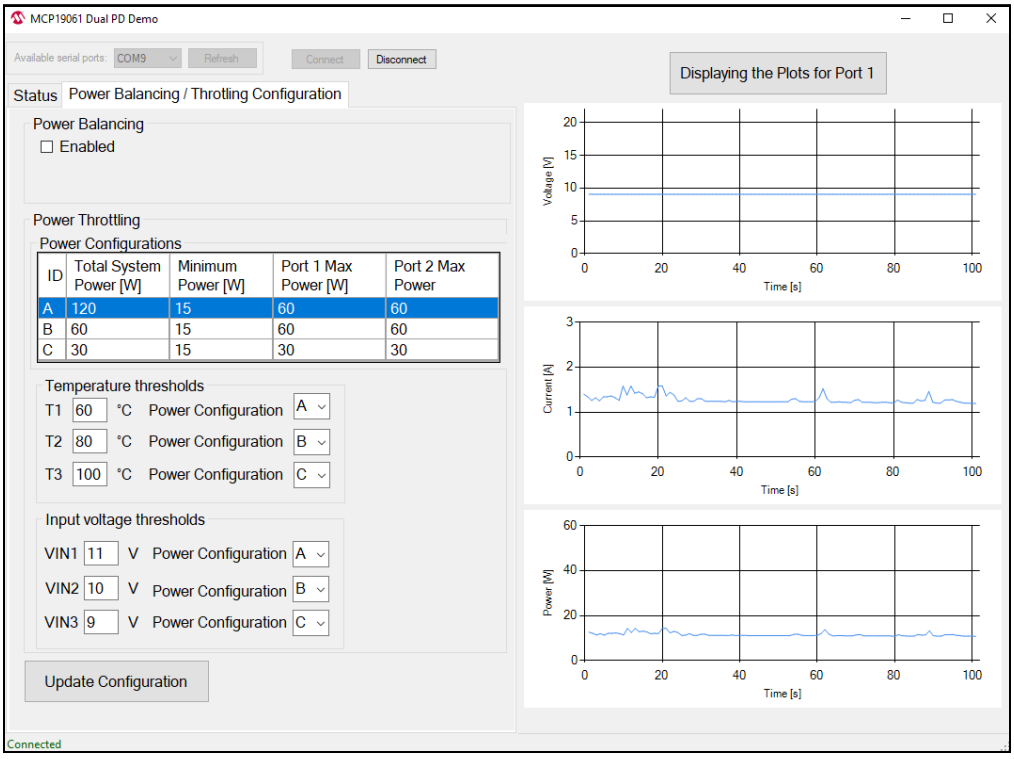

FIGURE 3-5: *GUI Power Balancing/Throttling Configuration Tab.*

3.1.3.1 POWER BALANCING

The Power Balancing option can be activated by ticking the "Enabled" check box from the Power Balancing group box, choosing the Highest Priority option from the drop-down list and pressing the "Update Configuration" button. The selected port will receive prioritized power allocation if the total power available from the board is insufficient for both ports. When Power Balancing is active, the power given to the Sink is adapted to its own capabilities.

Even if the power available at the moment (Port Maximum Power) is greater than the computed power based on Sink capabilities (Sink Maximum Power), the power balancing will allocate only Sink Maximum Power for the given port. The difference between Port Maximum Power and Sink Maximum Power will be held in reserve for the another port.

3.1.3.2 POWER THROTTLING

The Power Configurations table lists the power limits for each individual port as well as the combined total for both ports. The selected Power Configuration row is updated in real-time and it is highlighted in the Power Configurations table. The main triggers for this are excessive heat and insufficient input voltage. The Temperature thresholds, which are user configurable, can be assigned to any of the listed Power Configurations. To prevent PCB overheating, higher temperature thresholds should be assigned to lower power levels.

Also, the Input voltage thresholds are user configurable and can be assigned to any of the Power Configurations available. Lower input voltages for a given output power result in increased input current, leading to higher thermal losses. Then, the maximum power levels should be reduced to avoid thermal shutdown events or input current limits occurring too early.

When the selected options are ready, press Update Configuration to upload the values to the MCP19061 DCP Board.

For more in-depth details about the way these options work together with the USB-PD protocol, refer to the "USB Power Delivery Software Stack (PDS) User Guide", Chapter 7.1 "Power Balancing (PB)" and chapter "7.2 Power Throttling."

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Chapter 4. Firmware Update

4.1 WHERE TO FIND THE FIRMWARE

The firmware for the MCP19061 Dual Charge Port board is available:

- On the board's webpage as a compiled binary hex file
- As part of Microchip Power Delivery Stack (PDS), in the path: "\Demo\dual_port_19061_301_350\firmware", as MPLAB® X project with full source code.

4.2 REQUIRED EQUIPMENT

- 12V, 2A Power Supply
- PICKit™ 4
- Windows® PC

4.3 INSTALL THE SOFTWARE ON THE WINDOWS PC

1. Download the latest version of MPLAB X IDE for Windows® from https://www.microchip.com/en-us/tools-resources/develop/mplab-x-ide.
2. Run the installer. Both MPLAB® X IDE or MPLAB® IPE can be used to program the board. For simplicity, the following information refers exclusively to the MPLAB IPE option with the provided hex file. When asked to select the applications to install, check only "MPLAB® IPE" and "32-bit MCUs" check boxes.

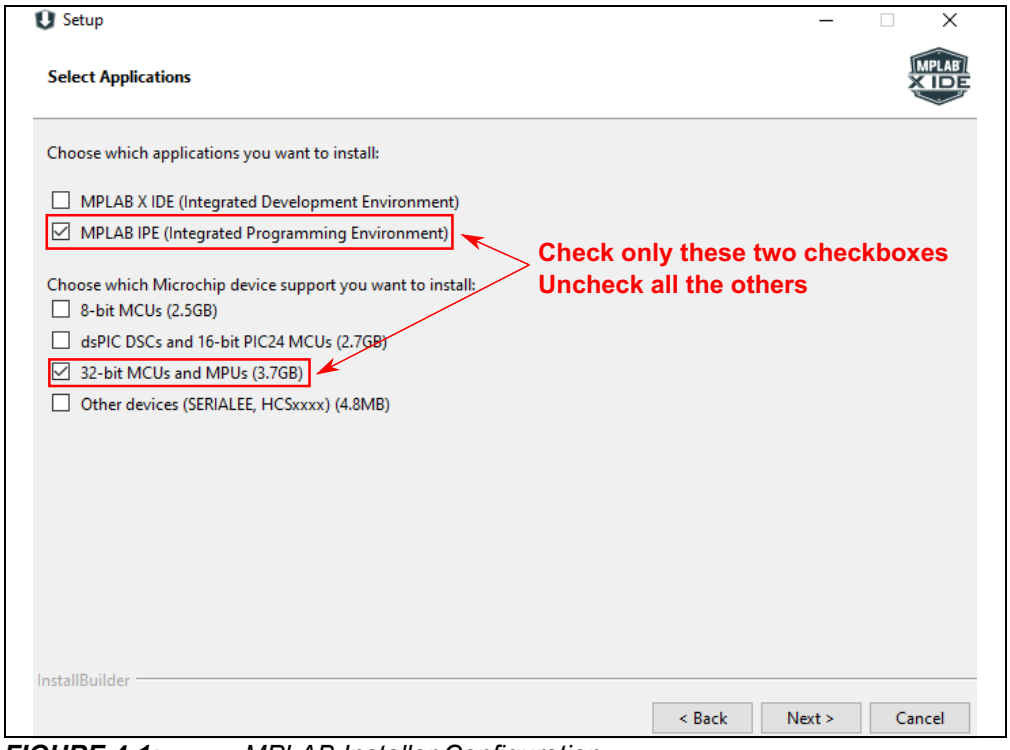

FIGURE 4-1: *MPLAB Installer Configuration.*

4.4 FIRMWARE UPDATE PROCEDURE

> **Note:** These steps must be followed in this specific order to avoid damaging the board.

1. Connect the PICKit 4 to the USB port of the PC.
2. Connect the PICKit 4 to the programming header J3 of the board as in the picture below. The power supply must be turned OFF while doing this.

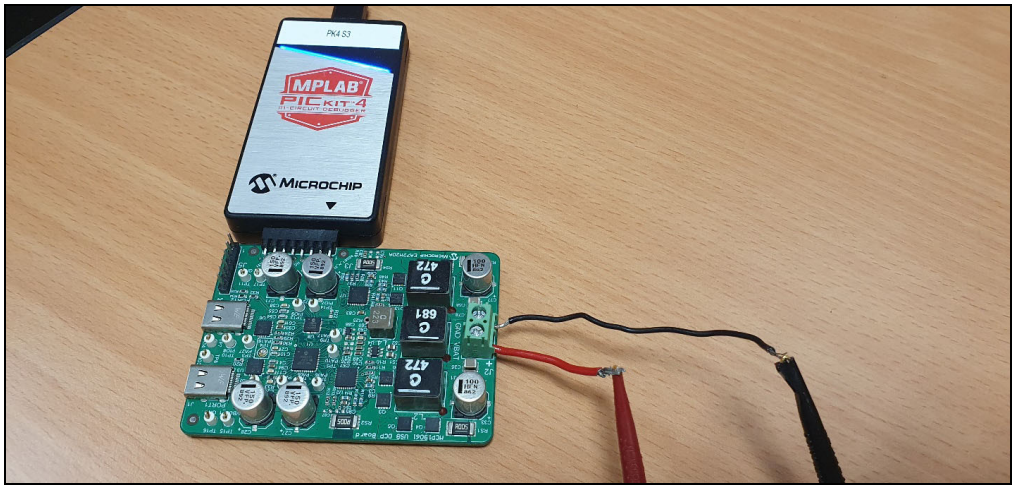

FIGURE 4-2: *DCP Programming Setup.*

3. Connect the 12V power supply to the J2 header, with the polarity indicated on the board.
4. Turn on the 12V supply.
5. Open MPLAB® IPE on the PC.
6. Select Family = "32-bit MCUs (PIC32C/SAM)", Device = "ATSAMD20E16" and then click "Apply".

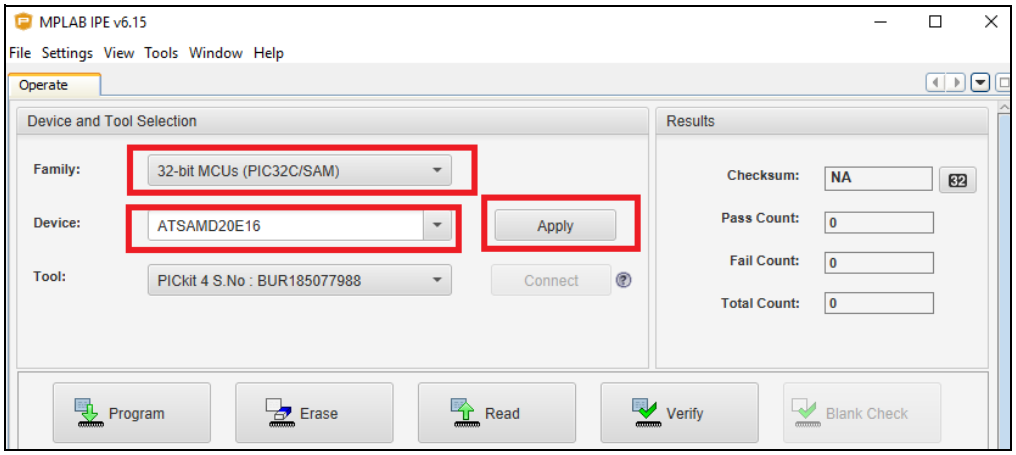

FIGURE 4-3: *MPLAB Device Configuration.*

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7. In the “Hex file” section, click on “Browse” and select the provided hex file to be programmed on this board. Then, click on “Program”. If “Programming complete” appears after that, the programming was successful.

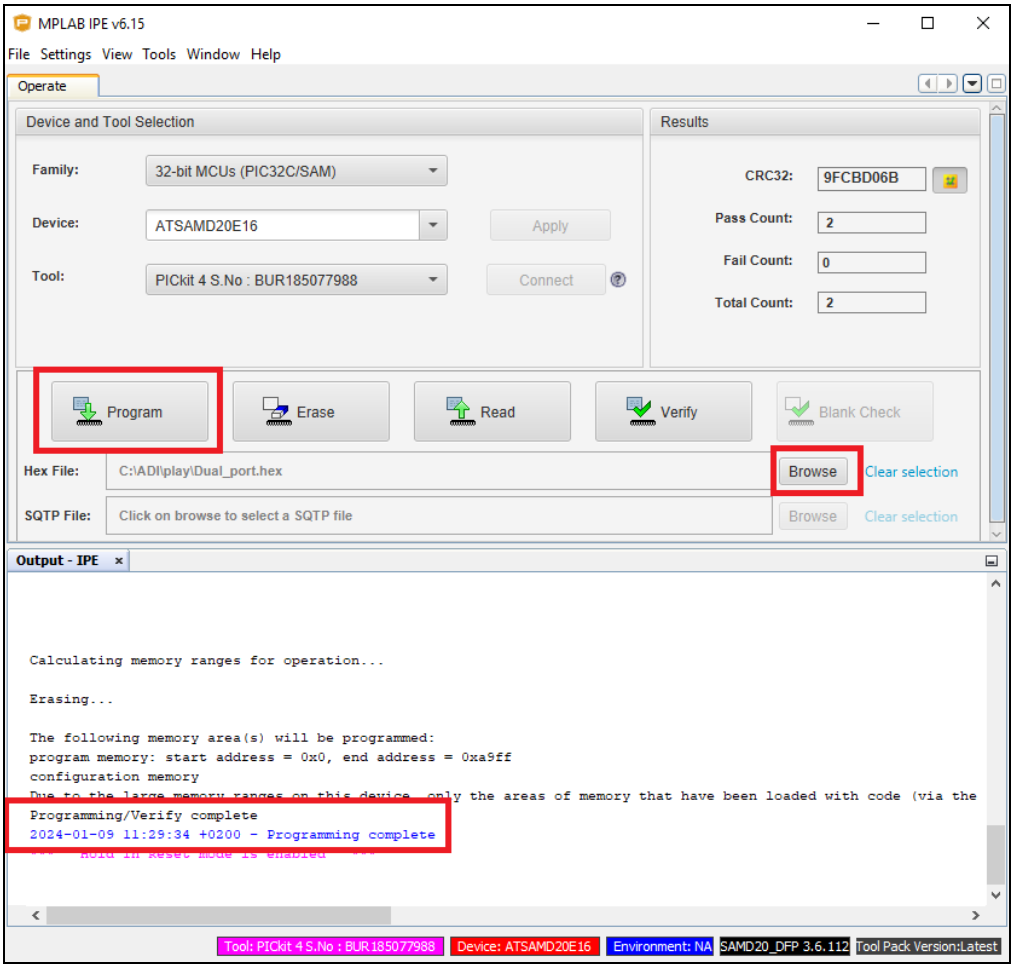

FIGURE 4-4: *MPLAB Running, Programming and Result.*

8. Turn off the 12V supply.
9. Disconnect the PICKit 4 from the programming header J3 of the board.

NOTES:

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Appendix A. Schematic and Layouts

A.1 INTRODUCTION

This appendix contains the following schematic and layouts for the MCP19061 Dual Charge Port Board:

- Board – Block Diagram
- Board – Schematic 1
- Board – Schematic 2
- Board – Top Silk
- Board – Top Copper and Silk
- Board – Top Copper
- Board – Bottom Copper
- Board – Bottom Copper and Silk
- Board – Bottom Silk

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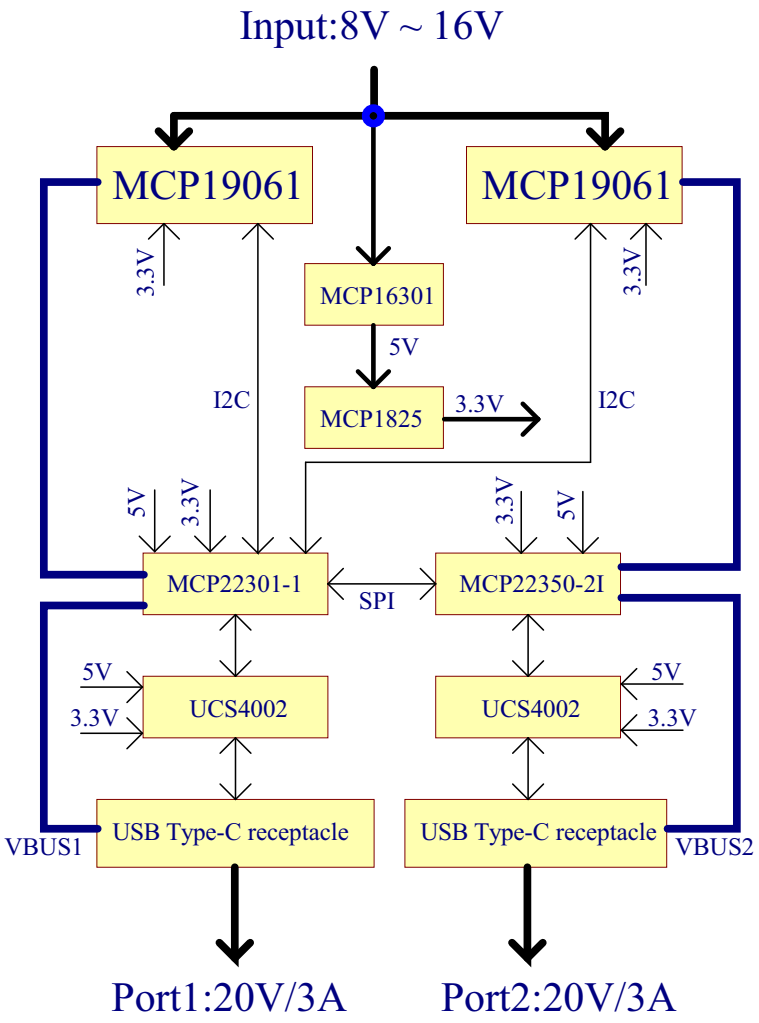
A.2 BOARD – BLOCK DIAGRAM



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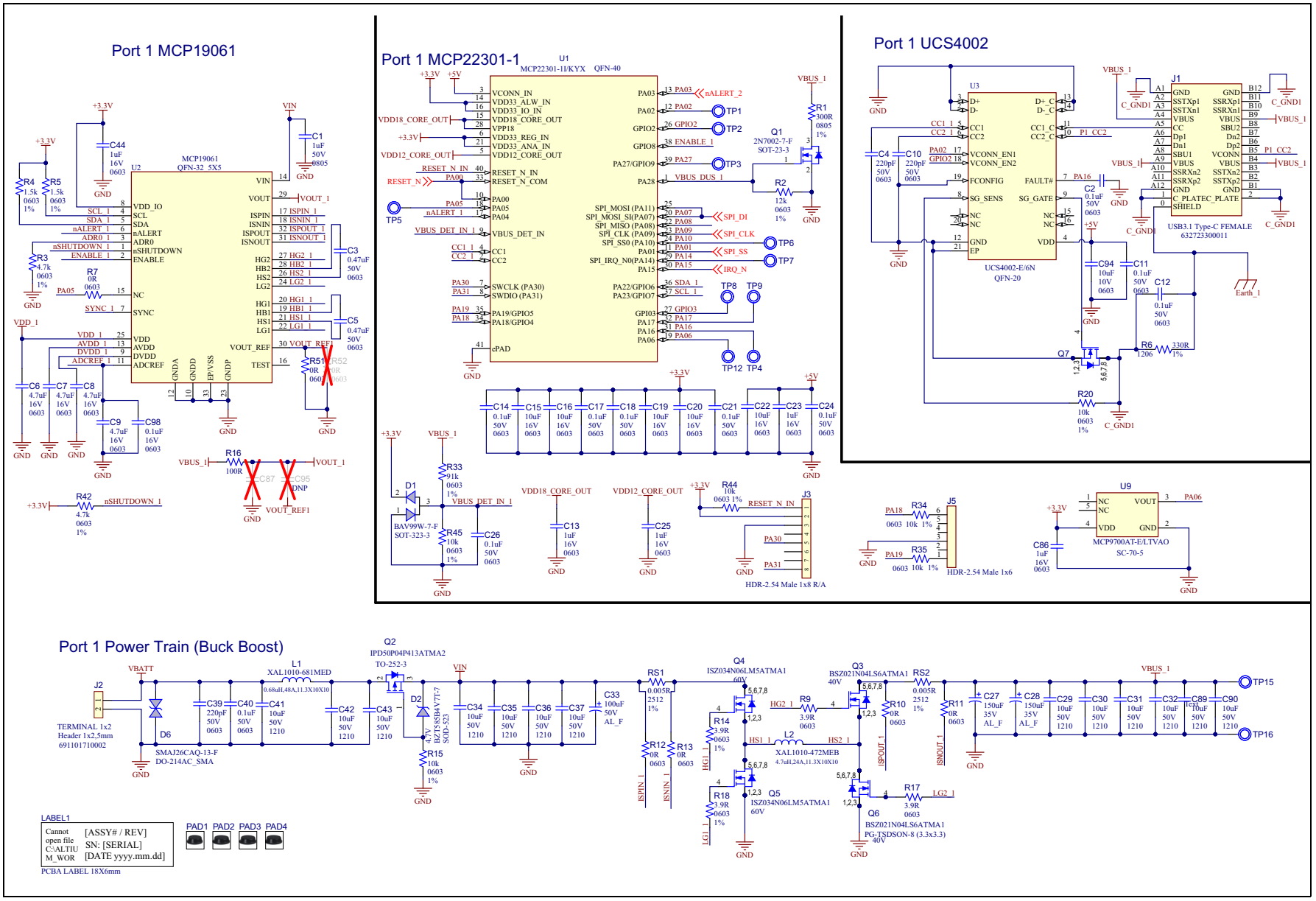
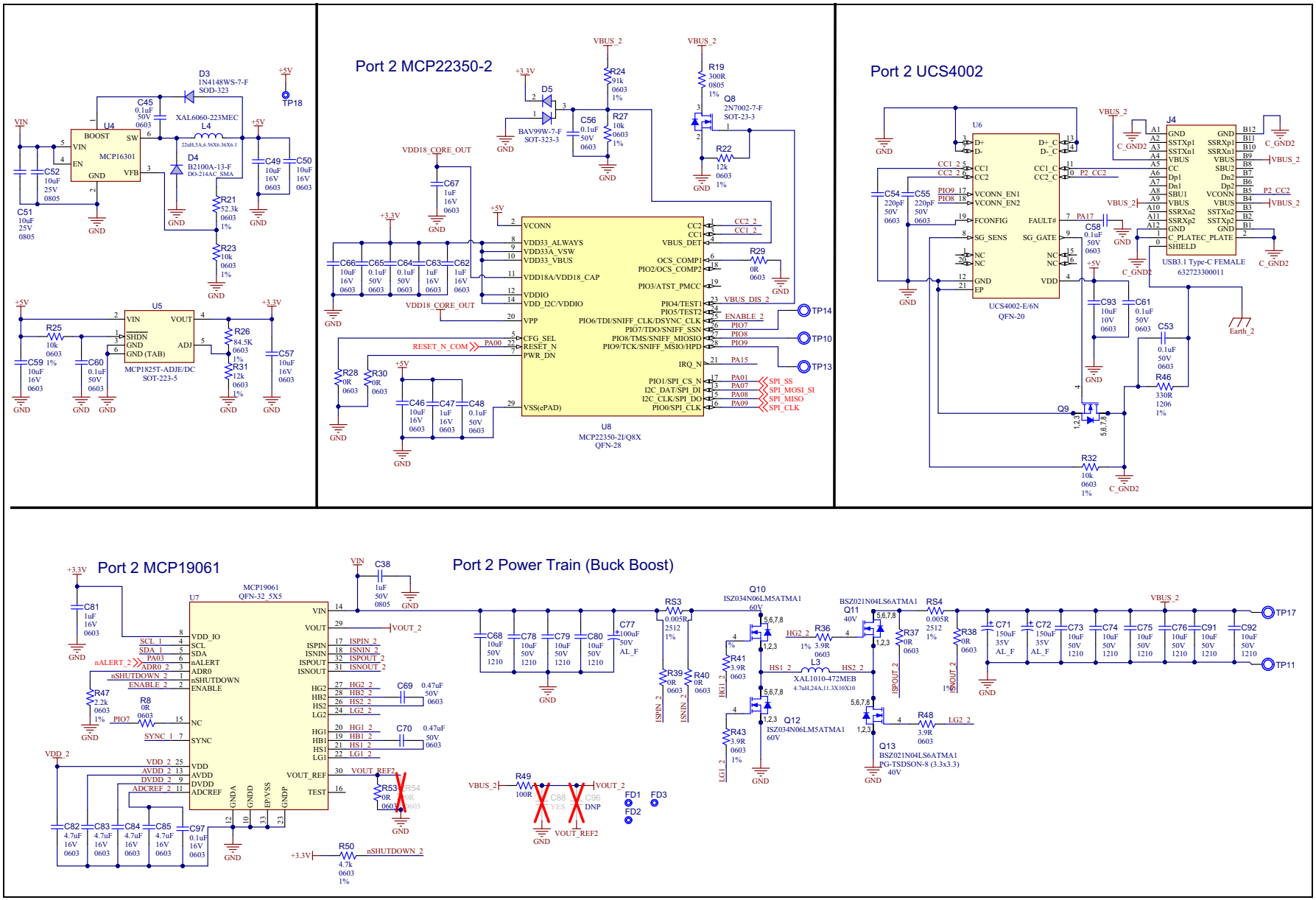
A.3 BOARD – SCHEMATIC 1



A.4 BOARD – SCHEMATIC 2



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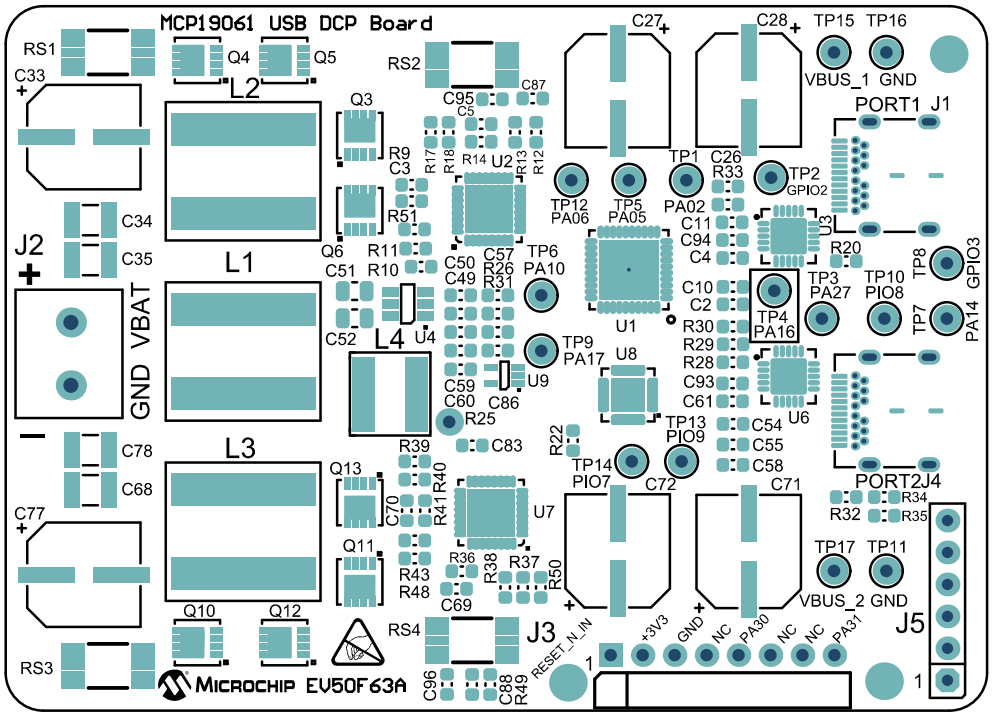
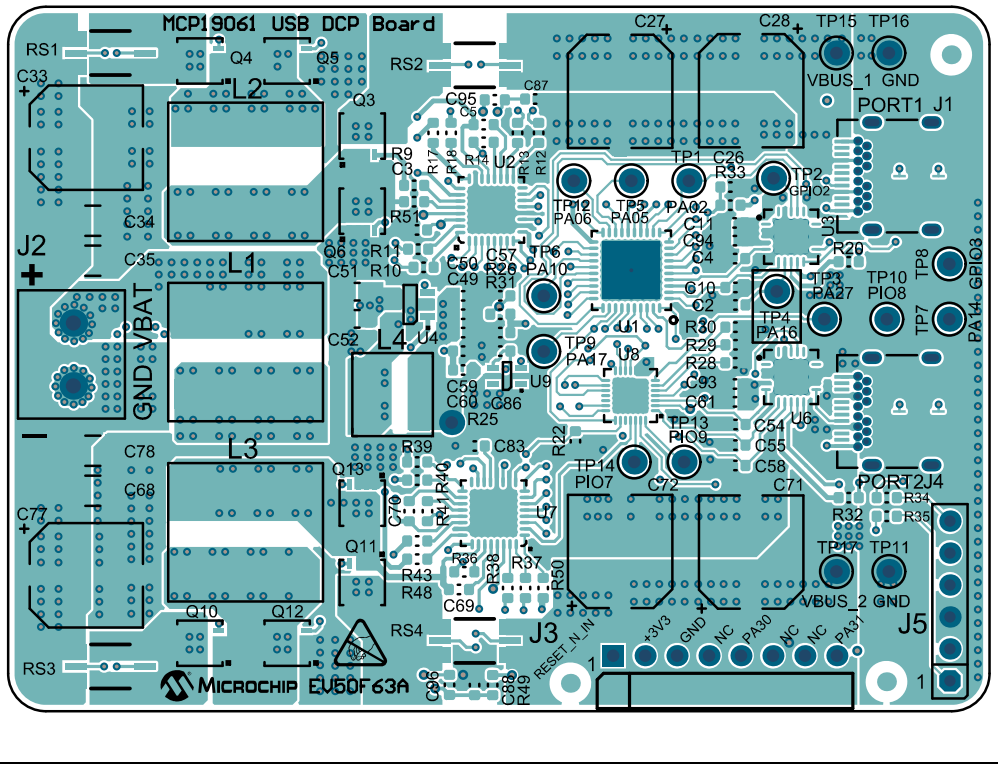
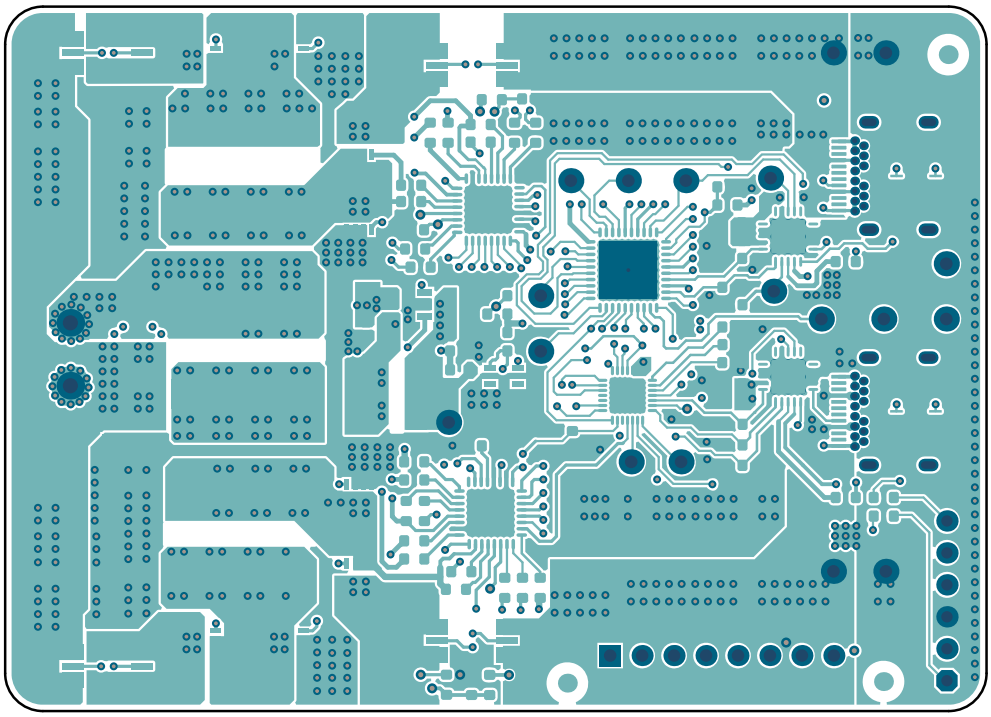
A.5 BOARD – TOP SILK



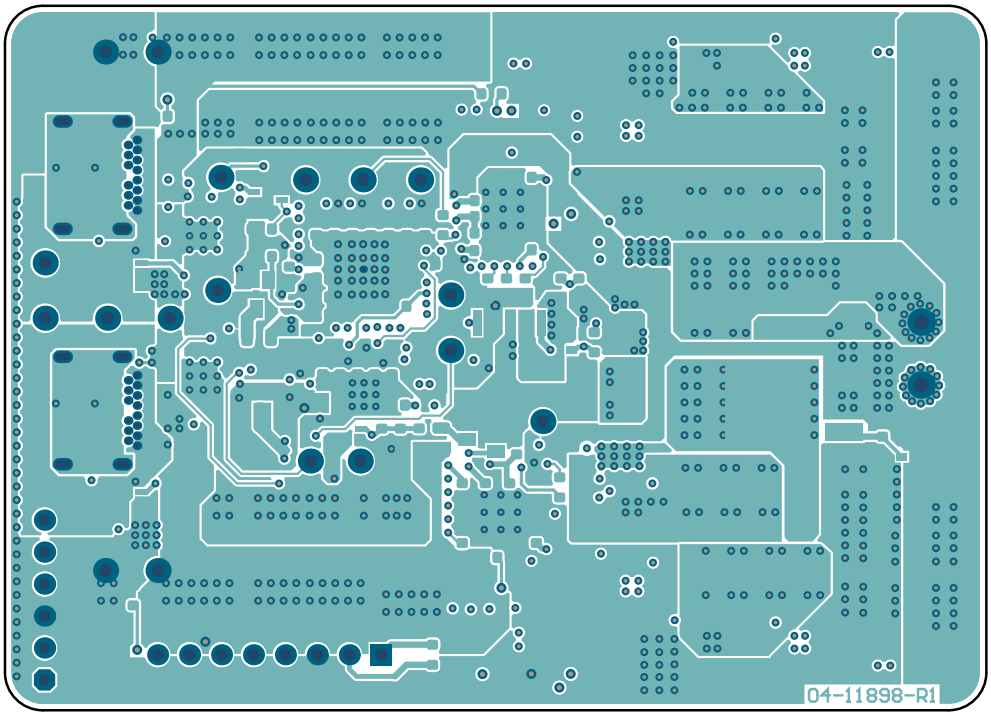
A.6 BOARD – TOP COPPER AND SILK



A.7 BOARD – TOP COPPER



A.8 BOARD – BOTTOM COPPER



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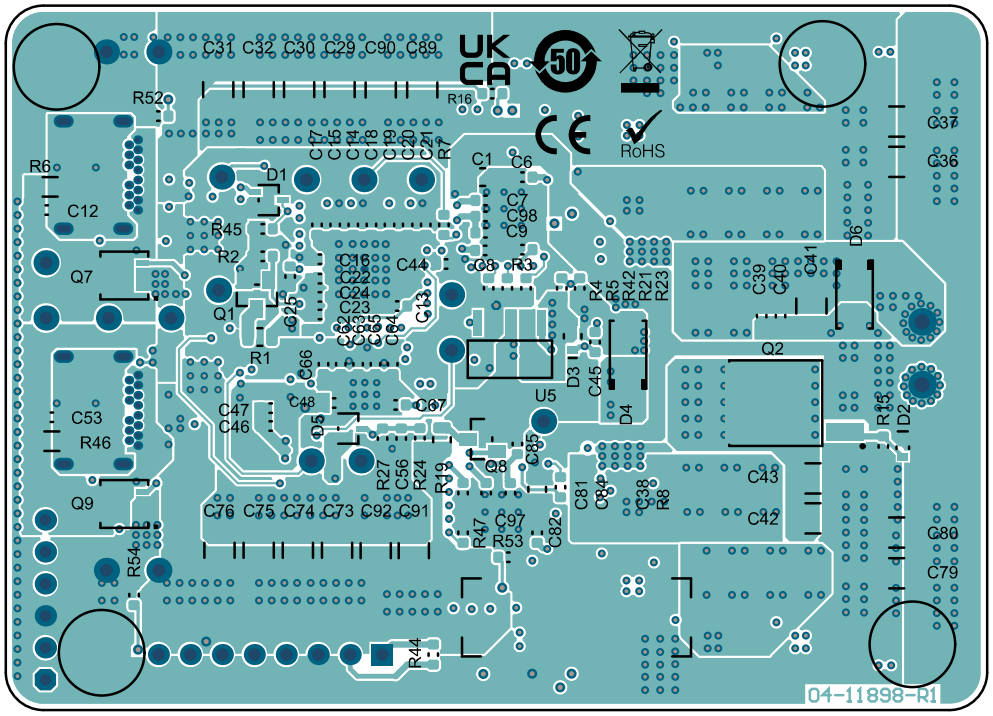
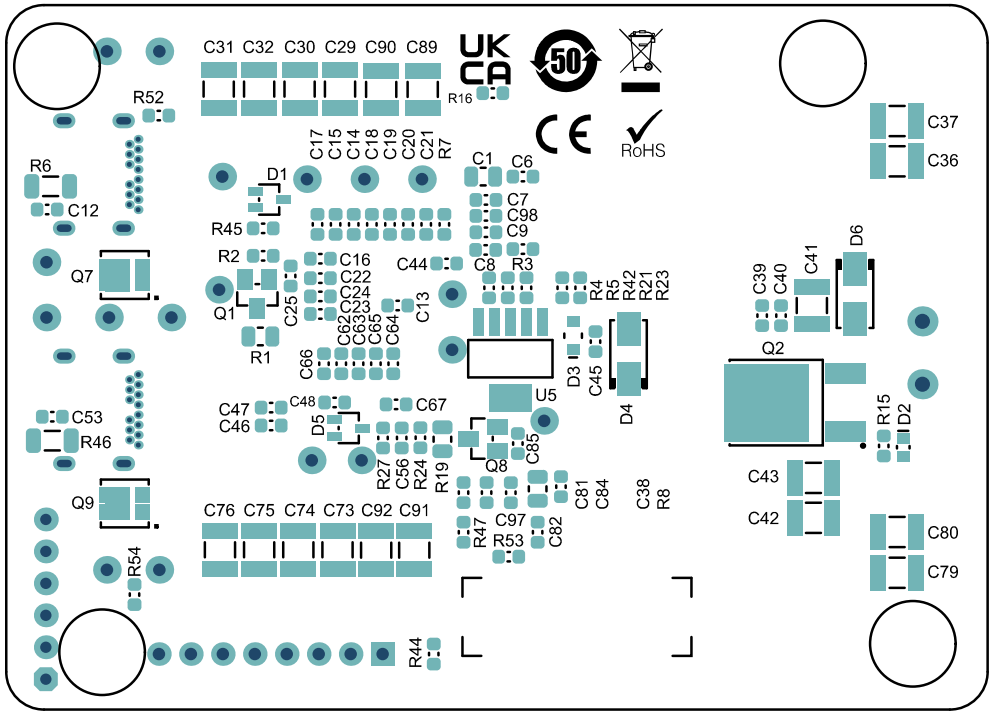
A.9 BOARD – BOTTOM COPPER AND SILK



A.10 BOARD – BOTTOM SILK



NOTES:

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Appendix B. Bill of Materials (BOM)

TABLE B-1: BILL OF MATERIALS (BOM)

Qty.	Reference	Description	Manufacturer	Part Number
2	C1, C38	Capacitor, ceramic, 1 µF, 50V, 10%, X7R, 0805, AEC-Q200	TDK Corporation	CGA4J3X7R1H105K125AB
19	C2, C11, C12, C14, C17, C18, C21, C24, C26, C40, C45, C48, C53, C56, C58, C60, C61, C64, C65	Capacitor, ceramic, 0.1 µF, 50V, 10%, X7R, SMD, 0603, AEC-Q200	Kyocera AVX	06035C104K4Z4A
4	C3, C5, C69, C70	Capacitor, ceramic, 0.47 µF, 50V, 10%, X7R, SMD, 0603	TDK Corporation	C1608X7R1H474K080AC
5	C4, C10, C39, C54, C55	Capacitor, ceramic, 220 pF, 50V, 5%, C0G, SMD, 0603, AEC-Q200	Kyocera AVX	06035A221J4T2A
8	C6, C7, C8, C9, C82, C83, C84, C85	Capacitor, ceramic, 4.7 µF, 16V, 10%, X5R, SMD, 0603	Murata Electronics®	GRM188R61C475KE11D
4	C13, C23, C25, C86	Capacitor, ceramic, 1 µF, 25V, 10%, X7R, SMD, 0603, AEC-Q200	Samsung Eletro-Mechanics America, Inc.	CL10B105KA8VPNC
11	C15, C16, C19, C20, C22, C46, C49, C50, C57, C59, C66	Capacitor, ceramic,10 µF, 16V, 10%, X5R, SMD, 0603, AEC-Q200	Murata Electronics	GRT188R61C106KE13D
4	C27, C28, C71, C72	Capacitor, aluminum, 150 µF, 35V, 20%, 0.08R, SMD F, AEC-Q200	Panasonic® - ECG	EEE-FP1V151AL
23	C29, C30, C31, C32, C34, C35, C36, C37, C41, C42, C43, C68, C73, C74, C75, C76, C78, C79, C80, C89, C90, C91, C92	Capacitor, ceramic, 10 µF, 50V, 10%, X7R, SMD, 1210, AEC-Q200	Kyocera AVX	CM32X7R106K50AT
2	C33, C77	Capacitor, aluminum, 100 µF, 50V, 20%, 0.34R, SMD F, AEC-Q200	Panasonic - ECG	EEE-FN1H101L
6	C44, C47, C62, C63, C67, C81	Capacitor, ceramic, 1 µF, 16V, 10%, X7R, SMD, 0603	Kyocera AVX	0603YC105KAT2A
2	C51, C52	Capacitor, ceramic, 10 µF, 25V, 10%, X5R, SMD, 0805	TDK Corporation	C2012X5R1E106K125AB
2	C93, C94	Capacitor, ceramic, 10 µF, 10V, 20%, X5R, SMD, 0603	Murata Electronics	GRM188R61A106MAALD

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
2	C97, C98	Capacitor, ceramic, 0.1 µF, 16V, 10%, X7R, SMD, 0603, AEC-Q200	Kyocera AVX	0603YC104K4T4A
2	D1, D5	Diode, rectifier, TARR BAV99, 1.25V, 150 mA, 75V, SOT-323	Diodes Incorporated®	BAV99W-7-F
1	D2	Diode, zener, BZT585B4V7T-7, 4.7V, 350 mW, SMD, SOD-523	Diodes Incorporated	BZT585B4V7T-7
1	D3	Diode, rectifier, 1N4148WS, 1.25V, 150 mA, 75V, SOD-323	Diodes Incorporated	1N4148WS-7-F
1	D4	Diode, Schottky, B2100A-13-F 790 mV, 2A, 100V, SMD, DO-214AC_SMA	Diodes Incorporated	B2100A-13-F
1	D6	Diode, TVS, BI-DIR, SMAJ26-CAQ-13-F, 26V, 400W, SMD, DO-214AC_SMA AEC-Q101	Diodes Incorporated	SMAJ26CAQ-13-F
2	J1, J4	Connector, USB3.1, Type-C female, TH, R/A	Wurth Elektronik	632723300011
1	J2	Connector, terminal, 5 mm, 1x2, female, 12-26AWG, 18A, TH, R/A	Phoenix Contact	1935161
1	J3	Connector, HDR-2.54 Male, 1x8, gold, 5.84 MH, TH, R/A	Sullins Connector Solutions	PBC08SBAN
1	J5	Connector, HDR-2.54, male, 1x6, Tin, 5.84 MH, TH, vertical	Sullins Connector Solutions	PEC06SAAN
1	L1	Inductor, 0.68 µH, 48A, 20%, SMD, XAL1010	Coilcraft	XAL1010-681MED
		Inductor, 680 nH, 20A, 20%, SMD, L8.8W8.3H8	Würth Elektronik	744393580068
2	L2, L3	Inductor, 4.7 µH, 24A, 20%, SMD, AEC-Q200, L11.3W10H10	Coilcraft	XAL1010-472MEB
		Inductor, 4.7 µH, 27A, 20%, SMD, L11.6W10.5H8.8	Würth Elektronik	74439369047
1	L4	Inductor, 22 µH, 5.6A, 20%, SMD, 6.56x6.36x6.1	Coilcraft	XAL6060-223MEC
		Inductor, 22 µH, 3.5A, 20%, SMD, AEC-Q200, L5.55W5.35H5.1	Würth Elektronik	744393305220
1	LABEL1	Label, PCBA, 18x6 mm, Datamatrix, Assy# / Rev / Serial / Date	ACT Logimark AS	505462
2	Q1, Q8	Transistor, FET, N-CH, 60V, 170 mA, 370 mW, SOT-23-3	Diodes Incorporated	2N7002-7-F
1	Q2	Transistor, FET, P-CH, -40V, -50A, 0.0126R, 58W, TO-252-3, AEC-Q100	Infineon Technologies AG	IPD50P04P413ATMA2
4	Q3, Q6, Q11, Q13	Transistor, FET, N-CH, 40V, 40A, 0.0024R, 83W, TDSON-8	Infineon Technologies AG	BSZ021N04LS6ATMA1
4	Q4, Q5, Q10, Q12	Transistor, FET, N-CH, 60V, 112A, 0.0034R, 83W, TDSON-8	Infineon Technologies AG	ISZ034N06LM5ATMA1
2	Q7, Q9	Transistor, FET, N-CH, 60V, 18A, 0.028R, 62W TDSON-8, AEC-Q101	Vishay Siliconix	SQ7414CENW-T1_GE3

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
2	R1, R19	Resistor, thick film, 300R, 1%, 1/8W, SMD, 0805	Panasonic - ECG	ERJ-6ENF3000V
3	R2, R22, R31	Resistor, thick film, 12k, 1%, 1/10W, SMD, 0603	Yageo Corporation	RC0603FR-0712KL
3	R3, R42, R50	Resistor, thick film, 4.7k, 1%, 1/10W, SMD, 0603, AEC-Q200	KOA Speer Electronics, Inc.	RK73H1JTTD4701F
2	R4, R5	Resistor, thick film, 1.5k, 1%, 1/8W, SMD, 0603	Stackpole Electronics, Inc.	RNCP0603FTD1K50
2	R6, R46	Resistor, thick film, 330R, 1%, 3/4W, SMD, 1206, AEC-Q200	Vishay/Dale	CRCW1206330RFKEAHP
15	R7, R8, R10, R11, R28, R29, R30, R37, R38, R51, R53	Resistor, thick film, 0R, 1/10W, SMD, 0603, AEC-Q200	Panasonic - ECG	ERJ-3GEY0R00V
8	R9, R14, R17, R18, R36, R41, R43, R48	Resistor, thick film, 3.9R, 1%, 1/3W, SMD, 0603, AEC-Q200	ROHM Semiconductor	SDR03EZPF3R90
4	R12, R13, R39, R40	Resistor, thick film, 10R, 1%, 1/10W, SMD, 0603	Yageo Corporation	RC0603FR-0710RL
10	R15, R20, R23, R25, R27, R32, R34, R35, R44, R45	Resistor, thick film, 10k, 1%, 1/10W, SMD, 0603, AEC-Q200	Panasonic - ECG	ERJ-3EKF1002V
2	R16, R49	Resistor, thick film, 100R, 0.5%, 1/16W, SMD, 0603	Susumu Co., Ltd.	RR0816P-101-D
1	R21	Resistor, thick film, 52.3k, 1%, 1/10W, SMD, 0603	Panasonic - ECG	ERJ-3EKF5232V
2	R24, R33	Resistor, thick film, 91k, 1%, 1/10W, SMD, 0603	Vishay/Dale	CRCW060391K0FKEA
1	R26	Resistor, thick film, 84.5k, 1%, 1/10W, SMD, 0603	Yageo Corporation	RC0603FR-0784K5L
1	R47	Resistor, TF, 2.2k, 1%, 1/8W, SMD, 0603	Vishay Beyschlag	MCT06030C2201FP500
4	RS1, RS2, RS3, RS4	Resistor, MF, 0.005R, 1%, WW, SMD, 2512	Bourns®, Inc.	CRE2512-FZ-R005E-3
17	TP1, TP2, TP3, TP4, TP5, TP6, TP7, TP8, TP9, TP10, TP11, TP12, TP13, TP14, TP15, TP16, TP17	Misc., test point, multi purpose mini, white	Keystone® Electronics Corp.	5002
4	PAD1, PAD2, PAD3, PAD4	Mechanical, header and wire pad, hemisphere, D6.4, H1.9, clear	3M	SJ5382
1	PCB1	Printed Circuit Board	Microchip Technology Inc.	04-11898-R1

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 (BOM) – MICROCHIP PARTS

Qty.	Reference	Description	Manufacturer	Part Number
1	U1	Interface, USB PD controller, VQFN-40	Microchip Technology Inc.	MCP22301-1I/KYX
2	U2	Analog PWM controller, 300-500 kHz, VQFN-32	Microchip Technology Inc.	MCP19061-E/RTB
2	U3, U6	Interface USB Type-C Port Protect, QFN-20, AECQ100	Microchip Technology Inc.	UCS4002-E/6N
1	U4	Analog switcher, Buck 2 to 15V, SOT-23-6	Microchip Technology Inc.	MCP16301T-E/CH
1	U5	Analog LDO, ADJ, SOT-223-5	Microchip Technology Inc.	MCP1825T-ADJE/DC
1	U7	Analog PWM controller, 300 kHz, VQFN-32	Microchip Technology Inc.	MCP19061-E/RTB
1	U8	Interface USB Type C PD Port controller, SPI, DB, QFN-28	Microchip Technology Inc.	MCP22350-2I/Q8X
1	U9	Analog Temperature Sensor, -40C to +150C, SC-70-5	Microchip Technology Inc.	MCP9700AT-E/LT

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-3: BILL OF MATERIALS (BOM) – DO NOT POPULATE PARTS

Qty.	Reference	Description	Manufacturer	Part Number
0	C87, C88, C95, C96	Capacitor, ceramic, 0.1 µF, 16V, 10%, X7R, SMD, 0603	Taiyo Yuden Co., Ltd.	EMK107B7104KA-T
0	R52, R54	Resistor, thick film, 0R, 1/10W, SMD, 0603, AEC-Q200	Panasonic - ECG	ERJ-3GEY0R00V

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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