MCP19061
Four Switch Buck-Boost Evaluation Board User's Guide

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MCP19061 FOUR SWITCH BUCK-BOOST EVALUATION BOARD USER'S GUIDE

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Preface

NOTICE TO CUSTOMERS

All documentation becomes dated, and this manual is no exception. Microchip tools and documentation are constantly evolving to meet customer needs, so some actual dialogs and/or tool descriptions may differ from those in this document. Please refer to our 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 Four Switch Buck-Boost Evaluation Board. Items discussed in this chapter include:

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

DOCUMENT LAYOUT

This chapter describes how to use the MCP19061 Four Switch Buck-Boost Evaluation Board as a development tool to emulate and debug firmware on a target board. The manual layout is as follows:

- **Chapter 1. "Product Overview"** – Includes a short overview of the MCP19061 device, and a general description of the MCP19061 Four Switch Buck-Boost Evaluation Board.
- **Chapter 2. "Installation and Operation"** – Includes instructions on how to get started with the Four Switch Buck-Boost Evaluation Board, a detailed description of the board, and the typical waveforms that are obtained from the board.
- **Appendix A. "Schematics and Layouts"** – Shows the schematic and layout diagrams for the Four Switch Buck-Boost Evaluation Board.
- **Appendix B. "Bill of Materials (BOM)"** – Lists the parts used to build the Four Switch Buck-Boost Evaluation Board.

CONVENTIONS USED IN THIS GUIDE

This manual uses the following documentation conventions:

DOCUMENTATION CONVENTIONS

Description	Represents	Examples
Arial font:		
Italic characters	Referenced books	*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 MCP19061 Four Switch Buck-Boost Evaluation Board. Another useful document is listed below. The following Microchip document is available and recommended as a supplemental reference resource:

- **MCP19061 Data Sheet – *"USB-PD Four Switch Buck-Boost Analog Front End"* (DS20006888) –** This data sheet provides detailed information regarding the MCP19061 devices.

THE MICROCHIP WEBSITE

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

- **Product Support** – Data sheets and errata, application notes and sample programs, design resources, user's guides and hardware support documents, latest software releases and archived software
- **General Technical Support** – Frequently Asked Questions (FAQs), technical support requests, online discussion groups, Microchip consultant program member listing
- **Business of Microchip** – Product selector and ordering guides, latest Microchip press releases, listing of seminars and events, listings of Microchip sales offices, distributors and factory representatives

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The Development Systems product group categories are:

- **Compilers** - The latest information on Microchip C compilers, assemblers, linkers and other language tools. These include all MPLAB C compilers; all MPLAB assemblers (including MPASM assembler); all MPLAB linkers (including MPLINK object linker); and all MPLAB librarians (including MPLIB object librarian).
- **Emulators** - The latest information on Microchip in-circuit emulators.This includes the MPLAB REAL ICE™ and MPLAB ICE 2000 in-circuit emulators.
- **In-Circuit Debuggers** - The latest information on the Microchip in-circuit debuggers. This includes MPLAB ICD 3 in-circuit debuggers and PICkit 3 Debug Express.
- **MPLAB IDE** - The latest information on Microchip MPLAB IDE, the Windows Integrated Development Environment for development systems tools. This list is focused on the MPLAB IDE, MPLAB IDE Project Manager, MPLAB Editor and MPLAB SIM simulator, as well as general editing and debugging features.
- **Programmers** - The latest information on Microchip programmers. These include production programmers such as MPLAB REAL ICE in-circuit emulator, MPLAB ICD 3 in-circuit debugger and MPLAB PM3 device programmers. Also included are nonproduction development programmers such as PICSTART Plus and PICkit 2 and 3 programmers.

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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 website at:
http://www.microchip.com/support.

DOCUMENT REVISION HISTORY

Revision A (March 2024)

- Initial release of this document.

Chapter 1. Product Overview

1.1 INTRODUCTION

This chapter provides an overview of the MCP19061 Four Switch Buck-Boost Evaluation Board and covers the following topics:

- MCP19061 Device – Short Overview
- What is the MCP19061 Four Switch Buck-Boost Evaluation Board?
- What Does the MCP19061 Four Switch Buck-Boost Evaluation Board Kit Include?

1.2 MCP19061 DEVICE – SHORT OVERVIEW

The MCP19061 is a highly-integrated, mixed-signal, four switch buck-boost controller which includes a digital PWM controller with a serial communication bus for external programmability and reporting.The MCP19061 can be used for USB power delivery and can provide USB-PD compatibility with a minimum of external components. It can be used in applications such as USB-PD, four switch buck-boost converter, battery chargers, general purpose constant voltage constant current power supply, and LED driver.

Since the MCP19061 uses digital control circuitry to regulate the output of the DC/DC converter, the integration of a high-speed I^2C serial bus is used for device communications from the MCP19061 to the system controller. These communications can provide a full configurability of an (AFE) controller for device operating parameters such as: output range (constant current operation, constant voltage operation), switching frequency range of 300 kHz to 500 kHz, protections (input and output overcurrent, input over/undervoltage, output over/under voltage, load dump, overtemperature, internal regulator fault, output discharge fail, bootstrap undervoltage detection, vsafe0 detection).

The MCP19061 is designed to efficiently operate from 4.5V to 36V and can stand 42V nonoperating.

The MCP19061 can deliver an adjustable output range of 3V to 36V. It features integrated synchronous 4-switch buck/boost architecture, three internal linear regulator and MOSFET drivers, all in a space-saving 32-pin, 5 x 5 mm, QFN package.

The board can be configured according to the user's application using the MCP2221A USB to I^2C Bridge present on the board. The configuration can be done through the Graphic User Interface (GUI).

The Digital Interface is externally supplied using the VDDIO selection header (J6).

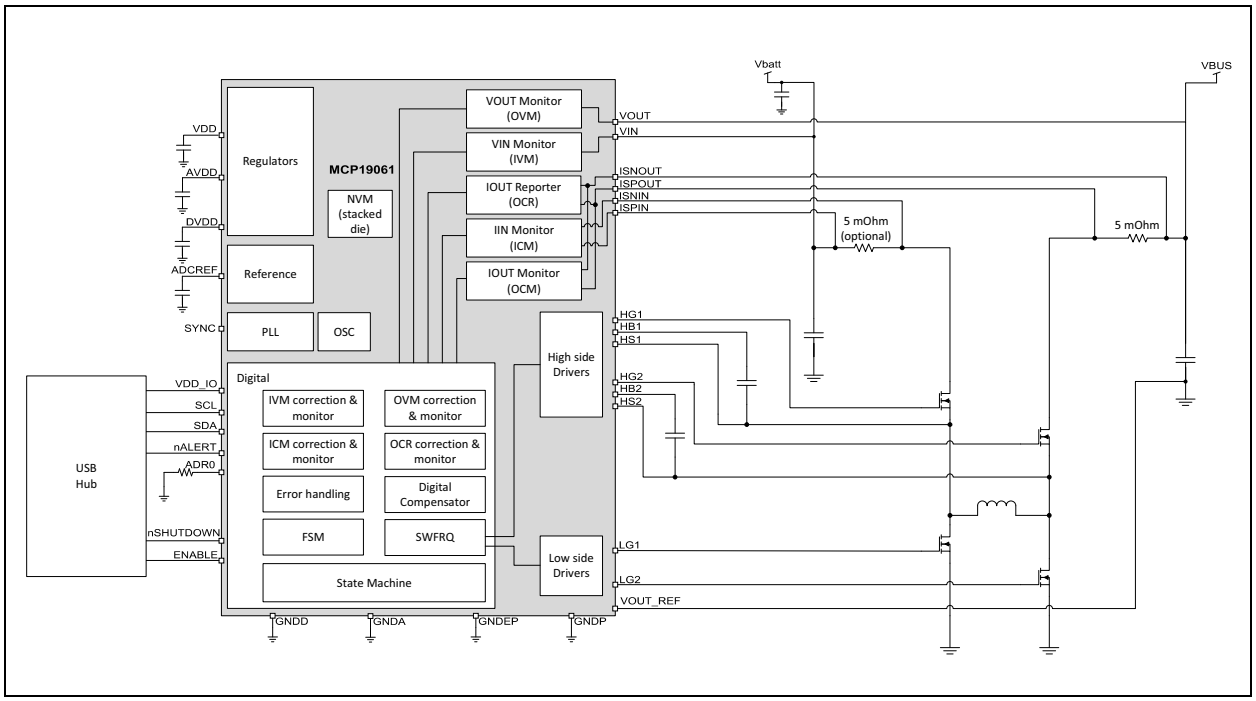


FIGURE 1-1: *MCP19061 Four Switch Buck-Boost Block Diagram.*

1.3 WHAT IS THE MCP19061 FOUR SWITCH BUCK-BOOST EVALUATION BOARD?

The MCP19061 Four Switch Buck-Boost Evaluation Board demonstrates how the MCP19061 device operates in Buck, Boost and Buck-Boost topologies over a wide input voltage and load range. Nearly all operational and control system parameters are programmable by utilizing the I^2C MCP2221 module.

For precise measurements of output current, a 5 mΩ shunt is used.

The Graphical User Interface (GUI) can be used to modify the functioning parameters, and check operational status. To simplify the connection, a USB-to-I^2C communication bridge is implemented on board, using the MCP2221-I/ML, 16-Lead, 4x4 QFN, allowing standard interface to any Microsoft® Windows® computer.

The MCP19061 Four Switch Buck-Boost Evaluation Board is also intended to demonstrate an optimized Printed Circuit Board (PCB) layout that minimizes parasitic noise while increasing efficiency and power density. Proper PCB layout is critical to achieve optimum MCP19061 operation, as well as power train efficiency and noise minimization.

1.4 WHAT DOES THE MCP19061 FOUR SWITCH BUCK-BOOST EVALUATION BOARD KIT INCLUDE?

This MCP19061 Four Switch Buck-Boost Evaluation Board kit includes:

- The MCP19061 Four Switch Buck-Boost Evaluation Board (EV82S16A)
- USB-A to USB-C Cable
- Important Information Sheet

Chapter 2. Installation and Operation

2.1 INTRODUCTION

This chapter provides a detailed description of the MCP19061 Four Switch Buck-Boost Evaluation Board, instructions on how to use the board, and lists the typical waveforms obtained from it.

The chapter is laid out as follows:

- MCP19061 Four Switch Buck-Boost Evaluation Board Features
- Getting Started
- Setup Procedure
- Operating the MCP19061 Four Switch Buck-Boost Evaluation Board
- Typical Performance Data and Waveforms

2.2 MCP19061 FOUR SWITCH BUCK-BOOST EVALUATION BOARD FEATURES

The MCP19061 Four Switch Buck-Boost Evaluation Board was developed to provide a compact, low-cost and highly-efficient DC/DC conversion for medium-to-high output currents.

The key features of the MCP19061 Four Switch Buck-Boost Evaluation Board include:

- Input Voltage Range: 4.5V to 36V
- Adjustable Output Voltage Range: 3V to 36V
- Maximum Output Current: 10A (can be adjusted from 0A to 10A)
- Maximum Power: 100W
- Switching Frequency Range: 300 kHz to 500 kHz (can be adjusted)
- On-Board High Performance Power MOSFET Transistors
- Input and Output Overcurrent Protections
- Input and Output Undervoltage and Overvoltage Protections
- Load dump, Overtemperature and Internal Regulator Fault Protections
- Status Report (including errors, input voltage, output voltage and current) via I^2C Communication
- Internal Events Detection Pin (nALERT)
- Input Undervoltage (IVMUVF) and Overvoltage (IVMOVR) Lockout with Programmable Thresholds (via the GUI)
- Output Undervoltage (OVMUVF) andOvervoltage (OVMOVR) with Programmable Thresholds (via the GUI)
- Output Overcurrent (OCROCR) with Programmable Rising Threshold (via the GUI).

2.3 GETTING STARTED

The MCP19061 Four Switch Buck-Boost Evaluation Board is fully assembled and tested to evaluate and demonstrate the MCP19061 device capabilities.

2.3.1 Necessary Instruments and Tools Required for Operation

- Adjustable DC power supply with 0V–36V/15 ADC range output capability
- Electronic load with at least 5A current capability and load stepping capability
- Digital oscilloscope with a minimum bandwidth of 50 MHz
- Digital voltmeter/ammeter
- Wires for connections; these wires must sustain high currents:
  - 15A for the connection between the adjustable DC power supply and board
  - 10A for the connection between the board and the electronic load

2.4 SETUP PROCEDURE

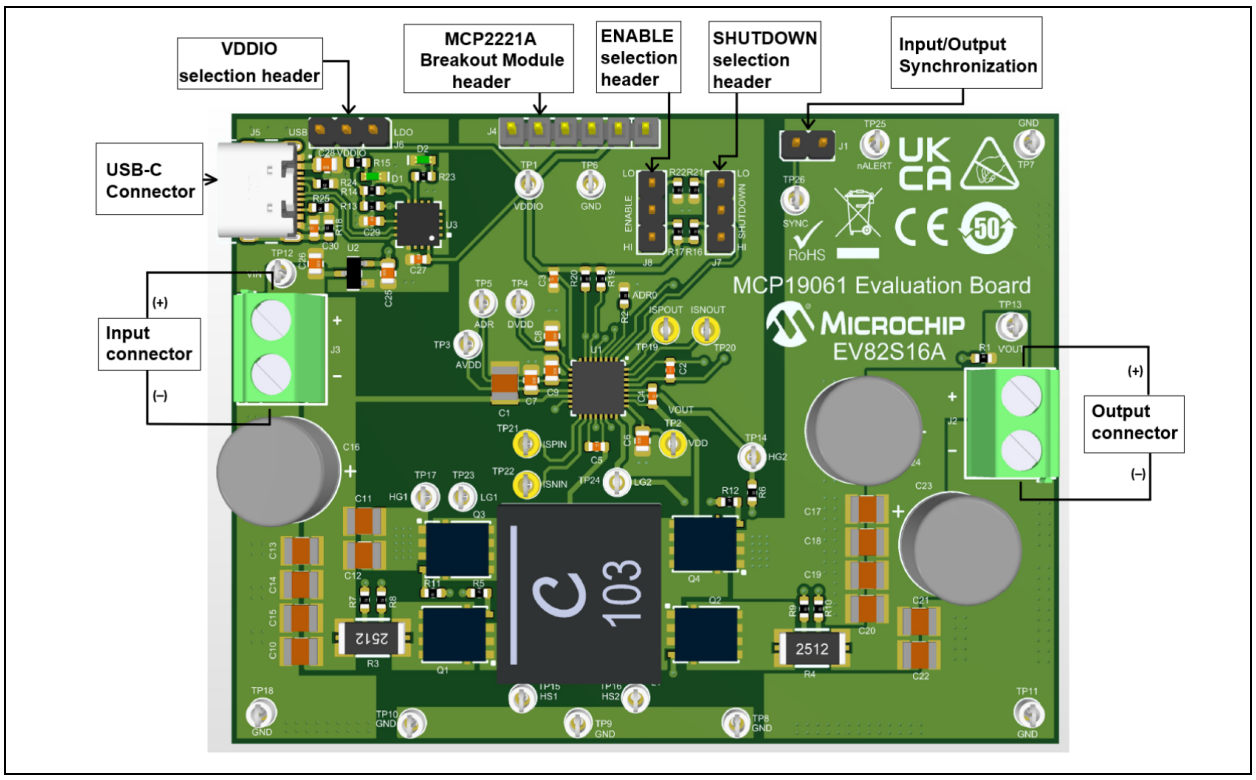


FIGURE 2-1: *MCP19061 Four Switch Buck-Boost Evaluation Board – Top View.*

To set up the MCP19061 Four Switch Buck-Boost Evaluation Board, complete the following steps:

1. Connect the electronic load to J2 with the correct polarity (positive side (+) and negative side (-) as shown in Figure 2-1).
2. Connect the adjustable DC power supply to J3 with the correct polarity (positive side (+) and negative side (-) as shown in Figure 2-1).
3. Set the DC voltage supplied by the adjustable DC power supply to 12V and turn it on.
4. Place the VDDIO selection header jumper in the LDO position and the shutdown selection header jumper in the HI position.
5. The board is preconfigured to supply 5V on the Output, with the current set to its

maximum value, when the enable selection header jumper is placed in the HI position (power train Enable).

6. For additional control, connect the MCP19061 Evaluation Board to the computer (on which the MCP19061 Monitoring GUI is installed) via the USB-A to USB type C cable supplied, by using the J5 connector on the board. When using the GUI, the enable selection header jumper should be placed in the LO position (I^2C Control).
7. Open the MCP19061 Dev Board GUI and the board should be automatically recognized by the GUI and the Basic PSU tab becomes active. If the board is not recognized press the "**Scan**" button, select Address 0x51 and click "**Connect**".
8. To enable the output, set a voltage value in the "Vout [V] WRITE" box, and press the "**OUTPUT ON/OFF**" button. The button will turn green and the output should rise to the programmed voltage.

2.4.1 Graphic User Interface (GUI)

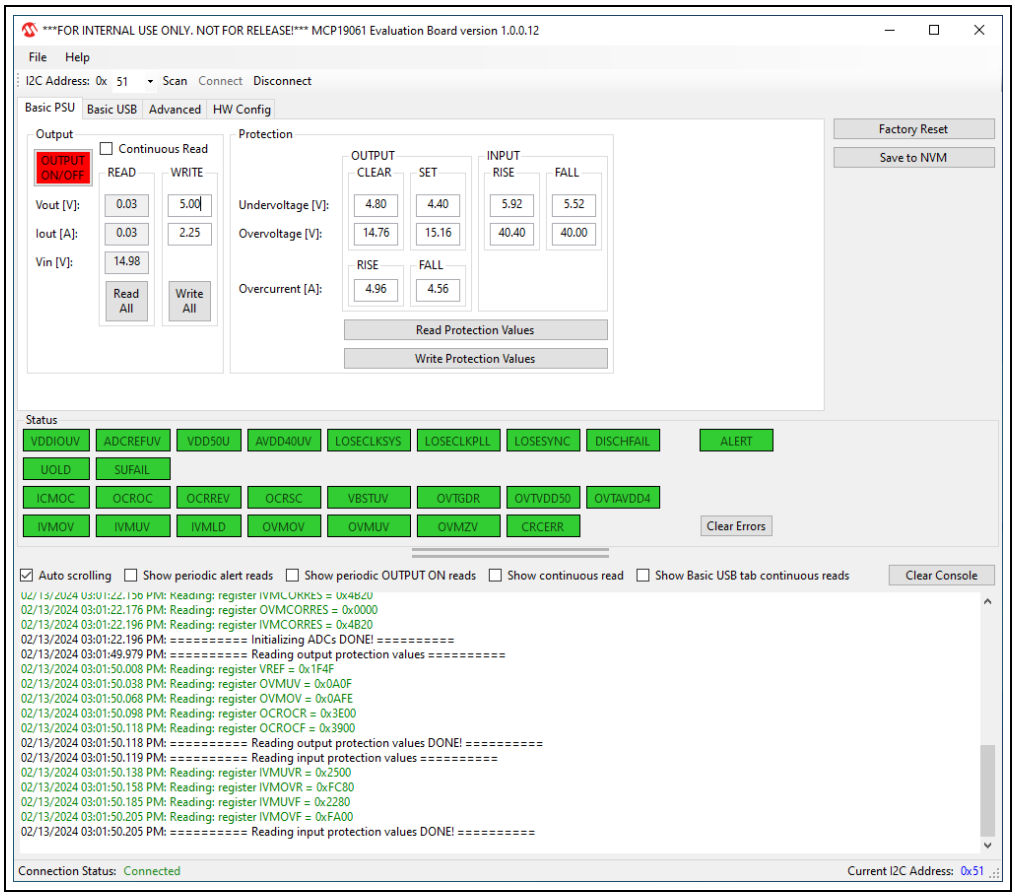


FIGURE 2-2: *MCP19061 GUI.*

The GUI provides the necessary parameter settings and allows the user to save the configuration for the selected operation mode.

The GUI is organized in the following tabs:

- **Basic PSU** - Operates as a simple power supply controller and offers the user the option to set the output voltage, output current (for constant current operation), output and input voltage protection levels, output current protections and can signal alerts for overvoltage, overcurrent, overtemperature etc., by reading the Error Flags.
- **Basic USB** - Operates as a USB power supply where the user can select USB

power profiles. The protection levels are automatically updated with respect to the selected USB power profile.

- **Advanced** - Operates as a power supply as described in Basic PSU, but with access to more advanced features such as setting control loop parameters ramp, gain, switching frequency, etc., by directly accessing the memory.
- **Hardware Configuration (HW Config)** - Sets the system parameters with respect to the system hardware configuration. The options are: output capacitor and inductor values, shunt resistor values, switching frequency, dead time, dithering.

TABLE 2-1: MCP19061 FOUR SWITCH BUCK-BOOST EVALUATION BOARD GUI DESCRIPTION

Item	Description
OUTPUT ON	When pressed, enables/disables the power train. The button turns RED when the power train is OFF and GREEN when power train is ON. (Note 1)
Read All	Retrieves the values read by the ADC for the input voltage, output voltage, input current.
Continuous Read	When checked, enables ADC continuous readings for: input voltage, output voltage, output current.
Write All	When pressed, writes the setpoints for the output voltage and output current.
Read Protection Values	When pressed, reads the current values for the input/output undervoltage, overvoltage, and output overcurrent protections.
Write Protection Values	When pressed, writes to the NVM the current values for the input/output undervoltage, overvoltage, and output overcurrent protections.
Factory Reset	When pressed, restores the initial default factory values for all the parameters shown in the current window.
Load From NVM	When pressed, all the parameters in the present window are loaded from the nonvolatile memory (NVM).
Save To NVM	When pressed, all the parameters in the present window are saved to the nonvolatile memory and will be automatically loaded to registers on the next power cycle.
Clear Errors	When pressed, clears all error flags. If an error is still present, the "ALERT" indicator will turn red.

Note 1: The OUTPUT ON button is available only when jumper J8 placed in the LO (I^2C Control) positon.

2.4.1.1 ERROR FLAGS

- **VDDIOUV** - VDD_IO undervoltage was detected
- **ADCREFUV** - ADC reference undervoltage was detected
- **VDD50UV** - VDD, 5V rail undervoltage was detected
- **AVDD40UV** - Analog 4V supply undervoltage was detected
- **LOSECLKSYS** - System clock loss was detected
- **LOSECLKPLL** - PLL clock loss was detected
- **LOSESYNC** - Synchronization loss was detected
- **DISCHFAIL** - Output discharge fail was detected
- **UOLD** - USB overload was detected
- **SUFAIL** - Startup failure was detected
- **ICMOC** - Input overcurrent was detected
- **OCROC** - Output overcurrent was detected
- **OCRREVC** - Output reverse current was detected
- **OCRSC** - Output short circuit was detected
- **VBSTUV** - Bootstrap supply undervoltage was detected
- **OVTGDR** - Gate drivers overtemperature was detected

- **OVTVDD50** - 5V VDD regulator overtemperature was detected
- **OVTAVDD40** - 4V Analog VDD regulator overtemperature was detected
- **IVMOV** - Input overvoltage was detected
- **IVMUV** - Input undervoltage was detected
- **IVMLD** - Input load dump was detected
- **OVMOV** - Output overvoltage was detected
- **OVMZV** - Output vsafe0 was detected
- **CRCERR** - NVM CRC error was detected

2.4.1.2 SAVING THE CONFIGURATION

The GUI offers the possibility to download the current register configuration to .csv file by selecting the “File” menu and “Save registers to file”.

To load a saved register configuration, select “Load registers from file” in the “File” menu.

To generate a C header file with the current register configuration, select “Export register map to C file” from the “File” menu, or you can use the “**Export register map to C file**” button in the “**Advanced**” tab.

2.4.1.3 BASIC USB

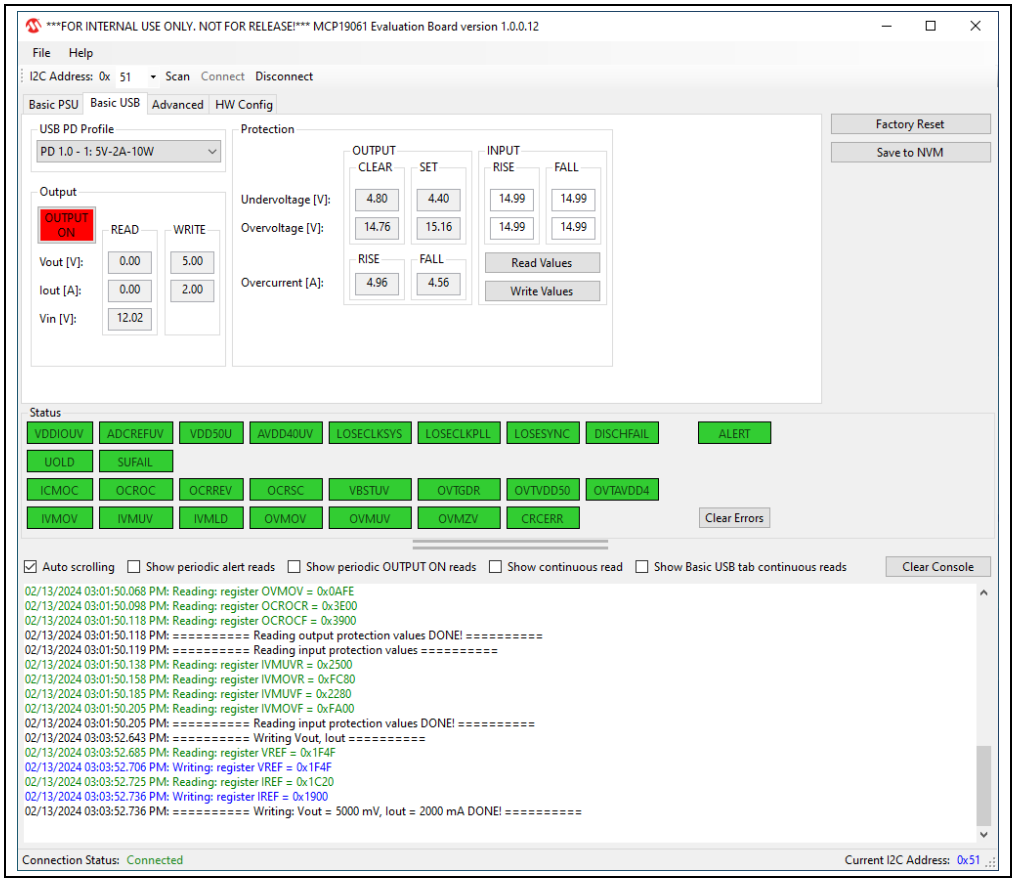


FIGURE 2-3: *Basic USB Tab.*

The **Basic USB** tab is used as a shortcut to set the output voltage, current and protection values for the following predefined USB profiles:

TABLE 2-2: PREDEFINED USB PROFILES

Protocol	Profiles	Output Voltage	Current	Protection Values
PD 1.0	1	5V	2A	10W
PD 1.0	2	12V	1.5A	18W
PD 1.0	3	12V	3A	36W
PD 1.0	4	20V	3A	60W
PD 1.0	5	20V	5A	100W
PD 2.0/3.0	1	5V	3A	15W
PD 2.0/3.0	2	9V	3A	27W
PD 2.0/3.0	3	15V	3A	45W
PD 2.0/3.0	4	20V	5A	100W

Output ON/OFF, Read Values, Write Values, Factory Reset, perform the exact functions as described in the Basic PSU tab.

When a USB power profile is selected, the recommended values for the output protection will be loaded automatically in the current window but will not be written in the registers until "**Write Protection Values**" button is pressed.

2.4.1.4 ADVANCED

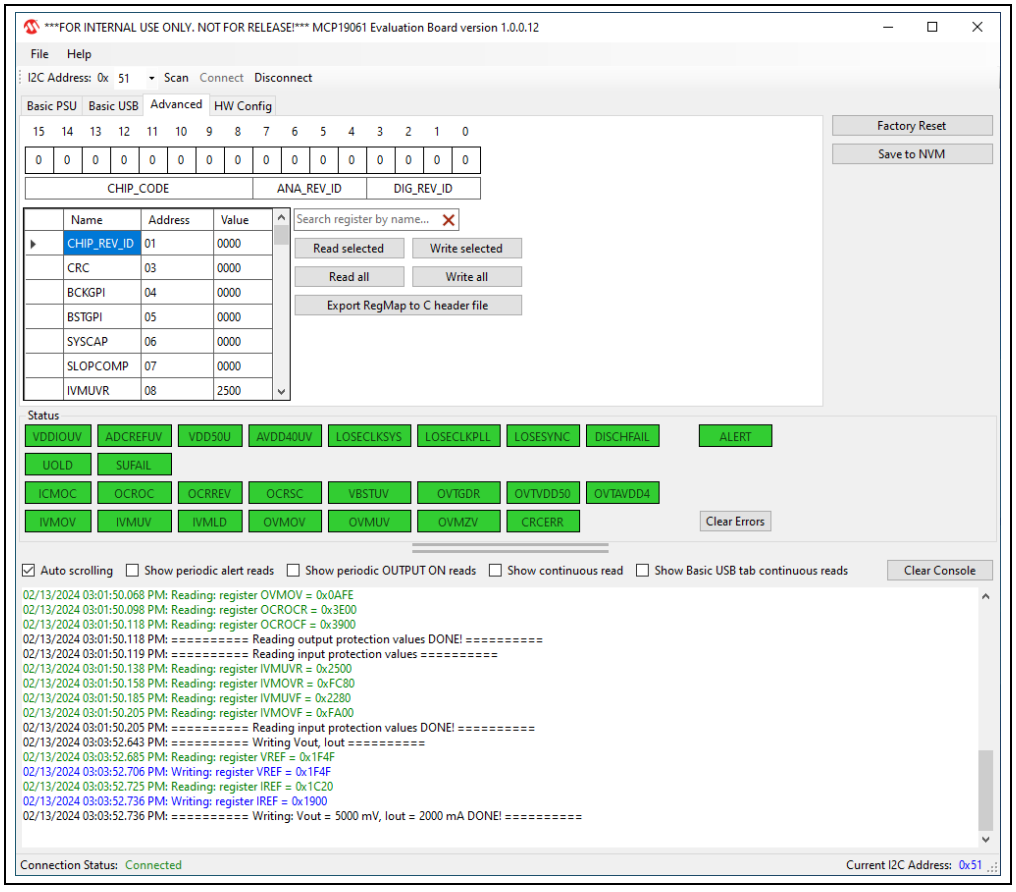


FIGURE 2-4: *Advanced Tab.*

- The Advanced tab offers direct access to the Register Map.
- The upper row shows the detailed bitwise description of the selected register and the corresponding fields.
- The value of the register can be modified by clicking and writing the desired value

in the value field of the corresponding register. The value can also be modified bitwise by clicking the corresponding bit, which will toggle it.

For a detailed description of each register, please see the MCP19061 Data Sheet.

TABLE 2-3: ADVANCED TAB BUTTON DESCRIPTION

Item	Description
Read Selected	Returns the value of the current selected register.
Read All	Returns the values for the whole Register Map.
Write Selected	Writes the value for the current selected register.
Write All	Writes the entire Register Map using the values in the selection window.

2.4.1.5 HARDWARE CONFIGURATION

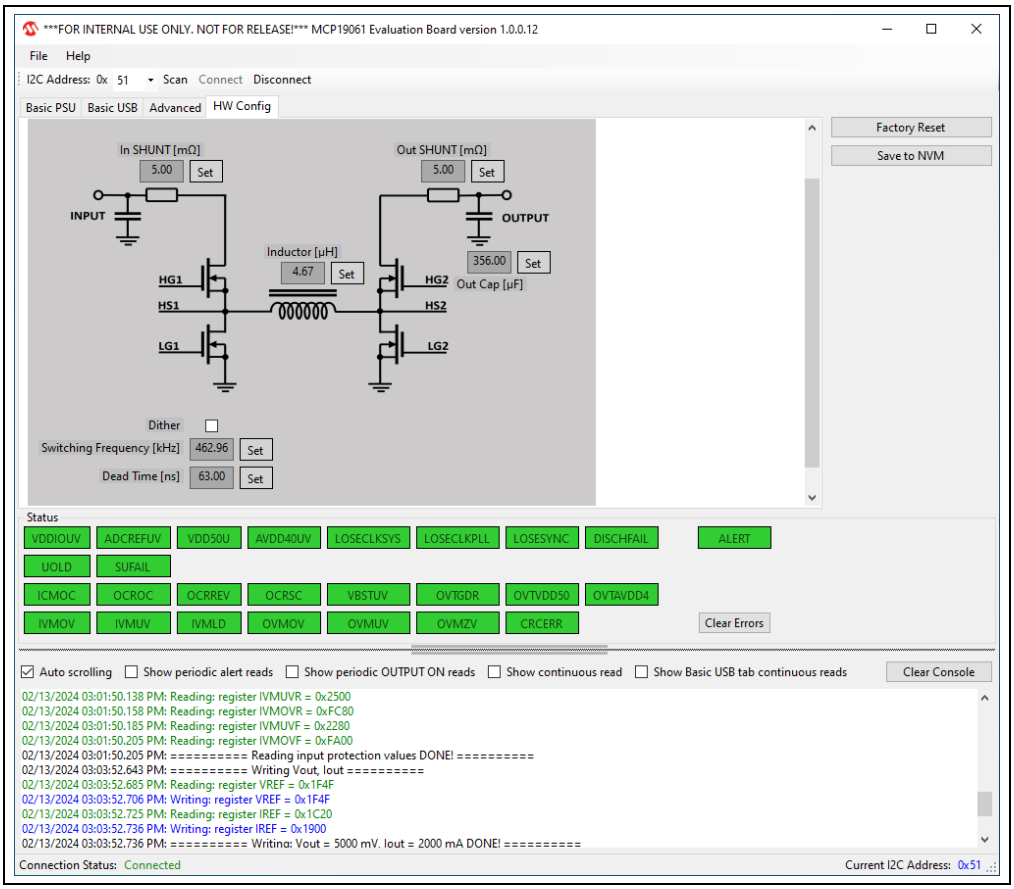


FIGURE 2-5: *Hardware Configuration Tab.*

The Hardware Configuration (HW Config) tab allows the user to input the parameters of the hardware setup for proper operation:

- Out SHUNT value is used for current regulation (I_{OUT}) and output current reporting.
- In SHUNT is used for the input overcurrent protection.
- The Output capacitor and inductor values impact the system stability and transient response.
- The Dither checkbox enables the frequency dither, to spread the noise spectrum.
- Dead Time box offers the option to set the deadtime between high side and the low side switch. The available range is 0 to 186 ns in steps of 6 ns.

2.5 OPERATING THE MCP19061 FOUR SWITCH BUCK-BOOST EVALUATION BOARD

Figure 2-6 shows the board typical test setup.

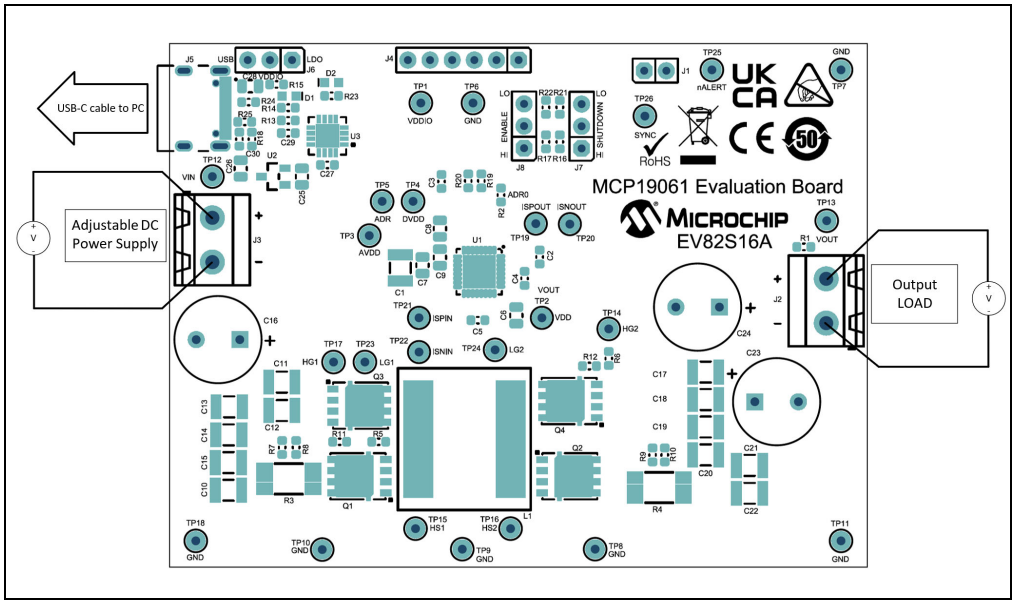


FIGURE 2-6: *MCP19061 Four Switch Buck-Boost Evaluation Board - Typical Test Setup.*

Table 2-4 lists all the available test points on the board.

The user can connect various instruments to the listed test points to evaluate the parameters of the converter. The typical performance data, curves and waveforms are presented in **Section 2.6** .

TABLE 2-4: TEST POINTS DESCRIPTION

Label	Function	Description
TP6, TP7, TP8, TP9, TP10, TP11, TP18	GND	Power GND
TP12	V_{IN}	Input Voltage
TP13	V_{OUT}	Output Voltage
TP1	VDD_IO	Digital Interface Supply
TP2	VDD	Internal Regulator Output
TP3	AVDD	Analog Voltage Regulator Output
TP4	DVDD	Digital Supply
TP5	ADR	Analog to Digital Converters Reference
TP17	HG1	Buck Leg High Gate
TP23	LG1	Buck Leg Low Gate
TP14	HG2	Boost Leg High Gate
TP24	LG2	Boost Leg Low Gate
TP15	HS1	Buck Leg Switching Node
TP16	HS2	Boost Leg Switching Node
TP21	ISPIN	Input Current Sense Amplifier (+)
TP22	ISNIN	Input Current Sense Amplifier (-)
TP19	ISPOUT	Output Current Sense Amplifier (+)

TABLE 2-4: TEST POINTS DESCRIPTION (CONTINUED)

Label	Function	Description
TP20	ISNOUT	Output Current Sense Amplifier (-)
TP25	nALERT	Internal Events Detect
TP26	SYNC	Configurable Input or Output Synchronization

TABLE 2-5: CONNECTORS DESCRIPTION

Label	Description
J1	Synchronization selection
J2	Output Voltage
J3	Input Voltage
J4	PICkit™ Serial/MCP2221
J5	USB-C
J6	VDDIO Selection
J7	SHUTDOWN selection
J8	ENABLE Selection

2.6 TYPICAL PERFORMANCE DATA AND WAVEFORMS

Table 2-6 describes the converter parameters.

TABLE 2-6: MCP19061 EVALUATION BOARD PARAMETERS

Parameter	Value	Comments
Input Voltage Range (V)	4.5-36	—
Output Voltage Range (V)	3-36	± 2.5% tolerance
Maximum Output Current (A)	10	Steady state output current
Output Voltage Ripple (mV)	< 50	V_{IN} = 12V, I_{OUT} = 1 A
Switching Frequency Range (kHz)	300-500	—

Figure 2-7 through Figure 2-13 show the typical waveforms that are obtained from the evaluation board.

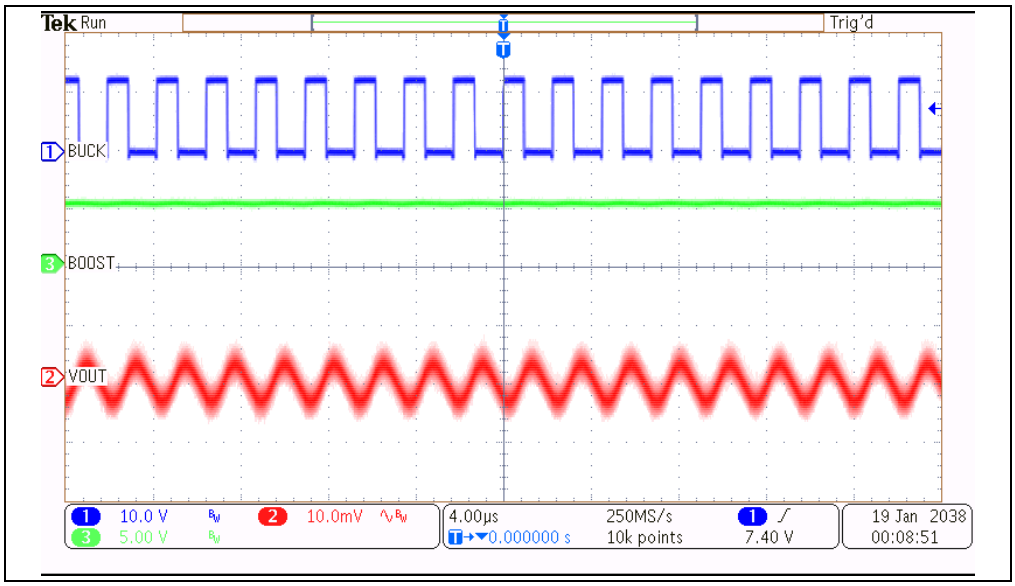


FIGURE 2-7: *Output Voltage Ripple/Noise (V_{IN} = 12V, V_{OUT} = 5V, I_{OUT} = 1A, BW = 20 MHz).*

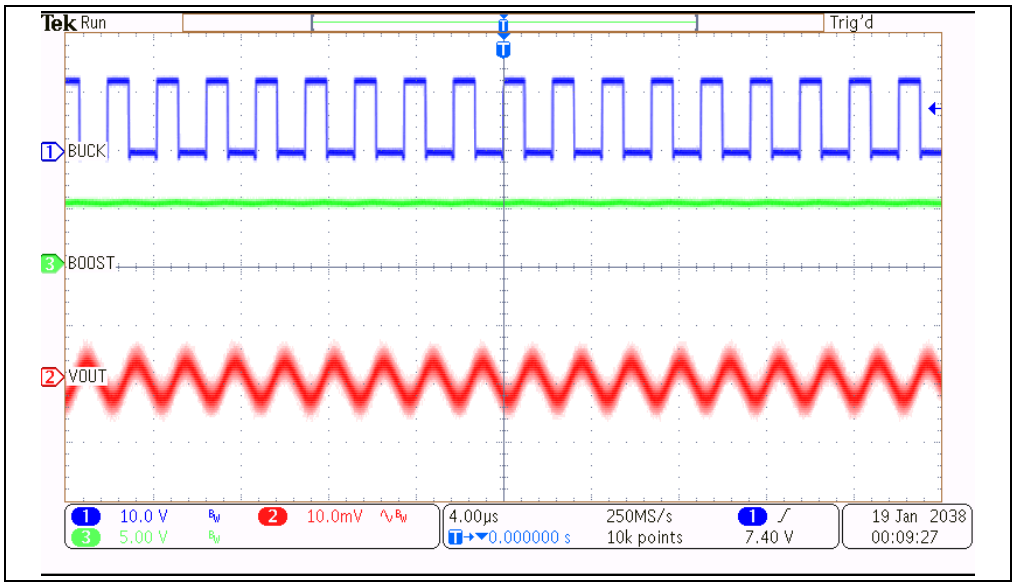


FIGURE 2-8: *Output Voltage Ripple/Noise (V_{IN} = 12V, V_{OUT} = 5V, I_{OUT} = 3A, BW = 20 MHz).*

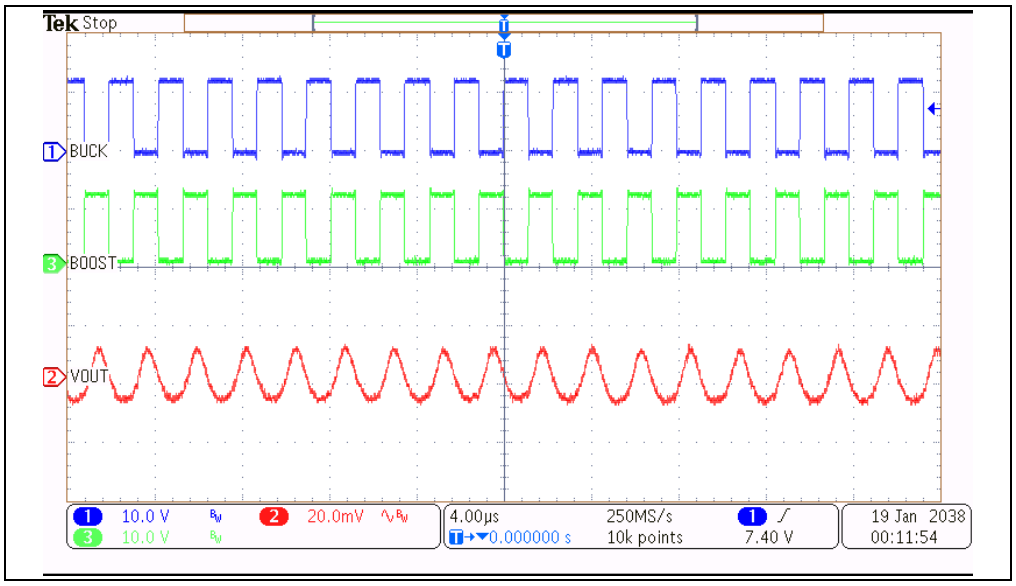


FIGURE 2-9: *Output Voltage Ripple/Noise (V_{IN} = 12V, V_{OUT} = 12V, I_{OUT} = 1A, BW = 20 MHz).*

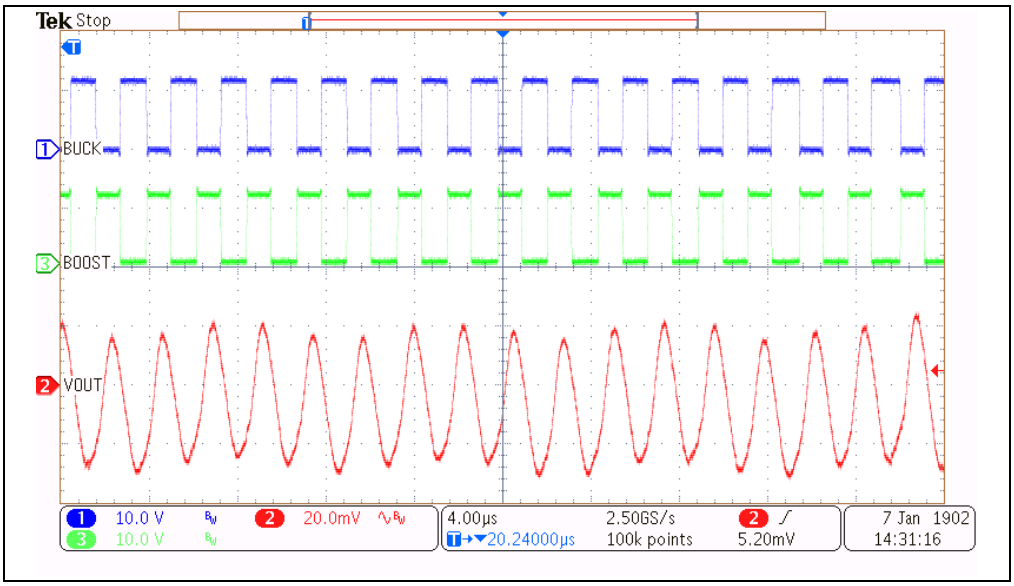


FIGURE 2-10: *Output Voltage Ripple/Noise (V_{IN} = 12V, V_{OUT} = 12V, I_{OUT} = 3A, BW = 20 MHz).*

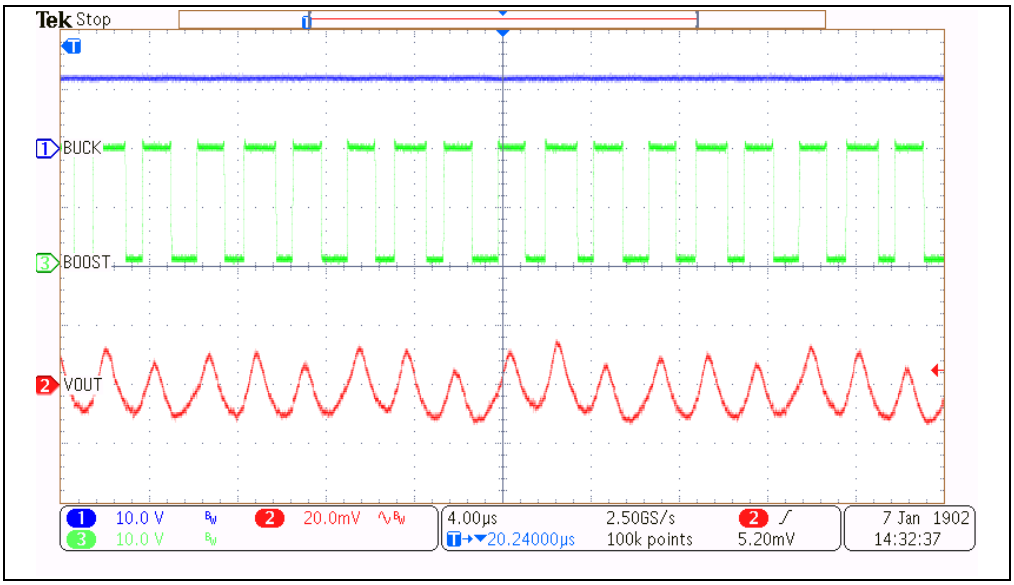


FIGURE 2-11: *Output Voltage Ripple/Noise (V_{IN} = 12V, V_{OUT} = 20V, I_{OUT} = 1A, BW = 20 MHz).*

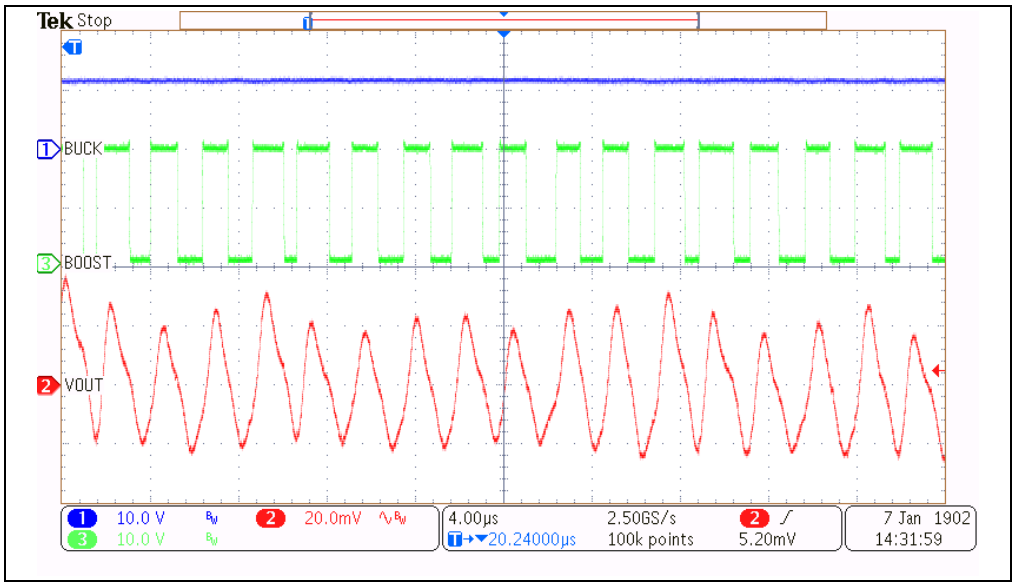


FIGURE 2-12: *Output Voltage Ripple/Noise (V_{IN} = 12V, V_{OUT} = 20V, I_{OUT} = 3A, BW = 20 MHz).*

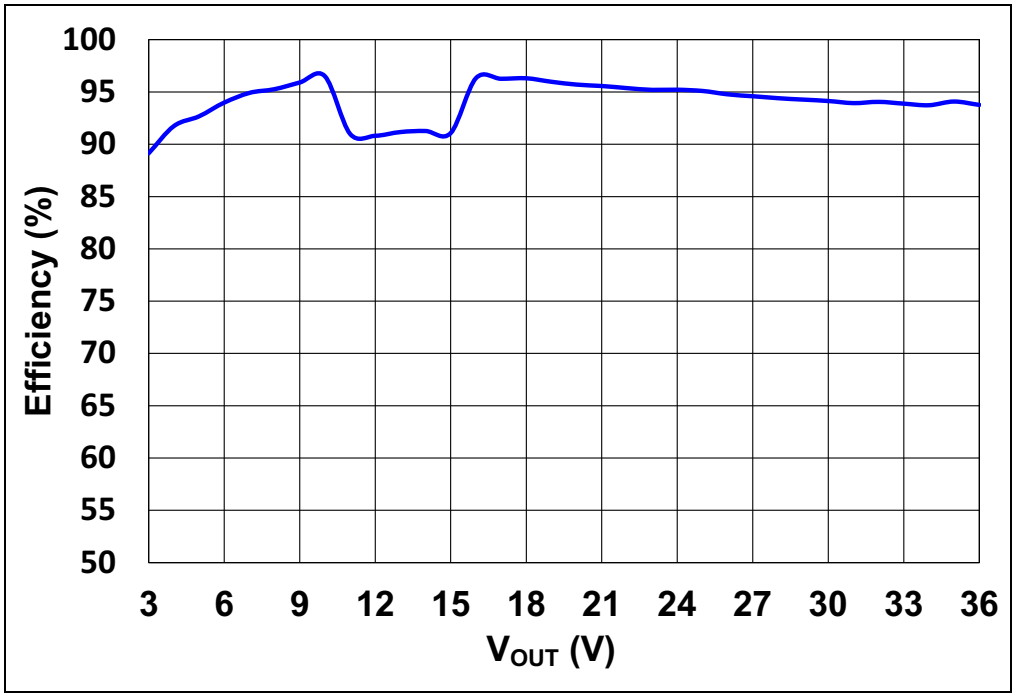


FIGURE 2-13: *MCP19061 Evaluation Board Efficiency (V_{IN} = 12V, I_{OUT} = 3A).*

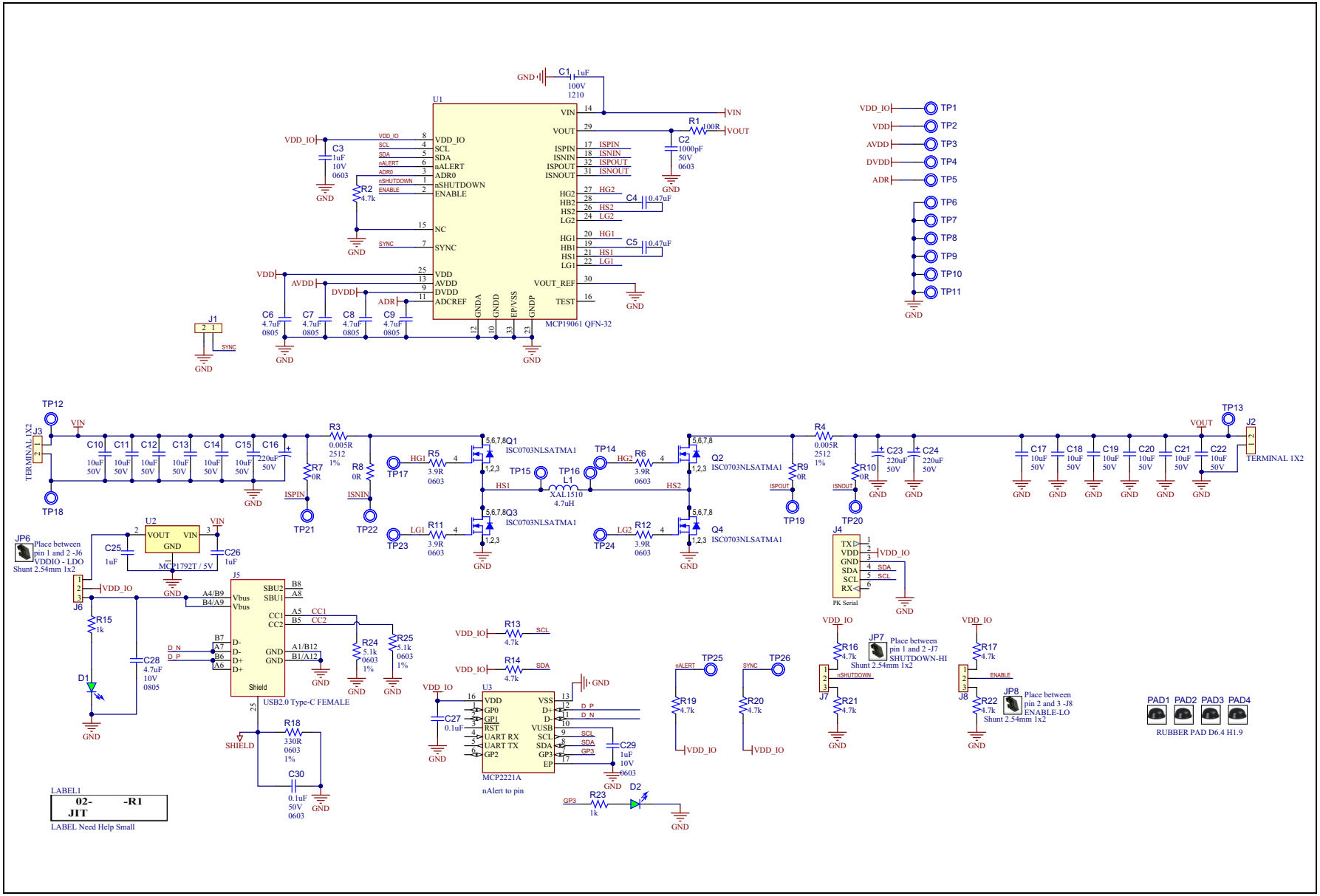
Appendix A. Schematics and Layouts

A.1 INTRODUCTION

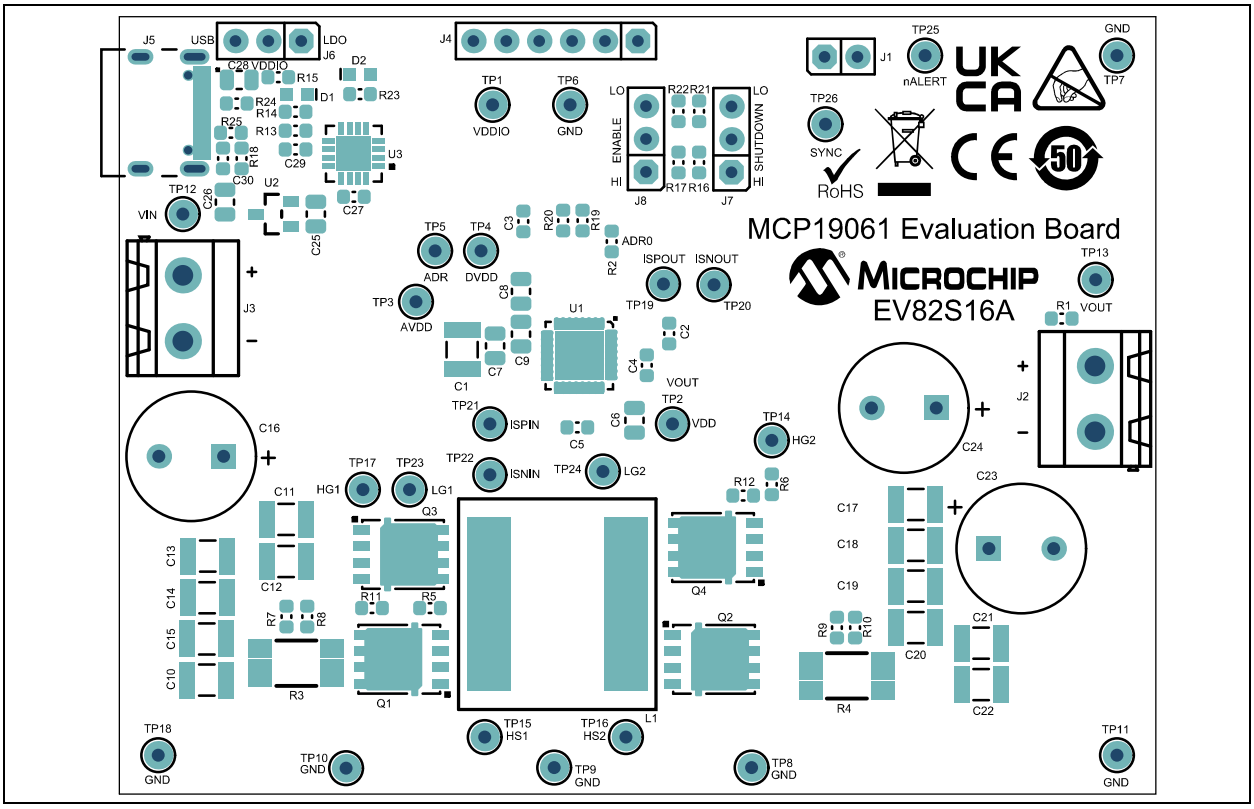
This appendix contains the following schematics and layouts for the MCP19061 Four Switch Buck-Boost Evaluation Board (EV82S16A):

- Board – Schematic
- Board – Top Silk
- Board – Top Copper and Silk
- Board – Top Copper
- Board – Bottom Copper
- Board – Bottom Copper and Silk
- Board – Bottom Silk

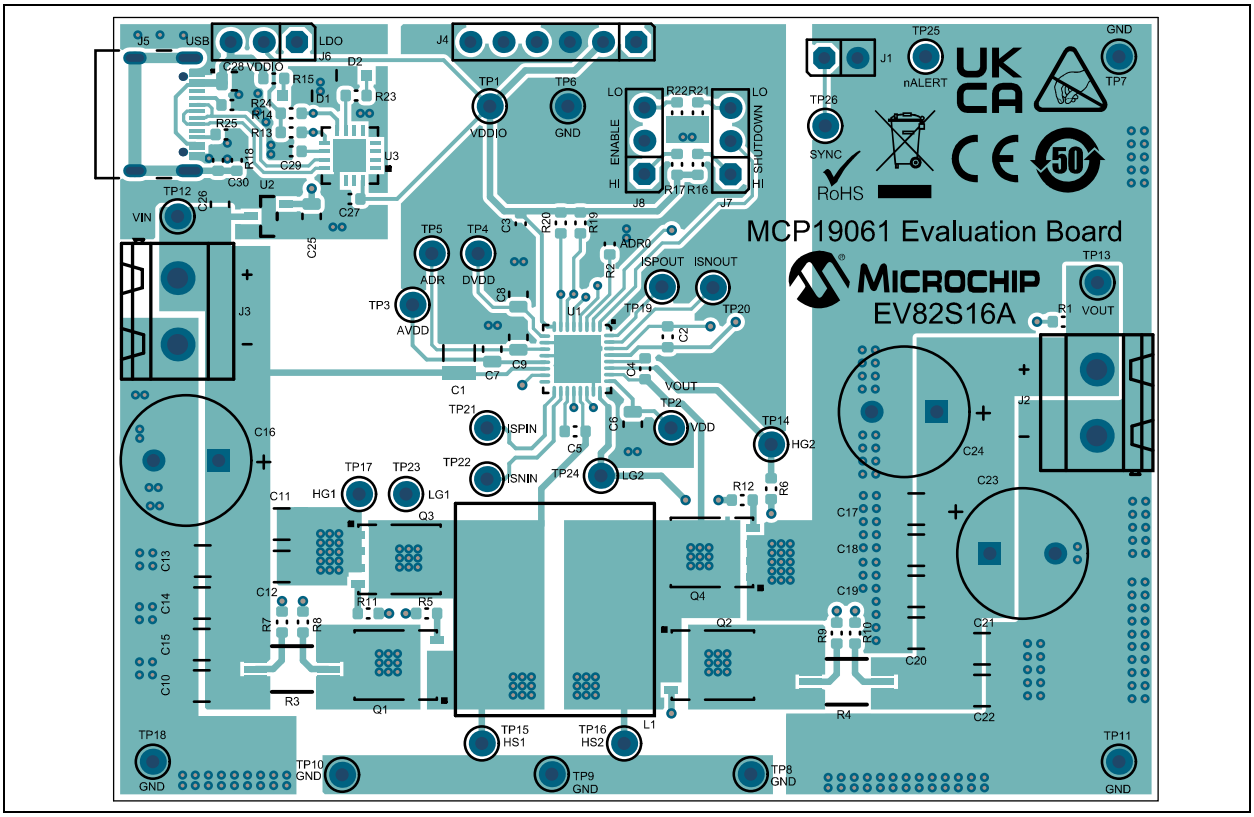
A.2 BOARD – SCHEMATIC



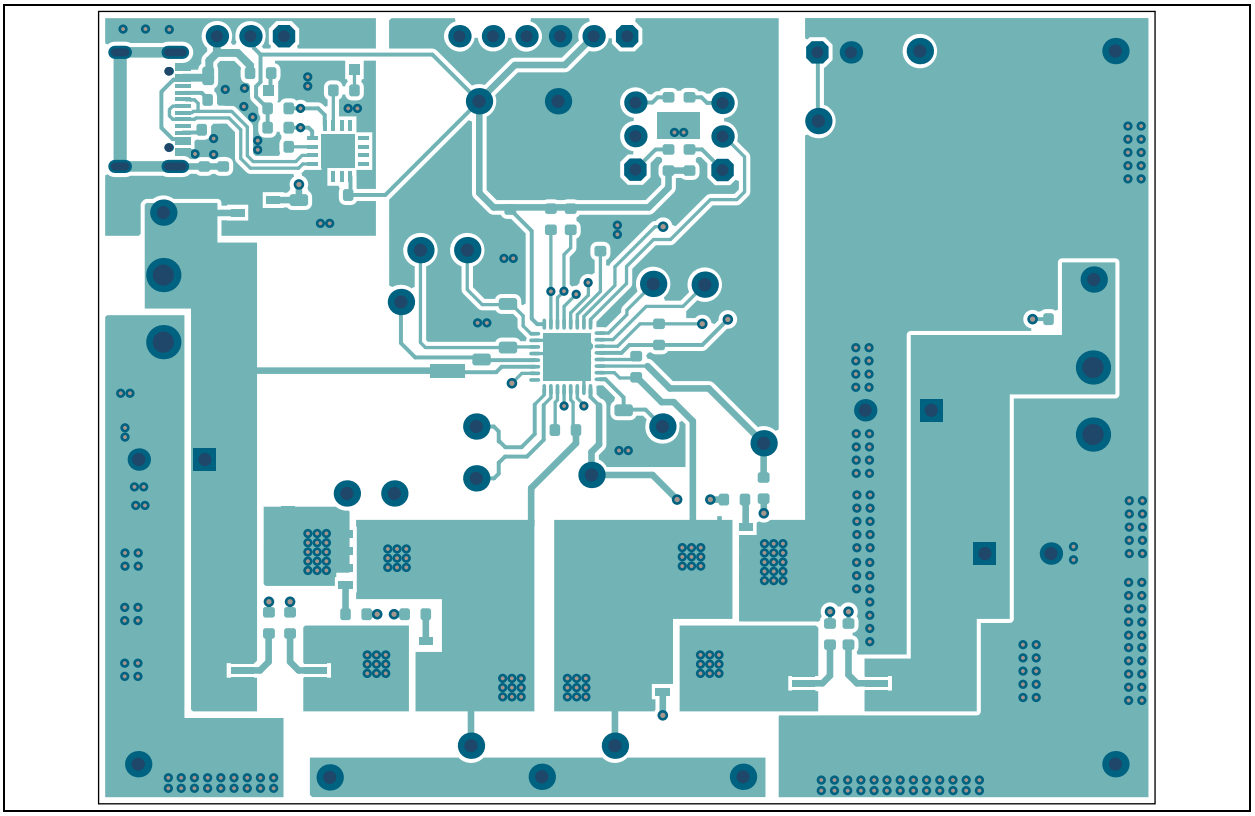
A.3 BOARD – TOP SILK



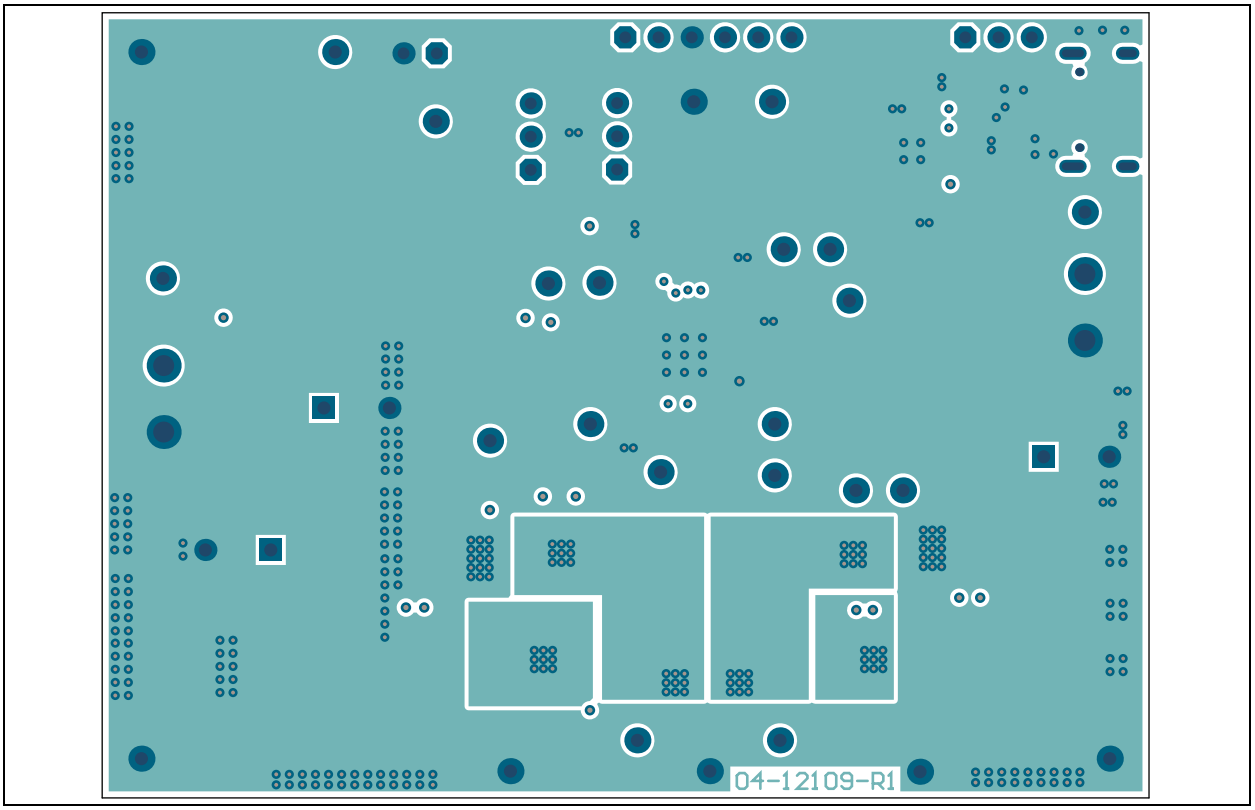
A.4 BOARD – TOP COPPER AND SILK



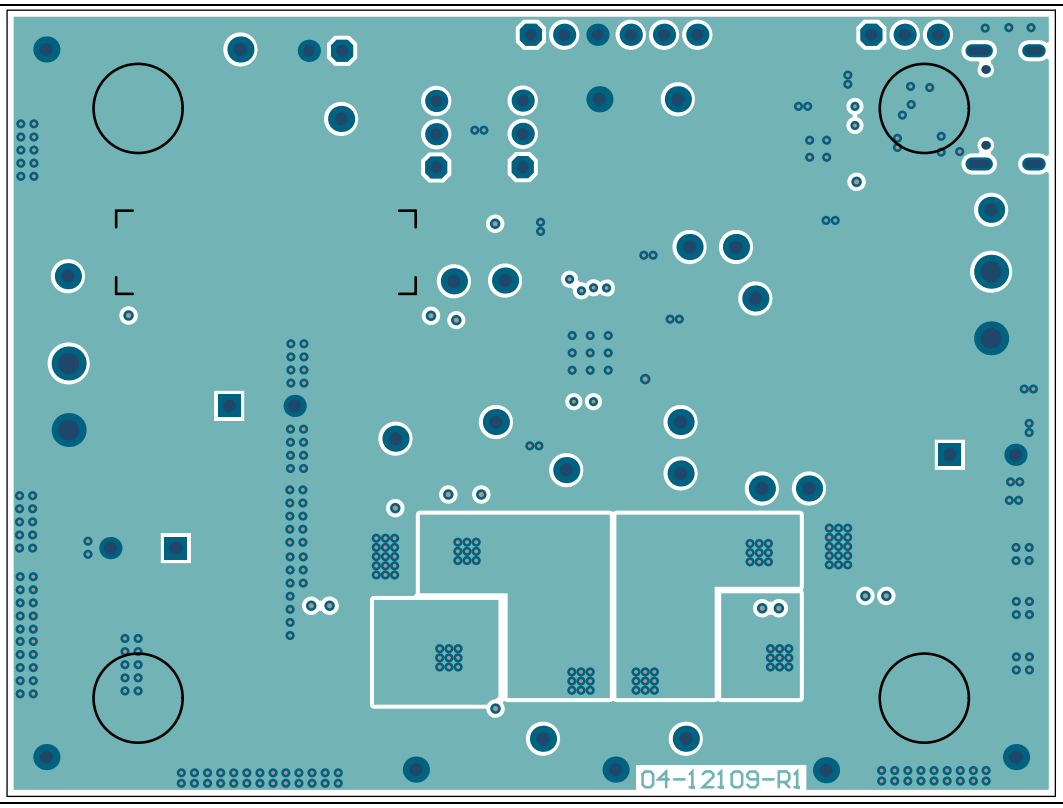
A.5 BOARD – TOP COPPER



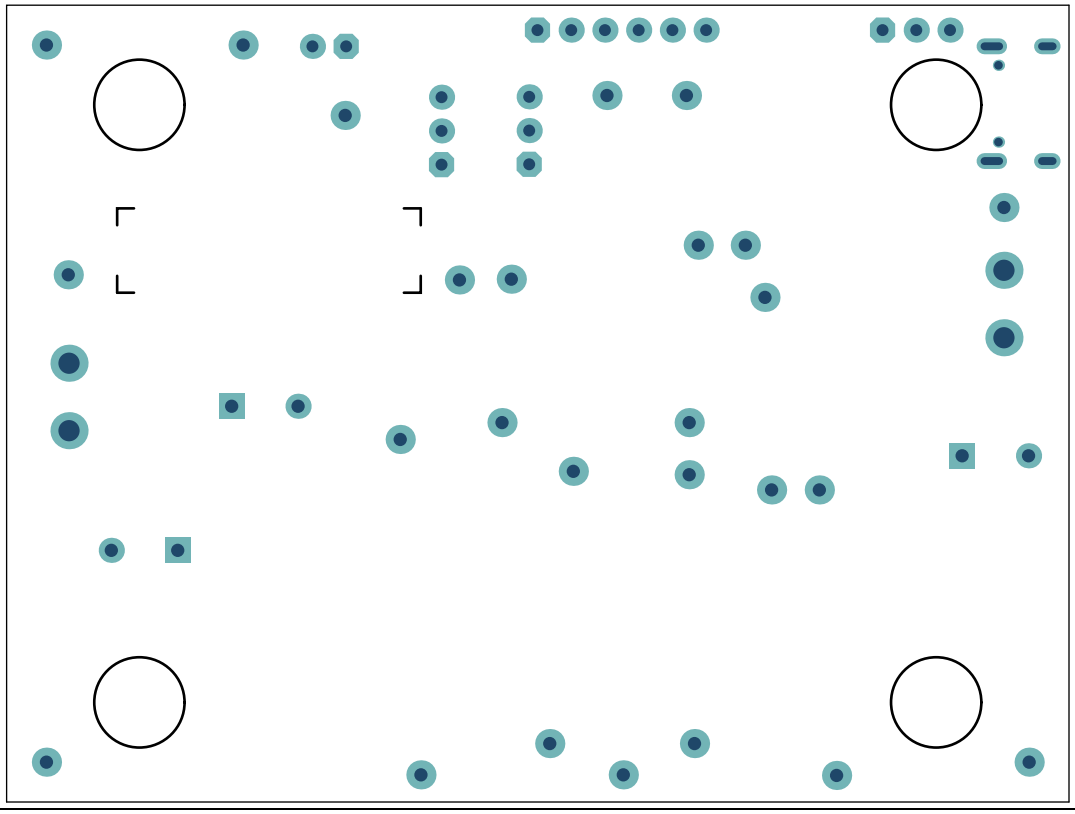
A.6 BOARD – BOTTOM COPPER



A.7 BOARD – BOTTOM COPPER AND SILK



A.8 BOARD – BOTTOM SILK



NOTES:

Appendix B. Bill of Materials (BOM)

TABLE B-1: BILL OF MATERIALS (BOM)

Qty.	Reference	Description	Manufacturer	Part Number
1	C1	Capacitor, ceramic, 1 µF, 100V, 10%, X7R, SMD, 1210	KEMET	C1210C105K1RACTU
1	C2	Capacitor, ceramic, 1000 pF, 50V, 20%, X7R, SMD, 0603	TDK Corporation	C1608X7R2A102K080AA
1	C3	Capacitor, ceramic, 1 µF, 10V, 20%, X7R, SMD, 0603	Samsung Electro-Mechanics America, Inc.	CL10B105KP8NNNC
2	C4, C5	Capacitor, ceramic, 0.47 µF, 16V, 10%, X7R, SMD, 0603	Murata Electronics®	GRM188R71C474KA88D
5	C6, C7, C8, C9, C28	Capacitor, ceramic, 4.7 µF, 10V, 10%, X7R, SMD, 0805	TDK Corporation	C2012X7R1A475K125AC
12	C10, C11, C12, C13, C14, C15, C17, C18, C19, C20, C21, C22	Capacitor, ceramic, 10 µF, 50V, 20%, X7R, SMD, 1210	Kyocera AVX®	CM32X7R106M50AT
3	C16, C23, C24	Capacitor, aluminum, 220 µF, 50V, 20%, RAD, P5D10H15.7	Panasonic® - ECG	EEH-AZS1H221B
2	C25, C26	Capacitor, ceramic, 1 µF, 50V, 10%, X7R, SMD, 0805	Samsung Electro-Mechanics America, Inc.	CL21B105KBFNNNE
2	C27, C30	Capacitor, ceramic, 0.1 µF, 50V, 20%, X7R, SMD, 0603	TDK Corporation	C1608X7R1H104M080AA
1	C29	Capacitor, ceramic, 1 µF, 10V, 10%, X5R, SMD, 0603	Murata Electronics	GRM188R61A105KA61D
2	D1, D2	LED, yellow, green, 0603, SMD	Vishay® Intertechnology, Inc.	VLMG1300-GS08
1	J1	Connector, header-2.54, male, 1x2, gold, 5.84 MH, TH, vertical	Würth Elektronik	61300211121
2	J2, J3	Connector, terminal, 5.08 mm, 1X2, female, 16-30AWG, 13.5A, TH, RA	TE Connectivity, Ltd.	282836-2
1	J4	Connector, header-2.54, male, 1x6, Tin, 5.84 MH, TH, vertical	Sullins Connector Solutions	PEC06SAAN
1	J5	Connector, USB 2.0, Type-C, female, SMD/TH, R/A	GCT Semiconductor Inc.	USB4105-GF-A
3	J6, J7, J8	Connector, header-2.54, male, 1x3, Tin, 5.84 MH, TH, vertical	Samtec, Inc.	TSW-103-07-T-S
3	JP6, JP7, JP8	Mechanical, headers and wires, jumper, 2.54 mm, 1x2	Amphenol ICC (FCI)	63429-202LF

Note: 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)

Qty.	Reference	Description	Manufacturer	Part Number
1	L1	Inductor, 4.7 µH, 29A, 20%, 0.0038R, SMD, L16.2W15.2H10, AEC-Q200	Coilcraft	XAL1510-472MED
1	LABEL1	Label, assembly with rev level (small modules) per MTS-0002	Raynen	10010276
4	PAD1, PAD2, PAD3, PAD4	Mechanical, headers and wires, rubber pad, hemisphere, D6.4, H1.9, clear	3M	SJ5382
4	Q1, Q2, Q3, Q4	Transistor, MOSFET, N-Channel, 60V, 57A, 0.0069R, TDSON-8	Infineon Technologies AG	ISC0703NLSATMA1
1	R1	Resistor, thick film, 100R, 5%, 1/10W, SMD, 0603	Vishay Intertechnology, Inc.	CRCW0603100RJNEA
9	R2, R13, R14, R16, R17, R19, R20, R21, R22	Resistor, thick film, 4.7k, 5%, 1/10W, SMD, 0603	Panasonic - ECG	ERJ-3GEYJ472V
2	R3, R4	Resistor, metal film, 0.005R, 1%, WW, SMD, 2512	Bourns® Inc.	CRE2512-FZ-R005E-3
4	R5, R6, R11, R12	Resistor, thick film, 3.9R, 1%, 1/3W, SMD, 0603, AEC-Q200	ROHM Semiconductor	SDR03EZPF3R90
4	R7, R8, R9, R10	Resistor, thick film, 0R, 1/10W, SMD, 0603, AEC-Q200	Panasonic - ECG	ERJ-3GEY0R00V
2	R15, R23	Resistor, thick film, 1k, 5%, 1/10W, SMD, 0603	Panasonic - ECG	ERJ-3GEYJ102V
1	R18	Resistor, thick film, 330R, 1%, 1/10W, SMD, 0603	Panasonic - ECG	ERJ-3EKF3300V
2	R24, R25	Resistor, thick film, 5.1k, 1%, 1/10W, SMD, 0603	Panasonic - ECG	ERJ-3EKF5101V
21	TP1, TP3, TP4, TP5, TP6, TP7, TP8, TP9, TP10, TP11, TP12, TP13, TP14, TP15, TP16, TP17, TP18, TP23, TP24, TP25, TP26	Miscellaneous, test point, multi purpose, mini, white	Keystone® Electronics Corp.	5002
5	TP2, TP19, TP20, TP21, TP22	Miscellaneous, test point, PC, Mini, 0.040", D, yellow	Keystone Electronics Corp.	5004
1	U1	Analog, PWM controller, 300-500 kHz, VQFN-32	Microchip Technology Inc.	MCP19061-E/RTB
1	U2	Analog, voltage, regulator, 5.0V, 3LD, SOT-23A-3	Microchip Technology Inc.	MCP1792T-5002H/CB
1	U3	Interface, USB, I^2C/UART, QFN-16	Microchip Technology Inc.	MCP2221A-I/ML
1	PCB1	Printed Circuit Board	—	04-12109-R1

Note: 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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