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MCP1661
High-Voltage Boost and
SEPIC Converters
Evaluation Board
User's Guide

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**Object of Declaration: MCP1661 High-Voltage Boost and SEPIC Converters
Evaluation Board**

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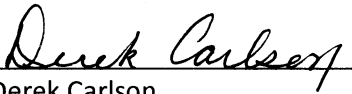
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Derek Carlson

VP Development Tools

16-July-2013

Date

NOTES:



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MCP1661 HIGH-VOLTAGE BOOST AND SEPIC CONVERTERS 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 web site (www.microchip.com) to obtain the latest documentation available.

Documents are identified with a “DS” number. This number is located on the bottom of each page, in front of the page number. The numbering convention for the DS number is “DSXXXXXXA”, where “XXXXXX” 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 MCP1661 High-Voltage Boost and SEPIC Converters Evaluation Board. Items discussed in this chapter include:

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

DOCUMENT LAYOUT

This document describes how to use the MCP1661 High-Voltage Boost and SEPIC Converters Evaluation Board as a development tool. The manual layout is as follows:

- **Chapter 1. “Product Overview”** – Important information about the MCP1661 High-Voltage Boost and SEPIC Converters Evaluation Board.
- **Chapter 2. “Installation and Operation”** – Includes instructions on how to get started with the MCP1661 High-Voltage Boost and SEPIC Converters Evaluation Board and a description of the user's guide.
- **Appendix A. “Schematic and Layouts”** – Shows the schematic and layout diagrams for the MCP1661 High-Voltage Boost and SEPIC Converters Evaluation Board.
- **Appendix B. “Bill of Materials (BOM)”** – Lists the parts used to build the MCP1661 High-Voltage Boost and SEPIC Converters 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	<i>MPLAB[®] IDE User's Guide</i>
	Emphasized text	...is the <i>only</i> 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	<u><i>File>Save</i></u>
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	<i>file.o</i> , where <i>file</i> can be any valid filename
Square brackets []	Optional arguments	mcc18 [options] <i>file</i> [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 MCP1661 High-Voltage Boost and SEPIC Converters Evaluation Board. Other useful documents are listed below. The following Microchip document is available and recommended as a supplemental reference resource.

- **MCP1661 Data Sheet - “High-Voltage Integrated Switch PWM Boost Regulator with UVLO” (DS20005315A)**

THE MICROCHIP WEB SITE

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

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

DOCUMENT REVISION HISTORY

Revision A (June 2014)

- Initial Release of this Document.

NOTES:



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MCP1661 HIGH-VOLTAGE BOOST AND SEPIC CONVERTERS EVALUATION BOARD USER'S GUIDE

Chapter 1. Product Overview

1.1 INTRODUCTION

This chapter provides an overview of the MCP1661 High-Voltage Boost and SEPIC Converters Evaluation Board and covers the following topics:

- MCP1661 Short Overview
- What is MCP1661 High-Voltage Boost and SEPIC Converters Evaluation Board?
- What the MCP1661 High-Voltage Boost and SEPIC Converters Evaluation Board Contains

1.2 MCP1661 SHORT OVERVIEW

The MCP1661 is a compact, high-efficiency, fixed-frequency, non-synchronous step-up DC/DC converter which integrates a 36V, 800 mΩ switch. This product provides a space-efficient high voltage step-up, easy-to-use power supply solution. The applications require a minimum number of external components for applications powered by two-cell or three-cell alkaline, Energizer[®] Ultimate Lithium, Ni-Cd, Ni-MH batteries, or one-cell Li-Ion or Li-Polymer batteries.

The MCP1661 operates in Pulse-Width Modulation (PWM), at a fixed 500 kHz switching frequency. The device features an undervoltage lockout (UVLO) which prevents fault operation below 1.85V (UVLO Stop) corresponding to the value of two discharged batteries. The MCP1661 starts its normal operation at 2.3V input voltage (UVLO Start) and the operating input voltage ranges from 2.4V to 5.5V.

For standby applications, MCP1661 can be put in Shutdown by pulling the EN pin to GND. The device will stop switching and will consume a few μA of input current (including feedback divider current; the device consumes less than 200 nA). In the Boost configuration, the input voltage will be bypassed to output through the inductor and Schottky diode. In SEPIC configuration, there is no direct path from input to output and connecting the EN pin to GND will provide an output disconnect.

MCP1661 also provides overvoltage protection (OVP) in the event of:

- Short-circuit of the feedback pin to GND
- Disconnected feedback divider

In these conditions, the OVP function will stop the internal driver and prevent damage to the device. This feature is disabled during the start-up sequence and Thermal Shutdown state.

The goal of the MCP1661 High-Voltage Boost and SEPIC Converters Evaluation Board is to demonstrate the higher output voltage capabilities of the MCP1661 regulator in the Boost and SEPIC topologies.

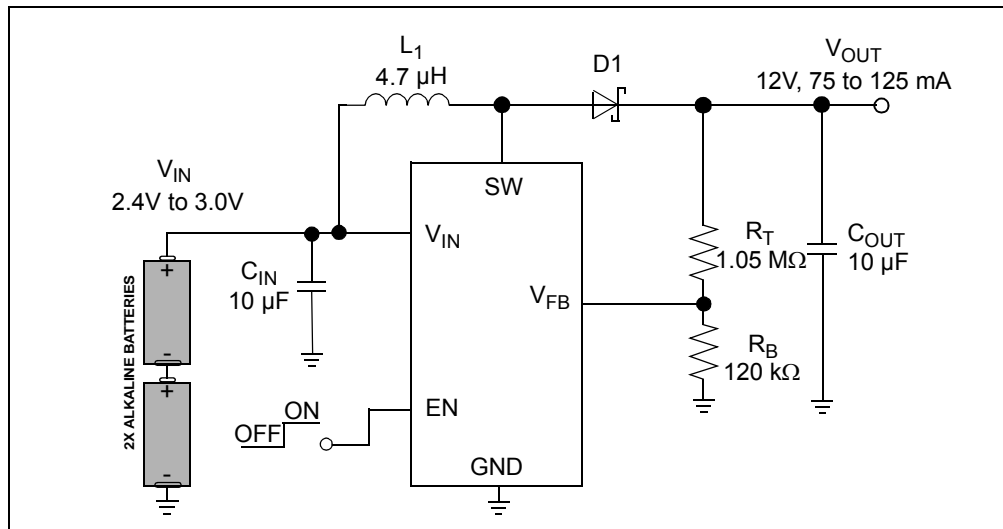


FIGURE 1-1: Typical MCP1661 Boost Converter Two Cells Battery Input.

1.2.1 SEPIC TOPOLOGY

The Single Ended Primary Inductor Converter (SEPIC) topology follows the flyback design, adding a coupling capacitor between the two windings of a transformer.

The input voltage may be lower or higher than the output voltage, resulting in a buck or boost operation.

This topology can use two separate inductors, or 1:1 coupled inductors. The coupled inductor solution requires a smaller PCB area and reduces radiated electromagnetic interference (EMI). Another advantage of using coupled inductor is the fact that only half of the calculated inductance is needed. A capacitor connected between the first inductor and the second inductor offers DC isolation and protection against a shorted load. The capacitor clamps the winding leakage inductance energy and eliminates the need for a snubber circuit. The input inductor smooths the current draw and reduces the required input filtering.

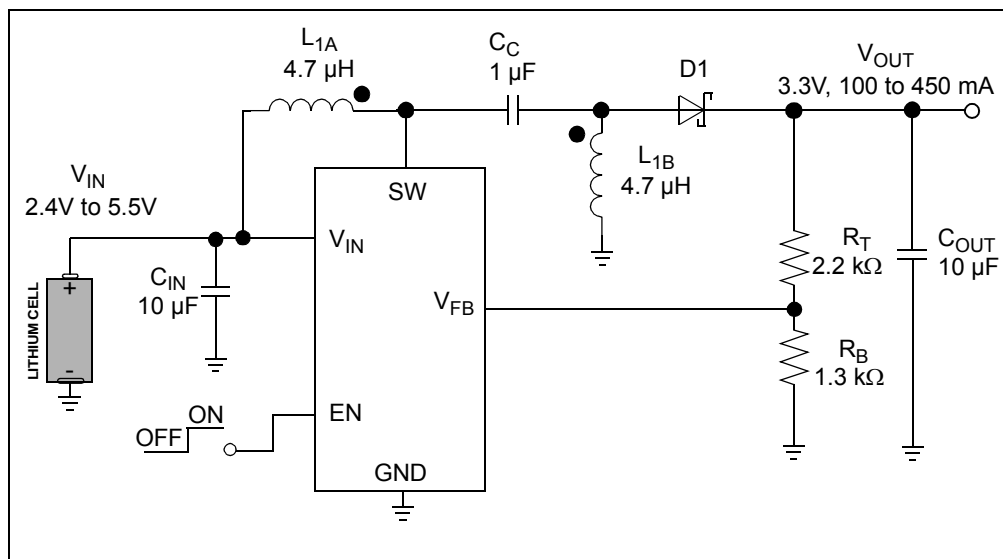


FIGURE 1-2: Typical MCP1661 3.3V output SEPIC Converter Application.

1.3 WHAT IS THE MCP1661 HIGH-VOLTAGE BOOST AND SEPIC CONVERTERS EVALUATION BOARD?

The MCP1661 High-Voltage Boost and SEPIC Converters Evaluation Board is used to evaluate and demonstrate Microchip Technology's MCP1661 product. This board demonstrates the MCP1661 capabilities in two different topologies:

- 12V output Boost Converter application supplied from an external voltage source ($V_{IN} < 5.5V$ e.g. two cell boost to 12V)
- 3.3V output SEPIC Converter application supplied from a Li-Ion Cell.

It can be used to evaluate the SOT-23-5 package. The MCP1661 High-Voltage Boost and SEPIC Converters Evaluation Board was developed to help engineers reduce product design cycle time.

In both the MCP1661 Boost Application and MCP1661 SEPIC Application, the output voltage is set to the proper value using an external resistor divider, resulting in a simple and compact solution.

In the MCP1661 SEPIC Application, a switch is used to enable and disable the converter. When enabled, the MCP1661 will regulate the output voltage; when disabled, the MCP1661 SEPIC Application will disconnect the path from input to output.

1.4 WHAT THE MCP1661 HIGH-VOLTAGE BOOST AND SEPIC CONVERTERS EVALUATION BOARD KIT CONTAINS

This MCP1661 High-Voltage Boost and SEPIC Converters Evaluation Board kit includes:

- MCP1661 High-Voltage Boost and SEPIC Converters Evaluation Board (ADM00566)
- Important Information Sheet

NOTES:



Chapter 2. Installation and Operation

2.1 INTRODUCTION

MCP1661 is a non-synchronous, fixed-frequency step-up DC/DC converter which has been developed for applications that require higher output voltage capabilities. MCP1661 can regulate the output voltage up to 32V and can deliver a more than 125 mA load at 3.3V input and 12V output (see Figure 2-1). At light loads, MCP1661 skips pulses to keep the output ripple low. The regulated output voltage (V_{OUT}) should be greater than or equal to the input voltage (V_{IN}).

Another important feature is that the device integrates the compensation and protection circuitry, such that the final solution lowers total system cost, eases implementation and requires a minimum number of additional components and board area.

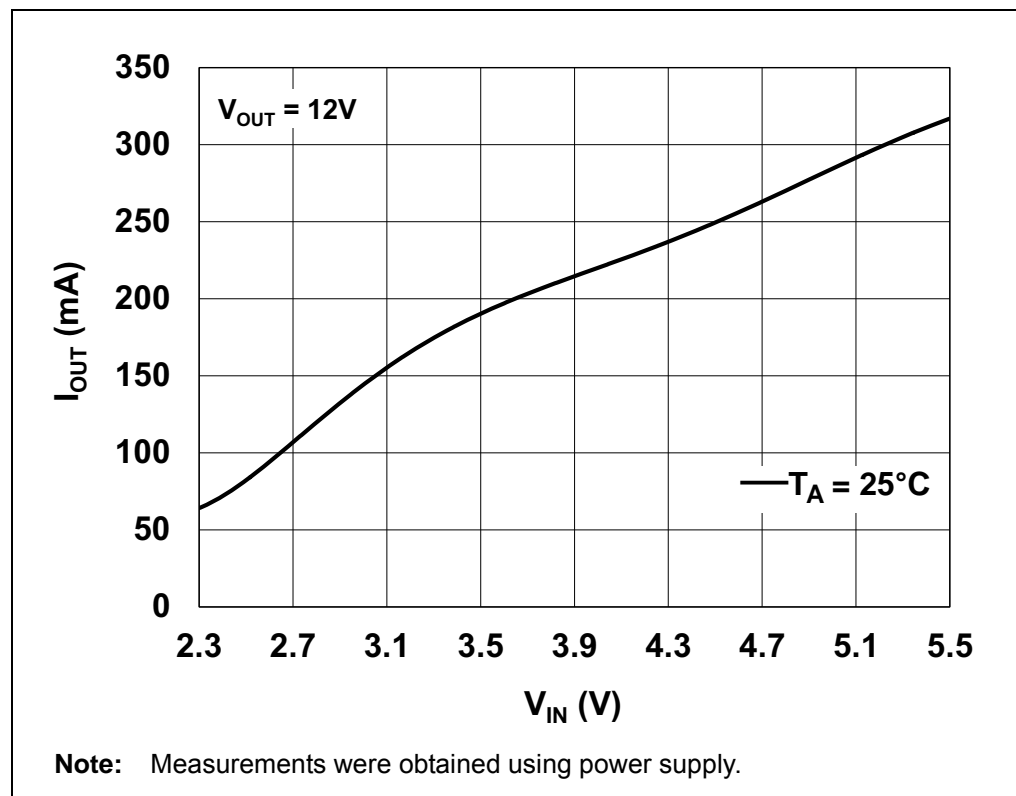


FIGURE 2-1: MCP1661 Boost - 12.0 V_{OUT} Maximum I_{OUT} vs. V_{IN} with max. 10% Output Drop.

The SEPIC converter was developed for applications where a positive regulated 3.3V output voltage is needed from an input voltage that varies from above to below this value. Refer to [Figure 2-2](#) for the maximum output current that can be obtained for different input voltages.

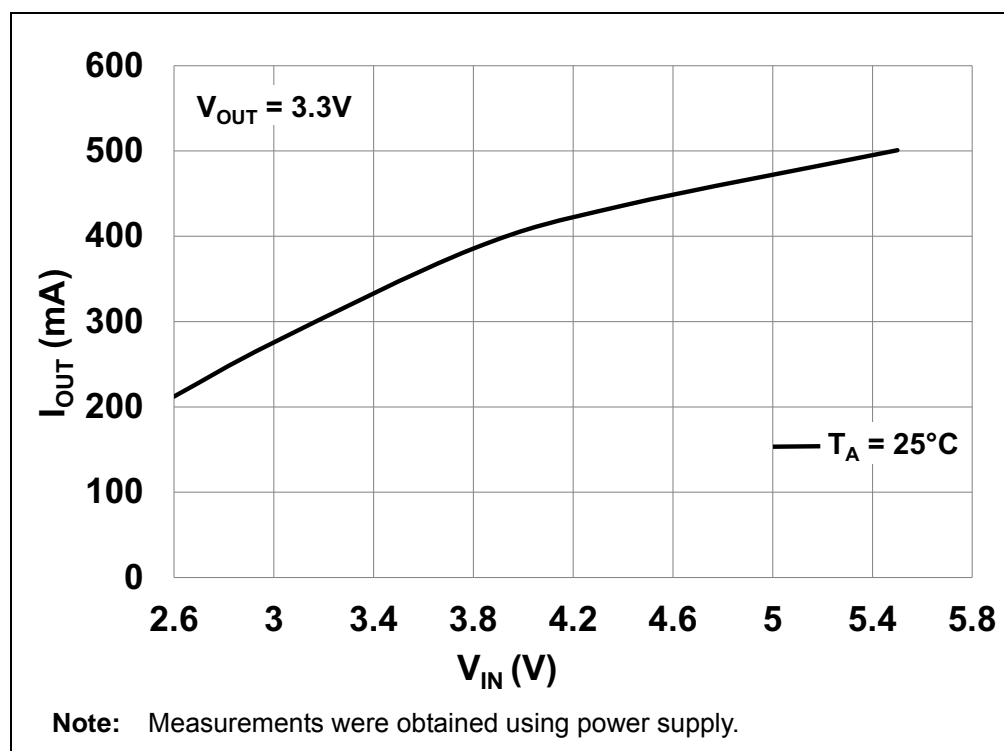


FIGURE 2-2: MCP1661 SEPIC - 3.3V V_{OUT} Maximum I_{OUT} vs. V_{IN} .

2.1.1 Battery Considerations

When considering a power solution for a design, the battery needs to be carefully selected. Alkaline batteries are a commonly available option that delivers good performance in a variety of applications. Energizer® Ultimate Lithium batteries are an alternative power solution that provides superior-performance high drains and allows designers to utilize the full power range of the MCP1661 without sacrificing size or runtime.

Energizer Ultimate Lithium batteries utilize a primary cell chemistry that contains higher energy than alkaline batteries, and have much better high drain performance. Ultimate Lithium batteries produce a high, flat voltage profile that enables them to provide a high energy capacity even at high drains. Additionally, Ultimate Lithium batteries have a very low internal resistance, allowing them to maintain a high voltage at very high loads.

2.1.2 MCP1661 High Voltage Boost Converter & SEPIC Converter Evaluation Board Features

The MCP1661 High Voltage Boost Converter & SEPIC Converter Evaluation Board has the following features:

- MCP1661 device can be evaluated in two separate applications: Boost and SEPIC
- Undervoltage Lockout (UVLO)
- Start-up Voltage: 2.3V (UVLO Start)
- Input Voltage range (V_{IN}) after start-up: 2.4V to 5.5V, with $V_{IN} \leq V_{OUT}$
- Output Voltage:
 - 12V (for MCP1661 Boost Application)
 - 3.3V (for MCP1661 SEPIC Application)
- Output Current: typical 125 mA @ 12V Output, 3.3V Input (for the Boost Converter)
- PWM Operation
- PWM Switching Frequency: 500 kHz
- Enable state selectable using EN switch (for MCP1661 SEPIC Application)
- Peak Input Current Limit of 1.3A
- Internal Compensation
- Soft Start
- Overtemperature Protection (if the die temperature exceeds +150°C, with 15°C hysteresis)

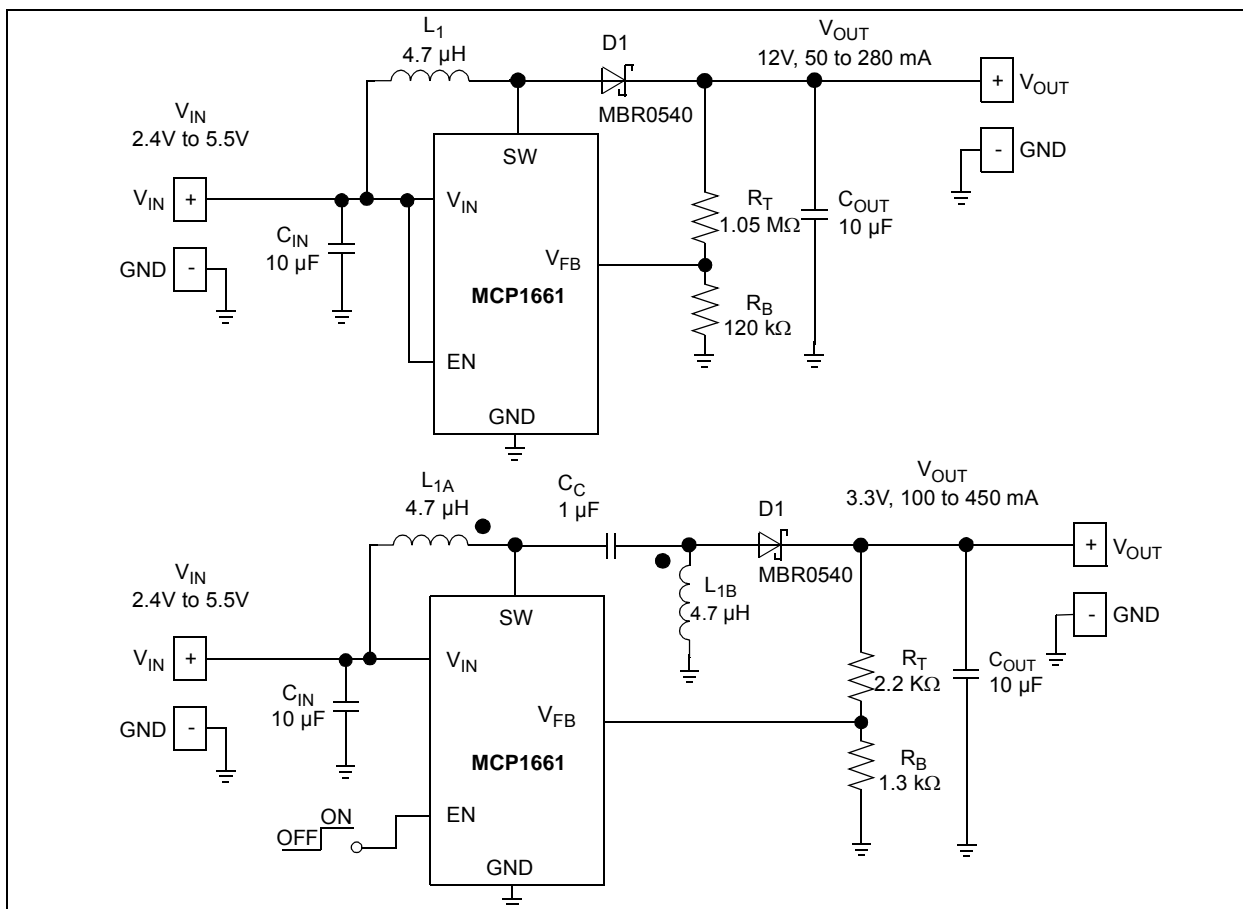


FIGURE 2-3: MCP1661 Boost and SEPIC Typical Applications.

2.2 GETTING STARTED

The MCP1661 High Voltage Boost Converter & SEPIC Converter Evaluation Board is fully assembled and tested to evaluate and demonstrate the MCP1661 product. This board requires the use of external laboratory supplies and load.

2.2.1 Power Input and Output Connection

2.2.1.1 POWERING THE MCP1661 HIGH VOLTAGE BOOST CONVERTER & SEPIC CONVERTER EVALUATION BOARD

The MCP1661 High Voltage Boost Converter & SEPIC Converter Evaluation Board was designed to be used to evaluate the MCP1661 device. The package selected is SOT-23.

Soldered test points are available for input voltage connections. The maximum input voltage should not exceed 5.5V.

Soldered test points are available to connect a load. The switch peak current limit will provide a safe maximum current value. The maximum output current for the converter will vary with input and output voltages; refer to [Figure 2-3](#) or the MCP1661 data sheet for more information on the maximum output current.

2.2.1.2 BOARD POWER-UP PROCEDURE

1. Connect the input supply as shown in [Figure 2-4](#). The input voltage should not be higher than 5.5V.
2. Connect system load to V_{OUT} and GND terminals; maximum load varies with input and output voltage. Typically, the MCP1661 can supply a 12V output with 125 mA from a 3.3V input source at room temperature. Connect the (+) side of the load to V_{OUT} and the negative (-) load to ground (GND).
3. For the Boost application, the Enable pin is connected to V_{IN} .
4. For the SEPIC application, turn the device On/Off using the EN switch. In this case, the input voltage can be higher or lower than the output voltage which will remain constant at 3.3V. Note that the input voltage should not exceed 5.5V.

Additional test points are available to visualize different signals (SW, EN).

Installation and Operation

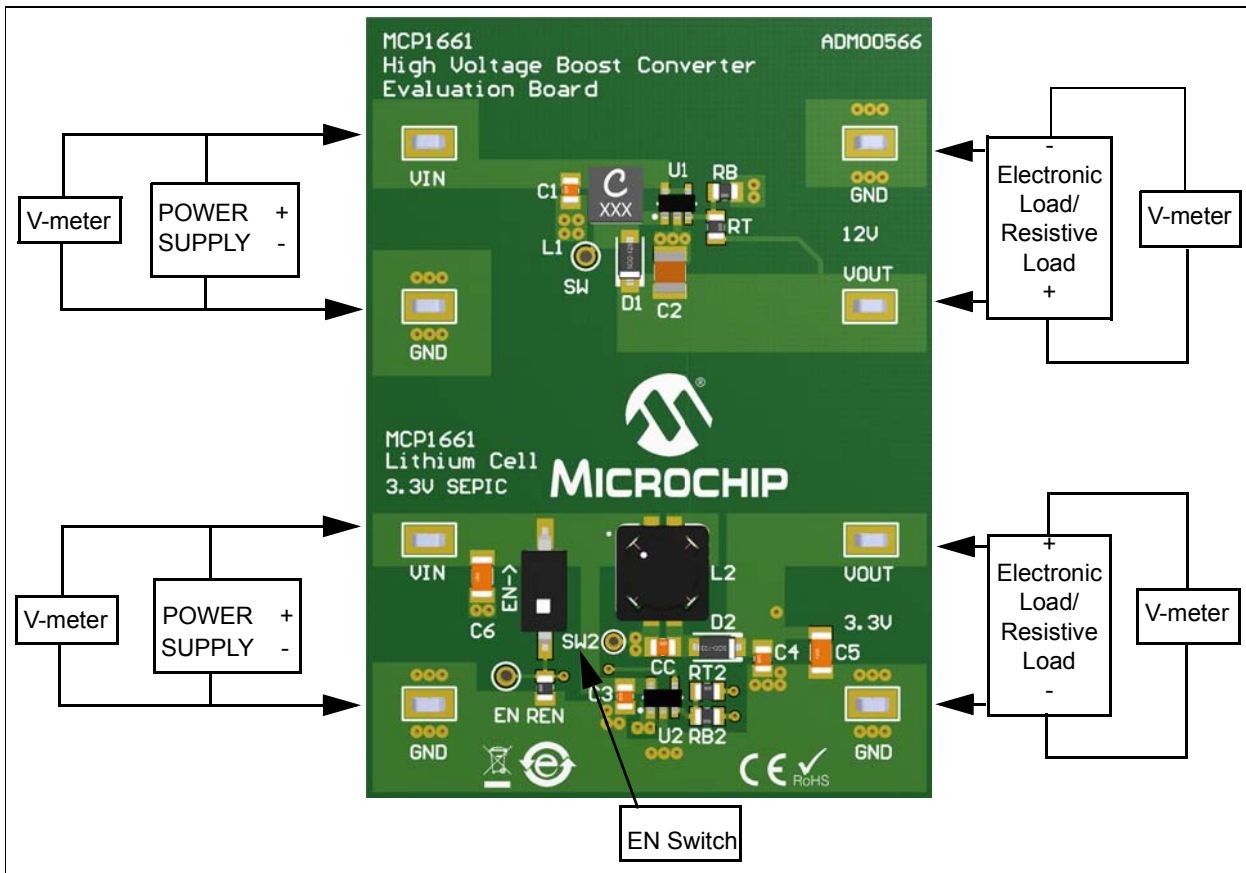


FIGURE 2-4: MCP1661 High Voltage Boost Converter & SEPIC Converter Evaluation Board Setup.

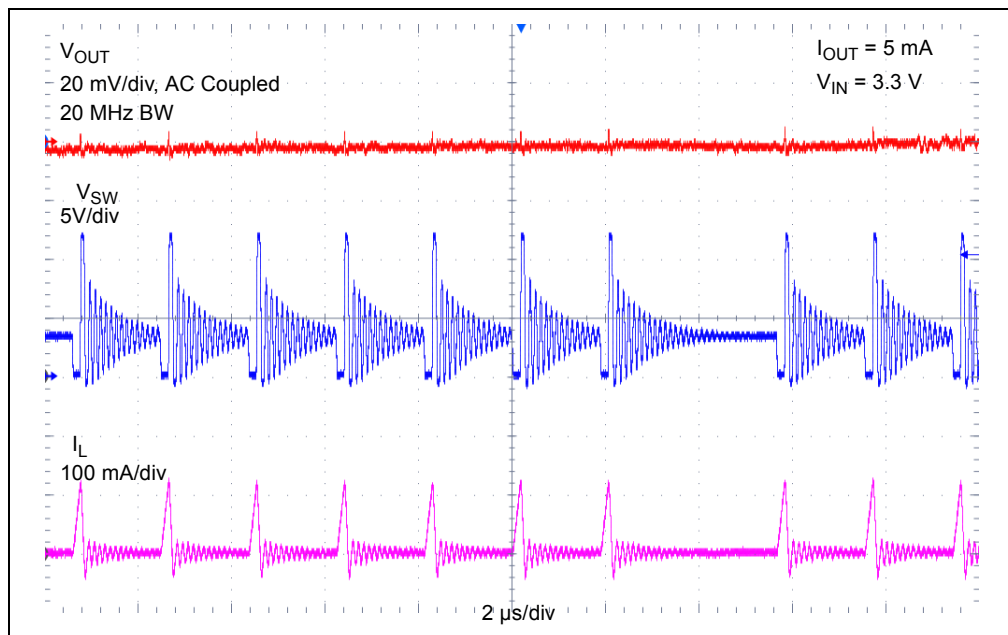


FIGURE 2-5: MCP1661 12.0V V_{OUT} Light Load PWM Mode Waveforms.

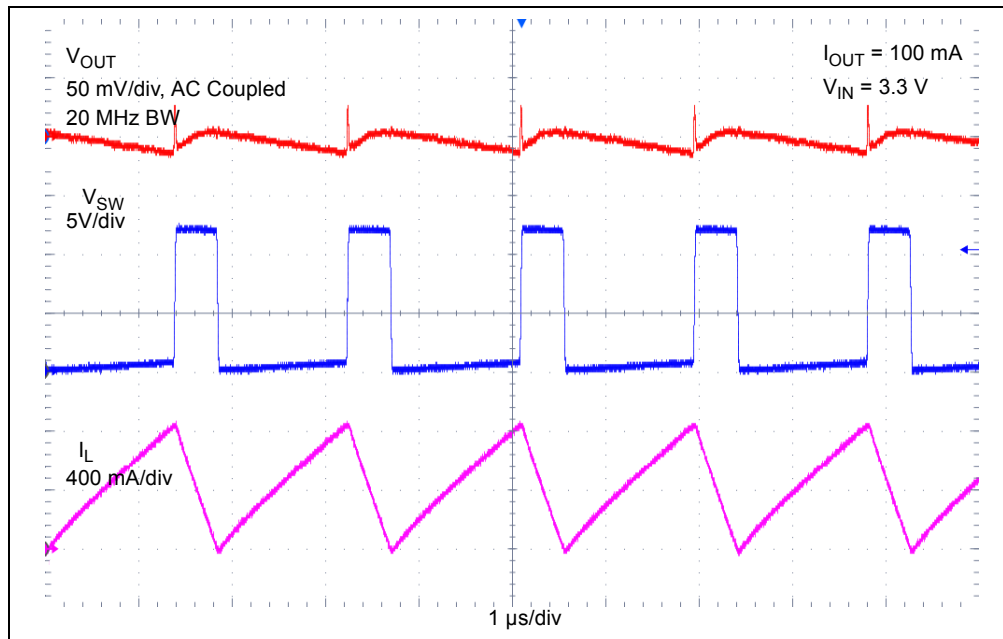


FIGURE 2-6: MCP1661 12V V_{OUT} High Load PWM Mode Waveforms.

2.2.1.3 ADJUSTABLE V_{OUT} SETTING

The board comes with the output value set to 12V and 3.3V respectively. If a different output is desired, the resistor divider consisting of R_T and R_B (R_{T2} and R_{B2} for the SEPIC application respectively) is used to set the converter output voltage. The value of the resistors can be calculated using Equation 2-1. For output voltages higher than 15V, the inductor value should also be increased. See Table 2-1 for more information.

EQUATION 2-1:

$$R_T = R_B \times \left[\left(\frac{V_{OUT}}{V_{FB}} \right) - 1 \right]$$

Where: $V_{FB} = 1.227V$

TABLE 2-1: RESISTOR DIVIDER AND INDUCTOR VALUES

V_{OUT}	Inductor Value	R_T	R_B
6.0V	4.7 μH	1050 k Ω	270 k Ω
9.0V	4.7 μH	1000 k Ω	160 k Ω
12V	4.7 μH	1050 k Ω	120 k Ω
24V	10 μH	1050 k Ω	56 k Ω
32V	10 μH	1100 k Ω	43 k Ω



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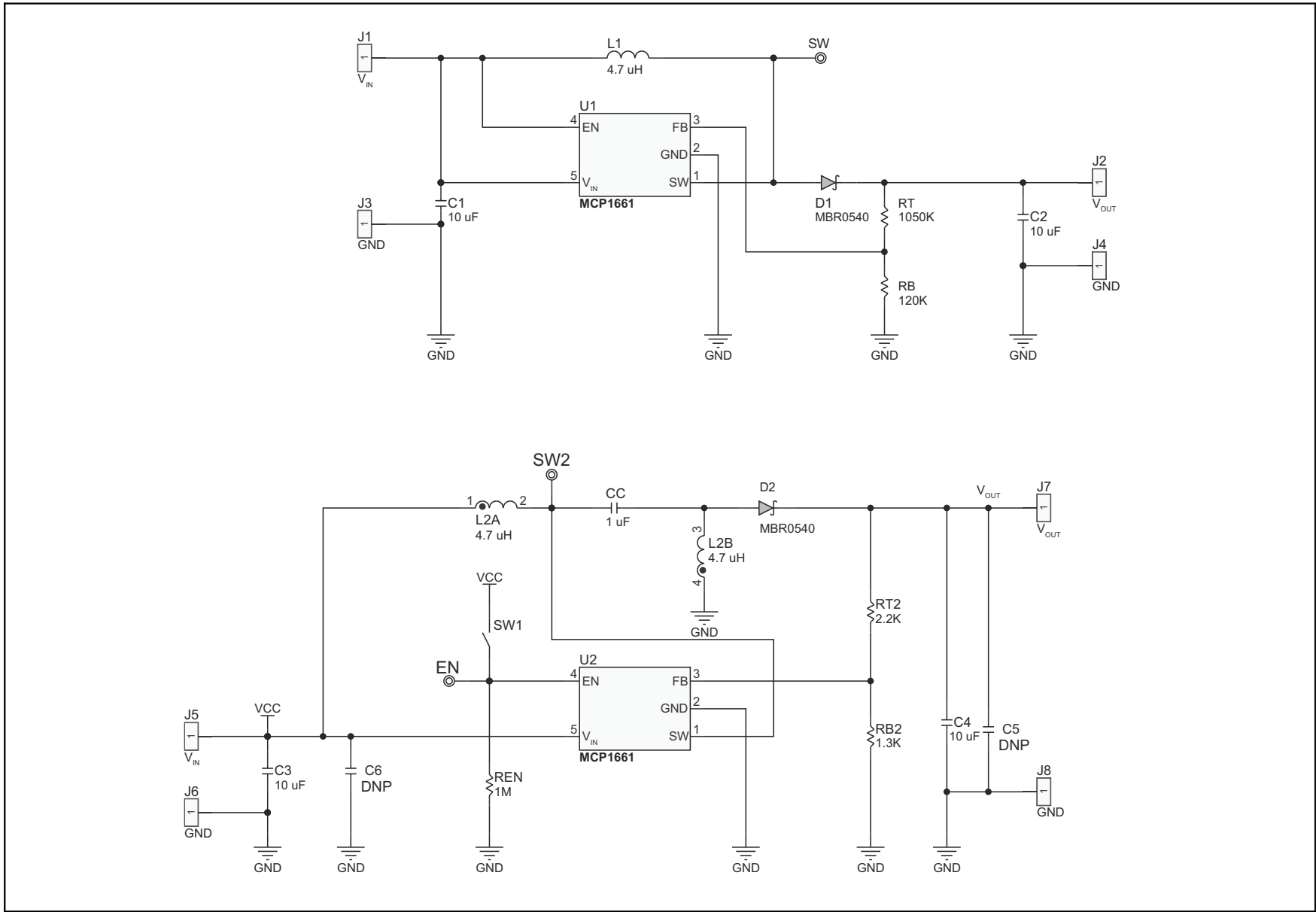
Appendix A. Schematic and Layouts

A.1 INTRODUCTION

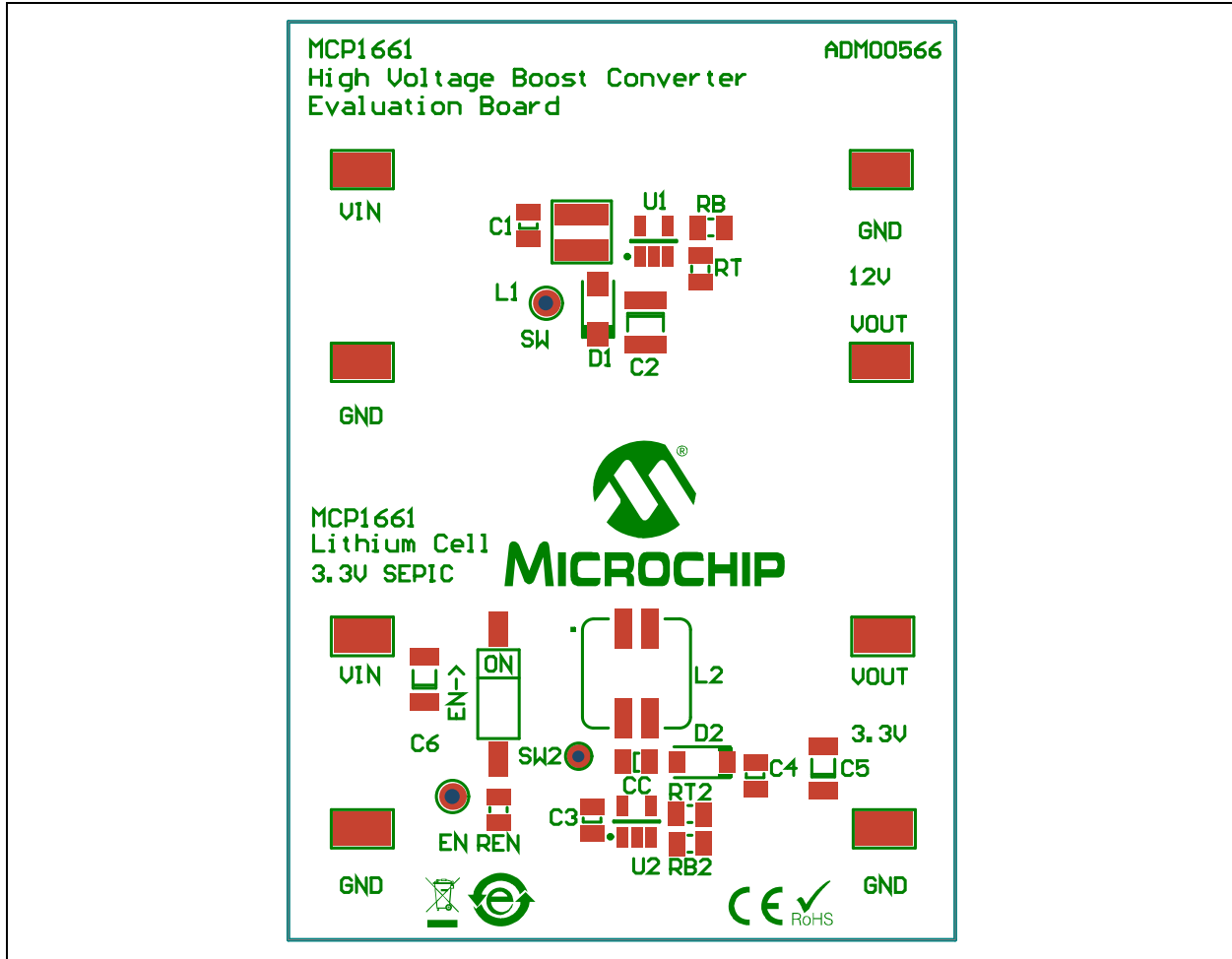
This appendix contains the following schematics and layouts for the MCP1661 High-Voltage Boost and SEPIC Converters Evaluation Board:

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

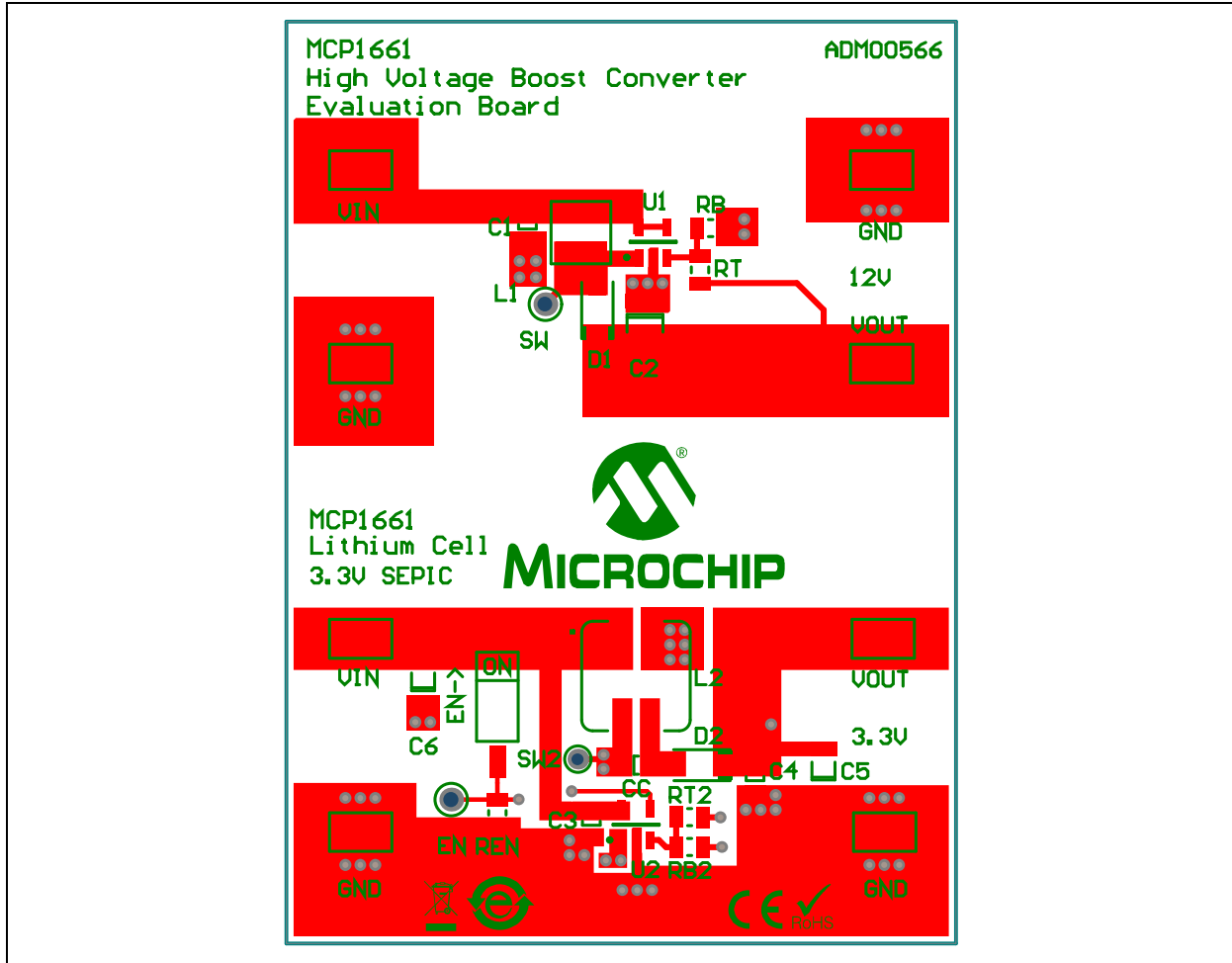
A.2 BOARD – SCHEMATIC



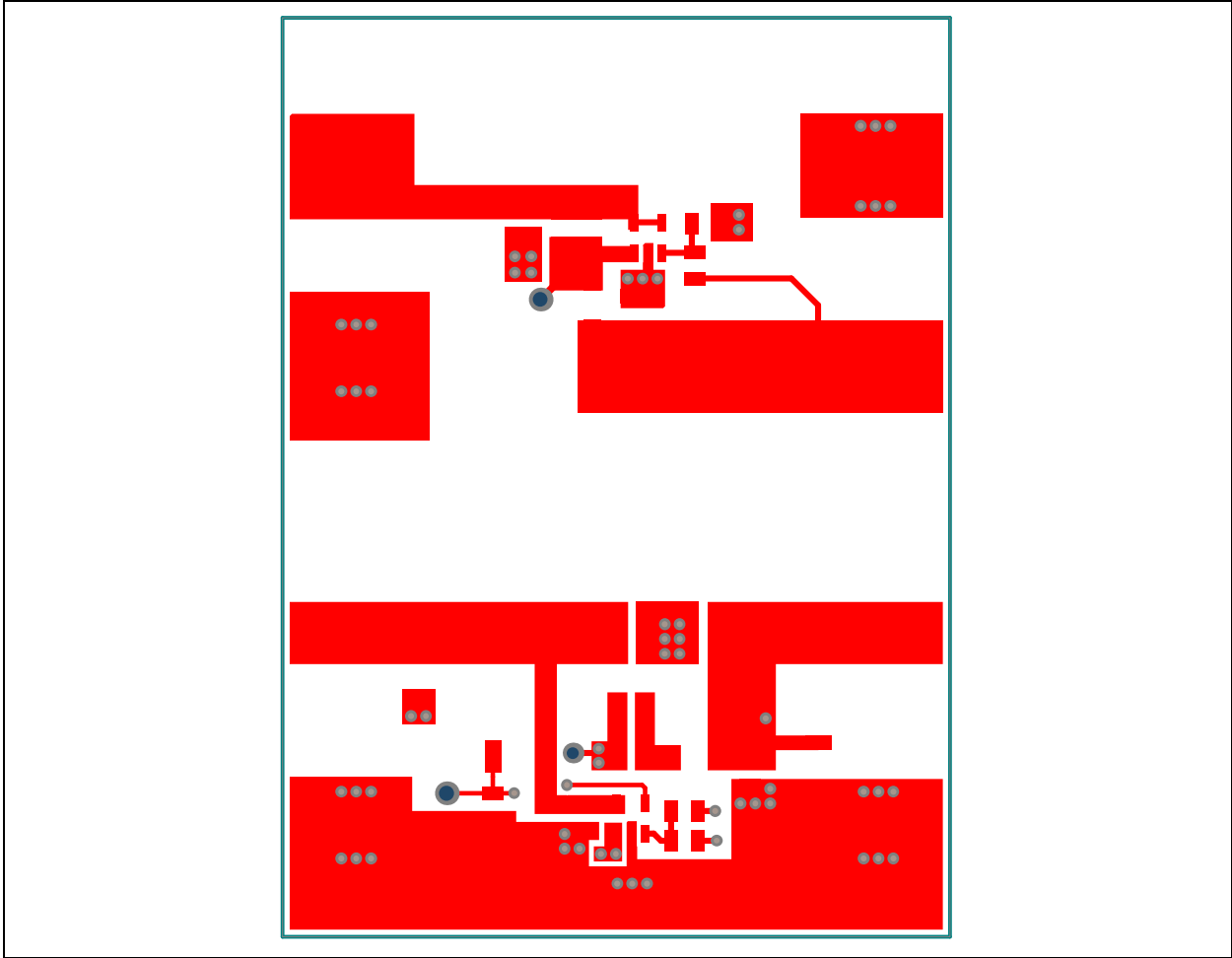
A.3 BOARD – TOP SILK



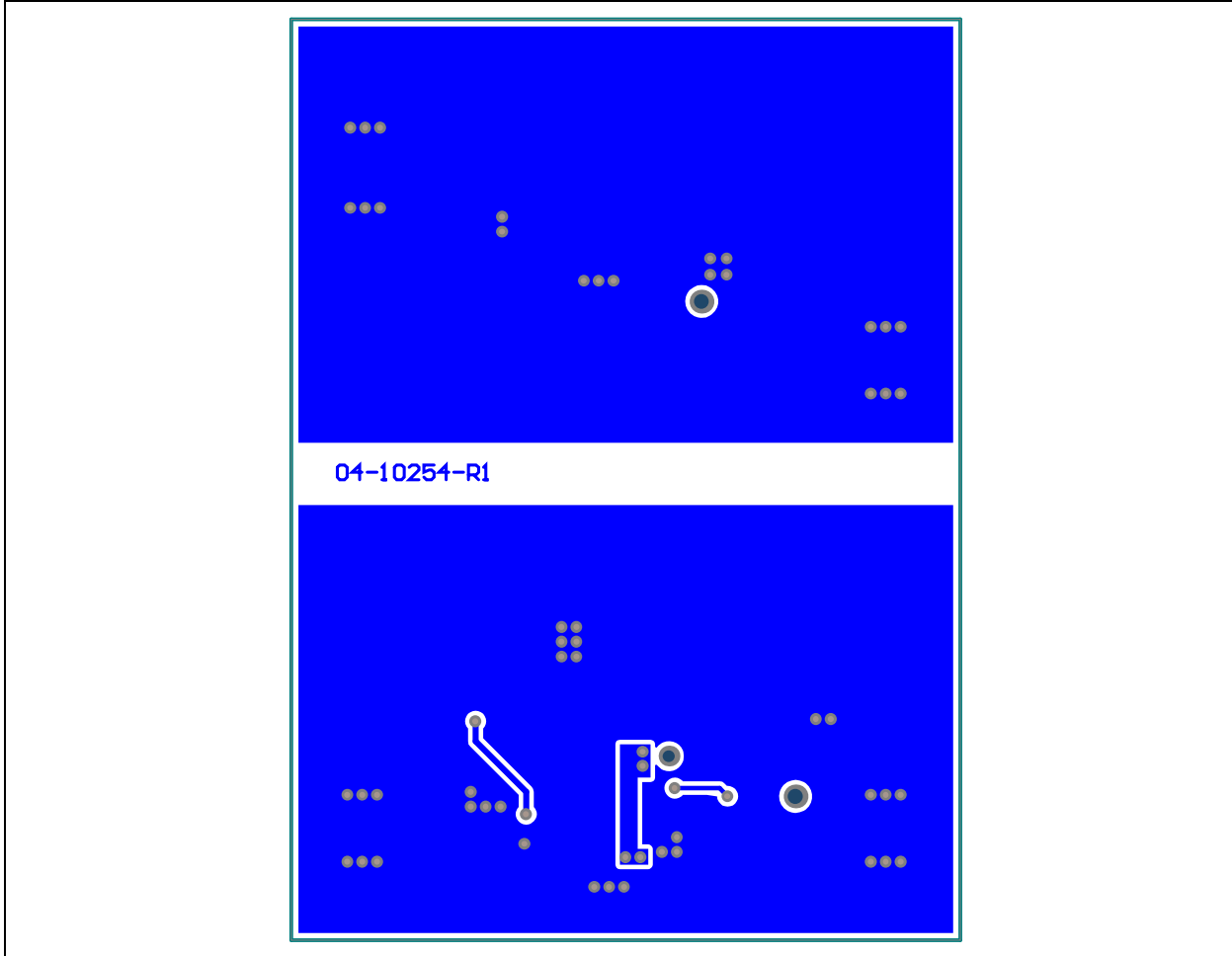
A.4 BOARD – TOP SILK AND COPPER



A.5 BOARD – TOP COPPER



A.6 BOARD – BOTTOM COPPER





MCP1661 HIGH-VOLTAGE BOOST AND SEPIC CONVERTERS EVALUATION BOARD USER'S GUIDE

Appendix B. Bill of Materials (BOM)

TABLE B-1: BILL OF MATERIALS (BOM)

Qty.	Reference	Description	Manufacturer	Part Number
3	C1, C3, C4	Cap. ceramic 10 μ F 10V 10% X7R 0805	TDK Corporation	C2012X7R1A106K125AC
1	C2	Cap. ceramic 10 μ F 25V 20% X7R 1210	TDK Corporation	C3225X7R1E106M250AC
1	CC	Cap. ceramic 1 μ F 25V 10% X7R 0805	TDK Corporation	C2012X7R1E105K125AB
2	D1, D2	Diode Schottky 40V 0.5A SOD123	Micro Commercial Components	MBR0540TPMSCT-ND
8	J1, J2, J3, J4, J5, J6, J7, J8	PC Test Point Tin SMD	Harwin Plc.	S1751-46R
1	L1	Inductor 4.7 μ H 2A 20% SMD XFL4020	Coilcraft	XFL4020-472MEB
1	L2	Coupled Inductor SEPIC/CUK 4.7 μ H	Würth Elektronik	744878004
1	RB	Resistor 120 k Ω 1/8W 1% 0805 SMD	Yageo Corporation	RC0805FR-07120KL
1	RB2	Resistor 1.30 k Ω 1/8W 1% 0805 SMD	Yageo Corporation	RC0805FR-071K3L
1	REN	Resistor 1.00 M Ω 1/8W 1% 0805 SMD	Yageo Corporation	RC0805FR-071ML
1	RT	Resistor 1.05 M Ω 1/8W 1% 0805 SMD	Yageo Corporation	RC0805FR-071M05L
1	RT2	Resistor 2.20 k Ω 1/8W 1% 0805 SMD	Yageo Corporation	RC0805FR-072K2L
1	SW1	Switch SPST 24V 25 mA 418121270801 SMD	Würth Elektronik	418121270801
2	U1, U2	High Voltage Boost Converter	Microchip Technology Inc.	MCP1661T-E/OT

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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