MCP16301
High Voltage Buck-Boost Demo Board User's Guide

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MCP16301 HIGH VOLTAGE BUCK-BOOST DEMO 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 "DSXXXXXA", where "XXXXX" 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 MCP16301 High Voltage Buck-Boost Demo 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 MCP16301 High Voltage Buck-Boost Demo Board. The manual layout is as follows:

- **Chapter 1. "Product Overview"** – Important information about the MCP16301 High Voltage Buck-Boost Demo Board.
- **Chapter 2. "Installation and Operation"** – Includes instructions on how to get started with the MCP16301 High Voltage Buck-Boost Demo Board and a description of the user's guide.
- **Appendix A. "Schematic and Layouts"** – Shows the schematic and layout diagrams for the MCP16301 High Voltage Buck-Boost Demo Board.
- **Appendix B. "Bill of Materials"** – Lists the parts used to build the MCP16301 High Voltage Buck-Boost Demo 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 MCP16301 High Voltage Buck-Boost Demo Board. Other useful documents are listed below. The following Microchip documents are available and recommended as supplemental reference resources.

- **MCP16301 Data Sheet –** ***"High Voltage Input Integrated Switch Step-Down Regulator"*** **(DS25004)**

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

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

DOCUMENT REVISION HISTORY

Revision A (January 2012)

- Initial Release of this Document.

NOTES:

Chapter 1. Product Overview

1.1 INTRODUCTION

This chapter provides an overview of the MCP16301 High Voltage Buck-Boost Demo Board and covers the following topics:

- MCP16301 Short Overview
- What is the MCP16301 High Voltage Buck-Boost Demo Board?
- MCP16301 High Voltage Buck-Boost Demo Board Kit Contents

1.2 MCP16301 SHORT OVERVIEW

The MCP16301 is a highly integrated, high-efficiency, fixed frequency, step-down DC-DC converter in a popular 6-pin SOT23 package that operates from input voltage sources up to 30V. Integrated features include a high-side switch, fixed-frequency peak-current mode control, internal compensation, peak current limit and over-temperature protection. Minimal external components are necessary to develop a complete step-down DC-DC converter power supply.

High converter efficiency is achieved by integrating the current limited, low resistance, high-speed N-Channel MOSFET and associated drive circuitry. High switching frequency minimizes the size of external filtering components resulting in a small solution size.

The MCP16301 can supply 600 mA of continuous current while regulating the output voltage from 2.0V to 15V. An integrated high performance, peak-current mode architecture keeps the output voltage tightly regulated, even during input voltage steps and output current transient conditions that are common in power systems.

With the addition of a MOSFET driver, an external N-channel MOSFET and a second Schottky diode, the MCP16301 can function properly as a buck-boost converter.

The capabilities of this buck-boost converter are an input voltage range of 5V to 30V, an output voltage range of 2V to 30V and an output current dependent upon V_{IN}. The typical maximum output current for a 12V output can be seen in **Figure 2-1: "Typical Maximum Output Current vs. Input Voltage"**.

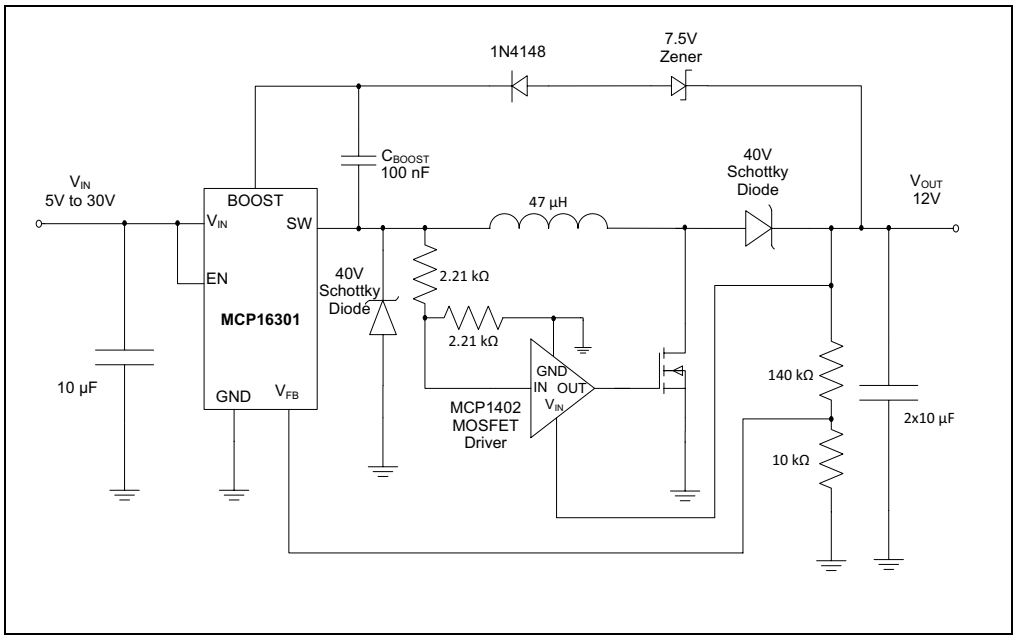


FIGURE 1-1: *Typical MCP16301 Buck-Boost Application.*

1.3 WHAT IS THE MCP16301 HIGH VOLTAGE BUCK-BOOST DEMO BOARD?

The MCP16301 High Voltage Buck-Boost Demo Board is designed to operate from a 5V to 30V input and regulate the output to 12V. Test points for input power and load are provided to demonstrate the capability of the demo board over the entire range. The MCP16301 High Voltage Buck-Boost Demo Board was designed using small surface-mount components to show application size for a high voltage buck-boost design.

1.4 MCP16301 HIGH VOLTAGE BUCK-BOOST DEMO BOARD KIT CONTENTS

This MCP16301 High Voltage Buck-Boost Demo Board kit includes the following items:

- MCP16301 High Voltage Buck-Boost Demo Board, 102-00399
- Important Information Sheet

Chapter 2. Installation and Operation

2.1 INTRODUCTION

2.1.1 MCP16301 Features

The MCP16301 device has been developed to provide high input voltage applications with a precise regulated rail while operating at high efficiency.

The key features of the MCP16301 include:

- Up to 96% Typical Efficiency
- Input Voltage Range: 4.0V to 30V
- Output Voltage Range: 2.0V to 15V
- 2% Output Voltage Accuracy
- Integrated N-Channel Switch: 460 mΩ
- 500 kHz Fixed Frequency
- Adjustable Output Voltage
- Low Device Shutdown Current
- Peak Current Mode Control
- Internal Compensation
- Stable with Ceramic Capacitors
- Internal Soft-Start
- Cycle-by-Cycle Peak Current Limit
- Under Voltage Lockout (UVLO): 3.5V
- Overtemperature Protection
- Available Package: SOT23-6

A high performance peak-current mode control system is used to deliver fast response to sudden line and load changes.

2.1.1.1 MCP16301 HIGH VOLTAGE BUCK-BOOST DEMO BOARD FEATURES

The MCP16301 High Voltage Buck-Boost Demo Board is developed to demonstrate how the MCP16301 device operates as a Buck-Boost topology over a wide input voltage and load range. Test points are provided for input and output, allowing the demo board to be connected directly to a system.

The MCP1402 Tiny 500 mA, High-Speed Power MOSFET Driver is utilized to drive the external N-Channel MOSFET allowing the MCP16301 to buck and boost. The maximum output current of the MCP16301 High Voltage Buck-Boost Demo Board is dependent upon input voltage and inductance. The MCP16301 will regulate the output to 12V until the peak current in the inductor reaches the maximum-rated value. Figure 2-1 shows the typical maximum output current vs. input voltage for an output voltage of 12V.

A copper via connected to the EN input can be used to turn the MCP16301 on and off. Turning the device on (EN>1.4V) when the undervoltage lockout threshold is met (V_{IN}>3.5V), will enable the device.

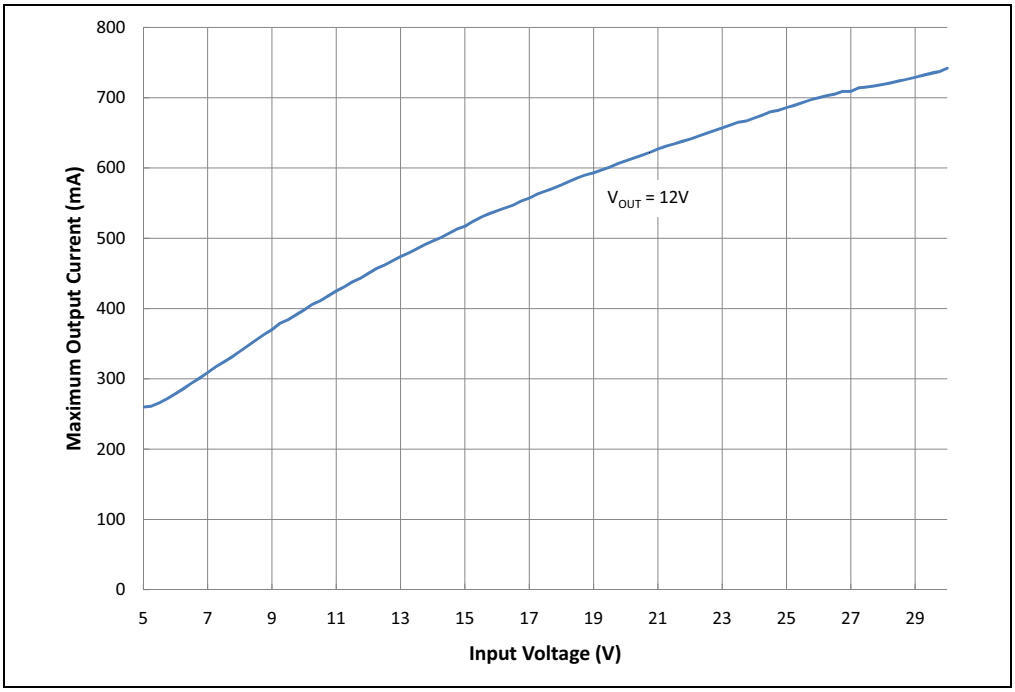


FIGURE 2-1: *Typical Maximum Output Current vs. Input Voltage*

2.2 GETTING STARTED

The MCP16301 High Voltage Buck-Boost Demo Board is fully assembled and tested to evaluate and demonstrate the MCP16301 operation in a buck-boost topology.

2.2.1 Power Input and Output Connection

2.2.1.1 POWERING THE MCP16301 HIGH VOLTAGE BUCK-BOOST DEMO BOARD

The MCP16301 High Voltage Buck-Boost Demo Board is fully assembled, tested and ready to begin evaluation. Apply positive input voltage to the V_{IN} terminal and its return to the GND terminal. The maximum input voltage should not exceed 30V. An electronic load or resistive load can be used for evaluation or the intended system load can be connected. Electronic loads attempt to sink current at 0V during startup, a resistive load or constant resistance is recommended for startup evaluation. Connect the positive voltage terminal of the load to the V_{OUT} terminal on the demo board and connect the negative or return side of the load to the GND terminal.

2.2.1.2 BOARD TESTING

To test the board, follow the next steps:

1. Apply input voltage.
2. An internal pull up resistor is connected from V_{IN} to the EN input of the MCP16301, once the input voltage is greater than 3.5V the device will begin to switch. Apply greater than 5V to the input for proper operation, a minimum load is required to regulate the output to 12V. Detailed information is provided in the MCP16301 data sheet (DS25004) for minimum load requirements for light load conditions.
3. The measured output voltage should be 12V typical, adjusting the input voltage and load should not cause the output to vary more than a few mV over the operating range of the converter.

2.2.1.3 HOW THE MCP16301 HIGH SIDE DRIVE BOOST CIRCUIT OPERATES

The MCP16301 integrates a low resistance N-Channel MOSFET. A high side or floating supply is needed to drive the gate of the N-Channel MOSFET above the input voltage to turn it on. The demo board uses the output voltage and a 7.5V zener diode to charge the boost cap while the inductor current flows, clamping the SW node to a diode drop below ground. Prior to startup, there is no inductor current, so an internal precharge circuit charges the boost cap up to a minimum threshold. Once charged, the N-Channel can be turned on, ramping current into the inductor.

The worst case operating conditions, for charging the boost capacitor, occur at minimum V_{IN} and no load. At minimum V_{IN} (5V), there is not enough head room to precharge the boost cap to a satisfactory value. At no load, the converter is operating at a minimum or very low duty cycle, putting a small amount of current into the inductor. When the switch turns off, the inductor current decays very quickly, resulting in a short time to recharge the boost capacitor.

NOTES:

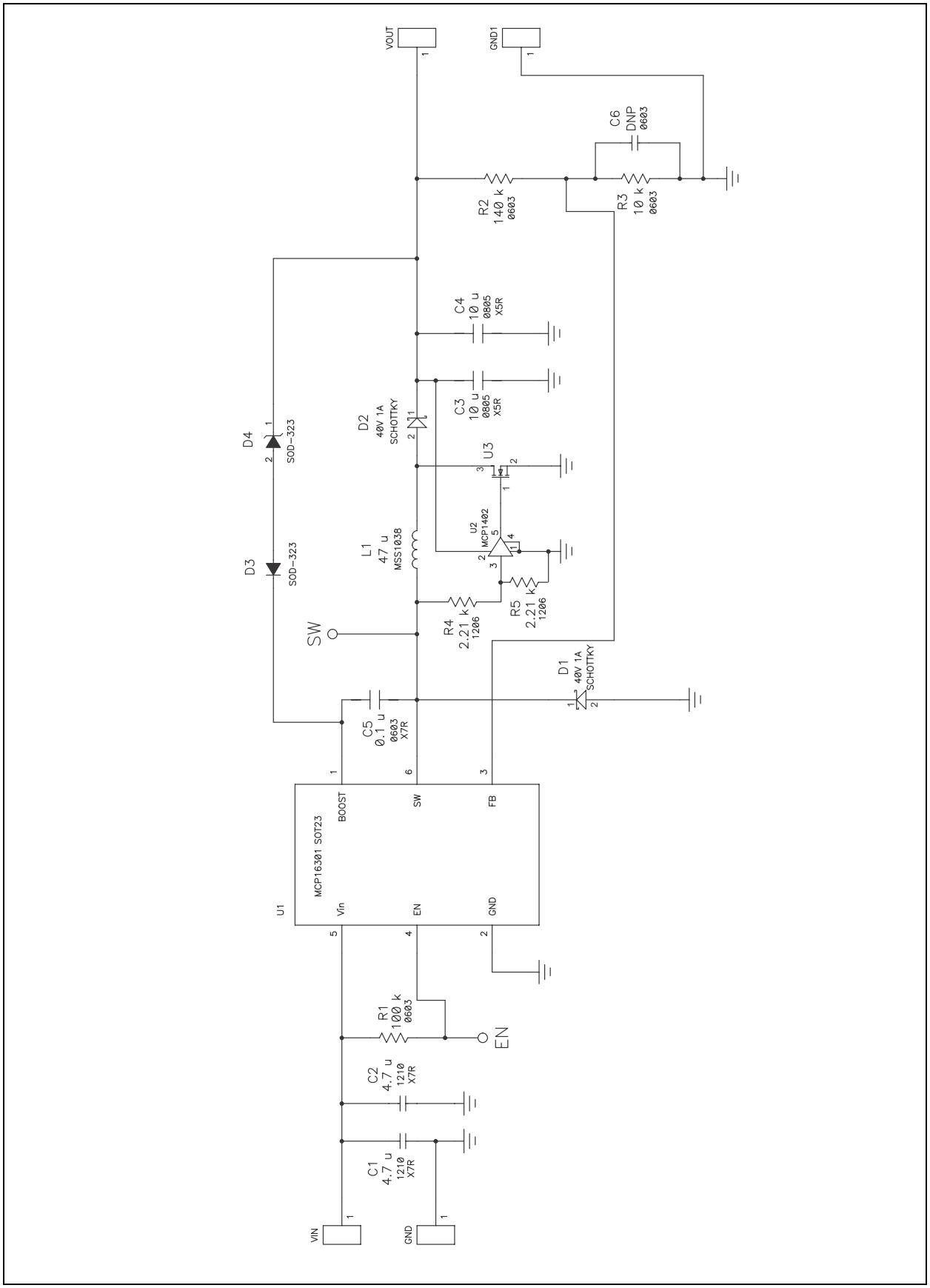
Appendix A. Schematic and Layouts

A.1 INTRODUCTION

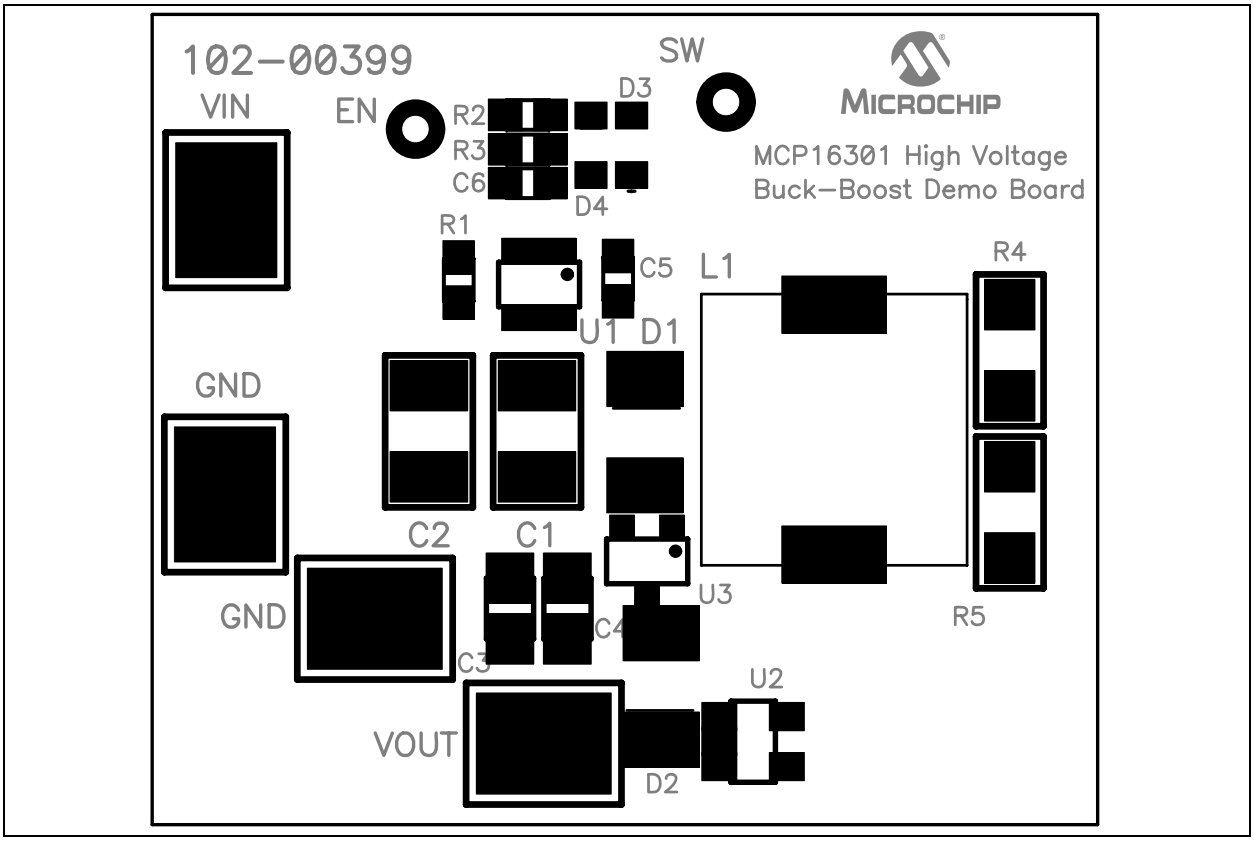
This appendix contains the following schematics and layouts for the MCP16301 High Voltage Buck-Boost Demo Board:

- Board – Schematic
- Board – Top Layer
- Board – Top Copper Layer
- Board – Bottom Copper Layer

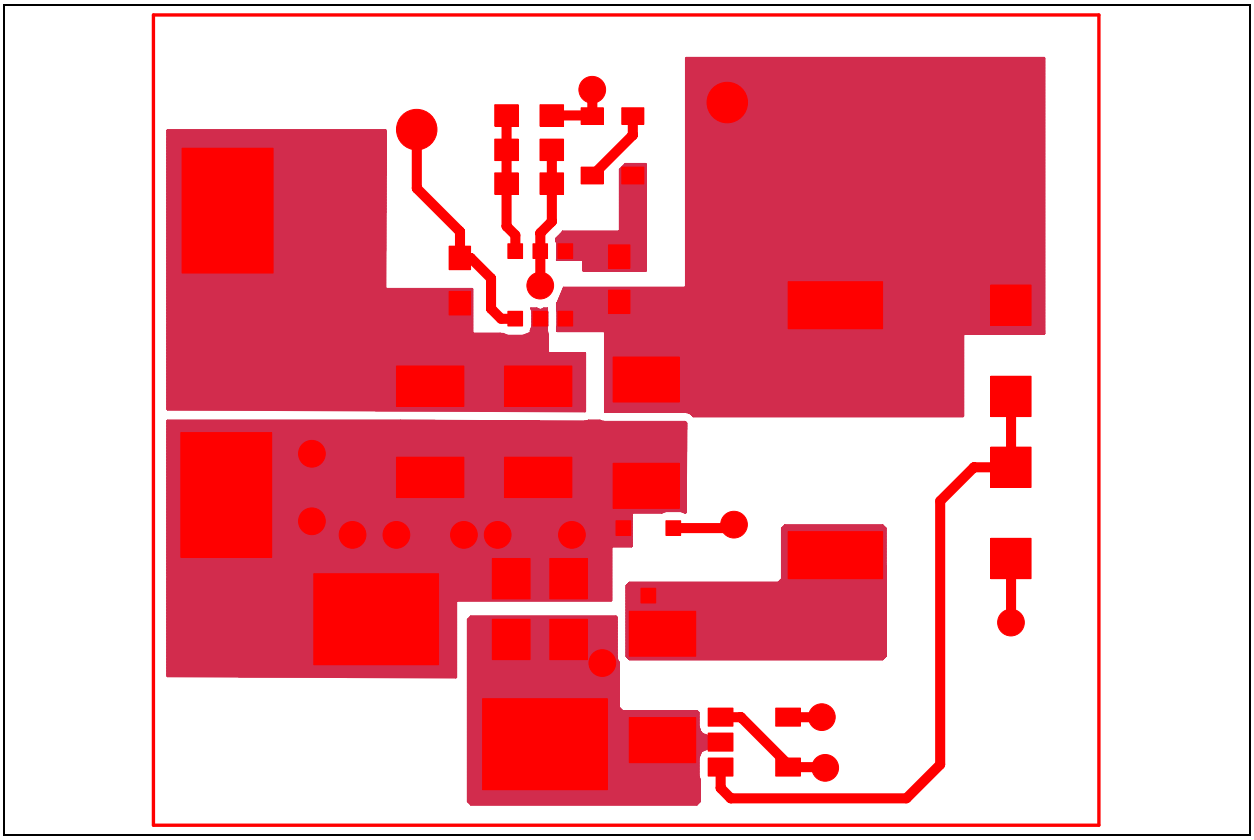
A.2 BOARD – SCHEMATIC



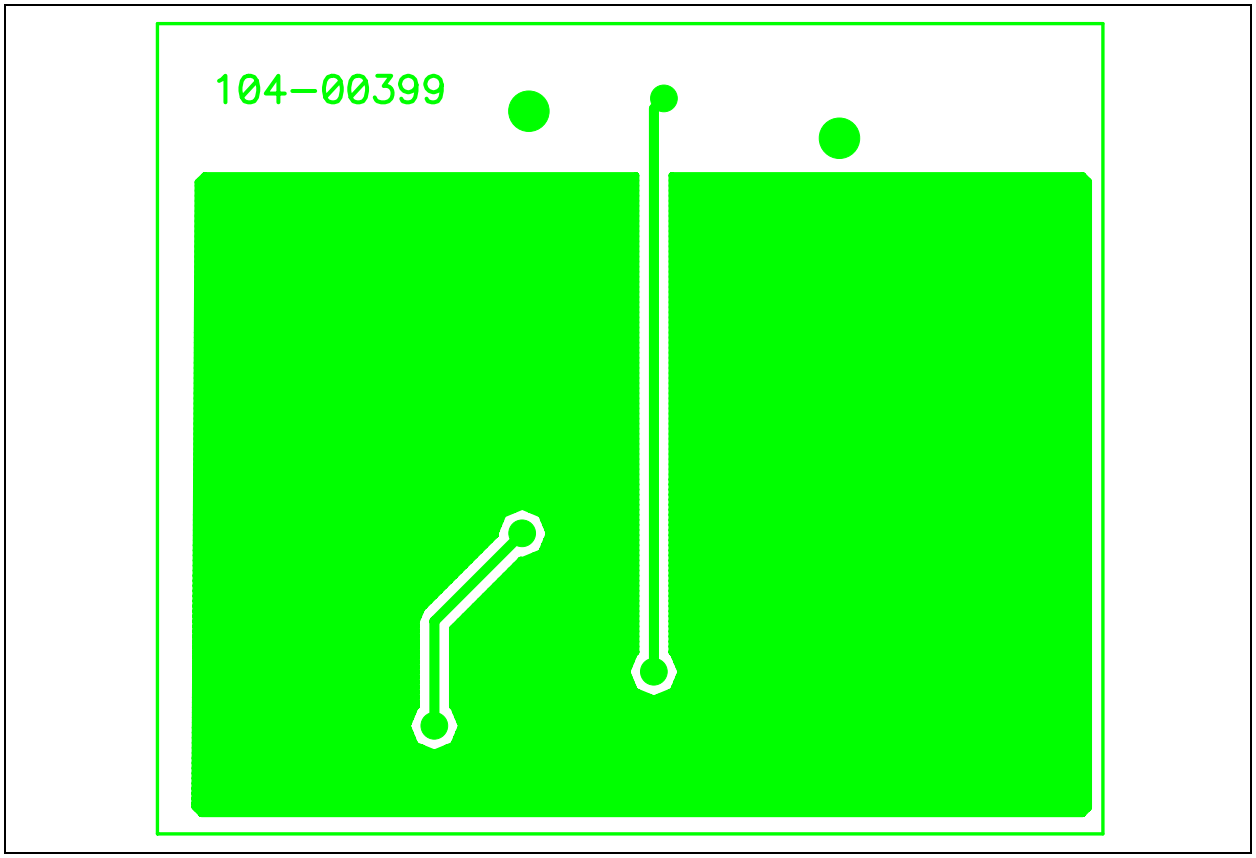
A.3 BOARD – TOP LAYER



A.4 BOARD – TOP COPPER



A.5 BOARD – BOTTOM COPPER



Appendix B. Bill of Materials

TABLE B-1: BILL OF MATERIALS (BOM)

Qty	Reference	Description	Manufacturer	Part Number
4		BUMPON SQUARE .40X.10 BLACK	3M	SJ5007-0-ND
1	–	RoHS Compliant Bare PCB, MCP16301 Buck-Boost	Microchip Technology Inc.	104-00399
2	C1; C2	CAP 4.7uF 50V CERAMIC X7R 1210 10%	Taiyo Yuden Co., Ltd.	587-2673-2-ND
2	C3;C4	CAP CER 10uF 16V X5R 0805	TDK Corporation	445-4115-1-ND
1	C5	CAP 0.1uF 16V CERAMIC X7R 0603 10%	AVX Corporation	478-1239-1-ND
1	C6	Not Installed. Do not populate.	–	–
1	D1; D2	DIODE SCHOTTKY 40V 1A SMA	Diodes Incorporated®	B140-FDICT-ND
1	D3	DIODE SWITCH 75V 200MW SOD-323	Diodes Incorporated	1N4448WS-FDICT-ND
1	D4	DIODE ZENER 7.5V 200MW SOD323	Diodes Incorporated	BZT52C7V5S-FDICT-ND
1	L1	MSS1038 47uH Shielded Power Inductor	Coilcraft	MSS1038-473ML
1	R1	RES 100K OHM 1/10W 1% 0603 SMD	Panasonic-ECG®	P100KHCT-ND
1	R2	RES 140K OHM 1/10W 1% 0603 SMD	Panasonic-ECG	P140KHCT-ND
1	R3	RES 10.0K OHM 1/10W 1% 0603 SMD	Panasonic-ECG	P10.0KHCT-ND
2	R4; R5	RES 2.21K OHM 1/4W 1% 1206 SMD	Panasonic-ECG	P2.21KFCT-ND
4	TP1;TP2; TP3;TP4	PC TEST POINT TIN SMD	Harwin PLC.	952-1478-1-ND
1	U1	MCP16301 High Voltage Input Buck Converter SOT23	Microchip Technology Inc.	MCP16301T-I/CHY
1	U2	MCP1402 Tiny 500 mA, High-Speed Power MOSFET Driver	Microchip Technology Inc.	MCP1402T-E/OT
1	U3	MOSFET N-CH 30V 2.7A SSOT3	Fairchild Semiconductor®	FDN359BNCT-ND

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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