MCP1665 12V Output Boost Regulator Evaluation Board User's Guide

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MCP1665 12V OUTPUT BOOST REGULATOR 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 "XXXXXXX" 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 MCP1665 12V Output Boost Regulator 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 MCP1665 12V Output Boost Regulator Evaluation Board as a development tool. The manual layout is as follows:

- **Chapter 1. "Product Overview"** – Important information about the MCP1665 12V Output Boost Regulator Evaluation Board.
- **Chapter 2. "Installation and Operation"** – Includes instructions on how to get started with the MCP1665 12V Output Boost Regulator Evaluation Board and a description of the user's guide.
- **Appendix A. "Schematic and Layouts"** – Shows the schematic and layout diagrams for the MCP1665 12V Output Boost Regulator Evaluation Board.
- **Appendix B. "Bill of Materials (BOM)"** – Lists the parts used to build the MCP1665 12V Output Boost Regulator 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 MCP1665 12V Output Boost Regulator Evaluation Board. Another useful document is listed below. The following Microchip document is available and recommended as a supplemental reference resource.

- **MCP1665 Data Sheet - "High-Voltage 3.6A Integrated Switch PFM/PWM Boost Regulator" (DS20005872A)**

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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://www.microchip.com/support.

DOCUMENT REVISION HISTORY

Revision A (October 2017)

- Initial Release of this Document.

NOTES:

Chapter 1. Product Overview

1.1 INTRODUCTION

This chapter provides an overview of the MCP1665 12V Output Boost Regulator Evaluation Board and covers the following topics:

- MCP1665 Device Overview
- What is the MCP1665 12V Output Boost Regulator Evaluation Board?
- What DOES the MCP1665 12V Output Boost Regulator Evaluation Board Kit Contain?

1.2 MCP1665 DEVICE OVERVIEW

The MCP1665 is a compact, high-efficiency, fixed-frequency, nonsynchronous step-up DC/DC converter that integrates a 36V, 100 mΩ NMOS switch. This product provides a space-efficient high-voltage step-up, easy-to-use power supply solution. The MCP1665 was developed for applications powered by Li-Ion or Li-Polymer batteries, three-cell alkaline, Energizer® Lithium Primary, Ni-Cd, Ni-MH or two-cell Lead-acid batteries.

The MCP1665 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 2.7V ($UVLO_{STOP}$) corresponding to the value of three discharged batteries. The MCP1665 starts its normal operation at 2.9V input voltage ($UVLO_{START}$), then the operating input voltage ranges from 2.7V up to 5V.

For standby applications, MCP1665 can be set in Shutdown by pulling the EN pin to GND. The device will stop switching and will consume tens of µA of input current including the feedback divider (the chip itself consumes approx.1 µA). In the Boost configuration, the input voltage will be bypassed to output through the inductor and the Schottky diode.

MCP1665 also provides two protection features:

- An open-load protection (OLP) in the event of:
  - Short-circuit of the feedback pin to GND
  - Disconnected feedback divider

  In these conditions, the OLP function stops the internal driver and prevents damaging the device and load. This feature is disabled during start-up sequence and Thermal Shutdown state.
- An overvoltage protection (OVP) in the event of feedback voltage increasing more than 5% above its nominal value, meant to protect the device and the load against excessive overshoots during load steps.

The goal of the MCP1665 12V Output Boost Regulator Evaluation Board is to demonstrate the higher output voltage and output current capabilities of the MCP1665 Boost Converter.

1.3 WHAT IS THE MCP1665 12V OUTPUT BOOST REGULATOR EVALUATION BOARD?

The MCP1665 12V Output Boost Regulator Evaluation Board was developed to help engineers reduce product design cycle time. It comes fully populated and ready to be tested with a typical 5V input and a 12V output.

Powering the board with a lower voltage in the permitted range can be done after inspecting the MCP1665 data sheet and adjusting the output current expectations accordingly.

The output voltage is set to the proper value using an external resistor divider, resulting in a simple and compact solution.

1.4 WHAT DOES THE MCP1665 12V OUTPUT BOOST REGULATOR EVALUATION BOARD KIT CONTAIN?

This MCP1665 12V Output Boost Regulator Evaluation Board kit includes:

- MCP1665 12V Output Boost Regulator Evaluation Board (ADM00865)
- Information Sheet

Chapter 2. Installation and Operation

2.1 INTRODUCTION

MCP1665 is a non-synchronous, fixed-frequency step-up DC/DC converter that has been developed for applications that require higher output voltage capabilities. MCP1665 can regulate the output voltage up to 32V and can deliver up to 1A to the load at 5V input and 12V output (see Figure 2-3).

At light loads, there are two ways the MCP1665 keeps its input current low. The first one is SKIPPING pulses to keep the output ripple low (this happens when the MODE pin is pulled to GND). The second one (when the MODE pin is pulled up to V_{IN}) is the PFM mode. This reduces the input current even further by completely stopping the switching as long as the output voltage remains within the permitted range. It comes at the cost of a higher output ripple, in the range of hundreds of millivolts.

The regulated output voltage (V_{OUT}) should be at least one volt higher than 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.

2.1.1 MCP1665 12V Output Boost Regulator Evaluation Board Features

The MCP1665 12V Output Boost Regulator Evaluation Board has the following features:

- Typical 12V Output when supplied from a low-input voltage source
- Input Voltage range (V_{IN}): 3V to 5V, with $V_{IN} < V_{OUT}$ -1V
- Output Current: max 1 A @ 12V Output with 5V Input
- Enabled state is selectable by using EN jumper
- Light-load power saving method is selectable by toggling the MODE switch
- Undervoltage Lockout (UVLO)
  - UVLO Start: 2.9V
  - UVLO Stop: 2.7V
- PWM/PFM Operation
- PWM Switching Frequency: 500 kHz
- Peak Input Current Limit of 3.6A (typical)
- Internal Compensation, so no compensation network is needed on the board
- Soft Start
- Protection in case of feedback pin shorted to GND
- Overtemperature Protection (if the die temperature exceeds +150°C, with 15°C hysteresis)

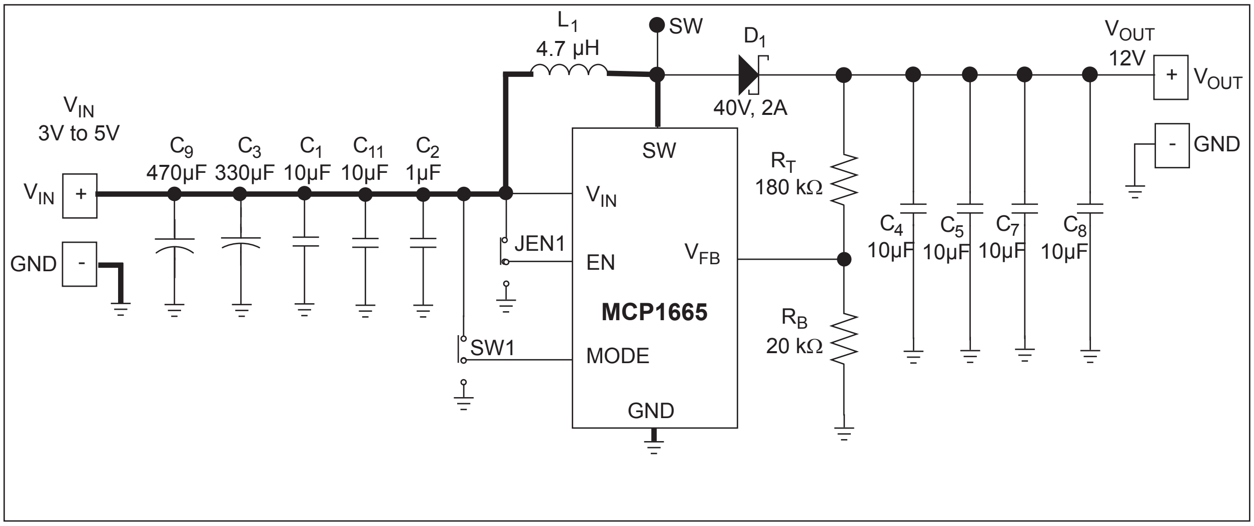


FIGURE 2-1: *MCP1665 Evaluation Board Schematic.*

2.2 GETTING STARTED

The MCP1665 12V Output Boost Regulator Evaluation Board is fully assembled and tested to evaluate and demonstrate the MCP1665 product capabilities. 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 MCP1665 12V OUTPUT BOOST REGULATOR EVALUATION BOARD

The MCP1665 12V Output Boost Regulator Evaluation Board was designed to evaluate the MCP1665 device.

Soldered test points and screw terminal blocks are available for the input voltage connections and for load connections. The switch peak current limit will provide a safe maximum current value. The maximum output current for the converter varies with input and output voltages; refer to Figure 2-3 or the MCP1665 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 2-2. The input voltage should not be higher than 5V.
2. Connect system load to V_{OUT} and GND terminals; maximum load varies with input and output voltage. Connect the (+) side of the load to V_{OUT} and the negative (–) side to ground (GND).
3. The MODE SELECT switch SW1 can be used to change between the two power saving modes:
   - PFM/PWM when the switch is in PFM position
   - PWM only, when the switch is in PWM position

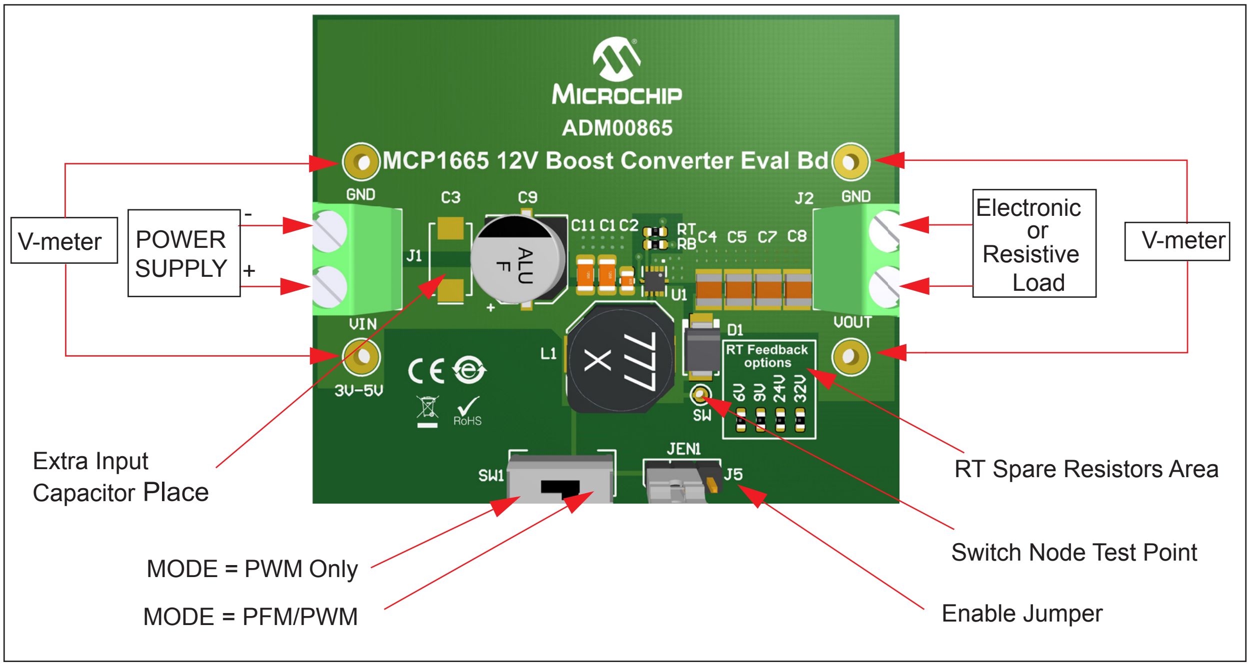


FIGURE 2-2: *MCP1665 12V Output Boost Regulator Evaluation Board Setup.*

2.2.1.3 ADJUSTABLE V_{OUT} SETTING

The top circuit comes with the output voltage set to 12V. If a different output is desired, recalculate the resistor divider (RT1 and RB1) using Equation 2-1.

Note that V_{IN} must be lower than V_{OUT} by at least 1 volt.

EQUATION 2-1:

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

Where: V_{FB} = 1.2V

For output voltages higher than 15V, the inductor value should be increased. See Table 2-1 for more information.

TABLE 2-1: RECOMMENDED RESISTOR DIVIDER AND INDUCTOR VALUES

V_{OUT}	Inductor Value	RT	RB
6.0V	4.7 µH	80.6 kΩ	20 kΩ
9.0V	4.7 µH	130 kΩ	20 kΩ
12V	4.7 µH	180 kΩ	20 kΩ
24V	10 µH	383 kΩ	20 kΩ
32V	10 µH	513 kΩ	20 kΩ

2.3 TEST RESULTS FOR TYPICAL APPLICATION USING MCP1665

2.3.1 Test Results for MCP1665

This chapter provides specific operation waveforms and graphs. Refer to the MCP1665 Data Sheet (DS20005872A) for more information.

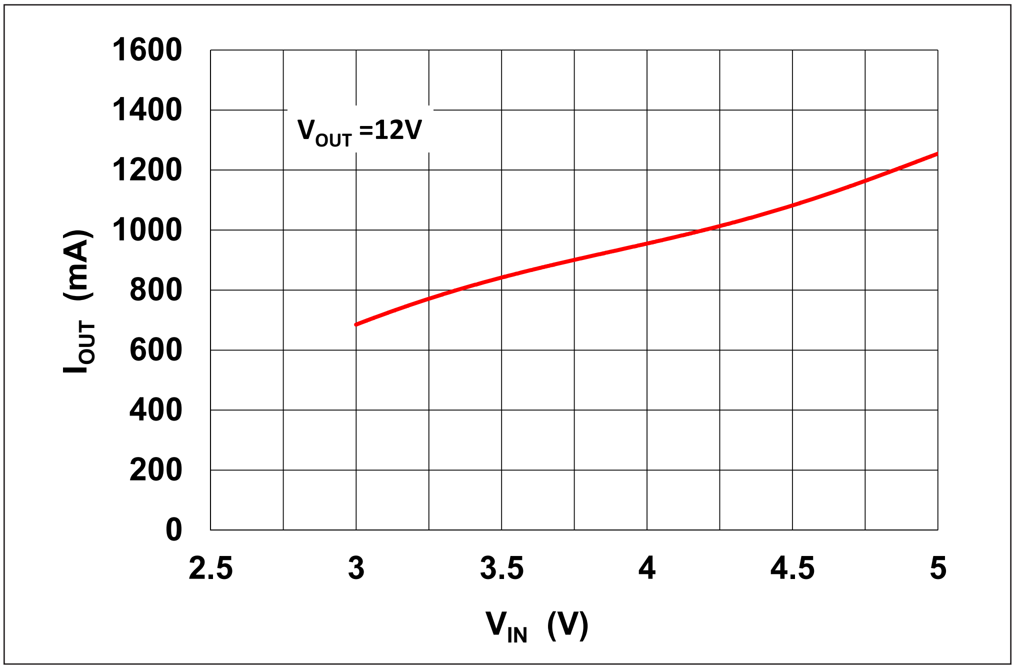


FIGURE 2-3: *MCP1665 Boost 12.0 V_{OUT} Maximum I_{OUT} vs. V_{IN} with Maximum 5% Output Drop.*

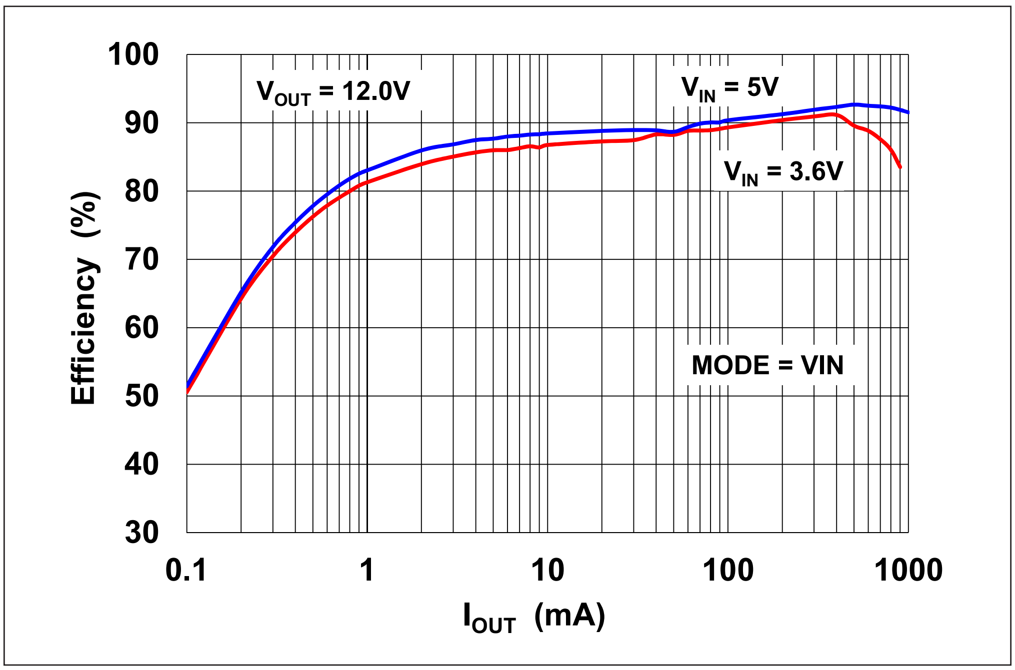


FIGURE 2-4: *MCP1665 12V Output Efficiency vs. I_{OUT}.*

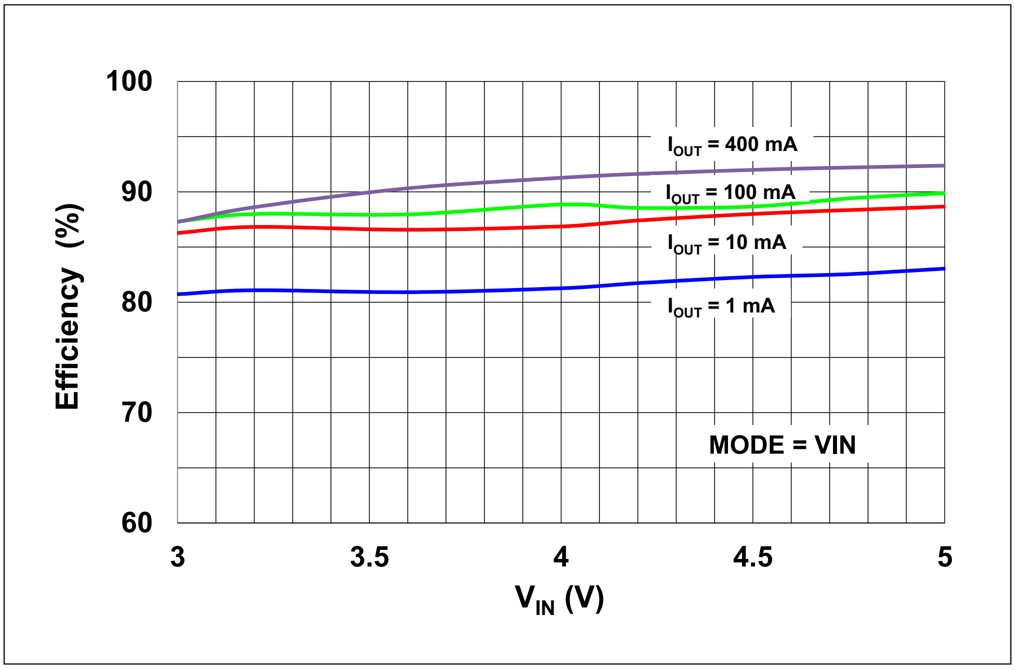


FIGURE 2-5: *MCP1665 12V Output Efficiency vs. V_{IN}.*

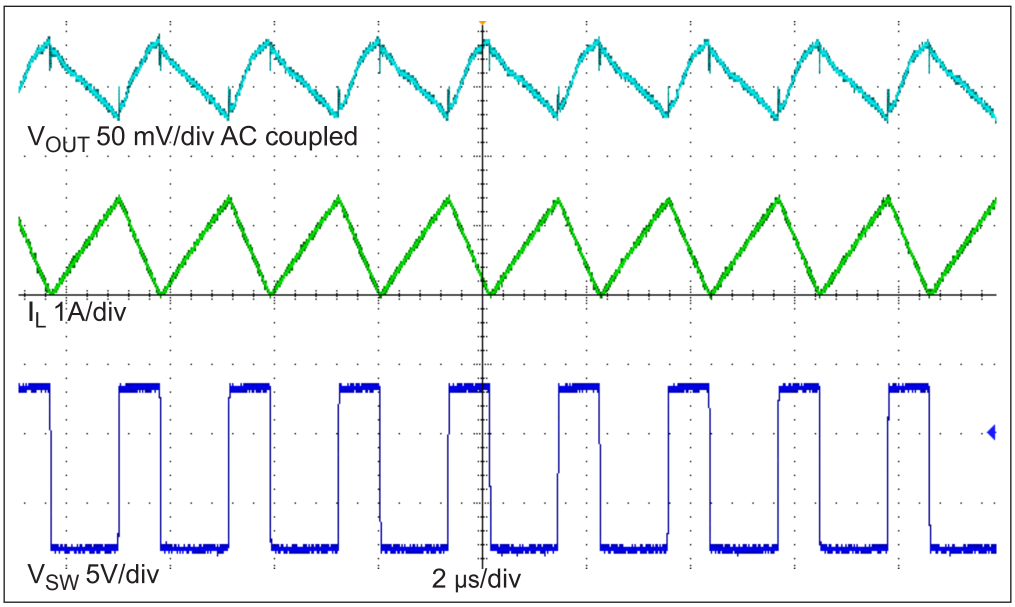


FIGURE 2-6: *MCP1665 12V Output 3.6V Input 1A Load Operation Waveform.*

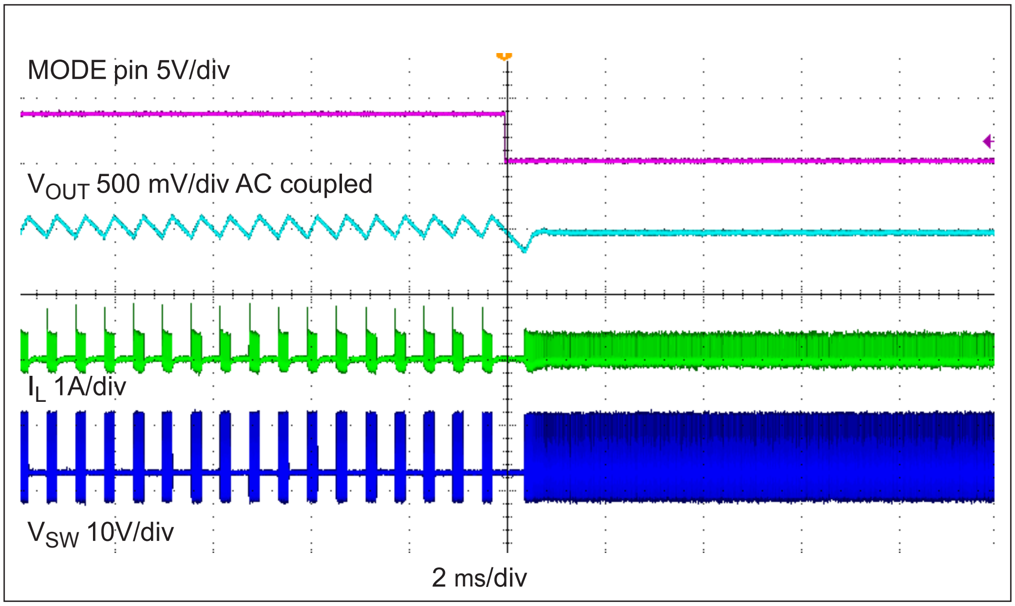


FIGURE 2-7: *MCP1665 PFM (MODE =HIGH) to Skipping (MODE=LOW) Transition at 12V Output 5V Input 10 mA Load.*

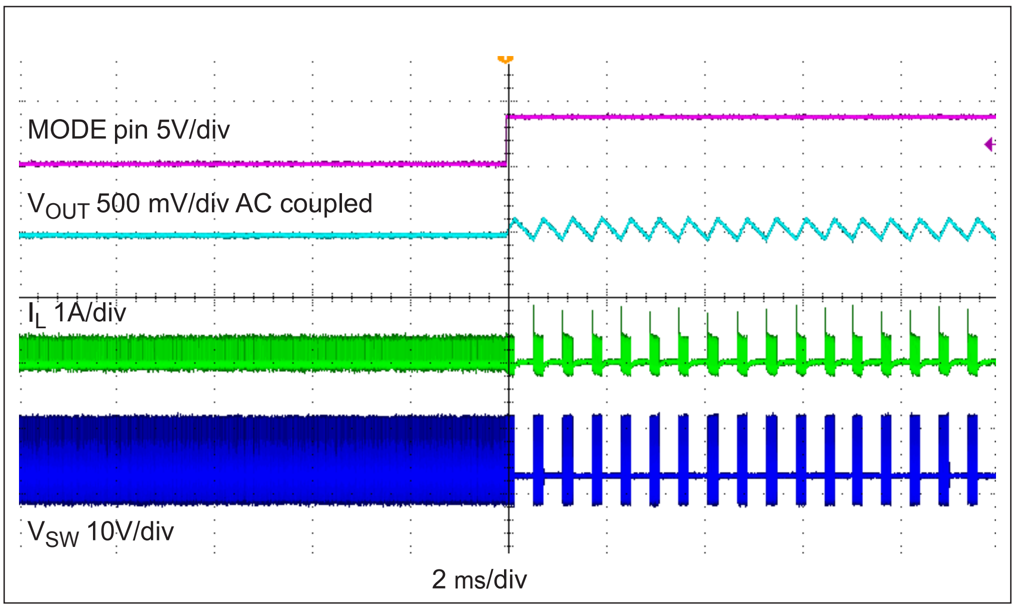


FIGURE 2-8: *MCP1665 Skipping (MODE=LOW) to PFM (MODE =HIGH) Transition at 12V Output 5V Input 10 mA Load.*

2.4 BATTERY CONSIDERATIONS

When considering the power solution for this design, select a battery carefully. The battery should be able to sustain the boost converter's input voltage even under the heaviest load expected. Currents in excess of 3 amps can be drawn by the MCP1665 boost converter's input and the power supply should be able to sustain its voltage.

Weak batteries may cause the MCP1665 input voltage to drop under the UVLO threshold and force the converter to work intermittently. Lithium and nickel cells are recommended. Input connections should be kept short and thick to maintain the boost converter's performance within the expected range.

2.5 EXTRA INPUT CAPACITANCE

An extra capacitor place (C3) is available on the MCP1665 12V Output Boost Regulator Evaluation Board (see Figure 2-2).

It is useful for input decoupling if, for some reason, the power supply's impedance can not be kept as low as needed. This includes, but is not limited to: longer wires, V_{IN} being derived from another power supply with a slow response, fast load, as well as stepping, causing high-input current spikes.

If intermittent operation or a bus-pumping behavior is noticed, this should be one of the first steps in troubleshooting. Check to see if the input voltage of the MCP1665 is permanently above the UVLO threshold. Probing the input voltage should be done by attaching the oscilloscope probes to the GND and VIN test points on the board.

The recommended BOM part to be soldered in the DNP position is a tantalum polymer 330 µF/10V capacitor with a low ESR.

2.6 RT SPARE RESISTORS AREA

The RT Feedback options board area contains the four spare R Top feedback resistors. The resistor values are chosen to closely match the four output voltage options labeled next to them (6V, 9V, 24V, 32V). These resistors should be soldered in the RT position on the board, by replacing the 12V option resistor provided by default.

NOTES:

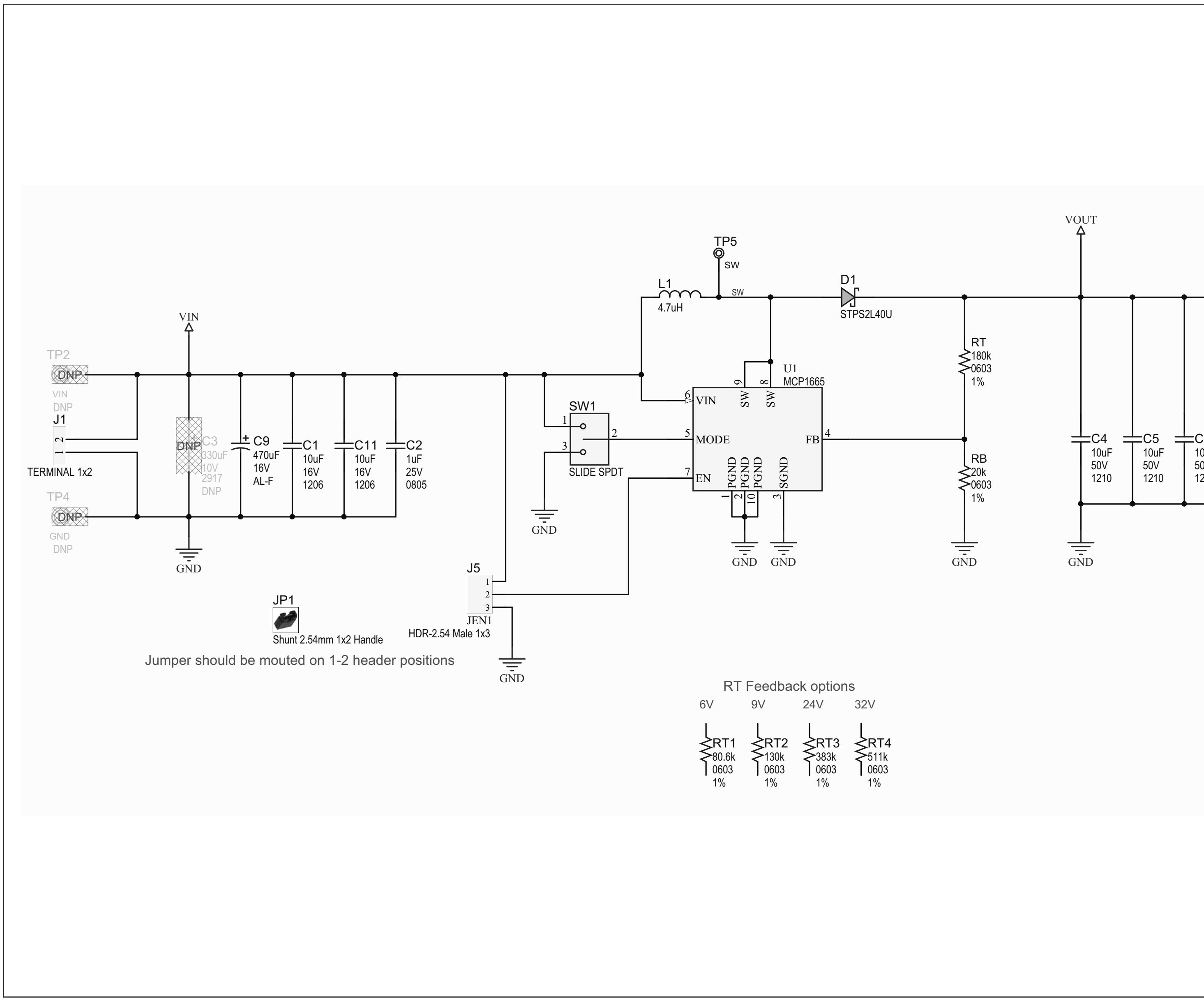
Appendix A. Schematic and Layouts

A.1 INTRODUCTION

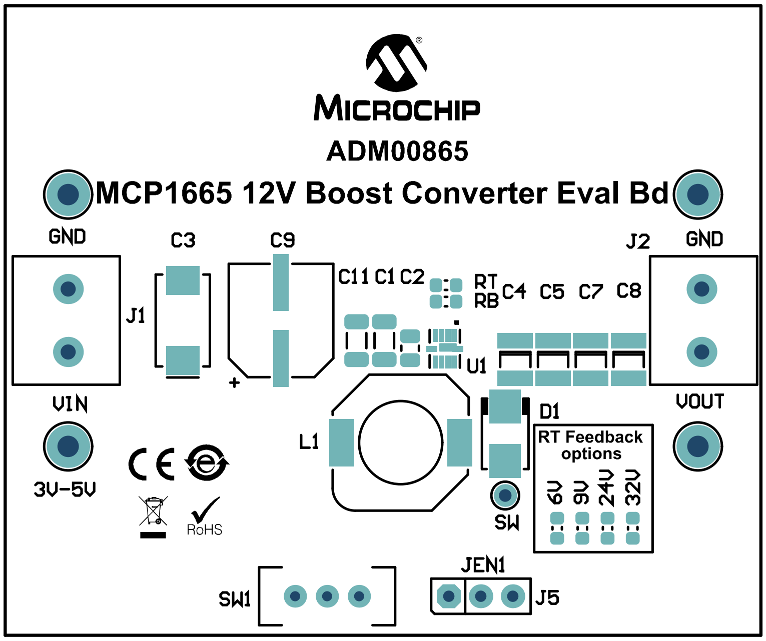
This appendix contains the following schematics and layouts for the MCP1665 12V Output Boost Regulator Evaluation Board:

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

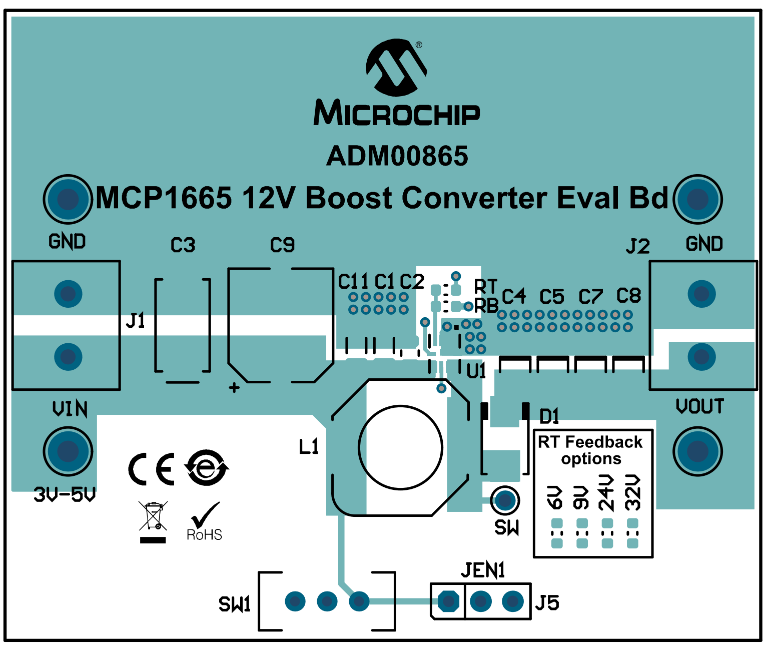
A.2 BOARD – SCHEMATIC



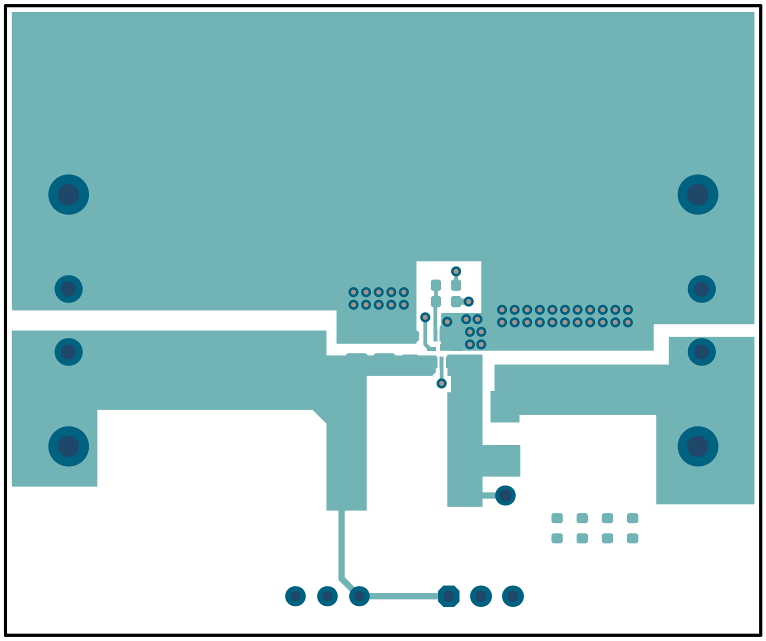
A.3 BOARD – TOP SILK AND PADS



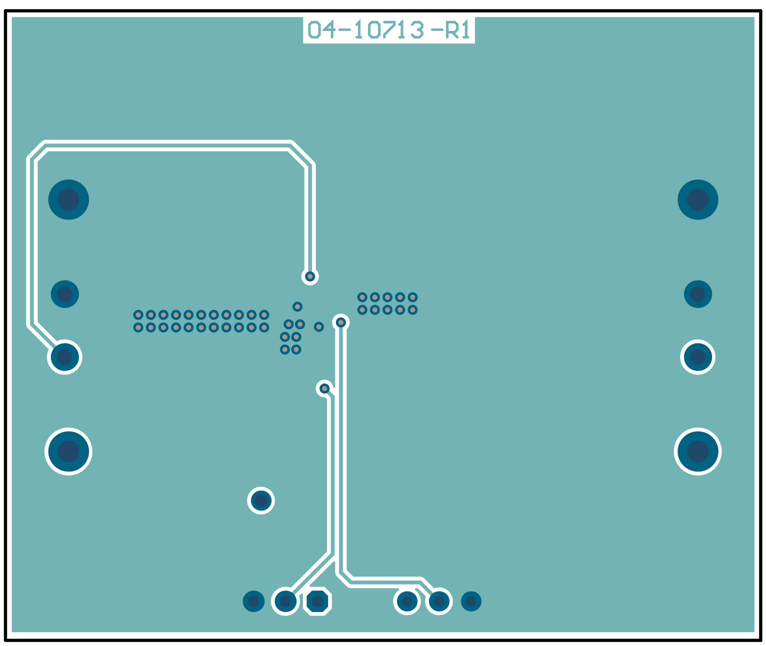
A.4 BOARD – TOP SILK AND COPPER



A.5 BOARD – TOP COPPER



A.6 BOARD – BOTTOM COPPER



Appendix B. Bill of Materials (BOM)

TABLE B-1: BILL OF MATERIALS (BOM)

Qty.	Reference	Description	Manufacturer	Part Number
2	C1, C11	CAP CER 10 µF 16V 10% X7R SMD 1206	TDK Corporation	C3216X7R1C106K
1	C2	CAP CER 1 µF 25V 10% X5R SMD 0805	Murata Electronics North America, Inc.	GRM216R61E105KA12D
0	C3	CAP TANT 330 µF 10V 20% 2917	Panasonic® - ECG	10TPE330M
4	C4, C5, C7, C8	CAP CER 10 µF 50V 20% X7R SMD 1210	TDK Corporation	C3225X7R1H106M250AC
1	C9	CAP ALU 470 µF 16V 20% SMD F	Panasonic - ECG	EEE-1CA471UP
1	D1	DIO SCTKY STPS2L40U 340 mV 2A 40V DO-214AA_SMB	STMicroelectronics	STPS2L40U
2	J1, J2	CON TERMINAL 5 mm 1x2 Female 12-26AWG 18A TH R/A	PHOENIX CONTACT	1935161
1	J5	CON HDR-2.54 Male 1x3 Tin 6.75 MH TH VERT	Molex®	90120-0123
1	L1	INDUCTOR 4.7 µH 6.9A 30% SMD L10W10.2H4.8	Coilcraft	MSS1048-472NL
1	LABEL1	Label, AIPD Board Assembly		
4	PAD1, PAD2, PAD3, PAD4	MECH HW RUBBER PAD CYLINDRICAL D7.9 H5.3 BLACK	3M	SJ61A11
1	PCB1	Printed Circuit Board		04-10713-R1
1	R1	RES TKF 180k 1% 1/10W SMD 0603	Yageo Corporation	RC0603FR-07180KL
1	R2	RES TKF 20k 1% 1/10W SMD 0603	Panasonic® - ECG	ERJ-3EKF2002V
1	RT1	RES TKF 80.6k 1% 1/10W SMD 0603	Panasonic® - ECG	ERJ3EKF8062V
1	RT2	RES TKF 130k 1% 1/10W SMD 0603	Panasonic® - ECG	ERJ3EKF1303V
1	RT3	RES TKF 383k 1% 1/10W SMD 0603	Panasonic® - ECG	ERJ3EKF3833V
1	RT4	RES TKF 511k 1% 1/10W SMD 0603	Panasonic® - ECG	ERJ3EKF5113V
1	SW1	SWITCH SLIDE SPDT 30V 0.1A SS12SDP2 TH	NKK Switches	SS12SDP2
0	TP1, TP2, TP3, TP4	CON TP PIN Tin TH	Harwin Plc.	H2121-01
1	U1	MCHP ANALOG BOOST CONVERTER 12V MCP1665T-E/MRA VQFN-10	Microchip Technology Inc.	**MCP1665T-E/MRA**

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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