MCP16411 Low I_Q Boost with Programmable UVLO Evaluation Board User's Guide

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MCP16411 LOW I_Q BOOST WITH PROGRAMMABLE UVLO 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 on-line help. Select the Help menu, and then Topics to open a list of available on-line help files.

INTRODUCTION

This chapter contains general information that will be useful to know before using the MCP16411 Low I_Q Boost with Programmable UVLO Evaluation 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 MCP16411 Low I_Q Boost with Programmable UVLO Evaluation Board as a development tool. The manual layout is as follows:

- **Chapter 1. "Product Overview"** – Important information about the MCP16411 Low I_Q Boost with Programmable UVLO Evaluation Board.
- **Chapter 2. "Installation and Operation"** – Includes instructions on how to get started with this user's guide and a description of the user's guide.
- **Appendix A. "Schematic and Layouts"** – Shows the schematic and layout diagrams for the MCP16411 Low I_Q Boost with Programmable UVLO Evaluation Board.
- **Appendix B. "Bill of Materials (BOM)"** – Lists the parts used to build the MCP16411 Low I_Q Boost with Programmable UVLO Evaluation Board.

CONVENTIONS USED IN THIS GUIDE

This manual uses the following documentation conventions:

DOCUMENTATION CONVENTIONS

<table>
<tr><th>Description</th><th>Represents</th><th>Examples</th></tr>
<tr><td colspan="3">Arial font:</td></tr>
<tr><td rowspan="2">Italic characters</td><td>Referenced books</td><td>MPLAB® IDE User’s Guide</td></tr>
<tr><td>Emphasized text</td><td>...is the only compiler...</td></tr>
<tr><td rowspan="3">Initial caps</td><td>A window</td><td>the Output window</td></tr>
<tr><td>A dialog</td><td>the Settings dialog</td></tr>
<tr><td>A menu selection</td><td>select Enable Programmer</td></tr>
<tr><td>Quotes</td><td>A field name in a window or dialog</td><td>“Save project before build”</td></tr>
<tr><td>Underlined, italic text with right angle bracket</td><td>A menu path</td><td><u>File>Save</u></td></tr>
<tr><td rowspan="2">Bold characters</td><td>A dialog button</td><td>Click OK</td></tr>
<tr><td>A tab</td><td>Click the Power tab</td></tr>
<tr><td>N‘Rnnnn</td><td>A number in verilog format, where N is the total number of digits, R is the radix and n is a digit.</td><td>4‘b0010, 2‘hF1</td></tr>
<tr><td>Text in angle brackets < ></td><td>A key on the keyboard</td><td>Press <Enter>, <F1></td></tr>
<tr><td colspan="3">Courier New font:</td></tr>
<tr><td rowspan="7">Plain Courier New</td><td>Sample source code</td><td><code>#define START</code></td></tr>
<tr><td>Filenames</td><td><code>autoexec.bat</code></td></tr>
<tr><td>File paths</td><td><code>c:\mcc18\h</code></td></tr>
<tr><td>Keywords</td><td><code>_asm, _endasm, static</code></td></tr>
<tr><td>Command-line options</td><td><code>-Opa+, -Opa-</code></td></tr>
<tr><td>Bit values</td><td><code>0, 1</code></td></tr>
<tr><td>Constants</td><td><code>0xFF, ‘A’</code></td></tr>
<tr><td>Italic Courier New</td><td>A variable argument</td><td><code>file.o</code>, where <code>file</code> can be any valid filename</td></tr>
<tr><td>Square brackets [ ]</td><td>Optional arguments</td><td><code>mcc18 [options] file [options]</code></td></tr>
<tr><td>Curly brackets and pipe character: { | }</td><td>Choice of mutually exclusive arguments; an OR selection</td><td><code>errorlevel {0|1}</code></td></tr>
<tr><td rowspan="2">Ellipses...</td><td>Replaces repeated text</td><td><code>var_name [, var_name...]</code></td></tr>
<tr><td>Represents code supplied by user</td><td><code>void main (void)
{ ...
}</code></td></tr>
</table>

RECOMMENDED READING

This user's guide describes how to use the MCP16411 Low I_Q Boost with Programmable UVLO Evaluation Board. Other useful documents are listed below. The following Microchip documents are available and recommended as supplemental reference resources.

- **MCP1641X Data Sheet – "*Low I_Q Boost Converter with Programmable Low Battery, UVLO and Automatic Input-to-Output Bypass Operation*"**

This user's guide details how to use the MCP16411 device in specific applications.

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:

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- **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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- 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 (September 2020)

- Initial Release of this Document.

NOTES:

MCP16411 LOW I_Q BOOST WITH PROGRAMMABLE UVLO EVALUATION BOARD USER'S GUIDE

Chapter 1. Product Overview

1.1 INTRODUCTION

This chapter provides an overview of the MCP16411 Low I_Q Boost with Programmable UVLO Evaluation Board and covers the following topics:

- MCP16411 Device Overview
- The MCP16411 Low I_Q Boost with Programmable UVLO Evaluation Board Key Features
- The MCP16411 Low I_Q Boost with Programmable UVLO Evaluation Board Kit Contents

1.2 MCP16411 DEVICE OVERVIEW

The MCP1641X is a low-voltage boost converter with battery monitoring features, which delivers high efficiency over a wide load range of inputs: single cell, two-cell, alkaline/NiMH batteries or single cell Li-Ion/Li-Polymer batteries can be used.

A high level of integration lowers total system cost, eases implementation, reduces the BOM and board area.

This family of devices features low quiescent current, a programmable start-up voltage (Undervoltage Lockout (UVLO)), Low Battery Indication (LBO), adjustable output voltage and dual mode of operation: PFM/PWM and PWM Only, integrated synchronous switch, internal compensation, low noise anti-ringing control, inrush current limit and soft start.

The Undervoltage Lockout (UVLO) prevents Fault operation below 0.8V ($UVLO_{STOP}$) and the boost converter starts in normal operation, by default, at 0.85V ($UVLO_{START}$). The programmable $UVLO_{START}$ threshold can be set through an external resistive divider, but cannot be lower than 0.85V. Additionally, a low battery circuit is implemented with a LBO warning pin if the battery's voltage is below the UVLO's trip point.

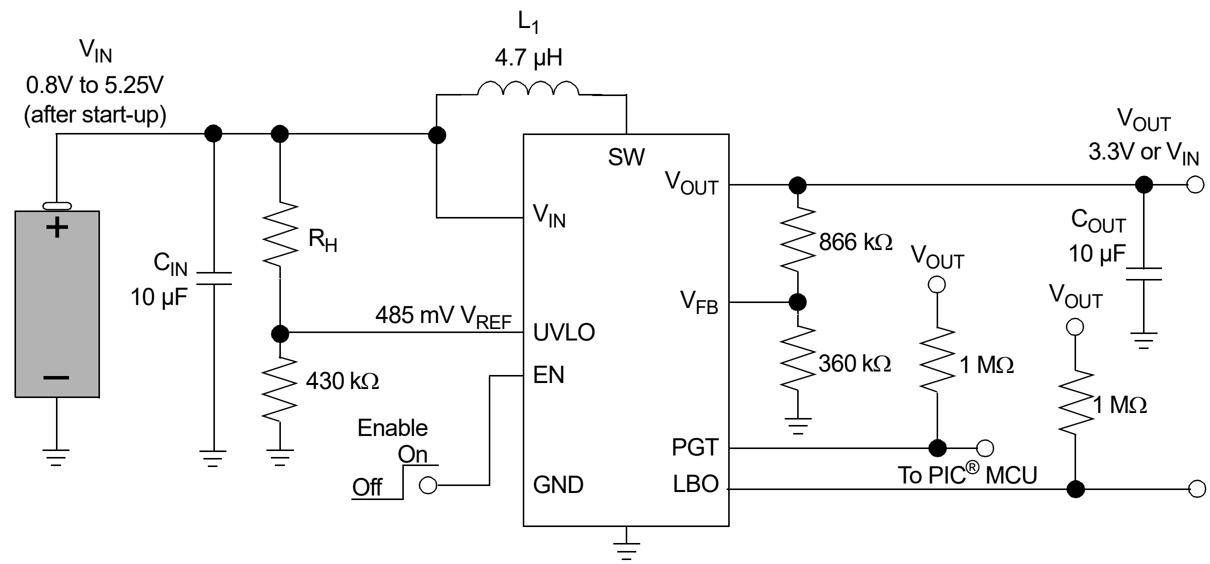
A battery friendly feature for the Microchip's step-up converter family is the Automatic Input-to-Output Bypass. This function helps optimize the battery's capacity usage, and keeps efficiency high and noise low for a narrow step-up conversion ratio (e.g., two fresh alkaline cells powering a boost converter for a 3.0V output voltage). With an automatic transition from Input-to-Output Bypass to Boost mode operation and with the low noise anti-ringing control circuitry, in addition to the PWM Only mode switching, the MCP1641X devices offer a good low noise DC-DC solution for compact battery-powered systems.

The Automatic Input-to-Output Bypass mode is active when the V_{IN} is close to the selected V_{OUT} or higher. In this situation, V_{OUT} will track V_{IN}, which is "bypassed" to the output; the device will resume Boost mode if V_{OUT} falls to approximately 90% of the set regulation voltage.

An additional safety feature, while powering a device from batteries, is the monitoring of the internal device's temperature. The Power Good and Die Overtemperature (PGT) pin provides an error signal if the temperature of the integrated circuit die exceeds 75°C.

Furthermore, the step-up converter family provides Output Discharge and Input-to-Output Bypass features, while the device is in shutdown, by pulling the EN pin to GND. During this mode, a low quiescent current, 2.3 µA, typically, is consumed from the input.

The goal of the MCP16411 Low I_Q Boost with Programmable UVLO Evaluation Board is to demonstrate the features and capabilities of the MCP16411 device.



Note: For $V_{IN} < V_{OUT}$, the device operates in Boost mode; otherwise, for $V_{IN} > V_{OUT}$, V_{IN} is bypassed to V_{OUT}.

FIGURE 1-1: *MCP16411 Typical Application.*

The MCP1641X family is available in eight different options (see Table 1-1).

TABLE 1-1: DEVICE OPTIONS

Part Number	EN Pin Shutdown Option	Switching Mode Option	PGT/PG Pin Option
MCP16411	Output Discharge	PFM/PWM	Power Good and Die Overtemperature Output
MCP16412	Output Discharge	PWM Only	Power Good and Die Overtemperature Output
MCP16413	In-Out Bypass	PFM/PWM	Power Good and Die Overtemperature Output
MCP16414	In-Out Bypass	PWM Only	Power Good and Die Overtemperature Output
MCP16415	Output Discharge	PFM/PWM	Power Good Output
MCP16416	Output Discharge	PWM Only	Power Good Output
MCP16417	In-Out Bypass	PFM/PWM	Power Good Output
MCP16418	In-Out Bypass	PWM Only	Power Good Output

The MCP1641X devices are available in the 10-Lead MSOP and 10-Lead 3 mm x 3 mm TDFN packages. For additional information on the MCP16411 device, refer to the *“MCP1641X Data Sheet”* (DS20006394).

1.3 THE MCP16411 LOW I_Q BOOST WITH PROGRAMMABLE UVLO EVALUATION BOARD KEY FEATURES

The MCP16411 Low I_Q Boost with Programmable UVLO Evaluation Board is used to evaluate and demonstrate Microchip Technology's MCP16411 product. This board demonstrates the MCP16411 device's capabilities in a boost converter application with programmable UVLO, and comes fully populated and ready to be tested over the whole input voltage range, while the output voltage is set to 3.3V. The output voltage can be adjusted by replacing the external resistive divider connected to the FB pin.

The Evaluation Board has two switches which can be used as specified below:

- A switch connected to the EN pin is used to enable and disable the converter. When enabled, the MCP16411 will regulate the output voltage; when disabled, the MCP16411 will be in Output Discharge mode, returning 0V at its output.
- The second switch is connected to the UVLO pin and it is used to set the UVLO start-up threshold. When it is in the on position, the UVLO start-up is set to 1.1V, while for the off (top) position, UVLO start-up is equal to the default value of 0.85V.

1.4 THE MCP16411 LOW I_Q BOOST WITH PROGRAMMABLE UVLO EVALUATION BOARD KIT CONTENTS

This MCP16411 Low I_Q Boost with Programmable UVLO Evaluation Board kit includes:

- MCP16411 Low I_Q Boost with Programmable UVLO Evaluation Board (ADM00867)
- Important Information Sheet

NOTES:

Chapter 2. Installation and Operation

2.1 INTRODUCTION

The MCP16411 device can regulate the output voltage over a 1.8V to 5.25V range, and can deliver over 200 mA of load current at a 3.3V output, when supplied from a single 1.5V cell. The input voltage range is 0.8V to 5.25V with a low 0.85V start-up voltage.

The MCP16411 has been developed for applications that require programmable start-up (Undervoltage Lockout) thresholds to adapt to the type of battery used. The boost converter has both Pulse-Width Modulation (PWM) and Pulse Frequency Modulation (PFM) operating modes and automatically selects the best operating mode for achieving high efficiency.

The device features a Power Good and Die Overtemperature (PGT) open-drain output pin. The combined Power Good and Die Overtemperature output warning shows when either the output voltage drops below 10% of its nominal value with 5% hysteresis, or the die temperature exceeds 75°C with 10°C hysteresis. The internal low battery comparator provides an open-drain output signal, Low Battery Output (LBO), which indicates the input voltage state. The state is a high level until the voltage on the UVLO pin drops below 485 mV with 20 mV hysteresis (the internal reference voltage value).

The MCP16411 can be enabled/disabled using the EN switch. The Output Discharge will automatically discharge the output capacitor when the device is disabled.

2.2 MCP16411 LOW I_Q BOOST WITH PROGRAMMABLE UVLO EVALUATION BOARD FEATURES

The MCP16411 Low I_Q Boost with Programmable UVLO Evaluation Board has the following features:

- Can be powered by one-cell, two-cell or three-cell alkaline, NiMH, one-cell Li-Ion or Li-Polymer batteries; Input Voltage Range (V_{IN}): 0.8V to 5.25V
- Inductor Peak Current Limit: 1A, typically
- Minimum Start-up Voltage: 0.85V at V_{OUT} = 3.3V and I_{OUT} = 10 mA, resistive load
- Undervoltage Lockout (UVLO):
  - Programmable UVLO Start-up Threshold ($UVLO_{START}$, 0.85V default value)
  - Fixed $UVLO_{STOP}$: 0.8V, typically
- Output Voltage: 3.3V
- Output Current: 200 mA @ 3.3V output, 1.5V input
- Automatic PFM/PWM operation
- PWM Switching Frequency: 500 kHz, typically
- LED Indicator for:
  - Power Good and Die Overtemperature (on PGT Pin)
  - Low Battery Output (on LBO Pin)
- Automatic Input-to-Output Bypass when $V_{IN} \geq V_{OUT}$
- Output Discharge: Shutdown mode (EN = GND)

2.3 GETTING STARTED

The MCP16411 Low I_Q Boost with Programmable UVLO Evaluation Board is fully assembled and tested to evaluate and demonstrate the MCP16411 product. This board requires the use of external laboratory supplies and load.

2.3.1 Power Input and Output Connection

2.3.1.1 POWERING THE MCP16411 LOW I_Q BOOST WITH PROGRAMMABLE UVLO EVALUATION BOARD

The MCP16411 Low I_Q Boost with Programmable UVLO Evaluation Board was designed to evaluate the MCP16411 in the selected 10-Lead MSOP package.

Soldered test points are available for input and output (load) connections. The maximum applied input voltage should not be higher than 5.25V. The output voltage will not remain in regulation for input voltages that are greater than or equal to the output voltage; in that case, the output voltage will track the input voltage (Automatic Input-to-Output Bypass).

The inductor peak current limit of 1A, typically, will provide a safe maximum current value. The maximum output current for the converter varies with input and output voltages; refer to Figure 2-2 or the *"MCP1641X Data Sheet"* for more information on the maximum output current.

2.3.1.2 BOARD POWER-UP PROCEDURE:

1. Connect the power supply/battery as shown in Figure 2-1. The positive terminal must be connected to V_{IN} and the negative terminal to GND. The input voltage should not be higher than 5.25V.
2. Set the desired UVLO start-up voltage using the UVLO start-up switch.
3. Connect the system load to the V_{OUT} and GND terminals. Connect the (+) side of the load to V_{OUT} and the negative (-) load to ground (GND). The maximum applied load varies with input and output voltage.
4. Set the "UVLO START-UP" switch in the "0.85V" top position.
5. Set the "ENABLE" switch in the "ON" top position.
6. If a power supply is used, increase the input voltage from 0.8V to 1.5V. Measure with a voltmeter the input voltage threshold when the V_{OUT} is starting regulation. The regulation of output voltage occurs when V_{IN} is approximately 0.85V.
7. Check with a voltmeter (connected between the V_{OUT} and GND terminals) that the output voltage is approximately 3.3V (±100 mV).
8. Increase the input voltage; when V_{IN} is close to V_{OUT}, measure with a voltmeter the input voltage threshold when the device enters Automatic Input-to-Output Bypass mode and check the output voltage with another voltmeter (it should be 3.3V ±100 mV).
9. Increase the input voltage from $V_{IN} \geq V_{OUT}$, up to 5.25V, and verify with the voltmeters the input and the output voltages. In this situation, V_{OUT} will track V_{IN}.
10. Set the input power supply to 1.5V and move the "ENABLE" switch in the "OFF" bottom position.
11. Check with a voltmeter that the output voltage is 0V (±100 mV) to ensure that the converter is disabled.

If the “UVLO START-UP” switch is set in the bottom position, “1.1V” (Step 4), then the input voltages measured at Step 6 should be 1.1V. Decrease the input voltage of the power supply until the “LBO” LED lights up; this occurs when V_{IN} is lower than 1.1V. Measure the input voltage.

> **Note:** If the V_{OUT} < 95% of the nominal V_{OUT} and the IC’s die exceeds 75°C, the “PGT” LED will light up. Check the output voltage with a voltmeter.

Additional test points are available to visualize different signals (SW, PGT, UVLO, LBO).

Capacitors, C2 and C4, are not populated(*Appendix B). The component pads are provided for experimental use.

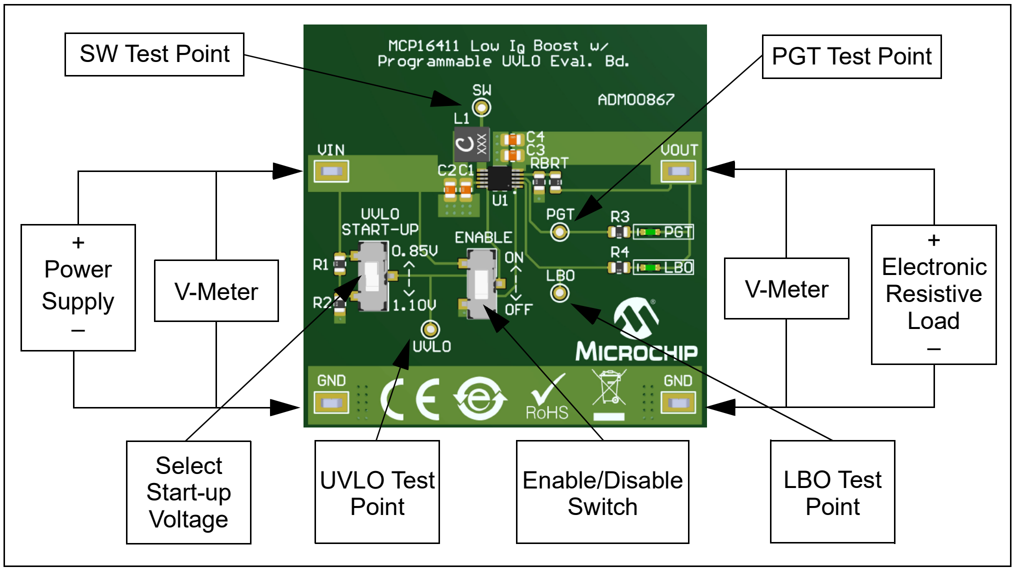


FIGURE 2-1: *MCP16411 Low I_Q Boost with Programmable UVLO Evaluation Board Setup.*

2.3.1.3 ENABLE AND UVLO START-UP SWITCHES FUNCTION

Table 2-1 shows how the switches affect the functionality of the evaluation board.

TABLE 2-1: FUNCTION OF BOARD SWITCHES

State of Switches		MCP16411 Operation Mode
ENABLE	**UVLO START-UP**	
ON	ON	Enabled, UVLO = 0.85V
ON	OFF	Enabled, UVLO = 1.1V
OFF	N/A	The device is disabled

2.3.1.4 ADJUSTABLE V_{OUT} SETTING

The board comes with the output value set to 3.3V. If a different output voltage is desired, the resistive divider consisting of R_T and R_B (used to set the converter output voltage) can be calculated using Equation 2-1.

EQUATION 2-1:

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

Where: V_{FB} = 0.97V.

.

> **Note:** For output voltage below or equal to 2.0V, the inductor value must be reduced to 2.2 µH and the output capacitor value must be increased to 20 µF. See Table 2-2 for more information.

TABLE 2-2: RECOMMENDED FB RESISTOR DIVIDER AND INDUCTOR VALUES

V_{OUT}	Inductor Value	R_T	R_B
1.8V	2.2 µH	309 kΩ	360 kΩ
2V	2.2 µH	383 kΩ	360 kΩ
3V	4.7 µH	768 kΩ	360 kΩ
5V	4.7 µH	1.5 MΩ	360 kΩ

2.3.1.5 ADJUSTABLE UVLO START-UP VOLTAGE SETTING

The board comes with the $UVLO_{START-UP}$ voltage set to 0.85V (default value) and 1.1V, respectively. If a different $UVLO_{START-UP}$ voltage is desired, the resistive divider, consisting of R1 and R2, is used to set the $UVLO_{START-UP}$ voltage. The value of the resistors for a different $UVLO_{START-UP}$ voltage can be calculated using Equation 2-2.

EQUATION 2-2:

$$R1 = R2 \times \left[\left(\frac{UVLO_{START\text{-}UP}}{V_{REF\_UVLO}}\right) - 1\right]$$

Where: V_{REF_UVLO}= 485 mV.

For different $UVLO_{START-UP}$ voltages, see Table 2-3. Note that the $UVLO_{STOP}$ value is fixed at 0.8V, as it cannot be changed.

TABLE 2-3: RECOMMENDED UVLO RESISTOR DIVIDER VALUES

$UVLO_{START-UP}$	R1	R2
1.8V	1.15 MΩ	430 kΩ
2.4V	1.69 MΩ	430 kΩ
3.3V	2.5 MΩ	430 kΩ

2.4 TEST RESULTS FOR TYPICAL APPLICATION USING MCP16411

This chapter provides specific operation waveforms and graphs. Refer to the MCP1641X Data Sheet (DS20006394) for more information.

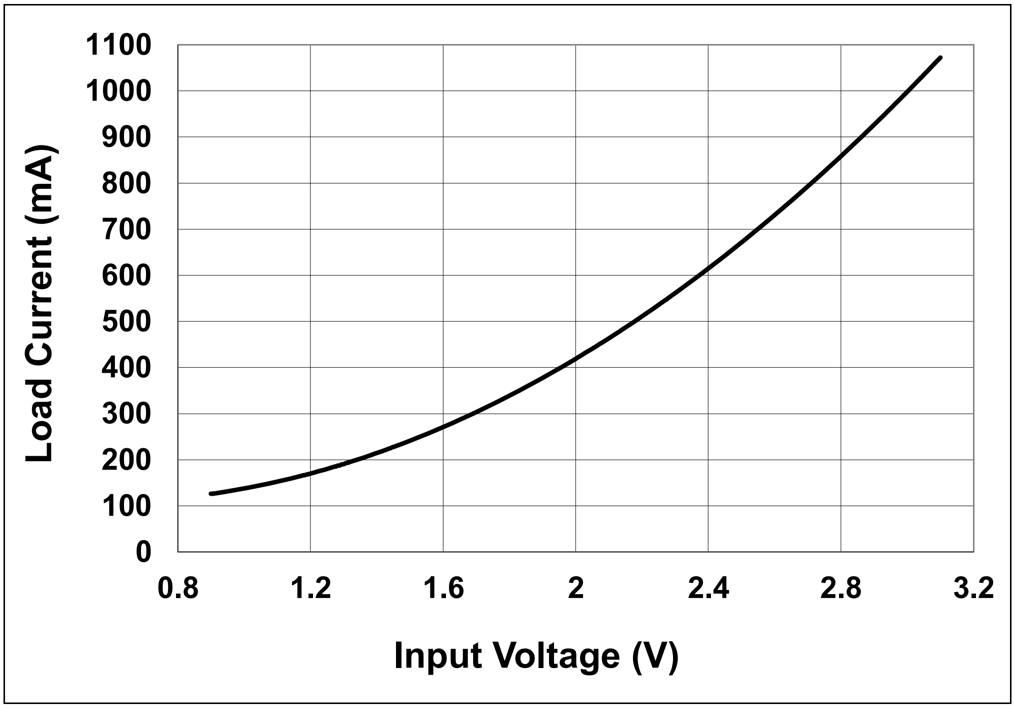


FIGURE 2-2: *3.3V V_{OUT}, Maximum I_{OUT} vs. V_{IN}, Using Power Supply.*

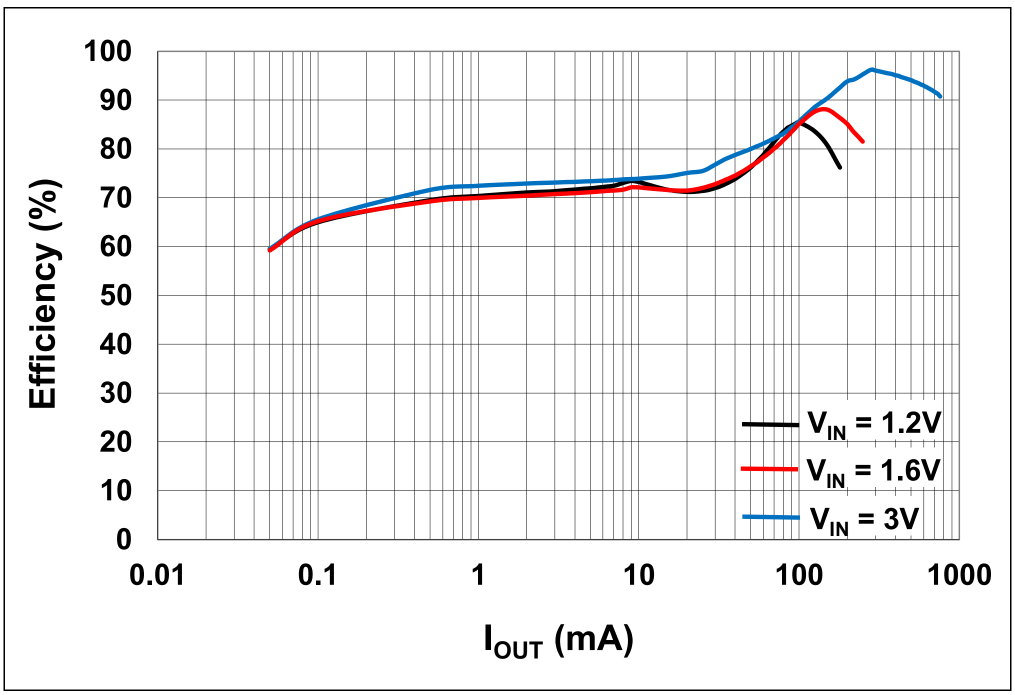


FIGURE 2-3: *3.3V V_{OUT}, Efficiency vs. I_{OUT}.*

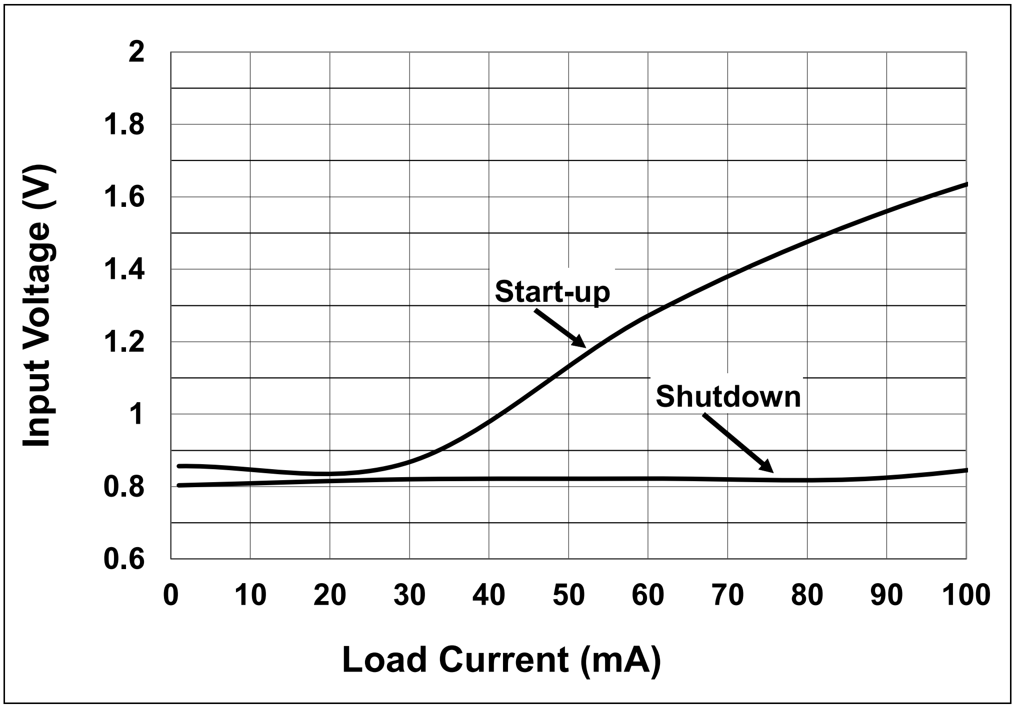


FIGURE 2-4: *Minimum Start-up and Shutdown V_{IN} into Resistive Load vs. I_{OUT}.*

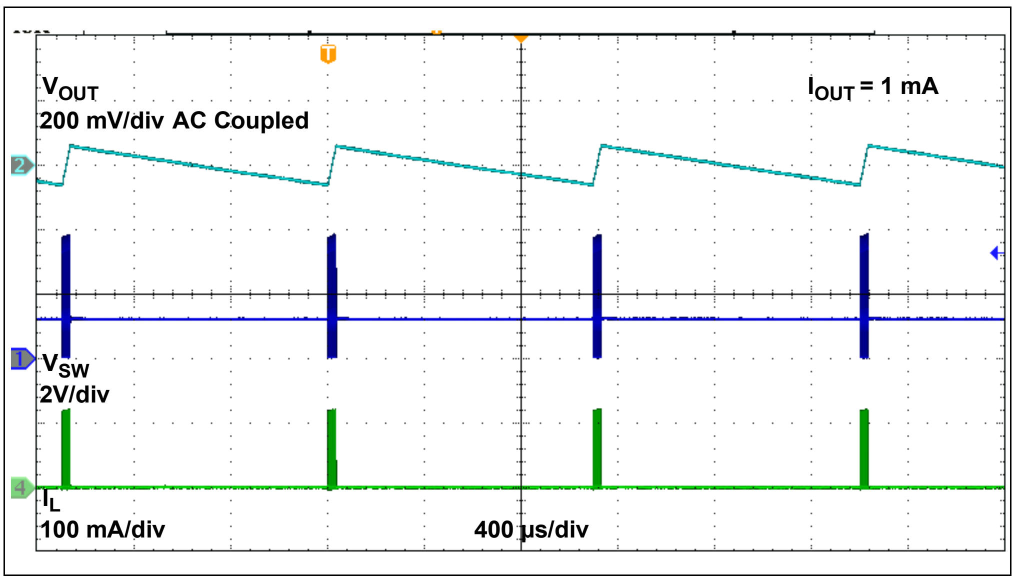


FIGURE 2-5: *3.3V V_{OUT}, PFM Mode Waveforms.*

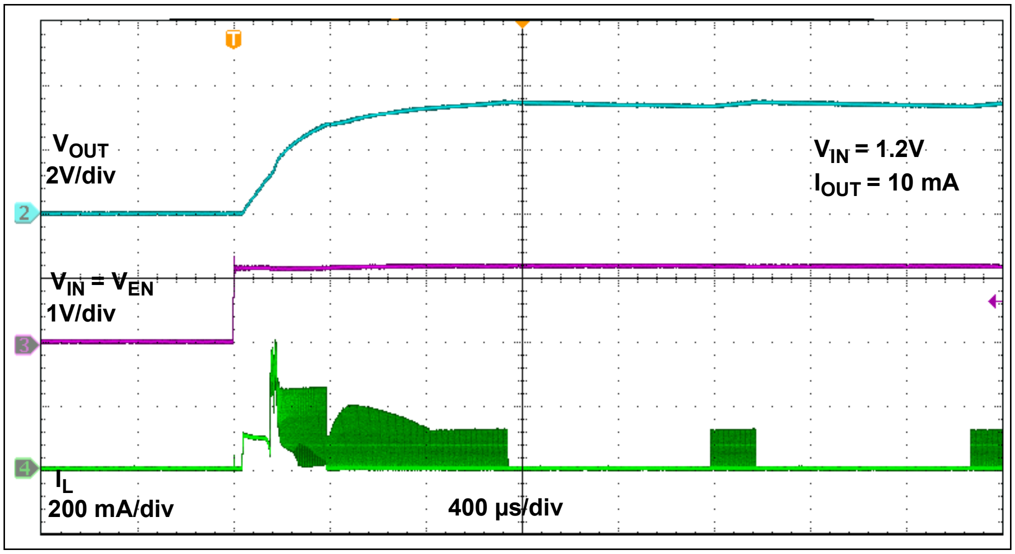


FIGURE 2-6: *3.3V V_{OUT}, PFM Mode, Start-up from V_{IN} Waveforms.*

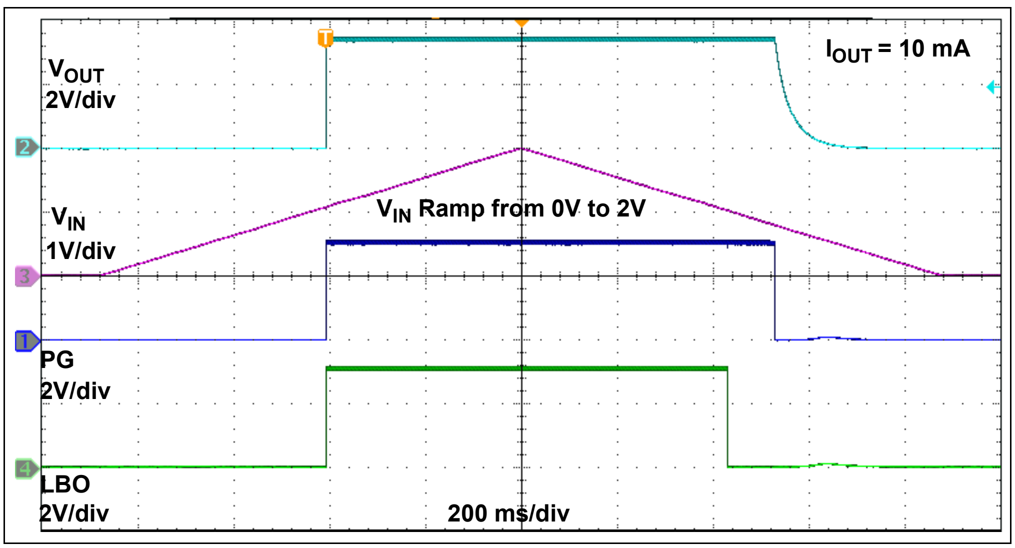


FIGURE 2-7: *3.3V V_{OUT}, UVLO Connected to Resistive Divider Set at 1.1V Waveforms.*

NOTES:

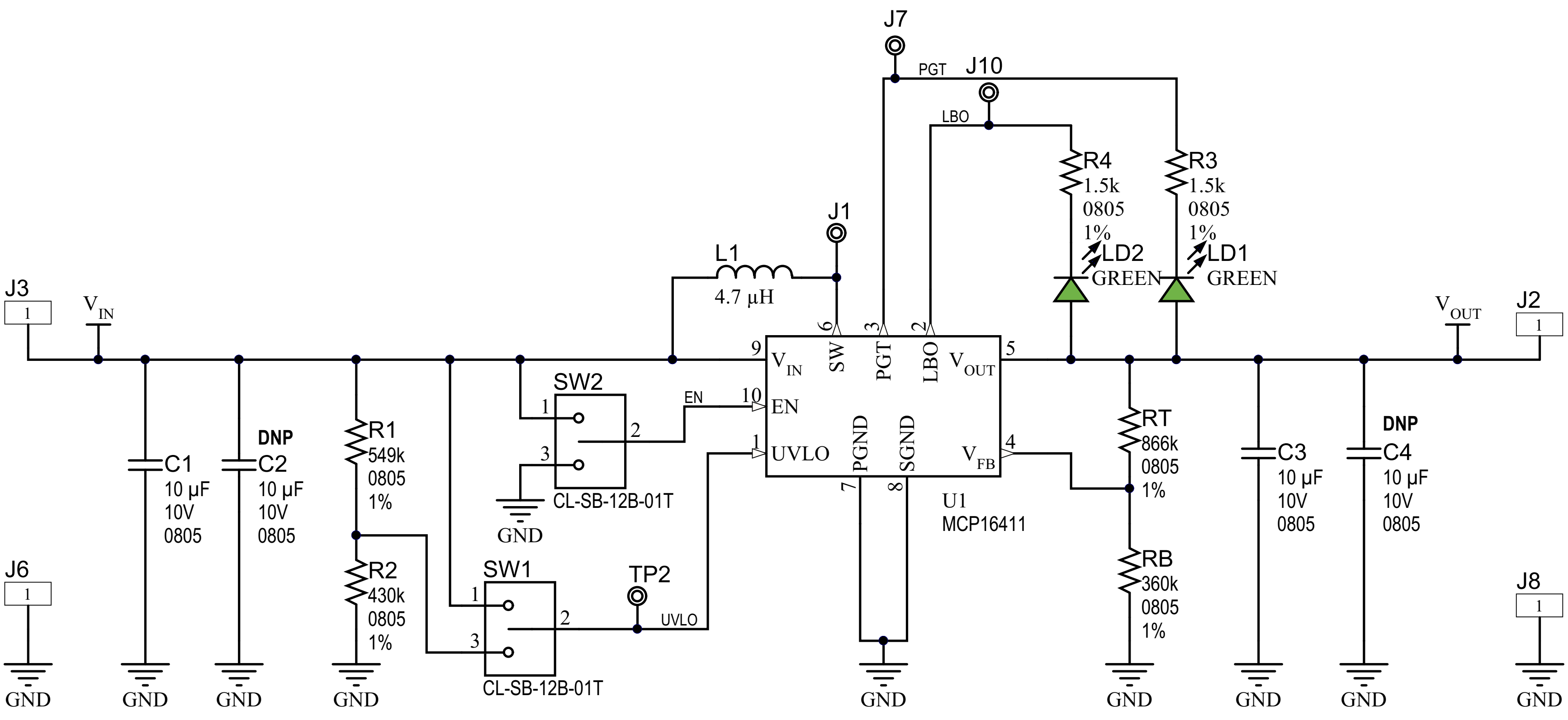
Appendix A. Schematic and Layouts

A.1 INTRODUCTION

This appendix contains the following schematic and layouts for the MCP16411 Low I_Q Boost with Programmable UVLO Evaluation Board:

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

A.2 BOARD – SCHEMATIC



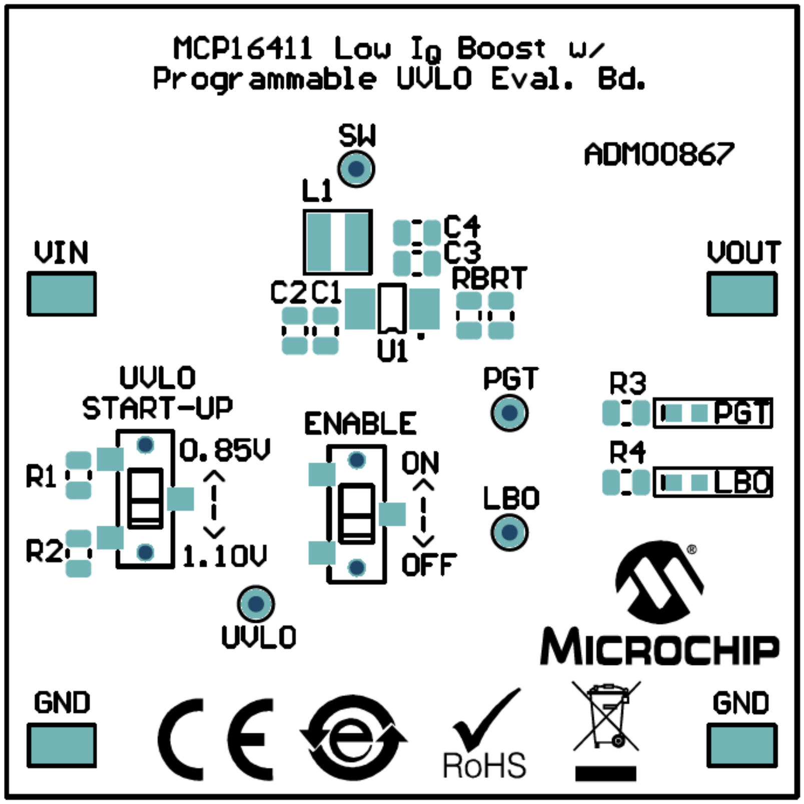
Note 1: C2 and C4 DNP (Do Not Populate).

2: Calculate RT resistors for a particular V_{OUT} as follows: RT = RB x ((V_{OUT}/V_{FB}) – 1).

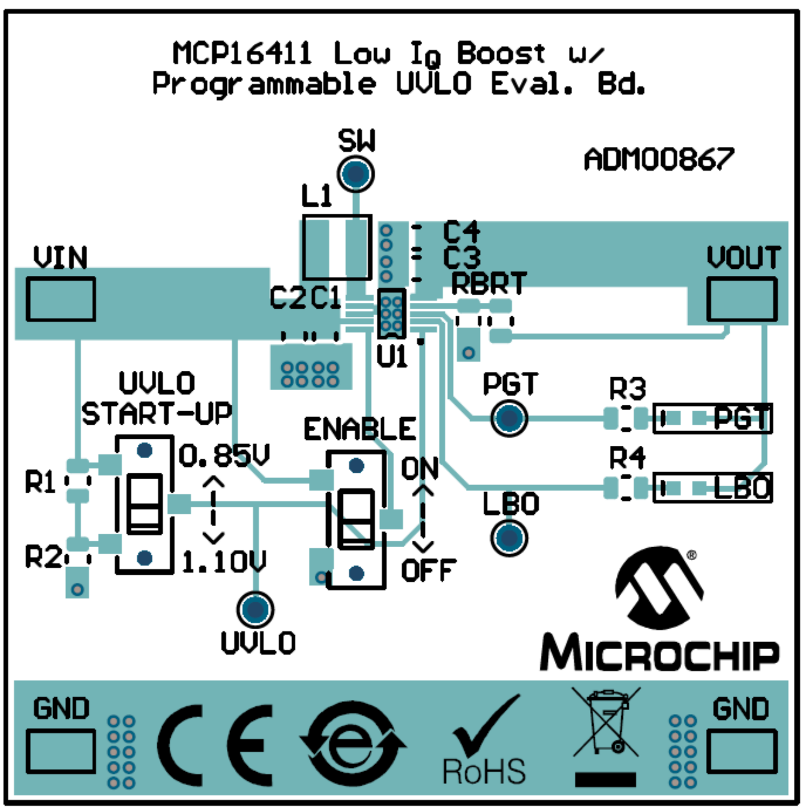
3: Calculate R1 resistors for a particular UVLO as follows: R1 = R2 x (($UVLO_{START}$/485 mV) – 1).

4: For V_{OUT} below or equal to 2.0V, L1 = 2.2 µH and C4 = 10 µF (output capacitor); it must be populated (*Appendix B).

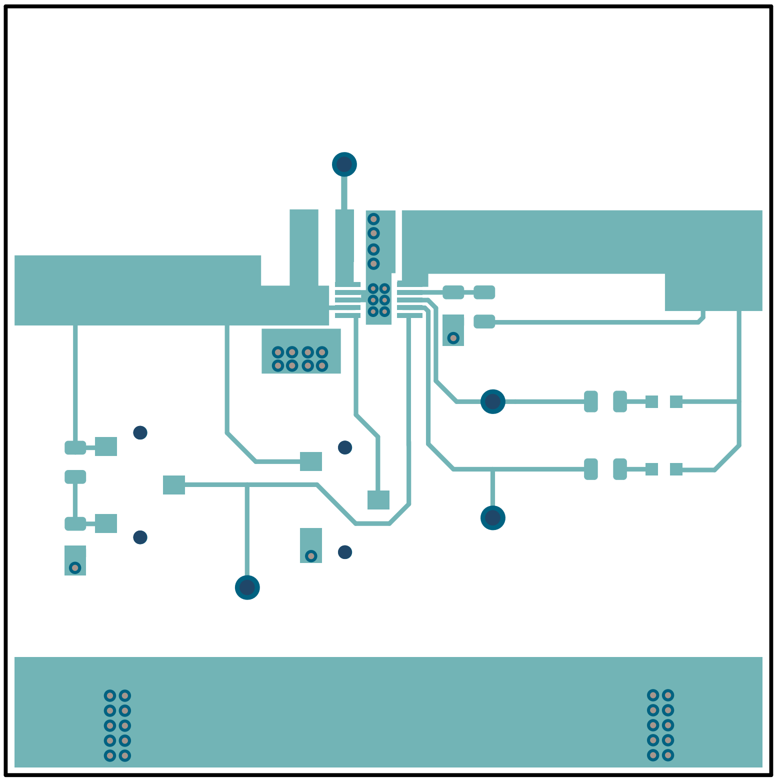
A.3 BOARD – TOP SILK



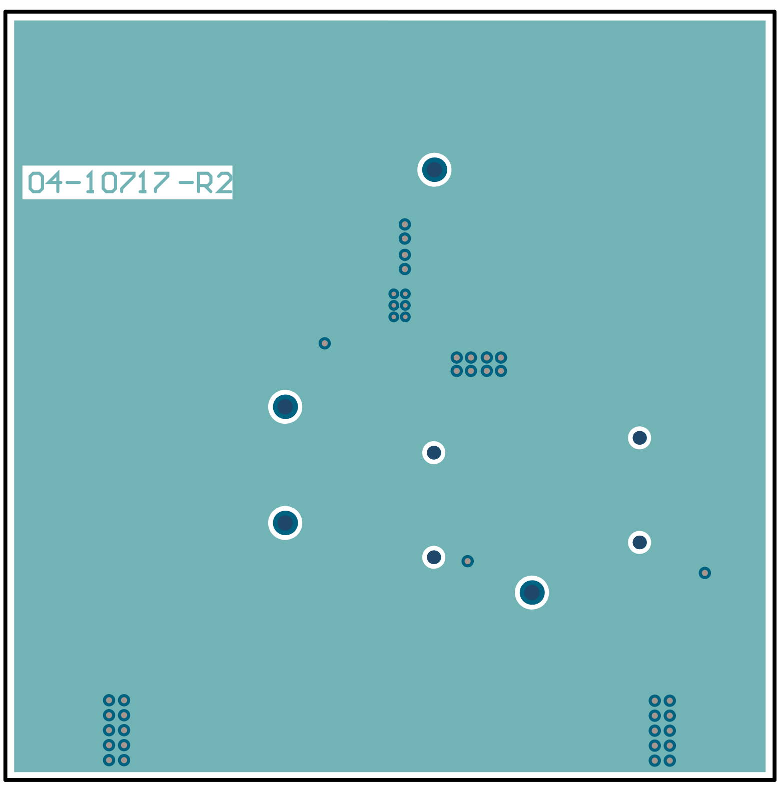
A.4 BOARD – TOP COPPER AND SILK



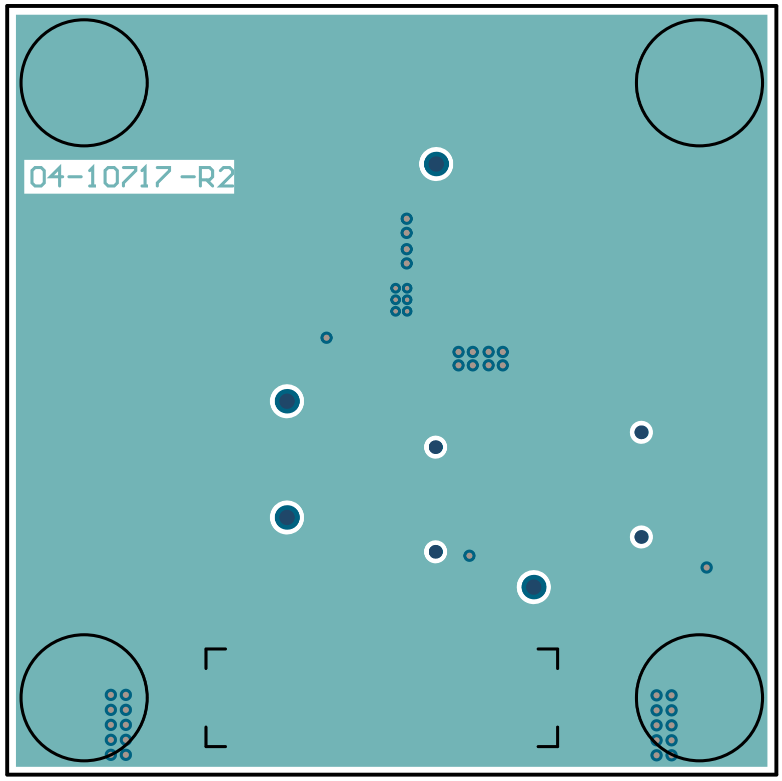
A.5 BOARD – TOP COPPER



A.6 BOARD – BOTTOM COPPER



A.7 BOARD – BOTTOM COPPER AND SILK



NOTES:

Appendix B. Bill of Materials (BOM)

TABLE B-1: BILL OF MATERIALS (BOM)

Qty.	Reference	Description	Manufacturer	Part Number
2	C1, C3	Capacitor, Ceramic, 10 µF, 10V, 10%, X7R, SMD, 0805	TDK Corporation	C2012X7R1A106K125AC
2	C2, C4	Capacitor, Ceramic, 10 µF, 10V, 10%, X7R, SMD, 0805 ***DO NOT POPULATE**	TDK Corporation	C2012X7R1A106K125AC
4	J2, J3, J6, J8	Connector, TP, Loop, Tin, SMD	Harwin Inc.	S1751-46R
1	L1	Inductor, 4.7 µH, 2A, 20%, SMD, XFL4020	Coilcraft, Inc.	XFL4020-472MEB
2	LD1, LD2	Diode, LED, Green, 1.7V, 20 mA, 3.92 mcd, Diffuse, SMD, 0603	OSRAM Opto Semiconductors	LG L29K-G2J1-24-Z
1	R1	Resistor, TKF, 549 kΩ, 1%, 1/8W, SMD, 0805, AEC-Q200	Panasonic® Electronic Components	ERJ-6ENF5493V
1	R2	Resistor, TKF, 430 kΩ, 1%, 1/8W, SMD, 0805, AEC-Q200	Panasonic Electronic Components	ERJ-6ENF4303V
2	R3, R4	Resistor, TKF, 1.5 kΩ, 1%, 1/8W, SMD, 0805	Panasonic Electronic Components	ERJ-6ENF1501V
1	RT	Resistor, TKF, 866 kΩ, 1%, 1/8W, SMD, 0805, AEC-Q200	Panasonic Electronic Components	ERJ-6ENF8663V
1	RB	Resistor, TKF, 360 kΩ, 1%, 1/8W, SMD, 0805	Panasonic Electronic Components	ERJ-6ENF3603V
2	SW1, SW2	Switch, Slide, SPDT, 200 mA, 12V	Copal Electronics, Inc.	CL-SB-12B-01T
1	U1	MCP16411	Microchip Technology Inc.	**MCP16411T-I/UN**
4	PAD1, PAD2, PAD3, PAD4	Mechanical Hardware, Rubber Pad, Hemisphere, D6.4 H1.9, Clear	3M	SJ5382
1	PCB	Printed Circuit Board	Microchip Technology Inc.	**04-10717-R2**

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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