



**MICROCHIP**

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**MIC23350**  
**Evaluation Board**  
**User's Guide**

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## Preface

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### 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](http://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 MIC23350 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 MIC23350 Evaluation Board as a development tool. The manual layout is as follows:

- **Chapter 1. “Product Overview”** – Important information about the MIC23350 Evaluation Board.
- **Chapter 2. “Installation and Operation”** – Includes instructions on installing and starting the MIC23350 Evaluation Board.
- **Appendix A. “Schematic and Layouts”** – Shows the schematic and layout diagrams for the MIC23350 Evaluation Board.
- **Appendix B. “Bill of Materials (BOM)”** – Lists the parts used to build the MIC23350 Evaluation Board.

## CONVENTIONS USED IN THIS GUIDE

This manual uses the following documentation conventions:

### DOCUMENTATION CONVENTIONS

Description	Represents	Examples
<b>Arial font:</b>		
Italic characters	Referenced books	<i>MPLAB<sup>®</sup> 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&gt;Save</i></u>
Bold characters	A dialog button	Click <b>OK</b>
	A tab	Click the <b>Power</b> 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>
<b>Courier New font:</b>		
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 the MIC23350 Evaluation Board. Another useful document is listed below. The following Microchip document is available and recommended as a supplemental reference resource.

- **MIC23350 Data Sheet – “Step-Down Converter with Hyperlight Load™ and Voltage Select” (DS20006126)**

This data sheet provides detailed information regarding the MIC23350 device.

## THE MICROCHIP WEBSITE

Microchip provides online support via our website at [www.microchip.com](http://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
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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://support.microchip.com>.

## DOCUMENT REVISION HISTORY

### Revision A (December 2018)

- Initial release of this document.

## Chapter 1. Product Overview

### 1.1 INTRODUCTION

This chapter provides an overview of the MIC23350 Evaluation Board and covers the following topics:

- [MIC23350 Device Short Overview](#)
- [What is the MIC23350 Evaluation Board?](#)
- [Contents of the MIC23350 Evaluation Board Kit](#)

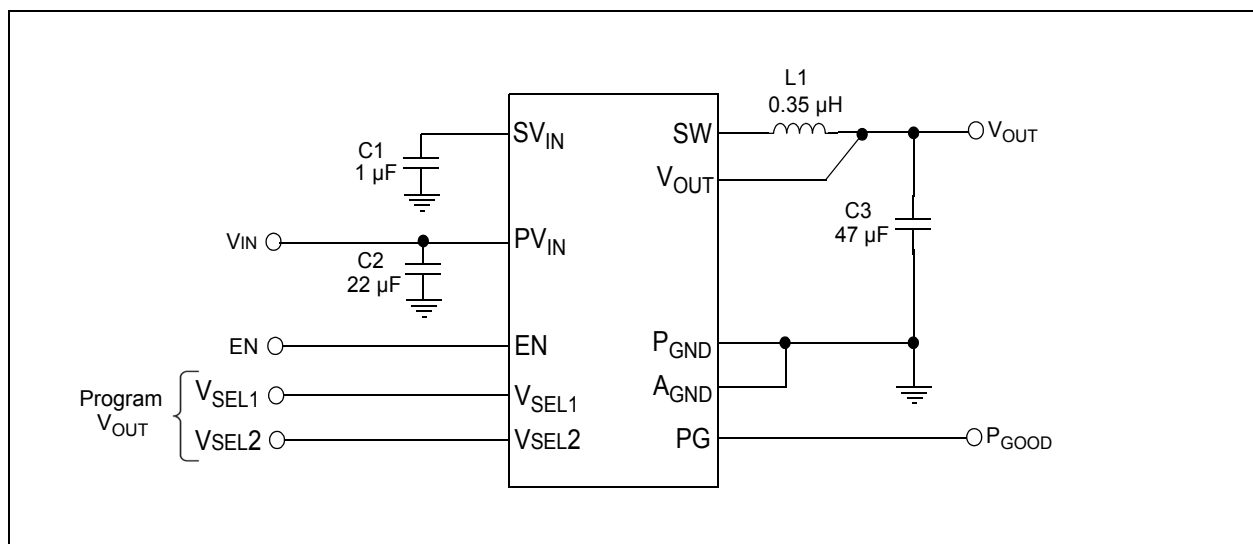
### 1.2 MIC23350 DEVICE SHORT OVERVIEW

The MIC23350 device is a compact, high-efficiency, low-voltage, 3A continuous current, synchronous step-down regulator. The HyperLight Load™ provides very high efficiency at light loads, while still having an ultra-fast transient response. The MIC23350 device's output voltage is set by two  $V_{SEL}$  (Voltage Selection) three-state pins, which allow for nine possible combinations. [Table 2-1](#) details the possible combinations and the resulting output voltage. The 2.4V to 5.5V input voltage range, low shutdown and quiescent currents make the MIC23350 device ideal for single-cell Li-Ion battery-powered applications. The 100% duty cycle capability provides low-dropout operation, extending the operating range in portable systems.

An open-drain Power Good (PG) output is provided to indicate when the output voltage is within 9% of regulation and facilitates output voltage monitoring and supply sequencing. When set in shutdown (EN = GND), the MIC23350 device draws a typical current of 1.5  $\mu$ A.

MIC23350 is available in a thermally efficient, 16-lead 2.5 mm x 2.5 mm x 0.55 mm thin FTQFN package, with an operating junction temperature range from  $-40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ .

More detailed information regarding the capabilities of the MIC23350 device is available in the “[MIC23350 Data Sheet](#)”.



**FIGURE 1-1:** Typical MIC23350 Step-Down Application.

## 1.3 WHAT IS THE MIC23350 EVALUATION BOARD?

The MIC23350 Evaluation Board is used to evaluate and demonstrate the MIC23350 device. This board demonstrates the MIC23350 device in a buck converter application, supplied from an external voltage source (from 2.4V to 5.5V), to a pin-programmed regulated output. Two jumpers are provided on the board to select the desired output voltage, chosen from nine preset values (as shown in [Table 2-1](#)).

## 1.4 CONTENTS OF THE MIC23350 EVALUATION BOARD KIT

This MIC23350 Evaluation Board kit includes:

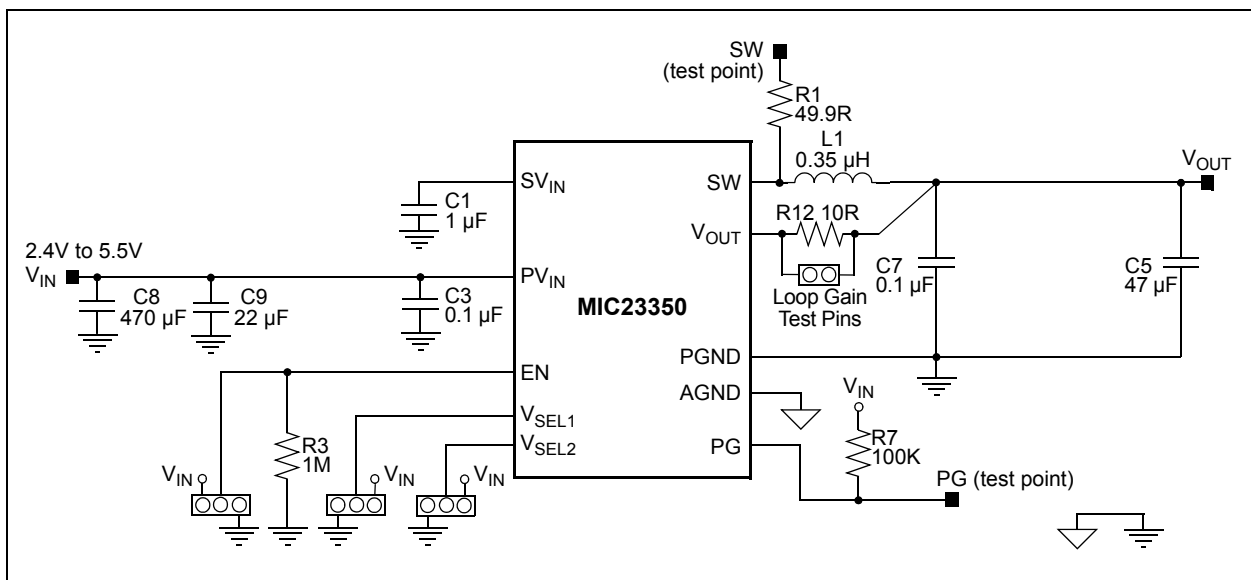
- One MIC23350 Evaluation Board unit (ADM00880)
- Important Information Sheet



## Chapter 2. Installation and Operation

### 2.1 INTRODUCTION

MIC23350 has been developed for applications suited for 2.4V to 5.5V input voltage range, low shutdown and quiescent currents, 3A continuous output current. This makes the MIC23350 device ideal for single cell Li-Ion battery-powered applications. The 100% duty cycle capability provides low-dropout operation, extending the operating range in portable systems.



**FIGURE 2-1:** MIC23350 Step-Down Evaluation Board with Pin-Selectable Output Voltage.

### 2.2 FEATURES

The MIC23350 Evaluation Board has the following features:

- 2.4V to 5.5V Input Voltage Range
- 3A Continuous Output Current
- Programmable Voltage Output through  $V_{SEL}$  Pins:
  - 0.6V, 0.8V, 0.9V, 1.0V, 1.2V, 1.5V, 1.8V, 2.5V or 3.3V Output Voltage
- High Efficiency (up to 95%)
- $\pm 1.5\%$  Output Voltage Accuracy Over Line/Load/Temperature Range
- Supports Safe Start-up with Pre-Biased Output
- Output Discharge when Disabled (typically 10 $\Omega$ )
- Typical 1.5  $\mu$ A Shutdown Supply Current
- Low-Dropout Operation (100% duty cycle)
- Ultra-Fast Transient Response
- Latch-Off Thermal Shutdown Protection
- Hiccup Current Limit Protection
- Power Good Open-Drain Output

## 2.3 GETTING STARTED

The MIC23350 Evaluation Board is fully assembled and tested to evaluate and demonstrate the MIC23350 product. This board requires the use of external lab supplies.

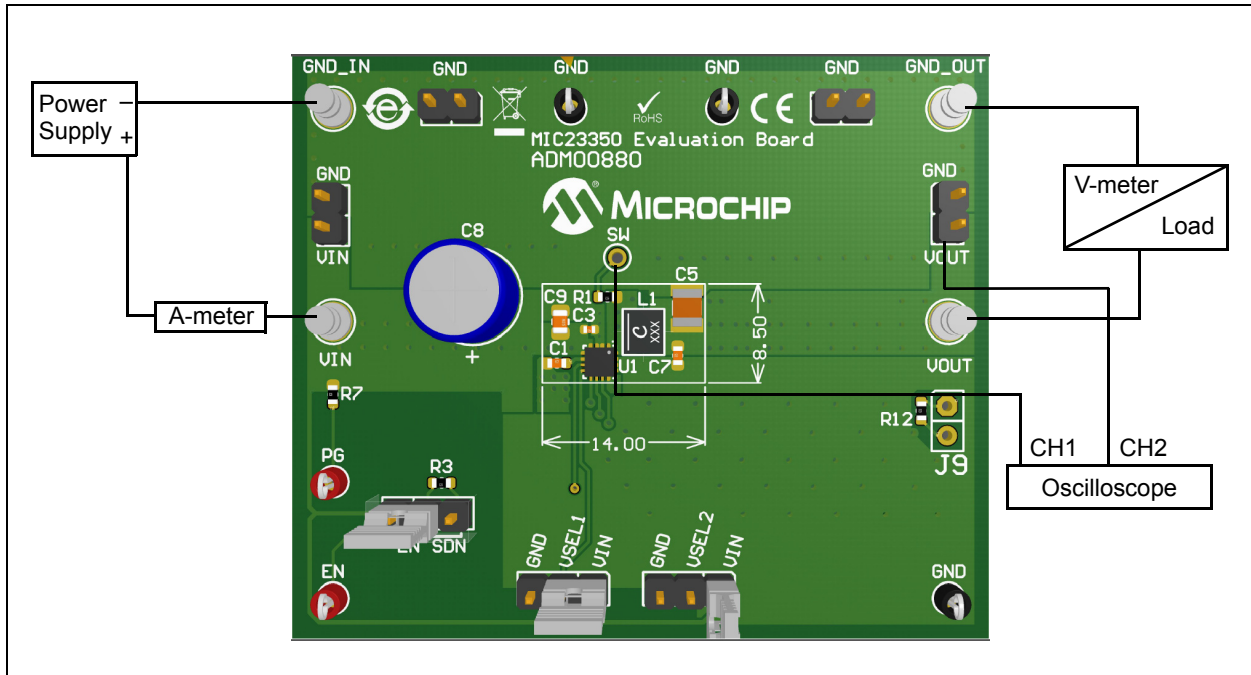
### 2.3.1 Power Input and Output Connection

#### 2.3.1.1 POWERING THE MIC23350 EVALUATION BOARD

When the MIC23350 Evaluation Board is ready for evaluation, apply positive input voltage to the  $V_{IN}$  terminal and the corresponding return to the  $GND_{IN}$  terminal. The maximum input voltage should not exceed 5.5V. An electronic load or a resistive load can be used for evaluation. Some electronic loads can sink the programmed current, starting from very low output voltage levels during start-up. For a more realistic start-up behavior evaluation, a resistive load or a constant resistance electronic load is recommended. Connect the positive voltage terminal of the load to the  $V_{OUT}$  terminal on the MIC23350 Evaluation Board and connect the negative or the return side of the load to the  $GND_{OUT}$  terminal.

#### 2.3.1.2 BOARD POWER-UP PROCEDURE

1. Connect the input supply, voltmeter, amperemeter and load as shown in [Figure 2-2](#).
2. Place  $V_{SEL1}$  and  $V_{SEL2}$  jumpers to obtain the desired output voltage, according to [Table 2-1](#).
3. Fit the enable jumper on the J6 header according to the silkscreen indication (see [Figure 2-2](#)).
4. Once the input is greater than 2.35V, the MIC23350 device begins to operate normally.
5. The voltmeter is now indicating an output voltage according to the  $V_{SEL1}/V_{SEL2}$  jumpers' combination. 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. Note that because of the relatively high internal resistance of some amperemeters, only a very limited amount of load should be applied, as long as the amperemeter is connected in series with the input power supply.
6. Optionally, for more advanced readings, place the oscilloscope probe CH1 in the SW test point in order to measure the switching waveforms. Place the probe CH2 on the output header (close to the output capacitors) to measure the AC ripple of the output voltage.
7. Remove the EN jumper and check the amperemeter indication. The measured shutdown current should be approximately 1.5  $\mu$ A (typical).



**FIGURE 2-2:** MIC23350 Evaluation Board Setup.

### 2.3.1.3 ADJUSTING THE OUTPUT VOLTAGE

There is no need for a resistor divided network on the MIC23350 device. The output voltage is simply selected before the power-up, through the  $V_{SEL1}$  and  $V_{SEL2}$  pins. [Table 2-1](#) displays the possible combinations.

**TABLE 2-1: OUTPUT VOLTAGE SETTINGS**

$V_{SEL2}$	$V_{SEL1}$	$V_{OUT}$
GND	GND	0.6V
GND	OPEN	0.8V
GND	$V_{IN}$	0.9V
OPEN	GND	1.0V
OPEN	OPEN	1.2V
OPEN	$V_{IN}$	1.5V
$V_{IN}$	GND	1.8V
$V_{IN}$	OPEN	2.5V
$V_{IN}$	$V_{IN}$	3.3V

The oscilloscope screen capture in [Figure 2-3](#) displays the MIC23350 device's switching waveforms during normal operation, when supplied from a 5V input, at full load (3A).

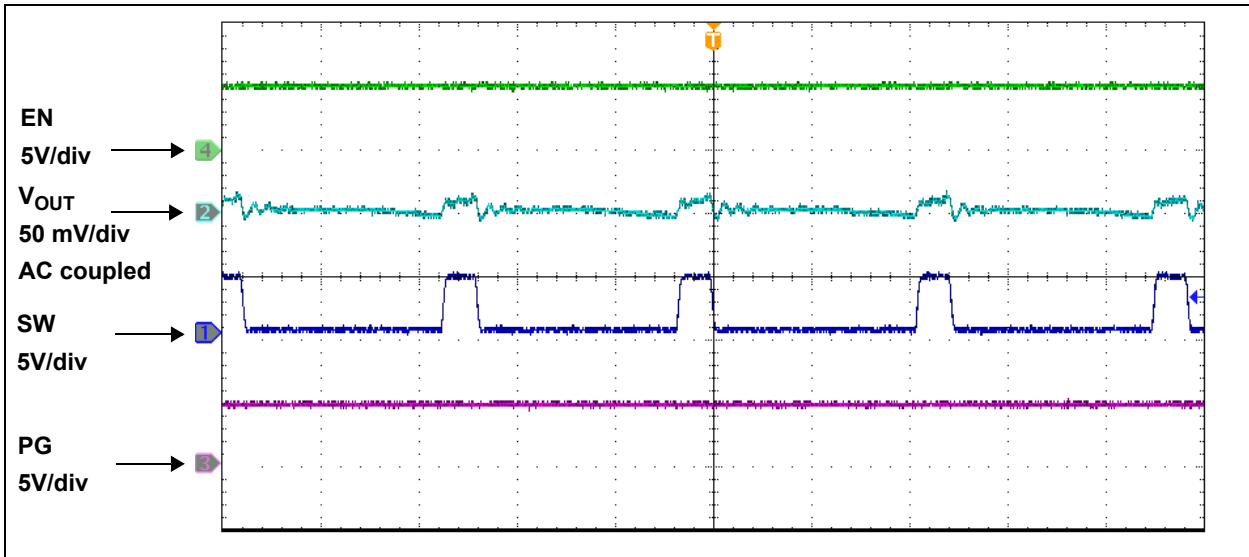


FIGURE 2-3: Normal Operation at 0.6V Output, 3A Load.

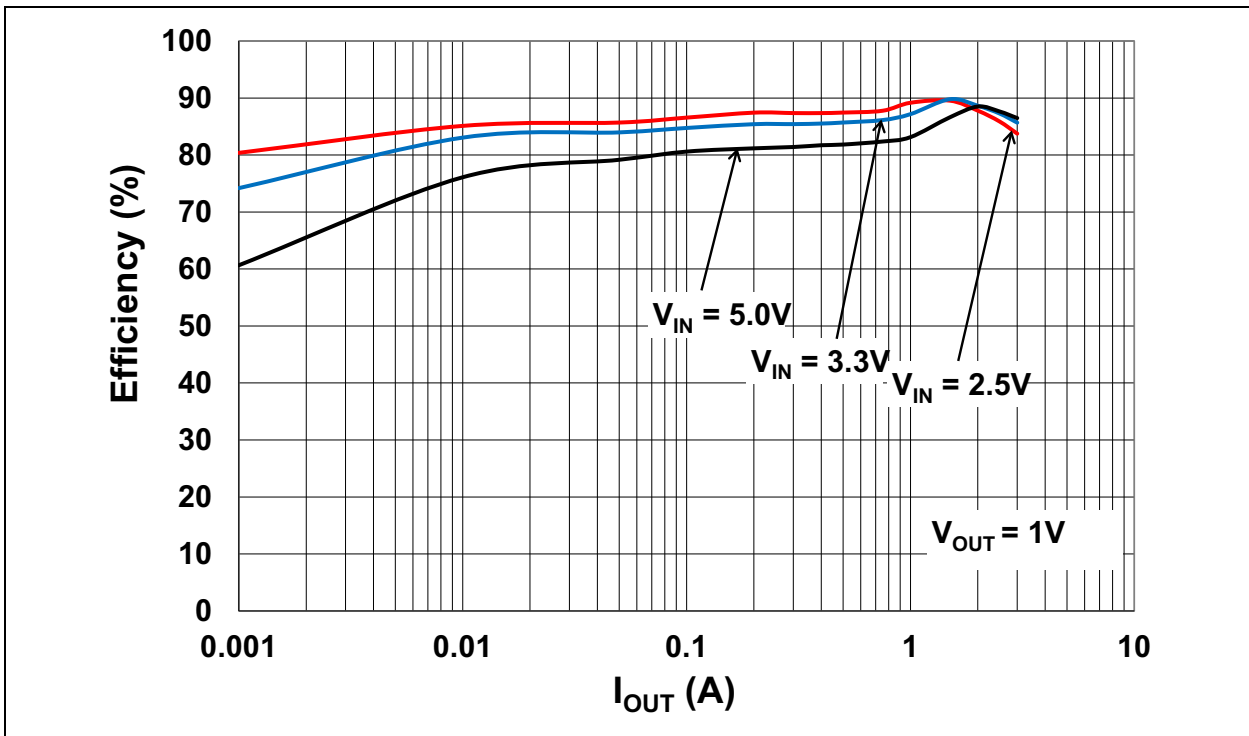
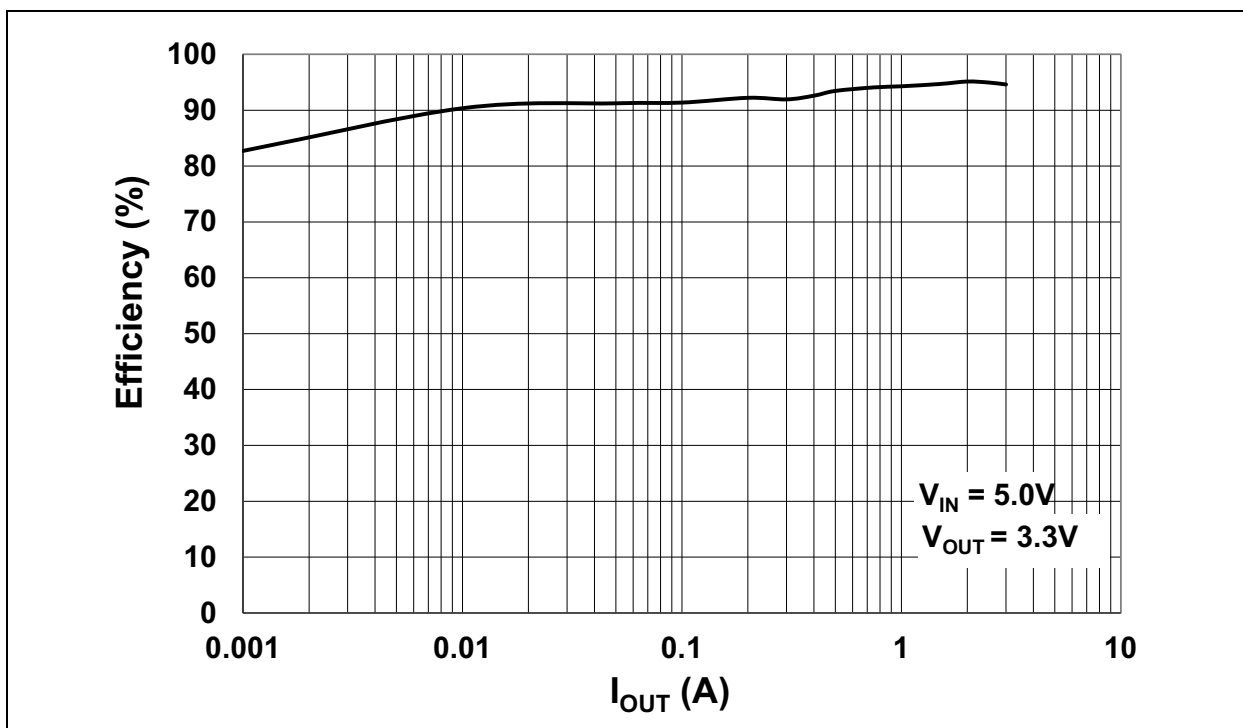


FIGURE 2-4: Efficiency vs I<sub>OUT</sub> at 1V.



**FIGURE 2-5:** Efficiency vs.  $I_{OUT}$  at 3.3V

#### 2.3.1.4 LOOP GAIN MEASUREMENT

The MIC23350 Evaluation Board provides injection points and a termination resistor (R12) for AC loop gain measurements. If needed, the value of R12 can be changed to optimize the injection signal level. Inject the oscillator at J9 through the insulation transformer (for instance, across resistor R12), and connect the A (CH1) and B (CH2) channels at TP1 and TP2, respectively, or as indicated by the operating instructions of the particular loop gain analyzer in use.

#### 2.3.1.5 BENCH TESTING AT HIGH CURRENT

When testing the MIC23350 device at high load currents, or when checking the over-current protection behavior, it may be necessary to remove the series A-meter, shown in [Figure 2-2](#), or to replace it with a very low-value shunt resistor. This is because the internal resistance of many Digital Multimeters (DMMs) used for current measurements is generally too high.

The MIC23350 Evaluation Board also comes populated with a 470  $\mu$ F electrolytic bulk capacitor, especially recommended when long wires are used in combination with high currents or load transitions. This capacitor prevents the input voltage from exceeding the device rating due to voltage spikes and allows for a more stable, controlled input voltage.

### NOTICE

In order to obtain the best performance with the minimum occupied board space, proper layout techniques must be followed. First, the input and output capacitors should be placed as close to the MIC23350 device as possible, and on the same layer as the IC. This ensures low ripple and improved performance. Secondly, vias must be used under the MIC23350 device, from its exposed pad to the GND plane, in order to allow for best heat dissipation. Lastly, the switching node (from the SW pin of the MIC23350 device to the inductor) should be as small as possible to decrease EMI emission.

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## **Appendix A. Schematic and Layouts**

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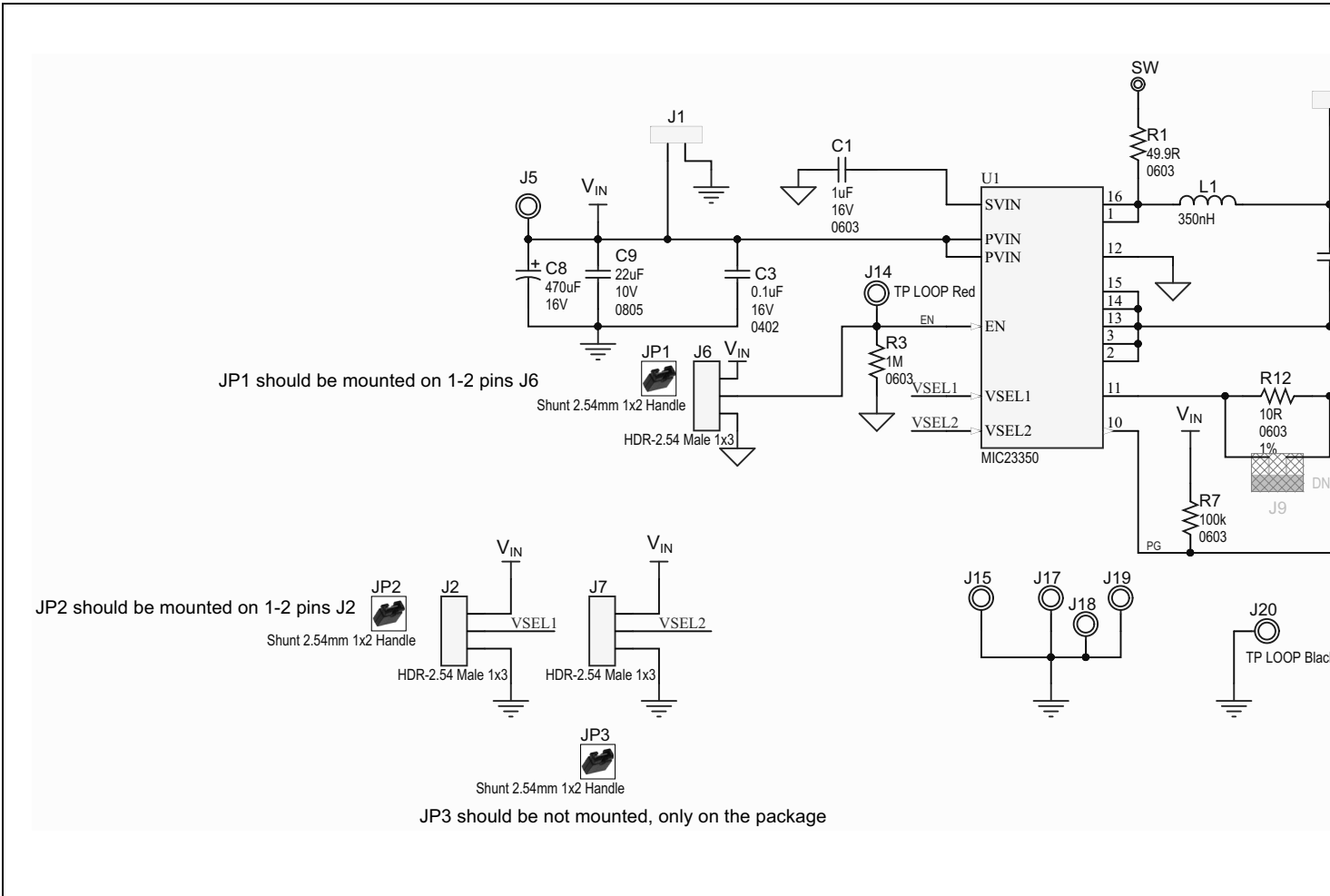
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### **A.1 INTRODUCTION**

This appendix contains the following schematics and layouts for the MIC23350 Evaluation Board:

- [Board – Schematic](#)
- [Board – Top Silk](#)
- [Board – Top Copper and Silk](#)
- [Board – Top Copper](#)
- [Board – Mid Layer 1](#)
- [Board – Mid Layer 2](#)
- [Board – Bottom Copper](#)
- [Board – Bottom Copper and Silk](#)
- [Board – Bottom Silk](#)

### A.2 BOARD – SCHEMATIC

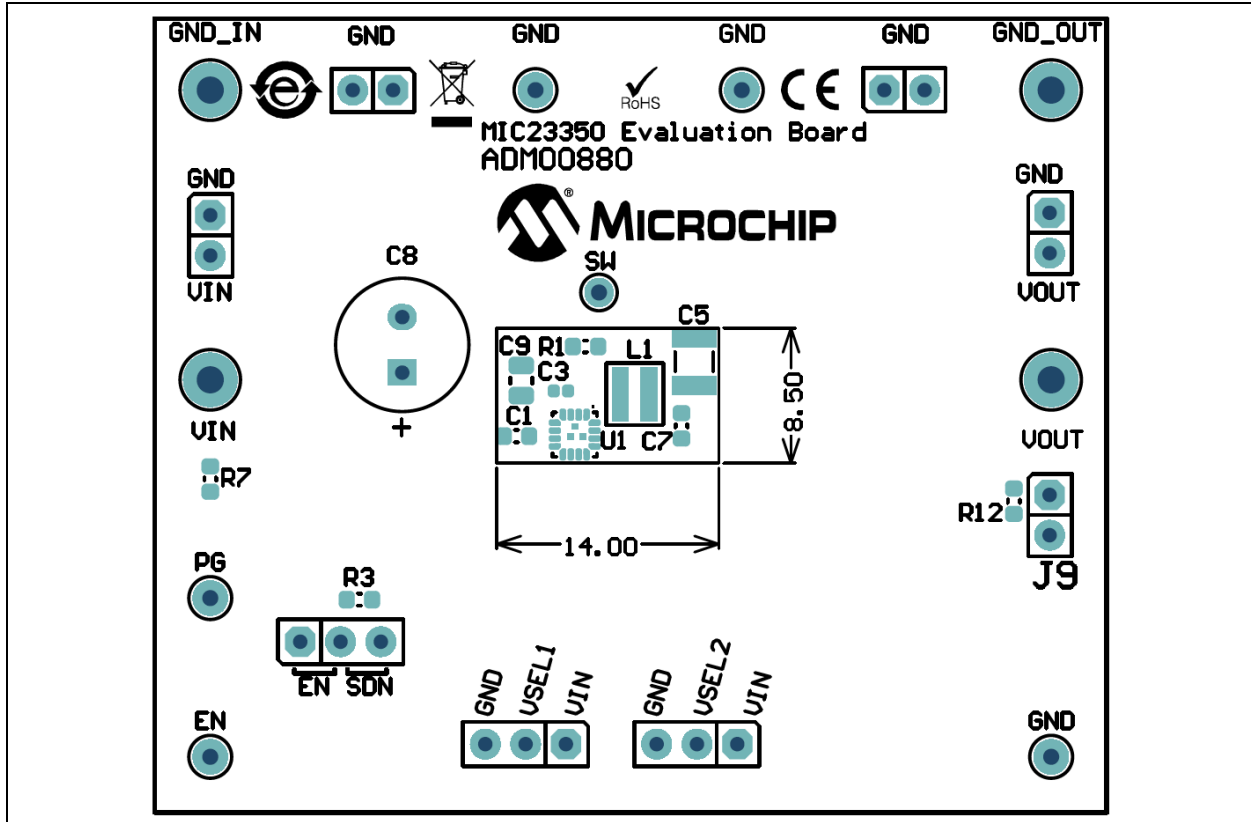


JP1 should be mounted on 1-2 pins J6

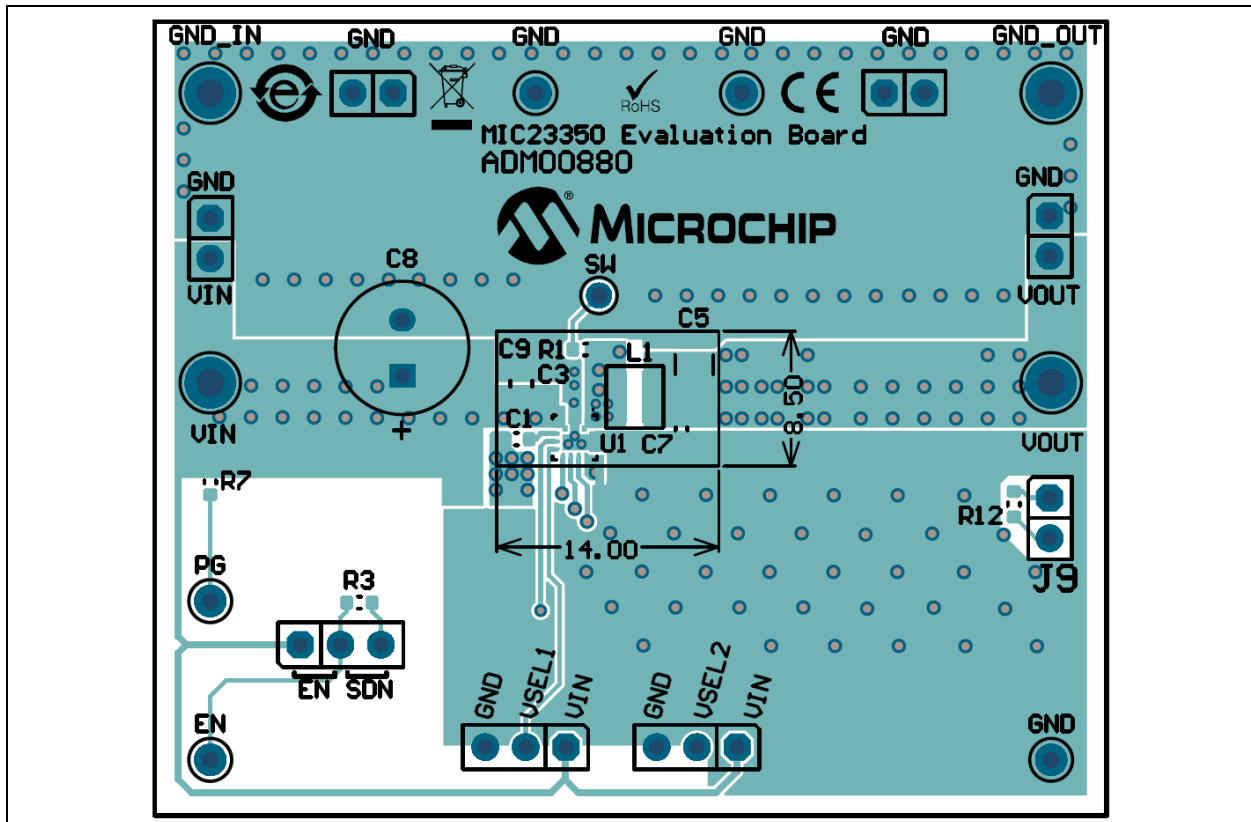
JP2 should be mounted on 1-2 pins J2

JP3 should be not mounted, only on the package

## A.3 BOARD – TOP SILK

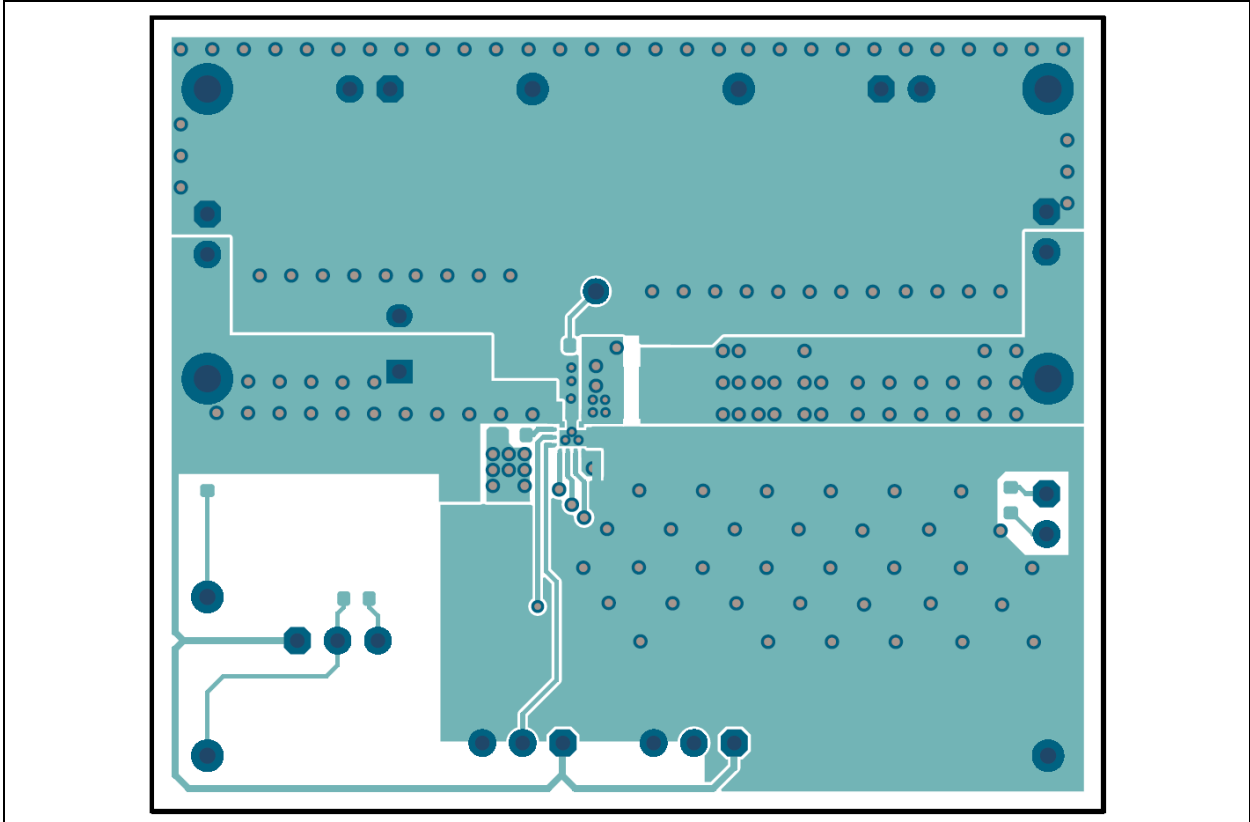


## A.4 BOARD – TOP COPPER AND SILK

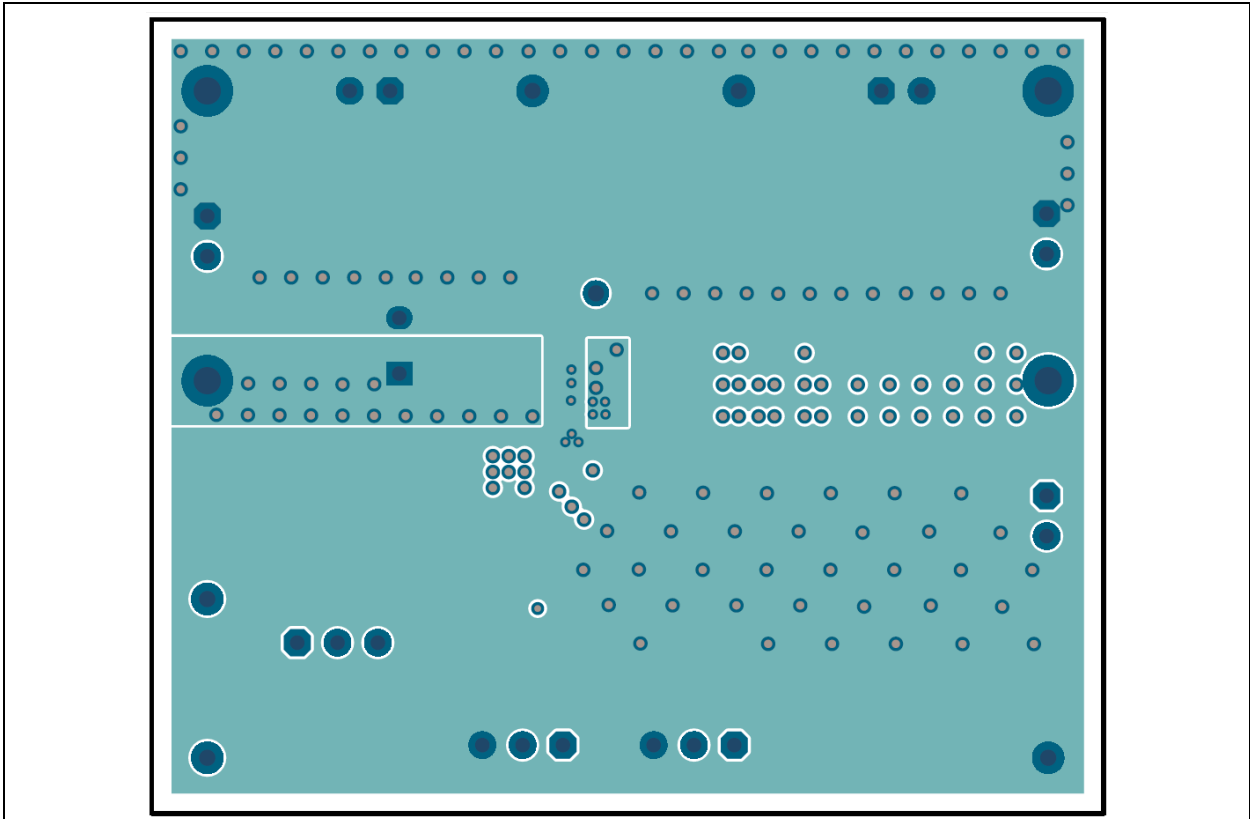




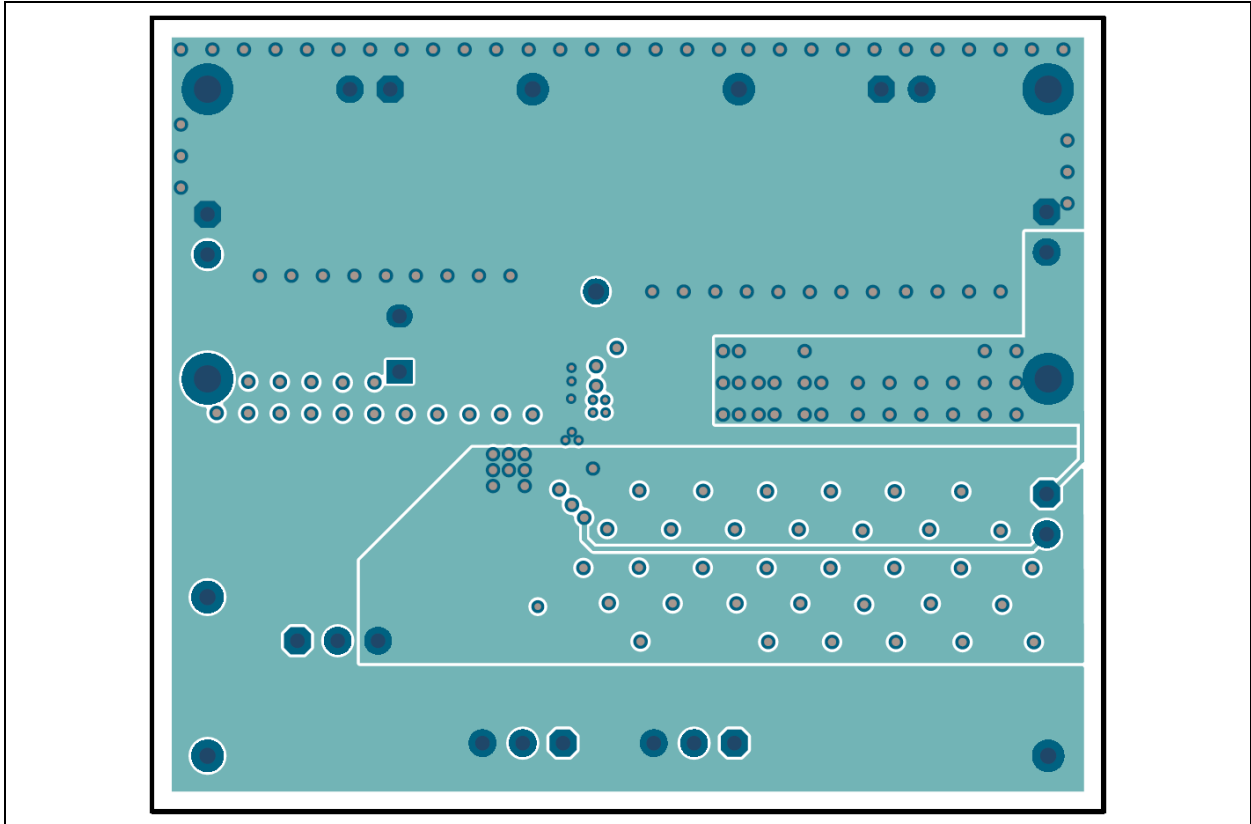
## A.5 BOARD – TOP COPPER



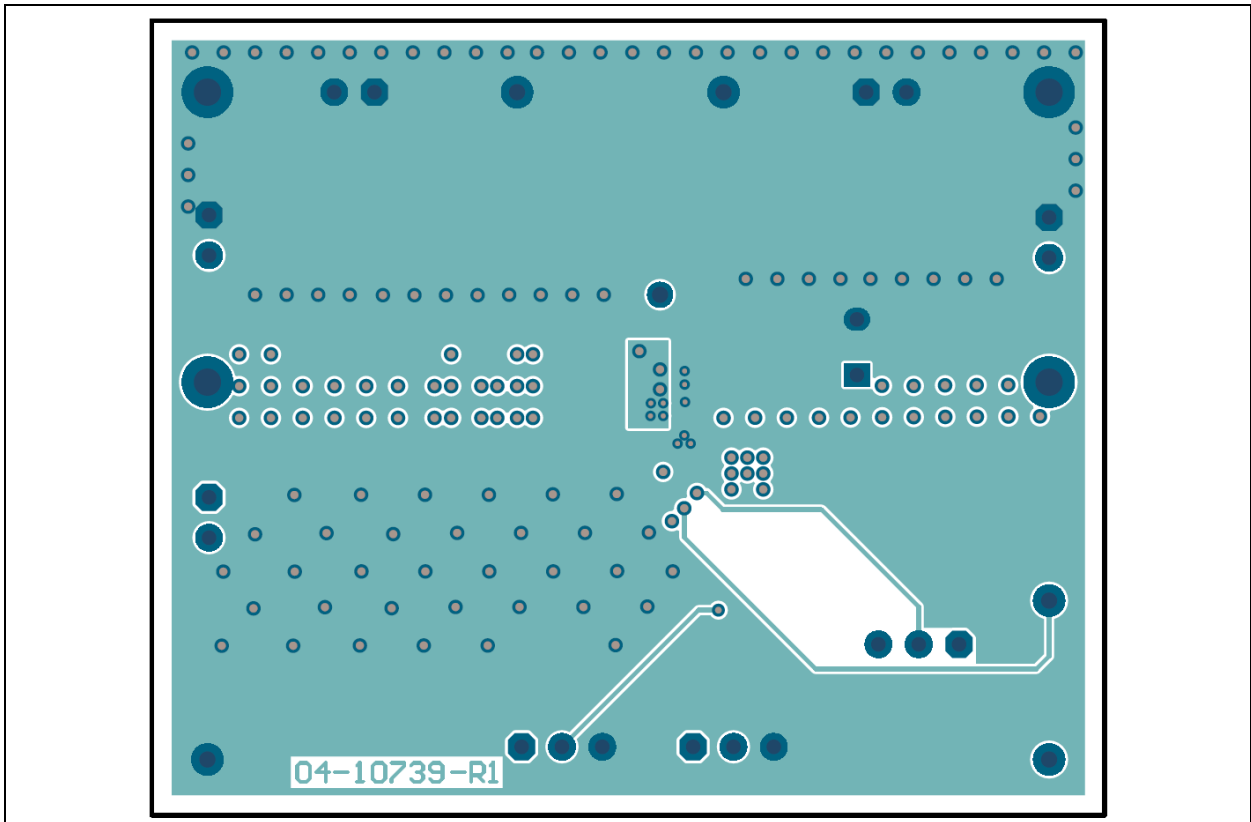
## A.6 BOARD – MID LAYER 1



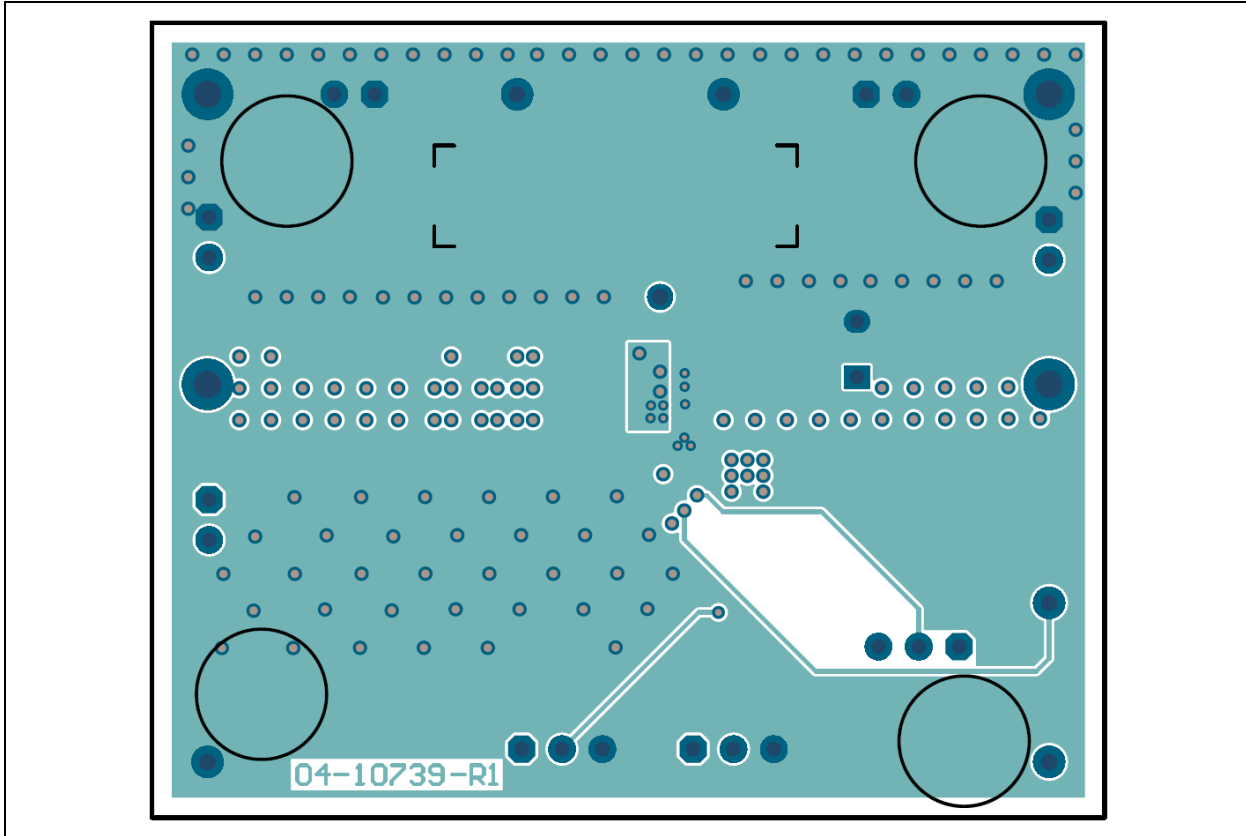
## A.7 BOARD – MID LAYER 2



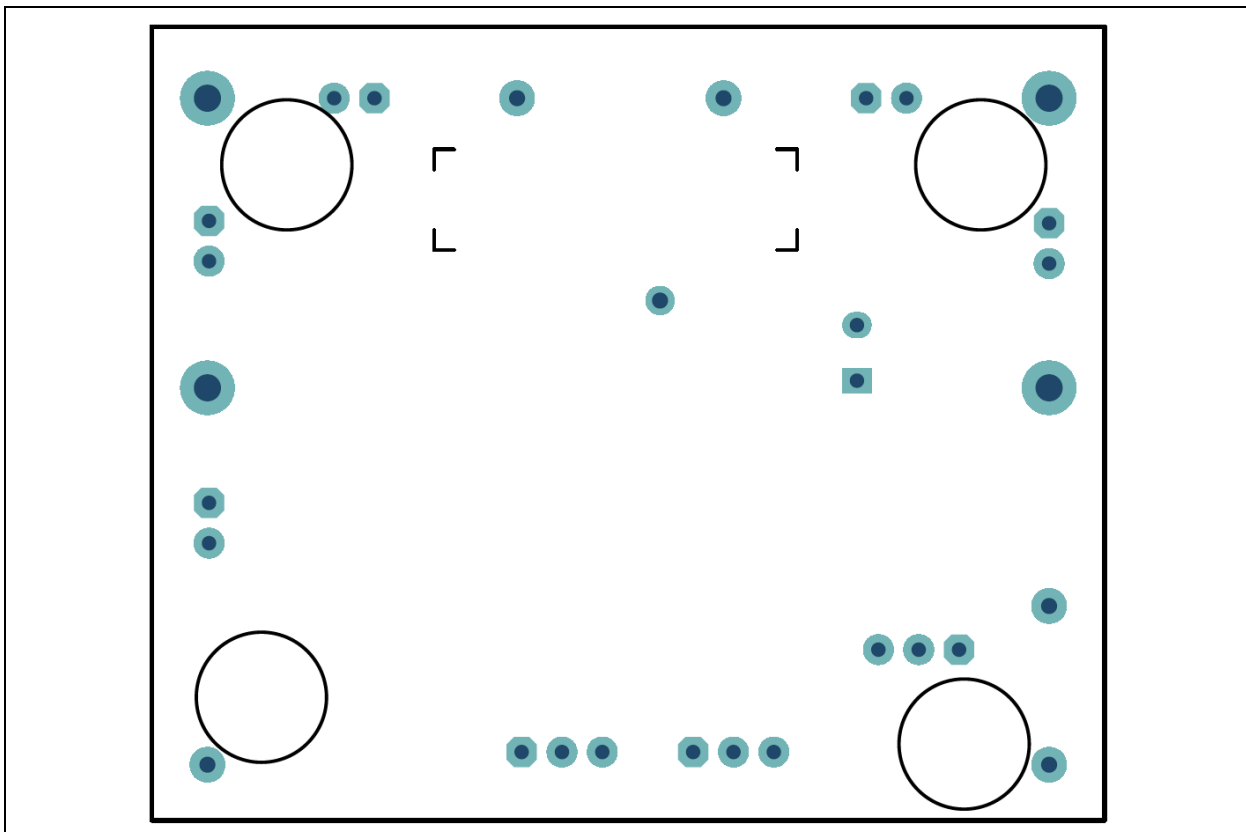
## A.8 BOARD – BOTTOM COPPER



## A.9 BOARD – BOTTOM COPPER AND SILK



## A.10 BOARD – BOTTOM SILK



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## Appendix B. Bill of Materials (BOM)

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**TABLE B-1: MIC23350 EVALUATION BOARD – BILL OF MATERIALS (BOM)**

Qty.	Reference	Description	Manufacturer	Part Number
1	C1	Ceramic capacitor, 1 $\mu$ F, 16V, 10%, X7R, SMD, 0603	Wurth Elektronik	885012206052
1	C3	Ceramic capacitor, 0.1 $\mu$ F, 16V, 10%, X7R, SMD, 0402	Murata Electronics North America, Inc.	GRM155R71C104- KA88D
1	C5	Ceramic capacitor, 47 $\mu$ F, 10V, 20%, X7R, SMD, 1210	Taiyo Yuden Co., Ltd.	LMK325B7476MM-TR
1	C7	Ceramic capacitor, 0.1 $\mu$ F, 16V, 10%, X7R, SMD, 0603	Wurth Elektronik	885012206046
1	C8	Aluminum capacitor, 470 $\mu$ F, 16V, 20%, RAD, P3.5D8H11.5	Nichicon Corporation	UVZ1C471MPD
1	C9	Ceramic capacitor, 22 $\mu$ F, 10V, 20%, X7S, SMD, 0805	TDK Corporation	C2012X7S1A226M125A C
4	J1, J3, J12, J13	Connector, HDR-2.54, Male, 1x2, Gold, 5.84MH, TH, Vertical	FCI	77311-118-02LF
2	J14, J21	Misc, Test Point, Multipurpose, Mini, Red	Keystone Electronics Corp.	5000
3	J17, J18, J20	Misc, Test Point, Multipurpose, Mini, Black	Keystone Electronics Corp.	5001
3	J2, J6, J7	Connector, HDR-2.54, Male, 1x3, Tin, 5.84MH, TH, Vertical	Samtec, Inc.	TSW-103-07-T-S
4	J4, J5, J15, J19	Connector, TP, PIN, Tin, TH	Harwin	H2121-01
0	J9	<b>NOT POPULATED</b>	FCI	77311-118-02LF
1	L1	Inductor, 350 nH, 3.3A, 20%, SMD, L3.2W3.5H1.5	Coilcraft	XEL3515-351
1	PCB1	MIC23350 Evaluation Board – Printed Circuit Board	Microchip Technology Inc.	<b>04-10739-R1</b>
1	R1	Resistor, TKF, 49.9R, 1%, 1/10W, SMD, 0603	Panasonic® - ECG	ERJ-3EKF49R9V
1	R12	Resistor, TKF, 10R, 1%, 1/10W, SMD, 0603	Panasonic - ECG	ERJ-3EKF10R0V
1	R3	Resistor, TKF, 1M, 1%, 1/10W, SMD, 0603	Panasonic - ECG	ERJ-3EKF1004V
1	R7	Resistor, TKF, 100 k $\Omega$ , 1%, 1/10W, SMD, 0603	TE Connectivity	1622827-1
1	U1	Microchip Analog Switcher Buck 2.4V to 5.5V MIC23350YFT FTQFN-16	Microchip Technology Inc.	<b>MIC23350YFT</b>

**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.

# Bill of Materials (BOM)

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**TABLE B-2: BILL OF MATERIALS - MECHANICAL PARTS**

Qty.	Reference	Description	Manufacturer	Part Number
3	JP1, JP2, JP3	Mechanical HW Jumper, 2.54 mm, 1x2, Phosphor Bronze, w/ Handle	Jameco Valuepro	2012JH-R
1	LABEL1	Label, Assembly w/Rev Level (Small Modules) Per MTS-0002	—	—
4	PAD1, PAD2, PAD3, PAD4	Mechanical HW Rubber Pad, Cylindrical, D7.9 H5.3, Black	3M	SJ61A11

**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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