



MIC23350
Evaluation Board
User's Guide

Note the following details of the code protection feature on Microchip devices:

- Microchip products meet the specification contained in their particular Microchip Data Sheet.
- Microchip believes that its family of products is one of the most secure families of its kind on the market today, when used in the intended manner and under normal conditions.
- There are dishonest and possibly illegal methods used to breach the code protection feature. All of these methods, to our knowledge, require using the Microchip products in a manner outside the operating specifications contained in Microchip's Data Sheets. Most likely, the person doing so is engaged in theft of intellectual property.
- Microchip is willing to work with the customer who is concerned about the integrity of their code.
- Neither Microchip nor any other semiconductor manufacturer can guarantee the security of their code. Code protection does not mean that we are guaranteeing the product as "unbreakable."

Code protection is constantly evolving. We at Microchip are committed to continuously improving the code protection features of our products. Attempts to break Microchip's code protection feature may be a violation of the Digital Millennium Copyright Act. If such acts allow unauthorized access to your software or other copyrighted work, you may have a right to sue for relief under that Act.

Information contained in this publication regarding device applications and the like is provided only for your convenience and may be superseded by updates. It is your responsibility to ensure that your application meets with your specifications. MICROCHIP MAKES NO REPRESENTATIONS OR WARRANTIES OF ANY KIND WHETHER EXPRESS OR IMPLIED, WRITTEN OR ORAL, STATUTORY OR OTHERWISE, RELATED TO THE INFORMATION, INCLUDING BUT NOT LIMITED TO ITS CONDITION, QUALITY, PERFORMANCE, MERCHANTABILITY OR FITNESS FOR PURPOSE. Microchip disclaims all liability arising from this information and its use. Use of Microchip devices in life support and/or safety applications is entirely at the buyer's risk, and the buyer agrees to defend, indemnify and hold harmless Microchip from any and all damages, claims, suits, or expenses resulting from such use. No licenses are conveyed, implicitly or otherwise, under any Microchip intellectual property rights unless otherwise stated.

Microchip received ISO/TS-16949:2009 certification for its worldwide headquarters, design and wafer fabrication facilities in Chandler and Tempe, Arizona; Gresham, Oregon and design centers in California and India. The Company's quality system processes and procedures are for its PIC® MCUs and dsPIC® DSCs, KEELoQ® code hopping devices, Serial EEPROMs, microperipherals, nonvolatile memory and analog products. In addition, Microchip's quality system for the design and manufacture of development systems is ISO 9001:2000 certified.

**QUALITY MANAGEMENT SYSTEM
CERTIFIED BY DNV
= ISO/TS 16949 =**

Trademarks

The Microchip name and logo, the Microchip logo, AnyRate, AVR, AVR logo, AVR Freaks, BitCloud, chipKIT, chipKIT logo, CryptoMemory, CryptoRF, dsPIC, FlashFlex, flexPWR, Helder, JukeBlox, KeeLoq, Klear, LANCheck, LINK MD, maXStylus, maXTouch, MediaLB, megaAVR, MOST, MOST logo, MPLAB, OptoLyzer, PIC, picoPower, PICSTART, PIC32 logo, Prochip Designer, QTouch, SAM-BA, SpyNIC, SST, SST Logo, SuperFlash, tinyAVR, UNI/O, and XMEGA are registered trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

ClockWorks, The Embedded Control Solutions Company, EtherSynch, Hyper Speed Control, HyperLight Load, IntelliMOS, mTouch, Precision Edge, and Quiet-Wire are registered trademarks of Microchip Technology Incorporated in the U.S.A.

Adjacent Key Suppression, AKS, Analog-for-the-Digital Age, Any Capacitor, AnyIn, AnyOut, BodyCom, CodeGuard, CryptoAuthentication, CryptoAutomotive, CryptoCompanion, CryptoController, dsPICDEM, dsPICDEM.net, Dynamic Average Matching, DAM, ECAN, EtherGREEN, In-Circuit Serial Programming, ICSP, INICnet, Inter-Chip Connectivity, JitterBlocker, KlearNet, KlearNet logo, memBrain, Mindi, MiWi, motorBench, MPASM, MPF, MPLAB Certified logo, MPLIB, MPLINK, MultiTRAK, NetDetach, Omniscient Code Generation, PICDEM, PICDEM.net, PICKit, PICtail, PowerSmart, PureSilicon, QMatrix, REAL ICE, Ripple Blocker, SAM-ICE, Serial Quad I/O, SMART-I.S., SQI, SuperSwitcher, SuperSwitcher II, Total Endurance, TSHARC, USBCheck, VariSense, ViewSpan, WiperLock, Wireless DNA, and ZENA are trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

SQTP is a service mark of Microchip Technology Incorporated in the U.S.A.

Silicon Storage Technology is a registered trademark of Microchip Technology Inc. in other countries.

GestIC is a registered trademark of Microchip Technology Germany II GmbH & Co. KG, a subsidiary of Microchip Technology Inc., in other countries.

All other trademarks mentioned herein are property of their respective companies.

© 2018, Microchip Technology Incorporated, All Rights Reserved.
ISBN: 978-1-5224-4008-6

Table of Contents

Preface	4
Introduction	4
Document Layout	4
Conventions Used in this Guide	5
Recommended Reading	6
The Microchip Website	6
Customer Support	6
Document Revision History	6
Chapter 1. Product Overview	
1.1 Introduction	7
1.2 MIC23350 Device Short Overview	7
1.3 What is the MIC23350 Evaluation Board?	8
1.4 Contents of the MIC23350 Evaluation Board Kit	8
Chapter 2. Installation and Operation	
2.1 Introduction	9
2.2 Features	9
2.3 Getting Started	10
2.3.1 Power Input and Output Connection	10
Appendix A. Schematic and Layouts	
A.1 Introduction	13
A.2 Board – Schematic	14
A.3 Board – Top Silk	15
A.4 Board – Top Copper and Silk	15
A.5 Board – Top Copper	16
A.6 Board – Mid Layer 1	16
A.7 Board – Mid Layer 2	17
A.8 Board – Bottom Copper	17
A.9 Board – Bottom Copper and Silk	18
A.10 Board – Bottom Silk	18
Appendix B. Bill of Materials (BOM)	
Worldwide Sales and Service	21

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 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
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 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. 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
- **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

CUSTOMER SUPPORT

Users of Microchip products can receive assistance through several channels:

- 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 μA .

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 $-40^{\circ}C$ to $+125^{\circ}C$.

More detailed information regarding the capabilities of the MIC23350 device is available in the “*MIC23350 Data Sheet*”.

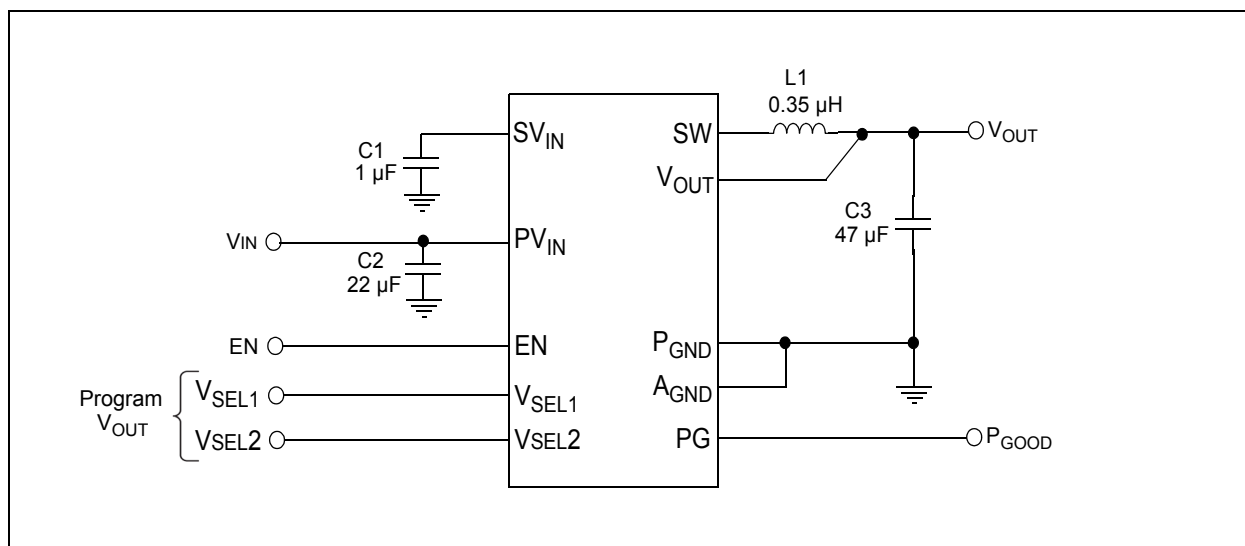


FIGURE 1-1: Typical MIC23350 Step-Down Application.

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.

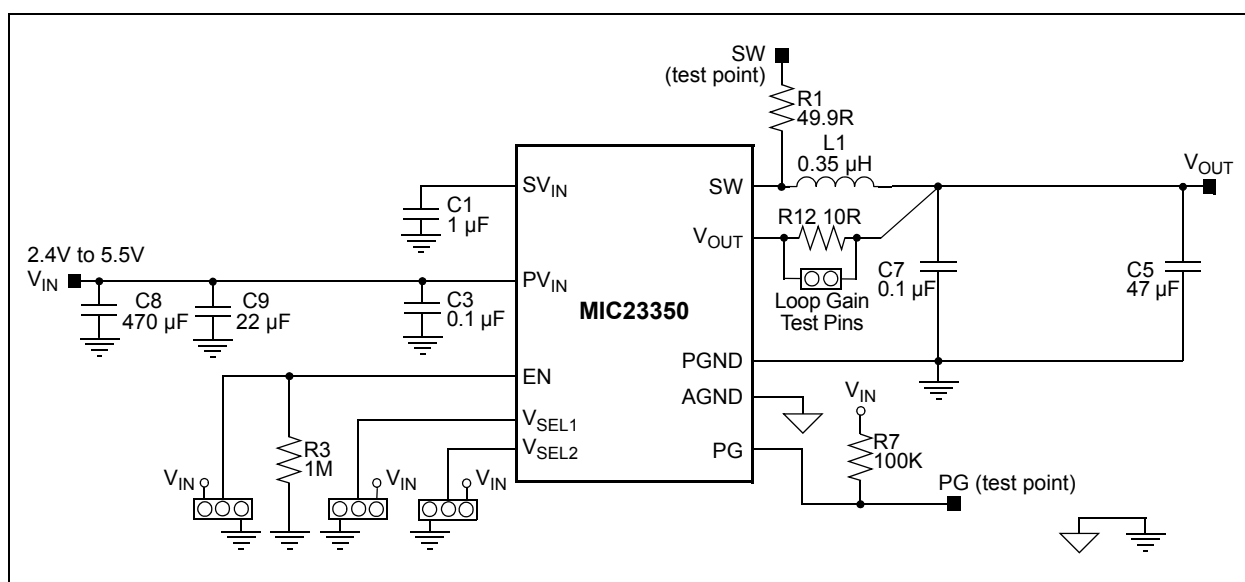


FIGURE 2-1: MIC23350 Step-Down Evaluation Board with Pin-Selectable Output Voltage.

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%)
- ±1.5% Output Voltage Accuracy Over Line/Load/Temperature Range
- Supports Safe Start-up with Pre-Biased Output
- Output Discharge when Disabled (typically 10Ω)
- Typical 1.5 µA 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 μA (typical).

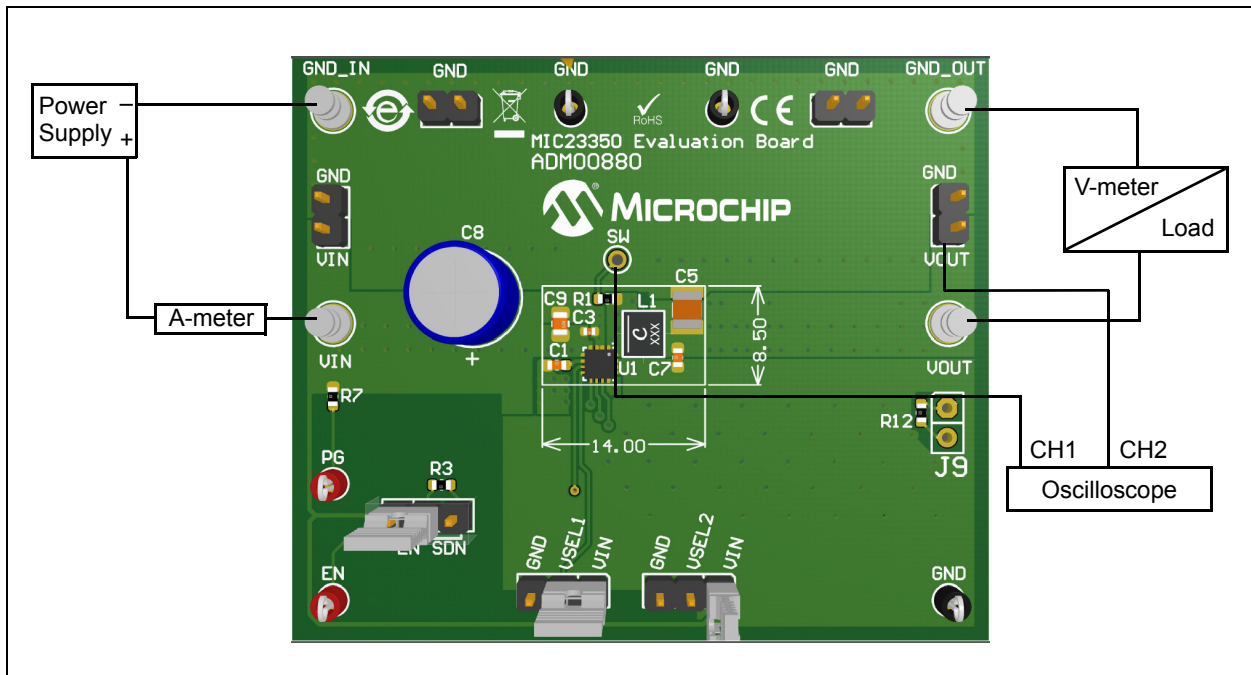


FIGURE 2-2: MIC23350 Evaluation Board Setup.

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).

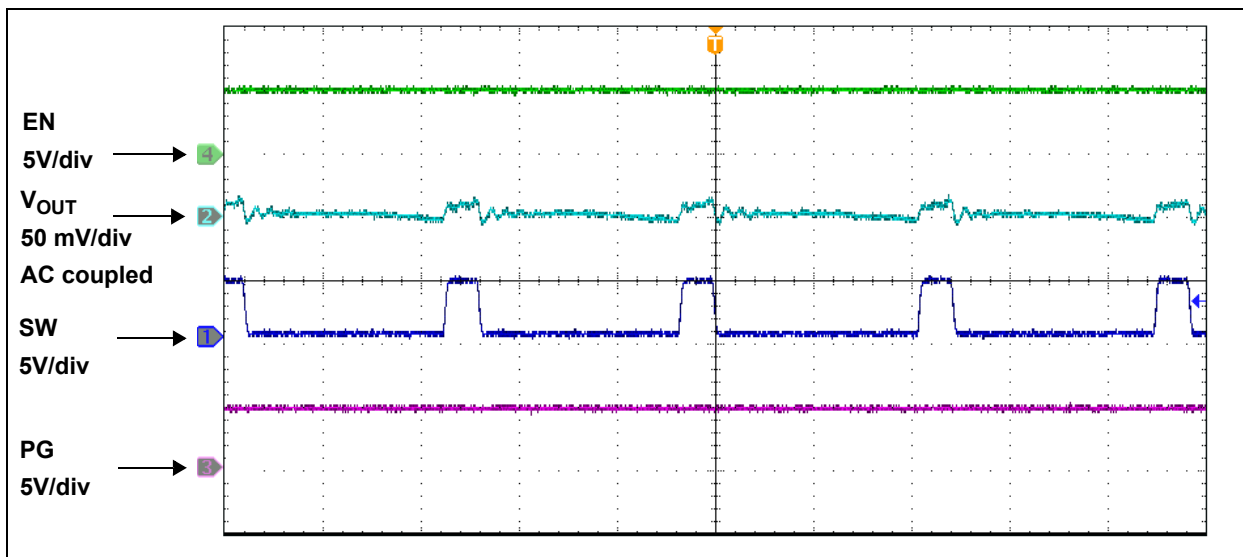


FIGURE 2-3: Normal Operation at 0.6V Output, 3A Load.

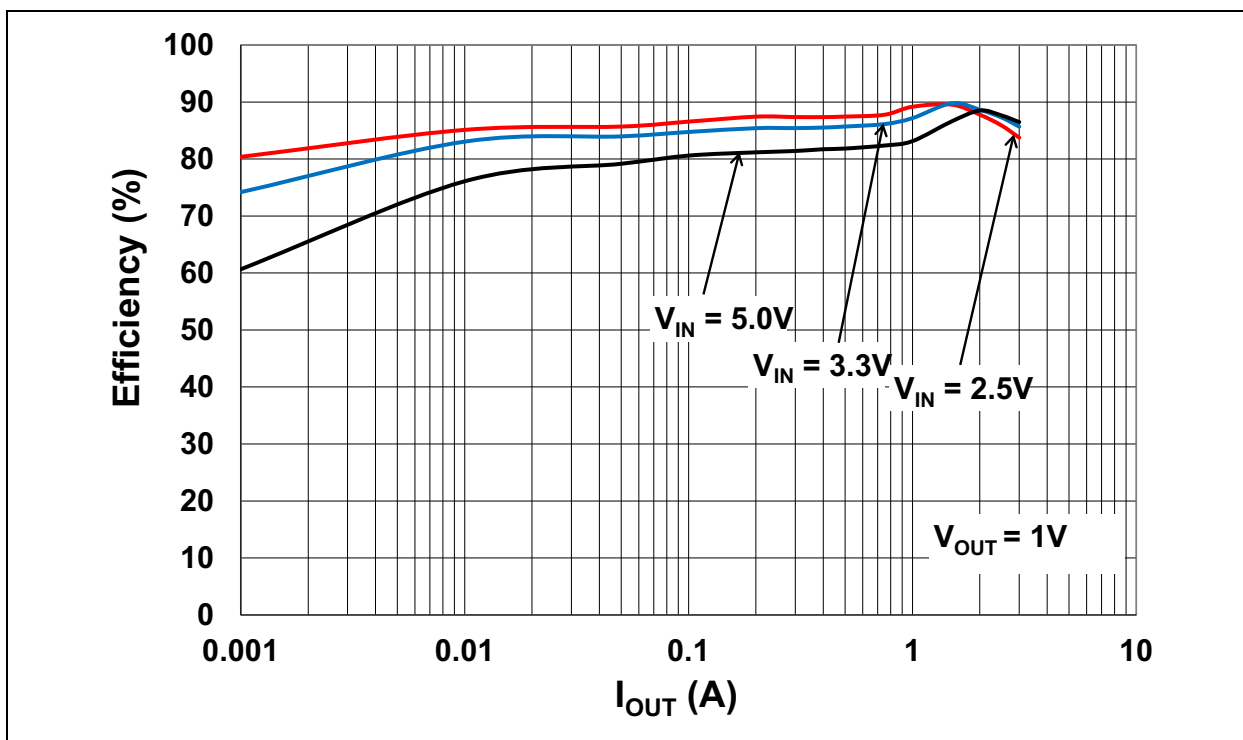


FIGURE 2-4: Efficiency vs I_{OUT} at 1V.

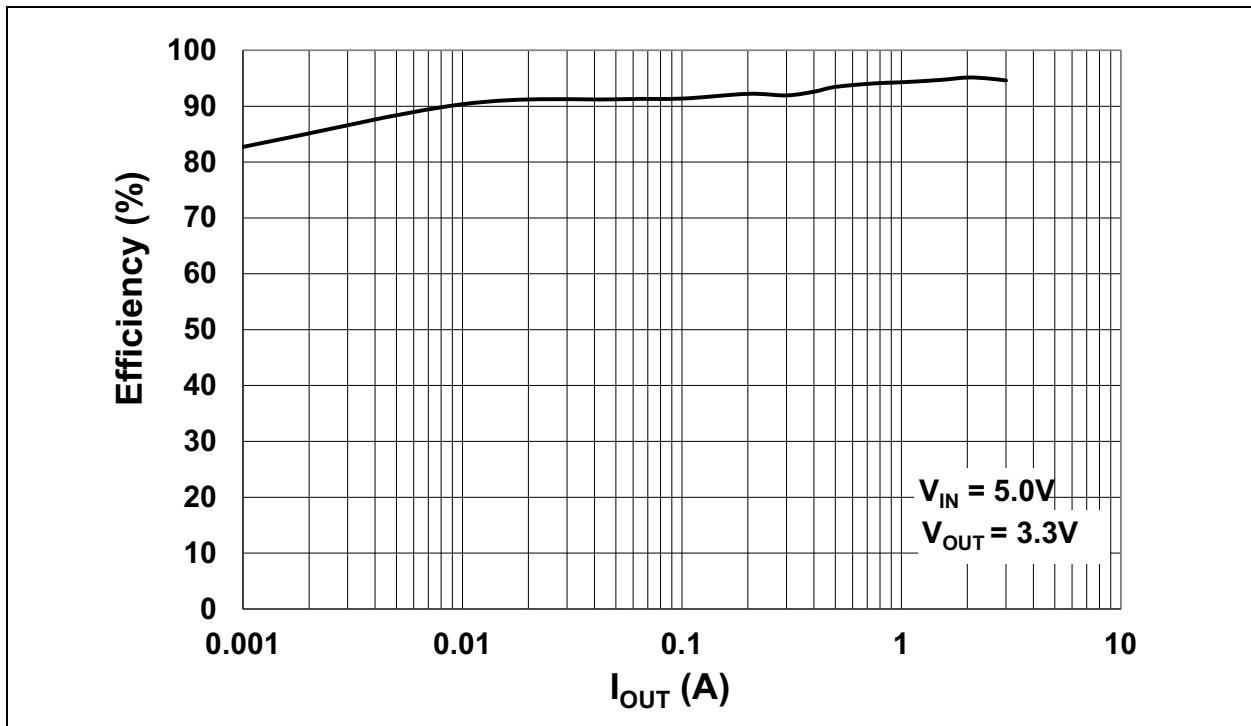


FIGURE 2-5: Efficiency vs. I_{OUT} at 3.3V

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 μ 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.

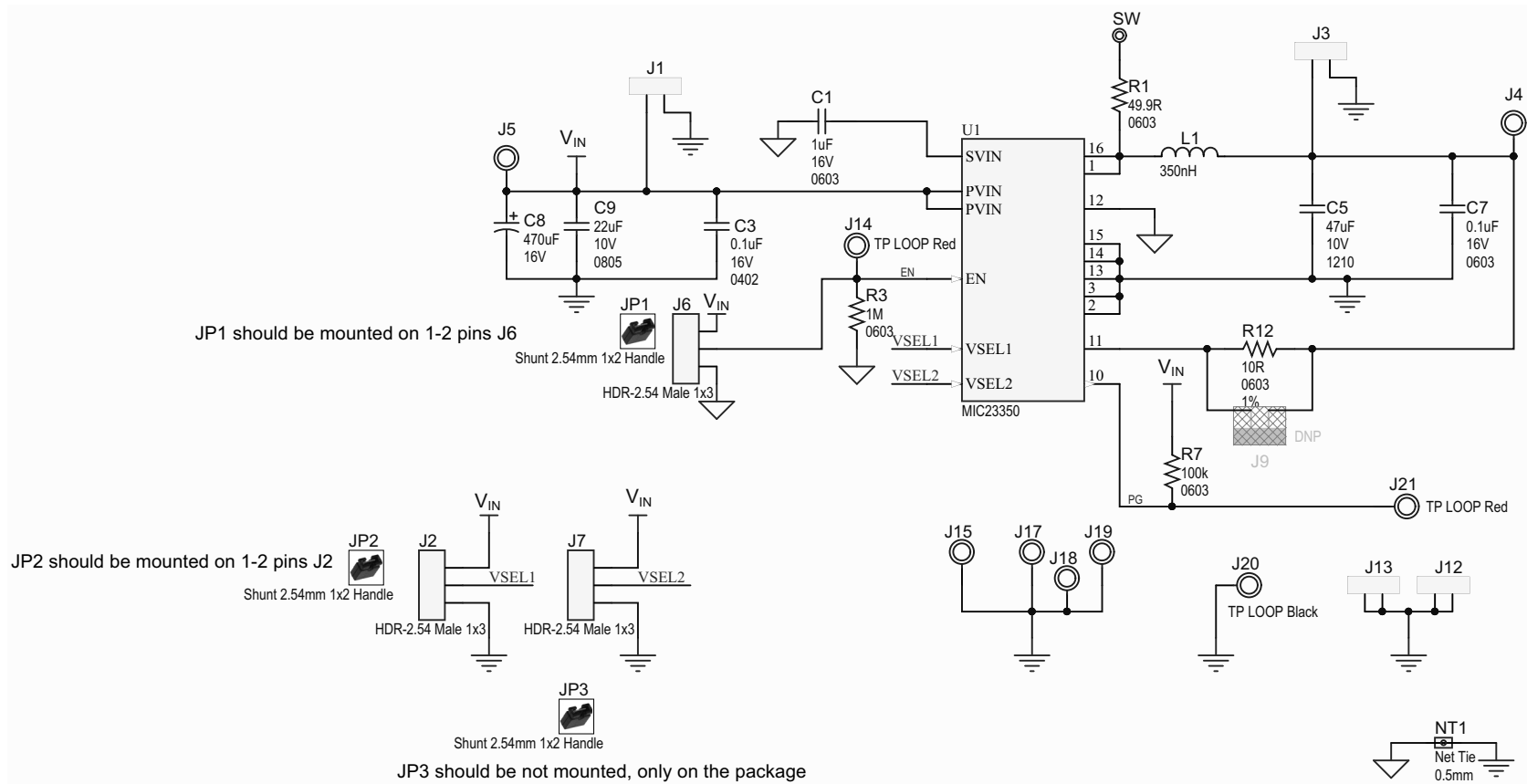
Appendix A. Schematic and Layouts

A.1 INTRODUCTION

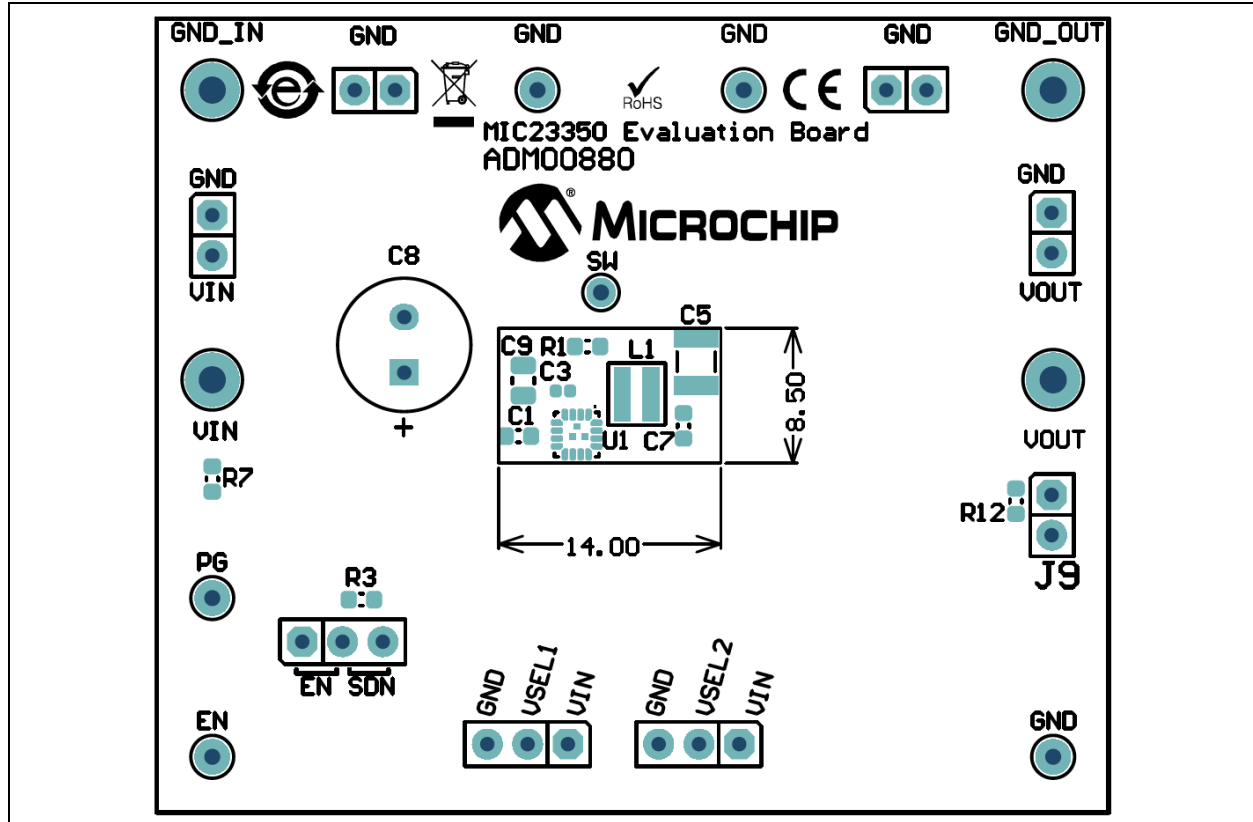
This appendix contains the following schematics and layouts for the MIC23350 Evaluation Board:

- [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](#)

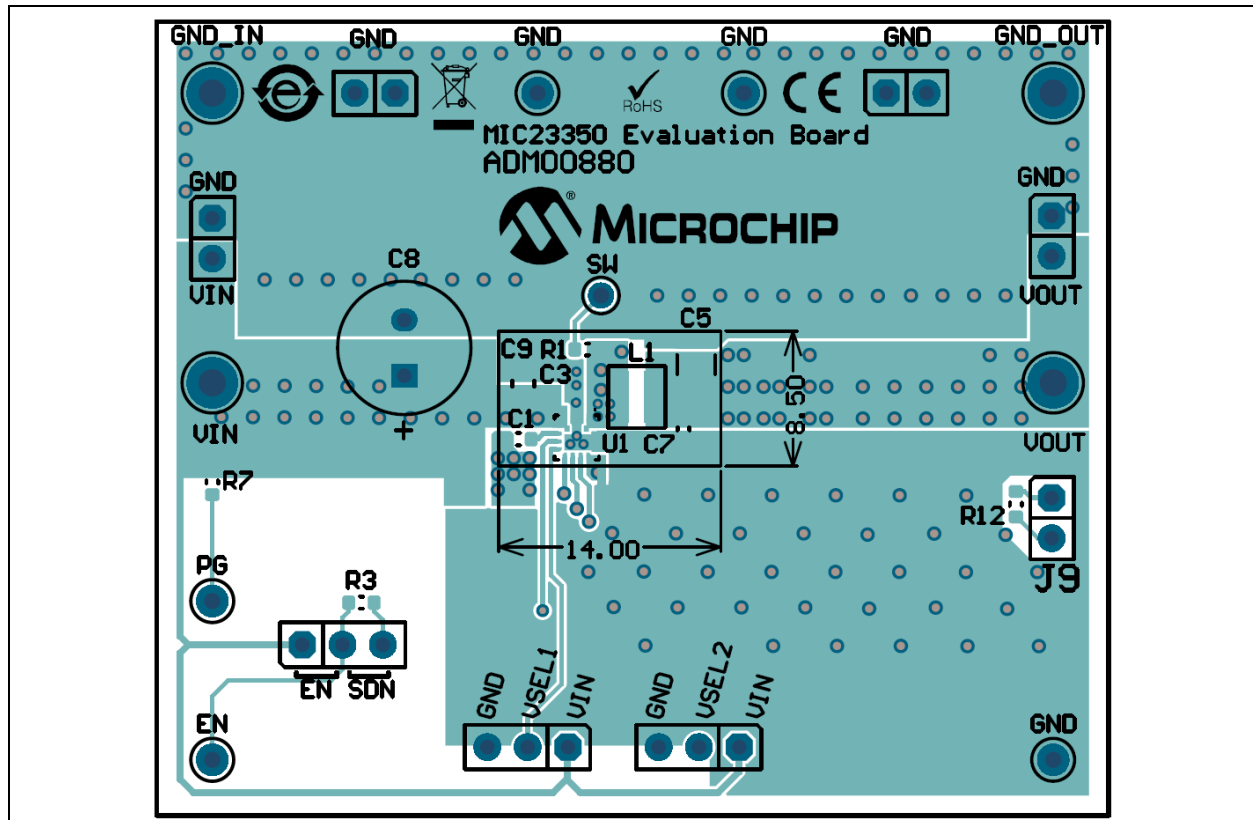
A.2 BOARD – SCHEMATIC



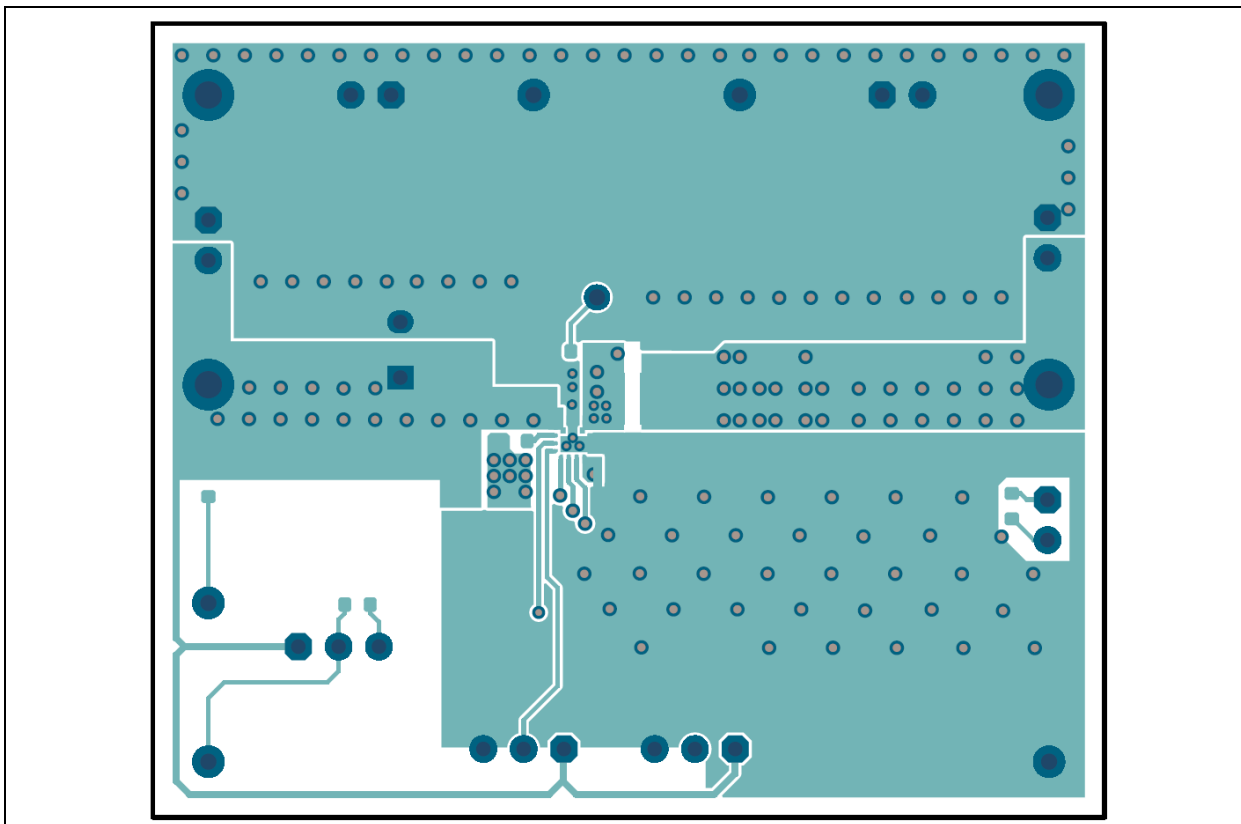
A.3 BOARD – TOP SILK



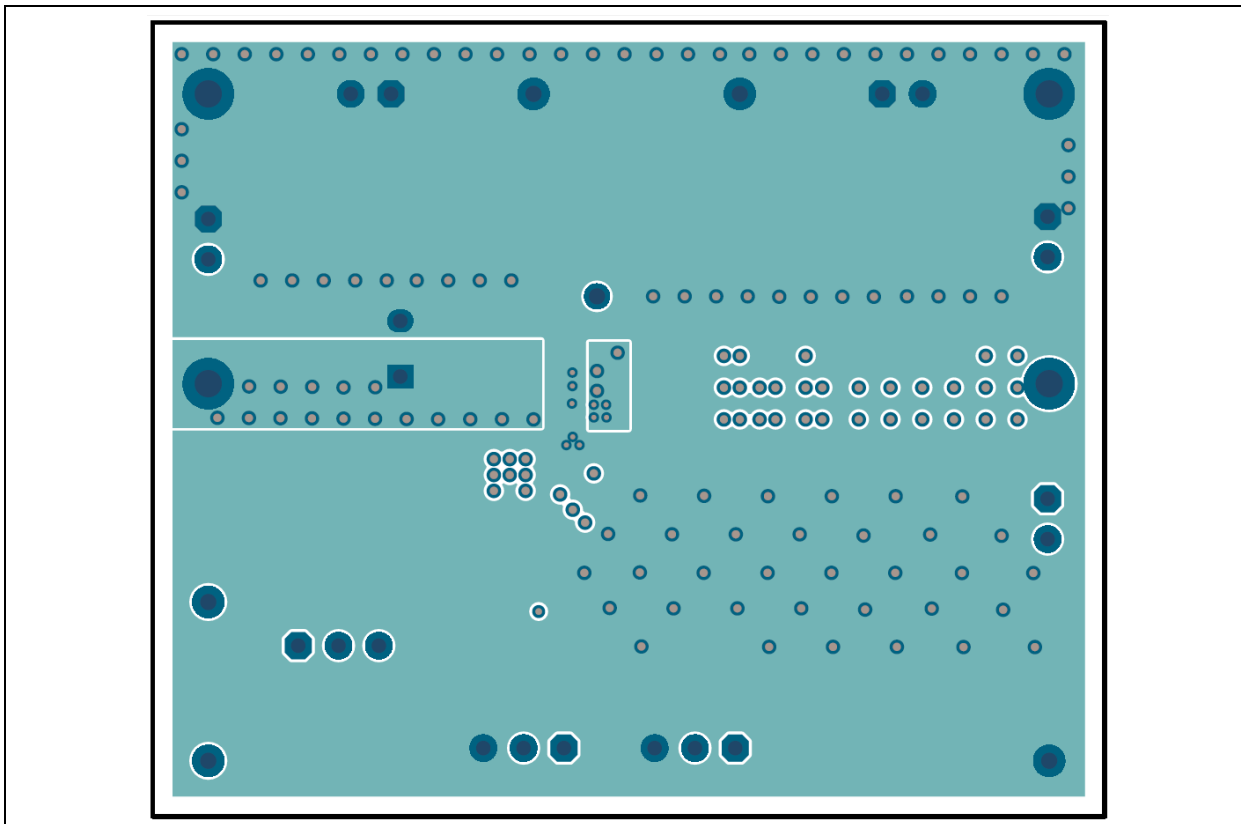
A.4 BOARD – TOP COPPER AND SILK



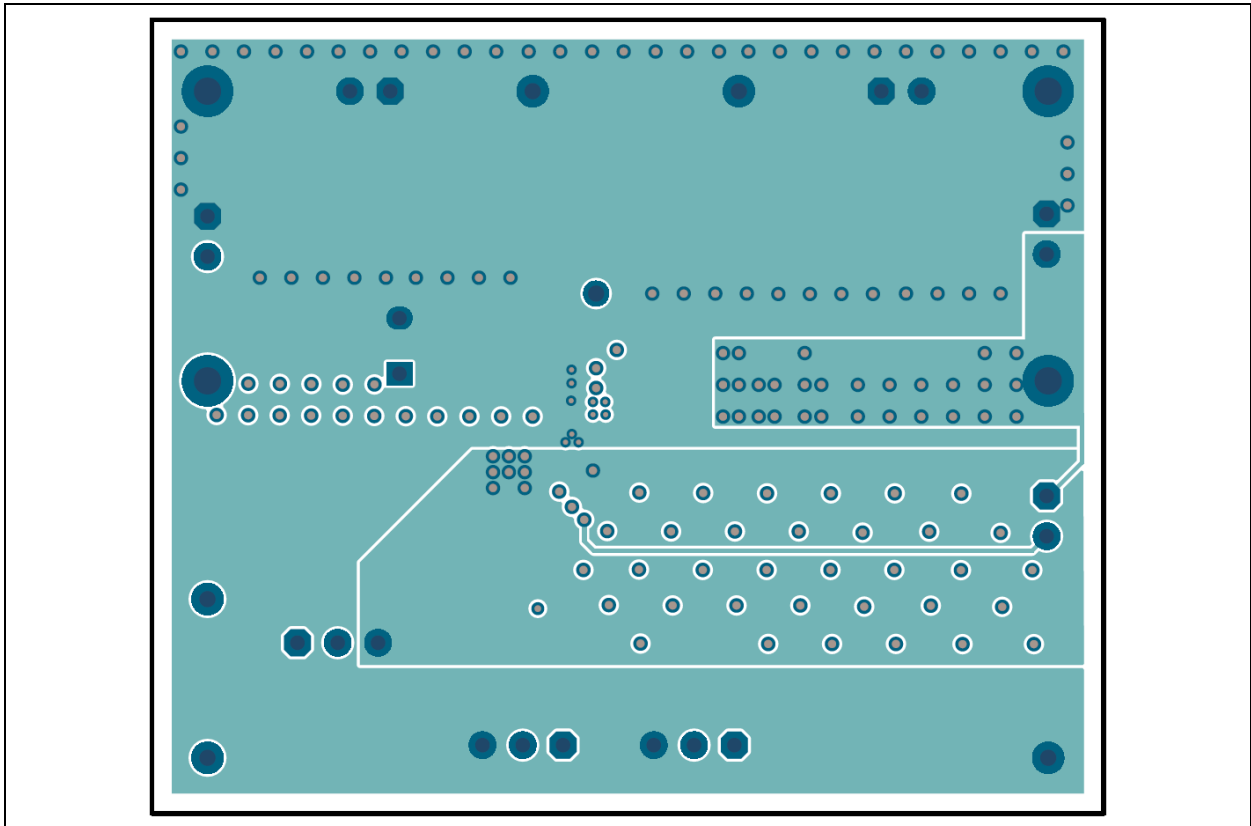
A.5 BOARD – TOP COPPER



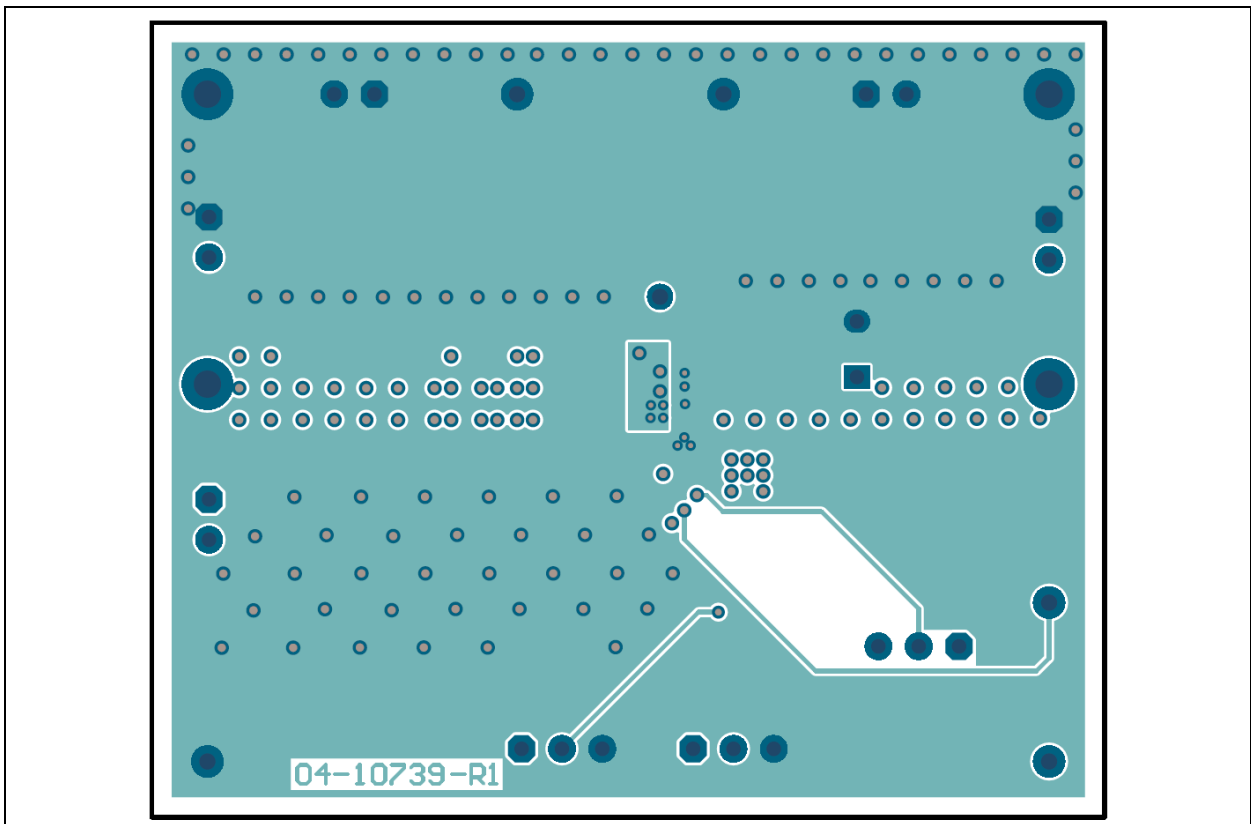
A.6 BOARD – MID LAYER 1



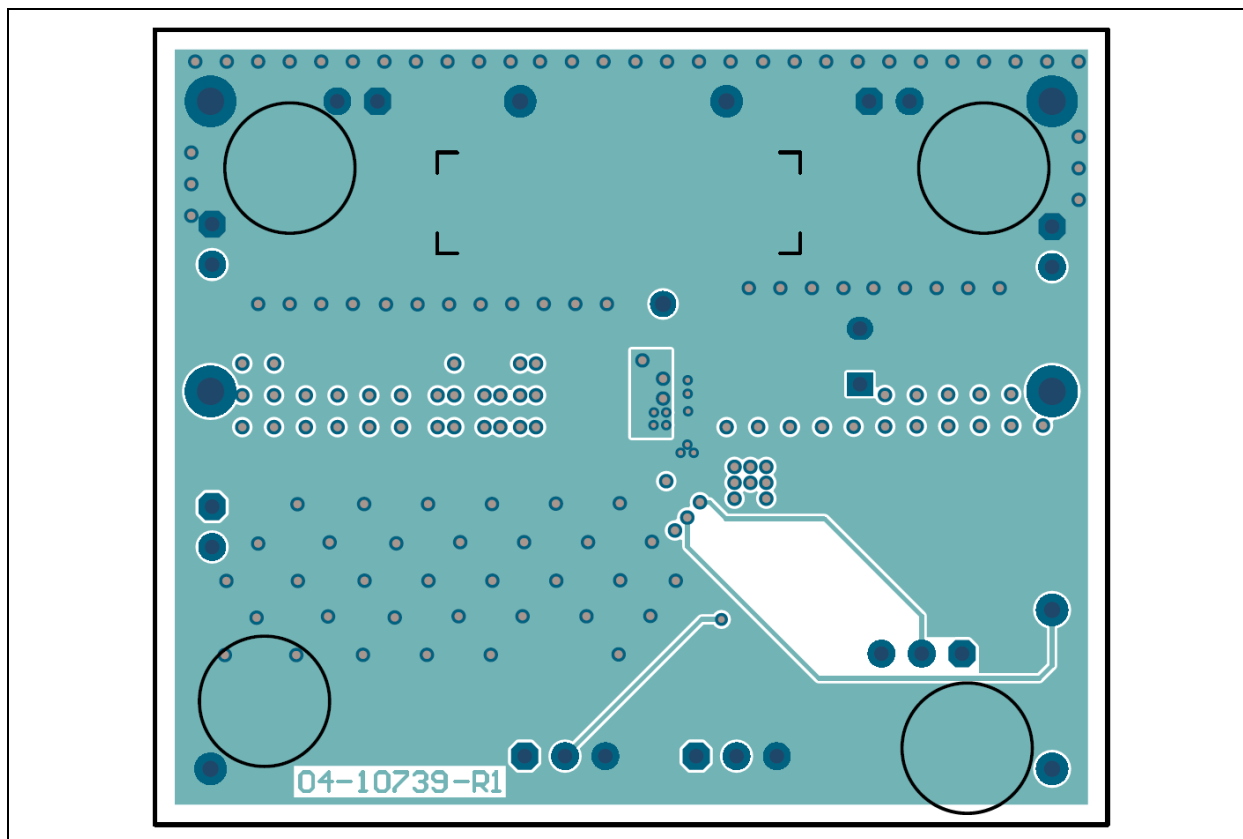
A.7 BOARD – MID LAYER 2



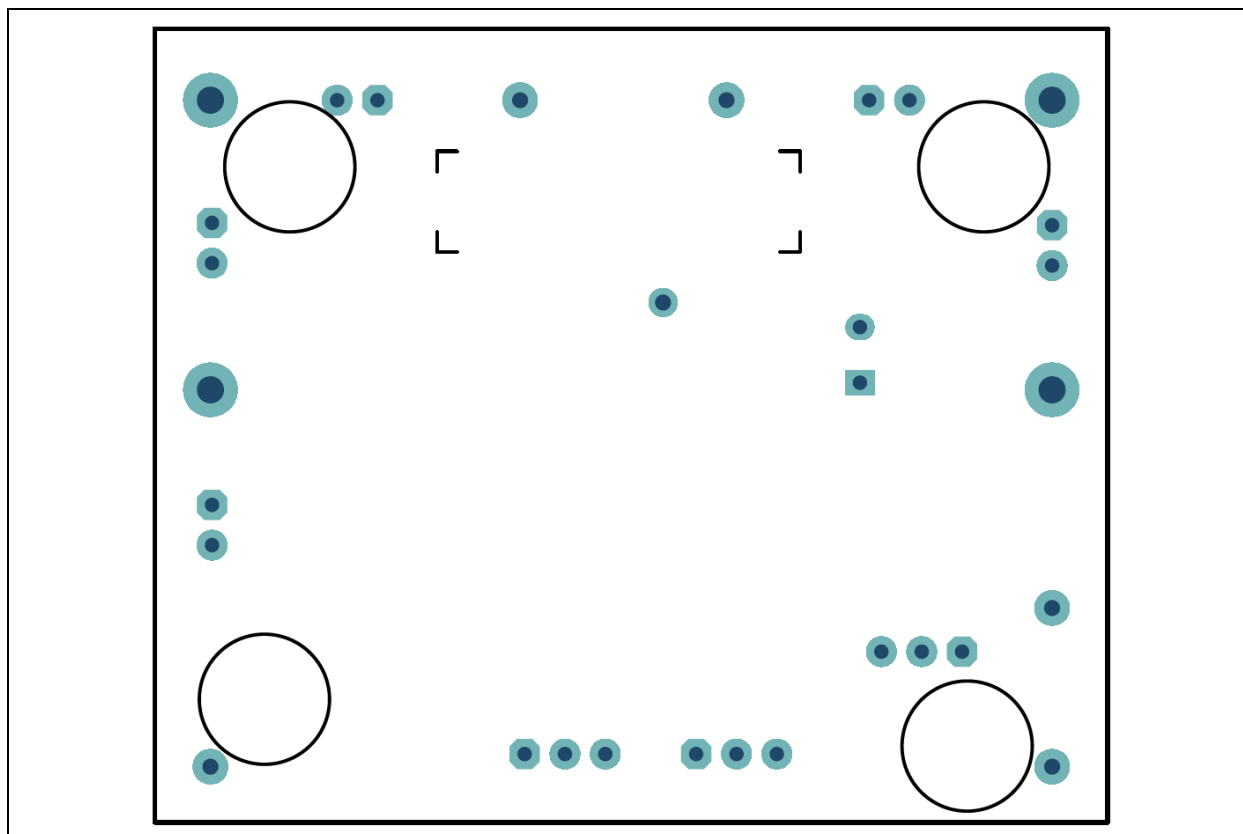
A.8 BOARD – BOTTOM COPPER



A.9 BOARD – BOTTOM COPPER AND SILK



A.10 BOARD – BOTTOM SILK



Appendix B. Bill of Materials (BOM)

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

Qty.	Reference	Description	Manufacturer	Part Number
1	C1	Ceramic capacitor, 1 μ F, 16V, 10%, X7R, SMD, 0603	Wurth Elektronik	885012206052
1	C3	Ceramic capacitor, 0.1 μ F, 16V, 10%, X7R, SMD, 0402	Murata Electronics North America, Inc.	GRM155R71C104- KA88D
1	C5	Ceramic capacitor, 47 μ F, 10V, 20%, X7R, SMD, 1210	Taiyo Yuden Co., Ltd.	LMK325B7476MM-TR
1	C7	Ceramic capacitor, 0.1 μ F, 16V, 10%, X7R, SMD, 0603	Wurth Elektronik	885012206046
1	C8	Aluminum capacitor, 470 μ F, 16V, 20%, RAD, P3.5D8H11.5	Nichicon Corporation	UVZ1C471MPD
1	C9	Ceramic capacitor, 22 μ 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	NOT POPULATED	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.	04-10739-R1
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 Ω , 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.	MIC23350YFT

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)

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.

Worldwide Sales and Service

AMERICAS

Corporate Office
2355 West Chandler Blvd.
Chandler, AZ 85224-6199
Tel: 480-792-7200
Fax: 480-792-7277
Technical Support:
<http://www.microchip.com/support>
Web Address:
www.microchip.com

Atlanta
Duluth, GA
Tel: 678-957-9614
Fax: 678-957-1455

Austin, TX
Tel: 512-257-3370

Boston
Westborough, MA
Tel: 774-760-0087
Fax: 774-760-0088

Chicago
Itasca, IL
Tel: 630-285-0071
Fax: 630-285-0075

Dallas
Addison, TX
Tel: 972-818-7423
Fax: 972-818-2924

Detroit
Novi, MI
Tel: 248-848-4000

Houston, TX
Tel: 281-894-5983

Indianapolis
Noblesville, IN
Tel: 317-773-8323
Fax: 317-773-5453
Tel: 317-536-2380

Los Angeles
Mission Viejo, CA
Tel: 949-462-9523
Fax: 949-462-9608
Tel: 951-273-7800

Raleigh, NC
Tel: 919-844-7510

New York, NY
Tel: 631-435-6000

San Jose, CA
Tel: 408-735-9110
Tel: 408-436-4270

Canada - Toronto
Tel: 905-695-1980
Fax: 905-695-2078

ASIA/PACIFIC

Australia - Sydney
Tel: 61-2-9868-6733

China - Beijing
Tel: 86-10-8569-7000

China - Chengdu
Tel: 86-28-8665-5511

China - Chongqing
Tel: 86-23-8980-9588

China - Dongguan
Tel: 86-769-8702-9880

China - Guangzhou
Tel: 86-20-8755-8029

China - Hangzhou
Tel: 86-571-8792-8115

China - Hong Kong SAR
Tel: 852-2943-5100

China - Nanjing
Tel: 86-25-8473-2460

China - Qingdao
Tel: 86-532-8502-7355

China - Shanghai
Tel: 86-21-3326-8000

China - Shenyang
Tel: 86-24-2334-2829

China - Shenzhen
Tel: 86-755-8864-2200

China - Suzhou
Tel: 86-186-6233-1526

China - Wuhan
Tel: 86-27-5980-5300

China - Xian
Tel: 86-29-8833-7252

China - Xiamen
Tel: 86-592-2388138

China - Zhuhai
Tel: 86-756-3210040

ASIA/PACIFIC

India - Bangalore
Tel: 91-80-3090-4444

India - New Delhi
Tel: 91-11-4160-8631

India - Pune
Tel: 91-20-4121-0141

Japan - Osaka
Tel: 81-6-6152-7160

Japan - Tokyo
Tel: 81-3-6880-3770

Korea - Daegu
Tel: 82-53-744-4301

Korea - Seoul
Tel: 82-2-554-7200

Malaysia - Kuala Lumpur
Tel: 60-3-7651-7906

Malaysia - Penang
Tel: 60-4-227-8870

Philippines - Manila
Tel: 63-2-634-9065

Singapore
Tel: 65-6334-8870

Taiwan - Hsin Chu
Tel: 886-3-577-8366

Taiwan - Kaohsiung
Tel: 886-7-213-7830

Taiwan - Taipei
Tel: 886-2-2508-8600

Thailand - Bangkok
Tel: 66-2-694-1351

Vietnam - Ho Chi Minh
Tel: 84-28-5448-2100

EUROPE

Austria - Wels
Tel: 43-7242-2244-39
Fax: 43-7242-2244-393

Denmark - Copenhagen
Tel: 45-4450-2828
Fax: 45-4485-2829

Finland - Espoo
Tel: 358-9-4520-820

France - Paris
Tel: 33-1-69-53-63-20
Fax: 33-1-69-30-90-79

Germany - Garching
Tel: 49-8931-9700

Germany - Haan
Tel: 49-2129-3766400

Germany - Heilbronn
Tel: 49-7131-67-3636

Germany - Karlsruhe
Tel: 49-721-625370

Germany - Munich
Tel: 49-89-627-144-0
Fax: 49-89-627-144-44

Germany - Rosenheim
Tel: 49-8031-354-560

Israel - Ra'anana
Tel: 972-9-744-7705

Italy - Milan
Tel: 39-0331-742611
Fax: 39-0331-466781

Italy - Padova
Tel: 39-049-7625286

Netherlands - Drunen
Tel: 31-416-690399
Fax: 31-416-690340

Norway - Trondheim
Tel: 47-7288-4388

Poland - Warsaw
Tel: 48-22-3325737

Romania - Bucharest
Tel: 40-21-407-87-50

Spain - Madrid
Tel: 34-91-708-08-90
Fax: 34-91-708-08-91

Sweden - Gothenberg
Tel: 46-31-704-60-40

Sweden - Stockholm
Tel: 46-8-5090-4654

UK - Wokingham
Tel: 44-118-921-5800
Fax: 44-118-921-5820