MIC45404
Evaluation Board
User's Guide

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Object of Declaration: MIC45404 Evaluation Board

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Manufacturer: Microchip Technology Inc.
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                  USA

This declaration of conformity is issued by the manufacturer.

The development/evaluation tool is designed to be used for research and development in a laboratory environment. This development/evaluation tool is not a Finished Appliance, nor is it intended for incorporation into Finished Appliances that are made commercially available as single functional units to end users under EU EMC Directive 2004/108/EC and as supported by the European Commission's Guide for the EMC Directive 2004/108/EC (8th February 2010).

This development/evaluation tool complies with EU RoHS2 Directive 2011/65/EU.

This development/evaluation tool, when incorporating wireless and radio-telecom functionality, is in compliance with the essential requirement and other relevant provisions of the R&TTE Directive 1999/5/EC and the FCC rules as stated in the declaration of conformity provided in the module datasheet and the module product page available at www.microchip.com.

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Signed for and on behalf of Microchip Technology Inc. at Chandler, Arizona, USA

Derek Carlson   12-Sep-14
VP Development Tools   Date

NOTES:

MIC45404 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 web site (www.microchip.com) to obtain the latest documentation available.

Documents are identified with a "DS" number. This number is located on the bottom of each page, in front of the page number. The numbering convention for the DS number is "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 MIC45404 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 MIC45404 Evaluation Board. The manual layout is as follows:

• **Chapter 1. "Product Overview"**– Important information about the MIC45404 Evaluation Board.
• **Chapter 2. "Installation and Operation"**– This chapter includes instructions on how to use the MIC45404 Evaluation Board.
• **Appendix A. "Schematic and Layouts"**– Shows the schematic and layout diagrams for the MIC45404 Evaluation Board.
• **Appendix B. "Bill of Materials (BOM)"**– Lists the parts used to build the MIC45404 Evaluation Board.

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CONVENTIONS USED IN THIS GUIDE

This manual uses the following documentation conventions:

DOCUMENTATION CONVENTIONS

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

	Represents code supplied by user	`void main (void)`
		`{ ...`
		`}`

RECOMMENDED READING

This user's guide describes how to use the MIC45404 Evaluation Board. Other useful documents are listed below. The following Microchip documents are available and recommended as supplemental reference resources:

- **MIC45404 Data Sheet –** *"19V 5A Ultra-Low Profile DC-to-DC Power Module"* **(DS20005478)**.

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- 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 (December 2015)

- Initial release of this document.

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MIC45404 EVALUATION BOARD USER'S GUIDE

Chapter 1. Product Overview

1.1   INTRODUCTION

This chapter provides an overview of the MIC45404 Evaluation Board and covers the following topics:

- MIC45404 Device Short Overview
- MIC45404 Evaluation Board Overview
- What the MIC45404 Evaluation Board User's Guide Kit Contains

1.2   MIC45404 DEVICE SHORT OVERVIEW

The MIC45404 device is a 19V, 5A ultra-low profile, synchronous step-down regulator module optimized for high efficiency at low output voltages. The module incorporates a DC-to-DC regulator, bootstrap capacitor, high-frequency input capacitor and an inductor in a single package. The module pinout is optimized to simplify the Printed Circuit Board (PCB) layout process. This highly integrated solution expedites system design and improves product time to market. The internal MOSFETs and inductor are optimized to achieve high efficiency at low output voltage. Due to the fully optimized design, MIC45404 can deliver up to 5A current with a wide input voltage range of 4.5V to 19V.

The MIC45404 is available in a 54-lead 6 mm ✕ 10 mm ✕ 2.0 mm QFN package with a junction operating temperature range from -40°C to +125°C.

1.3   MIC45404 EVALUATION BOARD OVERVIEW

The MIC45404 Evaluation Board is intended to facilitate the evaluation of the MIC45404 power module under various settings and operating conditions.

The basic parameters of the MIC45404 Evaluation Board are a V_{IN} supply of 4.5V to 19V, an output voltage of 0.7V to up to 3.3V at 5A.

Due to the optimized pinout of the MIC45404, the evaluation board can achieve a 2-layer only routing (top and bottom), while internal planes are connected to GND and kept as solid as possible for better thermal performance (see **Appendix A. "Schematic and Layouts"**).

Also, an on-board load transient generator circuit and connections for loop gain measurements are provided.

1.4   WHAT THE MIC45404 EVALUATION BOARD USER'S GUIDE KIT CONTAINS

The MIC45404 Evaluation Board User's Guide kit includes:

- MIC45404 Evaluation Board (EM45404-D1X-PWBA)
- Important Information Sheet

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Chapter 2. Installation and Operation

2.1 INTRODUCTION

The MIC45404 Evaluation Board requires only a single power supply with at least 5A current capability. The MIC45404 has an internal V_{DDA} LDO, so no external linear regulator is required to power the internal biasing of the module.

WARNING
The evaluation board does not have reverse polarity protection. Applying a negative voltage to the V_{IN} terminal may damage the device. The maximum V_{IN} operating voltage of the MIC45404 Evaluation Board is 19V.

2.2 GETTING STARTED

To power up the MIC45404 Evaluation Board, the following steps must be completed:

1. Connect a power supply to the V_{IN} and GND_IN terminals. An ammeter may be placed between the input supply and the V_{IN} terminal to the evaluation board. Ensure that the supply voltage is monitored at the V_{IN} terminal (CON1 or J2). The ammeter and/or power lead resistance can reduce the voltage supplied to the input. Keep the power supply disabled; do not apply power until Step 5.

2. Connect the load to the V_{OUT} and GND_OUT terminals.The load can be either passive (resistive) or active (electronic load). An ammeter can be placed between the load and the V_{OUT} terminal. Ensure that the output voltage is monitored at the V_{OUT} terminal (CON5 or J1). Alternatively, for high-speed load transient testing at low output voltages, the on-board load transient generator can be used (see **Section 2.3 "MIC45404 Evaluation Board Operation"**).

3. An EN/DLY connector (J5) is provided on the evaluation board. In the MIC45404, the EN/DLY pin is internally pulled up by a 2 µA current source. Keep the MIC45404 disabled by installing a jumper across J5-2/J5-3 or by driving J5-2 low externally. Do not enable until Step 6.

4. I_{LIM}, FREQ, VOSET0, VOSET1 selection inputs.
   The MIC45404 can be programmed through the pins' setting for current limit (at J7), switching frequency (at J8) and output voltage (at J11, J12).
   See **Section 2.3 "MIC45404 Evaluation Board Operation"** for the desired selection.

5. Turn on the V_{IN} power supply.

6. Enable the MIC45404 by removing the jumper across J5-2/J5-3, or by driving EN/DLY (J5-2) high, and verify that the output voltage is regulated to the desired V_{OUT} setting.

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2.3   MIC45404 EVALUATION BOARD OPERATION

2.3.1   Setting the Current Limit

The MIC45404 Valley Current mode current limit on the low-side MOSFET can be programmed by means of pin I_{LIM} (J7-2), as shown in Table 2-1 below.

TABLE 2-1:   CURRENT LIMIT SETTINGS

I_{LIM} Pin	J7-2	Valley Current Mode Current Limit (Typ.)	Rated Output Current
0	Shunt to J7-3 (GND)	4.6A	3A
1	Shunt to J7-1 (V_{DDA})	6.2A	4A
High Z	Open	6.8A	5A

The highest current limit setting (6.8A) is intended to comfortably accommodate a 5A application (see **Section 2.3.4 "Permissible MIC45404 Settings Combinations"**).

2.3.2   Setting the Switching Frequency

The MIC45404 switching frequency can be programmed using the FREQ pin (J8-2), as shown in Table 2-2 below.

TABLE 2-2:   SWITCHING FREQUENCY SETTINGS

FREQ Pin	J8-2	Frequency
High Z	Open	400 kHz
0	Shunt to J8-3 (GND)	565 kHz
1	Shunt to J8-1 (V_{DDA})	790 kHz

Please note that the switching frequency setting is not arbitrary, but it needs to be adjusted according to the particular output voltage selection (see **Section 2.3.4 "Permissible MIC45404 Settings Combinations"**).

2.3.3   Setting the Output Voltage

The MIC45404 output voltage can be programmed by means of pins VOSET0 and VOSET1, as shown in Table 2-3 below.

TABLE 2-3:   OUTPUT VOLTAGE SETTINGS

VOSET1 Pin (J11-2)	VOSET0 Pin (J12-2)	Output Voltage
0 (GND)	0 (GND)	3.3V
0 (GND)	1 (V_{DDA})	2.5V (2.49V)
1 (V_{DDA})	0 (GND)	1.8V
1 (V_{DDA})	1 (V_{DDA})	1.5V
0 (GND)	High Z (open)	1.2V
High Z (open)	0 (GND)	1.0V
1 (V_{DDA})	High Z (open)	0.9V
High Z (open)	1 (V_{DDA})	0.8V
High Z (open)	High Z (open)	0.7V

2.3.4 Permissible MIC45404 Settings Combinations

The MIC45404 allowable settings are constrained as described in Table 2-4:

TABLE 2-4: PERMISSIBLE MIC45404 SETTINGS COMBINATIONS

Output Voltage	Frequency
3.3V	790 kHz
2.5V (2.49V)	
1.8V	565 kHz
1.5V	
1.2V	400 kHz
1.0V	
0.9V	
0.8V	
0.7V	

2.3.5 On-Board Load Transient Generator

The MIC45404 Evaluation Board provides circuitry to enable load transient testing with fast current rise time and fast, yet controlled, fall time. This is done by a fast turn-on, controlled turn-off MOSFET switch (Q2). Resistive loads (R10 to R13) can be selectively connected by means of header J15. The total transient load current can be monitored with a current probe simply by installing a short wire loop at WR1-WR2. MOSFET Q2 must be driven by an external signal generator, connected at J14, using a square wave (suggested low level = 0V, high level = 5V-6V). Drive levels can be adjusted to modify the switching speed of Q2, but should always ensure complete turn-on and turn-off of Q2 after settling, while not exceeding, its V_{GS} ratings. It is very important not to exceed the power dissipation limit of R10 to R13. Using 2512 resistors (1W rating), the constraint is (R_{LOAD} takes the values of R10 to R13):

EQUATION 2-1:

$$D \cdot \frac{V_{OUT}^2}{R_{LOAD}} < 1W$$

Where:

D = The on time duty cycle of Q2

V_{OUT} = The selected output voltage (see Table 2-3)

R_{LOAD} = the value of resistors R10 to R13 (default board value is 1Ω)

The on-board load transient generator is especially useful when testing at very low output voltages, since not many active loads can perform well under those conditions, while current rise times achievable with external load boards are limited by stray inductance.

2.3.6 Loop Gain Measurement

The MIC45404 Evaluation Board provides injection points and a termination resistor for AC loop gain measurements. Replace R1 with a suitable value (typically, 20Ω to 50Ω), inject the oscillator at J18 through the insulation transformer and connect the A (CH1) and B (CH2) channels at J17 and J19, respectively, or as indicated by the operating instructions of the particular loop gain analyzer in use.

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Appendix A. Schematic and Layouts

A.1   INTRODUCTION

This appendix contains the following schematics and layouts for the MIC45404 Evaluation Board:

- Board – Schematic
- Board – Top Layer (Routing)
- Board – Mid Layer 1 (GND Plane)
- Board – Mid Layer 2 (GND Plane)
- Bottom Layer (Routing)

A.2   BOARD – SCHEMATIC
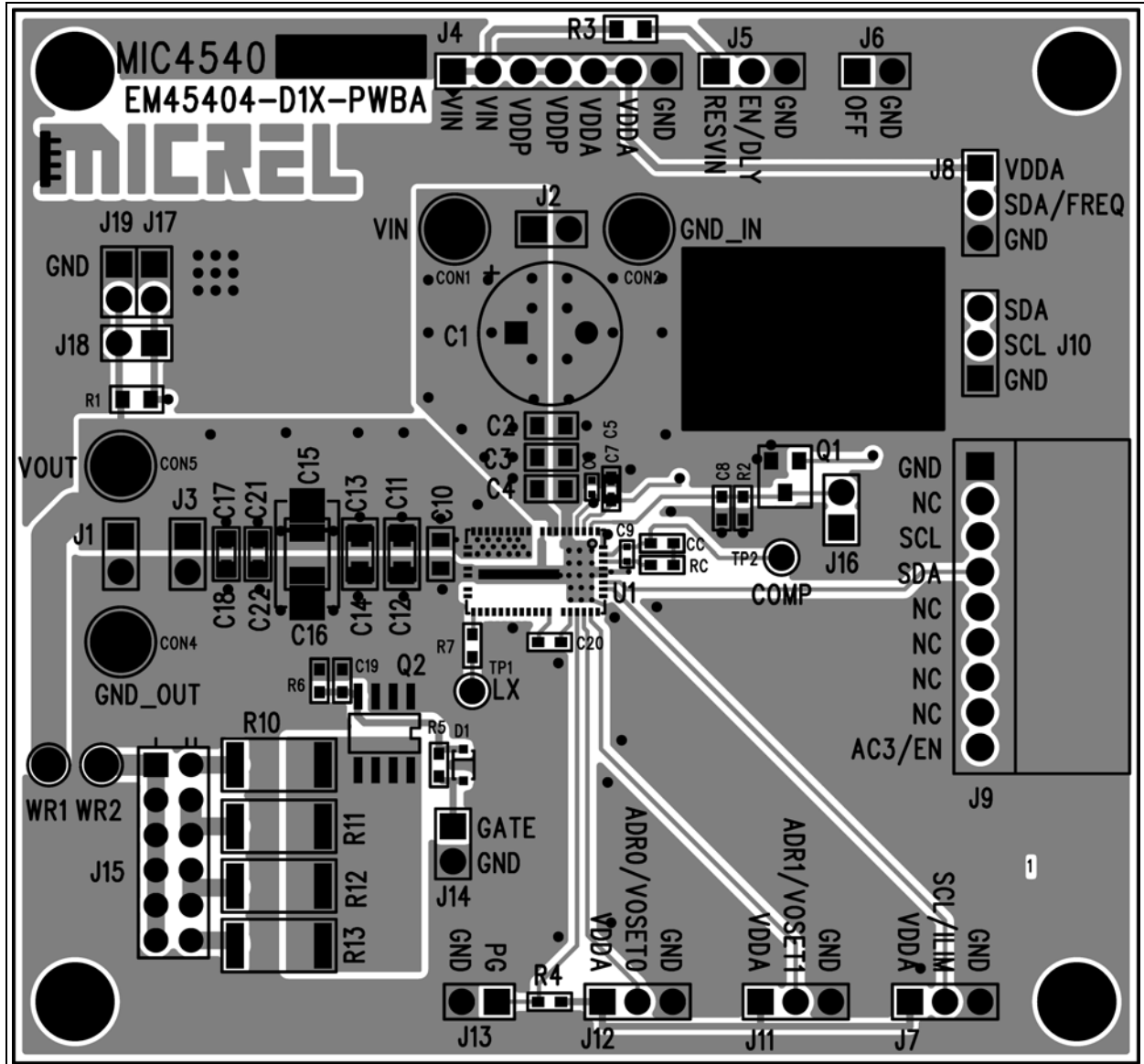
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Replace R1 and populate J17, J18 and J19 for loop gain measurements

C11 and C12 overlapped
C13 and C14 overlapped
C15 and C16 overlapped
C17 and C18 overlapped
C21 and C22 overlapped

C5 and C7 overlapped

J1 for VOUT DC measurement, J3 for ripple probing

WR1, WR2 pads
Install wire loop in WR1, WR2 for onboard load transient generator current probing

On-board load transient generator

A.3   BOARD – TOP LAYER (ROUTING)

A.4   BOARD – MID LAYER 1 (GND PLANE)

2 GND

A.5   BOARD – MID LAYER 2 (GND PLANE)

3 GND
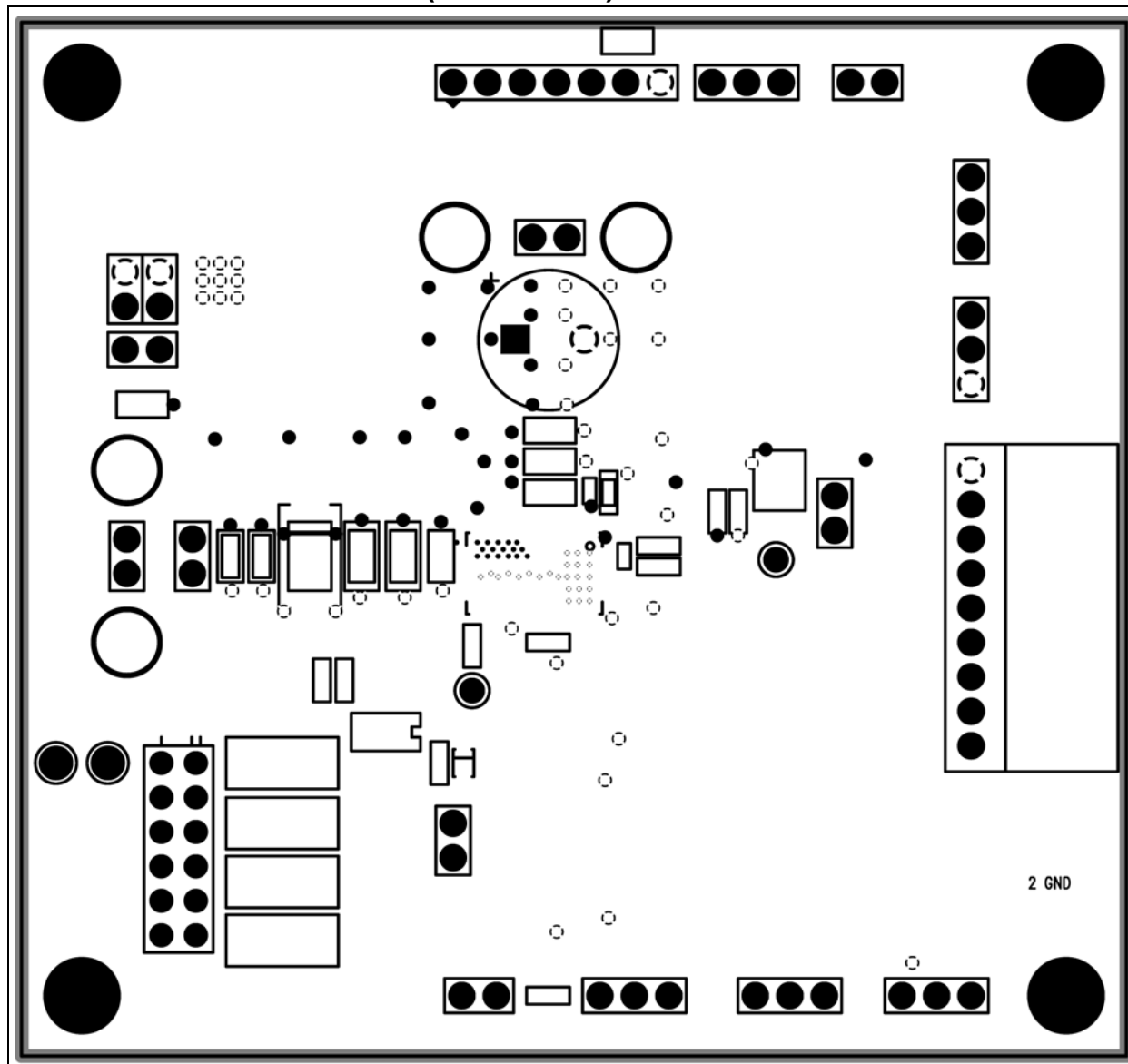
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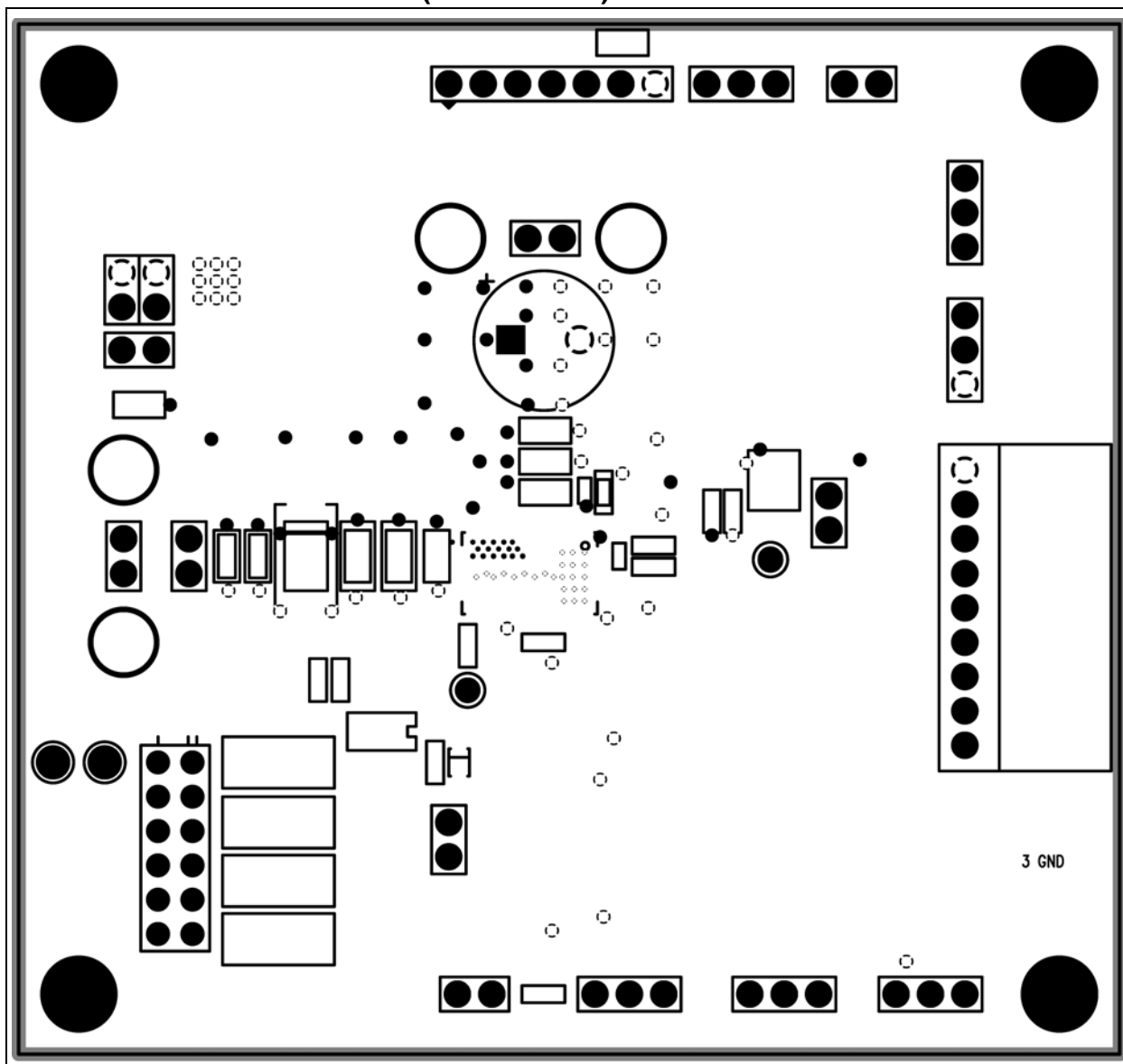
A.6   BOTTOM LAYER (ROUTING)
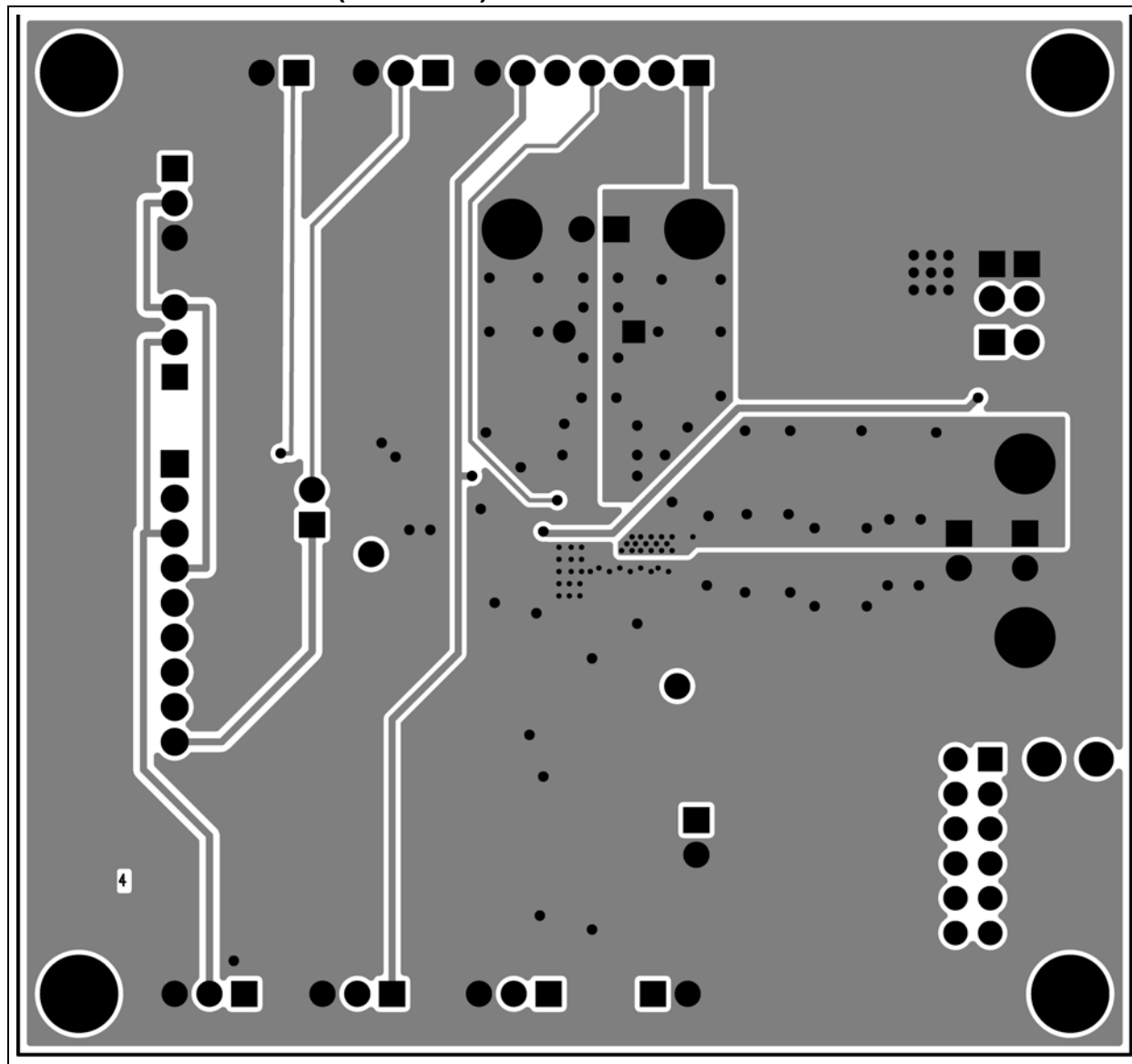
Appendix B. Bill of Materials (BOM)

TABLE B-1:   BILL OF MATERIALS (BOM)

Qty	Reference	Description	Manufacturer	Part Number
1	CC	Ceramic Capacitor, C0G, 10 nF, 50V, 5%, Size 0603	Murata Electronics®	GRM1885C1H103JA01
3	C2, C3, C4	Ceramic Capacitor, X5R, 22 µF, 25V, 20%, Size 0805	Murata Electronics®	GRM21BR61E226ME44
1	C5	Ceramic Capacitor, X7R, 2.2 µF, 25V, 10%, Size 0603	Murata Electronics®	GRM188R61E225KA12
2	C10, C21	Ceramic Capacitor, X5R, 22 µF, 10V, 20%, Size 0805	Murata Electronics®	GRM21BR61A226ME44
2	C11, C13	Ceramic Capacitor, X5R, 100 µF, 6.3V, 20%, Size 1206	Murata Electronics®	GRM31CR60J107ME39
1	C18	Ceramic Capacitor, X7R, 0.1 µF, 50V, 10%, Size 0603	Murata Electronics®	GRM188R71H104KA93
1	D1	Diode, 1N4148, SOD-323	Diodes® Incorporated	1N4148WS-7-F
1	PCB	Printed Circuit Board – MIC45404 Evaluation Board	Microchip Technology Inc.	**EM45404-D1X-PWBA**
1	Q2	MOSFET, N-CH, FDS6670A, SO-8	Fairchild Semiconductor®	FDS6670A
1	RC	Resistor CHIP, 2.55 kΩ, 1%, Size 0603	Yageo Corporation	RC0603FR-072K55L
1	R1	Resistor CHIP, 0Ω, Size 0805	Yageo Corporation	RC0805JR-07000RL
1	R4	Resistor CHIP, 10 kΩ, 5%,Size 0603	Yageo Corporation	RC0603JR-0710K0L
1	R5	Resistor CHIP, 1 kΩ, 5%, Size 0603	Yageo Corporation	RC0603JR-071K00L
1	R6	Resistor CHIP, 20 kΩ, 5%, Size 0603	Yageo Corporation	RC0603JR-0720K0L
1	R7	Resistor CHIP, 49.9Ω, 1%, Size 0603	Yageo Corporation	RC0603FR-0749R9L
4	R10, R11, R12, R13	Resistor CHIP, 1Ω, 5%, Size 2512	Yageo Corporation	RC2512JR-071R00L
1	U1	19V 5A Ultra-Low Profile DC-to-DC Power Module	Microchip Technology Inc.	**MIC45404YMP**

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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