MIC4609 Evaluation Board User's Guide

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Derek Carlson
VP Development Tools

12-Sep-14
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NOTES:

MIC4609 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 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 MIC4609 Evaluation Board. Items discussed in this chapter include:

- Document Layout
- Conventions Used in This Guide
- Recommended Reading
- The Microchip Web Site
- Customer Support
- Revision History

DOCUMENT LAYOUT

This document describes how to install the MIC4609 Evaluation Board. It also describes how to operate the Evaluation Board. The manual layout is as follows:

- **Chapter 1. "Product Overview"** – Important information about the MIC4609 Evaluation Board.
- **Chapter 2. "Installation and Operation"** – Includes instructions on how to get started with the MIC4609 Evaluation Board.
- **Appendix A. "Schematic and Layouts"** – Shows the schematic and layout diagrams for the MIC4609 Evaluation Board.
- **Appendix B. "Bill of Materials (BOM)"** – Lists the parts used to build the MIC4609 Evaluation Board.

CONVENTIONS USED IN THIS GUIDE

This manual uses the following documentation conventions:

DOCUMENTATION CONVENTIONS

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

RECOMMENDED READING

This user's guide describes how to use MIC4609 Evaluation Board. Another useful document is listed below. The following Microchip document is available and recommended as supplemental reference resource:

- **MIC4609 Data Sheet –** ***"600V 3-Phase MOSFET/IGBT Driver"*** **(DS20005531A)**

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- Field Application Engineer (FAE)
- Technical Support

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Technical support is available through the website at:
http://www.microchip.com/support.

REVISION HISTORY

Revision A (March 2016)

- Original release of this document.

NOTES:

Chapter 1. Product Overview

1.1 INTRODUCTION

This chapter provides an overview of the MIC4609 Evaluation Board and covers the following topics:

- MIC4609 Short Overview
- What is the MIC4609 Evaluation Board?
- MIC4609 Evaluation Board Kit Contents

1.2 MIC4609 SHORT OVERVIEW

The MIC4609 Evaluation Board is a 600V, 3-Phase driver that can be used with either IGBTs or MOSFETs. The MIC4609 features a 300 ns typical input filtering time to prevent unwanted pulses and a 550 ns of propagation delay. The board is available in an 28-pin wide SOIC package, with an operating junction temperature range of –40°C to +125°C.

1.3 WHAT IS THE MIC4609 EVALUATION BOARD?

The board is comprised of the MIC4609 3-phase driver, 6 IGBTs and provisions for current/voltage sensing. Right angle header J1 provides an interface to a controller board for input drive signals, control signals and V_{DD}/AV_{DD} supply voltages. The input drive signals may also be accessed with jumpers J2, J3, J5, J6, J10 and J11. TP4 and J16 are connected to the V_{DD} supply voltage. The high voltage V_{BUS}, power ground and the 3-phase motor connections are made through connector J9.

1.4 MIC4609 EVALUATION BOARD KIT CONTENTS

The MIC4609 Evaluation Board includes the following items:

- MIC4609 Evaluation Board (ADM00749)
- Important Information Sheet

NOTES:

Chapter 2. Installation and Operation

2.1 SYSTEM AND CONFIGURATION REQUIREMENTS

The MIC4609 Evaluation Board requires a V_{DD} power supply with an output between 10V and 20V, an AV_{DD} supply of 3.3V or 5V and a high voltage V_{BUS} power supply that is used to driver the Motor or other load. Do not exceed 450V on V_{BUS} unless C17 is removed.

Note: The evaluation board does not have reverse polarity protection. Applying a negative voltage to the V_{BUS} (J16), VAV_{DD} (J1.12) or V_{DD} (J16 or J1.10) terminals may damage the device. Do not exceed 450V on V_{BUS} due to the 450V rating of the 10 µF Aluminum Electrolytic capacitor (C17). Remove C17 if voltages between 450V and 600V are required.

2.2 CIRCUIT DESCRIPTION

The MIC4609 driver stage interfaces the incoming PWM signals to the IGBT power stage. Refer to the MIC4609 data sheet for detailed information on the driver's operation. Figure 2-1 is a partial schematic showing the components for phase A.

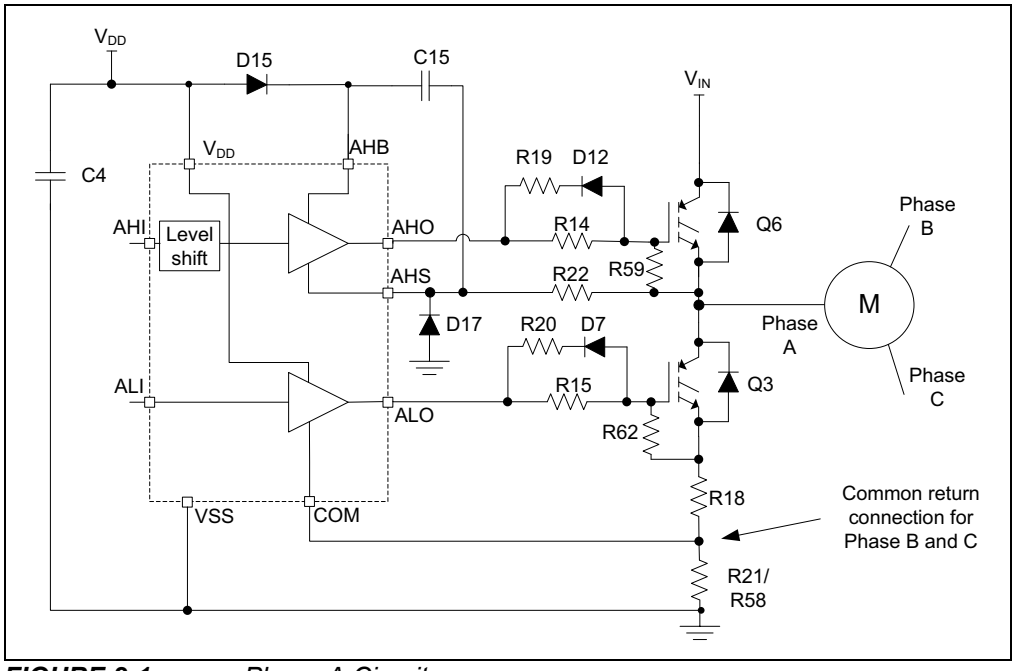


FIGURE 2-1: *Phase A Circuitry*

A resistor diode network is connected between the high and low-side driver output and the IGBT gate. Resistors R14 and R15 limit the driver output current into the gate, which slows down both the turn-on and turn-off of the IGBTs. The diode resistor combination in parallel with the series resistors (R19/D12 and R20/D7) allows the turn off to be faster than the turn-on.

Resistor R22 and diode D17 clamp the HS pin to prevent it from going too negative. This can occur when the high-side IGBT turns off and the motor current freewheels through the low-side IGBT (Q3).

Resistors R59 and R62 prevent charge from building up on the gates (and causing shoot-through current if both IGBTs turn-on) when V_{IN} is present but V_{DD} is not.

Current sense resistors in Phase A (R18) and Phase B (R35, not shown) provide a current signal to the controller for FOC or similar control architectures. Phase C does not have a sense resistor.

Parallel resistors R21 and R58 sense the current from all three phases and are used for overcurrent detection. The voltage across these resistors is sensed by the OC circuitry in the MIC4609, which shuts off the driver outputs if the OC threshold is exceeded.

2.2.1 Overcurrent and Fault circuitry

The MIC4609 can detect an overcurrent condition by sensing the voltage across a current sense resistor (R21/R58) and comparing it to an internal reference. If the peak voltage sensed exceeds the reference, the output drivers are turned off for a period of time before being allowed to turn back on. The delay is set with capacitor C31. Refer to the MIC4609 data sheet for additional information on setting the delay.

The FAULT pin goes low during the overcurrent event. This signal can be read by the controller to indicate a fault condition. The FAULT pin is pulled up to AV_{DD} with a 100 kΩ resistor. The fault signal can be monitored on TP1 or on pin 7 of jumper J1.

2.2.2 Enable Pin (EN)

A 3-pin header (J8) connected to the enable pin allows it to be set high (ON) or low (OFF). When the jumper is set high, it is pulled up to AV_{DD} through a 1 kΩ resistor. The signal is connected to pin 9 of J1. A high level on the EN pin turns ON the internal bias' in the driver and allows the driver to operate normally. Setting the EN pin low puts the device into a low IQ state and turns off all six driver outputs.

An external connection may be used to set the EN pin state. When using an external connection, make sure the EN pin voltage does not exceed V_{DD}.

2.2.3 Input Pins (xHI/xLI)

Connections to the six input pins are made through connector J1 (pins 1-6) or through individual headers (J2, J3, J5, J6, J10, and J11). The individual headers can be used to monitor the signals or to set them high or low.

Resistors in series with the inputs (as well as the EN and FAULT pins) can be used to limit current back to the controller if there is a fault condition or reverse voltage connection.

2.2.4 Power and Motor connections

There are four voltage dividers on the board that provide sensing feedback to the controller:

- VBUS_SNS monitors the high voltage BUS
- FB_PHA, FB_PHB and FB_PHC monitor the phase voltages.

RECN is the reconstructed neutral voltage. These signals are filtered and clamped to AV_{DD} for noise and surge overvoltage protection.

The sense voltage is the output of the voltage dividers and can be calculated using the following equation:

EQUATION 2-1:

$$VFB\_PHA = V_{PhaseA} \times \left(\frac{R41}{R41 + R44 + R48} \right)$$

Similar calculations are made for Phases B, C and the V_{BUS} sense.

The resistor values on the board generate a 2V FB signal for a 300V BUS or phase voltage. If higher or lower voltage motors are used, the resistor divider values must be recalculated.

2.2.5 Power Stage and Motor connections

The V_{BUS} and power GND connections as well as the three motor phase connections are accessed through connector J9. In the existing evaluation board configuration, the maximum voltage on V_{BUS} is 450V DC. This is limited by the voltage rating of the electrolytic capacitor, C17. If the capacitor is removed, V_{BUS} can increase to 600V.

Locations for an RC snubber for each of the phase nodes are located on the back of the board. These are not populated but are available to attenuate ringing if necessary.

NOTES:

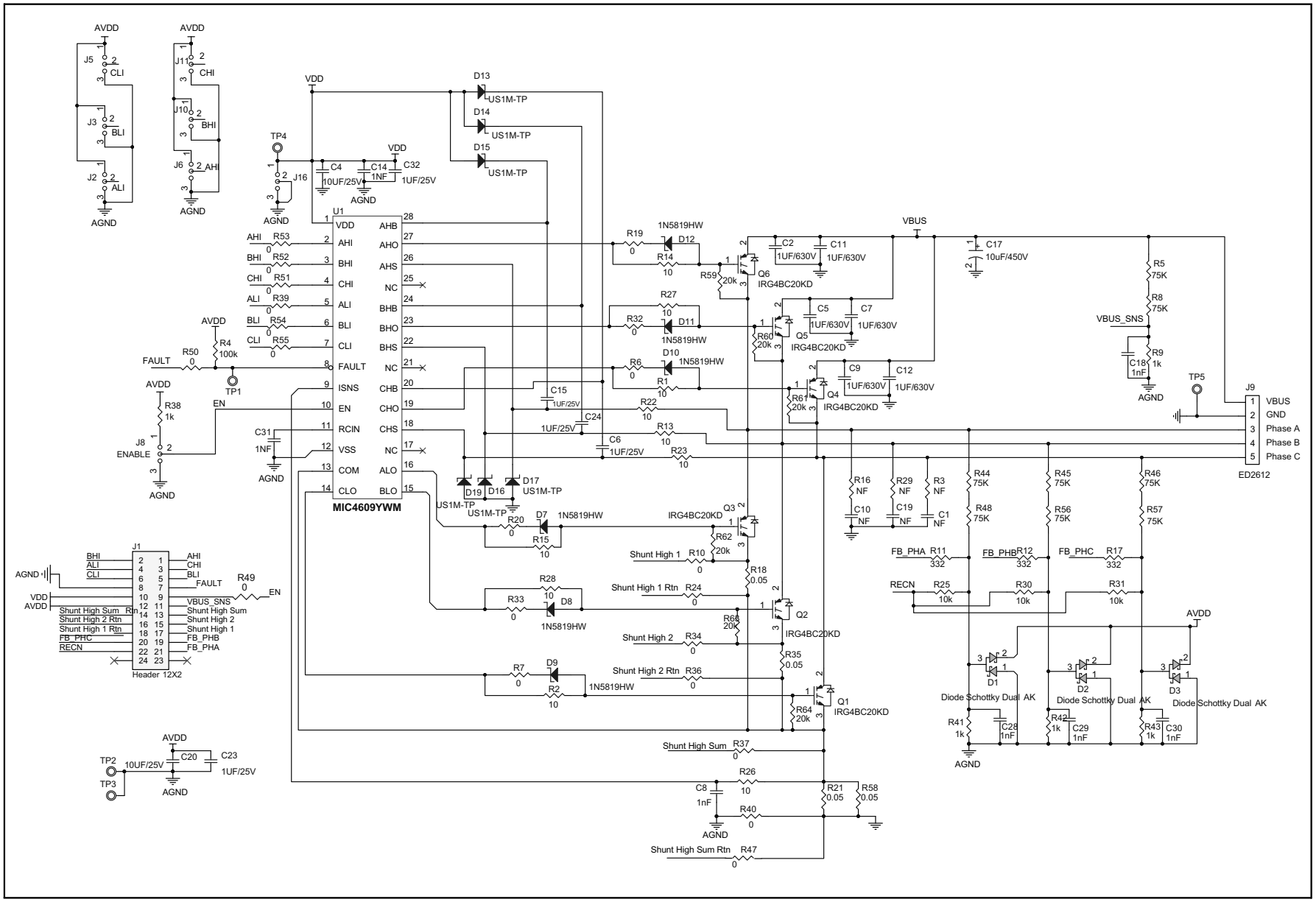
Appendix A. Schematic and Layouts

A.1 INTRODUCTION

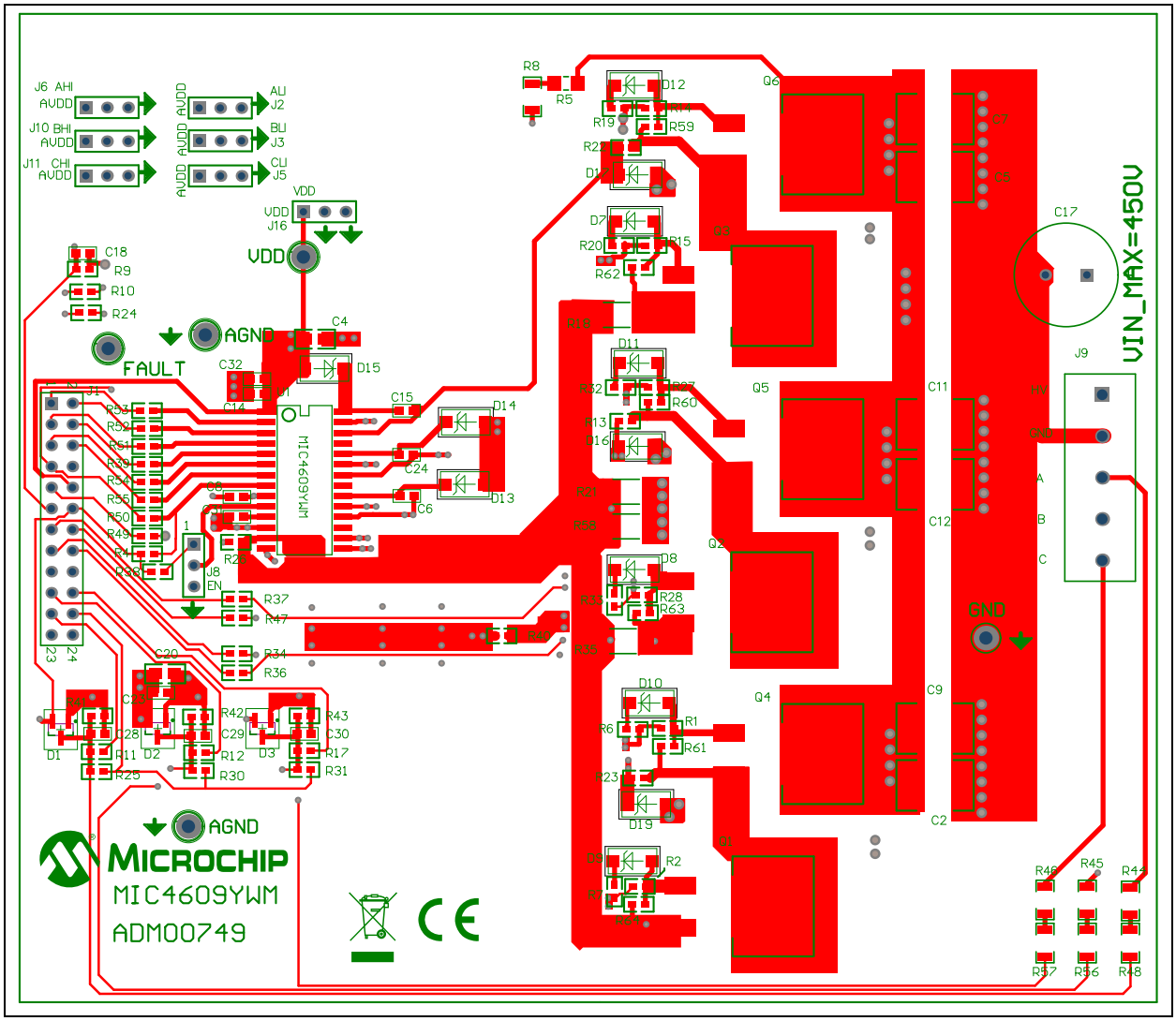
This appendix contains the following schematics and layouts for the MIC4609 Evaluation Board:

- Board – Schematic
- Board – Top Layer
- Board – Top Copper
- Board – Mid Layer 1
- Board – Mid Layer 2
- Board – Bottom Copper
- Board – Bottom Layer

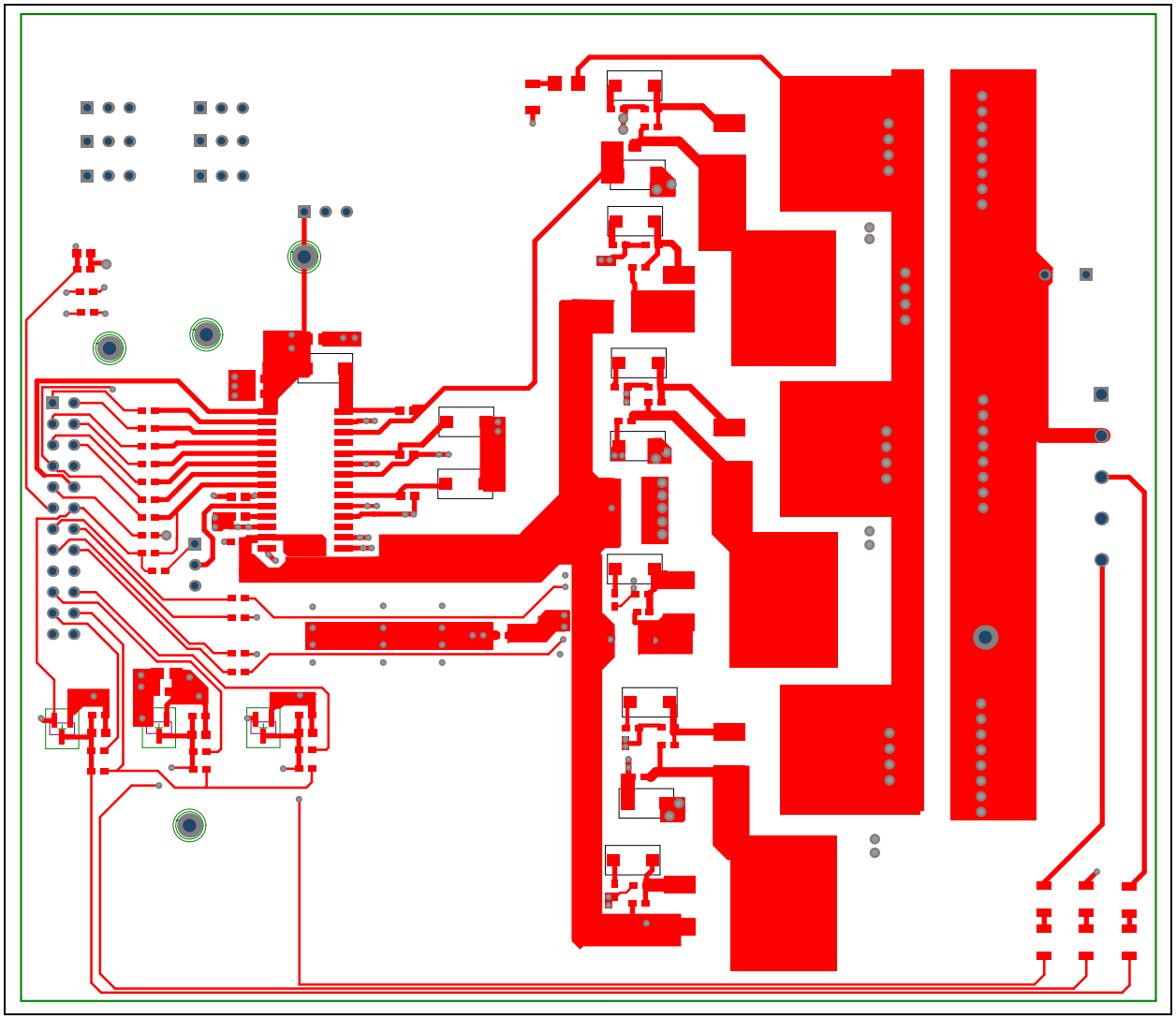
A.2 BOARD – SCHEMATIC



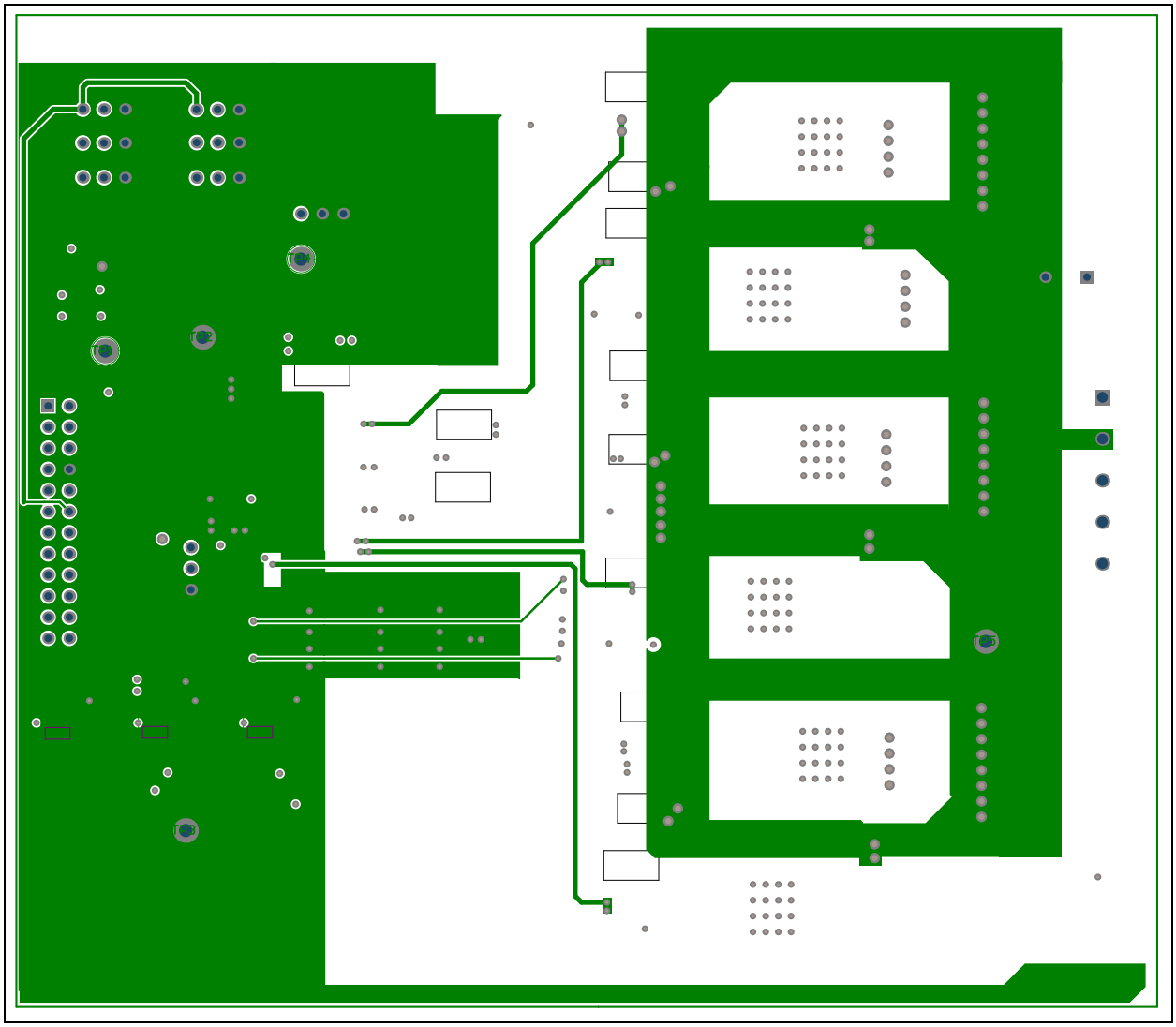
A.3 BOARD – TOP LAYER



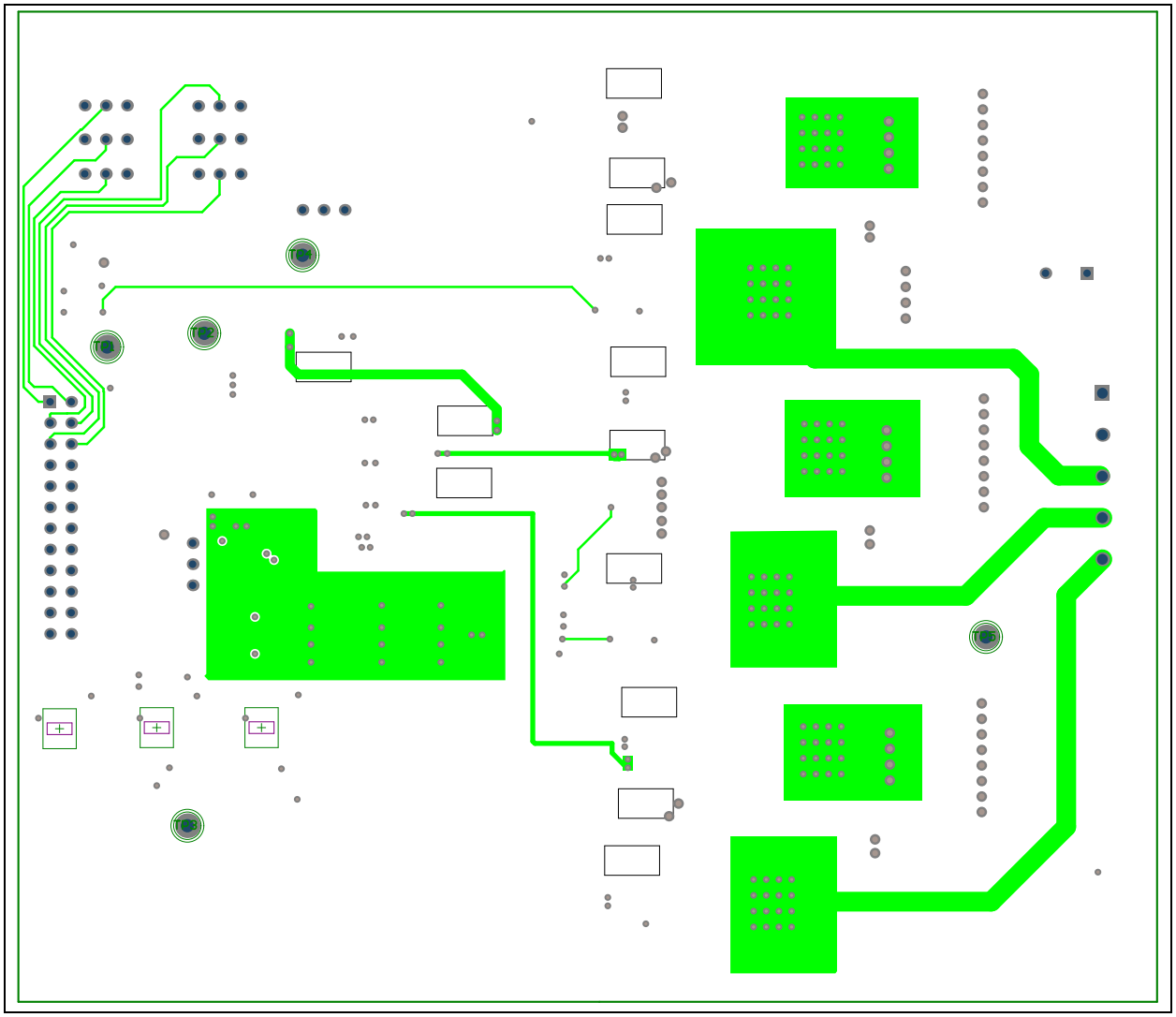
A.4 BOARD – TOP COPPER



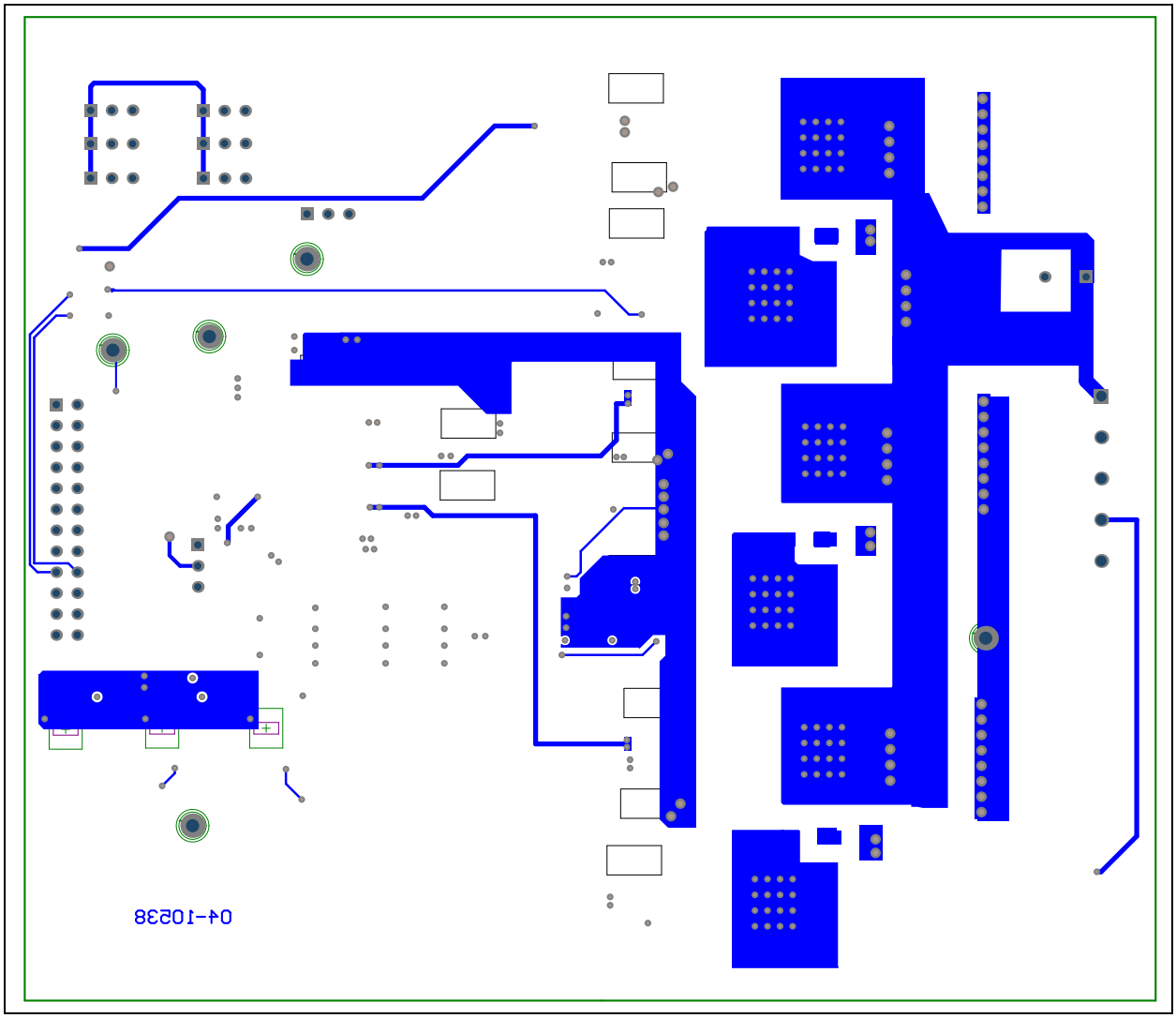
A.5 BOARD – MID LAYER 1



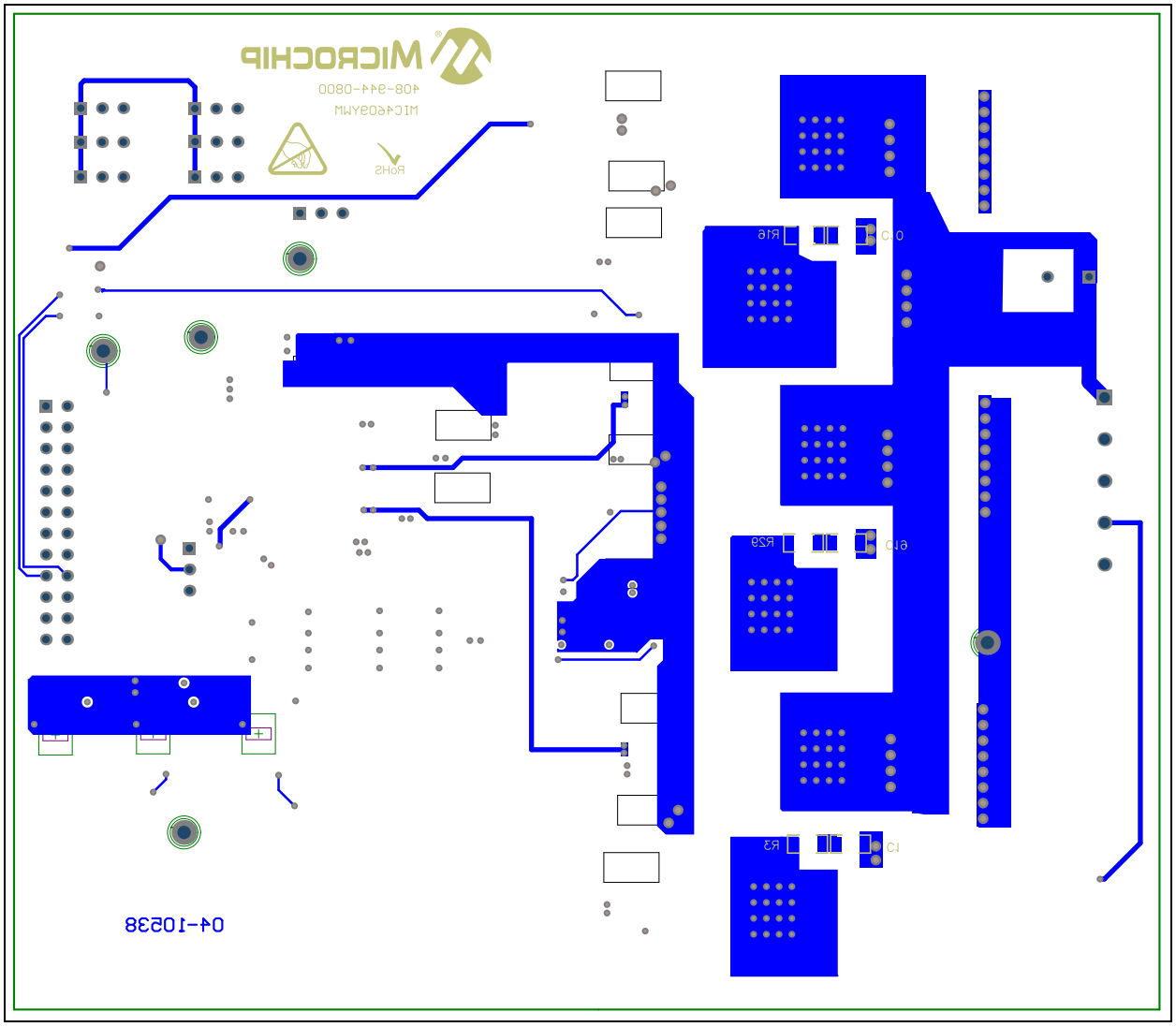
A.6 BOARD – MID LAYER 2



A.7 BOARD – BOTTOM COPPER



A.8 BOARD – BOTTOM LAYER



Appendix B. Bill of Materials (BOM)

TABLE B-1: BILL OF MATERIALS (BOM)

Qty.	Reference	Description	Manufacturer	Part Number
3	C1, C10, C19	1206 size capacitor **DO NOT POPULATE**		
6	C2, C5, C7, C9, C11, C12	1 µF/630V	TDK Corporation	CKG57NX7T2J105M500JH
2	C4, C20	10 µF/25V	TDK Corporation	C2012X5R1E106K085AC
5	C6, C15, C23, C24, C32	1 µF/25V	TDK Corporation	C1608X7R1E105K080AB
7	C8, C14, C18, C28, C29, C30, C31	1nF/50V	TDK Corporation	C1608X7R1H102K080AE
1	C17	10 µF/450V Al. El	Panasonic® - ECG	EEU-EE2W100
1	U1	600V, 3-phase driver	Microchip Technology, Inc.	**MIC4609YWM**
3	R3, R16, R29	1206 size resistor **DO NOT POPULATE**		
1	R4	100K, 1%, 1/4W	Panasonic- ECG	ERJ-3EKF1003V
10	R1, R2, R13, R14, R15, R22, R23, R26, R27, R28	10, 1%, 1/10W	Panasonic- ECG	ERJ-3EKF10R0V
5	'R9, R38, R41, R42, R43	1k, 1%, 1/10W	Panasonic- ECG	ERJ-3EKF1001V
3	R25, R30, R31	10K, 1%, 1/10W	Panasonic- ECG	ERJ-3EKF1002V
8	R5, R8, R44, R45, R46, R48, R56, R57	75K, 1%, 1/4W	Panasonic- ECG	ERJ-8ENF7502V
21	R6, R7, R10, R19, R20, R24, R32, R33, R34, R36, R37, R39, R40, R47, R49, R50, R51, R52, R53, R54, R55	0, 1%, 1/10W	Panasonic- ECG	ERJ-3GEY0R00V
3	R11, R12, R17	332Ω,1%, 1/10W	Panasonic- ECG	ERJ-3EKF3320V
4	R18, R21, R35, R58	0.05Ω, 1W 1%	Panasonic- ECG	ERJ-M1WSF50MU
6	R59, R60, R61, R62, R63, R64	20K, 1%, 1/10W	Panasonic- ECG	ERJ-3EKF2002V

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.

TABLE B-2: BILL OF MATERIALS (BOM) - MECHANICAL PARTS

Qty	Reference	Description	Manufacturer	Part Number
3	D1, D2, D3	Diode Schottky Dual AK 40V/200mA	Diodes Incorporated®	BAS40-04
6	D7, D8, D9, D10, D11, D12	Schottky, 1A/40V	Diodes Incorporated	1N5819HW
6	D13, D14, D15, D16, D17, D19	100V/1A Ultra fast diode	Diodes Incorporated	US1M-TP
1	J1	Header, 12-Pin, dual row, right angle	FCI	68021-224HLF
8	J2, J3, J5, J6, J8, J10, J11, J16	Header, 3-pin	FCI	68000-103HLF
1	J9	5 position terminal block	On-Shore Technology, Inc.	ED2612
6	Q1, Q2, Q3, Q4, Q5, Q6 (**Note 2**)	IGBT	Infineon Technologies AG	IRG4BC20KD
		IGBT	Infineon Technologies AG	IKB06N60T
		IGBT	Fairchild Semiconductor®	SGW10N60RUFD
		IGBT	STMicroelectronics	STGB10NC60KD

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.

2: Note that only one set of six IGBTs are used at a time. You can choose the IGBT produced by one of the three listed manufacturers.

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