MIC4607A MOSFET Driver Evaluation Board User's Guide

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Preface

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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 MIC4607A MOSFET Driver Evaluation Board. Items discussed in this chapter include:

- Document Layout
- Conventions Used in this Guide
- Recommended Reading
- The Microchip Website
- Development Systems Customer Change Notification Service
- Customer Support
- Document Revision History

DOCUMENT LAYOUT

This document describes how to use the MIC4607A MOSFET Driver Evaluation Board. The manual layout is as follows:

- **Chapter 1. "Product Overview"** – Important information about the MIC4607A MOSFET Driver Evaluation Board.
- **Chapter 2. "Installation and Operation"** – Includes instructions on installing and using the MIC4607A MOSFET Driver Evaluation Board.
- **Appendix A. "Schematics and Layouts"** – Shows the schematic and layout diagrams for the MIC4607A MOSFET Driver Evaluation Board.
- **Appendix B. "Bill of Materials (BOM)"** – Lists the parts used to build the MIC4607A MOSFET Driver 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 the MIC4607A MOSFET Driver Evaluation Board. Other useful documents are listed below. The following Microchip documents are available and recommended as supplemental reference resources:

- **MIC4607A Data Sheet -** ***"85V, Three-Phase MOSFET Driver with Adaptive Dead-Time, Anti-Shoot-Through and Overcurrent Protection"*** **(DS2000XXXX)** – This data sheet provides detailed information regarding the MIC4607A product family.

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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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The Development Systems product group categories are:

- **Compilers** - The latest information on Microchip C compilers, assemblers, linkers and other language tools. These include all MPLAB® C compilers; all MPLAB assemblers (including MPASM assembler); all MPLAB linkers (including MPLINK object linker); and all MPLAB librarians (including MPLIB object librarian).
- **Emulators** - The latest information on Microchip in-circuit emulators.This includes the MPLAB REAL ICE™ and MPLAB ICE 2000 in-circuit emulators.
- **In-Circuit Debuggers** - The latest information on the Microchip in-circuit debuggers. This includes MPLAB ICD 3 in-circuit debuggers and PICkit 3/4 Debug Express.
- **MPLAB IDE** - The latest information on Microchip MPLAB IDE, the Windows Integrated Development Environment for development systems tools. This list is focused on the MPLAB IDE, MPLAB IDE Project Manager, MPLAB Editor and MPLAB SIM simulator, as well as general editing and debugging features.
- **Programmers** - The latest information on Microchip programmers. These include production programmers such as MPLAB REAL ICE in-circuit emulator, MPLAB ICD 3 in-circuit debugger and MPLAB PM3 device programmers. Also included are nonproduction development programmers such as PICSTART Plus and PICkit 2, 3 and 4 programmers.

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- Distributor or Representative
- Local Sales Office
- Field Application Engineer (FAE)
- Technical Support

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

DOCUMENT REVISION HISTORY

Revision A (December 2024)

- Initial Release of this Document.

Chapter 1. Product Overview

1.1 INTRODUCTION

This chapter covers the following topics:

- MIC4607A MOSFET Driver Evaluation Board Overview
- What is the MIC4607A MOSFET Driver Evaluation Board?
- What does the MIC4607A MOSFET Driver Evaluation Board Kit Include?

1.2 MIC4607A MOSFET DRIVER EVALUATION BOARD OVERVIEW

The MIC4607A MOSFET Driver Evaluation Board is used to demonstrate the driver capabilities offered by the MIC4607A.

The board is designed to be very versatile, two-layered, low-cost, high-current, and easily configurable to meet as many customer's preferences as possible by using the MIC4607A for a three-phase MOSFET driver.

The board is composed of a final stage that contains a three-phase half bridge. By applying the required signals on the PWM and Enable inputs, the user can configure the board to be the final stage of a BLDC motor or a three-phase inverter.

Several key test points are available on the board in order to facilitate the user's measurements, tuning, and motor control optimization.

1.3 WHAT IS THE MIC4607A MOSFET DRIVER EVALUATION BOARD?

The MIC4607A MOSFET Driver Evaluation Board is a MOSFET controller for driving brushless DC motors (BLDC). The board can drive a three-phase brushless DC motor rated at up to 20A and 85V. The input voltage range for the MOSFET bridge is -0.3V to +85V and the input voltage range for MIC4607A is 5.25V to 16V.

The board consists of two main units:

- MIC4607A MOSFET Driver
- Three phases MOSFET Bridge

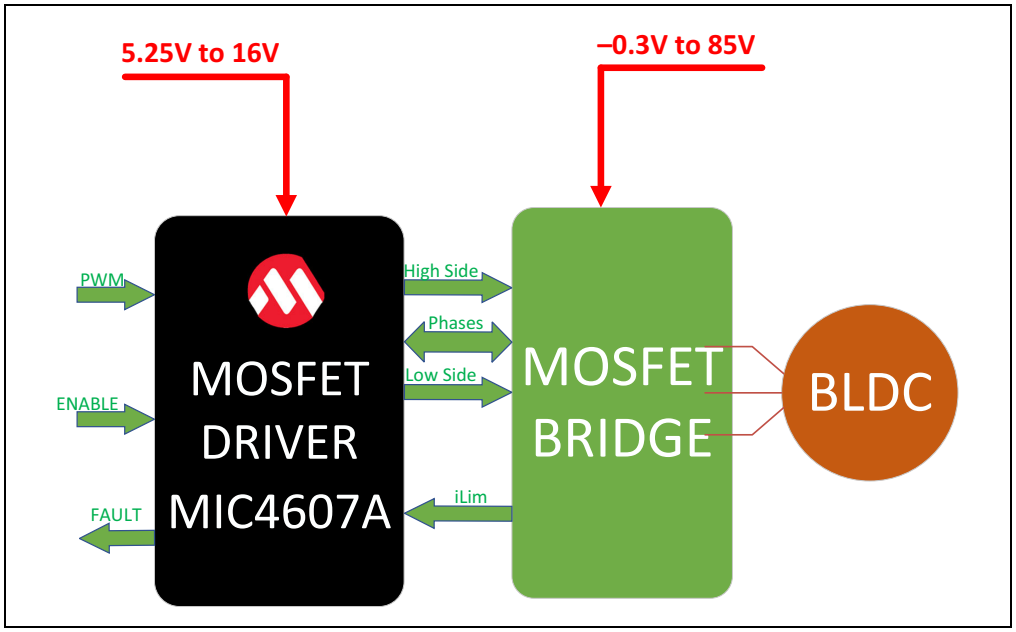


FIGURE 1-1: *MIC4607A MOSFET Driver Evaluation Board Block Diagram.*

The board is equipped with one sum shunt resistor. The voltage drop through it is sensed by the Differential Current-Limit comparator. If the peak voltage across this resistor exceeds the VILIM+ threshold, it will cause all six outputs to latch off.

The PWM's and Enable signals can be inputted through the AHI, ALI, BHI, BLI, CHI, CLI, EN terminal blocks. The fault and ILIM signals can be measured using the FLT, ILIM- and ILIM+ terminal blocks.

Several key test points are available on the board in order to facilitate the user's measurements.

Two input terminal block connectors are provided to apply the input voltages to the MIC4607A and the inverter stage and another output connector is provided to attach the BLDC.

For a simple evaluation, the six MOSFETs of the MIC4607A evaluation board can be switched with a pulse generator, but will require a microcontroller (µC) or another control device to properly drive a three-phase motor. Refer to the MIC4607A data sheet for detailed operating information.

1.4 WHAT DOES THE MIC4607A MOSFET DRIVER EVALUATION BOARD KIT INCLUDE?

The MIC4607A MOSFET Driver Evaluation Board kit includes:

- The MIC4607A MOSFET Driver Evaluation Board (EV42B57A).
- Key Information Sheet.

Chapter 2. Installation and Operation

2.1 INTRODUCTION

The MIC4607A MOSFET Driver Evaluation Board is used to demonstrate the driver capabilities offered by the MIC4607A.

The MIC4607A is a 85V, three-phase MOSFET driver that features active anti-shoot-through and adaptive dead-time control, overcurrent protection, and small propagation delays. The MIC4607A includes a high-voltage internal diode that charges the high-side gate-drive bootstrap capacitors.

The MIC4607A operates over a wide input voltage supply range (5.5V to 85V). Gate-drive voltage is adjustable and is set by the VDD supply voltage.

The MIC4607A uses an adaptive dead-time circuit to improve efficiency and prevent shoot-through in the external high- and low-side MOSFETs. Overcurrent sensing guards against excessive power dissipation and provides protection against short-circuit conditions.

2.2 FEATURES

The MIC4607A MOSFET Driver Evaluation Board has the following features:

- MIC4607A supply operating voltage range: 5.25V to 16V
- MOSFET bridge supply voltage: -0.3V to 85V
- Typical 1A of peak gate drive sink/source current for external N-Channel MOSFETs
- Drives up to a 20A RMS loads
- PWM signal test headers
- Fault signal test header
- UVLO protections on VDD and bootstrap: 4.4V
- External MOSFET overcurrent protection: 200 mV (across the current sense resistor)
- PWM dead-time insertion: 35 ns
- Forced commutation if output does not switch after 250 ns

2.3 GETTING STARTED

The MIC4607A MOSFET Driver Evaluation Board is fully assembled and tested for driving for driving a three-phase MOSFET bridge.

The MIC4607A evaluation board requires a VIN power supply up to 85V and a VDD supply between 5.5V and 16V. The board is presented in Figures 2-1 and 2-2. A three-phase motor and a microcontroller (µC) to supply the proper gate-drive voltage are also required.

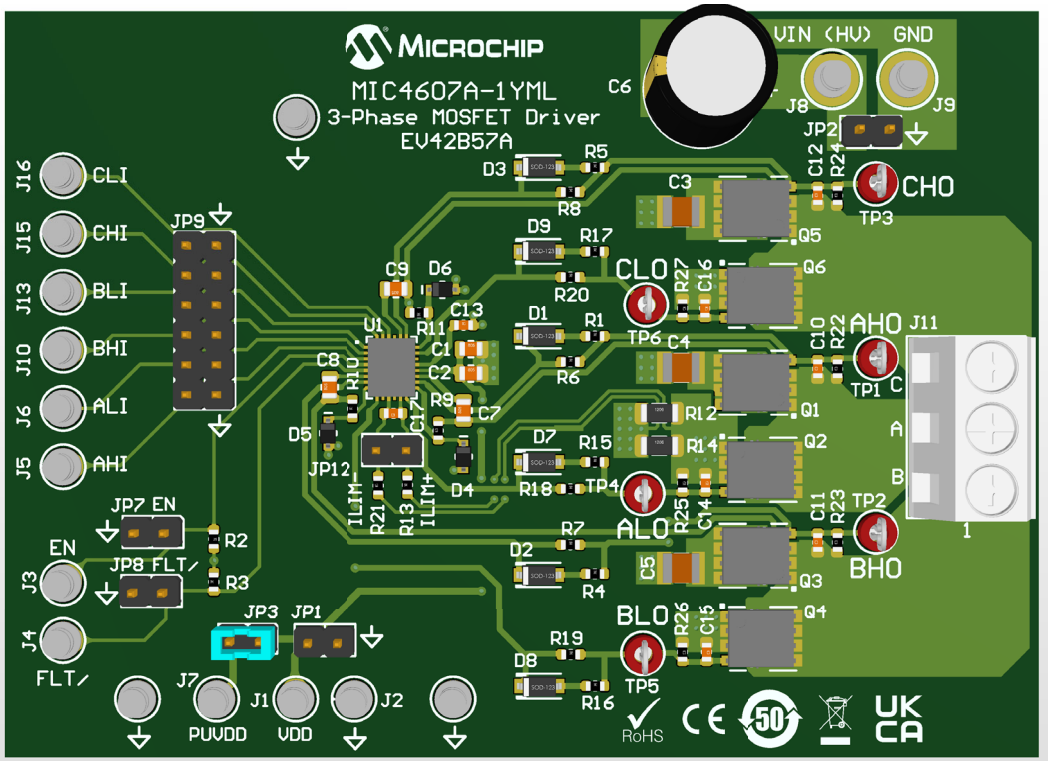


FIGURE 2-1: *MIC4607A MOSFET Driver Evaluation Board PCB (Top).*

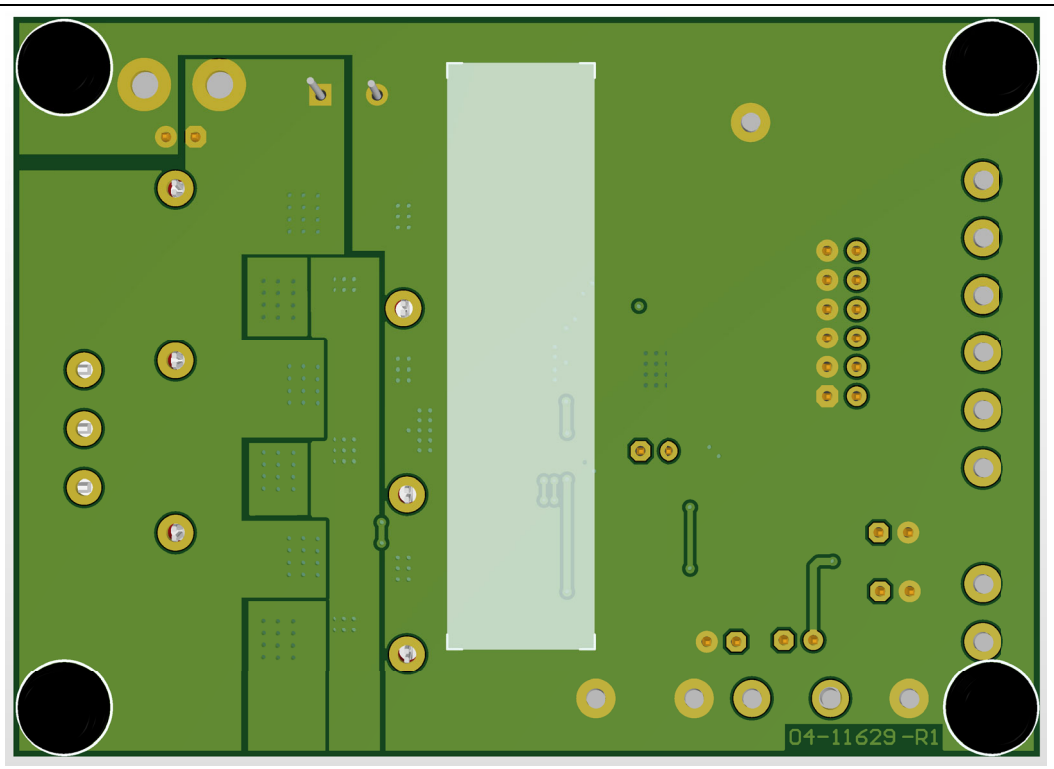


FIGURE 2-2: *MIC4607A MOSFET Driver Evaluation Board PCB (Bottom).*

2.3.1 EN, xHI, xLI, and xPWM Inputs

The input signals for the three phases can be applied to the MIC4607A through either the JP9 header or through the labeled board pins. The enable and inputs are standard TTL threshold compatible and are all referenced to ground. The maximum amplitude must not exceed VDD.

If commanded by a microcontroller, the EN pin should be pulled up to the power voltage of the microcontroller through a 100 kΩ resistor (R2). This is required because the microcontroller may be damaged if the pullup is connected to the VDD voltage of MIC4607A. Otherwise, if the board is not commanded by a microcontroller, the EN pin can be pulled up to VDD by adding a jumper on JP3.

Pulling the EN pin (J3, JP7) low disables all six driver outputs, while leaving the EN pin open - or actively driving it above the EN threshold - enables all outputs.

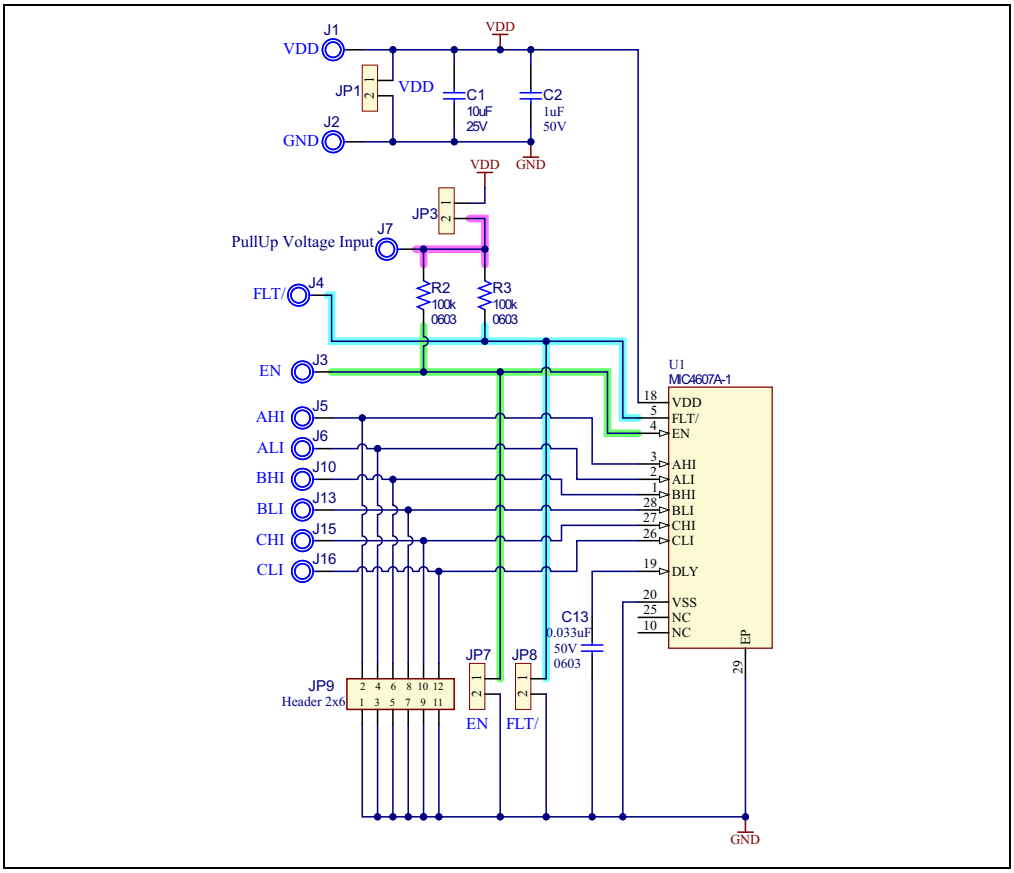


FIGURE 2-3: *EN Pin Pull Up.*

FLT/ Pin

The fault (FLT/) pin is pulled up to VDD through R3 and can be monitored at the J4 terminal or JP8 header. This pin is low during an overcurrent fault.

DLY Pin

A capacitor connected to the DLY pin determines the amount of time the gate-drive outputs are latched off before they can be restarted.

The delay time can be approximately calculated using the Equation 2-1.

EQUATION 2-1:

$$t_{DLY} = \frac{C_{DLY} \times V_{DLY+}}{I_{DLY}}$$

Where:

C_{DLY} = External capacitance on the DLY pin
I_{DLY} = DLY pin current source (0.44 µA, typical)
V_{DLY+} = Internal comparator threshold (1.5V, typical)

Current Limit (ILIM)

The current-limit pins sense voltage across parallel resistors R12 and R14. The peak current-limit threshold can be calculated by:

EQUATION 2-2:

$$I_{LIM\_PK} = \frac{V_{ILIM+}}{R_{SNS}}$$

Where:

V_{ILIM+} = Overcurrent threshold (0.2V, typical)
R_{SNS} = Parallel combination of R12 and R14

The evaluation board current limit is:

EQUATION 2-3:

$$I_{LIM\_PK} = \frac{0.2V}{0,025\Omega} = 8A$$

The R13/R21/C17 filter prevents false triggering of the overcurrent circuit due to noise and the effects of the low-side, gate-driver currents flowing through the current-sense resistors.

2.3.2 Connections

2.3.2.1 PRECAUTIONS

The MIC4607A MOSFET Driver Evaluation Board does not have reverse polarity protection. Applying a negative voltage to the VIN (J8) or VDD (J1) terminals can damage the device. To prevent damage to the driver, do not exceed 85V on the VIN terminal or 16V on the VDD terminal.

The EN and FLT/ pins are pulled up to VDD. This can cause damage to an external controller whose supply voltage is less than VDD. If these signals are connected to a device with a supply voltage less than VDD, the R2 and R3 resistors should be removed or connected to a suitable pull-up voltage to prevent damage to the controller.

2.3.2.2 JUMPER SETTINGS

The MIC4607A MOSFET Driver Evaluation Board has several user-configurable jumpers. The jumpers are described in Table 2-1 below. The configuration jumpers positioning is illustrated in Figure 2-4.

TABLE 2-1: MIC4607A MOSFET DRIVER EVALUATION BOARD JUMPERS

Jumper	Positions	Function Description
JP3	On/Off	Populate to pull up the “Enable” pin to VDD.
JP7	On/Off	Populate to pull the “Enable” pin low. This will deactivate the phase outputs and the device will enter into a low current shutdown mode.
JP8	On/Off	Populate to pull the “Fault” pin low.
JP12	On/Off	Populate to short current limit comparator inputs. This stops the MIC4607A from registering an over-current on the MOSTEF bridge.

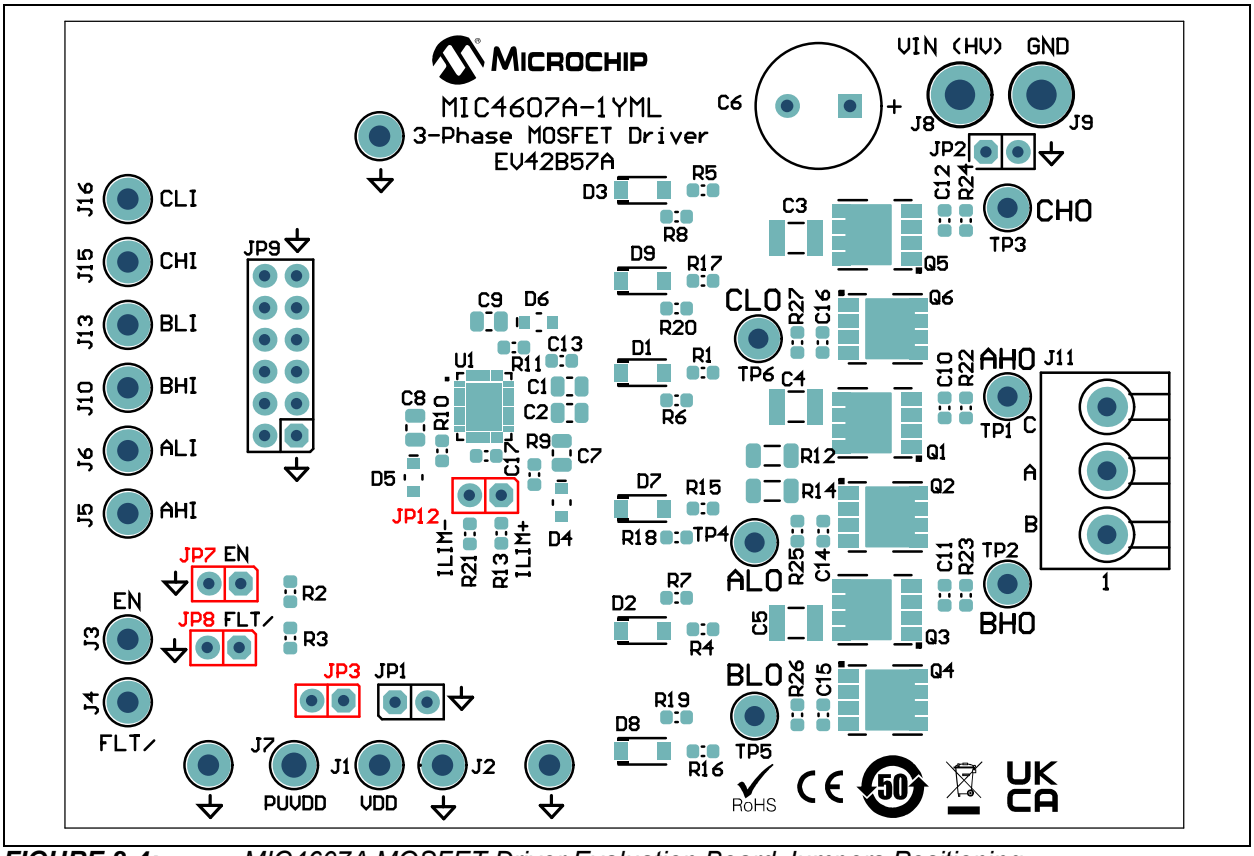


FIGURE 2-4: *MIC4607A MOSFET Driver Evaluation Board Jumpers Positioning.*

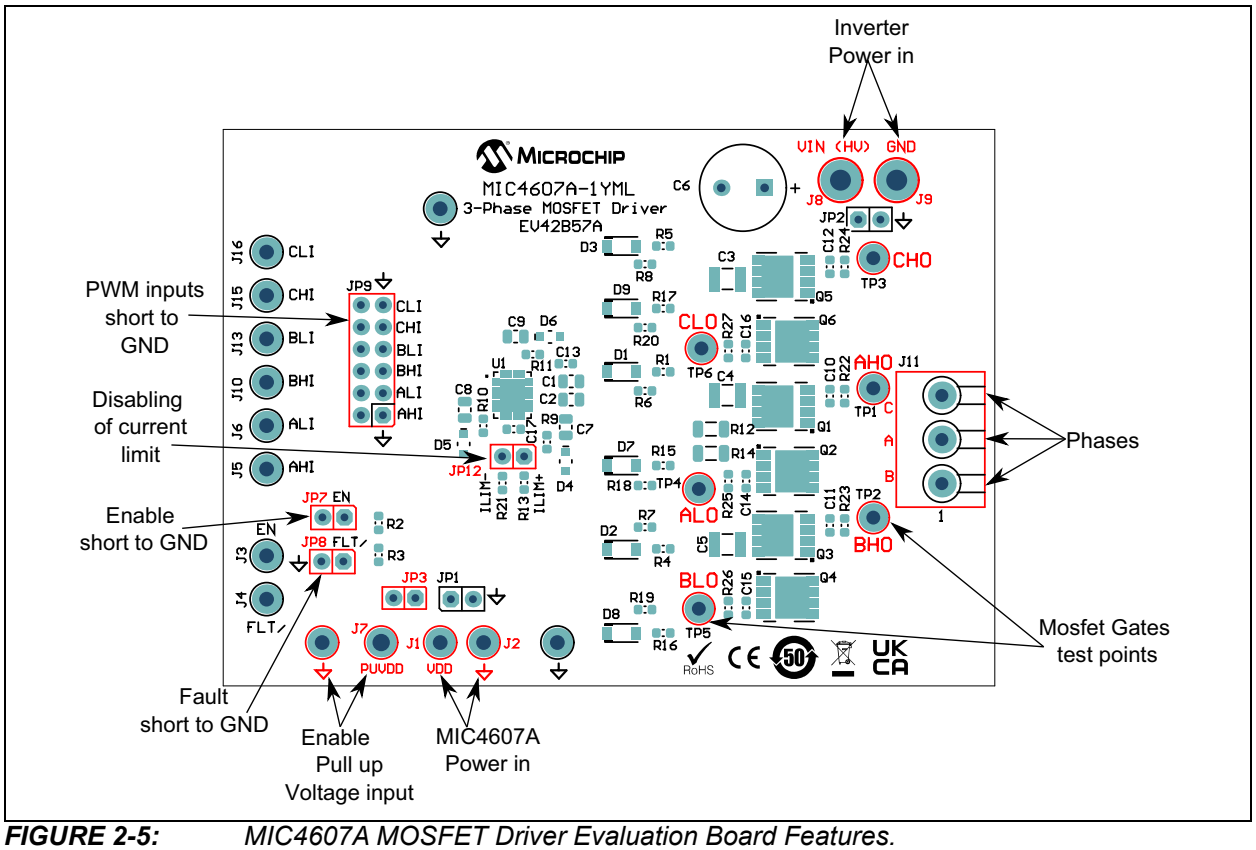


FIGURE 2-5: *MIC4607A MOSFET Driver Evaluation Board Features.*

2.3.3 Test Points

There are several test points on the board that allow the probing of voltages, currents and signals. An abridged listing is shown in Table 2-2.

TABLE 2-2: TEST POINTS DESCRIPTION

Test Point Name	Description
VIN (HV)	Power supply for MOSFET bridge (+)
GND	Power supply ground (-)
VDD	Power supply for MIC4607A
PVDD	Supply voltage for Enable pull up (same as microcontroller supply voltage)
EN	Enable input for MIC4607A
ELT	Fault output
ILIM-/ILIM+	Voltage drop on MOSFET bridge shunt resistor
ALI/BLI/CLI	PWM low side inputs
AHI/BHI/CHI	PWM high side inputs
ALO/BLO/CLO	PWM low side outputs
AHO/BHO/CHO	PWM high side outputs

2.3.4 Asymmetric Turn On/Off External MOSFET Bridge

The evaluation board has available asymmetric on/off for both H/L side external MOSFET bridge for all three phases in order to achieve a slowdown commutation and high tight of the MOSFET gates to the lowest potential.

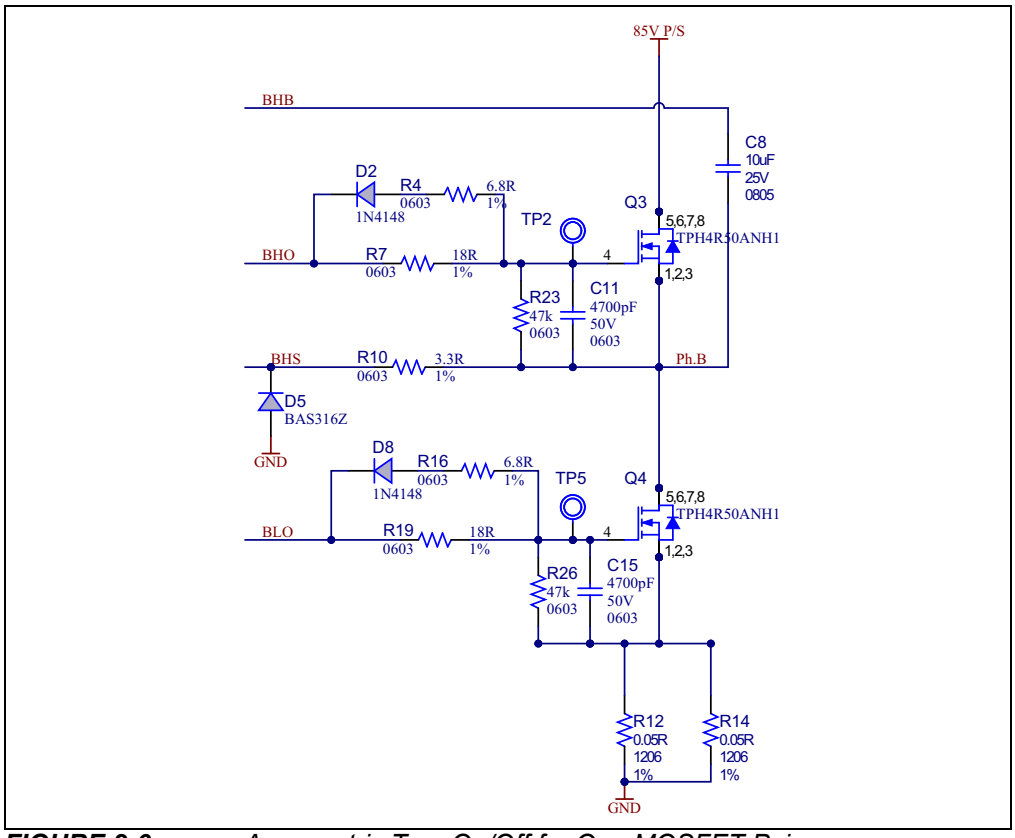


FIGURE 2-6: *Asymmetric Turn On/Off for One MOSFET Pair.*

Low-Side Gate Drivers

A resistor in series between the low-side driver output and MOSFET gate helps reduce the peak driver current flowing through the current-sense resistor. The value of this resistor can increase or decrease depending upon the current-sense resistor value and MOSFET gate capacitance. The series diode resistor circuit - in parallel with the gate resistor in the low-side drivers - should be used to allow proper operation of the adaptive dead-time circuit. Refer to the MIC4607A data sheet for a description of the active anti-shoot-through feature.

High-Side Gate Drivers

The R6, R7, and R8 resistors can be used to adjust the high-side MOSFET turn-on and turn-off times. Additionally, the R1, R4, and R5 resistors can be used to adjust only the MOSFET's turn-off time.

NOTES:

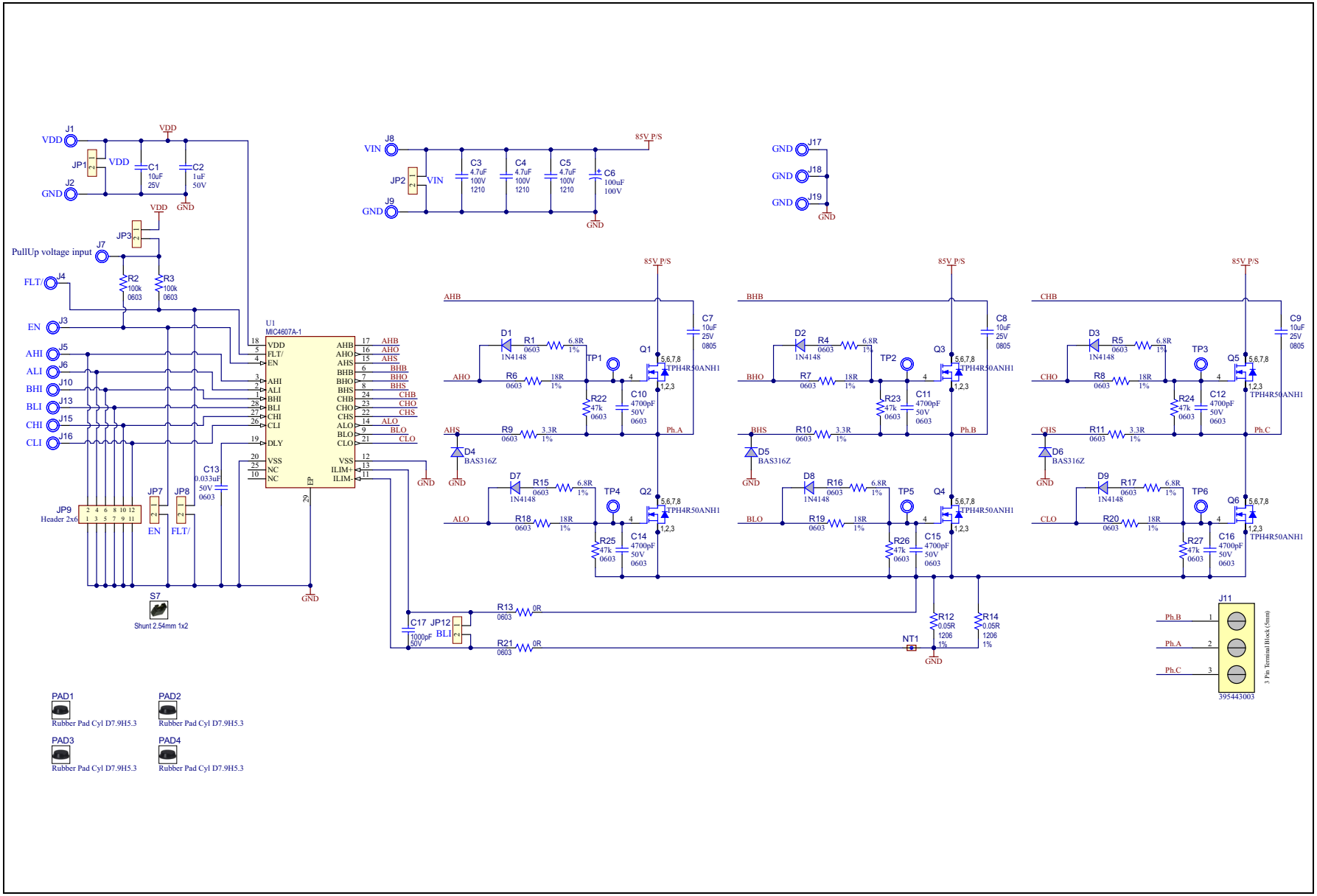
Appendix A. Schematics and Layouts

A.1 INTRODUCTION

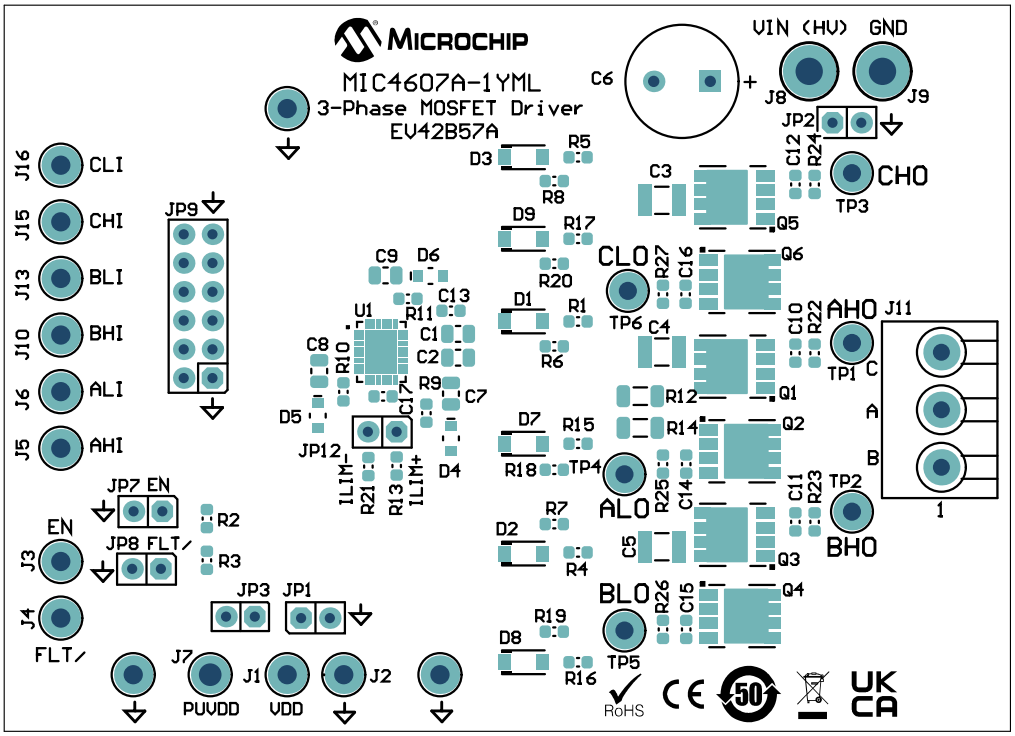
This appendix contains the schematics and layouts of the MIC4607A MOSFET Driver Evaluation Board:

- EV42B57A – Schematic
- EV42B57A – Top Silk
- EV42B57A – Top Copper and Silk
- EV42B57A – Top Copper
- EV42B57A – Bottom Copper
- EV42B57A – Bottom Copper and Silk
- EV42B57A – Bottom Silk

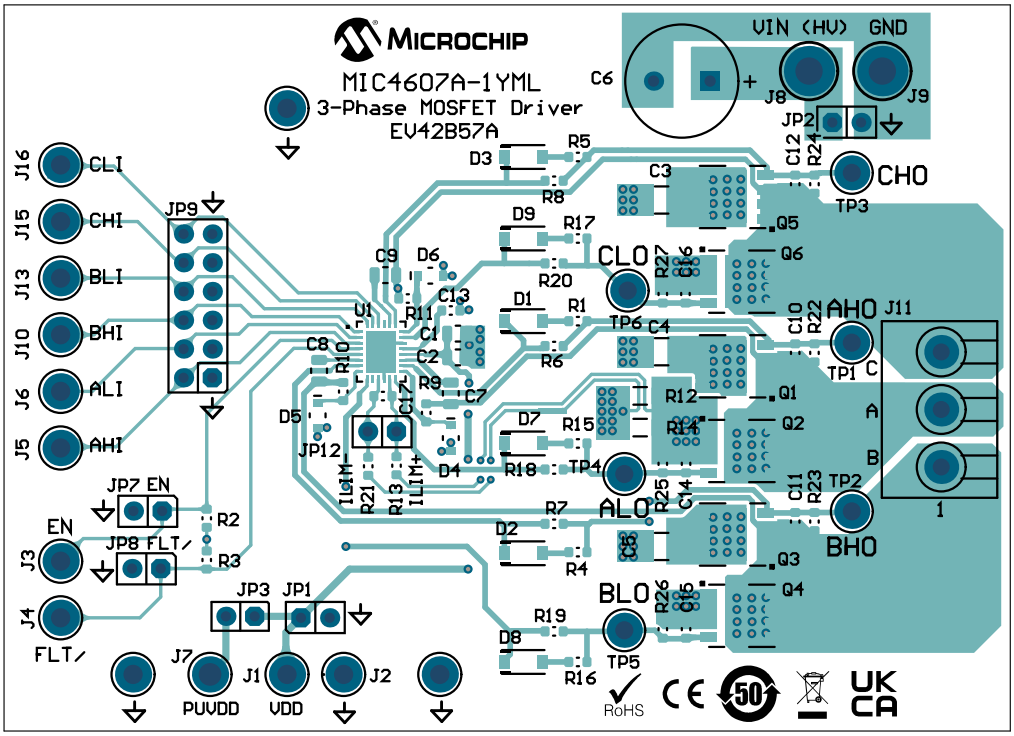
A.2 EV42B57A – SCHEMATIC



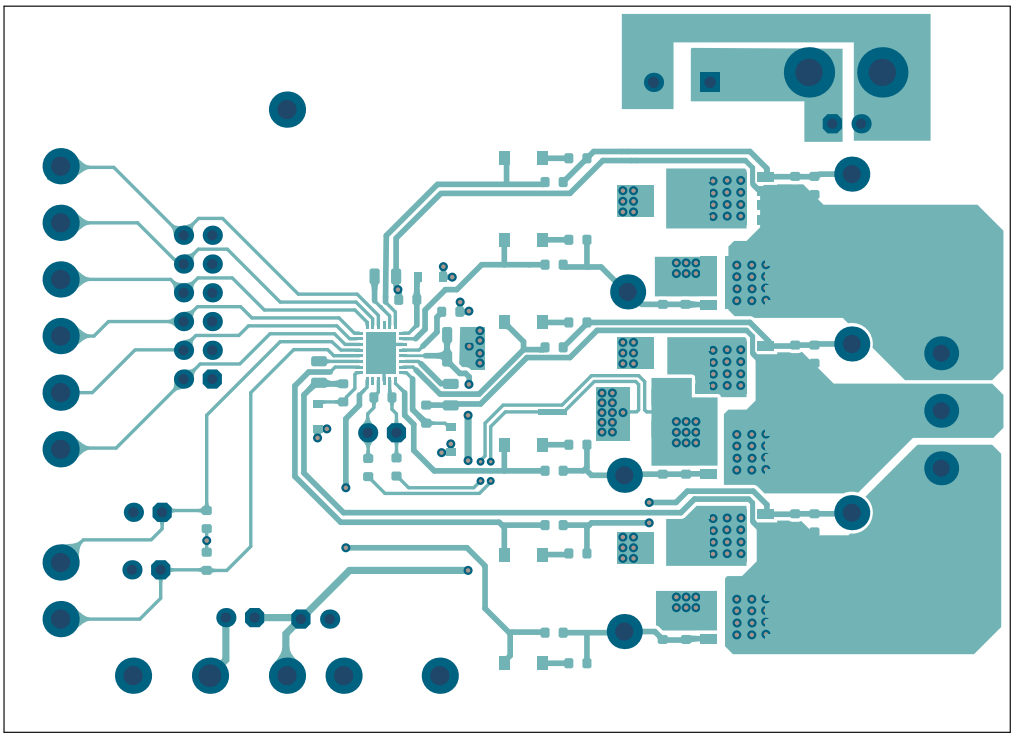
A.3 EV42B57A – TOP SILK



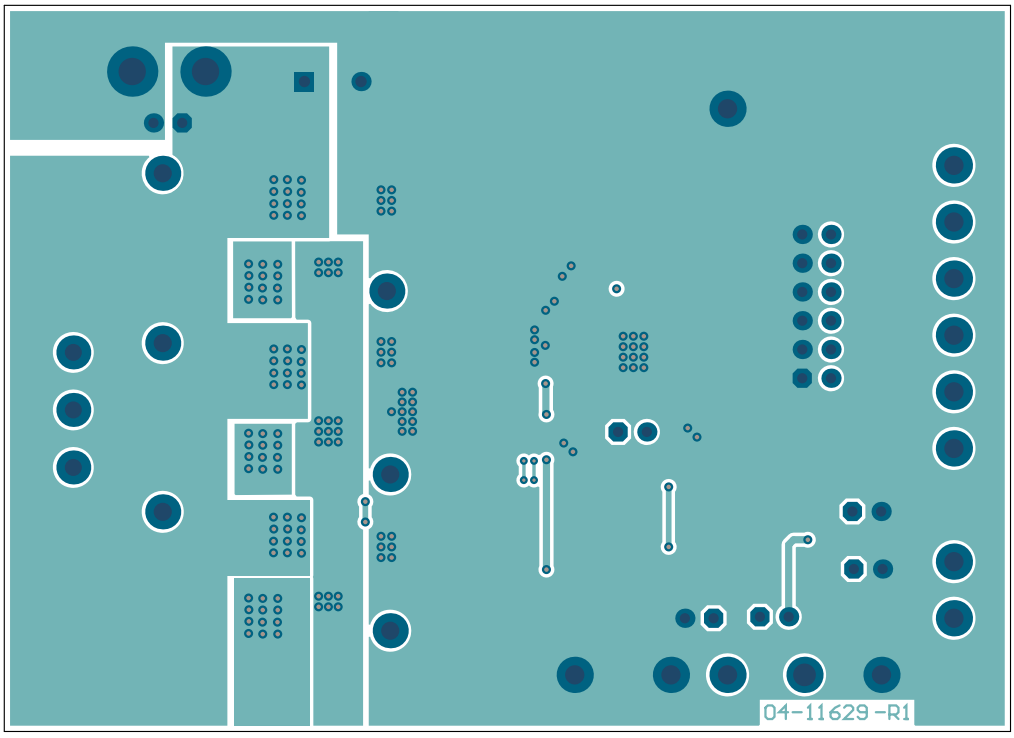
A.4 EV42B57A – TOP COPPER AND SILK



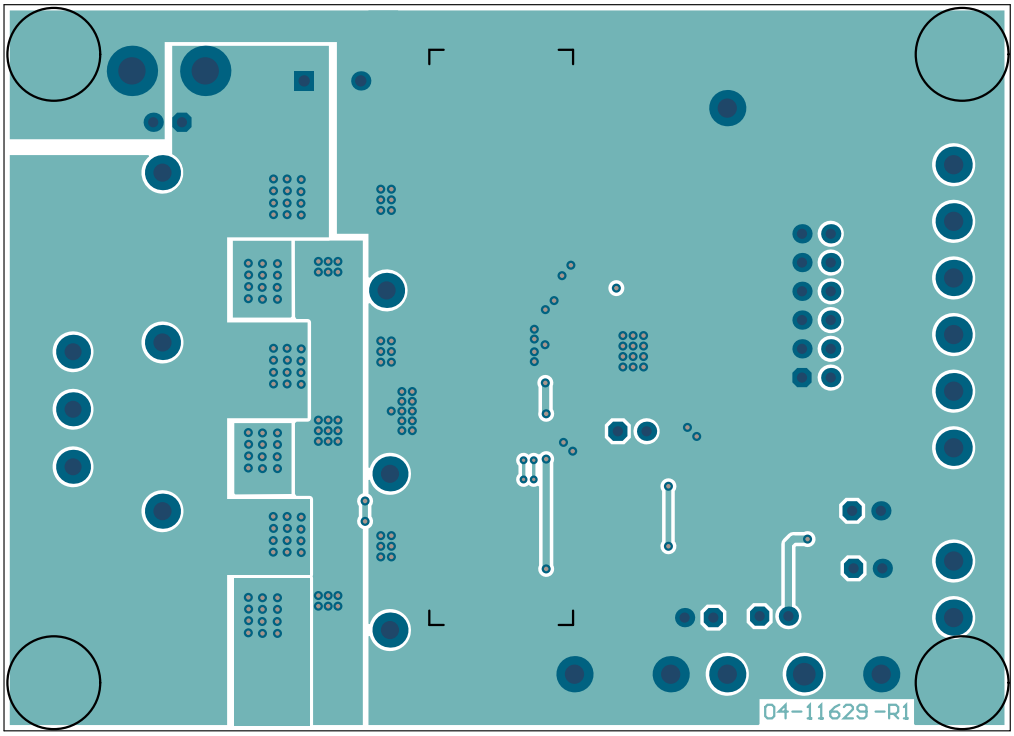
A.5 EV42B57A – TOP COPPER



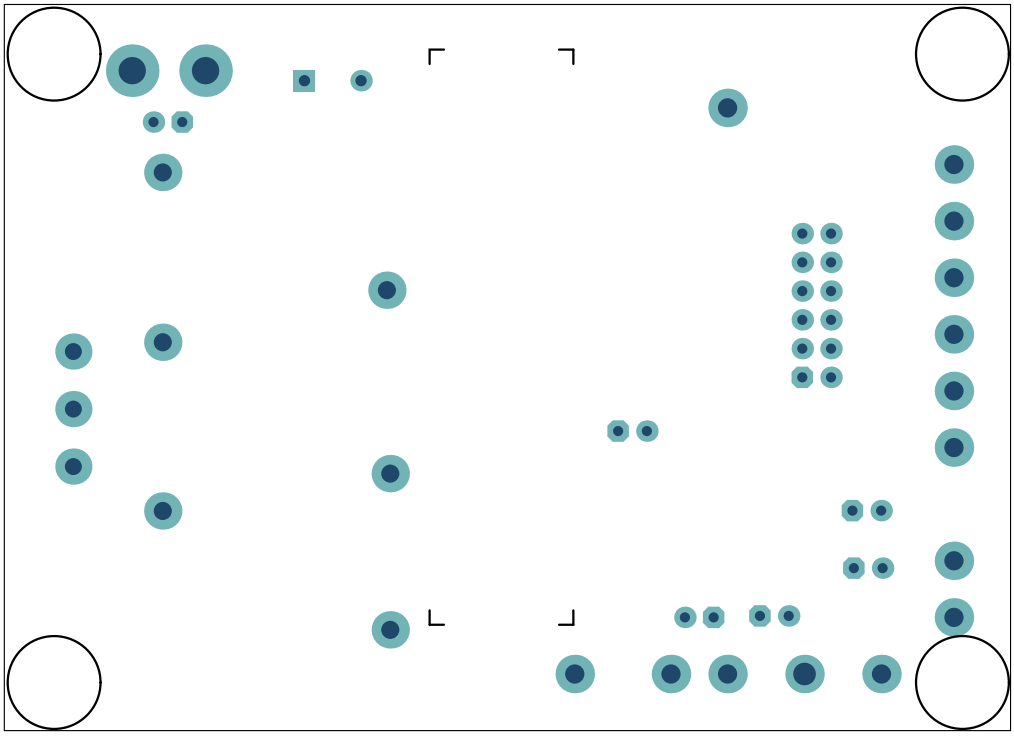
A.6 EV42B57A – BOTTOM COPPER



A.7 EV42B57A – BOTTOM COPPER AND SILK



A.8 EV42B57A – BOTTOM SILK



NOTES:

Appendix B. Bill of Materials (BOM)

TABLE B-1: BILL OF MATERIALS (BOM)

Qty.	Reference	Description	Manufacturer	Part Number
1	C1	Capacitor, Ceramic, 10 µF, 25V, 10%, X5R, SMD, 0805	TDK Corporation	C2012X5R1E106K125AB
1	C2	Capacitor, Ceramic, 1 µF, 50V, 10%, X7R, SMD, 0805	Würth Elektronik	885012207103
3	C3, C4, C5	Capacitor, Ceramic, 4.7 µF, 100V, 10%, X7S, SMD, 1210, AEC-Q200	Taiyo Yuden Co., Ltd.	HMK325C7475KMHPE
1	C6	Capacitor, Aluminum, 10 µF, 100V, 20%, RAD, P5D10H25	Nichicon Corporation	UHE2A101MPD
3	C7, C8, C9	Capacitor, Ceramic, 10 µF, 25V, 20%, X5R, SMD, 0805	TDK Corporation	C2012X5R1E106M085AC
6	C10, C11, C12, C14, C15, C16	Capacitor, Ceramic, 4700 pF, 50V, 10%, X7R, SMD, 0603	KEMET	C0603C472K5RACTU
1	C13	Capacitor, Ceramic, 0.033 µF, 50V, 10%, X7R, SMD, 0603, AEC-Q200	KEMET	C0603C333K5RACAUTO
1	C17	Capacitor, Ceramic, 1000 pF, 50V, 5%, C0G, SMD, 0603	Kyocera AVX	06035A102JAT2A
6	D1, D2, D3, D7, D8, D9	Diode, Rectifier, 1.25V, 150 mA, 100V, SOD-123	Taiwan Semiconductor	1N4148W-G RHG
3	D4, D5, D6	Diode, Rectifier, 1.25V, 250 mA, 100V, SOD-323	Nexperia	BAS316Z
14	J1, J2, J3, J4, J5, J6, J7, J10, J13, J15, J16, J17, J18, J19	Connector, Test Point, PIN, Tin, Through Hole	Harwin Plc.	H2121-01
2	J8, J9	Connector, Test Point, PIN, Tin, Through Hole	Keystone® Electronics Corp.	1502-2
1	J11	Connector, Terminal, 5.08 mm, 1x3, Side, Ent, Through Hole	Molex, LLC	395443003
6	JP1, JP2, JP3, JP7, JP8, JP12	Connector, HDR-2.54 Male, 1x2, Gold, 5.84 MH, Through Hole, Vertical	FCI	77311-118-02LF
1	JP9	Connector, HDR-2.54 Male, 2x6, Gold,5.84MH, Through Hole, Vertical	Samtec, Inc.	TSW-106-07-G-D
1	PCB1	Printed Circuit Board	—	04-11629-R1
1	PCBA1	PCB Assembly	—	02-00533-R1

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-1: BILL OF MATERIALS (BOM) (CONTINUED)

Qty.	Reference	Description	Manufacturer	Part Number
6	Q1, Q2, Q3, Q4, Q5, Q6	Transistor, FET, N-Channel, 100V, 92A, 0.0045R, 800 mW, 8-SOP, Advance	Toshiba	TPH4R50ANH1,LQ
6	R1, R4, R5, R15, R16, R17	Resistor, Thick Film, 6.8R, 1%, 1/10W, SMD, 0603	Yageo Corporation	RC0603FR-076R8L
2	R2, R3	Resistor, Thick Film, 100k, 1%, 1/4W, SMD, 0603	Vishay Intertechnology, Inc.	CRCW0603100KFKEAHP
6	R6, R7, R8, R18, R19, R20	Resistor, Thick Film, 18R, 1%, 1/10W, 0603	Yageo Corporation	RC0603FR-0718RL
3	R9, R10, R11	Resistor, Thick Film, 3.3R, 1%, 1/10W, SMD, 0603	Panasonic® - ECG	ERJ-3RQF3R3V
2	R12, R14	Resistor, Metal Strip, 0.05R, 1%, 1W, SMD ,1206	Vishay Intertechnology, Inc.	WSLP1206R0500FEA
2	R13, R21	Resistor, Thick Film, 0R, 1/10W, SMD, 0603	Panasonic® - ECG	ERJ-3GSY0R00V
6	R22, R23, R24, R25, R26, R27	Resistor, Thick Film, 47k, 1%, 1/10W, SMD, 0603	Stackpole Electronics, Inc.	RMCF0603FT47K0
6	TP1, TP2, TP3, TP4, TP5, TP6	Connector, Test Point, Loop, Red, Through Hole	Keystone® Electronics Corp.	5010

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) – MICROCHIP PARTS

Qty.	Reference	Description	Manufacturer	Part Number
1	U1	Analog Motor Driver, VQFN-28	Microchip Technology, Inc.	MIC4607A-1YML

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-3: BILL OF MATERIALS (BOM) – MECHANICAL

Qty.	Reference	Description	Manufacturer	Part Number
1	LABEL1	Label, "Need Help?" with Assy#/Serial#	—	—
4	PAD1, PAD2, PAD3, PAD4	Mechanical, Headers & Wires, Rubber, Pad, Cylindrical, D7.9, H5.3, Black	3M	SJ61A11
1	S7	Mechanical, Headers & Wires, Jumper, 2.54 mm, 1x2	3M	969102-0000-DA

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.