



**MICROCHIP**

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**ATA6847L**  
**QFN48 BLDC Motor Driver**  
**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 ATA6847L QFN48 BLDC Motor 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 ATA6847L QFN48 BLDC Motor Driver Evaluation Board. The manual layout is as follows:

- **Chapter 1. “Product Overview”** – Important information about the ATA6847L QFN48 BLDC Motor Driver Evaluation Board.
- **Chapter 2. “Installation and Operation”** – Includes instructions on installing and using the ATA6847L QFN48 BLDC Motor Driver Evaluation Board.
- **Appendix A. “Schematics and Layouts”** – Shows the schematic and layout diagrams for the ATA6847L QFN48 BLDC Motor Driver Evaluation Board.
- **Appendix B. “Bill of Materials (BOM)”** – Lists the parts used to build the ATA6847L QFN48 BLDC Motor Driver Evaluation Board.
- **Appendix C. “Software”** – Provides information about the demo application and where the source code can be found.

## 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® 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) { ... }

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## RECOMMENDED READING

This user's guide describes how to use the ATA6847L QFN48 BLDC Motor Driver Evaluation Board. Other useful documents are listed below. The following Microchip documents are available and recommended as supplemental reference resources:

- **ATA6847L Data Sheet - "3-Phase Motor Gate Driver System Basis Chip with Power Module, Sleep Mode, and LIN Transceiver" (DS20006940)** – This data sheet provides detailed information regarding the ATA6847L product family.
- **dsPIC33CK256MP508 Data Sheet - "Digital Signal Controllers with High-Resolution PWM and CAN Flexible Data (CAN FD)" (DS70005349)** - This data sheet provides detailed information regarding the dsPIC33CK256MP205 product family.
- **dsPIC33E/PIC24E Family Reference Manual (DS70573)**
- **dsPIC33AK128MC106 Family Data Sheet - "High-Performance dsPIC33A Core with Floating-Point Unit, High-Speed ADCs and High-Resolution PWM" (DS70005539)** - This data sheet contains anomalies and clarifications for the dsPIC33AK128MC106 processor.
- **SAM C21 Family Data Sheet - "32-bit Arm Cortex-M0+ with 5V Support, CAN-FD, PTC, and Advanced Analog" (DS60001479)** - This data sheet contains anomalies and clarifications for the ATSAMC21J18A processor.
- **AN1078 - "Sensorless Field Oriented Control of a PMSM" (DS01078)**
- **AN1160 - "Sensorless BLDC Control with Back-EMF Filtering Using a Majority Function" (DS01160)**
- **AN992 - "Sensorless BLDC Motor Control Using dsPIC30F2010" (DS00992)**
- **AN1292 - "Sensorless Field Oriented Control (FOC) for a Permanent Magnet Synchronous Motor (PMSM) Using a PLL Estimator and Field Weakening (FW)" (DS01292)**
- **AN901 - "Using the dsPIC30F for Sensorless BLDC Control" (DS00901)**

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- **General Technical Support** – Frequently Asked Questions (FAQs), technical support requests, online discussion groups, Microchip consultant program member listing
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- **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.

## 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://www.microchip.com/support>.

## DOCUMENT REVISION HISTORY

### Revision A (July 2025)

- Initial release of this document.

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## Chapter 1. Product Overview

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### 1.1 INTRODUCTION

This chapter covers the following topics:

- [ATA6847L QFN48 BLDC Motor Driver Evaluation Board Overview](#)
- [What is the ATA6847L QFN48 BLDC Motor Driver Evaluation Board?](#)
- [What does the ATA6847L QFN48 BLDC Motor Driver Evaluation Board Kit Include?](#)

### 1.2 ATA6847L QFN48 BLDC MOTOR DRIVER EVALUATION BOARD OVERVIEW

The ATA6847L QFN48 BLDC Motor Driver Evaluation Board is used to demonstrate the driver capabilities offered by the ATA6847L variant with LIN and a VIO voltage of 3.3V in BLDC/PMSM motor applications.

The two-layered, high current board is designed to be very versatile, low cost, and easily configurable to meet as many customer preferences as possible. It uses the ATA6847L QFN48 as a 3-phase Brushless DC (BLDC) motor gate driver and the dsPIC33CK256MP205 Motor Control DIM provided by Microchip. In order to implement different types of algorithms, like the sinusoidal dual/single shunt FOC or the trapezoidal motor control algorithm in sensed or sensorless mode, the board can be easily configured by using the jumpers and connectors located on the board. Furthermore, the desired firmware should be implemented accordingly to the desired hardware configuration.

As provided, the ATA6847L QFN48 BLDC Motor Driver Evaluation Board is ready to drive a BLDC motor using the FOC method in sensorless mode. The board is equipped with a Start/Stop button and a potentiometer that can be used to adjust the speed of the motor. The evaluation board can drive a BLDC motor with a supply voltage of up to 32.5V and a motor current up to 35A RMS. For higher load currents, a custom heat sink can be attached on the bottom side. The ATA6847L QFN48 BLDC Motor Driver Evaluation Board provides user selectable 3.3V/5V/100 mA LDOs, a 3.3V Buck Regulator, a LIN communication interface, a USB Serial connection, a MikroE connector, an Xplained Pro extension header, three current sense operational amplifiers, and Hall-effect sensors inputs. Moreover, the ATA6847L has many configuration capabilities for OCP/Limit, Overvoltage, Undervoltage, Overtemperature protections due to its internal dedicated registers that are available via its SPI interface.

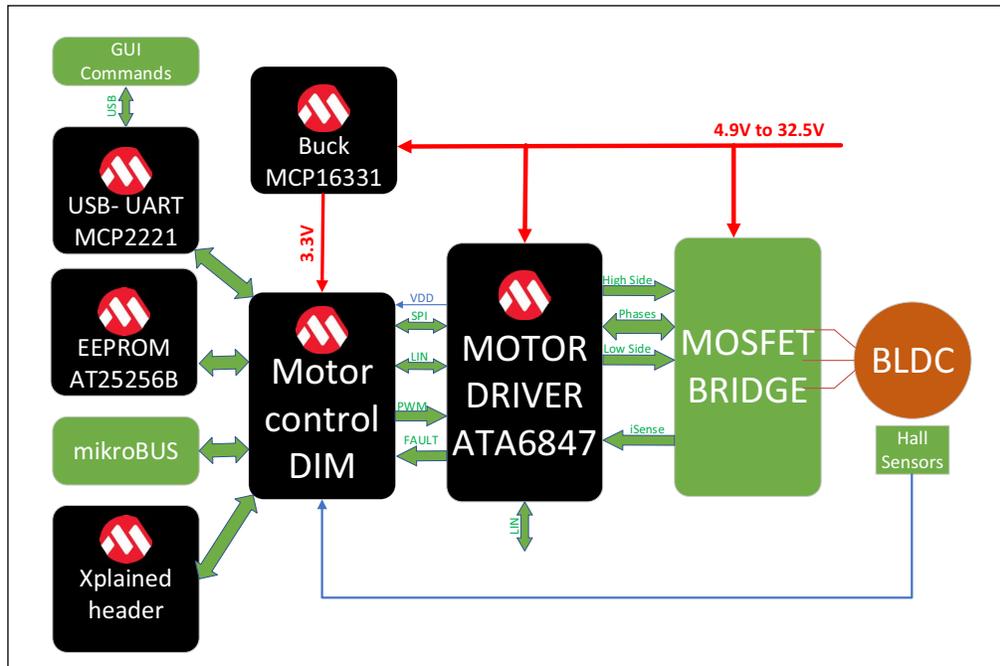
Several key test points are available on the board in order to facilitate the user's measurements, tuning or motor control optimization.

The evaluation board provides several optical indicators, such as RunLED, FitLED for the status indication, PwLED for voltage presence, VDD1 and VDD2 for LDO voltage presence, RX and TX indication of serial connection to computer and six on-board LEDs for Pulse-Width Modulation (PWM) inputs.

## 1.3 WHAT IS THE ATA6847L QFN48 BLDC MOTOR DRIVER EVALUATION BOARD?

The ATA6847L QFN48 BLDC Motor Driver Evaluation Board is a complete motor controller for brushless DC motors (BLDC). The board can drive a three-phase brushless DC motor rated at up to 35A and 32.5V. The input voltage motor operating range for the board is +4.9V to +32.5V. The board consists of three main units:

- ATA6847L QFN48 Motor Driver
- DIM connector to attach one of the compatible motor control DIMs, like dsPIC33CK256MP205 Motor Control DIM.
- Three phases MOSFET Bridge



**FIGURE 1-1:** ATA6847L QFN48 BLDC Motor Driver Evaluation Board Block Diagram.

The on-board ATA6847L generates 3.3V using internal voltage regulators (VDD2) for the attached host microcontroller (or 5V for other microcontroller type/Hall sensors). The ATA6847L also contains two charge pumps for the low and high side of the Gate Driver Unit to allow operation up to 100% duty cycle.

A LIN communication interface included by ATA6847L gives the possibility for external systems interfacing that use this communication protocol.

An input terminal block connector is provided to apply the input voltage to the board, and another output connector is provided to attach the BLDC.

A programming header connector is available for programming/updating the firmware contained in the dsPIC33CK256MP205 from the motor control DIM, using a PICKIT programmer/debugger.

An input terminal block is supplied on the board, to allow users to connect the Hall sensors with selectable voltage supply (5V/3.3V).

Four push buttons (**RST**, **PB1**, **RUN** and **WAKE**) are available for different events generation (as start, stop, direction change, reset, etc). A reference speed potentiometer is available to set the desired motor velocity.

An optional spare buck power supply is available for ATA6847-3333L which has INH signal for external source activation or for external interfaces if the required current exceeds the device capability.

Finally, the PCB layout design can serve as a reference example for a robust, low-cost, two-layered, low-voltage, high-current board.

### **1.4 WHAT DOES THE ATA6847L QFN48 BLDC MOTOR DRIVER EVALUATION BOARD KIT INCLUDE?**

The ATA6847L QFN48 BLDC Motor Driver Evaluation Board kit includes:

- The ATA6847L QFN48 BLDC Motor Driver Evaluation Board (EV92R69A).
- The dsPIC33CK256MP205 Motor Control DIM (EV53A92A).

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## Chapter 2. Installation and Operation

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### 2.1 INTRODUCTION

The ATA6847L QFN48 BLDC Motor Driver Evaluation Board demonstrates the features of Microchip's 3-Phase Brushless DC (BLDC) Motor Driver with Power Module, ATA6847L, used in a BLDC motor driver application. When used in conjunction with a microcontroller, the ATA6847L will provide the necessary drive signals to drive a 3-Phase BLDC motor.

The ATA6847L contains all necessary functional blocks for developing high performance BLDC/PMSM motor drivers: high and low side MOSFET drivers, three gain/offset configurable Op Amps, protection circuitry and SPI interface for the configuration of the internal registers.

The board is equipped with a DIM slot for one of Microchip's motor control DIMs and is compatible with dsPIC33CK256MP205 Motor Control DIM high performance Digital Signal Controller (DSC) and can handle simple motor control algorithms like the six-step or high-performance algorithm like the Field Oriented Control (FOC). The dsPIC (DSC) present on the Motor Control DIM is used to provide the PWM inputs to the ATA6847L as well as handle the high-speed Analog-to-Digital Conversion (ADC) supporting up to 50 kHz PWM operation for the FOC motor control technique or higher for trapezoidal. The microcontroller supports a large range of motor control applications due to its specific synchronization between different peripherals.

The motor current can be measured using the dual or single shunt techniques described in AN1078. A high-performance current sense amplifier is implemented using two/three of the ATA6847's internal Op Amps. The third internal OPAMP can be configured either as BEMF or current sense amplifier.

### 2.2 FEATURES

The ATA6847L QFN48 BLDC Motor Driver Evaluation Board has the following features:

- Input operating voltage range: 4.9V to 32.5V
- Maximum of 10/27 $\Omega$  of gate drive sink/source resistance for external N-Channel MOSFETs and programmable LS/HS slew rate control: 12.5%, 25%, 50%, 100%
- Drives up to a 35A RMS BLDC motor
- Three programmable gain/offset current sense amplifiers (G = 8, 16, 32, 64)
- ON/OFF push button (RUN)
- Reset push button (RST)
- PB1 user-programmable push button ( $\mu$ C/Wk)
- Wake-up push button
- PWM signal LED indicators
- Fault signal LED indicator
- IRQ signal LED indicator
- PICkit debugger interface
- Speed control potentiometer
- Terminal block for 3.3V and 5V Hall-effect sensors
- UVLO, OVLO and DUVLO protections

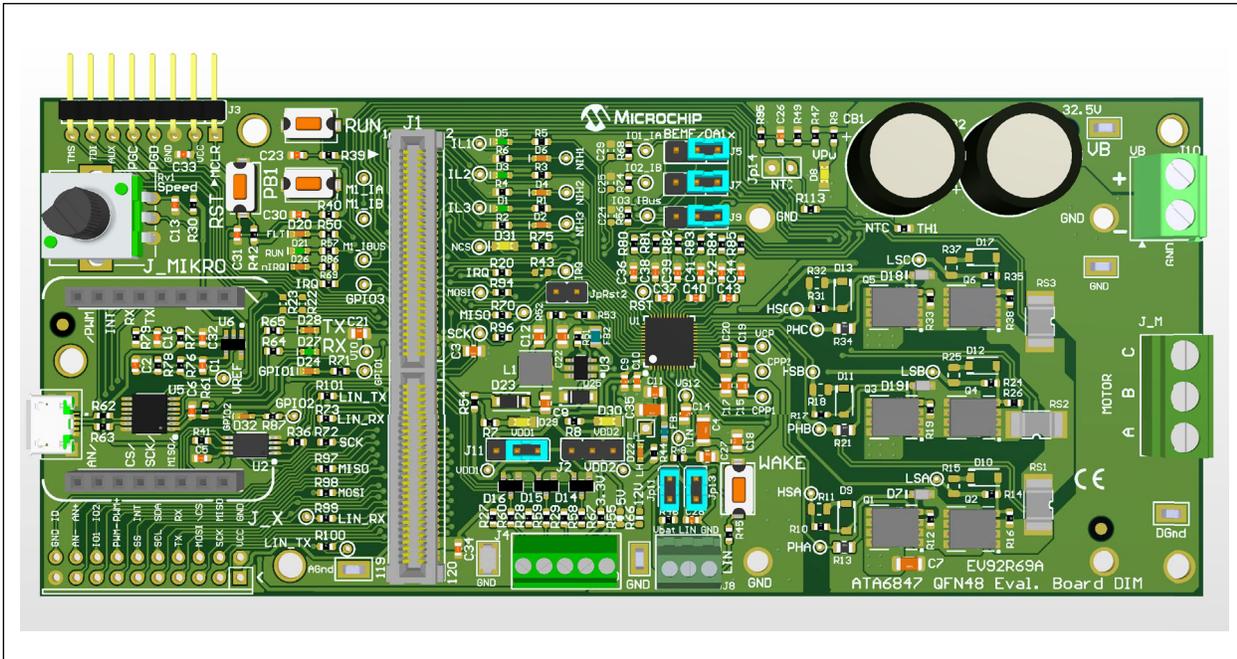
# ATA6847L QFN48 BLDC Motor Driver Evaluation Board User's Guide

- Programmable external MOSFET overcurrent protection 125 mV to 1.75V
- Programmable PWM dead-time protection 100 ns to 6.3  $\mu$ s (100 ns step)
- Thermal shutdown protection
- Programmable timing filters for current and voltages
- Complete “C” source code (provided on the Motor Driver Evaluation Board webpage)

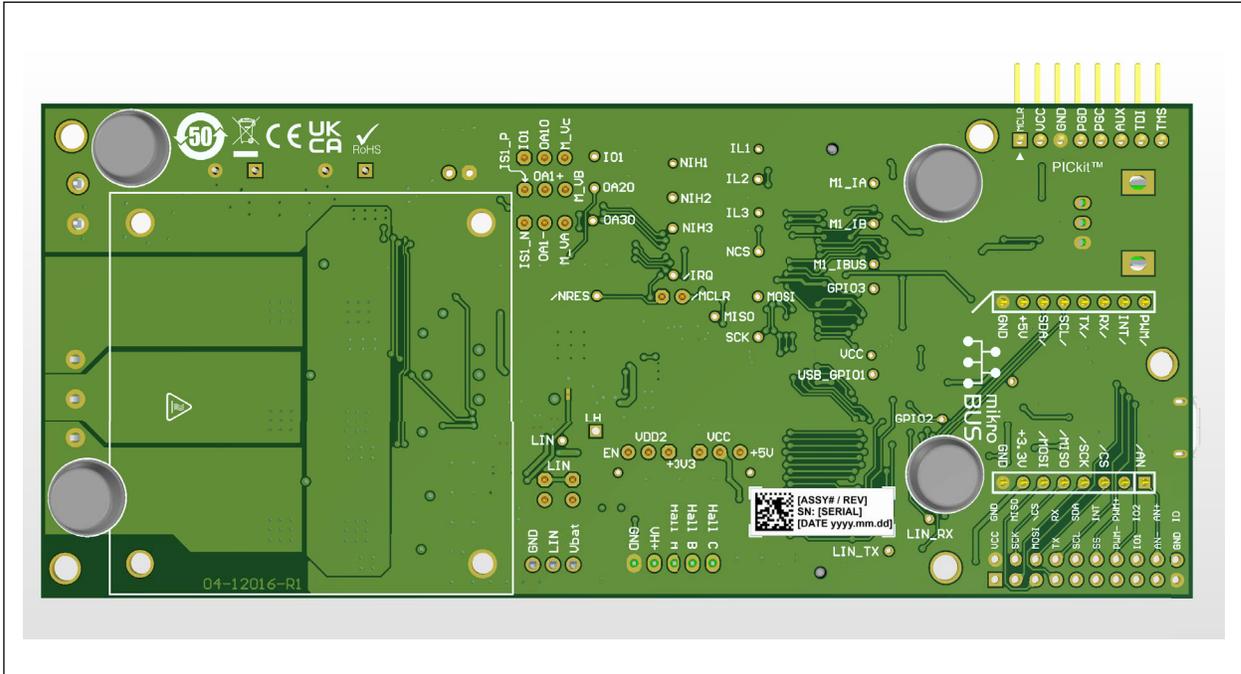
## 2.3 GETTING STARTED

The ATA6847L QFN48 BLDC Motor Driver Evaluation Board is fully assembled and tested for driving a BLDC motor. The board can be easily configured to drive a BLDC motor in sensored or sensorless mode, as well as for sinusoidal single shunt FOC or trapezoidal motor control algorithm.

The board requires the use of an external voltage source capable of supplying 4.9V to 32.5V at the rated motor current. The board is presented in [Figure 2-1](#). The 24V, 3-phase, AC300022 BLDC Motor is also required to evaluate the motor driver.



**FIGURE 2-1:** ATA6847L QFN48 BLDC Motor Driver Evaluation Board PCB (Top).



**FIGURE 2-2:** ATA6847L QFN48 BLDC Motor Driver Evaluation Board PCB (Bottom).

## 2.3.1 Connections

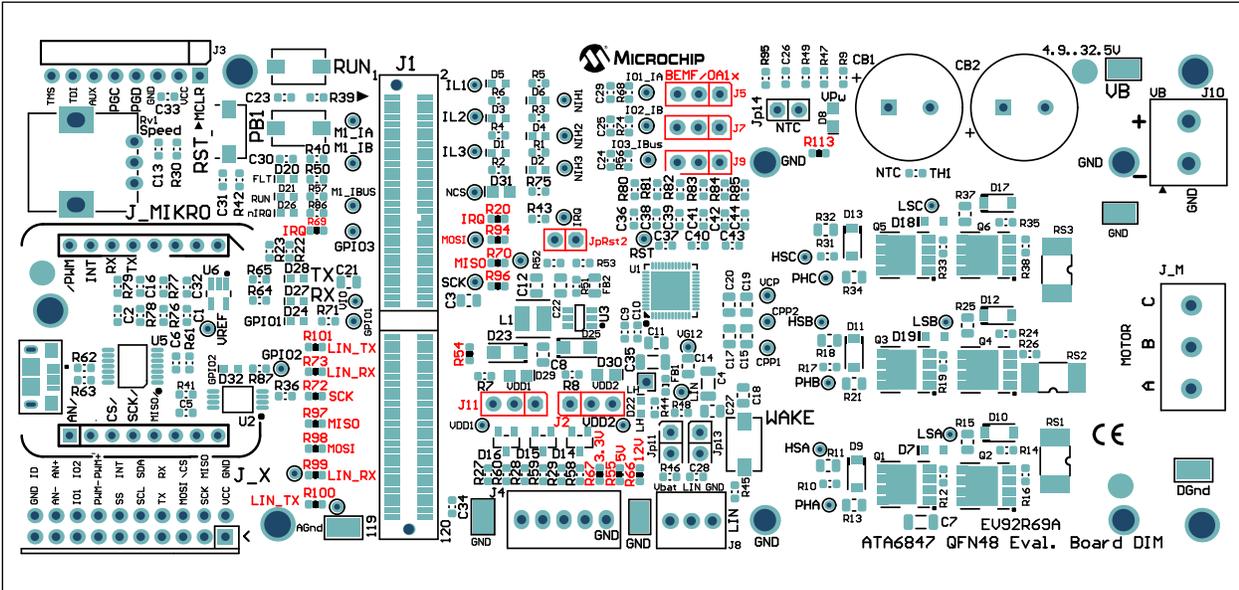
### 2.3.1.1 JUMPER SETTINGS

The ATA6847L QFN48 BLDC Motor 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 2-3](#):

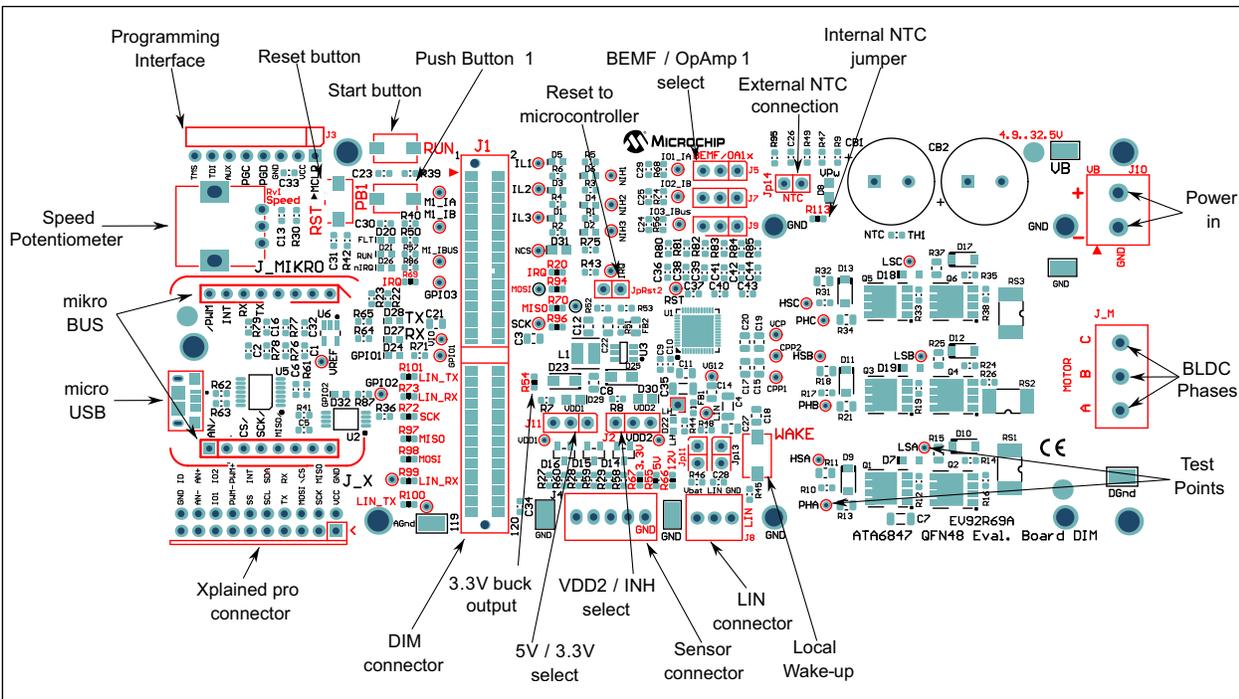
**TABLE 2-1: ATA6847L QFN48 BLDC MOTOR DRIVER EVALUATION BOARD JUMPERS**

Jumper	Positions	Function Description
JpRst2	On/Off	Connect/Disconnect MCLR and nRST signals (for WDT operation)
J5,7,9	BMFx/OAx	BMF block signals/OpAmp1 hardware configuration
R55/R66/R67	5V/12V/3.3V	5V/12V/3.3V Hall power voltage selection
Jp11	On/Off	Connect / Disconnect LIN bus to an external Battery
Jp13	On/Off	Connect / Disconnect LIN bus to Commander LIN capacitor
J2	VDD2/INH	Route VDD2 to DSP PwS or INH to Auxiliary Buck (ATA6847-3333L). Do not place the jumper if powered from the buck.
J11	3V3/5V	Power microcontroller with 3.3V or 5V
R54	SMD Resistor 0Ω	Populate if auxiliary buck is used and J2 = INH or not placed
R113	SMD Resistor 0Ω	Populate if the surface mounted NTC "TH1" is used
R20/R69	On/Off	Connect/Disconnect IRQ line
R70/R97	On/Off	Connect/Disconnect MISO line
R94/R98	On/Off	Connect/Disconnect MOSI line
R72/R96	On/Off	Connect/Disconnect SCK line
R73/R99	On/Off	Connect/Disconnect LIN_RX line
R100/R101	On/Off	Connect/Disconnect LIN_TX line

# ATA6847L QFN48 BLDC Motor Driver Evaluation Board User's Guide



**FIGURE 2-3:** ATA6847L QFN48 BLDC Motor Driver Evaluation Board Jumpers Positioning.



**FIGURE 2-4:** ATA6847L QFN48 BLDC Motor Driver Evaluation Board Features.

The board can be easily configured for different types of motor and control algorithms:

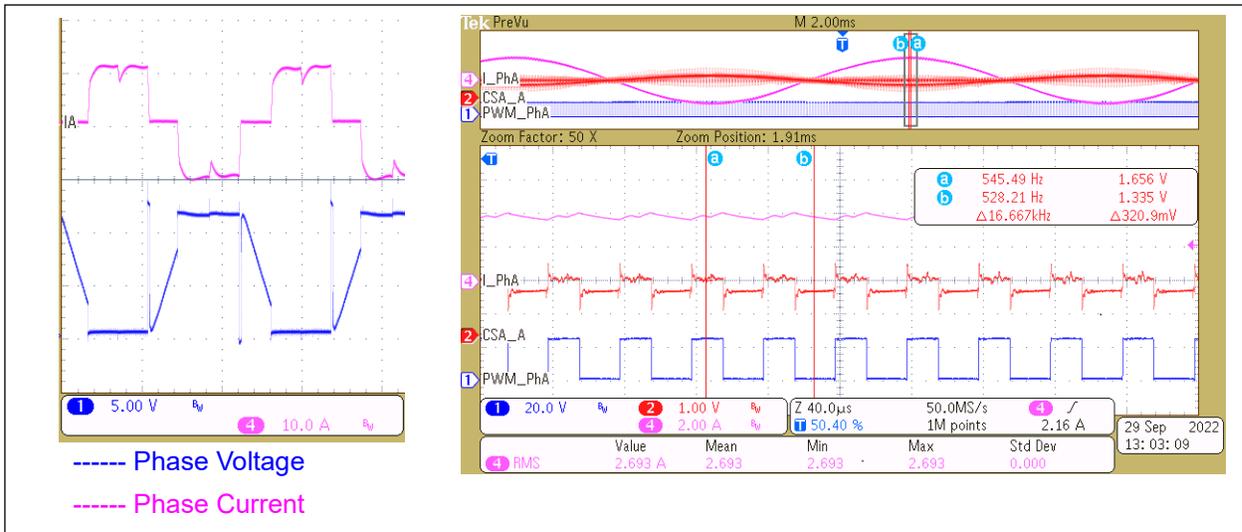
- BLDC Trapezoidal sensorless based on B-EMF null cross detection
- BLDC Trapezoidal based on sensor position detection
- PMSM, FOC, three shunt sensorless (with/without wind milling)
- PMSM, FOC, three shunt based on sensor position detection

Table 2-2 describes the jumpers' settings, for different motor control modes.

**TABLE 2-2: HARDWARE MOTOR CONTROL MODE SETUP**

Jumper	Positions	Description
<b>Trapezoidal Sensorless Mode</b>		
J5	BEMF3	Route OPO1 as BEMF3 ZCD output to DSC
J7	BEMF2	Route OPP1 as BEMF2 ZCD output to DSC
J9	BEMF1	Route OPN1 as BEMF1 ZCD output to DSC
<b>FOC Sinusoidal Sensorless Mode</b>		
J5	IO1	Route OPO1 CSA output to DSC
J7	In1+	Route OPP1 as CSA to IS+
J9	In1-	Route OPN1 as CSA to IS-
<b>Trapezoidal Sensored Mode</b>		
R67 or R55 or R66	HALL 3.3V	Route 3.3V to power Hall sensors
	HALL 5V	Route 5V to power Hall sensors
	HALL 12V	Route 12V to power Hall sensors
<b>FOC Sinusoidal Sensored Mode</b>		
J5	IO1	Route OPO1 CSA output to DSC
J7	In1+	Route OPP1 as CSA to IS+
J9	In1-	Route OPN1 as CSA to IS-
R67 or R55 or R66	HALL 3.3V	Route 3.3V to power Hall sensors
	HALL 5V	Route 5V to power Hall sensors
	HALL 12V	Route 12V to power Hall sensors

For the same motor, Figure 2-5 shows the currents for sensorless trapezoidal and sensorless sinusoidal modes, taken on this board.



**FIGURE 2-5: Trapezoidal and Sinusoidal Motor Control Modes.**

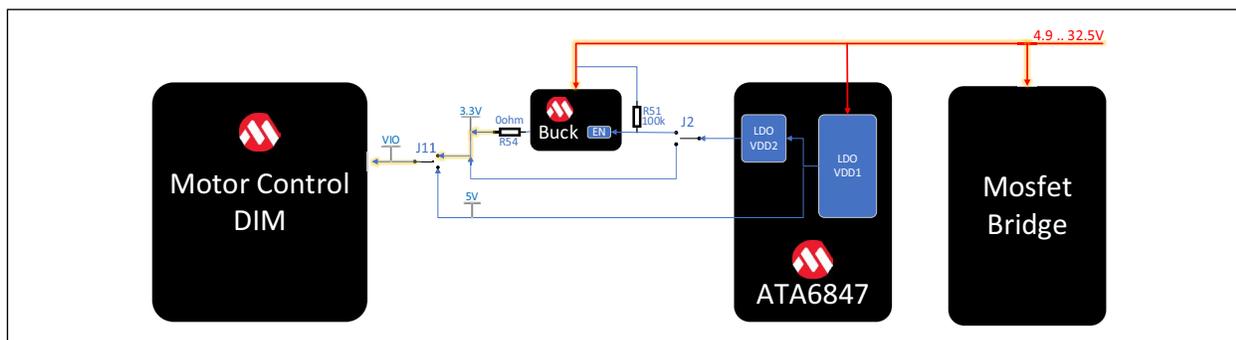
Pressing the Sw1 (WAKE) push button wakes the system up.

Pressing the ST3 (RST) push button forces a host controller reset.

**Jp11** and **Jp13** are used to pull up LIN to the external battery voltage and to add a LIN commander capacitor, respectively.

**J2** is dedicated for the VDD2/INH pin and, when the board is equipped with the ATA6847-3333L, must be put in **INH** (right) position, to be used as external power supply activator (the second LDO is not available for this variant). At the same time, R54 (0Ω) has to be populated to tie the external power supply output to the +3.3V line, in order to supply the dsPIC33CK256MP205 Motor Control DIM.

The INH jumper should be skipped if R51 - Enable PullUp - is present on the board.



**FIGURE 2-6:** Evaluation Board Power Supply Diagram.

### 2.3.1.2 AVAILABLE INTERFACING CONNECTORS

For external board interfacing and communication, the following connectors are available:

- J3 is dedicated for microcontroller programming/debugging. After programming, it can be used for other purposes, e.g. for rotary encoder interfacing, due to the microcontroller pin remapping feature.
- J\_M is the motor driver output. This is the connection to the BLDC motor.
- J10 is the power supply connection. The board needs to be connected to a power supply with an output range of 4.9 to 32.5V, according to the voltage ratings of the motor utilized by the user.
- J4 connects the Hall effect sensors to the dsPIC33CK256MP205 microcontroller. Before connecting the Hall effect sensors, the user must make sure that the Hall effect sensors are powered with the right voltage by putting the 0R resistor in location R67 for 3.3V, in location R55 for 5V or in location R66 for 12V.

#### Interface Connectors

- J10 (**VPwS**) input power supply connector.

Pin	Name	Description
1	GND	Power Supply Ground
2	VPwS	+Power Supply Voltage

- JM (**MOTOR**) three phases output connector.

Pin	Name	Description
1	A	Motor A phase
2	B	Motor B phase
3	C	Motor C phase

- J3 (**PICKITProg**) is mainly dedicated for microcontroller programming/debugging.

Pin	Name	Description
1	MCLR	UART Output (from USB to MCU)
2	V <sub>PP</sub>	+3.3V Power-programming
3	V <sub>SS</sub>	Microcontroller GND
4	PGD	Programming Data
5	PGC	Programming Clock
6	Aux	Not used
7	TDI	Not used
8	TMS	Not used

- J6 (**Sensors**) Hall sensors interfacing connector. Could be used also for other interfacing sensors, e.g. QEI).

Pin	Name	Description
5	VH-	Hall GND
4	VH+	Hall power supply +3.3/5V/12V
3	HallA	HallA sensor output
2	HallB	HallB sensor output
1	HallA	HallA sensor output

- J8 (**LIN**) can be used to communicate with external systems based on LIN protocol or for external Wakeup command when SLEEP mode was induced.

Pin	Name	Description
1	V <sub>BAT</sub>	External battery LIN biasing
2	LIN	LIN bus signal
3	GNDLIN	LIN ground reference

### 2.3.1.3 POWERING THE ATA6847L QFN48 BLDC MOTOR DRIVER EVALUATION BOARD

- Apply the input voltage to the input power terminal block, **VB**, with respect to polarity. The input voltage source should be limited to +32.5V. For proper operation with a common motor, the input voltage should be between +4.9V and +32.5V, in concordance with the motor rated voltage. Connect the positive side of the input power source (+) to pin 1 of **VB**. Connect the negative or return side (-) of the input source to pin 2 of **VB**. Refer to [Figure 2-3](#).

### 2.3.1.4 CONNECTING A MOTOR TO THE ATA6847L QFN48 BLDC MOTOR DRIVER EVALUATION BOARD

- Connect each phase winding of a three-phase BLDC motor to the appropriate terminal of the motor terminals (PhA, PhB, PhC).

### 2.3.2 Operating a Motor

1. Turn the SPEED adjust potentiometer (RV1) fully counterclockwise to obtain the slowest speed setting. Now turn the speed adjust approximately ¼ turn clockwise to allow for 25% motor speed.
2. Turn on the power supply. At this moment, the red Fault LED is blinking at around 10 Hz.
3. Press and release the RUN push button (ST1) to start the motor. In this moment, the PWM's LEDs indicate the motor powering.
4. Turn the Speed potentiometer clockwise to increase motor speed and counterclockwise to decrease motor speed. The Speed Adjust changes the PWM duty cycle of the PWM signals being sent to the ATA6847L.
5. Press and release the RUN push button again to stop the motor.

## 2.3.3 Indicator LEDs

The ATA6847L QFN48 BLDC Motor Driver Evaluation Board has eight LEDs to indicate system status. [Table 2-3](#) lists the LED indicators and their description.

**TABLE 2-3: LED INDICATORS**

PCB Location	Name	Description
D1, D3, D5	PWMxL	PWM Phase x low – side
D2, D4, D6	PWMxH	PWM Phase x high – side
D8	VPw	Indicates power supply presence
D21	Run	Motor running state
D20	Flt Fault	Indicates FAULT status
D22	LH	Optical indicator for Limp Home, V <sub>DD</sub> independent high voltage failure output
D24	GPIO1	LED connected to debugging pin. Used by user for code debugging purposes
D26	nIRQ	Indicates nIRQ status
D27	RX	Data activity received by MCP2221A on RX line
D28	TX	Data activity transmitted by MCP2221A on TX line
D29	VDD1	Presence of voltage on the VDD1 line
D30	VDD2	Presence of voltage on the VDD2 line
D31	NCS	Indicates chip select status
D32	GPIO2	LED connected to debugging pin. Used by user for code debugging purposes.

## 2.3.4 Test Points

There are several test points on the board that allow probing of voltages, currents and signals (see [Table 2-4](#)).

**TABLE 2-4: TEST POINTS DESCRIPTION**

Test Point Name	Description
+4.9...32V	Power supply (+)
GND	Power supply ground (-)
VDD2	3.3V LDO output voltage
VDD1	5V internal LDO output
VIO	Microcontroller supply voltage
VG12	12V internal low side LDO output
CPP1	Charge Pump Positive 1
CPP2	Charge Pump Positive 2
VCP	Output Charge Pump 2 output (respect with VDH)
MOSI	SPI Host Output Client Input
MISO	SPI Host Input Client Output
SCK	SPI Serial Clock
NCS	SPI Chip Select
IRQ	Interrupt request
IL1...3	PWMs Low driver inputs
IH1...3	PWMs High driver inputs
GL1...3	A/B/C Phase Low driver outputs
GH1...3	A/B/C Phase High driver outputs
SH1...3	A/B/C motor/driver phase signals

**TABLE 2-4: TEST POINTS DESCRIPTION (CONTINUED)**

Test Point Name	Description
RST	ATA6847L reset ' Host
LIN	LIN Bus in/output
RX	LIN Rx (ATA6847L Out)
TX	LIN Tx (ATA6847L In)
LH	Limp Home ATA6847L
GPIO1	Spare dsPIC test signal (debugging purposes)
GPIO2	Spare dsPIC test signal (debugging purposes)
GPIO3	Spare dsPIC test signal (debugging purposes)
IO1_IA	opAmp1 output (current through phase 1)
IO2_IB	opAmp2 output (current through phase 2)
IO3_IBus	opAmp3 output (current through phases)
M1_IA	DIM Internal opAmp output (current through phase 1)
M1_IB	DIM Internal opAmp output (current through phase 2)
M1_IBUS	DIM Internal opAmp output (current through phase 3)

### 2.3.5 Reprogramming the dsPIC33CK256MP205 Motor Control DIM

The dsPIC33CK256MP205 Motor Control DIM can be reprogrammed with the user's desired firmware. The processor may be programmed by using an external power source and a PICKit 3, MPLAB REAL ICE in-circuit emulator, PICKit 4 or PICKit 5 programmer.

1. Connect the power source to the board, as explained in [Section 2.3.1.3](#)
2. Connect a PICKit 3, PICKit 4, or PICKit 5 to the **J3** header
3. Start up the MPLABX Integrated Development Environment (IDE) and load the EV92R69A\_ck\_205.X Motor Driver Evaluation Board firmware project. In the "ATA6847.h" file, configure the desired application parameters
4. In the "UserParms.h" file, the desired motor parameters can be configured (see [Appendix C. "Software"](#))
5. Build the project
6. Program the device
7. Press the RESET switch on the board to reset the processor and allow it to execute the new firmware program.

**Note:** The following project options may need to be changed for the computer used to build the firmware:

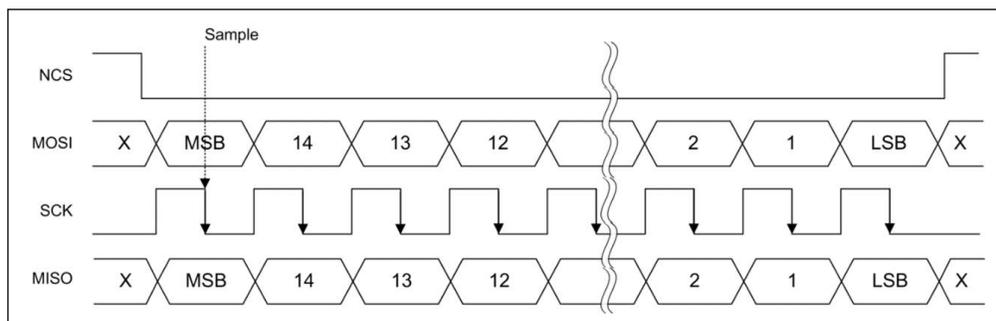
- Add Library `libdsp-elf.a` located in the XC16 `???\src\Libdsp\lib` directory.
- Add XC16-as ASM. Include Directory in XC16 `???\src\Libdsp\asm`.
- Set hardware tool to "PICKit 3", "PICKit 4", "PICKit 5" or "REAL ICE".

### 2.3.6 Configuring the ATA6847L

The ATA6847L has configuration registers that may be used to modify the operating parameters of the device. The parameters are modified by sending commands to the ATA6847L using the SPI communication interface. Bit sampling is performed on the falling edge of the clock and data is shifted in/out on the rising edge, as illustrated in [Figure 2-7](#). 16 bits must be transmitted to the device for a single register write

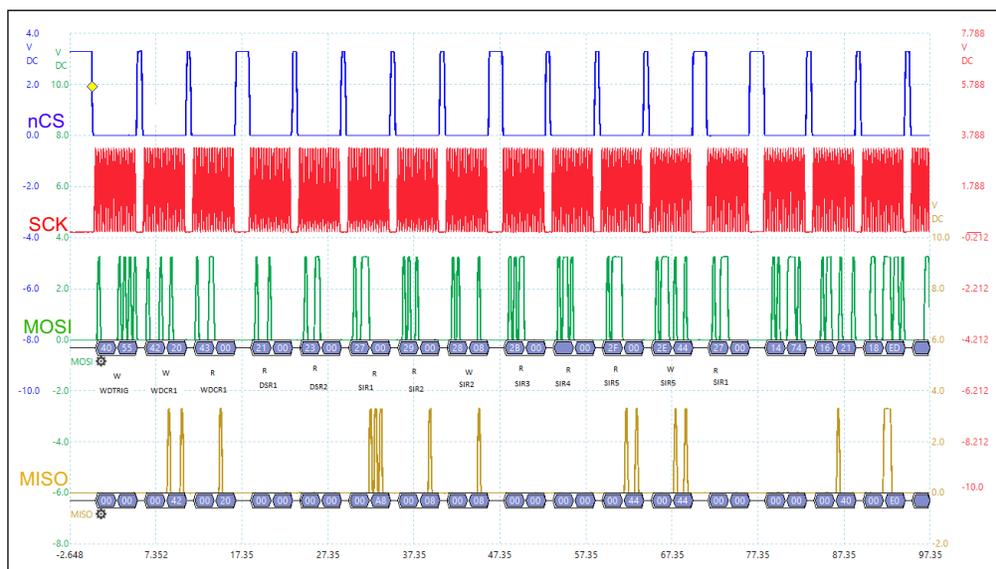
# ATA6847L QFN48 BLDC Motor Driver Evaluation Board User's Guide

operation. The first byte contains the 7-bit address along with a 'read/write' bit (the LSB). The second byte contains the data to be written to the register. If the R/W bit is 0, it is a write operation, otherwise a read one.



**FIGURE 2-7:** SPI Timing Protocol.

The user may add code to the evaluation board firmware to communicate with the registers. The evaluation board software contains a subroutine which initializes the ATA6847L registers. The configuration registers are summarized in [Table 2-5](#). Detailed information is available in the datasheet. An example of waveforms SPI communication is shown in [Figure 2-8](#).



**FIGURE 2-8:** SPI Registers Configuration - Waveform Example.

**TABLE 2-5: CONFIGURATION MESSAGE COMMANDS (XXXXXXXX = BY DEFAULT)**

Register	Address	Description	Asserted Parameters/Modes
DOPMCR	0x01	Device Operation Mode Control Register	Deep sleep mode
			Sleep mode
			Standby mode (by default)
			Normal mode
LOPMCR	0x02	LIN Operation Mode Control Register	LIN Standby mode
			LIN Normal mode
GOPMCR	0x03	Gate Driver Unit Operation Mode Control Register	GDU OFF mode
			GDU Standby mode
			GDU Normal mode

**TABLE 2-5: CONFIGURATION MESSAGE COMMANDS (XXXXXXXX = BY DEFAULT)**

Register	Address	Description	Asserted Parameters/Modes
WUCR	0x04	Wake-up Control Register	Local Wake-up Enable
			LIN bus remote wake-up enable
GDUCR1	0x05	GDU Control Register 1	BEMF det. enable/disable bit
			Cross conduction enable/disable bit
			$T_{CC} = 100 \text{ ns} \times N$ , N = 0 to 63
GDUCR2	0x06	GDU Control Register 2	Edge blanking time control bits
			Cross conduction protection time
			LSOFF, LS = 0 when GDU = Standby
			HSOFF, HS = 0 when GDU = Standby
GDUCR3	0x07	GDU Control Register 3	Low side slew rate control
			High side slew rate control
			Low side Adaptive dead time
			High side Adaptive dead time
GDUCR4	0x08	GDU Control Register 4	VGS under-voltage filter time
			VGS/VG UVLO level selection
			VGS UVLO detection enable/disable bit
			Complementary control enable/disable bit
ILIMCR	0x09	Current Limitation Control Register	Current limit shutdown enable/disable bit
			Current limitation filter time
			Current limits enable/disable bit
ILIMTH	0x0A	Current Limitation Threshold Register	VILIM_TH = $5/3.3V/128 \times \text{DAC}$
SCPCR	0x0B	Short Circuit Protection Control Register	Short circuit detection threshold
			Short circuit filter time
			Short circuit shutdown enable/disable bit
CSCR	0x0C	Current Sensing OpAmp Control Register	CS OpAmp gain control
			CS OpAmp output offset control
			Enable CS OpAmp1 enable/disable bit
			Enable CS OpAmp2 enable/disable bit
			Enable CS OpAmp3 enable/disable bit

### 2.3.7 ATA6847L Message Responses

When a fault event has occurred, depending on the desired protections that have been enabled, the driver generates an interrupt to the host controller by pulling down the **NIRQ** line. At this moment, the host should initiate the SPI communication to read the status registers (DSR1, 2) and the system interrupt registers (SIR1...5) and to find out the fault cause. [Table 2-6](#) summarizes the registers that should be read.

**TABLE 2-6: CONFIGURATION MESSAGE RESPONSES**

Register	Address	Description
DSR1	0x10	Device Status Register 1
DSR2	0x11	Device Status Register 2
SIR1	0x13	System Interrupt Register 1
SIR2	0x14	System Interrupt Register 2
SIR3	0x15	System Interrupt Register 3

**TABLE 2-6: CONFIGURATION MESSAGE RESPONSES (CONTINUED)**

Register	Address	Description
SIR4	0x16	System Interrupt Register 4
SIR5	0x17	System Interrupt Register 5
SIECER1	0x18	System Interrupt Event Capture Enable Register 1
SIECER2	0x19	System Interrupt Event Capture Enable Register 2

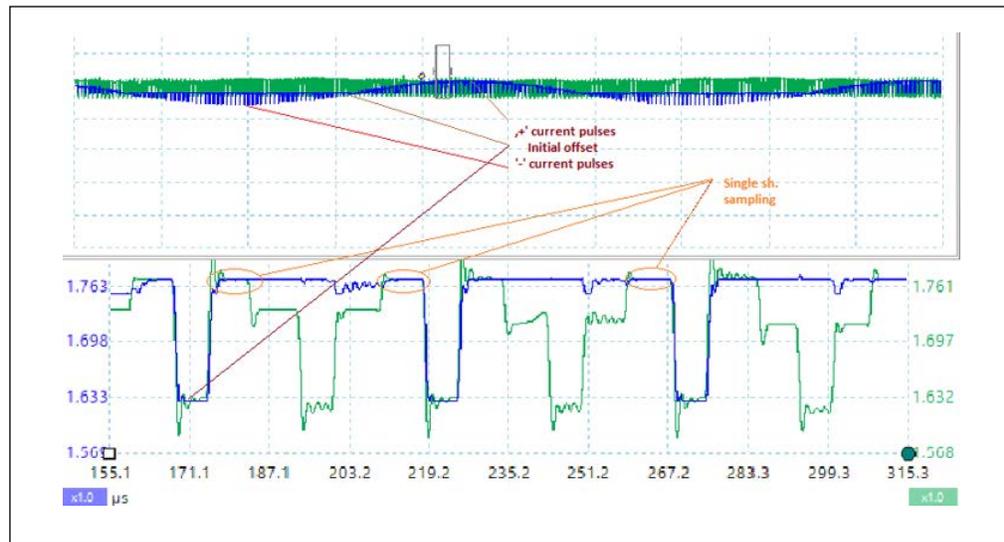
## 2.4 SCHEMATIC FEATURES

### 2.4.1 Shunt Topology

The evaluation board is designed in a combined shunt configuration. Two CSAs are connected on two of the three phases, while the third is summing all three phases in single shunt configuration. See the complete shunt topology used on this board in [A.2 “EV92R69A – Top Schematic”](#).

For taking maximum advantage of the part's features, the evaluation board is configured as illustrated in the picture above, which summarizes the connections between external current sense resistors and the internal available CSAs and GDU - External MOSFETs bridge. In this configuration, the evaluation board offers the option of evaluating either a combined shunt topology or a single shunt topology. The third CSA can monitor the bus current so it can be used for single shunt mode or for limitation of the maximum motor current in FOC or Trapezoidal control mode.

Generally, the motor phases are equilibrated, so only two-phase current are required to be measured, while the third will be the algebraic sum of the other two. This gives the possibility to use the third CSA to evaluate the current pulses across the summing shunt. The main advantage is that these pulses are only in positive range related to the initial offset and could be directed to the internal current limit comparator, without any particular software/hardware processing.

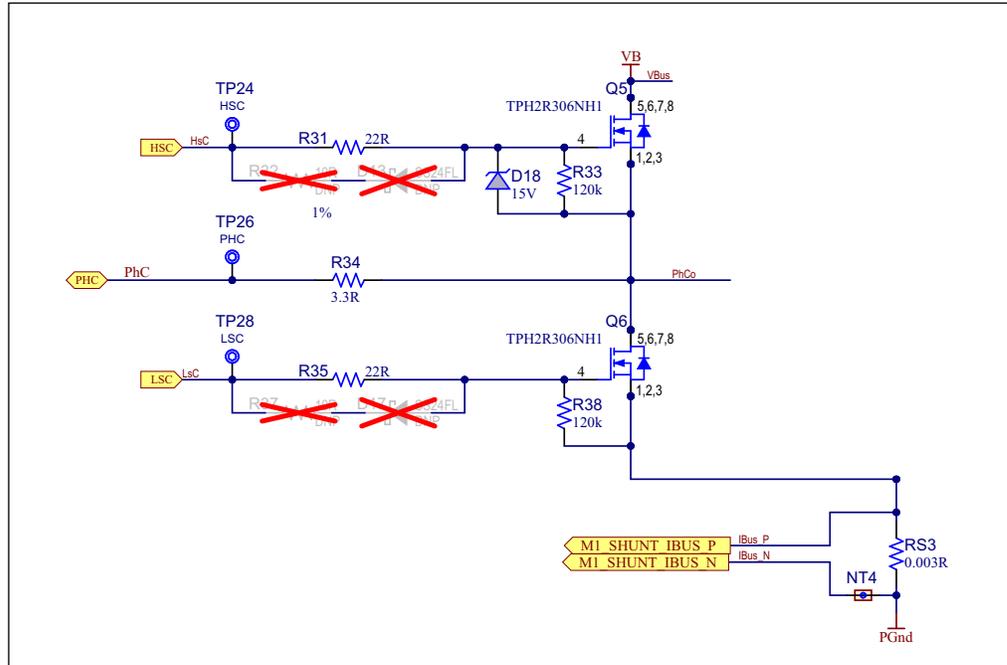


**FIGURE 2-9:** CSA's Outputs in Combined Shunts Topology.

Finally, by applying the procedure for currents reconstruction, the evaluation board offers the possibility to develop and evaluate the single shunt configuration with ATA6847L motor driver.

## 2.4.2 Asymmetric Turn On/Off External MOSFET Bridge

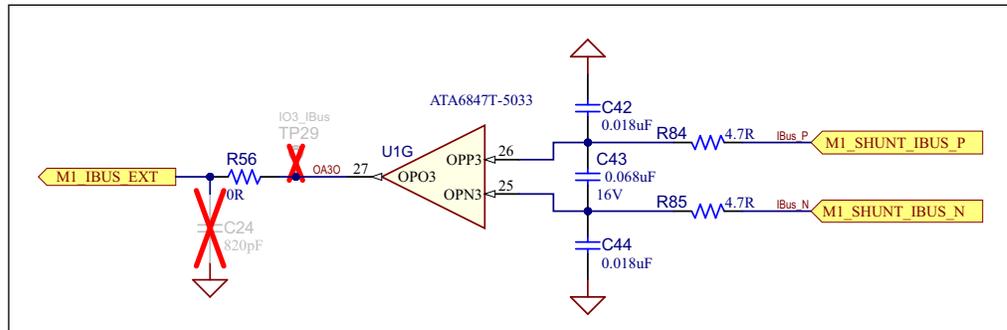
The evaluation board offers an additional feature, to configure an asymmetric on/off for both H/L side external MOSFET bridge by populating R32+D13 and R37+D17 groups for all three phases, in order to achieve a slowdown turn-on MOSFET commutation and fast commutation of the MOSFET gates to the lowest potential. Furthermore, the part could be configured to sink/surge 25%/50%/75% or 100% slew rate speed for LS and HS independently.



**FIGURE 2-10:** Optional Asymmetric Turn On-Off.

## 2.4.3 Current Sense Amplifier (CSA)

To ensure the ADC range conversion, the initial offset of CSA is set to approximately 1.65V. The total gain of the CSA is  $G_t = 16$ . For high motor currents, it is necessary to decrease the equivalent shunt resistor value, in order to avoid CSA output limitation. This reduces the losses and avoids analog limitation or overflows in numerical computation. For sense current detection, the available internal operational amplifiers are configured as presented in Figure 2-11, for a high-speed and robust operation of the CSA.



**FIGURE 2-11:** Current Sense Amplifier from ATA6847.

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## Appendix A. Schematics and Layouts

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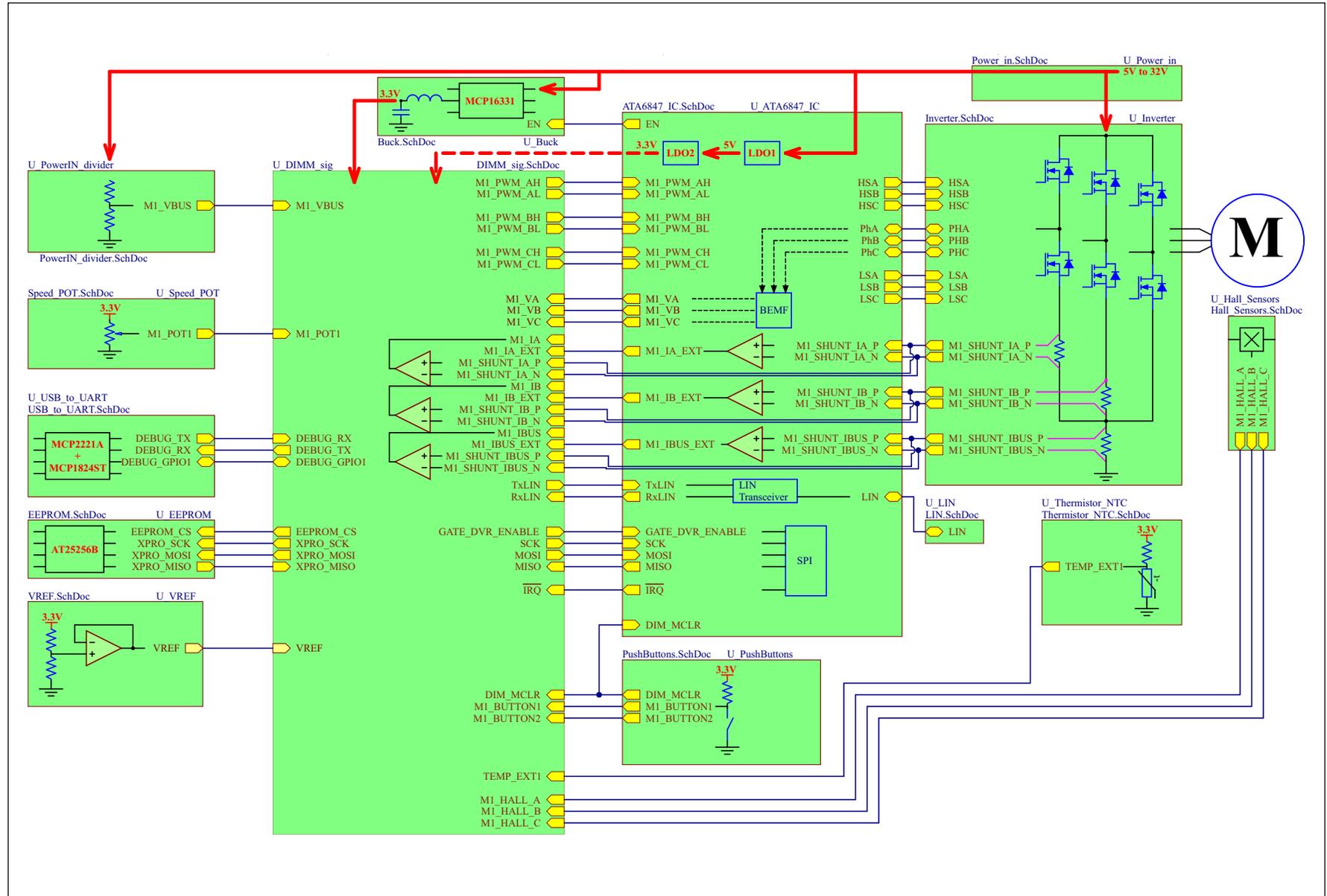
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### A.1 INTRODUCTION

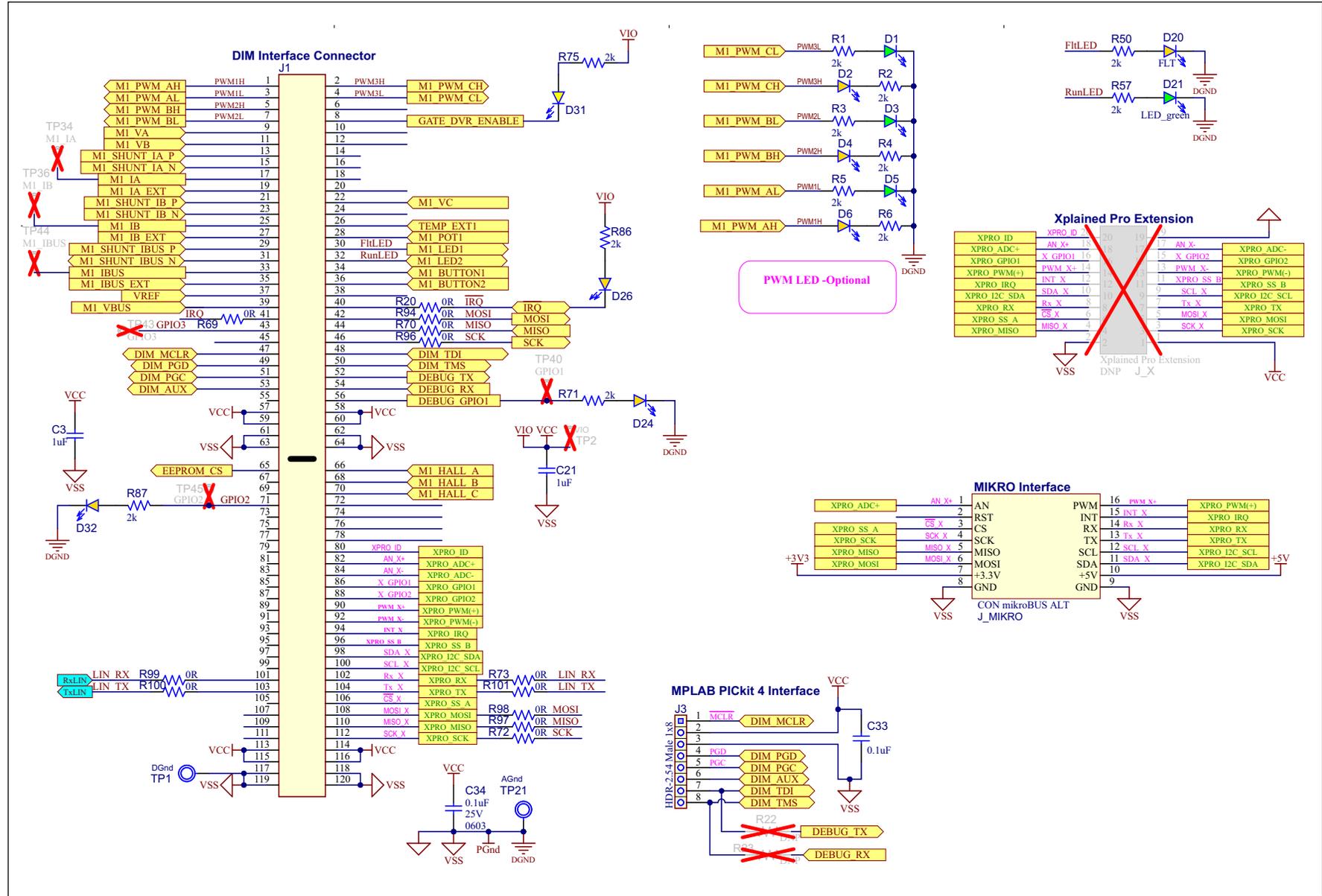
This appendix contains the schematics and layouts of the ATA6847L QFN48 BLDC Motor Driver Evaluation Board:

- [EV92R69A – Top Schematic](#)
- [EV92R69A – DIM](#)
- [EV92R69A – IC](#)
- [EV92R69A – Buck Converter](#)
- [EV92R69A – 3-Phase Inverter](#)
- [EV92R69A – USB UART Converter](#)
- [EV92R69A – Hall Effect Sensors Connector](#)
- [EV92R69A – Speed Potentiometer](#)
- [EV92R69A – LIN Interface Connector](#)
- [EV92R69A – EEPROM](#)
- [EV92R69A – Power Input connector](#)
- [EV92R69A – Top Silk](#)
- [EV92R69A – Top Copper and Silk](#)
- [EV92R69A – Top Copper](#)
- [EV92R69A – Bottom Copper](#)
- [EV92R69A – Bottom Copper and Silk](#)
- [EV92R69A – Bottom Silk](#)

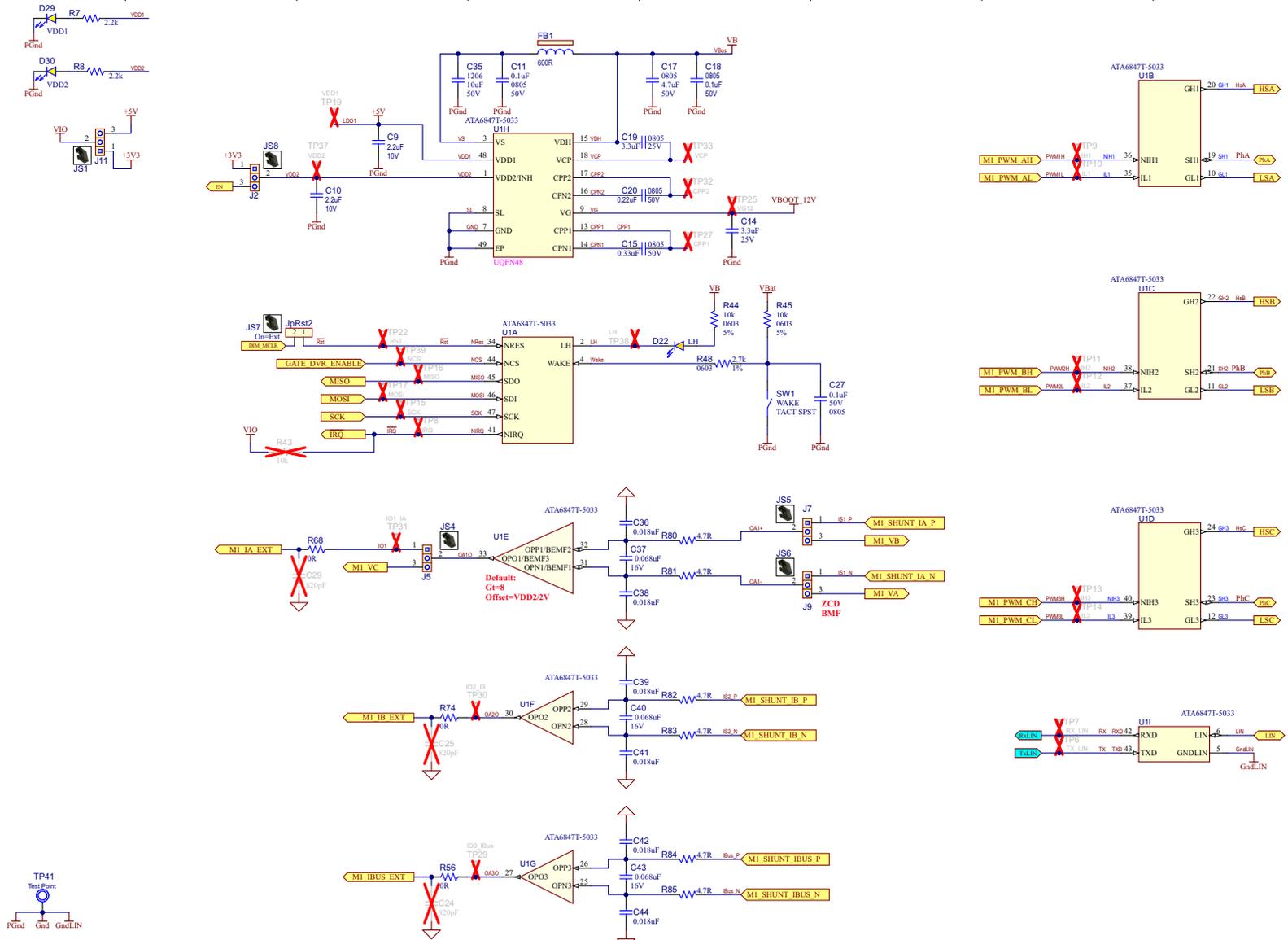
## A.2 EV92R69A – TOP SCHEMATIC



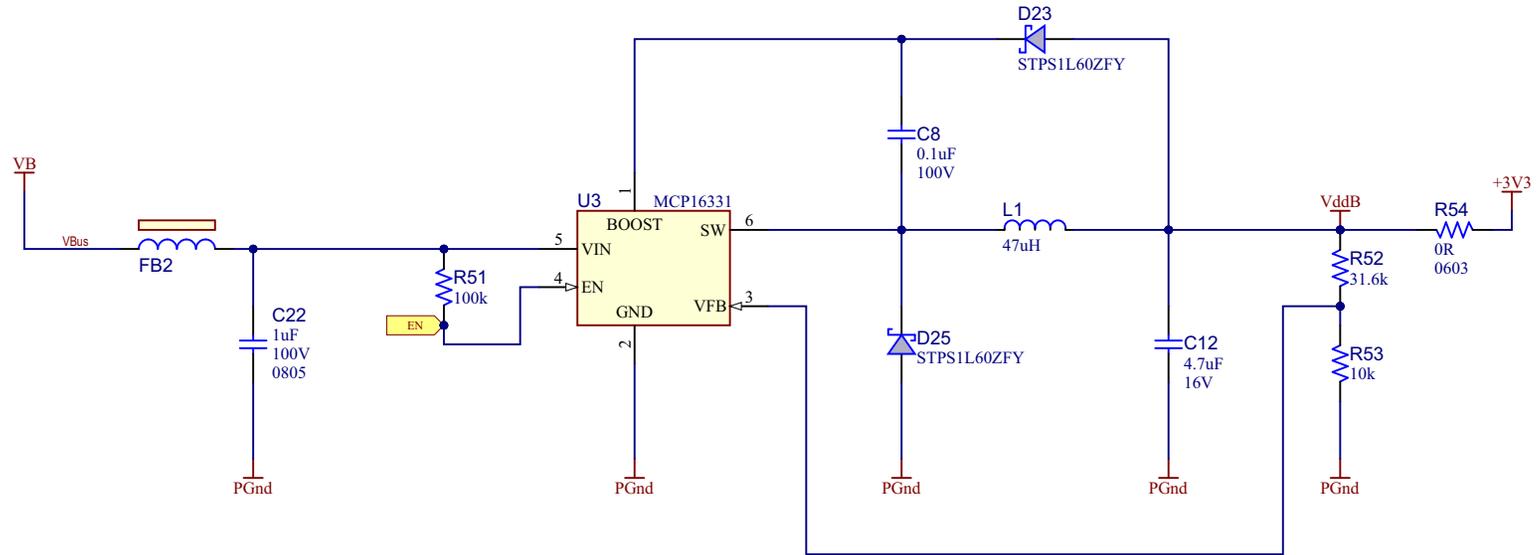
### A.3 EV92R69A – DIM



# A.4 EV92R69A – IC

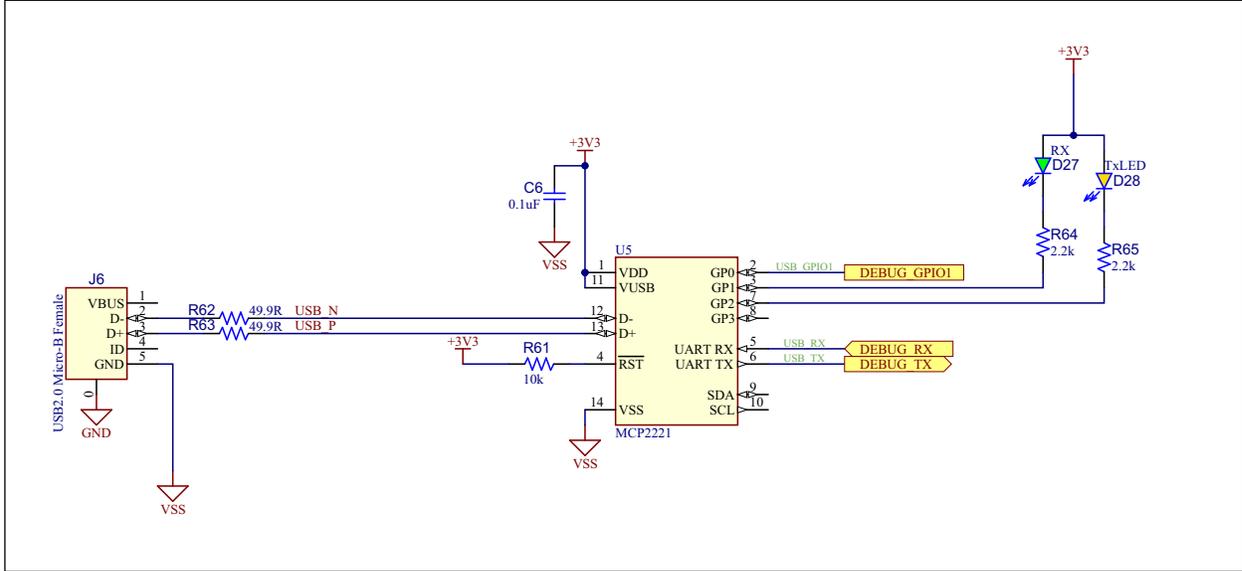


### A.5 EV92R69A – BUCK CONVERTER

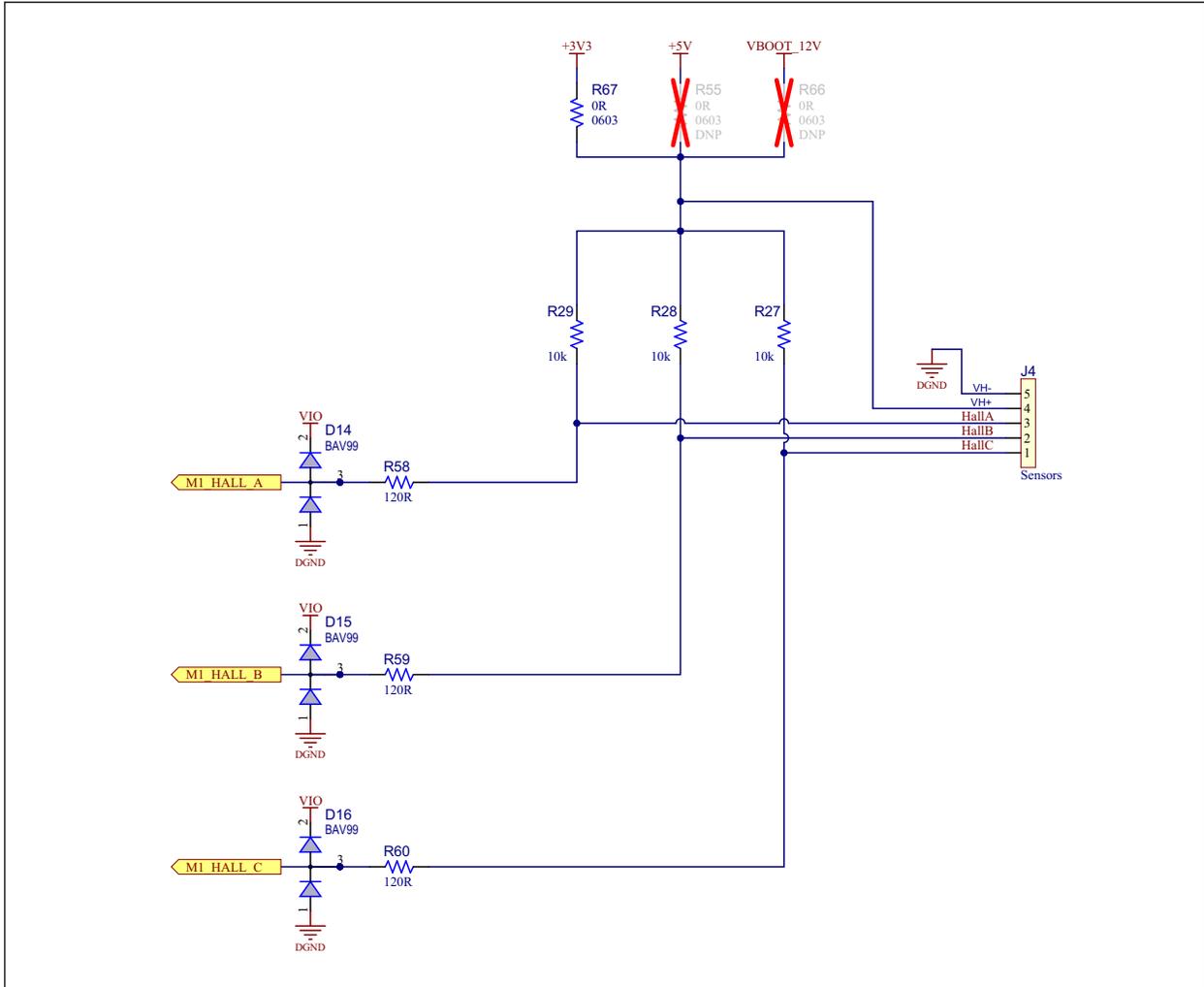




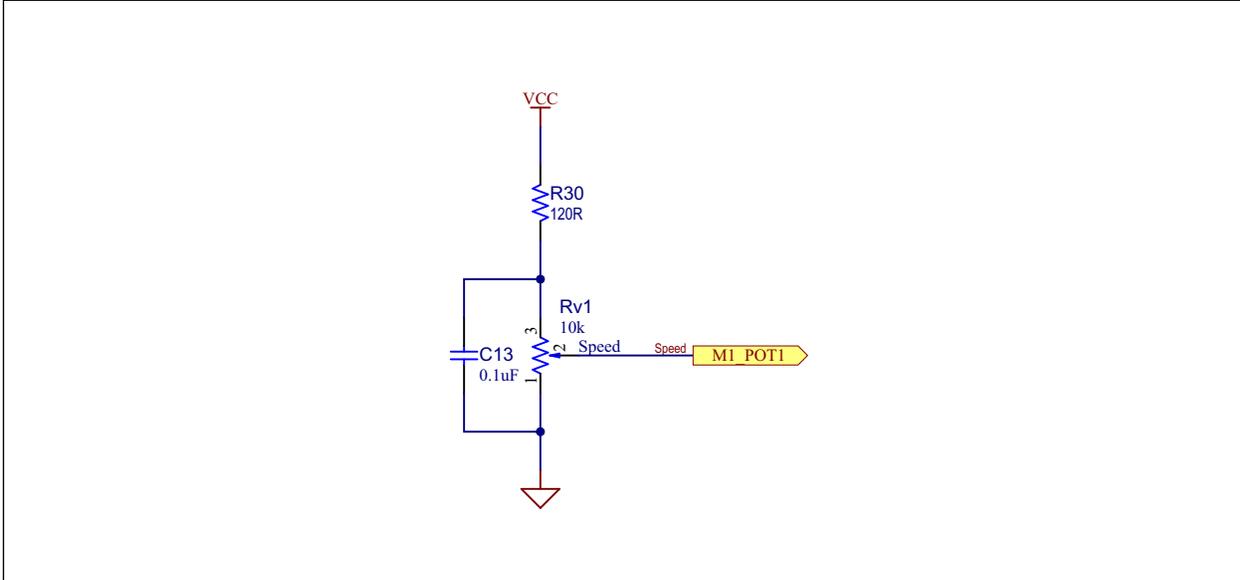
**A.7 EV92R69A – USB UART CONVERTER**



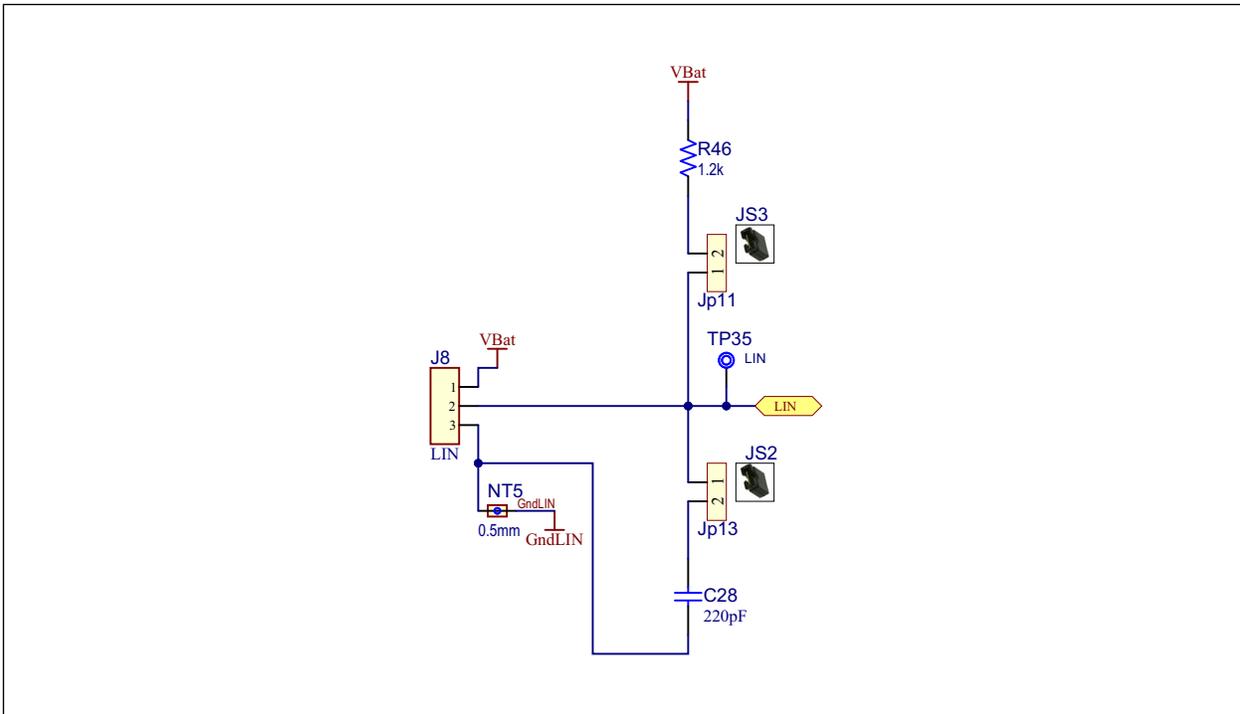
**A.8 EV92R69A – HALL EFFECT SENSORS CONNECTOR**



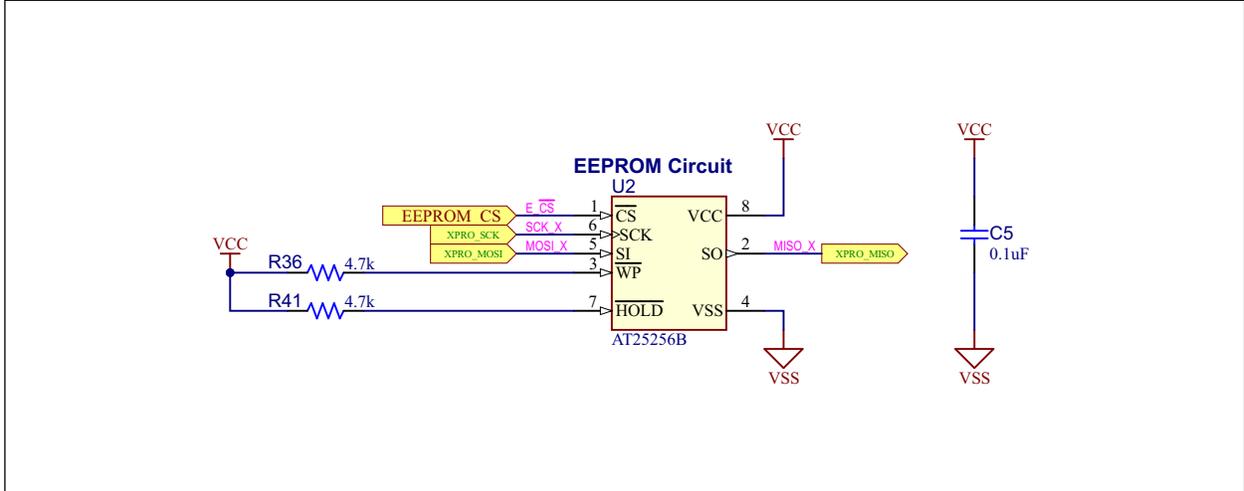
## A.9 EV92R69A – SPEED POTENTIOMETER



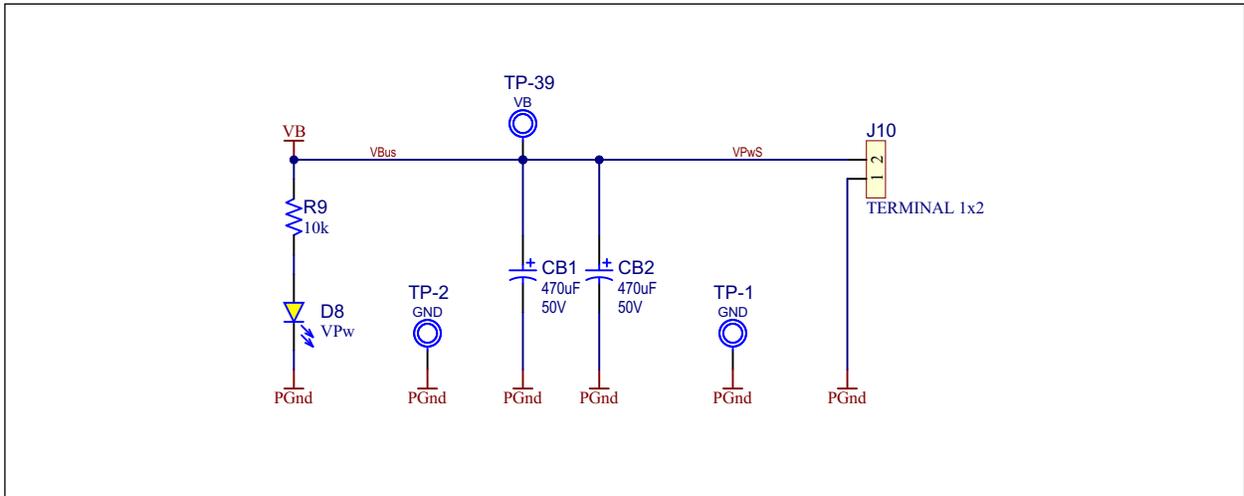
## A.10 EV92R69A – LIN INTERFACE CONNECTOR



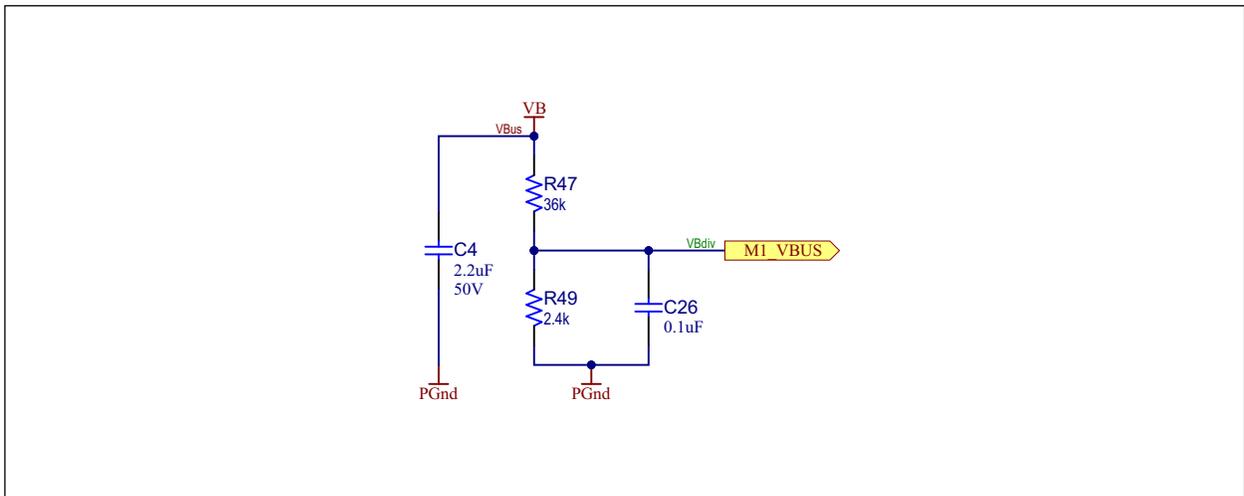
**A.11 EV92R69A – EEPROM**



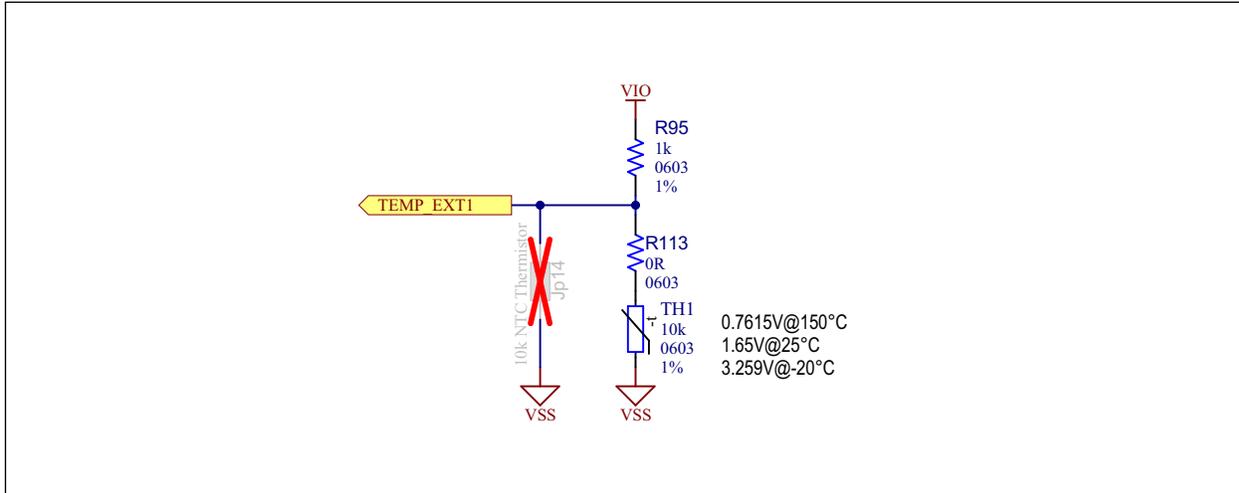
**A.12 EV92R69A – POWER INPUT CONNECTOR**



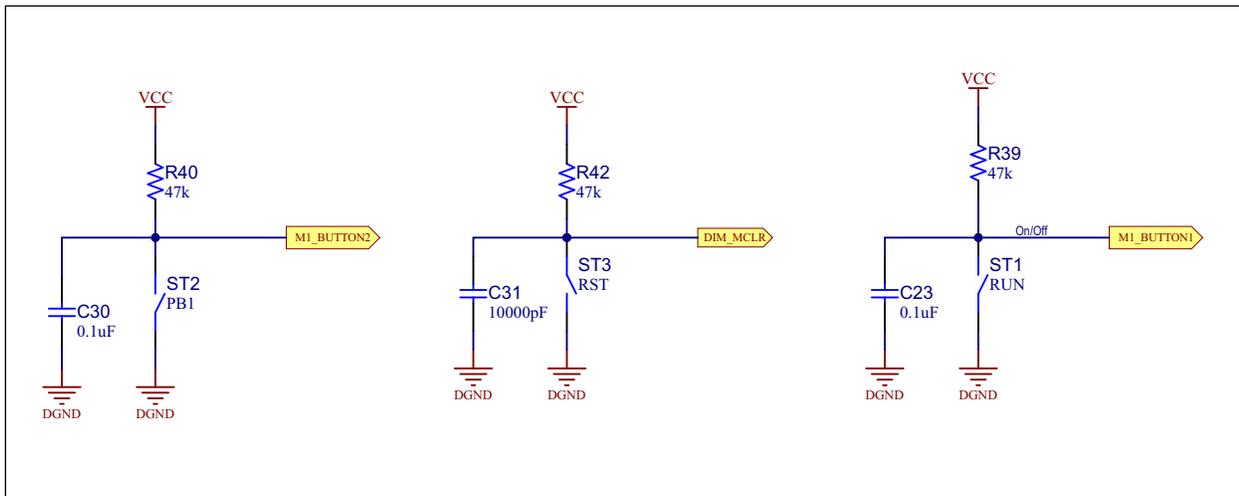
**A.13 EV92R69A – INPUT VOLTAGE DIVIDER**



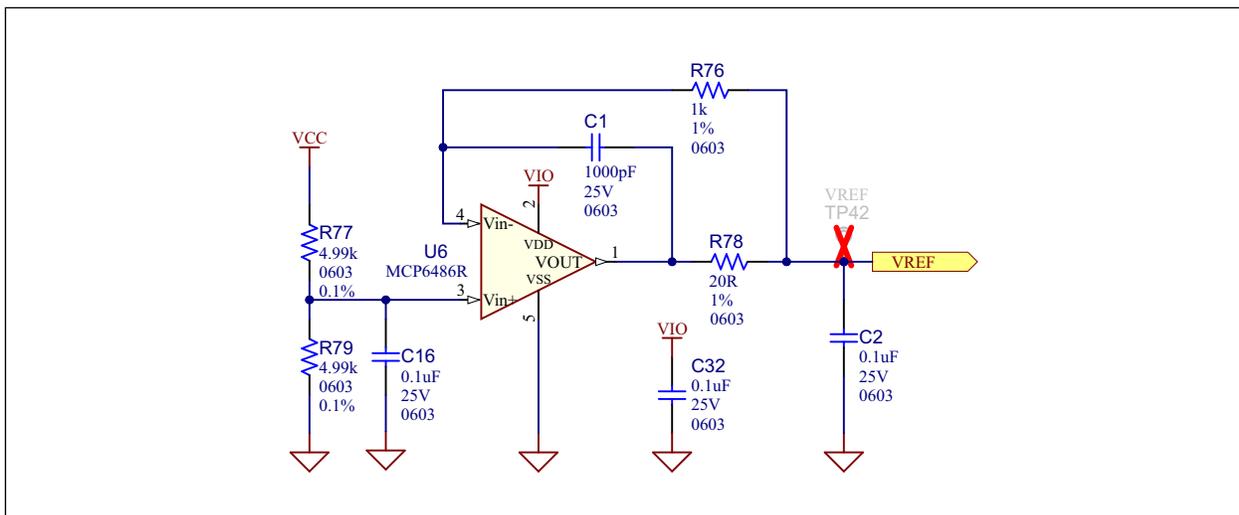
## A.14 EV92R69A – NTC THERMISTOR



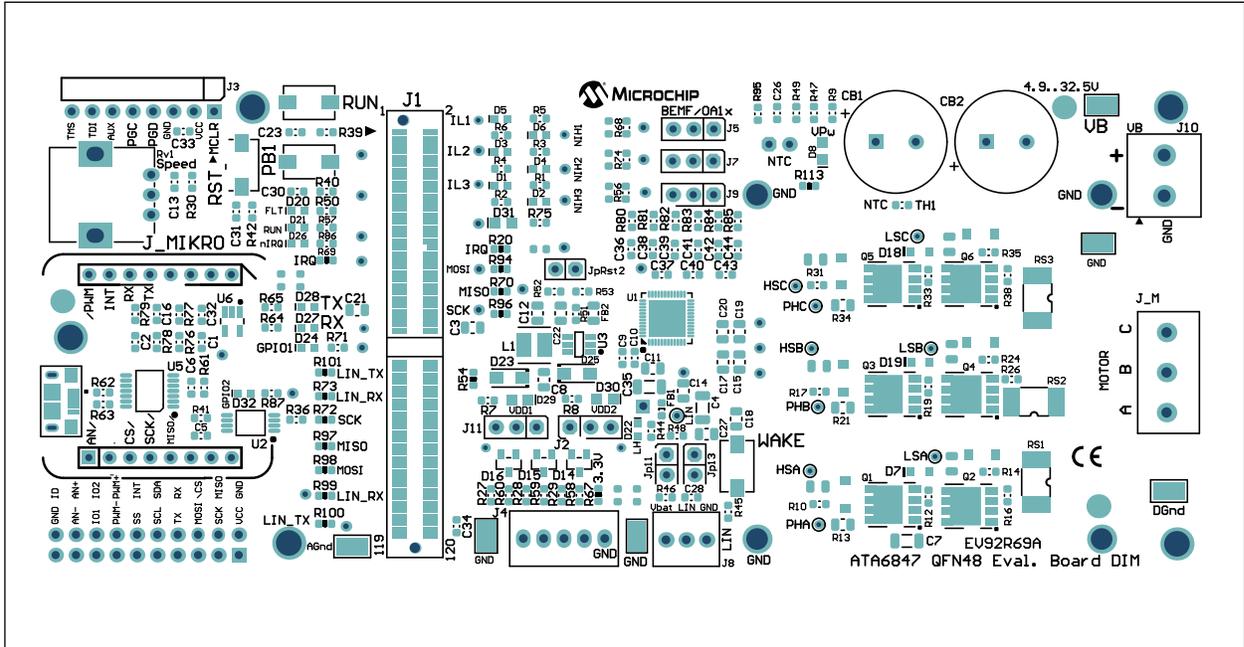
## A.15 EV92R69A – PUSH BUTTONS



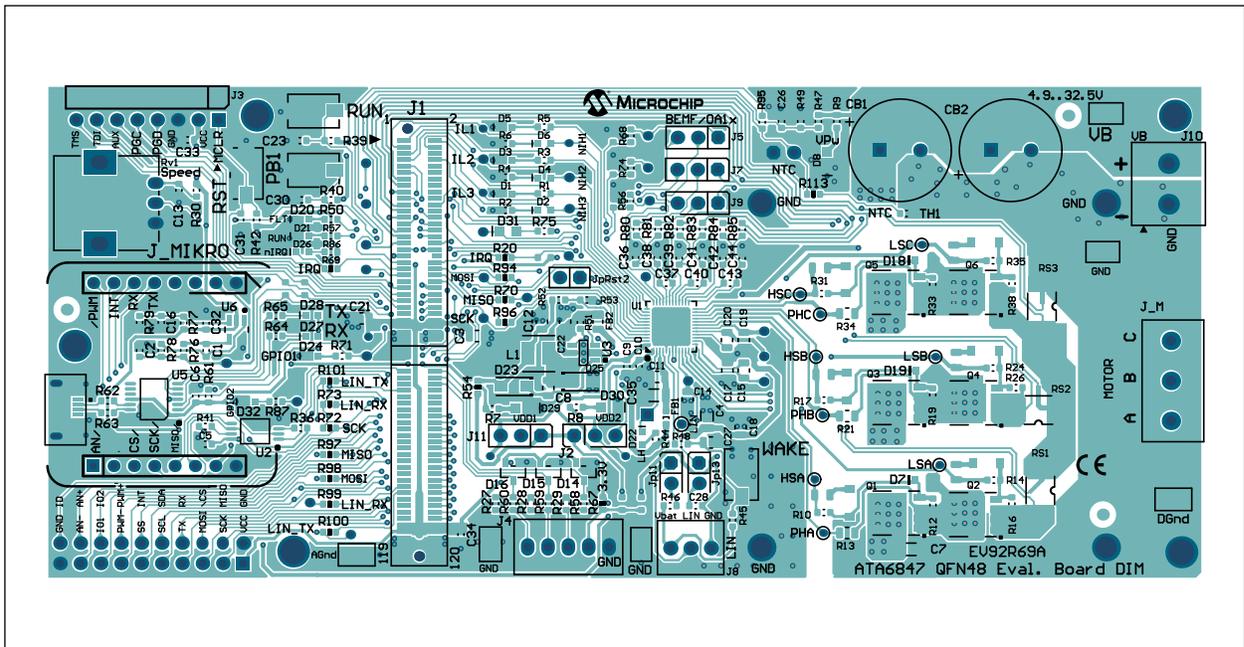
## A.16 EV92R69A – VREF OPAMP



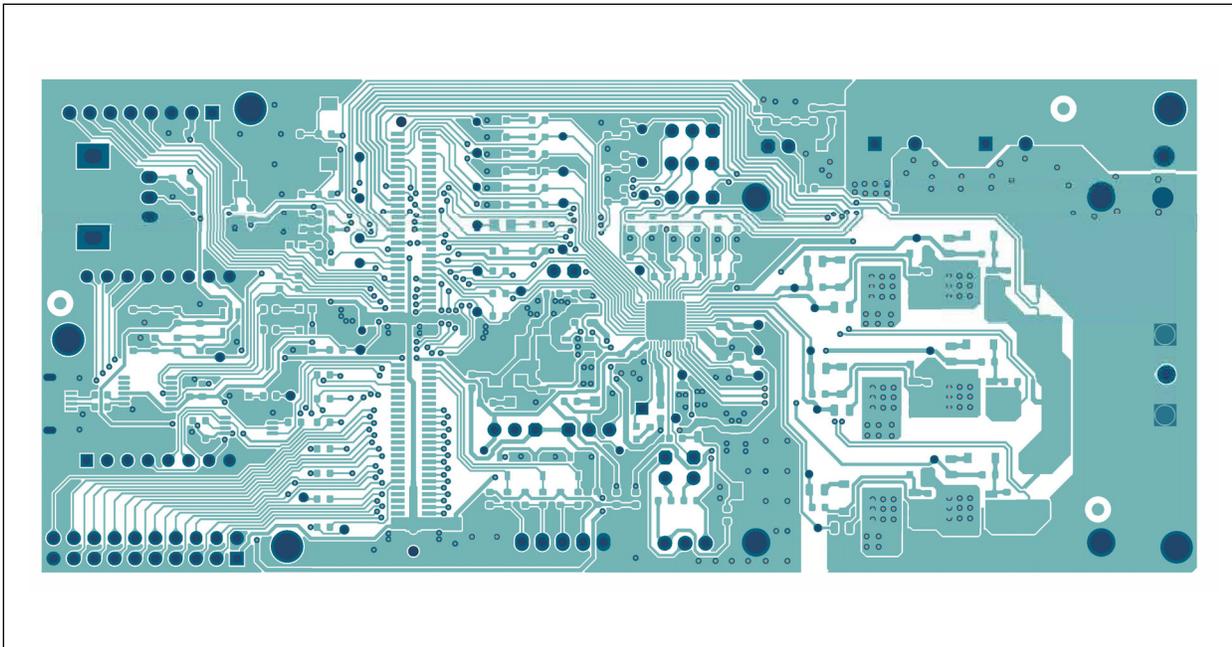
A.17 EV92R69A – TOP SILK



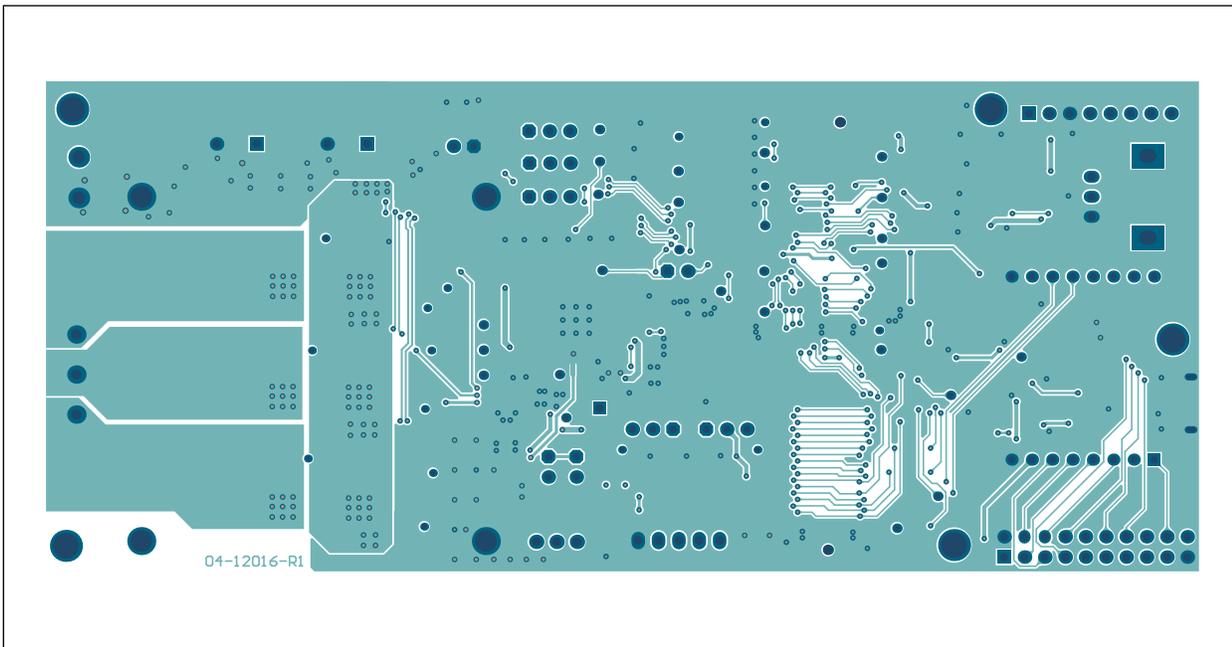
A.18 EV92R69A – TOP COPPER AND SILK



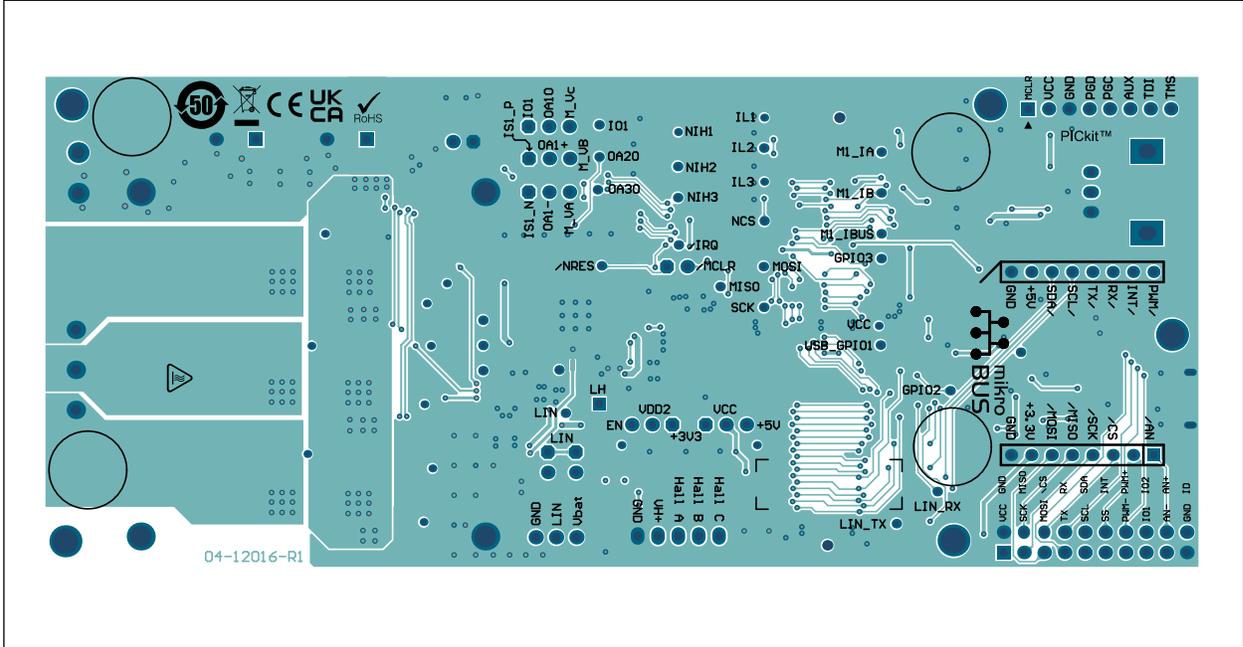
## A.19 EV92R69A – TOP COPPER



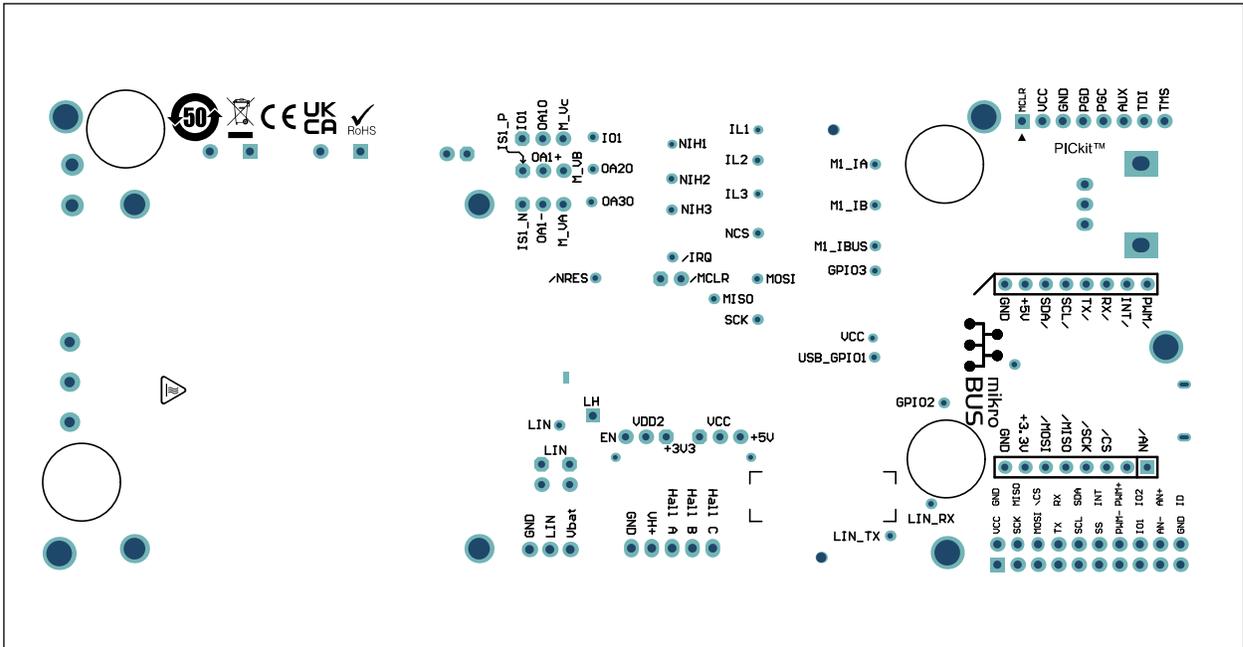
## A.20 EV92R69A – BOTTOM COPPER



A.21 EV92R69A – BOTTOM COPPER AND SILK



A.22 EV92R69A – BOTTOM SILK



**Appendix B. Bill of Materials (BOM)**

**TABLE B-1: BILL OF MATERIALS (BOM)**

Qty.	Reference	Description	Manufacturer	Part Number
1	C1	Capacitor, ceramic, 1000 pF, 25V, 5%, COG/NP0, SMD, 0603	KEMET	C0603C102J3GACTU
11	C2, C5, C6, C13, C16, C23, C26, C30, C32, C33, C34	Capacitor, ceramic, 0.1 µF, 25V, 10%, X7R, SMD, 0603	KYOCERA AVX®, AVX Corporation	06033C104KAT2A
2	C3, C21	Capacitor, ceramic, 1 µF, 25V, 10%, X7R, SMD, 0805	TDK Corporation	C2012X7R1E105K125AB
2	C4, C7	Capacitor, ceramic, 2. µF, 50V, 10%, X7R, SMD, 1206, AEC-Q200	Taiyo Yuden Co., Ltd.	UMK316B7225KLHT
1	C8	Capacitor, ceramic, 0.1 µF, 100V, 10%, X7R, SMD, 0805	TDK Corporation	C2012X7R2A104K125AA
2	C9, C10	Capacitor, ceramic, 2.2 µF, 10V, 10%, X7R, SMD, 0603	Taiyo Yuden Co., Ltd.	LMK107B7225KA-T
3	C11, C18, C27	Capacitor, ceramic, 0.1 µF, 50V, 10%, X7R, SMD, 0805	Yageo Corporation	CC0805KRX7R9BB104
1	C12	Capacitor, ceramic, 4.7 µF, 16V, 20%, Y5V, SMD, 0805	Yageo Corporation	CC0805ZKY5V7BB475
2	C14, C19	Capacitor, ceramic, 3.3 µF, 25V, 10%, X7R, SMD, 0805	TDK Corporation	C2012X7R1E335K125AB
1	C15	Capacitor, ceramic, 0.33 µF, 50V, 10%, X7R, SMD, 0805	Samsung Electro-Mechanics	CL21B334KBFNNNE
1	C17	Capacitor, ceramic, 4.7 µF, 50V, 10%, X5R, SMD, 0805	TDK Corporation	C2012X5R1H475K125AB
1	C20	Capacitor, ceramic, 0.22 µF, 50V, 10%, X7R, SMD, 0805	Murata Electronics®	GCM21BR71H224KA37L
1	C22	Capacitor, ceramic, 1 µF, 100V, 10%, X7S, SMD, 0805	TDK Corporation	C2012X7S2A105K125AB
1	C28	Capacitor, ceramic, 220 pF, 50V, 10%, X7R, SMD, 0603	TDK Corporation	C1608X7R1H221K
1	C31	Capacitor, ceramic, 10000 pF, 50V, 20%, X7R, SMD, 0603	TDK Corporation	C1608X7R1H103M080AA
1	C35	Capacitor, ceramic, 10 µF, 50V, 10%, X7R, SMD, 1206	Samsung Electro-Mechanics America, Inc.	CL31B106KBHNNNE
6	C36, C38, C39, C41, C42, C44	Capacitor, ceramic, 0.018 µF, 16V, 10%, X7R, SMD, 0603	KEMET	C0603C183K4RAC7867
3	C37, C40, C43	Capacitor, ceramic, 0.068 µF, 16V, 10%, X7R, SMD, 0603	Panasonic - ECG®	ECJ-1VB1C683K
2	CB1, CB2	Capacitor, aluminum, 470 µF, 50V, 20%, RAD, P5D12.5H20	United Chemi-Con	EKZE500ELL471MK20S

**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.

# ATA6847L QFN48 BLDC Motor Driver Evaluation Board User's Guide

**TABLE B-1: BILL OF MATERIALS (BOM) (CONTINUED)**

Qty.	Reference	Description	Manufacturer	Part Number
5	D1, D3, D5, D21, D27	Diode, LED, Green, 1.7V, 20 mA, 3.92 mcd, Diffuse, SMD, 0603	ams-OSRAM AG	LP L296-J2L2-25-0-20-R18-Z
9	D2, D4, D6, D20, D22, D24, D26, D28, D32	Diode, LED, amber, 2.1V, 25 mA, 2 mcd, clear, SMD, 0603	Lite-On®, Inc.	LTST-C190AKT
3	D7, D18, D19	Diode, Zener, PZU15B,115, 15V, 310 mW, SMD, SOD-323	Nexperia USA Inc.	PZU15B,115
4	D8, D29, D30, D31	Diode, LED, yellow, 2.1V, 30 mA, 10 mcd, Diffuse, SMD, 0805	Lumex Opto/Components Inc.	SML-LXT0805YW-TR
3	D14, D15, D16	Diode, rectifier, array, 1.25V, 200 mA, 70V, SOT-23-3	Micro Commercial Components (MCC)®	BAV99-TP
2	D23, D25	Diode, Schottky, 570 mV, 1A, 60V, SMD, SOD-123F	STMicroelectronics	STPS1L60ZFY
1	FB1	Ferrite, 600R@100 MHz, 300 mA SMD 0603	Murata Electronics North America, Inc.	BLM18AG601SN1D
1	FB2	Ferrite, 30R@100 MHz, 8.5A, AEC-Q200, SMD, 0805	Murata Electronics North America, Inc.	BLM21SN300SH1D
1	J1	Connector, EDGE, HTEC8, 0.80 mm, 120P, female, SMD, vertical	Samtec, Inc.	HTEC8-160-01-L-DV-A-K-TR
5	J2, J5, J7, J9, J11	Connector, HDR-2.54, male, 1x3, tin, 5.84 MH, TH, vertical	Samtec, Inc.	TSW-103-07-T-S
1	J3	Connector, HDR-2.54, male, 1x8, gold, 5.84 MH, TH, R/A	Sullins Connector Solutions	PBC08SBAN
1	J4	Connector, terminal, 2.54 mm, 1x5, female, 20-30AWG, 6A, TH, R/A	Phoenix Contact	1725685
1	J6	Connector, USB2.0, Micro-B, female, SMD, R/A	Amphenol ICC / FCI	101181930001LF
1	J8	Connector, terminal, 2.54 mm, 1x3, female, 20-30AWG, 6A, TH, R/A	On-Shore Technology, Inc.	OSTVN03A150
1	J10	Connector, terminal, 5.08 mm, 1x2, female, 12-28AWG, 16A, TH, R/A	On-Shore Technology, Inc.	OSTVI022152
1	J_M	Connector, terminal, 5 mm, 1x3, female, 12-30AWG, 16A, TH, R/A	Würth Elektronik	691137710003
2	J_MIKRO	Connector, header, 8 Position, 0.100" (2.54mm) tin, TH	Sullins Connector Solutions	PPTC081LFBN-RC
3	Jp11, Jp13, JpRst2	Connector, HDR-2.54, male, 1x2, tin, 6.75MH TH vertical	Molex®, LLC	90120-0122
1	L1	Fixed Inductor, 47 µH, 450 MA, 834 mΩ	Würth Elektronik	74406032470
1	LABEL1	Label, PCBA, 18x6 mm, Datamatrix, Assy#/Rev/Serial/Date	ACT Logimark AS	505462
1	PCB1	Printed Circuit Board	—	04-12016-R1
1	PCBA1	PCB Assembly	—	02-00943-R1
6	Q1, Q2, Q3, Q4, Q5, Q6	Transistor, FET, N-Channel, 60V, 136A, 0.0023R, 800 mW, VDFN-8	Toshiba Semiconductor and Storage	TPH2R306NH1,LQ

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

Qty.	Reference	Description	Manufacturer	Part Number
12	R1, R2, R3, R4, R5, R6, R50, R57, R71, R75, R86, R87	Resistor, Thick Film, 2k, 1%, 1/10W, SMD, 0603, AEC-Q200	Yageo Corporation	RC0603FR-072KL
4	R7, R8, R64, R65	Resistor, Thick Film, 2.2k, 5%, 1/10W, SMD, 0603	Yageo Corporation	RC0603JR-072K2L
8	R9, R27, R28, R29, R44, R45, R53, R61	Resistor, Thick Film, 10k, 5%, 1/10W, SMD, 0603	Panasonic Electronic Components	ERJ-3GEYJ103V
6	R10, R14, R17, R24, R31, R35	Resistor, Thick Film, 22R, 1%, 1/10W, SMD, 0603	Panasonic - ECG	ERJ-3EKF22R0V
6	R12, R16, R19, R26, R33, R38	Resistor, Thick Film, 120k, 1%, 1/10W, SMD, 0603, AEC-Q200	KOA Speer Electronics, Inc.®	RK73H1JTDD1203F
3	R13, R21, R34	Resistor, Thick Film, 3.3R, 1%, 1/8W, SMD, 0805	Vishay® Dale	CRCW08053R30FKEA
18	R20, R54, R56, R67, R68, R69, R70, R72, R73, R74, R94, R96, R97, R98, R99, R100, R101, R113	Resistor, Thick Film, 0R, 1/10W, SMD, 0603	Vishay Dale, Stackpole Electronics, Inc.	CRCW06030000Z0EA, RMCF0603ZT0R00
4	R30, R58, R59, R60	Resistor, Thick Film, 120R, 1%, 1/10W, SMD, 0603	Stackpole Electronics, Inc	RMCF0603FT120R
2	R36, R41	Resistor, Thick Film, 4.7k, 1%, 1/10W, SMD, 0603, AEC-Q200	Panasonic - ECG	ERJ-3EKF4701V
3	R39, R40, R42	Resistor, Thick Film, 47k, 1%, 1/10W, SMD, 0603	Panasonic - ECG	ERJ-3EKF4702V
1	R46	Resistor, Thick Film, 1.2k, 1%, 1/10W, SMD, 0603	Stackpole Electronics, Inc	RMCF0603FT1K20
1	R47	Resistor, Thick Film, 36k, 1%, 1/10W, SMD, 0603	Panasonic - ECG	ERJ-3EKF3602V
1	R48	Resistor, Thick Film, 2.7k, 1%, 1/10W, SMD, 0603, AEC-Q200	Vishay Dale	CRCW06032K70FKEA
1	R49	Resistor, Thick Film, 2.4k, 1%, 1/10W, SMD, 0603	Yageo Corporation	RC0603FR-072K4L
1	R51	Resistor, Thick Film, 100k, 5%, 1/10W, SMD, 0603, (Don't Use, Duplicate, Use RSMT0026)	Panasonic - ECG	ERJ-3GEYJ104V
1	R52	Resistor, Thick Film, 31.6K, 1%, 1/10W, SMD, 0603	Panasonic - ECG	ERJ-3EKF3162V
2	R62, R63	Resistor, Thick Film, 49.9R, 1%, 1/10W, SMD, 0603, AEC-Q200	Stackpole Electronics, Inc.	RMCF0603FT49R9
2	R76, R95	Resistor, Thick Film, 1k, 1%, 1/10W, SMD, 0603	Yageo Corporation	RC0603FR-071KL
2	R77, R79	Resistor, Thin Film, 4.99k, 0.1%, 1/10W, SMD, 0603, AEC-Q200	Panasonic - ECG	ERA-3AEB4991V
1	R78	Resistor, Thick Film, 20R, 1%, 1/10W, SMD, 0603, AEC-Q200	Panasonic - ECG	ERJ-3EKF20R0V

**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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**TABLE B-1: BILL OF MATERIALS (BOM) (CONTINUED)**

Qty.	Reference	Description	Manufacturer	Part Number
6	R80, R81, R82, R83, R84, R85	Resistor, Thick Film, 4.7R, 1%, 1/10W, SMD, 0603	Yageo Corporation	AC0603FR-074R7L
3	RS1, RS2, RS3	Resistor, Shunt, ME, 0.003R, 1%, 4W, AEC-Q200, SMD, 2512	Vishay Dale	WSLF25123L000FEA
1	Rv1	Resistor, variable, 10k, 20%, TH, P090S	BI Technologies/ TT Electronics	P090S-14T20BR10K
4	ST1, ST2, ST3, SW1	Switch, TACT, SPST, 24V, 50 mA, KSR231GLFS, SMD, 6X3.5mm	TE Connectivity Alcoswitch Switches	147873-2
1	TH1	Resistor, thermistor, 10k, 1%, SMD, 0603	TDK Corporation	NTCG163JF103FTDS
2	TP1, TP21	Connector, test point, TAB, silver, Mini, 3.8x2.03, SMD	Keystone® Electronics Corp.	5019
4	TP41, TP-1, TP-2, TP-39	Connector, test point, TAB, silver, Mini, 3.8x2.03 SMD	Keystone Electronics Corp.	5019

**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, UQFN-48	Microchip Technology, Inc.	ATA6847T-5033LH/ZWX
1	U2	Memory, Serial EEPROM, 256K, SPI, TSSOP-8	Microchip Technology, Inc.	AT25256B-XHL-T
1	U3	Analog, Switcher, Buck, 2 to 24V, SOT-23-6	Microchip Technology, Inc.	MCP16331T-E/CH
1	U5	Interface, USB, I2C, UART, TSSOP-14	Microchip Technology, Inc.	MCP2221-I/ST
1	U6	Analog, OpAmp, 1-Ch, 10 MHz SOT-23-5	Microchip Technology, Inc.	MCP6486RT-E/OT

**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 PARTS**

Qty.	Reference	Description	Manufacturer	Part Number
8	JS1, JS2, JS3, JS4, JS5, JS6, JS7, JS8	Mechanical, hardware, jumper, 2.54 mm, 1x2	Multicomp Pro	MC-2228CG
4	PAD1, PAD2, PAD3, PAD4	Mechanical, hardware, rubber pad, cylindrical flat top, D9.5, H4.8, clear	Bumper Specialties	BS35CL01X02RP

**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-4: BILL OF MATERIALS (BOM) – DO NOT POPULATE PARTS**

Qty.	Reference	Description	Manufacturer	Part Number
0	C24, C25, C29	Capacitor, ceramic, 820 pF, 50V, 10%, X7R, SMD, 0603	Murata Electronics®	GRM188R71H821KA01D
0	D9, D10, D11, D12, D13, D17	Diode, Schottky, 40V, 2A, SOD-123F	onsemi™	SS24FL

**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-4: BILL OF MATERIALS (BOM) – DO NOT POPULATE PARTS (CONTINUED)**

Qty.	Reference	Description	Manufacturer	Part Number
0	HS1	Mechanical, hardware, heatsink	Advanced Thermal Solutions	ATS-CPX050050025-124-C 1-R0
0	J_X	Connector, HDR-2.54, female, 2x10, gold, TH, RT, angle	Sullins Connector Solutions	PPPC102LJBN-RC
0	Jp14	Connector, HDR-2.54, male, 1x2, tin, 6.75 MH, TH, vertical	Molex, LLC	90120-0122
0	R11, R15, R18, R25, R32, R37	Resistor, Thick Film, 10R, 1% 1/8W, SMD, 0805	ROHM Semiconductor	MCR10EZHF10R0
0	R22, R23, R55, R66	Resistor, Thick Film, 0R, 1/10W, SMD, 0603	Stackpole Electronics, Inc.	RMCF0603ZT0R00
0	R43	Resistor, TKF, 10k, 5%, 1/10W, SMD, 0603	Panasonic - ECG	ERJ-3GEYJ103V

**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.

## Appendix C. Software

### C.1 SOFTWARE LOCATION

The application software may be downloaded from the ATA6847L webpage located on the Microchip website, <http://www.microchip.com>.

### C.2 SELECTED FIRMWARE CONSTANTS AND DEFINITIONS

The desired driver application parameters can be set in "ATA6847L.h" file. Below are defined the driver registers and their specific properties.

```

//**** ATA6847L Application Limit Values settings *****/
#define VRefDAC          3300 // [mV] or 5000[mV] //
#define CCPT_nS         700 // Cross conduction protection time= 0,100,..6300[nS]
#define EGBLTime_nS    750 // Edge blanking time, 250 (default)
#define AdTSWO_nS      250 // Ad Force time switch, 250 (default)
#define VGSUVFLT_nS    1250 // VGS under-voltage filter time=500..7500, 2000[nS] (default)
#define ILIMFLT_nS     1000 // Current limitation filter time=2000 (default)
#define MOS_OCL         1890 // MOSFET Overcurrent Limit=[0..VRefDAC] [mV]
#define SCThrVal_mV    250 // Short circuit detection threshold 125mV to 1750mV
#define SCFLT_nS       1000 // Short circuit filter time,2000 (default)

```

All required configuration functions are implemented in the "ATA6847L.c" file and can be called in the main application function after the power-up sequence.

```

//////////////////// Functions conversion prototype //////////////////////
inline uint8_t SetCCPTime( unsigned CCPTime );
inline uint8_t Set_VGSUVFLT( unsigned Time_nS );
inline uint8_t TimeConversion( unsigned Time_ns );
inline uint8_t SetSCThrVal( unsigned SCThrVal );
inline uint8_t SetCurrLim( long unsigned CurrThrVal );
inline uint8_t SetAd_TSWO( uint8_t Ad_TSWO_ns );

//////////////////// Prepare registers content for writing //////////////////////
void ATA6847_Reg_Init(void);

//////////////////// Write command, configures register content //////////////////////
void ATA6847_Write_Reg( uint8_t reg_address, uint8_t reg_config );

//////////////////// Read command, returns register content //////////////////////
uint8_t ATA6847_Read_Reg( uint8_t reg_address );

//////////////////// Usefull functions //////////////////////
uint8_t ATA6847_Init_Normal_Mode( void );
void ATA6847_Init_Standby_Mode( void );
void ATA6847_Reg_Write_Init_Regs( void );
void ATA6847_Reg_Read_Init_Regs( void );
inline void ClearFaults( void );
inline void Fault_manage( void );

```

The implementation of the internal ATA6847L registers and bitwise definition can be found in the “ATA6847.h” file.

```

//*****
// ATA6847L registers bitwise definition
//*****

////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////
#define DOPMCR (0x01) // Device operation mode control register
////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////
typedef union {
    struct {
        uint8_t DvOpMd :3; // Select Device Operation Mode, Default=1
        uint8_t :3; // Unused (read as 0)
        uint8_t VdIOVSD:1; // Vdd
        uint8_t RSTLVL :1; // Under-voltage (UVDD1 < UVDD1_UV_Set)
    };
    BYTE CFG;
} tDOPMCR;

#define DOPM_DSleep 0b001 // Deep sleep mode
#define DOPM_Sleep 0b010 // Sleep mode
#define DOPM_St_By 0b100 // Standby mode (default)
#define DOPM_Normal 0b111 // Normal mode

// 76543210
#define DOPM_Sleep_or_DSleep_MASK 0b00000100

////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////
#define LOPMCR (0x02) // LIN TRX operation mode control register
////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////
typedef union {
    struct {
        uint8_t LOPM :2; // Select LIN Transceiver operation modes
        uint8_t :6; // Unused (read as 0)
    };
    BYTE CFG;
} tLOPMCR;

#define LIN_St_By 0b01 // 2'b01 LIN Standby mode (default)
#define LIN_Normal 0b10 // 2'b10 LIN Normal mode
// Other Invalid mode selection

////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////
#define GOPMCR (0x03) // GDU operation mode control register
////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////
typedef union {
    struct {
        uint8_t GDUOPM :3; // Select GDU operation modes
        uint8_t :5; // Unused (read as 0)
    };
    BYTE CFG;
} tGOPMCR;

#define GDU_OFF 0b001 // GDU OFF mode 1 (default)
#define GDU_St_By 0b100 // GDU Standby mode 4
#define GDU_Normal 0b111 // GDU Normal mode 7
// Other Invalid mode selection

```

The configuration functions are called by the `ATA6847_Drv_Init()` function, as shown in following example.

```

//////////////////////////////// Registers content initialization //////////////////////////////////
// In this function the registers are configured
// with application required configuration
////////////////////////////////////////////////////////////////////////////////////////////////
void ATA6847_Reg_Init( void ) // Registers content initialization
{
    ////////////////////////////////// WatchDog-disabling //////////////////////////////////
    ATA6847_REGS.REG_VAL.WDTRIG_CFG.WD_TRIG = 0x55; //-- valid WWD trigger
    ATA6847_REGS.REG_VAL.WDCR1_CFG.WDC      = WGD_OFF ; //-- keep WWD off // WGD_TOM (default) //
    WGD_WOM

    ////////////////////////////////// LIN TRX operation mode control //////////////////////////////////
    ATA6847_REGS.REG_VAL.LOPMCR_CFG.LOPM     = LIN_Normal; //LIN_St_By;// Operation mode

    ////////////////////////////////// GDU operation mode control //////////////////////////////////
    ATA6847_REGS.REG_VAL.GOPMCR_CFG.GDUOPM   = GDU_OFF;//GDU_Normal; // Operation mode

    ////////////////////////////////// Wake-up control register //////////////////////////////////
    ATA6847_REGS.REG_VAL.WUCR_CFG.LINWUE    = Active;//Inactive;// // Operation mode
    ATA6847_REGS.REG_VAL.WUCR_CFG.LOCWUE    = Active; // Operation mode

    ////////////////////////////////// GDU control register 1, Back-EMF, Cross conduction filter time
    ATA6847_REGS.REG_VAL.GDUCR1_CFG.BEMFEN   = Inactive;
    ATA6847_REGS.REG_VAL.GDUCR1_CFG.CCEN     = Active; // cross-conduction timer and adaptive dead-
    time
    ATA6847_REGS.REG_VAL.GDUCR1_CFG.CCPT     = SetCCPTime( CCPT_nS ); // 100 {nS}

    ////////////////////////////////// Edge blanking time, Cross conduction time,////////////////////////////////
    ATA6847_REGS.REG_VAL.GDUCR2_CFG.EGBLT    = TimeConversion( EGBLTime_nS );
    ATA6847_REGS.REG_VAL.GDUCR2_CFG.TSWO     = SetAd_TSWO( AdTSWO_nS );
    ATA6847_REGS.REG_VAL.GDUCR2_CFG.LSOFF    = Active; //Inactive; // 0, LS=TrS or 1, LS=0 when
    GDU= Standby
    ATA6847_REGS.REG_VAL.GDUCR2_CFG.HSOFF    = Active; //Inactive; // 0, HS=TrS or 1, HS=0 when
    GDU= Standby

    ////////////////////////////////// GDU Control Register 3, Adaptive dead-time, Slew rate
    ATA6847_REGS.REG_VAL.GDUCR3_CFG.ADDTHS   = AddDT_Dis ; // Adaptive dead-time HS disabled;
    ATA6847_REGS.REG_VAL.GDUCR3_CFG.ADDTLS   = AddDT_Dis ; // Adaptive dead-time LS disabled;
    ATA6847_REGS.REG_VAL.GDUCR3_CFG.HSSRC    = FullS_50_0; //FullSpeed;//FullS_12_5;// Slew rate HS
    ATA6847_REGS.REG_VAL.GDUCR3_CFG.LSSRC    = FullSpeed;// FullS_25_0; //FullS_12_5;// Slew rate LS

    ////////////////////////////////// GDU Control Register 4 //////////////////////////////////UUVGSLVL
    ATA6847_REGS.REG_VAL.GDUCR4_CFG.VGSUVFLT = Set_VGSUVFLT( VGSUVFLT_nS );
    ATA6847_REGS.REG_VAL.GDUCR4_CFG.UUVGSLVL = Active; // VGS/VG under-voltage detection level
    selection(default=1)
    ATA6847_REGS.REG_VAL.GDUCR4_CFG.UUVGSSEN = Active; // VGS under-voltage detection enable,
    default=1)
    ATA6847_REGS.REG_VAL.GDUCR4_CFG.VDHOVSD  = Active;
    ATA6847_REGS.REG_VAL.GDUCR4_CFG.COMPEN   = Inactive; // Complementary control enable, default=0
    IL+IH

    ////////////////////////////////// Current limitation control //////////////////////////////////
    ATA6847_REGS.REG_VAL.ILIMCR_CFG.ILIMSDEN = Active ;
    ATA6847_REGS.REG_VAL.ILIMCR_CFG.ILIMFLT  = TimeConversion( ILIMFLT_nS );
    ATA6847_REGS.REG_VAL.ILIMCR_CFG.ILIMEN   = Inactive; //Active ;

    ////////////////////////////////// Current limitation threshold //////////////////////////////////
    ATA6847_REGS.REG_VAL.ILIMTH_CFG.DAC      = SetCurrLim( MOS_OCL );

    ////////////////////////////////// Short circuit protection //////////////////////////////////
    ATA6847_REGS.REG_VAL.SCPCR_CFG.SCTHSEL   = SetSCThrVal( SCThrVal_mV );
    ATA6847_REGS.REG_VAL.SCPCR_CFG.SCFLT     = TimeConversion( SCFLT_nS );
    ATA6847_REGS.REG_VAL.SCPCR_CFG.SCSDEN    = Active ;//Inactive; // Short circuit shutdown enable

    ////////////////////////////////// Current Sensing OpAmp control register //////////////////////////////////
    ATA6847_REGS.REG_VAL.CSCR_CFG.CSAXEN    = CSCR_ALL_CSAX_DISABLED;
    ATA6847_REGS.REG_VAL.CSCR_CFG.GAIN      = Gain_16; // Gain=8,16,32,64 0b01
    ATA6847_REGS.REG_VAL.CSCR_CFG.OFFSET    = VRef_2 ; // VRef/2/4/8/16, 0b11
}

```

```

//////// System Interrupt Mask Register1, activates interrupts //////////
ATA6847_REGS.REG_VAL.SIECER1_CFG.OTPWM      = Active;      // Over temperature pre-warning
ATA6847_REGS.REG_VAL.SIECER1_CFG.SPIFM      = Active;      // SPI failure interrupt
ATA6847_REGS.REG_VAL.SIECER1_CFG.VSUVM      = Active;      // VS UV failure interrupt mask
(VVS< VVS_UV_Set)
ATA6847_REGS.REG_VAL.SIECER1_CFG.ILIMM      = Active;      // Current limitation event
ATA6847_REGS.REG_VAL.SIECER1_CFG.VDHOVM     = Active;      // VDH OV failure interrupt
ATA6847_REGS.REG_VAL.SIECER1_CFG.GSCM      = Active;      //Inactive// General short circuit failure

//////// System Interrupt Mask Register2, activates interrupts //////////
ATA6847_REGS.REG_VAL.SIECER2_CFG.VDD1OVM   = Active;      // VDD1 overvoltage event interrupt
ATA6847_REGS.REG_VAL.SIECER2_CFG.VDD2OVM   = Active;      // VDD2 over-voltage event interrupt
ATA6847_REGS.REG_VAL.SIECER2_CFG.VDD1UVLM  = Active;      // VDD1 IO under-voltage interrupt
(VVDD1< VVDD1_IO_UV_Set) event interrupt mask bit
ATA6847_REGS.REG_VAL.SIECER2_CFG.VDD1UVHM  = Active;      // VDD1 under-voltage interrupt
(VVDD1< VVDD1_UV_Set) event interrupt mask bit
ATA6847_REGS.REG_VAL.SIECER2_CFG.VDD2UVM   = Active;      // VDD2 under-voltage event interrupt

//////// Init default register with default startup value ////////////
ATA6847_REGS.REG_VAL.RWPCR_CFG.CFG = 0x00;
ATA6847_REGS.REG_VAL.MLDCR_CFG.CFG = 0x00;

////////// Test Device operation mode control ////////////
ATA6847_REGS.REG_VAL.DOPMCR_CFG.DvOpMd     = DOpM_Normal;///DOpM_St_By;// Operation mode
ATA6847_REGS.REG_VAL.DOPMCR_CFG.RSTLVL     = Active;///Inactive;
}

```

To write the parameters in the driver, a Write SPI function will be called:

```

////////// Write command, configures register content ////////////
void ATA6847_Write_Reg( uint8_t reg_address, uint8_t reg_config )
{
    SPI_Command SPI_WORD;
    SPI_WORD.ADDRESS = reg_address;
    SPI_WORD.W_R = Write;
    SPI_WORD.Reg_Config = reg_config;
    SPI1_Exchange16bit(SPI_WORD.SPI_Command);
}

```

To get a specific register content, a particular read function is implemented.

```

////////// Read command, returns register content ////////////
uint8_t ATA6847_Read_Reg( uint8_t reg_address )
{
    SPI_Command SPI_WORD;
    SPI_WORD.ADDRESS = reg_address;
    SPI_WORD.W_R = Read;
    SPI_WORD.Reg_Config = 0x00;
    SPI_WORD.Reg_Config = ( uint8_t ) (SPI1_Exchange16bit(SPI_WORD.SPI_Command));
    return SPI_WORD.Reg_Config;
}

```

### C.3 BLDC USER PARAMETERS

```
//////***** HURST Big*****//
#define HURST_Big
#define NOMINALSPEEDINRPM 3150
#define MINSPEEDINRPM 500 // 500
#define INITIALTORQUE 1.5 // Initial torque current
#define POLEPAIRS 5 // Number of pole pairs
#define PHASERES ((float)0.35) // Phase resistance in Ohms.
#define PHASEIND ((float)0.00033) // Phase inductance in Henrys
#define FILTERDELAY 90 // 90-(1..7) advance
/** Velocity Control Loop Coefficients ****
#define WKP Q15(0.11751)//Q15(0.3657)//
#define WKI Q15(0.01025)//Q15(0.0285)//

////////////////////////////////////
/******* Q Control Loop Coefficients *****/
#define QKP Q15(0.09275)//Q15(0.0975)//
#define QKI Q15(0.00725)//Q15(0.0095)//
#define QKC Q15(0.995)
#define QOUTMAX Q15(0.725)
/******* D Control Loop Coefficients *****/
#define DKP QKP
#define DKI QKI
#define DKC QKC
#define DOUTMAX QOUTMAX

#define SMC GAIN 0.525
#define MAXLINEARSMC 0.475 //
#endif
```

## C.4 DSPIC33CK256MP205 PORT USAGE

### C.4.1 Port's Mapping

Onboard Buttons:

```
#define On_Off_Set_Input()    (_TRISD11 = 1)
#define On_Off_GetValue()    (_RD11)
#define On_Off              !(_RD11)      //SW1 - BTN_1

#define SPB_Set_Input()      (_TRISE10 = 1)
#define SPB_GetValue()       (_RE10)
#define SPB                  !(_RE10)     //SW2 - BTN_2
```

BEMFs/Hall sensors:

```
// Halls or BEMF inputs
#define BMF_A_SetDigitalInput() (_TRISC6 = 1)
#define BMF_B_SetDigitalInput() (_TRISC7 = 1)
#define BMF_C_SetDigitalInput() (_TRISD10 = 1)

#define HallA_SetDigitalInput() (_TRISD5 = 1)
#define HallB_SetDigitalInput() (_TRISD6 = 1)
#define HallC_SetDigitalInput() (_TRISD7 = 1)

#define HallA_GetValue()        _RD5
#define HallB_GetValue()        _RD6
#define HallC_GetValue()        _RD7
```

### C.4.2 A/D Mappings

```
/*
 * Setting the Analog/Digital Configuration SFR(s)
 */
ANSELA = 0x0013;
ANSELB = 0x009F;
ANSELC = 0x0048;
ANSELD = 0x0400;
ANSELE = 0x000F;

I_Bus_SetAnalogInput(); // (_ANSELA0 = 1)
I_B_SetAnalogInput();  // (_ANSELA4 = 1)
I_A_SetAnalogInput();  // (_ANSELB2 = 1)
V_Bus_SetAnalogInput(); // (_ANSELC3 = 1)
SpRef_SetAnalogInput(); // (_ANSELC6 = 1)
// TempS_SetAnalogInput(); // (_ANSELC6 = 1)

HallA_SetDigitalInput();
HallB_SetDigitalInput();
HallC_SetDigitalInput();
```

### C.4.3 Communications Mappings

```

//////// SPI selection pin -> ATA6847L //////////////////////////////////
#define nCS_SetOutput()    ( _TRISD2 = 0)
#define nCS                _LATD2
#define nCS_Enable()      nCS = 0
#define nCS_Disable()     nCS = 1
#define SCK_Set_Output()  ( _TRISD12 = 0)
#define MISO_Set_Input()  ( _TRISC4 = 1)
#define MOSI_Set_Output() ( _TRISC5 = 0)
//////// UART1 pin selection -> ATA6847L LIN UART //////////////////////////////////
#define RX_Set_Input()    _TRISC8 = 1 //EvBComb
#define TX_Set_Output()   _TRISC9 = 0

```

### C.4.4 Used Peripherals Mappings

```

/*****
 * Set the PPS for used peripherals
 *****/
__builtin_write_RPCON( 0x0000 ); // unlock PPS
RPINR20bits.SCK1R = 0x004C; // RD12->SPI1:SCK1OUT
RPOR22bits.RP76R = 0x0006; // RD12->SPI1:SCK1OUT
RPOR10bits.RP53R = 0x0005; // RC5->SPI1:SDO1
RPINR20bits.SDI1R = 0x0034; // RC4->SPI1:SDI1
RPINR19bits.U2RXR = 0x004D; // RD13->UART2:U2RX
RPOR23bits.RP78R = 0x0003; // RD14->UART2:U2TX
__builtin_write_RPCON( 0x0800 ); // lock PPS

```

---

## SOFTWARE

### C.5 MPLAB X COMPILER STARTUP

1. Start up the MPLAB X compiler (not supplied, available on the Microchip website).
2. From the toolbar, select *File>Open Project*.
3. Browse to the evaluation board source code path.
4. Select the existing project file named `EV92R69A_3Sh_Comb.X`.
5. In the Projects window, right mouse-click on `EV92R69A_3Sh_Comb.X` and select Properties. The page contains the project properties. Processor, Compiler, Hardware and Config settings may be changed here.
6. Right mouse-click on `EV92R69A_3Sh_Comb.X` again and select “Make and Program Device”. This will compile the firmware and download it to the programming hardware.
7. The compiler results will be displayed in the Output window frame. Verify success.

### C.6 MPLAB X IDE AND PICKIT EXERCISE

1. Start up the MPLAB X (not supplied, available on the Microchip website).
2. From the toolbar, select *File>Open Project*.
3. Browse to the evaluation board source code path.
4. Select the existing workspace directory named `EV92R69A_3Sh_Comb.X` or create a new one.
5. Connect the C Align Pin 1 of the header with the Pin 1 mark on the programmer.
6. Set the bench power supply voltage control to minimum voltage output.
7. Turn on the power supply and set the output voltage to 13-14V. Turn off the power supply.
8. Connect the bench power supply to the evaluation board. Connect +V(14V) to J10-1 and -V (Ground) to J10-2.
9. Turn on the power supply.
10. Right mouse-click on `EV92R69A_3Sh_Comb.X` in the Projects window and select “Make and Program Device”. This will compile the firmware and program the dsPIC33CK256MP205 processor.
11. The compiler results will be displayed in the Output window frame. Verify success.
12. Connect a Brushless DC (BLDC) motor to connector JM (MOTOR). Connect the motor phase wires to the PH\_A (JM), PH\_B (JM), and PH\_C (JM) terminals.
13. Momentarily press the RESET switch on the evaluation board. This step is required to reset the dsPIC DSC device after programming.
14. Turn the SPEED adjustment fully counterclockwise. This sets the motor to the slowest speed.
15. Momentarily press the **RUN** switch to start the motor.
16. Momentarily press the **RUN** switch again to stop the motor.
17. Momentarily press the **RUN** switch again to start the motor.
18. Turn the SPEED adjustment clockwise. The motor speed should increase.
19. You may probe the different test points on the board to see the various signals being generated. The GLX, SHX, GHX (X=1..3) test points will show the external MOSFET gate drive signals. The D1 through D6 LEDs show the state of the PWM inputs to the ATA6847L.
20. Momentarily press the RUN switch again to stop the motor.

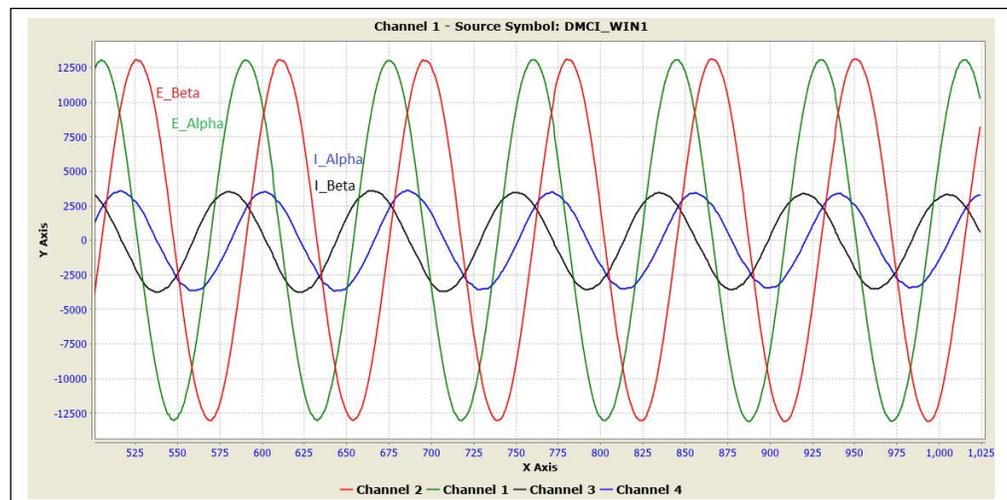
## C.7 MPLAB X DMC1 WINDOW EXERCISE

For debugging purposes, in MPLABX IDE there is a plugin tool available that can be used as follows:

1. In the open project, use the “UserParms.h” header file, find the line where the processor directive `//#undef DMC1_WIN` (which undefines the DMC1 window) is located. Comment that line.
2. In the `EV92R69A_3Sh_Comb.c`, the sections related to DMC1 will become active.
3. Find the section where the desired variables are assigned to the DMC1 declared vectors. For example, see the variables below:

```
#ifndef DMC1_WIN // For test purposes
DMCI_WIN1[indx]= SMO_est.Ealpha;//AngleEst.CurrTheta;//IPh.a;//
DMCI_WIN2[indx]= SMO_est.Ebeta;//IPh.b;//I_Ph_Comp.qIb;//
DMCI_WIN3[indx]= I_Alpha_Beta.alpha;//I_ADC.c;//
DMCI_WIN4[indx]= I_Alpha_Beta.beta;//Sp_Ref.qValue;//
indx++;
if(!(indx<WIN_DIM))
{indx=0;}
#endif
```

4. The PICkit should be attached at the J3 evaluation board connector.
5. From the toolbar, select *Debug->Debug Project*. Wait for compilation and debugging to launch and run.
6. After successful project compilation and board programming, press the RUN button and increase the speed at around 80% from full scale. Stop the motor by pressing again the RUN button.
7. Stop the debugging by pressing the Pause button or <Ctrl+Alt+8>.
8. From the toolbar, select *Tools->Embedded->DCMI-> DCM1 Window*.
9. In *Dynamic Data View* right click on each Data Source window and assign one of DMC1\_WIN1[] to DMC1\_WIN 4[] vectors for each of Data Source windows. In each Data Source window, the evolution of the assigned variable will appear. By merging all Data Source windows, all data can be displayed on the same graph, as illustrated below:



10. Notice that, after closing the debugging session, the board must be reprogrammed with the `#undef DMC1_WIN` line uncommented, as described above, in the C6 section, in the desired motor control mode.