ATA6847
QFN40 BLDC Motor 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 ATA6847 QFN40 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 ATA6847 QFN40 BLDC Motor Driver Evaluation Board. The manual layout is as follows:

- **Chapter 1. "Product Overview"** – Important information about the ATA6847 QFN40 BLDC Motor Driver Evaluation Board.
- **Chapter 2. "Installation and Operation"** – Includes instructions on installing and using the ATA6847 QFN40 BLDC Motor Driver Evaluation Board.
- **Appendix A. "Schematics and Layouts"** – Shows the schematic and layout diagrams for the ATA6847 QFN40 BLDC Motor Driver Evaluation Board.
- **Appendix B. "Bill of Materials (BOM)"** – Lists the parts used to build the ATA6847 QFN40 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
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 ATA6847 QFN40 BLDC Motor Driver Evaluation Board. Other useful documents are listed below. The following Microchip documents are available and recommended as supplemental reference resources:

- **ATA6847 Data Sheet -** ***"Three-Phase Brushless Motor Gate Driver SBC" (DS20006940)*** – This data sheet provides detailed information regarding the ATA6847 product family.
- **dsPIC33EPXXXGP50X, dsPIC33EPXXXMC20X/50X and PIC24EPXXXGP/MC20X Data Sheet -** ***"16-Bit Microcontrollers and Digital Signal Controllers with High-Speed PWM, Op Amps and Advanced Analog" (DS70000657)*** – This data sheet provides detailed information regarding the dsPIC33CK128MP503 product family.
- **dsPIC33/PIC24 Family Reference Manual** ***(DS70573)***
- **dsPIC33EPXXXGP50X, dsPIC33EPXXXMC20X/50X, and PIC24EPXXXGP/MC20X -** ***"Family Silicon Errata and Data Sheet Clarification" (DS80000533)*** – This data sheet contains anomalies and clarifications for the dsPIC33EPXXXMC504 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
- **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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- **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

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- 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:
https://www.microchip.com/support.

DOCUMENT REVISION HISTORY

Revision B (November 2024)

- Updated BLDC motor current values.
- Replaced **Figure 1-1: "ATA6847 QFN40 BLDC Motor Driver Evaluation Board Block Diagram."**

Revision A (October 2024)

- Initial release of this document.

Chapter 1. Product Overview

1.1 INTRODUCTION

This chapter covers the following topics:

- ATA6847 QFN40 BLDC Motor Driver Evaluation Board Overview
- What is the ATA6847 QFN40 BLDC Motor Driver Evaluation Board?
- What does the ATA6847 QFN40 BLDC Motor Driver Evaluation Board Kit Include?

1.2 ATA6847 QFN40 BLDC MOTOR DRIVER EVALUATION BOARD OVERVIEW

The ATA6847 QFN40 BLDC Motor Driver Evaluation Board is used to demonstrate the driver capabilities offered by the ATA6847-3333 and -5033 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 ATA6847 QFN40 as a 3-phase Brushless DC (BLDC) motor gate driver and the dsPIC33CK64MP205T digital signal microcontroller provided by Microchip. In order to implement different types of algorithms, like the sinusoidal three shunt FOC or the trapezoidal motor control algorithm in sensored 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 ATA6847 QFN40 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 ATA6847 QFN40 BLDC Motor Driver Evaluation Board provides 3.3V/5V/100 mA LDOs, a 3.3V buck regulator, a USB serial connection, three current sense operational amplifiers (one inside the ATA6847 and two inside the dsPIC33), a Back EMF detector and Hall-effect sensors inputs. Moreover, the ATA6847 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 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 and FltLED for the status indication, PwLED for voltage presence, RX and TX to indicate the serial connection to computer.

1.3 WHAT IS THE ATA6847 QFN40 BLDC MOTOR DRIVER EVALUATION BOARD?

The ATA6847 QFN40 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 five main units:

- ATA6847 Motor Driver
- DSPIC33CK64MP205T Digital Signal MCU
- Three phase MOSFET Bridge
- USB-UART
- Buck Converter

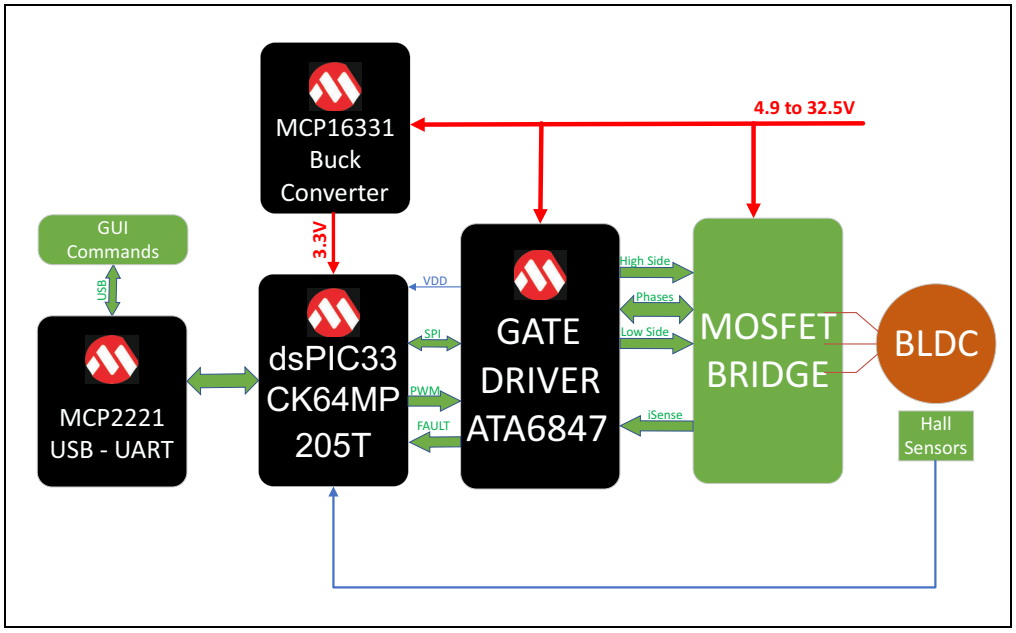


FIGURE 1-1: *ATA6847 QFN40 BLDC Motor Driver Evaluation Board Block Diagram.*

The on-board ATA6847 generates 3.3V using internal voltage regulators (VDD2) for the attached host microcontroller and 5V(VDD1) for the Hall sensors. The ATA6847 also contains two charge pumps for low and high side of the Gate Driver Unit to allow operation up to 100% duty cycle.

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 DSPIC33CK64MP205T firmware 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/3V3).

Four push buttons (**RST**, **Spare**, **ON/OFF** and **WakeUp**) are available for different events generation (start, stop, direction change, reset, etc). The motor speed can be adjusted using the available on board reference speed potentiometer.

An optional spare buck power supply is available for ATA6847-3333, which has an 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 ATA6847 QFN40 BLDC MOTOR DRIVER EVALUATION BOARD KIT INCLUDE?

The ATA6847 QFN40 BLDC Motor Driver Evaluation Board kit includes:

- The ATA6847 QFN40 BLDC Motor Driver Evaluation Board (EV43F54A).
- Key Information Sheet.

NOTES:

Chapter 2. Installation and Operation

2.1 INTRODUCTION

The ATA6847 QFN40 BLDC Motor Driver Evaluation Board demonstrates the features of Microchip's 3-Phase Brushless DC (BLDC) Motor Driver with Power Module, ATA6847, used in a BLDC motor driver application. When used in conjunction with a microcontroller, the ATA6847 will provide the necessary drive signals to drive a 3-Phase BLDC motor.

The ATA6847 contains all necessary functional blocks for developing high performance BLDC/PMSM motor drivers: high and low-side MOSFET drivers, two gain/offset configurable Op Amps, protection circuity, Back EMF detector and SPI interface for the configuration of the internal registers.

The board is equipped with the dsPIC33CK64MP205T high performance Digital Signal Controller (DSC) and can handle simple motor control algorithms, such as 6-step trapezoidal, or high-performance algorithms, such as the Field Oriented Control (FOC). The dsPIC (DSC) provides the PWM inputs to the ATA6847; it also handles 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 one of the ATA6847 internal Op Amps. The second internal Op Amp can be configured either as B-EMF or current sense amplifier. Two additional Op Amps are used from the dsPIC33CK64MP205T.

2.2 FEATURES

The ATA6847 QFN40 BLDC Motor Driver Evaluation Board has the following features:

- Input operating voltage range: 4.9V to 32.5V
- Maximum of 10/27Ω 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
- Two programmable gain/offset current sense amplifiers
- ON/OFF push button (RUN)
- Reset push button (RST)
- Spare user-programmable push button (µC/Wk)
- PWM signal LED indicators
- Fault signal LED indicator
- Wake-up push button
- PICkit debugger interface
- Speed control potentiometer
- Terminal block for 3.3V and 5V Hall-effect sensors
- UVLO, OVLO and DUVLO protections
- Programmable external MOSFET short circuit protection 125 mV to 1.75V
- Programmable PWM dead-time protection 100 ns to 6.3 µs (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 ATA6847 QFN40 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 Figures 2-1 and 2-2. The 24V, 3-phase, AC300022 BLDC Motor is also required to evaluate the motor driver.

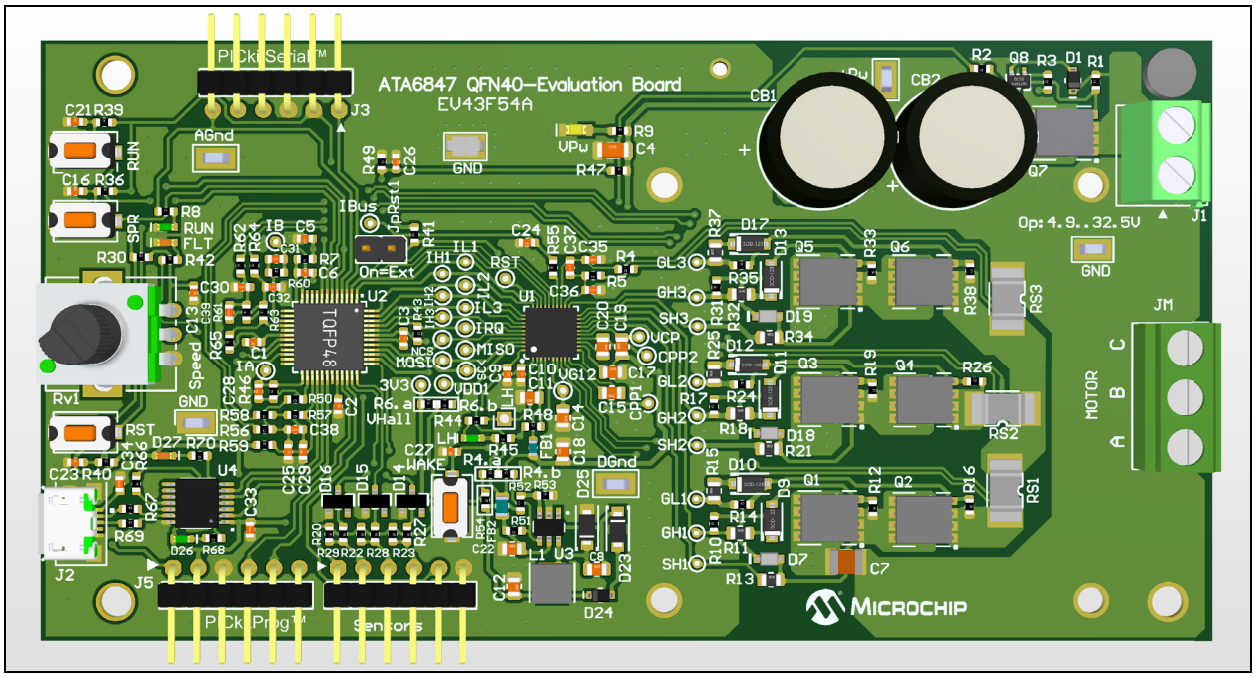


FIGURE 2-1: *ATA6847 QFN40 BLDC Motor Driver Evaluation Board PCB (Top).*

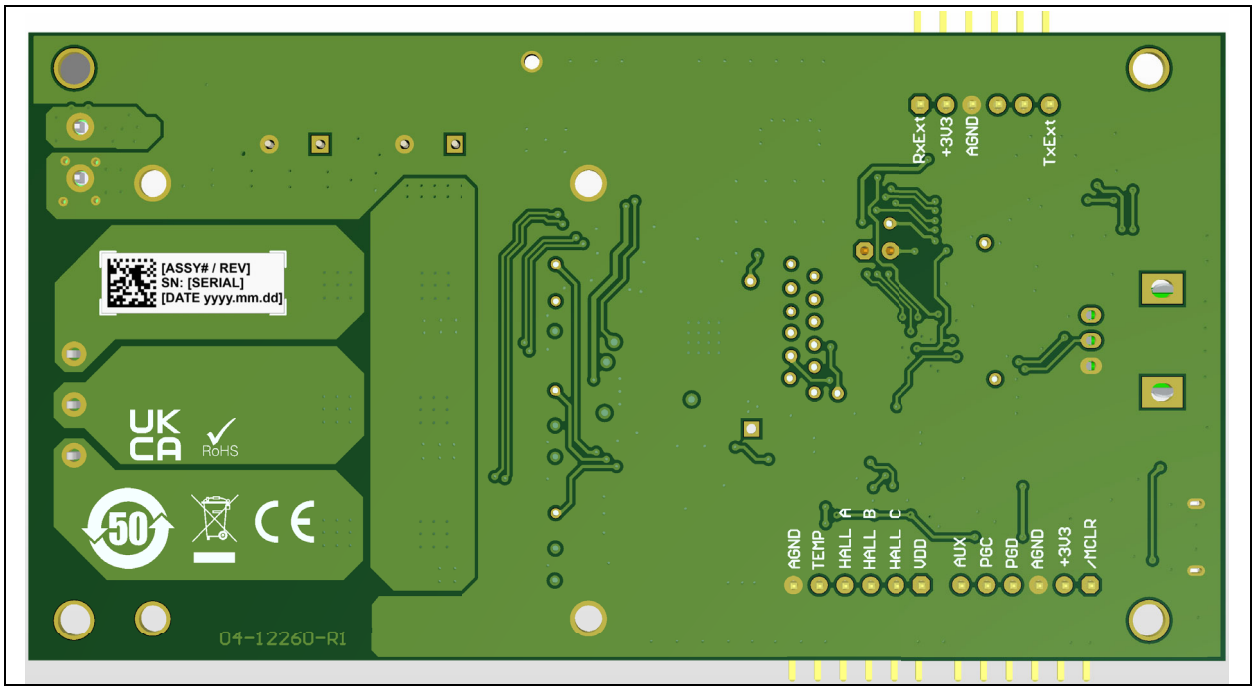


FIGURE 2-2: *ATA6847 QFN40 BLDC Motor Driver Evaluation Board PCB (Bottom).*

2.3.1 Connections

2.3.1.1 JUMPER SETTINGS

The ATA6847 QFN40 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: ATA6847 QFN40 BLDC MOTOR DRIVER EVALUATION BOARD JUMPERS

Jumper	Positions	Function Description
JpRst1	On/Off	Connect/Disconnect MCLR and nRST signals (for WDT operation)
R6.a/R6.b	3.3V/5V	3.3V/5V Hall power voltage supply selection
R4.a/R4.b	VDD2/INH	Route VDD2 to DSP PwS or INH to Auxiliary Buck (ATA6847-3333). Do not place the jumper if powered from the buck.
R54	SMD Resistor 0Ω	Populate if Auxiliary Buck is used.

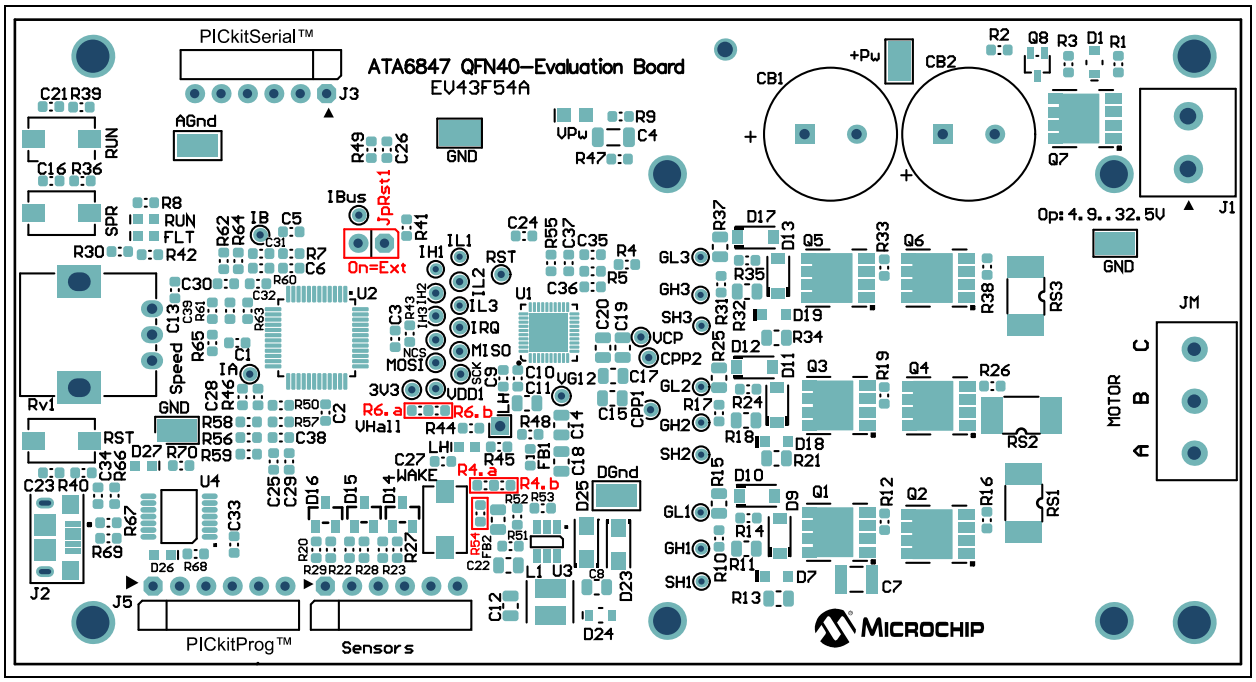


FIGURE 2-3: *ATA6847 QFN40 BLDC Motor Driver Evaluation Board Jumpers Positioning.*

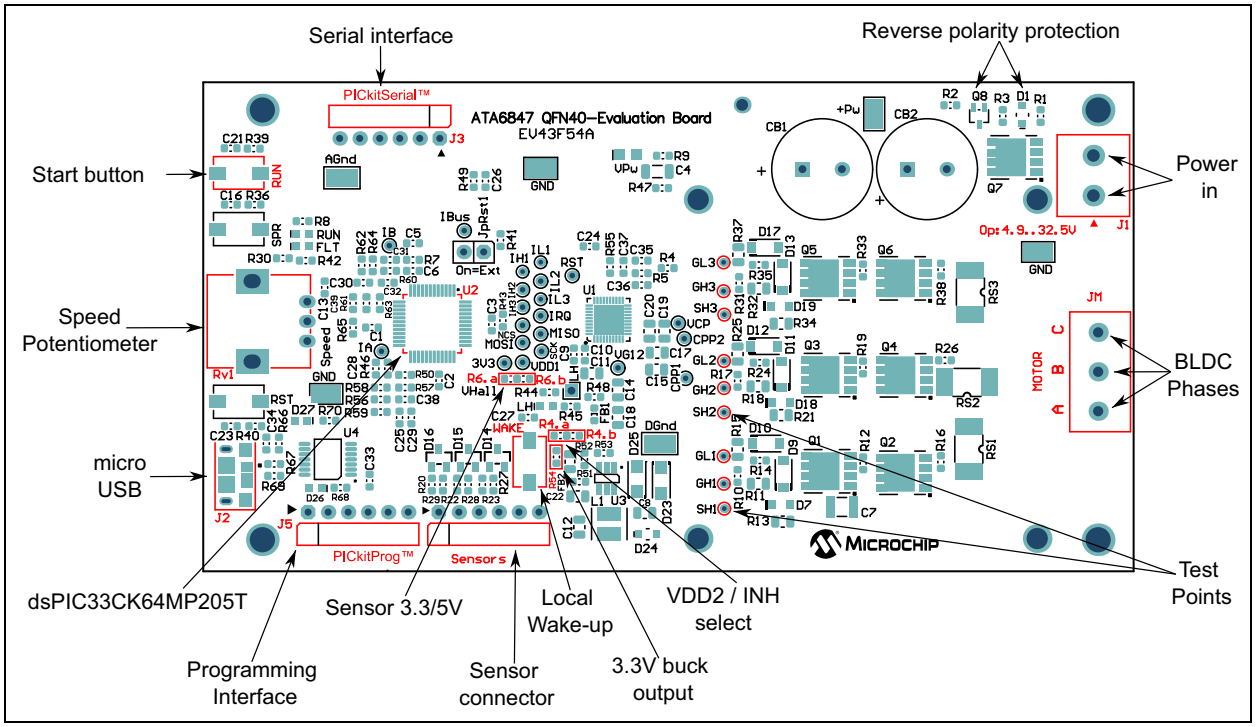


FIGURE 2-4: *ATA6847 QFN40 BLDC Motor Driver Evaluation Board Features.*

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
Trapezoidal Sensored Mode		
R6.a or R6.b	HALL 3.3V HALL 5V	Route 3.3V to power Hall sensors Route 5V to power Hall sensors
FOC Sinusoidal Sensored Mode		
R6.a or R6.b	HALL 3.3V HALL 5V	Route 3.3V to power Hall sensors Route 5V 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.

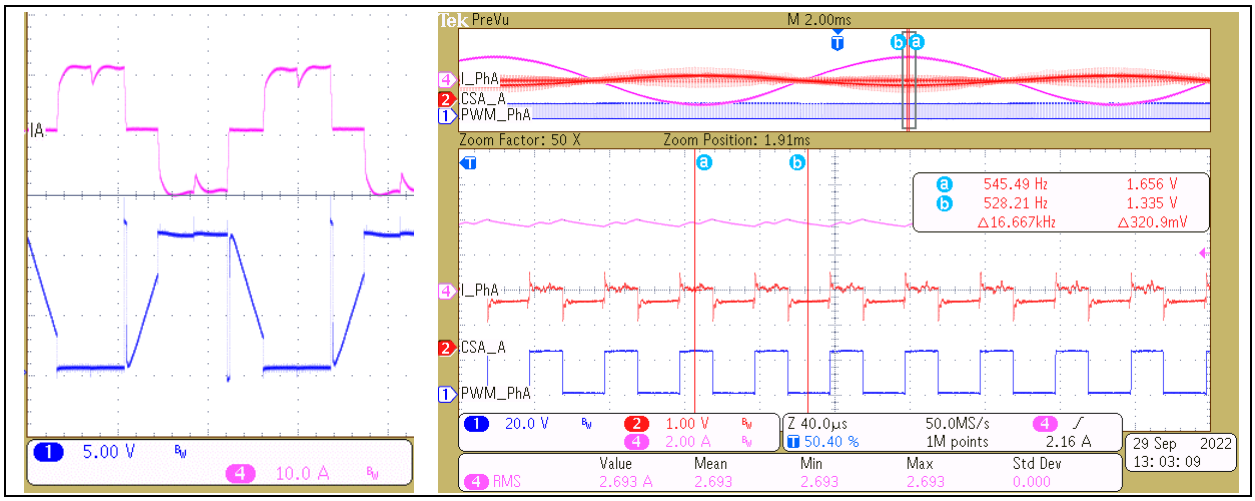


FIGURE 2-5: *Trapezoidal and Sinusoidal Motor Control Modes.*

Pressing the Sw1 push button wakes the system up.

Pressing the ST3 push button forces a host controller reset.

R4 is dedicated for the VDD2/INH pin and, when the board is equipped with ATA6847-3333, must be put in **INH (R4.b)** 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 +3.3V line, in order to supply the dsPIC33CK microcontroller.

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

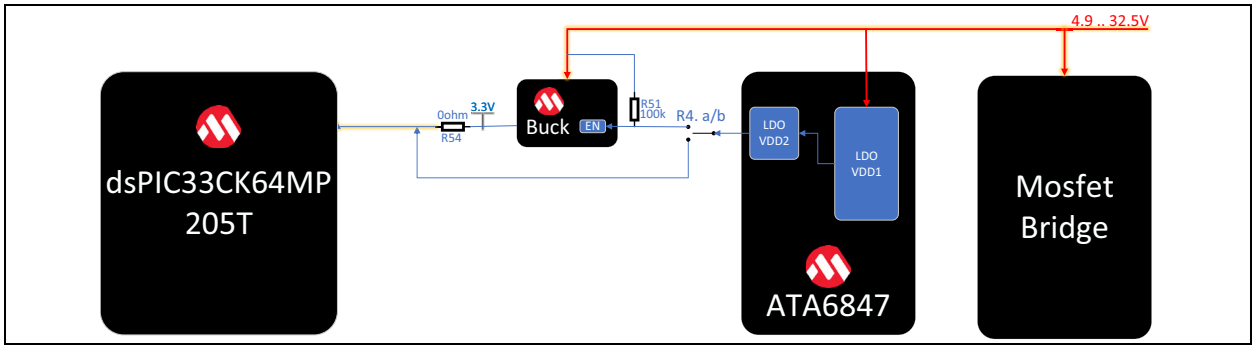


FIGURE 2-6: *Evaluation Board Power Supply Diagram.*

2.3.1.2 AVAILABLE INTERFACING CONNECTORS

Five connectors are available, as follows:

- J5 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.
- J3 is a simple header connector that can be used for serial communication, using a PICkit serial communication tool or a USB-to-serial bridge (e.g. ADM00559 provided by Microchip).
- JM is the motor driver output. This is the connection to the BLDC motor.
- J1 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.
- J6 connects the Hall effect sensors to the dsPIC33CK64MP205T 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 R6 0R resistor in the R6.a location for 3.3V or in the R6.b location for 5V.

Interface Connectors

- J1 (**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 (**Serial Interface**) UART Serial interface.

Pin	Name	Description
1	RxExt	UART Output (from USB to MCU)
2	+3.3V	3.3V Output
3	GND	Serial Interface GND
4	—	—
5	—	—
6	TxExt	UART Input (from MCU to USB)

- J5 (**PICKITProg**) is mainly dedicated for microcontroller programming/debugging.

Pin	Name	Description
1	MCLR	Microcontroller reset
2	V_{PP}	+3.3V Power-programming
3	V_{SS}	Microcontroller GND
4	PGD	Programming Data
5	PGC	Programming Clock
6	Aux	Not used

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

Pin	Name	Description
1	VH+	Hall power supply +3.3/5V
2	HallC	HallC sensor output
3	HallB	HallB sensor output
4	HallA	HallA sensor output
5	Temp	External temperature sensor input
6	VH-	Hall GND

2.3.1.3 POWERING THE ATA6847 QFN40 BLDC MOTOR DRIVER EVALUATION BOARD

- Apply the input voltage to the input power terminal block, **PwS,** 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 2 of **PwS**. Connect the negative or return side (-) of the input source to pin 1 of **PwS**. Refer to Figure 2-3.

2.3.1.4 CONNECTING A MOTOR TO THE ATA6847 QFN40 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. The motor is getting powered.
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 ATA6847.
5. Press and release the RUN push button again to stop the motor.

2.3.3 Indicator LEDs

The ATA6847 QFN40 BLDC Motor Driver Evaluation Board has six LEDs to indicate system status. Table 2-3 lists the LED indicators and their description.

TABLE 2-3: LED INDICATORS

PCB Location	Name	Description
D8	VPw	Indicates power supply presence.
D21	Run	Motor running state.
D20	Flt Fault	FAULT status.
D22	LH	Optical indicator for Limp Home, VDD independent high voltage failure output.
D26	RX	Data activity received by MCP2221A on RX line.
D27	TX	Data activity transmitted by MCP2221A on TX line.

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…32.5V	Motor Power supply (+)
GND	Power supply ground (-)
3V3	3.3V LDO/Buck output voltage
VDD1	5V internal LDO output
VG12	12V internal low side LDO output
CPP1	Charge Pump 1 Positive Clamp
CPP2	Charge Pump 2 Positive Clamp
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 side driver inputs
IH1...3	PWMs High side driver inputs
GL1...3	A/B/C Phase Low side driver outputs
GH1...3	A/B/C Phase High side driver outputs
SH1...3	A/B/C Motor/driver phase signals
RST	ATA6847 Reset to Host
LH	ATA6847 Limp Home
IO1_IA	OpAmp1 output (current through phase 1)
IO2_IB	OpAmp2 output (current through phase 2)
IO3_IBus	OpAmp3 output (current through phases)

2.3.5 Reprogramming the dsPIC33CK64MP205T 100 MHz High-Performance DSC

The dsPIC33CK64MP205T 100 MHz High-Performance DSC 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 J5 header.
3. Start up the MPLABX Integrated Development Environment (IDE) and load the EV43F54A_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 ATA6847

The ATA6847 has configuration registers that may be used to modify the operating parameters of the device. The parameters are modified by sending commands to the ATA6847 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 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.

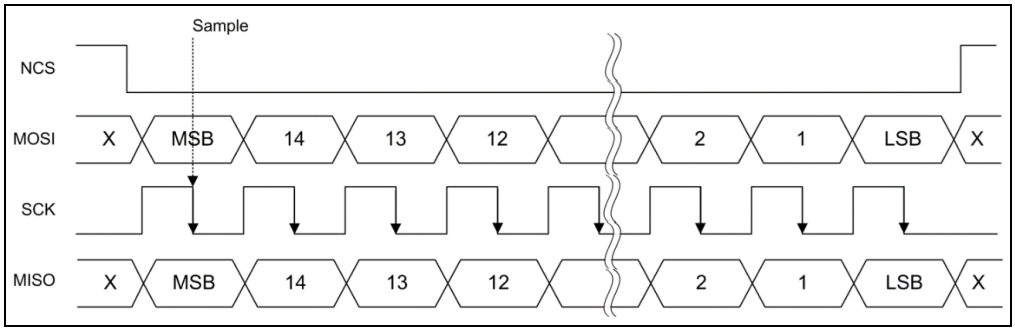


FIGURE 2-7: *SPI Timing Protocol.*

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 ATA6847 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.

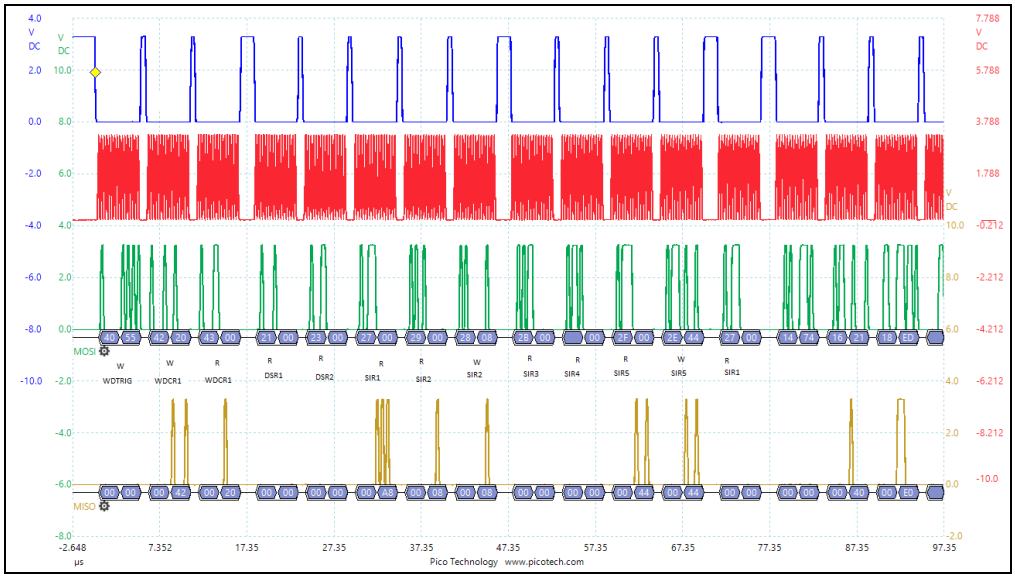


FIGURE 2-8: *SPI Registers Configuration - Waveform Example.*

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
GOPMCR	0x03	Gate Driver Unit Operation Mode Control Register	GDU OFF mode
			GDU Standby mode
			GDU Normal mode
WUCR	0x04	Wake-up Control Register	Local wake-up enable
GDUCR1	0x05	GDU Control Register 1	BEMF det. enable/disable bit
			Cross conduction enable/disable bit
			T_{CC} = 100 ns × 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 × 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 OpAmp3 enable/disable-bit

2.3.7 ATA6847 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	Asserted Parameters/Modes
DSR1	0x10	Device Status Register 1	
DSR2	0x11	Device Status Register 2	

TABLE 2-6: CONFIGURATION MESSAGE RESPONSES (CONTINUED)

Register	Address	Description	Asserted Parameters/Modes
SIR1	0x13	System Interrupt Register 1	
SIR2	0x14	System Interrupt Register 2	
SIR3	0x15	System Interrupt Register 3	
SIR4	0x16	System Interrupt Register 4	
SIR5	0x17	System Interrupt Register 5	

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 "EV43F54A – 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.

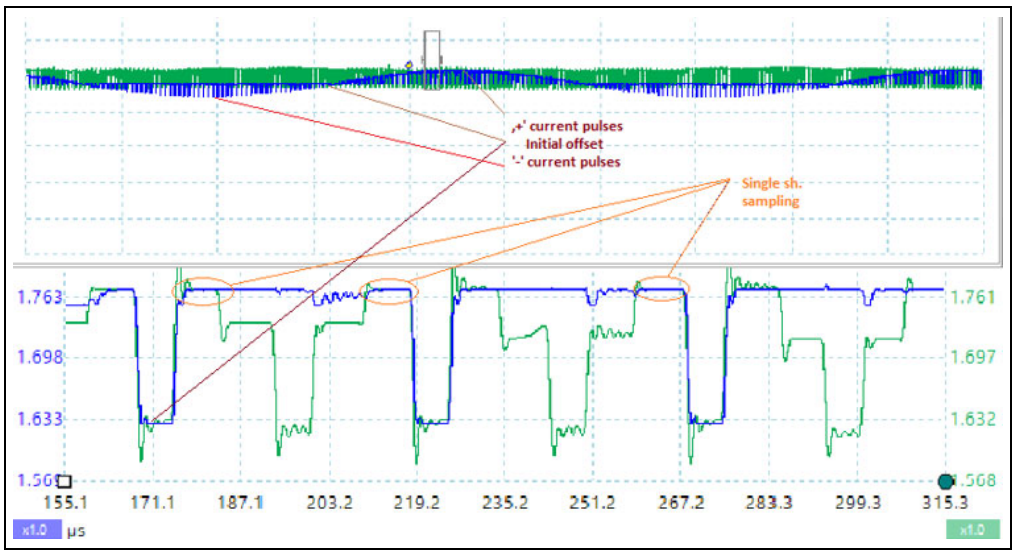


FIGURE 2-9: *CSA's Outputs in Combined Shunts Topology.*

Finally, by applying the particular procedure for currents reconstruction, the evaluation board offers the possibility to develop and evaluate the single shunt configuration with ATA6847 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 R11+D9 and R15+D10 groups for all three phases, in order to achieve a slowdown commutation and high tight 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.

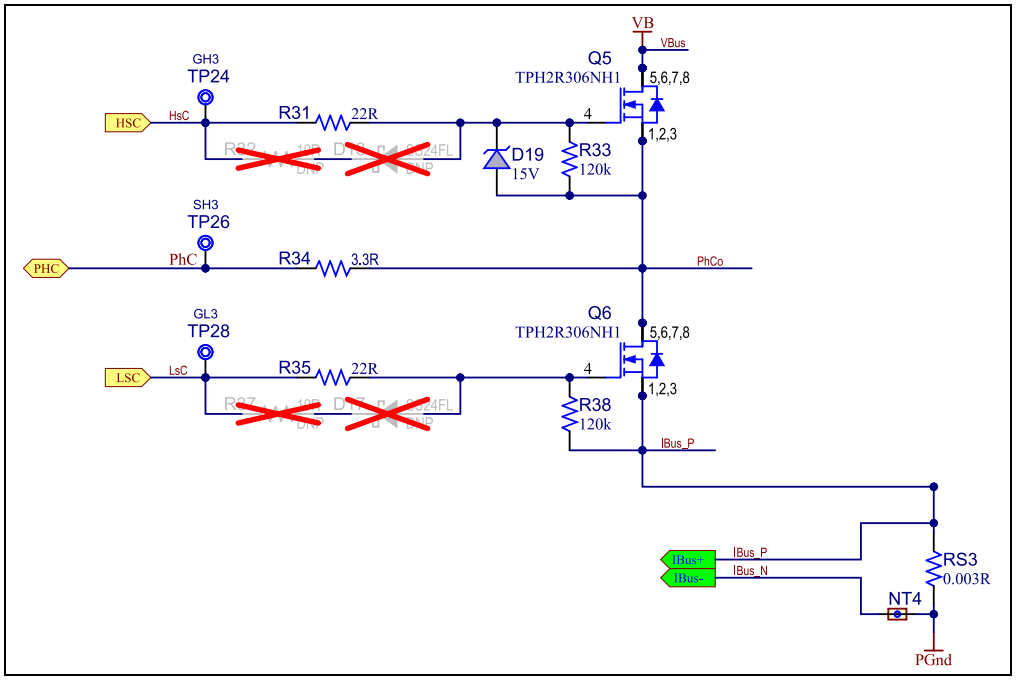


FIGURE 2-10: *Optional Asymmetric Turn On-Off.*

2.4.3 Current Sense Amplifier (CSA)

In order to avoid CSA output limitation and ensure the ADC range conversion, the initial offset of CSA is set to approximately 1.65V. The total gain of the CSA is Gt = 16. For high motor currents it is necessary to decrease the equivalent shunt resistor value. 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 and Figure 2-12, for a high-speed and robust operation of the CSA.

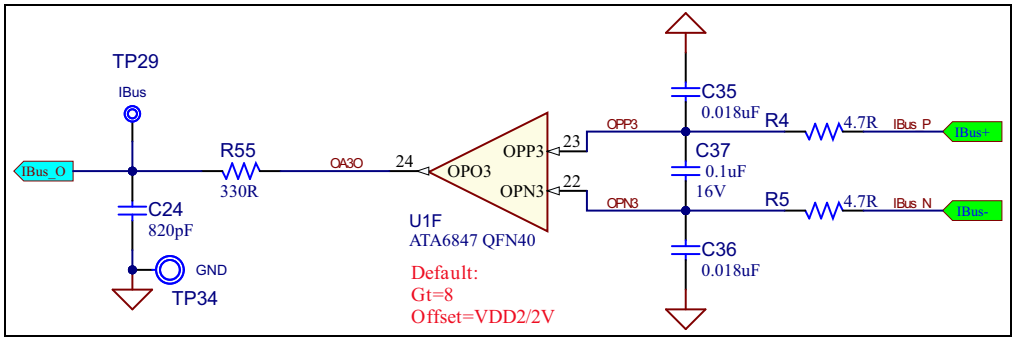


FIGURE 2-11: *Current Sense Amplifier from ATA6847.*

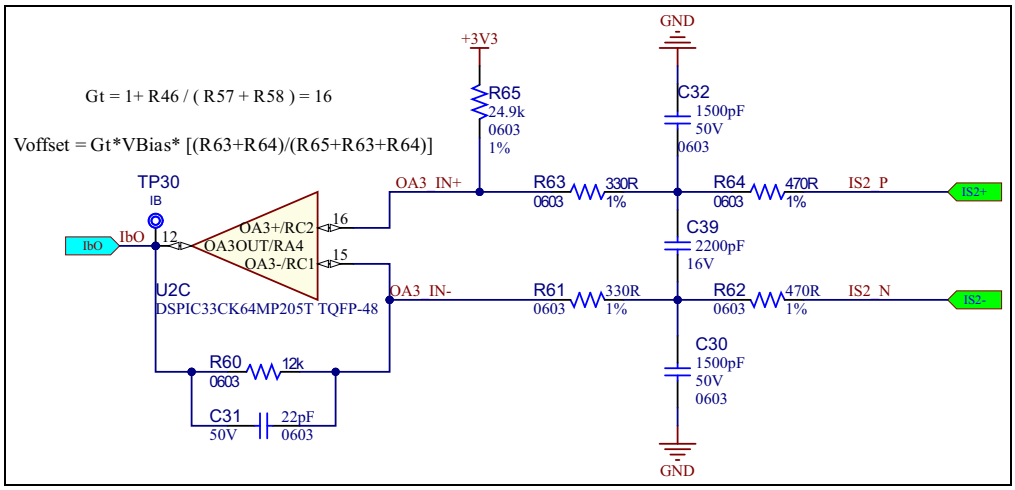


FIGURE 2-12: *Current Sense Amplifier from dsPIC33CK.*

NOTES:

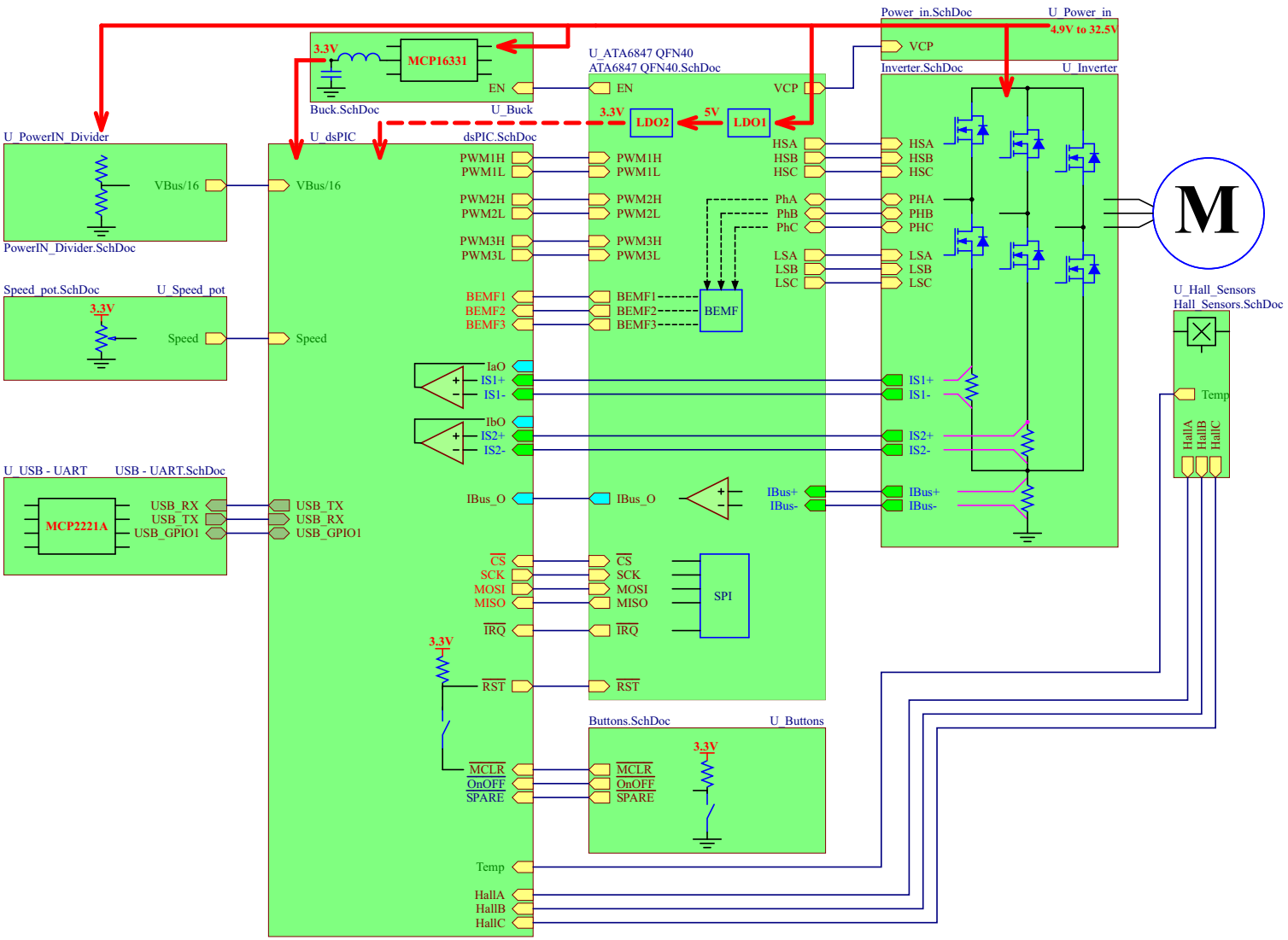
Appendix A. Schematics and Layouts

A.1 INTRODUCTION

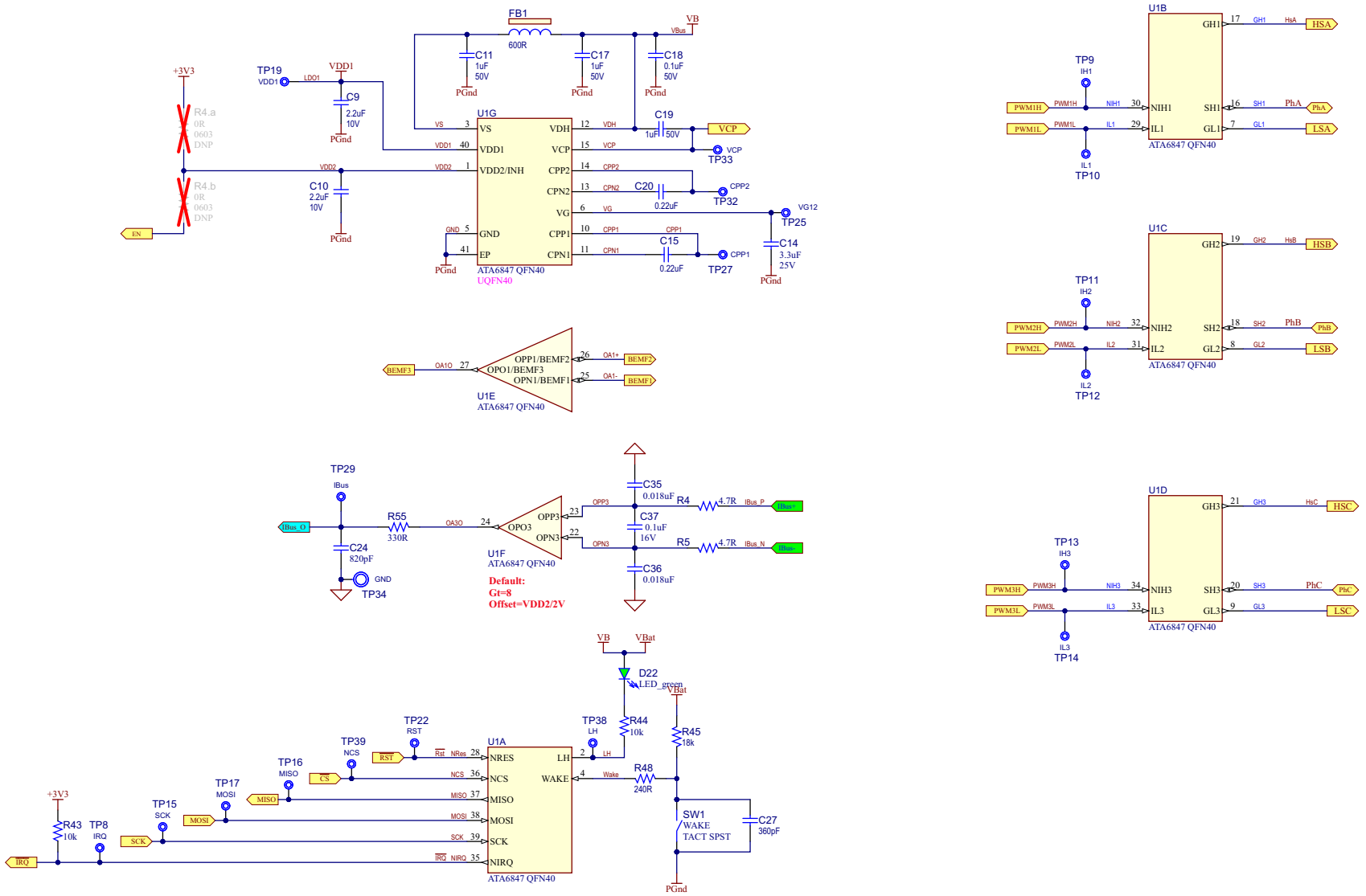
This appendix contains the schematics and layouts of the ATA6847 QFN40 BLDC Motor Driver Evaluation Board:

- EV43F54A – Top Schematic
- EV43F54A – ATA6847
- EV43F54A – dsPIC Connections
- EV43F54A – Hall Effect Sensors Connection
- EV43F54A – Inverter
- EV43F54A – Buck Converter
- EV43F54A – USB-UART Converter
- EV43F54A – Power Supply
- EV43F54A – Power Supply Divider
- EV43F54A – Push Buttons
- EV43F54A – Speed Potentiometer
- EV43F54A – Top Silk
- EV43F54A – Top Copper and Silk
- EV43F54A – Top Copper
- EV43F54A – Bottom Copper
- EV43F54A – Bottom Copper and Silk
- EV43F54A – Bottom Silk

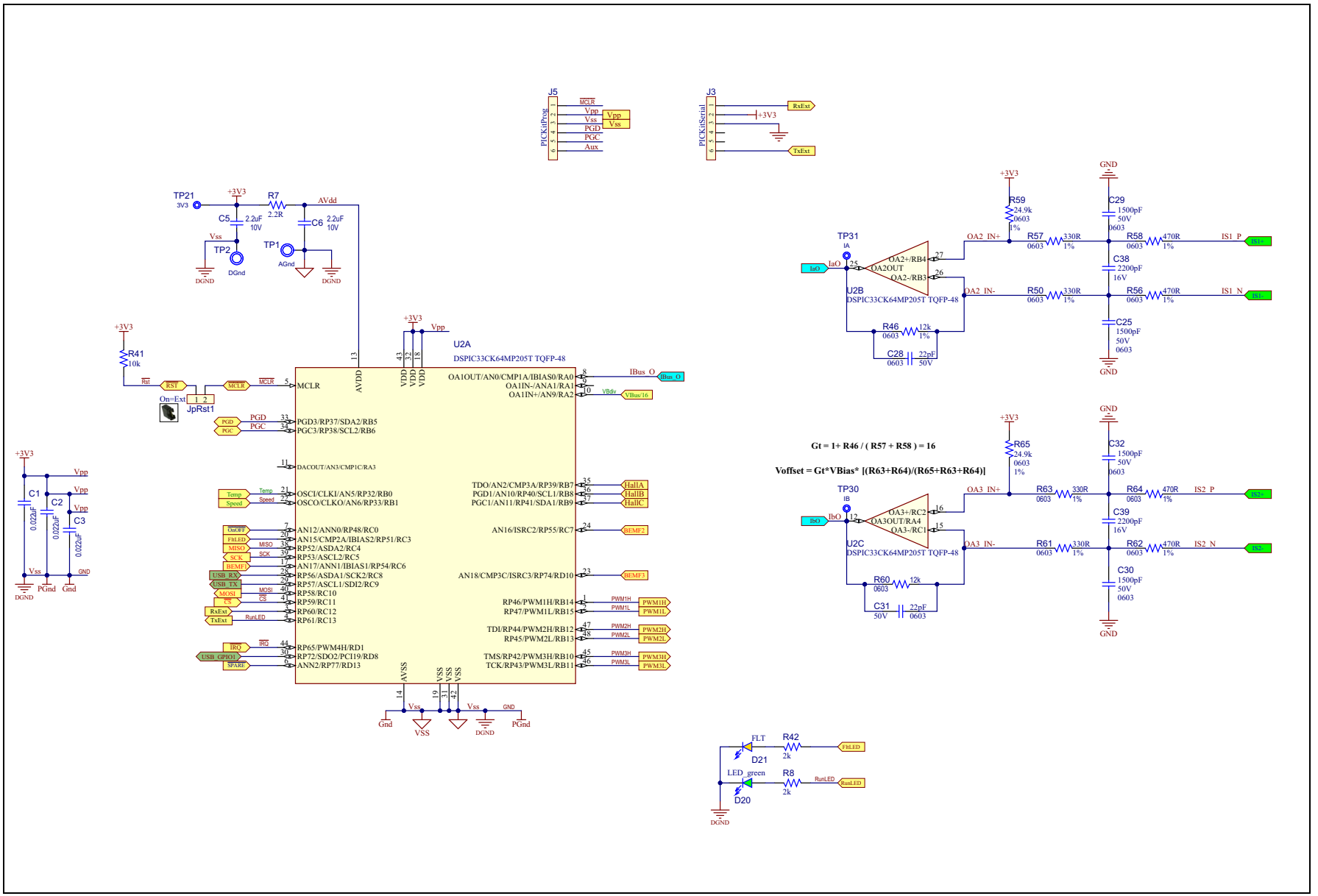
A.2 EV43F54A – TOP SCHEMATIC



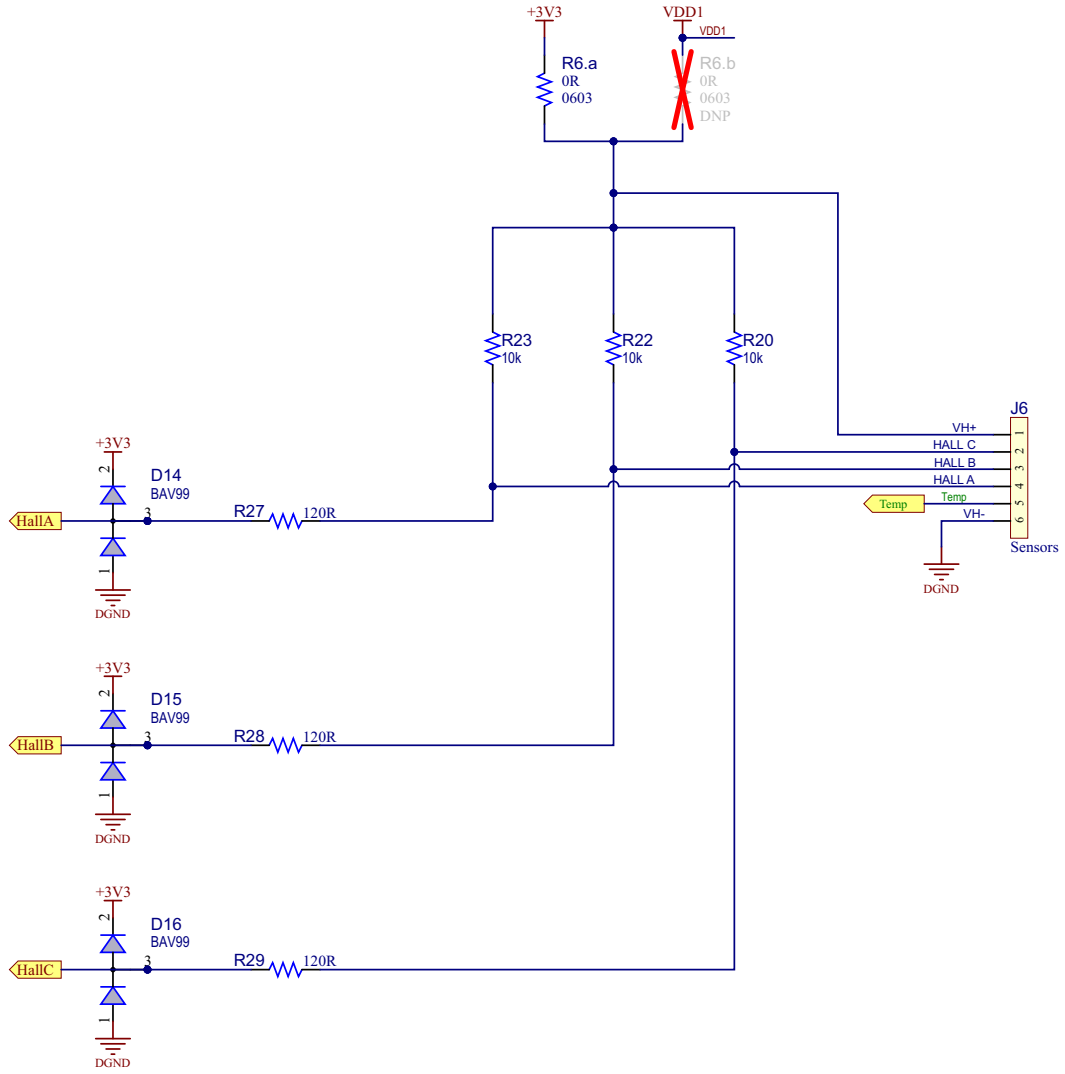
A.3 EV43F54A – ATA6847



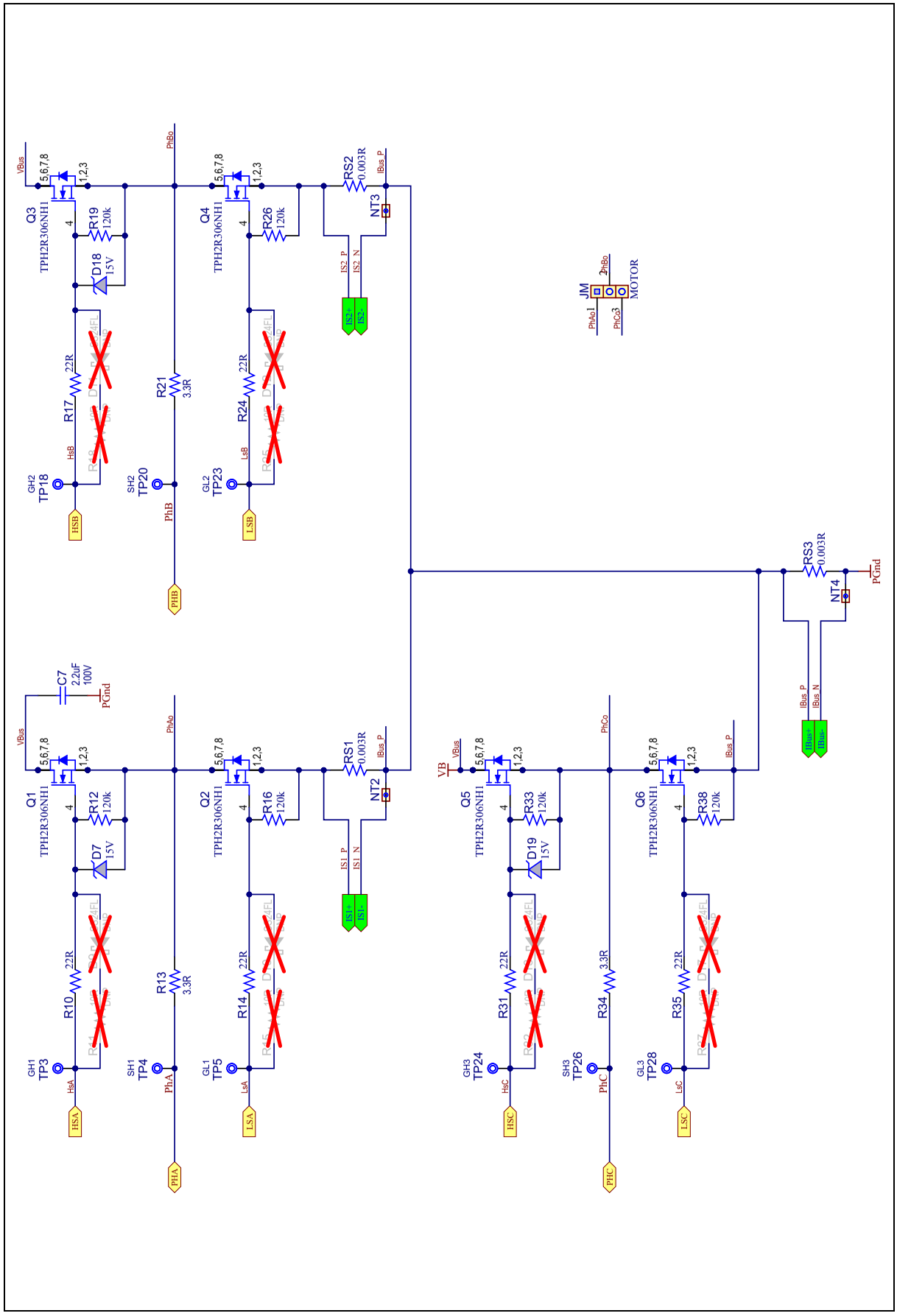
A.4 EV43F54A – DSPIC CONNECTIONS



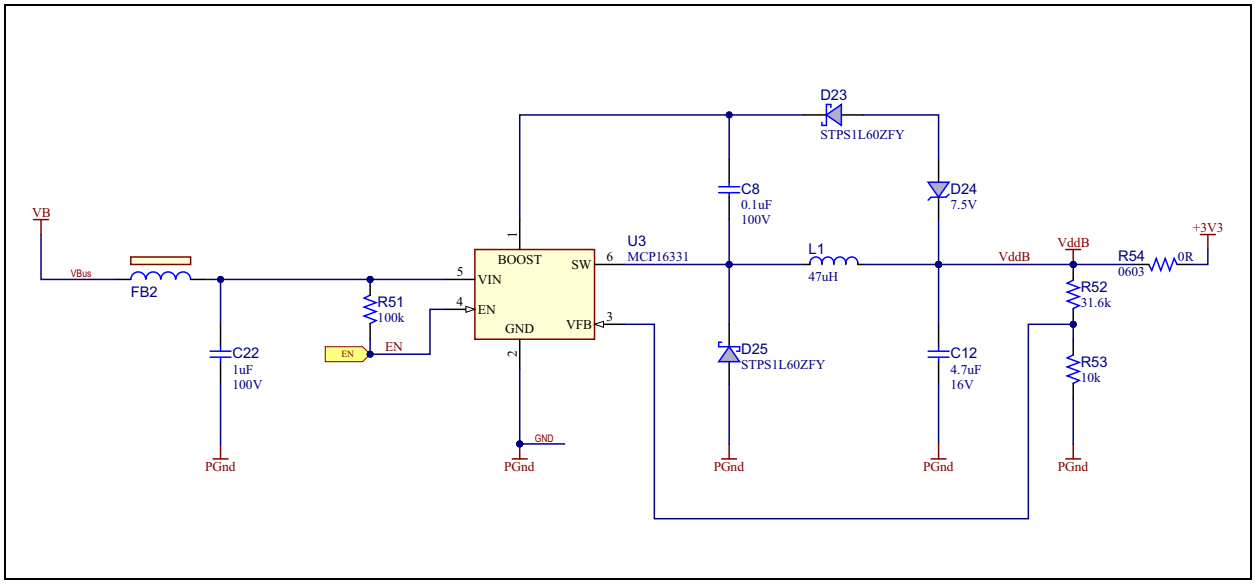
A.5 EV43F54A – HALL EFFECT SENSORS CONNECTION



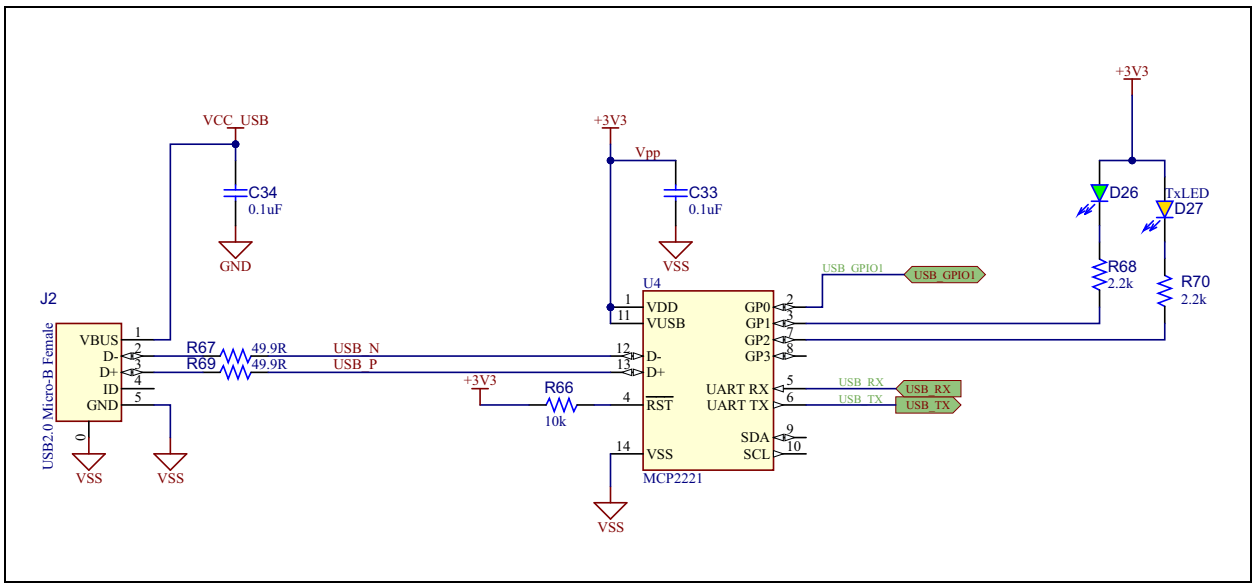
A.6 EV43F54A – INVERTER



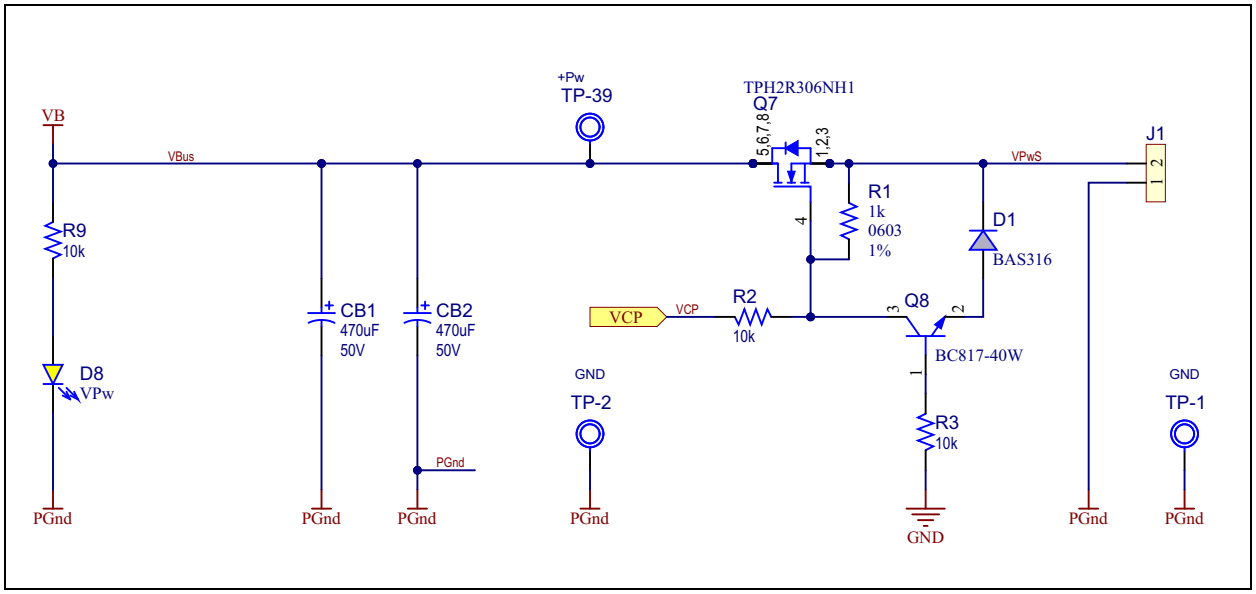
A.7 EV43F54A – BUCK CONVERTER



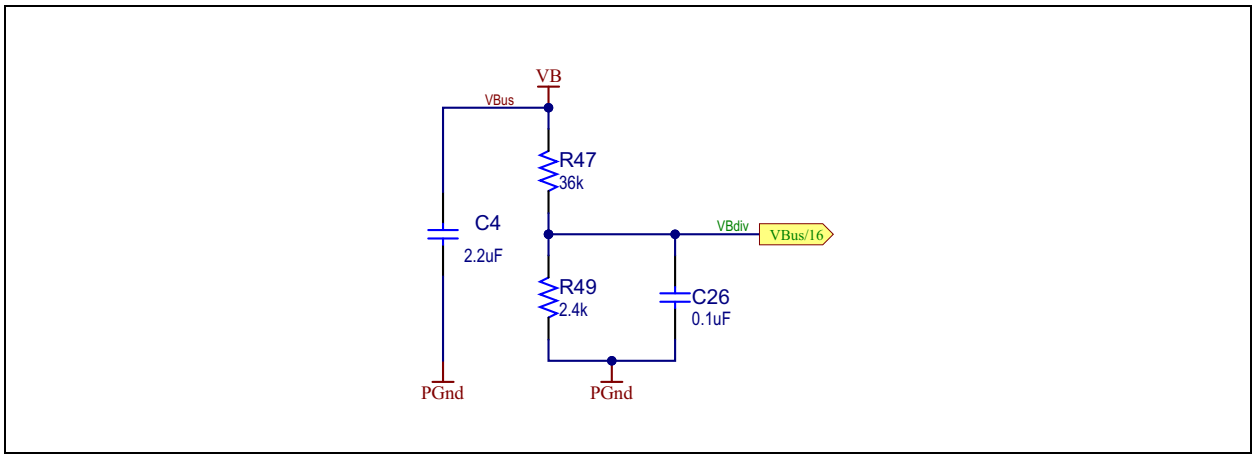
A.8 EV43F54A – USB-UART CONVERTER



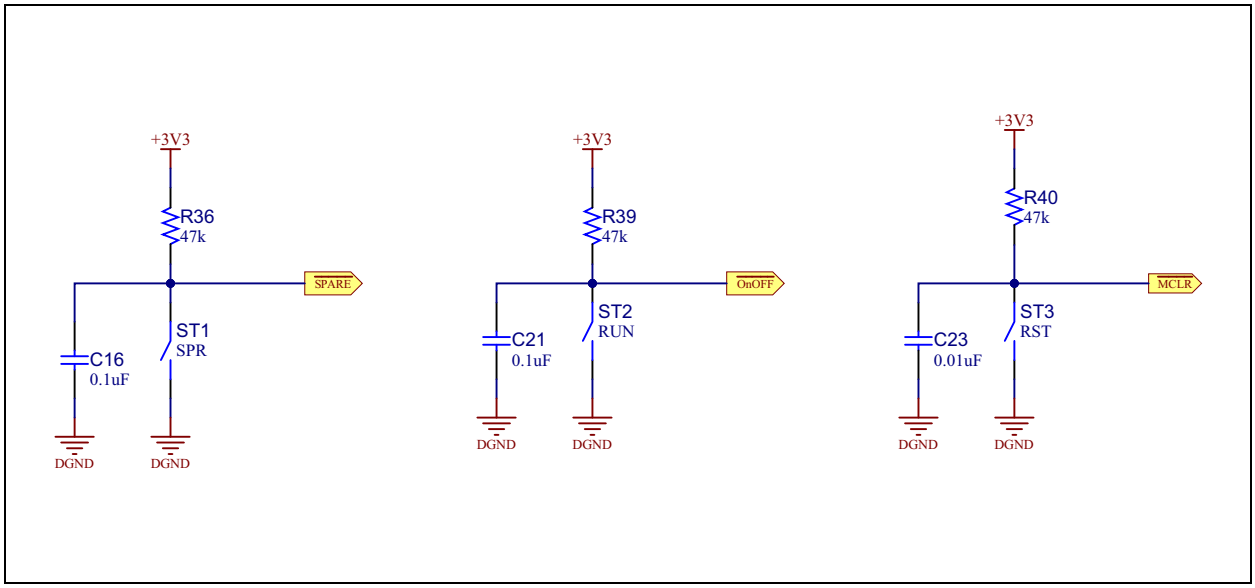
A.9 EV43F54A – POWER SUPPLY



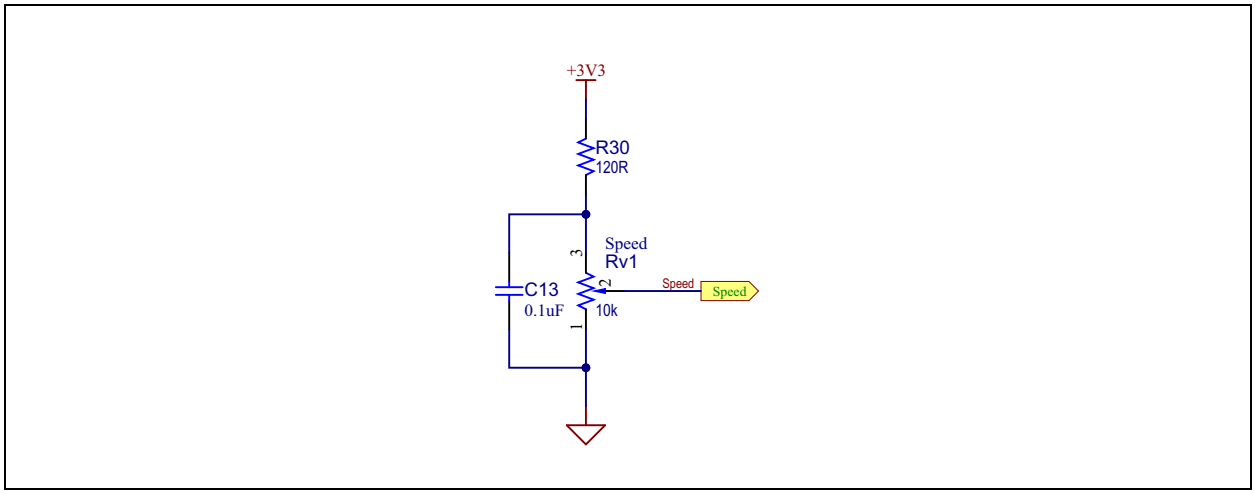
A.10 EV43F54A – POWER SUPPLY DIVIDER



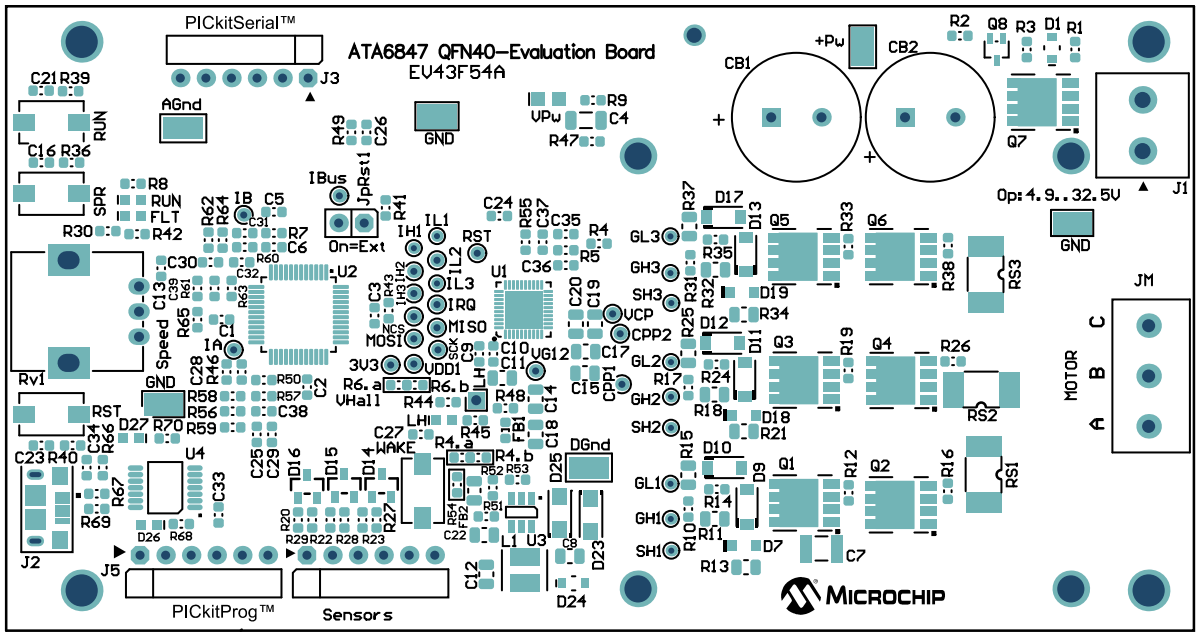
A.11 EV43F54A – PUSH BUTTONS



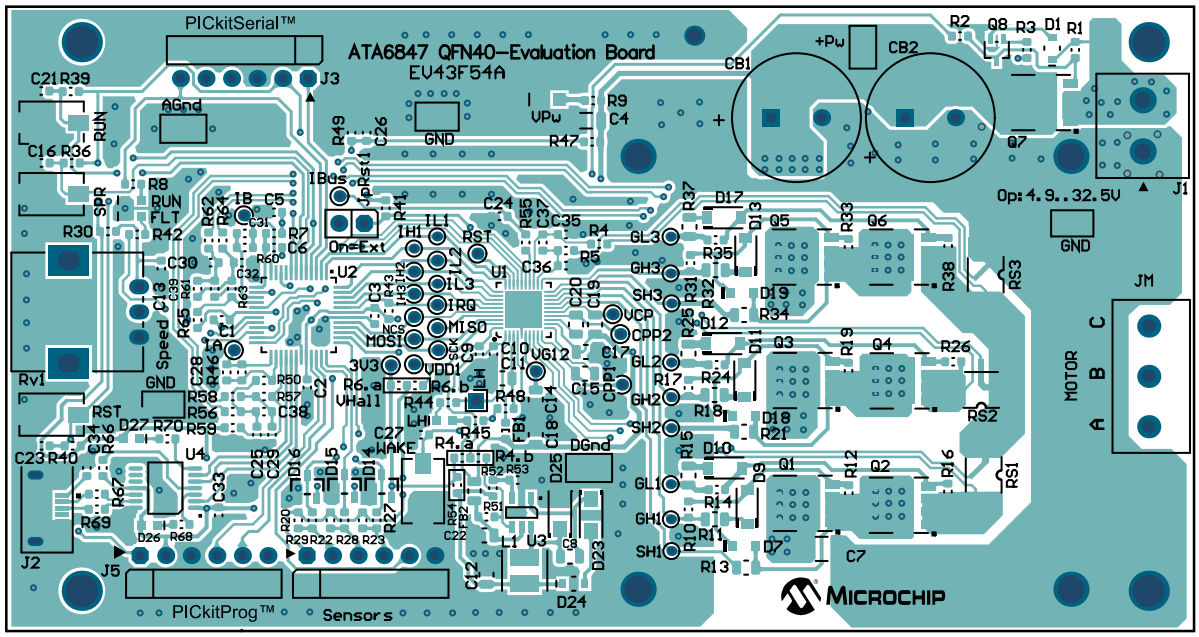
A.12 EV43F54A – SPEED POTENTIOMETER



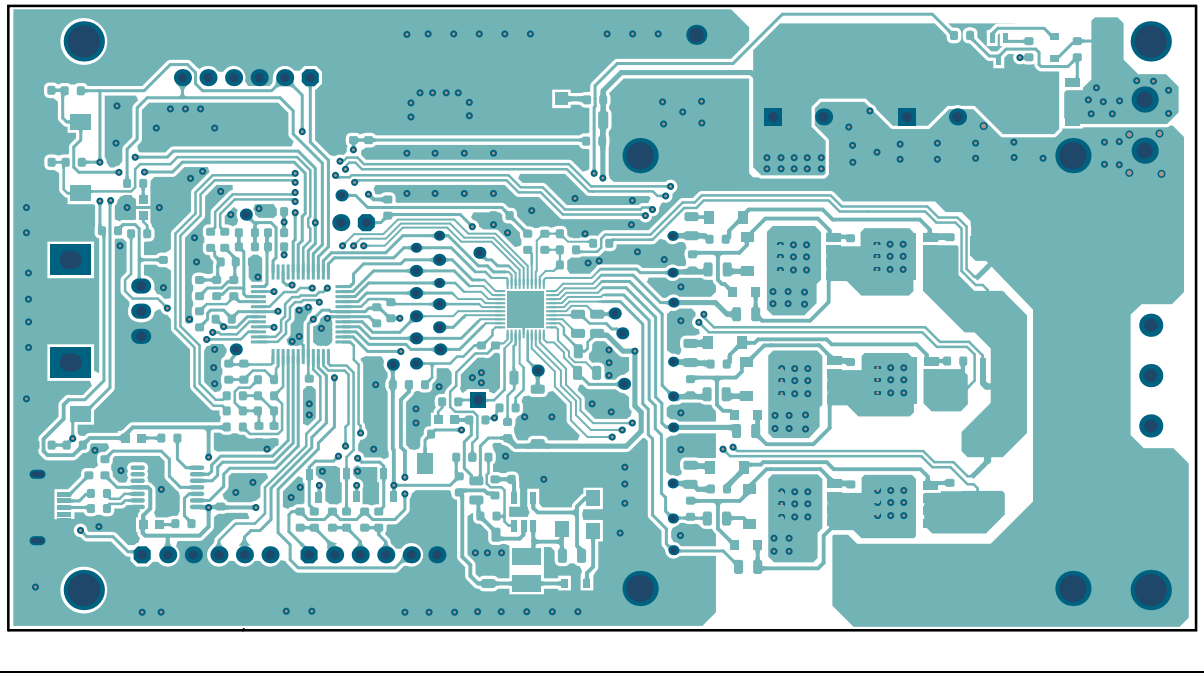
A.13 EV43F54A – TOP SILK



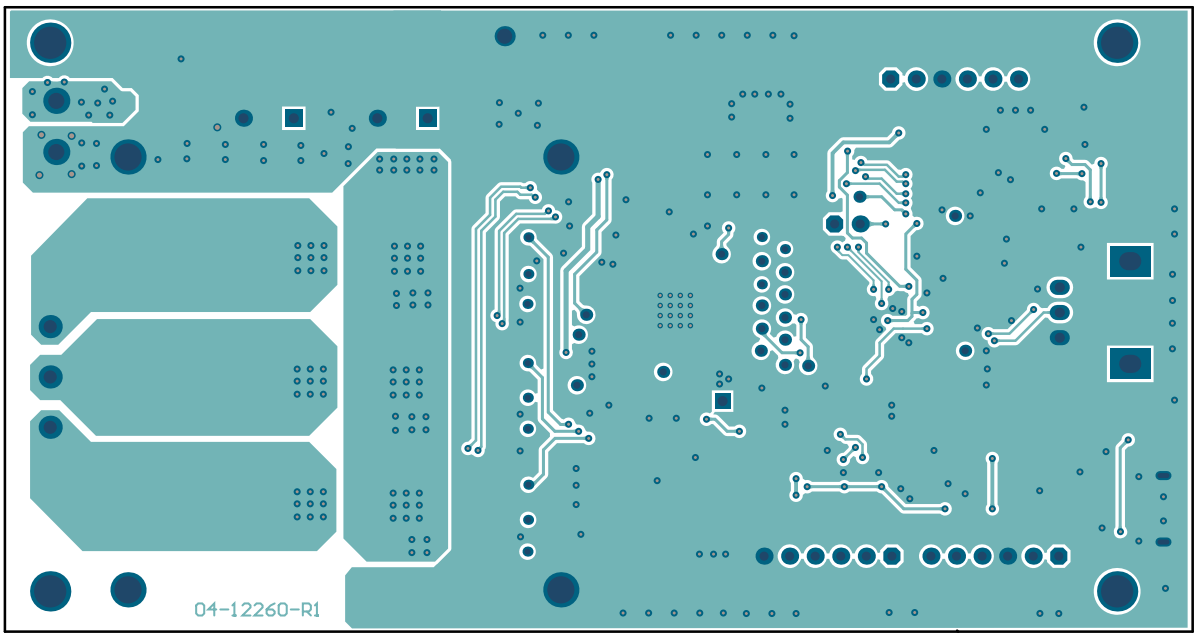
A.14 EV43F54A – TOP COPPER AND SILK



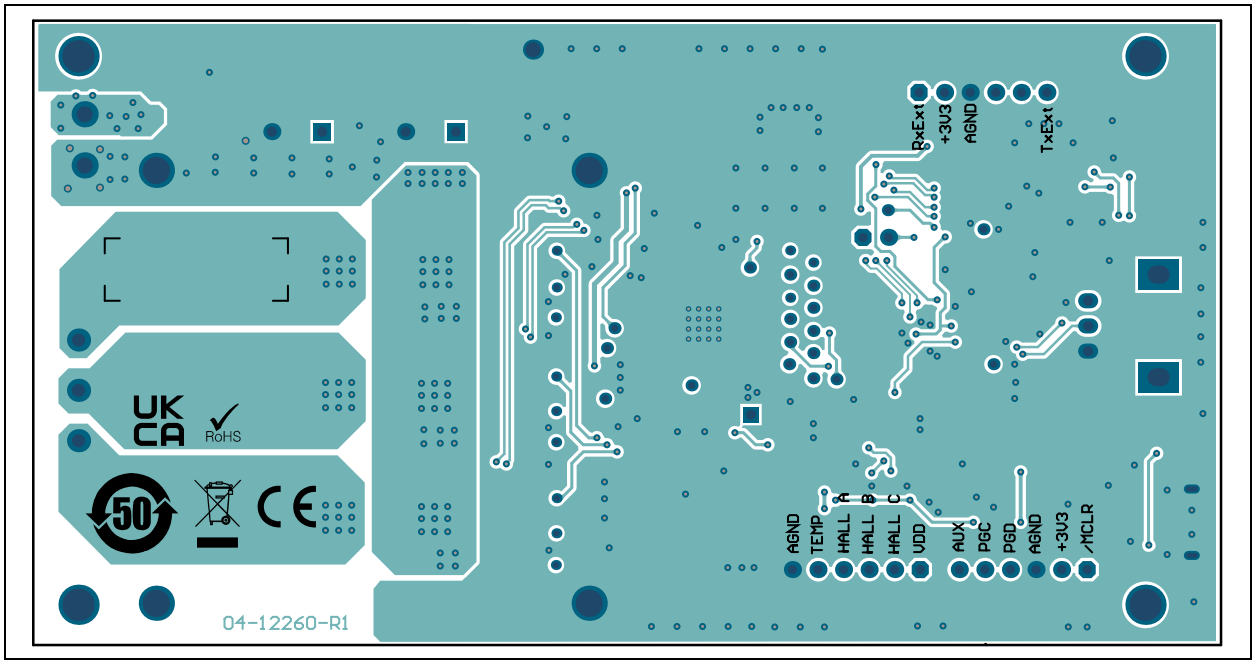
A.15 EV43F54A – TOP COPPER



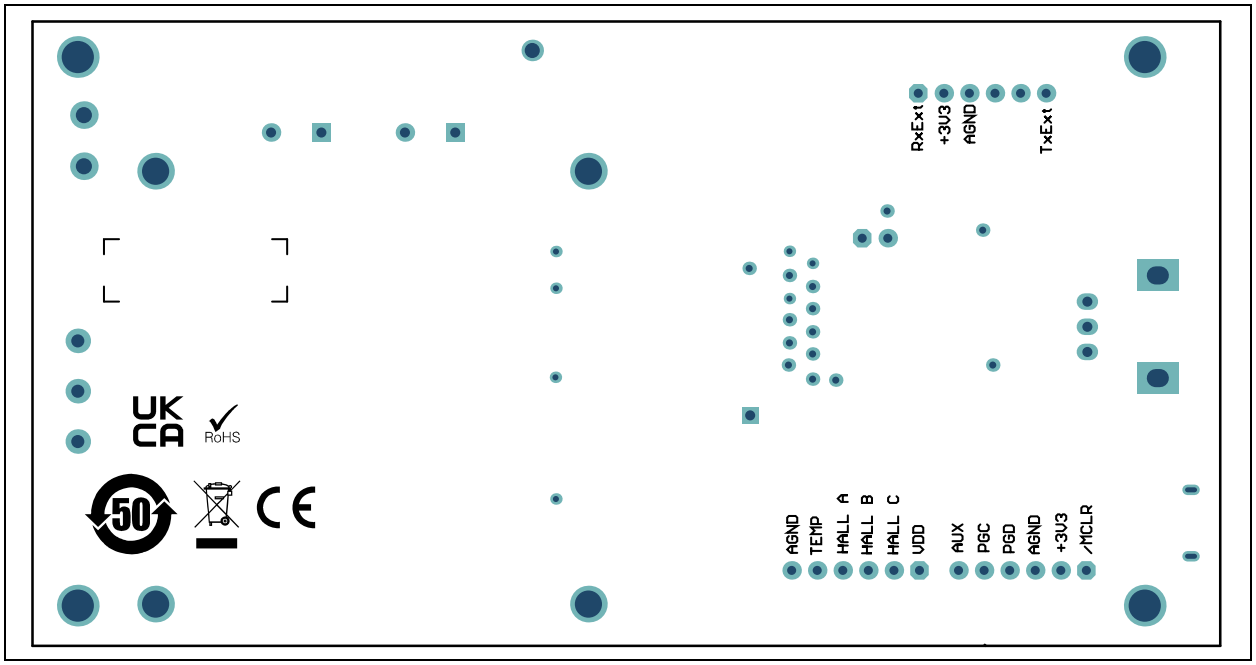
A.16 EV43F54A – BOTTOM COPPER



A.17 EV43F54A – BOTTOM COPPER AND SILK



A.18 EV43F54A – BOTTOM SILK



Appendix B. Bill of Materials (BOM)

TABLE B-1: BILL OF MATERIALS (BOM)

Qty.	Reference	Description	Manufacturer	Part Number
3	C1, C2, C3	Capacitor, ceramic, 0.022 µF, 25V, 10%, X7R, SMD, 0603	AVX Corporation	06033C223KAT2A
1	C4	Capacitor, ceramic, 2.2 µF, 50V, 10%, X7R, SMD, 1206	TDK Corporation	CGA5L3X7R1H225K160AB
4	C5, C6, C9, C10	Capacitor, ceramic, 2.2 µF, 10V, 10%, X7R, SMD, 0603	Taiyo Yuden Co., Ltd.	LMK107B7225KA-T
1	C7	Capacitor, ceramic, 2.2 µF, 100V, 10%, X7R, SMD, 1210	KEMET	C1210C225K1RACTU
1	C8	Capacitor, ceramic, 0.1 µF, 100V, 10%, X7R, SMD, 0805	AVX Corporation	08051C104K4T2A
3	C11, C17, C19	Capacitor, ceramic, 1 µF, 50V, 10%, X7R, SMD, 0805	Samsung Electro-Mechanics America, Inc.	CL21B105KBFNNNE
1	C12	Capacitor, ceramic, 4.7 µF, 16V, 10%, X7R, SMD, 0805	Murata Electronics	GRM21BR71C475KE51L
3	C13, C16, C21	Capacitor, ceramic, 0.1 µF, 25V, 20%, X7R, SMD, 0603	KEMET	C0603C104M3RACTU
1	C14	Capacitor, ceramic, 3.3 µF, 25V, 10%, X7R, SMD, 0805	TDK Corporation	C2012X7R1E335K125AB
2	C15, C20	Capacitor, ceramic, 0.22 µF, 50V, 10%, X7R, SMD, 0805	Murata	GCM21BR71H224KA37L
1	C18	Capacitor, ceramic, 0.1 µF, 50V, 10%, X7R, SMD, 0805	Yageo Corporation	08052R104K9B20D
1	C22	Capacitor, ceramic, 1 µF, 100V, 20%, X7S, SMD, 0805	TDK Corporation	C2012X7S2A105M125AB
1	C23	Capacitor, ceramic, 0.01 µF, 25V, 10%, X7R, SMD, 0603	Kyocera AVX®	06033C103KAT2A
1	C24	Capacitor, ceramic, 820 pF, 50V, 10%, X7R, SMD, 0603	Yageo Corporation	CC0603KRX7R9BB821
4	C25, C29, C30, C32	Capacitor, ceramic, 1500 pF, 50V, 10%, X7R, SMD, 0603	Yageo Corporation	CC0603KRX7R9BB152
1	C26	Capacitor, ceramic, 0.1 µF, 25V, 20%, Y5V, SMD, 0603	Samsung Electro-Mechanics America, Inc.	CL10F104ZA8NNNC
1	C27	Capacitor, ceramic, 360 pF, 50V, 5%, NP0, SMD, 0402	Murata Electronics North America	GRM1555C1H361JA01D
2	C28, C31	Capacitor, ceramic, 22 pF, 50V, 5%, NP0, SMD, 0603	Yageo Corporation	CC0603JRNP09BN220
2	C33, C34	Capacitor, ceramic, 0.1 µF, 25V, 10%, X7R, SMD, 0603	AVX Corporation	06033C104KAT2A

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
2	C35, C36	Capacitor, ceramic, 0.018 µF, 16V, 10%, X7R, SMD, 0603	KEMET	C0603C183K4RAC7867
1	C37	Capacitor, ceramic, 0.1 µF, 16V, 10%, X7R, SMD, 0603	Taiyo Yuden Co., Ltd.	EMK107B7104KA-T
2	C38, C39	Capacitor, ceramic, 2200 pF, 16V, 10%, X7R, SMD, 0603	AVX Corporation	0603YC222KAT2A
2	CB1, CB2	Capacitor, aluminum, 470 µF, 50V, 20%, RAD, P5D12.5H20	United Chemi-Con	EKZE500ELL471MK20S
1	D1	Diode, rectifier, BAS316, 1.25V, 250 mA, 100V, SOD-323	NXP Semiconductors	BAS316,115
3	D7, D18, D19	Diode, Zener, PZU15B,115, 15V 310 mW, SMD, SOD-323	Nexperia	PZU15B,115
1	D8	Diode, LED, yellow, 2.1V, 30 mA,10mcd, diffuse, SMD, 0805	Lumex Opto/Components Inc.	SML-LXT0805YW-TR
3	D14, D15, D16	Diode, rectifier, array, BAV99, 1.25V, 200 mA, 70V, SOT-23-3	Micro Commercial Components (MCC)®	BAV99-TP
3	D20, D22, D26	Diode, LED, green, 2V, 30 mA, 35mcd, clear, SMD, 0603	Lite-On®, Inc.	LTST-C190KGKT
2	D21, D27	Diode, LED, amber, 2.1V, 25 mA, 2mcd, clear, SMD, 0603	Lite-On, Inc.	LTST-C190AKT
2	D23, D25	Diode, Schottky, 570 mV,1A, 60V, SMD, SOD-123F	STMicroelectronics	STPS1L60ZFY
1	D24	Diode, Zener, 7.5V, 200 mW, SOD-323	Diodes Incorporated®	BZT52C7V5S-7-F
1	FB1	Ferrite, 600R@100 MHz, 300 mA, SMD, 0603	Murata Electronics North America	BLM18AG601SN1D
1	FB2	Ferrite, 30R@100 MHz, 8.5A, AEC-Q200, SMD, 0805	Murata Electronics North America	BLM21SN300SH1D
1	J1	Connector, terminal, 5.08 mm, 1x2, female, 12-28AWG, 16A, TH, R/A	On Shore Technology, Inc	EDZ350/2
1	J2	Connector, USB2.0, Micro-B, female, SMD, R/A	FCI	10118193-0001LF
3	J3, J5, J6	Connector, HDR-2.54, male, 1x6, gold, 5.84MH, TH, R/A	FCI	68016-106HLF
1	JM	Connector, terminal, 5 mm, 1x3, Female, 12-30AWG, 16A, TH, R/A	Wurth Electronics, Inc.	691137710003
1	JpRst1	Connector, HDR-2.54, male, 1x2, Tin, 6.75MH, TH, vertical	Molex Inc	0901200122
1	L1	Fixed Inductor, 47 µH, 450 mA, 834 mΩ	Wurth Electronik	74406032470
1	LABEL1	Label, PCBA, 18x6 mm, Datamatrix Assy#/Rev/Serial/Date	ACT Logimark AS	505462
1	PCB1	Printed Circuit Board	—	04-12260-R1
1	PCBA1	PCB Assembly	—	02-01196-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
7	Q1, Q2, Q3, Q4, Q5, Q6, Q7	Transistor, FET, N-Channel, 40V, 136A, 0.0023R, 800 mW, VDFN-8	Toshiba Semiconductor and Storage	TPH2R306NH1,LQ
1	Q8	Transistor, BJT, NPN, 45V, 500 mA, 200 mW, SOT-323-3	Diodes Incorporated	BC817-40W-7
1	R1	Resistor, Thick Film, 1k, 1%, 1/10W, SMD, 0603	Vishay® Dale	CRCW06031K00FKEA
2	R4, R5	Resistor, Thick Film, 4.7R, 1%, 1/10W, SMD, 0603	Vishay Dale	CRCW06034R70FNEA
1	R7	Resistor, Thick Film, 2.2R, 5%, 1/10W, SMD, 0603	Stackpole Electronics Inc	RMCF0603JT2R20
2	R8, R42	Resistor, Thick Film, 2k, 1%, 1/10W, SMD, 0603	Panasonic® - ECG	ERJ-3EKF2001V
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	Panasonic - ECG	ERJ-3EKF1203V
3	R13, R21, R34	Resistor, Thick Film, 3.3R, 1%, 1/8W, SMD, 0805	Vishay Dale	CRCW08053R30FKEA
7	R2, R3, R9, R20, R22, R23, R66	Resistor, Thick Film, 10k, 5%, 1/10W, SMD, 0603	Panasonic - ECG	ERJ-3GEYJ103V
4	R27, R28, R29, R30	Resistor, Thick Film, 120R, 1%, 1/10W, SMD, 0603	Stackpole Electronics Inc	RMCF0603FT120R
3	R36, R39, R40	Resistor, Thick Film, 47k, 1%, 1/10W, SMD, 0603	Panasonic - ECG	ERJ-3EKF4702V
3	R41, R43, R44	Resistor, Thick File, 10k, 1%, 1/16W, SMD, 0603	TE Connectivity Passive Product	CPF0603F10KC1
1	R45	Resistor, Thick Film, 18k, 5%, 1/10W, SMD, 0603	Panasonic - ECG	ERJ-3GEYJ183V
2	R46, R60	Resistor, Thick Film, 12k, 1%, 1/10W, SMD, 0603	Stackpole Electronics Inc	RMCF0603FT12K0
1	R47	Resistor, Thick Film, 36k, 1%, 1/10W, SMD, 0603	Panasonic - ECG	ERJ-3EKF3602V
1	R48	Resistor, Thick Film, 240R 1% 1/10W SMD 0603	Yageo Corporation	RC0603FR-07240RL
1	R49	Resistor, Thick Film, 2.4k, 1%, 1/10W, SMD 0603	Yageo Corporation	RC0603FR-072K4L
5	R50, R55, R57, R61, R63	Resistor, Thick Film, 330R, 1%, 1/10W, SMD, 0603	Panasonic - ECG	ERJ-3EKF3300V
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
1	R53	Resistor, Thick Film, 10k, 1%, 1/10W, SMD, 0603	TE Connectivity Passive Product	CRG0603F10K
1	R54	Resistor, Thick Film, 0R 1/10W, SMD, 0603, AEC-Q200	Panasonic - ECG	ERJ-3GEY0R00V

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
4	R56, R58, R62, R64	Resistor, Thick Film, 470R, 1%, 1/10W, SMD, 0603	Panasonic - ECG	ERJ-3EKF4700V
2	R59, R65	Resistor, Thick Film, 24.9k, 1%, 1/10W, SMD, 0603	Panasonic - ECG	ERJ-3EKF2492V
1	R6.a	Resistor, Thick Film, 0R, 1/10W, SMD, 0603	Panasonic - ECG	ERJ-3GSY0R00V
2	R67, R69	Resistor, Thick Film, 49.9R, 1%, 1/10W, SMD, 0603, AEC-Q200	Vishay Dale	CRCW060349R9FKEA
2	R68, R70	Resistor, Thick Film, 2.2k, 5%, 1/10W, SMD, 0603	Panasonic - ECG	ERJ-3GSYJ222V
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, 6X3.5 mm	TE Connectivity Alcoswitch Switches	147873-2
2	TP1, TP2	Connector, test point, TAB, silver, mini, 3.8x2.03 SMD	Keystone Electronics	5019
4	TP34, TP-1, TP-2, TP-39	Connector, test point, TAB, silver, mini, 3.8x2.03, SMD	Keystone Electronics	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, Lite, QFN-40	Microchip Technology, Inc.	ATA6847T-5033H/NHX
1	U2	MCU, 16-bit, 64K, TQFP-48	Microchip Technology, Inc.	DSPIC33CK64MP205-I/PT
1	U3	Analog Switcher Buck 2 to 24V SOT-23-6	Microchip Technology, Inc.	MCP16331T-E/CH
1	U4	Interface, USB, I2C, UART, TSSOP-14	Microchip Technology, Inc.	MCP2221-I/ST

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) – DO NOT POPULATE PARTS

Qty.	Reference	Description	Manufacturer	Part Number
0	D9, D10, D11, D12, D13, D17	Diode, Schottky, 40V, 2A, SOD-123F	onsemi™	SS24FL
0	R4.a, R4.b, R6.b	Resistor, Thick Film, 0R, 1/10W, SMD, 0603	Panasonic - ECG	ERJ-3GSY0R00V
0	R11, R15, R18, R25, R32, R37	Resistor, Thick Film, 10R, 1%, 1/8W, SMD, 0805	ROHMSemiconductor	MCR10EZHF10R0

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 ATA6847 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 "ATA6847.h" file. The driver registers and their specific properties are defined below.

```
//**** ATA6847 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 "ATA6847.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 ATA6847 registers and bitwise definition can be found in the “ATA6847.h” file.

```
//***************************************************************************//
//  ATA6847 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 VdIOOVSD: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.TSWTO     =  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    = AdDT_Dis ;  // Adaptive dead-time HS disabled;
   ATA6847_REGS.REG_VAL.GDUCR3_CFG.ADDTLS    = AdDT_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 ////////////////////////////UVVGSLVL
   ATA6847_REGS.REG_VAL.GDUCR4_CFG.VGSUVFLT  = Set_VGSUVFLT( VGSUVFLT_nS );
   ATA6847_REGS.REG_VAL.GDUCR4_CFG.UVVGSLVL  = Active;   // VGS/VG under-voltage detection level
selection(default=1)
   ATA6847_REGS.REG_VAL.GDUCR4_CFG.UVVGSSEN  = 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.ADDERSS = 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.ADDERSS    = 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************************//
#ifdef    HURST_Big
#define   NOMINALSPEEDINRPM  3150
#define   MINSPEEDINRPM      550  // 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   SMCGAIN            0.525
#define   MAXLINEARSMC       0.475   //
#endif
```

C.4 DSPIC33CK256MP508 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 -> ATA6847 ////////////////////
#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  -> ATA6847 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 `EV43F54A_ck_205.X`
5. In the Projects window, right mouse-click on `EV43F54A_ck_205.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 `EV43F54A_ck_205.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™ 3 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 `EV43F54A_ck_205.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 24V. Turn off the power supply.
8. Connect the bench power supply to the evaluation board. Connect +V(24V) to J1-2 and -V(Ground) to J1-1.
9. Turn on the power supply.
10. Right mouse-click on `EV43F54A_ck_205.X` in the Projects window and select “Make and Program Device”. This will compile the firmware and program the dsPIC33CK64MP205 processor.
11. The compiler results will be displayed in the Output window frame. Verify success.
12. Connect a Brushless DC (BLDC) motor to connector JM1 (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, 2, 3) test points will show the external MOSFET gate drive signals.
20. Momentarily press the RUN switch again to stop the motor.

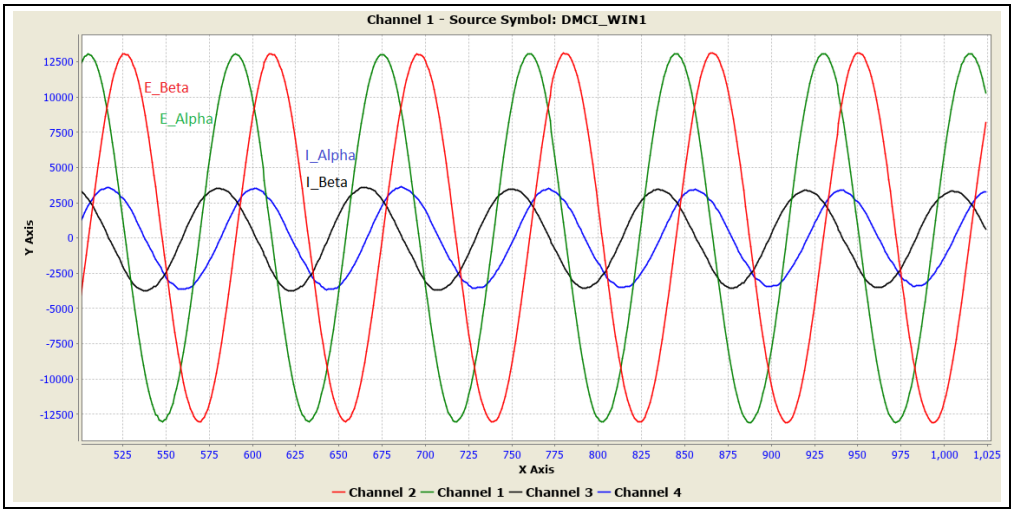
C.7 MPLAB® X DMCI WINDOW EXERCISE

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

1. In the opened project, open the “UserParms.h” header file, find the line where the processor directive `//#undef DMCI_WIN` (which undefines the DCMI window) is located. Comment that line.
2. In the `EV43F54A_ck_205.c`, the sections related to DMCI will become active.
3. Find the section where the desired variables are assigned to the DMCI declared vectors. For example, see the variables below:

```
#ifdef DMCI_WIN              // For test pourposes
    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 3(4)(5) 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-> DCMI Window*.
9. In *Dynamic Data View* right click on each Data Source window and assign one of DMCI_WIN1[ ] to DMCI_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 DMCI_WIN` line uncommented, as described above, in C6 section, in the desired motor control mode.