EVM User's Guide: MCF8315RRYEVM
MCF8315 Evaluation Module

TEXAS INSTRUMENTS

Description

The MCF8315RRYEVM allows users to evaluate the performance of a MCF8315 motor driver. The EVM includes an onboard FTDI chip to convert USB communication, from the micro-USB connector, into UART. An onboard MSP430FR2355 microcontroller (MCU) translates the UART communication into control signals, which is sent to the MCF8315 device. There are many user-selectable jumpers, resistors, connectors, and test points to assist with evaluating the many features of the MCF8315 IC and the configurable device-specific settings.

Get Started

1. Download the latest design files from the MCF8315RRYEVM tool page.
2. Download the latest version of the Motor Studio GUI and firmware from the Motor Studio tool page.

Features

- GUI software to simplify the MCx tuning process and performance evaluation
- MCU-to-MCx shunt jumper header with removable shunts to disconnect main signals going to the motor driver IC from the MCU
  - The shunts can be removed if the user desires to control the MCF8315 IC with an external MCU or to use the EVM MCU to control an external MCF8315 IC

Applications

- Brushless-DC (BLDC) motor modules
- Residential and living fans
- Air purifiers and humidifier fans
- Washer and dishwashers pumps
- Automotive fan and blowers
- CPAP machines
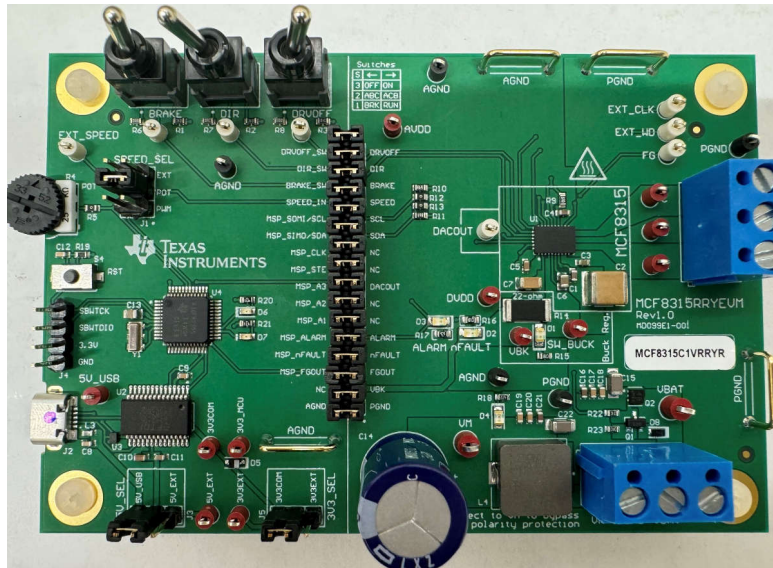
MCF8315RRYEVM (Top View)

1 Evaluation Module Overview

1.1 Introduction

This document is provided with the MCF8315 customer evaluation module (EVM) as a supplement to the MCF8315C Three-Phase Sensorless-FOC BLDC Motor Driver data sheet. This user's guide details the hardware setup instructions, GUI installation, and usage instructions.

Observe the following cautions and warnings as printed on the EVM board.

HOT SURFACE

Hot surface temperature. The EVM can have high surface temperatures marked by the FIRE triangular symbol on the EVM. Avoid touching the marked hot surface are when driving high currents to prevent potential burn damage.

1.2 Kit Contents

Table 1-1 lists the contents of the EVM kit. Contact the Texas Instruments Product Information Center nearest to you if any components are missing. TI highly recommends that users check the TI website at https://www.ti.com to verify that the latest version of the related software is being used.

Table 1-1. Kit Contents

Item	Quantity
MCF8315RRYEVM	1
USB A to USB B micro cable	1

1.3 Specification

The MCF8315RRYEVM can support voltages up to 35V and currents up to 4A. To prevent damage to both the IC and the EVM, confirm that these voltage and current specifications are not exceeded.

To check which MCF8315 chip is populated on the EVM by default by looking at the sticker label, see Figure 1-1 for the sticker label location, with the default part number of MCF8315 referenced.
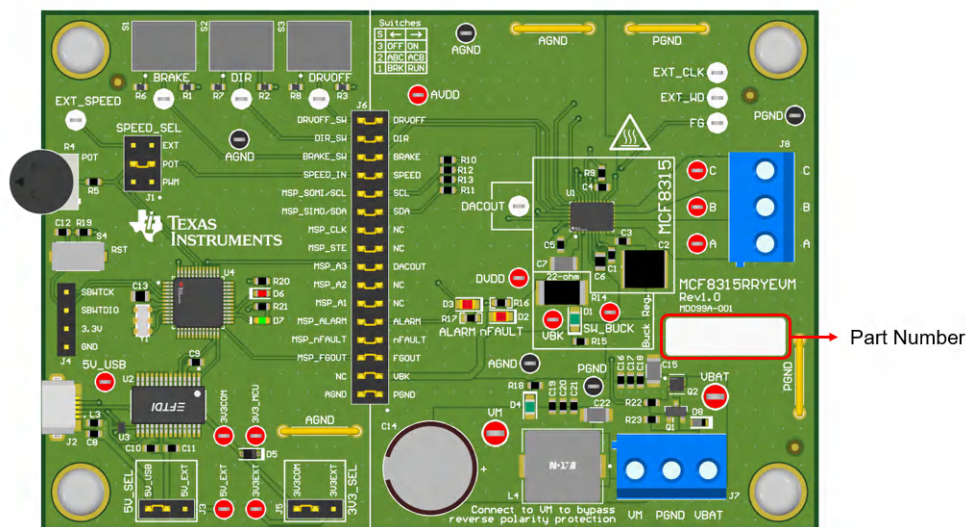

Figure 1-1. MCF8315RRYEVM Part Number

1.4 Device Information

The MCF8315 is a 4.5V to 35V, 4A peak integrated three-phase gate driver IC with code-free sensorless field-oriented control (FOC) for motor drive applications. The MCF8315 provides three accurately trimmed and temperature compensated half-bridge MOSFETS, gate drivers, charge pump, current sense amplifier, linear regulator for the external load and adjustable buck regulator. The I2C interface allows for configuration of the various device settings and reading fault diagnostic information through an external controller.

The internal sensorless FOC algorithm is highly configurable through register settings in a non-volatile EEPROM ranging from motor start-up behavior to closed loop operation, which allows for the device to operate stand-alone once the device has been configured. The device can receive a speed command through a PWM input, analog voltage, variable frequency square wave, or I2C command. There are a large number of protection features integrated into the MCF8315, intended to protect the device, motor, and system against fault events.

Table 1-2. MCx8315

Part Number	Commutation Type
MCF8315C1VRRYR	FOC

2 Hardware

2.1 Quick Start Guide

The MCF8315RRYEVM requires a power supply source, which has a recommended operating range from a 4.5V to 35V. To setup and power the EVM, follow the sequence below:

1. Connect motor phases to A, B, C on connector J8.
2. Do not turn on the power supply yet. Connect motor supply to VBAT/VM and PGND on connector J7.
   a. To enable reverse polarity protection and Pi filter, connect to VBAT. Note that when connecting to VBAT, VM is VM – 0.7V less, due to a diode drop in the reverse-polarity protection circuit.
   b. To disable reverse-polarity protection and the Pi filter, connect to VM.
3. Set J3 to 5V_USB and J5 to 3V3COM to power MSP430™ from USB power supply.
4. Connect the micro-USB cable to the computer.
5. Turn the potentiometer fully clockwise to set the motor to zero speed upon powerup.
6. Flip the switch S1 to the right to configure BRAKE = RUN, switch S2 to the left to configure DIR = ABC, and switch S3 to the right to configure DRVOFF = ON
7. Set J1 to POT to apply the analog voltage from potentiometer R4 to the SPEED pin.
8. Turn on the motor power supply.
9. Use the potentiometer R4 to control the speed of the motor and the switches to disable the motor driver, change the direction, or apply a brake to the motor. Optionally, use the GUI (as shown in Section 3) to monitor real-time speed of the motor, put the MCF8315 into a low-power sleep mode, and read status of the LEDs.
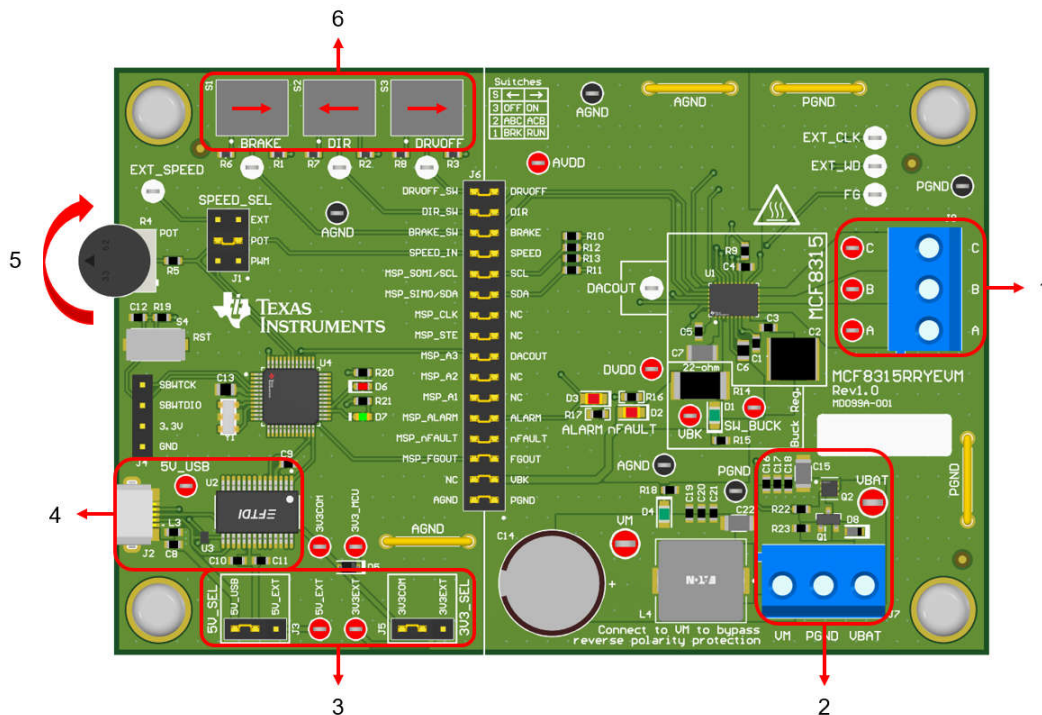

Figure 2-1. Reference for Quick Start Guide

2.2 Hardware Setup

The hardware required to run the motor is the MCF8315RRYEVM, a micro-USB cable, and a power supply with a DC output from 4.5V to 35V. Follow these steps to start up the MCF8315RRYEVM:

1. Connect the DC power supply to header J7. Connect to VBAT and PGND to apply reverse polarity protection and the pi filter to the EVM. Otherwise, connect to VM and PGND to bypass the reverse polarity protection and pi filter.
2. Apply user configurable jumper settings. See Section 2.7 for more information.
3. Flash the firmware into the MCU as described in Section 3.4. Launch Motor Studio and disconnect the 4-pin JTAG connections.
4. Turn on the power supply to power up the MCF8315RRYEVM.
5. Connect a micro-USB cable to the MCF8315RRYEVM and computer.

If using the MCF8315RRYEVM with an external microcontroller, remove all shunt jumpers from jumper bridge J6. Connect with external jumpers to the right side of the jumper bridge from the external MCU.

2.3 Hardware Connections Overview – MCF8315RRYEVM

Figure 2-2 shows the major blocks of MCF8315RRYEVM. The MCF8315RRYEVM is designed for an input supply from 4.5V to 35V. The MCF8315 includes three integrated half-bridges and implements a sensorless FOC algorithm to spin a motor with up to 4A peak current. The MCF8315 also integrates an adjustable buck regulator. For interfacing with the GUI, the MCF8315RRYEVM has an onboard FTDI chip and MSP430.
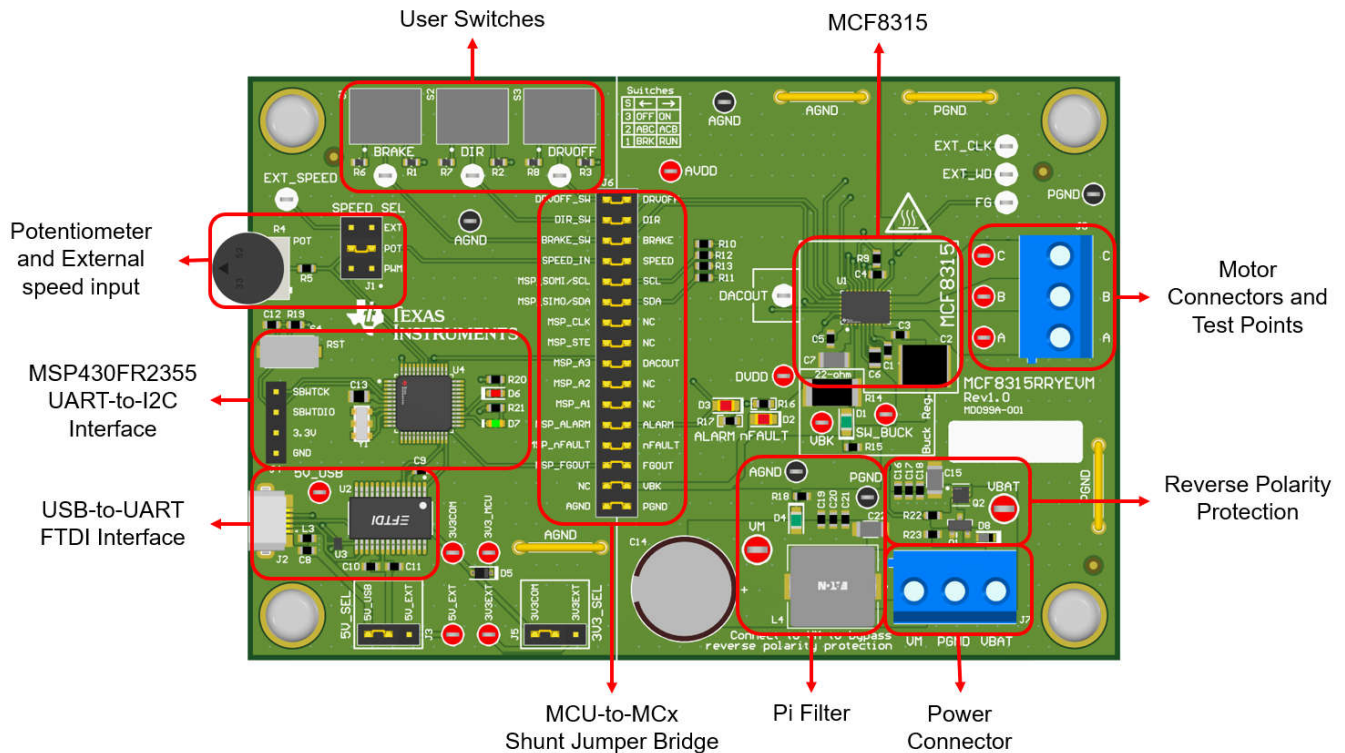

Figure 2-2. MCF8315RRYEVM Major Hardware Blocks

2.4 Connection Details

Figure 2-3 outline which connections must be made to the MCF8315RRYEVM to spin a 3-phase sensorless brushless-DC motor.

Connect a 4.5V to 35V power supply or battery to VBAT or VM and PGND terminals on connector J7. There is a reverse polarity protection and Pi filter implemented on the VBAT and PGND terminals. To bypass the reverse polarity protection and Pi filter, connect the power supply to the VM terminal or VM test point on the board and PGND.

Connect the three phases of the BLDC motor to the A, B, and C terminals of the screw terminal connector J8.
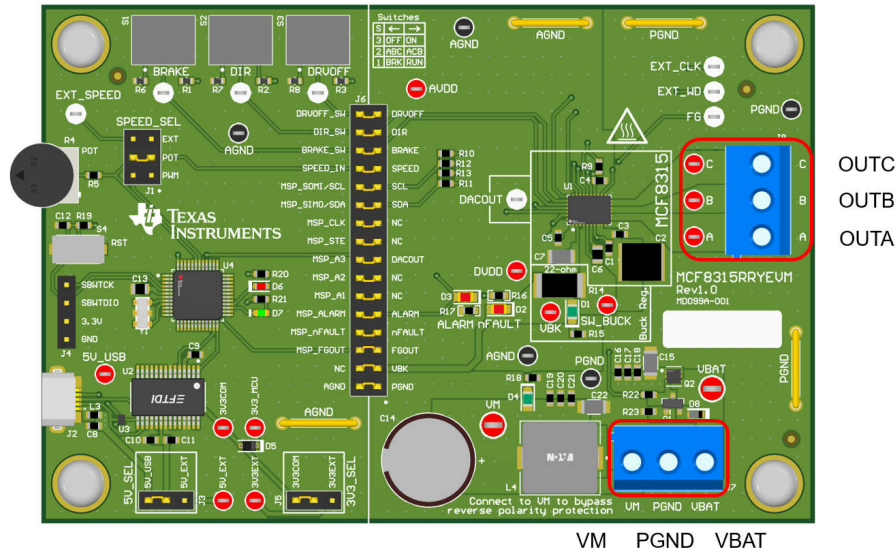
Figure 2-3. Connections from Motor to MCF8315RRYEVM

Figure 2-4 shows where the micro-USB cable is plugged into the MCF8315RRYEVM to provide communication between evaluation module and GUI. The USB data and 5V power from the USB is converted, by the FTDI chip, into UART data and 3.3V power which is used to power the MSP430FR2355 microcontroller. The 5V from the USB power is limited to 500mA and the 3.3V from the FTDI chip is limit to 30mA. If the user wishes to supply more current to these rails, then users can use the 5V_SEL jumper J3 and 3V3_SEL jumper J5 to connect external power rails.
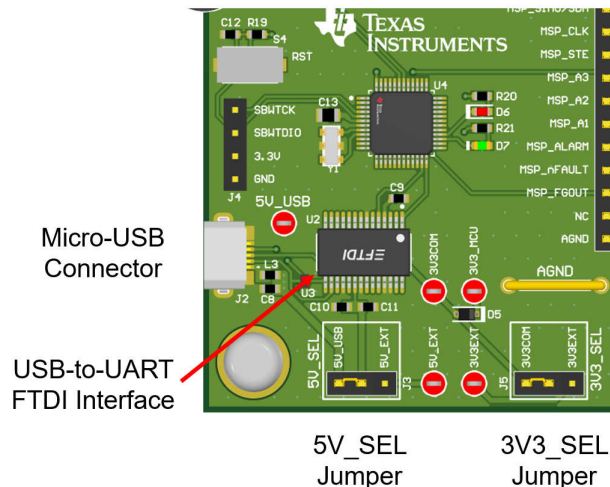

Figure 2-4. Micro-USB Connector and USB-to-UART interface

2.5 MSP430FR2355 Microcontroller

The MCF8315RRYEVM includes the MSP430FR2355 low-power MCU (as shown in Figure 2-5) to communicate via I2C with the MCF8315 IC.

To program the MSP430FR2355, an external MSP430 FET programmer must be connected to the Spy-Bi-Wire (SBW) interface connector J4. Many MSP430 LaunchPads™ provide an onboard eZ-FET Debug Probe that can be jumper-wired to the MCF8315RRYEVM to flash the firmware into the onboard MSP430FR2355 microcontroller.

The user can use the Reset (RST) S4 button at any time to restart the MCU program. Two active-low LEDs, D6 and D7, can be used for debug purposes as well.

The 32-pin shunt jumper bridge J6 ties all signals between the microcontroller and MCF8315 IC. These jumpers can be inserted or removed as needed to isolate the microcontroller from the gate driver. This allows for microcontroller signal debugging or using the MCF8315RRYEVM as a standalone gate driver with an external microcontroller.
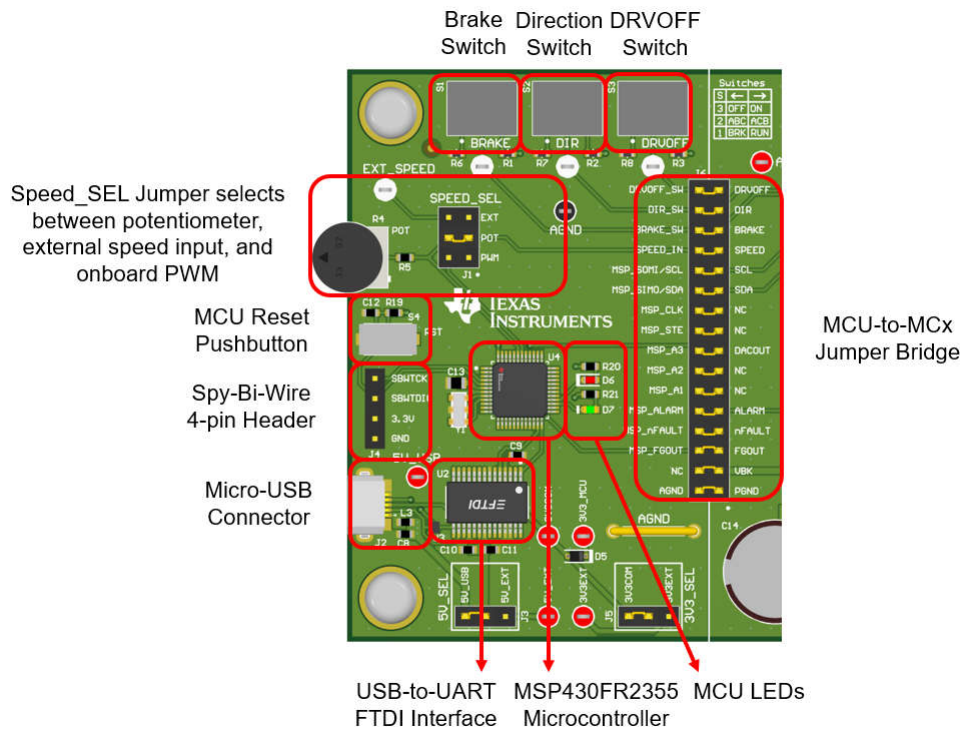

Figure 2-5. MSP430FR2355 MCU on MCF8315RRYEVM

2.6 LED Lights

The MCF8315RRYEVM has 6 status LEDs implemented that provide the status of power supplies and functionalities of the evaluation module. By default, the VM LED and 3.3V Buck LEDs light up when the board is powered and the program has been flashed onto the microcontroller. Table 2-1 shows LED descriptions including those that are on during power up in bold and Figure 2-6 shows the locations of the LEDs.

Table 2-1. Description of MCF8315RRYEVM LEDs (default in bold after powerup)

Designator	Name	Color	Description
D1	**Buck Regulator**	**Green**	**Internal buck regulator is voltage output**
D2	nFAULT	Red	Lights up when fault condition has occurred on MCF8315
D3	ALARM	Red	Lights up when alarm condition has occurred on MCF8315
D4	**VM**	**Green**	**Motor power is supplied to the board**
D6	**MSP_LED1**	**Red**	**Used for UART or debugging**
D7	MSP_LED2	Green	Used for UART or debugging
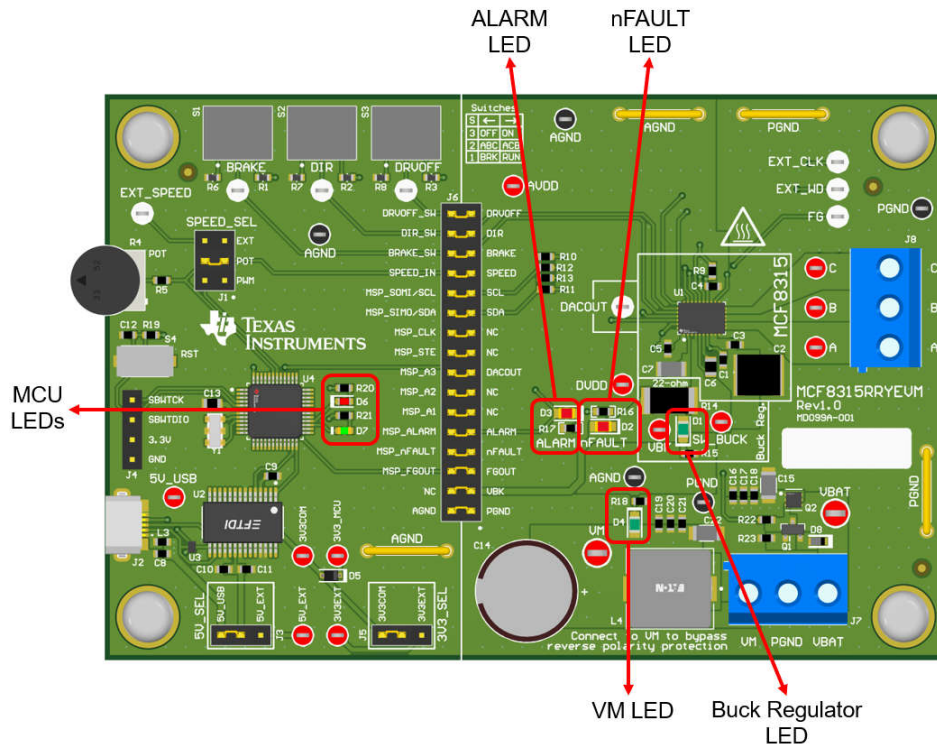
Figure 2-6. MCF8315RRYEVM LED Locations

2.7 User-Configurable Settings

The MCF8315RRYEVM includes a variety of user-selectable jumpers, switches, and resistors on the entirety of the evaluation board to configure settings. Table 2-2 summarizes all of these configurable settings.

Table 2-2. Description of User-Selectable Settings on MCF8315RRYEVM (Default in Bold)

Designator	Setting Name	Description	Layer	Position	Function
L1/L2/R14	Buck Regulator mode	User populates L1, L2, or R14 to choose switching component for buck regulator	Top	L1 = 47uH Inductor	Inductor Mode
			Bottom	L2 = 22µH	Inductor Mode
			Bottom	**R14 = 22Ω**	**Resistor Mode**
J5	3V3_SEL	Select 3.3V for MCU power	Top	J5 = 3V3EXT	External
				J5 = 3V3COM	**From FTDI (30mA)**
J3	5V_SEL	Select 5V for FTDI power	Top	J3 = 5V_EXT	External
				J3 = 5V_USB	**From USB power (500mA)**
J1	SPEED_SEL	Selects SPEED input source	Top	J1 = EXT	External EXT_SPEED test point
				J1 = POT	**From Potentiometer R4**
				J1 = PWM	On-board PWM from MSP430
J6	MSP to MCx Shunt jumper bridge	Connects signals from MCU and user switches to MCx8315 when jumpers are inserted	Top	**DRVOFF_SW**	**DRVOFF**
				DIR_SW	**DIR**
				BRAKE_SW	**BRAKE**
				SPEED_IN	**SPEED**
				MSP_SOMI/SCL	**SCL**
				MSP_SIMO/SDA	**SDA**
				MSP_CLK	**NC**
				MSP_STE	**NC**
				MSP_A3	**DACOUT**
				MSP_A2	**NC**
				MSP_A1	**NC**
				MSP_ALARM	**ALARM**
				MSP_nFAULT	**nFAULT**
				MSP_FGOUT	**FGOUT**
				NC	**VBK**
				AGND	**PGND**
S1	BRAKE	Turns on all low-side MOSFETs	Top	Left	Brake enabled
				Right	**Brake disabled**
S2	DIR	Controls direction of motor	Top	**Left**	**ABC**
				Right	ACB
S3	DRVOFF	Disables gate drivers	Top	Left	MCF8315 FETs disabled
				Right	**MCF8315 FETs enabled**

3 Software

3.1 Firmware and GUI Application

The MCF8315RRYEVM includes a USB-to-UART interface, using a MSP430FR2355 microcontroller, that serves as a communication bridge between a host PC and the MCF8315 device for configuring various device settings and reading fault diagnostic information.

The MCF8315RRYEVM is supported on the Motor Studio GUI which can be used to configure the MCF8315 though this communication interface. The Motor Studio GUI simplifies the tuning process of the MCF8315 by offering guided tuning instructions, a virtual oscilloscope for real-time variable monitoring, and more. The latest version of the Motor Studio GUI can be downloaded on ti.com.

By default, the onboard MSP430 microcontroller already contains the firmware needed to communicate with the Motor Studio GUI. If there is a firmware update or the GUI does not connect to the EVM, then the user must flash the firmware code into the MSP430 by following the steps outlined in Section 3.4.

Flashing the firmware code onto the MSP430 requires an integrated development environment (IDE) and an eZ-FET Debug Probe. The following example uses the Code Composer Studio™ (CCS) IDE and the MSPEXP430FR2355 LaunchPad™ Development Kit to provide the eZ-FET Debug Probe.

3.2 Downloading and Running Motor Studio

1. Connect the MCF8315RRYEVM as described in Section 2.2.
2. Download the latest version of the Motor Studio GUI.
3. Once the Motor Studio GUI is installed, run the Motor Studio GUI application.
4. Click the red *Setup Now* button under *Hardware Setup* on the bottom right side of the window.
5. After setting up the hardware settings of the MCF8315RRYEVM, click on the *Quick Spin* option to begin configuring the device.
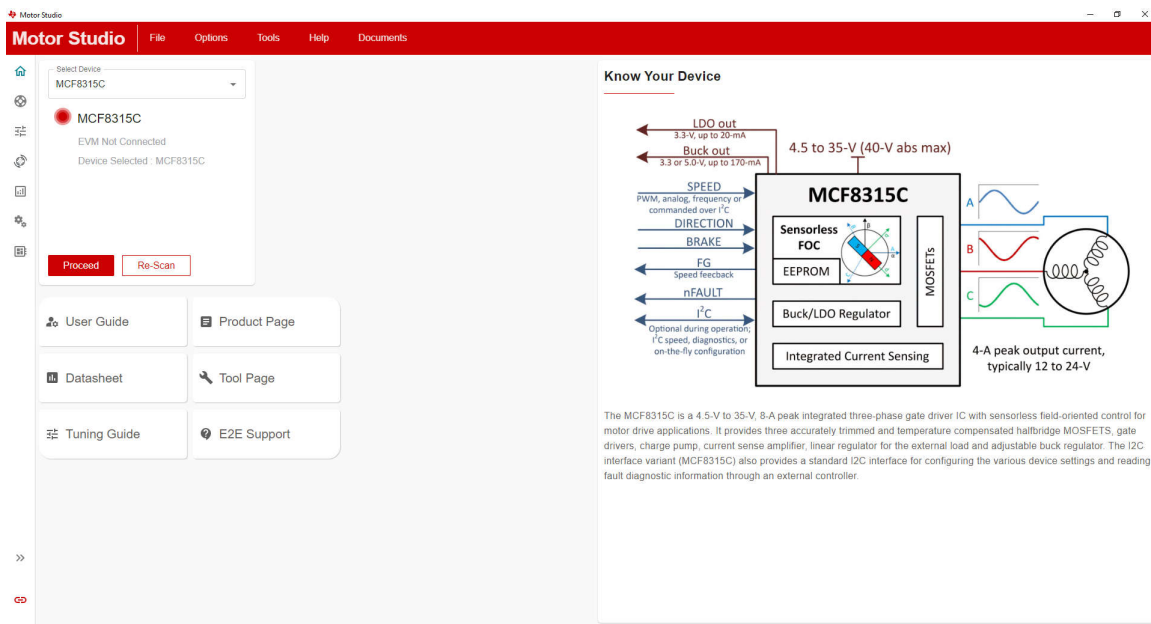
Figure 3-1. Motor Studio GUI MCF8315C Home Page

3.3 Downloading Code Composer Studio and Importing GUI Firmware Code

1. Download and extract the Motor Studio firmware to a location on the computer.
2. Download the latest version of Code Composer Studio. This sets up a ti folder in the directory C:\ti.
   a. Accept all agreements, default install locations, and click *Next* to proceed through the menus.
   b. In the *Select Components* window, make sure to check *MSP430 Low-Power MCUs* to install the required packages for the MSP430 LaunchPad Evaluation Kits.
3. After installing, run CCS and select a folder or the default to use as the workspace to store any new projects. The location and naming convention can be changed based on the user's preference. Click the *OK* button to accept.
4. In CCS, click on the *Project* tab and select *Import CCS Projects*. Click on *Browse*.
5. Select the folder created in Step 1 by extracting the Motor Studio firmware.
6. Import the project into your workspace as shown in Figure 3-2.

Figure 3-2. MSP430FR2355 Interface Firmware Code in Code Composer Studio

3.4 Using eZ-FET to Program the Onboard MSP430FR2355

The eZ-FET Debug Probe on the MSP430FR2355 LaunchPad uses a SPI-by-Wire JTAG interface to program the MSP430FR2355 MCU on the MCF8315RRYEVM. Consult the MSP430 LaunchPad Development Kits for MSP430 LaunchPads that include an onboard eZ-FET Debug Probe.

1. Remove the GND, 3V3, SBWTDIO, and SBWTCK jumpers from the MSP430 LaunchPad.
2. Connect the top pins on the eZ-FET side of the LaunchPad of the GND, 3V3, SBWTCK, and SBWTDIO signals to the respective pins on J4 of the MCF8315RRYEVM as shown in Table 3-1 and Figure 3-3.
3. Connect a micro-USB cable to the MSP430 LaunchPad and the PC.
4. Click on the *Build Project* icon or *CTRL + B* to make sure the project builds successfully. Accept any updates if needed from the Console.
5. Click on *Debug Project* to set up a debug session and press the *Play* button to run the code.
6. Stop the debug session, close Code Composer Studio, disconnect the SPI-by-Wire jumpers, and unplug the micro-USB cable from the MSP430 LaunchPad.

Table 3-1. SPY-BI-Wire Connections Needed to Program the MSP430FR2355

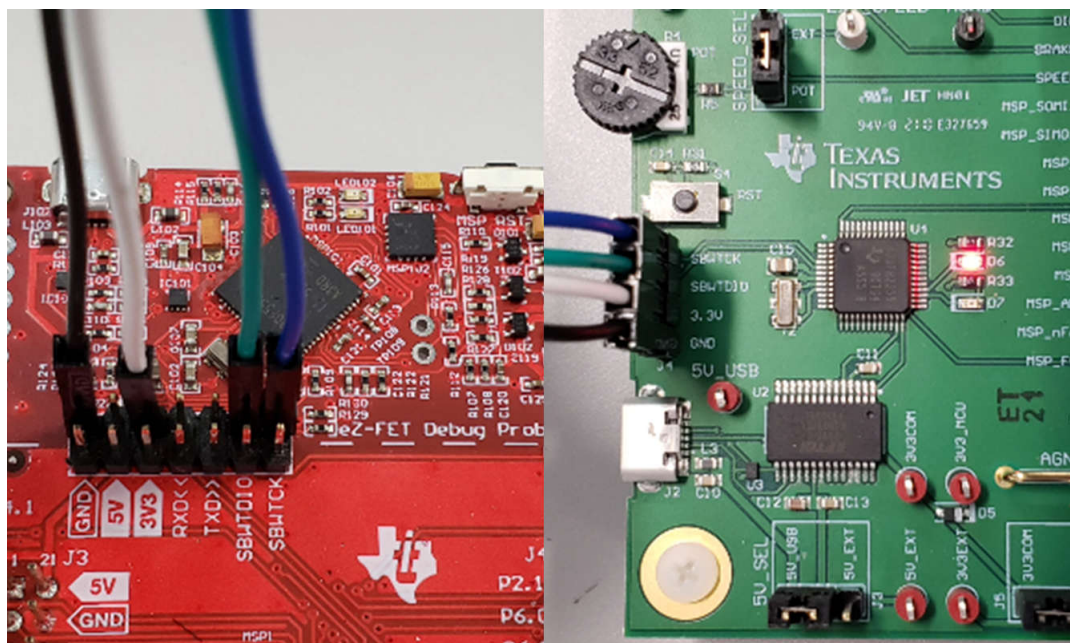| MSP430 LaunchPad (eZ-FET Debug Probe Side) (J101)	MCF8315RRYEVM 4-pin SPI-by-Wire Header (J4)
GND	GND
3V3	3.3V
SBWTDIO	SBWTDIO
SBWTCK	SBWTCK

Figure 3-3. MSP430 LaunchPad eZ-FET Probe Connected to MCF8315RRYEVM

4 Hardware Design Files

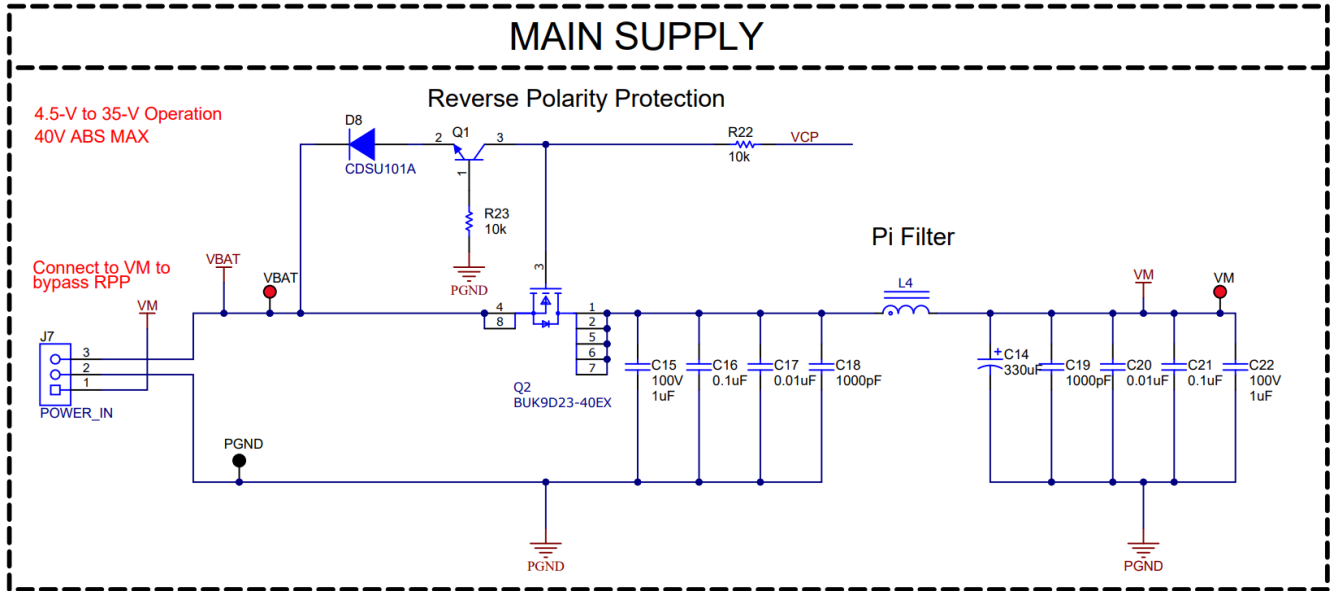## 4.1 Schematics

4.1.1 Main Supply and Pi Filter

Figure 4-1. Main Supply and Pi Filter Schematic
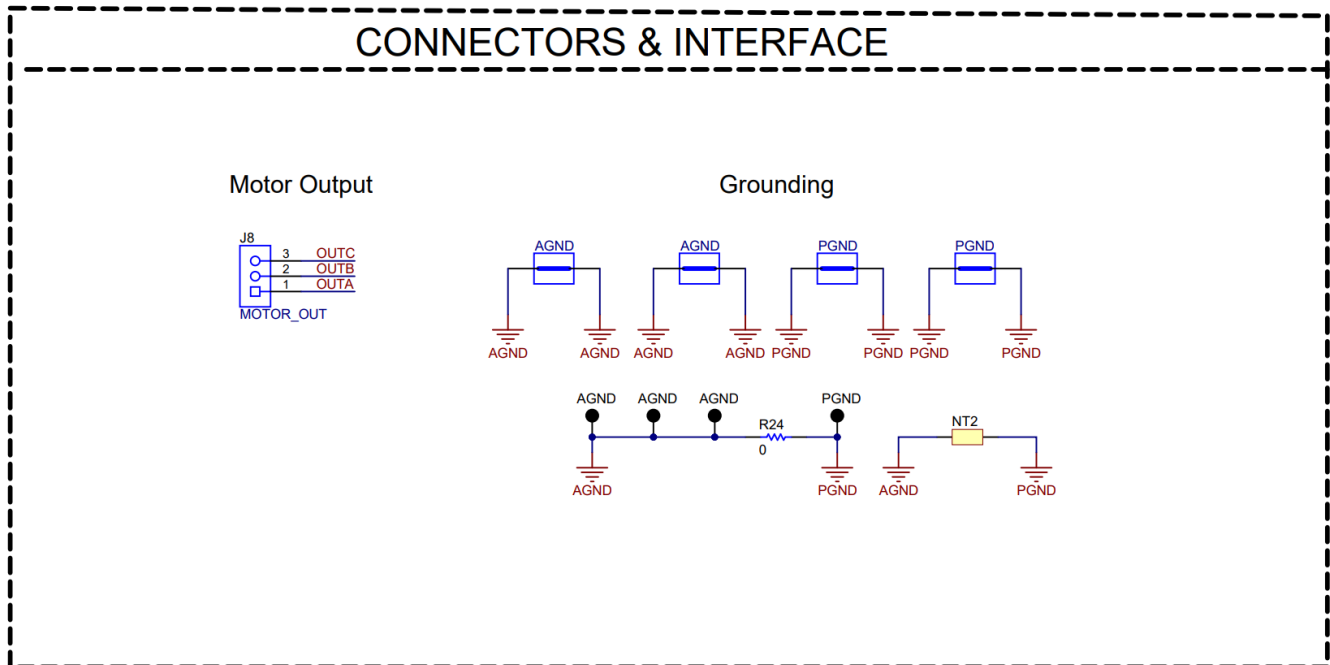
4.1.2 Connectors and Interface

Figure 4-2. Connectors and Interface Schematic
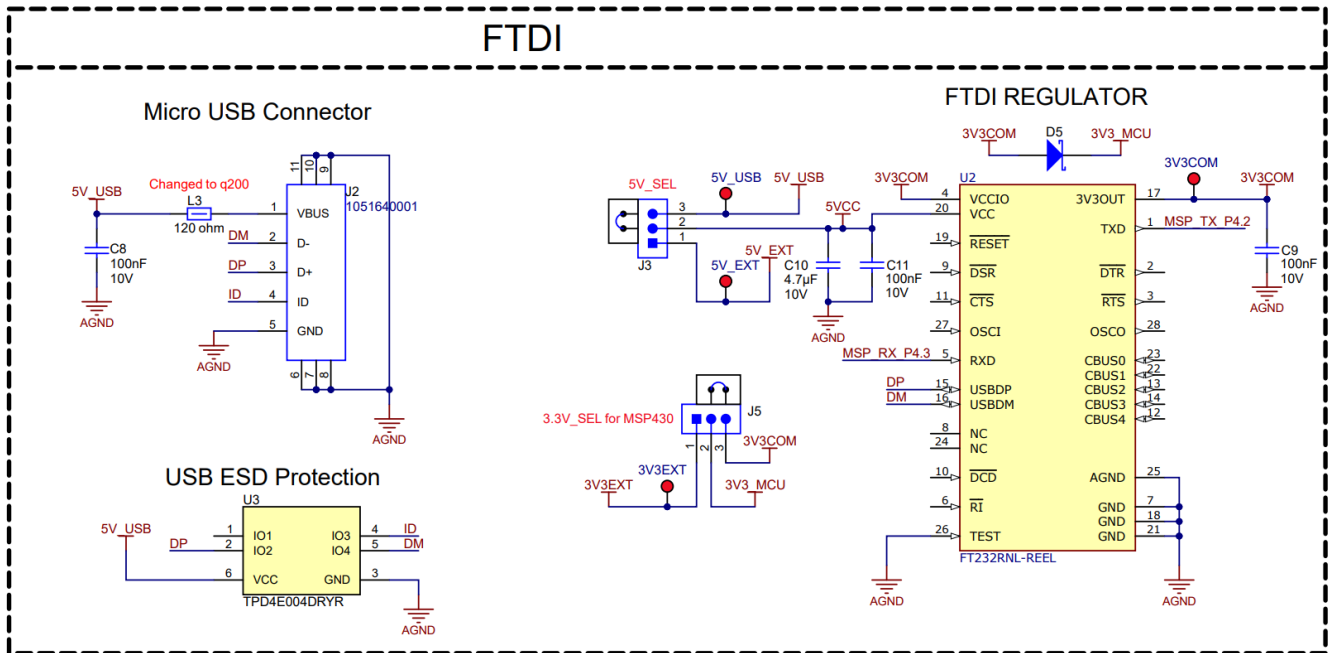
4.1.3 USB to UART

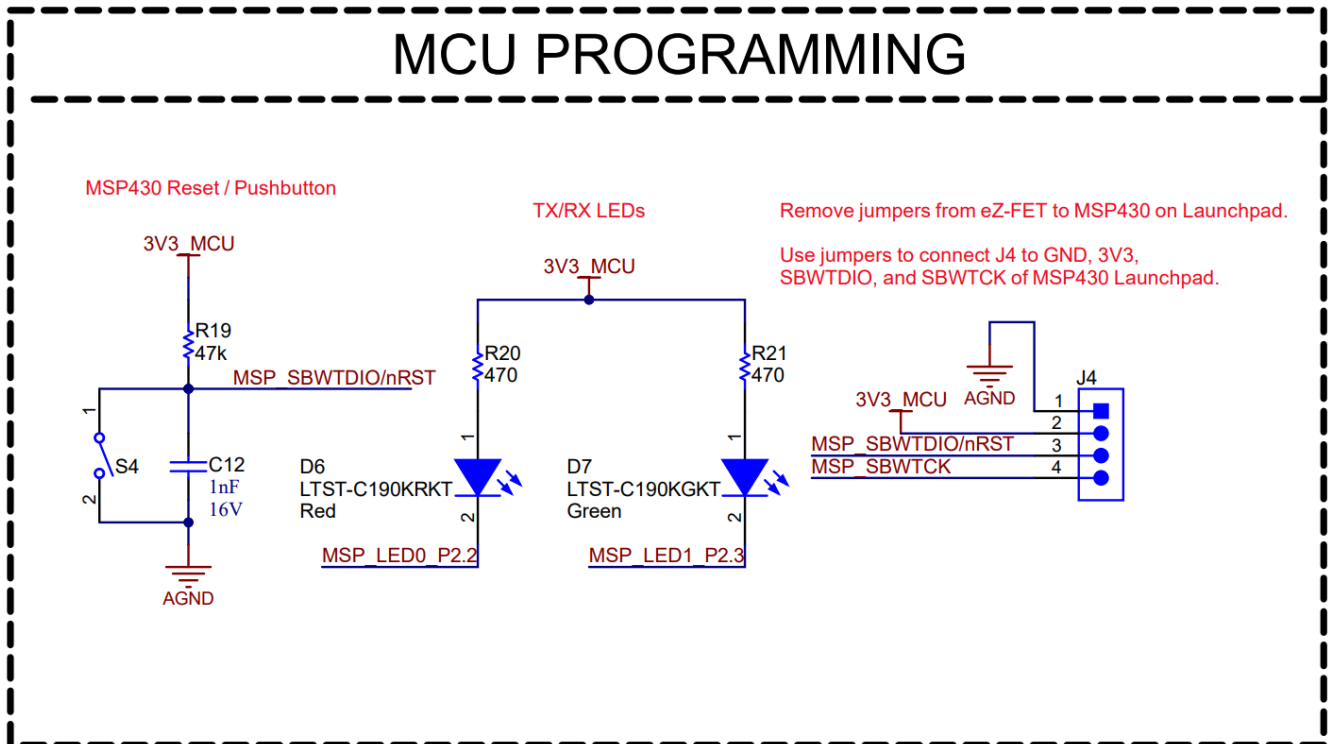**Figure 4-3. USB to UART Schematic**

4.1.4 MCU Programming and Debug

Figure 4-4. MCU Programming and Debug Schematic
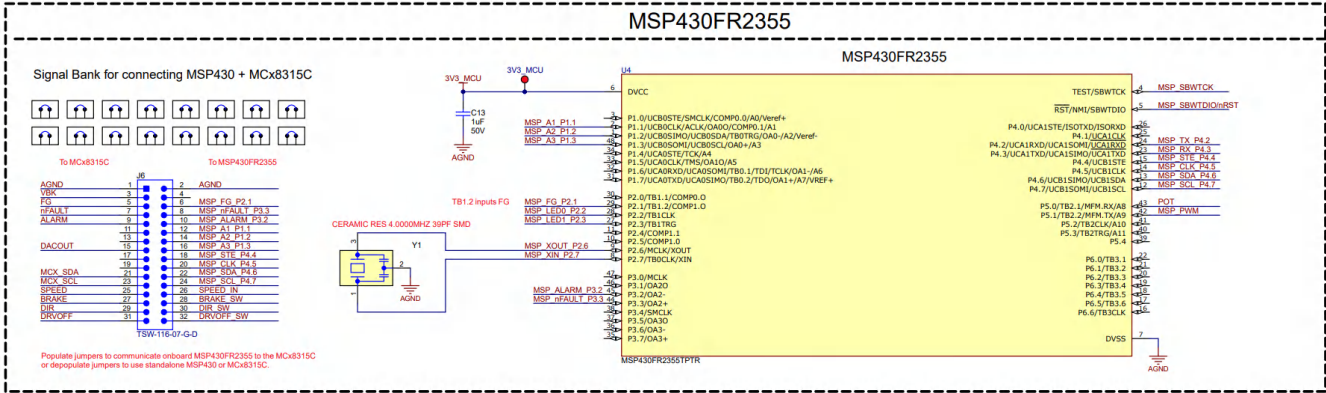
4.1.5 MSP430FR2355 MCU

Figure 4-5. MSP430FR2355 MCU Schematic

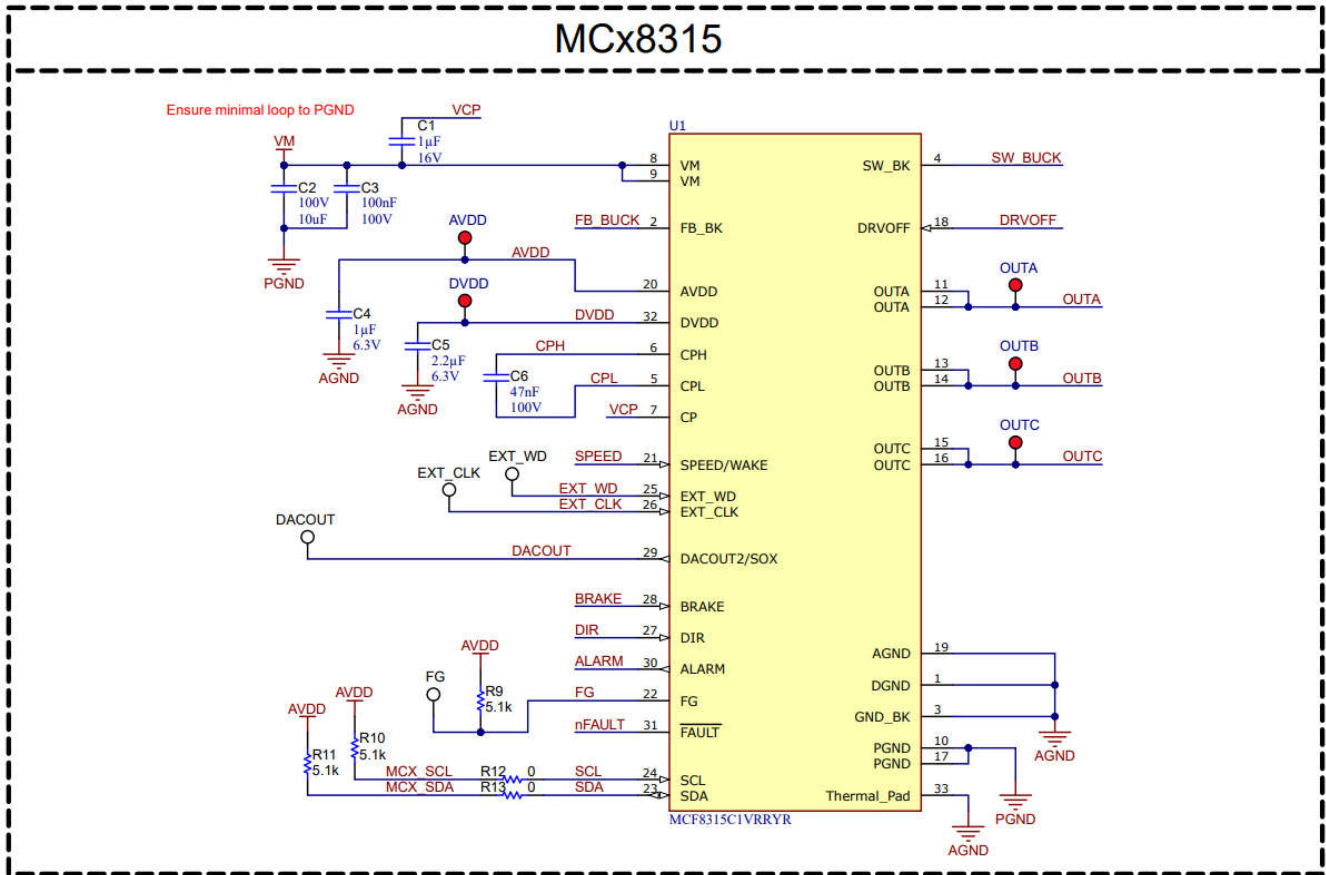### 4.1.6 MCF8315 3-Phase Sensorless FOC Integrated Driver

Figure 4-6. MCF8315 3-Phase Sensorless FOC Integrated Driver Schematic
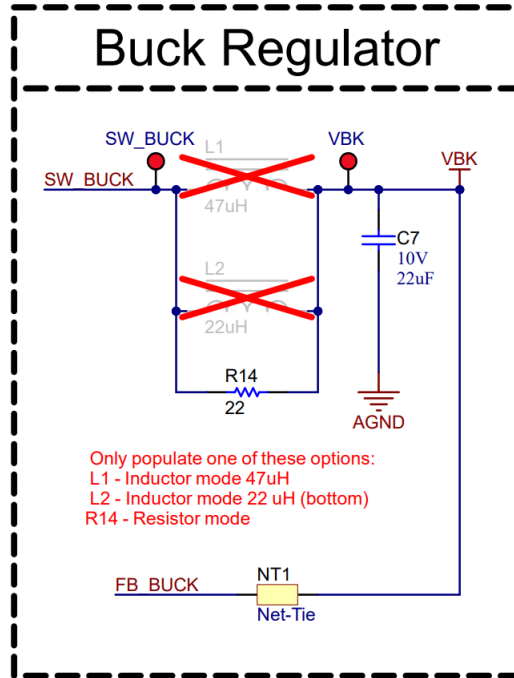
4.1.7 Buck Regulator

Figure 4-7. Buck Regulator Schematic
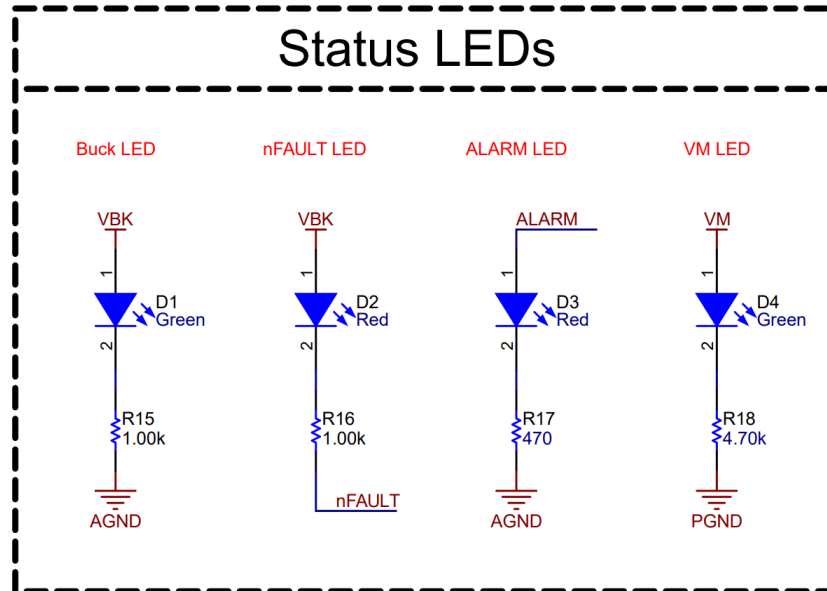
4.1.8 Status LEDs

Figure 4-8. Status LEDs Schematic

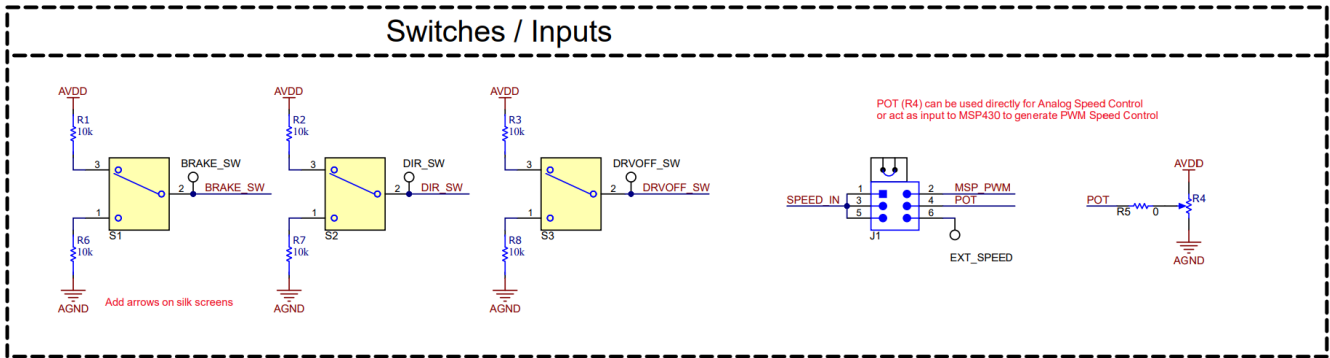### *4.1.9 Switches and Speed Input*

Figure 4-9. Switches and Speed Input Schematic
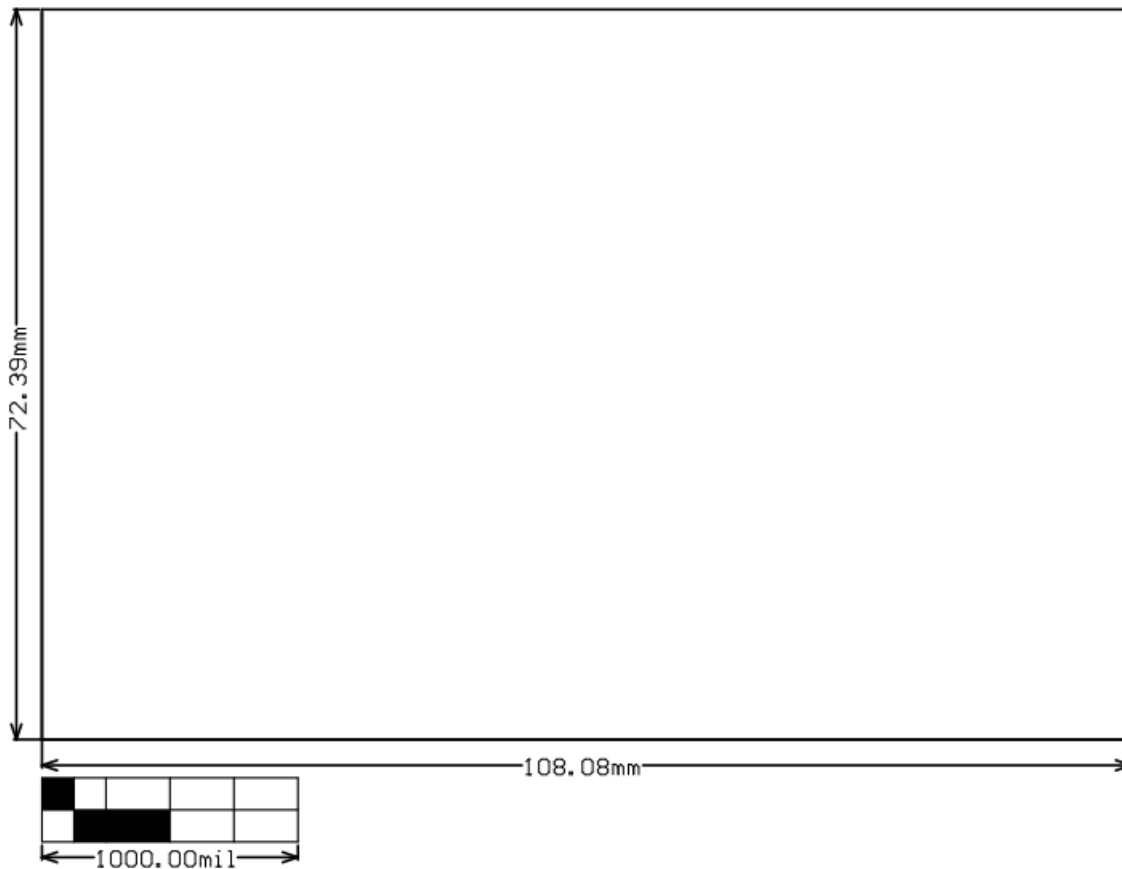
4.2 PCB Layouts

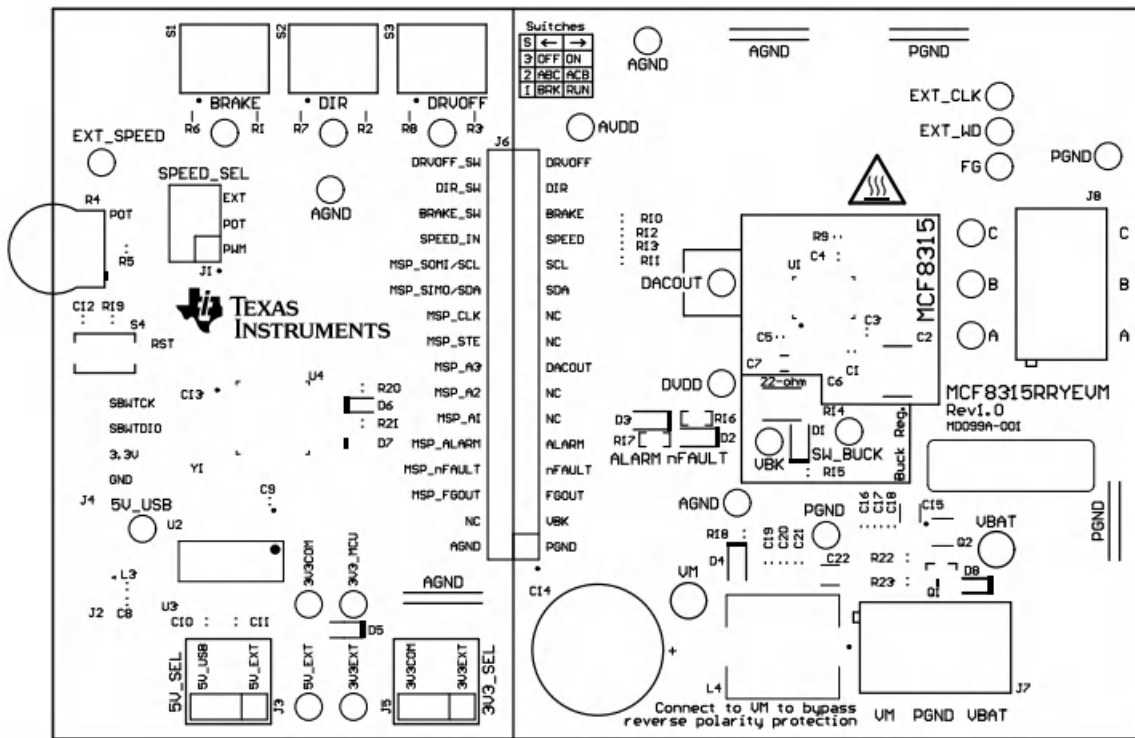**Figure 4-10. EVM Board Dimensions**

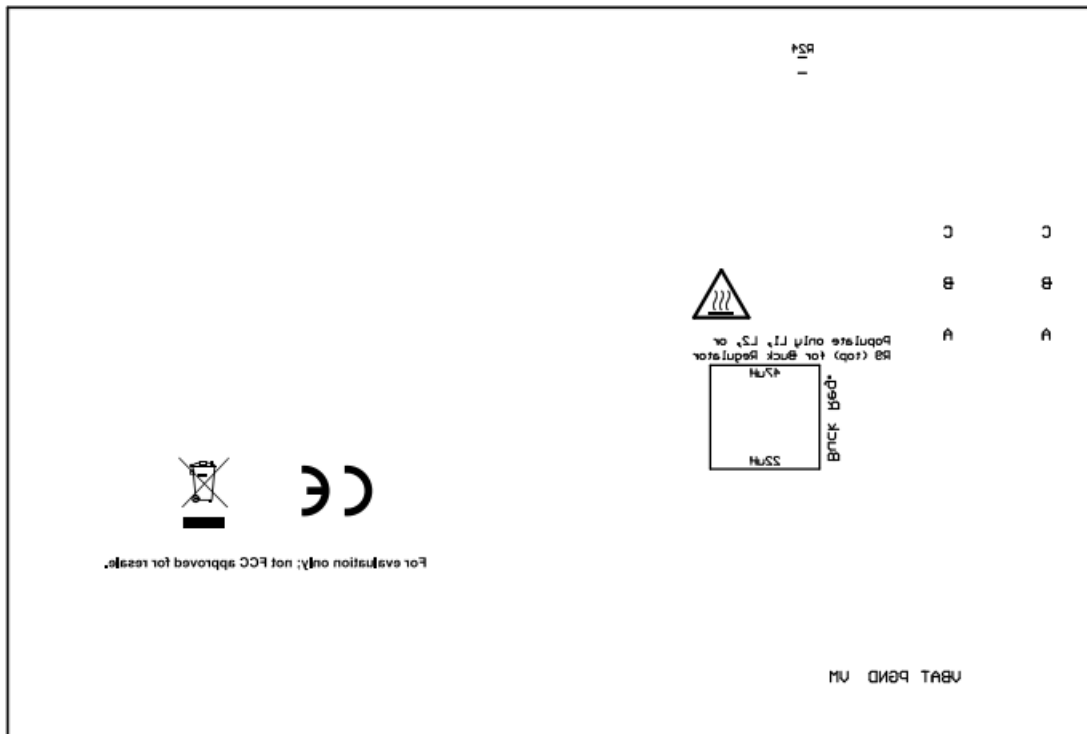**Figure 4-11. EVM Top Overlay**

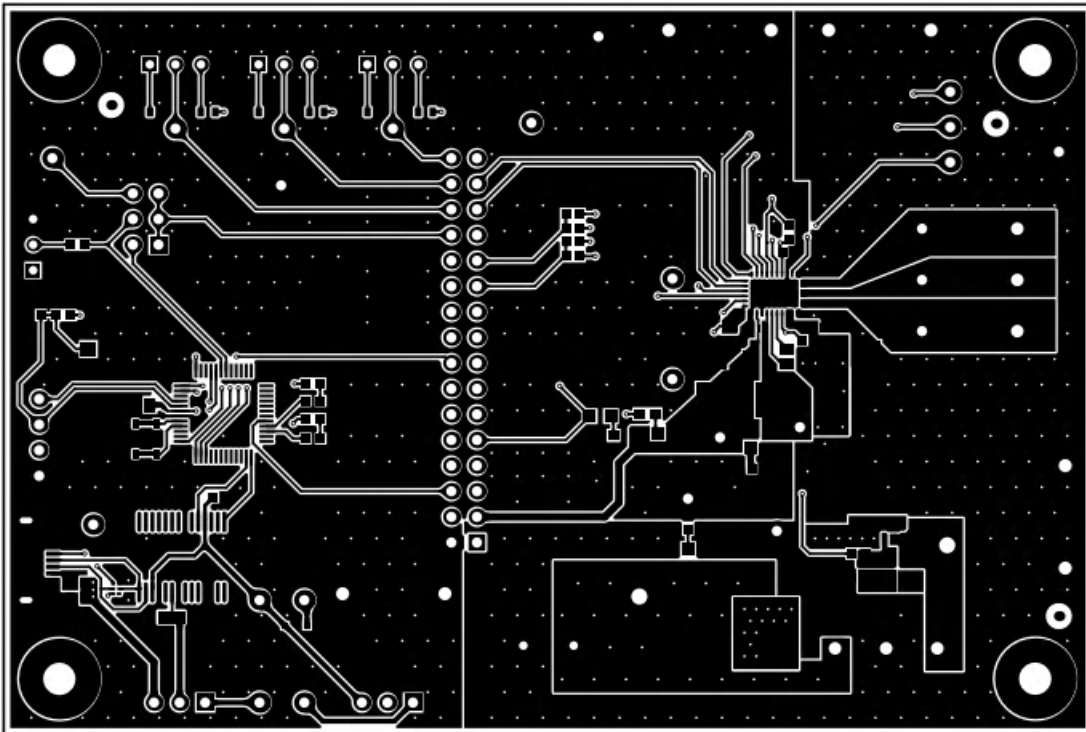**Figure 4-12. EVM Bottom Overlay**
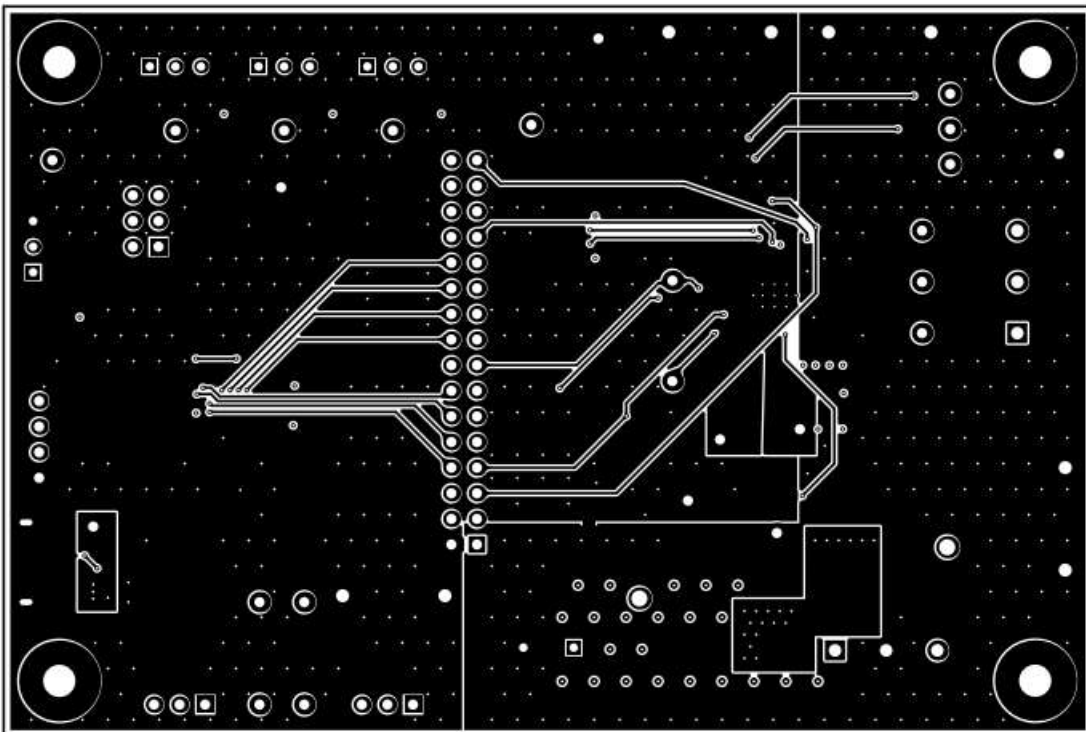
Figure 4-13. EVM Top Layer
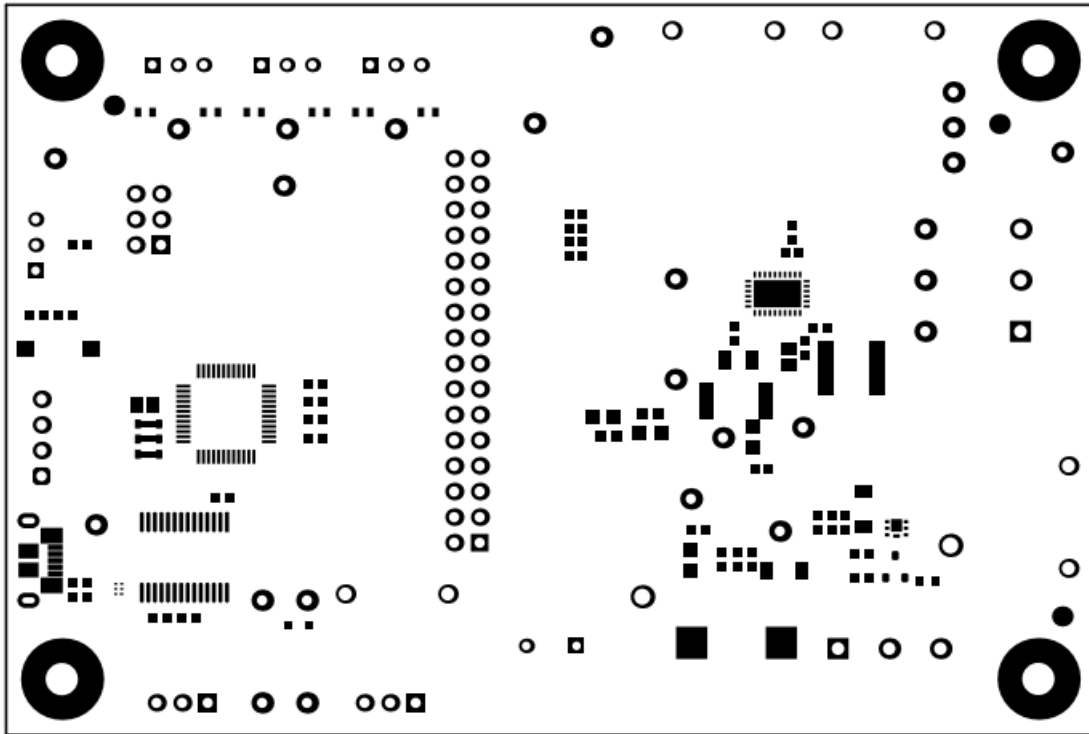

Figure 4-14. EVM Bottom Layer
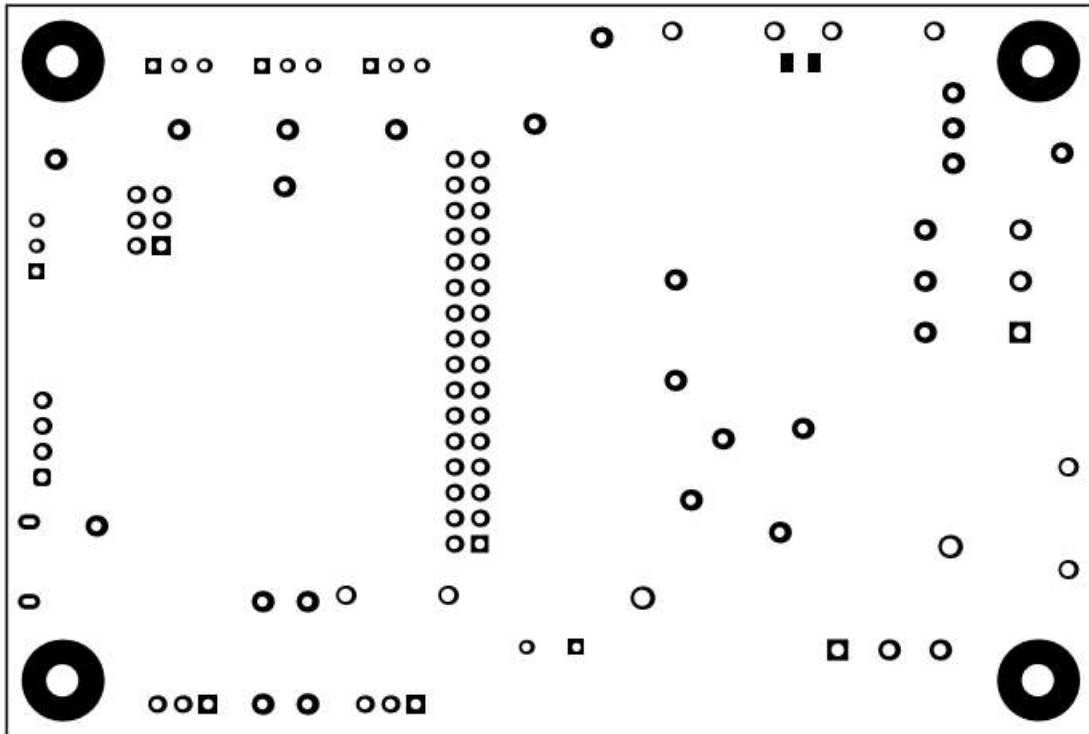
Figure 4-15. EVM Top Solder Mask

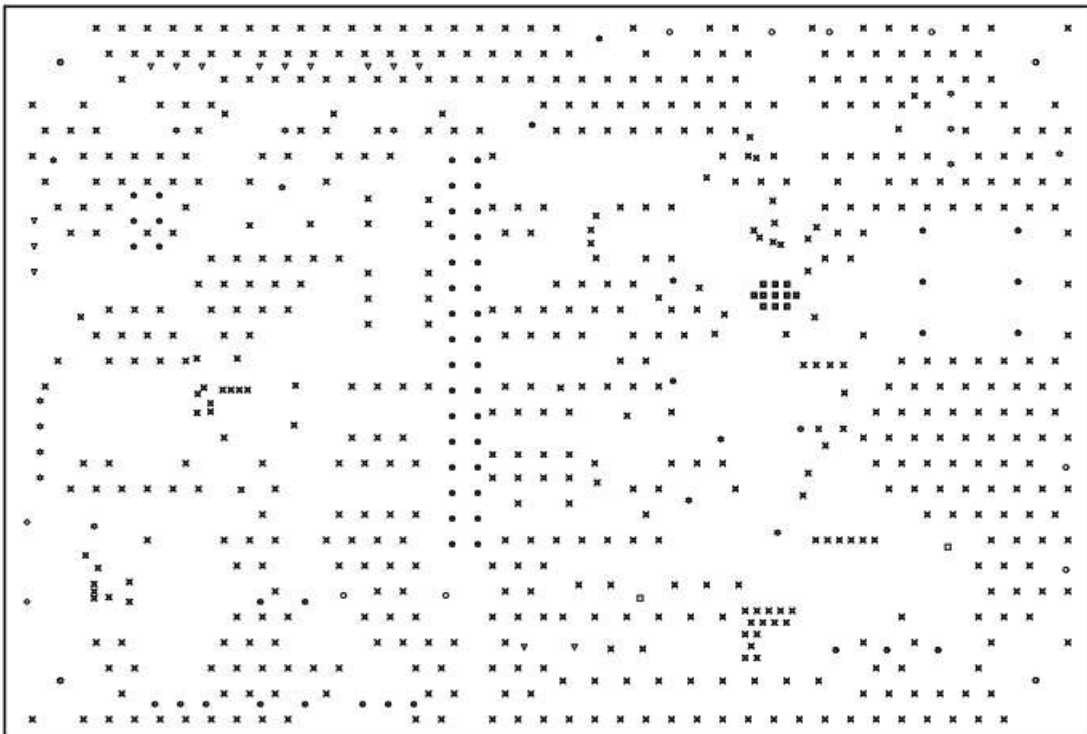**Figure 4-16. EVM Bottom Solder Mask**

Figure 4-17. EVM Drill Drawing

4.3 Bill of Materials (BOM)

Table 4-1. Bill of Materials

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
C1	1	1uF	CAP, CERM, 1µF, 16V,+/- 10%, X7R, AEC-Q200 Grade 1, 0603	0603	EMK107B7105KAHT	Taiyo Yuden
C2	1	10uF	CAP, CERM, 10uF, 100V, +/- 20%, X7R, 2220	2220	22201C106MAT2A	AVX
C3	1	0.1uF	CAP, CERM, 0.1uF, 100V, +/- 10%, X7R, 0603	0603	GRM188R72A104KA35D	MuRata
C4	1	1uF	CAP, CERM, 1µF, 6.3V,+/- 10%, X7R, AEC-Q200 Grade 1, 0603	0603	C0603C105K9RACAUTO	Kemet
C5	1	2.2uF	CAP, CERM, 2.2uF, 6.3V, +/- 10%, X7R, AEC-Q200 Grade 1, 0603	0603	GCM188R70J225KE22D	MuRata
C6	1	0.047uF	CAP, CERM, 0.047uF, 100V, +/- 10%, X7R, AEC-Q200 Grade 1, 0805	0805	CGA4J2X7R2A473K125AA	TDK
C7	1	22uF	CAP, CERM, 22uF, 10V, +/- 10%, X7R, 1206	1206	GRM31CR71A226KE15L	MuRata
C8, C9, C11	3	0.1uF	CAP, CERM, 0.1uF, 10V, +/- 10%, X7R, 0603	0603	0603ZC104KAT2A	AVX
C10	1	4.7uF	CAP, CERM, 4.7uF, 10V, +/- 20%, X7R, 0603	0603	GRM188Z71A475ME15D	MuRata
C12	1	1000pF	CAP, CERM, 1000pF, 16V, +/- 10%, X7R, 0603	0603	885012206034	Wurth Elektronik
C13	1	1uF	CAP, CERM, 1uF, 50V, +/- 10%, X7R, 0805	0805	885012207103	Wurth Elektronik
C14	1	330uF	CAP, AL, 330uF, 63V, +/- 20%, AEC-Q200 Grade 2, TH	D12.5xL20mm	ELXZ630ELL331MK20S	Chemi-Con
C15, C22	2	1uF	CAP, CERM, 1uF, 100V, +/- 10%, X7R, 1206	1206	CL31B105KCHNNNE	Samsung
C16, C21	2	0.1uF	CAP, CERM, 0.1uF, 100V, +/- 10%, X7S, AEC-Q200 Grade 1, 0603	0603	CGA3E3X7S2A104K080AB	TDK
C17, C20	2	0.01uF	CAP, CERM, 0.01uF, 100V, +/- 10%, X7R, AEC-Q200 Grade 1, 0603	0603	CGA3E2X7R2A103K080AA	TDK
C18, C19	2	1000pF	CAP, CERM, 1000pF, 100V, +/- 10%, X7R, AEC-Q200 Grade 1, 0603	0603	CGA3E2X7R2A102K080AA	TDK
D1, D4	2	Green	LED, Green, SMD	LED_0805	LTST-C170KGKT	Lite-On
D2, D3	2	Red	LED, Red, SMD	Red 0805 LED	LTST-C170KRKT	Lite-On
D5	1	40V	Diode, Schottky, 40V, 0.75A, AEC-Q101, SOD-323	SOD-323	BAT165E6327HTSA1	Infineon Technologies
D6	1	Red	LED, Red, SMD	Red LED, 1.6x0.8x0.8mm	LTST-C190KRKT	Lite-On

Table 4-1. Bill of Materials (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
D7	1	Green	LED, Green, SMD	1.6x0.8x0.8mm	LTST-C190KGKT	Lite-On
D8	1	90V	Diode, Switching, 90V, 0.1A, SOD-523F	SOD-523F	CDSU101A	Comchip Technology
FID1, FID2, FID3	3		Fiducial mark. There is nothing to buy or mount.	N/A	N/A	N/A
H1, H2, H3, H4	4		Machine Screw, Round, #4-40 x 1/4, Nylon, Philips panhead	Screw	NY PMS 440 0025 PH	B&F Fastener Supply
H5, H6, H7, H8	4		Standoff, Hex, 0.5"L #4-40 Nylon	Standoff	1902C	Keystone
J1	1		Header, 100mil, 3x2, Gold, TH	3x2 Header	TSW-103-07-G-D	Samtec
J2	1		Receptacle, USB 2.0, Micro B, 5 Position, R/A, SMT	Receptacle, USB 2.0, Micro B, 5 Pos, 0.65mm Pitch, R/A, SMT	1051640001	Molex
J3, J5	2		Header, 100mil, 3x1, Gold, TH	PBC03SAAN	PBC03SAAN	Sullins Connector Solutions
J4	1		Header, 100mil, 4x1, Gold, TH	4x1 Header	TSW-104-07-G-S	Samtec
J6	1		Header, 100mil, 16x2, Gold, TH	16x2 Header	TSW-116-07-G-D	Samtec
J7, J8	2		Terminal Block, 5.08mm, 3x1, Brass, TH	3x1 5.08mm Terminal Block	ED120/3DS	On-Shore Technology
L3	1		Inductor, Ferrite Bead, Ferrite, 3A, 120 ohm, AEC-Q200 Grade 1, SMD	0603	BLM18SG121TZ1D	MuRata
L4	1	1uH	1µH Shielded - Inductor 19A 3.1mOhm Max Nonstandard	SMD2	HCM1A1104V2-1R0-R	Eaton
LBL1	1			PCB Label 0.650 x 0.200 inch	THT-14-423-10	Brady
Q1	1	80V	Transistor, NPN, 80V, 1.5A, AEC-Q101, SOT-23	SOT-23	FMMT620TA	Diodes Inc.
Q2	1		N-Channel 40V 8A (Ta) 15W (Tc) Surface Mount DFN2020MD-6	SOT1220	BUK9D23-40EX	Nexperia
R1, R2, R3, R6, R7, R8	6	10k	Res Thin Film 0603 10K Ohm 0.1% 1/10W ±10ppm/°C Molded SMD SMD Punched Carrier T/R	0603	ERA-3ARB103V	Panasonic
R4	1	25 kohm	Trimmer Potentiometer, 25kohm, 0.5W, TH	9.53x8.89mm	3352T-1-253LF	Bourns
R5, R12, R13	3	0	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	ERJ-3GEY0R00V	Panasonic

Table 4-1. Bill of Materials (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
R9, R10, R11	3	5.1k	RES, 5.1 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW06035K10JNEA	Vishay-Dale
R14	1	22	RES, 22, 5%, 1.5 W, AEC-Q200 Grade 0, 2512	2512	CRCW251222R0JNEGHP	Vishay-Dale
R15, R16	2	1.00k	RES, 1.00 k, 1%, 0.1 W, 0603	0603	RC0603FR-071KL	Yageo
R17, R20, R21	3	470	RES, 470, 5%, 0.1 W, 0603	0603	RC0603JR-07470RL	Yageo
R18	1	4.70k	RES, 4.70 k, 0.1%, 0.1 W, 0603	0603	RT0603BRD074K7L	Yageo America
R19	1	47k	RES, 47 k, 5%, 0.1 W, 0603	0603	RC0603JR-0747KL	Yageo
R22, R23	2	10k	RES, 10 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060310K0JNEA	Vishay-Dale
R24	1	0	RES, 0, 5%, 0.25 W, AEC-Q200 Grade 0, 1206	1206	RCA12060000ZSEA	Vishay-Dale
S1, S2, S3	3		SWITCH TOGGLE SPDT 0.4VA 28V	6.8x23.1x8.8mm	B12AP	NKK Switches
S4	1		Switch, Tactile, SPST, 12V, SMD	SMD, 6x3.9mm	434121025816	Wurth Elektronik
SH-J1, SH-J2, SH-J3, SH-J4, SH-J5, SH-J6, SH-J7, SH-J8, SH-J9, SH-J10, SH-J11, SH-J12, SH-J13, SH-J14, SH-J15, SH-J16, SH-J17, SH-J18, SH-J19	19	1x2	Shunt, 100mil, Gold plated, Black	Shunt	SNT-100-BK-G	Samtec
TP1, TP2, TP3, TP4, TP10, TP11, TP12, TP13	8		Test Point, Miniature, White, TH	White Miniature Testpoint	5002	Keystone
TP5, TP6, TP7, TP8, TP9, TP14, TP15, TP16, TP17, TP18, TP19, TP20	12		Test Point, Miniature, Red, TH	Red Miniature Testpoint	5000	Keystone
TP21, TP22	2		Test Point, Compact, Red, TH	Red Compact Testpoint	5005	Keystone
TP23, TP28, TP29, TP30, TP31	5		Test Point, Miniature, Black, TH	Black Miniature Testpoint	5001	Keystone

Table 4-1. Bill of Materials (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
TP24, TP25, TP26, TP27	4		1mm Uninsulated Shorting Plug, 10.16mm spacing, TH	Shorting Plug, 10.16mm spacing, TH	D3082-05	Harwin
U1	1		Sensorless Field Oriented Control (FOC) Integrated FET BLDC Driver, WQFN32	WQFN32	MCF8315C1VRRYR	Texas Instruments
U2	1		UART Interface IC USB Full Speed to Serial UART IC, Includes Oscillator and EEPROM, SSOP-28	SSOP28	FT232RNL-REEL	FTDI
U3	1		4-Channel ESD Protection Array for High-Speed Data Interfaces, DRY0006A (USON-6)	DRY0006A	TPD4E004DRYR	Texas Instruments
U4	1		CPU16 MSP430 FRAM Microcontroller IC 16-Bit 24MHz 32KB (32K x 8) FRAM 48-LQFP (7x7)	LQFP48	MSP430FR2355TPTR	Texas Instruments
Y1	1		Resonator, 4MHz, 39pF, AEC-Q200 Grade 1, SMD	4.5x1.2x2 mm	CSTCR4M00G55B-R0	MuRata
L1	0	47uH	Inductor, Shielded, Powdered Iron, 47uH, 0.39A, 2.3 ohm, AEC-Q200 Grade 1, SMD	SMD, 2-Leads, Body 3x3mm	78438335470	Wurth Elektronik
L2	0	22uH	Inductor, Shielded, Powdered Iron, 22uH, 0.6A, 1.04 ohm, AEC-Q200 Grade 1, SMD	SMD, 2-Leads, Body 3x3mm	78438335220	Wurth Elektronik

5 Additional Information

5.1 Trademarks

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2. *Limited Warranty and Related Remedies/Disclaimers*:

   2.1 These terms do not apply to Software. The warranty, if any, for Software is covered in the applicable Software License Agreement.

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   2.3 TI's sole liability shall be at its option to repair or replace EVMs that fail to conform to the warranty set forth above, or credit User's account for such EVM. TI's liability under this warranty shall be limited to EVMs that are returned during the warranty period to the address designated by TI and that are determined by TI not to conform to such warranty. If TI elects to repair or replace such EVM, TI shall have a reasonable time to repair such EVM or provide replacements. Repaired EVMs shall be warranted for the remainder of the original warranty period. Replaced EVMs shall be warranted for a new full ninety (90) day warranty period.

WARNING

Evaluation Kits are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems.

User shall operate the Evaluation Kit within TI's recommended guidelines and any applicable legal or environmental requirements as well as reasonable and customary safeguards. Failure to set up and/or operate the Evaluation Kit within TI's recommended guidelines may result in personal injury or death or property damage. Proper set up entails following TI's instructions for electrical ratings of interface circuits such as input, output and electrical loads.

NOTE:
EXPOSURE TO ELECTROSTATIC DISCHARGE (ESD) MAY CAUSE DEGREDATION OR FAILURE OF THE EVALUATION KIT; TI RECOMMENDS STORAGE OF THE EVALUATION KIT IN A PROTECTIVE ESD BAG.

3   *Regulatory Notices:*

   3.1   *United States*

         3.1.1   *Notice applicable to EVMs not FCC-Approved:*

   FCC NOTICE: This kit is designed to allow product developers to evaluate electronic components, circuitry, or software associated with the kit to determine whether to incorporate such items in a finished product and software developers to write software applications for use with the end product. This kit is not a finished product and when assembled may not be resold or otherwise marketed unless all required FCC equipment authorizations are first obtained. Operation is subject to the condition that this product not cause harmful interference to licensed radio stations and that this product accept harmful interference. Unless the assembled kit is designed to operate under part 15, part 18 or part 95 of this chapter, the operator of the kit must operate under the authority of an FCC license holder or must secure an experimental authorization under part 5 of this chapter.

         3.1.2   *For EVMs annotated as FCC – FEDERAL COMMUNICATIONS COMMISSION Part 15 Compliant:*

   CAUTION

   This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

   Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

   FCC Interference Statement for Class A EVM devices

   NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

   FCC Interference Statement for Class B EVM devices

   NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

   - *Reorient or relocate the receiving antenna.*
   - *Increase the separation between the equipment and receiver.*
   - *Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.*
   - *Consult the dealer or an experienced radio/TV technician for help.*

   3.2   *Canada*

         3.2.1   *For EVMs issued with an Industry Canada Certificate of Conformance to RSS-210 or RSS-247*

   Concerning EVMs Including Radio Transmitters:

   This device complies with Industry Canada license-exempt RSSs. Operation is subject to the following two conditions:

   (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

   Concernant les EVMs avec appareils radio:

   Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes: (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

   Concerning EVMs Including Detachable Antennas:

   Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication. This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

4   *EVM Use Restrictions and Warnings:*

4.1 EVMS ARE NOT FOR USE IN FUNCTIONAL SAFETY AND/OR SAFETY CRITICAL EVALUATIONS, INCLUDING BUT NOT LIMITED TO EVALUATIONS OF LIFE SUPPORT APPLICATIONS.

4.2 User must read and apply the user guide and other available documentation provided by TI regarding the EVM prior to handling or using the EVM, including without limitation any warning or restriction notices. The notices contain important safety information related to, for example, temperatures and voltages.

4.3 *Safety-Related Warnings and Restrictions:*

4.3.1 User shall operate the EVM within TI's recommended specifications and environmental considerations stated in the user guide, other available documentation provided by TI, and any other applicable requirements and employ reasonable and customary safeguards. Exceeding the specified performance ratings and specifications (including but not limited to input and output voltage, current, power, and environmental ranges) for the EVM may cause personal injury or death, or property damage. If there are questions concerning performance ratings and specifications, User should contact a TI field representative prior to connecting interface electronics including input power and intended loads. Any loads applied outside of the specified output range may also result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM user guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative. During normal operation, even with the inputs and outputs kept within the specified allowable ranges, some circuit components may have elevated case temperatures. These components include but are not limited to linear regulators, switching transistors, pass transistors, current sense resistors, and heat sinks, which can be identified using the information in the associated documentation. When working with the EVM, please be aware that the EVM may become very warm.

4.3.2 EVMs are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems. User assumes all responsibility and liability for proper and safe handling and use of the EVM by User or its employees, affiliates, contractors or designees. User assumes all responsibility and liability to ensure that any interfaces (electronic and/or mechanical) between the EVM and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard. User assumes all responsibility and liability for any improper or unsafe handling or use of the EVM by User or its employees, affiliates, contractors or designees.

4.4 User assumes all responsibility and liability to determine whether the EVM is subject to any applicable international, federal, state, or local laws and regulations related to User's handling and use of the EVM and, if applicable, User assumes all responsibility and liability for compliance in all respects with such laws and regulations. User assumes all responsibility and liability for proper disposal and recycling of the EVM consistent with all applicable international, federal, state, and local requirements.

5. *Accuracy of Information:* To the extent TI provides information on the availability and function of EVMs, TI attempts to be as accurate as possible. However, TI does not warrant the accuracy of EVM descriptions, EVM availability or other information on its websites as accurate, complete, reliable, current, or error-free.

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8. *Limitations on Damages and Liability:*

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