EVM User's Guide: MCF8329RRYEVM

MCF8329RRYEVM Evaluation Module

Description

The MCF8329RRYEVM enables users to evaluate the performance of a 32 pin VQFN packaged MCF8329 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 either control signals or SPI formatted data, which is sent to the MCF8329. There are many user-selectable jumpers, resistors, connectors, and test points to assist with evaluating the many features of the MCF8329 IC and the configurable device-specific settings.

Get Started

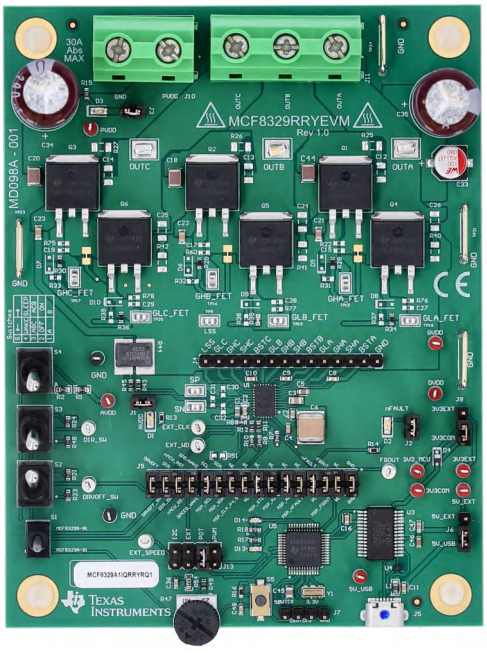
1. Download the latest design files from the MCF8329RRYEVM tool page on ti.com
2. Download the latest version of the Motor Studio GUI and firmware from the Motor Studio tool page on ti.com

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 MCF8329 IC with an external MCU or to use the EVM MCU to control an external MCF8329 IC

Applications

- Brushless-DC (BLDC) motor modules
- Coolant, water, fuel, and oil pumps
- Automotive body electronics
- Automotive thermal management



MCF8329RRYEVM (Top View)

1 Evaluation Module Overview

1.1 Introduction

The user's guide details how to set up, configure, and operate the Motor Studio GUI and MCF8329RRYEVM. Throughout this document, the terms evaluation board, evaluation module, and EVM are synonymous with the MCF8329RRYEVM. This document also provides information on the operating procedure, input and output connections, an electrical schematic, printed circuit board (PCB) layout drawings, and a bill of materials (BOM) for the EVM.

WARNING

	**Hot Surface**	Contact with marked surfaces can cause burns. Do not touch.

1.2 Kit Contents

The contents of the EVM kit are listed in Table 1-1. Contact your nearest Texas Instruments Product Information Center 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
MCF8329RRYEVM	1
USB-A to USB-B micro-cable	1

1.3 Device Information

The MCF8329 is a 4.5V to 60V, three-phase brushless-DC gate driver IC with code-free sensorless field oriented control (FOC) for motor drive applications. The MCF8329 integrates a charge pump and uses bootstrap architecture to drive three high-side and three low-side N-channel MOSFETs with up to 1A peak source and 2A peak sink current. The MCF8329 also integrates a trickle charge pump to support 100% PWM duty cycle.

The internal sensorless FOC algorithm register configuration can be stored in non-volatile EEPROM enabling the device to operate stand-alone once the algorithm has been configured. Motor current is sensed using an integrated current sense amplifier supporting a single external shunt resistor. 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 MCF8329, intended to protect the device, motor, and system against fault events.

Part Number	Firmware Version
MCF8329A1IQRRYRQ1	A

1.4 Specification

The MCF8329RRYEVM is rated for operation of 60V absolute maximum and currents up to 30A peak. To prevent personal injury, electrical shock hazard, damage the EVM, or a combination confirm that the EVMs voltage and current specifications are not exceeded.

The MCF8329EVM can support multiple variants of the MCF8329. To check which MCF8329 chip is populated on the EVM, check the sticker label for the part number of the chip populated by default.

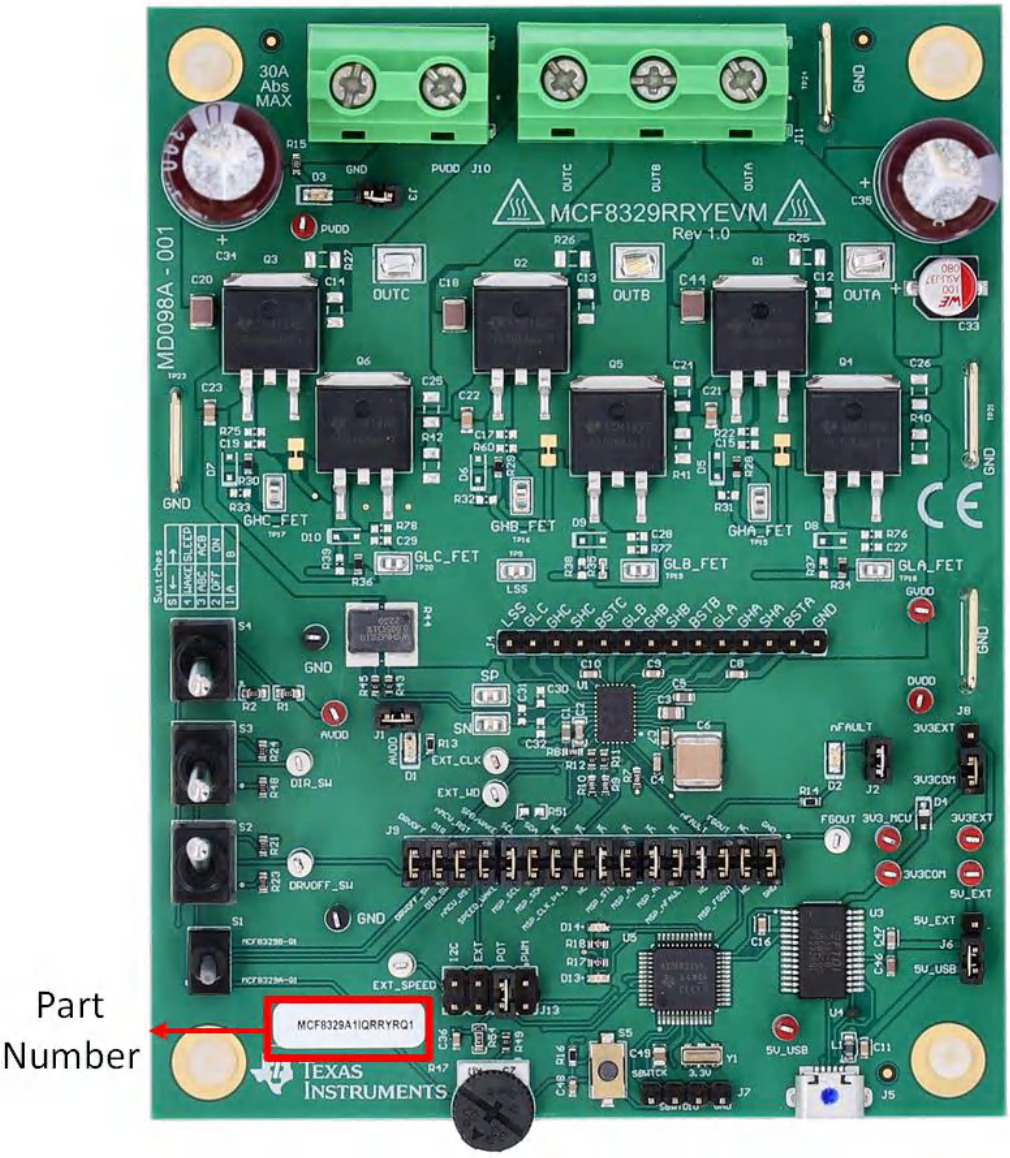


Figure 1-1. MCF8329RRYEVM Part Number

2 Hardware

2.1 Quick Start Guide

The MCF8329RRYEVM requires a power supply source, which has a recommended operating range from a 4.5V to 60V. To setup and power the EVM, follow the sequence below:

1. Connect motor phases to A, B, and C on connector J11.
2. Do not turn on the power supply yet. Connect the motor supply to PVDD and GND on connector J10.
3. Select J6 to 5V_USB and J8 to 3V3COM to power MSP430 from USB power supply.
4. Connect the micro-USB cable into the computer.
5. Turn the potentiometer fully clockwise to set the motor to zero speed upon power up.
6. Flip Switch S2 to the top to set DRVOFF on, S3 to the bottom to set DIR as ABC, and S4 to the bottom to set the set the device to the WAKE state.
7. Flip switch S1 into the down position to set the EVM to support the MCF8329A-Q1.
8. Set the jumper on J13 to the POT position to apply the analog voltage from potentiometer R47 to the SPEED/WAKE pin.
9. Turn on the motor power supply.
10. Use the potentiometer R47 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 to monitor the real-time speed of the motor, put the MCF8329 into a low-power sleep mode, and read status of the LEDs as shown in Section 3.

Note

If using the MCF8329B-Q1, then set S1 into the up position to set the EVM to support the MCF8329B-Q1.

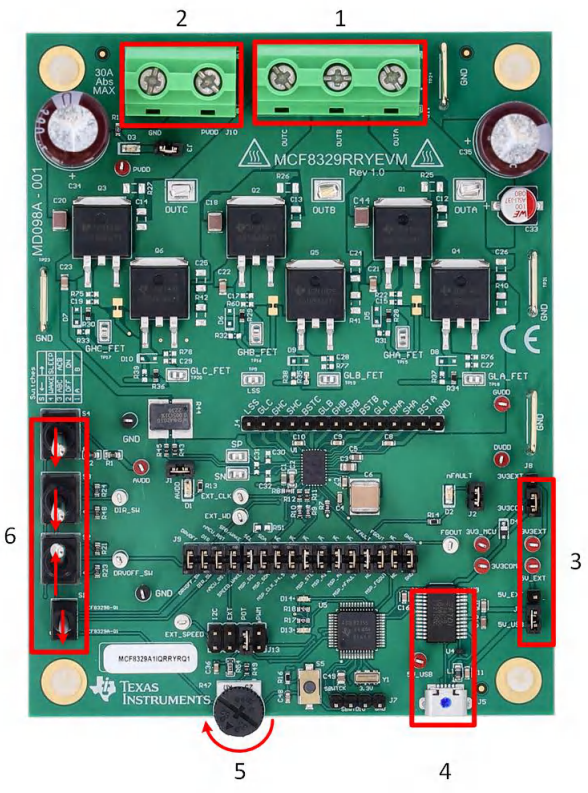


Figure 2-1. Reference for Quick Start Guide

2.2 Hardware Setup

The hardware required to run the motor is the MCF8329RRYEVM, a micro-USB cable, and a power supply with a DC output from 4.5V to 60V. Follow these steps to start up the MCF8329RRYEVM:

1. Connect the DC power supply to header J10. Connect to PVDD and GND.
2. Set user configurable jumper settings. For more information, see Section 2.7.
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 MCF8329RRYEVM.
5. Connect a Micro-USB cable to the MCF8329RRYEVM and computer.

If using the MCF8329RRYEVM with an external microcontroller, then remove all shunt jumpers from jumper bridge J9. Connect the external MCUs pins to the respective jumpers on the right side of the jumper bridge J9.

2.3 Hardware Connections Overview

The major blocks of MCF8329RRYEVM are shown in Figure 2-2. The MCF8329RRYEVM is designed for an input supply from 4.5V to 60V at 30A max. The MCF8329RRYEVM includes a power stage with six external N-channel power MOSFETs and supporting passive components including a 5mΩ current sense shunt resistor. For interfacing with the GUI, the MCF8329RRYEVM has an onboard FTDI chip and MSP430FR2355.

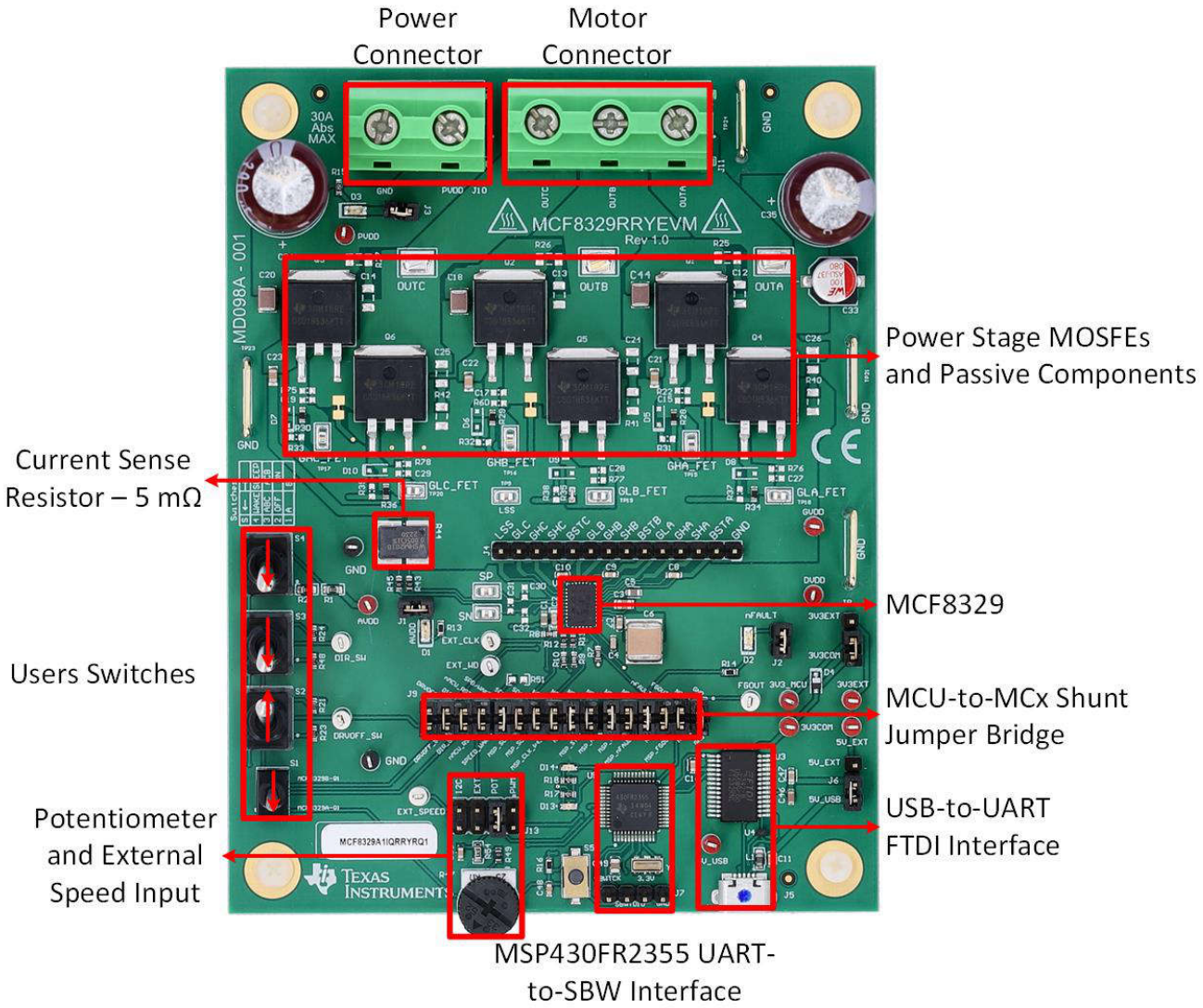


Figure 2-2. MCF8329RRYEVM Major Hardware Blocks

2.4 Connection Details

The specific connections that must be made to the MCF8329RRYEVM to spin a 3-phase sensorless brushless-DC motor are shown in Figure 2-3.

Connect a 4.5V to 60V power supply to the PVDD and GND terminals on connector J10.

Connect the three phases of the BLDC motor to the A, B, and C terminals of the screw terminal connector J11 or to the OUTA, OUTB, and OUTC test points.

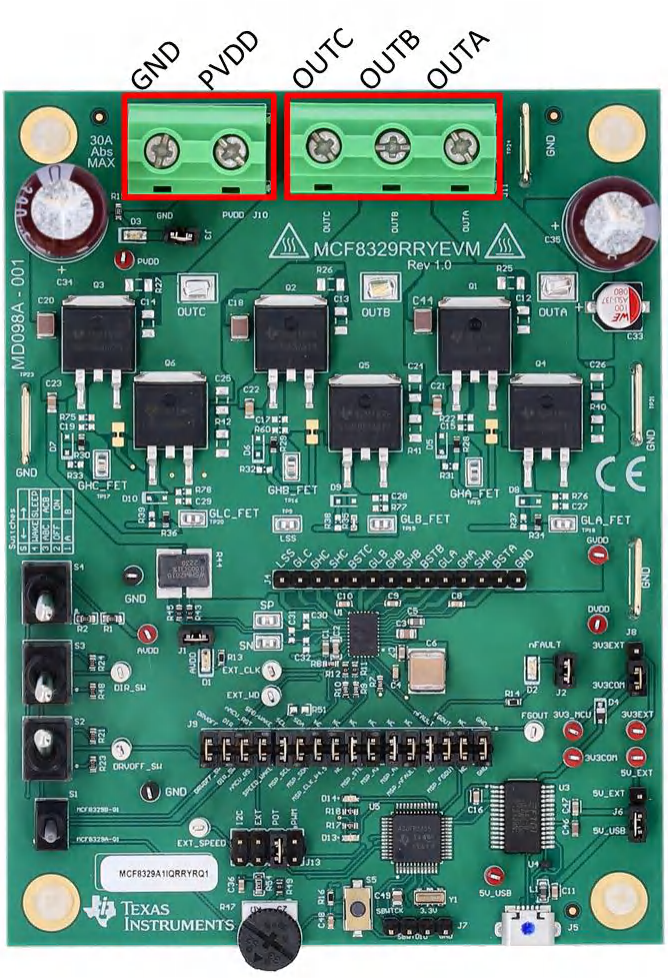


Figure 2-3. Connections from Motor to MCF8329RRYEVM

Where the micro-USB cable is plugged into the MCF8329RRYEVM to provide communication between evaluation module and GUI is shown in Figure 2-4. 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 limited to 30mA. To supply more current to these power rails, set the 5V_SEL jumper J3 to 5V_EXT and set the 3V3_SEL jumper J5 to 3V3EXT and connect the external supply to the 5V_EXT and 3V3EXT test points.

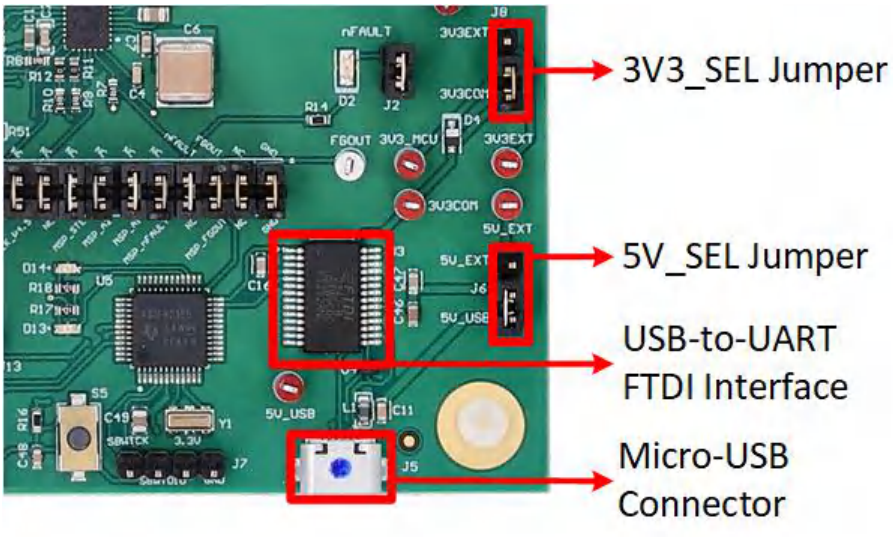


Figure 2-4. Micro-USB Connector and USB-to-UART Interface

2.5 MSP430FR2355 Microcontroller

The MCF8329RRYEVM includes a MSP430FR2355 low-power MCU, shown in Figure 2-5, to communicate via I2C with the MCF8329 IC.

To program the MSP430FR2355, an external MSP430 FET programmer must be connected to the Spy-Bi-Wire (SBW) interface connector J7. Many MSP430 LaunchPads™ provide an onboard eZ-FET Debug Probe that can be jumper-wired to the MCF8329RRYEVM to flash the firmware into the onboard MSP430FR2355 microcontroller.

The Reset (RST) button at any time to restart the MCU program. Two active-low LEDs, D13 and D14, can be used for debug purposes as well.

The 32-pin shunt jumper bridge J9 ties all signals between the microcontroller and MCF8329 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 MCF8329RRYEVM as a standalone gate driver with an external microcontroller.

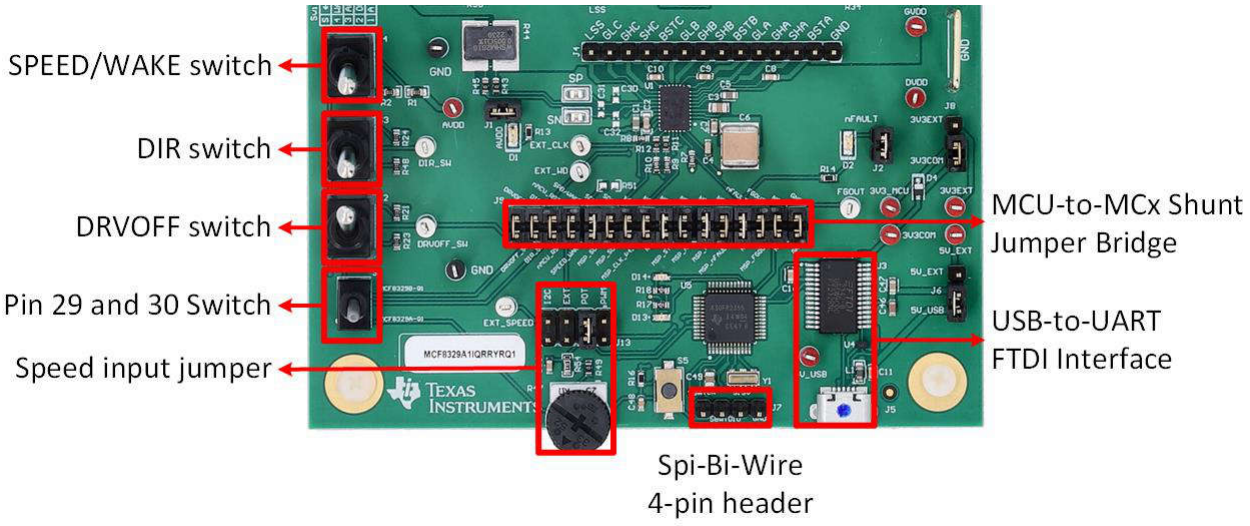


Figure 2-5. MSP430FR2355 MCU on MCF3829RRYEVM

2.6 LED Lights

The MCF8329RRYEVM has 5 status LEDs that provide the status of power supplies and functions of the evaluation module. By default, the PVDD LED and AVDD LED lights 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 with Figure 2-6 showing the locations of the LEDs.

Table 2-1. Description of MCF8329RRYEVM LEDs

Designator	Name	Color	Description
D1	3.3V	Green	Lights up when AVDD is turned ON
D2	nFAULT	Red	Lights up when fault condition has occurred on MCF8329
D3	PVDD	Green	Lights up when voltage is applied on PVDD
D13	MSP_LED1	Red	Used for UART or debugging
D14	MSP_LED2	Red	Used for UART or debugging

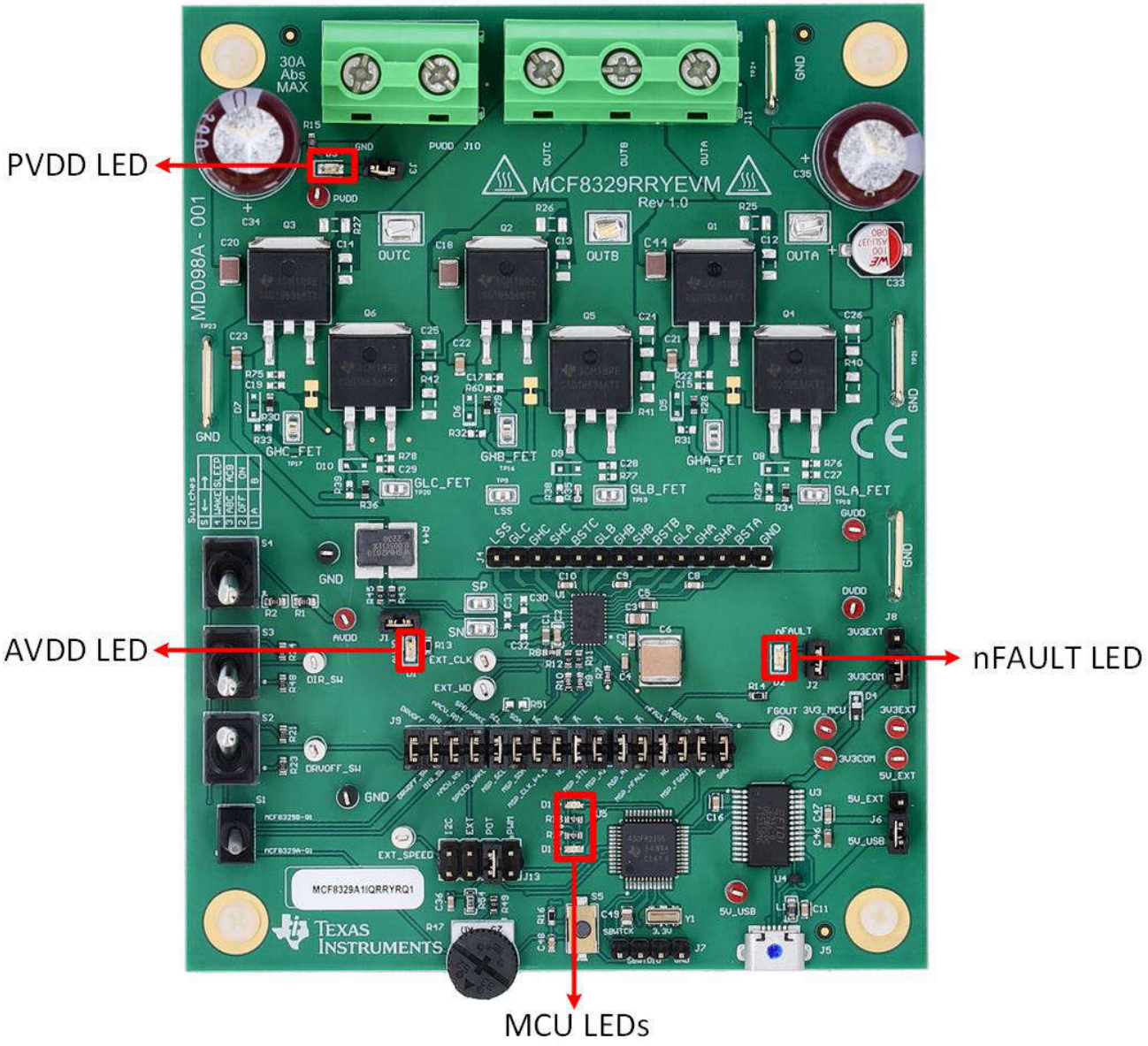


Figure 2-6. MCF8329RRYEVM LED Locations

2.7 User Configurable Settings

The MCF8329RRYEVM includes a variety of user-selectable jumpers, switches, and resistors on the entirety of the evaluation board to configure settings. A summary all of these configurable settings is provided in Table 2-2.

Table 2-2. Description of User-Selectable Settings on MCF8329RRYEVM

Designator	Setting Name	Description	Layer	Position	Function
J8	3V3_SEL	Select 3.3V source for MCU power	Top	J8 = 3V3EXT	External
				J8 = 3V3COM	From FTDI (30mA)
J6	5V_SEL	Select 5V source for FTDI power	Top	J6 = 5V_EXT	External
				J6 = 5V_USB	From USB power (500mA)
J13	SPEED_SEL	Selects SPEED input source	Top	J13 = I2C	From S4 switch
				J13 = EXT	External EXT_SPEED test point
				J13 = POT	From Potentiometer R47
				J13 = INT_PWM	From internal PWM. PWM Duty cycle can be varied by rotating the POT R47
J9	MSP to MCx Shunt jumper bridge	Connects signals from MVU and user switches to MCF8329 when jumpers are inserted	Top	DRVOFF_SW	DRVOFF
				DIR_SW	Pin 29
				MCU_RST	Pin 30
				SPEED_WAKE	SPEED/WAKE
				MSP_SCL	SCL
				MSP_SDA	SDA
				MSP_CLK_P4.5	NC
				NC	NC
				MSP_STE	NC
				MSP_A2	NC
				MSP_A1	GCTRL
				NC	NC
				MSP_nFAULT	nFAULT
				MSP_FGOUT	FGOUT
				NC	NC
				GND	GND
J12	VREG_SEL	Selects VREG power supply	Top	Right position	VREG powered by MOSFET Q7
J1	AVDD LED	Connects AVDD LED to 3.3V pull up	Top	Connected	D1 lights up when AVDD is turned ON
J2	nFAULT LED	Connects nFAULT LED to 3.3V pull up	Top	Connected	D2 Lights up when nFAULT is pulled low
J3	PVDD LED	Connects PVDD LED to 3.3V pull up	Top	Connected	D3 lights up when voltage is applied to PVDD
S1	N/A	Connects pins 29 and 30 to the appropriate signals based on MCF8329 variant	Top	Bottom	Set pins 29 and 30 for MCF8329A configuration
				Top	Set pins 29 and 30 for MCF8329B configuration
S2	DRVOFF	Disables gate drivers	Top	Bottom	MCF8329 Disabled
				Top	MCF8329 Enabled
S3	DIR	Controls direction of motor rotation	Top	Bottom	ABC
				Top	ACB
S4	SPEED/WAKE	Pulls SPEED/WAKE pin High or Low. Used to keep MCF8329 awake and not idle when in I2C speed mode	Top	Bottom	Pulls Speed/WAKE pin LOW
				Top	Pulls SPEED/WAKE pin High

3 Software

3.1 Firmware and GUI Application

The MCF8329RRYEVM includes a FTDI chip and MSP4302355 microcontroller which serve as a communication bridge between the host PC and the MCF8329 device for configuring various device settings and reading fault diagnostic information. Using this communication interface, the MC8329RRYEVM can connect to the Motor Studio GUI to configure the MCF8329. The Motor Studio GUI simplifies the tuning process of the MCF8329 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 MSP430FR2355 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 onto the EVM requires an external MSP430 LaunchPad™ that includes the eZ-FET Debug Probe and Code Composer Studio™ (CCS). The example in Section 3.4 uses the MSP-EXP430FR2355 LaunchPad Development Kit to provide the eZ-FET Debug Probe.

3.2 Downloading and Running Motor Studio

1. Connect the MCF8329RRYEVM 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 *Setup Now* button and follow the instructions to set up the EVM.
5. After setting up the MCF8329RRYEVM, click on *Quick Spin* to begin configuring the device.

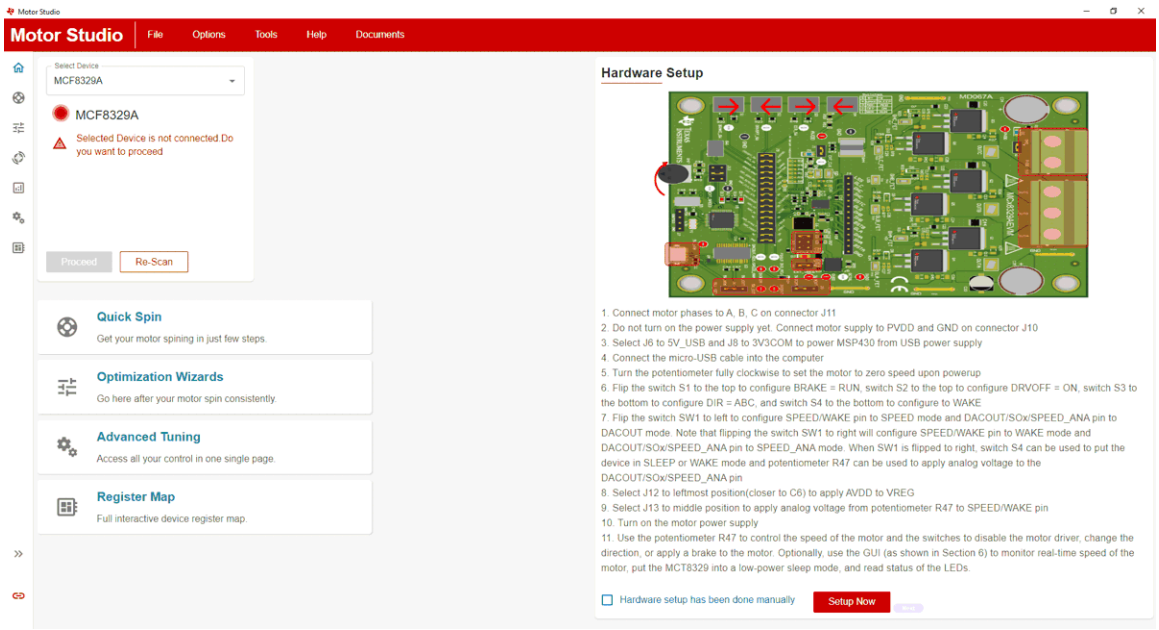


Figure 3-1. Motor Studio GUI MCF8329A Home Page

3.3 Downloading Code Composer Studio and Importing GUI Firmware

1. Download and extract the Motor Studio firmware to a location on your computer.
2. Download the latest version of Code Composer Studio to set up a folder in the directory C:\ti.
   a. Accept all agreements, default install instructions, and select *Next* to proceed through the menus.
   b. In the *Selected 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

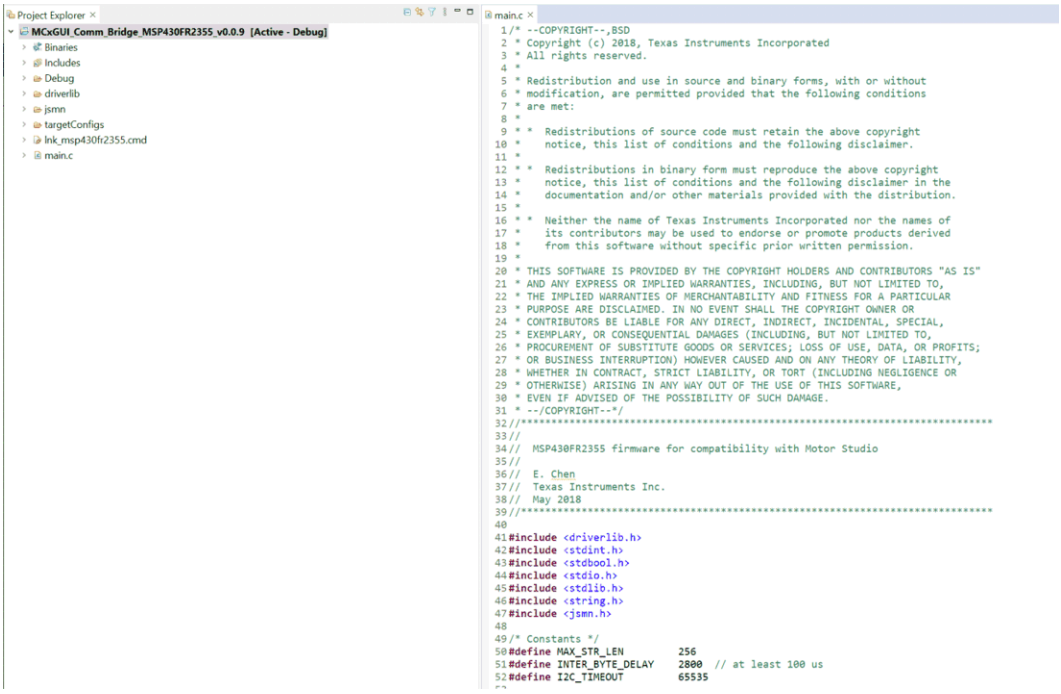


Figure 3-2. MSP430FR2355 Interface Firmware Code in Code Composer Studio

3.4 Using eZ-FET to Program the Onboard MSP430FR2355

The eZ-FET Debug Probe on the MSP430FR2355 LaunchPad uses a Spy-Bi-Wire JTAG interface to program the MSP430FR2355 MCU on the MCF8329RRYEVM. Consult the MSP430 Launchpad Development Kits for MSP430 Launchpad the 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, SBWTDIO, SBWTCK signals to the respective pins on J7 of the MCF8329RRYEVM 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 Spy-Bi-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)	MCF8329RRYEVM 4-pin Spy-Bi-Wire Header (J7)
GND	GND
3V3	3V3
SBWTDIO	SBWTDIO
SBWTCK	SBWTCK

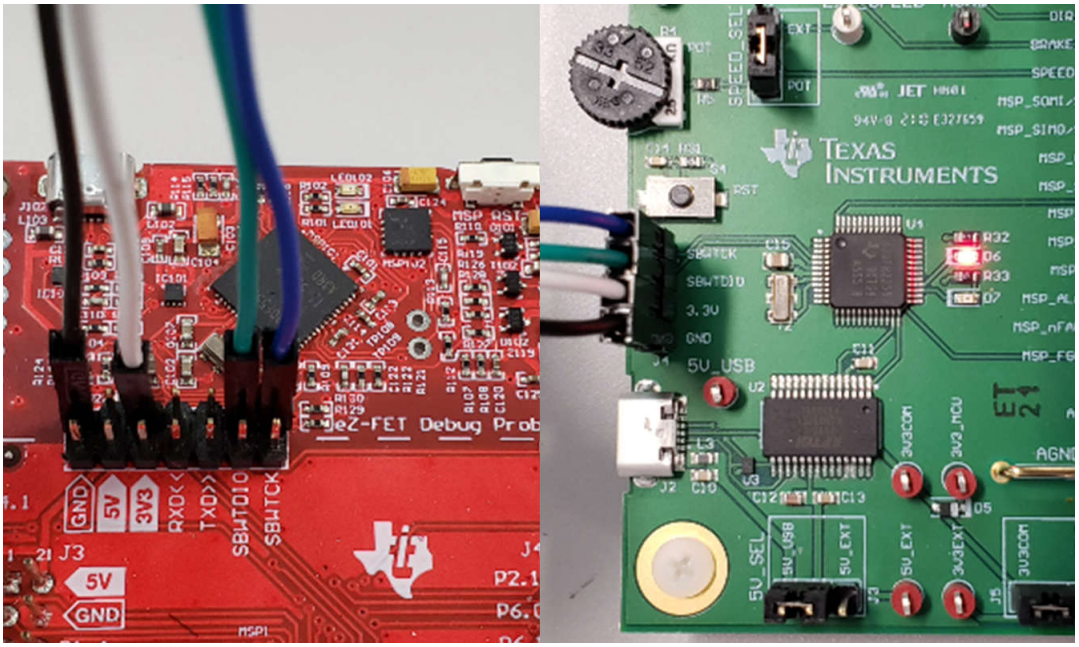


Figure 3-3. MSP430 LaunchPad eZ-FET Debug Probe Connected to MSP430FR2355

4 Hardware Design Files

4.1 Schematics

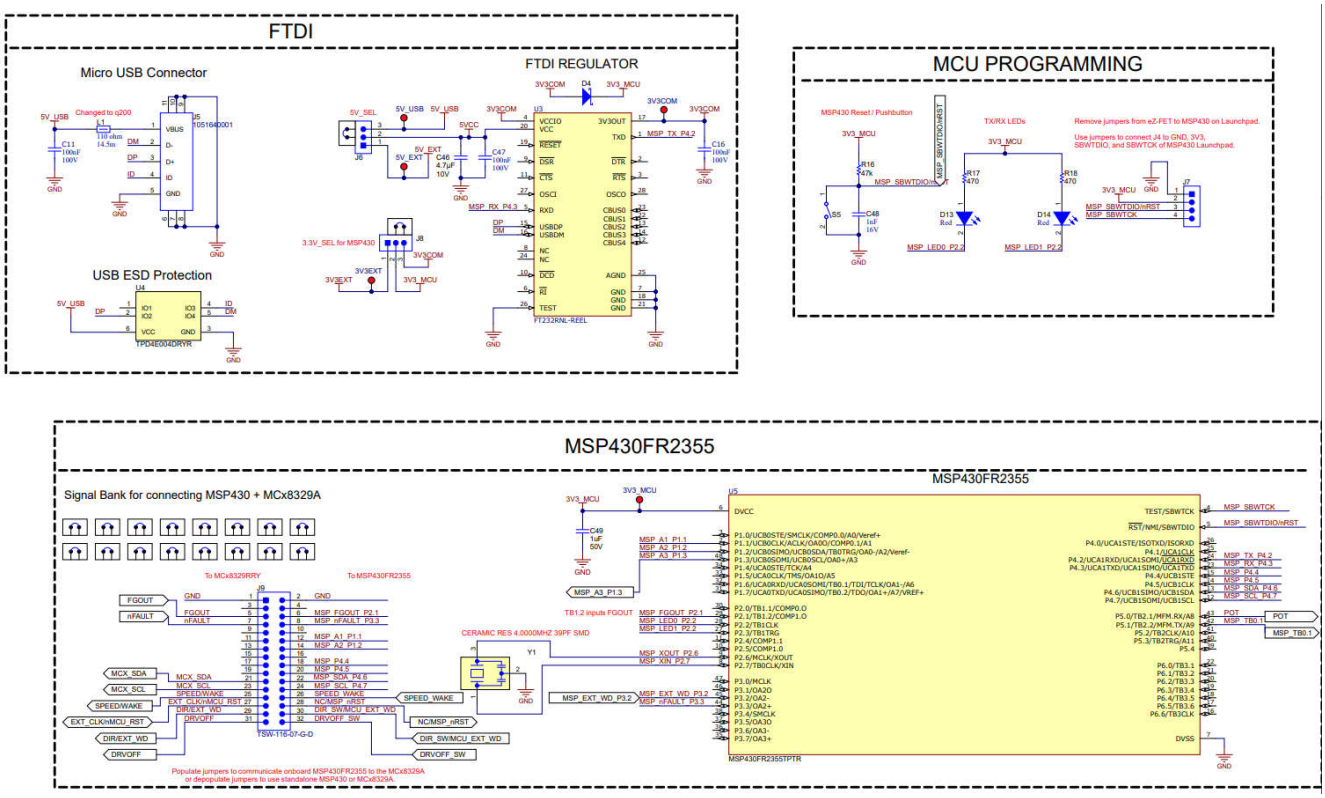


Figure 4-1. Interfaces

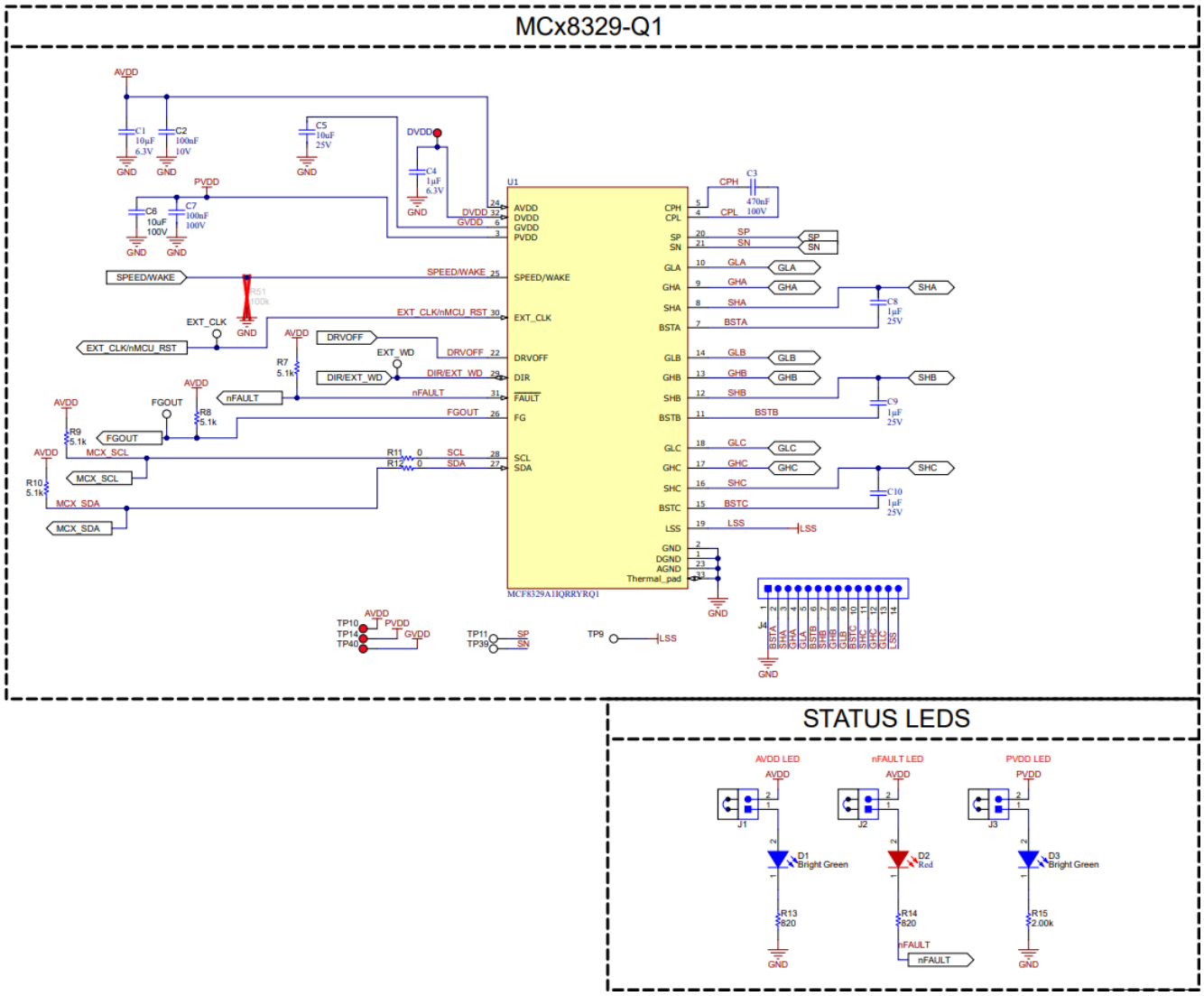


Figure 4-2. Driver

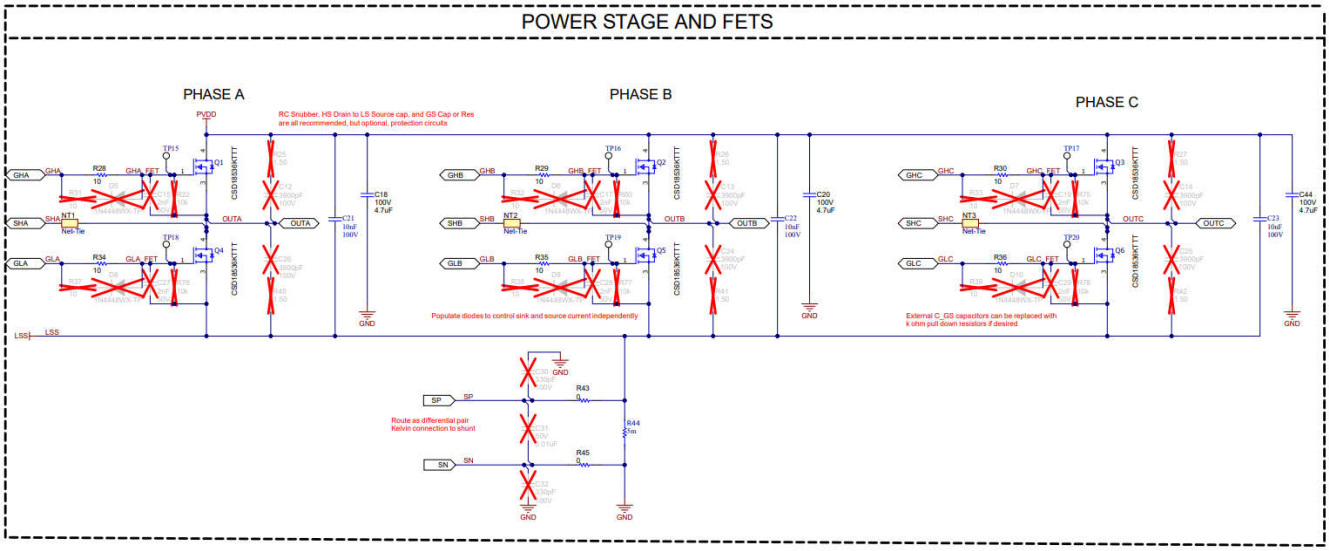


Figure 4-3. MOSFETs and Power Stage

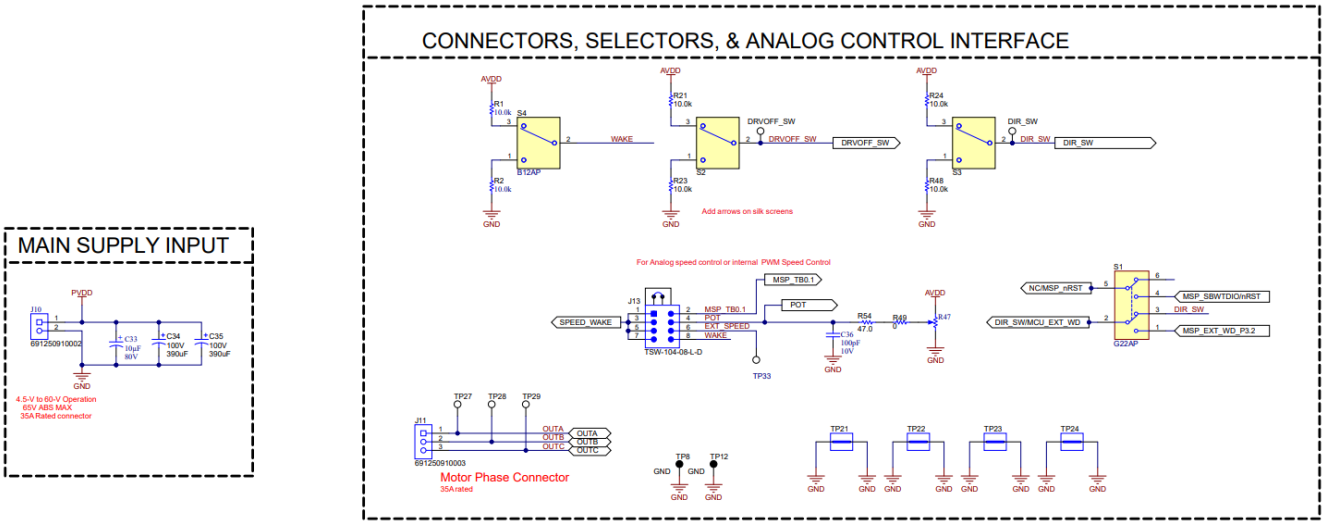


Figure 4-4. Power and Connectors

4.2 PCB Layouts

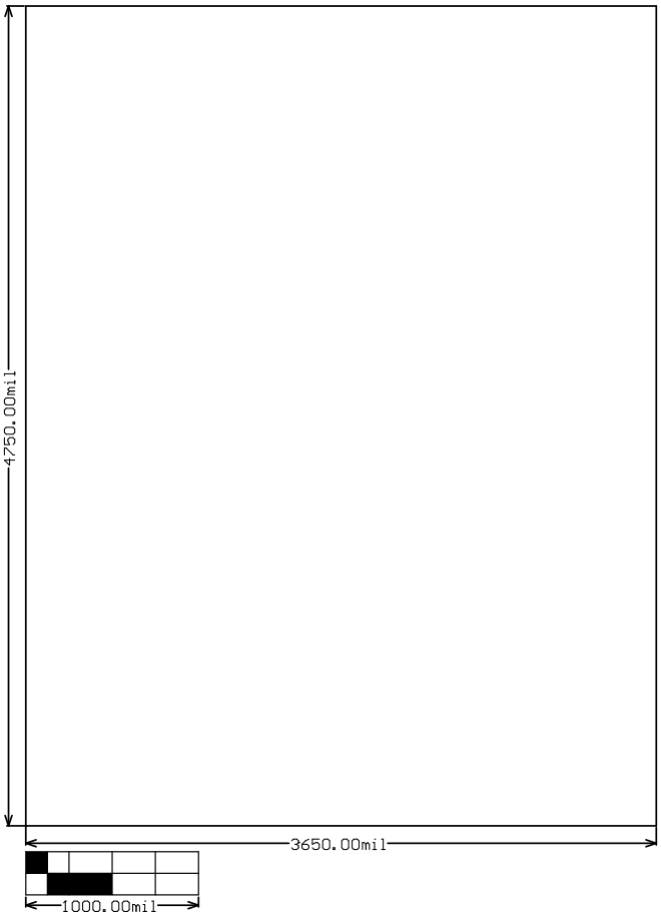


Figure 4-5. EVM Board Dimensions

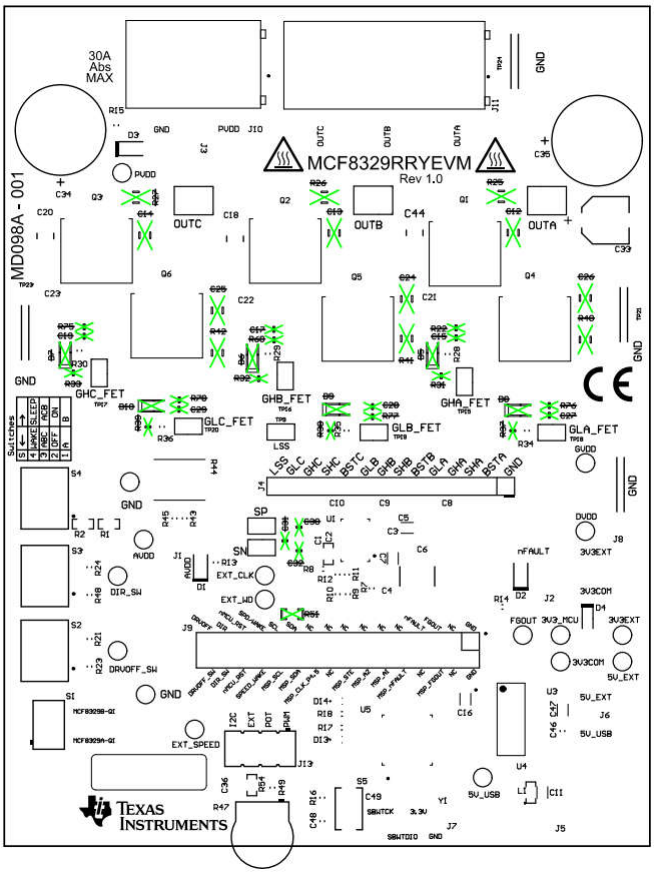


Figure 4-6. EVM Top Overlay

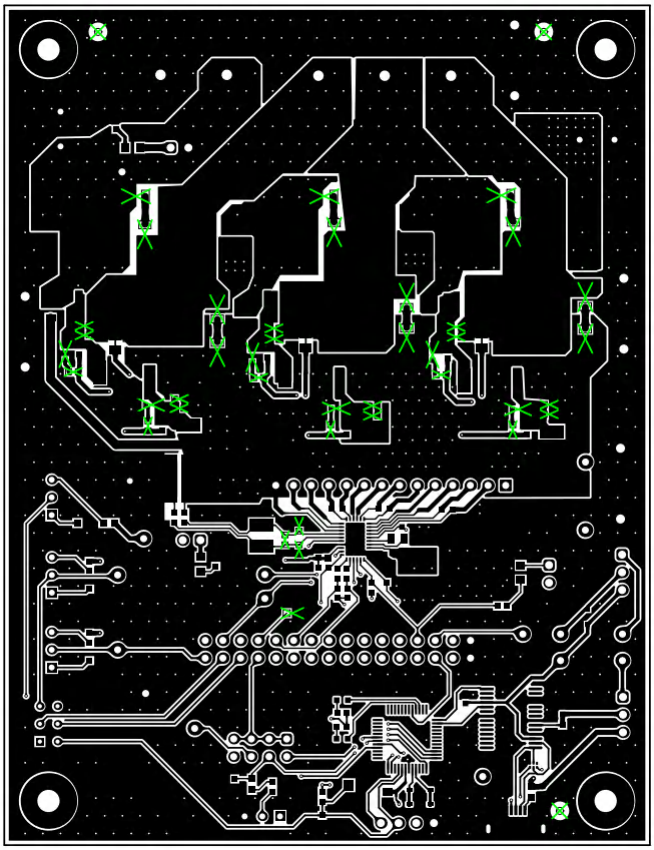


Figure 4-7. EVM Top Layer

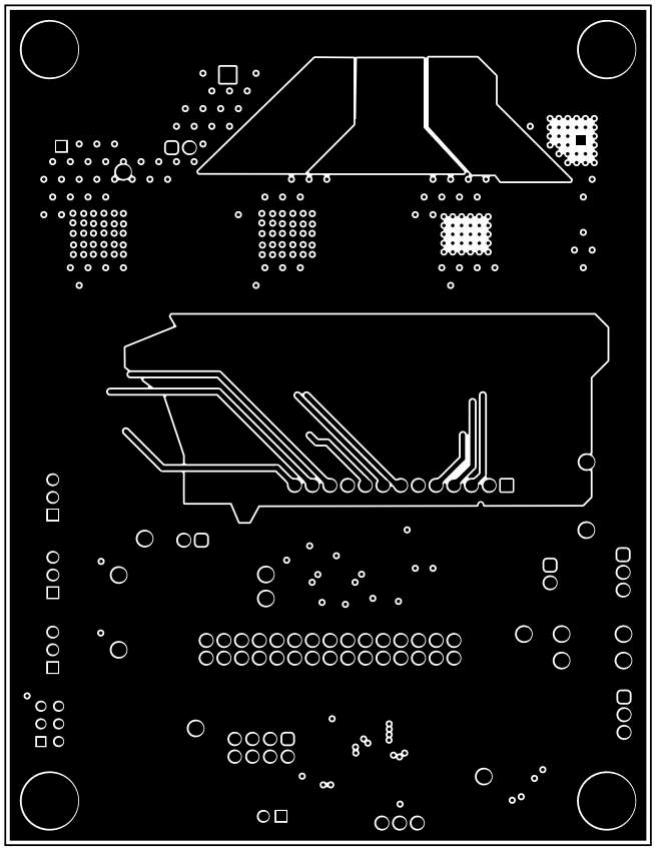


Figure 4-8. EVM Signal Layer 1

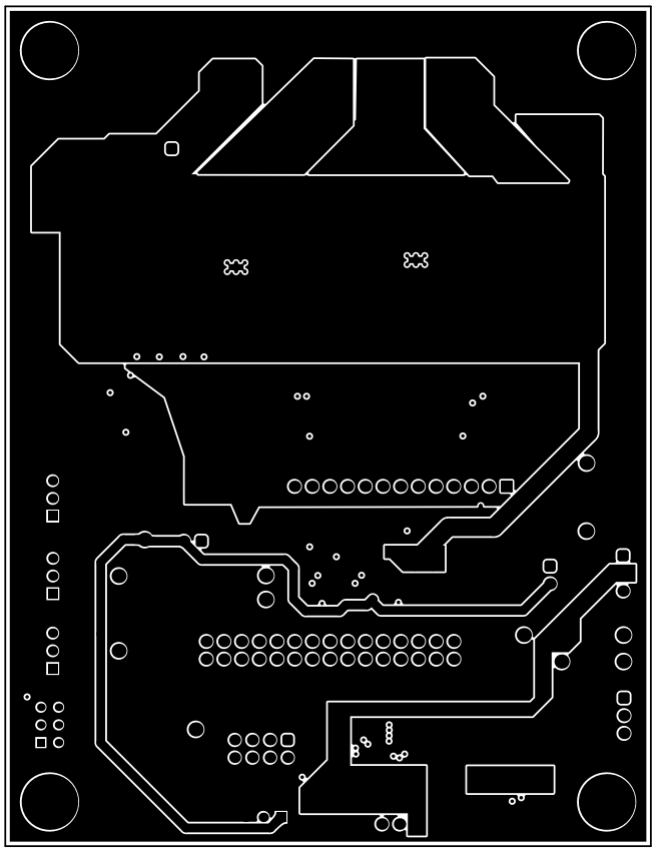


Figure 4-9. EVM Signal Layer 2

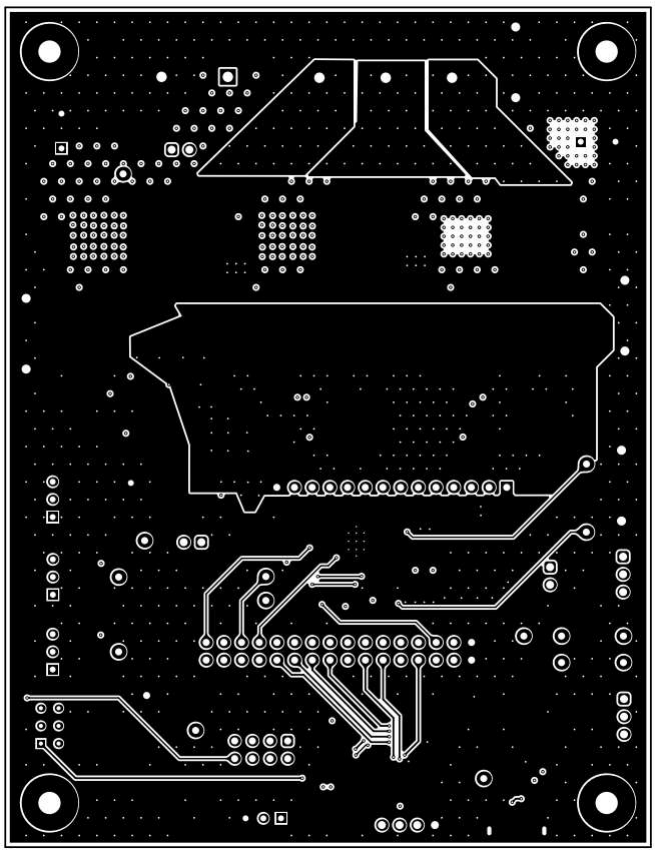


Figure 4-10. EVM Bottom Layer

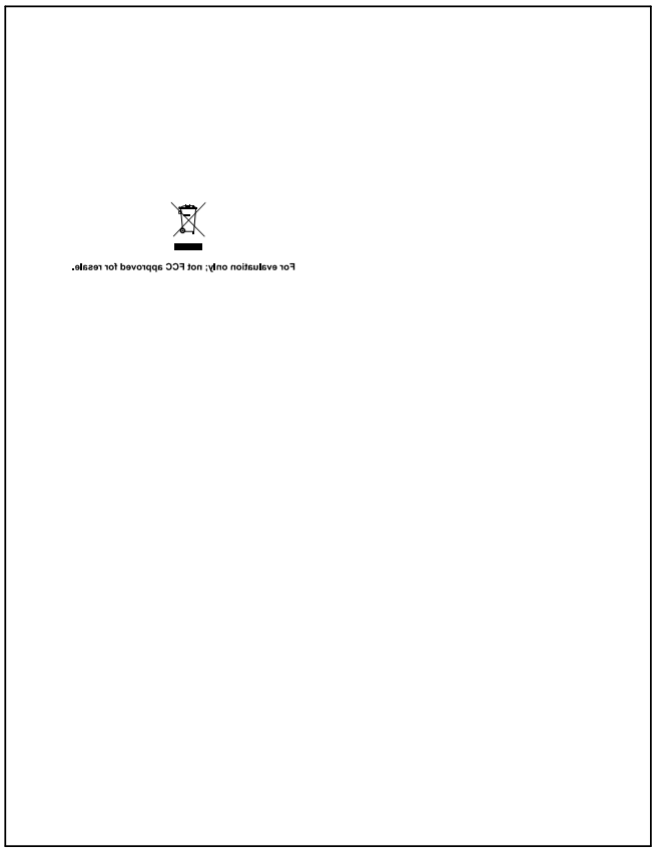


Figure 4-11. EVM Bottom Overlay

4.3 Bill of Materials (BOM)

Table 4-1. Bill of Materials

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
C1	1	10uF	WCAP-CSGP Multilayer Ceramic Chip Capacitor, General Purpose, size 0603, X5R, 10µF, 6.3VDC	603	885012106006	Wurth Elektronik
C2	1	0.1uF	CAP, CERM, 0.1uF, 10V,+/- 10%, X7R, 0603	603	885012206020	Wurth Elektronik
C3	1	470nF	WCAP-CSGP Multilayer Ceramic Chip Capacitor, General Purpose, size 0805, X7R Class II, 470nF, 100VDC	805	885012207130	Wurth Elektronik
C4	1	1uF	WCAP-CSGP Multilayer Ceramic Chip Capacitor, General Purpose, size 0603, X5R, 1µF, 6.3VDC	603	885012106003	Wurth Elektronik
C5	1	10µF	10µF ±20% 25V Ceramic Capacitor X5R 0603 (1608 Metric)	603	885012106031	Wurth
C6	1	10uF	CAP, CERM, 10uF, 100V, +/- 20%, X7R, 2220	2220	22201C106MAT2A	AVX
C7, C11, C16, C47	4	100nF	0.1µF ±10% 100V Ceramic Capacitor X7R 0603 (1608 Metric)	603	885012206120	Wurth Electronics
C8, C9, C10	3	1uF	WCAP-CSGP Multilayer Ceramic Chip Capacitor, General Purpose, size 0603, X5R, 1µF, 25VDC	603	885012106022	Wurth Elektronik
C18, C20, C44	3	4.7uF	CAP, CERM, 4.7uF, 100V, +/- 10%, X7S, 1210	1210	GRM32DC72A475KE01L	MuRata
C21, C22, C23	3	0.01uF	WCAP-CSGP Multilayer Ceramic Chip Capacitor, General Purpose, size 0805, X7R, 10nF, 100VDC	805	885012207122	Wurth Elektronik
C33	1	10uF	WCAP-ASLI Aluminum Electrolytic Capacitor, V-Chip, D6.3 x H7.7mm, 10uF, 80V	D6.3 x H7.7mm	865081745005	Wurth Elektronik
C34, C35	2	390uF	CAP, AL, 390uF, 100V, +/- 20%, 0.026 ohm, TH	D12.5xL35mm	EKYB101ELL391MK35S	Chemi-Con
C36	1	100pF	WCAP-CSGP Multilayer Ceramic Chip Capacitor, General Purpose, size 0603, X7R, 100pF, 10VDC	603	885012206003	Wurth Elektronik
C46	1	4.7uF	CAP, CERM, 4.7uF, 10V, +/- 20%, X7R, 0603	603	GRM188Z71A475ME15D	MuRata
C48	1	1000pF	CAP, CERM, 1000pF, 16V, +/- 10%, X7R, 0603	603	885012206034	Wurth Elektronik
C49	1	1uF	CAP, CERM, 1uF, 50V, +/- 10%, X7R, 0805	805	885012207103	Wurth Elektronik
D1, D3	2	Bright Green	LED, Bright Green, SMD	LED_0805	150080VS75000	Wurth Elektronik
D2	1	Red	LED, Red, SMD	LED_0805	150080RS75000	Wurth Elektronik
D4	1	40V	Diode, Schottky, 40V, 0.75A, AEC-Q101, SOD-323	SOD-323	BAT165E6327HTSA1	Infineon Technologies

Table 4-1. Bill of Materials (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
D13, D14	2	Red	Red 625nm LED Indication - Discrete 2V 0603 (1608 Metric)	603	150060RS75003	Wurth Electronics
H1, H2, H3, H4	4		Standoff, Hex, 1"L #4-40 Nylon	Standoff	1902E	Keystone
H5, H6, H7, H8	4		Machine Screw, Round, #4-40 x 1/4, Nylon, Philips panhead	Screw	NY PMS 440 0025 PH	B&F Fastener Supply
J1, J2, J3	3		Header, 2.54mm, 2x1, Gold, TH	Header, 2.54mm, 2x1, TH	61300211121	Wurth Elektronik
J4	1		Header, 100mil, 14x1, Gold, TH	14x1 Header	TSW-114-07-G-S	Samtec
J5	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
J6, J8	2		Header, 2.54mm, 3x1, Gold, TH	Header, 2.54mm, 3x1, TH	61300311121	Wurth Elektronik
J7	1		Header, 2.54mm, 4x1, Gold, TH	Header, 2.54mm, 4x1, TH	61300411121	Wurth Elektronik
J9	1		Header, 100mil, 16x2, Gold, TH	16x2 Header	TSW-116-07-G-D	Samtec
J10	1		2 Position Wire to Board Terminal Block Horizontal with Board 0.375" (9.53mm) Through Hole	CONN_TERM_BLK2	691250910002	Wurth Electronics
J11	1		3 Position Wire to Board Terminal Block Horizontal with Board 0.375" (9.53mm) Through Hole	CONN_TERM_BLK3	691250910003	Wurth Electronics
J13	1		Header, 2.54mm, 4x2, Gold, TH	Header, 2.54mm, 4x2, TH	TSW-104-08-L-D	Samtec
L1	1	110 ohm	Ferrite Bead, 110 ohm at 100MHz, 4.1A, 0603	603	74279228111	Wurth Elektronik
LBL1	1			PCB Label 0.650 x 0.200 inch	THT-14-423-10	Brady
Q1, Q2, Q3, Q4, Q5, Q6	6		MOSFET 60V, N channel NexFET power MOSFET, single D2PAK, 1.6 mOhm 3-DDPAK/TO-263 -55 to 175	DDPAK	CSD18536KTTT	Texas Instruments
R1, R2, R21, R23, R24, R48	6	10.0k	RES, 10.0 k, 0.05%, 0.1 W, AEC-Q200 Grade 0, 0603	603	ERA-3ARW103V	Panasonic
R7, R8, R9, R10	4	5.1k	RES, 5.1 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	603	CRCW06035K10JNEA	Vishay-Dale

Table 4-1. Bill of Materials (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
R11, R12, R43, R45, R49	5	0	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	603	ERJ-3GEY0R00V	Panasonic
R13, R14	2	820	RES, 820, 5%, 0.1 W, 0603	603	RC0603JR-07820RL	Yageo
R15	1	2.00k	RES, 2.00 k, 0.1%, 0.1 W, 0603	603	RG1608P-202-B-T5	Susumu Co Ltd
R16	1	47k	RES, 47 k, 5%, 0.1 W, 0603	603	RC0603JR-0747KL	Yageo
R17, R18	2	470	RES, 470, 5%, 0.1 W, 0603	603	RC0603JR-07470RL	Yageo
R28, R29, R30, R34, R35, R36	6	10	RES, 10, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	603	CRCW060310R0JNEA	Vishay-Dale
R44	1	5m	5 mOhms ±1% 7W Chip Resistor Nonstandard Automotive AEC-Q200, Current Sense, Moisture Resistant, Pulse Withstanding Metal Element	2818	WSHM28185L000FEA	Vishay
R47	1	25 kohm	Trimmer Potentiometer, 25kohm, 0.5W, TH	9.53x8.89mm	3352T-1-253LF	Bourns
R54	1	47	RES, 47.0, 0.1%, 0.1 W, 0603	603	RT0603BRD0747RL	Yageo America
S1	1		Switch, DPDT, On-On, 0.4 VA, 28V, TH	DPDT Switch, 4.5x7mm	G22AP	NKK Switches
S2, S3, S4	3		SWITCH TOGGLE SPDT 0.4VA 28V	6.8x23.1x8.8mm	B12AP	NKK Switches
S5	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-J8, SH-J10, SH-J11, SH-J12, SH-J13, SH-J14, SH-J15, SH-J16, SH-J17, SH-J18, SH-J19, SH-J20, SH-J21, SH-J22, SH-J23, SH-J24	22	1x2	Shunt, 2.54mm, Gold, Black	Shunt, 2.54mm, Black	60900213421	Wurth Elektronik
TP1, TP10, TP14, TP40, TP41, TP42, TP43, TP44, TP45	9		Test Point, Miniature, Red, TH	Red Miniature Test point	5000	Keystone
TP3, TP4, TP31, TP32, TP33, TP50	6		Test Point, Miniature, White, TH	White Miniature Test point	5002	Keystone

Table 4-1. Bill of Materials (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
TP8, TP12	2		Test Point, Miniature, Black, TH	Black Miniature Test point	5001	Keystone
TP9, TP11, TP15, TP16, TP17, TP18, TP19, TP20, TP39	9		Test Point, Miniature, SMT	Testpoint_Keystone_Miniature	5015	Keystone
TP21, TP22, TP23, TP24	4		1mm Uninsulated Shorting Plug, 10.16mm spacing, TH	Shorting Plug, 10.16mm spacing, TH	D3082-05	Harwin
TP27, TP28, TP29	3		Test Point, Compact, SMT	Testpoint_Keystone_Compact	5016	Keystone
U1	1		Automotive Sensorless Field Oriented Control (FOC) Three-phase BLDC Gate Driver	WQFN32	MCF8329A1IQRRYRQ1	Texas Instruments
U3	1		UART Interface IC USB Full Speed to Serial UART IC, Includes Oscillator and EEPROM, SSOP-28	SSOP28	FT232RNL-REEL	FTDI
U4	1		4-Channel ESD Protection Array for High-Speed Data Interfaces, DRY0006A (USON-6)	DRY0006A	TPD4E004DRYR	Texas Instruments
U5	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

5 Additional Information

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