Document Number: KT33816UG
Rev. 2.0, 4/2013

KIT33816AEEVM Evaluation Board

Featuring the MC33816 Automotive Engine Control IC with Smart Gate Control

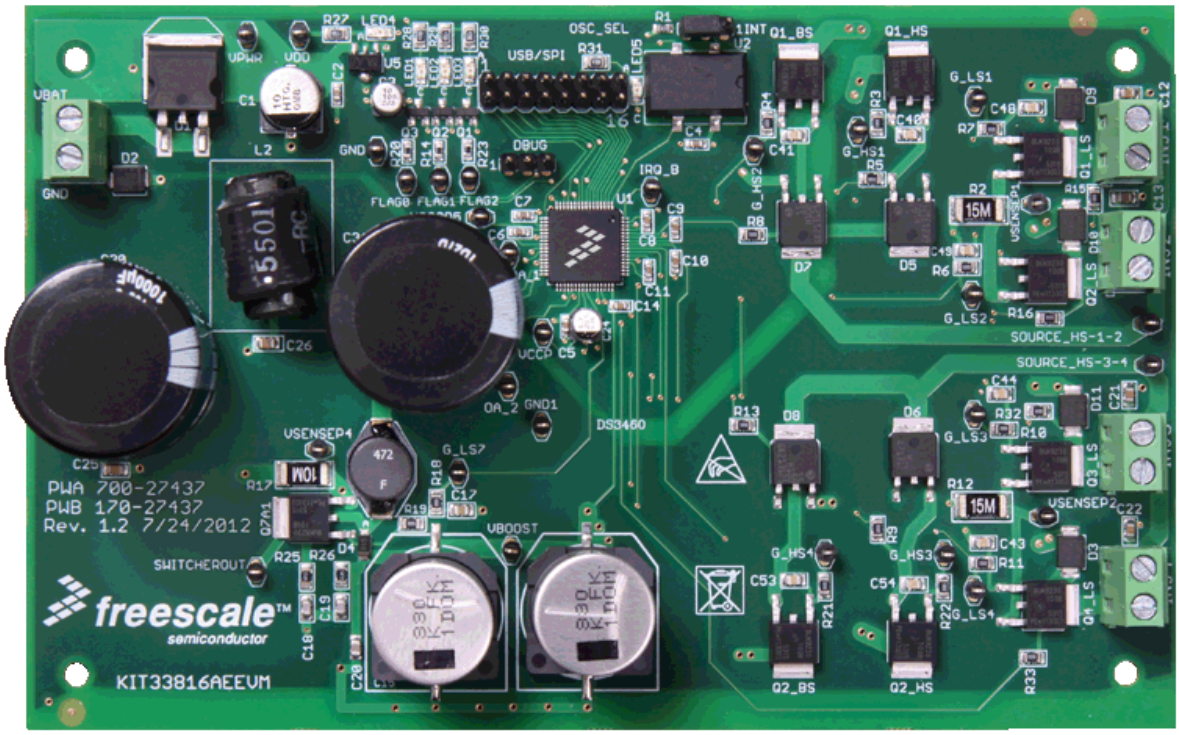

Figure 1. KIT33816AEEVM Evaluation Board

Table of Contents

1 Kit Contents / Packing List

- Assembled and tested evaluation board/module in anti-static bag.
- Warranty card

2 Jump Start

- Go to www.freescale.com/analogtools
- Locate your kit
- Review your Tool Summary Page
- Look for

- Download documents, software and other information

3 Important Notice

Freescale provides the enclosed product(s) under the following conditions:

This evaluation kit is intended for use of ENGINEERING DEVELOPMENT OR EVALUATION PURPOSES ONLY. It is provided as a sample IC pre-soldered to a printed circuit board to make it easier to access inputs, outputs, and supply terminals. This EVB may be used with any development system or other source of I/O signals by simply connecting it to the host MCU or computer board via off-the-shelf cables. This EVB is not a Reference Design and is not intended to represent a final design recommendation for any particular application. Final device in an application will be heavily dependent on proper printed circuit board layout and heat sinking design as well as attention to supply filtering, transient suppression, and I/O signal quality.

The goods provided may not be complete in terms of required design, marketing, and or manufacturing related protective considerations, including product safety measures typically found in the end product incorporating the goods. Due to the open construction of the product, it is the user's responsibility to take any and all appropriate precautions with regard to electrostatic discharge. In order to minimize risks associated with the customers applications, adequate design and operating safeguards must be provided by the customer to minimize inherent or procedural hazards. For any safety concerns, contact Freescale sales and technical support services.

Should this evaluation kit not meet the specifications indicated in the kit, it may be returned within 30 days from the date of delivery and will be replaced by a new kit.

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4 Introduction

The KIT33816AEEVM Evaluation Board (EVB) is an easy-to-use circuit board that allows the user to exercise all the functions of the MC33816 Direct Injection Pre-driver circuit. A PC communicates to the EVB through a USB/SPI dongle (KITUSBSPIDGLEVME) connected to the PC's USB port. The Freescale SPIGen (version 7.0 and above) program provides the user interface to the MC33816 SPI port and allows the user to program the Code RAM and Data Registers, send commands to the IC and receive status from the IC.

5 KIT33816AEEVM Features

This EVB consists of the following:

- A MC33816 Direct Injection Pre-driver Integrated Circuit
- A USB-to-SPI dongle interface
- Power-conditioning circuitry
- External MOSFETs
- A +5.0 Volt regulator supplies all +5.0 Volt VDD power required by the EVB
- A +12 V VBAT supply provides the power to the two internal voltage regulators, VCCP and VCCP2.5.

6 MC33816 Device Features

- Battery voltage range, 5.5 V < V_{BATT} < 32 V
- Pre-drive operating voltage up to 72 V
- High side/ low side pre-drive PWM capability up to 100 KHz–30 nC
- All pre-drivers have four selectable slew rates
- Eight selectable, pre-defined VDS monitoring thresholds
- Encryption for microcode protection
- Integrated 1.0 MHz back-up clock

Freescale analog ICs are manufactured using the SMARTMOS process, a combinational BiCMOS manufacturing flow that integrates precision analog, power functions and dense CMOS logic together on a single cost-effective die.

7 Equipment Required

Minimum equipment required:

- Power supply 12 V with current limit set initially to 4.0 A
- Oscilloscope (four-channel preferably) with current probe
- Multimeter
- PC with Windows XP or above
- SPIGen 7.0 or greater and USB/SPI dongle (KITUSBSPIDGLEVME)

8 Evaluation Board Configuration

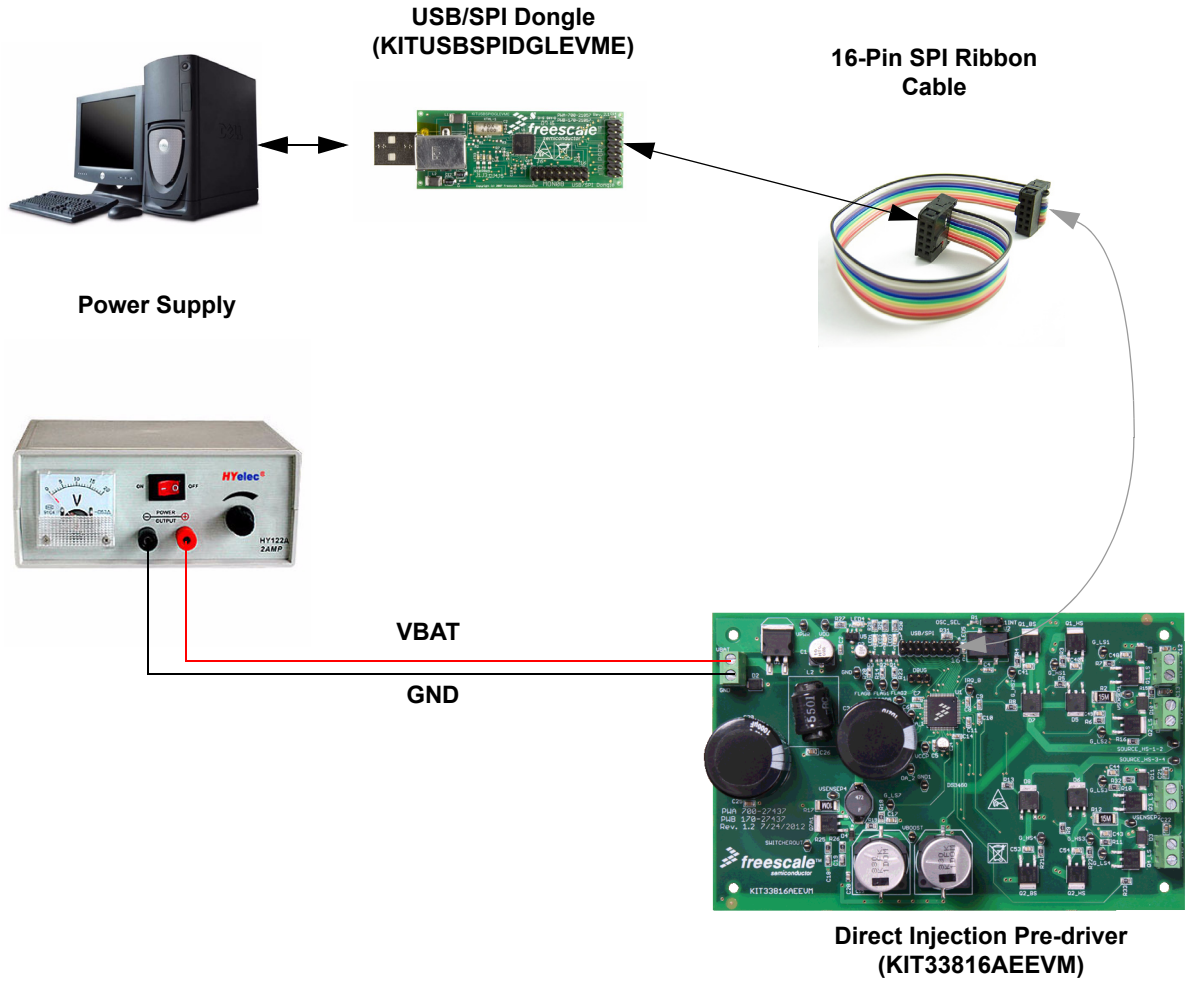


Figure 2. Evaluation Board Setup

9 Installing SPIGen Freeware on your Computer

The latest version of SPIGen is designed to run on any Windows 8, Windows 7, Vista or XP-based operating system. To install the software, go to www.freescale.com/analogtools and select your kit. Click on that link to open the corresponding Tool Summary Page. Look for “Jump Start Your Design”. Download to your computer desktop the SPIGen software as well as the associated configuration file.

Run the install program from the desktop. The Installation Wizard will guide you through the rest of the process.

To use SPIGen, go to the Windows Start menu, then Programs, then SPIGen, and click on the SPIGen icon. The SPIGen Graphic User Interface (GUI) will appear. Go to the file menu in the upper left hand corner of the GUI, and select “Open”. In the file selection window that appears, set the “Files of type: ” drop-down menu to “SPIGen Files (*.spi)”. (As an exceptional case, the file name may have a .txt extension, in which case you should set the menu to “All Files (*.*)”.) Next, browse for the configuration file you saved on your desktop earlier and select it. Click “Open”, and SPIGen will create a specially configured SPI command generator for your evaluation board.

The GUI is shown in **Figure 3**. The text at the top is the name of the configuration file loaded. The left side panel displays folders that group user interfaces. The interfaces in the pre-installed MC33816 folder pertain specifically to the board under discussion.The process of loading the configuration file has assigned a list of “Extra Pins” as well as a list “Quick Commands”, all of which are board-specific.

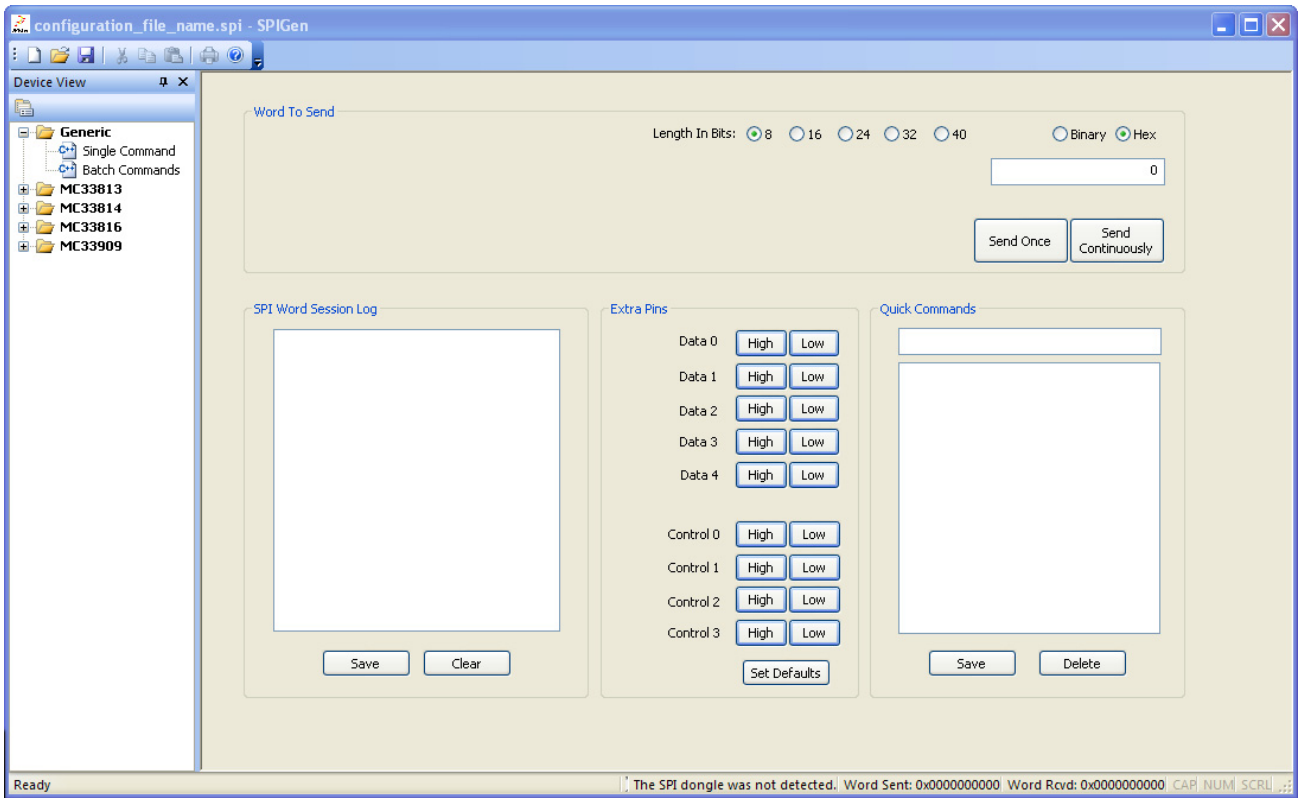


Figure 3. SPI Generator GUI

10 Setup and Using the Hardware

To perform the examples included in the software bundle, the following connections and setup must be performed:

1. Make sure the SPIGen 7.0 or higher program is installed on the PC and it can communicate with the USB/SPI dongle, as described in that kit's documentation.
2. Connect the USB/SPI dongle to the MC33816 EVB via a 16 conductor ribbon cable. Make sure to orient the cable connectors so that pin1 on both the USB/SPI dongle and the MC33816 EVB are connected correctly, pin 1 to pin 1.
3. Connect the USB/SPI dongle to a PC. LED 2 on the USB/SPI dongle and the USB ON LED on the MC33816 EVB should both be illuminated.
4. Attach the +12 VDC supply (do not turn on power yet) to the VBAT input connector on the MC33816 EVB, making sure to observe the GND and +12 V terminals. The current capability of the +12 V supply should exceed the maximum total current that the number of simultaneously ON loads will require.
5. Attach loads (Injectors) to the INJ1, INJ2, INJ3, and INJ4 output terminals as desired.
6. Turn on the +12 volt supply. Verify that all is working correctly by observing the VDD LED which should be illuminated.

10.1 Running an example program

1. Launch the SPIGen program.
2. Load the config file, by clicking on "File" then "Open" and browsing to the KIT33816SW.spi**.spi** file located inside the "**Injector Demo Files**" directory.
3. Go to the "**Single Command**" page in SPIGen and set the RESETB pin high.
4. Go to the "**Micro code**" page under "**MC33816**" and click on the folder icon on the right side of the "**Code Ram 1**" edit box. Browse to the location of the **MC33816_ch1.cip.bin** file, select it, and click on the "**Open**" button.
5. Click on the folder icon on the right side of the "**Code Ram 2**" edit box. Browse to the location of the **MC33816_ch2.cip.bin** file, select it, and click on the "**Open**" button.
6. Continue by selecting the **Data Ram** and **Register** files located inside the same directory as the microcode files. The file names should be self explanatory. After selecting all the files click "**Download All**" and wait for a confirmation message. Click on the "**Save Filenames**" button to save the code and register file configuration.
7. Click the "**Enable Flash on CH1 and Ch2**" button to run the code. At this point both channels should be operational.
8. Go to the "**Single command**" page and set "**Driver Enable**" high. This will enable all of the pre-drivers and the dc-dc boost converter should also start regulating. Approximately 40 V should be measured on the VBOOST output pin.

10.2 Running the example batch files -

1. Go to the "**Batch commands**" page and select the batch file you want to run. There are 5 choices. "**Start1**" through "**Start4**" pulse only one injector (1, 2, 3, or 4). The "**Start1-4**" batch command pulses all four injectors in sequence.
2. Click on the "**Send Continuously**" button and observe that the four loads attached to the MC33816 EVB board are turning on and then off in succession.

There are other demo batch examples that can be run and examined for learning how to use the EVB.

11 Evaluation Board Hardware Description

This EVB consists of a MC33816 Direct Injection Pre-driver Integrated Circuit, a USB to SPI dongle interface, power conditioning circuitry, and external MOSFETs. All +5.0 volt V_{DD} power required by the EVB is supplied from the +5.0 volt regulator. A +12 V V_{BAT} supply provides the power to the two internal voltage regulators, VCCP and VCCP2.5. The hardware block diagram is shown below:

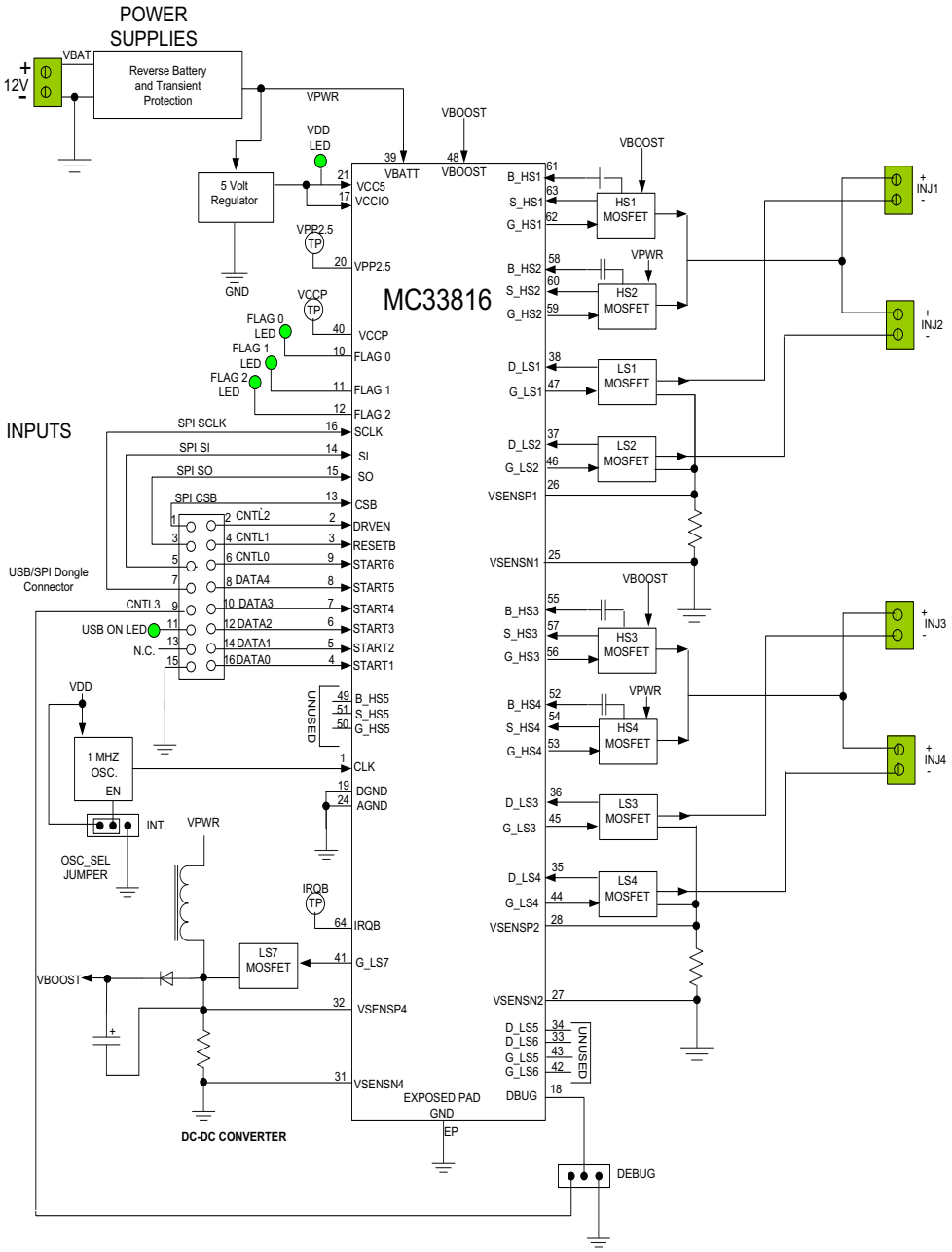


Figure 4. MC33816 Direct Injection Pre-driver EVB Block Diagram

11.1 LED Display

Five LED's are provided as visual output devices for the MC33816 EVB. A list of the LED devices is shown by the following:

1. **VDD LED** - Indicates that the +5.0 volt regulator is running.
2. **FLAG 0 LED** - Indicates that the digital FLAG 0 output is a logic 1.
3. **FLAG 1 LED** - Indicates that the digital FLAG 1 output is a logic 1.
4. **FLAG 2 LED** - Indicates that the digital FLAG 2 output is a logic 1.
5. **USB LED** - Indicates that the USB SPI dongle is connected properly and is attached to an active USB port on a PC.

11.2 Test Point Definitions -

The EVB contains twenty-eight (28) test point jumpers that provide access to certain signals in the MC33816 as follows:

1. VPWR - 12 volts (V_{BAT} minus a Schottky diode drop)
2. GND - 0.0 volts
3. VDD - 5.0 volts
4. VCCP - 7.0 volts
5. VCCP2.5 - 2.5 volts
6. FLAG 0 - 0 or 5.0 volts depending on the state of FLAG 0
7. FLAG 1 - 0 or 5.0 volts depending on the state of FLAG 1
8. FLAG 2 - 0 or 5.0 volts depending on the state of FLAG 2
9. OA_1 - 0 to 5.0 volts depending on the analog voltage out of OA_1.
10. OA_2 - 0 to 5.0 volts depending on the analog voltage out of OA_2.
11. IRQ_B - 0 or 5.0 volts depending on the state of the IRQ_B FLAG.
12. SWITCHEROUT - DC-DC switcher output frequency signal.
13. G_LS7 - 0 or 7.0 volt switching frequency when used as a DC-DC.
14. V_{BOOST} - 0 to 72 volts depending on programmed DC-DC voltage.
15. GND1 - 0.0 Volt ground reference point.
16. VSENSP4 - Voltage across R17 current sense resistor for the DC-DC.
17. G_HS1 - Gate signal to bank 1 high side V_{BAT} MOSFET.
18. G_HS2 - Gate signal to bank 1 high side V_{BOOST} MOSFET.
19. G_HS3 - Gate signal to bank 2 high side V_{BAT} MOSFET.
20. G_HS4 - Gate signal to bank 2 high side V_{BOOST} MOSFET.
21. G_LS1 - Gate signal to bank 1 low side 1 MOSFET.

22. G_LS2 - Gate signal to bank 1 low side 2 MOSFET.
23. G_LS3 - Gate signal to bank 2 low side 3 MOSFET.
24. G_LS4 - Gate signal to bank 2 low side 4 MOSFET.
25. VSENSP1 - Voltage across R2 current sense resistor for bank 1.
26. VSENSP2 - Voltage across R12 current sense resistor for bank 2.
27. SOURCE_HS-1-2 - High side output to bank 1 Injectors 1 and 2
28. SOURCE_HS-3-4 - High side output to bank 2 Injectors 3 and 4

11.3 Input Signal Definitions

The MC33816 EVB has nine logic level input signals that are used to control certain outputs or functions inside the circuit. These 9 signals are:

1. START1 - Provides start signal for Injector 1
2. START2 - Provides start signal for Injector 2
3. START3 - Provides start signal for Injector 3
4. START4 - Provides start signal for Injector 4
5. START5 - Provides start signal for Injector 5 (not used in EVB)
6. START6 - Provides start signal for Injector 6 (not used in EVB)
7. DRVEN - Controls the state of the all the pre-driver outputs
8. DBG - Provides the a logic level signal to the DBUG header.
9. RESETB - When the RESETB line is held low, the MC33816 is reset

These nine signals are provided by the nine parallel outputs from the USB/SPI interface as described by the following:

1. START1- Connected to the DATA0 signal
2. START2 - Connected to the DATA1 signal
3. START3 - Connected to the DATA2 signal
4. START4 - Connected to the DATA3 signal
5. START5 - Connected to the DATA4 signal
6. START6 - Connected to the CNTL0 signal
7. RESETB - Connected to the CNTL1 signal
8. DRVEN - Connected to the CNTL2 signal
9. DBUG pin 3 - Connected to the CNTL3 signal

DATA0 -DATA4 and CNTL0-CNTL3 signals are logic level outputs from the USB/SPI dongle that can be controlled directly from the SPIGen program. An example SPIGEN configuration file called KIT33816SW.spi is provided in the software bundle, which contains several batch file examples.

If the user prefers to supply the various MC33816 input signals externally, other than from the USB-SPI interface, the connections are available on the connector listed by the following.

11.4 USB/SPI Dongle Connector

The USB/SPI dongle connector is a 16 pin, 0.1” center, dual-row connector that is designed to interface directly to the USB/SPI dongle unit. The USB/SPI dongle connector consists of the following 16 pins.

Table 1. USB/SPI Dongle Pin Description

Pin Number	Name	Description
1	CSB	SPI signal, Chip Select Bar
2	CNTL2	CNTL2 connected to DRVEN
3	SO	SPI signal, Serial Out
4	CNTL1	CNTL1 connected to RESETB
5	SI	SPI signal, Serial In
6	CNTL0	CNTL0 connected to START6
7	SCLK	SPI signal, Serial Clock
8	DATA4	DATA4 connected to START5
9	CNTL3	CNTL3 connected to DBUG 3
10	DATA3	DATA3 connected to START4
11	VDD	+5.0 Volt VDD from USB
12	DATA2	DATA2 connected to START3
13	+3.3V	+3.3 V from USB (Not Used)(1)
14	DATA1	DATA1 connected to START2
15	GND	Signal Ground
16	DATA0	DATA0 connected to START1

Notes
1. This connection is unused in this EVB.

This connector mates with the 16-conductor flat cable that connects to the USB/SPI dongle (KITUSBSPIDGLEVME).

11.5 Screw Terminal Connections

The MC33816 EVB contains four injector outputs and one VBAT input screw terminal connection.

Figure 5 shows the locations of the screw terminals and their functional definitions:

11.6 Pin Jumpers

There are two 3-pin jumper headers on the MC33816 EVB.

1. OSC_SEL - This is a jumper for enabling or disabling the external 1.0 MHz oscillator. When the jumper is on pins 3 and 2, the external 1.0 MHz clock is enabled. When the jumper is on pins 1 and 2, the MC33816 internal oscillator is enabled.

2. DBUG- This is a header to connect to the MC33816 DBG flag. The pins are as follows:
   Pin 1 - connected ground
   Pin 2 - connected to MC33816 DBG pin.
   Pin 3 - connected to USB/SPI dongle connector pin 9, CNTL3

If the DBG flag from the MC33816 is to be used to display the debug information, then a serial monitor can be connected to pins 1 and 2.

If the DBG pin is to be used as a general purpose flag line (input), then placing a jumper between pins 2 and 3 will allow the SPIGen program to provide a digital input to the flag line.

11.7 MC33816 EVB Connectors

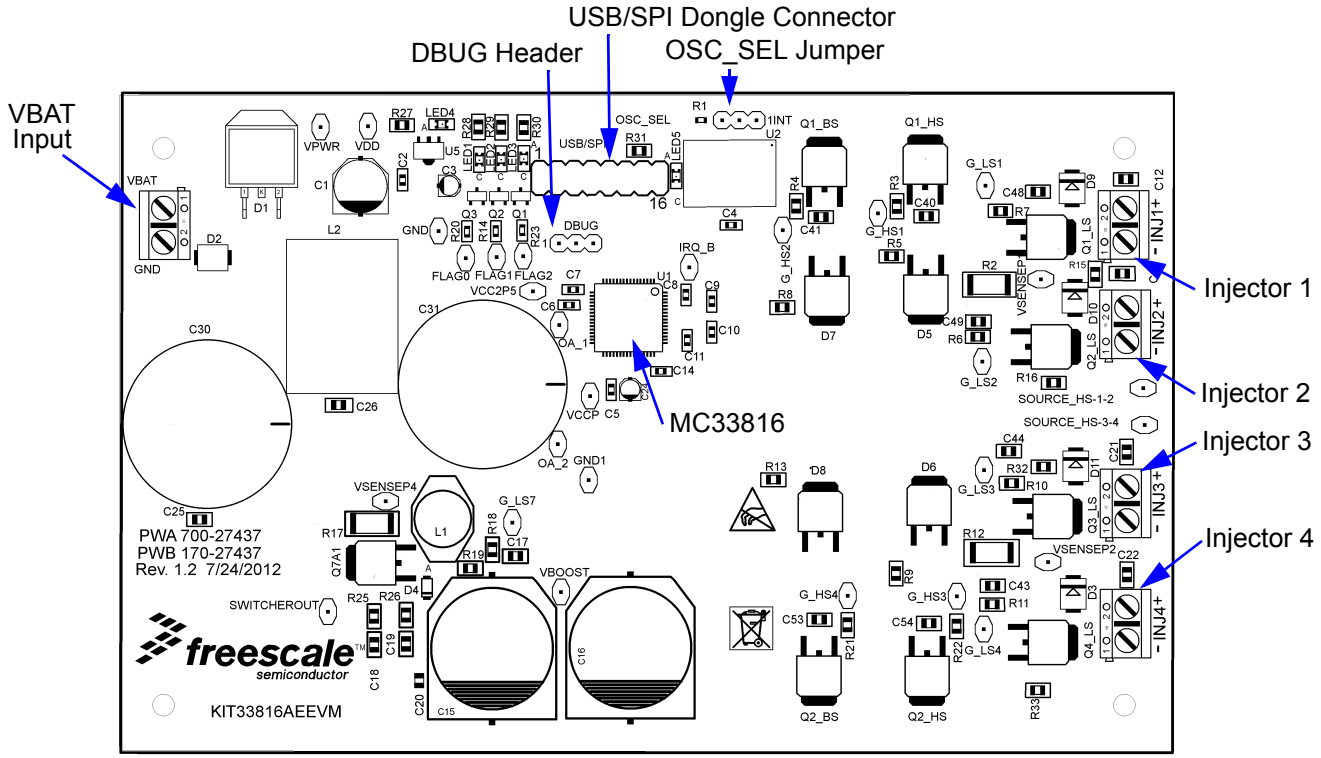


Figure 5. KIT33816AEEVM Evaluation Board Diagram

11.7.1 Input Connector

There is one input connector used to connect the EVB to +12 V.

1. (VBAT) +12 VOLT POWER SUPPLY INPUT -
   Screw Terminal 1 - VBAT (+12 V)
   Screw Terminal 2 - GND (-12 V)

11.7.2 Output Connectors

There are four output connectors that provide the four injector output signals:

1) (INJ1) INJECTOR OUTPUT 1 -
   Screw Terminal 1 - Low side drive
   Screw Terminal 2 - High side drive

2. (INJ2) INJECTOR OUTPUT 2 -
   Screw Terminal 1 - Low side drive
   Screw Terminal 2 - High side drive

3. (INJ3) INJECTOR OUTPUT 3 -
   Screw Terminal 1 - Low side drive
   Screw Terminal 2 - High side drive

4. (INJ4) INJECTOR OUTPUT 4 -
   Screw Terminal 1 - Low side drive
   Screw Terminal 2 - High side drive

11.8 Accessory Boards

The KITUSBSPIDGLEVME Evaluation board (shown below) provides a USB to SPI interface that features the MC68HC908JW32 with dongle. It is a working hardware/software example that allows a user to become familiar with the MC68HC908JW32 microcontroller by means of an actual useful application, a USB to SPI and USB to parallel converter. The main function provided by this kit is to allow a PC, that may not have a parallel port, to communicate with other Freescale Evaluation Kits, via a USB port. The USB port is a standard feature on almost every new PC. This kit makes use of the MC68HC908JW32's built-in USB, SPI and parallel ports.

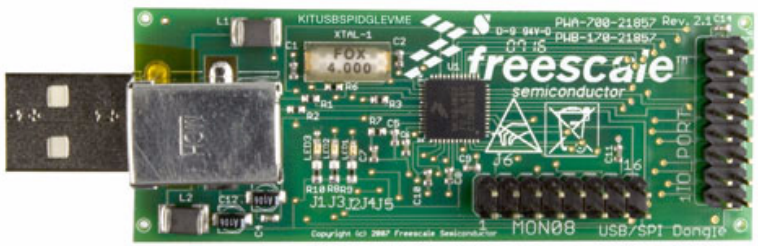


Figure 6. KITUSBSPIDGLEVME Evaluation Kit

12 Schematic

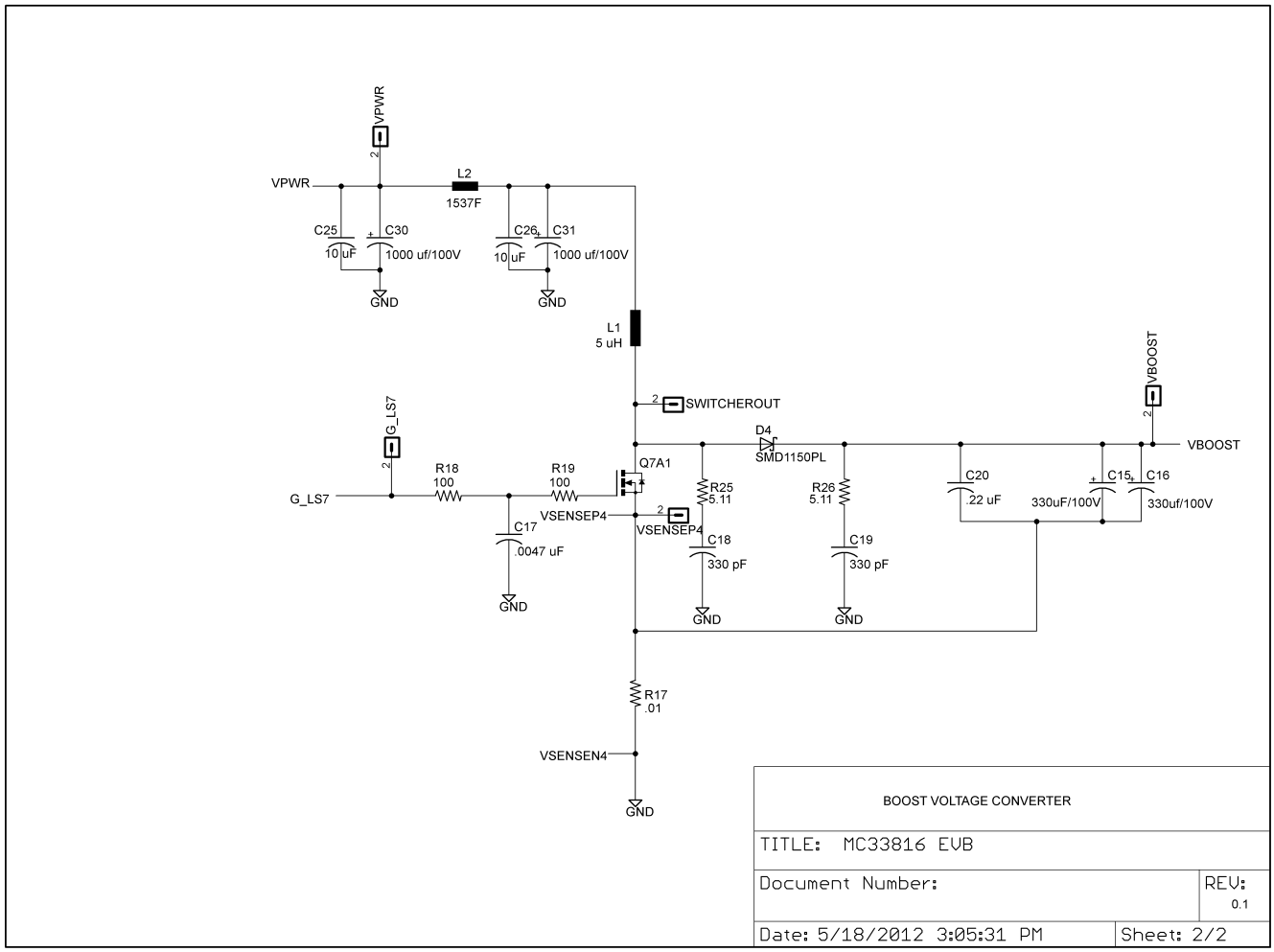


Figure 7. KIT33816AEEVM Evaluation Board Schematic

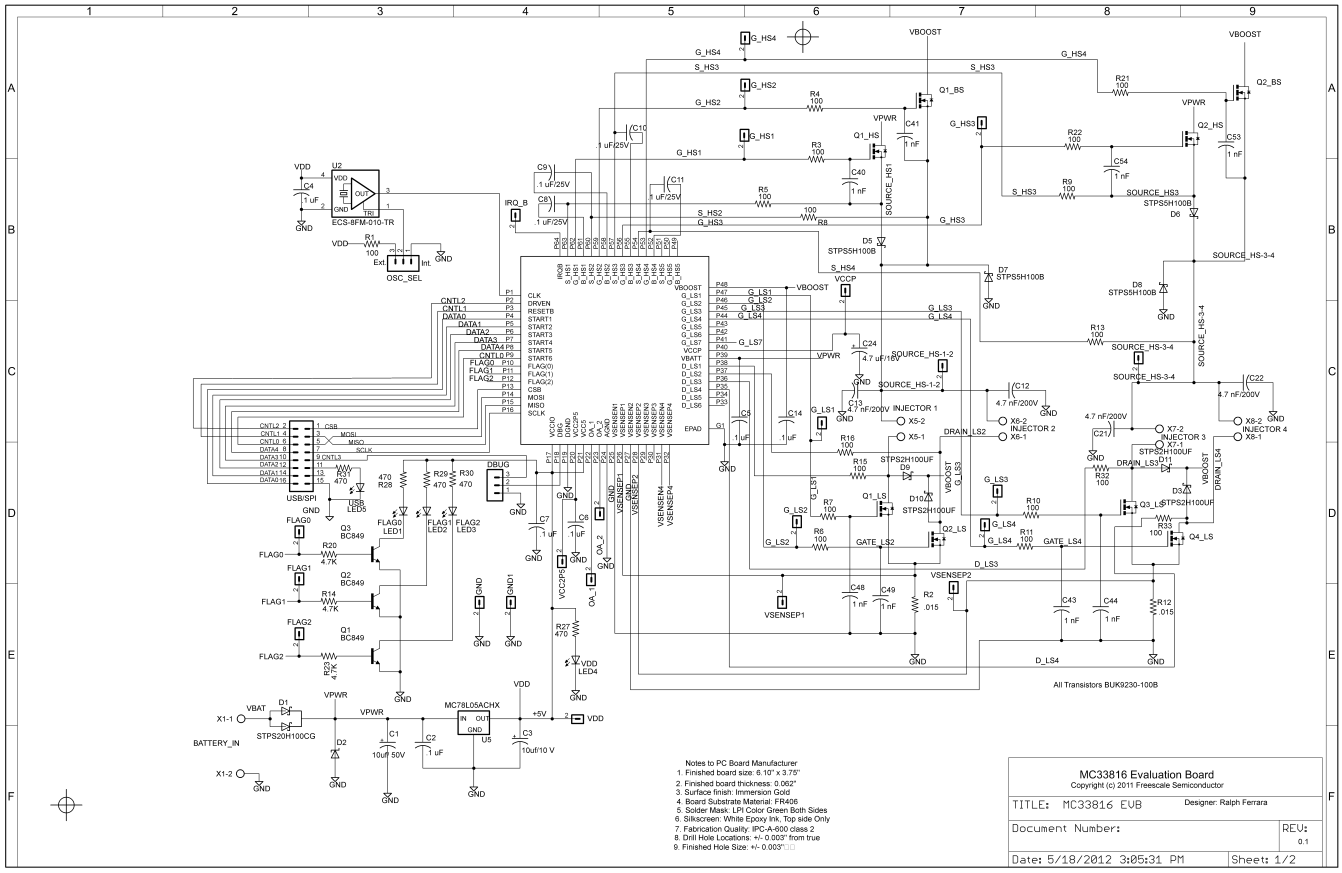
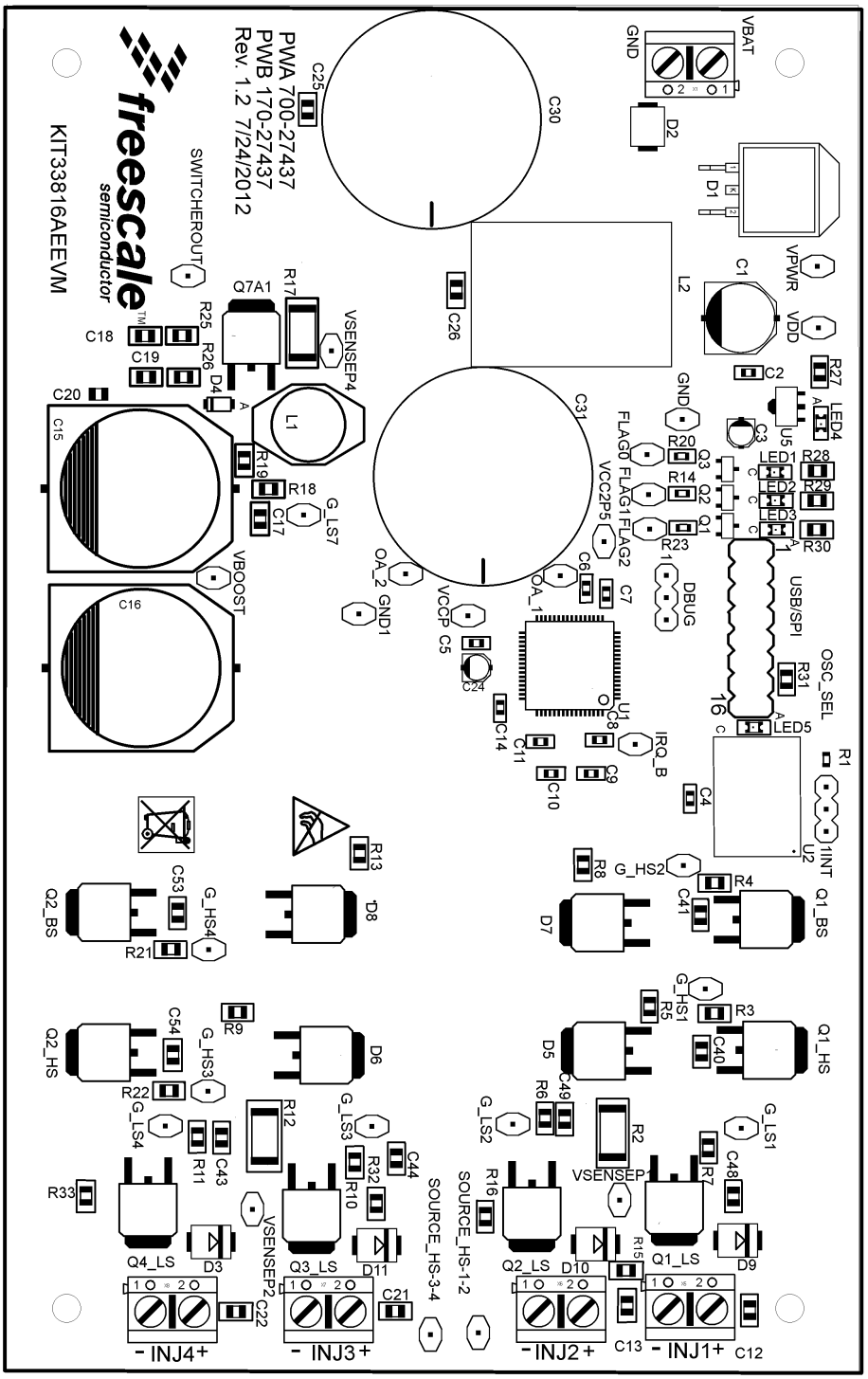


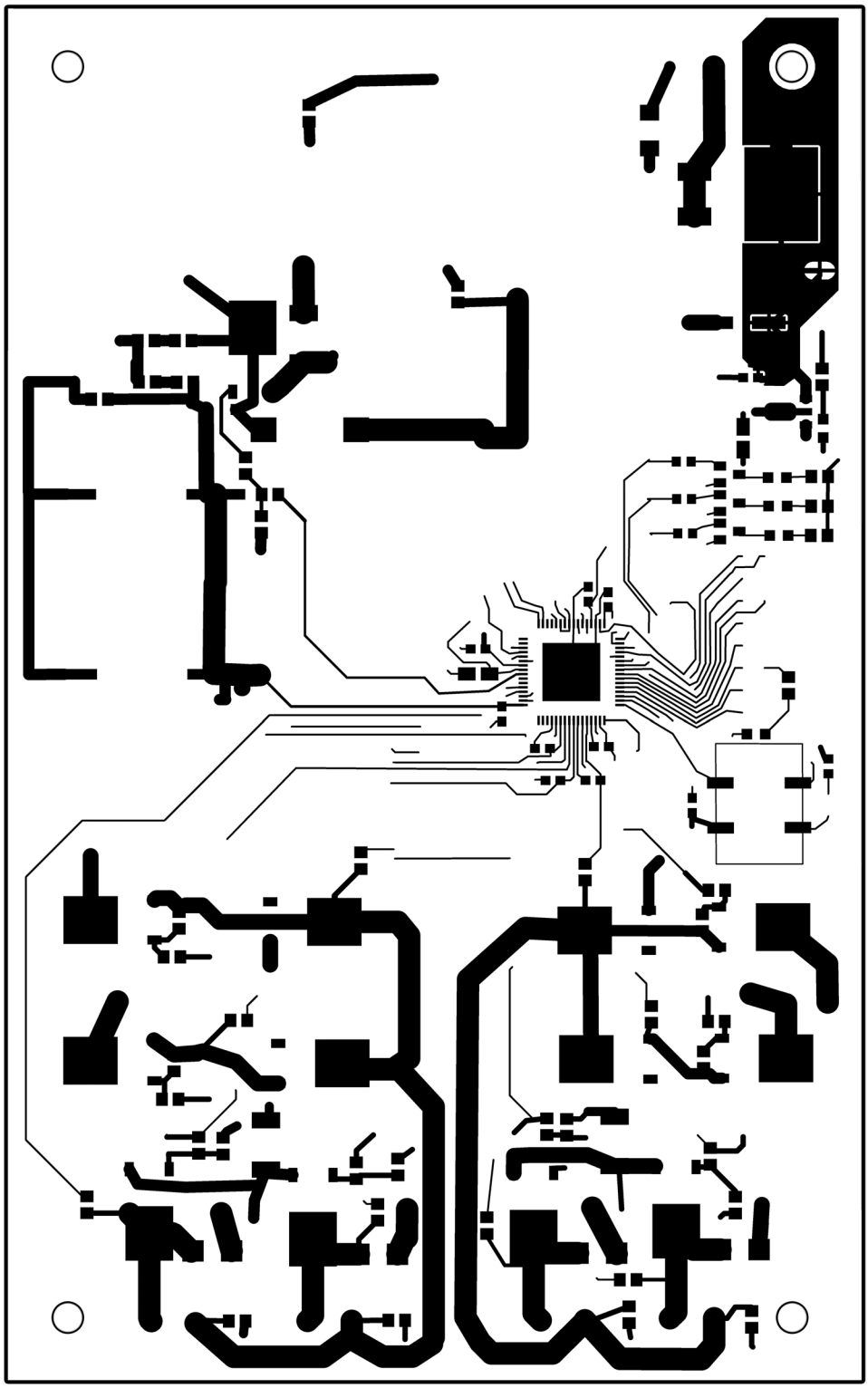
Figure 8. KIT33816AEEVM Evaluation Board Schematic

13 Board Layout

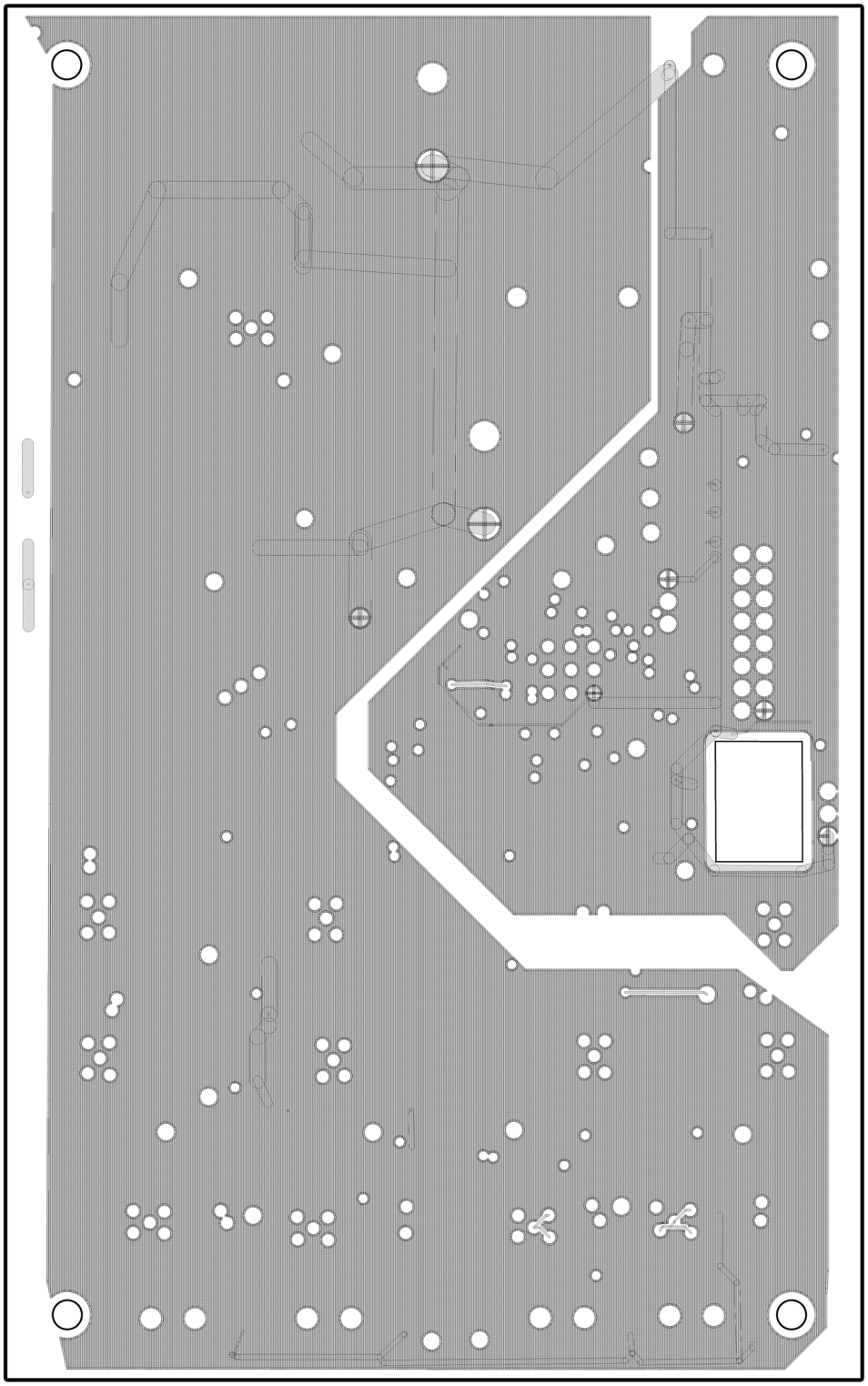
13.1 Assembly Layer Top



13.2 Top Layer Routing

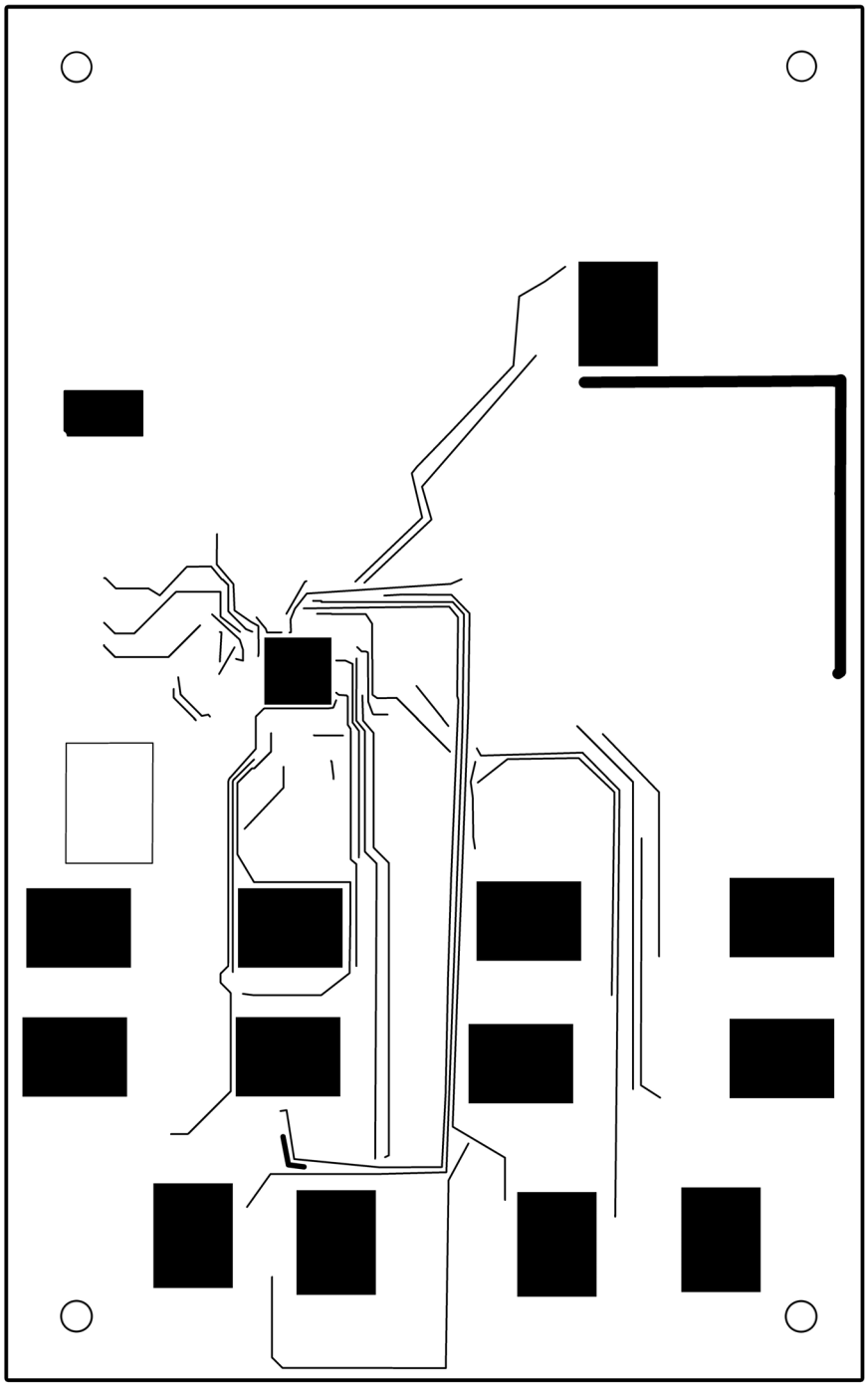


13.3 Inner Layer 1 Routing



13.4 Inner layer 2 Routing

13.5 Bottom Layer Routing



Note: For convenience when viewing the actual board, this image has been flipped horizontally with respect to the other layer images in this document.

14 Bill of Material

Qty	Schematic Label	Value	Description	Part Number	Package
Capacitors					
1	C1	10 μf, 50 V 20%	Capacitor Aluminum	EEE-TG1H100P	PANASONIC_E
10	C2, C4, C5, C6, C7, C8, C9, C10, C11, C14	0.1 μF, 100 V 10% X7S	Capacitor Ceramic	C1608X7S2A104K	0603
1	C3	10 μf, 10 V 20%	Capacitor Aluminum	ECE-V1AA100NR	PANASONIC_A
5	C12, C13, C17, C21, C22	4700 pF, 200 V 10% X7S	Capacitor Ceramic	08052C472KAT2A	0805
2	C15, C16	330 μF, 80 V 20%	Capacitor Aluminum	EEE-FK1K331AM	PANASONIC_R
2	C18, C19	330 pF, 200 V 10% X7R	Capacitor Ceramic	08052C331KAT2A	0805
1	C20	.22 μF, 100 V 10% X7R	Capacitor Ceramic	HMK212B7224KG-T	0805
1	C24	4.7 μF, 25 V	Capacitor Aluminum	ECE-V1EA4R7SR	PANASONIC_A
2	C25, C26	1.0 μF, 100 V 10% X7S	Capacitor Ceramic	C2012X7S2A105K	0805
2	C30, C31	1000 μf, 100 V 20%	Capacitor Aluminum	ECO-S2AA102CA	Snap-in 0.393
7	C40, C43, C44, C48, C49, C53, C54	1000 pF, 100 V 10% X7R	Capacitor Ceramic	C2012X7R2A102K	0805
Resistors					
1	R1	100 Ohm, 0.1 W 5%	Resistor	ERJ-3GEYJ101V	0603
2	R2, R12	0.015 Ohm, 1.0 W 5%	Resistor	ERJ-M1WSJ15MU	2512
18	R3, R4, R5, R6, R7, R8, R9, R10, R11, R13, R15, R16, R18, R19, R21, R22, R32, R33	100 Ohm, 0.33 W 5%	Resistor	CRCW0805100RJNEAHP	0805
3	R14, R20, R23	4.7 k, 0.1 W 5%	Resistor	ERJ-3GEYJ472V	0603
1	R17	0.010 Ohm, 1.0 W 1%	Resistor	ERJ-M1WSF10MU	2512
2	R25, R26	5.11 Ohm, 0.125 W 1%	Resistor	RC0805FR-075R11L	0805
5	R27, R28, R29, R30, R31	470 Ohm, 0.125 W 5%	Resistor	ERJ-6GEYJ471V	0805
Inductors					
1	L1	5.0 μH 20%, 3.0 A	Inductor	DO3316P472ML_	DO3316P
1	L2	5.0 μH 20%, 10 A	Inductor	5501-RC	5501
Diodes					
1	D1	100 V, 10 A	Diode Schottky	STPS20H100CG	TO263AB D2PAK
1	D2	600 W, 40 V 5%	TVS Unidirect	SMBJ40A-E3/52	SMBJ
4	D3, D9, D10, D11	100 V, 2.0 A	Diode Schottky	STPS2H100UF	SMB

Qty	Schematic Label	Value	Description	Part Number	Package
1	D4	150 V, 1.0 A	Diode Schottky	SMD1150PL-TP	SOD123FL
4	D5, D6, D7, D8	100 V, 5.0 A	Diode Schottky	STPS5H100B-TR	DPAK
LEDs					
5	LED1, LED2, LED3, LED4, LED5	Mini TOPLED Green	LED	LT M673-P2R1-25-Z	CHIPLED_0805
Transistors					
1	Q1_BS	47 A, 100 V	MOSFET N-CH	BUK9230-100B,118	D-PAK_TO252A
1	Q1_HS	47 A, 100 V	MOSFET N-CH	BUK9230-100B,119	D-PAK_TO252A
7	Q1_LS, Q2_BS, Q2_HS, Q2_LS, Q3_LS, Q4_LS, Q7A1	47 A, 100 V	MOSFET N-CH	BUK9230-100B,120	D-PAK_TO252A
3	Q1, Q2, Q3	100 mA, 30 V	Transistor NPN	BC849B-TP	SOT23-BEC
Integrated Circuits					
1	U1		DGDI/DDI Injector Driver	MC33816AE	LQFP-64
1	U2	1.000 MHZ, 5.0 V	Oscillator	ECS-8FM-010-TR	SMD-ECS-8F
1	U5	5.0 V, 100 mA	Voltage Regulator	MC78L05ACHX	SOT-89
Connectors, Jumpers and Push Buttons					
2	DBUG, OSC_SEL	0.100" 3 pos. 15 AU	Connector Header	87224-3	MA03-1
1	USB/SPI	0.100" 16 Pos 15 AU	Connector Header	87227-8	MA08-2
28	FLAG0, FLAG1, FLAG2, GND, GND1, G_HS1, G_HS2, G_HS3, G_HS4, G_LS1, G_LS2, G_LS3, G_LS4, G_LS7, IRQ_B, OA_1, OA_2, SOURCE_HS-1-2, SOURCE_HS-3-4, SWITCHEROUT, VBOOST, VCC2P5, VCCP, VDD, VPWR, VSENSEP1, VSENSEP2, VSENSEP4	Black 0.040"	Test Point PC Mini	5001	MA01-1
1	BATTERY_IN	2 POS 5.08 mm PCB	Connector Terminal Block	1729128	AK500/2
1	INJ1	3 POS 5.08 mm PCB	Connector Terminal Block	1729128	AK500/2

Qty	Schematic Label	Value	Description	Part Number	Package
1	INJ2	4 POS 5.08 mm PCB	Connector Terminal Block	1729128	AK500/2
1	INJ3	5 POS 5.08 mm PCB	Connector Terminal Block	1729128	AK500/2
1	INJ4	6 POS 5.08 mm PCB	Connector Terminal Block	1729128	AK500/2

Note: Freescale does not assume liability, endorse, or warrant components from external manufacturers that are referenced in circuit drawings or tables. While Freescale offers component recommendations in this configuration, it is the customer's responsibility to validate their application.

15 References

The following table contains URLs where you can obtain information on KIT33816AEEVM and other Freescale products and product solutions:

Freescale.com Support Pages	URL
MC33816 Product Summary Page	http://www.freescale.com/webapp/sps/site/prod_summary.jsp?code=MC33816
KITUSBSPIDGLEVME Tool Summary Page	http://www.freescale.com/webapp/sps/site/ prod_summary.jsp?code=KITUSBSPIDGLEVME
SPIGen Reference Tool Summary Page	http://www.freescale.com/files/soft_dev_tools/software/device_drivers/ SPIGen.html?fsrch=1&sr=11
Analog Home Page	www.freescale.com/analog
Automotive Home Page	www.freescale.com/automotive

15.1 Support

Visit Freescale.com/support for a list of phone numbers within your region.

15.2 Warranty

Visit Freescale.com/warranty for a list of phone numbers within your region.

16 Revision History

Revision	Date	Description of Changes
1.0	2/2013	•Initial Release
2.0	4/2013	•Add Jump Start link for downloading software and/or documents. •Update SPIGen section to match latest template

How to Reach Us:

Home Page:
freescale.com

Web Support:
freescale.com/support

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Document Number: KT33816UG
Rev. 2.0
4/2013