



# 1 Kit Contents / Packing List

- Evaluation Board
- CD 09XS3400
- Warranty Card

## 2 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.

Freescale reserves the right to make changes without further notice to any products herein. Freescale makes no warranty, representation or guarantee regarding the suitability of its products for any particular purpose, nor does Freescale assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation consequential or incidental damages. "Typical" parameters can and do vary in different applications and actual performance may vary over time. All operating parameters, including "Typical", must be validated for each customer application by customer's technical experts.

Freescale does not convey any license under its patent rights nor the rights of others. Freescale products are not designed, intended, or authorized for use as components in systems intended for surgical implant into the body, or other applications intended to support or sustain life, or for any other application in which the failure of the Freescale product could create a situation where personal injury or death may occur.

Should the buyer purchase or use Freescale products for any such unintended or unauthorized application, the buyer shall indemnify and hold Freescale and its officers, employees, subsidiaries, affiliates, and distributors harmless against all claims, costs, damages, and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if such claim alleges that Freescale was negligent regarding the design or manufacture of the part. Freescale™ and the Freescale logo are trademarks of Freescale Semiconductor, Inc. All other product or service names are the property of their respective owners. © Freescale Semiconductor, Inc. 2012.

## 3 Introduction

This Evaluation Board demonstrates the capability of the MC09XS3400 as a 12 V quad high side switch product family, with integrated control and a high number of protective and diagnostic functions.

The MC09XS3400 is one in a family of devices designed for low-voltage automotive lighting applications. Its four low  $R_{DS(ON)}$  MOSFETs (quad 9.0 m $\Omega$ ) can control four separate 55 W / 28 W bulbs, and/or Xenon modules, and/or LEDs.

Programming, control and diagnostics are accomplished using a 16-bit SPI interface. Output slew rates are selectable to control electromagnetic emissions. Additionally, each output has its own parallel input or SPI control for pulse-width modulation (PWM) control if desired. The MC09XS3400 allows the user to program via the SPI the fault current trip levels and duration of acceptable lamp inrush. The device has fail-safe mode to provide fail-safe functionality of the outputs in case of MCU damage.

The four channels can be controlled individually by external/internal clock-signals or by direct inputs. Using the internal clock allows fully autonomous device operation. Programmable output voltage slew rates (individually programmable) helps improve EMC performance. To avoid shutting off the device upon inrush current, while still being able to closely track the load current, a dynamic over-current threshold profile is featured. Switching current of each channel can be sensed with a programmable sensing ratio. Whenever communication with the external microcontroller is lost, the device enters a fail-safe operation mode, but remains operational, controllable, and protected.

### 3.1 Evaluation Board Features

This family of devices is designed for low-voltage automotive lighting applications. Its four low  $R_{DS(ON)}$  MOSFETs can control:

- Four separate 55 W / 28 W bulbs
- Four separate Xenon modules
- Four separate LEDs
- Four separate Other type of loads

In addition, this family of devices has the following features:

- Programming, control, and diagnostics are accomplished using a 16-bit SPI interface
- Its output with selectable slew-rate allows to satisfy electromagnetic compatibility (EMC) requirements
- Each output can be controlled with an internal PWM modulated clock signal, instead of an external clock

### 3.2 Device Description/Features

- Four protected high side switches
- Operating voltage range of 6.0 to 20 V with sleep current < 5.0  $\mu$ A, extended mode from 4.0 to 28 V
- 8.0 MHz 16-bit 3.3 V and 5.0 V SPI control and status reporting with daisy chain capability
- PWM module using external clock or calibratable internal oscillator with programmable outputs delay management
- Smart over-current shutdown, severe short-circuit, over-temperature protections with time limited auto-retry, and fail-safe mode in case of MCU damage
- Output OFF or ON open-load detection compliant to bulbs or LEDs and short-to-battery detection. Analog current feedback with selectable ratio and board temperature feedback

### 3.3 Required Equipment

Minimum required equipment:

- Power DC supply 40 A/20 V
- Optional DC supply 1.0 A/ 5.0 V
- Typical load (lamps,...)
- USB enabled computer with Windows XP, Windows 2000, or Windows NT
- KITUSBSPIEVME

## 4 Installing SPIGen Freeware on your Computer

The current version of SPIGen is designed to run on a USB enabled computer with Windows XP, Windows 2000, or Windows NT.

This version of SPIGen includes a README.txt file which will describe the operating systems where the software should be installed. Before you install the program, refer to the SPIGen README.txt file to check the compatibility of the installation program and your computer operating system.

To install the software from the CD-ROM, insert the CD-ROM into your CD drive. Click the Start button, and then click "Run..."

While running Windows NT, Windows 2000, or Windows XP, type "D:\SPIGen\_Win\_NT\_2000\_XP\Setup.exe" in the box, and then click "OK".

Several temporary files will be copied to your computer, and then 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 "Generic SPI Generator" graphic user interface (GUI) will appear. Go to the File menu in the upper left hand corner of the GUI, and select Open, then browse the CD to find and select the SPIGen Configuration ".spi" file for the EVB you are using. Click Open, and SPIGen will open a specifically configured SPI command generator for your EVB.

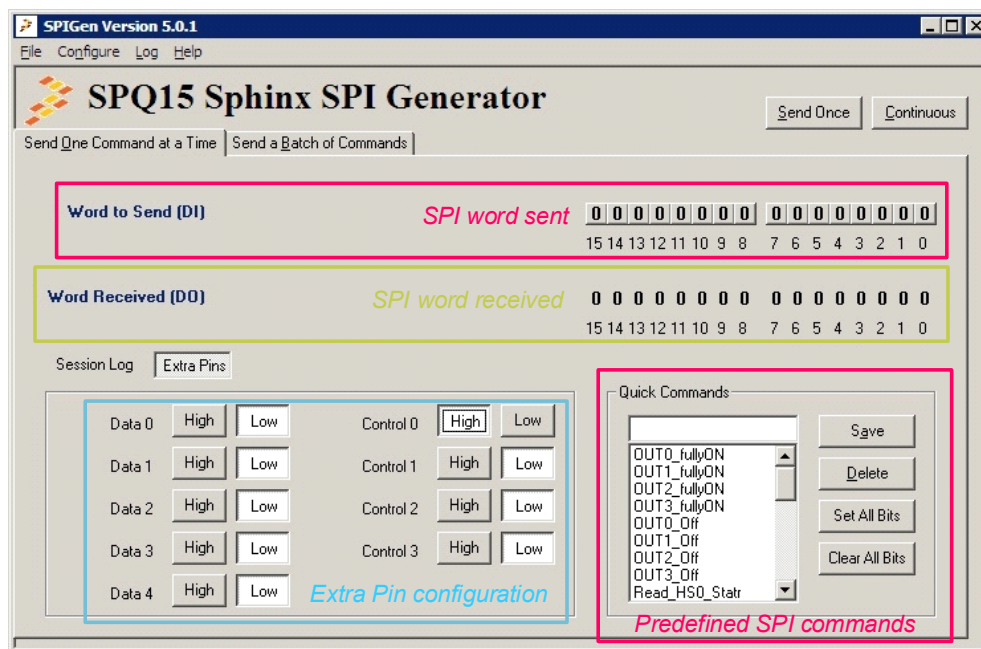


Figure 2. SPIGen GUI

# 5 EVB Setup Configuration

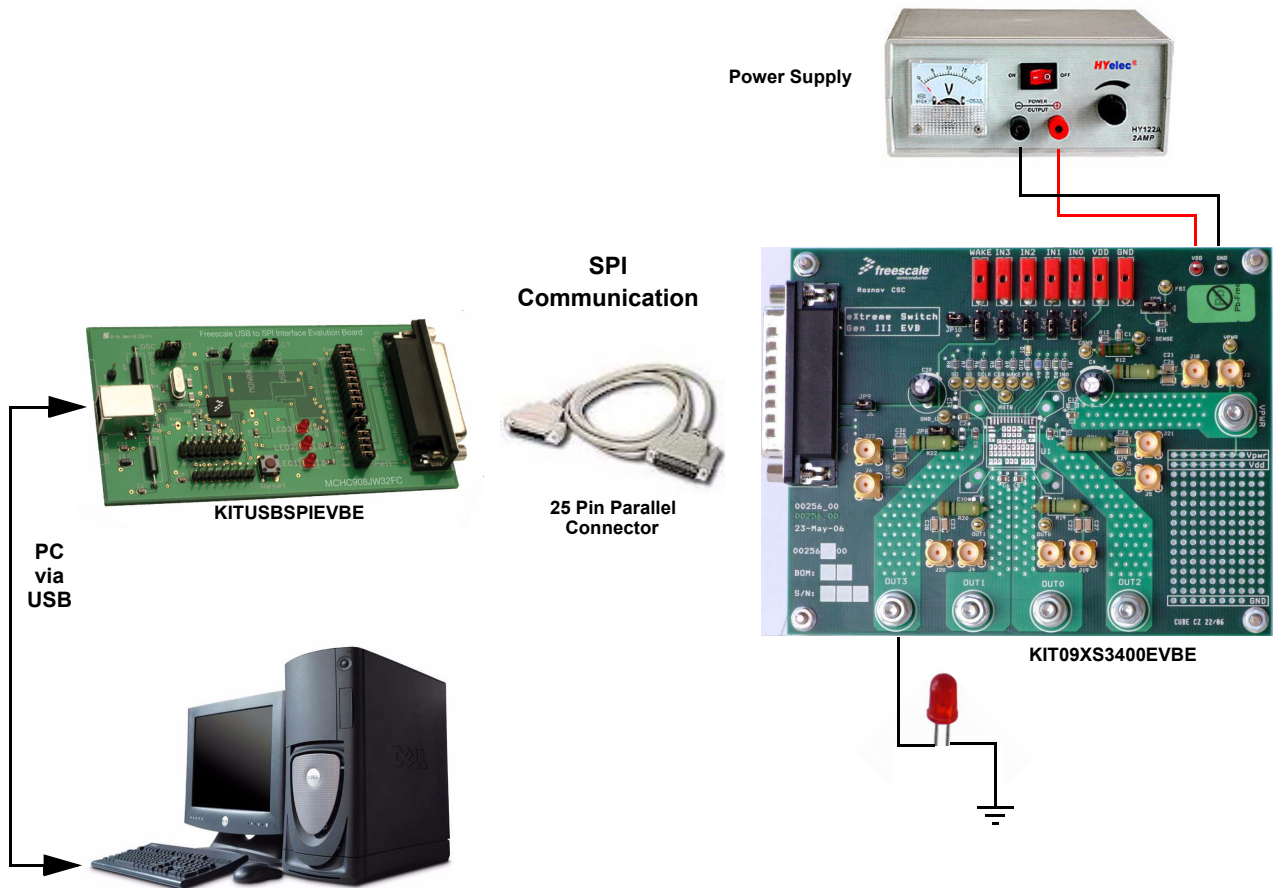


Figure 3. KIT09XS3400EVBE Setup Configuration Diagram

## 6 Using the EVB

**Warning: Always wear Safety Glasses when working around electronic modules and when soldering.**

Remove the capacitor C4 when testing reverse supply on  $V_{PWR}$ .

1. The EVB allows the customer to quickly evaluate features of the device with a simple bench top setup. All switch inputs may be evaluated using the onboard switch banks or actual system switches connected to the switch input edge connector.
2. Using a standard 25 pin Sub-D parallel port cable and the enclosed SPIGen SPI Driver software, you can use a personal computer to provide the serial peripheral interface (SPI) communication with this EVB (see SETUP\_EVB).
3. Connect the power supply to the VPWR and GND terminals on the EVB. Make sure the voltages provided are in accordance with the device data sheet and that the supply currents are sufficient to supply the switch contact wetting current. For the SPI communication is needed +5.0 V. This voltage can be provided from PC via parallel cable (JP9 must be inserted) or through external power supply via connector VDD. Without +5.0 V, the device will be in Fail-safe mode.
4. Connect desired external load between one of the output (OUT0 - OUT3) and power supply ground.
5. For direct control of the outputs, apply +5.0 V on connectors IN0 - IN3. The corresponding high side output turns-on. Each IN input wakes the device.
6. To prepare the evaluation board for SPIGen, place jumpers JP9 and JP10 in the 1-2 position.
7. To use SPIGen, Go to the Windows Start menu, then Programs, then SPIGen, and click on the SPIGen icon. The SPIGen "Generic SPI Generator" GUI will appear. Go to the File menu in the upper left hand corner of the GUI, and select Open, then browse the CD to find and select the *Device\_EVB\_CONFIGURATION\_FILE.spi* file for the Kit. Click Open, and SPIGen will open a specifically configured SPI command generator for the Kit. The configuration file will set all parameters for SPI signals from the PC and provide a list of commands that may be sent to the EVB.
8. To set up the device to read switch inputs the user may use the batch commands from the "Send a Batch of Commands" tab. In the "Send a Batch of Commands" window, the Full Initialize batch will appear. To send the batch of commands to the EVB, click the Send Once tab. To quickly evaluate the EVB and device, simply click on the "Send one Command at a Time" tab, select the switch status command from the Quick Commands list, and click the Send Continuous tab. The opening and closing of switches may now be seen on the Word Received bits window field. Refer to the device data sheet for detailed information on I/O communication and device operation.



## 7 Using Hardware and Software

The KIT09XS3400EVBE operates with a single DC power supply from 4.0 to 28 V, and is fully controlled via SPI with the help of an USB-SPI KITUSBSPIEVME EVB kit requiring a 5.0 V DC power supply.

Starting up the KIT09XS3400EVBE:

To Start working with the KIT09XS3400EVBE, provide the 12 V input voltage between 4.0 to 28 V, connecting the (+) probe to the VPWR terminal and the (-) probe to the GND terminal on the Input power terminal block. Then apply a 5.0 V input voltage between VDD and the GND terminal.

The load is connected between the HS0 (or HS1) terminal and the (-) terminal of 12 V power supply.

Controlling the KIT09XS3400EVBE via the SPI:

The KITUSBSPIEVME EVB kit allows interaction with the KIT09XS3400EVBE using the graphical user interface (GUI) developed by Freescale to fully operate the MC09XS3400 device.

## 8 Jumper Connections

Name	Description
JP1 JP2 JP3 JP4	Allows independent control of each high side switch output 1-2 selection: outputs are controlled via SPIGen or connectors J7 - J10 2-3 selection: direct control of the output, appropriate output is ON
JP5	FSI selection 1-2: FSI terminal connected through 6.8 kOhm resistor to ground 2-3: FSI terminal connected to ground
JP6	Allows wake-up function of IC. 1-2 selection will give external control through connector J12. 2-3 selection is to wake-up from battery voltage, i.e. in the case of ignition.
JP7	Selection of supplying of FSB LED 1-2: FSB LED D1 connected to VDD (5.0 V) 2-3: FSB LED D1 connected to $V_{PWR}$ (12 V)
JP9	Source of VDD (+5.0 V) 1-2: +5.0 V is provided by PC via parallel cable Floating: +5.0 V must be connected to J11, otherwise the device is in fail-safe mode (the output states depend on R11 value)
JP10	Connection of RSTB input 1-2 position: control through SPIGen Floating: RSTB is ground. This means that the IC is in Sleep mode
JP11	Connection of VDD to the device 1-2 position: VDD connected to the device Floating: Device without VDD
JP12	R8 bypassing 1-2 position: R8 is bypassed with 0 Ohm. For higher speed of SPI (MCU control of the device only) Floating: Low speed SPI operation with SPIGen software
TEST POINTS	Several test points are presented on the evaluation board to check some signals using an oscilloscope if necessary.

# 9 Schematic

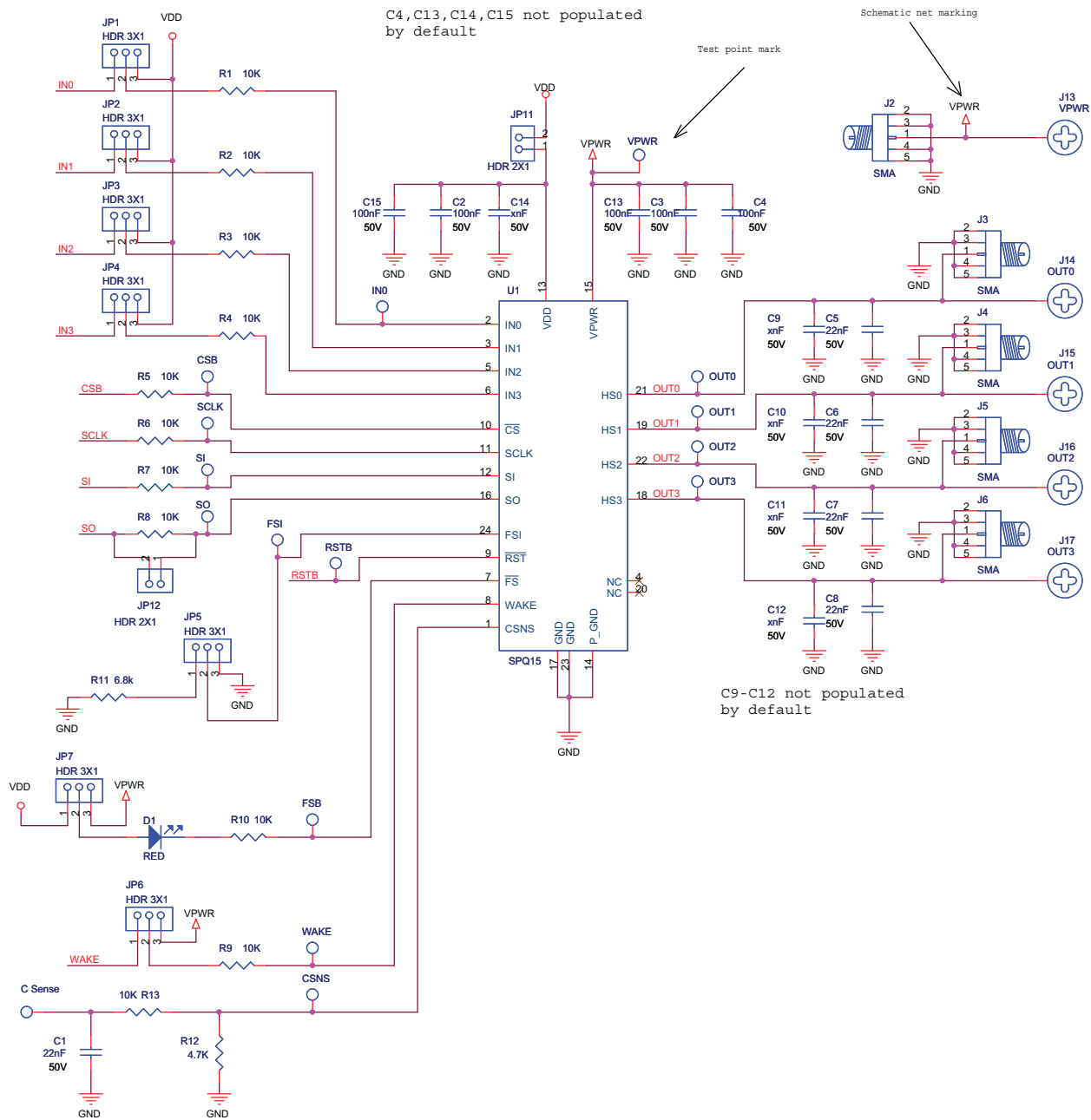


Figure 4. Schematic Part One

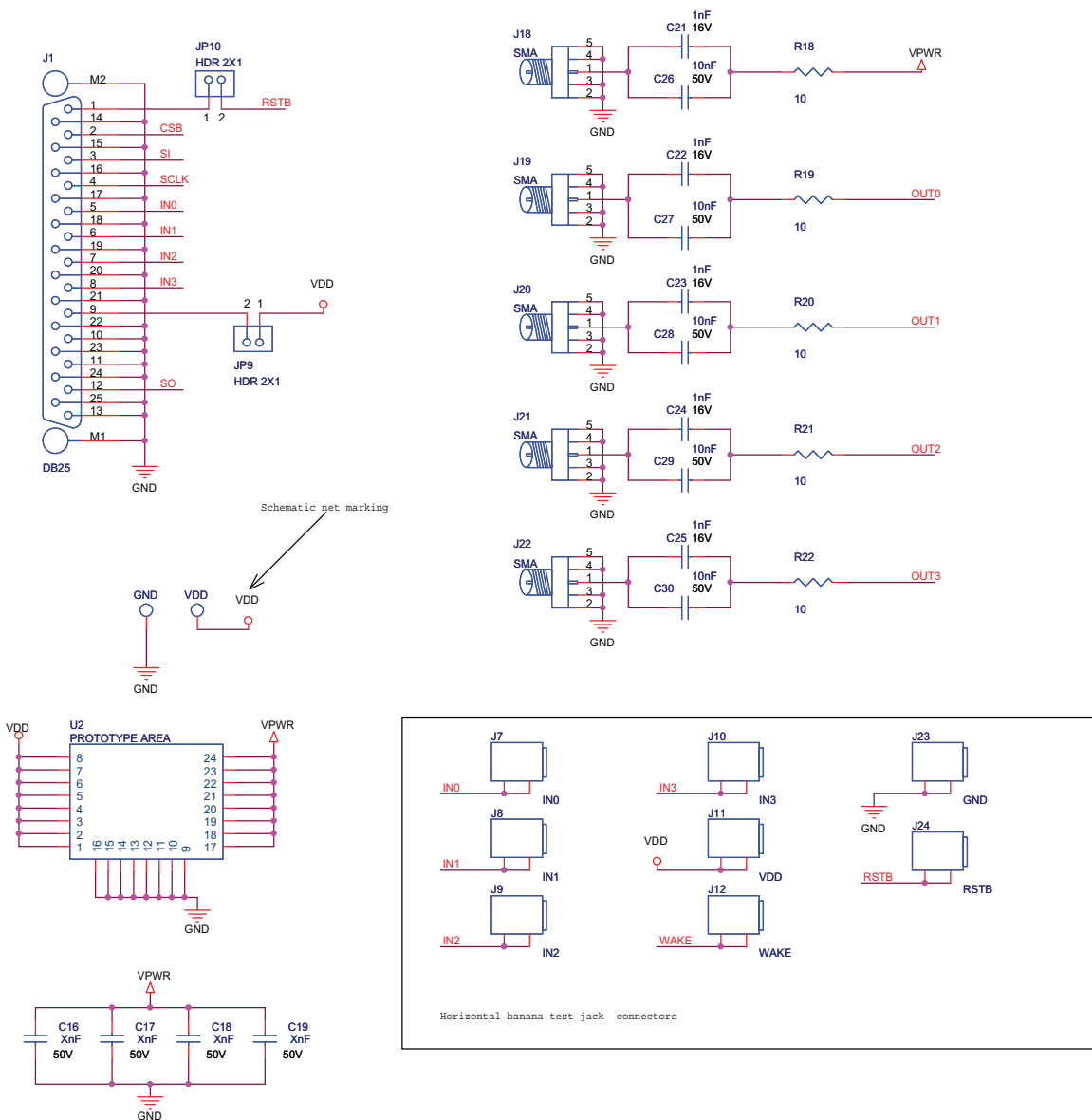


Figure 5. Schematic Part Two

# 10 Board Layout

## 10.1 Top Assembly Layer

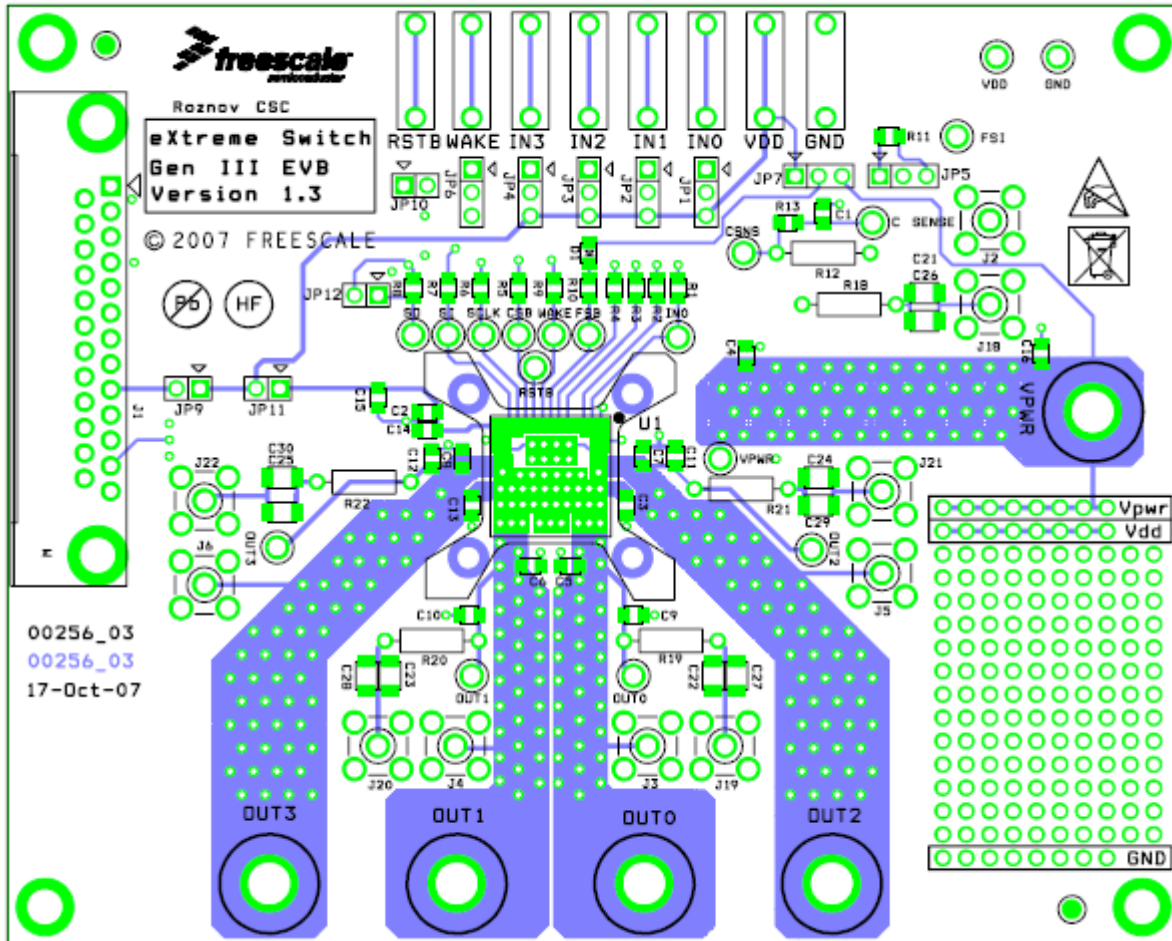


Figure 6. Top Assembly Layer

## 10.2 Bottom Assembly Layer

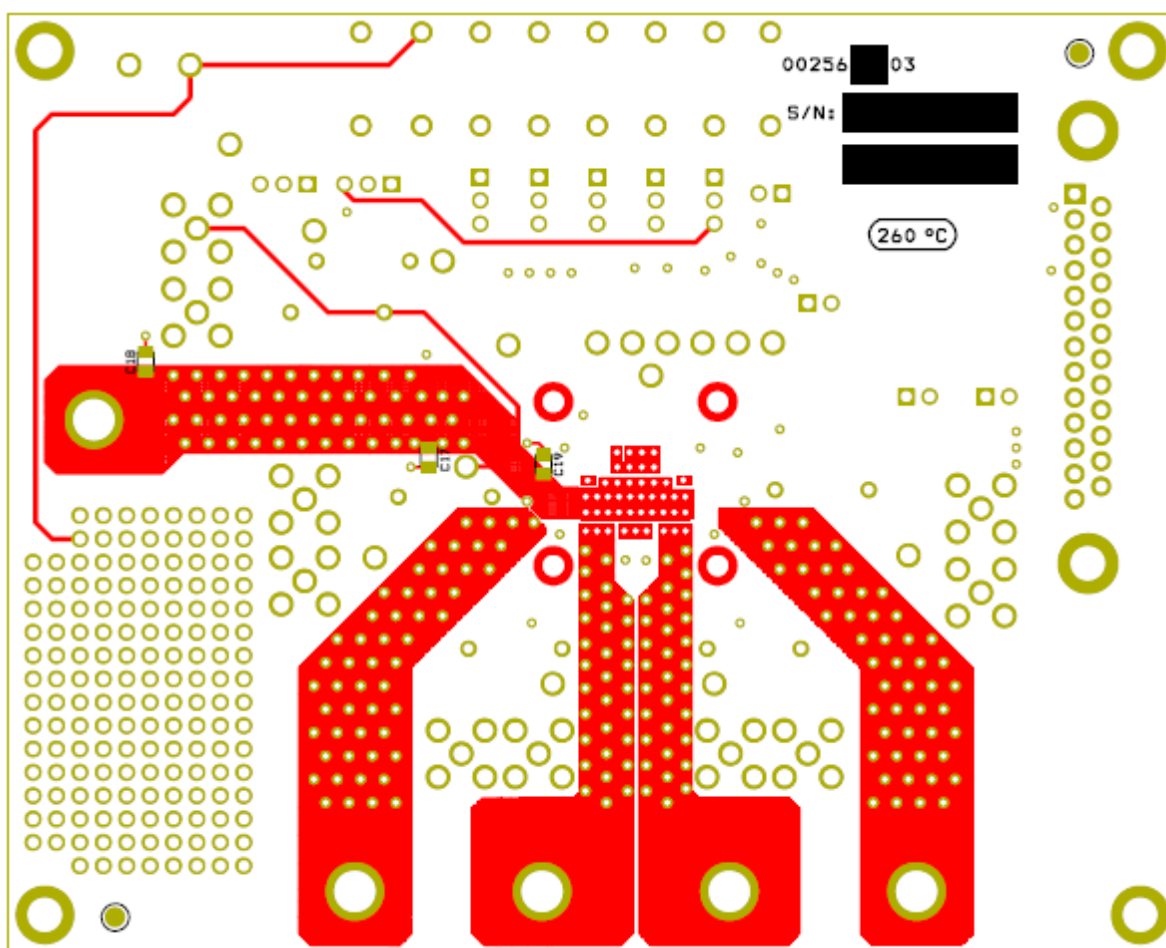


Figure 7. Bottom Assembly Layer

### 10.3 PCB Top Layer

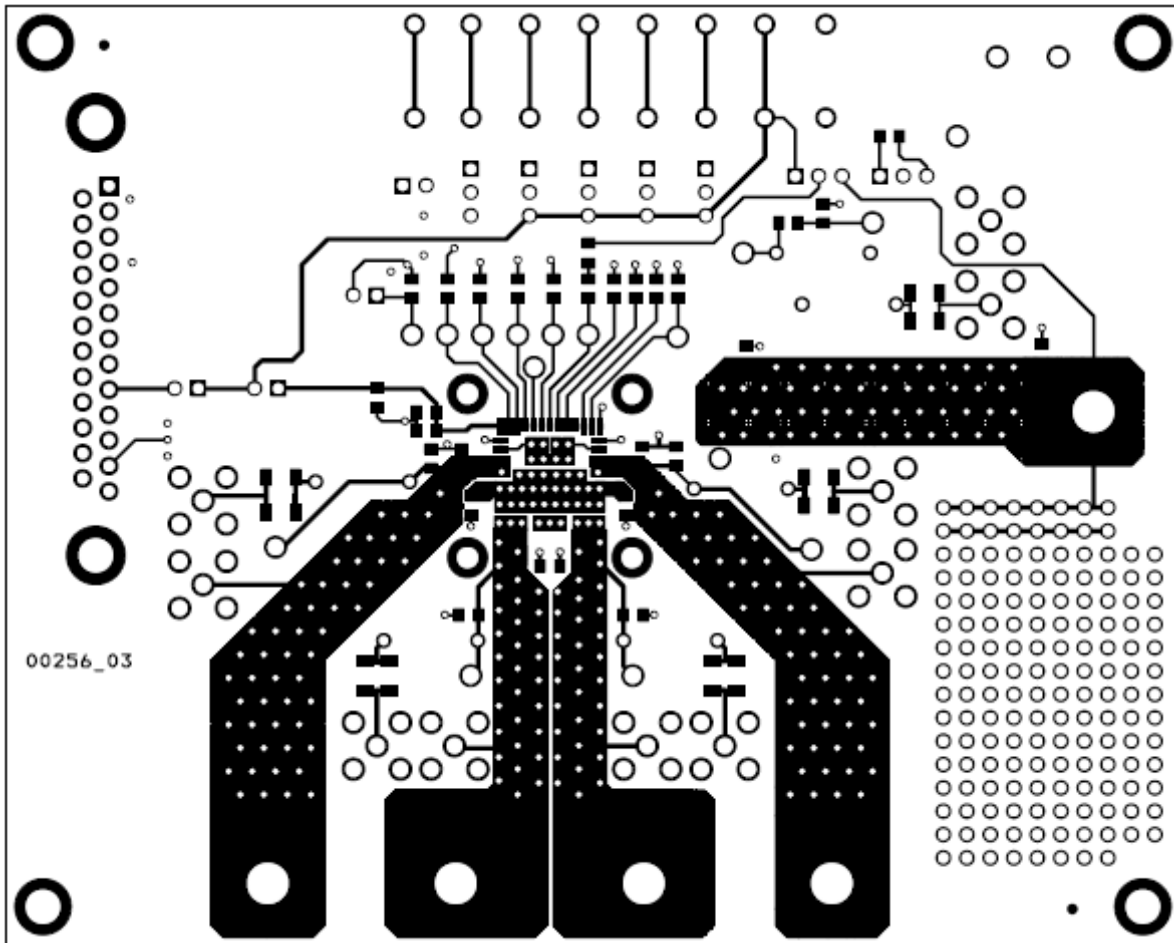


Figure 8. PCB Top Layer

## 10.4 PCB Bottom Layer

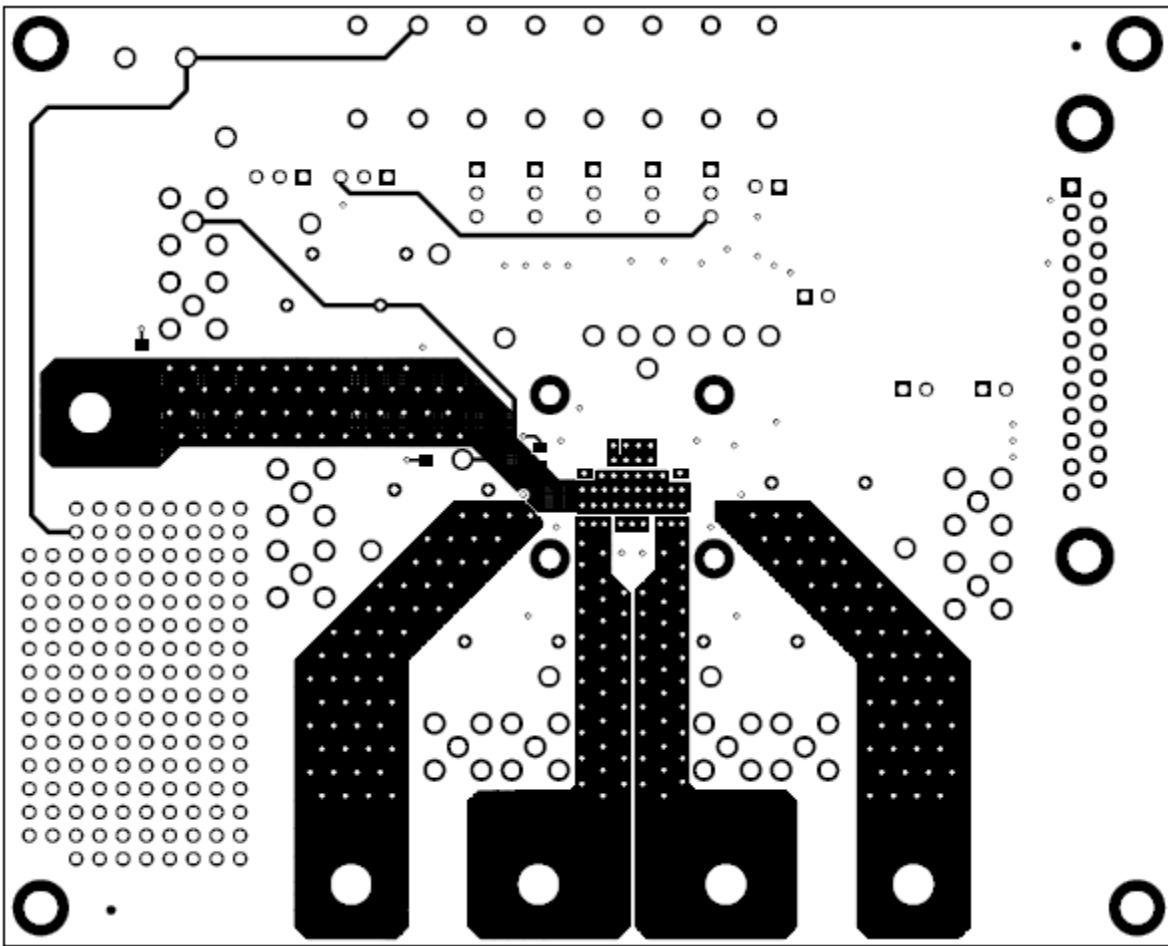


Figure 9. PCB Bottom Layer



# 11 Bill of Material

**Table 1. KIT09XS3400EVBE Bill of Material <sup>(1)</sup>**

PART NUMBER	VALUE/RATING	QTY	PART DESIGNATION
Resistor 5% SMD 0805	10 k	11	R1, R2, R3, R4, R5, R6, R7, R8, R9, R10, R13
Resistor 1% SMD 0805	6.8 k	1	R11
Resistor 1% Thru-hole 10mm	2.7 k	1	R12
Resistor 5% 1.0 W Thru-hole 10 mm	10 R	5	R18, R19, R20, R21, R22
Ceramic Capacitor 50 V SMD 0805 AVX	10 nF	1	C1
Ceramic Capacitor 50 V SMD 1206 AVX	10 nF	5	C26, C27, C28, C29, C30
Ceramic Capacitor 50 V SMD 0805 AVX	100 nF	4	C2, C3, C13, C15
Electrolytic Capacitor 63 V Thru - hole 5.0 mm	10 $\mu$ F	2	C4, C20
Ceramic Capacitor 50 V SMD 0805 AVX	22 nF	4	C5, C6, C7, C8
Ceramic Capacitor SMD 0805	For EMC tuning	9	C9, C10, C11, C12, C14, C16, C17, C18, C19
Ceramic Capacitor 50 V SMD 1206 AVX	1.0 nF	5	C21, C22, C23, C24, C25
SMD 0805 Lumex	Red LED	1	D1
Freescale Quad High Side Switch	MC09XS3400AFK	1	U1
Samtec	Header 3x1	7	JP1, JP2, JP3, JP4, JP5, JP6, JP7
Samtec	Header 2x1	4	JP9, JP10, JP11, JP12
PCB connector 90° ZEDB25PBA ITT CANNON	25-pin	1	J1
SMA 19-46-1-TGG MULTICOMP	Jack	10	J2, J3, J4, J5, J6, J18, J19, J20, J21, J22
Horizontal Test jack 105-0752-001 Johnson Components	YES	8	J7, J8, J9, J10, J11, J12, J23, J24
Screw diameter + 2 nuts + 2 washers each for power connector	4.0 mm	5	J13, J14, J15, J16, J17
PCB Test Terminal 200-203 William Hughes	YES	18	OUT1,OUT2, OUT3, WAKE, VPWR, VDD, SO, SI, SCLK, RSTB, OUT0, IN0, GND, FSI, FSB, CSNS, CSB, C Sense

**Notes**

1. 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.

## 12 References

The following table contains URLs where you can obtain information on other Freescale products and MC09XS3400 product solutions:

DESCRIPTION	URL
<a href="http://www.freescale.com/webapp/sps/site/prod_summary.jsp?code=MC09XS3400">MC09XS3400 Product Summary Page</a>	<a href="http://www.freescale.com/webapp/sps/site/prod_summary.jsp?code=MC09XS3400">http://www.freescale.com/webapp/sps/site/prod_summary.jsp?code=MC09XS3400</a>
<a href="http://www.freescale.com/files/analog/doc/data_sheet/MC09XS3400.pdf">MC09XS3400 Data Sheet</a>	<a href="http://www.freescale.com/files/analog/doc/data_sheet/MC09XS3400.pdf">www.freescale.com/files/analog/doc/data_sheet/MC09XS3400.pdf</a>
<a href="http://www.freescale.com/files/analog/doc/fact_sheet/MC09XS3400FS.pdf">MC09XS3400 Fact Sheet</a>	<a href="http://www.freescale.com/files/analog/doc/fact_sheet/MC09XS3400FS.pdf">www.freescale.com/files/analog/doc/fact_sheet/MC09XS3400FS.pdf</a>
<a href="http://www.freescale.com/files/soft_dev_tools/software/device_drivers/SPIGen.html">SPIGEN Reference</a>	<a href="http://www.freescale.com/files/soft_dev_tools/software/device_drivers/SPIGen.html">http://www.freescale.com/files/soft_dev_tools/software/device_drivers/SPIGen.html</a>
<a href="http://www.freescale.com/analog">Freescale's Analog Web Site</a>	<a href="http://www.freescale.com/analog">www.freescale.com/analog</a>
<a href="http://www.freescale.com/automotive">Freescale's Automotive Applications Web Site</a>	<a href="http://www.freescale.com/automotive">www.freescale.com/automotive</a>

### 12.1 Support

Visit [Freescale.com/support](http://www.freescale.com/support) for a list of phone numbers within your region.

### 12.2 Warranty

Visit [Freescale.com/warranty](http://www.freescale.com/warranty) for a list of phone numbers within your region.

## 13 Revision History

REVISION	DATE	DESCRIPTION OF CHANGES
1.0	8/2012	<ul style="list-style-type: none"><li>Initial Release</li></ul>
2.0	8/2012	<ul style="list-style-type: none"><li>Minor text edits, no technical changes</li></ul>

**How to Reach Us:**

**Home Page:**

freescale.com

**Web Support:**

freescale.com/support

Information in this document is provided solely to enable system and software implementers to use Freescale products. There are no express or implied copyright licenses granted hereunder to design or fabricate any integrated circuits based on the information in this document.

Freescale reserves the right to make changes without further notice to any products herein. Freescale makes no warranty, representation, or guarantee regarding the suitability of its products for any particular purpose, nor does Freescale assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation consequential or incidental damages. "Typical" parameters that may be provided in Freescale data sheets and/or specifications can and do vary in different applications, and actual performance may vary over time. All operating parameters, including "typicals," must be validated for each customer application by customer's technical experts. Freescale does not convey any license under its patent rights nor the rights of others. Freescale sells products pursuant to standard terms and conditions of sale, which can be found at the following address: [store.esellerate.net/store/Policy.aspx?Selector=RT&s=STR0326182960&pc](http://store.esellerate.net/store/Policy.aspx?Selector=RT&s=STR0326182960&pc).

Freescale, the Freescale logo, Altivec, C-5, CodeTest, CodeWarrior, ColdFire, C-Ware, Energy Efficient Solutions logo, Kinetis, mobileGT, PowerQUICC, Processor Expert, QorIQ, Qorivva, StarCore, Symphony, and VortiQa are trademarks of Freescale Semiconductor, Inc., Reg. U.S. Pat. & Tm. Off. Airfast, BeeKit, BeeStack, ColdFire+, CoreNet, Flexis, MagniV, MXC, Platform in a Package, QorIQ Qonverge, QUICC Engine, Ready Play, SafeAssure, SMARTMOS, TurboLink, Vybrid, and Xtrinsic are trademarks of Freescale Semiconductor, Inc. All other product or service names are the property of their respective owners.

© 2012 Freescale Semiconductor, Inc.

Document Number: KT09XS3400UG

Rev. 2.0

8/2012