Freescale Semiconductor
Application Note

AN3568
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EMC, ESD AND FAST TRANSIENT PULSES PERFORMANCES

For the MC15XS3400

1 Introduction

This application note relates the EMC, fast transient pulses and ESD capability for the 15XS3400 device.

The 15XS3400 is one in a family of devices designed for low-voltage automotive lighting applications. Its four low $R_{DS(ON)}$ MOSFETs (quad 15 mΩ) can control four separate 55W / 28W bulbs, and/or Xenon modules, and/or LEDs.

Programming, control and diagnostics are accomplished using a 16-bit SPI interface. Its output with selectable slew-rate improves electromagnetic compatibility (EMC) behavior. Additionally, each output has its own parallel input or SPI control for pulse-width modulation (PWM) control if desired. The 15XS3400 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 damaged.

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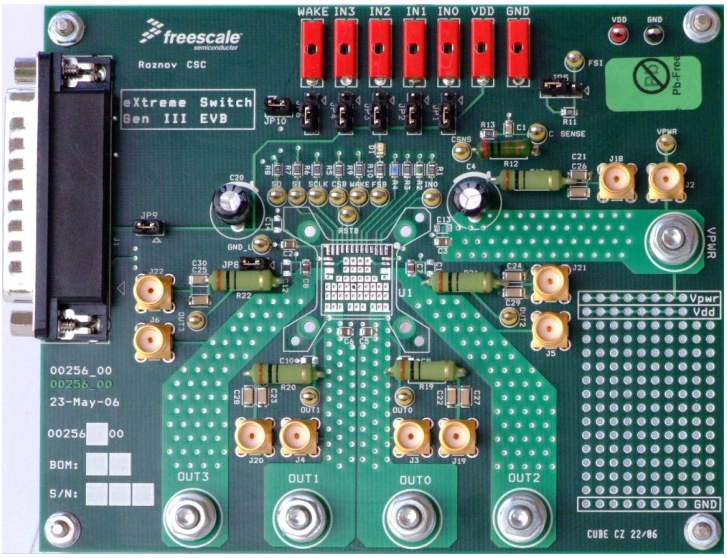
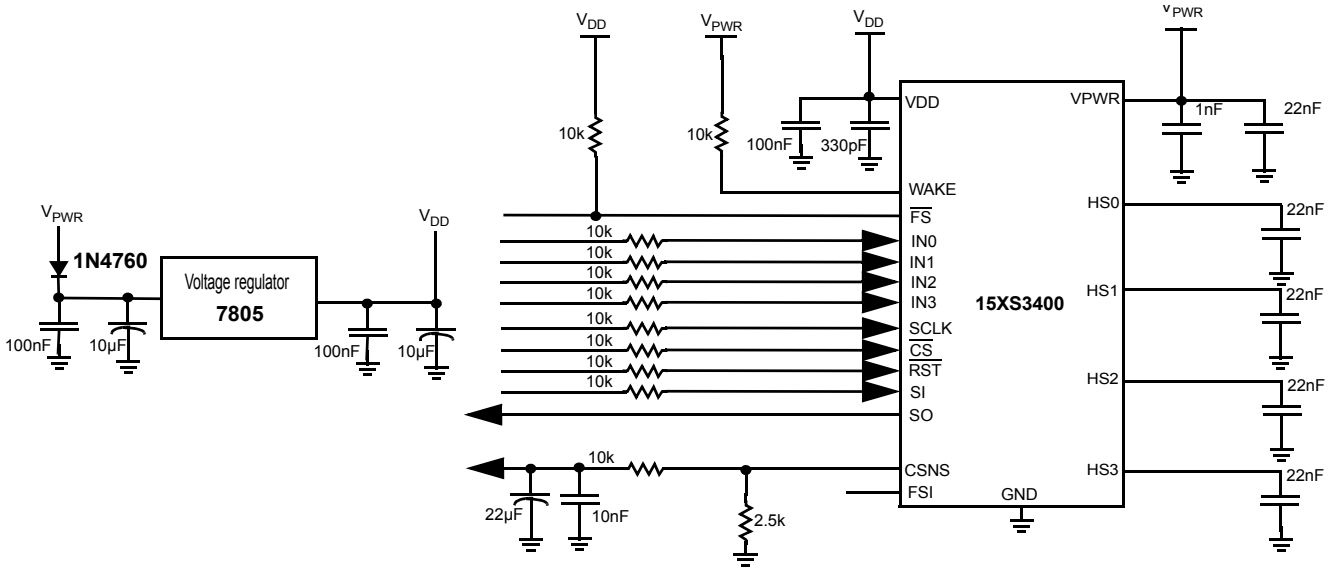
For feature information, refer to the device data sheets for the 15XS3400.

2 Board Setup

The evaluation board composed of 4 layers (EVB) has been used for those tests with the following capacitors (X7R 50V):

- on VPWR: 22nF located to the supply connector and a 1.0nF close to the 15XS3400 device,
- for each output: 22nF located at the output connector,
- low pass filter on CSNS output pin: 10kΩ + 10nF//22µF





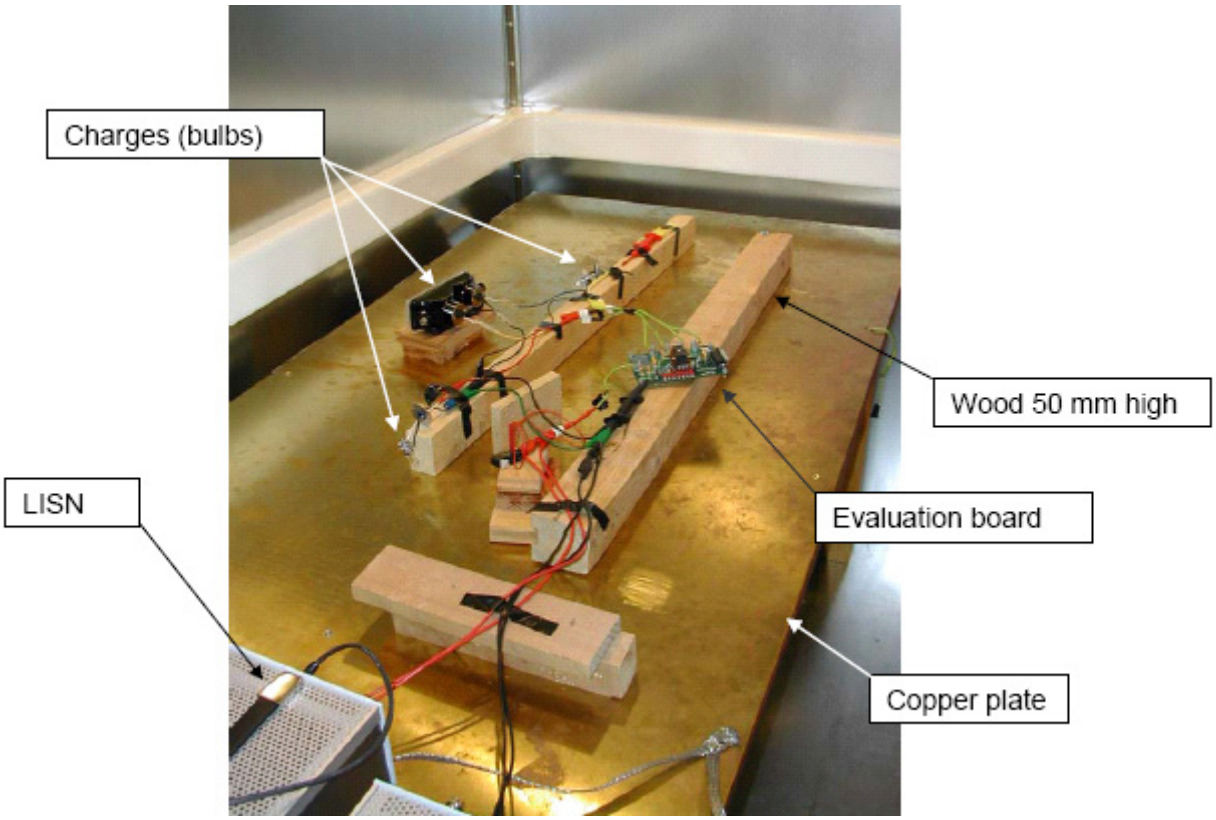
3 Measurements

3.1 Conducted Emission Measurements

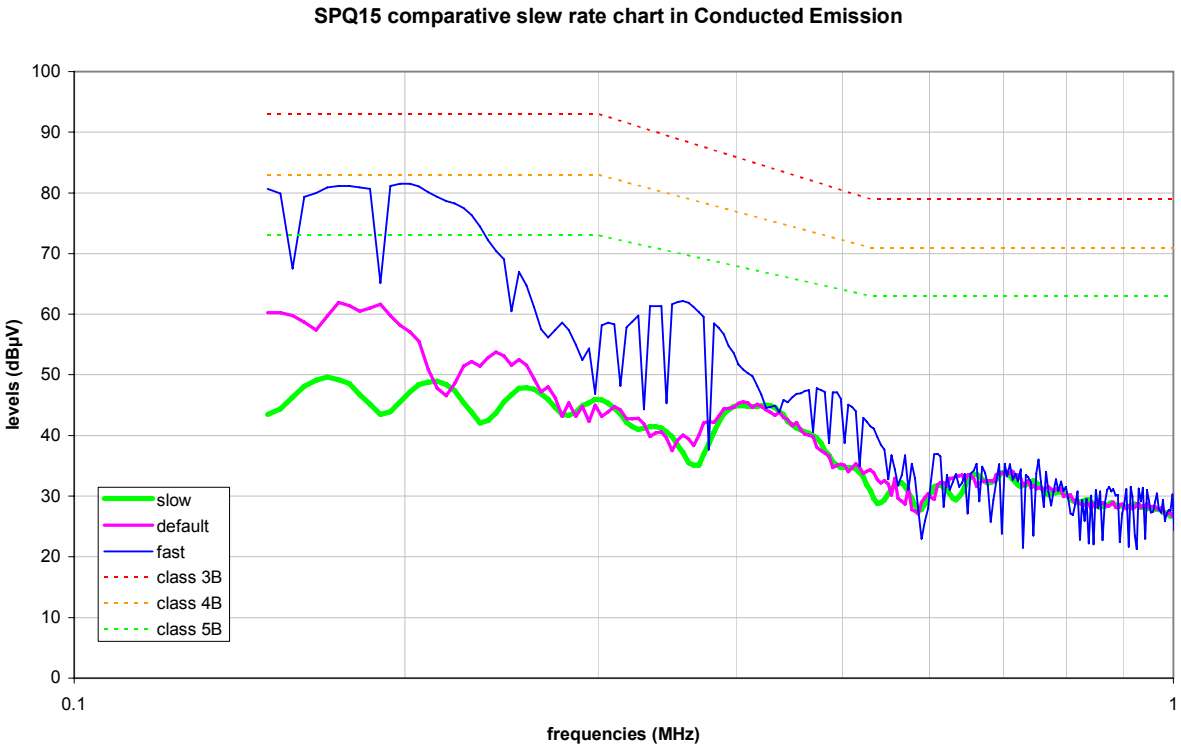
Conducted emission is the emission produced by the device on the battery cable. The test bench is described by the CISPR25 standard. The Line Impedance Stabilization Network (LISN), also called the Artificial Network (AN), in a given frequency range (150kHz to 108MHz), provides a specified load impedance for the measurement of disturbance voltages, and isolates the equipment under test (EUT) from the supply in that frequency range. The EUT must operate under typical loading and other conditions, just as it must in the vehicle, so a maximum emission state occurs. These operating conditions must be clearly defined in the test plan to ensure that both supplier and customer are performing identical tests.

For the testing described, the device was in Normal mode and each HS terminal of the 15XS3400 was connected to a H3-55W bulb. Only one output was switched at 200Hz with a duty cycle of 50%. The ground return of the bulb was connected to the chassis and the ground path of the EUT flowed into the LISN. The power supply voltage is 12V (car battery).

To perform a conducted emission measurement in accordance with the CISPR 25 standard, the test bench below was developed.



The results of those measurements are represented in the next figure. The board is in accordance with the Class 5 limits of the CISPR25 for the default and slow slew-rates and with the Class 4 limits for the fast slew-rate.



3.2 Conducted Immunity Measurements

Conducted immunity is the device susceptibility for RF injection applied directly on a device terminal. The test bench is described by the 62132-4 specification (Direct Power Injection) from the International Electrotechnical Commission. The following performance grades have been used to characterize the device performance:

Class A: All functions of the IC perform as designed during and after exposure to a disturbance.

Class B: All functions of the IC perform as designed during exposure, however, one or more of them may go beyond the specified tolerance. All functions return automatically to within normal limits after exposure is removed. Memory functions shall remain in class A.

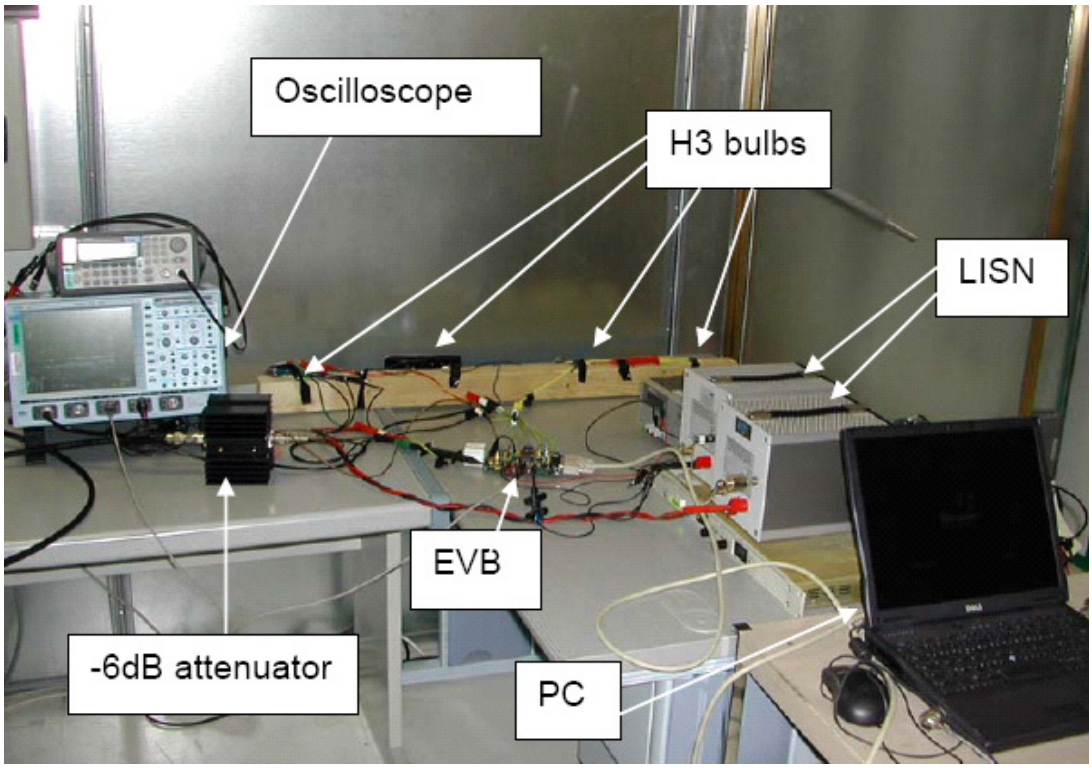
Class C: A function of the IC doesn't perform as designed during exposure but returns automatically to normal operation after exposure is removed.

Class D: A function of the IC doesn't perform as designed during exposure and doesn't return to normal operation until exposure is removed and the IC is reset by simple operator action (e.g.: put off supply...).

Class E: One or more functions of an integrated circuit do not perform as designed during and after exposure and cannot be returned to proper operation.

For the testing described, the device was in Normal or FailSafe mode and each HS terminal of the 15XS3400 was connected to a H3-55W bulb. Only one output was switched "on" or "off". The ground return of the bulb was connected to the chassis and the ground path of the EUT flowed into the LISN. The power supply voltage is 12V (car battery).

To perform a conducted immunity measurement in accordance with the IEC 62132-4 standard, the test bench below was developed.



The results of those measurements are represented in the next table. All features of the device are in accordance with the Class A for 37dBm of power injection from 1MHz to 1GHz.

Feature	Mode	Comment	Class
Light fully-on (command by direct IN)	FailSafe	NTR	A
Light PWM (command by direct IN)	Normal	NTR	A
Light fully-on (command by SPI)	Normal	NTR	A
Current recopy	Normal	NTR	A
Over-current fault detection in steady state	Normal	NTR 0.5Ω of short in parallel to H3-55W bulb	A
Load diagnostic features	Normal	NTR Open-load detection and Output shorted to VPWR in OFF state	A
Erratic fault detection	Normal	NTR	A

3.3 Coupled Immunity Measurements

Coupled immunity is the device susceptibility for RF injection applied on the wire harness. The test bench is described by the 62132-3 specification (Bulk Current Injection) from the International Electrotechnical Commission.

For the testing described, the device was in Normal mode and each HS terminal of the 15XS3400 was connected to a H3-55W bulb. Only one output was switched “on”. The ground return of the bulb was connected to the chassis and the ground path of the EUT flowed into the LISN. The power supply voltage is 12V (car battery).

The results of those measurements are represented in the next table. The device is in accordance with the Class A for 200mA of power injection from 1MHz to 400MHz. CW and FM modulations have been applied and at 75cm and 15cm distances between the injector and the EVB.

Feature	Mode	Comment	Class
Light fully-on (command by SPI)	Normal	NTR	A
Current recopy	Normal	NTR	A
Erratic fault detection	Normal	NTR	A

3.4 Radiated Immunity Measurements

Radiated immunity is the device susceptibility for RF injection applied on the wire harness. The test bench is described by the 11452-2 specification from the International Electrotechnical Commission.

For the testing described, the device was in Normal mode and each HS terminal of the 15XS3400 was connected to a H3-55W bulb. Only one output was switched “on”. The ground return of the bulb was connected to the chassis and the ground path of the EUT flowed into the LISN. The power supply voltage is 12V (car battery).

The results of those measurements are represented in the next table. All features of the device are in accordance with the Class A for 200V/m of power injection from 200MHz to 1GHz (vertical antenna), and 400MHz to 1GHz (horizontal antenna). CW and FM modulations have been applied.

Feature	Mode	Comment	Class
Light fully-on (command by SPI)	Normal	NTR	A
Current recopy	Normal	NTR	A
Erratic fault detection	Normal	NTR	A

3.5 Fast Transient Pulse Measurements

Transient pulse immunity is the device susceptibility for fast transient pulse applied directly on VPWR and the output lines (HS[0:3]). The transient pulses are described by the ISO7637-2 standard from the International Electrotechnical Commission. The power supply voltage is 13.5V.

For the testing on VPWR, the device was in Normal or FailSafe mode, each HS terminal of the 15XS3400 was connected to a 2.0Ω resistive load, and all outputs were “on” or “off”. The results of those measurements are represented in the next table. After the pulse, the device is in accordance with the Class A.

Schaffner pulses applied on VPWR	Mode	All outputs “off”	All “outputs “on”
Pulse 1 (Ri=10Ω, -100V, 3000 occurrences)	FailSafe	Class A	Class A
Pulse 2a (Ri=2Ω, +50V, 3000 occurrences)	FailSafe	Class A	Class A
Pulse 3a (Ri=50Ω, -150V, 15min)	Normal	Class A	Class A
Pulse 3b (Ri=50Ω, +100V, 15min)	Normal	Class A	Class A
Pulse 5a (Ri=10Ω, +30V, 10 occurrences)	FailSafe	Class A	Class A
Pulse 5b (Ri=10Ω, +87V clamped at +42V, 10 occurrences)	Normal	Class A	Class A

For the testing on one output, the device was in FailSafe mode and the fast negative pulse is applied on one output unloaded, other outputs are loaded with a 2.0Ω resistive load and commanded “off”. The results of those measurements are represented in the next table. After the pulse, the device is in accordance with the Class A.

Schaffner pulses applied on the HS output	Mode	Pulse applied on one output, other outputs “off” and loaded
Pulse 1 (Ri=10Ω, -100V, 10 occurrences)	FailSafe	Class A
Pulse D from Ford specification (Ri=10Ω, -220V, 10 occurrences)	FailSafe	Class A

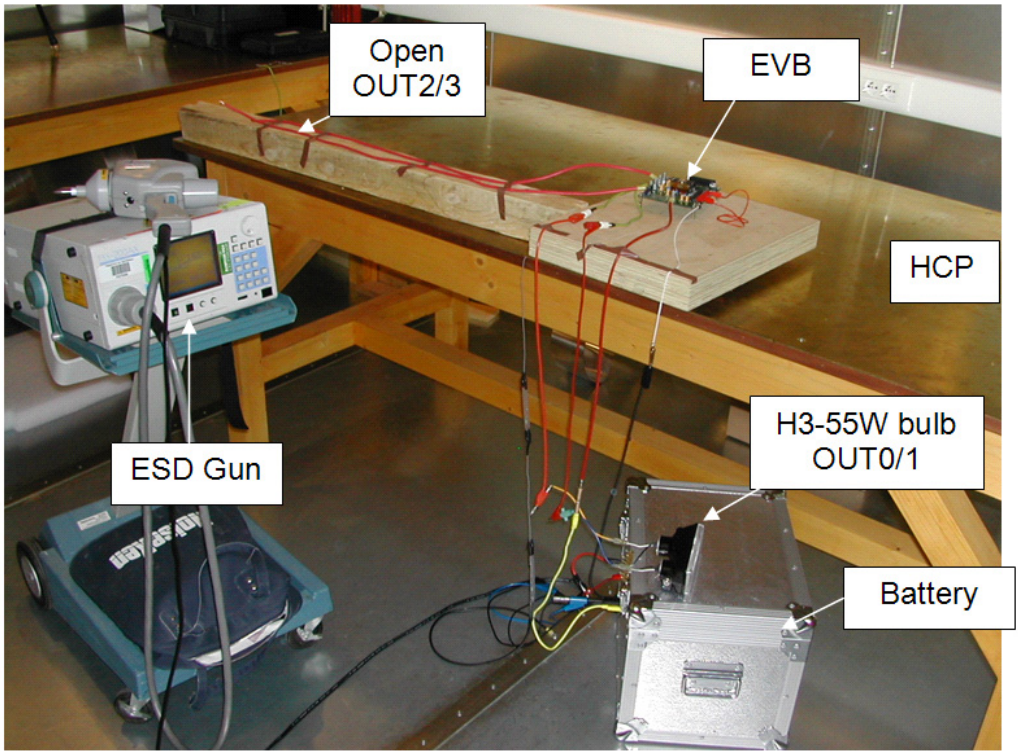
3.6 Electrostatic Discharge Measurements

The aim of the experiment is to characterize Electrostatic Discharge Immunity Test of the 15XS3400 product in Normal and FailSafe modes with many bulbs configurations, in order to convert the whole application. The test bench is described in 61000-4-2 from the International Electrotechnical Commission. The Gun impedance was 330Ω + 150pF, with direct application on OUTs, VPWR, GND on wires at 1 meter from the IC and Horizontal Coupling Plate contacts (HCP). Positive and negative contact discharge levels from 2.0kV to 15kV must be considered (2 single pulses with 1sec between each pulse).

For the testing described, each HS terminal was configured as described in the following table. The power supply voltage is 12V (car battery).

Mode	OUT0	OUT1	OUT2	OUT3	Comment
Normal	ON loaded with H3-55W	OFF loaded with H3-55W	ON opened	OFF opened	- IN0 and IN2 commanded through SPI, - RSTB=VDD, - OUT2 and OUT3 Openload features in OFF state disabled
FailSafe	ON loaded with H3-55W	OFF loaded with H3-55W	ON opened	OFF opened	- IN0=IN2 connected to external 5V

To perform a Gun electrostatic discharge measurement in accordance with the IEC61000-4-2 standard, the test bench below was developed.



The results of those measurements are represented in the next table.

Gun ESD level	Mode	Comment	Class
+8kV	FailSafe	NTR	A
-8kV	FailSafe	NTR	A
+8kV	Normal	NTR	A
-8kV	Normal	Unexpected reset occurred	B
-5.75kV	Normal	NTR	A
+15kV	Normal	NTR	A
-15kV	Normal	Unexpected reset occurred	B

4 References

- MC15XS3400 - Switch Data sheet (Quad High Side Switch (Quad 15mΩ))

5 Revision History

REVISION	DATE	DESCRIPTION OF CHANGES
1.0	10/2008	• Initial Release

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USA/Europe or Locations Not Listed:
Freescale Semiconductor, Inc.
Technical Information Center, EL516
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Tempe, Arizona 85284
+1-800-521-6274 or +1-480-768-2130
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Europe, Middle East, and Africa:
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Technical Information Center
Schatzbogen 7
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+44 1296 380 456 (English)
+46 8 52200080 (English)
+49 89 92103 559 (German)
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Japan:
Freescale Semiconductor Japan Ltd.
Headquarters
ARCO Tower 15F
1-8-1, Shimo-Meguro, Meguro-ku,
Tokyo 153-0064
Japan
0120 191014 or +81 3 5437 9125
support.japan@freescale.com

Asia/Pacific:
Freescale Semiconductor Hong Kong Ltd.
Technical Information Center
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