Freescale Semiconductor
Application Note

AN3569
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EMC, ESD and Fast Transient Pulses Performances

(MC10XS3412)

1 Introduction

This application note relates the EMC, fast transient pulses and ESD capability for the 10XS3412 device.

The 10XS3412 is one in a family of devices designed for low-voltage automotive lighting applications. Its four low $R_{DS(ON)}$ MOSFETs (dual 10mΩ and dual 12mΩ) 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 10XS3412 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 safe functionality of the outputs in case of MCU damaged.

For feature information, refer to the device data sheets for the 10XS3412.

Contents

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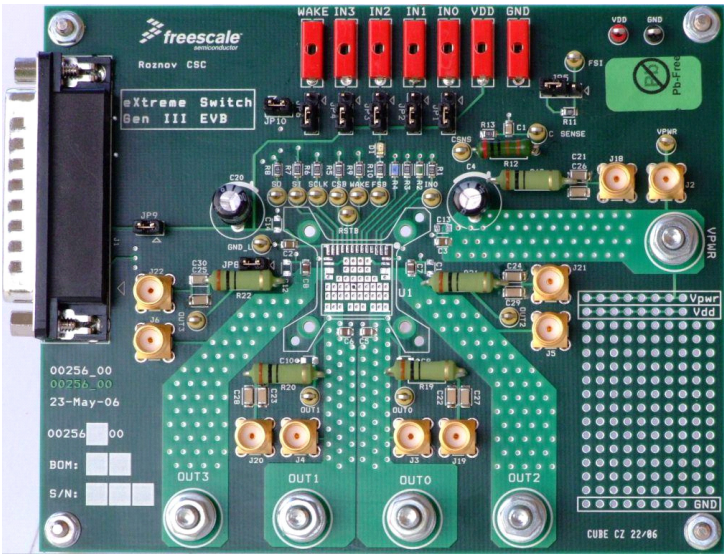
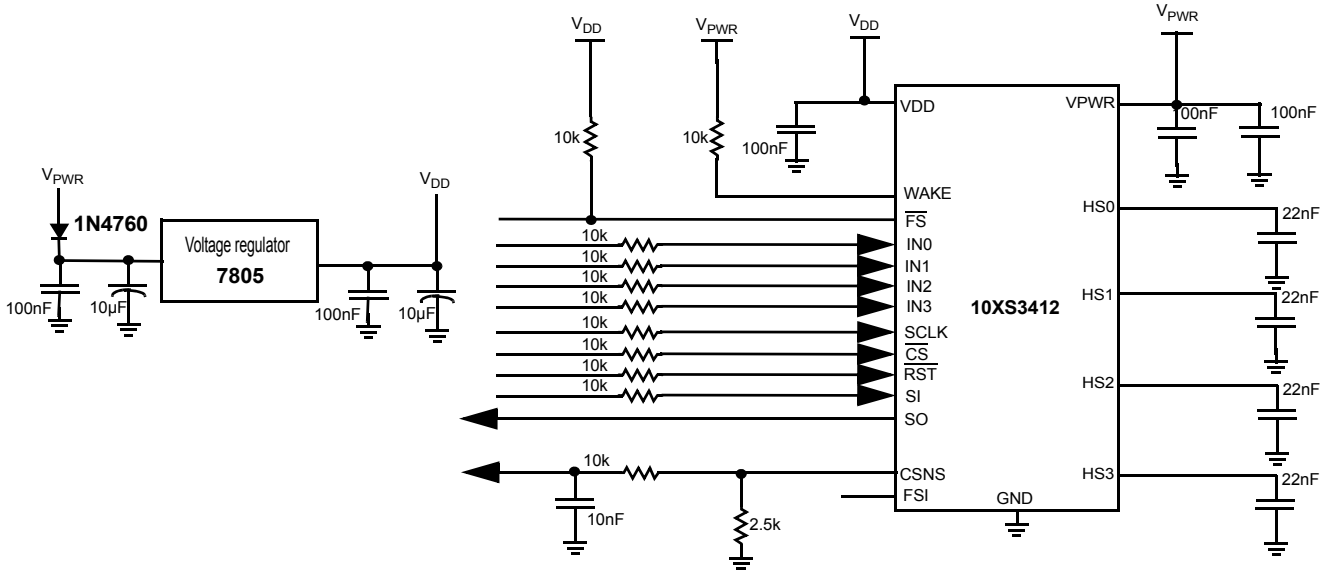
2 Board Setup

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

- On VPWR: 2 times of 100nF closed to the 10XS3412 device
- For each output: 22nF located at the output connector
- Low pass filter on CSNS output pin: 10kΩ + 10nF





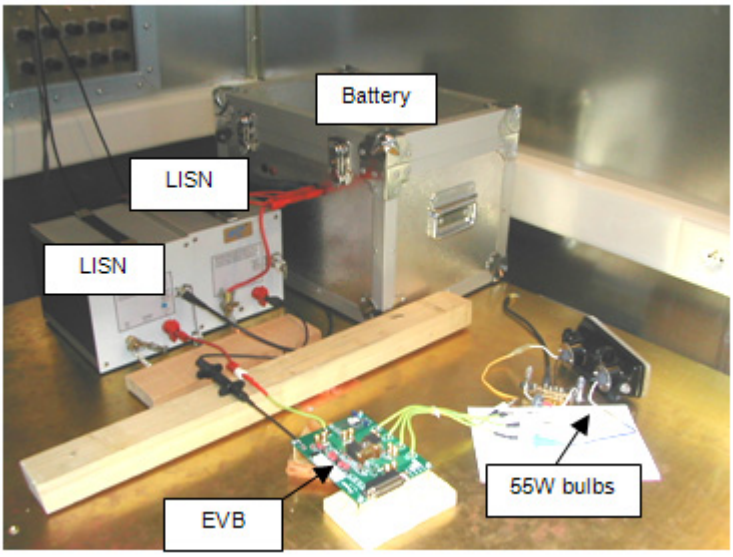
3 Measurements

3.1 Conducted Emission Measurements

Conducted emission is the emission produced by the device on the battery cable. The bench test is described by the CISPR25 standard. The Line Impedance Stabilization Network (LISN), also called the Artificial Network (AN), in a given frequency range (150 kHz to 108 MHz), 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 10XS3412 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 bench test below was developed.



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

Conducted Emissions	Mode	CISPR25 level
All outputs OFF	Standby current mode	Class 5
One 55W bulb commanded in PWM with 50% of duty-cycle	Normal mode with default slew-rate	Class 5
One 55W bulb commanded in PWM with 50% of duty-cycle	Normal mode with slow slew-rate	Class 5
One 55W bulb commanded in PWM with 50% of duty-cycle	Normal mode with fast slew-rate	Class 4

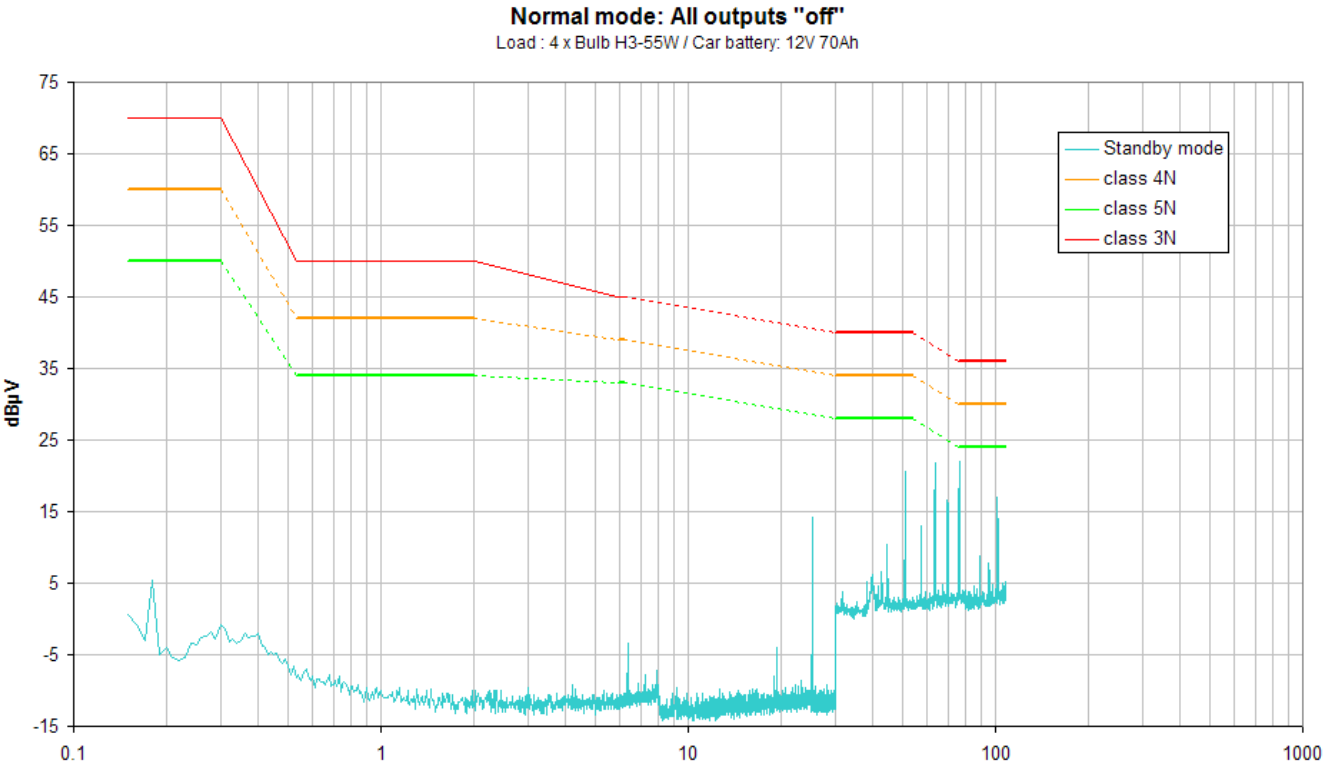


Figure 1. Normal Mode - All Outputs Off

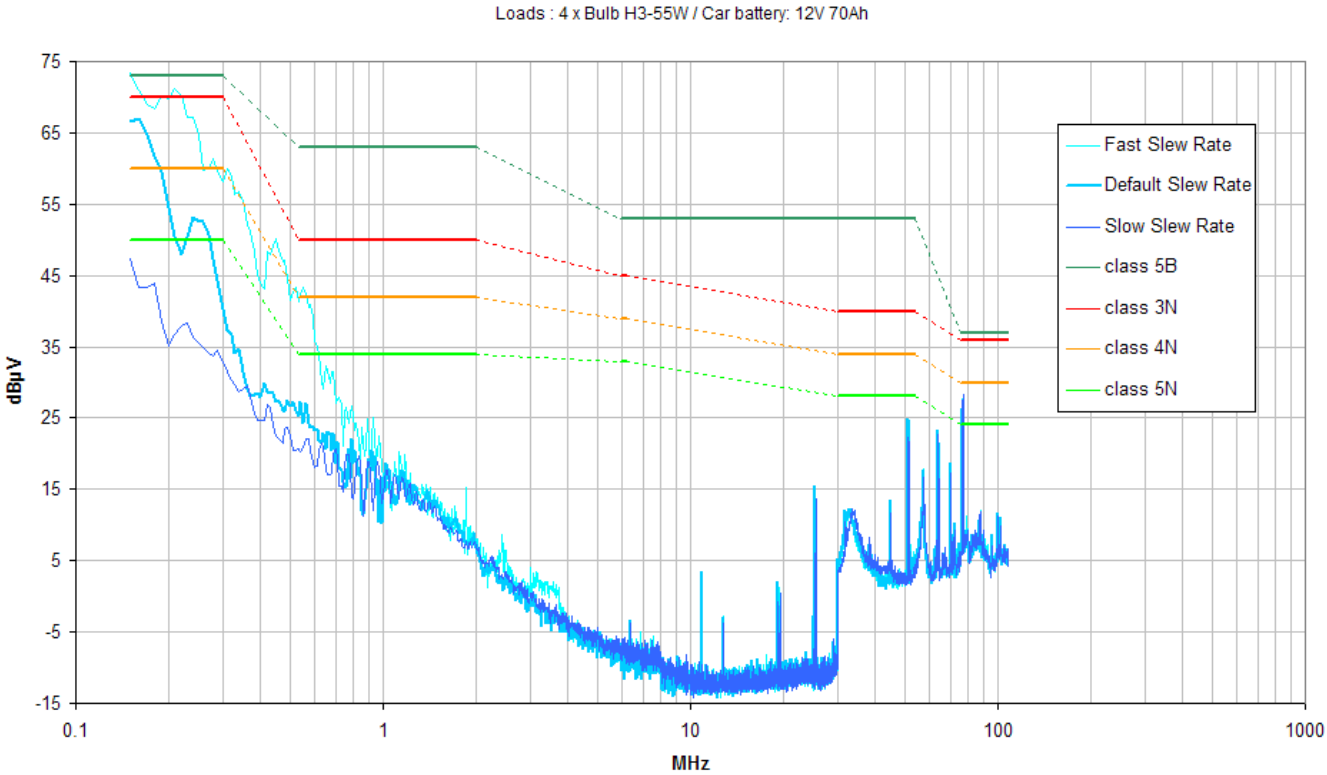


Figure 2. Normal Mode - One Output in PWM Mode at 50% of Duty Cycle

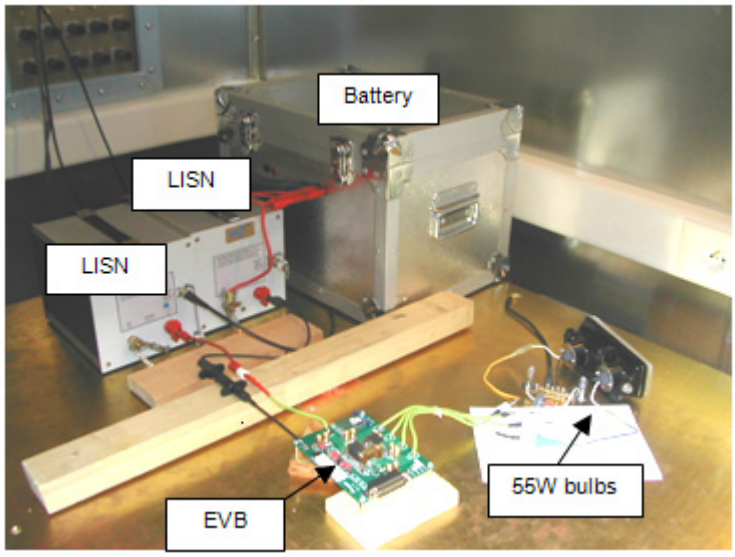
3.2 Conducted Immunity Measurements

Conducted immunity is the device susceptibility for RF injection applied directly on a device terminal. The bench test is described by the 62132-4 specification (Direct Power Injection) from the International Electro technical 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 Fail-safe mode and each HS terminal of the 10XS3412 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 bench test 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 bench test is described by the 62132-3 specification (Bulk Current Injection) from the International Electro technical Commission.

For the testing described, the device was in Normal mode and each HS terminal of the 10XS3412 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 bench test is described by the 11452-2 specification from the International Electro technical Commission.

For the testing described, the device was in Normal mode and each HS terminal of the 10XS3412 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 Electro technical Commission. The power supply voltage is 13.5V.

For the testing on VPWR, the device was in Normal or Fail-safe mode, each HS terminal of the 10XS3412 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, 1000 occurrences)	Normal & Fail-safe	Class A	Class A
Pulse 2a (Ri=2Ω, +50V, 1000 occurrences)	Normal & Fail-safe	Class A	Class A
Pulse 3a (Ri=50Ω, -150V, 8min)	Normal & Fail-safe	Class A	Class A
Pulse 3b (Ri=50Ω, +100V, 8min)	Normal & Fail-safe	Class A	Class A
Pulse 5b (Ri=1Ω, +87V clamped at +42V, 10 occurrences)	Normal & Fail-safe	Class A	Class A

Without loads, it is mandatory to use an external transient voltage suppressor between VPWR and GND in order to sustain the pulse 1.

For testing on one output, the device was in Fail-safe 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”. 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, trise=1µsec, 10 occurrences)	Fail-safe	Class A w/o decoupling cap on output
Pulse 1 (Ri=10Ω, -200V, trise=1µsec, 10 occurrences)	Fail-safe	Class A w/o decoupling cap on output
Pulse 3 (Ri=10Ω, -300V, trise=3µsec, 10 occurrences)	Fail-safe	Class A w/o decoupling cap on output
Pulse D from Ford specification (Ri=4Ω, -300V, trise=1µsec, 10 occurrences)	Fail-safe	Class A with 22nF of output decoupling capacitor

3.6 Electrostatic Discharge Measurements

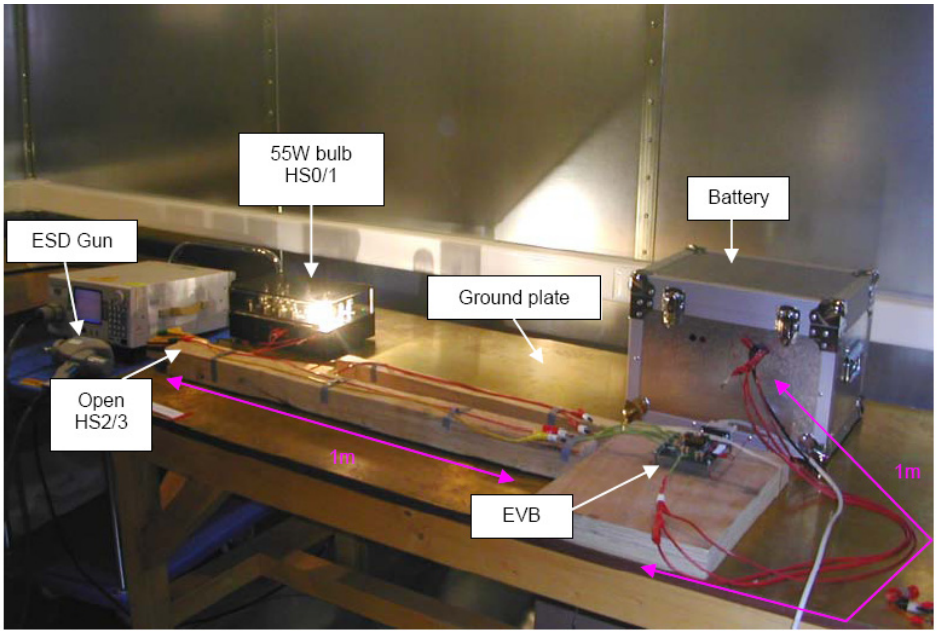
The aim of the experiment is to characterize Electrostatic Discharge Immunity Test of the 10XS3412 product in Normal and Fail-safe modes with many bulbs configurations, in order to convert the whole application. The bench test is described in 10605 from the International Standard Organization. The Gun impedance was 2kΩ + 330pF, with direct application on outputs (HS) and VPWR on wires at 1 meter. Positive and negative air and contact discharge levels must be considered (3 single pulses with 5sec between each pulse):

- positive and negative contact discharge level to 15kV,
- positive and negative air discharge level to 25kV.

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

Mode	HS0	HS1	HS2	HS3	Comment
Normal	ON loaded with H3-55W	OFF loaded with H3-55W	ON opened	OFF opened	- IN0 and IN2 commanded through SPI, - $\overline{RST}$=VDD, - OUT2 and OUT3 Open load features in OFF state disabled, - FSI grounded.
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 ISO 10605 standard, the bench test below was developed.



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

Fail-safe Mode	HS0	HS1	HS2	HS3	VPWR
-15kV contact discharges	Class A	Class A	Class A	Class A	Class A
+15kV contact discharges	Class A	Class A	Class A	Class A ≤ +5kV Class B > +6kV	Class A
-25kV air discharges	Class A	Class A	Class A	Class A	Class A
+25kV air discharges	Class A	Class A	Class A	Class A	Class A

Class B corresponds to lamp turn-off during the exposure to interference. The device returns automatically to normal operation after the exposure to interference.

Normal Mode	HS0	HS1	HS2	HS3	VPWR
-15kV contact discharges	Class A	Class A	Class A ≥ -4.5kV Class B <-4.5kV Class D <-5.5kV	Class A ≥ -3.5kV Class D<-4.0kV	Class A
+15kV contact discharges	Class A	Class A	Class A ≤ +5kV Class D > +5.5kV	Class A ≤ +4.5kV Class D > +5kV	Class A
-25kV air discharges	Class A	Class A	Class A	Class A	Class A
+25kV air discharges	Class A	Class A	Class A	Class A unexpected fault reporting “output shorted to VPWR”	Class A

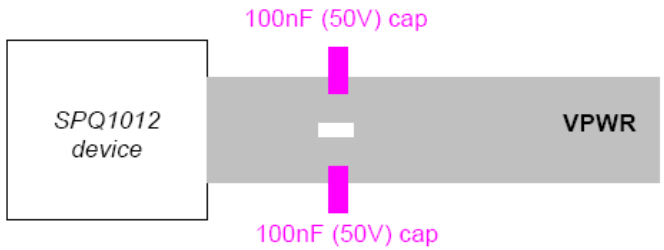
Class D corresponds to unexpected power on reset (POR). The 10XS3412 device reports POR and UV faults. The MCU must configure again the device after the exposure to interference.

3.7 Decoupling Capacitors Role

The following table summarizes the mission of each decoupling capacitor:

Signal	Location	Mission	Value
VPWR	closed to 10XS3412 device	Reduction of emission and immunity	2 x 100nF
VDD	closed to 10XS3412 device	Reduction of emission and immunity	100nF
HS outputs	closed to output connectors	Reduction of emission and fast transient negative pulse sustaining	22nF
CSNS	closed to the MCU	Low pass filter to remove noise during immunity test	10kΩ + 10nF

Recommended PCB layout for VPWR signal decoupling:



4 References

- MC10XS3412 - Quad High Side Switch (Dual 10mΩ and Dual 12mΩ) Data Sheet.

5 Revision History

REVISION	DATE	DESCRIPTION OF CHANGES
1.0	10/2008	• Initial Release
2.0	5/2009	• Added paragraph to Fast Transient Pulse Measurements on page on page 7

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