Freescale Semiconductor
Application Note

AN4144
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EMC, ESD and Fast Transient Pulses Performances

(MC10XS3535)

1 Introduction

This Application Note is for the EMC, fast transient pulses and ESD capability for the 10XS3535 device.

The 10XS3535 is one in a family of devices designed for low-voltage automotive lighting applications. Its five low $R_{DS(ON)}$ MOSFETs (triple 10mΩ and dual 35mΩ) can control five separate 55W / 28W bulbs, and/or Xenon modules, and/or LEDs. The 35XS3500 is a derived device including five 35mΩ MOSFETs.

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 are controlled through SPI for pulse-width modulation (PWM). The 10XS3535 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.

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 VBAT: 100nF closed to the 10XS3535 device
- For each output: 22nF located at the output connector
- Low pass filter on CSNS output pin: 10kΩ + 10nF

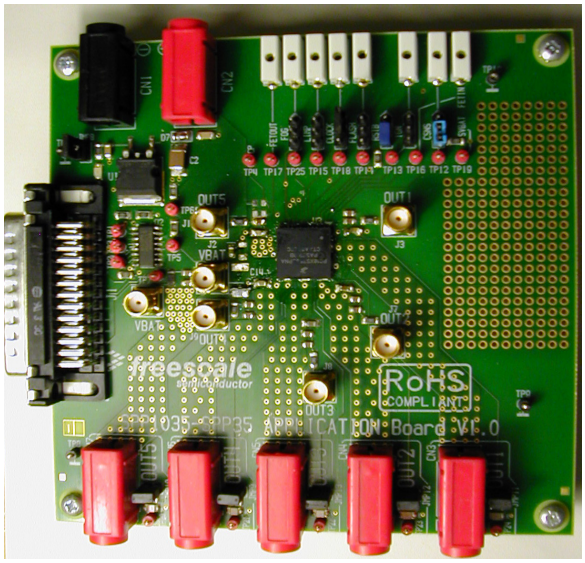

Figure 1. Kit Evaluation Board

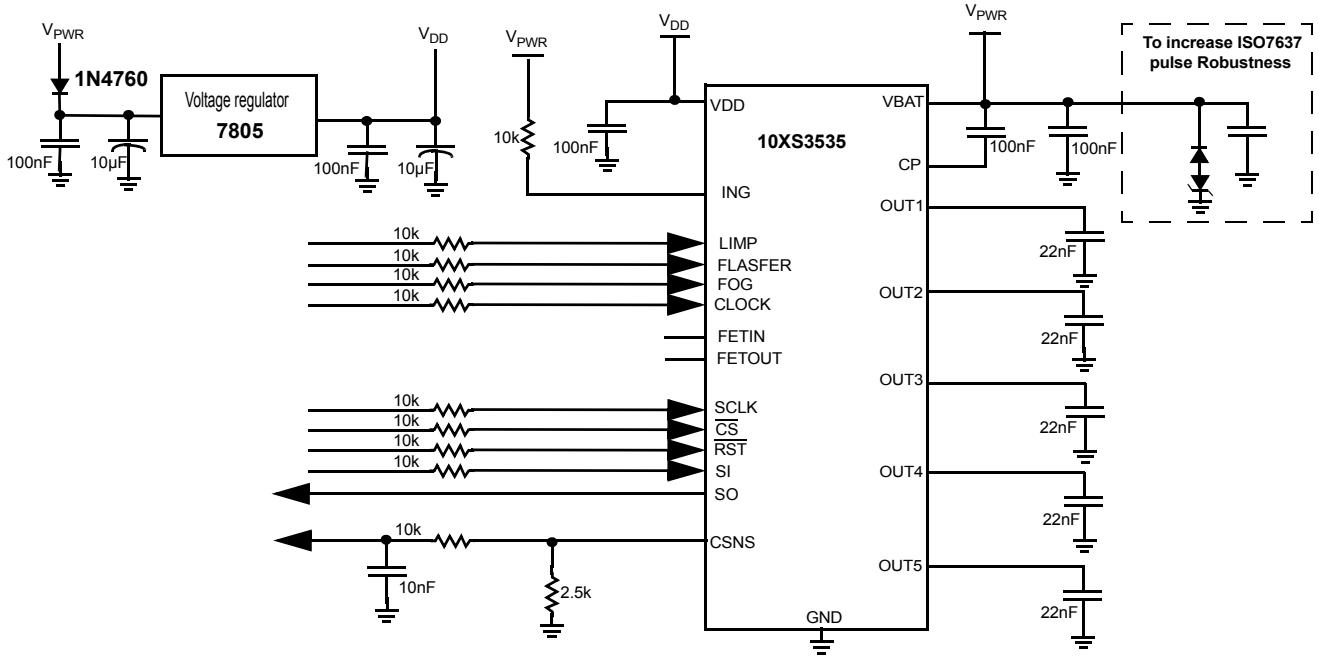

Figure 2. Simplified Application Diagram

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 the OUT[1,5] and OUT[2-4] terminals of the 10XS3535 were connected respectively to a 21W bulb and a H4-60W lamp. Only one output was switched at 200Hz with a duty cycle of 80%. 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:

Conducted Emissions	Mode	CISPR25 level
All outputs OFF	Standby current mode	Class 5
One 60W bulb commanded in PWM with 80% of duty-cycle	Normal mode	Class 5
One 21W bulb commanded in PWM with 80% of duty-cycle	Normal mode	Class 5

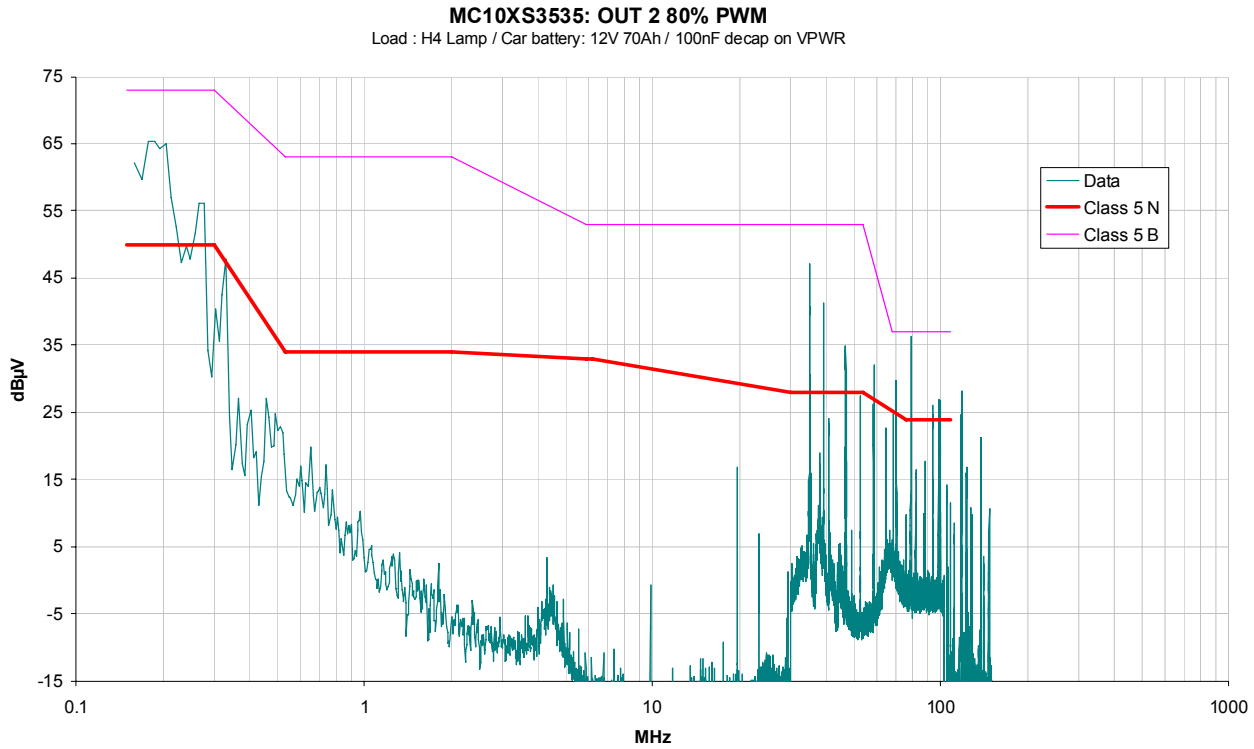

Figure 3. Normal Mode - One Output in PWM Mode at 80% of Duty Cycle

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 the OUT[1,5] and OUT[2-4] terminals of the 10XS3535 were connected respectively to a 21W bulb and a H4-60W lamp. 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).

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)	Fail-safe	NTR	A
Light PWM (command by direct IN)	Fail-safe	NTR	A
Light fully-on (command by SPI)	Normal	NTR	A
Current recopy	Normal	NTR	A
Erratic fault detection	Normal	NTR	A

3.3 Fast Transient Pulse Measurements

Transient pulse immunity is the device susceptibility for fast transient pulse applied directly on VBAT and the output lines (OUT[1:5]). 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 VBAT, the device was in Sleep state or Fail-safe mode with IGN=5.0V, the OUT[1,5] and OUT[2-4] terminals of the 10XS3535 were connected respectively to a 4.0Ω and 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	Sleep-state OUT[1:5] off-state	Fail-safe mode OUT[1] on-state and OUT[2:5] off
Pulse 1 (Ri=10Ω, -100V, 1000 occurrences)	Class A	Class A
Pulse 2a (Ri=2Ω, +50V, 1000 occurrences)	Class A	Class A
Pulse 3a (Ri=50Ω, -150V, 8min)	Class A	Class A
Pulse 3b (Ri=50Ω, +100V, 8min)	Class A	Class A
Pulse 5b (Ri=1Ω, +87V clamped at +41V, 10 occurrences)	Class A	Class A

In case of open load condition, the transient pulses shall be handled by the application with a transient voltage suppressor between VBAT and GND as presented in the paragraph entitled Decoupling Capacitors Role on page 7.

During the un-clamped load dump, the VBAT pin voltage is limited at $V_{BATCLAMP}$ by active clamp circuitry through the load. The load could be damaged if a low powered lamp is connected to the output: 10W lamp connected to 10mΩ channel or 5W lamp connected to 35mΩ channel.

For testing on one output, the device was in Sleep-state mode and the fast negative pulse is applied on one output unloaded, other outputs are loaded with a 4.0Ω and 2.0Ω resistive load for respectively 35mΩ and 10mΩ channel 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 output (OUTx)	**Mode**	**Pulse applied on one output, other outputs “off” and loaded**
Pulse 1 (Ri=10Ω, -150V, trise=1µsec, 100 occurrences)	Sleep-state	Class A w/o decoupling cap on output
Pulse 1 (Ri=50Ω, -300V, trise=1µsec, 100 occurrences)	Sleep-state	Class A w/o decoupling cap on output

3.4 Electrostatic Discharge Measurements

The aim of the experiment is to characterize Electrostatic Discharge Immunity Test of the 10XS3535 product in Fail-safe mode. The bench test is described in 10605 from the International Standard Organization. The Gun impedance was 2kΩ + 330pF, with direct application on outputs (OUT) and VBAT 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 OUT terminal was configured as described in the following table. The power supply voltage is 12V (car battery).

Mode	OUT1	OUT2	OUT3	OUT4	OUT5	Comment
Fail-safe	ON loaded with 21W	OFF loaded with H4-55W	OFF open	ON open	OFF loaded with 21W	IGN = 5.0V

The maximum ESD Gun levels to sustain the class A are represented in the next table:

Fail-safe Mode	OUT1	OUT2	OUT3	OUT4	OUT5	VPWR
positive contact discharges	+12kV	+12kV	+12kV	+8kV	+8kV	+15kV
contact discharges	-12kV	-12kV	-12kV	-10kV	-12kV	-20kV
negative air discharges	+25kV	+25kV	+25kV	+25kV	+25kV	+25kV
+positive air discharges	-25kV	-25kV	-25kV	-25kV	-25kV	-25kV

3.5 Decoupling Capacitors Role

The following table summarizes the mission of each component:

Signal	Location	Mission	Value
VBAT	closed to 10XS3535 device	Reduction of emission and immunity	100nF (X7R 50V)
VDD	closed to 10XS3535 device	Reduction of emission and immunity	100nF (X7R 50V)
OUTx	closed to output connectors	Reduction of emission and fast transient negative pulse sustaining	22nF (X7R 50V)
CSNS	closed to the MCU	Low pass filter to remove noise during immunity test	10kΩ + 10nF (X7R 16V)
To increase fast transient pulses robustness			
VBAT	closed to ECU connector	Sustain pulse #1 in case of LED loads (or without loads)	Additional 100nF (X7R 50V) plus 16V zener diode (1N5353) and a diode (MUR140) in series per battery line
VBAT	closed to 10XS3535 device	Sustain pulse #2 without loads	Additional 10µF (X7R 50V)

4 References

- MC10XS3535 - Penta High Side Switch (Triple 10mΩ and Dual 35mΩ) Data Sheet.
- MC35XS3500 - Penta High Side Switch (Penta 35mΩ) Data Sheet.

5 Revision History

REVISION	DATE	DESCRIPTION OF CHANGES
1.0	6/2010	• Initial Release

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