

AN4269

Diagnostic and protection features in eXtreme switch family

Rev. 2.0 — 25 January 2017

Application note

Document information

Information	Content
Keywords	AN4269
Abstract	The purpose of this document is to provide an overview of the diagnostic features offered in MC12XS3 eXtreme switch family.



1 Introduction

This document provides an overview of the diagnostic features offered in eXtreme switch MC12XS3 family, specifically for quads and the dual high-side drive devices. A description of the diagnostic functionality, including its limitations (at very low or very high duty cycles), is further developed.

This document extends the information already stated in the data sheet, so consider the data sheet as main source of information. Values presented in graphs throughout the document represent only one sample characterization and do not replace the parameters shown in the specification. They are mainly to highlight how certain parameters behave with changes in temperature and supply voltage.

2 Diagnostic and protection features

[Table 1](#) summarizes the diagnostic features offered within the MC12XS3 eXtreme switch family, which is further explained in each of the sub-sections.

Table 1. MC12XS3 eXtreme switch diagnostic and protection duty cycle limitations

Diagnostic and protection features	Low duty cycle limitation	High duty cycle limitation
Open load ON	3.40 %	100 %
Open load OFF	0 %	86 %
Short-circuit to VBATT	0 %	96 %
Short-circuit to GND	3.40 %	100 %
Current sensing	3.40 %	100 %
Temperature feedback	0 %	100 %
Undervoltage	0 %	100 %
Overvoltage	0 %	100 %

The following conditions are used to create the above table:

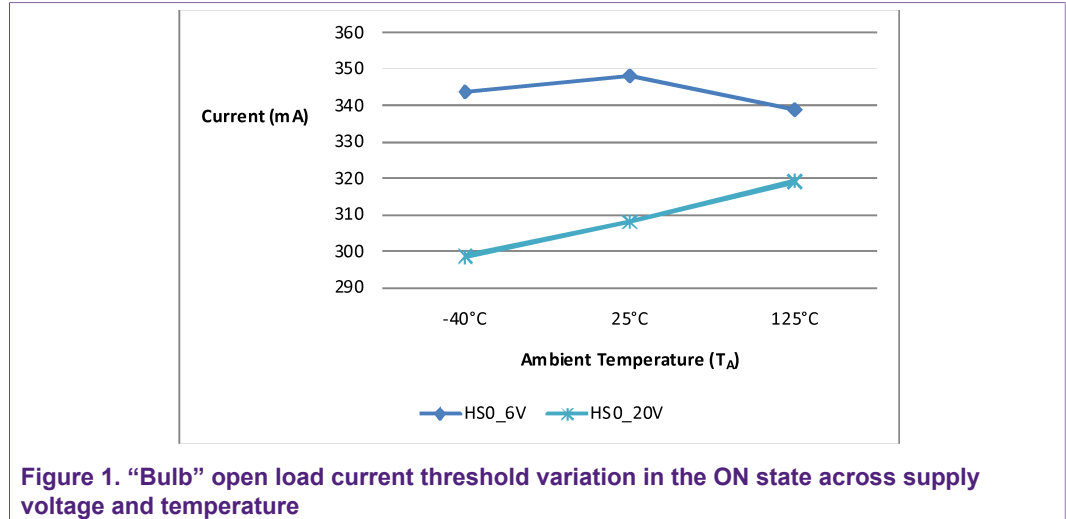
- bulb loads (200 Hz) with default slew rate selection
- LED
- loads (400 Hz) with fast slew rate selection
- done on evaluation board with soldered part and 22 nF output capacitor, with V_{PWR} from 11 V to 18 V and -40 to 125 °C ambient temperature

In case of a 100 Hz switching frequency (bulb load), the diagnostic limitations are reduced by half of what is considered in [Table 1](#) for 200 Hz. For example, the open load ON low duty cycle limitation of 3.4 % at 200 Hz, would actually be 1.7 % low duty cycle limitation at 100 Hz, since both represent the same amount of detection time.

2.1 Open load in ON state (for bulbs)

The internal mechanism used to detect an open load condition operates basically by monitoring the amount of current flowing through the high-side switch. When it is configured for regular bulbs, the threshold would be at a typical 300 mA value.

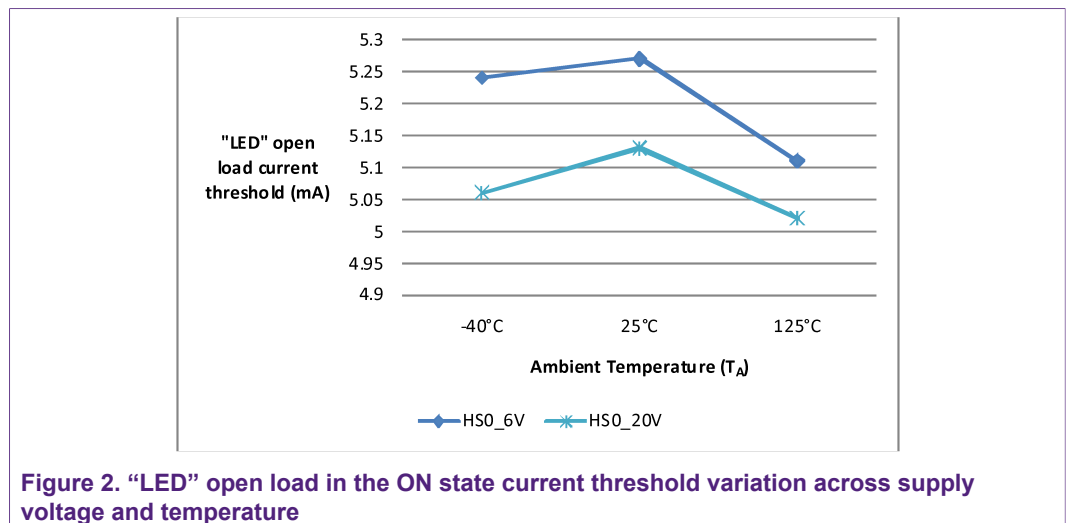
This detection circuitry integrates a typical 4.0 μs filter, to properly recognize an open load condition in the ON state. Due to the output transition from OFF to ON, it is not possible to detect an open load condition for a short output pulse (low duty cycle). In this case, the open load in OFF state diagnosis can be used to report this fault.



2.2 Open load in ON state (for LEDs)

In case of an open load when the ON state diagnostic is configured for LEDs, the detection threshold is reduced to a typical 5.0 mA value. The detection concept (patented) is based on initiating a controlled turn-off of the power MOSFET, together with a “weak” pull-up of the output (a current source circuit is only activated for a short period of time, typically 150 μs , while in the ON state).

The behavior of the output voltage, compared to the gate voltage of the power MOSFET, is evaluated during this time. If the output voltage is higher than the gate voltage during this short period, it is recognized as an open load in the ON state condition.



2.3 Open load in OFF state

This diagnostic operates differently from the previous two open load ON diagnostic features. The detection principle used is to allow a very small current (55 μA typical) to flow through the load, just enough to increase the output voltage. The voltage is continuously measured and compared to the open load threshold.

If the voltage is above a predefined 2.3 V typical threshold, this condition is identified as an open load condition. To perform this diagnosis mechanism, a certain amount of time is required, thus limiting the diagnostic capabilities at very high duty cycles.

Figure 3 and Figure 4 are shown as references to illustrate the behavior of the threshold and the source current variations at different temperatures and supply voltages. These graphs represent the average value of tests performed in one lot of devices.

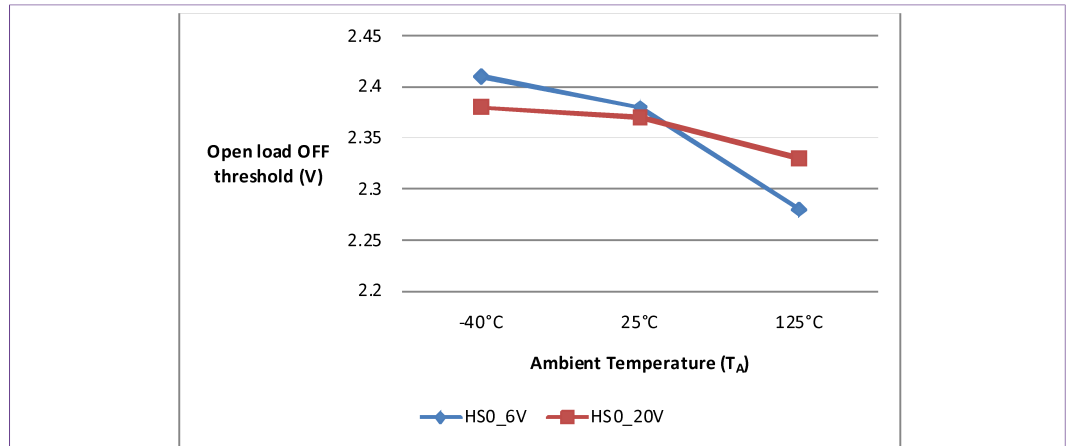


Figure 3. Open load in the OFF state threshold variation due to temperature and supply voltage

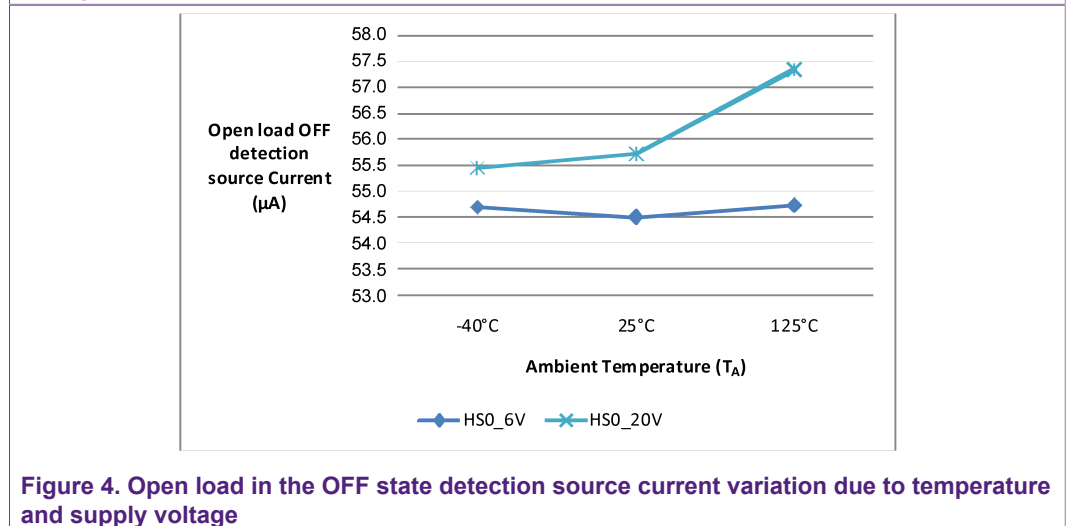


Figure 4. Open load in the OFF state detection source current variation due to temperature and supply voltage

2.4 Short-circuit to V_{BATT}

To detect this condition, the voltage at the output is monitored in the OFF state. If the voltage is higher than the predefined $V_{OSD(THRES)}$ threshold voltage, the output is reported to be a short-circuit to V_{BATT} .

Since this measurement is done in the OFF state, the output needs to remain in this state for a short period of time to be able to perform this diagnostic measurement. By using this feature, it is possible to distinguish between a short-circuit to V_{BATT} and an open load in the OFF state.

Figure 5 shows how the $V_{OSD(THRES)}$ typical value varies with temperature and supply voltage on each of the different outputs.

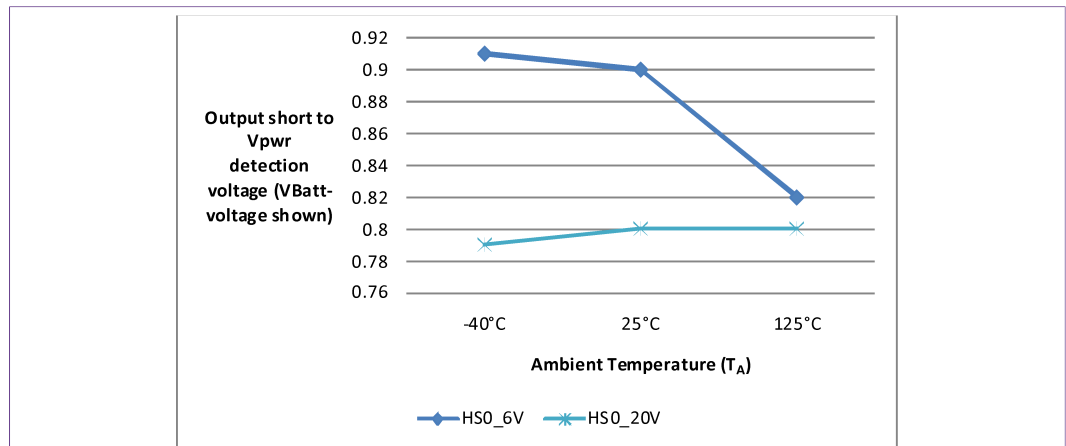


Figure 5. $V_{OSD(THRES)}$ variation due to ambient temperature and supply voltage variations

The voltage shown in Figure 5 is the voltage difference between V_{BATT} and the output.

2.5 Short-circuit to GND

Detecting a short-circuit to GND is done by monitoring the high-side MOSFET current. This information is used to detect both a severe short-circuit condition or an overload of the high-side switch.

This detection circuitry has a typical time filter of 3.0 μ s, meaning that the output needs to be turned ON for a minimum duration for this condition to be detected.

2.6 Severe short-circuit to GND

During the OFF to ON transition of the output, the load impedance is compared to an internal reference. When the impedance is smaller than the internal reference, the output is turned OFF without allowing the current to reach it's maximum possible level. In this way, the thermal stress inside the device is minimized.

This R_{SHORT} value is guaranteed by design.

The duration of the OFF to ON transition depends on the characteristics of the short-circuit (inductance, resistance, and ground shift).

2.7 Overload current on the high-side MOSFET

The current monitored through the high-side switch is compared with a level that changes according to a selected overcurrent protection profile, and also with the amount of time the load has been turned ON. See AN4049 for more details.

2.8 Current sensing

The current sensing functionality is explained in detail in the [AN3848](#) (MC15XS3400) and the [AN3853](#) (MC35XS3400) application notes.

2.9 Temperature feedback

In addition to the temperature sensors located on each of the different power MOSFETs, these devices contain an additional temperature sensor, located on the “control die” and positioned on top of the main ground terminal. This temperature is accessible to be read through the CSNS pin.

Different from the behavior of the current sense feedback, a proportional current to the load current comes out of the CSNS pin. For temperature feedback, the output is a voltage that can be directly read by an A/D pin from the MCU.

2.10 Undervoltage detection

These devices contain a monitoring circuit for the supply voltage. If this voltage drops below a predefined 3.85 V typical threshold, due to a long input line and severe short-circuit condition, the outputs are automatically turned OFF before reaching the overcurrent level.

The outputs are automatically latched-OFF, in case of an undervoltage condition.

[Figure 6](#) shows the variation of the undervoltage threshold and its behavior versus temperature.

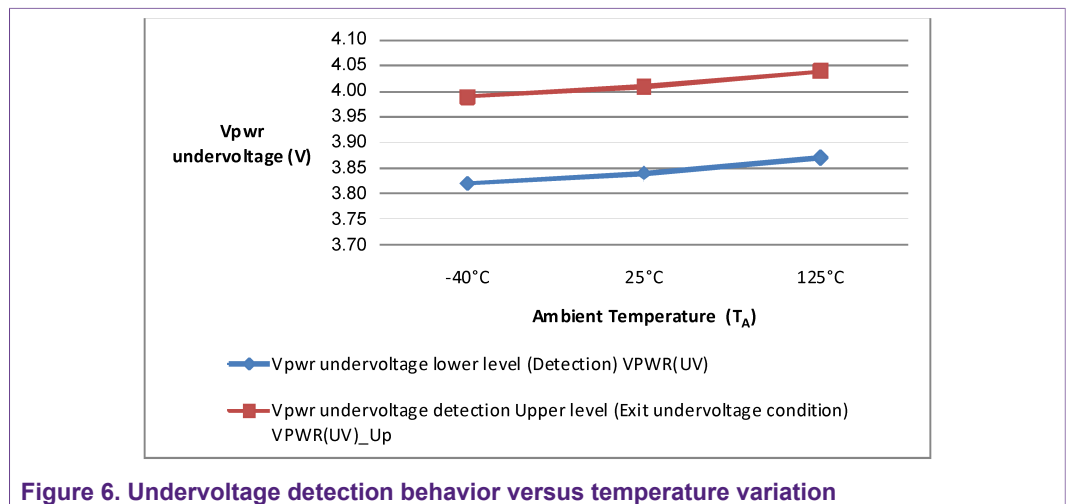


Figure 6. Undervoltage detection behavior versus temperature variation

2.11 Overvoltage detection

If the supply voltage goes above a predefined 32 V typical threshold, the outputs are turned OFF. The outputs remain OFF until the overvoltage condition is removed (considering the defined hysteresis of the detection circuit).

[Figure 7](#) shows the variation of the overvoltage threshold and its behavior versus temperature.

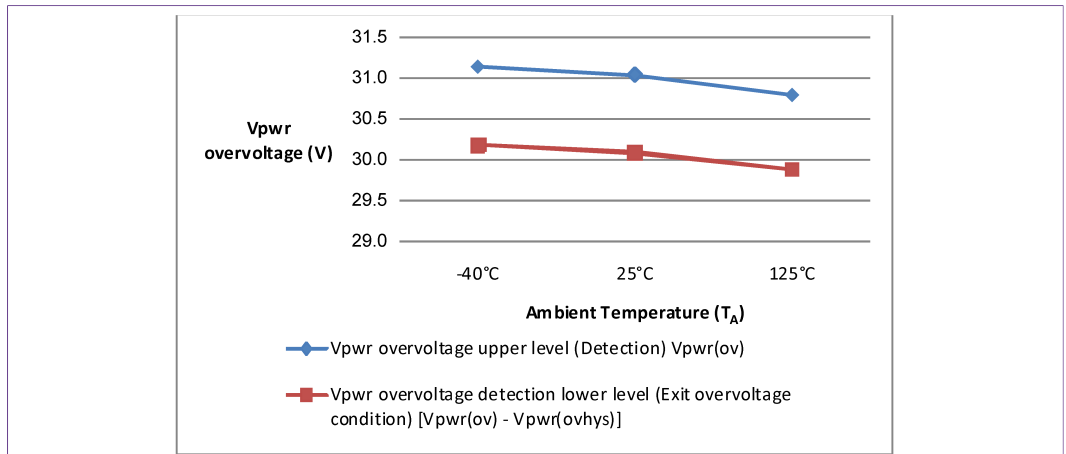


Figure 7. Overvoltage detection behavior versus temperature variation

3 Revision history

Table 2. Revision history

Revision	Date	Description of changes
2.0	1/2017	<ul style="list-style-type: none"> Corrected minor typos
1.0	8/2011	<ul style="list-style-type: none"> Initial release

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