BTS5682E, BTS5672E, BTS5662E, BTS5572E and BTS5562E

SPI Power Controller

Application Note

Short Circuit to VBB and Open Load Detection

Automotive Power

Never stop thinking

1 Abstract

Note: The following information is given as a hint for the implementation of the device only and shall not be regarded as a description or warranty of a certain functionality, condition or quality of the device.

This Application Note is intended to provide detailed application hints regarding the short circuit to V_{BB} detection of the BTS5682E, BTS5672E, BTS5662E, BTS5572E and BTS5562E SPI Power Controllers. Furthermore, an open load in off detection can be implemented with the use of an external resistor. General information about the SPI Power Controller can be found in the BTS5682E, BTS5672E, BTS5662E, BTS5572E and BTS5562E data sheets.

2 Introduction

The BTS5682E, BTS5672E, BTS5662E, BTS5572E and BTS5562E are six or five channel high-side power switches, which are especially designed to control standard exterior front and rear lighting in automotive applications.

Configuration and status diagnosis is done via SPI. Additionally, there is a current sense signal available for each channel that is routed via a multiplexer to one diagnostic pin.

This document will show how to use the internal function of the switch bypass monitor (SBM) to detect whether the output is connected via a low resistance to V_{BB} or not. For this short circuit to V_{BB} detection no external hardware is required. For the implementation of an open load in off detection an external resistor is required.

3 Functionality of Switch Bypass Monitor (SBM)

The switch bypass monitor (SBM) is a part of the device logic, which evaluates the V_{DS}-voltage of the DMOS. There is only one SBM comparator on the device for all five channels. Thus, there is an additional multiplexer implemented, which connects the outputs of the channels to the SBM comparator. This multiplexer is also programmed by the current sense multiplexer bits of the diagnosis control register. For further details please refer to the datasheet.

In case of a short circuit to V_{BB} and $V_{DS} < V_{DS(SB)}$ the SBM-bit within the HWCR register indicates the short circuit to V_{BB}. This can be seen in the following two tables for off- and on-state:

Table 1 SBM and Current Sense during off-state

Operation mode	Current sense	SBM-bit
Normal operation	Z	1
Short Circuit to GND	Z	1
Over Temperature	Z	x
Short Circuit to V_{BB}	Z	0
Open Load	Z	x

Table 2 SBM and Current Sense during on-state

Operation mode	Current sense	SBM-bit
Normal operation	I_L / k_{ILIS}	0
Current Limitation	Z	x
Short Circuit to GND	Z	1
Over Temperature	Z	x
Short Circuit to V_{BB}	$< I_L / k_{ILIS}$	0
Open Load	Z	0

Z = high impedance, potential depends on leakage currents and external circuits, x = undefined

Note: During off-state the SBM-bit depends on the potential at the output pin. The potential of the output pin depends in open load case on leakage currents. As a result, the SBM bit can be set or reset during an open load in off-state.

3.1 Use of SBM for Short Circuit to V_{BB} Detection

In case of a short circuit between the output-pin and the V_{BB}-pin a major part of the load current will flow through the short circuit. As a result, a lower current compared with the normal operation will flow through the DMOS of the BTS5682E, BTS5672E, BTS5662E, BTS5572E and BTS5562E, which can be recognized at the current sense signal.

In case of a current sense signal below the normal value, a software strategy is required to verify, whether an over temperature failure or a short circuit to V_{BB} leads to the low current sense signal.

The following flow chart shows a possible way to implement a software strategy:

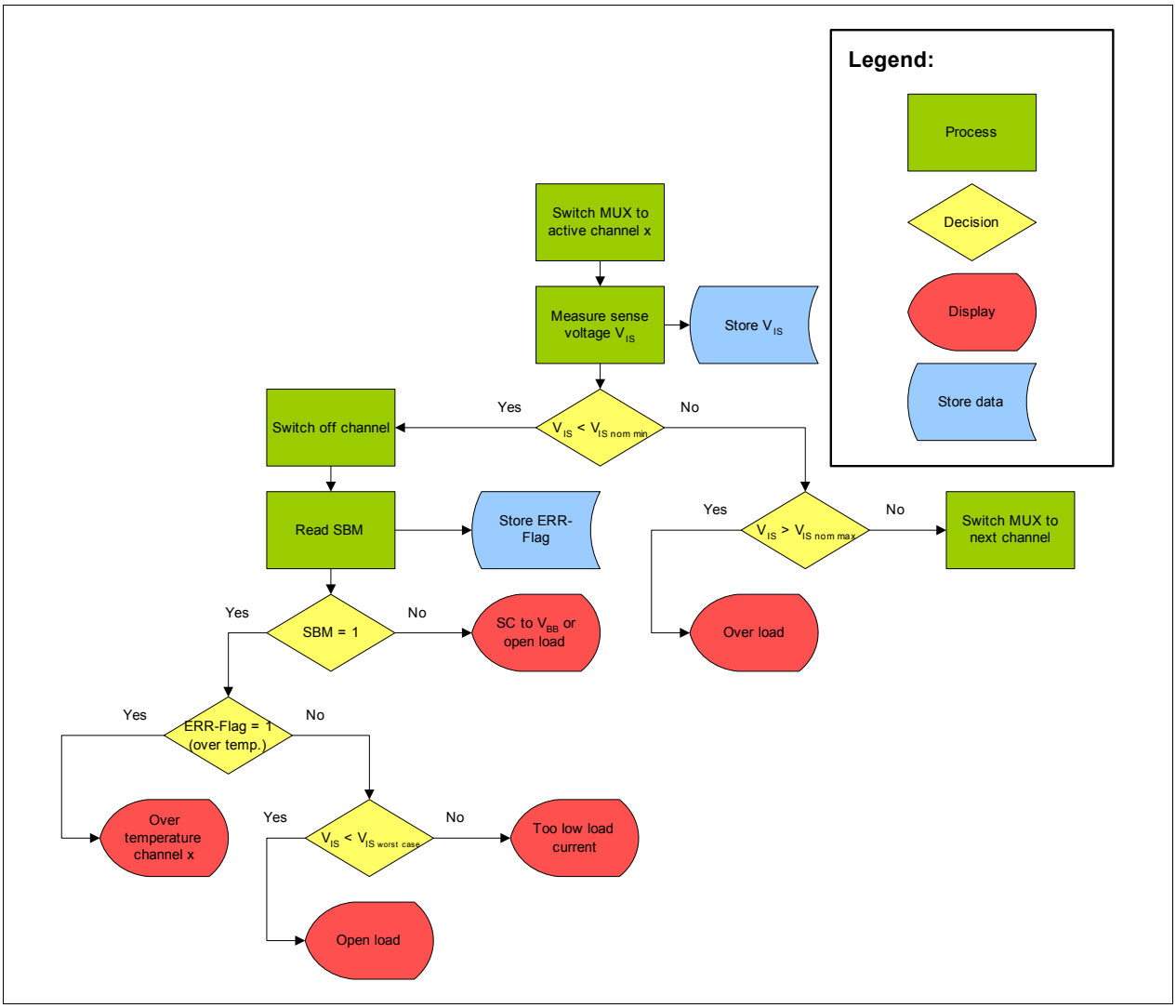

Figure 1 Flow Chart for the Verification, if a Short Circuit to V_{BB} or an Over Temperature Shutdown occurred

With this software routine it is possible to distinguish between short circuit to V_{BB} and over temperature. A complete differentiation between short circuit to V_{BB} and open load is not possible, because during open load the output potential depends on leakage currents. This can also cause a V_{DS} voltage below $V_{DS(SB)}$. Therefore, the open load case may behave like a short circuit to V_{BB}.

For the determination of $V_{IS\ nom\ min}$ and $V_{IS\ nom\ max}$ please refer to the following two equations.

$$V_{IS\ nom\ min} = \frac{I_{nom\ min}}{k_{ILIS\ max}} \cdot R_{IS\ min} \quad (1)$$

$$V_{IS\ nom\ max} = \frac{I_{nom\ max}}{k_{ILIS\ min}} \cdot R_{IS\ max} \quad (2)$$

For the determination of $V_{IS\ worst\ case}$ please refer to the following calculation.

For example: The nominal load of channel 0 is a 21 W bulb. But it is also possible to put a 10 W or 5 W bulb into the socket of the 21 W load. Therefore, it might be interesting to recognize, if there is an open load or only a wrong bulb connected. The implementation of a V_{IS}-threshold with a value of 0.5 V for a sense resistor R_{IS} = 4.7 kΩ is recommended. So, if the V_{IS} voltage is below this threshold, then an open load failure is detected, otherwise a too low load current caused the failure.

The following calculation shows an example with typical values in bulb-mode, how the minimum sense voltage can be calculated. For devices with LED-mode higher accuracies can be achieved by switching into LED-mode.

Nominal current of a 10 W bulb: $I_{nom\ 10\ W}$ = 0.74 A

Typical k_{ILIS} ratio for channel 0 in bulb-mode: k_{ILIS} = 3100

Typical sense resistor: R_{IS} = 4.7 kΩ

$$V_{IS} = \frac{I_{nom\ 10\ W}}{k_{ILIS}} \cdot R_{IS} = \frac{0.74\ A}{3100} \cdot 4.7\ k\Omega = 1.1\ V \quad (3)$$

For the worst case calculation the following formula should be used:

$$V_{IS\ worst\ case} = \frac{I_{nom\ 10\ W\ min}}{k_{ILIS\ max}} \cdot R_{IS\ min} \quad (4)$$

The implemented threshold should be below this value.

3.2 Use of SBM for Differentiation between Short Circuit to V_{BB} and Open Load

If a short circuit to V_{BB} should be distinguished from an open load (e.g. broken bulb) an external output pull down resistor is required. The following figure shows the circuit with the additional output pull down resistor $R_{OUT\ pd}$:

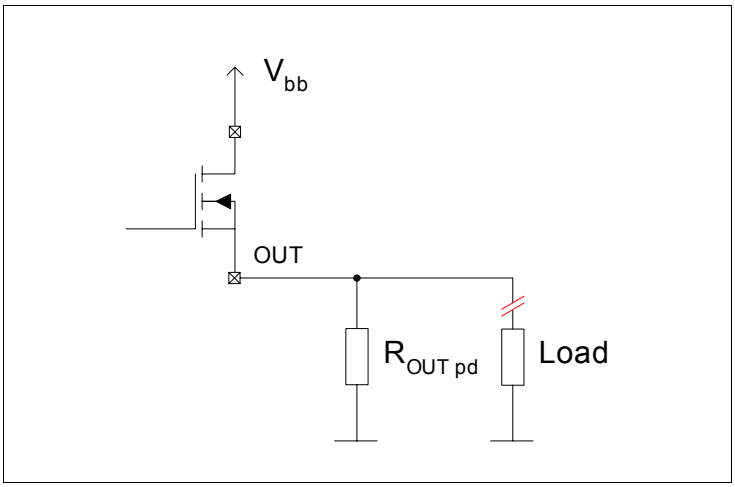

Figure 2 External Circuit for Open Load Detection in Off-state

With the following formula the output pull down resistor $R_{OUT\ pd}$ can be calculated to ensure during open load condition that device and system leakage currents do not cause the SBM-bit to transition to a logic 0.

$$R_{OUT\ pd} < \frac{V_{BB} - V_{DS(SB)max}}{I_{L(OFF)max} + I_{Leakage\ system}} \quad (5)$$

Here an example:

$$R_{OUT\ pd} < \frac{9\ V - 2.5\ V}{40\ \mu A} = 162.5\ k\Omega \quad (6)$$

So, a pull down resistor of $R_{OUT\ pd}$ = 100 kΩ could be used, if the leakage currents of the system are neglectable.

The following figure shows the flow chart for the software strategy to distinguish between an open load or short circuit to V_{BB} failure:

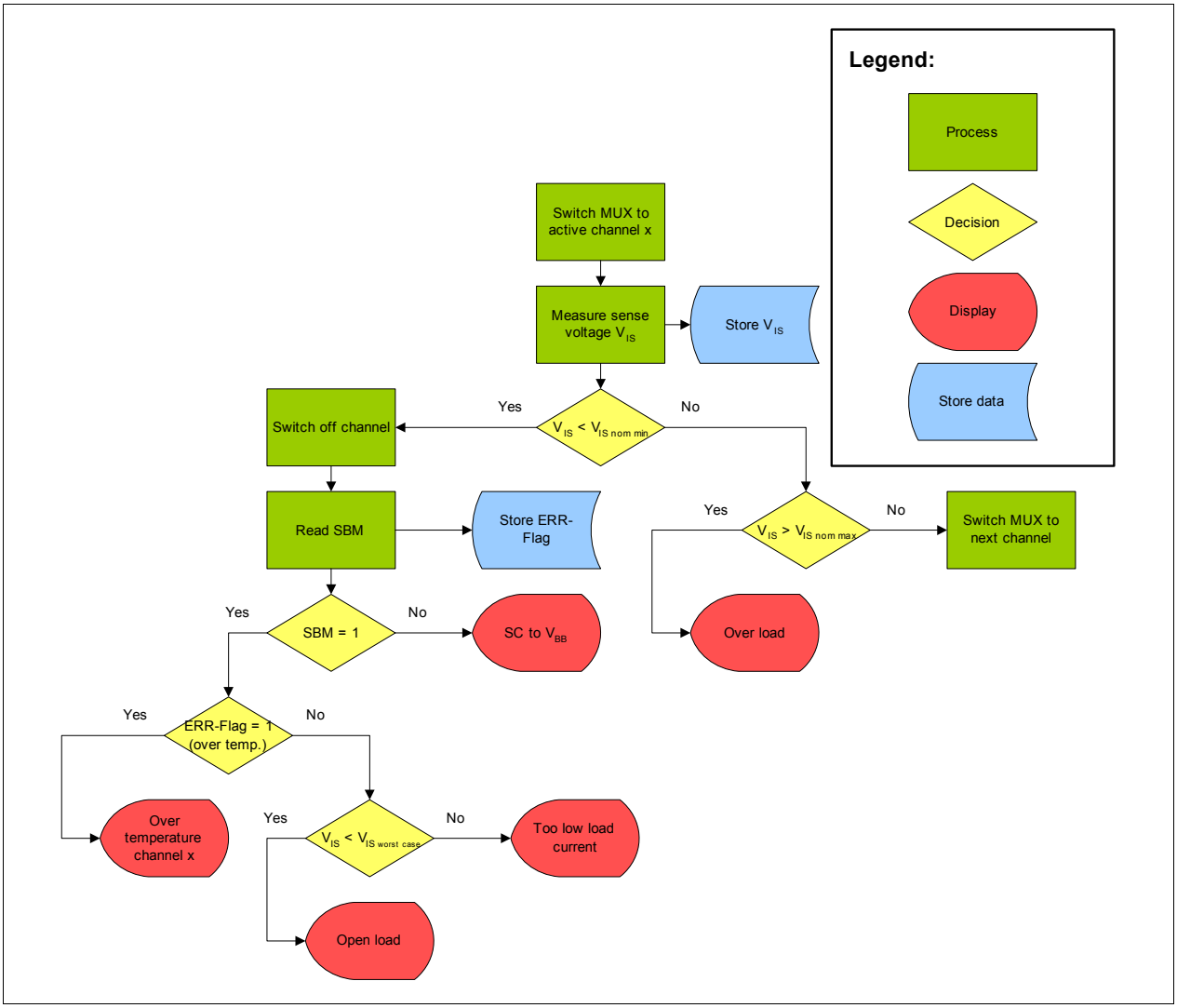

Figure 3 Flow Chart for the Verification, if a Short Circuit to V_{BB}, an Over Temperature Shutdown or an Open Load Failure occurred

In the figure above a the differentiation between open load and a too low load current can be done by the implementation of a V_{IS}-threshold voltage as described in the **Chapter 3.1**.

4 Conclusion

By the use of the switch bypass monitor it is possible to distinguish between the in **Table 1** described operation modes. Therefore, a sophisticated software strategy is required.

Summary:

- Without any external hardware it is possible to distinguish between short circuit to V_{BB}, over temperature and a too low load current. A complete differentiation between short circuit to V_{BB} and open load is not possible.
- By using an external output pull down resistor it is possible to distinguish between short circuit to V_{BB}, open load, over temperature and a too low load current.

5 Additional Information

Type	Ordering Code	Package
BTS5682E, BTS5672E, BTS5662E, BTS5572E and BTS5562E	on request	PG-DSO-36-36

More information regarding SPI Power Controllers can be found at **http://www.infineon.com/spoc**

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