

BTS5590G, BTS5576G and BTS5566G

SPI Power Controller

Application Note

Software Strategy for Diagnosis during PWM-
Operation

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 implementation of a software strategy for diagnosis during PWM-operation of the BTS5590G, BTS5576G and BTS5566G SPI Power Controllers. General information about the SPI Power Controller can be found in the BTS5590G, BTS5576G and BTS5566G data sheets.

2 Introduction

The BTS5590G, BTS5576G and BTS5566G are 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 implement a software strategy to ensure a correct diagnosis evaluation during PWM-operation.

3 Functionality of Over Load and Short Circuit Detection

The BTS5590G, BTS5576G and BTS5566G have an integrated status diagnosis, which provides information about each channel. The error flags, an “OR-combination” of the over temperature flags and the over load ($I_L > I_{L(LIM)}$) monitoring signals are provided in the SPI standard diagnosis bits `ERRn`.

The over load monitoring signals are latched in the error flags and cleared each time the standard diagnosis is transmitted via SPI. In detail, they are cleared between the second and third raising edge of the SCLK signal.

The over temperature flags, which cause an overheated channel to stay switched off, are latched directly at the gate control block. The latches are cleared by SPI command `HWCR.CTL`.

In case of high duty cycles (off state of output $< t_{off\ state_min}$) the V_{DS} may not reach the steady state off-value of V_{bb} for the power Mosfet. Due to this the over load monitoring signals may be set and latched in the error flags.

For further details please refer to the datasheet.

3.1 Behavior of Error Flags during PWM

During PWM-operation (Pulse Width Modulation) with high duty cycles, where the off-phase (via input or via SPI-register `OUT.x`) of the channel is shorter than 350 μ s for bulb-mode or 150 μ s in LED-mode respectively the over load flag within the standard diagnosis may be set. It may be set during the switching on transition.

The ERR-flag activated due to the above mentioned condition will be reset with a single readout of the standard diagnosis. The standard diagnosis is read with every write command or with the explicit standard diagnosis read command 01h.

In case of an over temperature error the ERR-flag will not be reset by reading the standard diagnosis only, because the thermal latch has to be cleared as well (`HWCR.CTL`).

The following scope plots show the continuous readouts of the standard diagnosis for PWM-operation of channel 0 with an ohmic load. The curves show the discrete input signal, the SPI clock, the SO signal and the output voltage V_{OUT} .

Functionality of Over Load and Short Circuit Detection

The first plot shows the behavior for an off state time $t_{\text{off state}} = 350\mu\text{s}$:

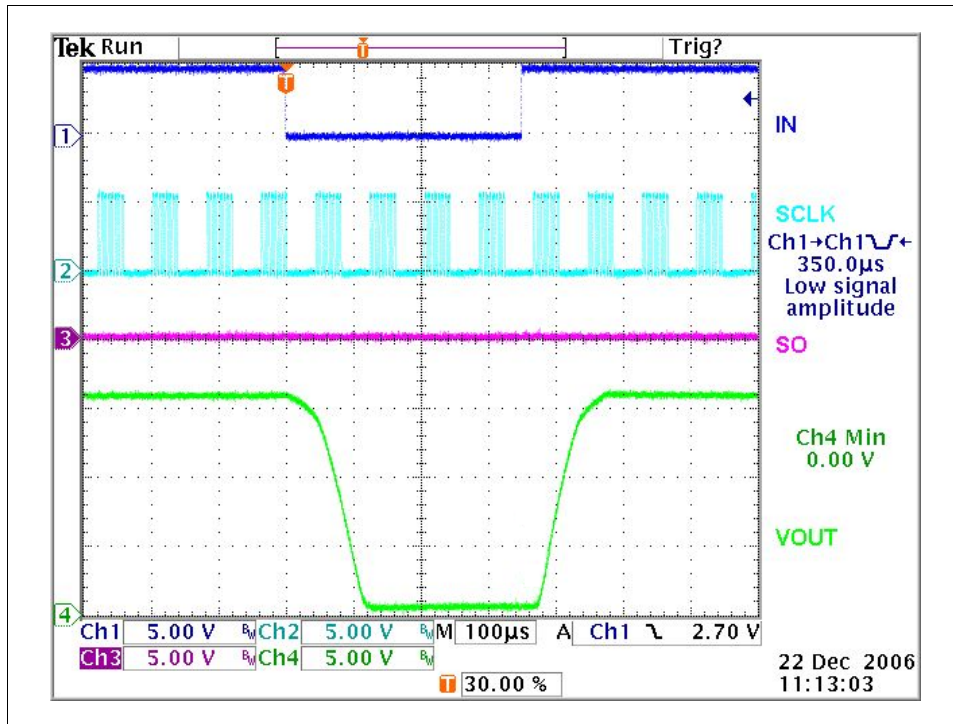


Figure 1 PWM-operation with $t_{\text{off state}} = 350\mu\text{s}$, no ERR-flag set during switching

The next figure shows the activation of the error flag due to an off-phase shorter than $t_{\text{off state_min}}$:

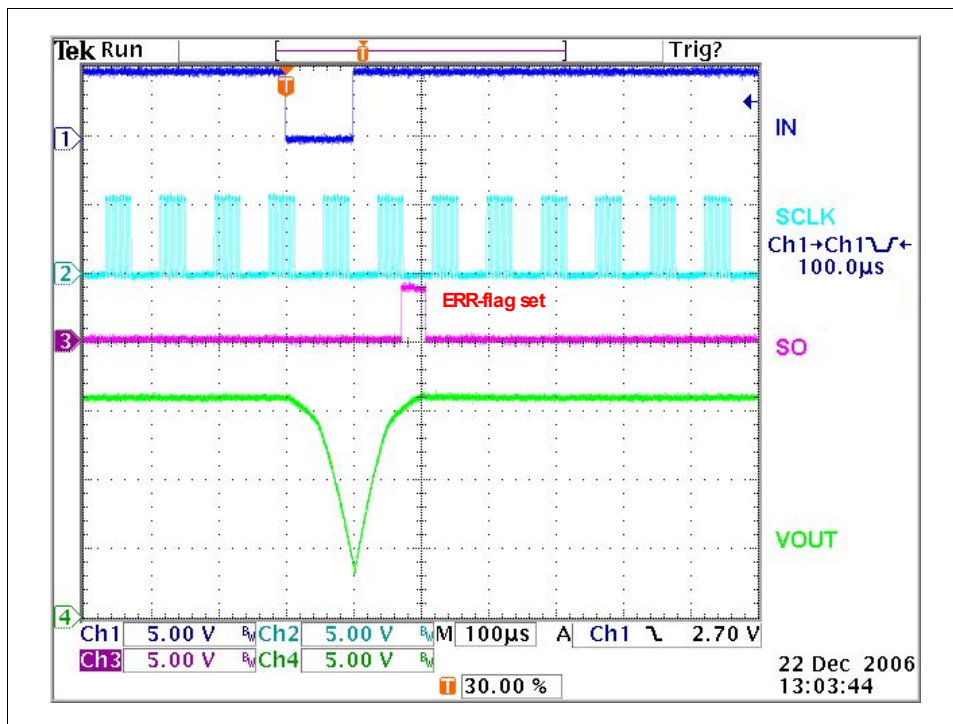


Figure 2 PWM-operation with $t_{\text{off state}} = 100\mu\text{s}$, ERR-flag set during switching on

Figure 2 shows that the activated over load flag is reset by the readout of the standard diagnosis. According to this the following software strategy can be used to ensure a correct interpretation of the error flags.

3.2 Software Strategy during PWM-Operation

The possible software strategy depends on the minimum off state time $t_{off\ state}$ of the application during PWM-operation. According to the parameter $t_{off\ state\ application}$ two software strategies can be defined:

- a) $t_{off\ state\ application} > t_{off\ state_min}$: The error flags of a single readout of the standard diagnosis can be used. No double readout of the standard diagnosis is required.
- b) $t_{off\ state\ application} \leq t_{off\ state_min}$: The error flags of the first readout after the activation have to be abolished. Immediately after the first readout the second readout of the standard diagnosis has to be done. The according error flag information can be used for further interpretation. The two readouts have to be done in the same on-phase of the channel (no switch off between the two readouts).

The following flow chart shows a possible way to implement a software strategy for PWM-operation:

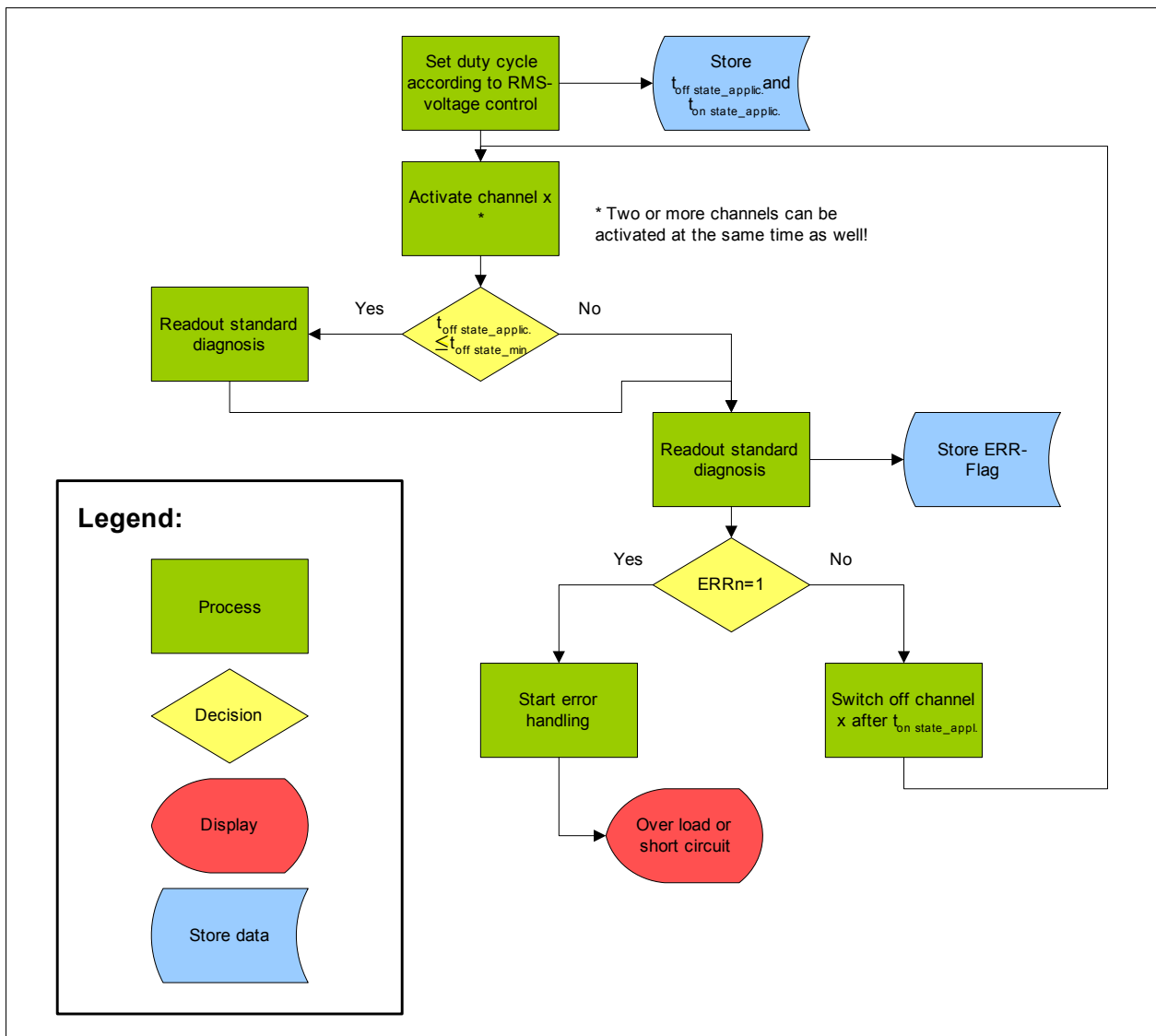


Figure 3 Flow Chart for the correct evaluation of the error flags during PWM-Operation

Due to simplification reasons it is also possible to do the double readout of the standard diagnosis all the time. It is only important to use the data from the second readout in case of PWM-operation with high duty cycles.

Note: In the interest of simplification it could also be possible to use different approaches, e.g.: the setting of the current sense multiplexer is also a write command, which clears the over load flag.

4 Conclusion

For using the entire diagnosis functionality of the BTS5590G, BTS5576G and BTS5566G during PWM-operation with high duty cycles a double readout of the standard diagnosis is required.

Summary:

- During DC-operation of the channels and PWM-operation with low duty cycles a single readout of the standard diagnosis is enough to ensure a correct evaluation of the standard diagnosis.
- In case of PWM-operation with high duty cycles ($t_{\text{off state application}} \leq t_{\text{off state_min}}$) a double readout of the standard diagnosis is required to ensure a correct reading of the error flags. The double readout of the standard diagnosis has to be done within the same on-phase (no switch off between the two readouts).
- A readout of the standard diagnosis is done with every write command or with the explicit standard diagnosis read command 01h.

5 Additional Information

Type	Ordering Code	Package
BTS5590G, BTS5576G and BTS5566G	on request	PG-DSO-36-34

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

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