
L9945 H-Bridge direction switching recommendations

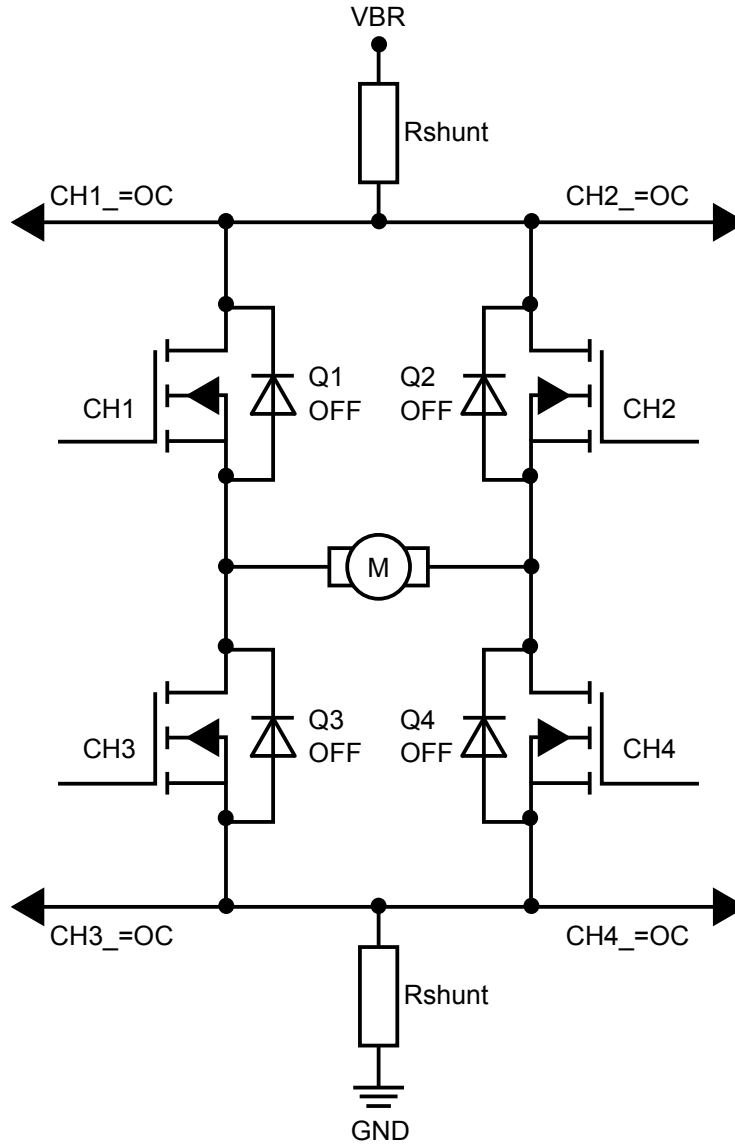
Introduction

This document provides recommendation about the timing constraints to be fulfilled in order to allow a smooth direction switching when operating L9945 in H-Bridge configuration.

1 DIR switching recommendations

This section contains the description of L9945 H-Bridge controller and its behavior in response to DIR and NPWM input variations. Detailed recommendations about the timing relations between the two signals will be provided, along with recommendations to follow in order to ensure the best switching performances.

1.1 Output behavior following DIR & NPWM transitions

Figure 1. H-Bridge schematic

Table 1. Output response in case of DIR transition

DIR transition	Q1/Q5	Q2/Q6	Q3/Q7	Q4/Q8
0 → 1	Turns ON after HBx_dead_time , if NPWM was "0" before DIR switch and did not toggle during dead time	Turns OFF immediately	Turns OFF immediately	Turns ON after HBx_dead_time
1 → 0	Turns OFF immediately	Turns ON after HBx_dead_time , if NPWM was "0" before DIR switch and did not toggle during dead time	Turns ON after HBx_dead_time	Turns OFF immediately

Note: NPWM should be stable before applying the DIR transition, and it should not be switched during the dead-time due to DIR switch. Otherwise, once dead-time for DIR switch event has expired, the dead-time for NPWM transition will start, resulting in twice the dead-time applied.

The dead timers also operate during NPWM switching activity. Transitions are described in the following table.

Table 2. Output response in case of NPWM transition

	DIR = 1	DIR = 0	DIR = 1		DIR = 0	
NPWM transition	Q1/Q5	Q2/Q6	Q3/Q7		Q4/Q8	
			HBx_AFW = 0	HBx_AFW = 1	HBx_AFW = 0	HBx_AFW = 1
0 → 1	Turns OFF after HBx_dead_time if NPWM is still "1"	Turns OFF immediately	Kept OFF	Turns ON after 2*HBx_dead_time if NPWM is still "1"	Kept OFF	Turns ON after 2*HBx_dead_time if NPWM is still "1"
1 → 0	Turns OFF immediately. Then, it turns ON after HBx_dead_time if NPWM is still "0"	Turns ON after HBx_dead_time if NPWM is still "0"	Kept OFF	Turns OFF immediately	Kept OFF	Turns OFF immediately

Note: in case NPWM is switched with a very high frequency, which is incompatible with HBx_dead_time, the HS will be kept OFF. This happens because every time NPWM toggles 1 → 0, the HS output is reset to its default value of "0". However, this condition should be avoided by choosing switching frequency and duty-cycle in order to allow dead-time to expire after both transitions.

1.2 DIR switching (normal behavior)

Figure 2. DIR switching: normal behavior

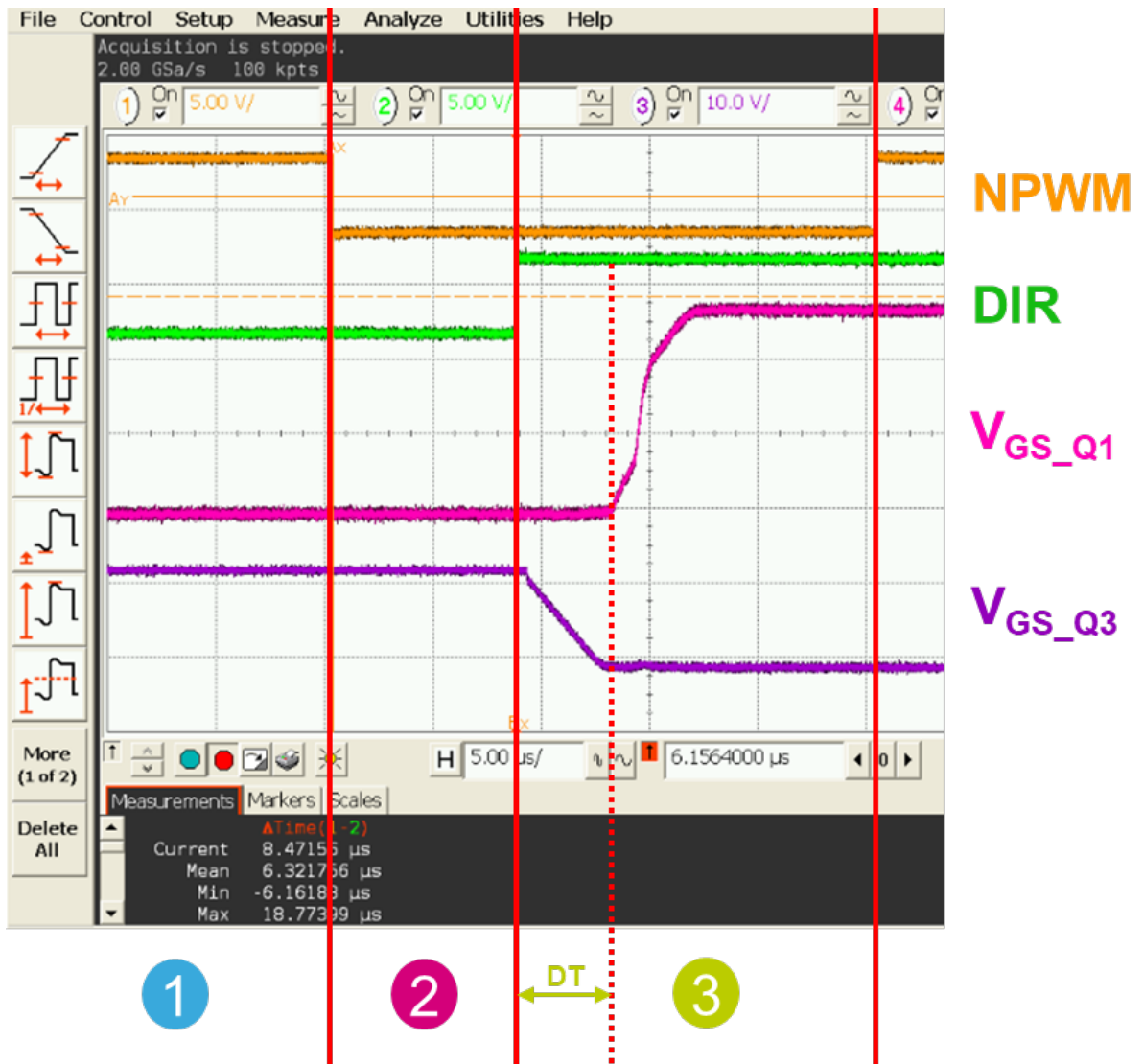
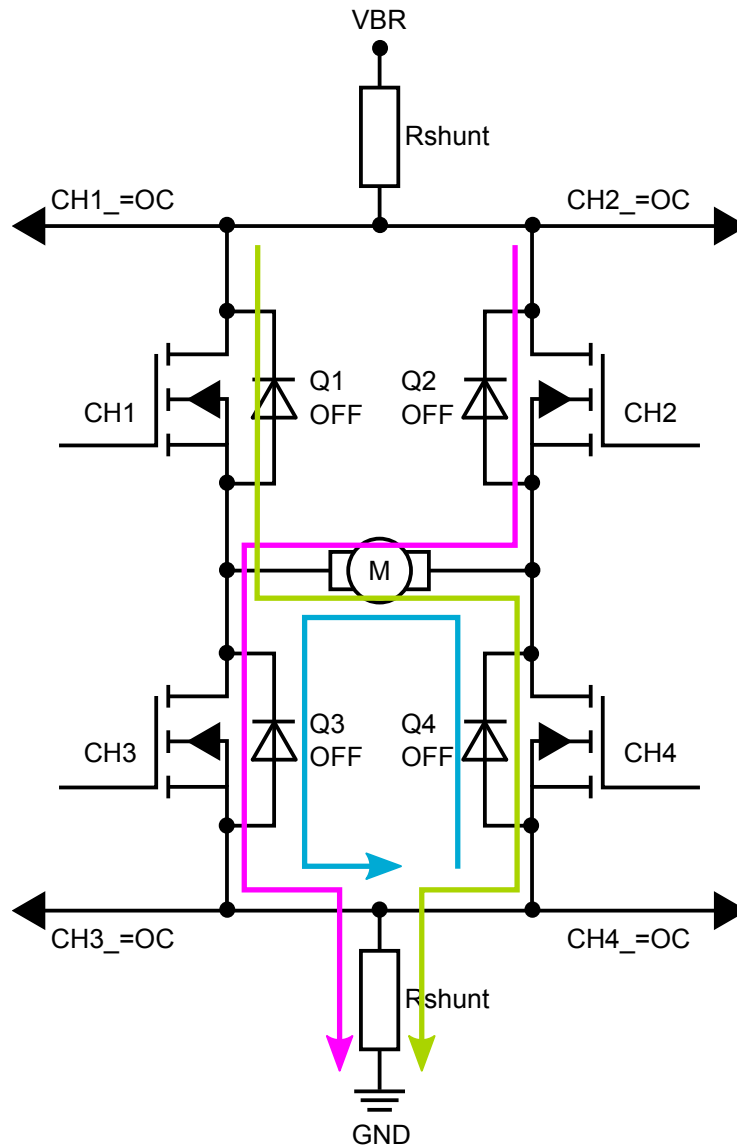


Figure 3. Current paths during H-Bridge direction switching in normal operation


1 - Active freewheeling on Q4.

2 - DT upon NPWM transition:
passive freewheeling on Q4, then Q2 ON.

3 - DIR switching. Q2 and Q3 immediately OFF.
Q1 and Q4 ON after DT.

1.3 DT management according DIR pin

DT is implemented through a timer having both start and reset control input

- DT START pulse is generated when either NPWM or DIR toggles
 - It causes the DT timer to start counting
- DT RESET pulse is generated when either NPWM or DIR toggles, and the counter is still running
 - It causes the DT timer value to be reset to the default value, thus overriding any ongoing DT
- DT EXPIRED pulse is generated when counter reaches the programmed DT threshold
 - It causes the safe turn ON of the involved FET, avoiding cross-conduction

In case both DT RESET and DT EXPIRED pulses occur simultaneously, the latter has higher priority and a DT EXPIRED condition is considered as valid

- Up to 5 clock periods might be necessary to generate either of the two pulses, accounting for synchronization delays

1.4 DIR switching (cross-conduction)

Figure 4. DIR switching: cross conduction

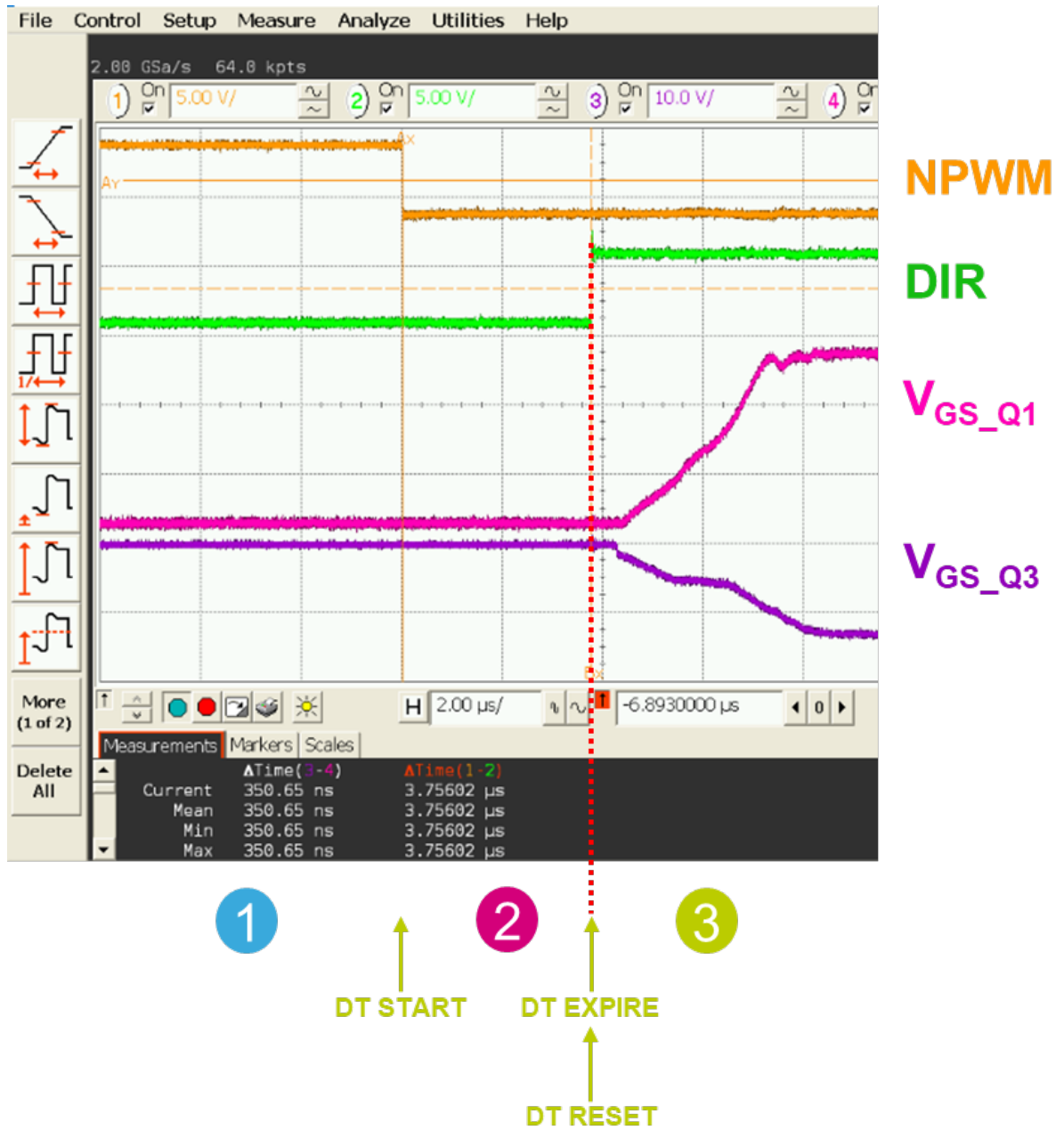
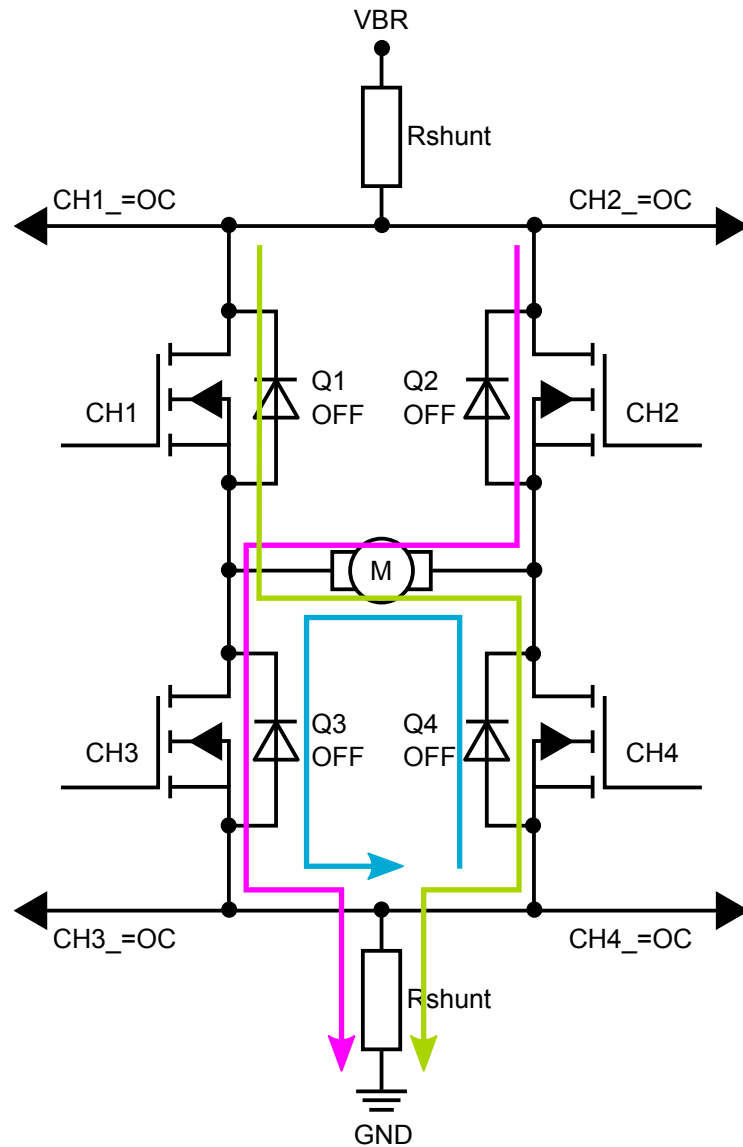


Figure 5. Current paths during H-Bridge direction switching in cross-conduction


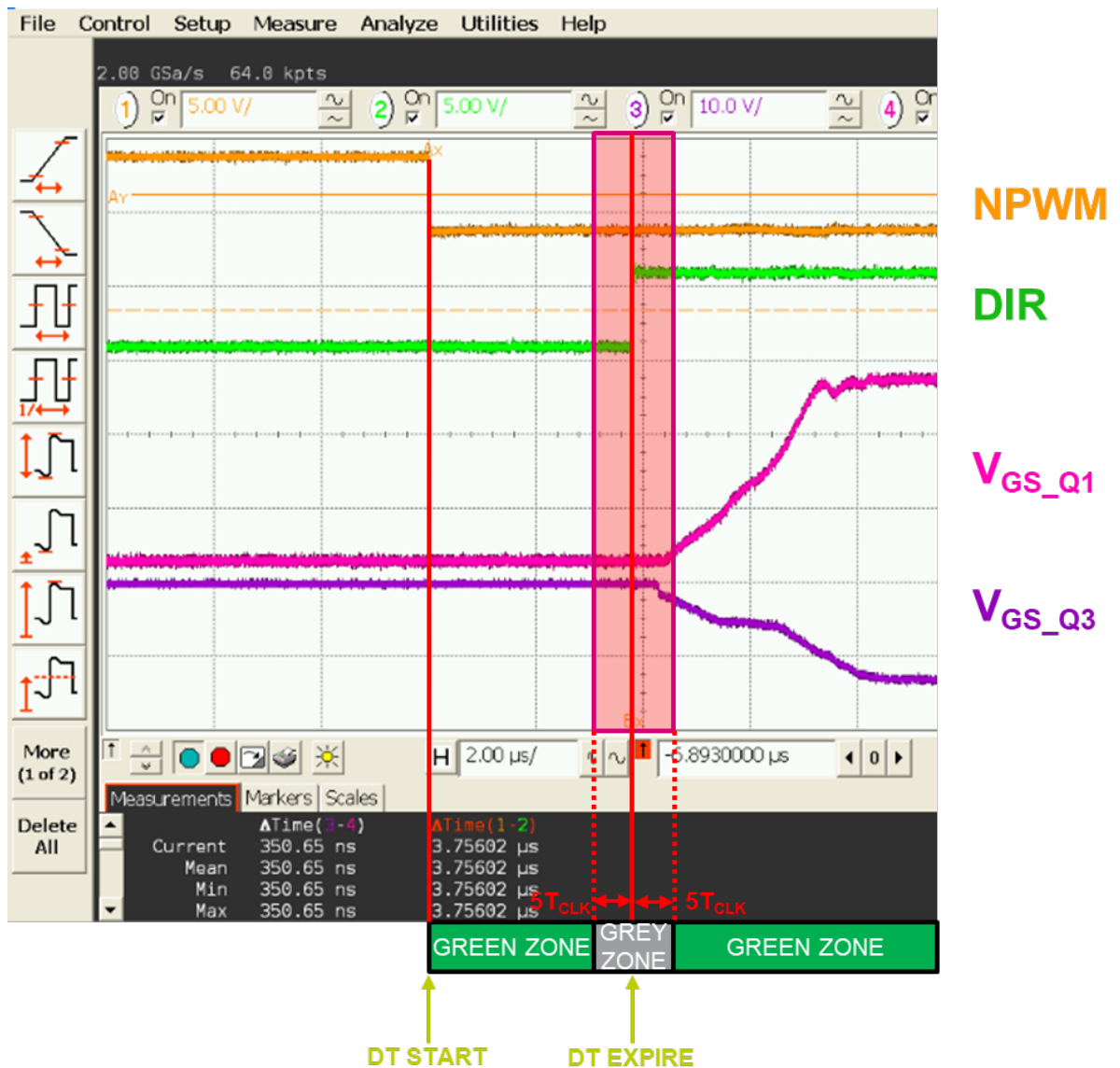
1 - Active freewheeling on Q4.

2 - DT upon NPWM transition:
passive freewheeling on Q4, then Q2 ON.

3 - DIR switching. Q2 and Q3 immediately OFF.
The DT EXPIRE pulse is aligned to the DT RESET event.
This causes the immediate turn ON of Q1,
skipping the additional DT.

1.5 Recommended DIR operation in respect to NPWM

Figure 6. Definition of DIR switching forbidden zone



To avoid inadvertent cross-conduction due to the overlapping of DT EXPIRE and DT RESET pulses, it is recommended to avoid switching the DIR input within the GREY ZONE.

The recommended GREY ZONE window is:

$$t_{GREY} = t_{NPWM_SWITCH} + HB_{x_dead_time} \pm \frac{5}{f_{MAIN_CLK1}} \quad (1)$$

Where:

- t_{NPWM_SWITCH} is the time instant where NPWM signal is toggled;
- $HB_{x_dead_time}$ is the DT configured via SPI;
- f_{MAIN_CLK1} is the main oscillator frequency (10 MHz typ).

To add design robustness, 600 ns grey zone semi-amplitude is recommended.

Revision history

Table 3. Document revision history

Date	Version	Changes
14-Oct-2019	1	Initial release.

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