Benefits of the TLE985x Bridge Driver

About this document

Scope and purpose

The "Benefits of the TLE985x Bridge Driver" Application Note explains the benefits and key features of the TLE985x Bridge Driver.

Intended audience

Everybody who assesses the performance of the TLE985x Bridge Driver.

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1 Benefits at a glance

Advanced topology with integrated 2-stage charge pump

- Start/Stop operation (MOSFET $V_{GS} \geq 7$ V @ $V_{BAT} \geq 6$ V)
- Duty cycle range from 0 ... 100 %
- Low external component count

Advantages by System on Chip approach

- Monitoring of more signals possible than in discrete systems
- Fast reaction times by software interrupts

Faster time to market by programmable current-driven gate control

- SW adjustable instead of HW fixed: reduced development effort
- Switching behavior can be optimized on-the-fly during EMC tests

Advanced features

- „Sequencer“: short delay times (less power dissipation) and slow slopes (less EME) at the same time
- „Adaptive Gate Control“: compensate parameter variations in running system

2 Topology

The TLE985x Bridge Driver consists of up to 4 floating gate drivers supplied by a 2-stage charge pump as shown in the following application diagram:

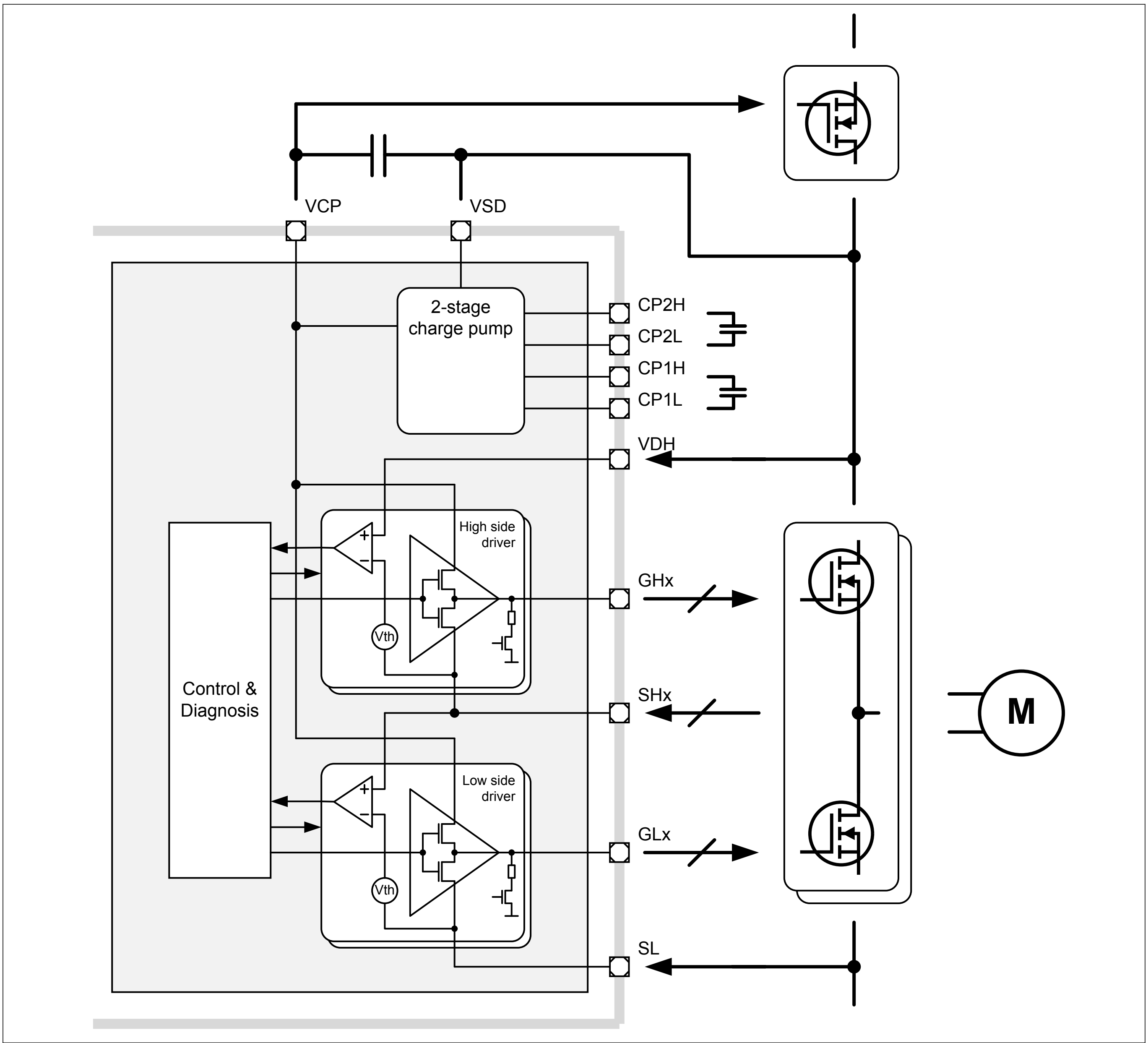

Figure 1 **Bridge Driver application diagram**

The benefits of this topology are:

- Motor operation for $V_{BAT} \geq 6$ V
  - With MOSFET $V_{GS} \geq 7$ V
  - Enables „Start/Stop“ operation
- Duty cycle range: 0 ... 100 %
- Less external components compared to boot strap approach
- Charge pump output VCP allows usage of an n-channel MOSFET for reverse-polarity protection

3 Diagnosis and protection

The following figure shows the diagnosis and protection features of the TLE985x Bridge Driver:

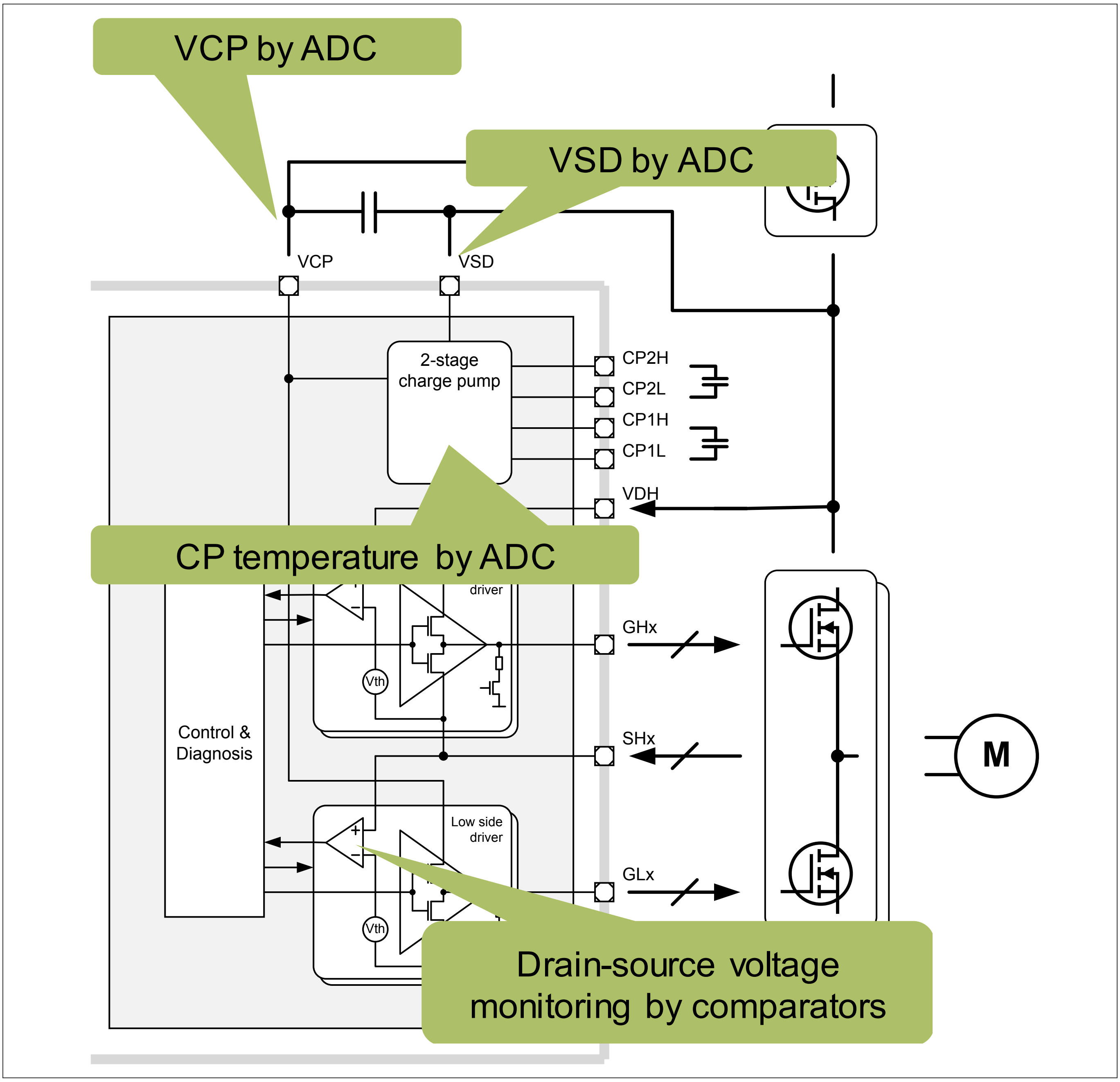

Figure 2 **Voltage and temperature monitoring**

A "System on Chip" solution like the TLE985x provides the following benefits:

- Monitoring of more signals possible than in discrete systems
- Thresholds are programmable by software
- Fast signalling by interrupts
- Flexible reaction by software
- Optional automatic shutdown

4 Current-driven gate control

The TLE985x Bridge Driver provides current-driven gate control which shows some benefits compared to voltage-driven gate control.

Voltage-driven gate control defines the switching behavior of the external MOSFETs on hardware level by external components like resistors, capacitors, and diodes:

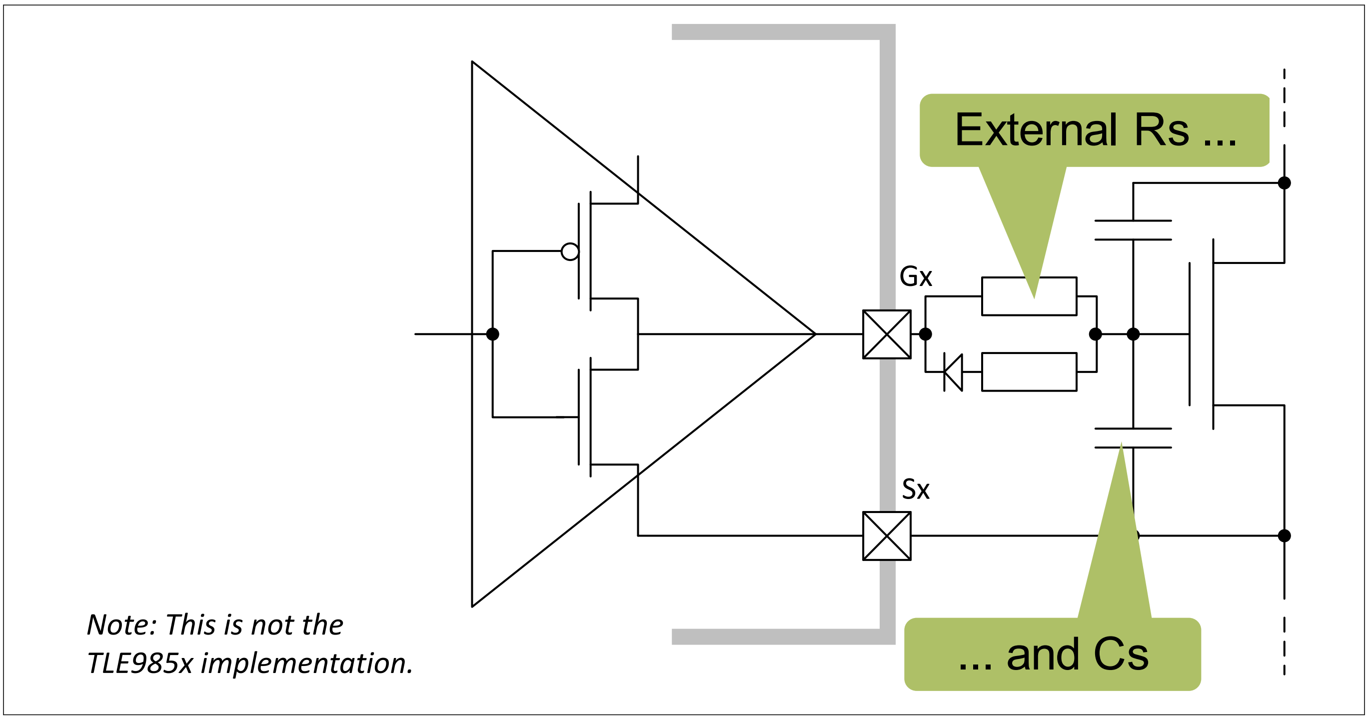

Figure 3 Voltage-driven gate control: predetermined by HW

Current-driven gate control, as in the TLE985x, gives more flexibility by defining the switching behavior of the external MOSFETs by software-programmable gate currents:

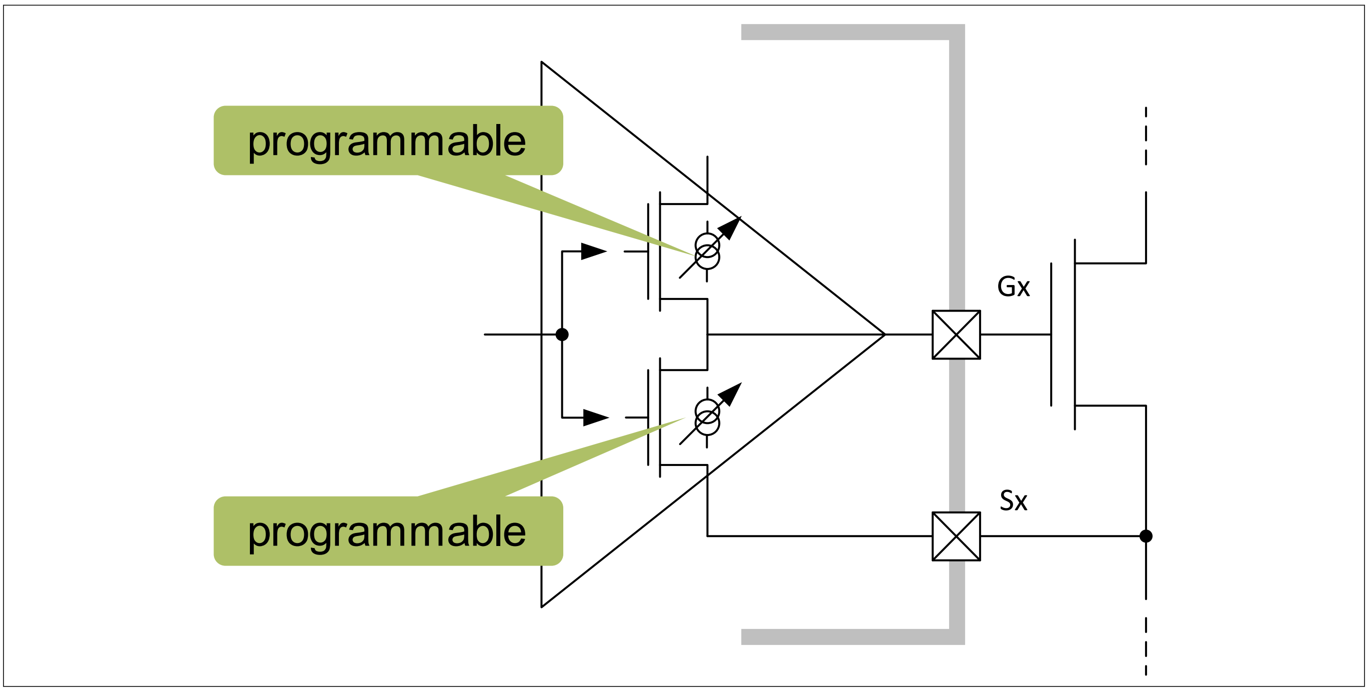

Figure 4 Current-driven gate control: flexible by SW

4 Current-driven gate control

Shortly summarized, software-programmable current-driven gate control allows (see below for details):

- Less external components
- End-of-line trimming
- Different settings for charge and discharge to preserve duty cycles
- Different settings for active free-wheeling to reduce power dissipation
- On-the-fly optimization during e.g. EMC tests
- Advanced gate control
  - „Sequencer“
  - „Adaptive gate control“

Programmable gate currents preserve duty cycle

MOSFETs show asymmetric switching behavior if the charge current value equals the discharge current value which distorts the duty cycle:

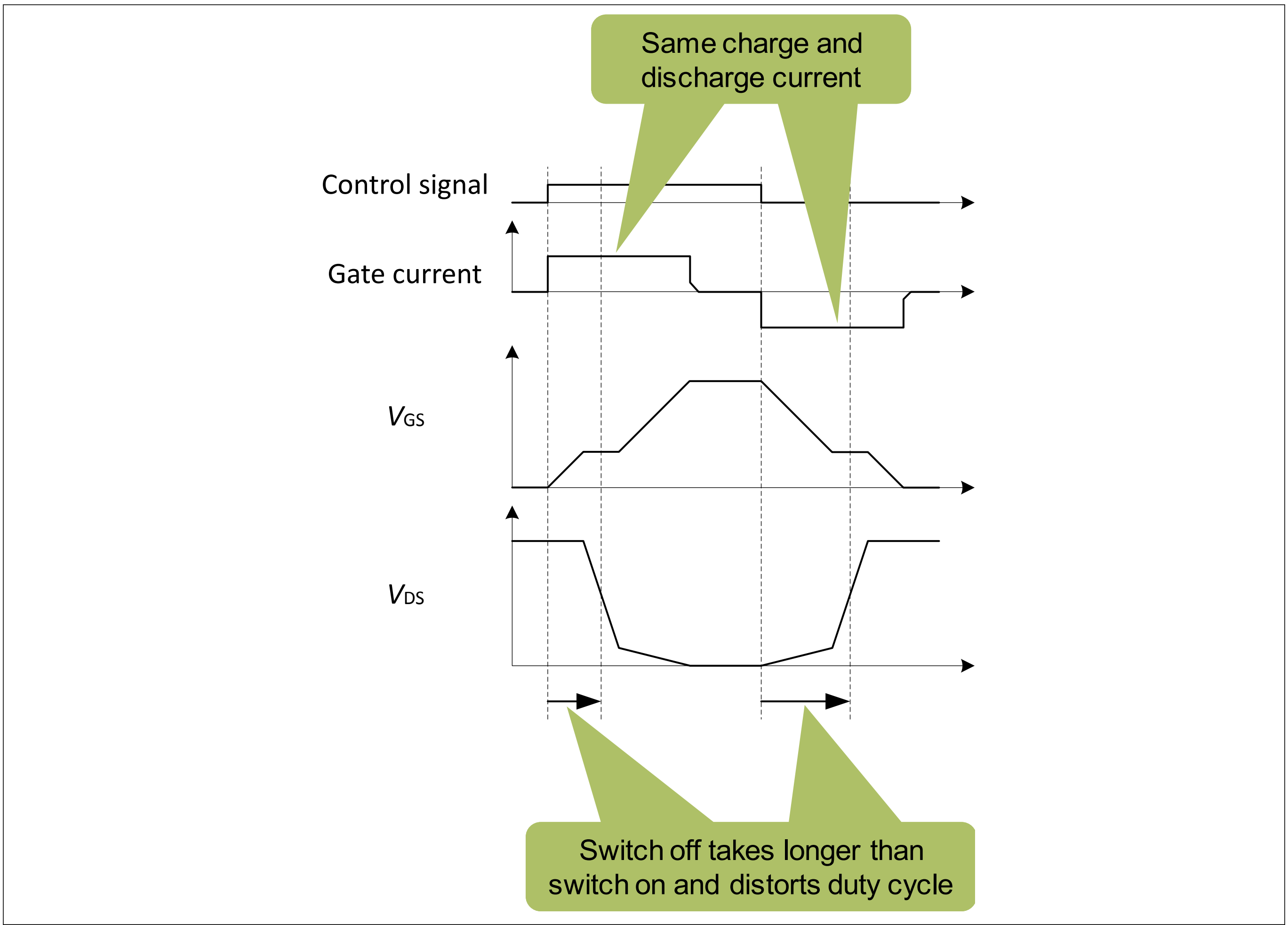

Figure 5 **Asymmetric switching behavior of MOSFETs**

The input duty cycle can be preserved by programming different values for the gate charge current than for the gate discharge current:

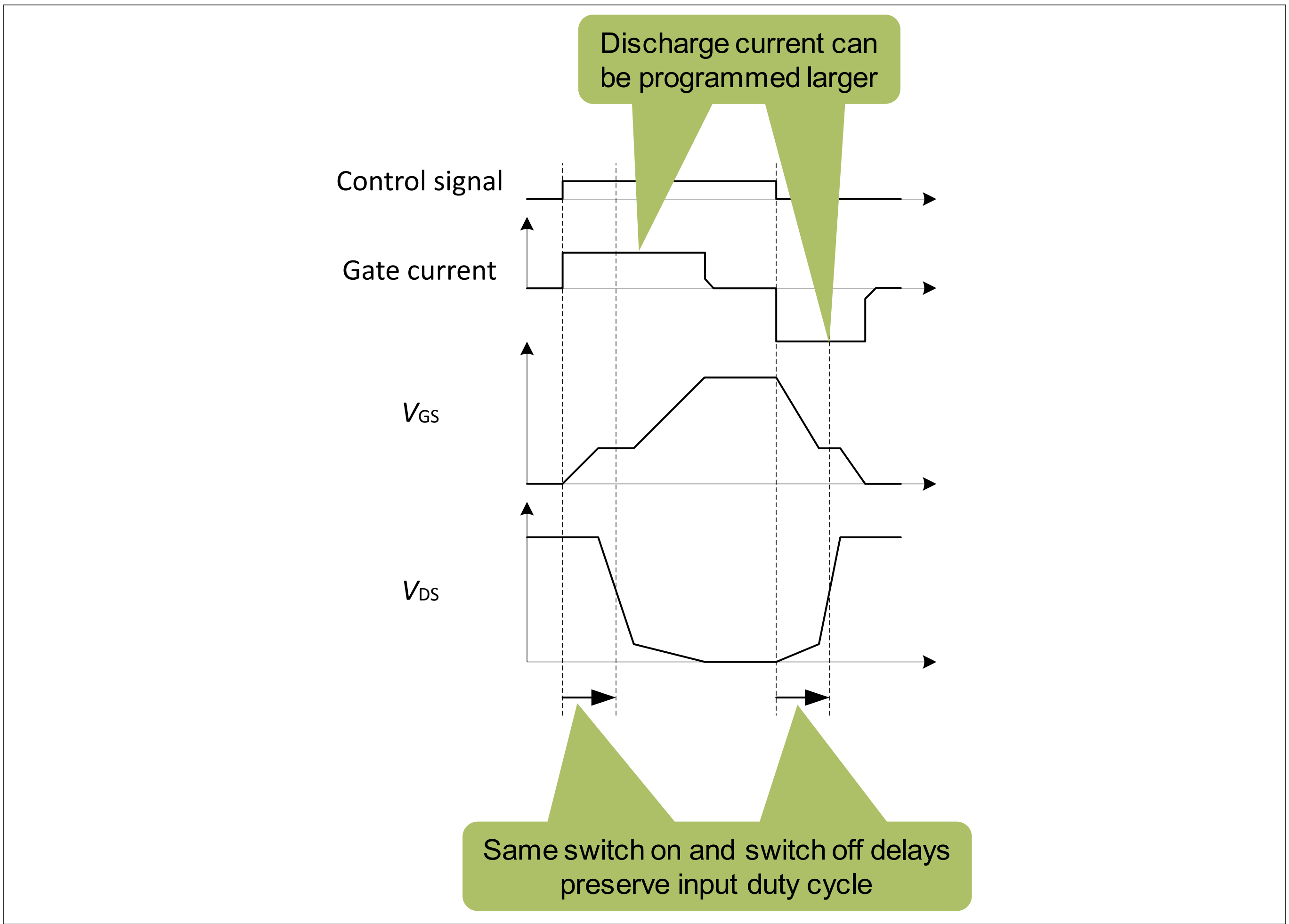

Figure 6 Symmetric on and off delays

Programmable gate currents reduce power dissipation

Using the same gate current setting for all MOSFETs (i.e. for the PWM MOSFETs and the free-wheeling MOSFETs) leads to a certain level of power dissipation during the "passive free-wheeling" phase:

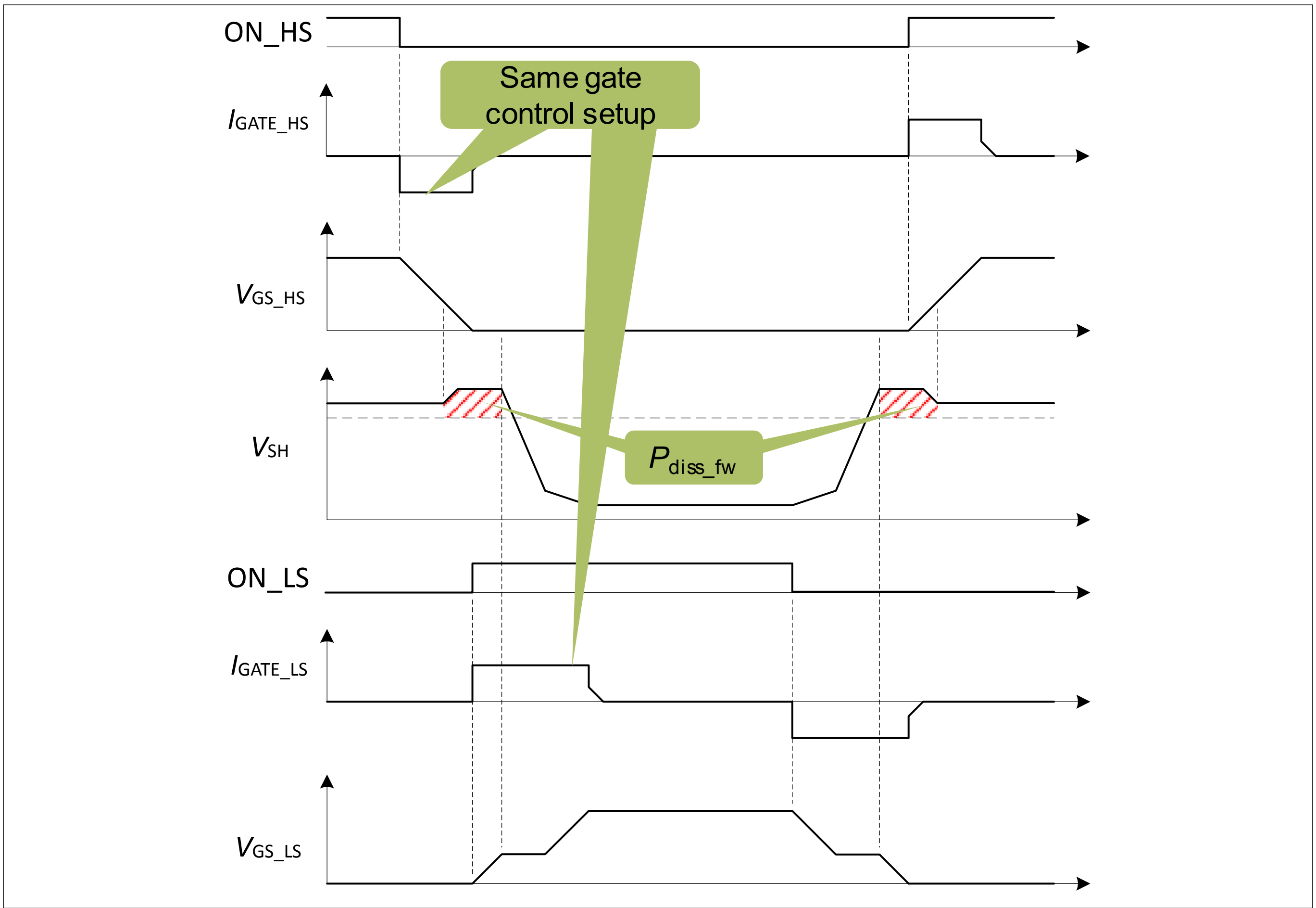

Figure 7 **Same gate current settings for all MOSFETs**

The TLE985x Bridge Driver gives the possibility to choose different gate current values for the free-wheeling MOSFETs to reduce the duration of the "passive free-wheeling" phases:

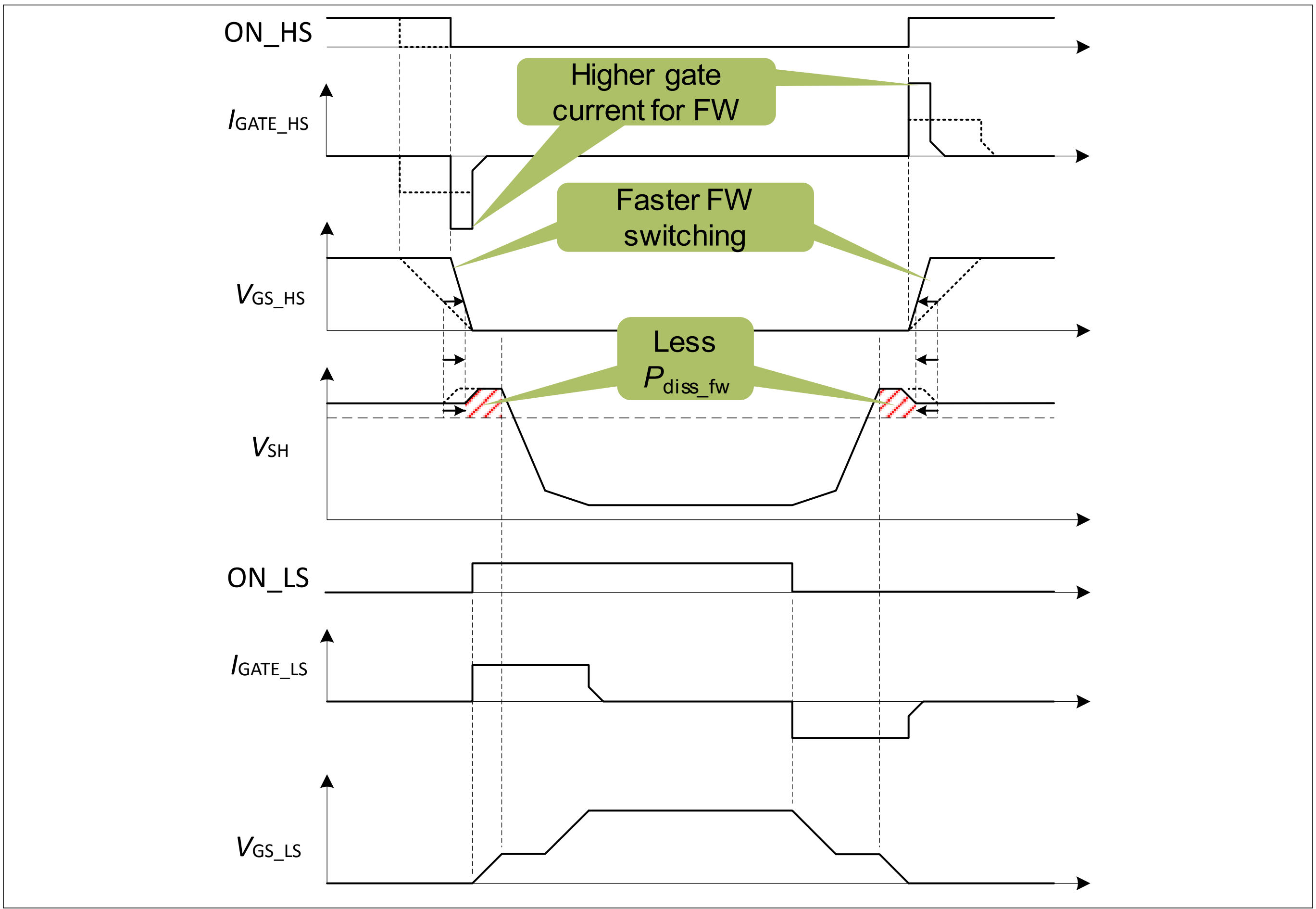

Figure 8 **Less power losses due to different gate current settings for free-wheeling MOSFET**

5 Advanced gate control

Sequencer

Large gate current settings lead to short delays and short times to $V_{GS(max)}$ but fast slopes:

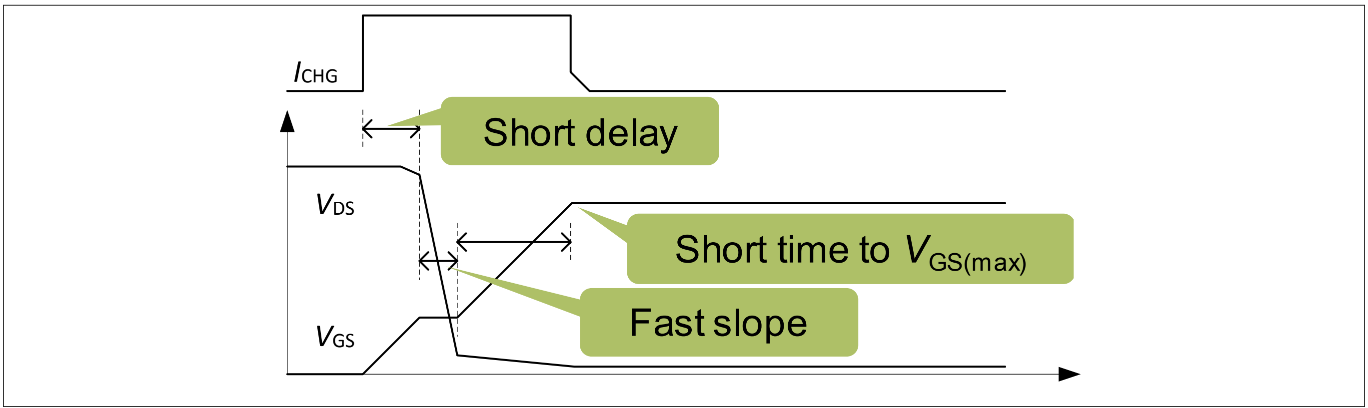

Figure 9 Effects of large gate current settings

Small gate current settings lead to slow slopes but long delays and long times to $V_{GS(max)}$:

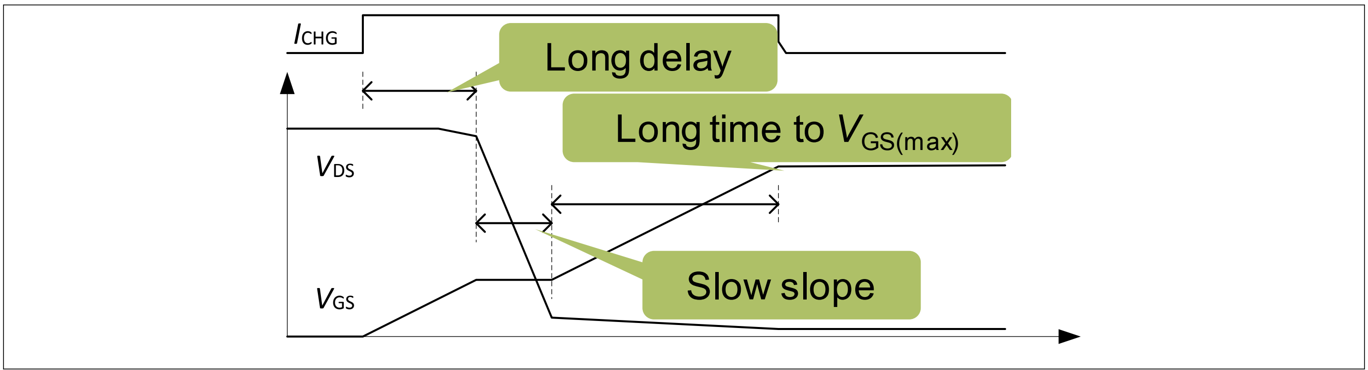

Figure 10 Effects of small gate current settings

The sequencer varies the gate current settings within the switching phase and thus allows a combination of the positive effects

- short delays to reduce power dissipation in the free-wheeling MOSFET,
- slow slopes to improve the EME behavior, and
- short times to $V_{GS(max)}$ to reduce power dissipation in the PWM MOSFET

as shown here:

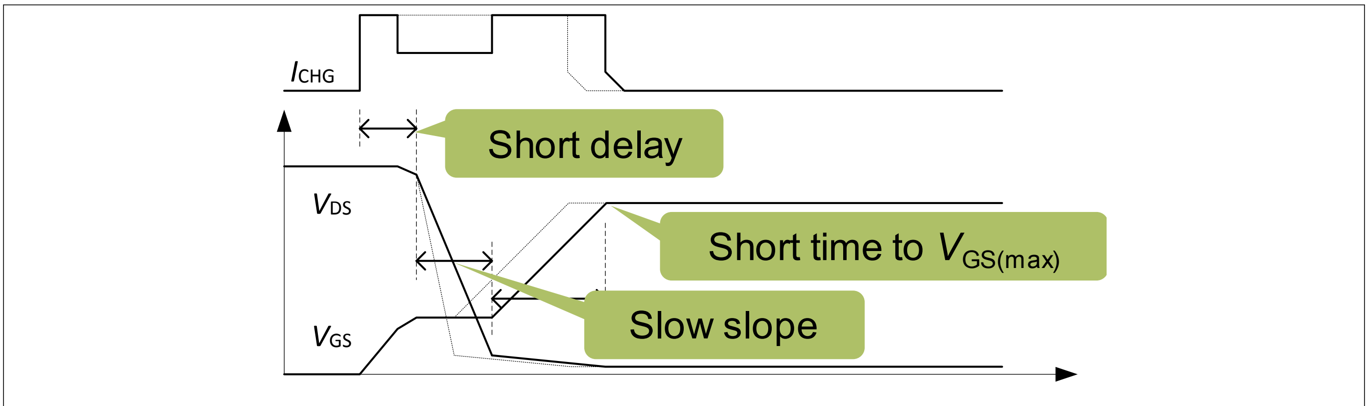

Figure 11 Effects of the time-variant gate current settings provided by the sequencer

Adaptive gate control

The adaptive gate control allows to define a target delay and iteratively adapts the gate current in the first phase of the sequencer based on measurement results of the actual delay:

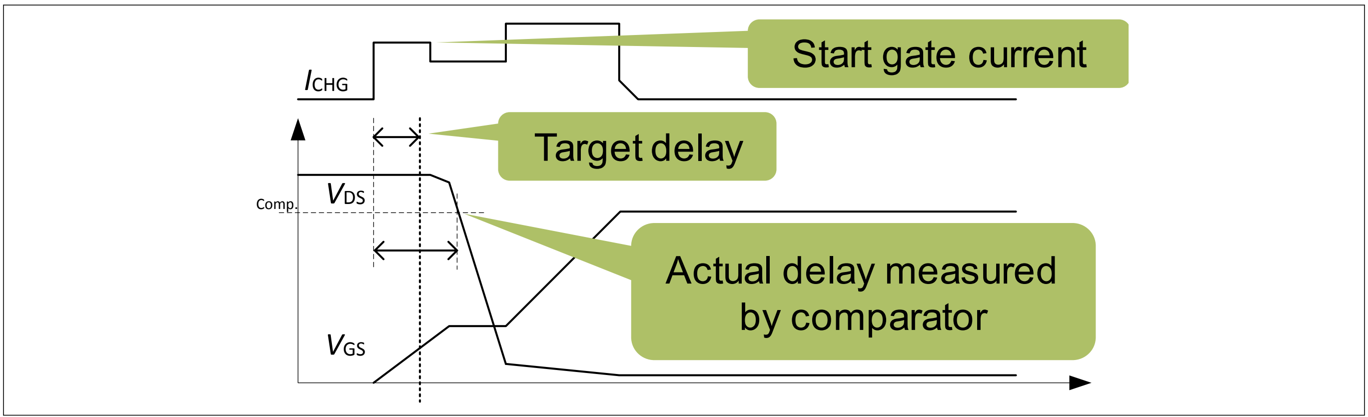

Figure 12 Definition of target timing and start condition

For example, if the measured delay is too long the gate current of the first phase of the sequencer is increased by one step at the next PWM cycle:

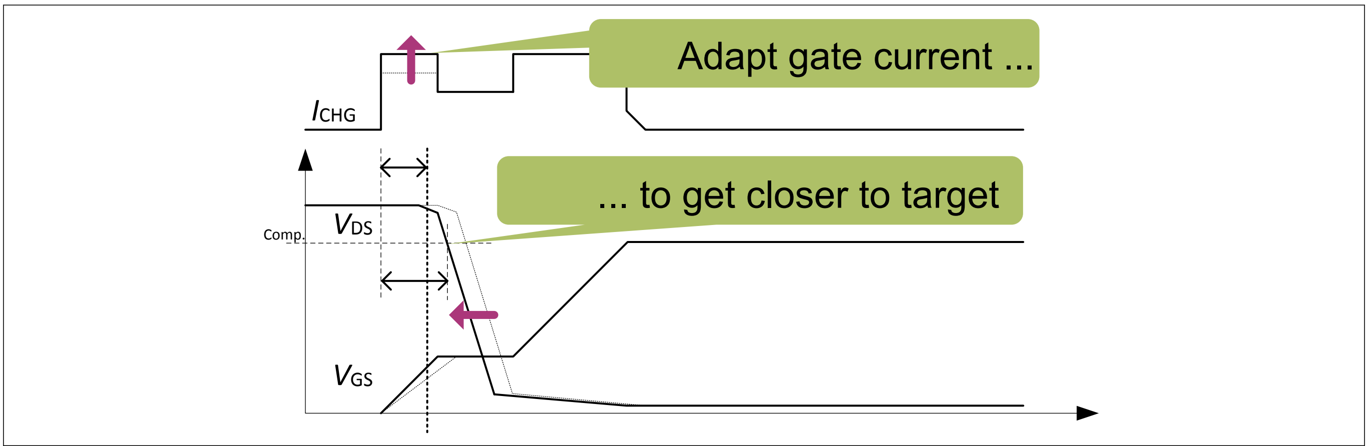

Figure 13 Iterative adaption of gate current phase 1

As a benefit, adaptive gate control can compensate MOSFET/gate driver parameter variations in the running system, e.g.:

- production spread
- temperature changes
- operating point changes
- aging effects
- non-symmetric placing on PCB

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