

Motor Drive Protection With TI Smart Gate Drive

Luis Riveros, Analog Motor Drive



Introduction

The integrity and function of the power stage MOSFETs are crucial in any motor control system. A fault or breakdown of the MOSFETs can cause damage to the motor system. Whether due to improper gate timing, or dV/dt coupling, the damage from the resulting shoot-through condition can be catastrophic to the power stage of the motor since this is a high power handling section of a design.

TI's Smart Gate Drive technology provides protection against MOSFET failures through the TDRIVE state machine making the system more robust and efficient while driving the external power MOSFETs. The TDRIVE state machine consists of three main protection features including dead time optimization, preventing dV/dt turn ons, and MOSFET monitoring with fault reporting.

Dead Time Optimization

One key function of Smart Gate Drive and the TDRIVE state machine is dead-time optimization. This feature calculates the optimal dead time between the high and low-side of the power MOSFETs during the switching period to prevent an event known as shoot-through. A shoot-through condition occurs when both the high and low side of the MOSFETs are turned on at the same time creating a virtual short to ground incident and potentially damaging the whole system. See Figure 1.

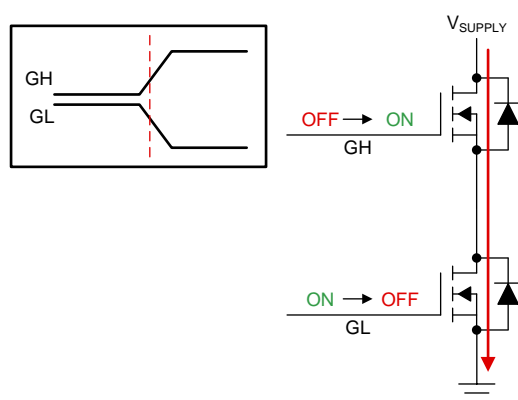


Figure 1. Shoot-Through Condition

The TDRIVE state machine avoids this condition by monitoring the voltages of the gates (V_{GS}), in both high and low-side MOSFETs, and inserts a handshake mechanism that ensures "break before make" as shown in Figure 2. This internal mechanism provides an optimized dead time to minimize switching losses. Additionally, with SPI enabled devices, there is an option to further adjust the dead time if needed for a specific design.

Smart Gate Drive: Dead time on the output

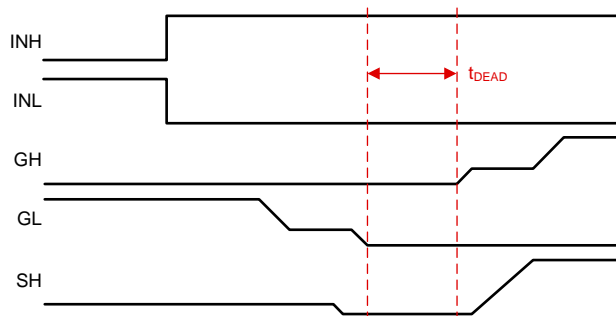


Figure 2. Dead Time Insertion

Preventing dV/dt Turn-on

Another challenge when switching power MOSFETs in a motor drive system is reducing voltage transients on the low-side MOSFET due to dV/dt parasitics. When the high-side of the MOSFET is switching, voltage can couple into the low-side through the parasitic capacitance, this is another case of a shoot-through condition which can damage the motor system.

The TDRIVE state machine enables a strong current sink or pulldown on the gate opposite of the slewing MOSFET, $I_{PULLDOWN}$ in Figure 3. This provides a strong discharge path on the low side gate while the high side is switching, removing parasitic charge and reducing the overall induced voltage on the gate without the need of external pulldown resistors.

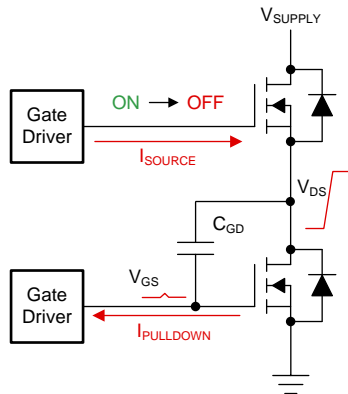


Figure 3. Strong Current Pulldown

V_{GS} Monitoring and Fault Reporting

The Smart Gate Drive architecture also provides protection to the MOSFETs by monitoring the gate-to-source voltage as shown in Figure 4. This protection scheme identifies gate faults such as pin-to-pin solder defects, or a condition when the MOSFETs gets stuck high or low.

The V_{GS} voltage threshold is checked by the smart gate driver after switching is completed. When the thresholds are not met due to an abnormal event, a gate drive fault (GDF) will be reported from the DRV device. Once the fault is detected, the Smart Gate Drive device will disable the power stage safely in order to protect the system, providing the designer an opportunity to correct and re-enable the system after the fault is identified.

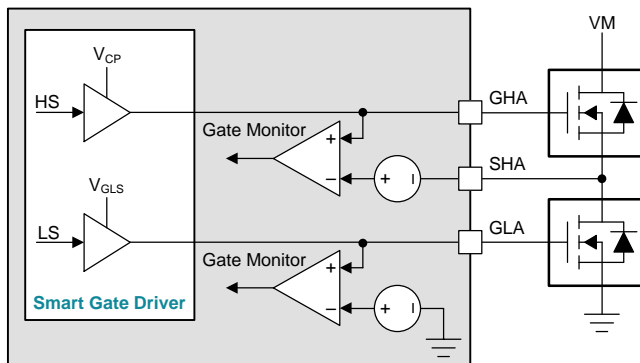


Figure 4. V_{GS} Monitoring

Conclusion

TI's Smart Gate Drive architecture enables robust motor control systems by providing comprehensive protection features without the need for additional components external to the gate driver. For more detailed information on the benefits of Smart Gate Drive, see the application note "[Understanding IDRIVE and TDRIVE in TI Smart Gate Drivers](#)."

Table 1. Smart Gate Drive Device Recommendations

Brushless DC Gate Drivers	Stepper Gate Driver	Brushed DC Gate Drivers
DRV8304 , DRV8305 , DRV8305-Q1 , DRV8306 , DRV8320 , DRV8320R , DRV8323 , DRV8323R , DRV8350 , DRV8350R , DRV8353 , DRV8353R	DRV8711	DRV8701 , DRV8702-Q1 , DRV8702D-Q1 , DRV8703-Q1 , DRV8703D-Q1

Related Documentation

- [Understanding IDRIVE and TDRIVE in TI Smart Gate Drivers](#)
- [Field Oriented Control \(FOC\) Made Easy for Brushless DC \(BLDC\) Motors Using TI Smart Gate Drivers](#)
- [Reduce Motor Drive BOM and PCB Area with TI Smart Gate Drive](#)
- [Improving EVM performance with TI Smart Gate Drive](#)

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