

100-V half-bridge gate driver spins your motor while handling negative voltage and protecting from cross-conduction

Ritesh Oza

ABSTRACT

Moderate power levels, high switching frequencies, and board layout parasitic elements cause excessive electrical noise, voltage ringing, and undesired negative voltages in motor drive applications as well as in many other power supply applications.

This application note will outline how electrical switching noise in motor drive applications cause excessive ringing and negative voltage at various pins of the gate driver IC. New features such as negative voltage handling capability and cross conduction protection of the UCC27282 are explained in this application note. Experimental waveforms shows that the UCC27282 half-bridge gate driver not only performs satisfactorily but also improves system robustness in high switching noise operating conditions.

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1 Introduction

Many advanced applications such as e-bikes, vacuum cleaners, warehouse robots, drones, appliances, and many more, use some type of motor drives. In most of the medium to low power motor drives multiple MOSFET half-bridges are used to drive the phase of the motor. Gate drivers are needed to drive these MOSFET half-bridges as most digital controllers and many analog controllers do not have enough source current capability to drive these MOSFETs. Due to the nature of these applications, the electrical components are subject to harsh electrical conditions. The strenuous motor operating conditions coupled with layout limitations cause electrical noise to exist at almost every node in the circuit.

2 Electrical noise in motor drives

Figure 1 shows how noise gets injected into the gate driver circuit. The bias supply pin, input pins, switch node, and output pins can be subjected to noise. This noise can result in malfunction or complete damage to not only gate driver but also to the power stage. This can lead to unreliable equipment performance or even reduced lifetime of the equipment.

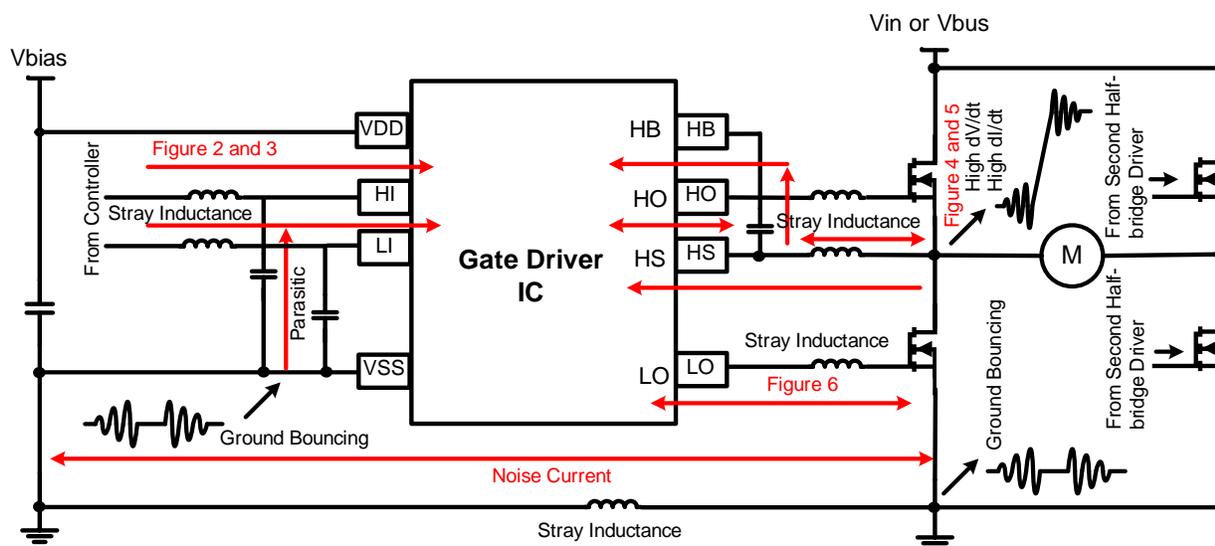


Figure 1. Switching noise paths in typical motor drive application

3 Protection against input negative voltage

In most motor drive applications gate drivers are placed relatively close to the power MOSFET compared to the controller IC. As the power stage ground and the gate driver ground are the same, the switching of the power MOSFETs can cause ringing on the input pins of the gate driver IC. The ringing on the input can result in negative voltage on the input pins of the gate driver. Therefore, the gate driver needs to sustain this negative voltage in such a way that the output of the gate driver must not be affected. Many semiconductor devices are not designed to handle this negative voltage and thus they are damaged or they malfunction in these applications. To avoid this situation, the UCC27282 is designed to handle maximum 5V negative voltage at its inputs, e.g. HI and LI. Figure 2 shows that gate driver is performing satisfactorily under negative input voltages. To simplify the test, HS pin is connected to the VSS pin of the UCC27282 and VDD pin is connected to the HB pin. Capacitors are used as load on the output pins instead of MOSFET in this test setup. The same performance was also observed when tested under actual 100V half-bridge configuration.

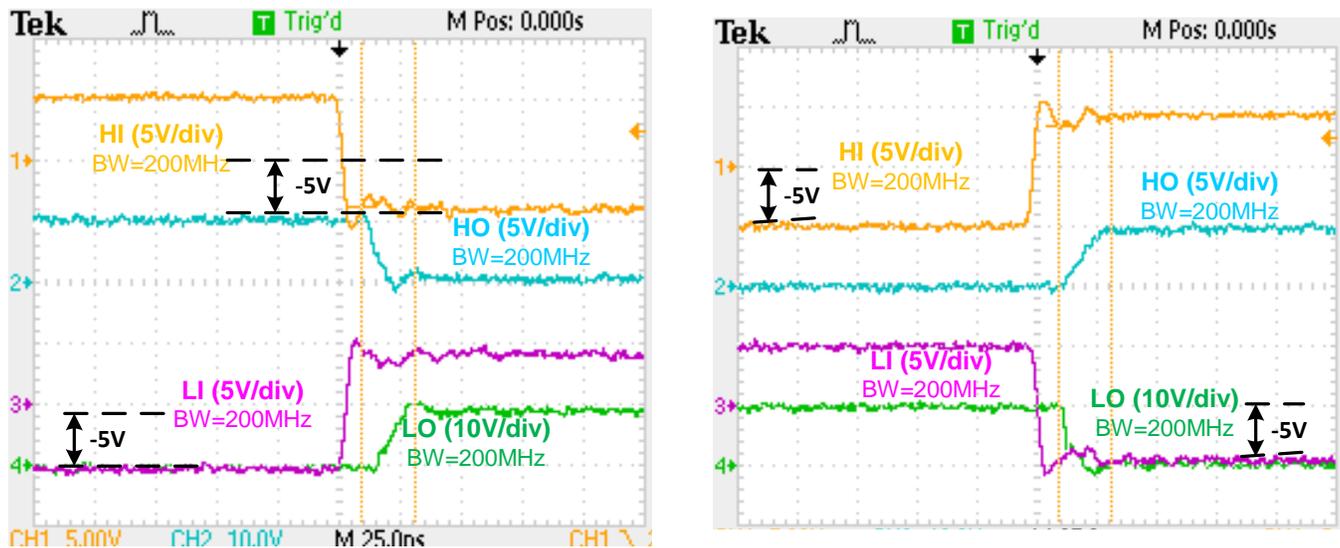


Figure 2. Input negative voltage handling capability of the UCC27282

4 Cross conduction protection/Input interlock

The other effect of switching noise getting into input stage of the gate driver is that the input stage can be corrupted, and can also cause two inputs to be high at the same time. In other words stray inductances, stray capacitance, and switching noise can cause input signals to overlap. Most two-input half-bridge gate drivers would reproduce the output. Which means outputs would overlap as well. Referring back to [Figure 1](#), this output overlap would cause cross conduction or shoot-through condition that may damage the power stage. To avoid this situation, the UCC27282 is designed with cross-conduction protection in the device. When the two inputs are high, the gate driver internal logic turns off both the outputs. [Figure 3](#) shows the interlock feature of the UCC27282. This feature prevents output cross-conduction and shoot-through current. Functional block diagram in the UCC27282 datasheet shows simplified implementation of input overlap protection circuit. Low voltage test setup is used to obtain these waveforms but the same performance was confirmed on high voltage half-bridge configuration.

Input overlap due to high frequency noise can be avoided by implementing a filter circuit at the input of the gate driver IC. However, by doing so a fixed delay is introduced in the system which gets reflected on the switching performance of the MOSFETs. It is also worth noting that in many applications there is not enough board area available to layout these passive filters.

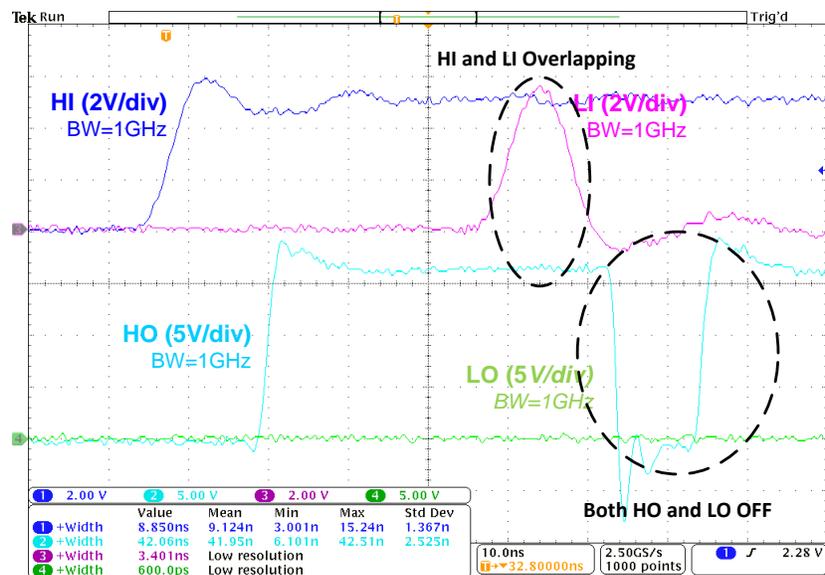


Figure 3. Interlock functionality of the UCC27282 half-bridge gate driver

5 Switch node (HS) negative voltage handling

For half-bridge power stage of motor drive applications, switch node (node that connects high-side and low-side power MOSFET) swings negative every switching cycle. Parasitic diode of low-side power MOSFET in this configuration clamps this negative voltage to the diode drop. Most of these diodes have relatively slow recovery characteristic and therefore the negative voltage on switch node exist for significant amount of time. The same negative voltage appears on the half-bridge gate driver IC. If the gate driver IC is not designed to handle this negative voltage, the gate driver might malfunction or might get damaged completely. The UCC27282 is designed to handle negative voltage on the HS node. **Figure 4** shows the switch node (HS) negative voltage handling capability of the UCC27282. The supply current was monitored during the test and observed no difference in supply current drawn by the UCC27282 half-bridge gate driver. The UCC27282 was fully tested before and after the test and no shift in any of the electrical characteristics was observed.

Figure 4 shows DC negative voltage handling capability of the UCC27282 half-bridge gate driver. The UCC27282 can handle maximum of negative 10V DC and negative 14V short duration transient. In most applications, HS voltage goes negative for short duration as explained earlier in this section. UCC27282 has -14V rating for short duration pulses on HS pin. **Figure 5** shows this negative transient voltage handling capability of the UCC27282. All the waveforms were taken using single ended (ground referenced) probe. This waveform shows that HO was held low before, during, and after the -14V transient on HS node. The state of the output pins did not change due to this negative transient.

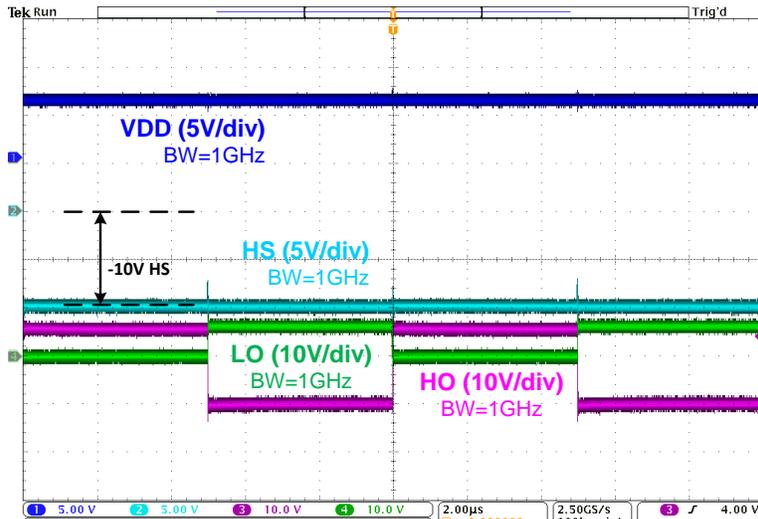


Figure 4. Switch node (HS) DC negative voltage handling capability of the UCC27282

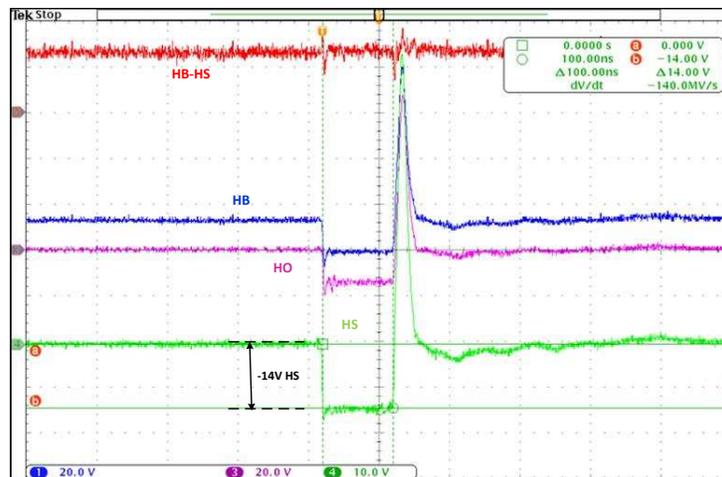


Figure 5. Switch node (HS) negative transient voltage handling capability of the UCC27282

6 Negative voltage ringing on the output pins

During transient operating conditions in motor drives such as start-up, stalling, and load transients, the gate driver output pins may be exposed to the negative voltage. The anti-parallel diode of gate driver internal MOSFET conducts when output goes negative. The state of the output pins must not change due to this negative transient. **Figure 6** shows negative voltage handling capability of the UCC27282 half-bridge gate driver. The UCC27282 is designed to handle -2V transient on its outputs, e.g. HO and LO. External clamp diode needs to be used in applications where gate driver cannot handle this negative voltage.

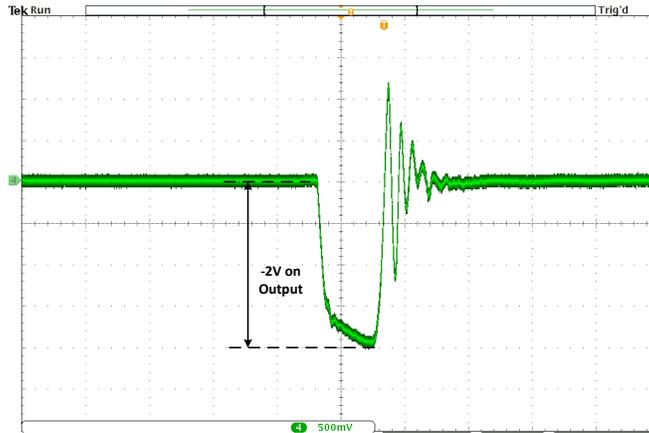


Figure 6. Output (HO & LO) negative voltage handling capability of the UCC27282

7 Enable/disable capability

In many motor drive applications the power stage need to be turned-off during some operating conditions such as stand-by or fault. The UCC27282 has dedicated enable pin. When this pin is pulled to ground, both the outputs are turned-off. This enable pin is internally pulled down which helps prevent erroneous gate driver output during some operating conditions such as start-up and floating inputs. **Figure 7** shows enable functionality of the UCC27282 half-bridge gate driver. Here there is no motor connected to high voltage half-bridge power stage unlike shown in **Figure 1** and therefore one could observe the flat region in HO waveform as HO was measured with ground referenced probe and not with high voltage differential probe.

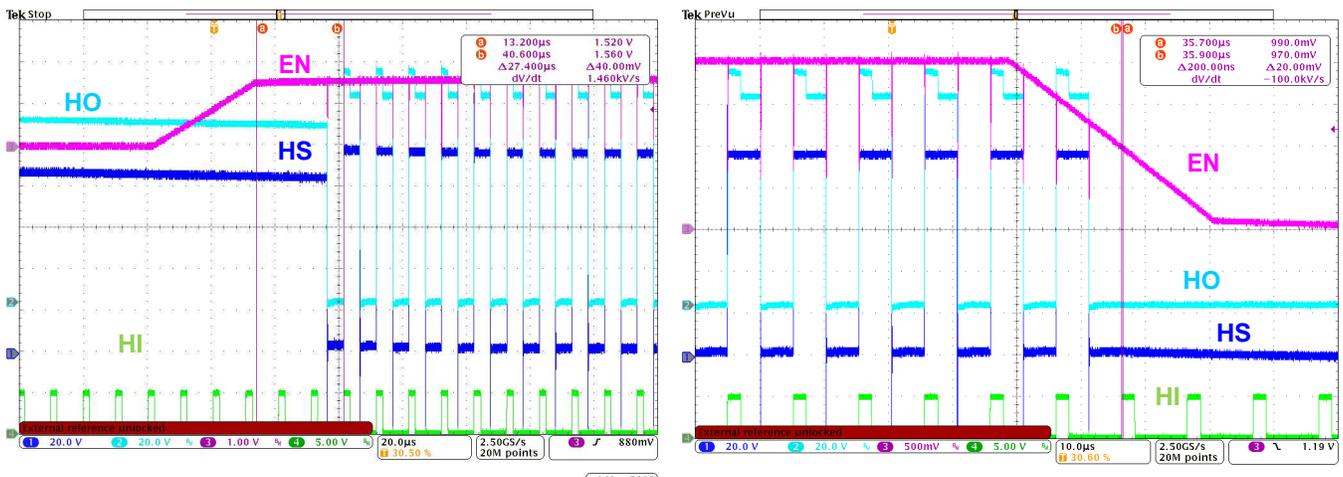


Figure 7. Enable/disable functionality of the UCC27282

8 Summary

Advanced motor drive applications operate in harsh environments and they need to be robust. This application note discussed how input, switch node, and output pins are exposed to negative voltage transients. It is evident that the gate driver IC needs to handle such negative transient voltage to ensure system robustness and reliability. It is also clear that excessive electrical noise can cause false logic, such as overlapping inputs, at the input of the gate driver IC. If driver IC is not designed to account for input overlap, then both the outputs can turn-on at the same time which can cause damage to the system. The UCC 27282 features, such as cross-conduction protection or input interlock, negative voltage handling capability on input and output pins, and enable/disable functionality helps improve the robustness of many advanced motor drive applications.

9 References

- [UCC27282 120-V Half-Bridge Driver with Cross Conduction Protection and Low Switching Losses](#)

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