Low-side gate drivers with UVLO versus BJT totem-pole

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Using the BJT totem-pole to drive power switches in low-side applications has increasingly been replaced by gate drivers, which come with many built-in safety features, eliminating risks associated with the lack of protection in a discrete solution. When driving MOSFETs and IGBTs, safety features are important in ensuring a predictable switching, robust gate drive. This technical note compares use of the UCC27517 device and the discrete totem-pole, as well as their respective performances at undervoltage lockout (UVLO) conditions.

Importance of Undervoltage Lockout

The UCC27517 device has an important built-in protection feature that grounds the output of the driver when the power supply has not reached the UVLO threshold. Figure 1 shows how different values of VGS impact the MOSFET for a given drain-to-source voltage. The right side of the red curve is the saturation region, defined by a constant drain-to-source current, dependent on the gate-to-source voltage and independent of the drain-to-source voltage. This area is where power losses can be high, due to a simultaneous presence of high-drain current and high drain-to-source voltage. The left side of the red curve is the linear region, where the drain current is proportional to the low $R_{ds(on)}$ of the MOSFET. For applications with high-drain current, a drop in gate-to-source voltage can be dangerous for the MOSFET. UCC27517, and other UCC family of low-side drivers from TI, prevent that with their built-in UVLO and allow for safe power up.

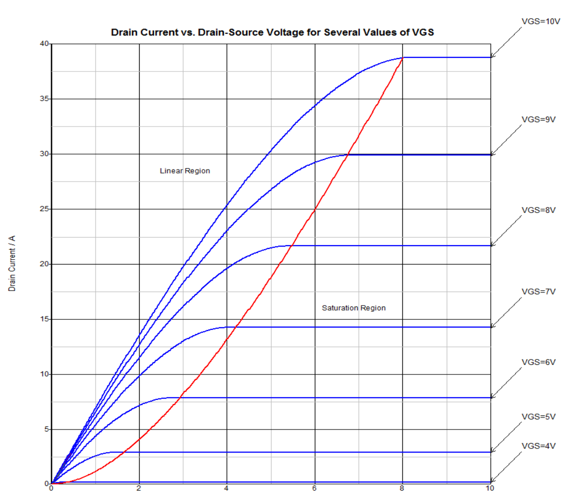

Figure 1. MOSFET IV Characteristics

BJT Totem-Pole Offers No Protection

Figure 2 shows the BJT totem-pole configuration, to drive the MOSFET. Figure 2 shows a typical gate-drive circuit achieved using a bypass capacitor and an additional base resistance, to limit input current. At power on and power off, before the BJT drive supply settles, the MOSFET can be subject to the combination of high voltage and high current. An external UVLO circuitry can be added to this circuit, but this addition results in an increase in component count, board footprint, and BOM cost.

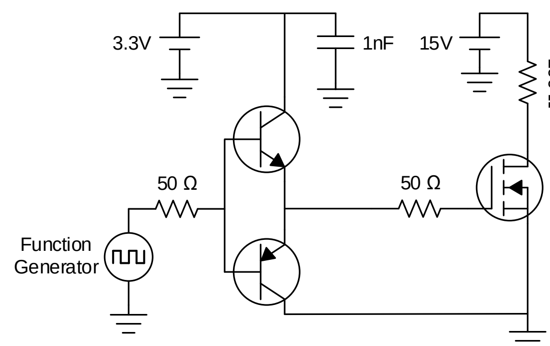

Figure 2. BJT Totem-Pole Schematic

Figure 3 shows the UCC27517 device driving the power switch in the same conditions with the built-in UVLO, which is typically 4.2 V with 300-mV typical hysteresis. When the supply voltage reaches UVLO, the output of the driver rises with VDD until it reaches steady state. This solution also uses fewer components, has a lower footprint, and saves on BOM cost.

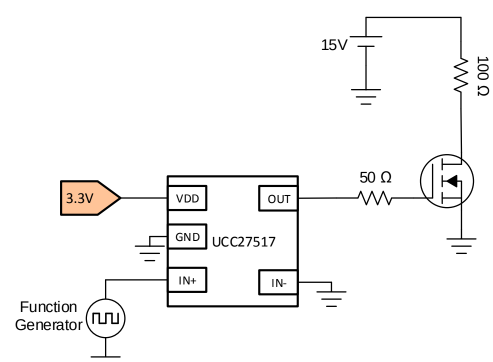

Figure 3. UCC27517 Schematic

Protect MOSFET and IBGT Using UCC27517 With UVLO

At 3.3-V start-up, there is a significant difference in the thermal behavior of both gate drives. The UCC27517 device clamps its output, preventing switching as well as drain-to-source voltage drop across the FET at its output. The waveforms in Figure 4 illustrate this event, where channel 2, VDS_517, captures no voltage drop across the MOSFET and channel 4, IDS_517, shows the drain current grounded during power up. This process occurs until the supply voltage reaches the UVLO rising threshold. However, the BJT allows a voltage drop across the MOSFET captured by channel 1, VDS_BJT, while the drain current rises significantly, as shown by channel 3, IDS_BJT. This rise in current leads to excessive power dissipation and can potentially damage the MOSFET.

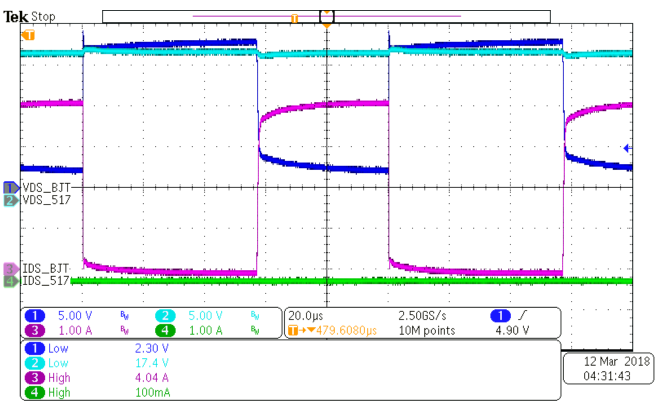

Figure 4. Waveforms of UCC27517 and BJT Totem-Pole Gate Drives at 3.3-V Power Up

Figure 5 shows a thermal image of this event, where on the left, UCC27517 driving the MOSFET, with its built-in UVLO, prevents overheating at the FET junctions by grounding its output. The driver's output stays grounded regardless of its input during UVLO conditions. However, on the right, the FET at the BJT totem-pole output, with no protection, is exposed to overheating due to increased power dissipation.

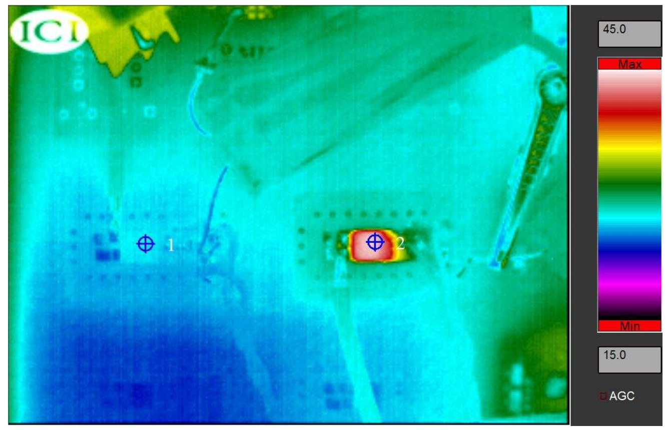

Figure 5. Thermal Image of UCC27517-Driven MOSFET (Left) and BJT-Driven MOSFET (Right) at 3.3-V Power Up

Summary

UVLO is an important feature, allowing smooth power up and power down of the MOSFET by ensuring that switching only occurs when enough voltage is supplied. The UCC27517 device takes care of this issue with its internal UVLO, by grounding its output thereby preventing overheating of the MOSFET. This feature is essential, because this excessive power dissipation at the MOSFET junctions can occur during power up and power off and can potentially damage the FET. This internal UVLO protection is not limited to the UCC27517 device, it extends to other the UCC family of low-side gate drivers from TI.

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