Rail-to-Rail Output Gate Drive Optocouplers

Tee Chun Keong, Technical Marketing Engineer, Avago Technologies Gate drive optocouplers are widely used for driving IGBT and Power MOSFET because of the high output current driving capability. Traditionally, gate drive optocoupler use bipolar transistors for the output stage to deliver high output current. With process improvement, the high power drive and speed of bipolar can be replaced by high breakdown voltage DMOS which can pull the output to the rail. This article will discuss about the rail-to-rail output drive and its advantages.

Rail-to-Rail Output

Figure 1 shows a typical gate driver optocoupler's high current output stage with three bipolar transistors in Darlington configuration. This configuration gives a higher current gain than a single transistor. However, the drawback is the increase in saturation voltage. The last output transistor will not saturate because its collector-emitter voltage is now equal to the sum of its own base-emitter voltage and the collector-emitter voltage of the previous transistors. Hence, the base-collector junction of the last transistor cannot be reverse-biased to remain in saturation operation. VOUT will always be 3 diode drops from VCC (VOUT = VCC-3VBE).

The IGBT typically requires a gate voltage of 15 V to achieve the rated VCE(ON) voltage. At gate voltage below 13 V, the VCE(ON) voltage increases dramatically, especially at higher current. At very low gate voltage (below 10 V), the IGBT may operate in the linear region and quickly overheat. Hence, it is necessary to ensure an accurate VOUT voltage in order to achieve IGBT rated VCE(ON) voltage.

And to account for the 3 VBE drop and to ensure an accurate VOUT voltage, the level of VCC is sometime raised to VCC + 3 VBE. When driving an IGBT, the output current will drop to zero due to a capacitive load. During this short period of time, the output voltage will slowly rise from VCC to VCC + 3 VBE. And to limit the output voltage to VCC, a pull-down resistor, RPULL-DOWN between the output and VEE is recommended to sink a static current while the output is high.

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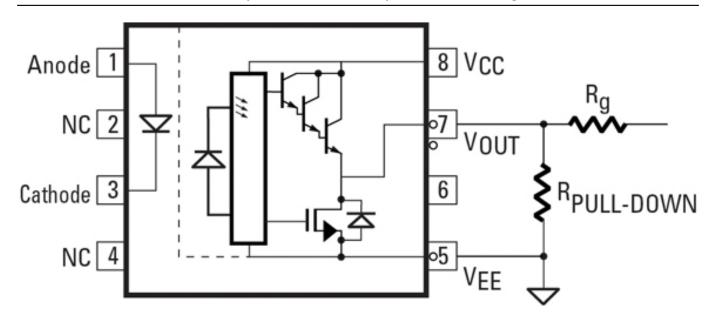
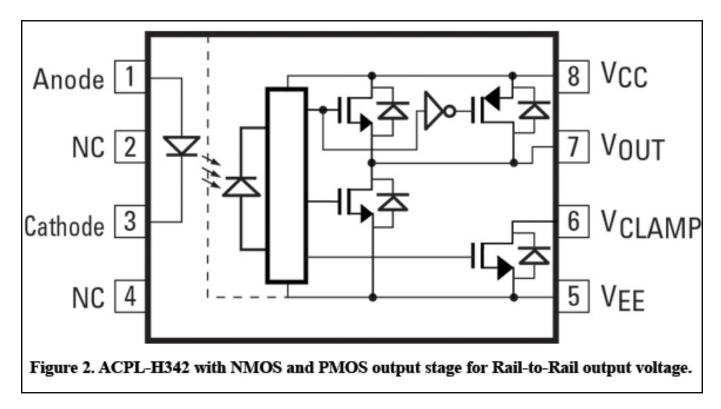


Figure 1. Typical gate driver with output stage in darlington configuration.

A recently introduced gate drive optocoupler utilizes the BCDMOS(Bipolar CMOS DMOS) technology to combine the advantages of high density and low power consumption of CMOS with high current drive and speed of bipolar. It uses a power NMOS follower stage to deliver the initial large current and a smaller PMOS to pull it to VCC to achieve rail-to-rail output voltage. This will ensure that the IGBT's gate voltage is driven to the optimum intended level with minimum power loss across IGBT even when an unstable power supply is used. This is especially so when bootstrap power supply is used. The bootstrap capacitor holding the VCC will experience voltage drop when charging the IGBT gate. The ability of the gate driver being able to pull to the rail will minimize this problem.



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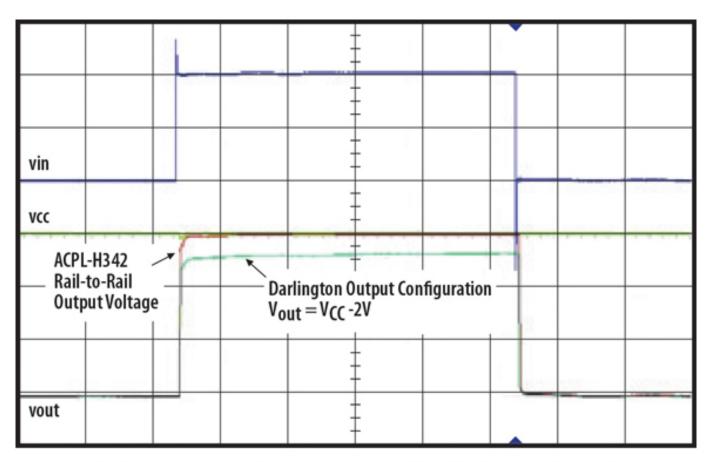


Figure 3. Comparing ACPL-H342 rail-to-rail output and Darlington output.

Lowering Power Dissipation

Another disadvantage due to the increase in saturation voltage of the Darlington transistor is the increase in power dissipation for the same amount of output current. Figure 4 shows the typical motor control application conditions using IGBTs at the inverter stage. The power dissipation of the gate drive optocoupler decreases by as much as 30 percent with a lower saturation voltage and without needing to compensate VCC due to the 3 VBE diode drop. This will translate to an overall improvement of the system efficiency.

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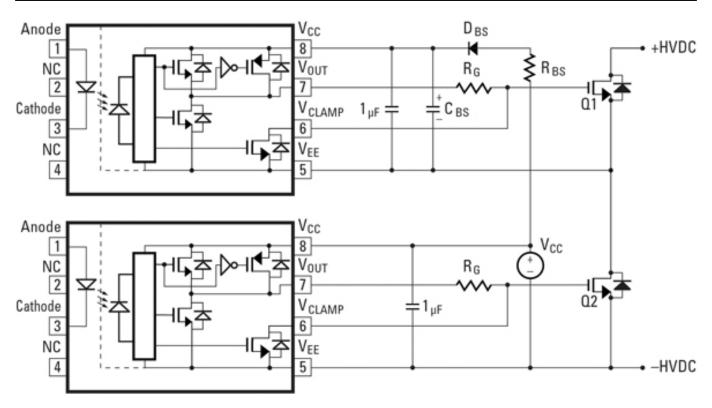


Figure 4. Half-bridge topology using a bootstrap power supply.

Rail-to-Rail Performance

Gate drive optocouplers with MOS pull-up stage are not new but datasheet specifications show that few reach the rail. Figure 5 shows the Avago Technologies ACPL-H342's rail-to-rail performance with very small drift across temperature. The output voltage is pulling to the rail with a very small typical value of 0.03 V away from VCC.

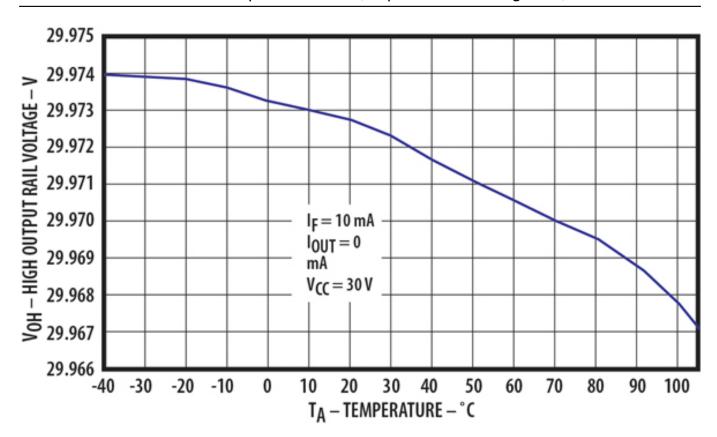


Figure 5. High output rail voltage vs. temperature

Table 1 compares the rail-to-rail performance among different MOS pull-up stage gate drive optocouplers.

	ACPL-H342	Brand T	Brand N	Brand S
V _{OH} (MIN) @ I _{OUT} =100mA	V _{CC} - 2.0V	V _{CC} - 4.0V	V_{CC} -3.0 V	$V_{CC} - 4.0V$

Table 1. Comparisons of gate drive optocouplers Rail-to-Rail performance. Conclusion

A gate drive optocoupler that uses bipolar Darlington transistors to deliver high output current has some disadvantages like higher saturation voltage and power dissipation. By changing to MOS pull-up stage, the gate drive optocoupler now has rail-to-rail output performance with the benefits of more reliable IGBT drive and lower power dissipation.

References

- 1. "ACPL-H342 and ACPL-K342 2.5 Amp Output Current IGBT Gate Driver Optocoupler with Active Miller Clamping, Rail-to-Rail Output Voltage and UVLO in Stretched SO8, Data Sheet," Avago Technologies, AV02-2526EN.
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