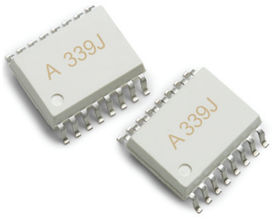
Driving and Protecting IGBTs in Inverter



Introduction

The ACPL-339J is an advanced 1.0 A dual-output, easy-to-use, intelligent IGBT gate drive optocoupler interface. Uniquely designed to support MOSFET buffer of various current ratings, the ACPL-339J makes it easier for system engineers to support different system power ratings using one hardware platform by interchanging the MOSFET buffers and power IGBT/ MOSFET switches. This concept maximizes gate drive design scalability for motor control and power conversion applications ranging from low to high power ratings.

The ACPL-339J is also integrated with short circuit protection, under voltage lockout (UVLO), "soft" IGBT turn-off, and isolated fault feedback to provide maximum design flexibility and circuit protection.

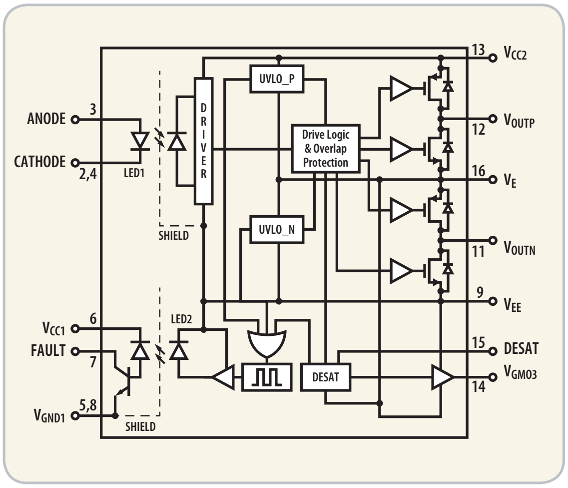


Figure 1: Functional diagram of the ACPL-339J gate drive optocoupler

Driving IGBTs

One of the key feature of gate drive optocoupler is its ability to provide high peak output current to charge or discharge the gate of the IGBT quickly to prevent switching loss. Avago's gate drive optocoupler has output current ranging from 0.4A up to 5A which can be used to drive small IGBT directly. For IGBT with higher ratings, discrete PNP/NPN bipolar buffer stage is usually used. By changing the buffer stage to MOSFET, it maximizes gate drive design scalability and power conversion efficiency.

Figure 2 shows different BIPOLAR buffers are used to drive different class of IGBTs from 50A to 600A. As the size of IGBT gets bigger, higher peak current is required at the gate of the IGBT to turn it on efficiently. The magnitude

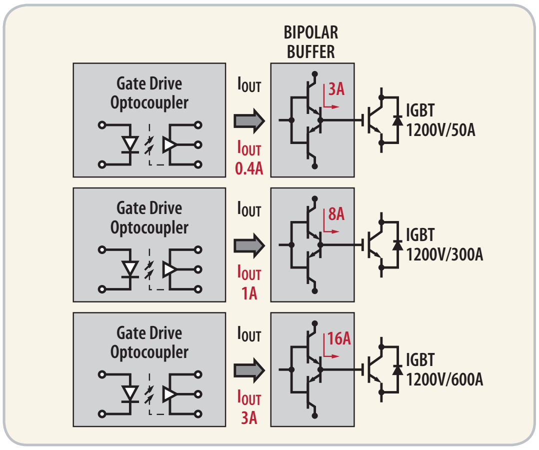


Figure 2: Gate drivers with different output currents to match BIPOLAR buffers

of the BIPOLAR's output current is a factor of its base current, I_B and the transistor current gain, β. In another words, gate drivers with different peak output currents and matching BIPOLAR buffers are needed to achieve the peak gate current required by different class of IGBTs.

MOSFET buffers on the other hand are voltage controlled devices and their current amplifications are independent on the previous gate driver stage. Figure 3 shows MOSFET buffers with different internal turn-on resistance, R_{DSON} to deliver the peak gate current required by the different class of IGBTs. Although the ACPL-339J output is specified at 1A, the switching of the MOSFET buffer will happen as long as the ACPL-339J output voltage crosses the input threshold of the MOSFET buffer.

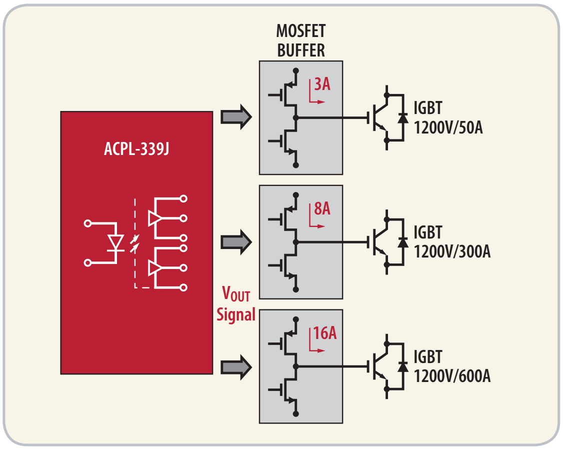


Figure 3: ACPL-339J to drive MOSFET buffer with different output current capability

The ACPL-339J makes it easier to support different system power ratings using one gate drive platform by interchanging the MOSFET buffers and power IGBT/MOSFET switches. And all these changes can be made without redesigning the critical circuit isolation and short circuit protection.

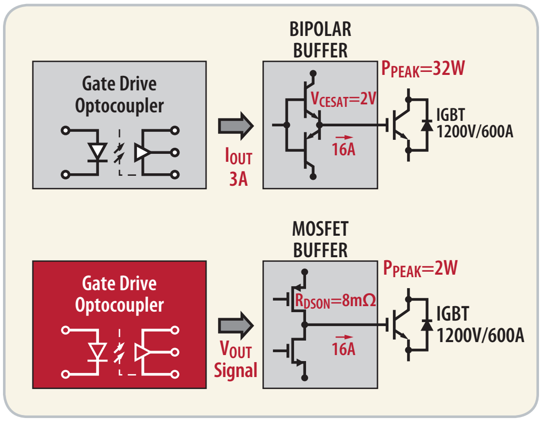


Figure 4: MOSFET buffer consumes less power and improves the overall efficiency

BIPOLAR buffer uses a compounded structure consisting of 2 or more transistor stages cascaded to achieve high current gain. The drawback is the increased in saturation voltage, V_{CESAT} and the output not able to pull to the rail. This results in high power losses when the BIPOLAR buffer delivers high peak output current to the gate of the IGBT. The power loss from the BIPOLAR buffer increase tremendously as higher peak current is needed by the gate of the IGBT.

MOSFET buffer has "rail-to-rail" output and lower internal turn-on resistance, R_{DSON} while delivering higher peak current compared to bipolar buffer. The MOSFET buffer in figure 4 shows significant power reduction when compared to the BIPOLAR buffer delivering the same peak current.

Protecting IGBTs

The IGBT's collector-emitter voltage (V_{CE}) can be monitored by ACPL-339J DESAT pin during IGBT normal operation. When short circuit occurs, high current flows through the IGBT and it comes out of saturation into DESAT mode. This causes the IGBT's V_{CE} to increase rapidly from a saturation voltage of 2V. Once its crosses the ACPL-339J's threshold of 8V, a short circuit fault is registered and soft shutdown is triggered. The ACPL-339J's V_{GMOS} pin will switch on an external transistor to slowly discharge the gate of the IGBT to achieve the soft shutdown effect. The rate of the soft shutdown can be adjusted by the size of the external transistor and resistor to minimize the overshoot at the IGBT. And lastly, the entire DESAT operation is completed by reporting the FAULT through a built-in insulated feedback path to the controller.

Summary

The concept of ACPL-339J driving MOSFET buffer helps to maximize gate drive design scalability from low to high power systems. This helps to reduce design cycle time and together with the integrated short circuit protection and feedback, the gate drive design is simplified with less PCB space and costs.

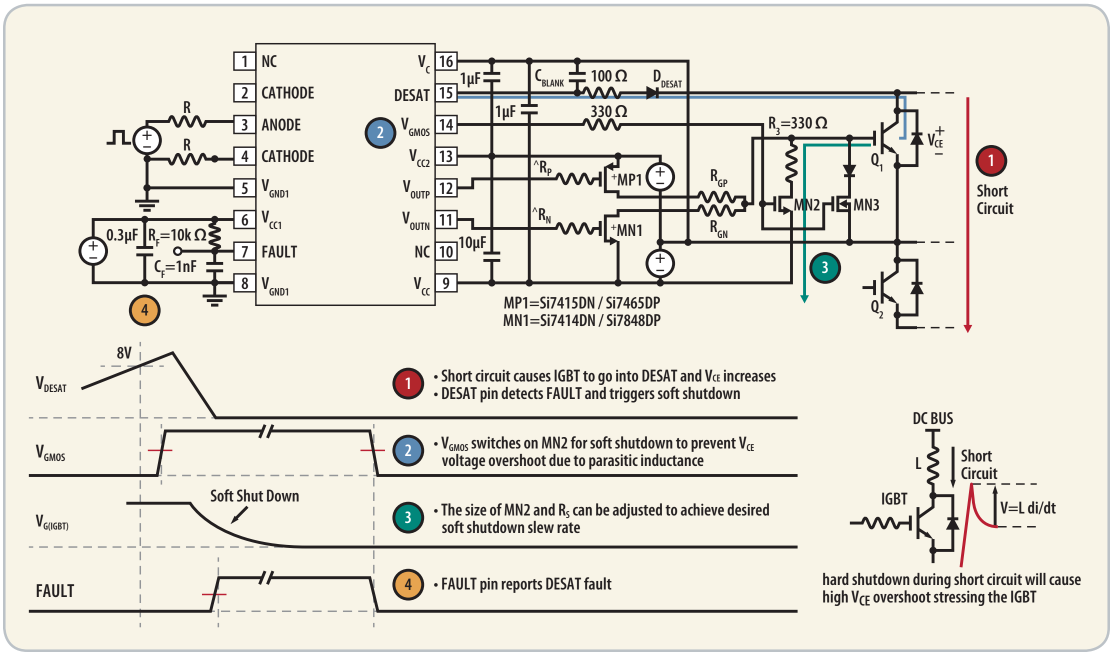


Figure 5: Short circuit protection, "soft" IGBT turn-off, and isolated fault feedback

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