

# Short-Circuit Protection for Power Inverters

By Andrea Merello, International Rectifier

## INTRODUCTION

Short-circuit protection on low- and medium-power inverterized motor drives is becoming essential to comply with safety standards. However, the implementation of such a feature can consistently increase board component count and system complexity when using traditional sensors and optocouplers.

The IR2x14 and IR2x141 gate driver families are designed specifically to protect half bridge and three-phase inverter switches. Desaturation detection of the power switch is fully integrated, resulting in increased system reliability and drastically reduced part count and layout space. Moreover, this gate driver family features gate driving capability of up to 3A with anti-shoot-through and under-voltage lockout for both high- and low-voltage side.

## MONOLITHIC 1200V GATE DRIVING CAPABILITY

IR's monolithic high voltage technology allows the IR2x14 and IR2x141 families to safely drive 110Vac to 380Vac applications and provide capability to withstand up to 600Vdc or 1200Vdc voltages. Typical half bridge configurations require only 14 components.

This gate driver family is designed for medium power, half bridge gate driving. High current capability (2A source, 3A sink) and 20V-capable output stages allow this device to control a wide range of power devices. Each output stage has three separate pins for gate control to allow flexible customization of the IGBT gate charge.

The two separate channels allow safe inverter control thanks to the anti-shoot-through input circuit and minimum deadtime insertion of 330ns. The floating channel can be easily supplied by the widely used bootstrap technique because of its low quiescent current. Under-voltage conditions in floating and low voltage circuits are managed independently and, when an under-voltage condition occurs, the respective power switch is turned off.

The gate driver I/Os are 3.3V CMOS/TTL-compatible to ease communication with the system controller. Separated inputs are available for high- and low-side driver control. A shutdown pin is also available and it is shared with the open drain fault output that becomes active (low) in the case of under-voltage or desaturation detection event.

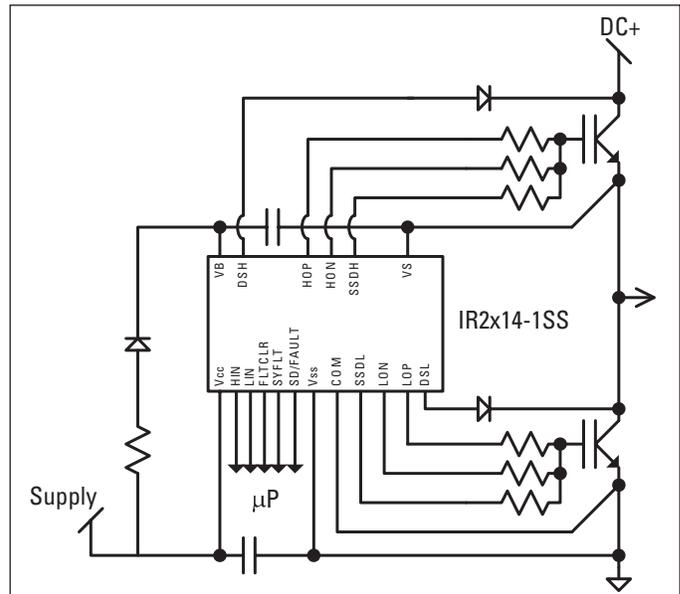


Figure 1: Typical application.

The logic ground and power ground are separated to decouple the large amount of noise caused by inverter switching noise while, at the same time, meeting the requirement of having separated grounds for applications using emitter shunt topologies for current sensing.

## DESATURATION PROTECTION

Inverter power switch short-circuit protection is fully integrated. A desaturation detection circuit is embedded in both the high- and low-side output stages and monitors the IGBT collector-to-emitter voltage by means of an external high voltage diode.

Diode sensing is made by an internal circuit that compares the anode voltage with an internal reference voltage of 8V. The same circuit also manages high frequency spikes, rejecting noise coupling and provides an active diode biasing by means of a patented structure (IR2x141 family).

Under short-circuit conditions, current in the power switch can be as high as 10 times the nominal current (Figure 3 shows an example using a 25A IGBT power module). Whenever the switch is turned-off to block the current path, this high current generates relevant voltage transients in the power stage that need to be smoothed out to avoid definitive inverter failure. The gate driver

# SHORT-CIRCUIT PROTECTION FOR POWER INVERTERS

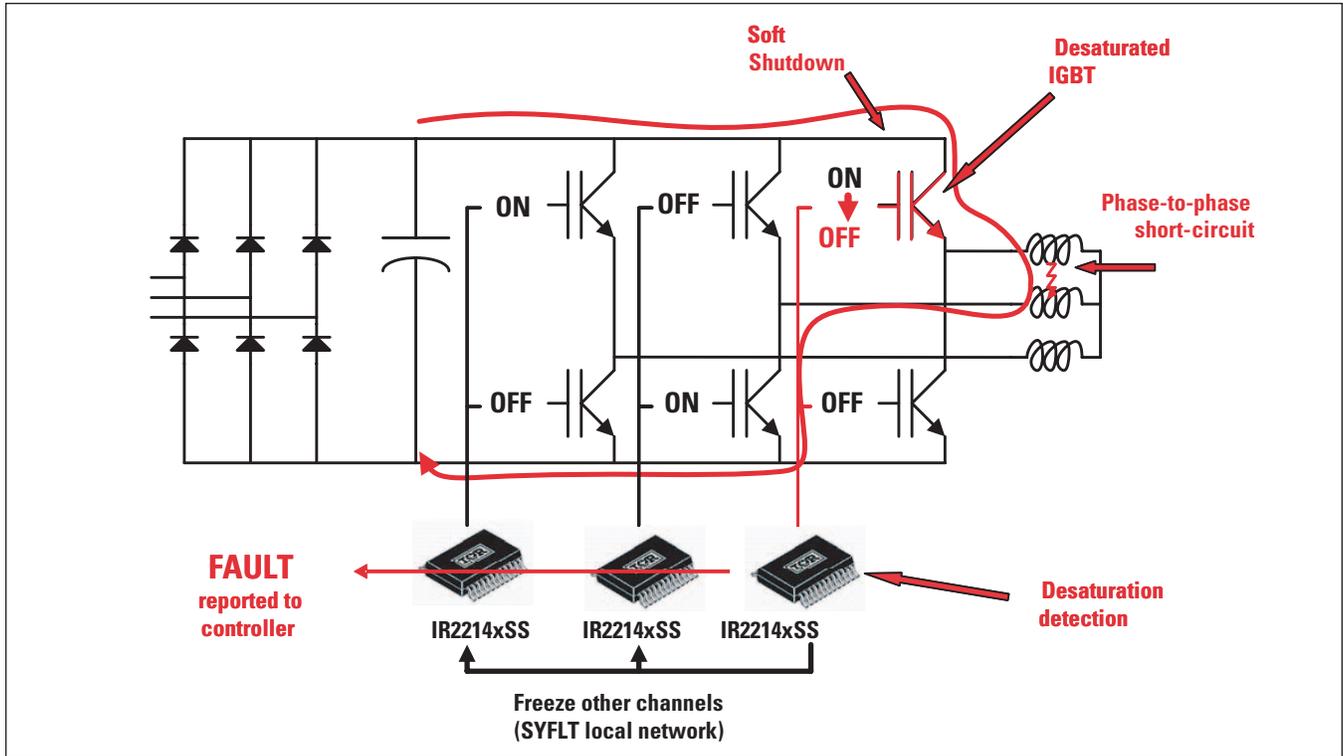


Figure 2: Phase-to-phase short circuit.

accomplishes the transients' control by smoothly turning off the desaturated switch by means of the SSD pin (typ. 90Ω series resistor internally provided).

In a multi-phase system, the half bridge gate drivers share a dedicated local network to properly manage phase-to-phase short-circuits as illustrated in Figure 3. The gate drivers synchronize each other to freeze their state, becoming insensitive to input commands until the short-circuit current is exhausted. This procedure is necessary to avoid undesired hard shutdown due to controller command during the soft shutdown sequence.

The fault pin becomes active as soon as the soft shutdown procedure has finished. The fault clear pin is used to restore the normal operation mode.

## CONCLUSION

The IR2x14-1 half bridge gate driver family is well suited to low- and medium-power designs up to 10kW, providing high performance drive capability as well as including valuable protection features. Low external component count and an SSOP-24 package with a 8.13x8.2 mm<sup>2</sup> footprint design of the gate driving section design particularly small and simple.

IRMD2214SS and IRMD22141SS Reference Design Kits are also available at [www.irf.com](http://www.irf.com).

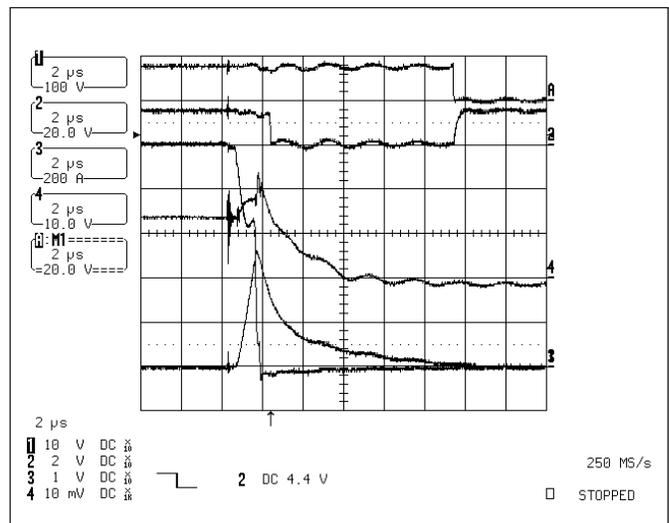


Figure 3: Phase-to-DC minus short-circuit condition:  
 CH1: phase voltage  
 CH2: SY\_FLT  
 CH3: phase current (200A/div)  
 CH4: desaturated IGBT gate turning off smoothly  
 CHA: FAULT