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SIMPLE HIGH SIDE DRIVE PROVIDES FAST SWITCHING AND CONTINUOUS ON-TIME

By Laszlo Kiraly

INTRODUCTION

P-channel power MOSFETs are typically used as high-side switches in low power applications because of simplier gate drive circuitry. As power levels, either voltage or current, increase, the advantages of P-channel devices are quickly offset by their increased on-resistance, limited voltage range, increased cost, and increased complexity of the gate drive circuitry. By switching to an N-channel device, it is possible to improve on the P-channel's disadvantages, at the expense of increased gate drive complexity. For high power levels, the IGBT is extremely well suited for use as a high-side switch, yet all currently available IGBTs are N-channel devices. Presented is a circuit that, with the use of an extra IC and a few passive components, solves the N-channel gate drive circuit issue.

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The Control IC drivers from International Rectifier provide ground referenced, logic level inputs, and high energy, low impedance gate drive for MOSFET or IGBT power transistors up to 500V DC operating voltage when used in switchmode applications. These Control ICs use the bootstrap technique to create gate voltage for the MOS-gated device and to power the floating section of the high-side driver. The advantages of the bootstrap circuit are its simplicity and the fast switching times, but to keep the bootstrap capacitor charged the MOS-gated device has to periodically be turned off. With the addition of a simple charge pump, both the fast switching of the bootstrap circuit and unlimited on-time of the charge pump circuit can be achieved.

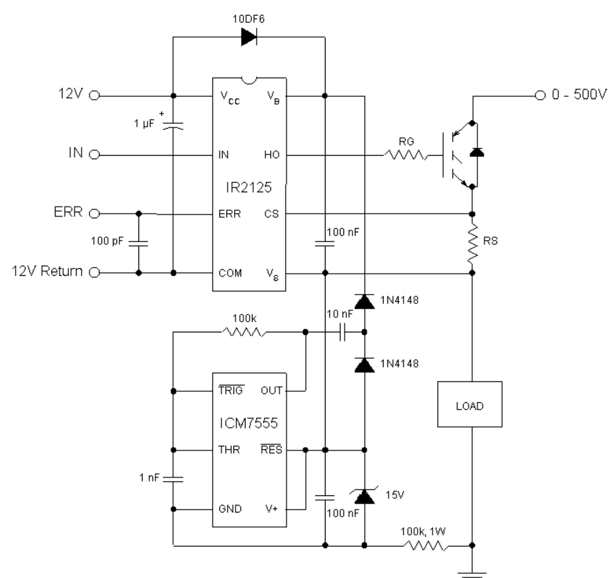

Figure 1
High side drive provides fast switching, continuous on-time and protection for the switching device

CIRCUIT AND TEST RESULTS

The schematic diagram of the circuit is shown in Figure 1. The IR2125 Control IC was selected to demonstrate the cooperation of the charge pump and the bootstrap circuits. The IR2125 also has an over-current shut down capability, providing protection for the MOS-gated device. To provide the low operating current requirement of the IR2125, the charge pump employs a 555 CMOS timer.

When the IGBT is off, the bootstrap capacitor is charged through the 10DF6 diode and the load resistor. When the IGBT is on, the 100 kΩ resistor connected to ground charges the 100 nF capacitor connected between leads 1 and 8 of the 555 timer generating -15V referenced to lead 5 of the IR2125. The charge pump circuit formed by the two 1N4148 diodes and the 10 nF capacitor which converts the 7.5 kHz square wave at lead 3 of the 555 timer to +15V referenced to V_S and charges the bootstrap capacitor.

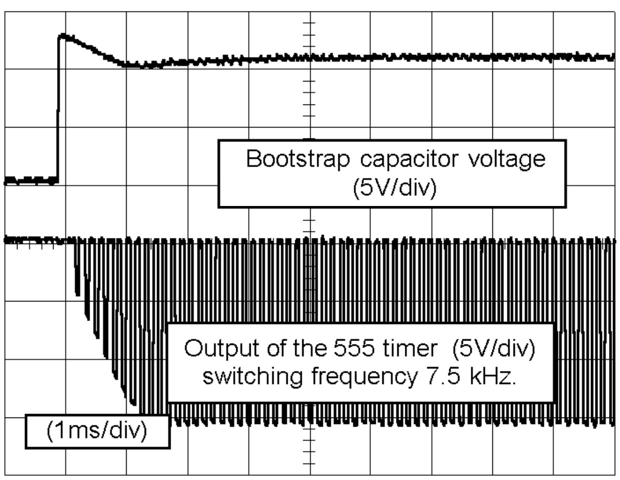

Figure 2
Wafeforms at start-up

Figure 2 shows the circuit waveforms at start-up. As the IGBT turns on, the bootstrap diode disconnects lead 8 of the IR2125 from the +12V power supply, and the voltage across the bootstrap capacitor starts dropping. At the same time the 100k resistor located between lead 1 of the 555 timer and ground starts charging the 100 nF capacitor connected to it and generates supply voltage for the CMOS (MAXIM ICL71555IPA) timer. The output voltage of the charge pump increases with increasing supply voltage. The charge pump maintains the voltage in the bootstrap capacitor, keeping the voltage above the undervoltage threshold level of the IR2125.

DESIGN CONSIDERATIONS

- The absolute maximum voltage supply voltage for the 555 is 18V, consider this when selecting the zener diode and its tolerance.
- The supply current at the V_B pin (I_{QBS}) of the IR2125 increases with increasing temperature.
- The 100k 1kW resistor should be sized according the maximum supply current at the high side of the IR2125, the minimum operating power supply voltage and the timing requirements.

CONCLUSION

This simple, inexpensive charge pump circuit overcomes the maximum on-time limitation of the bootstrap circuit. The circuit presented above utilizes the advantages of the bootstrap and charge pump technique providing excellent switching speed and steady state operation allowing the use of an N-channel MOS-gated power device as a high-side switch. This improves system efficiency, expands voltage range, and reduces the cost of the power device required.

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