

## IGBT DRIVE USING MOSFET GATE DRIVERS

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### IGBT Drive Requirements

Insulated gate bipolar transistors (IGBTs) are gaining considerable use in circuits requiring high voltage and current at moderate switching frequencies. Typically these circuits are in motor control, uninterruptible power supply and other similar inverter applications. Much of the IGBTs popularity stems from its simple MOSFET-like gate drive requirement. In comparison to bipolar transistors which were formally used in such designs, the IGBT offers a considerable reduction in both size and complexity of the drive circuitry. Recent improvements in IGBT switching speed has yielded devices suitable for power supply applications, thus IGBTs will compete with MOSFETs for certain high voltage applications as well. Many designers have therefore turned to MOSFET drivers for their IGBT drive requirements.

opposing devices can occur in such circuits, often with catastrophic results if proper gate drive and layout precautions are not followed. This behavior is caused by parasitic collector to gate (miller) capacitance, effectively forming a capacitive divider with the gate to emitter capacitance and thus inducing a gate to emitter voltage as illustrated in figure 1.

When high off-state  $dv/dt$  is not present, the IGBT can be driven like a MOSFET using any of the gate drive circuits in the UC37XX family as well as from the drivers internal to many switching power supply controllers. Normally 15 volts is applied gate to emitter during the on-state to minimize saturation voltage. The gate resistor or gate drive current directly controls IGBT turn-on, however turn-off is partially governed by minority carrier behavior and is less effected by gate drive.

There are several techniques which can be employed to eliminate simultaneous conduction when high off-state  $dv/dt$  is present. The most important technique, which should always be employed, is a Kelvin connection between the IGBT emitter and the driver's ground. High  $di/dt$  present in the emitter circuit can cause substantial transient voltages to develop in the gate drive circuit if it is not properly referenced. The Kelvin drive connection also minimizes the effective driver impedance for maximum attenuation of the  $dv/dt$  induced gate voltage. This requirement adds complication to driving multiple ground referenced IGBTs due to finite ground circuit impedance. Substantial voltages may develop across the ground impedance during switching, requiring level shift or isolation circuitry at the command signal to allow Kelvin drive circuit connections.

### Bipolar Gate Driver

A Kelvin connected unipolar driver may often be adequate at lower switching speeds, however negative gate bias must be applied during the off-state to utilize the IGBT at higher rates. This becomes apparent when one considers that the gate to emitter threshold voltage drops to approximately 1.4 volts at high temperature. With high  $dv/dt$  at the collector, a very low and impractical drive

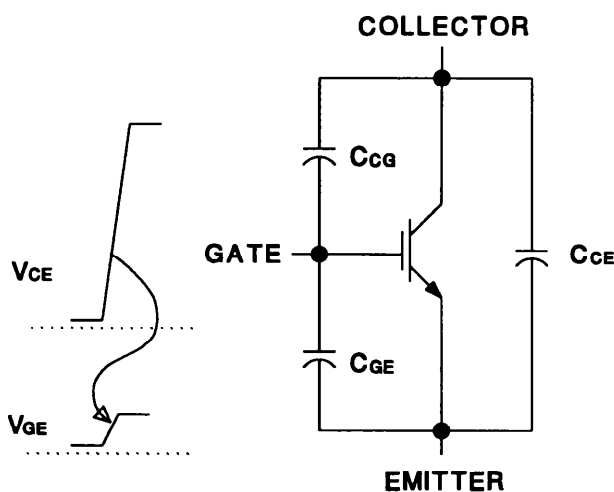


Figure 1. High  $dv/dt$  at the collector couples to the gate through parasitic capacitance.

IGBT drive requirements can be divided into two basic application categories: Those that do not apply high  $dv/dt$  to the collector/emitter of the IGBT when it is off, and those that do. Examples of the former are buck regulators and forward converters, where only one switch is employed or multiple switches are activated synchronously. High  $dv/dt$  is applied during the off-state in most bridge circuits such as inverters and motor controllers, when opposing devices are turned on. Simultaneous conduction of

impedance is required to assure that the device remains off. By utilizing a negative turn-off bias, an adequate voltage margin is easily achieved, allowing the use of a more practical gate impedance. Fortunately most gate drivers have sufficient voltage capability to be used with bipolar

insufficient supply voltage is present. The positive supply, +Vcc, is normally 15 to 16 volts and the negative supply, -VEE, typically ranges between -5 and -15 volts depending on circuit conditions. A PNP level shift circuit references the drive signal to ground. Opto-couplers are also commonly employed, and may be interfaced directly to the gate driver by referencing the signal to the negative supply. Note that this is a very demanding application for optocouplers, and only devices rated for high CMRR should be used.

Isolated Gate Driver

A bipolar IGBT gate driver with over-current protection can be implemented using the UC3724/UC3725 isolated gate driver pair as shown in figure 3. The UC3724/UC3725 transmits both power and signal across a small pulse transformer, thereby achieving low cost, high voltage isolation. An additional transformer winding develops a negative voltage, providing a bipolar supply for the UC3708. The UC3724/UC3725 can also be used for circuits which do not require negative turn-off bias by simply eliminating the negative supply and external driver, and using the UC3725 to drive the IGBT gate directly. Application note U-127 covers the UC3724/UC3725 in depth.

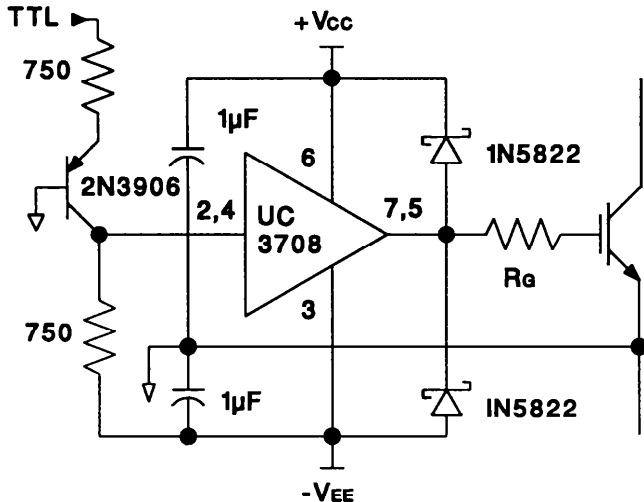


Figure 2. Bipolar IGBT gate drive using the U3708

power supplies. The UC3708 shown in figure 2 can deliver up to 6 amps peak with both output's paralleled, and is particularly suited to driving IGBTs. For added reliability during power sequencing, its output's "self bias", actively sinking current when

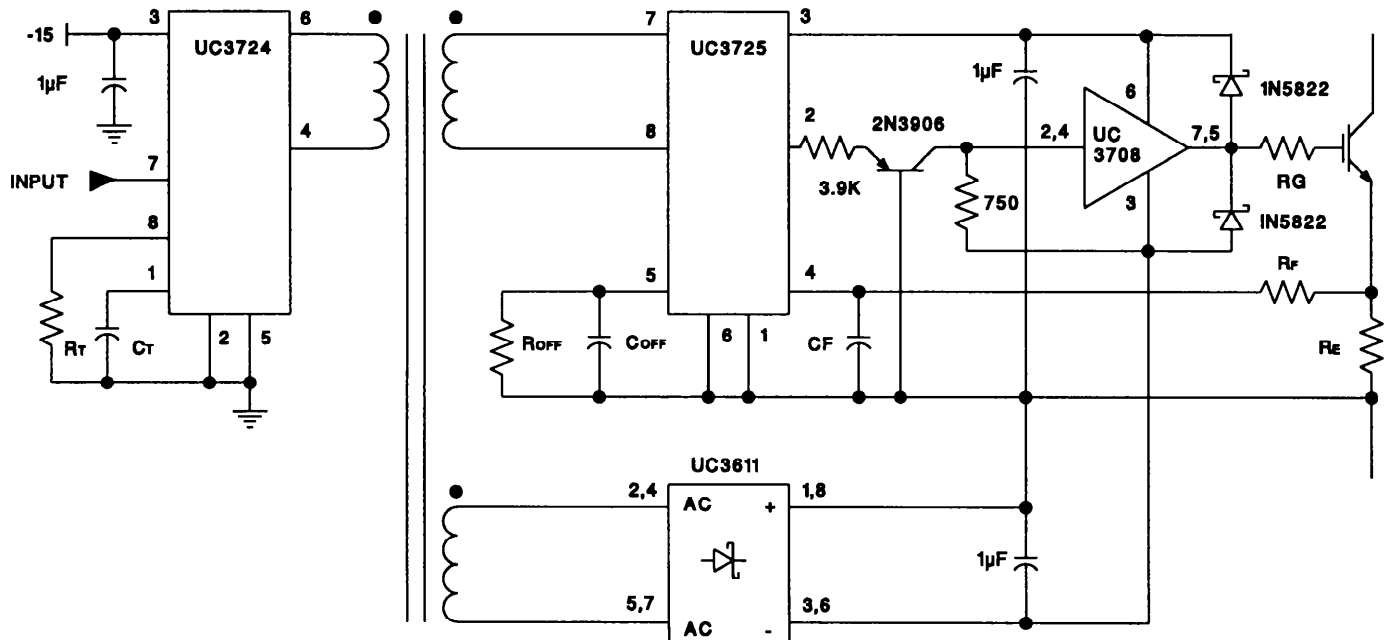


Figure 3. Power and signal are coupled to the UC3708 through the UC3724 / UC3725 Isolated Gate Driver Pair.