A simple high-voltage MOSFET inverter solves the problem of driving a high-side MOSFET, using a low-voltage transistor, $Q_1$, and a special arrangement involving $D_6$ (Figure 1). This inverter is much faster than those that optocouplers drive, so dead-time problems are minimal. The inverter has the usual blocking diodes $D_4$ and $D_6$, and the parallel diodes $D_5$ and $D_8$. $Q_3$ provides the turn-off signal to $Q_2$. When $Q_3$ turns on, $Q_2$'s gate short-circuits to ground through $R_4$. $R_4$ limits current and dampens oscillations. $Q_1$'s gate discharges quickly; only the value of $R_4$ limits discharge time. $Q_1$ stays off, thanks to $R_2$, and $C_3$ charges to 12V through $D_2$. The gate pulse creates a current through $C_4$, and $D_3$ protects the base-emitter junction of $Q_1$.

In the turn-on of $Q_2$, the following scenario occurs: When the control input, PWM, goes low, $Q_3$ quickly turns off, thanks to $D_7$. A displacement current, $C_4 \times dV/dt$, flows through $C_4$ to the base of $Q_1$. $Q_1$ charges the output capacitance of $Q_3$ and the gate capacitance of $Q_2$, and $Q_2$ turns on. $C_3$ supplies the collector current. If the period is long, $Q_1$ keeps conducting and compensating the leakage of $Q_3$. If $D_6$ were a Schottky diode, which is leaky, you would have to reduce the value of $R_4$. A short cross-conduction period exists between the two MOSFETs, a phenomenon that is more apparent when $Q_3$ turns off and $Q_2$ turns on. A small inductor, $L_1$, in series with the main supply limits the current spikes. The inductor needs a snubber comprising $D_1$, $R_1$, and $C_2$. Note that the inductor value is conservative and can be smaller.

The values are for a 370W, three-phase inverter with 150% overload capacity. If you change the MOSFET, the value of $C_4$ has to change according to the total gate charge plus the output capacitance of $Q_3$, which is much lower and, in fact, negligible. $Q_1$ amplifies the capacitor current, so $C_4$ is proportional to $Q_1 \times h_{FE1}$. Make $C_4$'s value no higher than necessary, because the base current in $Q_1$ would be too high. To obtain all the speed advantages of the circuit, the PWM signal should be able to quickly drive $Q_3$. If necessary, you can use a buffer circuit (Figure 2). You can drive the circuit with a single CMOS gate. The circuit in Figure 1 is probably the simplest high-voltage inverter you can design. It has served in thousands of three-phase motor drives from 0.37 to 0.75 kW.

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