Standard Gate-Driver Optocouplers

AN-3009/D

HOW DOES A STANDARD GATE−DRIVER OPTOCOUPLER WORK?

The FOD31xx family of gate drivers functions as a power buffer to control the gate of a power MOSFET or IGBT. It is designed to supply the peak charging current required by the MOSFET or IGBT's gate input to turn the device ON. It does this by providing a positive voltage (V_{OH}) to the power semiconductor's gate. Turning the MOSFET or IGBT OFF is accomplished by pulling the gate of the driven device to zero voltage (V_{OL}) or lower.

Many power control applications use a "totem pole" high− and low−side connection of two or more series−connected power semiconductors. The high−side N−channel MOSFET drain is connected to a positive (+) terminal of a supply and its source is connected to the drain of the low−side transistor. The source of the low−side transistor is connected to the negative (−) side of the system supply. One side of the driven load is connected at the common node of the high−side and low−side transistors. Proper control of the high−side and low−side transistors requires that neither transistor is ON or conducting at the same time. The current through these series high−side and low−side devices is called "shoot−through" current. Shoot−through current wastes power and can cause damage to the high− and low−side transistors.

The most common technique to eliminate shoot−through There are three power supplies in a typical inverter application. The first is a logic supply (+3.3 V or +5 V or +10 V). The second is an isolated low and high side driver supply (+20 V FOD3182, +25 V FOD3120). The third is a high−voltage supply to power the MOSFETs / IGBTs. To minimize any impact of the bias supply stabilization time, one solution is to control the sequence of power supply activation:

- First: logic supply − initial condition, LED current = 0 mA, LED OFF.
- Second: isolated low− and high−side driver supply, $V_O = V_O = 0$ V, power MOSFETS OFF.
- Third: high−voltage supply to power MOSFETS.

The turn−on sequence delay should accommodate power−on reset for logic control and bootstrap charge time for the driver isolated supply.

LED Drive

The peak forward current, $I_{F(peak)}$, is <1 A (1 s, 300 pps). The recommended operational current is 10 mA to 16 mA. The rate of current rise is less than 250 ns. The fast rate of LED−current rise minimizes propagation delay and output switching jitter.

Power Supply Considerations

The FOD31xx products are high−gain (23 db), high−power−output, optical amplifiers. They require a power supply with a low output impedance over the range of DC to 40 MHz. Using low−ESR bypass capacitors and a signal ground plane helps minimize self−induced power−supply noise and degraded output rise and fall times.

Propagation Delay on the FOD3182

Figure 2 shows that the propagation delay is independent of the load capacitance and that the typical pulse−width distortion, PWD, is less than 40 ns.

the traditional "series" switching connection. A shoot−through fault can result if the high−side gate drive is momentarily turned ON while the low−side switch is ON. Figure 10 shows the CMT drawing current through the high−side's LED. The magnitude of the LED current is dependent on: CMT's dv/dt, assembly input−output parasitic capacitance, and the impedances surrounding the LED. These impedances include the LED current−setting resistor, R2, and the C_{CE} of T1 driving the LED.

An inverter used to generate a 240 V_{AC} power source may create an LED current of 3 mApk with a pulse width of approximately 100 ns. This pulse is sufficient to activate the high−side driver and cause a shoot−through fault. The susceptibility to this fault can be minimized by reducing the off−state impedances surrounding the LED. These lower impedances provide an alternative path for the CMT current caused by the −dv/dt switching action.

The −dv/dt switching action, shown in Figure 9, creates a CMT also seen by the low−side IGBT driver. This transient attempts to draw current through the low−side LED. This transient has minimal effect. The LED is already ON, so forcing more LED current only ensures the correct low−side switching action and the incremental CMT current is shunted to GND1 via transistor T2.

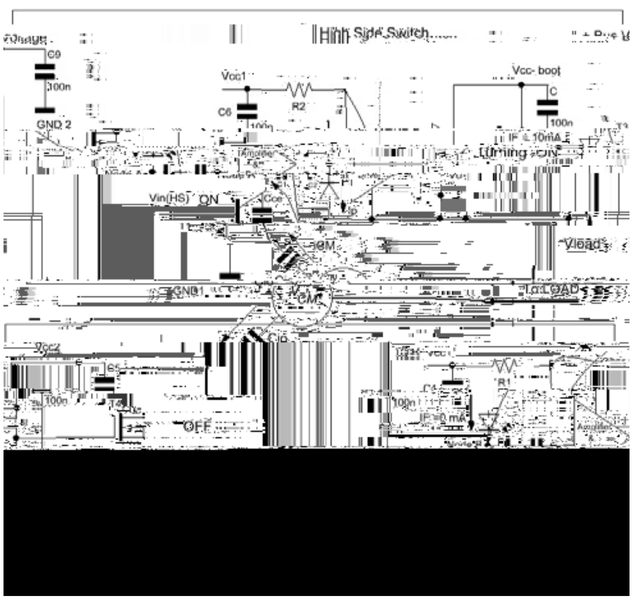

Figure 10. Positive dv/dt − High−Side Switch Turning ON

A positive dv/dt is created when the high−side switch turns ON. Figure 10 shows the effect that this +dv/dt has on the OFF low−side switch. The positive CMT can draw current through the OFF LED in the low−side driver. If the dv/dt is large enough, this CMT can momentarily force the low−side IGBT driver to turn ON. This positive CMT is also seen by the high−side switch. This dv/dt typ

External or self−generated common−mode and normal−mode noise can cause operational malfunction.

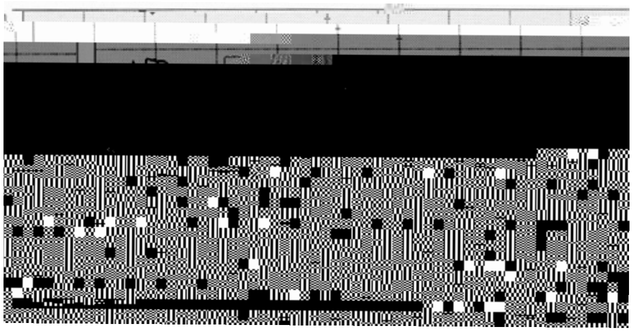

Figure 14. FOD3120 Output Current and Voltage

Figure 14 shows the output current waveform when the

Assumptions:

V_{CC} = 30 V
C_{gs} = 2730 pF
R_{ds} = 1.0
r = r1 + $R_{DS(ON)}$
r1 = R_{GS}(c_{GS}−ESR) = 25

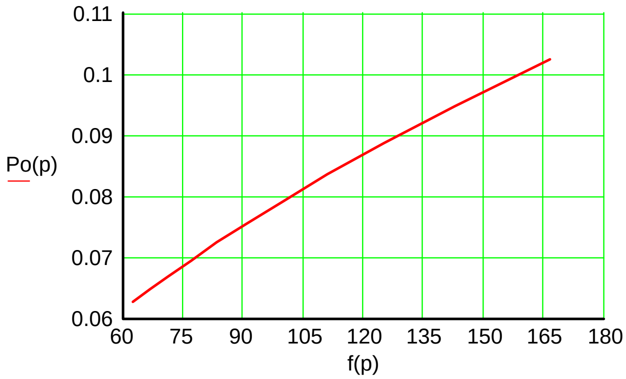

Figure 17. Output Power Dissipation (W) vs. Operation Frequency (kHz)

Figure 17 illustrates that if the $R_{DS(ON)}$ is equal to 1.0 ; driving the FQA9N90C_F109 MOSFET at 100°C and V_{CC}