

APPLICATION DATA SHEET



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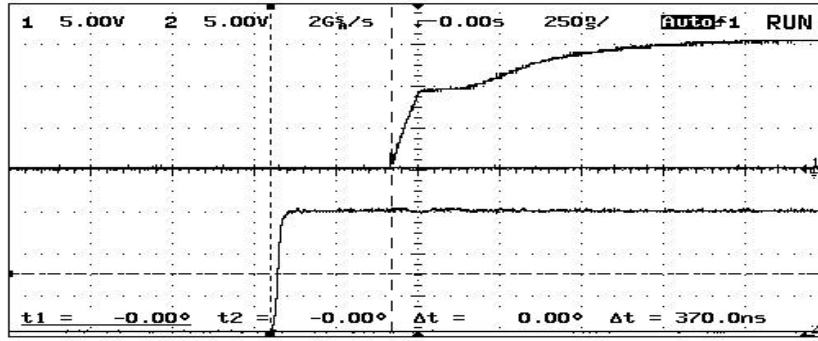
IGBT DUAL OPTO DRIVE

The intelligent dual drive is a universal drive designed for switching any power IGBT up to 400 AMPS and 1200 VOLTS. The high output current capability, up to 12 Amps peak, makes it ideal for driving large IGBT modules with no need for other components or interface stages.

INPUT STAGE

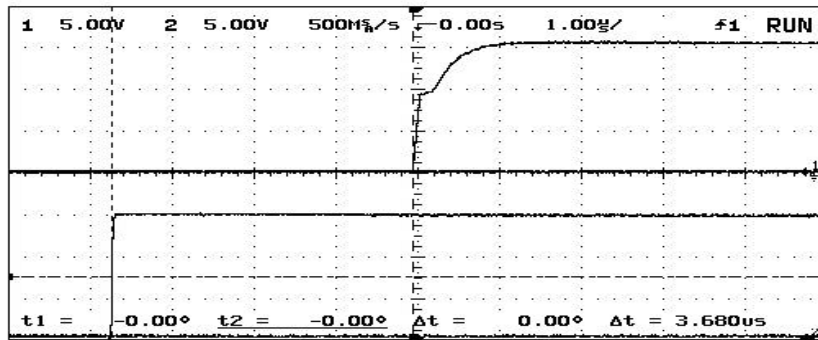
The input side has a SCHMITT trigger to eliminate spurious pulses and pull down resistors; thus, no extra protection is needed for an unconnected input. The input level can be 5 or 15 volts selectable by jumpers J1 and J2. The top-bottom interlock circuitry prevents two IGBT's from the same leg to be turned on at the same time. Due to the turn on/off times and rising/falling times of the power semiconductors one has to delay the turn-on of one IGBT before the gate charge of the other one is completely removed. The typical dead time is 3 μ sec but it can be adjusted to any value between 0 to 10 μ sec. Typically the user has to select a dead time that is longer than the turn-off delay time plus falling time of the IGBT driven. Figures 1,2 and 3 depict output signal to the IGBT gate versus input signal to the drive in three different situations:

- a) In figure 1 the dead time is set to zero therefore the propagation time can be measured. This is the absolute minimum delay time between the input and the output of the drive.
- b) In figure 2 the dead time is set to 3.3 μ sec and in this case the total turn-on delay time is the sum of the propagation time plus the desired dead time.
- c) In figure 3 the dead-time is also set to 3.3 μ sec and the total turn-off delay is given by the propagation time only while the desired value of the dead-time has no influence



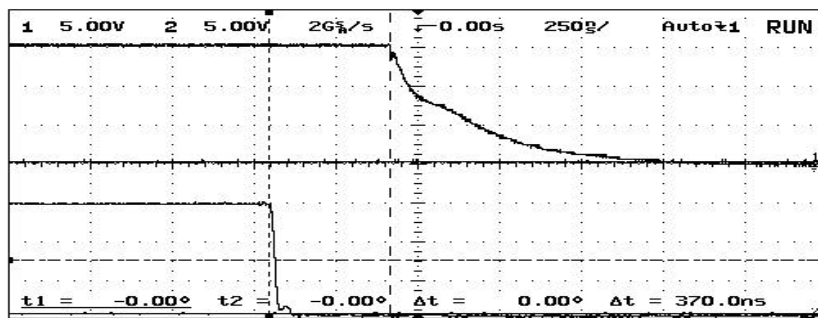
TOP : GATE-EMITTER VOLTAGE
 BOTTOM : INPUT PULSE TO THE DRIVE
 DEAD-TIME : 0 uSEC
 PROPAGATION TIME : 370 nSEC

Figure 1



TOP : GATE-EMITTER VOLTAGE
 BOTTOM : INPUT PULSE TO THE DRIVE
 DEAD-TIME : 3.3 uSEC
 PROPAGATION DRIVE : approx 380nSEC

Figure 2



TOP : GATE-EMITTER VOLTAGE
 BOTTOM : INPUT PULSE TO THE DRIVE
 DEAD-TIME : 3.3 uSEC
 PROPAGATION TIME : approx 370nSEC
 NOTE THAT THE DEAD-TIME HAS NO INFLUENCE FOR THE TURN-OFF PROCESS

Figure 3

Power Supply and DC/DC Converter

The input voltage of the drive is 15 volts +/-5%. It should be emphasized that this voltage may have a common ground with the PWM pulses or it may be completely isolated from the power supply that is being used for the circuitry that generates the pulses. When there is no isolation between the two voltages mentioned above, the drive generates internally a 5V signal needed for the logic and primary side of the optocouplers. The same input voltage is applied to a DC/DC converter that provides two isolated voltages for the two secondary sides of the drive. When the user has a digital system to generate the PWM pulses then the same 5V signal can be used for the primary side of the drive and the +15 volts input is only used to develop the two isolated secondary side voltages; thus, there is a double isolation between the control and the power side.

The maximum input current drawn is considered when the input voltage is used for generating both the internal 5V and the secondary side voltages.

SHORT CIRCUIT PROTECTION

The drive provides short circuit protection for both IGBT's of the half bridge by monitoring the collector-emitter voltage of each device (also known as desaturation protection). When the IGBT is on, the voltage drop between collector-emitter is low (typically less than 3.5 volts for IGBT's up to 400Amps/1200 Volts). When the IGBT is off, this voltage is very high, and typically equals the voltage of the DC-link stage of the power converter. If the drive senses that the voltage across the IGBT is greater than 7 volts when the transistor is commanded on, then a short circuit condition has been detected and the transistor is immediately switched off with a FAULT signal being reported back to the control side within 5 μ sec. In normal operation, the FAULT is at high level (approximately 5V); when a short circuit is detected the FAULT signal goes low. Once a short circuit condition has been detected, the transistor remains latched in the off state until the RESET input is pulled to ground. Note that the RESET line is connected through a resistor to 5V. In the case of a failure of the secondary side voltage, a 20Kohms and 15V Transzorb are connected across the gate-emitter to protect the IGBT. Note that the desaturation protection must remain disabled for a very short period of time right after the turn-on command to allow the voltage to fall below the 7V threshold. This blanking time is internally set to approx 2.8 μ sec; it is not recommended that this be changed since it should cover all the applications for which the drive is designed.

Undervoltage Lockout Feature

Another feature of the drive is the under-voltage lockout that is designed to prevent the application of insufficient gate voltage to the IGBT. This could be dangerous, as it would drive the IGBT out of saturation and into the linear operation where the losses are very high and quickly overheat. The undervoltage lockout feature causes the output to be clamped when the secondary side voltage from the DC/DC converter drops below 15 volts.

TURN ON/TURN OFF RESISTORS

In order to optimize the turn on and turn off speed of a particular IGBT, the user must carefully choose the proper turn on/turn off resistors. The values of these resistors determine the maximum amount of gate charging/discharging current and should ensure correct and safe commutation of the IGBT. When calculating the peak charging/discharging currents for a particular IGBT the user must observe the following:

1. The maximum peak output current is 12 Amps/channel
2. The maximum output average current is 45ma/channel
3. For a particular application, the user must determine from the IGBT's data sheet (the gate charge characteristic Q_{GE} versus gate voltage V_{GE}) for a given DC link operation and at 15 volts gate. This is the maximum gate charge Q_{GATE} . For a given switching frequency f (Khz) the output average current can be calculated as follows:

$$I_{OUT-AVERAGE} \text{ (mA)} = f \text{ (Khz)} * Q_{GATE} \text{ (nC)}$$

This value must be less than 45mA for the drive to be able to correctly operate.

4. The equivalent input gate emitter capacitance of the IGBT is next calculated as

$$C_{IN} = Q_{GATE}/V_{GE} , \text{ where } V_{GE} = 15 \text{ Volts in our case}$$

It is important to note that this is the true capacitance seen by the drive during the commutation process and it should not be confused with C_{ISS} specified on the IGBT data sheet because this is the input capacitance measured with a very small collector voltage (typically less than 30 Volts) and does not take into account the internal feedback effect that takes place during switching (the MILLER effect). Only if a resonant zero voltage switching topology is used can the C_{ISS} be used as equivalent input capacitance for calculating the required power to drive the IGBT.

1. The total power used to for driving the IGBT can now be calculated:

$$P = f \text{ (KHz)} * C_{IN} * V_{GE}^2 \text{ (W)} \quad \text{where } V_{GE} = 15 \text{ Volts}$$

2. Next the gate resistor must be selected $R_{GATE} = V_{GE}/I_{PEAK}$

$$\text{Clearly we can write } R_{GATE}(\text{MIN}) = V_{GE}/I_{PEAK}(\text{MAX}), \\ \text{where } V_{GE} = 15 \text{ Volts and } I_{PEAK}(\text{MAX}) = 12 \text{ Amps}$$

Note that there is a provision for using different turn on /turn off resistors, however the equivalent turn off resistor is also influenced by the turn on resistor. The turn on resistors are R7 and R16 respectively while the turn-off resistors are R8 and R17. The equivalent turn off resistors is R7 in parallel with R8 and R16 in parallel with R17, respectively. For correct operation the turn on and the equivalent turn off resistors should limit the peak

output current to 12A. If the same peak current is to be used for both turn on and turn off, then the turn off resistor should not be mounted.

GUIDELINES FOR CHOOSING THE GATE RESISTORS

When selecting the gate turn on and turn off resistors, the user tries to charge/discharge the IGBT's gate as quickly as possible in order to reduce the switching losses. However it is important to acknowledge that extremely fast turn on of the IGBT will cause a high overcurrent due to the turn-off behavior of the freewheeling diode of the other IGBT in the arm. The limited di/dt capability of the free-wheeling diode is usually the main factor that dictates the maximum turn-on speed of a given IGBT; often in trying to speed up the IGBT switching time the diode will fail in overvoltage or the losses will increase because the diode cannot turn off fast enough and therefore a short circuit path is being developed between the IGBT that turns on and the free-wheeling diode that turns off. Another important aspect is to minimize the parasitic inductance in the DC link circuit in order to keep the turn off overvoltage of the IGBT within the maximum value specified in the data sheet of the IGBT. Low inductance snubber capacitors and low inductance distributed bus bar layout are mandatory at current levels above 50 Amps. Careful analysis and correct interpretation of both drive and IGBT's data sheets are required in order to correctly choose the gate resistor values. Figures 4,5 and 6 depict typical waveforms when switching an IGBT:

- In figure 4 the gate current charging is displayed along the gate emitter voltage. Note that the current peak is a function of the gate resistor.
- In figure 5 the collector-emitter and gate emitter voltage are displayed for the turn-on situation of an IGBT SKM 150 GA.
- In figure 6 the collector-emitter and gate emitter voltage are displayed for the turn-off situation of an IGBT SKM 150 GA.

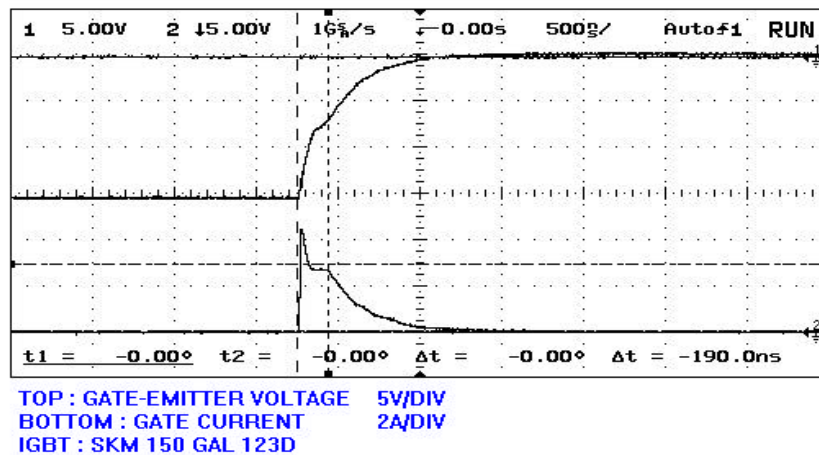


Figure 4

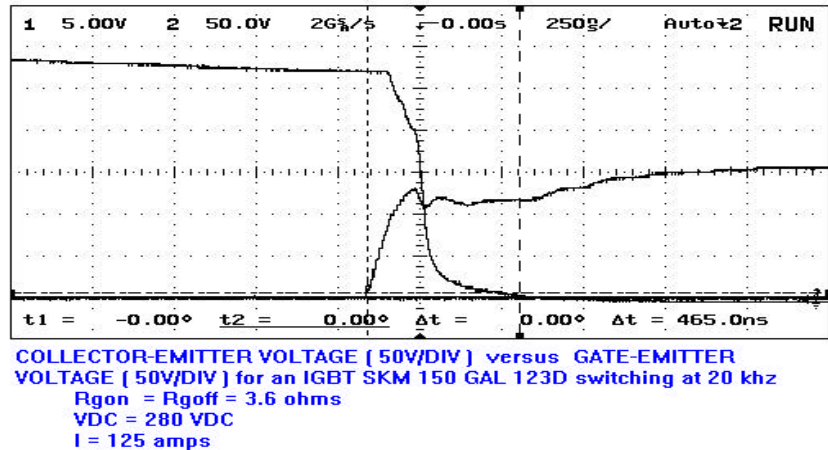


Figure 5

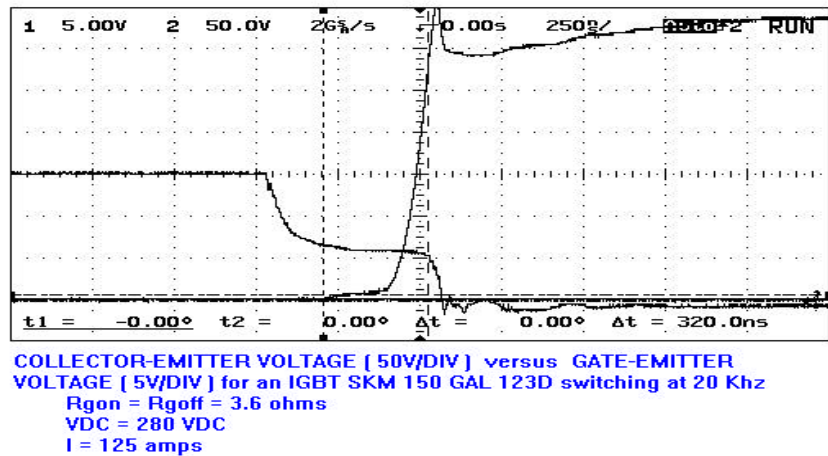


Figure 6

ELECTRICAL CHARACTERISTICS (Ta = 25 C)

Input supply voltage: 15 Volts +/- 5%

Maximum input current (for an output average current of 45 ma on each channel):
 750mA

Output average current: 45 mA for each channel

Output peak current: 12 Amps

Minimum gate turn-on resistance: 1.25 ohm

Minimum gate turn-off resistance: see step 6 above about calculating the gate resistors

Collector-emitter voltage sense: 1200 Volts

Reference for VCE monitoring: 7 Volts

Error output – input propagation time: 5 ?sec

Input threshold voltage high (min): 12 Volts (for 15V input)

2.4 Volts (for 5V)

Input threshold voltage low (max): 3.6 Volts (for 15V input)
0.5 Volts (for 5V)

Common mode rejection: typical 30 Kvolts/? sec
min 15 Kvolts/? sec

Input–output momentary withstand voltage: 3750 volts rms (1min, RH<50%, T = 25C)

Capacitance input – output: less than 5 pF

Dead-time range: 0 to 10 ? sec (higher values are also possible)
3.5 ? sec standard factory preset

Propagation delay time: min 100 nsec
typical 300nsec
maximum 500nsec

(NOTE: The above delay times are considered for the case with no dead time)

Operating temperature: -40 to 100 C

Storage temperature: -40 to 100 C

Turn on output voltage: 15 Volts

Turn off output voltage: 0 Volts

DRIVE CONNECTORS

1. INPUT CONNECTOR (MICROFIT JUNIOR P/N 43025-1000):

Pin 1	First PWM pulse
Pins 2,3,4	PWM pulse ground
Pin 5	Second PWM pulse
Pin 6	5 VDC (internally generated or external)
Pin 7	Input supply ground
Pin 8	RESET (input)
Pin 9	FAULT (output)
Pin 10	Input supply (+ 15 volts)

2. OUTPUT CONNECTORS (MICROFIT JUNIOR P/N 43645-0600)

Pin 1:	IGBT's emitter
Pin 2:	IGBT's gate
Pins 3,4,5	Not connected
Pin 6:	IGBT's collector

3. TERMINALS: Female-tin (MOLEX P/N 43030-0007) Female-gold (MOLEX P/N 43030-0009)

IMPORTANT NOTES:

- 1) By default J1 and J2 jumpers are OFF enabling 15V PWM input pulses. If the PWM input pulses are 5V level, then jumper J1 and J2.
- 2) The default dead time value is 3.5µs but any value is possible. For different values please consult factory.
- 3) Pin 6 of P1 is an internally generated 5V. Do not connect any external voltage to this pin.
- 4) The FAULT signal is 5V when there is no error and it becomes less than 0.5V when a short circuit is detected.
- 5) In the event of a short circuit the drive will latch in the off position. The user must use the FAULT signal (pin 9 from P1) and disable any other drives in the circuit, for instance the other two drives of a three-phase converter, from the controller. The digital controller should then reset the corresponding drive by pulling the RESET line (pin 8 from P1) to ground and normal operation can resume.

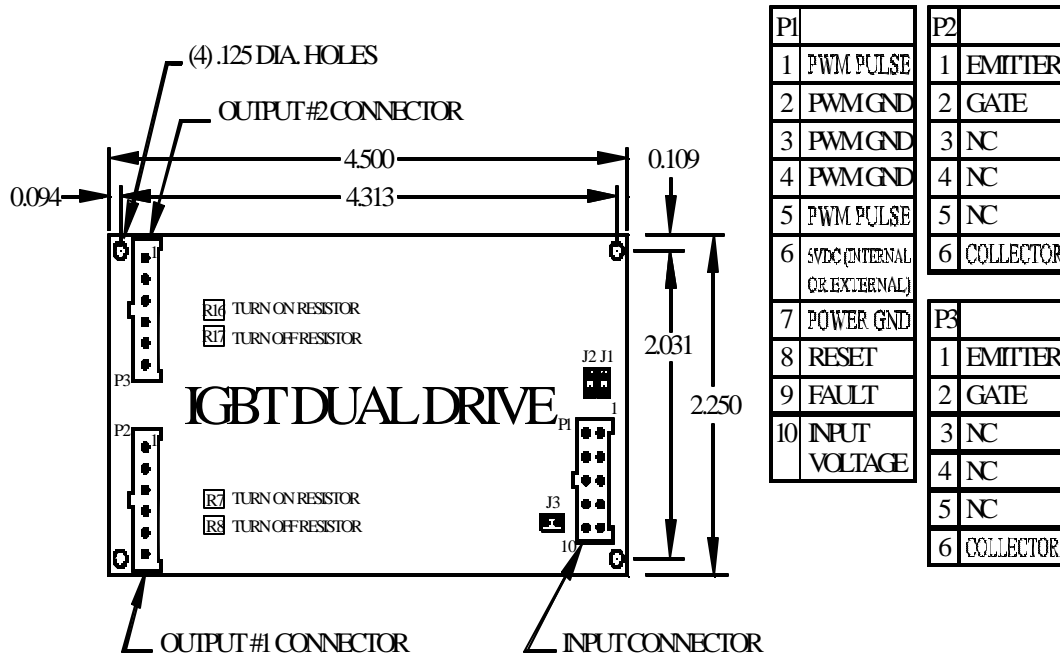


Figure 7

A typical one-line diagram showing the interconnections between a controller and the dual IGBT driver is depicted in figure 8. For a typical three-phase power converter three IGBT dual drives can be used with a digital controller such as 331 DSP CONTROLLER as shown in figure 9.

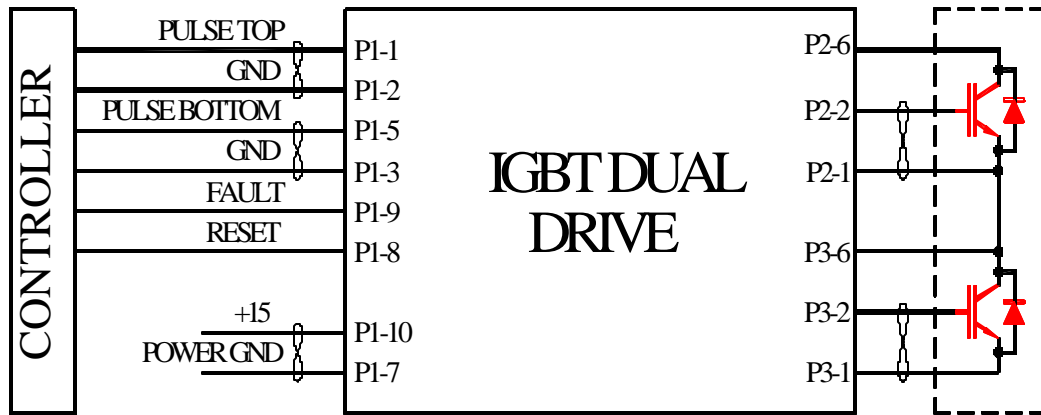


Figure 8

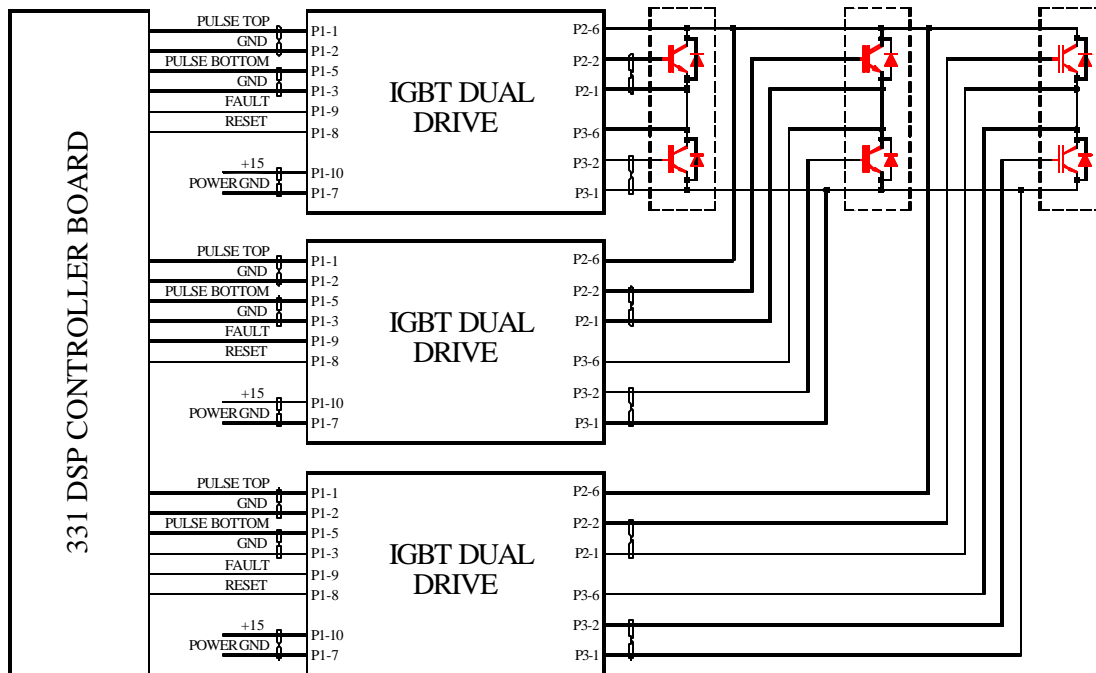


Figure 9