

Data Sheet	August 2003
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# 27A, 600V, UFS Series N-Channel IGBTs

This family of MOS gated high voltage switching devices combine the best features of MOSFETs and bipolar transistors. These devices have the high input impedance of a MOSFET and the low on-state conduction loss of a bipolar transistor. The much lower on-state voltage drop varies only moderately between 25°C and 150°C.

The IGBT is ideal for many high voltage switching applications operating at moderate frequencies where low conduction losses are essential, such as: AC and DC motor controls, power supplies and drivers for solenoids, relays and contactors.

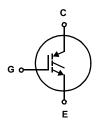
Formerly developmental type TA49171.

## **Ordering Information**

PART NUMBER	PACKAGE	BRAND
HGTG12N60B3	TO-247	G12N60B3

NOTE: When ordering, use the entire part number.

# Symbol

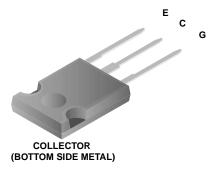


### **Features**

- 27A, 600V,  $T_C = 25^{\circ}C$
- · 600V Switching SOA Capability
- · Short Circuit Rating
- Low Conduction Loss

## **Packaging**

**JEDEC STYLE TO-247** 



FAIRC	HILD CORPORA	TION IGBT PROD	UCT IS COVERE	D BY ONE OR MO	RE OF THE FOLI	OWING U.S. PAT	TENTS
4,364,073	4,417,385	4,430,792	4,443,931	4,466,176	4,516,143	4,532,534	4,587,713
4,598,461	4,605,948	4,620,211	4,631,564	4,639,754	4,639,762	4,641,162	4,644,637
4,682,195	4,684,413	4,694,313	4,717,679	4,743,952	4,783,690	4,794,432	4,801,986
4,803,533	4,809,045	4,809,047	4,810,665	4,823,176	4,837,606	4,860,080	4,883,767
4,888,627	4,890,143	4,901,127	4,904,609	4,933,740	4,963,951	4,969,027	

### HGTG12N60B3

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## **Absolute Maximum Ratings** $T_C = 25^{\circ}C$ , Unless Otherwise Specified

	HGTG12N60B3	UNITS
Collector to Emitter Voltage	600	V
Collector Current ContinuousI <sub>C25</sub>	27	Α
At $T_C = 110^{\circ}C$	12	Α
Collector Current Pulsed (Note 1)	110	Α
Gate to Emitter Voltage ContinuousV <sub>GES</sub>	±20	V
Gate to Emitter Voltage Pulsed	±30	V
Switching Safe Operating Area at T <sub>J</sub> = 150 <sup>o</sup> C (Figure 2)	96A at 600V	
Maximum Power Dissipation	104	W
Linear Derating Factor	0.83	W/oC
Reverse Voltage Avalanche Energy	100	mJ
Operating and Storage Temperature	-55 to 150	°С
Maximum Temperature for Soldering		
Leads at 0.063in (1.6mm) from Case for 10sT <sub>L</sub>	300	οС
Package Body for 10s, see Tech Brief 334	260	°C
Short Circuit Withstand Time (Note 2) at V <sub>GE</sub> = 12Vt <sub>SC</sub>	5	μs
Short Circuit Withstand Time (Note 2) at V <sub>GE</sub> = 10Vt <sub>SC</sub>	10	μs

CAUTION: Stresses above those listed in "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress only rating and operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied.

#### NOTES:

- 1. Pulse width limited by maximum junction temperature.
- 2.  $V_{CE(PK)} = 360V$ ,  $T_J = 125^{\circ}C$ ,  $R_G = 25\Omega$ .

# **Electrical Specifications** $T_C = 25^{\circ}C$ , Unless Otherwise Specified

PARAMETER	SYMBOL	TEST C	CONDITIONS	MIN	TYP	MAX	UNITS
Collector to Emitter Breakdown Voltage	BV <sub>CES</sub>	I <sub>C</sub> = 250μA, V <sub>GE</sub> = 0V		600	-	-	V
Emitter to Collector Breakdown Voltage	BV <sub>ECS</sub>	I <sub>C</sub> = -10mA, V <sub>GE</sub>	= 0V	20	-	-	V
Collector to Emitter Leakage Current	I <sub>CES</sub>	V <sub>CE</sub> = 600V	$T_{C} = 25^{\circ}C$	-	-	250	μΑ
			$T_{C} = 150^{\circ}C$	-	-	2.0	mA
Collector to Emitter Saturation Voltage	V <sub>CE(SAT)</sub>	I <sub>C</sub> = 12A	$T_{C} = 25^{\circ}C$	-	1.6	2.1	V
		V <sub>GE</sub> = 15V	$T_{C} = 150^{\circ}C$	-	1.7	2.5	V
Gate to Emitter Threshold Voltage	V <sub>GE(TH)</sub>	I <sub>C</sub> = 250μA, V <sub>CE</sub>	= V <sub>GE</sub>	4.5	4.9	6.0	V
Gate to Emitter Leakage Current	IGES	V <sub>GE</sub> = ±20V		-	-	±250	nA
Switching SOA	SSOA	$T_J = 150^{\circ}C$ , $R_G = 25\Omega$ , $V_{GE} = 15V$ $L = 100\mu H$ , $V_{CE} = 600V$		96	-	-	А
Gate to Emitter Plateau Voltage	V <sub>GEP</sub>	I <sub>C</sub> = 12A, V <sub>CE</sub> = 0.5 BV <sub>CES</sub>		-	7.3	-	V
On-State Gate Charge	Q <sub>g(ON)</sub>	$V_{CE} = 12A$ $V_{CE} = 15V$ $V_{GE} = 20V$		-	51	60	nC
				-	68	78	nC
Current Turn-On Delay Time	t <sub>d(ON)I</sub>	IGBT and Diode at $T_J = 25^{\circ}\text{C}$ $I_{CE} = 12\text{A}$ $V_{CE} = 480\text{V}$ $V_{GE} = 15\text{V}$ $R_G = 25\Omega$ L = 1mH  Test Circuit (Figure 17)		-	26	-	ns
Current Rise Time	t <sub>rl</sub>			-	23	-	ns
Current Turn-Off Delay Time	t <sub>d(OFF)I</sub>			-	150	-	ns
Current Fall Time	t <sub>fl</sub>			-	62	-	ns
Turn-On Energy (Note 4)	E <sub>ON1</sub>			-	150	-	μJ
Turn-On Energy (Note 4)	E <sub>ON2</sub>			-	304	350	μJ
Turn-Off Energy (Note 3)	E <sub>OFF</sub>			-	250	350	μJ

### HGTG12N60B3

**Electrical Specifications**  $T_C = 25^{\circ}C$ , Unless Otherwise Specified (Continued)

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNITS
Current Turn-On Delay Time	t <sub>d</sub> (ON)I	IGBT and Diode at T <sub>J</sub> = 150 <sup>o</sup> C	-	22	-	ns
Current Rise Time	t <sub>rl</sub>	I <sub>CE</sub> = 12A V <sub>CE</sub> = 480V	-	23	-	ns
Current Turn-Off Delay Time	t <sub>d</sub> (OFF)I	V <sub>GE</sub> = 15V	-	280	295	ns
Current Fall Time	t <sub>fl</sub>	$R_G = 25\Omega$ L = 1mH	-	112	175	ns
Turn-On Energy (Note 4)	E <sub>ON1</sub>	Test Circuit (Figure 17)	-	165	-	μJ
Turn-On Energy (Note 4)	E <sub>ON2</sub>		-	500	525	μЈ
Turn-Off Energy (Note 3)	E <sub>OFF</sub>		-	660	800	μЈ
Thermal Resistance Junction To Case	$R_{ heta JC}$		-	-	1.2	oC/W

#### NOTES:

- 3. Turn-Off Energy Loss (E<sub>OFF</sub>) is defined as the integral of the instantaneous power loss starting at the trailing edge of the input pulse and ending at the point where the collector current equals zero (I<sub>CE</sub> = 0A). All devices were tested per JEDEC Standard No. 24-1 Method for Measurement of Power Device Turn-Off Switching Loss. This test method produces the true total Turn-Off Energy Loss.
- 4. Values for two Turn-On loss conditions are shown for the convenience of the circuit designer. E<sub>ON1</sub> is the turn-on loss of the IGBT only. E<sub>ON2</sub> is the turn-on loss when a typical diode is used in the test circuit and the diode is at the same T<sub>J</sub> as the IGBT. The diode type is specified in Figure 17.

# Typical Performance Curves Unless Otherwise Specified

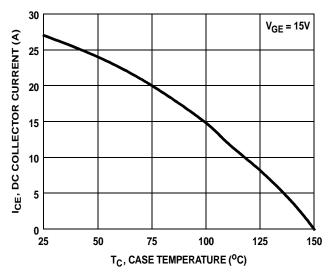


FIGURE 1. DC COLLECTOR CURRENT vs CASE TEMPERATURE

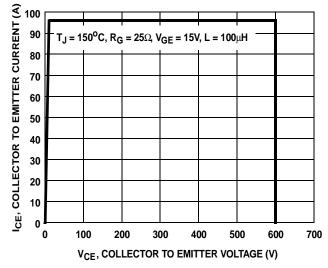


FIGURE 2. MINIMUM SWITCHING SAFE OPERATING AREA

### Typical Performance Curves Unless Otherwise Specified (Continued)

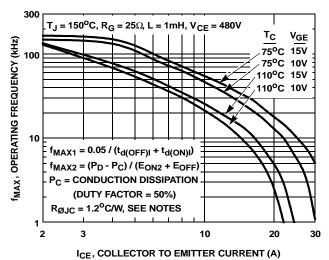


FIGURE 3. OPERATING FREQUENCY vs COLLECTOR TO EMITTER CURRENT

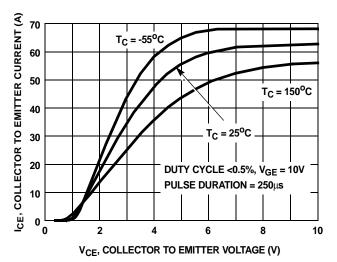


FIGURE 5. COLLECTOR TO EMITTER ON-STATE VOLTAGE

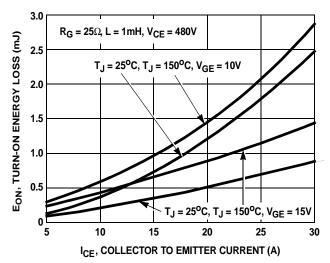


FIGURE 7. TURN-ON ENERGY LOSS vs COLLECTOR TO EMITTER CURRENT

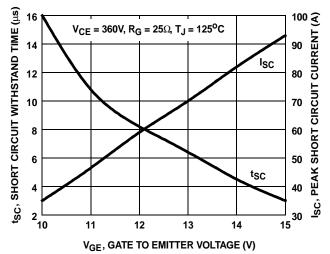


FIGURE 4. SHORT CIRCUIT WITHSTAND TIME

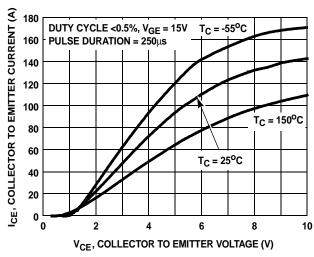


FIGURE 6. COLLECTOR TO EMITTER ON-STATE VOLTAGE

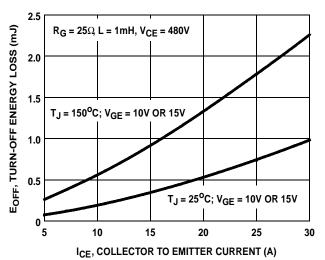


FIGURE 8. TURN-OFF ENERGY LOSS vs COLLECTOR TO EMITTER CURRENT

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## Typical Performance Curves Unless Otherwise Specified (Continued)

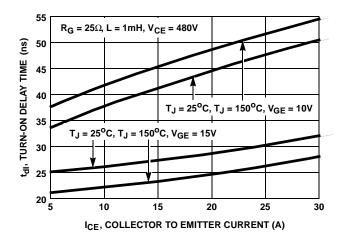


FIGURE 9. TURN-ON DELAY TIME vs COLLECTOR TO EMITTER CURRENT

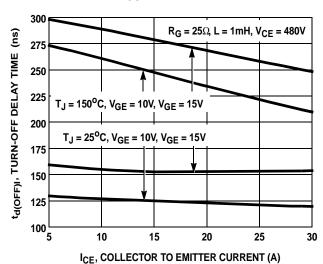
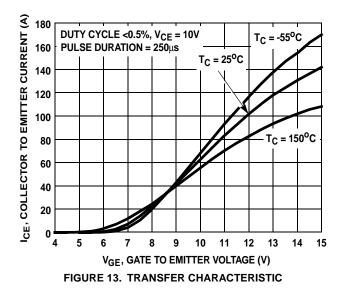


FIGURE 11. TURN-OFF DELAY TIME vs COLLECTOR TO EMITTER CURRENT



150 125  $T_J = 25^{\circ}C$ ,  $T_J = 150^{\circ}C$ ,  $V_{GE} = 10$ t<sub>rl</sub>, RISE TIME (ns) 100 75 50 25  $T_J = 25^{\circ}C$  and  $T_J = 150^{\circ}C$ ,  $V_{GE} = 15V$ 0 5 25 10 15 30 ICE, COLLECTOR TO EMITTER CURRENT (A)

FIGURE 10. TURN-ON RISE TIME vs COLLECTOR TO EMITTER CURRENT

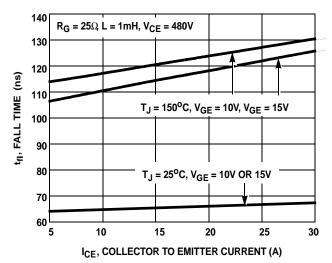


FIGURE 12. FALL TIME vs COLLECTOR TO EMITTER CURRENT

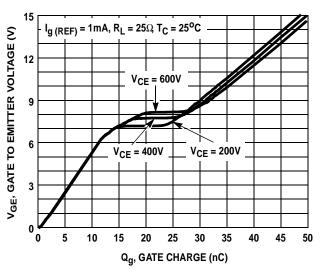


FIGURE 14. GATE CHARGE WAVEFORM

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## Typical Performance Curves Unless Otherwise Specified (Continued)

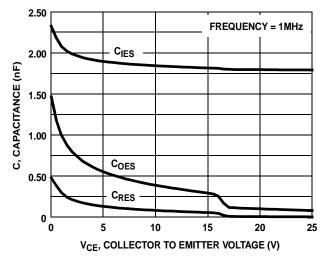


FIGURE 15. CAPACITANCE vs COLLECTOR TO EMITTER VOLTAGE

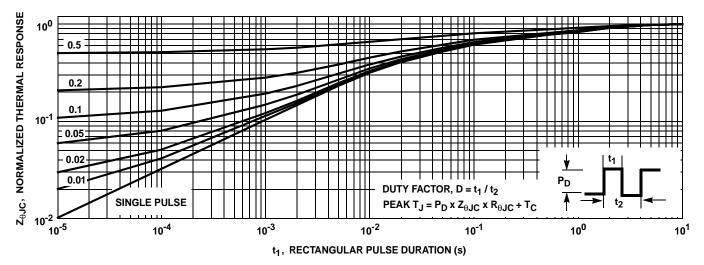


FIGURE 16. NORMALIZED TRANSIENT THERMAL RESPONSE, JUNCTION TO CASE

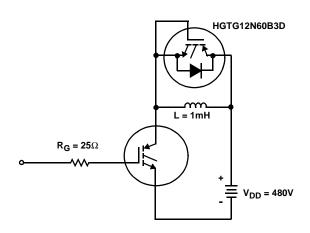


FIGURE 17. INDUCTIVE SWITCHING TEST CIRCUIT

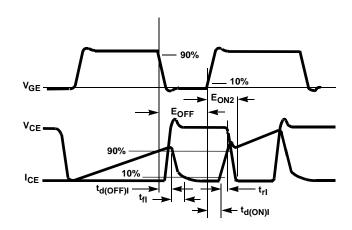


FIGURE 18. SWITCHING TEST WAVEFORMS

## Handling Precautions for IGBTs

Insulated Gate Bipolar Transistors are susceptible to gate-insulation damage by the electrostatic discharge of energy through the devices. When handling these devices, care should be exercised to assure that the static charge built in the handler's body capacitance is not discharged through the device. With proper handling and application procedures, however, IGBTs are currently being extensively used in production by numerous equipment manufacturers in military, industrial and consumer applications, with virtually no damage problems due to electrostatic discharge. IGBTs can be handled safely if the following basic precautions are taken:

- Prior to assembly into a circuit, all leads should be kept shorted together either by the use of metal shorting springs or by the insertion into conductive material such as "ECCOSORBD<sup>TM</sup> LD26" or equivalent.
- When devices are removed by hand from their carriers, the hand being used should be grounded by any suitable means - for example, with a metallic wristband.
- 3. Tips of soldering irons should be grounded.
- Devices should never be inserted into or removed from circuits with power on.
- Gate Voltage Rating Never exceed the gate-voltage rating of V<sub>GEM</sub>. Exceeding the rated V<sub>GE</sub> can result in permanent damage to the oxide layer in the gate region.
- 6. Gate Termination The gates of these devices are essentially capacitors. Circuits that leave the gate open-circuited or floating should be avoided. These conditions can result in turn-on of the device due to voltage buildup on the input capacitor due to leakage currents or pickup.
- Gate Protection These devices do not have an internal monolithic Zener diode from gate to emitter. If gate protection is required an external Zener is recommended.

## Operating Frequency Information

Operating frequency information for a typical device (Figure 3) is presented as a guide for estimating device performance for a specific application. Other typical frequency vs collector current ( $I_{CE}$ ) plots are possible using the information shown for a typical unit in Figures 5, 6, 7, 8, 9 and 11. The operating frequency plot (Figure 3) of a typical device shows  $f_{MAX1}$  or  $f_{MAX2}$ ; whichever is smaller at each point. The information is based on measurements of a typical device and is bounded by the maximum rated junction temperature.

 $f_{MAX1}$  is defined by  $f_{MAX1}=0.05/(t_{d(OFF)I}+t_{d(ON)I}).$  Deadtime (the denominator) has been arbitrarily held to 10% of the on-state time for a 50% duty factor. Other definitions are possible.  $t_{d(OFF)I}$  and  $t_{d(ON)I}$  are defined in Figure 18. Device turn-off delay can establish an additional frequency limiting condition for an application other than  $T_{JM}.\ t_{d(OFF)I}$  is important when controlling output ripple under a lightly loaded condition.

 $f_{MAX2}$  is defined by  $f_{MAX2} = (P_D - P_C)/(E_{OFF} + E_{ON2}).$  The allowable dissipation  $(P_D)$  is defined by  $P_D = (T_{JM} - T_C)/R_{\theta JC}.$  The sum of device switching and conduction losses must not exceed  $P_D.$  A 50% duty factor was used (Figure 3) and the conduction losses  $(P_C)$  are approximated by  $P_C = (V_{CE} \times I_{CE})/2.$ 

 $E_{ON2}$  and  $E_{OFF}$  are defined in the switching waveforms shown in Figure 18.  $E_{ON2}$  is the integral of the instantaneous power loss (I\_CE x V\_CE) during turn-on and  $E_{OFF}$  is the integral of the instantaneous power loss (I\_CE x V\_CE) during turn-off. All tail losses are included in the calculation for  $E_{OFF}$ ; i.e., the collector current equals zero (I\_CF = 0).

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