

# UFS Series N-Channel IGBT with Anti-Parallel Hyperfast Diode

24 A, 600 V



## HGTG12N60C3D

The HGTG12N60C3D is a MOS gated high voltage switching device combining the best features of MOSFETs and bipolar transistors. The device has 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 used is the development type TA49123. The diode used in anti parallel with the IGBT is the development type TA49061.

This IGBT is ideal for many high voltage switching applications operating at moderate frequencies where low conduction losses are essential.

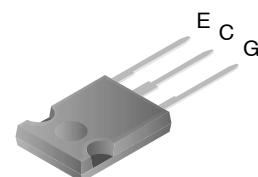
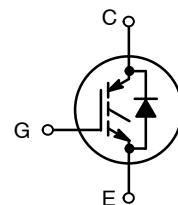
Formerly Developmental Type TA49117.

### Features

- 24 A, 600 V at  $T_C = 25^\circ\text{C}$
- Typical Fall Time 210 ns at  $T_J = 150^\circ\text{C}$
- Short Circuit Rating
- Low Conduction Loss
- Hyperfast Anti-Parallel Diode
- This is a Pb-Free Device

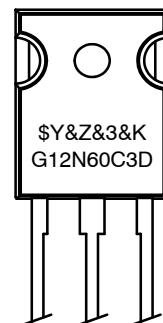
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TO-247-3LD SHORT LEAD  
CASE 340CK  
JEDEC STYLE

### MARKING DIAGRAM



\$Y = ON Semiconductor Logo  
&Z = Assembly Plant Code  
&3 = Numeric Date Code  
&K = Lot Code  
G12N60C3D = Specific Device Code

### ORDERING INFORMATION

See detailed ordering and shipping information on page 7 of this data sheet.

# HGTG12N60C3D

## ABSOLUTE MAXIMUM RATINGS (T<sub>C</sub> = 25°C unless otherwise specified)

Parameter	Symbol	HGTG12N60C3D	Unit
Collector to Emitter Voltage	BV <sub>CES</sub>	600	V
Collector Current Continuous At T <sub>C</sub> = 25°C At T <sub>C</sub> = 110°C	I <sub>C25</sub> I <sub>C110</sub>	24 12	A A
Average Diode Forward Current at 110°C	I <sub>(AVG)</sub>	15	A
Collector Current Pulsed (Note 1)	I <sub>CM</sub>	96	A
Gate to Emitter Voltage Continuous	V <sub>GES</sub>	±20	V
Gate to Emitter Voltage Pulsed	V <sub>GEM</sub>	±30	V
Switching Safe Operating Area at T <sub>J</sub> = 150°C	SSOA	24 A at 600 V	
Power Dissipation Total at T <sub>C</sub> = 25°C	P <sub>D</sub>	104	W
Power Dissipation Derating T <sub>C</sub> > 25°C		0.83	W/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>STG</sub>	-40 to 150	°C
Maximum Lead Temperature for Soldering	T <sub>L</sub>	260	°C
Short Circuit Withstand Time (Note 2) at V <sub>GE</sub> = 15 V	t <sub>SC</sub>	4	μs
Short Circuit Withstand Time (Note 2) at V <sub>GE</sub> = 10 V	t <sub>SC</sub>	13	μs

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

1. Pulse width limited by maximum junction temperature.
2. V<sub>CE(PK)</sub> = 360 V, T<sub>J</sub> = 125°C, R<sub>G</sub> = 25 Ω

## ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise specified)

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Collector to Emitter Breakdown Voltage	BV <sub>CES</sub>	I <sub>C</sub> = 250 μA, V <sub>GE</sub> = 0 V	600	—	—	V
Emitter to Collector Breakdown Voltage	BV <sub>ECS</sub>	I <sub>C</sub> = 10 mA, V <sub>GE</sub> = 0 V	15	25	—	V
Collector to Emitter Leakage Current	I <sub>CES</sub>	V <sub>CE</sub> = BV <sub>CES</sub>	T <sub>C</sub> = 25°C	—	—	250 μA
		V <sub>CE</sub> = BV <sub>CES</sub>	T <sub>C</sub> = 150°C	—	—	2.0 mA
Collector to Emitter Saturation Voltage	V <sub>CE(SAT)</sub>	I <sub>C</sub> = I <sub>C110</sub> , V <sub>GE</sub> = 15 V	T <sub>C</sub> = 25°C	—	1.65	2.0 V
			T <sub>C</sub> = 150°C	—	1.85	2.2 V
		I <sub>C</sub> = 15 A, V <sub>GE</sub> = 15 V	T <sub>C</sub> = 25°C	—	1.80	2.2 V
			T <sub>C</sub> = 150°C	—	2.0	2.4 V
Gate to Emitter Threshold Voltage	V <sub>GE(TH)</sub>	I <sub>C</sub> = 250 μA, V <sub>CE</sub> = V <sub>GE</sub>	T <sub>C</sub> = 25°C	3.0	5.0	6.0 V
Gate to Emitter Leakage Current	I <sub>GES</sub>	V <sub>GE</sub> = ±20 V		—	—	±100 nA
Switching SOA	SSOA	T <sub>J</sub> = 150°C, V <sub>GE</sub> = 15 V, R <sub>G</sub> = 25 Ω, L = 100 μH	V <sub>CE(PK)</sub> = 480 V	80	—	— A
			V <sub>CE(PK)</sub> = 600 V	24	—	— A
Gate to Emitter Plateau Voltage	V <sub>GEP</sub>	I <sub>C</sub> = I <sub>C110</sub> , V <sub>CE</sub> = 0.5 BV <sub>CES</sub>		—	7.6	— V
On-State Gate Charge	Q <sub>G(ON)</sub>	I <sub>C</sub> = I <sub>C110</sub> , V <sub>CE</sub> = 0.5 BV <sub>CES</sub>	V <sub>GE</sub> = 15 V	—	48	55 nC
			V <sub>GE</sub> = 20 V	—	62	71 nC
Current Turn-On Delay Time	t <sub>d(ON)I</sub>	T <sub>J</sub> = 150°C, I <sub>CE</sub> = I <sub>C110</sub> , V <sub>CE(PK)</sub> = 0.8 BV <sub>CES</sub> , V <sub>GE</sub> = 15 V, R <sub>G</sub> = 25 Ω, L = 100 μH		—	14	— ns
Current Rise Time	t <sub>rl</sub>			—	16	— ns
Current Turn-Off Delay Time	t <sub>d(OFF)I</sub>			—	270	400 ns
Current Fall Time	t <sub>fl</sub>			—	210	275 ns
Turn-On Energy	E <sub>ON</sub>			—	380	— μJ
Turn-Off Energy (Note 3)	E <sub>OFF</sub>			—	900	— μJ
Diode Forward Voltage	V <sub>EC</sub>	I <sub>EC</sub> = 12 A		—	1.7	2.0 V

# HGTG12N60C3D

## ELECTRICAL CHARACTERISTICS ( $T_C = 25^\circ\text{C}$ unless otherwise specified) (continued)

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Diode Reverse Recovery Time	$t_{rr}$	$I_{EC} = 12 \text{ A}, dI_{EC}/dt = 100 \text{ A}/\mu\text{s}$	—	34	42	ns
		$I_{EC} = 1.0 \text{ A}, dI_{EC}/dt = 100 \text{ A}/\mu\text{s}$	—	30	37	ns
Thermal Resistance	$R_{\theta JC}$	IGBT	—	—	1.2	$^\circ\text{C}/\text{W}$
		Diode	—	—	1.5	$^\circ\text{C}/\text{W}$

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

3. Turn-Off Energy Loss ( $E_{OFF}$ ) 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 ( $I_{CE} = 0 \text{ A}$ ). The HGTG12N60C3D was 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. Turn-On losses include diode losses.

## TYPICAL PERFORMANCE CURVES

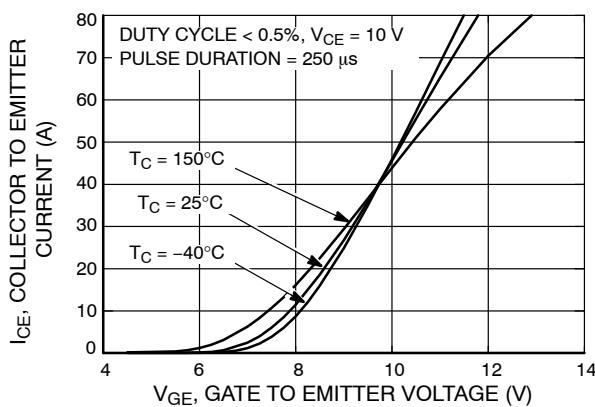


Figure 1. TRANSFER CHARACTERISTICS

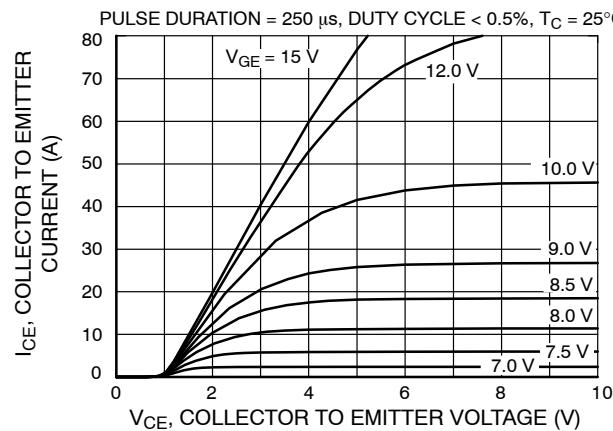


Figure 2. SATURATION CHARACTERISTICS

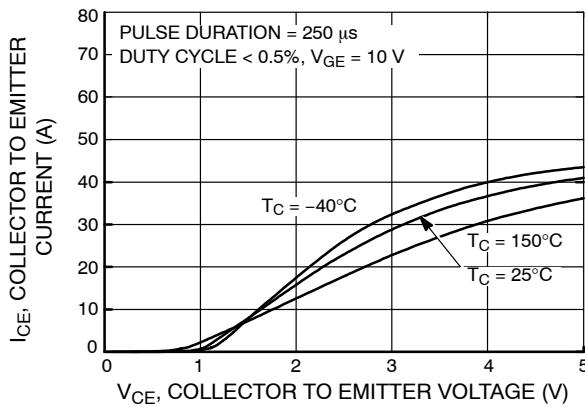


Figure 3. COLLECTOR TO Emitter On-State Voltage

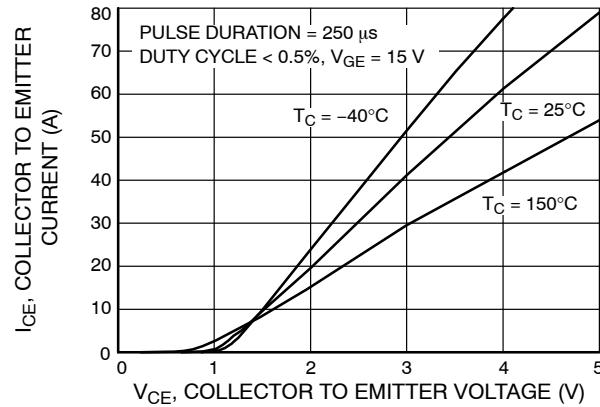
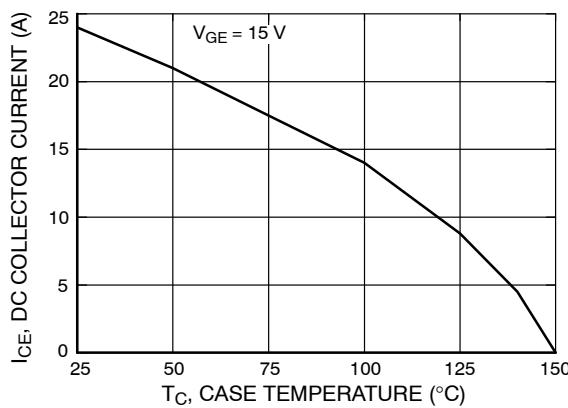
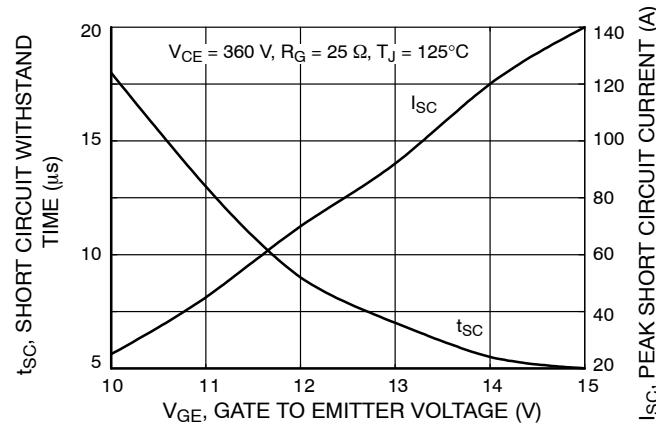


Figure 4. COLLECTOR TO Emitter On-State Voltage

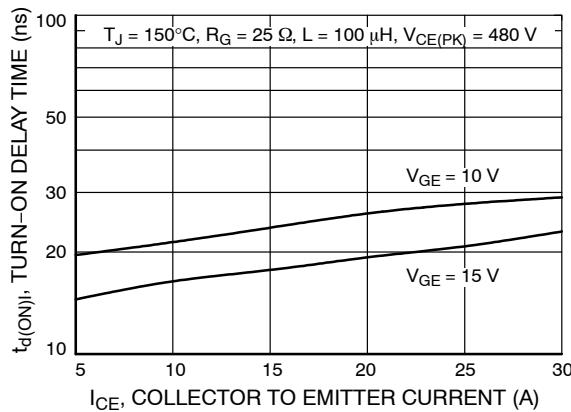
## TYPICAL PERFORMANCE CURVES (continued)



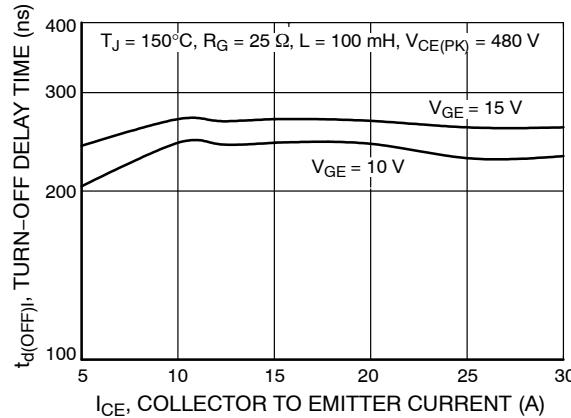
**Figure 5. MAXIMUM DC COLLECTOR CURRENT vs. CASE TEMPERATURE**



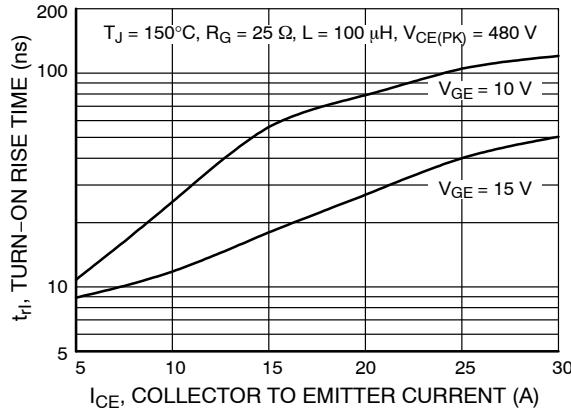
**Figure 6. SHORT CIRCUIT WITHSTAND TIME**



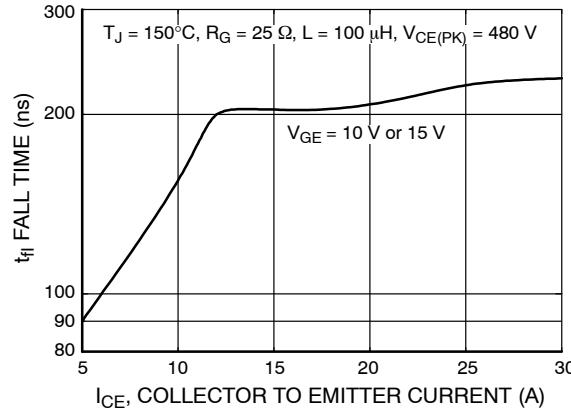
**Figure 7. TURN-ON DELAY TIME vs. COLLECTOR TO Emitter CURRENT**



**Figure 8. TURN-OFF DELAY TIME vs. COLLECTOR TO Emitter CURRENT**



**Figure 9. TURN-ON RISE TIME vs. COLLECTOR TO Emitter CURRENT**



**Figure 10. TURN-OFF FALL TIME vs. COLLECTOR TO Emitter CURRENT**

## TYPICAL PERFORMANCE CURVES (continued)

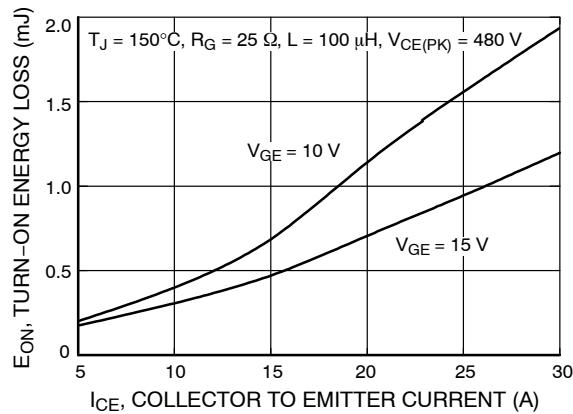


Figure 11. TURN-ON ENERGY LOSS vs.  
COLLECTOR TO Emitter CURRENT

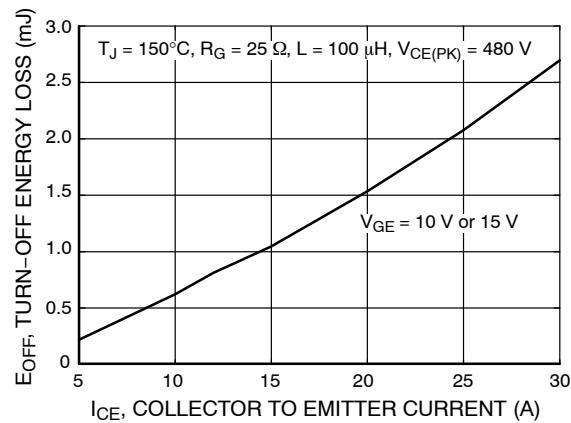


Figure 12. TURN-OFF ENERGY LOSS vs.  
COLLECTOR TO Emitter CURRENT

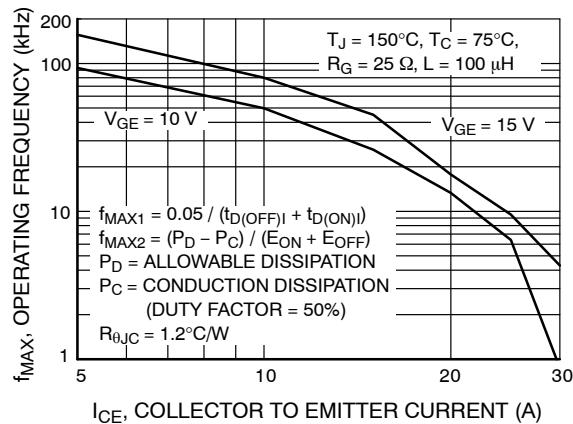


Figure 13. OPERATING FREQUENCY vs.  
COLLECTOR TO Emitter CURRENT

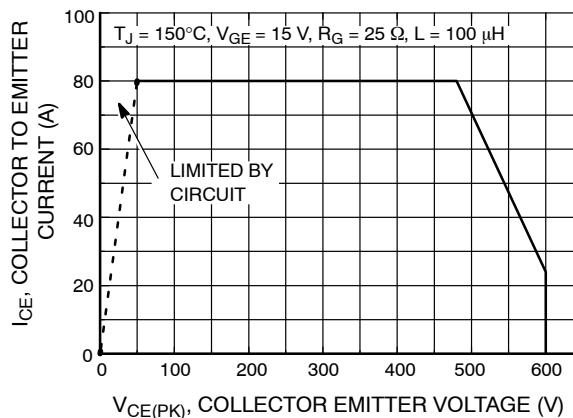


Figure 14. SWITCHING SAFE OPERATING AREA

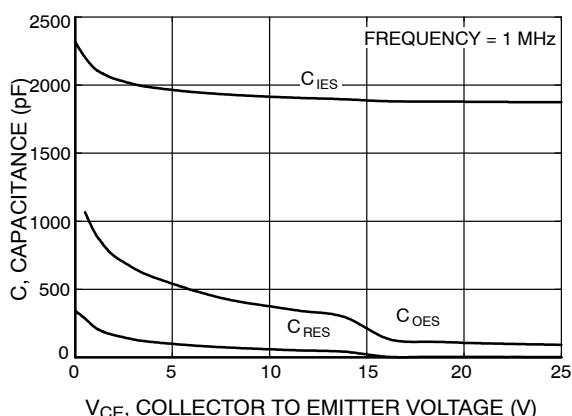


Figure 15. CAPACITANCE vs. COLLECTOR TO  
EMITTER VOLTAGE

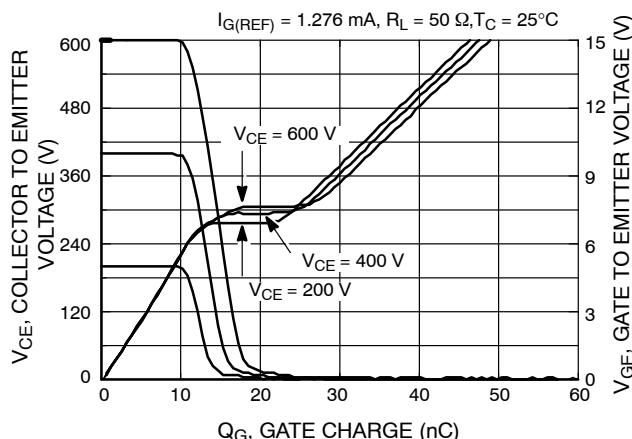


Figure 16. GATE CHARGE WAVEFORMS

## TYPICAL PERFORMANCE CURVES (continued)

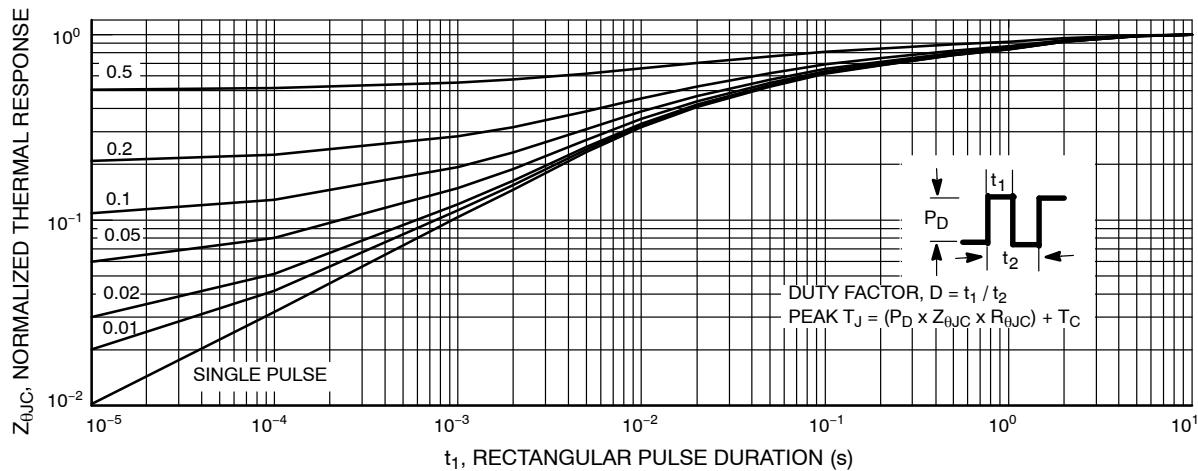


Figure 17. IGBT NORMALIZED TRANSIENT THERMAL IMPEDANCE, JUNCTION TO CASE

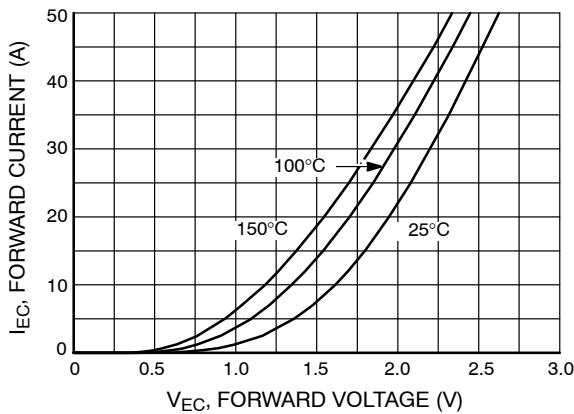


Figure 18. DIODE FORWARD CURRENT vs. FORWARD VOLTAGE DROP

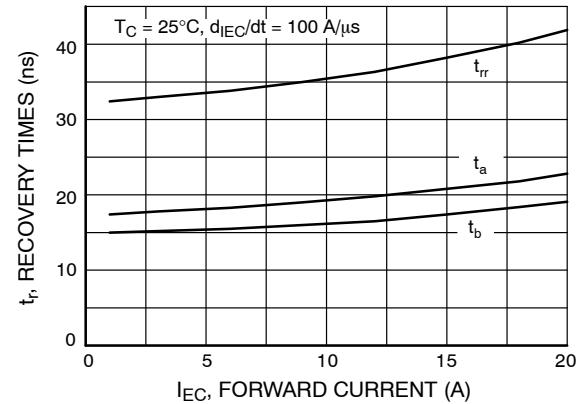


Figure 19. RECOVERY TIMES vs. FORWARD CURRENT

## TEST CIRCUIT AND WAVEFORMS

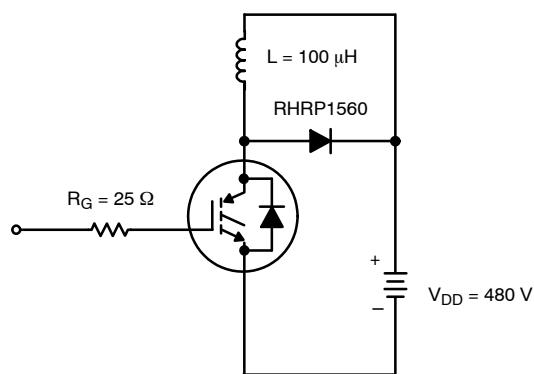


Figure 20. INDUCTIVE SWITCHING TEST CIRCUIT

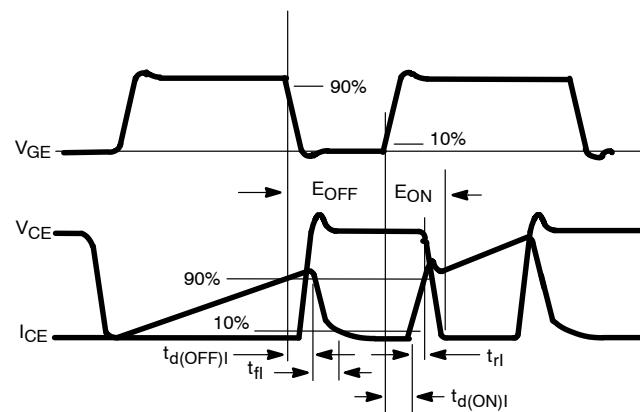


Figure 21. SWITCHING TEST WAVEFORMS

## 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:

1. 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™ LD26" or equivalent.
2. 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.
4. Devices should never be inserted into or removed from circuits with power on.
5. Gate Voltage Rating – Never exceed the gate-voltage rating of  $V_{GEM}$ . Exceeding the rated  $V_{GE}$  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.
7. 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.

## ORDERING INFORMATION

Part Number	Package	Brand	Shipping
HGTG12N60C3D	TO-247	G12N60C3D	450 Units / Tube

NOTE: When ordering, use the entire part number.

## OPERATING FREQUENCY INFORMATION

Operating frequency information for a typical device (Figure 13) 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 4, 7, 8, 11 and 12. The operating frequency plot (Figure 13) 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.

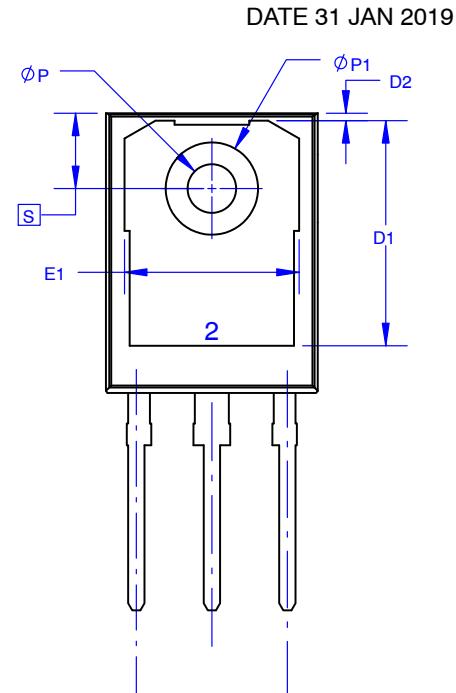
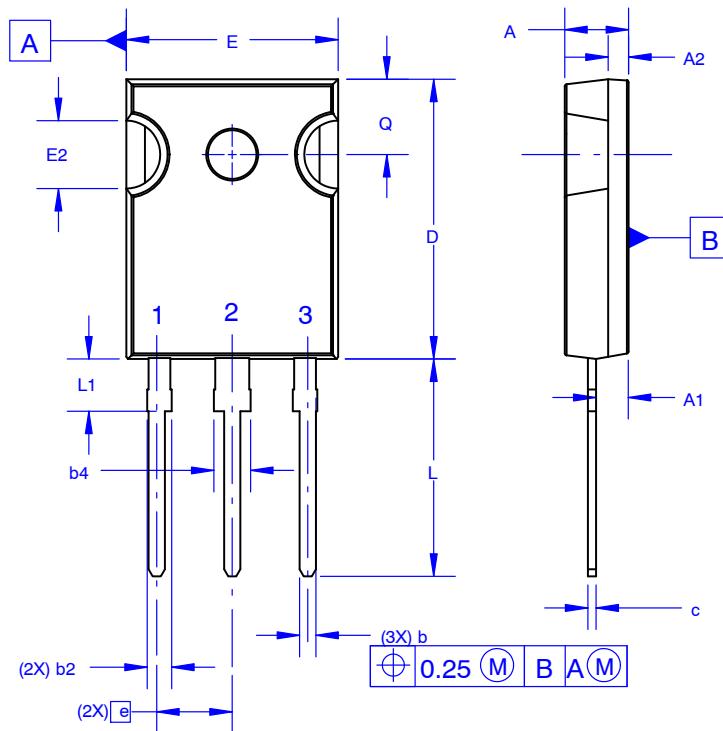
$f_{MAX1}$  is defined by  $f_{MAX1} = 0.05 / (t_{D(OFF)I} + t_{D(ON)I})$ . Deadtime (the denominator) has been arbitrarily held to 10% of the on-state time for a 50% duty factor. Other definitions are possible.  $t_{D(OFF)I}$  and  $t_{D(ON)I}$  are defined in Figure 21.

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  $f_{MAX2} = (P_D - P_C) / (E_{OFF} + E_{ON})$ . The allowable dissipation ( $P_D$ ) is defined by  $P_D = (T_{JM} - T_C) / R_{QJC}$ . The sum of device switching and conduction losses must not exceed  $P_D$ . A 50% duty factor was used (Figure 13) and the conduction losses ( $P_C$ ) are approximated by  $P_C = (V_{CE} \times I_{CE}) / 2$ .

$E_{ON}$  and  $E_{OFF}$  are defined in the switching waveforms shown in Figure 21.  $E_{ON}$  is the integral of the instantaneous power loss ( $I_{CE} \times V_{CE}$ ) during turn-on and  $E_{OFF}$  is the integral of the instantaneous power loss during turn-off. All tail losses are included in the calculation for  $E_{OFF}$ ; i.e. the collector current equals zero ( $I_{CE} = 0$ ).

TO-247-3LD SHORT LEAD  
CASE 340CK  
ISSUE A



NOTES: UNLESS OTHERWISE SPECIFIED.

- A. DIMENSIONS ARE EXCLUSIVE OF BURRS, MOLD FLASH, AND TIE BAR EXTRUSIONS.
- B. ALL DIMENSIONS ARE IN MILLIMETERS.
- C. DRAWING CONFORMS TO ASME Y14.5 - 2009.
- D. DIMENSION A1 TO BE MEASURED IN THE REGION DEFINED BY L1.
- E. LEAD FINISH IS UNCONTROLLED IN THE REGION DEFINED BY L1.

**GENERIC  
MARKING DIAGRAM\***



XXXX = Specific Device Code

A = Assembly Location

Y = Year

WW = Work Week

ZZ = Assembly Lot Code

\*This information is generic. Please refer to device data sheet for actual part marking. Pb-Free indicator, "G" or microdot "■", may or may not be present. Some products may not follow the Generic Marking.

DIM	MILLIMETERS		
	MIN	NOM	MAX
A	4.58	4.70	4.82
A1	2.20	2.40	2.60
A2	1.40	1.50	1.60
b	1.17	1.26	1.35
b2	1.53	1.65	1.77
b4	2.42	2.54	2.66
c	0.51	0.61	0.71
D	20.32	20.57	20.82
D1	13.08	~	~
D2	0.51	0.93	1.35
E	15.37	15.62	15.87
E1	12.81	~	~
E2	4.96	5.08	5.20
e	~	5.56	~
L	15.75	16.00	16.25
L1	3.69	3.81	3.93
ØP	3.51	3.58	3.65
ØP1	6.60	6.80	7.00
Q	5.34	5.46	5.58
S	5.34	5.46	5.58

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