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

## 600 V

### HGTG7N60A4D, HGTP7N60A4D, HGT1S7N60A4DS

The HGTG7N60A4D, HGTP7N60A4D and HGT1S7N60A4DS are MOS gated high voltage switching devices combining 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 used is the development type TA49331. The diode used in anti-parallel is the development type TA49370.

This IGBT is ideal for many high voltage switching applications operating at high frequencies where low conduction losses are essential. This device has been optimized for high frequency switch mode power supplies.

Formerly Developmental Type TA49333.

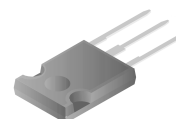
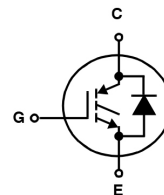
#### Features

- >100 kHz Operation at 390 V, 7 A
- 200 kHz Operation at 390 V, 5 A
- 600 V Switching SOA Capability
- Typical Fall Time: 75 ns at  $T_J = 125^\circ\text{C}$
- Low Conduction Loss
- Temperature Compensating SABER™ Model [www.onsemi.com](http://www.onsemi.com)
- These Devices are Pb-Free, Halogen Free/BFR Free and are RoHS Compliant

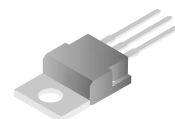


ON Semiconductor®

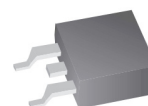
[www.onsemi.com](http://www.onsemi.com)



TO-247-3LD  
CASE 340CK

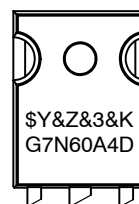


TO-220-3LD  
CASE 340AT



D2PAK-3  
CASE 418AJ

#### MARKING DIAGRAMS



- |          |                                 |
|----------|---------------------------------|
| &Y       | = ON Semiconductor Logo         |
| &Z       | = Assembly Plant Code           |
| &3       | = 3-Digit Date Code             |
| &K       | = 2-Digit Lot Traceability Code |
| G7N60A4D | = Specific Device Code          |

#### ORDERING INFORMATION

See detailed ordering and shipping information on page 2 of this data sheet.

# HGTG7N60A4D, HGTP7N60A4D,

## ORDERING INFORMATION

PART NUMBER	PACKAGE	BRAND
HGTG7N60A4D	TO-247	G7N60A4D
HGTP7N60A4D	TO-220AB	G7N60A4D
HGT1S7N60A4DS	TO-263AB	G7N60A4D

NOTE: When ordering, use the entire part number. Add the suffix 9A to obtain the TO-263AB variant in tape and reel, e.g., HGT1S7N60A4DS9A.

## PACKAGING

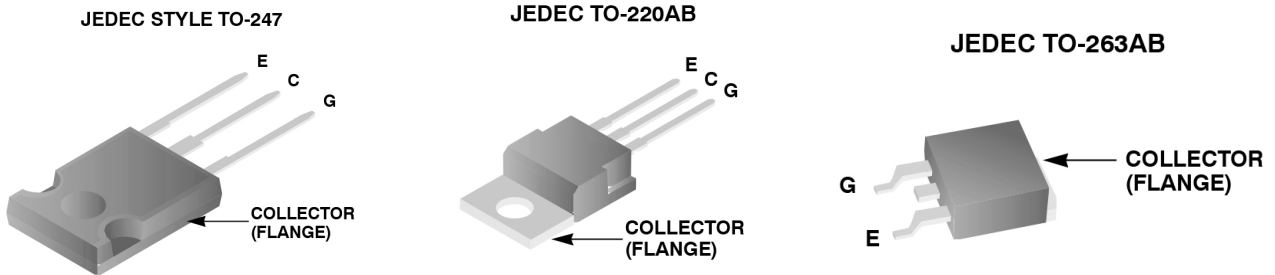


Figure 1.

## ABSOLUTE MAXIMUM RATINGS $T_C = 25^\circ\text{C}$ Unless Otherwise Specified

Description	Symbol	All Types	Units
Collector to Emitter Voltage	$BV_{CES}$	600	V
Collector Current Continuous			
At $T_C = 25^\circ\text{C}$	$I_{C25}$	34	A
At $T_C = 110^\circ\text{C}$	$I_{C110}$	14	A
Collector Current Pulsed (Note 1)	$I_{CM}$	56	A
Gate to Emitter Voltage Continuous	$V_{GES}$	$\pm 20$	V
Gate to Emitter Voltage Pulsed	$V_{GEM}$	$\pm 30$	V
Switching Safe Operating Area at $T_J = 150^\circ\text{C}$ (Figure 1)	SSOA	35 A at 600 V	
Power Dissipation Total at $T_C = 25^\circ\text{C}$	$P_D$	125	W
Power Dissipation Derating $T_C > 25^\circ\text{C}$		1.0	W/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	$T_J, T_{STG}$	-55 to 150	$^\circ\text{C}$
Maximum Lead Temperature for Soldering			
Leads at 0.063 in (1.6 mm) from case for 10 s	$T_L$	300	
Package Body for 10 s, see Tech Brief 334	$T_{PKG}$	260	

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.

# HGTG7N60A4D, HGTP7N60A4D,

**ELECTRICAL SPECIFICATIONS**  $T_J = 25\text{ }^\circ\text{C}$  Unless Otherwise Specified

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNITS	
Collector to Emitter Breakdown Voltage	$BV_{CES}$	$I_C = 250\ \mu\text{A}$ , $V_{GE} = 0\ \text{V}$	600	-	-	V	
Collector to Emitter Leakage Current	$I_{CES}$	$V_{CE} = 600\ \text{V}$	$T_C = 25^\circ\text{C}$	-	-	250	$\mu\text{A}$
			$T_C = 125^\circ\text{C}$	-	-	2	mA
Collector to Emitter Saturation Voltage	$V_{CE(SAT)}$	$I_C = 7\ \text{A}$ , $V_{GE} = 15\ \text{V}$	$T_C = 25^\circ\text{C}$	-	1.9	2.7	V
			$T_C = 150^\circ\text{C}$	-	1.6	2.2	V
Gate to Emitter Threshold Voltage	$V_{GE(TH)}$	$I_C = 250\ \mu\text{A}$ , $V_{CE} = 600\ \text{V}$	4.5	5.9	7	V	
Gate to Emitter Leakage Current	$I_{GES}$	$V_{GE} = \pm 20\ \text{V}$	-	-	$\pm 250$	nA	
Switching SOA	SSOA	$T_J = 150^\circ\text{C}$ , $R_G = 25\ \Omega$ , $V_{GE} = 15\ \text{V}$ , $L = 100\ \mu\text{H}$ , $V_{CE} = 600\ \text{V}$	35	-	-	A	
Gate to Emitter Plateau Voltage	$V_{GEP}$	$I_C = 7\ \text{A}$ , $V_{CE} = 300\ \text{V}$	-	9	-	V	
On-State Gate Charge	$Q_{G(ON)}$	$I_C = 7\ \text{A}$ , $V_{CE} = 300\ \text{V}$	$V_{GE} = 15\ \text{V}$	-	37	45	nC
			$V_{GE} = 20\ \text{V}$	-	48	60	nC
Current Turn-On Delay Time	$t_{d(ON)I}$	IGBT and Diode at $T_J = 25^\circ\text{C}$ , $I_{CE} = 7\ \text{A}$ , $V_{CE} = 390\ \text{V}$ , $V_{GE} = 15\ \text{V}$ , $R_G = 25\ \Omega$ , $L = 1\ \text{mH}$ , Test Circuit (Figure 24)	-	11	-	ns	
Current Rise Time	$t_{rI}$		-	11	-	ns	
Current Turn-Off Delay Time	$t_{d(OFF)I}$		-	100	-	ns	
Current Fall Time	$t_{fI}$		-	45	-	ns	
Turn-On Energy	$E_{ON1}$		-	55	-	$\mu\text{J}$	
Turn-On Energy	$E_{ON2}$		-	120	150	$\mu\text{J}$	
Turn-Off Energy (Note 3)	$E_{OFF}$		-	60	75	$\mu\text{J}$	
Current Turn-On Delay Time	$t_{d(ON)I}$		IGBT and Diode at $T_J = 150^\circ\text{C}$ , $I_{CE} = 7\ \text{A}$ , $V_{CE} = 390\ \text{V}$ , $V_{GE} = 15\ \text{V}$ , $R_G = 25\ \Omega$ , $L = 1\ \text{mH}$ , Test Circuit (Figure 24)	-	10	-	ns
Current Rise Time	$t_{rI}$	-		7	-	ns	
Current Turn-Off Delay Time	$t_{d(OFF)I}$	-		130	150	ns	
Current Fall Time	$t_{fI}$	-		75	85	ns	
Turn-On Energy	$E_{ON1}$	-		50	-	$\mu\text{J}$	
Turn-On Energy	$E_{ON2}$	-		200	215	$\mu\text{J}$	
Turn-Off Energy (Note 3)	$E_{OFF}$	-		125	170	$\mu\text{J}$	
Diode Forward Voltage	$V_{EC}$	$I_{EC} = 7\ \text{A}$		-	2.4	-	V
Diode Reverse Recovery Time	$t_{rr}$	$I_{EC} = 7\ \text{A}$ , $di_{EC}/dt = 200\ \text{A}/\mu\text{s}$	-	34	-	ns	
		$I_{EC} = 1\ \text{A}$ , $di_{EC}/dt = 200\ \text{A}/\mu\text{s}$	-	22	-	ns	
Thermal Resistance Junction To Case	$R_{\theta JC}$	IGBT	-	-	1.0	$^\circ\text{C}/\text{W}$	
		Diode	-	-	2.2	$^\circ\text{C}/\text{W}$	

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.

2. Values for two Turn-On loss conditions are shown for the convenience of the circuit designer.  $E_{ON1}$  is the turn-on loss of the IGBT only.  $E_{ON2}$  is the turn-on loss when a typical diode is used in the test circuit and the diode is at the same  $T_J$  as the IGBT. The diode type is specified in Figure 24.

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 ( $I_{CE} = 0\ \text{A}$ ). 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.

# HGTG7N60A4D, HGTP7N60A4D,

## TYPICAL PERFORMANCE CURVES

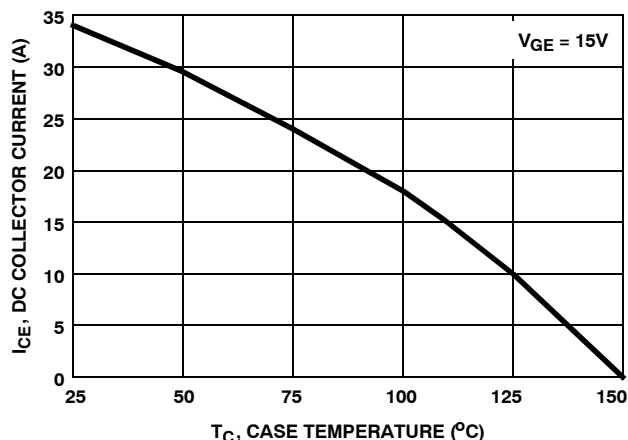


Figure 1. DC COLLECTOR CURRENT vs CASE TEMPERATURE

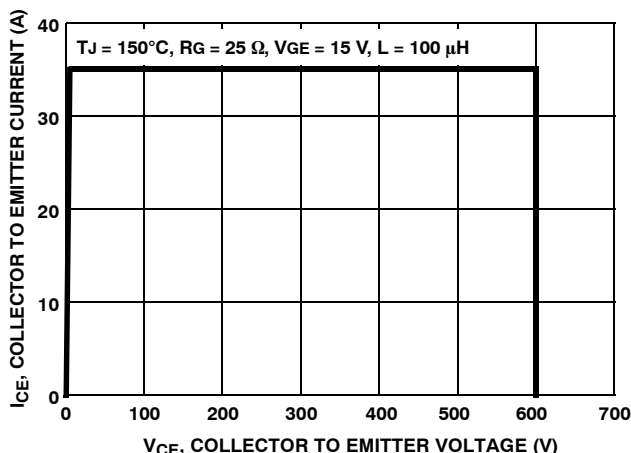


Figure 2. MINIMUM SWITCHING SAFE OPERATING AREA

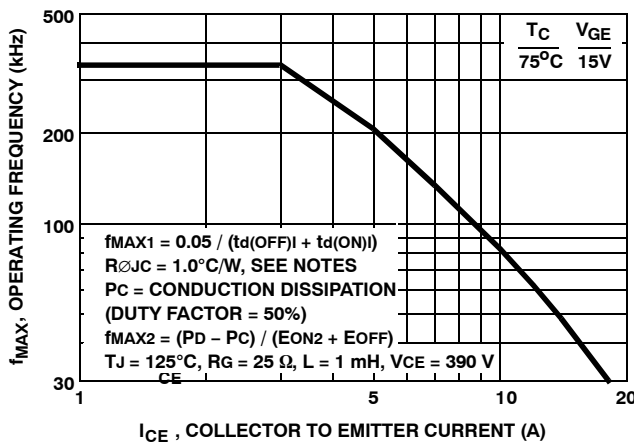


Figure 3. OPERATING FREQUENCY vs COLLECTOR TO EMITTER CURRENT

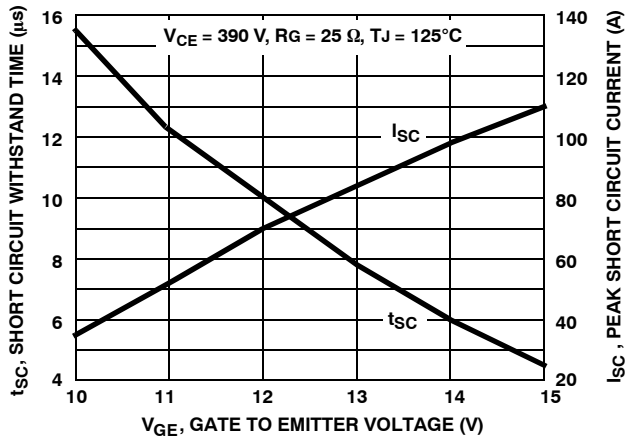


Figure 4. SHORT CIRCUIT WITHSTAND TIME

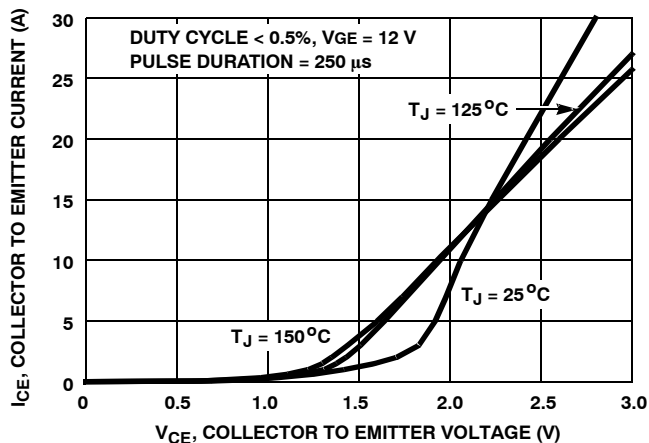


Figure 5. COLLECTOR TO EMITTER ON-STATE VOLTAGE

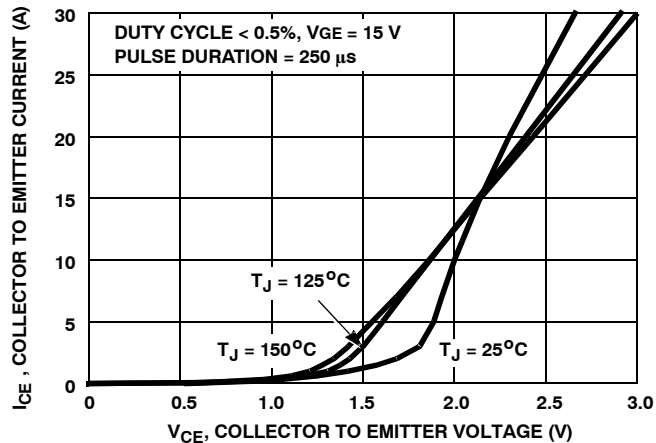


Figure 6. COLLECTOR TO EMITTER ON-STATE VOLTAGE

# HGTG7N60A4D, HGTP7N60A4D,

## TYPICAL PERFORMANCE CHARACTERISTICS (continued)

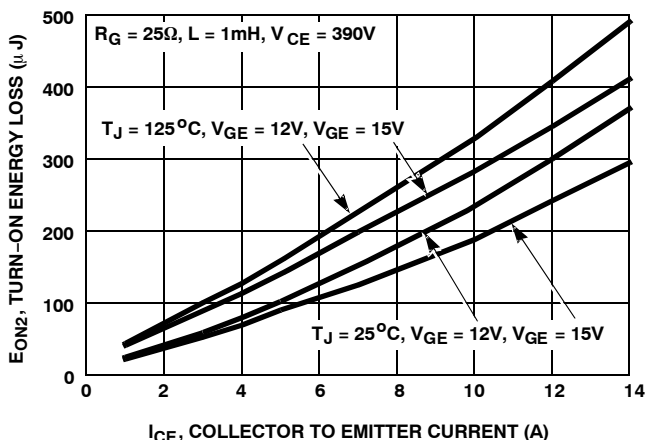


Figure 7. TURN-ON ENERGY LOSS vs COLLECTOR TO EMITTER CURRENT

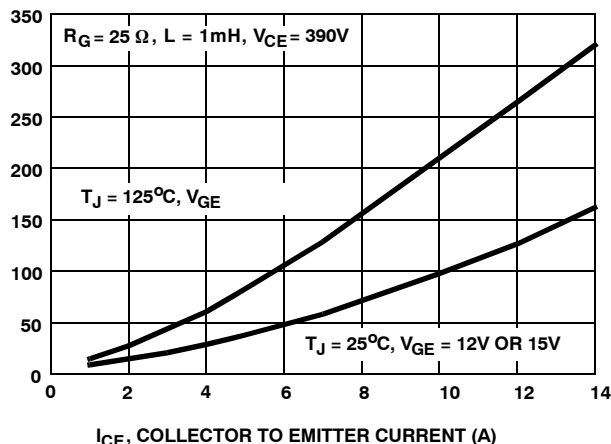


Figure 8. TURN-OFF ENERGY LOSS vs COLLECTOR TO EMITTER CURRENT

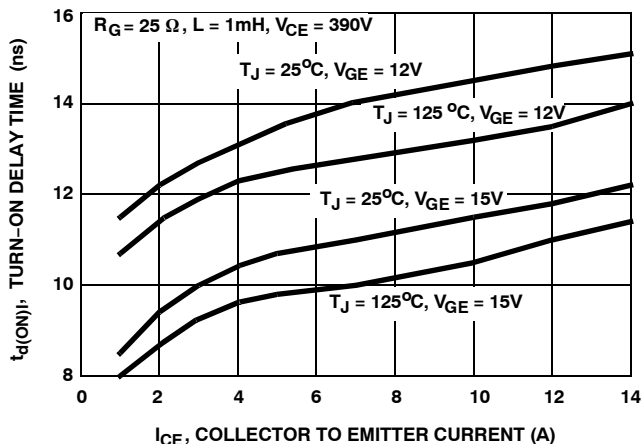


Figure 9. TURN-ON DELAY TIME vs COLLECTOR TO EMITTER CURRENT

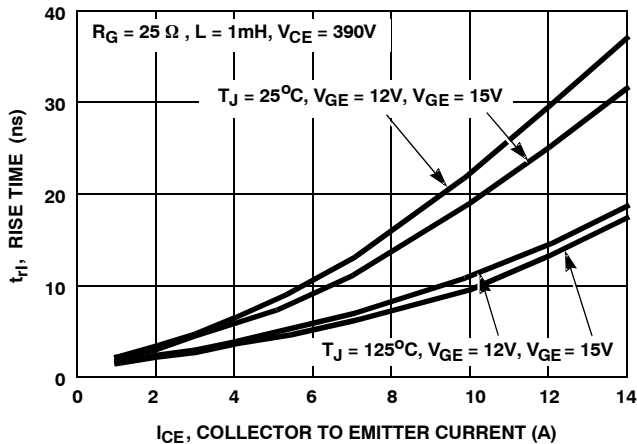


Figure 10. TURN-ON RISE TIME vs COLLECTOR TO EMITTER CURRENT

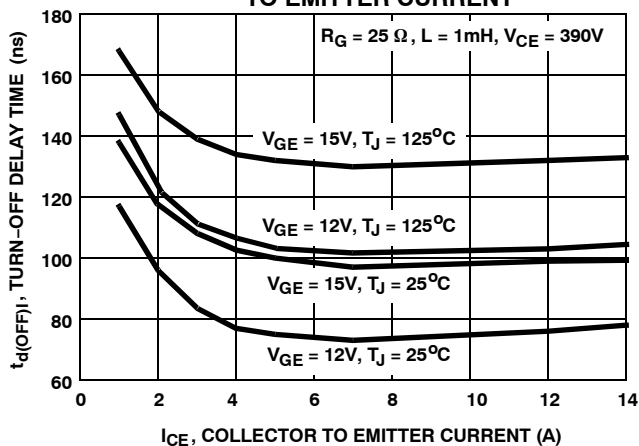


Figure 11. TURN-OFF DELAY TIME vs COLLECTOR TO EMITTER CURRENT

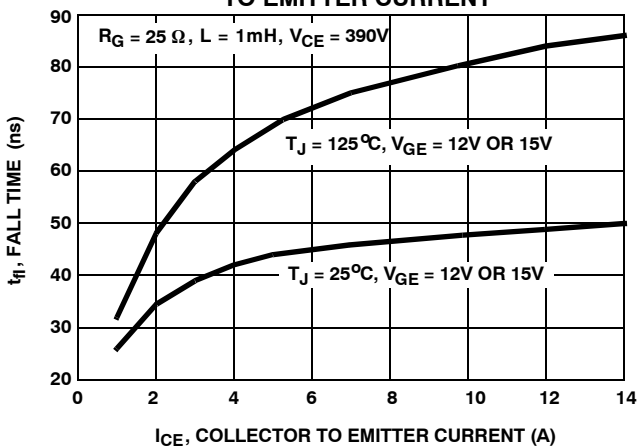


Figure 12. FALL TIME vs COLLECTOR TO EMITTER CURRENT

# HGTG7N60A4D, HGTP7N60A4D,

## TYPICAL PERFORMANCE CHARACTERISTICS (continued)

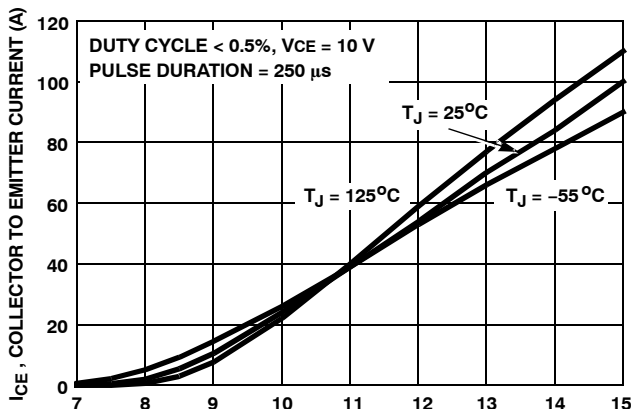


Figure 13. TRANSFER CHARACTERISTIC

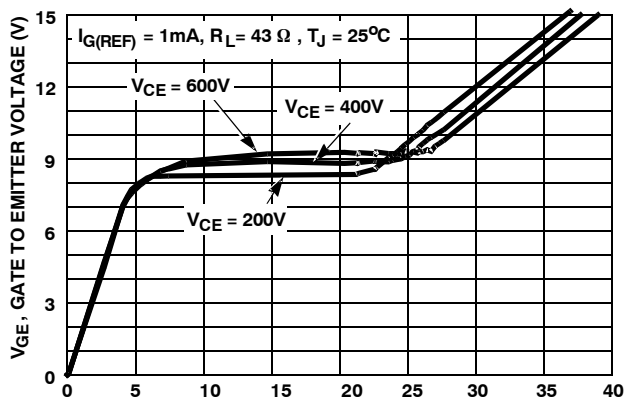


Figure 14. GATE CHARGE WAVEFORMS

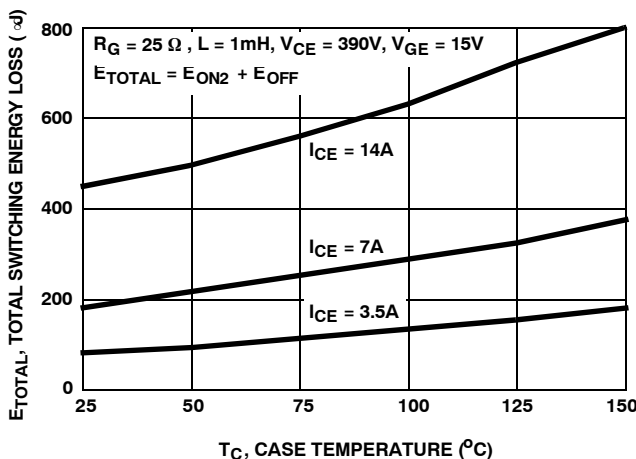


Figure 15. TOTAL SWITCHING LOSS vs CASE TEMPERATURE

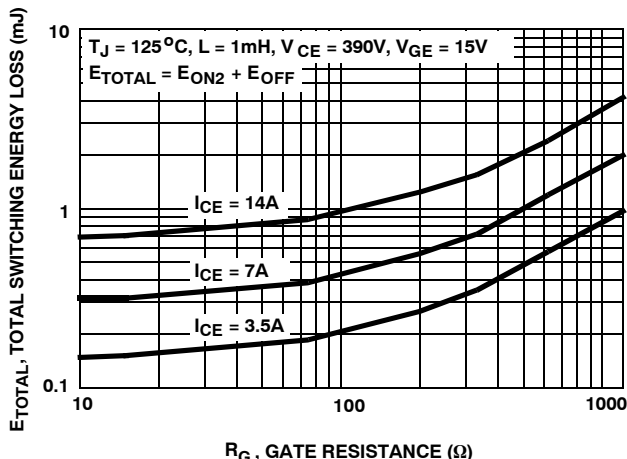


Figure 16. TOTAL SWITCHING LOSS vs GATE RESISTANCE

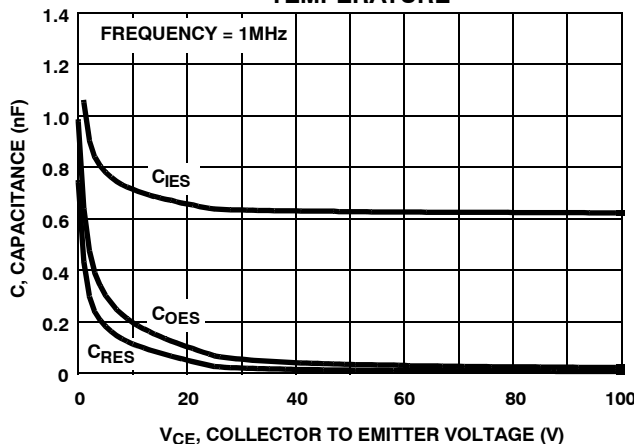


Figure 17. CAPACITANCE vs COLLECTOR TO EMITTER VOLTAGE

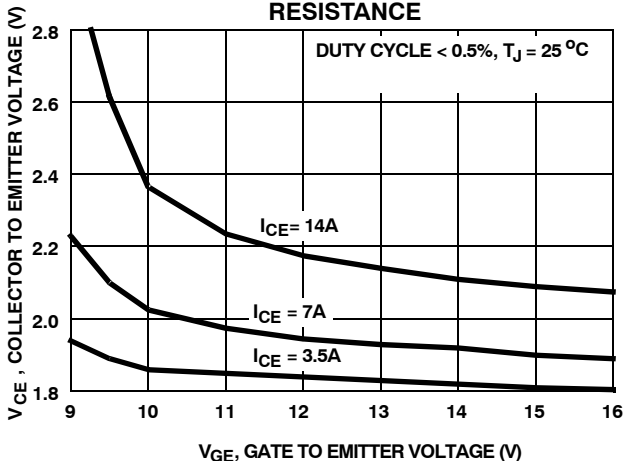


Figure 18. COLLECTOR TO EMITTER ON-STATE VOLTAGE vs GATE TO EMITTER VOLTAGE

# HGTG7N60A4D, HGTP7N60A4D,

## TYPICAL PERFORMANCE CHARACTERISTICS (continued)

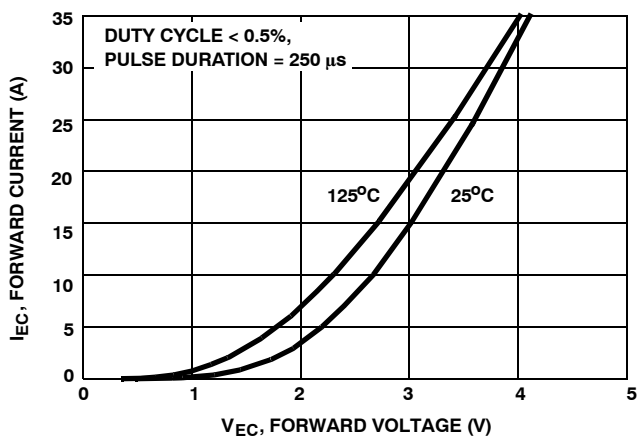


Figure 19. DIODE FORWARD CURRENT vs FORWARD VOLTAGE DROP

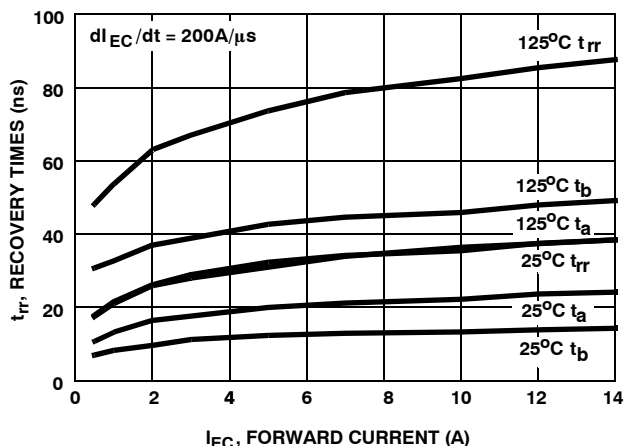


Figure 20. DIODE FORWARD CURRENT vs FORWARD VOLTAGE DROP

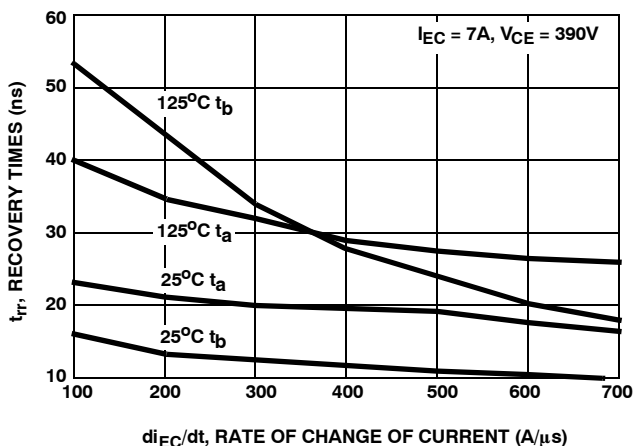


Figure 21. RECOVERY TIMES vs RATE OF CHANGE OF CURRENT

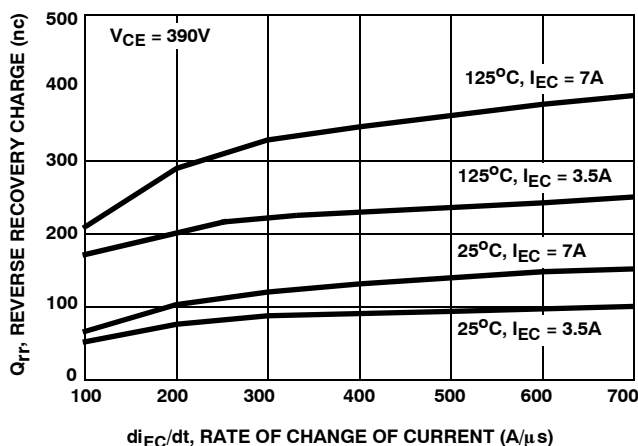


Figure 22. STORED CHARGE vs RATE OF CHANGE OF CURRENT

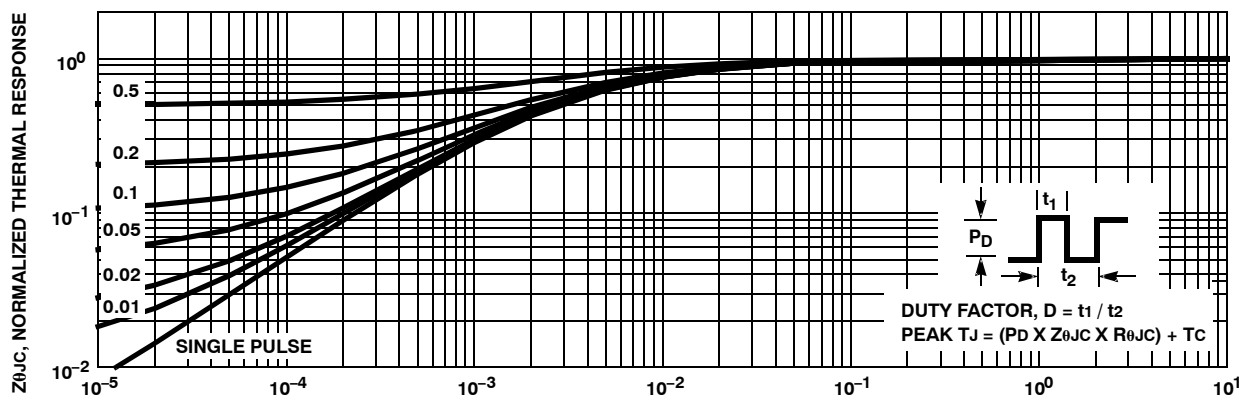


Figure 23. IGBT NORMALIZED TRANSIENT THERMAL RESPONSE, JUNCTION TO CASE



TEST CIRCUITS AND WAVEFORMS

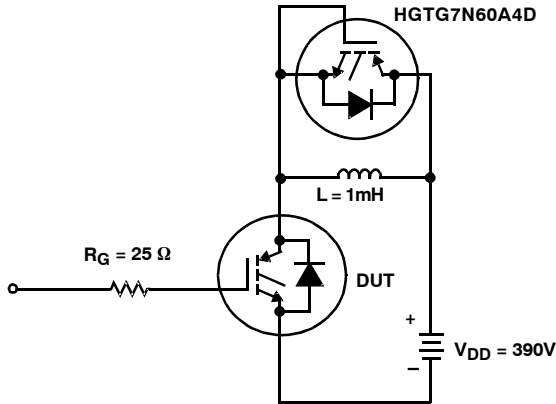


Figure 24. INDUCTIVE SWITCHING TEST CIRCUIT

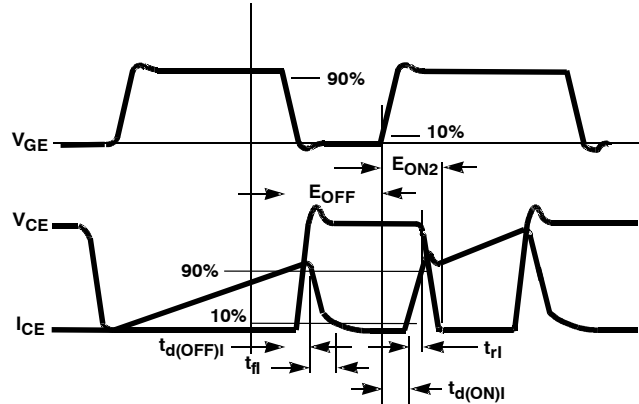


Figure 25. SWITCHING TEST WAVEFORMS

**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 “ECCOSORB™ 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<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
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

**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<sub>CE</sub>) plots are possible using the information shown for a typical unit in Figures 6, 7, 8, 9 and 11. The operating frequency plot (Figure 3) of a typical device shows f<sub>MAX1</sub> or f<sub>MAX2</sub>; 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<sub>MAX1</sub> 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<sub>d(OFF)I</sub> and t<sub>d(ON)I</sub> are defined in Figure 25. Device turn-off delay can establish an additional frequency limiting condition for an application other than T<sub>JM</sub>. t<sub>d(OFF)I</sub> is important when controlling output ripple under a lightly loaded condition.

f<sub>MAX2</sub> is defined by  $f_{MAX2} = (P_D - P_C) / (E_{OFF} + E_{ON2})$ . The allowable dissipation (P<sub>D</sub>) is defined by  $P_D = (T_{JM} - T_C) / R_{θJC}$ . The sum of device switching and conduction losses must not exceed P<sub>D</sub>. A 50% duty factor was used (Figure 3) and the conduction losses (P<sub>C</sub>) are approximated by

$$P_C = (V_{CE} \times I_{CE}) / 2 \quad \text{(eq. 1)}$$

E<sub>ON2</sub> and E<sub>OFF</sub> are defined in the switching waveforms shown in Figure 25. E<sub>ON2</sub> is the integral of the instantaneous power loss (I<sub>CE</sub> x V<sub>CE</sub>) during turn-on and E<sub>OFF</sub> is the integral of the instantaneous power loss (I<sub>CE</sub> x V<sub>CE</sub>) during turn-off. All tail losses are included in the calculation for E<sub>OFF</sub>; i.e., the collector current equals zero (I<sub>CE</sub> = 0).

HGTG7N60A4D, HGTP7N60A4D,

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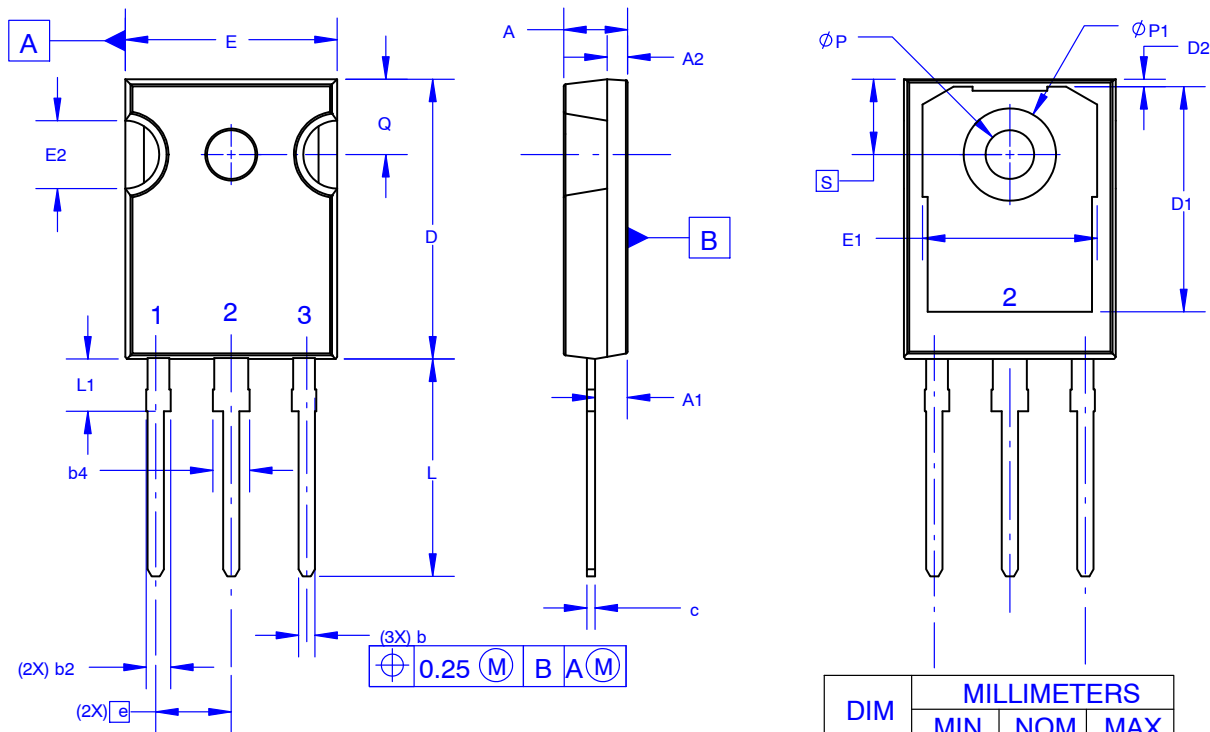
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# HGTG7N60A4D, HGTP7N60A4D,

## PACKAGE DIMENSIONS

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

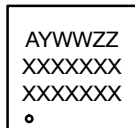
DATE 31 JAN 2019



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

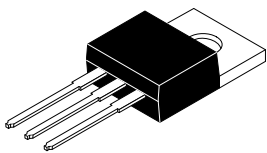
\*This information is generic. Please refer to device data sheet for actual part marking. Pb-Free indicator, "G" or microdot "•", may or may not be present. Some products may not follow the Generic Marking.

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
φP	3.51	3.58	3.65
φP1	6.60	6.80	7.00
Q	5.34	5.46	5.58
S	5.34	5.46	5.58

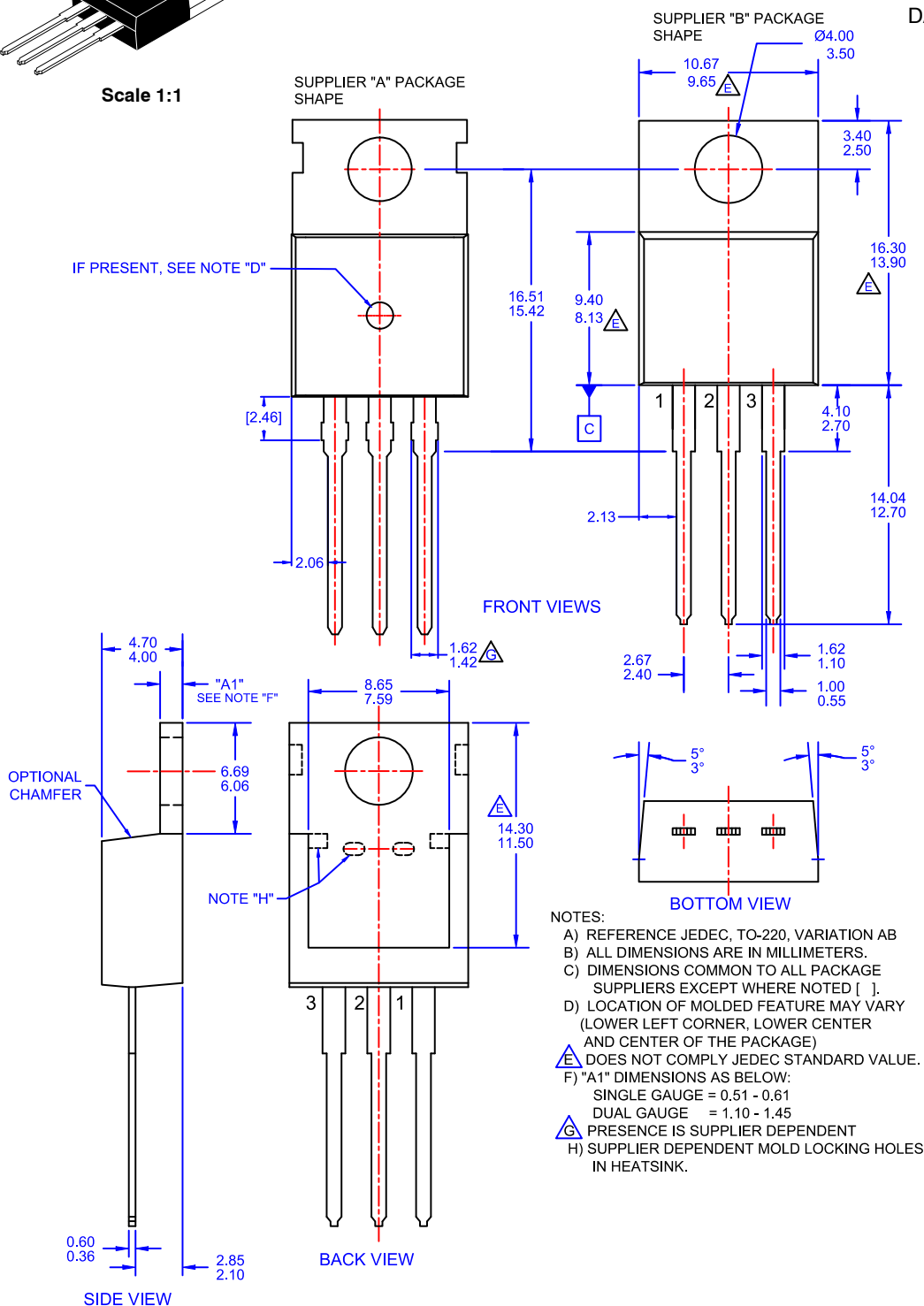
# HGTG7N60A4D, HGTP7N60A4D,

TO-220-3LD  
CASE 340AT  
ISSUE A

DATE 03 OCT 2017



Scale 1:1

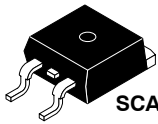


- NOTES:
- A) REFERENCE JEDEC, TO-220, VARIATION AB
  - B) ALL DIMENSIONS ARE IN MILLIMETERS.
  - C) DIMENSIONS COMMON TO ALL PACKAGE SUPPLIERS EXCEPT WHERE NOTED [ ].
  - D) LOCATION OF MOLDED FEATURE MAY VARY (LOWER LEFT CORNER, LOWER CENTER AND CENTER OF THE PACKAGE)
  - E) DOES NOT COMPLY JEDEC STANDARD VALUE.
  - F) "A1" DIMENSIONS AS BELOW:  
SINGLE GAUGE = 0.51 - 0.61  
DUAL GAUGE = 1.10 - 1.45
  - G) PRESENCE IS SUPPLIER DEPENDENT
  - H) SUPPLIER DEPENDENT MOLD LOCKING HOLES IN HEATSINK.

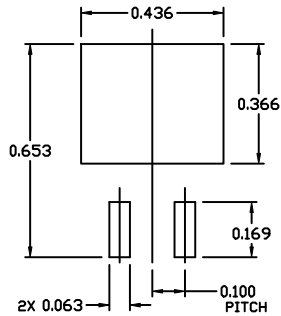
# HGTG7N60A4D, HGTP7N60A4D,

D<sup>2</sup>PAK-3 (TO-263, 3-LEAD)  
CASE 418AJ  
ISSUE E

DATE 25 OCT 2019

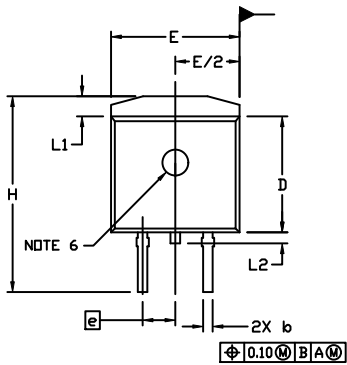


SCALE 1:1



**RECOMMENDED MOUNTING FOOTPRINT**

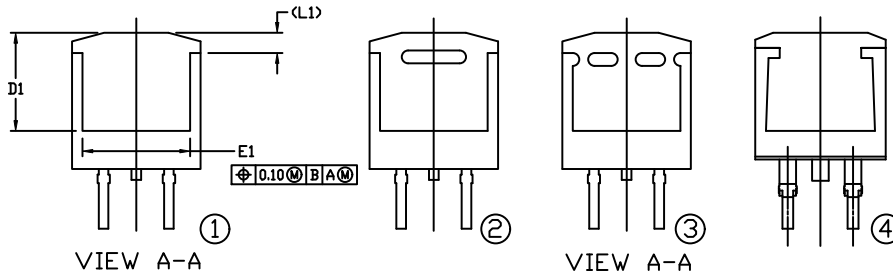
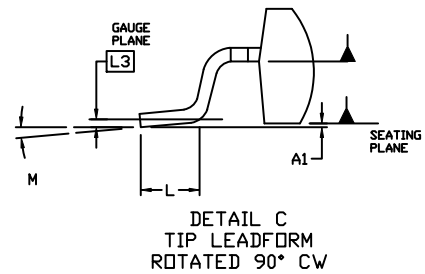
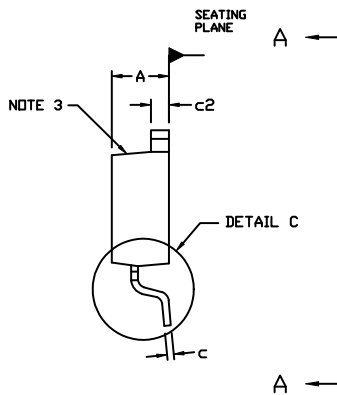
For additional information on our Pb-Free strategy and soldering details, please download the IHS Semiconductor Soldering and Mounting Techniques Reference Manual, SSI\_0609/0.



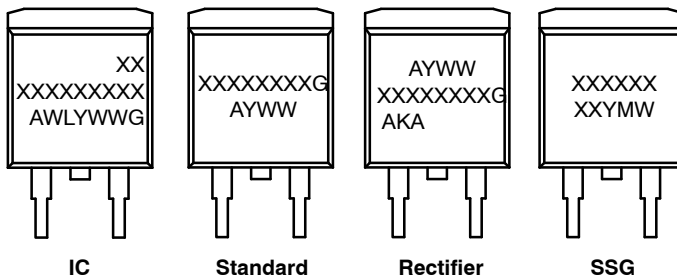
**NOTES:**

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 2009.
2. CONTROLLING DIMENSION: INCHES
3. CHAMFER OPTIONAL.
4. DIMENSIONS D AND E DO NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED 0.005 PER SIDE. THESE DIMENSIONS ARE MEASURED AT THE OUTERMOST EXTREMES OF THE PLASTIC BODY AT DATUM H.
5. THERMAL PAD CONTOUR IS OPTIONAL WITHIN DIMENSIONS E, L1, D1, AND E1.
6. OPTIONAL MOLD FEATURE.
7. Ⓛ, Ⓜ ... OPTIONAL CONSTRUCTION FEATURE CALL OUTS.

DIM	INCHES		MILLIMETERS	
	MIN.	MAX.	MIN.	MAX.
A	0.160	0.190	4.06	4.83
A1	0.000	0.010	0.00	0.25
b	0.020	0.039	0.51	0.99
c	0.012	0.029	0.30	0.74
c2	0.045	0.065	1.14	1.65
D	0.330	0.380	8.38	9.65
D1	0.260	---	6.60	---
E	0.380	0.420	9.65	10.67
E1	0.245	---	6.22	---
e	0.100	BSC	2.54	BSC
H	0.575	0.625	14.60	15.88
L	0.070	0.110	1.78	2.79
L1	---	0.066	---	1.68
L2	---	0.070	---	1.78
L3	0.010	BSC	0.25	BSC
M	-8°	8°	-8°	8°




**GENERIC MARKING DIAGRAMS\***



- XXXXXX = Specific Device Code
- A = Assembly Location
- WL = Wafer Lot
- Y = Year
- WW = Work Week
- W = Week Code (SSG)
- M = Month Code (SSG)
- G = Pb-Free Package
- AKA = Polarity Indicator

\*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.

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