

# Designer's™ Data Sheet

## Insulated Gate Bipolar Transistor with Anti-Parallel Diode

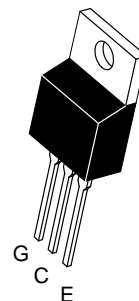
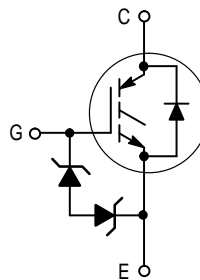
### N-Channel Enhancement-Mode Silicon Gate

**MGP11N60ED**

IGBT & DIODE IN TO-220  
11 A @ 90°C  
15 A @ 25°C  
600 VOLTS  
SHORT CIRCUIT RATED  
LOW ON-VOLTAGE

This Insulated Gate Bipolar Transistor (IGBT) is co-packaged with a soft recovery ultra-fast rectifier and uses an advanced termination scheme to provide an enhanced and reliable high voltage-blocking capability. Its new 600 V IGBT technology is specifically suited for applications requiring both a high temperature short circuit capability and a low  $V_{CE(on)}$ . It also provides fast switching characteristics and results in efficient operation at high frequencies. Co-packaged IGBTs save space, reduce assembly time and cost. This new E-series introduces an energy efficient, ESD protected, and rugged short circuit device.

- Industry Standard TO-220 Package
- High Speed:  $E_{off} = 60 \mu\text{J}$  per Amp typical at 125°C
- High Voltage Short Circuit Capability – 10  $\mu\text{s}$  minimum at 125°C, 400 V
- Low On-Voltage — 2.0 V typical at 8.0 A
- Soft Recovery Free Wheeling Diode is included in the Package
- Robust High Voltage Termination
- ESD Protection Gate-Emitter Zener Diodes



CASE 221A-09  
STYLE 9  
TO-220AB

#### MAXIMUM RATINGS ( $T_J = 25^\circ\text{C}$ unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	$V_{CES}$	600	Vdc
Collector-Gate Voltage ( $R_{GE} = 1.0 \text{ M}\Omega$ )	$V_{CGR}$	600	Vdc
Gate-Emitter Voltage — Continuous	$V_{GE}$	$\pm 20$	Vdc
Collector Current — Continuous @ $T_C = 25^\circ\text{C}$ — Continuous @ $T_C = 90^\circ\text{C}$ — Repetitive Pulsed Current (1)	$I_{C25}$ $I_{C90}$ $I_{CM}$	15 11 22	Adc Apk
Total Power Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	$P_D$	96 0.77	Watts W/°C
Operating and Storage Junction Temperature Range	$T_J, T_{stg}$	-55 to 150	°C
Short Circuit Withstand Time ( $V_{CC} = 400 \text{ Vdc}$ , $V_{GE} = 15 \text{ Vdc}$ , $T_J = 125^\circ\text{C}$ , $R_G = 20 \Omega$ )	$t_{sc}$	10	$\mu\text{s}$
Thermal Resistance — Junction to Case – IGBT — Junction to Case – Diode — Junction to Ambient	$R_{\theta JC}$ $R_{\theta JC}$ $R_{\theta JA}$	1.3 2.3 65	°C/W
Maximum Lead Temperature for Soldering Purposes, 1/8" from case for 5 seconds	$T_L$	260	°C
Mounting Torque, 6-32 or M3 screw		10 lbf•in (1.13 N•m)	

(1) Pulse width is limited by maximum junction temperature. Repetitive rating.

**Designer's Data for "Worst Case" Conditions** — The Designer's Data Sheet permits the design of most circuits entirely from the information presented. SOA Limit curves — representing boundaries on device characteristics — are given to facilitate "worst case" design. Designer's™ is a trademark of Motorola, Inc.

# MGP11N60ED

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

Characteristic	Symbol	Min	Typ	Max	Unit
<b>OFF CHARACTERISTICS</b>					
Collector-to-Emitter Breakdown Voltage (V <sub>GE</sub> = 0 Vdc, I <sub>C</sub> = 250 μAdc) Temperature Coefficient (Positive)	V <sub>(BR)CES</sub>	600 —	— 870	— —	Vdc mV/°C
Zero Gate Voltage Collector Current (V <sub>CE</sub> = 600 Vdc, V <sub>GE</sub> = 0 Vdc) (V <sub>CE</sub> = 600 Vdc, V <sub>GE</sub> = 0 Vdc, T <sub>J</sub> = 125°C)	I <sub>CES</sub>	— —	— —	10 200	μAdc
Gate-Body Leakage Current (V <sub>GE</sub> = ± 20 Vdc, V <sub>CE</sub> = 0 Vdc)	I <sub>GES</sub>	—	—	50	μAdc

## ON CHARACTERISTICS (1)

Collector-to-Emitter On-State Voltage (V <sub>GE</sub> = 15 Vdc, I <sub>C</sub> = 4.0 Adc) (V <sub>GE</sub> = 15 Vdc, I <sub>C</sub> = 4.0 Adc, T <sub>J</sub> = 125°C) (V <sub>GE</sub> = 15 Vdc, I <sub>C</sub> = 8.0 Adc)	V <sub>CE(on)</sub>	— — —	1.6 1.5 2.0	1.9 — 2.4	Vdc
Gate Threshold Voltage (V <sub>CE</sub> = V <sub>GE</sub> , I <sub>C</sub> = 1.0 mAdc) Threshold Temperature Coefficient (Negative)	V <sub>GE(th)</sub>	4.0 —	6.0 10	8.0 —	Vdc mV/°C
Forward Transconductance (V <sub>CE</sub> = 10 Vdc, I <sub>C</sub> = 8.0 Adc)	g <sub>fe</sub>	—	3.5	—	Mhos

## DYNAMIC CHARACTERISTICS

Input Capacitance	(V <sub>CE</sub> = 25 Vdc, V <sub>GE</sub> = 0 Vdc, f = 1.0 MHz)	C <sub>ies</sub>	—	779	—	pF
Output Capacitance		C <sub>oes</sub>	—	81	—	
Transfer Capacitance		C <sub>res</sub>	—	13	—	

## SWITCHING CHARACTERISTICS (1)

Turn-On Delay Time	(V <sub>CC</sub> = 360 Vdc, I <sub>C</sub> = 8.0 Adc, V <sub>GE</sub> = 15 Vdc, L = 300 μH, R <sub>G</sub> = 20 Ω) Energy losses include "tail"	t <sub>d(on)</sub>	—	46	—	ns
Rise Time		t <sub>r</sub>	—	34	—	
Turn-Off Delay Time		t <sub>d(off)</sub>	—	102	—	
Fall Time		t <sub>f</sub>	—	226	—	mJ
Turn-Off Switching Loss		E <sub>off</sub>	—	0.32	0.40	
Turn-On Switching Loss		E <sub>on</sub>	—	0.11	—	
Total Switching Loss		E <sub>ts</sub>	—	0.43	—	
Turn-On Delay Time	(V <sub>CC</sub> = 360 Vdc, I <sub>C</sub> = 8.0 Adc, V <sub>GE</sub> = 15 Vdc, L = 300 μH, R <sub>G</sub> = 20 Ω, T <sub>J</sub> = 125°C) Energy losses include "tail"	t <sub>d(on)</sub>	—	42	—	ns
Rise Time		t <sub>r</sub>	—	26	—	
Turn-Off Delay Time		t <sub>d(off)</sub>	—	214	—	
Fall Time		t <sub>f</sub>	—	228	—	mJ
Turn-Off Switching Loss		E <sub>off</sub>	—	0.48	—	
Turn-On Switching Loss		E <sub>on</sub>	—	0.16	—	
Total Switching Loss		E <sub>ts</sub>	—	0.64	—	
Gate Charge	(V <sub>CC</sub> = 360 Vdc, I <sub>C</sub> = 8.0 Adc, V <sub>GE</sub> = 15 Vdc)	Q <sub>T</sub>	—	39.2	—	nC
		Q <sub>1</sub>	—	8.7	—	
		Q <sub>2</sub>	—	17.4	—	

## DIODE CHARACTERISTICS

Diode Forward Voltage Drop (I <sub>EC</sub> = 3.25 Adc) (I <sub>EC</sub> = 3.25 Adc, T <sub>J</sub> = 125°C) (I <sub>EC</sub> = 6.5 Adc)	V <sub>FEC</sub>	— — 1.7	1.63 1.24 2.0	— — 2.3	Vdc
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(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%.

(continued)

**ELECTRICAL CHARACTERISTICS — continued** ( $T_J = 25^\circ\text{C}$  unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit	
<b>DIODE CHARACTERISTICS — continued</b>						
Reverse Recovery Time	$(I_F = 8.0 \text{ Adc}, V_R = 360 \text{ Vdc}, dI_F/dt = 200 \text{ A}/\mu\text{s})$	$t_{rr}$	—	57	—	ns
		$t_a$	—	18	—	
		$t_b$	—	39	—	
Reverse Recovery Stored Charge	$Q_{RR}$	—	107	—	$\mu\text{C}$	
Reverse Recovery Time	$(I_F = 8.0 \text{ Adc}, V_R = 360 \text{ Vdc}, dI_F/dt = 200 \text{ A}/\mu\text{s}, T_J = 125^\circ\text{C})$	$t_{rr}$	—	91	—	ns
		$t_a$	—	28	—	
		$t_b$	—	63	—	
Reverse Recovery Stored Charge	$Q_{RR}$	—	275	—	$\mu\text{C}$	
<b>INTERNAL PACKAGE INDUCTANCE</b>						
Internal Emitter Inductance (Measured from the emitter lead 0.25" from package to emitter bond pad)	$L_E$	—	7.5	—	nH	

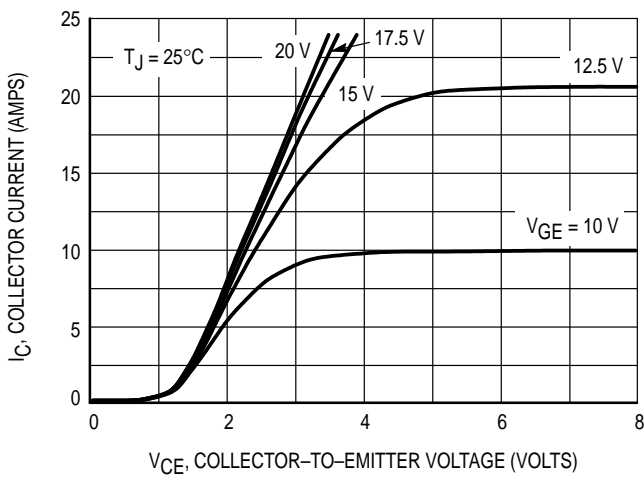


Figure 1. Output Characteristics

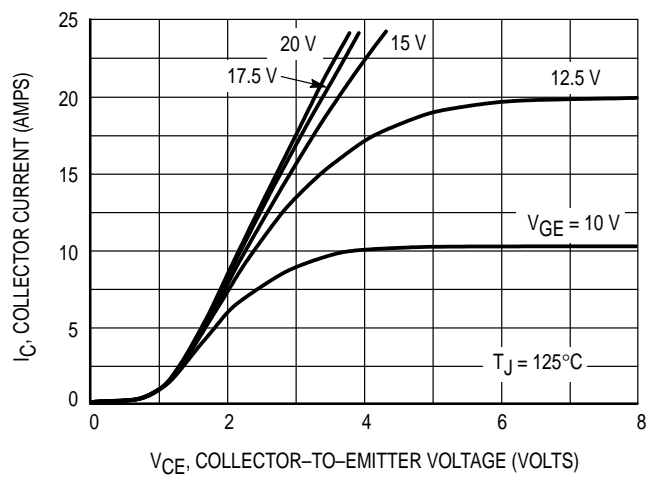


Figure 2. Output Characteristics

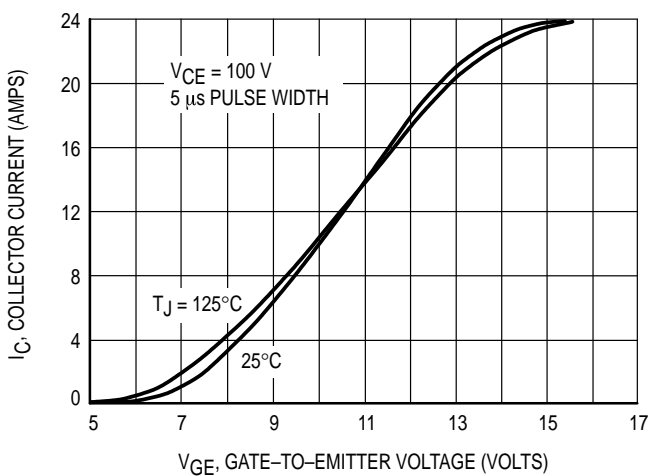


Figure 3. Transfer Characteristics

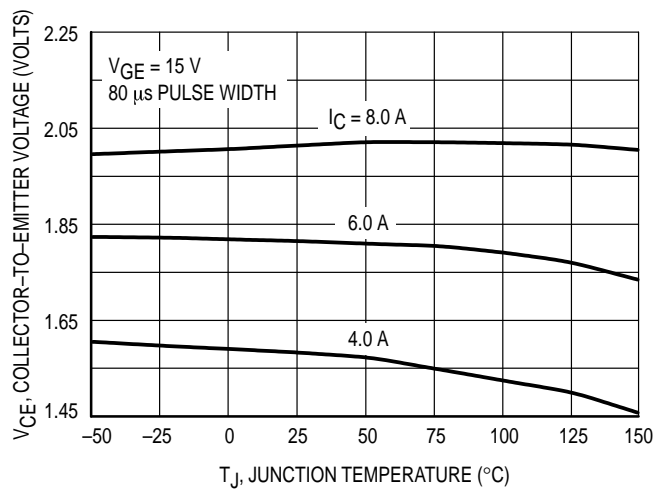
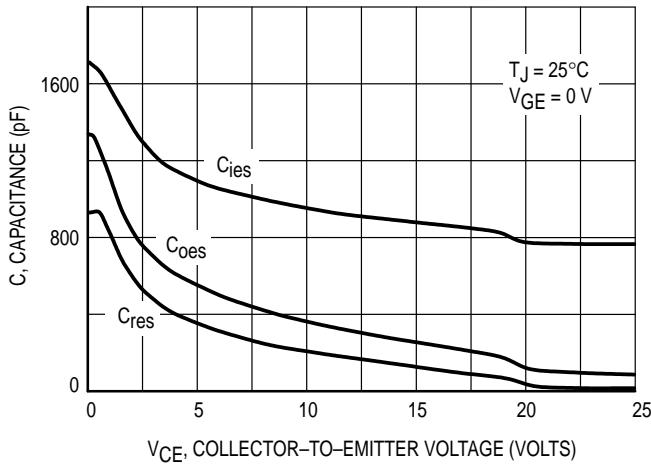
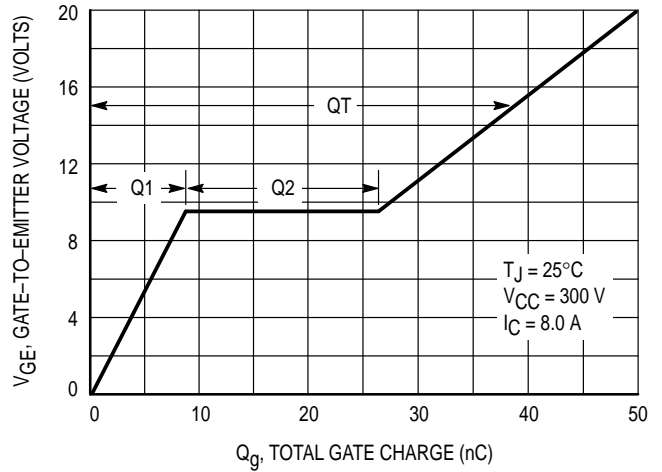


Figure 4. Collector-To-Emitter Saturation Voltage versus Junction Temperature

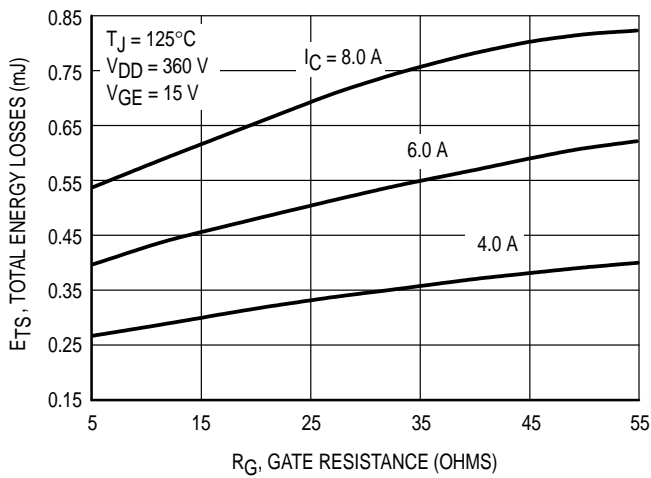
**MGP11N60ED**



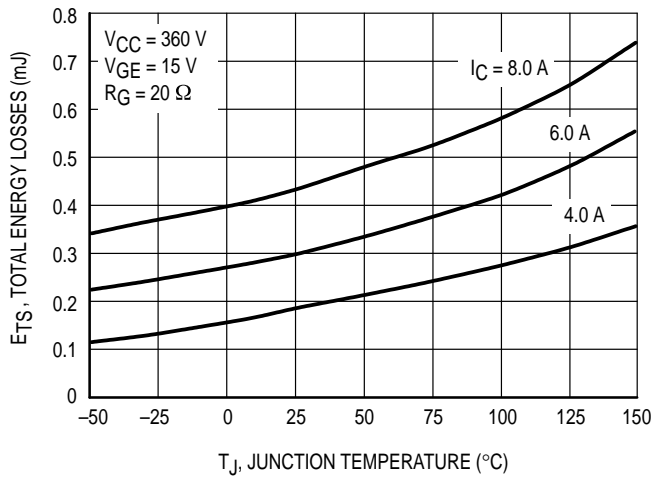
**Figure 5. Capacitance Variation**



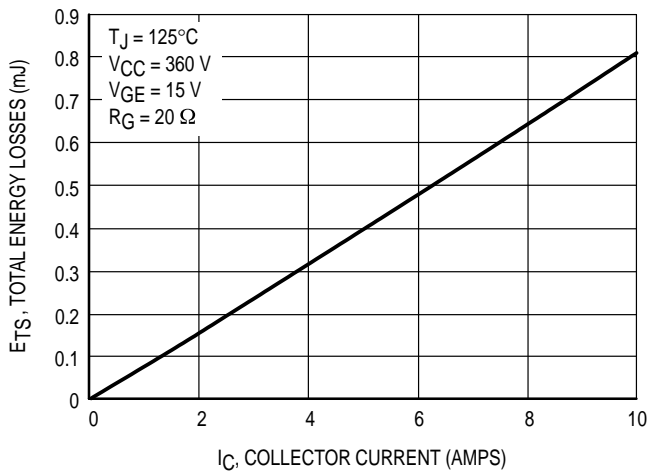
**Figure 6. Gate-To-Emitter Voltage versus Total Charge**



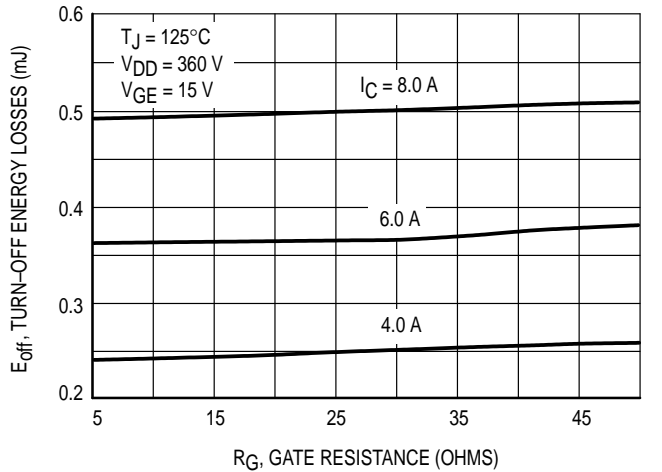
**Figure 7. Total Energy Losses versus Gate Resistance**



**Figure 8. Total Energy Losses versus Junction Temperature**



**Figure 9. Total Energy Losses versus Collector Current**



**Figure 10. Turn-Off Losses versus Gate Resistance**

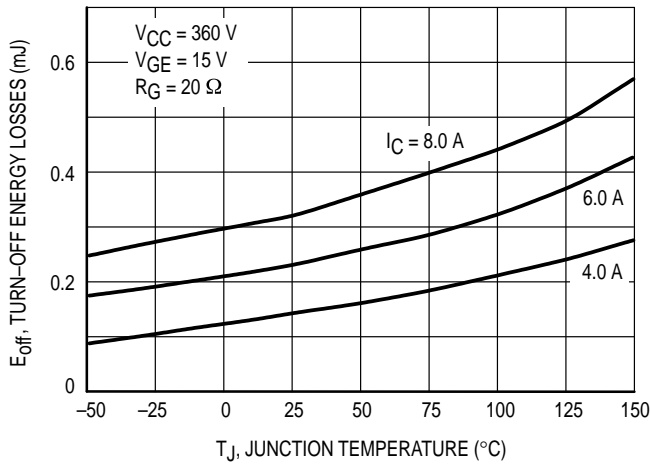


Figure 11. Turn-Off Losses versus Junction Temperature

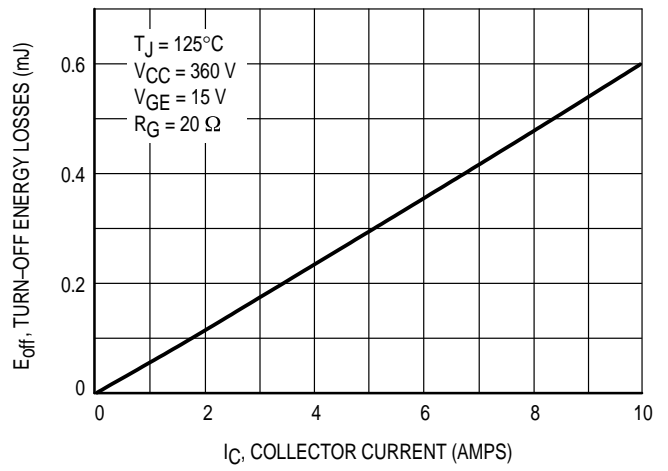


Figure 12. Turn-Off Losses versus Collector Current

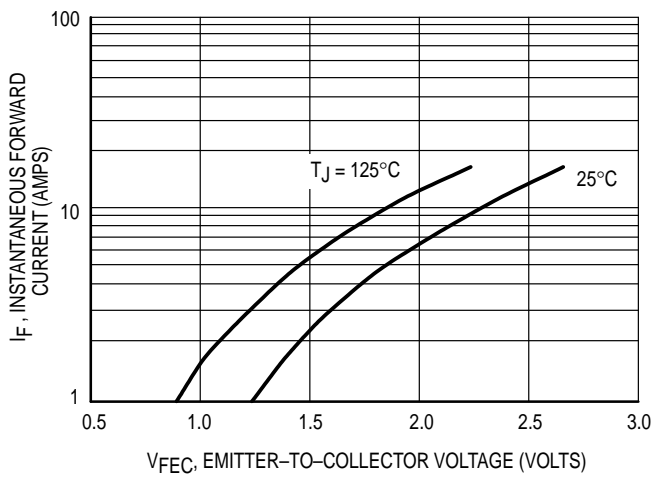


Figure 13. Forward Characteristics versus Current

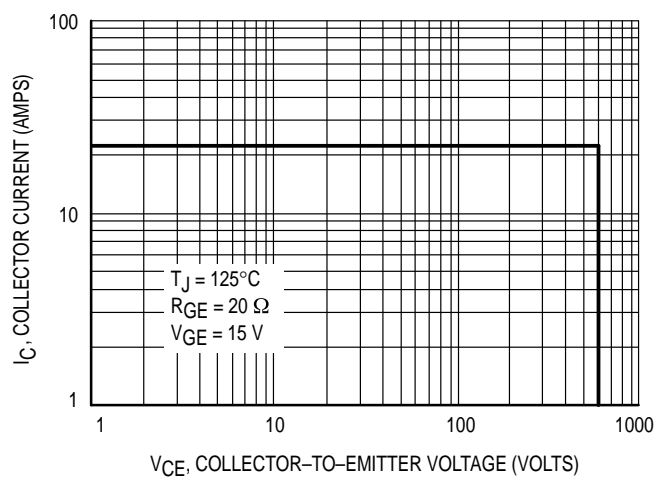
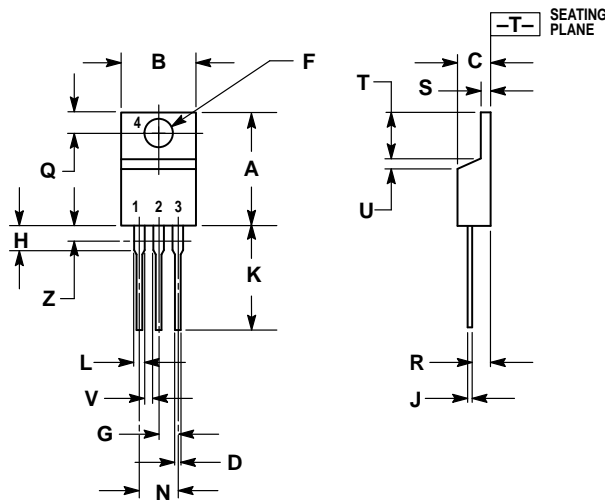


Figure 14. Reverse Biased Safe Operating Area

PACKAGE DIMENSIONS



- NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
  2. CONTROLLING DIMENSION: INCH.
  3. DIMENSION Z DEFINES A ZONE WHERE ALL BODY AND LEAD IRREGULARITIES ARE ALLOWED.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.570	0.620	14.48	15.75
B	0.380	0.405	9.66	10.28
C	0.160	0.190	4.07	4.82
D	0.025	0.035	0.64	0.88
F	0.142	0.147	3.61	3.73
G	0.095	0.105	2.42	2.66
H	0.110	0.155	2.80	3.93
J	0.018	0.025	0.46	0.64
K	0.500	0.562	12.70	14.27
L	0.045	0.060	1.15	1.52
N	0.190	0.210	4.83	5.33
Q	0.100	0.120	2.54	3.04
R	0.080	0.110	2.04	2.79
S	0.045	0.055	1.15	1.39
T	0.235	0.255	5.97	6.47
U	0.000	0.050	0.00	1.27
V	0.045	—	1.15	—
Z	—	0.080	—	2.04

CASE 221A-09  
TO-220AB  
ISSUE Z

- STYLE 9:  
PIN 1. GATE  
2. COLLECTOR  
3. EMITTER  
4. COLLECTOR

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