

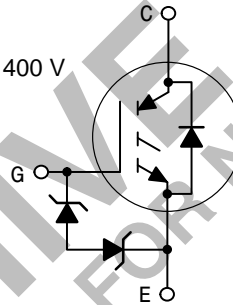
# Designer's™ Data Sheet

## Insulated Gate Bipolar Transistor with Anti-Parallel Diode

### N-Channel Enhancement-Mode Silicon Gate

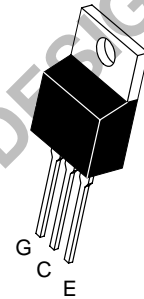
This Insulated Gate Bipolar Transistor (IGBT) is co-packaged with a soft recovery ultra-fast rectifier and uses an advanced termination scheme to provide an enhanced and reliable high voltage-blocking capability. Its new 600 V IGBT technology is specifically suited for applications requiring both a high 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 short circuit rugged device.

- Industry Standard TO-220 Package
- High Speed:  $E_{off} = 60 \mu\text{J/A}$  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 3.0 A, 125°C
- Soft Recovery Free Wheeling Diode is Included in the Package
- Robust High Voltage Termination
- ESD Protection Gate-Emitter Zener Diodes



**MGP4N60ED**

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



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)	$I_{C25}$ $I_{C90}$ $I_{CM}$	6.0 4.0 8.0	Adc Apk
Total Power Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	$P_D$	62.5 0.51	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	$R_{\theta JC}$ $R_{\theta Jc}$ $R_{\theta JA}$	2.0 3.6 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.

# MGP4N60ED

## 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> = 25 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> = 1.5 Adc) (V <sub>GE</sub> = 15 Vdc, I <sub>C</sub> = 1.5 Adc, T <sub>J</sub> = 125°C) (V <sub>GE</sub> = 15 Vdc, I <sub>C</sub> = 3.0 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> = 3.0 Adc)	g <sub>fe</sub>	—	1.8	—	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>	—	342	—	pF
Output Capacitance		C <sub>oes</sub>	—	40	—	
Transfer Capacitance		C <sub>res</sub>	—	3.0	—	

## SWITCHING CHARACTERISTICS (1)

Turn-On Delay Time	(V <sub>CC</sub> = 360 Vdc, I <sub>C</sub> = 3.0 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>	—	34	—	ns
Rise Time		t <sub>r</sub>	—	30	—	
Turn-Off Delay Time		t <sub>d(off)</sub>	—	36	—	
Fall Time		t <sub>f</sub>	—	216	—	μJ
Turn-Off Switching Loss		E <sub>off</sub>	—	100	150	
Turn-On Switching Loss		E <sub>on</sub>	—	25	—	
Total Switching Loss		E <sub>ts</sub>	—	125	—	
Turn-On Delay Time	(V <sub>CC</sub> = 360 Vdc, I <sub>C</sub> = 3.0 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>	—	33	—	ns
Rise Time		t <sub>r</sub>	—	32	—	
Turn-Off Delay Time		t <sub>d(off)</sub>	—	56	—	
Fall Time		t <sub>f</sub>	—	340	—	μJ
Turn-Off Switching Loss		E <sub>off</sub>	—	170	—	
Turn-On Switching Loss		E <sub>on</sub>	—	50	—	
Total Switching Loss		E <sub>ts</sub>	—	220	—	
Gate Charge	(V <sub>CC</sub> = 360 Vdc, I <sub>C</sub> = 3.0 Adc, V <sub>GE</sub> = 15 Vdc)	Q <sub>T</sub>	—	18.1	—	nC
		Q <sub>1</sub>	—	3.8	—	
		Q <sub>2</sub>	—	7.8	—	

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%.

**DIODE CHARACTERISTICS**

Diode Forward Voltage Drop ( $I_{EC} = 1.25 \text{ Adc}$ ) ( $I_{EC} = 1.25 \text{ Adc}, T_J = 125^\circ\text{C}$ ) ( $I_{EC} = 2.5 \text{ Adc}$ )		$V_{FEC}$	—	1.7	—	Vdc
			—	1.3	—	
			—	2.0	2.3	
Reverse Recovery Time	(I <sub>F</sub> = 2.5 Adc, V <sub>R</sub> = 360 Vdc, di <sub>F</sub> /dt = 200 A/μs)	t <sub>rr</sub>	—	39	—	ns
		t <sub>a</sub>	—	15	—	
		t <sub>b</sub>	—	24	—	
Reverse Recovery Stored Charge		Q <sub>RR</sub>	—	51	—	nC
Reverse Recovery Time	(I <sub>F</sub> = 2.5 Adc, V <sub>R</sub> = 360 Vdc, di <sub>F</sub> /dt = 200 A/μs, T <sub>J</sub> = 125°C)	t <sub>rr</sub>	—	68	—	ns
		t <sub>a</sub>	—	21	—	
		t <sub>b</sub>	—	47	—	
Reverse Recovery Stored Charge		Q <sub>RR</sub>	—	115	—	nC

**INTERNAL PACKAGE INDUCTANCE**

Internal Emitter Inductance (Measured from the emitter lead 0.25" from package to emitter bond pad)	L <sub>E</sub>	—	7.5	—	nH
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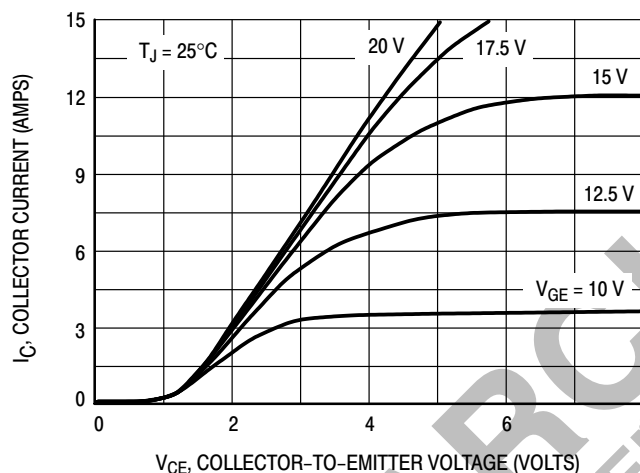


Figure 1. Output Characteristics

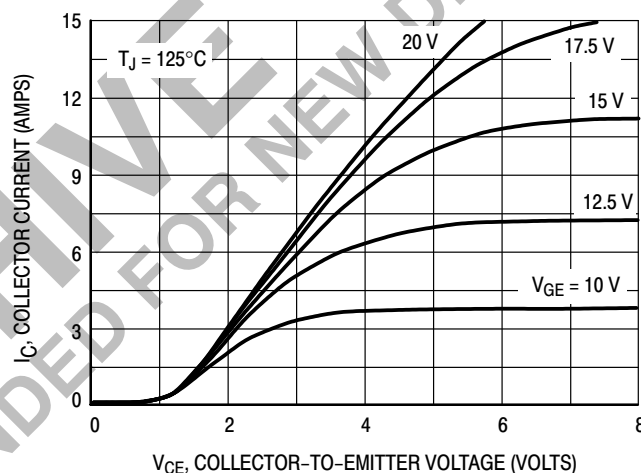


Figure 2. Output Characteristics

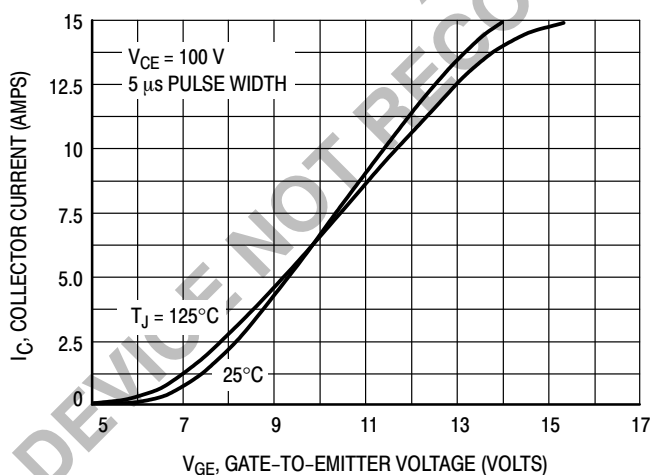


Figure 3. Transfer Characteristics

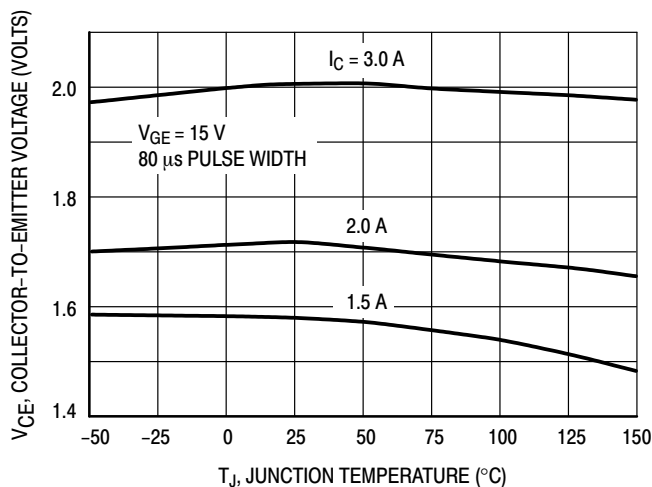


Figure 4. Collector-To-Emitter Saturation Voltage versus Junction Temperature

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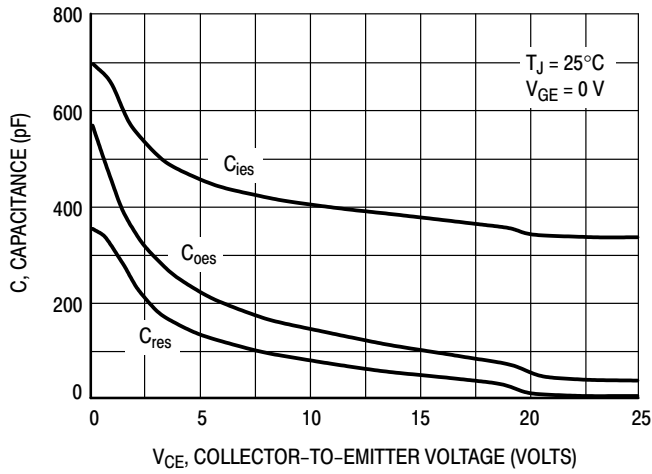


Figure 5. Capacitance Variation

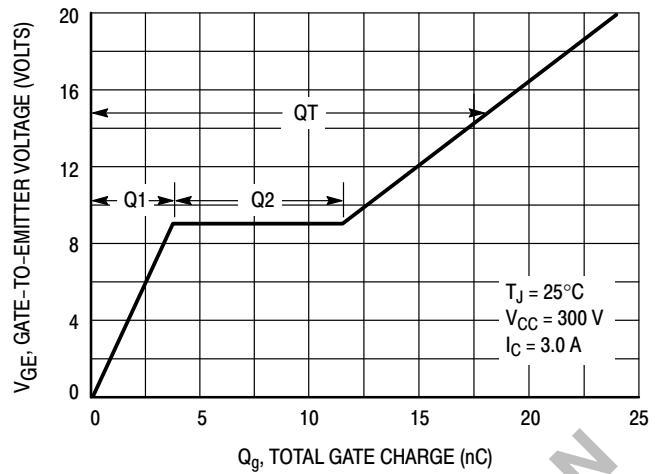


Figure 6. Gate-To-Emitter Voltage versus Total Charge

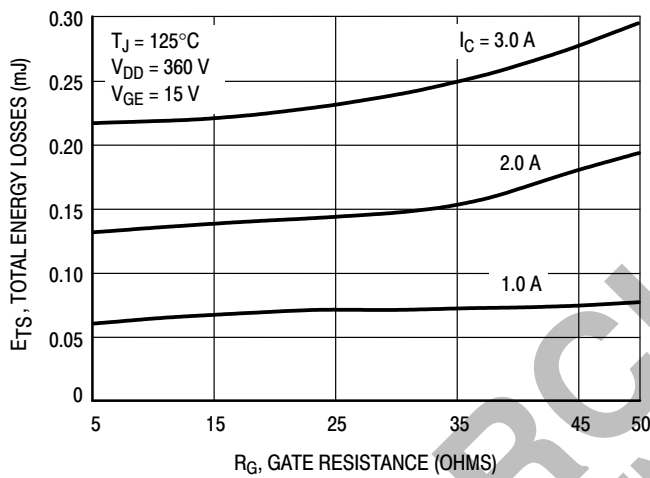


Figure 7. Total Energy Losses versus Gate Resistance

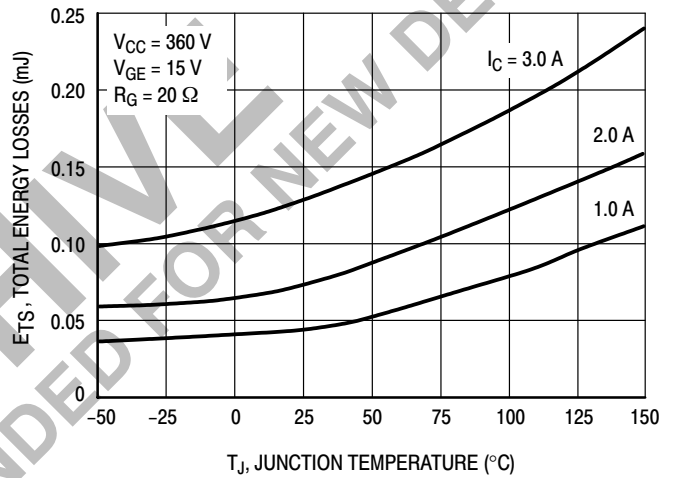


Figure 8. Total Energy Losses versus Junction Temperature

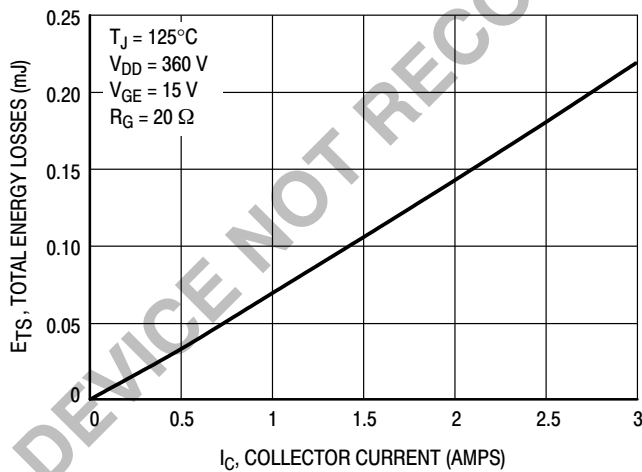


Figure 9. Total Energy Losses versus Collector Current

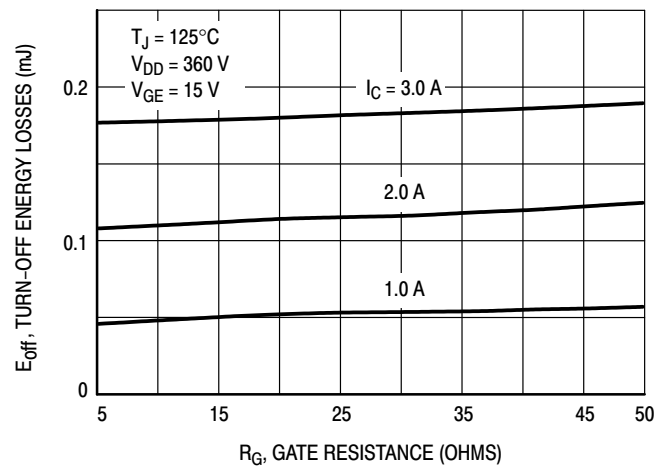


Figure 10. Turn-Off Losses versus Gate Resistance

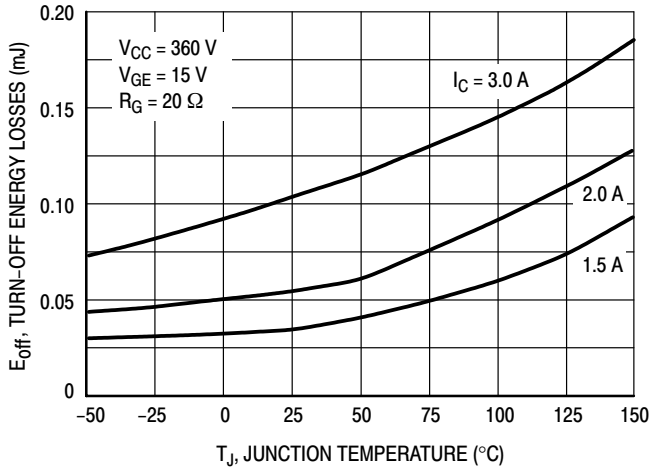


Figure 11. Turn-Off Losses versus Junction Temperature

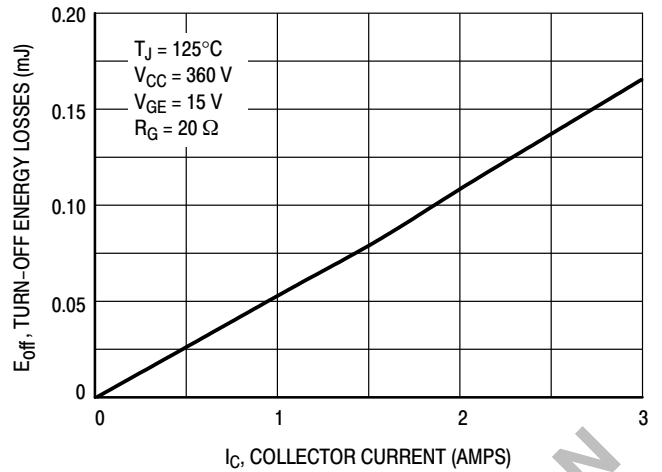


Figure 12. Turn-Off Losses versus Collector Current

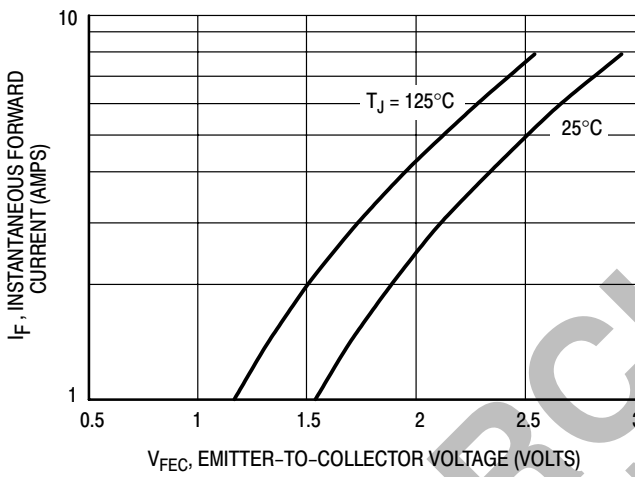


Figure 13. Forward Characteristics versus Current

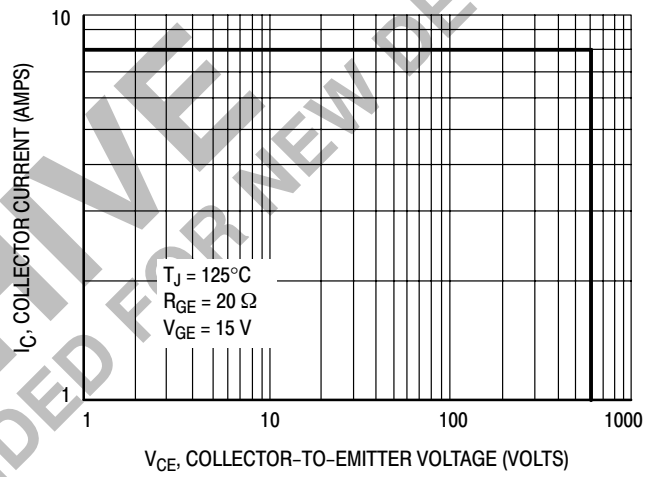
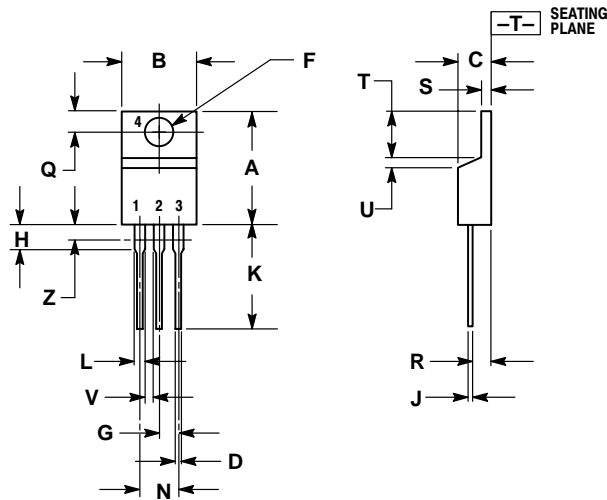


Figure 14. Reverse Biased Safe Operating Area

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

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

CASE 221A-09  
 TO-220AB  
 ISSUE Z

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