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# IRGI4060DPbF

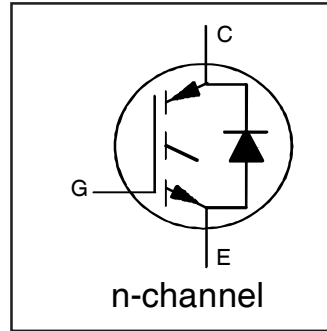
## INSULATED GATE BIPOLAR TRANSISTOR WITH ULTRAFAST SOFT RECOVERY DIODE

### Features

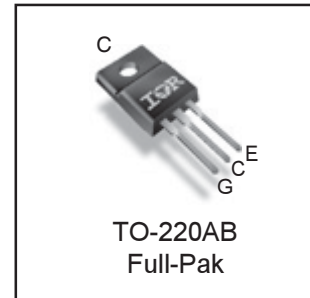
- Low  $V_{CE(on)}$  Trench IGBT Technology
- Low Switching Losses
- 5 $\mu$ s SCSOA
- Square RBSOA
- 100% of The Parts Tested for  $I_{LM}$  ①
- Positive  $V_{CE(on)}$  Temperature Coefficient.
- Ultra Fast Soft Recovery Co-pak Diode
- Tighter Distribution of Parameters
- Lead-Free Package

### Benefits

- High Efficiency in a Wide Range of Applications
- Suitable for a Wide Range of Switching Frequencies due to Low  $V_{CE(ON)}$  and Low Switching Losses
- Rugged Transient Performance for Increased Reliability
- Excellent Current Sharing in Parallel Operation
- Low EMI



$V_{CES} = 600V$
$I_C = 7.5A, T_C = 100^\circ C$
$t_{sc} > 5\mu s, T_{jmax} = 150^\circ C$
$V_{CE(on) typ.} = 1.50V$



<b>G</b>	<b>C</b>	<b>E</b>
Gate	Collector	Emitter

### Absolute Maximum Ratings

	Parameter	Max.	Units
$V_{CES}$	Collector-to-Emitter Breakdown Voltage	600	V
$I_C @ T_C = 25^\circ C$	Continuous Collector Current	14	A
$I_C @ T_C = 100^\circ C$	Continuous Collector Current	7.5	
$I_{CM}$	Pulse Collector Current, $V_{GE}=15V$	23	
$I_{LM}$	Clamped Inductive Load Current, $V_{GE}=20V$ ①	30	
$I_F @ T_C=25^\circ C$	Diode Continuous Forward Current	14	
$I_F @ T_C=100^\circ C$	Diode Continuous Forward Current	7.5	
$I_{FM}$	Diode Maximum Forward Current ②	30	
$V_{GE}$	Continuous Gate-to-Emitter Voltage	$\pm 20$	V
	Transient Gate-to-Emitter Voltage	$\pm 30$	
$P_D @ T_C = 25^\circ C$	Maximum Power Dissipation	37	W
$P_D @ T_C = 100^\circ C$	Maximum Power Dissipation	15	
$T_J$ $T_{STG}$	Operating Junction and Storage Temperature Range	-55 to + 150	$^\circ C$
	Soldering Temperature, for 10 seconds	300 (0.063 in. (1.6mm) from case)	
	Mounting Torque, 6-32 or M3 Screw	10 lbf-in (1.1 N-m)	

### Thermal Resistance

	Parameter	Min.	Typ.	Max.	Units
$R_{\theta JC}$	Junction-to-Case - IGBT ③	—	—	3.40	$^\circ C/W$
$R_{\theta JC}$	Junction-to-Case - Diode ③	—	—	6.10	
$R_{\theta CS}$	Case-to-Sink, flat, greased surface	—	0.5	—	
$R_{\theta JA}$	Junction-to-Ambient, typical socket mount ③	—	—	65	
Wt	Weight	—	2.0	—	g

**Electrical Characteristics @  $T_J = 25^\circ\text{C}$  (unless otherwise specified)**

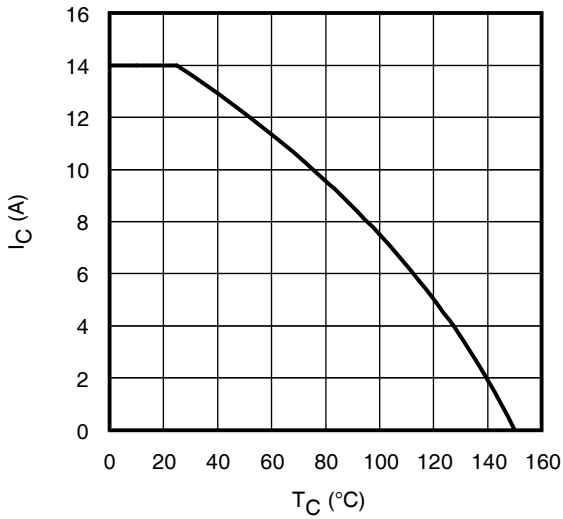
	Parameter	Min.	Typ.	Max.	Units	Conditions
$V_{(BR)CES}$	Collector-to-Emitter Breakdown Voltage	600	—	—	V	$V_{GE} = 0V, I_C = 100 \mu\text{A}$ ④
$\Delta V_{(BR)CES}/\Delta T_J$	Temperature Coeff. of Breakdown Voltage	—	0.66	—	V/°C	$V_{GE} = 0V, I_C = 250 \mu\text{A}$ ( -55 -150 °C ) ④
$V_{CE(on)}$	Collector-to-Emitter Saturation Voltage	—	1.50	1.72		$I_C = 7.5A, V_{GE} = 15V, T_J = 25^\circ\text{C}$
		—	1.75	—	V	$I_C = 7.5A, V_{GE} = 15V, T_J = 125^\circ\text{C}$
		—	1.81	—		$I_C = 7.5A, V_{GE} = 15V, T_J = 150^\circ\text{C}$
$V_{GE(th)}$	Gate Threshold Voltage	4.0		6.5	V	$V_{CE} = V_{GE}, I_C = 250 \mu\text{A}$
$\Delta V_{GE(th)}/\Delta T_J$	Threshold Voltage temp. coefficient	—	-12	—	mV/°C	$V_{CE} = V_{GE}, I_C = 1.0\text{mA}$ ( -55 -150 °C )
$g_{fe}$	Forward Transconductance	—	5	—	S	$V_{CE} = 50V, I_C = 7.5A, PW = 80\mu\text{s}$
$I_{CES}$	Collector-to-Emitter Leakage Current	—	1.0	25	$\mu\text{A}$	$V_{GE} = 0V, V_{CE} = 600V$
		—	400	—	$\mu\text{A}$	$V_{GE} = 0V, V_{CE} = 600V, T_J = 150^\circ\text{C}$
$V_{FM}$	Diode Forward Voltage Drop	—	2.18	3.00	V	$I_F = 7.5A$
		—	1.60	—		$I_F = 7.5A, T_J = 150^\circ\text{C}$
$I_{GES}$	Gate-to-Emitter Leakage Current	—	—	$\pm 100$	nA	$V_{GE} = \pm 20 V$

**Switching Characteristics @  $T_J = 25^\circ\text{C}$  (unless otherwise specified)**

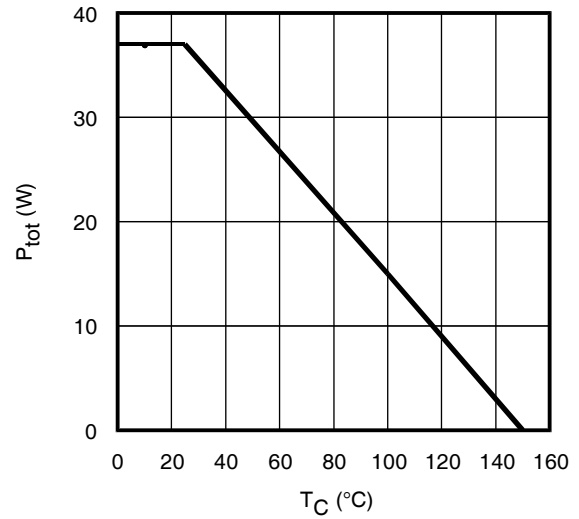
	Parameter	Min.	Typ.	Max.	Units	Conditions
$Q_g$	Total Gate Charge (turn-on)	—	19	29	nC	$I_C = 7.5A$ $V_{CC} = 400V$ $V_{GE} = 15V$
$Q_{ge}$	Gate-to-Emitter Charge (turn-on)	—	4.3	6		
$Q_{gc}$	Gate-to-Collector Charge (turn-on)	—	8.3	12		
$E_{on}$	Turn-On Switching Loss	—	47	89	$\mu\text{J}$	$I_C = 7.5A, V_{CC} = 400V, V_{GE} = 15V$ $R_G = 47\Omega, L = 1\text{mH}, L_S = 150\text{nH}, T_J = 25^\circ\text{C}$ Energy losses include tail and diode reverse recovery
$E_{off}$	Turn-Off Switching Loss	—	141	248		
$E_{total}$	Total Switching Loss	—	188	337		
$t_{d(on)}$	Turn-On delay time	—	29	38	ns	$I_C = 7.5A, V_{CC} = 400V$ $R_G = 47\Omega, L = 1\text{mH}, L_S = 150\text{nH}$ $T_J = 25^\circ\text{C}$
$t_r$	Rise time	—	16	25		
$t_{d(off)}$	Turn-Off delay time	—	101	112		
$t_f$	Fall time	—	28	37		
$E_{on}$	Turn-On Switching Loss	—	107	—	$\mu\text{J}$	$I_C = 7.5A, V_{CC} = 400V, V_{GE} = 15V$ $R_G = 47\Omega, L = 1\text{mH}, L_S = 150\text{nH}, T_J = 150^\circ\text{C}$ Energy losses include tail and diode reverse recovery
$E_{off}$	Turn-Off Switching Loss	—	196	—		
$E_{total}$	Total Switching Loss	—	304	—		
$t_{d(on)}$	Turn-On delay time	—	28	—	ns	$I_C = 7.5A, V_{CC} = 400V$ $R_G = 47\Omega, L = 1\text{mH}, L_S = 150\text{nH}$ $T_J = 150^\circ\text{C}$
$t_r$	Rise time	—	17	—		
$t_{d(off)}$	Turn-Off delay time	—	118	—		
$t_f$	Fall time	—	53	—		
$C_{ies}$	Input Capacitance	—	537	—	pF	$V_{GE} = 0V$ $V_{CC} = 30V$ $f = 1\text{Mhz}$
$C_{oes}$	Output Capacitance	—	47	—		
$C_{res}$	Reverse Transfer Capacitance	—	16	—		
RBSOA	Reverse Bias Safe Operating Area	FULL SQUARE				$T_J = 150^\circ\text{C}, I_C = 30A$ $V_{CC} = 480V, V_p = 600V$ $R_G = 47\Omega, V_{GE} = +20V \text{ to } 0V$
SCSOA	Short Circuit Safe Operating Area	5	—	—	$\mu\text{s}$	$V_{CC} = 400V, V_p = 600V$ $R_G = 47\Omega, V_{GE} = +15V \text{ to } 0V$
$E_{rec}$	Reverse recovery energy of the diode	—	102	—	$\mu\text{J}$	$T_J = 150^\circ\text{C}$
$t_{rr}$	Diode Reverse recovery time	—	73	—	ns	$V_{CC} = 400V, I_F = 7.5A$
$I_{rr}$	Peak Reverse Recovery Current	—	11	—	A	$V_{GE} = 15V, R_G = 47\Omega, L = 1\text{mH}, L_S = 150\text{nH}$

## Notes:

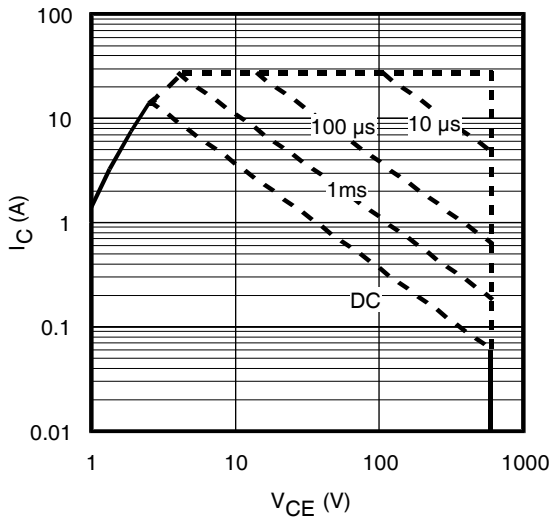
- ①  $V_{CC} = 80\% (V_{CES}), V_{GE} = 20V, L = 28 \mu\text{H}, R_G = 47 \Omega$
- ② Pulse width limited by max. junction temperature.
- ③  $R_\theta$  is measured at  $T_J$  approximately  $90^\circ\text{C}$
- ④ Refer to AN-1086 for guidelines for measuring  $V_{(BR)CES}$  safely



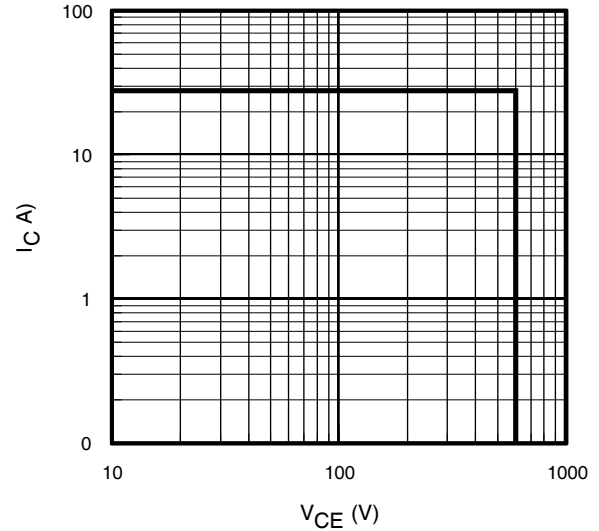
**Fig. 1** - Maximum DC Collector Current vs. Case Temperature



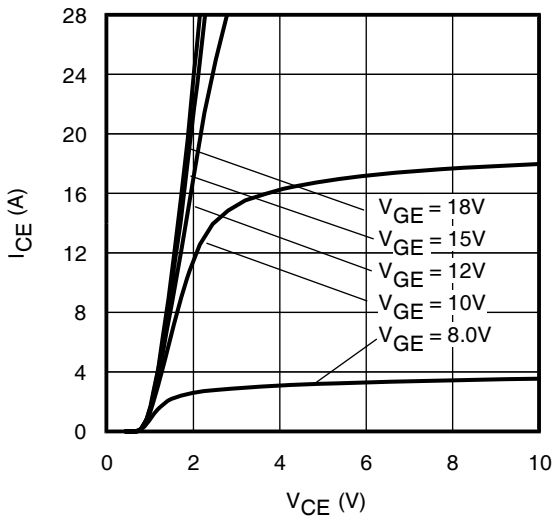
**Fig. 2** - Power Dissipation vs. Case Temperature



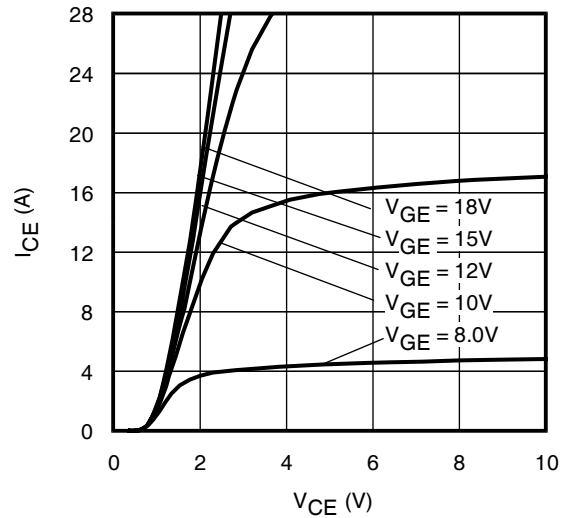
**Fig. 3** - Forward SOA,  
 $T_C = 25^\circ\text{C}$ ;  $T_J \leq 150^\circ\text{C}$



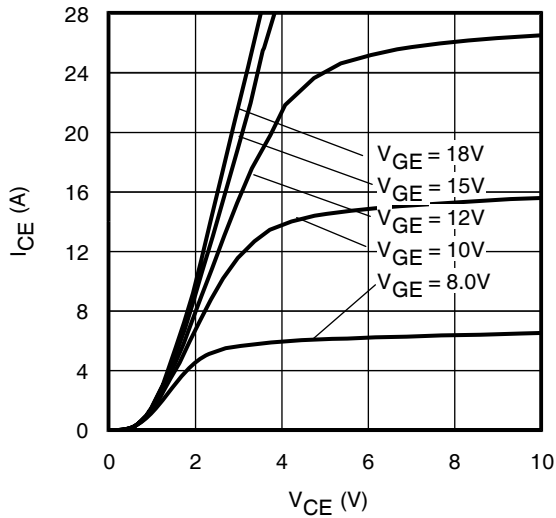
**Fig. 4** - Reverse Bias SOA  
 $T_J = 150^\circ\text{C}$ ;  $V_{CE} = 15\text{V}$



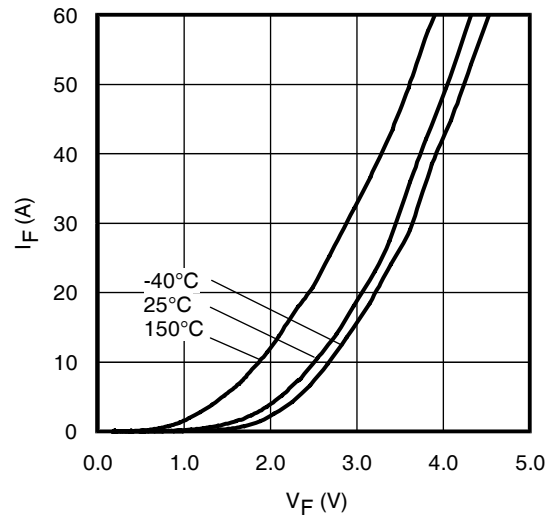
**Fig. 5** - Typ. IGBT Output Characteristics  
 $T_J = -40^\circ\text{C}$ ;  $t_p < 60\mu\text{s}$



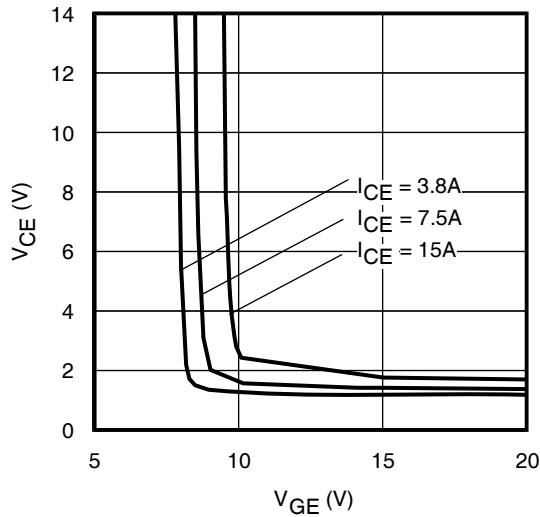
**Fig. 6** - Typ. IGBT Output Characteristics  
 $T_J = 25^\circ\text{C}$ ;  $t_p < 60\mu\text{s}$



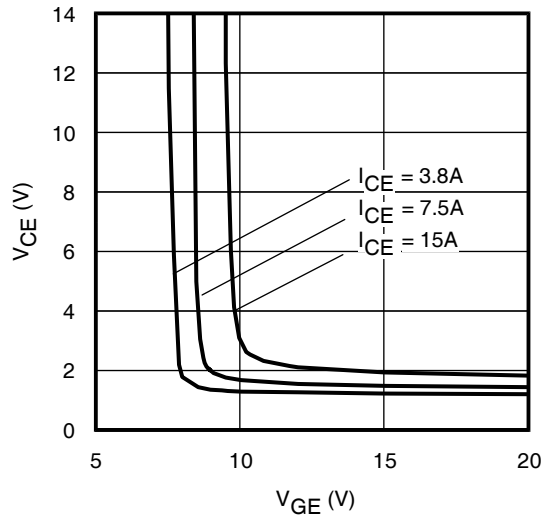
**Fig. 7** - Typ. IGBT Output Characteristics  
 $T_J = 150^\circ\text{C}$ ;  $t_p < 60\mu\text{s}$



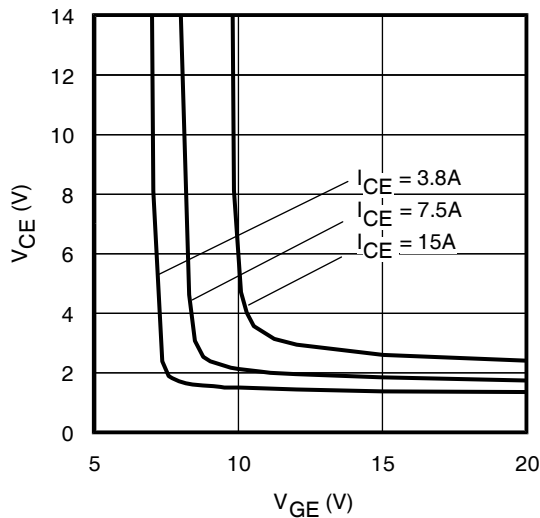
**Fig. 8** - Typ. Diode Forward Characteristics  
 $t_p < 60\mu\text{s}$



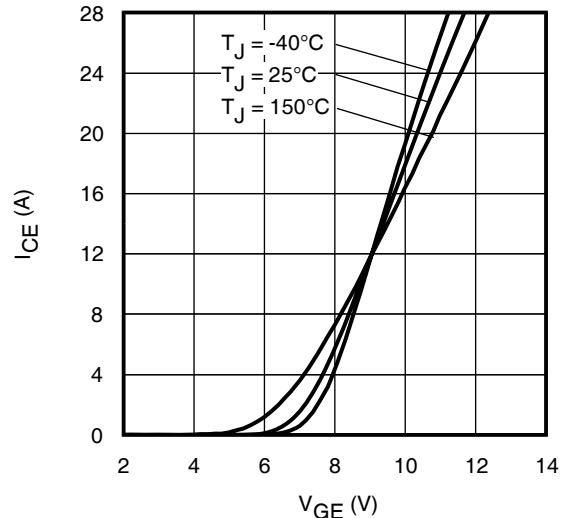
**Fig. 9** - Typical  $V_{CE}$  vs.  $V_{GE}$   
 $T_J = -40^\circ\text{C}$



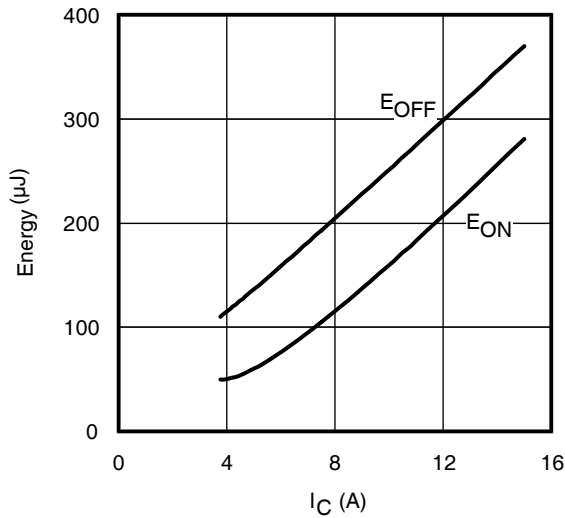
**Fig. 10** - Typical  $V_{CE}$  vs.  $V_{GE}$   
 $T_J = 25^\circ\text{C}$



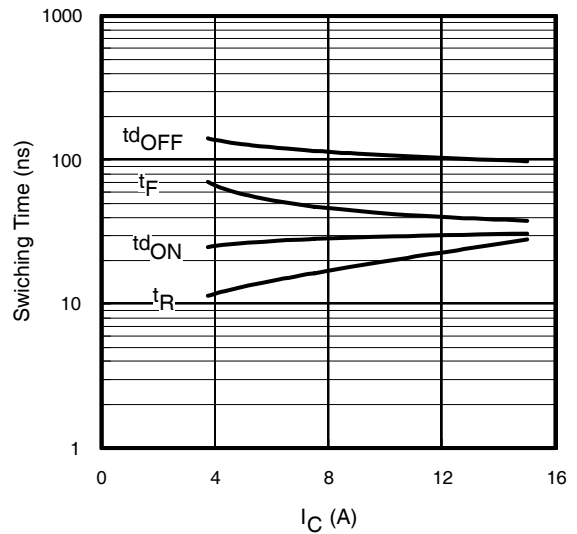
**Fig. 11** - Typical  $V_{CE}$  vs.  $V_{GE}$   
 $T_J = 150^\circ\text{C}$



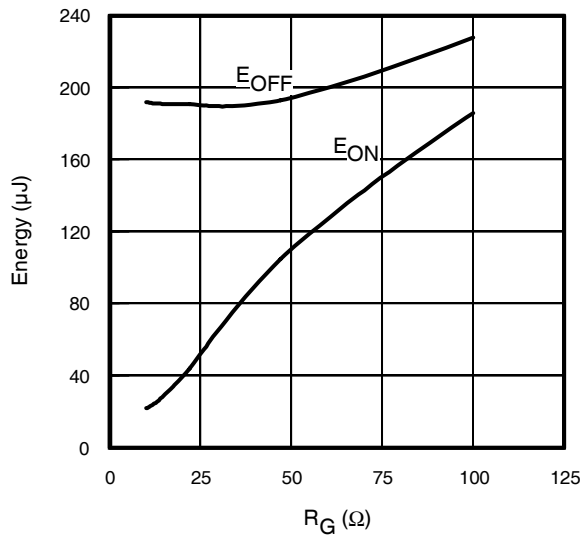
**Fig. 12** - Typ. Transfer Characteristics  
 $V_{CE} = 50\text{V}$ ;  $t_p < 60\mu\text{s}$



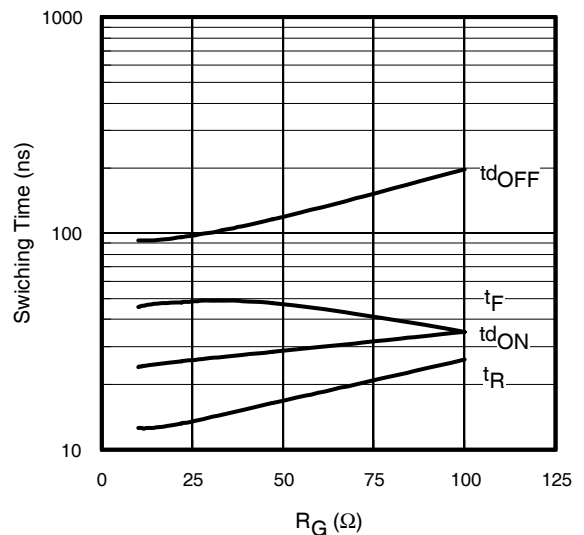
**Fig. 13** - Typ. Energy Loss vs.  $I_C$   
 $T_J = 150^\circ\text{C}$ ;  $L = 1\text{mH}$ ;  $V_{CE} = 400\text{V}$ ;  $R_G = 47\Omega$ ;  $V_{GE} = 15\text{V}$ .



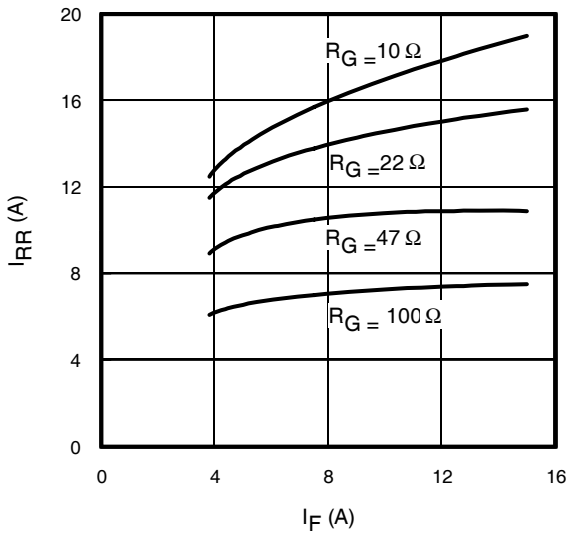
**Fig. 14** - Typ. Switching Time vs.  $I_C$   
 $T_J = 150^\circ\text{C}$ ;  $L = 1\text{mH}$ ;  $V_{CE} = 400\text{V}$   
 $R_G = 47\Omega$ ;  $V_{GE} = 15\text{V}$



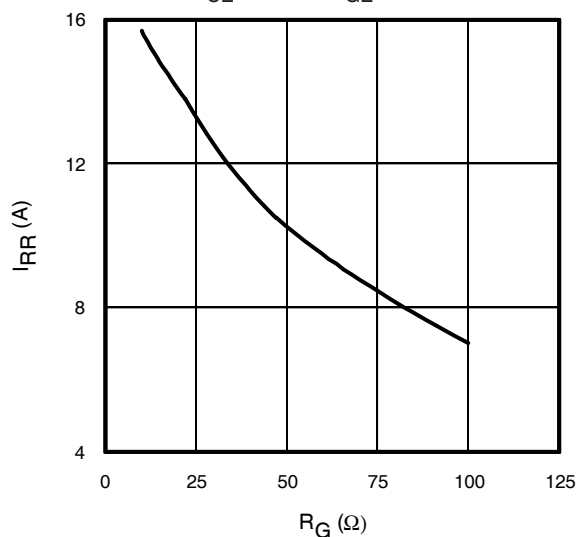
**Fig. 15** - Typ. Energy Loss vs.  $R_G$   
 $T_J = 150^\circ\text{C}$ ;  $L = 1\text{mH}$ ;  $V_{CE} = 400\text{V}$ ;  $I_{CE} = 7.5\text{A}$ ;  $V_{GE} = 15\text{V}$



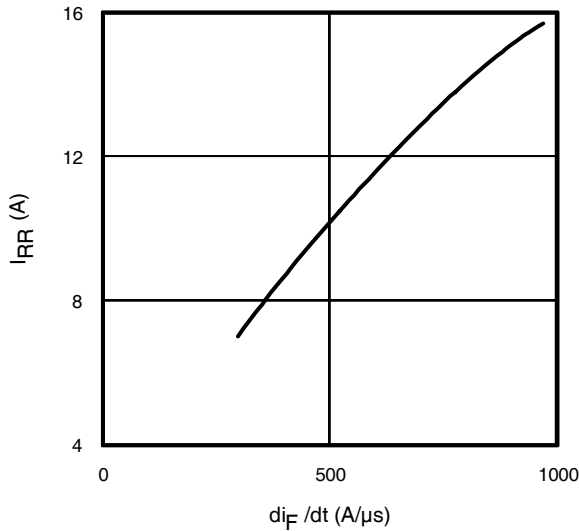
**Fig. 16** - Typ. Switching Time vs.  $R_G$   
 $T_J = 150^\circ\text{C}$ ;  $L = 1\text{mH}$ ;  $V_{CE} = 400\text{V}$   
 $I_{CE} = 7.5\text{A}$ ;  $V_{GE} = 15\text{V}$



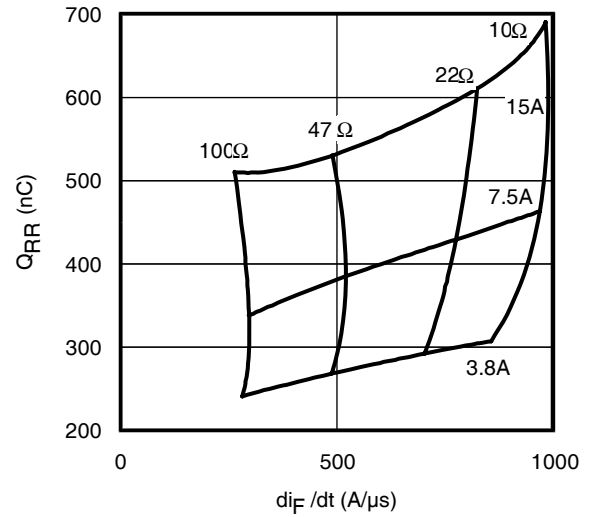
**Fig. 17** - Typical Diode  $I_{RR}$  vs.  $I_F$   
 $T_J = 150^\circ\text{C}$



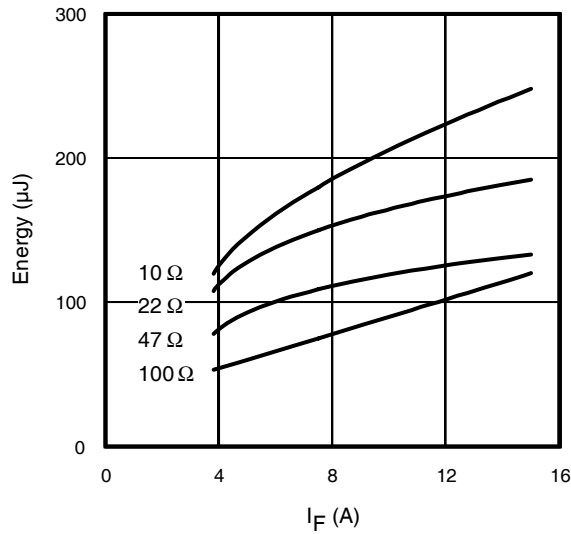
**Fig. 18** - Typical Diode  $I_{RR}$  vs.  $R_G$   
 $T_J = 150^\circ\text{C}$ ;  $I_F = 7.5\text{A}$



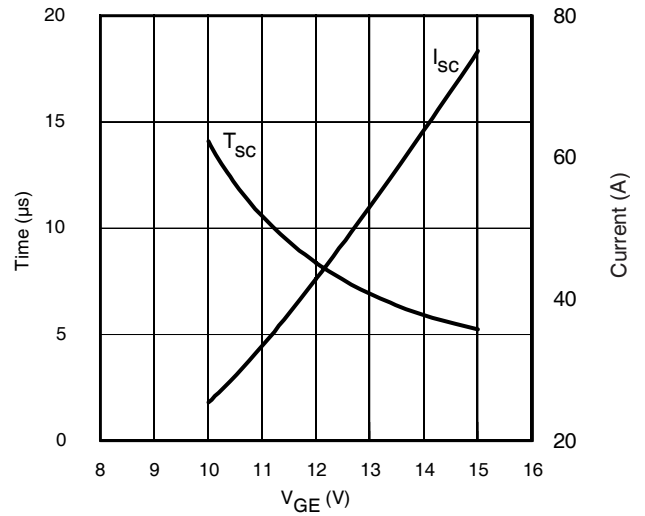
**Fig. 19** - Typical Diode  $I_{RR}$  vs.  $di_F/dt$   
 $V_{CC}=400V$ ;  $V_{GE}=15V$ ;  
 $I_{CE}=7.5A$ ;  $T_J=150^\circ C$



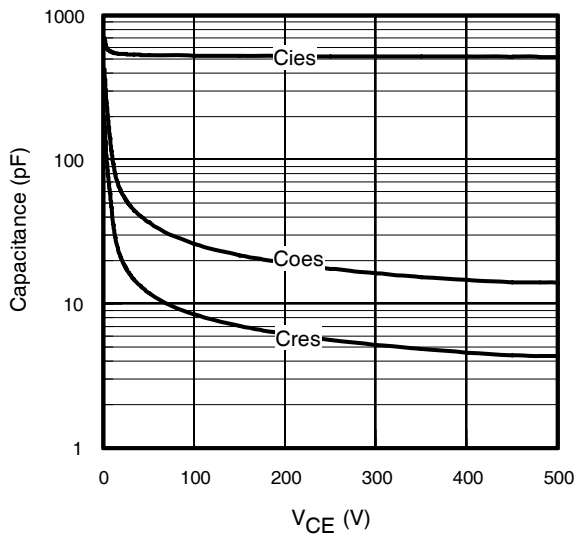
**Fig. 20** - Typical Diode  $Q_{RR}$   
 $V_{CC}=400V$ ;  $V_{GE}=15V$ ;  $T_J=150^\circ C$



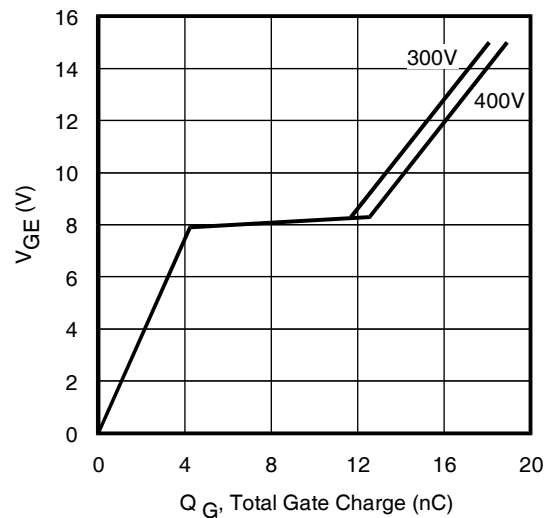
**Fig. 21** - Typical Diode  $E_{RR}$  vs.  $I_F$   
 $T_J=150^\circ C$



**Fig. 22** - Typ.  $V_{GE}$  vs Short Circuit Time  
 $V_{CC}=400V$ ,  $T_C=25^\circ C$



**Fig. 23** - Typ. Capacitance vs.  $V_{CE}$   
 $V_{GE}=0V$ ;  $f=1MHz$



**Fig. 24** - Typical Gate Charge vs.  $V_{GE}$   
 $I_{CE}=7.5A$ ,  $L=600\mu H$

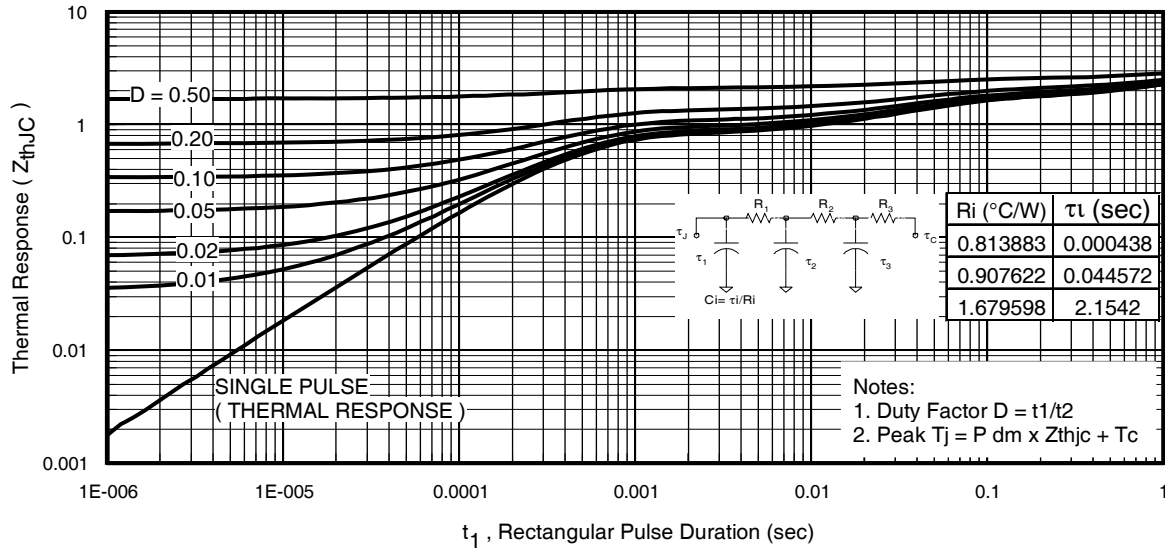


Fig 25. Maximum Transient Thermal Impedance, Junction-to-Case (IGBT)

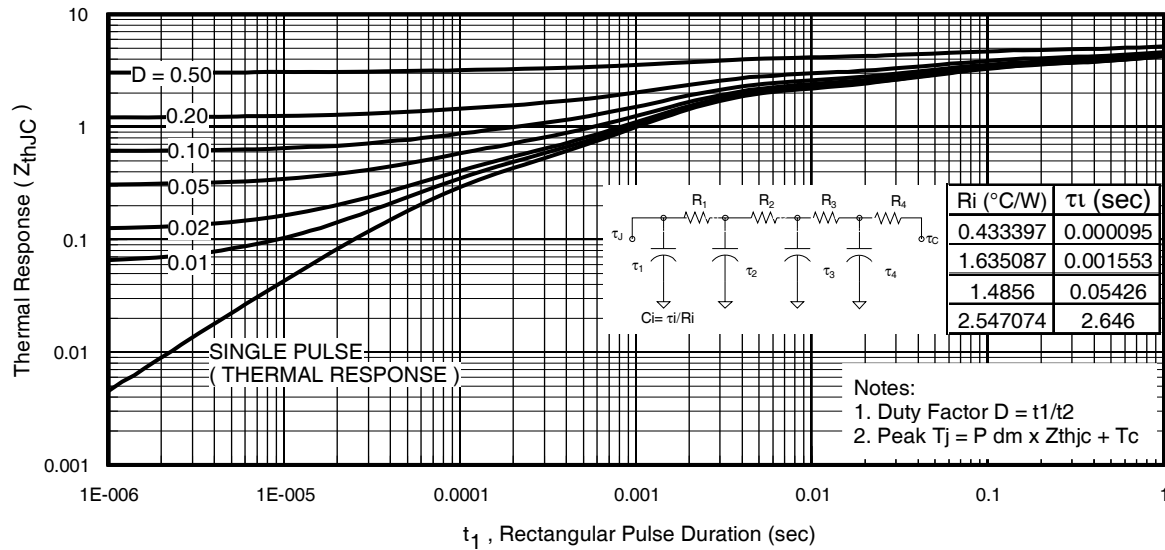
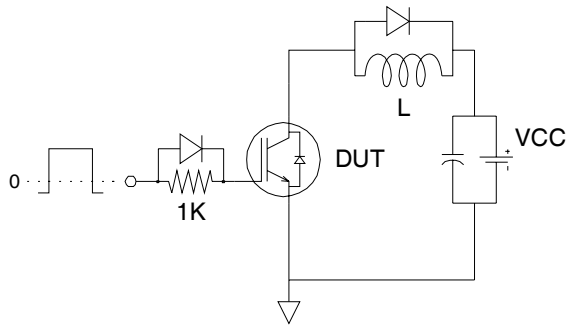
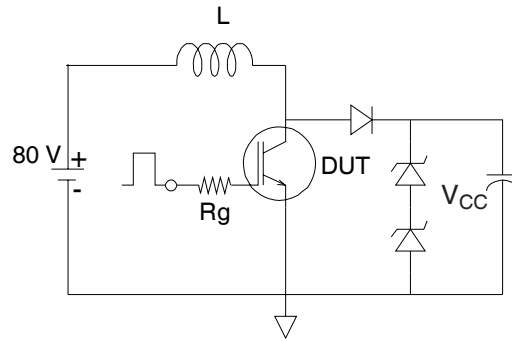


Fig. 26. Maximum Transient Thermal Impedance, Junction-to-Case (DIODE)

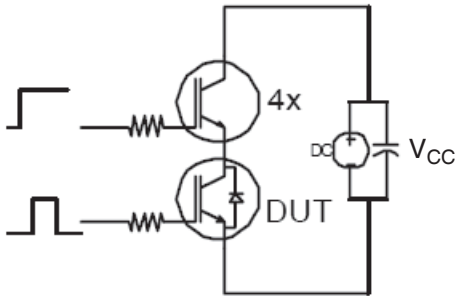




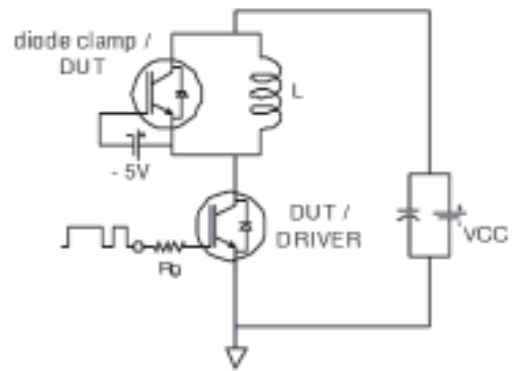
**Fig.C.T.1 - Gate Charge Circuit (turn-off)**



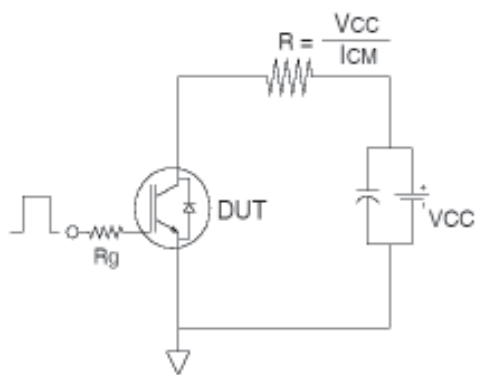
**Fig.C.T.2 - RBSOA Circuit**



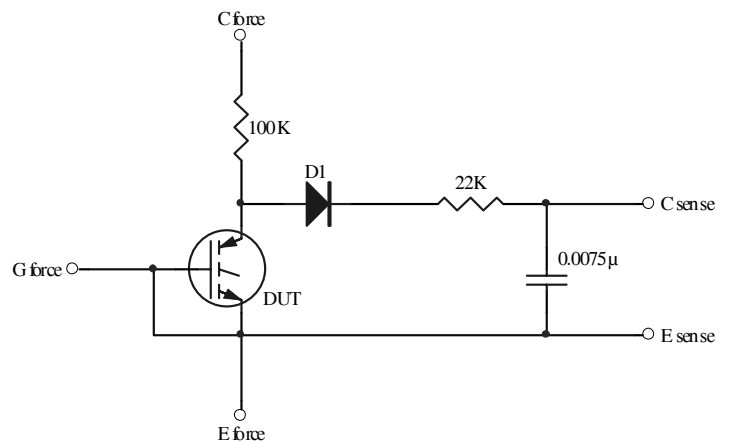
**Fig.C.T.3 - S.C.SOA Circuit**



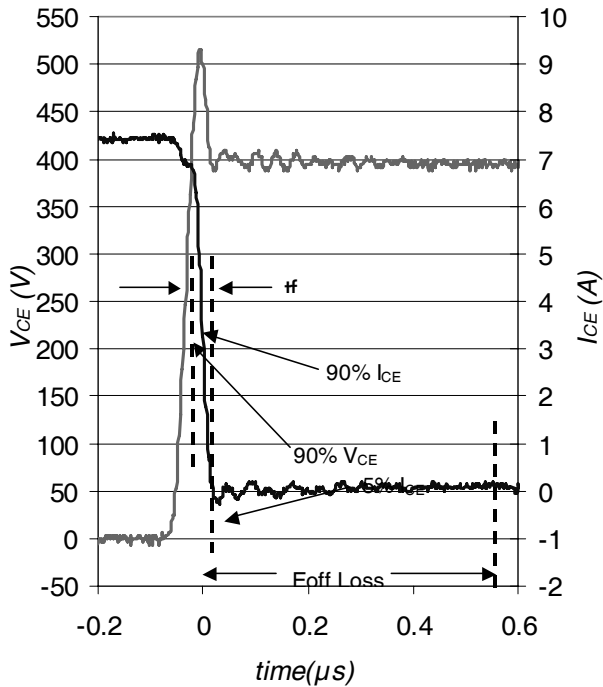
**Fig.C.T.4 - Switching Loss Circuit**



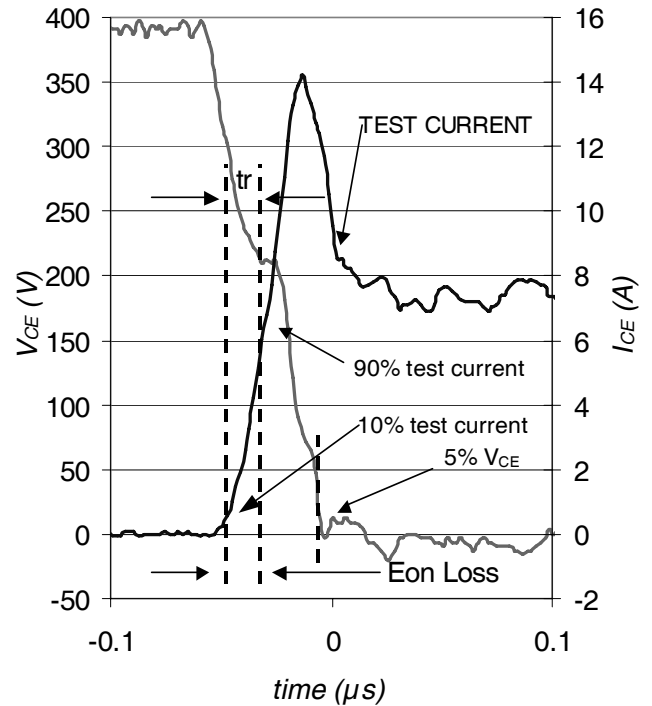
**Fig.C.T.5 - Resistive Load Circuit**



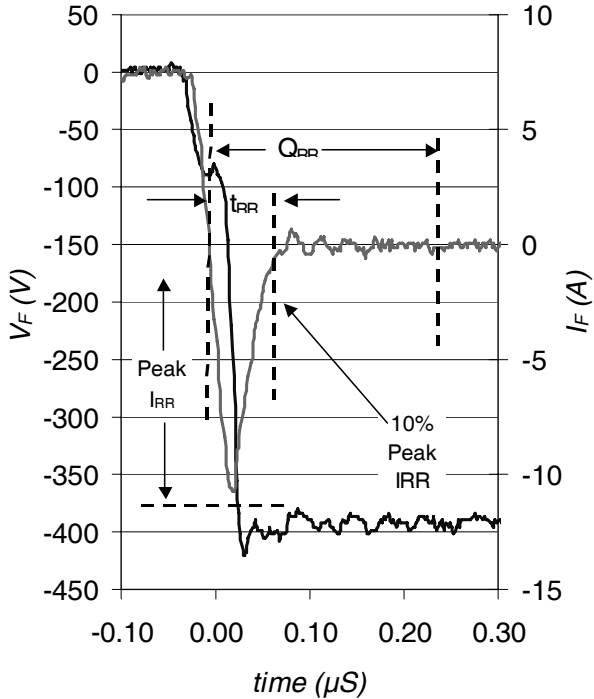
**Fig.C.T.6 - Typical Filter Circuit for  $V_{(BR)CES}$  Measurement**



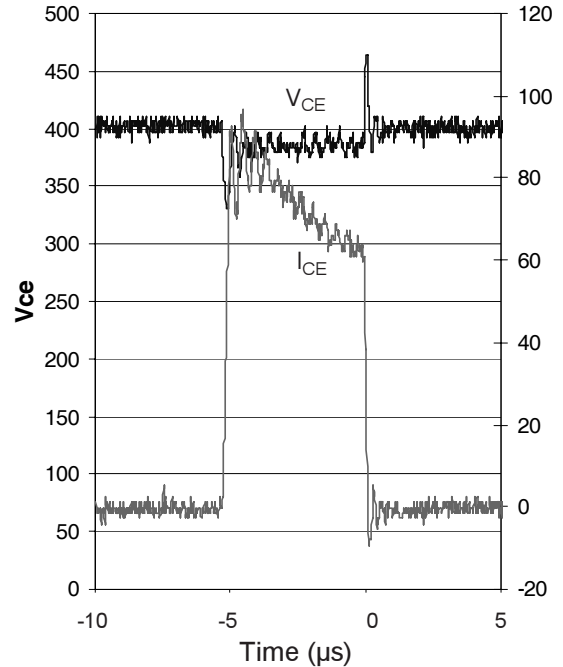
**Fig. WF1** - Typ. Turn-off Loss Waveform  
@  $T_J = 150^\circ C$  using Fig. CT.4



**Fig. WF2** - Typ. Turn-on Loss Waveform  
@  $T_J = 150^\circ C$  using Fig. CT.4



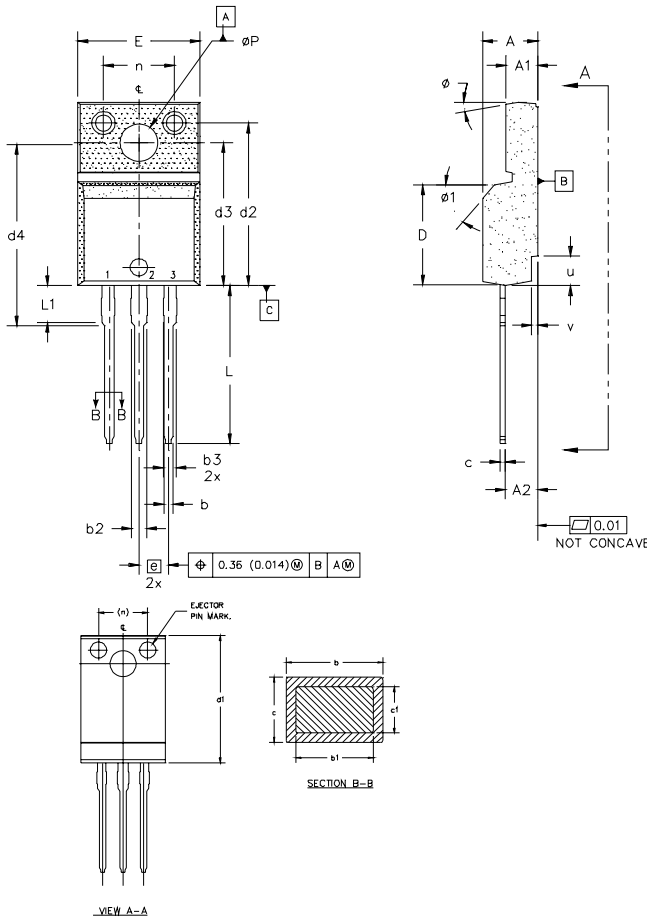
**WF.3-** Typ. Reverse Recovery Waveform  
@  $T_J = 150^\circ C$  using CT.4



**WF.4-** Typ. Short Circuit Waveform  
@  $T_J = 25^\circ C$  using CT.3

## TO-220 Full-Pak Package Outline

Dimensions are shown in millimeters (inches)



**NOTES:**

- 1.0 DIMENSIONING AND TOLERANCING PER ASME Y14.5 M- 1994.
- 2.0 DIMENSIONS ARE SHOWN IN MILLIMETERS [INCHES].
- 3.0 LEAD DIMENSION AND FINISH UNCONTROLLED IN L1.
- 4.0 DIMENSION D & E DO NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED 0.008" (0.127) PER SIDE, THESE DIMENSIONS ARE MEASURED AT THE OUTERMOST EXTREMES OF THE PLASTIC BODY.
- 5.0 DIMENSION b1 APPLY TO BASE METAL ONLY.
- 6.0 STEP OPTIONAL ON PLASTIC BODY DEFINED BY DIMENSIONS u & v.
- 7.0 CONTROLLING DIMENSION : INCHES.

SYMBOL	DIMENSIONS				NOTES
	MILLIMETERS		INCHES		
	MIN.	MAX.	MIN.	MAX.	
A	4.57	4.83	0.180	0.190	5
A1	2.57	2.83	0.101	0.114	
A2	2.51	2.85	0.099	0.112	
b	0.622	0.89	0.024	0.035	
b1	0.622	0.838	0.024	0.033	
b2	1.229	1.400	0.048	0.055	
b3	1.229	1.400	0.048	0.055	
c	0.440	0.629	0.017	0.025	4
c1	0.440	0.584	0.017	0.023	
D	8.65	9.80	0.341	0.386	
d1	15.80	16.12	0.622	0.635	
d2	13.97	14.22	0.550	0.560	
d3	12.30	12.92	0.484	0.509	
d4	8.64	9.91	0.340	0.390	
E	10.36	10.63	0.408	0.419	4
e	2.54 BSC		0.100 BSC		
L	13.20	13.73	0.520	0.541	3
L1	3.10	3.50	0.122	0.138	
n	6.05	6.15	0.238	0.242	6
øP	3.05	3.45	0.120	0.136	
u	2.40	2.50	0.094	0.098	6
v	0.40	0.50	0.016	0.020	
ø	3"	7"	3"	7"	6
ø1	45°	45°	45°	45°	

**LEAD ASSIGNMENTS**

**HEXFET**

- 1.- GATE
- 2.- DRAIN
- 3.- SOURCE

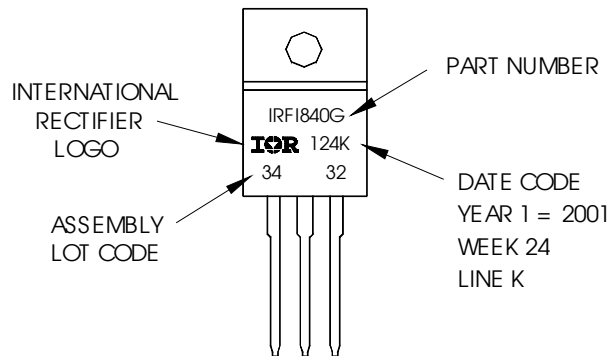
**IGBTs, CoPACK**

- 1.- GATE
- 2.- COLLECTOR
- 3.- EMITTER

## TO-220 Full-Pak Part Marking Information

EXAMPLE: THIS IS AN IRF1840G  
WITH ASSEMBLY  
LOT CODE 3432  
ASSEMBLED ON WW 24, 2001  
IN THE ASSEMBLY LINE "K"

Note: "P" in assembly line position  
indicates "Lead-Free"



TO-220 Full-Pak package is not recommended for Surface Mount Application.

Note: For the most current drawing please refer to IR website at: <http://www.irf.com/package/>

Data and specifications subject to change without notice.  
This product has been designed and qualified for Industrial market.  
Qualification Standards can be found on IR's Web site.