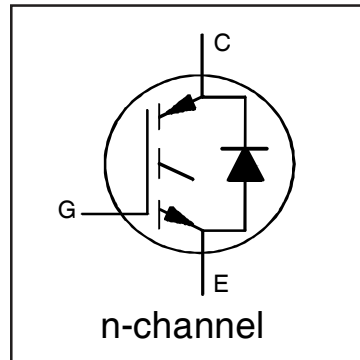


IRGI4056DPbF

INSULATED GATE BIPOLAR TRANSISTOR WITH ULTRAFAST SOFT RECOVERY DIODE

Features

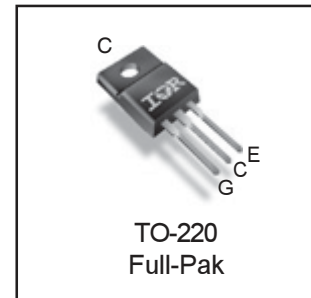
- Low $V_{CE(ON)}$ trench IGBT technology
- Low switching losses
- 5 μ S short circuit SOA
- Square RBSOA
- 100% of the parts tested for I_{LM} ①
- Positive $V_{CE(ON)}$ temperature co-efficient
- Ultra fast soft recovery co-pak diode
- Tight parameter distribution
- Lead-Free package



$V_{CES} = 600V$
$I_C = 9.0A, T_C = 100^\circ C$
$t_{SC} \geq 5\mu s, T_{J(max)} = 150^\circ C$
$V_{CE(on)} \text{ typ.} = 1.44V$

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



G	C	E
Gate	Collector	Emitter

Absolute Maximum Ratings

	Parameter	Max.	Units
V_{CES}	Collector-to-Emitter Voltage	600	V
$I_C @ T_C = 25^\circ C$	Continuous Collector Current	18	A
$I_C @ T_C = 100^\circ C$	Continuous Collector Current	9.0	
I_{CM}	Pulse Collector Current, $V_{GE} = 15V$	27	
I_{LM}	Clamped Inductive Load Current, $V_{GE} = 20V$ ①	36	
$I_F @ T_C = 25^\circ C$	Diode Continuous Forward Current	18	
$I_F @ T_C = 100^\circ C$	Diode Continuous Forward Current	9.0	
I_{FM}	Diode Maximum Forward Current ②	36	
V_{GE}	Continuous Gate-to-Emitter Voltage	± 20	V
	Transient Gate-to-Emitter Voltage	± 30	
$P_D @ T_C = 25^\circ C$	Maximum Power Dissipation	34	W
	$P_D @ T_C = 100^\circ C$	Maximum Power Dissipation	
T_J T_{STG}	Operating Junction and Storage Temperature Range	-55 to +150	$^\circ C$
	Soldering Temperature, for 10 sec.	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
$R_{\theta JC}$ (IGBT)	Thermal Resistance Junction-to-Case-(each IGBT)	—	—	3.7	$^\circ C/W$
$R_{\theta JC}$ (Diode)	Thermal Resistance Junction-to-Case-(each Diode)	—	—	6.6	
$R_{\theta CS}$	Thermal Resistance, Case-to-Sink (flat, greased surface)	—	0.50	—	
$R_{\theta JA}$	Thermal Resistance, Junction-to-Ambient (typical socket mount)	—	—	65	

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

	Parameter	Min.	Typ.	Max.	Units	Conditions	Ref.Fig
$V_{(BR)CES}$	Collector-to-Emitter Breakdown Voltage	600	—	—	V	$V_{GE} = 0V, I_C = 100\mu A$ ②	CT6
$\Delta V_{(BR)CES}/\Delta T_J$	Temperature Coeff. of Breakdown Voltage	—	0.66	—	V/ $^\circ\text{C}$	$V_{GE} = 0V, I_C = 1.0mA$ (-55 $^\circ\text{C}$ -150 $^\circ\text{C}$)	CT6
$V_{CE(on)}$	Collector-to-Emitter Saturation Voltage	—	1.44	1.65	V	$I_C = 9.0A, V_{GE} = 15V, T_J = 25^\circ\text{C}$	5,6,7
		—	1.69	—		$I_C = 9.0A, V_{GE} = 15V, T_J = 125^\circ\text{C}$	9,10,11
		—	1.72	—		$I_C = 9.0A, V_{GE} = 15V, T_J = 150^\circ\text{C}$	
$V_{GE(th)}$	Gate Threshold Voltage	4.0	—	6.5	V	$V_{CE} = V_{GE}, I_C = 350\mu A$	9, 10,
$\Delta V_{GE(th)}/\Delta T_J$	Threshold Voltage temp. coefficient	—	-13	—	mV/ $^\circ\text{C}$	$V_{CE} = V_{GE}, I_C = 1.0mA$ (-55 $^\circ\text{C}$ - 150 $^\circ\text{C}$)	11, 12
g_{fe}	Forward Transconductance	—	7.1	—	S	$V_{CE} = 50V, I_C = 9.0A$	
I_{CES}	Collector-to-Emitter Leakage Current	—	—	20	μA	$V_{GE} = 0V, V_{CE} = 600V$	
		—	60	—		$V_{GE} = 0V, V_{CE} = 600V, T_J = 150^\circ\text{C}$	
V_{FM}	Diode Forward Voltage Drop	—	2.3	3.0	V	$I_F = 9.0A$	8
		—	1.7	—		$I_F = 9.0A, T_J = 150^\circ\text{C}$	
I_{GES}	Gate-to-Emitter Leakage Current	—	—	± 100	nA	$V_{GE} = \pm 20V$	

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

	Parameter	Min.	Typ.	Max.	Units	Conditions	Ref.Fig
Q_g	Total Gate Charge (turn-on)	—	25	38	nC	$I_C = 9.0A$ $V_{GE} = 15V$ $V_{CC} = 400V$	24
Q_{ge}	Gate-to-Emitter Charge (turn-on)	—	6.6	9.9			CT1
Q_{gc}	Gate-to-Collector Charge (turn-on)	—	9.5	14			
E_{on}	Turn-On Switching Loss	—	59	143	μJ	$I_C = 9.0A, V_{CC} = 400V, V_{GE} = 15V$ $R_G = 22\Omega, L = 1.0mH, T_J = 25^\circ\text{C}$ Energy losses include tail & diode reverse recovery	CT4
E_{off}	Turn-Off Switching Loss	—	177	264			
E_{total}	Total Switching Loss	—	236	407			
$t_{d(on)}$	Turn-On delay time	—	34	52	ns	$I_C = 9.0A, V_{CC} = 400V, V_{GE} = 15V$ $R_G = 22\Omega, L = 1.0mH, T_J = 25^\circ\text{C}$	CT4
t_r	Rise time	—	12	29			
$t_{d(off)}$	Turn-Off delay time	—	84	103			
t_f	Fall time	—	24	42			
E_{on}	Turn-On Switching Loss	—	131	—			μJ
E_{off}	Turn-Off Switching Loss	—	276	—	CT4		
E_{total}	Total Switching Loss	—	407	—	WF1, WF2		
$t_{d(on)}$	Turn-On delay time	—	31	—	ns	$I_C = 9.0A, V_{CC} = 400V, V_{GE} = 15V$ $R_G = 22\Omega, L = 1.0mH$ $T_J = 150^\circ\text{C}$	14, 16
t_r	Rise time	—	15	—			CT4
$t_{d(off)}$	Turn-Off delay time	—	104	—			WF1
t_f	Fall time	—	86	—			WF2
C_{ies}	Input Capacitance	—	769	—			pF
C_{oes}	Output Capacitance	—	59	—			
C_{res}	Reverse Transfer Capacitance	—	21	—			
RBSOA	Reverse Bias Safe Operating Area	FULL SQUARE				$T_J = 150^\circ\text{C}, I_C = 36A$ $V_{CC} = 480V, V_p = 600V$ $R_G = 22\Omega, V_{GE} = +20V$ to 0V	4 CT2
SCSOA	Short Circuit Safe Operating Area	5	—	—	μs	$V_{CC} = 400V, V_p = 600V$ $R_G = 75\Omega, V_{GE} = +15V$ to 0V	22, CT3 WF4
E_{rec}	Reverse Recovery Energy of the Diode	—	176	—	μJ	$T_J = 150^\circ\text{C}$	17, 18, 19
t_{rr}	Diode Reverse Recovery Time	—	72	—	ns	$V_{CC} = 400V, I_F = 9.0A$	20, 21
I_{rr}	Peak Reverse Recovery Current	—	19	—	A	$V_{GE} = 15V, R_G = 22\Omega, L = 1.0mH$	WF3

Notes:

- ① $V_{CC} = 80\% (V_{CES}), V_{GE} = 20V, L = 80\mu H, R_G = 22\Omega$.
- ② Pulse width limited by max. junction temperature.
- ③ Refer to AN-1086 for guidelines for measuring $V_{(BR)CES}$ safely.

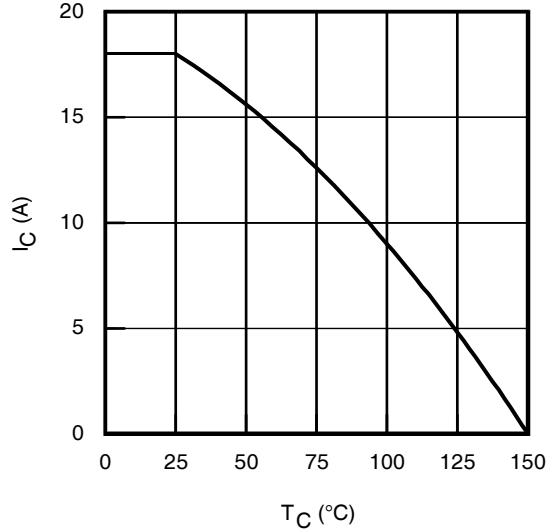


Fig. 1 - Maximum DC Collector Current vs. Case Temperature

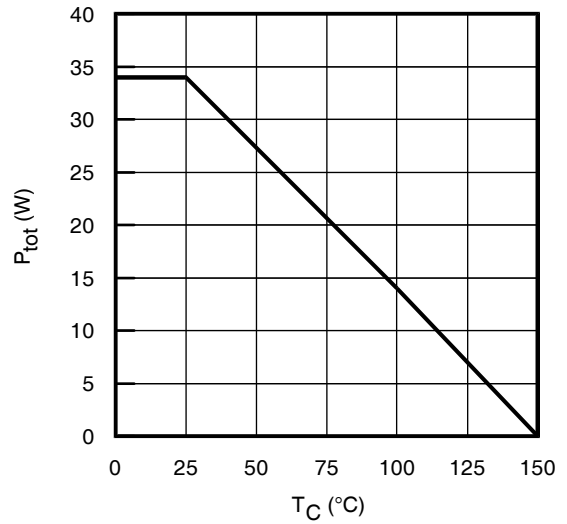


Fig. 2 - Power Dissipation vs. Case Temperature

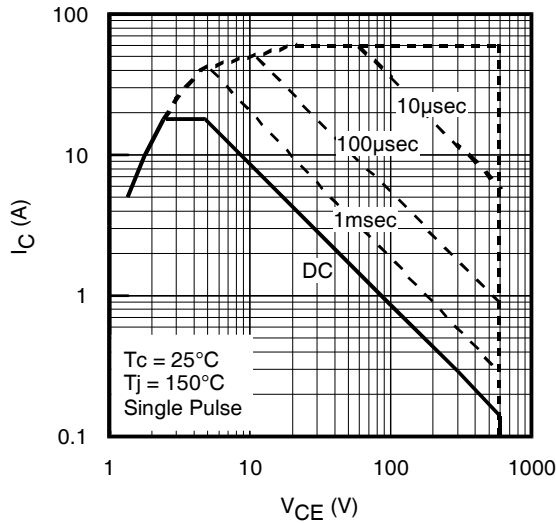


Fig. 3 - Forward SOA

$T_C = 25^\circ\text{C}$, $T_J \leq 150^\circ\text{C}$; $V_{GE} = 15\text{V}$

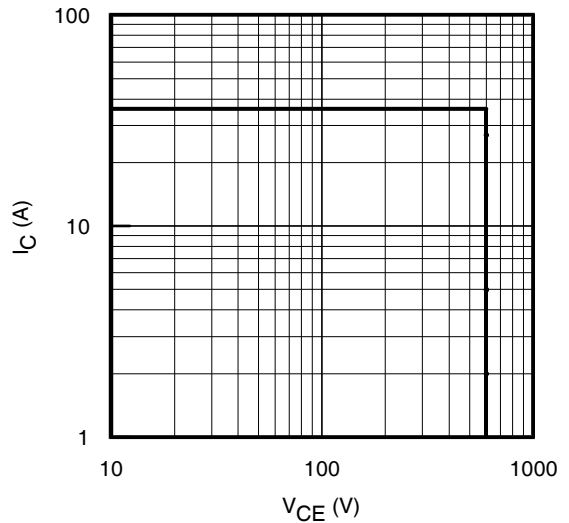


Fig. 4 - Reverse Bias SOA

$T_J = 150^\circ\text{C}$; $V_{GE} = 20\text{V}$

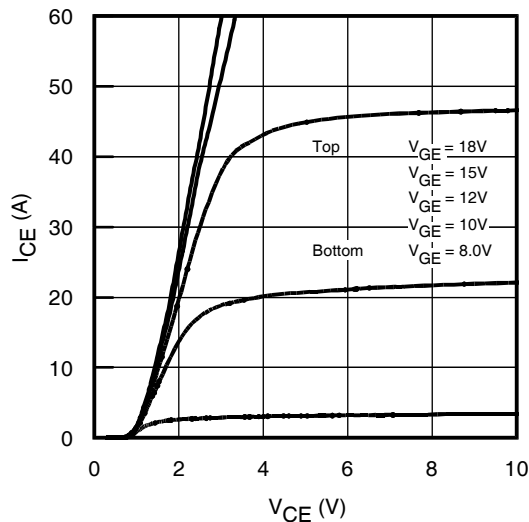


Fig. 5 - Typ. IGBT Output Characteristics
 $T_J = -40^\circ\text{C}$; $t_p = 80\mu\text{s}$

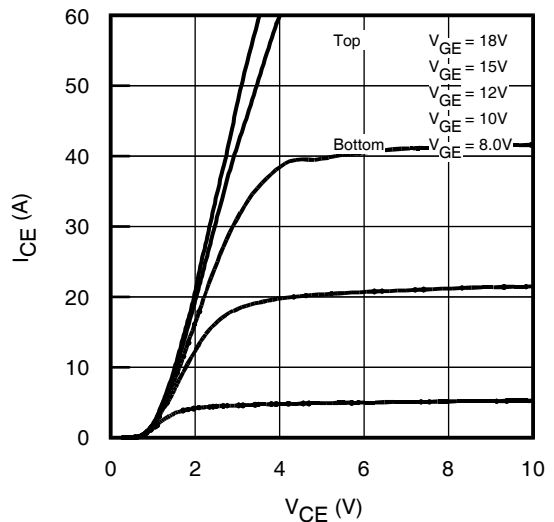


Fig. 6 - Typ. IGBT Output Characteristics
 $T_J = 25^\circ\text{C}$; $t_p = 80\mu\text{s}$

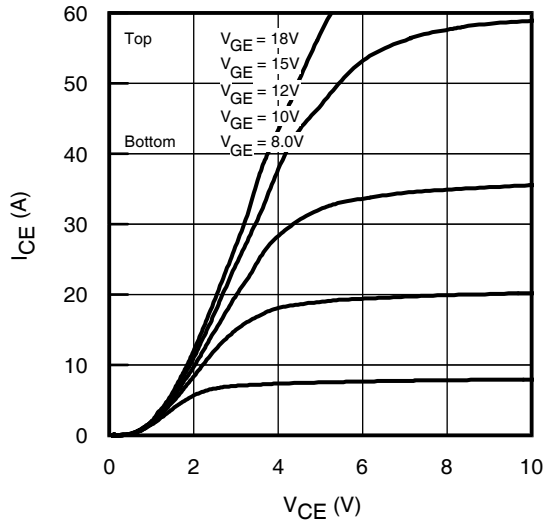


Fig. 7 - Typ. IGBT Output Characteristics
 $T_J = 150^\circ\text{C}$; $t_p = 80\mu\text{s}$

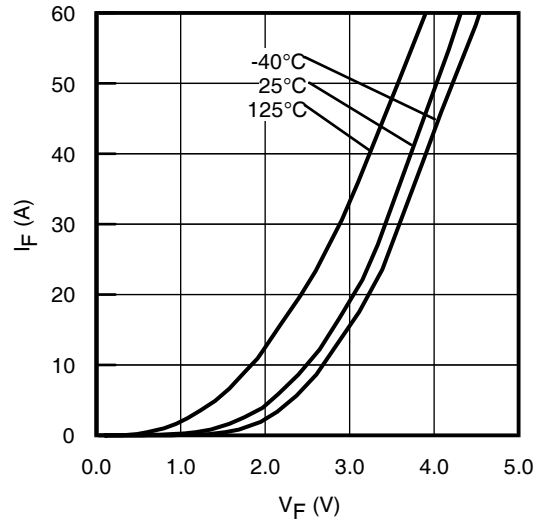


Fig. 8 - Typ. Diode Forward Characteristics
 $t_p = 80\mu\text{s}$

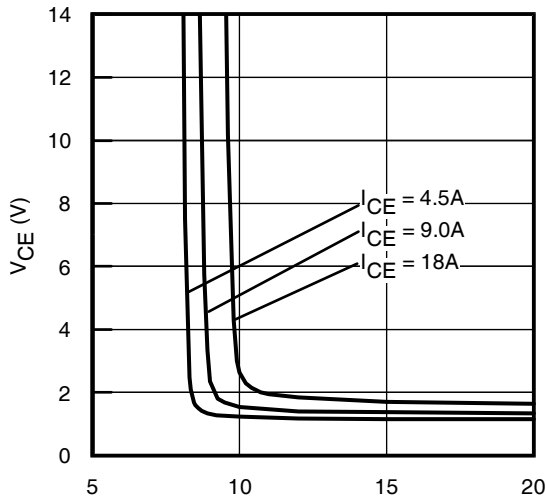


Fig. 9 - Typical V_{CE} vs. V_{GE}
 $T_J = -40^\circ\text{C}$

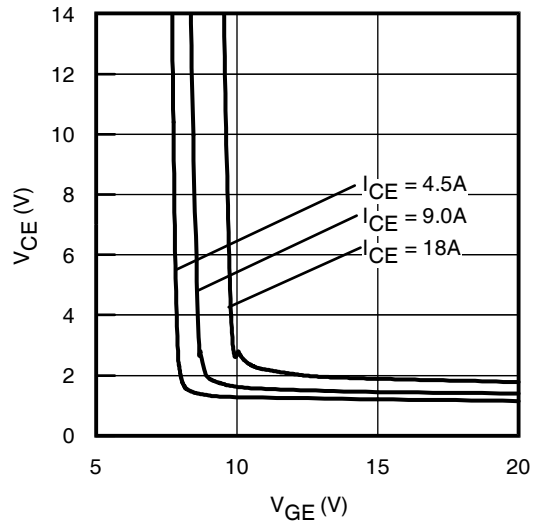


Fig. 10 - Typical V_{CE} vs. V_{GE}
 $T_J = 25^\circ\text{C}$

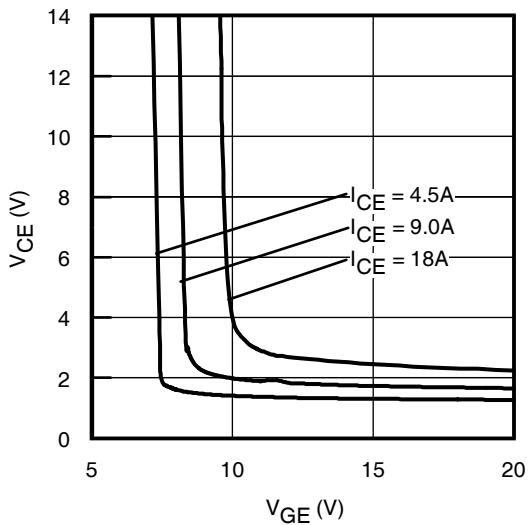


Fig. 11 - Typical V_{CE} vs. V_{GE}
 $T_J = 150^\circ\text{C}$

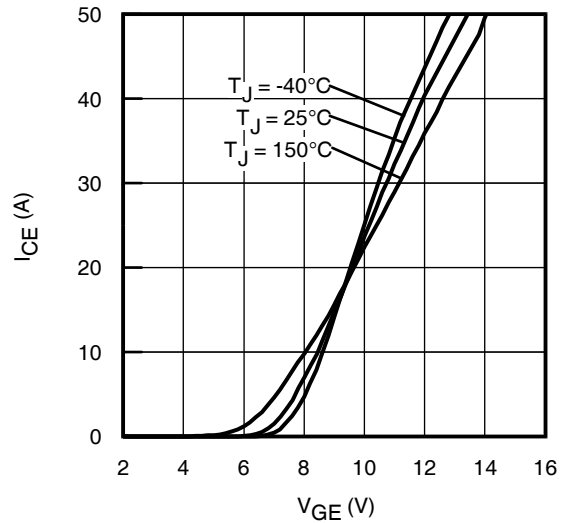


Fig. 12 - Typ. Transfer Characteristics
 $V_{CE} = 50\text{V}$; $t_p = 10\mu\text{s}$

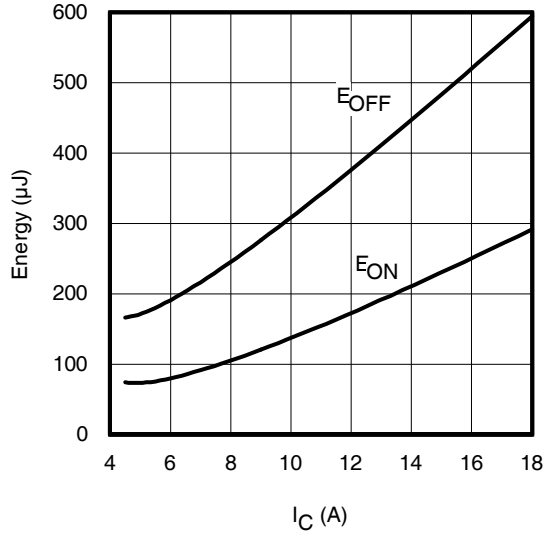


Fig. 13 - Typ. Energy Loss vs. I_C

$T_J = 150^\circ\text{C}$; $L = 1.0\text{mH}$; $V_{CE} = 400\text{V}$, $R_G = 22\Omega$; $V_{GE} = 15\text{V}$

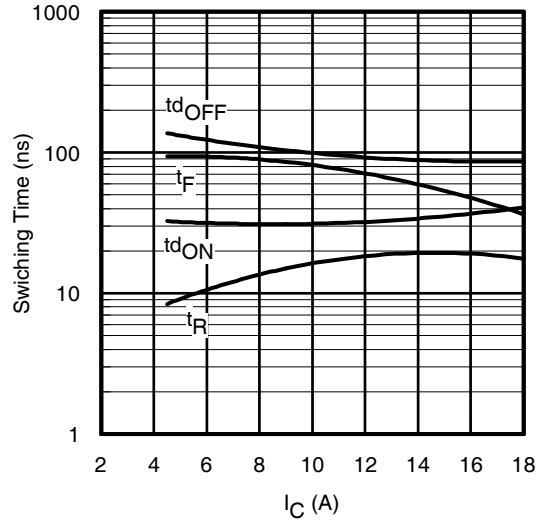


Fig. 14 - Typ. Switching Time vs. I_C

$T_J = 150^\circ\text{C}$; $L = 1.0\text{mH}$; $V_{CE} = 400\text{V}$, $R_G = 22\Omega$; $V_{GE} = 15\text{V}$

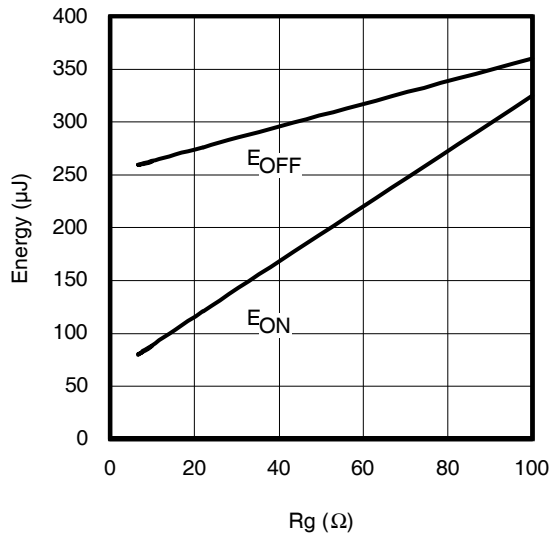


Fig. 15 - Typ. Energy Loss vs. R_G

$T_J = 150^\circ\text{C}$; $L = 1.0\text{mH}$; $V_{CE} = 400\text{V}$, $I_{CE} = 9.0\text{A}$; $V_{GE} = 15\text{V}$

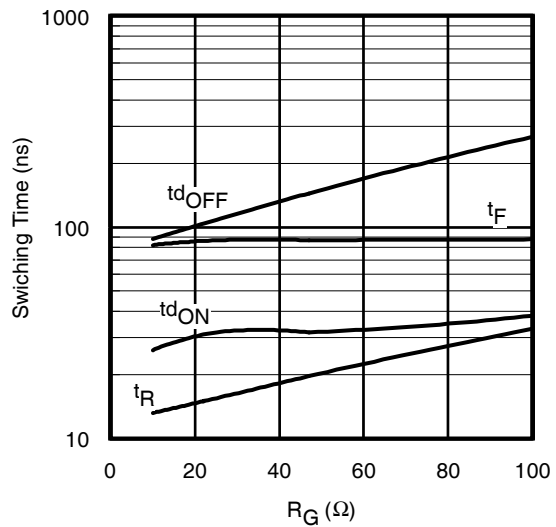


Fig. 16 - Typ. Switching Time vs. R_G

$T_J = 150^\circ\text{C}$; $L = 1.0\text{mH}$; $V_{CE} = 400\text{V}$, $I_{CE} = 9.0\text{A}$; $V_{GE} = 15\text{V}$

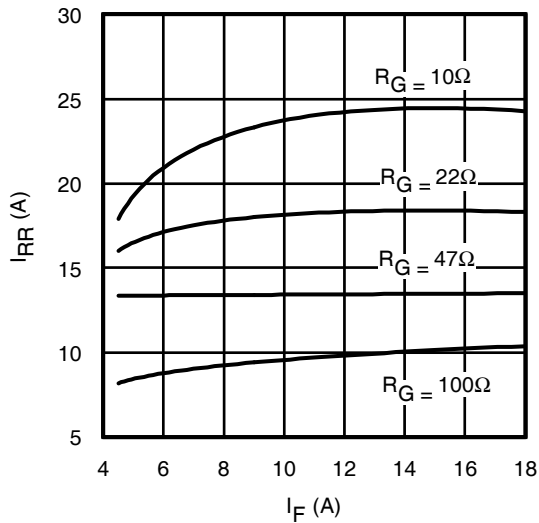


Fig. 17 - Typ. Diode I_{RR} vs. I_F

$T_J = 150^\circ\text{C}$

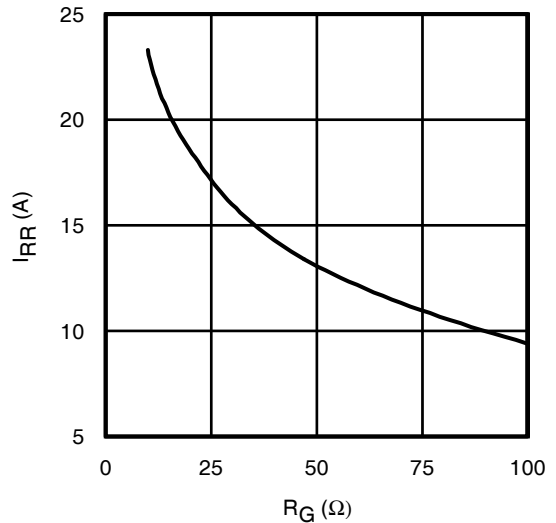


Fig. 18 - Typ. Diode I_{RR} vs. R_G

$T_J = 150^\circ\text{C}$

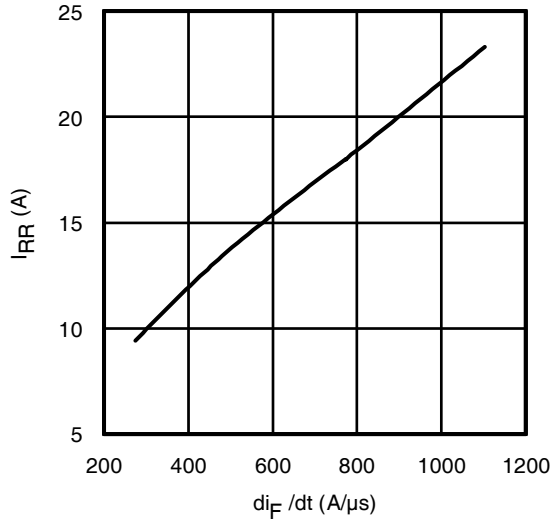


Fig. 19 - Typ. Diode I_{RR} vs. di_F/dt
 $V_{CC} = 400V$; $V_{GE} = 15V$; $I_F = 9.0A$; $T_J = 150^\circ C$

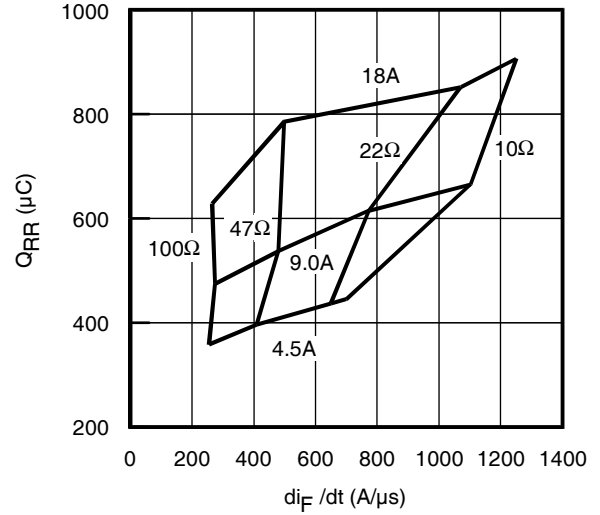


Fig. 20 - Typ. Diode Q_{RR} vs. di_F/dt
 $V_{CC} = 400V$; $V_{GE} = 15V$; $T_J = 150^\circ C$

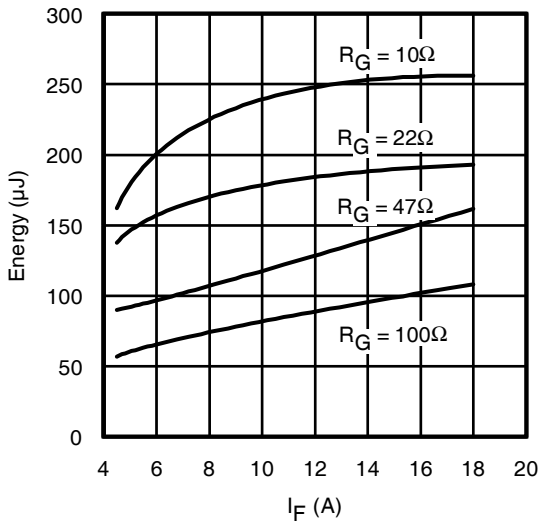


Fig. 21 - Typ. Diode E_{RR} vs. I_F
 $T_J = 150^\circ C$

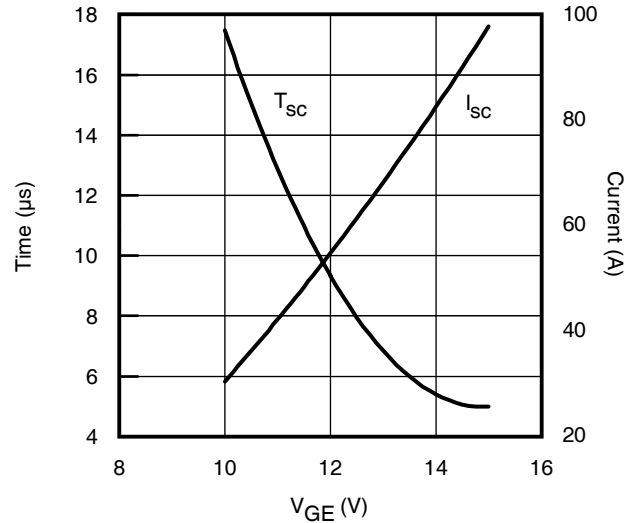


Fig. 22 - V_{GE} vs. Short Circuit Time
 $V_{CC} = 400V$; $T_C = 25^\circ C$

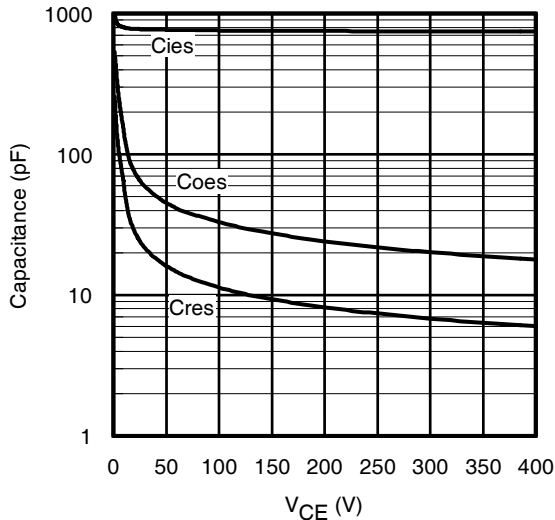


Fig. 23 - Typ. Capacitance vs. V_{CE}
 $V_{GE} = 0V$; $f = 1MHz$

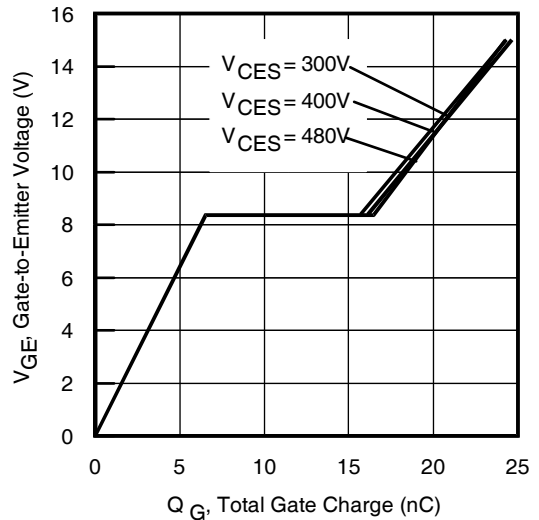


Fig. 24 - Typical Gate Charge vs. V_{GE}
 $I_{CE} = 9.0A$; $L = 1.0mH$

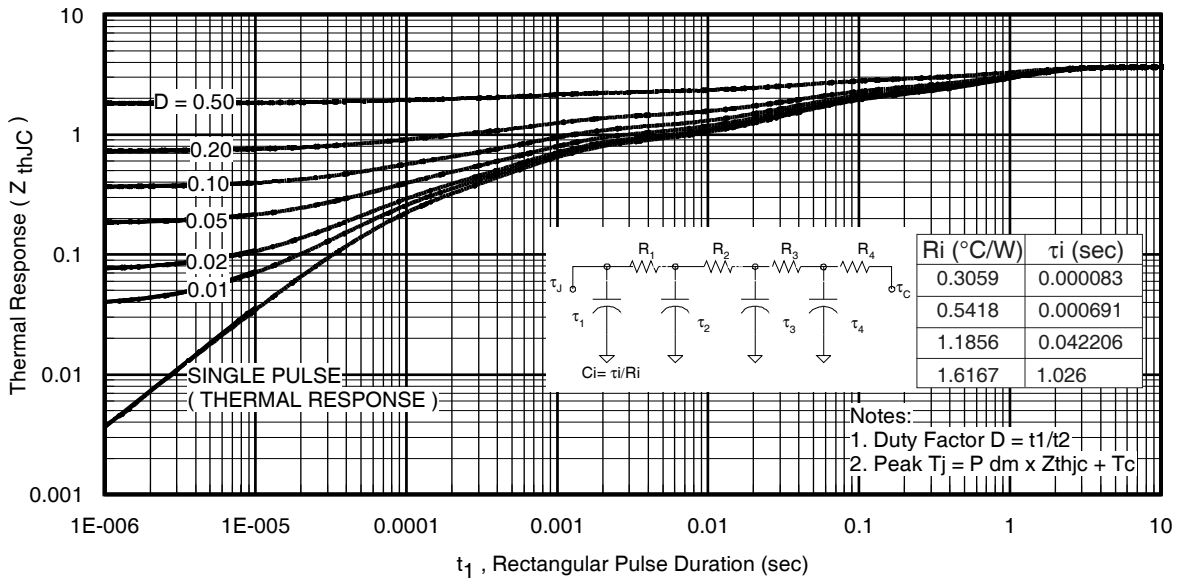


Fig 23. Maximum Transient Thermal Impedance, Junction-to-Case (IGBT)

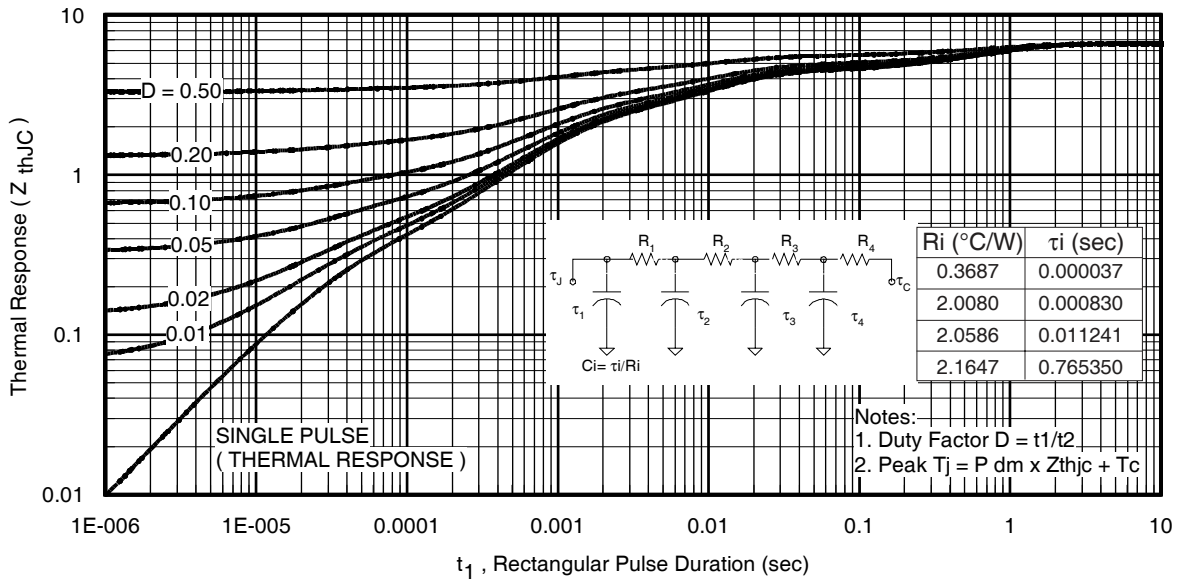


Fig. 24. Maximum Transient Thermal Impedance, Junction-to-Case (DIODE)

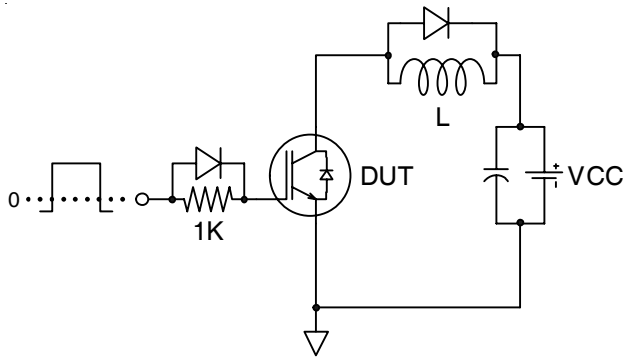


Fig.C.T.1 - Gate Charge Circuit (turn-off)

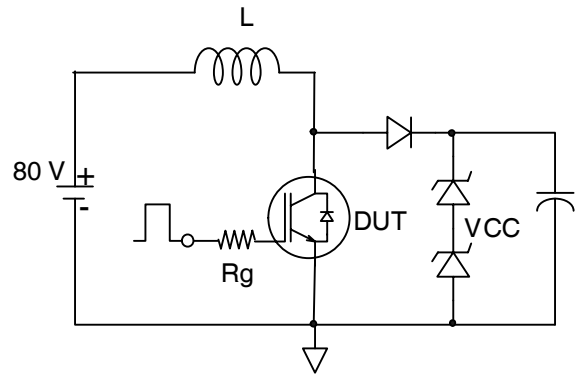


Fig.C.T.2 - RBSOA Circuit

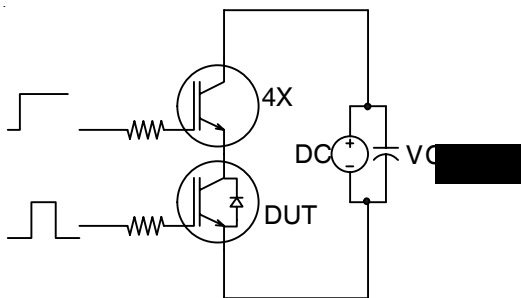


Fig.C.T.3 - S.C. SOA Circuit

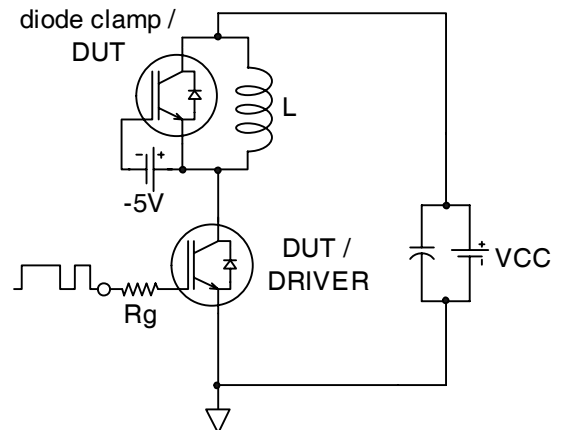


Fig.C.T.4 - Switching Loss Circuit

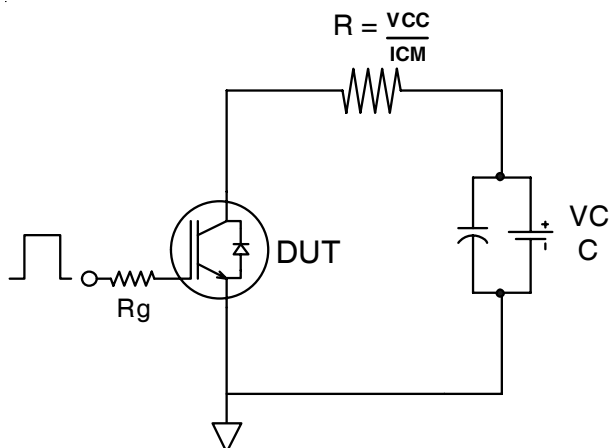


Fig.C.T.5 - Resistive Load Circuit

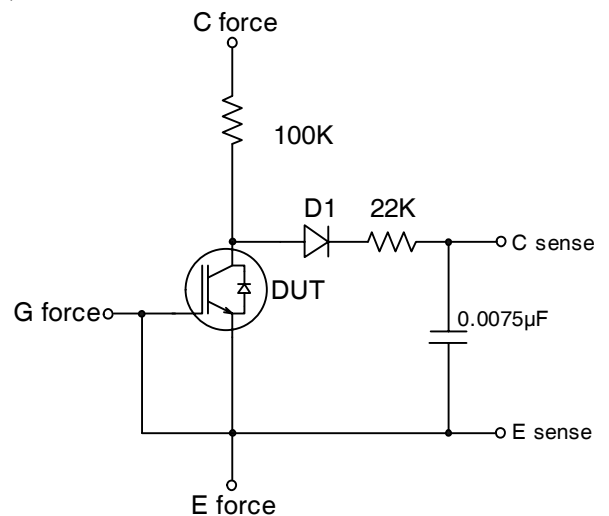


Fig.C.T.6 - BVCES Filter Circuit

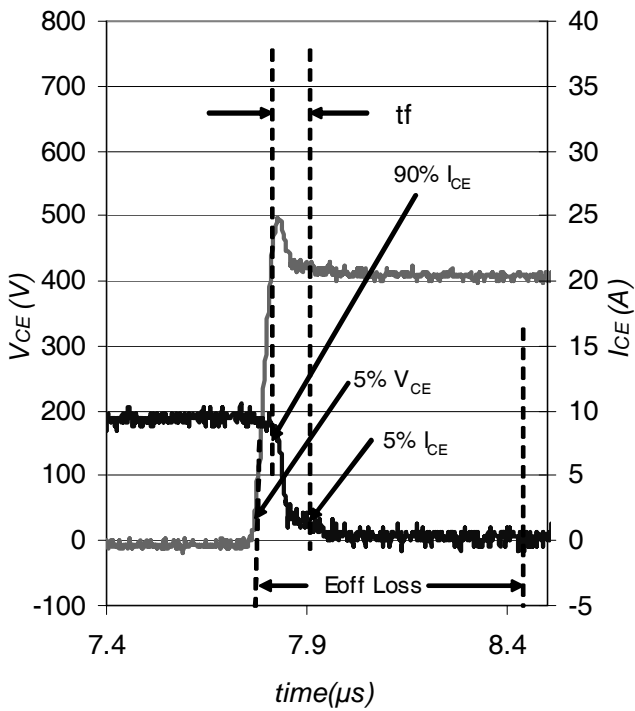


Fig. WF1 - Typ. Turn-off Loss Waveform
@ $T_J = 150^\circ C$ using Fig. CT.4

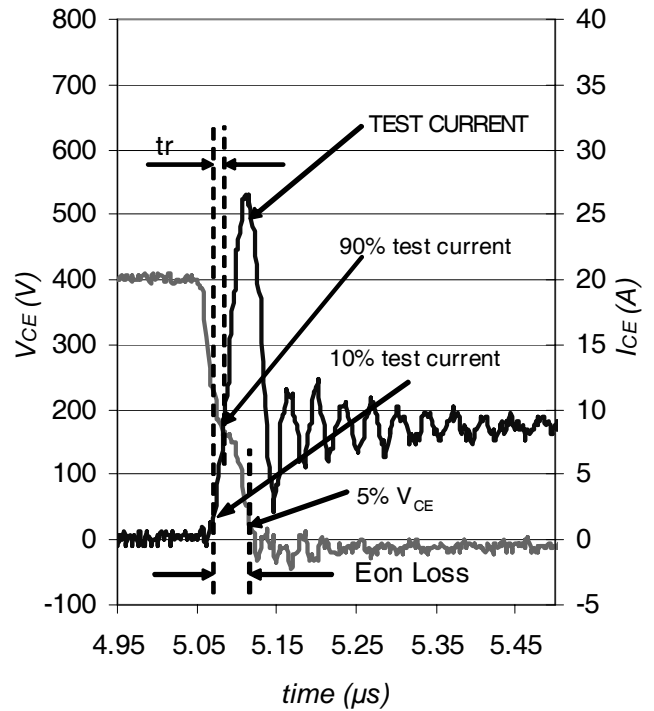


Fig. WF2 - Typ. Turn-on Loss Waveform
@ $T_J = 150^\circ C$ using Fig. CT.4

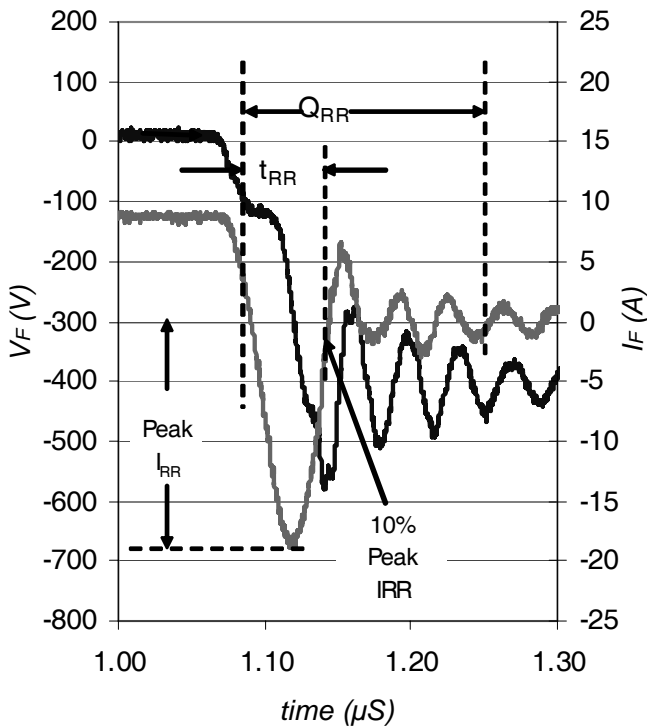


Fig. WF3 - Typ. Diode Recovery Waveform
@ $T_J = 150^\circ C$ using Fig. CT.4

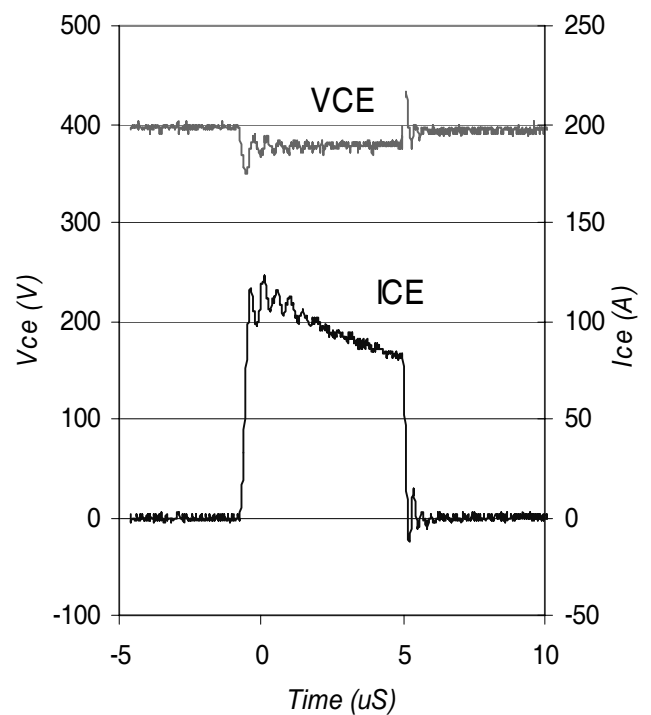
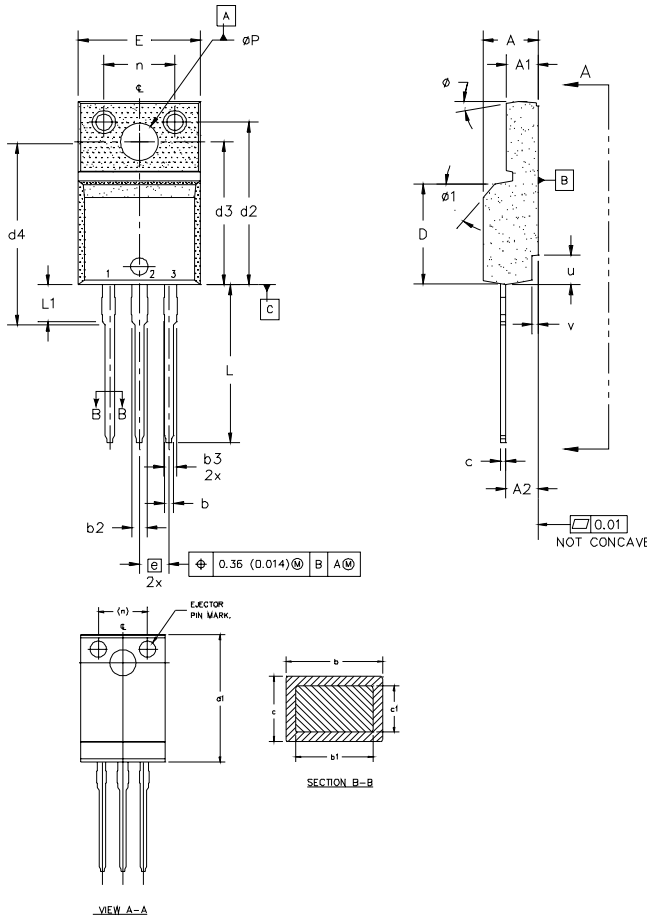


Fig. WF4 - Typ. S.C. Waveform
@ $T_J = 25^\circ C$ using Fig. CT.3

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 0.005" (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	
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	5
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	
d	0.440	0.584	0.017	0.023	4
d1	8.65	9.80	0.341	0.386	
d2	15.80	16.12	0.622	0.635	
d3	13.97	14.22	0.550	0.560	
d4	12.30	12.92	0.484	0.509	
d5	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	
L1	3.10	3.50	0.122	0.138	3
n	6.05	6.15	0.238	0.242	
phi P	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	6
phi	3"	7"	3"	7"	
phi 1		45'		45'	

LEAD ASSIGNMENTS

HEXFET

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

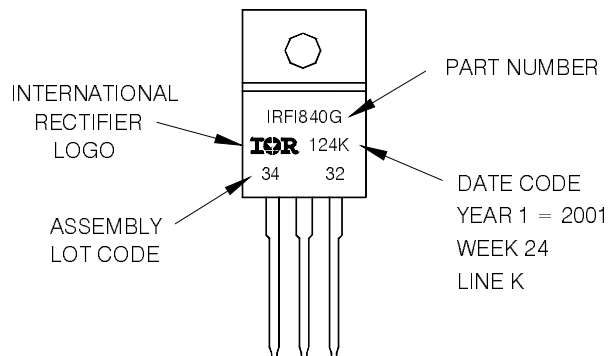
IGBTs, CoPACK

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

TO-220 Full-Pak Part Marking Information

EXAMPLE: THIS IS AN IRFI840G
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.

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.