

**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
- Lead-Free, RoHS Compliant
- Automotive Qualified \*

**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

**Applications**

- Air Conditioning Compressor
- EV Inverter
- Battery charger
- DC-DC converter

**Absolute Maximum Ratings**

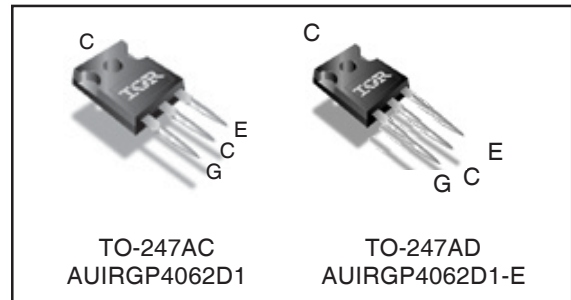
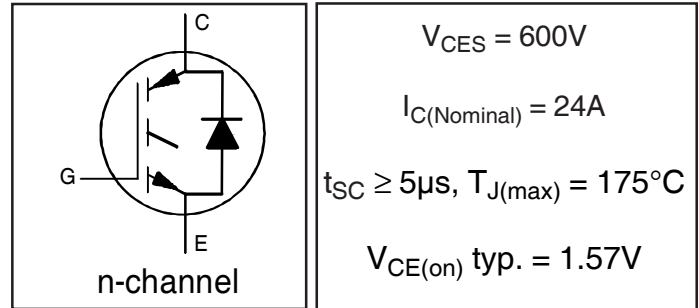
Stresses beyond those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. These are stress ratings only; and functional operation of the device at these or any other condition beyond those indicated in the specifications is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability. The thermal resistance and power dissipation ratings are measured under board mounted and still air conditions. Ambient temperature ( $T_A$ ) is 25°C, unless otherwise specified

	Parameter	Max.	Units
$V_{CES}$	Collector-to-Emitter Voltage	600	V
$I_C @ T_C = 25^\circ C$	Continuous Collector Current	55	A
$I_C @ T_C = 100^\circ C$	Continuous Collector Current	36	
$I_{NOMINAL}$	Nominal Current	24	
$I_{CM}$	Pulse Collector Current, $V_{GE} = 15V$	72	
$I_{LM}$	Clamped Inductive Load Current, $V_{GE} = 20V$ ①	96	
$I_F @ T_C = 25^\circ C$	Diode Continuous Forward Current	55	
$I_F @ T_C = 100^\circ C$	Diode Continuous Forward Current	36	V
$I_{FM}$	Diode Maximum Forward Current ②	96	
$V_{GE}$	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	217	W
$P_D @ T_C = 100^\circ C$	Maximum Power Dissipation	109	
$T_J$	Operating Junction and	-55 to +175	$^\circ C$
$T_{STG}$	Storage Temperature Range		
	Soldering Temperature, for 10 sec. (1.6mm from case)	300	
	Mounting Torque, 6-32 or M3 Screw	10 lbf·in (1.1N·m)	

**Thermal Resistance**

	Parameter	Min.	Typ.	Max.	Units
$R_{\theta JC}$ (IGBT)	Thermal Resistance Junction-to-Case (IGBT) ③	---	---	0.69	$^\circ C/W$
$R_{\theta JC}$ (Diode)	Thermal Resistance Junction-to-Case (Diode) ③	---	---	1.2	
$R_{\theta CS}$	Thermal Resistance, Case-to-Sink (flat, greased surface)	---	0.24	---	
$R_{\theta JA}$	Thermal Resistance, Junction-to-Ambient	---	40	---	

\*Qualification standards can be found at <http://www.irf.com/>



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

## Electrical Characteristics @ T<sub>J</sub> = 25°C (unless otherwise specified)

	Parameter	Min.	Typ.	Max.	Units	Conditions
V <sub>(BR)CES</sub>	Collector-to-Emitter Breakdown Voltage	600	—	—	V	V <sub>GE</sub> = 0V, I <sub>C</sub> = 100μA ①
ΔV <sub>(BR)CES</sub> /ΔT <sub>J</sub>	Temperature Coeff. of Breakdown Voltage	—	0.3	—	V/°C	V <sub>GE</sub> = 0V, I <sub>C</sub> = 10mA (25°C-175°C)
V <sub>CE(on)</sub>	Collector-to-Emitter Saturation Voltage	—	1.57	1.77	V	I <sub>C</sub> = 24A, V <sub>GE</sub> = 15V, T <sub>J</sub> = 25°C
		—	1.87	—		I <sub>C</sub> = 24A, V <sub>GE</sub> = 15V, T <sub>J</sub> = 150°C
		—	1.94	—		I <sub>C</sub> = 24A, V <sub>GE</sub> = 15V, T <sub>J</sub> = 175°C
V <sub>GE(th)</sub>	Gate Threshold Voltage	4.0	—	6.5	V	V <sub>CE</sub> = V <sub>GE</sub> , I <sub>C</sub> = 700μA
ΔV <sub>GE(th)</sub> /ΔT <sub>J</sub>	Threshold Voltage temp. coefficient	—	-17	—	mV/°C	V <sub>CE</sub> = V <sub>GE</sub> , I <sub>C</sub> = 1.0mA (25°C - 175°C)
g <sub>fe</sub>	Forward Transconductance	—	12	—	S	V <sub>CE</sub> = 50V, I <sub>C</sub> = 24A, PW = 20μs
I <sub>CES</sub>	Collector-to-Emitter Leakage Current	—	1.0	25	μA	V <sub>GE</sub> = 0V, V <sub>CE</sub> = 600V
		—	3.5	—	mA	V <sub>GE</sub> = 0V, V <sub>CE</sub> = 600V, T <sub>J</sub> = 175°C
V <sub>FM</sub>	Diode Forward Voltage Drop	—	1.57	—	V	I <sub>F</sub> = 24A
		—	1.40	—		I <sub>F</sub> = 19A
		—	1.47	—		I <sub>F</sub> = 24A, T <sub>J</sub> = 175°C
I <sub>GES</sub>	Gate-to-Emitter Leakage Current	—	—	±100	nA	V <sub>GE</sub> = ±20V

## Switching Characteristics @ T<sub>J</sub> = 25°C (unless otherwise specified)

	Parameter	Min.	Typ.	Max.	Units	Conditions
Q <sub>g</sub>	Total Gate Charge (turn-on)	—	51	77	nC	I <sub>C</sub> = 24A
Q <sub>ge</sub>	Gate-to-Emitter Charge (turn-on)	—	14	21		V <sub>GE</sub> = 15V
Q <sub>gc</sub>	Gate-to-Collector Charge (turn-on)	—	21	32		V <sub>CC</sub> = 400V
E <sub>on</sub>	Turn-On Switching Loss	—	532	754	μJ	I <sub>C</sub> = 24A, V <sub>CC</sub> = 400V, V <sub>GE</sub> = 15V
E <sub>off</sub>	Turn-Off Switching Loss	—	311	526		R <sub>G</sub> = 10Ω, L = 210μH, T <sub>J</sub> = 25°C
E <sub>total</sub>	Total Switching Loss	—	843	1280		Energy losses include tail & diode reverse recovery
t <sub>d(on)</sub>	Turn-On delay time	—	19	36	ns	I <sub>C</sub> = 24A, V <sub>CC</sub> = 400V, V <sub>GE</sub> = 15V
t <sub>r</sub>	Rise time	—	24	41		R <sub>G</sub> = 10Ω, L = 210μH, T <sub>J</sub> = 25°C
t <sub>d(off)</sub>	Turn-Off delay time	—	90	109		
t <sub>f</sub>	Fall time	—	23	40		
E <sub>on</sub>	Turn-On Switching Loss	—	726	—		μJ
E <sub>off</sub>	Turn-Off Switching Loss	—	549	—	μJ	R <sub>G</sub> = 10Ω, L = 210μH, T <sub>J</sub> = 175°C ④
E <sub>total</sub>	Total Switching Loss	—	1275	—		Energy losses include tail & diode reverse recovery
t <sub>d(on)</sub>	Turn-On delay time	—	12	—	ns	I <sub>C</sub> = 24A, V <sub>CC</sub> = 400V, V <sub>GE</sub> = 15V
t <sub>r</sub>	Rise time	—	23	—		R <sub>G</sub> = 10Ω, L = 200μH, L <sub>S</sub> = 150nH
t <sub>d(off)</sub>	Turn-Off delay time	—	92	—		T <sub>J</sub> = 175°C
t <sub>f</sub>	Fall time	—	84	—		
C <sub>ies</sub>	Input Capacitance	—	1487	—	pF	V <sub>GE</sub> = 0V
C <sub>oes</sub>	Output Capacitance	—	118	—		V <sub>CC</sub> = 30V
C <sub>res</sub>	Reverse Transfer Capacitance	—	44	—		f = 1.0Mhz
RBSOA	Reverse Bias Safe Operating Area	FULL SQUARE				T <sub>J</sub> = 175°C, I <sub>C</sub> = 96A V <sub>CC</sub> = 480V, V <sub>p</sub> ≤ 600V R <sub>G</sub> = 10Ω, V <sub>GE</sub> = +20V to 0V
SCSOA	Short Circuit Safe Operating Area	5	—	—	μs	V <sub>CC</sub> = 400V, V <sub>p</sub> ≤ 600V R <sub>G</sub> = 10Ω, V <sub>GE</sub> = +15V to 0V
E <sub>rec</sub>	Reverse Recovery Energy of the Diode	—	773	—	μJ	T <sub>J</sub> = 175°C
t <sub>rr</sub>	Diode Reverse Recovery Time	—	102	—	ns	V <sub>CC</sub> = 200V, I <sub>F</sub> = 24A
I <sub>rr</sub>	Peak Reverse Recovery Current	—	32	—	A	V <sub>GE</sub> = 15V, R <sub>G</sub> = 10Ω, L = 210μH

### Notes:

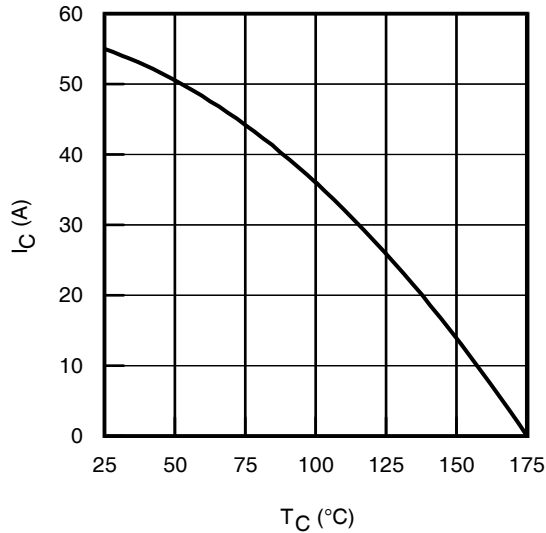
- ① V<sub>CC</sub> = 80% (V<sub>CES</sub>), V<sub>GE</sub> = 20V, L = 210μH, R<sub>G</sub> = 50Ω.
- ② Pulse width limited by max. junction temperature.
- ③ R<sub>θ</sub> is measured at T<sub>J</sub> of approximately 90°C.
- ④ Maximum limits are based on statistical sample size characterization.

## Qualification Information†

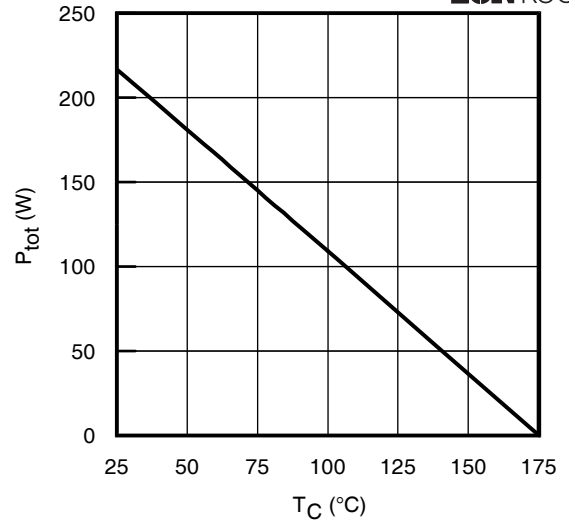
<b>Qualification Level</b>		Automotive (per AEC-Q101) ††	
		Comments: This part number(s) passed Automotive qualification. IR's Industrial and Consumer qualification level is granted by extension of the higher Automotive level.	
<b>Moisture Sensitivity Level</b>		3L-TO-247AC	N/A
		3L-TO-247AD	
<b>ESD</b>	Machine Model	Class M4 (+/- 700V ) (per AEC-Q101-002)	
	Human Body Model	Class H1C (+/- 2000V ) (per AEC-Q101-001)	
	Charged Device Model	Class C5(+/- 2000V ) (per AEC-Q101-005)	
<b>RoHS Compliant</b>		Yes	

† Qualification standards can be found at International Rectifier's web site: <http://www.irf.com/>

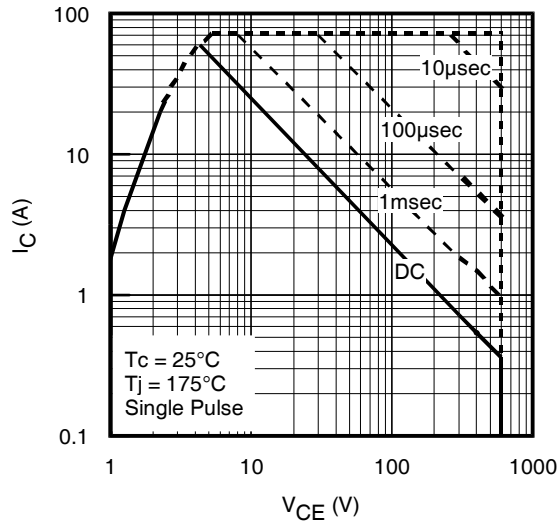
†† Highest passing voltage.



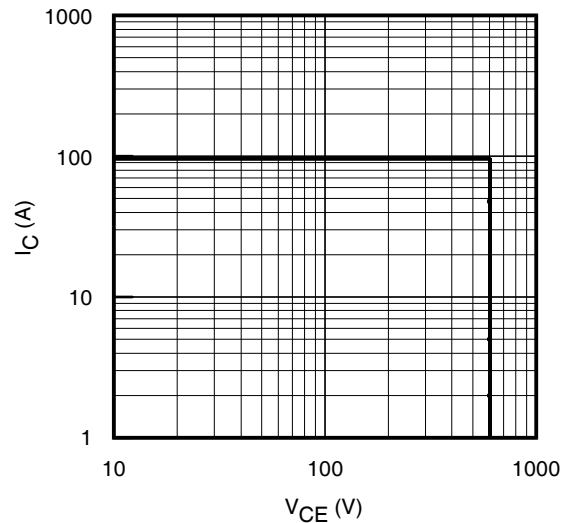
**Fig. 1** - Maximum DC Collector Current vs. Case Temperature



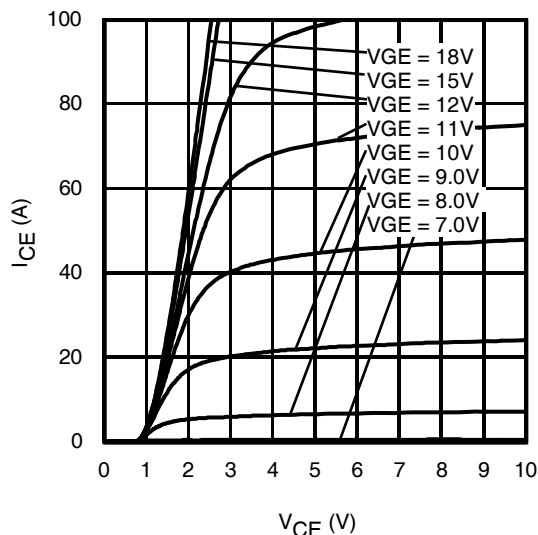
**Fig. 2** - Power Dissipation vs. Case Temperature



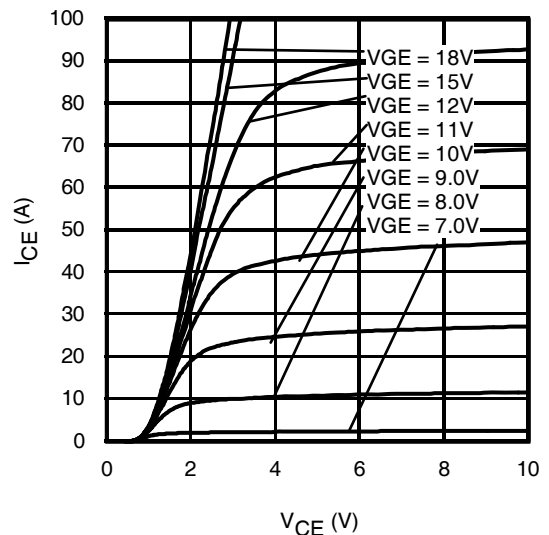
**Fig. 3** - Forward SOA  
 $T_C = 25^\circ\text{C}$ ,  $T_J \leq 175^\circ\text{C}$ ;  $V_{GE} = 15\text{V}$



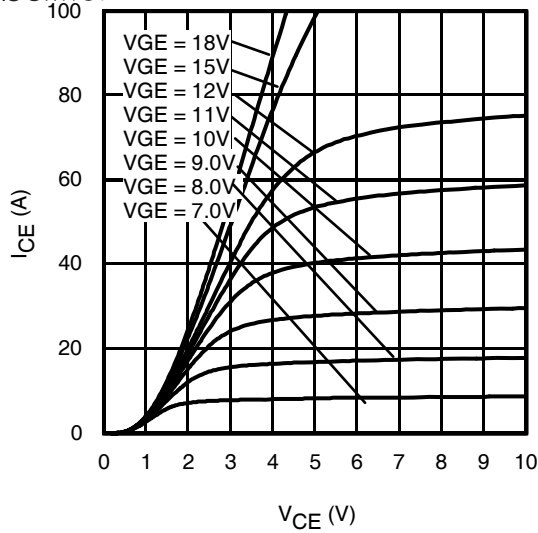
**Fig. 4** - Reverse Bias SOA  
 $T_J = 175^\circ\text{C}$ ;  $V_{GE} = 20\text{V}$



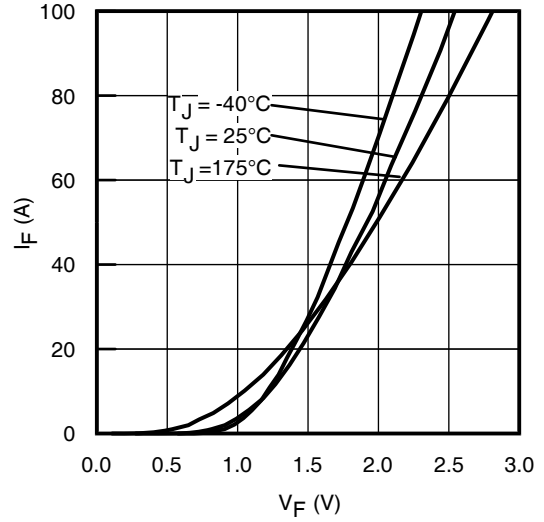
**Fig. 5** - Typ. IGBT Output Characteristics  
 $T_J = -40^\circ\text{C}$ ;  $t_p = 20\mu\text{s}$



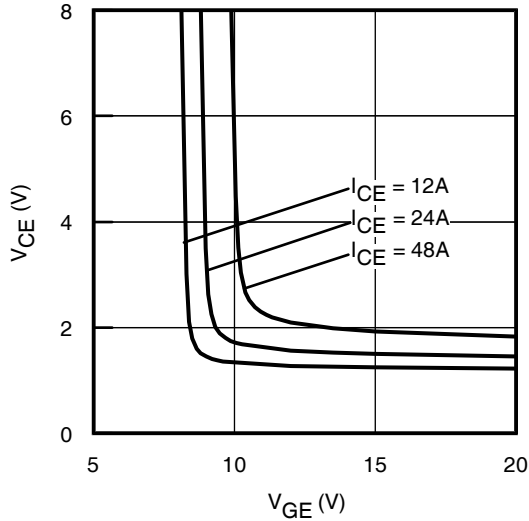
**Fig. 6** - Typ. IGBT Output Characteristics  
 $T_J = 25^\circ\text{C}$ ;  $t_p = 20\mu\text{s}$



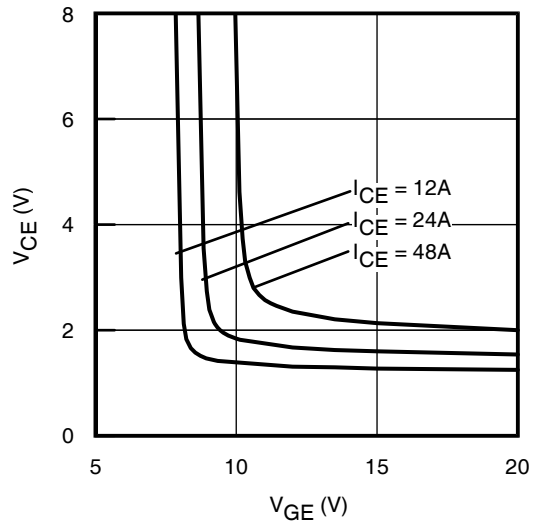
**Fig. 7 - Typ. IGBT Output Characteristics**  
 $T_J = 175^\circ\text{C}$ ;  $t_p = 20\mu\text{s}$



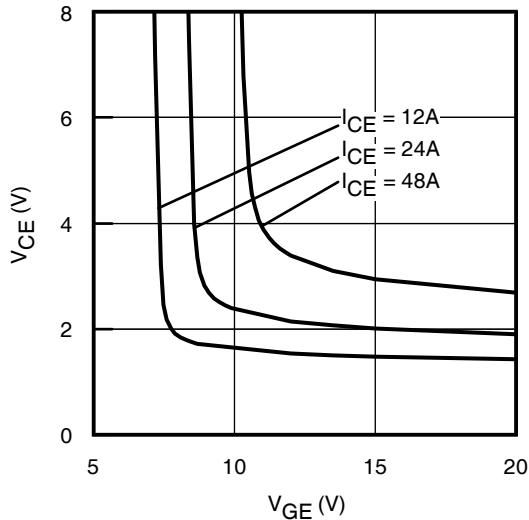
**Fig. 8 - Typ. Diode Forward Characteristics**  
 $t_p = 20\mu\text{s}$



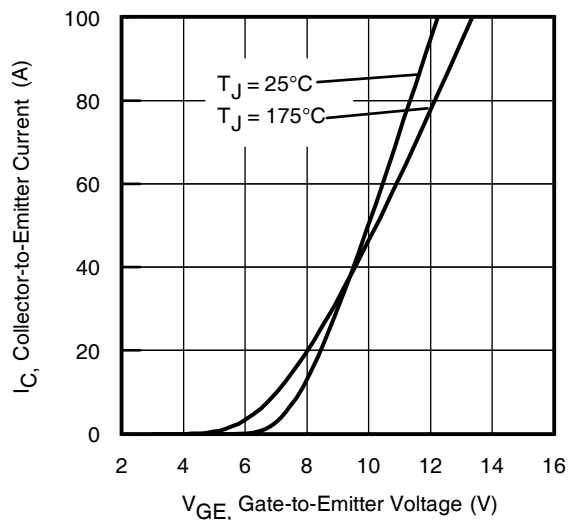
**Fig. 9 - Typical  $V_{CE}$  vs.  $V_{GE}$**   
 $T_J = -40^\circ\text{C}$



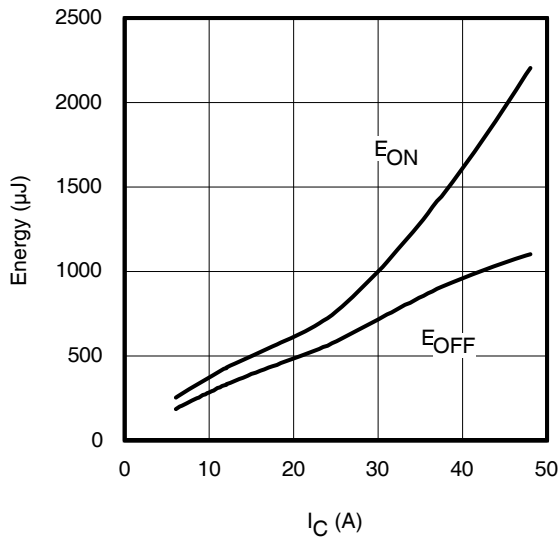
**Fig. 10 - Typical  $V_{CE}$  vs.  $V_{GE}$**   
 $T_J = 25^\circ\text{C}$



**Fig. 11 - Typical  $V_{CE}$  vs.  $V_{GE}$**   
 $T_J = 175^\circ\text{C}$

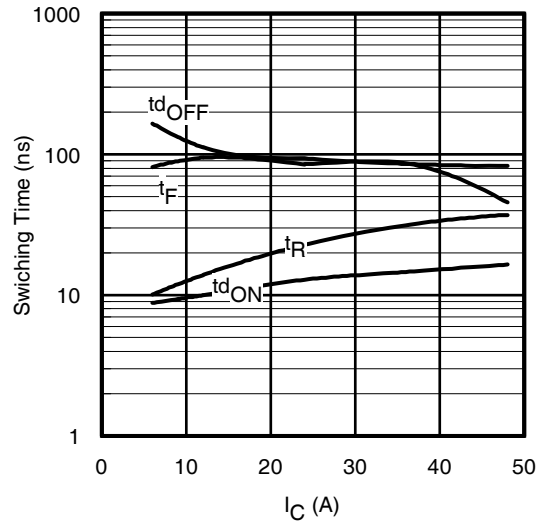


**Fig. 12 - Typ. Transfer Characteristics**  
 $V_{CE} = 50\text{V}$ ;  $t_p = 20\mu\text{s}$



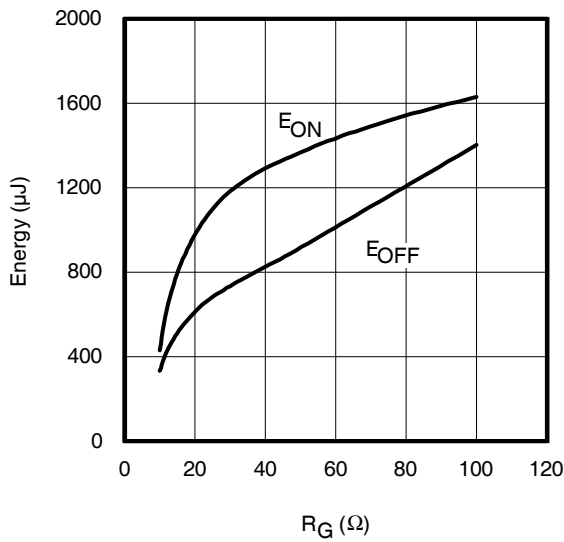
**Fig. 13** - Typ. Energy Loss vs.  $I_C$

$T_J = 175^\circ\text{C}$ ;  $L = 210\mu\text{H}$ ;  $V_{CE} = 400\text{V}$ ,  $R_G = 10\Omega$ ;  $V_{GE} = 15\text{V}$



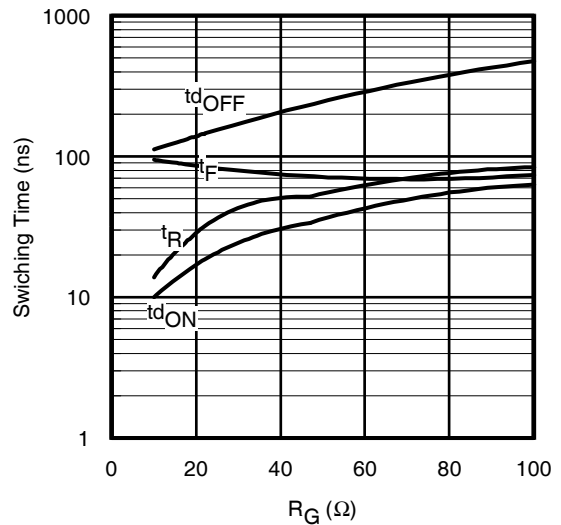
**Fig. 14** - Typ. Switching Time vs.  $I_C$

$T_J = 175^\circ\text{C}$ ;  $L = 210\mu\text{H}$ ;  $V_{CE} = 400\text{V}$ ,  $R_G = 10\Omega$ ;  $V_{GE} = 15\text{V}$



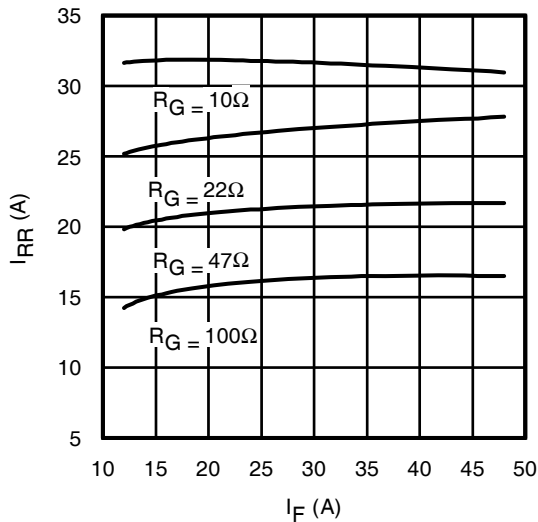
**Fig. 15** - Typ. Energy Loss vs.  $R_G$

$T_J = 175^\circ\text{C}$ ;  $L = 210\mu\text{H}$ ;  $V_{CE} = 400\text{V}$ ,  $I_{CE} = 24\text{A}$ ;  $V_{GE} = 15\text{V}$



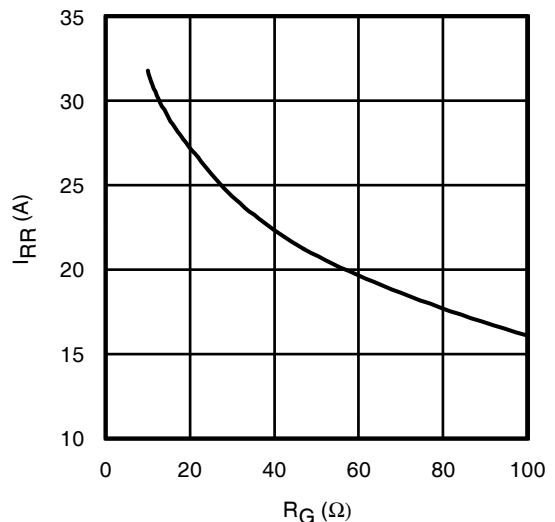
**Fig. 16** - Typ. Switching Time vs.  $R_G$

$T_J = 175^\circ\text{C}$ ;  $L = 210\mu\text{H}$ ;  $V_{CE} = 400\text{V}$ ,  $I_{CE} = 24\text{A}$ ;  $V_{GE} = 15\text{V}$



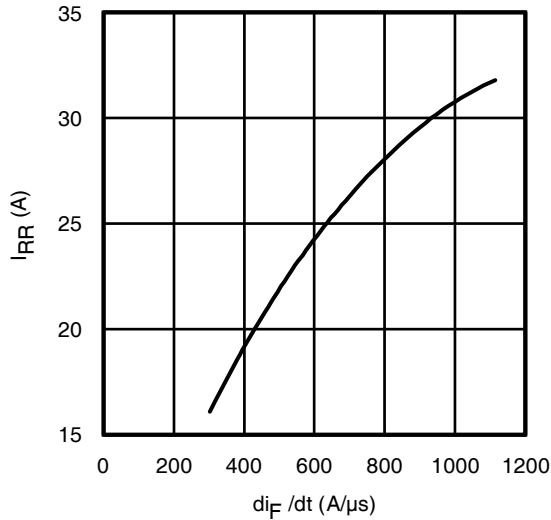
**Fig. 17** - Typ. Diode  $I_{RR}$  vs.  $I_F$

$T_J = 175^\circ\text{C}$

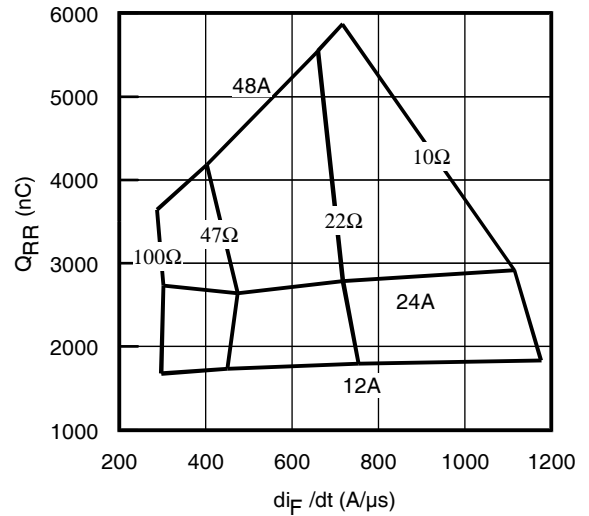


**Fig. 18** - Typ. Diode  $I_{RR}$  vs.  $R_G$

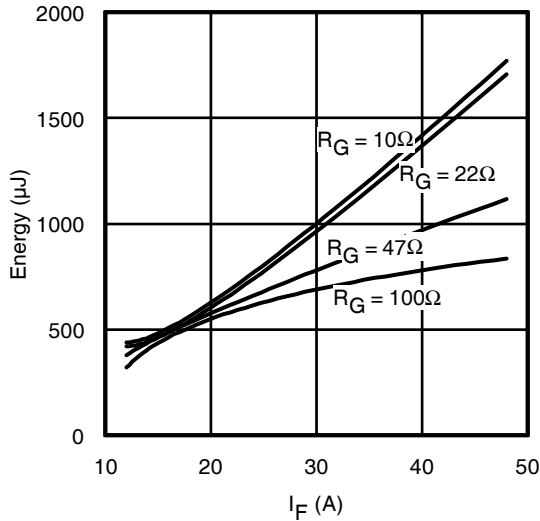
$T_J = 175^\circ\text{C}$



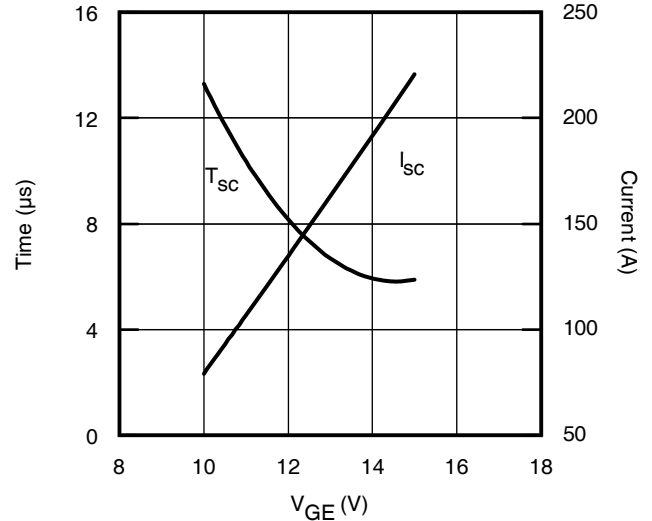
**Fig. 19** - Typ. Diode  $I_{RR}$  vs.  $di_F/dt$   
 $V_{CC} = 400V$ ;  $V_{GE} = 15V$ ;  $I_F = 24A$ ;  $T_J = 175^\circ C$



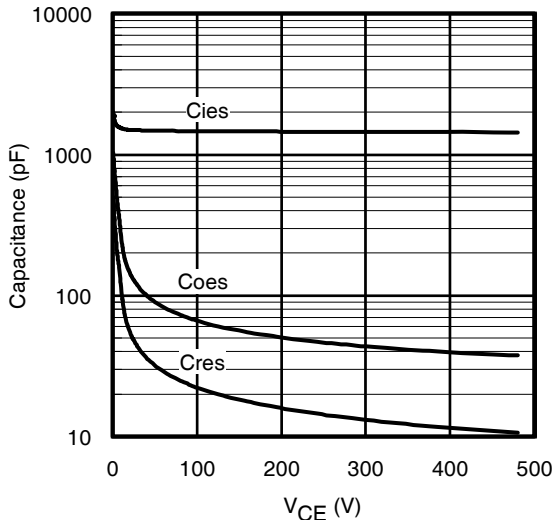
**Fig. 20** - Typ. Diode  $Q_{RR}$  vs.  $di_F/dt$   
 $V_{CC} = 400V$ ;  $V_{GE} = 15V$ ;  $T_J = 175^\circ C$



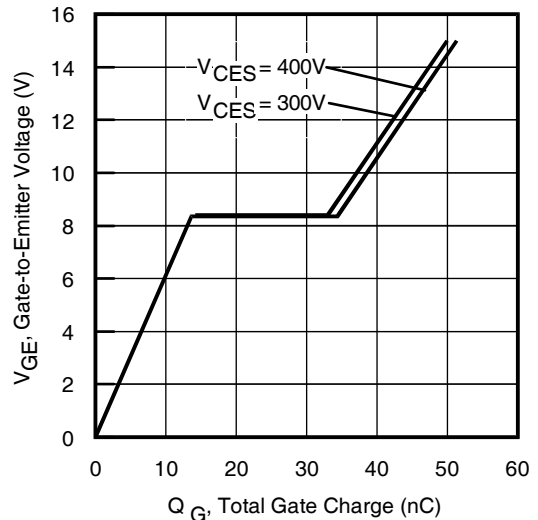
**Fig. 21** - Typ. Diode  $E_{RR}$  vs.  $I_F$   
 $T_J = 175^\circ C$



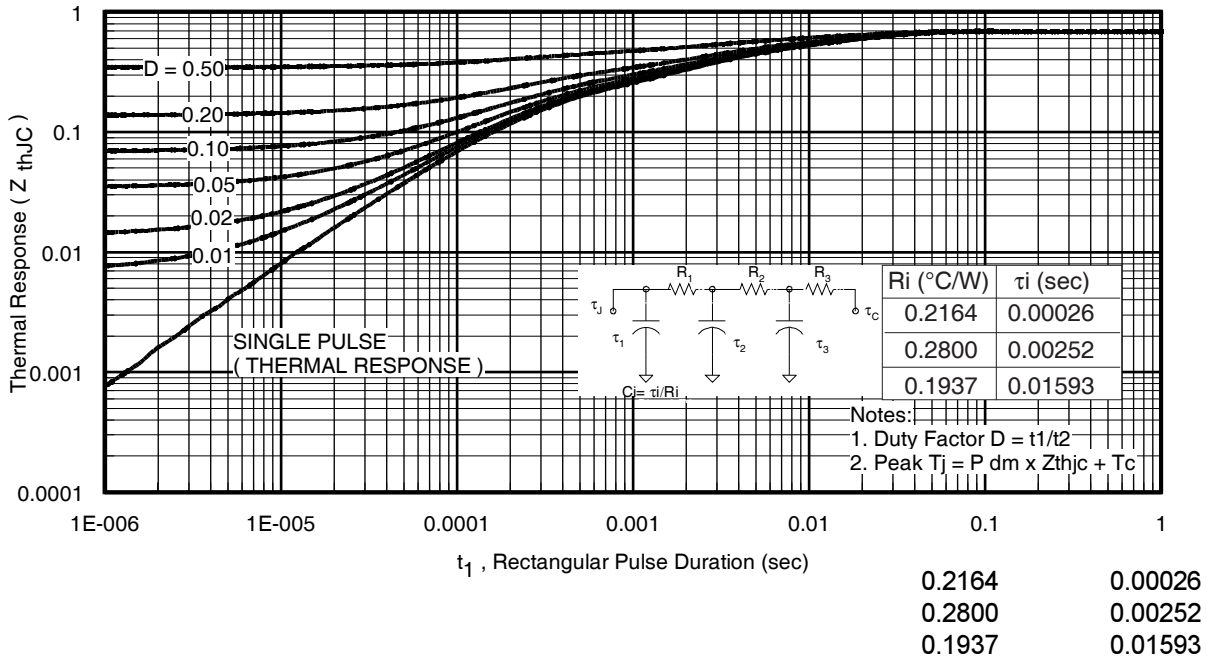
**Fig. 22** -  $V_{GE}$  vs. Short Circuit Time  
 $V_{CC} = 400V$ ;  $T_C = 25^\circ C$



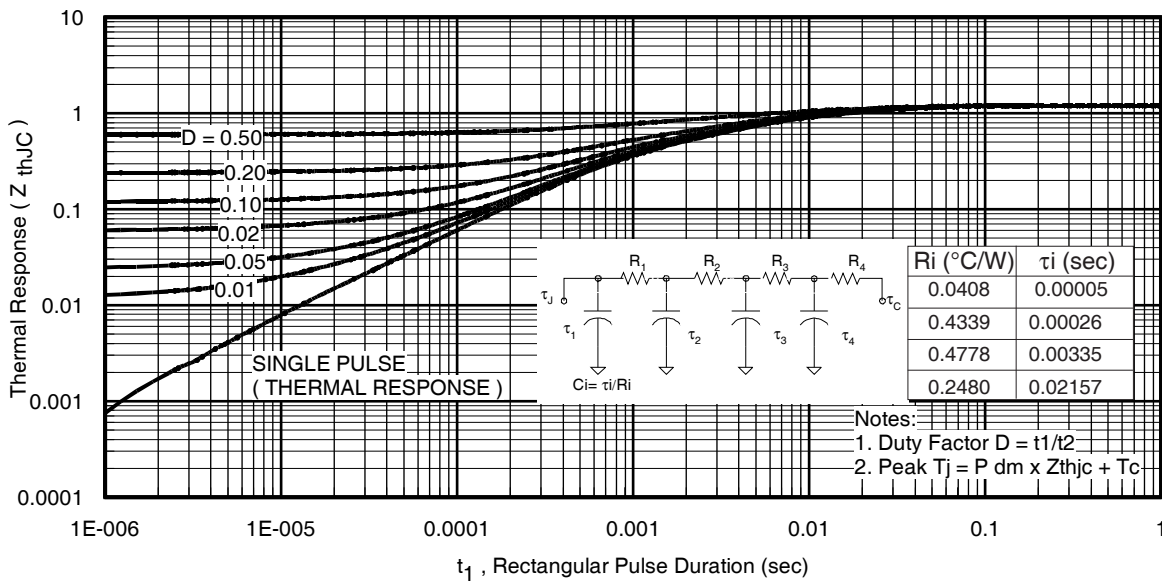
**Fig. 23** - Typ. Capacitance vs.  $V_{CE}$   
 $V_{GE} = 0V$ ;  $f = 1MHz$



**Fig. 24** - Typical Gate Charge vs.  $V_{GE}$   
 $I_{CE} = 24A$ ;  $L = 585\mu H$

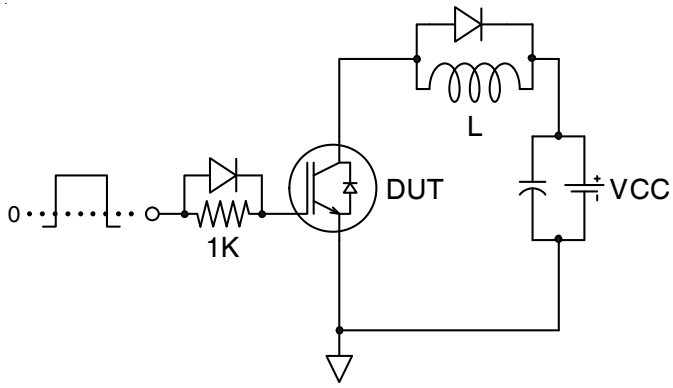


**Fig 25.** Maximum Transient Thermal Impedance, Junction-to-Case (IGBT)

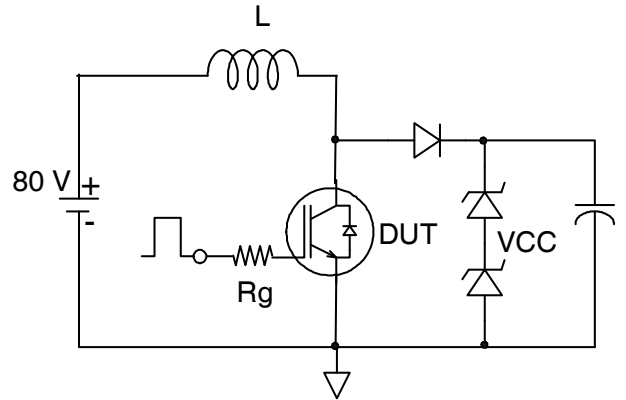


**Fig. 26.** Maximum Transient Thermal Impedance, Junction-to-Case (DIODE)

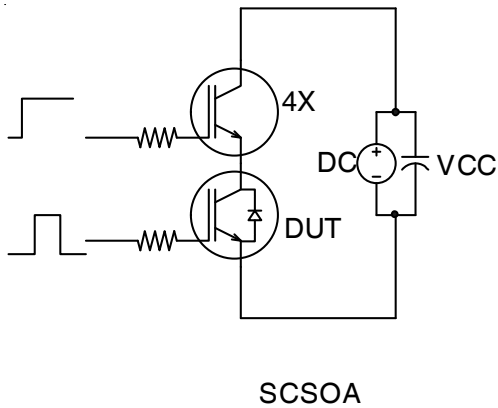




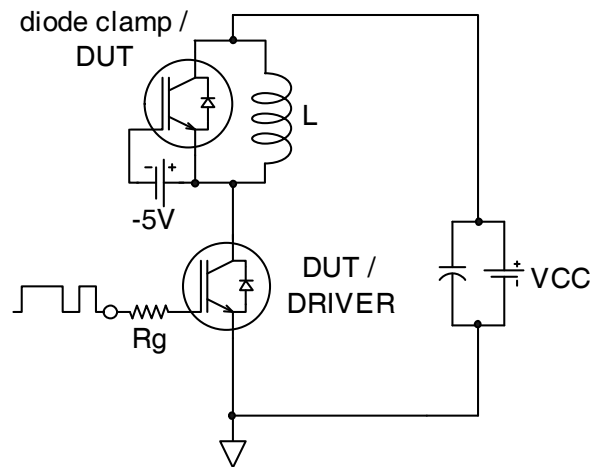
**Fig.C.T.1** - Gate Charge Circuit (turn-off)



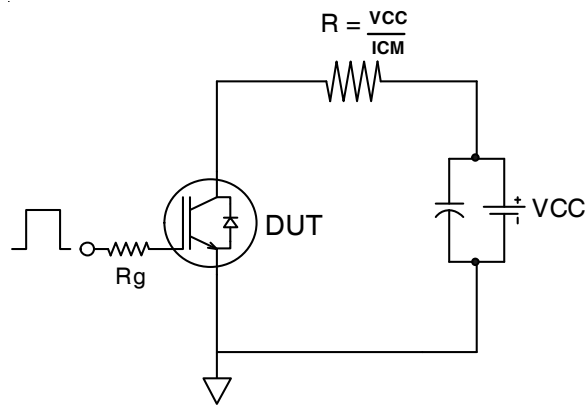
**Fig.C.T.2** - RBSOA Circuit



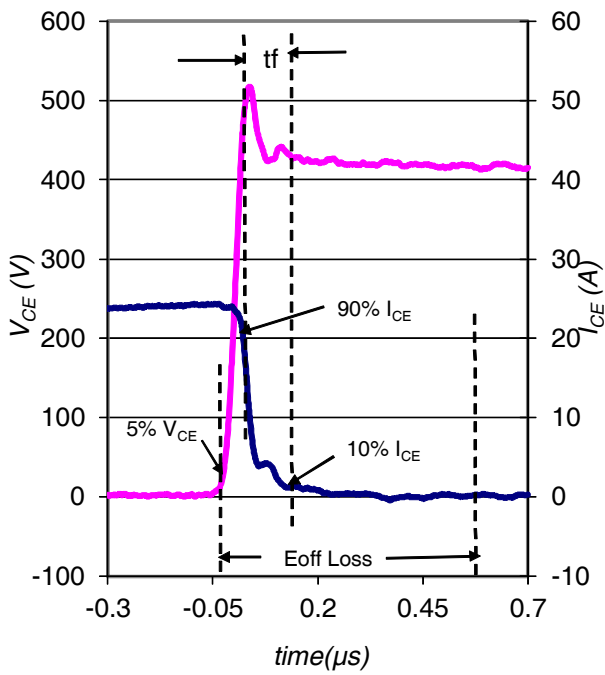
**Fig.C.T.3** - S.C. SOA Circuit



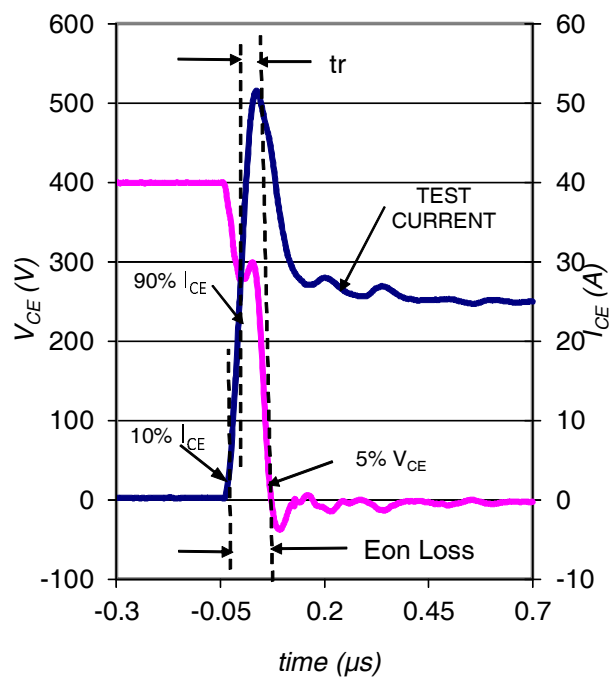
**Fig.C.T.4** - Switching Loss Circuit



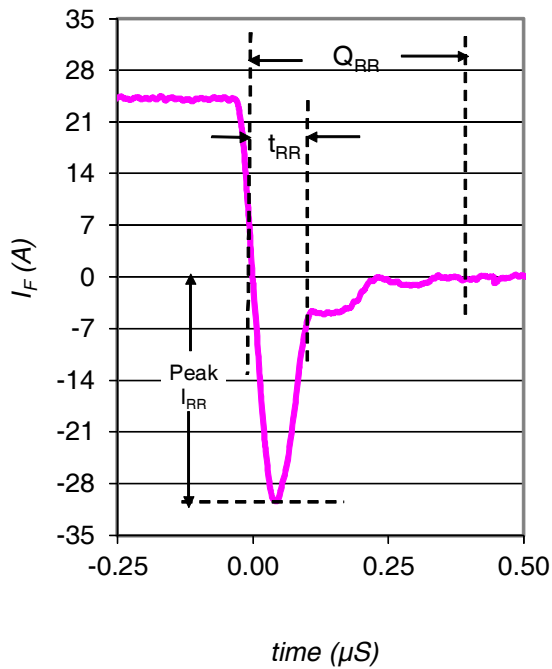
**Fig.C.T.5** - Resistive Load Circuit



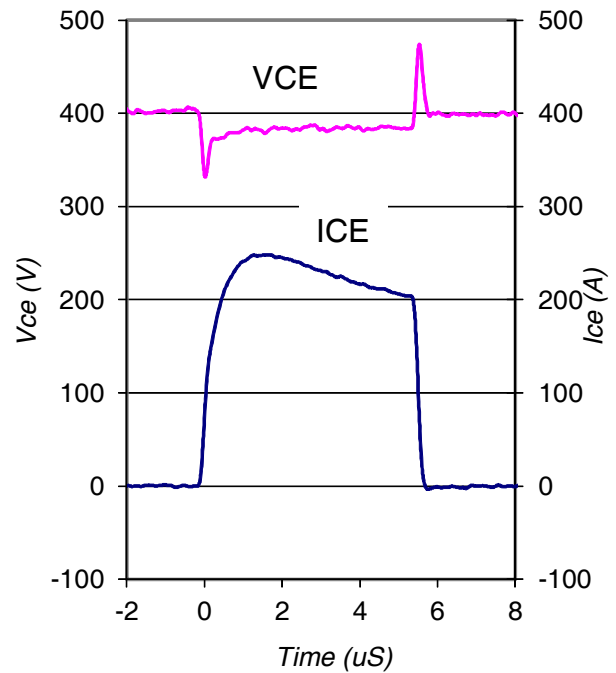
**Fig. WF1** - Typ. Turn-off Loss Waveform  
@  $T_J = 175^\circ\text{C}$  using Fig. CT.4



**Fig. WF2** - Typ. Turn-on Loss Waveform  
@  $T_J = 175^\circ\text{C}$  using Fig. CT.4



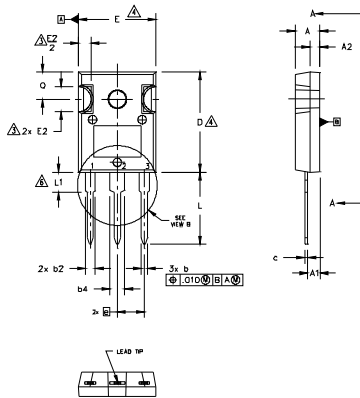
**Fig. WF3** - Typ. Diode Recovery Waveform  
@  $T_J = 175^\circ\text{C}$  using Fig. CT.4



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

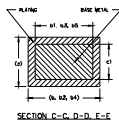
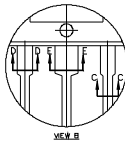
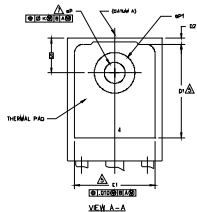
## TO-247AC Package Outline

Dimensions are shown in millimeters (inches)



**NOTES:**

1. DIMENSIONING AND TOLERANCING AS PER ASME Y14.5M 1994.
2. DIMENSIONS ARE SHOWN IN INCHES.
3. CONTOUR OF SLOT OPTIONAL.
4. DIMENSION D & E DO NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED .005" (0.127) PER SIDE. THESE DIMENSIONS ARE MEASURED AT THE OUTERMOST EXTREMES OF THE PLASTIC BODY.
5. THERMAL PAD CONTOUR OPTIONAL WITHIN DIMENSIONS D1 & E1.
6. LEAD FINISH UNCONTROLLED IN L1.
7. ØP TO HAVE A MAXIMUM DRAFT ANGLE OF 1.5 ° TO THE TOP OF THE PART WITH A MAXIMUM HOLE DIAMETER OF .154 INCH.
8. OUTLINE CONFORMS TO JEDEC OUTLINE TO-247AC .



SYMBOL	DIMENSIONS				NOTES
	INCHES		MILLIMETERS		
	MIN.	MAX.	MIN.	MAX.	
A	.183	.209	4.65	5.31	
A1	.087	.102	2.21	2.59	
A2	.059	.098	1.50	2.49	
b	.039	.055	0.99	1.40	
b1	.039	.053	0.99	1.35	
b2	.065	.094	1.65	2.39	
b3	.065	.092	1.65	2.34	
b4	.102	.135	2.59	3.43	
b5	.102	.133	2.59	3.38	
c	.015	.035	0.38	0.89	
c1	.015	.033	0.38	0.84	
D	.776	.815	19.71	20.70	4
D1	.515	-	13.08	-	5
D2	.020	.053	0.51	1.35	
E	.602	.625	15.29	15.87	4
E1	.530	-	13.46	-	
E2	.178	.216	4.52	5.49	
e	.215 BSC		5.46 BSC		
Øk	.010		0.25		
L	.559	.634	14.20	16.10	
L1	.146	.169	3.71	4.29	
ØP	.140	.144	3.56	3.66	
ØP1	-	.291	-	7.39	
Q	.209	.224	5.31	5.69	
S	.217 BSC		5.51 BSC		

**LEAD ASSIGNMENTS**

**HEXFET**

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

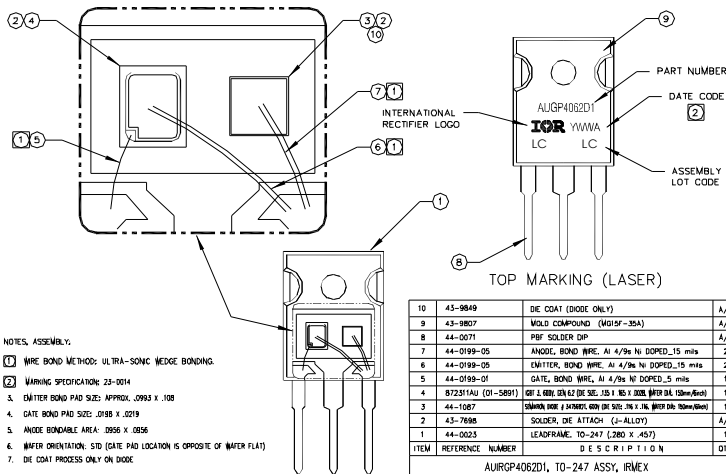
**IGBTs, CoPACK**

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

**DIODES**

- 1.- ANODE/OPEN
- 2.- CATHODE
- 3.- ANODE

## TO-247AC Part Marking Information



**NOTES, ASSEMBLY:**

1. WIRE BOND METHOD: ULTRA-SONIC WEDGE BONDING
2. WIRING SPECIFICATION: 23-0014
3. EMITTER BOND PAD SIZE: APPROX. .0983 x .108
4. GATE BOND PAD SIZE: .098 x .0219
5. ANODE BONDABLE AREA: .0958 x .0556
6. WAFER ORIENTATION: STD (GATE PAD LOCATION IS OPPOSITE OF WAFER FLAT)
7. DIE COAT PROCESS ONLY ON DIE

**NOTES, PACKAGING**  
1. TUBE - 25 UNITS/TUBE

ALL DIMENSIONS ARE SHOWN IN INCHES [MILLIMETERS]

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



## Ordering Information

Base part number	Package Type	Standard Pack		Complete Part Number
		Form	Quantity	
AUIRGP4062D1	TO-247AC	Tube	25	AUIRGP4062D1
AUIRGP4062D1-E	TO-247AD	Tube	25	AUIRGP4062D1-E

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