

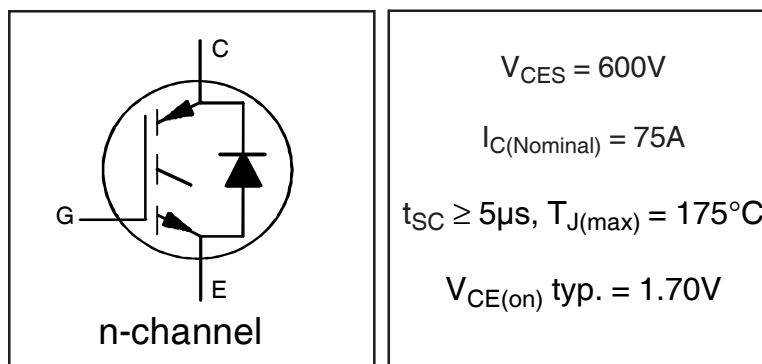
## INSULATED GATE BIPOLAR TRANSISTOR WITH ULTRAFAST SOFT RECOVERY DIODE

### Features

- Low  $V_{CE(ON)}$  Trench IGBT Technology
- Low switching losses
- Maximum Junction temperature 175 °C
- 5  $\mu$ S short circuit SOA
- Square RBSOA
- 100% of the parts tested for 4X rated current ( $I_{LM}$ )<sup>①</sup>
- Positive  $V_{CE(ON)}$  Temperature Coefficient
- Soft Recovery Co-Pak Diode
- Tight parameter distribution
- 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

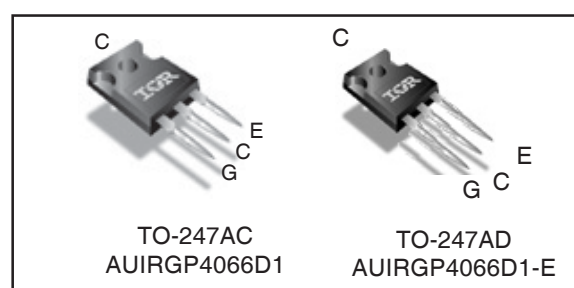


$$V_{CES} = 600V$$

$$I_{C(Nominal)} = 75A$$

$$t_{SC} \geq 5\mu s, T_{J(max)} = 175^{\circ}C$$

$$V_{CE(on)} \text{ typ.} = 1.70V$$



G	C	E
Gate	Collector	Emitter

### 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	140 <sup>⑤</sup>	A
$I_C @ T_C = 100^{\circ}C$	Continuous Collector Current	90	
$I_{NOMINAL}$	Nominal Current	75	
$I_{CM}$	Pulse Collector Current $V_{GE} = 15V$	225	
$I_{LM}$	Clamped Inductive Load Current $V_{GE} = 20V$ <sup>①</sup>	300	
$I_{F(NOMINAL)}$	Diode Nominal Current <sup>②</sup>	75 <sup>③</sup>	
$I_{FM}$	Diode Maximum Forward Current <sup>②</sup>	300	V
$V_{GE}$	Continuous Gate-to-Emitter Voltage	$\pm 20$	
	Transient Gate-to-Emitter Voltage	$\pm 30$	
$P_D @ T_C = 25^{\circ}C$	Maximum Power Dissipation	454	W
$P_D @ T_C = 100^{\circ}C$	Maximum Power Dissipation	227	
$T_J$	Operating Junction and	-55 to +175	°C
$T_{STG}$	Storage Temperature Range		
	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) <sup>③</sup>	—	—	0.33	°C/W
$R_{\theta JC}$ (Diode)	Thermal Resistance Junction-to-Case-(each Diode) <sup>③</sup>	—	—	0.53	
$R_{\theta CS}$	Thermal Resistance, Case-to-Sink (flat, greased surface)	—	0.24	—	
$R_{\theta JA}$	Thermal Resistance, Junction-to-Ambient (typical socket mount)	—	40	—	

## 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	$V_{GE} = 0V, I_C = 200\mu A$ ④
$\Delta V_{(BR)CES}/\Delta T_J$	Temperature Coeff. of Breakdown Voltage	—	0.30	—	V/°C	$V_{GE} = 0V, I_C = 15mA$ (25°C-175°C)
$V_{CE(on)}$	Collector-to-Emitter Saturation Voltage	—	1.70	2.1	V	$I_C = 75A, V_{GE} = 15V, T_J = 25^\circ\text{C}$ ②
		—	2.0	—		$I_C = 75A, V_{GE} = 15V, T_J = 150^\circ\text{C}$ ②
		—	2.1	—		$I_C = 75A, V_{GE} = 15V, T_J = 175^\circ\text{C}$ ②
$V_{GE(th)}$	Gate Threshold Voltage	4.0	—	6.5	V	$V_{CE} = V_{GE}, I_C = 2.1mA$
$\Delta V_{GE(th)}/\Delta T_J$	Threshold Voltage temp. coefficient	—	-13	—	mV/°C	$V_{CE} = V_{GE}, I_C = 20mA$ (25°C - 175°C)
$g_{fe}$	Forward Transconductance	—	50	—	S	$V_{CE} = 50V, I_C = 75A, PW = 25\mu s$
$I_{CES}$	Collector-to-Emitter Leakage Current	—	3.0	200	$\mu A$	$V_{GE} = 0V, V_{CE} = 600V$
		—	10	—	mA	$V_{GE} = 0V, V_{CE} = 600V, T_J = 175^\circ\text{C}$
$V_{FM}$	Diode Forward Voltage Drop	—	1.60	1.77	V	$I_F = 75A$
		—	1.54	—		$I_F = 75A, T_J = 175^\circ\text{C}$
$I_{GES}$	Gate-to-Emitter Leakage Current	—	—	$\pm 100$	nA	$V_{GE} = \pm 20V$

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

	Parameter	Min.	Typ.	Max.	Units	Conditions
$Q_g$	Total Gate Charge (turn-on)	—	150	225	nC	$I_C = 75A$
$Q_{ge}$	Gate-to-Emitter Charge (turn-on)	—	40	60		$V_{GE} = 15V$
$Q_{gc}$	Gate-to-Collector Charge (turn-on)	—	60	90		$V_{CC} = 400V$
$E_{on}$	Turn-On Switching Loss	—	4240	5190	$\mu J$	$I_C = 75A, V_{CC} = 400V, V_{GE} = 15V$
$E_{off}$	Turn-Off Switching Loss	—	2170	3060		$R_G = 10\Omega, L = 100\mu H, T_J = 25^\circ\text{C}$
$E_{total}$	Total Switching Loss	—	6410	8250		Energy losses include diode & diode reverse recovery
$t_{d(on)}$	Turn-On delay time	—	50	70	ns	$I_C = 75A, V_{CC} = 400V, V_{GE} = 15V$
$t_r$	Rise time	—	80	100		$R_G = 10\Omega, L = 100\mu H$
$t_{d(off)}$	Turn-Off delay time	—	200	230		$T_J = 25^\circ\text{C}$
$t_f$	Fall time	—	60	80		
$E_{on}$	Turn-On Switching Loss	—	6210	—		$\mu J$
$E_{off}$	Turn-Off Switching Loss	—	2815	—	$R_G = 10\Omega, L = 100\mu H, T_J = 175^\circ\text{C}$	
$E_{total}$	Total Switching Loss	—	9025	—	Energy losses include diode & diode reverse recovery	
$t_{d(on)}$	Turn-On delay time	—	45	—	ns	$I_C = 75A, V_{CC} = 400V, V_{GE} = 15V$
$t_r$	Rise time	—	70	—		$R_G = 10\Omega, L = 100\mu H$
$t_{d(off)}$	Turn-Off delay time	—	240	—		$T_J = 175^\circ\text{C}$
$t_f$	Fall time	—	80	—		
$C_{ies}$	Input Capacitance	—	4470	—	pF	$V_{GE} = 0V$
$C_{oes}$	Output Capacitance	—	350	—		$V_{CC} = 30V$
$C_{res}$	Reverse Transfer Capacitance	—	140	—		$f = 1.0MHz$
RBSOA	Reverse Bias Safe Operating Area	FULL SQUARE				$T_J = 175^\circ\text{C}, I_C = 300A$ $V_{CC} = 480V, V_p \leq 600V$ $R_G = 10\Omega, V_{GE} = +20V$ to 0V
SCSOA	Short Circuit Safe Operating Area	5	—	—	$\mu s$	$V_{CC} = 400V, V_p \leq 600V$ $R_G = 10\Omega, V_{GE} = +15V$ to 0V
$E_{rec}$	Reverse Recovery Energy of the Diode	—	680	—	$\mu J$	$T_J = 175^\circ\text{C}$
$t_{rr}$	Diode Reverse Recovery Time	—	240	—	ns	$V_{CC} = 400V, I_F = 75A$
$I_{rr}$	Peak Reverse Recovery Current	—	50	—	A	$V_{GE} = 15V, R_G = 10\Omega, L = 100\mu H$

### Notes:

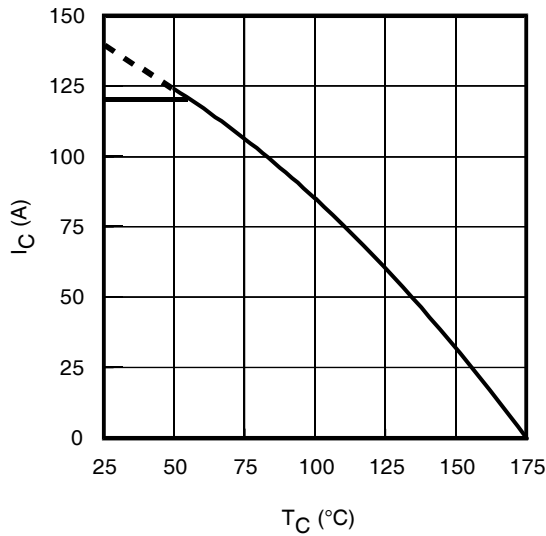
- $V_{CC} = 80\% (V_{CES}), V_{GE} = 20V, L = 100\mu H, R_G = 50\Omega$ , tested in production  $I_{LM} \leq 400A$ .
- Pulse width limited by max. junction temperature.
- Refer to AN-1086 for guidelines for measuring  $V_{(BR)CES}$  safely.
- $R_{\theta}$  is measured at  $T_J$  of approximately  $90^\circ\text{C}$ .
- Calculated continuous current based on maximum allowable junction temperature. Package IGBT current limit is 120A. Package diode current limit is 120A. Note that current limitations arising from heating of the device leads may occur.

## Qualification Information<sup>†</sup>

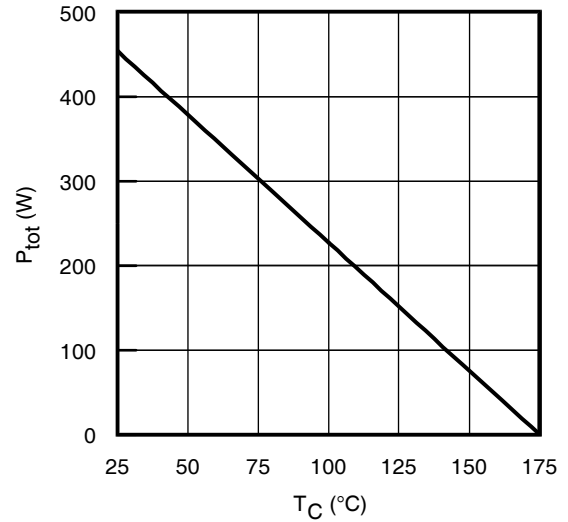
<b>Qualification Level</b>		Automotive (per AEC-Q101)	
		Comments: This part number(s) passed Automotive qualification. IR's Industrial and Consumer qualification level is granted by extension of the higher Automotive level.	
<b>Moisture Sensitivity Level</b>		TO-247AC	N/A
		TO-247AD	
<b>ESD</b>	Machine Model	Class M4 (+/-425V) <sup>††</sup> AEC-Q101-002	
	Human Body Model	Class H2 (+/-4000V) <sup>††</sup> AEC-Q101-001	
	Charged Device Model	Class C5 (+/-1125V) <sup>††</sup> AEC-Q101-005	
<b>RoHS Compliant</b>		Yes	

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

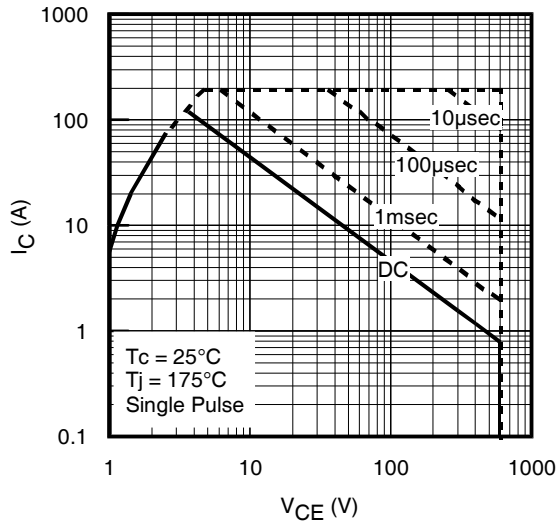
<sup>††</sup> Highest passing voltage



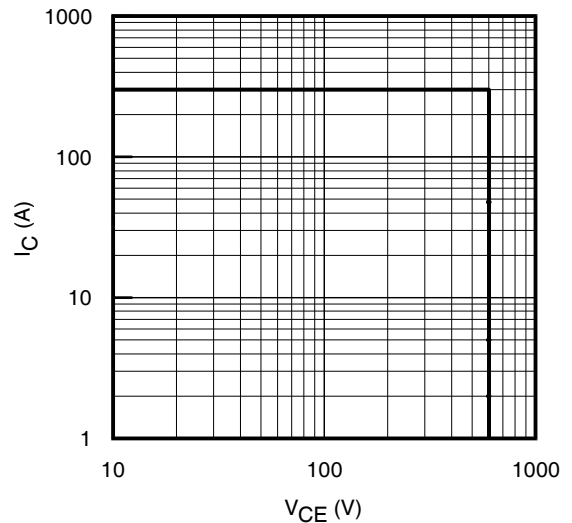
**Fig. 1** - Maximum DC Collector Current vs. Case Temperature



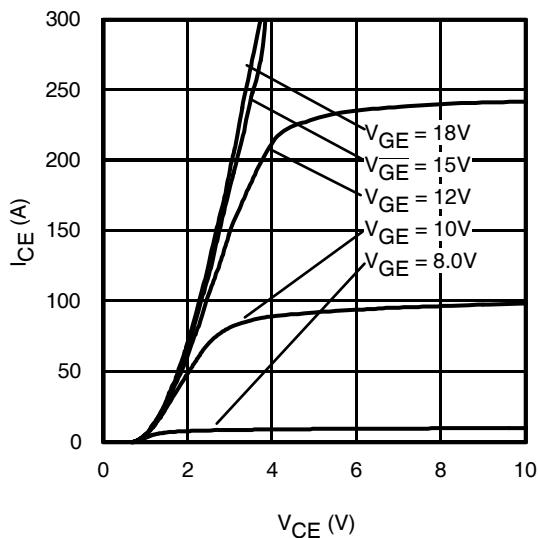
**Fig. 2** - Power Dissipation vs. Case Temperature



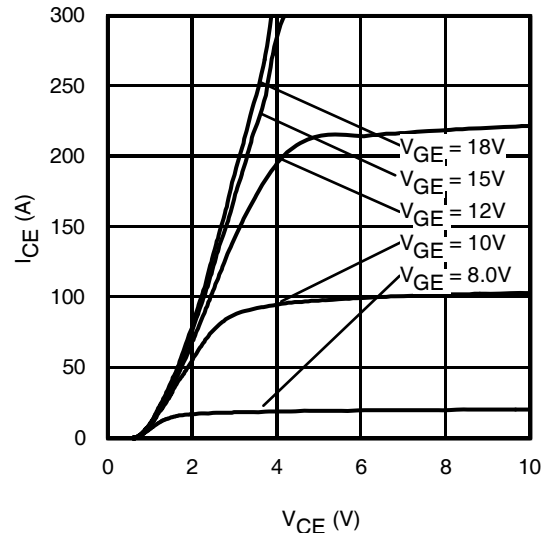
**Fig. 3** - Forward SOA  
 $T_C = 25^\circ\text{C}$ ,  $T_J \leq 175^\circ\text{C}$ ;  $V_{GE} = 15\text{V}$



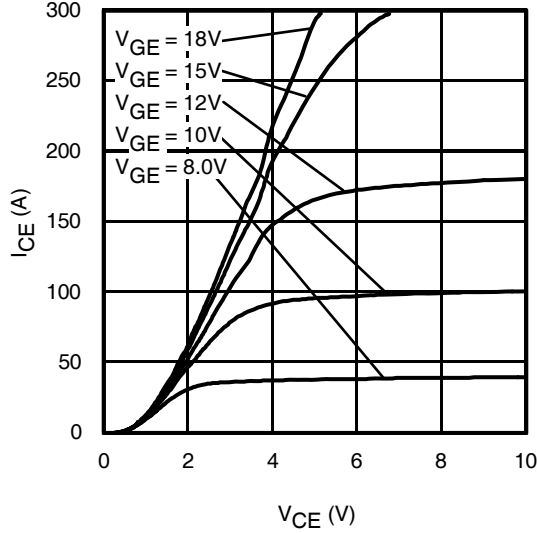
**Fig. 4** - Reverse Bias SOA  
 $T_J = 175^\circ\text{C}$ ;  $V_{GE} = 20\text{V}$



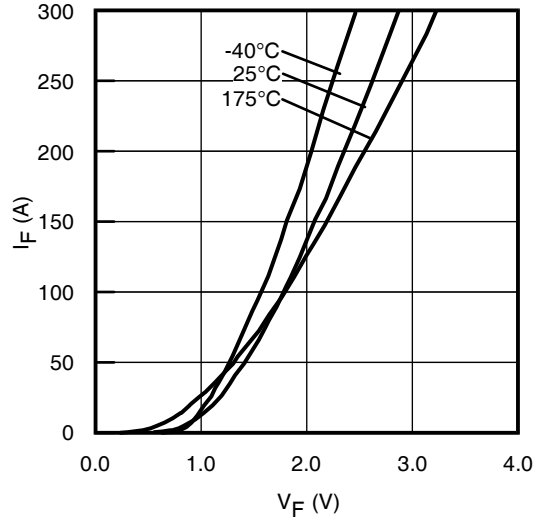
**Fig. 5** - Typ. IGBT Output Characteristics  
 $T_J = -40^\circ\text{C}$ ;  $t_p = \leq 60\mu\text{s}$



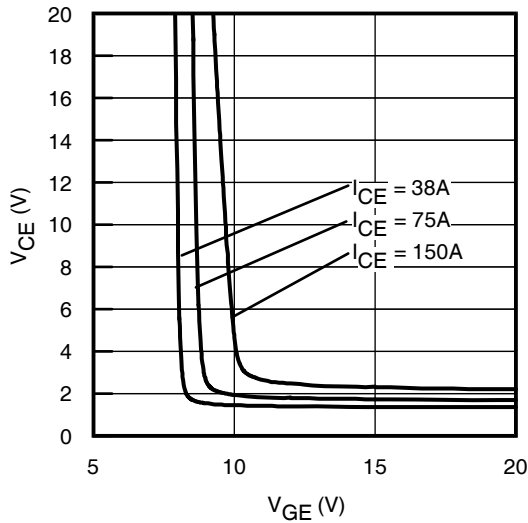
**Fig. 6** - Typ. IGBT Output Characteristics  
 $T_J = 25^\circ\text{C}$ ;  $t_p = \leq 60\mu\text{s}$



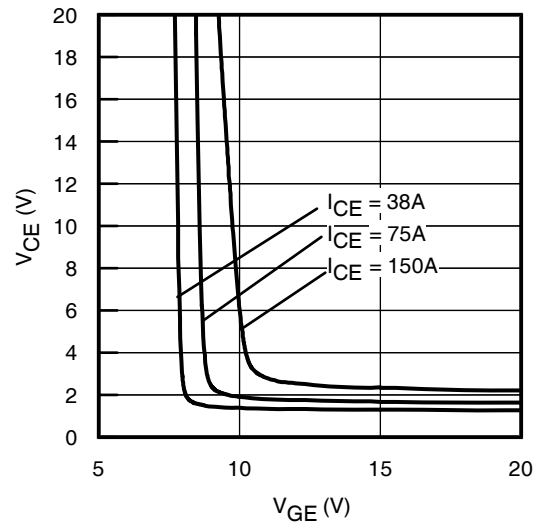
**Fig. 7 - Typ. IGBT Output Characteristics**  
 $T_J = 175^\circ\text{C}$ ;  $t_p = \leq 60\mu\text{s}$



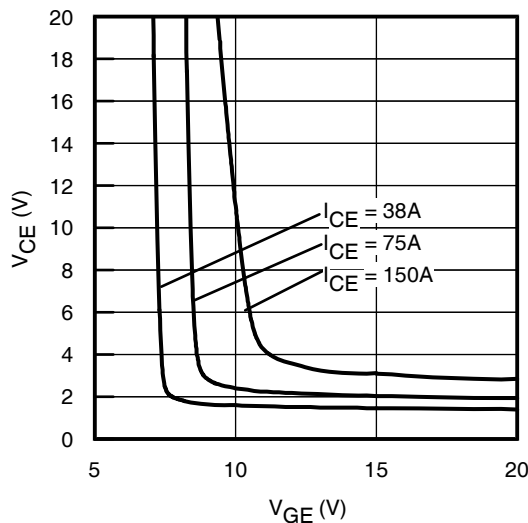
**Fig. 8 - Typ. Diode Forward Characteristics**  
 $t_p = \leq 60\mu\text{s}$



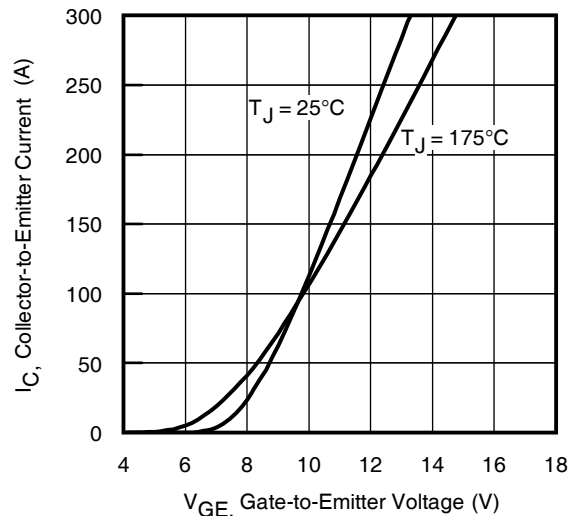
**Fig. 9 - Typical  $V_{CE}$  vs.  $V_{GE}$**   
 $T_J = -40^\circ\text{C}$



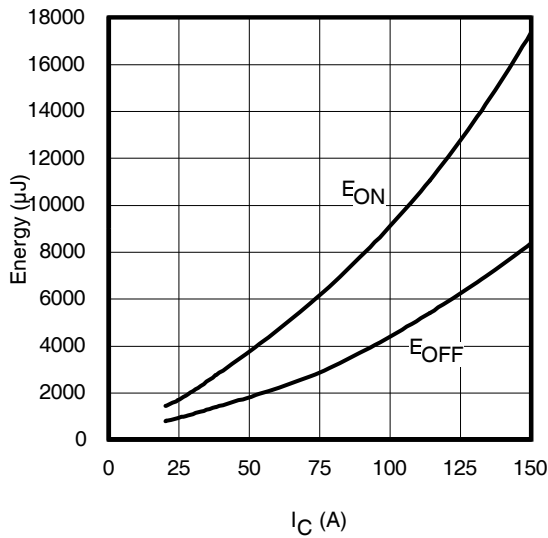
**Fig. 10 - Typical  $V_{CE}$  vs.  $V_{GE}$**   
 $T_J = 25^\circ\text{C}$



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

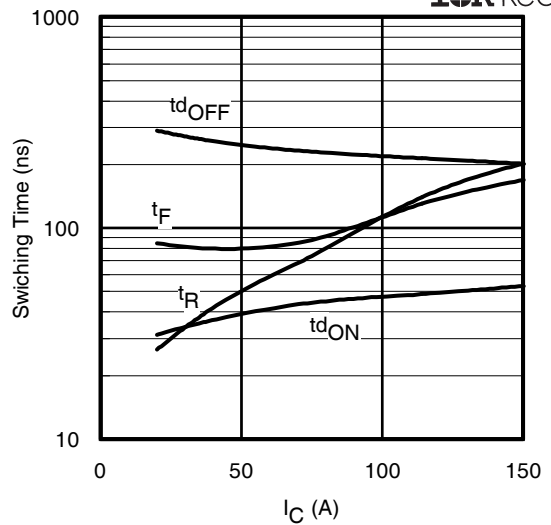


**Fig. 12 - Typ. Transfer Characteristics**  
 $V_{CE} = 50\text{V}$ ;  $t_p = \leq 60\mu\text{s}$



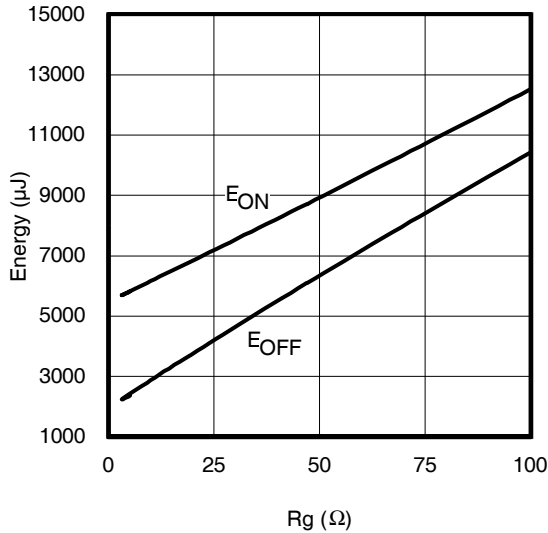
**Fig. 13** - Typ. Energy Loss vs.  $I_C$

$T_J = 175^\circ\text{C}$ ;  $L = 100\mu\text{H}$ ;  $V_{CE} = 400\text{V}$ ,  $R_G = 10\Omega$ ;  $V_{GE} = 15\text{V}$



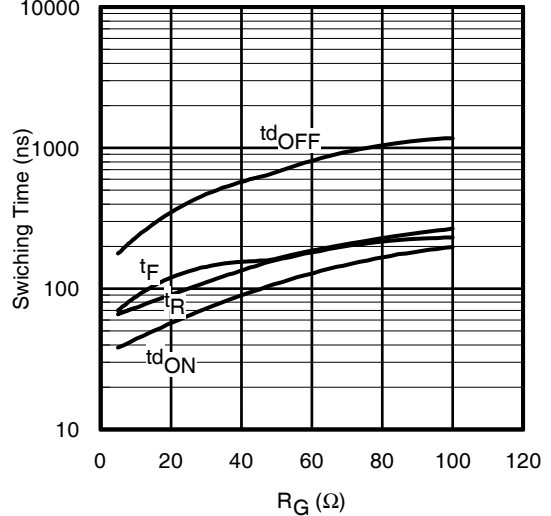
**Fig. 14** - Typ. Switching Time vs.  $I_C$

$T_J = 175^\circ\text{C}$ ;  $L = 100\mu\text{H}$ ;  $V_{CE} = 400\text{V}$ ,  $R_G = 10\Omega$ ;  $V_{GE} = 15\text{V}$



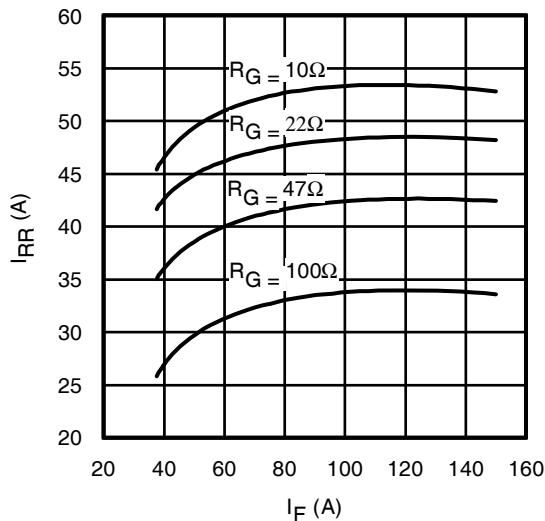
**Fig. 15** - Typ. Energy Loss vs.  $R_G$

$T_J = 175^\circ\text{C}$ ;  $L = 100\mu\text{H}$ ;  $V_{CE} = 400\text{V}$ ,  $I_{CE} = 75\text{A}$ ;  $V_{GE} = 15\text{V}$



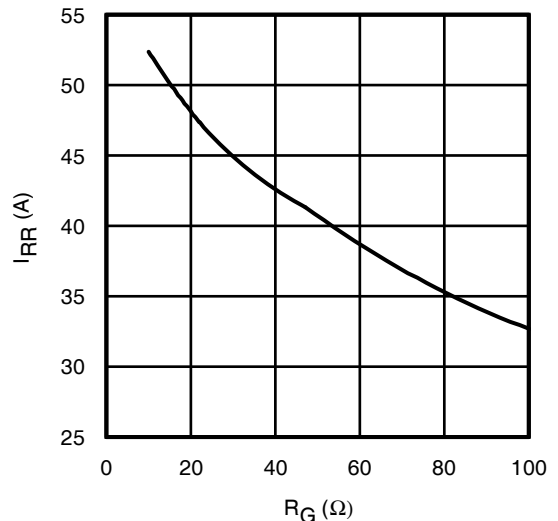
**Fig. 16** - Typ. Switching Time vs.  $R_G$

$T_J = 175^\circ\text{C}$ ;  $L = 100\mu\text{H}$ ;  $V_{CE} = 400\text{V}$ ,  $I_{CE} = 75\text{A}$ ;  $V_{GE} = 15\text{V}$



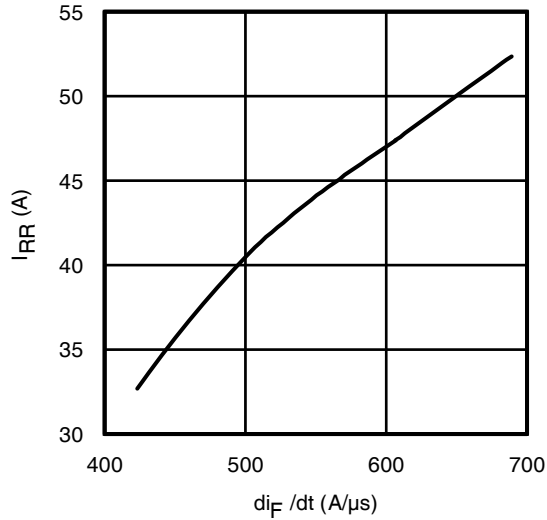
**Fig. 17** - Typ. Diode  $I_{RR}$  vs.  $I_F$

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

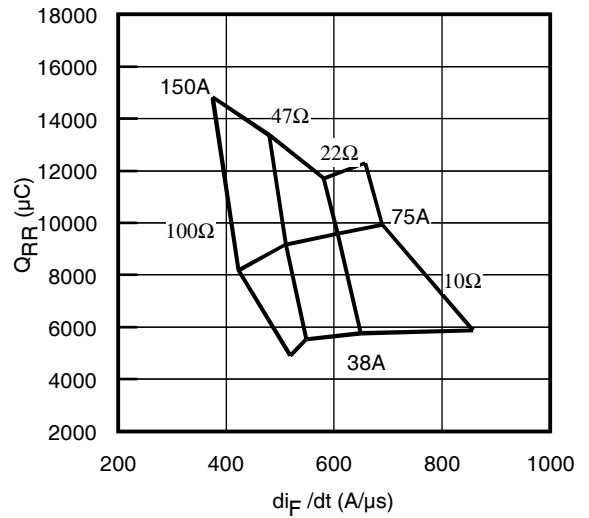


**Fig. 18** - Typ. Diode  $I_{RR}$  vs.  $R_G$

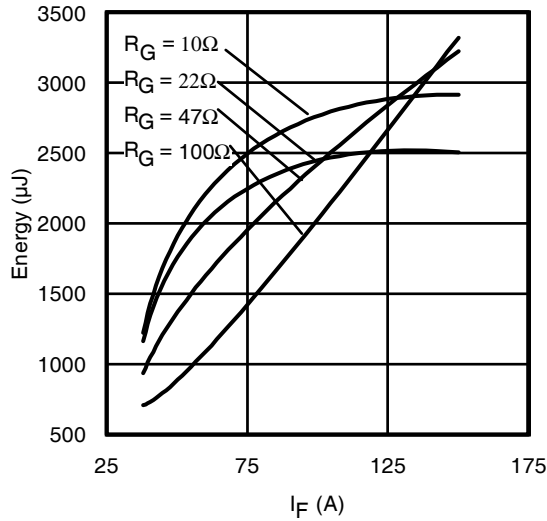
$T_J = 175^\circ\text{C}$



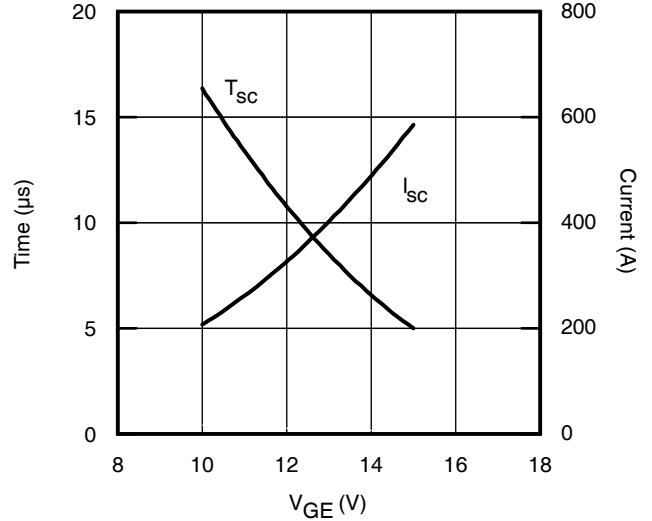
**Fig. 19** - Typ. Diode  $I_{RR}$  vs.  $di_F/dt$   
 $V_{CC} = 400V$ ;  $V_{GE} = 15V$ ;  $I_F = 75A$ ;  $T_J = 175^\circ C$



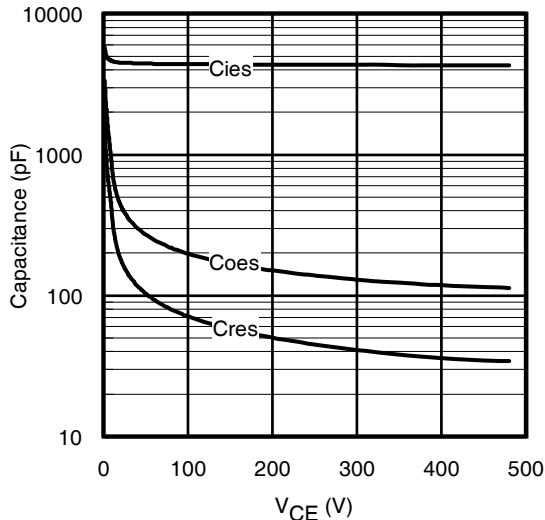
**Fig. 20** - Typ. Diode  $Q_{RR}$  vs.  $di_F/dt$   
 $V_{CC} = 400V$ ;  $V_{GE} = 15V$ ;  $T_J = 175^\circ C$



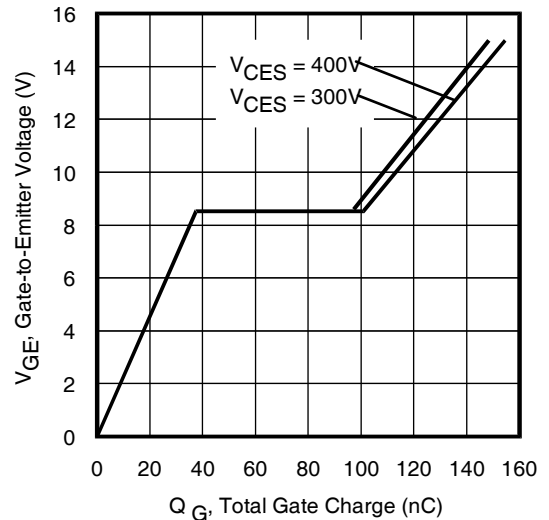
**Fig. 21** - Typ. Diode  $E_{RR}$  vs.  $I_F$   
 $T_J = 175^\circ C$



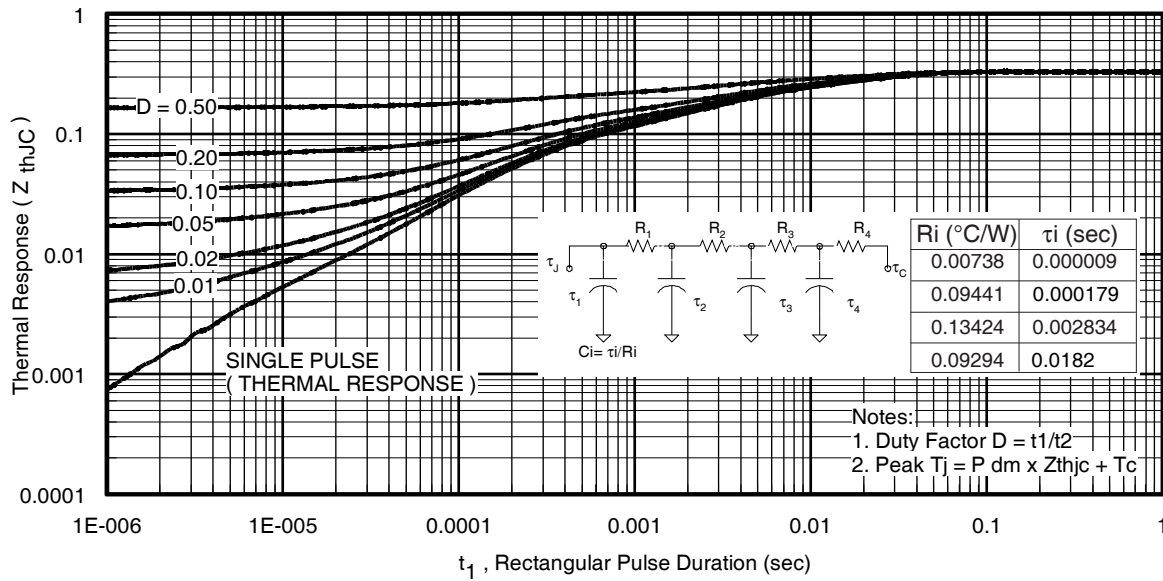
**Fig. 22** -  $V_{GE}$  vs. Short Circuit Time  
 $V_{CC} = 400V$ ;  $T_C = 25^\circ C$



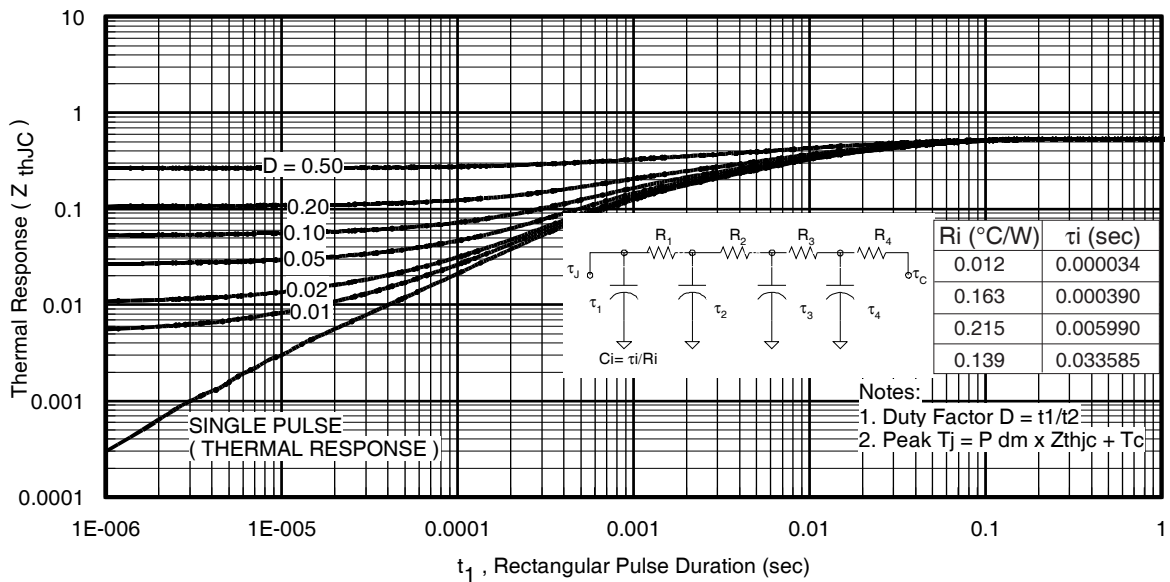
**Fig. 23** - Typ. Capacitance vs.  $V_{CE}$   
 $V_{GE} = 0V$ ;  $f = 1MHz$



**Fig. 24** - Typical Gate Charge vs.  $V_{GE}$   
 $I_{CE} = 75A$ ;  $L = 485\mu H$

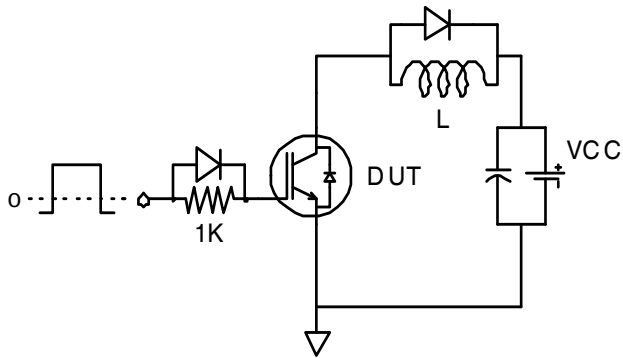


**Fig 25.** Maximum Transient Thermal Impedance, Junction-to-Case (IGBT)

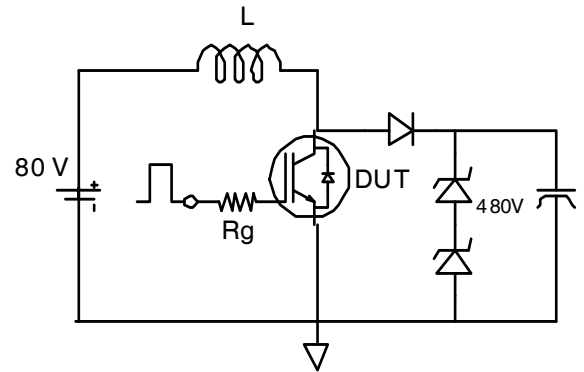


**Fig. 26.** Maximum Transient Thermal Impedance, Junction-to-Case (DIODE)

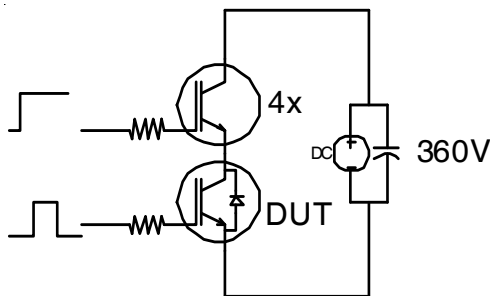




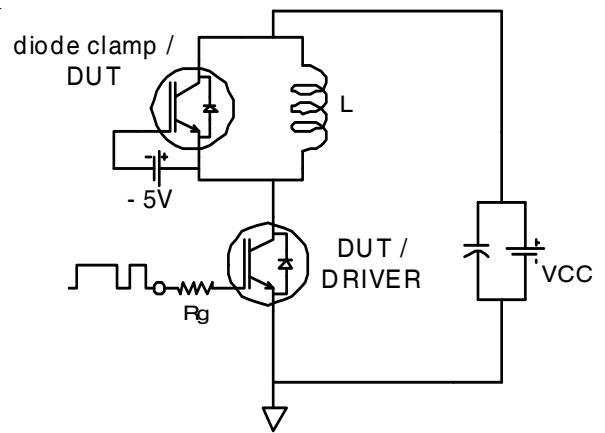
**Fig.C.T.1** - Gate Charge Circuit (turn-off)



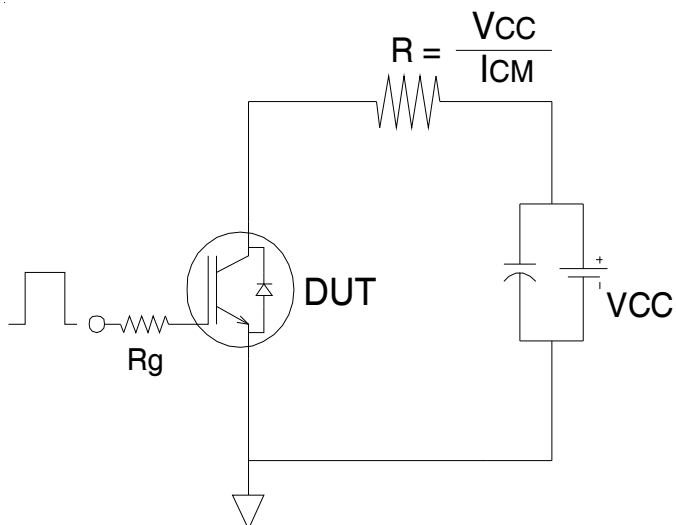
**Fig.C.T.2** - RBSOA Circuit



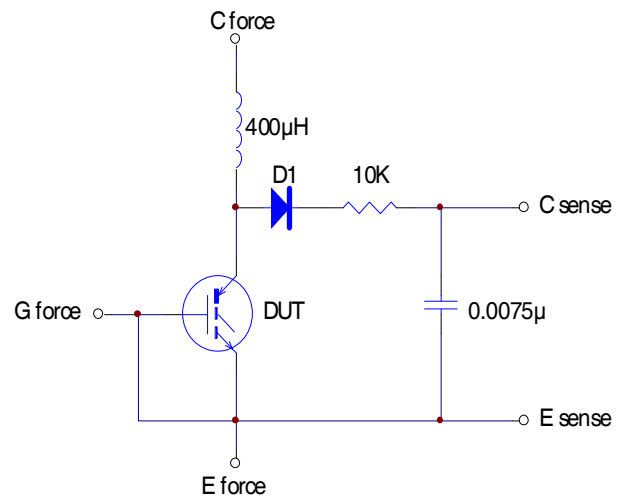
**Fig.C.T.3** - S.C. SOA Circuit



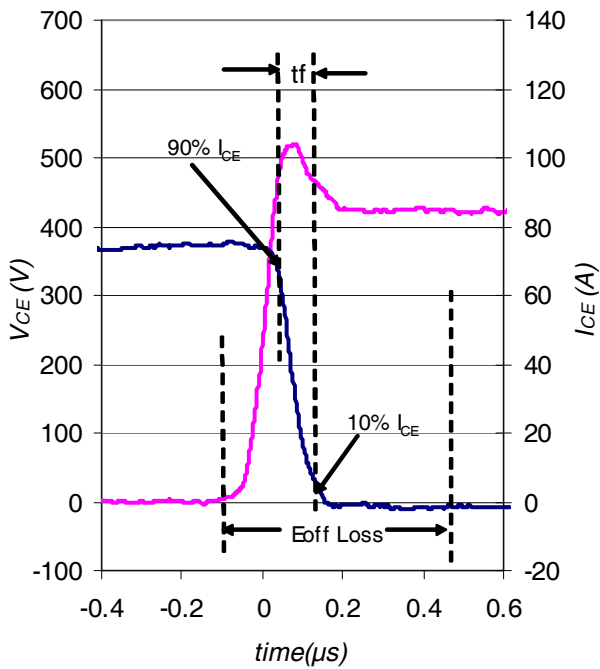
**Fig.C.T.4** - Switching Loss Circuit



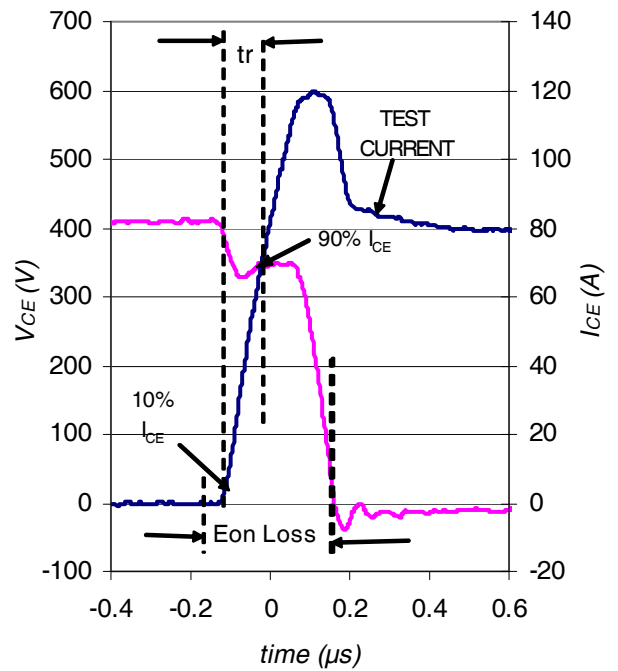
**Fig.C.T.5** - Resistive Load Circuit



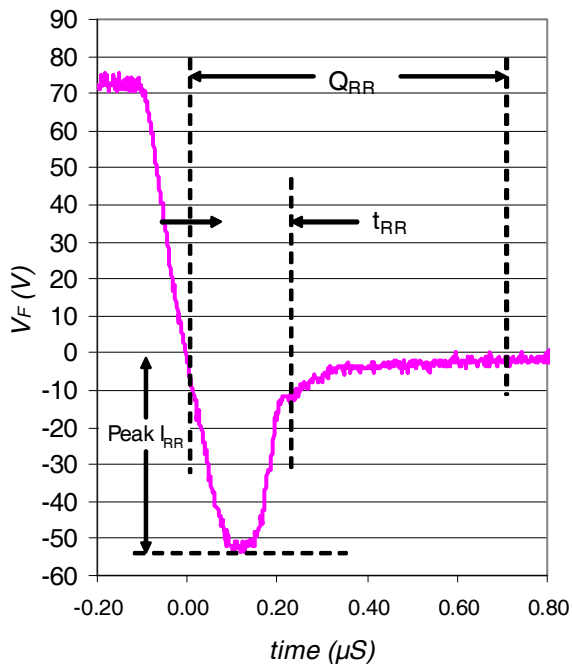
**Fig.C.T.6** - BVCES Filter Circuit



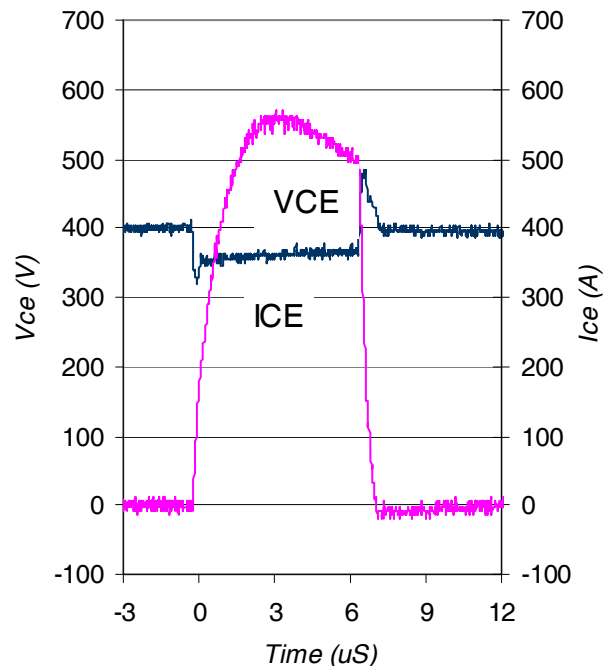
**Fig. WF1** - Typ. Turn-off Loss Waveform  
@  $T_J = 175^\circ\text{C}$  using Fig. CT.4



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



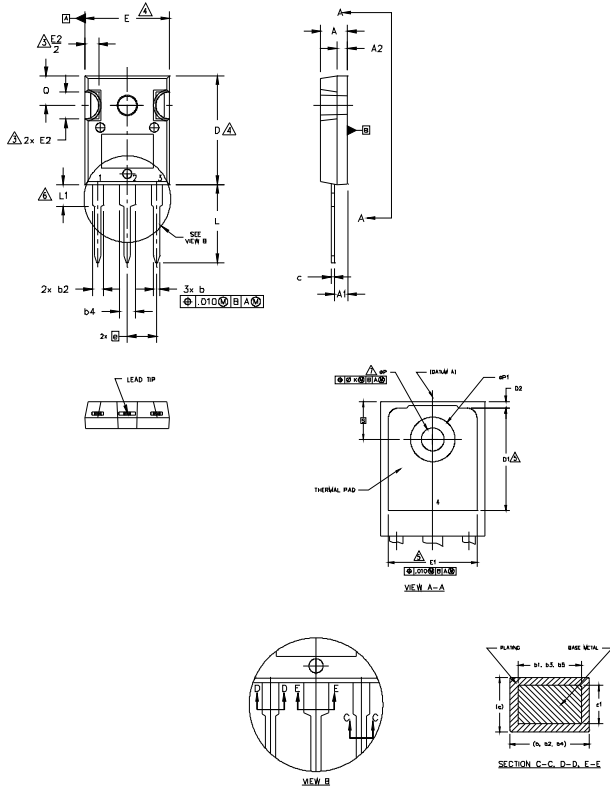
**Fig. WF3** - Typ. Diode Recovery Waveform  
@  $T_J = 175^\circ\text{C}$  using Fig. CT.4



**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. ϕP 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	INCHES		MILLIMETERS		NOTES
	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		
ϕk	.010		0.25		
L	.559	.634	14.20	16.10	
L1	.146	.169	3.71	4.29	
ϕP	.140	.144	3.56	3.66	
ϕP1	-	.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

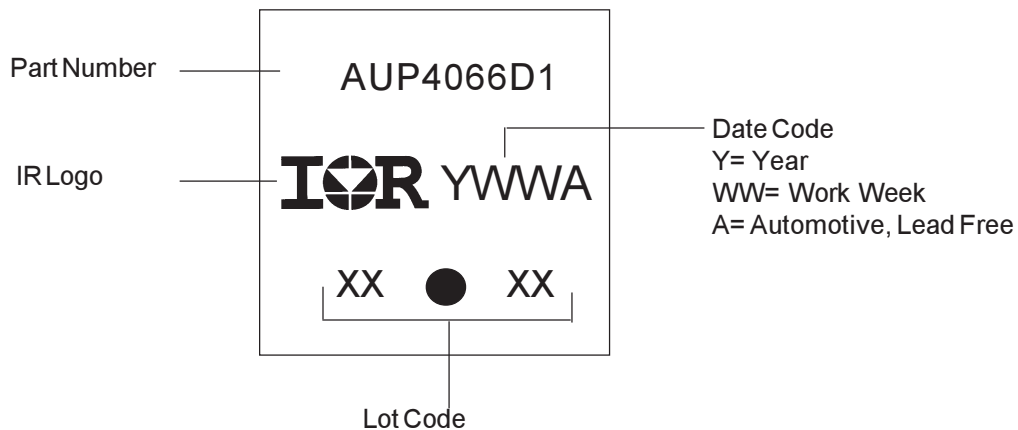
**IGBTs, CoPACK**

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

**DIODES**

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

## TO-247AC Part Marking Information

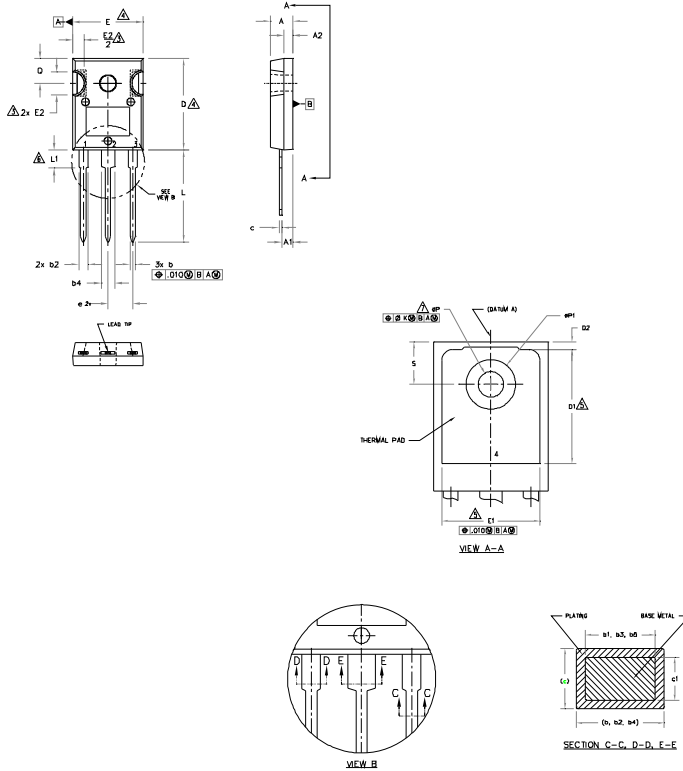


TO-247AC package is not recommended for Surface Mount Application.

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

## TO-247AD 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-247AD.

SYMBOL	DIMENSIONS				NOTES
	INCHES		MILLIMETERS		
	MIN.	MAX.	MIN.	MAX.	
A	.190	.203	4.83	5.13	
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	.780	.827	19.57	21.00	
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

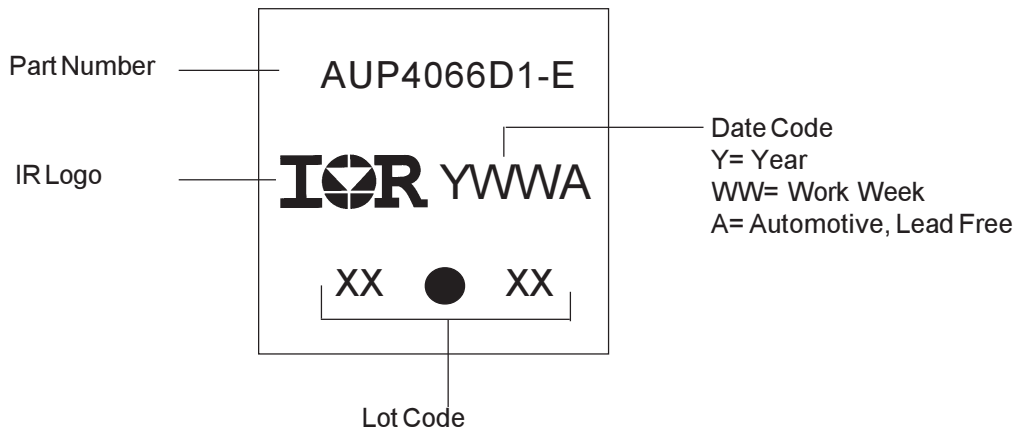
**IGBTs, CoPACK**

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

**DIODES**

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

## TO-247AD Part Marking Information



TO-247AD 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/>

## Ordering Information

Base part number	Package Type	Standard Pack		Complete Part Number
		Form	Quantity	
AUIRGP4066D1	TO-247AC	Tube	25	AUIRGP4066D1
AUIRGP4066D1-E	TO-247AD	Tube	25	AUIRGP4066D1-E

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