

# AUIRGR4045D AUIRGU4045D

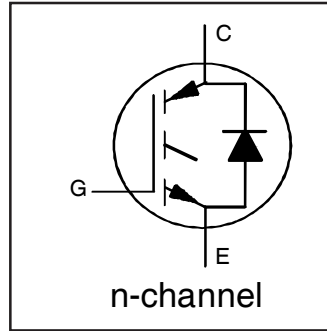
## INSULATED GATE BIPOLAR TRANSISTOR WITH ULTRAFAST SOFT RECOVERY DIODE

### Features

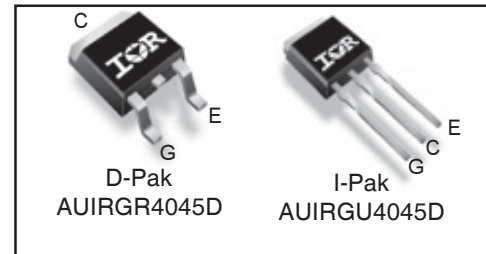
- Low  $V_{CE(on)}$  Trench IGBT Technology
- Low Switching Losses
- Maximum Junction temperature 175 °C
- 5µs SCSOA
- Square RBSOA
- 100% of the parts tested for  $I_{LM}$ ①
- Positive  $V_{CE(on)}$  Temperature Coefficient.
- Ultra Fast Soft Recovery Co-pak Diode
- Tighter Distribution of Parameters
- Lead-Free, 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



$V_{CES} = 600V$   
 $I_C = 6.0A, T_C = 100^\circ C$   
 $V_{CE(on) typ.} = 1.7V$



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 Breakdown Voltage	600	V
$I_C @ T_C = 25^\circ C$	Continuous Collector Current	12	A
$I_C @ T_C = 100^\circ C$	Continuous Collector Current	6.0	
$I_{CM}$	Pulsed Collector Current, $V_{GE} = 15V$	18	
$I_{LM}$	Clamped Inductive Load Current, $V_{GE} = 20V$ ①	24	
$I_F @ T_C = 25^\circ C$	Diode Continuous Forward Current	8.0	
$I_F @ T_C = 100^\circ C$	Diode Continuous Forward Current	4.0	
$I_{FM}$	Diode Maximum Forward Current ②	24	V
$V_{GE}$	Continuous Gate-to-Emitter Voltage	± 20	
	Transient Gate-to-Emitter Voltage	± 30	
$P_D @ T_C = 25^\circ$	Maximum Power Dissipation	77	W
$P_D @ T_C = 100^\circ$	Maximum Power Dissipation	39	
$T_J$	Operating Junction and	-55 to + 175	°C
$T_{STG}$	Storage Temperature Range		
	Soldering Temperature, for 10 seconds	300 (0.063 in. (1.6mm) from case)	

### Thermal Resistance

	Parameter	Min.	Typ.	Max.	Units
$R_{\theta JC}$	Junction-to-Case - IGBT ③	—	—	1.9	°C/W
$R_{\theta JC}$	Junction-to-Case - Diode ③	—	—	6.8	
$R_{\theta JA}$	Junction-to-Ambient (PCB Mount) ⑤	—	—	50	
$R_{\theta JA}$	Junction-to-Ambient	—	—	110	

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

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

	Parameter	Min.	Typ.	Max.	Units	Conditions	Ref.Fig
V <sub>(BR)CES</sub>	Collector-to-Emitter Breakdown Voltage	600	—	—	V	V <sub>GE</sub> = 0V, I <sub>C</sub> = 100 μA ④	CT6
ΔV <sub>(BR)CES</sub> /ΔT <sub>J</sub>	Temperature Coeff. of Breakdown Voltage	—	0.36	—	V/°C	V <sub>GE</sub> = 0V, I <sub>C</sub> = 250μA ( 25 -175 °C ) ④	
V <sub>CE(on)</sub>	Collector-to-Emitter Saturation Voltage	—	1.7	2.0	V	I <sub>C</sub> = 6.0A, V <sub>GE</sub> = 15V, T <sub>J</sub> = 25°C	5,6,7,9, 10,11
		—	2.07	—		I <sub>C</sub> = 6.0A, V <sub>GE</sub> = 15V, T <sub>J</sub> = 150°C	
		—	2.14	—		I <sub>C</sub> = 6.0A, V <sub>GE</sub> = 15V, T <sub>J</sub> = 175°C	
V <sub>GE(th)</sub>	Gate Threshold Voltage	3.5	—	6.5	V	V <sub>CE</sub> = V <sub>GE</sub> , I <sub>C</sub> = 150μA	9,10,11,12
ΔV <sub>GE(th)</sub> /ΔT <sub>J</sub>	Threshold Voltage temp. coefficient	—	-13	—	mV/°C	V <sub>CE</sub> = V <sub>GE</sub> , I <sub>C</sub> = 250μA ( 25 -175 °C )	
g <sub>fe</sub>	Forward Transconductance	—	5.8	—	S	V <sub>CE</sub> = 25V, I <sub>C</sub> = 6.0A, PW = 80μs	
I <sub>CES</sub>	Collector-to-Emitter Leakage Current	—	—	25	μA	V <sub>GE</sub> = 0V, V <sub>CE</sub> = 600V	8
		—	—	250		V <sub>GE</sub> = 0V, V <sub>CE</sub> = 600V, T <sub>J</sub> = 175°C	
V <sub>FM</sub>	Diode Forward Voltage Drop	—	1.60	2.30	V	I <sub>F</sub> = 6.0A	
		—	1.30	—		I <sub>F</sub> = 6.0A, T <sub>J</sub> = 175°C	
I <sub>GES</sub>	Gate-to-Emitter Leakage Current	—	—	±100	nA	V <sub>GE</sub> = ± 20 V	

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

	Parameter	Min.	Typ.	Max.	Units	Conditions	Ref.Fig
Q <sub>g</sub>	Total Gate Charge (turn-on)	—	13	19.5	nC	I <sub>C</sub> = 6.0A	24 CT1
Q <sub>ge</sub>	Gate-to-Emitter Charge (turn-on)	—	3.1	4.65		V <sub>CC</sub> = 400V	
Q <sub>gc</sub>	Gate-to-Collector Charge (turn-on)	—	6.4	9.6		V <sub>GE</sub> = 15V	
E <sub>on</sub>	Turn-On Switching Loss	—	56	86	μJ	I <sub>C</sub> = 6.0A, V <sub>CC</sub> = 400V, V <sub>GE</sub> = 15V	CT4
E <sub>off</sub>	Turn-Off Switching Loss	—	122	143		R <sub>G</sub> = 47Ω, L=1mH, L <sub>S</sub> = 150nH, T <sub>J</sub> = 25°C	
E <sub>total</sub>	Total Switching Loss	—	178	229		Energy losses include tail and diode reverse recovery	
t <sub>d(on)</sub>	Turn-On delay time	—	27	35	ns	I <sub>C</sub> = 6.0A, V <sub>CC</sub> = 400V	CT4
t <sub>r</sub>	Rise time	—	11	15		R <sub>G</sub> = 47Ω, L=1mH, L <sub>S</sub> = 150nH	
t <sub>d(off)</sub>	Turn-Off delay time	—	75	93		T <sub>J</sub> = 25°C	
t <sub>f</sub>	Fall time	—	17	22			
E <sub>on</sub>	Turn-On Switching Loss	—	140	—		μJ	
E <sub>off</sub>	Turn-Off Switching Loss	—	189	—	R <sub>G</sub> = 47Ω, L=1mH, L <sub>S</sub> = 150nH, T <sub>J</sub> = 175°C		
E <sub>total</sub>	Total Switching Loss	—	329	—	Energy losses include tail and diode reverse recovery		
t <sub>d(on)</sub>	Turn-On delay time	—	26	—	ns	I <sub>C</sub> = 6.0A, V <sub>CC</sub> = 400V	14,16 CT4 WF1,WF2
t <sub>r</sub>	Rise time	—	12	—		R <sub>G</sub> = 47Ω, L=1mH, L <sub>S</sub> = 150nH	
t <sub>d(off)</sub>	Turn-Off delay time	—	95	—		T <sub>J</sub> = 175°C	
t <sub>f</sub>	Fall time	—	32	—			
C <sub>ies</sub>	Input Capacitance	—	350	—	pF	V <sub>GE</sub> = 0V	23
C <sub>oes</sub>	Output Capacitance	—	29	—		V <sub>CC</sub> = 30V	
C <sub>res</sub>	Reverse Transfer Capacitance	—	10	—		f = 1Mhz	
RBSOA	Reverse Bias Safe Operating Area	FULL SQUARE				T <sub>J</sub> = 175°C, I <sub>C</sub> = 24A V <sub>CC</sub> = 500V, V <sub>p</sub> = 600V R <sub>G</sub> = 100Ω, V <sub>GE</sub> = +20V to 0V	4 CT2
SCSOA	Short Circuit Safe Operating Area	—	5	—	μs	V <sub>CC</sub> = 400V, V <sub>p</sub> = 600V R <sub>G</sub> = 100Ω, V <sub>GE</sub> = +15V to 0V	22 CT3, WF4
E <sub>rec</sub>	Reverse recovery energy of the diode	—	178	—	μJ	T <sub>J</sub> = 175°C	17,18,19
t <sub>rr</sub>	Diode Reverse recovery time	—	74	—	ns	V <sub>CC</sub> = 400V, I <sub>F</sub> = 6.0A	20,21
I <sub>rr</sub>	Peak Reverse Recovery Current	—	12	—	A	V <sub>GE</sub> = 15V, R <sub>G</sub> = 47Ω, L=1mH, L <sub>S</sub> =150nH	WF3

### Notes:

- ① V<sub>CC</sub> = 80% (V<sub>CES</sub>), V<sub>GE</sub> = 15V, L = 1.0mH, R<sub>G</sub> = 47Ω.
- ② Pulse width limited by max. junction temperature.
- ③ R<sub>θ</sub> is measured at T<sub>J</sub> approximately 90°C.
- ④ Refer to AN-1086 for guidelines for measuring V<sub>(BR)CES</sub> safely.
- ⑤ When mounted on 1" square PCB (FR-4 or G-10 Material). For recommended footprint and soldering techniques refer to application note #AN-994.

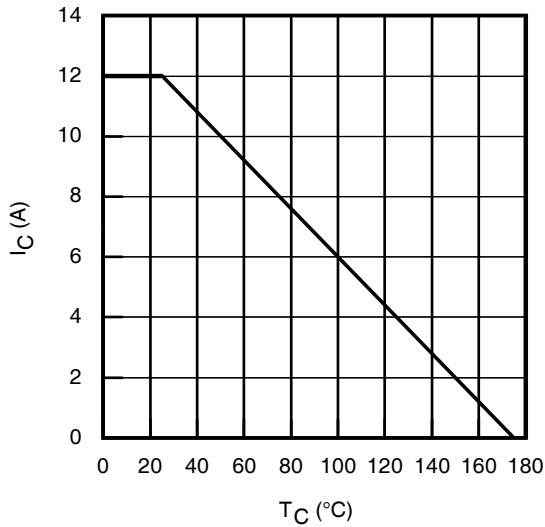
**Qualification Information<sup>†</sup>**

<b>Qualification Level</b>		Automotive (per AEC-Q101) <sup>††</sup>	
		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>		D-Pak	MSL1
		I-PAK	
<b>ESD</b>	Machine Model	Class M2 (+/- 200V) <sup>†††</sup> AEC-Q101-002	
	Human Body Model	Class H1A (+/- 500V) <sup>†††</sup> AEC-Q101-001	
	Charged Device Model	Class C5 (+/- 1000V) <sup>†††</sup> AEC-Q101-005	
<b>RoHS Compliant</b>		Yes	

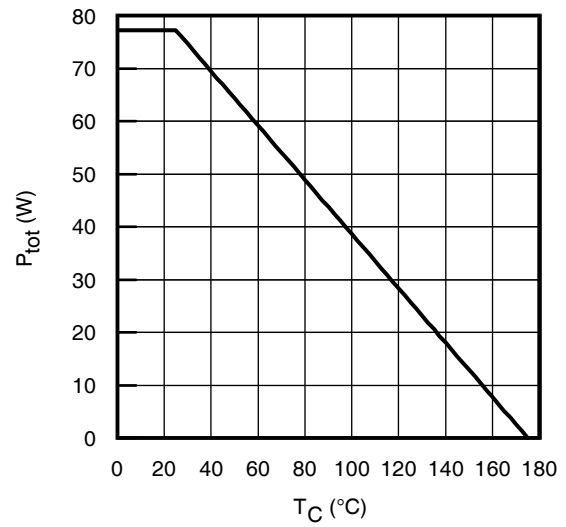
† Qualification standards can be found at International Rectifier's web site: <http://www.irf.com>

†† Exceptions to AEC-Q101 requirements are noted in the qualification report.

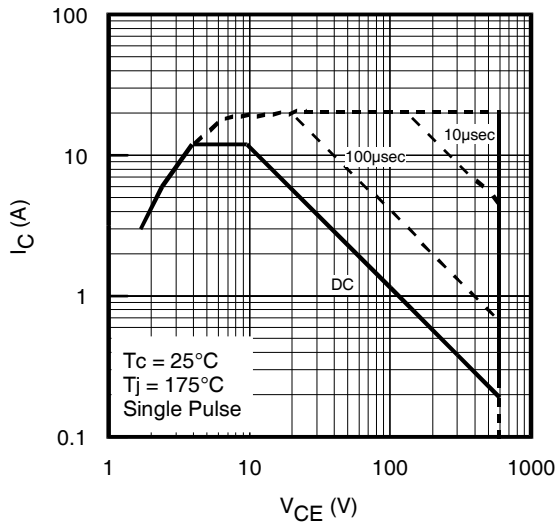
††† Highest passing voltage.



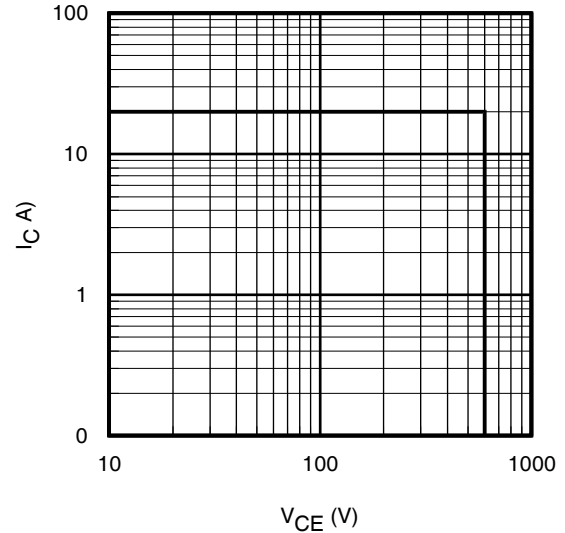
**Fig. 1** - Maximum DC Collector Current vs. Case Temperature



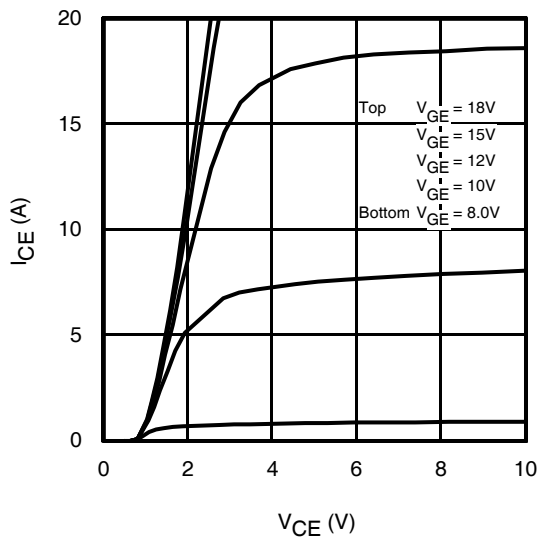
**Fig. 2** - Power Dissipation vs. Case Temperature



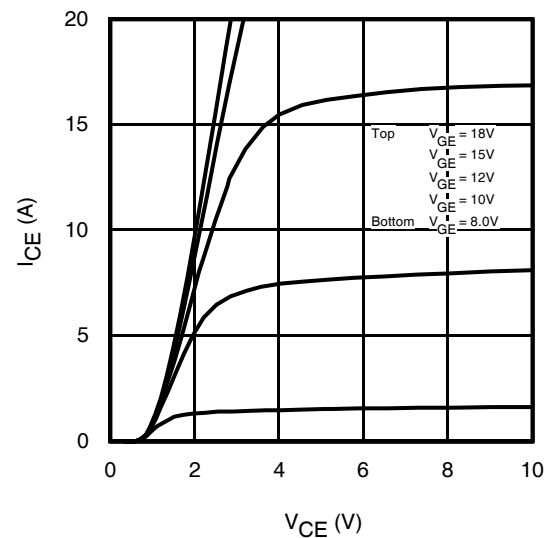
**Fig. 3** - Forward SOA,  
 $T_C = 25^\circ\text{C}$ ,  $T_J \leq 175^\circ\text{C}$ ,  $V_{GE} = 15\text{V}$



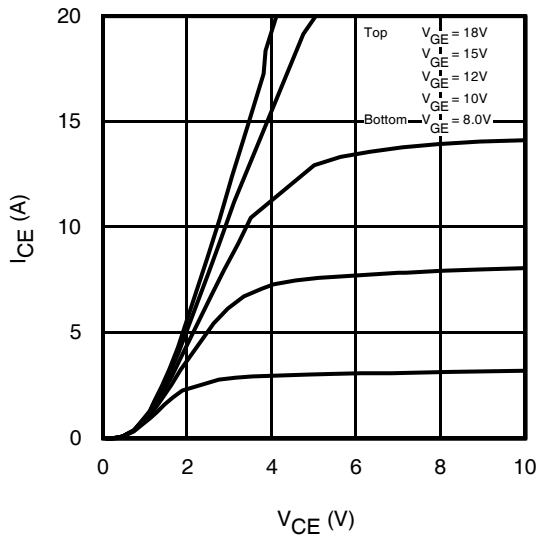
**Fig. 4** - Reverse Bias SOA  
 $T_J = 175^\circ\text{C}$ ,  $V_{GE} = 20\text{V}$



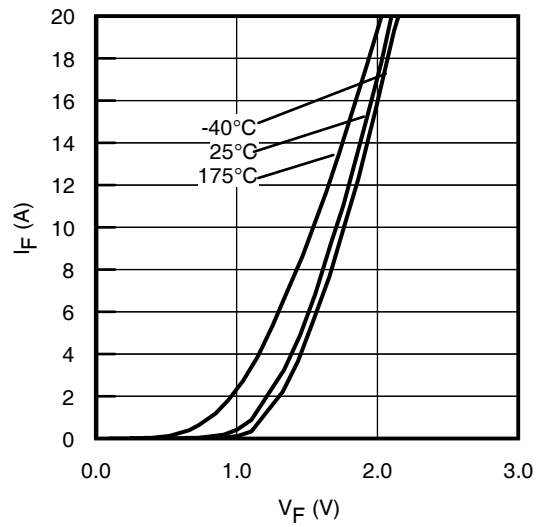
**Fig. 5** - Typ. IGBT Output Characteristics  
 $T_J = -40^\circ\text{C}$ ;  $t_p = 80\mu\text{s}$



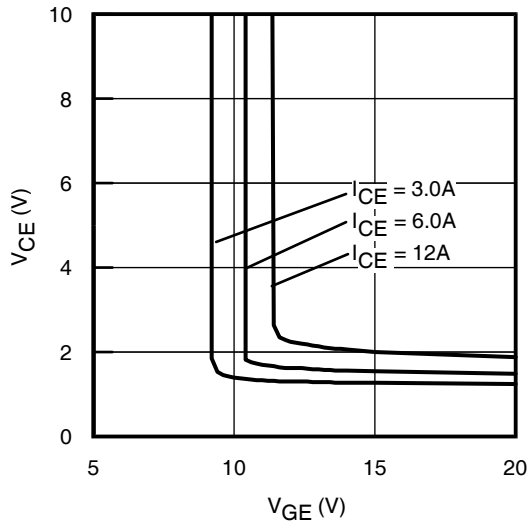
**Fig. 6** - Typ. IGBT Output Characteristics  
 $T_J = 25^\circ\text{C}$ ;  $t_p = 80\mu\text{s}$



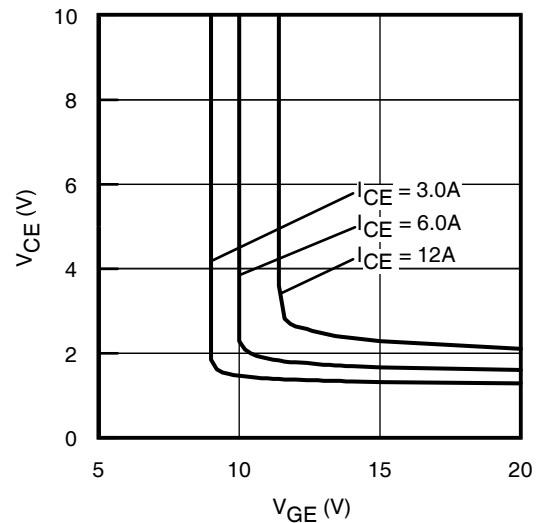
**Fig. 7** - Typ. IGBT Output Characteristics  
 $T_J = 175^\circ\text{C}$ ;  $t_p = 80\mu\text{s}$



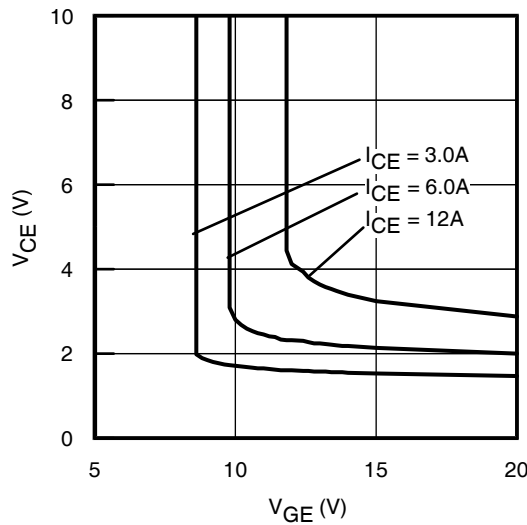
**Fig. 8** - Typ. Diode Forward Characteristics  
 $t_p = 80\mu\text{s}$



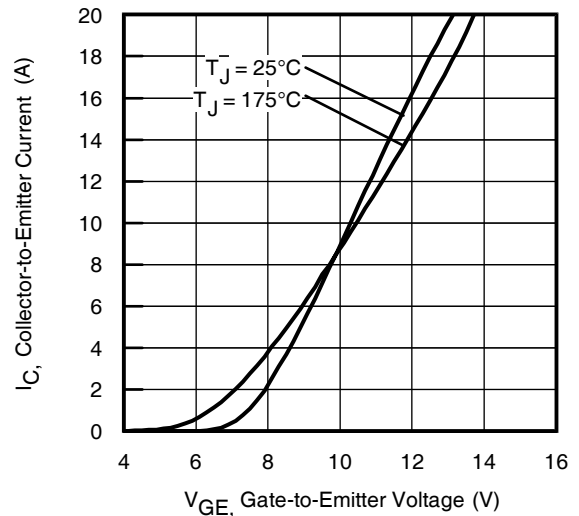
**Fig. 9** - Typical  $V_{CE}$  vs.  $V_{GE}$   
 $T_J = -40^\circ\text{C}$



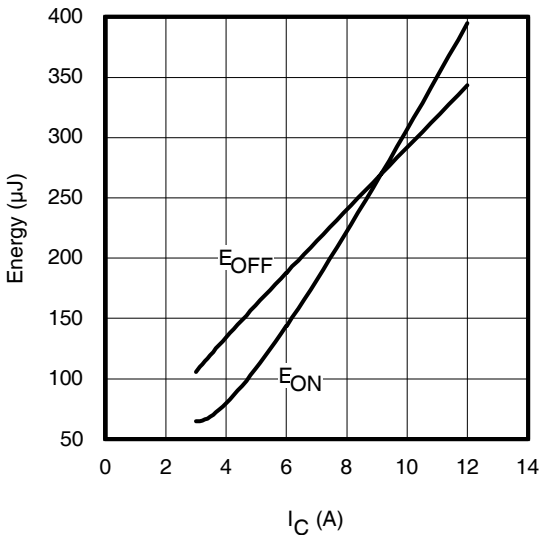
**Fig. 10** - Typical  $V_{CE}$  vs.  $V_{GE}$   
 $T_J = 25^\circ\text{C}$



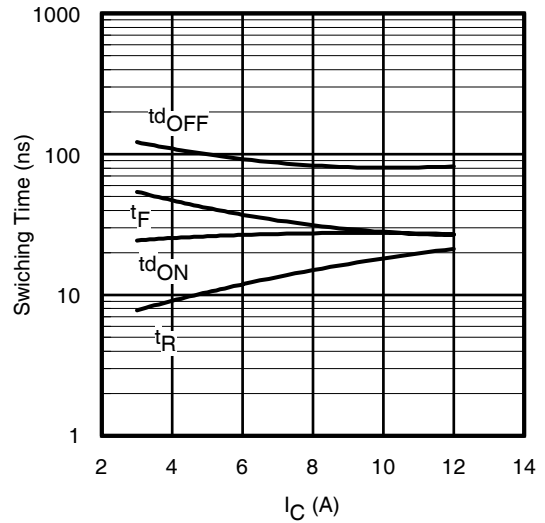
**Fig. 11** - Typical  $V_{CE}$  vs.  $V_{GE}$   
 $T_J = 175^\circ\text{C}$



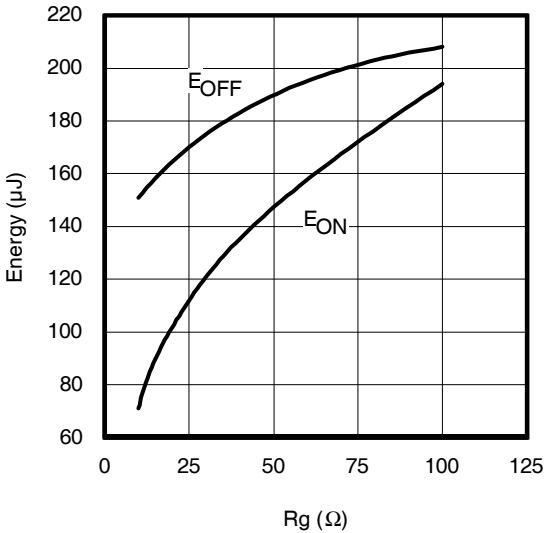
**Fig. 12** - Typ. Transfer Characteristics  
 $V_{CE} = 50\text{V}$ ;  $t_p = 10\mu\text{s}$



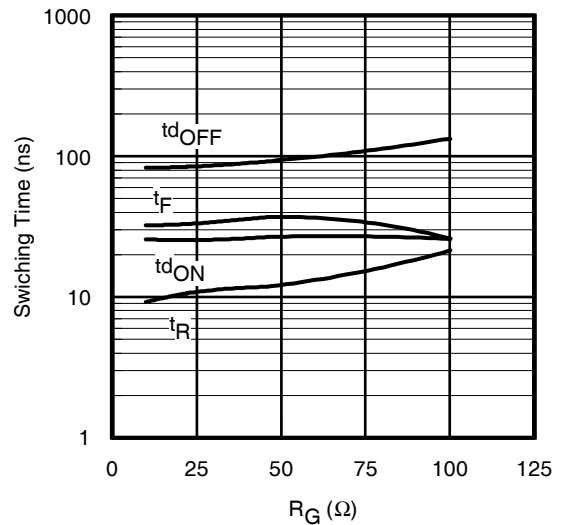
**Fig. 13** - Typ. Energy Loss vs.  $I_C$   
 $T_J = 175^\circ\text{C}$ ;  $L = 1\text{mH}$ ;  $V_{CE} = 400\text{V}$ ;  $R_G = 47\Omega$ ;  $V_{GE} = 15\text{V}$ .



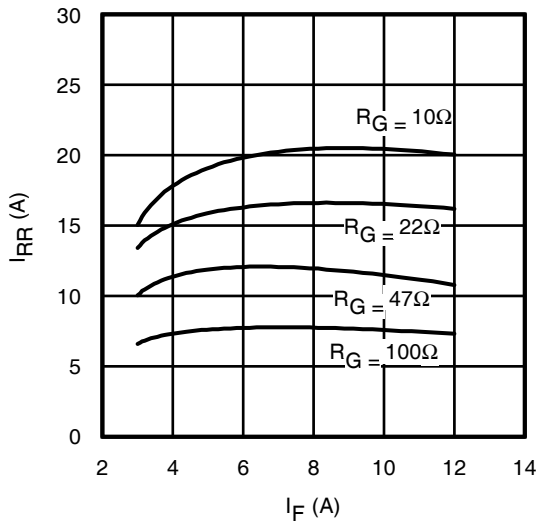
**Fig. 14** - Typ. Switching Time vs.  $I_C$   
 $T_J = 175^\circ\text{C}$ ;  $L = 1\text{mH}$ ;  $V_{CE} = 400\text{V}$   
 $R_G = 47\Omega$ ;  $V_{GE} = 15\text{V}$



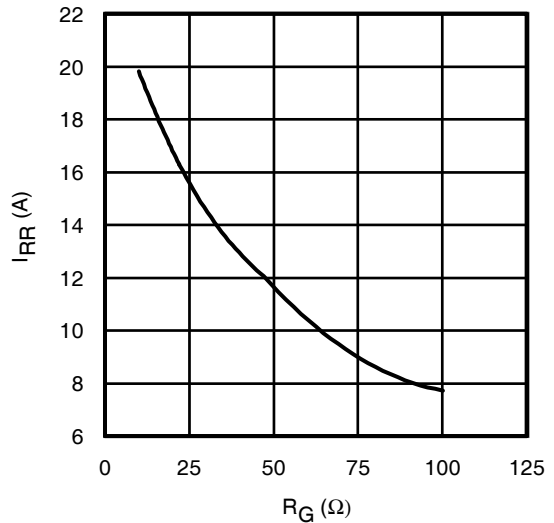
**Fig. 15** - Typ. Energy Loss vs.  $R_G$   
 $T_J = 175^\circ\text{C}$ ;  $L = 1\text{mH}$ ;  $V_{CE} = 400\text{V}$ ;  $I_{CE} = 6.0\text{A}$ ;  $V_{GE} = 15\text{V}$



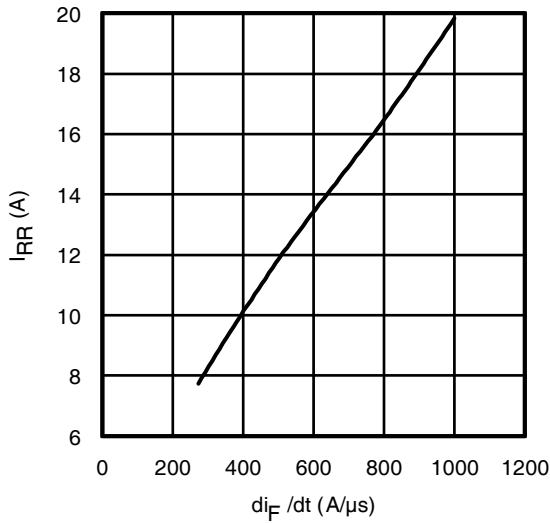
**Fig. 16** - Typ. Switching Time vs.  $R_G$   
 $T_J = 175^\circ\text{C}$ ;  $L = 1\text{mH}$ ;  $V_{CE} = 400\text{V}$   
 $I_{CE} = 6.0\text{A}$ ;  $V_{GE} = 15\text{V}$



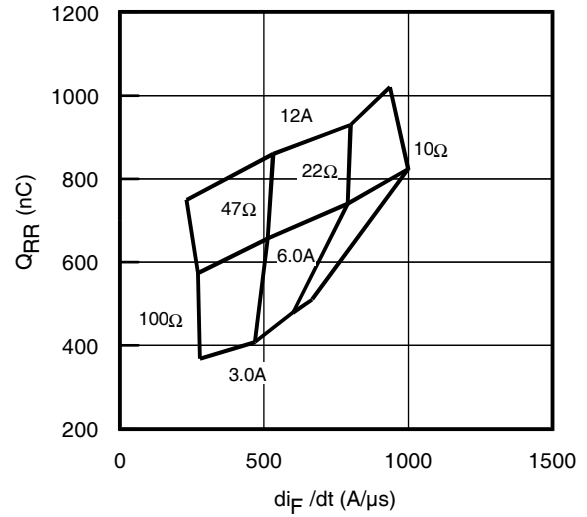
**Fig. 17** - Typical Diode  $I_{RR}$  vs.  $I_F$   
 $T_J = 175^\circ\text{C}$



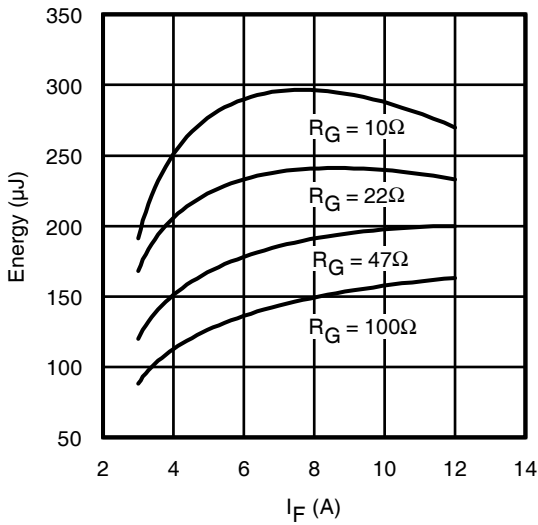
**Fig. 18** - Typical Diode  $I_{RR}$  vs.  $R_G$   
 $T_J = 175^\circ\text{C}$ ;  $I_F = 6.0\text{A}$



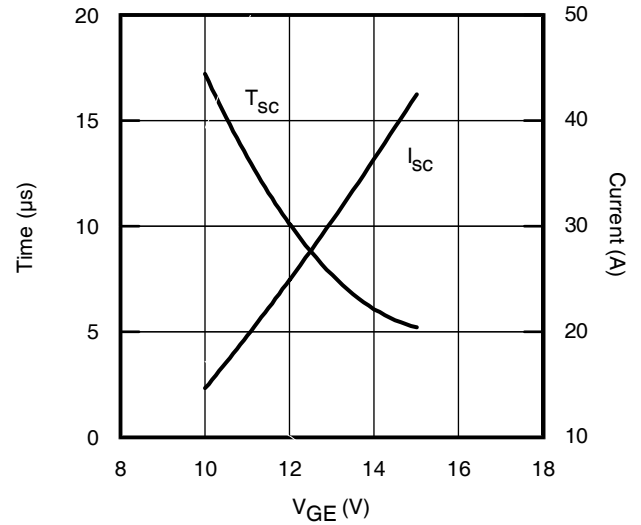
**Fig. 19**- Typical Diode  $I_{RR}$  vs.  $di_F/dt$   
 $V_{CC}=400V$ ;  $V_{GE}=15V$ ;  
 $I_{CE}=6.0A$ ;  $T_J=175^\circ C$



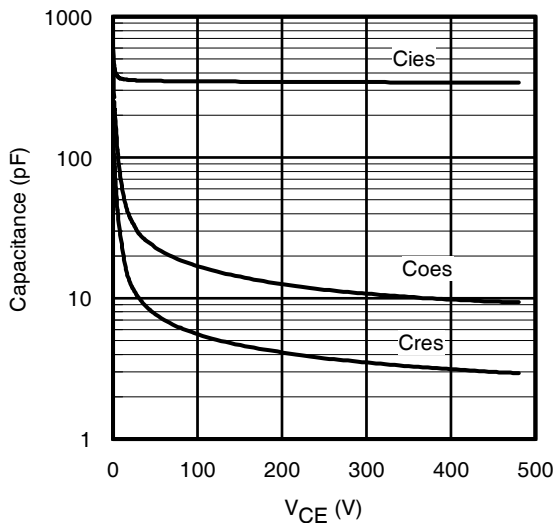
**Fig. 20** - Typical Diode  $Q_{RR}$   
 $V_{CC}=400V$ ;  $V_{GE}=15V$ ;  $T_J=175^\circ C$



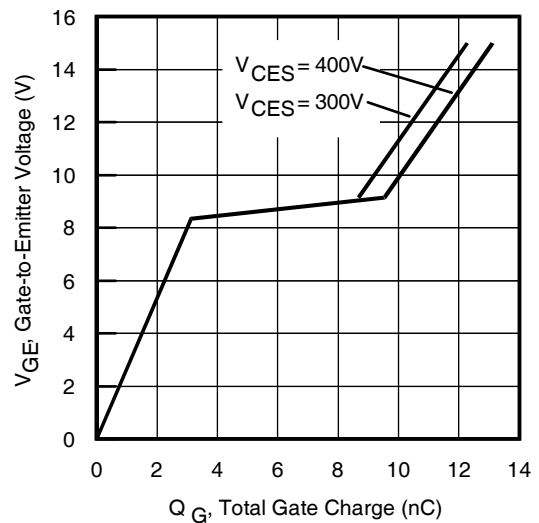
**Fig. 21** - Typical Diode  $E_{RR}$  vs.  $I_F$   
 $T_J=175^\circ C$



**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.  $V_{GE}$   
 $I_{CE}=6.0A$ ,  $L=600\mu H$

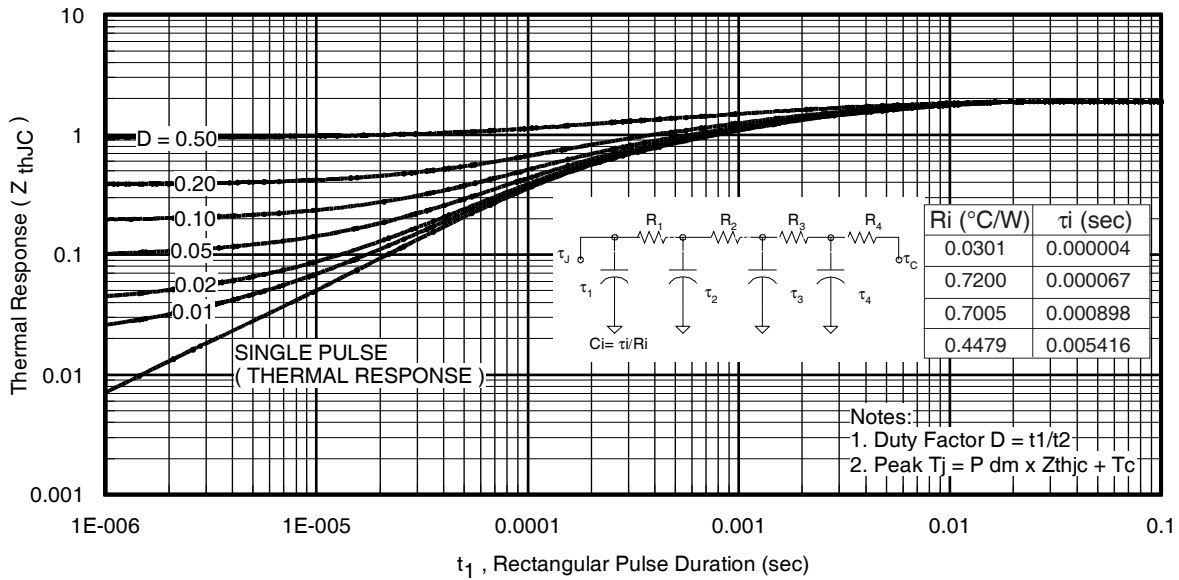


Fig 25. Maximum Transient Thermal Impedance, Junction-to-Case (IGBT)

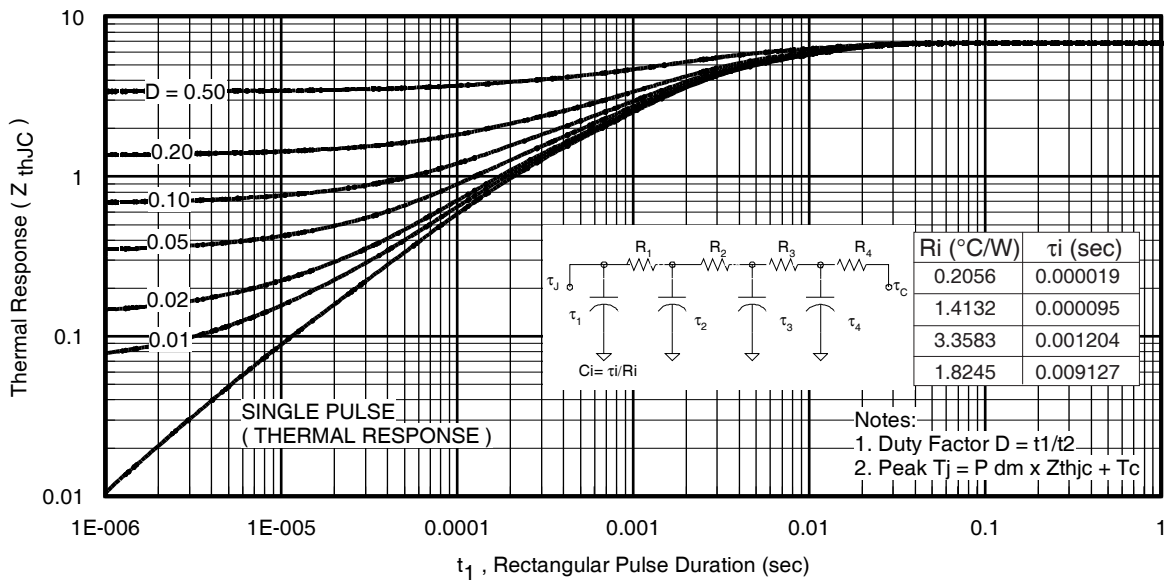


Fig. 26. Maximum Transient Thermal Impedance, Junction-to-Case (DIODE)



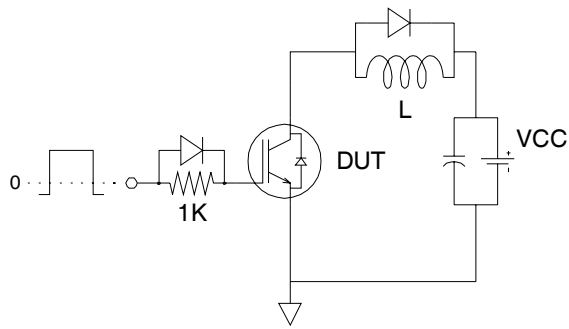


Fig.C.T.1 - Gate Charge Circuit (turn-off)

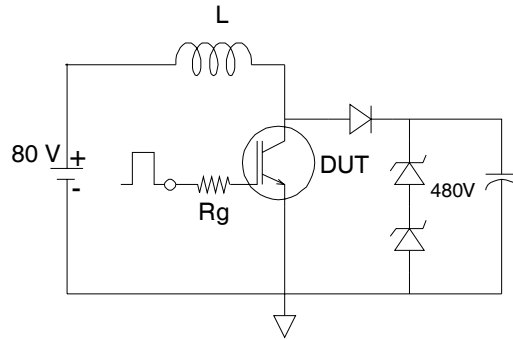


Fig.C.T.2 - RBSOA Circuit

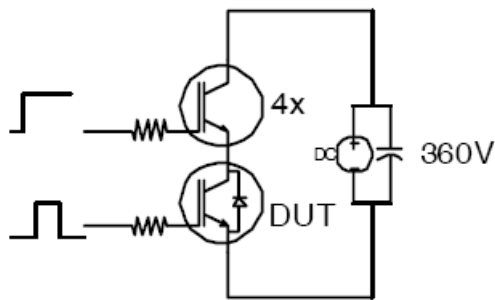


Fig.C.T.3 - S.C.SOA Circuit

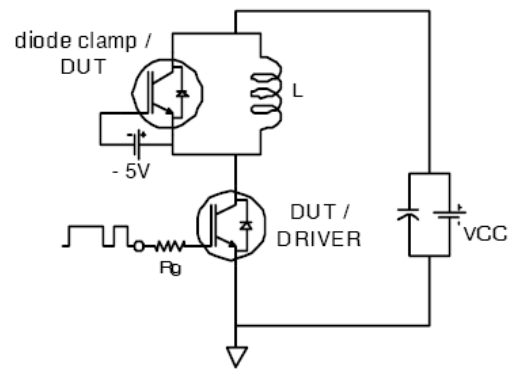


Fig.C.T.4 - Switching Loss Circuit

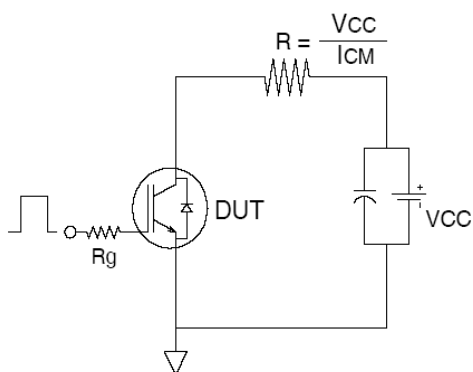


Fig.C.T.5 - Resistive Load Circuit

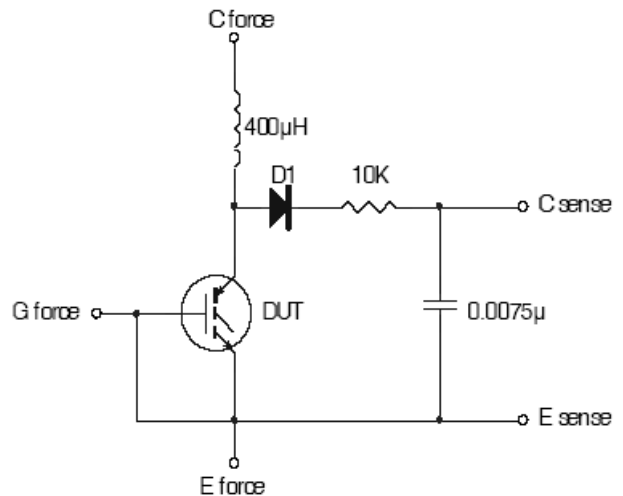
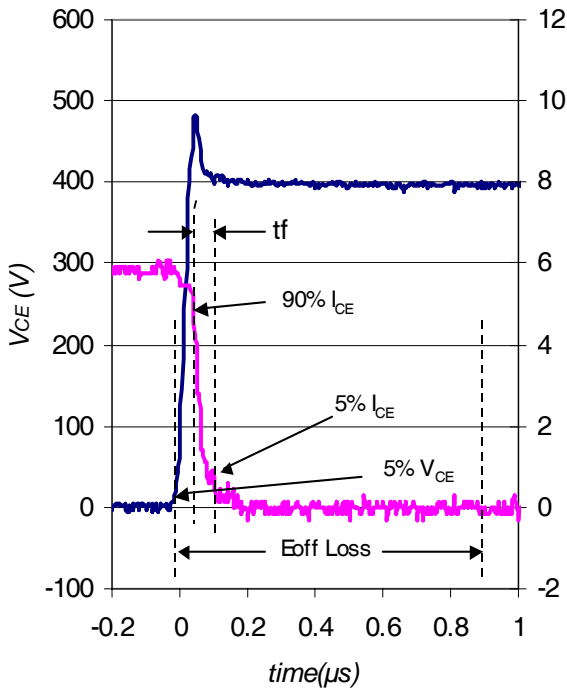
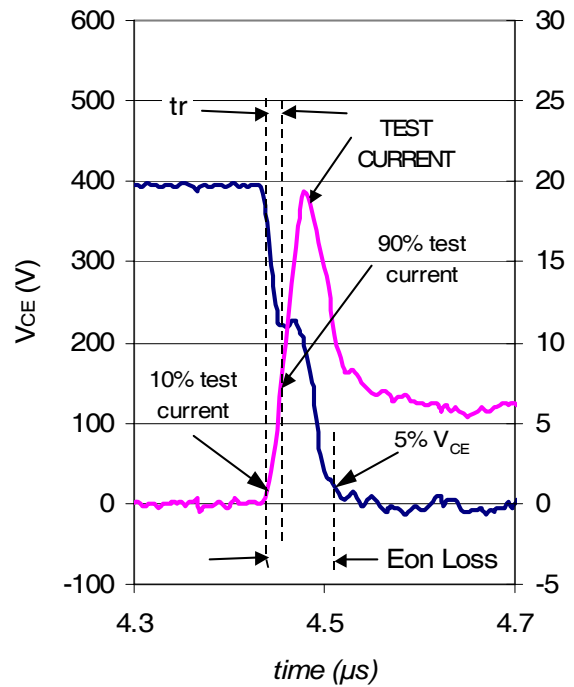


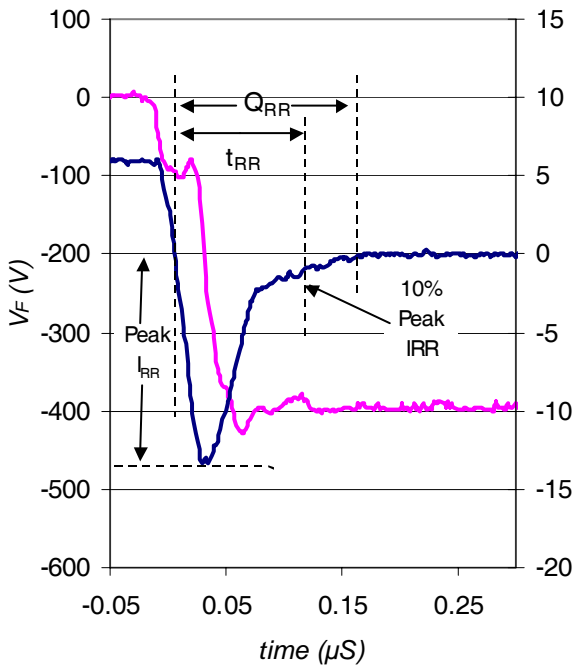
Fig.C.T.6 - Typical Filter Circuit for  $V_{(BR)CES}$  Measurement



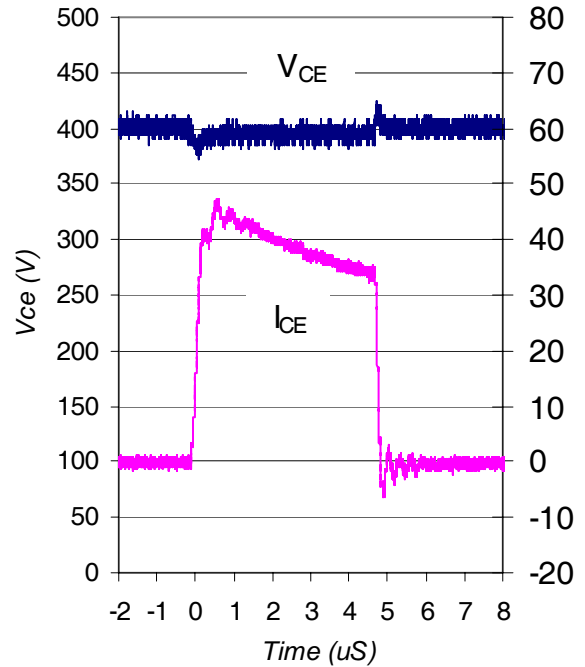
**Fig. WF1** - Typ. Turn-off Loss Waveform  
@  $T_J = 175^\circ\text{C}$  using Fig. CT.4



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



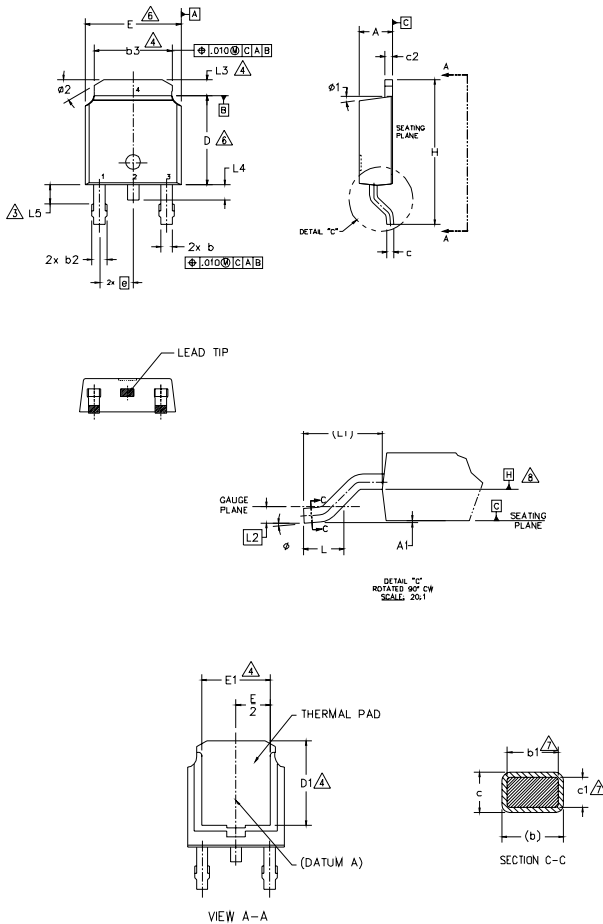
**WF.3**- Typ. Diode Recovery Waveform  
@  $T_J = 175^\circ\text{C}$  using CT.4



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

**D-Pak (TO-252AA) Package Outline**

Dimensions are shown in millimeters (inches)



NOTES:

- 1.- DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994
- 2.- DIMENSIONS ARE SHOWN IN INCHES [MILLIMETERS]
- △ LEAD DIMENSION UNCONTROLLED IN L5.
- △ DIMENSION D1, E1, L3 & b3 ESTABLISH A MINIMUM MOUNTING SURFACE FOR THERMAL PAD.
- 5.- SECTION C-C DIMENSIONS APPLY TO THE FLAT SECTION OF THE LEAD BETWEEN .005 AND 0.10 [0.13 AND 0.25] FROM THE LEAD TIP.
- △ DIMENSION D & E DO NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED .005 [0.13] PER SIDE. THESE DIMENSIONS ARE MEASURED AT THE OUTMOST EXTREMES OF THE PLASTIC BODY.
- △ DIMENSION b1 & c1 APPLIED TO BASE METAL ONLY.
- △ DATUM A & B TO BE DETERMINED AT DATUM PLANE H.
- 9.- OUTLINE CONFORMS TO JEDEC OUTLINE TO-252AA.

SYMBOL	DIMENSIONS				NOTES
	MILLIMETERS		INCHES		
	MIN.	MAX.	MIN.	MAX.	
A	2.18	2.39	.086	.094	
A1	-	0.13	-	.005	
b	0.64	0.89	.025	.035	
b1	0.65	0.79	.025	.031	7
b2	0.76	1.14	.030	.045	
b3	4.95	5.46	.195	.215	4
c	0.46	0.61	.018	.024	
c1	0.41	0.56	.016	.022	7
c2	0.46	0.89	.018	.035	
D	5.97	6.22	.235	.245	6
D1	5.21	-	.205	-	4
E	6.35	6.73	.250	.265	6
E1	4.32	-	.170	-	4
e	2.29 BSC		.090 BSC		
H	9.40	10.41	.370	.410	
L	1.40	1.78	.055	.070	
L1	2.74 BSC		.108 REF.		
L2	0.51 BSC		.020 BSC		
L3	0.89	1.27	.035	.050	4
L4	-	1.02	-	.040	
L5	1.14	1.52	.045	.060	3
φ	0"	10"	0"	10"	
φ1	0"	15"	0"	15"	
φ2	25"	35"	25"	35"	

LEAD ASSIGNMENTS

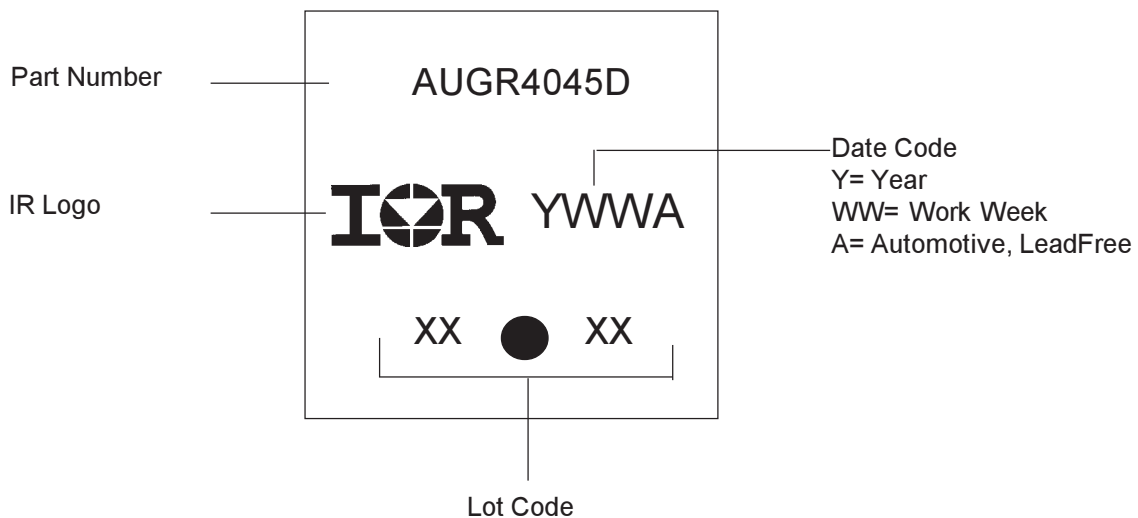
HEXFET

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

IGBT & CoPAK

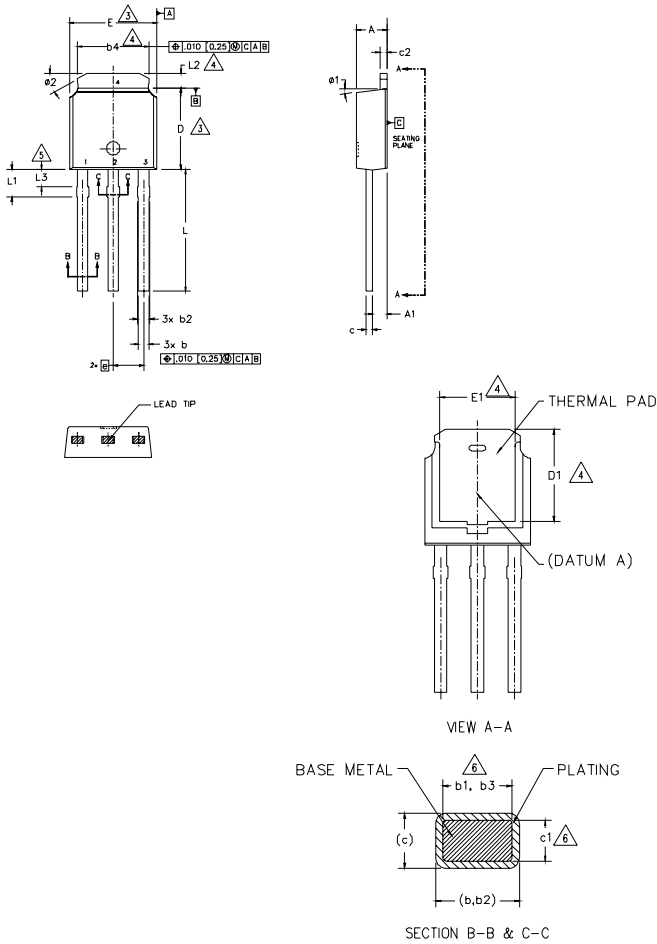
- 1.- GATE
- 2.- COLLECTOR
- 3.- EMITTER
- 4.- COLLECTOR

**D-Pak Part Marking Information**



## I-Pak (TO-251AA) Package Outline

Dimensions are shown in millimeters (inches)



**NOTES:**

- 1.- DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994
- 2.- DIMENSION ARE SHOWN IN INCHES [MILLIMETERS].
- △ DIMENSION D & E DO NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED .005 [0.13] PER SIDE. THESE DIMENSIONS ARE MEASURED AT THE OUTMOST EXTREMES OF THE PLASTIC BODY.
- △- THERMAL PAD CONTOUR OPTION WITHIN DIMENSION b4, L2, E1 & D1.
- △- LEAD DIMENSION UNCONTROLLED IN L3.
- △- DIMENSION b1, b3 & c1 APPLY TO BASE METAL ONLY.
- 7.- OUTLINE CONFORMS TO JEDEC OUTLINE TO-251AA (Date 06/02).
- 8.- CONTROLLING DIMENSION : INCHES.

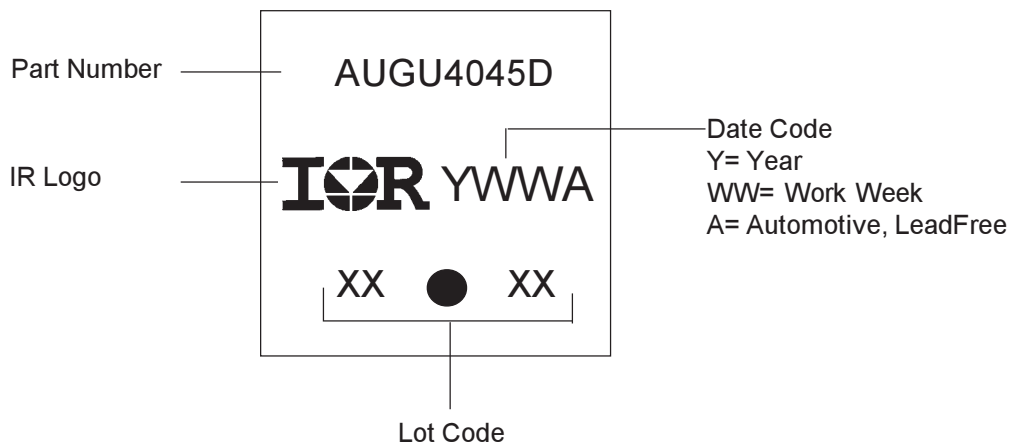
SYMBOL	DIMENSIONS				NOTES
	MILLIMETERS		INCHES		
	MIN.	MAX.	MIN.	MAX.	
A	2.18	2.39	.086	.094	6
A1	0.89	1.14	.035	.045	
b	0.64	0.89	.025	.035	6
b1	0.65	0.79	.025	.031	
b2	0.76	1.14	.030	.045	4
b3	0.76	1.04	.030	.041	
b4	4.95	5.46	.195	.215	3
c	0.46	0.61	.018	.024	
c1	0.41	0.56	.016	.022	4
c2	0.46	0.89	.018	.035	
D	5.97	6.22	.235	.245	3
D1	5.21	-	.205	-	
E	6.35	6.73	.250	.265	4
E1	4.32	-	.170	-	
e	2.29 BSC		.090 BSC		5
L	8.89	9.65	.350	.380	
L1	1.91	2.29	.045	.090	4
L2	0.89	1.27	.035	.050	
L3	1.14	1.52	.045	.060	5
ø1	0"	15"	0"	15"	
ø2	25"	35"	25"	35"	

**LEAD ASSIGNMENTS**

**HEXFET**

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

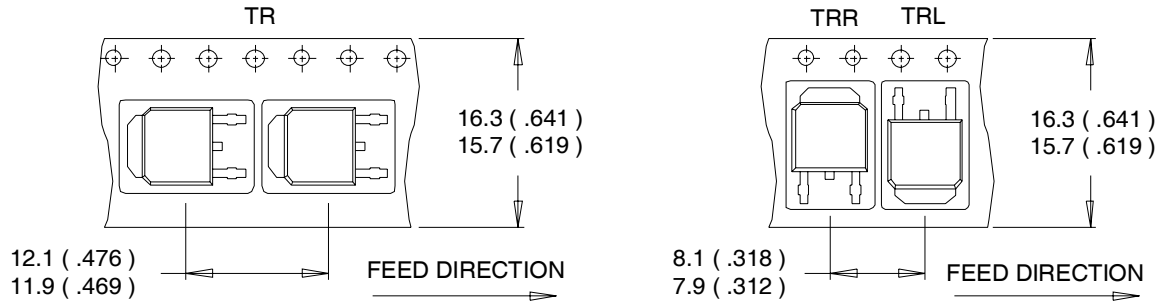
## I-Pak Part Marking Information



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

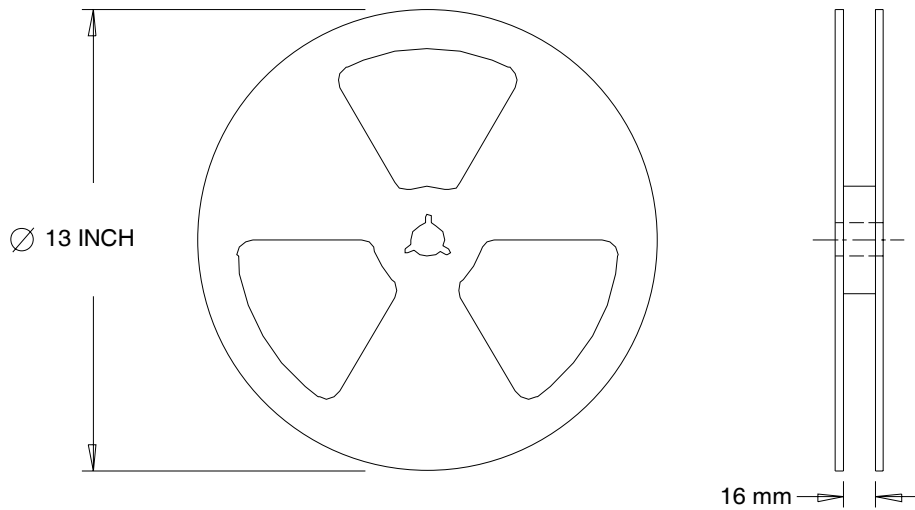
## D-Pak (TO-252AA) Tape & Reel Information

Dimensions are shown in millimeters (inches)



**NOTES :**

1. CONTROLLING DIMENSION : MILLIMETER.
2. ALL DIMENSIONS ARE SHOWN IN MILLIMETERS ( INCHES ).
3. OUTLINE CONFORMS TO EIA-481 & EIA-541.



**NOTES :**

1. OUTLINE CONFORMS TO EIA-481.

## Ordering Information

Base part number	Package Type	Standard Pack		Complete Part Number
		Form	Quantity	
AUIRGR4045D	Dpak	Tube	75	AUIRGR4045D
		Tape and Reel	2000	AUIRGR4045DTR
		Tape and Reel Left	3000	AUIRGR4045DTRL
		Tape and Reel Right	3000	AUIRGR4045DTRR
AUIRGU4045D	Ipak	Tube	75	AUIRGU4045D

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