

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	$V_{GE} = 0V, I_C = 100\mu A$ ④	CT6
$\Delta V_{(BR)CES}/\Delta T_J$	Temperature Coeff. of Breakdown Voltage	—	0.36	—	V/°C	$V_{GE} = 0V, I_C = 250\mu A$ (25 -175 °C) ④	
$V_{CE(on)}$	Collector-to-Emitter Saturation Voltage	—	1.7	2.0	V	$I_C = 6.0A, V_{GE} = 15V, T_J = 25^\circ\text{C}$	5,6,7,9, 10,11
		—	2.07	—		$I_C = 6.0A, V_{GE} = 15V, T_J = 150^\circ\text{C}$	
		—	2.14	—		$I_C = 6.0A, V_{GE} = 15V, T_J = 175^\circ\text{C}$	
$V_{GE(th)}$	Gate Threshold Voltage	3.5	—	6.5	V	$V_{CE} = V_{GE}, I_C = 150\mu A$	9,10,11,12
$\Delta V_{GE(th)}/\Delta T_J$	Threshold Voltage temp. coefficient	—	-13	—	mV/°C	$V_{CE} = V_{GE}, I_C = 250\mu A$ (25 -175 °C)	
g_{fe}	Forward Transconductance	—	5.8	—	S	$V_{CE} = 25V, I_C = 6.0A, PW = 80\mu s$	
I_{CES}	Collector-to-Emitter Leakage Current	—	—	25	μA	$V_{GE} = 0V, V_{CE} = 600V$	8
		—	—	250		$V_{GE} = 0V, V_{CE} = 600V, T_J = 175^\circ\text{C}$	
V_{FM}	Diode Forward Voltage Drop	—	1.60	2.30	V	$I_F = 6.0A$	
		—	1.30	—		$I_F = 6.0A, T_J = 175^\circ\text{C}$	
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)	—	13	19.5	nC	$I_C = 6.0A$	24 CT1
Q_{ge}	Gate-to-Emitter Charge (turn-on)	—	3.1	4.65		$V_{CC} = 400V$	
Q_{gc}	Gate-to-Collector Charge (turn-on)	—	6.4	9.6		$V_{GE} = 15V$	
E_{on}	Turn-On Switching Loss	—	56	86	μJ	$I_C = 6.0A, V_{CC} = 400V, V_{GE} = 15V$	CT4
E_{off}	Turn-Off Switching Loss	—	122	143		$R_G = 47\Omega, L = 1mH, L_S = 150nH, T_J = 25^\circ\text{C}$	
E_{total}	Total Switching Loss	—	178	229		Energy losses include tail and diode reverse recovery	
$t_{d(on)}$	Turn-On delay time	—	27	35	ns	$I_C = 6.0A, V_{CC} = 400V$	CT4
t_r	Rise time	—	11	15		$R_G = 47\Omega, L = 1mH, L_S = 150nH$	
$t_{d(off)}$	Turn-Off delay time	—	75	93		$T_J = 25^\circ\text{C}$	
t_f	Fall time	—	17	22			
E_{on}	Turn-On Switching Loss	—	140	—	μJ	$I_C = 6.0A, V_{CC} = 400V, V_{GE} = 15V$	13,15 CT4 WF1,WF2
E_{off}	Turn-Off Switching Loss	—	189	—		$R_G = 47\Omega, L = 1mH, L_S = 150nH, T_J = 175^\circ\text{C}$	
E_{total}	Total Switching Loss	—	329	—		Energy losses include tail and diode reverse recovery	
$t_{d(on)}$	Turn-On delay time	—	26	—	ns	$I_C = 6.0A, V_{CC} = 400V$	14,16 CT4 WF1,WF2
t_r	Rise time	—	12	—		$R_G = 47\Omega, L = 1mH, L_S = 150nH$	
$t_{d(off)}$	Turn-Off delay time	—	95	—		$T_J = 175^\circ\text{C}$	
t_f	Fall time	—	32	—			
C_{ies}	Input Capacitance	—	350	—	pF	$V_{GE} = 0V$	23
C_{oes}	Output Capacitance	—	29	—		$V_{CC} = 30V$	
C_{res}	Reverse Transfer Capacitance	—	10	—		$f = 1Mhz$	
RBSOA	Reverse Bias Safe Operating Area	FULL SQUARE				$T_J = 175^\circ\text{C}, I_C = 24A$ $V_{CC} = 500V, V_p = 600V$ $R_G = 100\Omega, V_{GE} = +20V \text{ to } 0V$	4 CT2
SCSOA	Short Circuit Safe Operating Area	—	5	—	μs	$V_{CC} = 400V, V_p = 600V$ $R_G = 100\Omega, V_{GE} = +15V \text{ to } 0V$	22 CT3, WF4
E_{rec}	Reverse recovery energy of the diode	—	178	—	μJ	$T_J = 175^\circ\text{C}$	17,18,19 20,21 WF3
t_{rr}	Diode Reverse recovery time	—	74	—	ns	$V_{CC} = 400V, I_F = 6.0A$	
I_{rr}	Peak Reverse Recovery Current	—	12	—	A	$V_{GE} = 15V, R_G = 47\Omega, L = 1mH, L_S = 150nH$	

Notes:

- ① $V_{CC} = 80\% (V_{CES}), V_{GE} = 15V, L = 1.0mH, R_G = 47\Omega$.
- ② Pulse width limited by max. junction temperature.
- ③ R_θ is measured at T_J approximately 90°C .
- ④ Refer to AN-1086 for guidelines for measuring $V_{(BR)CES}$ 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[†]

Qualification Level		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.	
Moisture Sensitivity Level		D-Pak	MSL1
		I-PAK	
ESD	Machine Model	Class M2 (+/- 200V) ^{†††} AEC-Q101-002	
	Human Body Model	Class H1A (+/- 500V) ^{†††} AEC-Q101-001	
	Charged Device Model	Class C5 (+/- 1000V) ^{†††} AEC-Q101-005	
RoHS Compliant		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.

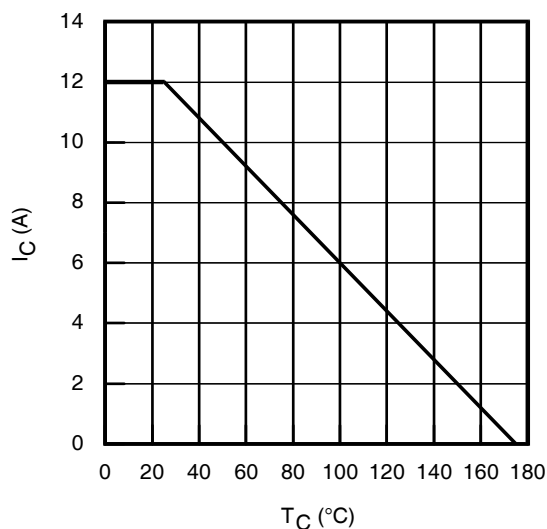


Fig. 1 - Maximum DC Collector Current vs. Case Temperature

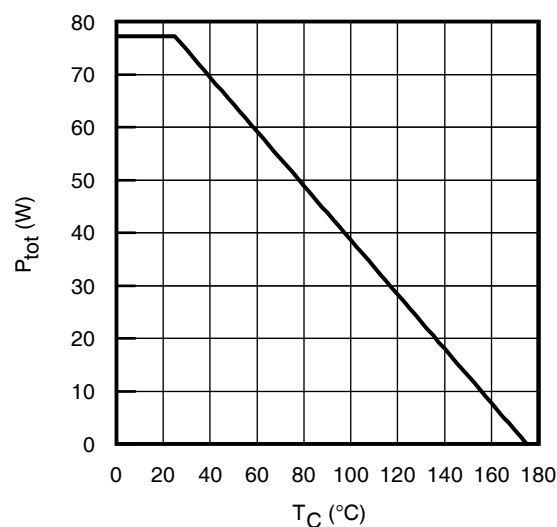


Fig. 2 - Power Dissipation vs. Case Temperature

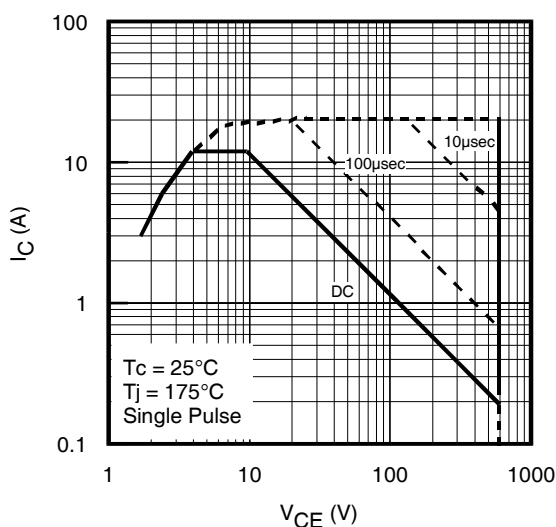


Fig. 3 - Forward SOA,
 $T_C = 25^{\circ}\text{C}$, $T_J \leq 175^{\circ}\text{C}$, $V_{GE} = 15\text{V}$

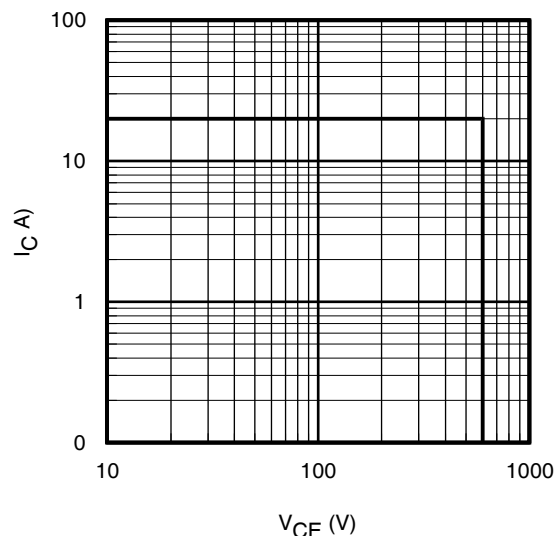


Fig. 4 - Reverse Bias SOA
 $T_J = 175^{\circ}\text{C}$, $V_{GE} = 20\text{V}$

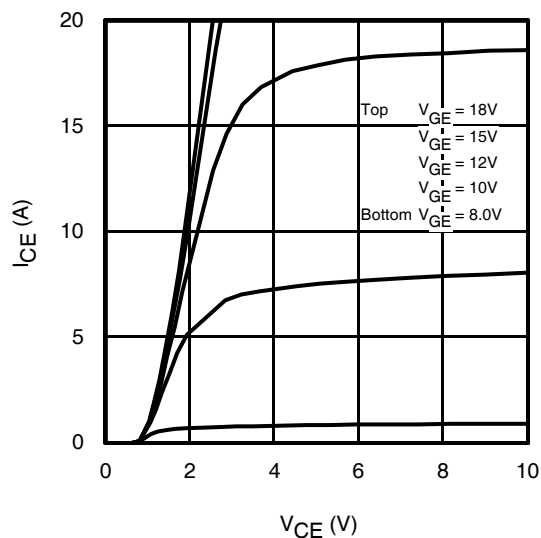


Fig. 5 - Typ. IGBT Output Characteristics
 $T_J = -40^{\circ}\text{C}$; $t_p = 80\mu\text{s}$

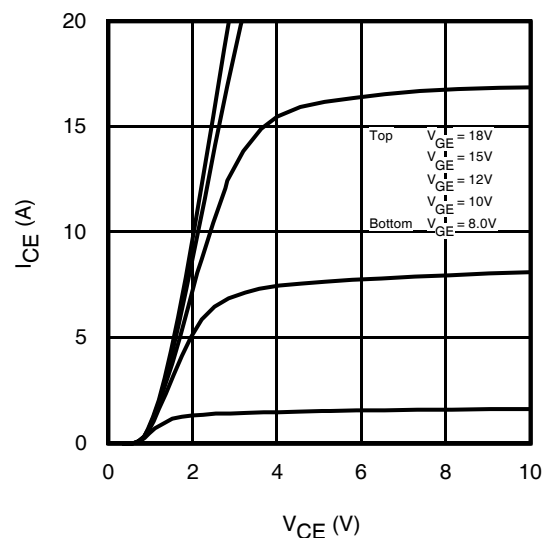


Fig. 6 - Typ. IGBT Output Characteristics
 $T_J = 25^{\circ}\text{C}$; $t_p = 80\mu\text{s}$

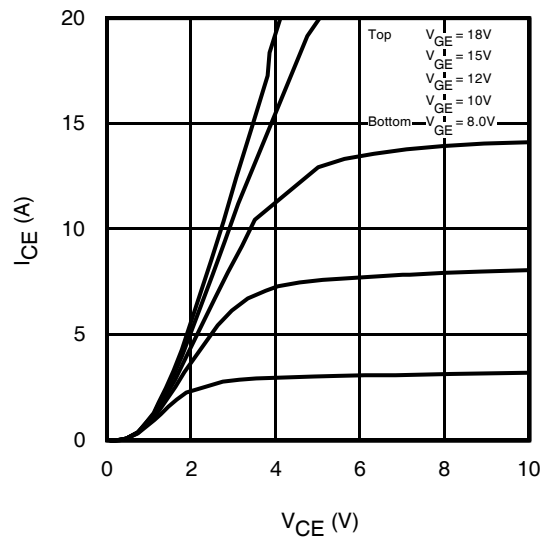


Fig. 7 - Typ. IGBT Output Characteristics
 $T_J = 175^\circ\text{C}$; $t_p = 80\mu\text{s}$

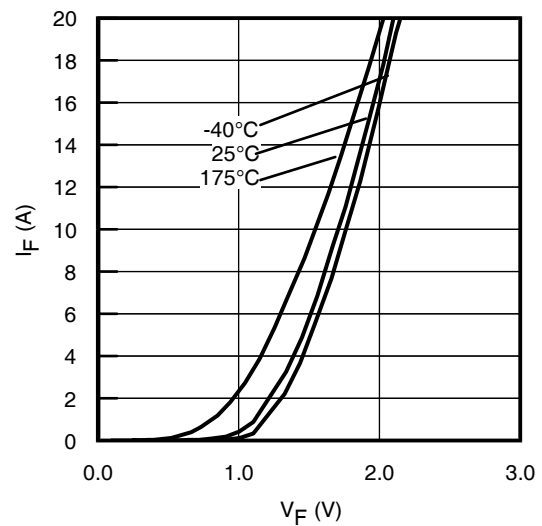


Fig. 8 - Typ. Diode Forward Characteristics
 $t_p = 80\mu\text{s}$

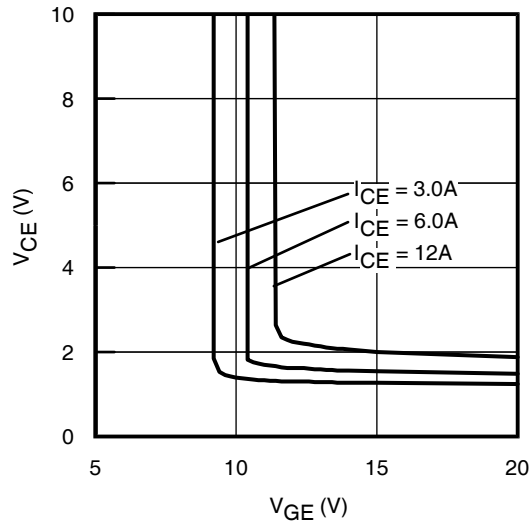


Fig. 9 - Typical V_{CE} vs. V_{GE}
 $T_J = -40^\circ\text{C}$

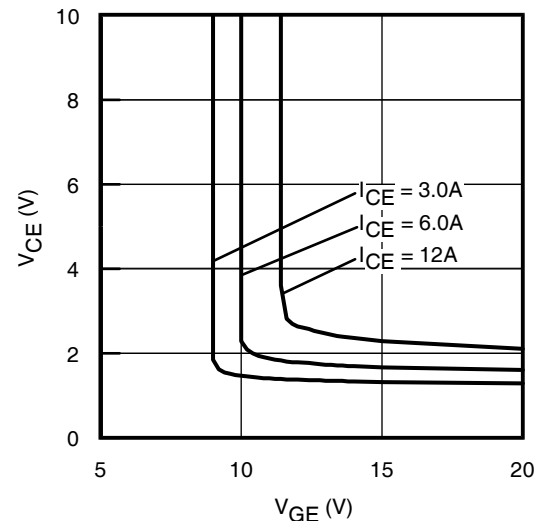


Fig. 10 - Typical V_{CE} vs. V_{GE}
 $T_J = 25^\circ\text{C}$

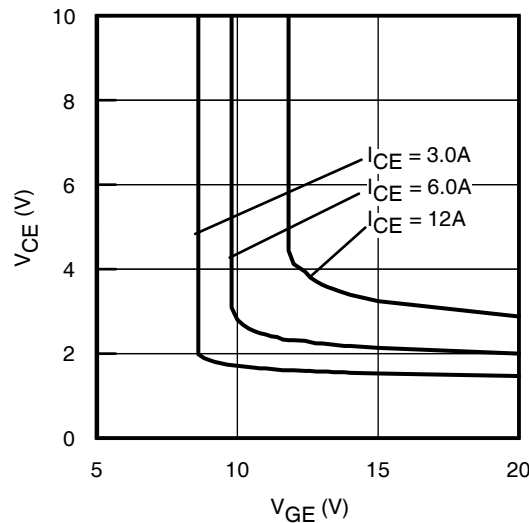


Fig. 11 - Typical V_{CE} vs. V_{GE}
 $T_J = 175^\circ\text{C}$

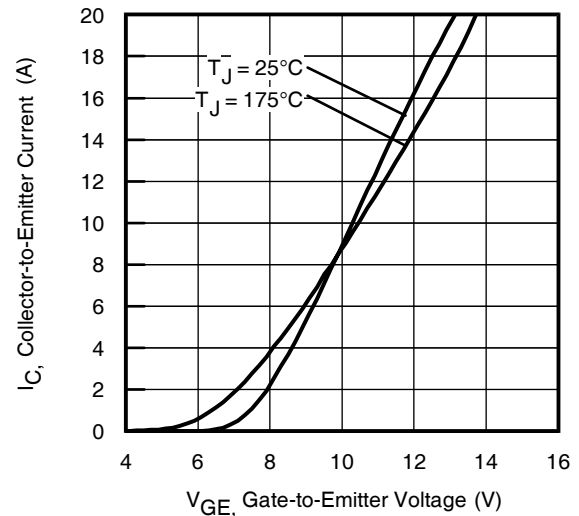


Fig. 12 - Typ. Transfer Characteristics
 $V_{CE} = 50\text{V}$; $t_p = 10\mu\text{s}$

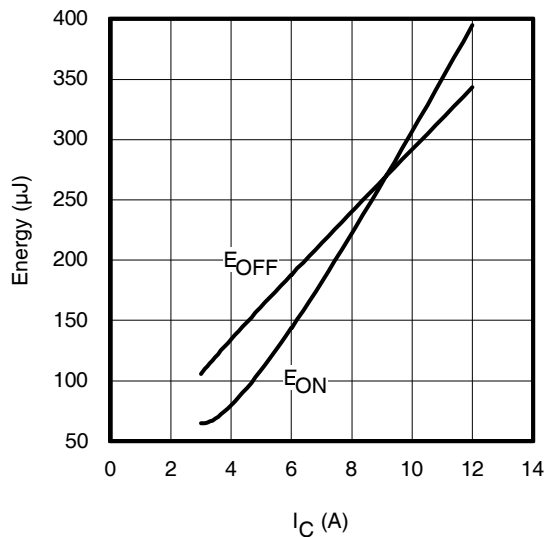


Fig. 13 - Typ. Energy Loss vs. I_C
 $T_J = 175^\circ\text{C}$; $L = 1\text{mH}$; $V_{CE} = 400\text{V}$; $R_G = 47\Omega$; $V_{GE} = 15\text{V}$.

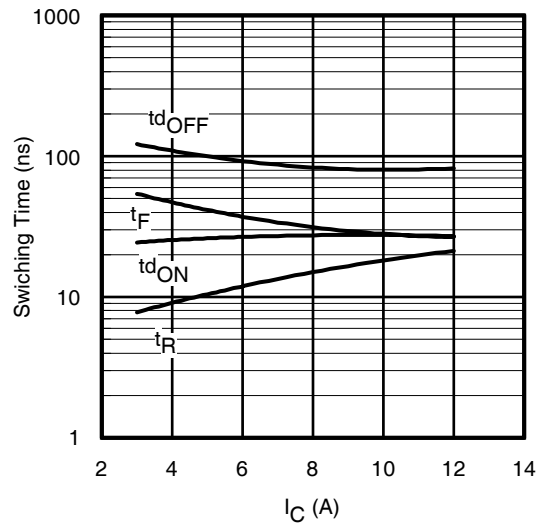


Fig. 14 - Typ. Switching Time vs. I_C
 $T_J = 175^\circ\text{C}$; $L = 1\text{mH}$; $V_{CE} = 400\text{V}$
 $R_G = 47\Omega$; $V_{GE} = 15\text{V}$

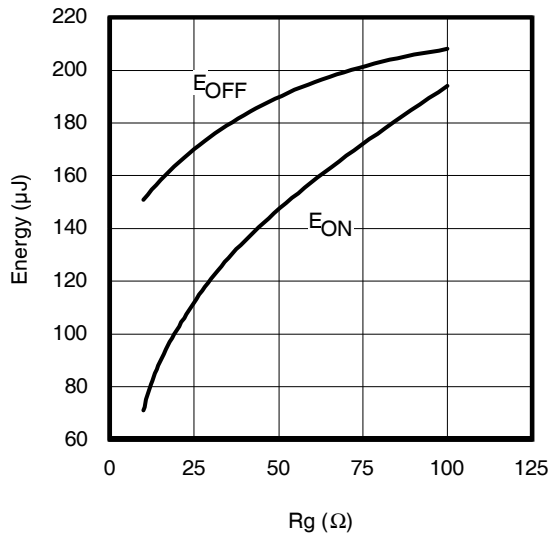


Fig. 15 - Typ. Energy Loss vs. R_G
 $T_J = 175^\circ\text{C}$; $L = 1\text{mH}$; $V_{CE} = 400\text{V}$; $I_{CE} = 6.0\text{A}$; $V_{GE} = 15\text{V}$

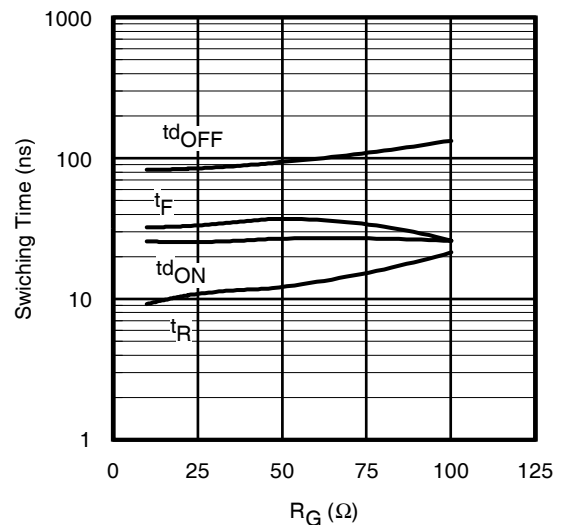


Fig. 16 - Typ. Switching Time vs. R_G
 $T_J = 175^\circ\text{C}$; $L = 1\text{mH}$; $V_{CE} = 400\text{V}$
 $I_{CE} = 6.0\text{A}$; $V_{GE} = 15\text{V}$

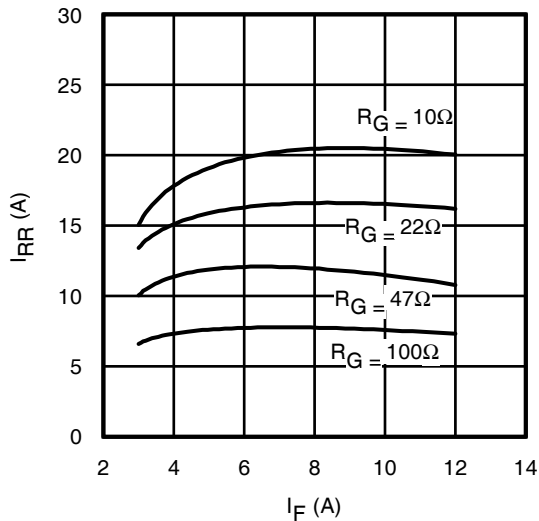


Fig. 17 - Typical Diode I_{RR} vs. I_F
 $T_J = 175^\circ\text{C}$

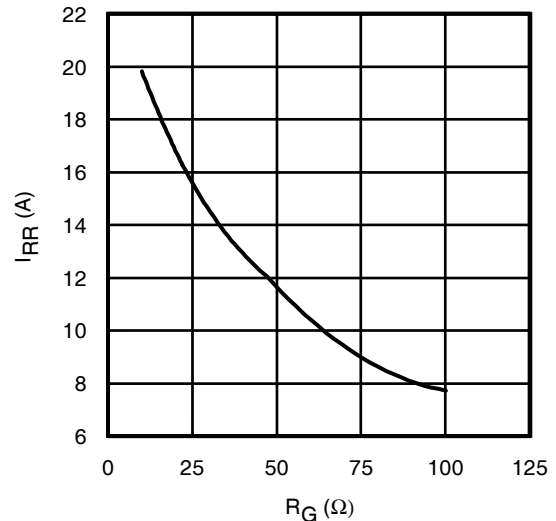


Fig. 18 - Typical Diode I_{RR} vs. R_G
 $T_J = 175^\circ\text{C}$; $I_F = 6.0\text{A}$

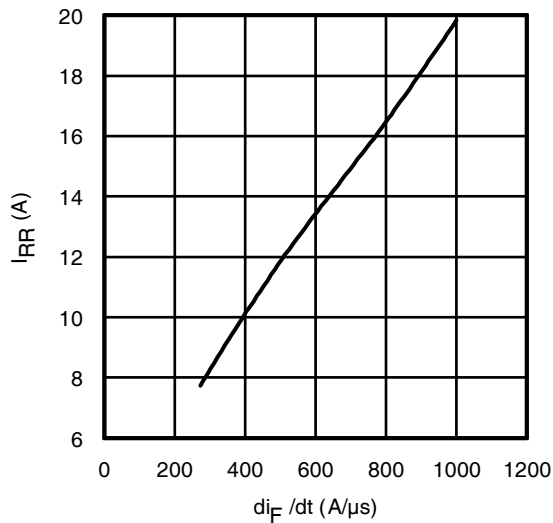


Fig. 19 - Typical Diode I_{RR} vs. di_F/dt
 $V_{CC} = 400V$; $V_{GE} = 15V$;
 $I_{CE} = 6.0A$; $T_J = 175^\circ C$

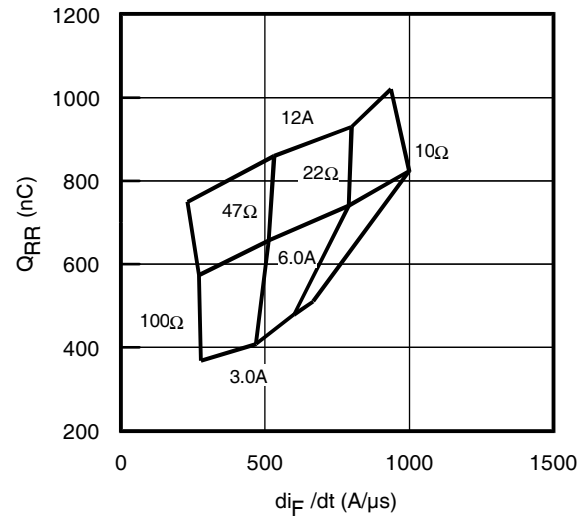


Fig. 20 - Typical Diode Q_{RR}
 $V_{CC} = 400V$; $V_{GE} = 15V$; $T_J = 175^\circ C$

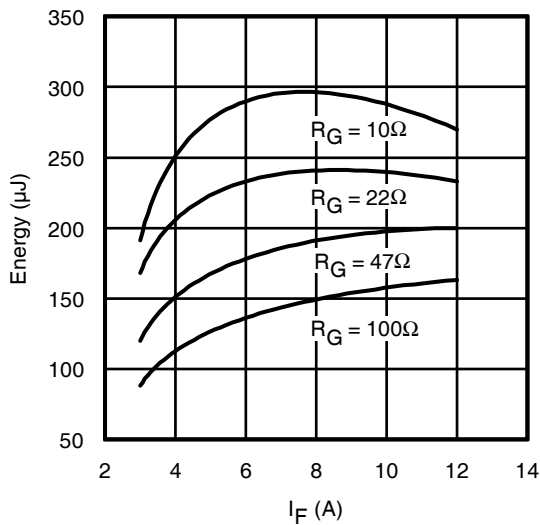


Fig. 21 - Typical Diode E_{RR} vs. I_F
 $T_J = 175^\circ C$

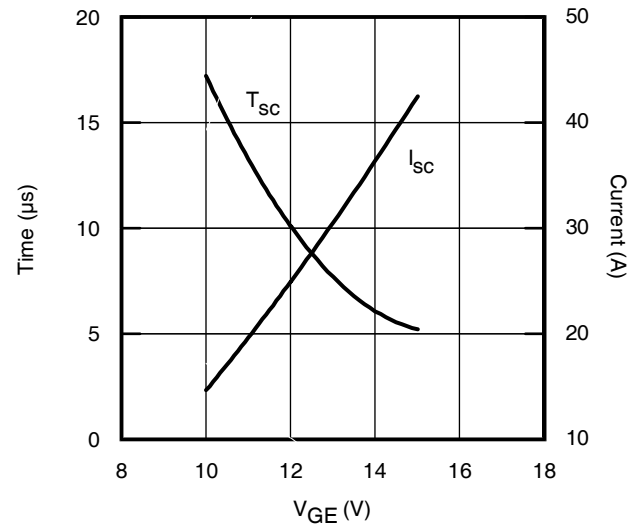


Fig. 22 - Typ. V_{GE} vs. Short Circuit Time
 $V_{CC} = 400V$, $T_C = 25^\circ C$

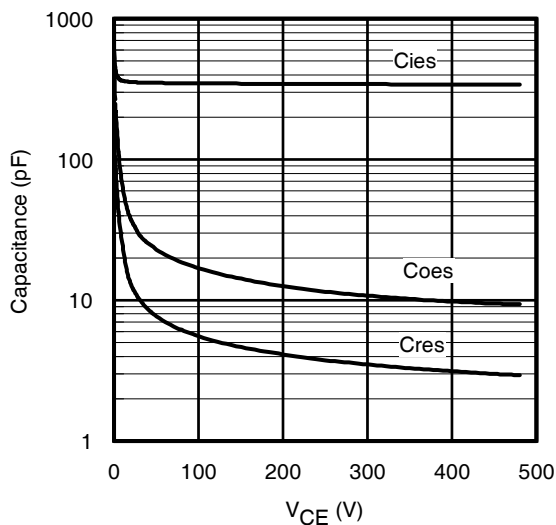


Fig. 23 - Typ. Capacitance vs. V_{CE}
 $V_{GE} = 0V$; $f = 1MHz$

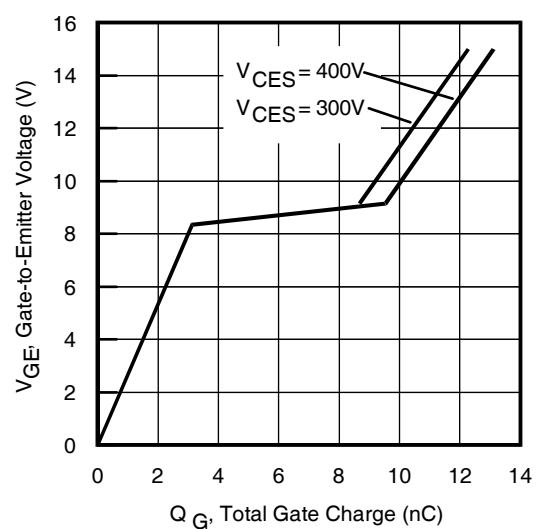


Fig. 24 - Typical Gate Charge vs. V_{GE}
 $I_{CE} = 6.0A$, $L = 600\mu H$

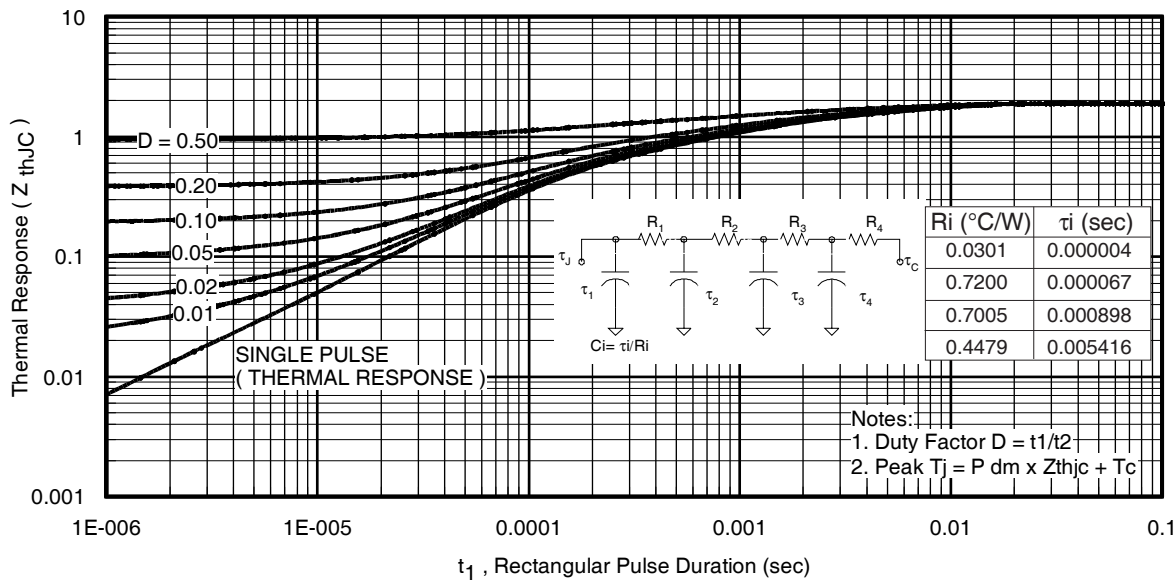


Fig 25. Maximum Transient Thermal Impedance, Junction-to-Case (IGBT)

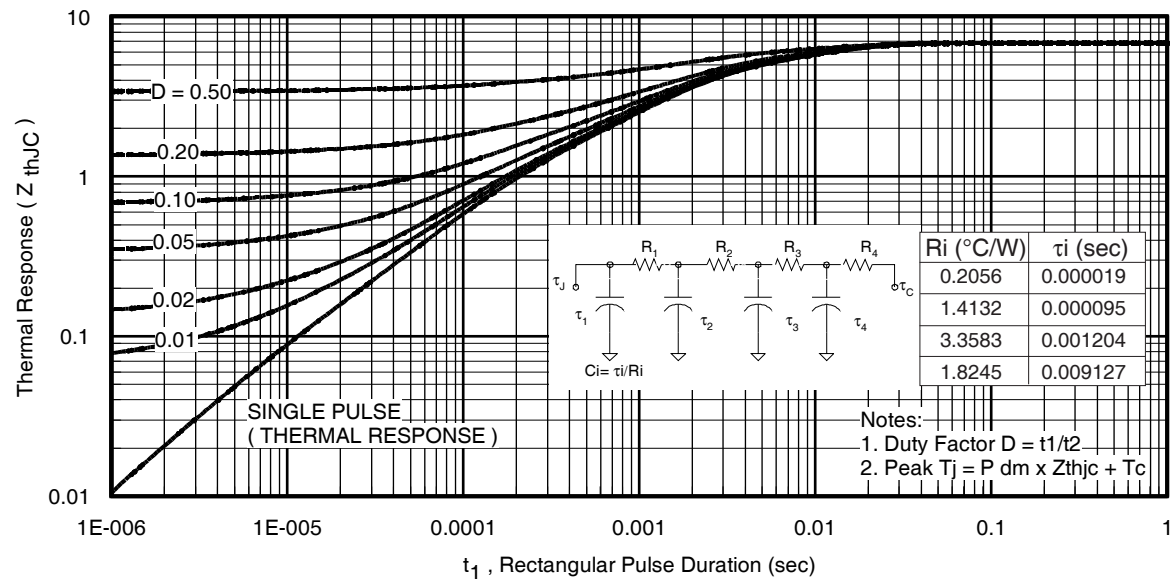


Fig 26. Maximum Transient Thermal Impedance, Junction-to-Case (DIODE)

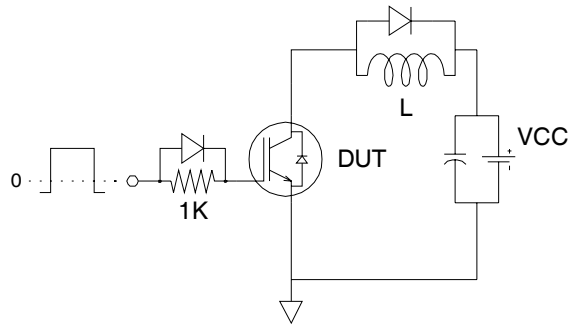


Fig.C.T.1 - Gate Charge Circuit (turn-off)

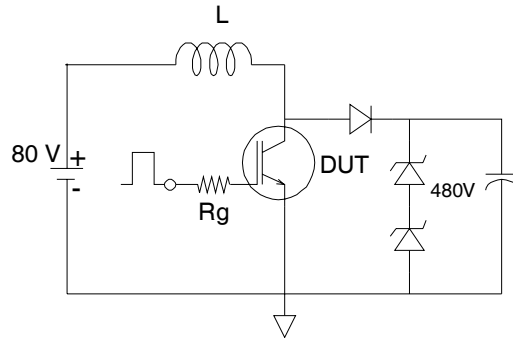


Fig.C.T.2 - RBSOA Circuit

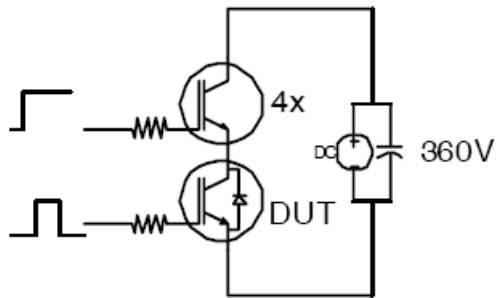


Fig.C.T.3 - S.C.SOA Circuit

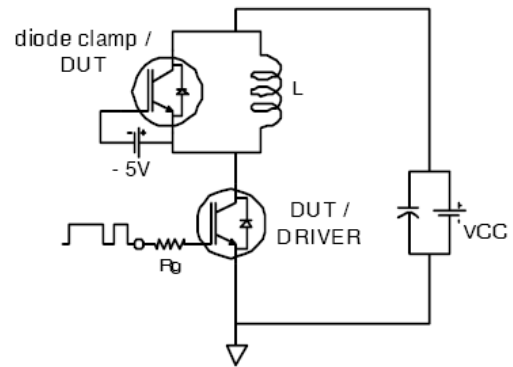


Fig.C.T.4 - Switching Loss Circuit

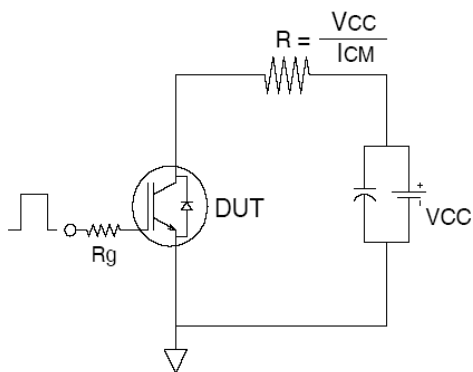


Fig.C.T.5 - Resistive Load Circuit

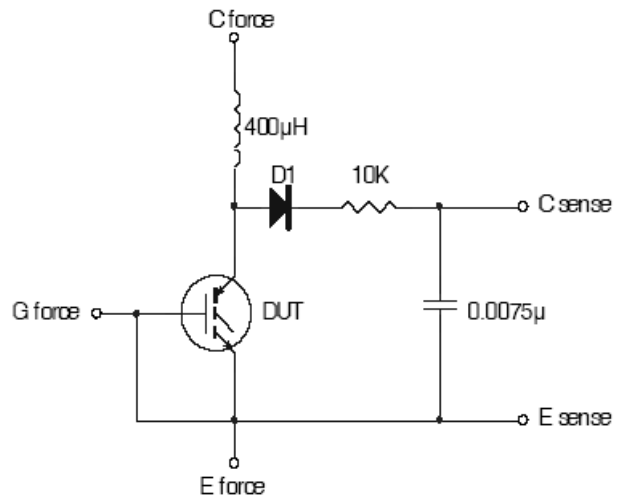


Fig.C.T.6 - Typical Filter Circuit for $V_{(BR)CES}$ Measurement

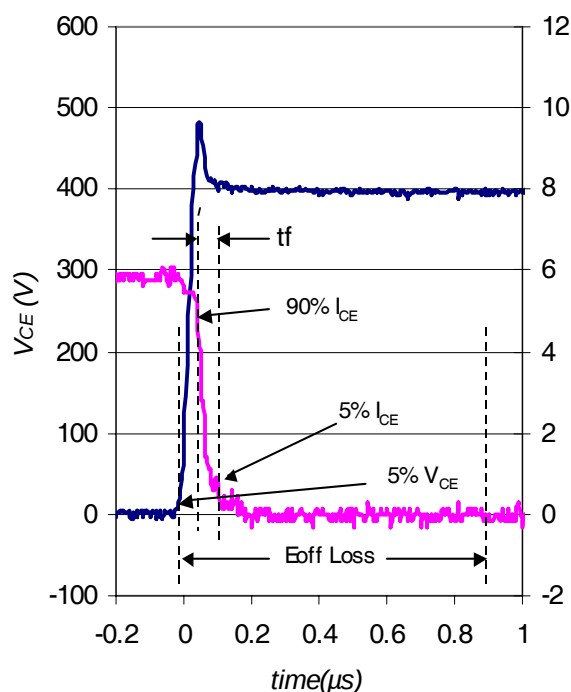


Fig. WF1 - Typ. Turn-off Loss Waveform
@ $T_J = 175^\circ\text{C}$ using Fig. CT.4

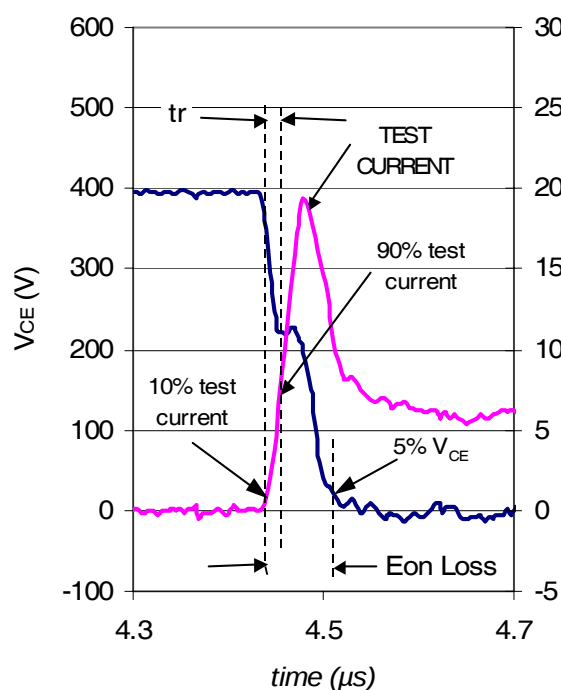
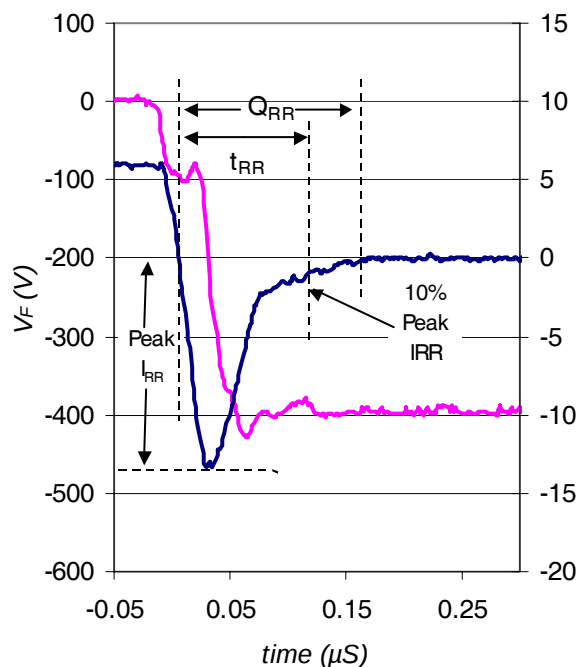
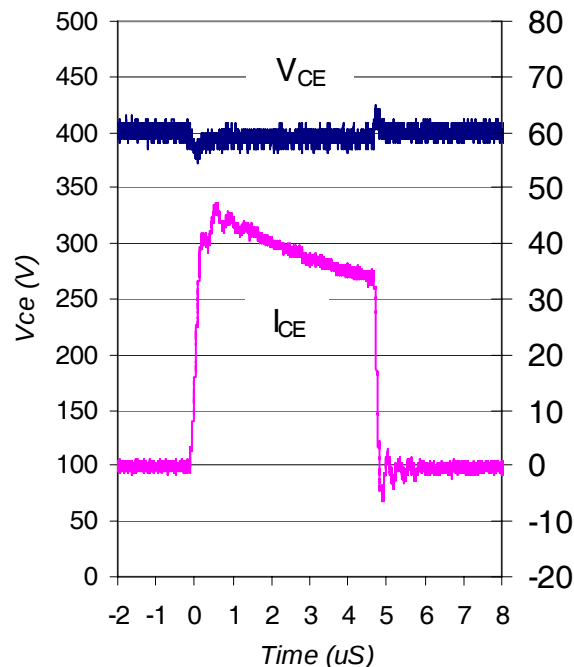


Fig. WF2 - Typ. Turn-on Loss Waveform
@ $T_J = 175^\circ\text{C}$ using Fig. CT.4



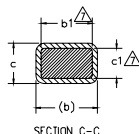
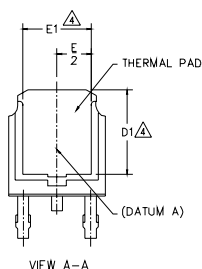
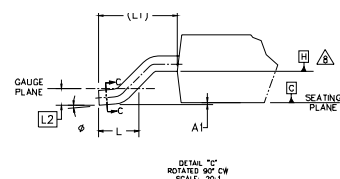
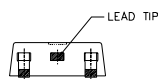
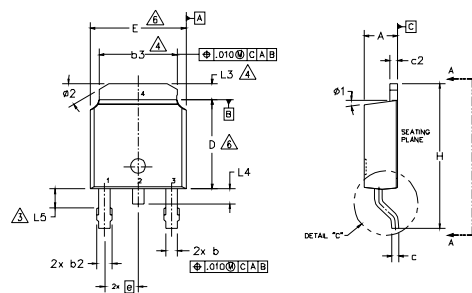
WF.3- Typ. Diode Recovery Waveform
@ $T_J = 175^\circ\text{C}$ using CT.4



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]
- 3.- LEAD DIMENSION UNCONTROLLED IN L5.
- 4.- 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.
- 6.- 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.
- 7.- DIMENSION b1 & c1 APPLIED TO BASE METAL ONLY.
- 8.- 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
ø	0"	10"	0"	10"	
ø1	0"	15"	0"	15"	
ø2	25"	35"	25"	35"	

LEAD ASSIGNMENTS

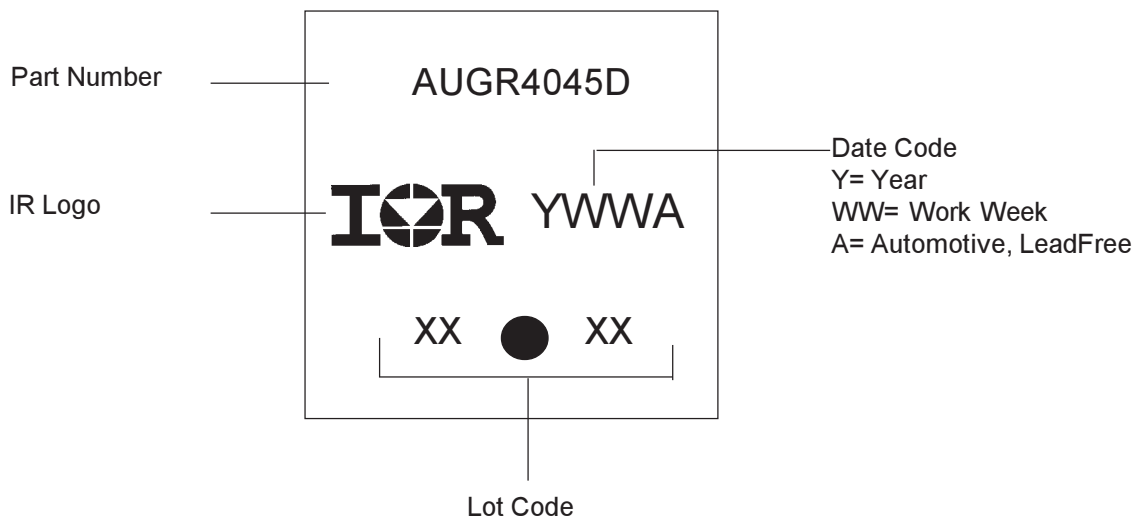
HEXFET

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

IGBT & CoPAK

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

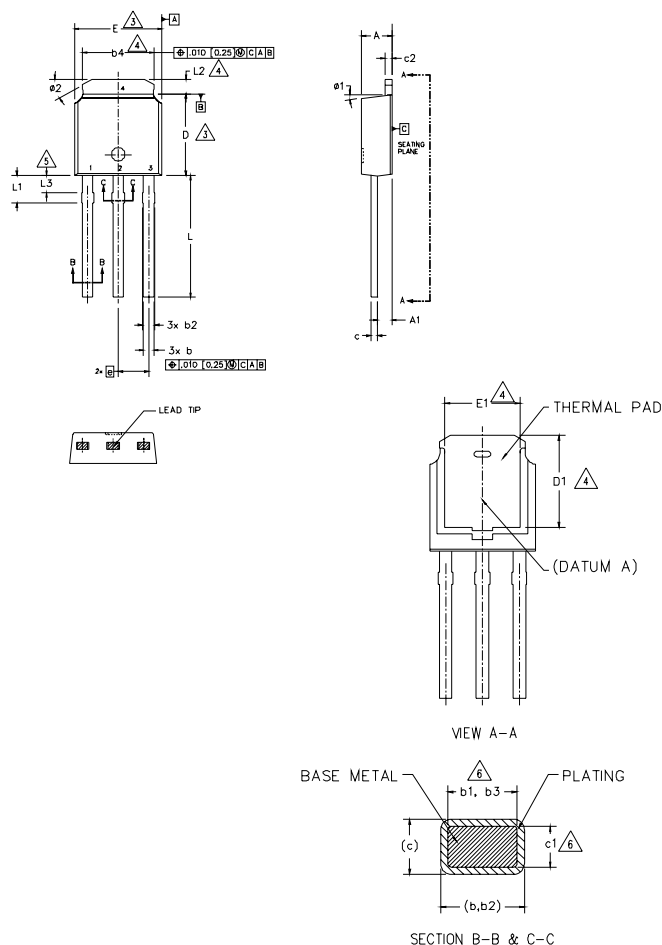
D-Pak Part Marking Information



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

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].
- 3.- 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.
- 4.- THERMAL PAD CONTOUR OPTION WITHIN DIMENSION b4, L2, E1 & D1.
- 5.- LEAD DIMENSION UNCONTROLLED IN L3.
- 6.- DIMENSION b1, b3 & c1 APPLY TO BASE METAL ONLY.
- 7.- OUTLINE CONFORMS TO JEDEC OUTLINE TO-251AA (Date 06/02).
- 8.- CONTROLLING DIMENSION : INCHES.

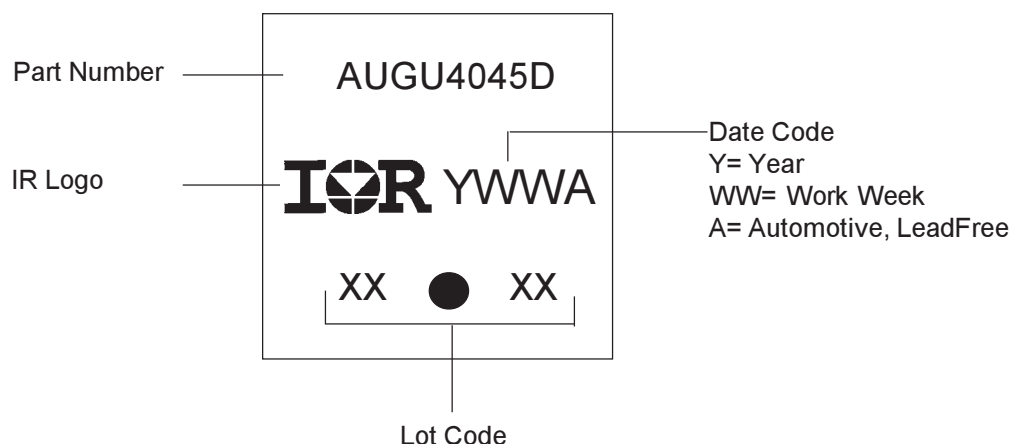
S Y M B O L	DIMENSIONS				N O T E S
	MILLIMETERS		INCHES		
			MIN.	MAX.	
A	2.18	2.39	.086	.094	6
A1	0.89	1.14	.035	.045	
b	0.64	0.89	.025	.035	
b1	0.65	0.79	.025	.031	6
b2	0.76	1.14	.030	.045	
b3	0.76	1.04	.030	.041	
b4	4.95	5.46	.195	.215	4
c	0.46	0.61	.018	.024	
c1	0.41	0.56	.016	.022	
c2	0.46	0.89	.018	.035	6
D	5.97	6.22	.235	.245	
D1	5.21	—	.205	—	
E	6.35	6.73	.250	.265	3
E1	4.32	—	.170	—	
e	2.29 BSC		.090 BSC		
L	8.89	9.65	.350	.380	4
L1	1.91	2.29	.045	.090	
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

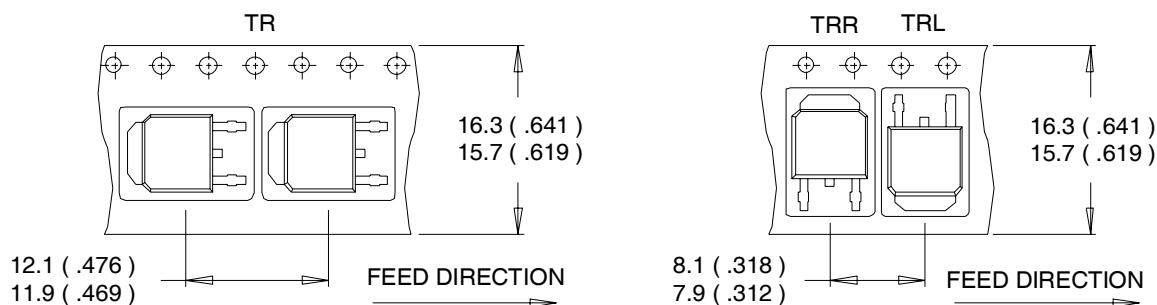
I-Pak Part Marking Information



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

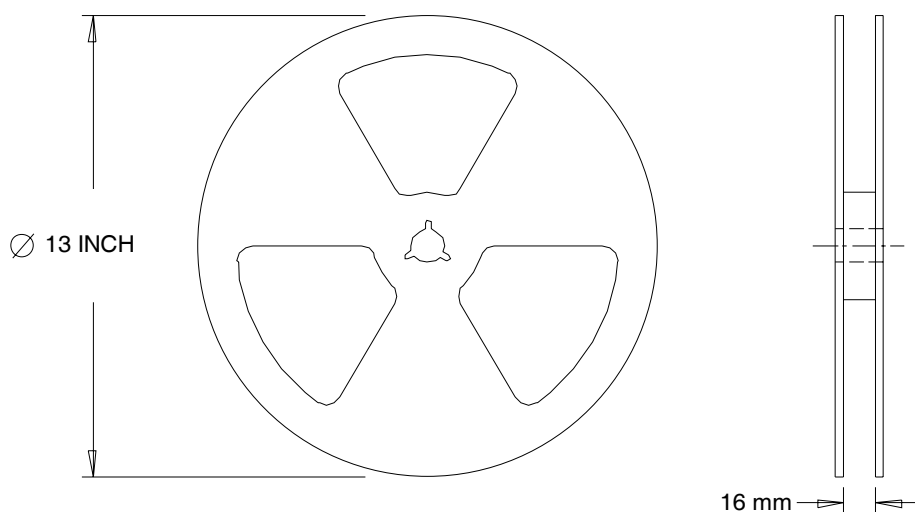
D-Pak (TO-252AA) Tape & Reel Information

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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