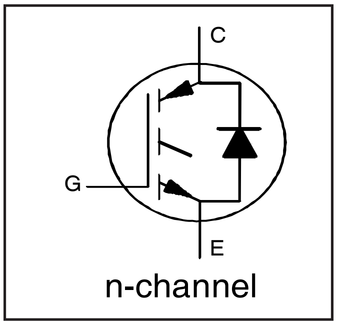
Insulated Gate Bipolar Transistor with Ultrafast Soft Recovery Diode

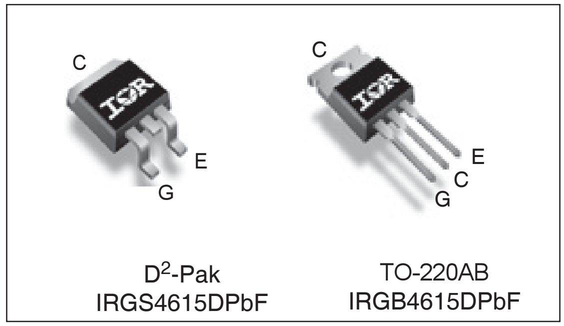
$V_{CES} = 600V$

$I_C = 15A$, $T_C = 100°C$

$t_{sc} > 5\mu s$, $T_{jmax} = 175°C$

$V_{CE(on)}$ typ. $= 1.55V$ @ 8A





G	C	E
Gate	Collector	Emitter

Applications
- Appliance Drives
- Inverters
- UPS

Features	→ Benefits
Low $V_{CE(ON)}$ and switching losses	High efficiency in a wide range of applications and switching frequencies
Square RBSOA and maximum junction temperature 175°C	Improved reliability due to rugged hard switching performance and higher power capability
Positive $V_{CE(ON)}$ temperature coefficient and tighter distribution of parameters	Excellent current sharing in parallel operation
5µs short circuit SOA	Enables short circuit protection scheme
Lead-free, RoHS compliant	Environmentally friendly

Base part number	Package Type	Standard Pack		Orderable Part Number
		Form	Quantity	
IRGS4615DPbF	D^2 PAK	Tube	50	IRGS4615DPbF
IRGS4615DTRRPbF		Tape and Reel Right	800	IRGS4615DTRRPbF
IRGS4615DTRLPbF		Tape and Reel Left	800	IRGS4615DTRLPbF
IRGB4615DPbF	TO-220AB	Tube	50	IRGB4615DPbF

Absolute Maximum Ratings

	Parameter	Max.	Units
V_{CES}	Collector-to-Emitter Breakdown Voltage	600	V
I_C@ T_C = 25°C	Continuous Collector Current	23	A
I_C@ T_C = 100°C	Continuous Collector Current	15	
I_{CM}	Pulsed Collector Current, V_{GE} = 15V	24	
I_{LM}	Clamped Inductive Load Current, V_{GE} = 20V ①	32	
I_F@T_C=25°C	Diode Continuous Forward Current	14	
I_F@T_C=100°C	Diode Continuous Forward Current	9	
I_{FM}	Diode Maximum Forward Current ④	32	
V_{GE}	Continuous Gate-to-Emitter Voltage	± 20	V
	Transient Gate-to-Emitter Voltage	± 30	
P_D @ T_C =25°	Maximum Power Dissipation	99	W
P_D @ T_C =100°	Maximum Power Dissipation	50	
T_J T_{STG}	Operating Junction and Storage Temperature Range	-40 to + 175	°C
	Soldering Temperature, for 10 seconds (1.6mm from case)	300	
	Mounting Torque, 6-32 or M3 Screw TO-220	10lbf. In (1.1 N.m)	

Thermal Resistance

	Parameter	Min.	Typ.	Max.	Units
$R_{\theta JC}$	Thermal Resistance, Junction-to-Case -(each IGBT) ②	——	——	1.51	°C/W
$R_{\theta JC}$	Thermal Resistance, Junction-to-Case -(each Diode) ②	——	——	3.66	
$R_{\theta CS}$	Thermal Resistance, Case-to-Sink (flat, greased surface)	——	0.5	——	
$R_{\theta JA}$	Thermal Resistance, Junction-to-Ambient (PCB mount D^2PAK) ⑥	——	——	40	
	Thermal Resistance, Junction-to-Ambient (Socket mount: TO-220)	——	——	62	

Electrical Characteristics @ T_J = 25°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 =100 µA ③
$\Delta V_{(BR)CES}/\Delta T_J$	Temperature Coeff. of Breakdown Voltage	—	0.3	—	V/°C	V_{GE} = 0V, I_c = 250µA (25 -175°C)
$V_{CE(on)}$	Collector-to-Emitter Saturation Voltage	—	1.55	1.85	V	I_C = 8.0A, V_{GE} = 15V, T_J = 25°C
		—	1.95	—		I_C = 8.0A, V_{GE} = 15V, T_J = 150°C
		—	2.00	—		I_C = 8.0A, V_{GE} = 15V, T_J = 175°C
$V_{GE(th)}$	Gate Threshold Voltage	4.0	—	6.5	V	V_{CE} = V_{GE}, I_C = 250µA
$\Delta V_{GE(th)}/\Delta TJ$	Threshold Voltage temp. coefficient	—	-18	—	mV/°C	V_{CE} = V_{GE}, I_C = 250µA (25 -175°C)
gfe	Forward Transconductance	—	5.6	—	S	V_{CE} = 50V, I_C = 8.0A, PW =80µs
I_{CES}	Collector-to-Emitter Leakage Current	—	—	25	µA	V_{GE} = 0V,V_{CE} = 600V
		—	400	—		V_{GE} = 0V, V_{CE} = 600V, T_J =175°C
V_{FM}	Diode Forward Voltage Drop	—	1.80	2.8	V	I_F = 8.0A
		—	1.30	—		I_F = 8.0A, T_J = 175°C
I_{GES}	Gate-to-Emitter Leakage Current	—	—	±100	nA	V_{GE} = ± 20 V

Switching Characteristics @ T_J = 25°C (unless otherwise specified)

	Parameter	Min.	Typ.	Max.	Units	Conditions
Q_g	Total Gate Charge (turn-on)	—	19	—	nC	I_C = 8.0A
Q_{ge}	Gate-to-Emitter Charge (turn-on)	—	5	—		V_{CC} = 400V
Q_{gc}	Gate-to-Collector Charge (turn-on)	—	8	—		V_{GE} = 15V
E_{on}	Turn-On Switching Loss	—	70	—	µJ	I_C = 8.0A, V_{CC} = 400V, V_{GE} = 15V
E_{off}	Turn-Off Switching Loss	—	145	—		R_G = 47Ω, L=1mH, L_S= 150nH, T_J = 25°C
E_{total}	Total Switching Loss	—	215	—		Energy losses include tail and diode reverse recovery ⑤
$t_{d(on)}$	Turn-On delay time	—	30	—	ns	I_C = 8.0A, V_{CC} = 400V
t_r	Rise time	—	15	—		R_G = 47Ω, L=1mH, L_S= 150nH
$t_{d(off)}$	Turn-Off delay time	—	95	—		T_J = 25°C
t_f	Fall time	—	20	—		
E_{on}	Turn-On Switching Loss	—	165	—	µJ	I_C = 8.0A, V_{CC} = 400V, V_{GE} = 15V
E_{off}	Turn-Off Switching Loss	—	240	—		R_G = 47Ω, L=1mH, L_S= 150nH, T_J = 175°C
E_{total}	Total Switching Loss	—	405	—		Energy losses include tail and diode reverse recovery ⑤
$t_{d(on)}$	Turn-On delay time	—	28	—	ns	I_C = 8.0A, V_{CC} = 400V
t_r	Rise time	—	17	—		R_G = 47Ω, L=1mH, L_S= 150nH
$t_{d(off)}$	Turn-Off delay time	—	117	—		T_J = 175°C
t_f	Fall time	—	35	—		
C_{ies}	Input Capacitance	—	535	—	pF	V_{GE} = 0V
C_{oes}	Output Capacitance	—	45	—		V_{CC} = 30V
C_{res}	Reverse Transfer Capacitance	—	15	—		f = 1Mhz
RBSOA	Reverse Bias Safe Operating Area	FULL SQUARE				T_J = 175°C, I_C = 32A V_{CC} = 480V, Vp =600V R_G = 47Ω, V_{GE} = +20V to 0V
SCSOA	Short Circuit Safe Operating Area	5	—	—	µs	V_{CC} = 400V, Vp =600V R_G = 47Ω, V_{GE} = +15V to 0V
Erec	Reverse recovery energy of the diode	—	165	—	µJ	T_J = 175°C
trr	Diode Reverse recovery time	—	60	—	ns	V_{CC} = 400V, I_F = 8.0A
Irr	Peak Reverse Recovery Current	—	14	—	A	V_{GE} = 15V, Rg = 47Ω, L=1mH, L_S=150nH

Notes:

① V_{CC} = 80% (V_{CES}), V_{GE} = 20V, L = 100 µH, R_G = 47 Ω.
② R_θ is measured at T_J approximately 90°C.
③ Refer to AN-1086 for guidelines for measuring $V_{(BR)CES}$ safely.
④ Pulse width limited by max. junction temperature.
⑤ Values influenced by parasitic L and C in measurement
⑥ When mounted on 1" square PCB (FR-4 or G-10 Material). For recommended footprint and soldering techniques refer to application note #AN-994: http://www.irf.com/technical-info/appnotes/an-994.pdf

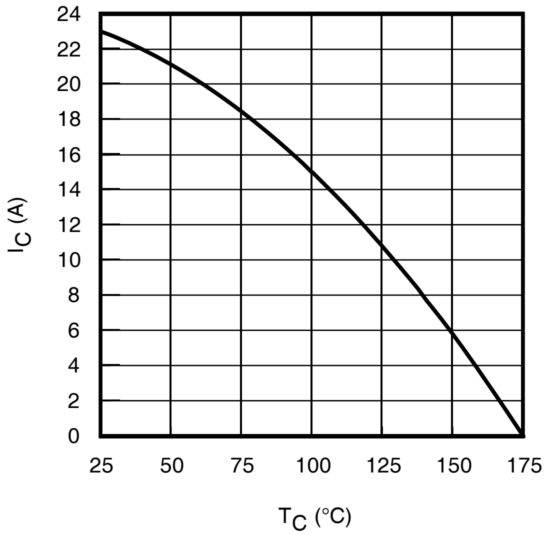


Fig. 1 - Maximum DC Collector Current vs. Case Temperature

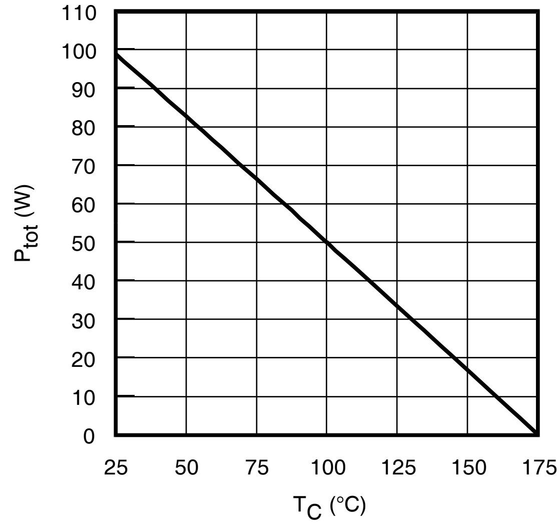


Fig. 2 - Power Dissipation vs. Case Temperature

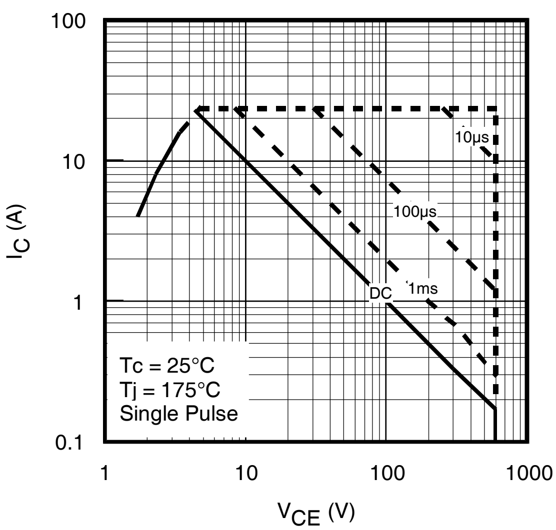


Fig. 3 - Forward SOA, $T_C = 25°C$; $T_J \leq 175°C$

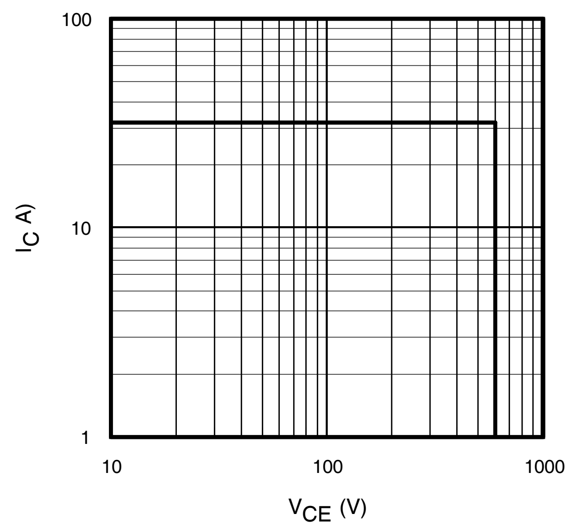


Fig. 4 - Reverse Bias SOA $T_J = 175°C$; $V_{CE} = 15V$

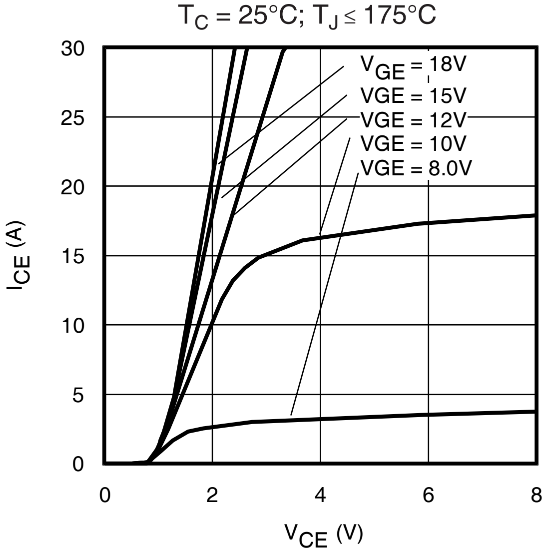


Fig. 5 - Typ. IGBT Output Characteristics $T_J = -40°C$; tp = 80µs

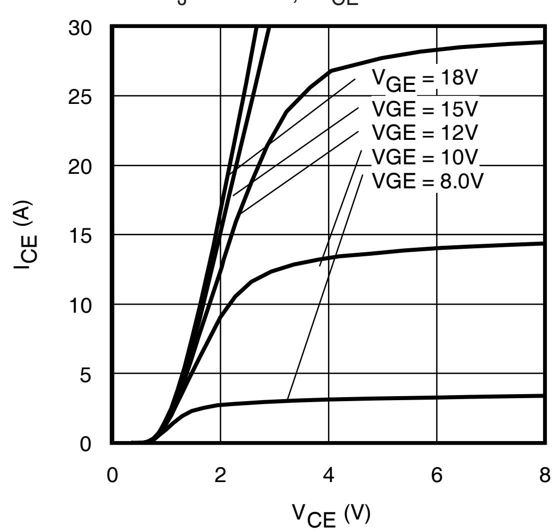


Fig. 6 - Typ. IGBT Output Characteristics $T_J = 25°C$; tp = 80µs

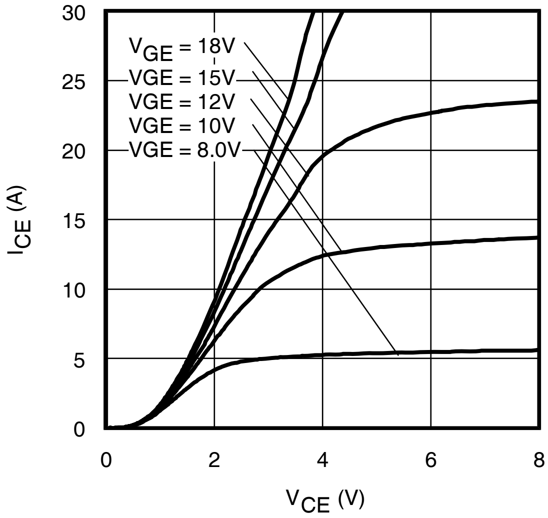


Fig. 7 - Typ. IGBT Output Characteristics
T_J = 175°C; tp = 80µs

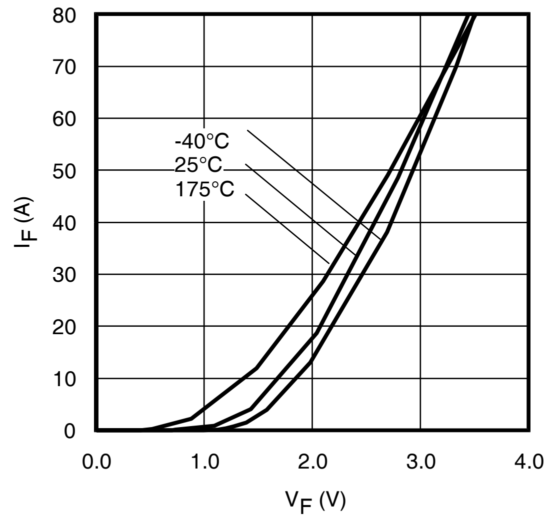


Fig. 8 - Typ. Diode Forward Characteristics
tp = 80µs

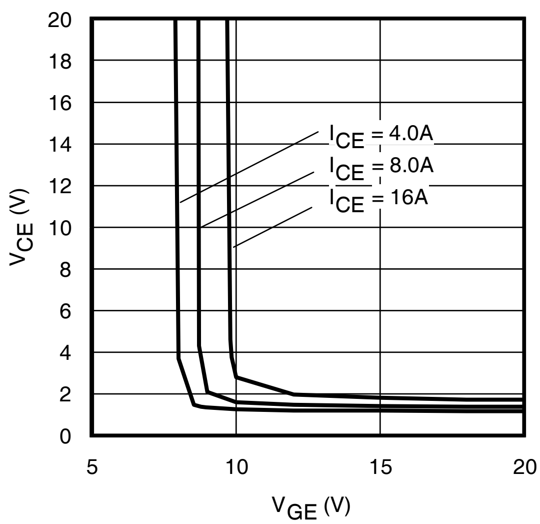


Fig. 9 - Typical V_{CE} vs. V_{GE}
T_J = -40°C

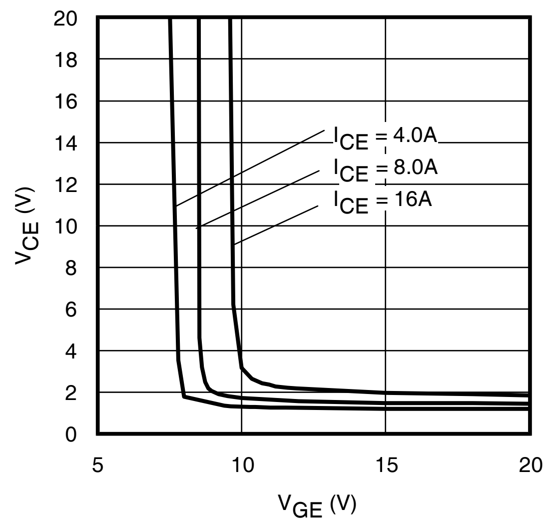


Fig. 10 - Typical V_{CE} vs. V_{GE}
T_J = 25°C

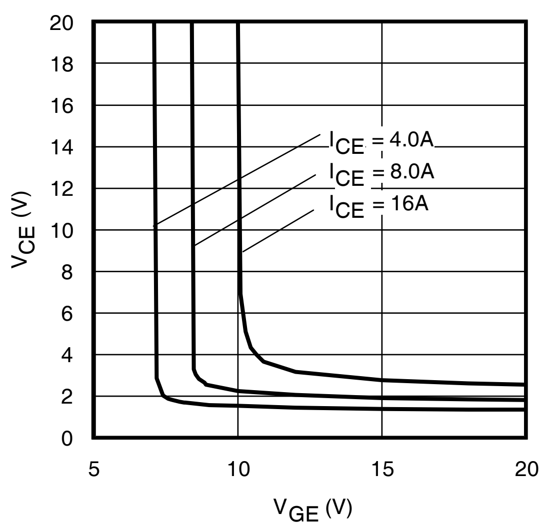


Fig. 11 - Typical V_{CE} vs. V_{GE}
T_J = 175°C

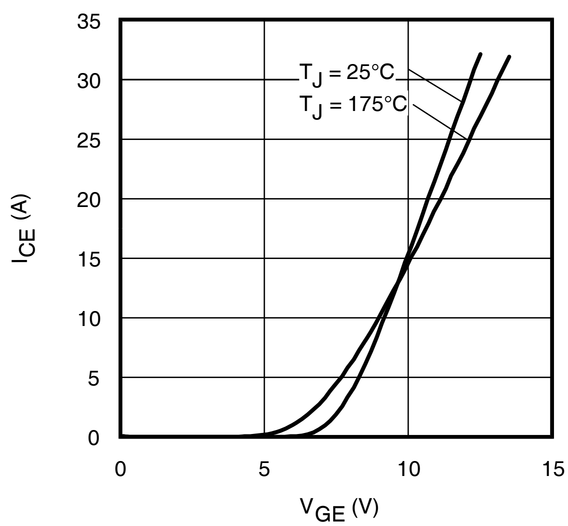


Fig. 12 - Typ. Transfer Characteristics
V_{CE} = 50V; tp = 10µs

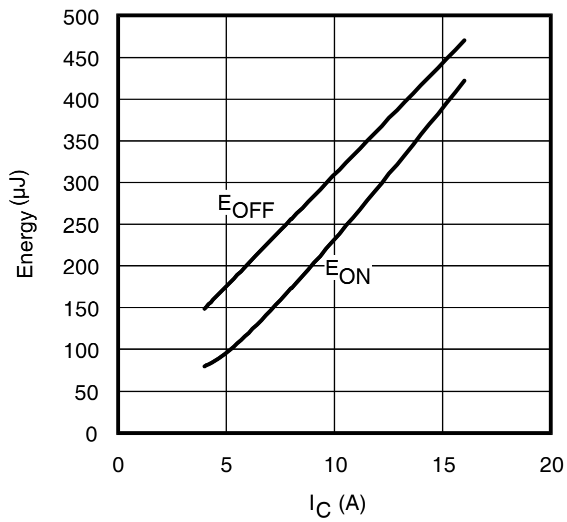


Fig. 13 - Typ. Energy Loss vs. I_C
T_J = 175°C; L = 1mH; V_{CE} = 400V, R_G = 47Ω; V_{GE} = 15V.

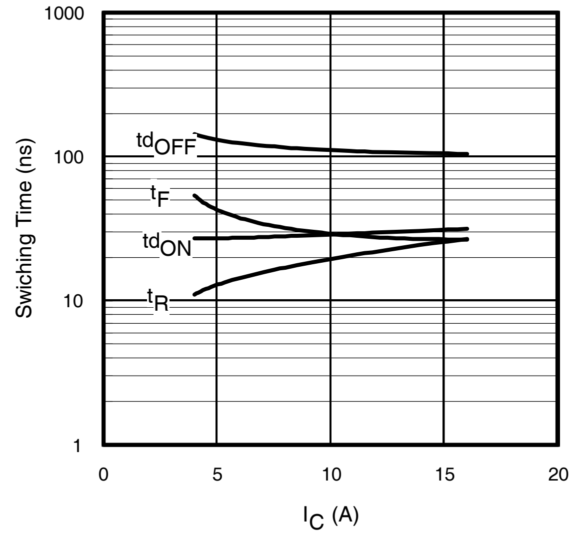


Fig. 14 - Typ. Switching Time vs. I_C
T_J = 175°C; L=1mH; V_{CE}= 400V
R_G= 47Ω; V_{GE}= 15V

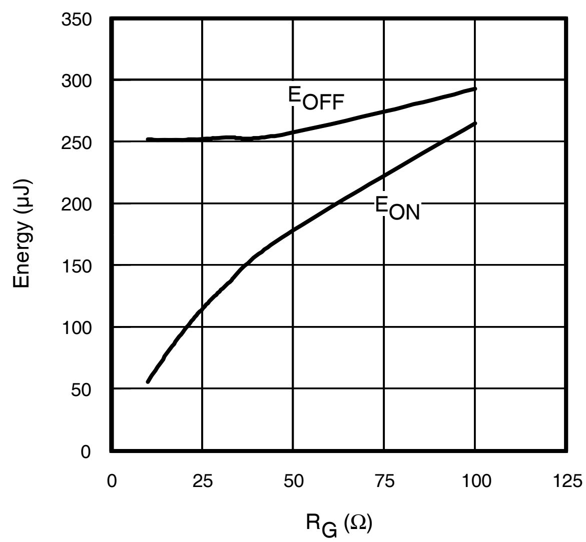


Fig. 15 - Typ. Energy Loss vs. R_G
T_J = 175°C; L = 1mH; V_{CE} = 400V, I_{CE} = 8A; V_{GE} = 15V

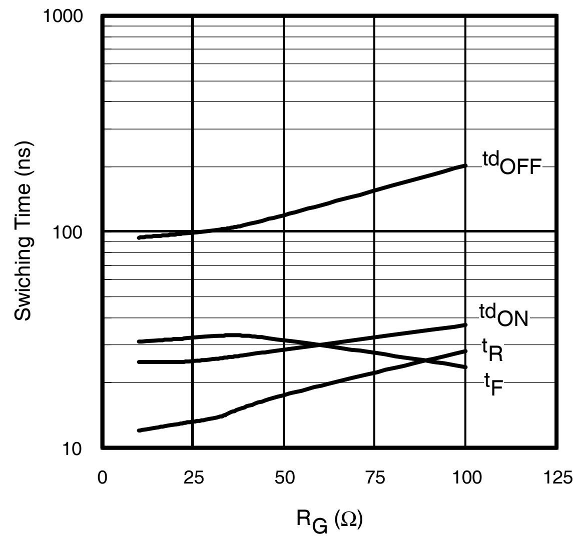


Fig. 16- Typ. Switching Time vs. R_G
T_J = 175°C; L=1mH; V_{CE}= 400V
I_{CE}= 8A; V_{GE}= 15V

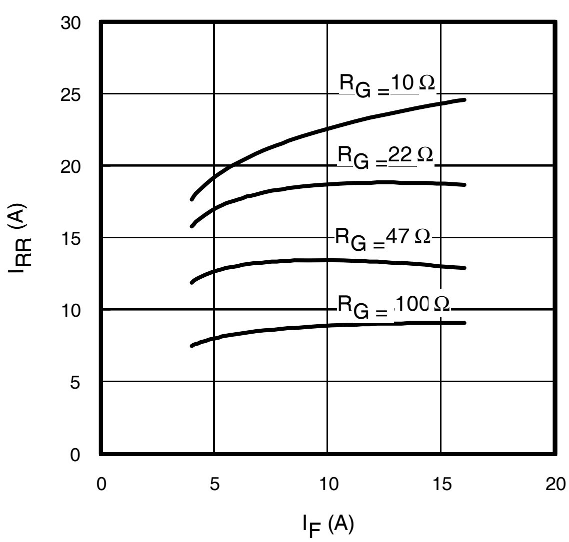


Fig. 17 - Typical Diode I_{RR} vs. I_F
T_J = 175°C

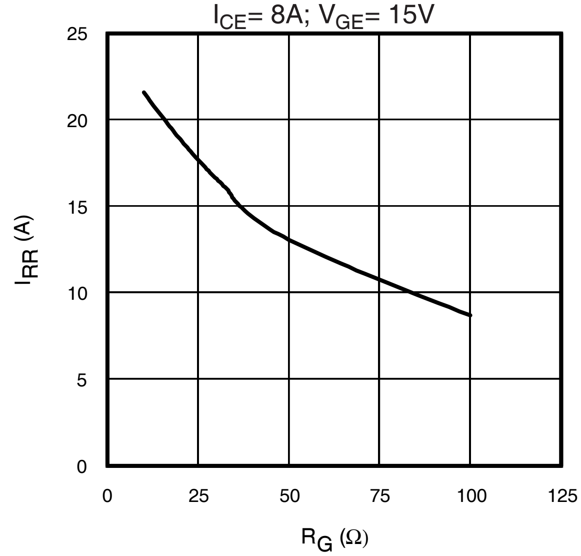


Fig. 18 - Typical Diode I_{RR} vs. R_G
T_J = 175°C; I_F = 8.0A

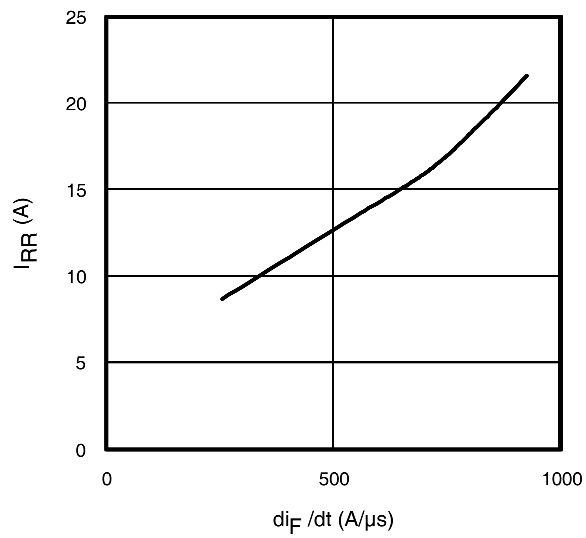


Fig. 19- Typical Diode I_{RR} vs. di_F/dt
V_{CC}= 400V; V_{GE}= 15V;
I_{CE}= 8A; T_J = 175°C

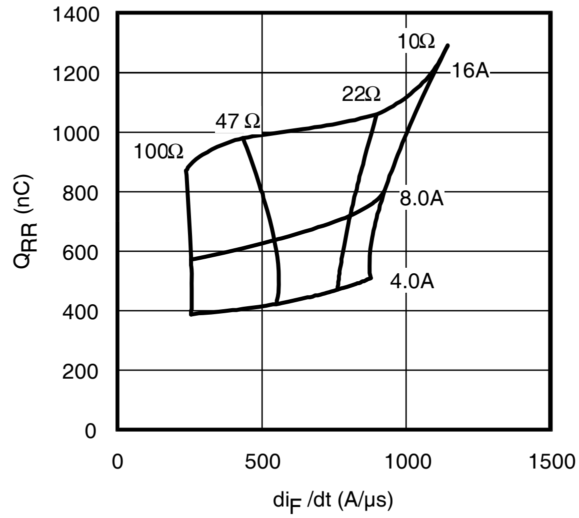


Fig. 20 - Typical Diode Q_{RR}
V_{CC}= 400V; V_{GE}= 15V; T_J = 175°C

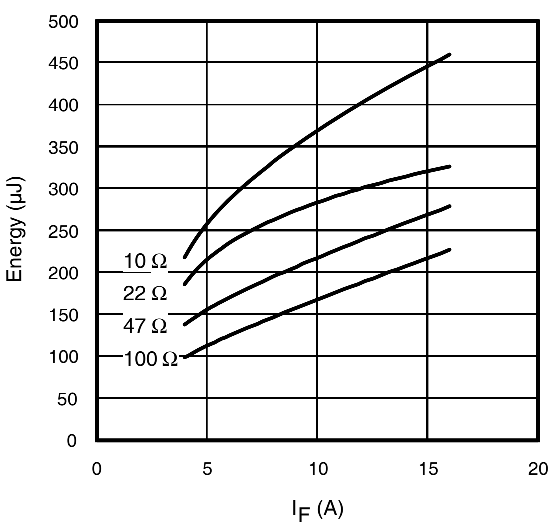


Fig. 21 - Typical Diode E_{RR} vs. I_F
T_J = 175°C

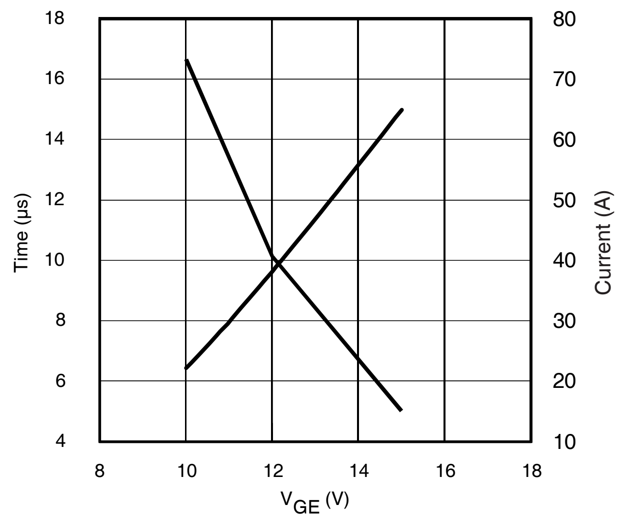


Fig. 22- Typ. V_{GE} vs Short Circuit Time
V_{CC}=400V, T_C =25°C

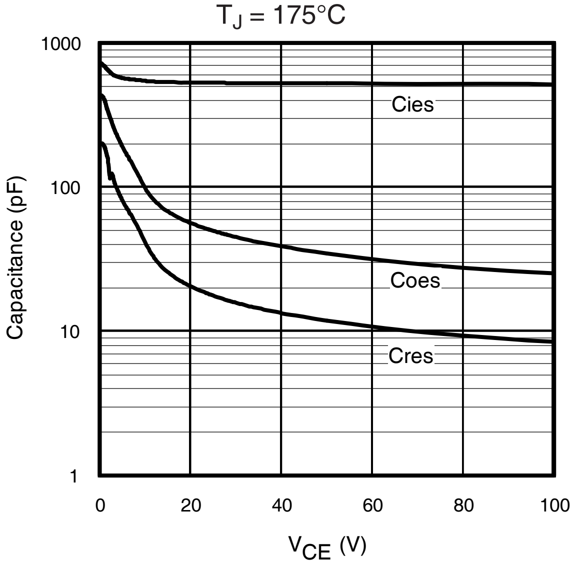


Fig. 23- Typ. Capacitance vs. V_{CE}
V_{GE}= 0V; f = 1MHz

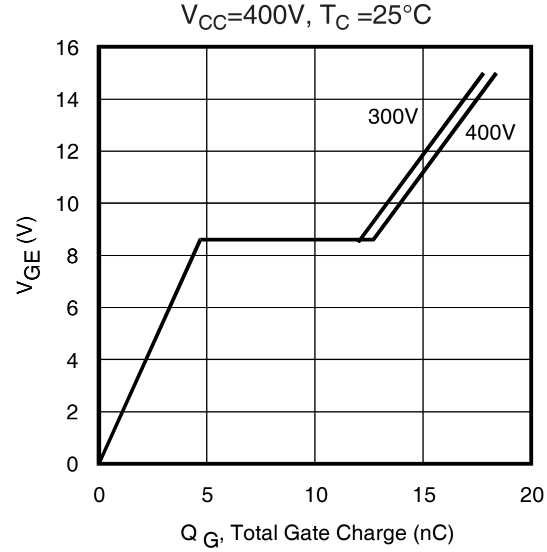


Fig. 24 - Typical Gate Charge vs. V_{GE}
I_{CE} = 8A, L=600µH

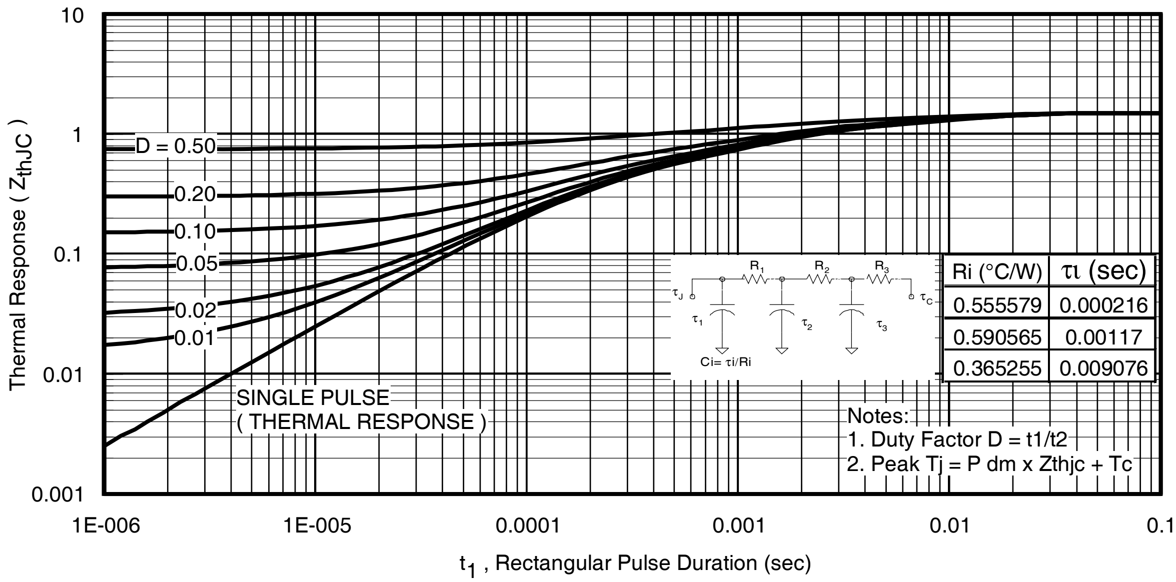


Fig 25. Maximum Transient Thermal Impedance, Junction-to-Case (IGBT)

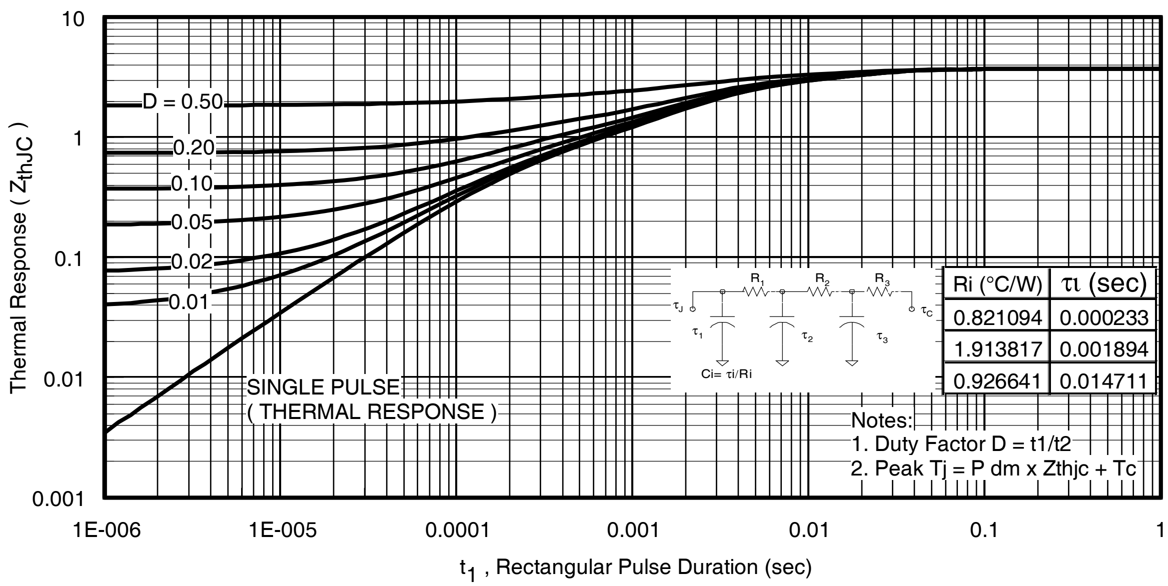


Fig. 26. Maximum Transient Thermal Impedance, Junction-to-Case (DIODE)

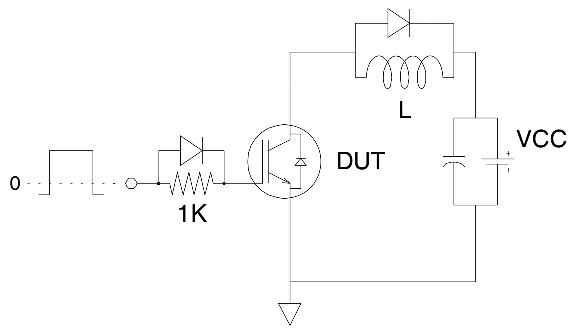


Fig.C.T.1 - Gate Charge Circuit (turn-off)

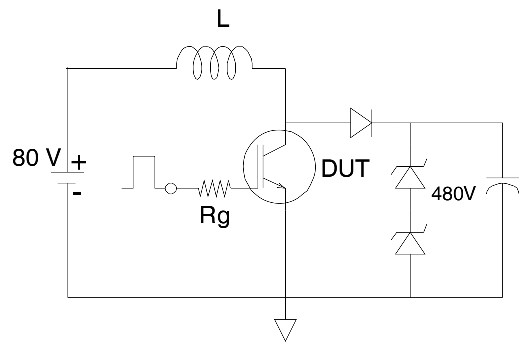


Fig.C.T.2 - RBSOA Circuit

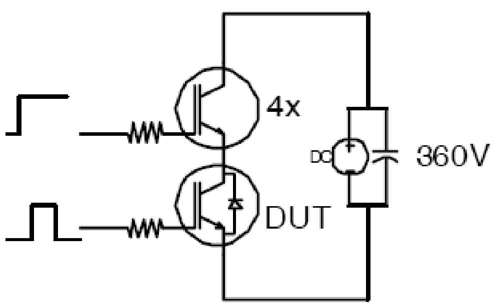


Fig.C.T.3 - S.C.SOA Circuit

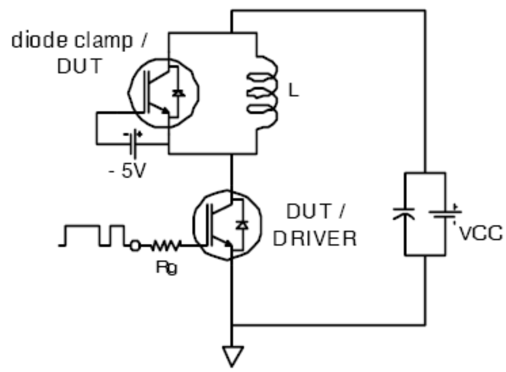


Fig.C.T.4 - Switching Loss Circuit

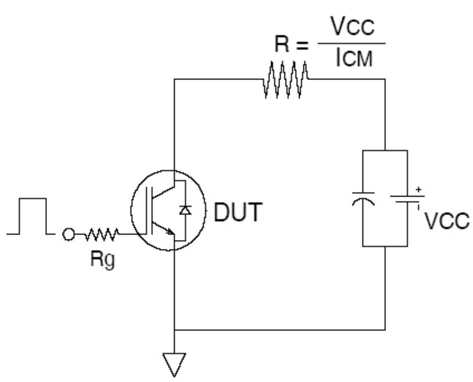


Fig.C.T.5 - Resistive Load Circuit

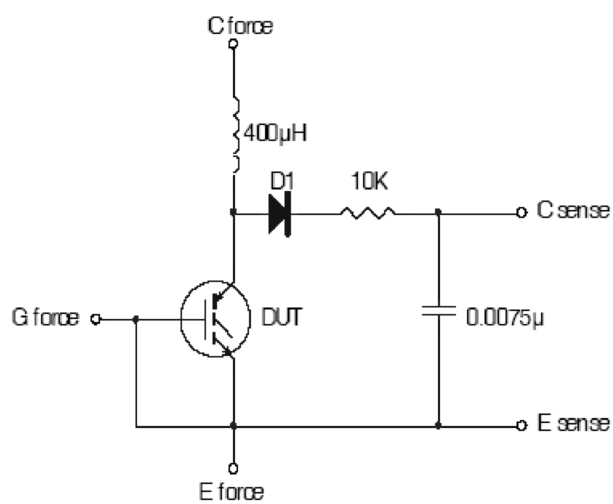


Fig.C.T.6 - Typical Filter Circuit for $V_{(BR)CES}$ Measurement

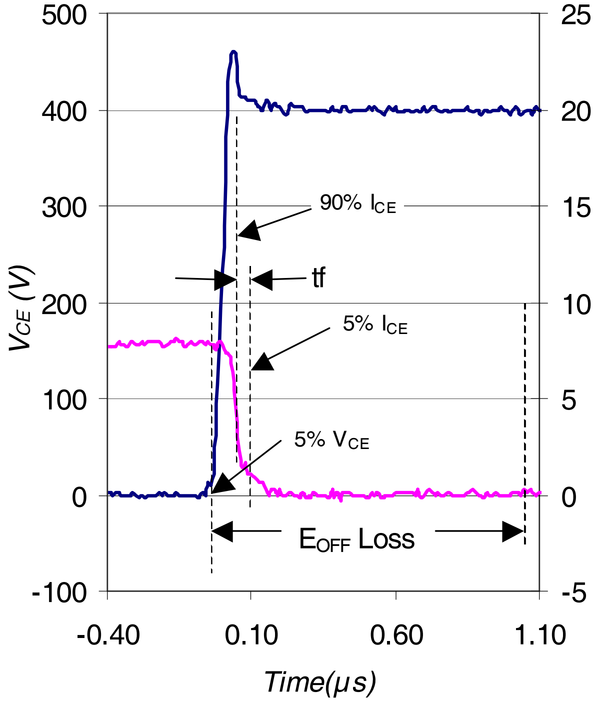


Fig. WF1 - Typ. Turn-off Loss Waveform
@ T_J = 175°C using Fig. CT.4

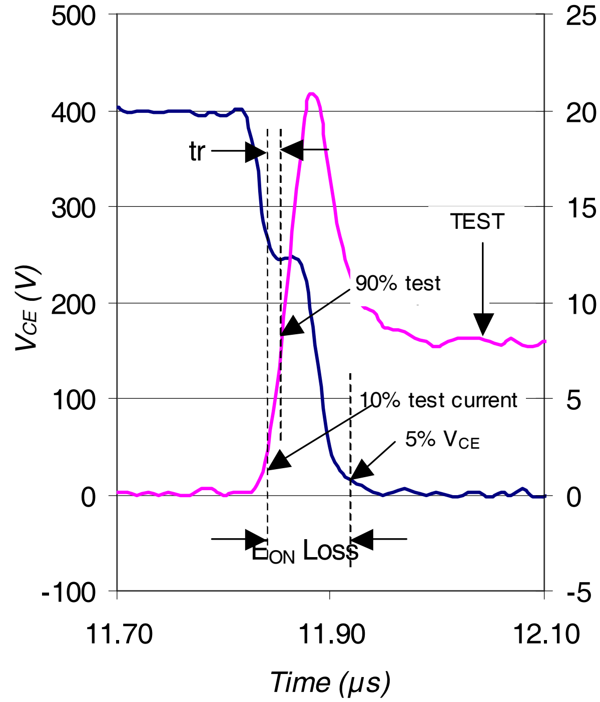
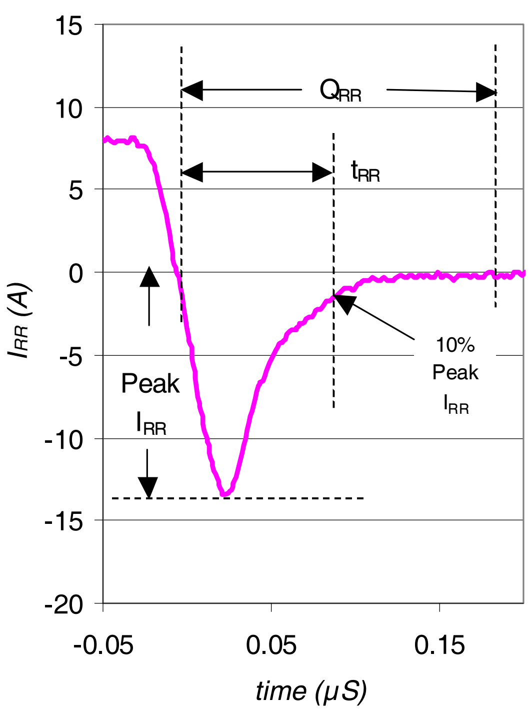
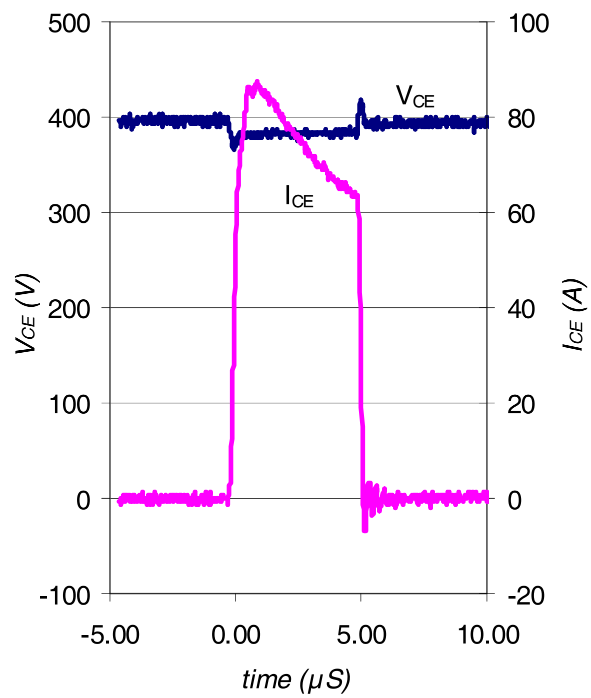


Fig. WF2 - Typ. Turn-on Loss Waveform
@ T_J = 175°C using Fig. CT.4

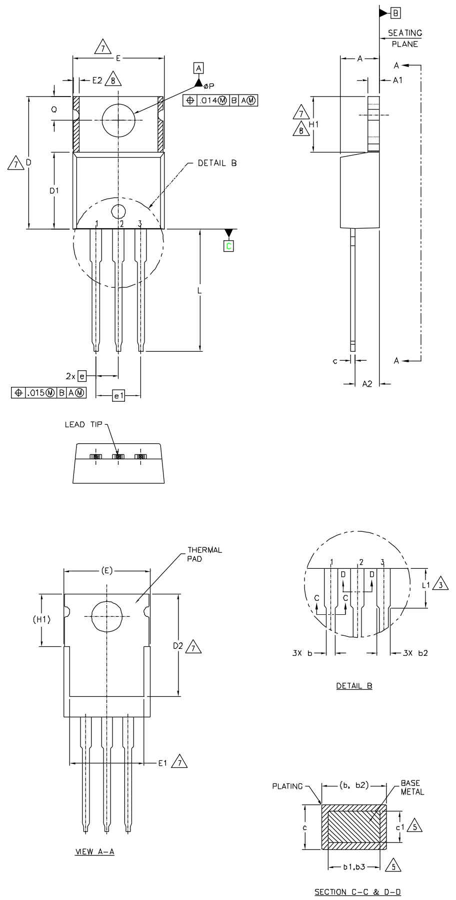


WF.3- Typ. Reverse Recovery Waveform
@ T_J = 175°C using CT.4



WF.4- Typ. Short Circuit Waveform
@ T_J = 25°C using CT.3

TO-220AB Package Outline (Dimensions are shown in millimeters (inches))



NOTES:

1.– DIMENSIONING AND TOLERANCING AS PER ASME Y14.5 M– 1994.
2.– DIMENSIONS ARE SHOWN IN INCHES [MILLIMETERS].
3.– LEAD DIMENSION AND FINISH UNCONTROLLED IN L1.
4.– DIMENSION D, D1 & 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.– DIMENSION b1, b3 & c1 APPLY TO BASE METAL ONLY.
6.– CONTROLLING DIMENSION : INCHES.
7.– THERMAL PAD CONTOUR OPTIONAL WITHIN DIMENSIONS E,H1,D2 & E1
8.– DIMENSION E2 X H1 DEFINE A ZONE WHERE STAMPING AND SINGULATION IRREGULARITIES ARE ALLOWED.
9.– OUTLINE CONFORMS TO JEDEC TO-220, EXCEPT A2 (max.) AND D2 (min.) WHERE DIMENSIONS ARE DERIVED FROM THE ACTUAL PACKAGE OUTLINE.

SYMBOL	DIMENSIONS				NOTES
	MILLIMETERS		INCHES		
	MIN.	MAX.	MIN.	MAX.	
A	3.56	4.83	.140	.190	
A1	1.14	1.40	.045	.055	
A2	2.03	2.92	.080	.115	
b	0.38	1.01	.015	.040	
b1	0.38	0.97	.015	.038	5
b2	1.14	1.78	.045	.070	
b3	1.14	1.73	.045	.068	5
c	0.36	0.61	.014	.024	
c1	0.36	0.56	.014	.022	5
D	14.22	16.51	.560	.650	4
D1	8.38	9.02	.330	.355	
D2	11.68	12.88	.460	.507	7
E	9.65	10.67	.380	.420	4,7
E1	6.86	8.89	.270	.350	7
E2	–	0.76	–	.030	8
e	2.54 BSC		.100 BSC		
e1	5.08 BSC		.200 BSC		
H1	5.84	6.86	.230	.270	7,8
L	12.70	14.73	.500	.580	
L1	3.56	4.06	.140	.160	3
ØP	3.54	4.08	.139	.161	
Q	2.54	3.42	.100	.135	

LEAD ASSIGNMENTS

HEXFET

1.– GATE
2.– DRAIN
3.– SOURCE

IGBTs, CoPACK

1.– GATE
2.– COLLECTOR
3.– EMITTER

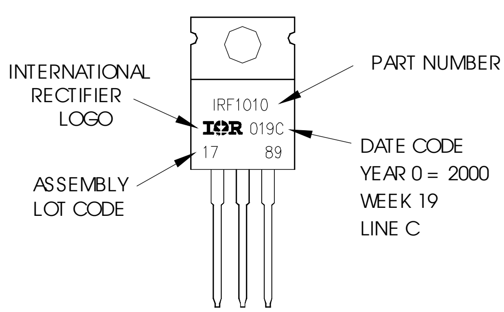
DIODES

1.– ANODE
2.– CATHODE
3.– ANODE

TO-220AB Part Marking Information

EXAMPLE: THIS IS AN IRF1010
LOT CODE 1789
ASSEMBLED ON WW 19, 2000
IN THE ASSEMBLY LINE "C"

Note: "P" in assembly line position indicates "Lead - Free"

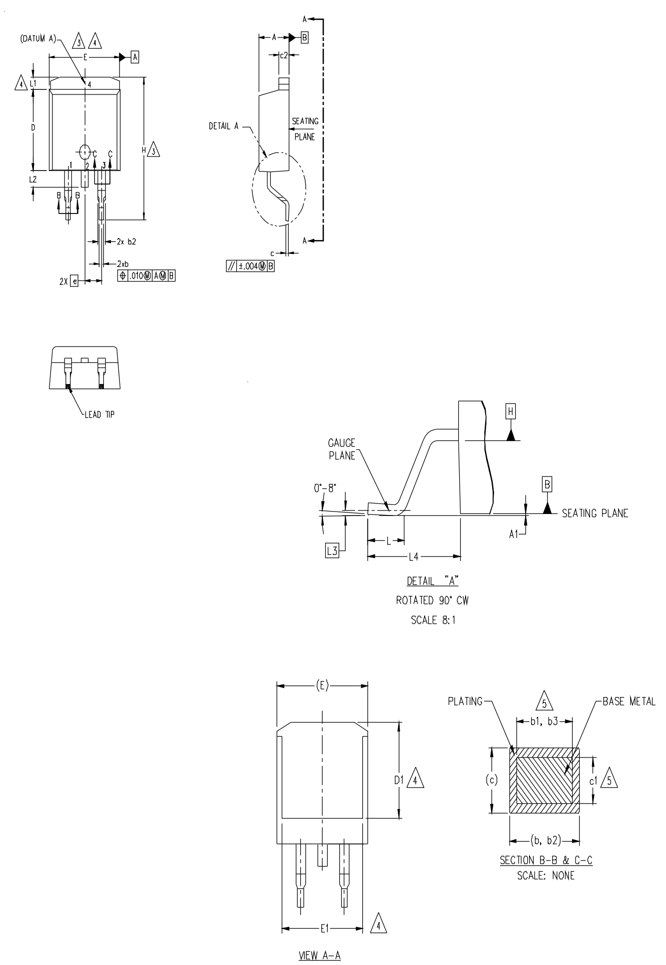


TO-220AB packages are not recommended for Surface Mount Application.

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

D²Pak Package Outline

Dimensions are shown in millimeters (inches)



SYMBOL	DIMENSIONS				NOTES
	MILLIMETERS		INCHES		
	MIN.	MAX.	MIN.	MAX.	
A	4.06	4.83	.160	.190	
A1	0.00	0.254	.000	.010	
b	0.51	0.99	.020	.039	
b1	0.51	0.89	.020	.035	5
b2	1.14	1.78	.045	.070	
b3	1.14	1.73	.045	.068	5
c	0.38	0.74	.015	.029	
c1	0.38	0.58	.015	.023	5
c2	1.14	1.65	.045	.065	
D	8.38	9.65	.330	.380	3
D1	6.86	–	.270		4
E	9.65	10.67	.380	.420	3,4
E1	6.22	–	.245		4
e	2.54 BSC		.100 BSC		
H	14.61	15.88	.575	.625	
L	1.78	2.79	.070	.110	
L1	–	1.65	–	.066	4
L2	–	1.78	–	.070	
L3	0.25 BSC		.010 BSC		
L4	4.78	5.28	.188	.208	

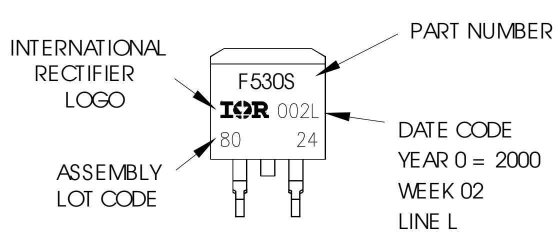
NOTES:

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994
2. DIMENSIONS ARE SHOWN IN MILLIMETERS [INCHES].
3. DIMENSION D & E DO NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED 0.127 [.005"] PER SIDE. THESE DIMENSIONS ARE MEASURED AT THE OUTMOST EXTREMES OF THE PLASTIC BODY AT DATUM H.
4. THERMAL PAD CONTOUR OPTIONAL WITHIN DIMENSION E, L1, D1 & E1.
5. DIMENSION b1 AND c1 APPLY TO BASE METAL ONLY.
6. DATUM A & B TO BE DETERMINED AT DATUM PLANE H.
7. CONTROLLING DIMENSION: INCH.
8. OUTLINE CONFORMS TO JEDEC OUTLINE TO-263AB.

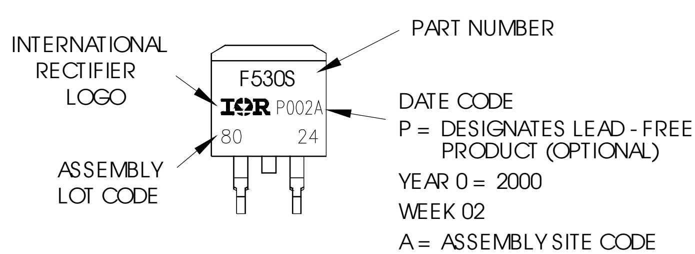
D²Pak Part Marking Information

EXAMPLE: THIS IS AN IRF530S WITH
LOT CODE 8024
ASSEMBLED ON WW 02, 2000
IN THE ASSEMBLY LINE "L"

Note: "P" in assembly line position indicates "Lead – Free"

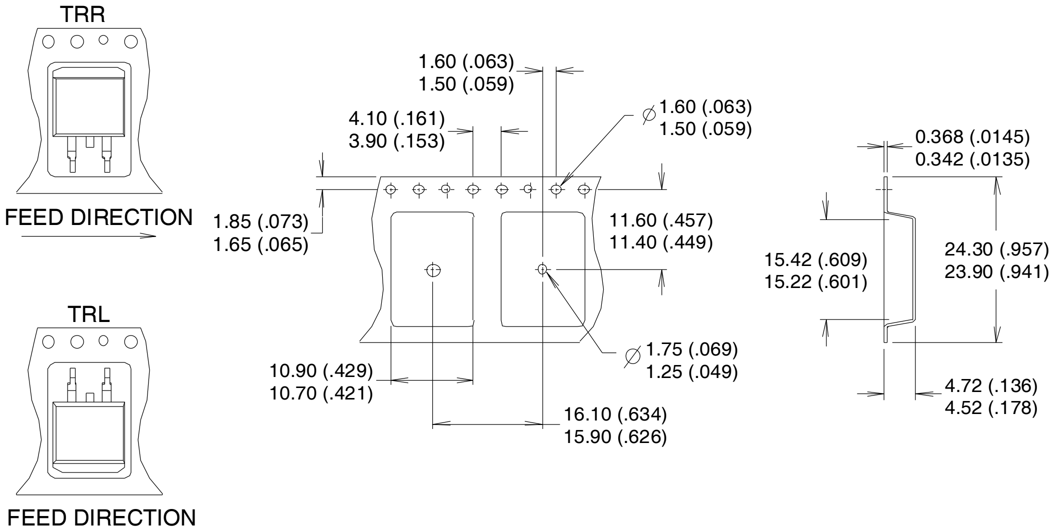


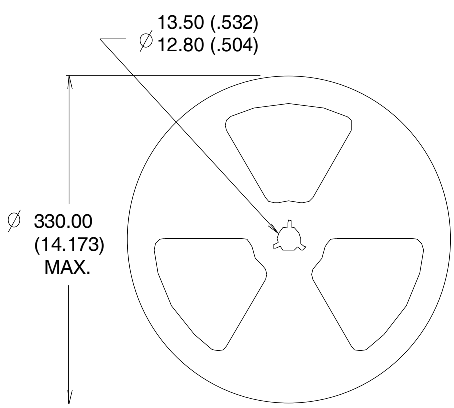
OR

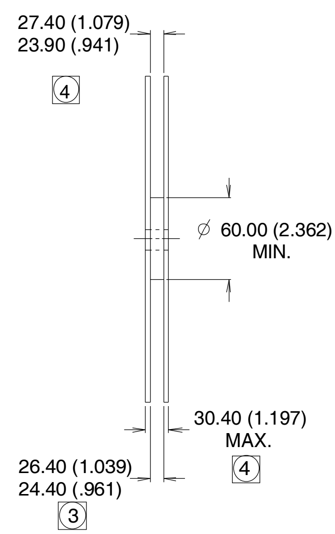


Note: For the most current drawing please refer to IR website at http://www.irf.com/package/

D^2Pak Tape & Reel Information (Dimensions are shown in millimeters (inches))







NOTES :
1. COMFORMS TO EIA-418.
2. CONTROLLING DIMENSION: MILLIMETER.
3. DIMENSION MEASURED @ HUB.
4. INCLUDES FLANGE DISTORTION @ OUTER EDGE.

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

Qualification Information†

Qualification Level	Industrial (per JEDEC JESD47F) ††	
Moisture Sensitivity Level	D^2Pak	MSL1
	TO-220	N/A
RoHS Compliant	Yes	

† Qualification standards can be found at International Rectifier's web site: http://www.irf.com/product-info/reliability
†† Applicable version of JEDEC standard at the time of product release

Revision History

Date	Comments
11/14/2014	• Added note ④ to I_{FM} Diode Maximum Forward Current on page 1. • Added note ⑤ to switching losses test condition on page 2. • Updated package outline on page 10.

International Rectifier
IR WORLD HEADQUARTERS: 101 N. Sepulveda Blvd., El Segundo, California 90245, USA
To contact International Rectifier, please visit http://www.irf.com/whoto-call/

