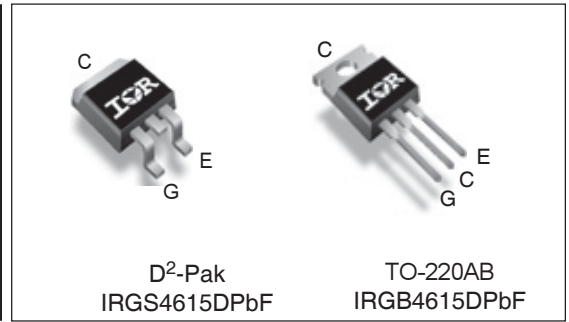
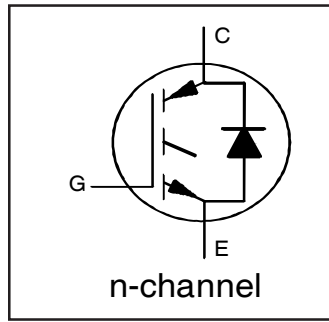


**Insulated Gate Bipolar Transistor with Ultrafast Soft Recovery Diode**

$V_{CES} = 600V$
$I_C = 15A, T_C = 100^\circ C$
$t_{sc} > 5\mu s, T_{jmax} = 175^\circ C$
$V_{CE(on) typ.} = 1.55V @ 8A$



<b>G</b>	<b>C</b>	<b>E</b>
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 <sup>2</sup> 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
$I_C @ T_C = 25^\circ C$	Continuous Collector Current	23	A
$I_C @ T_C = 100^\circ C$	Continuous Collector Current	15	
$I_{CM}$	Pulsed Collector Current, $V_{GE} = 15V \text{⓪}$	24	
$I_{LM}$	Clamped Inductive Load Current, $V_{GE} = 20V \text{⓪}$	32	
$I_F @ T_C = 25^\circ C$	Diode Continuous Forward Current	14	
$I_F @ T_C = 100^\circ C$	Diode Continuous Forward Current	9	
$I_{FM}$	Diode Maximum Forward Current $\text{⓪}$	32	
$V_{GE}$	Continuous Gate-to-Emitter Voltage	± 20	V
	Transient Gate-to-Emitter Voltage	± 30	
$P_D @ T_C = 25^\circ$	Maximum Power Dissipation	99	W
$P_D @ T_C = 100^\circ$	Maximum Power Dissipation	50	
$T_J$	Operating Junction and	-40 to + 175	°C
$T_{STG}$	Storage Temperature Range		
	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<sup>③</sup>**

	Parameter	Min.	Typ.	Max.	Units
$R_{\theta JC}$	Thermal Resistance, Junction-to-Case -(each IGBT)	—	—	1.51	°C/W
$R_{\theta JC}$	Thermal Resistance, Junction-to-Case -(each Diode)	—	—	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 <sup>④</sup> D <sup>2</sup> PAK)	—	40	—	
	Thermal Resistance, Junction-to-Ambient ( Socket mount: TO-220)	—	80	—	

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

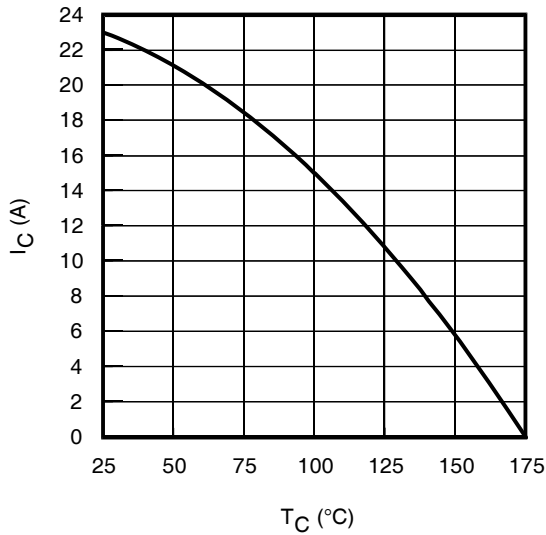
	Parameter	Min.	Typ.	Max.	Units	Conditions
$V_{(BR)CES}$	Collector-to-Emitter Breakdown Voltage	600	—	—	V	$V_{GE} = 0V, I_C = 100\mu A$ <sup>⑤</sup>
$\Delta V_{(BR)CES}/\Delta T_J$	Temperature Coeff. of Breakdown Voltage	—	0.3	—	V/°C	$V_{GE} = 0V, I_C = 250\mu A$ ( 25 -175 °C ) <sup>⑤</sup>
$V_{CE(on)}$	Collector-to-Emitter Saturation Voltage	—	1.55	1.85	V	$I_C = 8.0A, V_{GE} = 15V, T_J = 25^\circ\text{C}$
		—	1.95	—		$I_C = 8.0A, V_{GE} = 15V, T_J = 150^\circ\text{C}$
		—	2.00	—		$I_C = 8.0A, V_{GE} = 15V, T_J = 175^\circ\text{C}$
$V_{GE(th)}$	Gate Threshold Voltage	4.0	—	6.5	V	$V_{CE} = V_{GE}, I_C = 250\mu A$
$\Delta V_{GE(th)}/\Delta T_J$	Threshold Voltage temp. coefficient	—	-18	—	mV/°C	$V_{CE} = V_{GE}, I_C = 250\mu A$ ( 25 -175 °C )
$g_{fe}$	Forward Transconductance	—	5.6	—	S	$V_{CE} = 50V, I_C = 8.0A, PW = 80\mu s$
$I_{CES}$	Collector-to-Emitter Leakage Current	—	—	25	$\mu A$	$V_{GE} = 0V, V_{CE} = 600V$
		—	400	—		$V_{GE} = 0V, V_{CE} = 600V, T_J = 175^\circ\text{C}$
$V_{FM}$	Diode Forward Voltage Drop	—	1.80	2.8	V	$I_F = 8.0A$
		—	1.30	—		$I_F = 8.0A, T_J = 175^\circ\text{C}$
$I_{GES}$	Gate-to-Emitter Leakage Current	—	—	$\pm 100$	nA	$V_{GE} = \pm 20V$

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

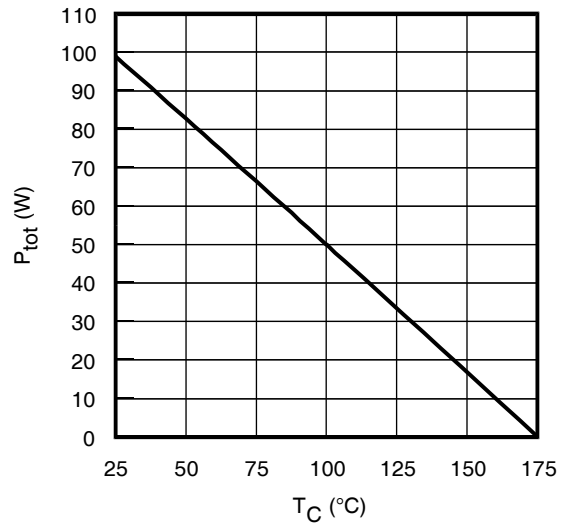
	Parameter	Min.	Typ.	Max.	Units	Conditions
$Q_g$	Total Gate Charge (turn-on)	—	19	—	nC	$I_C = 8.0A$
$Q_{ge}$	Gate-to-Emitter Charge (turn-on)	—	5	—		$V_{CC} = 400V$
$Q_{gc}$	Gate-to-Collector Charge (turn-on)	—	8	—		$V_{GE} = 15V$
$E_{on}$	Turn-On Switching Loss	—	70	—	$\mu J$	$I_C = 8.0A, V_{CC} = 400V, V_{GE} = 15V$
$E_{off}$	Turn-Off Switching Loss	—	145	—		$R_G = 47\Omega, L = 1mH, L_S = 150nH, T_J = 25^\circ\text{C}$
$E_{total}$	Total Switching Loss	—	215	—		Energy losses include tail and diode reverse recovery
$t_{d(on)}$	Turn-On delay time	—	30	—	ns	$I_C = 8.0A, V_{CC} = 400V$
$t_r$	Rise time	—	15	—		$R_G = 47\Omega, L = 1mH, L_S = 150nH$
$t_{d(off)}$	Turn-Off delay time	—	95	—		$T_J = 25^\circ\text{C}$
$t_f$	Fall time	—	20	—		
$E_{on}$	Turn-On Switching Loss	—	165	—	$\mu J$	$I_C = 8.0A, V_{CC} = 400V, V_{GE} = 15V$
$E_{off}$	Turn-Off Switching Loss	—	240	—		$R_G = 47\Omega, L = 1mH, L_S = 150nH, T_J = 175^\circ\text{C}$
$E_{total}$	Total Switching Loss	—	405	—		Energy losses include tail and diode reverse recovery
$t_{d(on)}$	Turn-On delay time	—	28	—	ns	$I_C = 8.0A, V_{CC} = 400V$
$t_r$	Rise time	—	17	—		$R_G = 47\Omega, L = 1mH, L_S = 150nH$
$t_{d(off)}$	Turn-Off delay time	—	117	—		$T_J = 175^\circ\text{C}$
$t_f$	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				$T_J = 175^\circ\text{C}, I_C = 32A$ $V_{CC} = 480V, V_p = 600V$ $R_G = 47\Omega, V_{GE} = +20V$ to 0V
SCSOA	Short Circuit Safe Operating Area	5	—	—	$\mu s$	$V_{CC} = 400V, V_p = 600V$ $R_G = 47\Omega, V_{GE} = +15V$ to 0V
$E_{rec}$	Reverse recovery energy of the diode	—	165	—	$\mu J$	$T_J = 175^\circ\text{C}$
$t_{rr}$	Diode Reverse recovery time	—	60	—	ns	$V_{CC} = 400V, I_F = 8.0A$
$I_{rr}$	Peak Reverse Recovery Current	—	14	—	A	$V_{GE} = 15V, R_G = 47\Omega, L = 1mH, L_S = 150nH$

**Notes:**

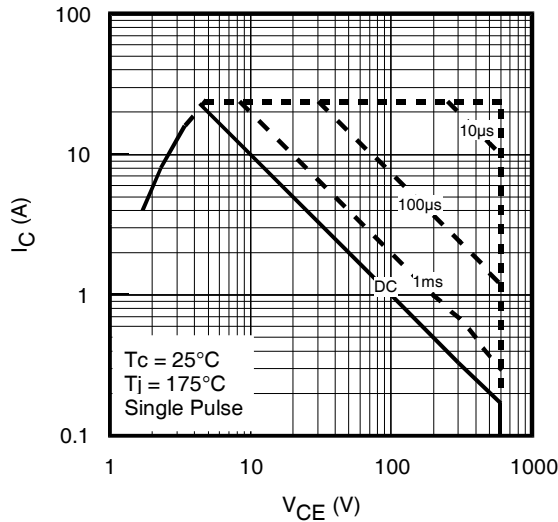
- ①  $V_{CC} = 80\% (V_{CES}), V_{GE} = 20V, L = 100\mu H, R_G = 47\Omega.$
- ② Pulse width limited by max. junction temperature.
- ③  $R_{\theta}$  is measured at  $T_J$  approximately  $90^\circ\text{C}.$
- ④ When mounted on 1" square PCB (FR-4 or G-10 Material). For recommended footprint and soldering techniques refer to application note #AN-994
- ⑤ Refer to AN-1086 for guidelines for measuring  $V_{(BR)CES}$  safely.



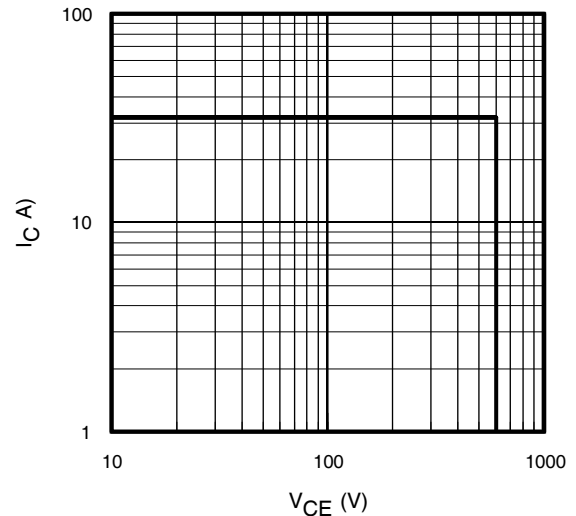
**Fig. 1 - Maximum DC Collector Current vs. Case Temperature**



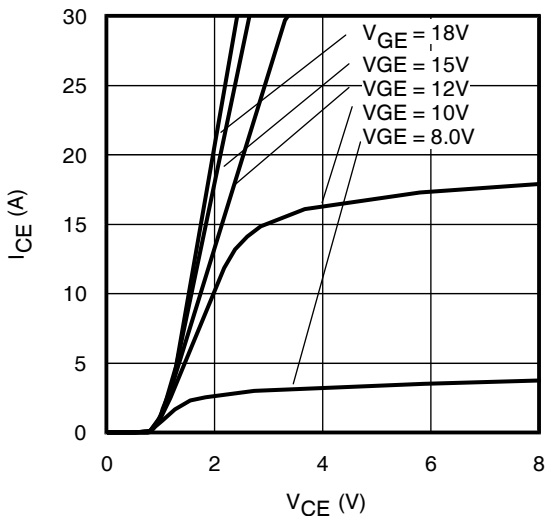
**Fig. 2 - Power Dissipation vs. Case Temperature**



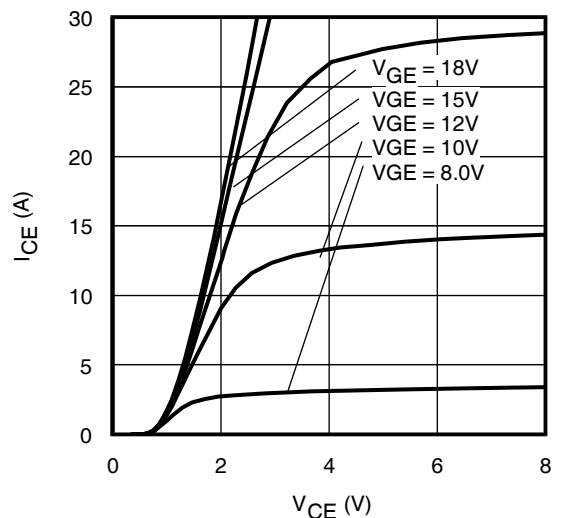
**Fig. 3 - Forward SOA,  
 $T_C = 25^\circ\text{C}$ ;  $T_J \leq 175^\circ\text{C}$**



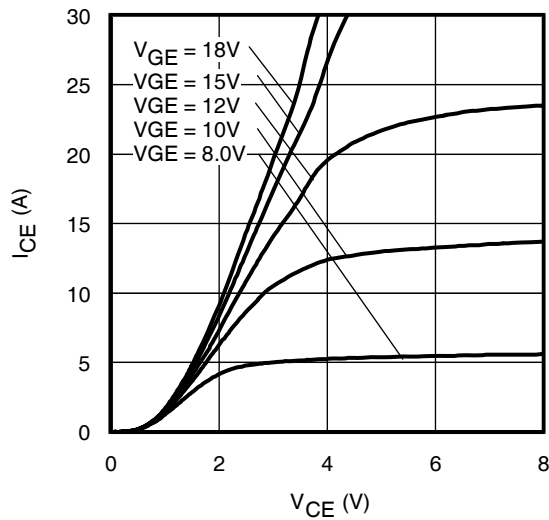
**Fig. 4 - Reverse Bias SOA  
 $T_J = 175^\circ\text{C}$ ;  $V_{CE} = 15\text{V}$**



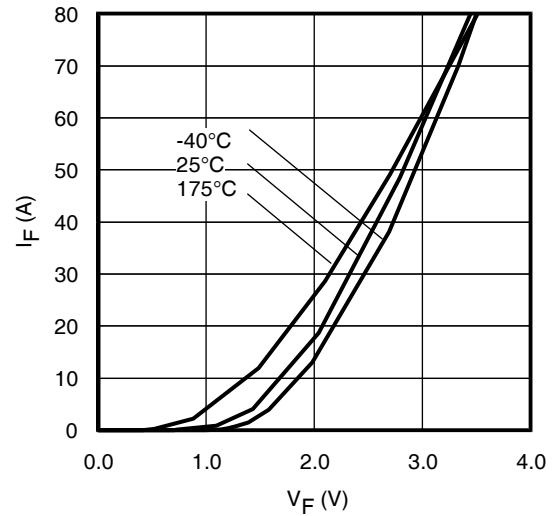
**Fig. 5 - Typ. IGBT Output Characteristics  
 $T_J = -40^\circ\text{C}$ ;  $t_p = 80\mu\text{s}$**



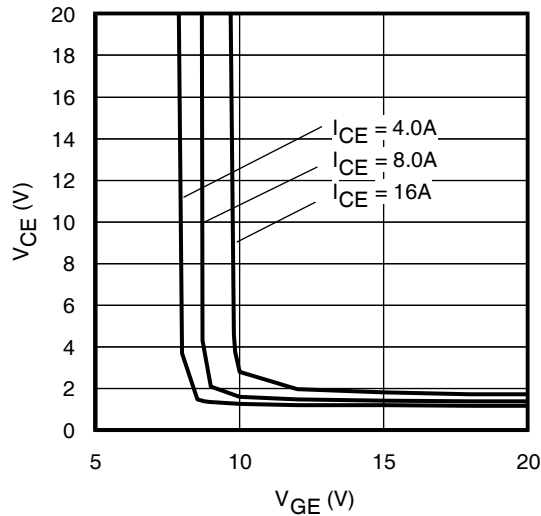
**Fig. 6 - Typ. IGBT Output Characteristics  
 $T_J = 25^\circ\text{C}$ ;  $t_p = 80\mu\text{s}$**



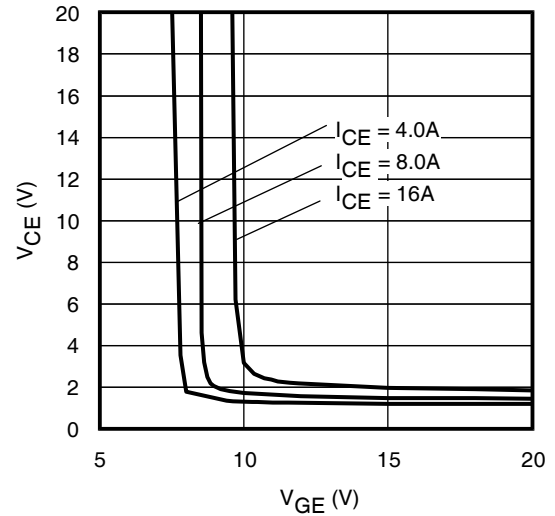
**Fig. 7 - Typ. IGBT Output Characteristics**  
 $T_J = 175^\circ\text{C}$ ;  $t_p = 80\mu\text{s}$



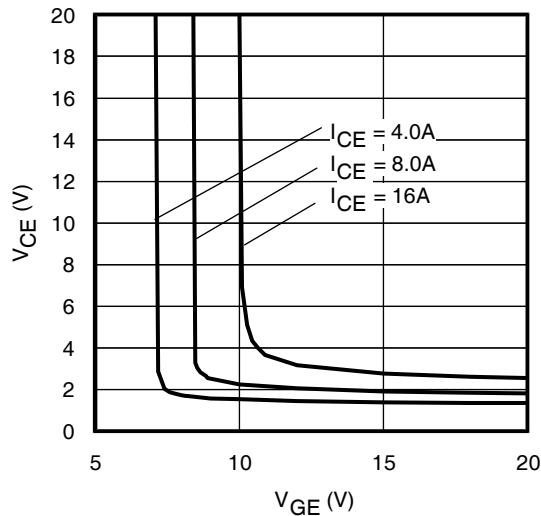
**Fig. 8 - Typ. Diode Forward Characteristics**  
 $t_p = 80\mu\text{s}$



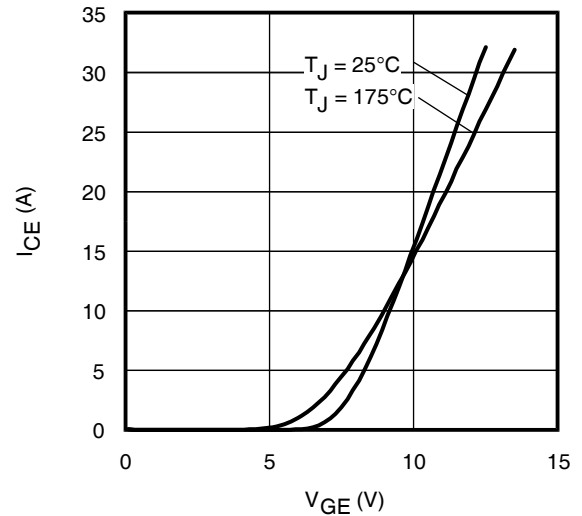
**Fig. 9 - Typical  $V_{CE}$  vs.  $V_{GE}$**   
 $T_J = -40^\circ\text{C}$



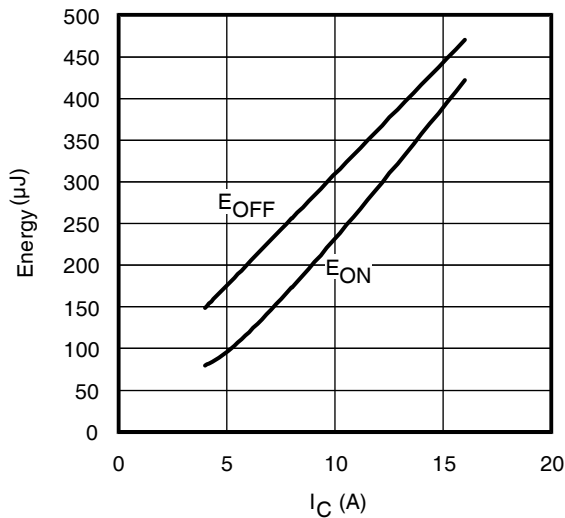
**Fig. 10 - Typical  $V_{CE}$  vs.  $V_{GE}$**   
 $T_J = 25^\circ\text{C}$



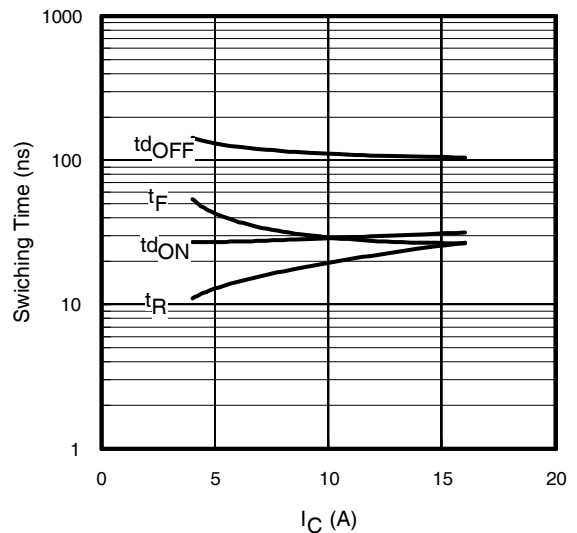
**Fig. 11 - Typical  $V_{CE}$  vs.  $V_{GE}$**   
 $T_J = 175^\circ\text{C}$



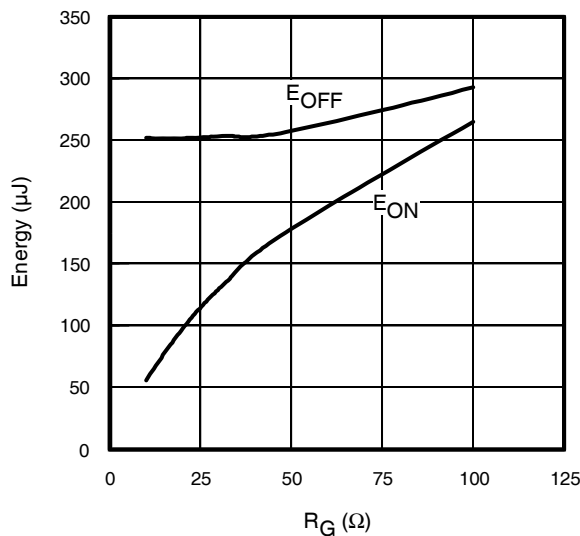
**Fig. 12 - Typ. Transfer Characteristics**  
 $V_{CE} = 50\text{V}$ ;  $t_p = 10\mu\text{s}$



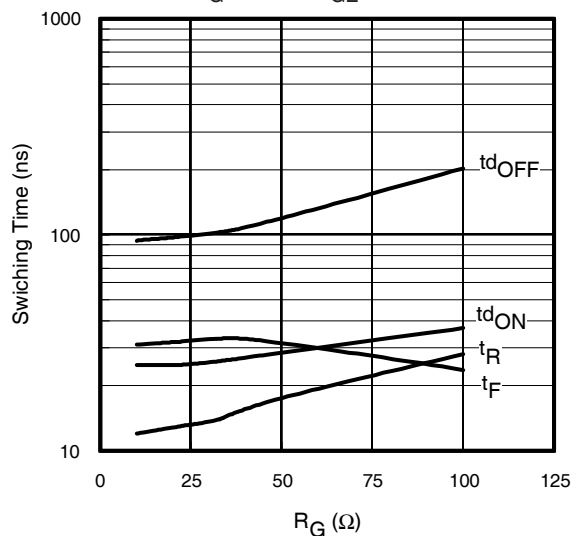
**Fig. 13** - Typ. Energy Loss vs.  $I_C$   
 $T_J = 175^\circ C$ ;  $L = 1mH$ ;  $V_{CE} = 400V$ ,  $R_G = 47\Omega$ ;  $V_{GE} = 15V$ .



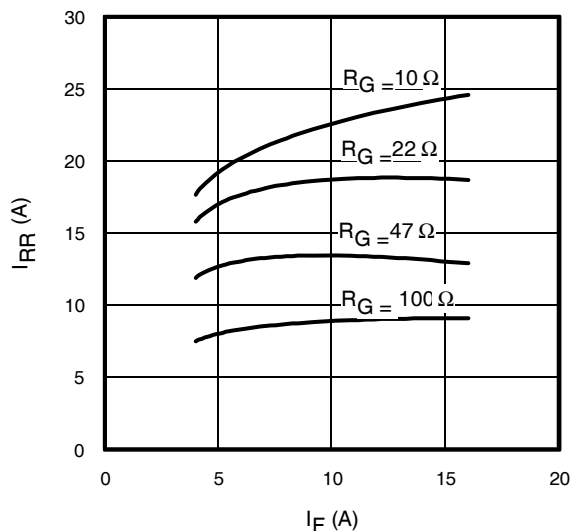
**Fig. 14** - Typ. Switching Time vs.  $I_C$   
 $T_J = 175^\circ C$ ;  $L = 1mH$ ;  $V_{CE} = 400V$   
 $R_G = 47\Omega$ ;  $V_{GE} = 15V$



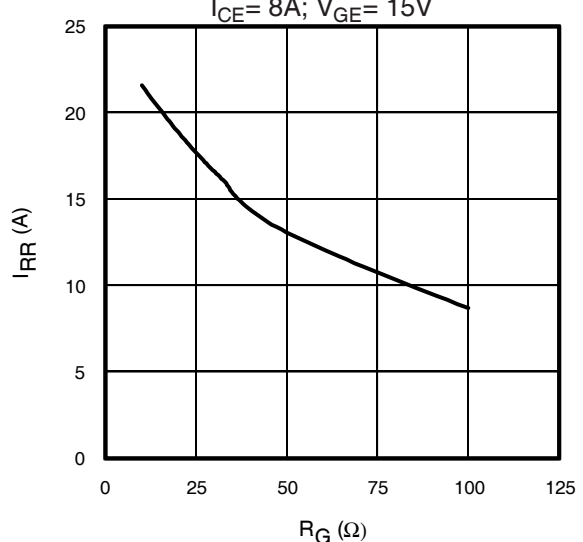
**Fig. 15** - Typ. Energy Loss vs.  $R_G$   
 $T_J = 175^\circ C$ ;  $L = 1mH$ ;  $V_{CE} = 400V$ ,  $I_{CE} = 8A$ ;  $V_{GE} = 15V$



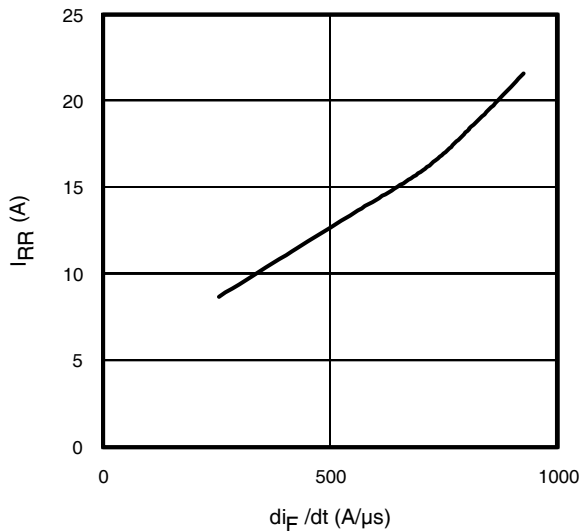
**Fig. 16** - Typ. Switching Time vs.  $R_G$   
 $T_J = 175^\circ C$ ;  $L = 1mH$ ;  $V_{CE} = 400V$   
 $I_{CE} = 8A$ ;  $V_{GE} = 15V$



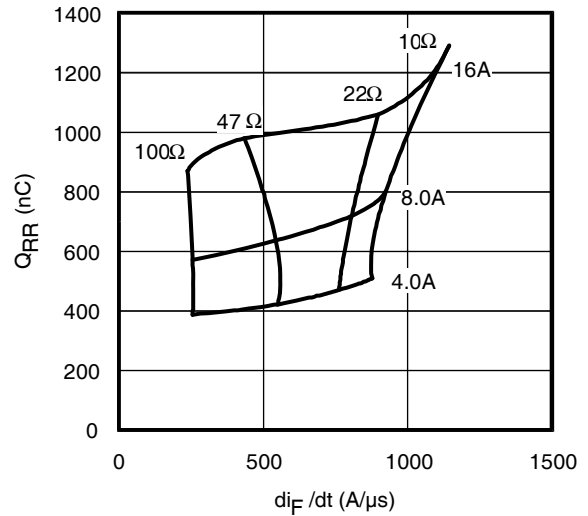
**Fig. 17** - Typical Diode  $I_{RR}$  vs.  $I_F$   
 $T_J = 175^\circ C$



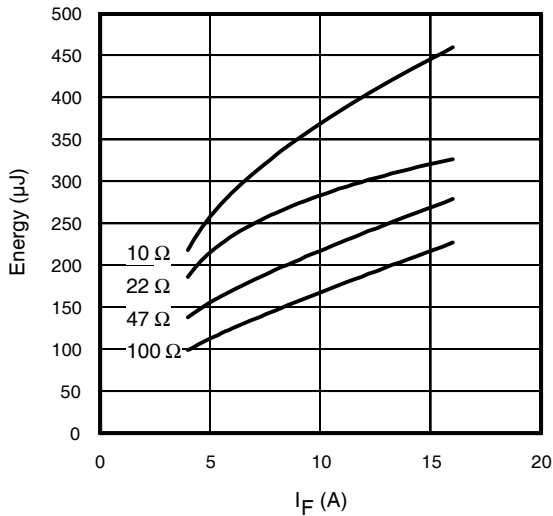
**Fig. 18** - Typical Diode  $I_{RR}$  vs.  $R_G$   
 $T_J = 175^\circ C$ ;  $I_F = 8.0A$



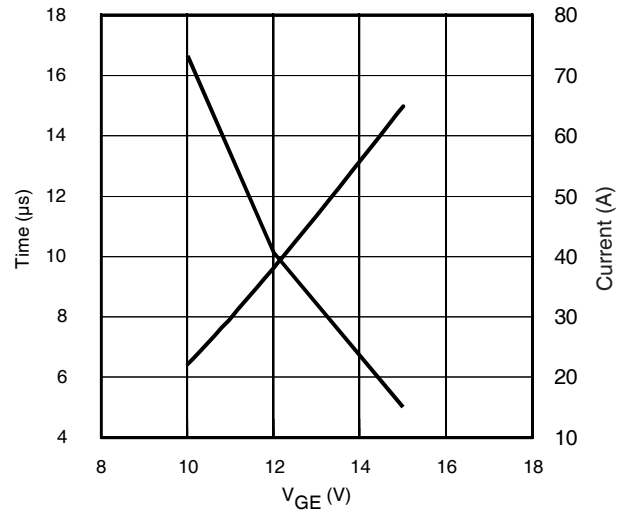
**Fig. 19** - Typical Diode  $I_{RR}$  vs.  $di_F/dt$   
 $V_{CC}=400V$ ;  $V_{GE}=15V$ ;  
 $I_{CE}=8A$ ;  $T_J=175^\circ C$



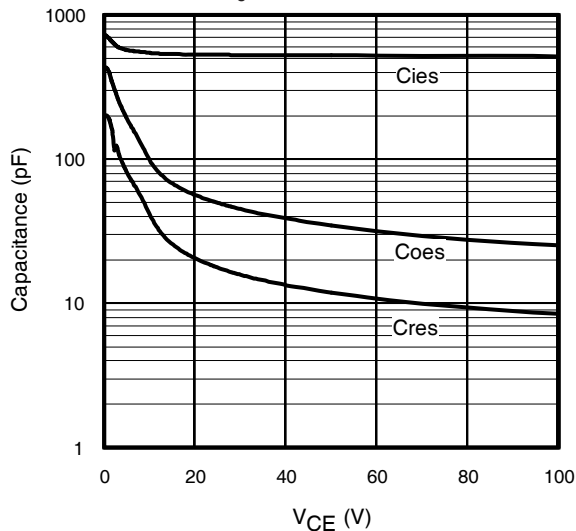
**Fig. 20** - Typical Diode  $Q_{RR}$   
 $V_{CC}=400V$ ;  $V_{GE}=15V$ ;  $T_J=175^\circ C$



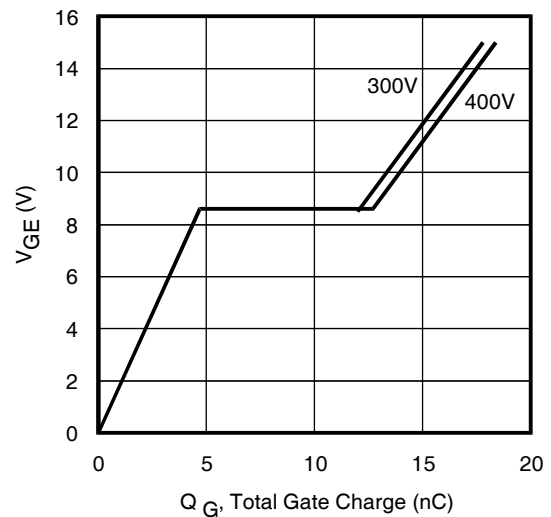
**Fig. 21** - Typical Diode  $E_{RR}$  vs.  $I_F$   
 $T_J=175^\circ C$



**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.  $V_{GE}$   
 $I_{CE}=8A$ ,  $L=600\mu H$

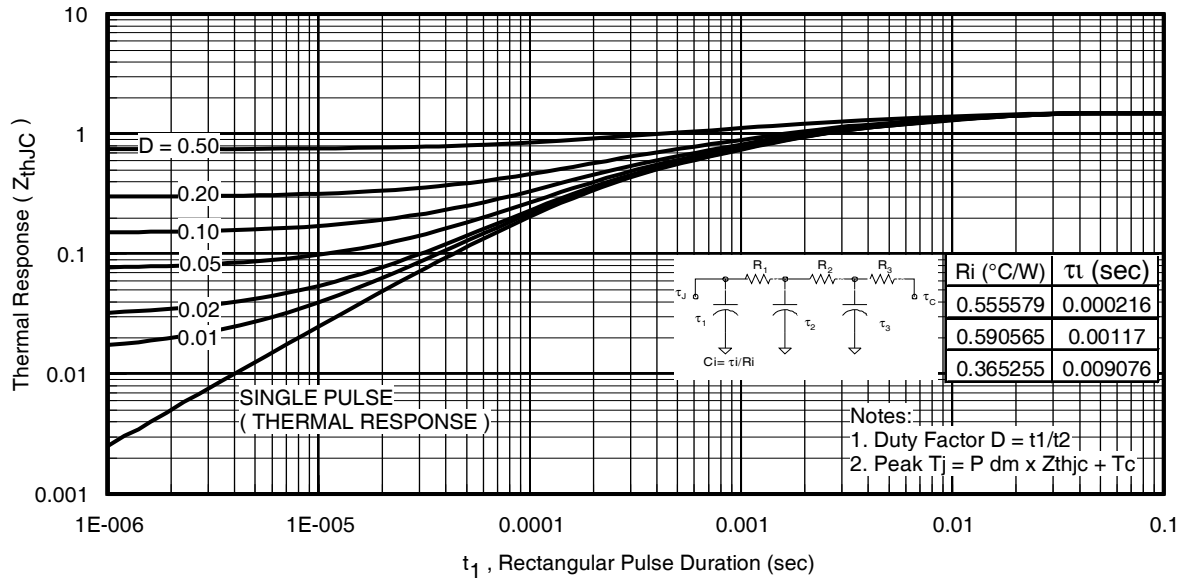


Fig 25. Maximum Transient Thermal Impedance, Junction-to-Case (IGBT)

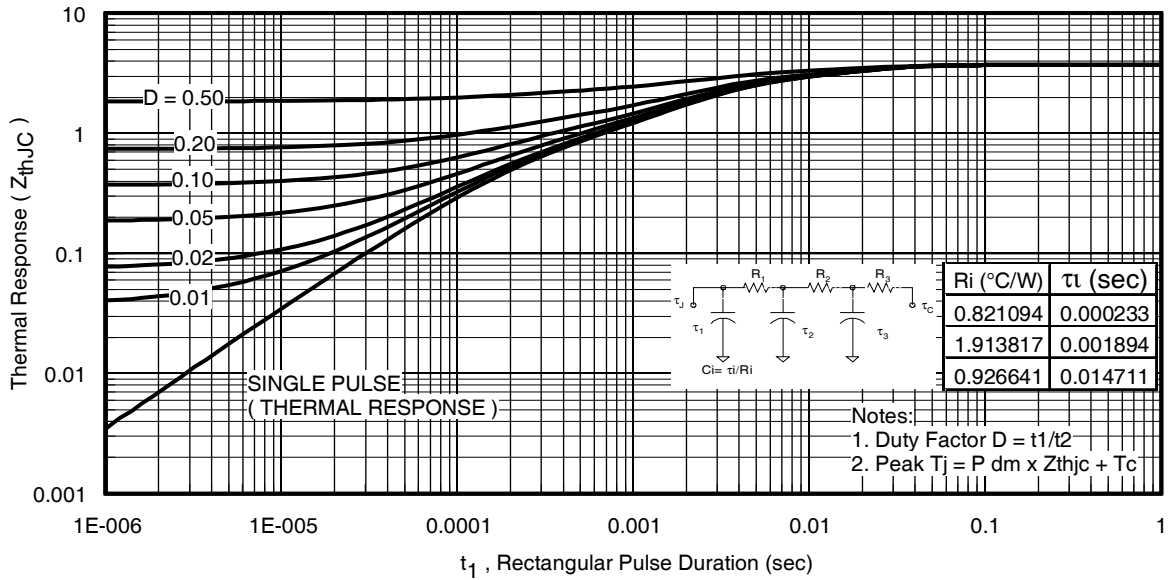
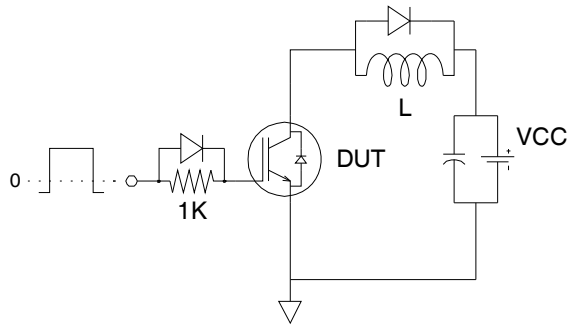
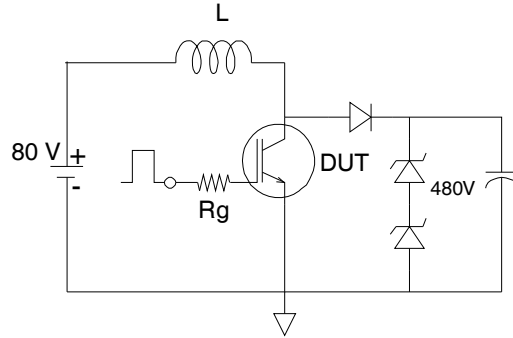
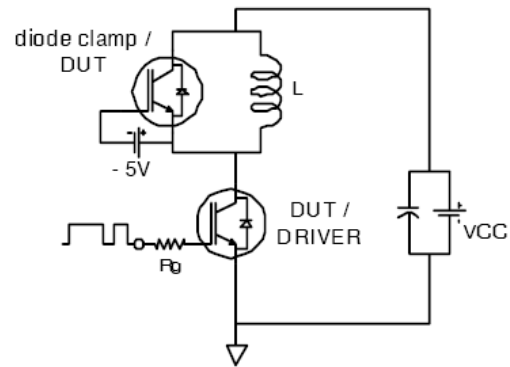
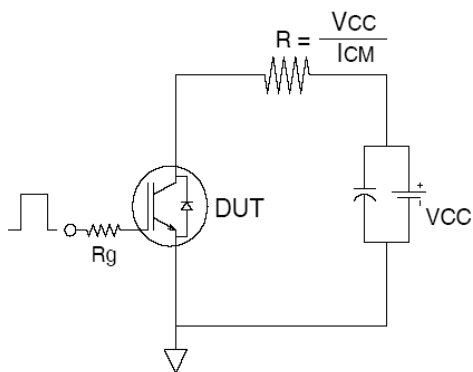
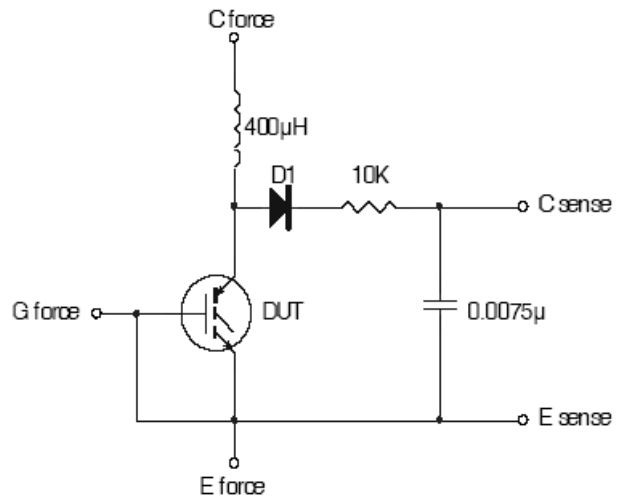
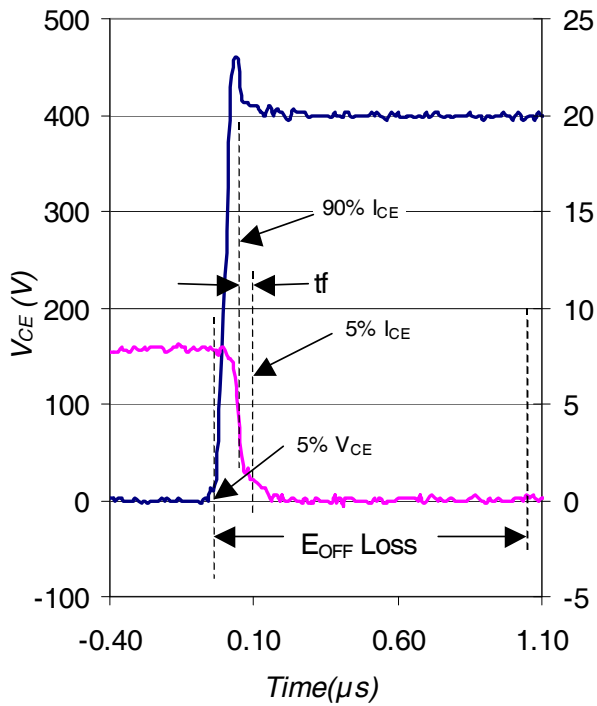


Fig. 26. Maximum Transient Thermal Impedance, Junction-to-Case (DIODE)

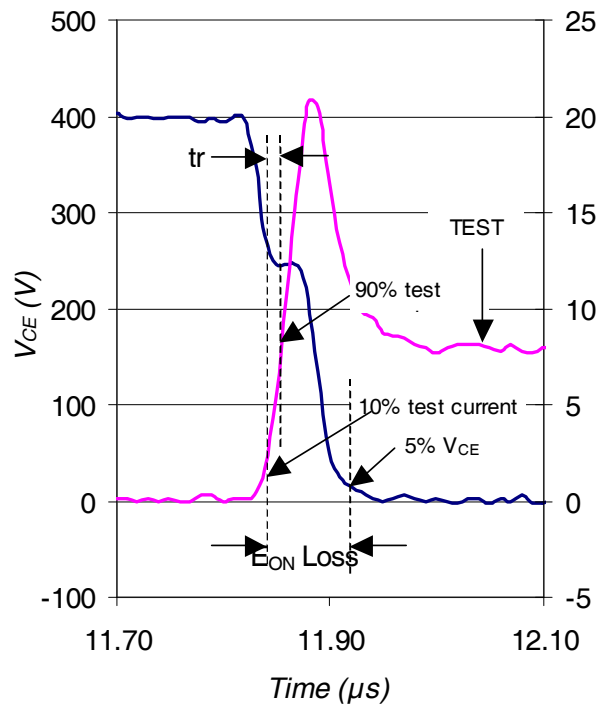

**Fig.C.T.1 - Gate Charge Circuit (turn-off)**

**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**

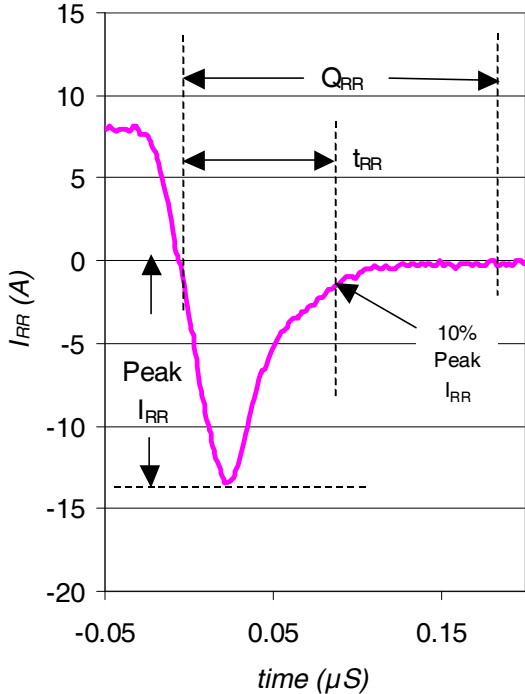




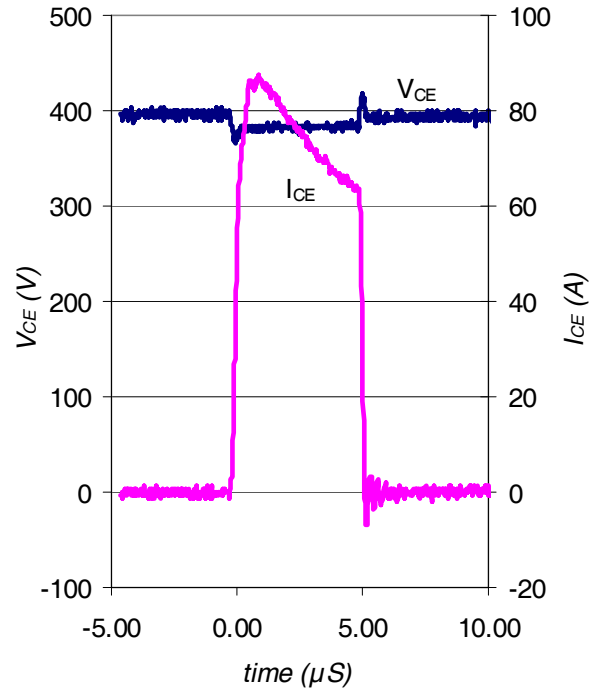
**Fig. WF1** - Typ. Turn-off Loss Waveform  
@  $T_J = 175^\circ\text{C}$  using Fig. CT.4



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

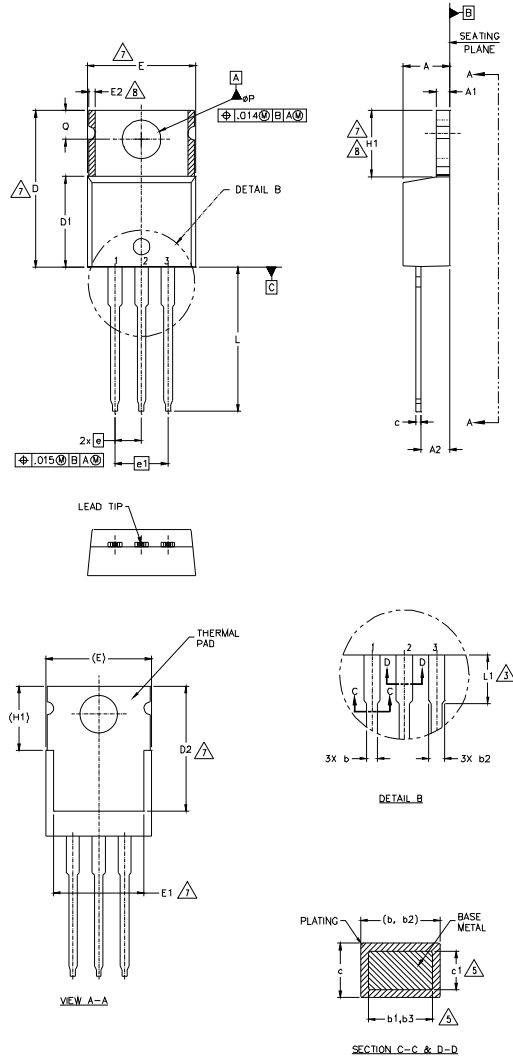


**WF.3-** Typ. Reverse Recovery Waveform  
@  $T_J = 175^\circ\text{C}$  using CT.4



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

## 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	0.51	1.40	.020	.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	-	6.35	-	.250	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

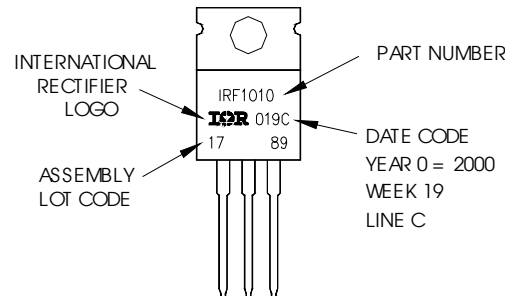
**DIODES**

- 1.- ANODE/OPEN
- 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"

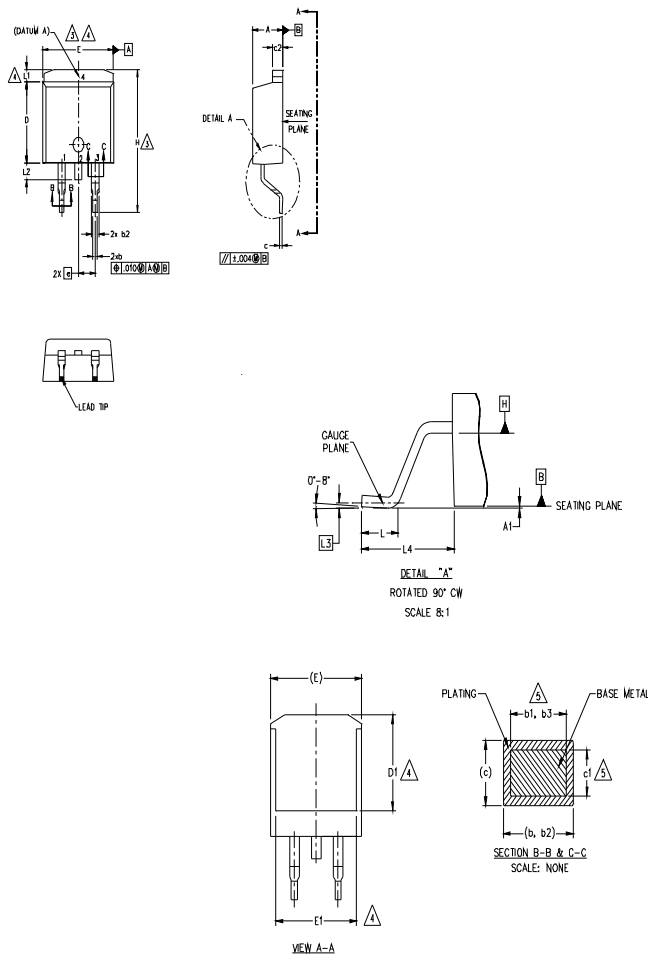


TO-220AB packages are not recommended for Surface Mount Application.

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

## D<sup>2</sup>Pak Package Outline

Dimensions are shown in millimeters (inches)



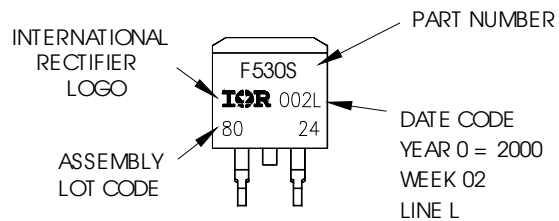
SYMBOL	DIMENSIONS				NOTES
	MILLIMETERS		INCHES		
	MIN.	MAX.	MIN.	MAX.	
A	4.06	4.83	.160	.190	5
A1	0.00	0.254	.000	.010	
b	0.51	0.99	.020	.039	
b1	0.51	0.89	.020	.035	
b2	1.14	1.78	.045	.070	
b3	1.14	1.73	.045	.068	
c	0.38	0.74	.015	.029	
c1	0.38	0.58	.015	.023	
c2	1.14	1.65	.045	.065	
D	8.38	9.65	.330	.380	
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	4
L	1.78	2.79	.070	.110	
L1	—	1.65	—	.066	
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 [0.005] 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.

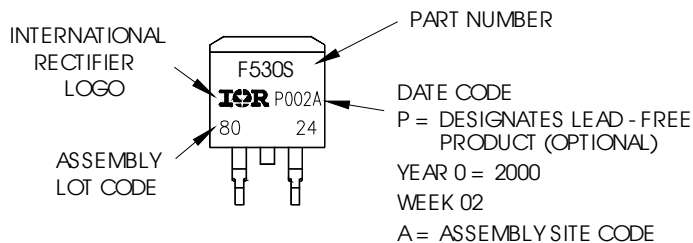
## D<sup>2</sup>Pak Part Marking Information

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

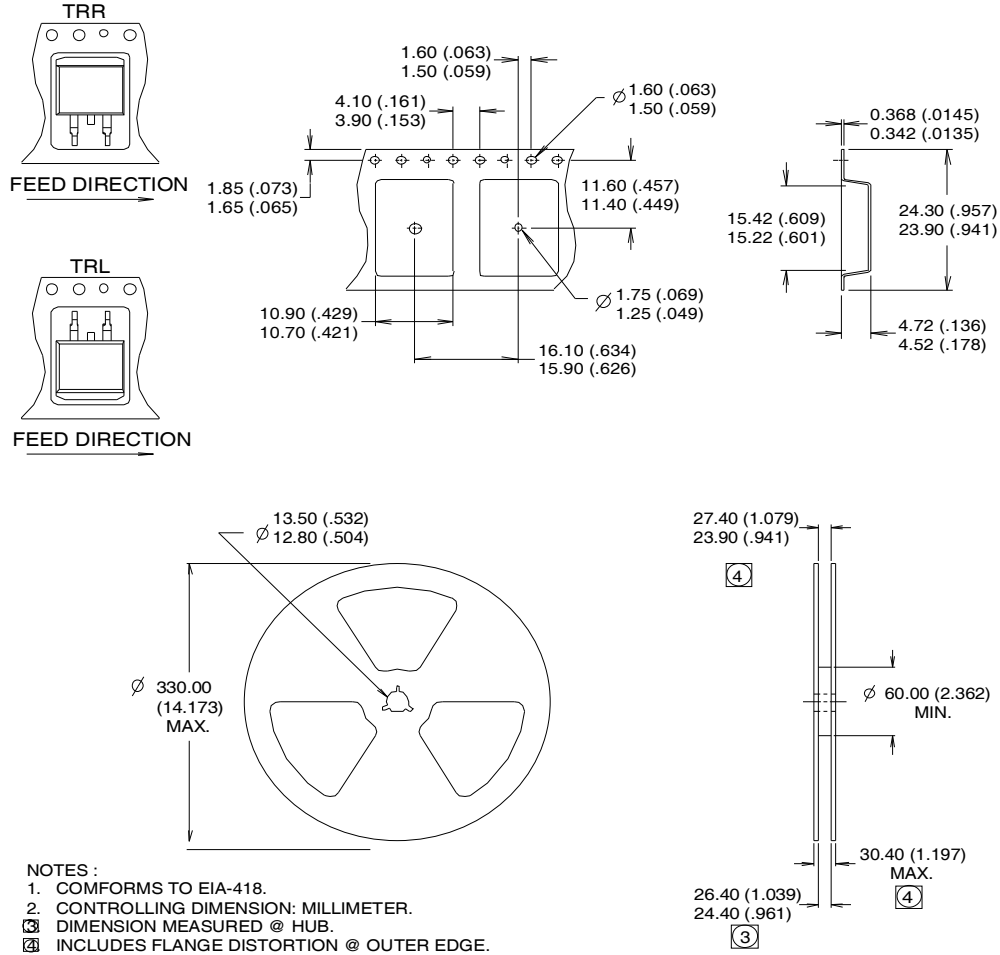
Note: "P" in assembly line position  
indicates "Lead - Free"



OR



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

**D<sup>2</sup>Pak Tape & Reel Information** (Dimensions are shown in millimeters (inches))


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

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

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

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

<sup>††</sup> Applicable version of JEDEC standard at the time of product release