

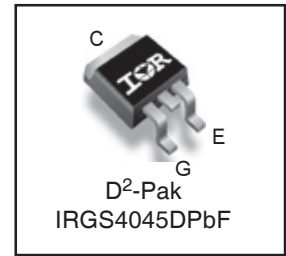
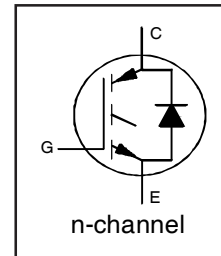
INSULATED GATE BIPOLAR TRANSISTOR WITH  
ULTRAFAST SOFT RECOVERY DIODE

$$V_{CES} = 600V$$

$$I_C = 6.0A, T_C = 100^\circ C$$

$$t_{sc} > 5\mu s, T_{jmax} = 175^\circ C$$

$$V_{CE(on) typ.} = 1.7V$$



<b>G</b>	<b>C</b>	<b>E</b>
Gate	Collector	Emitter

### Applications

- Appliance Motor Drive
- Inverters
- SMPS

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
Ultra fast soft recovery copak diode	Performance optimized for motor drive operation
Lead-free, RoHS compliant	Environmentally friendly

Base part number	Package Type	Standard Pack		Orderable Part Number
		Form	Quantity	
IRGS4045DPbF	D2Pak	Tube	50	IRGS4045DPbF
		Tape and Reel Left	800	IRGS4045DTRLpBF
		Tape and Reel Right	800	IRGS4045DTRRpBF

### 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	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	V
$I_{FM}$ Diode Maximum Forward Current ②	24	
$V_{GE}$ Continuous Gate-to-Emitter Voltage	± 20	W
$V_{GE}$ Transient Gate-to-Emitter Voltage	± 30	
$P_D @ T_C = 25^\circ$ Maximum Power Dissipation	77	°C
$P_D @ T_C = 100^\circ$ 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	—	—	6.3	
$R_{\theta CS}$ Case-to-Sink, Flat, Greased Surface	—	0.5	—	
$R_{\theta JA}$ Junction-to-Ambient (PCB Mountet, steady-state) ⑤	—	—	40	

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

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

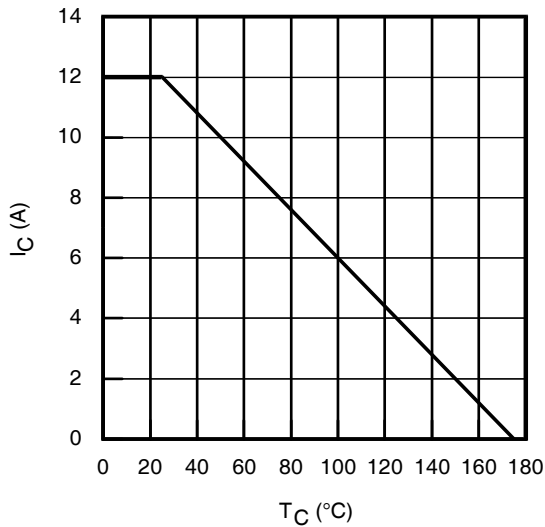
	Parameter	Min.	Typ.	Max.	Units	Conditions
V <sub>(BR)CES</sub>	Collector-to-Emitter Breakdown Voltage	600	—	—	V	V <sub>GE</sub> = 0V, I <sub>C</sub> = 100 μA ④
ΔV <sub>(BR)CES</sub> /ΔT <sub>J</sub>	Temperature Coeff. of Breakdown Voltage	—	0.36	—	V/°C	V <sub>GE</sub> = 0V, I <sub>C</sub> = 250 μA ( 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
		—	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	4.0	—	6.5	V	V <sub>CE</sub> = V <sub>GE</sub> , I <sub>C</sub> = 150 μA
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> = 250 μA ( 25 -175 °C )
g <sub>fe</sub>	Forward Transconductance	—	5.8	—	S	V <sub>CE</sub> = 25V, I <sub>C</sub> = 6.0A, PW = 80 μs
I <sub>CES</sub>	Collector-to-Emitter Leakage Current	—	—	25	μA	V <sub>GE</sub> = 0V, V <sub>CE</sub> = 600V
		—	—	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)**

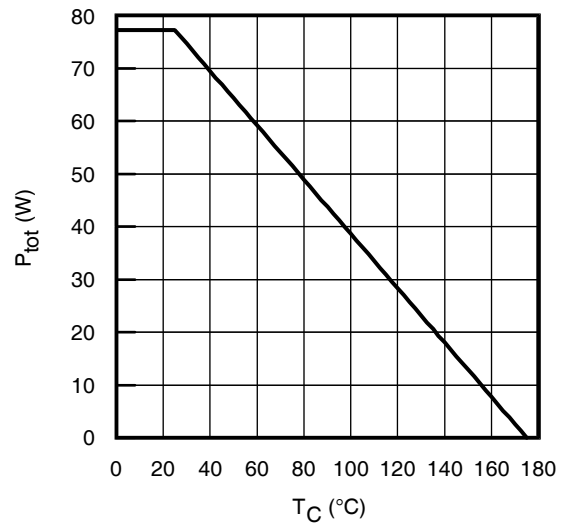
	Parameter	Min.	Typ.	Max. ⑥	Units	Conditions
Q <sub>g</sub>	Total Gate Charge (turn-on)	—	13	19.5	nC	I <sub>C</sub> = 6.0A
Q <sub>ge</sub>	Gate-to-Emitter Charge (turn-on)	—	3.1	4.65		V <sub>CC</sub> = 400V
Q <sub>gc</sub>	Gate-to-Collector Charge (turn-on)	—	6.4	9.6		V <sub>GE</sub> = 15V
E <sub>on</sub>	Turn-On Switching Loss	—	56	86	μJ	I <sub>C</sub> = 6.0A, V <sub>CC</sub> = 400V, V <sub>GE</sub> = 15V
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
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	I <sub>C</sub> = 6.0A, V <sub>CC</sub> = 400V, V <sub>GE</sub> = 15V
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
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
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
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
E <sub>rec</sub>	Reverse recovery energy of the diode	—	178	—	μJ	T <sub>J</sub> = 175°C
t <sub>rr</sub>	Diode Reverse recovery time	—	74	—	ns	V <sub>CC</sub> = 400V, I <sub>F</sub> = 6.0A
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

**Notes:**

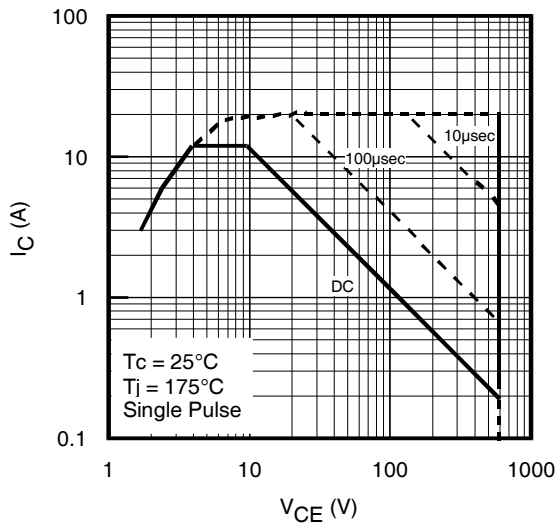
- ① V<sub>CC</sub> = 80% (V<sub>CES</sub>), V<sub>GE</sub> = 15V, L = 1.0mH, R<sub>G</sub> = 47Ω.
- ② Pulse width limited by max. junction temperature.
- ③ R<sub>θ</sub> is measured at T<sub>J</sub> approximately 90°C.
- ④ Refer to AN-1086 for guidelines for measuring V<sub>(BR)CES</sub> safely.
- ⑤ When mounted on 1" square PCB (FR-4 or G-10 Material). For recommended footprint and soldering techniques refer to application note #AN-994.
- ⑥ Maximum limits are based on statistical sample size characterization.



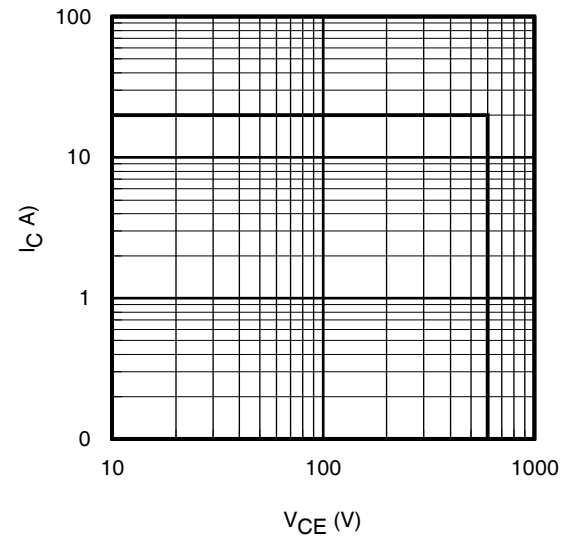
**Fig. 1 - Maximum DC Collector Current vs. Case Temperature**



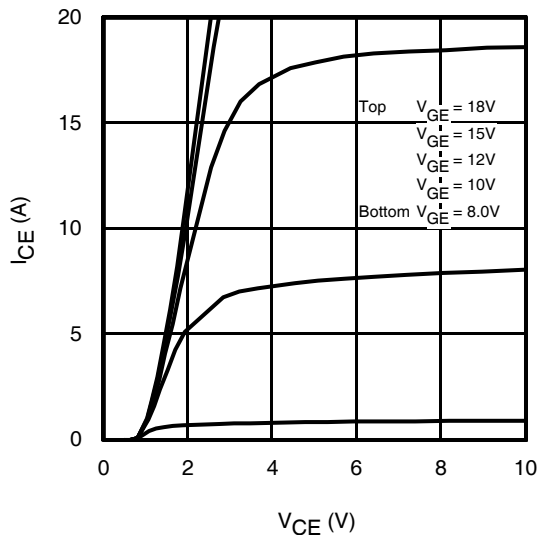
**Fig. 2 - Power Dissipation vs. Case Temperature**



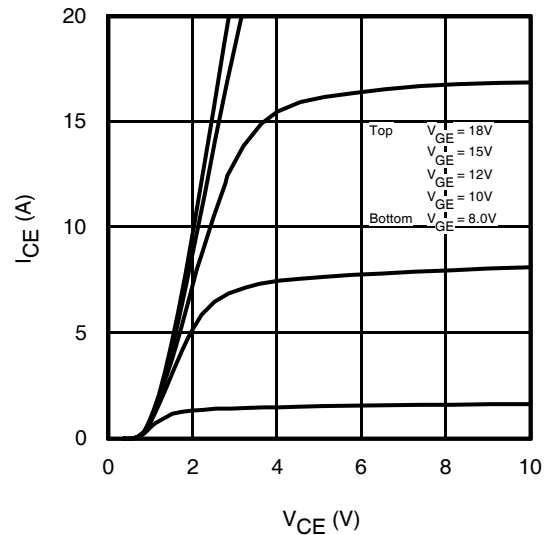
**Fig. 3 - Forward SOA,**  
 $T_C = 25^\circ\text{C}$ ,  $T_J \leq 175^\circ\text{C}$ ,  $V_{GE} = 15\text{V}$



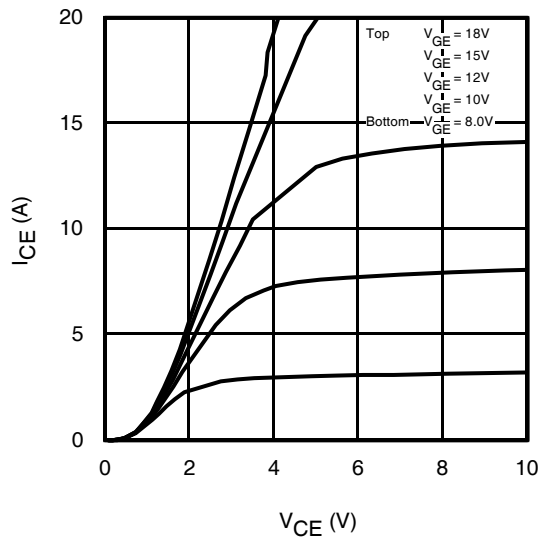
**Fig. 4 - Reverse Bias SOA**  
 $T_J = 175^\circ\text{C}$ ,  $V_{GE} = 20\text{V}$



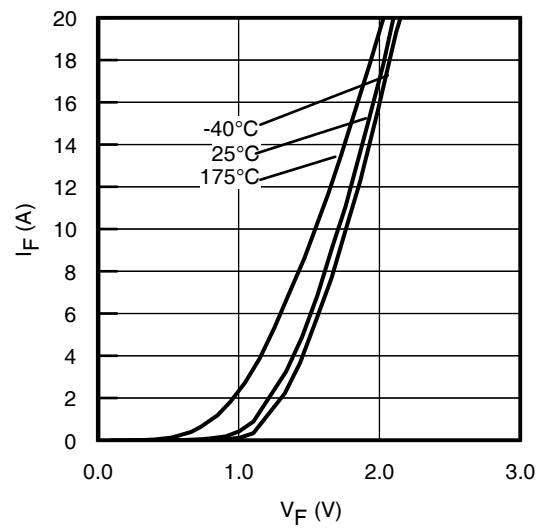
**Fig. 5 - Typ. IGBT Output Characteristics**  
 $T_J = -40^\circ\text{C}$ ;  $t_p = 80\mu\text{s}$



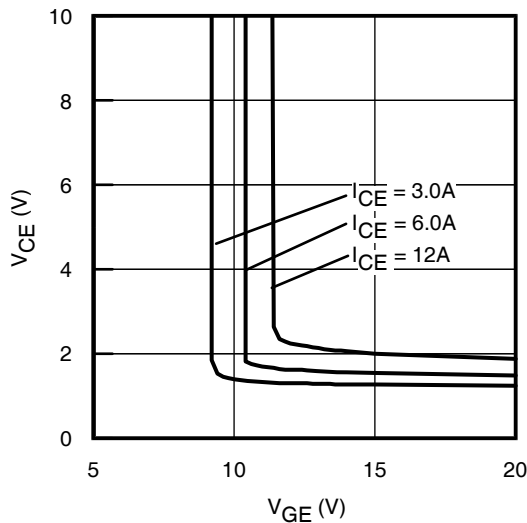
**Fig. 6 - Typ. IGBT Output Characteristics**  
 $T_J = 25^\circ\text{C}$ ;  $t_p = 80\mu\text{s}$



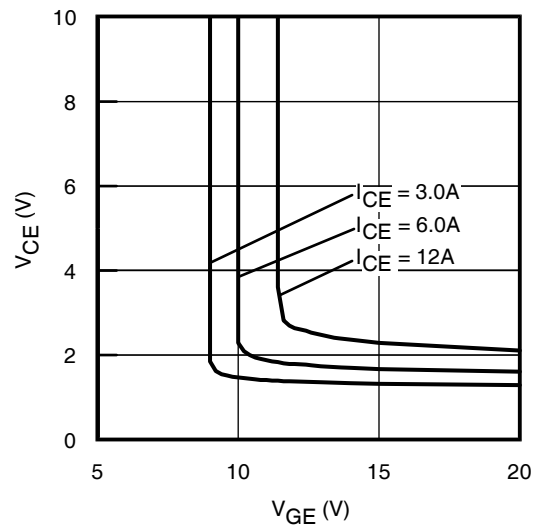
**Fig. 7 - Typ. IGBT Output Characteristics**  
 $T_J = 175^\circ C$ ;  $t_p = 80\mu s$



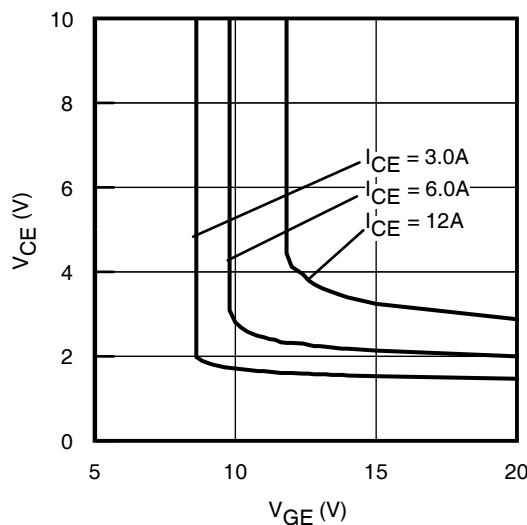
**Fig. 8 - Typ. Diode Forward Characteristics**  
 $t_p = 80\mu s$



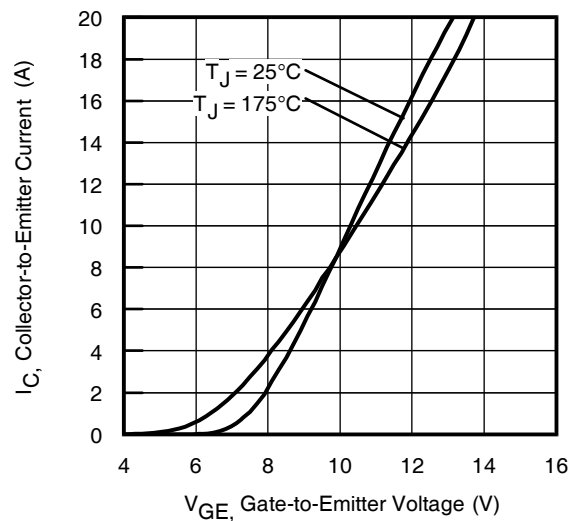
**Fig. 9 - Typical  $V_{CE}$  vs.  $V_{GE}$**   
 $T_J = -40^\circ C$



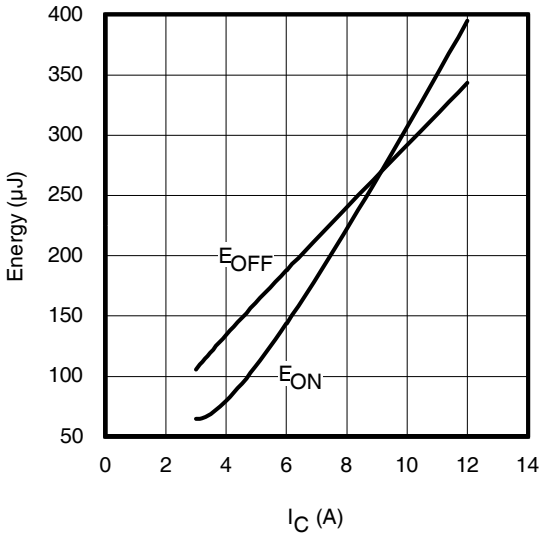
**Fig. 10 - Typical  $V_{CE}$  vs.  $V_{GE}$**   
 $T_J = 25^\circ C$



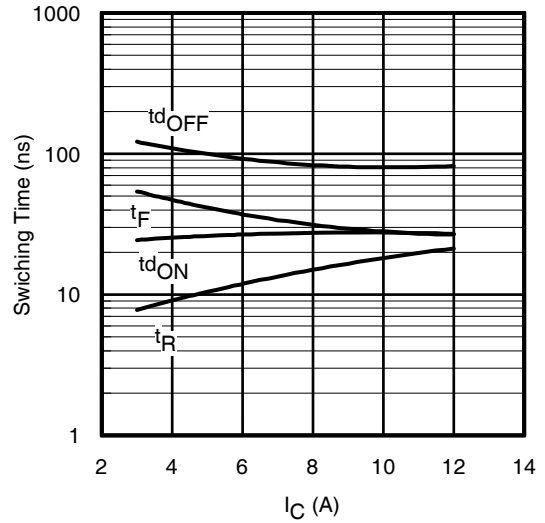
**Fig. 11 - Typical  $V_{CE}$  vs.  $V_{GE}$**   
 $T_J = 175^\circ C$



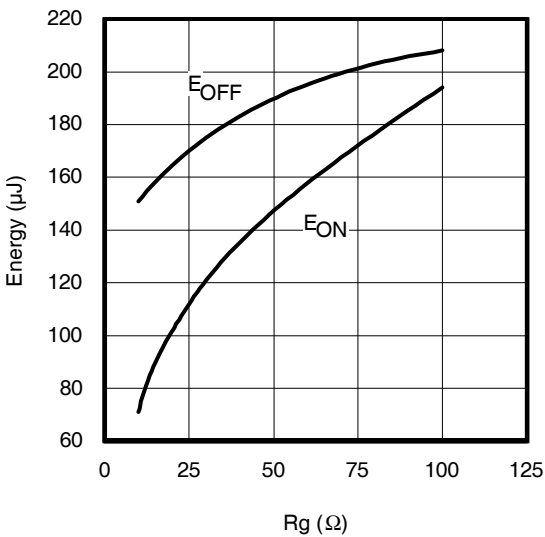
**Fig. 12 - Typ. Transfer Characteristics**  
 $V_{CE} = 50V$ ;  $t_p = 10\mu s$



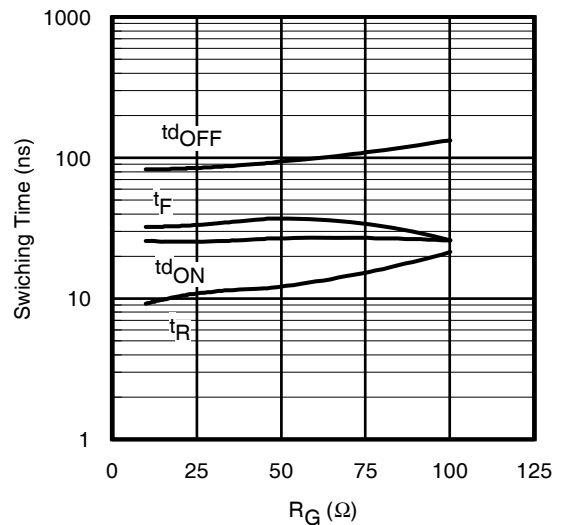
**Fig. 13** - Typ. Energy Loss vs.  $I_C$   
 $T_J = 175^\circ\text{C}$ ;  $L = 1\text{mH}$ ;  $V_{CE} = 400\text{V}$ ,  $R_G = 47\Omega$ ;  $V_{GE} = 15\text{V}$ .



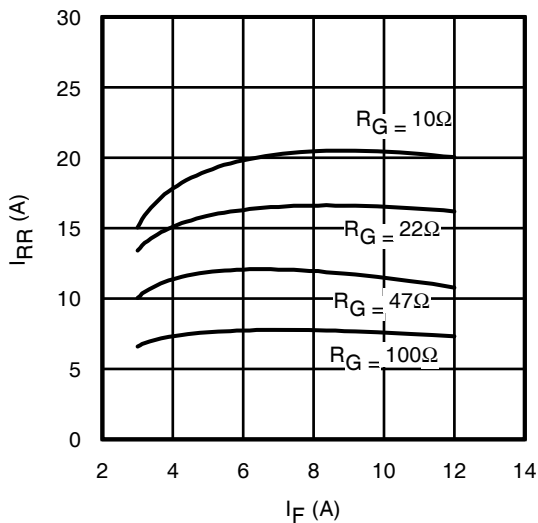
**Fig. 14** - Typ. Switching Time vs.  $I_C$   
 $T_J = 175^\circ\text{C}$ ;  $L = 1\text{mH}$ ;  $V_{CE} = 400\text{V}$   
 $R_G = 47\Omega$ ;  $V_{GE} = 15\text{V}$



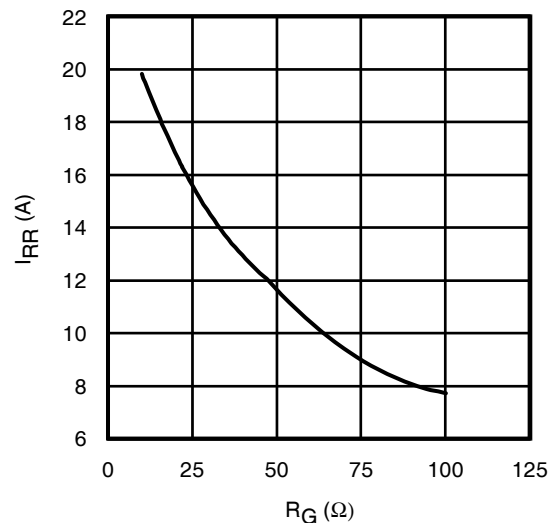
**Fig. 15** - Typ. Energy Loss vs.  $R_G$   
 $T_J = 175^\circ\text{C}$ ;  $L = 1\text{mH}$ ;  $V_{CE} = 400\text{V}$ ,  $I_{CE} = 6.0\text{A}$ ;  $V_{GE} = 15\text{V}$



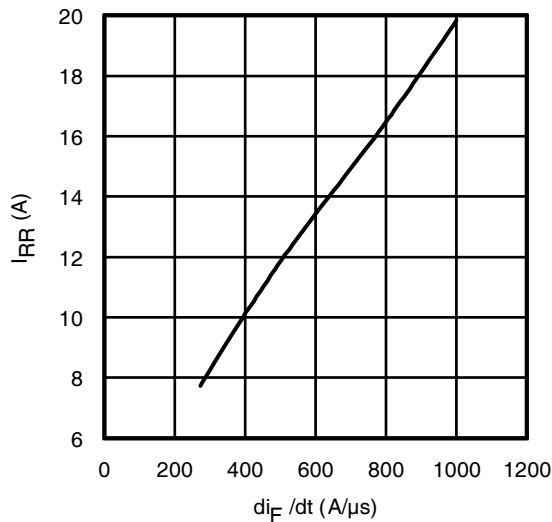
**Fig. 16** - Typ. Switching Time vs.  $R_G$   
 $T_J = 175^\circ\text{C}$ ;  $L = 1\text{mH}$ ;  $V_{CE} = 400\text{V}$   
 $I_{CE} = 6.0\text{A}$ ;  $V_{GE} = 15\text{V}$



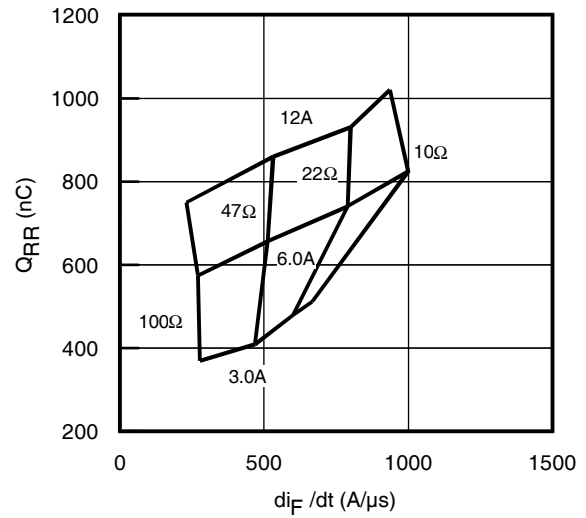
**Fig. 17** - Typical Diode  $I_{RR}$  vs.  $I_F$   
 $T_J = 175^\circ\text{C}$



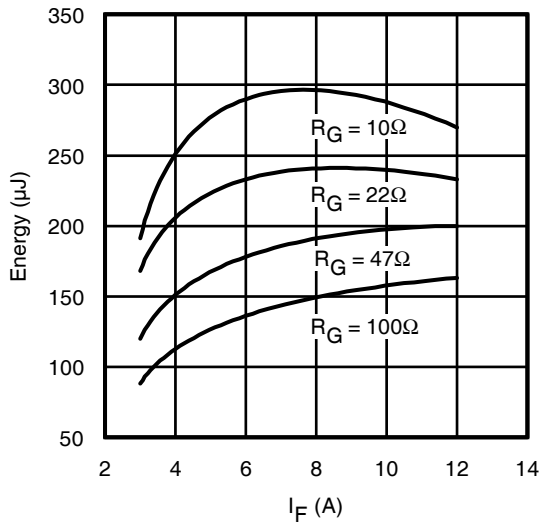
**Fig. 18** - Typical Diode  $I_{RR}$  vs.  $R_G$   
 $T_J = 175^\circ\text{C}$ ;  $I_F = 6.0\text{A}$



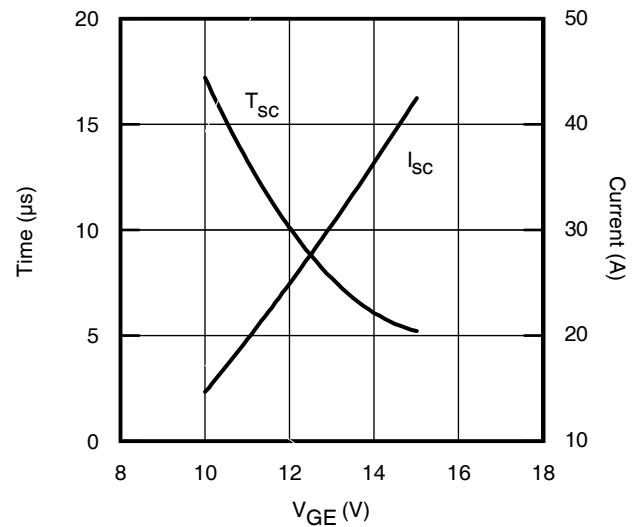
**Fig. 19**- Typical Diode  $I_{RR}$  vs.  $di_F/dt$   
 $V_{CC}= 400V$ ;  $V_{GE}= 15V$ ;  
 $I_{CE}= 6.0A$ ;  $T_J = 175^{\circ}C$



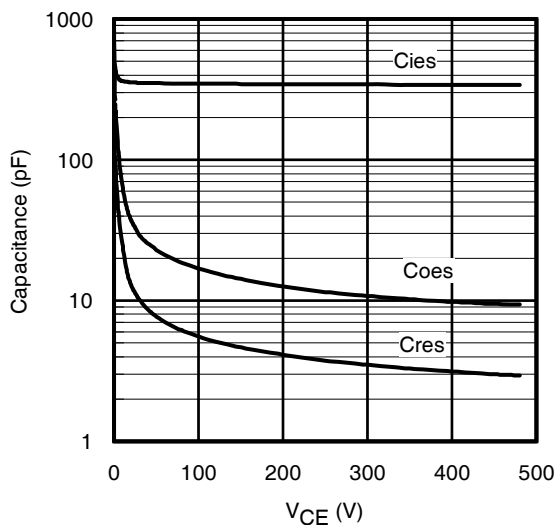
**Fig. 20** - Typical Diode  $Q_{RR}$   
 $V_{CC}= 400V$ ;  $V_{GE}= 15V$ ;  $T_J = 175^{\circ}C$



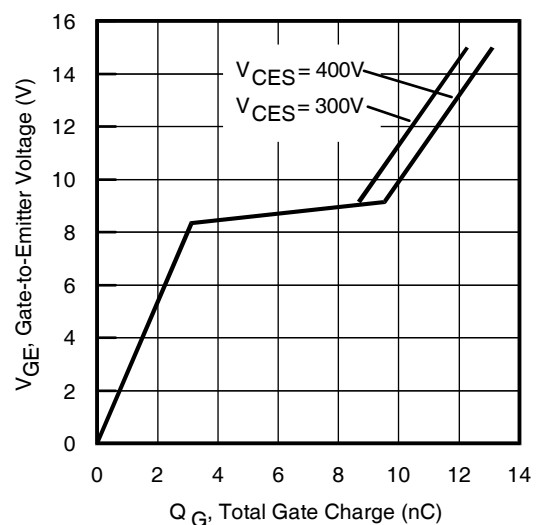
**Fig. 21** - Typical Diode  $E_{RR}$  vs.  $I_F$   
 $T_J = 175^{\circ}C$



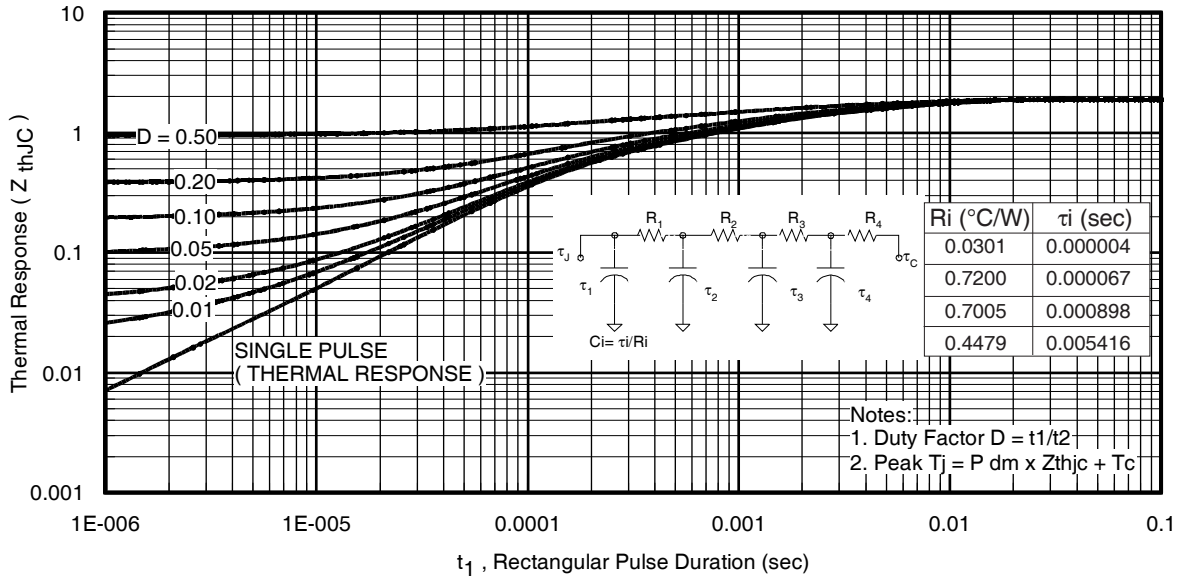
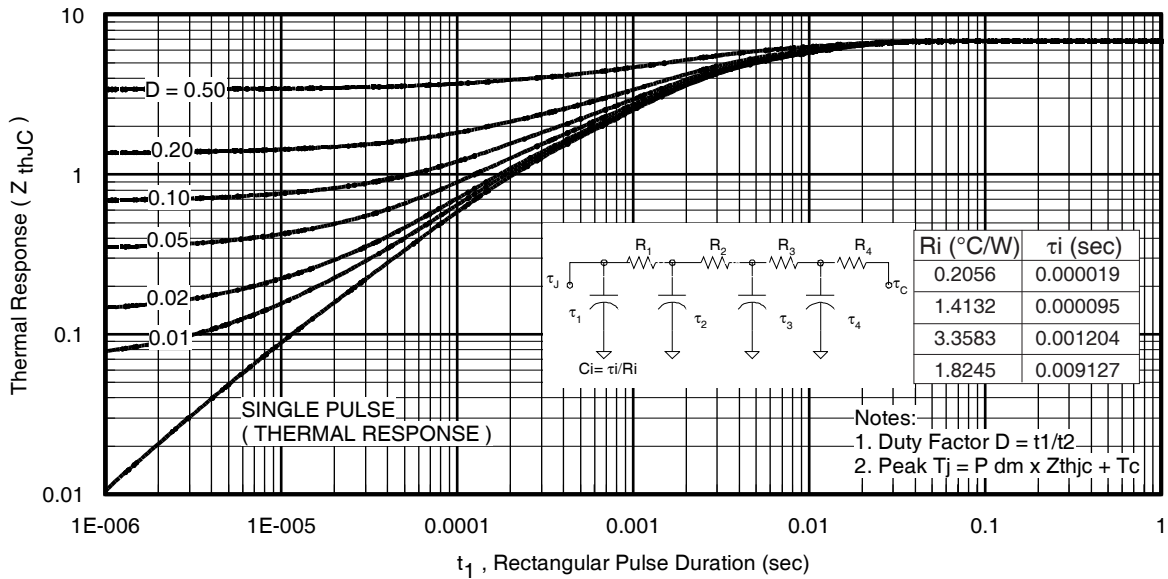
**Fig. 22**- Typ.  $V_{GE}$  vs. Short Circuit Time  
 $V_{CC}=400V$ ,  $T_C = 25^{\circ}C$

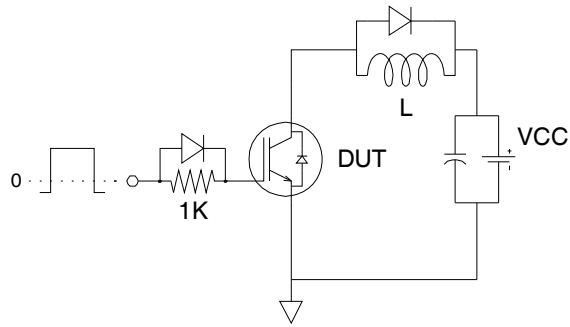
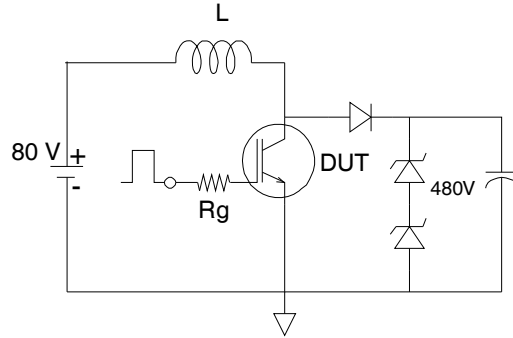
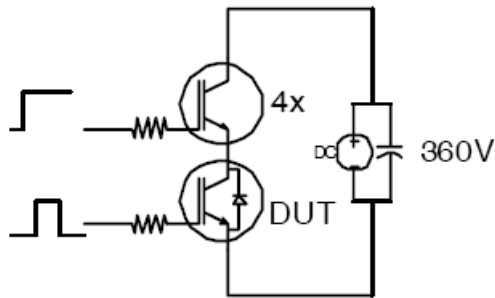
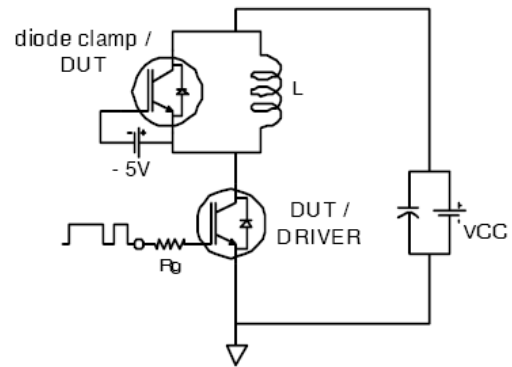
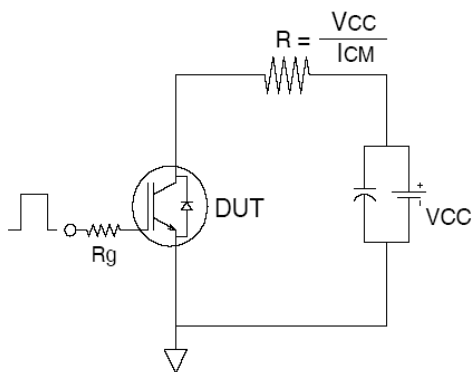
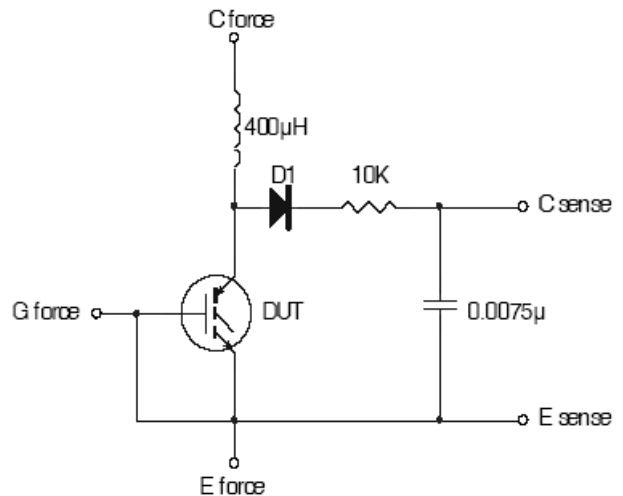


**Fig. 23**- Typ. Capacitance vs.  $V_{CE}$   
 $V_{GE}= 0V$ ;  $f = 1MHz$

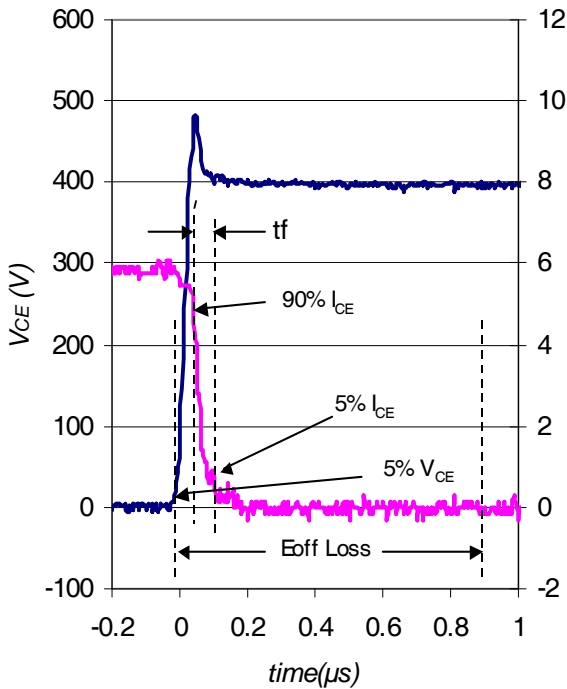


**Fig. 24** - Typical Gate Charge vs.  $V_{GE}$   
 $I_{CE} = 6.0A$ ,  $L=600\mu H$

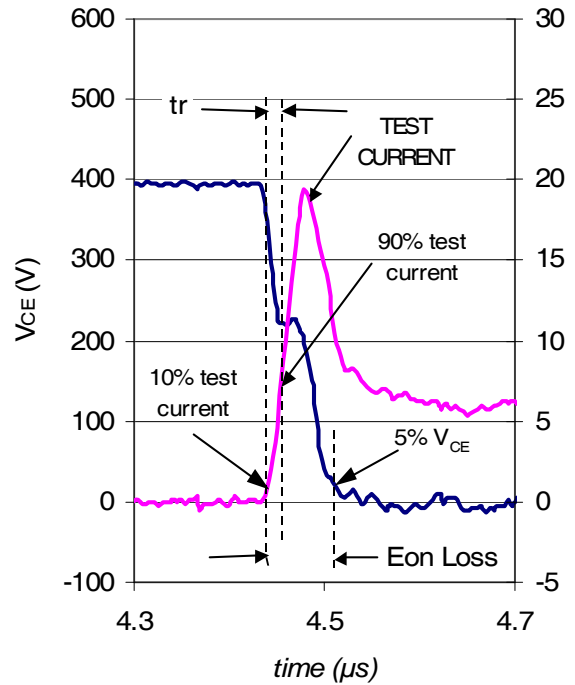

**Fig 25. Maximum Transient Thermal Impedance, Junction-to-Case (IGBT)**

**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**

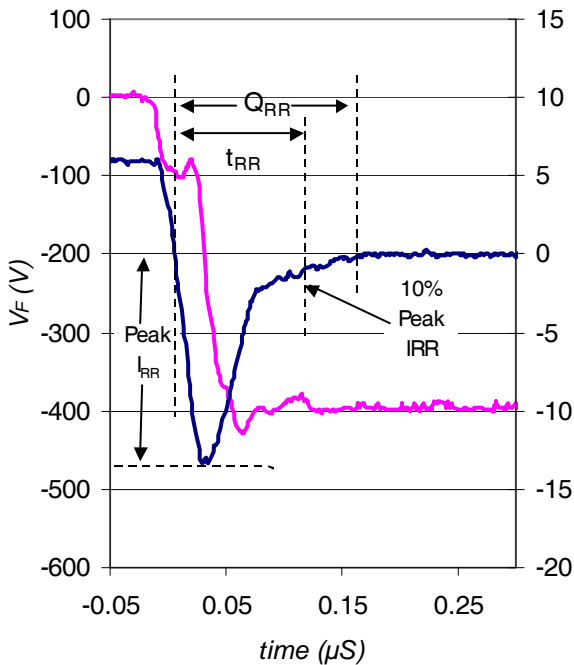




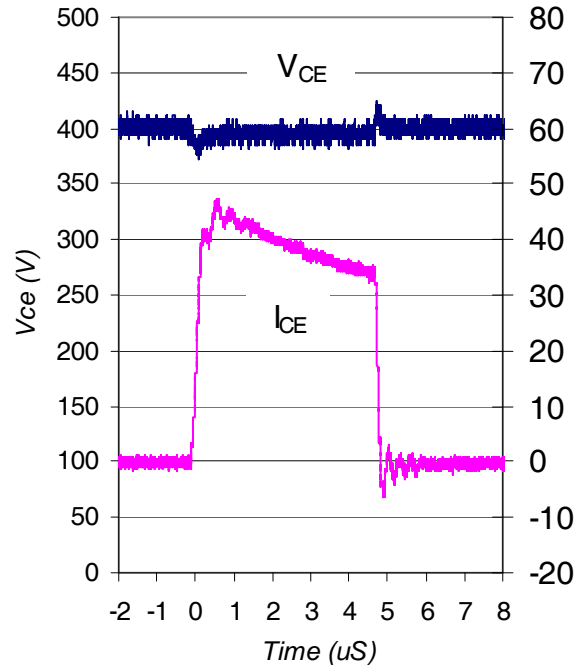
**Fig. WF1** - Typ. Turn-off Loss Waveform  
@  $T_J = 175^\circ\text{C}$  using Fig. CT.4



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



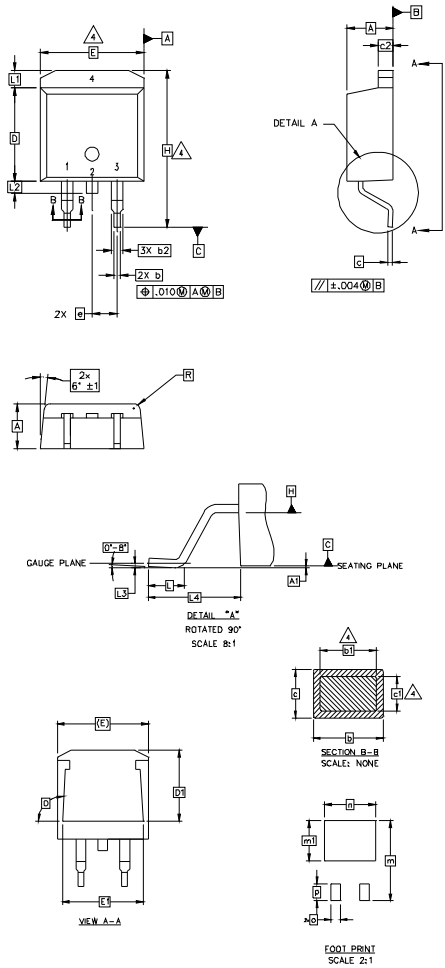
**WF.3-** Typ. Diode Recovery Waveform  
@  $T_J = 175^\circ\text{C}$  using CT.4



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

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

Dimensions are shown in millimeters (inches)



**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.
- △ DIMENSION b1 AND c1 APPLY TO BASE METAL ONLY.
5. CONTROLLING DIMENSION: INCH.

SYMBOL	DIMENSIONS				NOTES
	MILLIMETERS		INCHES		
	MIN.	MAX.	MIN.	MAX.	
A	4.06	4.83	.160	.190	4
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	
c	0.38	0.74	.015	.029	
c1	0.38	0.58	.015	.023	
c2	1.14	1.65	.045	.065	
D	8.51	9.65	.335	.380	
D1	6.86		.270		
E	9.65	10.67	.380	.420	3
E1	6.22		.245		
e	2.54 BSC		.100 BSC		3
h	14.61	15.88	.575	.625	
L	1.78	2.79	.070	.110	
L1		1.65		.065	
L2	1.27	1.78	.050	.070	
L3	0.25 BSC		.010 BSC		
L4	4.78	5.28	.188	.208	
m	17.78		.700		
m1	8.89		.350		
n	11.43		.450		
o	2.08		.082		
p	3.81		.150		
r	0.51	0.71	.020	.028	
θ	90°	93°	90°	93°	

LEAD ASSIGNMENTS

HEXFET

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

IGBTs, CoPACK

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

DIODES

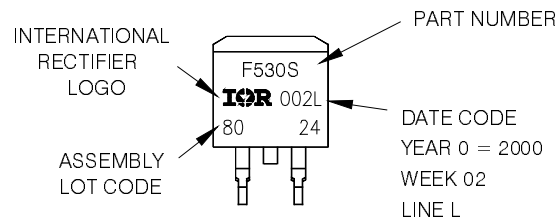
- 1.- ANODE \*
- 2, 4.- CATHODE
- 3.- ANODE

\* PART DEPENDENT.

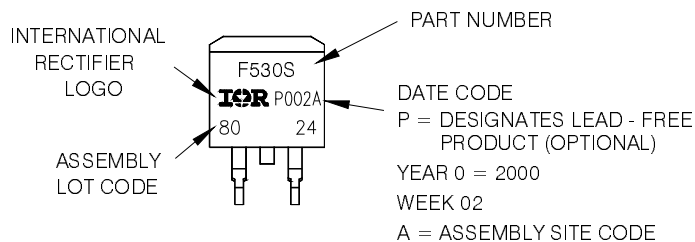
## D<sup>2</sup>Pak Part Marking Information

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"



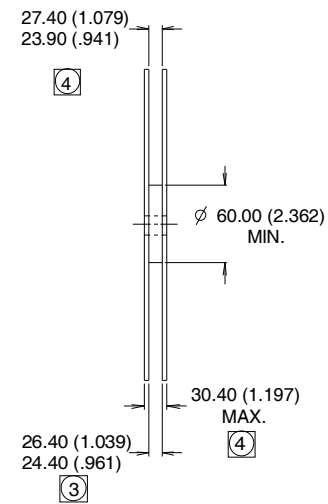
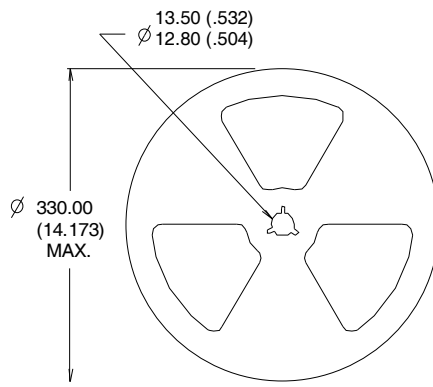
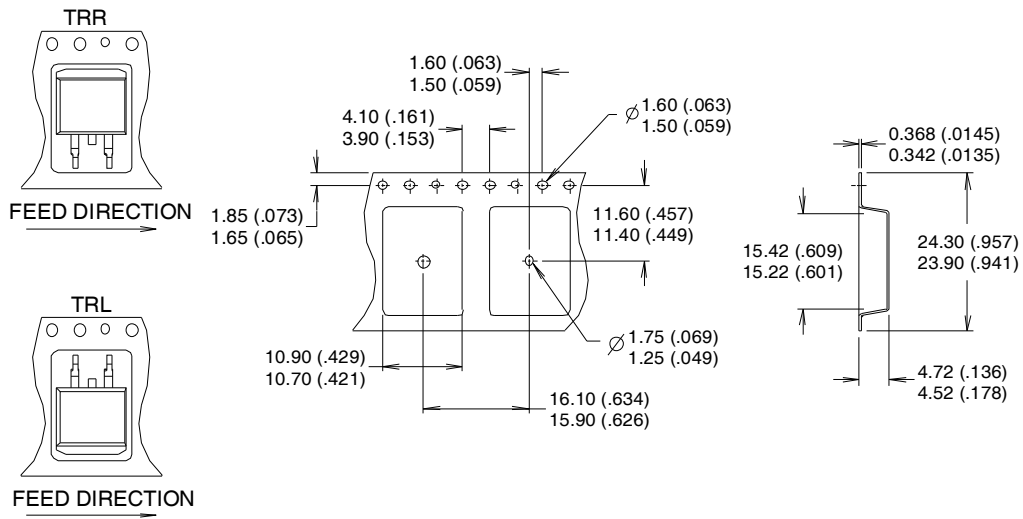
OR



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)



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

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

<b>Qualification Level</b>		Industrial <sup>††</sup> (per JEDEC JESD47F) <sup>†††</sup>	
<b>Moisture Sensitivity Level</b>		D2Pak	MSL1 (per JEDEC J-STD-020D) <sup>†††</sup>
<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/product-info/reliability/>

†† Higher qualification ratings may be available should the user have such requirements. Please contact your International Rectifier sales representative for further information: <http://www.irf.com/whoto-call/salesrep/>

††† Applicable version of JEDEC standard at the time of product release.

Data and specifications subject to change without notice.

International  
 Rectifier

**IR WORLD HEADQUARTERS:** 101 N. Sepulveda Blvd., El Segundo, California 90245, USA Tel: (310) 252-7105  
 TAC Fax: (310) 252-7903

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