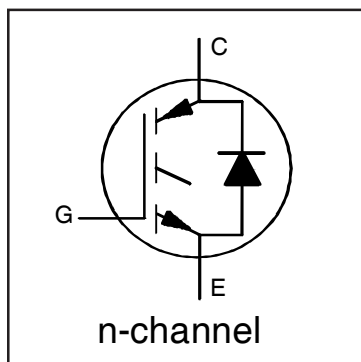


# IRGS4056DPbF

## INSULATED GATE BIPOLAR TRANSISTOR WITH ULTRAFAST SOFT RECOVERY DIODE

### Features

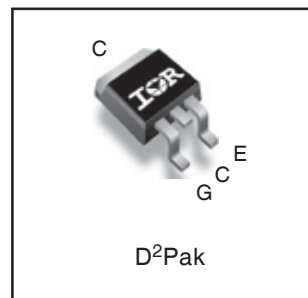
- Low  $V_{CE(ON)}$  Trench IGBT Technology
- Low switching losses
- Maximum Junction temperature 175 °C
- 5  $\mu$ S short circuit SOA
- Square RBSOA
- 100% of the parts tested for 4X rated current ( $I_{LM}$ )
- Positive  $V_{CE(ON)}$  Temperature co-efficient
- Ultra fast soft Recovery Co-Pak Diode
- Tight parameter distribution
- Lead Free Package



|                                                |
|------------------------------------------------|
| $V_{CES} = 600V$                               |
| $I_C = 12A, T_C = 100^\circ C$                 |
| $t_{SC} \geq 5\mu s, T_{J(max)} = 175^\circ C$ |
| $V_{CE(on)} \text{ typ.} = 1.55V$              |

### 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



| G    | C         | E       |
|------|-----------|---------|
| Gate | Collector | Emitter |

### Absolute Maximum Ratings

|                           | Parameter                          | Max.                              | Units      |
|---------------------------|------------------------------------|-----------------------------------|------------|
| $V_{CES}$                 | Collector-to-Emitter Voltage       | 600                               | V          |
| $I_C @ T_C = 25^\circ C$  | Continuous Collector Current       | 24                                | A          |
| $I_C @ T_C = 100^\circ C$ | Continuous Collector Current       | 12                                |            |
| $I_{CM}$                  | Pulse Collector Current            | 48                                |            |
| $I_{LM}$                  | Clamped Inductive Load Current ①   | 48                                |            |
| $I_F @ T_C = 25^\circ C$  | Diode Continuous Forward Current   | 24                                |            |
| $I_F @ T_C = 100^\circ C$ | Diode Continuous Forward Current   | 12                                | V          |
| $I_{FM}$                  | Diode Maximum Forward Current ②    | 48                                |            |
| $V_{GE}$                  | Continuous Gate-to-Emitter Voltage | $\pm 20$                          |            |
|                           | Transient Gate-to-Emitter Voltage  | $\pm 30$                          | W          |
| $P_D @ T_C = 25^\circ C$  | Maximum Power Dissipation          | 140                               |            |
| $P_D @ T_C = 100^\circ C$ | Maximum Power Dissipation          | 70                                | $^\circ C$ |
| $T_J$                     | Operating Junction and             | -55 to +175                       |            |
| $T_{STG}$                 | Storage Temperature Range          |                                   |            |
|                           | Soldering Temperature, for 10 sec. | 300 (0.063 in. (1.6mm) from case) |            |
|                           | Mounting Torque, 6-32 or M3 Screw  | 10 lbf-in (1.1 N-m)               |            |

### Thermal Resistance

|                         | Parameter                                                      | Min. | Typ. | Max. | Units        |
|-------------------------|----------------------------------------------------------------|------|------|------|--------------|
| $R_{\theta JC}$ (IGBT)  | Thermal Resistance Junction-to-Case-(each IGBT)                | —    | —    | 1.07 | $^\circ C/W$ |
| $R_{\theta JC}$ (Diode) | Thermal Resistance Junction-to-Case-(each Diode)               | —    | —    | 3.66 |              |
| $R_{\theta CS}$         | Thermal Resistance, Case-to-Sink (flat, greased surface)       | —    | 0.50 | —    |              |
| $R_{\theta JA}$         | Thermal Resistance, Junction-to-Ambient (typical socket mount) | —    | 80   | —    |              |

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

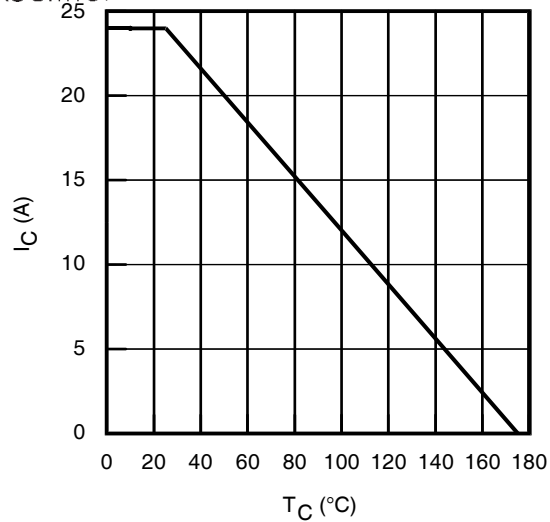
|                                 | Parameter                               | Min. | Typ. | Max.      | Units                | Conditions                                                                   | Ref.Fig |
|---------------------------------|-----------------------------------------|------|------|-----------|----------------------|------------------------------------------------------------------------------|---------|
| $V_{(BR)CES}$                   | 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 | —    | 0.30 | —         | V/ $^\circ\text{C}$  | $V_{GE} = 0V, I_C = 1mA$ (25 $^\circ\text{C}$ -175 $^\circ\text{C}$ )        | CT6     |
| $V_{CE(on)}$                    | Collector-to-Emitter Saturation Voltage | —    | 1.55 | 1.85      | V                    | $I_C = 12A, V_{GE} = 15V, T_J = 25^\circ\text{C}$                            | 5,6,7   |
|                                 |                                         | —    | 1.90 | —         |                      | $I_C = 12A, V_{GE} = 15V, T_J = 150^\circ\text{C}$                           | 9,10,11 |
|                                 |                                         | —    | 1.97 | —         |                      | $I_C = 12A, V_{GE} = 15V, T_J = 175^\circ\text{C}$                           |         |
| $V_{GE(th)}$                    | Gate Threshold Voltage                  | 4.0  | —    | 6.5       | V                    | $V_{CE} = V_{GE}, I_C = 350\mu A$                                            | 9, 10,  |
| $\Delta V_{GE(th)}/\Delta T_J$  | Threshold Voltage temp. coefficient     | —    | -18  | —         | mV/ $^\circ\text{C}$ | $V_{CE} = V_{GE}, I_C = 1.0mA$ (25 $^\circ\text{C}$ - 175 $^\circ\text{C}$ ) | 11, 12  |
| $g_{fe}$                        | Forward Transconductance                | —    | 7.7  | —         | S                    | $V_{CE} = 50V, I_C = 12A, PW = 80\mu s$                                      |         |
| $I_{CES}$                       | Collector-to-Emitter Leakage Current    | —    | 2.0  | 25        | $\mu A$              | $V_{GE} = 0V, V_{CE} = 600V$                                                 |         |
|                                 |                                         | —    | 475  | —         |                      | $V_{GE} = 0V, V_{CE} = 600V, T_J = 175^\circ\text{C}$                        |         |
| $V_{FM}$                        | Diode Forward Voltage Drop              | —    | 2.10 | 3.10      | V                    | $I_F = 12A$                                                                  | 8       |
|                                 |                                         | —    | 1.61 | —         |                      | $I_F = 12A, T_J = 175^\circ\text{C}$                                         |         |
| $I_{GES}$                       | Gate-to-Emitter Leakage Current         | —    | —    | $\pm 100$ | nA                   | $V_{GE} = \pm 20V$                                                           |         |

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

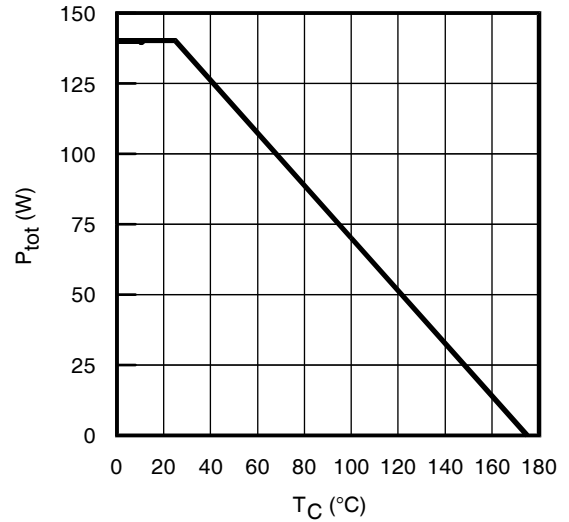
|              | Parameter                            | Min.        | Typ. | Max. | Units   | Conditions                                                                                                   | Ref.Fig        |
|--------------|--------------------------------------|-------------|------|------|---------|--------------------------------------------------------------------------------------------------------------|----------------|
| $Q_g$        | Total Gate Charge (turn-on)          | —           | 25   | 38   | nC      | $I_C = 12A$                                                                                                  | 24             |
| $Q_{ge}$     | Gate-to-Emitter Charge (turn-on)     | —           | 7.0  | 11   |         | $V_{GE} = 15V$                                                                                               | CT1            |
| $Q_{gc}$     | Gate-to-Collector Charge (turn-on)   | —           | 11   | 16   |         | $V_{CC} = 400V$                                                                                              |                |
| $E_{on}$     | Turn-On Switching Loss               | —           | 75   | 118  | $\mu J$ | $I_C = 12A, V_{CC} = 400V, V_{GE} = 15V$                                                                     | CT4            |
| $E_{off}$    | Turn-Off Switching Loss              | —           | 225  | 273  |         | $R_G = 22\Omega, L = 200\mu H, L_S = 150nH, T_J = 25^\circ\text{C}$                                          |                |
| $E_{total}$  | Total Switching Loss                 | —           | 300  | 391  |         | Energy losses include tail & diode reverse recovery                                                          |                |
| $t_{d(on)}$  | Turn-On delay time                   | —           | 31   | 40   | ns      | $I_C = 12A, V_{CC} = 400V, V_{GE} = 15V$                                                                     | CT4            |
| $t_r$        | Rise time                            | —           | 17   | 24   |         | $R_G = 22\Omega, L = 200\mu H, L_S = 150nH, T_J = 25^\circ\text{C}$                                          |                |
| $t_{d(off)}$ | Turn-Off delay time                  | —           | 83   | 94   |         |                                                                                                              |                |
| $t_f$        | Fall time                            | —           | 24   | 31   |         |                                                                                                              |                |
| $E_{on}$     | Turn-On Switching Loss               | —           | 185  | —    | $\mu J$ | $I_C = 12A, V_{CC} = 400V, V_{GE} = 15V$                                                                     | 13, 15         |
| $E_{off}$    | Turn-Off Switching Loss              | —           | 355  | —    |         | $R_G = 22\Omega, L = 100\mu H, L_S = 150nH, T_J = 175^\circ\text{C}$ ④                                       | CT4            |
| $E_{total}$  | Total Switching Loss                 | —           | 540  | —    |         | Energy losses include tail & diode reverse recovery                                                          | WF1, WF2       |
| $t_{d(on)}$  | Turn-On delay time                   | —           | 30   | —    | ns      | $I_C = 12A, V_{CC} = 400V, V_{GE} = 15V$                                                                     | 14, 16         |
| $t_r$        | Rise time                            | —           | 18   | —    |         | $R_G = 22\Omega, L = 200\mu H, L_S = 150nH$                                                                  | CT4            |
| $t_{d(off)}$ | Turn-Off delay time                  | —           | 102  | —    |         | $T_J = 175^\circ\text{C}$                                                                                    | WF1            |
| $t_f$        | Fall time                            | —           | 41   | —    |         |                                                                                                              | WF2            |
| $C_{ies}$    | Input Capacitance                    | —           | 765  | —    | pF      | $V_{GE} = 0V$                                                                                                | 23             |
| $C_{oes}$    | Output Capacitance                   | —           | 52   | —    |         | $V_{CC} = 30V$                                                                                               |                |
| $C_{res}$    | Reverse Transfer Capacitance         | —           | 23   | —    |         | $f = 1.0MHz$                                                                                                 |                |
| RBSOA        | Reverse Bias Safe Operating Area     | FULL SQUARE |      |      |         | $T_J = 175^\circ\text{C}, I_C = 48A$<br>$V_{CC} = 480V, V_p = 600V$<br>$R_G = 22\Omega, V_{GE} = +15V$ to 0V | 4<br>CT2       |
| SCSOA        | Short Circuit Safe Operating Area    | 5           | —    | —    | $\mu s$ | $V_{CC} = 400V, V_p = 600V$<br>$R_G = 22\Omega, V_{GE} = +15V$ to 0V                                         | 22, CT3<br>WF4 |
| $E_{rec}$    | Reverse Recovery Energy of the Diode | —           | 280  | —    | $\mu J$ | $T_J = 175^\circ\text{C}$                                                                                    | 17, 18, 19     |
| $t_{rr}$     | Diode Reverse Recovery Time          | —           | 68   | —    | ns      | $V_{CC} = 400V, I_F = 12A$                                                                                   | 20, 21         |
| $I_{rr}$     | Peak Reverse Recovery Current        | —           | 19   | —    | A       | $V_{GE} = 15V, R_G = 22\Omega, L = 200\mu H, L_S = 150nH$                                                    | WF3            |

**Notes:**

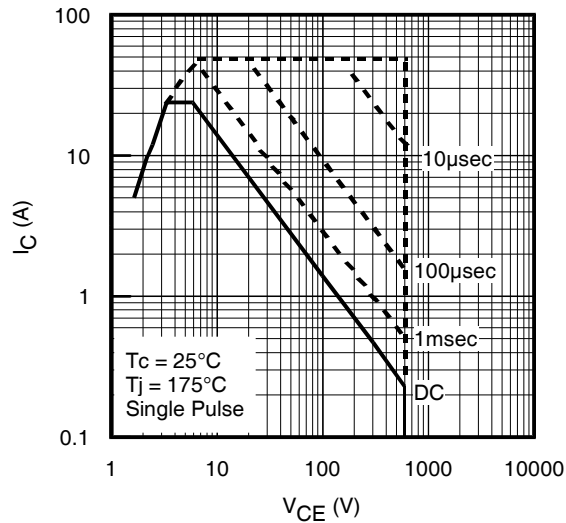
- ①  $V_{CC} = 80\% (V_{CES}), V_{GE} = 20V, L = 100\mu H, R_G = 22\Omega$ .
- ② This is only applied to TO-220AB package.
- ③ Pulse width limited by max. junction temperature.
- ④ Refer to AN-1086 for guidelines for measuring  $V_{(BR)CES}$  safely.



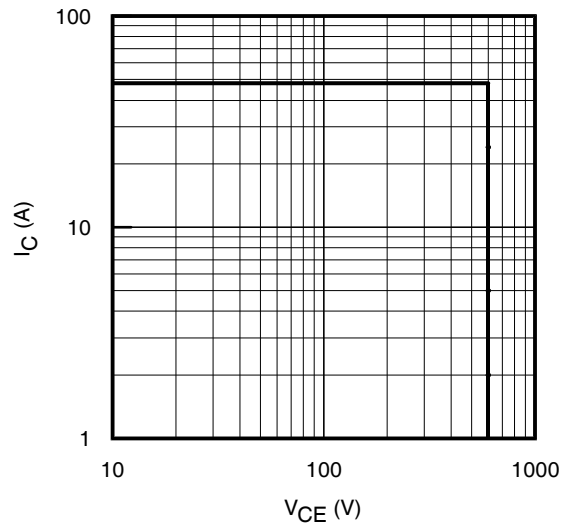
**Fig. 1** - Maximum DC Collector Current vs. Case Temperature



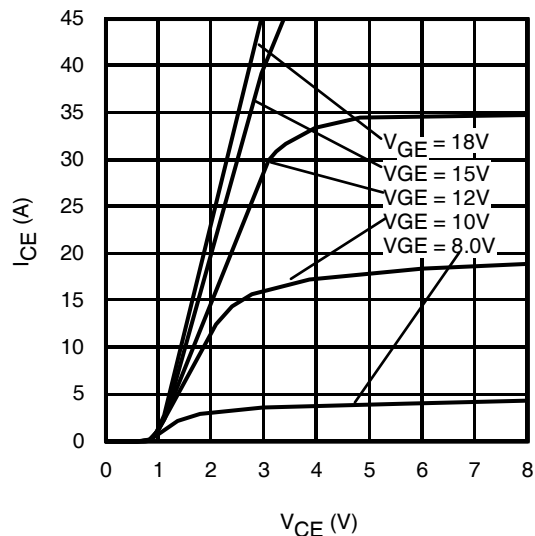
**Fig. 2** - Power Dissipation vs. Case Temperature



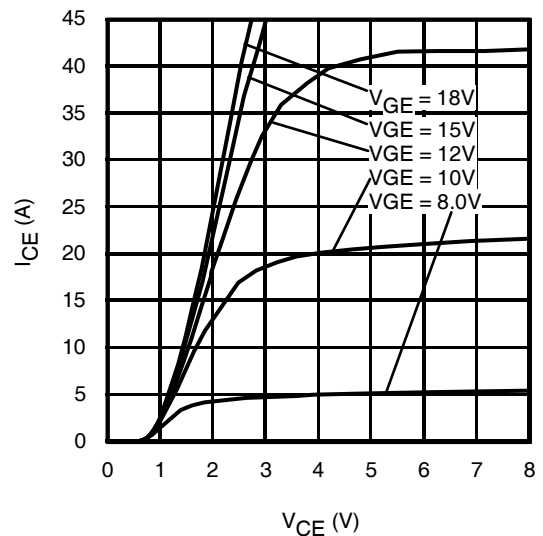
**Fig. 3** - Forward SOA  
 $T_C = 25^\circ\text{C}$ ,  $T_J \leq 175^\circ\text{C}$ ;  $V_{GE} = 15\text{V}$



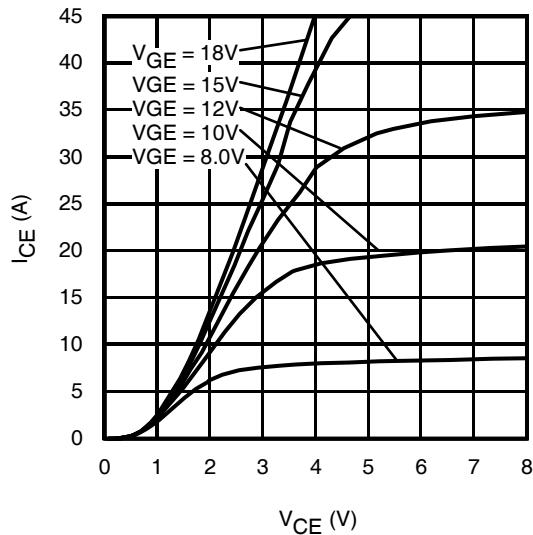
**Fig. 4** - Reverse Bias SOA  
 $T_J = 175^\circ\text{C}$ ;  $V_{GE} = 15\text{V}$



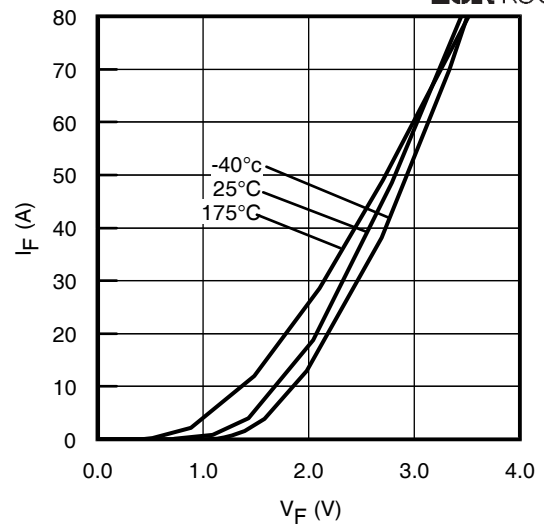
**Fig. 5** - Typ. IGBT Output Characteristics  
 $T_J = -40^\circ\text{C}$ ;  $t_p = 80\mu\text{s}$



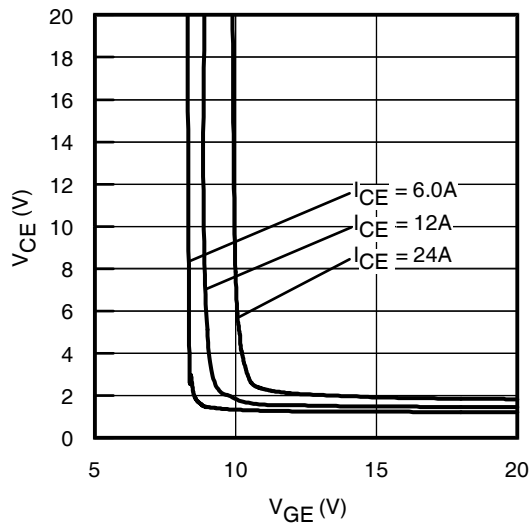
**Fig. 6** - Typ. IGBT Output Characteristics  
 $T_J = 25^\circ\text{C}$ ;  $t_p = 80\mu\text{s}$



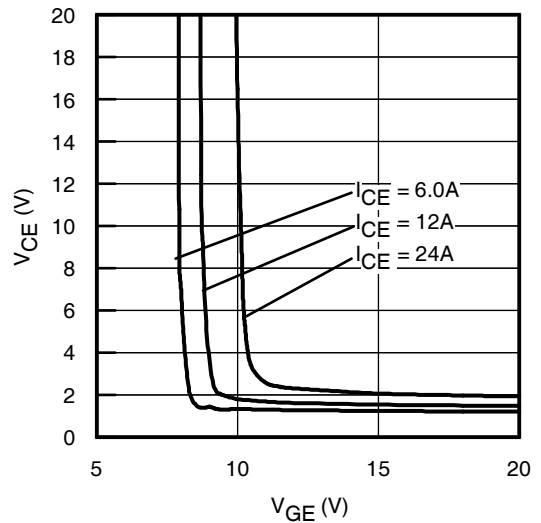
**Fig. 7** - Typ. IGBT Output Characteristics  
 $T_J = 175^\circ\text{C}$ ;  $t_p = 80\mu\text{s}$



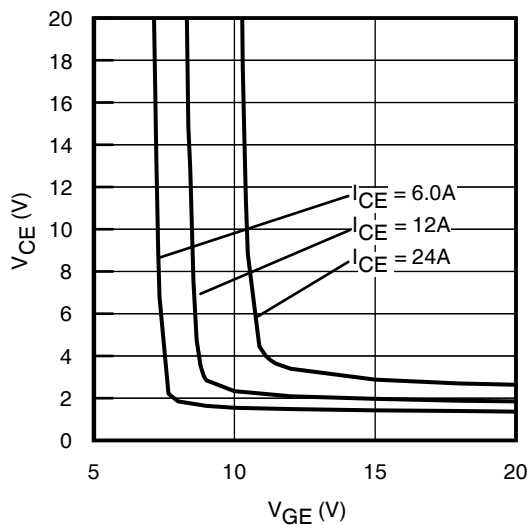
**Fig. 8** - Typ. Diode Forward Characteristics  
 $t_p = 80\mu\text{s}$



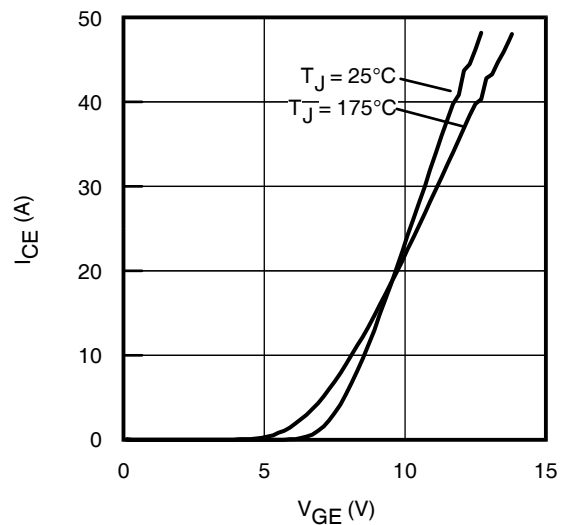
**Fig. 9** - Typical  $V_{CE}$  vs.  $V_{GE}$   
 $T_J = -40^\circ\text{C}$



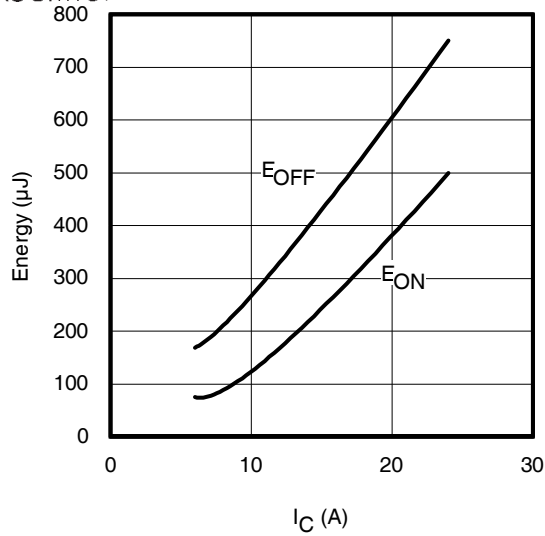
**Fig. 10** - Typical  $V_{CE}$  vs.  $V_{GE}$   
 $T_J = 25^\circ\text{C}$



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

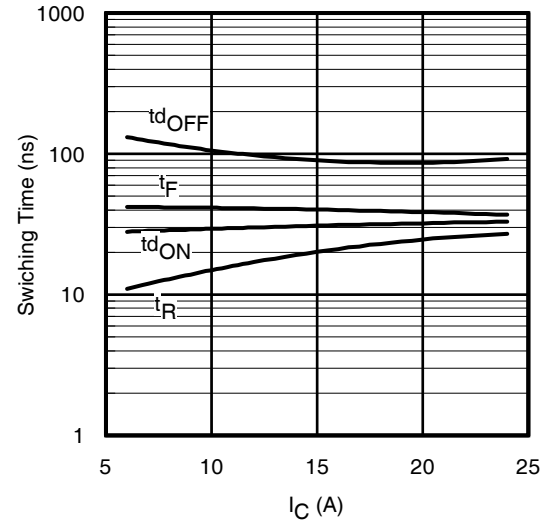


**Fig. 12** - Typ. Transfer Characteristics  
 $V_{CE} = 50\text{V}$ ;  $t_p = 10\mu\text{s}$



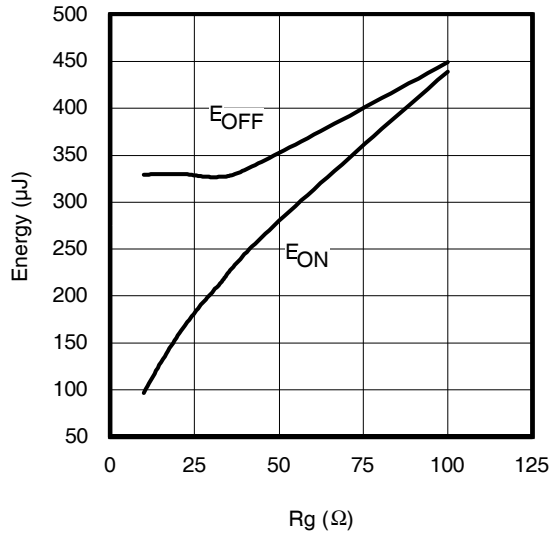
**Fig. 13** - Typ. Energy Loss vs.  $I_C$

$T_J = 175^\circ\text{C}$ ;  $L = 200\mu\text{H}$ ;  $V_{CE} = 400\text{V}$ ;  $R_G = 22\Omega$ ;  $V_{GE} = 15\text{V}$



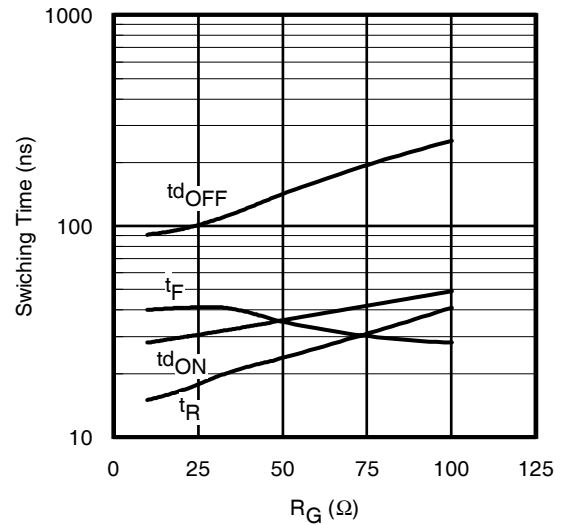
**Fig. 14** - Typ. Switching Time vs.  $I_C$

$T_J = 175^\circ\text{C}$ ;  $L = 200\mu\text{H}$ ;  $V_{CE} = 400\text{V}$ ;  $R_G = 22\Omega$ ;  $V_{GE} = 15\text{V}$



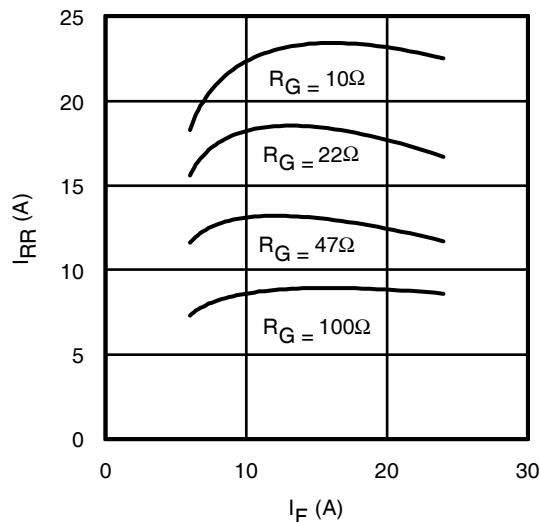
**Fig. 15** - Typ. Energy Loss vs.  $R_G$

$T_J = 175^\circ\text{C}$ ;  $L = 200\mu\text{H}$ ;  $V_{CE} = 400\text{V}$ ;  $I_{CE} = 12\text{A}$ ;  $V_{GE} = 15\text{V}$



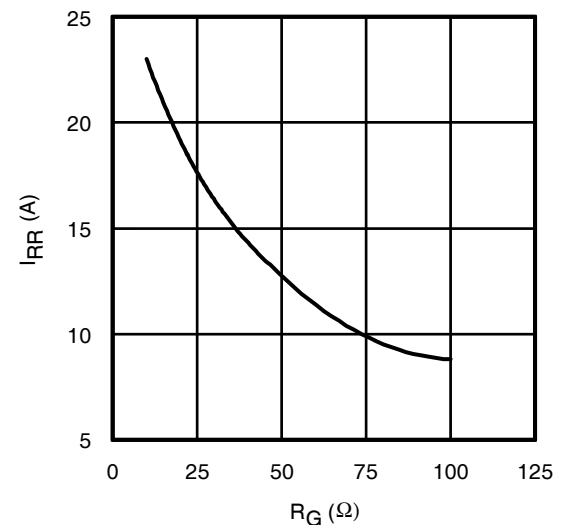
**Fig. 16** - Typ. Switching Time vs.  $R_G$

$T_J = 175^\circ\text{C}$ ;  $L = 200\mu\text{H}$ ;  $V_{CE} = 400\text{V}$ ;  $I_{CE} = 12\text{A}$ ;  $V_{GE} = 15\text{V}$



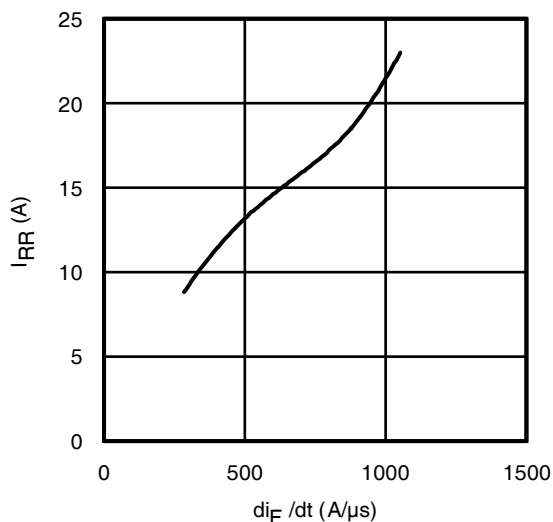
**Fig. 17** - Typ. Diode  $I_{RR}$  vs.  $I_F$

$T_J = 175^\circ\text{C}$

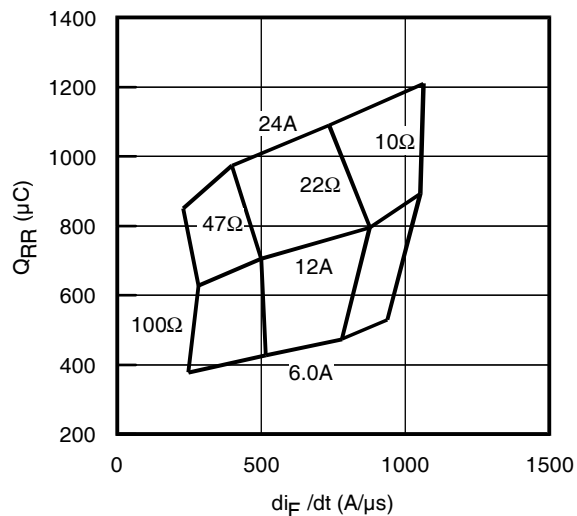


**Fig. 18** - Typ. Diode  $I_{RR}$  vs.  $R_G$

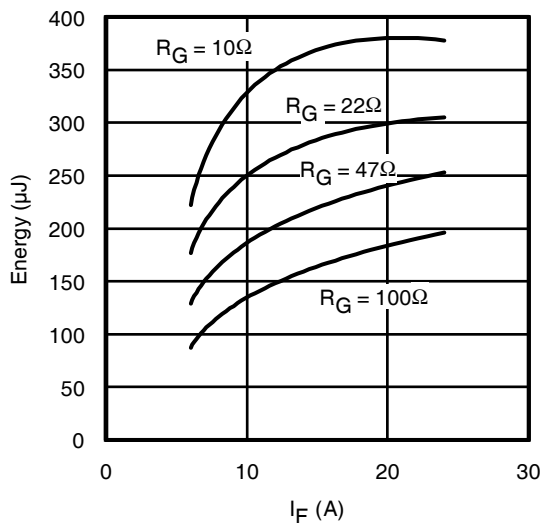
$T_J = 175^\circ\text{C}$



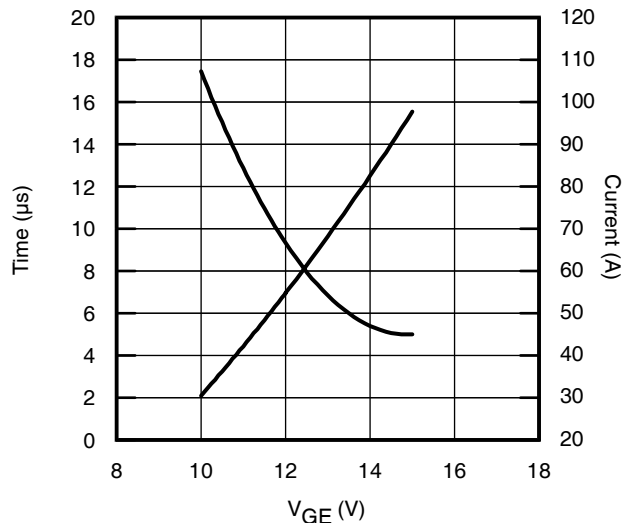
**Fig. 19** - Typ. Diode  $I_{RR}$  vs.  $di_F/dt$   
 $V_{CC} = 400V$ ;  $V_{GE} = 15V$ ;  $I_F = 12A$ ;  $T_J = 175^\circ C$



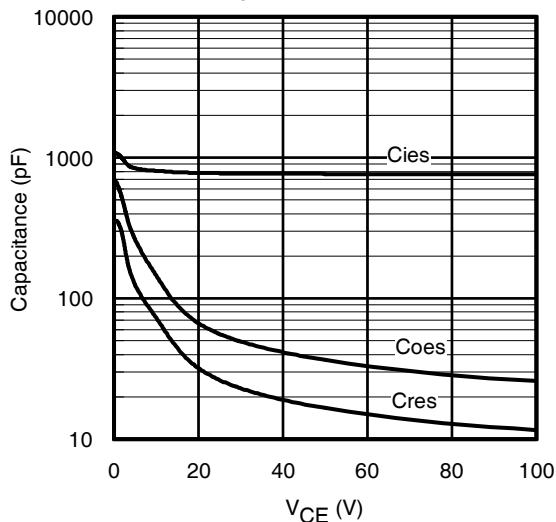
**Fig. 20** - Typ. Diode  $Q_{RR}$  vs.  $di_F/dt$   
 $V_{CC} = 400V$ ;  $V_{GE} = 15V$ ;  $T_J = 175^\circ C$



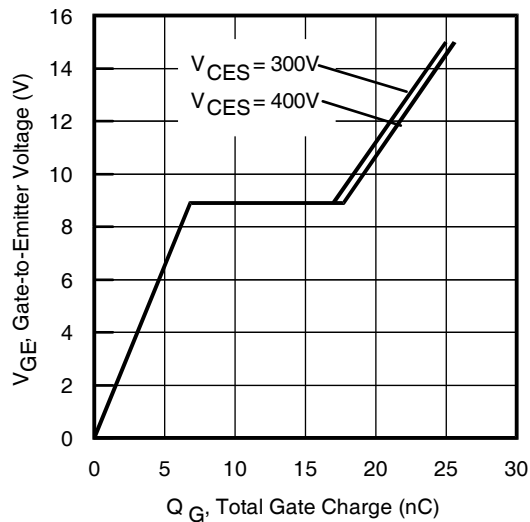
**Fig. 21** - Typ. Diode  $E_{RR}$  vs.  $I_F$   
 $T_J = 175^\circ C$



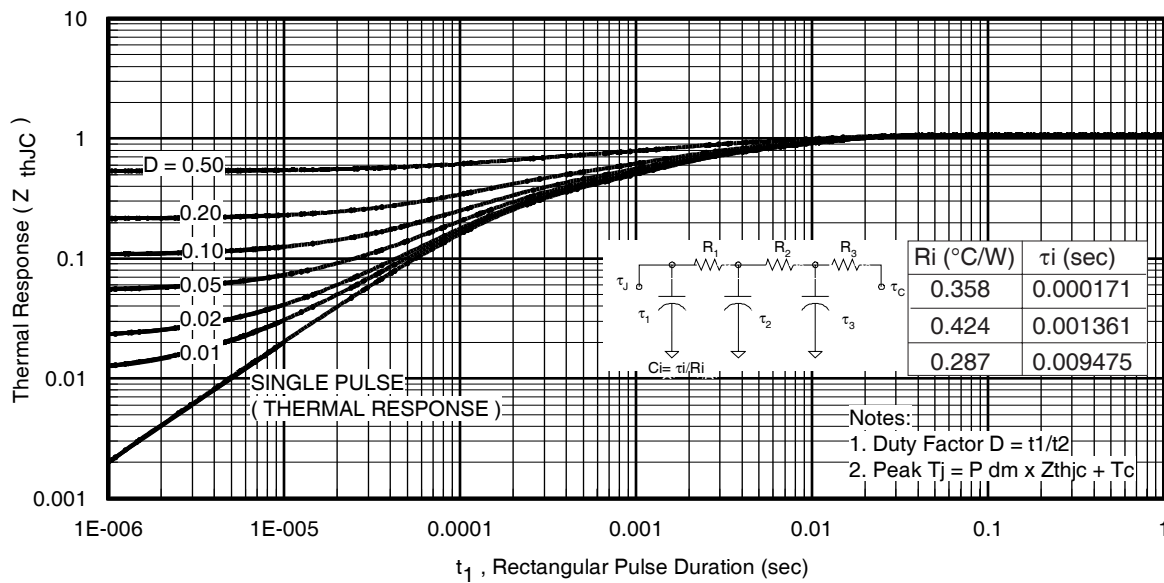
**Fig. 22** -  $V_{GE}$  vs. Short Circuit Time  
 $V_{CC} = 400V$ ;  $T_C = 25^\circ C$



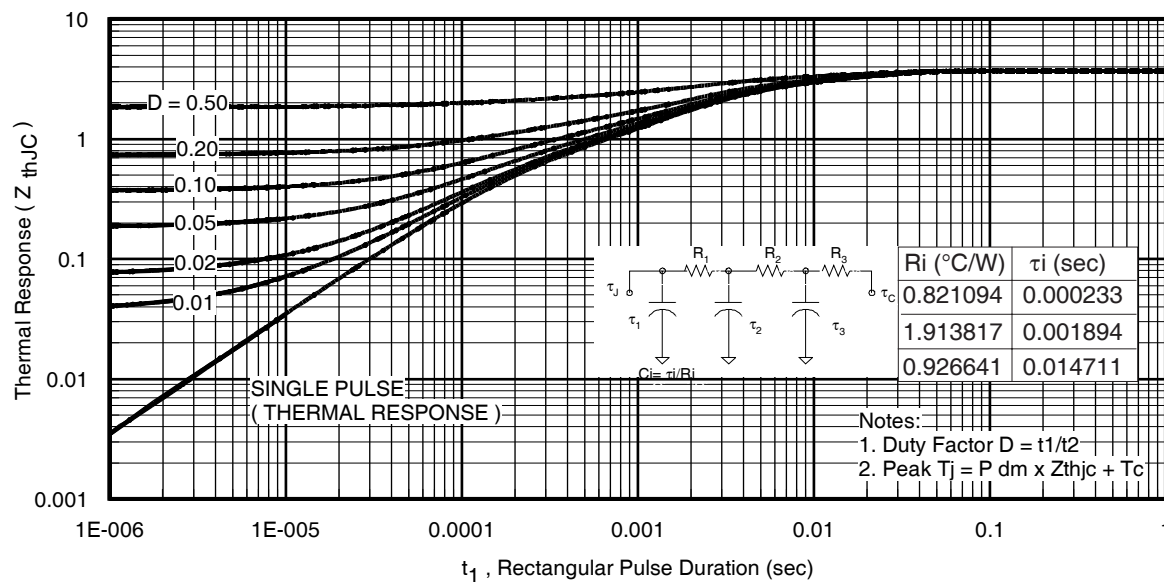
**Fig. 23** - Typ. Capacitance vs.  $V_{CE}$   
 $V_{GE} = 0V$ ;  $f = 1MHz$



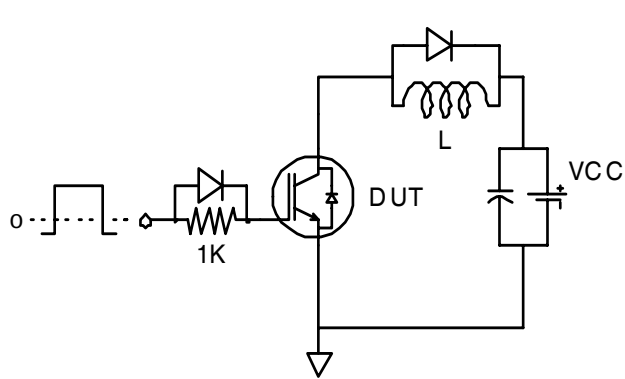
**Fig. 24** - Typical Gate Charge vs.  $V_{GE}$   
 $I_{CE} = 12A$ ;  $L = 600\mu H$



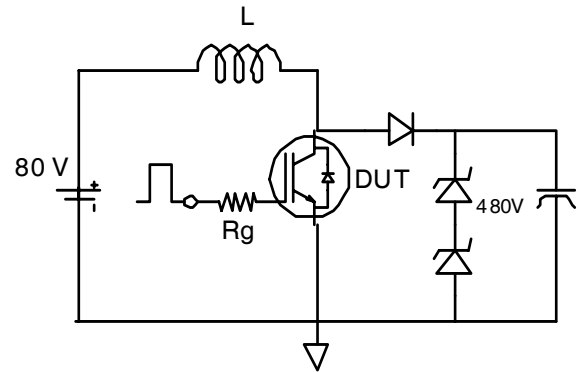
**Fig 25.** Maximum Transient Thermal Impedance, Junction-to-Case (IGBT)



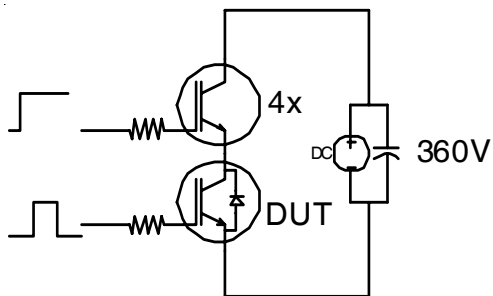
**Fig. 26.** Maximum Transient Thermal Impedance, Junction-to-Case (DIODE)



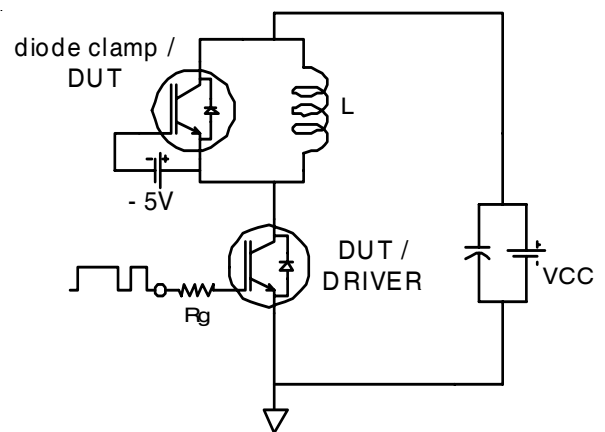
**Fig.C.T.1** - Gate Charge Circuit (turn-off)



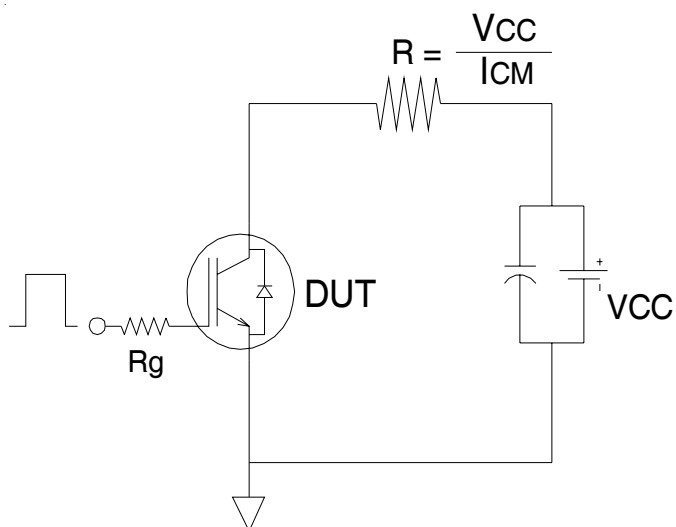
**Fig.C.T.2** - RBSOA Circuit



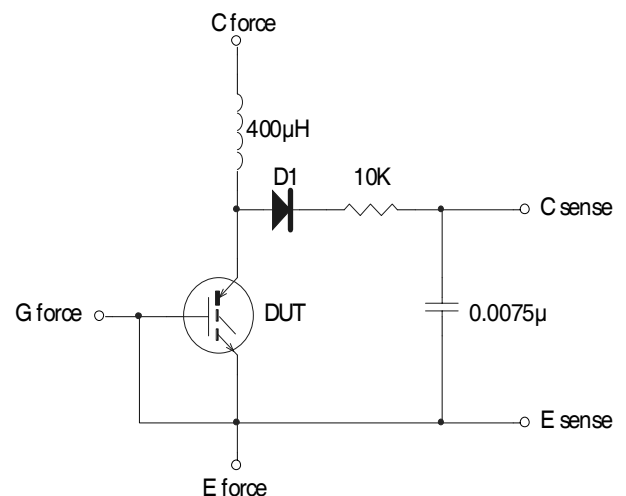
**Fig.C.T.3** - S.C. SOA Circuit



**Fig.C.T.4** - Switching Loss Circuit

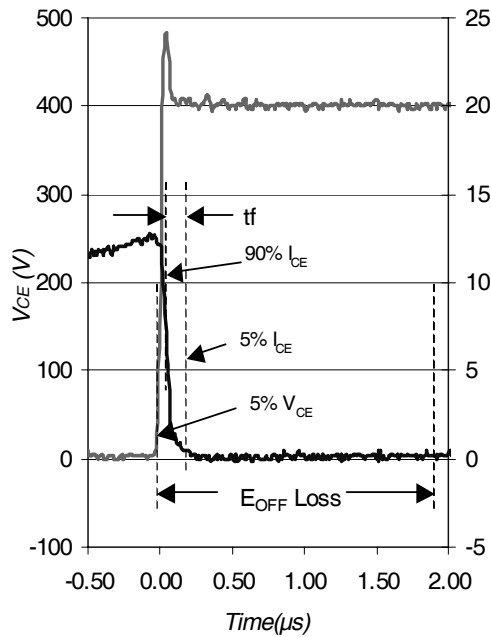


**Fig.C.T.5** - Resistive Load Circuit

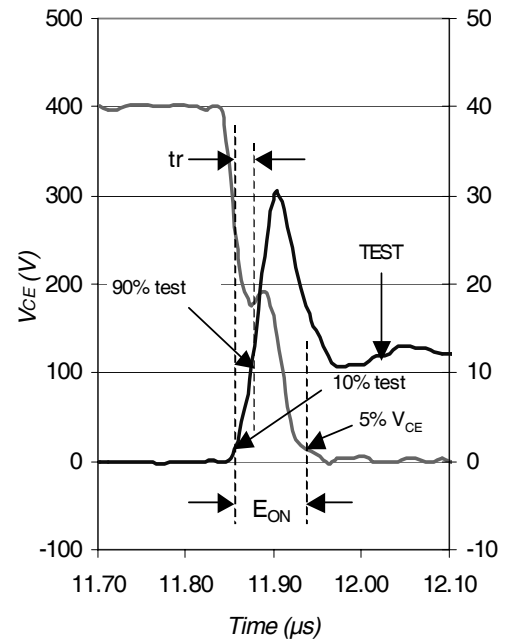


**Fig.C.T.6** - BVCEs Filter Circuit

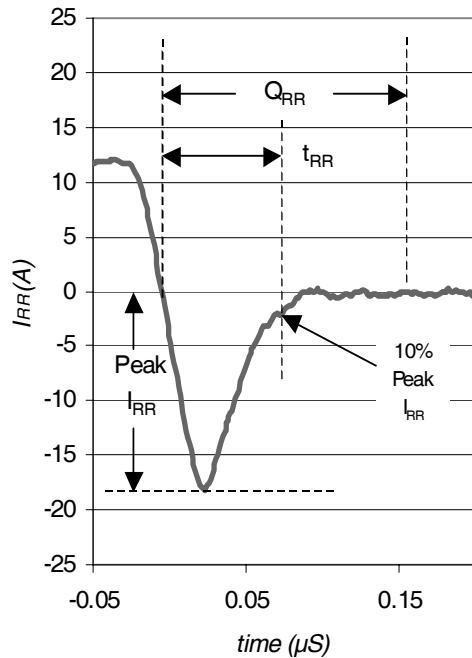




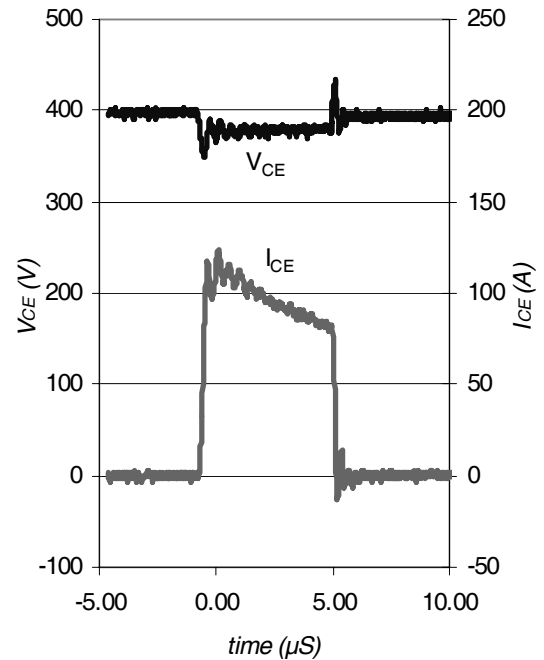
**Fig. WF1** - Typ. Turn-off Loss Waveform  
@  $T_J = 175^\circ\text{C}$  using Fig. CT.4



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



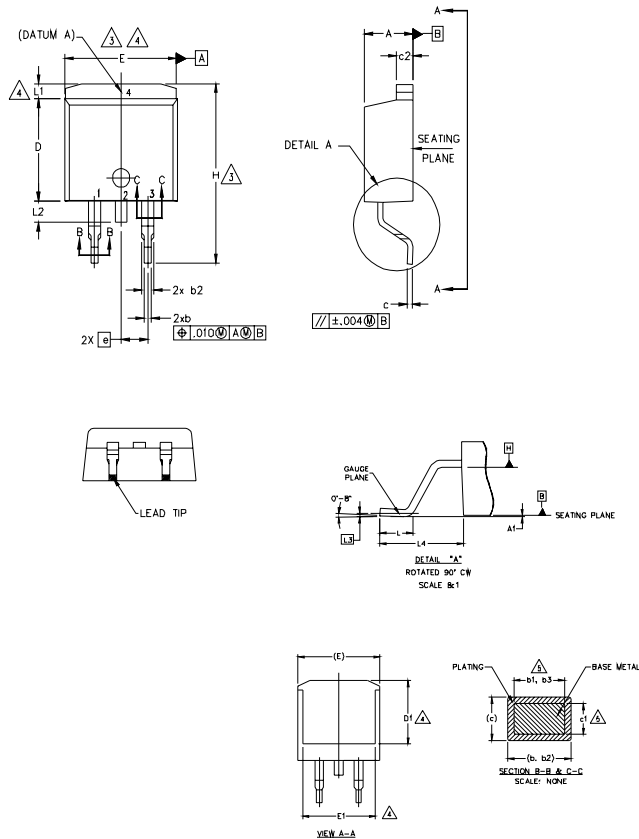
**Fig. WF3** - Typ. Diode Recovery Waveform  
@  $T_J = 175^\circ\text{C}$  using Fig. CT.4



**Fig. WF4** - Typ. S.C. Waveform  
@  $T_J = 25^\circ\text{C}$  using Fig. CT.3

D<sup>2</sup>Pak (TO-263AB) 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 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.

| SYM<br>BO<br>L | DIMENSIONS  |       |          |      | NO<br>TE<br>S |
|----------------|-------------|-------|----------|------|---------------|
|                | 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             | 1.27        | 1.78  | —        | .070 |               |
| L3             | 0.25 BSC    |       | .010 BSC |      |               |
| L4             | 4.78        | 5.28  | .188     | .208 |               |

## LEAD ASSIGNMENTS

## HEXFET

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

## IGBTs, CoPACK

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

## DIODES

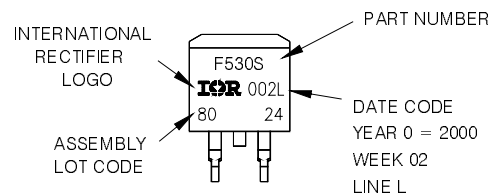
1. ANODE \*
- 2, 4. CATHODE
3. ANODE

\* PART DEPENDENT.

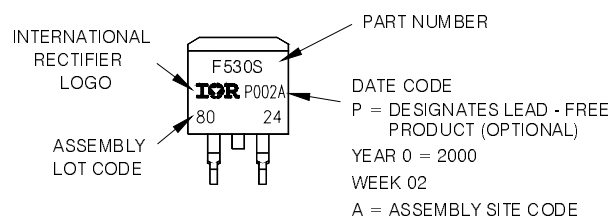
D<sup>2</sup>Pak (TO-263AB) Part Marking Information

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"

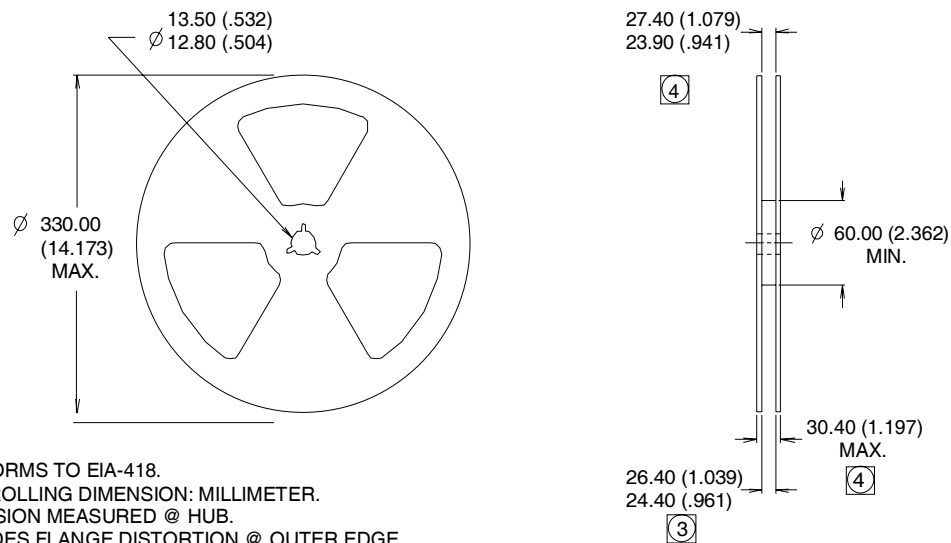


OR



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

Dimensions are shown in millimeters (inches)



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

Data and specifications subject to change without notice.  
This product has been designed and qualified for Industrial market.  
Qualification Standards can be found on IR's Web site.

International  
**IOR** Rectifier

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