

# IRGB4064DPbF

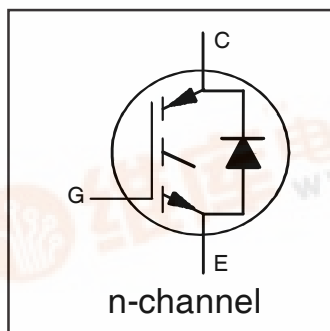
## INSULATED GATE BIPOLAR TRANSISTOR WITH ULTRAFAST SOFT RECOVERY DIODE

### Features

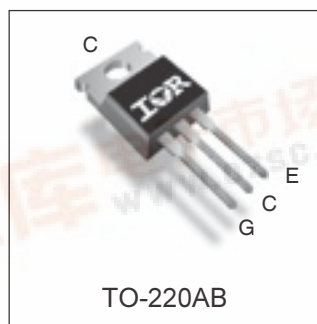
- Low  $V_{CE(on)}$  Trench IGBT Technology
- Low Switching Losses
- Maximum Junction temperature 175 °C
- 5μs SCSOA
- Square RBSOA
- 100% of The Parts Tested for  $I_{LM}$
- Positive  $V_{CE(on)}$  Temperature Coefficient.
- Ultra Fast Soft Recovery Co-pak Diode
- Tighter Distribution of Parameters
- Lead-Free Package

### 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



|                                           |
|-------------------------------------------|
| $V_{CES} = 600V$                          |
| $I_C = 10A, T_C = 100^\circ C$            |
| $t_{sc} > 5\mu s, T_{jmax} = 175^\circ C$ |
| $V_{CE(on) typ.} = 1.6V$                  |



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

### Absolute Maximum Ratings

|                                         | Parameter                                           | Max.                              | Units |
|-----------------------------------------|-----------------------------------------------------|-----------------------------------|-------|
| V <sub>CES</sub>                        | Collector-to-Emitter Breakdown Voltage              | 600                               | V     |
| I <sub>C</sub> @ T <sub>C</sub> = 25°C  | Continuous Collector Current                        | 20                                | A     |
| I <sub>C</sub> @ T <sub>C</sub> = 100°C | Continuous Collector Current                        | 10                                |       |
| I <sub>CM</sub>                         | Pulsed Collector Current                            | 40                                |       |
| I <sub>LM</sub>                         | Clamped Inductive Load Current ①                    | 40                                |       |
| I <sub>F</sub> @T <sub>C</sub> =25°C    | Diode Continuous Forward Current                    | 20                                |       |
| I <sub>F</sub> @T <sub>C</sub> =100°C   | Diode Continuous Forward Current                    | 10                                |       |
| I <sub>FM</sub>                         | Diode Maximum Forward Current ②                     | 40                                |       |
| V <sub>GE</sub>                         | Continuous Gate-to-Emitter Voltage                  | ±20                               | V     |
|                                         | Transient Gate-to-Emitter Voltage                   | ±30                               |       |
| P <sub>D</sub> @ T <sub>C</sub> =25°    | Maximum Power Dissipation                           | 101                               | W     |
| P <sub>D</sub> @ T <sub>C</sub> =100°   | Maximum Power Dissipation                           | 50                                |       |
| T <sub>J</sub><br>T <sub>STG</sub>      | Operating Junction and<br>Storage Temperature Range | -55 to + 175                      | °C    |
|                                         | Soldering Temperature, for 10 seconds               | 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 |
|-----------------|---------------------------------------------|------|------|------|-------|
| $R_{\theta JC}$ | Junction-to-Case - IGBT ③                   | —    | —    | 1.49 | °C/W  |
| $R_{\theta JC}$ | Junction-to-Case - Diode ③                  | —    | —    | 3.66 |       |
| $R_{\theta CS}$ | Case-to-Sink, flat, greased surface         | —    | 0.50 | —    |       |
| $R_{\theta JA}$ | Junction-to-Ambient, typical socket mount ③ | —    | —    | 62   |       |
| W               | Weight                                      |      | 1.44 |      | g     |

**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 | —    | 0.47 | —         | V/ $^\circ\text{C}$  | $V_{GE} = 0V, I_C = 500\mu A$ (-55 $^\circ\text{C}$ -175 $^\circ\text{C}$ )  |                   |
| $V_{CE(on)}$                    | Collector-to-Emitter Saturation Voltage | —    | 1.6  | 1.91      | V                    | $I_C = 10A, V_{GE} = 15V, T_J = 25^\circ\text{C}$                            | 5,6,7,9,<br>10,11 |
|                                 |                                         | —    | 1.9  | —         |                      | $I_C = 10A, V_{GE} = 15V, T_J = 150^\circ\text{C}$                           |                   |
|                                 |                                         | —    | 2.0  | —         |                      | $I_C = 10A, V_{GE} = 15V, T_J = 175^\circ\text{C}$                           |                   |
| $V_{GE(th)}$                    | Gate Threshold Voltage                  | 4.0  | —    | 6.5       | V                    | $V_{CE} = V_{GE}, I_C = 275\mu A$                                            | 9,10,11,12        |
| $\Delta V_{GE(th)}/\Delta T_J$  | Threshold Voltage temp. coefficient     | —    | -11  | —         | mV/ $^\circ\text{C}$ | $V_{CE} = V_{GE}, I_C = 1.0mA$ (25 $^\circ\text{C}$ - 175 $^\circ\text{C}$ ) |                   |
| $g_{fe}$                        | Forward Transconductance                | —    | 6.9  | —         | S                    | $V_{CE} = 50V, I_C = 10A, PW = 80\mu s$                                      |                   |
| $I_{CES}$                       | Collector-to-Emitter Leakage Current    | —    | —    | 25        | $\mu A$              | $V_{GE} = 0V, V_{CE} = 600V$                                                 | 8                 |
|                                 |                                         | —    | 328  | —         |                      | $V_{GE} = 0V, V_{CE} = 600V, T_J = 175^\circ\text{C}$                        |                   |
| $V_{FM}$                        | Diode Forward Voltage Drop              | —    | 2.5  | 3.1       | V                    | $I_F = 10A$                                                                  |                   |
|                                 |                                         | —    | 1.7  | —         |                      | $I_F = 10A, T_J = 175^\circ\text{C}$                                         |                   |
| $I_{GES}$                       | Gate-to-Emitter Leakage Current         | —    | —    | $\pm 100$ | nA                   | $V_{GE} = \pm 20V$                                                           |                   |

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

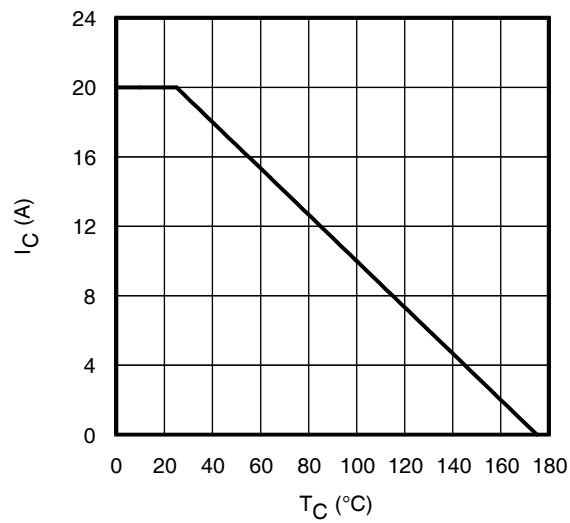
|              | Parameter                            | Min.        | Typ. | Max. | Units   | Conditions                                                                                                   | Ref.Fig                  |
|--------------|--------------------------------------|-------------|------|------|---------|--------------------------------------------------------------------------------------------------------------|--------------------------|
| $Q_g$        | Total Gate Charge (turn-on)          | —           | 21   | 32   | nC      | $I_C = 10A$                                                                                                  | 24<br>CT1                |
| $Q_{ge}$     | Gate-to-Emitter Charge (turn-on)     | —           | 5.3  | 8.0  |         | $V_{GE} = 15V$                                                                                               |                          |
| $Q_{gc}$     | Gate-to-Collector Charge (turn-on)   | —           | 8.9  | 13   |         | $V_{CC} = 400V$                                                                                              |                          |
| $E_{on}$     | Turn-On Switching Loss               | —           | 29   | 71   | $\mu J$ | $I_C = 10A, V_{CC} = 400V, V_{GE} = 15V$                                                                     | CT4                      |
| $E_{off}$    | Turn-Off Switching Loss              | —           | 200  | 308  |         | $R_G = 22\Omega, L = 1.0mH, T_J = 25^\circ\text{C}$                                                          |                          |
| $E_{total}$  | Total Switching Loss                 | —           | 229  | 339  |         | Energy losses include tail & diode reverse recovery                                                          |                          |
| $t_{d(on)}$  | Turn-On delay time                   | —           | 27   | 37   | ns      | $I_C = 10A, V_{CC} = 400V, V_{GE} = 15V$                                                                     | CT4                      |
| $t_r$        | Rise time                            | —           | 15   | 23   |         | $R_G = 22\Omega, L = 1.0mH, T_J = 25^\circ\text{C}$                                                          |                          |
| $t_{d(off)}$ | Turn-Off delay time                  | —           | 79   | 90   |         |                                                                                                              |                          |
| $t_f$        | Fall time                            | —           | 21   | 30   |         |                                                                                                              |                          |
| $E_{on}$     | Turn-On Switching Loss               | —           | 99   | —    | $\mu J$ | $I_C = 10A, V_{CC} = 400V, V_{GE} = 15V$                                                                     | 13,15<br>CT4<br>WF1,WF2  |
| $E_{off}$    | Turn-Off Switching Loss              | —           | 316  | —    |         | $R_G = 22\Omega, L = 1.0mH, T_J = 175^\circ\text{C}$ ④                                                       |                          |
| $E_{total}$  | Total Switching Loss                 | —           | 415  | —    |         | Energy losses include tail & diode reverse recovery                                                          |                          |
| $t_{d(on)}$  | Turn-On delay time                   | —           | 27   | —    | ns      | $I_C = 10A, V_{CC} = 400V, V_{GE} = 15V$                                                                     | 14,16<br>CT4<br>WF1,WF2  |
| $t_r$        | Rise time                            | —           | 16   | —    |         | $R_G = 22\Omega, L = 1.0mH, T_J = 175^\circ\text{C}$                                                         |                          |
| $t_{d(off)}$ | Turn-Off delay time                  | —           | 98   | —    |         |                                                                                                              |                          |
| $t_f$        | Fall time                            | —           | 33   | —    |         |                                                                                                              |                          |
| $C_{ies}$    | Input Capacitance                    | —           | 594  | —    | pF      | $V_{GE} = 0V$                                                                                                | 22                       |
| $C_{oes}$    | Output Capacitance                   | —           | 49   | —    |         | $V_{CC} = 30V$                                                                                               |                          |
| $C_{res}$    | Reverse Transfer Capacitance         | —           | 17   | —    |         | $f = 1.0MHz$                                                                                                 |                          |
| RBSOA        | Reverse Bias Safe Operating Area     | FULL SQUARE |      |      |         | $T_J = 175^\circ\text{C}, I_C = 40A$<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 | —           | 191  | —    | $\mu J$ | $T_J = 175^\circ\text{C}$                                                                                    | 17,18,19<br>20,21<br>WF3 |
| $t_{rr}$     | Diode Reverse Recovery Time          | —           | 62   | —    | ns      | $V_{CC} = 400V, I_F = 10A$                                                                                   |                          |
| $I_{rr}$     | Peak Reverse Recovery Current        | —           | 16   | —    | A       | $V_{GE} = 15V, R_G = 22\Omega, L = 1.0mH$                                                                    |                          |

## Notes:

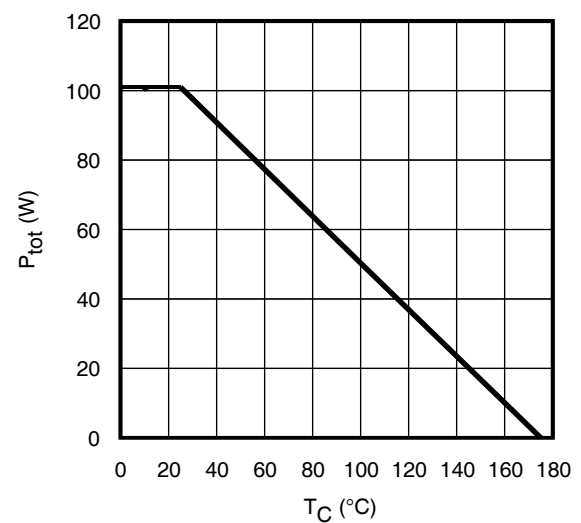
①  $V_{CC} = 80\% (V_{CES}), V_{GE} = 15V, L = 28 \mu H, R_G = 22 \Omega$ .

② Pulse width limited by max. junction temperature.

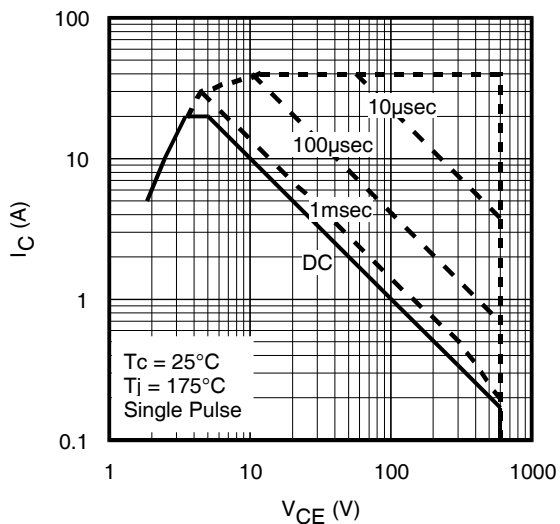
③  $R_\theta$  is measured at  $T_J$  approximately 90 $^\circ\text{C}$ ④ Refer to AN-1086 for guidelines for measuring  $V_{(BR)CES}$  safely



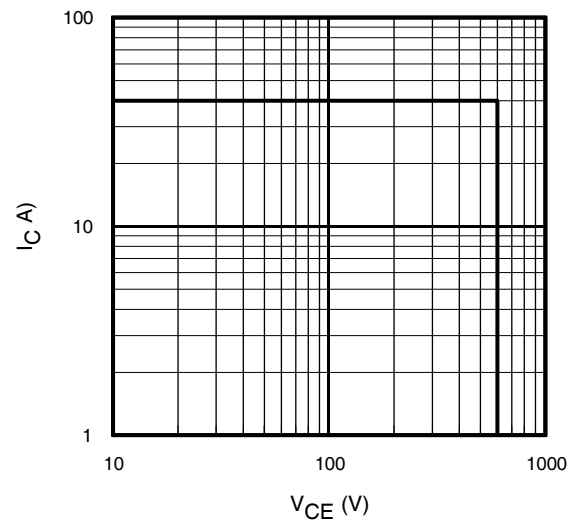
**Fig. 1** - Maximum DC Collector Current vs. Case Temperature



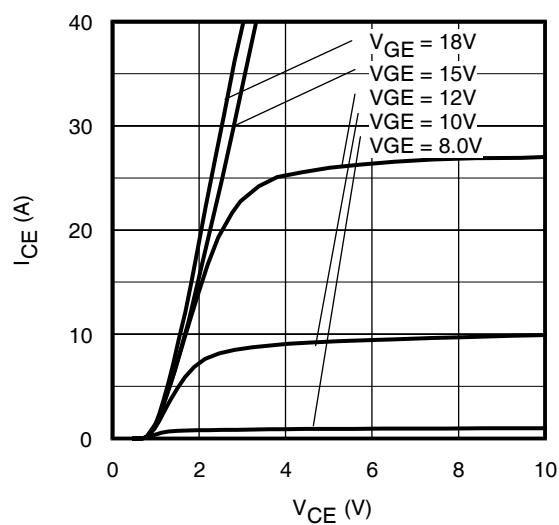
**Fig. 2** - Power Dissipation vs. Case Temperature



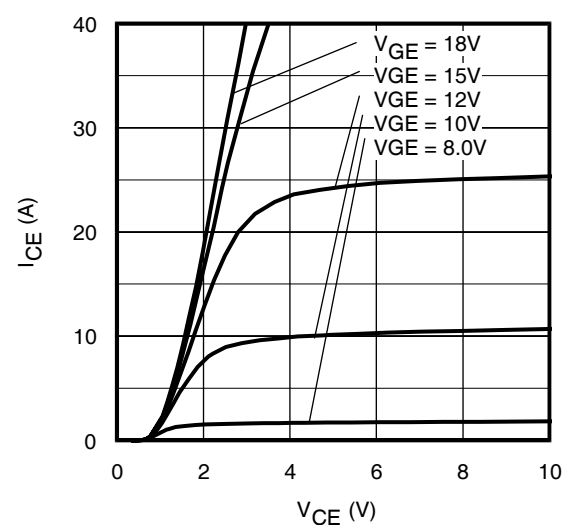
**Fig. 3** - Forward SOA,  
 $T_C = 25^\circ\text{C}$ ;  $T_J \leq 175^\circ\text{C}$



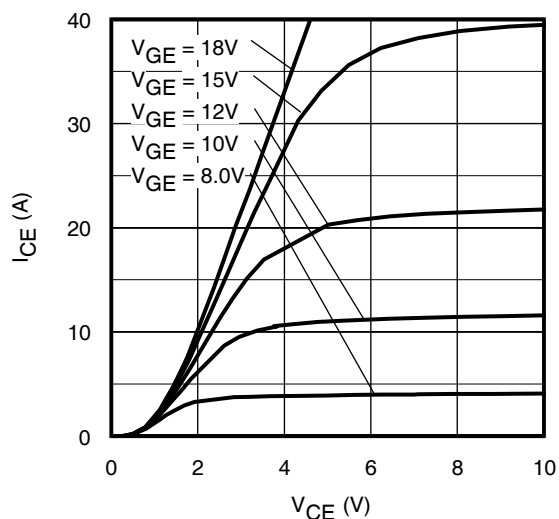
**Fig. 4** - Reverse Bias SOA  
 $T_J = 175^\circ\text{C}$ ;  $V_{CE} = 15\text{V}$



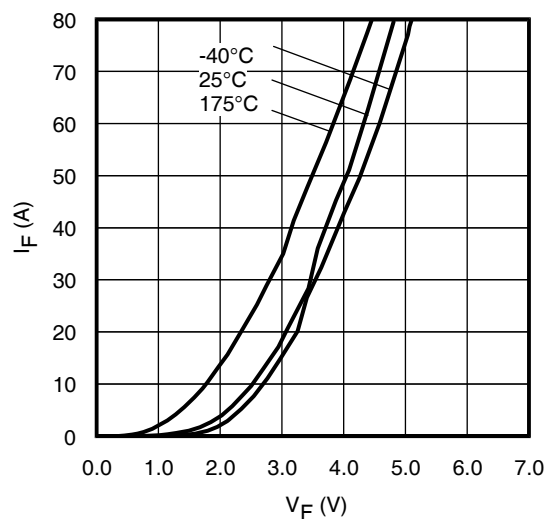
**Fig. 5** - Typ. IGBT Output Characteristics



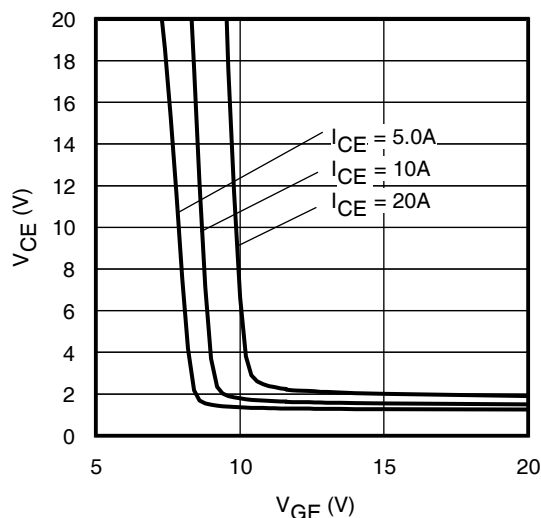
**Fig. 6** - Typ. IGBT Output Characteristics



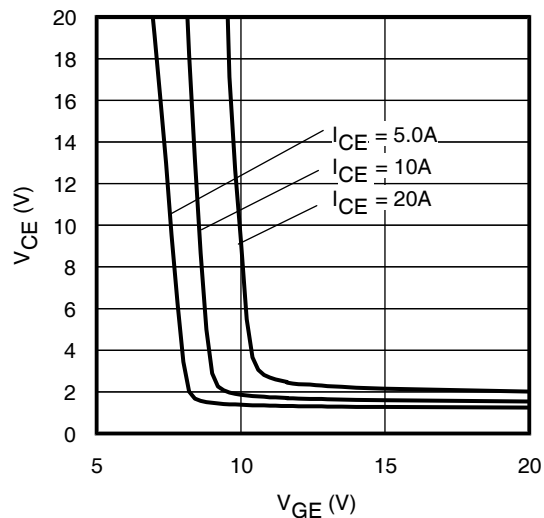
**Fig. 7** - Typ. IGBT Output Characteristics  
 $T_J = 175^\circ\text{C}$ ;  $t_p = 80\mu\text{s}$



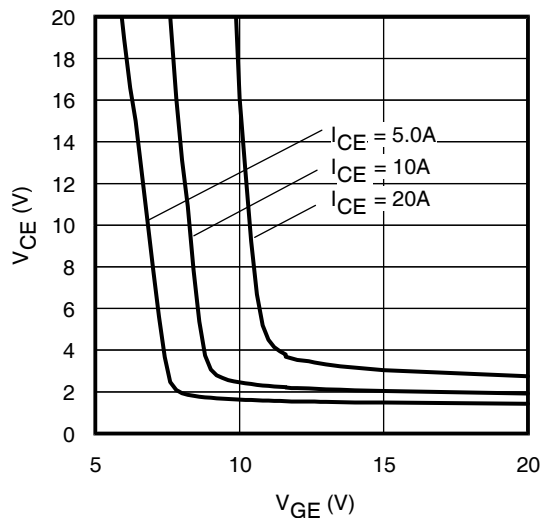
**Fig. 8** - Typ. Diode Forward Characteristics  
 $t_p = 80\mu\text{s}$



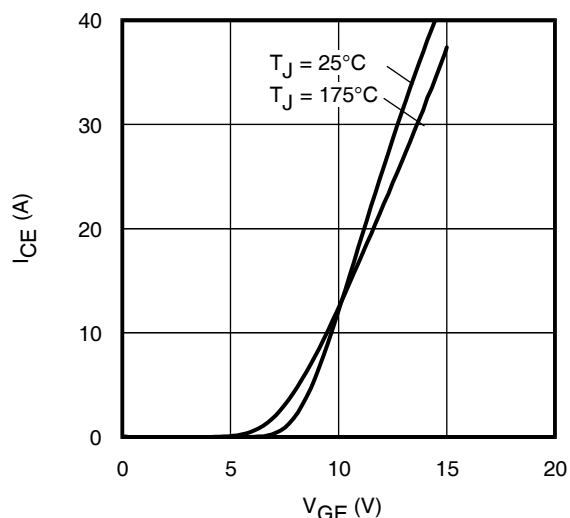
**Fig. 9** - Typical  $V_{CE}$  vs.  $V_{GE}$   
 $T_J = -40^\circ\text{C}$



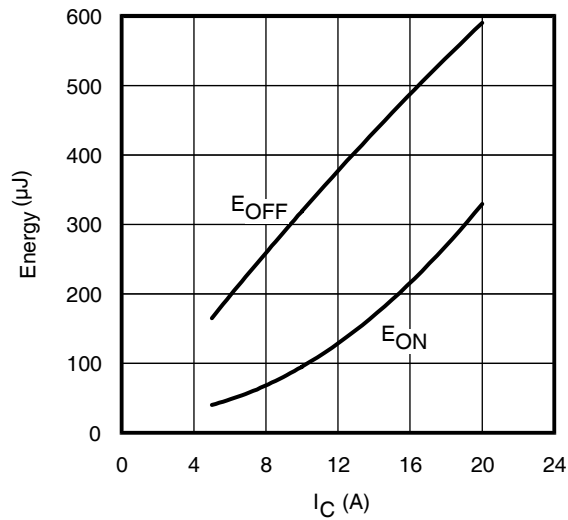
**Fig. 10** - Typical  $V_{CE}$  vs.  $V_{GE}$   
 $T_J = 25^\circ\text{C}$



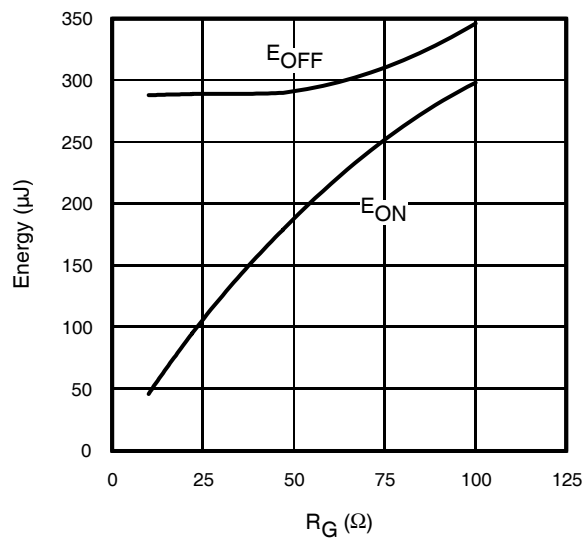
**Fig. 11** - Typical  $V_{CE}$  vs.  $V_{GE}$   
 $T_J = 175^\circ\text{C}$



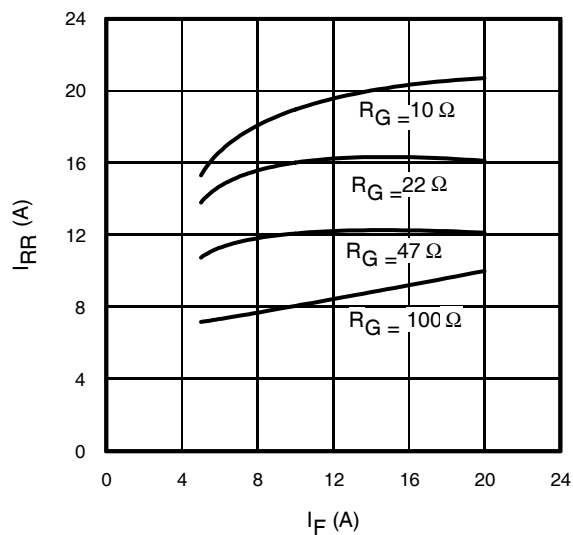
**Fig. 12** - Typ. Transfer Characteristics  
 $V_{CE} = 50\text{V}$ ;  $t_p = 10\mu\text{s}$



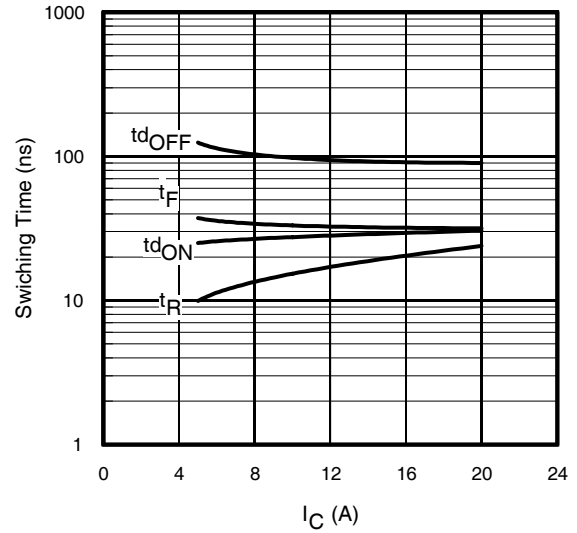
**Fig. 13** - Typ. Energy Loss vs.  $I_C$   
 $T_J = 175^\circ\text{C}$ ;  $L = 1\text{mH}$ ;  $V_{CE} = 400\text{V}$ ;  $R_G = 22\Omega$ ;  $V_{GE} = 15\text{V}$ .



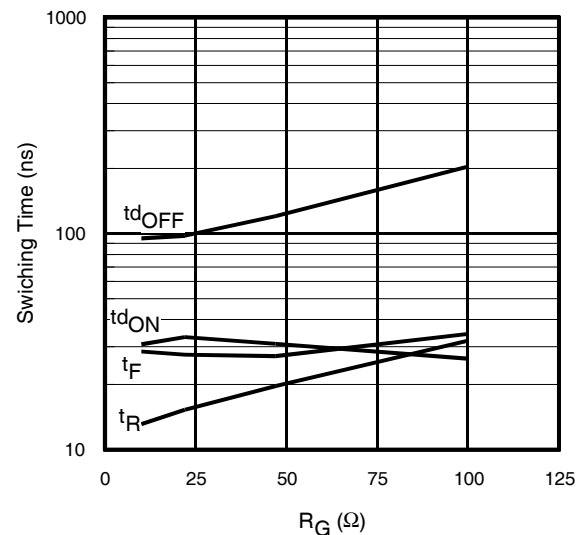
**Fig. 15** - Typ. Energy Loss vs.  $R_G$   
 $T_J = 175^\circ\text{C}$ ;  $L = 1\text{mH}$ ;  $V_{CE} = 400\text{V}$ ;  $I_{CE} = 10\text{A}$ ;  $V_{GE} = 15\text{V}$



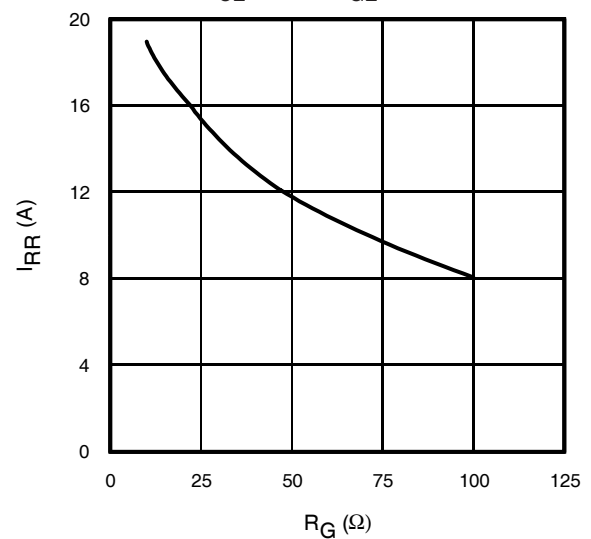
**Fig. 17** - Typical Diode  $I_{RR}$  vs.  $I_F$



**Fig. 14** - Typ. Switching Time vs.  $I_C$   
 $T_J = 175^\circ\text{C}$ ;  $L = 1\text{mH}$ ;  $V_{CE} = 400\text{V}$   
 $R_G = 22\Omega$ ;  $V_{GE} = 15\text{V}$



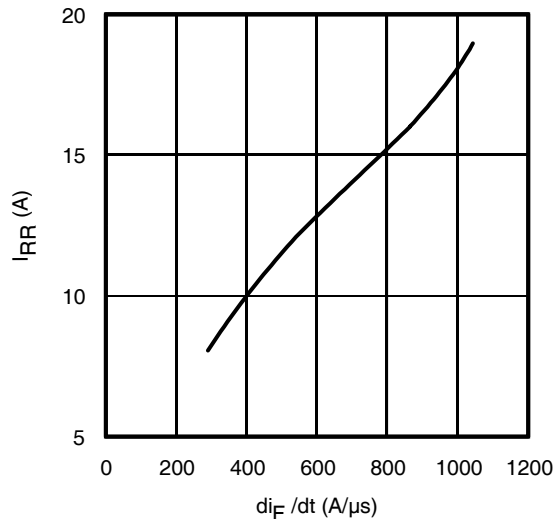
**Fig. 16** - Typ. Switching Time vs.  $R_G$   
 $T_J = 175^\circ\text{C}$ ;  $L = 1\text{mH}$ ;  $V_{CE} = 400\text{V}$   
 $I_{CE} = 10\text{A}$ ;  $V_{GE} = 15\text{V}$



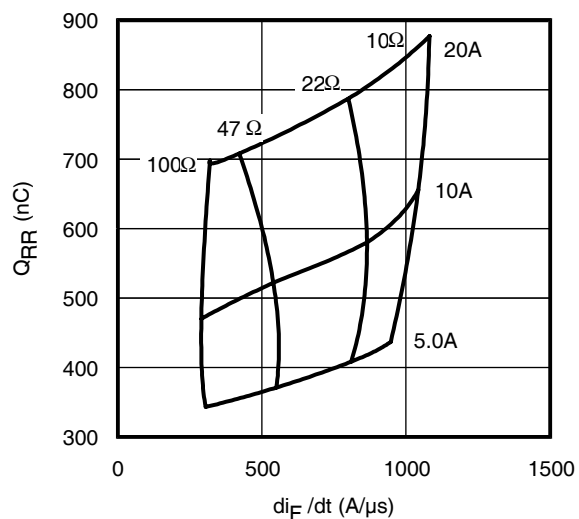
**Fig. 18** - Typical Diode  $I_{RR}$  vs.  $R_G$

# IRGB4064DPbF

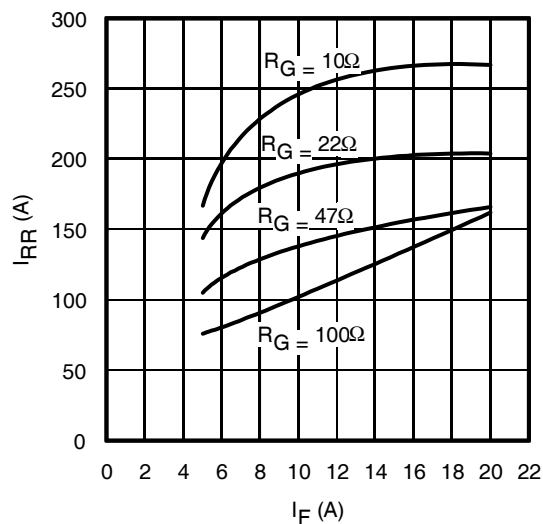
International  
**IR** Rectifier



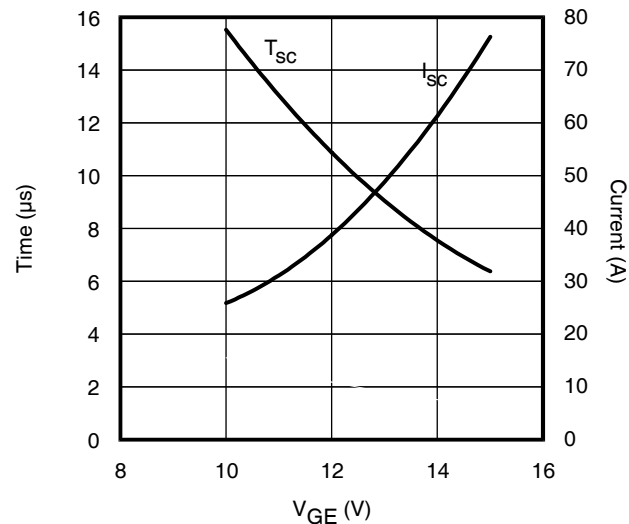
**Fig. 19-** Typical Diode  $I_{RR}$  vs.  $di_F/dt$   
 $V_{CC}=400V$ ;  $V_{GE}=15V$ ;  
 $I_{CE}=10A$ ;  $T_J=175^{\circ}C$



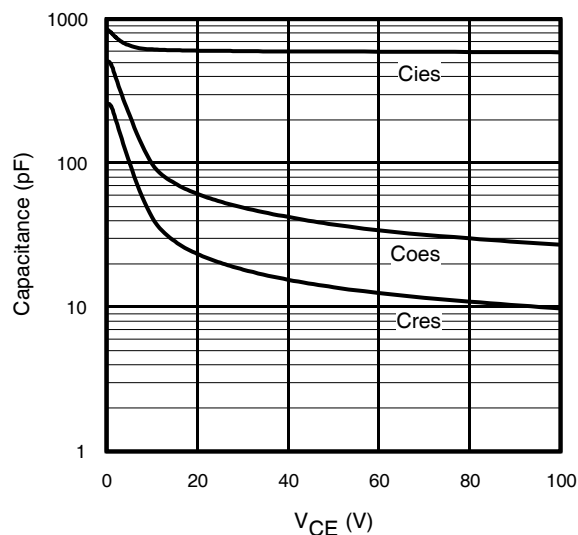
**Fig. 20 -** Typical Diode  $Q_{RR}$   
 $V_{CC}=400V$ ;  $V_{GE}=15V$ ;  $T_J=175^{\circ}C$



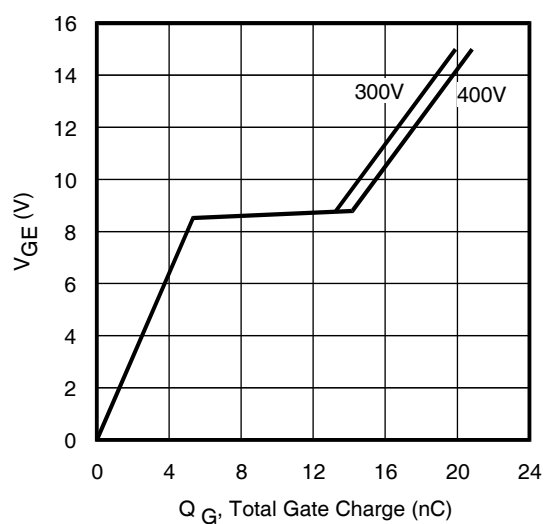
**Fig. 21 -** Typical Diode  $E_{RR}$  vs.  $I_F$   
 $T_J=175^{\circ}C$



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



**Fig. 23-** Typ. Capacitance vs  $V_{CE}$



**Fig. 24-** Typical  $Q_G$  vs  $V_{GE}$

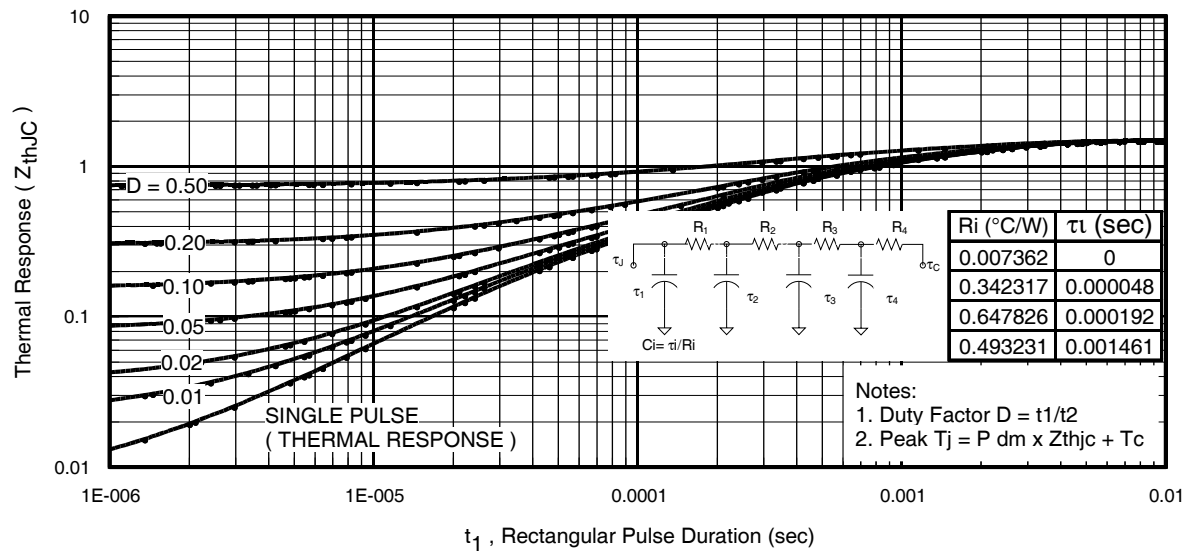


Fig 25. Maximum Transient Thermal Impedance, Junction-to-Case (IGBT)

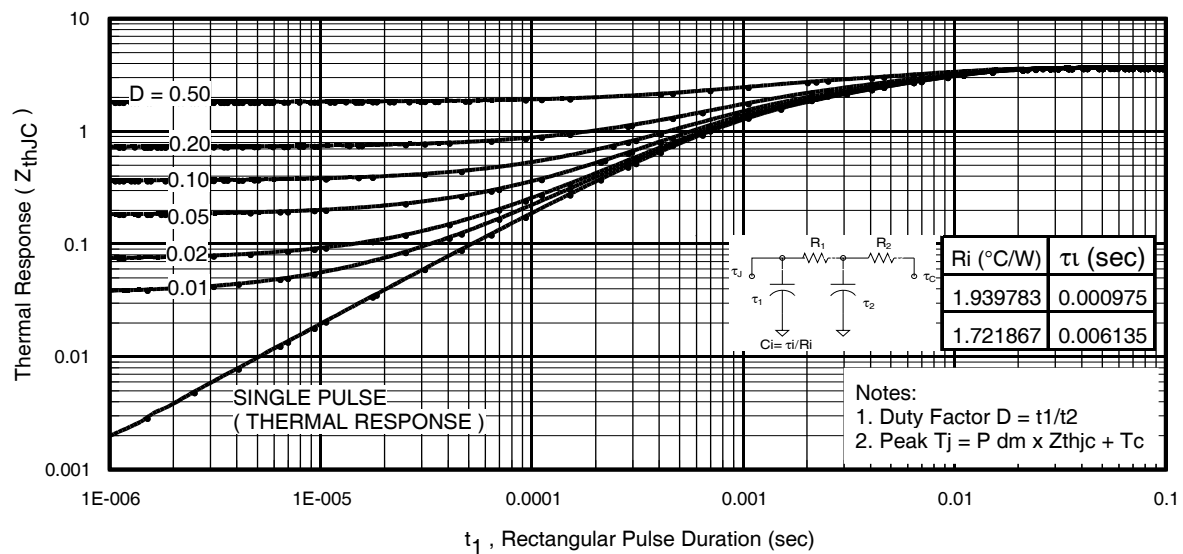
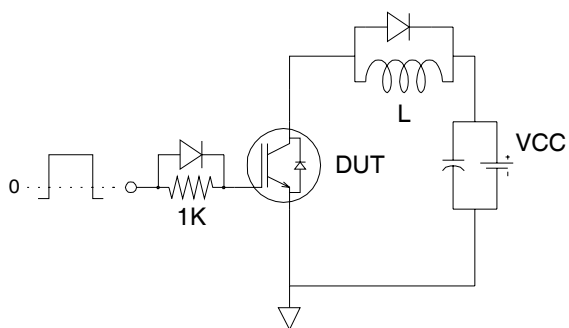
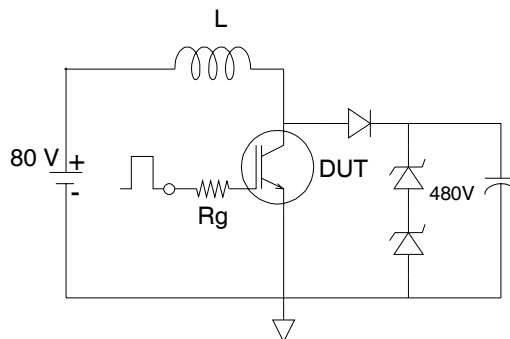


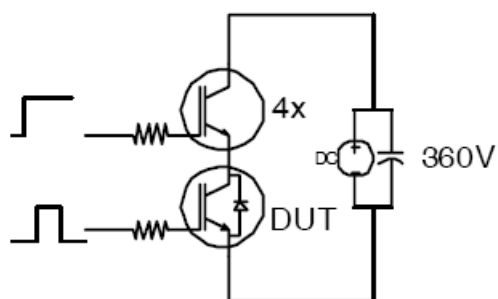
Fig. 26. Maximum Transient Thermal Impedance, Junction-to-Case (DIODE)



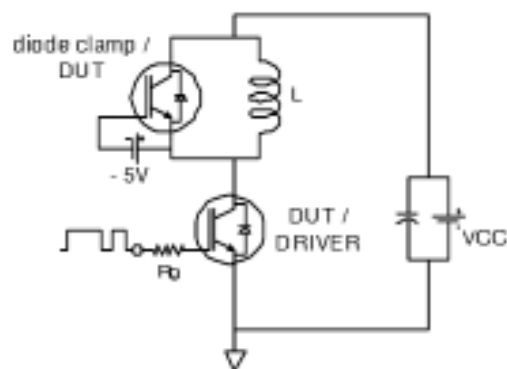
**Fig.C.T.1 - Gate Charge Circuit (turn-off)**



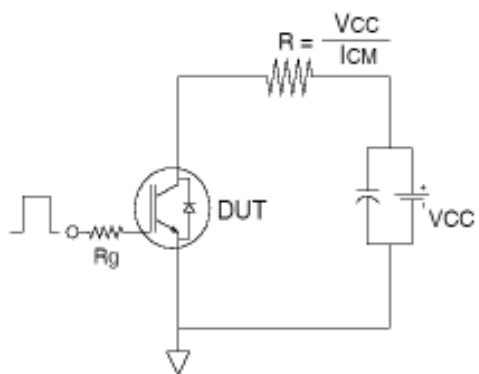
### Fig.C.T.2 - RBSOA Circuit



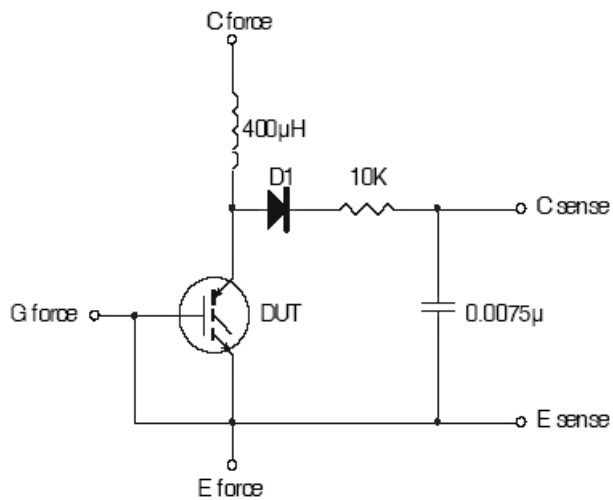
**Fig.C.T.3 - S.C.SOA Circuit**



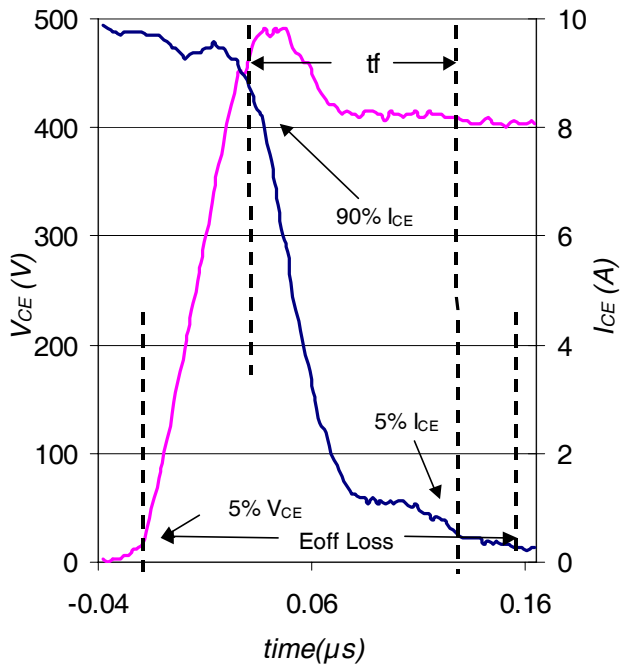
**Fig.C.T.4 - Switching Loss Circuit**



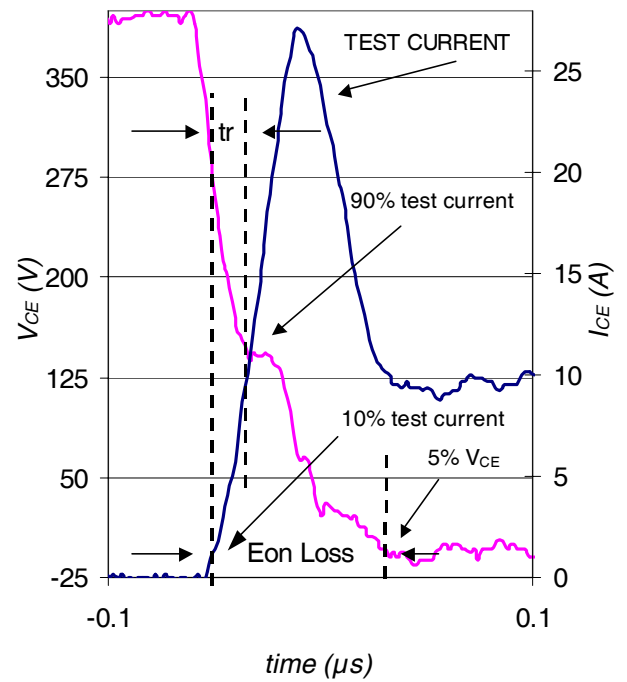
**Fig.C.T.5 - Resistive Load Circuit**



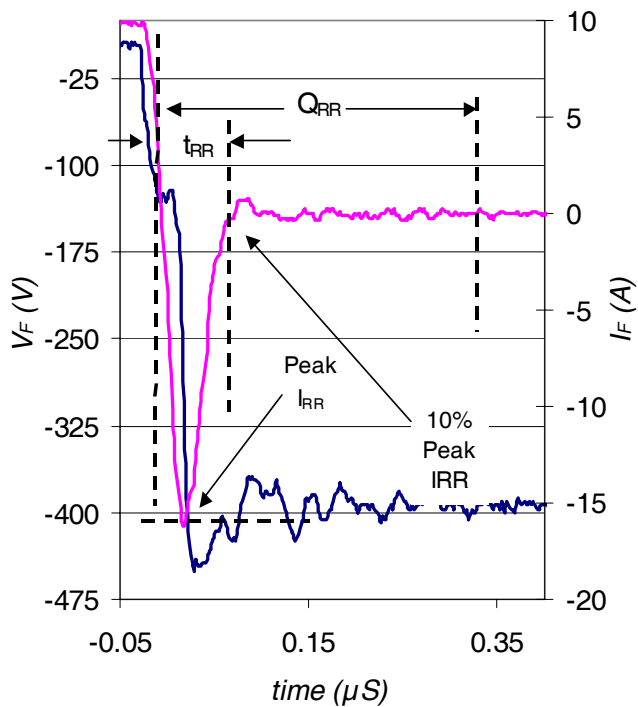
**Fig.C.T.6 - Typical Filter Circuit for  $V_{(BR)CES}$  Measurement**



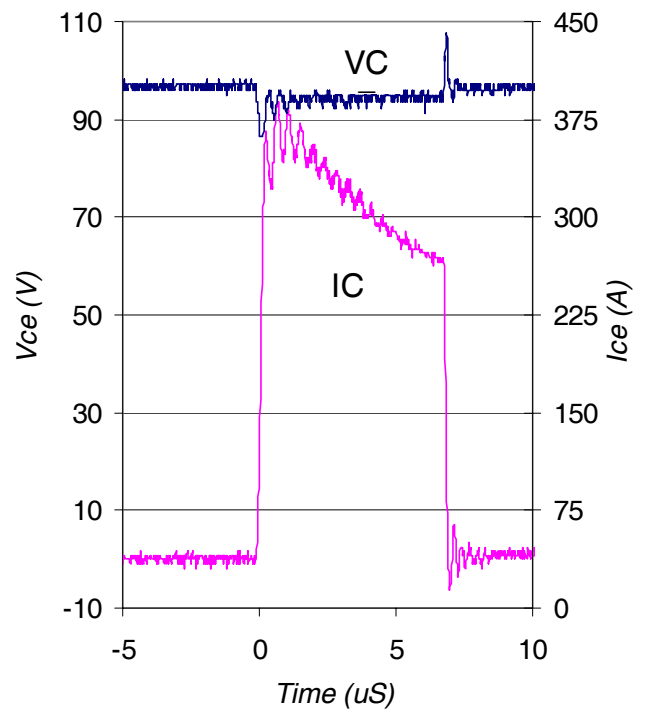
**Fig. WF1** - Typ. Turn-off Loss Waveform  
@  $T_J = 175^\circ\text{C}$  using Fig. CT.4



**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

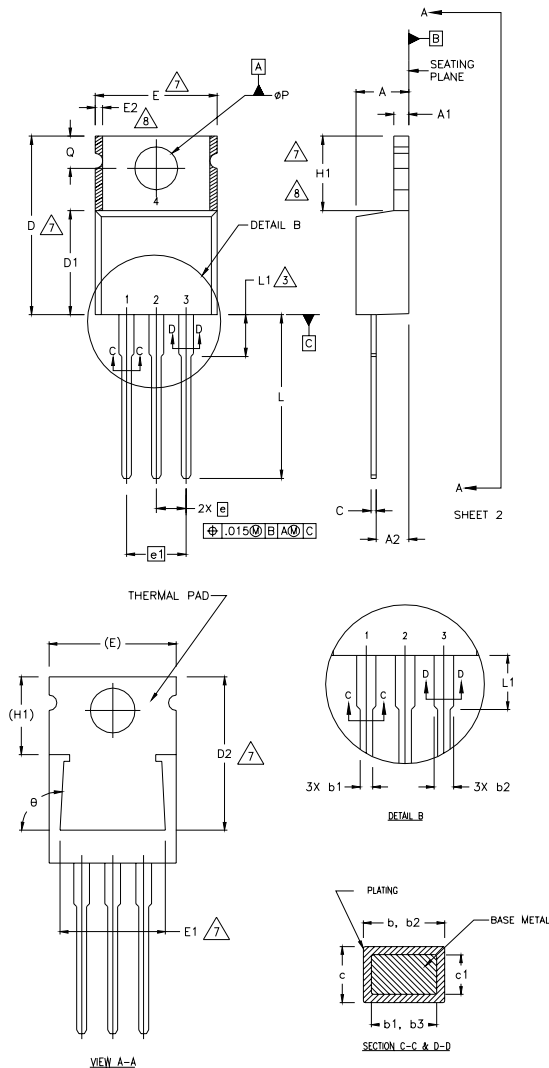


**WF.4-** Typ. Short Circuit Waveform  
@  $T_J = 25^\circ\text{C}$  using CT.3

# IRGB4064DPbF

International  
**IR** Rectifier

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



### NOTES:

- 1 DIMENSIONING AND TOLERANCING PER ASME Y14.5 M- 1994.
- 2 DIMENSIONS ARE SHOWN IN INCHES [MILLIMETERS].
- 3 LEAD DIMENSION AND FINISH UNCONTROLLED IN L1.
- 4 DIMENSION D & 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 & 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.

### LEAD ASSIGNMENTS

#### HEXFET

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

#### IGBTs, CoPACK

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

#### DIODES

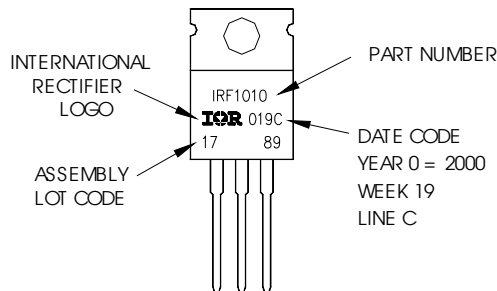
- 1.- ANODE/OPEN
- 2.- CATHODE
- 3.- ANODE

| SYMBOL | DIMENSIONS  |       |          |      | NOTES |
|--------|-------------|-------|----------|------|-------|
|        | MILLIMETERS |       | INCHES   |      |       |
|        | MIN.        | MAX.  | MIN.     | MAX. |       |
| A      | 3.56        | 4.82  | .140     | .190 | 5     |
| A1     | 0.51        | 1.40  | .020     | .055 |       |
| A2     | 2.04        | 2.92  | .080     | .115 |       |
| b      | 0.38        | 1.01  | .015     | .040 |       |
| b1     | 0.38        | 0.96  | .015     | .038 |       |
| b2     | 1.15        | 1.77  | .045     | .070 | 5     |
| b3     | 1.15        | 1.73  | .045     | .068 |       |
| c      | 0.36        | 0.61  | .014     | .024 |       |
| c1     | 0.36        | 0.56  | .014     | .022 |       |
| D      | 14.22       | 16.51 | .560     | .650 |       |
| D1     | 8.38        | 9.02  | .330     | .355 | 7     |
| D2     | 12.19       | 12.88 | .480     | .507 |       |
| E      | 9.66        | 10.66 | .380     | .420 | 4,7   |
| E1     | 8.38        | 8.89  | .330     | .350 | 7     |
| e      | 2.54 BSC    |       | .100 BSC |      | 7,8   |
| e1     | 5.08        |       | .200 BSC |      |       |
| H1     | 5.85        | 6.55  | .230     | .270 |       |
| L      | 12.70       | 14.73 | .500     | .580 | 3     |
| L1     | —           | 6.35  | —        | .250 |       |
| øP     | 3.54        | 4.08  | .139     | .161 |       |
| Q      | 2.54        | 3.42  | .100     | .135 |       |
| ø      | 90°–93°     |       | 90°–93°  |      |       |

## TO-220AB Part Marking Information

EXAMPLE: THIS IS AN IRF1010  
LOT CODE 1789  
ASSEMBLED ON VW 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.

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  
**IR** Rectifier

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