

## INSULATED GATE BIPOLAR TRANSISTOR WITH ULTRAFAST SOFT RECOVERY DIODE

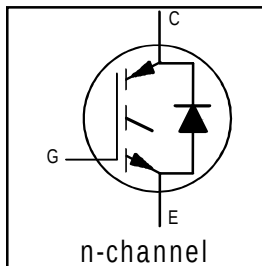
Fast CoPack IGBT

### Features

- Very Low 1.66V voltage drop
- 2.5kV, 60s insulation voltage ⑤
- 4.8 mm creepage distance to heatsink
- Fast: Optimized for medium operating frequencies ( 1-5 kHz in hard switching, >20 kHz in resonant mode).
- IGBT co-packaged with HEXFRED™ ultrafast, ultrasoft recovery antiparallel diodes
- Tighter parameter distribution
- Industry standard Isolated TO-220 Fullpak™ outline

### Benefits

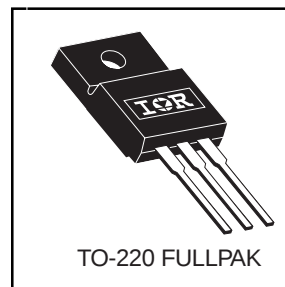
- Simplified assembly
- Highest efficiency and power density
- HEXFRED™ antiparallel Diode minimizes switching losses and EMI



$$V_{CES} = 600V$$

$$V_{CE(on)} \text{ typ.} = 1.66V$$

$$@V_{GE} = 15V, I_C = 9.0A$$



TO-220 FULLPAK

### Absolute Maximum Ratings

|                           | Parameter                                | Max.                              | Units      |
|---------------------------|------------------------------------------|-----------------------------------|------------|
| $V_{CES}$                 | Collector-to-Emitter Voltage             | 600                               | V          |
| $I_C @ T_C = 25^\circ C$  | Continuous Collector Current             | 14.3                              | A          |
| $I_C @ T_C = 100^\circ C$ | Continuous Collector Current             | 7.7                               |            |
| $I_{CM}$                  | Pulsed Collector Current ①               | 64                                |            |
| $I_{LM}$                  | Clamped Inductive Load Current ②         | 64                                |            |
| $I_F @ T_C = 100^\circ C$ | Diode Continuous Forward Current         | 6.5                               |            |
| $I_{FM}$                  | Diode Maximum Forward Current            | 64                                |            |
| Visol                     | RMS Isolation Voltage, Terminal to Case⑤ | 2500                              | V          |
| $V_{GE}$                  | Gate-to-Emitter Voltage                  | $\pm 20$                          | W          |
| $P_D @ T_C = 25^\circ C$  | Maximum Power Dissipation                | 34                                |            |
| $P_D @ T_C = 100^\circ C$ | Maximum Power Dissipation                | 14                                |            |
| $T_J$                     | Operating Junction and                   | -55 to +150                       | $^\circ C$ |
| $T_{STG}$                 | 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

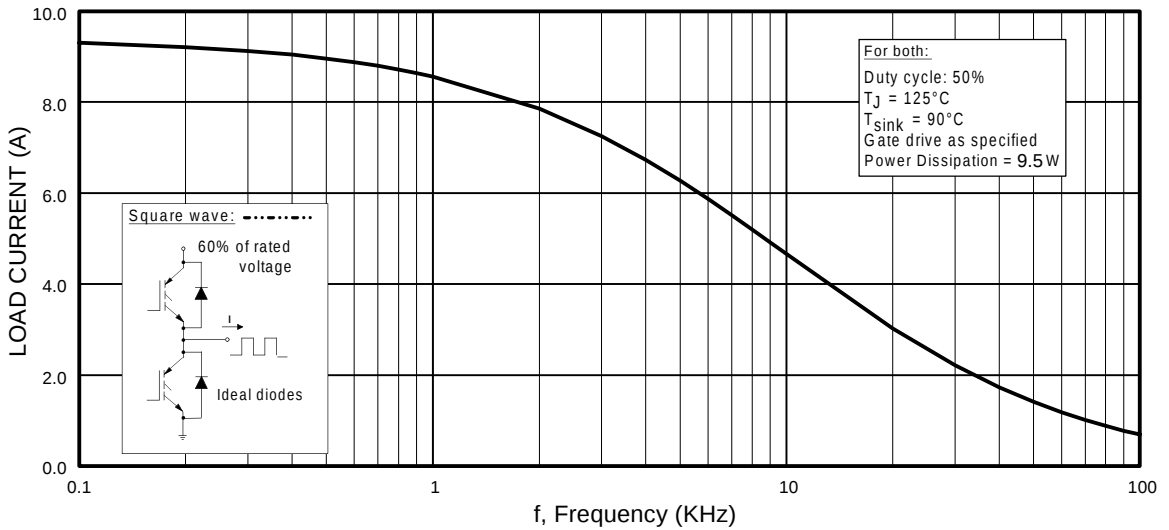
|                 | Parameter                                 | Typ.       | Max. | Units        |
|-----------------|-------------------------------------------|------------|------|--------------|
| $R_{\theta JC}$ | Junction-to-Case - IGBT                   | —          | 3.7  | $^\circ C/W$ |
| $R_{\theta JC}$ | Junction-to-Case - Diode                  | —          | 5.1  |              |
| $R_{\theta JA}$ | Junction-to-Ambient, typical socket mount | —          | 65   |              |
| Wt              | Weight                                    | 2.0 (0.07) | —    | g (oz)       |

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

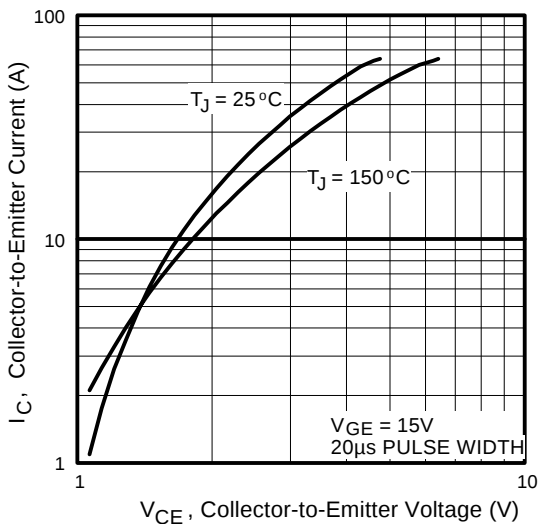
|                                 | Parameter                                           | Min. | Typ. | Max.      | Units                | Conditions                                            |
|---------------------------------|-----------------------------------------------------|------|------|-----------|----------------------|-------------------------------------------------------|
| $V_{(BR)CES}$                   | Collector-to-Emitter Breakdown Voltage <sup>③</sup> | 600  | —    | —         | V                    | $V_{GE} = 0V, I_C = 250\mu A$                         |
| $\Delta V_{(BR)CES}/\Delta T_J$ | Temperature Coeff. of Breakdown Voltage             | —    | 0.72 | —         | V/ $^\circ\text{C}$  | $V_{GE} = 0V, I_C = 1.0mA$                            |
| $V_{CE(on)}$                    | Collector-to-Emitter Saturation Voltage             | —    | 1.66 | 2.0       | V                    | $I_C = 9.0A$ $V_{GE} = 15V$                           |
|                                 |                                                     | —    | 2.06 | —         |                      | $I_C = 16A$ See Fig. 2, 5                             |
|                                 |                                                     | —    | 1.76 | —         |                      | $I_C = 9.0A, T_J = 150^\circ\text{C}$                 |
| $V_{GE(th)}$                    | Gate Threshold Voltage                              | 3.0  | —    | 6.0       |                      | $V_{CE} = V_{GE}, I_C = 250\mu A$                     |
| $\Delta V_{GE(th)}/\Delta T_J$  | Temperature Coeff. of Threshold Voltage             | —    | -11  | —         | mV/ $^\circ\text{C}$ | $V_{CE} = V_{GE}, I_C = 250\mu A$                     |
| $g_{fe}$                        | Forward Transconductance <sup>④</sup>               | 2.9  | 5.1  | —         | S                    | $V_{CE} = 100V, I_C = 9.0A$                           |
| $I_{CES}$                       | Zero Gate Voltage Collector Current                 | —    | —    | 250       | $\mu A$              | $V_{GE} = 0V, V_{CE} = 600V$                          |
|                                 |                                                     | —    | —    | 1700      |                      | $V_{GE} = 0V, V_{CE} = 600V, T_J = 150^\circ\text{C}$ |
| $V_{FM}$                        | Diode Forward Voltage Drop                          | —    | 1.4  | 1.7       | V                    | $I_C = 8.0A$ See Fig. 13                              |
|                                 |                                                     | —    | 1.3  | 1.6       |                      | $I_C = 8.0A, T_J = 150^\circ\text{C}$                 |
| $I_{GES}$                       | Gate-to-Emitter Leakage Current                     | —    | —    | $\pm 100$ | nA                   | $V_{GE} = \pm 20V$                                    |

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

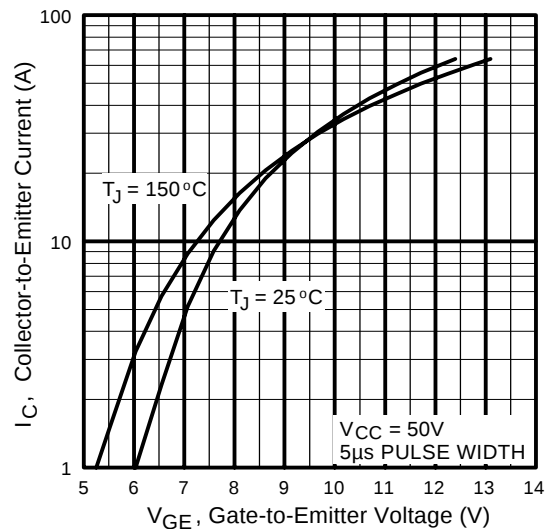
|                  | Parameter                                        | Min. | Typ. | Max. | Units      | Conditions                                               |
|------------------|--------------------------------------------------|------|------|------|------------|----------------------------------------------------------|
| $Q_g$            | Total Gate Charge (turn-on)                      | —    | 27   | 40   | nC         | $I_C = 9.0A$                                             |
| $Q_{ge}$         | Gate - Emitter Charge (turn-on)                  | —    | 4.2  | 6.2  |            | $V_{CC} = 400V$ See Fig. 8                               |
| $Q_{gc}$         | Gate - Collector Charge (turn-on)                | —    | 9.9  | 15   |            | $V_{GE} = 15V$                                           |
| $t_{d(on)}$      | Turn-On Delay Time                               | —    | 43   | —    | ns         | $T_J = 25^\circ\text{C}$                                 |
| $t_r$            | Rise Time                                        | —    | 20   | —    |            | $I_C = 9.0A, V_{CC} = 480V$                              |
| $t_{d(off)}$     | Turn-Off Delay Time                              | —    | 240  | 360  |            | $V_{GE} = 15V, R_G = 50\Omega$                           |
| $t_f$            | Fall Time                                        | —    | 150  | 220  |            | Energy losses include "tail" and diode reverse recovery. |
| $E_{on}$         | Turn-On Switching Loss                           | —    | 0.25 | —    | mJ         | See Fig. 9, 10, 18                                       |
| $E_{off}$        | Turn-Off Switching Loss                          | —    | 0.64 | —    |            |                                                          |
| $E_{ts}$         | Total Switching Loss                             | —    | 0.89 | 1.3  |            |                                                          |
| $t_{d(on)}$      | Turn-On Delay Time                               | —    | 41   | —    | ns         | $T_J = 150^\circ\text{C}$ , See Fig. 11, 18              |
| $t_r$            | Rise Time                                        | —    | 22   | —    |            | $I_C = 9.0A, V_{CC} = 480V$                              |
| $t_{d(off)}$     | Turn-Off Delay Time                              | —    | 320  | —    |            | $V_{GE} = 15V, R_G = 50\Omega$                           |
| $t_f$            | Fall Time                                        | —    | 290  | —    |            | Energy losses include "tail" and diode reverse recovery. |
| $E_{ts}$         | Total Switching Loss                             | —    | 1.35 | —    | mJ         |                                                          |
| $L_E$            | Internal Emitter Inductance                      | —    | 7.5  | —    | nH         | Measured 5mm from package                                |
| $C_{ies}$        | Input Capacitance                                | —    | 540  | —    | pF         | $V_{GE} = 0V$                                            |
| $C_{oes}$        | Output Capacitance                               | —    | 37   | —    |            | $V_{CC} = 30V$ See Fig. 7                                |
| $C_{res}$        | Reverse Transfer Capacitance                     | —    | 7.0  | —    |            | $f = 1.0MHz$                                             |
| $t_{rr}$         | Diode Reverse Recovery Time                      | —    | 37   | 55   | ns         | $T_J = 25^\circ\text{C}$ See Fig. 14                     |
|                  |                                                  | —    | 55   | 90   |            | $T_J = 125^\circ\text{C}$                                |
| $I_{rr}$         | Diode Peak Reverse Recovery Current              | —    | 3.5  | 5.0  | A          | $T_J = 25^\circ\text{C}$ See Fig. 15                     |
|                  |                                                  | —    | 4.5  | 8.0  |            | $T_J = 125^\circ\text{C}$                                |
| $Q_{rr}$         | Diode Reverse Recovery Charge                    | —    | 65   | 138  | nC         | $T_J = 25^\circ\text{C}$ See Fig. 16                     |
|                  |                                                  | —    | 124  | 360  |            | $T_J = 125^\circ\text{C}$                                |
| $di_{(rec)M}/dt$ | Diode Peak Rate of Fall of Recovery During $t_b$ | —    | 240  | —    | A/ $\mu s$ | $T_J = 25^\circ\text{C}$ See Fig. 17                     |
|                  |                                                  | —    | 210  | —    |            | $T_J = 125^\circ\text{C}$                                |



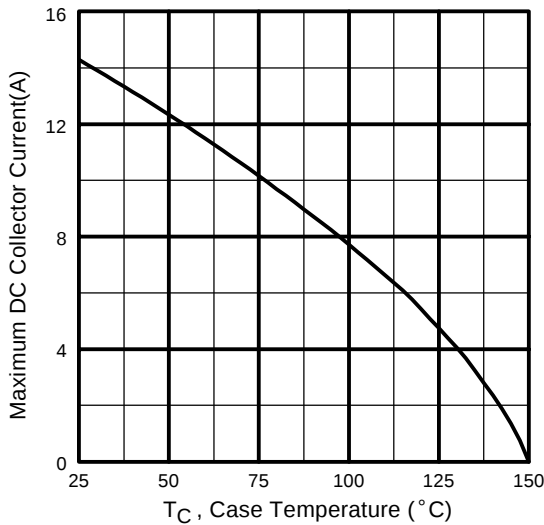
**Fig. 1 - Typical Load Current vs. Frequency**  
(Load Current =  $I_{\text{RMS}}$  of fundamental)



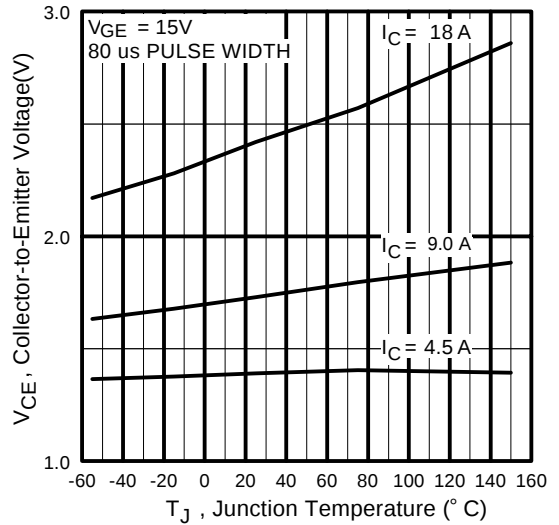
**Fig. 2 - Typical Output Characteristics**



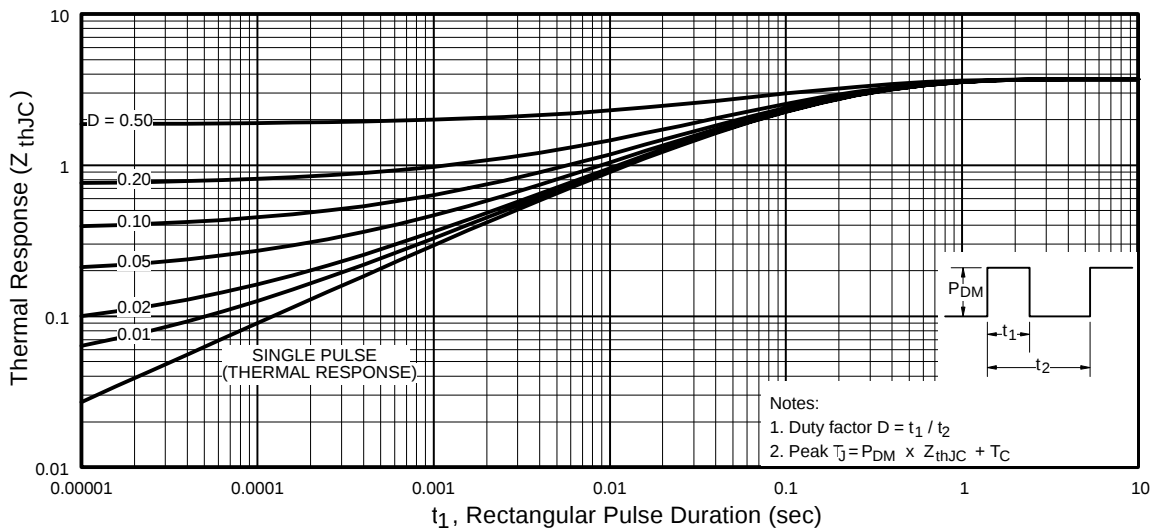
**Fig. 3 - Typical Transfer Characteristics**



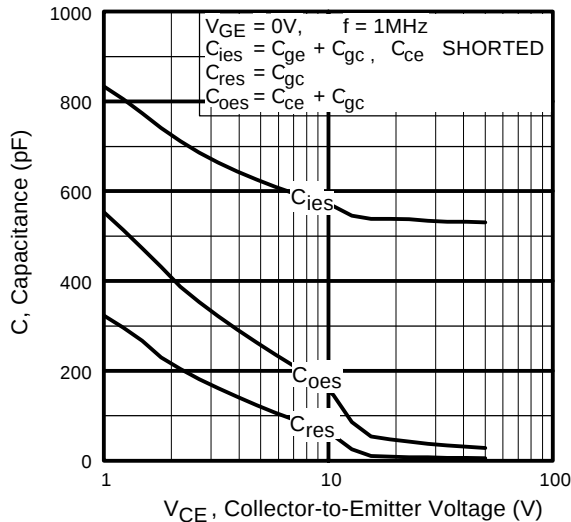
**Fig. 4** - Maximum Collector Current vs. Case Temperature



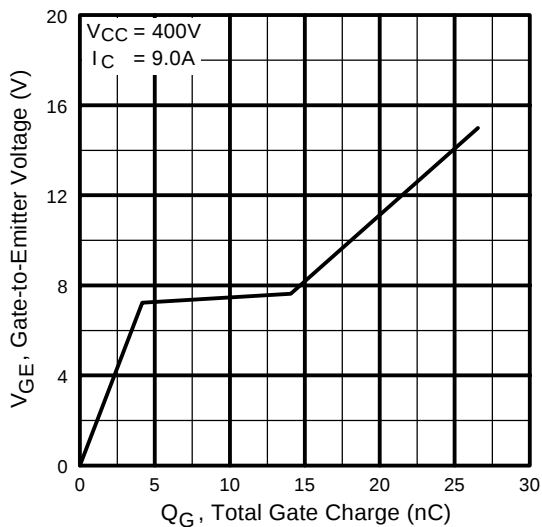
**Fig. 5** - Typical Collector-to-Emitter Voltage vs. Junction Temperature



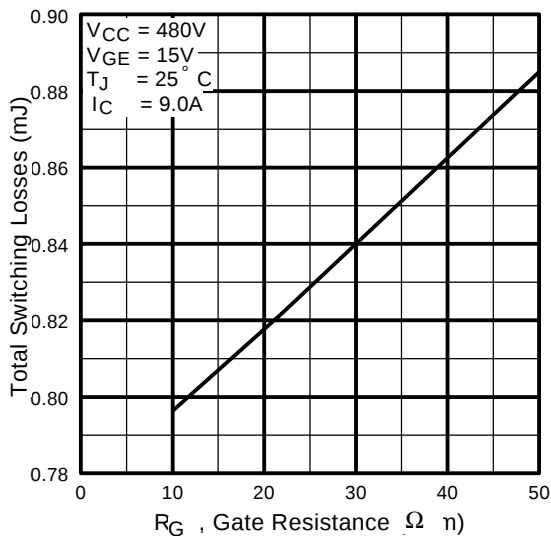
**Fig. 6** - Maximum Effective Transient Thermal Impedance, Junction-to-Case



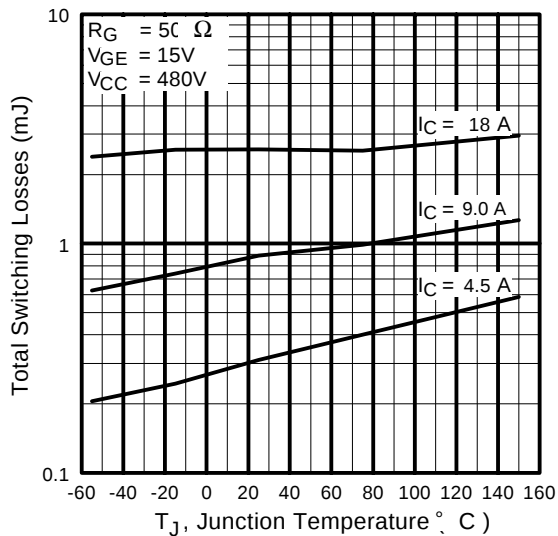
**Fig. 7** - Typical Capacitance vs. Collector-to-Emitter Voltage



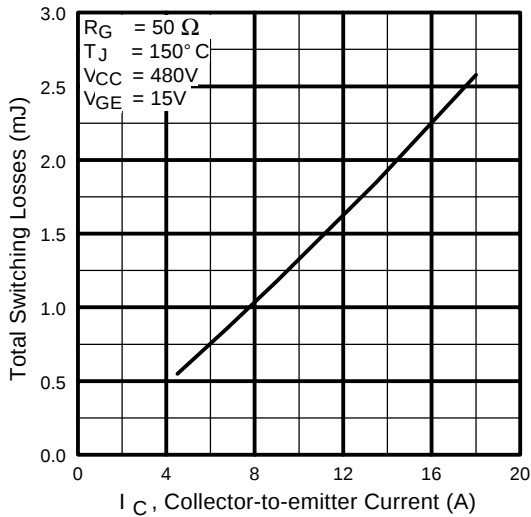
**Fig. 8** - Typical Gate Charge vs. Gate-to-Emitter Voltage



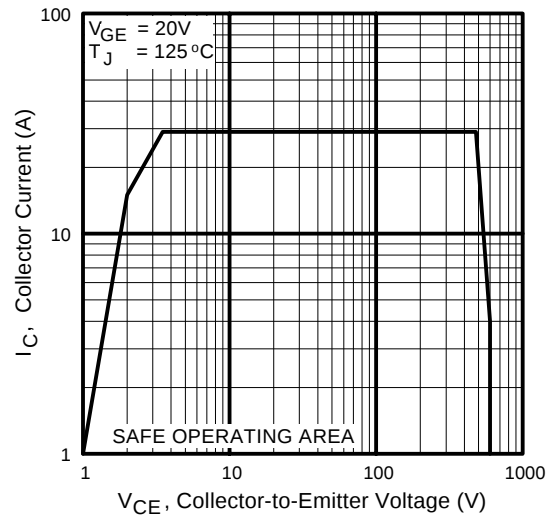
**Fig. 9** - Typical Switching Losses vs. Gate Resistance



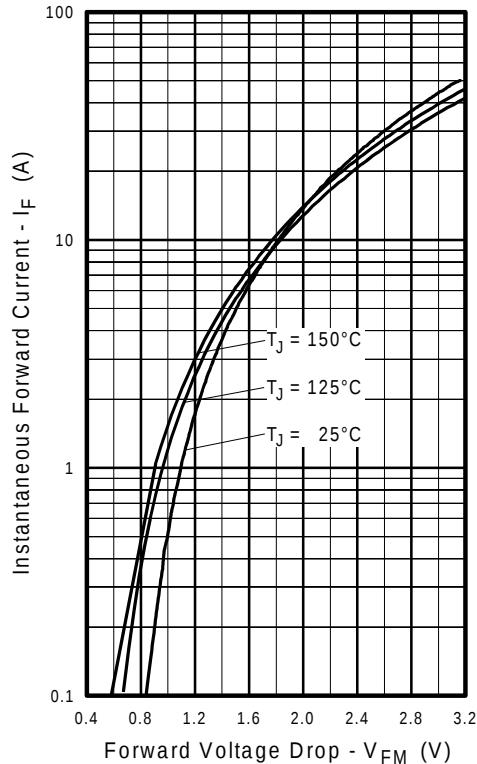
**Fig. 10** - Typical Switching Losses vs. Junction Temperature



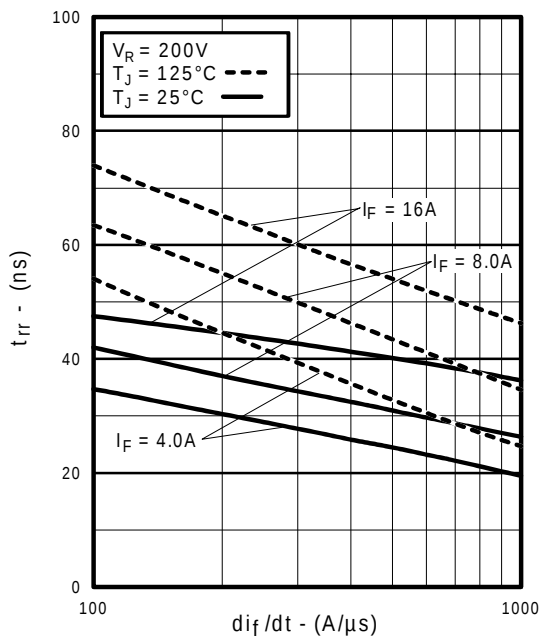
**Fig. 11** - Typical Switching Losses vs. Collector-to-Emitter Current



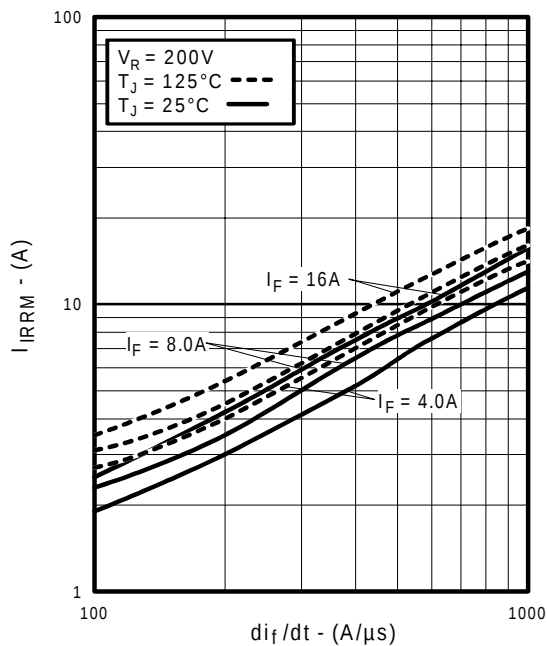
**Fig. 12** - Turn-Off SOA



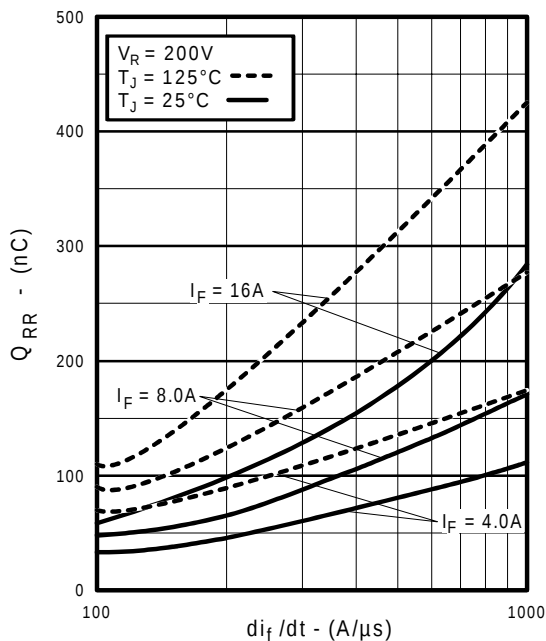
**Fig. 13** - Maximum Forward Voltage Drop vs. Instantaneous Forward Current



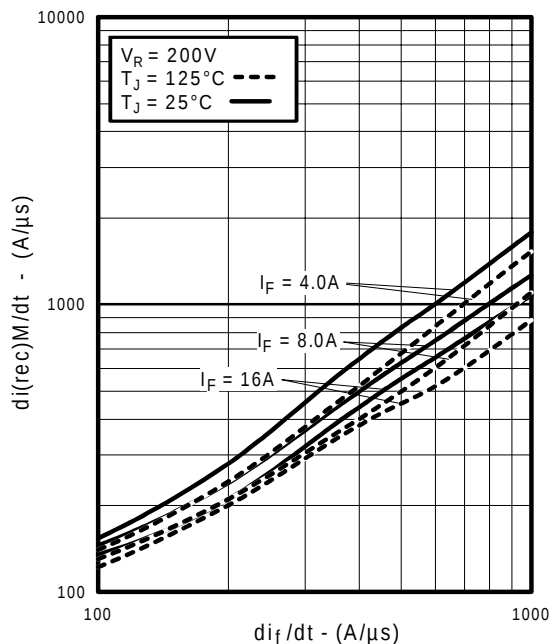
**Fig. 14** - Typical Reverse Recovery vs.  $di_f/dt$



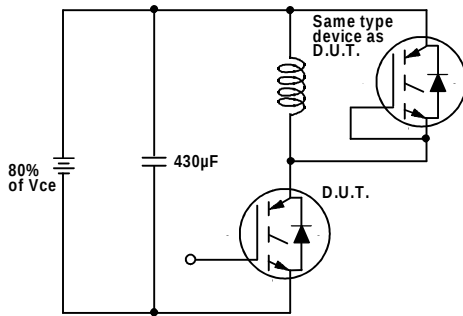
**Fig. 15** - Typical Recovery Current vs.  $di_f/dt$



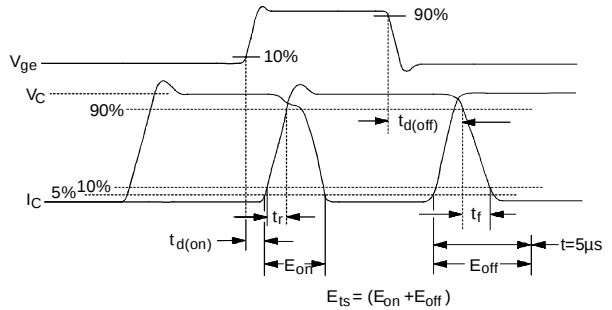
**Fig. 16** - Typical Stored Charge vs.  $di_f/dt$



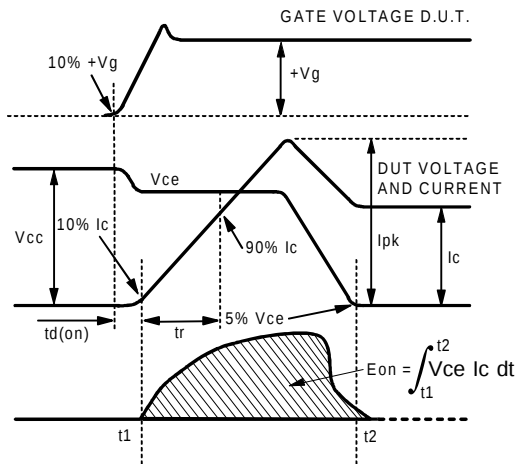
**Fig. 17** - Typical  $di_{(rec)M}/dt$  vs.  $di_f/dt$



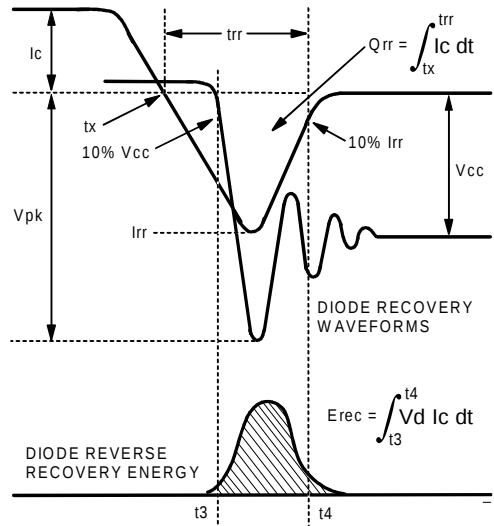
**Fig. 18a** - Test Circuit for Measurement of  $I_{LM}$ ,  $E_{on}$ ,  $E_{off}(\text{diode})$ ,  $t_{rr}$ ,  $Q_{rr}$ ,  $I_{rr}$ ,  $t_{d(on)}$ ,  $t_r$ ,  $t_{d(off)}$ ,  $t_f$



**Fig. 18b** - Test Waveforms for Circuit of Fig. 18a, Defining  $E_{off}$ ,  $t_{d(off)}$ ,  $t_r$



**Fig. 18c** - Test Waveforms for Circuit of Fig. 18a, Defining  $E_{on}$ ,  $t_{d(on)}$ ,  $t_r$



**Fig. 18d** - Test Waveforms for Circuit of Fig. 18a, Defining  $E_{rec}$ ,  $t_{rr}$ ,  $Q_{rr}$ ,  $I_{rr}$

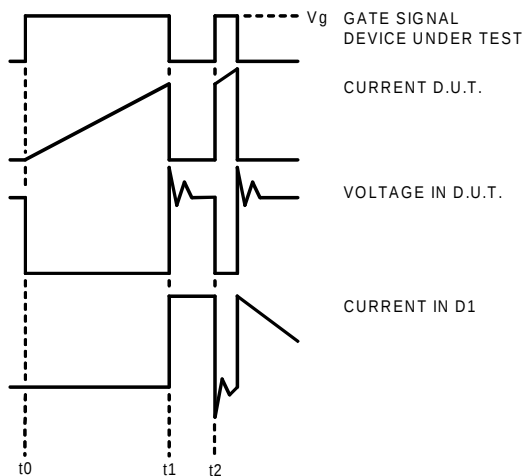


Figure 18e. Macro Waveforms for Figure 18a's Test Circuit

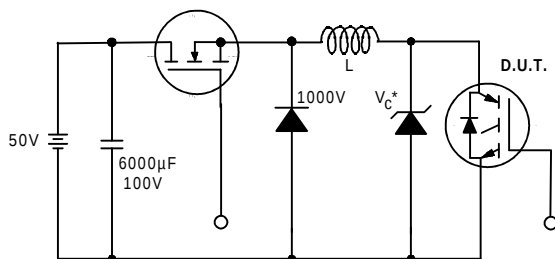


Figure 19. Clamped Inductive Load Test Circuit

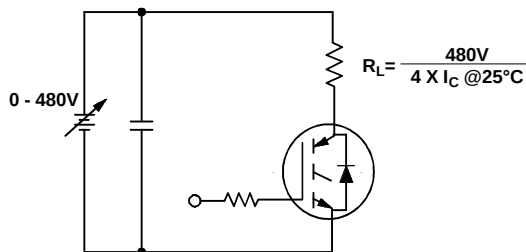


Figure 20. Pulsed Collector Current Test Circuit

## Notes:

- ① Repetitive rating:  $V_{GE}=20V$ ; pulse width limited by maximum junction temperature (figure 20)
- ②  $V_{CC}=80\%(V_{CES})$ ,  $V_{GE}=20V$ ,  $L=10\mu H$ ,  $R_G = 50\Omega$  (figure 19)
- ③ Pulse width  $\leq 80\mu s$ ; duty factor  $\leq 0.1\%$ .
- ④ Pulse width  $5.0\mu s$ , single shot.
- ⑤  $t = 60s$ ,  $f = 60Hz$

## Case Outline — TO-220 FULLPAK

