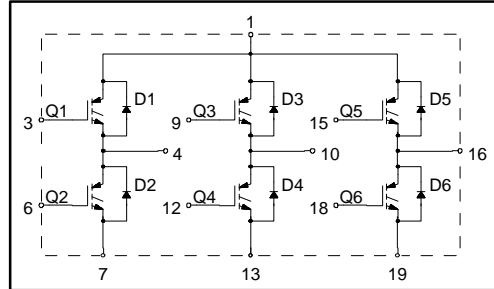


### IGBT SIP MODULE

### Ultra-Fast IGBT

#### Features

- Fully isolated printed circuit board mount package
- Switching-loss rating includes all "tail" losses
- HEXFRED™ soft ultrafast diodes
- Optimized for high operating frequency (over 5kHz)  
See Fig. 1 for Current vs. Frequency curve



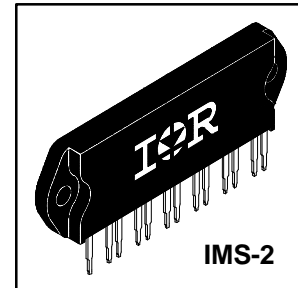
#### Product Summary

##### Output Current in a Typical 20 kHz Motor Drive

5.4 A<sub>RMS</sub> per phase (1.7 kW total) with T<sub>C</sub> = 90°C, T<sub>J</sub> = 125°C, Supply Voltage 360Vdc, Power Factor 0.8, Modulation Depth 80% (See Figure 1)

#### Description

The IGBT technology is the key to International Rectifier's advanced line of IMS (Insulated Metal Substrate) Power Modules. These modules are more efficient than comparable bipolar transistor modules, while at the same time having the simpler gate-drive requirements of the familiar power MOSFET. This superior technology has now been coupled to a state of the art materials system that maximizes power throughput with low thermal resistance. This package is highly suited to motor drive applications and where space is at a premium.



#### Absolute Maximum Ratings

|   | Parameter  | Max.                              | Units            |
|---|--|-----------------------------------|------------------|
| V <sub>CES</sub>                        | Collector-to-Emitter Voltage                     | 600                               | V                |
| I <sub>C</sub> @ T <sub>C</sub> = 25°C  | Continuous Collector Current, each IGBT          | 13                                | A                |
| I <sub>C</sub> @ T <sub>C</sub> = 100°C | Continuous Collector Current, each IGBT          | 6.8                               |                  |
| I <sub>CM</sub>                         | Pulsed Collector Current ①                       | 40                                |                  |
| I <sub>LM</sub>                         | Clamped Inductive Load Current ②                 | 40                                |                  |
| I <sub>F</sub> @ T <sub>C</sub> = 100°C | Diode Continuous Forward Current                 | 6.1                               |                  |
| I <sub>FM</sub>                         | Diode Maximum Forward Current                    | 40                                |                  |
| V <sub>GE</sub>                         | Gate-to-Emitter Voltage                          | ±20                               | V                |
| V <sub>ISOL</sub>                       | Isolation Voltage, any terminal to case, 1 min.  | 2500                              | V <sub>RMS</sub> |
| P <sub>D</sub> @ T <sub>C</sub> = 25°C  | Maximum Power Dissipation, each IGBT             | 36                                | W                |
| P <sub>D</sub> @ T <sub>C</sub> = 100°C | Maximum Power Dissipation, each IGBT             | 14                                |                  |
| T <sub>J</sub>                          | Operating Junction and Storage Temperature Range | -40 to +150                       | °C               |
|   | Soldering Temperature, for 10 sec.               | 300 (0.063 in. (1.6mm) from case) |                  |
|   | Mounting torque, 6-32 or M3 screw.               | 5-7 lbf•in (0.55-0.8 N•m)         |                  |

#### Thermal Resistance

|                           | Parameter   | Typ.     | Max. | Units  |
|---------------------------|---|----------|------|--------|
| R <sub>θJC</sub> (IGBT)   | Junction-to-Case, each IGBT, one IGBT in conduction   | —        | 3.5  | °C/W   |
| R <sub>θJC</sub> (DIODE)  | Junction-to-Case, each diode, one diode in conduction | —        | 5.5  |        |
| R <sub>θCS</sub> (MODULE) | Case-to-Sink, flat, greased surface                   | 0.1      | —    |        |
| Wt                        | Weight of module                                      | 20 (0.7) | —    | 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 ③ | 600  | —    | —         | V                   | $V_{GE} = 0V, I_C = 250\mu A$  |
| $\Delta V_{(BR)CES}/\Delta T_J$ | Temperature Coeff. of Breakdown Voltage  | —    | 0.63 | —         | $V/^\circ\text{C}$  | $V_{GE} = 0V, I_C = 1.0mA$   |
| $V_{CE(on)}$                    | Collector-to-Emitter Saturation Voltage  | —    | 1.9  | 2.4       | V                   | $I_C = 6.8A$<br>$I_C = 13A$<br>$I_C = 6.8A, T_J = 150^\circ\text{C}$ |
|                                 |  | —    | 2.3  | —         |                     |  |
|                                 |  | —    | 1.8  | —         |                     |  |
| $V_{GE(th)}$                    | Gate Threshold Voltage                   | 3.0  | —    | 5.5       |                     | $V_{CE} = V_{GE}, I_C = 250\mu A$                                    |
| $\Delta V_{GE(th)}/\Delta T_J$  | Temperature Coeff. of Threshold Voltage  | —    | -11  | —         | $mV/^\circ\text{C}$ | $V_{CE} = V_{GE}, I_C = 250\mu A$                                    |
| $g_{fe}$                        | Forward Transconductance ④               | 4.0  | 6.0  | —         | S                   | $V_{CE} = 100V, I_C = 6.8A$  |
| $I_{CES}$                       | Zero Gate Voltage Collector Current      | —    | —    | 250       | $\mu A$             | $V_{GE} = 0V, V_{CE} = 600V$   |
|                                 |  | —    | —    | 2500      |                     | $V_{GE} = 0V, V_{CE} = 600V, T_J = 150^\circ\text{C}$                |
| $V_{FM}$                        | Diode Forward Voltage Drop               | —    | 1.4  | 1.7       | V                   | $I_C = 12A$<br>$I_C = 12A, T_J = 150^\circ\text{C}$                  |
|                                 |  | —    | 1.3  | 1.6       |                     |  |
| $I_{GES}$                       | Gate-to-Emitter Leakage Current          | —    | —    | $\pm 500$ | 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)                      | —    | 29   | 36   | nC        | $I_C = 6.8A$<br>$V_{CC} = 400V$<br>See Fig. 8   |
| $Q_{ge}$         | Gate - Emitter Charge (turn-on)                  | —    | 4.8  | 6.8  |           |   |
| $Q_{gc}$         | Gate - Collector Charge (turn-on)                | —    | 12   | 17   |           |   |
| $t_{d(on)}$      | Turn-On Delay Time                               | —    | 25   | —    | ns        | $T_J = 25^\circ\text{C}$<br>$I_C = 6.8A, V_{CC} = 480V$<br>$V_{GE} = 15V, R_G = 23\Omega$<br>Energy losses include "tail" and diode reverse recovery.<br>See Fig. 9, 10, 11, 18 |
| $t_r$            | Rise Time  | —    | 15   | —    |           |   |
| $t_{d(off)}$     | Turn-Off Delay Time                              | —    | 92   | 200  |           |   |
| $t_f$            | Fall Time  | —    | 93   | 190  |           |   |
| $E_{on}$         | Turn-On Switching Loss                           | —    | 0.23 | —    | mJ        | See Fig. 9, 10, 11, 18  |
| $E_{off}$        | Turn-Off Switching Loss                          | —    | 0.13 | —    |           |   |
| $E_{ts}$         | Total Switching Loss                             | —    | 0.36 | 0.62 |           |   |
| $t_{d(on)}$      | Turn-On Delay Time                               | —    | 25   | —    | ns        | $T_J = 150^\circ\text{C}$ , See Fig. 9, 10, 11, 18<br>$I_C = 6.8A, V_{CC} = 480V$<br>$V_{GE} = 15V, R_G = 23\Omega$<br>Energy losses include "tail" and diode reverse recovery. |
| $t_r$            | Rise Time  | —    | 15   | —    |           |   |
| $t_{d(off)}$     | Turn-Off Delay Time                              | —    | 160  | —    |           |   |
| $t_f$            | Fall Time  | —    | 200  | —    |           |   |
| $E_{ts}$         | Total Switching Loss                             | —    | 0.71 | —    | mJ        |   |
| $C_{ies}$        | Input Capacitance                                | —    | 660  | —    | pF        | $V_{GE} = 0V$<br>$V_{CC} = 30V$<br>$f = 1.0MHz$<br>See Fig. 7   |
| $C_{oes}$        | Output Capacitance                               | —    | 100  | —    |           |   |
| $C_{res}$        | Reverse Transfer Capacitance                     | —    | 11   | —    |           |   |
| $t_{rr}$         | Diode Reverse Recovery Time                      | —    | 42   | 60   | ns        | $T_J = 25^\circ\text{C}$ See Fig. 14<br>$T_J = 125^\circ\text{C}$   |
|                  |  | —    | 80   | 120  |           |   |
| $I_{rr}$         | Diode Peak Reverse Recovery Current              | —    | 3.5  | 6.0  | A         | $T_J = 25^\circ\text{C}$ See Fig. 15<br>$T_J = 125^\circ\text{C}$   |
|                  |  | —    | 5.6  | 10   |           |   |
| $Q_{rr}$         | Diode Reverse Recovery Charge                    | —    | 80   | 180  | nC        | $T_J = 25^\circ\text{C}$ See Fig. 16<br>$T_J = 125^\circ\text{C}$   |
|                  |  | —    | 220  | 600  |           |   |
| $di_{(rec)M}/dt$ | Diode Peak Rate of Fall of Recovery During $t_b$ | —    | 180  | —    | $A/\mu s$ | $T_J = 25^\circ\text{C}$ See Fig. 17<br>$T_J = 125^\circ\text{C}$   |
|                  |  | —    | 116  | —    |           |   |

### Notes:

- ① Repetitive rating;  $V_{GE}=20V$ , pulse width limited by max. junction temperature. ( See fig. 20 )
- ②  $V_{CC}=80\%(V_{CES}), V_{GE}=20V, L=10\mu H, R_G=23\Omega$ , ( See fig. 19 )
- ③ Pulse width  $\leq 80\mu s$ ; duty factor  $\leq 0.1\%$ .
- ④ Pulse width  $5.0\mu s$ , single shot.

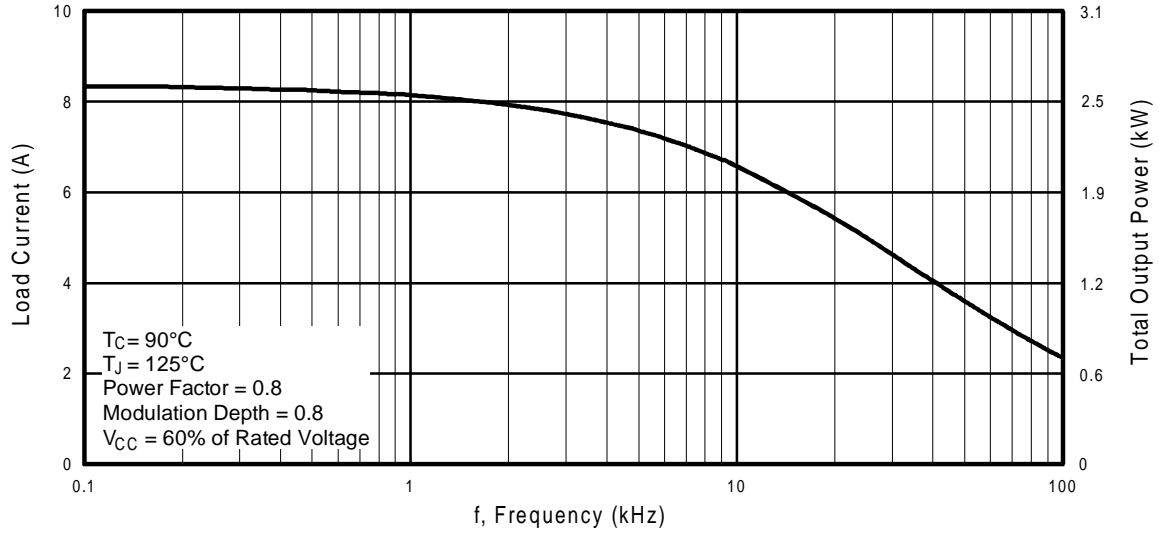


Fig. 1 - RMS Current and Output Power, Synthesized Sine Wave

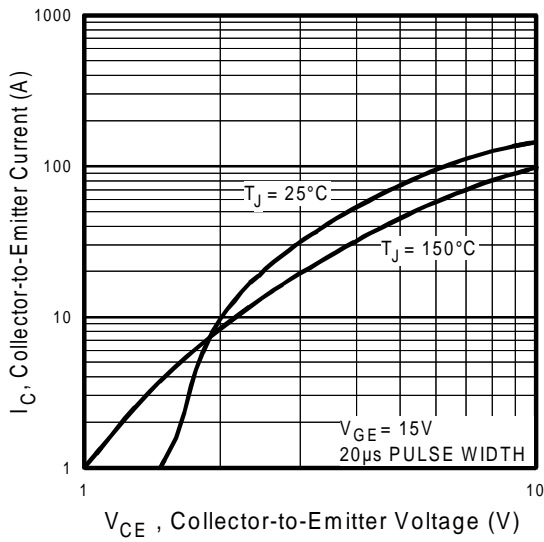


Fig. 2 - Typical Output Characteristics

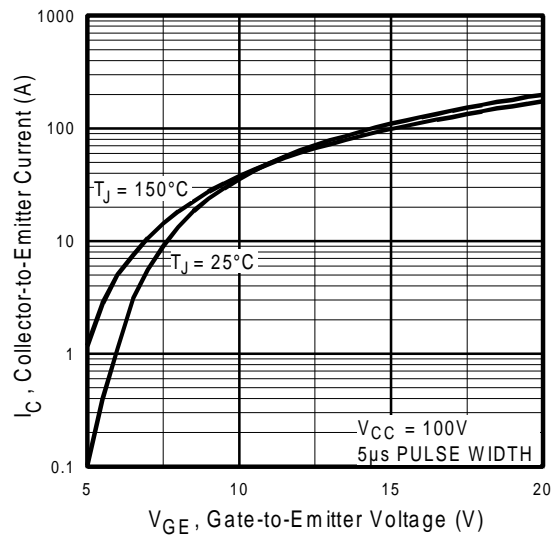
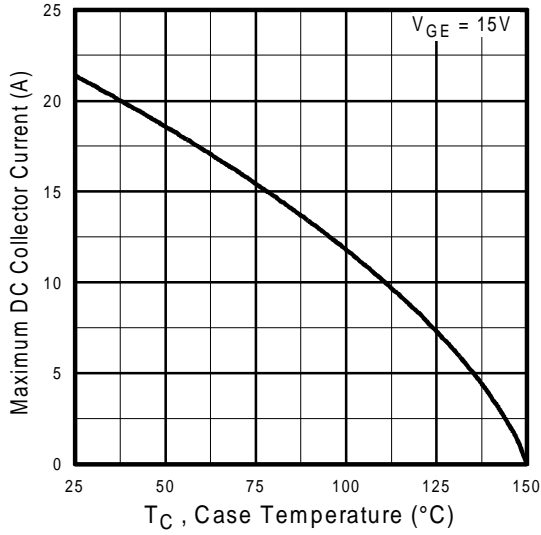
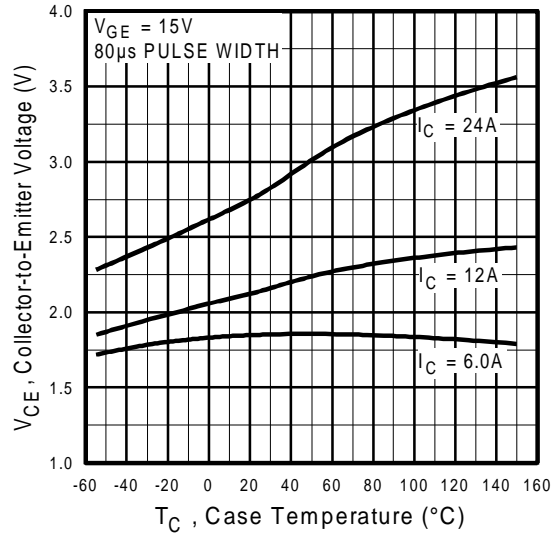


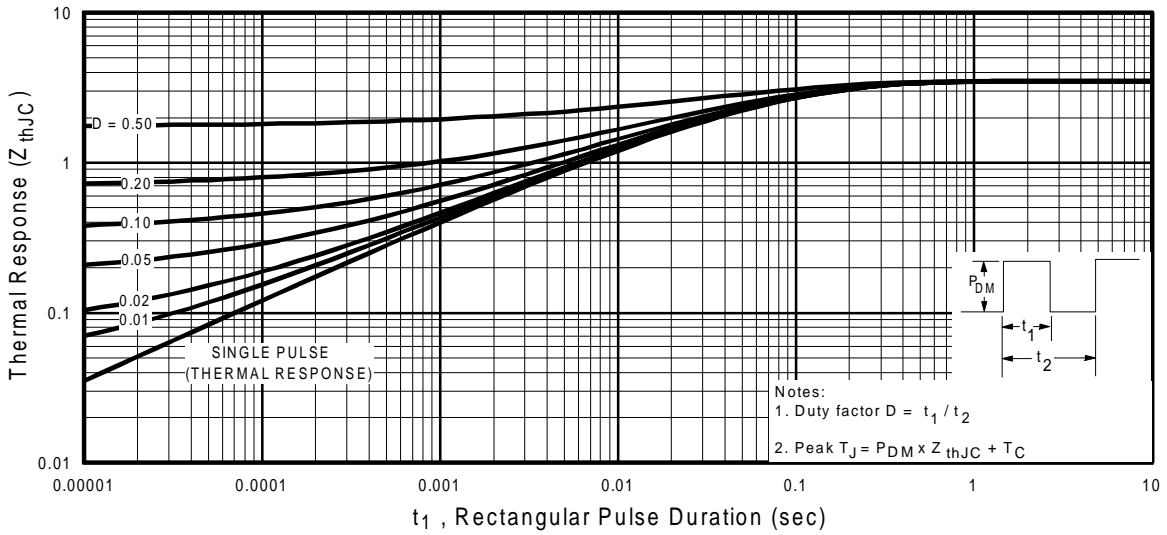
Fig. 3 - Typical Transfer Characteristics



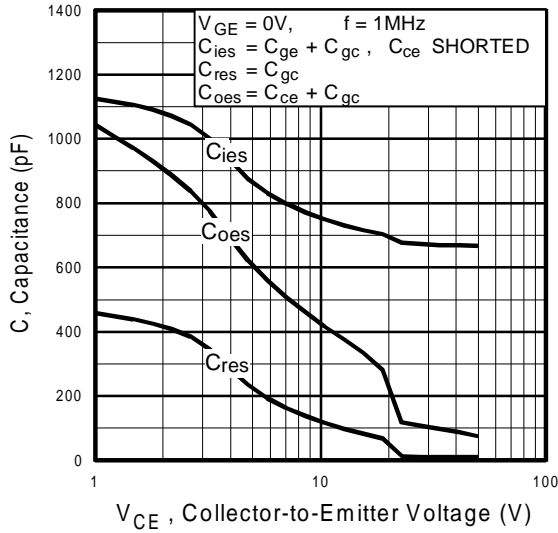
**Fig. 4 - Maximum Collector Current vs. Case Temperature**



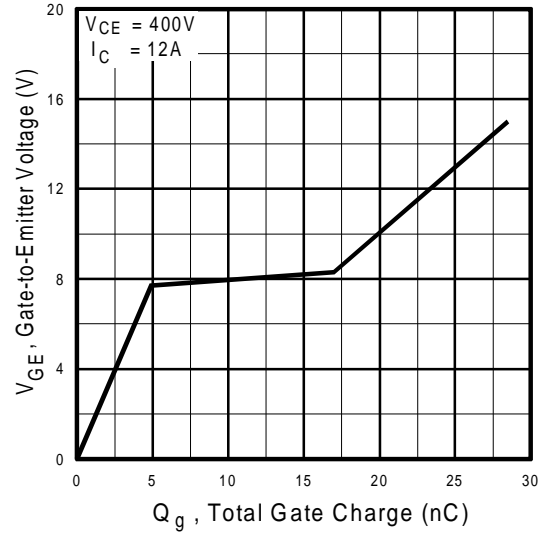
**Fig. 5 - Collector-to-Emitter Voltage vs. Case Temperature**



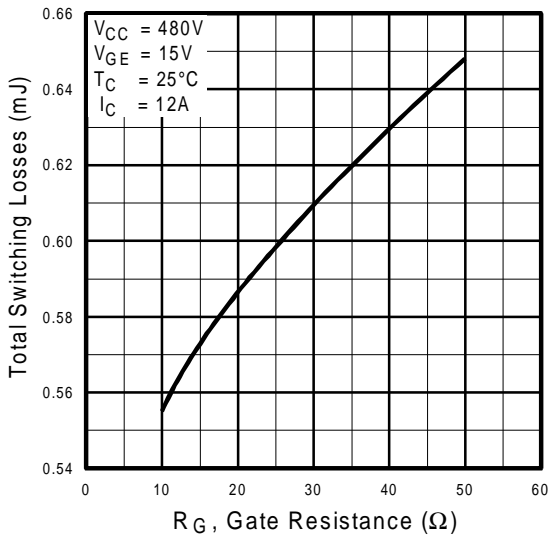
**Fig. 6 - Maximum IGBT Effective Transient Thermal Impedance, Junction-to-Case**



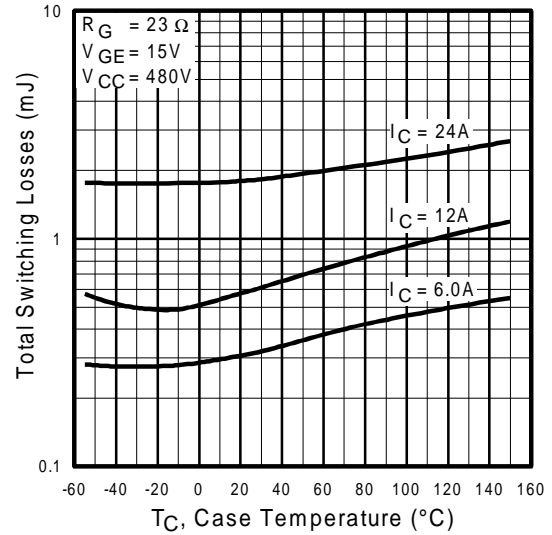
**Fig. 7 - Typical Capacitance vs. Collector-to-Emitter Voltage**



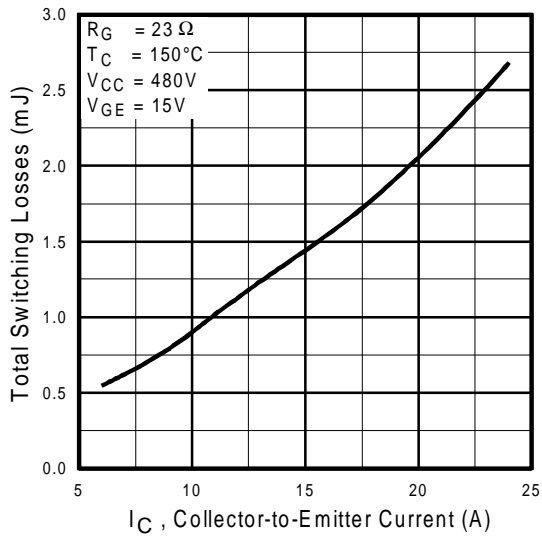
**Fig. 8 - Typical Gate Charge vs. Gate-to-Emitter Voltage**



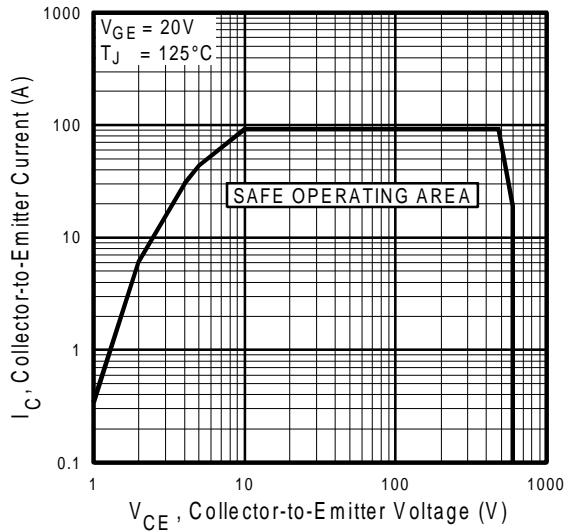
**Fig. 9 - Typical Switching Losses vs. Gate Resistance**



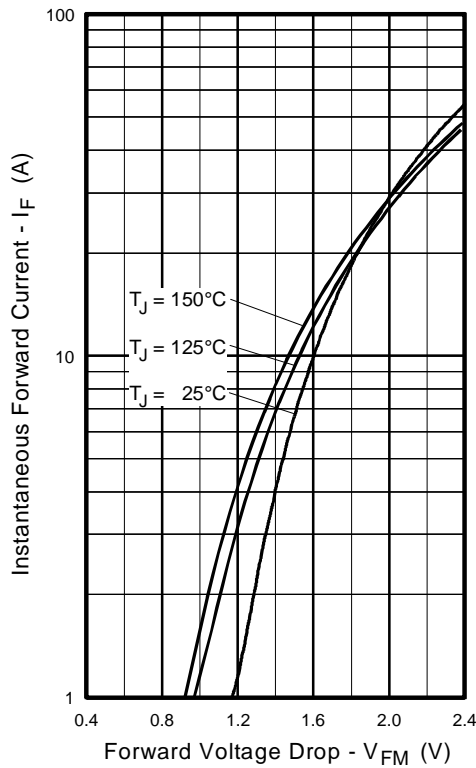
**Fig. 10 - Typical Switching Losses vs. Case Temperature**



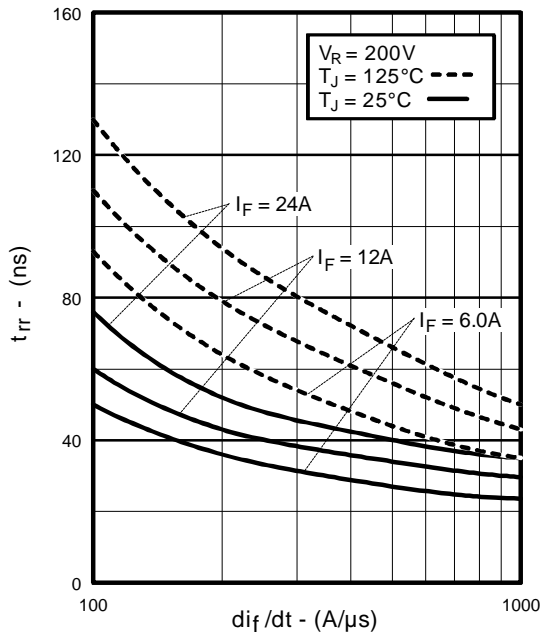
**Fig. 11** - Typical Switching Losses vs. Collector-to-Emitter Current



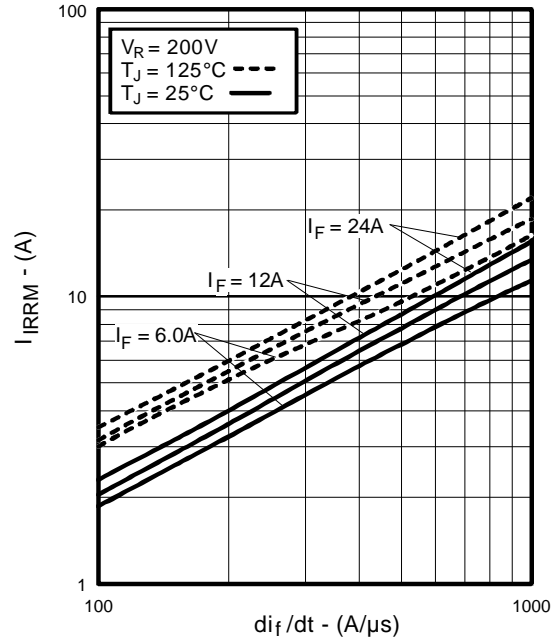
**Fig. 12** - Turn-Off SOA



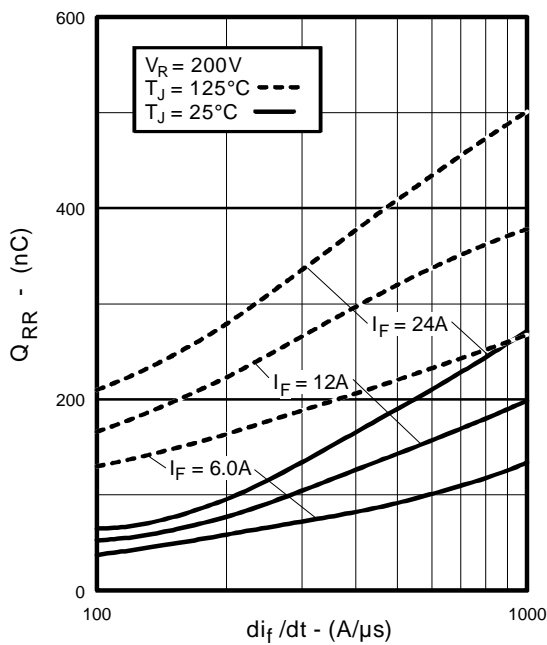
**Fig. 13** - Maximum Forward Voltage Drop vs. Instantaneous Forward Current



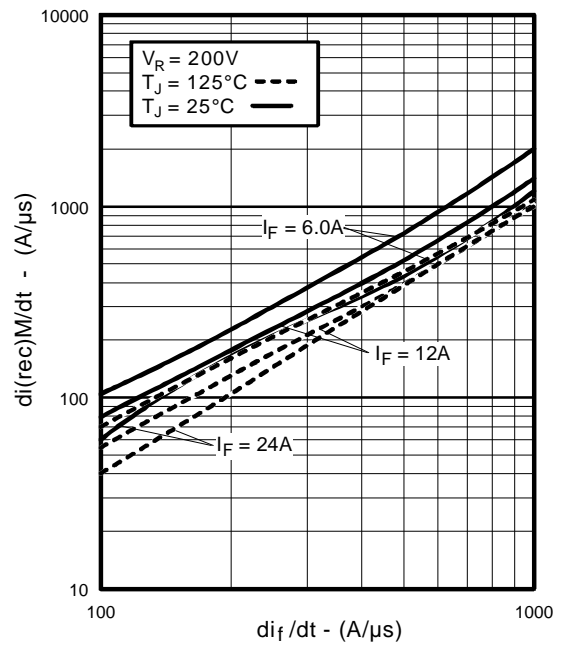
**Fig. 14 - Typical Reverse Recovery vs.  $di_f/dt$**



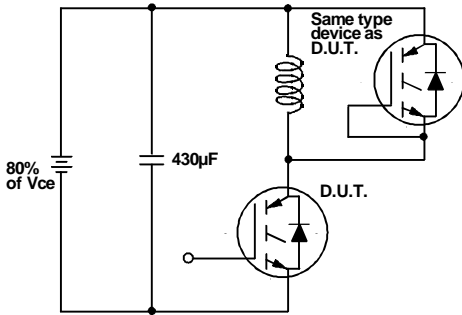
**Fig. 15 - Typical Recovery Current vs.  $di_f/dt$**



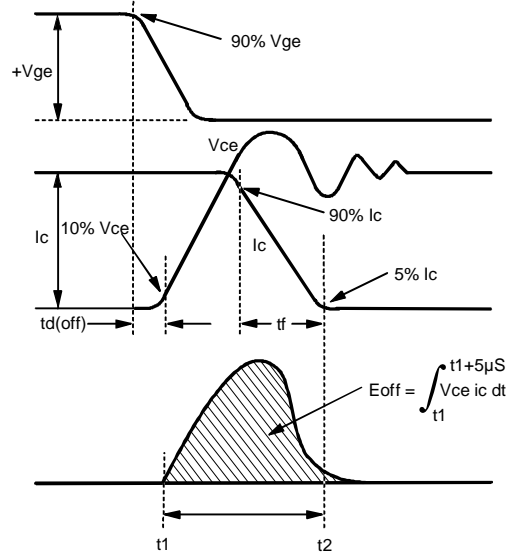
**Fig. 16 - Typical Stored Charge vs.  $di_f/dt$**



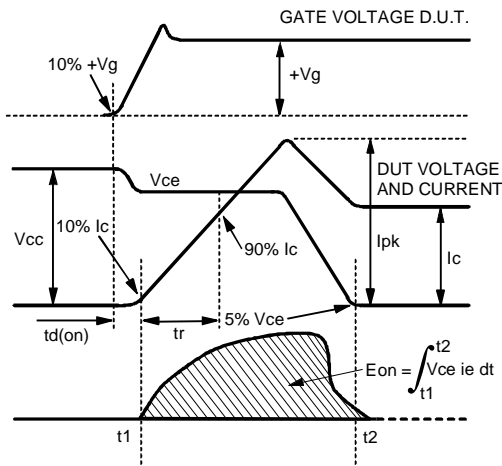
**Fig. 17 - Typical  $di_{(rec)M}/dt$  vs.  $di_f/dt$**



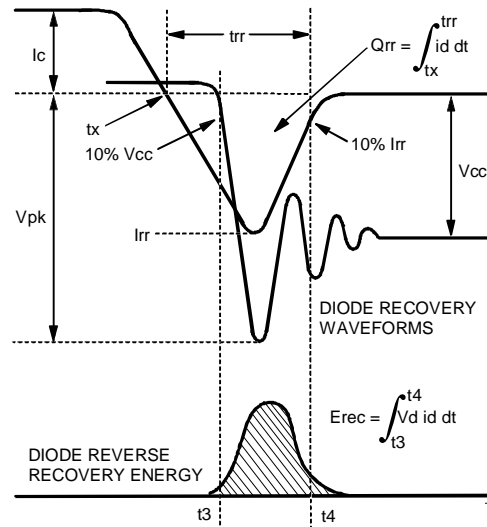
**Fig.18a** - Test Circuit for Measurement of  $I_{LM}$ ,  $E_{on}$ ,  $E_{off}(\text{diode})$ ,  $t_{rr}$ ,  $Q_{rr}$ ,  $I_{rr}$ ,  $t_{d(on)}$ ,  $t_r$ ,  $t_{d(off)}$ ,  $t_f$



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



**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  $E_{rec}$ ,  $t_{rr}$ ,  $Q_{rr}$ ,  $I_{rr}$

**Refer to Section D for the following:  
Appendix D: Section D - page D-6**

- Fig. 18e - Macro Waveforms for Test Circuit of Fig. 18a
- Fig. 19 - Clamped Inductive Load Test Circuit
- Fig. 20 - Pulsed Collector Current Test Circuit