

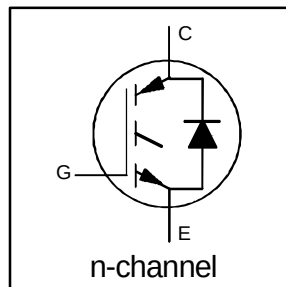
# IRGP440UD2

INSULATED GATE BIPOLAR TRANSISTOR  
WITH ULTRAFAST SOFT RECOVERY DIODE

UltraFast CoPack IGBT

## Features

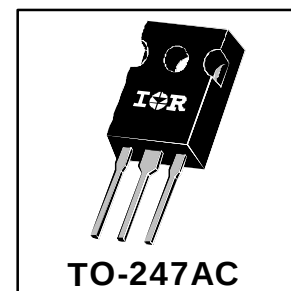
- Switching-loss rating includes all "tail" losses
- HEXFRED™ soft ultrafast diodes
- Optimized for high operating frequency (over 5kHz)  
See Fig. 1 for Current vs. Frequency curve



$V_{CES} = 500V$   
 $V_{CE(sat)} \leq 3.0V$   
@  $V_{GE} = 15V$ ,  $I_C = 22A$

## Description

Co-packaged IGBTs are a natural extension of International Rectifier's well known IGBT line. They provide the convenience of an IGBT and an ultrafast recovery diode in one package, resulting in substantial benefits to a host of high-voltage, high-current, motor control, UPS and power supply applications.



## Absolute Maximum Ratings

|                           | Parameter                          | Max.                                                     | Units      |
|---------------------------|------------------------------------|----------------------------------------------------------|------------|
| $V_{CES}$                 | Collector-to-Emitter Voltage       | 500                                                      | V          |
| $I_C @ T_C = 25^\circ C$  | Continuous Collector Current       | 40                                                       | A          |
| $I_C @ T_C = 100^\circ C$ | Continuous Collector Current       | 22                                                       |            |
| $I_{CM}$                  | Pulsed Collector Current ①         | 80                                                       |            |
| $I_{LM}$                  | Clamped Inductive Load Current ②   | 80                                                       |            |
| $I_F @ T_C = 100^\circ C$ | Diode Continuous Forward Current   | 15                                                       |            |
| $I_{FM}$                  | Diode Maximum Forward Current      | 80                                                       |            |
| $V_{GE}$                  | Gate-to-Emitter Voltage            | $\pm 20$                                                 | V          |
| $P_D @ T_C = 25^\circ C$  | Maximum Power Dissipation          | 160                                                      | W          |
| $P_D @ T_C = 100^\circ C$ | Maximum Power Dissipation          | 65                                                       |            |
| $T_J$                     | Operating Junction and             | -55 to +150                                              | $^\circ C$ |
| $T_{STG}$                 | Storage Temperature Range          |                                                          |            |
|                           | Soldering Temperature, for 10 sec. |                                                          |            |
|                           | Mounting Torque, 6-32 or M3 Screw. | 300 (0.063 in. (1.6mm) from case)<br>10 lbf•in (1.1 N•m) |            |

## Thermal Resistance

|                 | Parameter                                 | Min. | Typ.     | Max. | Units        |
|-----------------|-------------------------------------------|------|----------|------|--------------|
| $R_{\theta JC}$ | Junction-to-Case - IGBT                   | —    | —        | 0.77 | $^\circ C/W$ |
| $R_{\theta JC}$ | Junction-to-Case - Diode                  | —    | —        | 1.7  |              |
| $R_{\theta CS}$ | Case-to-Sink, flat, greased surface       | —    | 0.24     | —    |              |
| $R_{\theta JA}$ | Junction-to-Ambient, typical socket mount | —    | —        | 40   |              |
| $Wt$            | Weight                                    | —    | 6 (0.21) | —    | 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 | 500  | —    | —         | V                    | $V_{GE} = 0V, I_C = 250\mu A$                         |
| $\Delta V_{(BR)CES}/\Delta T_J$ | Temp. Coeff. of Breakdown Voltage        | —    | 0.35 | —         | V/ $^\circ\text{C}$  | $V_{GE} = 0V, I_C = 1.0mA$                            |
| $V_{CE(on)}$                    | Collector-to-Emitter Saturation Voltage  | —    | 2.4  | 3.0       | V                    | $I_C = 22A$ $V_{GE} = 15V$                            |
|                                 |                                          | —    | 2.8  | —         |                      | $I_C = 40A$ See Fig. 2, 5                             |
|                                 |                                          | —    | 2.4  | —         |                      | $I_C = 22A, T_J = 150^\circ\text{C}$                  |
| $V_{GE(th)}$                    | Gate Threshold Voltage                   | 3.0  | —    | 5.5       |                      | $V_{CE} = V_{GE}, I_C = 250\mu A$                     |
| $\Delta V_{GE(th)}/\Delta T_J$  | Temp. Coeff. of Threshold Voltage        | —    | -11  | —         | mV/ $^\circ\text{C}$ | $V_{CE} = V_{GE}, I_C = 250\mu A$                     |
| $g_{fe}$                        | Forward Transconductance ④               | 6.6  | 13   | —         | S                    | $V_{CE} = 100V, I_C = 22A$                            |
| $I_{CES}$                       | Zero Gate Voltage Collector Current      | —    | —    | 250       | $\mu A$              | $V_{GE} = 0V, V_{CE} = 500V$                          |
|                                 |                                          | —    | —    | 3500      |                      | $V_{GE} = 0V, V_{CE} = 500V, T_J = 150^\circ\text{C}$ |
| $V_{FM}$                        | Diode Forward Voltage Drop               | —    | 1.3  | 1.7       | V                    | $I_C = 15A$ See Fig. 13                               |
|                                 |                                          | —    | 1.2  | 1.6       |                      | $I_C = 15A, T_J = 150^\circ\text{C}$                  |
| $I_{GES}$                       | 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)                      | —    | 55   | 83   | nC         | $I_C = 22A$                                              |
| $Q_{ge}$         | Gate - Emitter Charge (turn-on)                  | —    | 11   | 17   |            | $V_{CC} = 400V$                                          |
| $Q_{gc}$         | Gate - Collector Charge (turn-on)                | —    | 19   | 29   |            | See Fig. 8                                               |
| $t_{d(on)}$      | Turn-On Delay Time                               | —    | 80   | —    | ns         | $T_J = 25^\circ\text{C}$                                 |
| $t_r$            | Rise Time                                        | —    | 68   | —    |            | $I_C = 22A, V_{CC} = 400V$                               |
| $t_{d(off)}$     | Turn-Off Delay Time                              | —    | 160  | 240  |            | $V_{GE} = 15V, R_G = 10\Omega$                           |
| $t_f$            | Fall Time                                        | —    | 130  | 220  |            | Energy losses include "tail" and diode reverse recovery. |
| $E_{on}$         | Turn-On Switching Loss                           | —    | 0.81 | —    | mJ         | See Fig. 9, 10, 11, 18                                   |
| $E_{off}$        | Turn-Off Switching Loss                          | —    | 0.82 | —    |            |                                                          |
| $E_{ts}$         | Total Switching Loss                             | —    | 1.6  | 2.4  |            |                                                          |
| $t_{d(on)}$      | Turn-On Delay Time                               | —    | 78   | —    | ns         | $T_J = 150^\circ\text{C}$ , See Fig. 9, 10, 11, 18       |
| $t_r$            | Rise Time                                        | —    | 64   | —    |            | $I_C = 22A, V_{CC} = 400V$                               |
| $t_{d(off)}$     | Turn-Off Delay Time                              | —    | 290  | —    |            | $V_{GE} = 15V, R_G = 10\Omega$                           |
| $t_f$            | Fall Time                                        | —    | 250  | —    |            | Energy losses include "tail" and diode reverse recovery. |
| $E_{ts}$         | Total Switching Loss                             | —    | 2.6  | —    | mJ         |                                                          |
| $L_E$            | Internal Emitter Inductance                      | —    | 13   | —    | nH         | Measured 5mm from package                                |
| $C_{ies}$        | Input Capacitance                                | —    | 1400 | —    | pF         | $V_{GE} = 0V$                                            |
| $C_{oes}$        | Output Capacitance                               | —    | 250  | —    |            | $V_{CC} = 30V$ See Fig. 7                                |
| $C_{res}$        | Reverse Transfer Capacitance                     | —    | 42   | —    |            | $f = 1.0MHz$                                             |
| $t_{rr}$         | Diode Reverse Recovery Time                      | —    | 42   | 60   | ns         | $T_J = 25^\circ\text{C}$ See Fig. 14                     |
|                  |                                                  | —    | 74   | 120  |            | $T_J = 125^\circ\text{C}$                                |
| $I_{rr}$         | Diode Peak Reverse Recovery Current              | —    | 4.0  | 6.0  | A          | $T_J = 25^\circ\text{C}$ See Fig. 15                     |
|                  |                                                  | —    | 6.5  | 10   |            | $T_J = 125^\circ\text{C}$                                |
| $Q_{rr}$         | Diode Reverse Recovery Charge                    | —    | 80   | 180  | nC         | $T_J = 25^\circ\text{C}$ See Fig. 16                     |
|                  |                                                  | —    | 220  | 600  |            | $T_J = 125^\circ\text{C}$                                |
| $di_{(rec)M}/dt$ | Diode Peak Rate of Fall of Recovery During $t_b$ | —    | 188  | —    | A/ $\mu s$ | $T_J = 25^\circ\text{C}$ See Fig. 17                     |
|                  |                                                  | —    | 160  | —    |            | $T_J = 125^\circ\text{C}$                                |

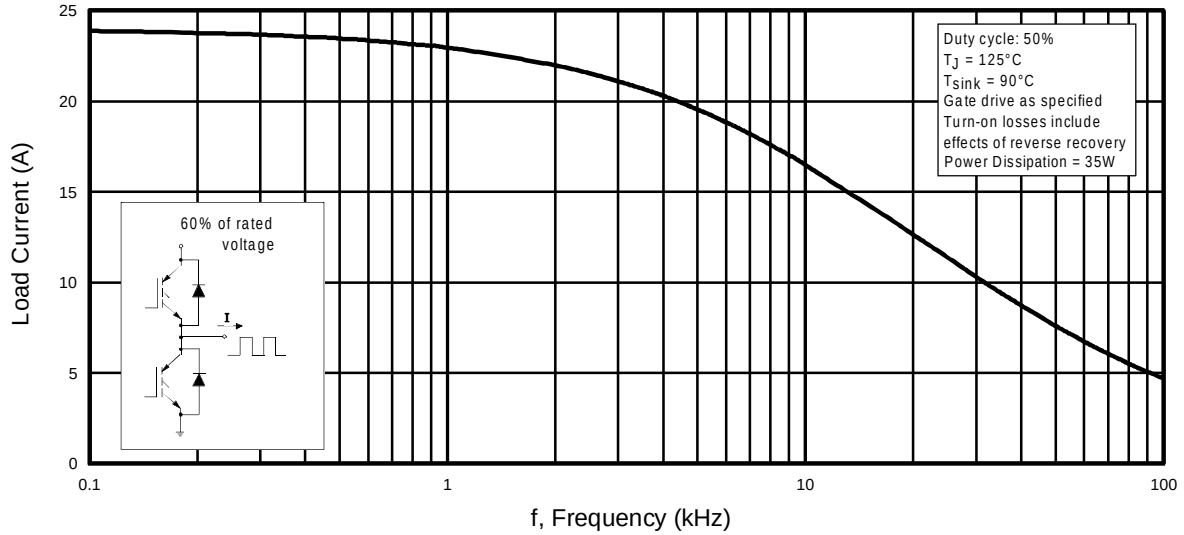
## Notes:

① Repetitive rating;  $V_{GE}=20V$ , pulse width limited by max. junction temperature.  
( See fig. 20 )

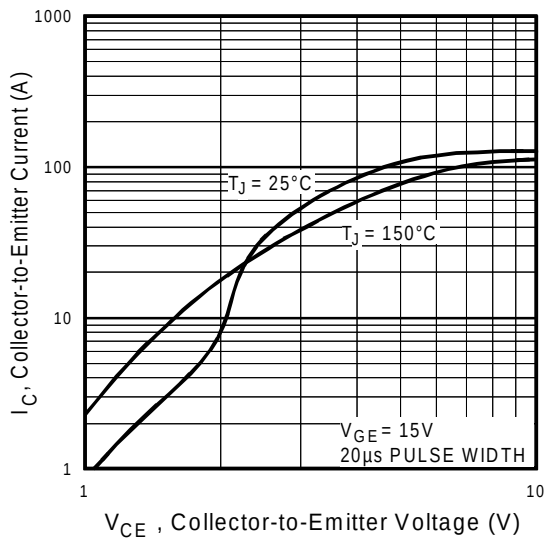
②  $V_{CC}=80\%(V_{CES})$ ,  $V_{GE}=20V$ ,  $L=10\mu H$ ,  
 $R_G=10\Omega$ , ( See fig. 19 )

③ Pulse width  $\leq 80\mu s$ ; duty factor  $\leq 0.1\%$ .

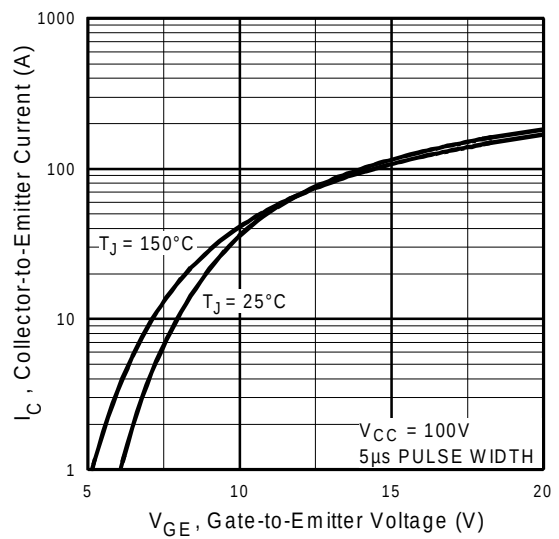
④ Pulse width 5.0 $\mu s$ ,  
single shot.



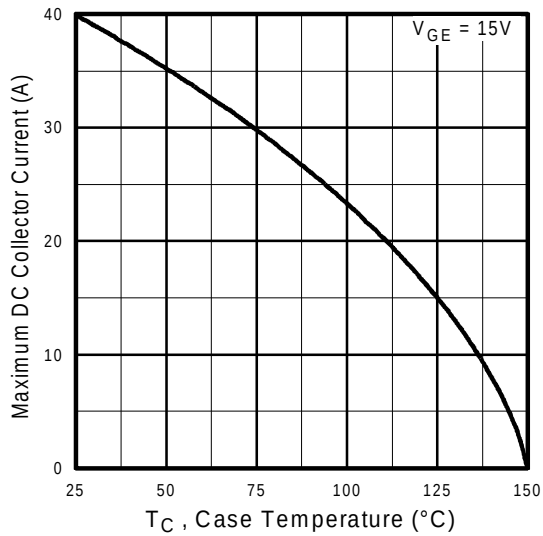
**Fig. 1 - Typical Load Current vs. Frequency**  
 (Load Current =  $I_{\text{RMS}}$  of fundamental)



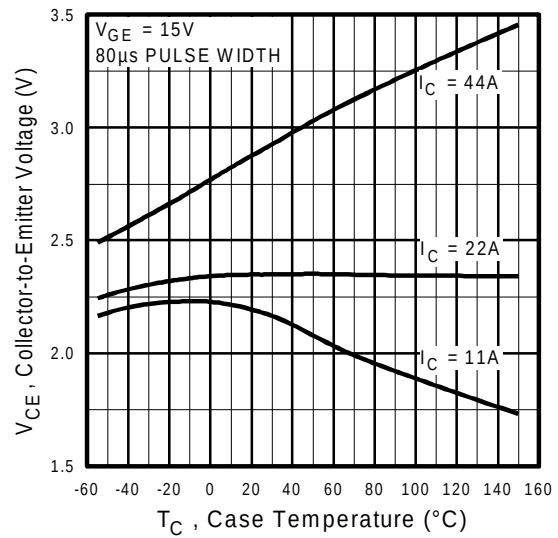
**Fig. 2 - Typical Output Characteristics**



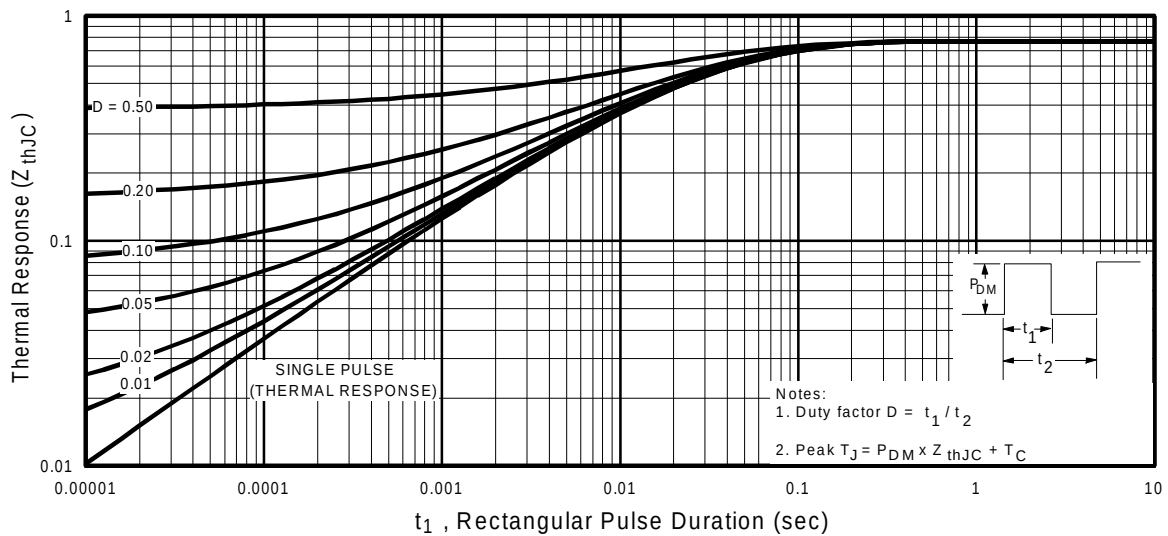
**Fig. 3 - Typical Transfer Characteristics**



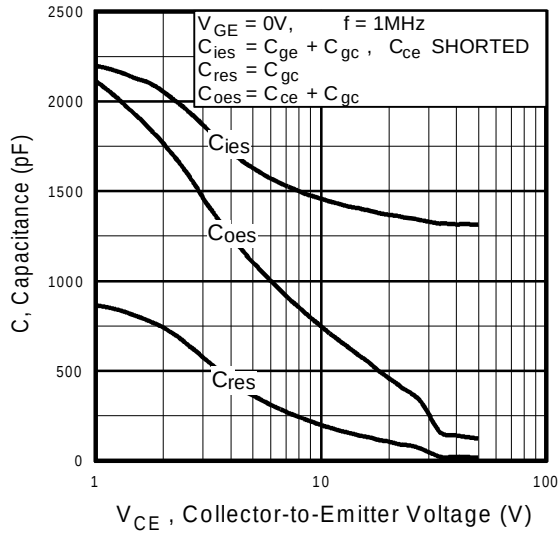
**Fig. 4 - Maximum Collector Current vs. Case Temperature**



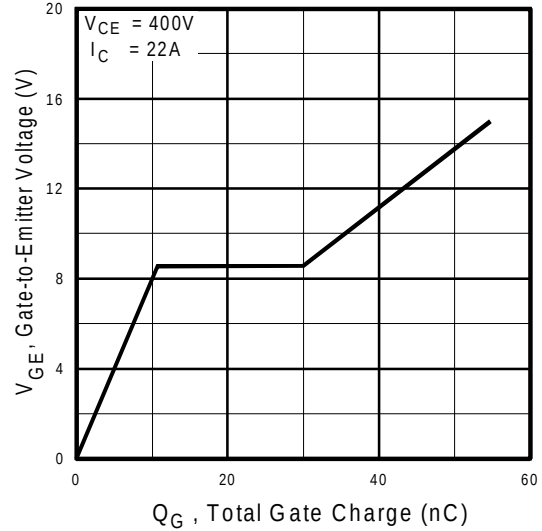
**Fig. 5 - Collector-to-Emitter Voltage vs. Case Temperature**



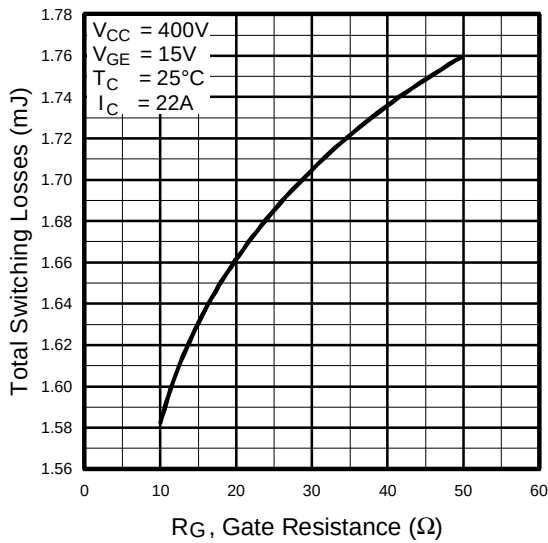
**Fig. 6 - Maximum IGBT Effective Transient Thermal Impedance, Junction-to-Case**



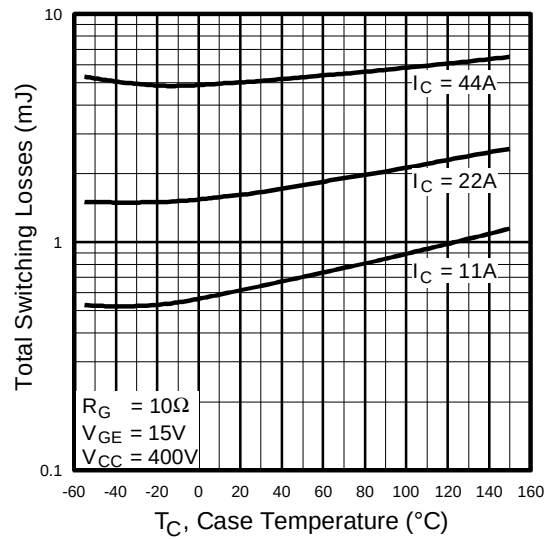
**Fig. 7** - Typical Capacitance vs. Collector-to-Emitter Voltage



**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

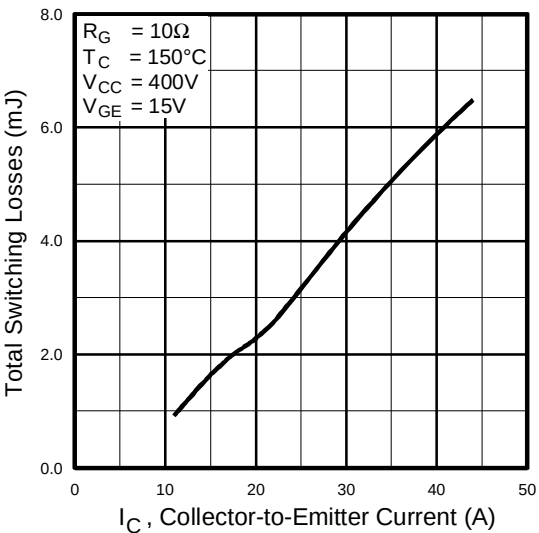


Fig. 11 - Typical Switching Losses vs. Collector-to-Emitter Current

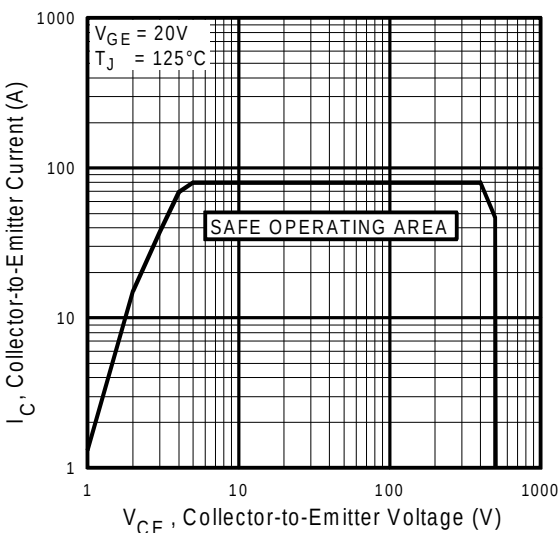


Fig. 12 - Turn-Off SOA

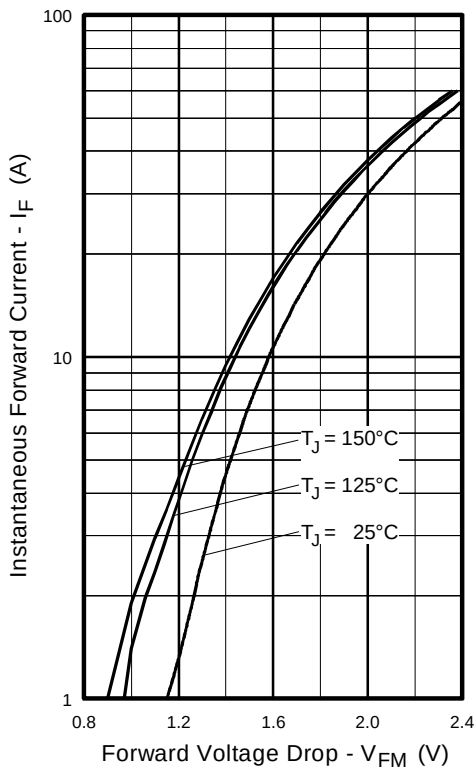
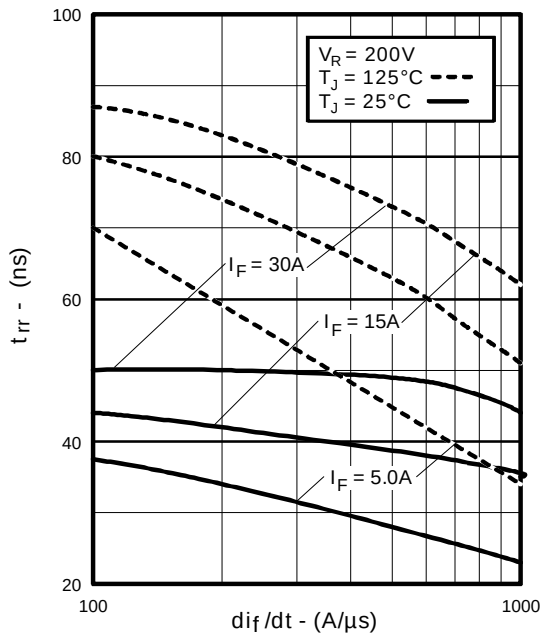
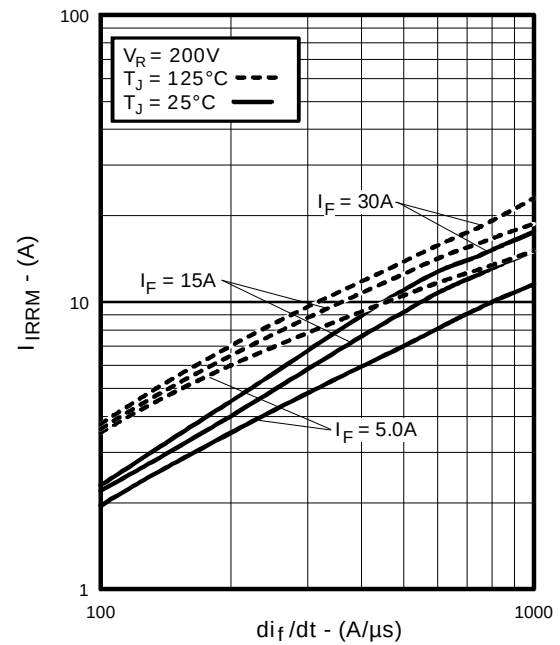


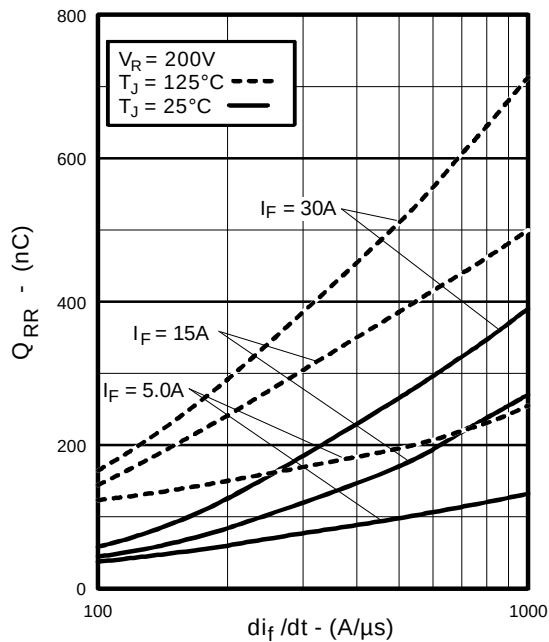
Fig. 13 - Maximum Forward Voltage Drop vs. Instantaneous Forward Current



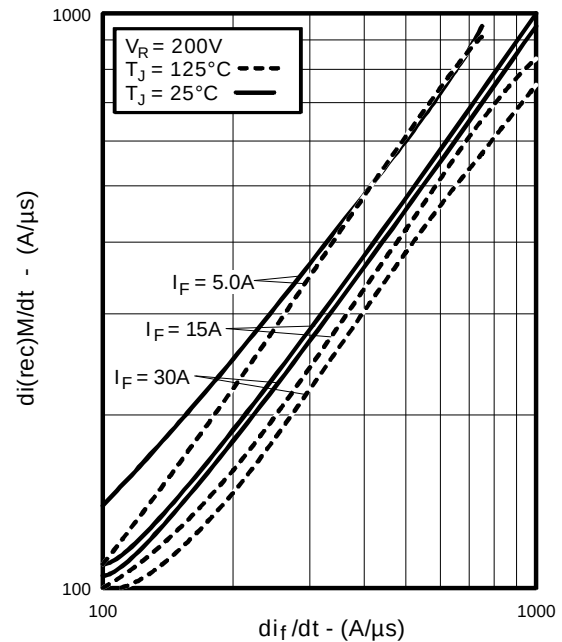
**Fig. 14** - Typical Reverse Recovery vs.  $di_f/dt$



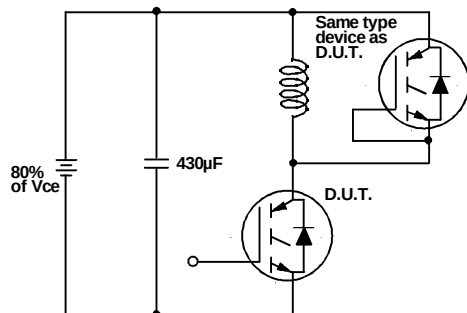
**Fig. 15** - Typical Recovery Current vs.  $di_f/dt$



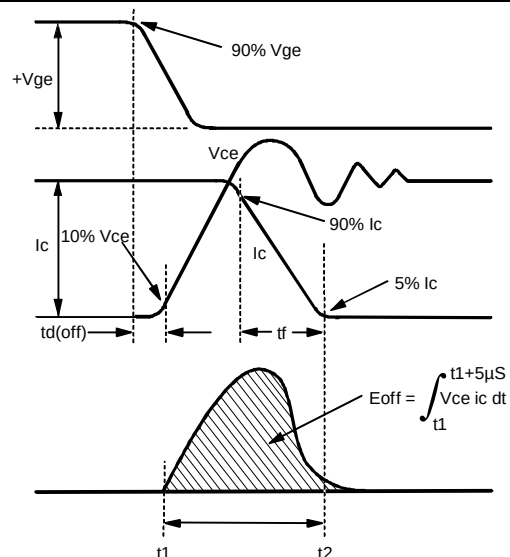
**Fig. 16** - Typical Stored Charge vs.  $di_f/dt$



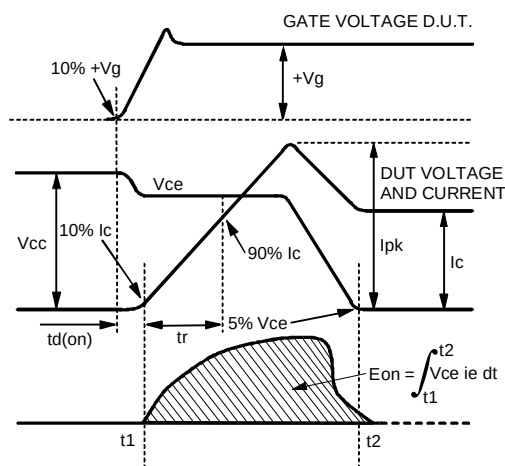
**Fig. 17** - Typical  $di_{(rec)M}/dt$  vs.  $di_f/dt$



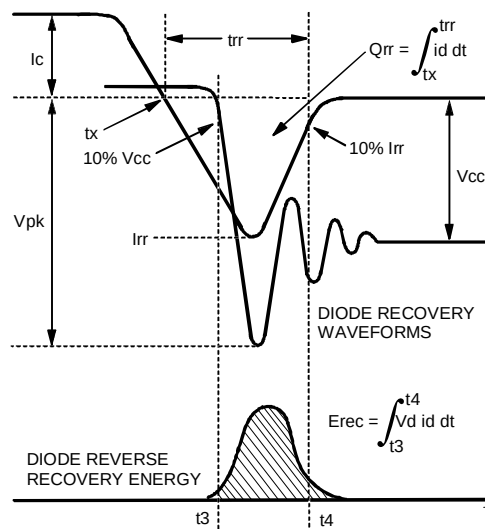
**Fig. 18a** - Test Circuit for Measurement of  $I_{LM}$ ,  $E_{on}$ ,  $E_{off}(\text{diode})$ ,  $t_{rr}$ ,  $Q_{rr}$ ,  $I_{rr}$ ,  $t_{d(on)}$ ,  $t_r$ ,  $t_{d(off)}$ ,  $t_f$



**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 B: Section D - page D-4

Fig. 18e - Clamped Inductive Load Test Circuit  
Fig. 19 - Pulsed Collector Current Test Circuit  
Fig. 20 - Switching Loss Test Circuit