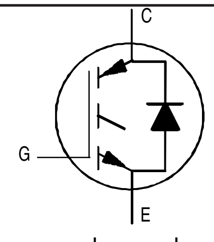
PD- 91577B

International
IOR Rectifier

# IRG4PH40KD

INSULATED GATE BIPOLAR TRANSISTOR WITH ULTRAFAST SOFT RECOVERY DIODE

Short Circuit Rated
UltraFast IGBT




$V_{CES}$ = 1200V

$V_{CE(on)\ typ.}$ = 2.74V

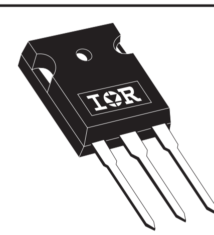
@$V_{GE}$ = 15V, $I_C$ = 15A

## Features

- High short circuit rating optimized for motor control, $t_{sc}$ =10µs, $V_{CC}$ = 720V , $T_J$ = 125°C, $V_{GE}$ = 15V
- Combines low conduction losses with high switching speed
- Tighter parameter distribution and higher efficiency than previous generations
- IGBT co-packaged with HEXFRED™ ultrafast, ultrasoft recovery antiparallel diodes

## Benefits

- Latest generation 4 IGBT's offer highest power density motor controls possible
- HEXFRED™ diodes optimized for performance with IGBTs. Minimized recovery characteristics reduce noise, EMI and switching losses
- This part replaces the IRGPH40KD2 and IRGPH40MD2 products
- For hints see design tip 97003



TO-247AC

## Absolute Maximum Ratings

| | Parameter | Max. | Units |
|---|---|---|---|
| $V_{CES}$ | Collector-to-Emitter Voltage | 1200 | V |
| $I_C$ @ $T_C$ = 25°C | Continuous Collector Current | 30 | A |
| $I_C$ @ $T_C$ = 100°C | Continuous Collector Current | 15 | |
| $I_{CM}$ | Pulsed Collector Current ① | 60 | |
| $I_{LM}$ | Clamped Inductive Load Current ② | 60 | |
| $I_F$ @ $T_C$ = 100°C | Diode Continuous Forward Current | 8.0 | |
| $I_{FM}$ | Diode Maximum Forward Current | 130 | |
| $t_{sc}$ | Short Circuit Withstand Time | 10 | µs |
| $V_{GE}$ | Gate-to-Emitter Voltage | ± 20 | V |
| $P_D$ @ $T_C$ = 25°C | Maximum Power Dissipation | 160 | W |
| $P_D$ @ $T_C$ = 100°C | Maximum Power Dissipation | 65 | |
| $T_J$<br>$T_{STG}$ | Operating Junction and<br>Storage Temperature Range | -55 to +150 | °C |
| | 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 |
|---|---|---|---|---|---|
| $R_{\theta JC}$ | Junction-to-Case - IGBT | —— | —— | 0.77 | °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°C (unless otherwise specified)

| | Parameter | Min. | Typ. | Max. | Units | Conditions | |
|---|---|---|---|---|---|---|---|
| $V_{(BR)CES}$ | Collector-to-Emitter Breakdown Voltage③ | 1200 | — | — | V | $V_{GE}$ = 0V, $I_C$ = 250µA | |
| $\Delta V_{(BR)CES}/\Delta T_J$ | Temperature Coeff. of Breakdown Voltage | — | 0.37 | — | V/°C | $V_{GE}$ = 0V, $I_C$ = 1.0mA | |
| $V_{CE(on)}$ | Collector-to-Emitter Saturation Voltage | — | 2.74 | 3.4 | V | $I_C$ = 15A | $V_{GE}$ = 15V |
| | | — | 3.29 | — | | $I_C$ = 30A | See Fig. 2, 5 |
| | | — | 2.53 | — | | $I_C$ = 15A, $T_J$ = 150°C | |
| $V_{GE(th)}$ | Gate Threshold Voltage | 3.0 | — | 6.0 | | $V_{CE} = V_{GE}$, $I_C$ = 250µA | |
| $\Delta V_{GE(th)}/\Delta T_J$ | Temperature Coeff. of Threshold Voltage | — | -3.3 | — | mV/°C | $V_{CE} = V_{GE}$, $I_C$ = 250µA | |
| $g_{fe}$ | Forward Transconductance ④ | 8.0 | 12 | — | S | $V_{CE}$ = 100V, $I_C$ = 15A | |
| $I_{CES}$ | Zero Gate Voltage Collector Current | — | — | 250 | µA | $V_{GE}$ = 0V, $V_{CE}$ = 1200V | |
| | | — | — | 3000 | | $V_{GE}$ = 0V, $V_{CE}$ = 1200V, $T_J$ = 150°C | |
| $V_{FM}$ | Diode Forward Voltage Drop | — | 2.6 | 3.3 | V | $I_C$ = 8.0A | See Fig. 13 |
| | | — | 2.4 | 3.1 | | $I_C$ = 8.0A, $T_J$ = 125°C | |
| $I_{GES}$ | Gate-to-Emitter Leakage Current | — | — | ±100 | nA | $V_{GE}$ = ±20V | |

## Switching Characteristics @ $T_J$ = 25°C (unless otherwise specified)

| | Parameter | Min. | Typ. | Max. | Units | Conditions | |
|---|---|---|---|---|---|---|---|
| $Q_g$ | Total Gate Charge (turn-on) | — | 94 | 140 | nC | $I_C$ = 15A | |
| $Q_{ge}$ | Gate - Emitter Charge (turn-on) | — | 14 | 22 | | $V_{CC}$ = 400V See Fig.8 | |
| $Q_{gc}$ | Gate - Collector Charge (turn-on) | — | 37 | 55 | | $V_{GE}$ = 15V | |
| $t_{d(on)}$ | Turn-On Delay Time | — | 50 | — | ns | | |
| $t_r$ | Rise Time | — | 31 | — | | $T_J$ = 25°C | |
| $t_{d(off)}$ | Turn-Off Delay Time | — | 96 | 140 | | $I_C$ = 15A, $V_{CC}$ = 800V | |
| $t_f$ | Fall Time | — | 220 | 330 | | $V_{GE}$ = 15V, $R_G$ = 10Ω | |
| $E_{on}$ | Turn-On Switching Loss | — | 1.31 | — | mJ | Energy losses include "tail" | |
| $E_{off}$ | Turn-Off Switching Loss | — | 1.12 | — | | and diode reverse recovery | |
| $E_{ts}$ | Total Switching Loss | — | 2.43 | 2.8 | | See Fig. 9,10,18 | |
| $t_{sc}$ | Short Circuit Withstand Time | 10 | — | — | µs | $V_{CC}$ = 720V, $T_J$ = 125°C | |
| | | | | | | $V_{GE}$ = 15V, $R_G$ = 10Ω , $V_{CPK}$ < 500V | |
| $t_{d(on)}$ | Turn-On Delay Time | — | 49 | — | ns | $T_J$ = 150°C, See Fig. 10,11,18 | |
| $t_r$ | Rise Time | — | 33 | — | | $I_C$ = 15A, $V_{CC}$ = 800V | |
| $t_{d(off)}$ | Turn-Off Delay Time | — | 290 | — | | $V_{GE}$ = 15V, $R_G$ = 10Ω, | |
| $t_f$ | Fall Time | — | 440 | — | | Energy losses include "tail" | |
| $E_{ts}$ | Total Switching Loss | — | 5.1 | — | mJ | and diode reverse recovery | |
| $L_E$ | Internal Emitter Inductance | — | 13 | — | nH | Measured 5mm from package | |
| $C_{ies}$ | Input Capacitance | — | 1600 | — | pF | $V_{GE}$ = 0V | |
| $C_{oes}$ | Output Capacitance | — | 77 | — | | $V_{CC}$ = 30V See Fig. 7 | |
| $C_{res}$ | Reverse Transfer Capacitance | — | 26 | — | | ƒ = 1.0MHz | |
| $t_{rr}$ | Diode Reverse Recovery Time | — | 63 | 95 | ns | $T_J$ = 25°C See Fig. | |
| | | — | 106 | 160 | | $T_J$ = 125°C 14 | $I_F$ = 8.0A |
| $I_{rr}$ | Diode Peak Reverse Recovery Current | — | 4.5 | 8.0 | A | $T_J$ = 25°C See Fig. | |
| | | — | 6.2 | 11 | | $T_J$ = 125°C 15 | $V_R$ = 200V |
| $Q_{rr}$ | Diode Reverse Recovery Charge | — | 140 | 380 | nC | $T_J$ = 25°C See Fig. | |
| | | — | 335 | 880 | | $T_J$ = 125°C 16 | di/dt = 200Aµs |
| $di_{(rec)M}/dt$ | Diode Peak Rate of Fall of Recovery | — | 133 | — | A/µs | $T_J$ = 25°C See Fig. | |
| | During $t_b$ | — | 85 | — | | $T_J$ = 125°C 17 | |

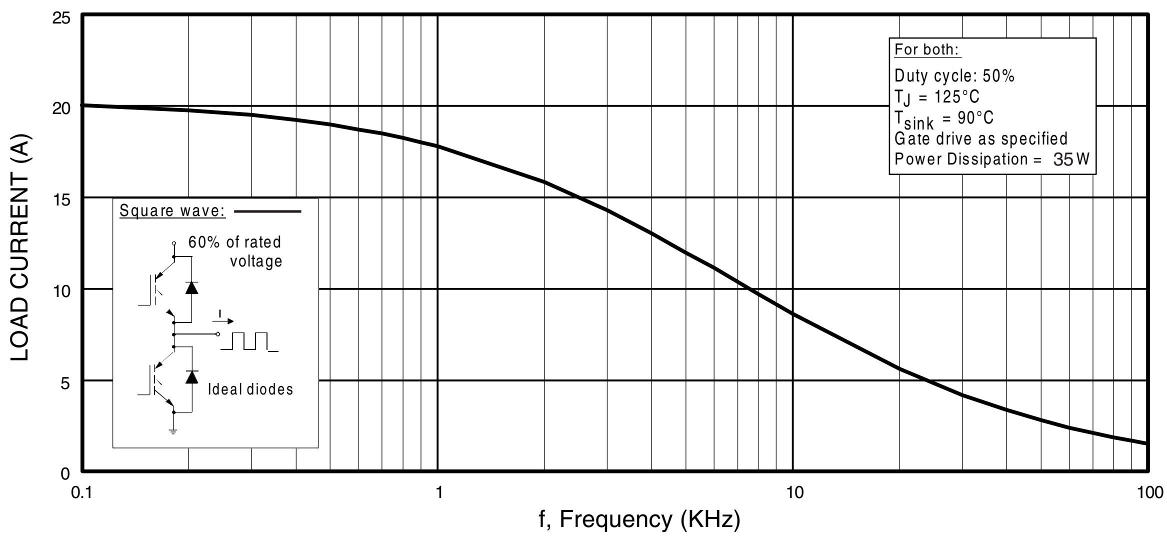



**Fig. 1** - Typical Load Current vs. Frequency
(Load Current = $I_{RMS}$ of fundamental)

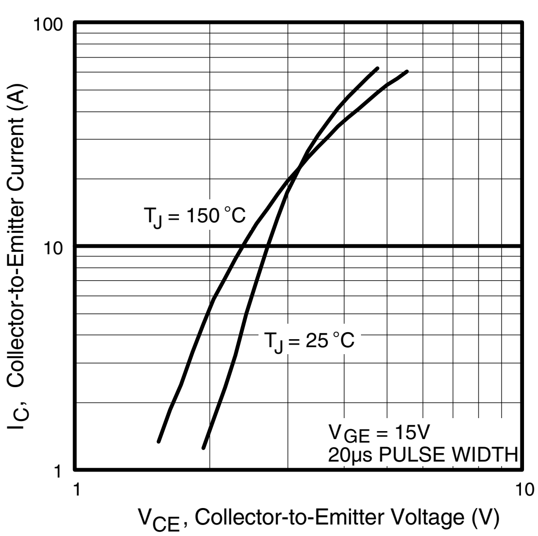



**Fig. 2** - Typical Output Characteristics

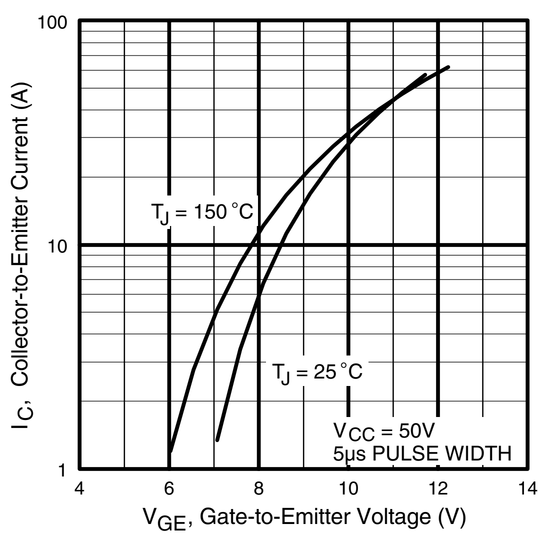



**Fig. 3** - Typical Transfer Characteristics

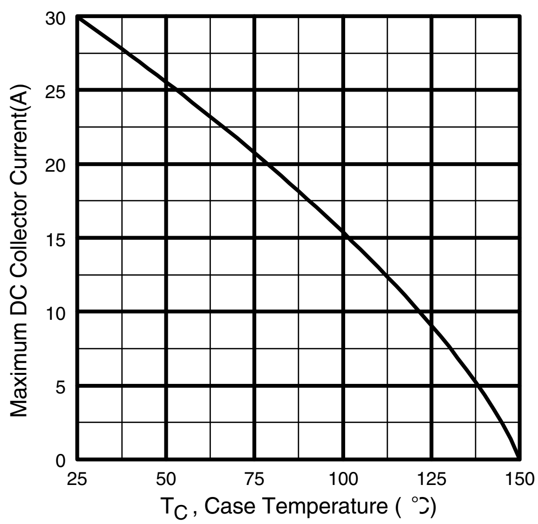



**Fig. 4** - Maximum Collector Current vs. Case Temperature

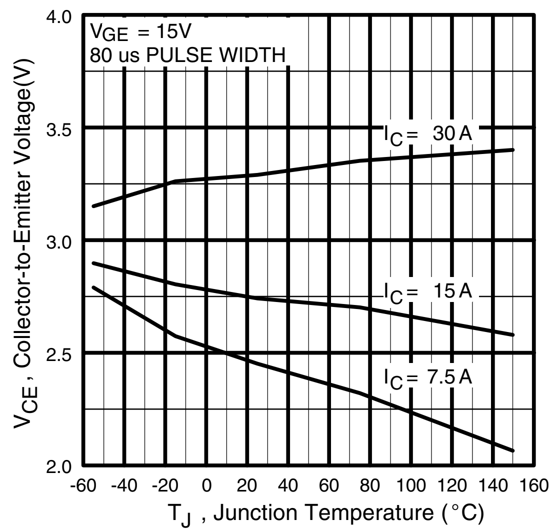



**Fig. 5** - Typical Collector-to-Emitter Voltage vs. Junction Temperature

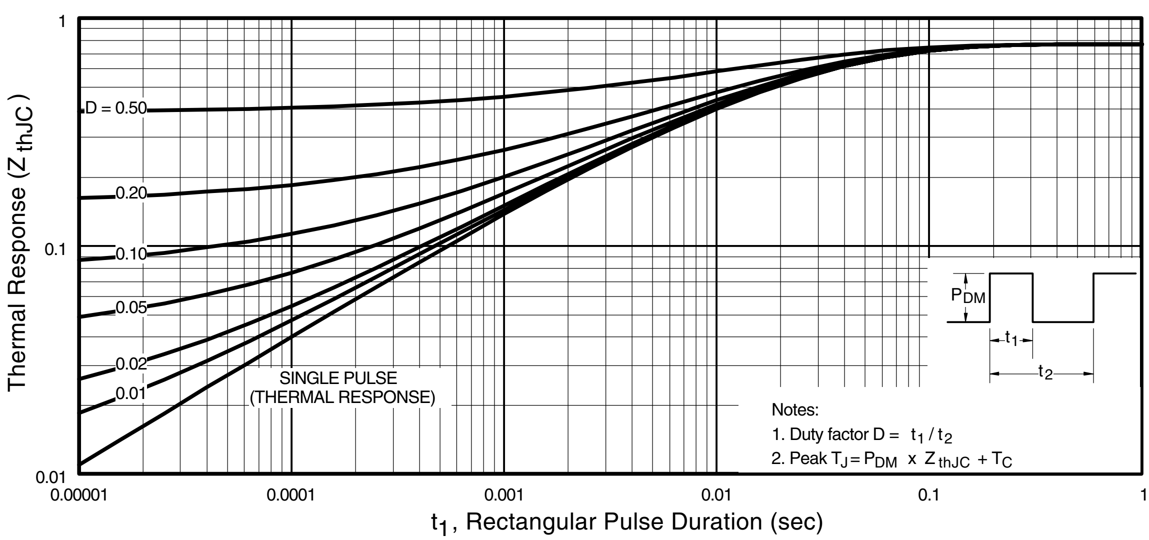



**Fig. 6** - Maximum Effective Transient Thermal Impedance, Junction-to-Case

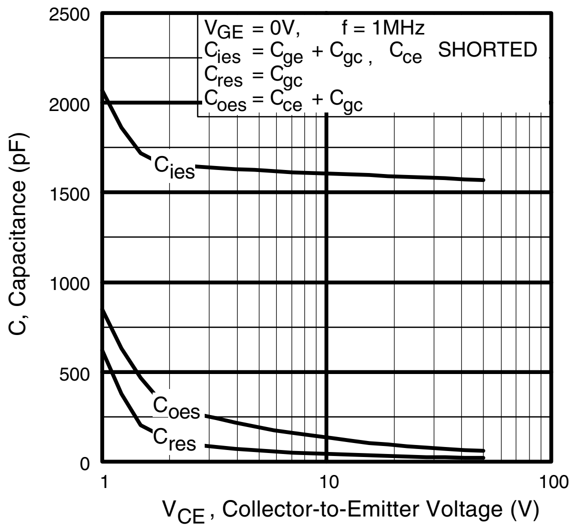



**Fig. 7 -** Typical Capacitance vs. Collector-to-Emitter Voltage

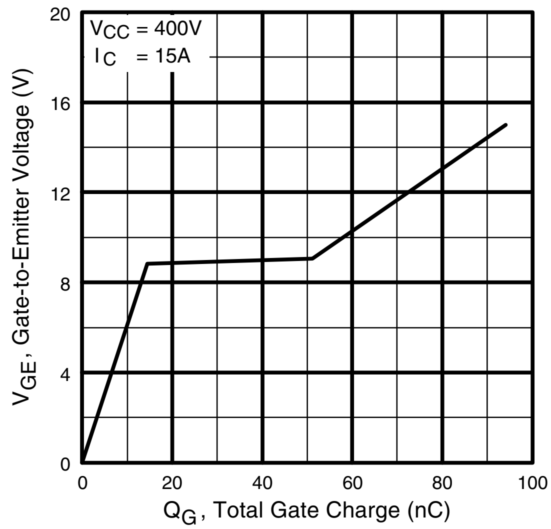



**Fig. 8** - Typical Gate Charge vs. Gate-to-Emitter Voltage

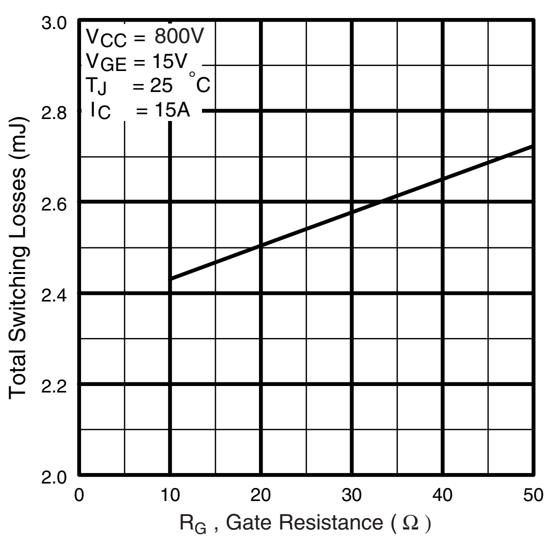



**Fig. 9** - Typical Switching Losses vs. Gate Resistance

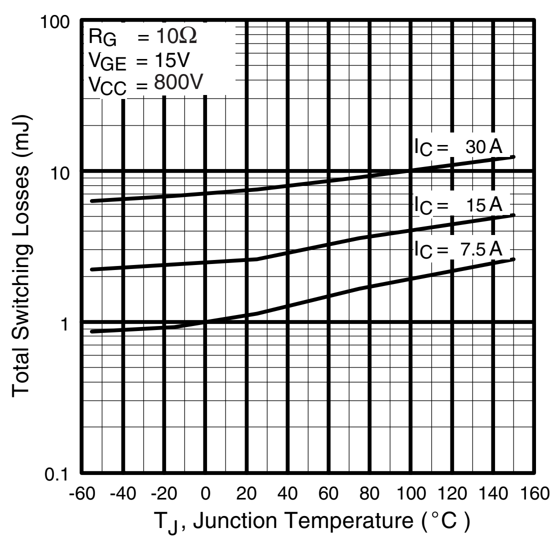



**Fig. 10** - Typical Switching Losses vs. Junction Temperature

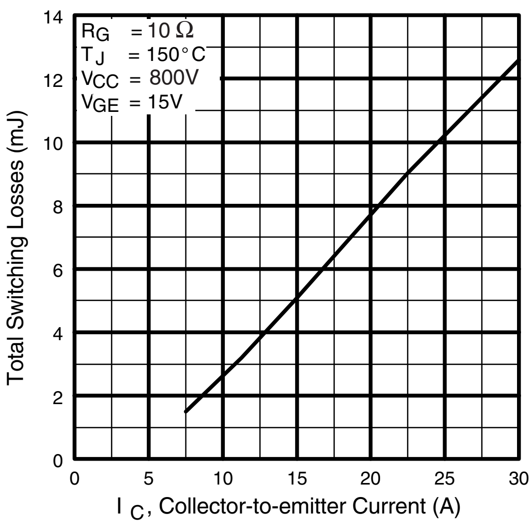



**Fig. 11 -** Typical Switching Losses vs. Collector-to-Emitter Current

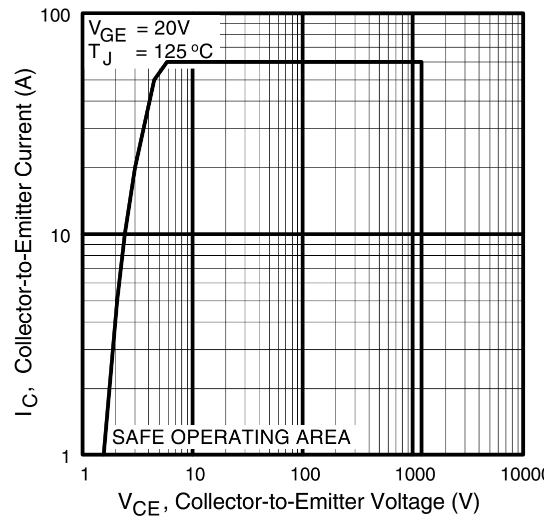



**Fig. 12** - Turn-Off SOA

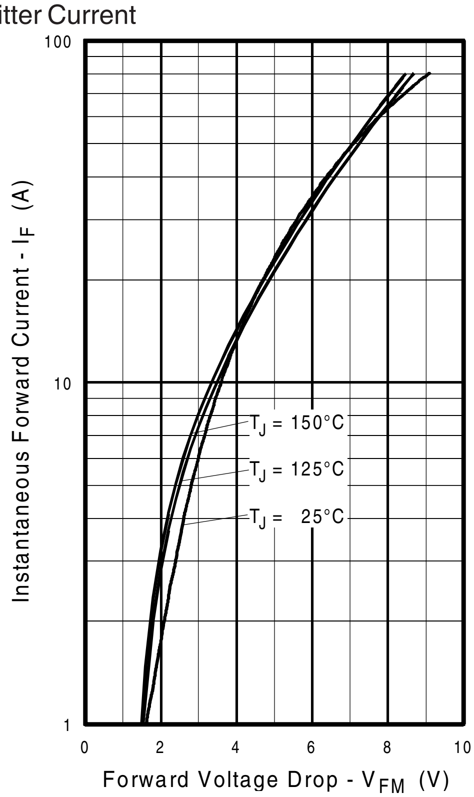



**Fig. 13** - Maximum Forward Voltage Drop vs. Instantaneous Forward Current

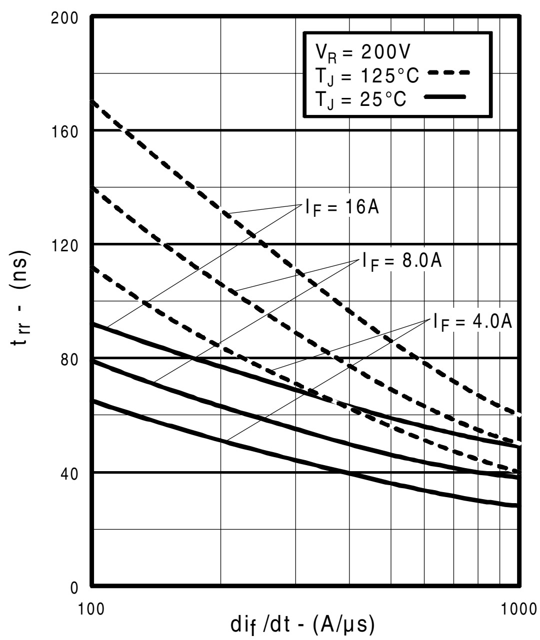



**Fig. 14** - Typical Reverse Recovery vs. $di_f/dt$

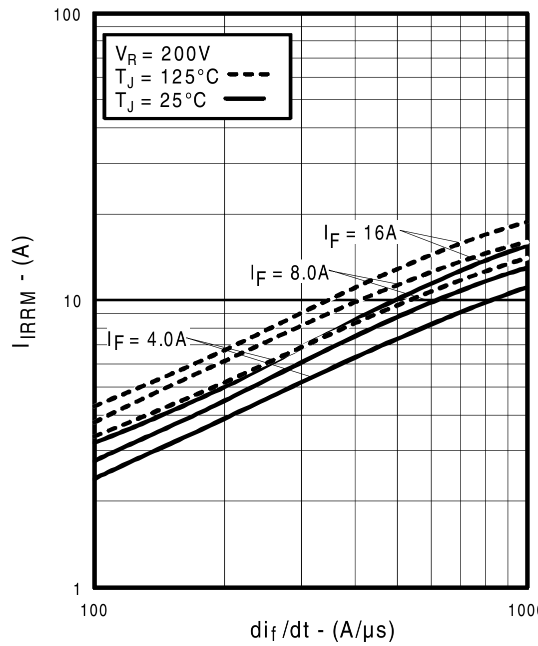



**Fig. 15** - Typical Recovery Current vs. $di_f/dt$

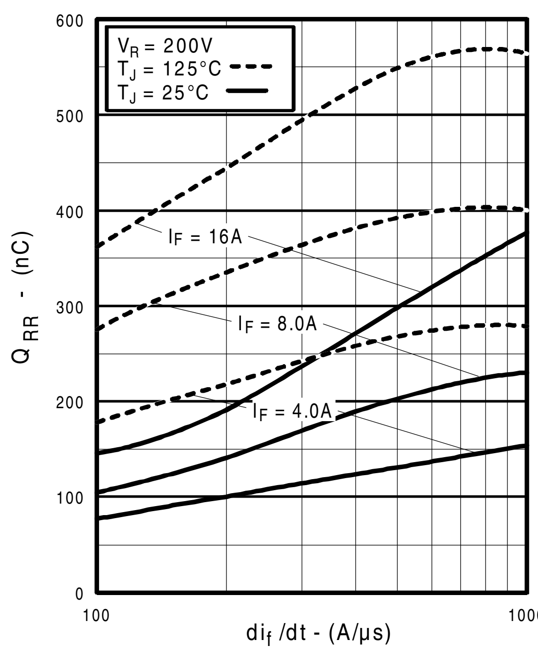



**Fig. 16** - Typical Stored Charge vs. $di_f/dt$

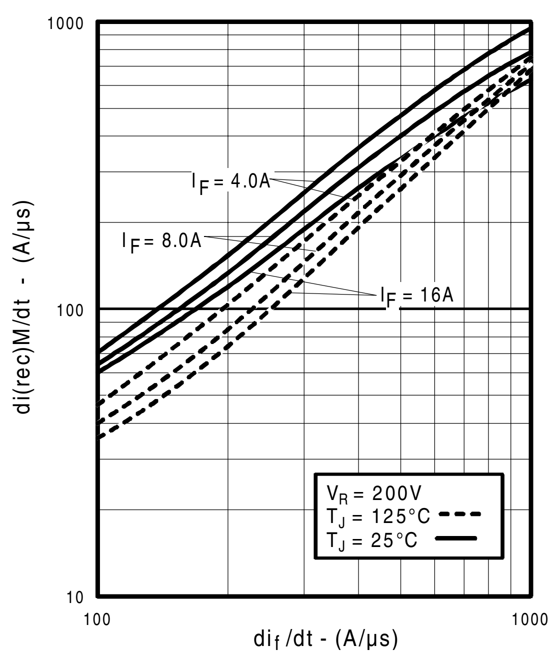



**Fig. 17** - Typical $di_{(rec)M}/dt$ vs. $di_f/dt$

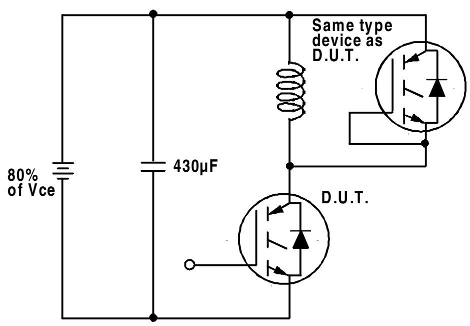



**Fig. 18a** - Test Circuit for Measurement of $I_{LM}$, $E_{on}$, $E_{off(diode)}$, $t_{rr}$, $Q_{rr}$, $I_{rr}$, $t_{d(on)}$, $t_r$, $t_{d(off)}$, $t_f$

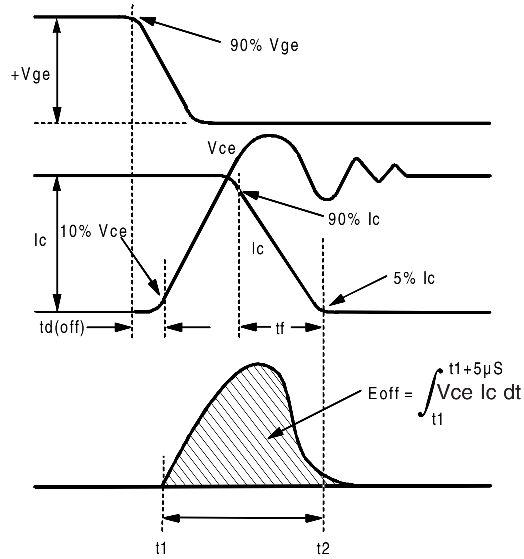



**Fig. 18b** - Test Waveforms for Circuit of Fig. 18a, Defining $E_{off}$, $t_{d(off)}$, $t_f$

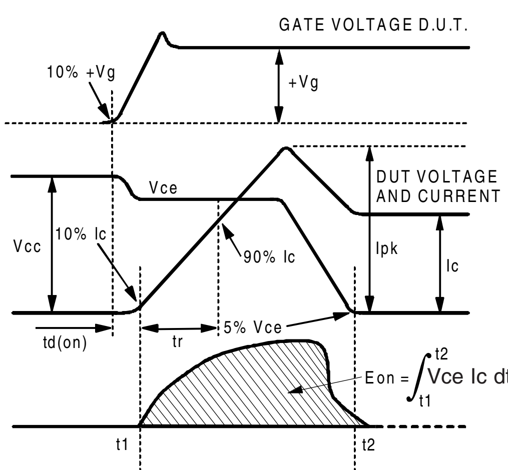



**Fig. 18c** - Test Waveforms for Circuit of Fig. 18a, Defining $E_{on}$, $t_{d(on)}$, $t_r$

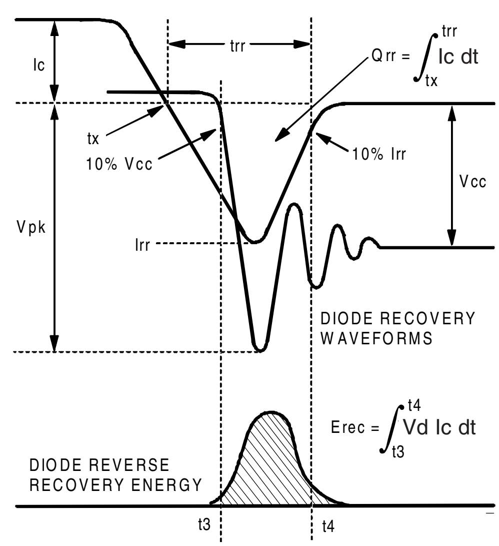



**Fig. 18d** - Test Waveforms for Circuit of Fig. 18a, Defining $E_{rec}$, $t_{rr}$, $Q_{rr}$, $I_{rr}$

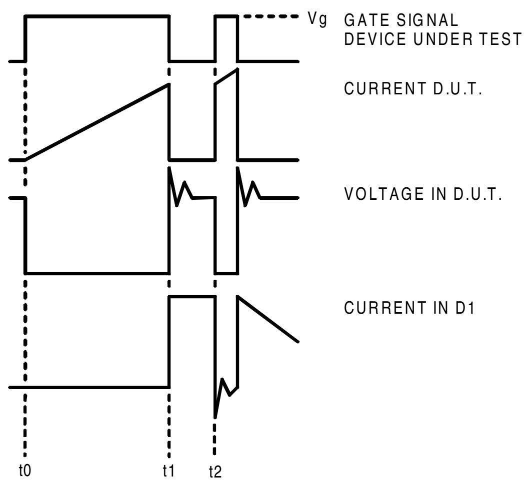



Figure 18e. Macro Waveforms for Figure 18a's Test Circuit

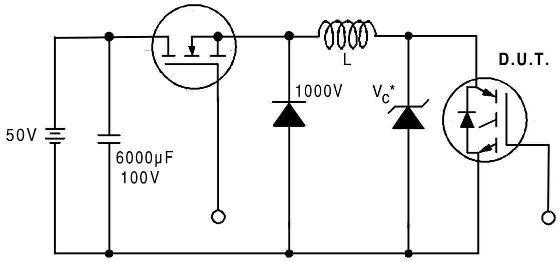



Figure 19. Clamped Inductive Load Test Circuit

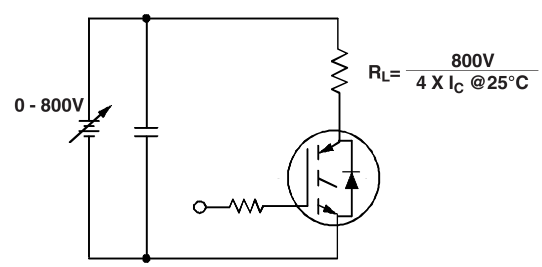



Figure 20. Pulsed Collector Current Test Circuit

## Notes:

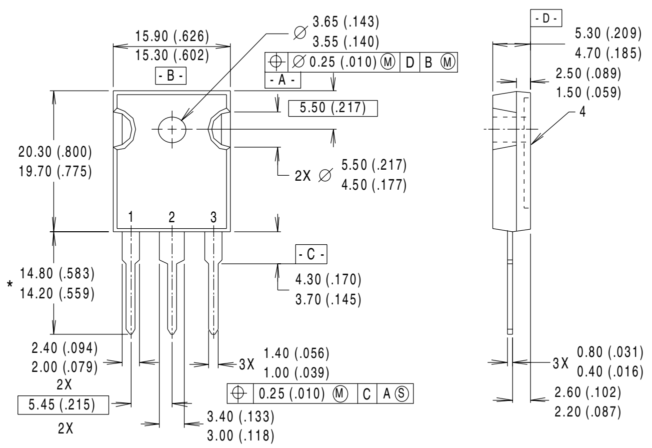
① Repetitive rating: $V_{GE}$=20V; pulse width limited by maximum junction temperature (figure 20)

② $V_{CC}$=80%($V_{CES}$), $V_{GE}$=20V, L=10µH, $R_G$= 10Ω (figure 19)

③ Pulse width ≤ 80µs; duty factor ≤ 0.1%.

④ Pulse width 5.0µs, single shot.

## Case Outline — TO-247AC




NOTES:
1 DIMENSIONS & TOLERANCING PER ANSI Y14.5M, 1982.
2 CONTROLLING DIMENSION : INCH.
3 DIMENSIONS ARE SHOWN MILLIMETERS (INCHES).
4 CONFORMS TO JEDEC OUTLINE TO-247AC.

LEAD ASSIGNMENTS
1 - GATE
2 - COLLECTOR
3 - EMITTER
4 - COLLECTOR

* LONGER LEADED (20mm) VERSION AVAILABLE (TO-247AD) TO ORDER ADD "-E" SUFFIX TO PART NUMBER

**CONFORMS TO JEDEC OUTLINE TO-247AC (TO-3P)**
Dimensions in Millimeters and (Inches)

International IOR Rectifier
**IR WORLD HEADQUARTERS:** 233 Kansas St., El Segundo, California 90245, USA Tel: (310) 252-7105
**IR EUROPEAN REGIONAL CENTRE:** 439/445 Godstone Rd, Whyteleafe, Surrey CR3 OBL, UK Tel: ++ 44 (0)20 8645 8000
**IR CANADA:** 15 Lincoln Court, Brampton, Ontario L6T3Z2, Tel: (905) 453 2200
**IR GERMANY:** Saalburgstrasse 157, 61350 Bad Homburg Tel: ++ 49 (0) 6172 96590
**IR ITALY:** Via Liguria 49, 10071 Borgaro, Torino Tel: ++ 39 011 451 0111
**IR JAPAN:** K&H Bldg., 2F, 30-4 Nishi-Ikebukuro 3-Chome, Toshima-Ku, Tokyo 171 Tel: 81 (0)3 3983 0086
**IR SOUTHEAST ASIA:** 1 Kim Seng Promenade, Great World City West Tower, 13-11, Singapore 237994 Tel: ++ 65 (0)838 4630
**IR TAIWAN:**16 Fl. Suite D. 207, Sec. 2, Tun Haw South Road, Taipei, 10673 Tel: 886-(0)2 2377 9936
*Data and specifications subject to change without notice. 6/00*