International
IOR Rectifier

PD -91784B

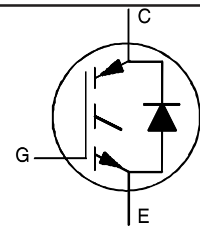
# IRG4BC10SD

INSULATED GATE BIPOLAR TRANSISTOR WITH ULTRAFAST SOFT RECOVERY DIODE

Standard Speed CoPack IGBT

## Features

- Extremely low voltage drop 1.1Vtyp. @ 2A
- S-Series: Minimizes power dissipation at up to 3 KHz PWM frequency in inverter drives, up to 4 KHz in brushless DC drives.
- Very Tight Vce(on) distribution
- IGBT co-packaged with HEXFRED™ ultrafast, ultra-soft-recovery anti-parallel diodes for use in bridge configurations
- Industry standard TO-220AB package



n-channel

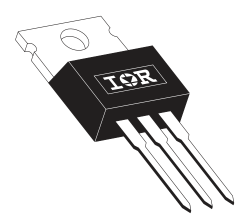
$V_{CES}$ = 600V

$V_{CE(on)\ typ.}$ = 1.10V

@$V_{GE}$ = 15V, $I_C$ = 2.0A

## Benefits

- Generation 4 IGBTs offer highest efficiencies available
- IGBTs optimized for specific application conditions
- HEXFRED diodes optimized for performance with IGBTs . Minimized recovery characteristics require less/no snubbing
- Lower losses than MOSFET's conduction and Diode losses


TO-220AB

## Absolute Maximum Ratings

| | Parameter | Max. | Units |
|---|---|---|---|
| $V_{CES}$ | Collector-to-Emitter Voltage | 600 | V |
| $I_C$ @ $T_C$ = 25°C | Continuous Collector Current | 14 | |
| $I_C$ @ $T_C$ = 100°C | Continuous Collector Current | 8.0 | |
| $I_{CM}$ | Pulsed Collector Current ① | 18 | A |
| $I_{LM}$ | Clamped Inductive Load Current ② | 18 | |
| $I_F$ @ $T_C$ = 100°C | Diode Continuous Forward Current | 4.0 | |
| $I_{FM}$ | Diode Maximum Forward Current | 18 | |
| $V_{GE}$ | Gate-to-Emitter Voltage | ± 20 | V |
| $P_D$ @ $T_C$ = 25°C | Maximum Power Dissipation | 38 | |
| $P_D$ @ $T_C$ = 100°C | Maximum Power Dissipation | 15 | W |
| $T_J$<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 | ---- | ---- | 3.3 | |
| $R_{\theta JC}$ | Junction-to-Case - Diode | ---- | ---- | 7.0 | °C/W |
| $R_{\theta CS}$ | Case-to-Sink, flat, greased surface | ---- | 0.50 | ---- | |
| $R_{\theta JA}$ | Junction-to-Ambient, typical socket mount | ---- | ---- | 80 | |
| Wt | Weight | ---- | 2.0(0.07) | ---- | g (oz) |



07/04/07

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

| | Parameter | Min. | Typ. | Max. | Units | Conditions | |
|---|---|---|---|---|---|---|---|
| $V_{(BR)CES}$ | Collector-to-Emitter Breakdown Voltage③ | 600 | — | — | V | $V_{GE}$ = 0V, $I_C$ = 250µA | |
| $\Delta V_{(BR)CES}/\Delta T_J$ | Temperature Coeff. of Breakdown Voltage | — | 0.64 | — | V/°C | $V_{GE}$ = 0V, $I_C$ = 1.0mA | |
| $V_{CE(on)}$ | Collector-to-Emitter Saturation Voltage | — | 1.58 | 1.8 | V | $I_C$ = 8.0A | $V_{GE}$ = 15V |
| | | — | 2.05 | — | | $I_C$ = 14.0A | See Fig. 2, 5 |
| | | — | 1.68 | — | | $I_C$ = 8.0A, $T_J$ = 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 | — | -9.5 | — | mV/°C | $V_{CE} = V_{GE}$, $I_C$ = 250µA | |
| $g_{fe}$ | Forward Transconductance④ | 3.65 | 5.48 | — | S | $V_{CE}$ = 100V, $I_C$ =8.0A | |
| $I_{CES}$ | Zero Gate Voltage Collector Current | — | — | 250 | µA | $V_{GE}$ = 0V, $V_{CE}$ = 600V | |
| | | — | — | 1000 | | $V_{GE}$ = 0V, $V_{CE}$ = 600V, $T_J$ = 150°C | |
| $V_{FM}$ | Diode Forward Voltage Drop | — | 1.5 | 1.8 | V | $I_C$ =4.0A | See Fig. 13 |
| | | — | 1.4 | 1.7 | | $I_C$ =4.0A, $T_J$ = 150°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) | — | 15 | 22 | nC | $I_C$ = 8.0A | | |
| Qge | Gate - Emitter Charge (turn-on) | — | 2.42 | 3.6 | | $V_{CC}$ = 400V | See Fig. 8 | |
| $Q_{gc}$ | Gate - Collector Charge (turn-on) | — | 6.53 | 9.8 | | $V_{GE}$ = 15V | | |
| $t_{d(on)}$ | Turn-On Delay Time | — | 76 | — | ns | $T_J$ = 25°C | | |
| $t_r$ | Rise Time | — | 32 | — | | $I_C$ = 8.0A, $V_{CC}$ = 480V | | |
| $t_{d(off)}$ | Turn-Off Delay Time | — | 815 | 1200 | | $V_{GE}$ = 15V, $R_G$ = 100Ω | | |
| $t_f$ | Fall Time | — | 720 | 1080 | | Energy losses include "tail" and | | |
| $E_{on}$ | Turn-On Switching Loss | — | 0.31 | — | mJ | diode reverse recovery. | | |
| $E_{off}$ | Turn-Off Switching Loss | — | 3.28 | — | | See Fig. 9, 10, 18 | | |
| $E_{ts}$ | Total Switching Loss | — | 3.60 | 10.9 | | | | |
| $E_{ts}$ | Total Switching Loss | — | 1.46 | 2.6 | mJ | $I_C$ = 5.0A | | |
| $t_{d(on)}$ | Turn-On Delay Time | — | 70 | — | ns | $T_J$ = 150°C, | See Fig. 10,11, 18 | |
| $t_r$ | Rise Time | — | 36 | — | | $I_C$ = 8.0A, $V_{CC}$ = 480V | | |
| $t_{d(off)}$ | Turn-Off Delay Time | — | 890 | — | | $V_{GE}$ = 15V, $R_G$ = 100Ω | | |
| $t_f$ | Fall Time | — | 890 | — | | Energy losses include "tail" and | | |
| $E_{ts}$ | Total Switching Loss | — | 3.83 | — | mJ | diode reverse recovery. | | |
| $L_E$ | Internal Emitter Inductance | — | 7.5 | — | nH | Measured 5mm from package | | |
| $C_{ies}$ | Input Capacitance | — | 280 | — | pF | $V_{GE}$ = 0V | | |
| $C_{oes}$ | Output Capacitance | — | 30 | — | | $V_{CC}$ = 30V | See Fig. 7 | |
| $C_{res}$ | Reverse Transfer Capacitance | — | 4.0 | — | | $f$ = 1.0MHz | | |
| $t_{rr}$ | Diode Reverse Recovery Time | — | 28 | 42 | ns | $T_J$ = 25°C | See Fig. | |
| | | — | 38 | 57 | | $T_J$ = 125°C | 14 | $I_F$ =4.0A |
| $I_{rr}$ | Diode Peak Reverse Recovery Current | — | 2.9 | 5.2 | A | $T_J$ = 25°C | See Fig. | |
| | | — | 3.7 | 6.7 | | $T_J$ = 125°C | 15 | $V_R$ = 200V |
| $Q_{rr}$ | Diode Reverse Recovery Charge | — | 40 | 60 | nC | $T_J$ = 25°C | See Fig. | |
| | | — | 70 | 105 | | $T_J$ = 125°C | 16 | di/dt = 200A/µs |
| $di_{(rec)M}/dt$ | Diode Peak Rate of Fall of Recovery | — | 280 | — | A/µs | $T_J$ = 25°C | See Fig. | |
| | During $t_b$ | — | 235 | — | | $T_J$ = 125°C | 17 | |

Details of note ① through ④ are on the last page

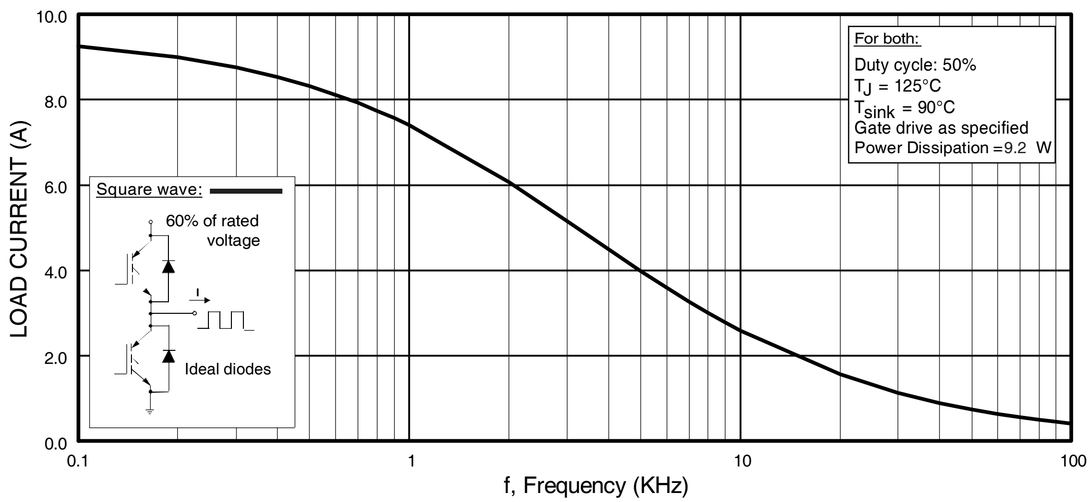



**Fig. 1** - Typical Load Current vs. Frequency
(Load Current = $I_{RMS}$ of fundamental)

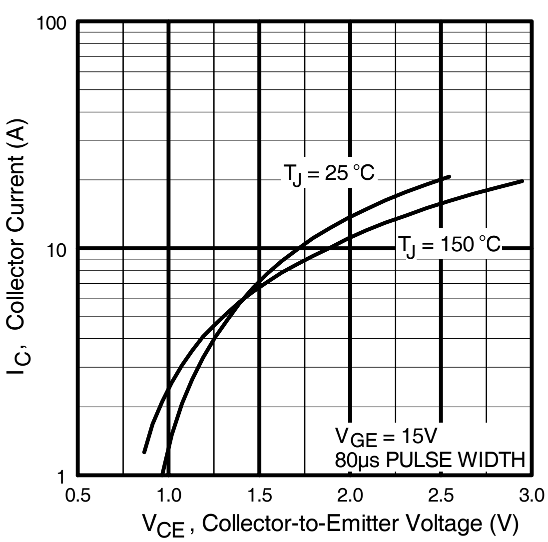



**Fig. 2** - Typical Output Characteristics

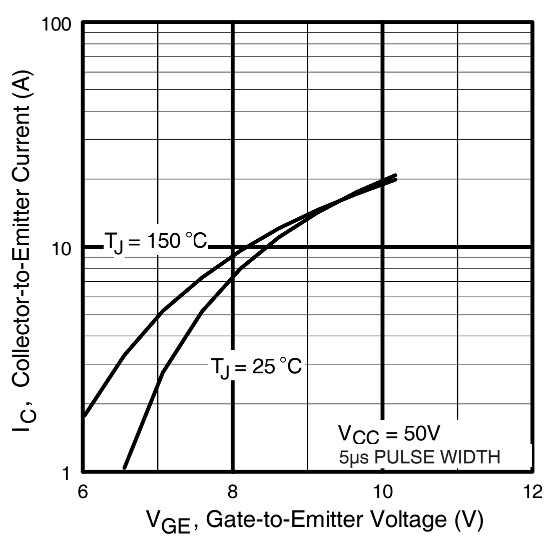



**Fig. 3** - Typical Transfer Characteristics

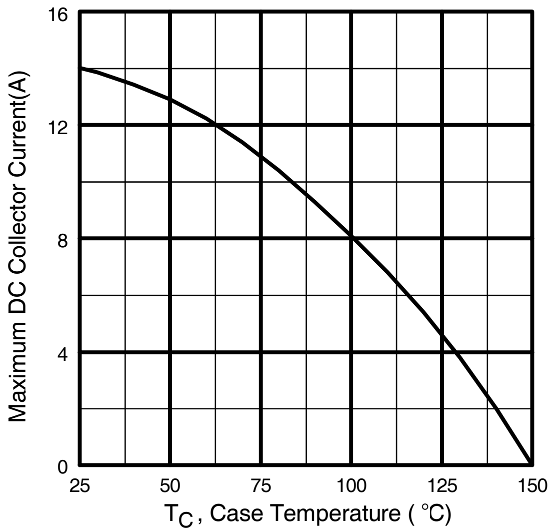



**Fig. 4** - Maximum Collector Current vs. Case Temperature

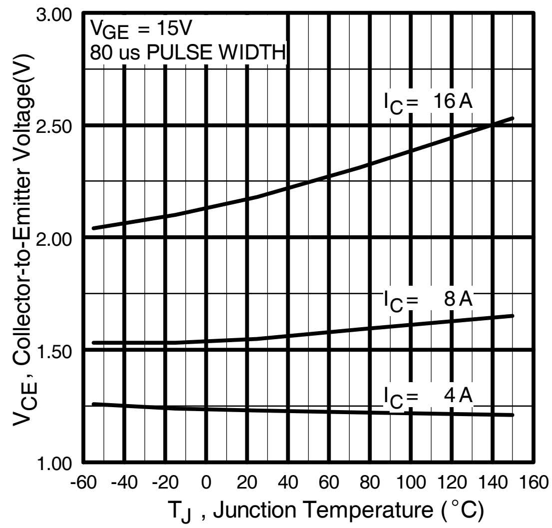



**Fig. 5** - Typical Collector-to-Emitter Voltage vs. Junction Temperature

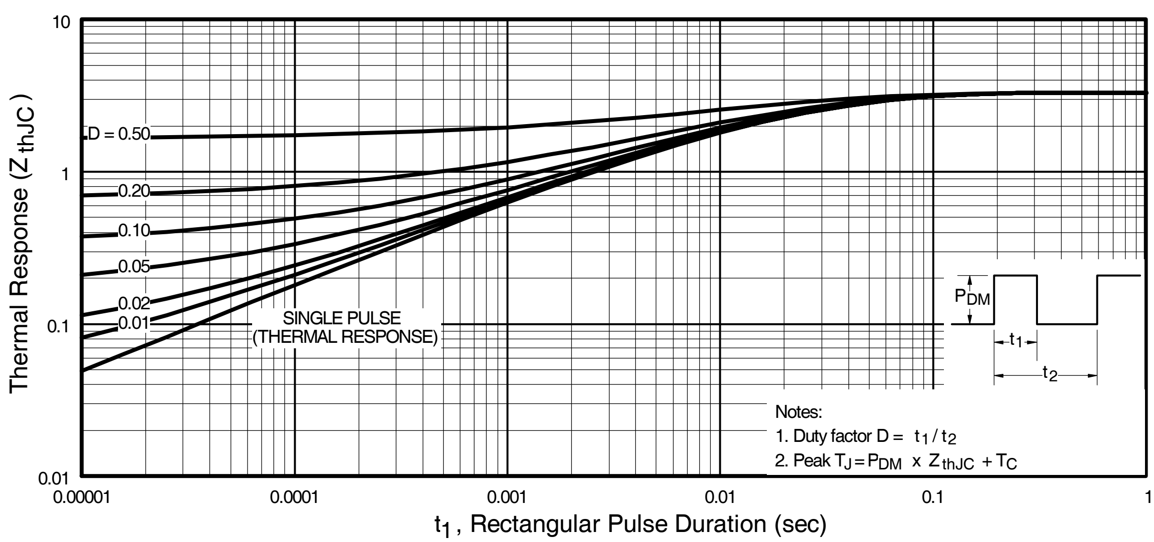



**Fig. 6** - Maximum Effective Transient Thermal Impedance, Junction-to-Case

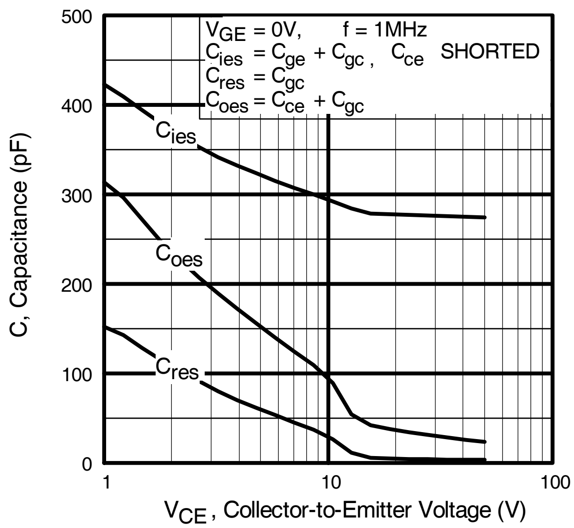



**Fig. 7 -** Typical Capacitance vs. Collector-to-Emitter Voltage

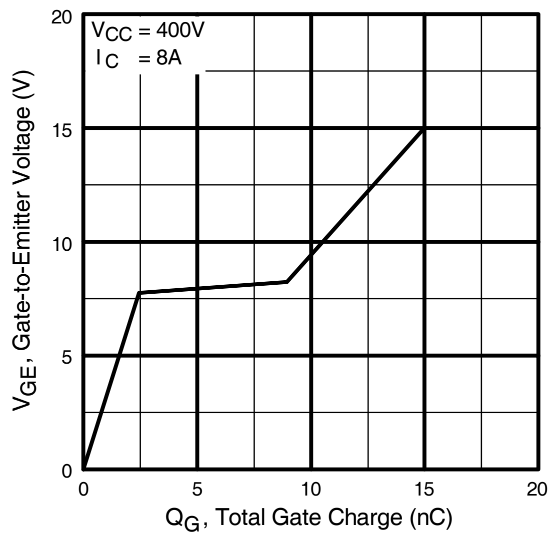



**Fig. 8** - Typical Gate Charge vs. Gate-to-Emitter Voltage

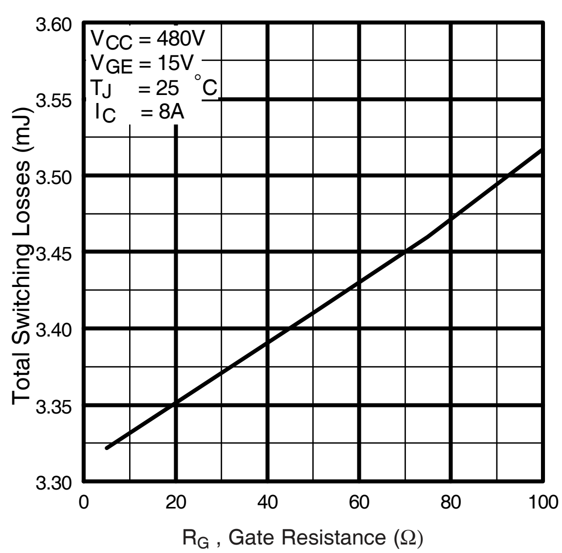



**Fig. 9** - Typical Switching Losses vs. Gate Resistance

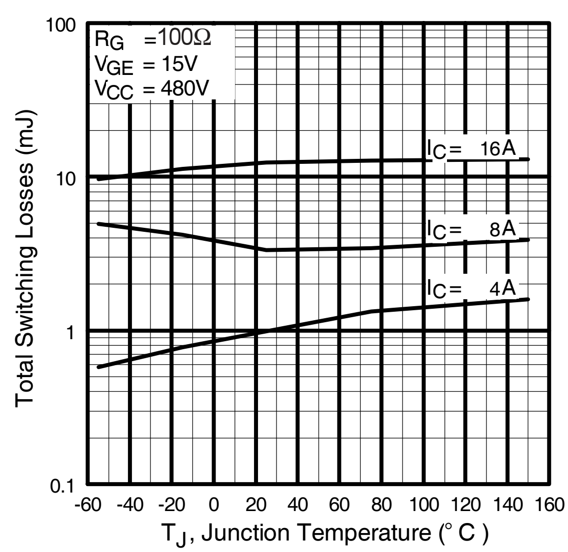



**Fig. 10** - Typical Switching Losses vs. Junction Temperature

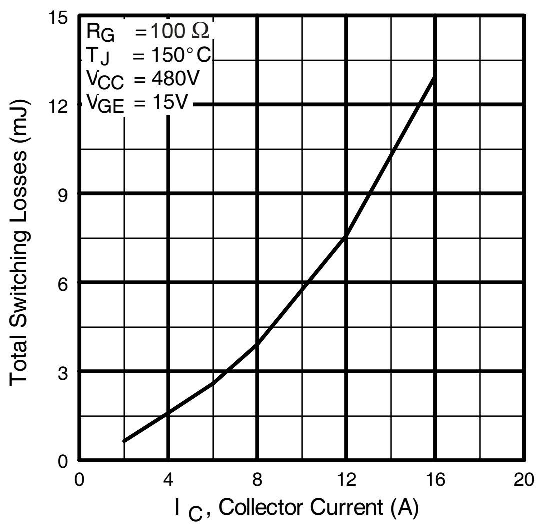



**Fig. 11 -** Typical Switching Losses vs. Collector Current

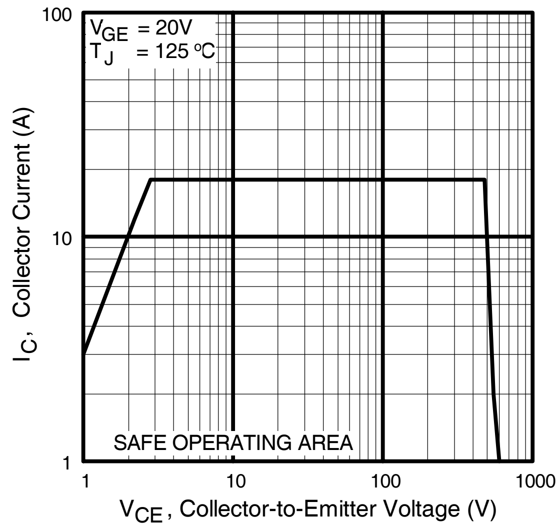



**Fig. 12** - Turn-Off SOA

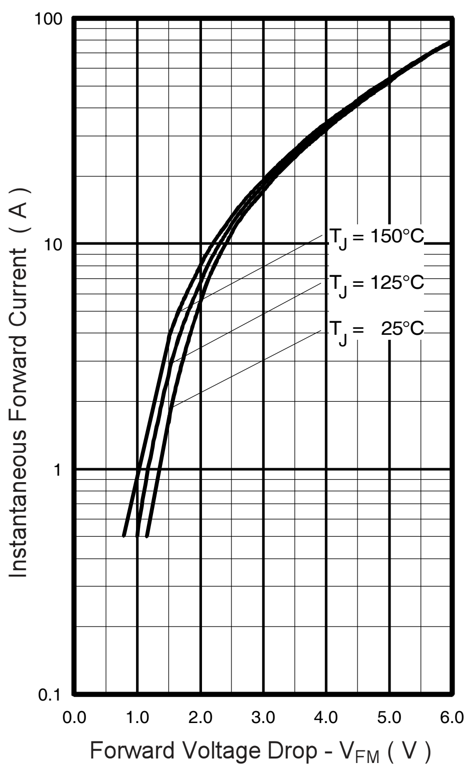



**Fig. 13** - Maximum Forward Voltage Drop vs. Instantaneous Forward Current

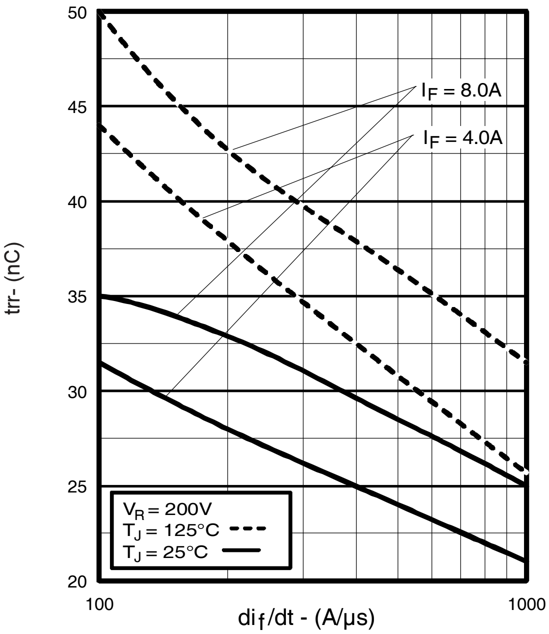



**Fig. 14** - Typical Reverse Recovery vs. $di_f/dt$

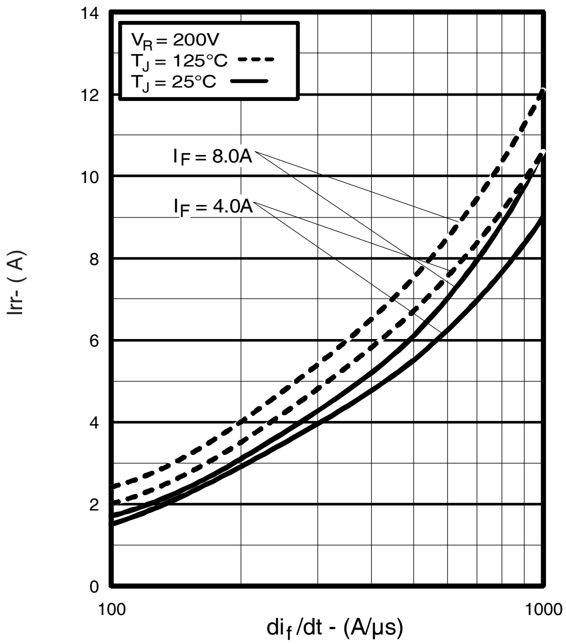



**Fig. 15** - Typical Recovery Current vs. $di_f/dt$

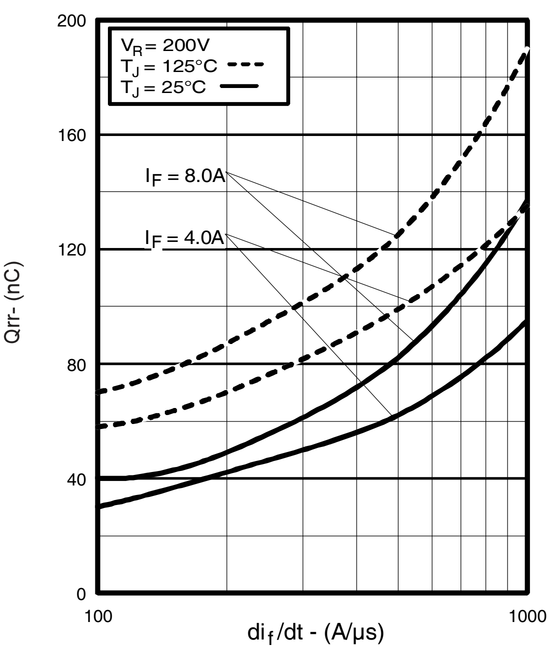



**Fig. 16** - Typical Stored Charge vs. $di_f/dt$

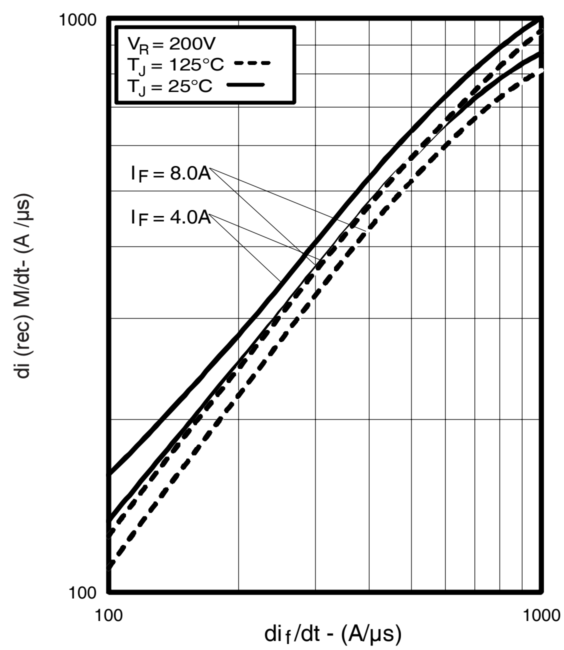



**Fig. 17** - Typical $di_{(rec)M}/dt$ vs. $di_f/dt$,

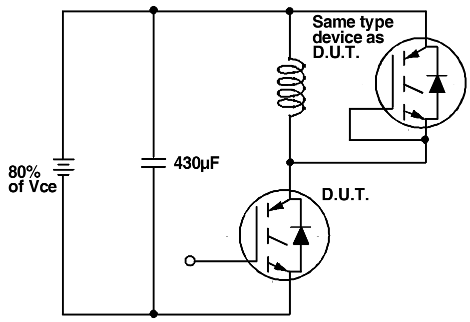



**Fig. 18a** - Test Circuit for Measurement of $I_{LM}$, $E_{on}$, $E_{off(diode)}$, $t_{rr}$, $Q_{rr}$, $I_{rr}$, $t_{d(on)}$, $t_r$, $t_{d(off)}$, $t_f$

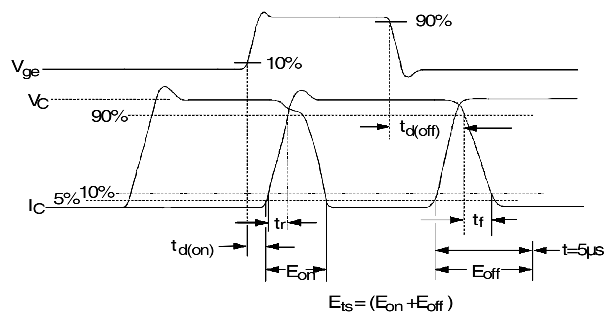



**Fig. 18b** - Test Waveforms for Circuit of Fig. 18a, Defining $E_{off}$, $t_{d(off)}$, $t_f$

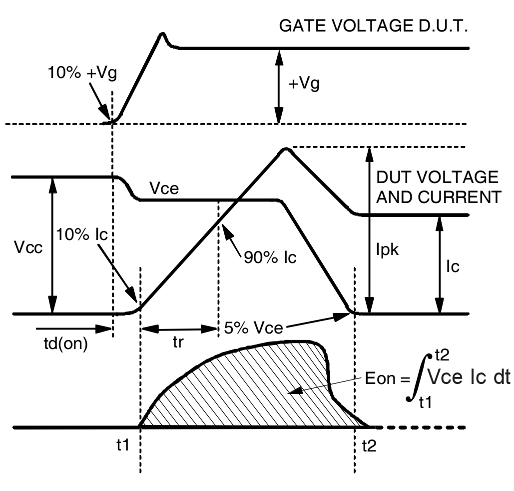



**Fig. 18c** - Test Waveforms for Circuit of Fig. 18a, Defining $E_{on}$, $t_{d(on)}$, $t_r$

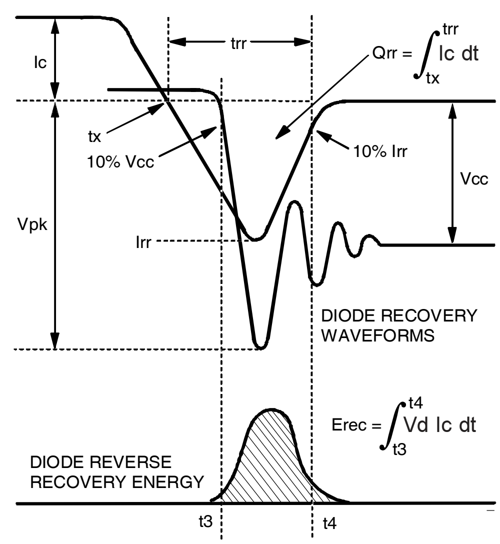



**Fig. 18d** - Test Waveforms for Circuit of Fig. 18a, Defining $E_{rec}$, $t_{rr}$, $Q_{rr}$, $I_{rr}$

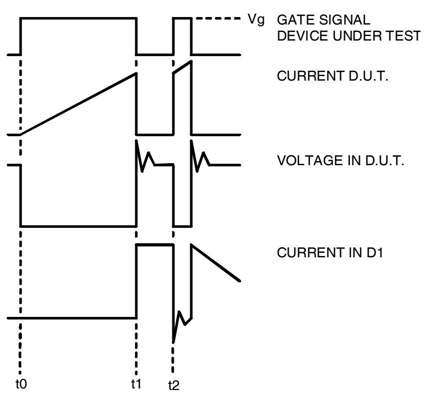



Figure 18e. Macro Waveforms for Figure 18a's Test Circuit

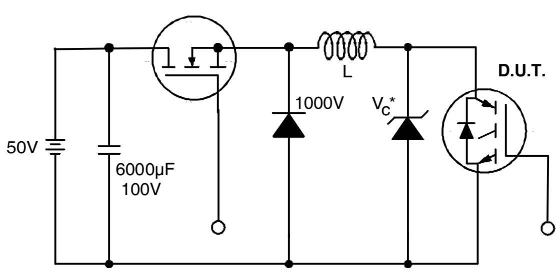



Figure 19. Clamped Inductive Load Test Circuit

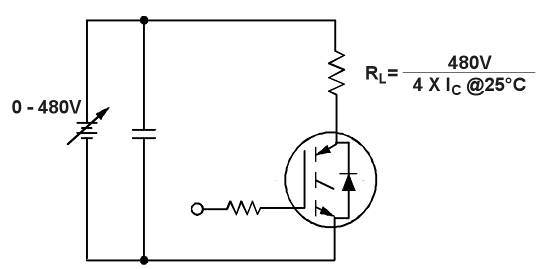



Figure 20. Pulsed Collector Current Test Circuit

## Notes:

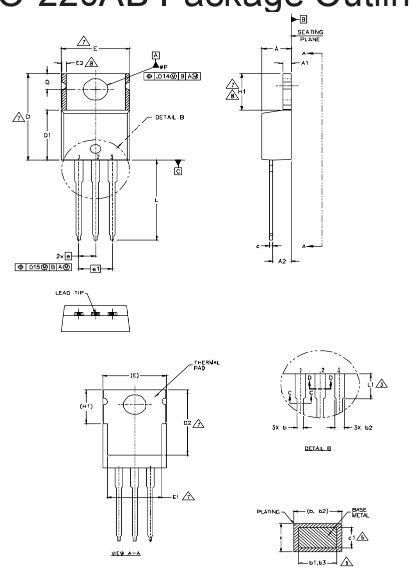
① Repetitive rating: $V_{GE}$=20V; pulse width limited by maximum junction temperature (figure 20)

② $V_{CC}$=80%($V_{CES}$), $V_{GE}$=20V, L=10µH, $R_G$ = 100W (figure 19)

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

④ Pulse width 5.0µs, single shot.

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




NOTES:

1.- DIMENSIONING AND TOLERANCING AS PER ASME Y14.5 M- 1994.
2.- DIMENSIONS ARE SHOWN IN INCHES [MILLIMETERS].
3.- LEAD DIMENSION AND FINISH UNCONTROLLED IN L1.
4.- DIMENSION D, D1 & 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, b3 & 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.
9.- OUTLINE CONFORMS TO JEDEC TO-220, EXCEPT A2 (max.) AND D2 (min.) WHERE DIMENSIONS ARE DERIVED FROM THE ACTUAL PACKAGE OUTLINE.

| SYMBOL | DIMENSIONS | | | | NOTES |
|---|---|---|---|---|---|
| | MILLIMETERS | | INCHES | | |
| | MIN. | MAX. | MIN. | MAX. | |
| A | 3.56 | 4.83 | .140 | .190 | |
| A1 | 0.51 | 1.40 | .020 | .055 | |
| A2 | 2.03 | 2.92 | .080 | .115 | |
| b | 0.38 | 1.01 | .015 | .040 | |
| b1 | 0.38 | 0.97 | .015 | .038 | 5 |
| b2 | 1.14 | 1.78 | .045 | .070 | |
| b3 | 1.14 | 1.73 | .045 | .068 | 5 |
| c | 0.36 | 0.61 | .014 | .024 | |
| c1 | 0.36 | 0.56 | .014 | .022 | 5 |
| D | 14.22 | 16.51 | .560 | .650 | 4 |
| D1 | 8.38 | 9.02 | .330 | .355 | |
| D2 | 11.68 | 12.88 | .460 | .507 | 7 |
| E | 9.65 | 10.67 | .380 | .420 | 4,7 |
| E1 | 6.86 | 8.89 | .270 | .350 | 7 |
| E2 | – | 0.76 | – | .030 | 8 |
| e | 2.54 BSC | | .100 BSC | | |
| e1 | 5.08 BSC | | .200 BSC | | |
| H1 | 5.84 | 6.86 | .230 | .270 | 7,8 |
| L | 12.70 | 14.73 | .500 | .580 | |
| L1 | – | 6.35 | – | .250 | 3 |
| øP | 3.54 | 4.08 | .139 | .161 | |
| Q | 2.54 | 3.42 | .100 | .135 | |

LEAD ASSIGNMENTS

HEXFET

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

IGBTs, CoPACK

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

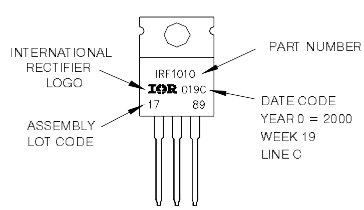
DIODES

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

## TO-220AB Part Marking Information

EXAMPLE: THIS IS AN IRF1010
LOT CODE 1789
ASSEMBLED ON WW 19, 2000
IN THE ASSEMBLY LINE "C"

Note: "P" in assembly line position indicates "Lead - Free"




**Note: For the most current drawing please refer to IR website at http://www.irf.com/package/**

Data and specifications subject to change without notice.

International IOR Rectifier

**IR WORLD HEADQUARTERS:** 233 Kansas St., El Segundo, California 90245, USA Tel: (310) 252-7105
TAC Fax: (310) 252-7903
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