

International

**IR** Rectifier

INSULATED GATE BIPOLAR TRANSISTOR WITH  
ULTRAFAST SOFT RECOVERY DIODE

**IRG4PC40FDPbF**

Fast CoPack IGBT

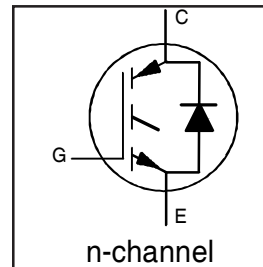
PD - 94911A

### Features

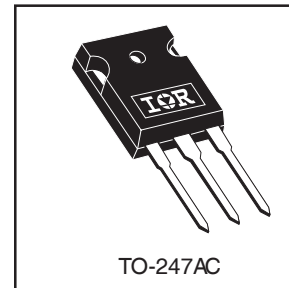
- Fast: Optimized for medium operating frequencies ( 1-5 kHz in hard switching, >20 kHz in resonant mode).
- Generation 4 IGBT design provides tighter parameter distribution and higher efficiency than Generation 3
- IGBT co-packaged with HEXFRED™ ultrafast, ultra-soft-recovery anti-parallel diodes for use in bridge configurations
- Industry standard TO-247AC package
- Lead-Free

### Benefits

- Generation -4 IGBT's offer highest efficiencies available
- IGBT's optimized for specific application conditions
- HEXFRED diodes optimized for performance with IGBT's . Minimized recovery characteristics require less/no snubbing
- Designed to be a "drop-in" replacement for equivalent industry-standard Generation 3 IR IGBT's



|                                   |
|-----------------------------------|
| $V_{CES} = 600V$                  |
| $V_{CE(on)} \text{ typ.} = 1.50V$ |
| @ $V_{GE} = 15V, I_C = 27A$       |



### Absolute Maximum Ratings

|                           | Parameter                          | Max.                                                     | Units      |
|---------------------------|------------------------------------|----------------------------------------------------------|------------|
| $V_{CES}$                 | Collector-to-Emitter Voltage       | 600                                                      | V          |
| $I_C @ T_C = 25^\circ C$  | Continuous Collector Current       | 49                                                       | A          |
| $I_C @ T_C = 100^\circ C$ | Continuous Collector Current       | 27                                                       |            |
| $I_{CM}$                  | Pulsed Collector Current ①         | 196                                                      |            |
| $I_{LM}$                  | Clamped Inductive Load Current ②   | 196                                                      |            |
| $I_F @ T_C = 100^\circ C$ | Diode Continuous Forward Current   | 15                                                       |            |
| $I_{FM}$                  | Diode Maximum Forward Current      | 200                                                      |            |
| $V_{GE}$                  | 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 <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             | ---- | 0.70 | ----      | V/ $^\circ\text{C}$  | $V_{GE} = 0V, I_C = 1.0mA$                            |
| $V_{CE(on)}$                    | Collector-to-Emitter Saturation Voltage             | ---- | 1.50 | 1.7       | V                    | $I_C = 27A, V_{GE} = 15V$                             |
|                                 |                                                     | ---- | 1.85 | ----      |                      | $I_C = 49A$                                           |
|                                 |                                                     | ---- | 1.56 | ----      |                      | $I_C = 27A, T_J = 150^\circ\text{C}$                  |
| $V_{GE(th)}$                    | 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             | ---- | -12  | ----      | mV/ $^\circ\text{C}$ | $V_{CE} = V_{GE}, I_C = 250\mu A$                     |
| $g_{fe}$                        | Forward Transconductance <sup>④</sup>               | 9.2  | 12   | ----      | S                    | $V_{CE} = 100V, I_C = 27A$                            |
| $I_{CES}$                       | Zero Gate Voltage Collector Current                 | ---- | ---- | 250       | $\mu A$              | $V_{GE} = 0V, V_{CE} = 600V$                          |
|                                 |                                                     | ---- | ---- | 3500      |                      | $V_{GE} = 0V, V_{CE} = 600V, T_J = 150^\circ\text{C}$ |
| $V_{FM}$                        | 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)                      | ---- | 100  | 150  | nC         | $I_C = 27A$                                              |
| $Q_{ge}$         | Gate - Emitter Charge (turn-on)                  | ---- | 15   | 23   |            | $V_{CC} = 400V$ See Fig. 8                               |
| $Q_{gc}$         | Gate - Collector Charge (turn-on)                | ---- | 35   | 53   |            | $V_{GE} = 15V$                                           |
| $t_{d(on)}$      | Turn-On Delay Time                               | ---- | 63   | ---- | ns         | $T_J = 25^\circ\text{C}$                                 |
| $t_r$            | Rise Time                                        | ---- | 32   | ---- |            | $I_C = 27A, V_{CC} = 480V$                               |
| $t_{d(off)}$     | Turn-Off Delay Time                              | ---- | 230  | 350  |            | $V_{GE} = 15V, R_G = 10\Omega$                           |
| $t_f$            | Fall Time                                        | ---- | 170  | 250  |            | Energy losses include "tail" and diode reverse recovery. |
| $E_{on}$         | Turn-On Switching Loss                           | ---- | 0.95 | ---- | mJ         | See Fig. 9, 10, 11, 18                                   |
| $E_{off}$        | Turn-Off Switching Loss                          | ---- | 2.01 | ---- |            |                                                          |
| $E_{ts}$         | Total Switching Loss                             | ---- | 2.96 | 4.0  |            |                                                          |
| $t_{d(on)}$      | Turn-On Delay Time                               | ---- | 63   | ---- | ns         | $T_J = 150^\circ\text{C}$ , See Fig. 9, 10, 11, 18       |
| $t_r$            | Rise Time                                        | ---- | 33   | ---- |            | $I_C = 27A, V_{CC} = 480V$                               |
| $t_{d(off)}$     | Turn-Off Delay Time                              | ---- | 350  | ---- |            | $V_{GE} = 15V, R_G = 10\Omega$                           |
| $t_f$            | Fall Time                                        | ---- | 310  | ---- |            | Energy losses include "tail" and diode reverse recovery. |
| $E_{ts}$         | Total Switching Loss                             | ---- | 4.7  | ---- | mJ         |                                                          |
| $L_E$            | Internal Emitter Inductance                      | ---- | 13   | ---- | nH         | Measured 5mm from package                                |
| $C_{ies}$        | Input Capacitance                                | ---- | 2200 | ---- | pF         | $V_{GE} = 0V$                                            |
| $C_{oes}$        | Output Capacitance                               | ---- | 140  | ---- |            | $V_{CC} = 30V$ See Fig. 7                                |
| $C_{res}$        | Reverse Transfer Capacitance                     | ---- | 29   | ---- |            | $f = 1.0MHz$                                             |
| $t_{rr}$         | 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  | ---- |            | $T_J = 125^\circ\text{C}$                                |

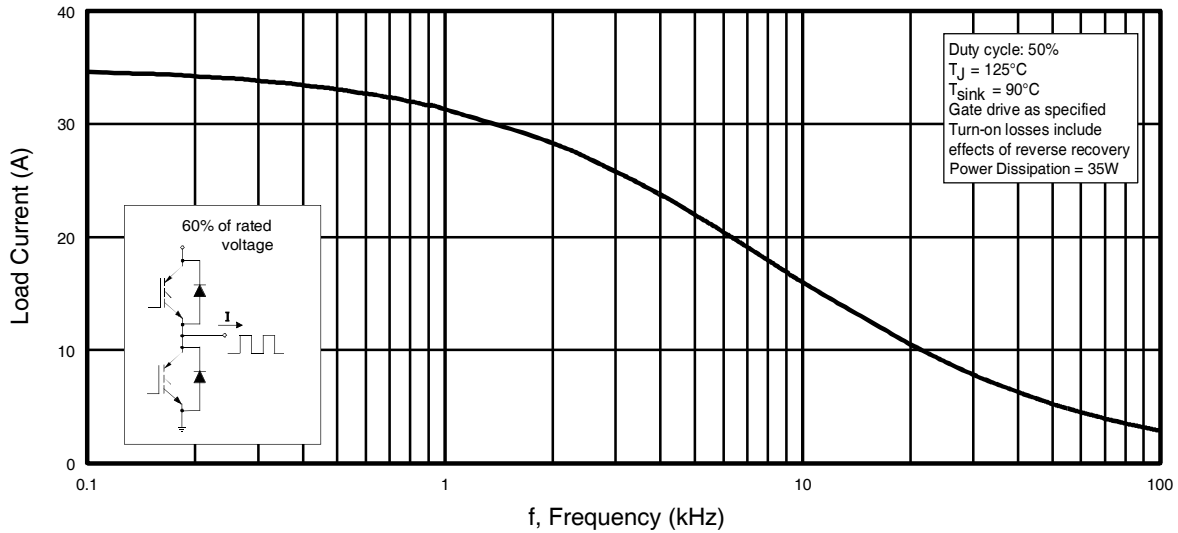


**Fig. 1 - Typical Load Current vs. Frequency**  
 (Load Current =  $I_{\text{RMS}}$  of fundamental)

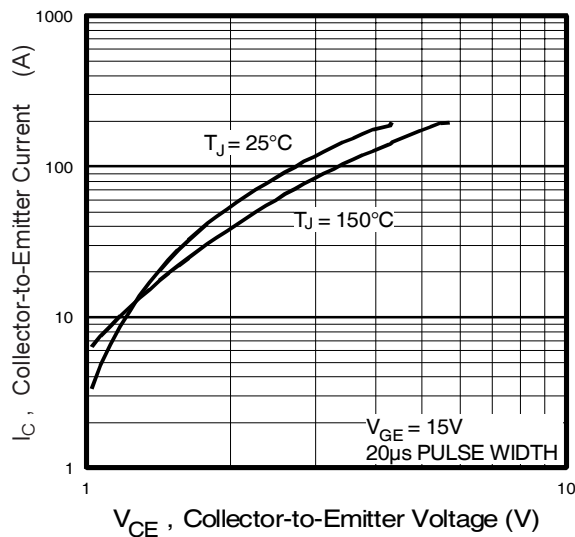


**Fig. 2 - Typical Output Characteristics**

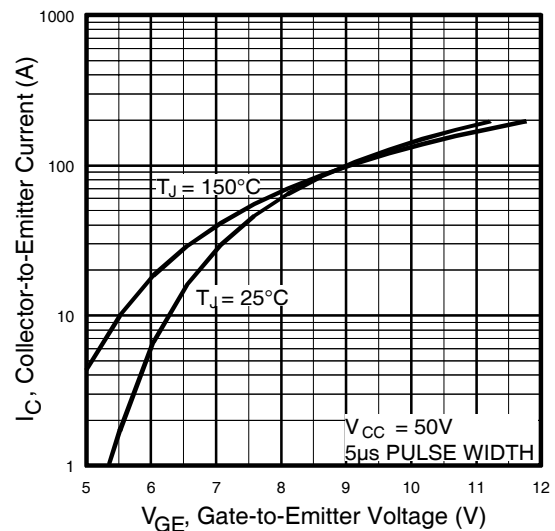


**Fig. 3 - Typical Transfer Characteristics**

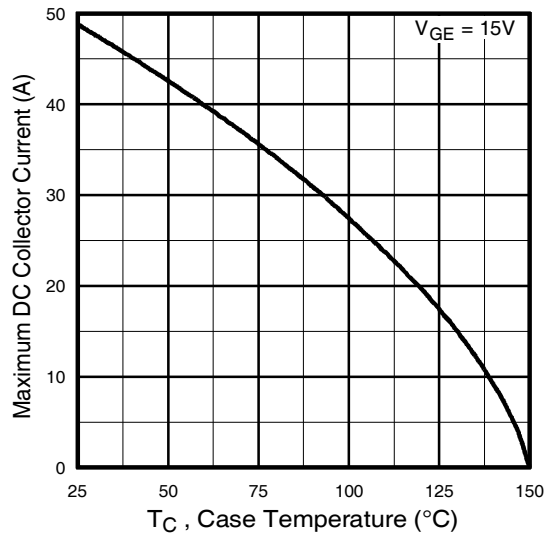


**Fig. 4** - Maximum Collector Current vs. Case Temperature

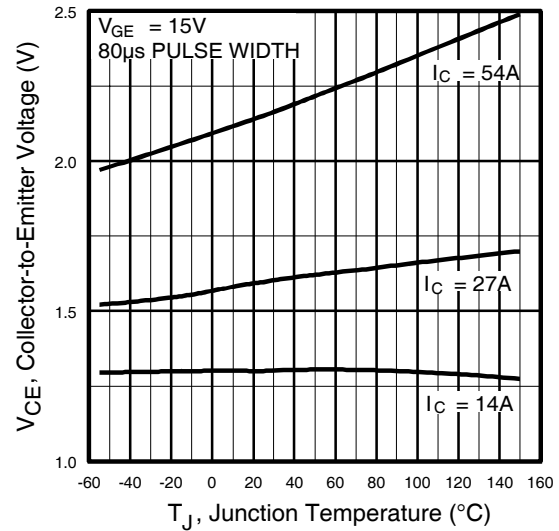


**Fig. 5** - Typical Collector-to-Emitter Voltage vs. Junction Temperature

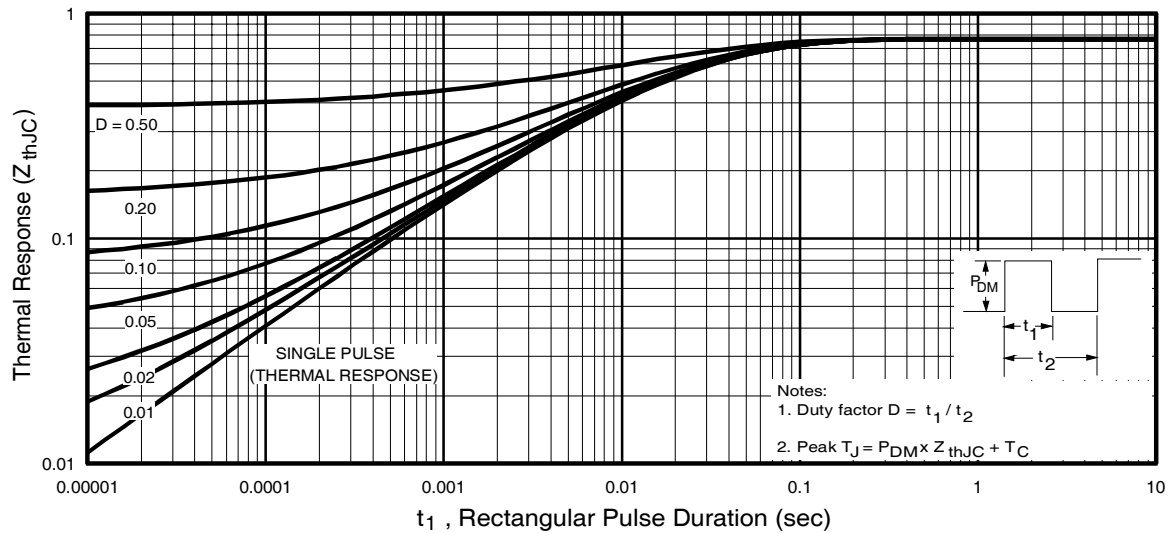


**Fig. 6** - Maximum Effective Transient Thermal Impedance, Junction-to-Case

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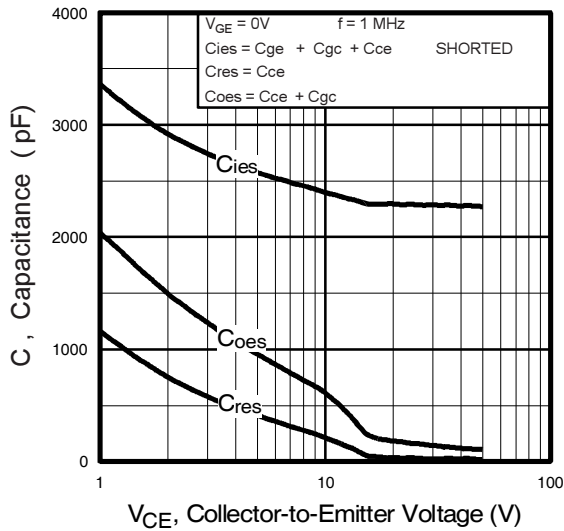


**Fig. 7** - Typical Capacitance vs. Collector-to-Emitter Voltage

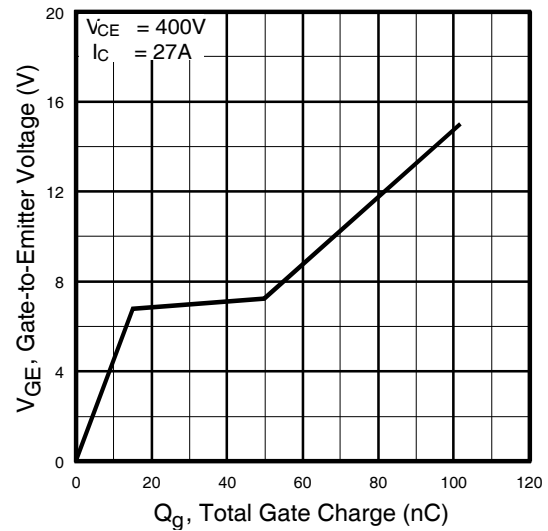


**Fig. 8** - Typical Gate Charge vs. Gate-to-Emitter Voltage

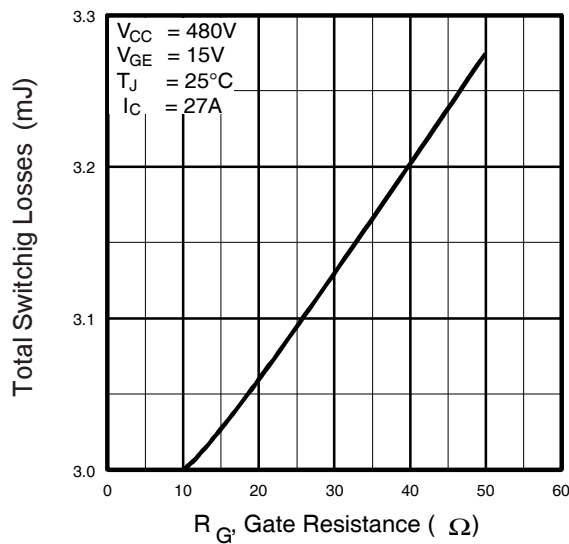


**Fig. 9** - Typical Switching Losses vs. Gate Resistance

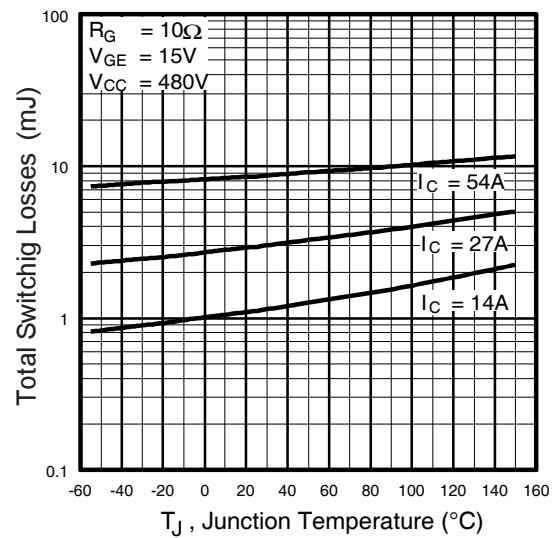


**Fig. 10** - Typical Switching Losses vs. Junction Temperature

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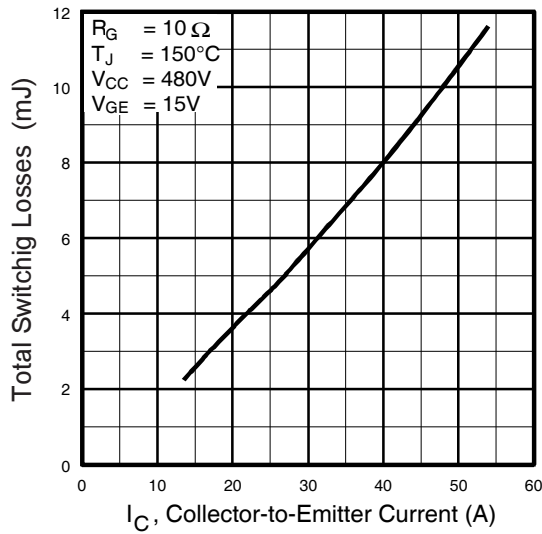


**Fig. 11** - Typical Switching Losses vs. Collector-to-Emitter Current

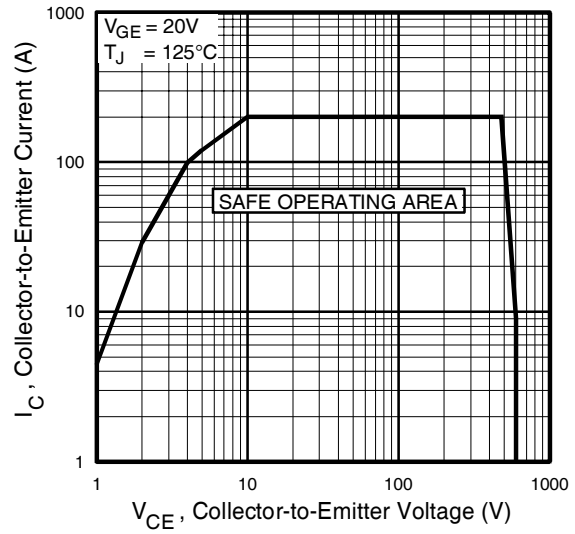


**Fig. 12** - Turn-Off SOA

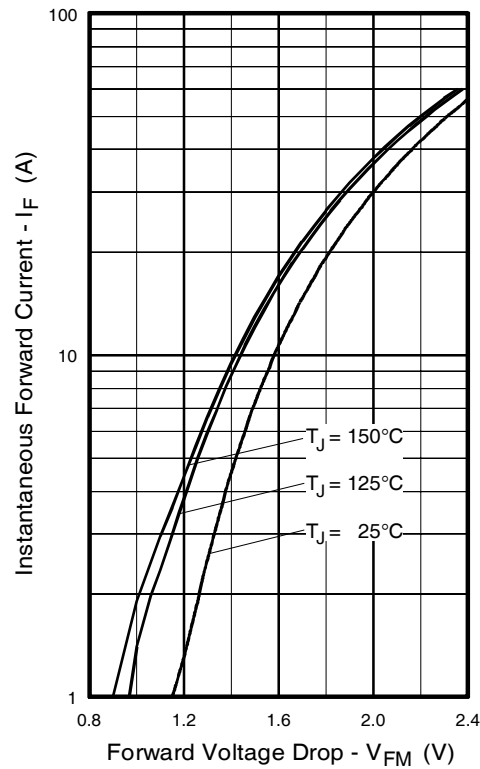


**Fig. 13** - Maximum Forward Voltage Drop vs. Instantaneous Forward Current

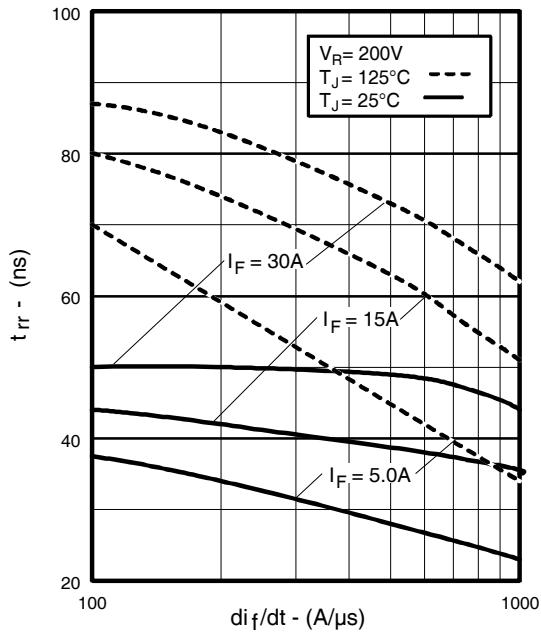


Fig. 14 - Typical Reverse Recovery vs.  $di_f/dt$

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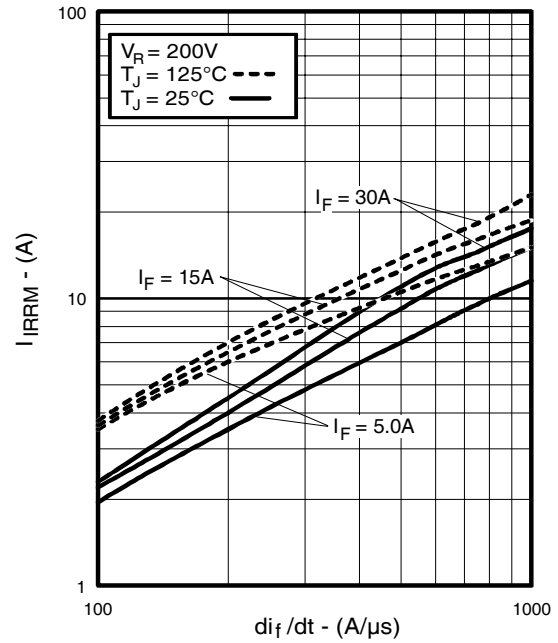


Fig. 15 - Typical Recovery Current vs.  $di_f/dt$

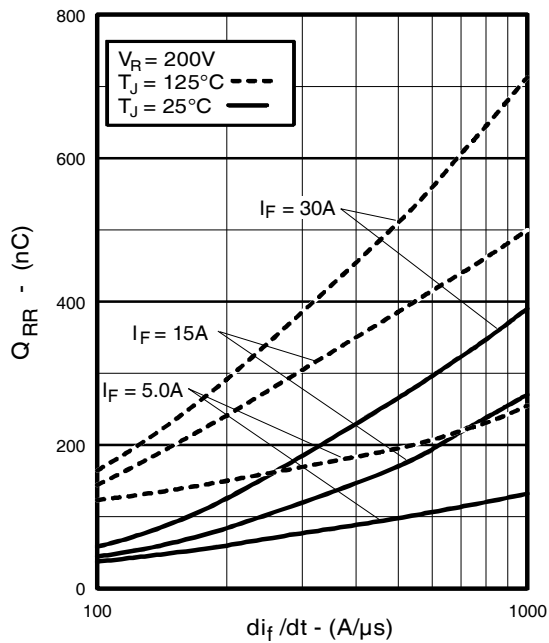


Fig. 16 - Typical Stored Charge vs.  $di_f/dt$

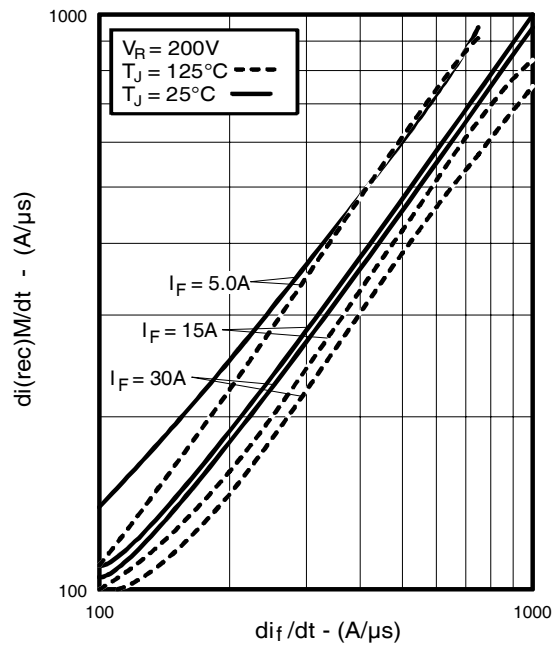


Fig. 17 - Typical  $di_{(rec)M}/dt$  vs.  $di_f/dt$

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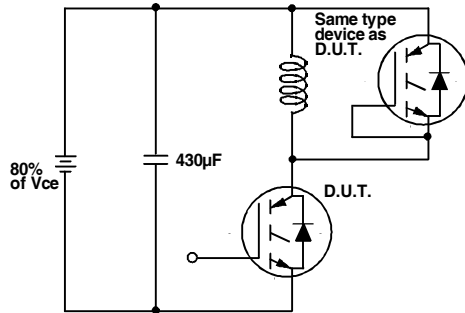


**Fig. 18a** - Test Circuit for Measurement of  $I_{LM}$ ,  $E_{on}$ ,  $E_{off}(\text{diode})$ ,  $t_{rr}$ ,  $Q_{rr}$ ,  $I_{rr}$ ,  $t_{d(on)}$ ,  $t_r$ ,  $t_{d(off)}$ ,  $t_f$

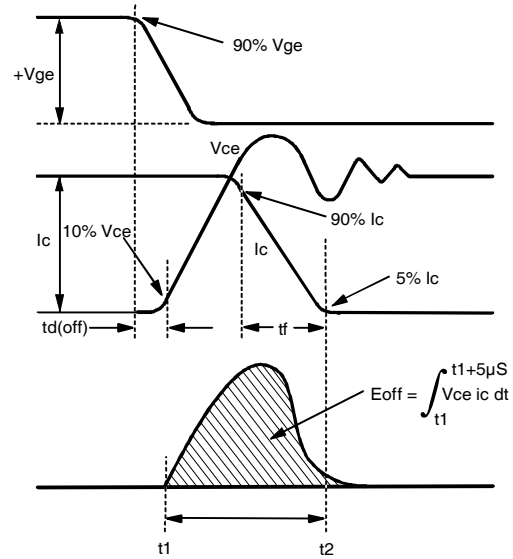


**Fig. 18b** - Test Waveforms for Circuit of Fig. 18a, Defining  $E_{off}$ ,  $t_{d(off)}$ ,  $t_f$

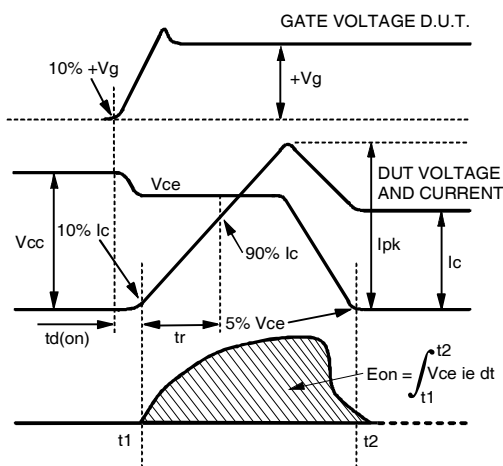


**Fig. 18c** - Test Waveforms for Circuit of Fig. 18a, Defining  $E_{on}$ ,  $t_{d(on)}$ ,  $t_r$

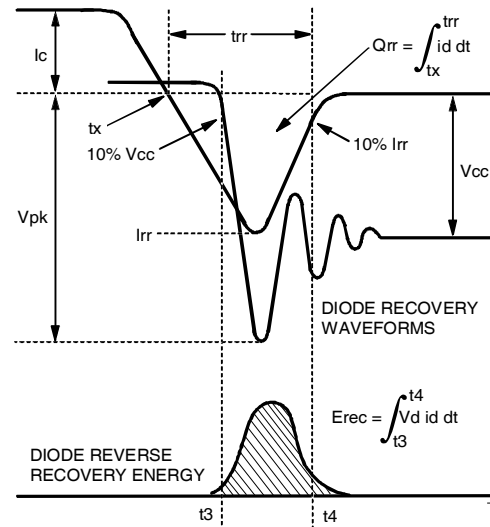


**Fig. 18d** - Test Waveforms for Circuit of Fig. 18a, Defining  $E_{rec}$ ,  $t_{rr}$ ,  $Q_{rr}$ ,  $I_{rr}$

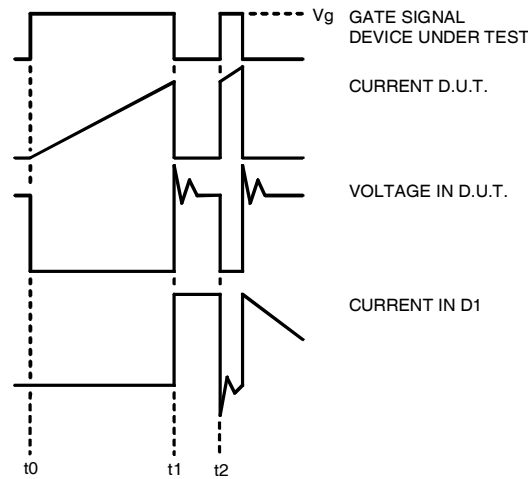


Figure 18e. Macro Waveforms for Figure 18a's Test Circuit

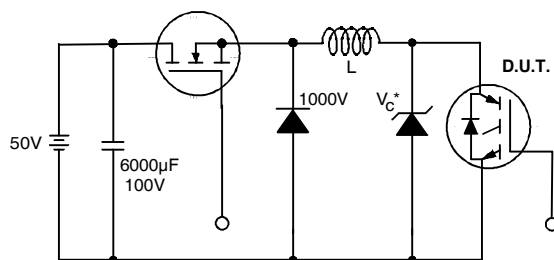


Figure 19. Clamped Inductive Load Test Circuit

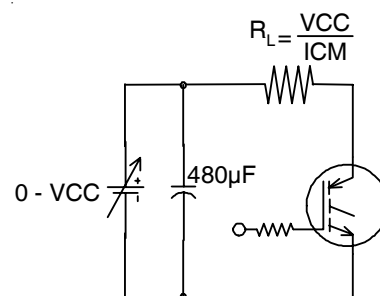


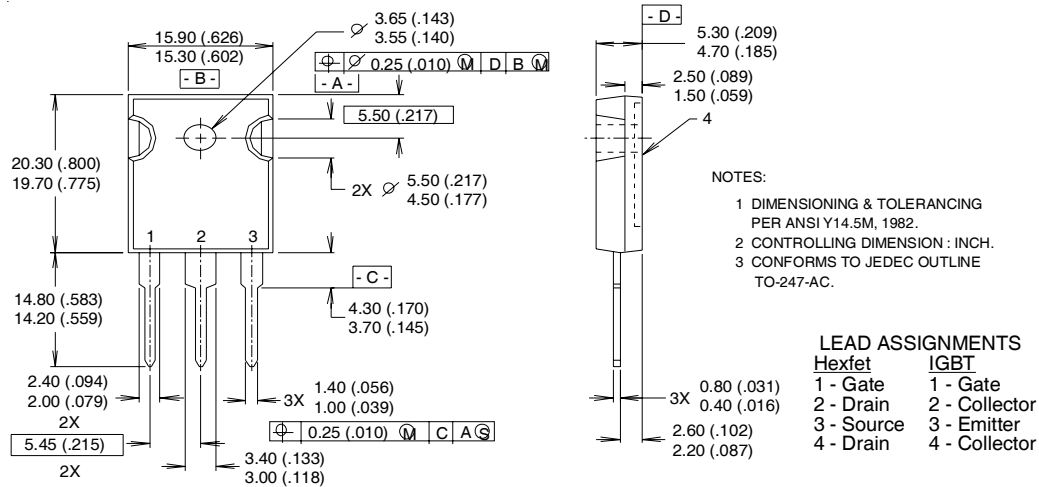
Figure 20. Pulsed Collector Current Test Circuit

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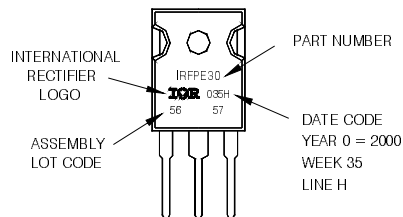
## TO-247AC Package Outline

Dimensions are shown in millimeters (inches)



## TO-247AC Part Marking Information

EXAMPLE: THIS IS AN IRFPE30  
WITH ASSEMBLY  
LOT CODE 5657  
ASSEMBLED ON WW 35, 2000  
IN THE ASSEMBLY LINE 'H'  
**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/>

### Notes:

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

Data and specifications subject to change without notice.

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TAC Fax: (310) 252-7903

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