

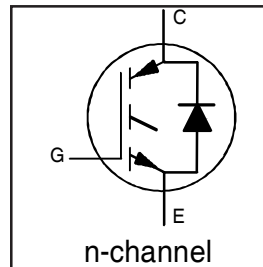
# IRG4PC40FDPbF

INSULATED GATE BIPOLAR TRANSISTOR WITH  
 ULTRAFAST SOFT RECOVERY DIODE

Fast CoPack IGBT

**Features**

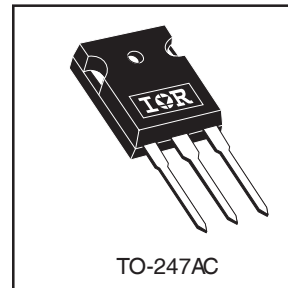
- Fast: Optimized for medium operating frequencies ( 1-5 kHz in hard switching, >20 kHz in resonant mode).
- Generation 4 IGBT design provides tighter parameter distribution and higher efficiency than Generation 3
- IGBT co-packaged with HEXFRED™ ultrafast, ultra-soft-recovery anti-parallel diodes for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



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

**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



**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 Storage Temperature Range | -55 to +150         | $^\circ C$ |
| $T_{STG}$                 |  |                     |            |
|                           |  |                     |            |
|                           | Mounting Torque, 6-32 or M3 Screw.               | 10 lbf•in (1.1 N•m) |            |

**Thermal Resistance**

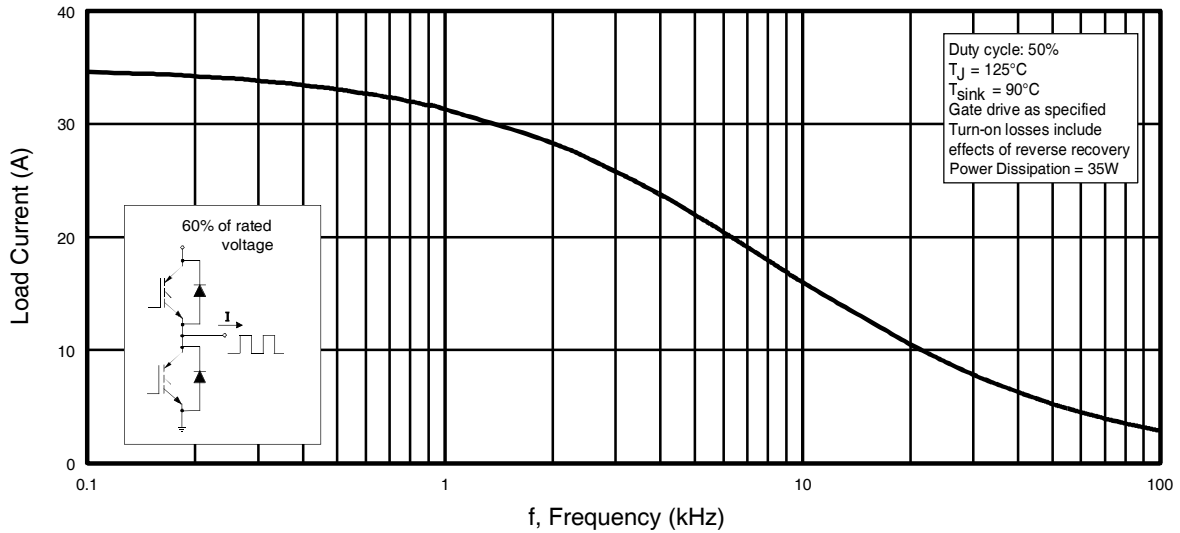
|                 | Parameter                                 | Min.  | Typ.     | Max.  | Units        |
|-----------------|---|-------|----------|-------|--------------|
| $R_{\theta JC}$ | Junction-to-Case - IGBT                   | ----- | -----    | 0.77  | $^\circ C/W$ |
| $R_{\theta JC}$ | Junction-to-Case - 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<sub>J</sub> = 25°C (unless otherwise specified)

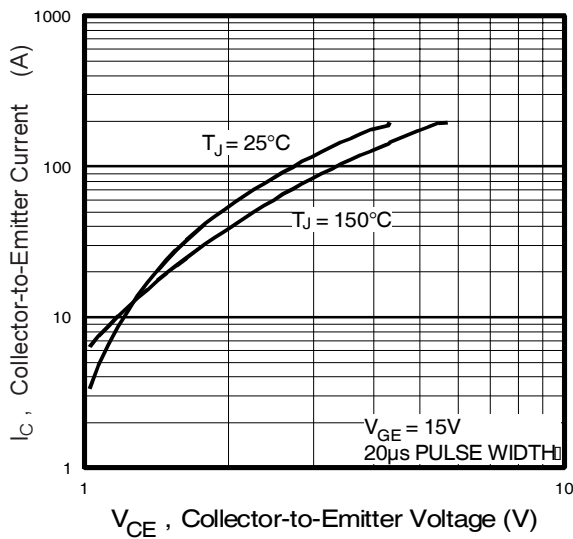
|  | Parameter   | Min. | Typ. | Max. | Units | Conditions   |
|--|---|------|------|------|-------|--|
| V <sub>(BR)CES</sub>                   | Collector-to-Emitter Breakdown Voltage <sup>③</sup> | 600  | ---- | ---- | V     | V <sub>GE</sub> = 0V, I <sub>C</sub> = 250μA                         |
| ΔV <sub>(BR)CES</sub> /ΔT <sub>J</sub> | Temperature Coeff. of Breakdown Voltage             | ---- | 0.70 | ---- | V/°C  | V <sub>GE</sub> = 0V, I <sub>C</sub> = 1.0mA                         |
| V <sub>CE(on)</sub>                    | Collector-to-Emitter Saturation Voltage             | ---- | 1.50 | 1.7  | V     | I <sub>C</sub> = 27A V <sub>GE</sub> = 15V                           |
|  |   | ---- | 1.85 | ---- |       | I <sub>C</sub> = 49A See Fig. 2, 5                                   |
|  |   | ---- | 1.56 | ---- |       | I <sub>C</sub> = 27A, T <sub>J</sub> = 150°C                         |
| V <sub>GE(th)</sub>                    | Gate Threshold Voltage                              | 3.0  | ---- | 6.0  |       | V <sub>CE</sub> = V <sub>GE</sub> , I <sub>C</sub> = 250μA           |
| ΔV <sub>GE(th)</sub> /ΔT <sub>J</sub>  | Temperature Coeff. of Threshold Voltage             | ---- | -12  | ---- | mV/°C | V <sub>CE</sub> = V <sub>GE</sub> , I <sub>C</sub> = 250μA           |
| g <sub>fe</sub>                        | Forward Transconductance <sup>④</sup>               | 9.2  | 12   | ---- | S     | V <sub>CE</sub> = 100V, I <sub>C</sub> = 27A                         |
| I <sub>CES</sub>                       | Zero Gate Voltage Collector Current                 | ---- | ---- | 250  | μA    | V <sub>GE</sub> = 0V, V <sub>CE</sub> = 600V                         |
|  |   | ---- | ---- | 3500 |       | V <sub>GE</sub> = 0V, V <sub>CE</sub> = 600V, T <sub>J</sub> = 150°C |
| V <sub>FM</sub>                        | Diode Forward Voltage Drop                          | ---- | 1.3  | 1.7  | V     | I <sub>C</sub> = 15A See Fig. 13                                     |
|  |   | ---- | 1.2  | 1.6  |       | I <sub>C</sub> = 15A, T <sub>J</sub> = 150°C                         |
| I <sub>GES</sub>                       | Gate-to-Emitter Leakage Current                     | ---- | ---- | ±100 | nA    | V <sub>GE</sub> = ±20V   |

## Switching Characteristics @ T<sub>J</sub> = 25°C (unless otherwise specified)

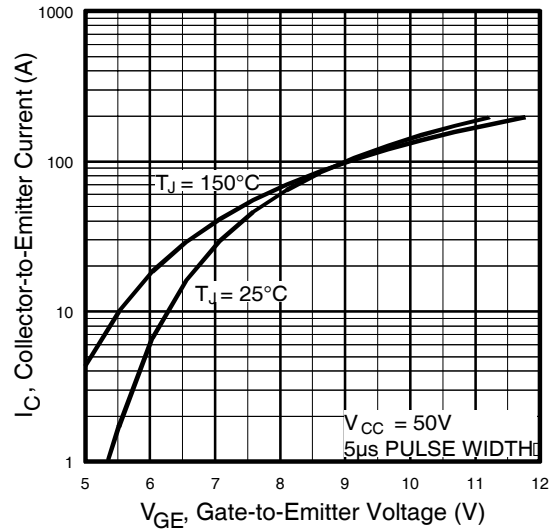
|                          | Parameter   | Min. | Typ. | Max. | Units | Conditions   |
|--------------------------|---|------|------|------|-------|--|
| Q <sub>g</sub>           | Total Gate Charge (turn-on)                               | ---- | 100  | 150  | nC    | I <sub>C</sub> = 27A                                     |
| Q <sub>ge</sub>          | Gate - Emitter Charge (turn-on)                           | ---- | 15   | 23   |       | V <sub>CC</sub> = 400V See Fig. 8                        |
| Q <sub>gc</sub>          | Gate - Collector Charge (turn-on)                         | ---- | 35   | 53   |       | V <sub>GE</sub> = 15V                                    |
| t <sub>d(on)</sub>       | Turn-On Delay Time  | ---- | 63   | ---- | ns    | T <sub>J</sub> = 25°C                                    |
| t <sub>r</sub>           | Rise Time   | ---- | 32   | ---- |       | I <sub>C</sub> = 27A, V <sub>CC</sub> = 480V             |
| t <sub>d(off)</sub>      | Turn-Off Delay Time                                       | ---- | 230  | 350  | mJ    | V <sub>GE</sub> = 15V, R <sub>G</sub> = 10Ω              |
| t <sub>f</sub>           | Fall Time   | ---- | 170  | 250  |       | Energy losses include "tail" and diode reverse recovery. |
| E <sub>on</sub>          | Turn-On Switching Loss                                    | ---- | 0.95 | ---- | mJ    | See Fig. 9, 10, 11, 18                                   |
| E <sub>off</sub>         | Turn-Off Switching Loss                                   | ---- | 2.01 | ---- |       |  |
| E <sub>ts</sub>          | Total Switching Loss                                      | ---- | 2.96 | 4.0  |       |  |
| t <sub>d(on)</sub>       | Turn-On Delay Time  | ---- | 63   | ---- | ns    | T <sub>J</sub> = 150°C, See Fig. 9, 10, 11, 18           |
| t <sub>r</sub>           | Rise Time   | ---- | 33   | ---- |       | I <sub>C</sub> = 27A, V <sub>CC</sub> = 480V             |
| t <sub>d(off)</sub>      | Turn-Off Delay Time                                       | ---- | 350  | ---- |       | V <sub>GE</sub> = 15V, R <sub>G</sub> = 10Ω              |
| t <sub>f</sub>           | Fall Time   | ---- | 310  | ---- |       | Energy losses include "tail" and diode reverse recovery. |
| E <sub>ts</sub>          | Total Switching Loss                                      | ---- | 4.7  | ---- | mJ    |  |
| L <sub>E</sub>           | Internal Emitter Inductance                               | ---- | 13   | ---- | nH    | Measured 5mm from package                                |
| C <sub>ies</sub>         | Input Capacitance   | ---- | 2200 | ---- | pF    | V <sub>GE</sub> = 0V                                     |
| C <sub>oes</sub>         | Output Capacitance  | ---- | 140  | ---- |       | V <sub>CC</sub> = 30V See Fig. 7                         |
| C <sub>res</sub>         | Reverse Transfer Capacitance                              | ---- | 29   | ---- |       | f = 1.0MHz   |
| t <sub>rr</sub>          | Diode Reverse Recovery Time                               | ---- | 42   | 60   | ns    | T <sub>J</sub> = 25°C See Fig. 14                        |
|                          |   | ---- | 74   | 120  |       | T <sub>J</sub> = 125°C                                   |
| I <sub>rr</sub>          | Diode Peak Reverse Recovery Current                       | ---- | 4.0  | 6.0  | A     | T <sub>J</sub> = 25°C See Fig. 15                        |
|                          |   | ---- | 6.5  | 10   |       | T <sub>J</sub> = 125°C                                   |
| Q <sub>rr</sub>          | Diode Reverse Recovery Charge                             | ---- | 80   | 180  | nC    | T <sub>J</sub> = 25°C See Fig. 16                        |
|                          |   | ---- | 220  | 600  |       | T <sub>J</sub> = 125°C                                   |
| di <sub>(rec)</sub> M/dt | Diode Peak Rate of Fall of Recovery During t <sub>b</sub> | ---- | 188  | ---- | A/μs  | T <sub>J</sub> = 25°C See Fig. 17                        |
|                          |   | ---- | 160  | ---- |       | T <sub>J</sub> = 125°C                                   |



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

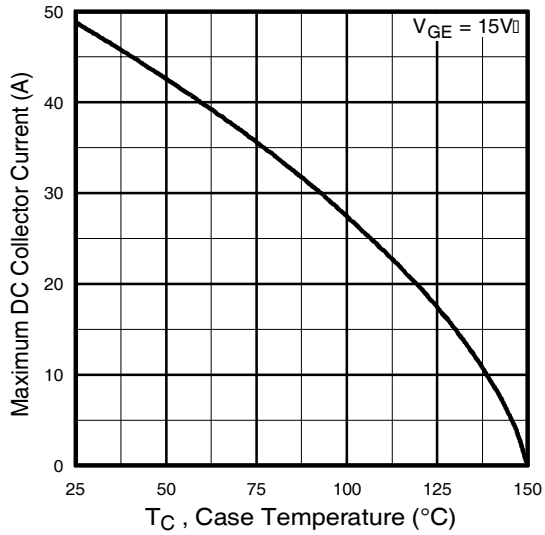


**Fig. 2 - Typical Output Characteristics**

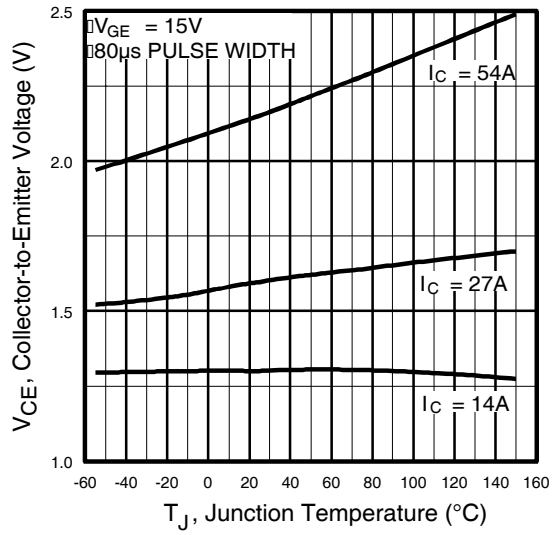


**Fig. 3 - Typical Transfer Characteristics**

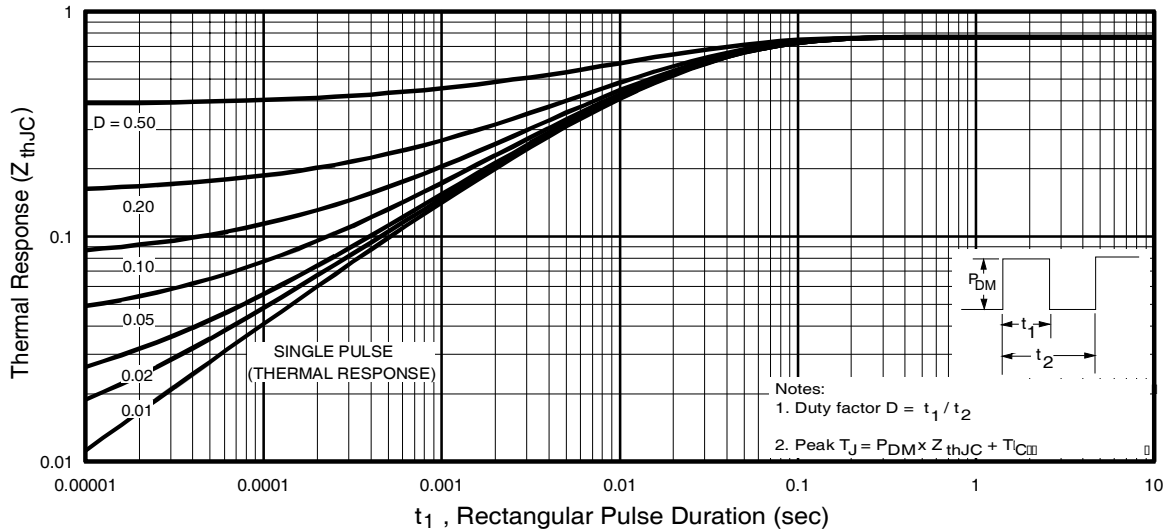
# IRG4PC40FDPbF



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

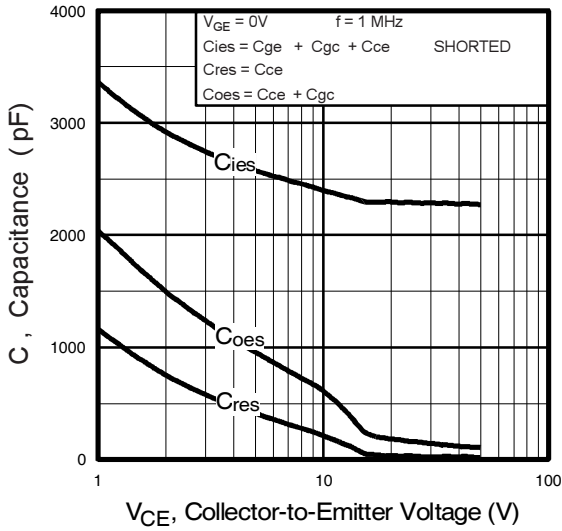


**Fig. 5 - Typical Collector-to-Emitter Voltage vs. Junction Temperature**

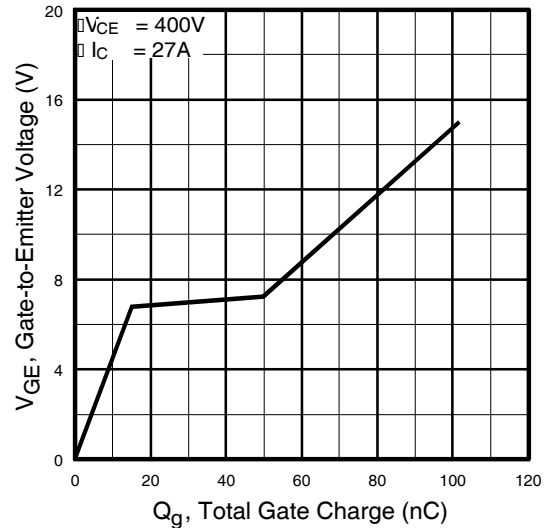


**Fig. 6 - Maximum Effective Transient Thermal Impedance, Junction-to-Case**

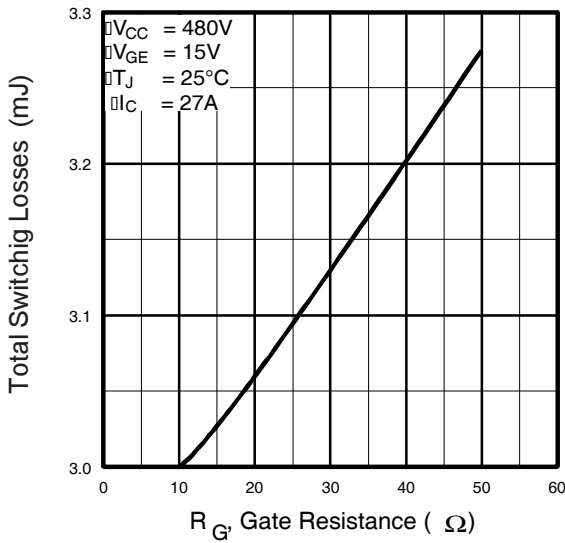
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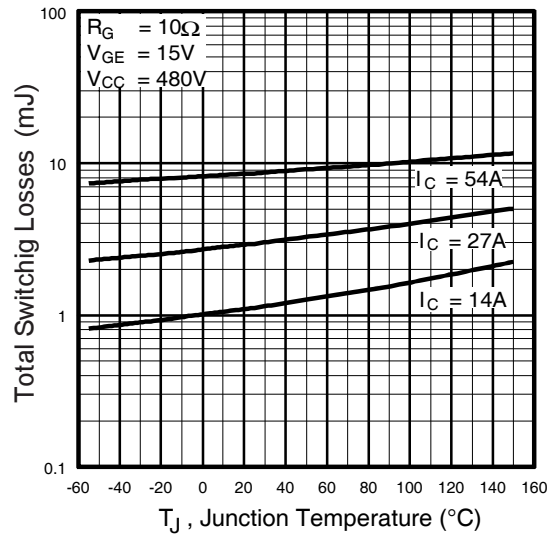
**Fig. 7** - Typical Capacitance vs. Collector-to-Emitter Voltage



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

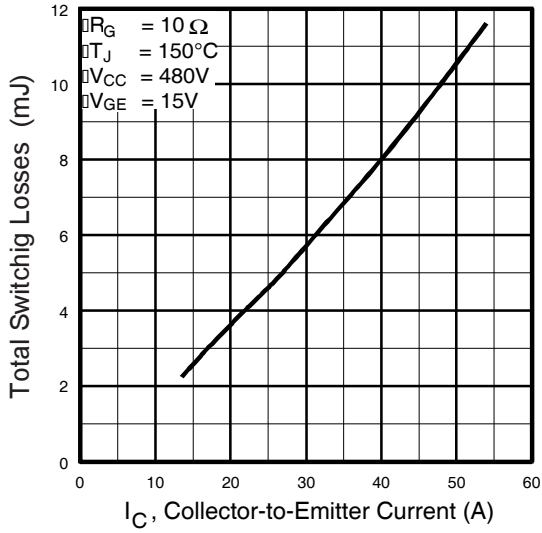


**Fig. 9** - Typical Switching Losses vs. Gate Resistance

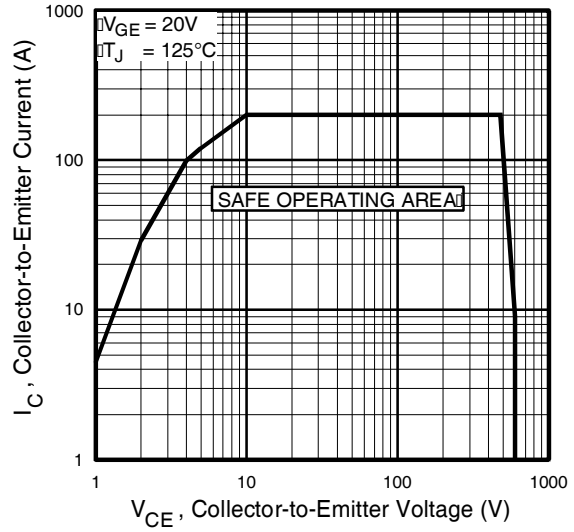


**Fig. 10** - Typical Switching Losses vs. Junction Temperature

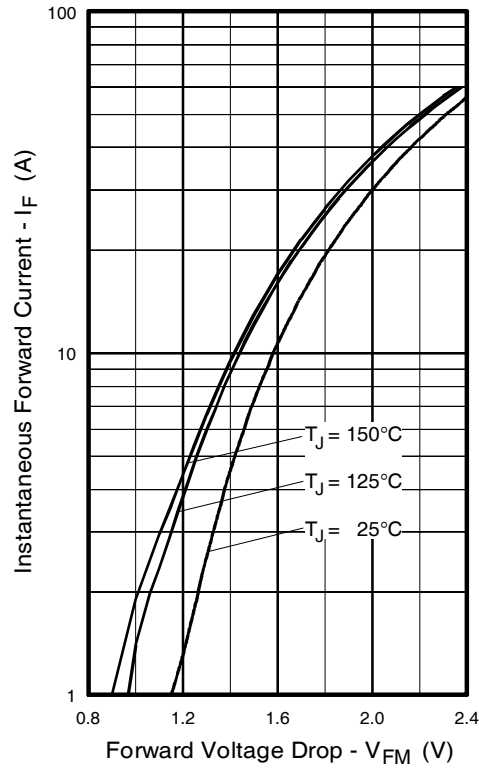
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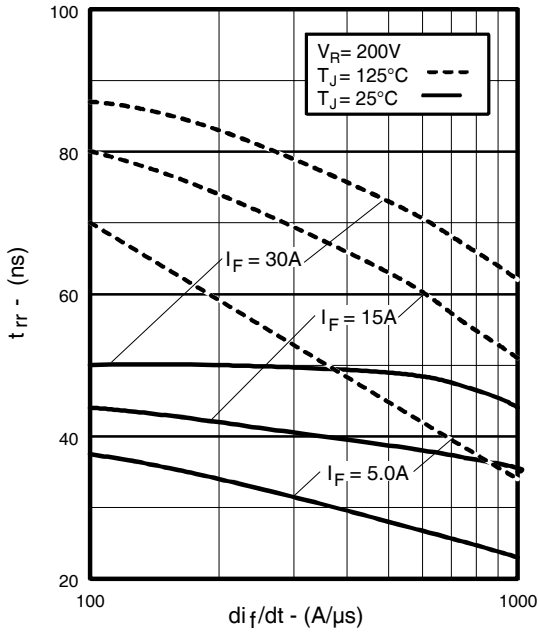
**Fig. 11** - Typical Switching Losses vs. Collector-to-Emitter Current



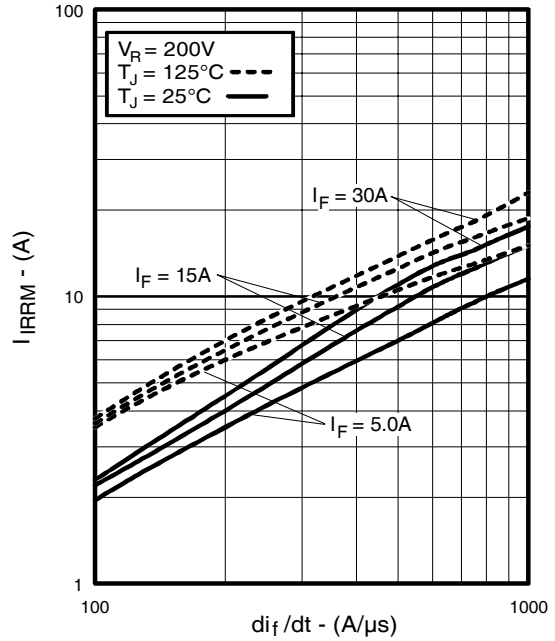
**Fig. 12** - Turn-Off SOA



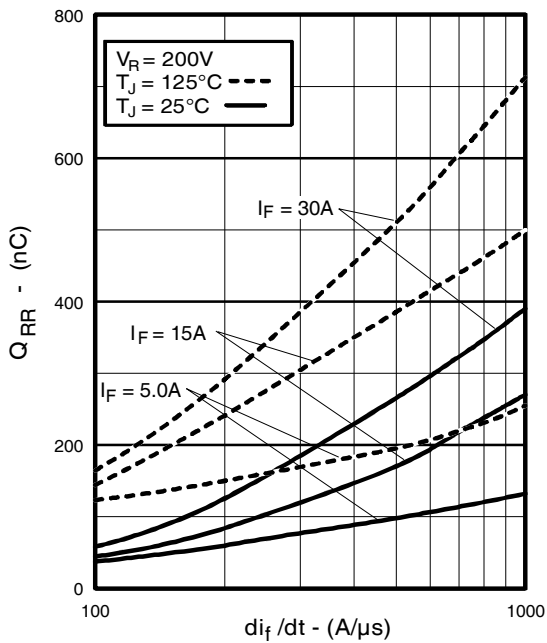
**Fig. 13** - Maximum Forward Voltage Drop vs. Instantaneous Forward Current



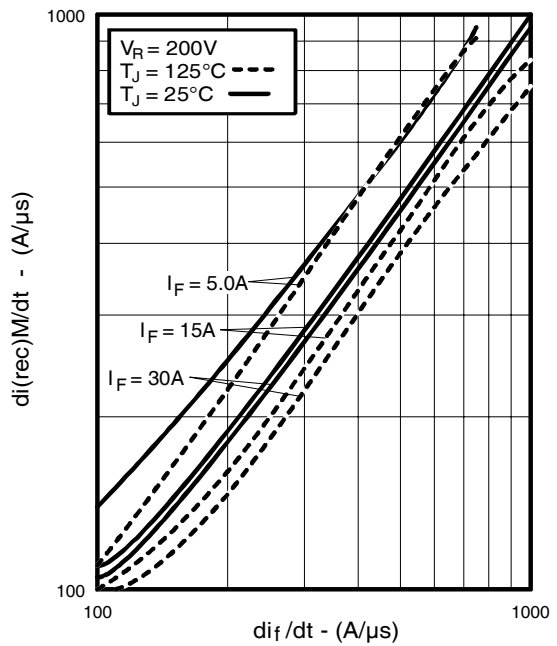
**Fig. 14** - Typical Reverse Recovery vs.  $di_f/dt$



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



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

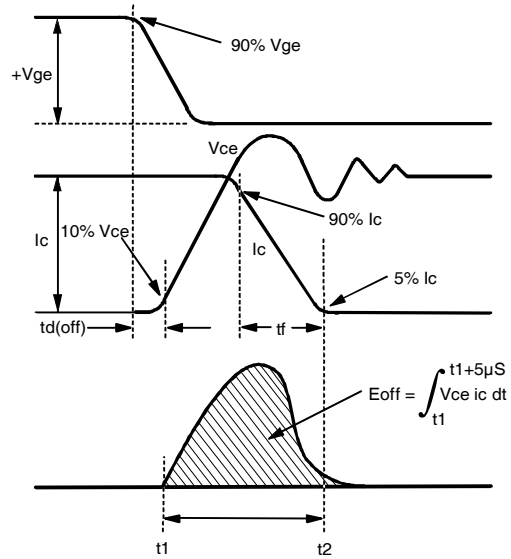


**Fig. 17** - Typical  $di_{(rec)M}/dt$  vs.  $di_f/dt$

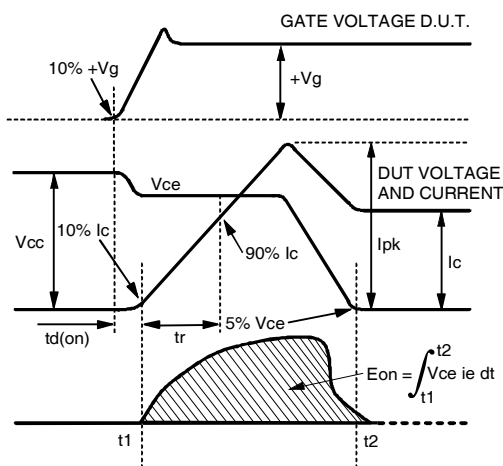
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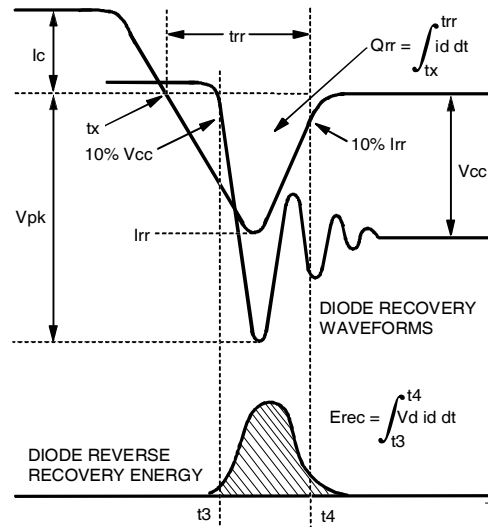
**Fig. 18a** - Test Circuit for Measurement of  $I_{LM}$ ,  $E_{on}$ ,  $E_{off}(\text{diode})$ ,  $t_{rr}$ ,  $Q_{rr}$ ,  $I_{rr}$ ,  $t_{d(on)}$ ,  $t_r$ ,  $t_{d(off)}$ ,  $t_f$



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



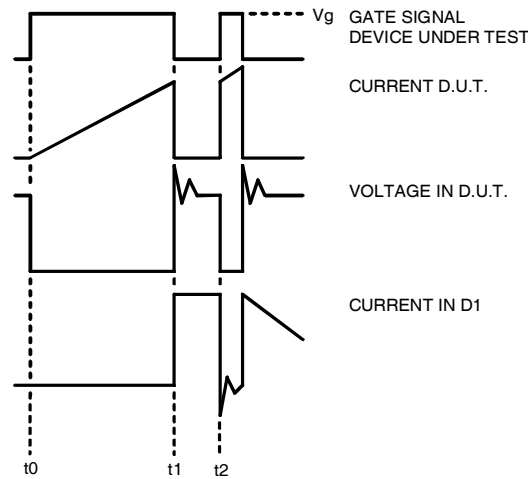


Figure 18e. Macro Waveforms for Figure 18a's Test Circuit

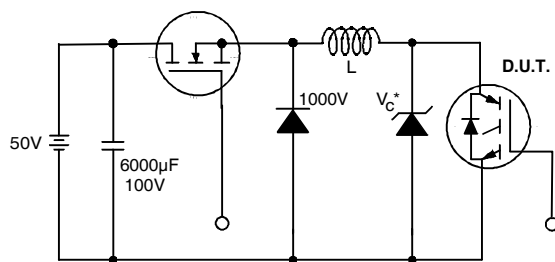


Figure 19. Clamped Inductive Load Test Circuit

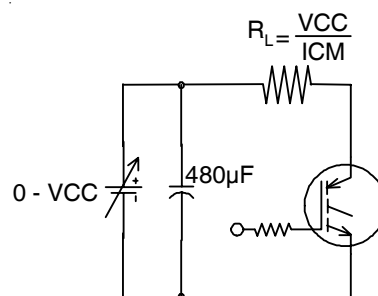


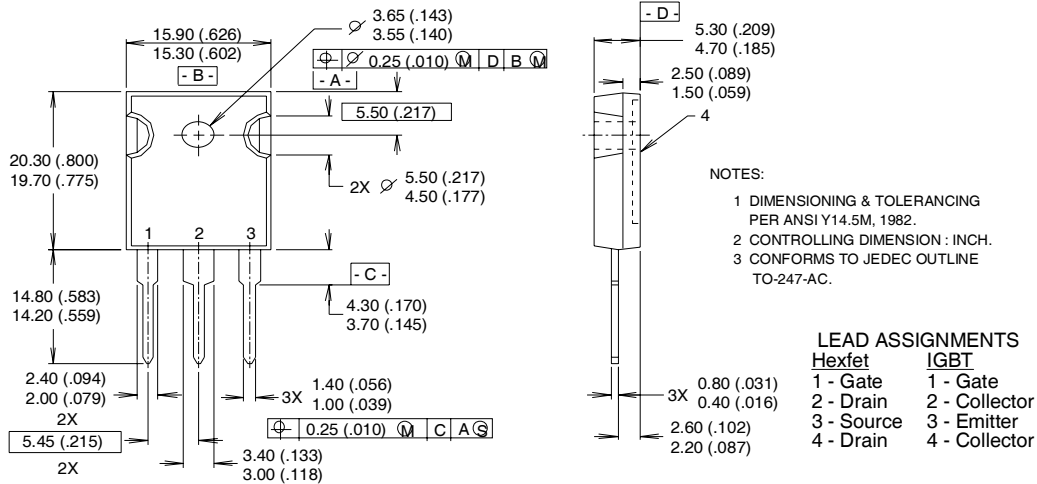
Figure 20. Pulsed Collector Current Test Circuit

# IRG4PC40FDPbF



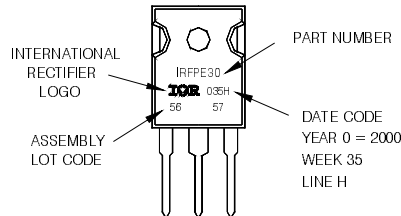
## TO-247AC Package Outline

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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