

# IRG4PH30KD

INSULATED GATE BIPOLAR TRANSISTOR WITH  
ULTRAFAST SOFT RECOVERY DIODE

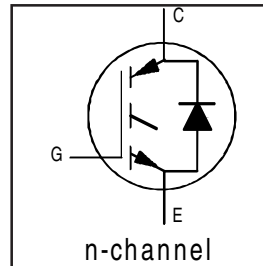
Short Circuit Rated  
UltraFast IGBT

## Features

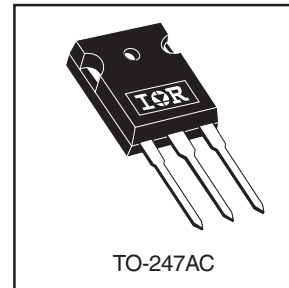
- High short circuit rating optimized for motor control,  $t_{sc} = 10\mu s$ ,  $V_{CC} = 720V$ ,  $T_J = 125^\circ C$ ,  $V_{GE} = 15V$
- Combines low conduction losses with high switching speed
- Tighter parameter distribution and higher efficiency than previous generations
- IGBT co-packaged with 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 IRGPH30MD2 products
- For hints see design tip 97003



|                                   |
|-----------------------------------|
| $V_{CES} = 1200V$                 |
| $V_{CE(on)} \text{ typ.} = 3.10V$ |
| @ $V_{GE} = 15V$ , $I_C = 10A$    |



## Absolute Maximum Ratings

|                           | Parameter                          | Max.                              | Units      |
|---------------------------|------------------------------------|-----------------------------------|------------|
| $V_{CES}$                 | Collector-to-Emitter Voltage       | 1200                              | V          |
| $I_C @ T_C = 25^\circ C$  | Continuous Collector Current       | 20                                | A          |
| $I_C @ T_C = 100^\circ C$ | Continuous Collector Current       | 10                                |            |
| $I_{CM}$                  | Pulsed Collector Current ①         | 40                                |            |
| $I_{LM}$                  | Clamped Inductive Load Current ②   | 40                                |            |
| $I_F @ T_C = 100^\circ C$ | Diode Continuous Forward Current   | 10                                |            |
| $I_{FM}$                  | Diode Maximum Forward Current      | 40                                |            |
| $t_{sc}$                  | Short Circuit Withstand Time       | 10                                | $\mu s$    |
| $V_{GE}$                  | Gate-to-Emitter Voltage            | $\pm 20$                          | V          |
| $P_D @ T_C = 25^\circ C$  | Maximum Power Dissipation          | 100                               | W          |
| $P_D @ T_C = 100^\circ C$ | Maximum Power Dissipation          | 42                                |            |
| $T_J$                     | Operating Junction and             | -55 to +150                       | $^\circ C$ |
| $T_{STG}$                 | Storage Temperature Range          |                                   |            |
|                           | 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                   | —    | —        | 1.2  | $^\circ C/W$ |
| $R_{\theta JC}$ | Junction-to-Case - Diode                  | —    | —        | 2.5  |              |
| $R_{\theta CS}$ | 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)       |

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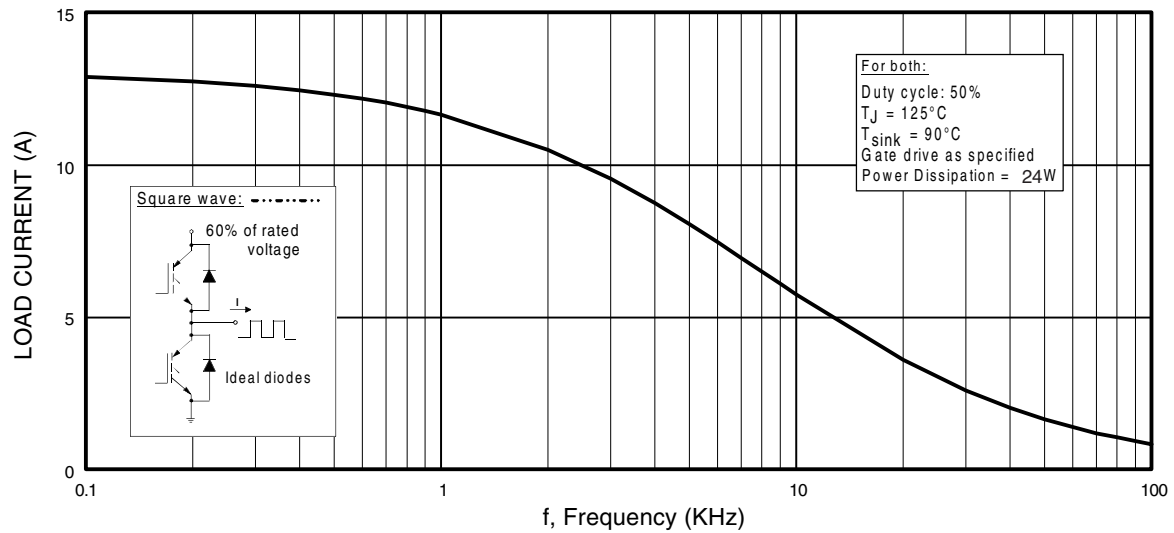
International  
**IR** Rectifier

## Electrical Characteristics @ $T_J = 25^\circ\text{C}$ (unless otherwise specified)

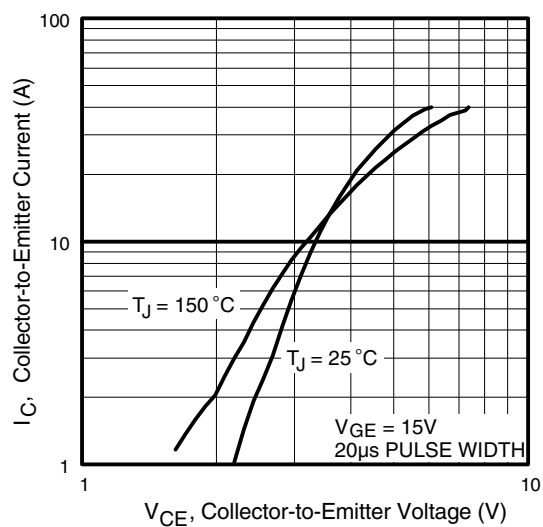
|                                 | Parameter                                           | Min. | Typ. | Max.      | Units                | Conditions                                             |
|---------------------------------|-----------------------------------------------------|------|------|-----------|----------------------|--------------------------------------------------------|
| $V_{(BR)CES}$                   | Collector-to-Emitter Breakdown Voltage <sup>③</sup> | 1200 | —    | —         | V                    | $V_{GE} = 0V, I_C = 250\mu A$                          |
| $\Delta V_{(BR)CES}/\Delta T_J$ | Temperature Coeff. of Breakdown Voltage             | —    | 0.19 | —         | V/ $^\circ\text{C}$  | $V_{GE} = 0V, I_C = 1.0mA$                             |
| $V_{CE(on)}$                    | Collector-to-Emitter Saturation Voltage             | —    | 3.10 | 4.2       | V                    | $I_C = 10A$ $V_{GE} = 15V$                             |
|                                 |                                                     | —    | 3.90 | —         |                      | $I_C = 20A$ See Fig. 2, 5                              |
|                                 |                                                     | —    | 3.01 | —         |                      | $I_C = 10A, T_J = 150^\circ\text{C}$                   |
| $V_{GE(th)}$                    | 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>               | 4.3  | 6.5  | —         | S                    | $V_{CE} = 100V, I_C = 10A$                             |
| $I_{CES}$                       | Zero Gate Voltage Collector Current                 | —    | —    | 250       | $\mu A$              | $V_{GE} = 0V, V_{CE} = 1200V$                          |
|                                 |                                                     | —    | —    | 3500      |                      | $V_{GE} = 0V, V_{CE} = 1200V, T_J = 150^\circ\text{C}$ |
| $V_{FM}$                        | Diode Forward Voltage Drop                          | —    | 3.4  | 3.8       | V                    | $I_C = 10A$ See Fig. 13                                |
|                                 |                                                     | —    | 3.3  | 3.7       |                      | $I_C = 10A, T_J = 150^\circ\text{C}$                   |
| $I_{GES}$                       | Gate-to-Emitter Leakage Current                     | —    | —    | $\pm 100$ | nA                   | $V_{GE} = \pm 20V$                                     |

## Switching Characteristics @ $T_J = 25^\circ\text{C}$ (unless otherwise specified)

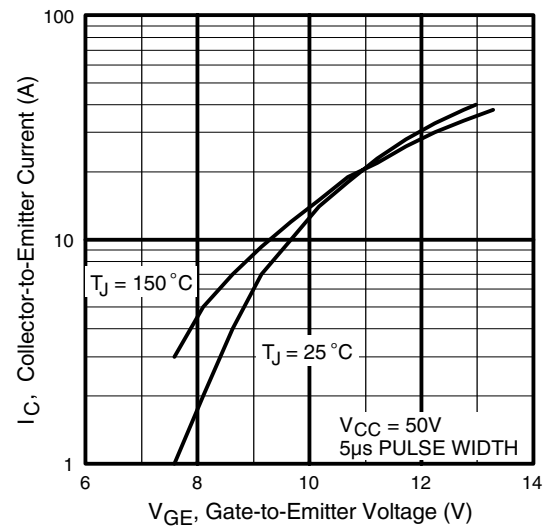
|                  | Parameter                                        | Min. | Typ. | Max. | Units      | Conditions                                                                                                                                                               |
|------------------|--------------------------------------------------|------|------|------|------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| $Q_g$            | Total Gate Charge (turn-on)                      | —    | 53   | 80   | nC         | $I_C = 10A$                                                                                                                                                              |
| $Q_{ge}$         | Gate - Emitter Charge (turn-on)                  | —    | 9.0  | 14   |            | $V_{CC} = 400V$ See Fig.8                                                                                                                                                |
| $Q_{gc}$         | Gate - Collector Charge (turn-on)                | —    | 21   | 32   |            | $V_{GE} = 15V$                                                                                                                                                           |
| $t_{d(on)}$      | Turn-On Delay Time                               | —    | 39   | —    | ns         | $T_J = 25^\circ\text{C}$<br>$I_C = 10A, V_{CC} = 800V$<br>$V_{GE} = 15V, R_G = 23\Omega$                                                                                 |
| $t_r$            | Rise Time                                        | —    | 84   | —    |            |                                                                                                                                                                          |
| $t_{d(off)}$     | Turn-Off Delay Time                              | —    | 220  | 340  |            |                                                                                                                                                                          |
| $t_f$            | Fall Time                                        | —    | 90   | 140  |            |                                                                                                                                                                          |
| $E_{on}$         | Turn-On Switching Loss                           | —    | 0.95 | —    | mJ         | Energy losses include "tail" and diode reverse recovery<br>See Fig. 9,10,18                                                                                              |
| $E_{off}$        | Turn-Off Switching Loss                          | —    | 1.15 | —    |            |                                                                                                                                                                          |
| $E_{ts}$         | Total Switching Loss                             | —    | 2.10 | 2.6  |            |                                                                                                                                                                          |
| $t_{sc}$         | Short Circuit Withstand Time                     | 10   | —    | —    | $\mu s$    | $V_{CC} = 720V, T_J = 125^\circ\text{C}$<br>$V_{GE} = 15V, R_G = 5.0\Omega$                                                                                              |
| $t_{d(on)}$      | Turn-On Delay Time                               | —    | 42   | —    | ns         | $T_J = 150^\circ\text{C}$ , See Fig. 10,11,18<br>$I_C = 10A, V_{CC} = 800V$<br>$V_{GE} = 15V, R_G = 23\Omega$<br>Energy losses include "tail" and diode reverse recovery |
| $t_r$            | Rise Time                                        | —    | 79   | —    |            |                                                                                                                                                                          |
| $t_{d(off)}$     | Turn-Off Delay Time                              | —    | 540  | —    |            |                                                                                                                                                                          |
| $t_f$            | Fall Time                                        | —    | 97   | —    |            |                                                                                                                                                                          |
| $E_{ts}$         | Total Switching Loss                             | —    | 3.5  | —    | mJ         |                                                                                                                                                                          |
| $L_E$            | Internal Emitter Inductance                      | —    | 13   | —    | nH         | Measured 5mm from package                                                                                                                                                |
| $C_{ies}$        | Input Capacitance                                | —    | 800  | —    | pF         | $V_{GE} = 0V$<br>$V_{CC} = 30V$ See Fig. 7<br>$f = 1.0MHz$                                                                                                               |
| $C_{oes}$        | Output Capacitance                               | —    | 60   | —    |            |                                                                                                                                                                          |
| $C_{res}$        | Reverse Transfer Capacitance                     | —    | 14   | —    |            |                                                                                                                                                                          |
| $t_{rr}$         | Diode Reverse Recovery Time                      | —    | 50   | 76   | ns         | $T_J = 25^\circ\text{C}$ See Fig. 14                                                                                                                                     |
|                  |                                                  | —    | 72   | 110  |            | $T_J = 125^\circ\text{C}$                                                                                                                                                |
| $I_{rr}$         | Diode Peak Reverse Recovery Current              | —    | 4.4  | 7.0  | A          | $T_J = 25^\circ\text{C}$ See Fig. 15                                                                                                                                     |
|                  |                                                  | —    | 5.9  | 8.8  |            | $T_J = 125^\circ\text{C}$                                                                                                                                                |
| $Q_{rr}$         | Diode Reverse Recovery Charge                    | —    | 130  | 200  | nC         | $T_J = 25^\circ\text{C}$ See Fig. 16                                                                                                                                     |
|                  |                                                  | —    | 250  | 380  |            | $T_J = 125^\circ\text{C}$                                                                                                                                                |
| $di_{(rec)M}/dt$ | Diode Peak Rate of Fall of Recovery During $t_b$ | —    | 210  | —    | A/ $\mu s$ | $T_J = 25^\circ\text{C}$ See Fig. 17                                                                                                                                     |
|                  |                                                  | —    | 180  | —    |            | $T_J = 125^\circ\text{C}$                                                                                                                                                |



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



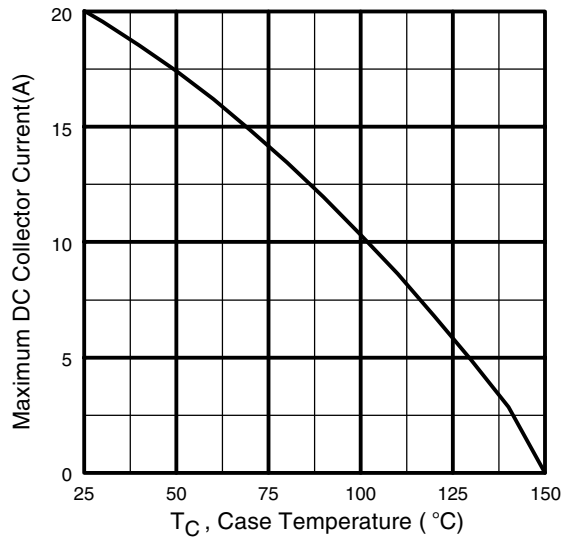
**Fig. 2** - Typical Output Characteristics



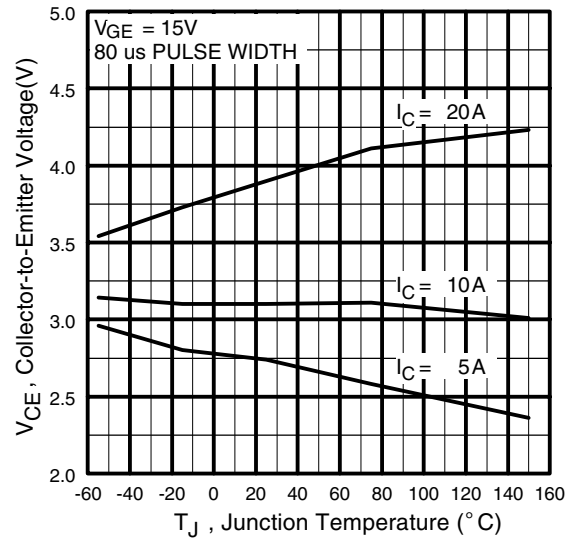
**Fig. 3** - Typical Transfer Characteristics

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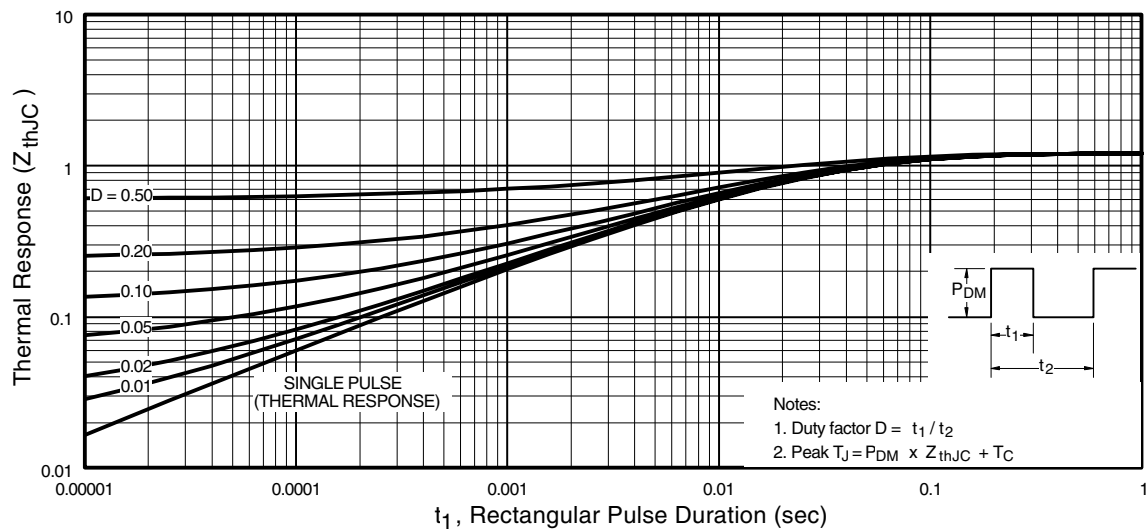
International  
**IR** Rectifier



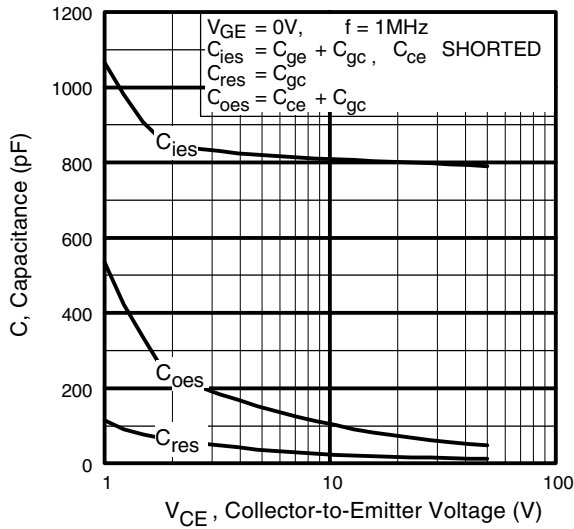
**Fig. 4** - Maximum Collector Current vs. Case Temperature



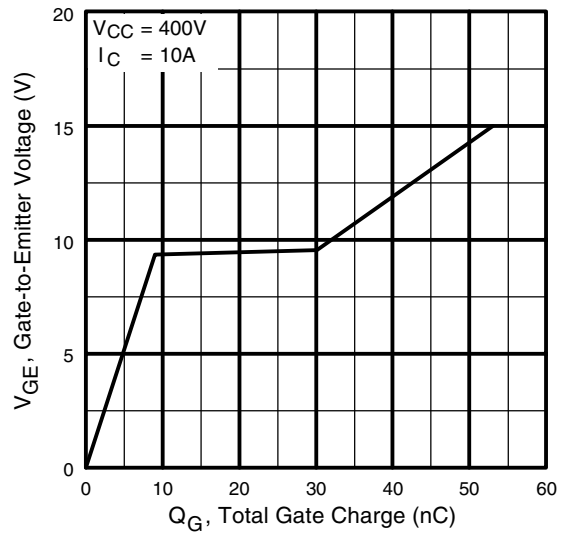
**Fig. 5** - Typical Collector-to-Emitter Voltage vs. Junction Temperature



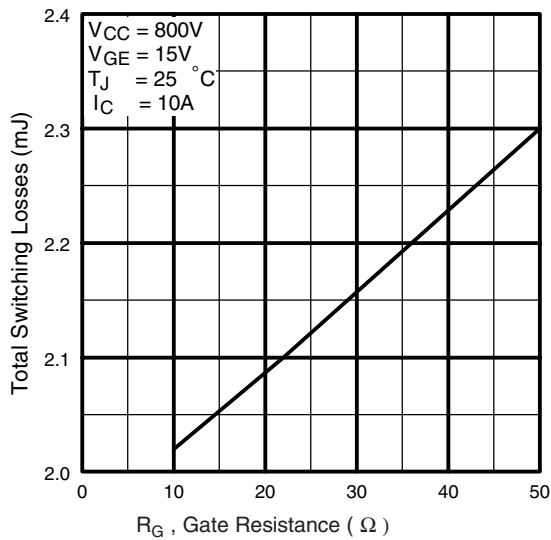
**Fig. 6** - Maximum Effective Transient Thermal Impedance, Junction-to-Case



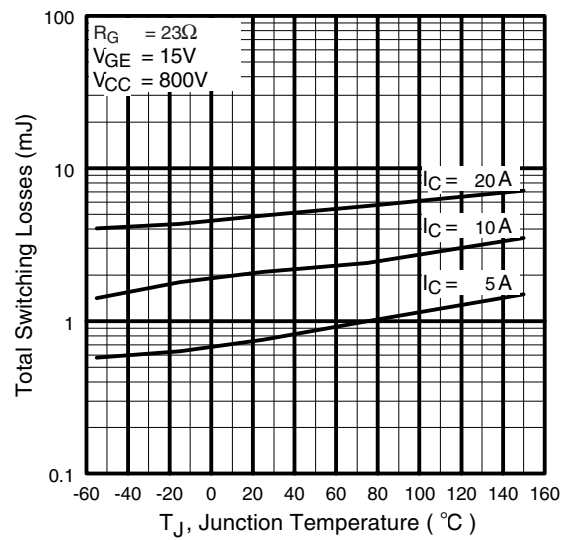
**Fig. 7** - Typical Capacitance vs. Collector-to-Emitter Voltage



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



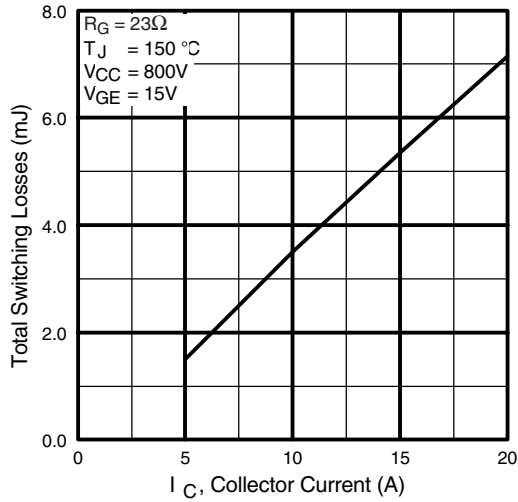
**Fig. 9** - Typical Switching Losses vs. Gate Resistance



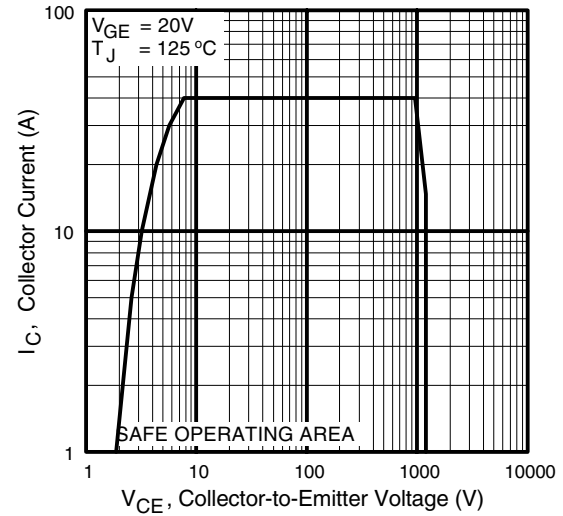
**Fig. 10** - Typical Switching Losses vs. Junction Temperature

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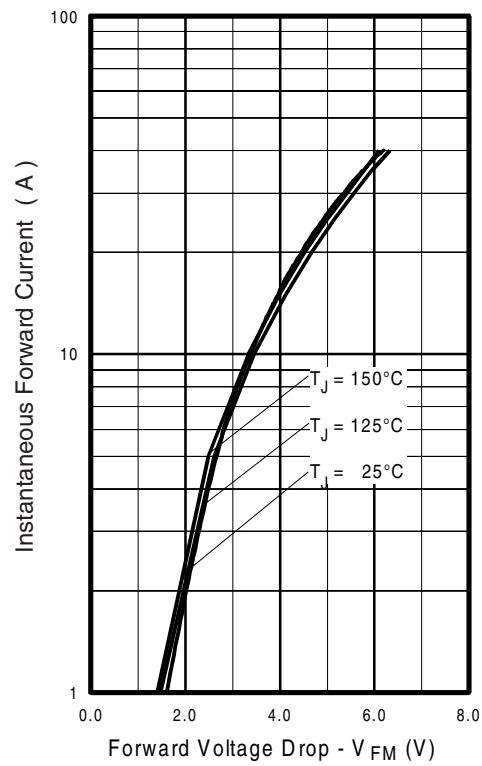
International  
**IR** Rectifier



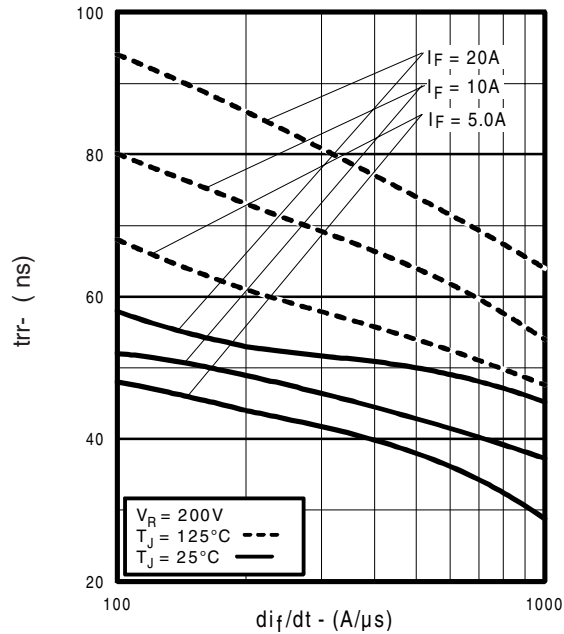
**Fig. 11** - Typical Switching Losses vs. Collector Current



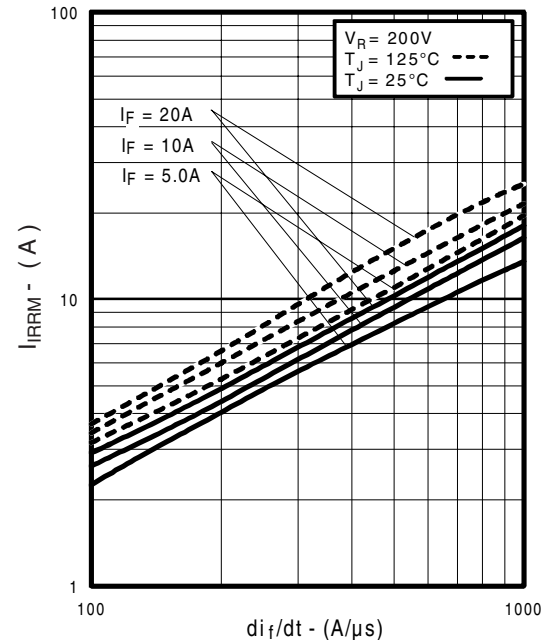
**Fig. 12** - Turn-Off SOA



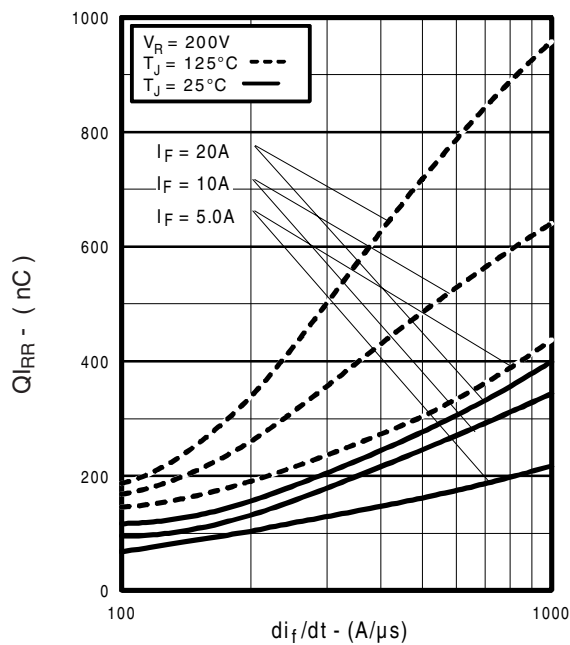
**Fig. 13** - Typical Forward Voltage Drop vs. Instantaneous Forward Current



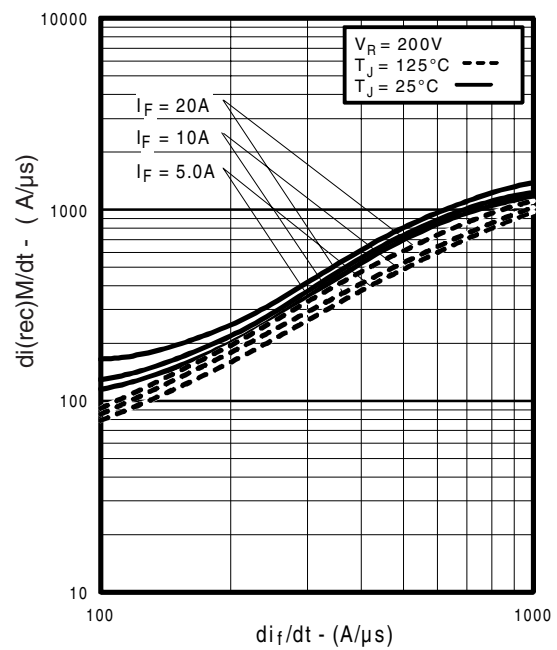
**Fig. 14** - Typical Reverse Recovery vs.  $di_f/dt$



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



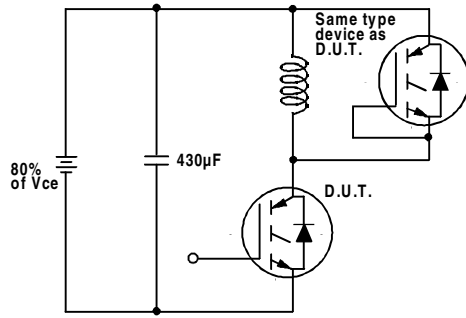
**Fig. 16** - Typical Stored Charge vs.  $di_f/dt$



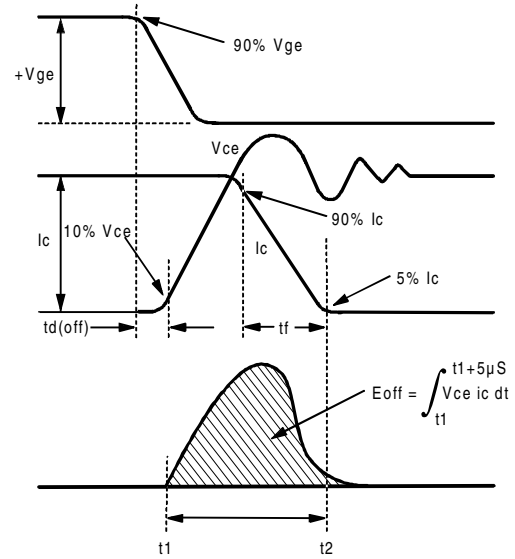
**Fig. 17** - Typical  $di_{(rec)}M/dt$  vs.  $di_f/dt$

# IRG4PH30KD

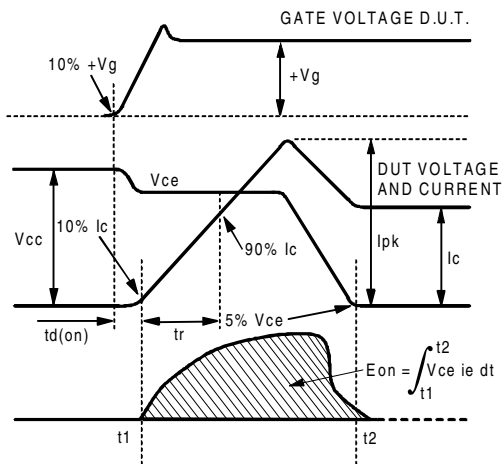
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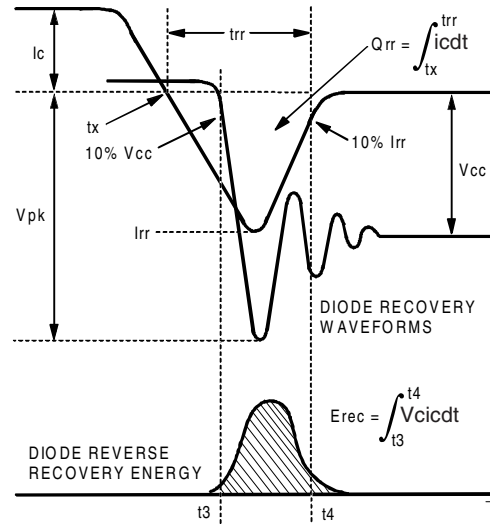
**Fig. 18a** - Test Circuit for Measurement of  $I_{LM}$ ,  $E_{on}$ ,  $E_{off}(\text{diode})$ ,  $t_{rr}$ ,  $Q_{rr}$ ,  $I_{rr}$ ,  $t_{d(on)}$ ,  $t_r$ ,  $t_{d(off)}$ ,  $t_f$



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



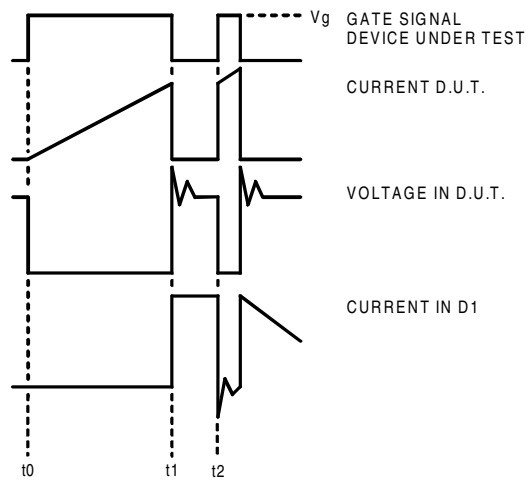


Figure 18e. Macro Waveforms for Figure 18a's Test Circuit

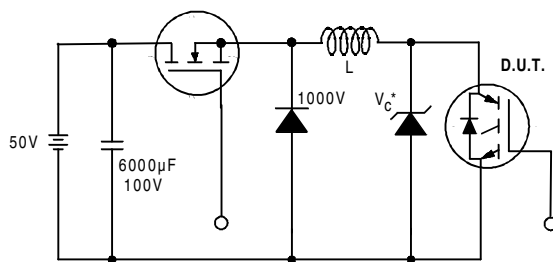


Figure 19. Clamped Inductive Load Test Circuit

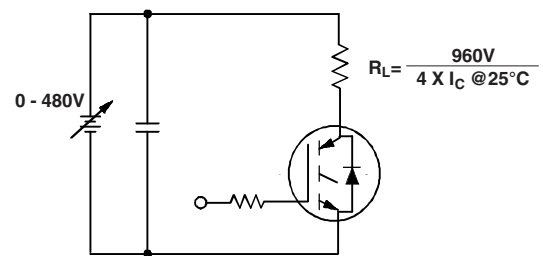


Figure 20. Pulsed Collector Current Test Circuit

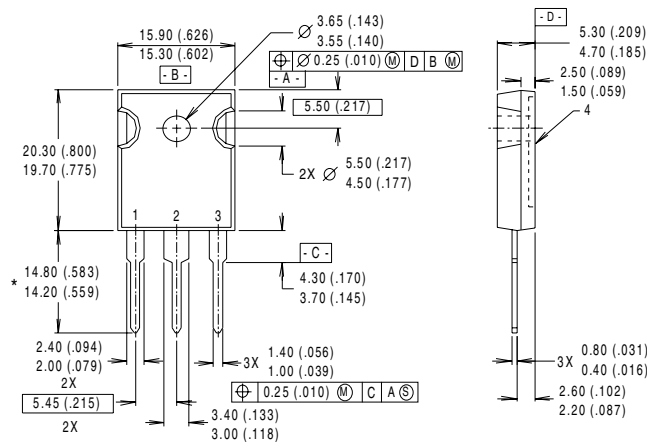
# IRG4PH30KD

International  
**IR** Rectifier

## Notes:

- ① Repetitive rating:  $V_{GE}=20V$ ; pulse width limited by maximum junction temperature (figure 20)
- ②  $V_{CC}=80\%(V_{CES})$ ,  $V_{GE}=20V$ ,  $L=10\mu H$ ,  $R_G=23\Omega$  (figure 19)
- ③ Pulse width  $\leq 80\mu s$ ; duty factor  $\leq 0.1\%$ .
- ④ Pulse width  $5.0\mu s$ , 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  
**IR** 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*