

# International **IR** Rectifier

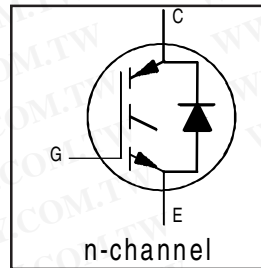
PD 91573A

## IRG4PH50UD

INSULATED GATE BIPOLAR TRANSISTOR WITH ULTRAFAST SOFT RECOVERY DIODE UltraFast CoPack IGBT

### Features

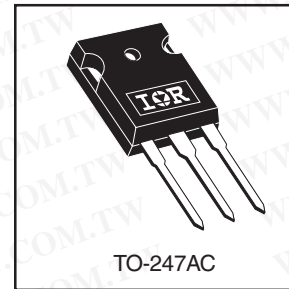
- UltraFast: Optimized for high operating frequencies up to 40 kHz in hard switching, >200 kHz in resonant mode
- New IGBT design provides tighter parameter distribution and higher efficiency than previous generations
- IGBT co-packaged with HEXFRED™ ultrafast, ultra-soft-recovery anti-parallel diodes for use in bridge configurations
- Industry standard TO-247AC package



$V_{CES} = 1200V$
$V_{CE(on)} \text{ typ.} = 2.78V$
@ $V_{GE} = 15V, I_C = 24A$

### Benefits

- Higher switching frequency capability than competitive IGBTs
- Highest efficiency available
- HEXFRED diodes optimized for performance with IGBT's. Minimized recovery characteristics require less/no snubbing



### Absolute Maximum Ratings

	Parameter	Max.	Units
$V_{CES}$	Collector-to-Emitter Breakdown Voltage	1200	V
$I_C @ T_C = 25^\circ C$	Continuous Collector Current	45	A
$I_C @ T_C = 100^\circ C$	Continuous Collector Current	24	
$I_{CM}$	Pulsed Collector Current ①	180	
$I_{LM}$	Clamped Inductive Load Current ②	180	
$I_F @ T_C = 100^\circ C$	Diode Continuous Forward Current	16	W
$I_{FM}$	Diode Maximum Forward Current	180	
$V_{GE}$	Gate-to-Emitter Voltage	$\pm 20$	V
$P_D @ T_C = 25^\circ C$	Maximum Power Dissipation	200	W
$P_D @ T_C = 100^\circ C$	Maximum Power Dissipation	78	
$T_J$	Operating Junction and Storage Temperature Range	-55 to + 150	$^\circ C$
$T_{STG}$			
	Mounting torque, 6-32 or M3 screw.	10 lbf•in (1.1N•m)	

### Thermal Resistance

	Parameter	Min.	Typ.	Max.	Units
$R_{\theta JC}$	Junction-to-Case - IGBT	—	—	0.64	$^\circ C/W$
$R_{\theta JC}$	Junction-to-Case - Diode	—	—	0.83	
$R_{\theta CS}$	Case-to-Sink, flat, greased surface	—	0.24	—	
$R_{\theta JA}$	Junction-to-Ambient, typical socket mount	—	—	40	
$W_t$	Weight	—	6 (0.21)	—	g (oz)

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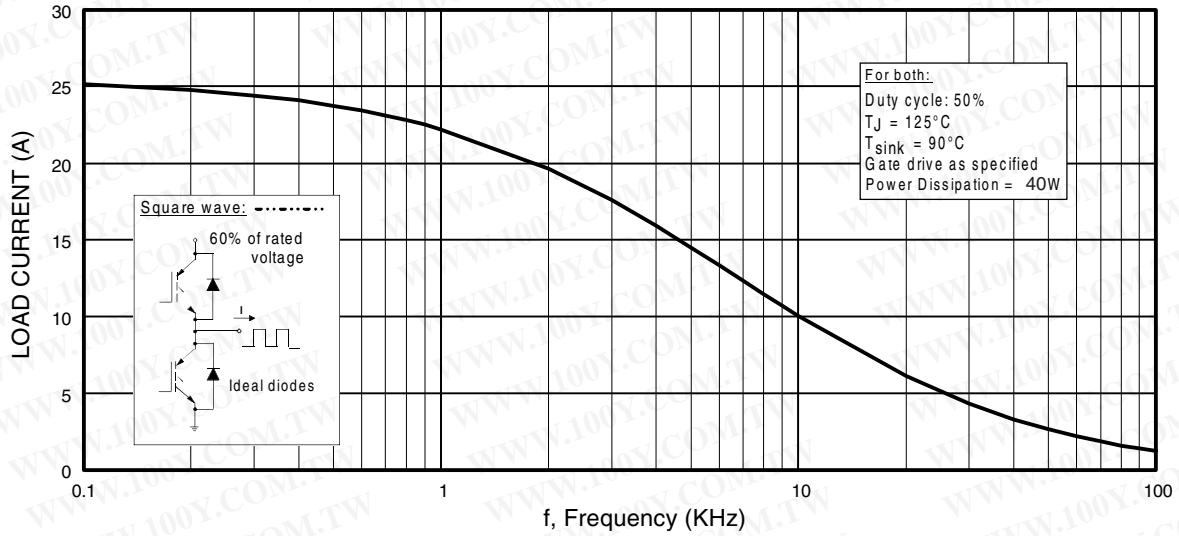
## Electrical Characteristics @ $T_J = 25^\circ\text{C}$ (unless otherwise specified)

	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	—	1.20	—	V/°C	$V_{GE} = 0V, I_C = 1.0mA$
$V_{CE(on)}$	Collector-to-Emitter Saturation Voltage	—	2.56	3.5	V	$I_C = 20A$ $V_{GE} = 15V$
		—	2.78	3.7		$I_C = 24A$
		—	3.20	—		$I_C = 45A$ See Fig. 2, 5
		—	2.54	—		$I_C = 24A, T_J = 150^\circ\text{C}$
$V_{GE(th)}$	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	—	-13	—	mV/°C	$V_{CE} = V_{GE}, I_C = 250\mu A$
$g_{fe}$	Forward Transconductance <sup>④</sup>	23	35	—	S	$V_{CE} = 100V, I_C = 24A$
$I_{CES}$	Zero Gate Voltage Collector Current	—	—	250	$\mu A$	$V_{GE} = 0V, V_{CE} = 1200V$
		—	—	6500		$V_{GE} = 0V, V_{CE} = 1200V, T_J = 150^\circ\text{C}$
$V_{FM}$	Diode Forward Voltage Drop	—	2.5	3.5	V	$I_C = 16A$ See Fig. 13
		—	2.1	3.0		$I_C = 16A, T_J = 150^\circ\text{C}$
$I_{GES}$	Gate-to-Emitter Leakage Current	—	—	$\pm 100$	nA	$V_{GE} = \pm 20V$

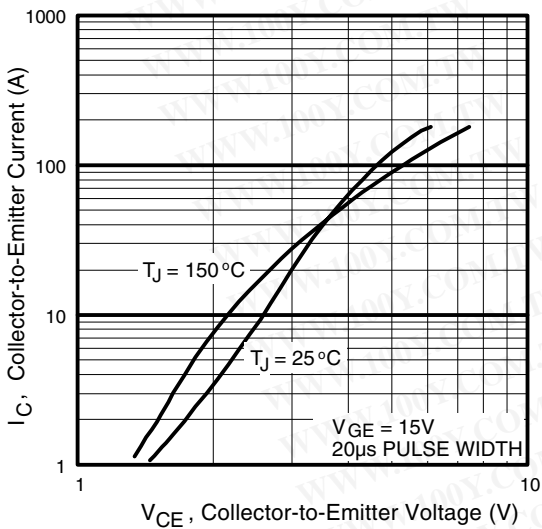
## Switching Characteristics @ $T_J = 25^\circ\text{C}$ (unless otherwise specified)

	Parameter	Min.	Typ.	Max.	Units	Conditions	
$Q_g$	Total Gate Charge (turn-on)	—	160	250	nC	$I_C = 24A$	
$Q_{ge}$	Gate - Emitter Charge (turn-on)	—	27	40		$V_{CC} = 400V$ See Fig. 8	
$Q_{gc}$	Gate - Collector Charge (turn-on)	—	53	80		$V_{GE} = 15V$	
$t_{d(on)}$	Turn-On Delay Time	—	47	—	ns	$T_J = 25^\circ\text{C}$	
$t_r$	Rise Time	—	24	—		$I_C = 24A, V_{CC} = 800V$	
$t_{d(off)}$	Turn-Off Delay Time	—	110	170		$V_{GE} = 15V, R_G = 5.0\Omega$	
$t_f$	Fall Time	—	180	260		Energy losses include "tail" and diode reverse recovery.	
$E_{on}$	Turn-On Switching Loss	—	2.10	—		mJ	See Fig. 9, 10, 18
$E_{off}$	Turn-Off Switching Loss	—	1.50	—			
$E_{ts}$	Total Switching Loss	—	3.60	4.6		mJ	$T_J = 150^\circ\text{C}$ , See Fig. 11, 18
$t_{d(on)}$	Turn-On Delay Time	—	46	—			$I_C = 24A, V_{CC} = 800V$
$t_r$	Rise Time	—	27	—			$V_{GE} = 15V, R_G = 5.0\Omega$
$t_{d(off)}$	Turn-Off Delay Time	—	240	—			Energy losses include "tail" and diode reverse recovery.
$E_{ts}$	Total Switching Loss	—	6.38	—	mJ	Measured 5mm from package	
$L_E$	Internal Emitter Inductance	—	13	—		nH	
$C_{ies}$	Input Capacitance	—	3600	—	pF	$V_{GE} = 0V$	
$C_{oes}$	Output Capacitance	—	160	—		$V_{CC} = 30V$ See Fig. 7	
$C_{res}$	Reverse Transfer Capacitance	—	31	—		$f = 1.0MHz$	
$t_{rr}$	Diode Reverse Recovery Time	—	90	135		ns	$T_J = 25^\circ\text{C}$ See Fig. 14
		—	164	245	$T_J = 125^\circ\text{C}$		
$I_{rr}$	Diode Peak Reverse Recovery Current	—	5.8	10	A	$T_J = 25^\circ\text{C}$ See Fig. 15	
		—	8.3	15		$T_J = 125^\circ\text{C}$	
$Q_{rr}$	Diode Reverse Recovery Charge	—	260	675	nC	$T_J = 25^\circ\text{C}$ See Fig. 16	
		—	680	1838		$T_J = 125^\circ\text{C}$	
$di_{(rec)M}/dt$	Diode Peak Rate of Fall of Recovery During $t_b$	—	120	—	A/ $\mu s$	$T_J = 25^\circ\text{C}$ See Fig. 17	
		—	76	—		$T_J = 125^\circ\text{C}$	

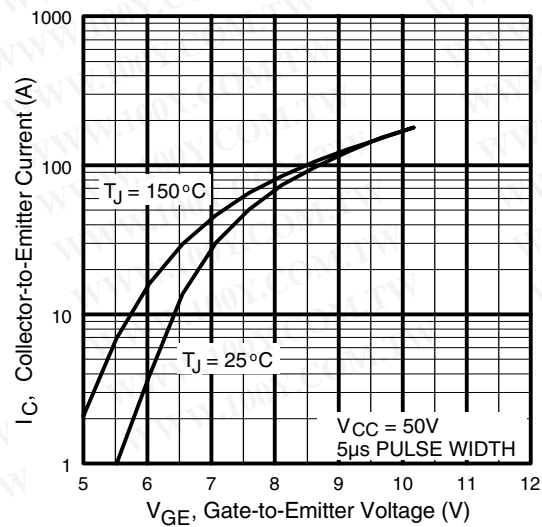
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**Fig. 1** - Typical Load Current vs. Frequency  
 (Load Current =  $I_{RMS}$  of fundamental)



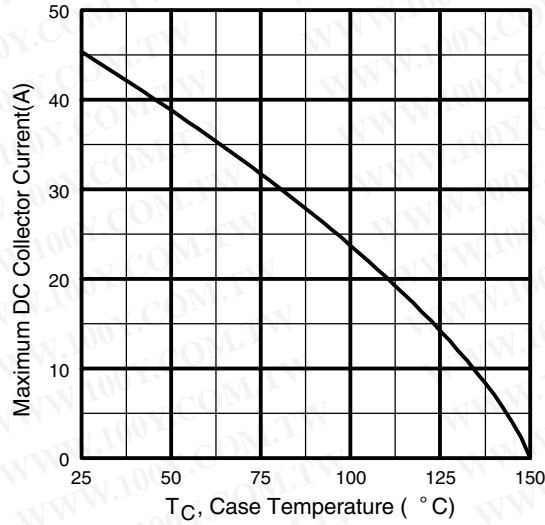
**Fig. 2** - Typical Output Characteristics  
[www.irf.com](http://www.irf.com)



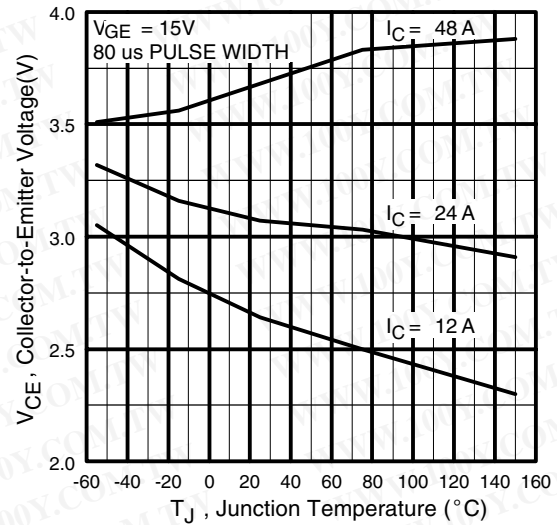
**Fig. 3** - Typical Transfer Characteristics

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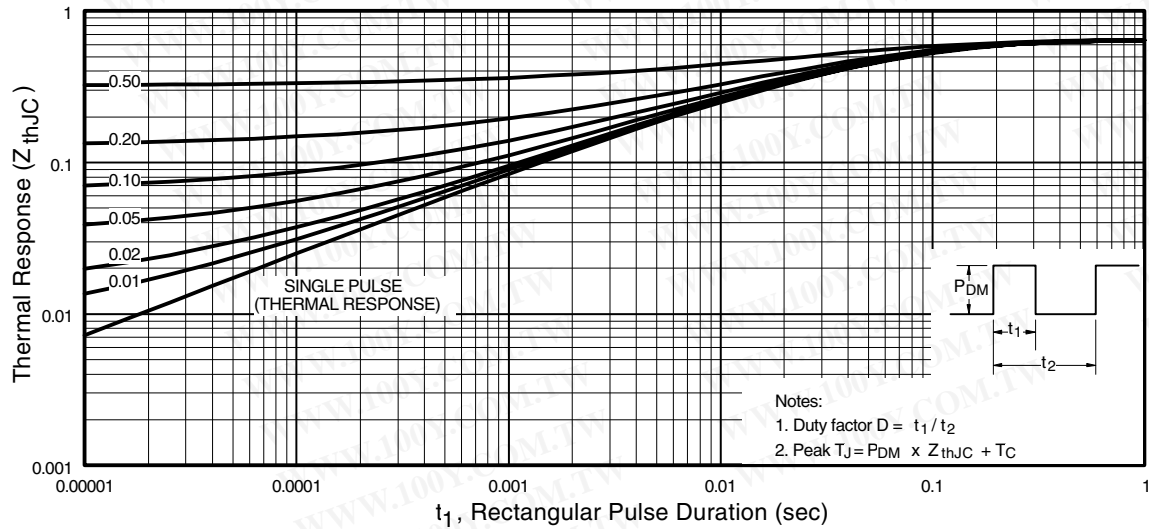
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**Fig. 4 - Maximum Collector Current vs. Case Temperature**



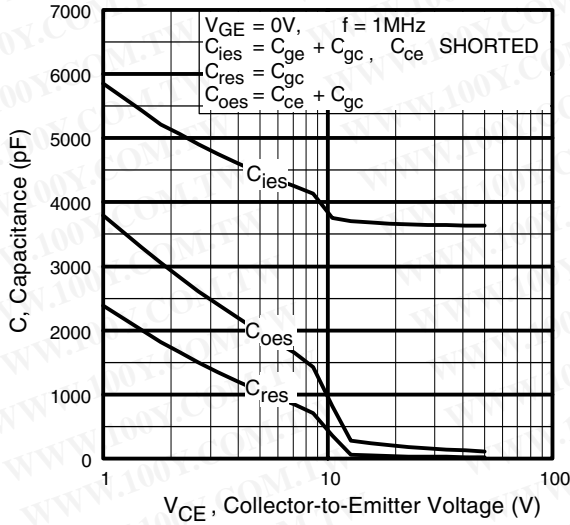
**Fig. 5 - Typical Collector-to-Emitter Voltage vs. Junction Temperature**



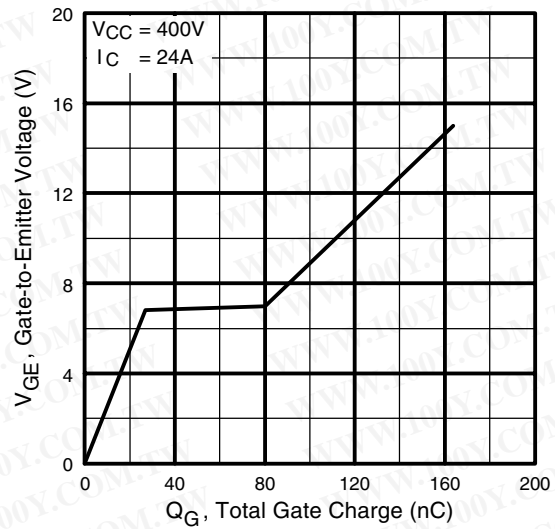
**Fig. 6 - Maximum Effective Transient Thermal Impedance, Junction-to-Case**

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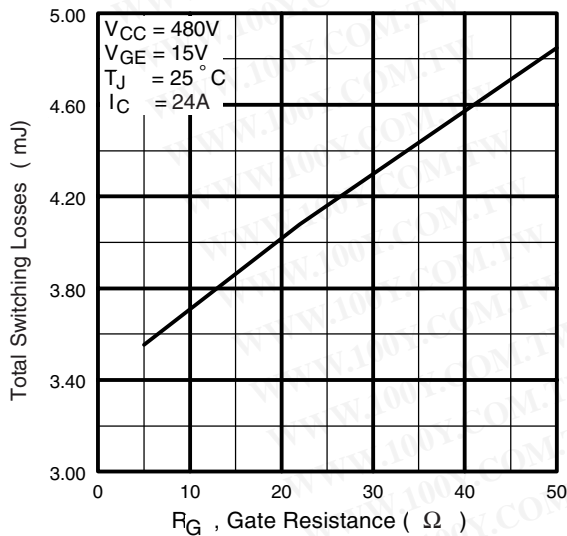
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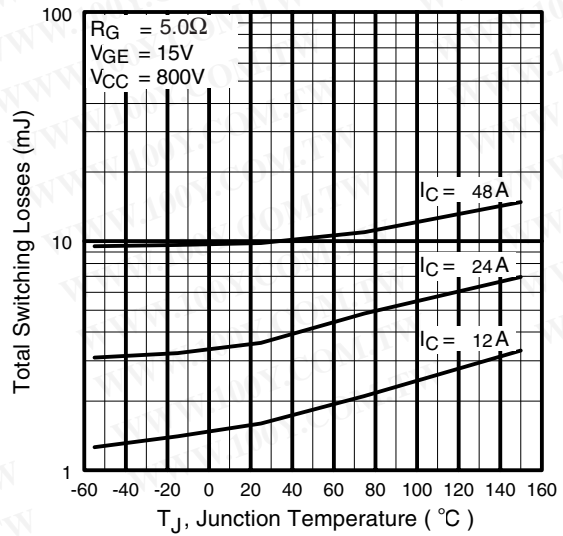
**Fig. 7** - Typical Capacitance vs. Collector-to-Emitter Voltage



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



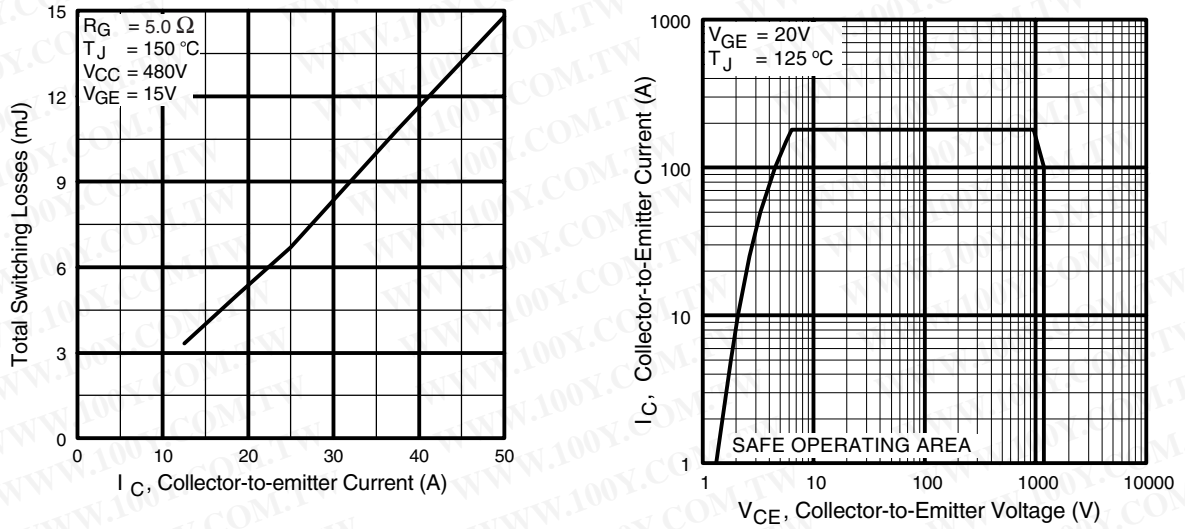
**Fig. 9** - Typical Switching Losses vs. Gate Resistance



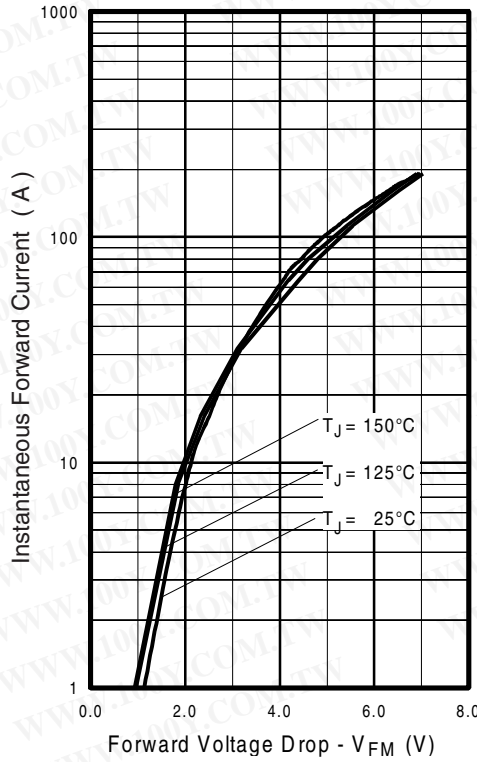
**Fig. 10** - Typical Switching Losses vs. Junction Temperature

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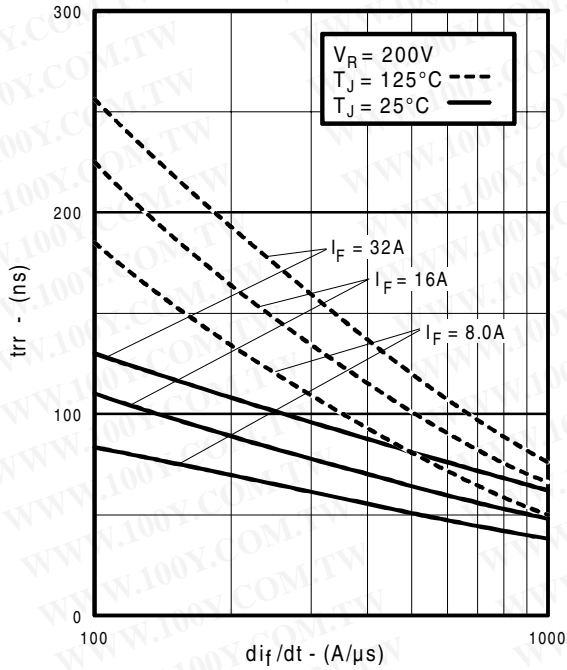
**Fig. 11 - Typical Switching Losses vs. Collector-to-Emitter Current**



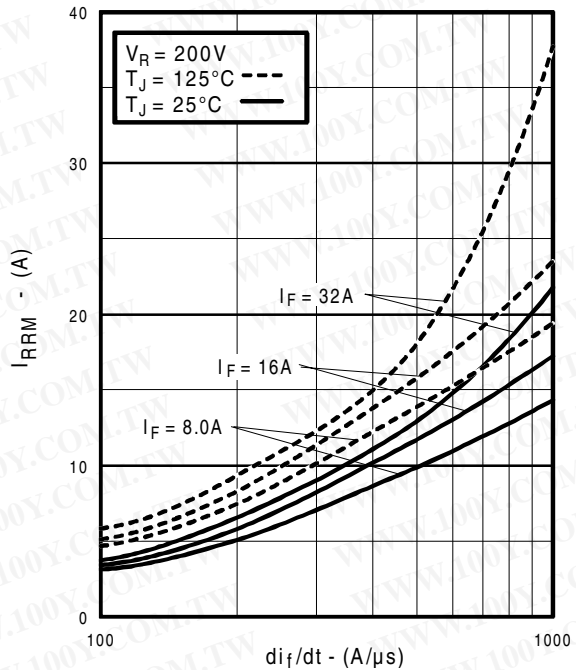
**Fig. 13 - Typical Forward Voltage Drop vs. Instantaneous Forward Current**

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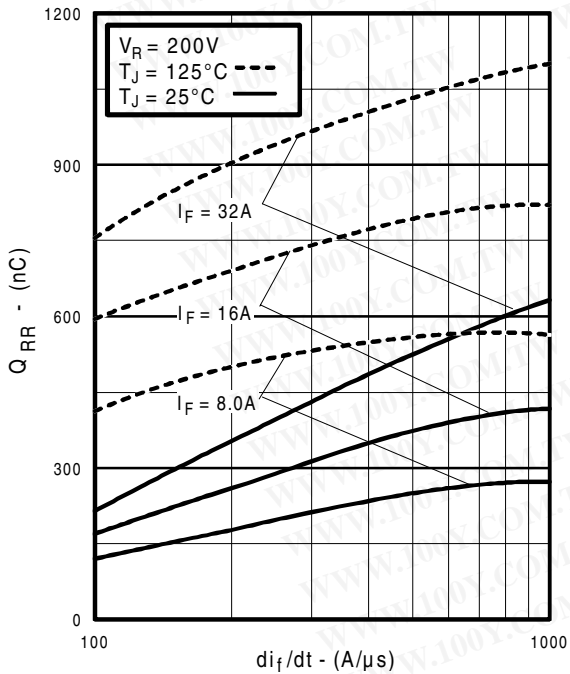
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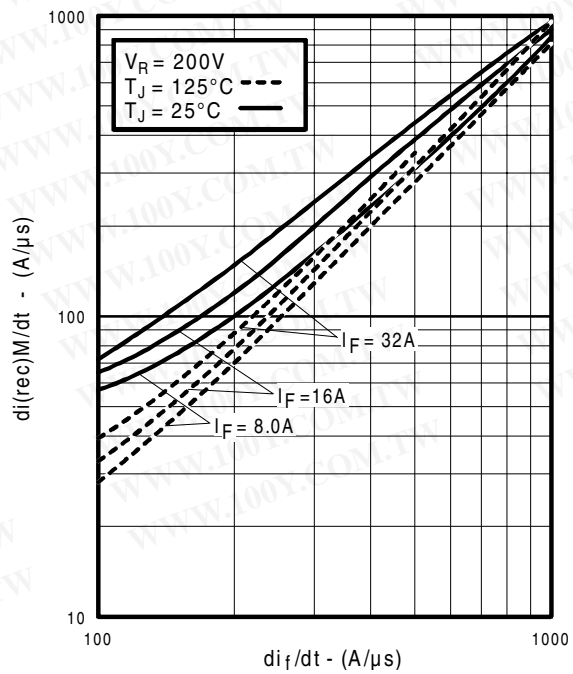
**Fig. 14** - Typical Reverse Recovery vs.  $di_f/dt$



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



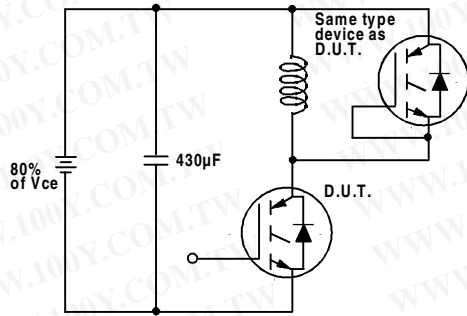
**Fig. 16** - Typical Stored Charge vs.  $di_f/dt$   
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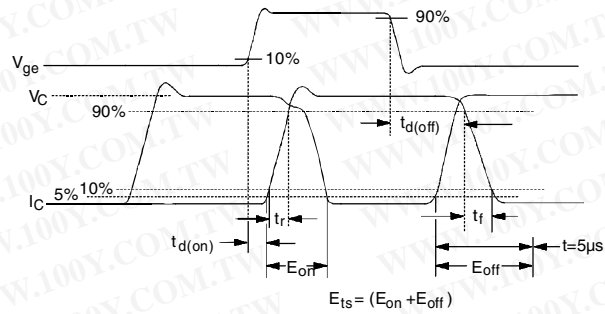
**Fig. 17** - Typical  $di_{(rec)M}/dt$  vs.  $di_f/dt$

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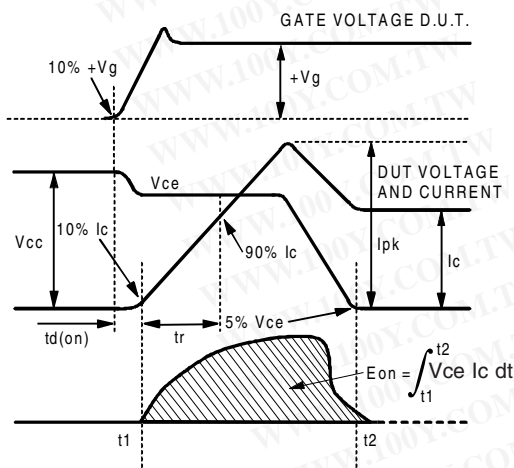
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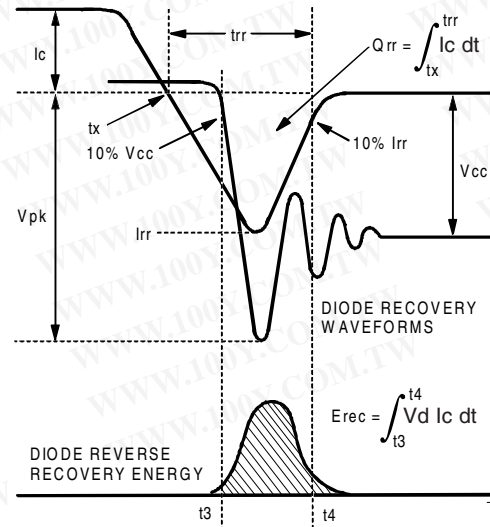
**Fig. 18a** - Test Circuit for Measurement of  $I_{LM}$ ,  $E_{on}$ ,  $E_{off}(\text{diode})$ ,  $t_{rr}$ ,  $Q_{rr}$ ,  $I_{rr}$ ,  $t_{d(on)}$ ,  $t_r$ ,  $t_{d(off)}$ ,  $t_f$



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



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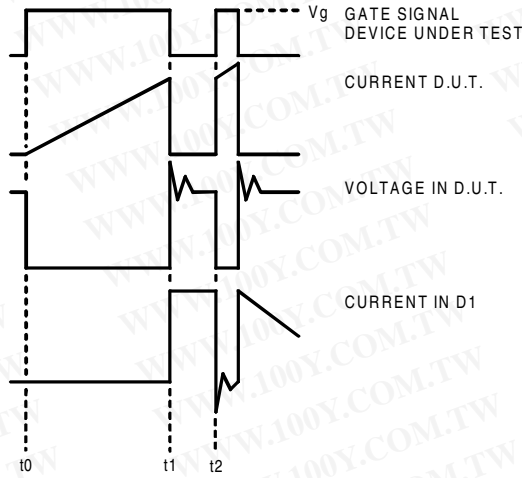


Figure 18e. Macro Waveforms for Figure 18a's Test Circuit

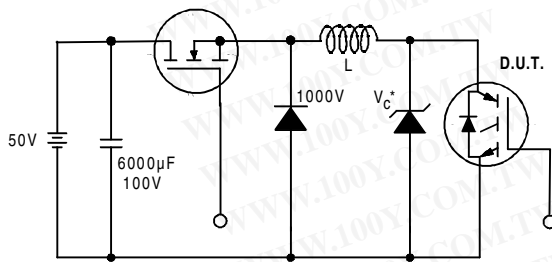


Figure 19. Clamped Inductive Load Test Circuit

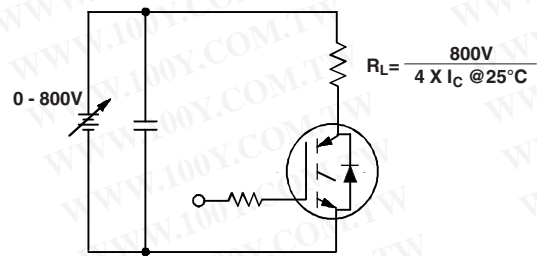


Figure 20. Pulsed Collector Current Test Circuit

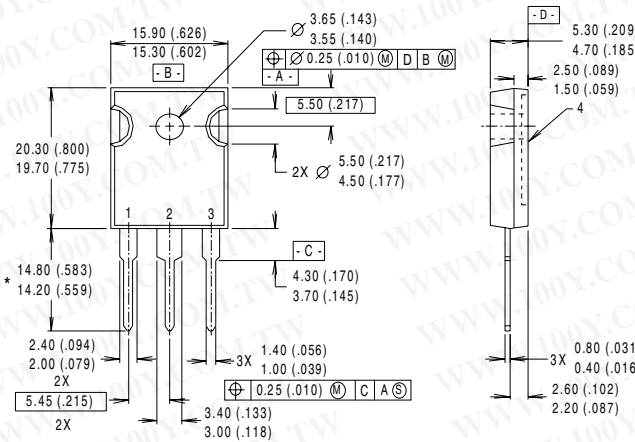
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## Notes:

- ① Repetitive rating:  $V_{GE}=20V$ ; pulse width limited by maximum junction temperature (figure 20)
- ②  $V_{CC}=80\%(V_{CES})$ ,  $V_{GE}=20V$ ,  $L=10\mu H$ ,  $R_G=5.0\Omega$  (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)

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**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. 7/00