

# IRG4PF50WD

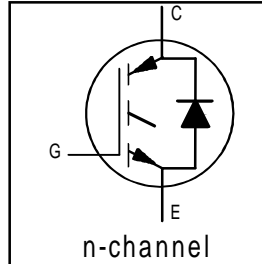
## INSULATED GATE BIPOLAR TRANSISTOR WITH ULTRAFAST SOFT RECOVERY DIODE

### Features

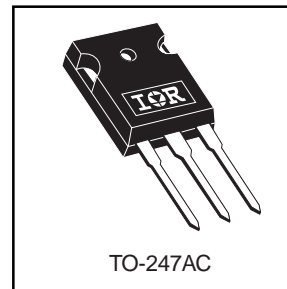
- Optimized for use in Welding and Switch-Mode Power Supply applications
- Industry benchmark switching losses improve efficiency of all power supply topologies
- 50% reduction of Eoff parameter
- Low IGBT conduction losses
- Latest technology IGBT design offers tighter parameter distribution coupled with exceptional reliability
- IGBT co-packaged with HEXFRED™ ultrafast, ultra-soft-recovery anti-parallel diodes for use in bridge configurations
- Industry standard TO-247AC package

### Benefits

- Lower switching losses allow more cost-effective operation and hence efficient replacement of larger-die MOSFETs up to 100kHz
- HEXFRED™ diodes optimized for performance with IGBTs. Minimized recovery characteristics reduce noise, EMI and switching losses



$V_{CES} = 900V$   
 $V_{CE(on) \text{ typ.}} = 2.25V$   
 @  $V_{GE} = 15V, I_C = 28A$



### Absolute Maximum Ratings

	Parameter	Max.	Units
$V_{CES}$	Collector-to-Emitter Breakdown Voltage	900	V
$I_C @ T_C = 25^\circ C$	Continuous Collector Current	51	A
$I_C @ T_C = 100^\circ C$	Continuous Collector Current	28	
$I_{CM}$	Pulsed Collector Current ①	204	
$I_{LM}$	Clamped Inductive Load Current ②	204	
$I_F @ T_C = 100^\circ C$	Diode Continuous Forward Current	16	
$I_{FM}$	Diode Maximum Forward Current	204	
$V_{GE}$	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	
$T_J$ $T_{STG}$	Operating Junction and Storage Temperature Range	-55 to + 150	°C
	Soldering Temperature, for 10 seconds	300 (0.063 in. (1.6mm) from case )	
	Mounting torque, 6-32 or M3 screw.	10 lbf•in (1.1N•m)	

### Thermal Resistance

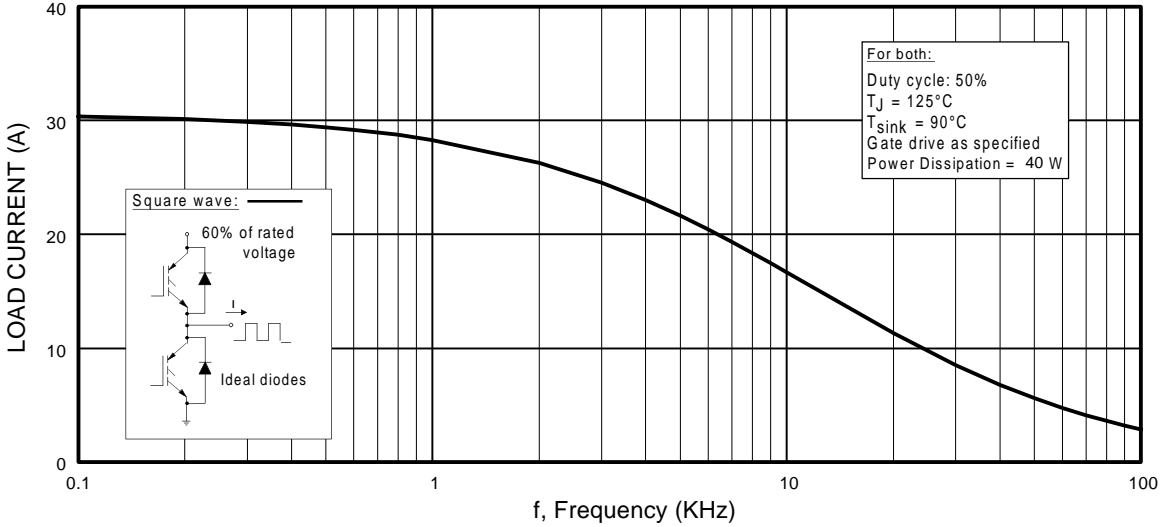
	Parameter	Min.	Typ.	Max.	Units
$R_{\theta JC}$	Junction-to-Case - IGBT	—	—	0.64	°C/W
$R_{\theta JC}$	Junction-to-Case - Diode	—	—	0.83	
$R_{\theta CS}$	Case-to-Sink, flat, greased surface	—	0.24	—	
$R_{\theta JA}$	Junction-to-Ambient, typical socket mount	—	—	40	
$W_t$	Weight	—	6 (0.21)	—	g (oz)

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

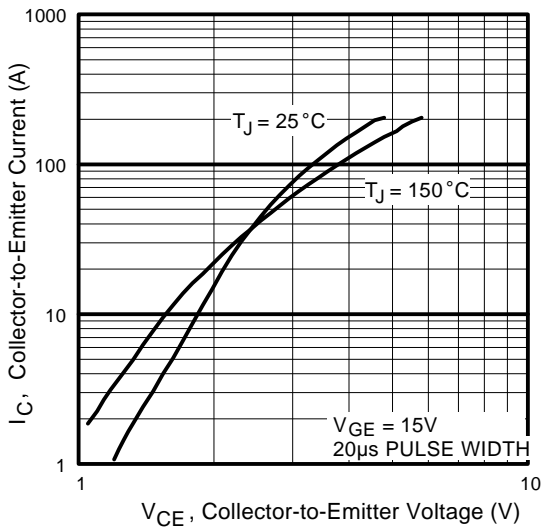
	Parameter	Min.	Typ.	Max.	Units	Conditions
V <sub>(BR)CES</sub>	Collector-to-Emitter Breakdown Voltage <sup>③</sup>	900	—	—	V	V <sub>GE</sub> = 0V, I <sub>C</sub> = 250μA
ΔV <sub>(BR)CES/ΔT<sub>J</sub></sub>	Temperature Coeff. of Breakdown Voltage	—	0.295	—	V/°C	V <sub>GE</sub> = 0V, I <sub>C</sub> = 3.5mA
V <sub>CE(on)</sub>	Collector-to-Emitter Saturation Voltage	—	2.25	2.7	V	I <sub>C</sub> = 28A V <sub>GE</sub> = 15V
		—	2.74	—		I <sub>C</sub> = 60A See Fig. 2, 5
		—	2.12	—		I <sub>C</sub> = 28A, 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)/ΔT<sub>J</sub></sub>	Temperature Coeff. of Threshold Voltage	—	-13	—	mV/°C	V <sub>CE</sub> = V <sub>GE</sub> , I <sub>C</sub> = 250μA
g <sub>fe</sub>	Forward Transconductance <sup>④</sup>	26	39	—	S	V <sub>CE</sub> = 50V, I <sub>C</sub> = 28A
I <sub>CES</sub>	Zero Gate Voltage Collector Current	—	—	500	μA	V <sub>GE</sub> = 0V, V <sub>CE</sub> = 900V
		—	—	2.0		V <sub>GE</sub> = 0V, V <sub>CE</sub> = 10V, T <sub>J</sub> = 25°C
		—	—	6.5	mA	V <sub>GE</sub> = 0V, V <sub>CE</sub> = 900V, T <sub>J</sub> = 150°C
V <sub>FM</sub>	Diode Forward Voltage Drop	—	2.5	3.5	V	I <sub>C</sub> = 16A See Fig. 13
		—	2.1	3.0		I <sub>C</sub> = 16A, 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)

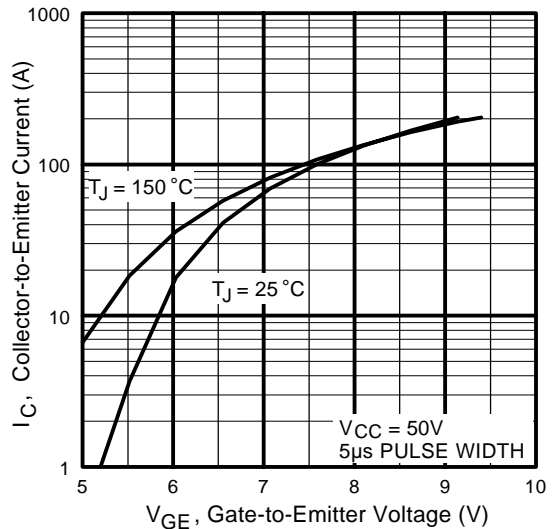
	Parameter	Min.	Typ.	Max.	Units	Conditions	
Q <sub>g</sub>	Total Gate Charge (turn-on)	—	160	240	nC	I <sub>C</sub> = 28A	
Q <sub>ge</sub>	Gate - Emitter Charge (turn-on)	—	19	29		V <sub>CC</sub> = 400V See Fig. 8	
Q <sub>gc</sub>	Gate - Collector Charge (turn-on)	—	53	80		V <sub>GE</sub> = 15V	
t <sub>d(on)</sub>	Turn-On Delay Time	—	71	—	ns	T <sub>J</sub> = 25°C	
t <sub>r</sub>	Rise Time	—	50	—		I <sub>C</sub> = 28A, V <sub>CC</sub> = 720V	
t <sub>d(off)</sub>	Turn-Off Delay Time	—	150	220		V <sub>GE</sub> = 15V, R <sub>G</sub> = 5.0Ω	
t <sub>f</sub>	Fall Time	—	110	170		Energy losses include "tail" and diode reverse recovery.	
E <sub>on</sub>	Turn-On Switching Loss	—	2.63	—		mJ	See Fig. 9, 10, 18
E <sub>off</sub>	Turn-Off Switching Loss	—	1.34	—			
E <sub>ts</sub>	Total Switching Loss	—	3.97	5.3			
t <sub>d(on)</sub>	Turn-On Delay Time	—	69	—	ns	T <sub>J</sub> = 150°C, See Fig. 11, 18	
t <sub>r</sub>	Rise Time	—	52	—		I <sub>C</sub> = 28A, V <sub>CC</sub> = 720V	
t <sub>d(off)</sub>	Turn-Off Delay Time	—	270	—		V <sub>GE</sub> = 15V, R <sub>G</sub> = 5.0Ω	
t <sub>f</sub>	Fall Time	—	190	—		Energy losses include "tail" and diode reverse recovery.	
E <sub>ts</sub>	Total Switching Loss	—	6.0	—		mJ	
L <sub>E</sub>	Internal Emitter Inductance	—	13	—	nH	Measured 5mm from package	
C <sub>ies</sub>	Input Capacitance	—	3300	—	pF	V <sub>GE</sub> = 0V	
C <sub>oes</sub>	Output Capacitance	—	200	—		V <sub>CC</sub> = 30V See Fig. 7	
C <sub>res</sub>	Reverse Transfer Capacitance	—	45	—		f = 1.0MHz	
t <sub>rr</sub>	Diode Reverse Recovery Time	—	90	135	ns	T <sub>J</sub> = 25°C See Fig. 14	
		—	164	245		T <sub>J</sub> = 125°C	
I <sub>rr</sub>	Diode Peak Reverse Recovery Current	—	5.8	10	A	T <sub>J</sub> = 25°C See Fig. 15	
		—	8.3	15		T <sub>J</sub> = 125°C	
Q <sub>rr</sub>	Diode Reverse Recovery Charge	—	260	675	nC	T <sub>J</sub> = 25°C See Fig. 16	
		—	680	1838		T <sub>J</sub> = 125°C	
di <sub>(rec)</sub> M/dt	Diode Peak Rate of Fall of Recovery During t <sub>b</sub>	—	120	—	A/μs	T <sub>J</sub> = 25°C See Fig. 17	
		—	76	—		T <sub>J</sub> = 125°C	



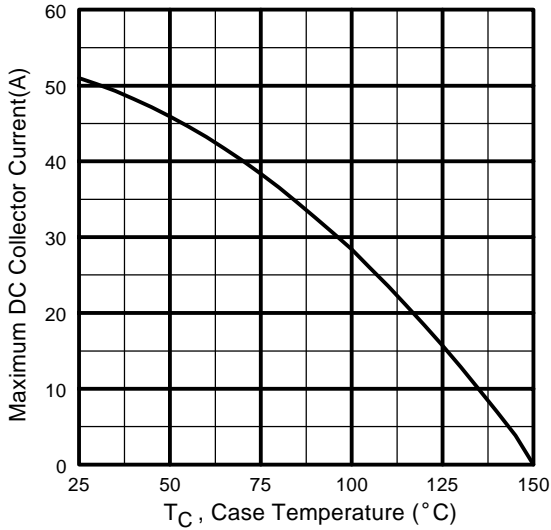
**Fig. 1 - Typical Load Current vs. Frequency**  
 (Load Current =  $I_{\text{RMS}}$  of fundamental)



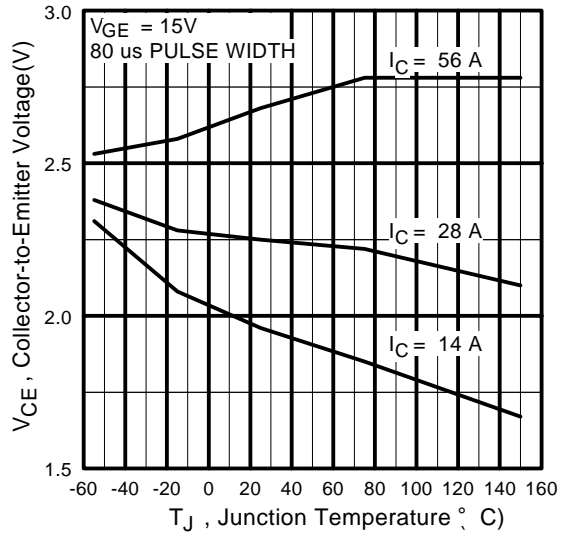
**Fig. 2 - Typical Output Characteristics**



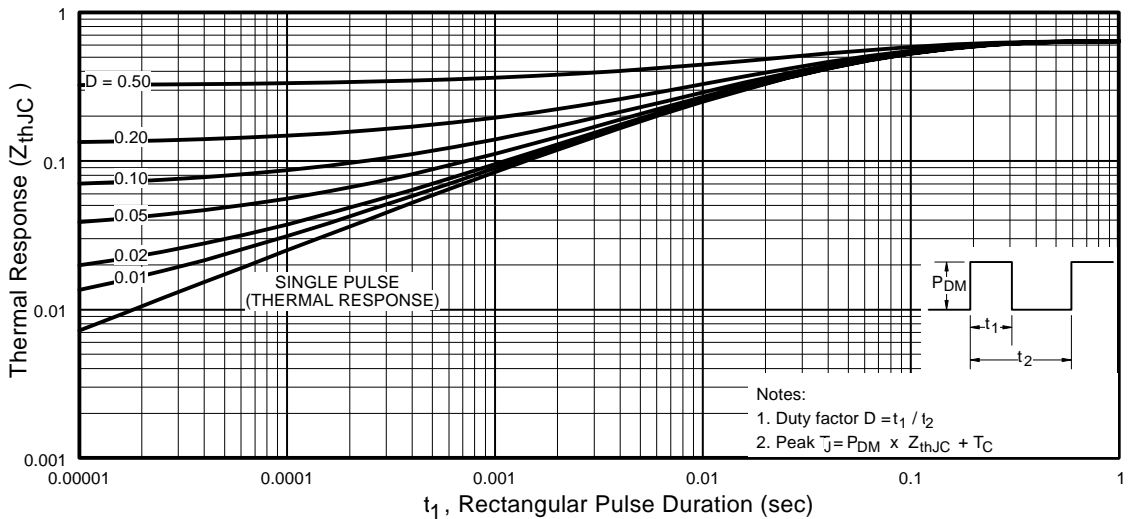
**Fig. 3 - Typical Transfer Characteristics**



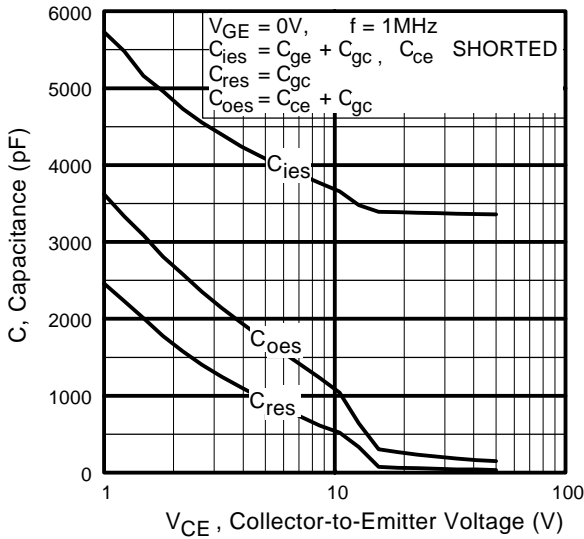
**Fig. 4** - Maximum Collector Current vs. Case Temperature



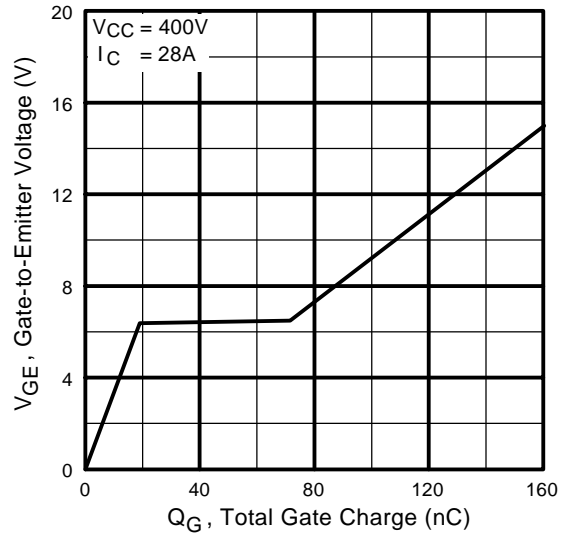
**Fig. 5** - Collector-to-Emitter Voltage vs. Junction Temperature



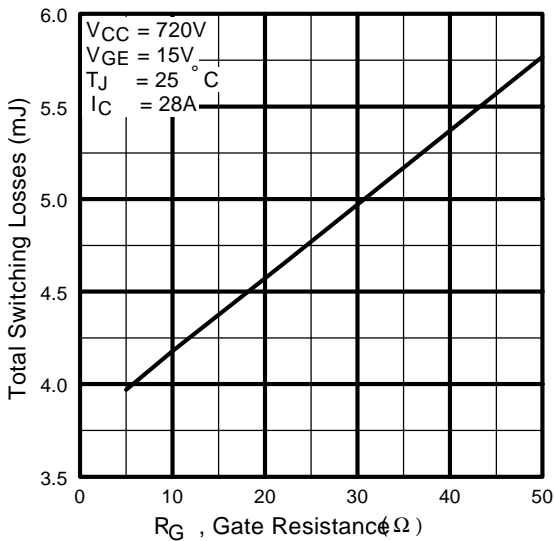
**Fig. 6** - Maximum Effective Transient Thermal Impedance, Junction-to-Case



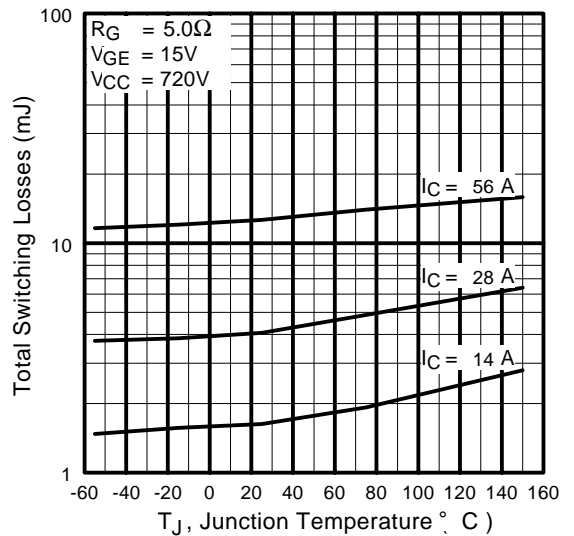
**Fig. 7** - Typical Capacitance vs. Collector-to-Emitter Voltage



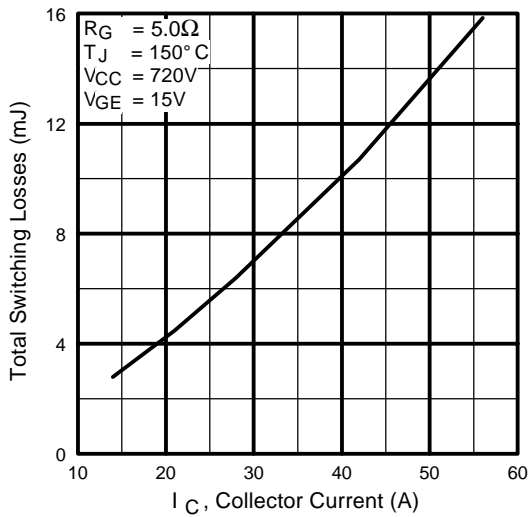
**Fig. 8** - Typical Gate Charge vs. Gate-to-Emitter Voltage



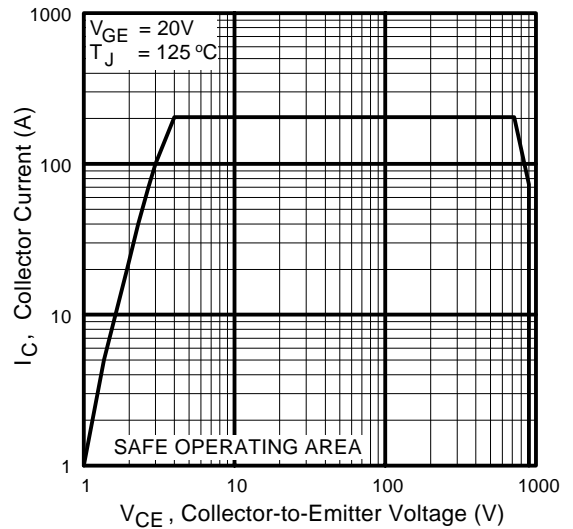
**Fig. 9** - Typical Switching Losses vs. Gate Resistance



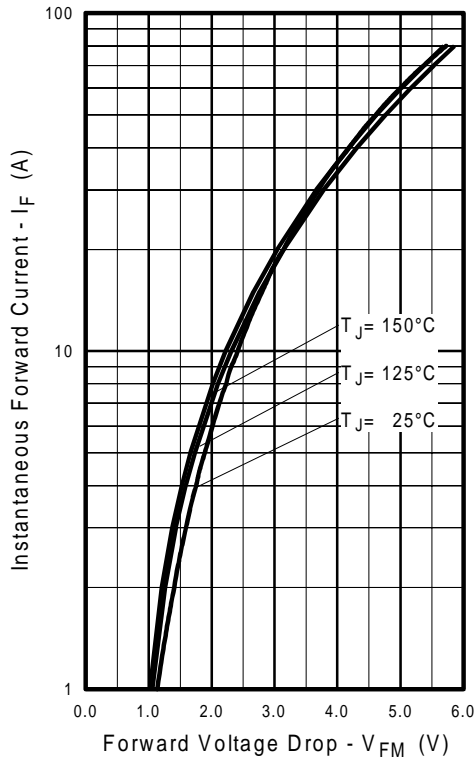
**Fig. 10** - Typical Switching Losses vs. Junction Temperature



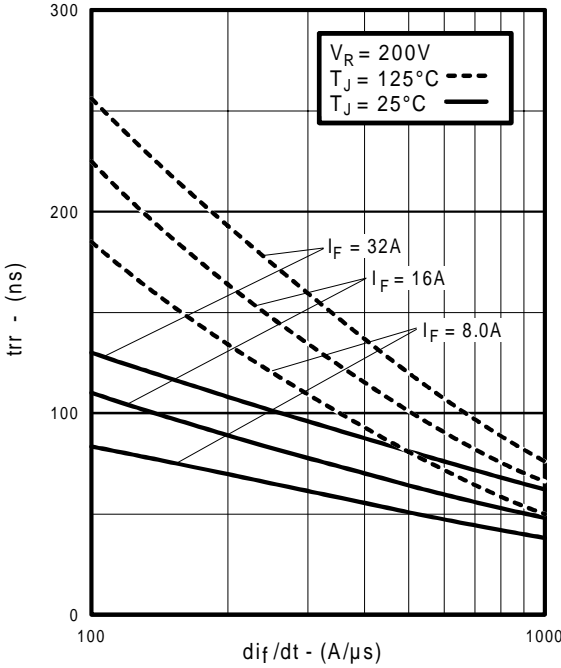
**Fig. 11** - Typical Switching Losses vs. Collector-to-Emitter Current



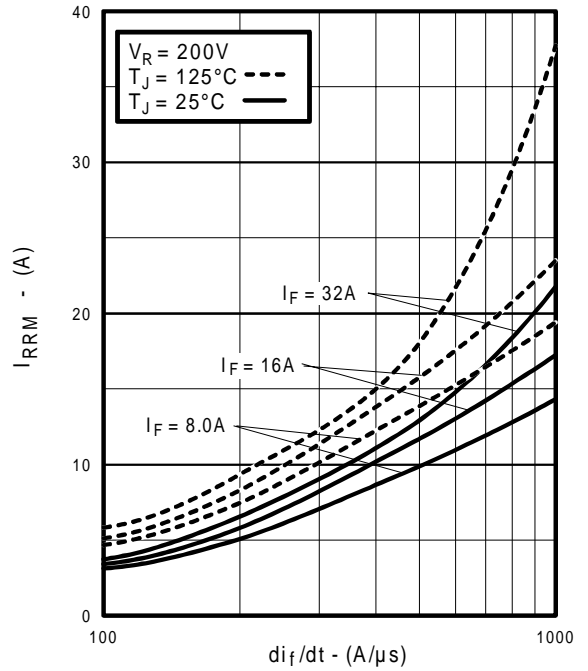
**Fig. 12** - Turn-Off SOA



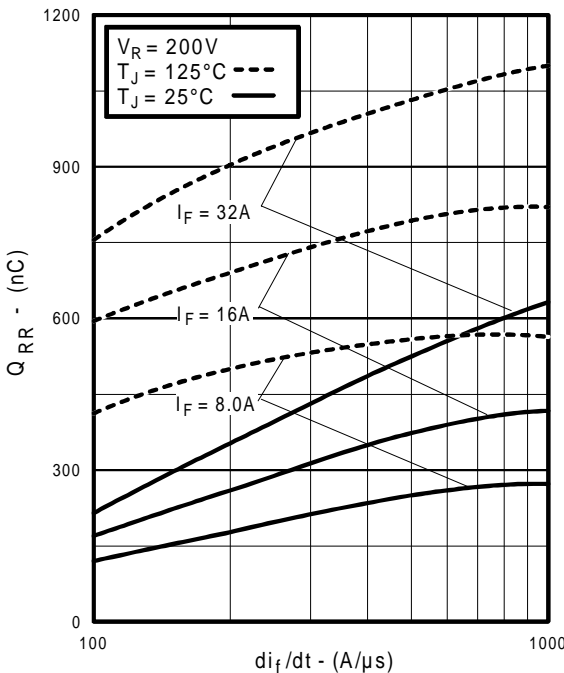
**Fig. 13** - Typical Forward Voltage Drop vs. Instantaneous Forward Current



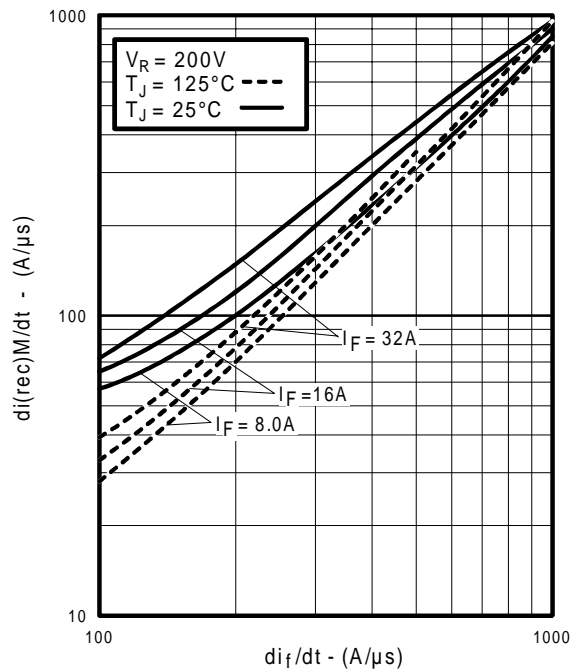
**Fig. 14** - Typical Reverse Recovery vs.  $di_f/dt$



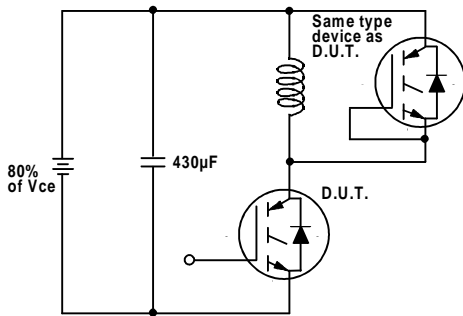
**Fig. 15** - Typical Recovery Current vs.  $di_f/dt$



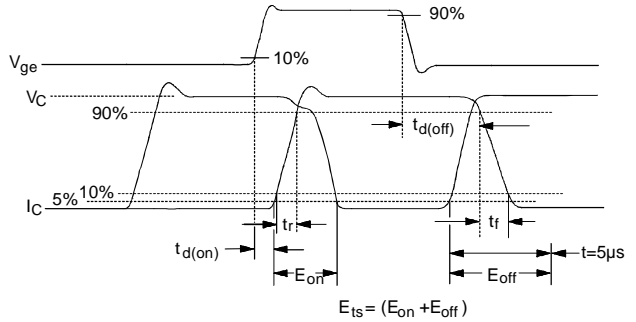
**Fig. 16** - Typical Stored Charge vs.  $di_f/dt$



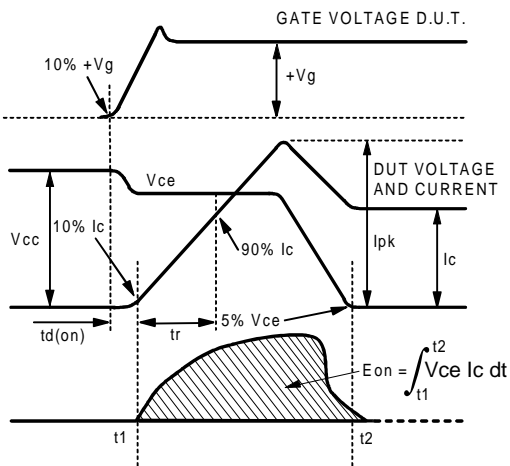
**Fig. 17** - Typical  $di_{(rec)M}/dt$  vs.  $di_f/dt$



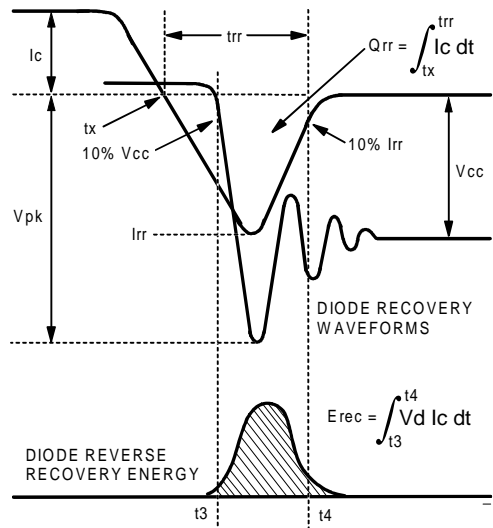
**Fig. 18a** - Test Circuit for Measurement of  $I_{LM}$ ,  $E_{on}$ ,  $E_{off}(\text{diode})$ ,  $t_{rr}$ ,  $Q_{rr}$ ,  $I_{rr}$ ,  $t_{d(on)}$ ,  $t_r$ ,  $t_{d(off)}$ ,  $t_f$



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



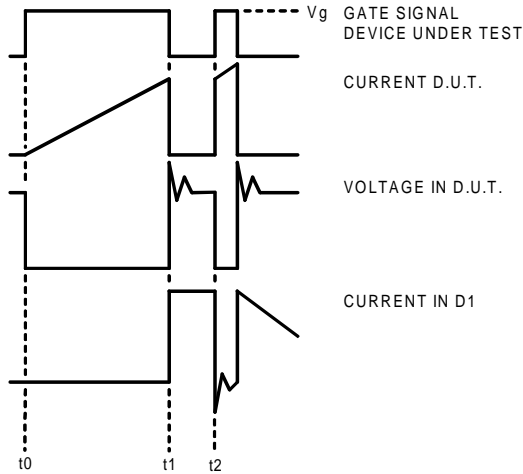


Figure 18e. Macro Waveforms for Figure 18a's Test Circuit

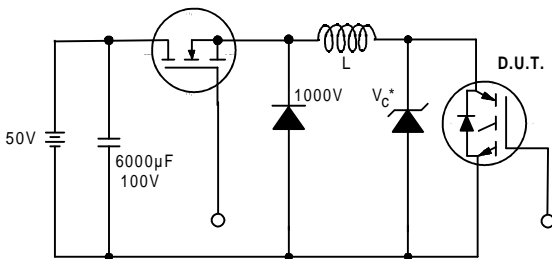


Figure 19. Clamped Inductive Load Test Circuit

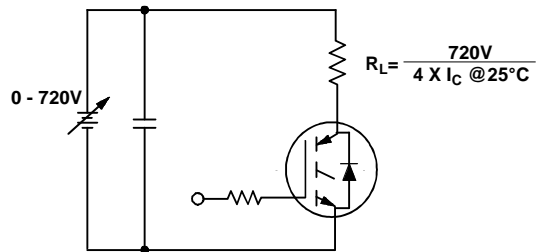
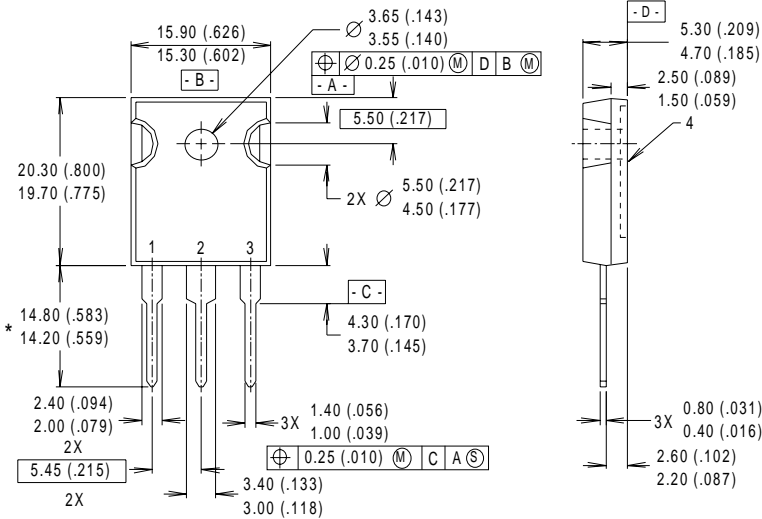


Figure 20. Pulsed Collector Current Test Circuit

## 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 and Dimensions — 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)