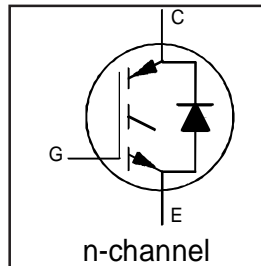


# IRG4PH40UD2

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

## Features

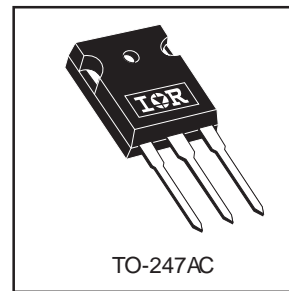
- UltraFast: Optimized for high operating frequencies up to 40 kHz in hard switching, >200 kHz in resonant mode
- New IGBT design provides tighter parameter distribution and higher efficiency than previous generations
- IGBT co-packaged with HEXFRED™ ultrafast, ultra-soft-recovery anti-parallel diodes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



$V_{CES} = 600V$
$V_{CE(on) typ.} = 1.72V$
@ $V_{GE} = 15V, I_C = 20A$

## 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 Voltage	600	V
$I_C @ T_C = 25^\circ C$	Continuous Collector Current	40	A
$I_C @ T_C = 100^\circ C$	Continuous Collector Current	20	
$I_{CM}$	Pulse Collector Current ①	160	
$I_{LM}$	Clamped Inductive Load current ①	160	
$I_F @ T_C = 100^\circ C$	Diode Continuous Forward Current	10	
$I_{FM}$	Diode Maximum Forward Current	40	
$V_{GE}$	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	°C
$T_{STG}$			
	Storage Temperature Range, for 10 sec.	300 (0.063 in. (1.6mm) from case)	
	Mounting Torque, 6-32 or M3 screw	10 lbf•in (1.1N•m)	

## Thermal / Mechanical Characteristics

	Parameter	Min.	Typ.	Max.	Units
$R_{\theta JC}$	Junction-to-Case- IGBT	—	—	0.77	°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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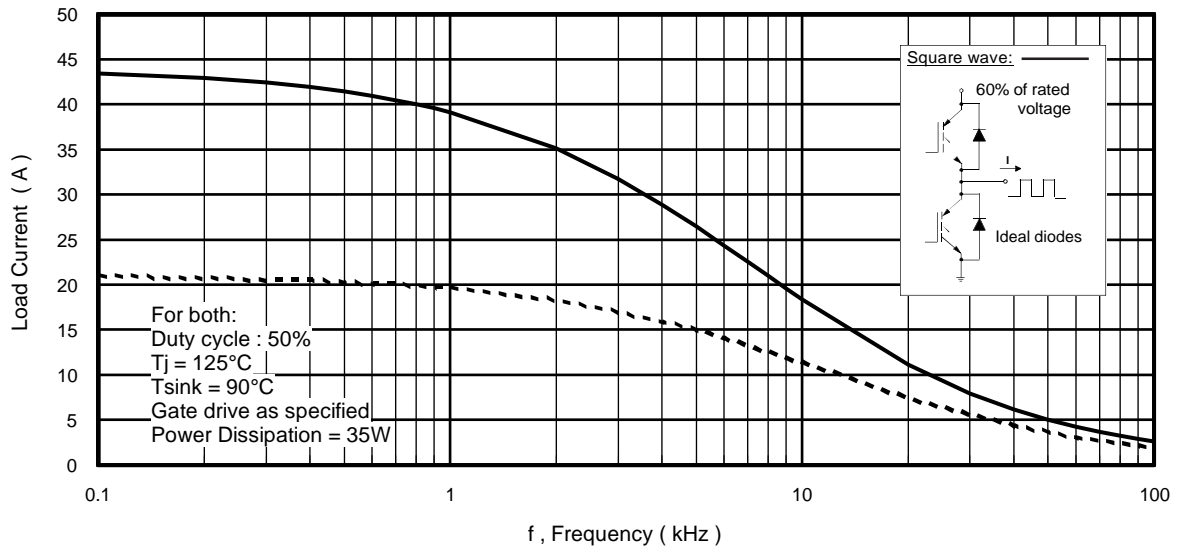
International  
**IR** Rectifier

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

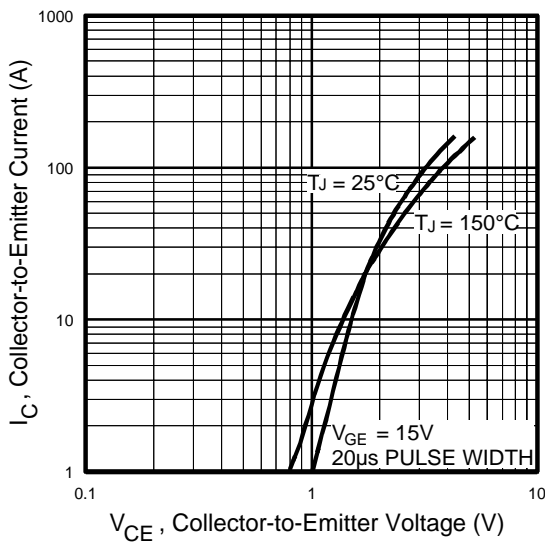
Parameter	Min.	Typ.	Max.	Units	Conditions	
V <sub>(BR)CES</sub>	600	—	—	V	V <sub>GE</sub> = 0V, I <sub>C</sub> = 250μA	
ΔV <sub>(BR)CES</sub> /ΔT <sub>J</sub>	—	0.63	—	V/°C	V <sub>GE</sub> = 0V, I <sub>C</sub> = 1mA (25°C-150°C)	
V <sub>CE(on)</sub>	Collector-to-Emitter Saturation Voltage	—	1.72	2.1	V	I <sub>C</sub> = 20A, V <sub>GE</sub> = 15V, T <sub>J</sub> = 25°C
		—	2.15	—		I <sub>C</sub> = 40A, V <sub>GE</sub> = 15V, T <sub>J</sub> = 125°C
		—	1.7	—		I <sub>C</sub> = 20A, V <sub>GE</sub> = 15V, T <sub>J</sub> = 150°C
V <sub>GE(th)</sub>	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>	—	-13	—	mV/°C	V <sub>CE</sub> = V <sub>GE</sub> , I <sub>C</sub> = 250μA	
g <sub>fe</sub>	11	18	—	S	V <sub>CE</sub> = 100V, I <sub>C</sub> = 20A	
I <sub>CES</sub>	Zero Gate Voltage Collector Current	—	—	250	μA	V <sub>GE</sub> = 0V, V <sub>CE</sub> = 600V
		—	—	2.0		V <sub>GE</sub> = 0V, V <sub>CE</sub> = 10V, T <sub>J</sub> = 25°C
		—	—	2500		V <sub>GE</sub> = 0V, V <sub>CE</sub> = 600V, T <sub>J</sub> = 150°C
V <sub>FM</sub>	Diode Forward Voltage Drop	—	3.4	3.8	V	I <sub>F</sub> = 10A, V <sub>GE</sub> = 0V
		—	3.3	3.7		I <sub>F</sub> = 10A, V <sub>GE</sub> = 0V, 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)

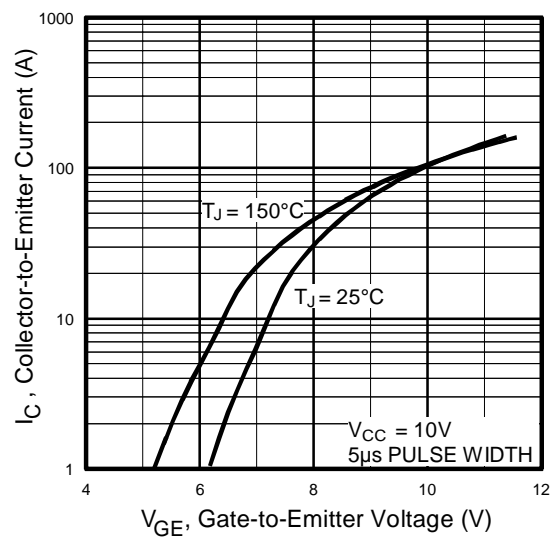
Parameter	Min.	Typ.	Max.	Units	Conditions	
Q <sub>g</sub>	—	110	130	nC	I <sub>C</sub> = 20A V <sub>CC</sub> = 400V V <sub>GE</sub> = 15V	
Q <sub>ge</sub>	—	18	24			
Q <sub>gc</sub>	—	36	53			
t <sub>d(on)</sub>	—	23	—	ns	I <sub>C</sub> = 20A, V <sub>CC</sub> = 600V V <sub>GE</sub> = 15V, R <sub>G</sub> = 10Ω T <sub>J</sub> = 25°C Energy losses included "tail"	
t <sub>r</sub>	—	27	—			
t <sub>d(off)</sub>	—	100	110			
t <sub>f</sub>	—	280	340			
E <sub>on</sub>	—	1440	—			
E <sub>off</sub>	—	1410	—	μJ	I <sub>C</sub> = 20A, V <sub>CC</sub> = 600V V <sub>GE</sub> = 15V, R <sub>G</sub> = 10Ω T <sub>J</sub> = 25°C	
E <sub>tot</sub>	—	2850	3740			
t <sub>d(on)</sub>	—	22	—			
t <sub>r</sub>	—	32	—	ns	I <sub>C</sub> = 20A, V <sub>CC</sub> = 600V V <sub>GE</sub> = 15V, R <sub>G</sub> = 10Ω, L = 1.0mH T <sub>J</sub> = 150°C Energy losses included "tail"	
t <sub>d(off)</sub>	—	190	—			
t <sub>f</sub>	—	630	—			
E <sub>TS</sub>	—	5360	—			
L <sub>E</sub>	Internal Emitter Inductance	—	13	nH	Measured 5mm from package	
C <sub>ies</sub>	Input Capacitance	—	2100	pF	V <sub>GE</sub> = 0V V <sub>CC</sub> = 30V f = 1.0MHz	
C <sub>oes</sub>	Output Capacitance	—	99			
C <sub>res</sub>	Reverse Transfer Capacitance	—	12			
t <sub>rr</sub>	Diode Reverse Recovery Time	—	50	76	ns	T <sub>J</sub> =25°C, V <sub>CC</sub> = 200V, I <sub>F</sub> = 10A, di/dt = 200A/μs
		—	72	110		T <sub>J</sub> =125°C, V <sub>CC</sub> = 200V, I <sub>F</sub> = 10A, di/dt = 200A/μs
I <sub>rr</sub>	Diode Peak Reverse Recovery Current	—	4.4	7.0	A	T <sub>J</sub> =25°C, V <sub>CC</sub> = 200V, I <sub>F</sub> = 10A, di/dt = 200A/μs
		—	5.9	8.8		T <sub>J</sub> =125°C, V <sub>CC</sub> = 200V, I <sub>F</sub> = 10A, di/dt = 200A/μs
Q <sub>rr</sub>	Diode Reverse Recovery Charge	—	130	200	nC	T <sub>J</sub> =25°C, V <sub>CC</sub> = 200V, I <sub>F</sub> = 10A, di/dt = 200A/μs
		—	250	380		T <sub>J</sub> =125°C, V <sub>CC</sub> = 200V, I <sub>F</sub> = 10A, di/dt = 200A/μs
di <sub>(rec)</sub> /dt	Diode Peak Rate of Fall of Recovery During t <sub>b</sub>	—	210	—	A/μs	T <sub>J</sub> =25°C, V <sub>CC</sub> = 200V, I <sub>F</sub> = 10A, di/dt = 200A/μs
		—	180	—		T <sub>J</sub> =125°C, V <sub>CC</sub> = 200V, I <sub>F</sub> = 10A, di/dt = 200A/μs



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

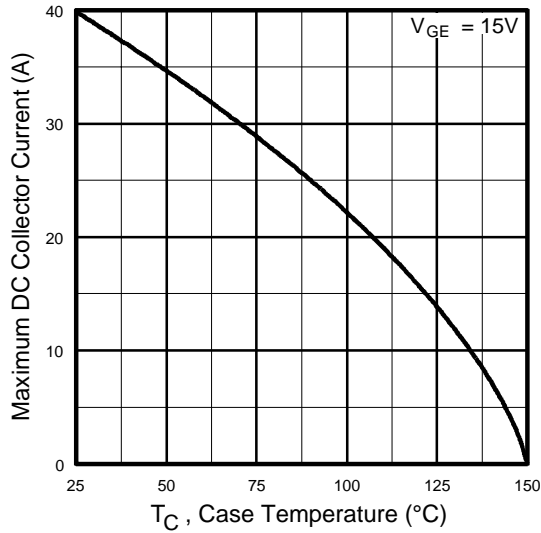


**Fig. 2 - Typical Output Characteristics**

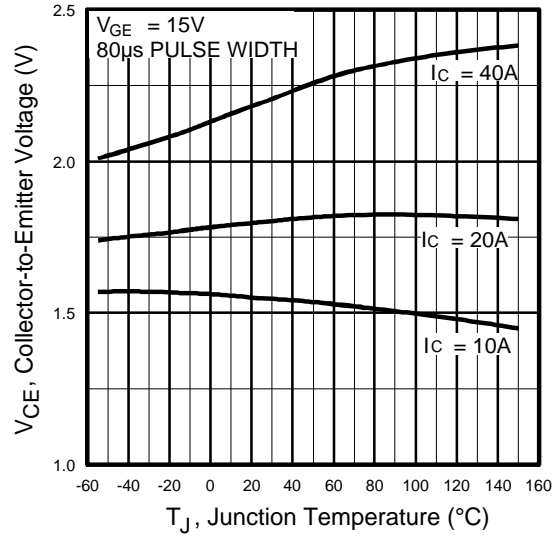


**Fig. 3 - Typical Transfer Characteristics**

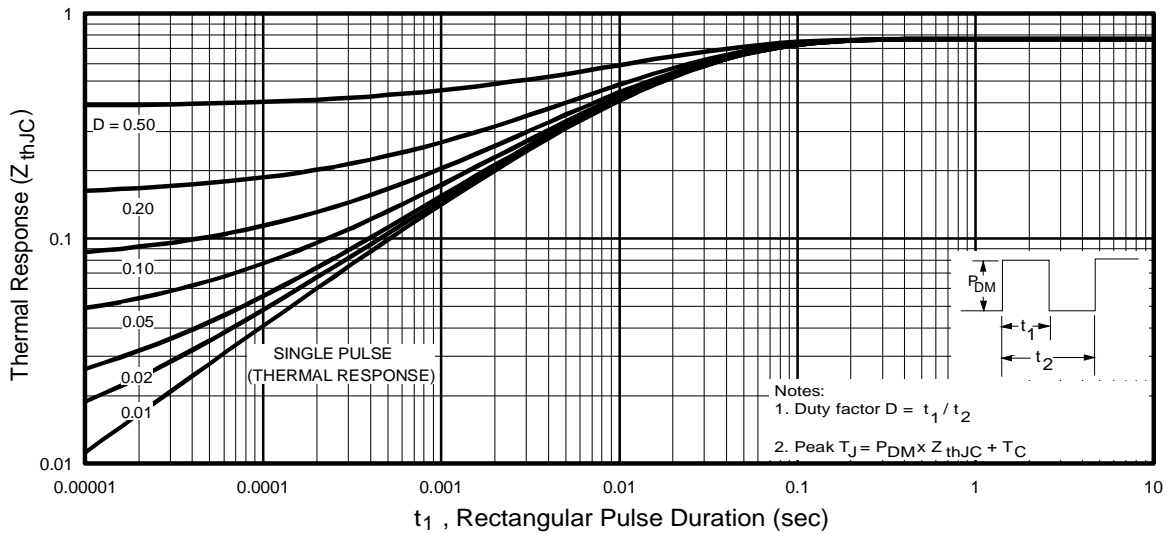
# IRG4PH40UD2



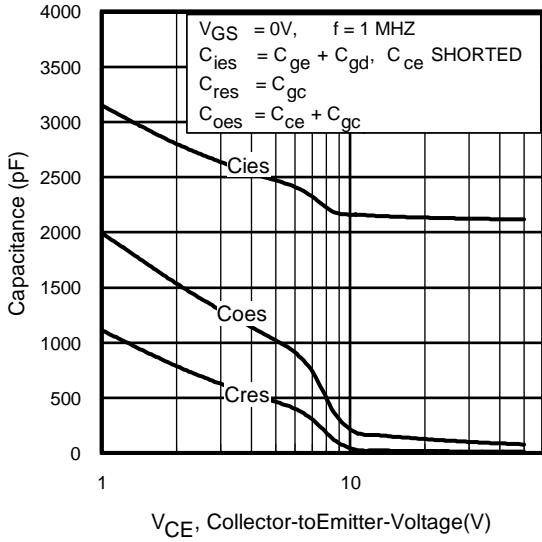
**Fig. 4 - Maximum Collector Current vs. Case Temperature**



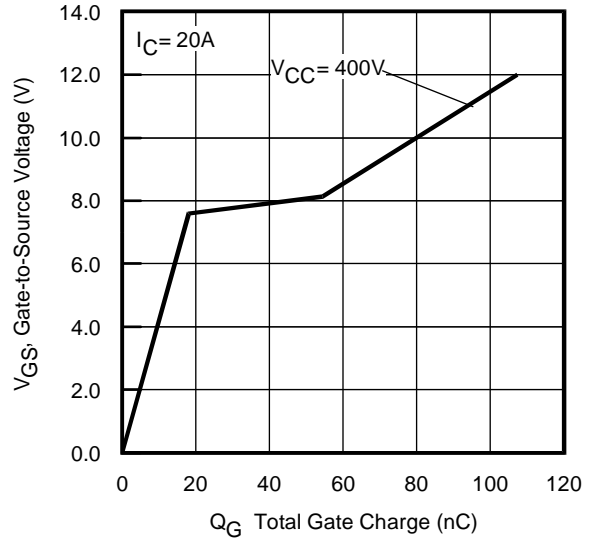
**Fig. 5 - Typical Collector-to-Emitter Voltage vs. Junction Temperature**



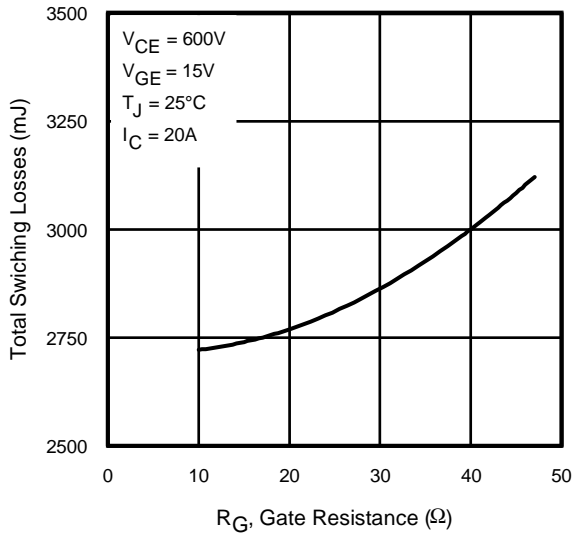
**Fig. 6 - Maximum Effective Transient Thermal Impedance, Junction-to-Case**



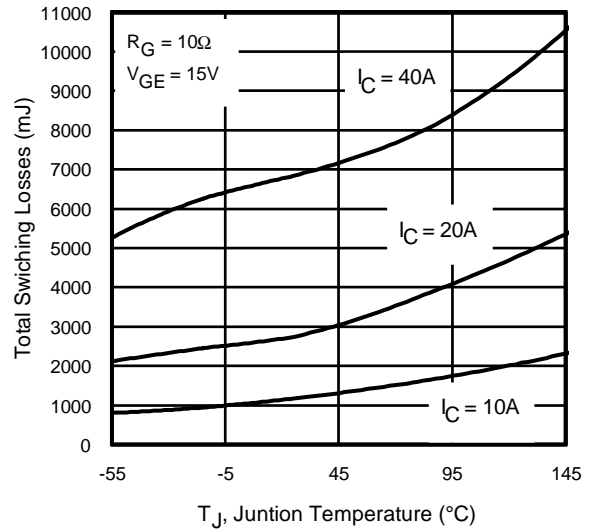
**Fig. 7 - Typical Capacitance vs. Collector-to-Emitter Voltage**



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

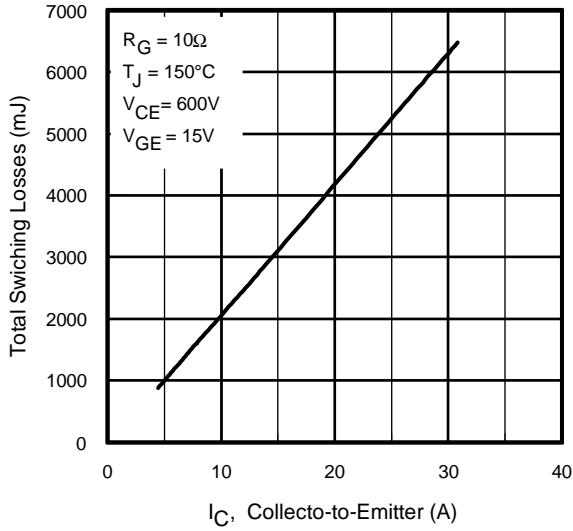


**Fig. 9 - Typical Switching Losses vs. Gate Resistance**

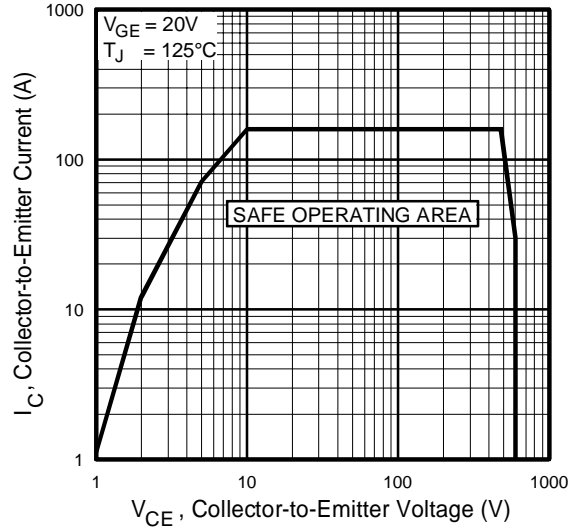


**Fig. 10 - Typical Switching Losses vs. Junction Temperature**

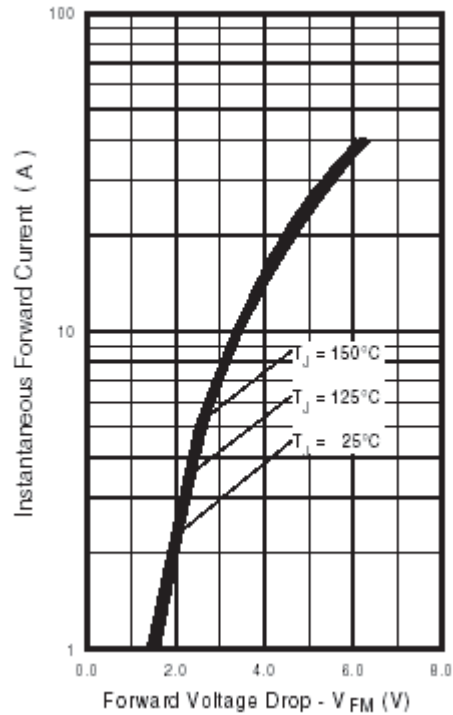
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**Fig. 11** - Typical Switching Losses vs. Collector-to-Emitter Current



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



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

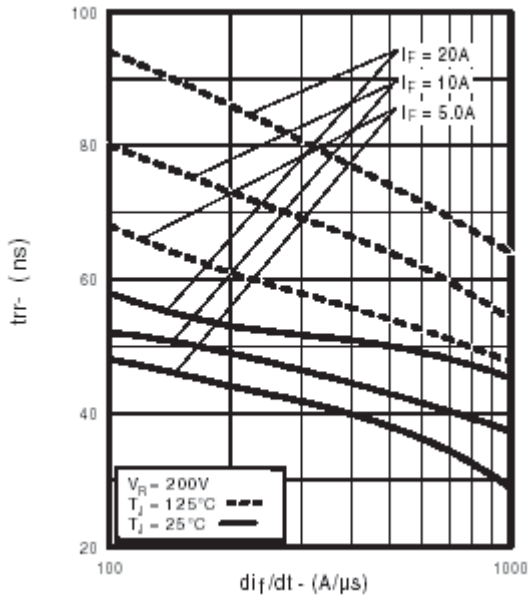


Fig. 14 - Typical Reverse Recovery vs.  $dI_T/dt$

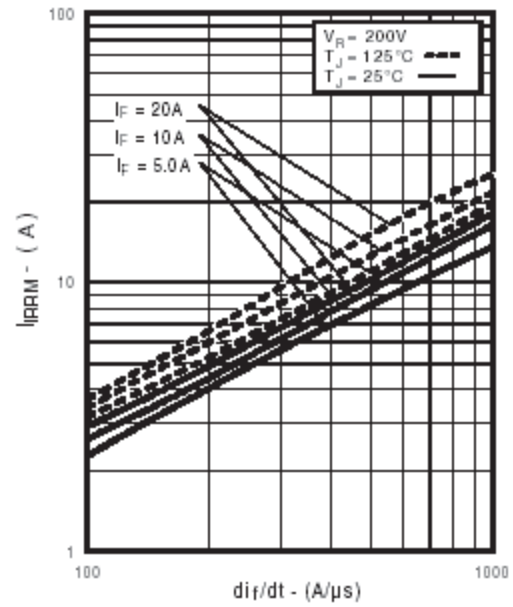


Fig. 15 - Typical Recovery Current vs.  $dI_T/dt$

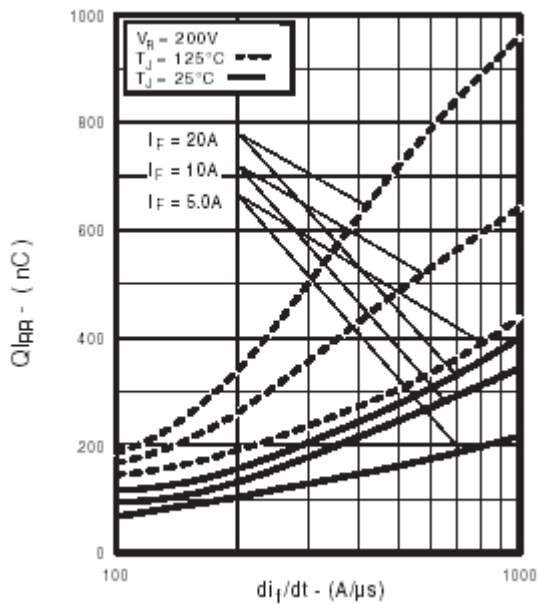


Fig. 16 - Typical Stored Charge vs.  $dI_T/dt$

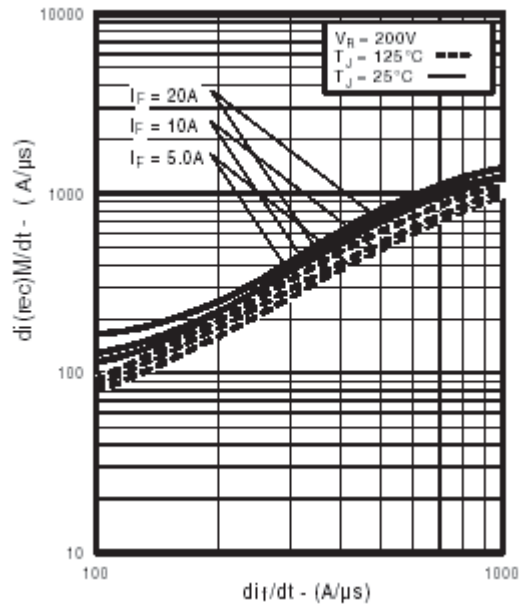
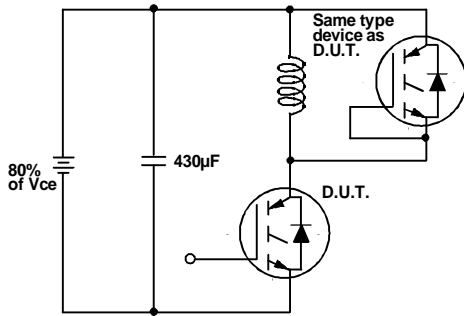
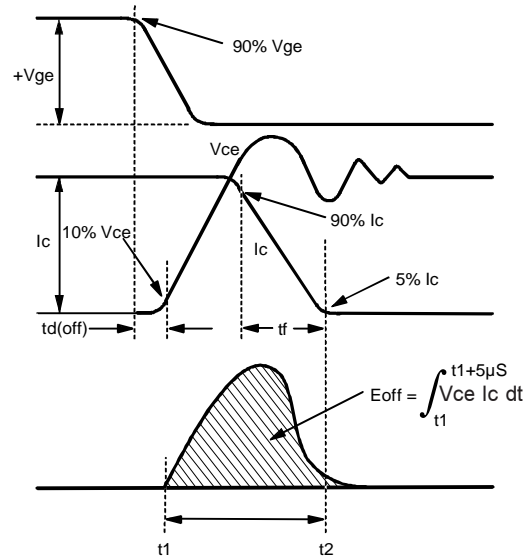


Fig. 17 - Typical  $dI_{(rec)M}/dt$  vs.  $dI_T/dt$

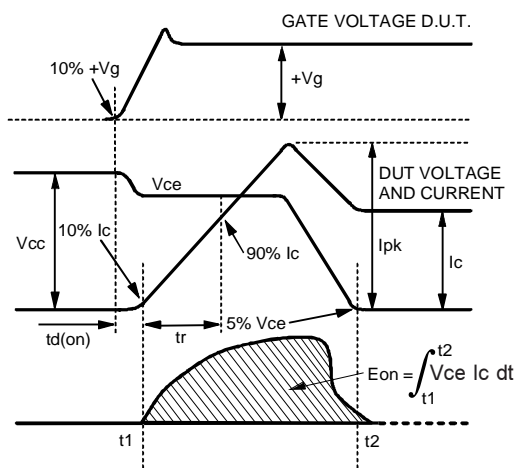
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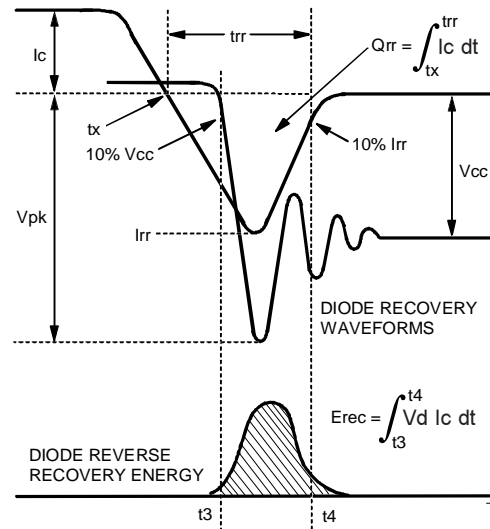
**Fig. 18a** - Test Circuit for Measurement of  $I_{LM}$ ,  $E_{on}$ ,  $E_{off}(\text{diode})$ ,  $t_{rr}$ ,  $Q_{rr}$ ,  $I_{rr}$ ,  $t_{d(on)}$ ,  $t_r$ ,  $t_{d(off)}$ ,  $t_f$



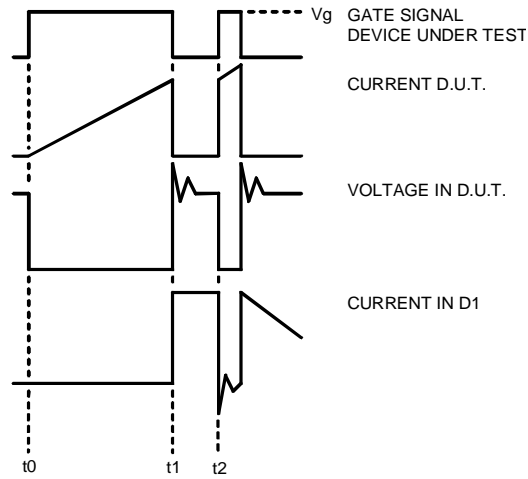
**Fig. 18b** - Test Waveforms for Circuit of Fig. 18a, Defining  $E_{off}$ ,  $t_{d(off)}$ ,  $t_f$



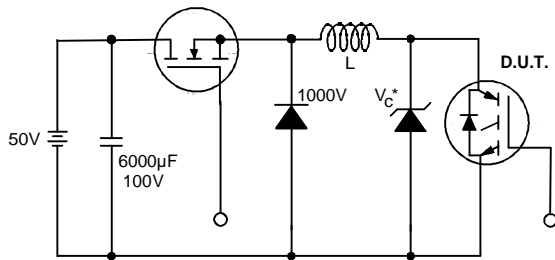
**Fig. 18c** - Test Waveforms for Circuit of Fig. 18a, Defining  $E_{on}$ ,  $t_{d(on)}$ ,  $t_r$



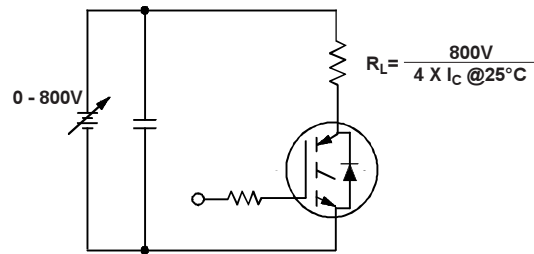
**Fig. 18d** - Test Waveforms for Circuit of Fig. 18a, Defining  $E_{rec}$ ,  $t_{rr}$ ,  $Q_{rr}$ ,  $I_{rr}$



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



19. Clamped Inductive Load Test Circuit



20. Pulsed Collector Current Test Circuit





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