

**INSULATED GATE BIPOLAR TRANSISTOR WITH  
 ULTRAFAST SOFT RECOVERY DIODE**

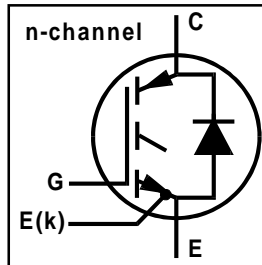
Surface Mountable  
 Short Circuit Rated  
 UltraFast IGBT

**Features**

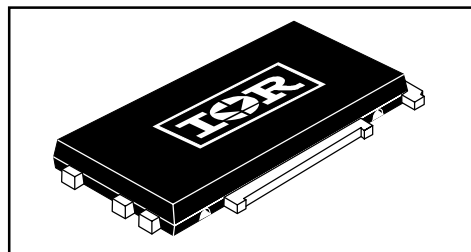
- High short circuit rating optimized for motor control,  $t_{sc} = 10\mu s$ ,  $V_{CC} = 360V$ ,  $T_J = 125^\circ C$ ,  $V_{GE} = 15V$
- IGBT co-packaged with HEXFRED™ ultrafast, ultra-soft-recovery antiparallel diodes for use in bridge configurations
- Combines low conduction losses with high switching speed
- Low profile low inductance SMD-10 Package
- Separated control & Power-connections for easy paralleling
- Good coplanarity
- Easy solder inspection and cleaning

**Benefits**

- Highest power density and efficiency available
- HEXFRED Diodes optimized for performance with IGBTs. Minimized recovery characteristics
- IGBTs optimized for specific application conditions



$V_{CES} = 600V$
$V_{CE(ON)typ} = 1.75V$
@ $V_{GE} = 15V, I_C = 60A$



**Absolute Maximum Ratings**

	Parameter	Max.	Units
$V_{CES}$	Collector-to-Emitter Voltage	600	V
$I_C @ T_C = 25^\circ C$	Continuous Collector Current	100	A
$I_C @ T_C = 100^\circ C$	Continuous Collector Current	60	
$I_{CM}$	Pulsed Collector Current ①	200	
$I_{LM}$	Clamped Inductive Load Current ②	200	
$I_F @ T_C = 100^\circ C$	Diode Continuous Forward Current	50	
$I_{FM}$	Diode Maximum Forward Current	200	
$t_{sc}$	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	350	W
$P_D @ T_C = 100^\circ C$	Maximum Power Dissipation	140	
$T_J$ $T_{STG}$	Operating Junction and Storage Temperature Range	-55 to +150	$^\circ C$

**Thermal Resistance**

	Parameter	Min.	Typ.	Max.	Units
$R_{\theta JC}$	Junction-to-Case - IGBT	—	—	0.36	$^\circ C/W$
$R_{\theta JC}$	Junction-to-Case - Diode	—	—	0.69	
$R_{\theta CS}$	SMD-10 Case-to-Heatsink (typical), *	—	0.44	—	
	Weight	—	6.0(0.21)	—	g (oz)

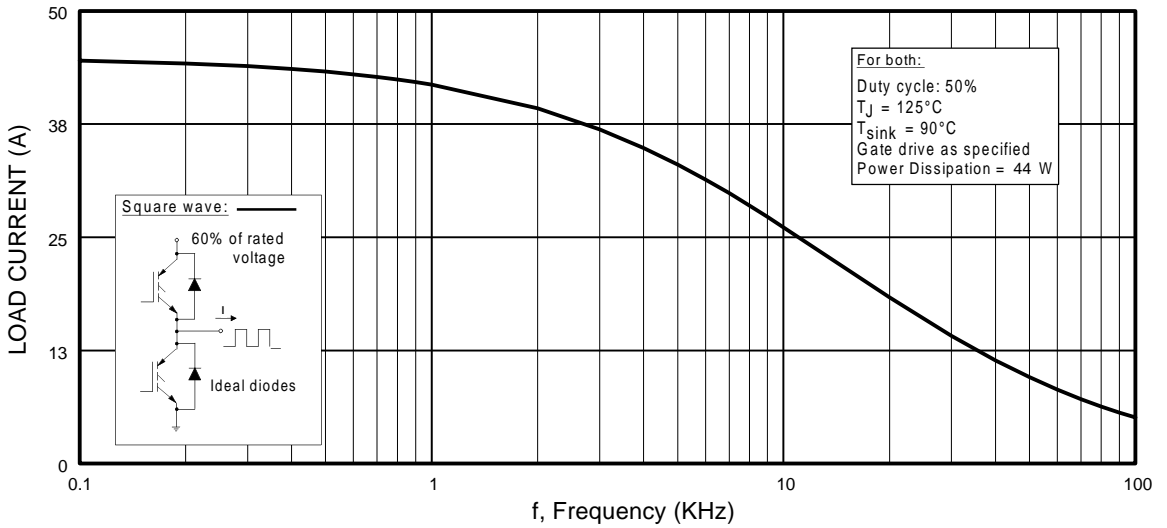
\* Assumes device soldered to 3.0 oz. Cu on 3.0mm IMS/Aluminum board, mounted to flat, greased heatsink.

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

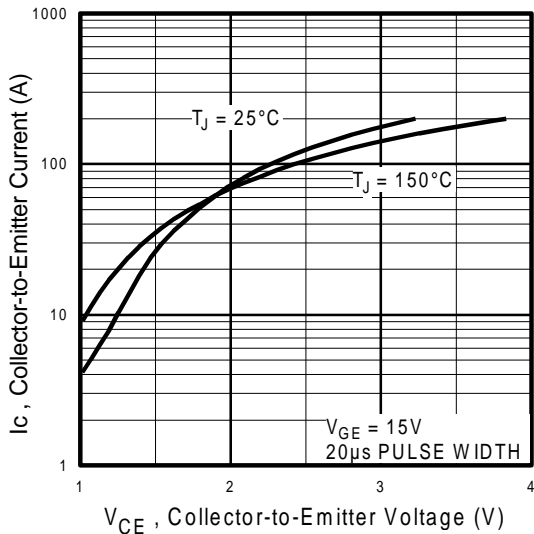
	Parameter	Min.	Typ.	Max.	Units	Conditions
V <sub>(BR)CES</sub>	Collector-to-Emitter Breakdown Voltage <sup>③</sup>	600	—	—	V	V <sub>GE</sub> = 0V, I <sub>C</sub> = 250μA
ΔV <sub>(BR)CES/ΔT<sub>J</sub></sub>	Temperature Coeff. of Breakdown Voltage	—	0.5	—	V/°C	V <sub>GE</sub> = 0V, I <sub>C</sub> = 10mA
V <sub>CE(on)</sub>	Collector-to-Emitter Saturation Voltage	—	1.75	2.3	V	I <sub>C</sub> = 60A I <sub>C</sub> = 100A I <sub>C</sub> = 60A, T <sub>J</sub> = 150°C
		—	2.15	—		
		—	1.75	—		
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	—	-10	—	mV/°C	V <sub>CE</sub> = V <sub>GE</sub> , I <sub>C</sub> = 1.5mA
g <sub>fe</sub>	Forward Transconductance <sup>④</sup>	31	46	—	S	V <sub>CE</sub> = 100V, I <sub>C</sub> = 60A
I <sub>CES</sub>	Zero Gate Voltage Collector Current	—	—	500	μA	V <sub>GE</sub> = 0V, V <sub>CE</sub> = 600V
		—	—	13	mA	V <sub>GE</sub> = 0V, V <sub>CE</sub> = 600V, T <sub>J</sub> = 150°C
V <sub>FM</sub>	Diode Forward Voltage Drop	—	1.4	1.7	V	I <sub>C</sub> = 60A I <sub>C</sub> = 60A, T <sub>J</sub> = 150°C
		—	1.4	—		
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)**

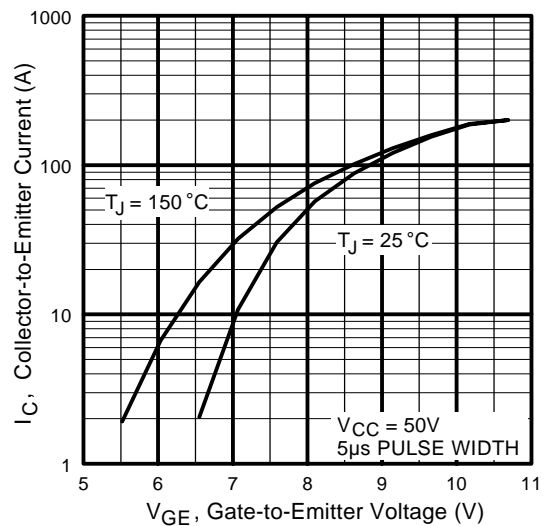
	Parameter	Min.	Typ.	Max.	Units	Conditions
Q <sub>g</sub>	Total Gate Charge (turn-on)	—	343	515	nC	I <sub>C</sub> = 60A V <sub>CC</sub> = 400V V <sub>GE</sub> = 15V
Q <sub>ge</sub>	Gate - Emitter Charge (turn-on)	—	44	66		
Q <sub>gc</sub>	Gate - Collector Charge (turn-on)	—	161	242		
t <sub>d(on)</sub>	Turn-On Delay Time	—	140	—	ns	T <sub>J</sub> = 25°C I <sub>C</sub> = 60A, V <sub>CC</sub> = 480V V <sub>GE</sub> = 15V, R <sub>G</sub> = 5.0Ω
t <sub>r</sub>	Rise Time	—	63	—		
t <sub>d(off)</sub>	Turn-Off Delay Time	—	475	710		
t <sub>f</sub>	Fall Time	—	133	200		
E <sub>on</sub>	Turn-On Switching Loss	—	1.49	—		
E <sub>off</sub>	Turn-Off Switching Loss	—	3.11	—	mJ	Energy losses include "tail" and diode reverse recovery See Fig. 9,10,18
E <sub>ts</sub>	Total Switching Loss	—	4.60	6.0		
t <sub>sc</sub>	Short Circuit Withstand Time	10	—	—	μs	V <sub>CC</sub> = 360V, T <sub>J</sub> = 125°C V <sub>GE</sub> = 15V, R <sub>G</sub> = 5.0Ω
t <sub>d(on)</sub>	Turn-On Delay Time	—	145	—	ns	T <sub>J</sub> = 150°C, See Fig. 10,11,18 I <sub>C</sub> = 60A, V <sub>CC</sub> = 480V V <sub>GE</sub> = 15V, R <sub>G</sub> = 5.0Ω, Energy losses include "tail" and diode reverse recovery
t <sub>r</sub>	Rise Time	—	65	—		
t <sub>d(off)</sub>	Turn-Off Delay Time	—	630	—		
t <sub>f</sub>	Fall Time	—	196	—		
E <sub>ts</sub>	Total Switching Loss	—	7.6	—		
L <sub>E</sub>	Internal Emitter Inductance	—	2.0	—	nH	Measured 5mm from package
C <sub>ies</sub>	Input Capacitance	—	6850	—	pF	V <sub>GE</sub> = 0V V <sub>CC</sub> = 30V f = 1.0MHz
C <sub>oes</sub>	Output Capacitance	—	730	—		
C <sub>res</sub>	Reverse Transfer Capacitance	—	190	—		
t <sub>rr</sub>	Diode Reverse Recovery Time	—	90	140	ns	T <sub>J</sub> = 25°C See Fig. 14 T <sub>J</sub> = 125°C
		—	120	180		
I <sub>rr</sub>	Diode Peak Reverse Recovery Current	—	7.3	11	A	T <sub>J</sub> = 25°C See Fig. 15 T <sub>J</sub> = 125°C
		—	11	16		
Q <sub>rr</sub>	Diode Reverse Recovery Charge	—	360	550	nC	T <sub>J</sub> = 25°C See Fig. 16 T <sub>J</sub> = 125°C
		—	780	1200		
di <sub>(rec)M/dt</sub>	Diode Peak Rate of Fall of Recovery During t <sub>b</sub>	—	370	—	A/μs	T <sub>J</sub> = 25°C See Fig. 17 T <sub>J</sub> = 125°C
		—	220	—		



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



**Fig. 2 - Typical Output Characteristics**



**Fig. 3 - Typical Transfer Characteristics**

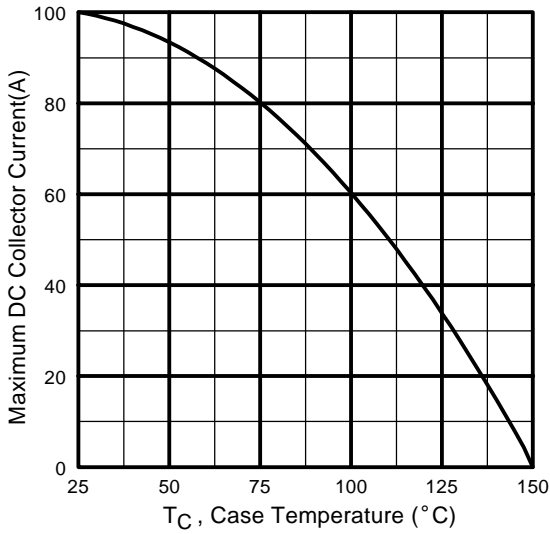


Fig. 4 - Maximum Collector Current vs. Case Temperature

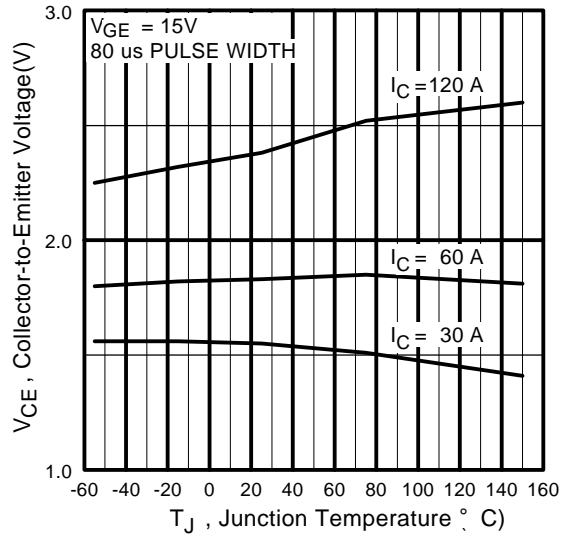


Fig. 5 - Typical Collector-to-Emitter Voltage vs. Junction Temperature

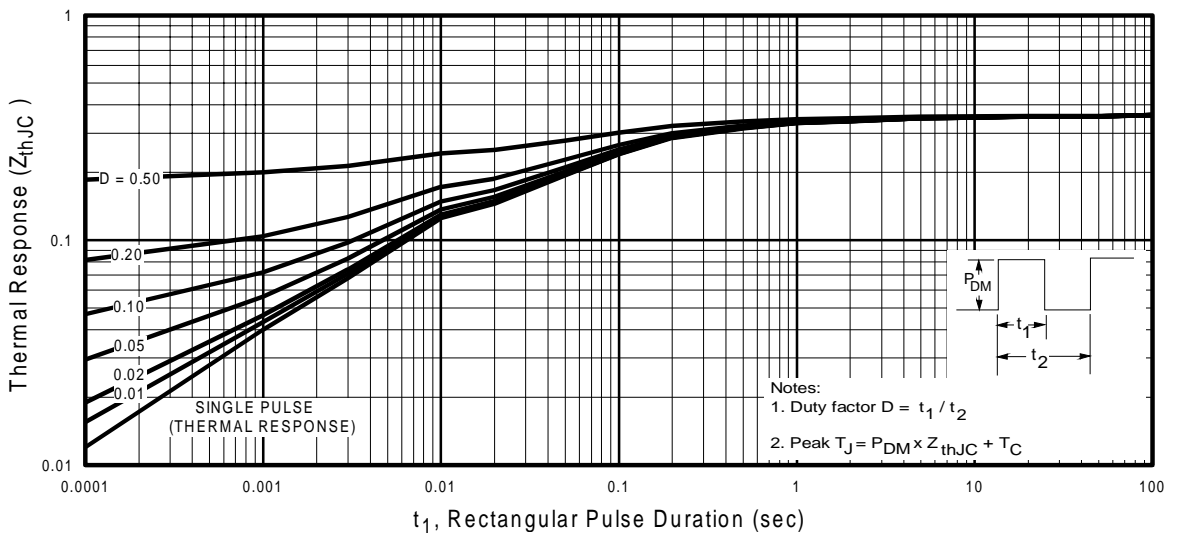
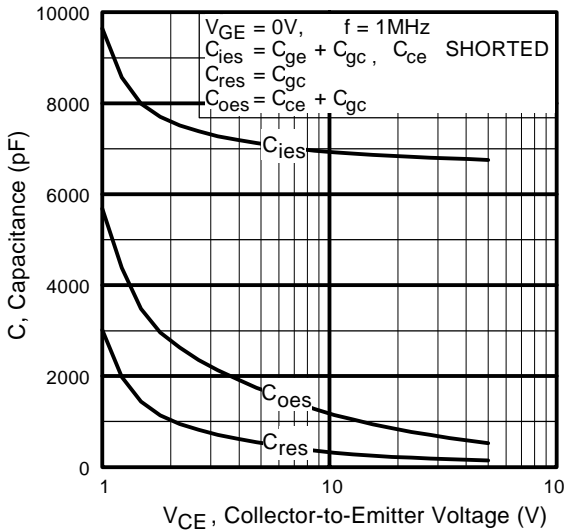
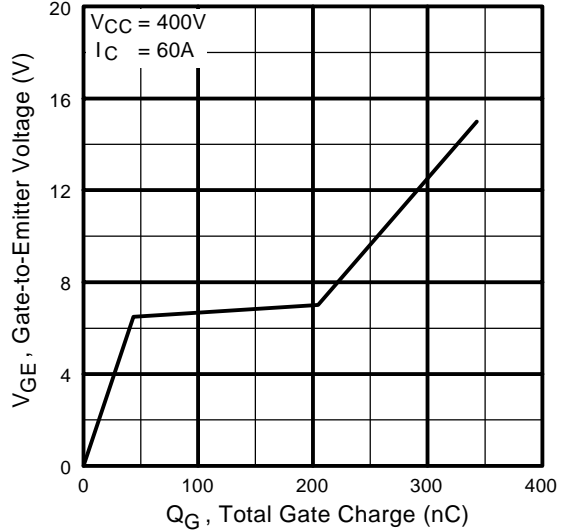


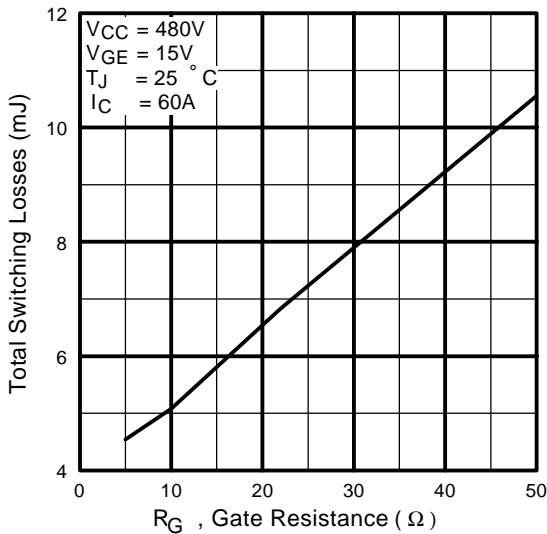
Fig. 6 - Maximum Effective Transient Thermal Impedance, Junction-to-Case



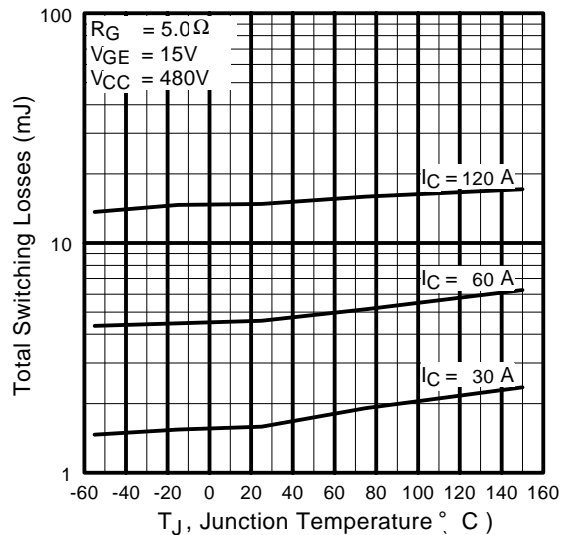
**Fig. 7** - Typical Capacitance vs. Collector-to-Emitter Voltage



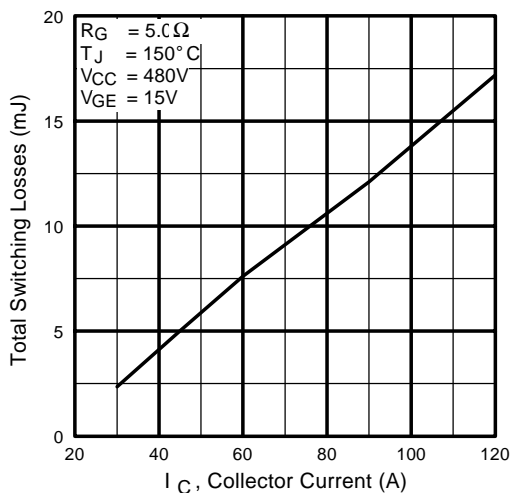
**Fig. 8** - Typical Gate Charge vs. Gate-to-Emitter Voltage



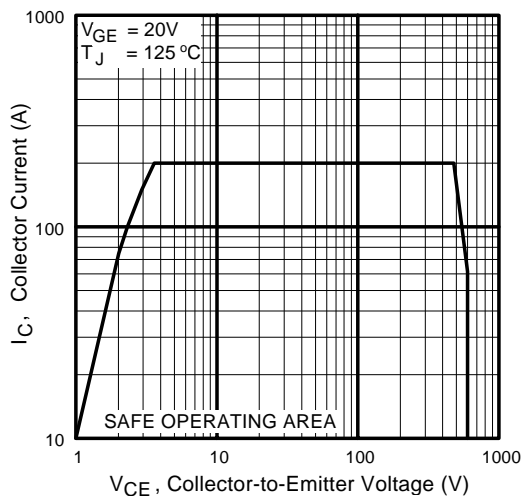
**Fig. 9** - Typical Switching Losses vs. Gate Resistance



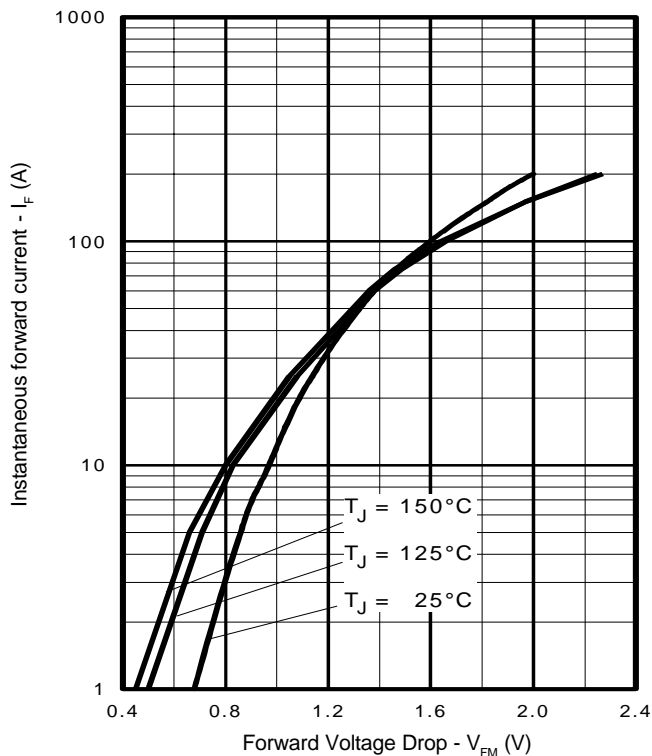
**Fig. 10** - Typical Switching Losses vs. Junction Temperature



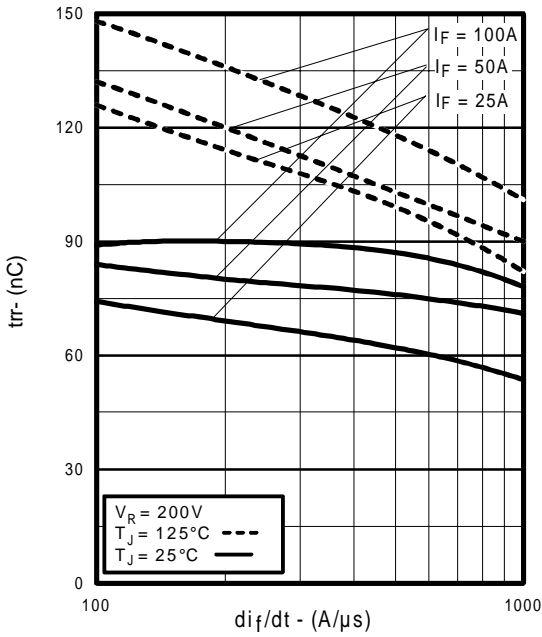
**Fig. 11** - Typical Switching Losses vs. Collector Current



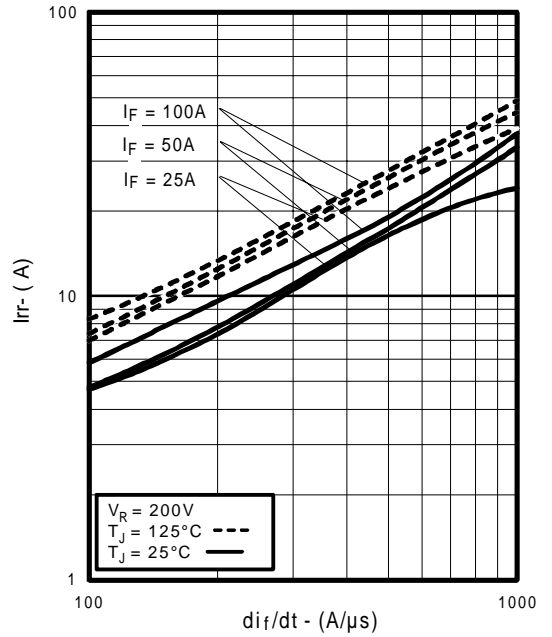
**Fig. 12** - Turn-Off SOA



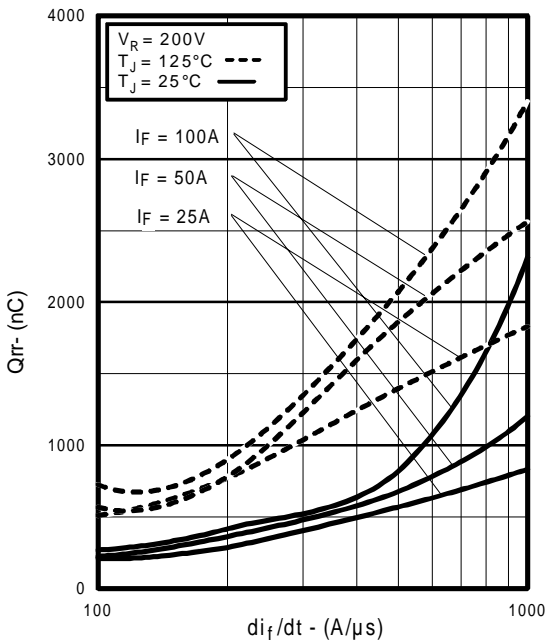
**Fig. 13** - Typical Forward Voltage Drop vs. Instantaneous Forward Current



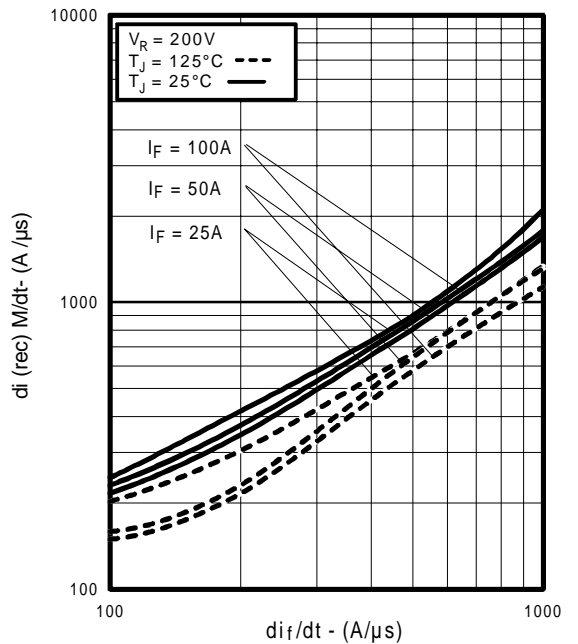
**Fig. 14** - Typical Reverse Recovery vs.  $di_f/dt$



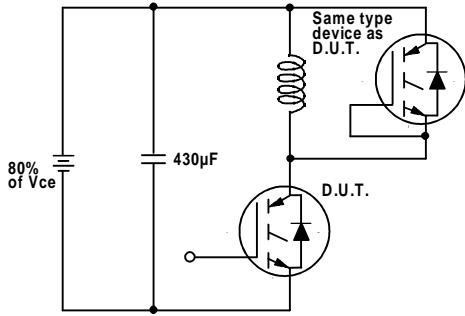
**Fig. 15** - Typical Recovery Current vs.  $di_f/dt$



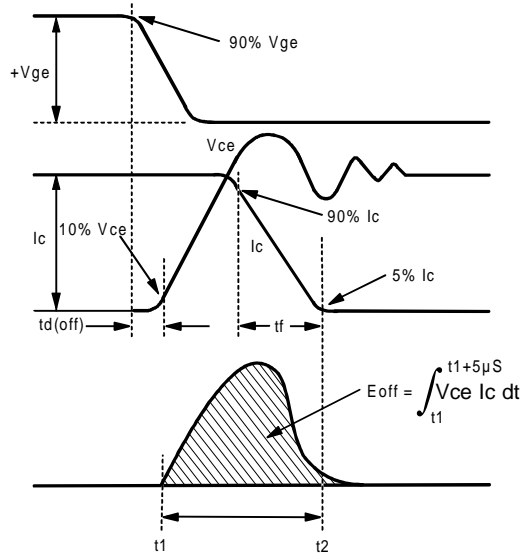
**Fig. 16** - Typical Stored Charge vs.  $di_f/dt$   
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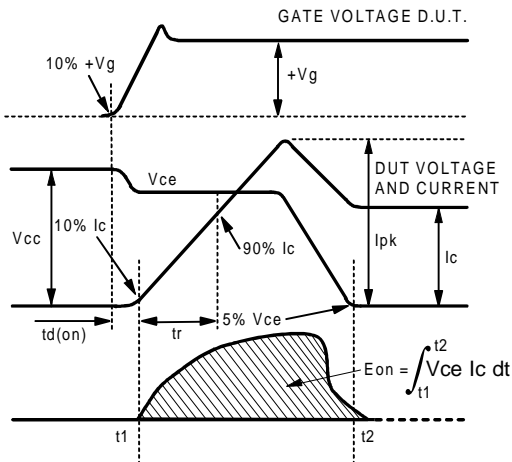
**Fig. 17** - Typical  $di_{(rec)}M/dt$  vs.  $di_f/dt$



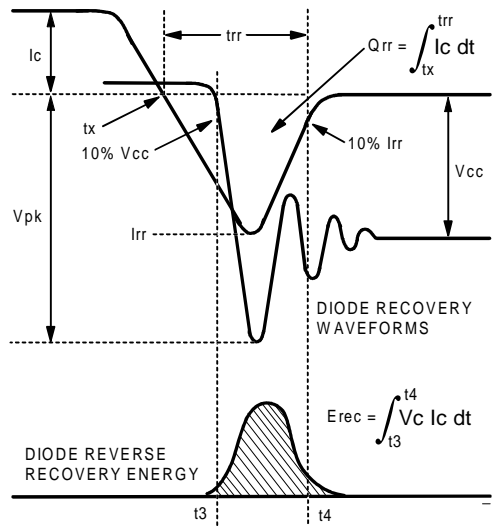
**Fig. 18a** - Test Circuit for Measurement of  $I_{LM}$ ,  $E_{on}$ ,  $E_{off}(\text{diode})$ ,  $t_{rr}$ ,  $Q_{rr}$ ,  $I_{rr}$ ,  $t_{d(on)}$ ,  $t_r$ ,  $t_{d(off)}$ ,  $t_f$



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



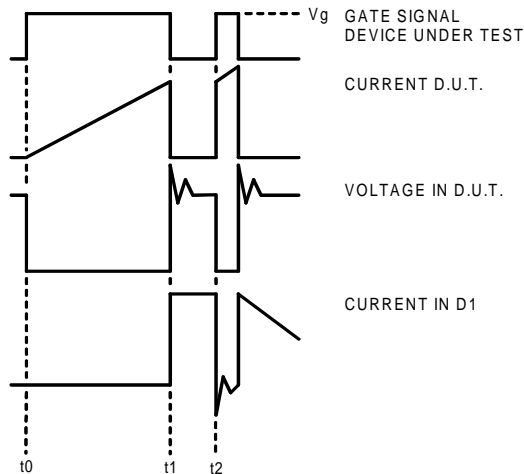


Figure 18e. Macro Waveforms for Figure 18a's Test Circuit

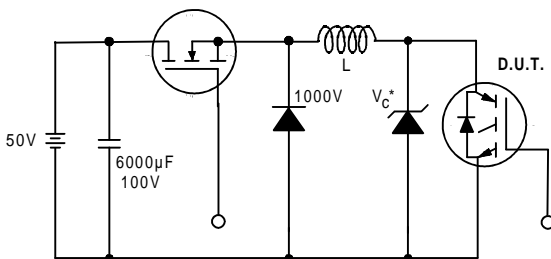


Figure 19. Clamped Inductive Load Test Circuit

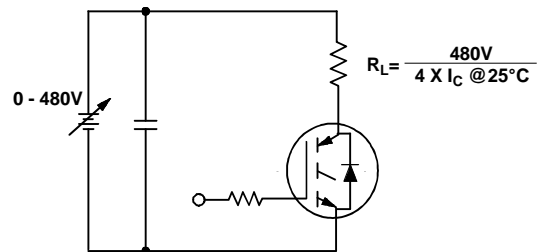


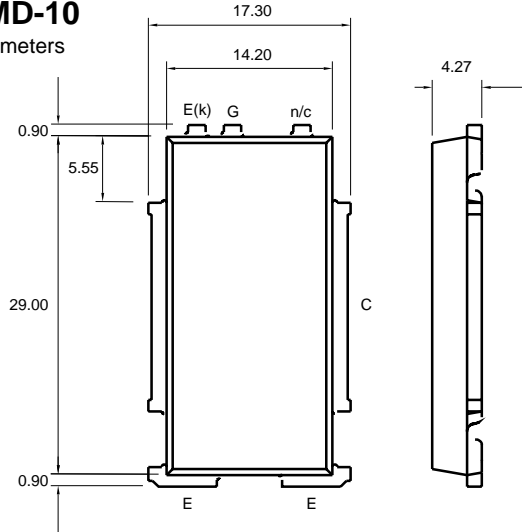
Figure 20. Pulsed Collector Current Test Circuit

**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 — SMD-10**

Dimensions are shown in millimeters



Recommended footprint

