

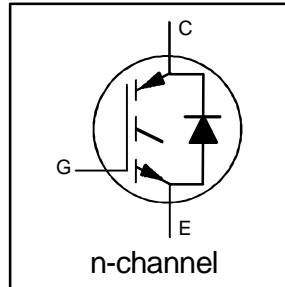
INSULATED GATE BIPOLAR TRANSISTOR  
WITH ULTRAFAST SOFT RECOVERY

Fast CoPack IGBT

DIODE

**Features**

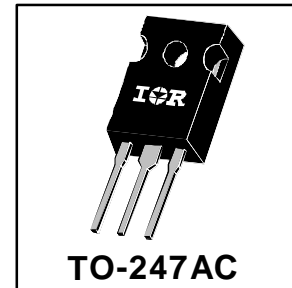
- Switching-loss rating includes all "tail" losses
- HEXFRED™ soft ultrafast diodes
- Optimized for medium operating frequency (1 to 10kHz) See Fig. 1 for Current vs. Frequency curve



$V_{CES} = 1200V$   
 $V_{CE(sat)} \leq 3.3V$   
@  $V_{GE} = 15V, I_C = 17A$

**Description**

Co-packaged IGBTs are a natural extension of International Rectifier's well known IGBT line. They provide the convenience of an IGBT and an ultrafast recovery diode in one package, resulting in substantial benefits to a host of high-voltage, high-current, motor control, UPS and power supply applications.



**Absolute Maximum Ratings**

	Parameter	Max.	Units
$V_{CES}$	Collector-to-Emitter Voltage	1200	V
$I_C @ T_C = 25^\circ C$	Continuous Collector Current	29	A
$I_C @ T_C = 100^\circ C$	Continuous Collector Current	17	
$I_{CM}$	Pulsed Collector Current ①	58	
$I_{LM}$	Clamped Inductive Load Current ②	58	
$I_F @ T_C = 100^\circ C$	Diode Continuous Forward Current	8.0	
$I_{FM}$	Diode Maximum Forward Current	130	V
$V_{GE}$	Gate-to-Emitter Voltage	$\pm 20$	
$P_D @ T_C = 25^\circ C$	Maximum Power Dissipation	160	W
$P_D @ T_C = 100^\circ C$	Maximum Power Dissipation	65	
$T_J$	Operating Junction and	-55 to +150	°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	—	—	0.77	°C/W
$R_{\theta JC}$	Junction-to-Case - Diode	—	—	1.7	
$R_{\theta CS}$	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)

# IRGPH40FD2



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

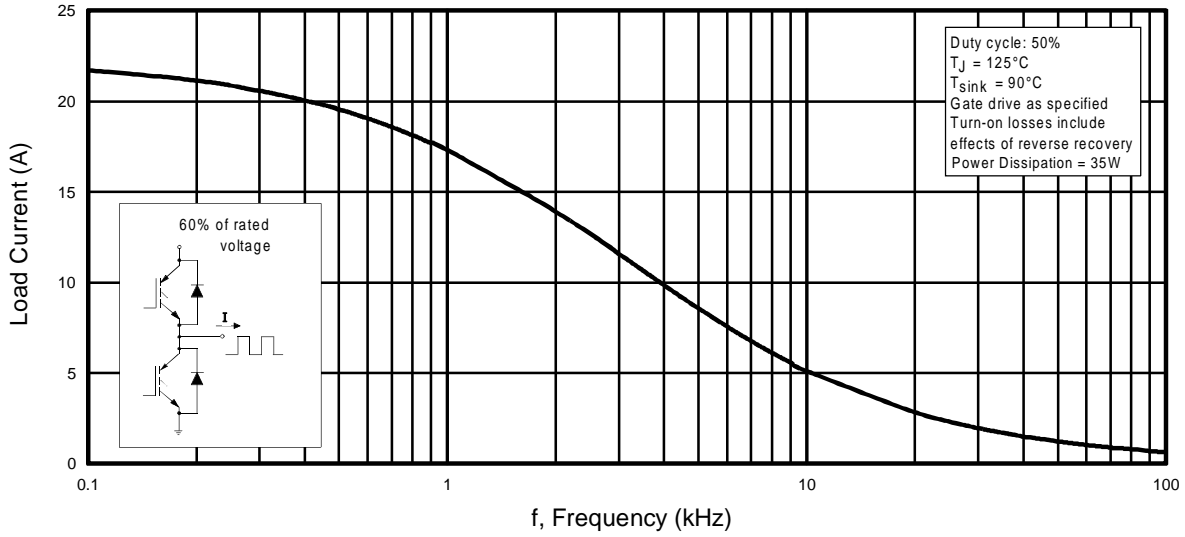
	Parameter	Min.	Typ.	Max.	Units	Conditions
$V_{(BR)CES}$	Collector-to-Emitter Breakdown Voltage ③	1200	—	—	V	$V_{GE} = 0V, I_C = 250\mu A$
$\Delta V_{(BR)CES}/\Delta T_J$	Temperature Coeff. of Breakdown Voltage	—	1.3	—	V/°C	$V_{GE} = 0V, I_C = 1.0mA$
$V_{CE(on)}$	Collector-to-Emitter Saturation Voltage	—	2.5	3.3	V	$I_C = 17A, V_{GE} = 15V$ See Fig. 2, 5
		—	3.2	—		
		—	3.0	—		
$V_{GE(th)}$	Gate Threshold Voltage	3.0	—	5.5		$V_{CE} = V_{GE}, I_C = 250\mu A$
$\Delta V_{GE(th)}/\Delta T_J$	Temperature Coeff. of Threshold Voltage	—	-13	—	mV/°C	$V_{CE} = V_{GE}, I_C = 250\mu A$
$g_{fe}$	Forward Transconductance ④	5.0	11	—	S	$V_{CE} = 100V, I_C = 17A$
$I_{CES}$	Zero Gate Voltage Collector Current	—	—	250	$\mu A$	$V_{GE} = 0V, V_{CE} = 1200V$
		—	—	1000		$V_{GE} = 0V, V_{CE} = 1200V, T_J = 150^\circ\text{C}$
$V_{FM}$	Diode Forward Voltage Drop	—	2.6	3.3	V	$I_C = 8.0A$ See Fig. 13
		—	2.3	3.0		$I_C = 8.0A, T_J = 150^\circ\text{C}$
$I_{GES}$	Gate-to-Emitter Leakage Current	—	—	$\pm 100$	nA	$V_{GE} = \pm 20V$

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

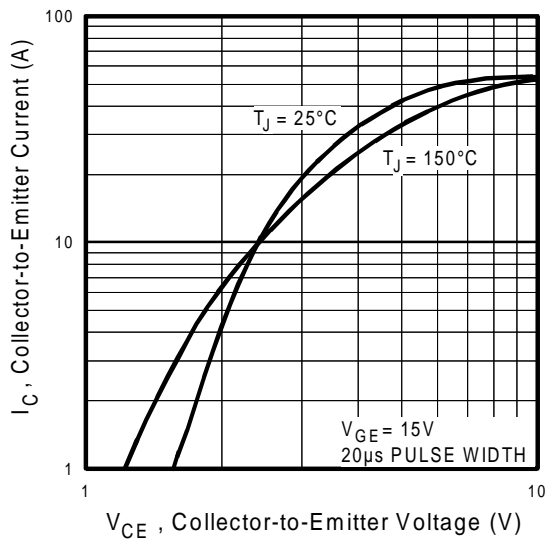
	Parameter	Min.	Typ.	Max.	Units	Conditions
$Q_g$	Total Gate Charge (turn-on)	—	45	67	nC	$I_C = 17A$ $V_{CC} = 400V$ See Fig. 8
$Q_{ge}$	Gate - Emitter Charge (turn-on)	—	11	16		
$Q_{gc}$	Gate - Collector Charge (turn-on)	—	17	26		
$t_{d(on)}$	Turn-On Delay Time	—	70	—	ns	$T_J = 25^\circ\text{C}$ $I_C = 17A, V_{CC} = 800V$ $V_{GE} = 15V, R_G = 10\Omega$ Energy losses include "tail" and diode reverse recovery. See Fig. 9, 10, 11, 18
$t_r$	Rise Time	—	58	—		
$t_{d(off)}$	Turn-Off Delay Time	—	320	550		
$t_f$	Fall Time	—	370	630		
$E_{on}$	Turn-On Switching Loss	—	2.6	—		
$E_{off}$	Turn-Off Switching Loss	—	5.4	—	mJ	$T_J = 150^\circ\text{C}$ , See Fig. 9, 10, 11, 18 $I_C = 17A, V_{CC} = 800V$ $V_{GE} = 15V, R_G = 10\Omega$ Energy losses include "tail" and diode reverse recovery.
$E_{ts}$	Total Switching Loss	—	8.0	15		
$t_{d(on)}$	Turn-On Delay Time	—	70	—		
$t_r$	Rise Time	—	54	—	ns	$T_J = 150^\circ\text{C}$ , See Fig. 9, 10, 11, 18 $I_C = 17A, V_{CC} = 800V$ $V_{GE} = 15V, R_G = 10\Omega$ Energy losses include "tail" and diode reverse recovery.
$t_{d(off)}$	Turn-Off Delay Time	—	670	—		
$t_f$	Fall Time	—	930	—		
$E_{ts}$	Total Switching Loss	—	15	—		
$L_E$	Internal Emitter Inductance	—	13	—	nH	Measured 5mm from package
$C_{ies}$	Input Capacitance	—	1200	—	pF	$V_{GE} = 0V$ $V_{CC} = 30V$ See Fig. 7 $f = 1.0MHz$
$C_{oes}$	Output Capacitance	—	75	—		
$C_{res}$	Reverse Transfer Capacitance	—	15	—		
$t_{rr}$	Diode Reverse Recovery Time	—	63	95	ns	$T_J = 25^\circ\text{C}$ See Fig. 14 $T_J = 125^\circ\text{C}$ 14
		—	106	160		
$I_{rr}$	Diode Peak Reverse Recovery Current	—	4.5	8.0	A	$T_J = 25^\circ\text{C}$ See Fig. 15 $T_J = 125^\circ\text{C}$ 15
		—	6.2	11		
$Q_{rr}$	Diode Reverse Recovery Charge	—	140	380	nC	$T_J = 25^\circ\text{C}$ See Fig. 16 $T_J = 125^\circ\text{C}$ 16
		—	335	880		
$di_{(rec)M}/dt$	Diode Peak Rate of Fall of Recovery During $t_b$	—	133	—	A/ $\mu s$	$T_J = 25^\circ\text{C}$ See Fig. 17 $T_J = 125^\circ\text{C}$ 17
		—	85	—		

### Notes:

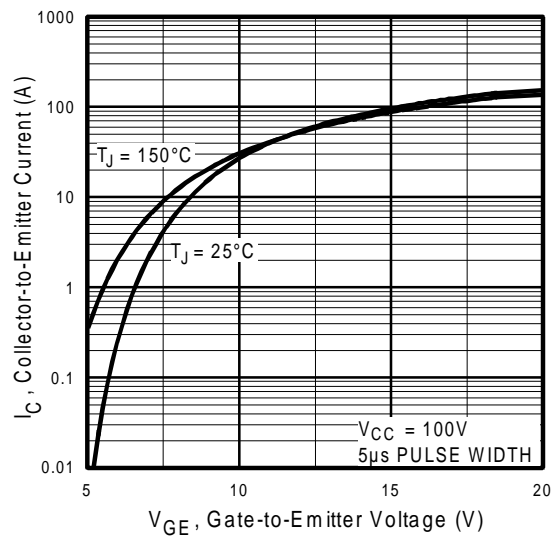
- ① Repetitive rating;  $V_{GE}=20V$ , pulse width limited by max. junction temperature. ( See fig. 20 )
- ②  $V_{CC}=80\%(V_{CES})$ ,  $V_{GE}=20V$ ,  $L=10\mu H$ ,  $R_G=10\Omega$ , ( See fig. 19 )
- ③ Pulse width  $\leq 80\mu s$ ; duty factor  $\leq 0.1\%$ .
- ④ Pulse width 5.0 $\mu s$ , single shot.



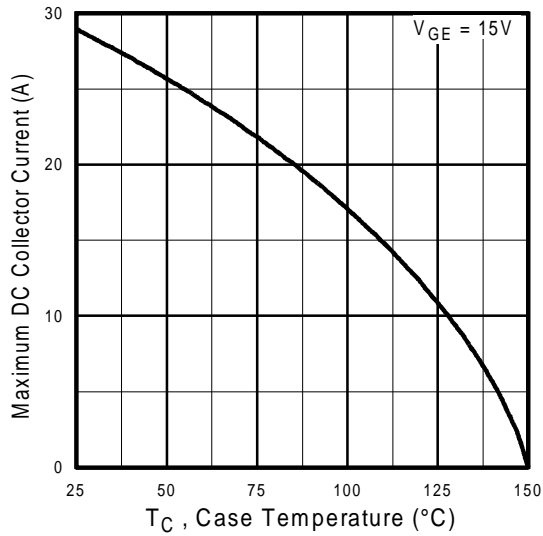
**Fig. 1 - Typical Load Current vs. Frequency**  
(Load Current =  $I_{RMS}$  of fundamental)



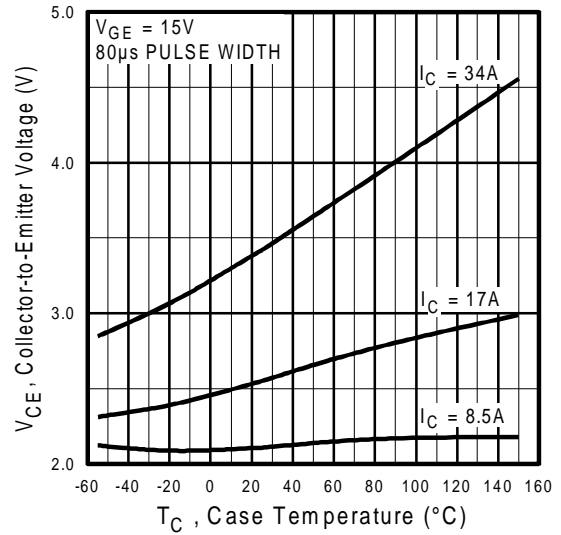
**Fig. 2 - Typical Output Characteristics**



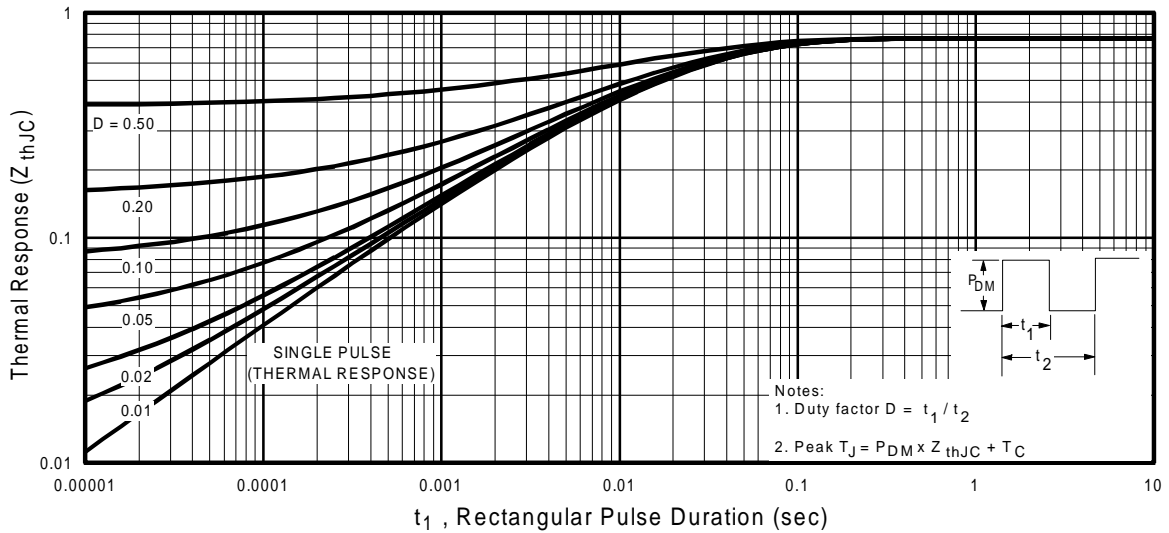
**Fig. 3 - Typical Transfer Characteristics**



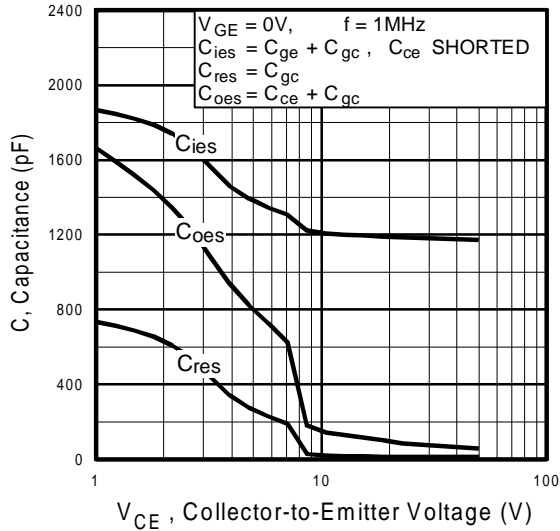
**Fig. 4 - Maximum Collector Current vs. Case Temperature**



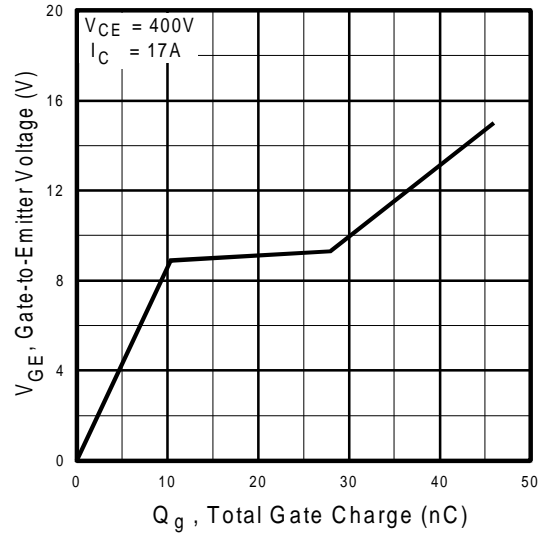
**Fig. 5 - Collector-to-Emitter Voltage vs. Case Temperature**



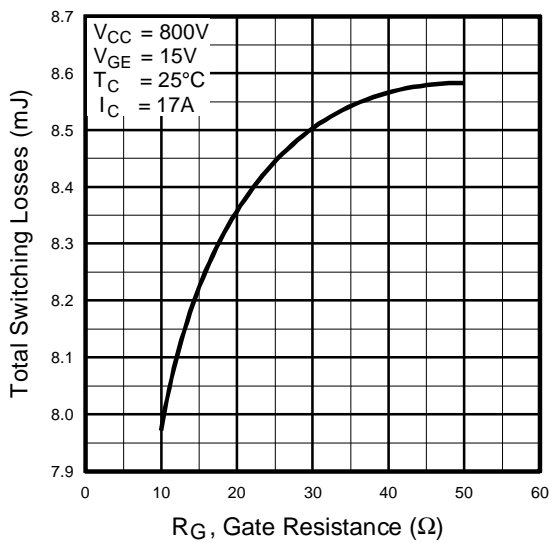
**Fig. 6 - Maximum IGBT Effective Transient Thermal Impedance, Junction-to-Case**



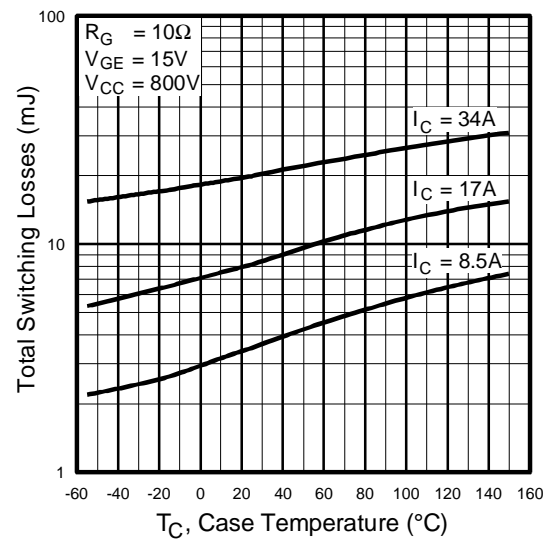
**Fig. 7** - Typical Capacitance vs. Collector-to-Emitter Voltage



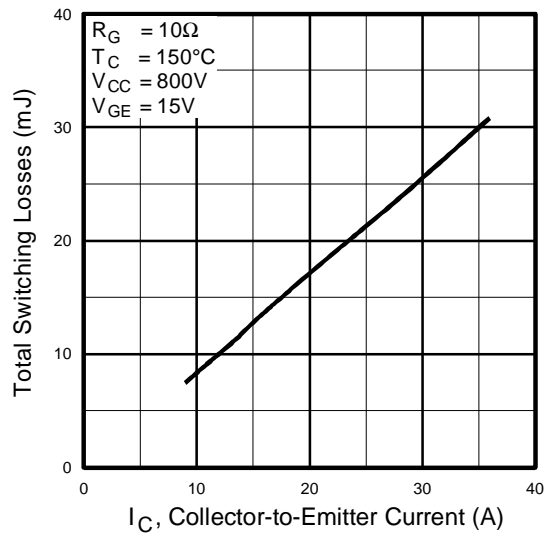
**Fig. 8** - Typical Gate Charge vs. Gate-to-Emitter Voltage



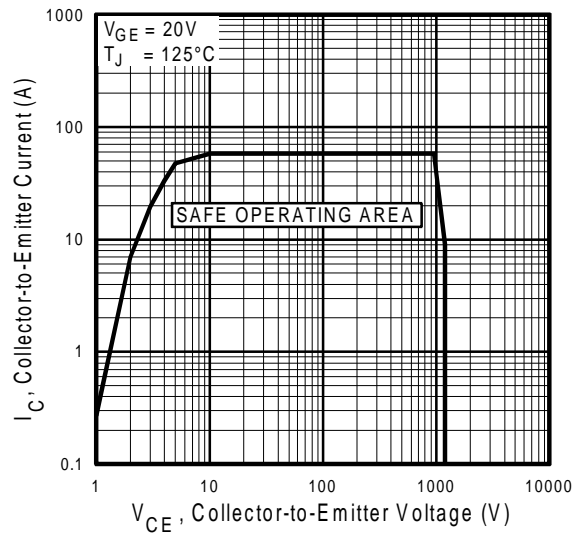
**Fig. 9** - Typical Switching Losses vs. Gate Resistance



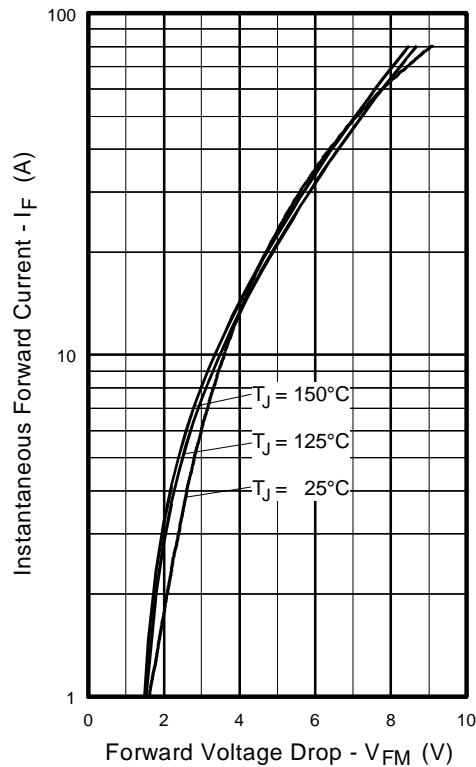
**Fig. 10** - Typical Switching Losses vs. Case Temperature



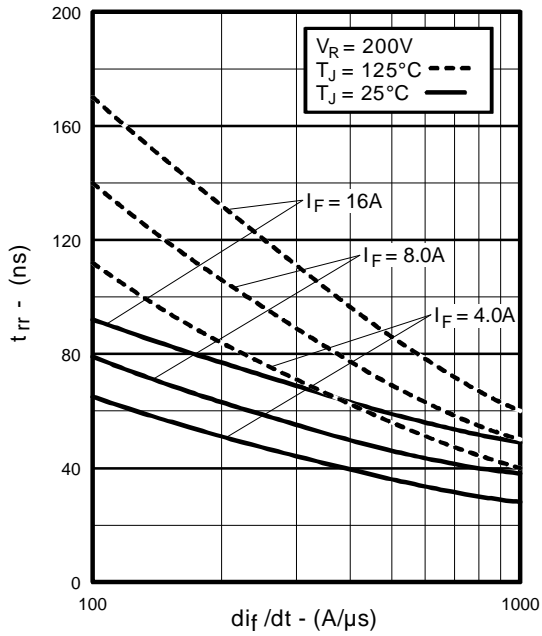
**Fig. 11** - Typical Switching Losses vs. Collector-to-Emitter Current



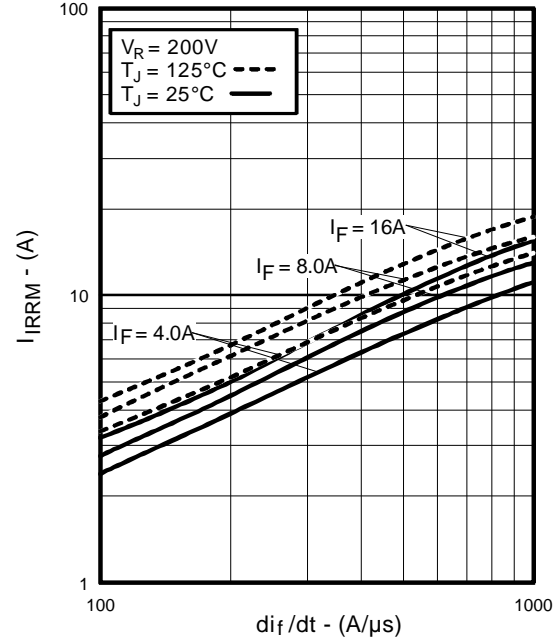
**Fig. 12** - Turn-Off SOA



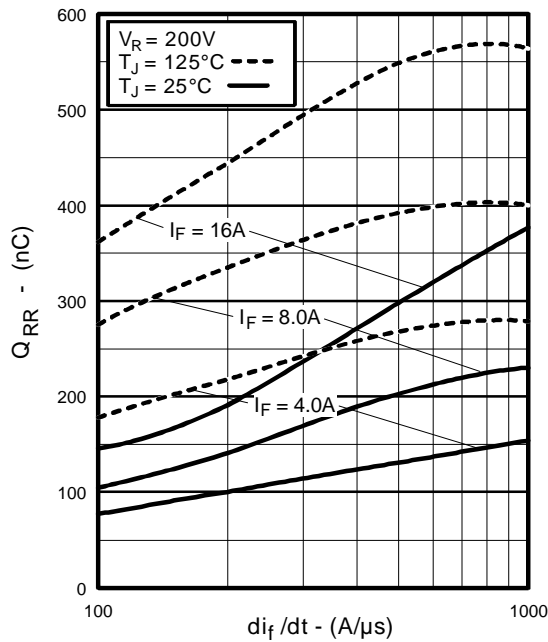
**Fig. 13** - Maximum Forward Voltage Drop vs. Instantaneous Forward Current



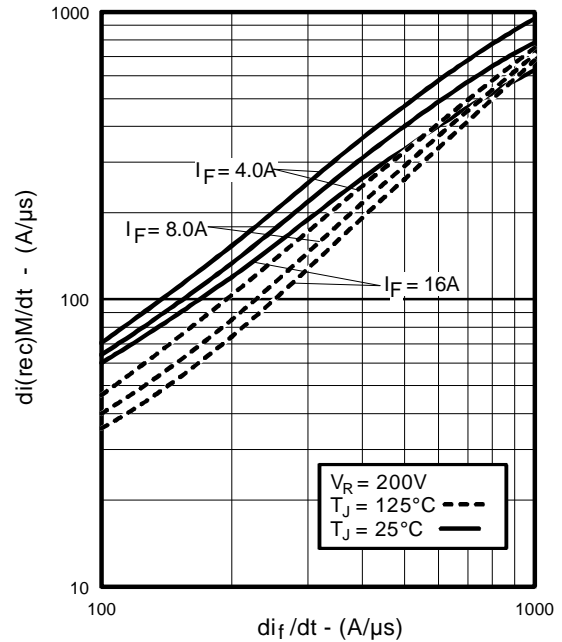
**Fig. 14 - Typical Reverse Recovery vs.  $di_f/dt$**



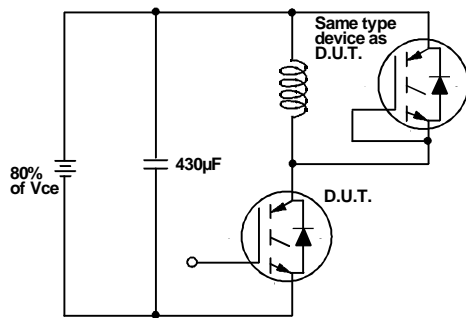
**Fig. 15 - Typical Recovery Current vs.  $di_f/dt$**



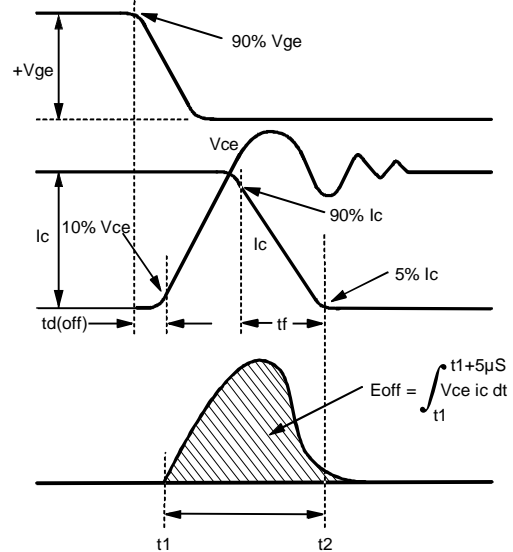
**Fig. 16 - Typical Stored Charge vs.  $di_f/dt$**



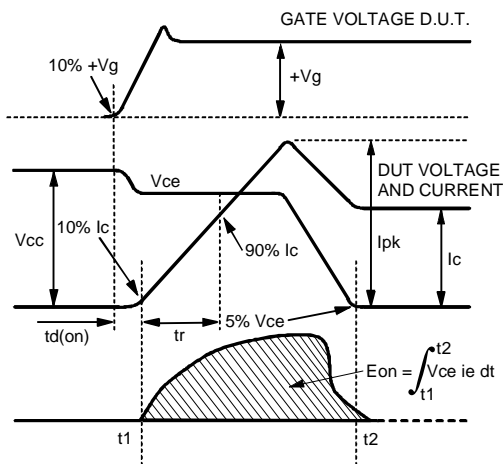
**Fig. 17 - Typical  $di_{(rec)M}/dt$  vs.  $di_f/dt$**



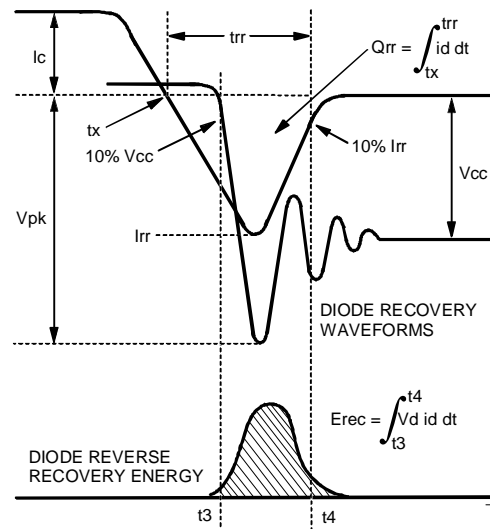
**Fig. 18a** - Test Circuit for Measurement of  $I_{LM}$ ,  $E_{on}$ ,  $E_{off}(\text{diode})$ ,  $t_{rr}$ ,  $Q_{rr}$ ,  $I_{rr}$ ,  $t_{d(on)}$ ,  $t_r$ ,  $t_{d(off)}$ ,  $t_f$



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

Refer to Section D for the following:  
Appendix H: Section D - page D-10

- Fig. 18e - Macro Waveforms for Test Circuit Fig. 18a
- Fig. 19 - Clamped Inductive Load Test Circuit
- Fig. 20 - Pulsed Collector Current Test Circuit