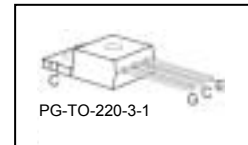
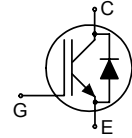


## Low Loss DuoPack : IGBT in TrenchStop® and Fieldstop technology with soft, fast recovery anti-parallel EmCon HE diode

- Very low  $V_{CE(sat)}$  1.5 V (typ.)
- Maximum Junction Temperature 175 °C
- Short circuit withstand time – 5µs
- Designed for :
  - Variable Speed Drive for washing machines, air conditioners and induction cooking
  - Uninterrupted Power Supply
- TrenchStop® and Fieldstop technology for 600 V applications offers :
  - very tight parameter distribution
  - high ruggedness, temperature stable behaviour
- Low EMI
- Very soft, fast recovery anti-parallel EmCon HE diode
- Qualified according to JEDEC<sup>1</sup> for target applications
- Pb-free lead plating; RoHS compliant
- Complete product spectrum and PSpice Models : <http://www.infineon.com/igbt/>



Type	$V_{CE}$	$I_C; T_C=100^\circ\text{C}$	$V_{CE(sat)}, T_J=25^\circ\text{C}$	$T_{j,max}$	Marking	Package
IKP06N60T	600V	6A	1.5V	175°C	K06T60	PG-TO-220-3-1

### Maximum Ratings

Parameter	Symbol	Value	Unit
Collector-emitter voltage	$V_{CE}$	600	V
DC collector current, limited by $T_{jmax}$ $T_C = 25^\circ\text{C}$ $T_C = 100^\circ\text{C}$	$I_C$	12 6	A
Pulsed collector current, $t_p$ limited by $T_{jmax}$	$I_{Cpuls}$	18	
Turn off safe operating area $V_{CE} \leq 600\text{V}, T_J \leq 175^\circ\text{C}$	-	18	
Diode forward current, limited by $T_{jmax}$ $T_C = 25^\circ\text{C}$ $T_C = 100^\circ\text{C}$	$I_F$	12 6	
Diode pulsed current, $t_p$ limited by $T_{jmax}$	$I_{Fpuls}$	18	
Gate-emitter voltage	$V_{GE}$	$\pm 20$	V
Short circuit withstand time <sup>2)</sup> $V_{GE} = 15\text{V}, V_{CC} \leq 400\text{V}, T_J \leq 150^\circ\text{C}$	$t_{SC}$	5	µs
Power dissipation $T_C = 25^\circ\text{C}$	$P_{tot}$	88	W
Operating junction temperature	$T_J$	-40...+175	°C
Storage temperature	$T_{stg}$	-55...+175	
Soldering temperature wavesoldering, 1.6 mm (0.063 in.) from case for 10s		260	

<sup>1</sup> J-STD-020 and JESD-022

<sup>2)</sup> Allowed number of short circuits: <1000; time between short circuits: >1s.

**Thermal Resistance**

Parameter	Symbol	Conditions	Max. Value	Unit
<b>Characteristic</b>				
IGBT thermal resistance, junction – case	$R_{thJC}$		1.7	K/W
Diode thermal resistance, junction – case	$R_{thJCD}$		2.6	
Thermal resistance, junction – ambient	$R_{thJA}$		62	

**Electrical Characteristic, at  $T_j = 25^\circ\text{C}$ , unless otherwise specified**

Parameter	Symbol	Conditions	Value			Unit
			min.	typ.	max.	
<b>Static Characteristic</b>						
Collector-emitter breakdown voltage	$V_{(BR)CES}$	$V_{GE}=0V$ , $I_C=0.25mA$	600	-	-	V
Collector-emitter saturation voltage	$V_{CE(sat)}$	$V_{GE} = 15V$ , $I_C=6A$ $T_j=25^\circ\text{C}$ $T_j=175^\circ\text{C}$	- -	1.5 1.8	2.05	
Diode forward voltage	$V_F$	$V_{GE}=0V$ , $I_F=6A$ $T_j=25^\circ\text{C}$ $T_j=175^\circ\text{C}$	- -	1.6 1.6	2.05 -	
Gate-emitter threshold voltage	$V_{GE(th)}$	$I_C=0.18mA$ , $V_{CE}=V_{GE}$	4.1	4.6	5.7	
Zero gate voltage collector current	$I_{CES}$	$V_{CE}=600V$ , $V_{GE}=0V$ $T_j=25^\circ\text{C}$ $T_j=175^\circ\text{C}$	- -	- -	40 700	$\mu\text{A}$
Gate-emitter leakage current	$I_{GES}$	$V_{CE}=0V$ , $V_{GE}=20V$	-	-	100	nA
Transconductance	$g_{fs}$	$V_{CE}=20V$ , $I_C=6A$	-	3.6	-	S
Integrated gate resistor	$R_{Gint}$		none			$\Omega$

**Dynamic Characteristic**

Input capacitance	$C_{iss}$	$V_{CE}=25V$ , $V_{GE}=0V$ , $f=1MHz$	-	368	-	pF
Output capacitance	$C_{oss}$		-	28	-	
Reverse transfer capacitance	$C_{riss}$		-	11	-	
Gate charge	$Q_{Gate}$	$V_{CC}=480V$ , $I_C=6A$ $V_{GE}=15V$	-	42	-	nC
Internal emitter inductance measured 5mm (0.197 in.) from case	$L_E$		-	7	-	nH
Short circuit collector current <sup>1)</sup>	$I_{C(SC)}$	$V_{GE}=15V$ , $t_{SC}\leq 5\mu\text{s}$ $V_{CC} = 400V$ , $T_j = 25^\circ\text{C}$	-	55	-	A

<sup>1)</sup> Allowed number of short circuits: <1000; time between short circuits: >1s.

### Switching Characteristic, Inductive Load, at $T_j=25^\circ\text{C}$

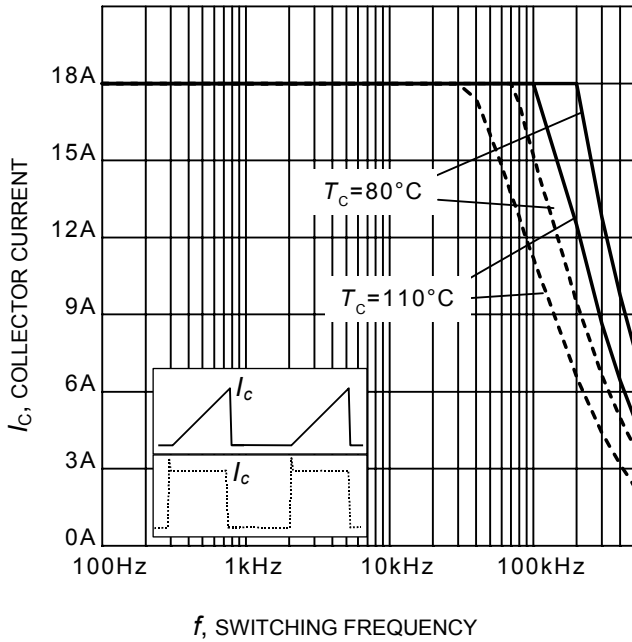
Parameter	Symbol	Conditions	Value			Unit
			min.	typ.	max.	
<b>IGBT Characteristic</b>						
Turn-on delay time	$t_{d(on)}$	$T_j=25^\circ\text{C}$ , $V_{CC}=400\text{V}$ , $I_C=6\text{A}$ , $V_{GE}=0/15\text{V}$ , $R_G=23\Omega$ , $L_{\sigma}^{(2)}=60\text{nH}$ , $C_{\sigma}^{(2)}=40\text{pF}$ Energy losses include "tail" and diode reverse recovery.	-	9	-	ns
Rise time	$t_r$		-	6	-	
Turn-off delay time	$t_{d(off)}$		-	130	-	
Fall time	$t_f$		-	58	-	
Turn-on energy	$E_{on}$		-	0.09	-	mJ
Turn-off energy	$E_{off}$		-	0.11	-	
Total switching energy	$E_{ts}$		-	0.2	-	
<b>Anti-Parallel Diode Characteristic</b>						
Diode reverse recovery time	$t_{rr}$	$T_j=25^\circ\text{C}$ , $V_R=400\text{V}$ , $I_F=6\text{A}$ , $di_F/dt=550\text{A}/\mu\text{s}$	-	123	-	ns
Diode reverse recovery charge	$Q_{rr}$		-	190	-	nC
Diode peak reverse recovery current	$I_{rrm}$		-	5.3	-	A
Diode peak rate of fall of reverse recovery current during $t_b$	$di_{rr}/dt$		-	450	-	A/ $\mu\text{s}$

### Switching Characteristic, Inductive Load, at $T_j=175^\circ\text{C}$

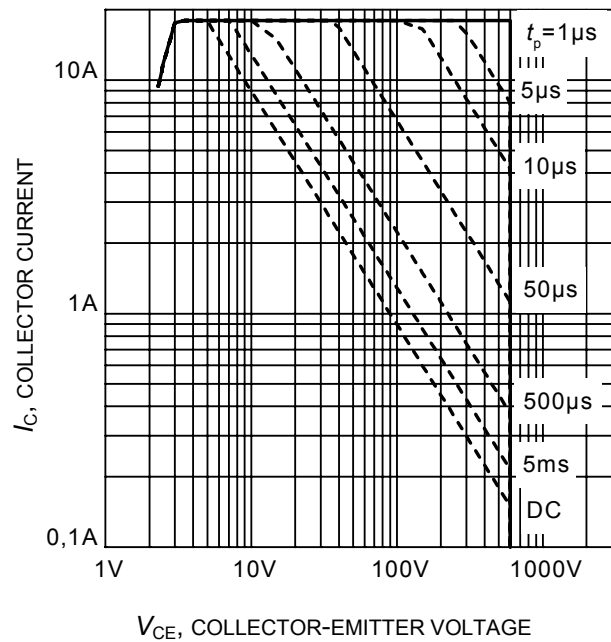
Parameter	Symbol	Conditions	Value			Unit
			min.	typ.	max.	
<b>IGBT Characteristic</b>						
Turn-on delay time	$t_{d(on)}$	$T_j=175^\circ\text{C}$ , $V_{CC}=400\text{V}$ , $I_C=6\text{A}$ , $V_{GE}=0/15\text{V}$ , $R_G=23\Omega$ , $L_{\sigma}^{(1)}=60\text{nH}$ , $C_{\sigma}^{(1)}=40\text{pF}$ Energy losses include "tail" and diode reverse recovery.	-	9	-	ns
Rise time	$t_r$		-	8	-	
Turn-off delay time	$t_{d(off)}$		-	165	-	
Fall time	$t_f$		-	84	-	
Turn-on energy	$E_{on}$		-	0.14	-	mJ
Turn-off energy	$E_{off}$		-	0.18	-	
Total switching energy	$E_{ts}$		-	0.335	-	
<b>Anti-Parallel Diode Characteristic</b>						
Diode reverse recovery time	$t_{rr}$	$T_j=175^\circ\text{C}$ , $V_R=400\text{V}$ , $I_F=6\text{A}$ , $di_F/dt=550\text{A}/\mu\text{s}$	-	180	-	ns
Diode reverse recovery charge	$Q_{rr}$		-	500	-	nC
Diode peak reverse recovery current	$I_{rrm}$		-	7.6	-	A
Diode peak rate of fall of reverse recovery current during $t_b$	$di_{rr}/dt$		-	285	-	A/ $\mu\text{s}$

2) Leakage inductance  $L_{\sigma}$  and Stray capacity  $C_{\sigma}$  due to dynamic test circuit in Figure E.

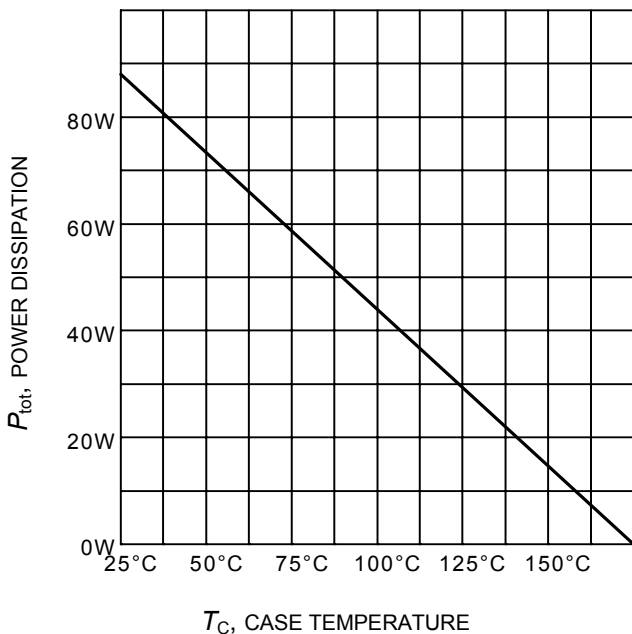
1) Leakage inductance  $L_{\sigma}$  and Stray capacity  $C_{\sigma}$  due to dynamic test circuit in Figure E.



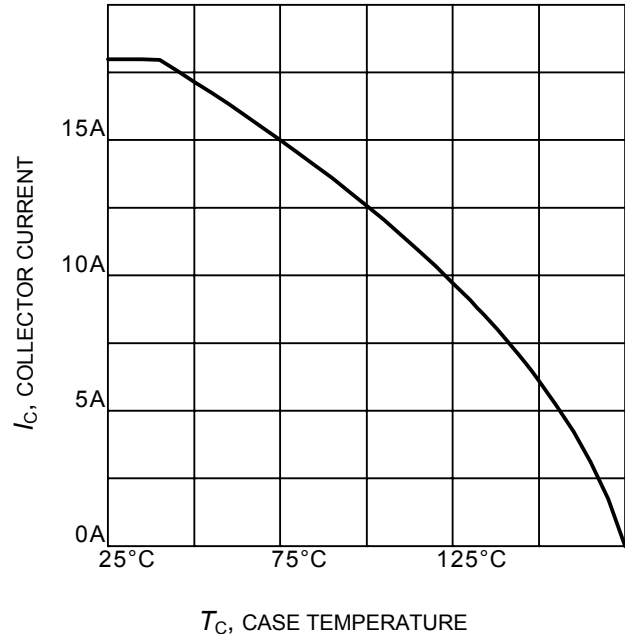
**Figure 1. Collector current as a function of switching frequency**  
 ( $T_j \leq 175^\circ\text{C}$ ,  $D = 0.5$ ,  $V_{CE} = 400\text{V}$ ,  
 $V_{GE} = 0/+15\text{V}$ ,  $R_G = 23\Omega$ )



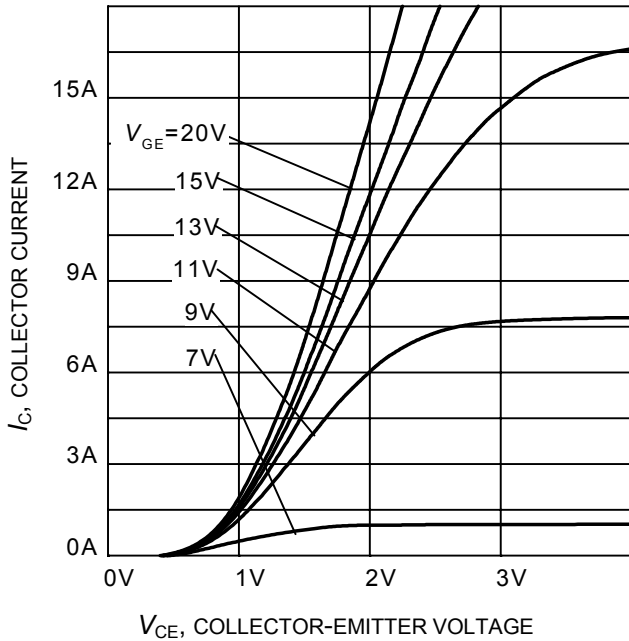
**Figure 2. Safe operating area**  
 ( $D = 0$ ,  $T_C = 25^\circ\text{C}$ ,  
 $T_j \leq 175^\circ\text{C}$ ;  $V_{GE} = 15\text{V}$ )



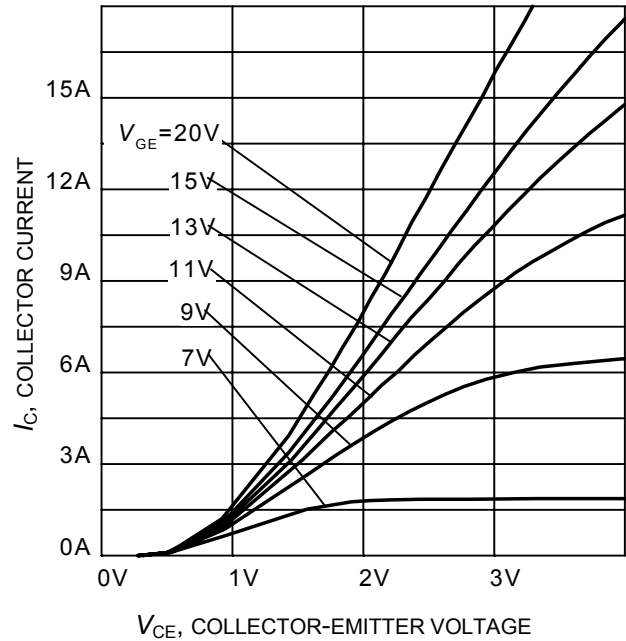
**Figure 3. Power dissipation as a function of case temperature**  
 ( $T_j \leq 175^\circ\text{C}$ )



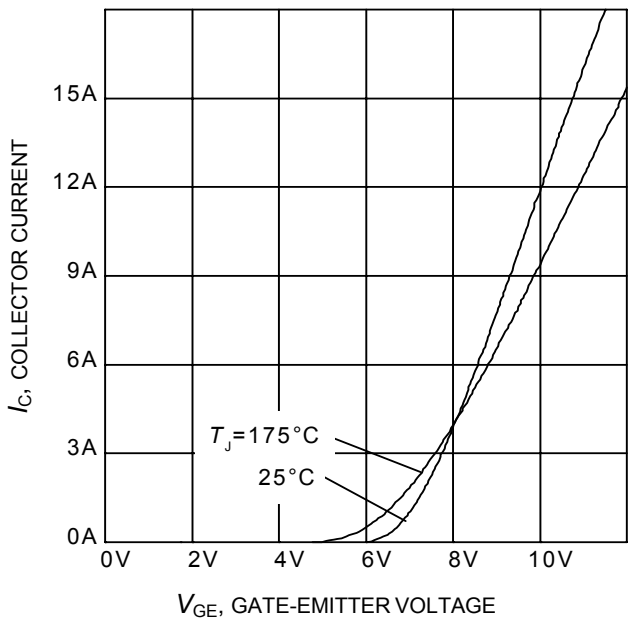
**Figure 4. Collector current as a function of case temperature**  
 ( $V_{GE} \geq 15\text{V}$ ,  $T_j \leq 175^\circ\text{C}$ )



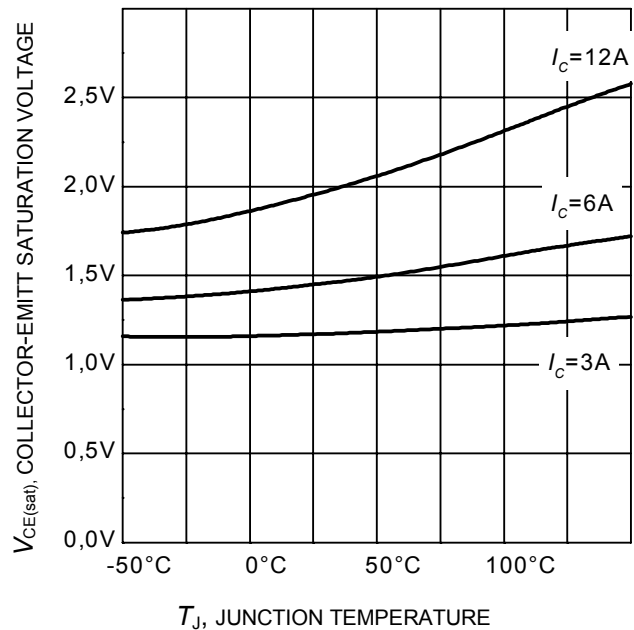
**Figure 5. Typical output characteristic**  
( $T_j = 25^\circ\text{C}$ )



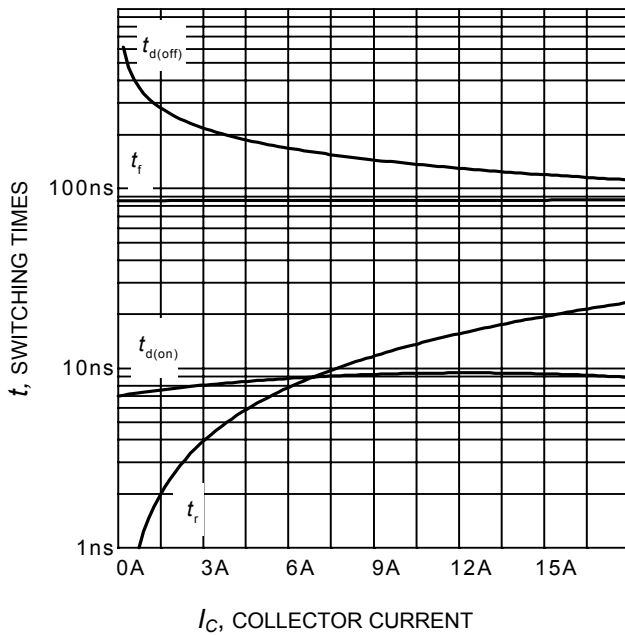
**Figure 6. Typical output characteristic**  
( $T_j = 175^\circ\text{C}$ )



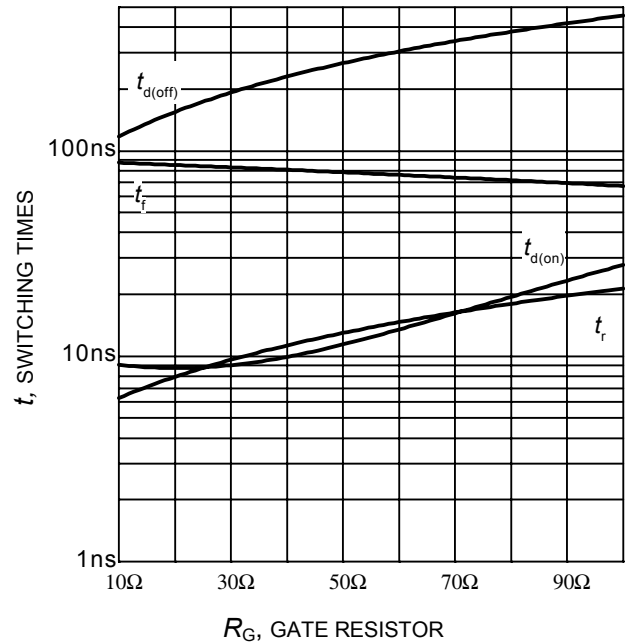
**Figure 7. Typical transfer characteristic**  
( $V_{CE} = 20\text{V}$ )



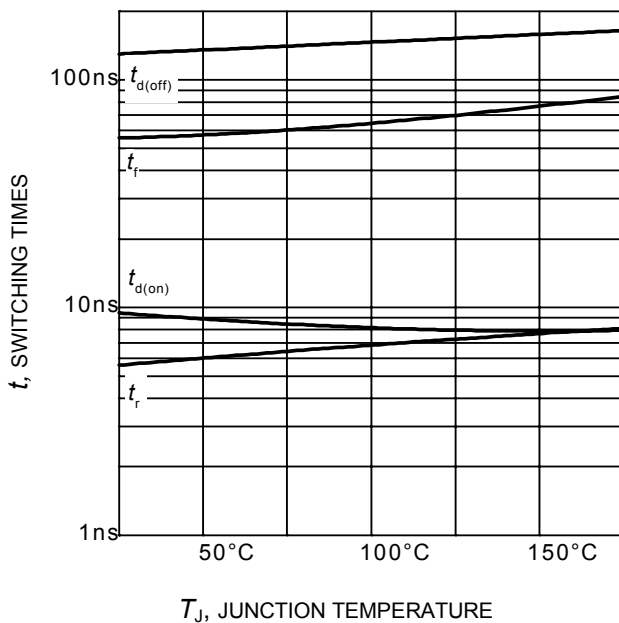
**Figure 8. Typical collector-emitter saturation voltage as a function of junction temperature**  
( $V_{GE} = 15\text{V}$ )



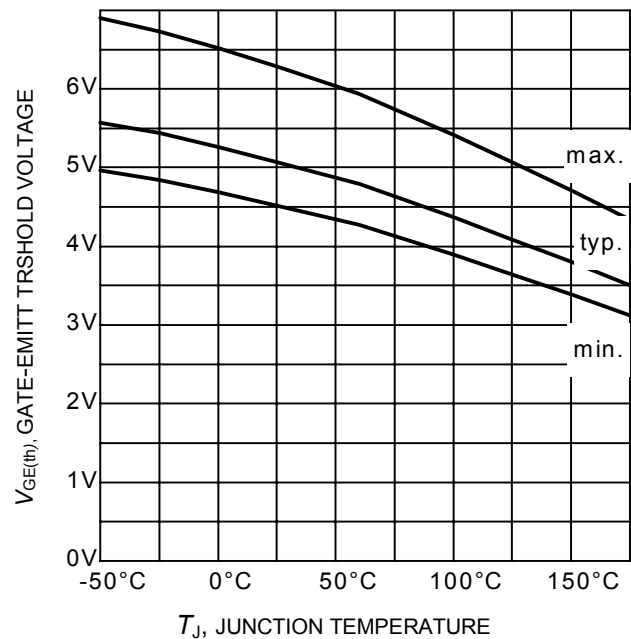
**Figure 9. Typical switching times as a function of collector current**  
 (inductive load,  $T_J=175^\circ\text{C}$ ,  $V_{CE} = 400\text{V}$ ,  $V_{GE} = 0/15\text{V}$ ,  $R_G = 23\Omega$ , Dynamic test circuit in Figure E)



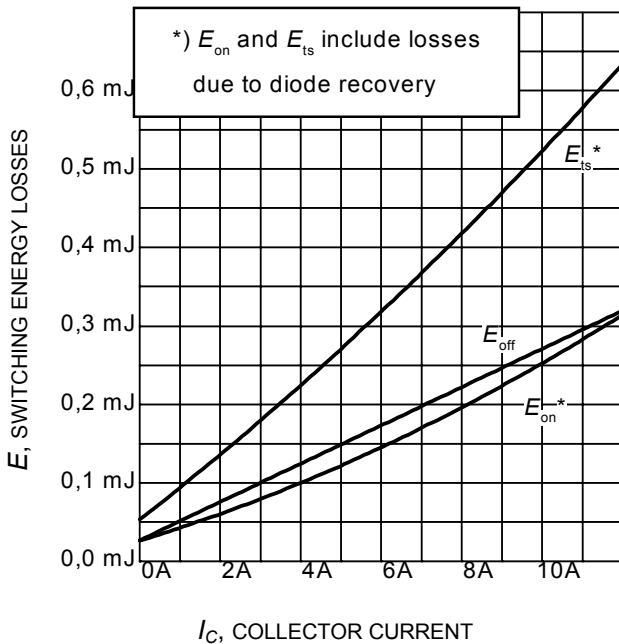
**Figure 10. Typical switching times as a function of gate resistor**  
 (inductive load,  $T_J=175^\circ\text{C}$ ,  $V_{CE} = 400\text{V}$ ,  $V_{GE} = 0/15\text{V}$ ,  $I_C = 6\text{A}$ , Dynamic test circuit in Figure E)



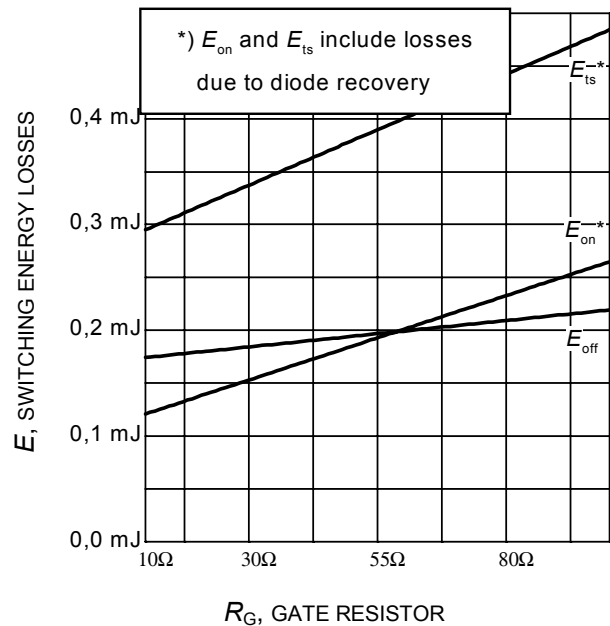
**Figure 11. Typical switching times as a function of junction temperature**  
 (inductive load,  $V_{CE} = 400\text{V}$ ,  $V_{GE} = 0/15\text{V}$ ,  $I_C = 6\text{A}$ ,  $R_G = 23\Omega$ , Dynamic test circuit in Figure E)



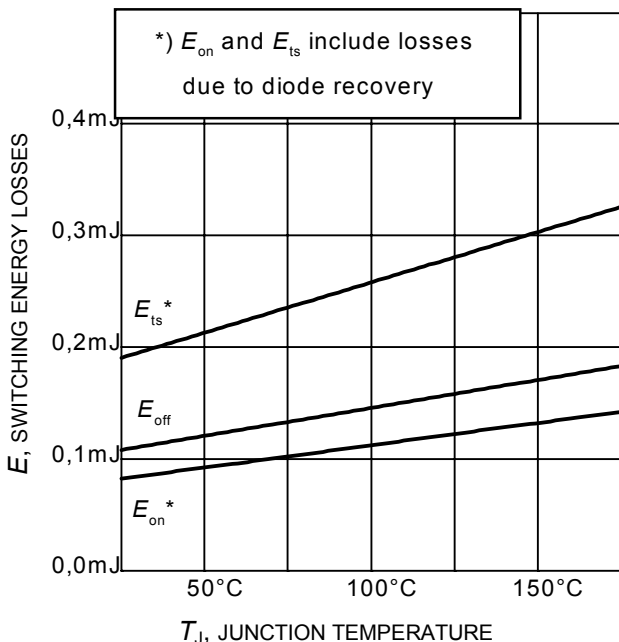
**Figure 12. Gate-emitter threshold voltage as a function of junction temperature**  
 ( $I_C = 0.18\text{mA}$ )



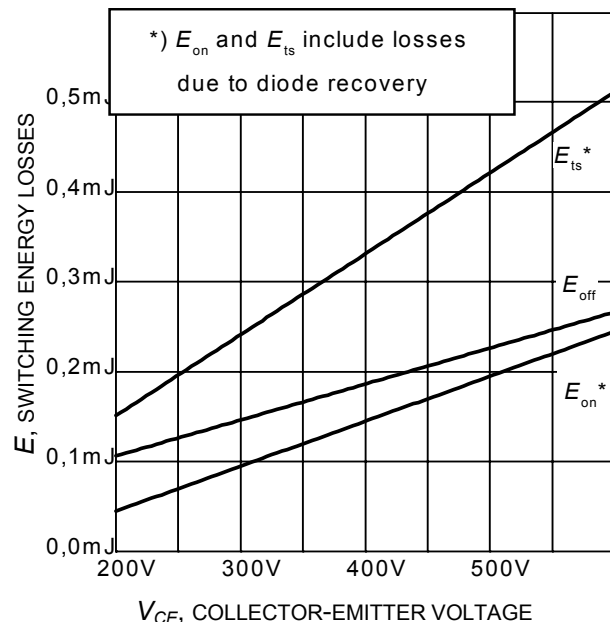
**Figure 13. Typical switching energy losses as a function of collector current**  
(inductive load,  $T_J=175^\circ\text{C}$ ,  $V_{CE}=400\text{V}$ ,  $V_{GE}=0/15\text{V}$ ,  $R_G=23\Omega$ , Dynamic test circuit in Figure E)



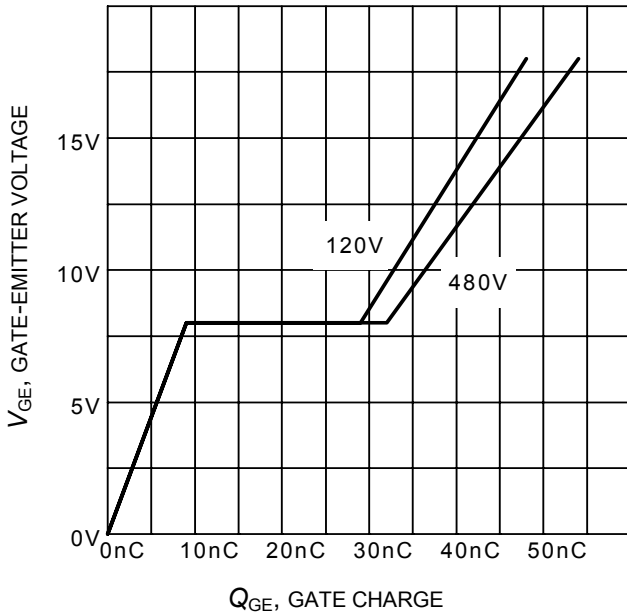
**Figure 14. Typical switching energy losses as a function of gate resistor**  
(inductive load,  $T_J=175^\circ\text{C}$ ,  $V_{CE}=400\text{V}$ ,  $V_{GE}=0/15\text{V}$ ,  $I_C=6\text{A}$ , Dynamic test circuit in Figure E)



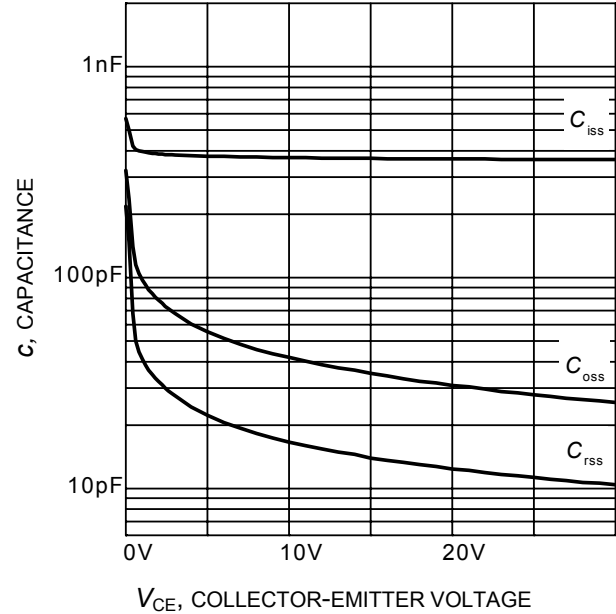
**Figure 15. Typical switching energy losses as a function of junction temperature**  
(inductive load,  $V_{CE}=400\text{V}$ ,  $V_{GE}=0/15\text{V}$ ,  $I_C=6\text{A}$ ,  $R_G=23\Omega$ , Dynamic test circuit in Figure E)



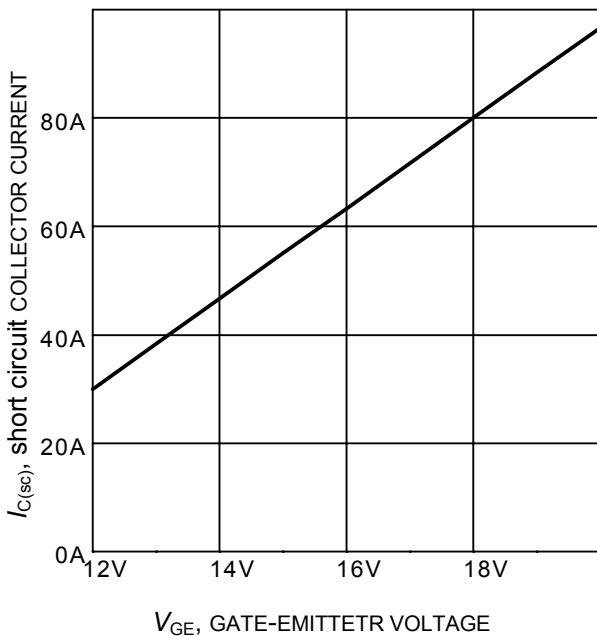
**Figure 16. Typical switching energy losses as a function of collector emitter voltage**  
(inductive load,  $T_J=175^\circ\text{C}$ ,  $V_{GE}=0/15\text{V}$ ,  $I_C=6\text{A}$ ,  $R_G=23\Omega$ , Dynamic test circuit in Figure E)



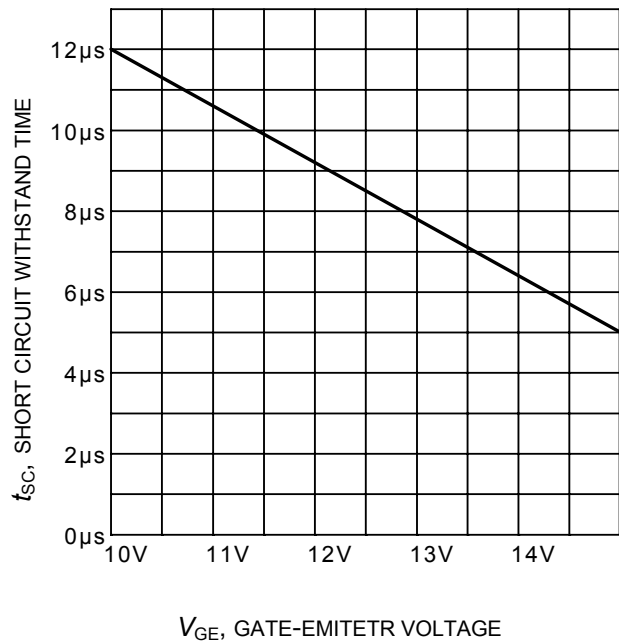
**Figure 17. Typical gate charge**  
( $I_C = 6\text{ A}$ )



**Figure 18. Typical capacitance as a function of collector-emitter voltage**  
( $V_{GE} = 0\text{ V}$ ,  $f = 1\text{ MHz}$ )



**Figure 19. Typical short circuit collector current as a function of gate-emitter voltage**  
( $V_{CE} \leq 400\text{ V}$ ,  $T_J \leq 150^\circ\text{C}$ )



**Figure 20. Short circuit withstand time as a function of gate-emitter voltage**  
( $V_{CE} = 600\text{ V}$ , start at  $T_J = 25^\circ\text{C}$ ,  $T_{Jmax} < 150^\circ\text{C}$ )



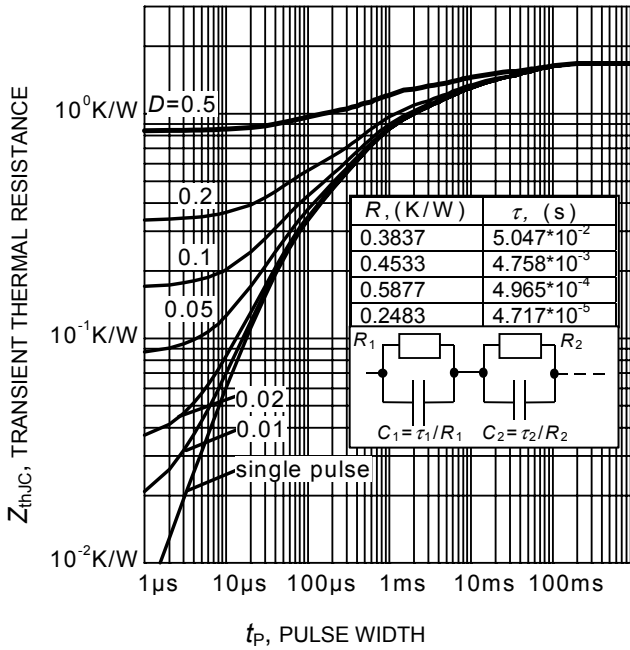


Figure 21. IGBT transient thermal resistance ( $D = t_p / T$ )

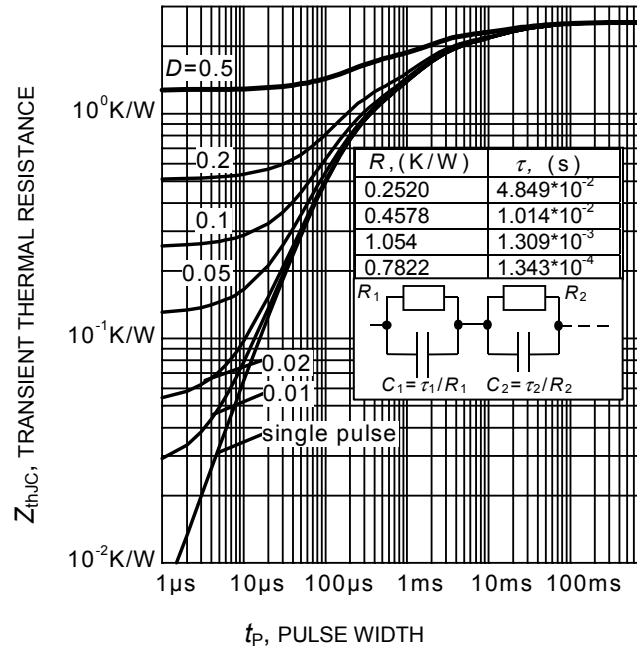


Figure 22. Diode transient thermal impedance as a function of pulse width ( $D = t_p / T$ )

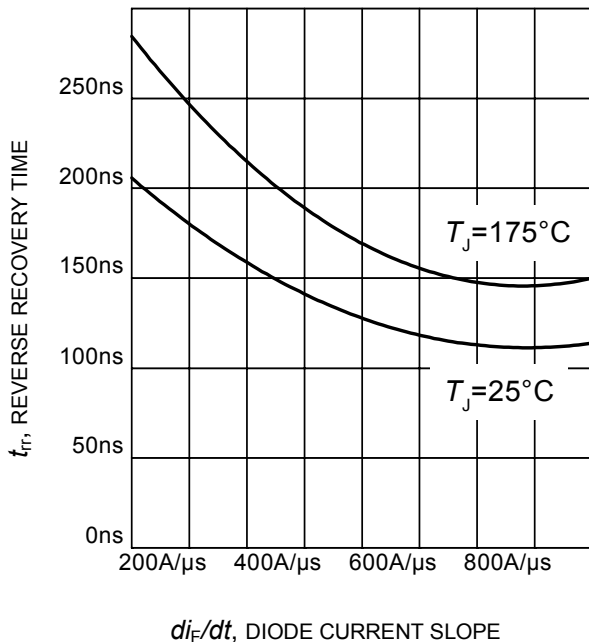


Figure 23. Typical reverse recovery time as a function of diode current slope ( $V_R = 400V$ ,  $I_F = 6A$ , Dynamic test circuit in Figure E)

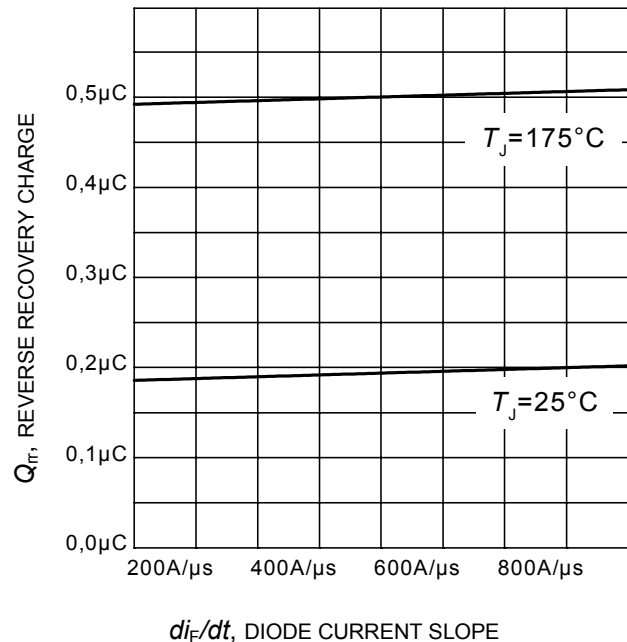
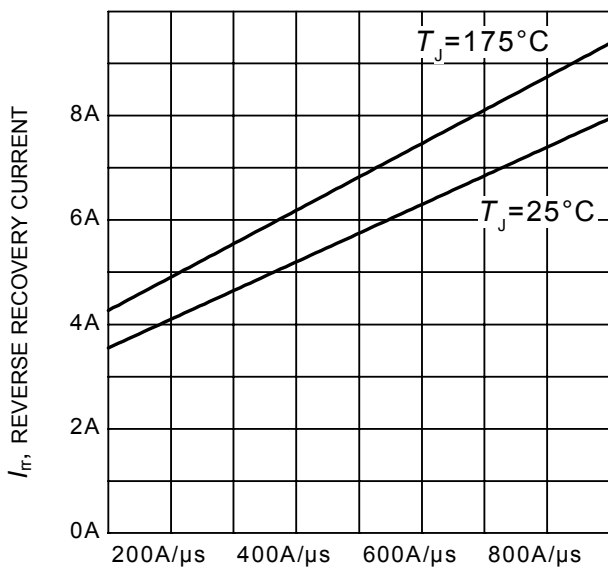


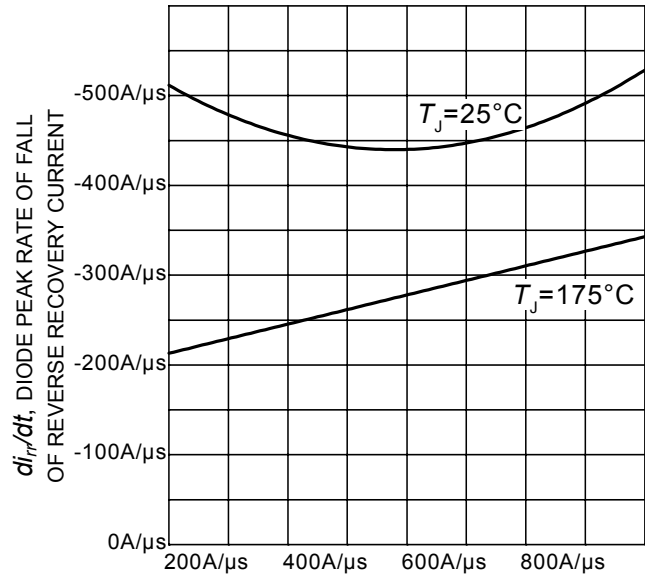
Figure 24. Typical reverse recovery charge as a function of diode current slope ( $V_R = 400V$ ,  $I_F = 6A$ , Dynamic test circuit in Figure E)



$di_F/dt$ , DIODE CURRENT SLOPE

**Figure 25. Typical reverse recovery current as a function of diode current slope**

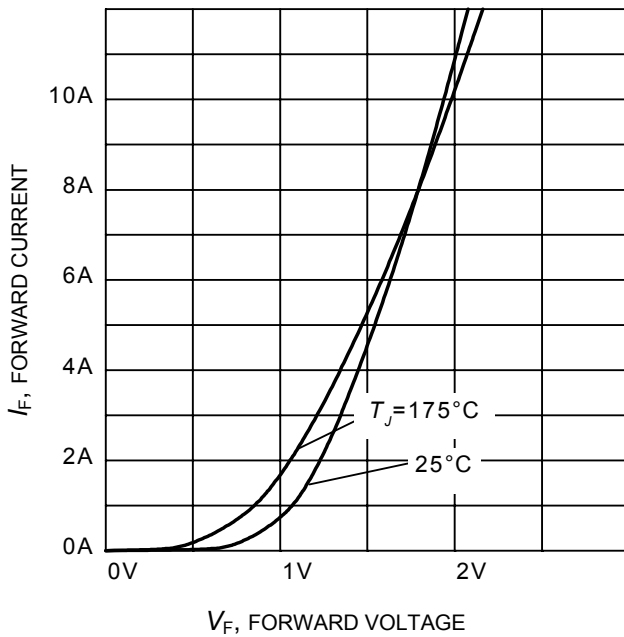
( $V_R = 400V$ ,  $I_F = 6A$ ,  
Dynamic test circuit in Figure E)



$di_F/dt$ , DIODE CURRENT SLOPE

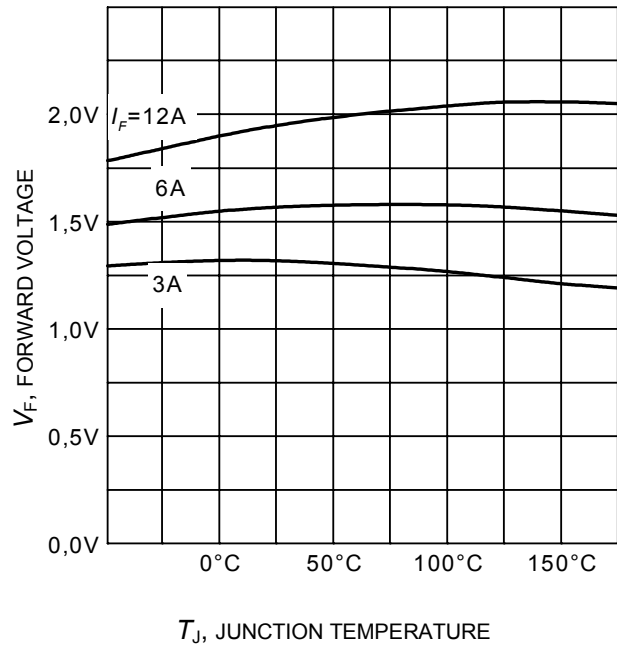
**Figure 26. Typical diode peak rate of fall of reverse recovery current as a function of diode current slope**

( $V_R = 400V$ ,  $I_F = 6A$ ,  
Dynamic test circuit in Figure E)



$V_F$ , FORWARD VOLTAGE

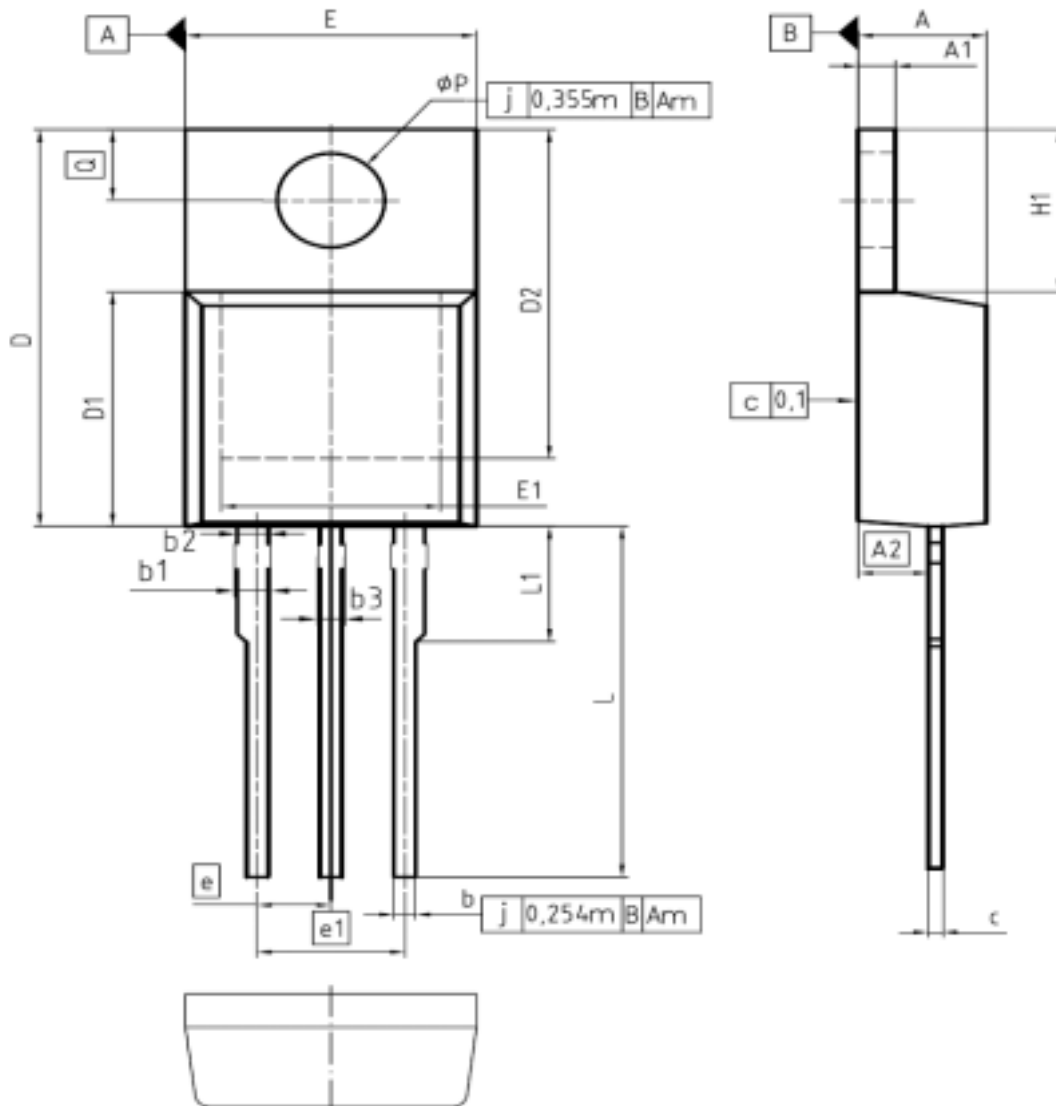
**Figure 27. Typical diode forward current as a function of forward voltage**



$T_J$ , JUNCTION TEMPERATURE

**Figure 28. Typical diode forward voltage as a function of junction temperature**

PG-TO-220-3-1



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.30	4.57	0.169	0.180
A1	1.17	1.40	0.046	0.055
A2	2.15	2.72	0.085	0.107
b	0.65	0.86	0.026	0.034
b1	0.95	1.40	0.037	0.055
b2	0.95	1.15	0.037	0.045
b3	0.65	1.15	0.026	0.045
c	0.33	0.60	0.013	0.024
D	14.81	15.95	0.583	0.628
D1	8.51	9.45	0.335	0.372
D2	12.19	13.10	0.480	0.516
E	9.70	10.36	0.382	0.408
E1	6.50	8.60	0.256	0.339
e	2.54		0.100	
e1	5.08		0.200	
N	3		3	
H1	5.90	6.90	0.232	0.272
L	13.00	14.00	0.512	0.551
L1	-	4.80	-	0.189
φP	3.60	3.89	0.142	0.153
Q	2.60	3.00	0.102	0.118

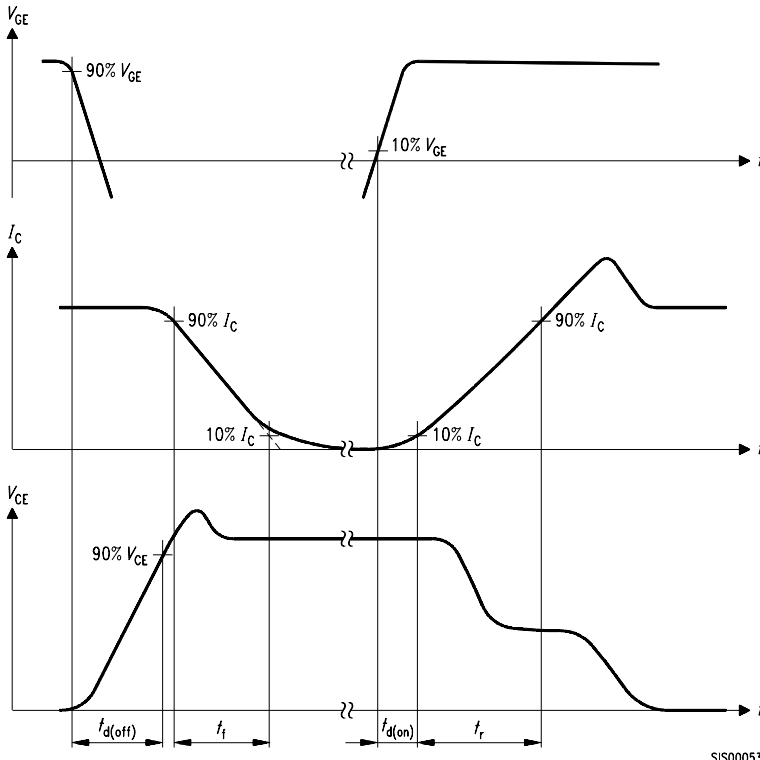
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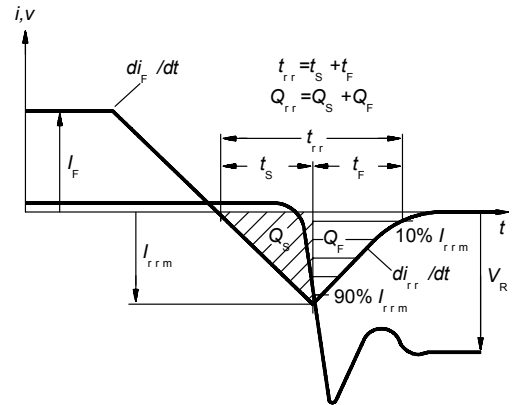
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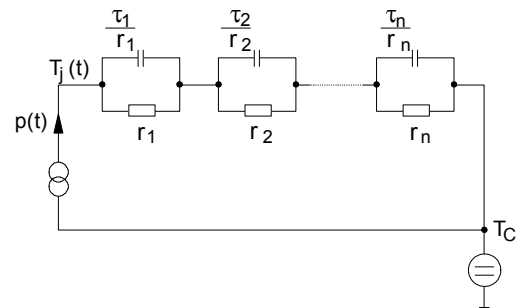
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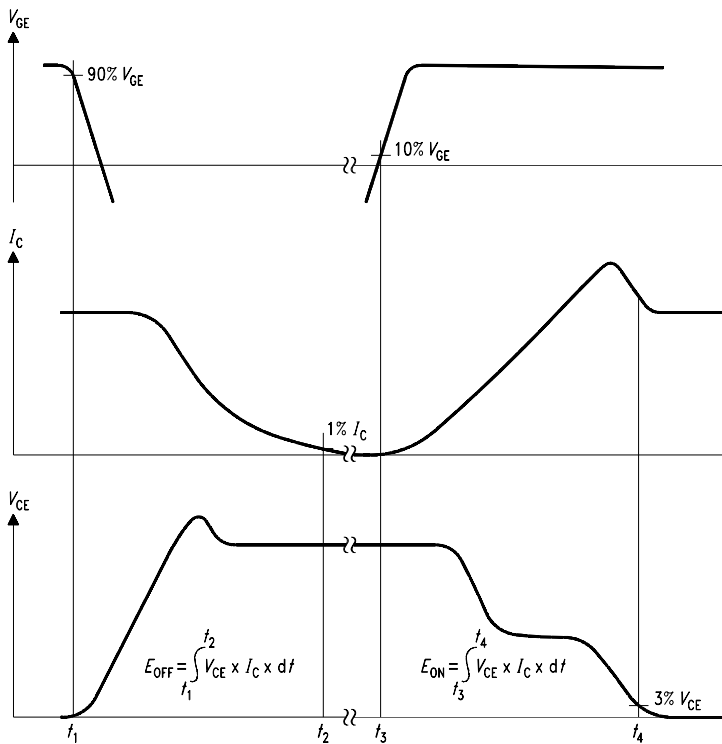
**Figure A. Definition of switching times**



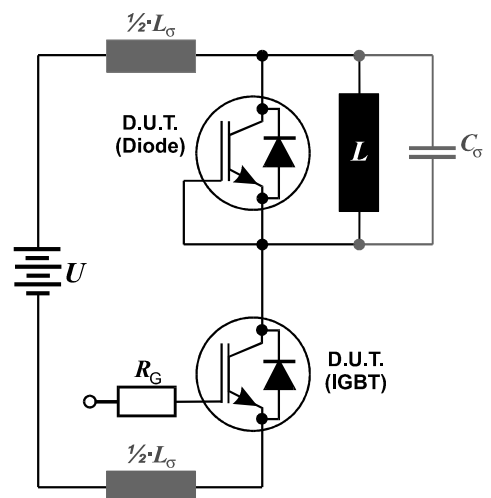
**Figure C. Definition of diodes switching characteristics**



**Figure D. Thermal equivalent circuit**



**Figure B. Definition of switching losses**



**Figure E. Dynamic test circuit**  
Leakage inductance  $L_{\sigma} = 60\text{nH}$   
and Stray capacity  $C_{\sigma} = 40\text{pF}$ .

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