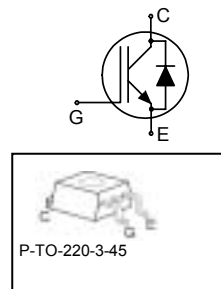


## High Speed IGBT in NPT-technology

- 30% lower  $E_{off}$  compared to previous generation
- Short circuit withstand time – 10  $\mu$ s
- Designed for operation above 30 kHz
- NPT-Technology for 600V applications offers:
  - parallel switching capability
  - moderate  $E_{off}$  increase with temperature
  - very tight parameter distribution
- High ruggedness, temperature stable behaviour
- Pb-free lead plating; RoHS compliant
- Qualified according to JEDEC<sup>1</sup> for target applications
- Complete product spectrum and PSpice Models : <http://www.infineon.com/igbt/>



Type	$V_{CE}$	$I_C$	$E_{off}$	$T_j$	Marking	Package
SKB15N60HS	600V	15A	200 $\mu$ J	150°C	K15N60HS	P-TO-220-3-45

### Maximum Ratings

Parameter	Symbol	Value	Unit
Collector-emitter voltage	$V_{CE}$	600	V
DC collector current	$I_C$	27	A
$T_C = 25^\circ\text{C}$		27	
$T_C = 100^\circ\text{C}$		15	
Pulsed collector current, $t_p$ limited by $T_{jmax}$	$I_{Cpuls}$	60	
Turn off safe operating area	-	60	
$V_{CE} \leq 600\text{V}, T_j \leq 150^\circ\text{C}$			
Diode forward current	$I_F$	40	
$T_C = 25^\circ\text{C}$		40	
$T_C = 100^\circ\text{C}$		20	
Diode pulsed current, $t_p$ limited by $T_{jmax}$	$I_{Fpuls}$	80	
Gate-emitter voltage static	$V_{GE}$	$\pm 20$	V
transient ( $t_p < 1\mu\text{s}, D < 0.05$ )		$\pm 30$	
Short circuit withstand time <sup>2)</sup>	$t_{SC}$	10	$\mu\text{s}$
$V_{GE} = 15\text{V}, V_{CC} \leq 400\text{V}, T_j \leq 150^\circ\text{C}$			
Power dissipation	$P_{tot}$	138	W
$T_C = 25^\circ\text{C}$			
Operating junction and storage temperature	$T_j, T_{stg}$	-55...+150	$^\circ\text{C}$
Time limited operating junction temperature for $t < 150\text{h}$	$T_{j(tl)}$	175	
Soldering temperature (reflow soldering, MSL1)	-	220	

<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	$R_{thJC}$		0.9	K/W
Diode thermal resistance, junction – case	$R_{thJCD}$		1.7	
Thermal resistance, junction – ambient	$R_{thJA}$		62	
SMD version, device on PCB <sup>1)</sup>	$R_{thJA}$		40	

## Electrical Characteristic, at $T_j = 25\text{ °C}$ , unless otherwise specified

Parameter	Symbol	Conditions	Value			Unit
			min.	Typ.	max.	
<b>Static Characteristic</b>						
Collector-emitter breakdown voltage	$V_{(BR)CES}$	$V_{GE}=0V, I_C=500\mu A$	600	-	-	V
Collector-emitter saturation voltage	$V_{CE(sat)}$	$V_{GE} = 15V, I_C=15A$ $T_j=25\text{ °C}$ $T_j=150\text{ °C}$		2.8 3.5	3.15 4.00	
Diode forward voltage	$V_F$	$V_{GE}=0V, I_F=15A$ $T_j=25\text{ °C}$ $T_j=150\text{ °C}$	-	1.5 1.5	2.0 2.0	
Gate-emitter threshold voltage	$V_{GE(th)}$	$I_C=400\mu A, V_{CE}=V_{GE}$	3	4	5	
Zero gate voltage collector current	$I_{CES}$	$V_{CE}=600V, V_{GE}=0V$ $T_j=25\text{ °C}$ $T_j=150\text{ °C}$	- -	- -	40 2000	$\mu A$
Gate-emitter leakage current	$I_{GES}$	$V_{CE}=0V, V_{GE}=20V$	-	-	100	nA
Transconductance	$g_{fs}$	$V_{CE}=20V, I_C=15A$	-	10		S

<sup>1)</sup> Device on 50mm\*50mm\*1.5mm epoxy PCB FR4 with 6cm<sup>2</sup> (one layer, 70μm thick) copper area for collector connection. PCB is vertical without blown air.

**Dynamic Characteristic**

Input capacitance	$C_{iss}$	$V_{CE}=25V,$ $V_{GE}=0V,$ $f=1MHz$	-	810		pF
Output capacitance	$C_{oss}$		-	123		
Reverse transfer capacitance	$C_{rss}$		-	51		
Gate charge	$Q_{Gate}$	$V_{CC}=480V, I_C=15A$ $V_{GE}=15V$	-	80		nC
Internal emitter inductance measured 5mm (0.197 in.) from case	$L_E$		-	7		nH
Short circuit collector current <sup>1)</sup>	$I_{C(SC)}$	$V_{GE}=15V, t_{SC} \leq 10\mu s$ $V_{CC} \leq 400V,$ $T_j \leq 150^\circ C$	-	135		A

**Switching Characteristic, Inductive Load, at  $T_j=25^\circ C$** 

Parameter	Symbol	Conditions	Value			Unit
			min.	typ.	max.	

**IGBT Characteristic**

Turn-on delay time	$t_{d(on)}$	$T_j=25^\circ C,$ $V_{CC}=400V, I_C=15A,$ $V_{GE}=0/15V,$ $R_G=23\Omega$ $L_{\sigma}^{2)} = 60nH,$ $C_{\sigma}^{2)} = 40pF$ Energy losses include "tail" and diode reverse recovery.	-	13		ns
Rise time	$t_r$		-	14		
Turn-off delay time	$t_{d(off)}$		-	209		
Fall time	$t_f$		-	15		mJ
Turn-on energy	$E_{on}$		-	0.32		
Turn-off energy	$E_{off}$		-	0.21		
Total switching energy	$E_{ts}$		-	0.53		

**Anti-Parallel Diode Characteristic**

Diode reverse recovery time	$t_{rr}$	$T_j=25^\circ C,$ $V_R=400V, I_F=15A,$ $di_F/dt=980A/\mu s$	-	111		ns
	$t_S$		-	27		
	$t_F$		-	83		
Diode reverse recovery charge	$Q_{rr}$		-	580		nC
Diode peak reverse recovery current	$I_{rrm}$		-	14		A
Diode peak rate of fall of reverse recovery current during $t_b$	$di_{rr}/dt$		-	520		A/ $\mu s$

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

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

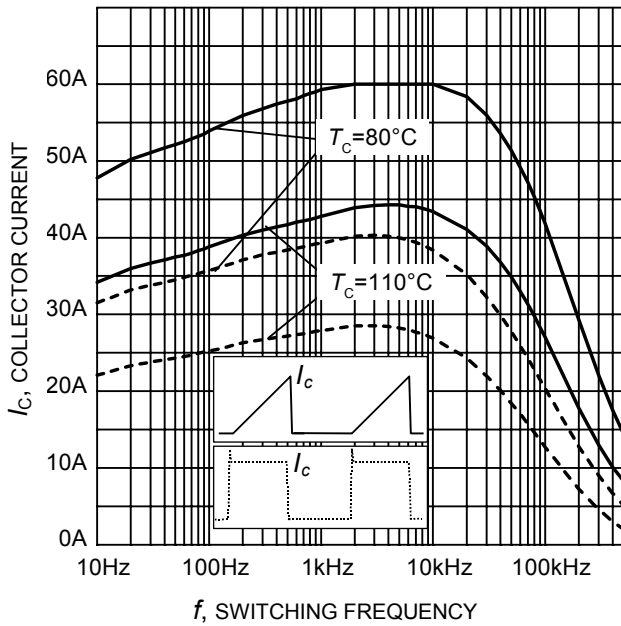
**Switching Characteristic, Inductive Load, at  $T_j=150^\circ\text{C}$** 

Parameter	Symbol	Conditions	Value			Unit	
			min.	typ.	max.		
<b>IGBT Characteristic</b>							
Turn-on delay time	$t_{d(on)}$	$T_j=150^\circ\text{C}$ $V_{CC}=400\text{V}, I_C=15\text{A},$ $V_{GE}=0/15\text{V},$ $R_G=3.6\Omega$ $L_{\sigma}^{(1)}=60\text{nH},$ $C_{\sigma}^{(1)}=40\text{pF}$ Energy losses include "tail" and diode reverse recovery.	-	11		ns	
Rise time	$t_r$		-	6			
Turn-off delay time	$t_{d(off)}$		-	72			
Fall time	$t_f$		-	26			
Turn-on energy	$E_{on}$		Energy losses include "tail" and diode reverse recovery.	-	0.38		mJ
Turn-off energy	$E_{off}$			-	0.20		
Total switching energy	$E_{ts}$			-	0.58		
Turn-on delay time	$t_{d(on)}$	$T_j=150^\circ\text{C}$ $V_{CC}=400\text{V}, I_C=15\text{A},$ $V_{GE}=0/15\text{V},$ $R_G=23\Omega$ $L_{\sigma}^{(1)}=60\text{nH},$ $C_{\sigma}^{(1)}=40\text{pF}$ Energy losses include "tail" and diode reverse recovery.	-	12		ns	
Rise time	$t_r$		-	15			
Turn-off delay time	$t_{d(off)}$		-	235			
Fall time	$t_f$		-	17			
Turn-on energy	$E_{on}$		Energy losses include "tail" and diode reverse recovery.	-	0.48		mJ
Turn-off energy	$E_{off}$			-	0.30		
Total switching energy	$E_{ts}$			-	0.78		

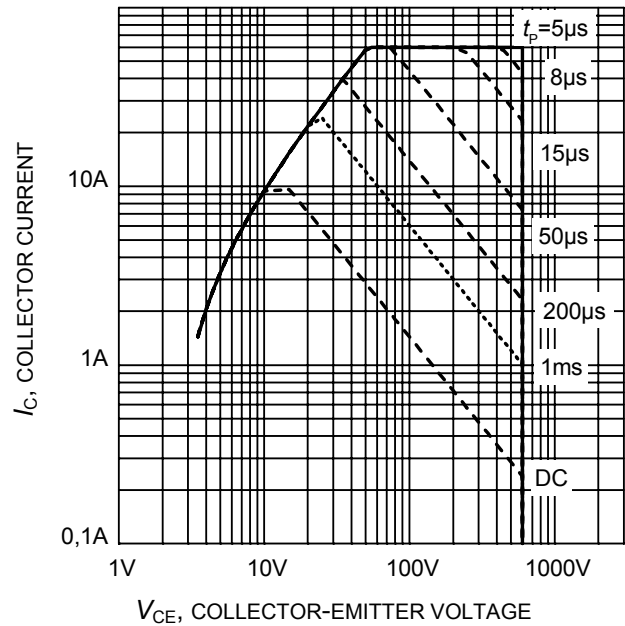
**Anti-Parallel Diode Characteristic**

Diode reverse recovery time	$t_{rr}$	$T_j=150^\circ\text{C}$ $V_R=400\text{V}, I_F=15\text{A},$ $di_F/dt=1070\text{A}/\mu\text{s}$	-	184		ns
	$t_S$		-	30		
	$t_F$		-	155		
Diode reverse recovery charge	$Q_{rr}$		-	1320		nC
Diode peak reverse recovery current	$I_{rrm}$		-	18		A
Diode peak rate of fall of reverse recovery current during $t_b$	$di_{rr}/dt$		-	360		A/ $\mu\text{s}$

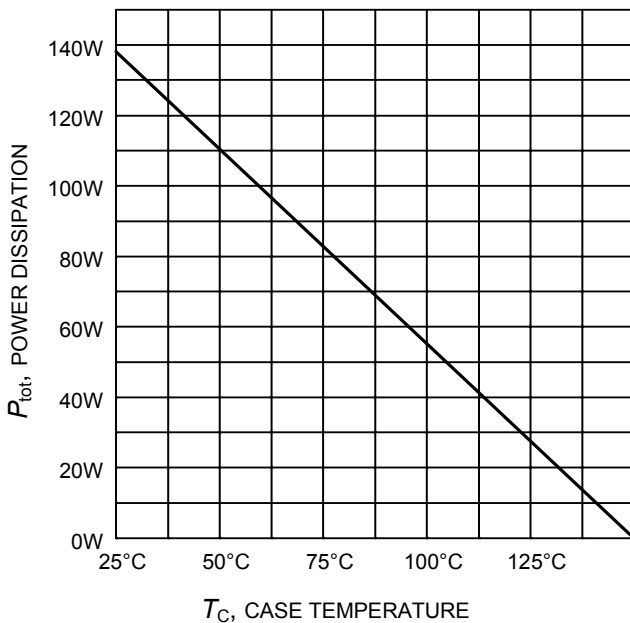
<sup>1)</sup> Leakage inductance  $L_{\sigma}$  and Stray capacity  $C_{\sigma}$  due to test circuit in Figure E.



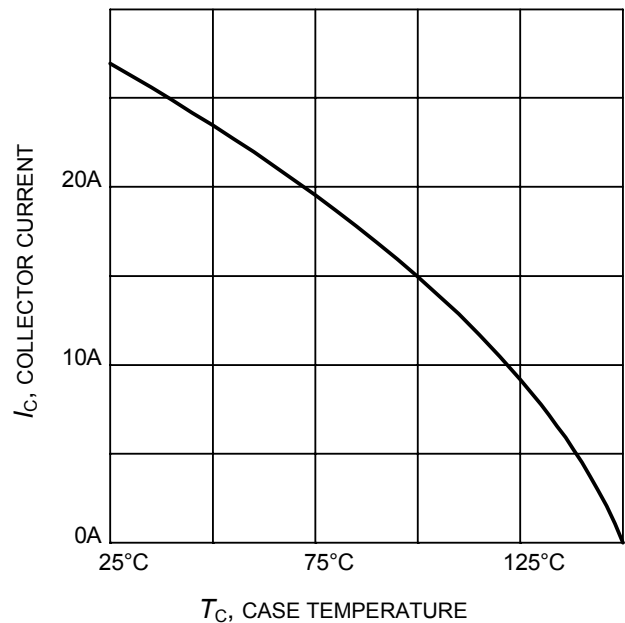
**Figure 1. Collector current as a function of switching frequency**  
 ( $T_j \leq 150^\circ\text{C}$ ,  $D = 0.5$ ,  $V_{CE} = 400\text{V}$ ,  
 $V_{GE} = 0/+15\text{V}$ ,  $R_G = 23\Omega$ )



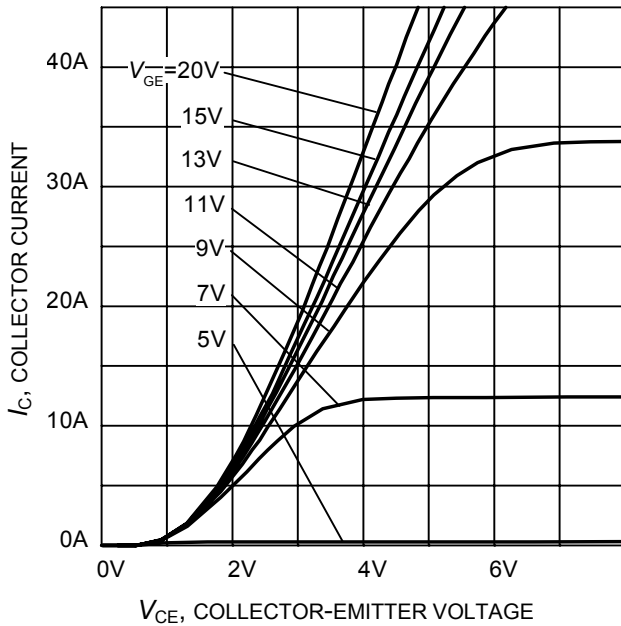
**Figure 2. Safe operating area**  
 ( $D = 0$ ,  $T_C = 25^\circ\text{C}$ ,  
 $T_j \leq 150^\circ\text{C}$ ;  $V_{GE} = 15\text{V}$ )



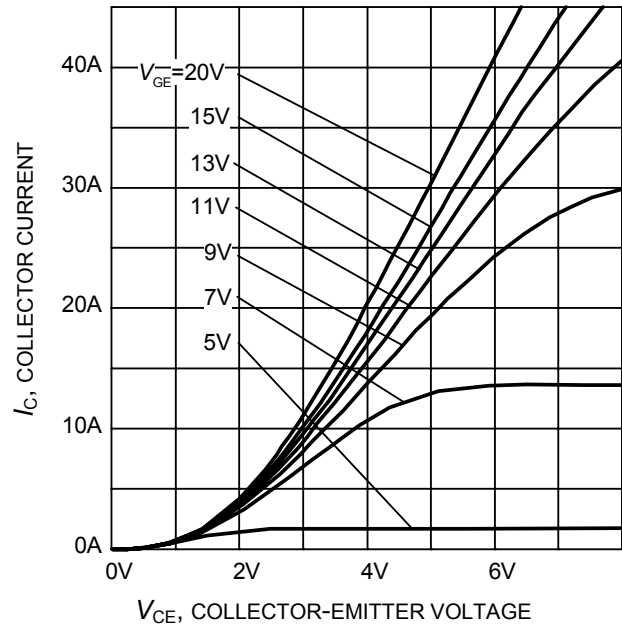
**Figure 3. Power dissipation as a function of case temperature**  
 ( $T_j \leq 150^\circ\text{C}$ )



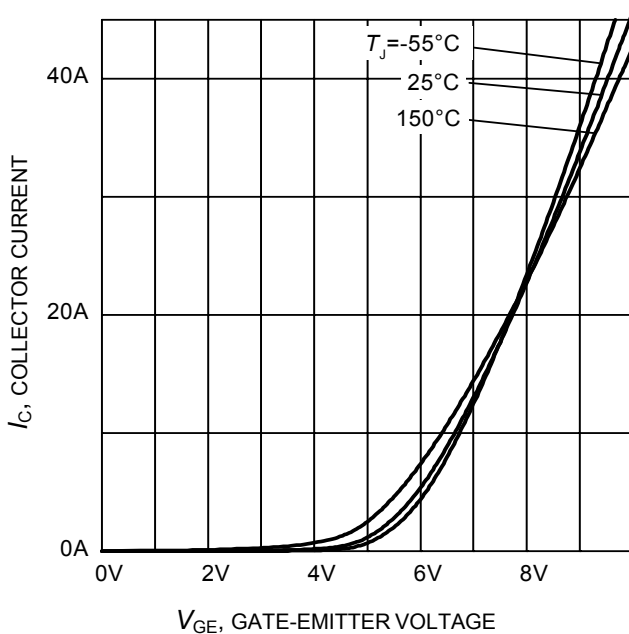
**Figure 4. Collector current as a function of case temperature**  
 ( $V_{GE} \leq 15\text{V}$ ,  $T_j \leq 150^\circ\text{C}$ )



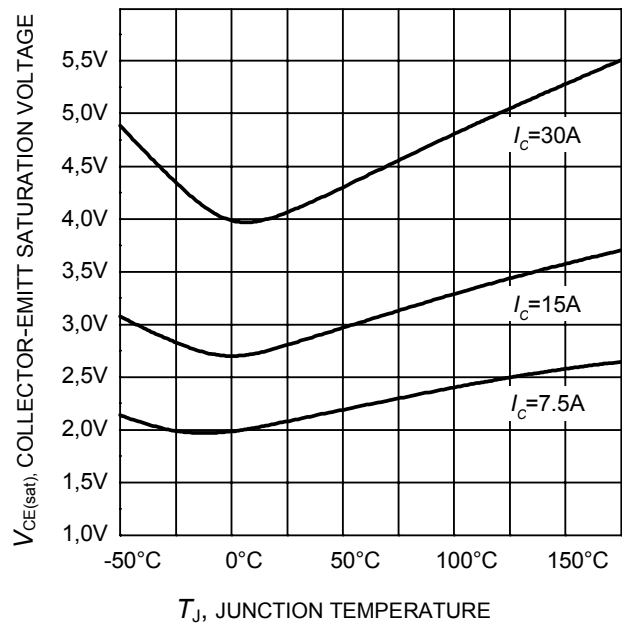
**Figure 5. Typical output characteristic**  
( $T_j = 25^\circ\text{C}$ )



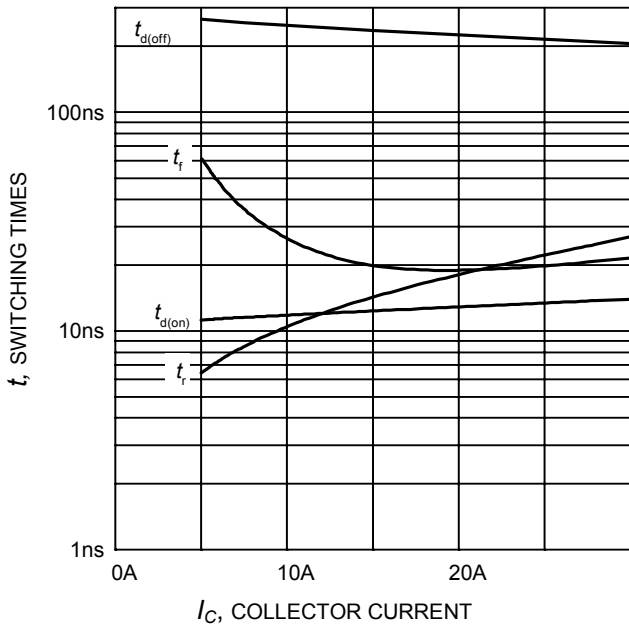
**Figure 6. Typical output characteristic**  
( $T_j = 150^\circ\text{C}$ )



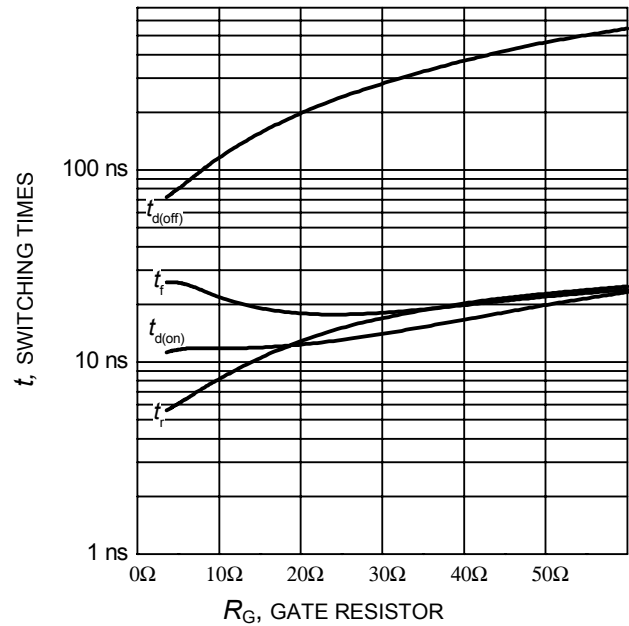
**Figure 7. Typical transfer characteristic**  
( $V_{CE} = 10\text{V}$ )



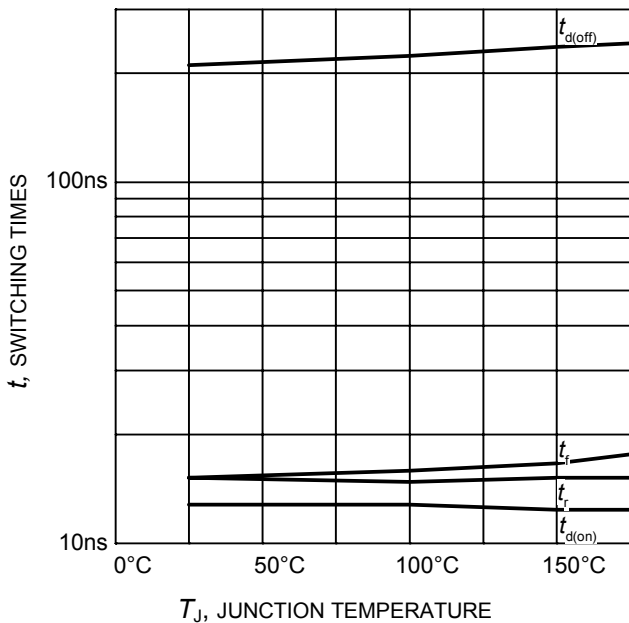
**Figure 8. Typical collector-emitter saturation voltage as a function of junction temperature**  
( $V_{GE} = 15\text{V}$ )



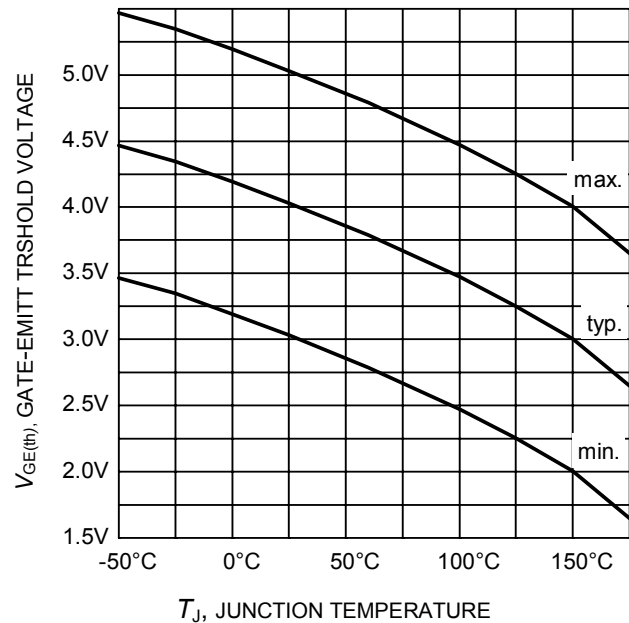
**Figure 9. Typical switching times as a function of collector current**  
(inductive load,  $T_J=150^{\circ}\text{C}$ ,  $V_{CE}=400\text{V}$ ,  $V_{GE}=0/15\text{V}$ ,  $R_G=23\Omega$ , Dynamic test circuit in Figure E)



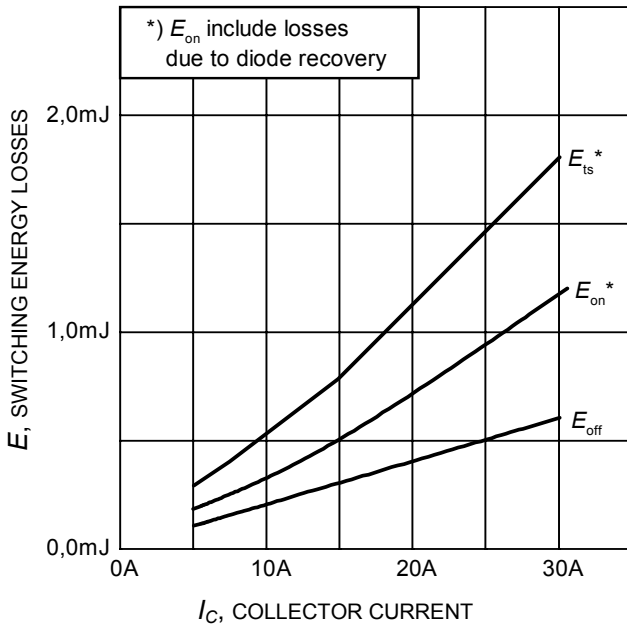
**Figure 10. Typical switching times as a function of gate resistor**  
(inductive load,  $T_J=150^{\circ}\text{C}$ ,  $V_{CE}=400\text{V}$ ,  $V_{GE}=0/15\text{V}$ ,  $I_C=15\text{A}$ , Dynamic test circuit in Figure E)



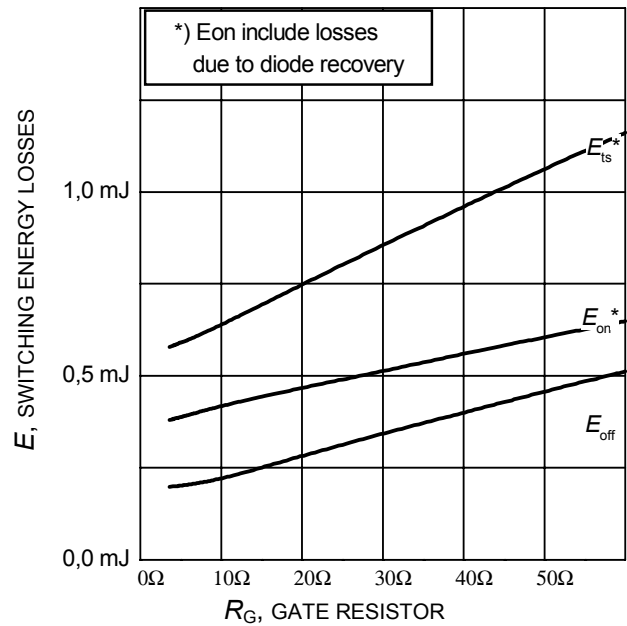
**Figure 11. Typical switching times as a function of junction temperature**  
(inductive load,  $V_{CE}=400\text{V}$ ,  $V_{GE}=0/15\text{V}$ ,  $I_C=15\text{A}$ ,  $R_G=23\Omega$ , Dynamic test circuit in Figure E)



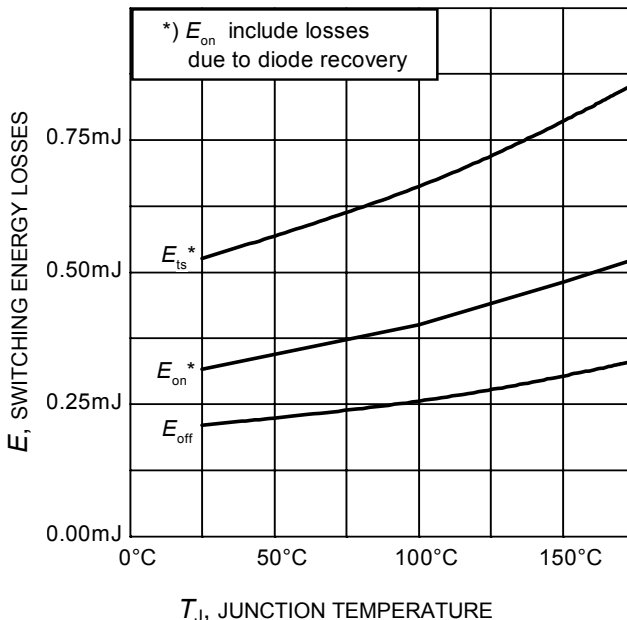
**Figure 12. Gate-emitter threshold voltage as a function of junction temperature**  
( $I_C = 0.5\text{mA}$ )



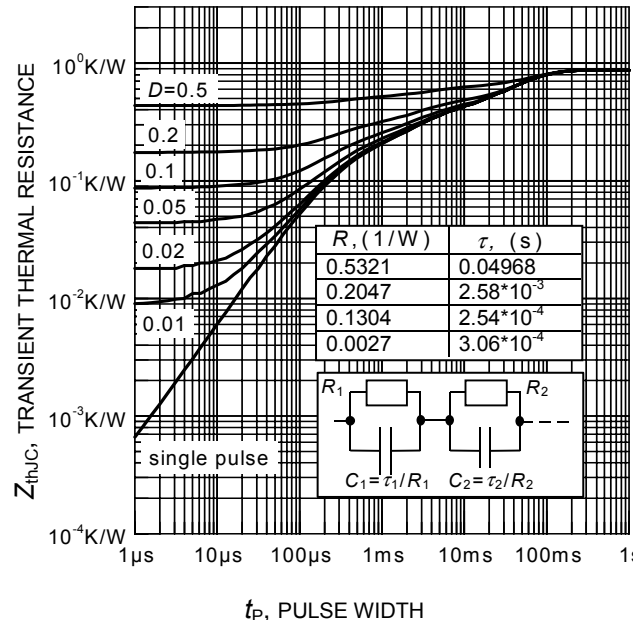
**Figure 13. Typical switching energy losses as a function of collector current**  
 (inductive load,  $T_J=150^\circ\text{C}$ ,  $V_{CE}=400\text{V}$ ,  $V_{GE}=0/15\text{V}$ ,  $R_G=23\Omega$ , Dynamic test circuit in Figure E)



**Figure 14. Typical switching energy losses as a function of gate resistor**  
 (inductive load,  $T_J=150^\circ\text{C}$ ,  $V_{CE}=400\text{V}$ ,  $V_{GE}=0/15\text{V}$ ,  $I_C=15\text{A}$ , Dynamic test circuit in Figure E)

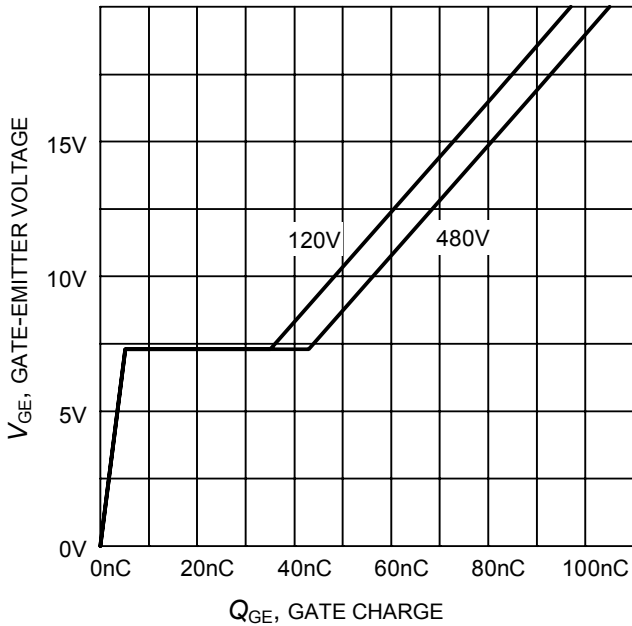


**Figure 15. Typical switching energy losses as a function of junction temperature**  
 (inductive load,  $V_{CE}=400\text{V}$ ,  $V_{GE}=0/15\text{V}$ ,  $I_C=20\text{A}$ ,  $R_G=23\Omega$ , Dynamic test circuit in Figure E)

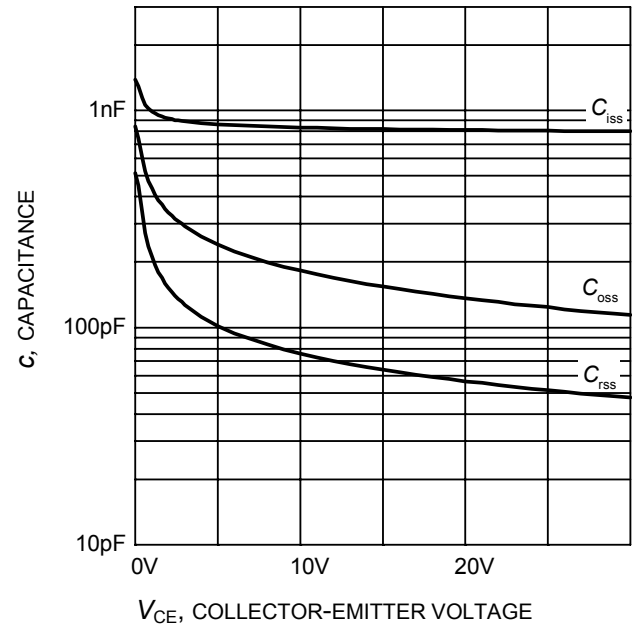


**Figure 16. IGBT transient thermal resistance**  
 ( $D = t_p / T$ )

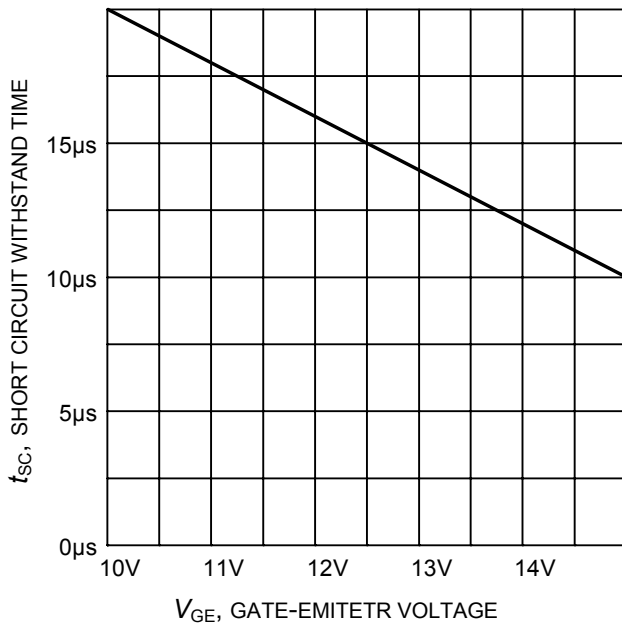




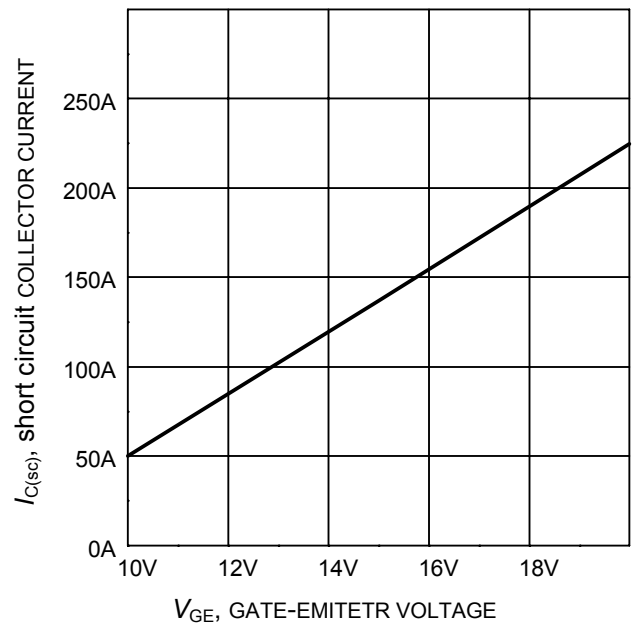
**Figure 17. Typical gate charge**  
( $I_C=15\text{ A}$ )



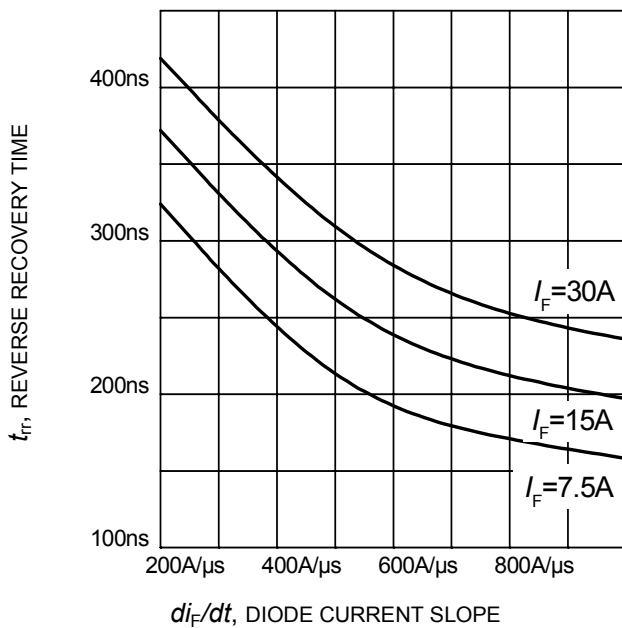
**Figure 18. Typical capacitance as a function of collector-emitter voltage**  
( $V_{GE}=0\text{V}$ ,  $f = 1\text{ MHz}$ )



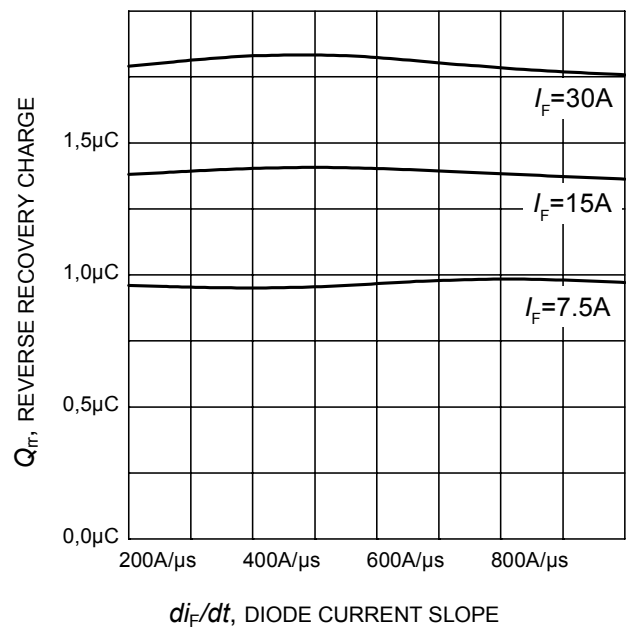
**Figure 19. Short circuit withstand time as a function of gate-emitter voltage**  
( $V_{CE}=600\text{V}$ , start at  $T_J=25^\circ\text{C}$ )



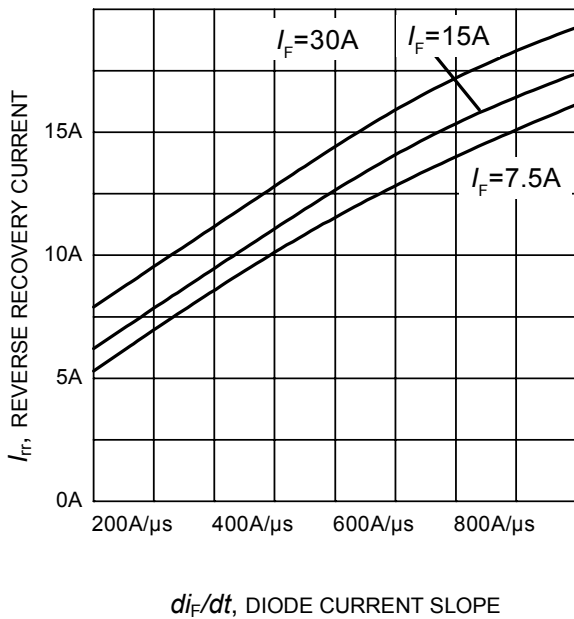
**Figure 20. Typical short circuit collector current as a function of gate-emitter voltage**  
( $V_{CE} \leq 400\text{V}$ ,  $T_J \leq 150^\circ\text{C}$ )



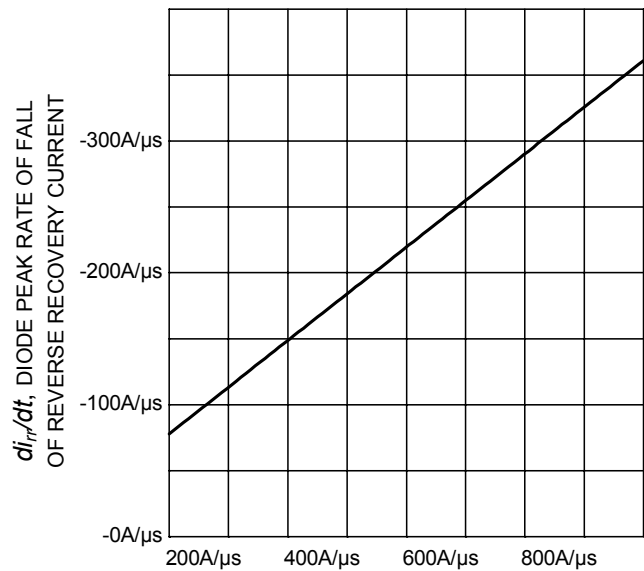
**Figure 21. Typical reverse recovery time as a function of diode current slope**  
 ( $V_R=400V$ ,  $T_J=150^\circ C$ ,  
 Dynamic test circuit in Figure E)



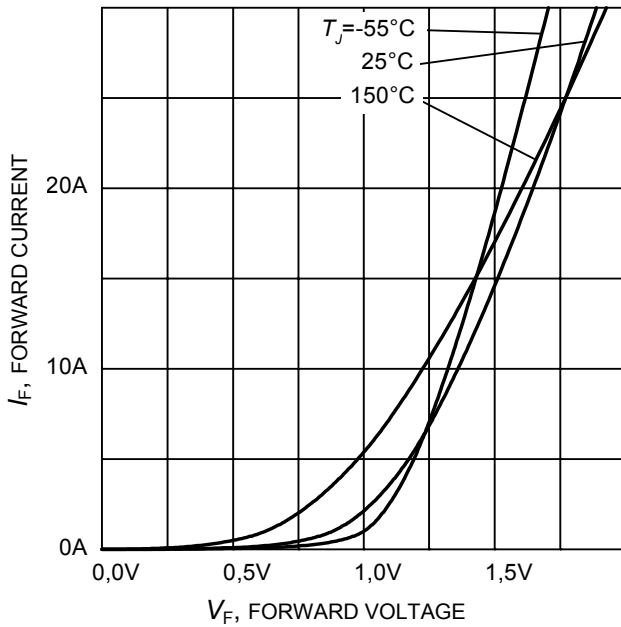
**Figure 22. Typical reverse recovery charge as a function of diode current slope**  
 ( $V_R=400V$ ,  $T_J=150^\circ C$ ,  
 Dynamic test circuit in Figure E)



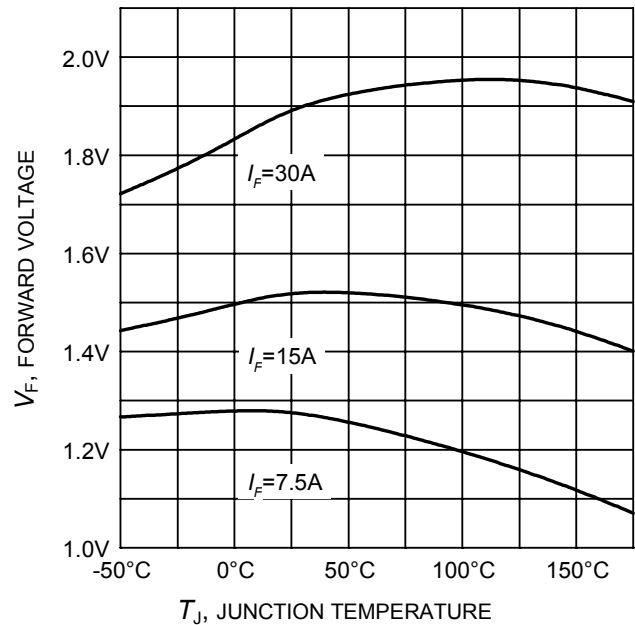
**Figure 23. Typical reverse recovery current as a function of diode current slope**  
 ( $V_R=400V$ ,  $T_J=150^\circ C$ ,  
 Dynamic test circuit in Figure E)



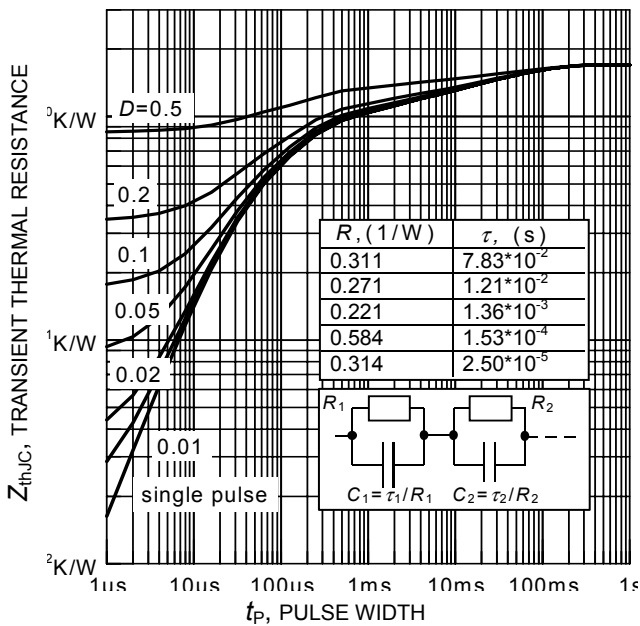
**Figure 24. Typical diode peak rate of fall of reverse recovery current as a function of diode current slope**  
 ( $V_R=400V$ ,  $T_J=150^\circ C$ ,  
 Dynamic test circuit in Figure E)



**Figure 25. Typical diode forward current as a function of forward voltage**

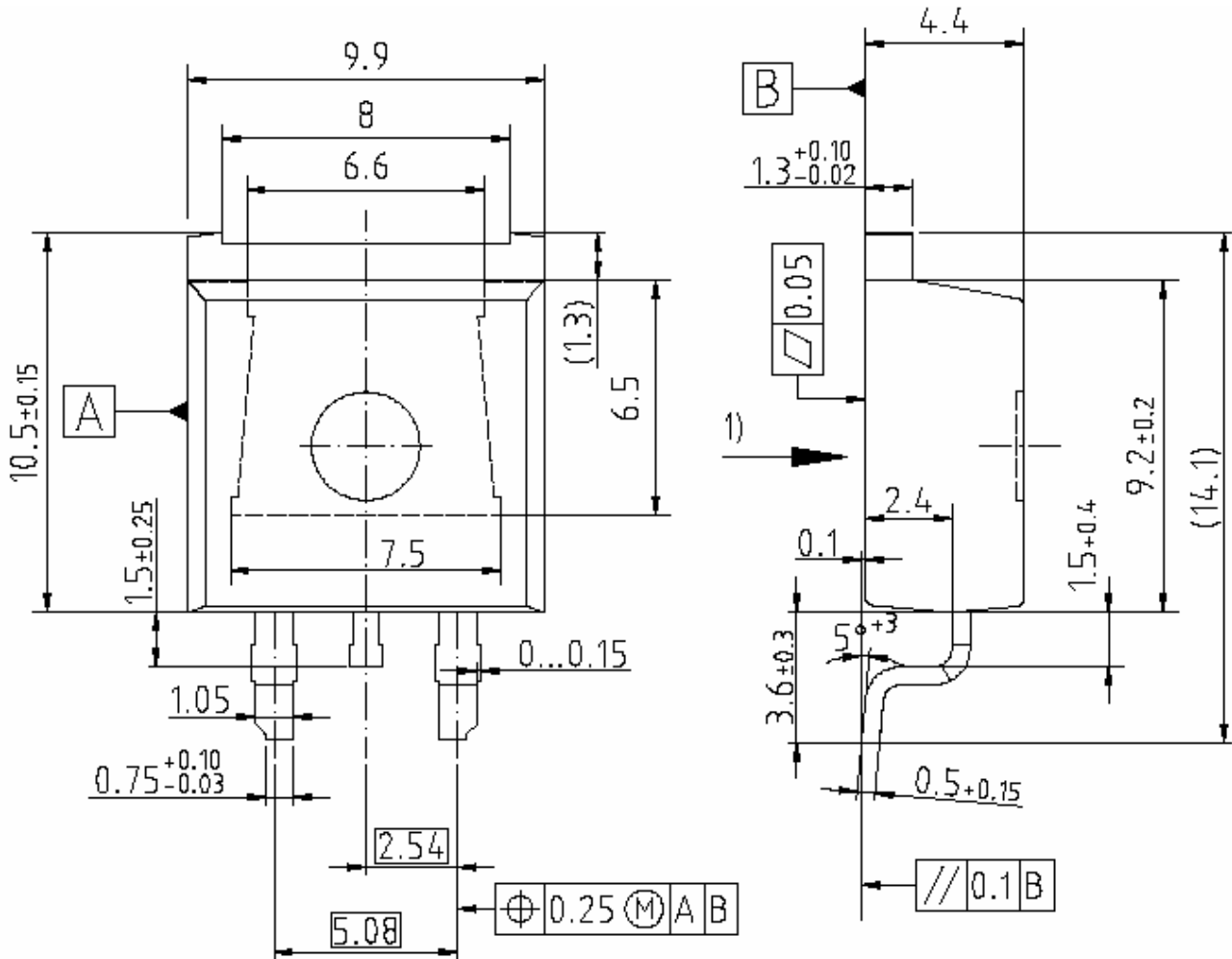


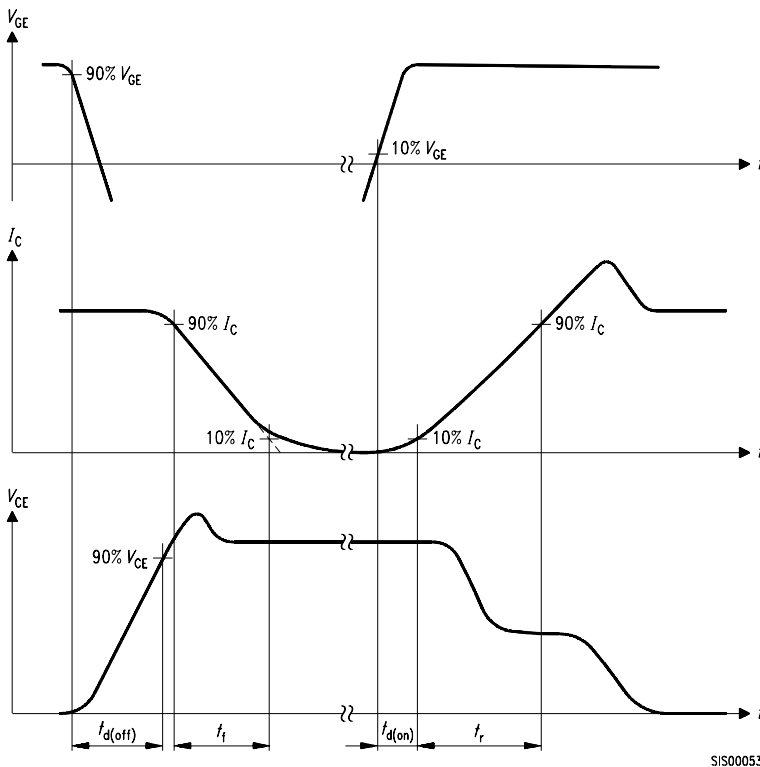
**Figure 26. Typical diode forward voltage as a function of junction temperature**



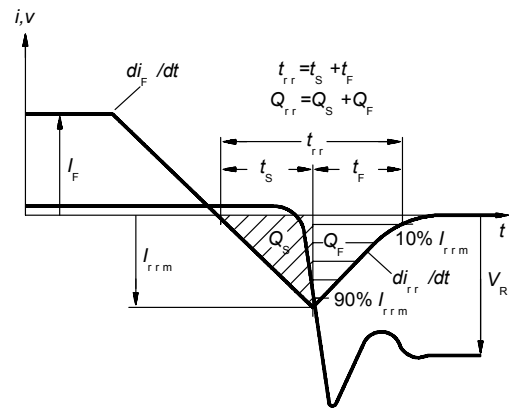
**Figure 27. Diode transient thermal impedance as a function of pulse width ( $D=t_p/T$ )**

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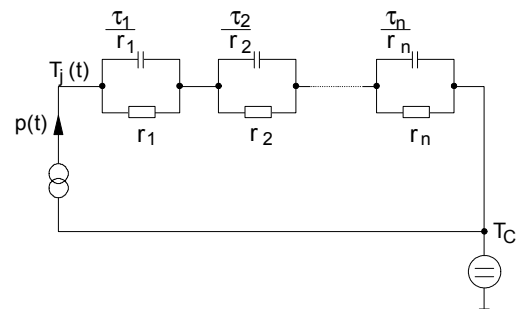




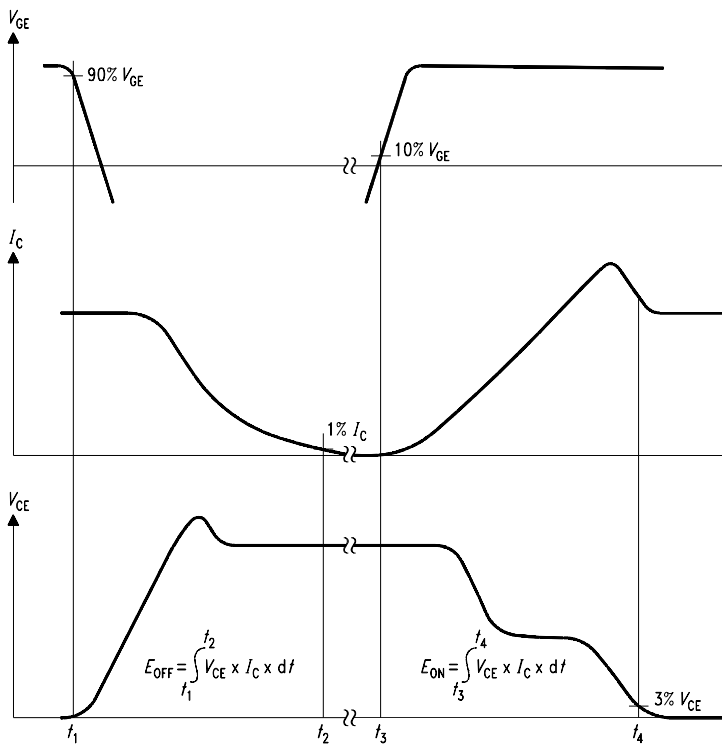
**Figure A. Definition of switching times**



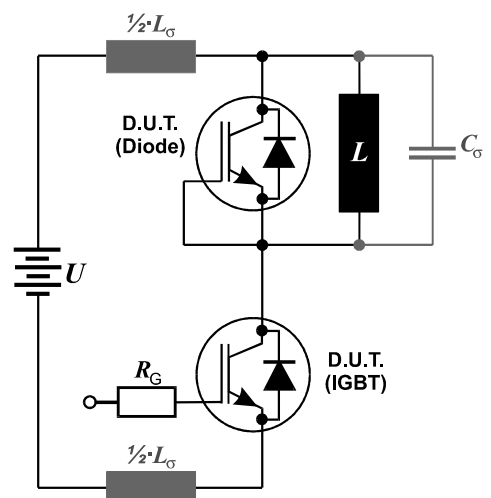
**Figure C. Definition of diodes switching characteristics**



**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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