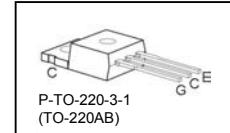
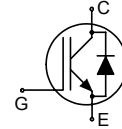


### Low Loss DuoPack : IGBT in Trench and Fieldstop technology with soft, fast recovery anti-parallel EmCon HE diode

- Very low  $V_{CE(sat)}$  1.5 V (typ.)
- Maximum Junction Temperature 175 °C
- Short circuit withstand time – 5 $\mu$ s
- Designed for :
  - Frequency Converters
  - Drives
- Trench and Fieldstop technology for 600 V applications offers :
  - very tight parameter distribution
  - high ruggedness, temperature stable behavior
  - very high switching speed
  - low  $V_{CE(sat)}$
- Positive temperature coefficient in  $V_{CE(sat)}$
- Low EMI
- Low Gate Charge
- Very soft, fast recovery anti-parallel EmCon HE diode
- Complete product spectrum and PSpice Models : <http://www.infineon.com/igbt/>



Type	$V_{CE}$	$I_C$	$V_{CE(sat), T_j=25^\circ C}$	$T_{j,max}$	Marking Code	Package	Ordering Code
IKP04N60T	600 V	4 A	1.5 V	175 °C	K04T60	TO-220	Q67040S4714

#### Maximum Ratings

Parameter	Symbol	Value	Unit
Collector-emitter voltage	$V_{CE}$	600	V
DC collector current, limited by $T_{j,max}$	$I_C$		A
$T_C = 25^\circ C$		8	
$T_C = 100^\circ C$		4	
Pulsed collector current, $t_p$ limited by $T_{j,max}$	$I_{C,puls}$	12	
Turn off safe operating area ( $V_{CE} \leq 600V, T_j \leq 175^\circ C$ )	-	12	
Diode forward current, limited by $T_{j,max}$	$I_F$		
$T_C = 25^\circ C$		4	
$T_C = 100^\circ C$		8	
Diode pulsed current, $t_p$ limited by $T_{j,max}$	$I_{F,puls}$	12	
Gate-emitter voltage	$V_{GE}$	$\pm 20$	V
Short circuit withstand time <sup>1)</sup>	$t_{SC}$	5	$\mu$ s
$V_{GE} = 15V, V_{CC} \leq 400V, T_j \leq 150^\circ C$			
Power dissipation $T_C = 25^\circ C$	$P_{tot}$	42	W
Operating junction temperature	$T_j$	-40...+175	$^\circ C$
Storage temperature	$T_{stg}$	-55...+175	
Soldering temperature, 1.6mm (0.063 in.) from case for 10s	-	260	

<sup>1)</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	$R_{thJC}$	TO-220-3-1	3.5	K/W
Diode thermal resistance, junction – case	$R_{thJCD}$	TO-220-3-1	5	
Thermal resistance, junction – ambient	$R_{thJA}$	TO-220-3-1	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	$V_{(BR)CES}$	$V_{GE}=0V, I_C=0.2mA$	600	-	-	V
Collector-emitter saturation voltage	$V_{CE(sat)}$	$V_{GE} = 15V, I_C=4A$ $T_j=25^\circ\text{C}$ $T_j=175^\circ\text{C}$	-	1.5	2.05	
			-	1.9	-	
Diode forward voltage	$V_F$	$V_{GE}=0V, I_F=4A$ $T_j=25^\circ\text{C}$ $T_j=175^\circ\text{C}$	-	1.65	2.05	
			-	1.6	-	
Gate-emitter threshold voltage	$V_{GE(th)}$	$I_C = 60\mu A, V_{CE} = V_{GE}$	4.1	4.9	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	$\mu A$
			-	-	1000	
Gate-emitter leakage current	$I_{GES}$	$V_{CE}=0V, V_{GE}=20V$	-	-	100	nA
Transconductance	$g_{fs}$	$V_{CE}=20V, I_C=4A$	-	2.2	-	S
Integrated gate resistor	$R_{Gint}$			-		$\Omega$

### Dynamic Characteristic

Input capacitance	$C_{iss}$	$V_{CE}=25V,$ $V_{GE}=0V,$ $f=1MHz$	-	252	-	pF
Output capacitance	$C_{oss}$		-	20	-	
Reverse transfer capacitance	$C_{rfs}$		-	7.5	-	
Gate charge	$Q_{Gate}$	$V_{CC}=480V, I_C=4A$ $V_{GE}=15V$	-	27	-	nC
Internal emitter inductance measured 5mm (0.197 in.) from case	$L_E$	TO-220-3-1	-	7	-	nH
Short circuit collector current <sup>1)</sup>	$I_{C(SC)}$	$V_{GE}=15V, t_{SC}\leq 5\mu s$ $V_{CC} = 400V,$ $T_j \leq 150^\circ\text{C}$	-	36	-	A

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

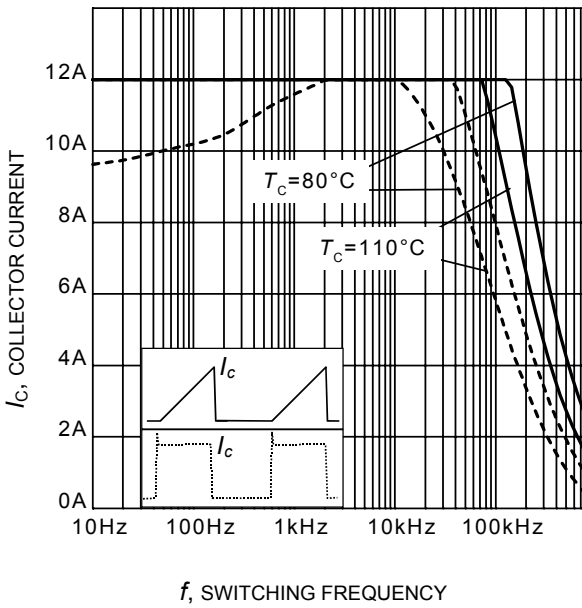
### Switching Characteristic, Inductive Load, at $T_j=25^\circ\text{C}$

Parameter	Symbol	Conditions	Value			Unit
			min.	Typ.	max.	
<b>IGBT Characteristic</b>						
Turn-on delay time	$t_{d(on)}$	$T_j=25^\circ\text{C}$ , $V_{CC}=400\text{V}$ , $I_C=4\text{A}$ , $V_{GE}=0/15\text{V}$ , $R_G=47\ \Omega$ , $L_{\sigma}^{1)}=150\text{nH}$ , $C_{\sigma}^{1)}=47\text{pF}$ Energy losses include "tail" and diode reverse recovery.	-	14	-	ns
Rise time	$t_r$		-	7	-	
Turn-off delay time	$t_{d(off)}$		-	164	-	
Fall time	$t_f$		-	43	-	
Turn-on energy	$E_{on}$		-	61	-	$\mu\text{J}$
Turn-off energy	$E_{off}$		-	84	-	
Total switching energy	$E_{ts}$		-	145	-	
<b>Anti-Parallel Diode Characteristic</b>						
Diode reverse recovery time	$t_{rr}$	$T_j=25^\circ\text{C}$ , $V_R=400\text{V}$ , $I_F=4\text{A}$ , $di_F/dt=610\text{A}/\mu\text{s}$	-	28	-	ns
Diode reverse recovery charge	$Q_{rr}$		-	79	-	nC
Diode peak reverse recovery current	$I_{rrm}$		-	5.3	-	A
Diode peak rate of fall of reverse recovery current during $t_b$	$di_{rr}/dt$		-	346	-	$\text{A}/\mu\text{s}$

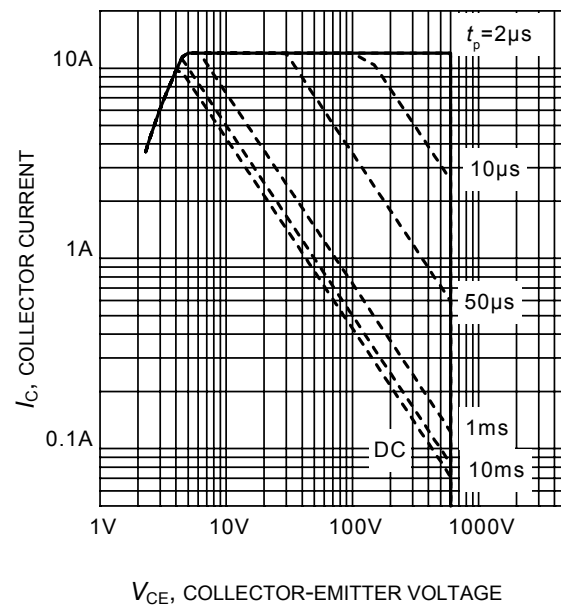
### Switching Characteristic, Inductive Load, at $T_j=175^\circ\text{C}$

Parameter	Symbol	Conditions	Value			Unit
			min.	Typ.	max.	
<b>IGBT Characteristic</b>						
Turn-on delay time	$t_{d(on)}$	$T_j=175^\circ\text{C}$ , $V_{CC}=400\text{V}$ , $I_C=4\text{A}$ , $V_{GE}=0/15\text{V}$ , $R_G=47\ \Omega$ , $L_{\sigma}^{1)}=150\text{nH}$ , $C_{\sigma}^{1)}=47\text{pF}$ Energy losses include "tail" and diode reverse recovery.	-	14	-	ns
Rise time	$t_r$		-	10	-	
Turn-off delay time	$t_{d(off)}$		-	185	-	
Fall time	$t_f$		-	83	-	
Turn-on energy	$E_{on}$		-	99	-	$\mu\text{J}$
Turn-off energy	$E_{off}$		-	97	-	
Total switching energy	$E_{ts}$		-	196	-	
<b>Anti-Parallel Diode Characteristic</b>						
Diode reverse recovery time	$t_{rr}$	$T_j=175^\circ\text{C}$ , $V_R=400\text{V}$ , $I_F=4\text{A}$ , $di_F/dt=610\text{A}/\mu\text{s}$	-	95	-	ns
Diode reverse recovery charge	$Q_{rr}$		-	291	-	nC
Diode peak reverse recovery current	$I_{rrm}$		-	6.6	-	A
Diode peak rate of fall of reverse recovery current during $t_b$	$di_{rr}/dt$		-	253	-	$\text{A}/\mu\text{s}$

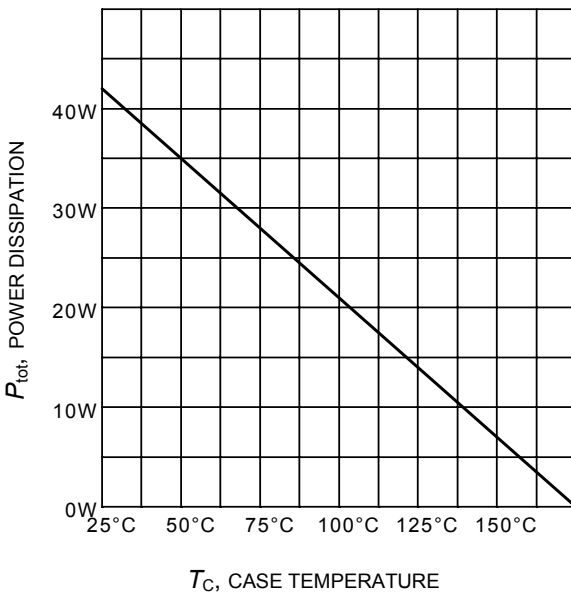
<sup>1)</sup> Leakage inductance  $L_{\sigma}$  and Stray capacity  $C_{\sigma}$  due to dynamic test circuit in Figure E.



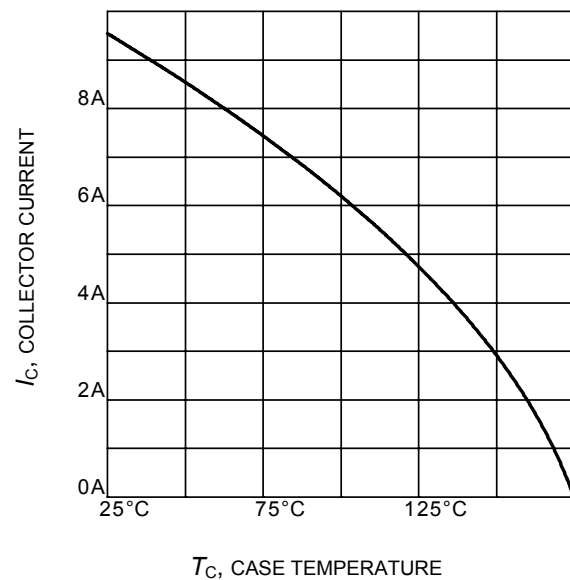
**Figure 1. Collector current as a function of switching frequency**  
 $(T_j \leq 175^\circ\text{C}, D = 0.5, V_{CE} = 400\text{V}, V_{GE} = 0/+15\text{V}, R_G = 47\Omega)$



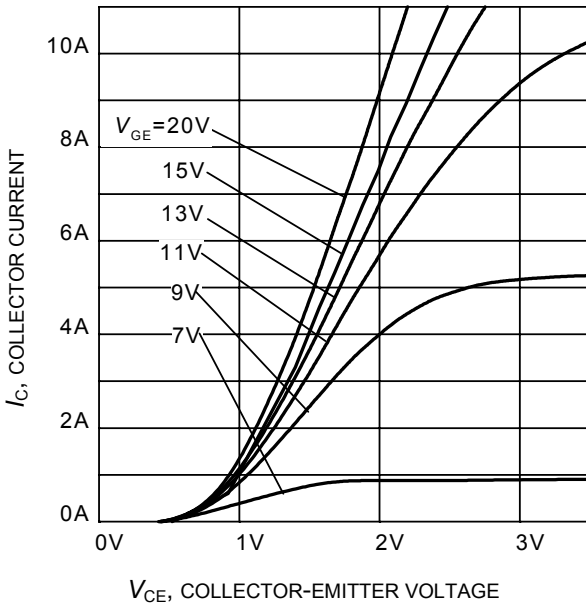
**Figure 2. Safe operating area**  
 $(D = 0, T_C = 25^\circ\text{C}, T_j \leq 175^\circ\text{C}, V_{GE} = 15\text{V})$



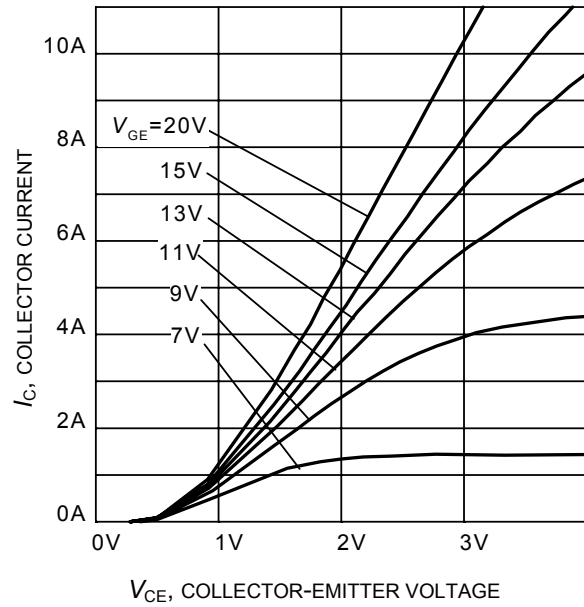
**Figure 3. Power dissipation as a function of case temperature**  
 $(T_j \leq 175^\circ\text{C})$



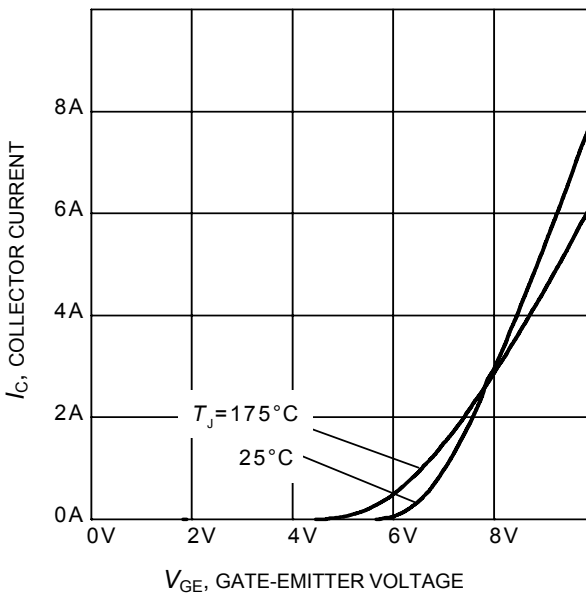
**Figure 4. Collector current as a function of case temperature**  
 $(V_{GE} \geq 15\text{V}, T_j \leq 175^\circ\text{C})$



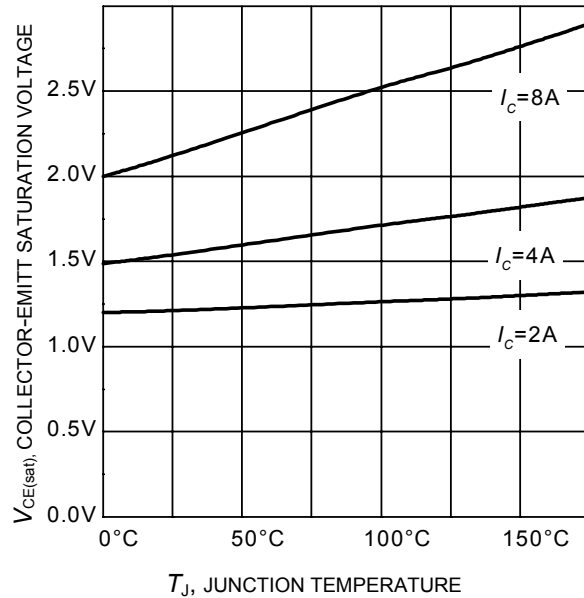
**Figure 5. Typical output characteristic**  
( $T_j = 25^\circ\text{C}$ )



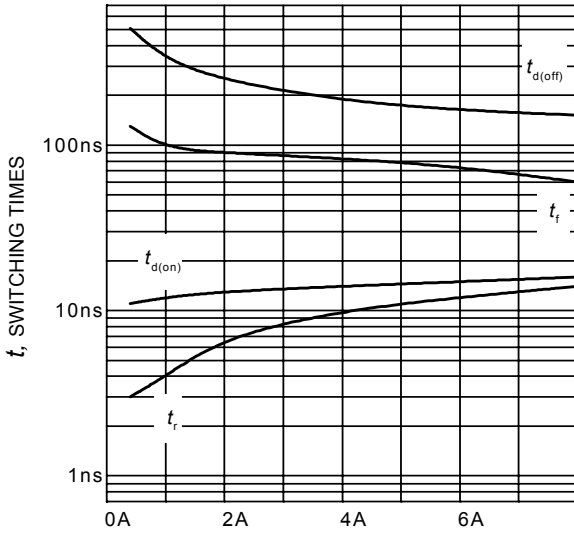
**Figure 6. Typical output characteristic**  
( $T_j = 175^\circ\text{C}$ )



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

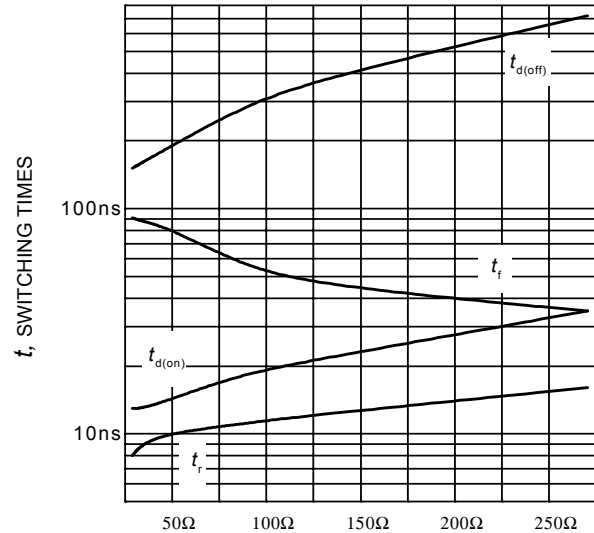


**Figure 8. Typical collector-emitter saturation voltage as a function of junction temperature**  
( $V_{GE} = 15\text{V}$ )



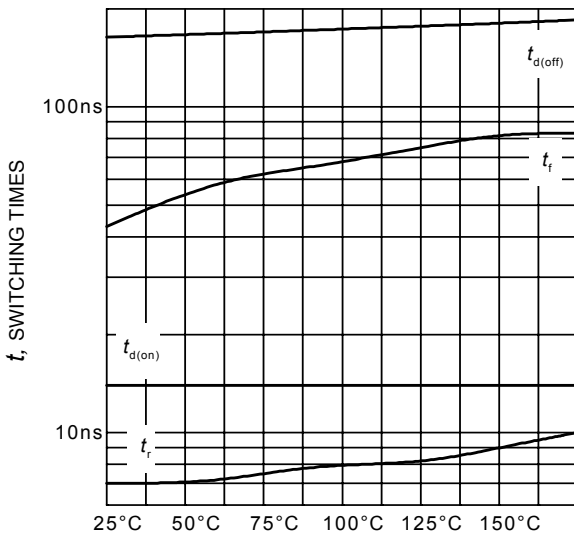
$I_C$ , COLLECTOR CURRENT

**Figure 9. Typical switching times as a function of collector current**  
(inductive load,  $T_J=175^\circ\text{C}$ ,  
 $V_{CE} = 400\text{V}$ ,  $V_{GE} = 0/15\text{V}$ ,  $R_G = 47\Omega$ ,  
Dynamic test circuit in Figure E)



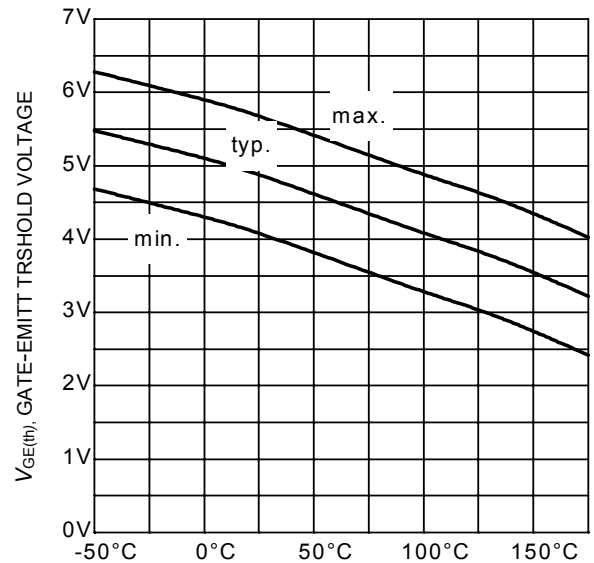
$R_G$ , GATE RESISTOR

**Figure 10. Typical switching times as a function of gate resistor**  
(inductive load,  $T_J = 175^\circ\text{C}$ ,  
 $V_{CE} = 400\text{V}$ ,  $V_{GE} = 0/15\text{V}$ ,  $I_C = 4\text{A}$ ,  
Dynamic test circuit in Figure E)



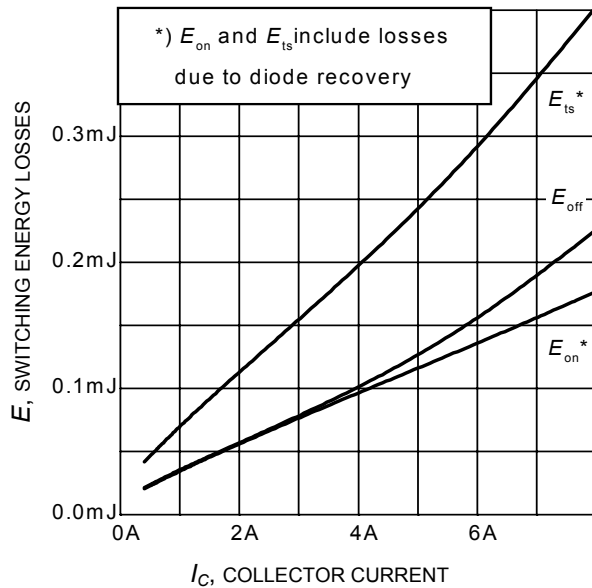
$T_J$ , JUNCTION TEMPERATURE

**Figure 11. Typical switching times as a function of junction temperature**  
(inductive load,  $V_{CE} = 400\text{V}$ ,  
 $V_{GE} = 0/15\text{V}$ ,  $I_C = 4\text{A}$ ,  $R_G=47\Omega$ ,  
Dynamic test circuit in Figure E)

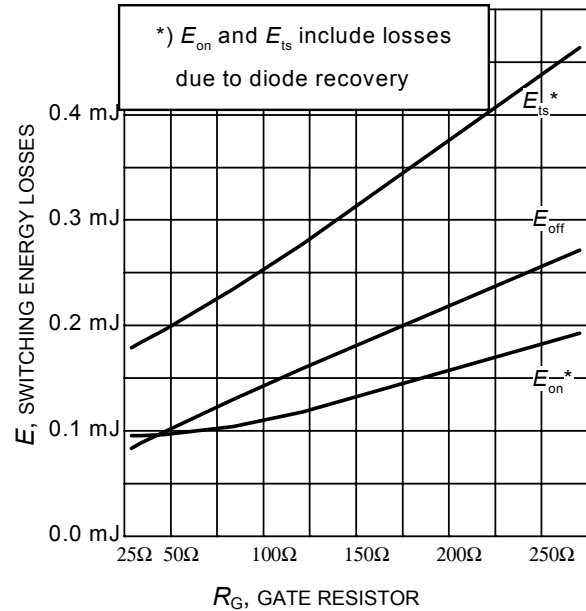


$T_J$ , JUNCTION TEMPERATURE

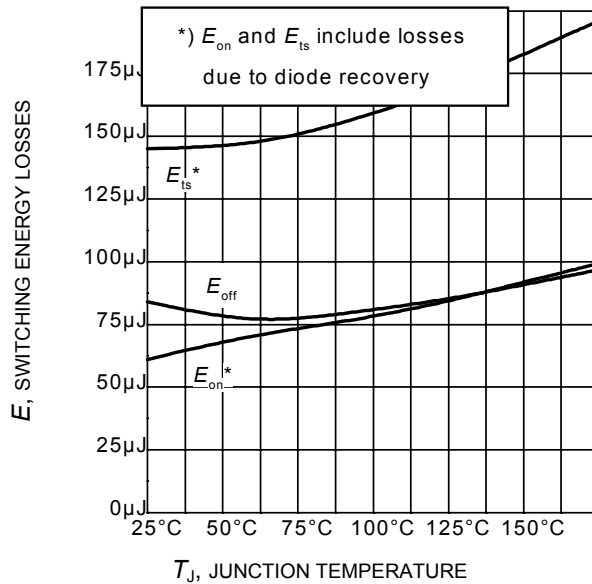
**Figure 12. Gate-emitter threshold voltage as a function of junction temperature**  
( $I_C = 60 \mu\text{A}$ )



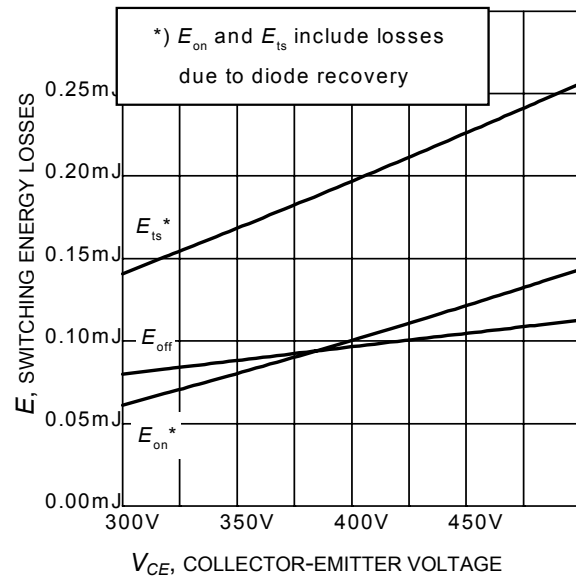
**Figure 13. Typical switching energy losses as a function of collector current**  
 (inductive load,  $T_J = 175^\circ\text{C}$ ,  $V_{CE} = 400\text{V}$ ,  $V_{GE} = 0/15\text{V}$ ,  $R_G = 47\Omega$ , Dynamic test circuit in Figure E)



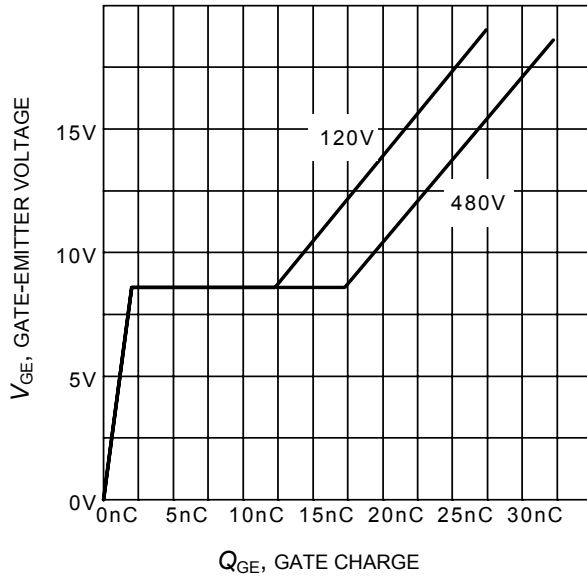
**Figure 14. Typical switching energy losses as a function of gate resistor**  
 (inductive load,  $T_J = 175^\circ\text{C}$ ,  $V_{CE} = 400\text{V}$ ,  $V_{GE} = 0/15\text{V}$ ,  $I_C = 4\text{A}$ , Dynamic test circuit in Figure E)



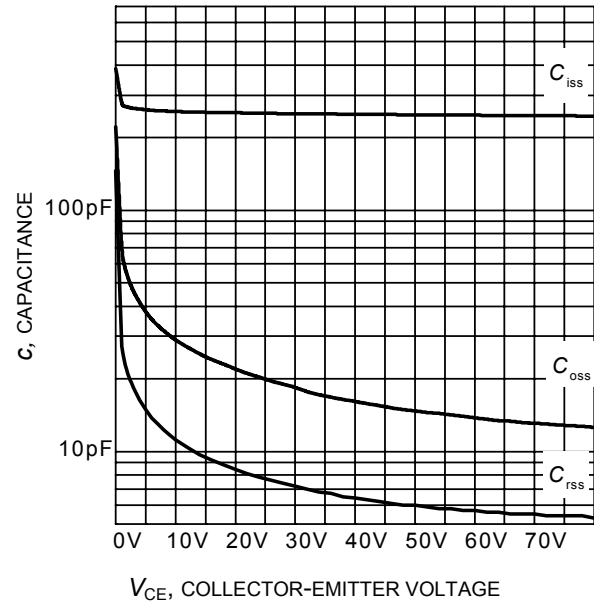
**Figure 15. Typical switching energy losses as a function of junction temperature**  
 (inductive load,  $V_{CE} = 400\text{V}$ ,  $V_{GE} = 0/15\text{V}$ ,  $I_C = 4\text{A}$ ,  $R_G = 47\Omega$ , Dynamic test circuit in Figure E)



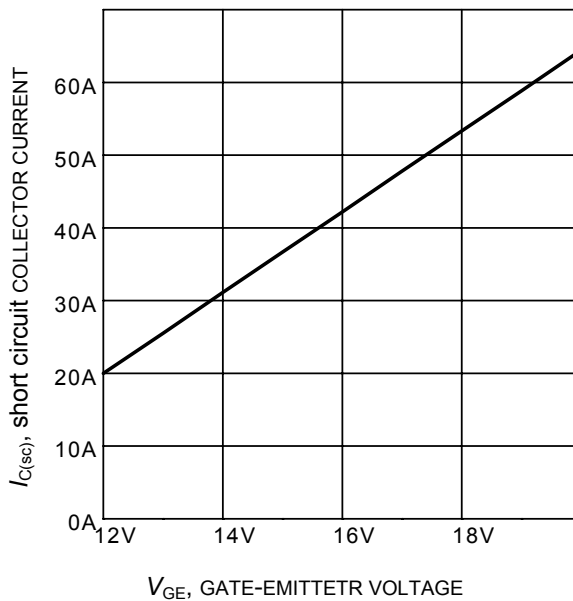
**Figure 16. Typical switching energy losses as a function of collector emitter voltage**  
 (inductive load,  $T_J = 175^\circ\text{C}$ ,  $V_{GE} = 0/15\text{V}$ ,  $I_C = 4\text{A}$ ,  $R_G = 47\Omega$ , Dynamic test circuit in Figure E)



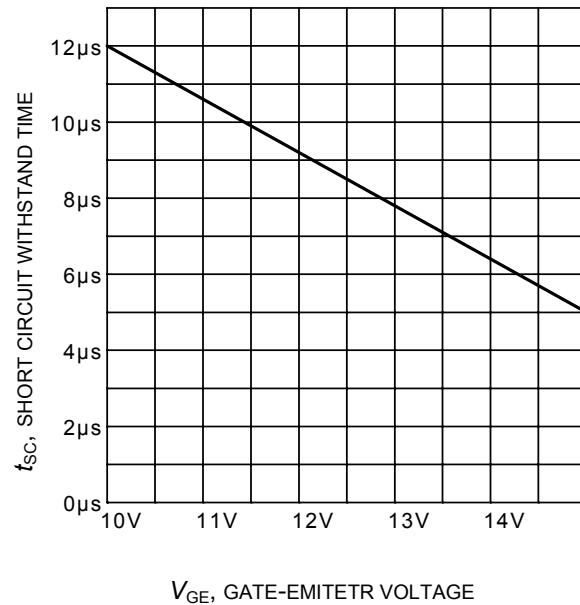
**Figure 17. Typical gate charge**  
( $I_C=4\text{ A}$ )



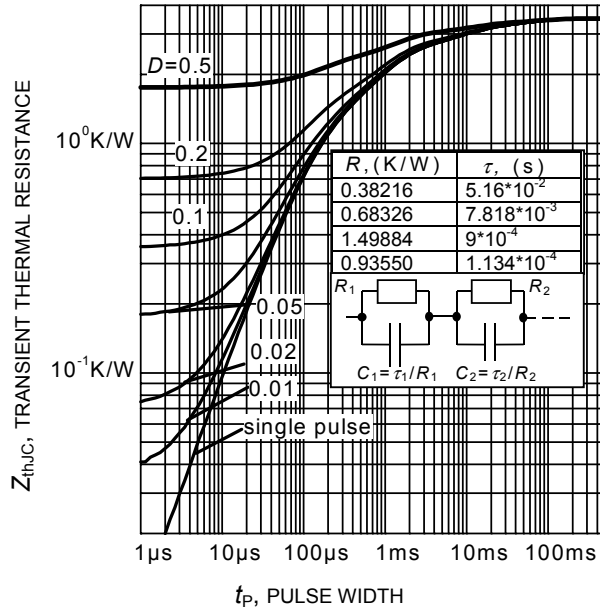
**Figure 18. Typical capacitance as a function of collector-emitter voltage**  
( $V_{GE}=0\text{V}$ ,  $f=1\text{ MHz}$ )



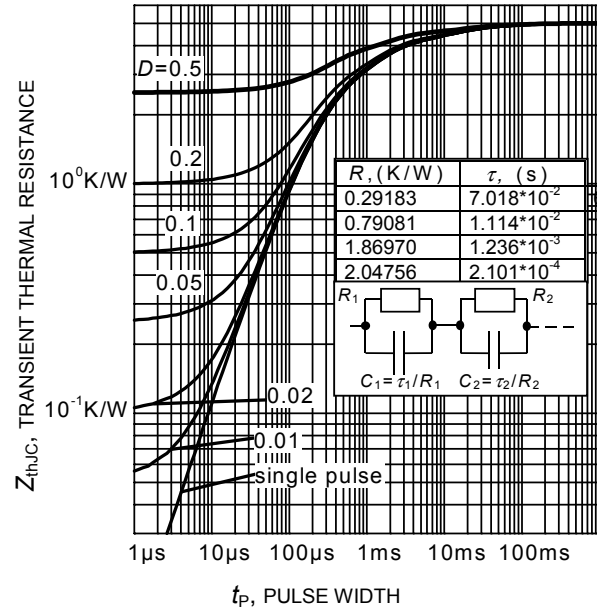
**Figure 19. Typical short circuit collector current as a function of gate-emitter voltage**  
( $V_{CE} \leq 400\text{V}$ ,  $T_j \leq 150^\circ\text{C}$ )



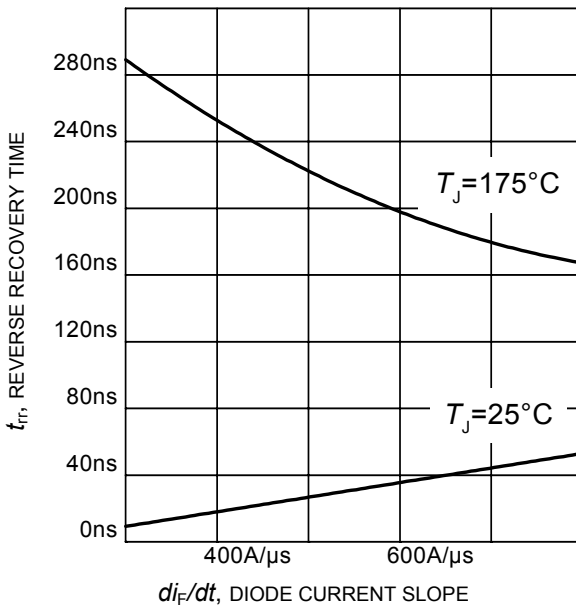
**Figure 20. Short circuit withstand time as a function of gate-emitter voltage**  
( $V_{CE}=600\text{V}$ , start at  $T_j=25^\circ\text{C}$ ,  $T_{jmax}<150^\circ\text{C}$ )



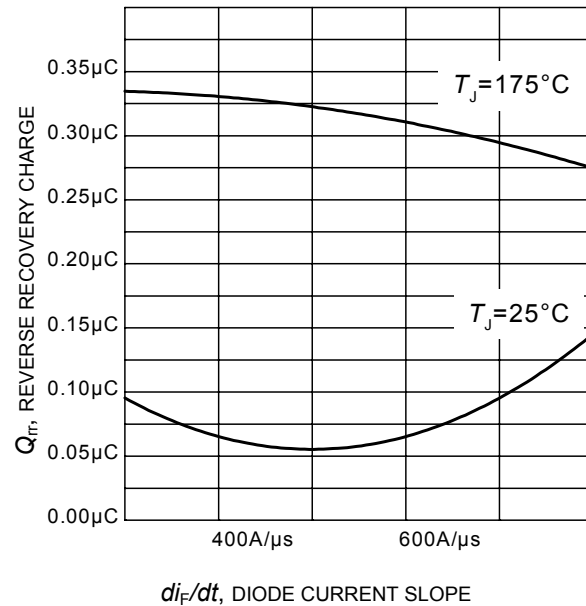
**Figure 21. IGBT transient thermal resistance**  
( $D = t_p / T$ )



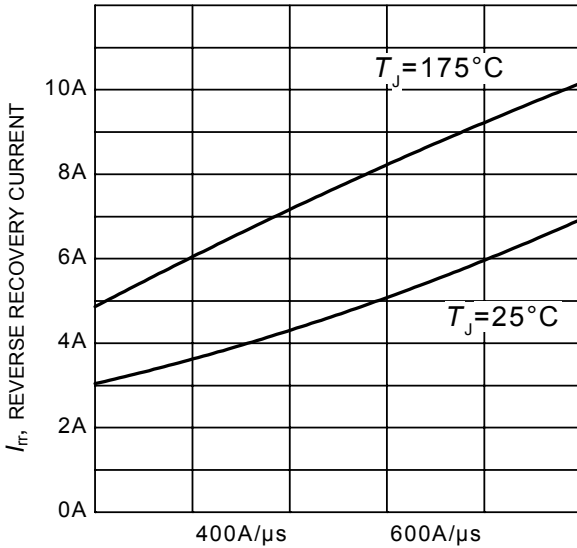
**Figure 22. Diode transient thermal impedance as a function of pulse width**  
( $D = t_p / T$ )



**Figure 23. Typical reverse recovery time as a function of diode current slope**  
( $V_R = 400V$ ,  $I_F = 4A$ ,  
Dynamic test circuit in Figure E)



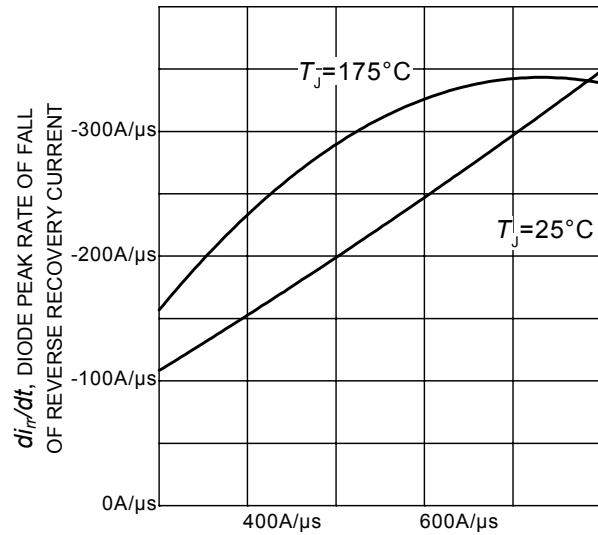
**Figure 24. Typical reverse recovery charge as a function of diode current slope**  
( $V_R = 400V$ ,  $I_F = 4A$ ,  
Dynamic test circuit in Figure E)



$di_F/dt$ , DIODE CURRENT SLOPE

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

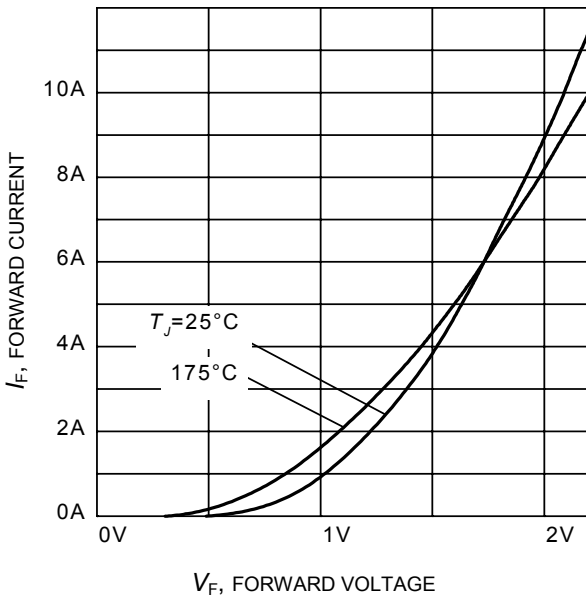
( $V_R = 400V$ ,  $I_F = 4A$ ,  
Dynamic test circuit in Figure E)



$di_F/dt$ , DIODE CURRENT SLOPE

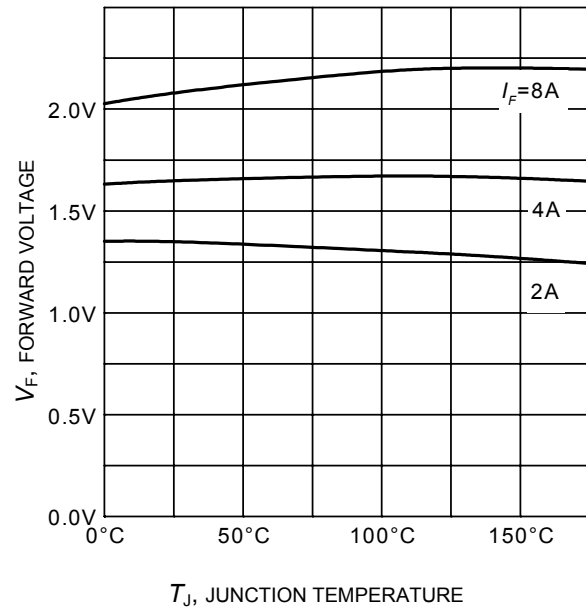
**Figure 26. Typical diode peak rate of fall of reverse recovery current as a function of diode current slope**

( $V_R = 400V$ ,  $I_F = 4A$ ,  
Dynamic test circuit in Figure E)



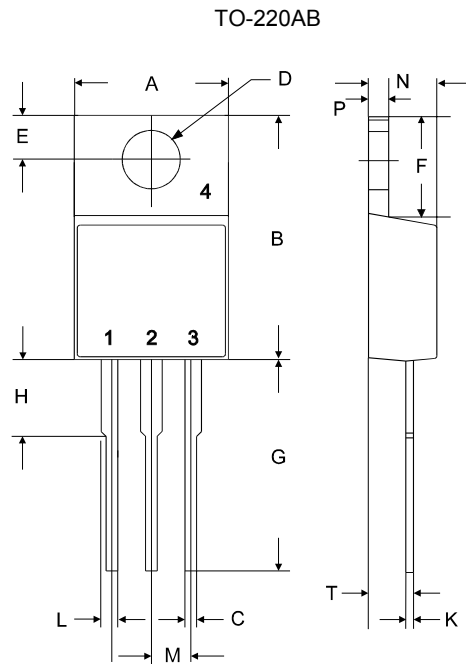
$V_F$ , FORWARD VOLTAGE

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

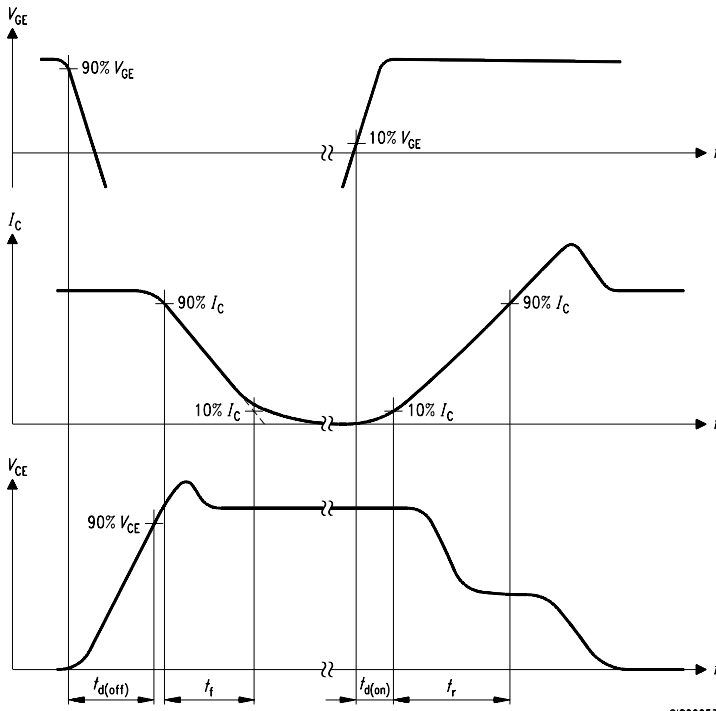


$T_J$ , JUNCTION TEMPERATURE

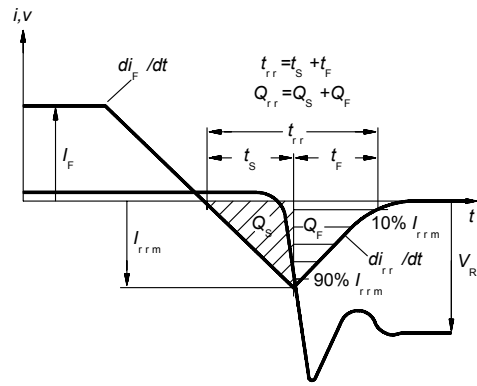
**Figure 28. Typical diode forward voltage as a function of junction temperature**



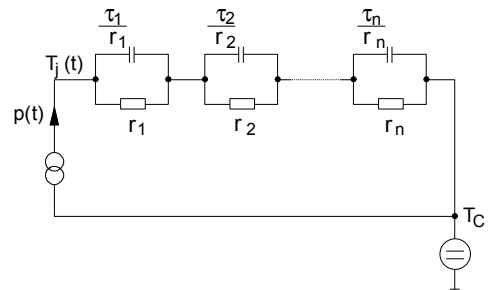
symbol	Dimensions			
	[mm]		[inch]	
	min	max	min	max
A	9.70	10.30	0.3819	0.4055
B	14.88	15.95	0.5858	0.6280
C	0.65	0.86	0.0256	0.0339
D	3.55	3.7	0.1398	0.1457
E	2.60	3.00	0.1024	0.1181
F	6.00	6.80	0.2362	0.2677
G	13.00	14.00	0.5118	0.5512
H	4.35	4.75	0.1713	0.1870
K	0.38	0.65	0.0150	0.0256
L	0.95	1.32	0.0374	0.0520
M	2.54 typ.		0.1 typ.	
N	4.30	4.50	0.1693	0.1772
P	1.17	1.40	0.0461	0.0551
T	2.30	2.72	0.0906	0.1071



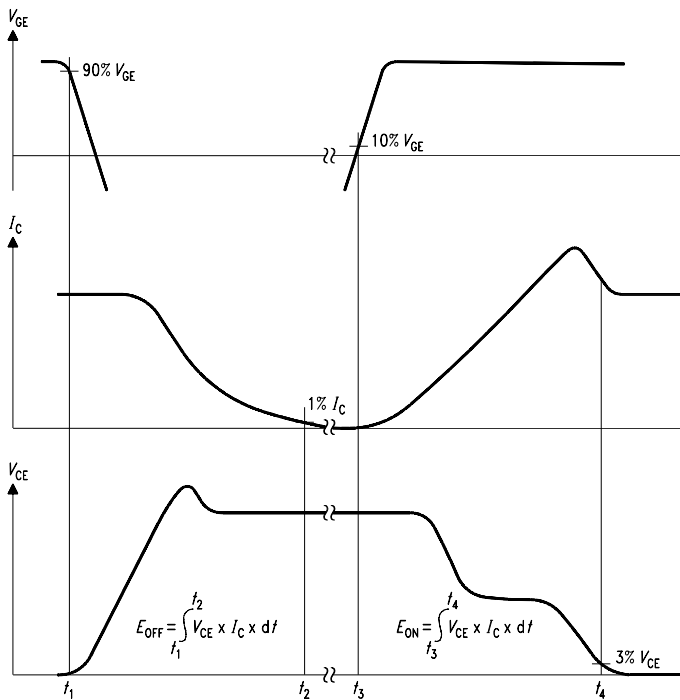
**Figure A. Definition of switching times**



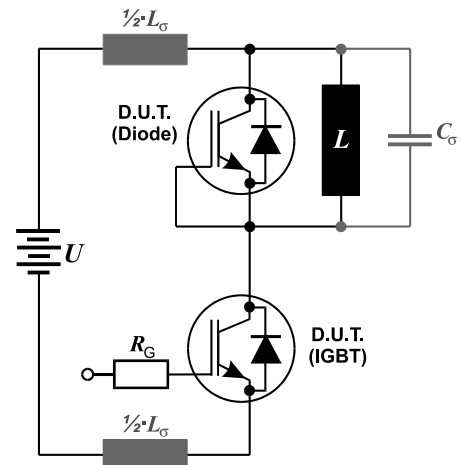
**Figure C. Definition of diodes switching characteristics**



**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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