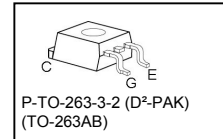
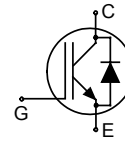


High Speed IGBT in NPT-technology

- 30% lower E_{off} compared to previous generation
- Short circuit withstand time – 10 μ 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
- Complete product spectrum and PSpice Models : <http://www.infineon.com/igbt/>

Type	V_{CE}	I_C	E_{off}	T_j	Package	Ordering Code
SKB06N60HS	600V	6A	80 μ J	150°C	TO-263AB	Q67040-S4544

Maximum Ratings

Parameter	Symbol	Value	Unit
Collector-emitter voltage	V_{CE}	600	V
DC collector current	I_C	12	A
$T_C = 25^\circ\text{C}$		6	
$T_C = 100^\circ\text{C}$			
Pulsed collector current, t_p limited by T_{jmax}	I_{Cpuls}	24	
Turn off safe operating area	-	24	
$V_{CE} \leq 600\text{V}, T_j \leq 150^\circ\text{C}$			
Diode forward current	I_F	12	
$T_C = 25^\circ\text{C}$		6	
$T_C = 100^\circ\text{C}$			
Diode pulsed current, t_p limited by T_{jmax}	I_{Fpuls}	24	
Gate-emitter voltage static	V_{GE}	± 20	V
transient ($t_p < 1\mu\text{s}, D < 0.05$)		± 30	
Short circuit withstand time ¹⁾	t_{SC}	10	μs
$V_{GE} = 15\text{V}, V_{CC} \leq 400\text{V}, T_j \leq 150^\circ\text{C}$			
Power dissipation	P_{tot}	68	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, 1.6mm (0.063 in.) from case for 10s	-	260	

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

Thermal Resistance

Parameter	Symbol	Conditions	Max. Value	Unit
Characteristic				
IGBT thermal resistance, junction – case	R_{thJC}		1.85	K/W
Diode thermal resistance, junction – case	R_{thJCD}		4.5	
Thermal resistance, junction – ambient	R_{thJA}	TO-263AB	62	
SMD version, device on PCB ¹⁾	R_{thJA}	TO-263AB	40	

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

Parameter	Symbol	Conditions	Value			Unit
			min.	Typ.	max.	
Static Characteristic						
Collector-emitter breakdown voltage	$V_{(BR)CES}$	$V_{GE}=0V, I_C=500\mu A$	600	-	-	V
Collector-emitter saturation voltage	$V_{CE(sat)}$	$V_{GE} = 15V, I_C=6A$ $T_j=25^{\circ}C$ $T_j=150^{\circ}C$		2.8 3.5	3.15 4.00	
Diode forward voltage	V_F	$V_{GE}=0V, I_F=6A$ $T_j=25^{\circ}C$ $T_j=150^{\circ}C$		1.5 1.55	2.05 2.05	
Gate-emitter threshold voltage	$V_{GE(th)}$	$I_C=200\mu A, V_{CE}=V_{GE}$	3	4	5	
Zero gate voltage collector current	I_{CES}	$V_{CE}=600V, V_{GE}=0V$ $T_j=25^{\circ}C$ $T_j=150^{\circ}C$	- -	- -	40 2000	μA
Gate-emitter leakage current	I_{GES}	$V_{CE}=0V, V_{GE}=20V$	-	-	100	
Transconductance	g_{fs}	$V_{CE}=20V, I_C=6A$	-	4		S

¹⁾ Device on 50mm*50mm*1.5mm epoxy PCB FR4 with 6cm² (one layer, 70μm thick) copper area for collector connection. PCB is vertical without blown air.

Dynamic Characteristic

Input capacitance	C_{iss}	$V_{CE}=25V,$	-	350		pF
Output capacitance	C_{oss}	$V_{GE}=0V,$	-	50		
Reverse transfer capacitance	C_{rss}	$f=1MHz$	-	23		
Gate charge	Q_{Gate}	$V_{CC}=480V, I_C=6A$ $V_{GE}=15V$	-	33		nC
Internal emitter inductance measured 5mm (0.197 in.) from case	L_E	TO-263AB	-	7		nH
Short circuit collector current ¹⁾	$I_{C(SC)}$	$V_{GE}=15V, t_{SC} \leq 10\mu s$ $V_{CC} \leq 400V,$ $T_j \leq 150^\circ C$	-	48		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	$t_{d(on)}$	$T_j=25^{\circ}\text{C}$, $V_{CC}=400\text{V}$, $I_C=6\text{A}$, $V_{GE}=0/15\text{V}$, $R_G=50\Omega$ $L_{\sigma}^{2)}=60\text{nH}$, $C_{\sigma}^{2)}=40\text{pF}$ Energy losses include “tail” and diode reverse recovery.	-	11		ns
Rise time	t_r		-	11		
Turn-off delay time	$t_{d(off)}$		-	196		
Fall time	t_f		-	41		
Turn-on energy	E_{on}		-	0.10		mJ
Turn-off energy	E_{off}		-	0.09		
Total switching energy	E_{ts}		-	0.19		

Anti-Parallel Diode Characteristic

Diode reverse recovery time	t_{rr}	$T_j=25^\circ C,$	-	100		ns
	t_S	$V_R=400V, I_F=6A,$	-	24		
	t_F	$di_F/dt=626A/\mu s$	-	76		
Diode reverse recovery charge	Q_{rr}		-	220		nC
Diode peak reverse recovery current	I_{rrm}		-	7		A
Diode peak rate of fall of reverse recovery current during t_b	di_{rr}/dt		-	315		A/ μs

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

²⁾ Leakage inductance L_σ and Stray capacity C_σ 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.		
IGBT Characteristic							
Turn-on delay time	$t_{d(on)}$	$T_j=150^{\circ}\text{C}$ $V_{CC}=400\text{V}, I_C=6\text{A},$ $V_{GE}=0/15\text{V},$ $R_G=8\Omega$ $L_{\sigma}^{1)}=60\text{nH},$ $C_{\sigma}^{1)}=40\text{pF}$ Energy losses include “tail” and diode reverse recovery.	-	8		ns	
Rise time	t_r		-	3			
Turn-off delay time	$t_{d(off)}$		-	63			
Fall time	t_f		-	59			
Turn-on energy	E_{on}			-	0.11		mJ
Turn-off energy	E_{off}		-	0.08			
Total switching energy	E_{ts}		-	0.19			
Turn-on delay time	$t_{d(on)}$	$T_j=150^{\circ}\text{C}$ $V_{CC}=400\text{V}, I_C=6\text{A},$ $V_{GE}=0/15\text{V},$ $R_G=50\Omega$ $L_{\sigma}^{1)}=60\text{nH},$ $C_{\sigma}^{1)}=40\text{pF}$ Energy losses include “tail” and diode reverse recovery.	-	10		ns	
Rise time	t_r		-	13			
Turn-off delay time	$t_{d(off)}$		-	216			
Fall time	t_f		-	29			
Turn-on energy	E_{on}			-	0.15		mJ
Turn-off energy	E_{off}			-	0.12		
Total switching energy	E_{ts}			-	0.27		

Anti-Parallel Diode Characteristic

Diode reverse recovery time	t_{rr}	$T_j=150^\circ\text{C}$ $V_R=400\text{V}, I_F=6\text{A},$ $di_F/dt=673\text{A}/\mu\text{s}$	-	150		ns
	t_s		-	27		
	t_F		-	123		
Diode reverse recovery charge	Q_{rr}		-	500		nC
Diode peak reverse recovery current	I_{rrm}		-	8.8		A
Diode peak rate of fall of reverse recovery current during t_b	di_{rr}/dt		-	280		A/ μs

¹⁾ Leakage inductance L_{σ} and Stray capacity C_{σ} due to test circuit in Figure E.

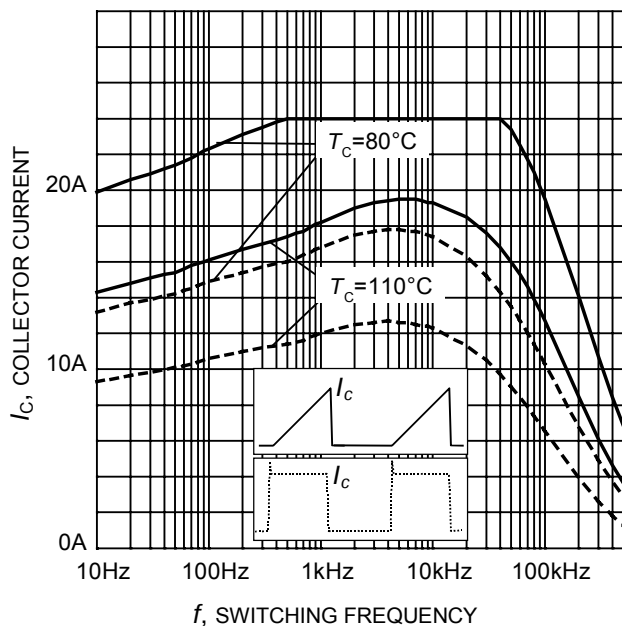


Figure 1. Collector current as a function of switching frequency
 $(T_j \leq 150^\circ\text{C}, D = 0.5, V_{CE} = 400\text{V}, V_{GE} = 0/+15\text{V}, R_G = 50\Omega)$

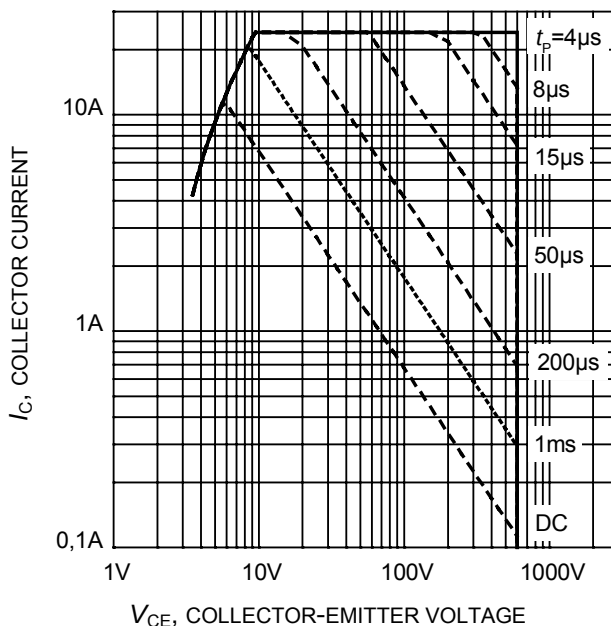


Figure 2. Safe operating area
 $(D = 0, T_C = 25^\circ\text{C}, T_j \leq 150^\circ\text{C}; V_{GE} = 15\text{V})$

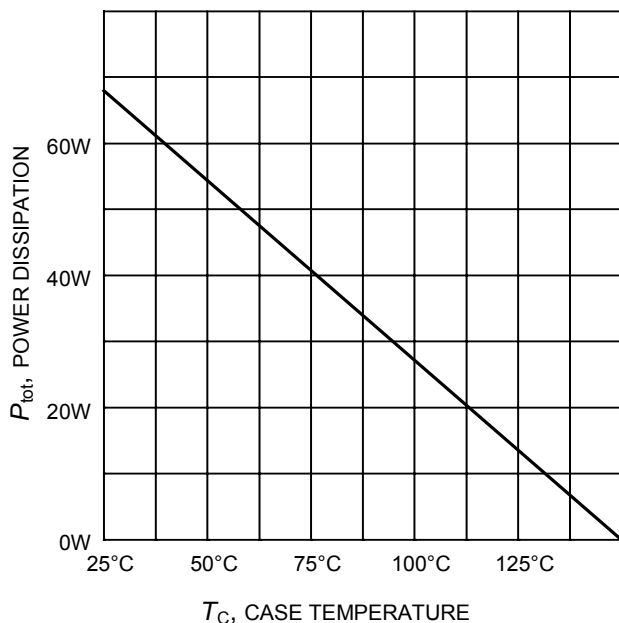


Figure 3. Power dissipation as a function of case temperature
 $(T_j \leq 150^\circ\text{C})$

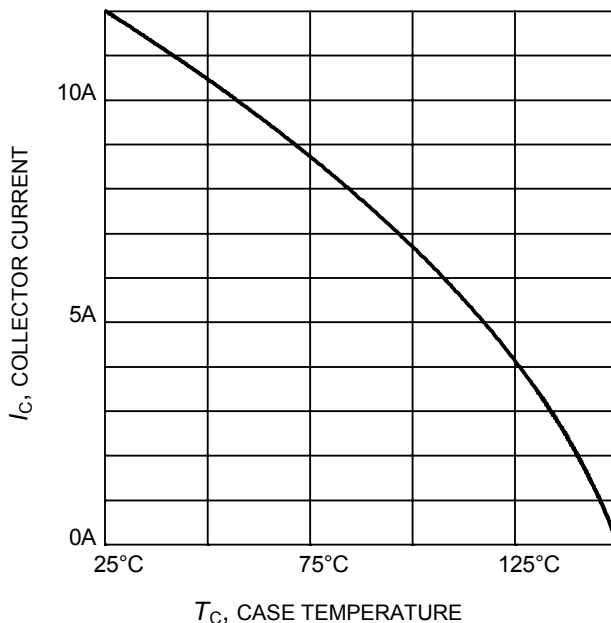


Figure 4. Collector current as a function of case temperature
 $(V_{GE} \leq 15\text{V}, T_j \leq 150^\circ\text{C})$

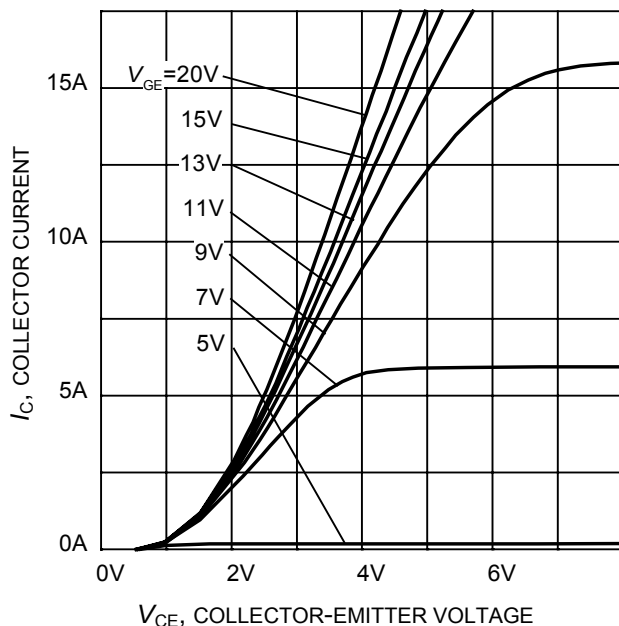


Figure 5. Typical output characteristic
($T_j = 25^\circ\text{C}$)

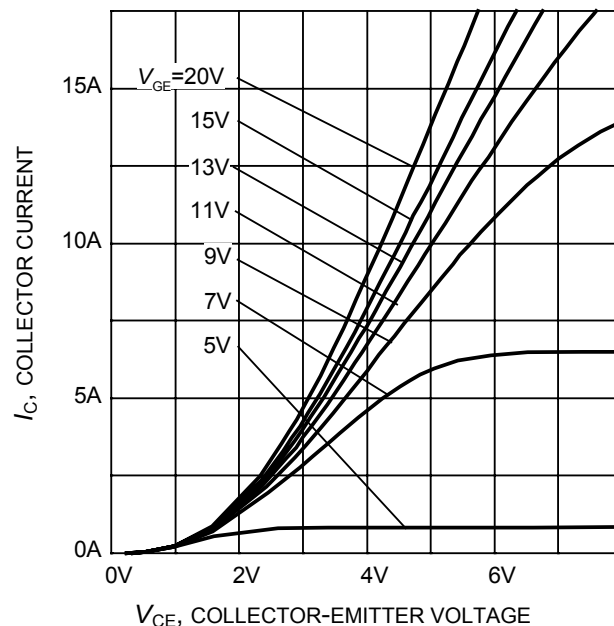


Figure 6. Typical output characteristic
($T_j = 150^\circ\text{C}$)

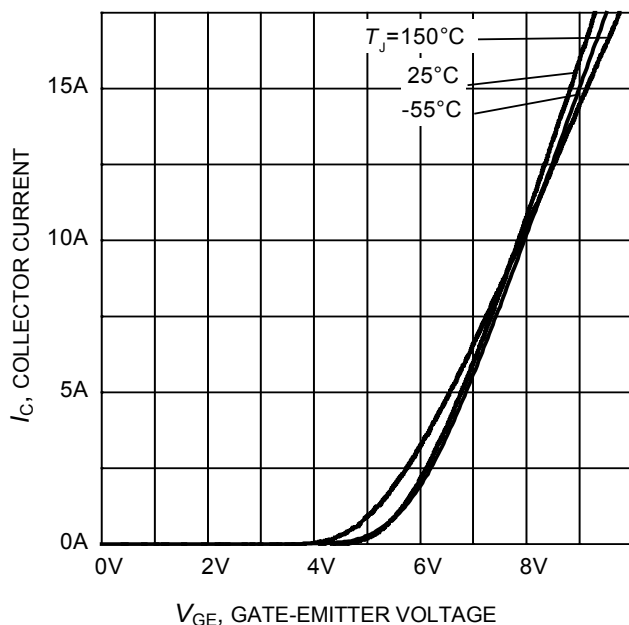


Figure 7. Typical transfer characteristic
($V_{ce} = 10\text{V}$)

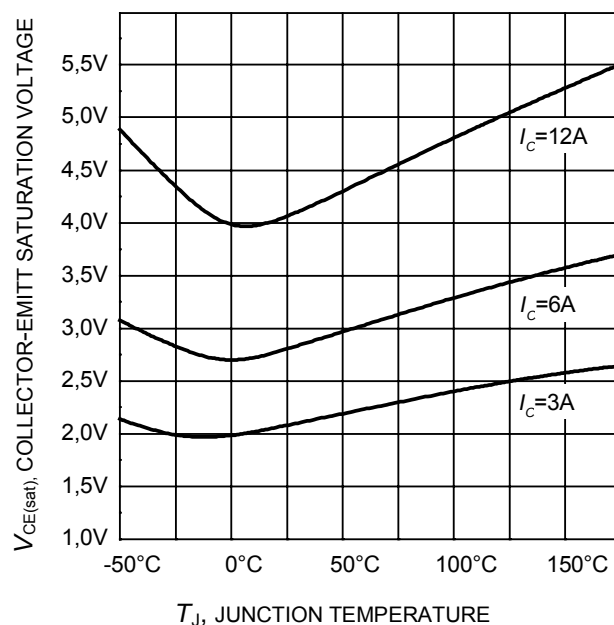


Figure 8. Typical collector-emitter saturation voltage as a function of junction temperature
($V_{ge} = 15\text{V}$)

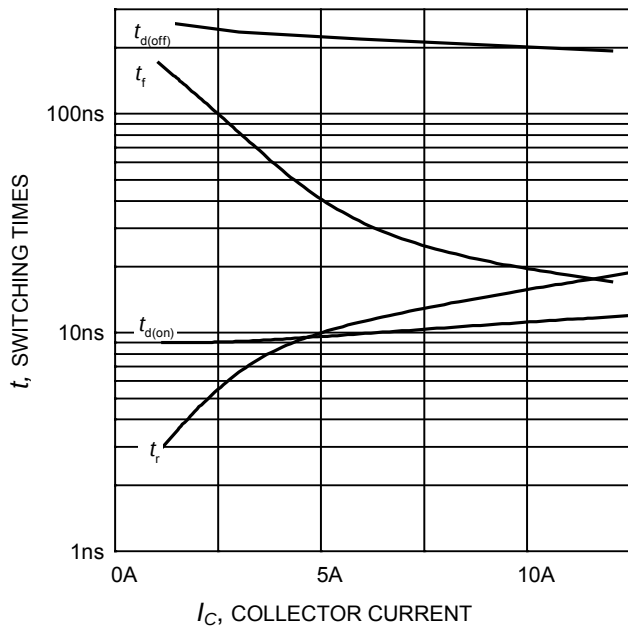


Figure 9. Typical switching times as a function of collector current
(inductive load, $T_J=150^\circ\text{C}$, $V_{CE}=400\text{V}$, $V_{GE}=0/15\text{V}$, $R_G=50\Omega$, Dynamic test circuit in Figure E)

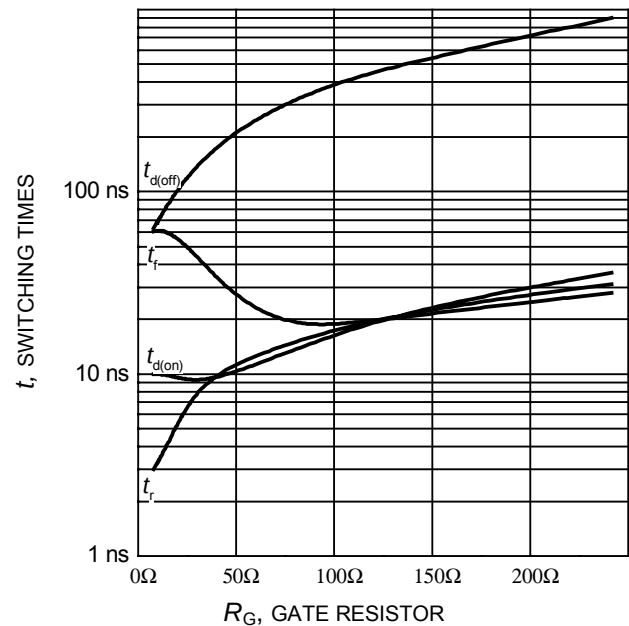


Figure 10. Typical switching times as a function of gate resistor
(inductive load, $T_J=150^\circ\text{C}$, $V_{CE}=400\text{V}$, $V_{GE}=0/15\text{V}$, $I_C=6\text{A}$, Dynamic test circuit in Figure E)

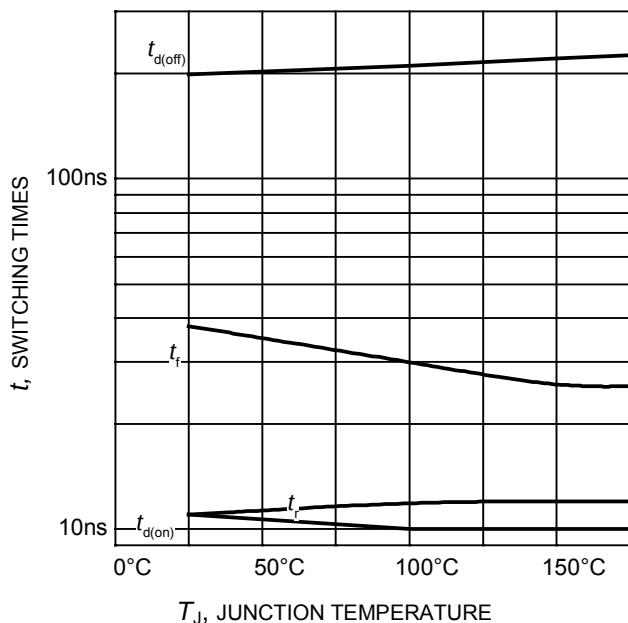


Figure 11. Typical switching times as a function of junction temperature
(inductive load, $V_{CE}=400\text{V}$, $V_{GE}=0/15\text{V}$, $I_C=6\text{A}$, $R_G=50\Omega$, Dynamic test circuit in Figure E)

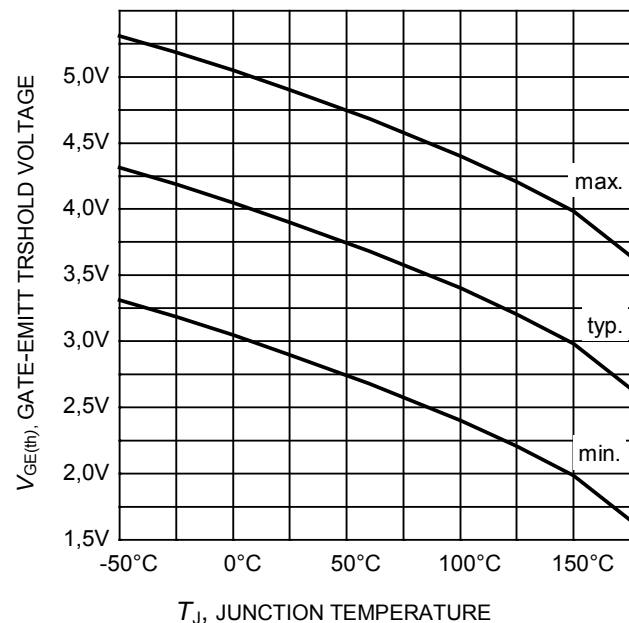


Figure 12. Gate-emitter threshold voltage as a function of junction temperature
($I_C = 0.5\text{mA}$)

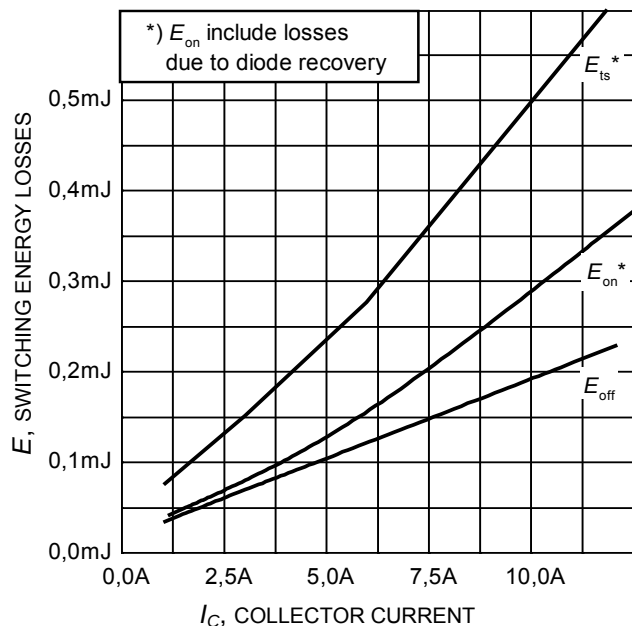


Figure 13. Typical switching energy losses as a function of collector current
(inductive load, $T_J=150^\circ\text{C}$, $V_{CE}=400\text{V}$, $V_{GE}=0/15\text{V}$, $R_G=50\Omega$, Dynamic test circuit in Figure E)

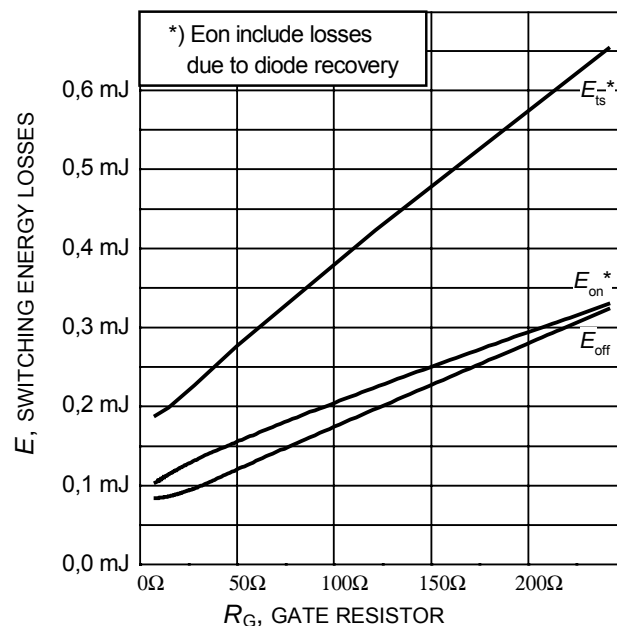


Figure 14. Typical switching energy losses as a function of gate resistor
(inductive load, $T_J=150^\circ\text{C}$, $V_{CE}=400\text{V}$, $V_{GE}=0/15\text{V}$, $I_C=6\text{A}$, Dynamic test circuit in Figure E)

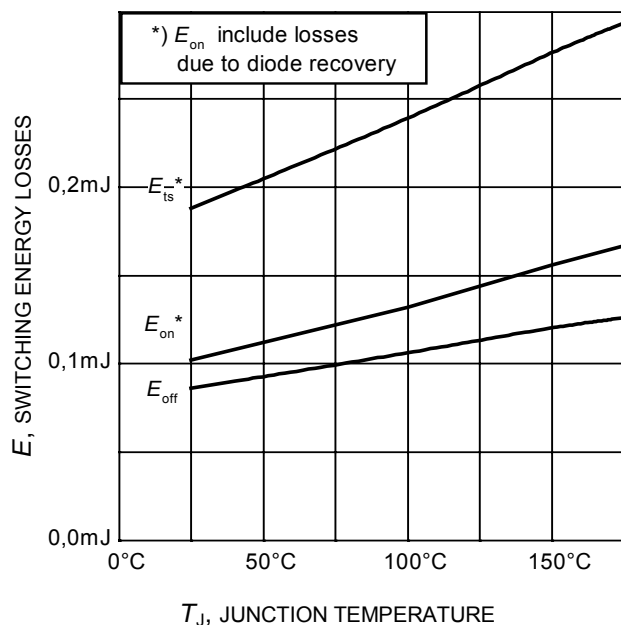


Figure 15. Typical switching energy losses as a function of junction temperature
(inductive load, $V_{CE}=400\text{V}$, $V_{GE}=0/15\text{V}$, $I_C=6\text{A}$, $R_G=50\Omega$, Dynamic test circuit in Figure E)

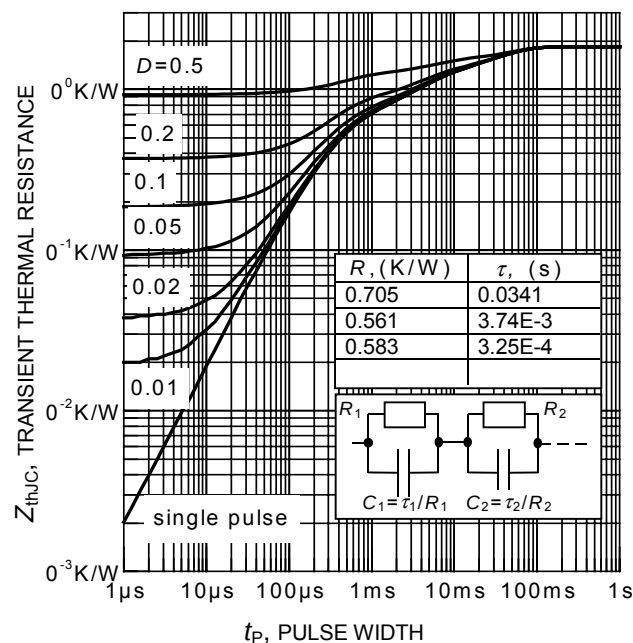


Figure 16. IGBT transient thermal resistance
($D = t_p / T$)

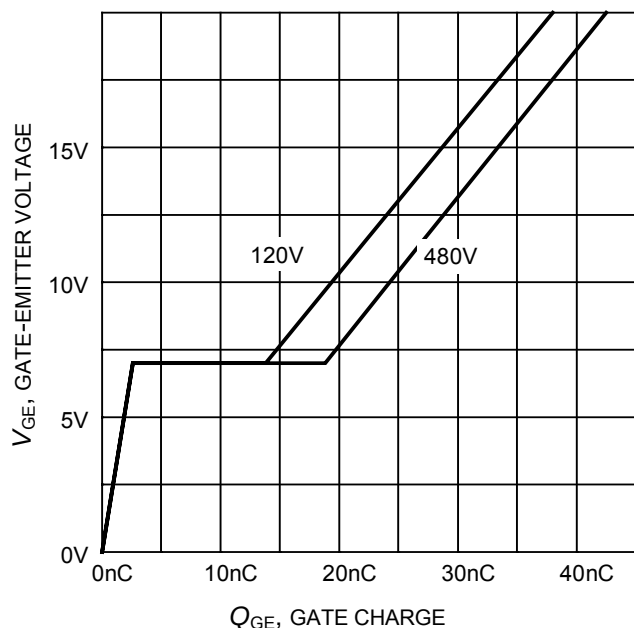


Figure 17. Typical gate charge
($I_C = 6\text{ A}$)

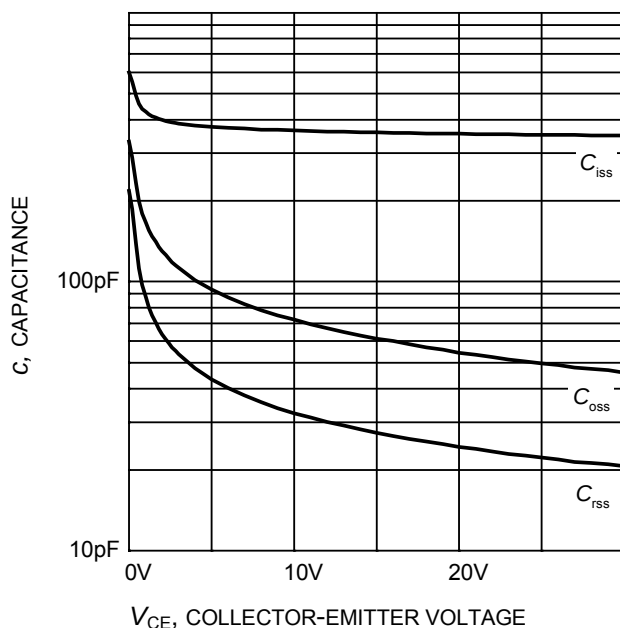


Figure 18. Typical capacitance as a function of collector-emitter voltage
($V_{GE} = 0\text{ V}$, $f = 1\text{ MHz}$)

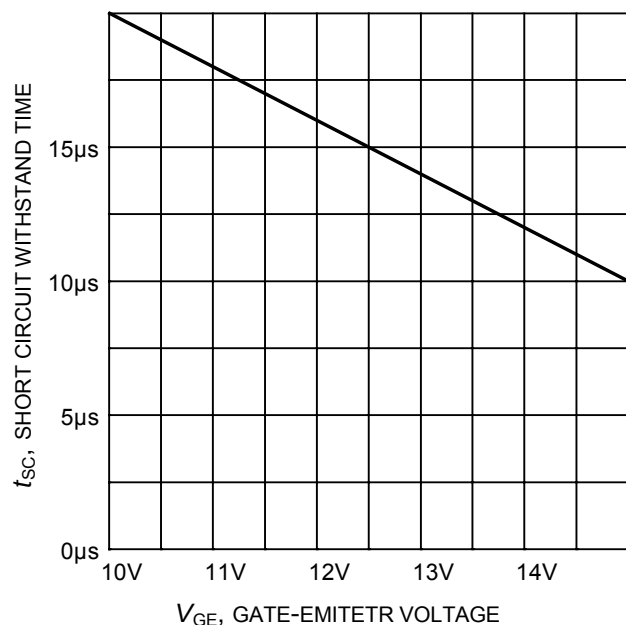


Figure 19. Short circuit withstand time as a function of gate-emitter voltage
($V_{CE} = 600\text{ V}$, start at $T_J = 25^\circ\text{C}$)

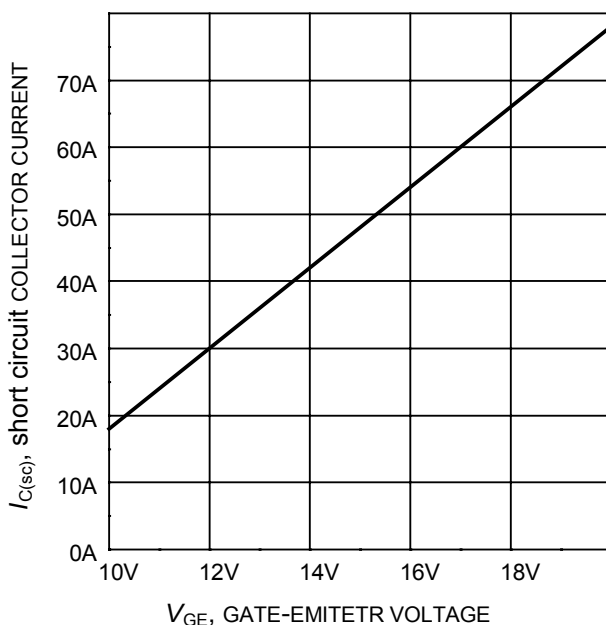


Figure 20. Typical short circuit collector current as a function of gate-emitter voltage
($V_{CE} \leq 400\text{ V}$, $T_J \leq 150^\circ\text{C}$)

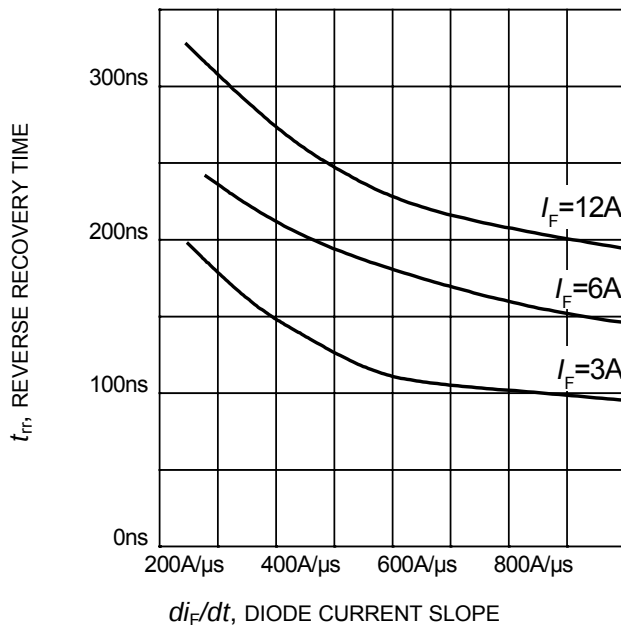


Figure 21. Typical reverse recovery time as a function of diode current slope
($V_R=400V$, $T_J=150^\circ C$,
Dynamic test circuit in Figure E)

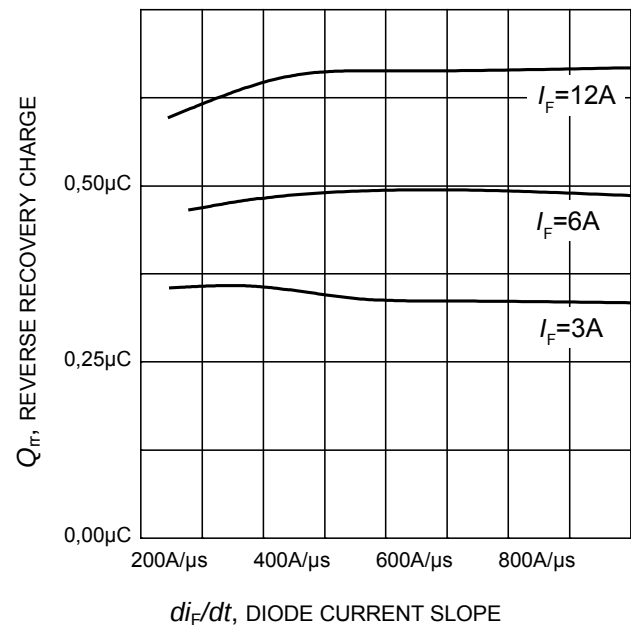


Figure 22. Typical reverse recovery charge as a function of diode current slope
($V_R=400V$, $T_J=150^\circ C$,
Dynamic test circuit in Figure E)

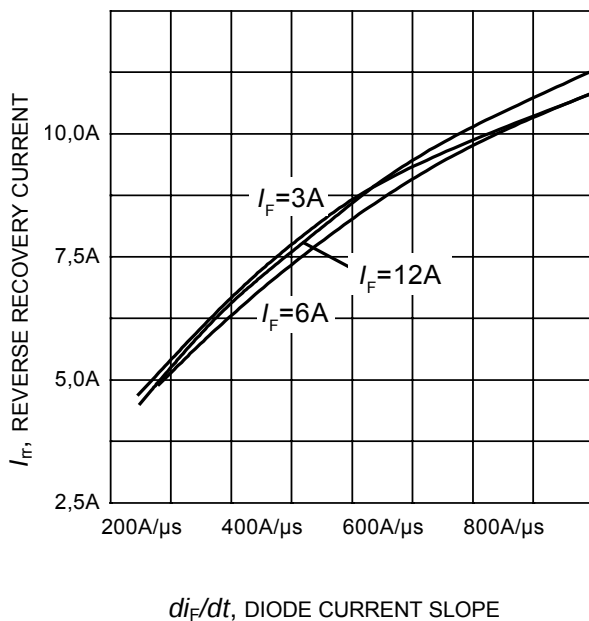


Figure 23. Typical reverse recovery current as a function of diode current slope
($V_R=400V$, $T_J=150^\circ C$,
Dynamic test circuit in Figure E)

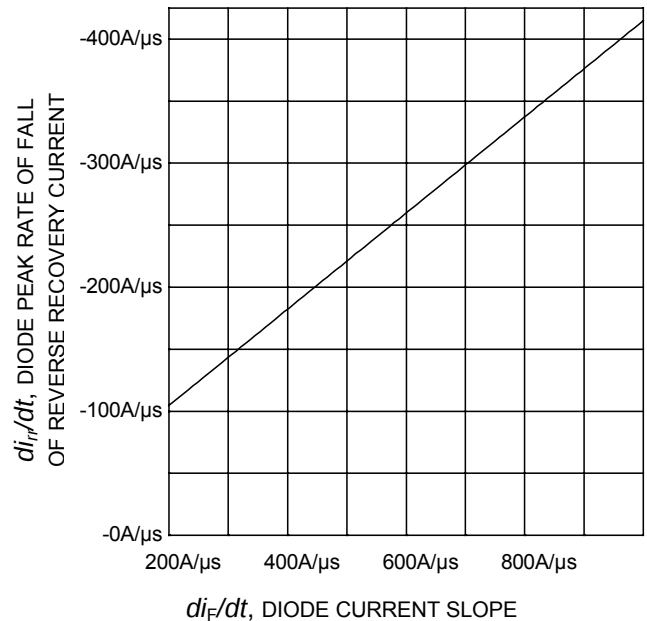


Figure 24. Typical diode peak rate of fall of reverse recovery current as a function of diode current slope
($V_R=400V$, $T_J=150^\circ C$,
Dynamic test circuit in Figure E)

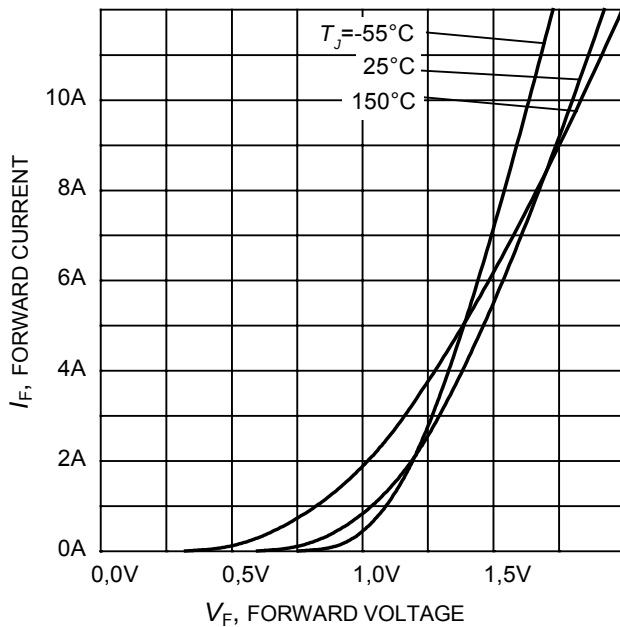


Figure 25. Typical diode forward current as a function of forward voltage

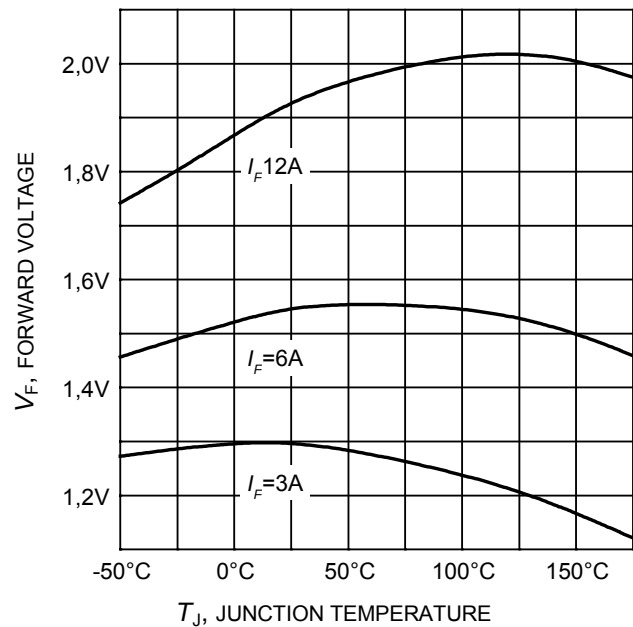


Figure 26. Typical diode forward voltage as a function of junction temperature

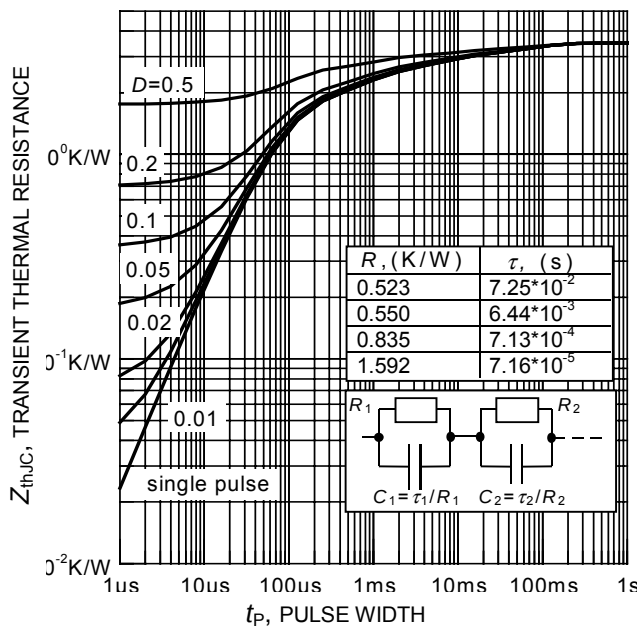
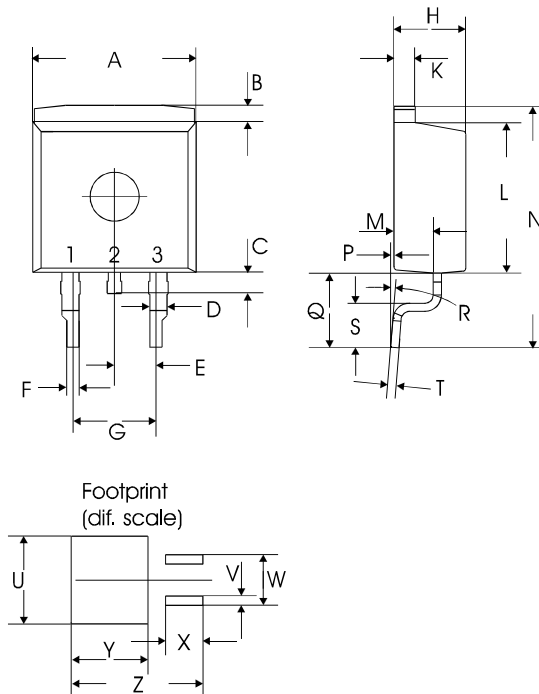


Figure 27. Diode transient thermal impedance as a function of pulse width
($D = t_p / T$)

TO-263AB (D²Pak)



symbol	dimensions			
	[mm]		[inch]	
	min	max	min	max
A	9.80	10.20	0.3858	0.4016
B	0.70	1.30	0.0276	0.0512
C	1.00	1.60	0.0394	0.0630
D	1.03	1.07	0.0406	0.0421
E	2.54 typ.		0.1 typ.	
F	0.65	0.85	0.0256	0.0335
G	5.08 typ.		0.2 typ.	
H	4.30	4.50	0.1693	0.1772
K	1.17	1.37	0.0461	0.0539
L	9.05	9.45	0.3563	0.3720
M	2.30	2.50	0.0906	0.0984
N	15 typ.		0.5906 typ.	
P	0.00	0.20	0.0000	0.0079
Q	4.20	5.20	0.1654	0.2047
R	8° max		8° max	
S	2.40	3.00	0.0945	0.1181
T	0.40	0.60	0.0157	0.0236
U	10.80		0.4252	
V	1.15		0.0453	
W	6.23		0.2453	
X	4.60		0.1811	
Y	9.40		0.3701	
Z	16.15		0.6358	

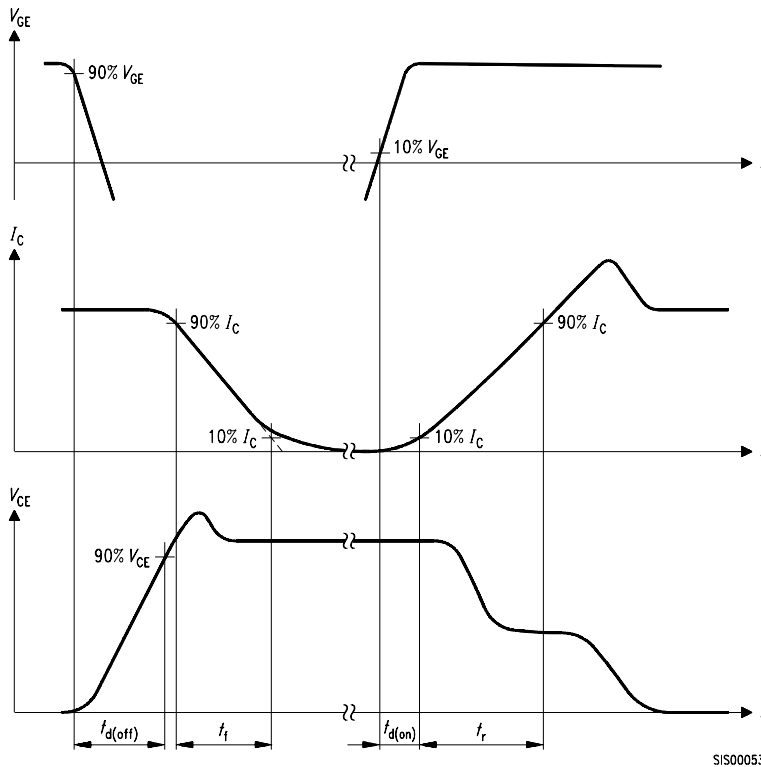


Figure A. Definition of switching times

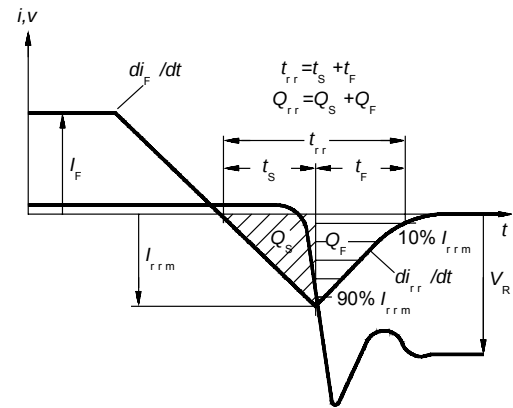


Figure C. Definition of diodes switching characteristics

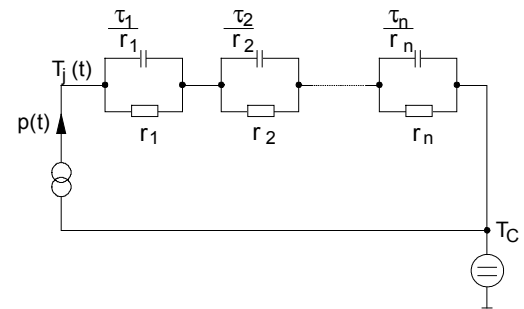


Figure D. Thermal equivalent circuit

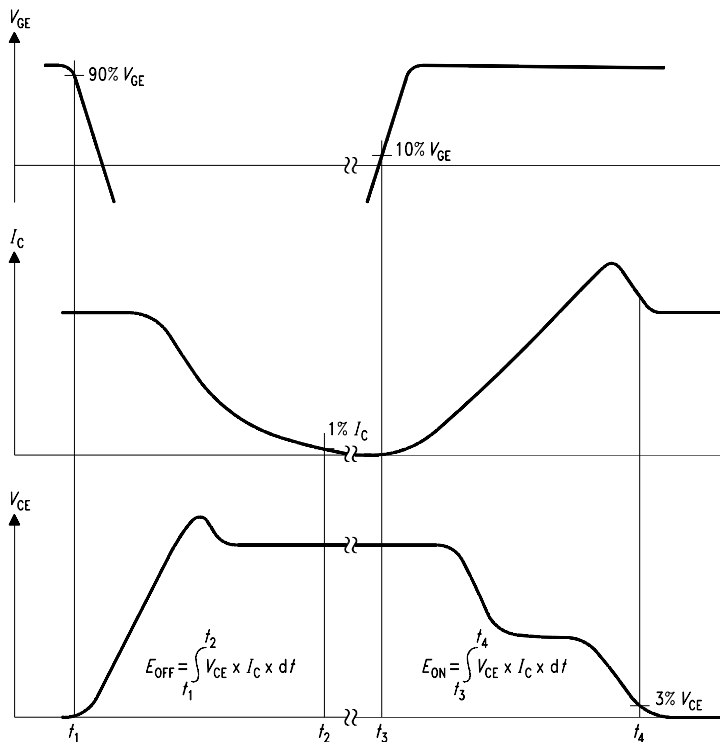


Figure B. Definition of switching losses

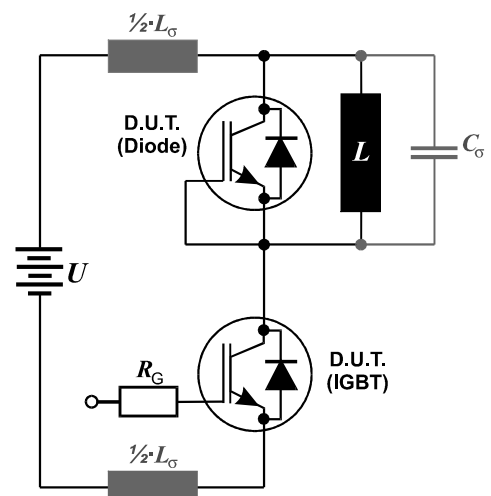


Figure E. Dynamic test circuit
Leakage inductance $L_{\sigma} = 60\text{nH}$
and Stray capacity $C_{\sigma} = 40\text{pF}$.

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