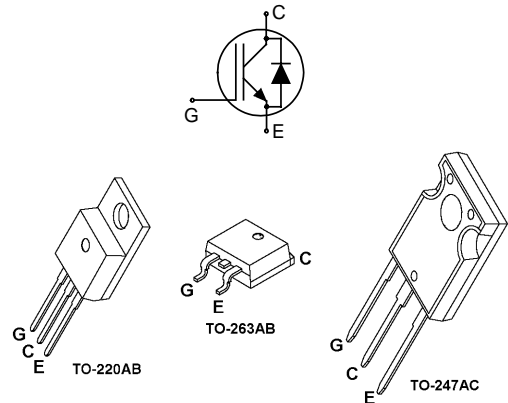


Fast S-IGBT in NPT-technology with soft, fast recovery anti-parallel EmCon diode

- 75% lower E_{off} compared to previous generation combined with low conduction losses
- Short circuit withstand time – 10 μ s
- Designed for:
 - Motor controls
 - Inverter
- NPT-Technology for 600V applications offers:
 - very tight parameter distribution
 - high ruggedness, temperature stable behaviour
 - parallel switching capability
- Very soft, fast recovery anti-parallel EmCon diode



Type	V_{CE}	I_C	$V_{CE(sat)}$	T_j	Package	Ordering Code
SKP10N60	600V	10A	2.2V	150°C	TO-220AB	Q67040-S4217
SKB10N60					TO-263AB	Q67040-S4218
SKW10N60					TO-247AC	Q67040-S4241

Maximum Ratings

Parameter	Symbol	Value	Unit
Collector-emitter voltage	V_{CE}	600	V
DC collector current	I_C		A
$T_C = 25^\circ\text{C}$		21	
$T_C = 100^\circ\text{C}$		10.9	
Pulsed collector current, t_p limited by T_{jmax}	I_{Cpuls}	42	
Turn off safe operating area $V_{CE} \leq 600\text{V}, T_j \leq 150^\circ\text{C}$	-	42	
Diode forward current	I_F		
$T_C = 25^\circ\text{C}$		21	
$T_C = 100^\circ\text{C}$		10	
Diode pulsed current, t_p limited by T_{jmax}	I_{Fpuls}	42	
Gate-emitter voltage	V_{GE}	± 20	V
Short circuit withstand time ¹⁾ $V_{GE} = 15\text{V}, V_{CC} \leq 600\text{V}, T_j \leq 150^\circ\text{C}$	t_{SC}	10	μ s
Power dissipation $T_C = 25^\circ\text{C}$	P_{tot}	104	W
Operating junction and storage temperature	T_j, T_{stg}	-55...+150	°C

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}		1.2	K/W
Diode thermal resistance, junction – case	R_{thJCD}		2.4	
Thermal resistance, junction – ambient	R_{thJA}	TO-220AB TO-247AC	62 40	
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	$V_{CE(sat)}$	$V_{GE} = 15V, I_C=10A$ $T_j=25^\circ\text{C}$ $T_j=150^\circ\text{C}$	1.7 -	2 2.2	2.4 2.7	
Diode forward voltage	V_F	$V_{GE}=0V, I_F=10A$ $T_j=25^\circ\text{C}$ $T_j=150^\circ\text{C}$	1.2 -	1.4 1.25	1.8 1.65	
Gate-emitter threshold voltage	$V_{GE(th)}$	$I_C=300\mu A, V_{CE}=V_{GE}$	3	4	5	
Zero gate voltage collector current	I_{CES}	$V_{CE}=600V, V_{GE}=0V$ $T_j=25^\circ\text{C}$ $T_j=150^\circ\text{C}$	- -	- -	40 1500	μA
Gate-emitter leakage current	I_{GES}	$V_{CE}=0V, V_{GE}=20V$	-	-	100	nA
Transconductance	g_{fs}	$V_{CE}=20V, I_C=10A$	-	6.7	-	S
Dynamic Characteristic						
Input capacitance	C_{iss}	$V_{CE}=25V,$ $V_{GE}=0V,$ $f=1\text{MHz}$	-	580	696	pF
Output capacitance	C_{oss}		-	70	84	
Reverse transfer capacitance	C_{riss}		-	50	60	
Gate charge	Q_{Gate}	$V_{CC}=480V, I_C=10A$ $V_{GE}=15V$	-	64	83	nC
Internal emitter inductance measured 5mm (0.197 in.) from case	L_E	TO-220AB TO-247AC	- -	7 13	- -	nH
Short circuit collector current ²⁾	$I_{C(SC)}$	$V_{GE}=15V, t_{SC}\leq 10\mu s$ $V_{CC}\leq 600V,$ $T_j\leq 150^\circ\text{C}$	-	100	-	A

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

²⁾ 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.	
IGBT Characteristic						
Turn-on delay time	$t_{d(on)}$	$T_j=25^\circ\text{C}$, $V_{CC}=400\text{V}$, $I_C=10\text{A}$, $V_{GE}=0/15\text{V}$, $R_G=25\Omega$,	-	29	35	ns
Rise time	t_r		-	21	25	
Turn-off delay time	$t_{d(off)}$		-	233	280	
Fall time	t_f		-	49	59	
Turn-on energy	E_{on}	Energy losses include "tail" and diode reverse recovery.	-	0.20	0.230	mJ
Turn-off energy	E_{off}		-	0.17	0.221	
Total switching energy	E_{ts}		-	0.370	0.451	

Anti-Parallel Diode Characteristic

Diode reverse recovery time	t_{rr}	$T_j=25^\circ\text{C}$, $V_R=200\text{V}$, $I_F=10\text{A}$, $di_F/dt=200\text{A}/\mu\text{s}$	-	220	-	ns
	t_S		-	20	-	
	t_F		-	200	-	
Diode reverse recovery charge	Q_{rr}		-	310	-	nC
Diode peak reverse recovery current	I_{rrm}		-	4.5	-	A
Diode peak rate of fall of reverse recovery current during t_b	di_{rr}/dt	-	180	-	A/ μs	

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	$t_{d(on)}$	$T_j=150^\circ\text{C}$ $V_{CC}=400\text{V}$, $I_C=10\text{A}$, $V_{GE}=0/15\text{V}$, $R_G=25\Omega$	-	29	35	ns
Rise time	t_r		-	21	25	
Turn-off delay time	$t_{d(off)}$		-	266	319	
Fall time	t_f		-	63	76	
Turn-on energy	E_{on}	Energy losses include "tail" and diode reverse recovery.	-	0.297	0.342	mJ
Turn-off energy	E_{off}		-	0.28	0.364	
Total switching energy	E_{ts}		-	0.577	0.706	

Anti-Parallel Diode Characteristic

Diode reverse recovery time	t_{rr}	$T_j=150^\circ\text{C}$ $V_R=200\text{V}$, $I_F=10\text{A}$, $di_F/dt=200\text{A}/\mu\text{s}$	-	350	-	ns
	t_S		-	36	-	
	t_F		-	314	-	
Diode reverse recovery charge	Q_{rr}		-	690	-	nC
Diode peak reverse recovery current	I_{rrm}		-	6.3	-	A
Diode peak rate of fall of reverse recovery current during t_b	di_{rr}/dt	-	200	-	A/ μs	

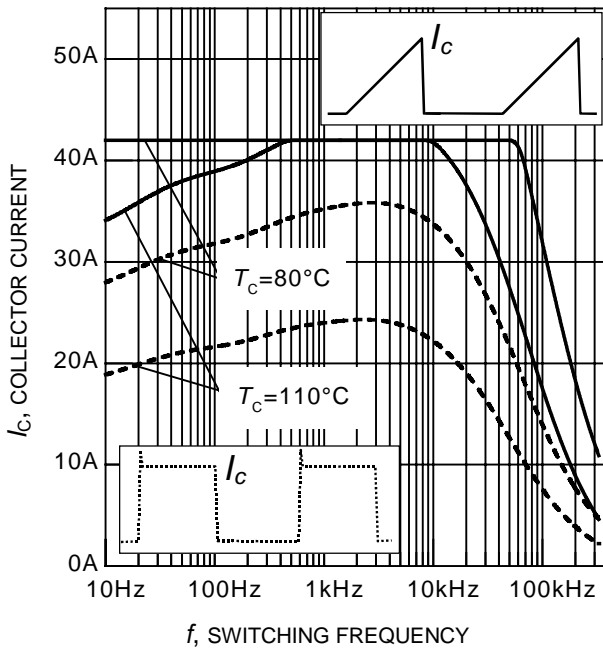


Figure 1. Collector current as a function of switching frequency
 ($T_j \leq 150^\circ\text{C}$, $D = 0.5$, $V_{CE} = 400\text{V}$,
 $V_{GE} = 0/+15\text{V}$, $R_G = 25\Omega$)

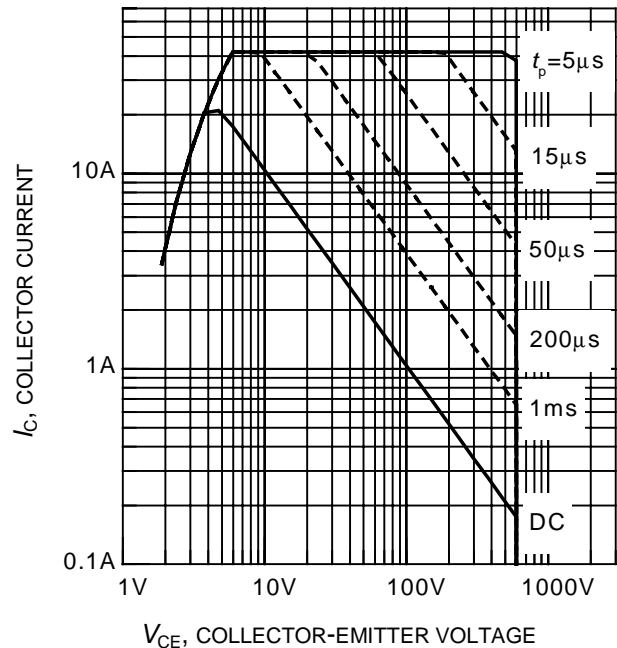


Figure 2. Safe operating area
 ($D = 0$, $T_C = 25^\circ\text{C}$, $T_j \leq 150^\circ\text{C}$)

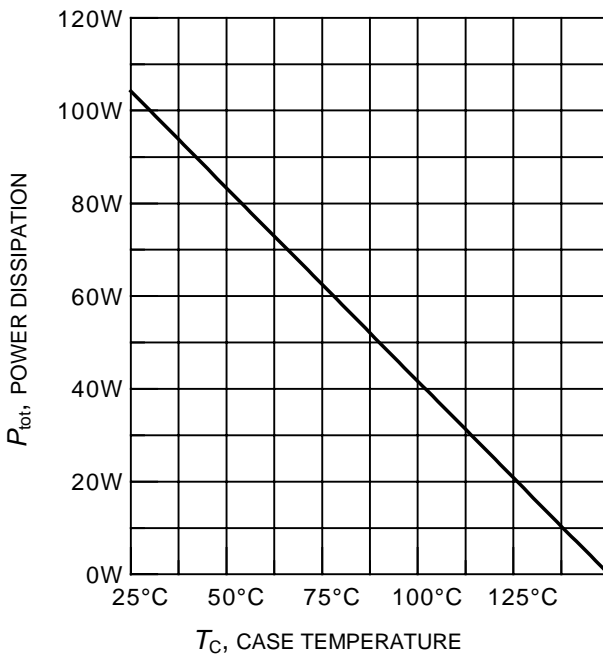


Figure 3. Power dissipation as a function of case temperature
 ($T_j \leq 150^\circ\text{C}$)

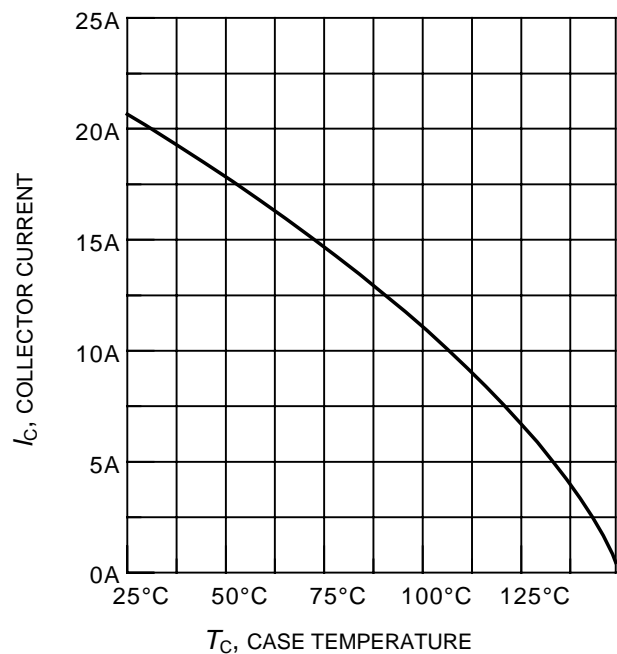


Figure 4. Collector current as a function of case temperature
 ($V_{GE} \leq 15\text{V}$, $T_j \leq 150^\circ\text{C}$)

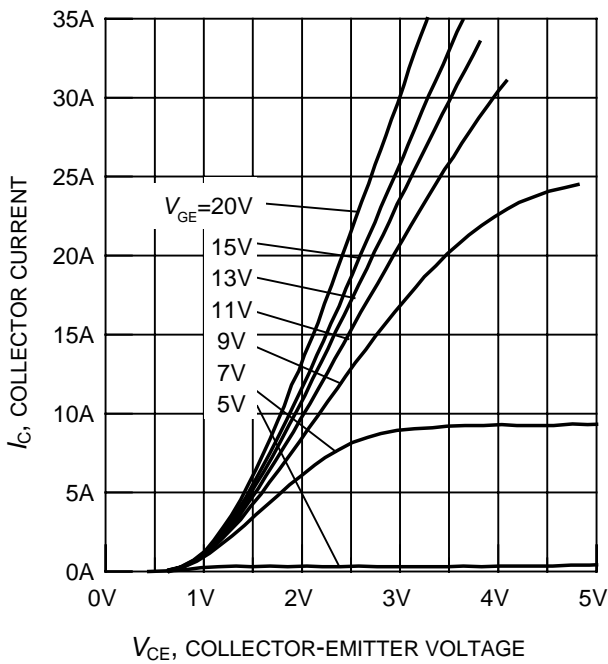


Figure 5. Typical output characteristics
($T_j = 25^\circ\text{C}$)

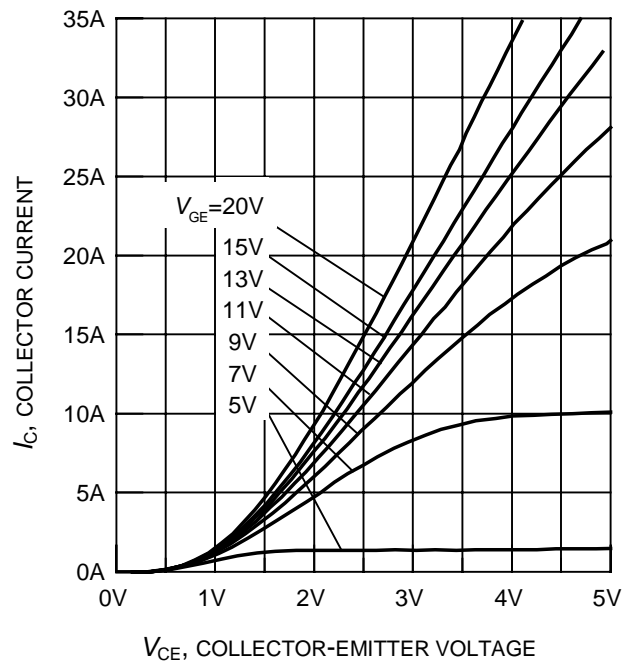


Figure 6. Typical output characteristics
($T_j = 150^\circ\text{C}$)

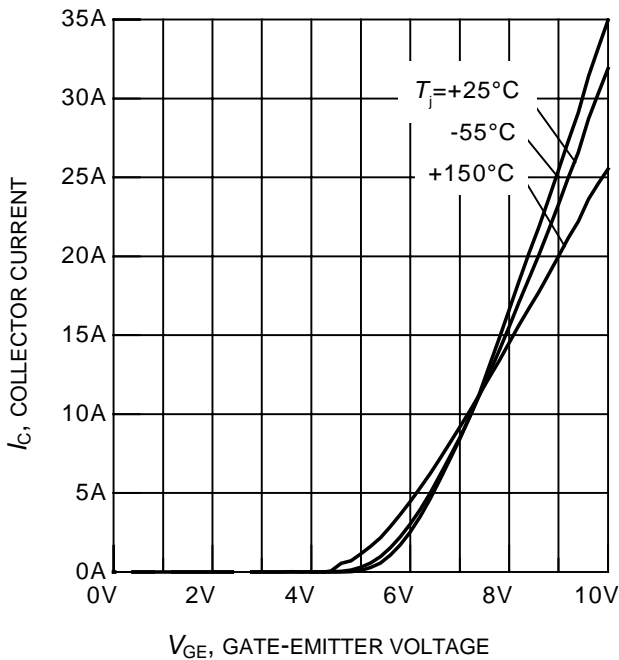


Figure 7. Typical transfer characteristics
($V_{CE} = 10\text{V}$)

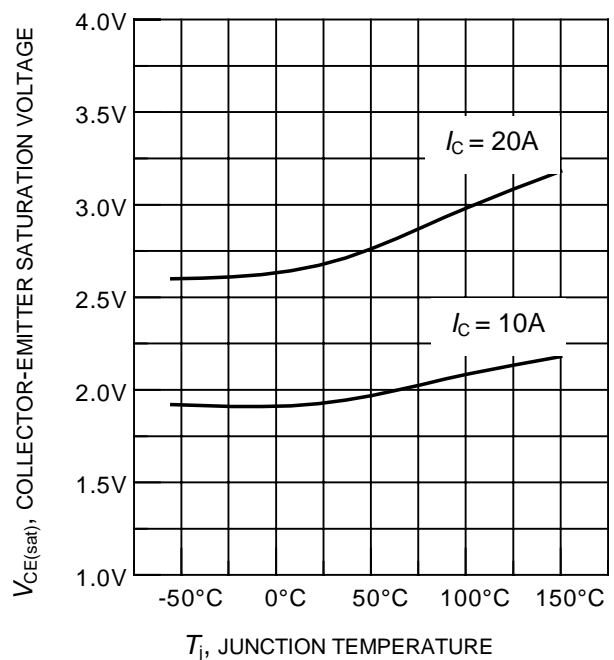


Figure 8. Typical collector-emitter saturation voltage as a function of junction temperature
($V_{GE} = 15\text{V}$)

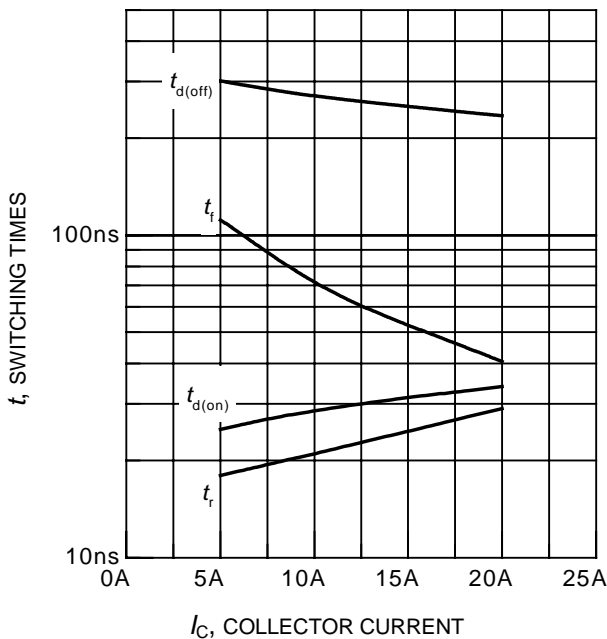


Figure 9. Typical switching times as a function of collector current
(inductive load, $T_j = 150^\circ\text{C}$, $V_{CE} = 400\text{V}$, $V_{GE} = 0/+15\text{V}$, $R_G = 25\Omega$)

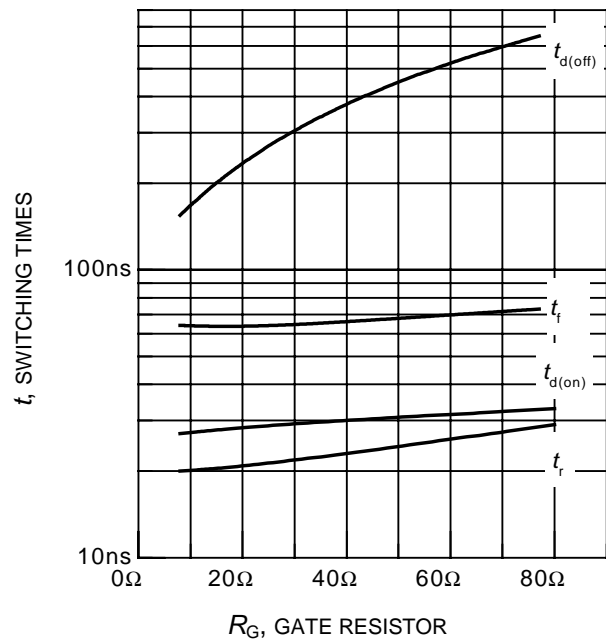


Figure 10. Typical switching times as a function of gate resistor
(inductive load, $T_j = 150^\circ\text{C}$, $V_{CE} = 400\text{V}$, $V_{GE} = 0/+15\text{V}$, $I_C = 10\text{A}$)

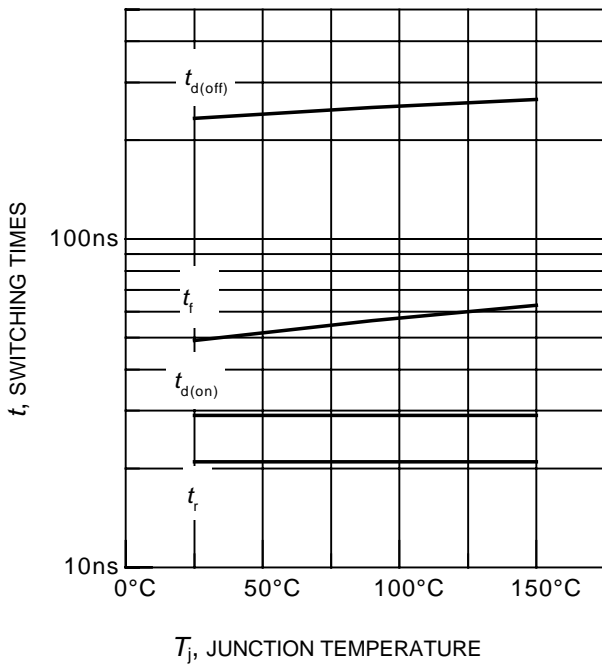


Figure 11. Typical switching times as a function of junction temperature
(inductive load, $V_{CE} = 400\text{V}$, $V_{GE} = 0/+15\text{V}$, $I_C = 10\text{A}$, $R_G = 25\Omega$)

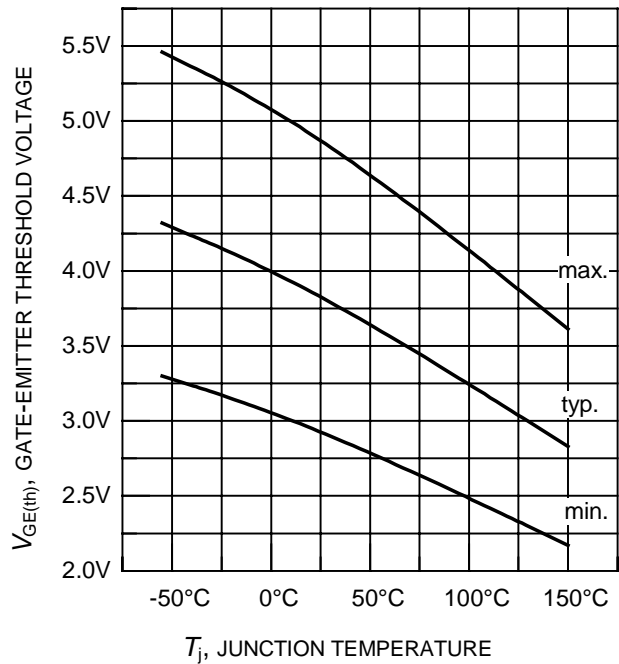


Figure 12. Gate-emitter threshold voltage as a function of junction temperature
($I_C = 0.3\text{mA}$)

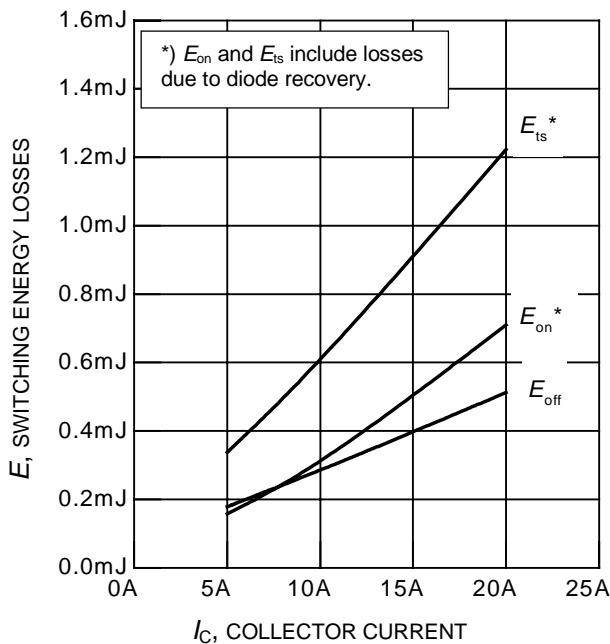


Figure 13. Typical switching energy losses as a function of collector current
(inductive load, $T_j = 150^\circ\text{C}$, $V_{CE} = 400\text{V}$, $V_{GE} = 0/+15\text{V}$, $R_G = 25\Omega$)

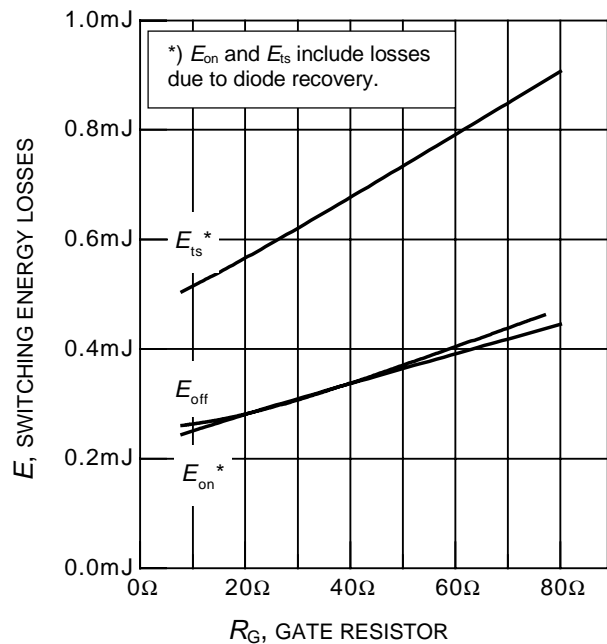


Figure 14. Typical switching energy losses as a function of gate resistor
(inductive load, $T_j = 150^\circ\text{C}$, $V_{CE} = 400\text{V}$, $V_{GE} = 0/+15\text{V}$, $I_C = 10\text{A}$)

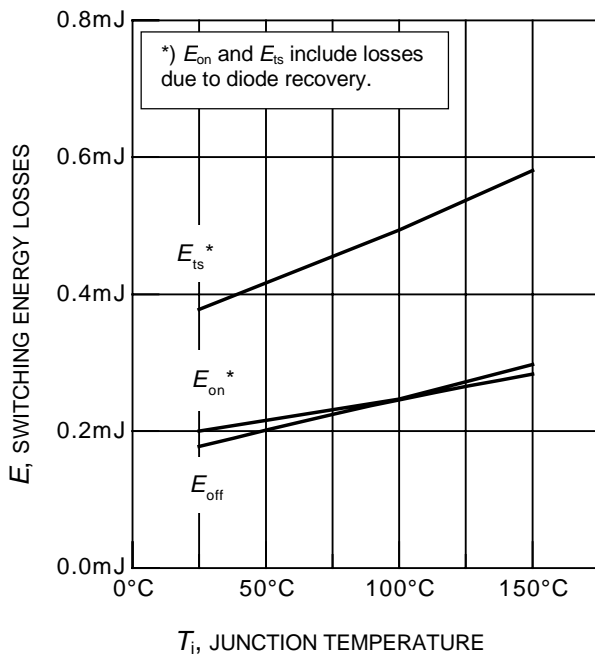


Figure 15. Typical switching energy losses as a function of junction temperature
(inductive load, $V_{CE} = 400\text{V}$, $V_{GE} = 0/+15\text{V}$, $I_C = 10\text{A}$, $R_G = 25\Omega$)

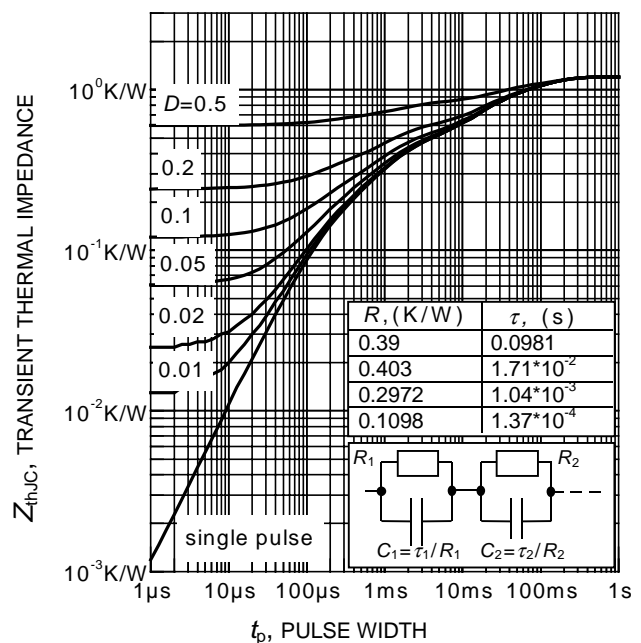


Figure 16. IGBT transient thermal impedance as a function of pulse width
($D = t_p / T$)

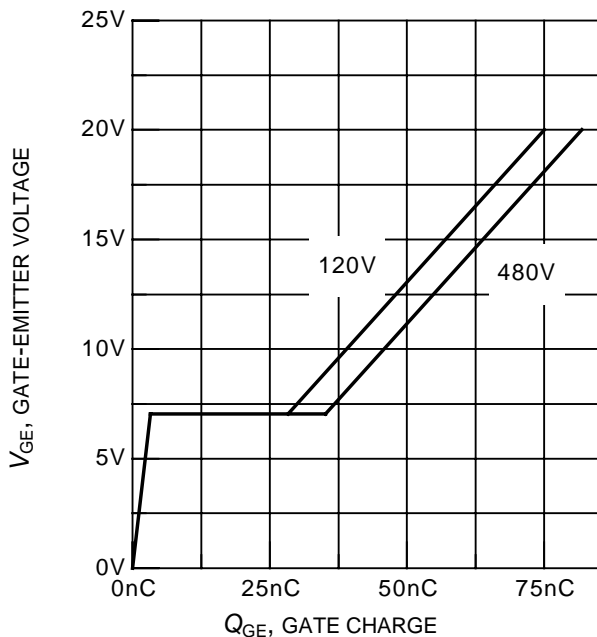


Figure 17. Typical gate charge
($I_C = 10A$)

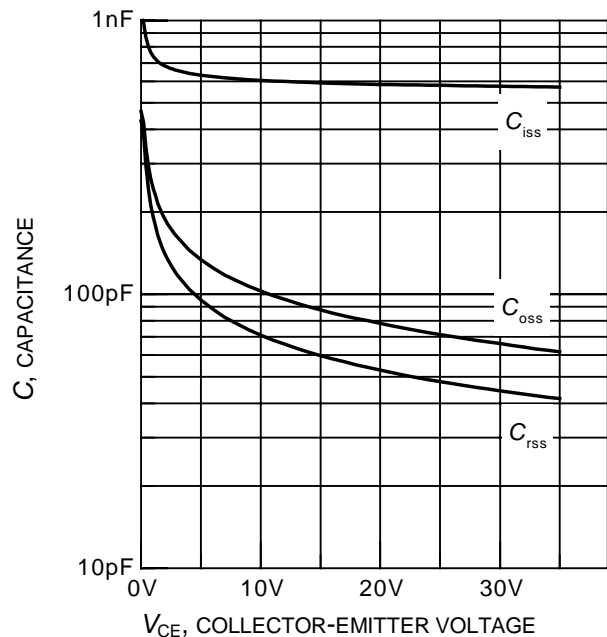


Figure 18. Typical capacitance as a function of collector-emitter voltage
($V_{GE} = 0V, f = 1MHz$)

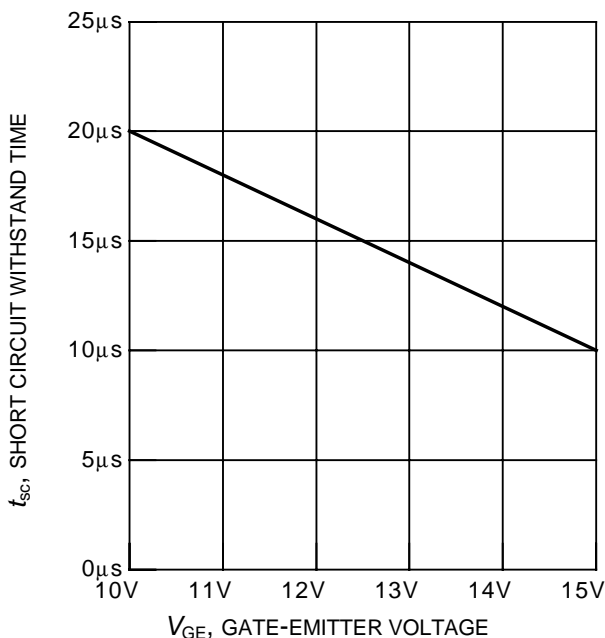


Figure 19. Short circuit withstand time as a function of gate-emitter voltage
($V_{CE} = 600V, \text{start at } T_j = 25^\circ C$)

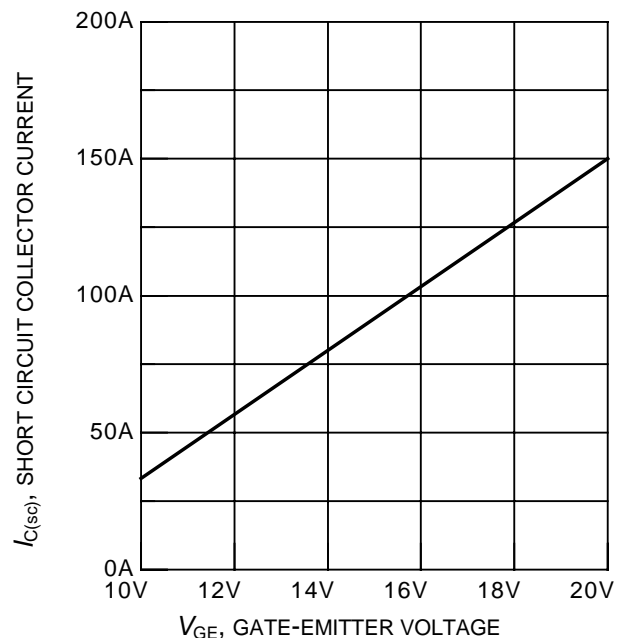
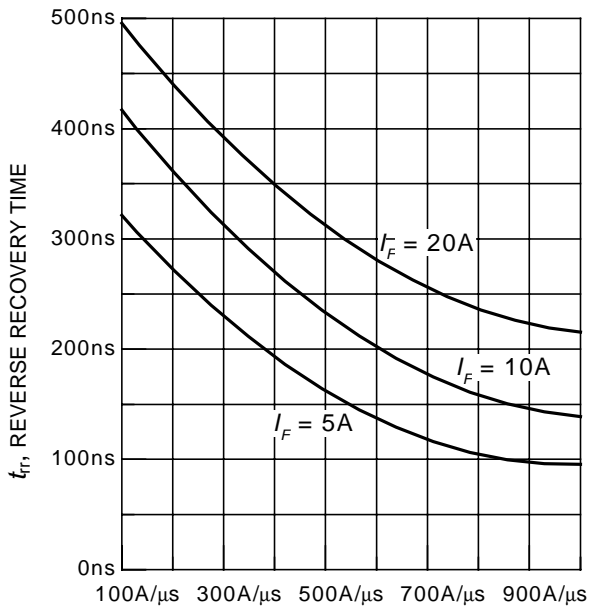
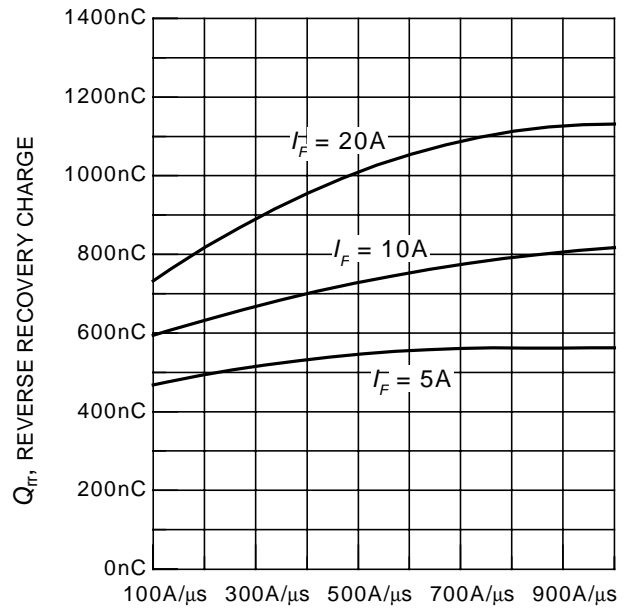


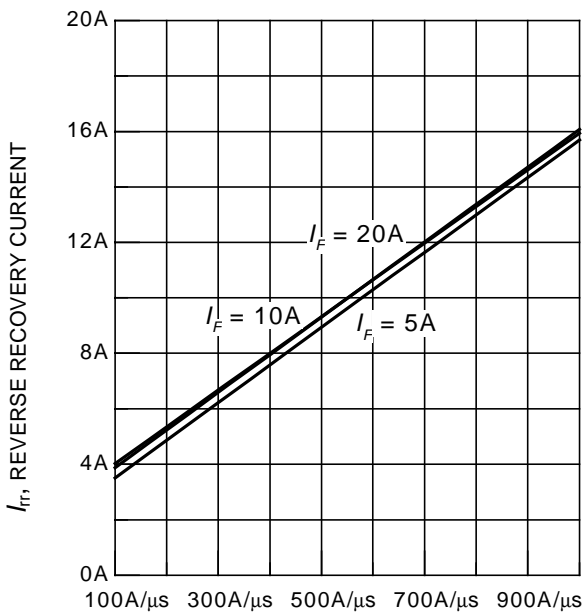
Figure 20. Typical short circuit collector current as a function of gate-emitter voltage
($V_{CE} \leq 600V, T_j = 150^\circ C$)



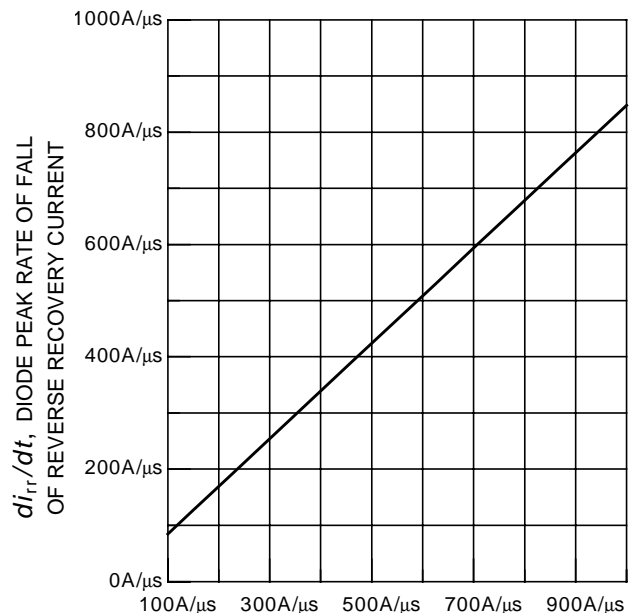
di_F/dt , DIODE CURRENT SLOPE
Figure 21. Typical reverse recovery time as a function of diode current slope
 ($V_R = 200V$, $T_j = 125^\circ C$)



di_F/dt , DIODE CURRENT SLOPE
Figure 22. Typical reverse recovery charge as a function of diode current slope
 ($V_R = 200V$, $T_j = 125^\circ C$)



di_F/dt , DIODE CURRENT SLOPE
Figure 23. Typical reverse recovery current as a function of diode current slope
 ($V_R = 200V$, $T_j = 125^\circ C$)



di_F/dt , DIODE CURRENT SLOPE
Figure 24. Typical diode peak rate of fall of reverse recovery current as a function of diode current slope
 ($V_R = 200V$, $T_j = 125^\circ C$)

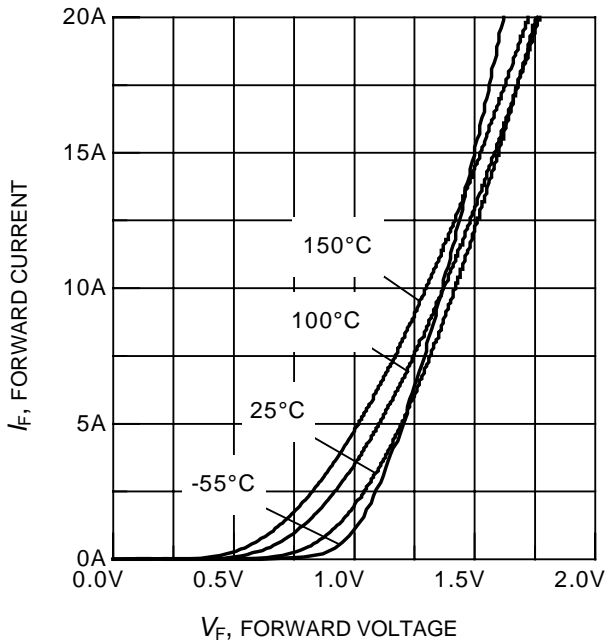


Figure 25. Typical diode forward current as a function of forward voltage

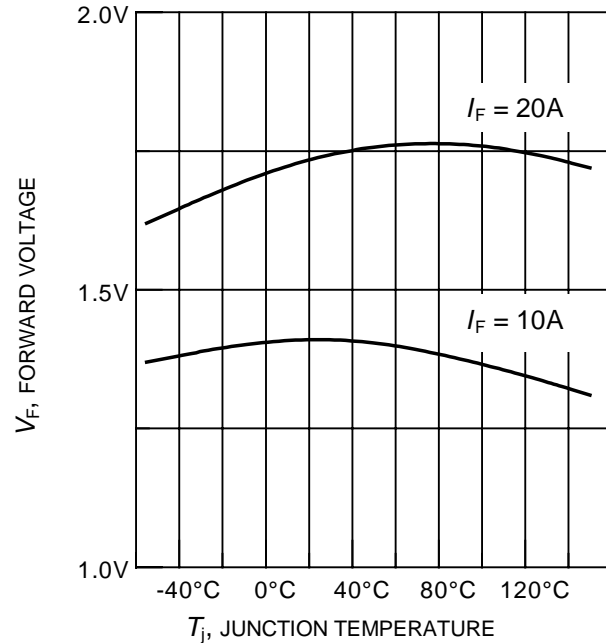


Figure 26. Typical diode forward voltage as a function of junction temperature

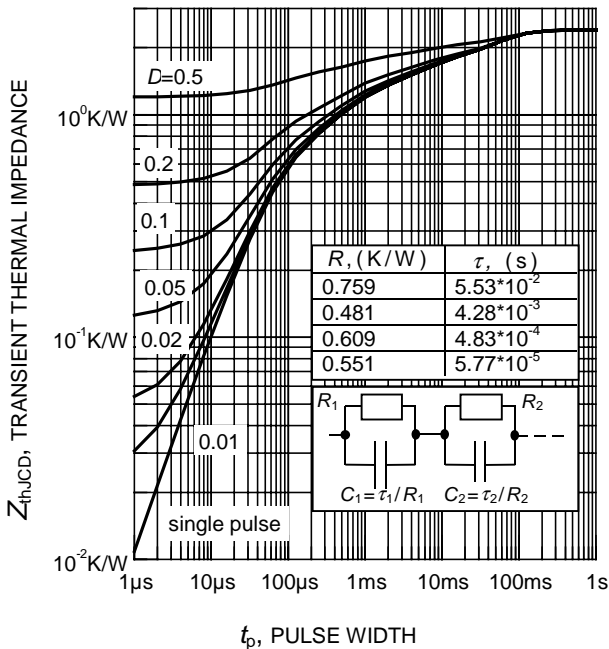
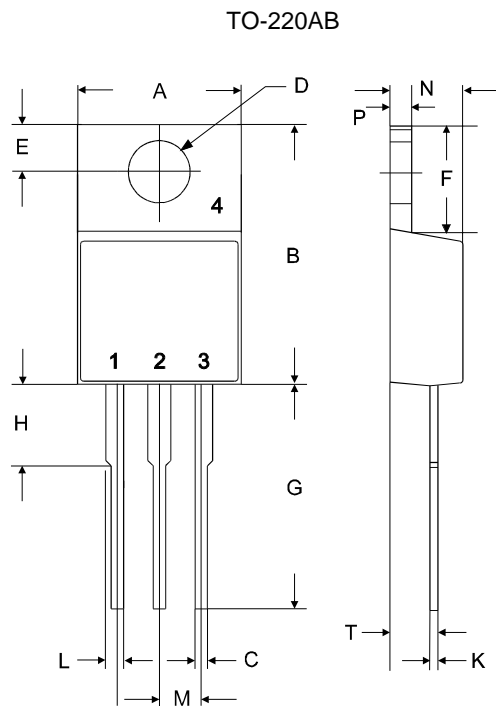
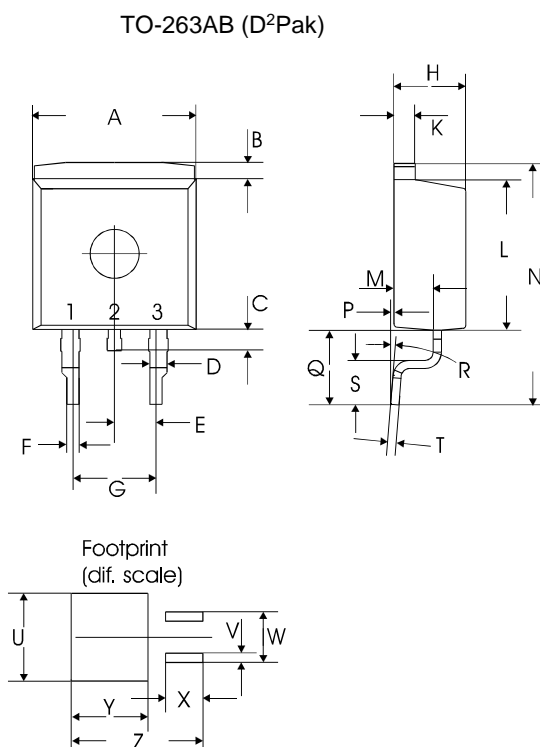


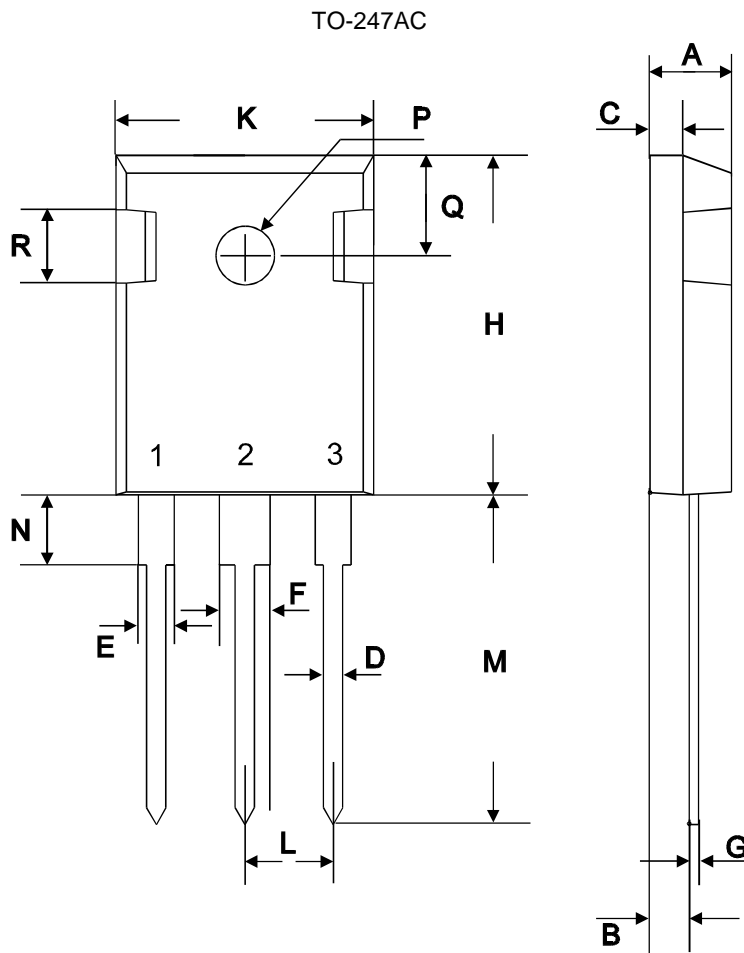
Figure 27. Diode transient thermal impedance as a function of pulse width ($D = t_p / T$)



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	3.89	0.1398	0.1531
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



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	



symbol	dimensions			
	[mm]		[inch]	
	min	max	min	max
A	4.78	5.28	0.1882	0.2079
B	2.29	2.51	0.0902	0.0988
C	1.78	2.29	0.0701	0.0902
D	1.09	1.32	0.0429	0.0520
E	1.73	2.06	0.0681	0.0811
F	2.67	3.18	0.1051	0.1252
G	0.76 max		0.0299 max	
H	20.80	21.16	0.8189	0.8331
K	15.65	16.15	0.6161	0.6358
L	5.21	5.72	0.2051	0.2252
M	19.81	20.68	0.7799	0.8142
N	3.560	4.930	0.1402	0.1941
∅P	3.61		0.1421	
Q	6.12	6.22	0.2409	0.2449

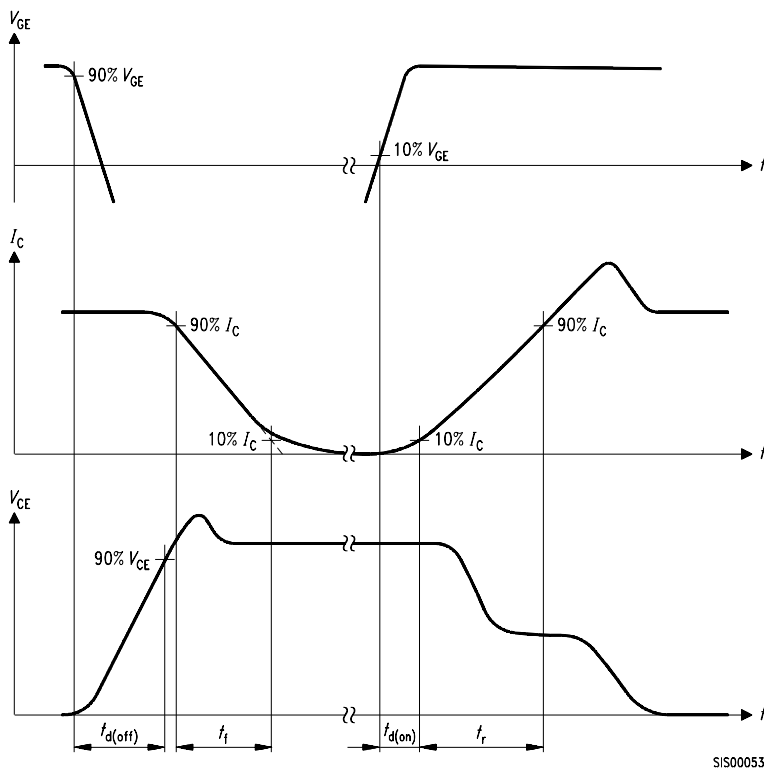


Figure A. Definition of switching times

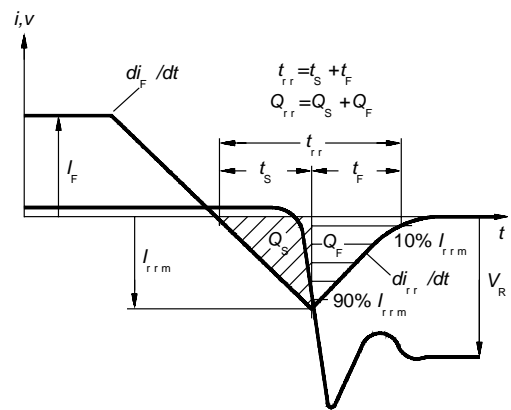


Figure C. Definition of diodes switching characteristics

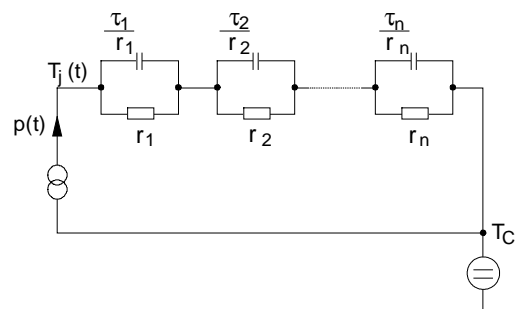


Figure D. Thermal equivalent circuit

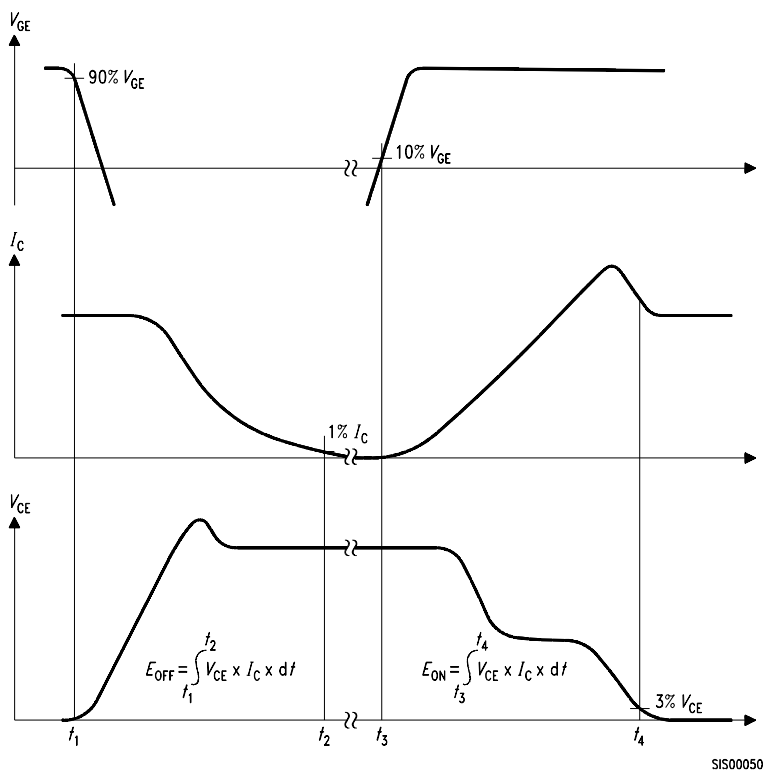


Figure B. Definition of switching losses

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