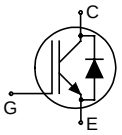
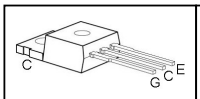
SKP06N60, SKB06N60 SKA06N60

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

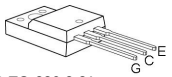
- 75% lower E_{off} compared to previous generation
  combined with low conduction losses
- Short circuit withstand time – 10 µs
- Designed for:
  - Motor controls
  - Inverter
- NPT-Technology for 600V applications offers:
  - very tight parameter distribution
  - high ruggedness, temperature stable behaviour
  - parallel switching capability
- Very soft, fast recovery anti-parallel EmCon diode
- Isolated TO-220, 2.5kV, 60s
- Complete product spectrum and PSpice Models : http://www.infineon.com/igbt/





P-TO-220-3-1
(TO-220AB)

P-TO-263-3-2 (D²-PAK)
(TO-263AB)



P-TO-220-3-31
(FullPAK)

Type	V_{CE}	I_C	$V_{CE(sat)}$	T_j	Package	Ordering Code
SKP06N60	600V	6A	2.3V	150°C	TO-220AB	Q67040-S4230
SKB06N60					TO-263AB	Q67040-S4231
SKA06N60		5A			TO-220-3-31	Q67040-S4340

Maximum Ratings

Parameter	Symbol	Value		Unit
		SKP06N60 SKB06N60	SKA06N60	
Collector-emitter voltage	V_{CE}	600	600	V
DC collector current	I_C			A
T_C = 25°C		12	9	
T_C = 100°C		6.9	5.0	
Pulsed collector current, t_p limited by T_{jmax}	I_{Cpuls}	24	24	
Turn off safe operating area $V_{CE} \le 600V$, $T_j \le 150°C$	-	24	24	
Diode forward current	I_F			
T_C = 25°C		12	12	
T_C = 100°C		6	6	
Diode pulsed current, t_p limited by T_{jmax}	I_{Fpuls}	24	24	
Gate-emitter voltage	V_{GE}	±20	±20	V
Short circuit withstand time[1)] V_{GE} = 15V, $V_{CC} \le 600V$, $T_j \le 150°C$	t_{SC}	10	10	µs
Power dissipation T_C = 25°C	P_{tot}	68	32	W
Mounting Torque, M3 Screw[2)]	M		1.0	Nm
Operating junction and storage temperature	T_j , T_{stg}	-55...+150	-55...+150	°C

[1)] Allowed number of short circuits: <1000; time between short circuits: >1s.
[2)] Maximum mounting processes: 3

Thermal Resistance

Parameter	Symbol	Conditions	Max. Value		Unit
			SKP06N60 SKB06N60	SKA06N60	
Characteristic					
IGBT thermal resistance, junction – case	R_{thJC}		1.85	3.9	K/W
Diode thermal resistance, junction – case	R_{thJCD}		3.5	5.0	
Thermal resistance, junction – ambient	R_{thJA}	TO-220AB TO220-3-31	62	 65	
SMD version, device on PCB[1)]	R_{thJA}	TO-263AB	40		

Electrical Characteristic, at T_j = 25 °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=500µA	600	-	-	V
Collector-emitter saturation voltage	$V_{CE(sat)}$	V_{GE} = 15V, I_C=6A				
		T_j=25°C	1.7	2.0	2.4	
		T_j=150°C	-	2.3	2.8	
Diode forward voltage	V_F	V_{GE}=0V, I_F=6A				
		T_j=25°C	1.2	1.4	1.8	
		T_j=150°C	-	1.25	1.65	
Gate-emitter threshold voltage	$V_{GE(th)}$	I_C=250µA, V_{CE}=V_{GE}	3	4	5	
Zero gate voltage collector current	I_{CES}	V_{CE}=600V, V_{GE}=0V				µA
		T_j=25°C	-	-	20	
		T_j=150°C	-	-	700	
Gate-emitter leakage current	I_{GES}	V_{CE}=0V, V_{GE}=20V	-	-	100	nA
Transconductance	g_{fs}	V_{CE}=20V, I_C=6A	-	4.2	-	S
Dynamic Characteristic						
Input capacitance	C_{iss}	V_{CE}=25V,	-	350	420	pF
Output capacitance	C_{oss}	V_{GE}=0V,	-	38	46	
Reverse transfer capacitance	C_{rss}	f=1MHz	-	23	28	
Gate charge	Q_{Gate}	V_{CC}=480V, I_C=6A	-	32	42	nC
		V_{GE}=15V				
Internal emitter inductance measured 5mm (0.197 in.) from case	L_E	TO-220AB	-	7	-	nH
Short circuit collector current[2)]	$I_{C(SC)}$	V_{GE}=15V, t_{SC}≤10µs V_{CC} ≤ 600V, T_j ≤ 150°C	-	60	-	A

[1)] Device on 50mm*50mm*1.5mm epoxy PCB FR4 with 6cm^2 (one layer, 70µm 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 °C

Parameter	Symbol	Conditions	Value			Unit
			min.	typ.	max.	
IGBT Characteristic						
Turn-on delay time	$t_{d(on)}$	T_j=25°C, V_{CC}=400V, I_C=6A, V_{GE}=0/15V, R_G=50Ω, L_σ [1)] =180nH, C_σ [1)] =250pF Energy losses include "tail" and diode reverse recovery.	-	25	30	ns
Rise time	t_r		-	18	22	
Turn-off delay time	$t_{d(off)}$		-	220	264	
Fall time	t_f		-	54	65	
Turn-on energy	E_{on}		-	0.110	0.127	mJ
Turn-off energy	E_{off}		-	0.105	0.137	
Total switching energy	E_{ts}		-	0.215	0.263	
Anti-Parallel Diode Characteristic						
Diode reverse recovery time	t_{rr}	T_j=25°C, V_R=200V, I_F=6A, di_F/dt=200A/µs	-	200	-	ns
	t_S		-	17	-	
	t_F		-	183	-	
Diode reverse recovery charge	Q_{rr}		-	200	-	nC
Diode peak reverse recovery current	I_{rrm}		-	2.8	-	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 °C

Parameter	Symbol	Conditions	Value			Unit
			min.	typ.	max.	
IGBT Characteristic						
Turn-on delay time	$t_{d(on)}$	T_j=150°C V_{CC}=400V, I_C=6A, V_{GE}=0/15V, R_G=50Ω, L_σ [1)]=180nH, C_σ [1)]=250pF Energy losses include "tail" and diode reverse recovery.	-	24	29	ns
Rise time	t_r		-	17	20	
Turn-off delay time	$t_{d(off)}$		-	248	298	
Fall time	t_f		-	70	84	
Turn-on energy	E_{on}		-	0.167	0.192	mJ
Turn-off energy	E_{off}		-	0.153	0.199	
Total switching energy	E_{ts}		-	0.320	0.391	
Anti-Parallel Diode Characteristic						
Diode reverse recovery time	t_{rr}	T_j=150°C V_R=200V, I_F=6A, di_F/dt=200A/µs	-	290	-	ns
	t_S		-	27	-	
	t_F		-	263	-	
Diode reverse recovery charge	Q_{rr}		-	500	-	nC
Diode peak reverse recovery current	I_{rrm}		-	5.0	-	A
Diode peak rate of fall of reverse recovery current during t_b	di_{rr}/dt		-	200	-	A/µs

[1)] Leakage inductance L_σ and Stray capacity C_σ due to dynamic test circuit in Figure E.

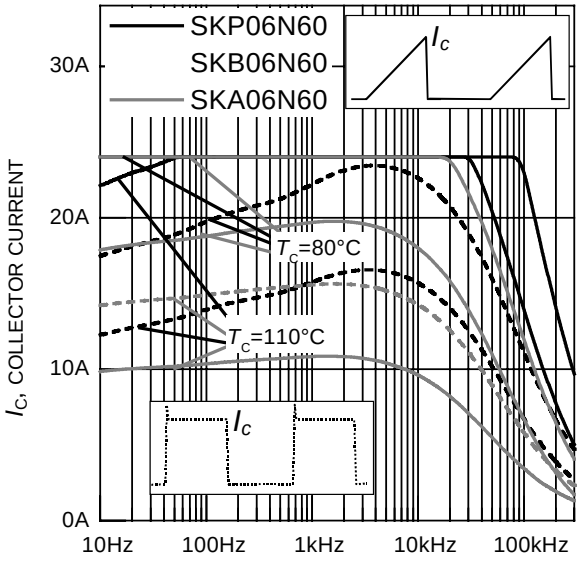


Figure 1. Collector current as a function of switching frequency
($T_j \le 150°C$, $D = 0.5$, $V_{CE} = 400V$, $V_{GE} = 0/+15V$, $R_G = 50\Omega$)

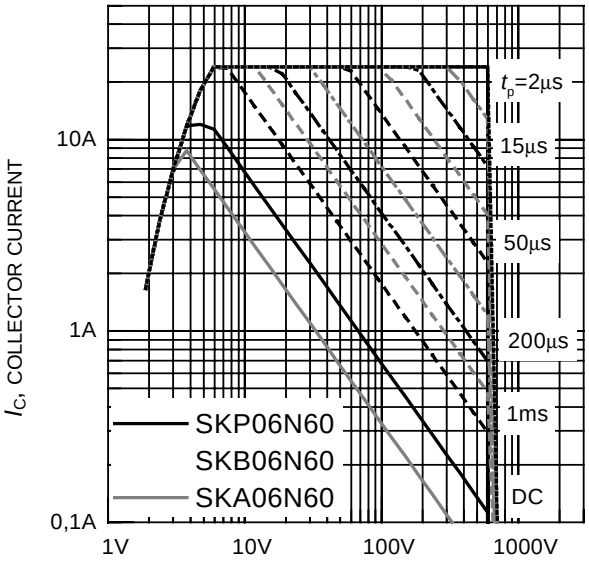


Figure 2. Safe operating area
($D = 0$, $T_C = 25°C$, $T_j \le 150°C$)

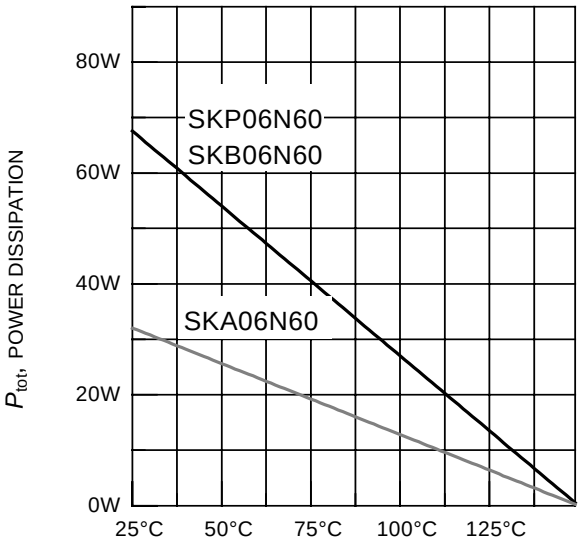


Figure 3. Power dissipation as a function of case temperature
($T_j \le 150°C$)

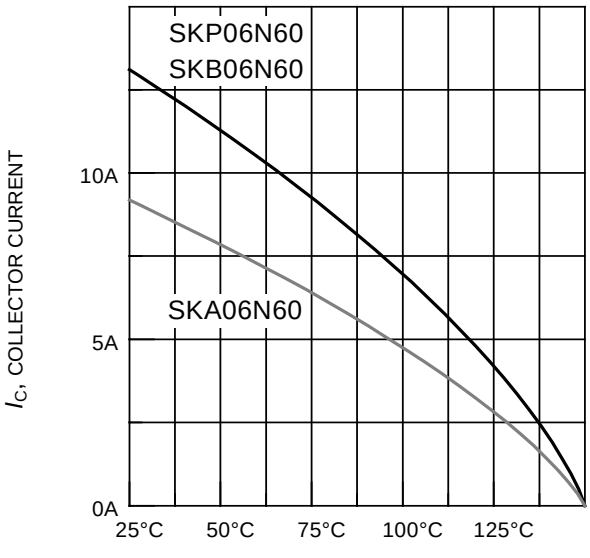


Figure 4. Collector current as a function of case temperature
($V_{GE} \le 15V$, $T_j \le 150°C$)

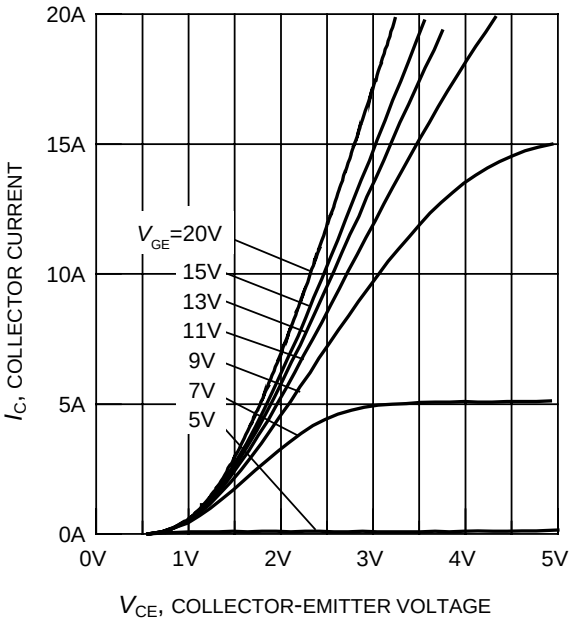


Figure 5. Typical output characteristics
(T_j = 25°C)

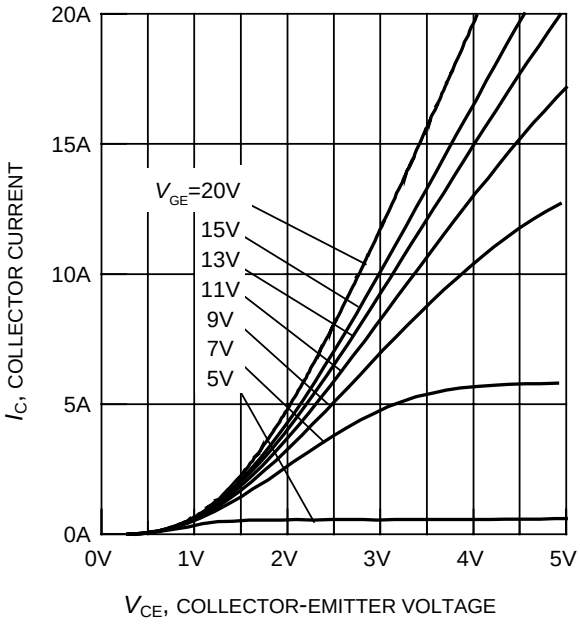


Figure 6. Typical output characteristics
(T_j = 150°C)

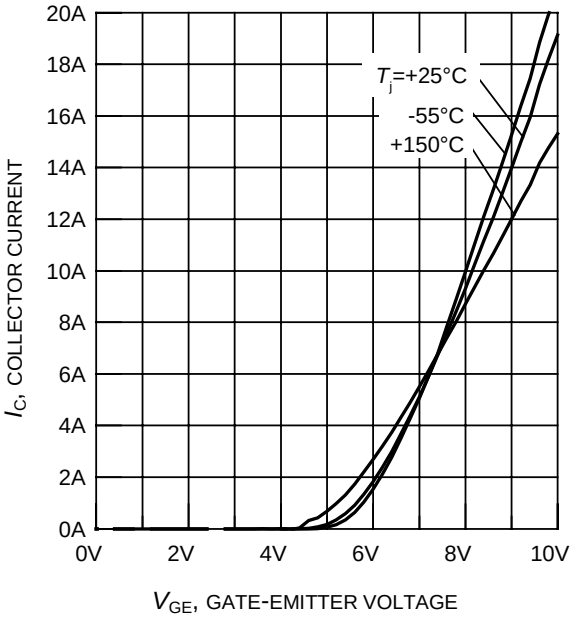


Figure 7. Typical transfer characteristics
(V_{CE} = 10V)

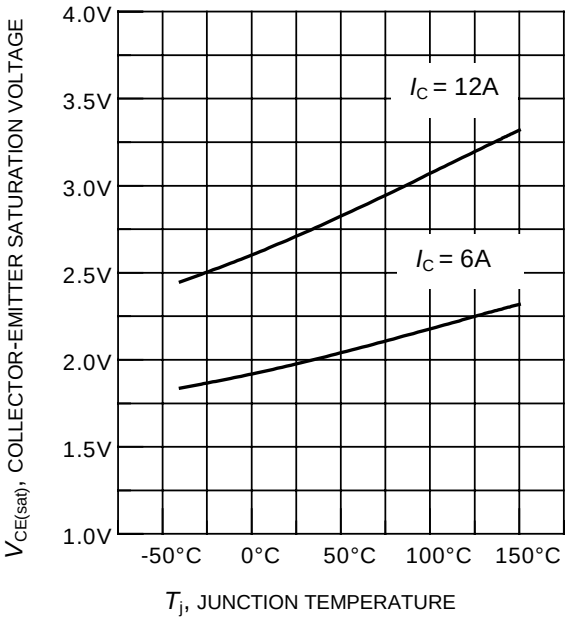


Figure 8. Typical collector-emitter saturation voltage as a function of junction temperature
(V_{GE} = 15V)

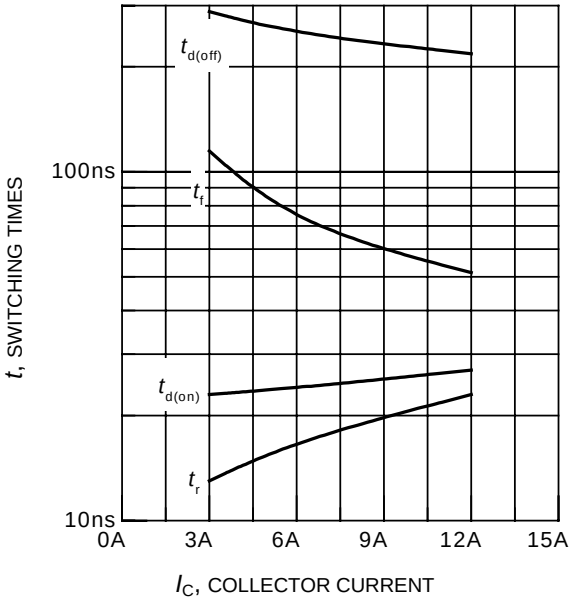


Figure 9. Typical switching times as a function of collector current
(inductive load, T_j = 150°C, V_{CE} = 400V, V_{GE} = 0/+15V, R_G = 50Ω, Dynamic test circuit in Figure E)

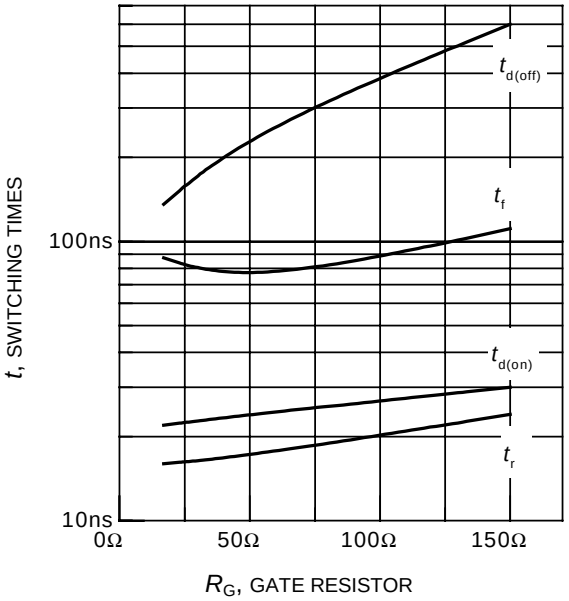


Figure 10. Typical switching times as a function of gate resistor
(inductive load, T_j = 150°C, V_{CE} = 400V, V_{GE} = 0/+15V, I_C = 6A, Dynamic test circuit in Figure E)

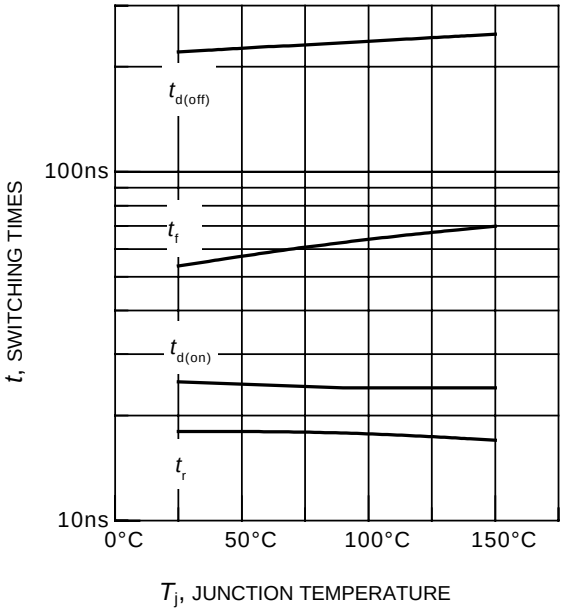


Figure 11. Typical switching times as a function of junction temperature
(inductive load, V_{CE} = 400V, V_{GE} = 0/+15V, I_C = 6A, R_G = 50Ω, Dynamic test circuit in Figure E)

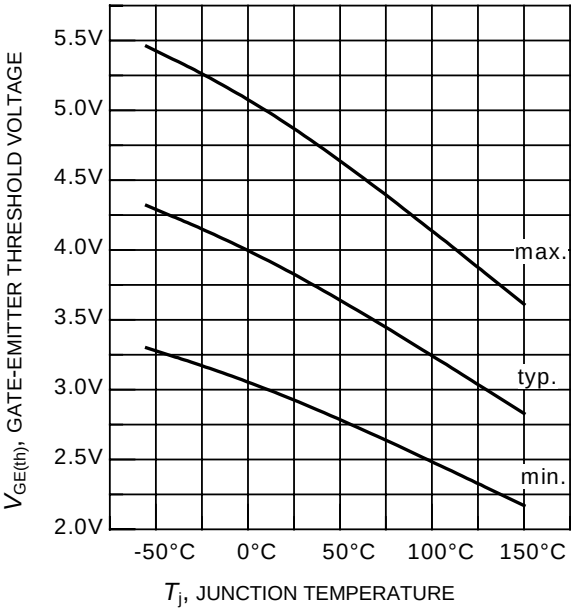


Figure 12. Gate-emitter threshold voltage as a function of junction temperature
(I_C = 0.25mA)

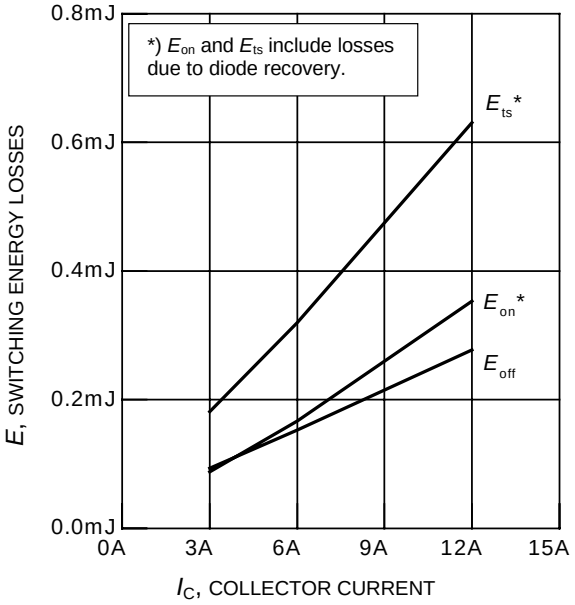


Figure 13. Typical switching energy losses as a function of collector current
(inductive load, T_j = 150°C, V_{CE} = 400V, V_{GE} = 0/+15V, R_G = 50Ω, Dynamic test circuit in Figure E)

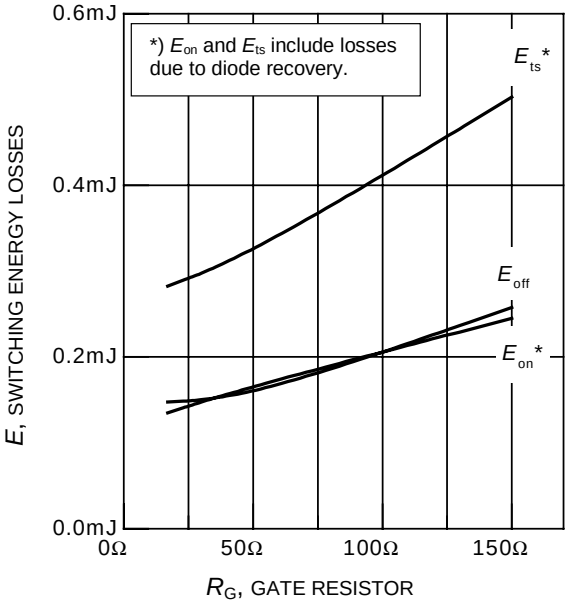


Figure 14. Typical switching energy losses as a function of gate resistor
(inductive load, T_j = 150°C, V_{CE} = 400V, V_{GE} = 0/+15V, I_C = 6A, Dynamic test circuit in Figure E)

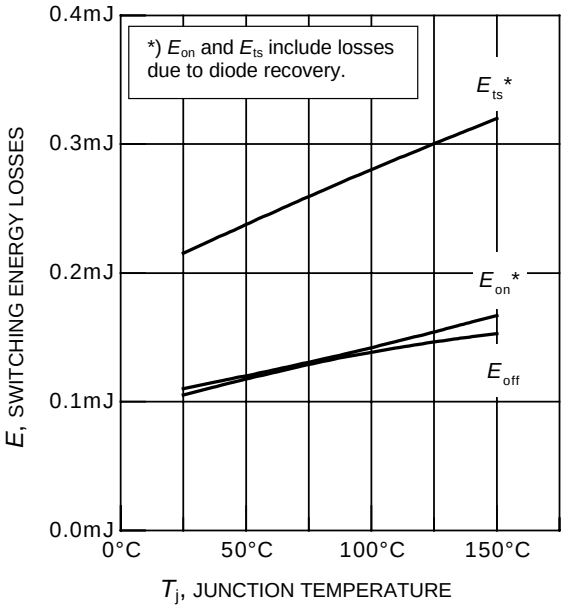


Figure 15. Typical switching energy losses as a function of junction temperature
(inductive load, V_{CE} = 400V, V_{GE} = 0/+15V, I_C = 6A, R_G = 50Ω, Dynamic test circuit in Figure E)

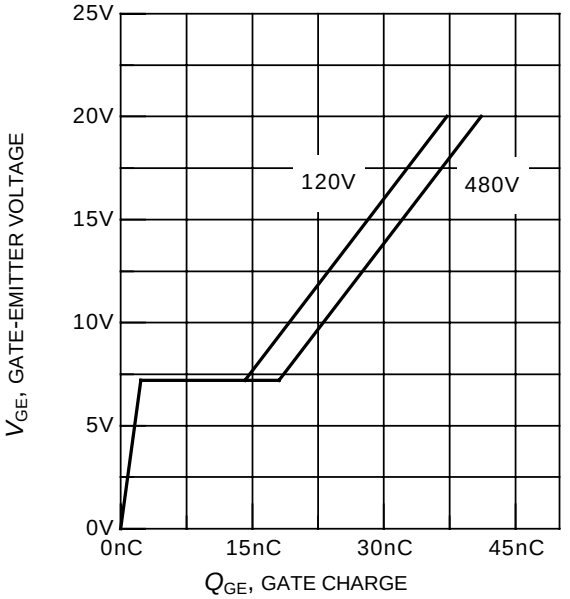


Figure 16. Typical gate charge
(I_C = 6A)

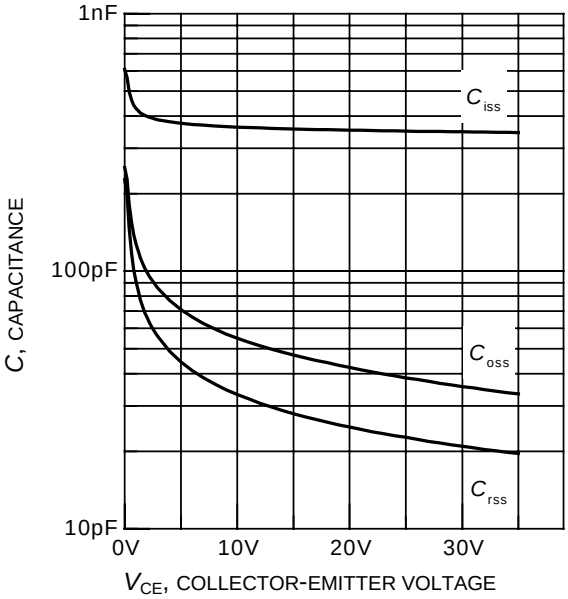


Figure 17. Typical capacitance as a function of collector-emitter voltage
(V_{GE} = 0V, f = 1MHz)

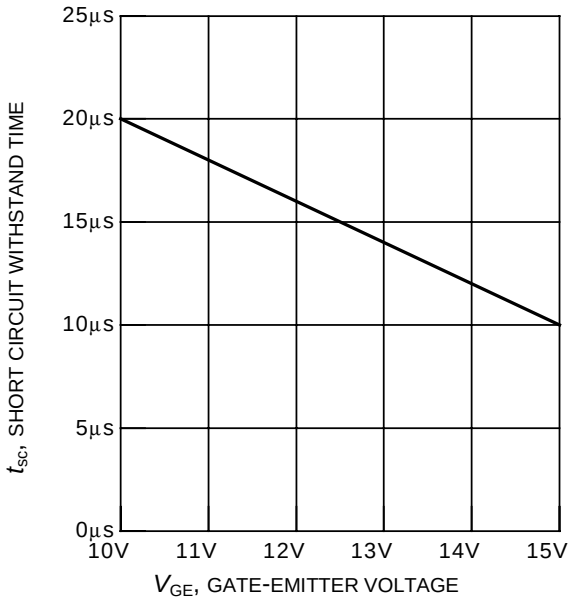


Figure 18. Short circuit withstand time as a function of gate-emitter voltage
(V_{CE} = 600V, start at T_j = 25°C)

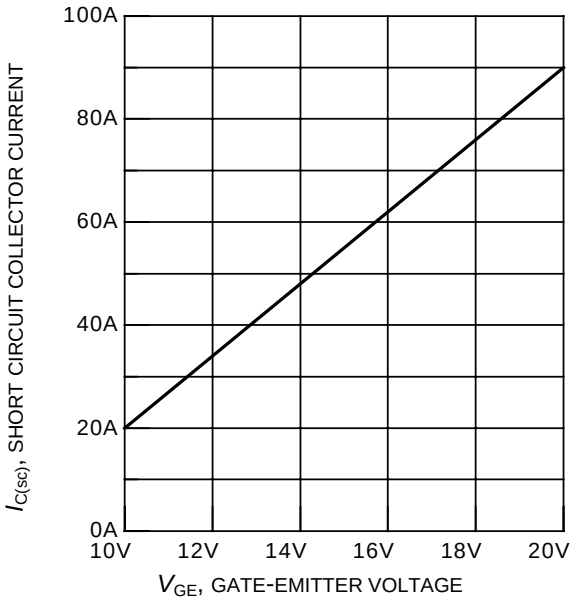


Figure 19. Typical short circuit collector current as a function of gate-emitter voltage
($V_{CE} \le$ 600V, T_j = 150°C)

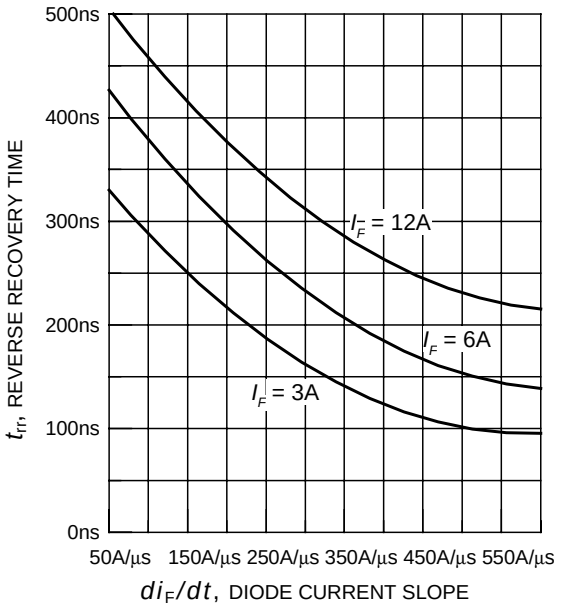


Figure 20. Typical reverse recovery time as a function of diode current slope
(V_R = 200V, T_j = 125°C,
Dynamic test circuit in Figure E)

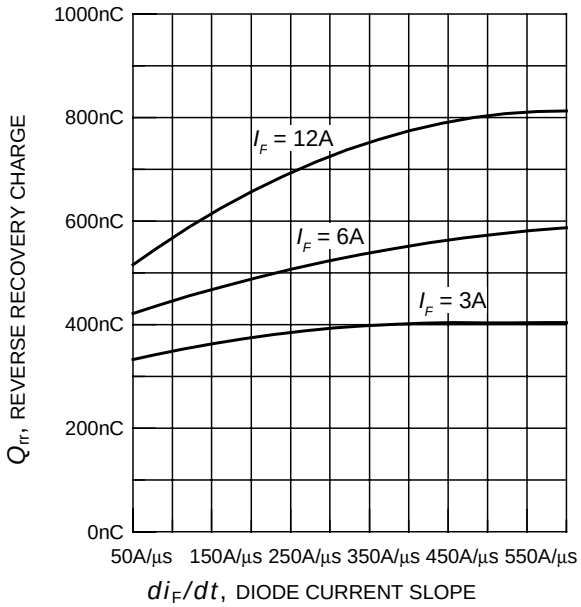


Figure 21. Typical reverse recovery charge as a function of diode current slope
(V_R = 200V, T_j = 125°C,
Dynamic test circuit in Figure E)

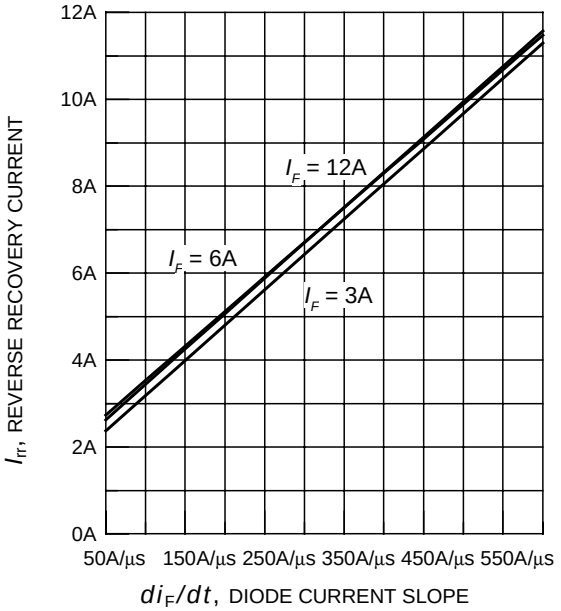


Figure 22. Typical reverse recovery current as a function of diode current slope
(V_R = 200V, T_j = 125°C,
Dynamic test circuit in Figure E)

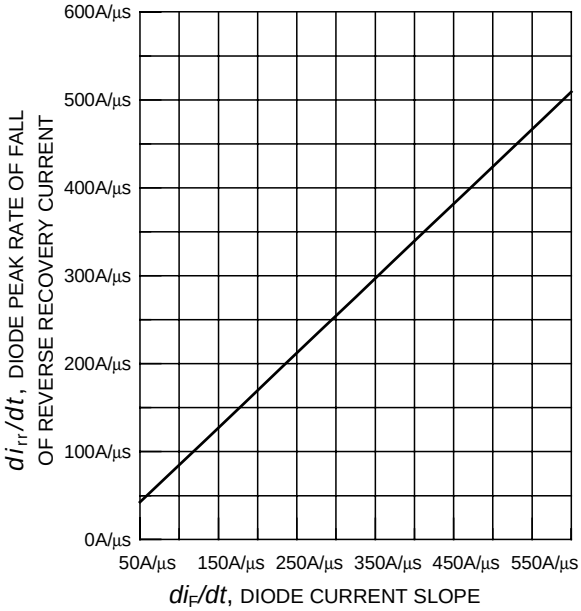


Figure 23. Typical diode peak rate of fall of reverse recovery current as a function of diode current slope
(V_R = 200V, T_j = 125°C,
Dynamic test circuit in Figure E)

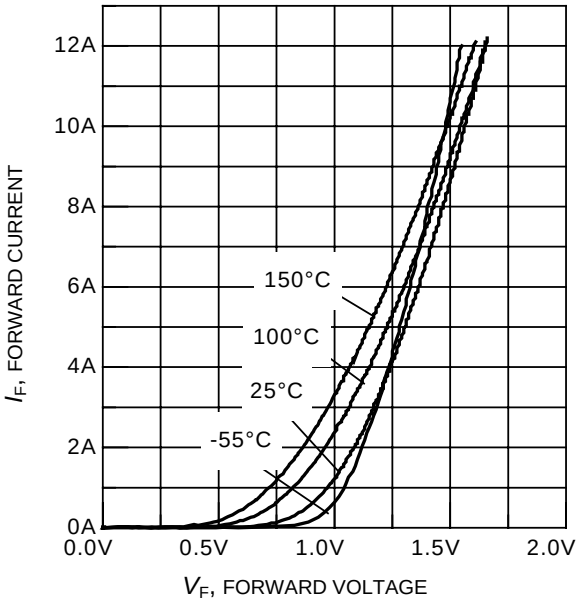


Figure 24. Typical diode forward current as a function of forward voltage

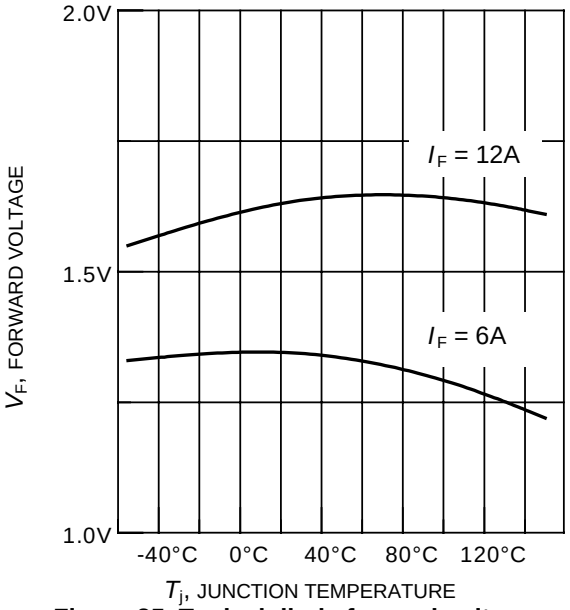


Figure 25. Typical diode forward voltage as a function of junction temperature

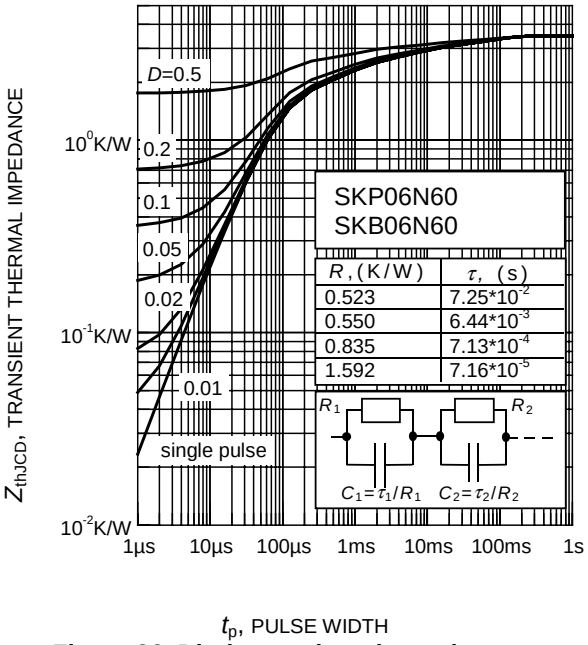


Figure 26. Diode transient thermal impedance as a function of pulse width
($D = t_p / T$)

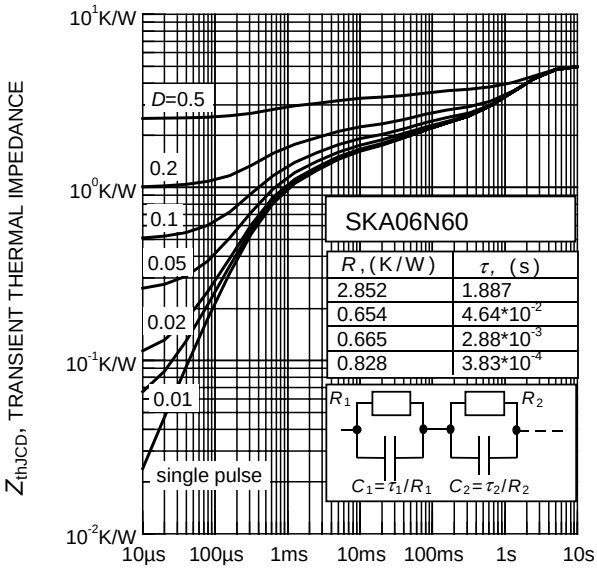


Figure 27. Diode transient thermal impedance as a function of pulse width
($D = t_p / T$)

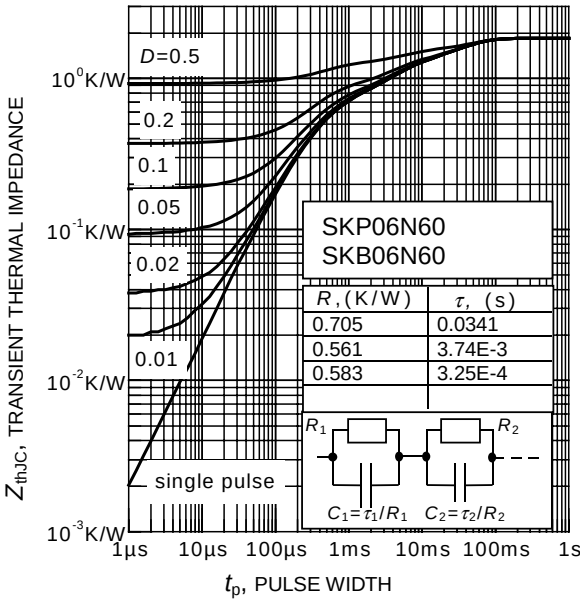


Figure 28. IGBT transient thermal impedance as a function of pulse width
($D = t_p / T$)

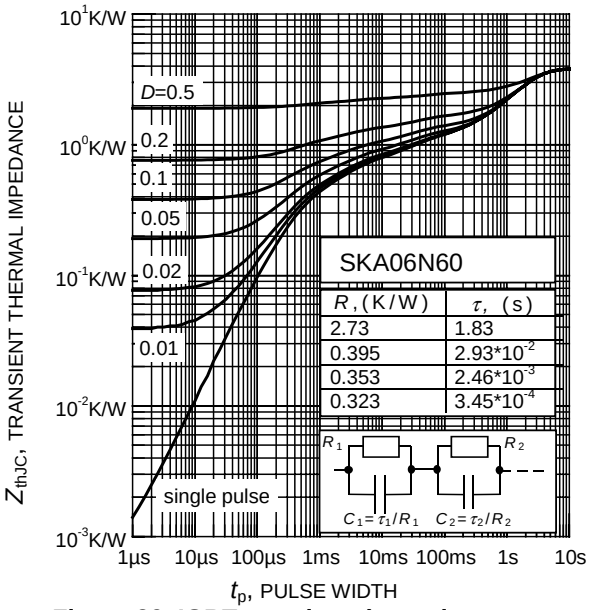
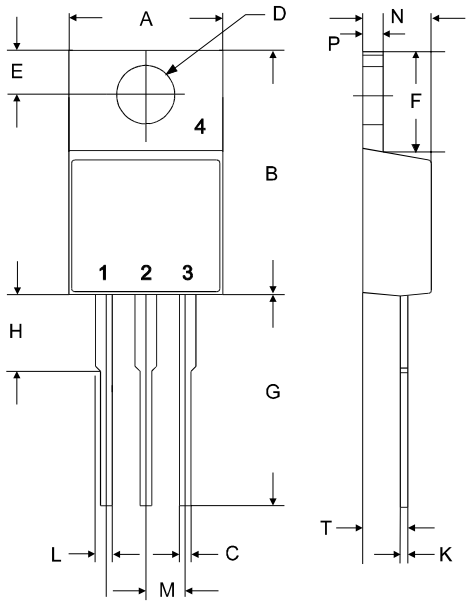


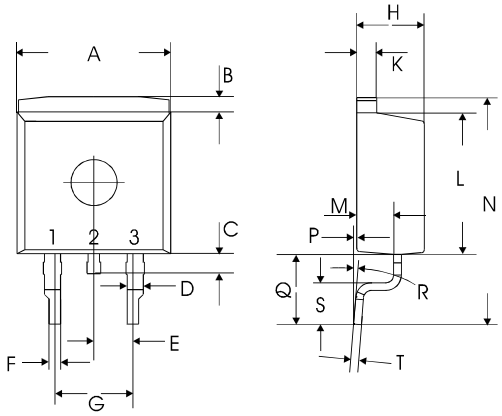
Figure 29. IGBT transient thermal impedance as a function of pulse width
($D = t_p / T$)

TO-220AB

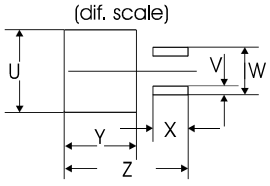


symbol	dimensions			
	[mm]		[inch]	
	min	max	min	max
A	9.70	10.30	0.3819	0.4055
B	14.88	15.95	0.5858	0.6280
C	0.65	0.86	0.0256	0.0339
D	3.55	3.89	0.1398	0.1531
E	2.60	3.00	0.1024	0.1181
F	6.00	6.80	0.2362	0.2677
G	13.00	14.00	0.5118	0.5512
H	4.35	4.75	0.1713	0.1870
K	0.38	0.65	0.0150	0.0256
L	0.95	1.32	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

TO-263AB (D^2Pak)

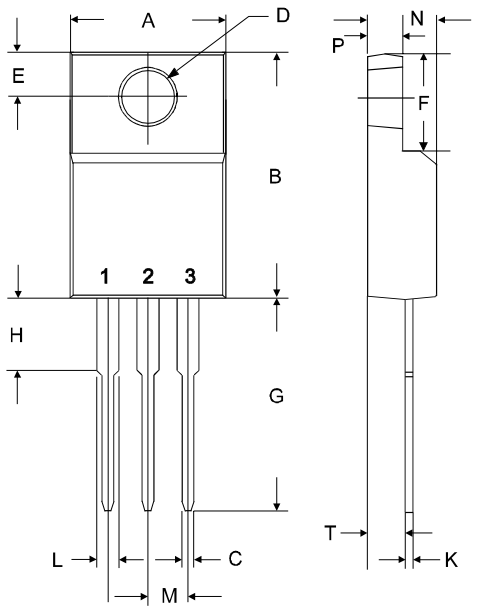


Footprint
(dif. scale)



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	

P-TO220-3-31



Please refer to mounting instructions (application note AN-TO220-3-31-01)

symbol	dimensions			
	[mm]		[inch]	
	min	max	min	max
A	10.37	10.63	0.4084	0.4184
B	15.86	16.12	0.6245	0.6345
C	0.65	0.78	0.0256	0.0306
D	2.95 typ.		0.1160 typ.	
E	3.15	3.25	0.124	0.128
F	6.05	6.56	0.2384	0.2584
G	13.47	13.73	0.5304	0.5404
H	3.18	3.43	0.125	0.135
K	0.45	0.63	0.0177	0.0247
L	1.23	1.36	0.0484	0.0534
M	2.54 typ.		0.100 typ.	
N	4.57	4.83	0.1800	0.1900
P	2.57	2.83	0.1013	0.1113
T	2.51	2.62	0.0990	0.1030

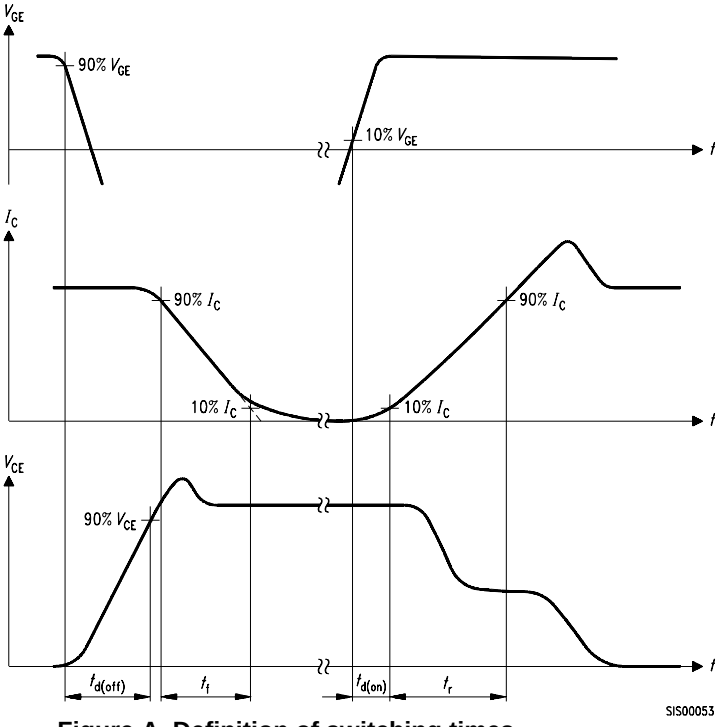


Figure A. Definition of switching times

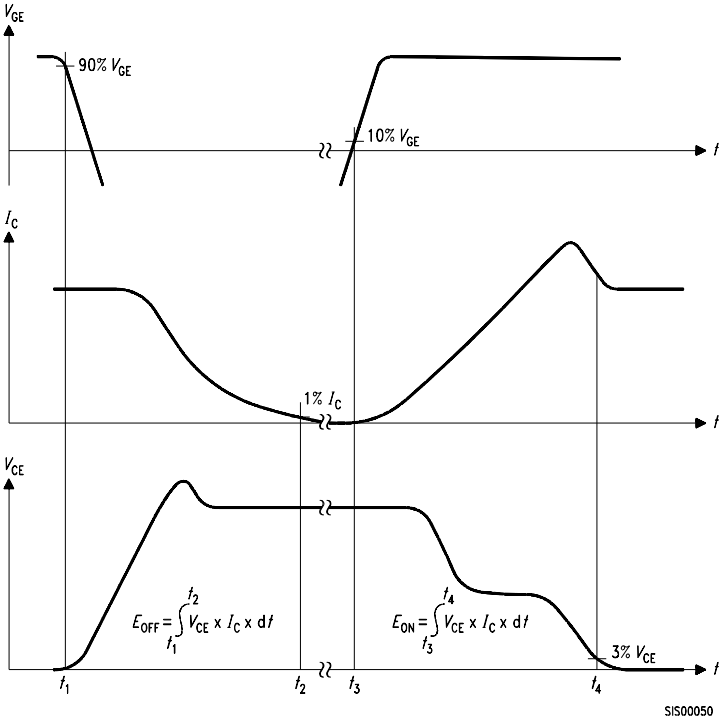


Figure B. Definition of switching losses

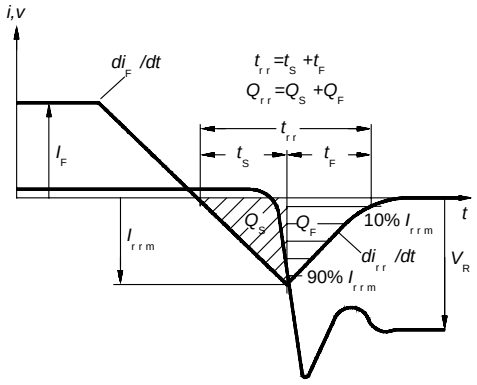


Figure C. Definition of diodes switching characteristics

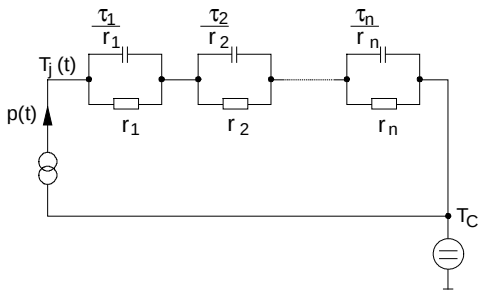


Figure D. Thermal equivalent circuit

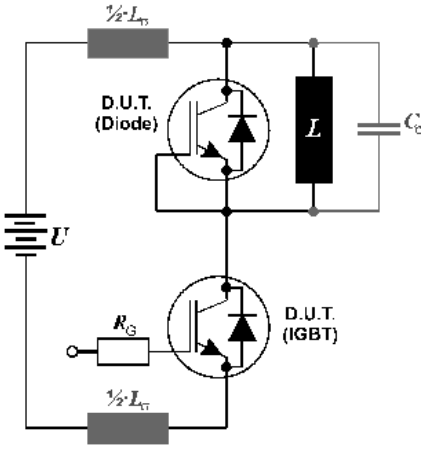


Figure E. Dynamic test circuit
Leakage inductance L_σ =180nH
and Stray capacity C_σ =250pF.

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