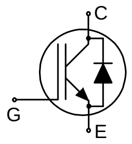
THE DATASHEET OF

SKB04N60ATMA1

Fast IGBT in NPT-technology with soft, fast recovery anti-parallel Emitter Controlled Diode



- 75% lower E_{off} compared to previous generation combined with low conduction losses
- Short circuit withstand time – 10 µs
- Designed for frequency inverters for washing machines, fans, pumps and vacuum cleaners
- NPT-Technology for 600V applications offers:
  - very tight parameter distribution
  - high ruggedness, temperature stable behaviour
  - parallel switching capability
- Very soft, fast recovery anti-parallel Emitter Controlled Diode
- Qualified according to JEDEC[1] for target applications
- Pb-free lead plating; RoHS compliant
- Complete product spectrum and PSpice Models : http://www.infineon.com/igbt/

PG-TO-263-3-2

Type	V_{CE}	I_C	$V_{CE(sat)}$	T_j	Marking	Package
SKB04N60	600V	4A	2.3V	150°C	K04N60	PG-TO-263-3-2

Maximum Ratings

Parameter	Symbol	Value	Unit
Collector-emitter voltage	V_{CE}	600	V
DC collector current	I_C		A
T_C = 25°C		9.4	
T_C = 100°C		4.9	
Pulsed collector current, t_p limited by T_{jmax}	I_{Cpuls}	19	
Turn off safe operating area $V_{CE} \le$ 600V, $T_j \le$ 150°C	-	19	
Diode forward current	I_F		
T_C = 25°C		10	
T_C = 100°C		4	
Diode pulsed current, t_p limited by T_{jmax}	I_{Fpuls}	19	
Gate-emitter voltage	V_{GE}	±20	V
Short circuit withstand time[2] V_{GE} = 15V, $V_{CC} \le$ 600V, $T_j \le$ 150°C	t_{SC}	10	µs
Power dissipation T_C = 25°C	P_{tot}	50	W
Operating junction and storage temperature	T_j , T_{stg}	-55...+150	°C
Soldering temperature (reflow soldering, MSL1)	T_s	260	°C

[1] J-STD-020 and JESD-022
[2] 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}		2.5	K/W
Diode thermal resistance, junction – case	R_{thJCD}		4.5	
SMD version, device on PCB[1)]	R_{thJA}		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=4A T_j=25°C T_j=150°C	 1.7 -	 2.0 2.3	 2.4 2.8	
Diode forward voltage	V_F	V_{GE}=0V, I_F=4A T_j=25°C T_j=150°C	 1.2 -	 1.4 1.25	 1.8 1.65	
Gate-emitter threshold voltage	$V_{GE(th)}$	I_C=200µA,V_{CE}=V_{GE}	3	4	5	
Zero gate voltage collector current	I_{CES}	V_{CE}=600V,V_{GE}=0V T_j=25°C T_j=150°C	 - -	 - -	 20 500	µA
Gate-emitter leakage current	I_{GES}	V_{CE}=0V,V_{GE}=20V	-	-	100	nA
Transconductance	g_{fs}	V_{CE}=20V, I_C=4A		3.1	-	S
Dynamic Characteristic						
Input capacitance	C_{iss}	V_{CE}=25V,	-	264	317	pF
Output capacitance	C_{oss}	V_{GE}=0V,	-	29	35	
Reverse transfer capacitance	C_{rss}	f=1MHz	-	17	20	
Gate charge	Q_{Gate}	V_{CC}=480V, I_C=4A V_{GE}=15V	-	24	31	nC
Internal emitter inductance measured 5mm (0.197 in.) from case	L_E		-	7	-	nH
Short circuit collector current[2)]	$I_{C(SC)}$	V_{GE}=15V,t_{SC}≤10µs V_{CC} ≤ 600V, T_j ≤ 150°C	-	40	-	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=4A, V_{GE}=0/15V, R_G=67Ω, L_σ[1] =180nH, C_σ[1] =180pF Energy losses include “tail” and diode reverse recovery.	-	22	26	ns
Rise time	t_r		-	15	18	
Turn-off delay time	$t_{d(off)}$		-	237	284	
Fall time	t_f		-	70	84	
Turn-on energy	E_{on}		-	0.070	0.081	mJ
Turn-off energy	E_{off}		-	0.061	0.079	
Total switching energy	E_{ts}		-	0.131	0.160	
Anti-Parallel Diode Characteristic						
Diode reverse recovery time	t_{rr}	T_j=25°C, V_R=200V, I_F=4A, di_F/dt=200A/µs	-	180	-	ns
	t_S		-	15	-	
	t_F		-	165	-	
Diode reverse recovery charge	Q_{rr}		-	130	-	nC
Diode peak reverse recovery current	I_{rrm}		-	2.5	-	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 °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=4A, V_{GE}=0/15V, R_G=67Ω, L_σ[1] =180nH, C_σ[1] =180pF Energy losses include “tail” and diode reverse recovery.	-	22	26	ns
Rise time	t_r		-	16	19	
Turn-off delay time	$t_{d(off)}$		-	264	317	
Fall time	t_f		-	104	125	
Turn-on energy	E_{on}		-	0.115	0.132	mJ
Turn-off energy	E_{off}		-	0.111	0.144	
Total switching energy	E_{ts}		-	0.226	0.277	
Anti-Parallel Diode Characteristic						
Diode reverse recovery time	t_{rr}	T_j=150°C V_R=200V, I_F=4A, di_F/dt=200A/µs	-	230	-	ns
	t_S		-	23	-	
	t_F		-	227	-	
Diode reverse recovery charge	Q_{rr}		-	300	-	nC
Diode peak reverse recovery current	I_{rrm}		-	4	-	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.

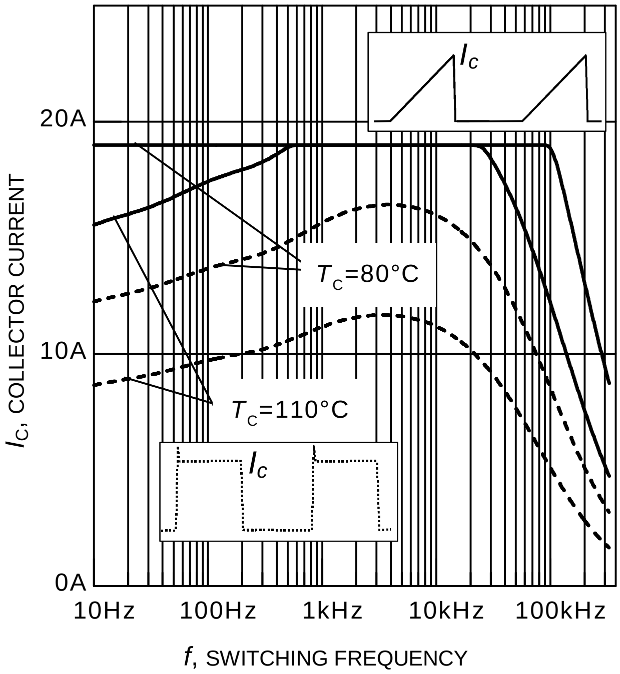


Figure 1. Collector current as a function of switching frequency
($T_j \leq 150°C$, $D = 0.5$, $V_{CE} = 400V$, $V_{GE} = 0/+15V$, $R_G = 67\Omega$)

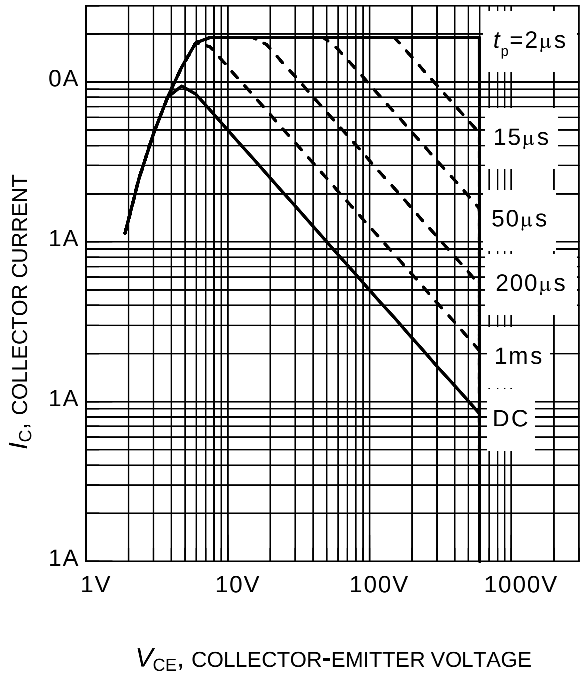


Figure 2. Safe operating area
($D = 0$, $T_C = 25°C$, $T_j \leq 150°C$)

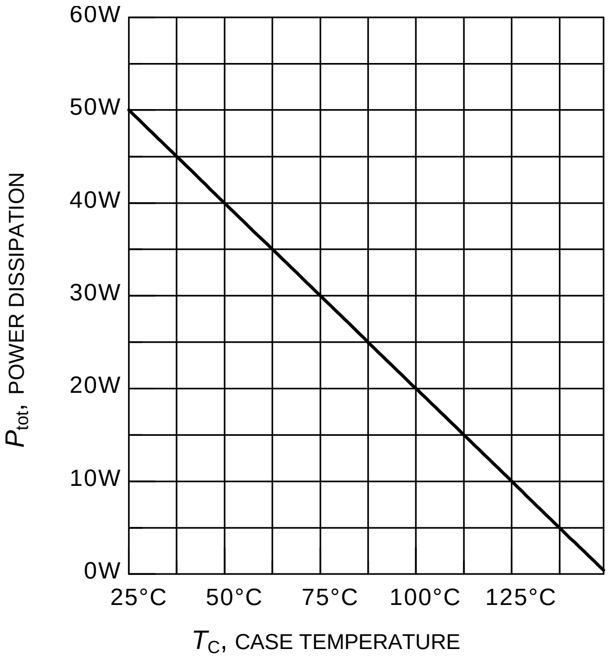


Figure 3. Power dissipation as a function of case temperature
($T_j \leq 150°C$)

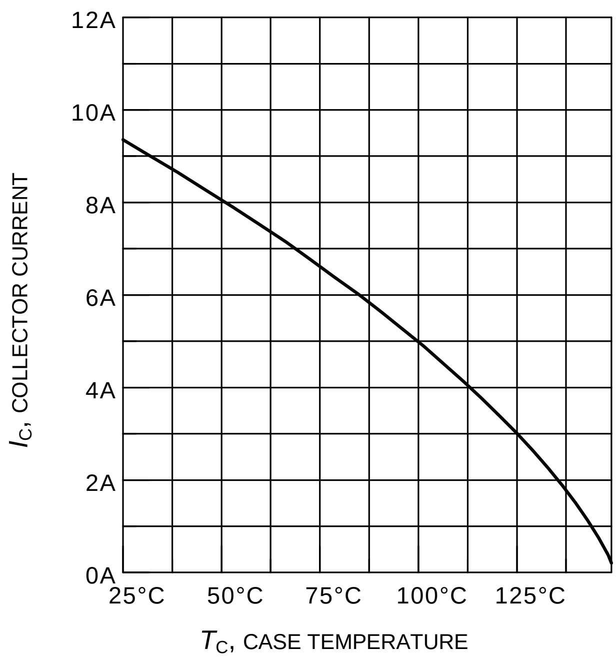


Figure 4. Collector current as a function of case temperature
($V_{GE} \leq 15V$, $T_j \leq 150°C$)

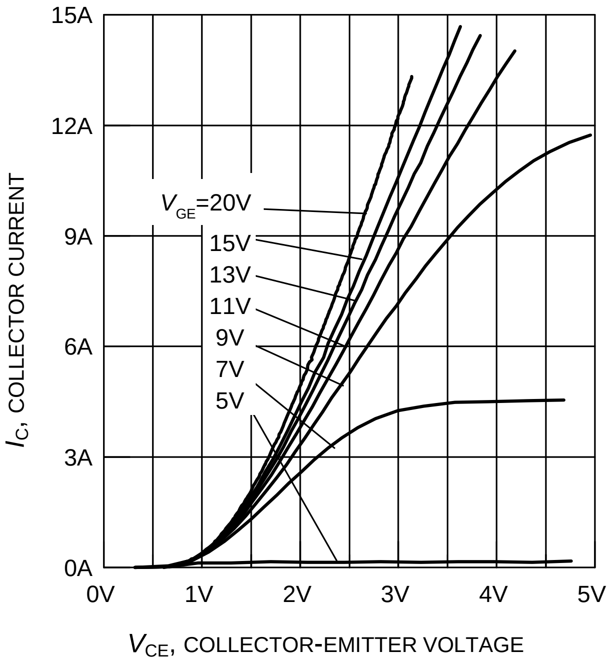


Figure 5. Typical output characteristics
(T_j = 25°C)

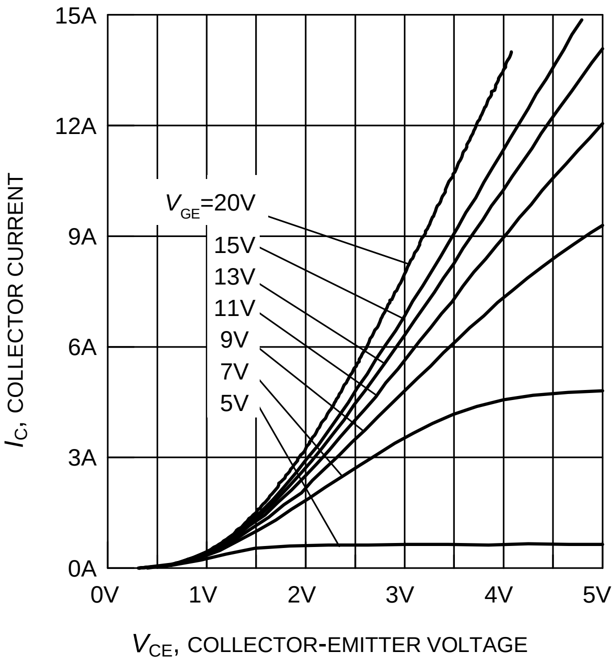


Figure 6. Typical output characteristics
(T_j = 150°C)

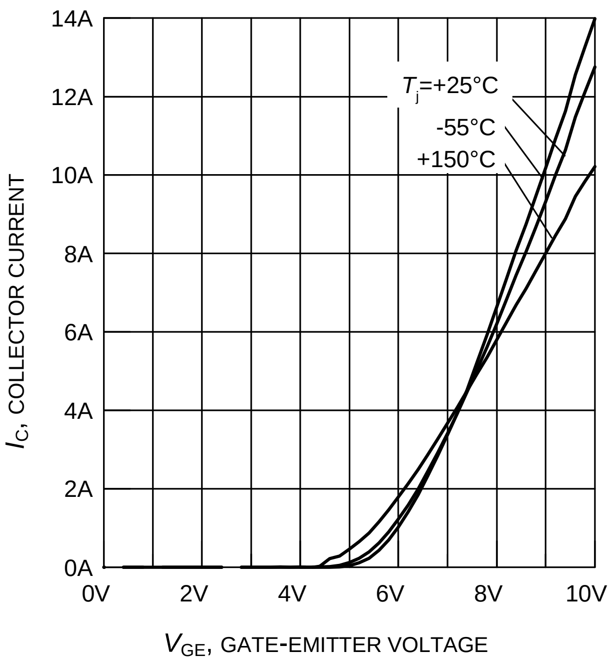


Figure 7. Typical transfer characteristics
(V_{CE} = 10V)

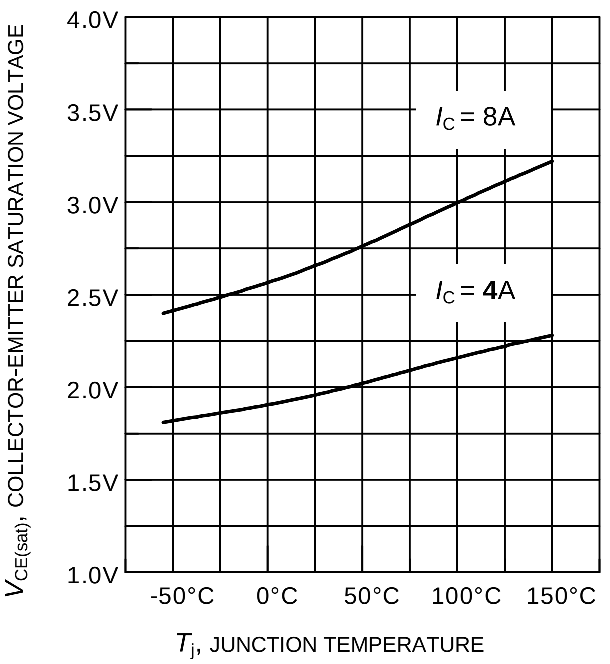


Figure 8. Typical collector-emitter saturation voltage as a function of junction temperature
(V_{GE} = 15V)

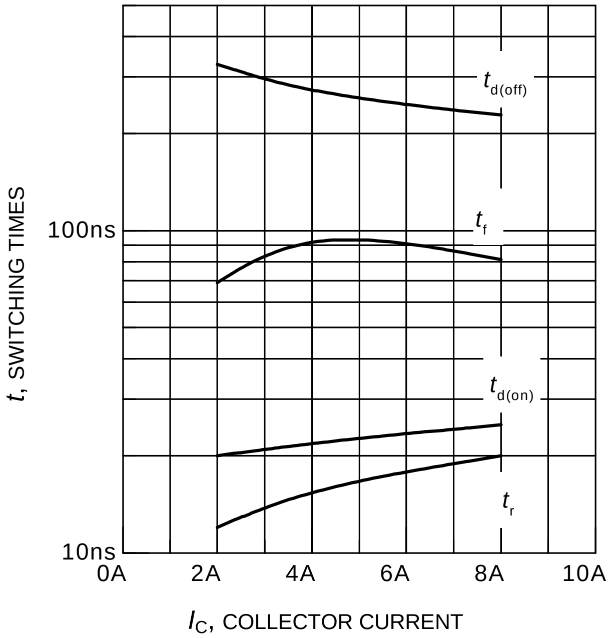


Figure 9. Typical switching times as a function of collector current
(inductive load, T_j = 150°C, V_{CE} = 400V, V_{GE} = 0/+15V, R_G = 67Ω, Dynamic test circuit in Figure E)

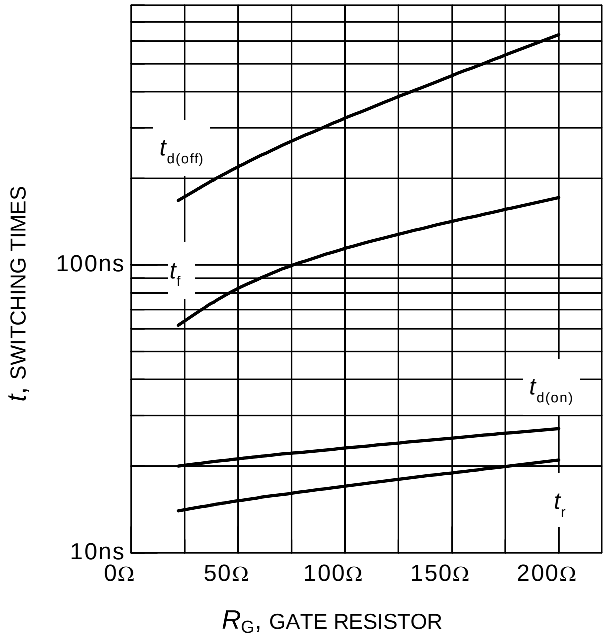


Figure 10. Typical switching times as a function of gate resistor
(inductive load, T_j = 150°C, V_{CE} = 400V, V_{GE} = 0/+15V, I_C = 4A, Dynamic test circuit in Figure E)

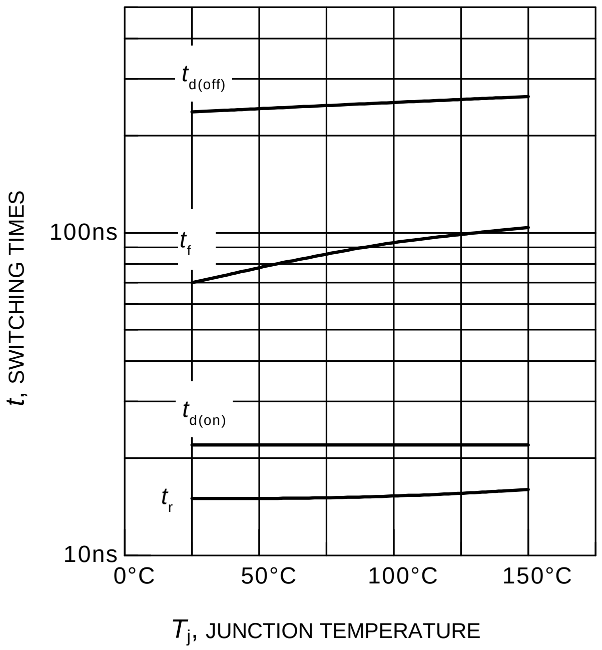


Figure 11. Typical switching times as a function of junction temperature
(inductive load, V_{CE} = 400V, V_{GE} = 0/+15V, I_C = 4A, R_G = 67Ω, Dynamic test circuit in Figure E)

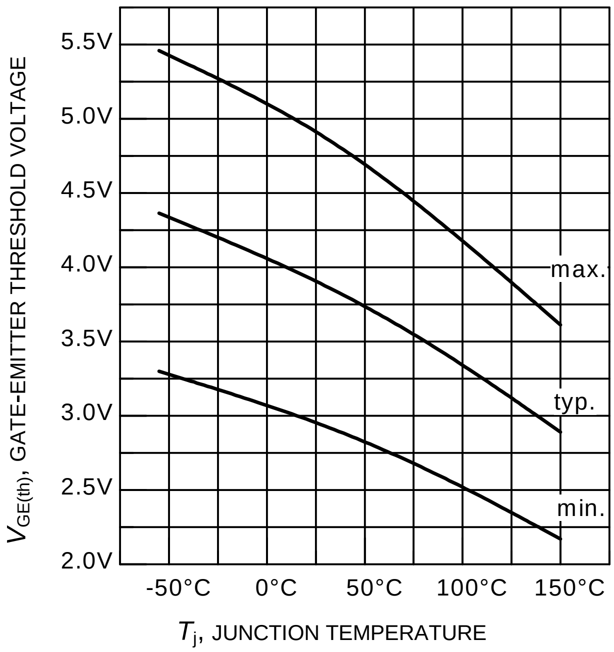


Figure 12. Gate-emitter threshold voltage as a function of junction temperature
(I_C = 0.2mA)

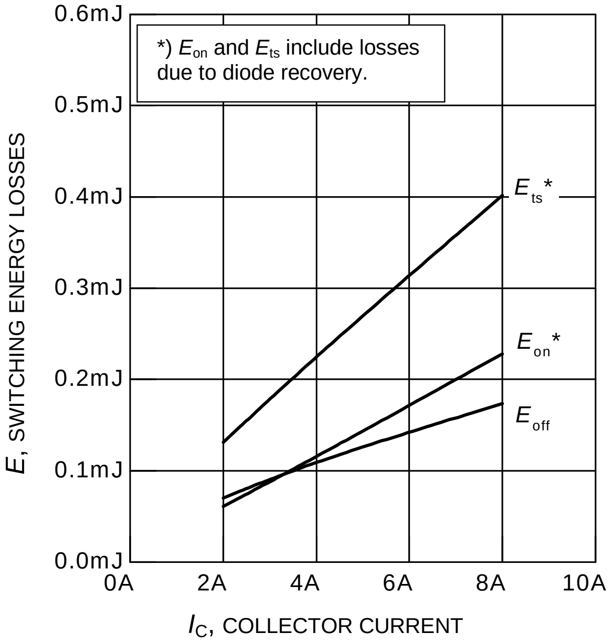


Figure 13. Typical switching energy losses as a function of collector current
(inductive load, T_j = 150°C, V_{CE} = 400V, V_{GE} = 0/+15V, R_G = 67Ω, Dynamic test circuit in Figure E)

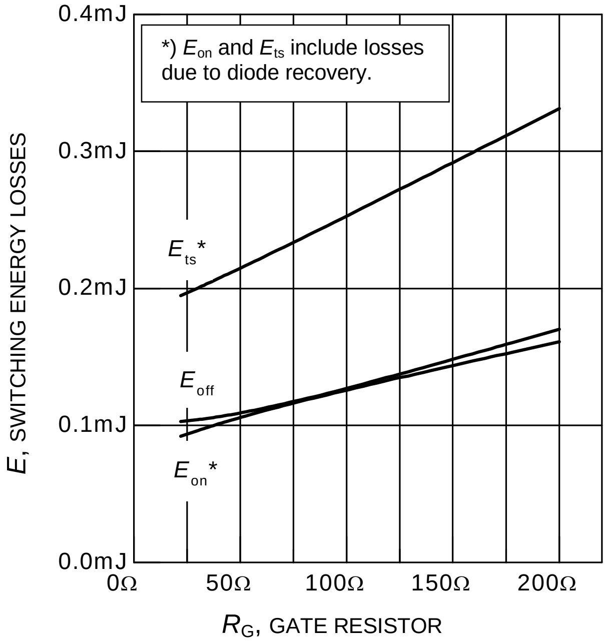


Figure 14. Typical switching energy losses as a function of gate resistor
(inductive load, T_j = 150°C, V_{CE} = 400V, V_{GE} = 0/+15V, I_C = 4A, Dynamic test circuit in Figure E)

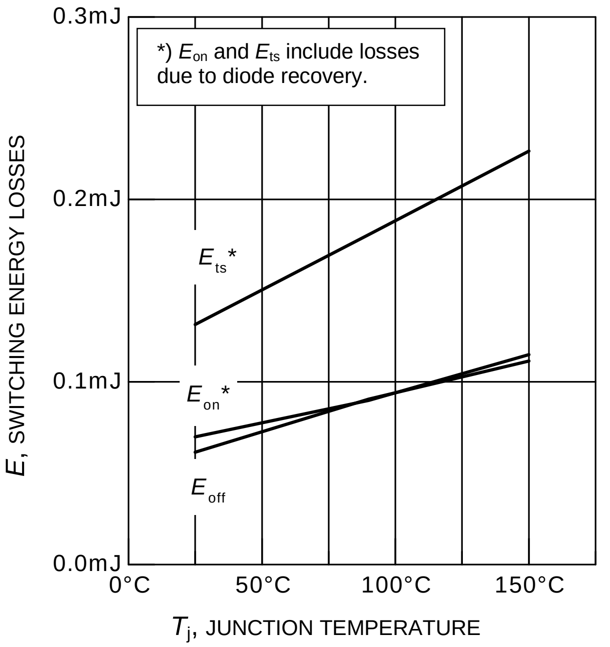


Figure 15. Typical switching energy losses as a function of junction temperature
(inductive load, V_{CE} = 400V, V_{GE} = 0/+15V, I_C = 4A, R_G = 67Ω, Dynamic test circuit in Figure E)

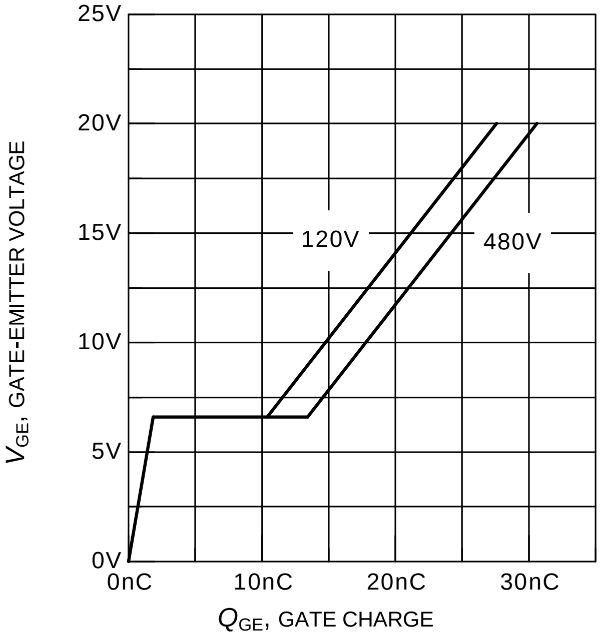


Figure 16. Typical gate charge
(I_C = 4A)

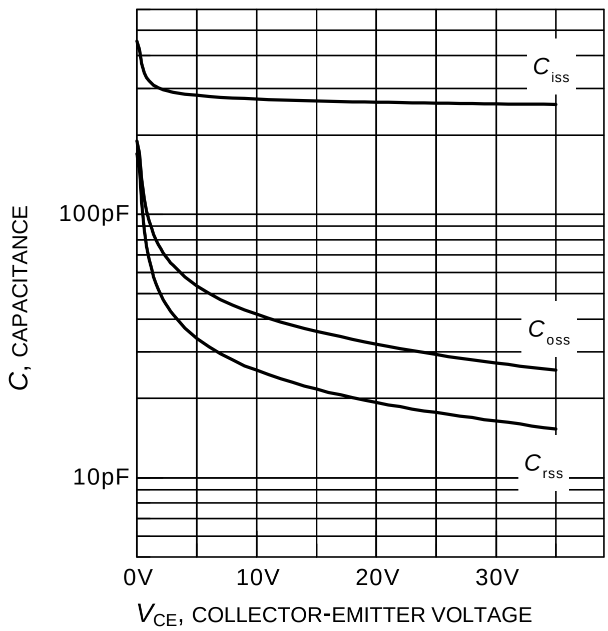


Figure 17. Typical capacitance as a function of collector-emitter voltage
(V_{GE} = 0V, f = 1MHz)

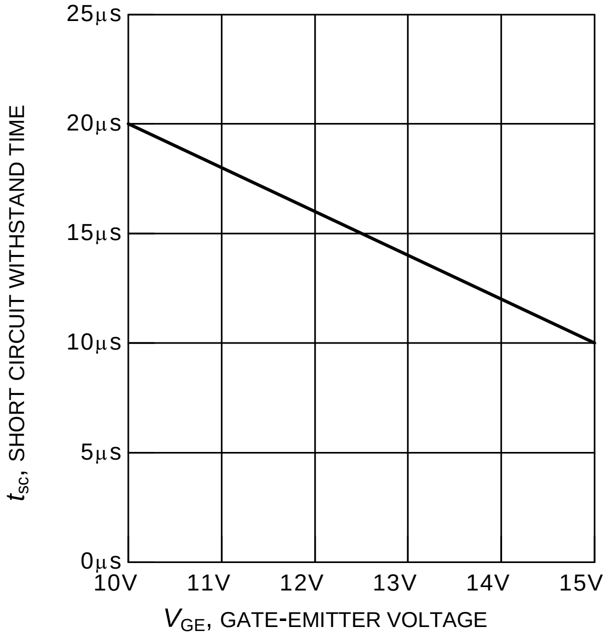


Figure 18. Short circuit withstand time as a function of gate-emitter voltage
(V_{CE} = 600V, start at T_j = 25°C)

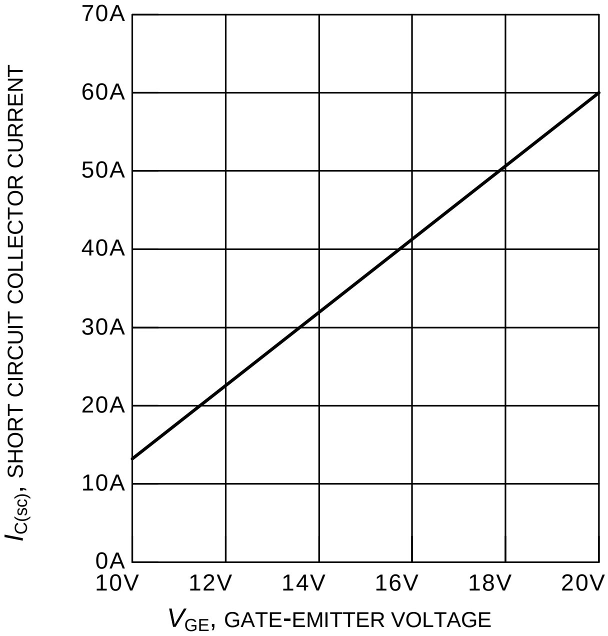


Figure 19. Typical short circuit collector current as a function of gate-emitter voltage
($V_{CE} \leq$ 600V, T_j = 150°C)

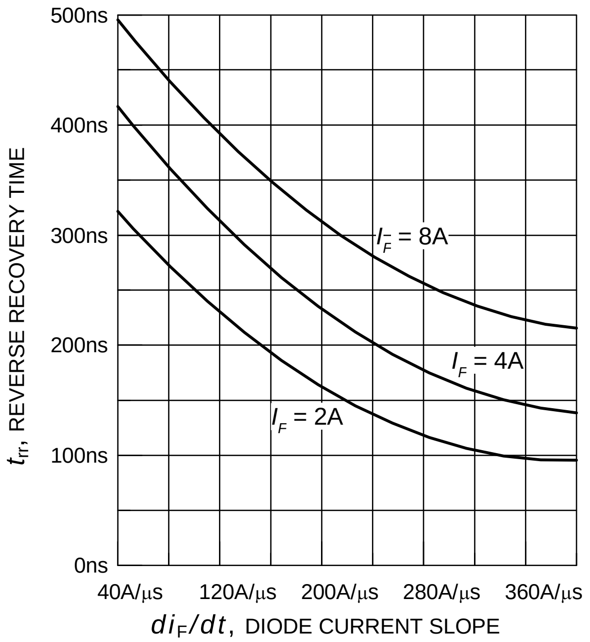


Figure 20. Typical reverse recovery time as a function of diode current slope
(V_R = 200V, T_j = 125°C,
Dynamic test circuit in Figure E)

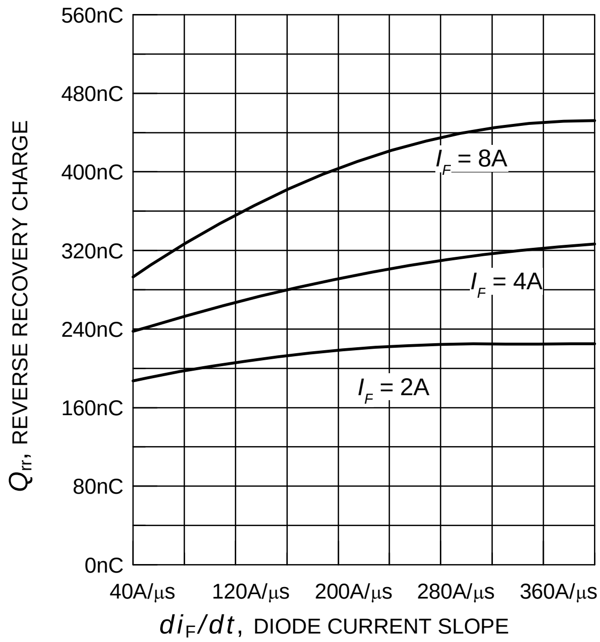


Figure 21. Typical reverse recovery charge as a function of diode current slope
(V_R = 200V, T_j = 125°C,
Dynamic test circuit in Figure E)

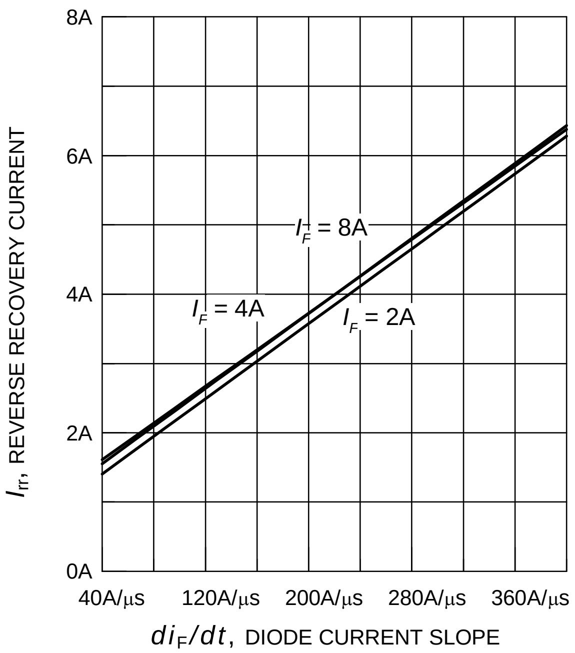


Figure 22. Typical reverse recovery current as a function of diode current slope
(V_R = 200V, T_j = 125°C,
Dynamic test circuit in Figure E)

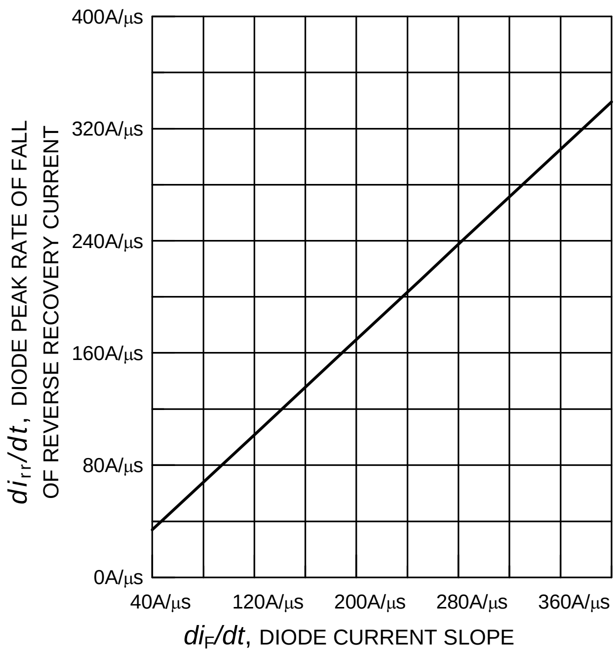


Figure 23. Typical diode peak rate of fall of reverse recovery current as a function of diode current slope
(V_R = 200V, T_j = 125°C,
Dynamic test circuit in Figure E)

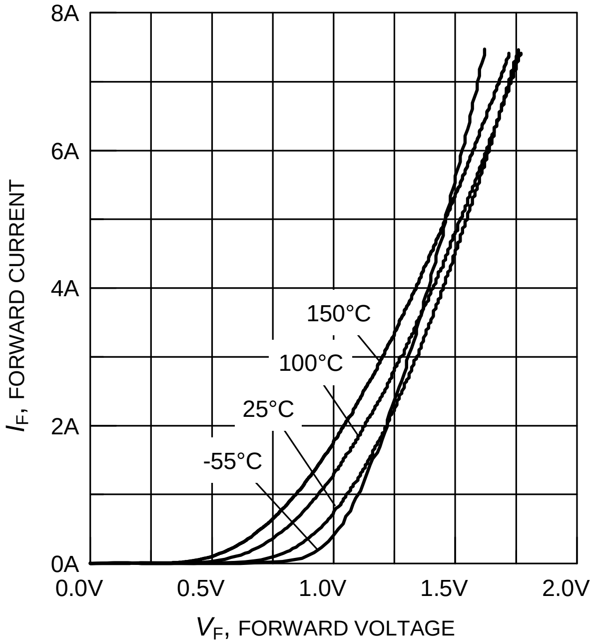


Figure 24. Typical diode forward current as a function of forward voltage

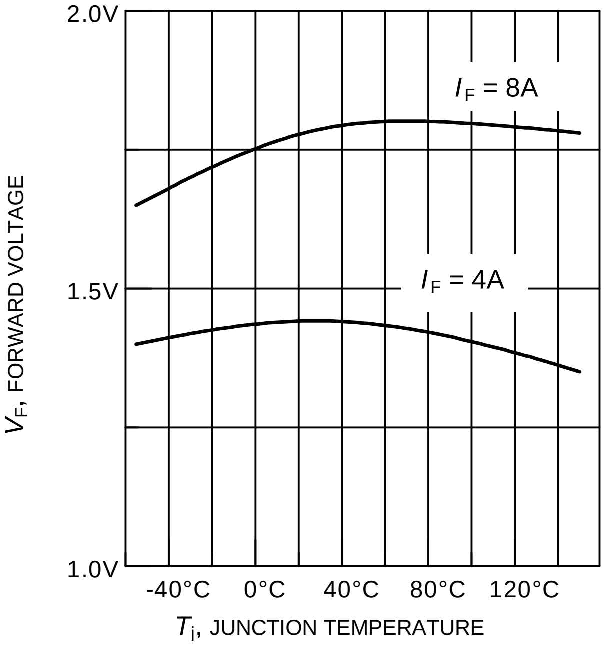


Figure 25. Typical diode forward voltage as a function of junction temperature

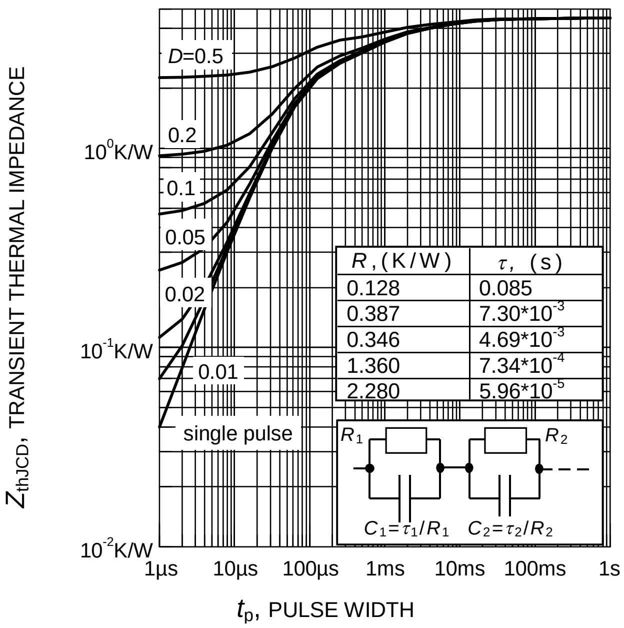


Figure 26. Diode transient thermal impedance as a function of pulse width
($D = t_p / T$)

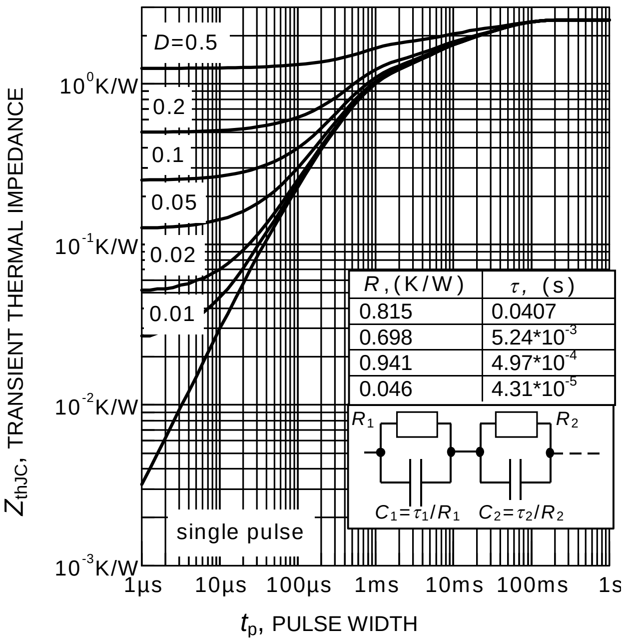
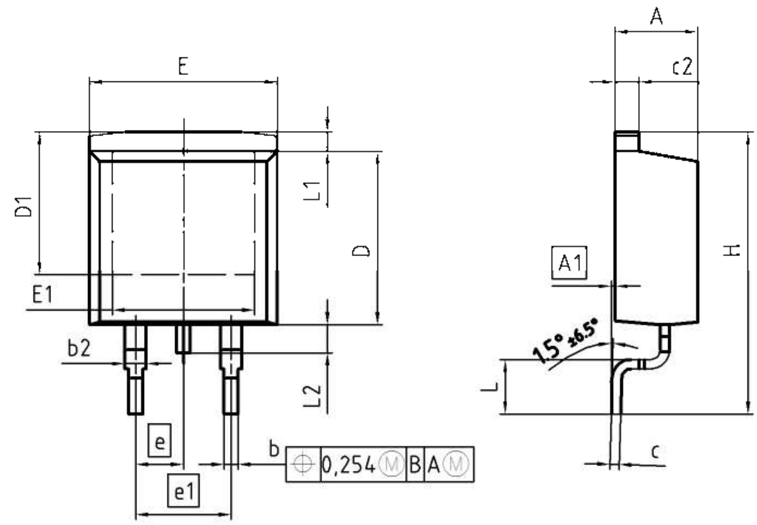
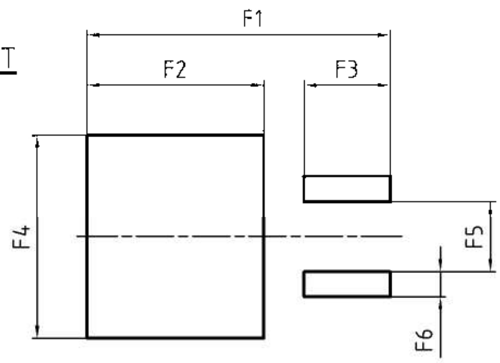


Figure 28. IGBT transient thermal impedance as a function of pulse width
($D = t_p / T$)

PG-TO263-3-2



FOOTPRINT



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.30	4.57	0.169	0.180
A1	0.00	0.25	0.000	0.010
b	0.65	0.85	0.026	0.033
b2	0.95	1.15	0.037	0.045
c	0.33	0.65	0.013	0.026
c2	1.17	1.40	0.046	0.055
D	8.51	9.45	0.335	0.372
D1	7.10	7.90	0.280	0.311
E	9.80	10.31	0.386	0.406
E1	6.50	8.60	0.256	0.339
e	2.54		0.100	
e1	5.08		0.200	
N	2		2	
H	14.61	15.88	0.575	0.625
L	2.29	3.00	0.090	0.118
L1	0.70	1.60	0.028	0.063
L2	1.00	1.78	0.039	0.070
F1	16.05	16.25	0.632	0.640
F2	9.30	9.50	0.366	0.374
F3	4.50	4.70	0.177	0.185
F4	10.70	10.90	0.421	0.429
F5	3.65	3.85	0.144	0.152
F6	1.25	1.45	0.049	0.057

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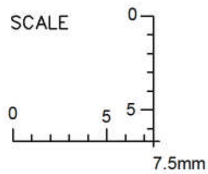
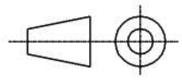
SCALE



EUROPEAN PROJECTION



ISSUE DATE
30-08-2007

REVISION
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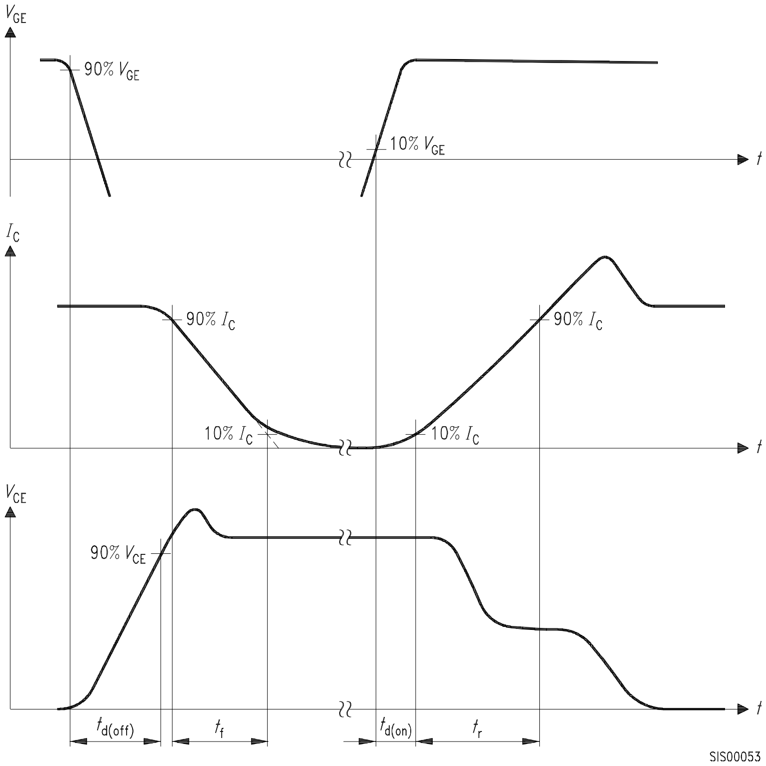

Figure A. Definition of switching times

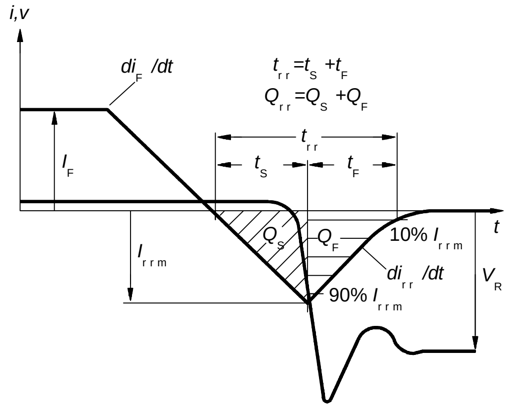

Figure C. Definition of diodes switching characteristics

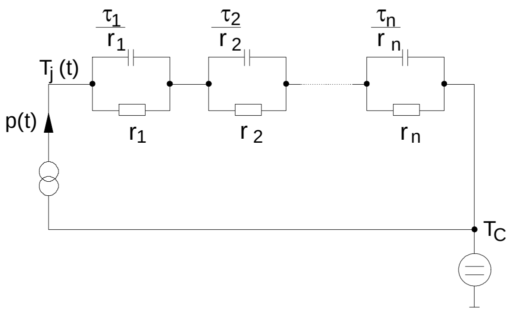

Figure D. Thermal equivalent circuit

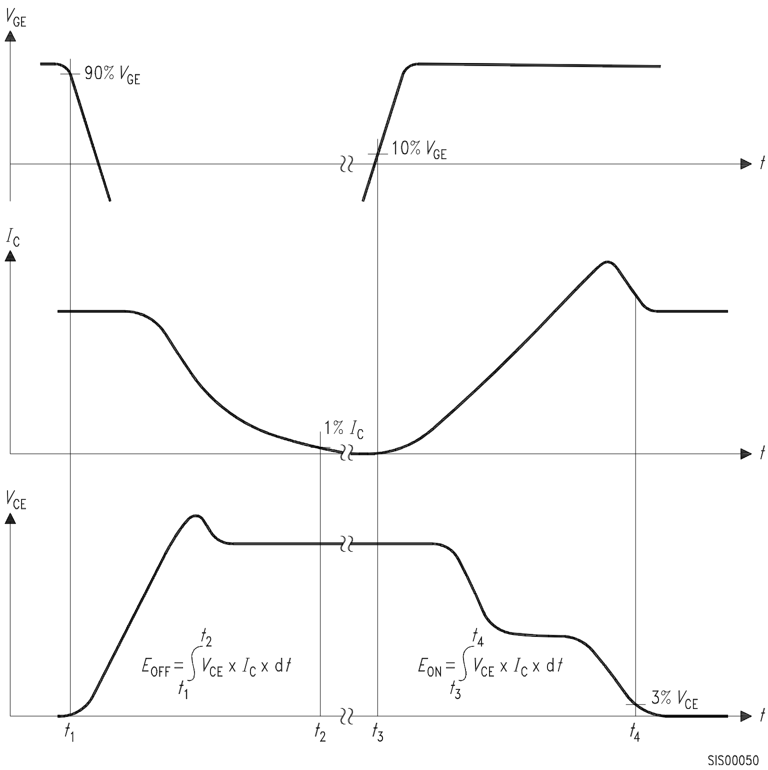

Figure B. Definition of switching losses

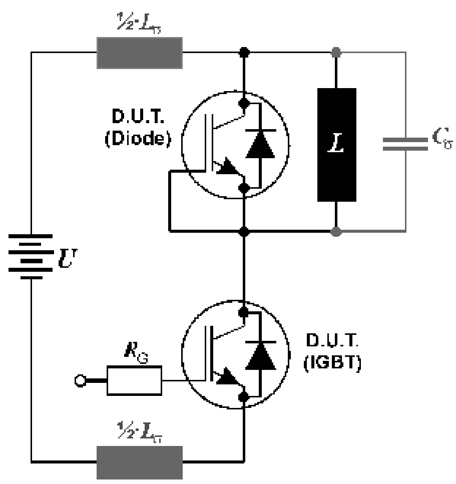

Figure E. Dynamic test circuit
Leakage inductance L_σ =180nH
and Stray capacity C_σ =180pF.

Published by
Infineon Technologies AG
81726 Munich, Germany

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