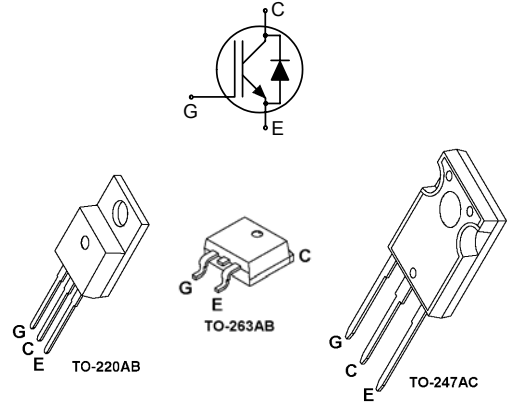


Fast S-IGBT in NPT-technology with soft, fast recovery anti-parallel EmCon diode

- 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	21	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	21	
$T_C = 25^\circ\text{C}$		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 $T_j=25\text{ }^\circ\text{C}$

Parameter	Symbol	Conditions	Value			Unit
			min.	typ.	max.	
IGBT Characteristic						
Turn-on delay time	$t_{d(on)}$	$T_j=25\text{ }^\circ\text{C}$, $V_{CC}=400\text{V}$, $I_C=10\text{A}$, $V_{GE}=0/15\text{V}$, $R_G=25\Omega$,	-	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}	$T_j=25\text{ }^\circ\text{C}$, $V_R=200\text{V}$, $I_F=10\text{A}$, $di_F/dt=200\text{A}/\mu\text{s}$	-	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 $T_j=150\text{ }^\circ\text{C}$

Parameter	Symbol	Conditions	Value			Unit
			min.	typ.	max.	
IGBT Characteristic						
Turn-on delay time	$t_{d(on)}$	$T_j=150\text{ }^\circ\text{C}$ $V_{CC}=400\text{V}$, $I_C=10\text{A}$, $V_{GE}=0/15\text{V}$, $R_G=25\Omega$	-	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}	$T_j=150\text{ }^\circ\text{C}$ $V_R=200\text{V}$, $I_F=10\text{A}$, $di_F/dt=200\text{A}/\mu\text{s}$	-	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	

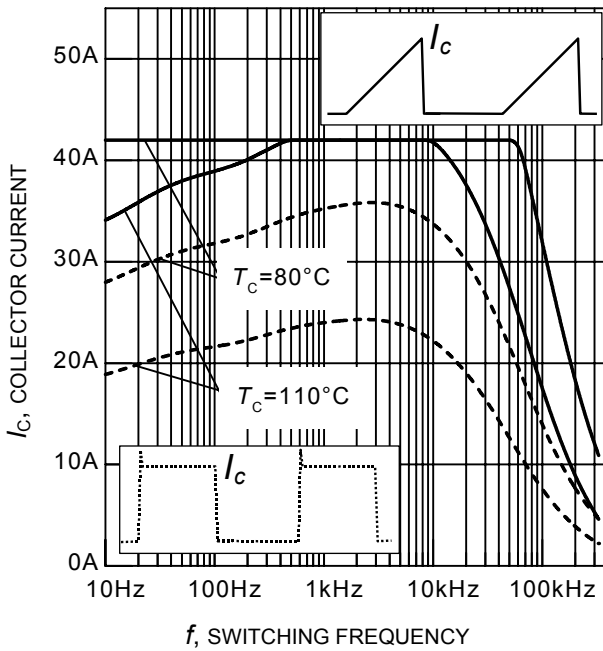


Figure 1. Collector current as a function of switching frequency
 ($T_J \leq 150^\circ\text{C}$, $D = 0.5$, $V_{CE} = 400\text{V}$,
 $V_{GE} = 0/+15\text{V}$, $R_G = 25\Omega$)

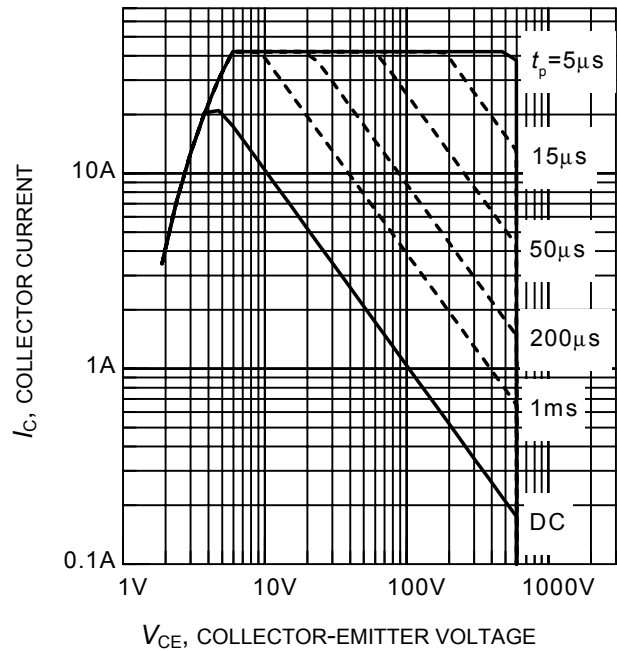


Figure 2. Safe operating area
 ($D = 0$, $T_C = 25^\circ\text{C}$, $T_J \leq 150^\circ\text{C}$)

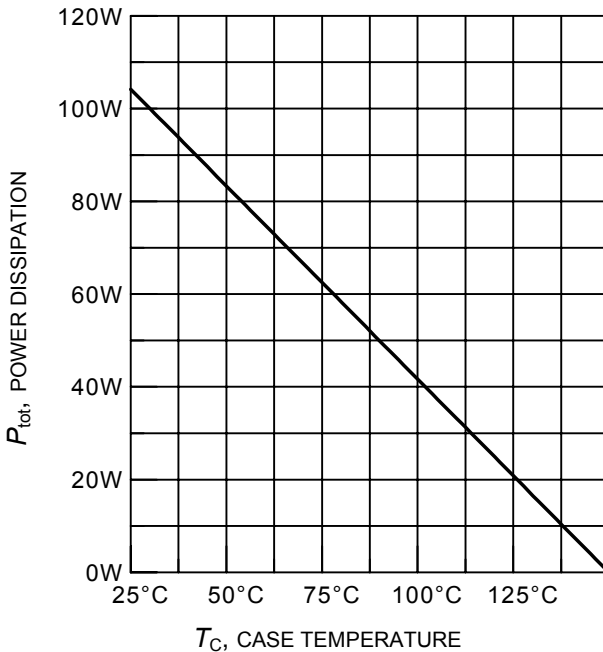


Figure 3. Power dissipation as a function of case temperature
 ($T_J \leq 150^\circ\text{C}$)

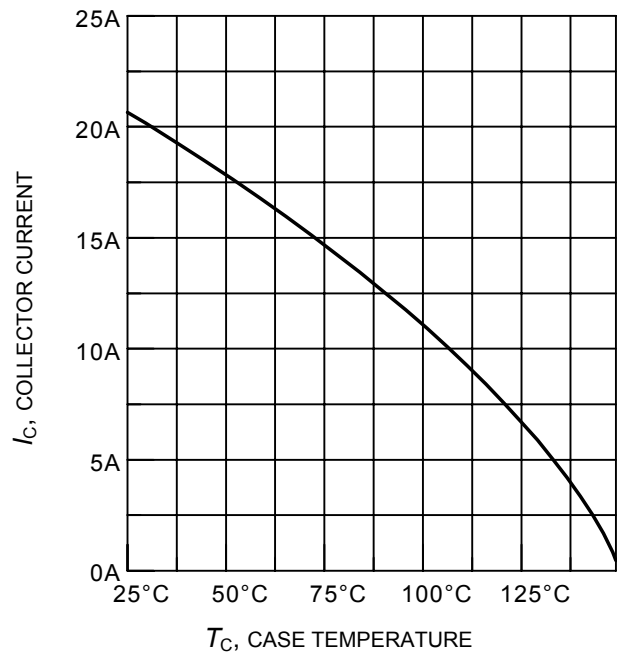


Figure 4. Collector current as a function of case temperature
 ($V_{GE} \leq 15\text{V}$, $T_J \leq 150^\circ\text{C}$)

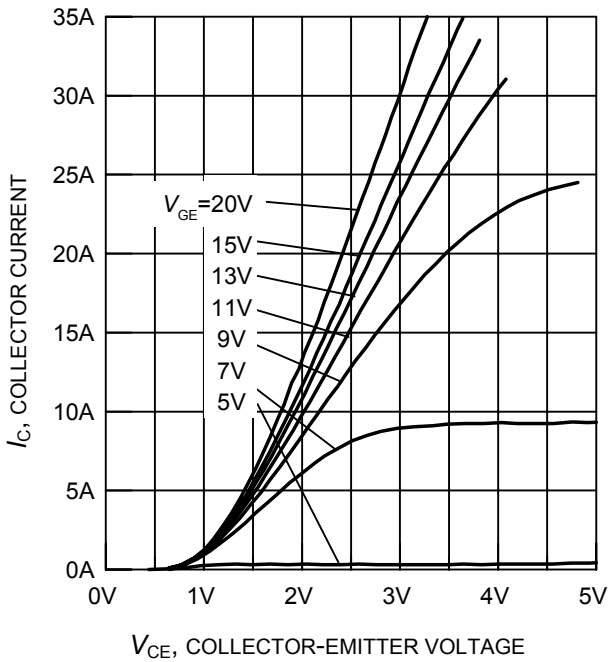


Figure 5. Typical output characteristics
($T_j = 25^\circ\text{C}$)

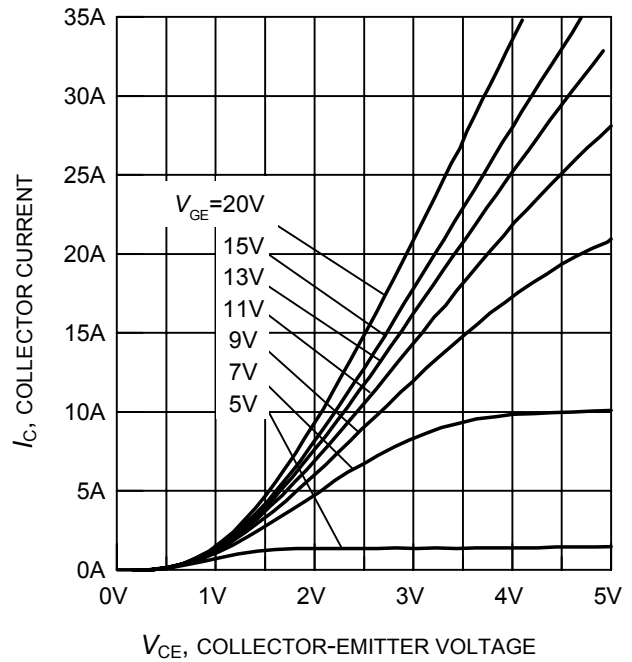


Figure 6. Typical output characteristics
($T_j = 150^\circ\text{C}$)

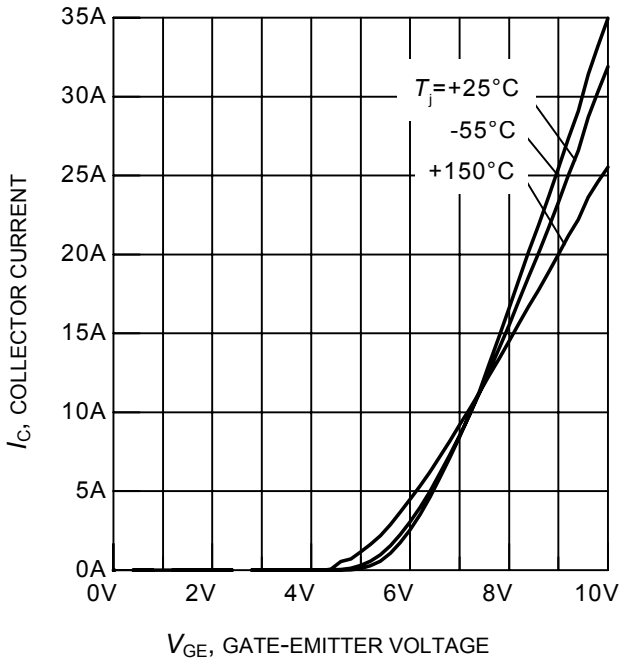


Figure 7. Typical transfer characteristics
($V_{CE} = 10\text{V}$)

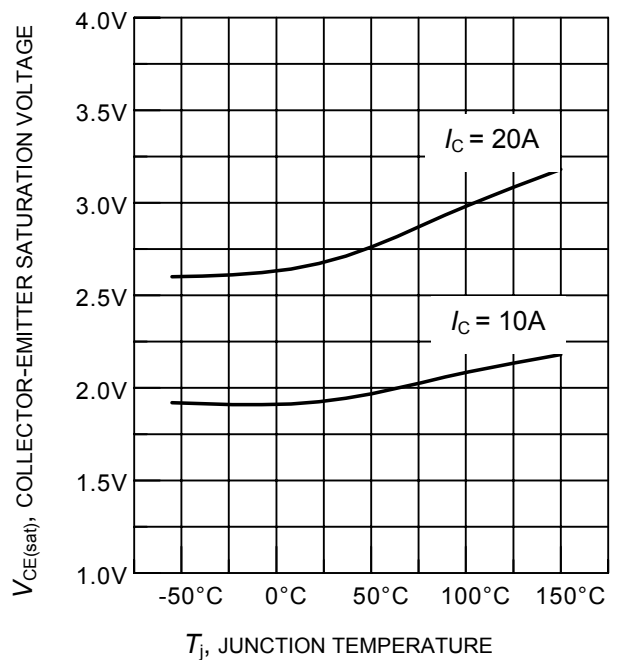


Figure 8. Typical collector-emitter saturation voltage as a function of junction temperature
($V_{GE} = 15\text{V}$)

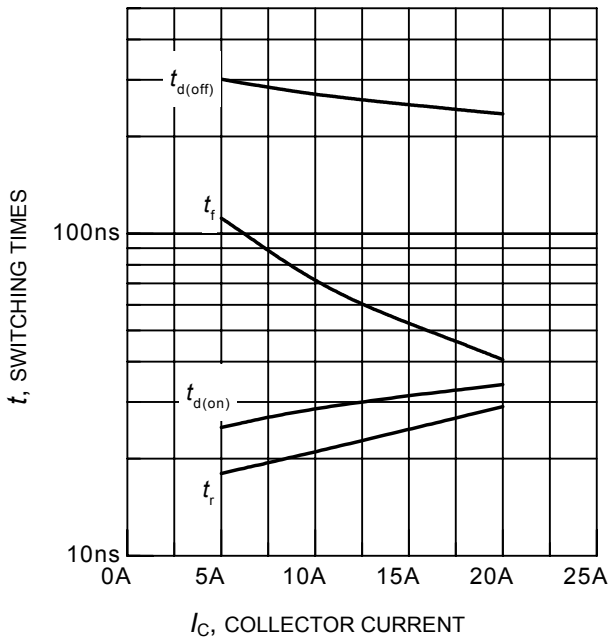


Figure 9. Typical switching times as a function of collector current
 (inductive load, $T_j = 150^\circ\text{C}$, $V_{CE} = 400\text{V}$, $V_{GE} = 0/+15\text{V}$, $R_G = 25\Omega$)

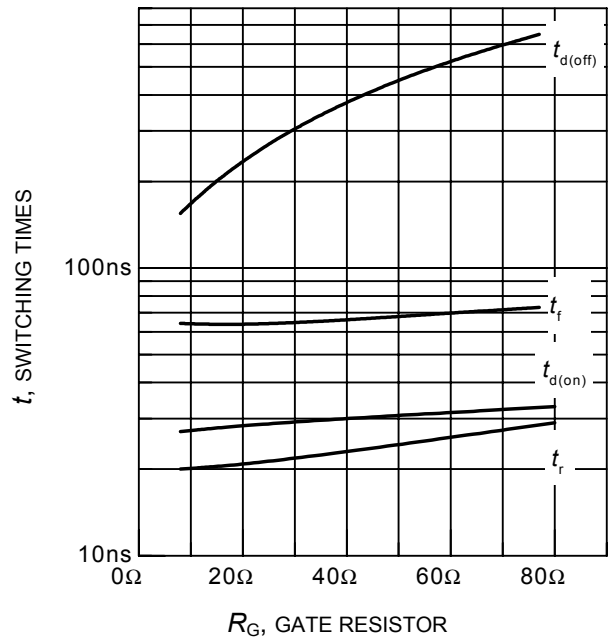


Figure 10. Typical switching times as a function of gate resistor
 (inductive load, $T_j = 150^\circ\text{C}$, $V_{CE} = 400\text{V}$, $V_{GE} = 0/+15\text{V}$, $I_C = 10\text{A}$)

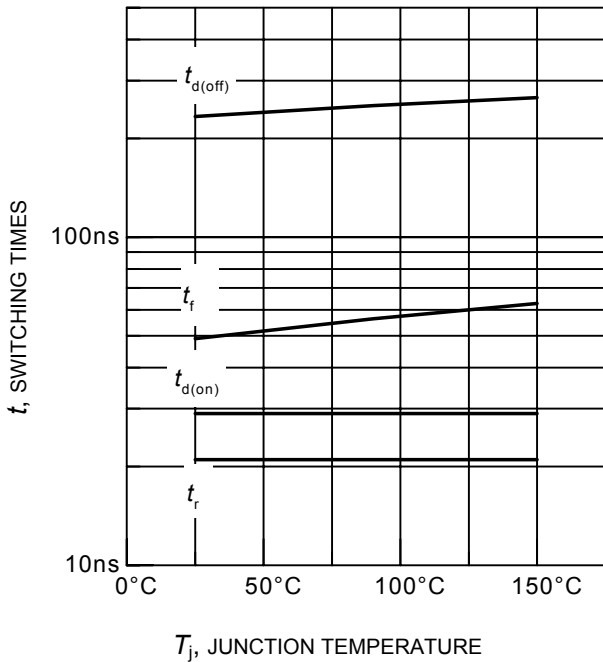


Figure 11. Typical switching times as a function of junction temperature
 (inductive load, $V_{CE} = 400\text{V}$, $V_{GE} = 0/+15\text{V}$, $I_C = 10\text{A}$, $R_G = 25\Omega$)

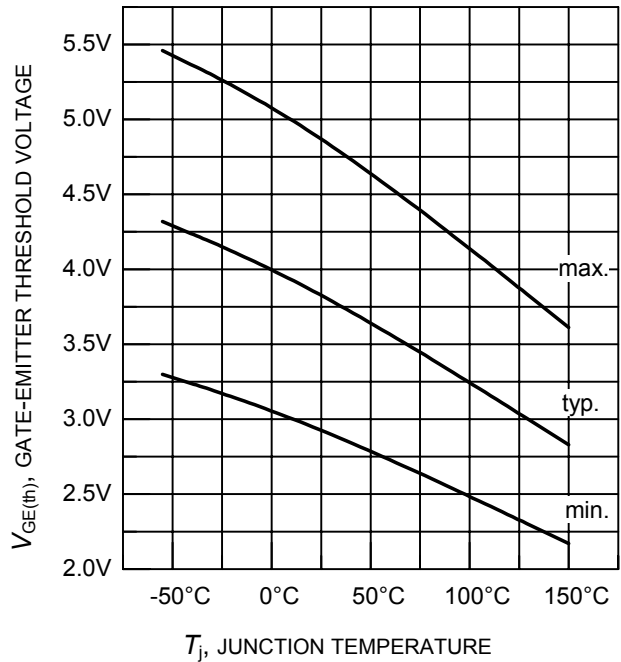


Figure 12. Gate-emitter threshold voltage as a function of junction temperature
 ($I_C = 0.3\text{mA}$)

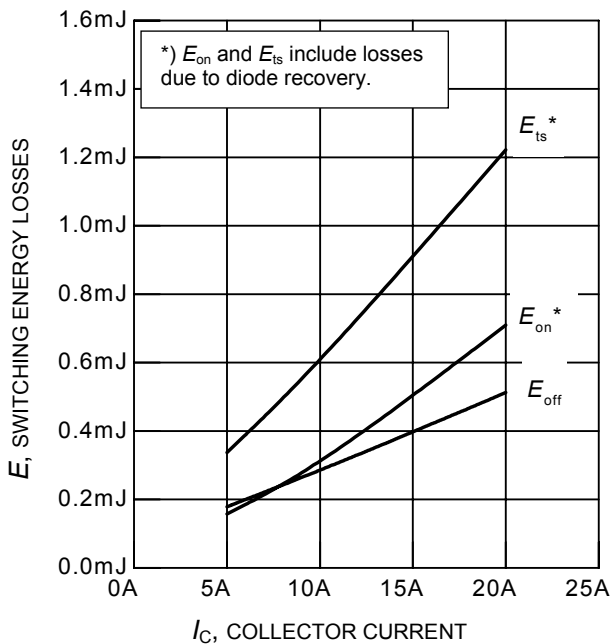


Figure 13. Typical switching energy losses as a function of collector current
(inductive load, $T_j = 150^\circ\text{C}$, $V_{CE} = 400\text{V}$, $V_{GE} = 0/+15\text{V}$, $R_G = 25\Omega$)

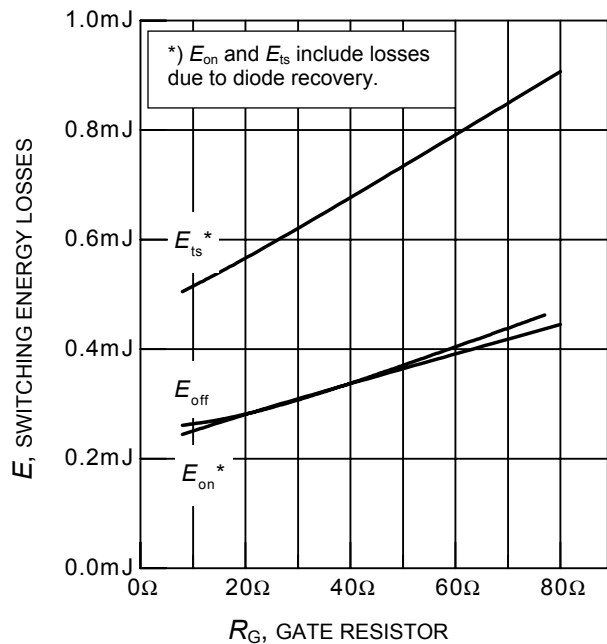


Figure 14. Typical switching energy losses as a function of gate resistor
(inductive load, $T_j = 150^\circ\text{C}$, $V_{CE} = 400\text{V}$, $V_{GE} = 0/+15\text{V}$, $I_C = 10\text{A}$)

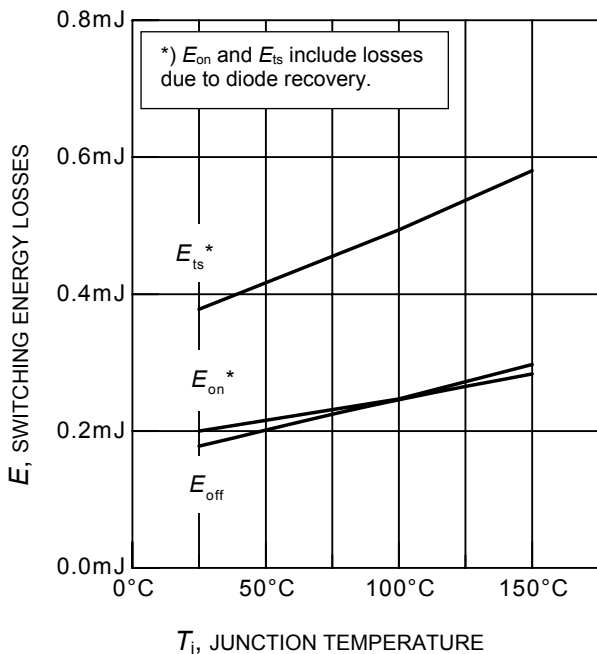


Figure 15. Typical switching energy losses as a function of junction temperature
(inductive load, $V_{CE} = 400\text{V}$, $V_{GE} = 0/+15\text{V}$, $I_C = 10\text{A}$, $R_G = 25\Omega$)

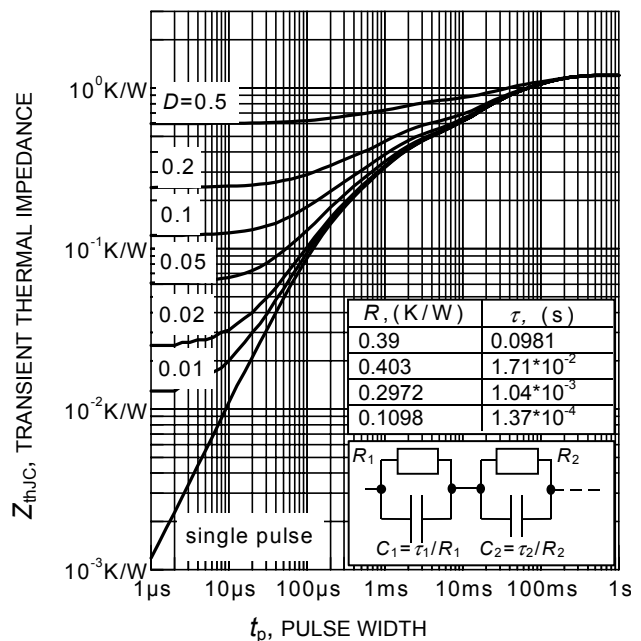


Figure 16. IGBT transient thermal impedance as a function of pulse width
($D = t_p / T$)

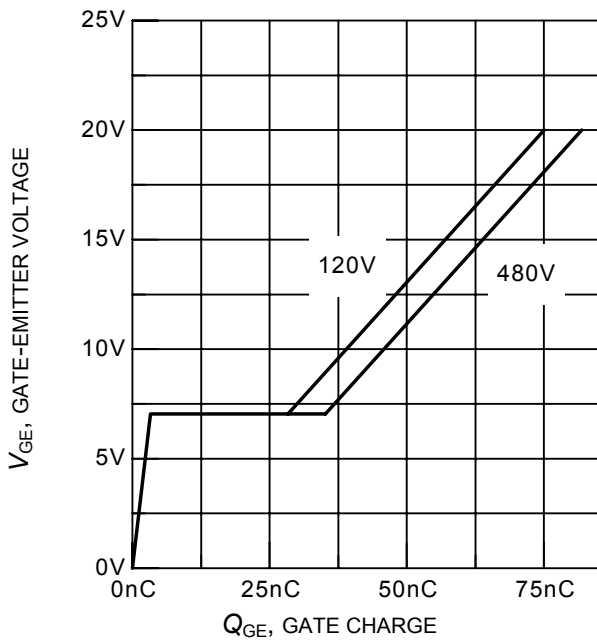


Figure 17. Typical gate charge
($I_C = 10A$)

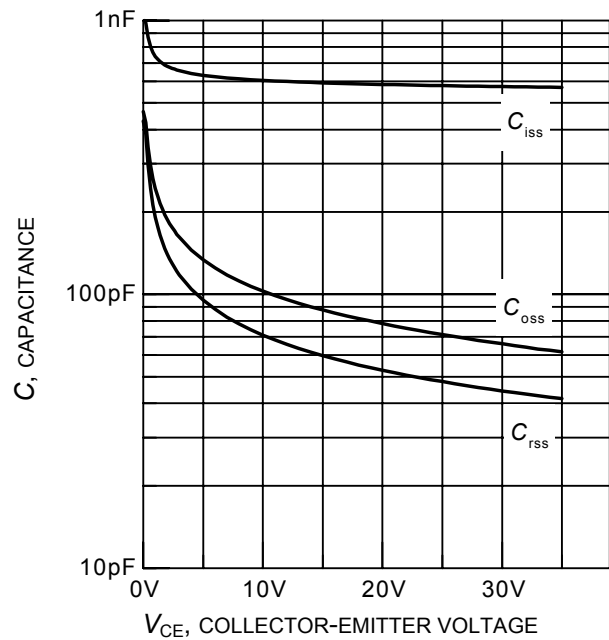


Figure 18. Typical capacitance as a function of collector-emitter voltage
($V_{GE} = 0V, f = 1MHz$)

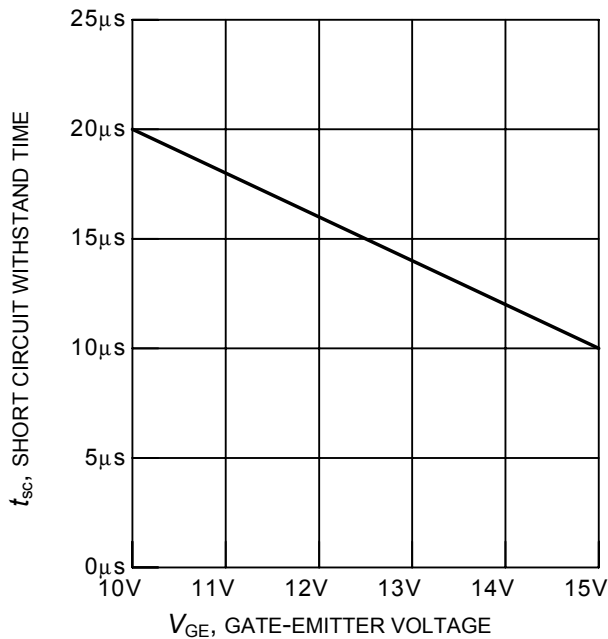


Figure 19. Short circuit withstand time as a function of gate-emitter voltage
($V_{CE} = 600V, \text{start at } T_j = 25^\circ C$)

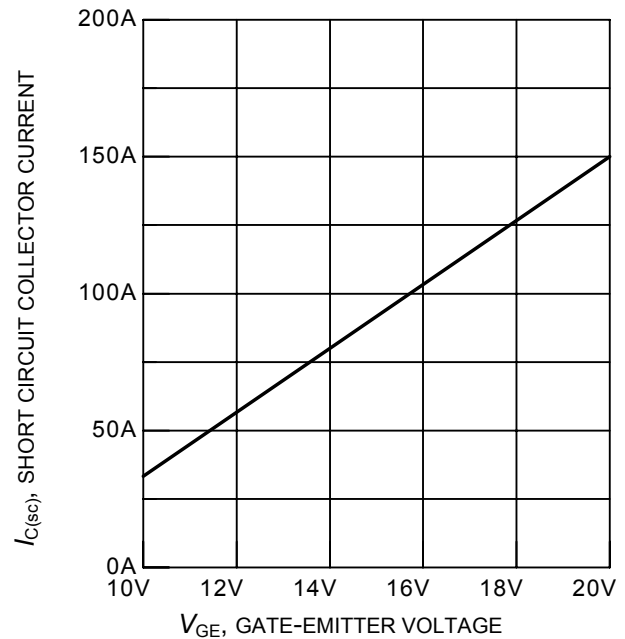
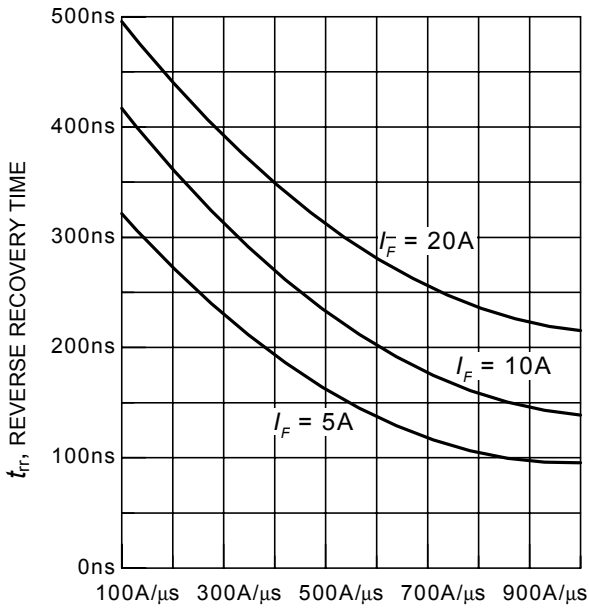
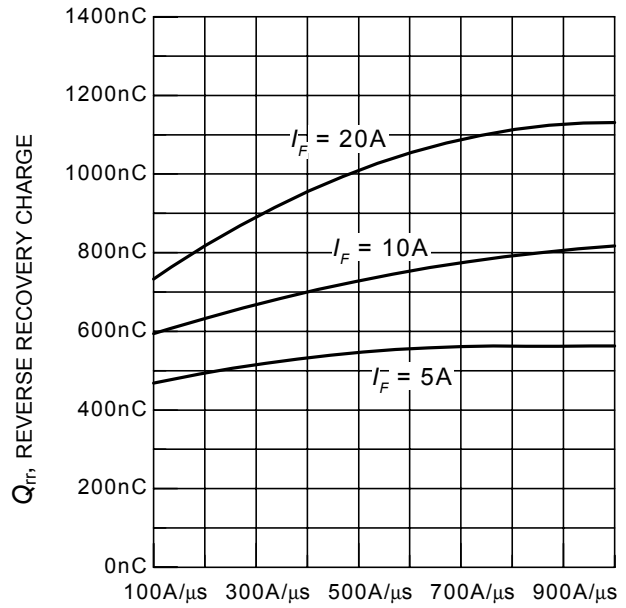


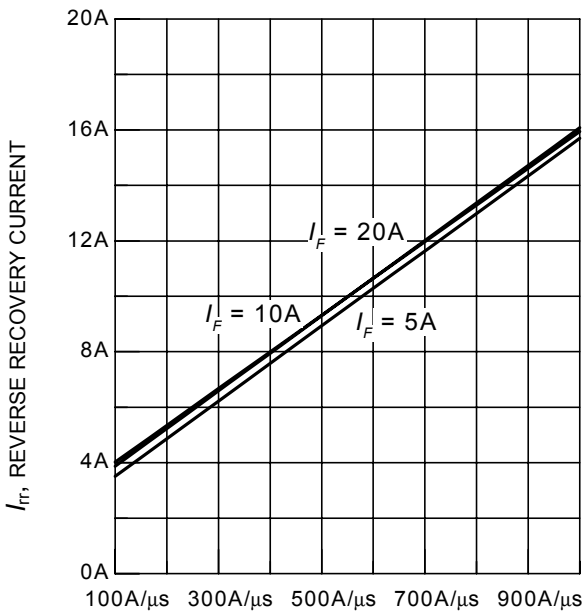
Figure 20. Typical short circuit collector current as a function of gate-emitter voltage
($V_{CE} \leq 600V, T_j = 150^\circ C$)



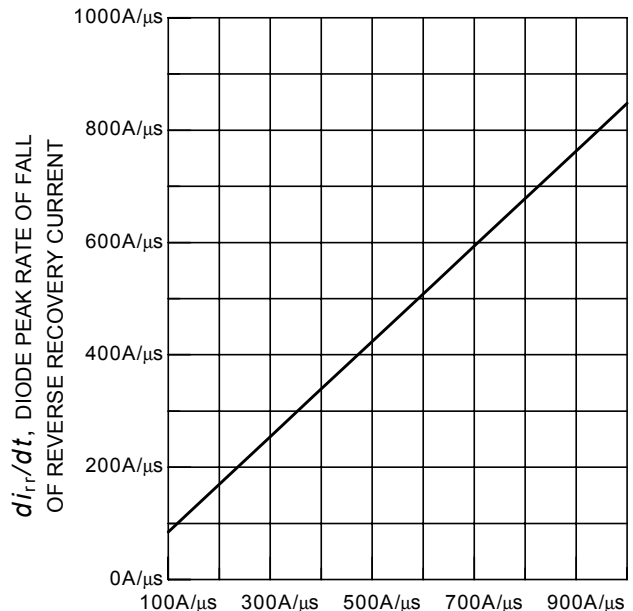
di_F/dt , DIODE CURRENT SLOPE
Figure 21. Typical reverse recovery time as a function of diode current slope
 ($V_R = 200V$, $T_j = 125^\circ C$)



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
 ($V_R = 200V$, $T_j = 125^\circ C$)

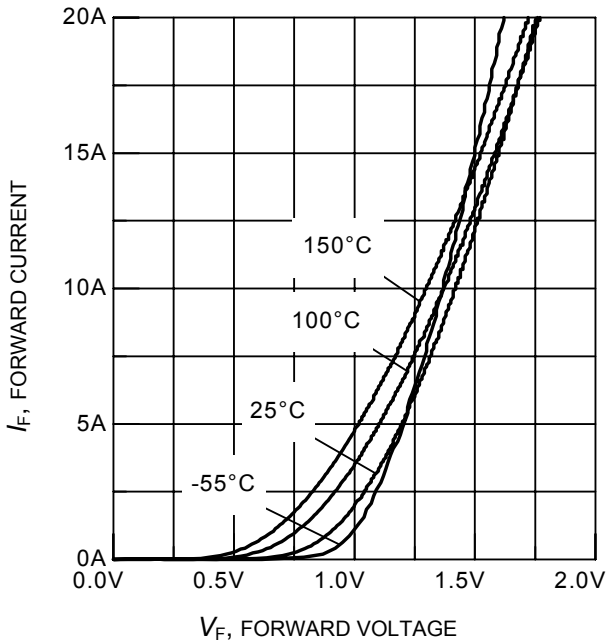


Figure 25. Typical diode forward current as a function of forward voltage

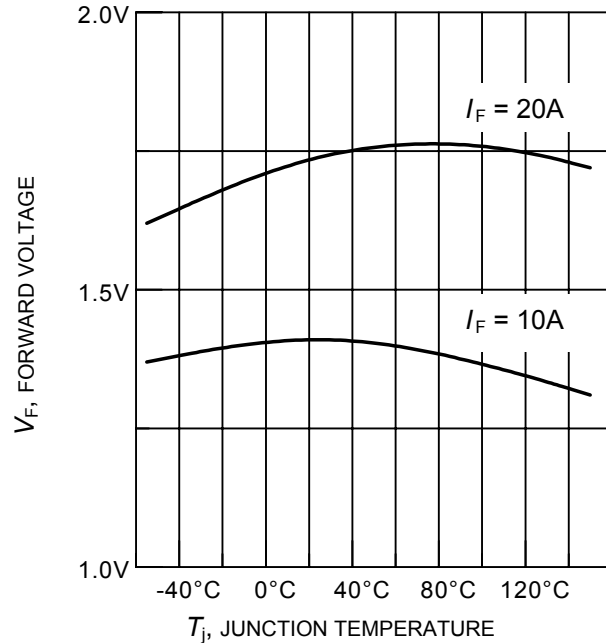


Figure 26. Typical diode forward voltage as a function of junction temperature

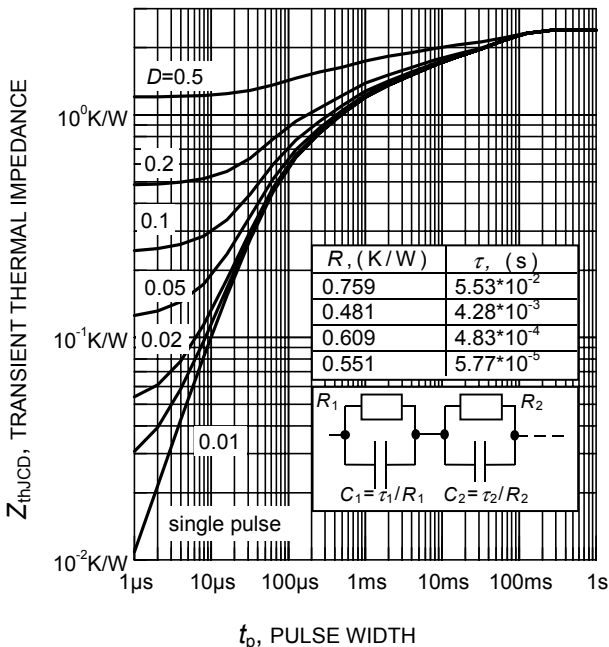
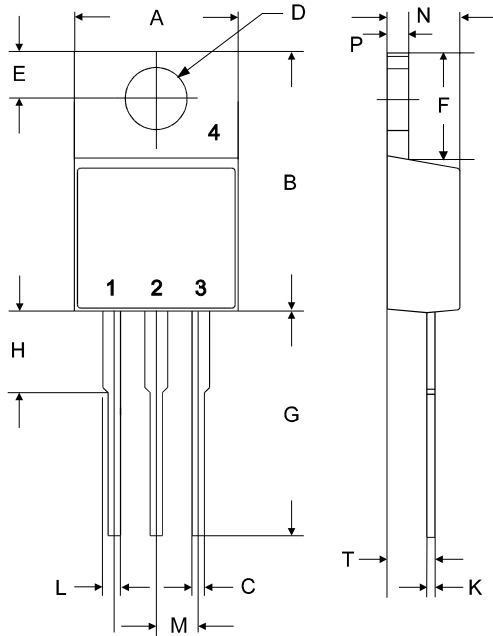


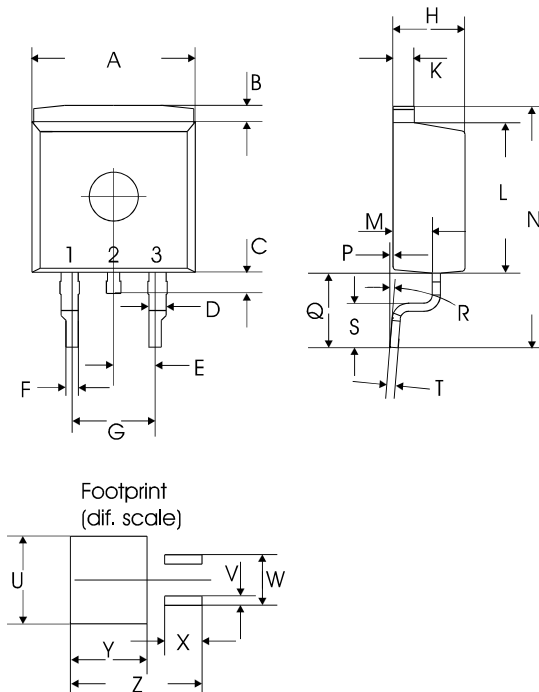
Figure 27. Diode transient thermal impedance as a function of pulse width ($D = t_p / T$)

TO-220AB



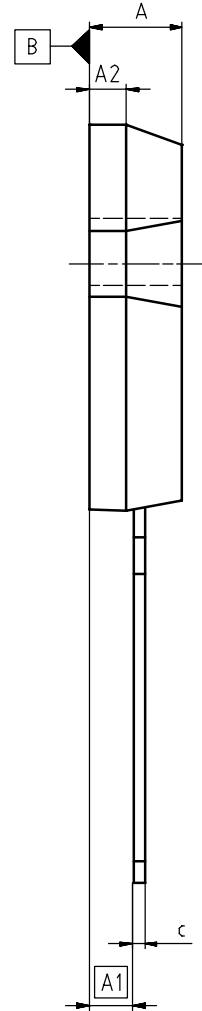
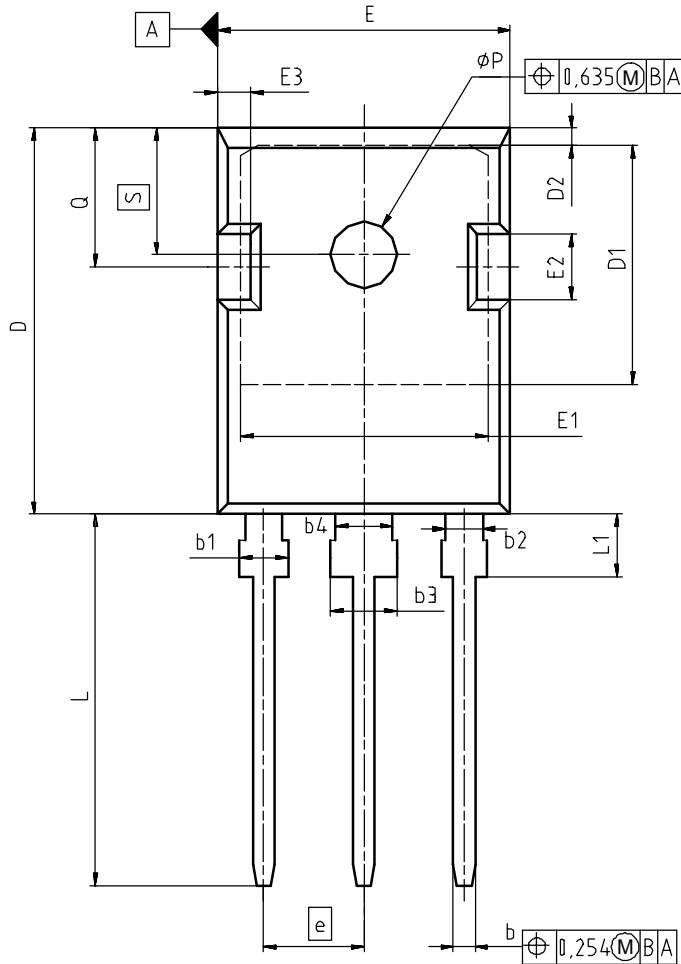
symbol	dimensions			
	[mm]		[inch]	
	min	max	min	max
A	9.70	10.30	0.3819	0.4055
B	14.88	15.95	0.5858	0.6280
C	0.65	0.86	0.0256	0.0339
D	3.55	3.89	0.1398	0.1531
E	2.60	3.00	0.1024	0.1181
F	6.00	6.80	0.2362	0.2677
G	13.00	14.00	0.5118	0.5512
H	4.35	4.75	0.1713	0.1870
K	0.38	0.65	0.0150	0.0256
L	0.95	1.32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

PG-TO247-3



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.90	5.16	0.193	0.203
A1	2.27	2.53	0.089	0.099
A2	1.85	2.11	0.073	0.083
b	1.07	1.33	0.042	0.052
b1	1.90	2.41	0.075	0.095
b2	1.90	2.16	0.075	0.085
b3	2.87	3.38	0.113	0.133
b4	2.87	3.13	0.113	0.123
c	0.55	0.68	0.022	0.027
D	20.82	21.10	0.820	0.831
D1	16.25	17.65	0.640	0.695
D2	1.05	1.35	0.041	0.053
E	15.70	16.03	0.618	0.631
E1	13.10	14.15	0.516	0.557
E2	3.68	5.10	0.145	0.201
E3	1.68	2.60	0.066	0.102
e	5.44		0.214	
N	3		3	
L	19.80	20.31	0.780	0.799
L1	4.17	4.47	0.164	0.176
φP	3.50	3.70	0.138	0.146
Q	5.49	6.00	0.216	0.236
S	6.04	6.30	0.238	0.248

DOCUMENT NO.
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SCALE

EUROPEAN PROJECTION

ISSUE DATE
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REVISION
03

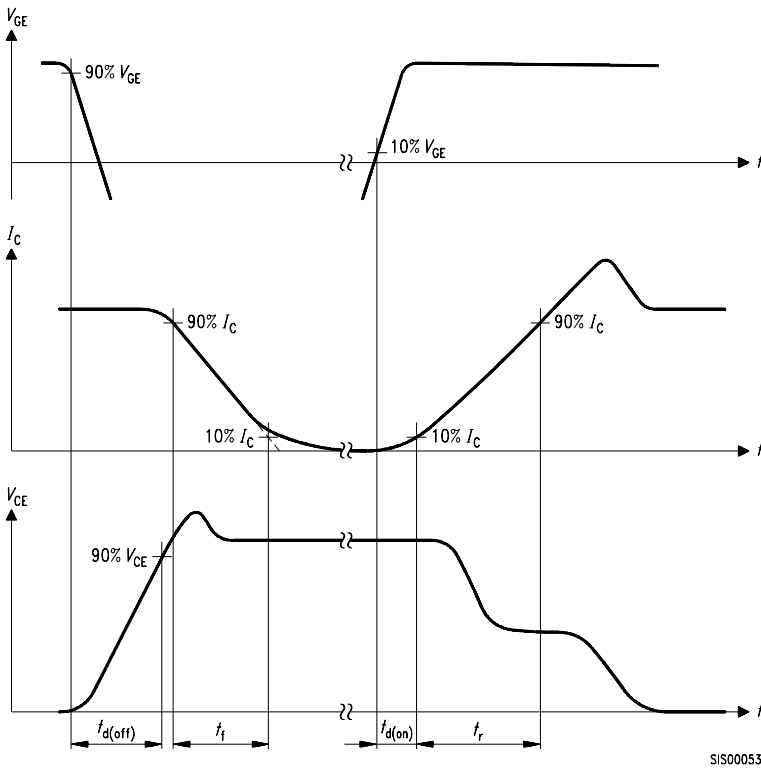


Figure A. Definition of switching times

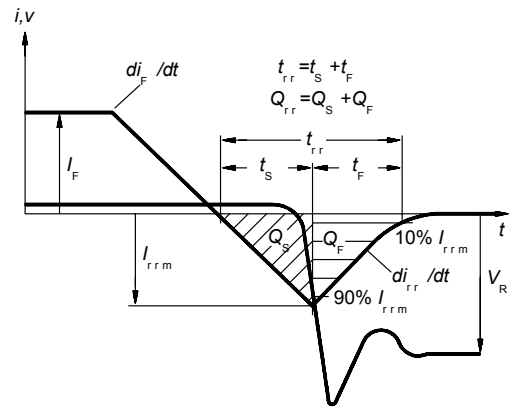


Figure C. Definition of diodes switching characteristics

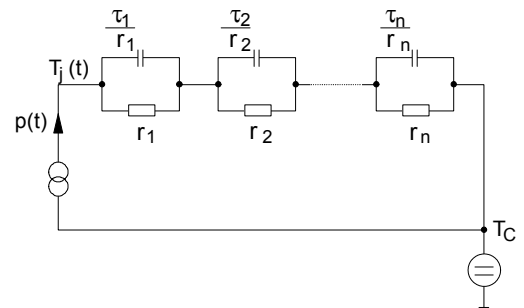


Figure D. Thermal equivalent circuit

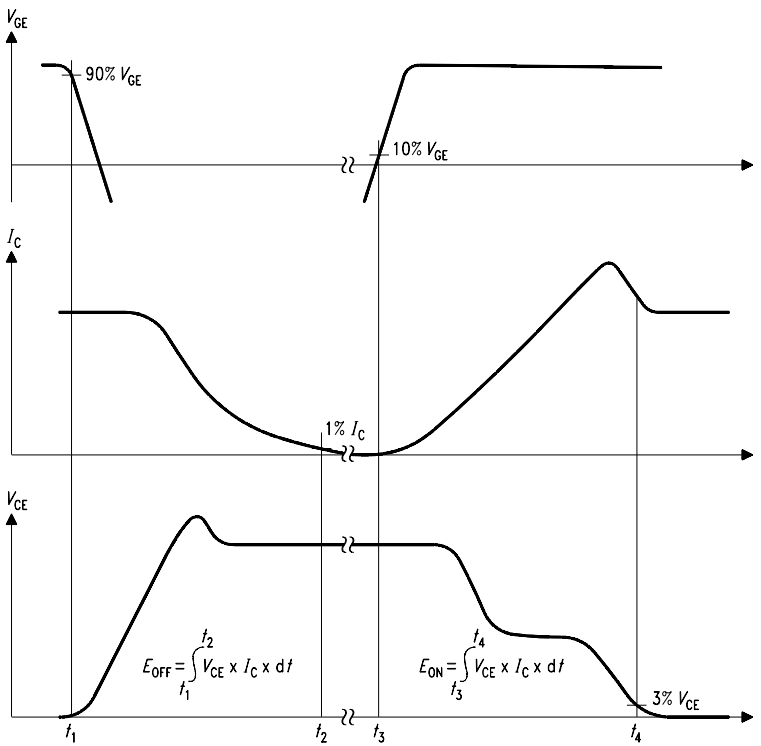


Figure B. Definition of switching losses

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For further information on technology, delivery terms and conditions and prices, please contact the nearest Infineon Technologies Office (www.infineon.com).

Warnings

Due to technical requirements, components may contain dangerous substances. For information on the types in question, please contact the nearest Infineon Technologies Office. Infineon Technologies components may be used in life-support devices or systems only with the express written approval of Infineon Technologies, if a failure of such components can reasonably be expected to cause the failure of that life-support device or system or to affect the safety or effectiveness of that device or system. Life support devices or systems are intended to be implanted in the human body or to support and/or maintain and sustain and/or protect human life. If they fail, it is reasonable to assume that the health of the user or other persons may be endangered.