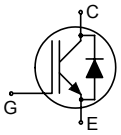
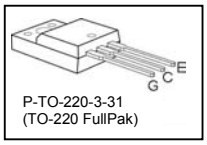
Low Loss DuoPack : IGBT in Trench and Fieldstop technology with soft, fast recovery anti-parallel EmCon HE diode



- Very low $V_{CE(sat)}$ 1.5 V (typ.)
- Maximum Junction Temperature 175 °C
- Short circuit withstand time – 5µs
- Designed for :
  - Variable Speed Drive for washing machines, air conditioners and induction cooking
  - Uninterrupted Power Supply
- Trench and Fieldstop technology for 600 V applications offers :
  - very tight parameter distribution
  - high ruggedness, temperature stable behavior
  - very high switching speed
  - low $V_{CE(sat)}$
- Low EMI
- Very soft, fast recovery anti-parallel EmCon HE diode
- Complete product spectrum and PSpice Models : http://www.infineon.com/igbt/



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

Type	V_{CE}	$I_{C;Tc=100°C}$	$V_{CE(sat),Tj=25°C}$	$T_{j,max}$	Marking Code	Package	Ordering Code
IKA06N60T	600V	6A	1.5V	175°C	K06T60	TO-220-FP	Q67040S4678

Maximum Ratings

Parameter	Symbol	Value	Unit
Collector-emitter voltage	V_{CE}	600	V
DC collector current, limited by T_{jmax}	I_C		A
T_C = 25°C		12	
T_C = 100°C		6	
Pulsed collector current, t_p limited by T_{jmax}	I_{Cpuls}	18	
Turn off safe operating area	-	18	
$V_{CE} \le 600V$, $T_j \le 175°C$			
Diode forward current, limited by T_{jmax}	I_F		
T_C = 25°C		12	
T_C = 100°C		6	
Diode pulsed current, t_p limited by T_{jmax}	I_{Fpuls}	18	
Gate-emitter voltage	V_{GE}	±20	V
Short circuit withstand time[1)]	t_{SC}	5	µs
V_{GE} = 15V, $V_{CC} \le 400V$, $T_j \le 150°C$			
Power dissipation	P_{tot}	28	W
T_C = 25°C			
Operating junction temperature	T_j	-40...+175	°C
Storage temperature	T_{stg}	-55...+175	

[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}		5.3	K/W
Diode thermal resistance, junction – case	R_{thJCD}		6.5	
Thermal resistance, junction – ambient	R_{thJA}		80	

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=0.25mA	600	-	-	V
Collector-emitter saturation voltage	$V_{CE(sat)}$	V_{GE} = 15V, I_C=6A				
		T_j=25°C	-	1.5	2.05	
		T_j=175°C	-	1.8		
Diode forward voltage	V_F	V_{GE}=0V, I_F=6A				
		T_j=25°C	-	1.6	2.05	
		T_j=175°C	-	1.6	-	
Gate-emitter threshold voltage	$V_{GE(th)}$	I_C=0.18mA, V_{CE}=V_{GE}	4.1	4.6	5.7	
Zero gate voltage collector current	I_{CES}	V_{CE}=600V, V_{GE}=0V				µA
		T_j=25°C	-	-	40	
		T_j=175°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	-	3.6	-	S
Integrated gate resistor	R_{Gint}		none			Ω

Dynamic Characteristic

Input capacitance	C_{iss}	V_{CE}=25V,	-	368	-	pF
Output capacitance	C_{oss}	V_{GE}=0V,	-	28	-	
Reverse transfer capacitance	C_{rss}	f=1MHz	-	11	-	
Gate charge	Q_{Gate}	V_{CC}=480V, I_C=6A V_{GE}=15V	-	42	-	nC
Internal emitter inductance measured 5mm (0.197 in.) from case	L_E	P-TO-220-3-31	-	7	-	nH
Short circuit collector current[1)]	$I_{C(SC)}$	V_{GE}=15V,t_{SC}≤5µs V_{CC} = 400V, T_j = 25°C	-	55	-	A

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=23Ω, L_σ[2)]=60nH, C_σ[2)]=40pF Energy losses include “tail” and diode reverse recovery.	-	9.4	-	ns
Rise time	t_r		-	5.6	-	
Turn-off delay time	$t_{d(off)}$		-	130	-	
Fall time	t_f		-	58	-	
Turn-on energy	E_{on}		-	0.09	-	mJ
Turn-off energy	E_{off}		-	0.11	-	
Total switching energy	E_{ts}		-	0.2	-	
Anti-Parallel Diode Characteristic						
Diode reverse recovery time	t_{rr}	T_j=25°C, V_R=400V, I_F=6A, di_F/dt=550A/µs	-	123	-	ns
Diode reverse recovery charge	Q_{rr}		-	190	-	nC
Diode peak reverse recovery current	I_{rrm}		-	5.3	-	A
Diode peak rate of fall of reverse recovery current during t_b	di_{rr}/dt		-	450	-	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 dynamic test circuit in Figure E.

Switching Characteristic, Inductive Load, at T_j=175 °C

Parameter	Symbol	Conditions	Value			Unit
			min.	typ.	max.	
IGBT Characteristic						
Turn-on delay time	$t_{d(on)}$	T_j=175°C, V_{CC}=400V, I_C=6A, V_{GE}=0/15V, R_G= 23Ω L_σ [1)]=60nH, C_σ [1)]=40pF Energy losses include "tail" and diode reverse recovery.	-	8.8	-	ns
Rise time	t_r		-	8.2	-	
Turn-off delay time	$t_{d(off)}$		-	165	-	
Fall time	t_f		-	84	-	
Turn-on energy	E_{on}		-	0.14	-	mJ
Turn-off energy	E_{off}		-	0.18	-	
Total switching energy	E_{ts}		-	0.335	-	
Anti-Parallel Diode Characteristic						
Diode reverse recovery time	t_{rr}	T_j=175°C V_R=400V, I_F=6A, di_F/dt=550A/µs	-	180	-	ns
Diode reverse recovery charge	Q_{rr}		-	500	-	nC
Diode peak reverse recovery current	I_{rrm}		-	7.6	-	A
Diode peak rate of fall of reverse recovery current during t_b	di_{rr}/dt		-	285	-	A/µs

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

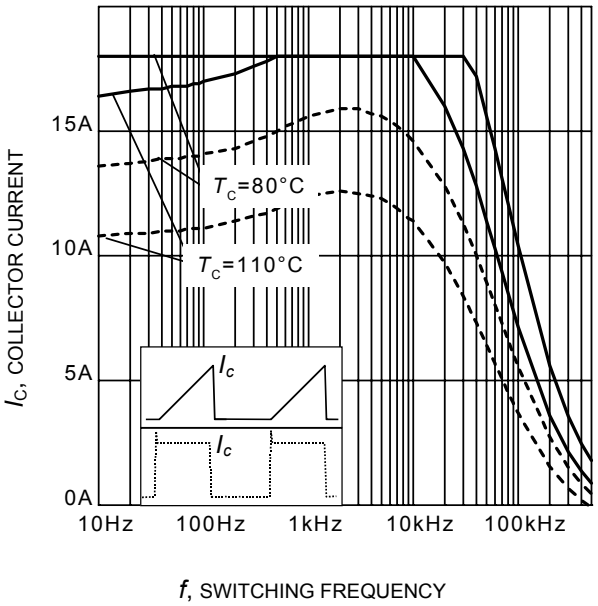


Figure 1. Collector current as a function of switching frequency
($T_j \le 175°C$, $D = 0.5$, $V_{CE} = 400V$, $V_{GE} = 0/+15V$, $R_G = 23\Omega$)

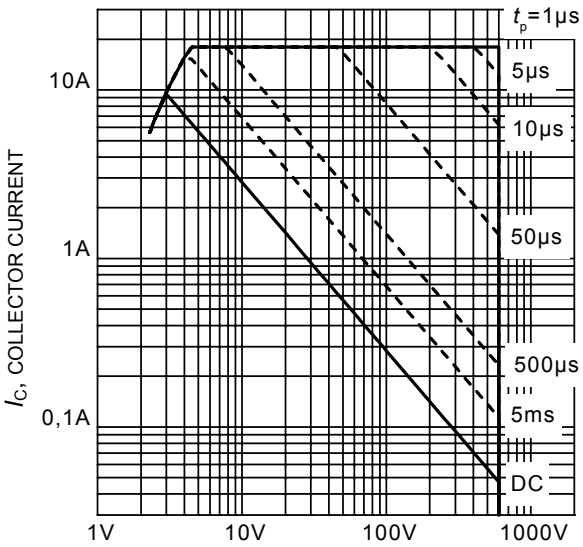


Figure 2. Safe operating area
($D = 0$, $T_C = 25°C$, $T_j \le 175°C$; V_{GE}=15V)

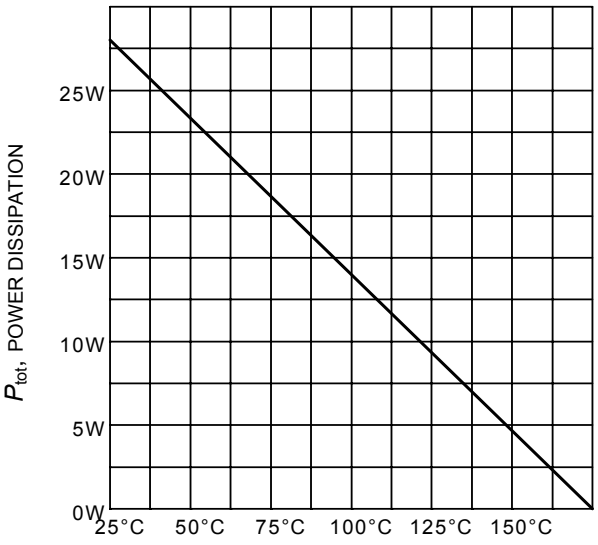


Figure 3. Power dissipation as a function of case temperature
($T_j \le 175°C$)

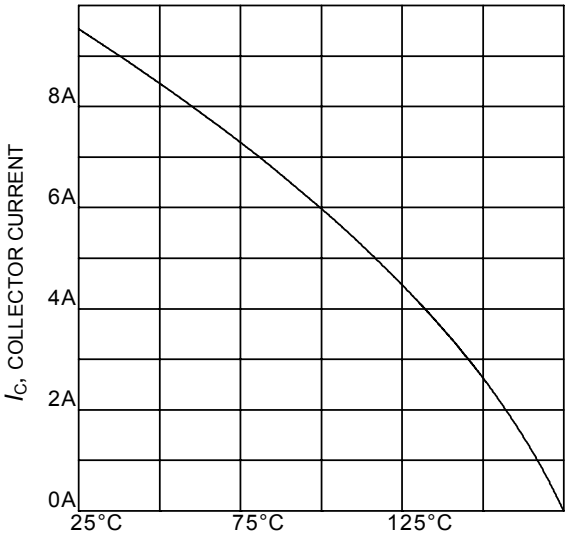


Figure 4. Collector current as a function of case temperature
($V_{GE} \ge 15V$, $T_j \le 175°C$)

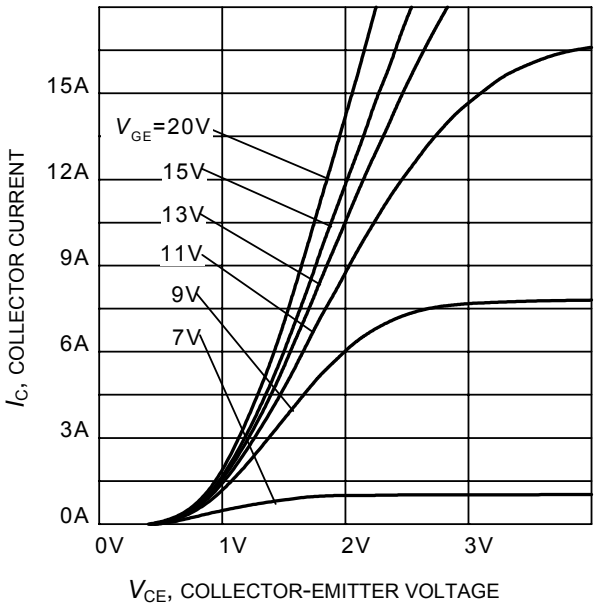


Figure 5. Typical output characteristic
(T_j = 25°C)

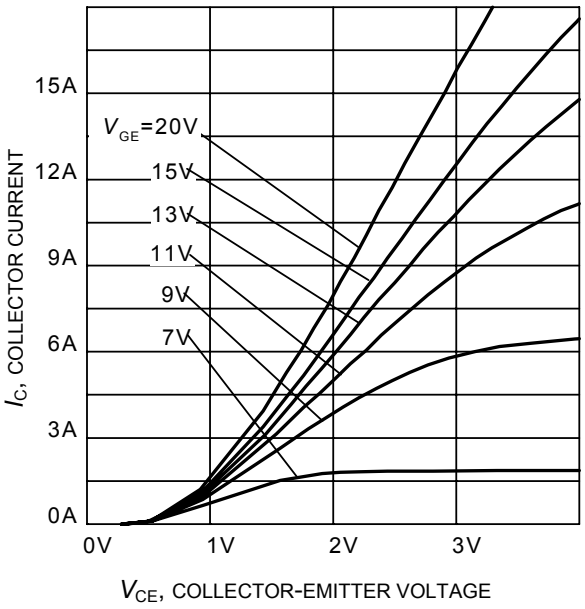


Figure 6. Typical output characteristic
(T_j = 175°C)

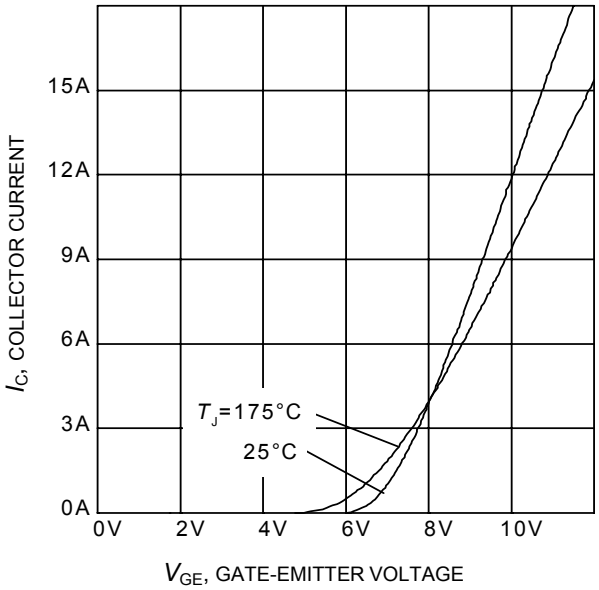


Figure 7. Typical transfer characteristic
(V_{CE}=20V)

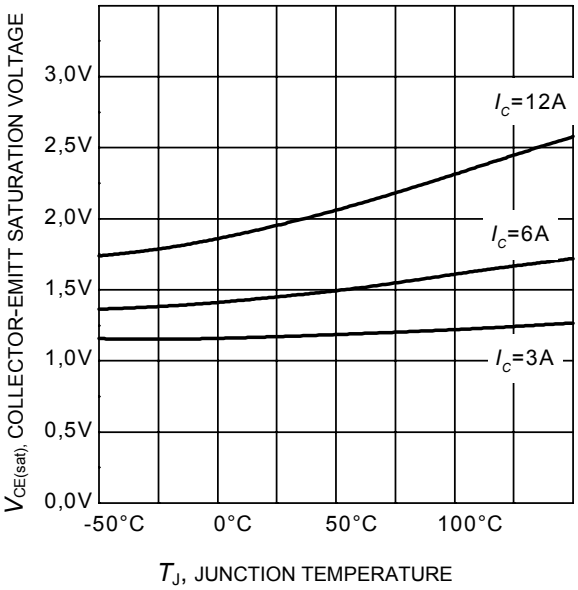


Figure 8. Typical collector-emitter saturation voltage as a function of junction temperature
(V_{GE} = 15V)

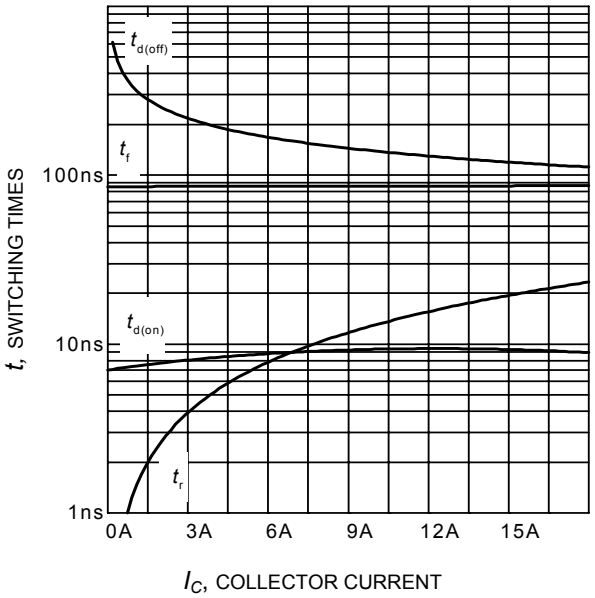


Figure 9. Typical switching times as a function of collector current
(inductive load, T_J=175°C,
V_{CE} = 400V, V_{GE} = 0/15V, R_G = 23Ω,
Dynamic test circuit in Figure E)

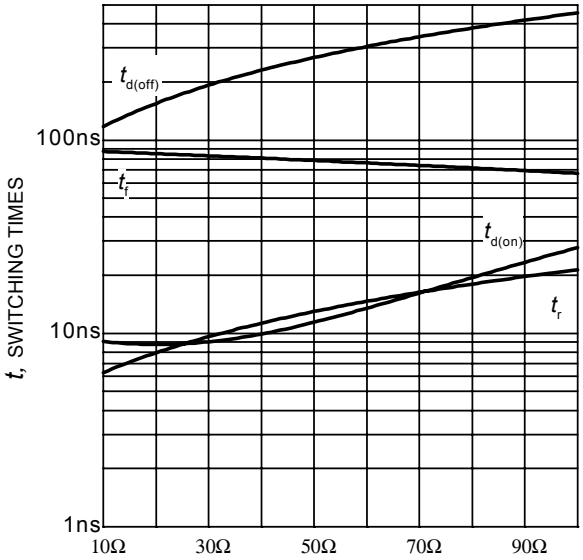


Figure 10. Typical switching times as a function of gate resistor
(inductive load, T_J=175°C,
V_{CE} = 400V, V_{GE} = 0/15V, I_C = 6A,
Dynamic test circuit in Figure E)

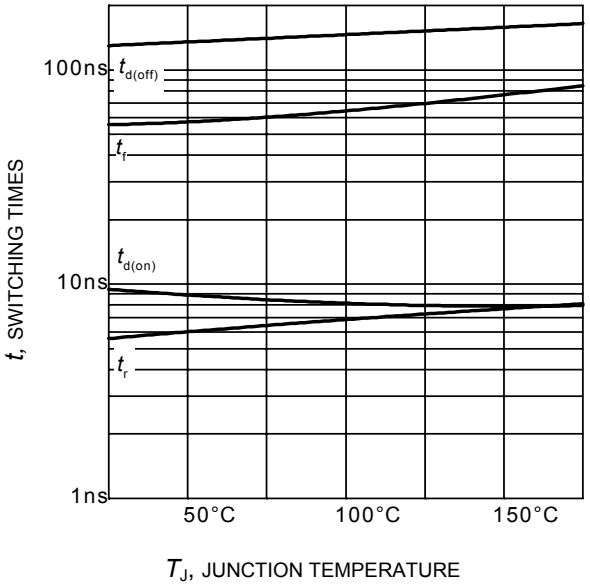


Figure 11. Typical switching times as a function of junction temperature
(inductive load, V_{CE} = 400V,
V_{GE} = 0/15V, I_C = 6A, R_G = 23Ω,
Dynamic test circuit in Figure E)

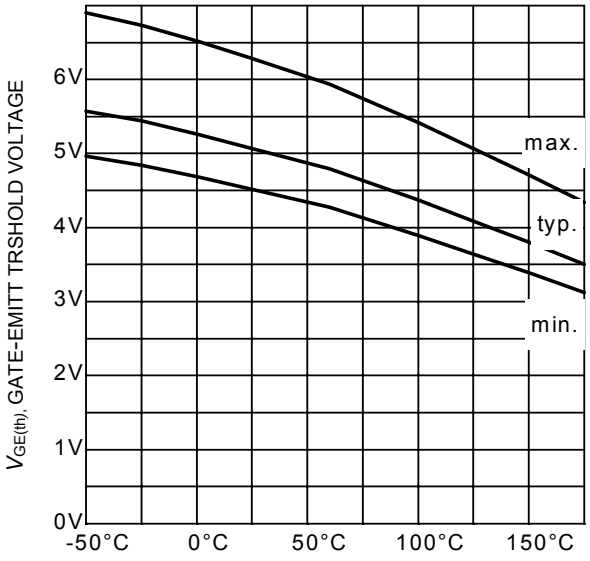


Figure 12. Gate-emitter threshold voltage as a function of junction temperature
(I_C = 0.18mA)

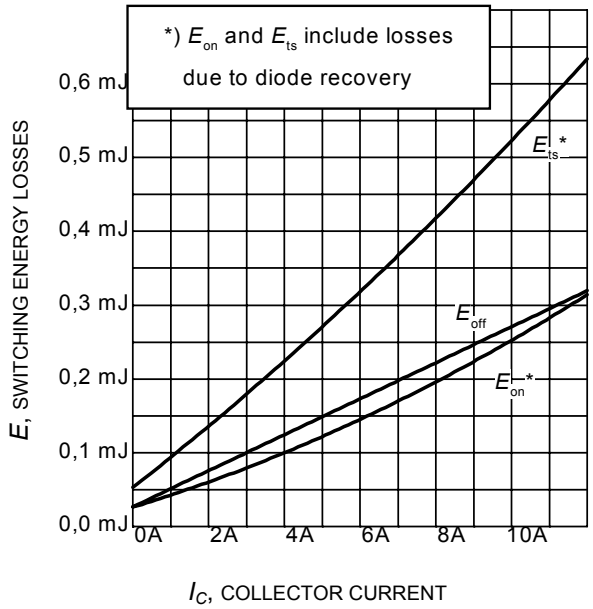


Figure 13. Typical switching energy losses as a function of collector current
(inductive load, T_J=175°C, V_{CE}=400V, V_{GE}=0/15V, R_G=23Ω, Dynamic test circuit in Figure E)

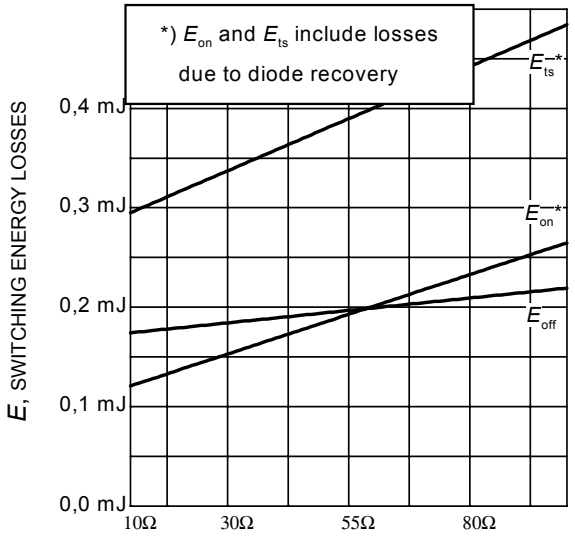


Figure 14. Typical switching energy losses as a function of gate resistor
(inductive load, T_J=175°C, V_{CE} = 400V, V_{GE} = 0/15V, I_C = 6A, Dynamic test circuit in Figure E)

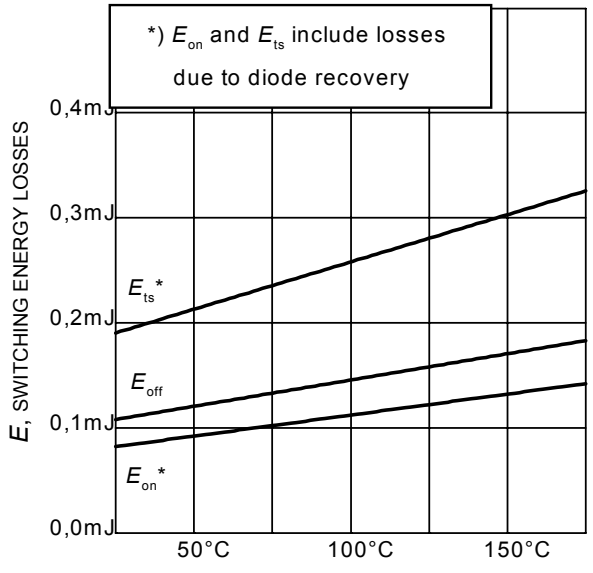


Figure 15. Typical switching energy losses as a function of junction temperature
(inductive load, V_{CE}=400V, V_{GE} = 0/15V, I_C = 6A, R_G = 23Ω, Dynamic test circuit in Figure E)

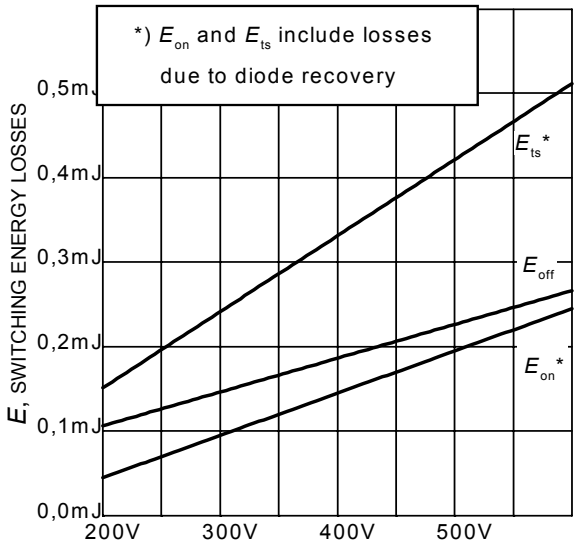


Figure 16. Typical switching energy losses as a function of collector emitter voltage
(inductive load, T_J = 175°C, V_{GE} = 0/15V, I_C = 6A, R_G = 23Ω, Dynamic test circuit in Figure E)

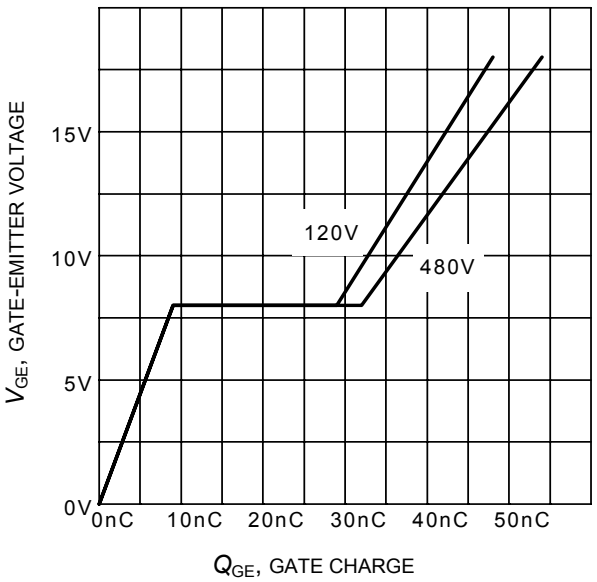


Figure 17. Typical gate charge
(I_C=6 A)

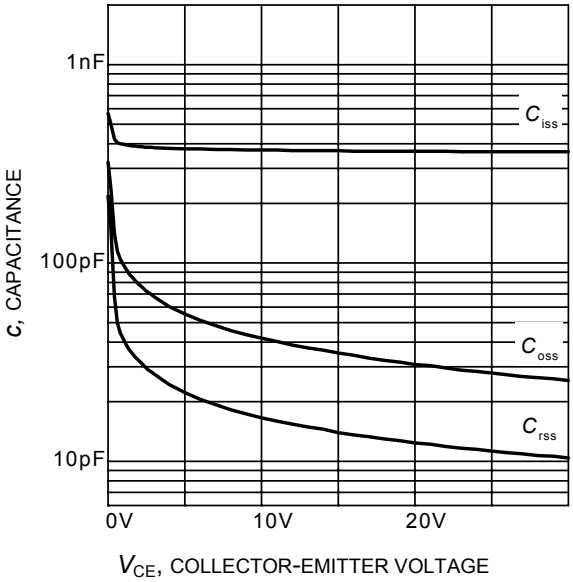


Figure 18. Typical capacitance as a function of collector-emitter voltage
(V_{GE}=0V, f = 1 MHz)

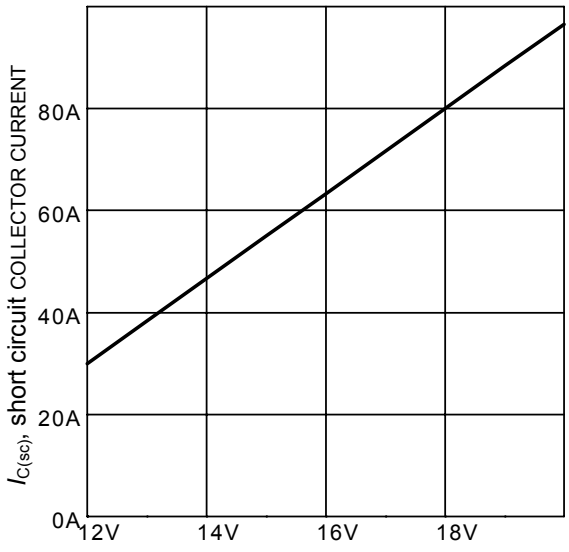


Figure 19. Typical short circuit collector current as a function of gate-emitter voltage
($V_{CE} \le 400V$, $T_j \le 150°C$)

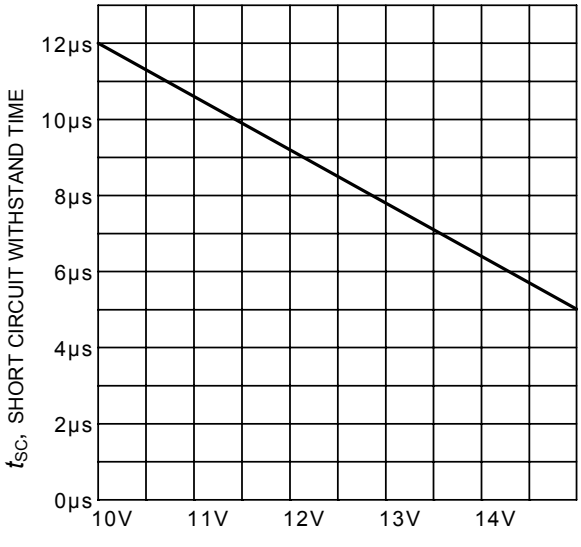


Figure 20. Short circuit withstand time as a function of gate-emitter voltage
(V_{CE}=600V, start at T_J=25°C, T_{Jmax}<150°C)

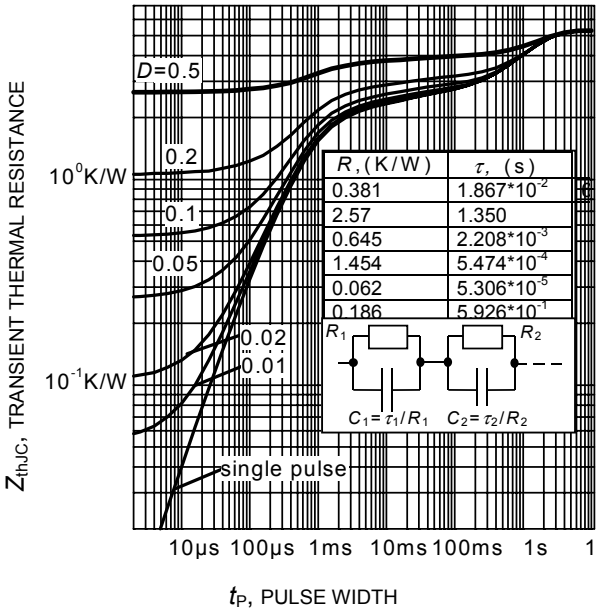


Figure 21. IGBT transient thermal resistance
($D = t_p / T$)

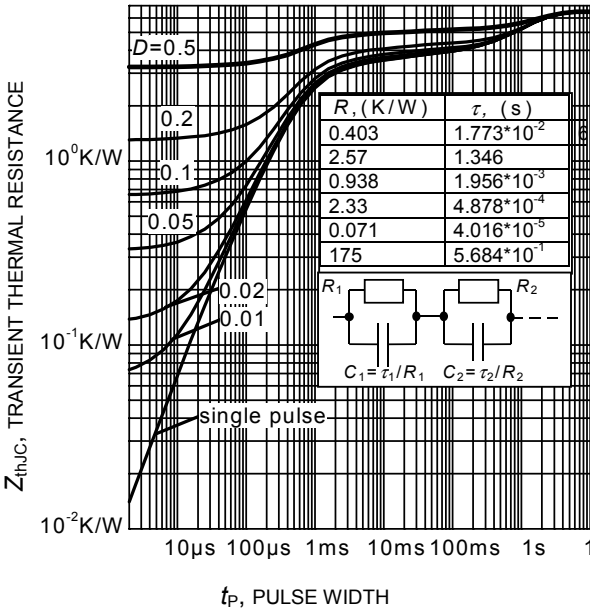


Figure 22. Diode transient thermal impedance as a function of pulse width
($D=t_P/T$)

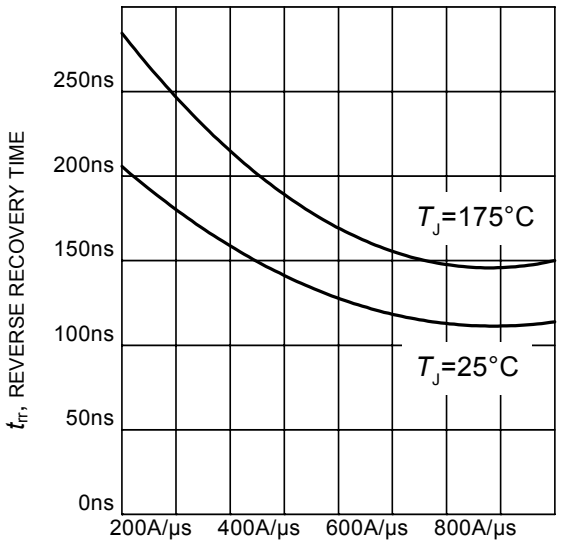


Figure 23. Typical reverse recovery time as a function of diode current slope
(V_R = 400V, I_F = 6A,
Dynamic test circuit in Figure E)

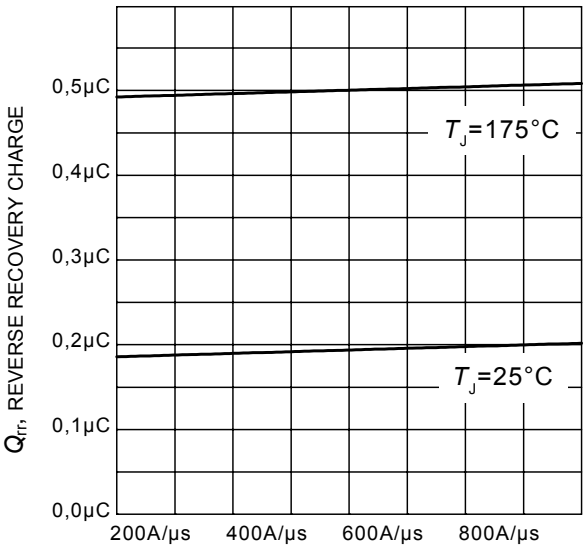


Figure 24. Typical reverse recovery charge as a function of diode current slope
(V_R = 400V, I_F = 6A,
Dynamic test circuit in Figure E)

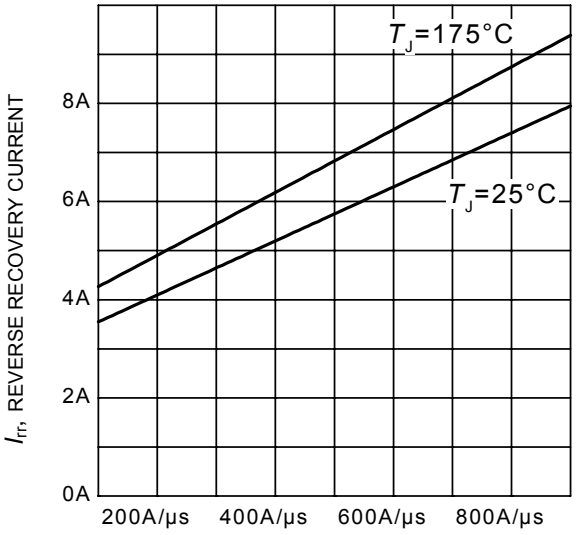


Figure 25. Typical reverse recovery current as a function of diode current slope
(V_R = 400V, I_F = 6A,
Dynamic test circuit in Figure E)

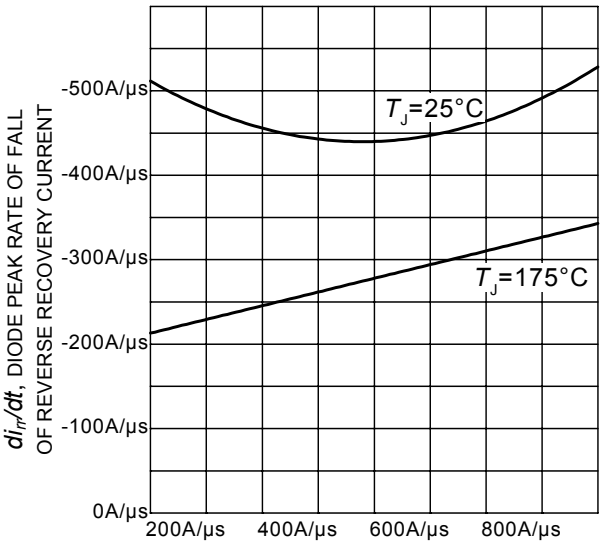


Figure 26. Typical diode peak rate of fall of reverse recovery current as a function of diode current slope
(V_R = 400V, I_F = 6A,
Dynamic test circuit in Figure E)

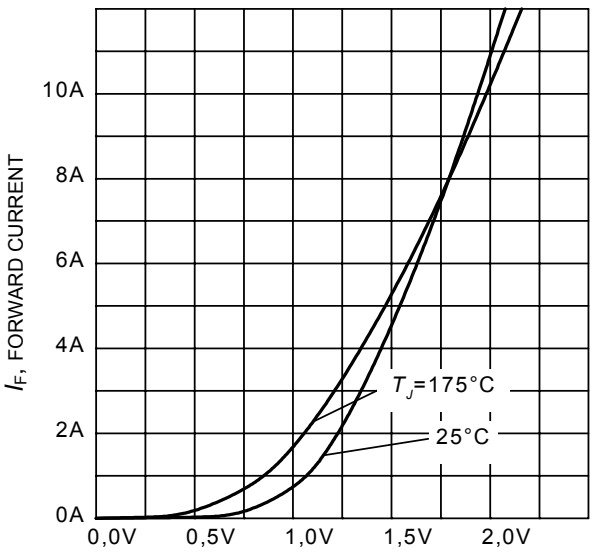


Figure 27. Typical diode forward current as a function of forward voltage

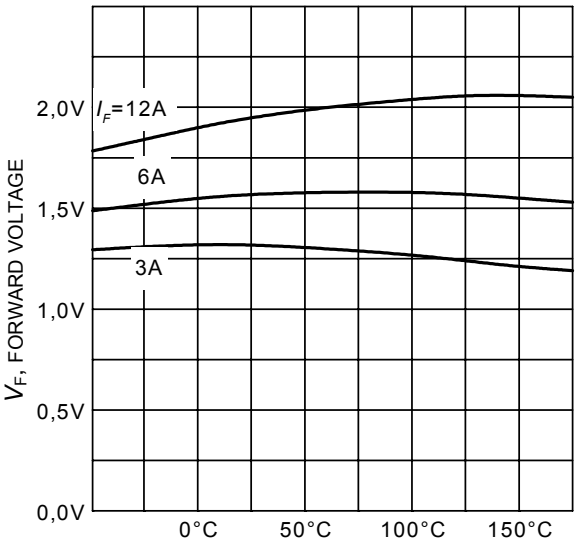


Figure 28. Typical diode forward voltage as a function of junction temperature

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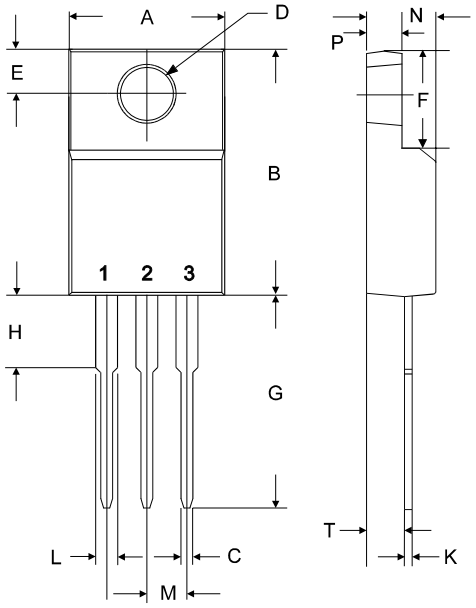

symbol	dimensions			
	[mm]		[inch]	
	min	max	min	max
A	10.37	10.63	0.4084	0.4184
B	15.86	16.12	0.6245	0.6345
C	0.65	0.78	0.0256	0.0306
D	2.95 typ.		0.1160 typ.	
E	3.15	3.25	0.124	0.128
F	6.05	6.56	0.2384	0.2584
G	13.47	13.73	0.5304	0.5404
H	3.18	3.43	0.125	0.135
K	0.45	0.63	0.0177	0.0247
L	1.23	1.36	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

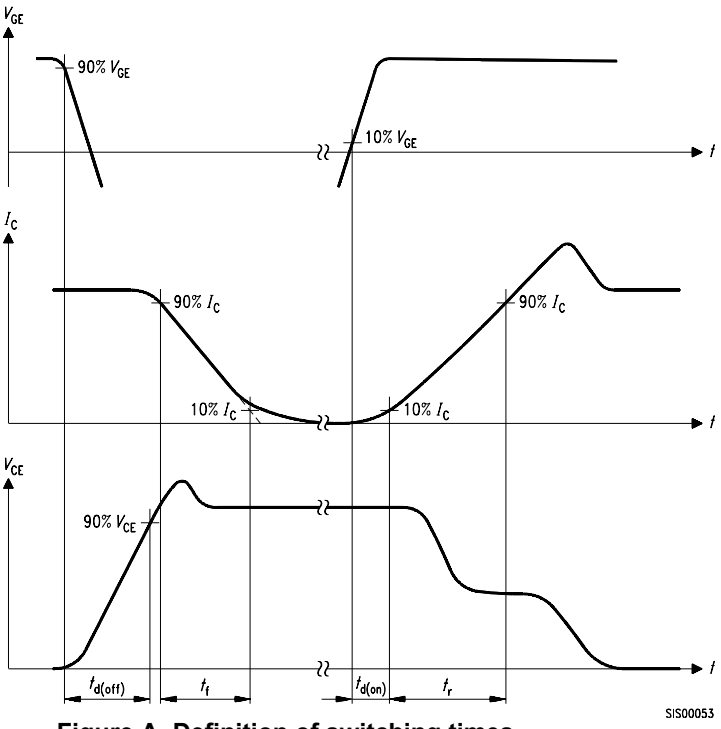

Figure A. Definition of switching times

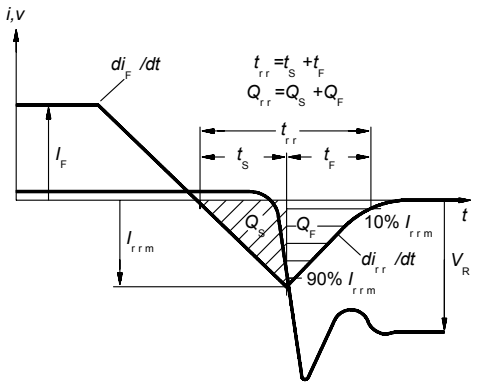

Figure C. Definition of diodes switching characteristics

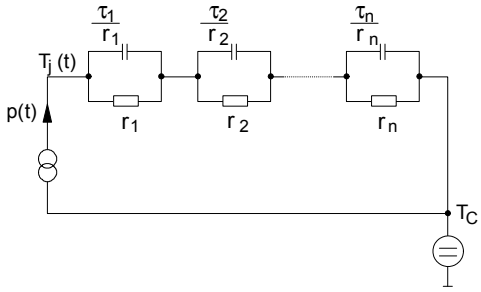

Figure D. Thermal equivalent circuit

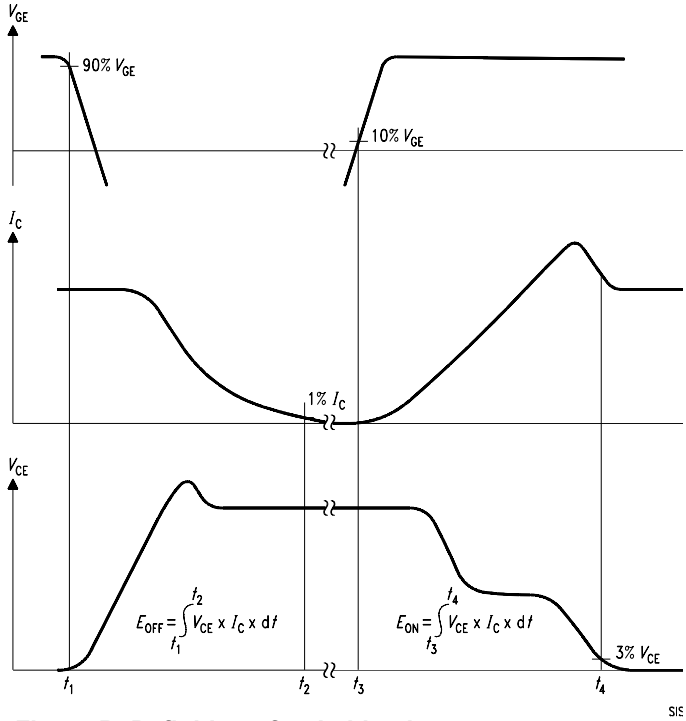

Figure B. Definition of switching losses

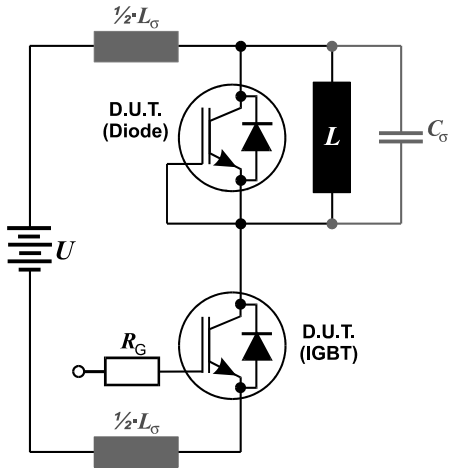

Figure E. Dynamic test circuit
Leakage inductance L_σ =60nH
and Stray capacity C_σ =40pF.

Published by
Infineon Technologies AG,
Bereich Kommunikation
St.-Martin-Strasse 53,
D-81541 München

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