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## Contact us

Tel: +86-755-8981 8866 Fax: +86-755-8427 6832

Email & Skype: info@chipsmall.com Web: www.chipsmall.com

Address: A1208, Overseas Decoration Building, #122 Zhenhua RD., Futian, Shenzhen, China



## IGBT

High speed DuoPack: IGBT in Trench and Fieldstop technology with soft, fast recovery anti-parallel diode

## IKW60N60H3

600V high speed switching series third generation

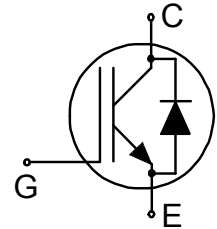
Data sheet

High speed IGBT in Trench and Fieldstop technology

**Features:**

TRENCHSTOP™ technology offering

- very low turn-off energy
- low  $V_{CEsat}$
- low EMI
- maximum junction temperature 175°C
- qualified according to JEDEC for target applications
- Pb-free lead plating, halogen-free mould compound, RoHS compliant
- complete product spectrum and PSpice Models:  
<http://www.infineon.com/igbt/>



**Applications:**

- uninterruptible power supplies
- welding converters
- converters with high switching frequency



**Package pin definition:**

- Pin 1 - gate
- Pin 2 & backside - collector
- Pin 3 - emitter



**Key Performance and Package Parameters**

Type	$V_{CE}$	$I_C$	$V_{CEsat}, T_{vj}=25^{\circ}C$	$T_{vjmax}$	Marking	Package
IKW60N60H3	600V	60A	1.85V	175°C	K60H603	PG-TO247-3



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**Maximum ratings**

Parameter	Symbol	Value	Unit
Collector-emitter voltage	$V_{CE}$	600	V
DC collector current, limited by $T_{vjmax}^{1)}$ $T_C = 25^\circ\text{C}$ $T_C = 115^\circ\text{C}$	$I_C$	80.0 60.0	A
Pulsed collector current, $t_p$ limited by $T_{vjmax}$	$I_{Cpuls}$	180.0	A
Turn off safe operating area $V_{CE} \leq 600\text{V}$ , $T_{vj} \leq 175^\circ\text{C}$	-	180.0	A
Diode forward current, limited by $T_{vjmax}$ $T_C = 25^\circ\text{C}$ $T_C = 115^\circ\text{C}$	$I_F$	80.0 30.0	A
Diode pulsed current, $t_p$ limited by $T_{vjmax}$	$I_{Fpuls}$	90.0	A
Gate-emitter voltage	$V_{GE}$	$\pm 20$	V
Short circuit withstand time $V_{GE} = 15.0\text{V}$ , $V_{CC} \leq 400\text{V}$ Allowed number of short circuits < 1000 Time between short circuits: $\geq 1.0\text{s}$ $T_{vj} = 150^\circ\text{C}$	$t_{SC}$	5	$\mu\text{s}$
Power dissipation $T_C = 25^\circ\text{C}$	$P_{tot}$	416.0	W
Operating junction temperature	$T_{vj}$	-40...+175	$^\circ\text{C}$
Storage temperature	$T_{stg}$	-55...+150	$^\circ\text{C}$
Soldering temperature, wave soldering 1.6 mm (0.063 in.) from case for 10s		260	$^\circ\text{C}$
Mounting torque, M3 screw Maximum of mounting processes: 3	$M$	0.6	Nm

**Thermal Resistance**

Parameter	Symbol	Conditions	Max. Value	Unit
<b>Characteristic</b>				
IGBT thermal resistance, junction - case	$R_{th(j-c)}$		0.36	K/W
Diode thermal resistance, junction - case	$R_{th(j-c)}$		1.05	K/W
Thermal resistance junction - ambient	$R_{th(j-a)}$		40	K/W

<sup>1)</sup> 80A value limited by bondwire

**Electrical Characteristic, at  $T_{vj} = 25^{\circ}\text{C}$ , unless otherwise specified**

Parameter	Symbol	Conditions	Value			Unit
			min.	typ.	max.	
<b>Static Characteristic</b>						
Collector-emitter breakdown voltage	$V_{(BR)CES}$	$V_{GE} = 0\text{V}, I_C = 2.00\text{mA}$	600	-	-	V
Collector-emitter saturation voltage	$V_{CEsat}$	$V_{GE} = 15.0\text{V}, I_C = 60.0\text{A}$ $T_{vj} = 25^{\circ}\text{C}$ $T_{vj} = 175^{\circ}\text{C}$	- -	1.85 2.25	2.30 -	V
Diode forward voltage	$V_F$	$V_{GE} = 0\text{V}, I_F = 30.0\text{A}$ $T_{vj} = 25^{\circ}\text{C}$ $T_{vj} = 175^{\circ}\text{C}$	- -	1.65 1.60	2.00	V
Gate-emitter threshold voltage	$V_{GE(th)}$	$I_C = 1.00\text{mA}, V_{CE} = V_{GE}$	4.1	5.1	5.7	V
Zero gate voltage collector current	$I_{CES}$	$V_{CE} = 600\text{V}, V_{GE} = 0\text{V}$ $T_{vj} = 25^{\circ}\text{C}$ $T_{vj} = 175^{\circ}\text{C}$	- -	- -	40.0 5000.0	$\mu\text{A}$
Gate-emitter leakage current	$I_{GES}$	$V_{CE} = 0\text{V}, V_{GE} = 20\text{V}$	-	-	100	nA
Transconductance	$g_{fs}$	$V_{CE} = 20\text{V}, I_C = 60.0\text{A}$	-	32.0	-	S

**Electrical Characteristic, at  $T_{vj} = 25^{\circ}\text{C}$ , unless otherwise specified**

Parameter	Symbol	Conditions	Value			Unit
			min.	typ.	max.	
<b>Dynamic Characteristic</b>						
Input capacitance	$C_{ies}$	$V_{CE} = 25\text{V}, V_{GE} = 0\text{V}, f = 1\text{MHz}$	-	3680	-	pF
Output capacitance	$C_{oes}$		-	160	-	
Reverse transfer capacitance	$C_{res}$		-	100	-	
Gate charge	$Q_G$	$V_{CC} = 480\text{V}, I_C = 60.0\text{A},$ $V_{GE} = 15\text{V}$	-	375.0	-	nC
Internal emitter inductance measured 5mm (0.197 in.) from case	$L_E$		-	13.0	-	nH
Short circuit collector current Max. 1000 short circuits Time between short circuits: $\geq 1.0\text{s}$	$I_{C(SC)}$	$V_{GE} = 15.0\text{V}, V_{CC} \leq 400\text{V},$ $t_{SC} \leq 5\mu\text{s}$ $T_{vj} = 150^{\circ}\text{C}$	-	534	-	A

**Switching Characteristic, Inductive Load, at  $T_{vj} = 25^{\circ}\text{C}$** 

Parameter	Symbol	Conditions	Value			Unit
			min.	typ.	max.	
<b>IGBT Characteristic</b>						
Turn-on delay time	$t_{d(on)}$	$T_{vj} = 25^{\circ}\text{C},$ $V_{CC} = 400\text{V}, I_C = 60.0\text{A},$ $V_{GE} = 0.0/15.0\text{V},$ $r_G = 6.0\Omega, L_{\sigma} = 90\text{nH},$ $C_{\sigma} = 50\text{pF}$ $L_{\sigma}, C_{\sigma}$ from Fig. E	-	27	-	ns
Rise time	$t_r$		-	44	-	ns
Turn-off delay time	$t_{d(off)}$		-	252	-	ns
Fall time	$t_f$		-	27	-	ns
Turn-on energy	$E_{on}$		Energy losses include "tail" and diode (IKW60N60H3) reverse recovery. Switching test with minimized Emitter Stray inductance, see High Speed 3 App Note on <a href="http://www.infineon.com">www.infineon.com</a> .	-	2.10	-
Turn-off energy	$E_{off}$		-	1.13	-	mJ
Total switching energy	$E_{ts}$		-	3.23	-	mJ

**Diode Characteristic, at  $T_{vj} = 25^{\circ}\text{C}$** 

Diode reverse recovery time	$t_{rr}$	$T_{vj} = 25^{\circ}\text{C}$ , $V_R = 400\text{V}$ , $I_F = 60.0\text{A}$ , $dI_F/dt = 1000\text{A}/\mu\text{s}$	-	143	-	ns
Diode reverse recovery charge	$Q_{rr}$		-	1.20	-	$\mu\text{C}$
Diode peak reverse recovery current	$I_{rrm}$		-	13.0	-	A
Diode peak rate of fall of reverse recovery current during $t_b$	$dI_{rr}/dt$		-	-108	-	$\text{A}/\mu\text{s}$

**Switching Characteristic, Inductive Load, at  $T_{vj} = 175^{\circ}\text{C}$** 

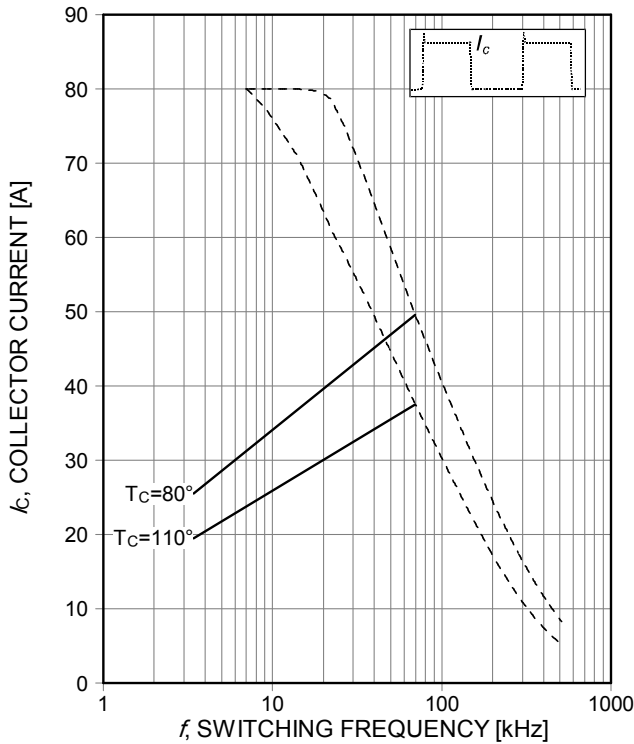
Parameter	Symbol	Conditions	Value			Unit
			min.	typ.	max.	

**IGBT Characteristic**

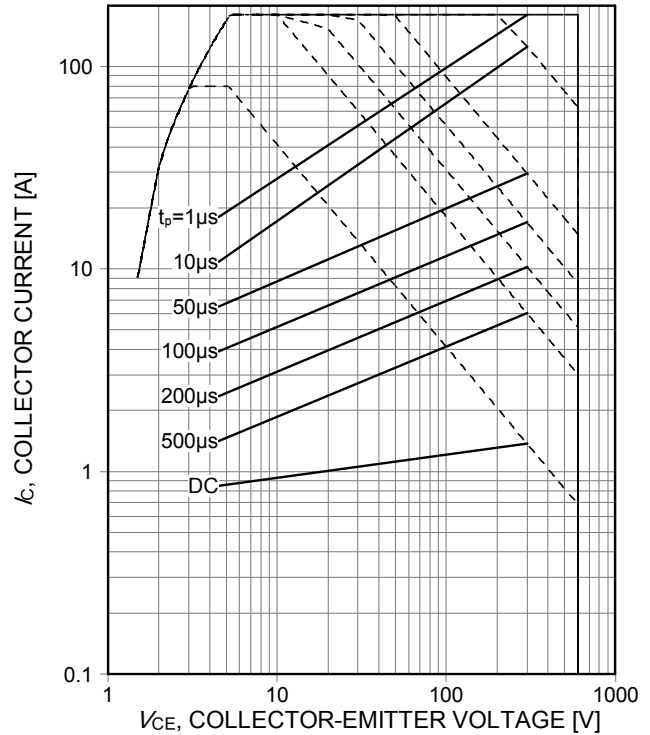
Turn-on delay time	$t_{d(on)}$	$T_{vj} = 175^{\circ}\text{C}$ , $V_{CC} = 400\text{V}$ , $I_C = 60.0\text{A}$ , $V_{GE} = 0.0/15.0\text{V}$ , $r_G = 6.0\Omega$ , $L_{\sigma} = 90\text{nH}$ , $C_{\sigma} = 50\text{pF}$ $L_{\sigma}$ , $C_{\sigma}$ from Fig. E Energy losses include "tail" and diode (IKW60N60H3) reverse recovery. Switching test with minimized Emitter Stray inductance, see High Speed 3 App Note on <a href="http://www.infineon.com">www.infineon.com</a> .	-	25	-	ns
Rise time	$t_r$		-	39	-	ns
Turn-off delay time	$t_{d(off)}$		-	291	-	ns
Fall time	$t_f$		-	23	-	ns
Turn-on energy	$E_{on}$		-	2.63	-	mJ
Turn-off energy	$E_{off}$		-	1.46	-	mJ
Total switching energy	$E_{ts}$		-	4.09	-	mJ

**Diode Characteristic, at  $T_{vj} = 175^{\circ}\text{C}$** 

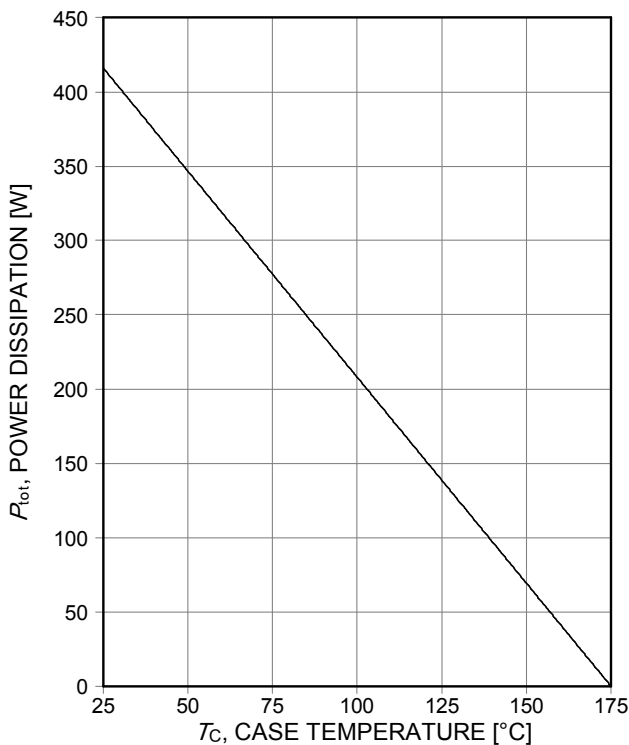
Diode reverse recovery time	$t_{rr}$	$T_{vj} = 175^{\circ}\text{C}$ , $V_R = 400\text{V}$ , $I_F = 60.0\text{A}$ , $dI_F/dt = 1000\text{A}/\mu\text{s}$	-	255	-	ns
Diode reverse recovery charge	$Q_{rr}$		-	2.80	-	$\mu\text{C}$
Diode peak reverse recovery current	$I_{rrm}$		-	23.0	-	A
Diode peak rate of fall of reverse recovery current during $t_b$	$dI_{rr}/dt$		-	-108	-	$\text{A}/\mu\text{s}$



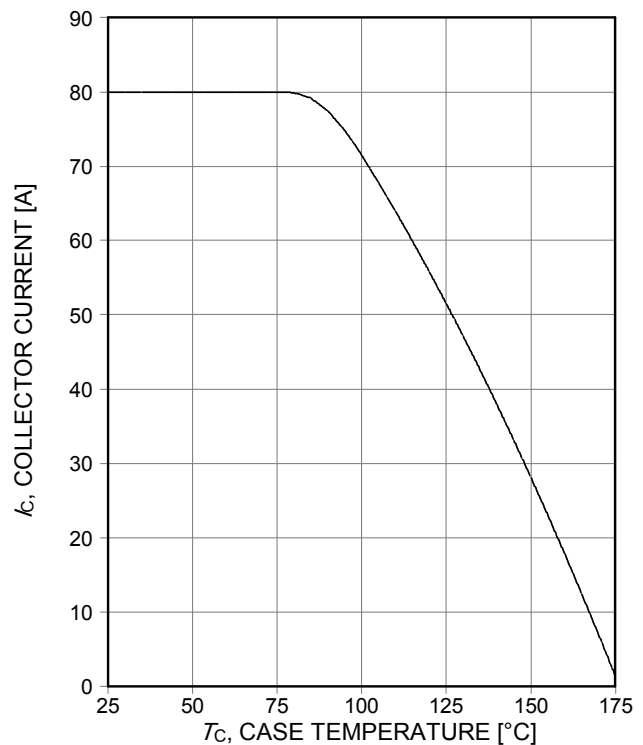
**Figure 1. Collector current as a function of switching frequency**  
 ( $T_j \leq 175^\circ\text{C}$ ,  $D=0.5$ ,  $V_{CE}=400\text{V}$ ,  $V_{GE}=15/0\text{V}$ ,  $r_G=6\Omega$ )



**Figure 2. Forward bias safe operating area**  
 ( $D=0$ ,  $T_C=25^\circ\text{C}$ ,  $T_j \leq 175^\circ\text{C}$ ;  $V_{GE}=15\text{V}$ )



**Figure 3. Power dissipation as a function of case temperature**  
 ( $T_j \leq 175^\circ\text{C}$ )



**Figure 4. Collector current as a function of case temperature**  
 ( $V_{GE} \geq 15\text{V}$ ,  $T_j \leq 175^\circ\text{C}$ )



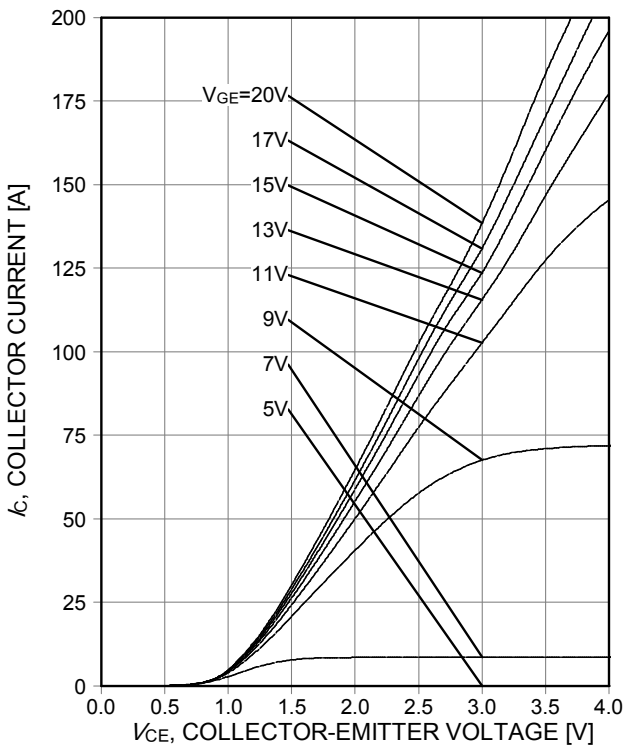


Figure 5. Typical output characteristic ( $T_j=25^\circ\text{C}$ )

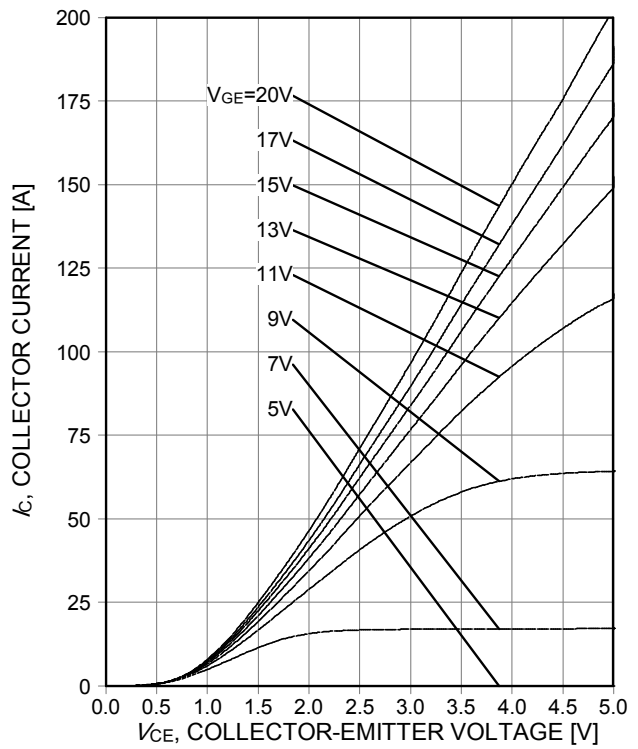


Figure 6. Typical output characteristic ( $T_j=175^\circ\text{C}$ )

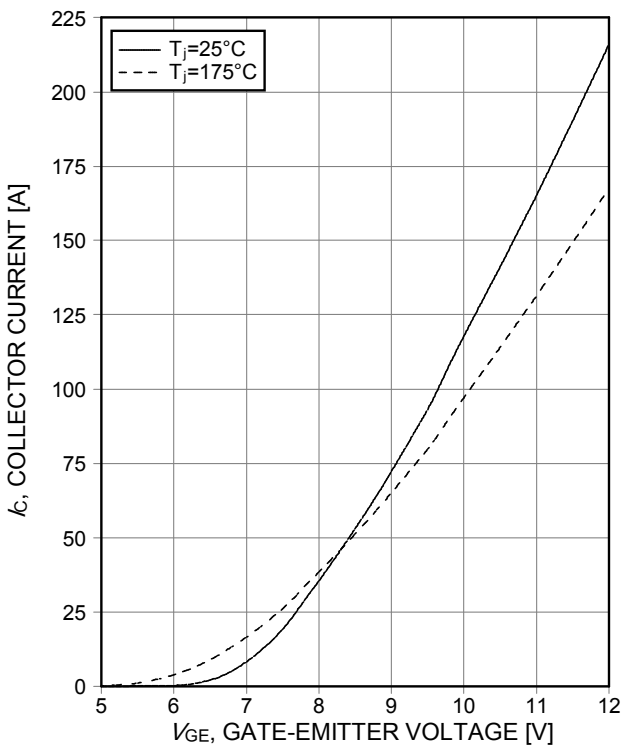


Figure 7. Typical transfer characteristic ( $V_{CE}=20\text{V}$ )

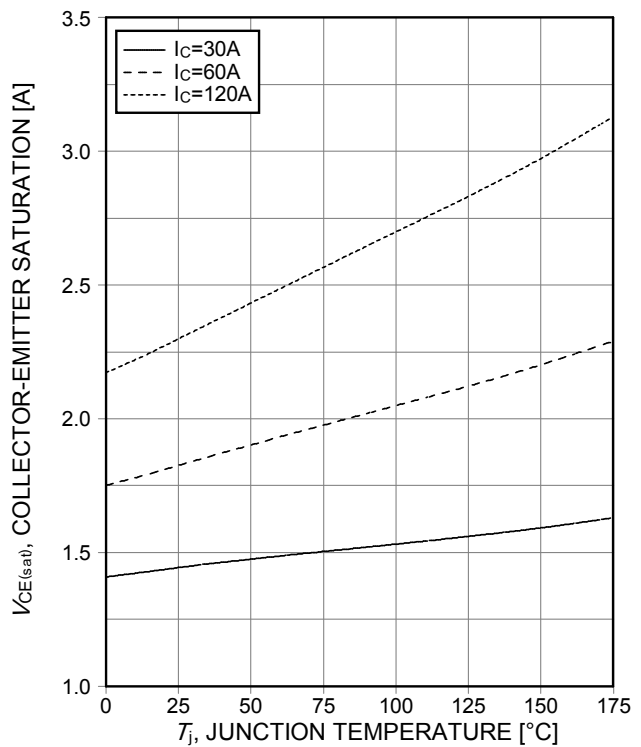
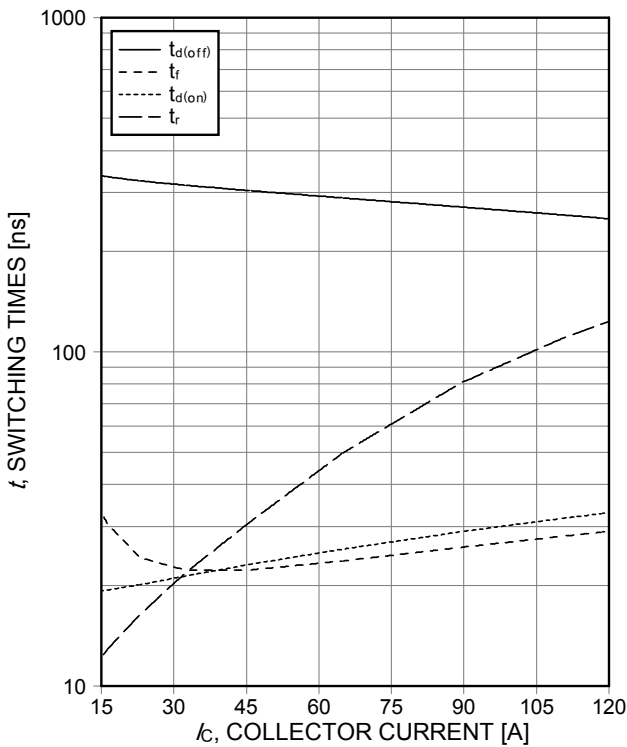
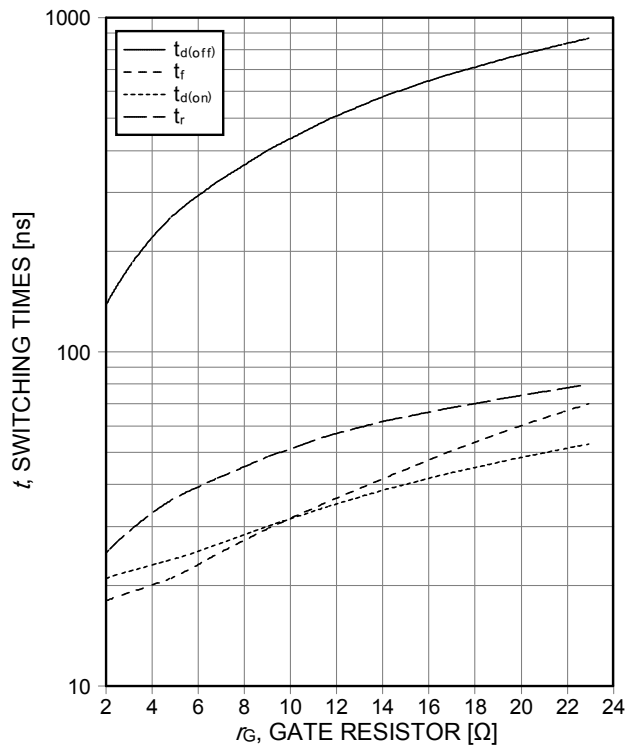


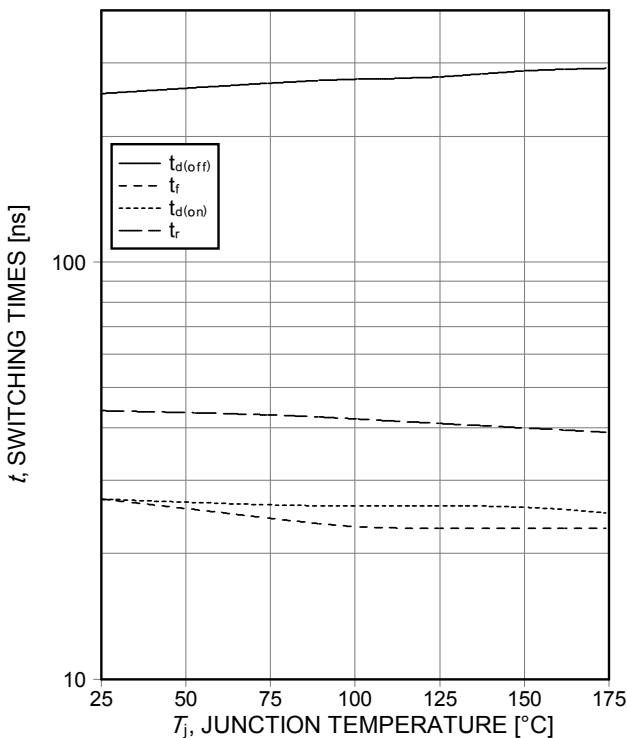
Figure 8. Typical collector-emitter saturation voltage as a function of junction temperature ( $V_{GE}=15\text{V}$ )



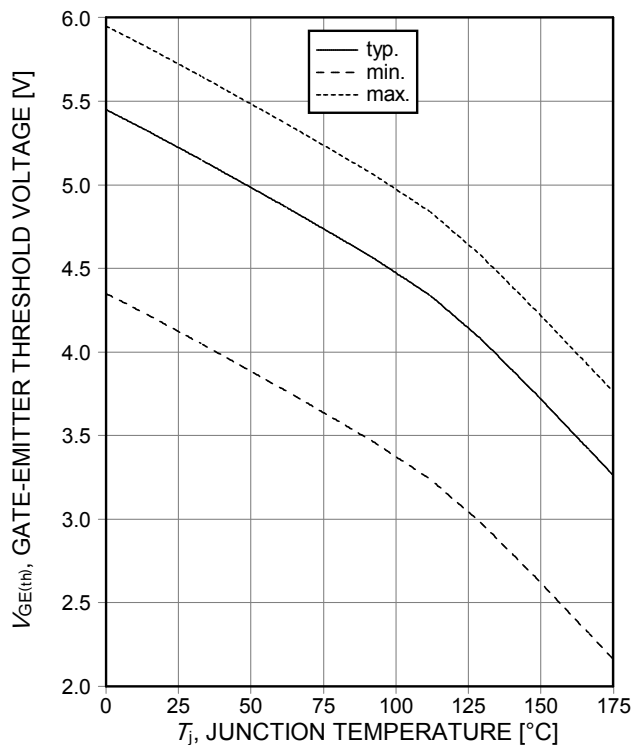
**Figure 9. Typical switching times as a function of collector current**  
(ind. load,  $T_j=175^\circ\text{C}$ ,  $V_{CE}=400\text{V}$ ,  $V_{GE}=15/0\text{V}$ ,  $r_G=6\Omega$ , test circuit in Fig. E)



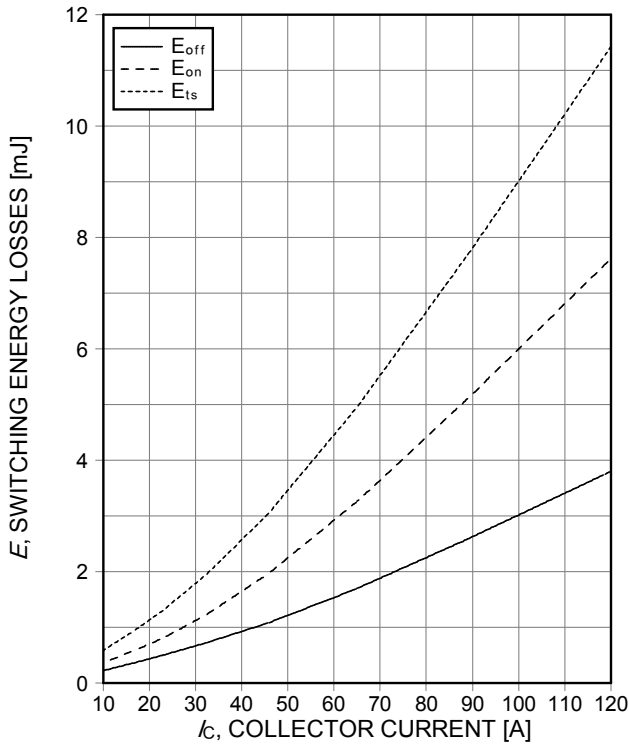
**Figure 10. Typical switching times as a function of gate resistor**  
(ind. load,  $T_j=175^\circ\text{C}$ ,  $V_{CE}=400\text{V}$ ,  $V_{GE}=15/0\text{V}$ ,  $I_C=60\text{A}$ , test circuit in Fig. E)



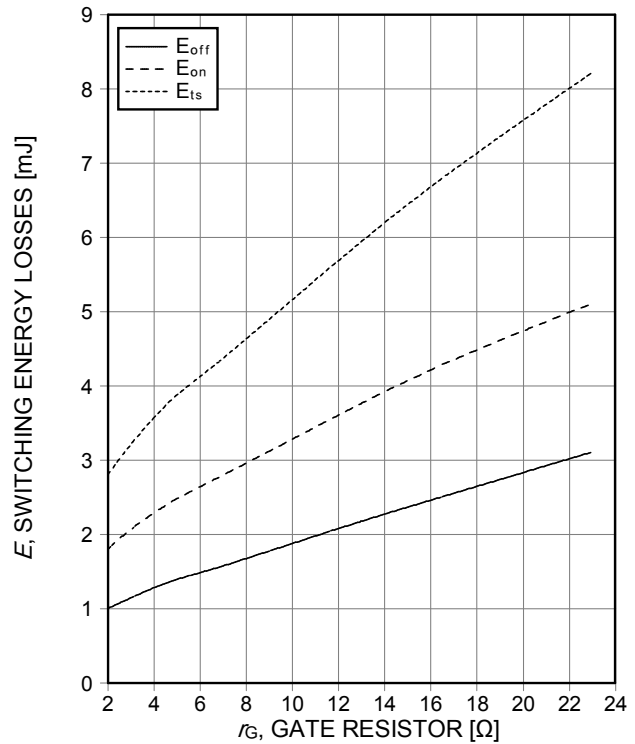
**Figure 11. Typical switching times as a function of junction temperature**  
(ind. load,  $V_{CE}=400\text{V}$ ,  $V_{GE}=15/0\text{V}$ ,  $I_C=60\text{A}$ ,  $r_G=6\Omega$ , test circuit in Fig. E)



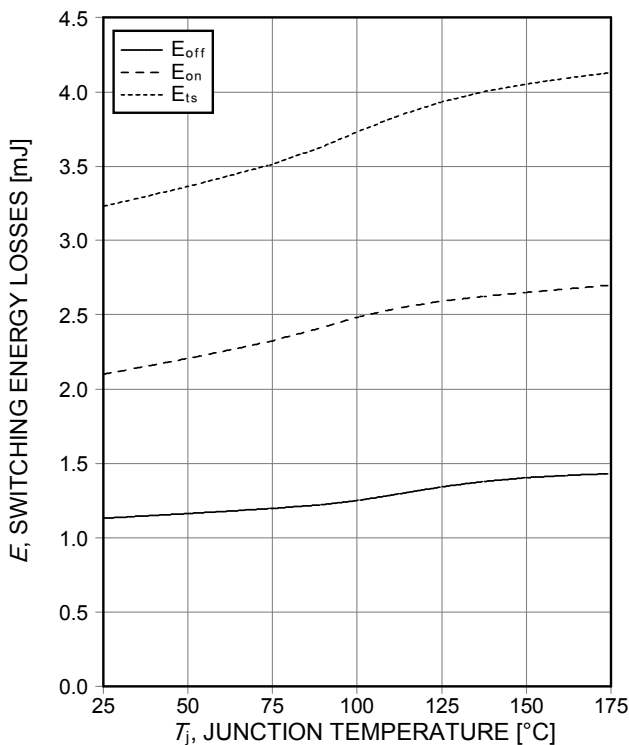
**Figure 12. Gate-emitter threshold voltage as a function of junction temperature**  
( $I_C=1\text{mA}$ )



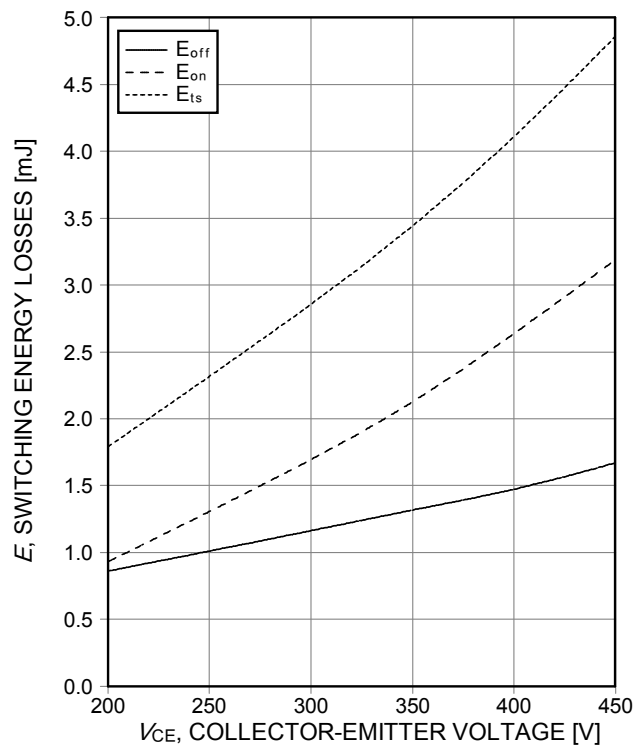
**Figure 13. Typical switching energy losses as a function of collector current**  
 (ind. load,  $T_j=175^\circ\text{C}$ ,  $V_{CE}=400\text{V}$ ,  $V_{GE}=15/0\text{V}$ ,  $r_G=6\Omega$ , test circuit in Fig. E)



**Figure 14. Typical switching energy losses as a function of gate resistor**  
 (ind. load,  $T_j=175^\circ\text{C}$ ,  $V_{CE}=400\text{V}$ ,  $V_{GE}=15/0\text{V}$ ,  $I_c=60\text{A}$ , test circuit in Fig. E)



**Figure 15. Typical switching energy losses as a function of junction temperature**  
 (ind. load,  $V_{CE}=400\text{V}$ ,  $V_{GE}=15/0\text{V}$ ,  $I_c=60\text{A}$ ,  $r_G=6\Omega$ , test circuit in Fig. E)



**Figure 16. Typical switching energy losses as a function of collector emitter voltage**  
 (ind. load,  $T_j=175^\circ\text{C}$ ,  $V_{GE}=15/0\text{V}$ ,  $I_c=60\text{A}$ ,  $r_G=6\Omega$ , test circuit in Fig. E)

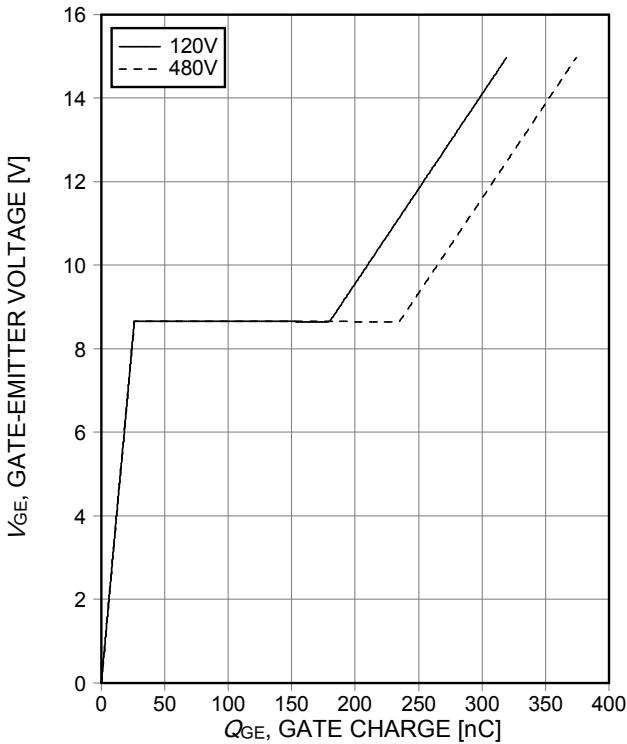


Figure 17. Typical gate charge  
( $I_C=60A$ )

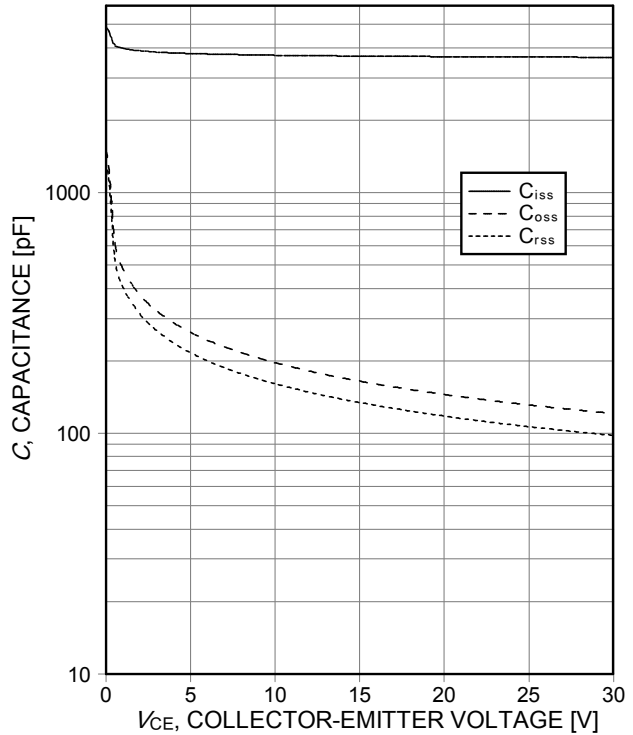


Figure 18. Typical capacitance as a function of collector-emitter voltage  
( $V_{GE}=0V$ ,  $f=1MHz$ )

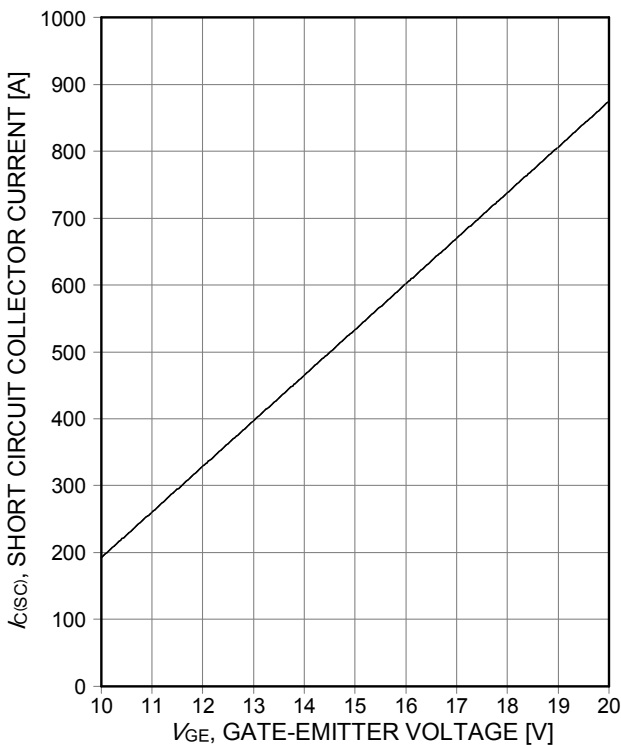


Figure 19. Typical short circuit collector current as a function of gate-emitter voltage  
( $V_{CE}\leq 400V$ , start at  $T_j=25^\circ C$ )

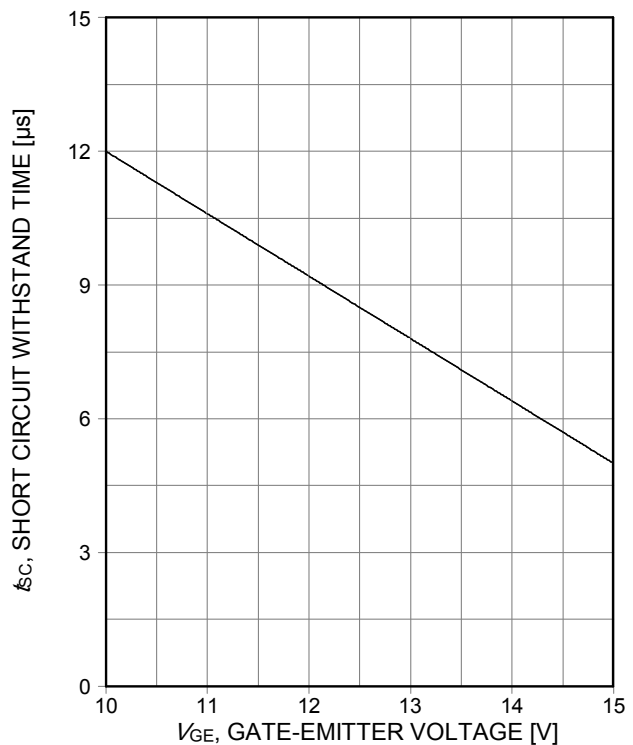


Figure 20. Short circuit withstand time as a function of gate-emitter voltage  
( $V_{CE}\leq 400V$ , start at  $T_j\leq 150^\circ C$ )

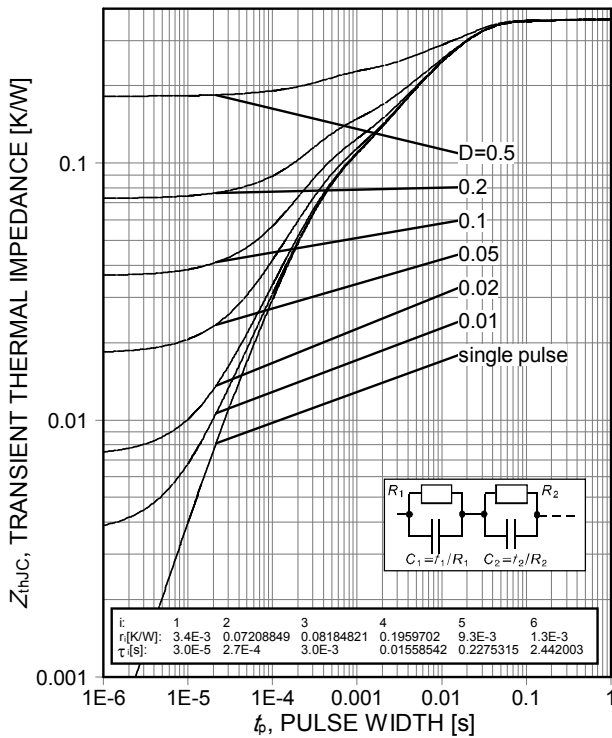


Figure 21. IGBT transient thermal impedance ( $D = t_p/T$ )

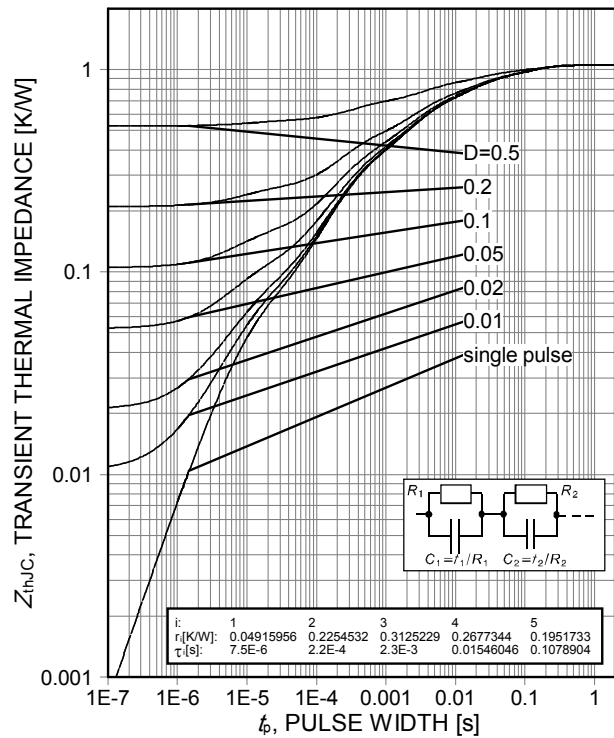


Figure 22. Diode transient thermal impedance as a function of pulse width ( $D = t_p/T$ )

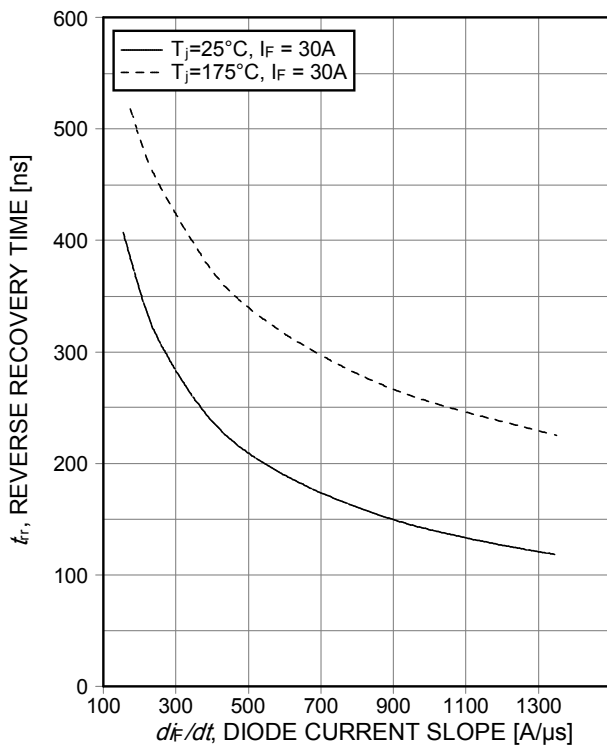


Figure 23. Typical reverse recovery time as a function of diode current slope ( $V_R = 400V$ )

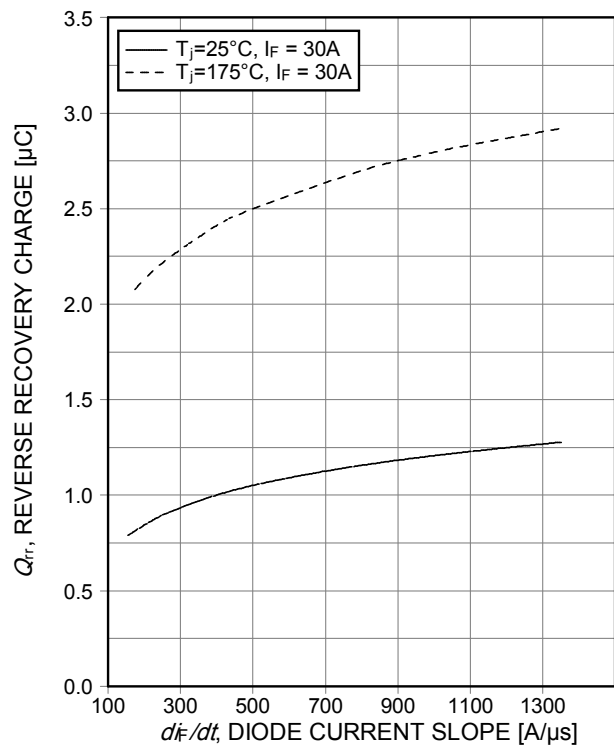


Figure 24. Typical reverse recovery charge as a function of diode current slope ( $V_R = 400V$ )

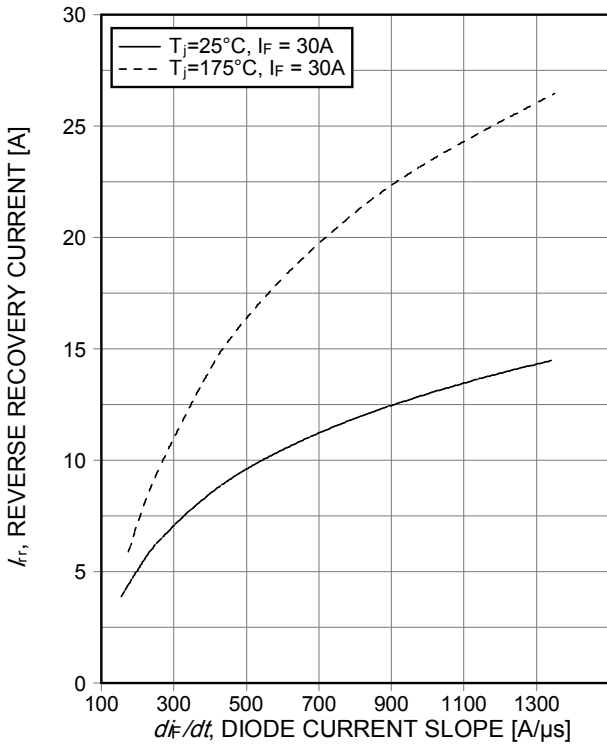


Figure 25. Typical reverse recovery current as a function of diode current slope ( $V_R=400V$ )

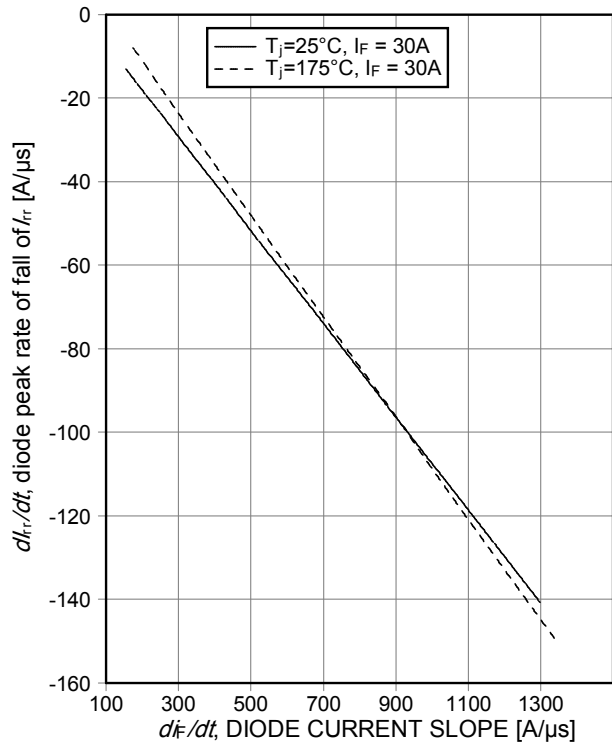


Figure 26. Typical diode peak rate of fall of reverse recovery current as a function of diode current slope ( $V_R=400V$ )

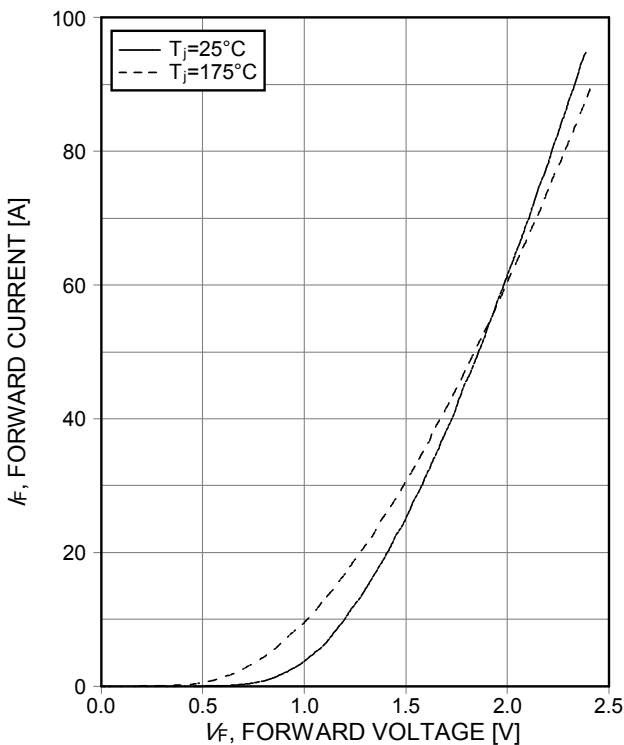


Figure 27. Typical diode forward current as a function of forward voltage

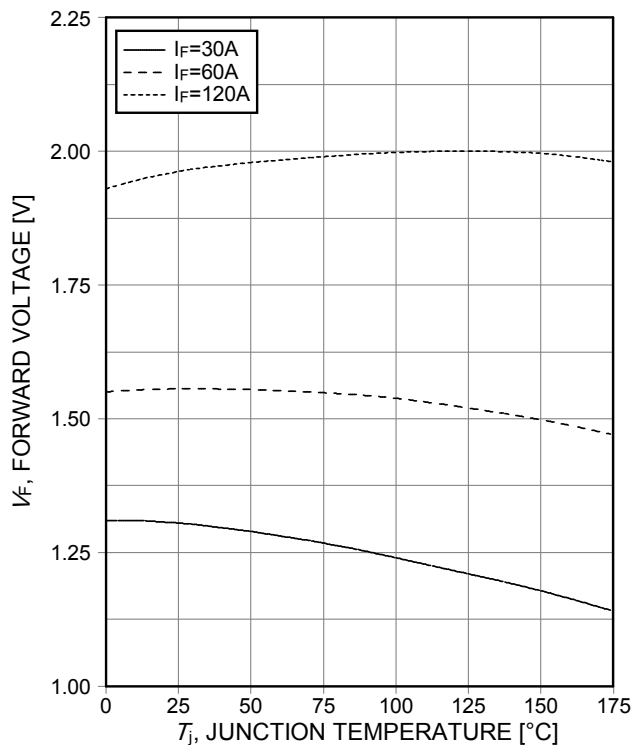
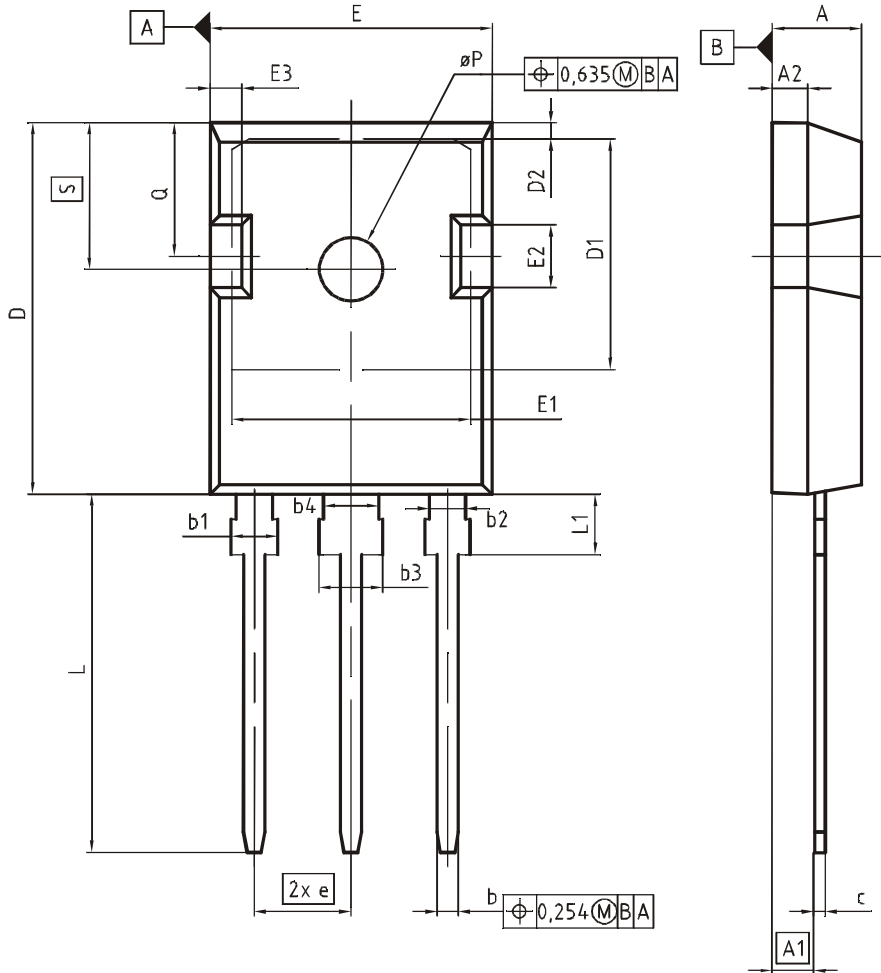


Figure 28. Typical diode forward voltage as a function of junction temperature

PG-TO247-3



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.83	5.21	0.190	0.205
A1	2.27	2.54	0.089	0.100
A2	1.85	2.16	0.073	0.085
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	20.80	21.10	0.819	0.831
D1	16.25	17.65	0.640	0.695
D2	0.95	1.35	0.037	0.053
E	15.70	16.13	0.618	0.635
E1	13.10	14.15	0.516	0.557
E2	3.68	5.10	0.145	0.201
E3	1.00	2.60	0.039	0.102
e	5.44 (BSC)		0.214 (BSC)	
N	3		3	
L	19.80	20.32	0.780	0.800
L1	4.10	4.47	0.161	0.176
$\phi P$	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

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SCALE

EUROPEAN PROJECTION

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REVISION  
05

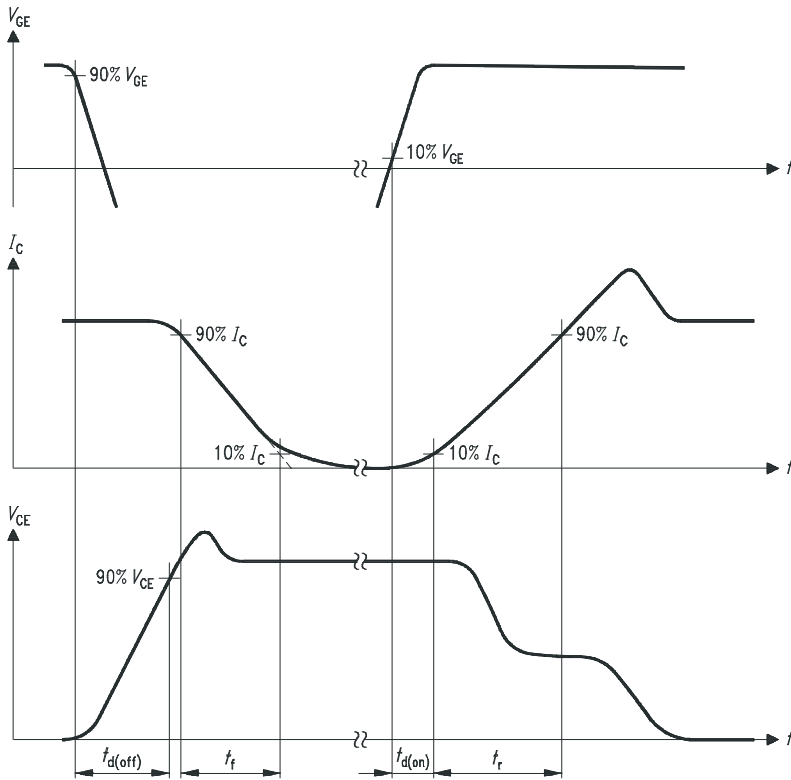


Figure A. Definition of switching times

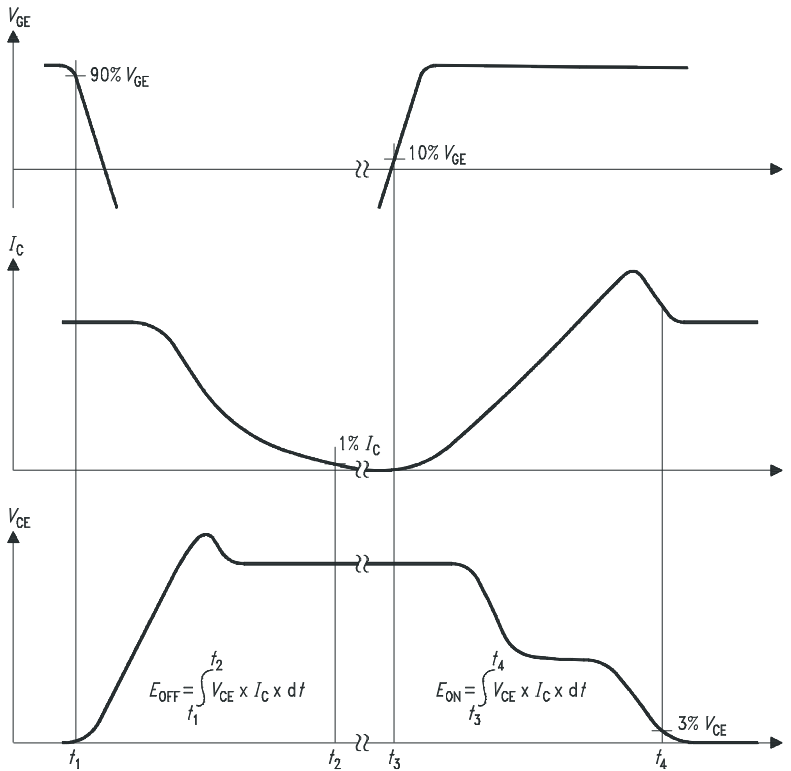


Figure B. Definition of switching losses

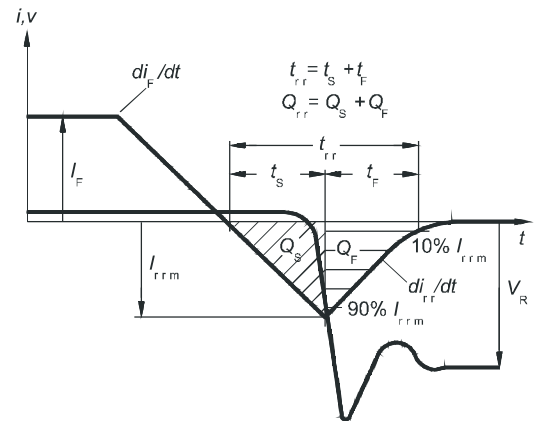


Figure C. Definition of diodes switching characteristics

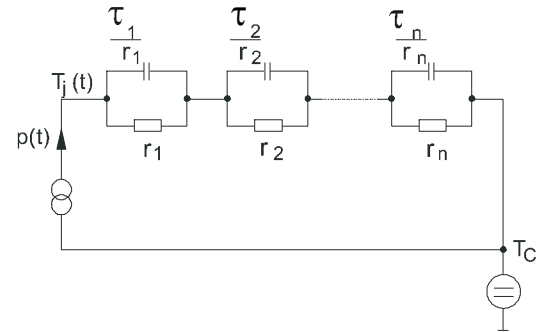


Figure D. Thermal equivalent circuit

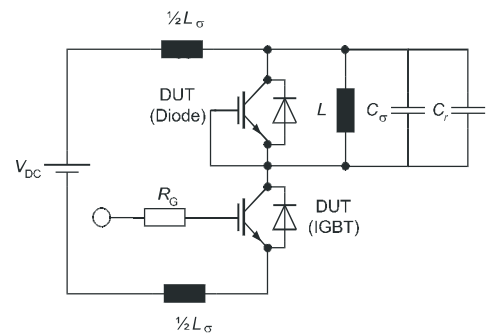


Figure E. Dynamic test circuit  
Parasitic inductance  $L_{\sigma}$ ,  
Parasitic capacitor  $C_{\sigma}$ ,  
Relief capacitor  $C_r$   
(only for ZVT switching)



**Revision History**

IKW60N60H3

**Revision: 2012-05-29, Rev. 1.2**

Previous Revision

Revision	Date	Subjects (major changes since last revision)
1.1	2012-04-23	Preliminary data sheet
1.2	2012-05-29	Prelim. switching conditions $I_c=60A$

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