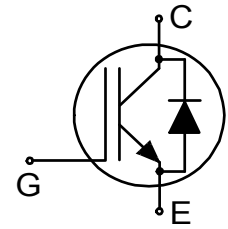


## TRENCHSTOP™ IGBT6

IGBT in trench and field-stop technology with soft, fast recovery anti-parallel Rapid diode

### Features and Benefits:

- Very low  $V_{CE(sat)}$  1.5V (typ.)
  - Maximum junction temperature 175°C
  - Short circuit withstand time 3μs
- Trench and field-stop technology for 650V applications offers :
- very tight parameter distribution
  - high ruggedness, temperature stable behavior
  - low  $V_{CEsat}$  and positive temperature coefficient
- Low gate charge  $Q_G$
  - Pb-free lead plating; RoHS compliant
  - Very soft, fast recovery anti-parallel Rapid diode
  - Complete product spectrum and PSpice Models:  
[www.infineon.com/igbt](http://www.infineon.com/igbt)



### Potential Applications:

Drives

- GPD (general purpose drives)

Major home appliances

- Air conditioning
- Other major home appliances

Small home appliances

- Other small home appliances

### Product Validation:

Qualified for industrial applications according to the relevant tests of JEDEC47/20/22



### Key Performance and Package Parameters

Type	$V_{CE}$	$I_C$	$V_{CEsat}, T_{vj}=25^{\circ}C$	$T_{vjmax}$	Marking	Package
IKA15N65ET6	650V	15A	1.5V	175°C	K15EET6	PG-TO220-3 FP

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TRENCHSTOP™ IGBT6

**Maximum Ratings**

For optimum lifetime and reliability, Infineon recommends operating conditions that do not exceed 80% of the maximum ratings stated in this datasheet.

Parameter	Symbol	Value	Unit
Collector-emitter voltage, $T_{vj} \geq 25^{\circ}\text{C}$	$V_{CE}$	650	V
DC collector current, limited by $T_{vjmax}^{1)}$ $T_c = 25^{\circ}\text{C}$ $T_c = 100^{\circ}\text{C}$	$I_C$	34.0 21.0	A
Pulsed collector current, $t_p$ limited by $T_{vjmax}$	$I_{Cpuls}$	57.5	A
Turn off safe operating area $V_{CE} \leq 650\text{V}$ , $T_{vj} \leq 175^{\circ}\text{C}$	-	57.5	A
Diode forward current, limited by $T_{vjmax}^{1)}$ $T_c = 25^{\circ}\text{C}$ $T_c = 100^{\circ}\text{C}$	$I_F$	24.0 14.0	A
Diode pulsed current, $t_p$ limited by $T_{vjmax}$	$I_{Fpuls}$	57.5	A
Gate-emitter voltage Transient Gate-emitter voltage ( $t_p \leq 10\mu\text{s}$ , $D < 0.010$ )	$V_{GE}$	$\pm 20$ $\pm 30$	V
Short circuit withstand time $V_{GE} = 15.0\text{V}$ , $V_{CC} \leq 360\text{V}$ Allowed number of short circuits < 1000 Time between short circuits: $\geq 1.0\text{s}$ $T_{vj} = 150^{\circ}\text{C}$	$t_{SC}$	3	$\mu\text{s}$
Power dissipation $T_c = 25^{\circ}\text{C}$ Power dissipation $T_c = 100^{\circ}\text{C}$	$P_{tot}$	35.3 17.6	W
Operating junction temperature	$T_{vj}$	-40...+175	$^{\circ}\text{C}$
Storage temperature	$T_{stg}$	-55...+150	$^{\circ}\text{C}$
Soldering temperature, wave soldering 1.6mm (0.063in.) from case for 10s		260	$^{\circ}\text{C}$
Mounting torque, M2.5 screw Maximum of mounting processes: 3	$M$	0.5	Nm
Isolation voltage RMS, $f = 50/60\text{Hz}$ , $t = 1\text{min}$	$V_{isol}$	2500	V

**Thermal Resistance**

Parameter	Symbol	Conditions	Value			Unit
			min.	typ.	max.	

**R<sub>th</sub> Characteristics**

IGBT thermal resistance, junction - case	$R_{th(j-c)}$		-	-	4.30	K/W
Diode thermal resistance, junction - case	$R_{th(j-c)}$		-	-	5.80	K/W
Thermal resistance junction - ambient	$R_{th(j-a)}$		-	-	65	K/W

<sup>1)</sup> Limited by maximum junction temperature. Applicable for TO220 standard package.

TRENCHSTOP™ IGBT6

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 <sup>1)</sup>	$V_{(BR)CES}$	$V_{GE} = 0\text{V}, I_C = 0.10\text{mA}$	650	-	-	V
Collector-emitter saturation voltage	$V_{CESat}$	$V_{GE} = 15.0\text{V}, I_C = 11.5\text{A}$ $T_{vj} = 25^{\circ}\text{C}$ $T_{vj} = 125^{\circ}\text{C}$ $T_{vj} = 150^{\circ}\text{C}$	- - -	1.50 1.65 1.75	1.90 - -	V
Diode forward voltage	$V_F$	$V_{GE} = 0\text{V}, I_F = 11.5\text{A}$ $T_{vj} = 25^{\circ}\text{C}$ $T_{vj} = 125^{\circ}\text{C}$ $T_{vj} = 150^{\circ}\text{C}$	- - -	1.50 1.48 1.43	1.95 - -	V
Gate-emitter threshold voltage	$V_{GE(th)}$	$I_C = 0.20\text{mA}, V_{CE} = V_{GE}$	4.8	5.6	6.4	V
Zero gate voltage collector current	$I_{CES}$	$V_{CE} = 650\text{V}, V_{GE} = 0\text{V}$ $T_{vj} = 25^{\circ}\text{C}$ $T_{vj} = 150^{\circ}\text{C}$	- -	- 450	30 -	$\mu\text{A}$
Gate-emitter leakage current	$I_{GES}$	$V_{CE} = 0\text{V}, V_{GE} = 20\text{V}$	-	-	100	nA
Transconductance	$g_{fs}$	$V_{CE} = 20\text{V}, I_C = 11.5\text{A}$	-	11.6	-	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	$C_{ies}$	$V_{CE} = 25\text{V}, V_{GE} = 0\text{V}, f = 1\text{MHz}$	-	1020	-	pF
Output capacitance	$C_{oes}$		-	50	-	
Reverse transfer capacitance	$C_{res}$		-	20	-	
Gate charge	$Q_G$	$V_{CC} = 520\text{V}, I_C = 11.5\text{A}, V_{GE} = 15\text{V}$	-	37.0	-	nC
Internal emitter inductance measured 5mm (0.197 in.) from case	$L_E$		-	7.0	-	nH
Short circuit collector current Max. 1000 short circuits Time between short circuits: $\geq 1.0\text{s}$	$I_{C(SC)}$	$V_{GE} = 15.0\text{V}, V_{CC} \leq 360\text{V}, t_{SC} \leq 3\mu\text{s}$ $T_{vj} = 150^{\circ}\text{C}$	-	120	-	A

<sup>1)</sup> Measured with filter network.

TRENCHSTOP™ IGBT6

Switching Characteristic, Inductive Load

Parameter	Symbol	Conditions	Value			Unit
			min.	typ.	max.	
<b>IGBT Characteristic, at <math>T_{vj} = 25^{\circ}\text{C}</math></b>						
Turn-on delay time	$t_{d(on)}$	$T_{vj} = 25^{\circ}\text{C}$ , $V_{CC} = 400\text{V}$ , $I_C = 11.5\text{A}$ , $V_{GE} = 0.0/15.0\text{V}$ , $R_{G(on)} = 47.0\Omega$ , $R_{G(off)} = 47.0\Omega$ , $L_{\sigma} = 30\text{nH}$ , $C_{\sigma} = 150\text{pF}$ $L_{\sigma}$ , $C_{\sigma}$ from Fig. E Energy losses include "tail" and diode reverse recovery.	-	30	-	ns
Rise time	$t_r$		-	22	-	ns
Turn-off delay time	$t_{d(off)}$		-	117	-	ns
Fall time	$t_f$		-	42	-	ns
Turn-on energy	$E_{on}$		-	0.23	-	mJ
Turn-off energy	$E_{off}$		-	0.11	-	mJ
Total switching energy	$E_{ts}$		-	0.34	-	mJ

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

Diode reverse recovery time	$t_{rr}$	$T_{vj} = 25^{\circ}\text{C}$ , $V_R = 400\text{V}$ , $I_F = 11.5\text{A}$ , $di_F/dt = 400\text{A}/\mu\text{s}$	-	69	-	ns
Diode reverse recovery charge	$Q_{rr}$		-	0.21	-	$\mu\text{C}$
Diode peak reverse recovery current	$I_{rrm}$		-	5.1	-	A
Diode peak rate of fall of reverse recovery current during $t_b$	$di_{rr}/dt$		-	-265	-	$\text{A}/\mu\text{s}$

Switching Characteristic, Inductive Load

Parameter	Symbol	Conditions	Value			Unit
			min.	typ.	max.	
<b>IGBT Characteristic, at <math>T_{vj} = 150^{\circ}\text{C}</math></b>						
Turn-on delay time	$t_{d(on)}$	$T_{vj} = 150^{\circ}\text{C}$ , $V_{CC} = 400\text{V}$ , $I_C = 11.5\text{A}$ , $V_{GE} = 0.0/15.0\text{V}$ , $R_{G(on)} = 47.0\Omega$ , $R_{G(off)} = 47.0\Omega$ , $L_{\sigma} = 30\text{nH}$ , $C_{\sigma} = 150\text{pF}$ $L_{\sigma}$ , $C_{\sigma}$ from Fig. E Energy losses include "tail" and diode reverse recovery.	-	27	-	ns
Rise time	$t_r$		-	23	-	ns
Turn-off delay time	$t_{d(off)}$		-	135	-	ns
Fall time	$t_f$		-	67	-	ns
Turn-on energy	$E_{on}$		-	0.32	-	mJ
Turn-off energy	$E_{off}$		-	0.18	-	mJ
Total switching energy	$E_{ts}$		-	0.50	-	mJ

Diode Characteristic, at  $T_{vj} = 150^{\circ}\text{C}$

Diode reverse recovery time	$t_{rr}$	$T_{vj} = 150^{\circ}\text{C}$ , $V_R = 400\text{V}$ , $I_F = 11.5\text{A}$ , $di_F/dt = 400\text{A}/\mu\text{s}$	-	113	-	ns
Diode reverse recovery charge	$Q_{rr}$		-	0.50	-	$\mu\text{C}$
Diode peak reverse recovery current	$I_{rrm}$		-	8.0	-	A
Diode peak rate of fall of reverse recovery current during $t_b$	$di_{rr}/dt$		-	-228	-	$\text{A}/\mu\text{s}$

TRENCHSTOP™ IGBT6

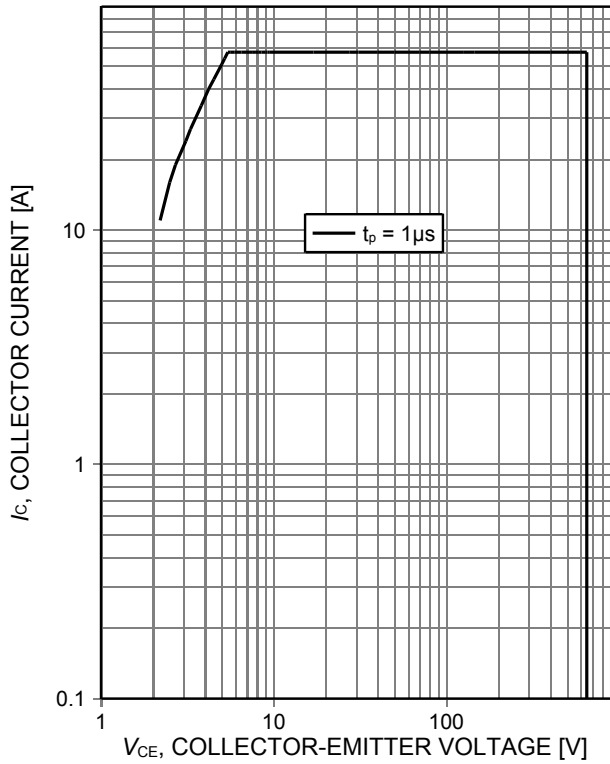


Figure 1. **Forward bias safe operating area**  
 ( $D=0$ ,  $T_C=25^\circ\text{C}$ ,  $T_{vj}\leq 175^\circ\text{C}$ ;  $V_{GE}=15\text{V}$ .  
 Recommended use at  $V_{GE}\geq 15\text{V}$ )

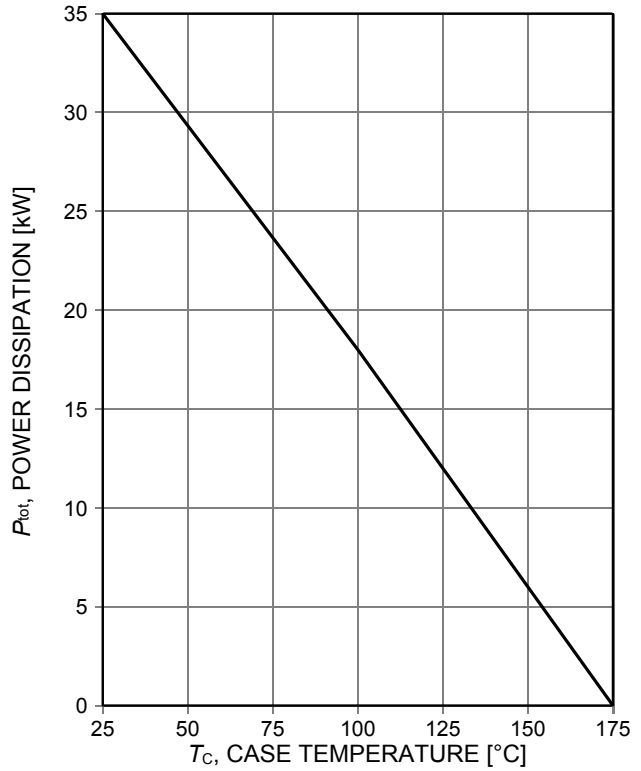


Figure 2. **Power dissipation as a function of case temperature**  
 ( $T_{vj}\leq 175^\circ\text{C}$ )

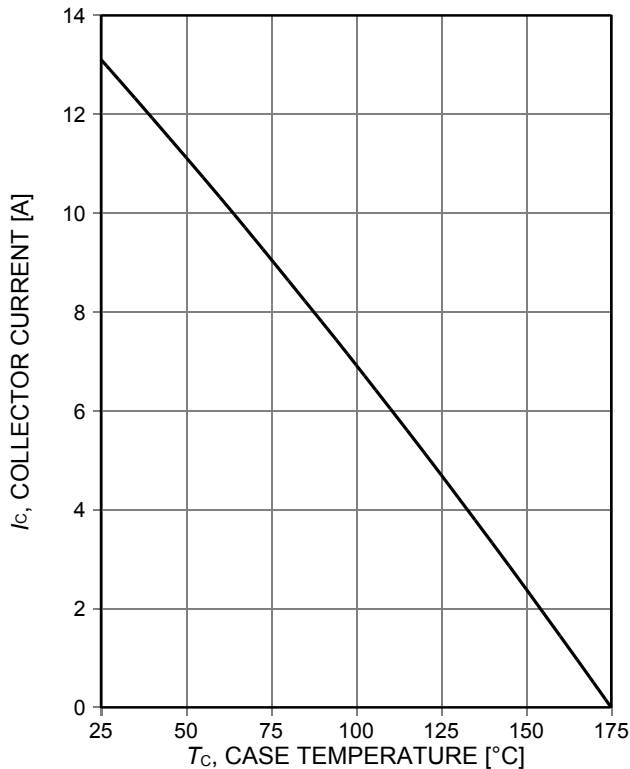


Figure 3. **Collector current as a function of case temperature**  
 ( $V_{GE}\geq 15\text{V}$ ,  $T_{vj}\leq 175^\circ\text{C}$ )

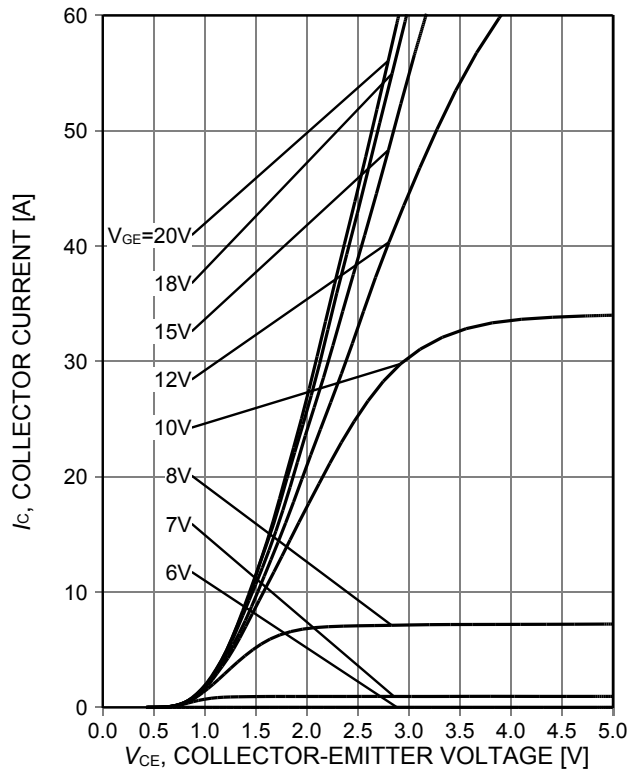


Figure 4. **Typical output characteristic**  
 ( $T_{vj}=25^\circ\text{C}$ )

TRENCHSTOP™ IGBT6

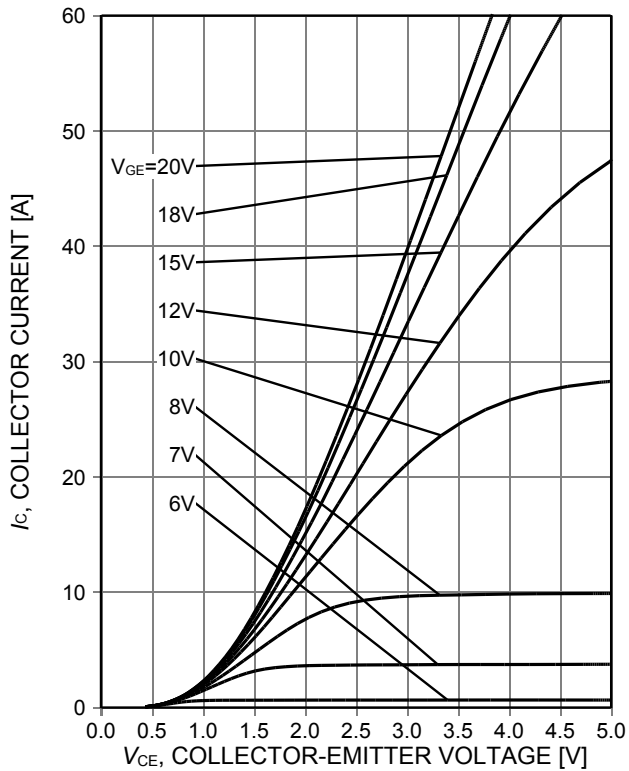


Figure 5. Typical output characteristic ( $T_{vj}=150^{\circ}\text{C}$ )

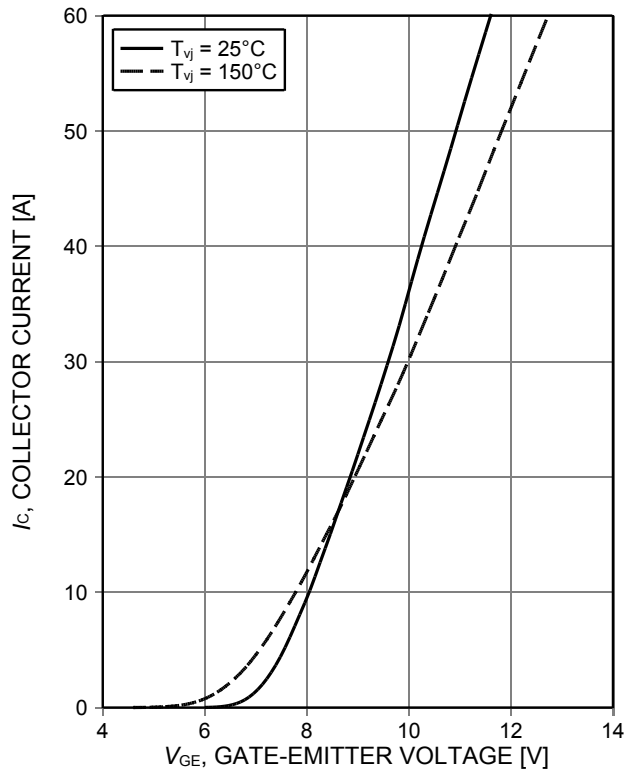


Figure 6. Typical transfer characteristic ( $V_{ce}=50\text{V}$ )

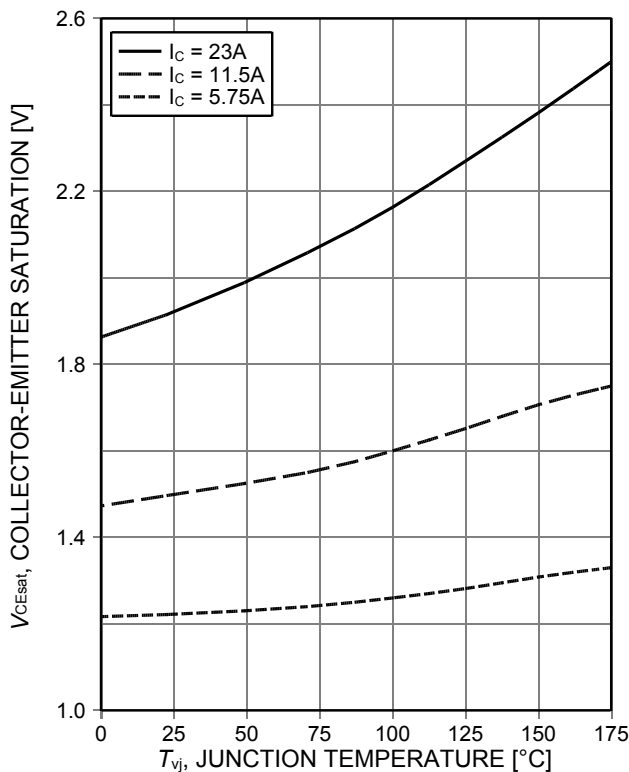


Figure 7. Typical collector-emitter saturation voltage as a function of junction temperature ( $V_{ge}=15\text{V}$ )

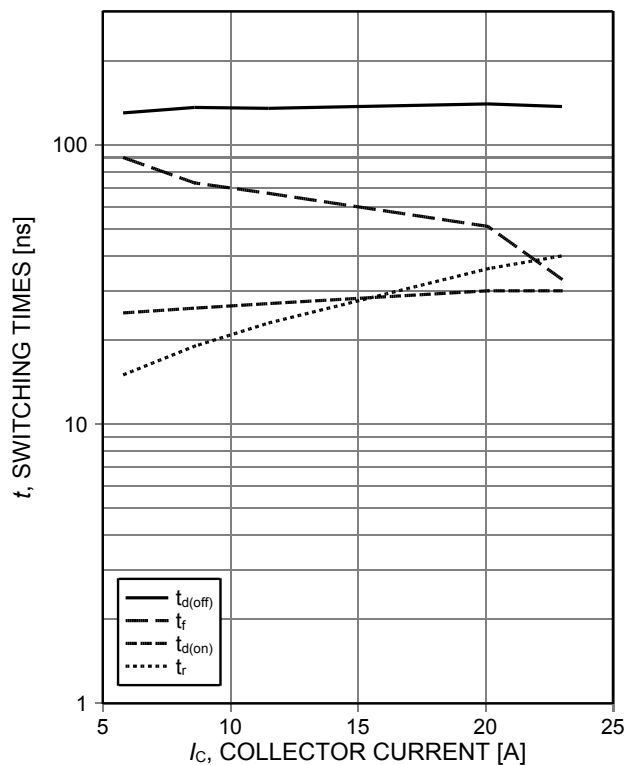


Figure 8. Typical switching times as a function of collector current (inductive load,  $T_{vj}=150^{\circ}\text{C}$ ,  $V_{ce}=400\text{V}$ ,  $V_{ge}=15/0\text{V}$ ,  $r_G=47\Omega$ , Dynamic test circuit in Figure E)

TRENCHSTOP™ IGBT6

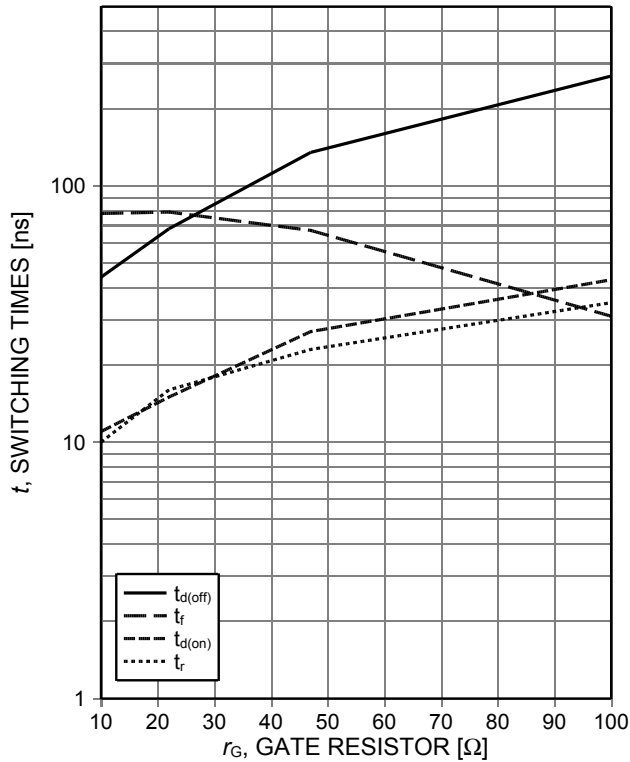


Figure 9. **Typical switching times as a function of gate resistor**  
 (inductive load,  $T_{vj}=150^{\circ}\text{C}$ ,  $V_{CE}=400\text{V}$ ,  $V_{GE}=15/0\text{V}$ ,  $I_C=11.5\text{A}$ , Dynamic test circuit in Figure E)

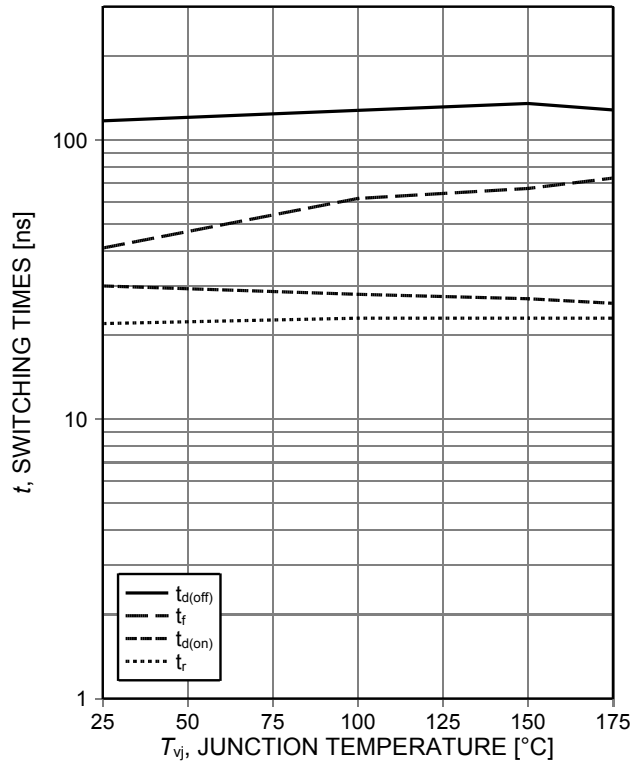


Figure 10. **Typical switching times as a function of junction temperature**  
 (inductive load,  $V_{CE}=400\text{V}$ ,  $V_{GE}=15\text{V}$ ,  $I_C=11.5\text{A}$ ,  $r_G=47\Omega$ , Dynamic test circuit in Figure E)

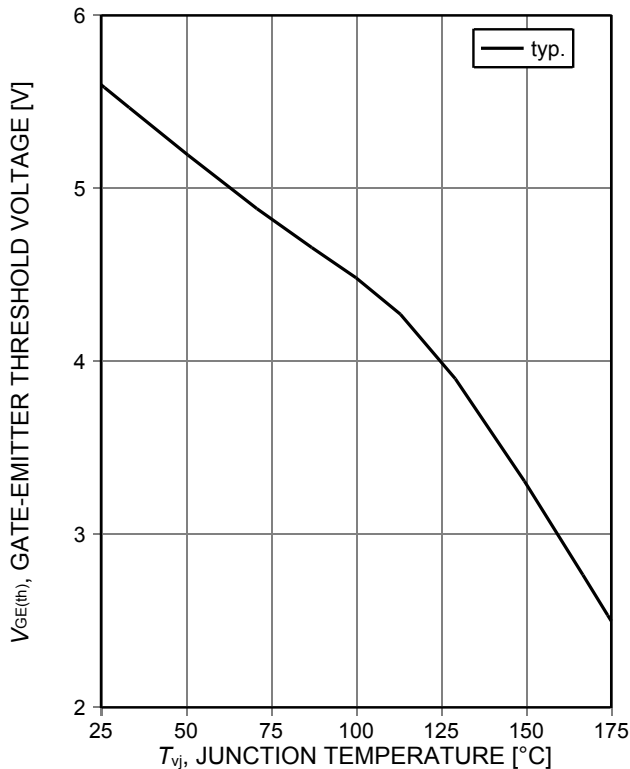


Figure 11. **Gate-emitter threshold voltage as a function of junction temperature**  
 ( $I_C=0.2\text{mA}$ )

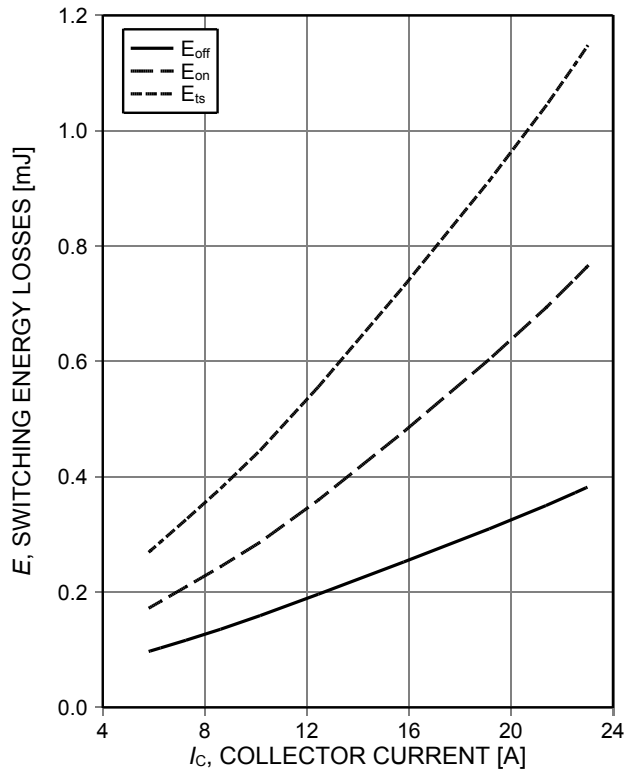


Figure 12. **Typical switching energy losses as a function of collector current**  
 (inductive load,  $T_{vj}=150^{\circ}\text{C}$ ,  $V_{CE}=400\text{V}$ ,  $V_{GE}=15/0\text{V}$ ,  $r_G=47\Omega$ , Dynamic test circuit in Figure E)



TRENCHSTOP™ IGBT6

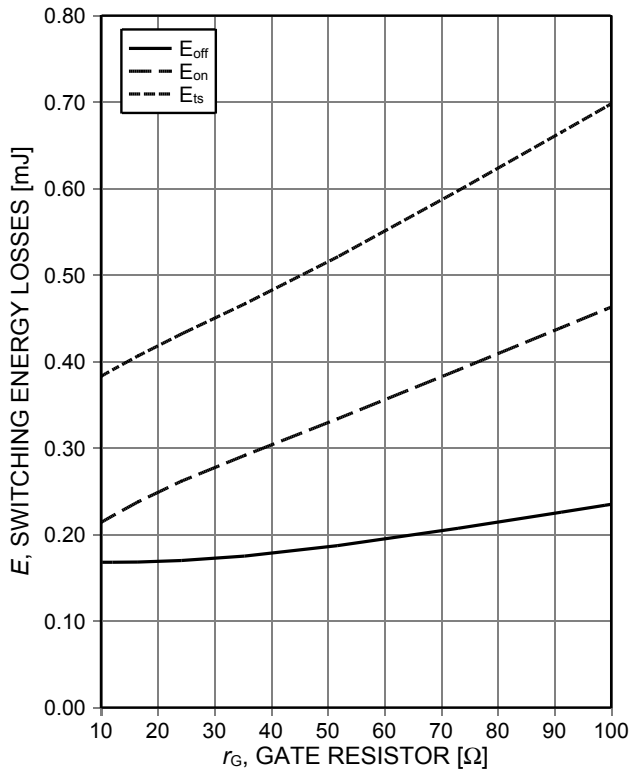


Figure 13. **Typical switching energy losses as a function of gate resistor**  
 (inductive load,  $T_{vj}=150^{\circ}\text{C}$ ,  $V_{CE}=400\text{V}$ ,  $V_{GE}=15/0\text{V}$ ,  $I_C=11.5\text{A}$ , Dynamic test circuit in Figure E)

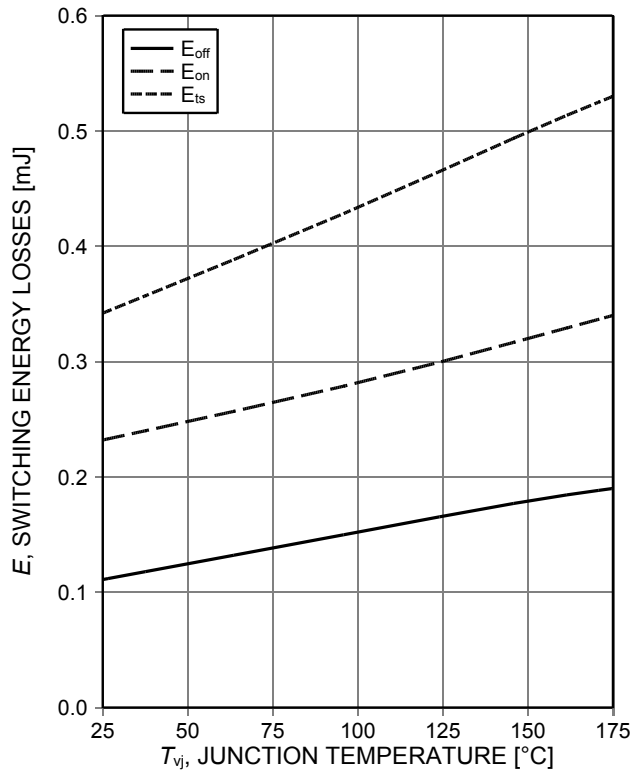


Figure 14. **Typical switching energy losses as a function of junction temperature**  
 (inductive load,  $V_{CE}=400\text{V}$ ,  $V_{GE}=15\text{V}$ ,  $I_C=11.5\text{A}$ ,  $r_G=47\Omega$ , Dynamic test circuit in Figure E)

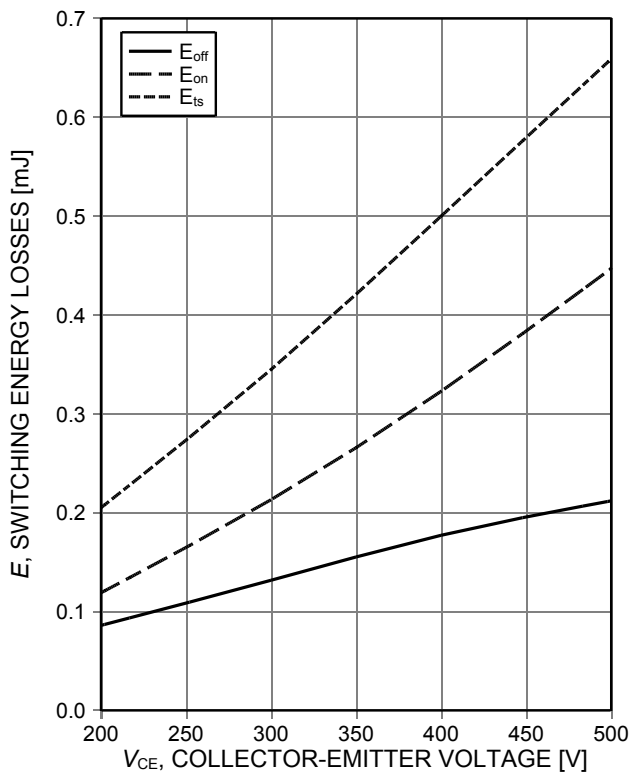


Figure 15. **Typical switching energy losses as a function of collector emitter voltage**  
 (inductive load,  $T_{vj}=150^{\circ}\text{C}$ ,  $V_{GE}=15/0\text{V}$ ,  $I_C=11.5\text{A}$ ,  $r_G=47\Omega$ , Dynamic test circuit in Figure E)

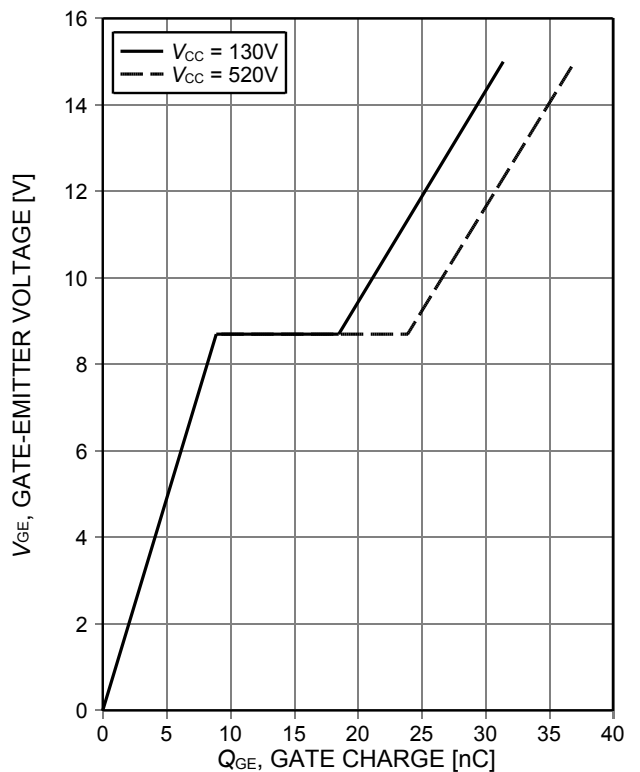


Figure 16. **Typical gate charge**  
 ( $I_C=11.5\text{A}$ )

TRENCHSTOP™ IGBT6

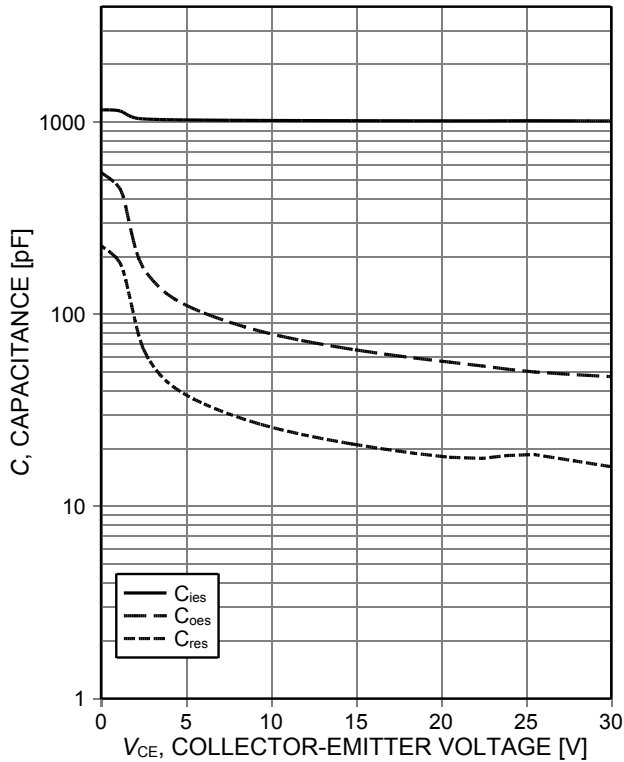


Figure 17. Typical capacitance as a function of collector-emitter voltage ( $V_{GE}=0V$ ,  $f=1MHz$ )

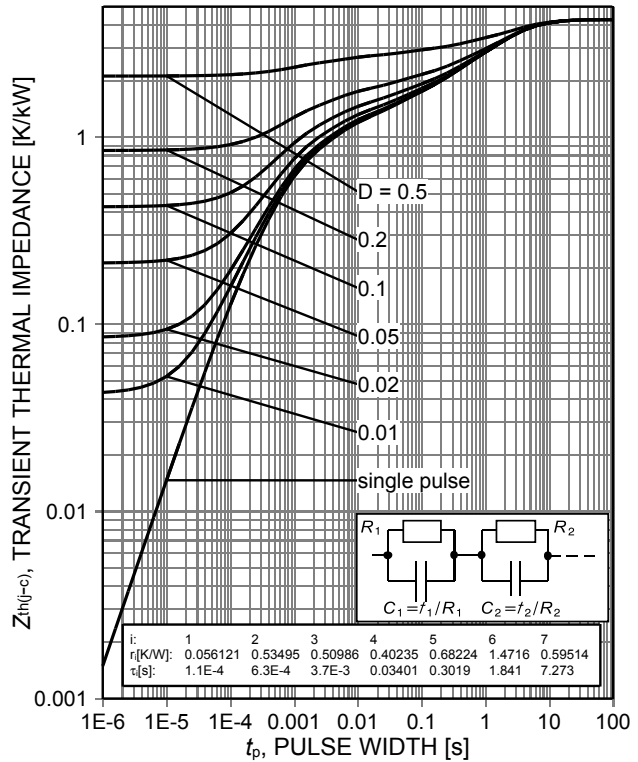


Figure 18. IGBT transient thermal impedance ( $D=t_p/T$ )

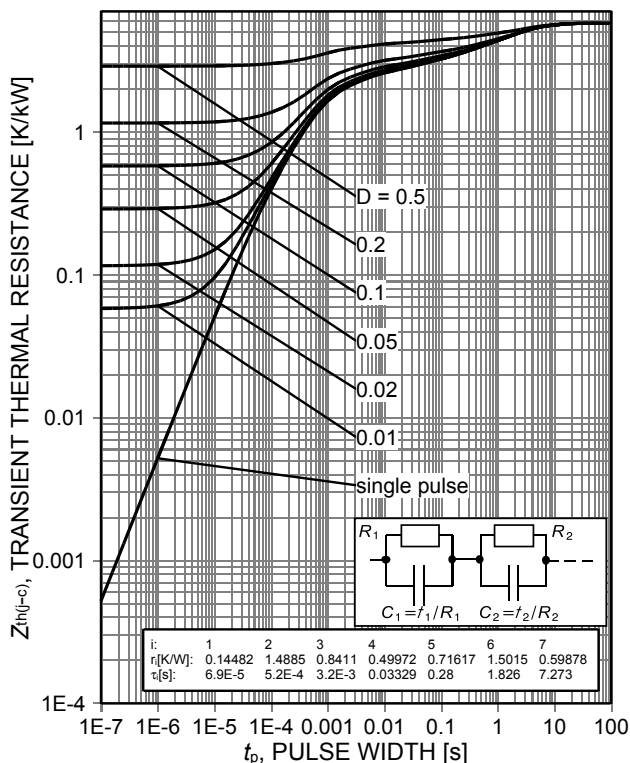


Figure 19. Diode transient thermal impedance as a function of pulse width ( $D=t_p/T$ )

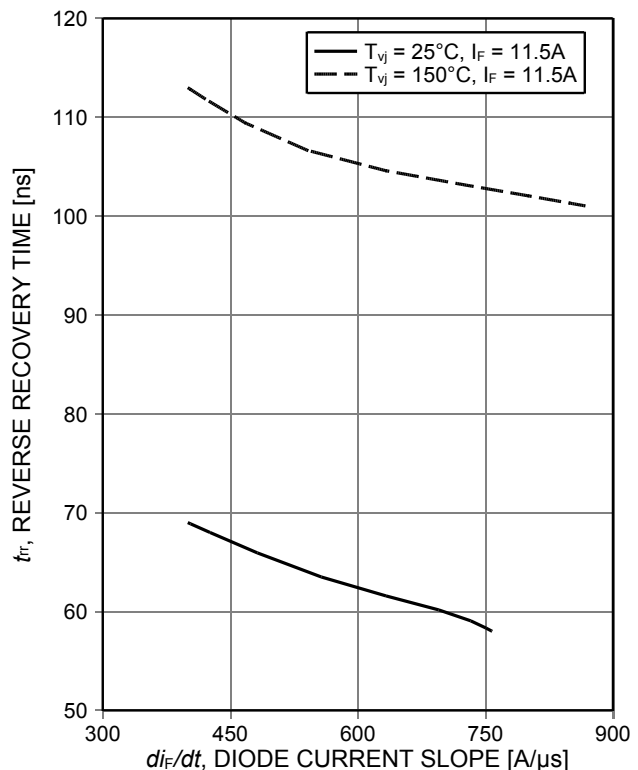


Figure 20. Typical reverse recovery time as a function of diode current slope ( $V_R=400V$ )

TRENCHSTOP™ IGBT6

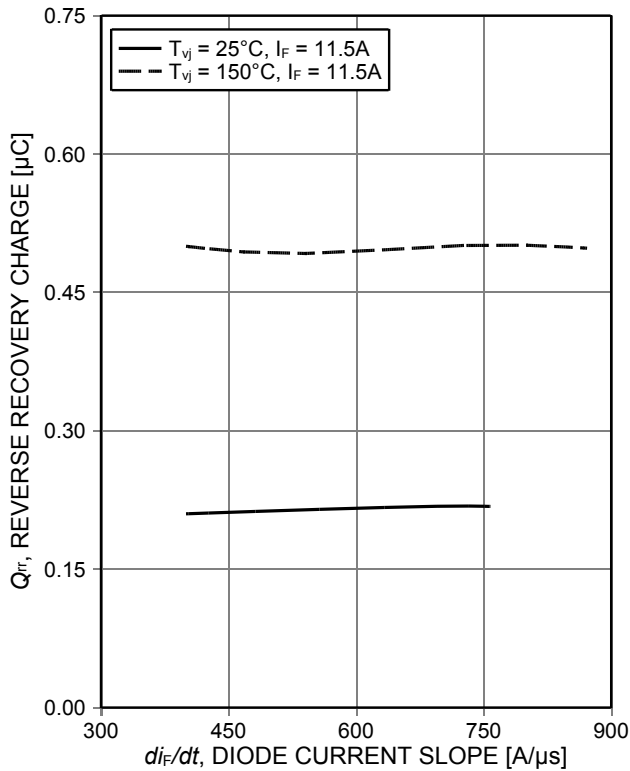


Figure 21. Typical reverse recovery charge as a function of diode current slope (VR=400V)

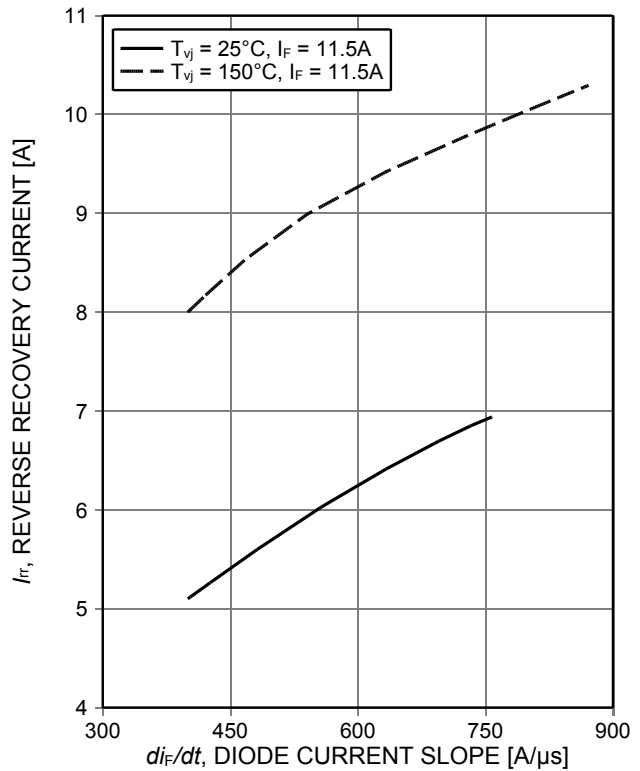


Figure 22. Typical reverse recovery current as a function of diode current slope (VR=400V)

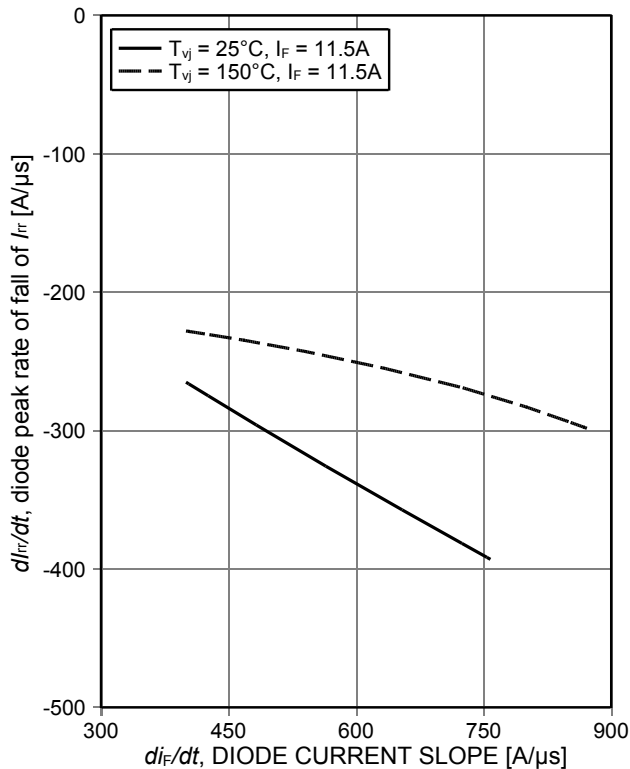


Figure 23. Typical diode peak rate of fall of reverse recovery current as a function of diode current slope (VR=400V)

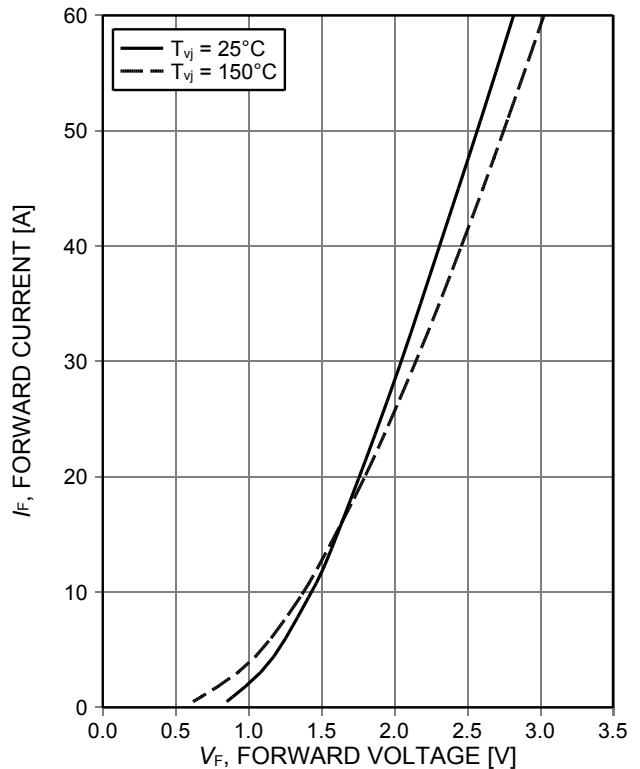


Figure 24. Typical diode forward current as a function of forward voltage

TRENCHSTOP™ IGBT6

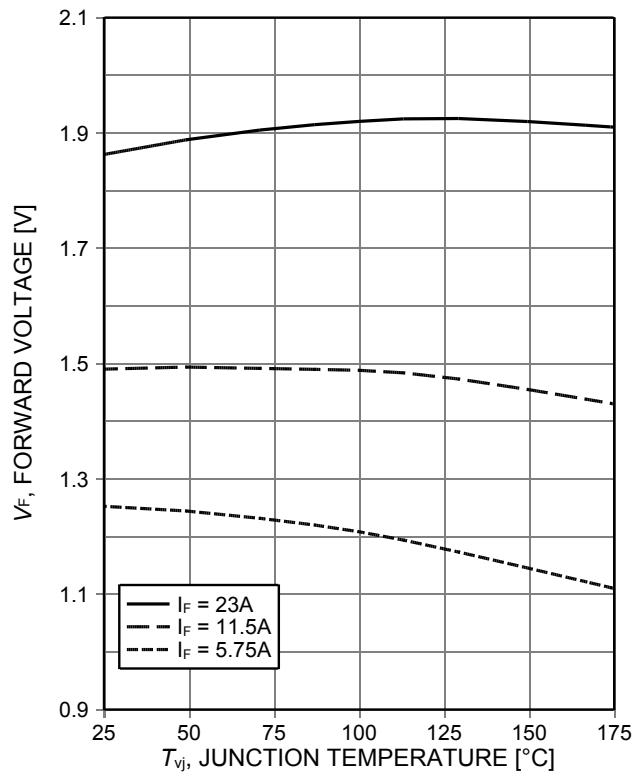
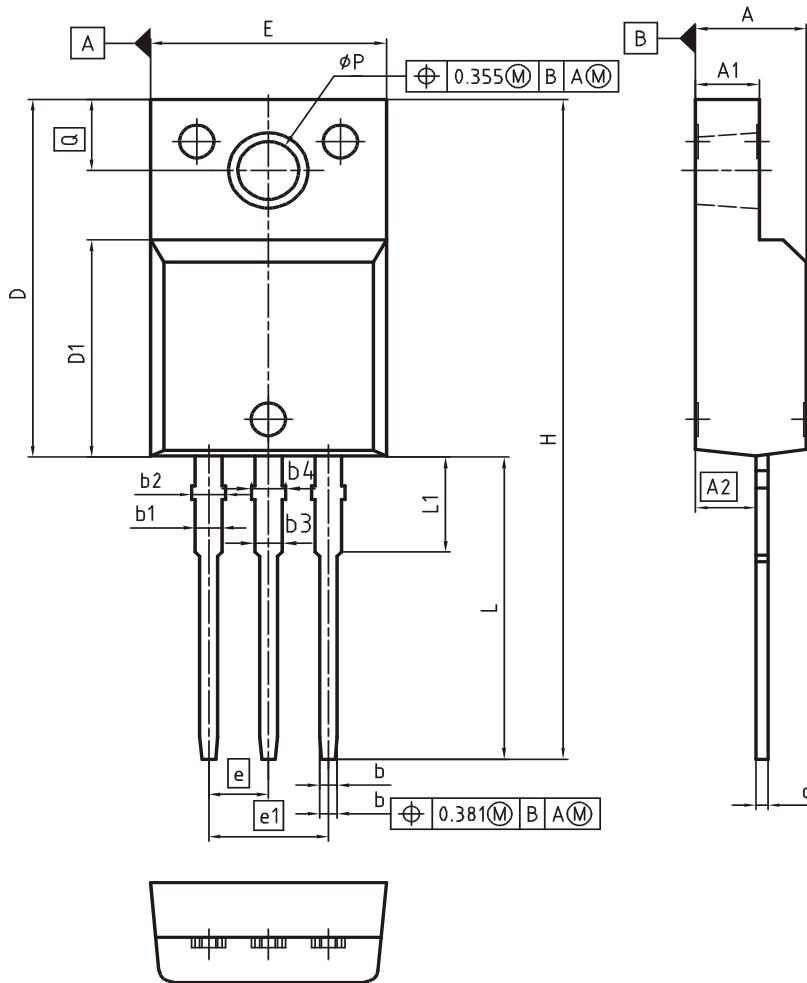


Figure 25. Typical diode forward voltage as a function of junction temperature

Package Drawing PG-TO220-3-FP



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.55	4.85	0.179	0.191
A1	2.55	2.85	0.100	0.112
A2	2.42	2.72	0.095	0.107
b	0.65	0.85	0.026	0.033
b1	0.95	1.33	0.037	0.052
b2	0.95	1.51	0.037	0.059
b3	0.65	1.33	0.026	0.052
b4	0.65	1.51	0.026	0.059
c	0.40	0.63	0.016	0.025
D	15.85	16.15	0.624	0.636
D1	9.53	9.83	0.375	0.387
E	10.35	10.65	0.407	0.419
e	2.54		0.100	
e1	5.08		0.200	
N	3		3	
H	29.45	29.75	1.159	1.171
L	13.45	13.75	0.530	0.541
L1	3.15	3.45	0.124	0.136
φP	2.95	3.20	0.116	0.126
Q	3.15	3.50	0.124	0.138

DOCUMENT NO.  
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SCALE

EUROPEAN PROJECTION

ISSUE DATE  
08-03-2007

REVISION  
03

Testing Conditions



Figure A. Definition of switching times



Figure B. Definition of switching losses



Figure C. Definition of diode 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)

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## TRENCHSTOP™ IGBT6

### Revision History

IKA15N65ET6

**Revision: 2019-09-13, Rev. 2.3**

Previous Revision

Revision	Date	Subjects (major changes since last revision)
2.1	2017-09-11	Final Datasheet
2.2	2017-11-30	New Gfs Value at VCE=20V
2.3	2019-09-13	Change of Rth/Zth values and maximum DC ratings

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