IGBT

IGBT with integrated diode in packages offering space saving advantage

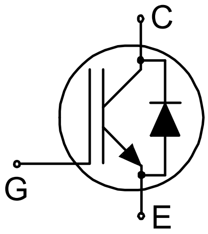
IKD04N60RF

TRENCHSTOP^{TM} RC-Series for hard switching applications up to 30 kHz

Data sheet

Industrial Power Control

IGBT with integrated diode in packages offering space saving advantage

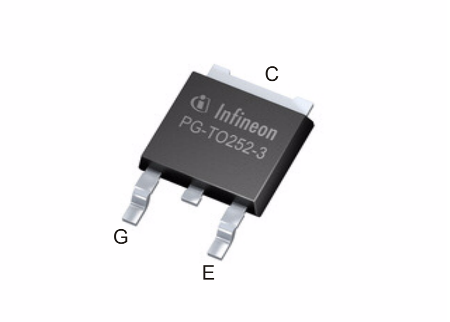


Features:

TRENCHSTOP^{TM} Reverse Conducting (RC) technology for 600V applications offering

- Optimized Eon, Eoff and Qrr for low switching losses
- Operating range of 4 to 30kHz
- Smooth switching performance leading to low EMI levels
- Very tight parameter distribution
- Maximum junction temperature 175°C
- Short circuit capability of 5µs
- Best in class current versus package size performance
- Qualified according to JEDEC for target applications
- Pb-free lead plating; RoHS compliant (solder temperature 260°C, MSL1)

Complete product spectrum and PSpice Models:
http://www.infineon.com/igbt/



Applications:

Domestic and industrial drives:

- Compressors
- Pumps
- Fans

Key Performance and Package Parameters

Type	V_{CE}	I_C	V_{CEsat}, T_{vj}=25°C	T_{vjmax}	Marking	Package
IKD04N60RF	600V	4A	2.2V	175°C	K04R60F	PG-TO252-3

Table of Contents

Maximum ratings

Parameter	Symbol	Value	Unit
Collector-emitter voltage	V_{CE}	600	V
DC collector current, limited by T_{vjmax} $T_C = 25°C$ $T_C = 100°C$	I_C	 8.0 4.0	A
Pulsed collector current, t_p limited by T_{vjmax}	I_{Cpuls}	12.0	A
Turn off safe operating area $V_{CE} \leq 600V$, $T_{vj} \leq 175°C$	-	12.0	A
Diode forward current, limited by T_{vjmax} $T_C = 25°C$ $T_C = 100°C$	I_F	 8.0 4.0	A
Diode pulsed current, t_p limited by T_{vjmax}	I_{Fpuls}	12.0	A
Gate-emitter voltage	V_{GE}	±20	V
Short circuit withstand time $V_{GE} = 15.0V$, $V_{CC} \leq 400V$ Allowed number of short circuits < 1000 Time between short circuits: ≥ 1.0s $T_{vj} = 150°C$	t_{SC}	 5	µs
Power dissipation $T_C = 25°C$	P_{tot}	75.0	W
Operating junction temperature	T_{vj}	-40...+175	°C
Storage temperature	T_{stg}	-55...+175	°C
Soldering temperature, reflow soldering (MSL1 according to JEDEC J-STA-020)		 260	°C

Thermal Resistance

Parameter	Symbol	Conditions	Max. Value	Unit
Characteristic				
IGBT thermal resistance,$^{1)}$ junction - case	$R_{th(j-c)}$		2.00	K/W
Diode thermal resistance,$^{2)}$ junction - case	$R_{th(j-c)}$		4.50	K/W
Thermal resistance, min. footprint junction - ambient	$R_{th(j-a)}$		75	K/W
Thermal resistance, 6cm² Cu on PCB junction - ambient	$R_{th(j-a)}$		50	K/W

---

1) Rth/Zth based on single cooling pulse. Please be aware that a correct Rth measurement of the IGBT, is not possible using a thermocouple.

2) Rth/Zth based on single cooling pulse. Please be aware that a correct Rth measurement of the Diode, is not possible using a thermocouple.

Electrical Characteristic, at T_{vj} = 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 = 0.20mA	600	-	-	V
Collector-emitter saturation voltage	V_{CEsat}	V_{GE} = 15.0V, I_C = 4.0A T_{vj} = 25°C T_{vj} = 175°C	- -	2.20 2.30	2.50 -	V
Diode forward voltage	V_F	V_{GE} = 0V, I_F = 4.0A T_{vj} = 25°C T_{vj} = 175°C	- -	2.10 2.00	2.40	V
Gate-emitter threshold voltage	$V_{GE(th)}$	I_C = 0.07mA, V_{CE} = V_{GE}	4.3	5.0	5.7	V
Zero gate voltage collector current[1]	I_{CES}	V_{CE} = 600V, V_{GE} = 0V T_{vj} = 25°C T_{vj} = 175°C	- -	- -	40.0 1000.0	µA
Gate-emitter leakage current	I_{GES}	V_{CE} = 0V, V_{GE} = 20V	-	-	100	nA
Transconductance	g_{fs}	V_{CE} = 20V, I_C = 4.0A	-	1.9	-	S
Integrated gate resistor	r_G			none		Ω

Electrical Characteristic, at T_{vj} = 25°C, unless otherwise specified

Parameter	Symbol	Conditions	Value			Unit
			min.	typ.	max.	
Dynamic Characteristic						
Input capacitance	C_{ies}	V_{CE} = 25V, V_{GE} = 0V, f = 1MHz	-	305	-	pF
Output capacitance	C_{oes}		-	18	-	
Reverse transfer capacitance	C_{res}		-	9	-	
Gate charge	Q_G	V_{CC} = 480V, I_C = 4.0A, V_{GE} = 15V	-	27.0	-	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: ≥ 1.0s	$I_{C(SC)}$	V_{GE} = 15.0V, V_{CC} ≤ 400V, t_{SC} ≤ 5µs T_{vj} = 25°C	-	32	-	A

---

[1] Not subject to production test - verified by design/characterization

Switching Characteristic, Inductive Load, at T_{vj} = 25°C

Parameter	Symbol	Conditions	Value			Unit
			min.	typ.	max.	
IGBT Characteristic						
Turn-on delay time	$t_{d(on)}$	T_{vj} = 25°C, V_{CC} = 400V, I_C = 4.0A, V_{GE} = 0.0/15.0V, r_G = 43.0Ω, L_σ = 60nH, C_σ = 40pF L_σ, C_σ from Fig. E	-	12	-	ns
Rise time	t_r		-	7	-	ns
Turn-off delay time	$t_{d(off)}$		-	116	-	ns
Fall time	t_f		-	37	-	ns
Turn-on energy	E_{on}		-	0.06	-	mJ
Turn-off energy	E_{off}		-	0.05	-	mJ
Total switching energy	E_{ts}		-	0.11	-	mJ

Diode Characteristic, at T_{vj} = 25°C

Diode reverse recovery time	t_{rr}	T_{vj} = 25°C, V_R = 400V, I_F = 4.0A, di_F/dt = 600A/µs	-	34	-	ns
Diode reverse recovery charge	Q_{rr}		-	0.09	-	µC
Diode peak reverse recovery current	I_{rrm}		-	4.6	-	A
Diode peak rate of fall of reverse recovery current during t_b	di_{rr}/dt		-	-220	-	A/µs

Switching Characteristic, Inductive Load, at T_{vj} = 175°C

Parameter	Symbol	Conditions	Value			Unit
			min.	typ.	max.	
IGBT Characteristic						
Turn-on delay time	$t_{d(on)}$	T_{vj} = 175°C, V_{CC} = 400V, I_C = 4.0A, V_{GE} = 0.0/15.0V, r_G = 43.0Ω, L_σ = 60nH, C_σ = 40pF L_σ, C_σ from Fig. E	-	11	-	ns
Rise time	t_r		-	7	-	ns
Turn-off delay time	$t_{d(off)}$		-	128	-	ns
Fall time	t_f		-	88	-	ns
Turn-on energy	E_{on}		-	0.11	-	mJ
Turn-off energy	E_{off}		-	0.08	-	mJ
Total switching energy	E_{ts}		-	0.19	-	mJ

Diode Characteristic, at T_{vj} = 175°C

Diode reverse recovery time	t_{rr}	T_{vj} = 175°C, V_R = 400V, I_F = 4.0A, di_F/dt = 600A/µs	-	82	-	ns
Diode reverse recovery charge	Q_{rr}		-	0.26	-	µC
Diode peak reverse recovery current	I_{rrm}		-	7.2	-	A
Diode peak rate of fall of reverse recovery current during t_b	di_{rr}/dt		-	-100	-	A/µs

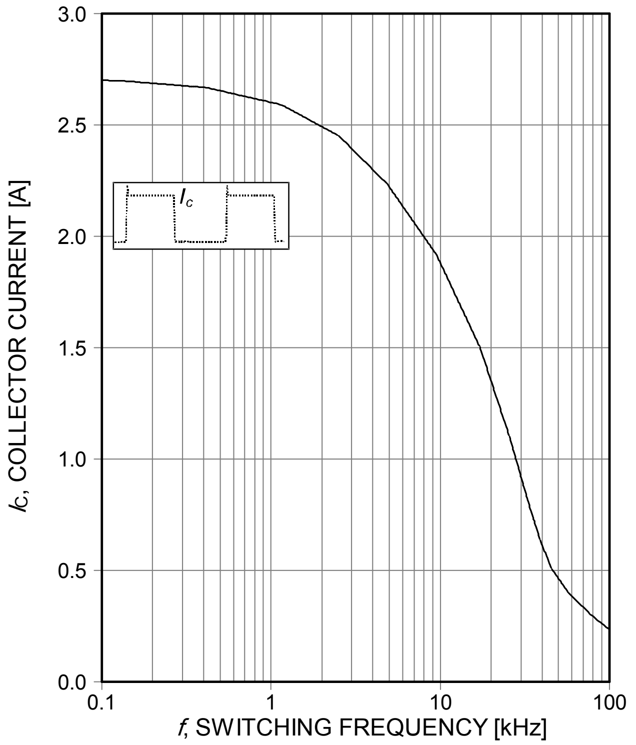


Figure 1. **Collector current as a function of switching frequency**
(T_{vj}≤175°C, T_a=55°C, D=0.5, V_{CE}=400V, V_{GE}=15/0V, r_G=43Ω, PCB mounting, 6cm2 Cu, Ptot=2,4W)

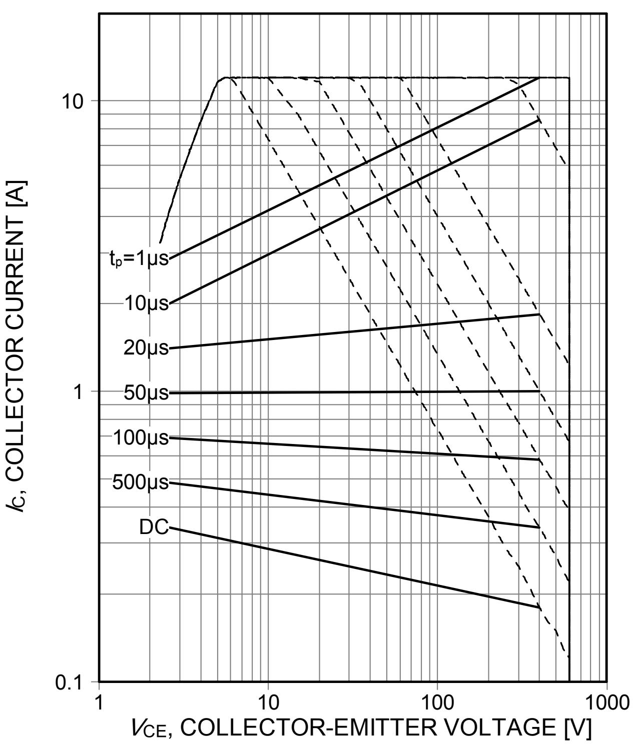


Figure 2. **Forward bias safe operating area**
(D=0, T_C=25°C, T_{vj}≤175°C; V_{GE}=15V)

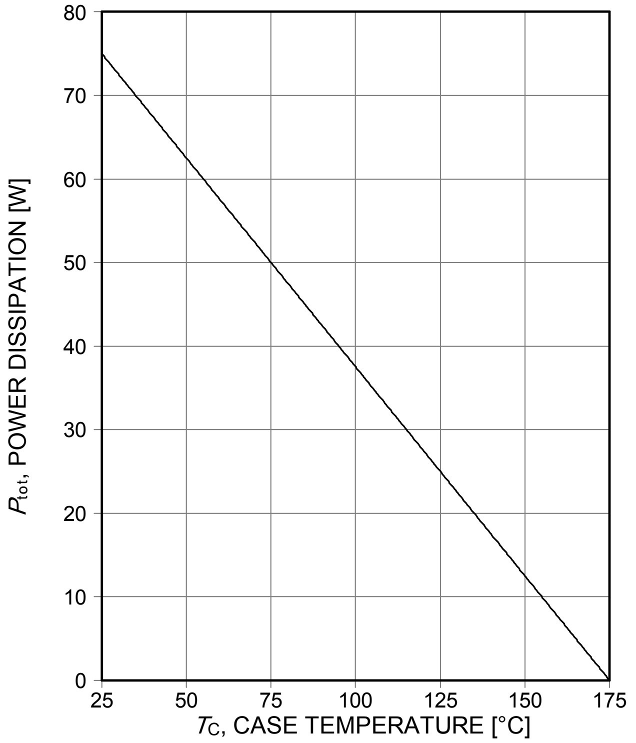


Figure 3. **Power dissipation as a function of case temperature**
(T_{vj}≤175°C)

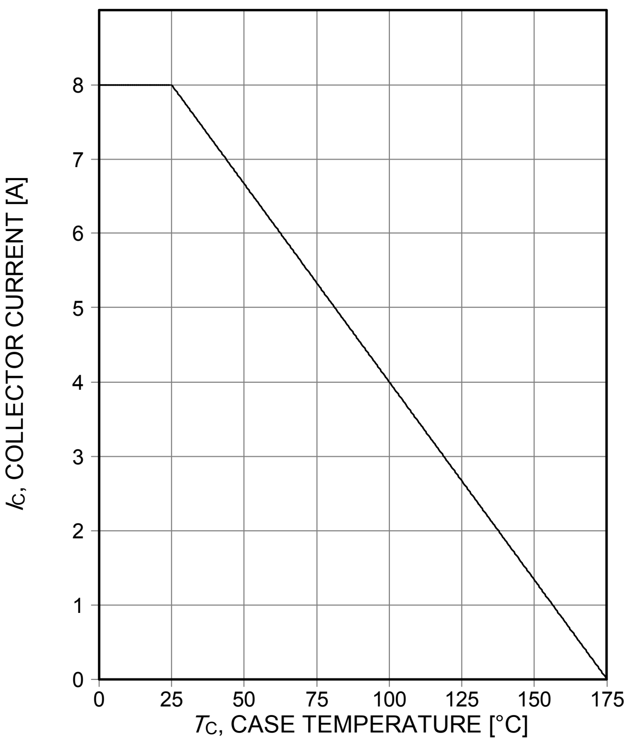


Figure 4. **Collector current as a function of case temperature**
(V_{GE}≥15V, T_{vj}≤175°C)

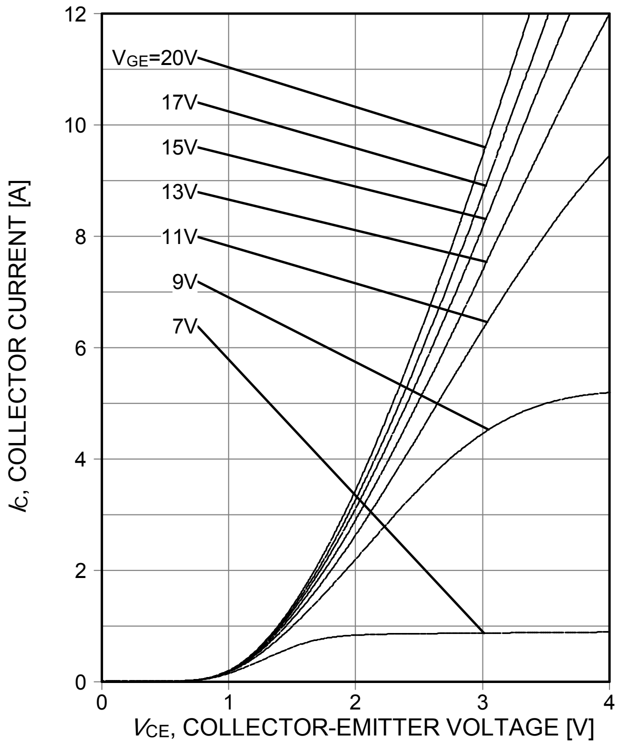


Figure 5. Typical output characteristic
(T_{vj}=25°C)

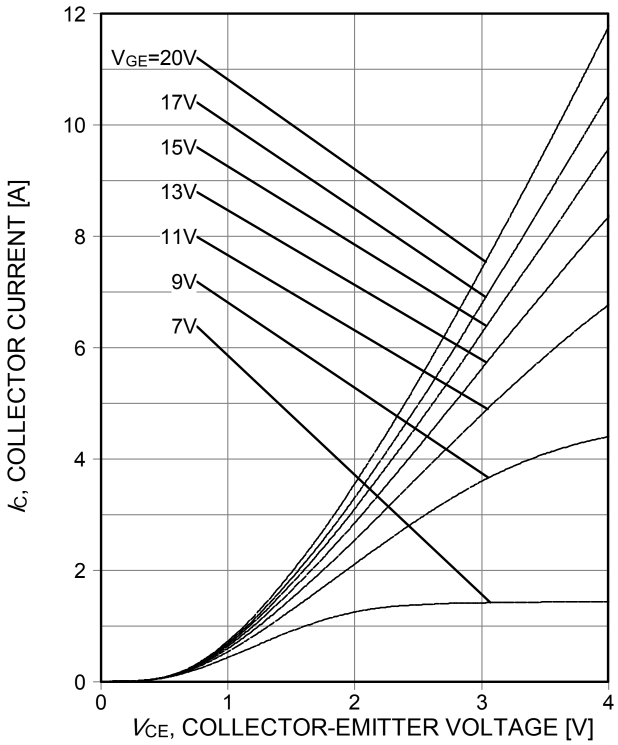


Figure 6. Typical output characteristic
(T_{vj}=175°C)

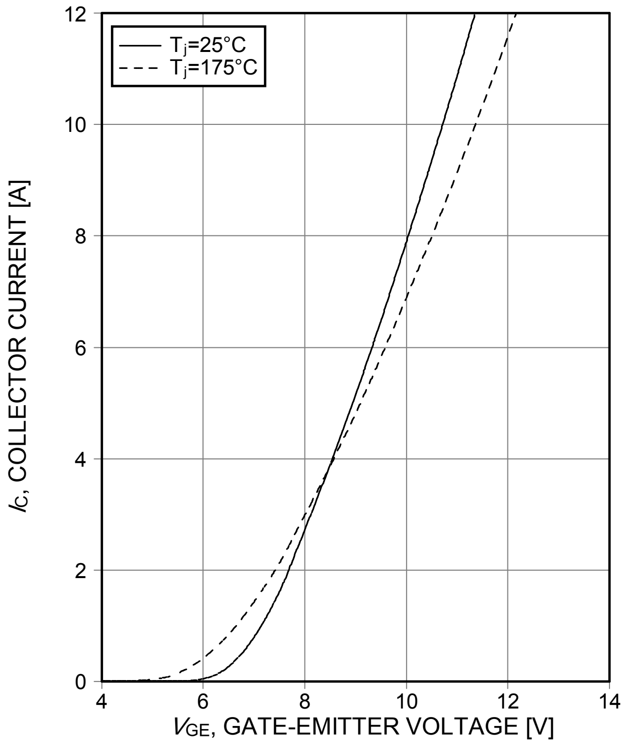


Figure 7. Typical transfer characteristic
(V_{CE}=10V)

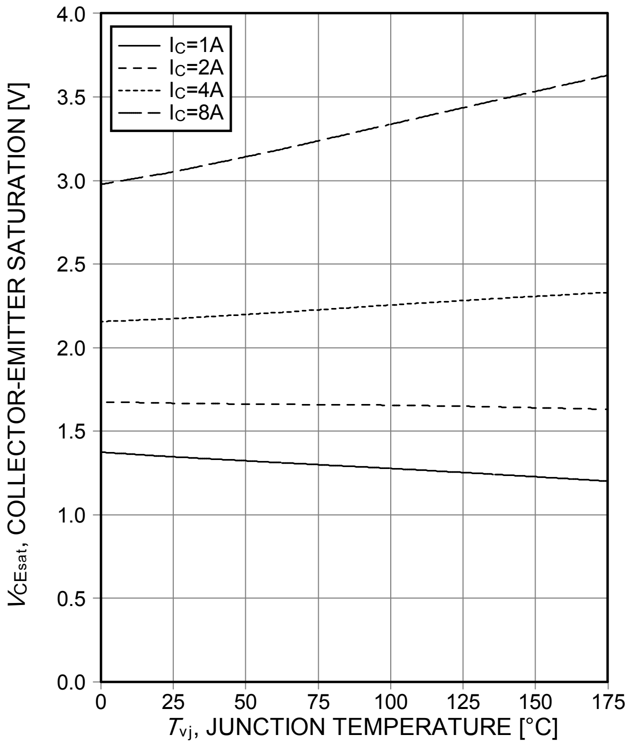


Figure 8. Typical collector-emitter saturation voltage as a function of junction temperature
(V_{GE}=15V)

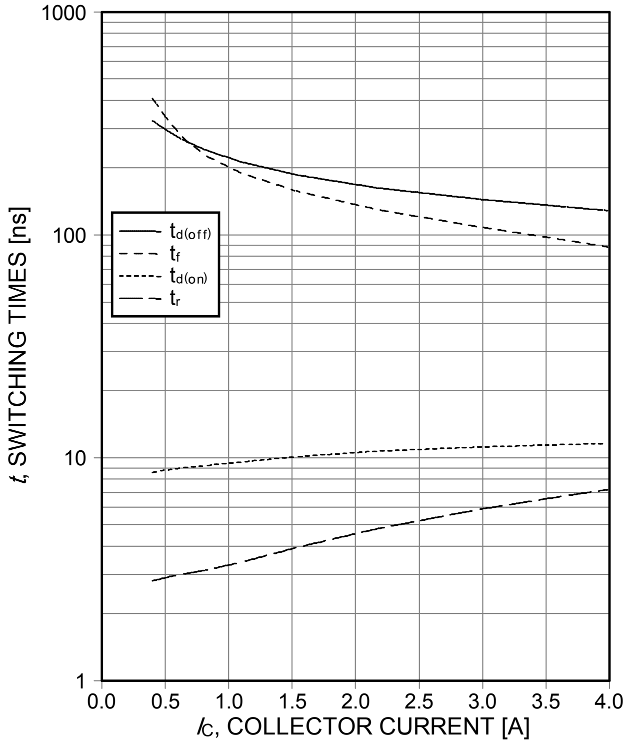


Figure 9. Typical switching times as a function of collector current
(inductive load, T_{vj}=175°C, V_{CE}=400V, V_{GE}=15/0V, r_G=43Ω, Dynamic test circuit in Figure E)

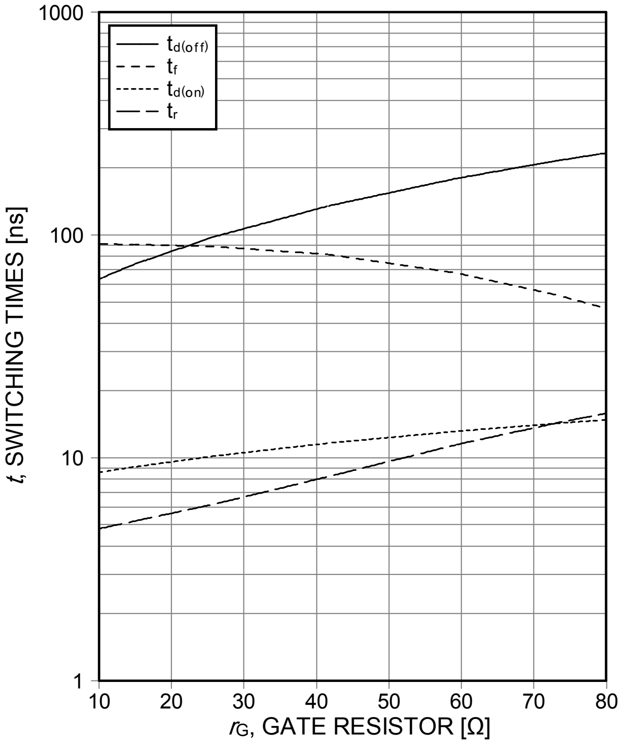


Figure 10. Typical switching times as a function of gate resistor
(inductive load, T_{vj}=175°C, V_{CE}=400V, V_{GE}=15/0V, I_C=4A, Dynamic test circuit in Figure E)

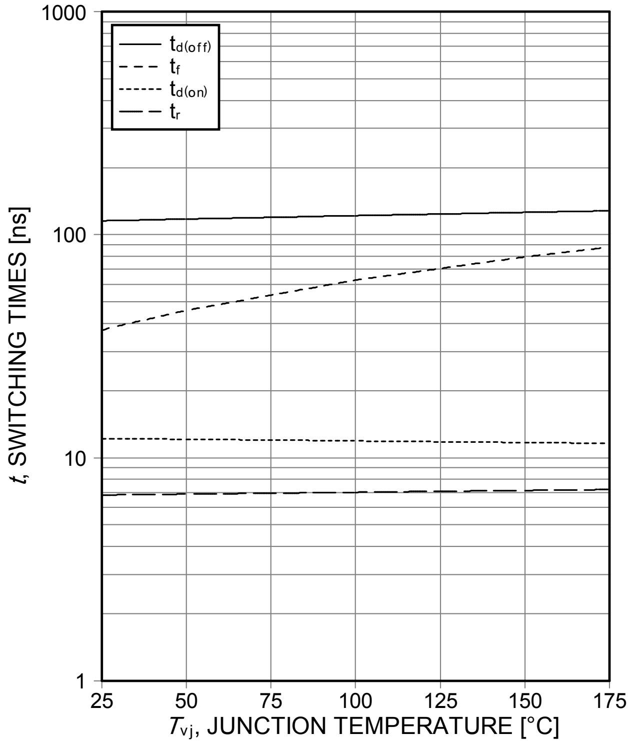


Figure 11. Typical switching times as a function of junction temperature
(inductive load, V_{CE}=400V, V_{GE}=15/0V, I_C=4A, r_G=43Ω, Dynamic test circuit in Figure E)

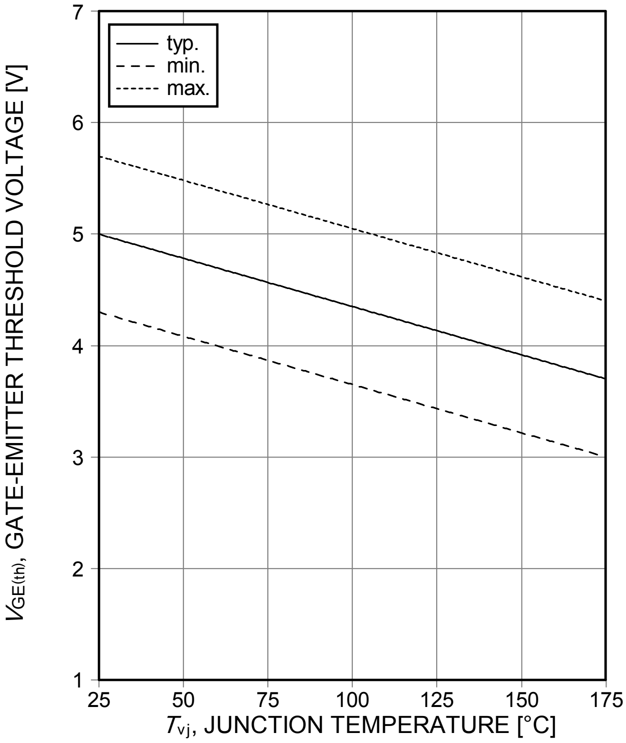


Figure 12. Gate-emitter threshold voltage as a function of junction temperature
(I_C=0,07mA)

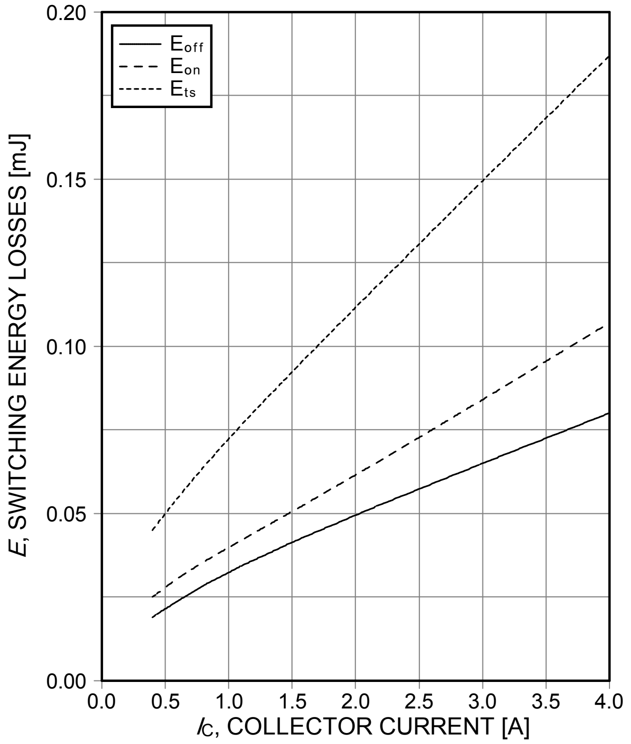


Figure 13. Typical switching energy losses as a function of collector current
(inductive load, T_{vj}=175°C, V_{CE}=400V, V_{GE}=15/0V, r_G=43Ω, Dynamic test circuit in Figure E)

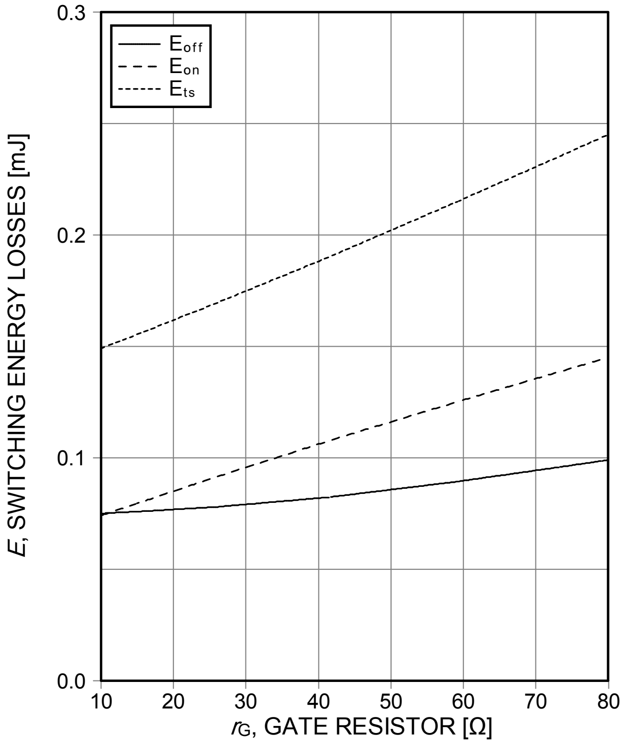


Figure 14. Typical switching energy losses as a function of gate resistor
(inductive load, T_{vj}=175°C, V_{CE}=400V, V_{GE}=15/0V, I_C=4A, Dynamic test circuit in Figure E)

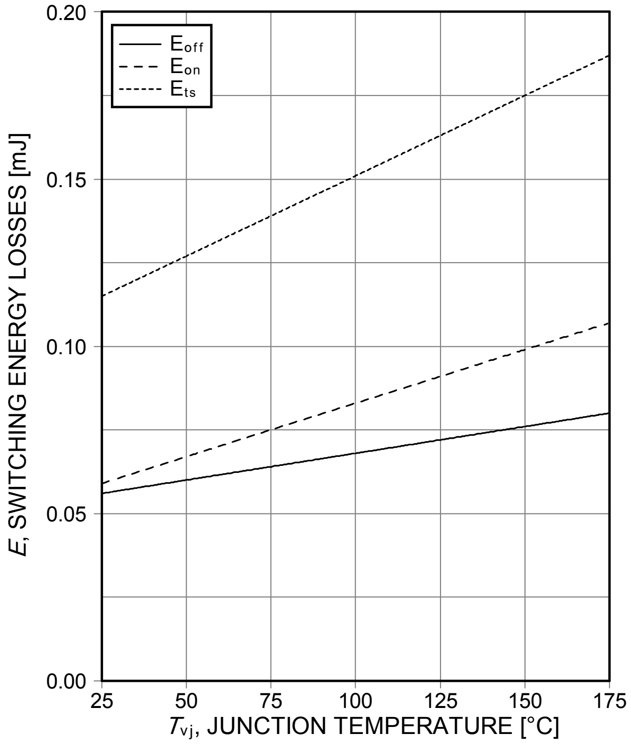


Figure 15. Typical switching energy losses as a function of junction temperature
(inductive load, V_{CE}=400V, V_{GE}=15/0V, I_C=4A, r_G=43Ω, Dynamic test circuit in Figure E)

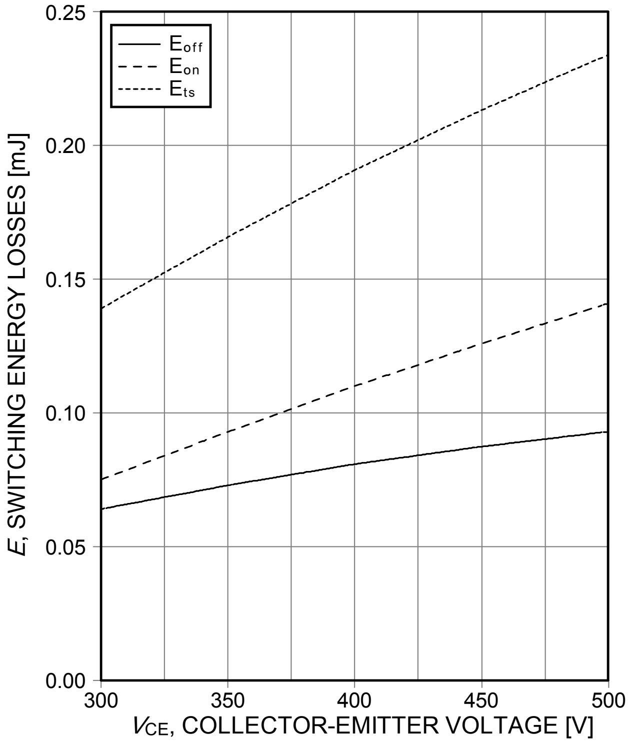


Figure 16. Typical switching energy losses as a function of collector emitter voltage
(inductive load, T_{vj}=175°C, V_{GE}=15/0V, I_C=4A, r_G=43Ω, Dynamic test circuit in Figure E)

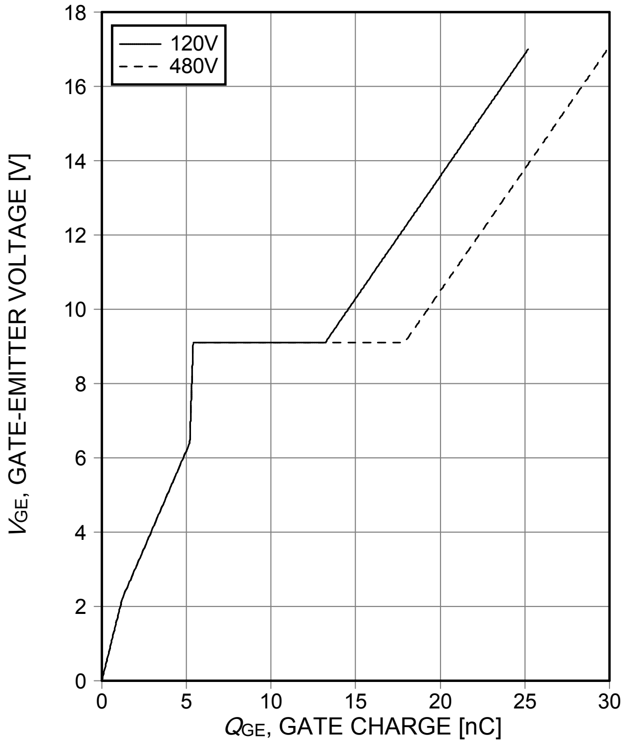


Figure 17. Typical gate charge
(I_C=4A)

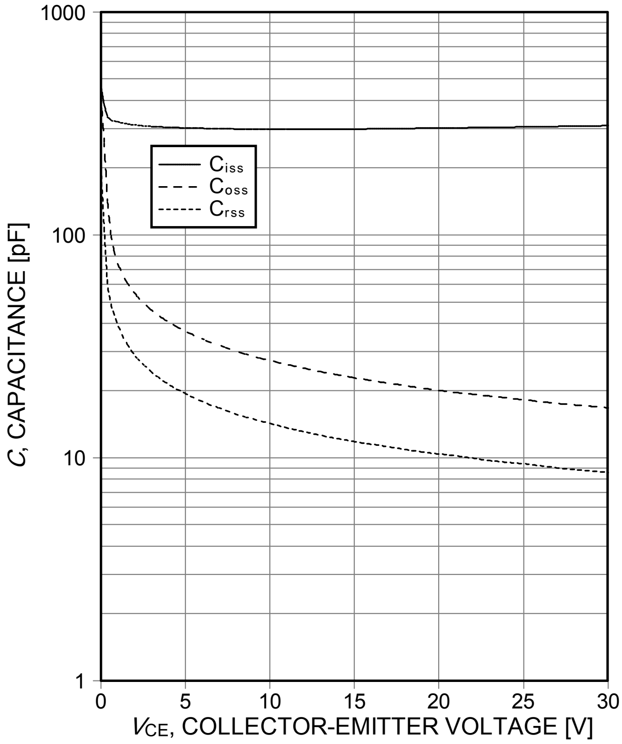


Figure 18. Typical capacitance as a function of collector-emitter voltage
(V_{GE}=0V, f=1MHz)

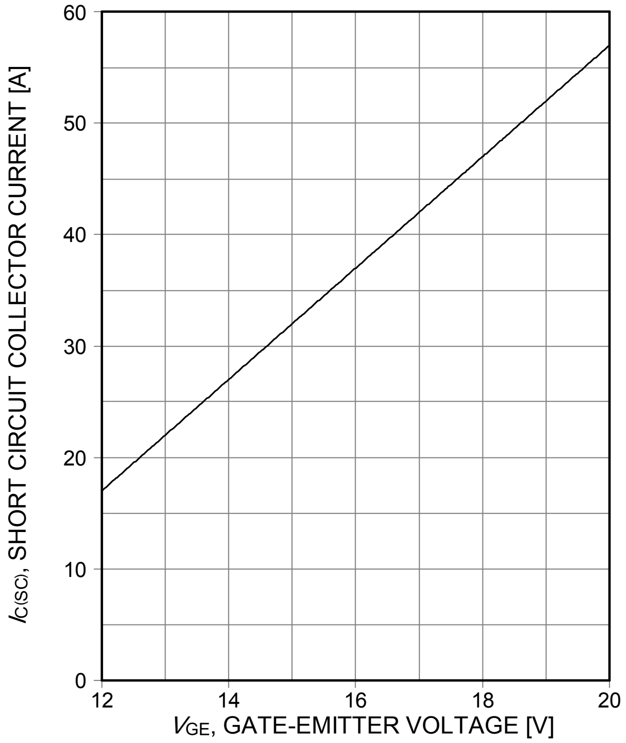


Figure 19. Typical short circuit collector current as a function of gate-emitter voltage
(V_{CE}≤400V, start at T_{vj}=25°C)

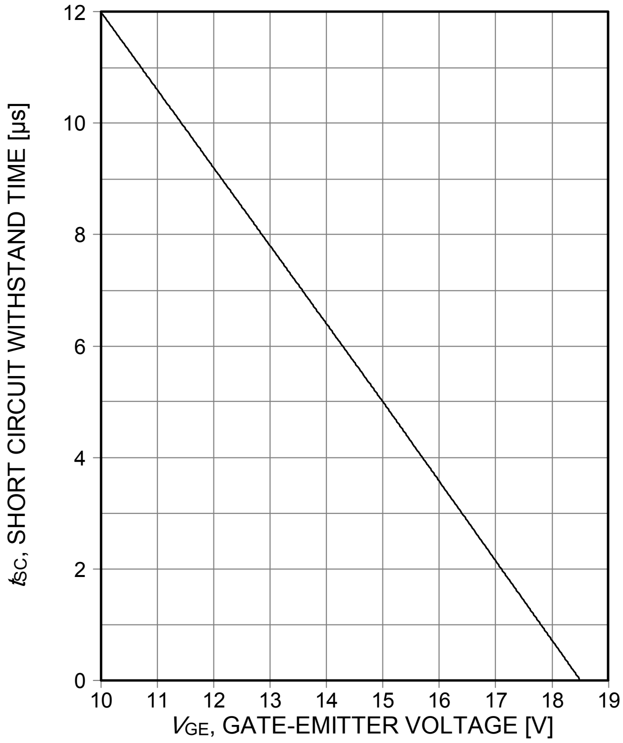
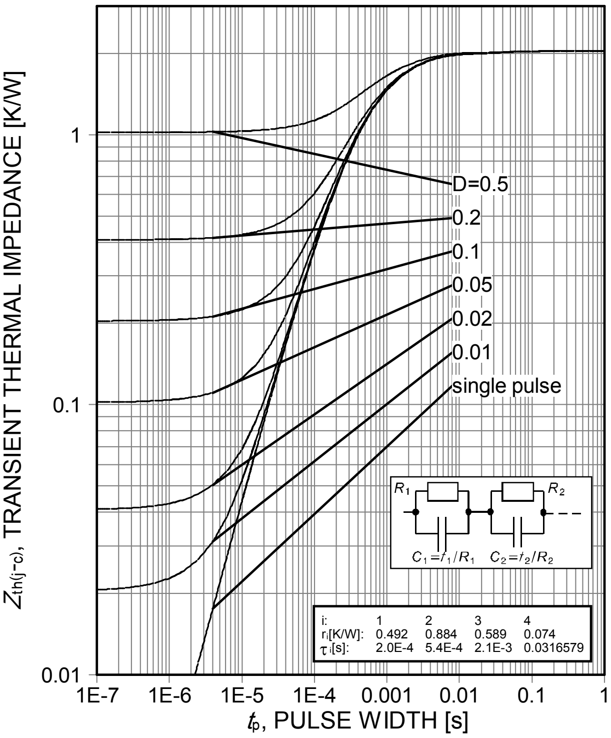
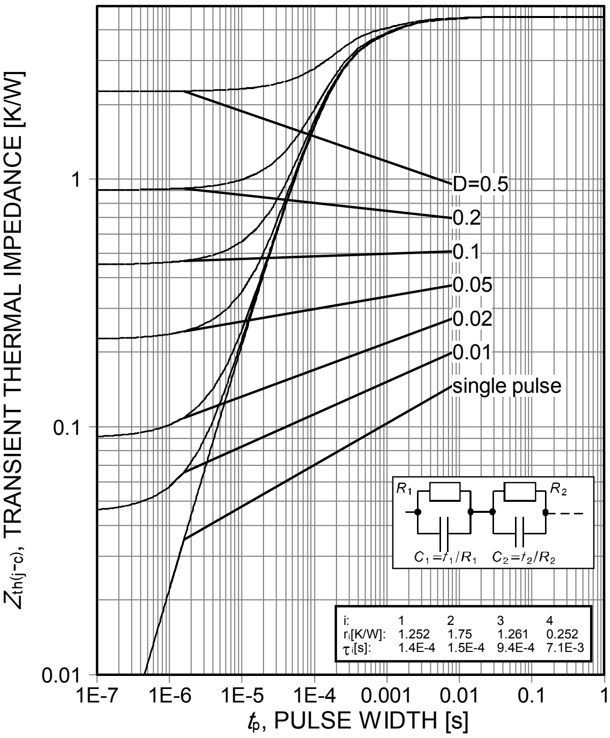


Figure 20. Short circuit withstand time as a function of gate-emitter voltage
(V_{CE}≤400V, start at T_{vj}=150°C)



i:	1	2	3	4
r_i[K/W]:	0.492	0.884	0.589	0.074
τ_i[s]:	2.0E-4	5.4E-4	2.1E-3	0.0316579

Figure 21. IGBT transient thermal impedance as a function of pulse width 1) (see page 4)
(D=t_p/T)



i:	1	2	3	4
r_i[K/W]:	1.252	1.75	1.261	0.252
τ_i[s]:	1.4E-4	1.5E-4	9.4E-4	7.1E-3

Figure 22. Diode transient thermal impedance as a function of pulse width 2) (see page 4)
(D=t_p/T)

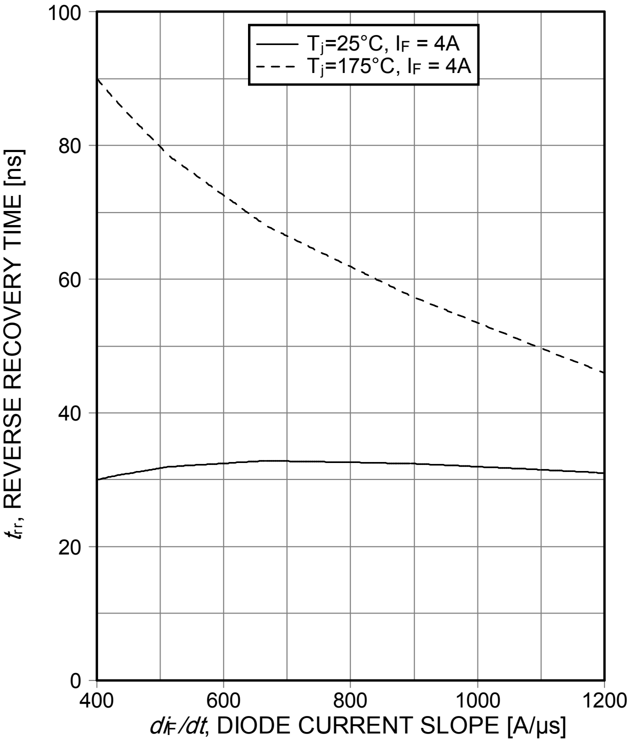


Figure 23. Typical reverse recovery time as a function of diode current slope
(V_R=400V)

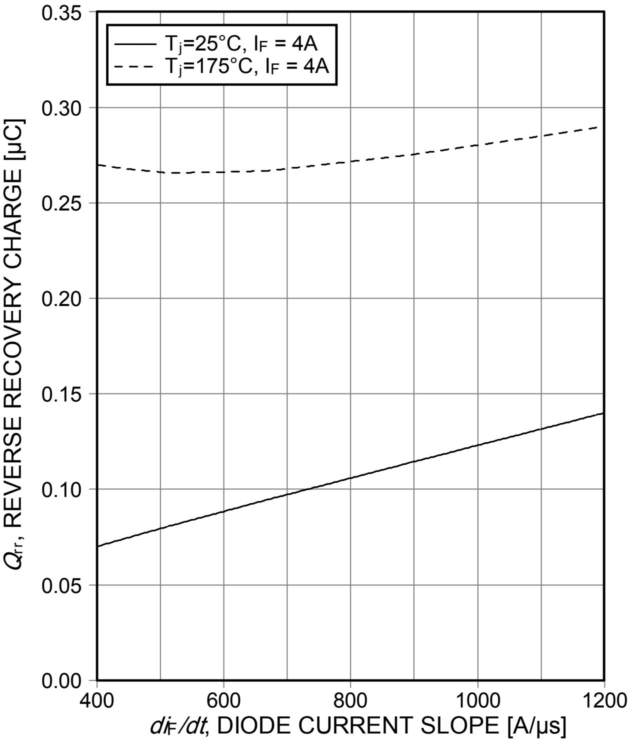


Figure 24. Typical reverse recovery charge as a function of diode current slope
(V_R=400V)

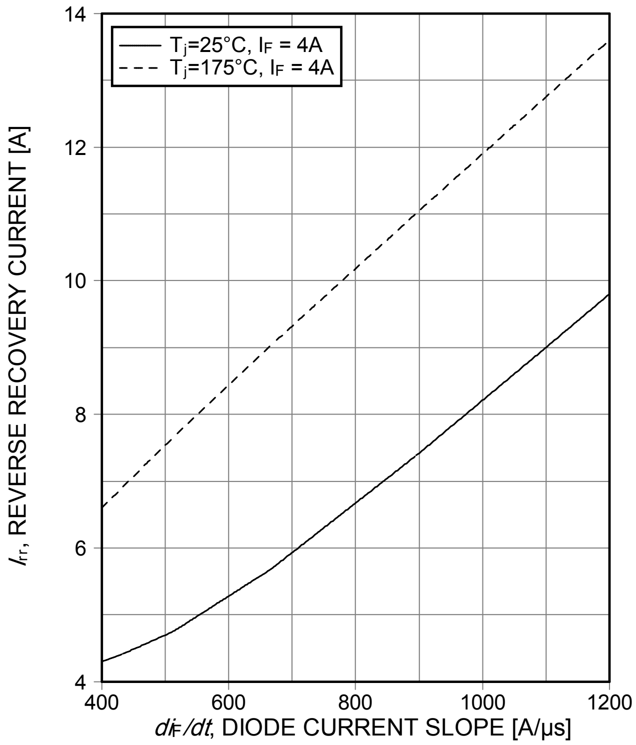


Figure 25. **Typical reverse recovery current as a function of diode current slope**
(V_R=400V)

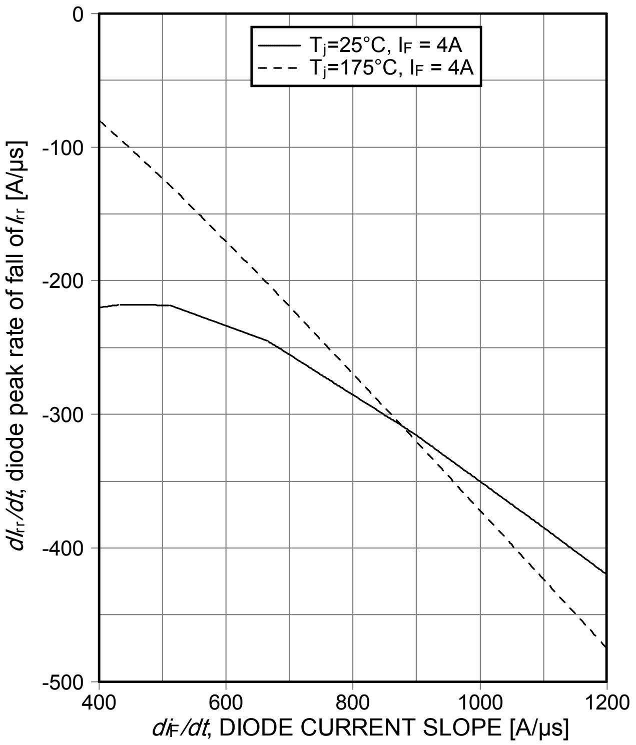


Figure 26. **Typical diode peak rate of fall of reverse recovery current as a function of diode current slope**
(V_R=400V)

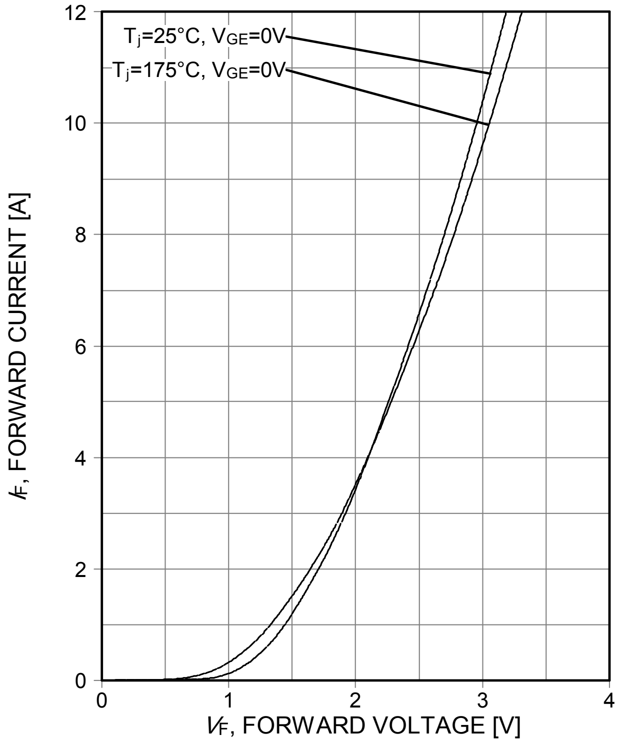


Figure 27. **Typical diode forward current as a function of forward voltage**

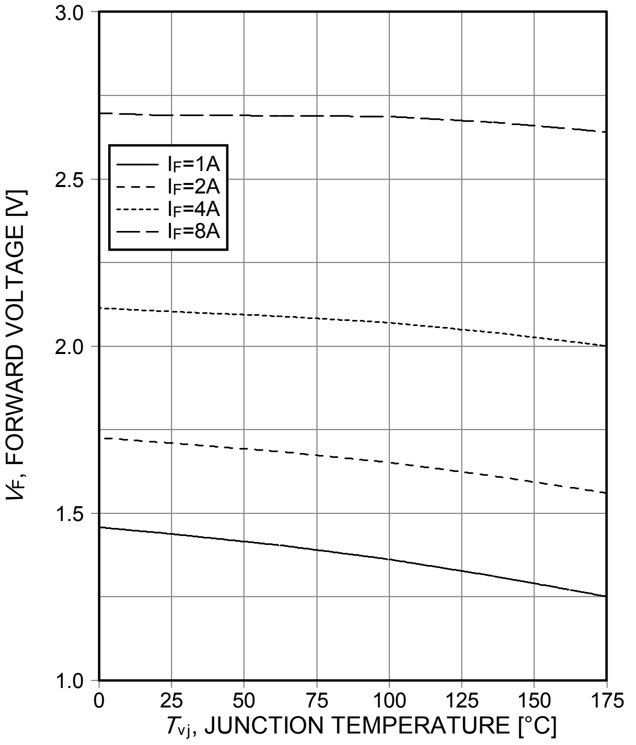
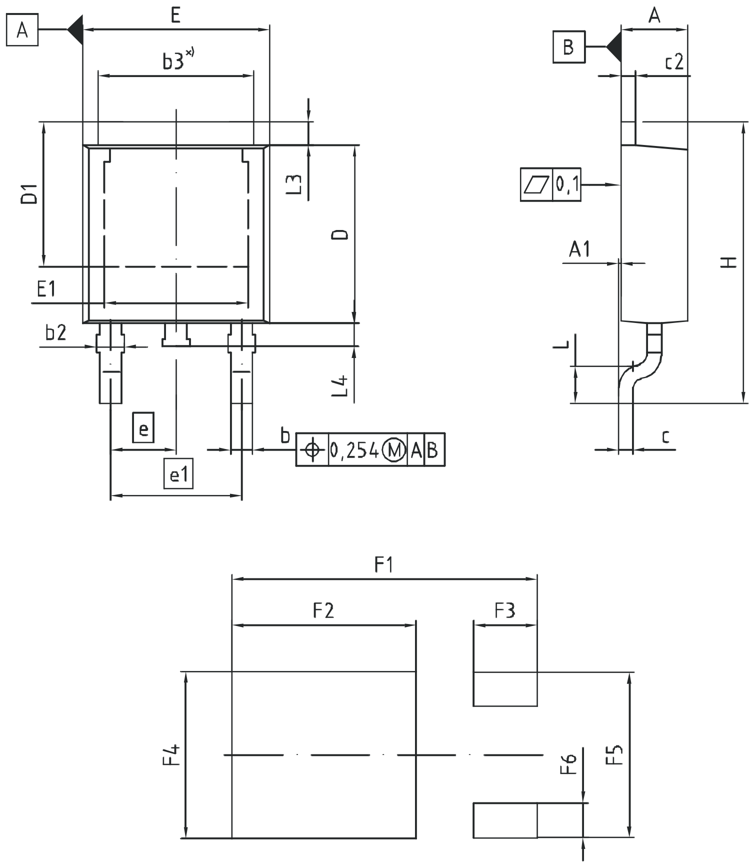


Figure 28. **Typical diode forward voltage as a function of junction temperature**

PG-TO252-3



*) mold flash not included

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	2.16	2.41	0.085	0.095
A1	0.00	0.15	0.000	0.006
b	0.64	0.89	0.025	0.035
b2	0.65	1.15	0.026	0.045
b3	5.00	5.50	0.197	0.217
c	0.46	0.60	0.018	0.024
c2	0.46	0.98	0.018	0.039
D	5.97	6.22	0.235	0.245
D1	5.02	5.84	0.198	0.230
E	6.40	6.73	0.252	0.265
E1	4.70	5.21	0.185	0.205
e	2.29 (BSC)		0.090 (BSC)	
e1	4.57		0.180	
N	3		3	
H	9.40	10.48	0.370	0.413
L	1.18	1.70	0.046	0.067
L3	0.90	1.25	0.035	0.049
L4	0.51	1.00	0.020	0.039
F1	10.60		0.417	
F2	6.40		0.252	
F3	2.20		0.087	
F4	5.80		0.228	
F5	5.76		0.227	
F6	1.20		0.047	

DOCUMENT NO.
Z8B00003328

SCALE 0 2.0 4mm

EUROPEAN PROJECTION

ISSUE DATE
16-02-2011

REVISION
04

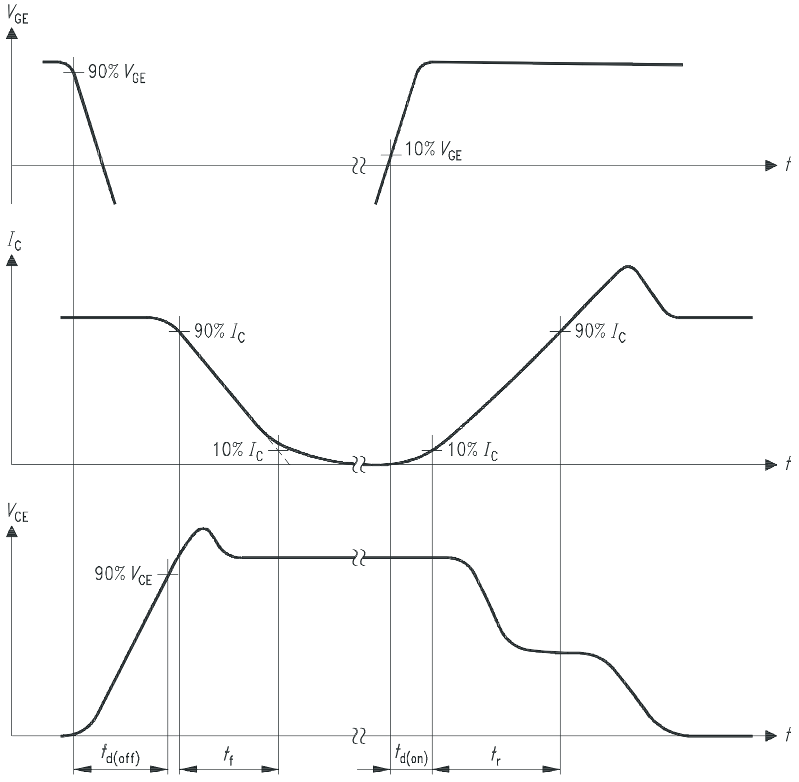


Figure A. Definition of switching times

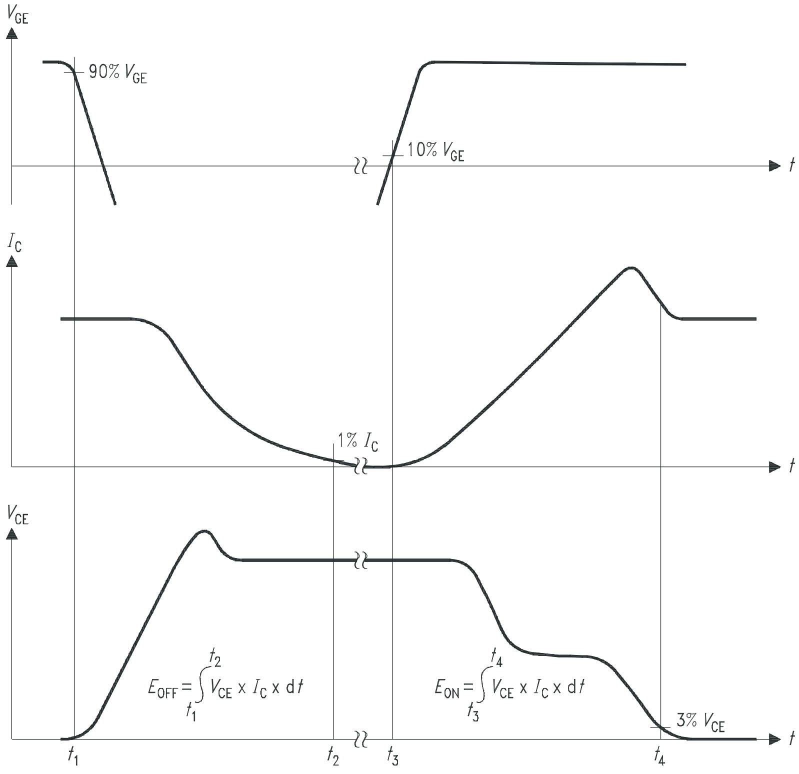


Figure B. Definition of switching losses

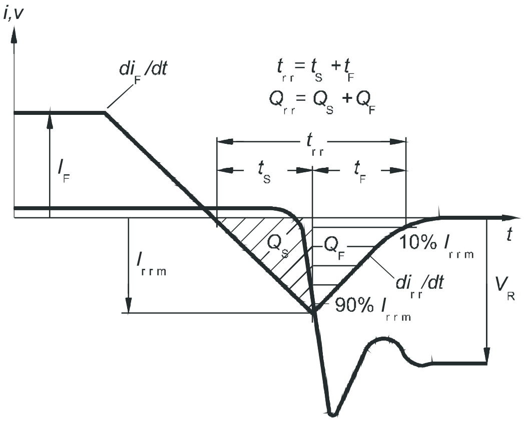


Figure C. Definition of diodes switching characteristics

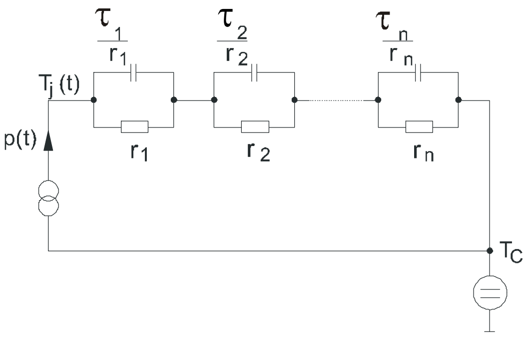


Figure D. Thermal equivalent circuit

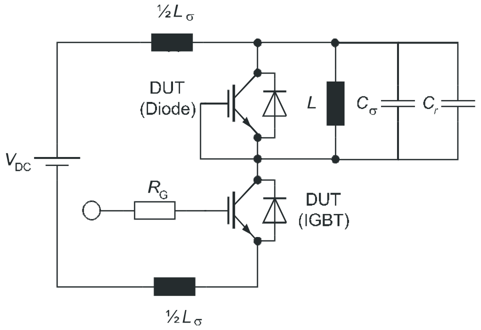


Figure E. Dynamic test circuit

Parasitic inductance L_σ,
Parasitic capacitor C_σ,
Relief capacitor C_r
(only for ZVT switching)

Revision History

IKD04N60RF

Revision: 2012-02-24, Rev. 2.2

Previous Revision

Revision	Date	Subjects (major changes since last revision)
1.1	2011-06-07	Preliminary Data sheet
2.2	2012-02-24	Final data sheet

We Listen to Your Comments

Any information within this document that you feel is wrong, unclear or missing at all ?
Your feedback will help us to continuously improve the quality of this document.
Please send your proposal (including a reference to this document) to: erratum@infineon.com

Published by
Infineon Technologies AG
81726 Munich, Germany
81726 München, Germany

Information

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.
The Infineon Technologies component described in this Data Sheet may be used in life-support devices or systems and/or automotive, aviation and aerospace applications 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, automotive, aviation and aerospace 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.