

TRENCHSTOP™ Advanced Isolation

High speed switching series third generation IGBT copacked with Rapid 1 fast and soft antiparallel diode in fully isolated package

Features:

TRENCHSTOP™ technology offers :

- Low $V_{CE(sat)}$
- Short circuit withstand time $5\mu s$ at $T_{vj} = 175^{\circ}C$
- Positive temperature coefficient in $V_{CE(sat)}$
- Low EMI
- Very soft, fast recovery anti-parallel diode
- Maximum junction temperature $175^{\circ}C$
- $2500 V_{RMS}$ electrical isolation, 50/60 Hz, $t = 1 \text{ min}$
- 100 % tested isolated mounting surface
- Pb-free lead plating; RoHS compliant
- Complete product spectrum and PSpice Models : <http://www.infineon.com/igbt>

Potential Applications:

- General Purpose Drives (GPD)
- Servo Drives
- Industrial SMPS
- Industrial UPS
- Charger
- Welding
- Solar String Inverter

Product Validation:

Qualified for industrial applications according to the relevant tests of JEDEC 47/20/22



Fully isolated package TO-247

**Key Performance and Package Parameters**

Type	V_{CE}	I_C	$V_{CEsat}, T_{vj}=25^{\circ}C$	T_{vjmax}	Marking	Package
IKFW60N60EH3	600V	50A	1.85V	$175^{\circ}C$	K60DEH3	PG-TO247-3-AI



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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}	600	V
DC collector current, limited by T_{vjmax} $T_h = 25^{\circ}\text{C}$ $T_h = 65^{\circ}\text{C}$ $T_h = 65^{\circ}\text{C}$	I_C	64.0 52.0 63.0 ¹⁾	A
Pulsed collector current, t_p limited by T_{vjmax}	I_{Cpuls}	200.0	A
Turn off safe operating area $V_{CE} \leq 600\text{V}$, $T_{vj} \leq 175^{\circ}\text{C}$, $t_p = 1\mu\text{s}$	-	200.0	A
Diode forward current, limited by T_{vjmax} $T_h = 25^{\circ}\text{C}$ $T_h = 65^{\circ}\text{C}$	I_F	80.0 60.0	A
Diode pulsed current, t_p limited by T_{vjmax}	I_{Fpuls}	200.0	A
Gate-emitter voltage Transient Gate-emitter voltage ($t_p \leq 10\mu\text{s}$, $D < 0.010$)	V_{GE}	± 20 ± 30	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	μs
Power dissipation $T_h = 25^{\circ}\text{C}$ Power dissipation $T_h = 65^{\circ}\text{C}$	P_{tot}	164.0 120.0	W
Operating junction temperature	T_{vj}	$-40 \dots +175$	$^{\circ}\text{C}$
Storage temperature	T_{stg}	$-55 \dots +150$	$^{\circ}\text{C}$
Soldering temperature, wave soldering 1.6mm (0.063in.) from case for 10s		260	$^{\circ}\text{C}$
Mounting torque, M3 screw Maximum of mounting processes: 3	M	0.6	Nm
Isolation voltage RMS, $f = 50/60\text{Hz}$, $t = 1\text{min}^{2)}$	V_{isol}	2500	V

Thermal Resistance

Parameter	Symbol	Conditions	Value			Unit
			min.	typ.	max.	

R_{th} Characteristics

IGBT thermal resistance, ³⁾ junction - heatsink	$R_{th(j-h)}$		-	0.77	0.91	K/W
Diode thermal resistance, ³⁾ junction - heatsink	$R_{th(j-h)}$		-	1.18	1.30	K/W
Thermal resistance junction - ambient	$R_{th(j-a)}$		-	-	65	K/W

¹⁾ Equivalent current rating in TO-247-3 at $T_h = 65^{\circ}\text{C}$ using reference insulation material: 152 μm , 1.3 W/mK, standard polyimide based reinforced carrier insulator

²⁾ For a proper handling and assembly of the advanced isolation device in the application refer to the note at the package drawing.

³⁾ At force on body $F = 500\text{N}$, $T_a = 25^{\circ}\text{C}$

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

Parameter	Symbol	Conditions	Value			Unit
			min.	typ.	max.	
Static Characteristic						
Collector-emitter breakdown voltage	$V_{(BR)CES}$	$V_{GE} = 0V, I_C = 0.50mA$	600	-	-	V
Collector-emitter saturation voltage	V_{CEsat}	$V_{GE} = 15.0V, I_C = 50.0A$ $T_{vj} = 25^{\circ}C$ $T_{vj} = 175^{\circ}C$	- -	1.85 2.25	2.30 -	V
Diode forward voltage	V_F	$V_{GE} = 0V, I_F = 50.0A$ $T_{vj} = 25^{\circ}C$ $T_{vj} = 175^{\circ}C$	- -	1.45 1.40	1.75 -	V
Gate-emitter threshold voltage	$V_{GE(th)}$	$I_C = 0.80mA, V_{CE} = V_{GE}$	4.1	5.1	5.7	V
Zero gate voltage collector current	I_{CES}	$V_{CE} = 600V, V_{GE} = 0V$ $T_{vj} = 25^{\circ}C$ $T_{vj} = 175^{\circ}C$	- -	- 880	40 -	μA
Gate-emitter leakage current	I_{GES}	$V_{CE} = 0V, V_{GE} = 20V$	-	-	100	nA
Transconductance	g_{fs}	$V_{CE} = 20V, I_C = 50.0A$	-	25.0	-	S

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

Parameter	Symbol	Conditions	Value			Unit
			min.	typ.	max.	
Dynamic Characteristic						
Input capacitance	C_{ies}	$V_{CE} = 25V, V_{GE} = 0V, f = 1MHz$	-	3216	-	pF
Output capacitance	C_{oes}		-	150	-	
Reverse transfer capacitance	C_{res}		-	90	-	
Gate charge	Q_G	$V_{CC} = 480V, I_C = 50.0A,$ $V_{GE} = 15V$	-	290.0	-	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: $\geq 1.0s$	$I_{C(SC)}$	$V_{GE} = 15.0V, V_{CC} \leq 400V,$ $t_{SC} \leq 5\mu s$ $T_{vj} = 150^{\circ}C$	-	330	-	A

Switching Characteristic, Inductive Load

Parameter	Symbol	Conditions	Value			Unit
			min.	typ.	max.	
IGBT Characteristic, at $T_{vj} = 25^{\circ}\text{C}$						
Turn-on delay time	$t_{d(on)}$	$T_{vj} = 25^{\circ}\text{C},$ $V_{CC} = 400\text{V}, I_C = 50.0\text{A},$ $V_{GE} = 0.0/15.0\text{V},$ $R_{G(on)} = 7.0\Omega, R_{G(off)} = 7.0\Omega,$ $L\sigma = 75\text{nH}, C\sigma = 30\text{pF}$ $L\sigma, C\sigma$ from Fig. E Energy losses include “tail” and diode reverse recovery.	-	27	-	ns
Rise time	t_r		-	37	-	ns
Turn-off delay time	$t_{d(off)}$		-	229	-	ns
Fall time	t_f		-	24	-	ns
Turn-on energy	E_{on}		-	1.74	-	mJ
Turn-off energy	E_{off}		-	0.93	-	mJ
Total switching energy	E_{ts}		-	2.67	-	mJ

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

Diode reverse recovery time	t_{rr}	$T_{vj} = 25^{\circ}\text{C},$ $V_R = 400\text{V},$ $I_F = 50.0\text{A},$ $di_F/dt = 1000\text{A}/\mu\text{s}$	-	91	-	ns
Diode reverse recovery charge	Q_{rr}		-	1.24	-	μC
Diode peak reverse recovery current	I_{rrm}		-	27.0	-	A
Diode peak rate of fall of reverse recovery current during t_b	di_{rr}/dt		-	-1955	-	$\text{A}/\mu\text{s}$

Switching Characteristic, Inductive Load

Parameter	Symbol	Conditions	Value			Unit
			min.	typ.	max.	

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

Turn-on delay time	$t_{d(on)}$	$T_{vj} = 175^{\circ}\text{C},$ $V_{CC} = 400\text{V}, I_C = 50.0\text{A},$ $V_{GE} = 0.0/15.0\text{V},$ $R_{G(on)} = 7.0\Omega, R_{G(off)} = 7.0\Omega,$ $L\sigma = 75\text{nH}, C\sigma = 30\text{pF}$ Energy losses include "tail" and diode reverse recovery.	-	26	-	ns
Rise time	t_r		-	37	-	ns
Turn-off delay time	$t_{d(off)}$		-	260	-	ns
Fall time	t_f		-	22	-	ns
Turn-on energy	E_{on}		-	2.60	-	mJ
Turn-off energy	E_{off}		-	1.02	-	mJ
Total switching energy	E_{ts}		-	3.62	-	mJ

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

Diode reverse recovery time	t_{rr}	$T_{vj} = 175^{\circ}\text{C},$ $V_R = 400\text{V},$ $I_F = 50.0\text{A},$ $di_F/dt = 1000\text{A}/\mu\text{s}$	-	139	-	ns
Diode reverse recovery charge	Q_{rr}		-	3.29	-	μC
Diode peak reverse recovery current	I_{rrm}		-	34.0	-	A
Diode peak rate of fall of reverse recovery current during t_b	di_{rr}/dt		-	-1489	-	$\text{A}/\mu\text{s}$

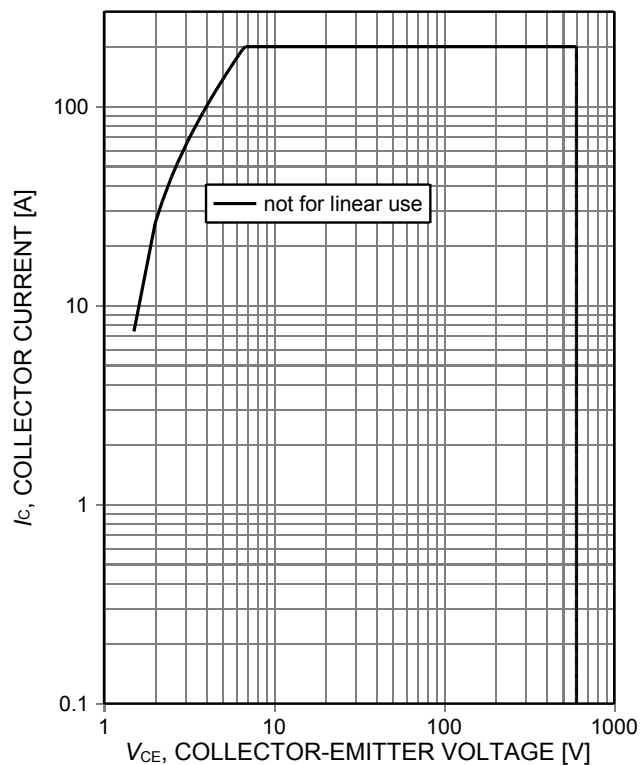


Figure 1. **Forward bias safe operating area**
($D=0$, $T_h=25^\circ\text{C}$, $T_j\leq 175^\circ\text{C}$, $V_{GE}=15\text{V}$, $t_p\leq 1\mu\text{s}$)

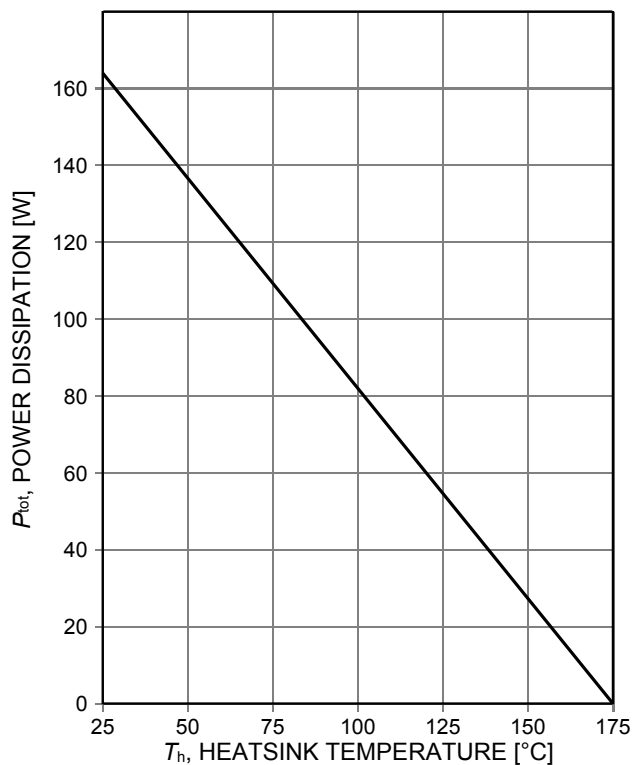


Figure 2. **Power dissipation as a function of heatsink temperature**
($T_j\leq 175^\circ\text{C}$)

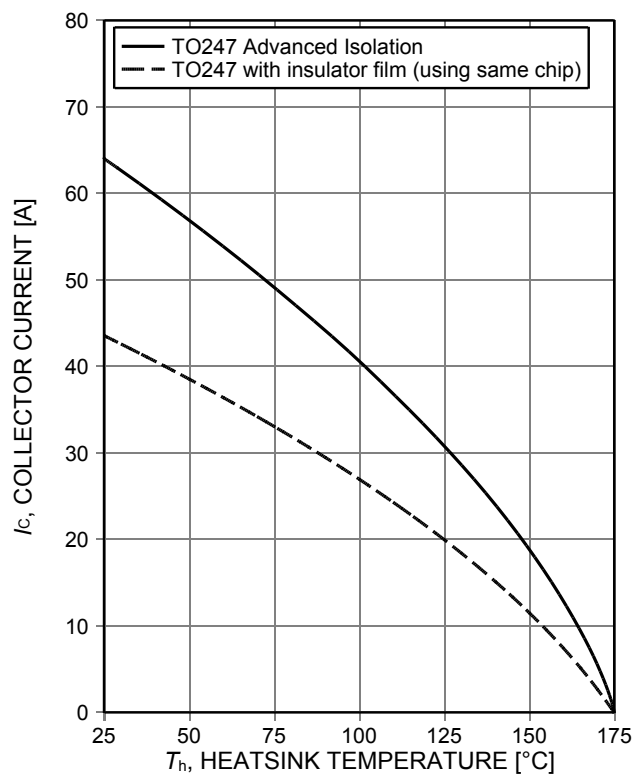


Figure 3. **Collector current as a function of heatsink temperature**
($V_{GE}\geq 15\text{V}$, $T_j\leq 175^\circ\text{C}$, insulator film: $152\mu\text{m}$, 1.3W/mK)

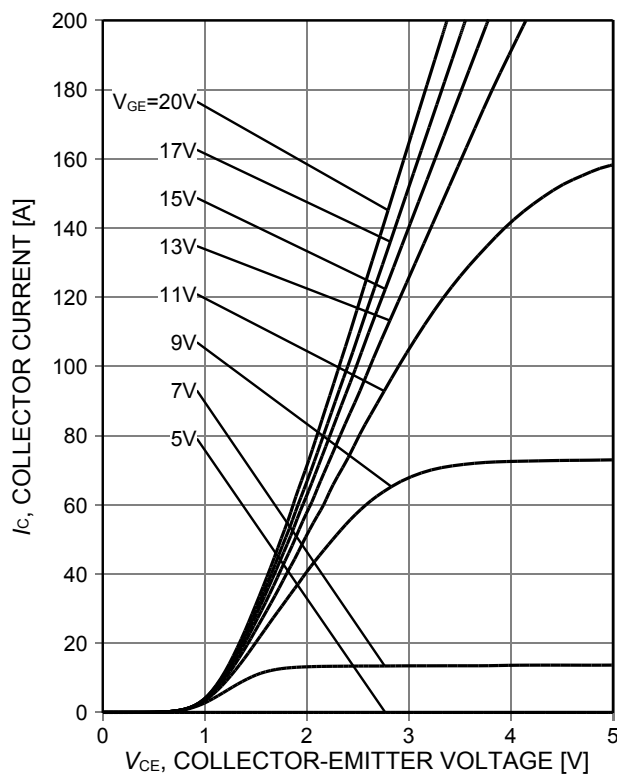


Figure 4. **Typical output characteristic**
($T_j=25^\circ\text{C}$)

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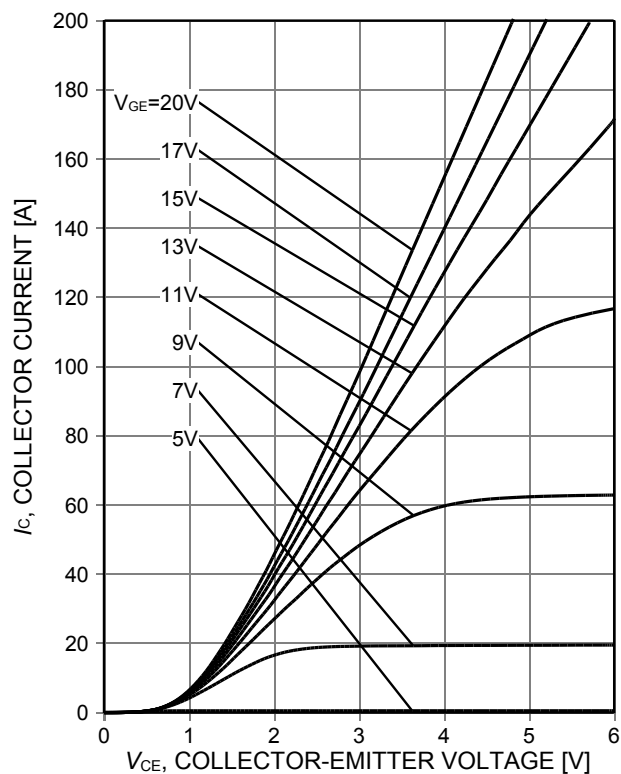


Figure 5. **Typical output characteristic**
($T_j=175^\circ\text{C}$)

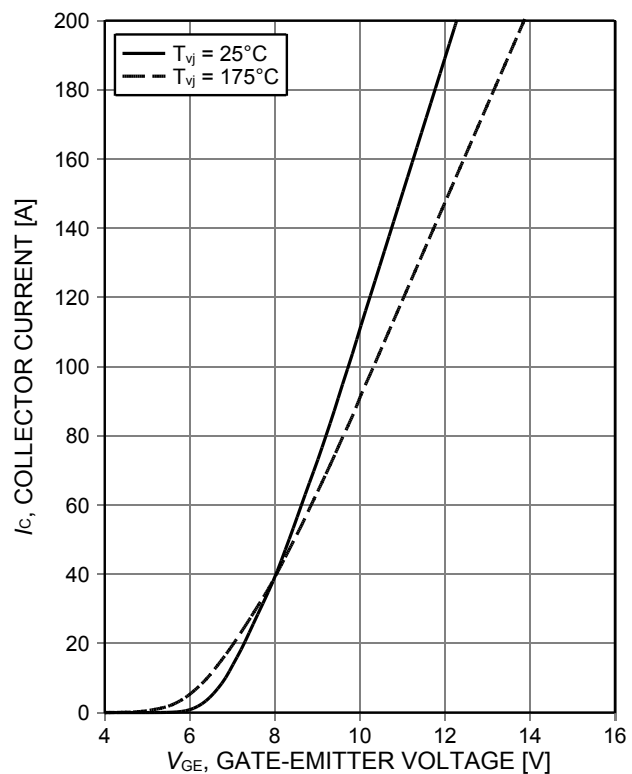


Figure 6. **Typical transfer characteristic**
($V_{CE}=20\text{V}$)

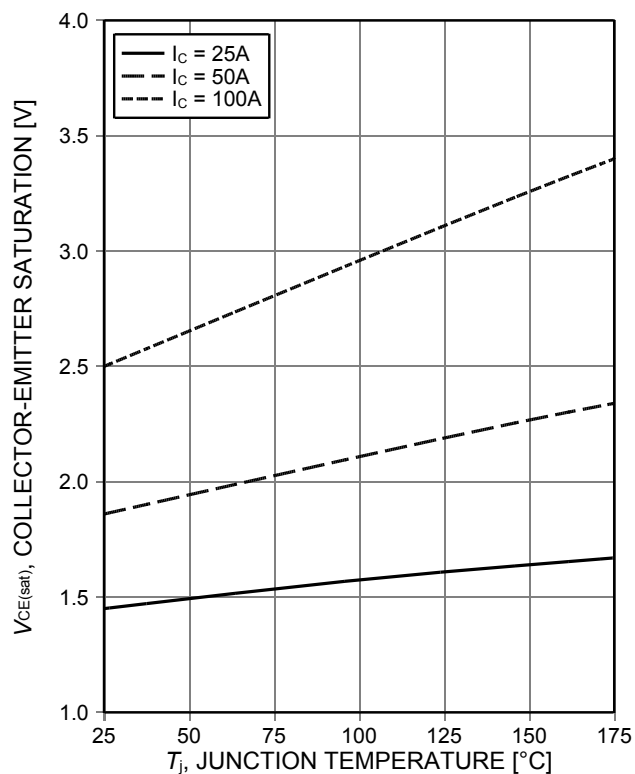


Figure 7. **Typical collector-emitter saturation voltage as a function of junction temperature**
($V_{GE}=15\text{V}$)

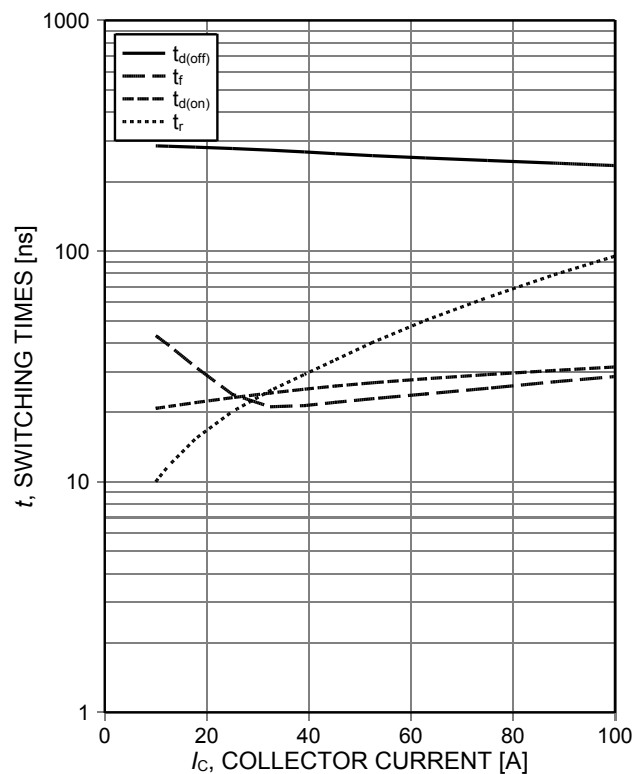


Figure 8. **Typical switching times as a function of collector current**
(ind. load, $T_j=175^\circ\text{C}$, $V_{CE}=400\text{V}$, $V_{GE}=0/15\text{V}$, $R_G=7\Omega$, test circuit in Fig. E)

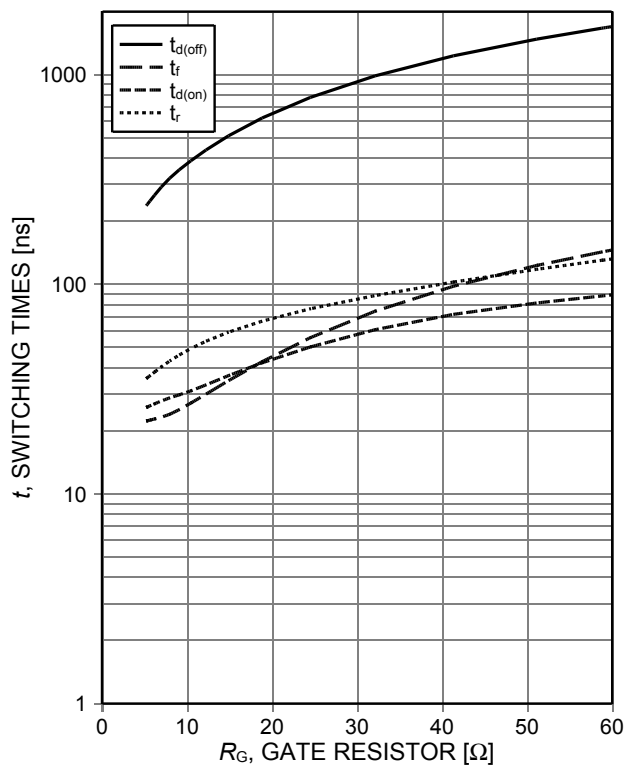


Figure 9. **Typical switching times as a function of gate resistor**
(ind. load, $T_j=175^\circ\text{C}$, $V_{CE}=400\text{V}$, $V_{GE}=0/15\text{V}$, $I_C=50\text{A}$, test circuit in Fig. E)

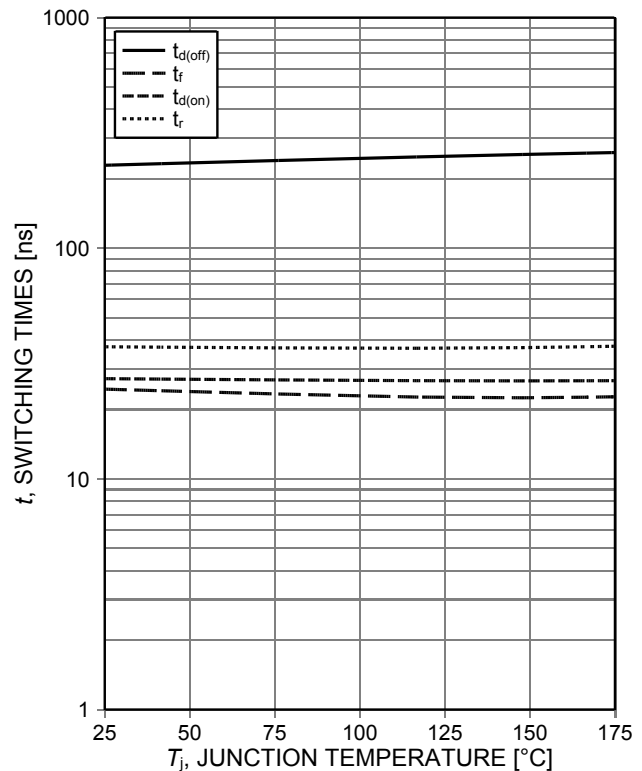


Figure 10. **Typical switching times as a function of junction temperature**
(ind. load, $V_{CE}=400\text{V}$, $V_{GE}=0/15\text{V}$, $I_C=50\text{A}$, $r_G=7\Omega$, test circuit in Fig. E)

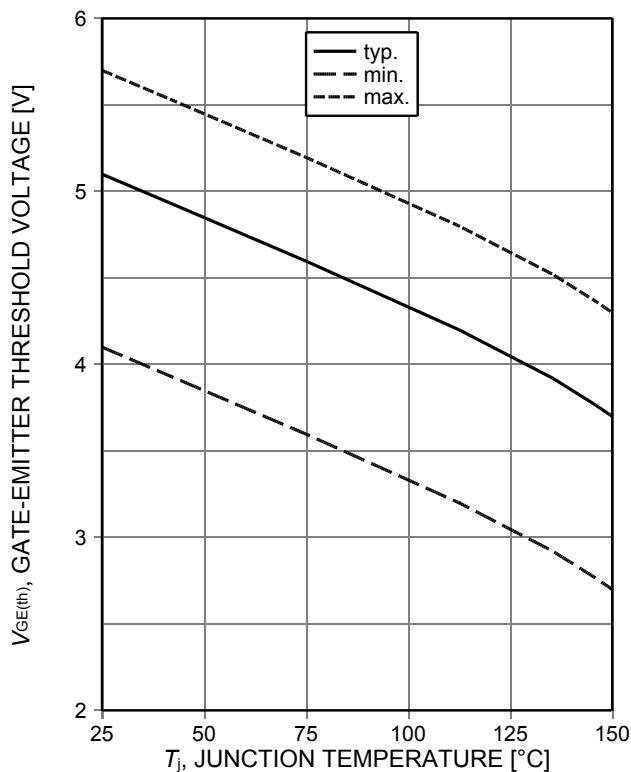


Figure 11. **Gate-emitter threshold voltage as a function of junction temperature**
($I_C=0.43\text{mA}$)

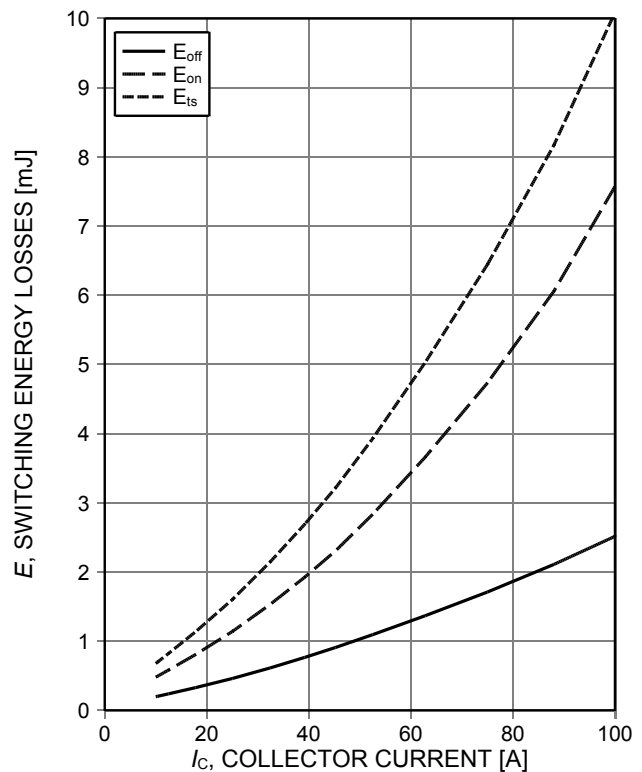


Figure 12. **Typical switching energy losses as a function of collector current**
(ind. load, $T_j=175^\circ\text{C}$, $V_{CE}=400\text{V}$, $V_{GE}=0/15\text{V}$, $R_G=7\Omega$, test circuit in Fig. E)

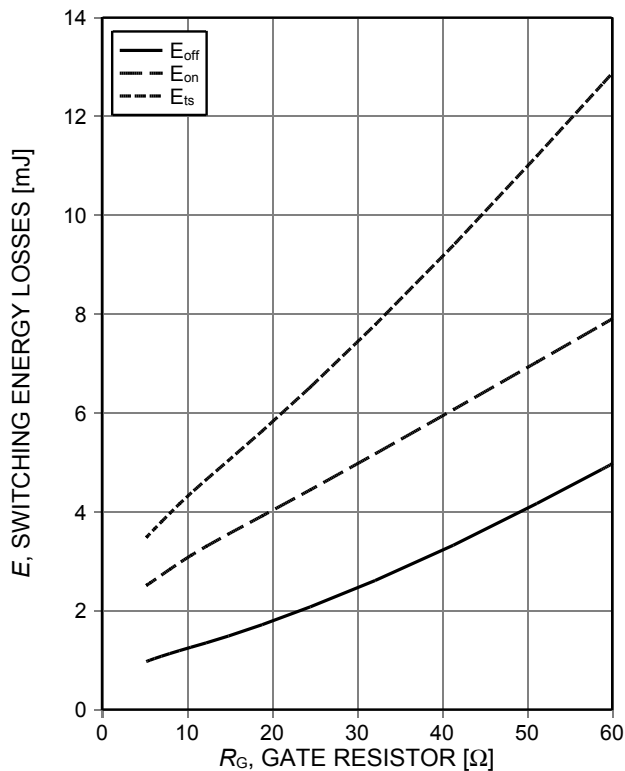


Figure 13. **Typical switching energy losses as a function of gate resistor**
(ind. load, $T_J=175^\circ\text{C}$, $V_{CE}=400\text{V}$, $V_{GE}=0/15\text{V}$, $I_C=50\text{A}$, test circuit in Fig. E)

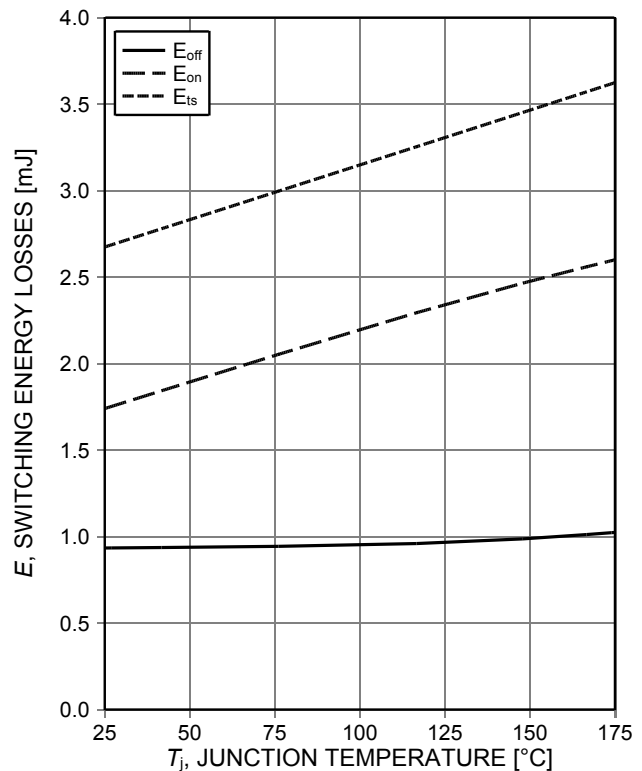


Figure 14. **Typical switching energy losses as a function of junction temperature**
(ind. load, $V_{CE}=400\text{V}$, $V_{GE}=0/15\text{V}$, $I_C=50\text{A}$, $R_G=7\Omega$, test circuit in Fig. E)

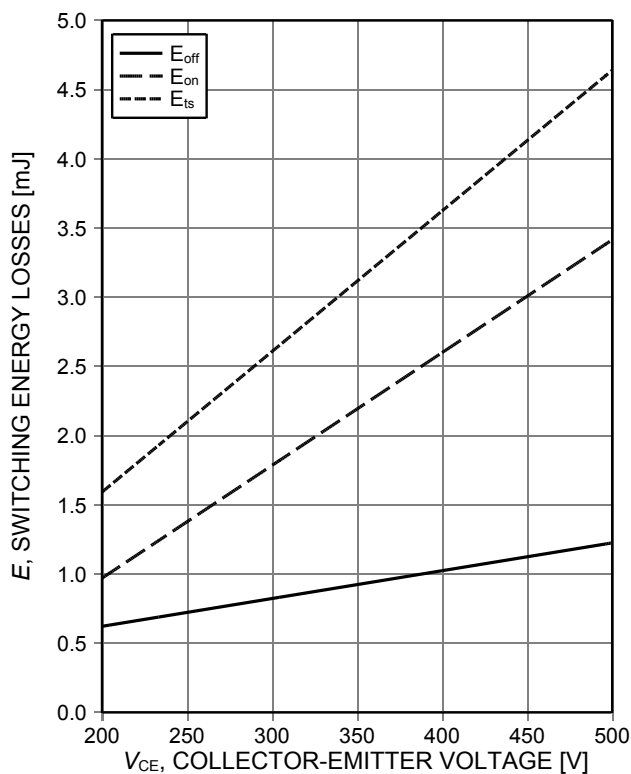


Figure 15. **Typical switching energy losses as a function of collector emitter voltage**
(ind. load, $T_J=175^\circ\text{C}$, $V_{GE}=0/15\text{V}$, $I_C=50\text{A}$, $R_G=7\Omega$, test circuit in Fig. E)

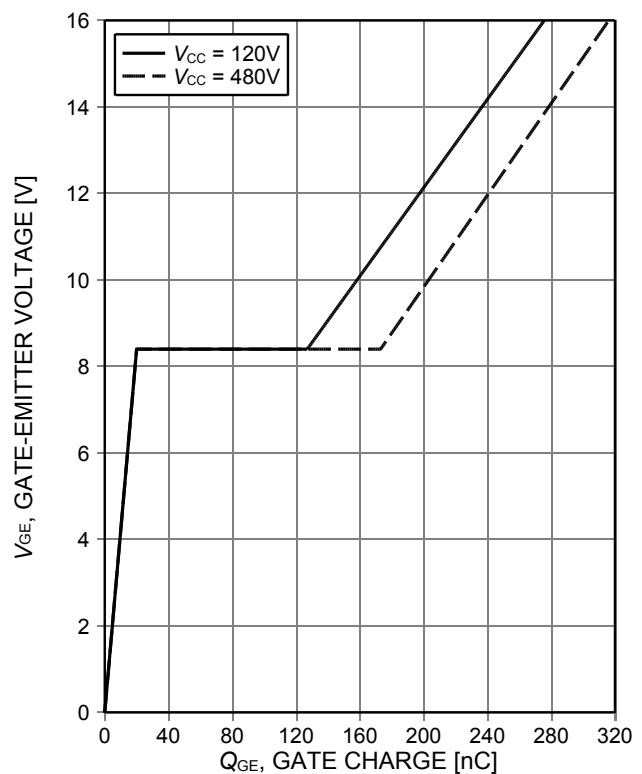


Figure 16. **Typical gate charge**
($I_C=50\text{A}$)

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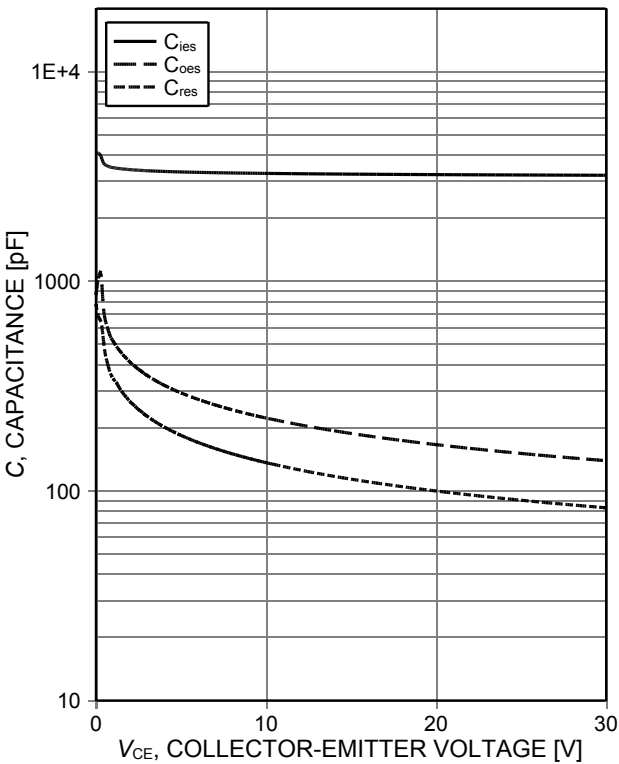


Figure 17. Typical capacitance as a function of collector-emitter voltage ($V_{GE}=0$ V, $f=1$ MHz)

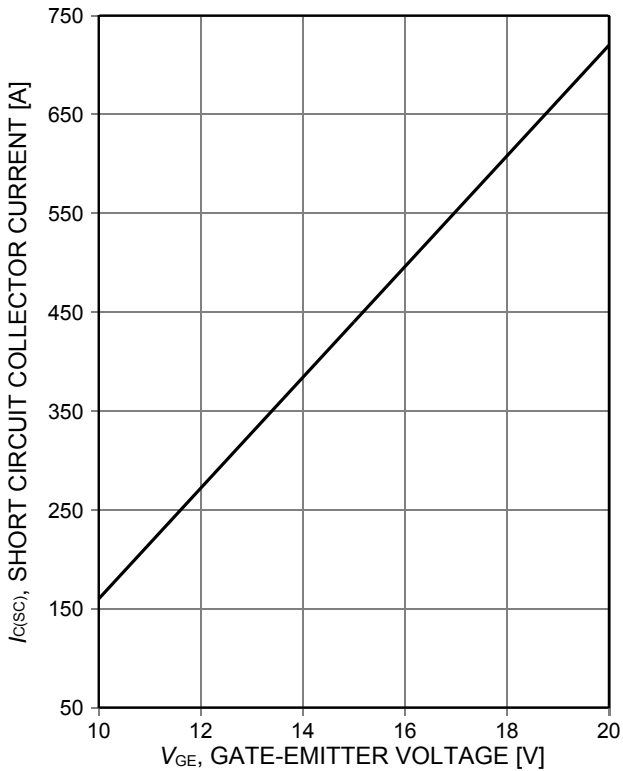


Figure 18. Typical short circuit collector current as a function of gate-emitter voltage ($V_{CE}\leq 400$ V, start at $T_J=25^\circ\text{C}$)

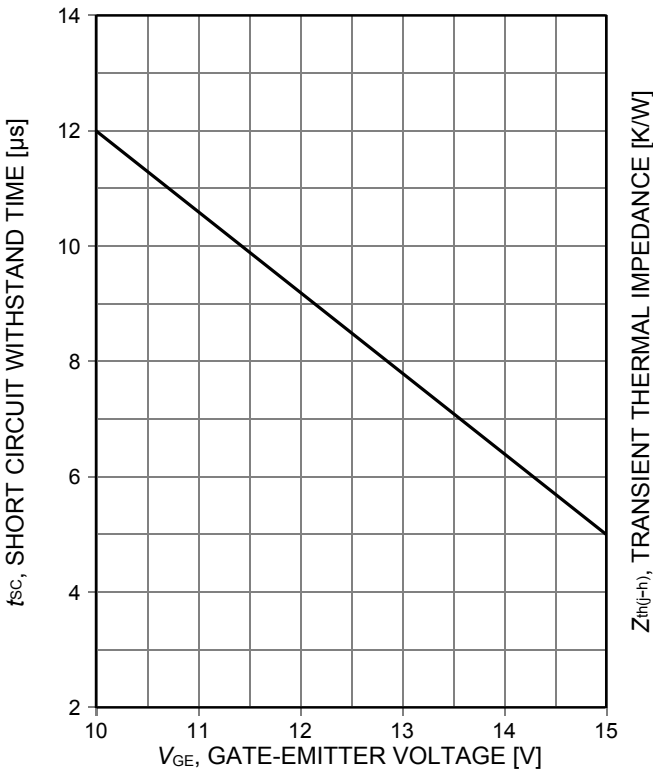


Figure 19. Short circuit withstand time as a function of gate-emitter voltage ($V_{CE}\leq 400$ V, start at $T_J\leq 150^\circ\text{C}$)

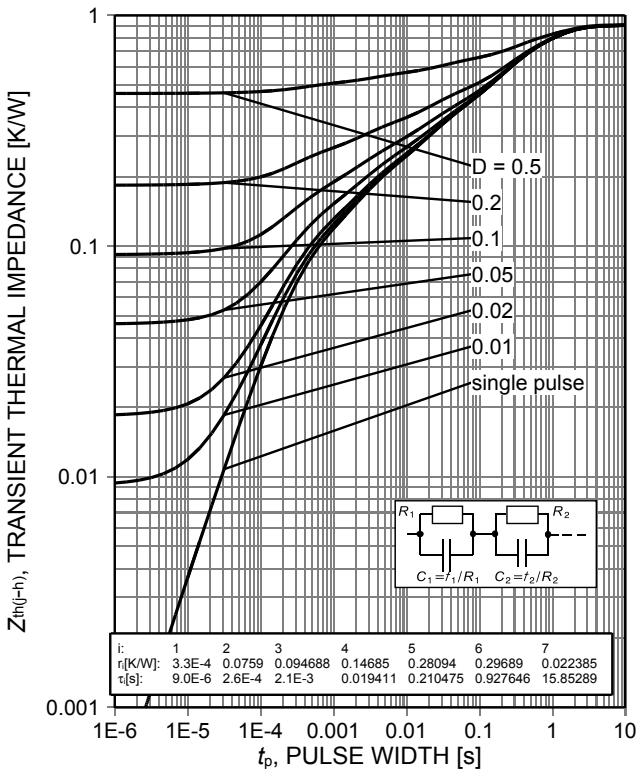


Figure 20. IGBT transient thermal impedance as a function of pulse width ($D=t_p/T$)

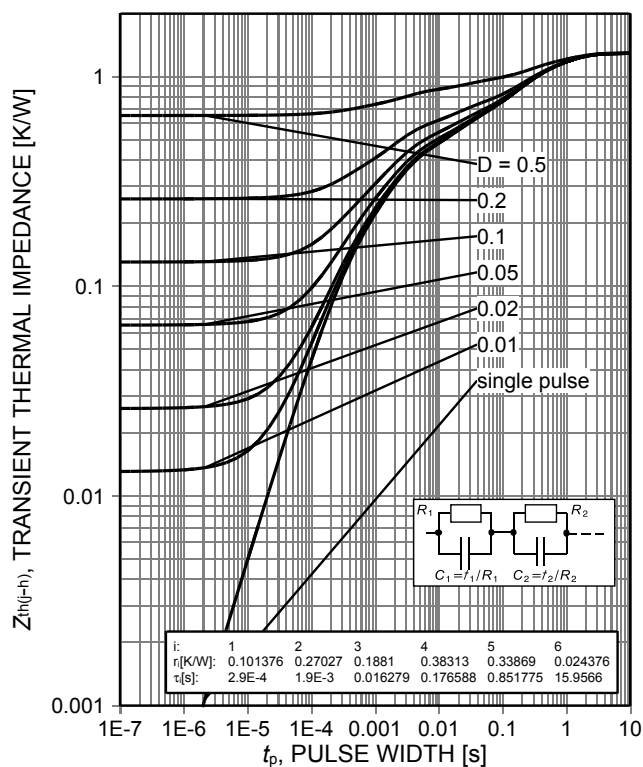


Figure 21. Diode transient thermal impedance as a function of pulse width ($D = t_p/T$)

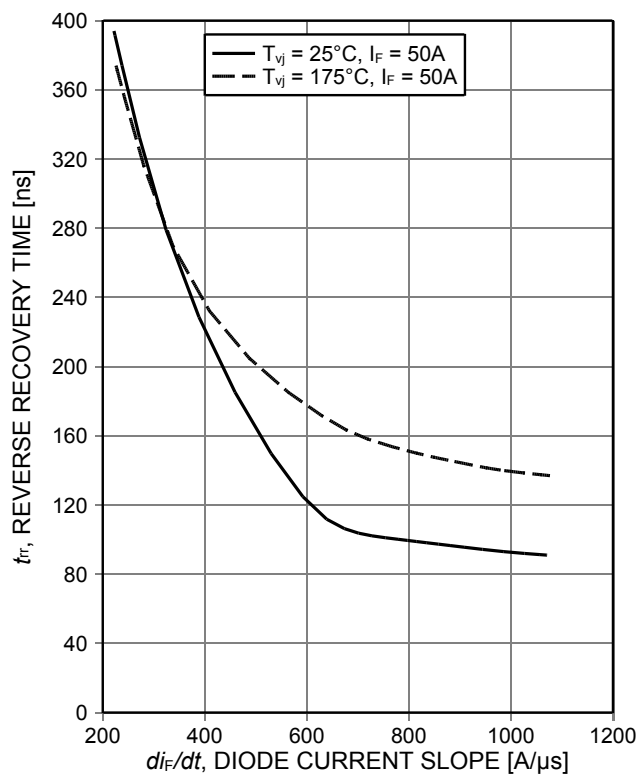


Figure 22. Typical reverse recovery time as a function of diode current slope ($V_R = 400V$)

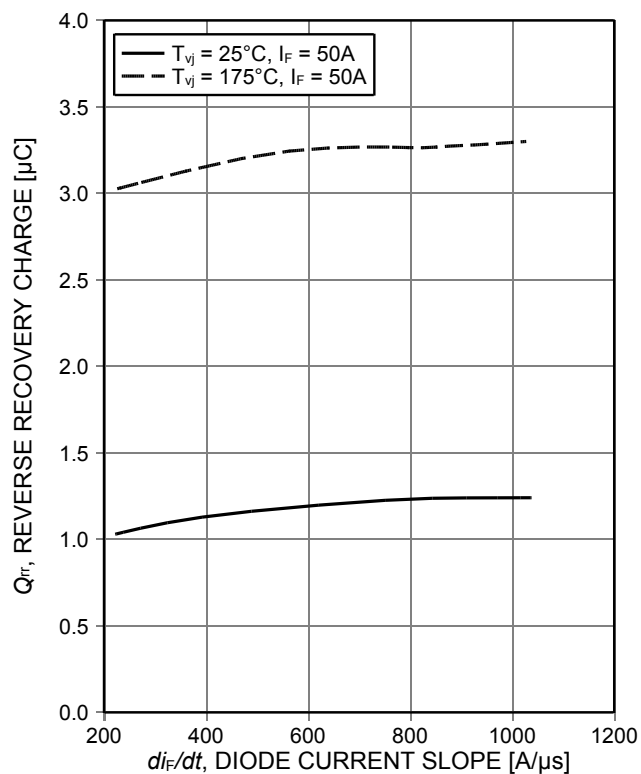


Figure 23. Typical reverse recovery charge as a function of diode current slope ($V_R = 400V$)

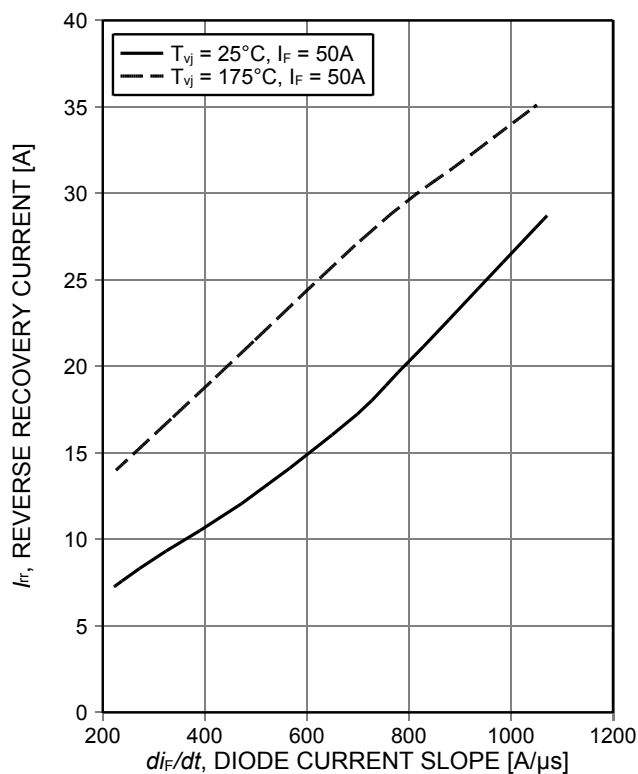


Figure 24. Typical reverse recovery current as a function of diode current slope ($V_R = 400V$)

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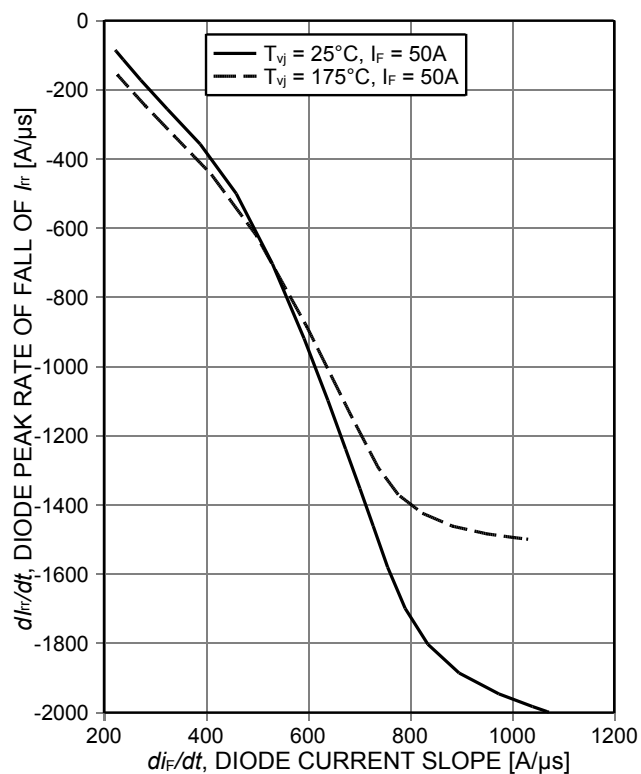


Figure 25. Typical diode peak rate of fall of reverse recovery current as a function of diode current slope ($V_R=400V$)

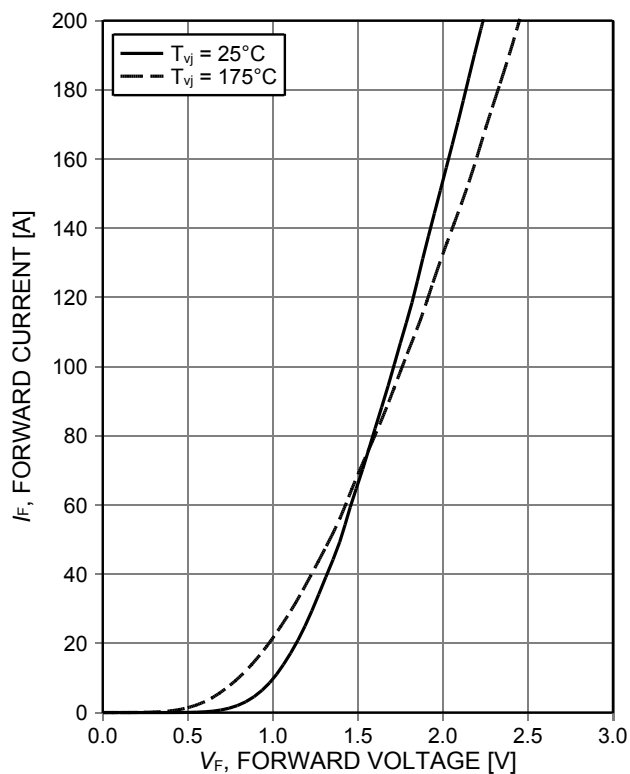


Figure 26. Typical diode forward current as a function of forward voltage

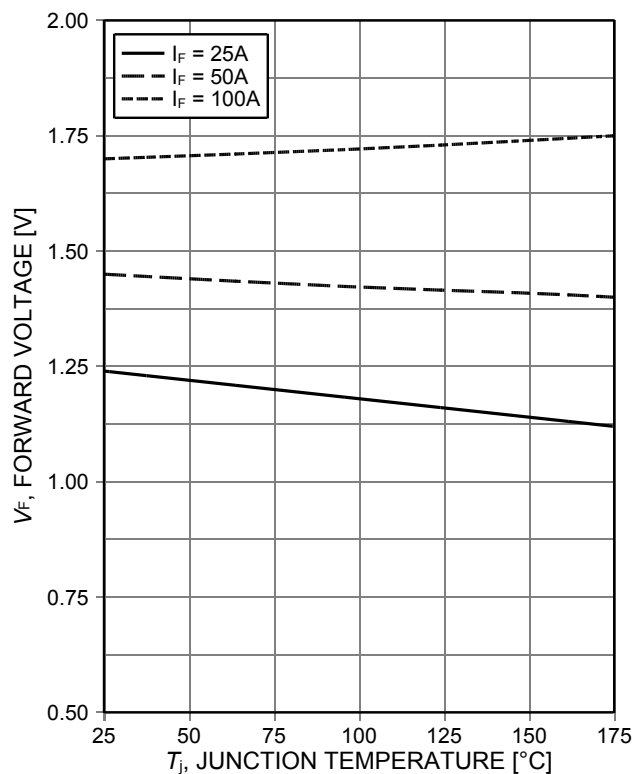
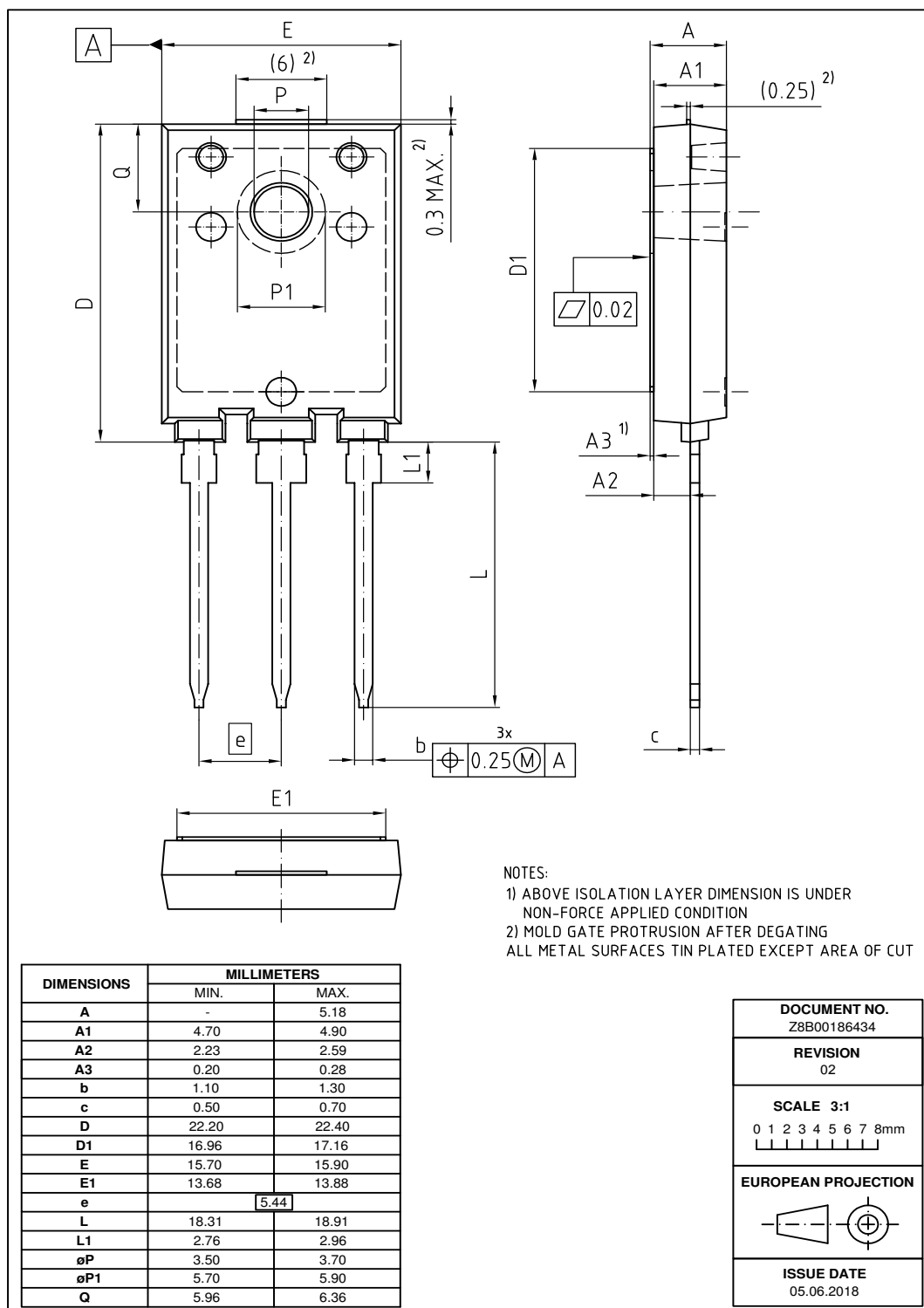


Figure 27. Typical diode forward voltage as a function of junction temperature

PG-TO247-3-AI (PG-HSIP247-3)

Note: For a proper handling and assembly of the advanced isolation device in the application the isolation layer must not be exposed to potential penetration via sharp implements or mechanical impacts/shocks, which exceed levels indicated in International Standard (IEC60068-2-6 and IEC60068-2-27). The advanced isolation device is intended only to be used assembled on an appropriate heatsink with recommended flatness of <20µm per 100mm and roughness of <10µm.

Testing Conditions



Figure A. Definition of switching times



Figure B. Definition of switching losses



Figure C. Definition of diode switching characteristics

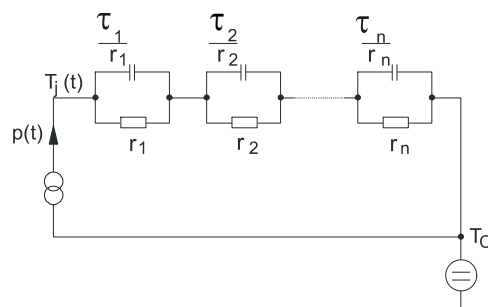


Figure D. Thermal equivalent circuit



Figure E. **Dynamic test circuit**
Parasitic inductance L_σ ,
parasitic capacitor C_σ ,
relief capacitor C_r ,
(only for ZVT switching)

Revision History

IKFW60N60EH3**Revision: 2017-09-21, Rev. 2.1**

Previous Revision

Revision	Date	Subjects (major changes since last revision)
2.1	2017-09-21	Final data sheet

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