

TRENCHSTOP™ 5 Advanced Isolation

TRENCHSTOP™ 5 high speed soft switching IGBT copacked with full current rated RAPID 1 fast and soft antiparallel diode

Features and Benefits:

- High speed S5 technology offering
- High speed smooth switching device for hard & soft switching
- Very Low V_{CEsat} , 1.35V at nominal current
- Plug and play replacement of previous generation IGBTs
- 650V breakdown voltage
- Low gate charge Q_G
- IGBT copacked with full rated RAPID 1 fast antiparallel diode
- Maximum junction temperature 175°C
- Pb-free lead plating; RoHS compliant
- Complete product spectrum and PSpice Models:
<http://www.infineon.com/igbt/>

Applications:

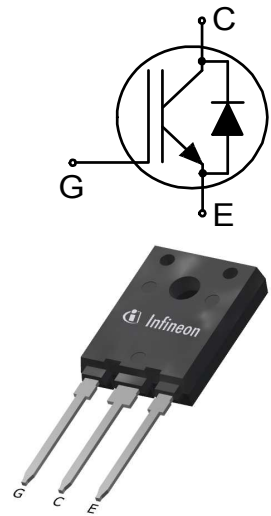
- Resonant converters
- Uninterruptible power supplies
- Welding converters
- Mid to high range switching frequency converters

Product Validation:

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

Package pin definition:

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



Fully isolated package TO-247



Key Performance and Package Parameters

Type	V_{CE}	I_C	V_{CEsat} , $T_{vj}=25^\circ\text{C}$	T_{vjmax}	Marking	Package
IKFW60N65ES5	650V	50A	1.35V	175°C	K60EES5	PG-HSIP247-3-2

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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}	650	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	77.0 60.0 85.0 ¹⁾	A
Pulsed collector current, t_p limited by T_{vjmax}	I_{Cpuls}	200.0	A
Turn off safe operating area $V_{CE} \leq 650\text{V}$, $T_{vj} \leq 175^{\circ}\text{C}$, $t_p = 1\mu\text{s}$	-	200.0	A
Diode forward current, limited by T_{vjmax} $T_h = 25^{\circ}\text{C}$ $T_h = 65^{\circ}\text{C}$	I_F	77.0 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
Power dissipation $T_h = 25^{\circ}\text{C}$ Power dissipation $T_h = 65^{\circ}\text{C}$	P_{tot}	138.0 101.0	W
Operating junction temperature	T_{vj}	-40...+175	$^{\circ}\text{C}$
Storage temperature	T_{stg}	-55...+150	$^{\circ}\text{C}$
Soldering temperature, wave soldering 1.6mm (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)}		-	0.92	1.09	K/W
Diode thermal resistance, ³⁾ junction - heatsink	R _{th(j-h)}		-	1.11	1.31	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	$V_{(BR)CES}$	$V_{GE} = 0V, I_C = 0.50mA$	650	-	-	V
Collector-emitter saturation voltage	V_{CEsat}	$V_{GE} = 15.0V, I_C = 50.0A$ $T_{vj} = 25^{\circ}C$ $T_{vj} = 175^{\circ}C$	- -	1.35 1.60	1.70 -	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 1.39	1.70 -	V
Gate-emitter threshold voltage	$V_{GE(th)}$	$I_C = 0.50mA, V_{CE} = V_{GE}$	3.2	4.0	4.8	V
Zero gate voltage collector current	I_{CES}	$V_{CE} = 650V, V_{GE} = 0V$ $T_{vj} = 25^{\circ}C$ $T_{vj} = 175^{\circ}C$	- -	- 2000	50 -	μA
Gate-emitter leakage current	I_{GES}	$V_{CE} = 0V, V_{GE} = 20V$	-	-	100	nA
Transconductance	g_{fs}	$V_{CE} = 20V, I_C = 50.0A$	-	63.0	-	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 = 1000kHz	-	3108	-	pF
Output capacitance	C _{oes}		-	90	-	
Reverse transfer capacitance	C _{res}		-	12	-	
Gate charge	Q _G	V _{CC} = 520V, I _C = 50.0A, V _{GE} = 15V	-	120.0	-	nC
Internal emitter inductance measured 5mm (0.197 in.) from case	L _E		-	13.0	-	nH

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	$t_{d(\text{on})}$	$T_{vj} = 25^{\circ}\text{C},$ $V_{CC} = 400\text{V}, I_C = 50.0\text{A},$ $V_{GE} = 0.0/15.0\text{V},$ $R_{G(\text{on})} = 8.2\Omega, R_{G(\text{off})} = 8.2\Omega,$ $L\sigma = 30\text{nH}, C\sigma = 30\text{pF}$ $L\sigma, C\sigma$ from Fig. E Energy losses include “tail” and diode reverse recovery.	-	20	-	ns
Rise time	t_r		-	27	-	ns
Turn-off delay time	$t_{d(\text{off})}$		-	127	-	ns
Fall time	t_f		-	34	-	ns
Turn-on energy	E_{on}		-	1.23	-	mJ
Turn-off energy	E_{off}		-	0.55	-	mJ
Total switching energy	E_{ts}		-	1.78	-	mJ

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

Diode reverse recovery time	t_{rr}	$T_{vj} = 25^{\circ}\text{C},$ $V_R = 400\text{V},$ $I_F = 50.0\text{A},$ $di_F/dt = 1000\text{A}/\mu\text{s}$	-	77	-	ns
Diode reverse recovery charge	Q_{rr}		-	1.21	-	μC
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		-	-1500	-	$\text{A}/\mu\text{s}$

Switching Characteristic, Inductive Load

Parameter	Symbol	Conditions	Value			Unit
			min.	typ.	max.	

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

Turn-on delay time	$t_{d(on)}$	$T_{vj} = 150^{\circ}\text{C},$ $V_{CC} = 400\text{V}, I_C = 50.0\text{A},$ $V_{GE} = 0.0/15.0\text{V},$ $R_{G(on)} = 8.2\Omega, R_{G(off)} = 8.2\Omega,$ $L\sigma = 30\text{nH}, C\sigma = 30\text{pF}$ Energy losses include "tail" and diode reverse recovery.	-	19	-	ns
Rise time	t_r		-	26	-	ns
Turn-off delay time	$t_{d(off)}$		-	151	-	ns
Fall time	t_f		-	47	-	ns
Turn-on energy	E_{on}		-	1.63	-	mJ
Turn-off energy	E_{off}		-	0.85	-	mJ
Total switching energy	E_{ts}		-	2.48	-	mJ

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

Diode reverse recovery time	t_{rr}	$T_{vj} = 150^{\circ}\text{C},$ $V_R = 400\text{V},$ $I_F = 50.0\text{A},$ $di_F/dt = 1000\text{A}/\mu\text{s}$	-	130	-	ns
Diode reverse recovery charge	Q_{rr}		-	2.85	-	μC
Diode peak reverse recovery current	I_{rrm}		-	35.0	-	A
Diode peak rate of fall of reverse recovery current during t_b	di_{rr}/dt		-	-1250	-	$\text{A}/\mu\text{s}$

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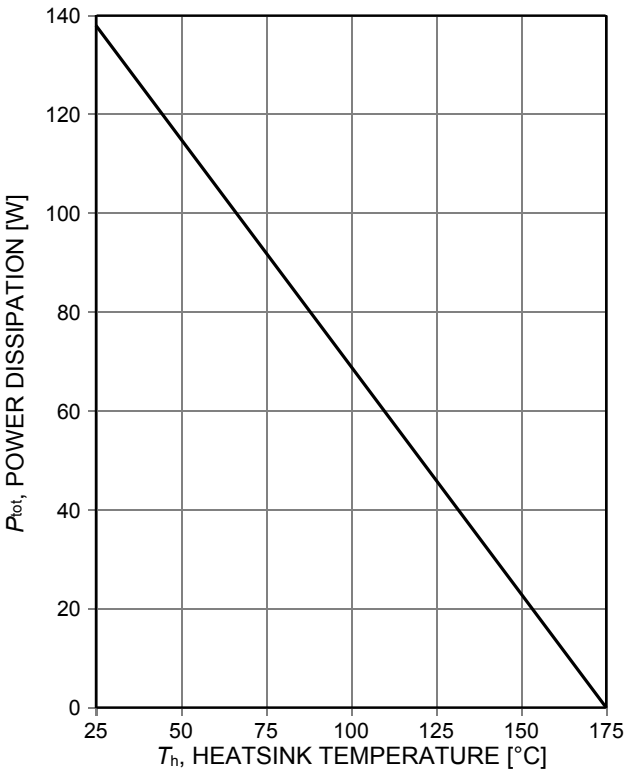


Figure 1. **Power dissipation as a function of heatsink temperature**
($T_j \leq 175^\circ\text{C}$)

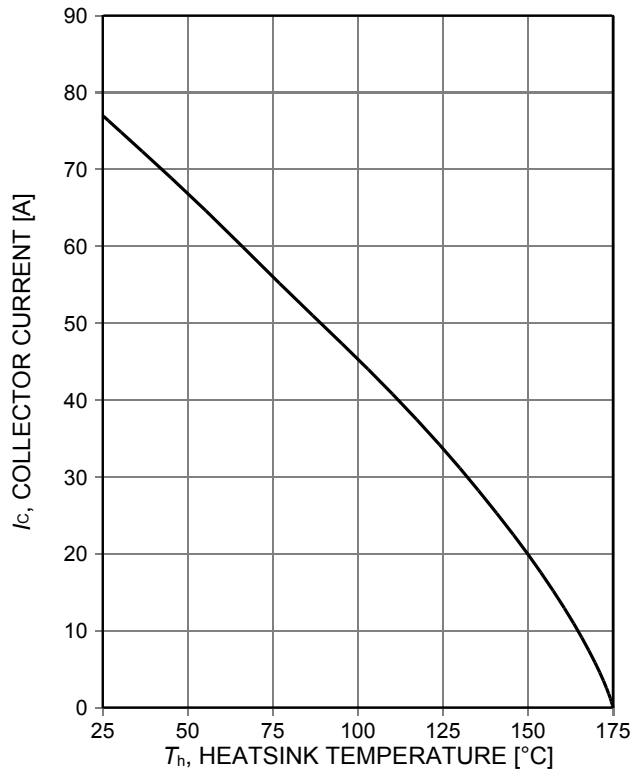


Figure 2. **Collector current as a function of heatsink temperature**
($V_{GE} \geq 15\text{V}$, $T_j \leq 175^\circ\text{C}$)

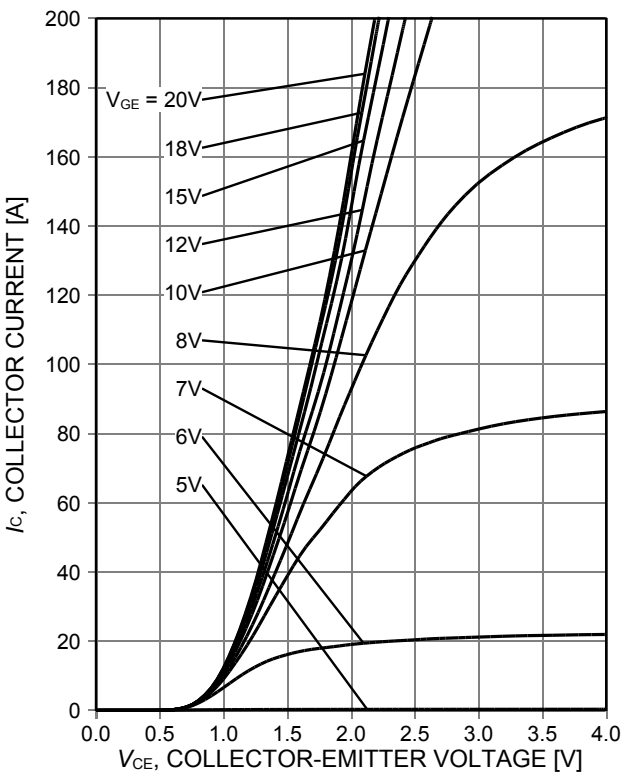


Figure 3. **Typical output characteristic**
($T_j = 25^\circ\text{C}$)

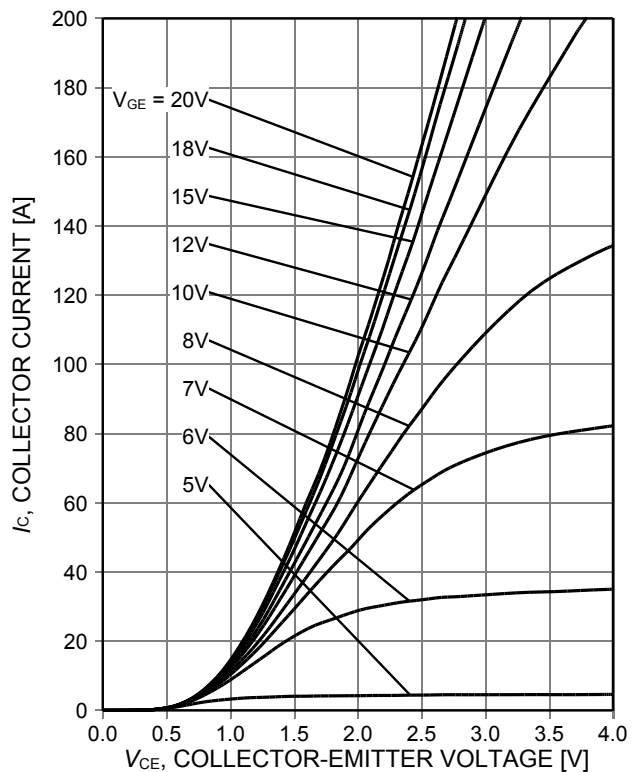


Figure 4. **Typical output characteristic**
($T_j = 175^\circ\text{C}$)

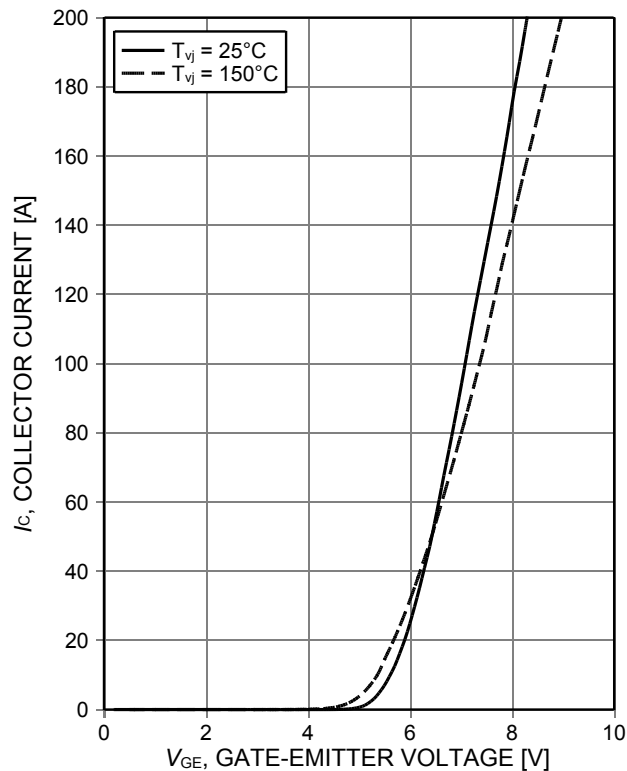


Figure 5. **Typical transfer characteristic**
($V_{CE}=20V$)

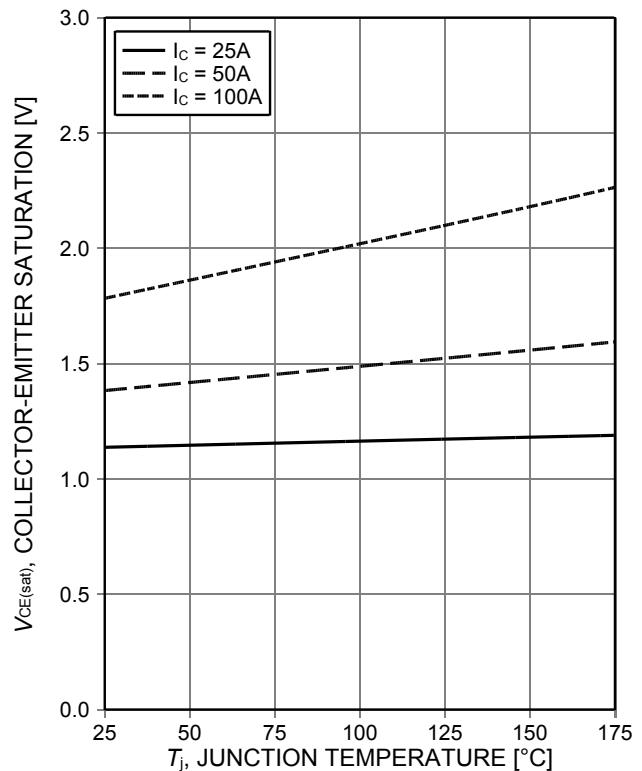


Figure 6. **Typical collector-emitter saturation voltage as a function of junction temperature**
($V_{GE}=15V$)

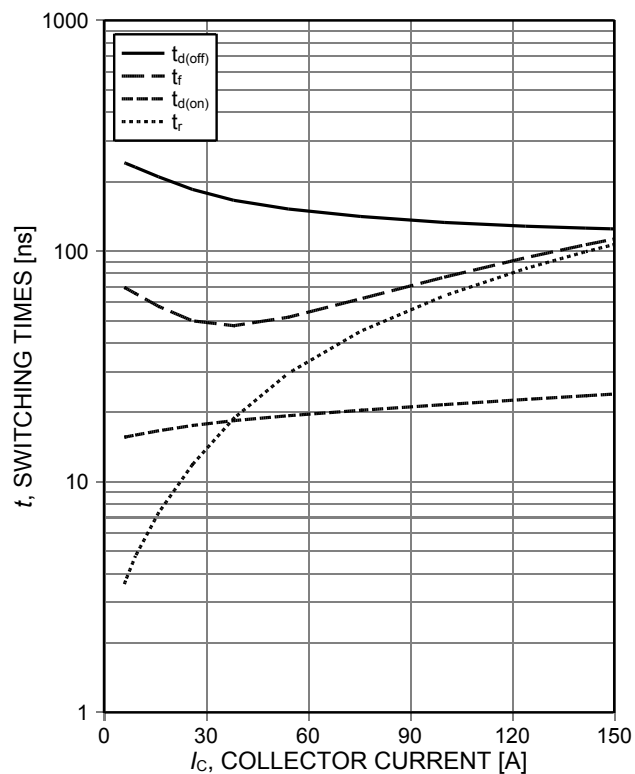


Figure 7. **Typical switching times as a function of collector current**
(ind. load, $T_j=150^\circ C$, $V_{CE}=400V$, $V_{GE}=0/15V$, $R_G=8.2\Omega$, test circuit in Fig. E)

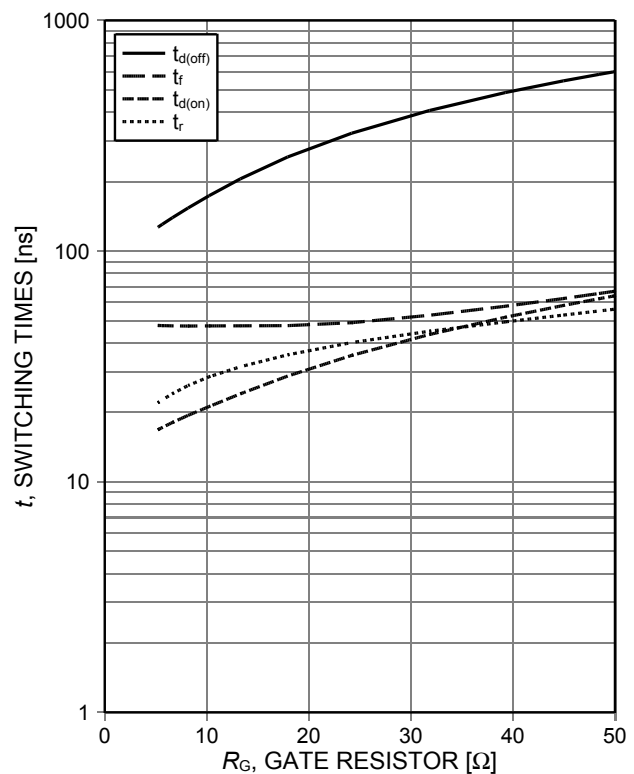


Figure 8. **Typical switching times as a function of gate resistor**
(ind. load, $T_j=150^\circ C$, $V_{CE}=400V$, $V_{GE}=0/15V$, $I_C=50A$, test circuit in Fig. E)

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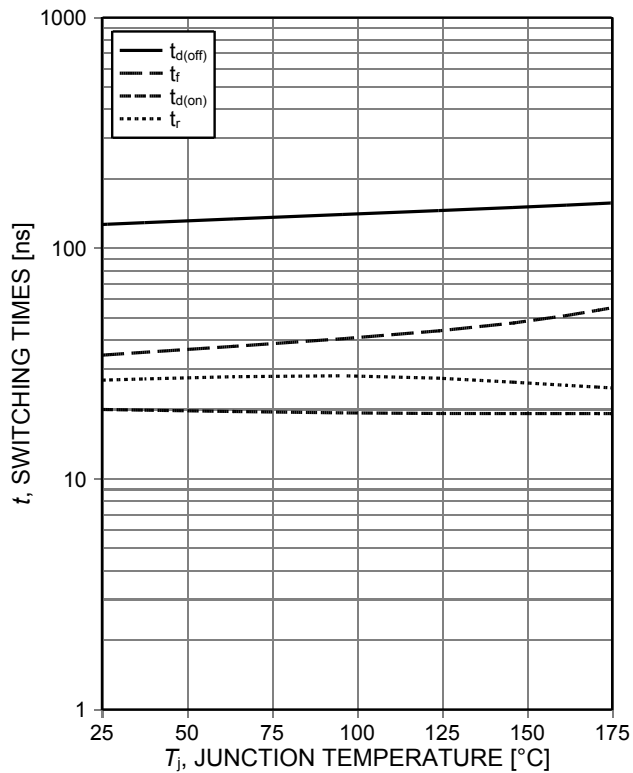


Figure 9. **Typical switching times as a function of junction temperature**
(ind. load, $V_{CE}=400V$, $V_{GE}=0/15V$, $I_C=50A$, $r_G=8.2\Omega$, test circuit in Fig. E)

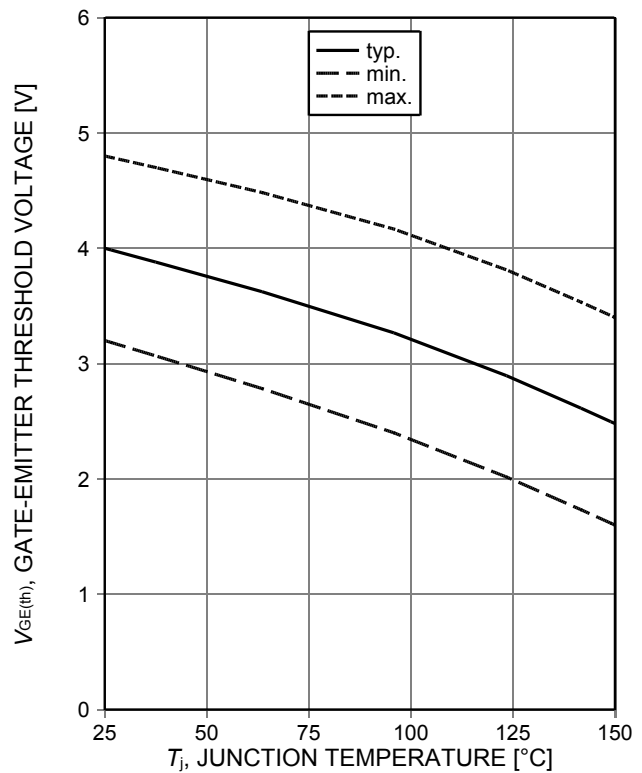


Figure 10. **Gate-emitter threshold voltage as a function of junction temperature**
($I_C=0.5mA$)

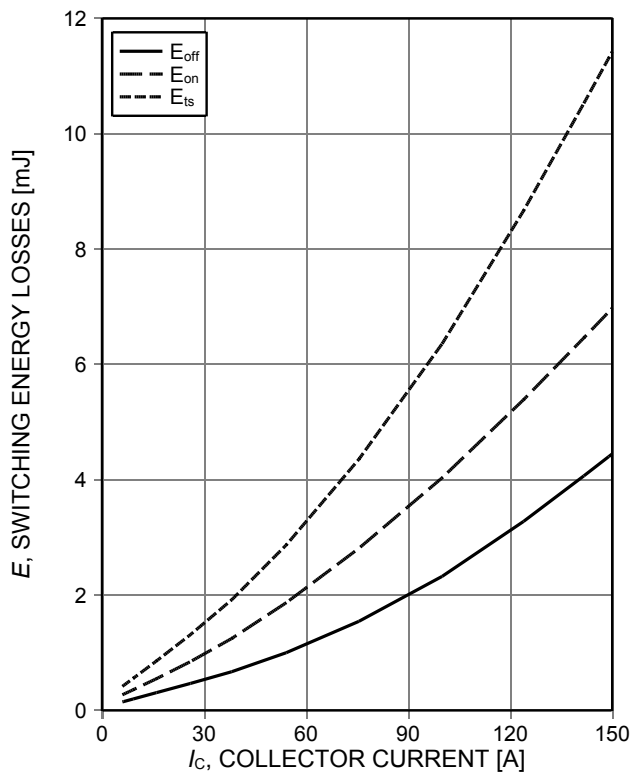


Figure 11. **Typical switching energy losses as a function of collector current**
(ind. load, $T_J=150^\circ C$, $V_{CE}=400V$, $V_{GE}=0/15V$, $R_G=8.2\Omega$, test circuit in Fig. E)

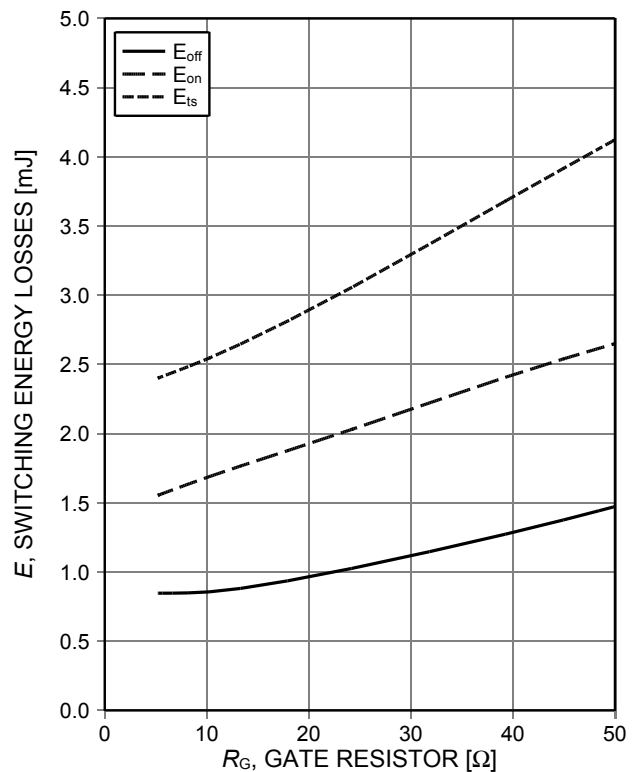


Figure 12. **Typical switching energy losses as a function of gate resistor**
(ind. load, $T_J=150^\circ C$, $V_{CE}=400V$, $V_{GE}=0/15V$, $I_C=50A$, test circuit in Fig. E)

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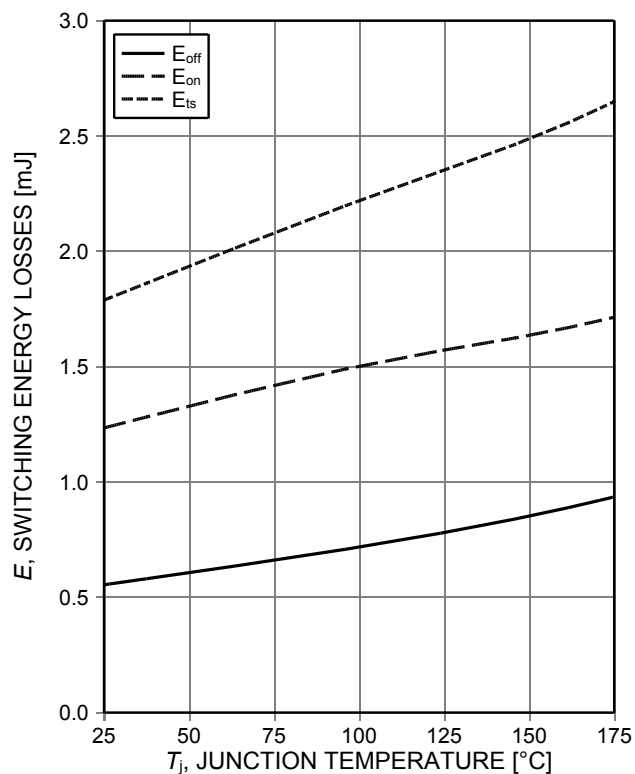


Figure 13. **Typical switching energy losses as a function of junction temperature**
(ind. load, $V_{CE}=400V$, $V_{GE}=0/15V$, $I_C=50A$, $R_G=8.2\Omega$, test circuit in Fig. E)

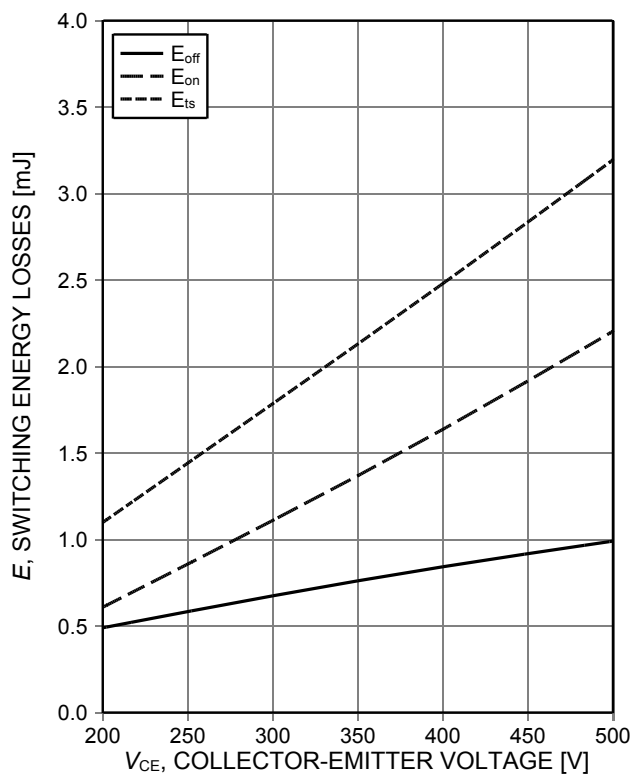


Figure 14. **Typical switching energy losses as a function of collector emitter voltage**
(ind. load, $T_j=150^\circ C$, $V_{GE}=0/15V$, $I_C=50A$, $R_G=8.2\Omega$, test circuit in Fig. E)

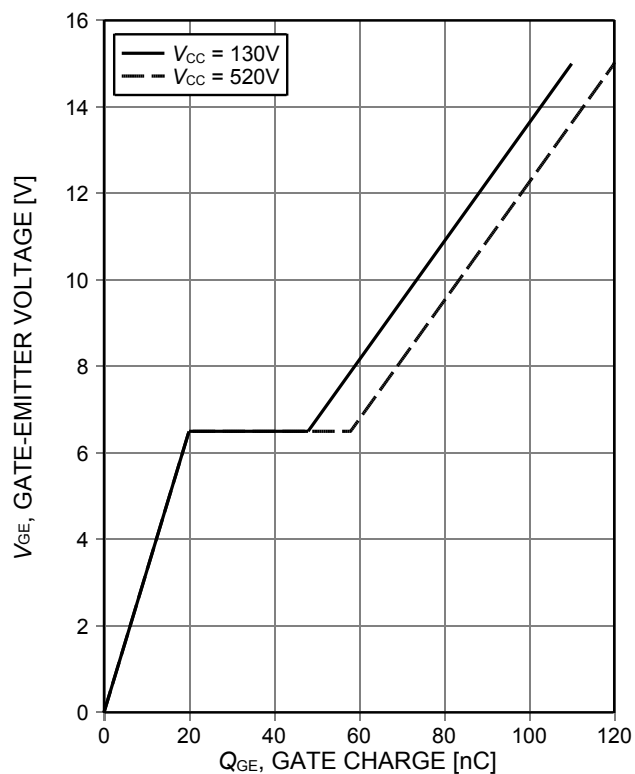


Figure 15. **Typical gate charge**
($I_C=50A$)

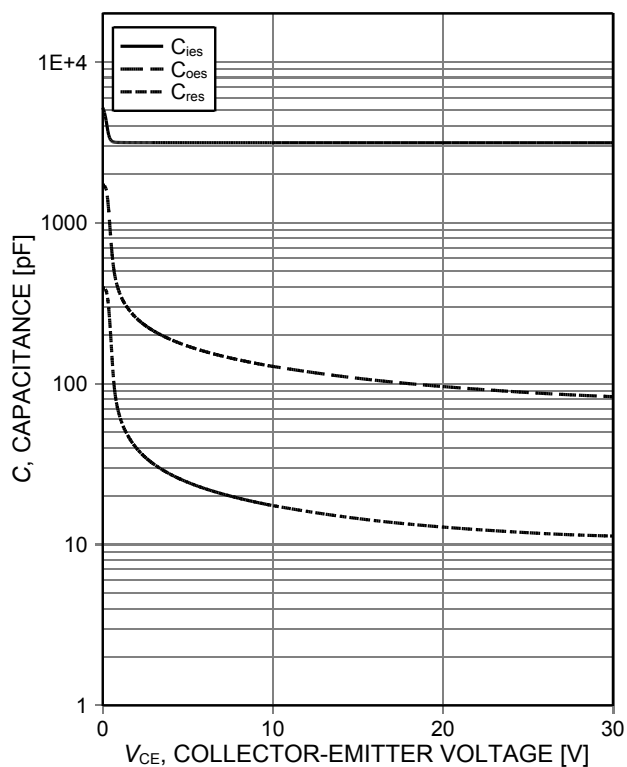


Figure 16. **Typical capacitance as a function of collector-emitter voltage**
($V_{GE}=0V$, $f=1MHz$)

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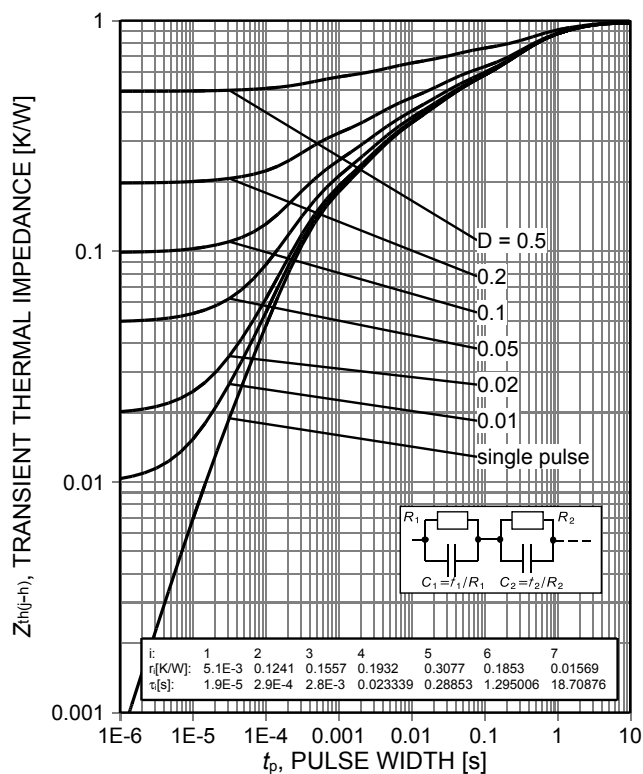


Figure 17. IGBT transient thermal impedance as a function of pulse width ($D=t_p/T$)

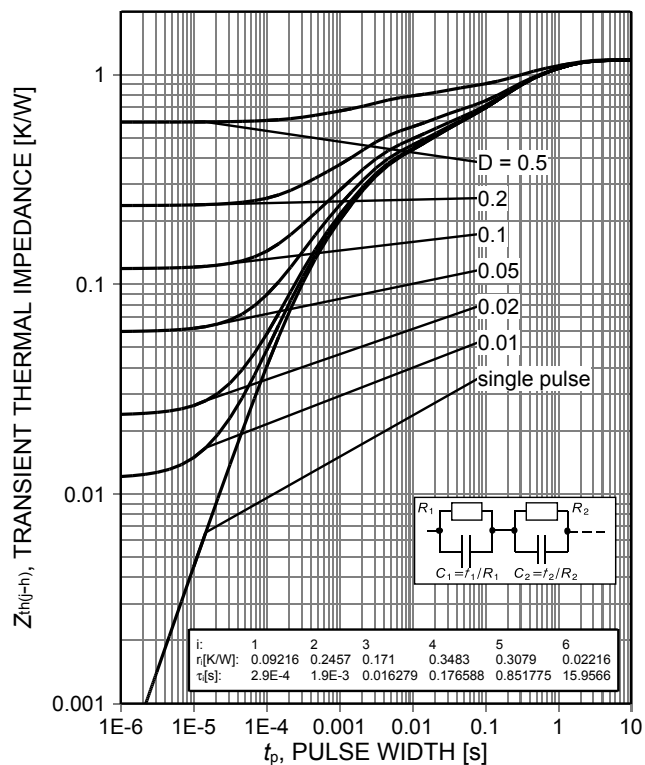


Figure 18. Diode transient thermal impedance as a function of pulse width ($D=t_p/T$)

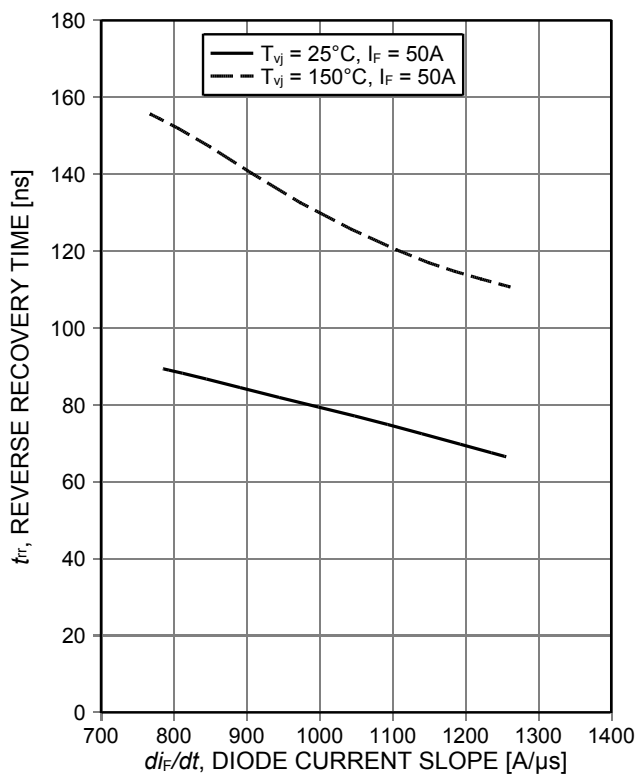


Figure 19. Typical reverse recovery time as a function of diode current slope ($V_R=400V$)

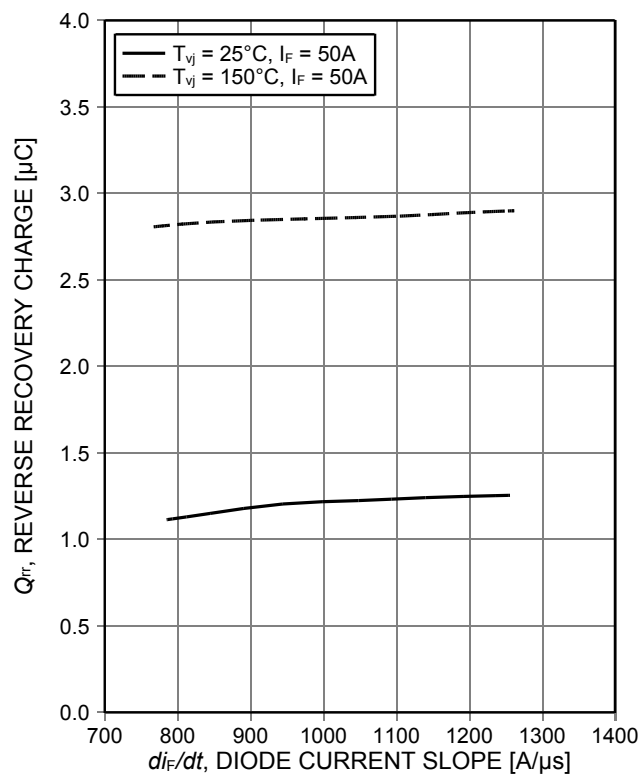


Figure 20. Typical reverse recovery charge as a function of diode current slope ($V_R=400V$)

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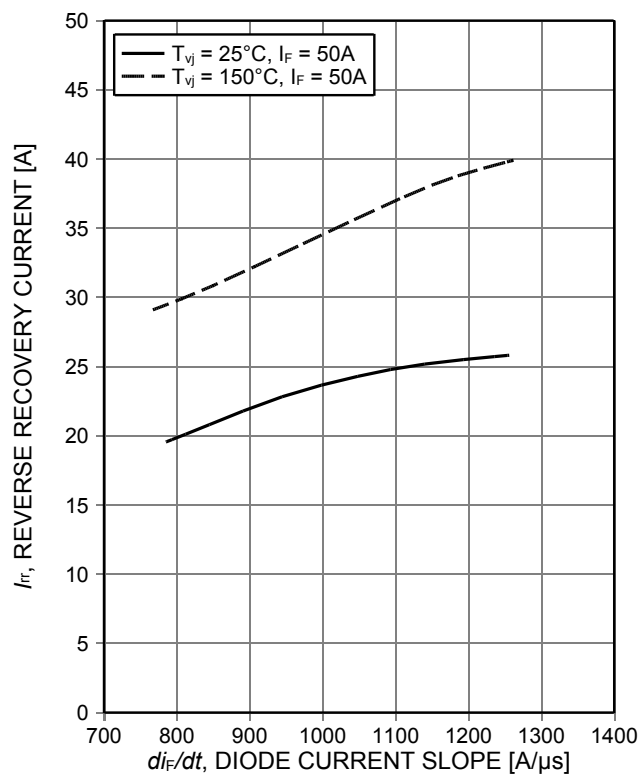


Figure 21. Typical reverse recovery current as a function of diode current slope ($V_R=400V$)

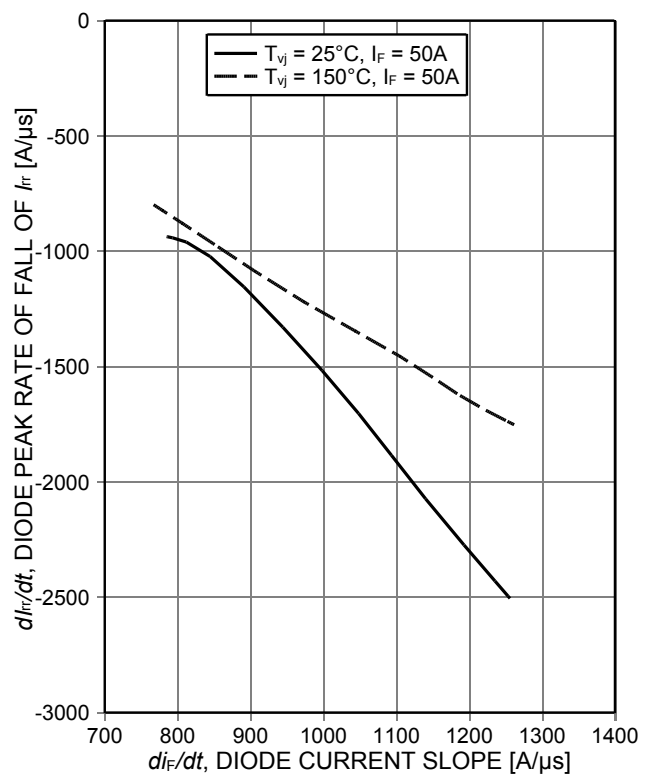


Figure 22. Typical diode peak rate of fall of reverse recovery current as a function of diode current slope ($V_R=400V$)

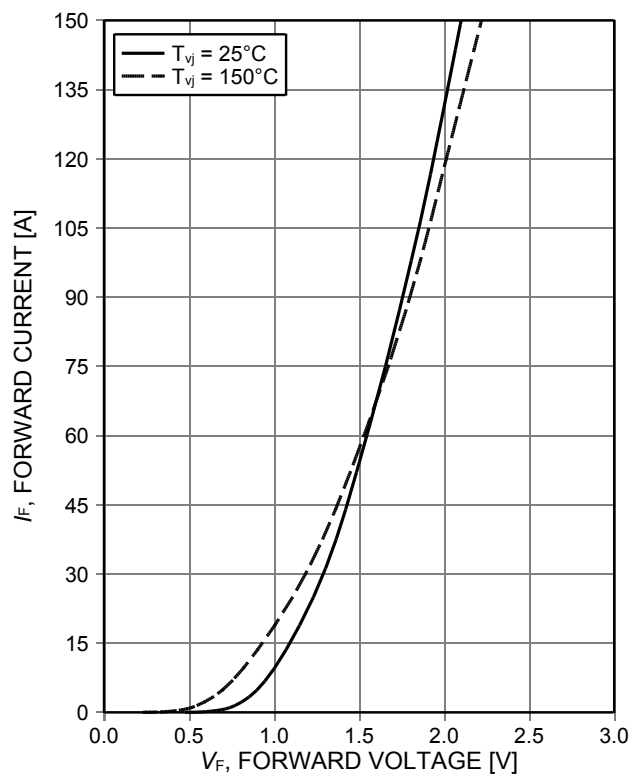


Figure 23. Typical diode forward current as a function of forward voltage

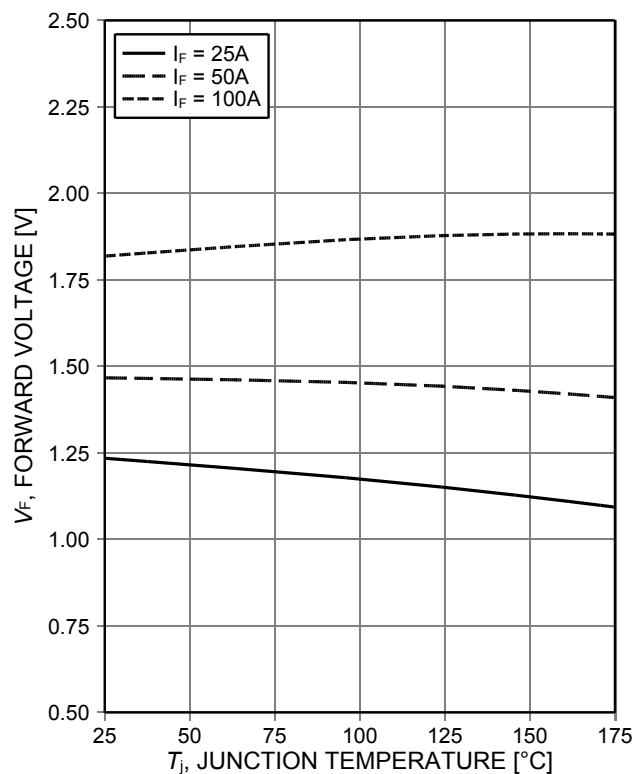
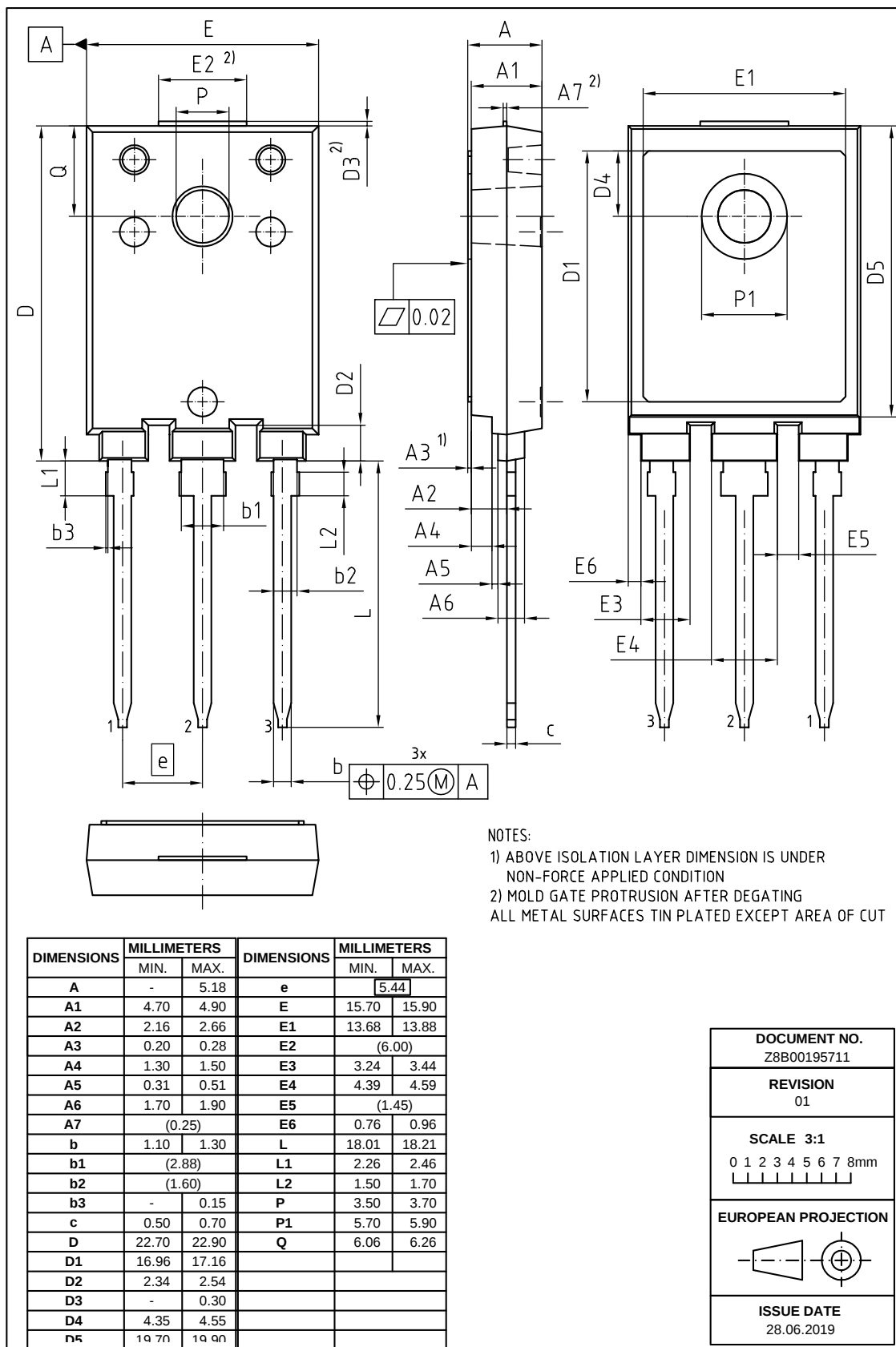


Figure 24. Typical diode forward voltage as a function of junction temperature

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Testing Conditions

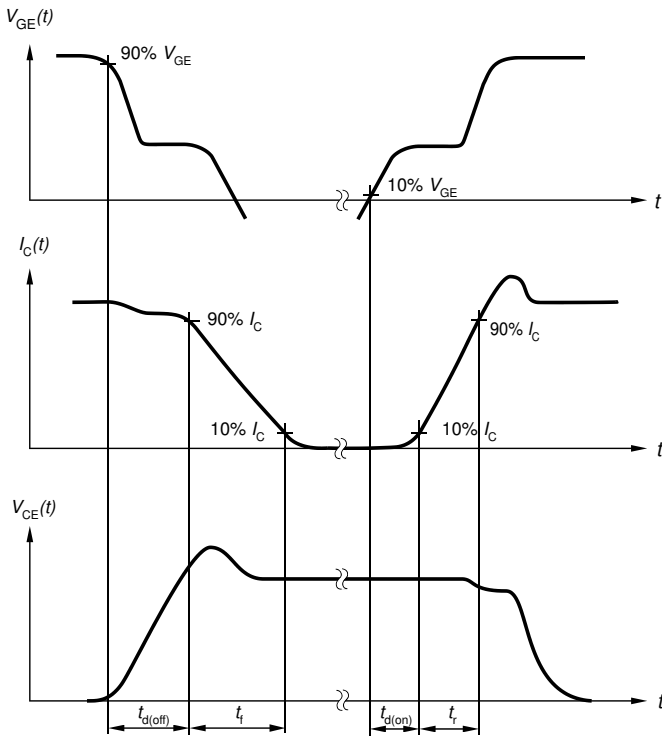


Figure A. Definition of switching times

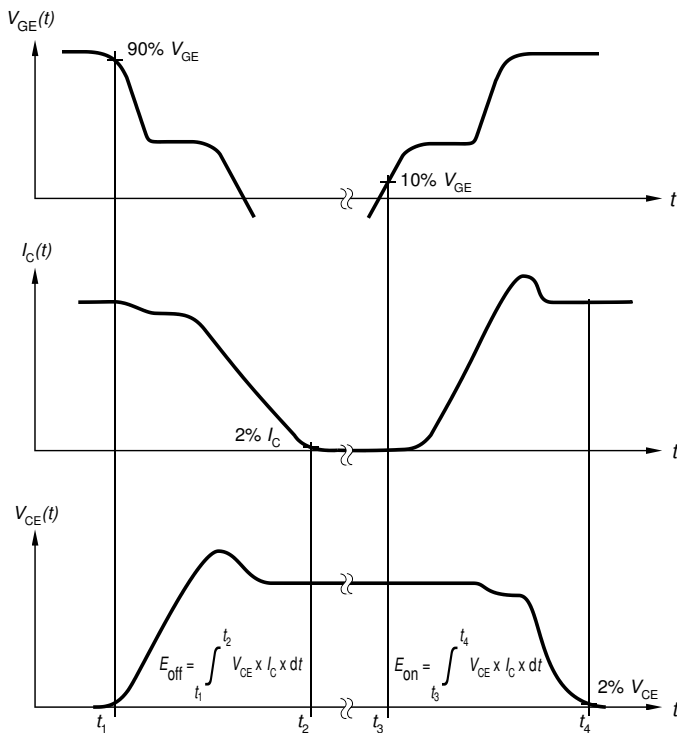


Figure B. Definition of switching losses

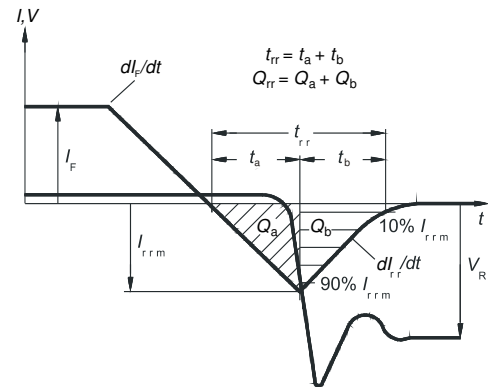


Figure C. Definition of diode switching characteristics

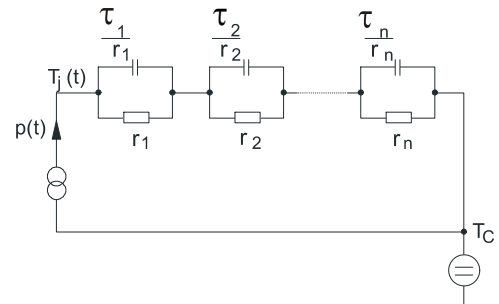


Figure D. Thermal equivalent circuit

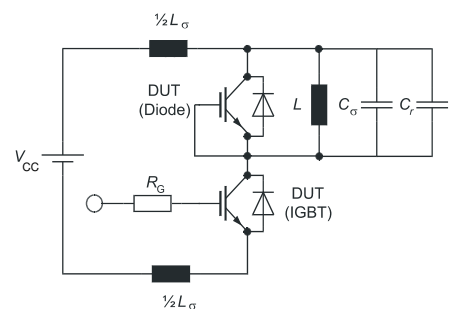


Figure E. **Dynamic test circuit**
Parasitic inductance L_σ ,
parasitic capacitor C_σ ,
relief capacitor C_r ,
(only for ZVT switching)

Revision History

IKFW60N65ES5**Revision: 2020-07-09, Rev. 2.1**

Previous Revision

Revision	Date	Subjects (major changes since last revision)
2.1	2020-07-09	Final Data Sheet

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