

High speed switching series 5th generation

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

Features and Benefits:

High speed S5 technology offering

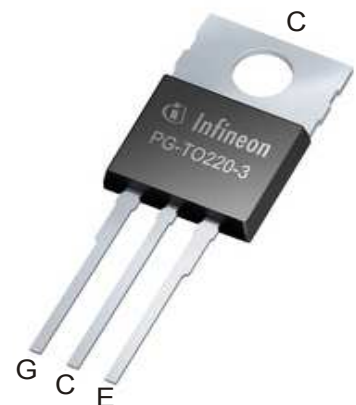
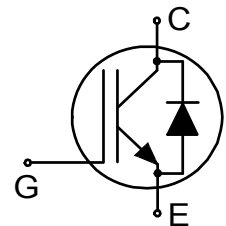
- High speed smooth switching device for hard & soft switching
- Very Low V_{CEsat}
- 650V breakdown voltage
- Low Q_G
- IGBT copacked with full rated current RAPID 1 fast antiparallel diode
- Maximum junction temperature 175°C
- Pb-free lead plating; RoHS compliant
- Complete product spectrum and PSpice Models:
<http://www.infineon.com/igbt/>

Potential Applications:

- Drives
- Industrial Power Supplies
 - Industrial SMPS
 - Industrial UPS
- Metal Treatment
 - Welding
- Energy Distribution
 - Energy Storage
- Infrastructure – Charge
 - Charger

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} , $T_{vj}=25^\circ\text{C}$	T_{vjmax}	Marking	Package
IKP28N65ES5	650V	28A	1.5V	175°C	K28EES5	PG-TO220-3

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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} $T_c = 25^{\circ}\text{C}$ $T_c = 100^{\circ}\text{C}$	I_C	38.0 28.0	A
Pulsed collector current, t_p limited by T_{vjmax}	I_{Cpuls}	90.0	A
Turn off safe operating area $V_{CE} \leq 650\text{V}$, $T_{vj} \leq 175^{\circ}\text{C}$, $t_p = 1\mu\text{s}$	-	90.0	A
Diode forward current, limited by T_{vjmax} $T_c = 25^{\circ}\text{C}$ value limited by bondwire $T_c = 100^{\circ}\text{C}$	I_F	40.0 27.0	A
Diode pulsed current, t_p limited by T_{vjmax}	I_{Fpuls}	90.0	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 $T_c = 25^{\circ}\text{C}$ Power dissipation $T_c = 100^{\circ}\text{C}$	P_{tot}	130.0 65.0	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

Thermal Resistance

Parameter	Symbol	Conditions	Value			Unit
			min.	typ.	max.	
R _{th} Characteristics						
IGBT thermal resistance, junction - case	R _{th(j-c)}		-	-	1.20	K/W
Diode thermal resistance, junction - case	R _{th(j-c)}		-	-	1.50	K/W
Thermal resistance junction - ambient	R _{th(j-a)}		-	-	62	K/W

High speed switching series 5th generationElectrical 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	$V_{(BR)CES}$	$V_{GE} = 0V, I_C = 0.20mA$	650	-	-	V
Collector-emitter saturation voltage	V_{CESat}	$V_{GE} = 15.0V, I_C = 28.0A$ $T_{vj} = 25^{\circ}C$ $T_{vj} = 125^{\circ}C$ $T_{vj} = 175^{\circ}C$	- - -	1.50 1.72 1.85	1.90 - -	V
Diode forward voltage	V_F	$V_{GE} = 0V, I_F = 28.0A$ $T_{vj} = 25^{\circ}C$ $T_{vj} = 125^{\circ}C$ $T_{vj} = 175^{\circ}C$	- - -	1.59 1.60 1.56	1.95 - -	V
Gate-emitter threshold voltage	$V_{GE(th)}$	$I_C = 0.28mA, V_{CE} = V_{GE}$	3.2	4.0	4.8	V
Zero gate voltage collector current	I_{CES}	$V_{CE} = 650V, V_{GE} = 0V$ $T_{vj} = 25^{\circ}C$ $T_{vj} = 175^{\circ}C$	- -	- 1400	50 -	μA
Gate-emitter leakage current	I_{GES}	$V_{CE} = 0V, V_{GE} = 20V$	-	-	100	nA
Transconductance	g_{fs}	$V_{CE} = 20V, I_C = 28.0A$	-	29.0	-	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	-	1200	-	pF
Output capacitance	C _{oes}		-	38	-	
Reverse transfer capacitance	C _{res}		-	5	-	
Gate charge	Q _G	V _{CC} = 520V, I _C = 28.0A, V _{GE} = 15V	-	50.0	-	nC
Internal emitter inductance measured 5mm (0.197 in.) from case	L _E		-	7.0	-	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	$t_{d(\text{on})}$	$T_{vj} = 25^{\circ}\text{C},$ $V_{CC} = 400\text{V}, I_C = 28.0\text{A},$ $V_{GE} = 0.0/15.0\text{V},$ $R_{G(\text{on})} = 34.0\Omega, R_{G(\text{off})} = 34.0\Omega,$ $L_{\sigma} = 30\text{nH}, C_{\sigma} = 30\text{pF}$ L_{σ}, C_{σ} from Fig. E Energy losses include “tail” and diode reverse recovery.	-	27	-	ns
Rise time	t_r		-	28	-	ns
Turn-off delay time	$t_{d(\text{off})}$		-	184	-	ns
Fall time	t_f		-	34	-	ns
Turn-on energy	E_{on}		-	0.53	-	mJ
Turn-off energy	E_{off}		-	0.40	-	mJ
Total switching energy	E_{ts}		-	0.93	-	mJ

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Turn-on delay time	$t_{d(on)}$	$T_{vj} = 25^{\circ}\text{C}$, $V_{CC} = 400\text{V}$, $I_C = 14.0\text{A}$, $V_{GE} = 0.0/15.0\text{V}$, $R_{G(on)} = 34.0\Omega$, $R_{G(off)} = 34.0\Omega$, $L\sigma = 30\text{nH}$, $C\sigma = 30\text{pF}$ $L\sigma$, $C\sigma$ from Fig. E Energy losses include "tail" and diode reverse recovery.	-	25	-	ns
Rise time	t_r		-	16	-	ns
Turn-off delay time	$t_{d(off)}$		-	193	-	ns
Fall time	t_f		-	27	-	ns
Turn-on energy	E_{on}		-	0.25	-	mJ
Turn-off energy	E_{off}		-	0.15	-	mJ
Total switching energy	E_{ts}		-	0.40	-	mJ

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

Diode reverse recovery time	t_{rr}	$T_{vj} = 25^{\circ}\text{C}$, $V_R = 400\text{V}$, $I_F = 28.0\text{A}$, $di_F/dt = 1020\text{A}/\mu\text{s}$	-	73	-	ns
Diode reverse recovery charge	Q_{rr}		-	0.60	-	μC
Diode peak reverse recovery current	I_{rrm}		-	15.5	-	A
Diode peak rate of fall of reverse recovery current during t_b	di_{rr}/dt		-	-324	-	A/ μs
Diode reverse recovery time	t_{rr}	$T_{vj} = 25^{\circ}\text{C}$, $V_R = 400\text{V}$, $I_F = 14.0\text{A}$, $di_F/dt = 1180\text{A}/\mu\text{s}$	-	61	-	ns
Diode reverse recovery charge	Q_{rr}		-	0.40	-	μC
Diode peak reverse recovery current	I_{rrm}		-	14.0	-	A
Diode peak rate of fall of reverse recovery current during t_b	di_{rr}/dt		-	-387	-	A/ μs

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	$t_{d(\text{on})}$	$T_{vj} = 150^{\circ}\text{C}$, $V_{CC} = 400\text{V}$, $I_C = 28.0\text{A}$, $V_{GE} = 0.0/15.0\text{V}$, $R_{G(\text{on})} = 34.0\Omega$, $R_{G(\text{off})} = 34.0\Omega$, $L\sigma = 30\text{nH}$, $C\sigma = 30\text{pF}$ $L\sigma$, $C\sigma$ from Fig. E Energy losses include “tail” and diode reverse recovery.	-	26	-	ns
Rise time	t_r		-	28	-	ns
Turn-off delay time	$t_{d(\text{off})}$		-	200	-	ns
Fall time	t_f		-	36	-	ns
Turn-on energy	E_{on}		-	0.65	-	mJ
Turn-off energy	E_{off}		-	0.50	-	mJ
Total switching energy	E_{ts}		-	1.15	-	mJ
Turn-on delay time	$t_{d(\text{on})}$	$T_{vj} = 150^{\circ}\text{C}$, $V_{CC} = 400\text{V}$, $I_C = 14.0\text{A}$, $V_{GE} = 0.0/15.0\text{V}$, $R_{G(\text{on})} = 34.0\Omega$, $R_{G(\text{off})} = 34.0\Omega$, $L\sigma = 30\text{nH}$, $C\sigma = 30\text{pF}$ $L\sigma$, $C\sigma$ from Fig. E Energy losses include “tail” and diode reverse recovery.	-	25	-	ns
Rise time	t_r		-	16	-	ns
Turn-off delay time	$t_{d(\text{off})}$		-	220	-	ns
Fall time	t_f		-	48	-	ns
Turn-on energy	E_{on}		-	0.35	-	mJ
Turn-off energy	E_{off}		-	0.25	-	mJ
Total switching energy	E_{ts}		-	0.60	-	mJ

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

Diode reverse recovery time	t_{rr}	$T_{vj} = 150^{\circ}\text{C},$ $V_R = 400\text{V},$ $I_F = 28.0\text{A},$ $di_F/dt = 830\text{A}/\mu\text{s}$	-	95	-	ns
Diode reverse recovery charge	Q_{rr}		-	1.25	-	μC
Diode peak reverse recovery current	I_{rrm}		-	20.0	-	A
Diode peak rate of fall of reverse recovery current during t_b	di_{rr}/dt		-	-395	-	A/ μs
Diode reverse recovery time	t_{rr}	$T_{vj} = 150^{\circ}\text{C},$ $V_R = 400\text{V},$ $I_F = 14.0\text{A},$ $di_F/dt = 1020\text{A}/\mu\text{s}$	-	78	-	ns
Diode reverse recovery charge	Q_{rr}		-	0.88	-	μC
Diode peak reverse recovery current	I_{rrm}		-	18.0	-	A
Diode peak rate of fall of reverse recovery current during t_b	di_{rr}/dt		-	-443	-	A/ μs

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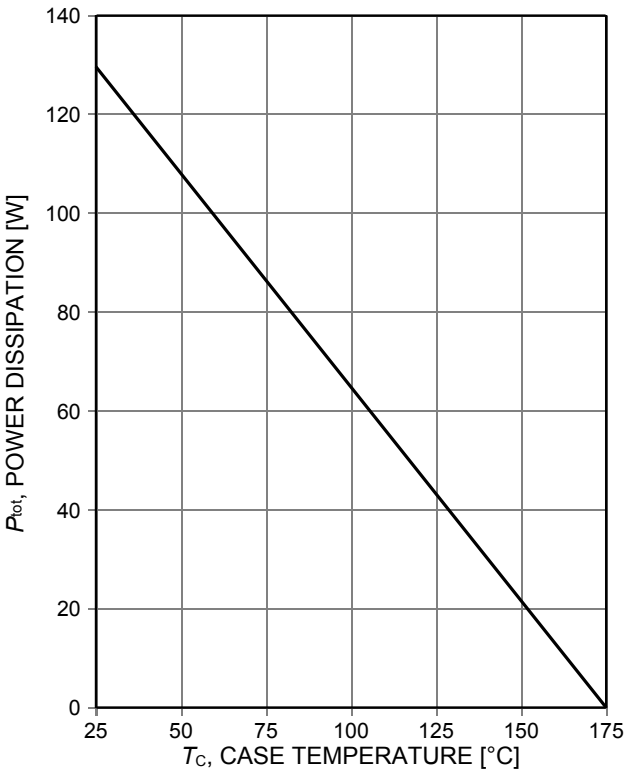


Figure 1. **Power dissipation as a function of case temperature**
($T_{vj} \leq 175^\circ\text{C}$)

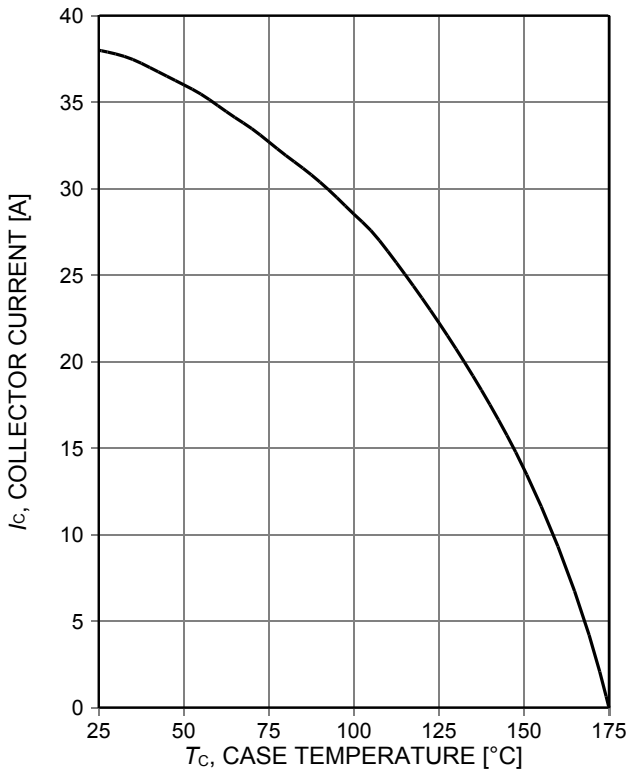


Figure 2. **Collector current as a function of case temperature**
($V_{GE} \geq 15\text{V}$, $T_{vj} \leq 175^\circ\text{C}$)

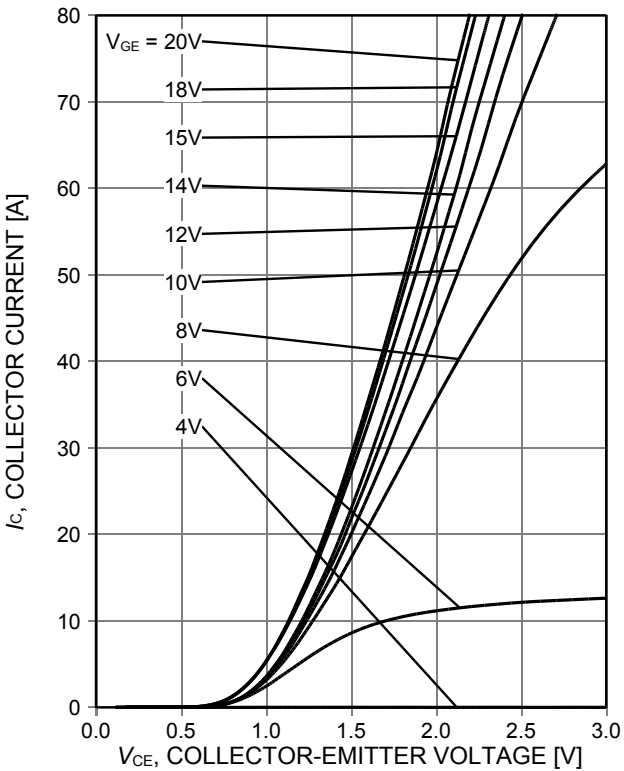


Figure 3. **Typical output characteristic**
($T_{vj} = 25^\circ\text{C}$)

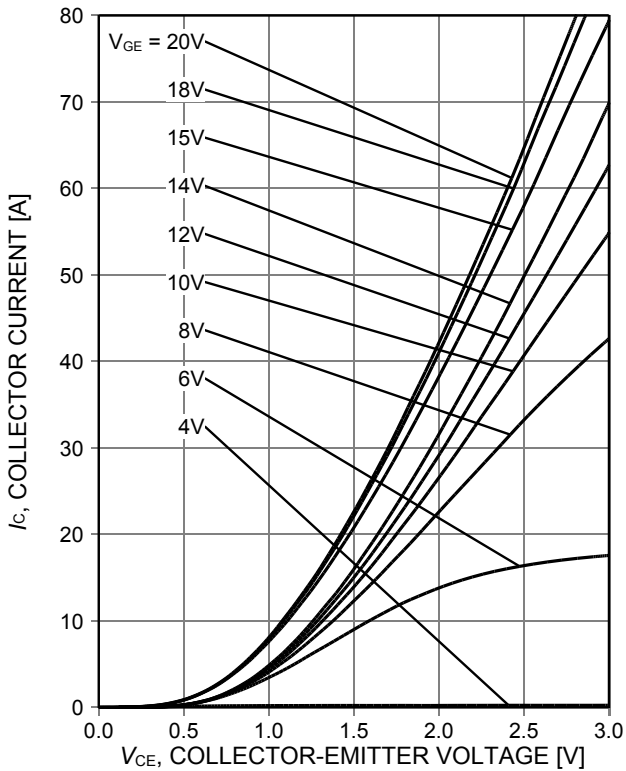


Figure 4. **Typical output characteristic**
($T_{vj} = 150^\circ\text{C}$)

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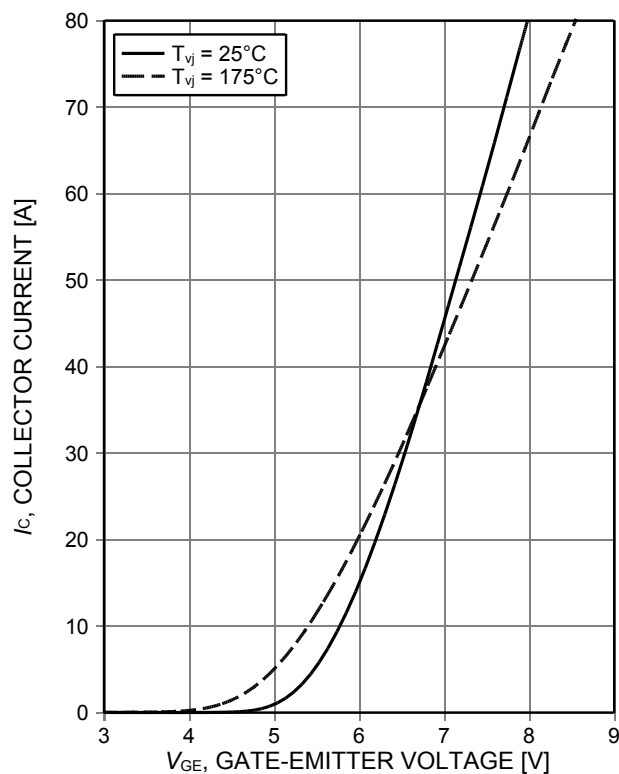


Figure 5. **Typical transfer characteristic**
($V_{CE}=20V$)

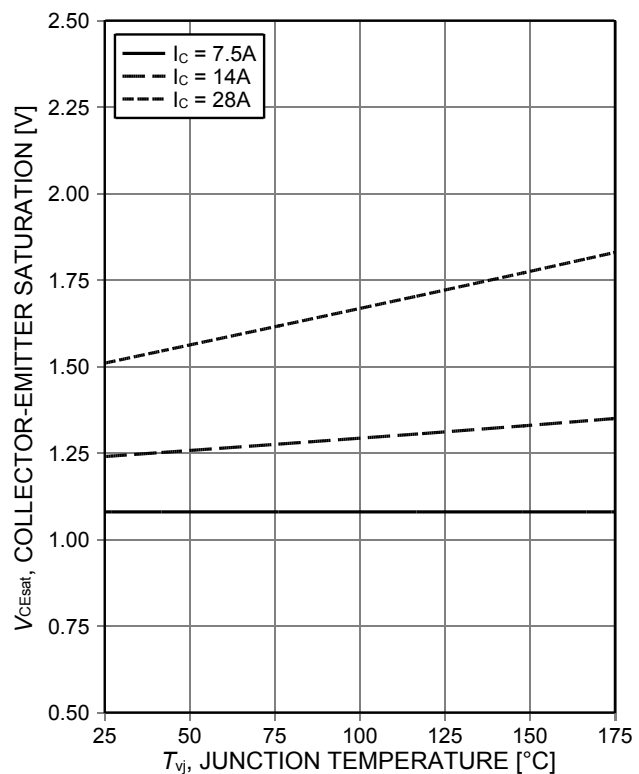


Figure 6. **Typical collector-emitter saturation voltage as a function of junction temperature**
($V_{GE}=15V$)

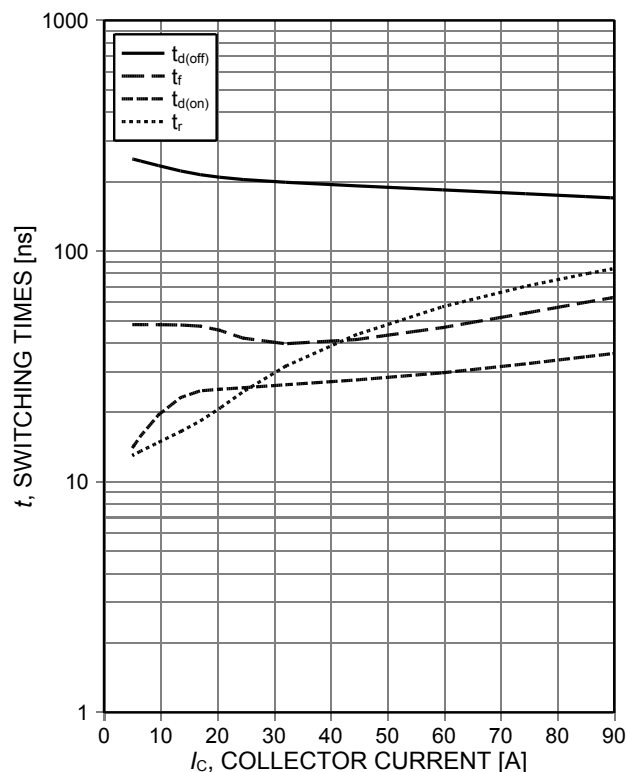


Figure 7. **Typical switching times as a function of collector current**
(inductive load, $T_{vj}=150^{\circ}C$, $V_{CE}=400V$, $V_{GE}=15/0V$, $r_G=34\Omega$, Dynamic test circuit in Figure E)

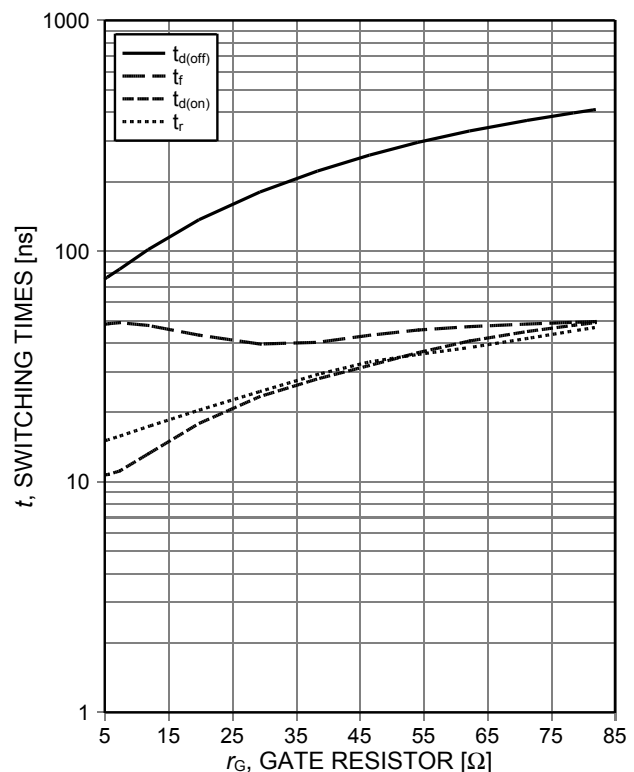


Figure 8. **Typical switching times as a function of gate resistor**
(inductive load, $T_{vj}=150^{\circ}C$, $V_{CE}=400V$, $V_{GE}=15/0V$, $I_C=28A$, Dynamic test circuit in Figure E)

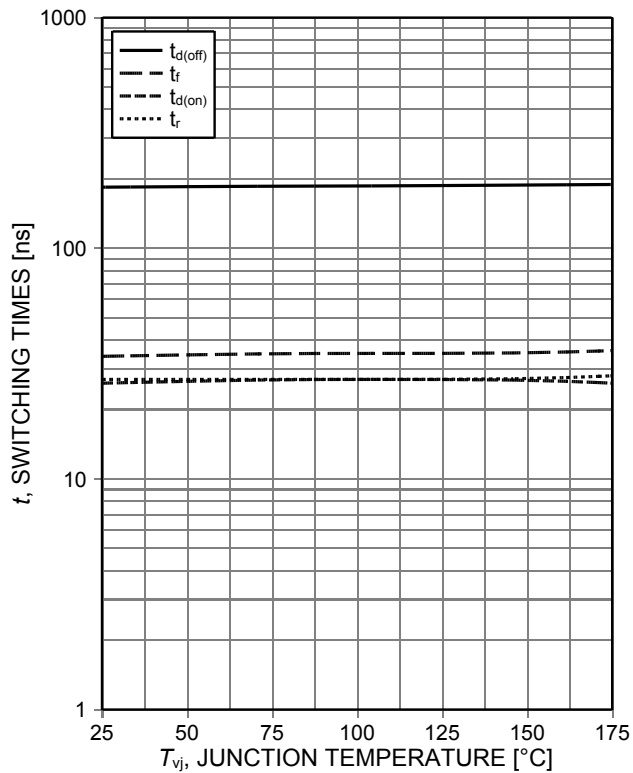
High speed switching series 5th generation

Figure 9. **Typical switching times as a function of junction temperature**
(inductive load, $V_{CE}=400V$, $V_{GE}=15/0V$, $I_C=28A$, $r_G=34\Omega$, Dynamic test circuit in Figure E)

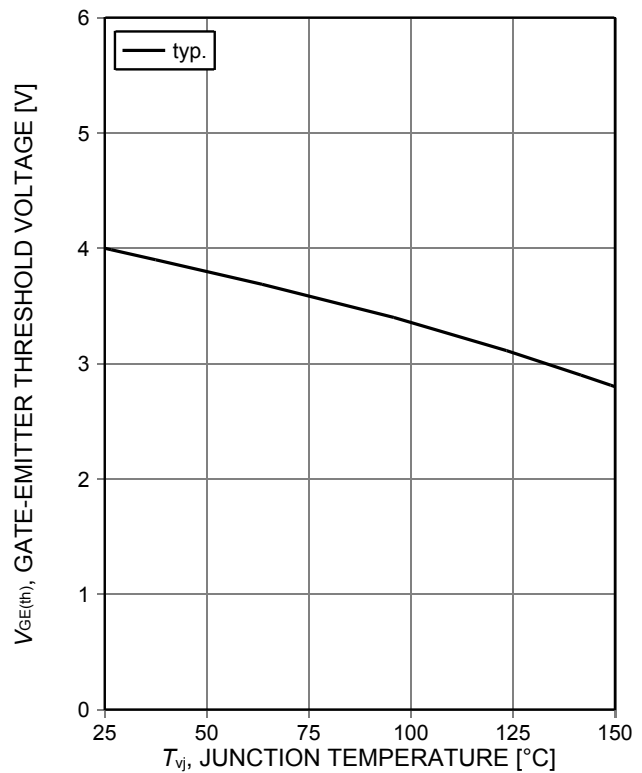


Figure 10. **Gate-emitter threshold voltage as a function of junction temperature**
($I_C=0.28mA$)

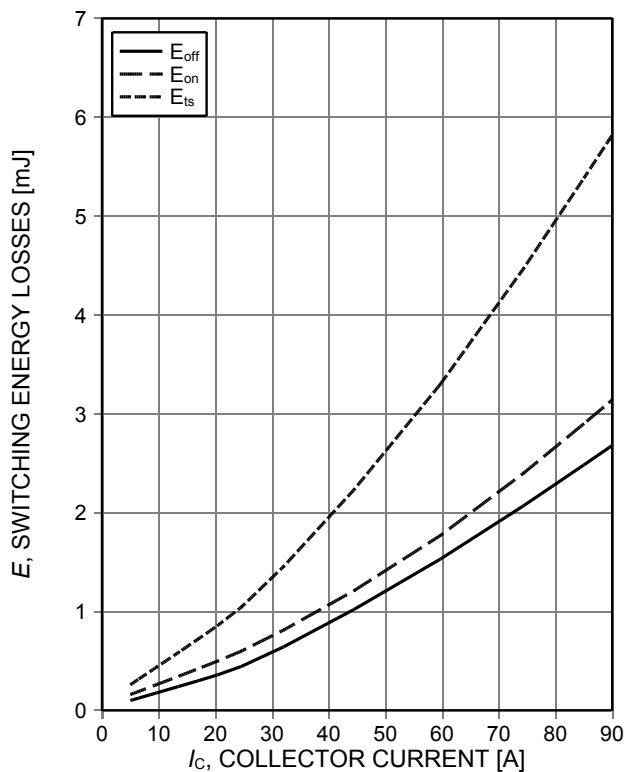


Figure 11. **Typical switching energy losses as a function of collector current**
(inductive load, $T_{vj}=150^{\circ}C$, $V_{CE}=400V$, $V_{GE}=15/0V$, $r_G=34\Omega$, Dynamic test circuit in Figure E)

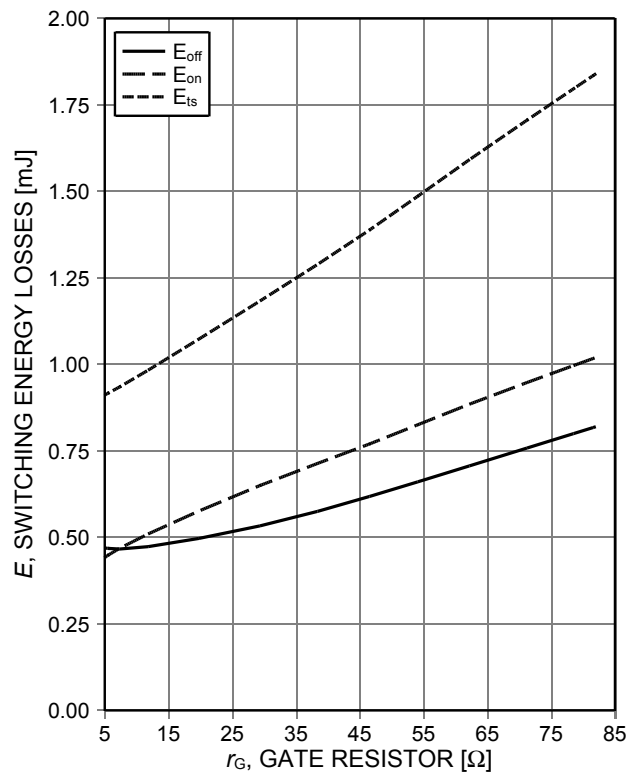


Figure 12. **Typical switching energy losses as a function of gate resistor**
(inductive load, $T_{vj}=150^{\circ}C$, $V_{CE}=400V$, $V_{GE}=15/0V$, $I_C=28A$, Dynamic test circuit in Figure E)

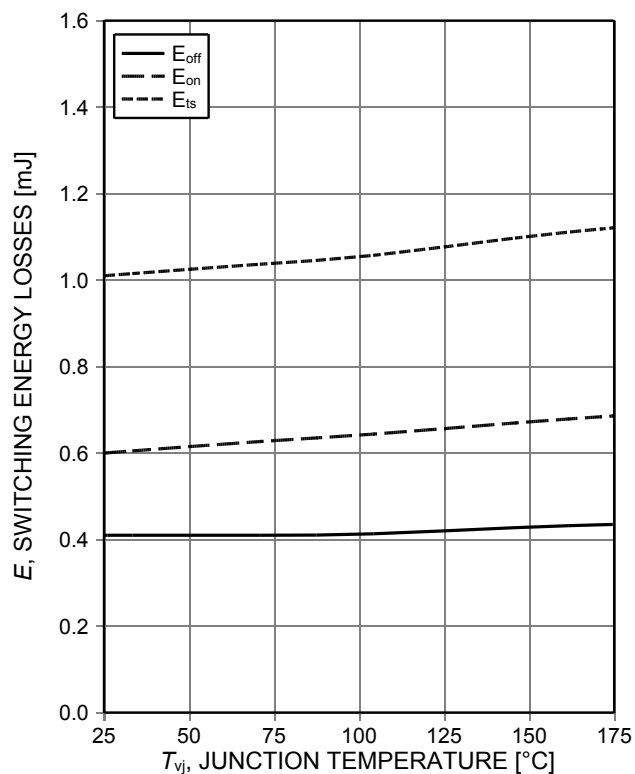
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Figure 13. **Typical switching energy losses as a function of junction temperature**
(inductive load, $V_{CE}=400V$, $V_{GE}=15/0V$, $I_C=28A$, $r_G=34\Omega$, Dynamic test circuit in Figure E)

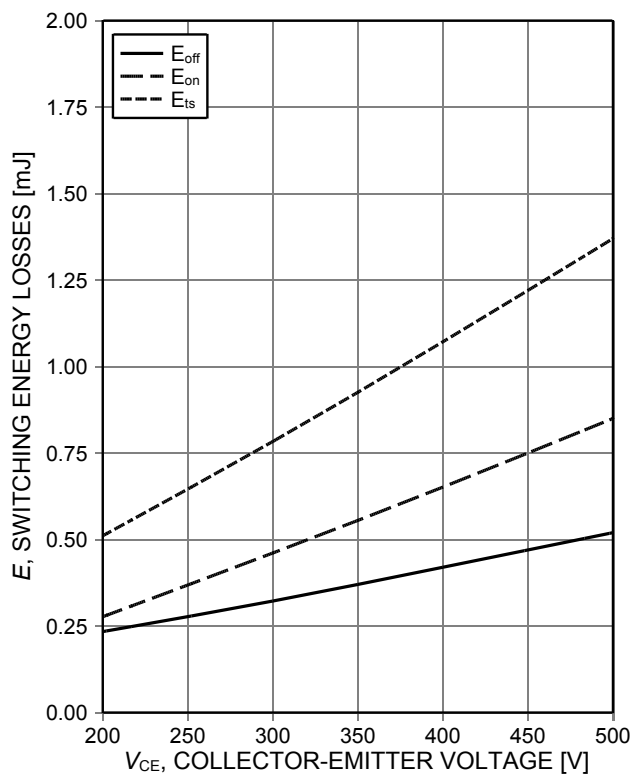


Figure 14. **Typical switching energy losses as a function of collector emitter voltage**
(inductive load, $T_{vj}=150^\circ C$, $V_{GE}=15/0V$, $I_C=28A$, $r_G=34\Omega$, Dynamic test circuit in Figure E)

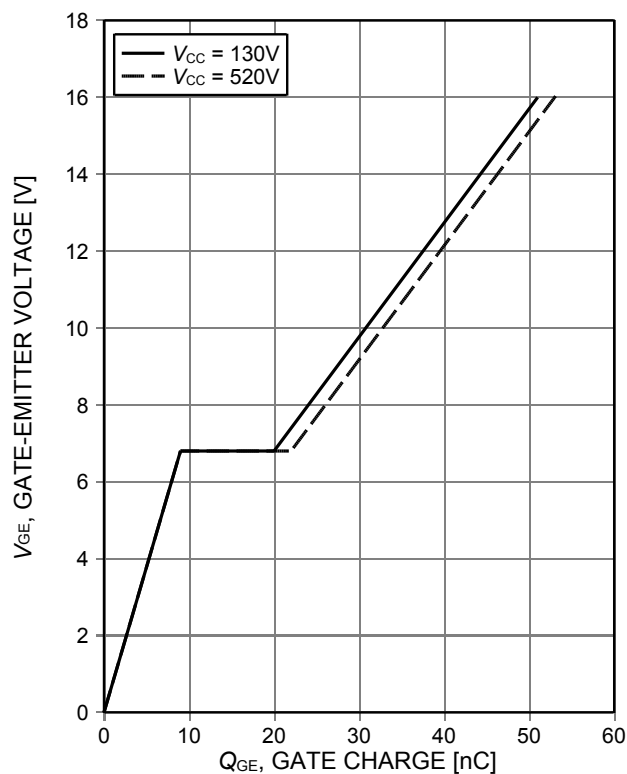


Figure 15. **Typical gate charge**
($I_C=28A$)

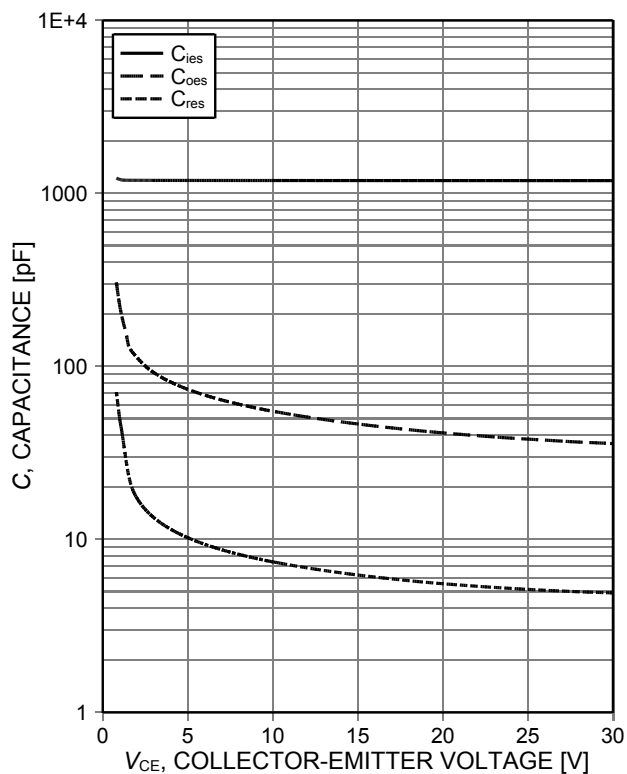
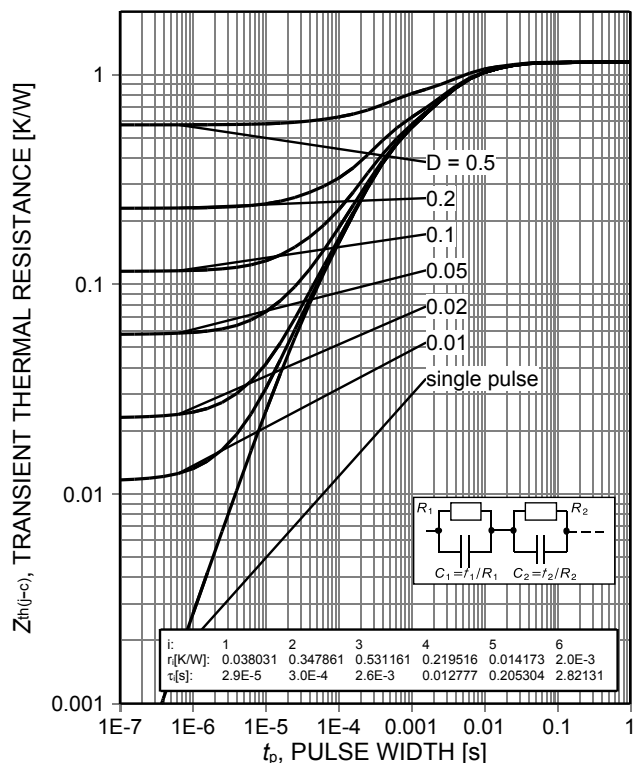
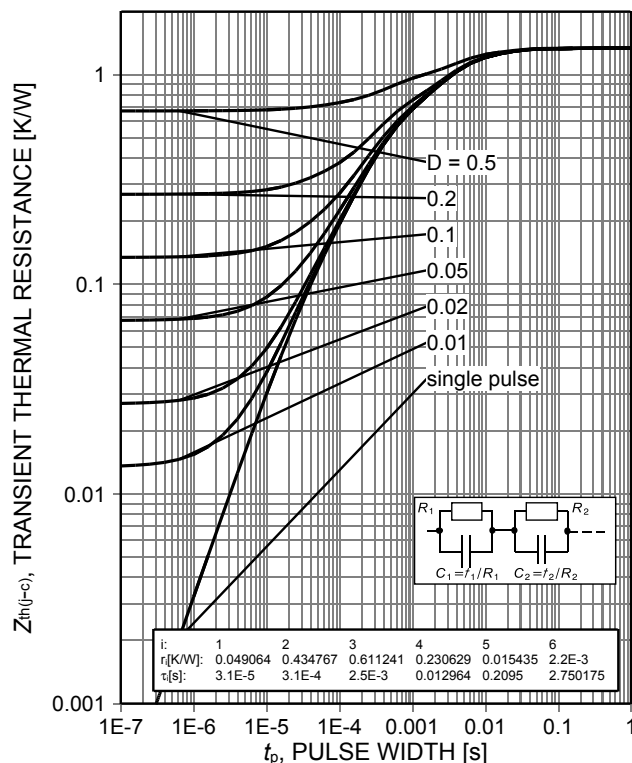
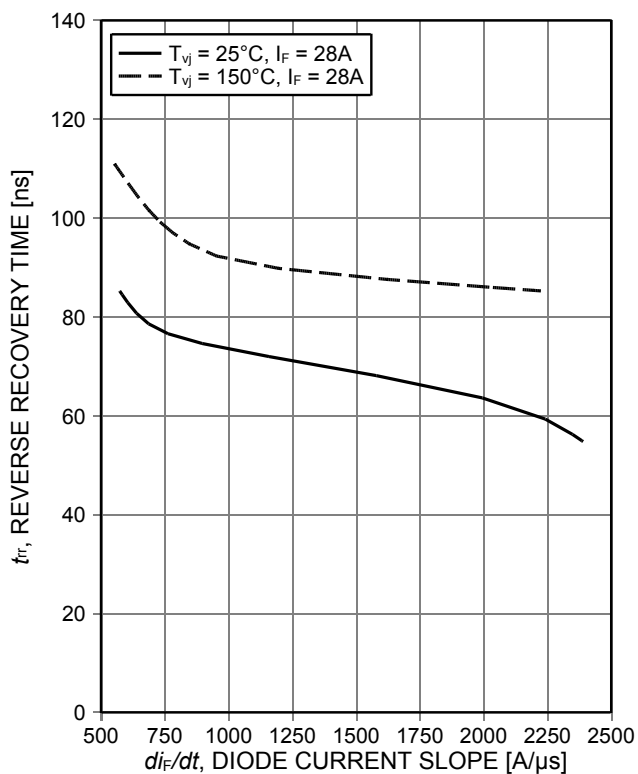
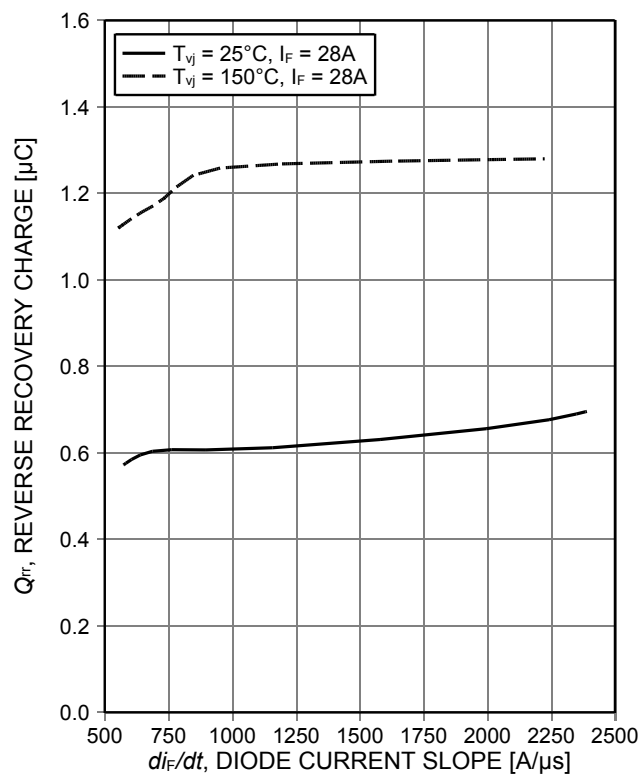


Figure 16. **Typical capacitance as a function of collector-emitter voltage**
($V_{GE}=0V$, $f=1MHz$)

High speed switching series 5th generationFigure 17. IGBT transient thermal resistance ($D=t_p/T$)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 ($V_R=400V$)

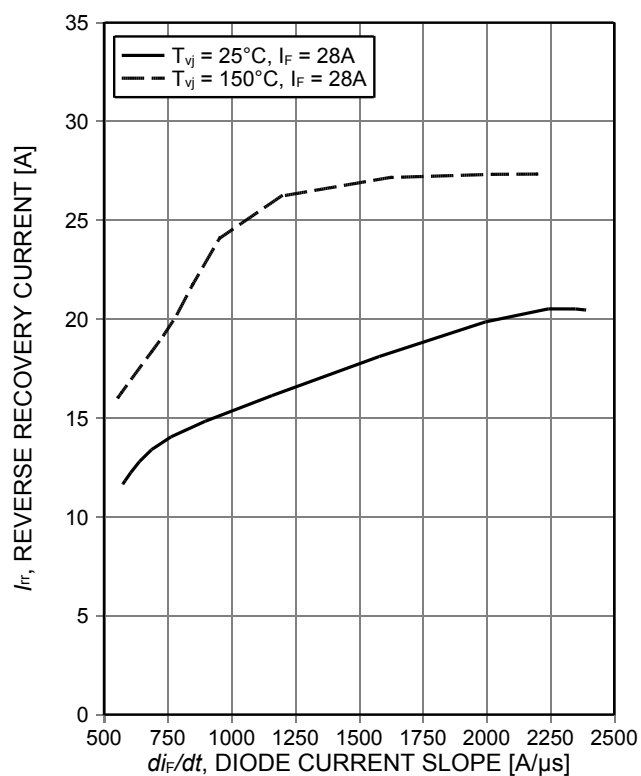
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Figure 21. Typical reverse recovery current as a function of diode current slope ($V_R=400V$)

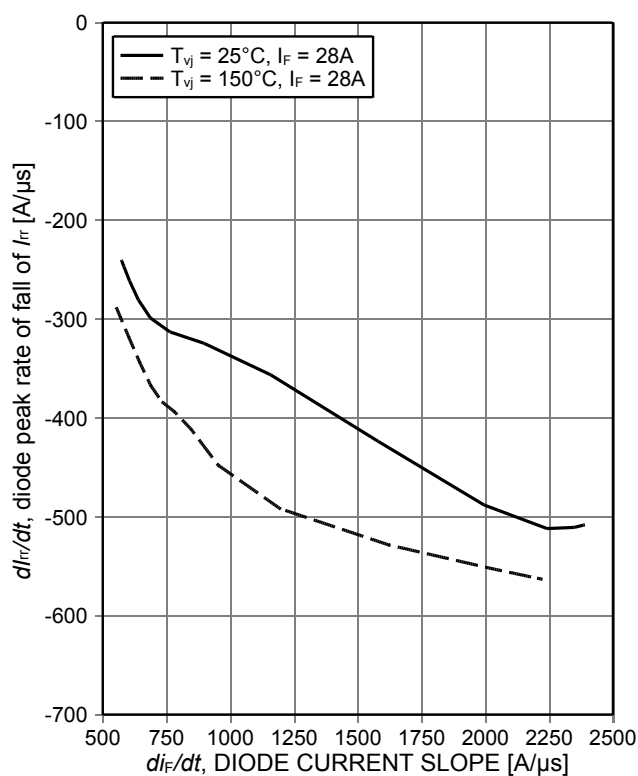


Figure 22. Typical diode peak rate of fall of reverse recovery current as a function of diode current slope ($V_R=400V$)

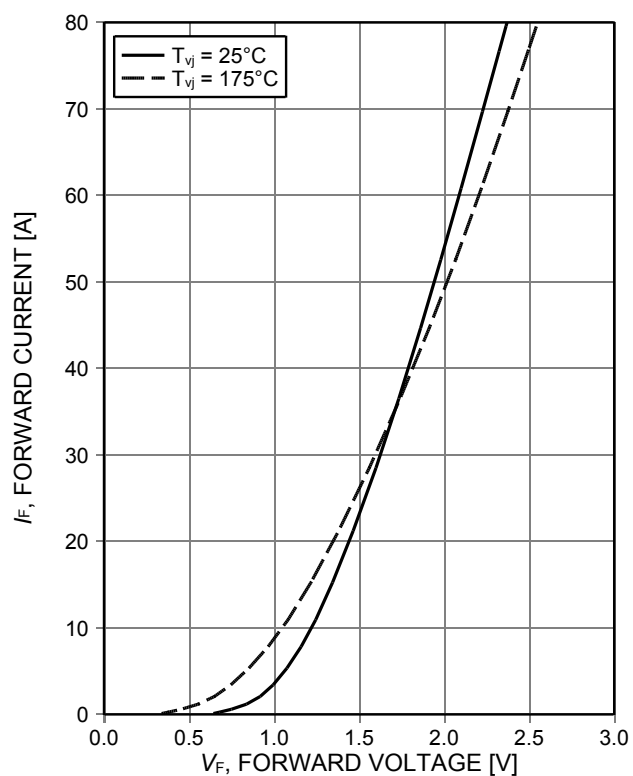


Figure 23. Typical diode forward current as a function of forward voltage

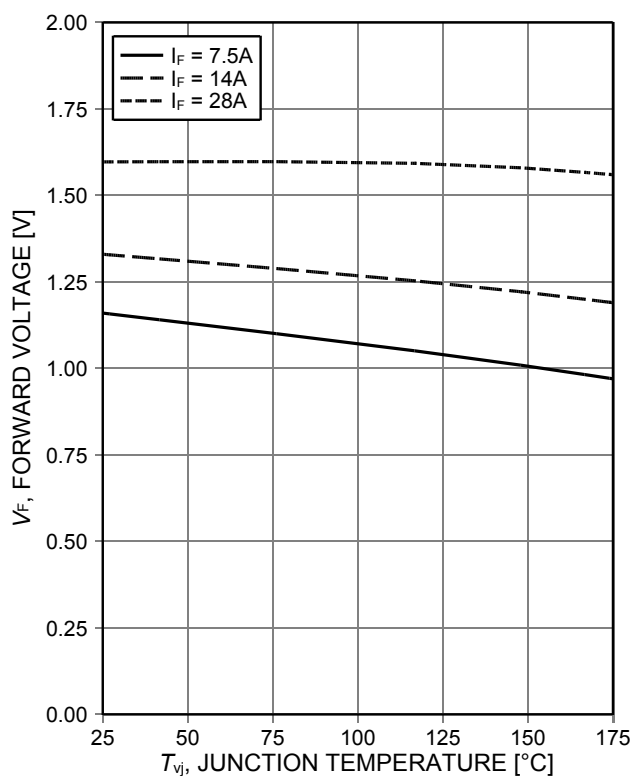
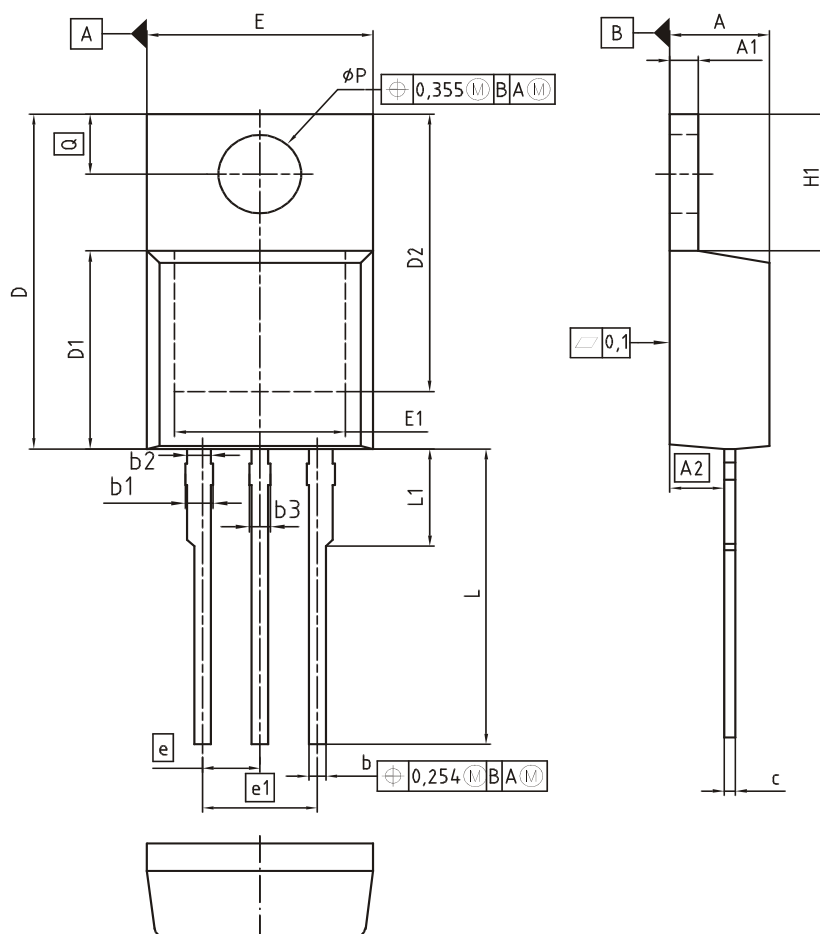
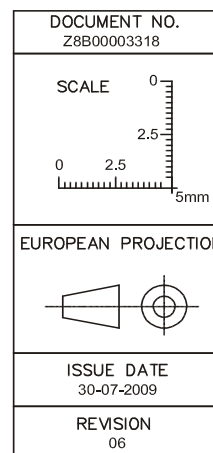


Figure 24. Typical diode forward voltage as a function of junction temperature

Package Drawing PG-TO220-3



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.30	4.57	0.169	0.180
A1	1.17	1.40	0.046	0.055
A2	2.15	2.72	0.085	0.107
b	0.65	0.86	0.026	0.034
b1	0.95	1.40	0.037	0.055
b2	0.95	1.15	0.037	0.045
b3	0.65	1.15	0.026	0.045
c	0.33	0.60	0.013	0.024
D	14.81	15.95	0.583	0.628
D1	8.51	9.45	0.335	0.372
D2	12.19	13.10	0.480	0.516
E	9.70	10.36	0.382	0.408
E1	6.50	8.60	0.256	0.339
e	2.54		0.100	
e1	5.08		0.200	
N	3		3	
H1	5.90	6.90	0.232	0.272
L	13.00	14.00	0.512	0.551
L1	-	4.80	-	0.189
øP	3.60	3.89	0.142	0.153
Q	2.60	3.00	0.102	0.118



Testing Conditions



Figure A. Definition of switching times



Figure B. Definition of switching losses



Figure C. Definition of diode switching characteristics

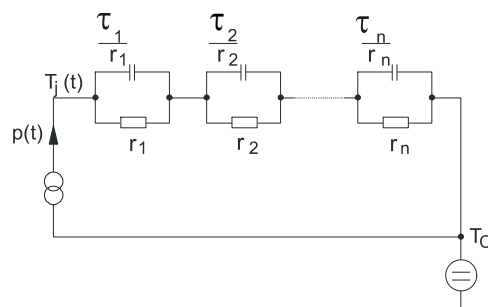


Figure D. Thermal equivalent circuit



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

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Revision History

IKP28N65ES5

Revision: 2019-01-25, Rev. 2.1

Previous Revision

Revision	Date	Subjects (major changes since last revision)
2.1	2019-01-25	Final data sheet

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Except as otherwise explicitly approved by Infineon Technologies in a written document signed by authorized representatives of Infineon Technologies, Infineon Technologies' products may not be used in any applications where a failure of the product or any consequences of the use thereof can reasonably be expected to result in personal injury.