High speed switching series 5 th 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°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, $T_{vj} \geq 25°C$	V_{CE}	650	V
DC collector current, limited by T_{vjmax} $T_c = 25°C$ $T_c = 100°C$	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 $V_{CE} \leq 650V$, $T_{vj} \leq 175°C$, $t_p = 1µs$	-	90.0	A
Diode forward current, limited by T_{vjmax} $T_c = 25°C$ value limited by bondwire $T_c = 100°C$	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 ($t_p \leq 10µs$, $D < 0.010$)	V_{GE}	±20 ±30	V
Power dissipation $T_c = 25°C$ Power dissipation $T_c = 100°C$	P_{tot}	130.0 65.0	W
Operating junction temperature	T_{vj}	-40...+175	°C
Storage temperature	T_{stg}	-55...+150	°C
Soldering temperature, wave soldering 1.6mm (0.063in.) from case for 10s		260	°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

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	650	-	-	V
Collector-emitter saturation voltage	V_{CEsat}	V_{GE} = 15.0V, I_C = 28.0A T_{vj} = 25°C T_{vj} = 125°C T_{vj} = 175°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°C T_{vj} = 125°C T_{vj} = 175°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°C T_{vj} = 175°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°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°C						
Turn-on delay time	$t_{d(on)}$	T_{vj} = 25°C, V_{CC} = 400V, I_C = 28.0A, V_{GE} = 0.0/15.0V, $R_{G(on)}$ = 34.0Ω, $R_{G(off)}$ = 34.0Ω, $L\sigma$ = 30nH, $C\sigma$ = 30pF $L\sigma$, $C\sigma$ from Fig. E Energy losses include “tail” and diode reverse recovery.	-	27	-	ns
Rise time	t_r		-	28	-	ns
Turn-off delay time	$t_{d(off)}$		-	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

Turn-on delay time	$t_{d(on)}$	T_{vj} = 25°C, V_{CC} = 400V, I_C = 14.0A, V_{GE} = 0.0/15.0V, $R_{G(on)}$ = 34.0Ω, $R_{G(off)}$ = 34.0Ω, $L\sigma$ = 30nH, $C\sigma$ = 30pF $L\sigma$, $C\sigma$ 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°C

Diode reverse recovery time	t_{rr}	T_{vj} = 25°C, V_R = 400V, I_F = 28.0A, di_F/dt = 1020A/µs	-	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°C, V_R = 400V, I_F = 14.0A, di_F/dt = 1180A/µs	-	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°C						
Turn-on delay time	$t_{d(on)}$	T_{vj} = 150°C, V_{CC} = 400V, I_C = 28.0A, V_{GE} = 0.0/15.0V, $R_{G(on)}$ = 34.0Ω, $R_{G(off)}$ = 34.0Ω, $L\sigma$ = 30nH, $C\sigma$ = 30pF $L\sigma$, $C\sigma$ from Fig. E Energy losses include "tail" and diode reverse recovery.	-	26	-	ns
Rise time	t_r		-	28	-	ns
Turn-off delay time	$t_{d(off)}$		-	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	$t_{d(on)}$	T_{vj} = 150°C, V_{CC} = 400V, I_C = 14.0A, V_{GE} = 0.0/15.0V, $R_{G(on)}$ = 34.0Ω, $R_{G(off)}$ = 34.0Ω, $L\sigma$ = 30nH, $C\sigma$ = 30pF $L\sigma$, $C\sigma$ from Fig. E Energy losses include "tail" and diode reverse recovery.	-	25	-	ns
Rise time	t_r		-	16	-	ns
Turn-off delay time	$t_{d(off)}$		-	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

Diode Characteristic, at T_{vj} = 150°C

Diode reverse recovery time	t_{rr}	T_{vj} = 150°C, V_R = 400V, I_F = 28.0A, di_F/dt = 830A/µs	-	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°C, V_R = 400V, I_F = 14.0A, di_F/dt = 1020A/µs	-	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

Figure 1. **Power dissipation as a function of case temperature**
(T_{vj}≤175°C)

Figure 2. **Collector current as a function of case temperature**
(V_{GE}≥15V, T_{vj}≤175°C)

Figure 3. **Typical output characteristic**
(T_{vj}=25°C)

Figure 4. **Typical output characteristic**
(T_{vj}=150°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** (inductive load, T_{vj}=150°C, V_{CE}=400V, V_{GE}=15/0V, r_G=34Ω, Dynamic test circuit in Figure E)

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

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=34Ω, 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°C, V_{CE}=400V, V_{GE}=15/0V, r_G=34Ω, Dynamic test circuit in Figure E)

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

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=34Ω, Dynamic test circuit in Figure E)

Figure 14. **Typical switching energy losses as a function of collector emitter voltage** (inductive load, T_{vj}=150°C, V_{GE}=15/0V, I_C=28A, r_G=34Ω, 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)

Figure 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)

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

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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

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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