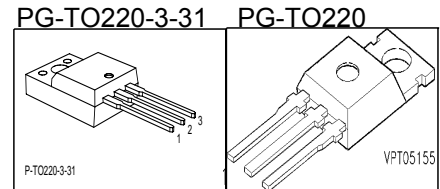


Cool MOS™ Power Transistor

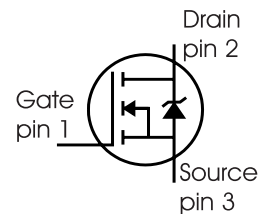
Feature

- New revolutionary high voltage technology
- Ultra low gate charge
- Periodic avalanche rated
- Extreme dv/dt rated
- Ultra low effective capacitances
- Improved transconductance
- PG-TO-220-3-31: Fully isolated package (2500 VAC; 1 minute)
- Pb-free lead plating; RoHS compliant
- Qualified according to JEDEC⁰⁾ for target applications

$V_{DS} @ T_{jmax}$	560	V
$R_{DS(on)}$	0.95	Ω
I_D	4.5	A



Type	Package	Ordering Code	Marking
SPP04N50C3	PG-TO220	Q67040-S4575	04N50C3
SPA04N50C3	PG-TO220-3-31	SP000216298	04N50C3



Maximum Ratings

Parameter	Symbol	Value		Unit
		SP	SPA	
Continuous drain current $T_C = 25\text{ }^\circ\text{C}$ $T_C = 100\text{ }^\circ\text{C}$	I_D	4.5 2.8	4.5 ¹⁾ 2.8 ¹⁾	A
Pulsed drain current, t_p limited by T_{jmax}	$I_{D\text{ puls}}$	13.5	13.5	A
Avalanche energy, single pulse $I_D=3.4\text{A}, V_{DD}=50\text{V}$	E_{AS}	130	130	mJ
Avalanche energy, repetitive t_{AR} limited by T_{jmax} ²⁾ $I_D=4.5\text{A}, V_{DD}=50\text{V}$	E_{AR}	0.4	0.4	
Avalanche current, repetitive t_{AR} limited by T_{jmax}	I_{AR}	4.5	4.5	A
Gate source voltage	V_{GS}	± 20	± 20	V
Gate source voltage AC ($f > 1\text{Hz}$)	V_{GS}	± 30	± 30	
Power dissipation, $T_C = 25\text{ }^\circ\text{C}$	P_{tot}	50	31	W
Operating and storage temperature	T_j, T_{stg}	-55...+150		$^\circ\text{C}$
Reverse diode dv/dt ⁷⁾	dv/dt	15		V/ns

Maximum Ratings

Parameter	Symbol	Value	Unit
Drain Source voltage slope $V_{DS} = 400 \text{ V}$, $I_D = 4.5 \text{ A}$, $T_j = 125 \text{ }^\circ\text{C}$	dv/dt	50	V/ns

Thermal Characteristics

Parameter	Symbol	Values			Unit
		min.	typ.	max.	
Thermal resistance, junction - case	R_{thJC}	-	-	2.5	K/W
Thermal resistance, junction - case, FullPAK	$R_{thJC \text{ FP}}$	-	-	4	
Thermal resistance, junction - ambient, leaded	R_{thJA}	-	-	62	
Thermal resistance, junction - ambient, FullPAK	$R_{thJA \text{ FP}}$	-	-	80	
SMD version, device on PCB: @ min. footprint @ 6 cm ² cooling area ³⁾	R_{thJA}	-	-	62	
Soldering temperature, wavesoldering 1.6 mm (0.063 in.) from case for 10s ⁴⁾	T_{sold}	-	-	260	°C

Electrical Characteristics, at $T_j=25^\circ\text{C}$ unless otherwise specified

Parameter	Symbol	Conditions	Values			Unit
			min.	typ.	max.	
Drain-source breakdown voltage	$V_{(BR)DSS}$	$V_{GS}=0\text{V}$, $I_D=0.25\text{mA}$	500	-	-	V
Drain-Source avalanche breakdown voltage	$V_{(BR)DS}$	$V_{GS}=0\text{V}$, $I_D=4.5\text{A}$	-	600	-	
Gate threshold voltage	$V_{GS(th)}$	$I_D=200\mu\text{A}$, $V_{GS}=V_{DS}$	2.1	3	3.9	
Zero gate voltage drain current	I_{DSS}	$V_{DS}=500\text{V}$, $V_{GS}=0\text{V}$, $T_j=25^\circ\text{C}$ $T_j=150^\circ\text{C}$	-	0.1	1	μA
Gate-source leakage current	I_{GSS}	$V_{GS}=20\text{V}$, $V_{DS}=0\text{V}$	-	-	100	
Drain-source on-state resistance	$R_{DS(on)}$	$V_{GS}=10\text{V}$, $I_D=2.8\text{A}$ $T_j=25^\circ\text{C}$ $T_j=150^\circ\text{C}$	-	0.85	0.95	Ω
Gate input resistance	R_G	$f=1\text{MHz}$, open drain	-	1.4	-	

Electrical Characteristics

Parameter	Symbol	Conditions	Values			Unit
			min.	typ.	max.	
Transconductance	g_{fs}	$V_{DS} \geq 2 \cdot I_D \cdot R_{DS(on)max}$, $I_D = 2.8A$	-	4.4	-	S
Input capacitance	C_{iss}	$V_{GS} = 0V$, $V_{DS} = 25V$,	-	470	-	pF
Output capacitance	C_{oss}	$f = 1MHz$	-	160	-	
Reverse transfer capacitance	C_{rss}		-	15	-	
Effective output capacitance, ⁵⁾ energy related	$C_{o(er)}$	$V_{GS} = 0V$, $V_{DS} = 0V$ to $400V$	-	27	-	
Effective output capacitance, ⁶⁾ time related	$C_{o(tr)}$		-	44	-	
Turn-on delay time	$t_{d(on)}$	$V_{DD} = 350V$, $V_{GS} = 0/10V$,	-	10	-	ns
Rise time	t_r	$I_D = 4.5A$,	-	5	-	
Turn-off delay time	$t_{d(off)}$	$R_G = 18\Omega$	-	70	-	
Fall time	t_f		-	10	-	

Gate Charge Characteristics

Gate to source charge	Q_{gs}	$V_{DD} = 400V$, $I_D = 4.5A$	-	2.2	-	nC
Gate to drain charge	Q_{gd}		-	10	-	
Gate charge total	Q_g	$V_{DD} = 400V$, $I_D = 4.5A$, $V_{GS} = 0$ to $10V$	-	22	-	
Gate plateau voltage	$V_{(plateau)}$	$V_{DD} = 400V$, $I_D = 4.5A$	-	5	-	V

⁰J-STD20 and JESD22

¹Limited only by maximum temperature

²Repetitive avalanche causes additional power losses that can be calculated as $P_{AV} = E_{AR} \cdot f$.

³Device on 40mm*40mm*1.5mm epoxy PCB FR4 with 6cm² (one layer, 70 μm thick) copper area for drain connection. PCB is vertical without blown air.

⁴Soldering temperature for TO-263: 220°C, reflow

⁵ $C_{o(er)}$ is a fixed capacitance that gives the same stored energy as C_{oss} while V_{DS} is rising from 0 to 80% V_{DSS} .

⁶ $C_{o(tr)}$ is a fixed capacitance that gives the same charging time as C_{oss} while V_{DS} is rising from 0 to 80% V_{DSS} .

⁷ $I_{SD} \leq I_D$, $di/dt \leq 400A/us$, $V_{Dclink} = 400V$, $V_{peak} < V_{BR, DSS}$, $T_j < T_{j,max}$.

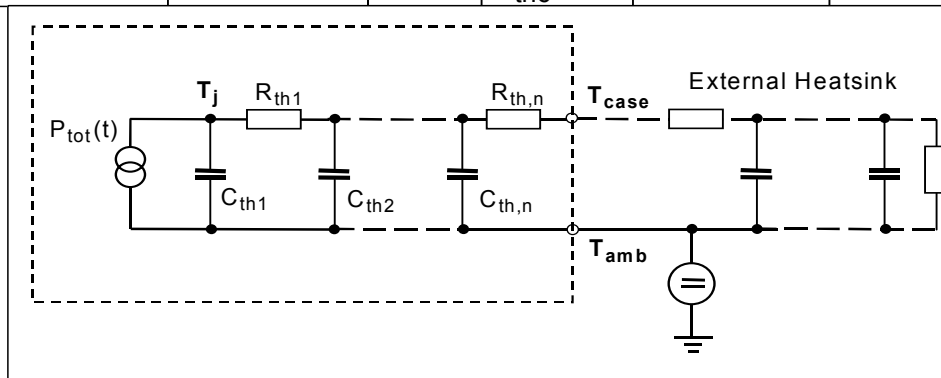
Identical low-side and high-side switch.

Electrical Characteristics

Parameter	Symbol	Conditions	Values			Unit
			min.	typ.	max.	
Inverse diode continuous forward current	I_S	$T_C=25^\circ\text{C}$	-	-	4.5	A
Inverse diode direct current, pulsed	I_{SM}		-	-	13.5	
Inverse diode forward voltage	V_{SD}	$V_{GS}=0\text{V}, I_F=I_S$	-	1	1.2	V
Reverse recovery time	t_{rr}	$V_R=400\text{V}, I_F=I_S,$	-	280	-	ns
Reverse recovery charge	Q_{rr}	$di_F/dt=100\text{A}/\mu\text{s}$	-	2.3	-	μC
Peak reverse recovery current	I_{rrm}		-	16	-	A
Peak rate of fall of reverse recovery current	di_{rr}/dt	$T_j=25^\circ\text{C}$	-	860	-	$\text{A}/\mu\text{s}$

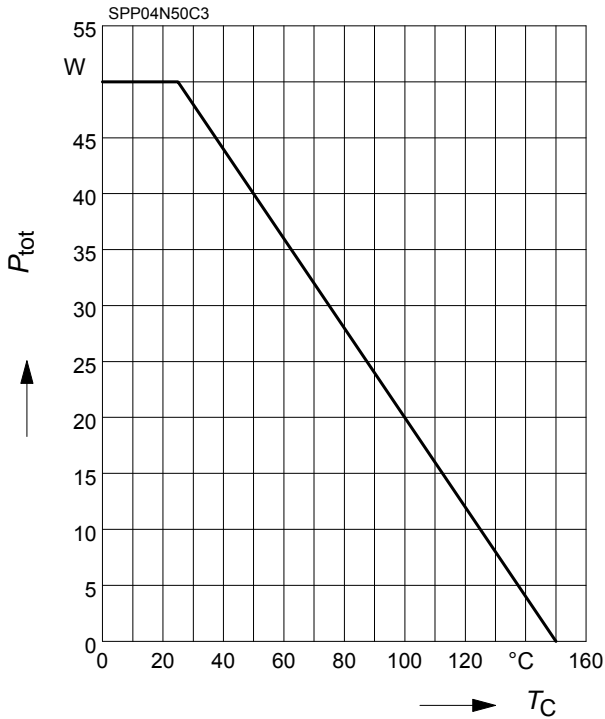
Typical Transient Thermal Characteristics

Symbol	Value		Unit	Symbol	Value		Unit
	SPP_B	SPA			SPP_B	SPA	
R_{th1}	0.039	0.039	K/W	C_{th1}	0.00007347	0.00007347	Ws/K
R_{th2}	0.074	0.074		C_{th2}	0.0002831	0.0002831	
R_{th3}	0.132	0.132		C_{th3}	0.0004062	0.0004062	
R_{th4}	0.555	0.272		C_{th4}	0.001215	0.001215	
R_{th5}	0.529	0.559		C_{th5}	0.00276	0.005633	
R_{th6}	0.169	2.523		C_{th6}	0.029	0.412	



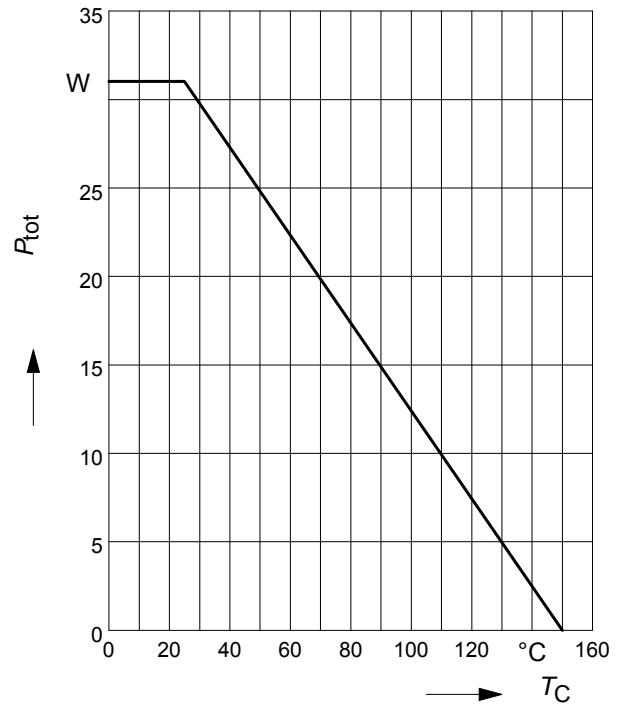
1 Power dissipation

$P_{tot} = f(T_C)$



2 Power dissipation FullPAK

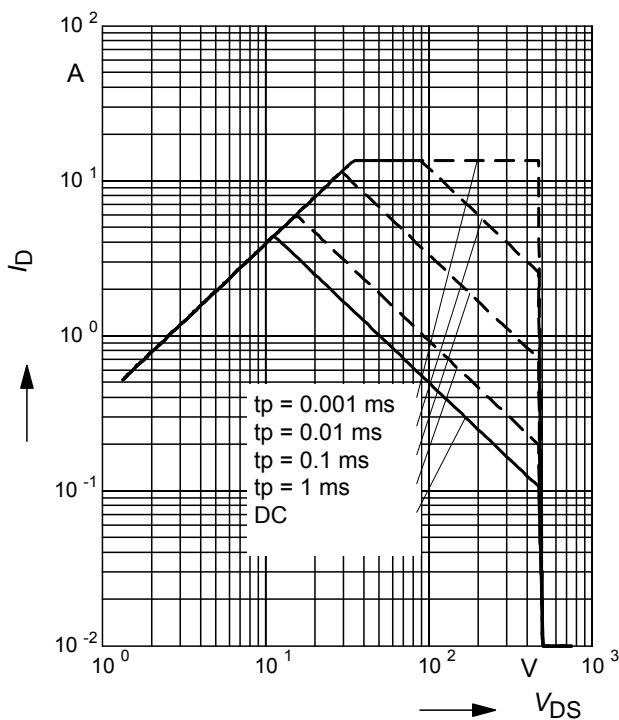
$P_{tot} = f(T_C)$



3 Safe operating area

$I_D = f(V_{DS})$

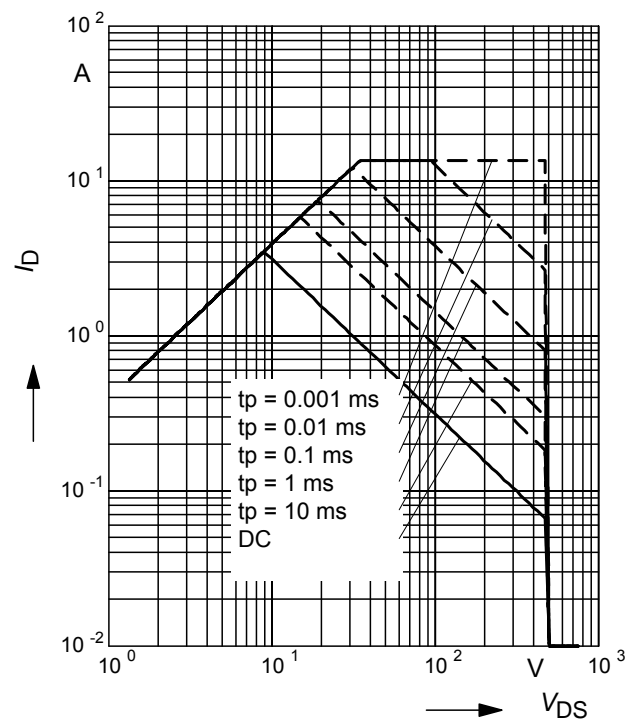
parameter : $D = 0$, $T_C = 25^\circ\text{C}$



4 Safe operating area FullPAK

$I_D = f(V_{DS})$

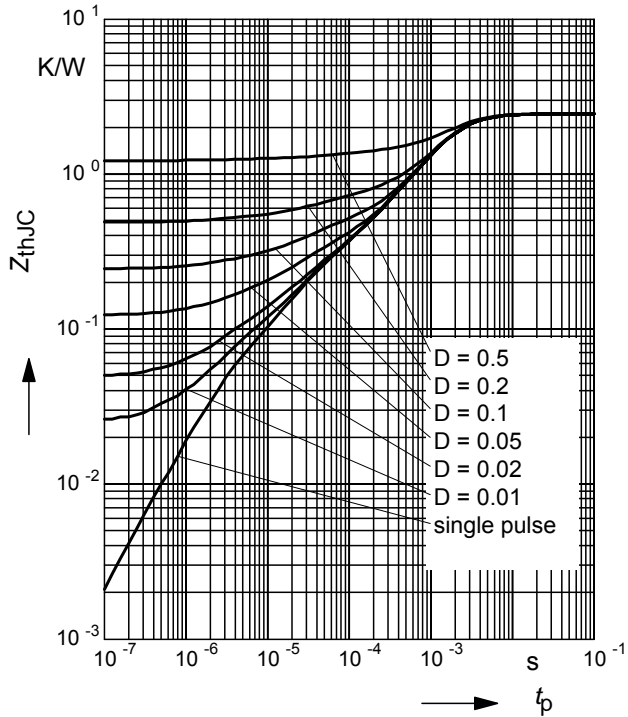
parameter: $D = 0$, $T_C = 25^\circ\text{C}$



5 Transient thermal impedance

$Z_{thJC} = f(t_p)$

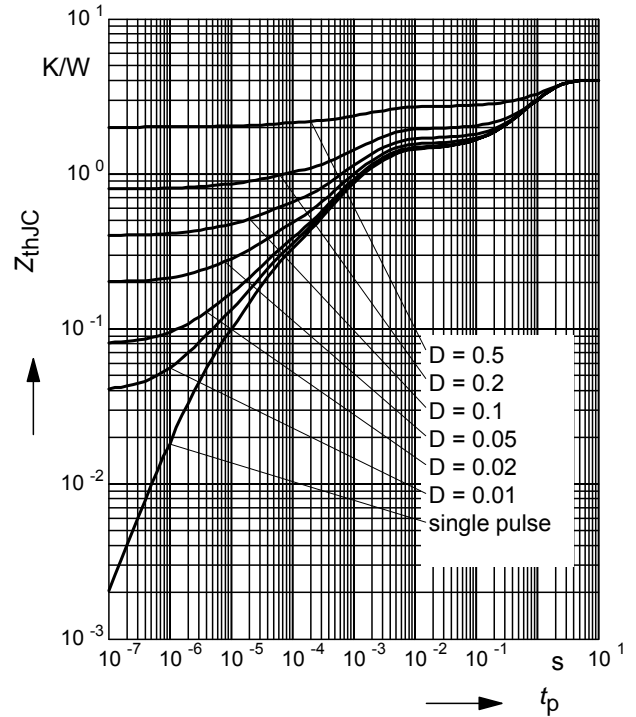
parameter: $D = t_p/T$



6 Transient thermal impedance FullPAK

$Z_{thJC} = f(t_p)$

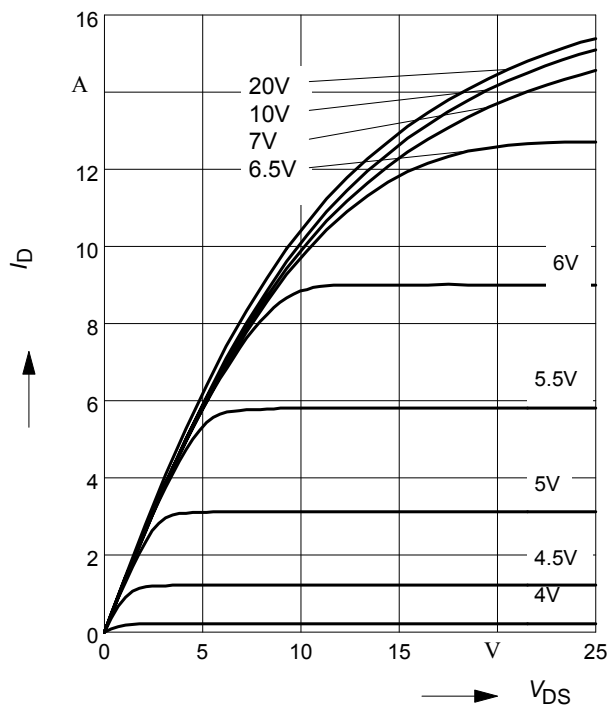
parameter: $D = t_p/t$



7 Typ. output characteristic

$I_D = f(V_{DS}); T_j=25^\circ\text{C}$

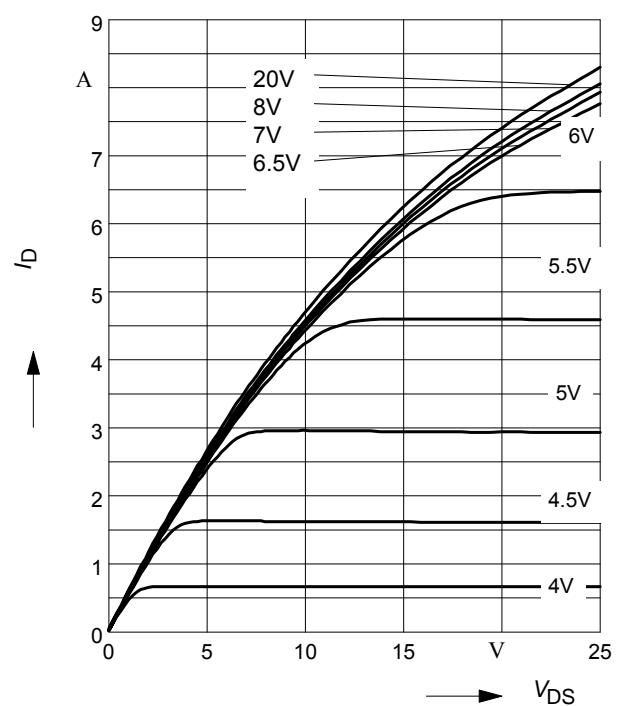
parameter: $t_p = 10 \mu\text{s}, V_{GS}$



8 Typ. output characteristic

$I_D = f(V_{DS}); T_j=150^\circ\text{C}$

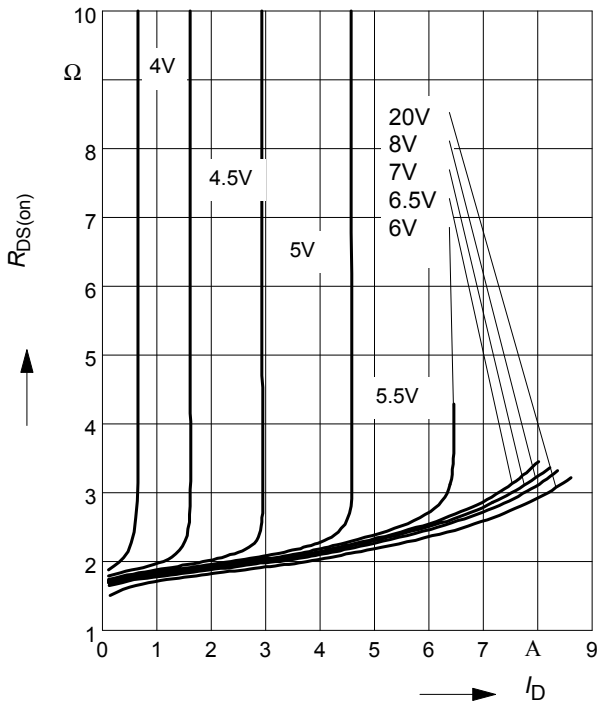
parameter: $t_p = 10 \mu\text{s}, V_{GS}$



9 Typ. drain-source on resistance

$$R_{DS(on)} = f(I_D)$$

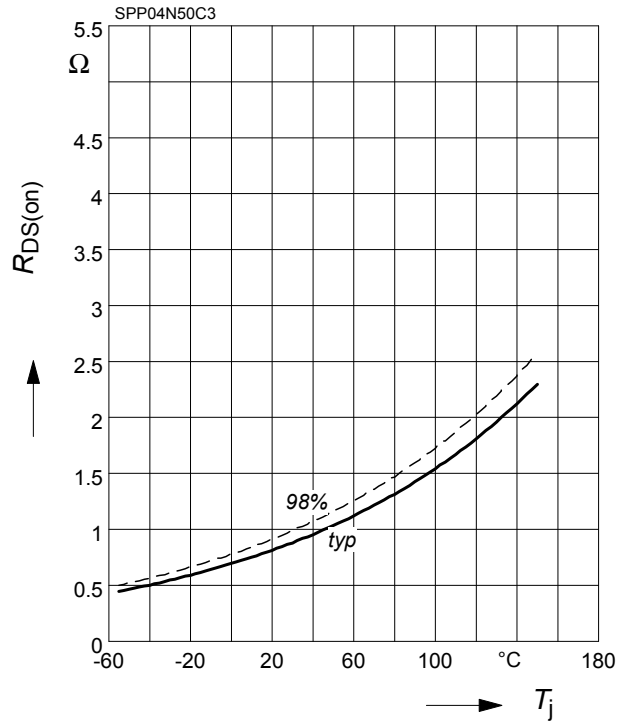
parameter: $T_j = 150^\circ\text{C}$, V_{GS}



10 Drain-source on-state resistance

$$R_{DS(on)} = f(T_j)$$

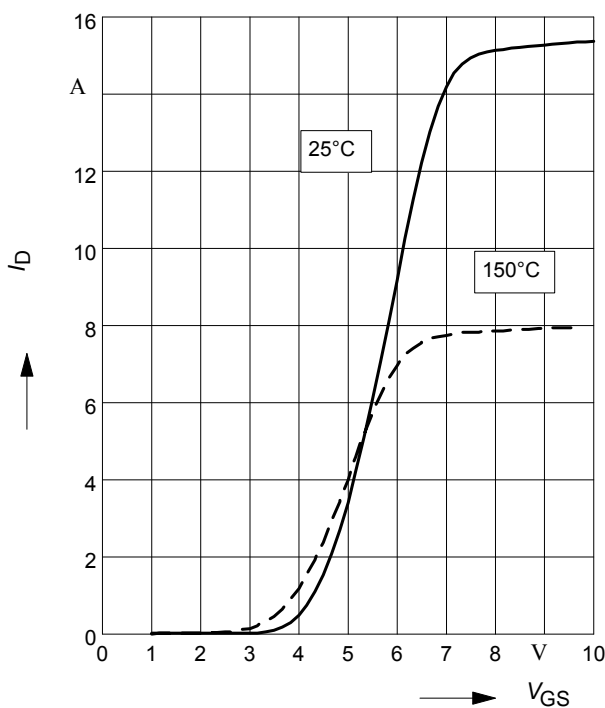
parameter: $I_D = 2.8\text{ A}$, $V_{GS} = 10\text{ V}$



11 Typ. transfer characteristics

$$I_D = f(V_{GS}); V_{DS} \geq 2 \times I_D \times R_{DS(on)\text{max}}$$

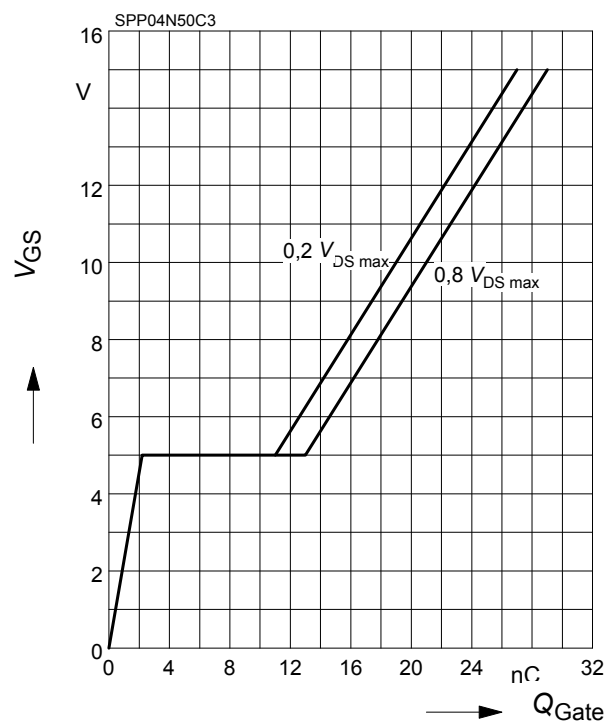
parameter: $t_p = 10\ \mu\text{s}$



12 Typ. gate charge

$$V_{GS} = f(Q_{\text{Gate}})$$

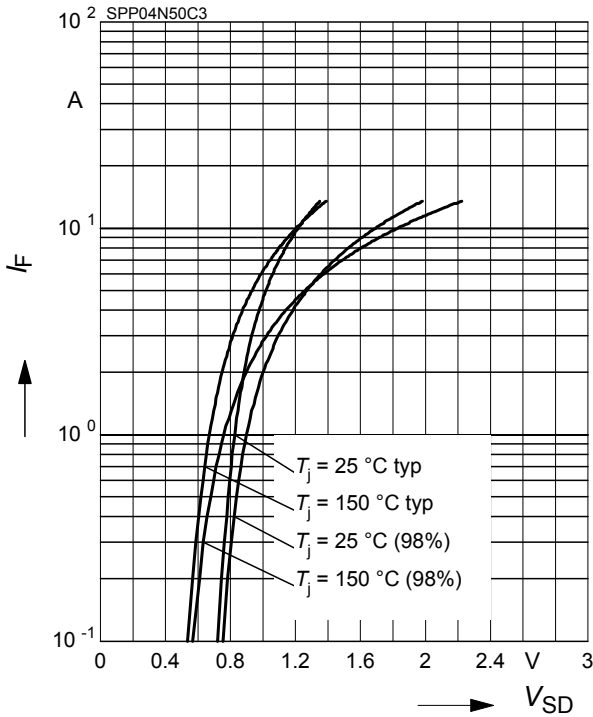
parameter: $I_D = 4.5\text{ A pulsed}$



13 Forward characteristics of body diode

$I_F = f(V_{SD})$

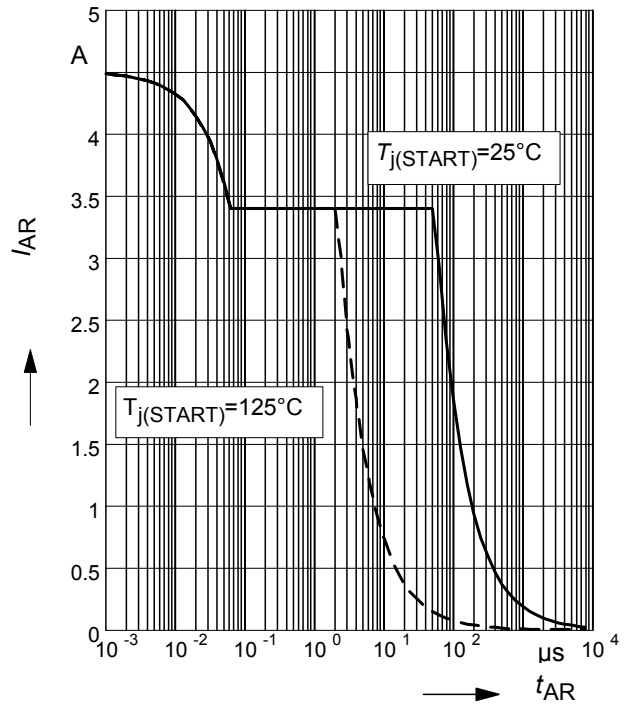
parameter: T_j , $t_p = 10 \mu s$



14 Avalanche SOA

$I_{AR} = f(t_{AR})$

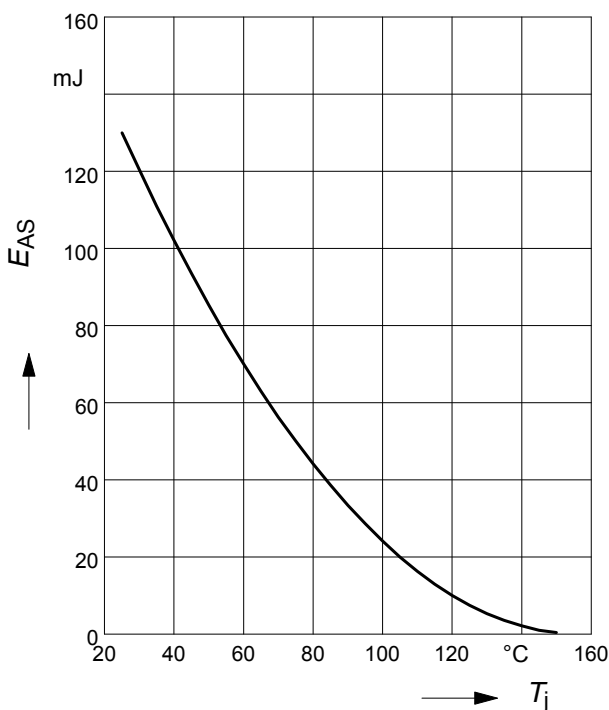
par.: $T_j \leq 150 \text{ °C}$



15 Avalanche energy

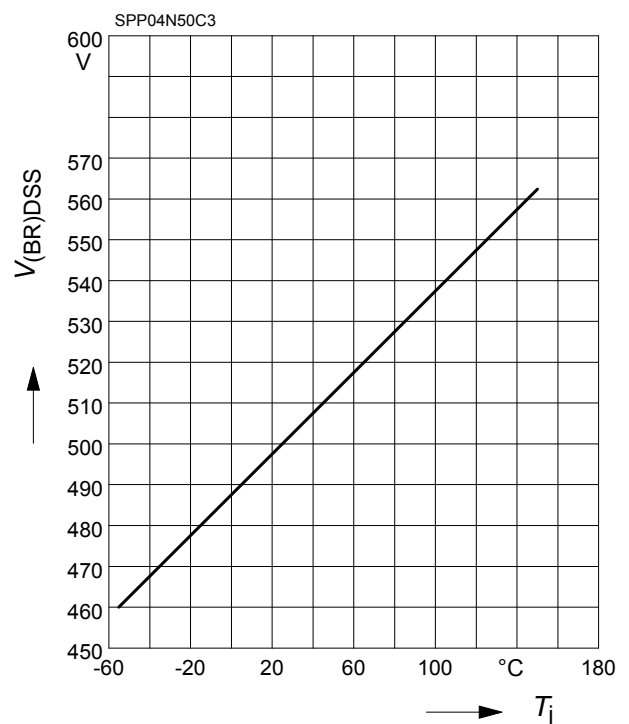
$E_{AS} = f(T_j)$

par.: $I_D = 3.4 \text{ A}$, $V_{DD} = 50 \text{ V}$



16 Drain-source breakdown voltage

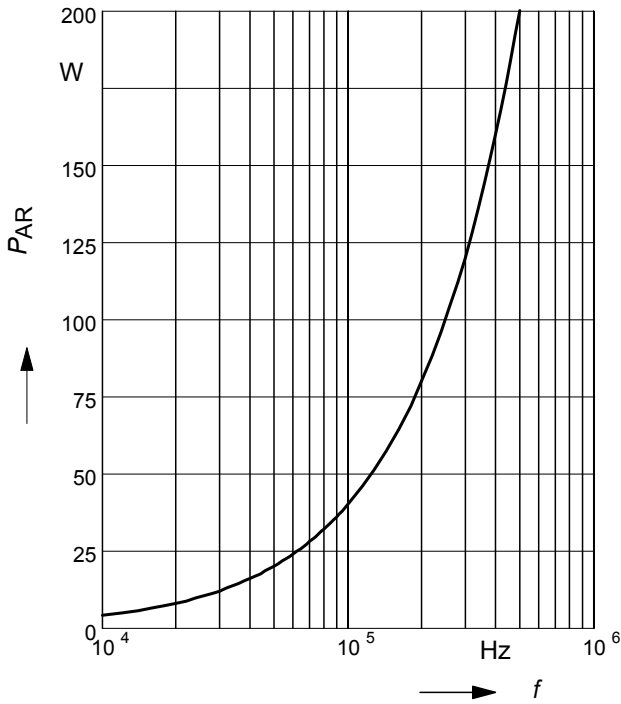
$V_{(BR)DSS} = f(T_j)$



17 Avalanche power losses

$$P_{AR} = f(f)$$

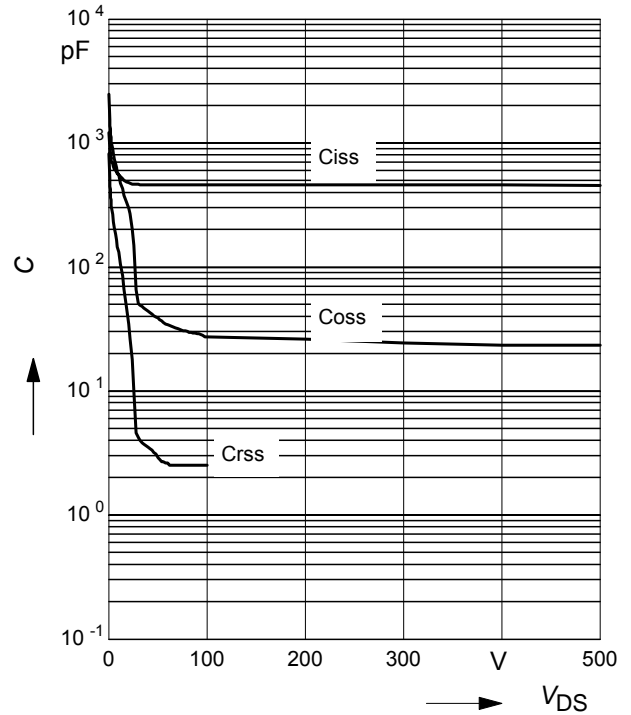
parameter: $E_{AR}=0.4\text{mJ}$



18 Typ. capacitances

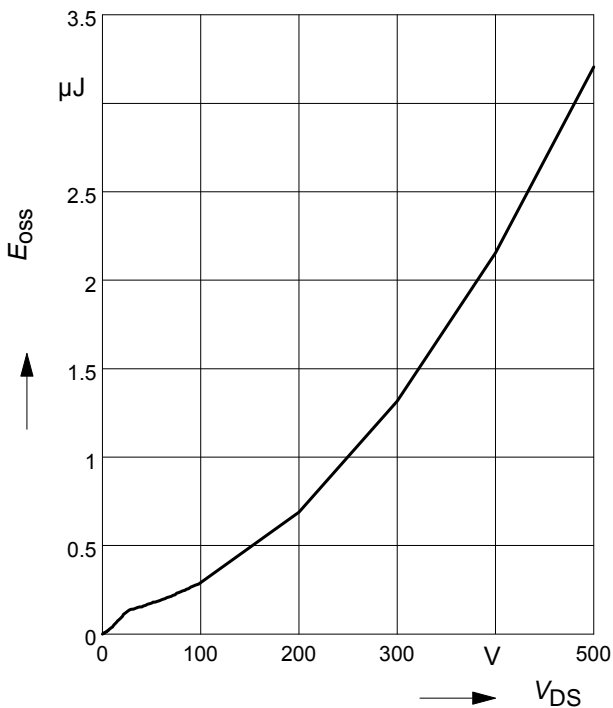
$$C = f(V_{DS})$$

parameter: $V_{GS}=0\text{V}$, $f=1\text{ MHz}$

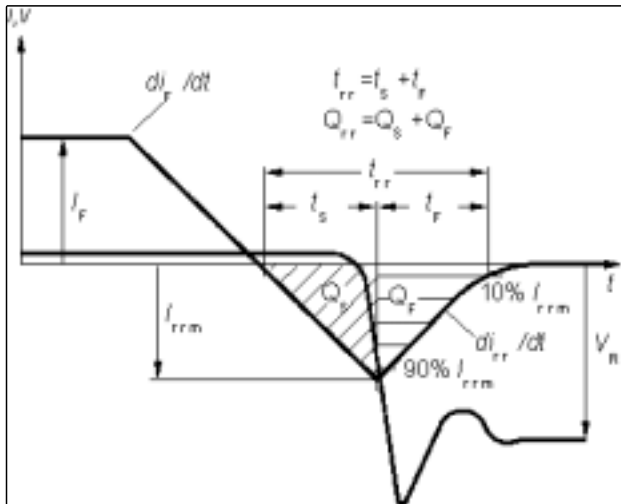


19 Typ. C_{oss} stored energy

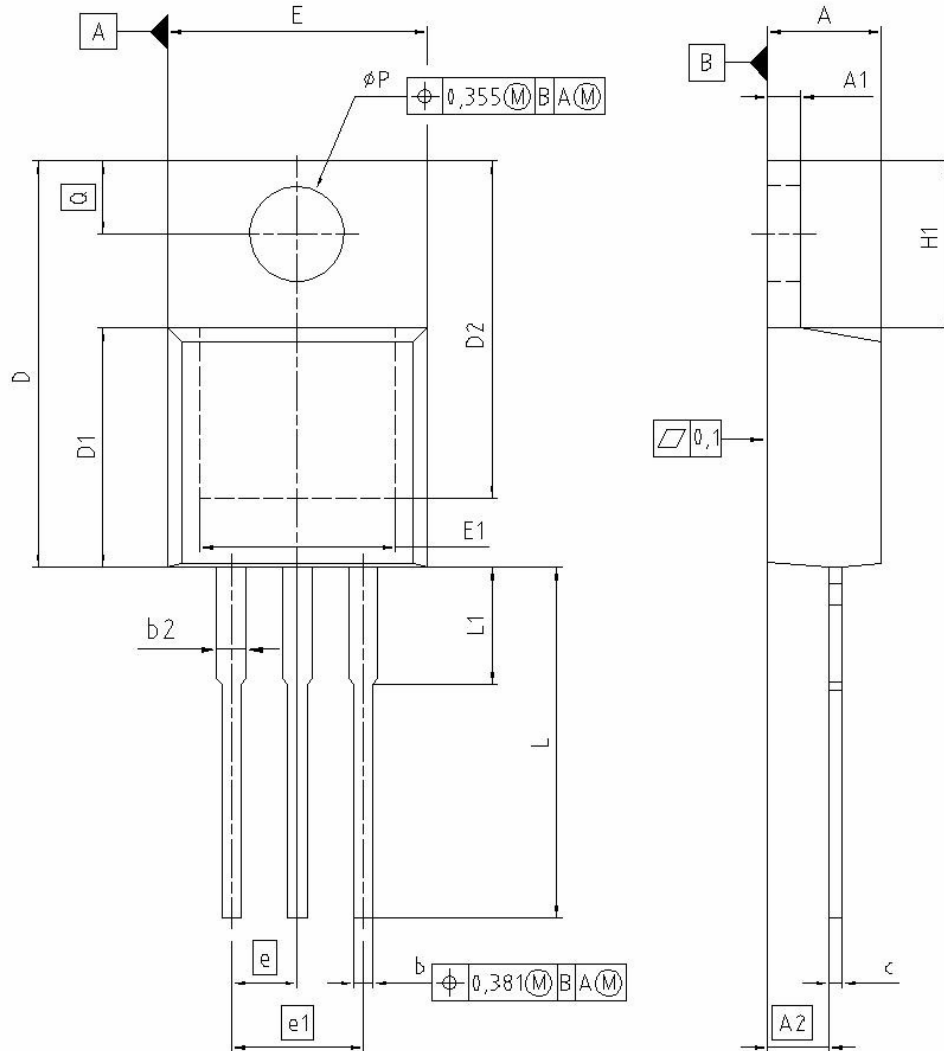
$$E_{oss} = f(V_{DS})$$



Definition of diodes switching characteristics



PG-TO220-3-1, PG-TO220-3-21



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.300	4.572	0.169	0.180
A1	1.170	1.400	0.046	0.055
A2	2.215	2.718	0.087	0.107
b	0.650	0.864	0.026	0.034
b2	0.635	1.778	0.025	0.070
c	0.330	0.600	0.013	0.024
D	14.808	15.950	0.583	0.628
D1	8.509	9.450	0.335	0.372
D2	12.850	13.100	0.506	0.516
E	9.700	10.363	0.382	0.408
E1	6.500	8.600	0.256	0.339
e	2.540		0.100	
e1	5.080		0.200	
N	3		3	
H1	5.900	6.900	0.232	0.272
L	13.000	14.000	0.512	0.551
L1	-	4.800	-	0.189
øP	3.700	3.886	0.146	0.153
Q	2.600	3.000	0.102	0.118

REFERENCE
JEDEC TO220

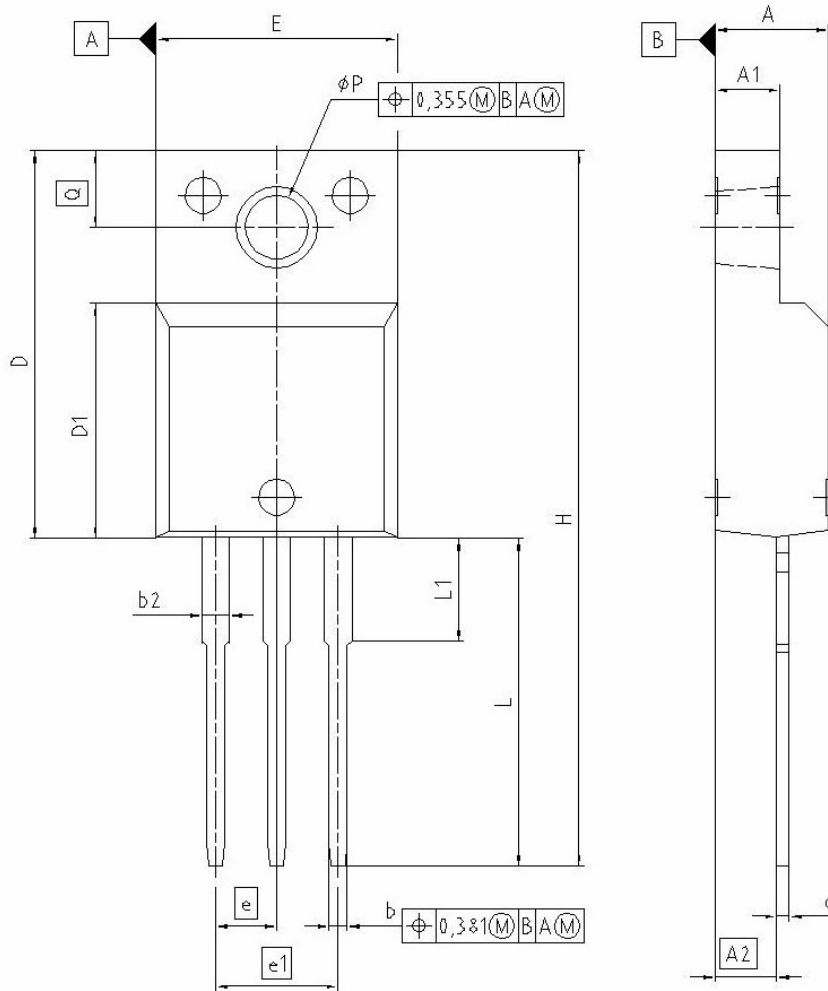
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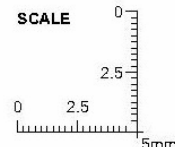
PG-TO220-3-31 (FullPAK)



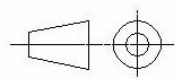
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.572	4.826	0.180	0.190
A1	2.573	2.827	0.101	0.111
A2	2.514	2.616	0.099	0.103
b	0.649	0.776	0.025	0.030
b2	1.143	1.509	0.045	0.059
c	0.449	0.627	0.017	0.027
D	15.863	16.117	0.624	0.634
D1	9.554	9.808	0.376	0.386
E	10.373	10.627	0.408	0.418
e	2.540		0.100	
e1	5.080		0.200	
N	3		3	
H	29.463	29.717	1.160	1.170
L	13.473	13.727	0.530	0.540
L1	3.175	3.429	0.125	0.135
phi P	2.949	3.025	0.119	0.116
Q	3.149	3.251	0.124	0.128

REFERENCE
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