

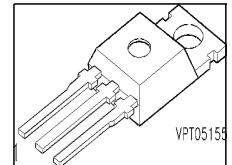
Cool MOS™ Power Transistor

Feature

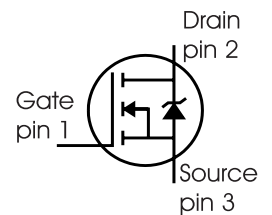
- New revolutionary high voltage technology
- Worldwide best $R_{DS(on)}$ in TO 220
- Ultra low gate charge
- Periodic avalanche rated
- Extreme dv/dt rated
- Ultra low effective capacitances
- Improved transconductance
- Pb-free lead plating; RoHS compliant
- Qualified according to JEDEC⁰⁾ for target applications

$V_{DS} @ T_{jmax}$	650	V
$R_{DS(on)}$	0.16	Ω
I_D	24.3	A

PG-TO220-3-1



Type	Package	Ordering Code	Marking
SPP24N60C3	PG-TO220-3-1	Q67040-S4639	24N60C3



Maximum Ratings

Parameter	Symbol	Value	Unit
Continuous drain current $T_C = 25\text{ °C}$ $T_C = 100\text{ °C}$	I_D	24.3 15.4	A
Pulsed drain current, t_p limited by T_{jmax}	$I_{D\text{ puls}}$	72.9	
Avalanche energy, single pulse $I_D = 10\text{ A}$, $V_{DD} = 50\text{ V}$	E_{AS}	780	mJ
Avalanche energy, repetitive t_{AR} limited by T_{jmax} ¹⁾ $I_D = 24.3\text{ A}$, $V_{DD} = 50\text{ V}$	E_{AR}	1	
Avalanche current, repetitive t_{AR} limited by T_{jmax}	I_{AR}	24.3	A
Gate source voltage static	V_{GS}	± 20	V
Gate source voltage AC ($f > 1\text{ Hz}$)	V_{GS}	± 30	
Power dissipation, $T_C = 25\text{ °C}$	P_{tot}	240	W
Operating and storage temperature	T_j, T_{stg}	-55... +150	°C
Reverse diode dv/dt ⁴⁾	dv/dt	15	V/ns

Maximum Ratings

Parameter	Symbol	Value	Unit
Drain Source voltage slope $V_{DS} = 480$, $I_D = 24.3$, $T_j = 125$ °C	dv/dt	50	V/ns

Thermal Characteristics

Parameter	Symbol	Values			Unit
		min.	typ.	max.	
Thermal resistance, junction - case	R_{thJC}	-	-	0.52	K/W
Thermal resistance, junction - ambient, leaded	R_{thJA}	-	-	62	
Soldering temperature, wavesoldering 1.6 mm (0.063 in.) from case for 10s	T_{sold}	-	-	260	°C

Electrical Characteristics, at $T_j=25$ °C unless otherwise specified

Parameter	Symbol	Conditions	Values			Unit
			min.	typ.	max.	
Drain-source breakdown voltage	$V_{(BR)DSS}$	$V_{GS}=0V$, $I_D=0.25mA$	600	-	-	V
Drain-Source avalanche breakdown voltage	$V_{(BR)DS}$	$V_{GS}=0V$, $I_D=24.3A$	-	700	-	
Gate threshold voltage	$V_{GS(th)}$	$I_D=1200\mu A$, $V_{GS}=V_{DS}$	2.1	3	3.9	
Zero gate voltage drain current	I_{DSS}	$V_{DS}=600V$, $V_{GS}=0V$, $T_j=25$ °C, $T_j=150$ °C	-	0.1	1	μA
			-	-	100	
Gate-source leakage current	I_{GSS}	$V_{GS}=20$, $V_{DS}=0V$	-	-	100	nA
Drain-source on-state resistance	$R_{DS(on)}$	$V_{GS}=10V$, $I_D=15.4A$, $T_j=25$ °C $T_j=150$ °C	-	0.14	0.16	Ω
			-	0.34	-	
Gate input resistance	R_G	$f=1MHz$, open Drain	-	0.66	-	

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

Parameter	Symbol	Conditions	Values			Unit
			min.	typ.	max.	
Transconductance	g_{fs}	$V_{DS} \geq 2 \cdot I_D \cdot R_{DS(on)max}$, $I_D = 15.4\text{A}$	-	21.5	-	S
Input capacitance	C_{iss}	$V_{GS} = 0\text{V}$, $V_{DS} = 25\text{V}$, $f = 1\text{MHz}$	-	3000	-	pF
Output capacitance	C_{oss}		-	1000	-	
Reverse transfer capacitance	C_{rss}		-	60	-	
Effective output capacitance, ²⁾ energy related	$C_{o(er)}$	$V_{GS} = 0\text{V}$, $V_{DS} = 0\text{V to } 480\text{V}$	-	141	-	pF
Effective output capacitance, ³⁾ time related	$C_{o(tr)}$		-	224	-	
Turn-on delay time	$t_{d(on)}$	$V_{DD} = 380\text{V}$, $V_{GS} = 0/10\text{V}$, $I_D = 24.3\text{A}$, $R_G = 3.3\Omega$	-	13	-	ns
Rise time	t_r		-	21	-	
Turn-off delay time	$t_{d(off)}$		-	140	-	
Fall time	t_f		-	14	-	

Gate Charge Characteristics

Gate to source charge	Q_{gs}	$V_{DD} = 480\text{V}$, $I_D = 24.3\text{A}$	-	12.7	-	nC
Gate to drain charge	Q_{gd}		-	45.8	-	
Gate charge total	Q_g	$V_{DD} = 480\text{V}$, $I_D = 24.3\text{A}$, $V_{GS} = 0\text{ to } 10\text{V}$	-	104.9	135	
Gate plateau voltage	$V_{(plateau)}$	$V_{DD} = 480\text{V}$, $I_D = 24.3\text{A}$	-	5	-	V

⁰ J-STD20 and JESD22

¹ Repetitive avalanche causes additional power losses that can be calculated as $P_{AV} = E_{AR} \cdot f$.

² $C_{o(er)}$ is a fixed capacitance that gives the same stored energy as C_{oss} while V_{DS} is rising from 0 to 80% V_{DSS} .

³ $C_{o(tr)}$ is a fixed capacitance that gives the same charging time as C_{oss} while V_{DS} is rising from 0 to 80% V_{DSS} .

⁴ $I_{SD} \leq I_D$, $di/dt \leq 200\text{A/us}$, $V_{DClk} = 400\text{V}$, $V_{peak} < V_{BR}$, DSS , $T_j < T_{j,max}$.

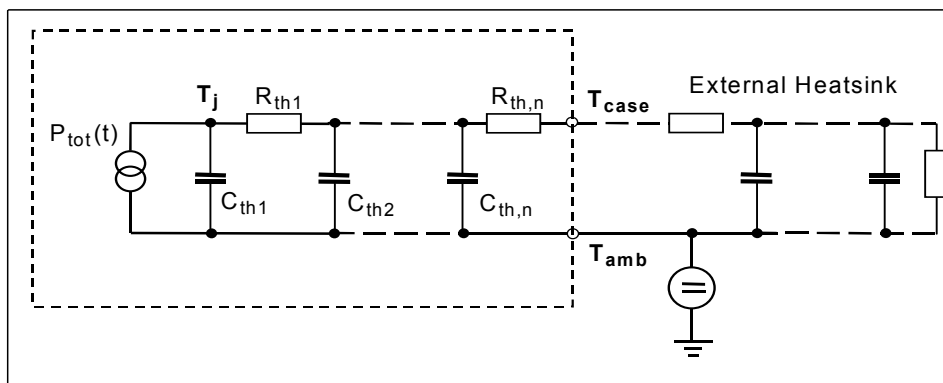
Identical low-side and high-side switch.

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

Parameter	Symbol	Conditions	Values			Unit
			min.	typ.	max.	
Inverse diode continuous forward current	I_S	$T_C=25^{\circ}\text{C}$	-	-	24.3	A
Inverse diode direct current, pulsed	I_{SM}		-	-	72.9	
Inverse diode forward voltage	V_{SD}	$V_{GS}=0\text{V}$, $I_F=I_S$	-	1	1.2	V
Reverse recovery time	t_{rr}	$V_R=480\text{V}$, $I_F=I_S$, $di_F/dt=100\text{A}/\mu\text{s}$	-	600	-	ns
Reverse recovery charge	Q_{rr}		-	13	-	μC
Peak reverse recovery current	I_{rrm}		-	70	-	A
Peak rate of fall of reverse recovery current	di_{rr}/dt		-	1400	-	$\text{A}/\mu\text{s}$

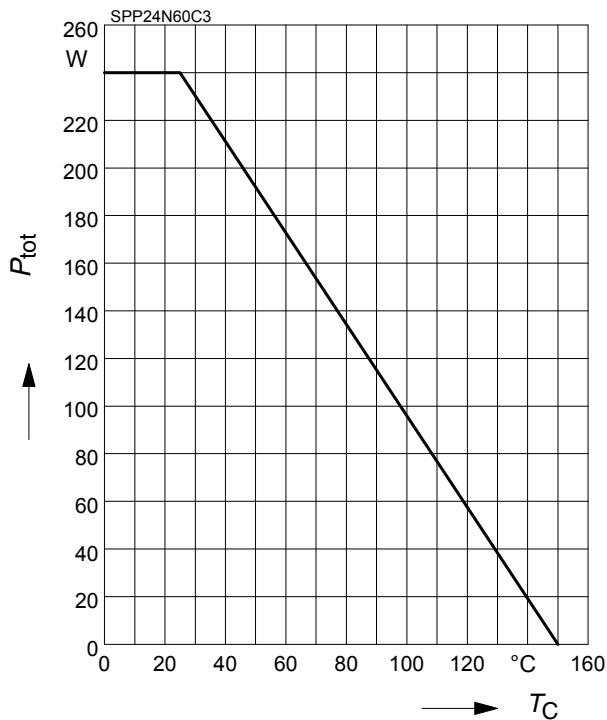
Typical Transient Thermal Characteristics

Symbol	Value	Unit	Symbol	Value	Unit
	typ.			typ.	
Thermal resistance			Thermal capacitance		
R_{th1}	0.006524	K/W	C_{th1}	0.0004439	Ws/K
R_{th2}	0.013		C_{th2}	0.001662	
R_{th3}	0.025		C_{th3}	0.002268	
R_{th4}	0.096		C_{th4}	0.006183	
R_{th5}	0.117		C_{th5}	0.014	
R_{th6}	0.053		C_{th6}	0.104	



1 Power dissipation

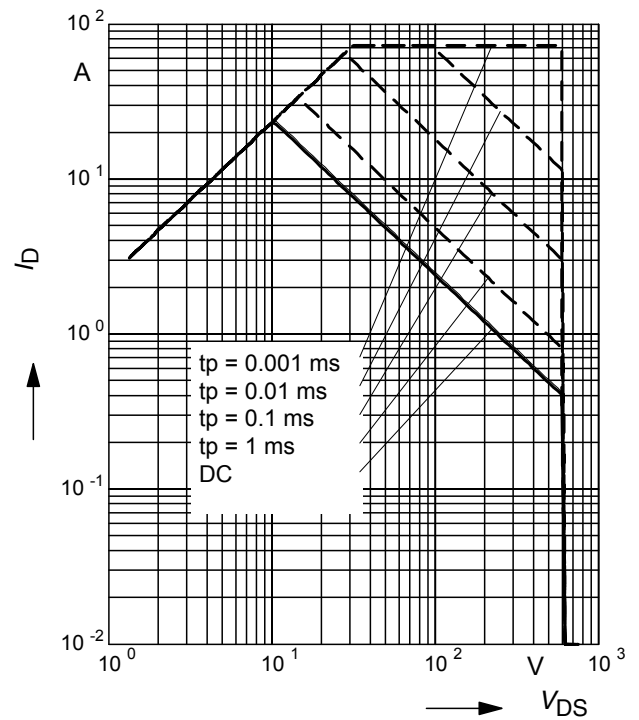
$$P_{\text{tot}} = f(T_C)$$



2 Safe operating area

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

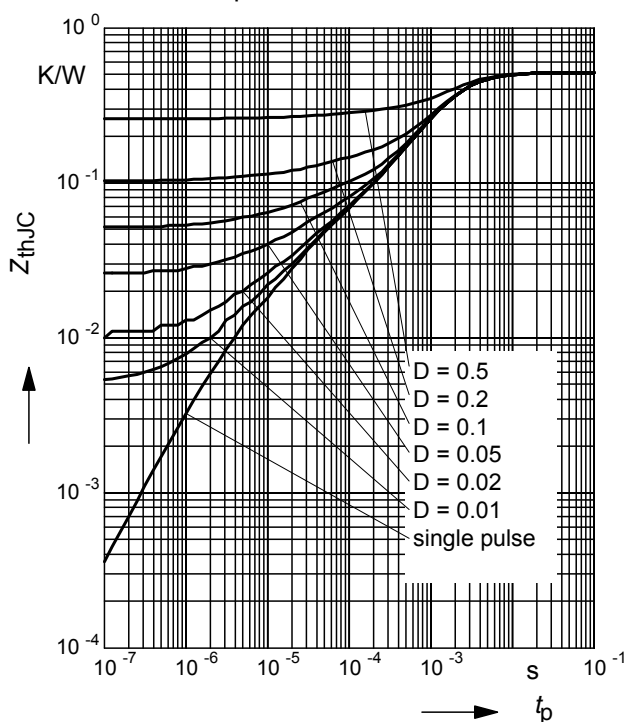
parameter : $D = 0$, $T_C = 25^\circ\text{C}$



3 Transient thermal impedance

$$Z_{\text{thJC}} = f(t_p)$$

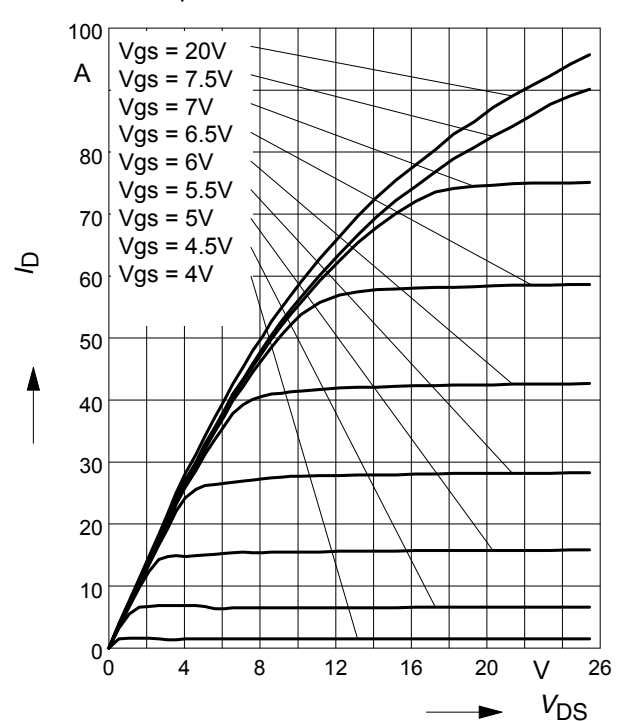
parameter: $D = t_p/T$



4 Typ. output characteristic

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

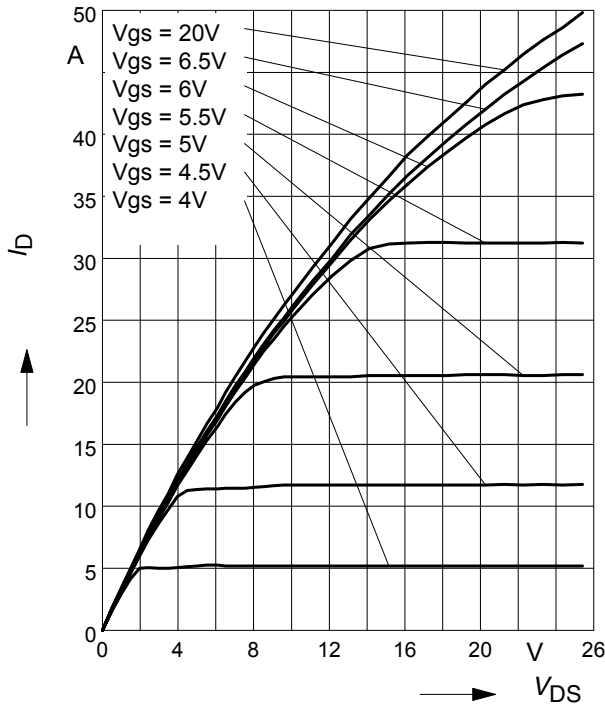
parameter: $t_p = 10 \mu\text{s}$, V_{GS}



5 Typ. output characteristic

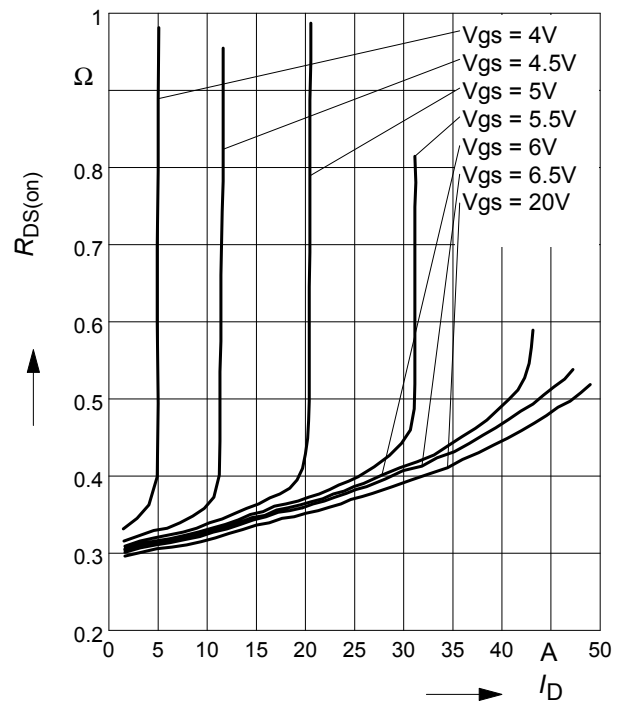
$$I_D = f(V_{DS}); T_j = 150^\circ\text{C}$$

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


6 Typ. drain-source on resistance

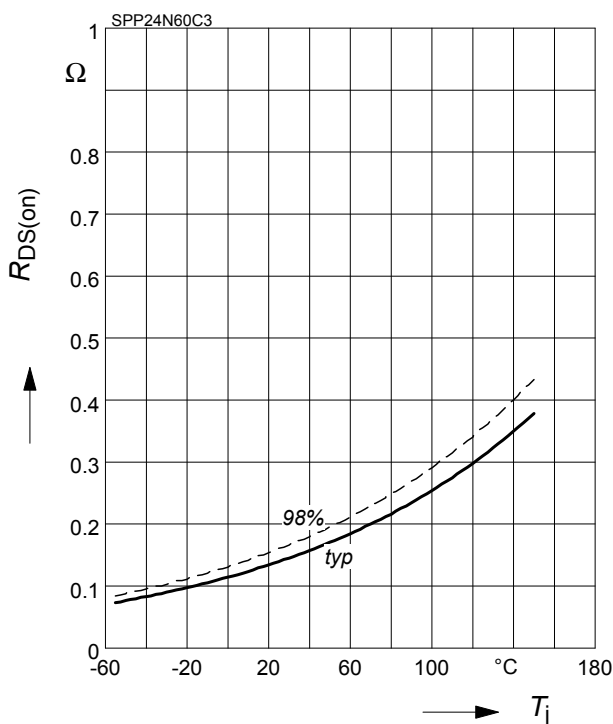
$$R_{DS(on)} = f(I_D)$$

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


7 Drain-source on-state resistance

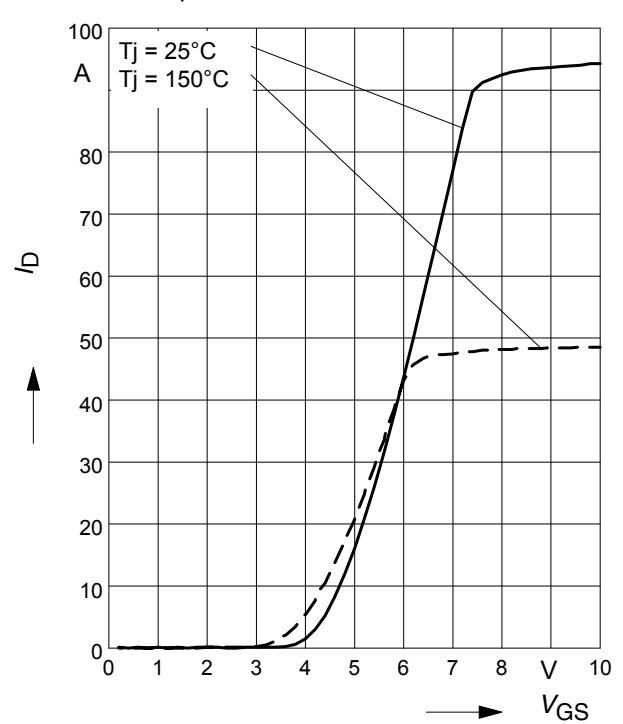
$$R_{DS(on)} = f(T_j)$$

parameter: $I_D = 15.4\ \text{A}$, $V_{GS} = 10\ \text{V}$


8 Typ. transfer characteristics

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

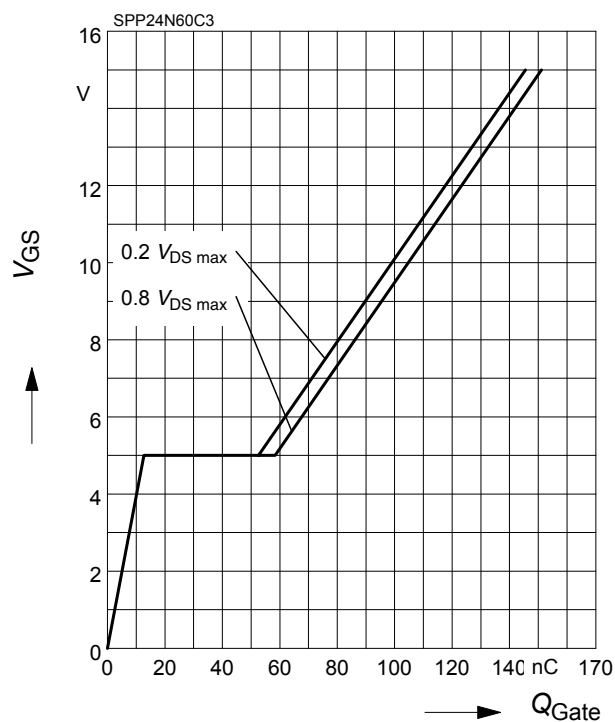
parameter: $t_p = 10\ \mu\text{s}$



9 Typ. gate charge

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

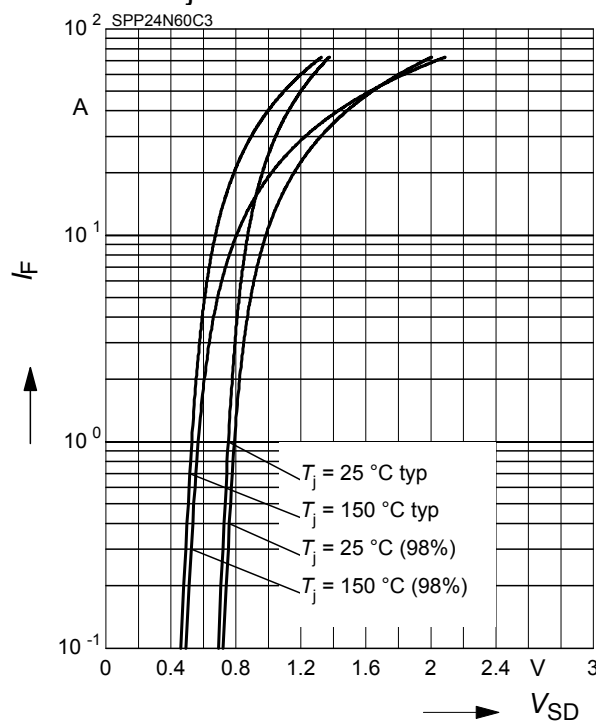
parameter: $I_D = 24.3$ A pulsed



10 Forward characteristics of body diode

$$I_F = f(V_{SD})$$

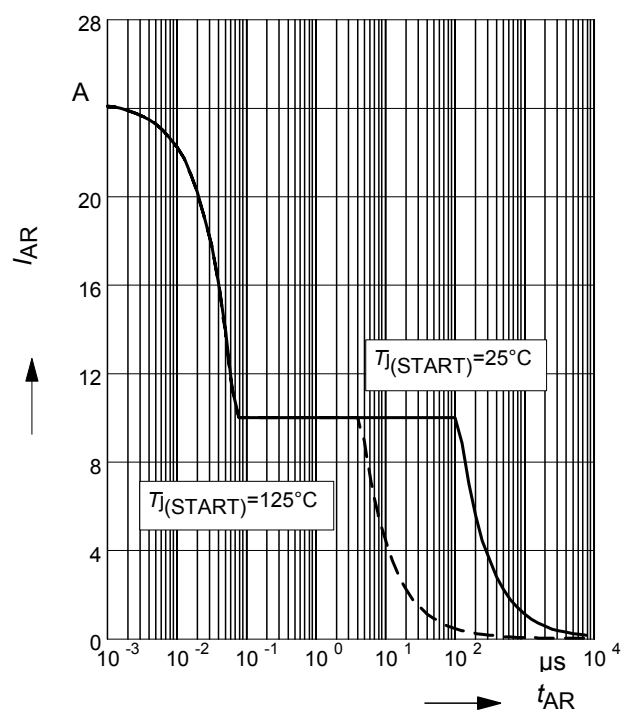
parameter: T_j , $t_p = 10$ μ s



11 Avalanche SOA

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

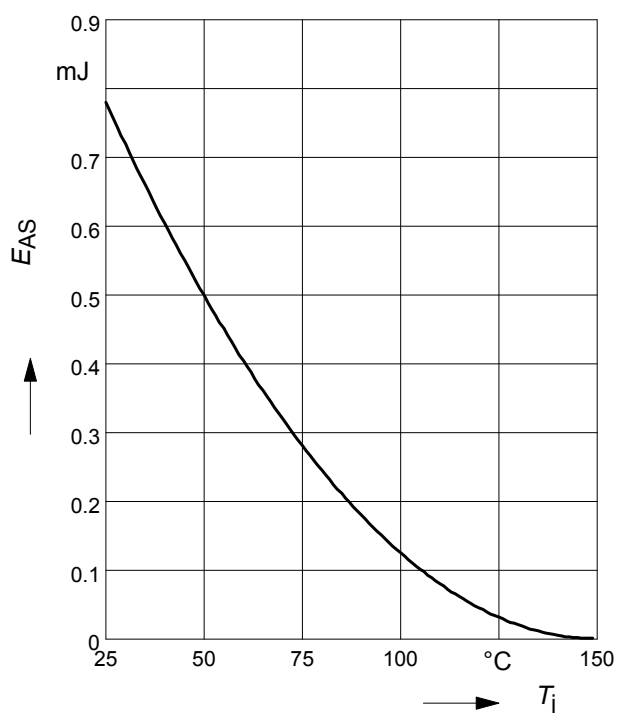
par.: $T_j \leq 150$ °C



12 Avalanche energy

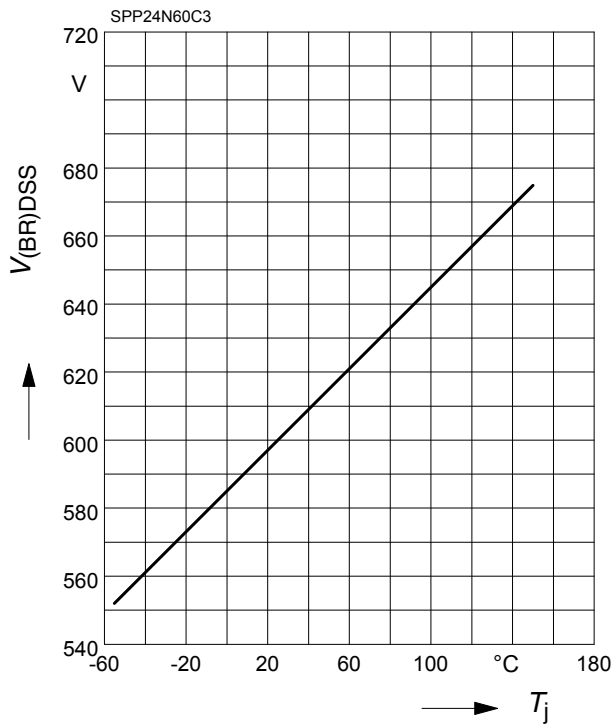
$$E_{AS} = f(T_j)$$

par.: $I_D = 10$ A, $V_{DD} = 50$ V



13 Drain-source breakdown voltage

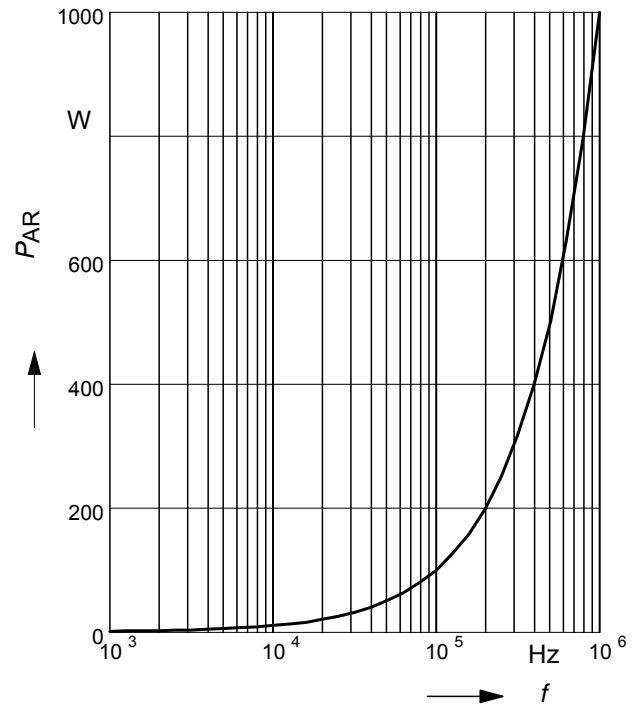
$$V_{(BR)DSS} = f(T_j)$$



14 Avalanche power losses

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

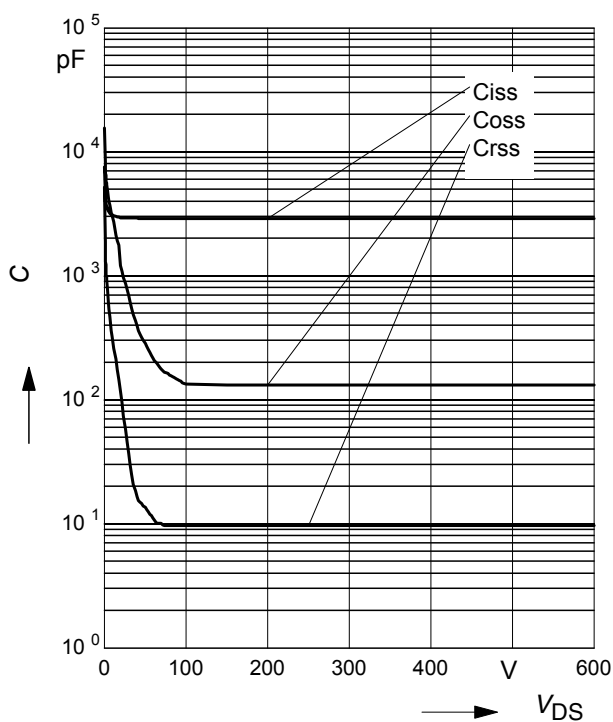
parameter: $E_{AR}=1\text{mJ}$



15 Typ. capacitances

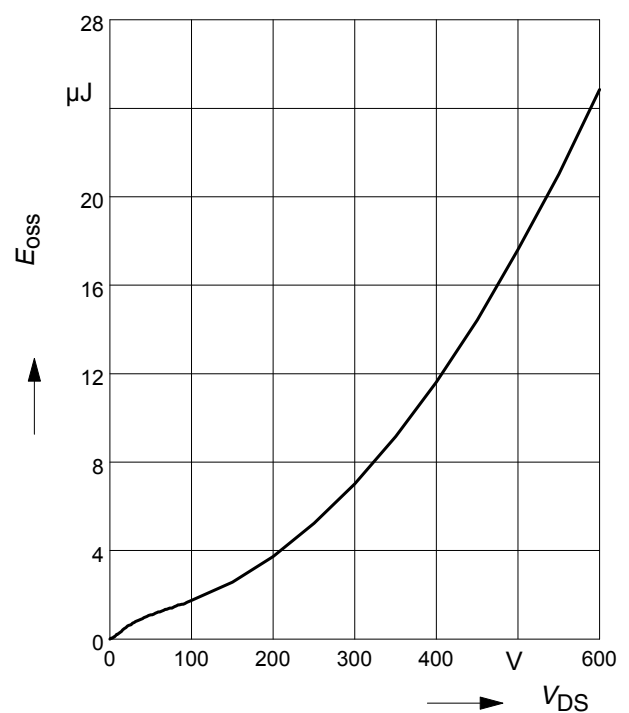
$$C = f(V_{DS})$$

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

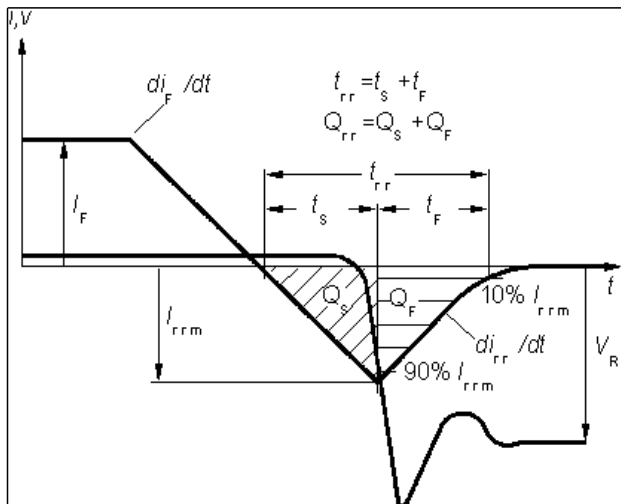


16 Typ. C_{oss} stored energy

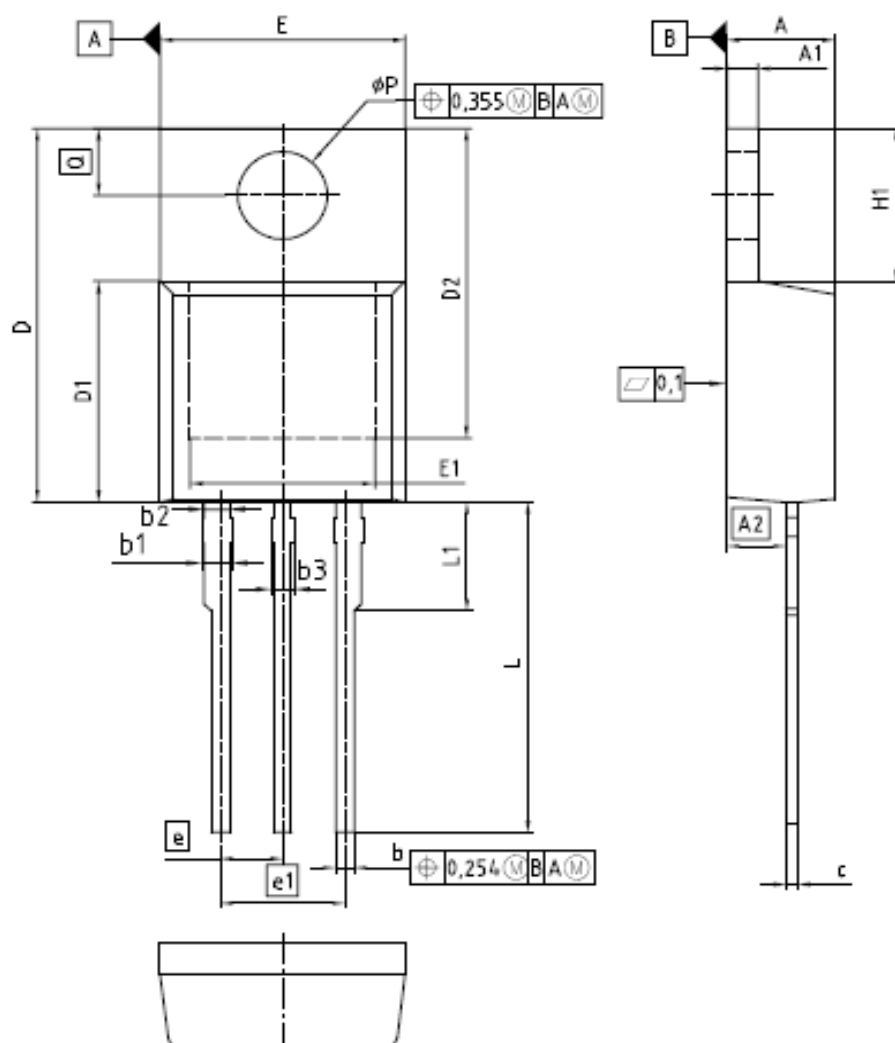
$$E_{oss}=f(V_{DS})$$



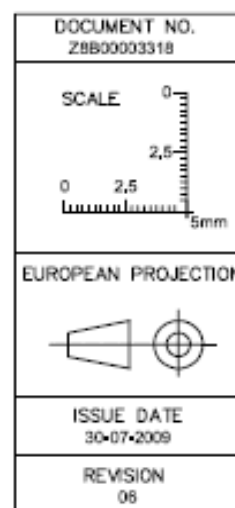
Definition of diodes switching characteristics



PG-TO-220-3-1



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	0,88	0,026	0,034
b1	0,95	1,40	0,037	0,055
b2	0,98	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	15,96	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
ϕP	3,60	3,89	0,142	0,153
Q	2,60	3,00	0,102	0,118



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