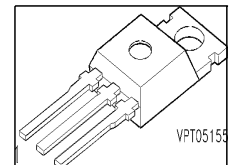


**Cool MOS™ Power Transistor**
**Feature**

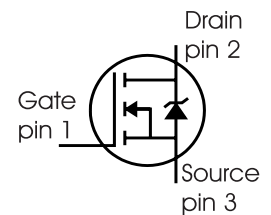
- New revolutionary high voltage technology
- Worldwide best  $R_{DS(on)}$  in TO 220
- Ultra low gate charge
- Periodic avalanche rated
- Extreme  $dv/dt$  rated
- Ultra low effective capacitances
- Improved transconductance
- Pb-free lead plating; RoHS compliant
- Qualified according to JEDEC<sup>0)</sup> for target applications

$V_{DS} @ T_{jmax}$	650	V
$R_{DS(on)}$	0.16	$\Omega$
$I_D$	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 $T_{jmax}$ <sup>1)</sup> $I_D = 24.3\text{ A}$ , $V_{DD} = 50\text{ V}$	$E_{AR}$	1	
Avalanche current, repetitive $t_{AR}$ limited by $T_{jmax}$	$I_{AR}$	24.3	A
Gate source voltage static	$V_{GS}$	$\pm 20$	V
Gate source voltage AC ( $f > 1\text{ Hz}$ )	$V_{GS}$	$\pm 30$	
Power dissipation, $T_C = 25\text{ °C}$	$P_{tot}$	240	W
Operating and storage temperature	$T_j, T_{stg}$	-55... +150	°C
Reverse diode $dv/dt$ <sup>4)</sup>	$dv/dt$	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 -	1 100	$\mu A$
Gate-source leakage current	$I_{GSS}$	$V_{GS}=20$ , $V_{DS}=0V$	-	-	100	
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 0.34	0.16 -	$\Omega$
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, <sup>2)</sup> energy related	$C_{o(er)}$	$V_{GS} = 0\text{V}$ , $V_{DS} = 0\text{V to } 480\text{V}$	-	141	-	pF
Effective output capacitance, <sup>3)</sup> 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	$Q_{gs}$	$V_{DD} = 480$ , $I_D = 24.3\text{A}$	-	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

<sup>0</sup>J-STD20 and JESD22

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

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

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

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

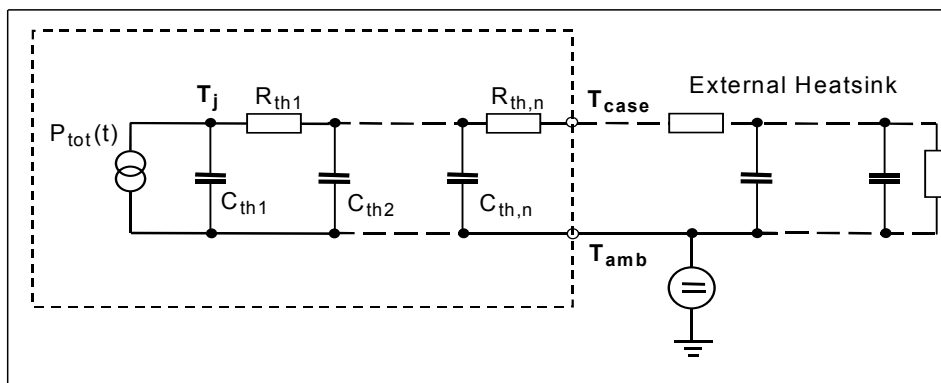
Identical low-side and high-side switch.

**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	$t_{rr}$	$V_R=480\text{V}, I_F=I_S,$	-	600	-	ns
Reverse recovery charge	$Q_{rr}$	$di_F/dt=100\text{A}/\mu\text{s}$	-	13	-	$\mu\text{C}$
Peak reverse recovery current	$I_{rrm}$		-	70	-	A
Peak rate of fall of reverse recovery current	$di_{rr}/dt$		-	1400	-	$\text{A}/\mu\text{s}$

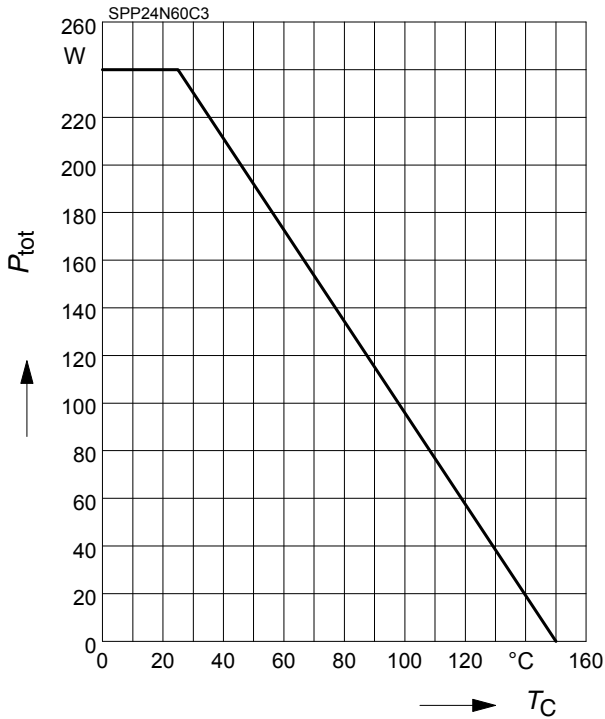
**Typical Transient Thermal Characteristics**

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

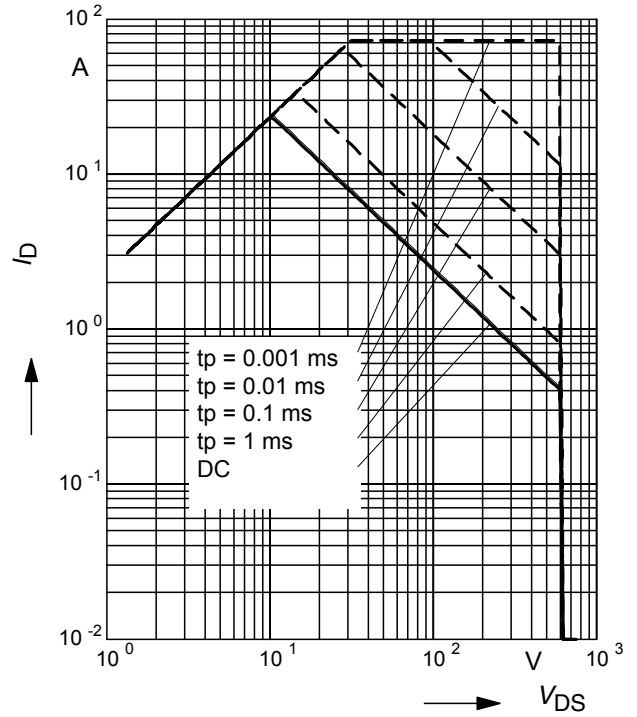
$$P_{tot} = f(T_C)$$



### 2 Safe operating area

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

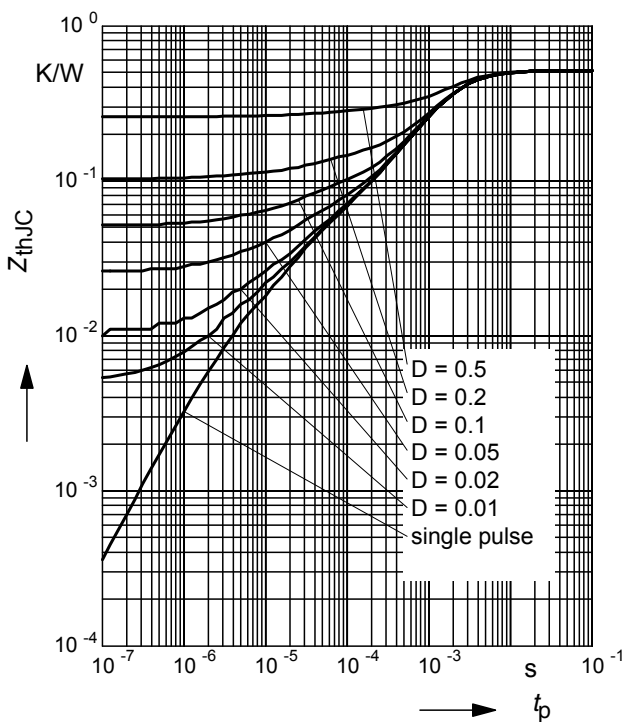
parameter :  $D = 0$  ,  $T_C = 25^\circ\text{C}$



### 3 Transient thermal impedance

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

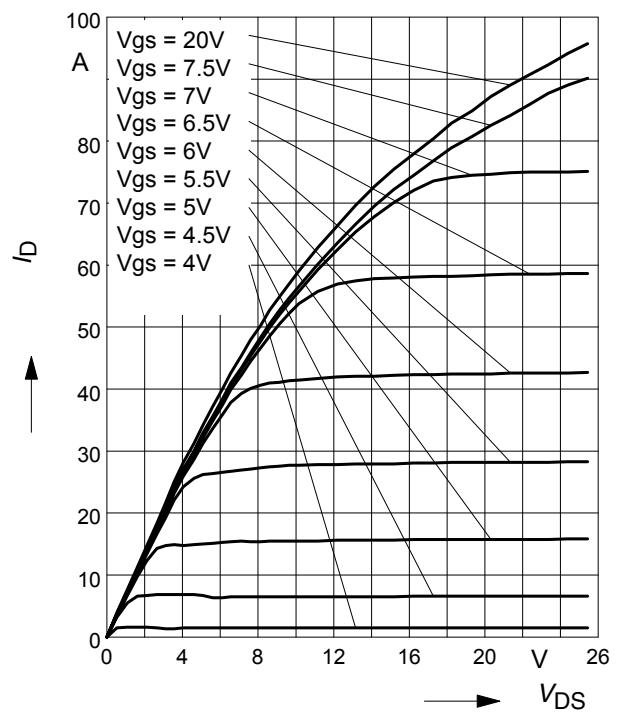
parameter:  $D = t_p/T$



### 4 Typ. output characteristic

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

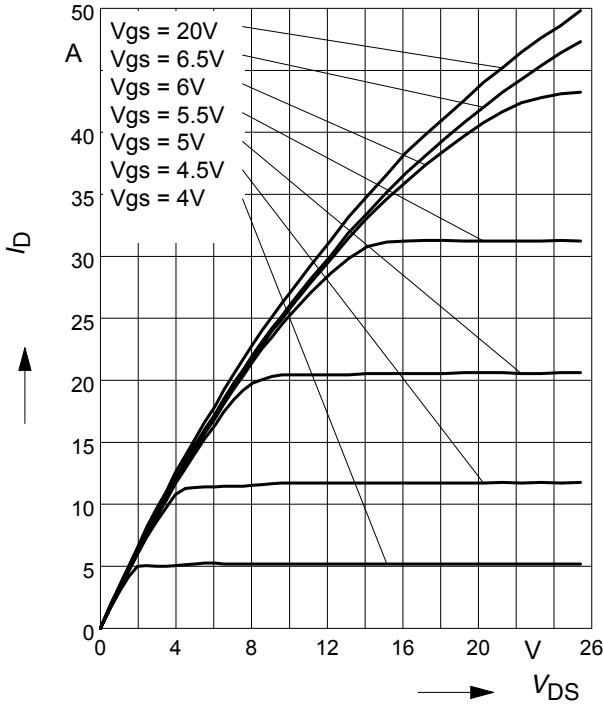
parameter:  $t_p = 10 \mu\text{s}$  ,  $V_{GS}$



**5 Typ. output characteristic**

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

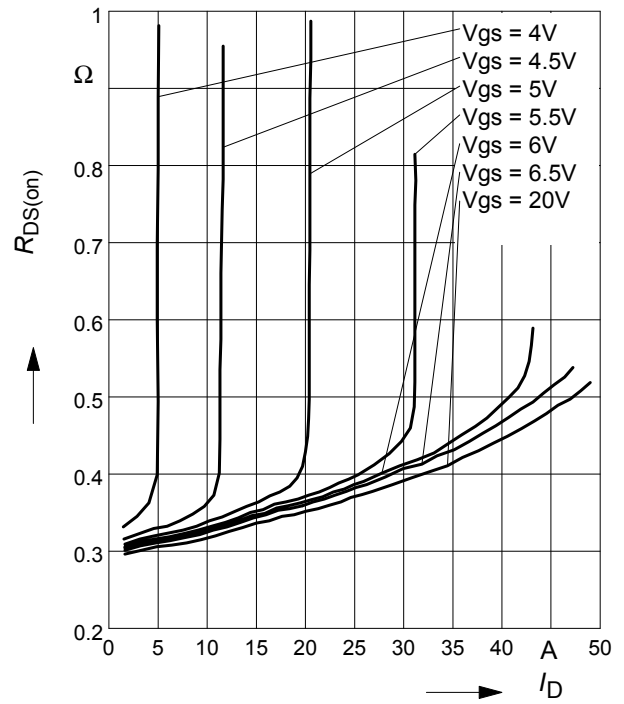
parameter:  $t_p = 10 \mu\text{s}, V_{GS}$



**6 Typ. drain-source on resistance**

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

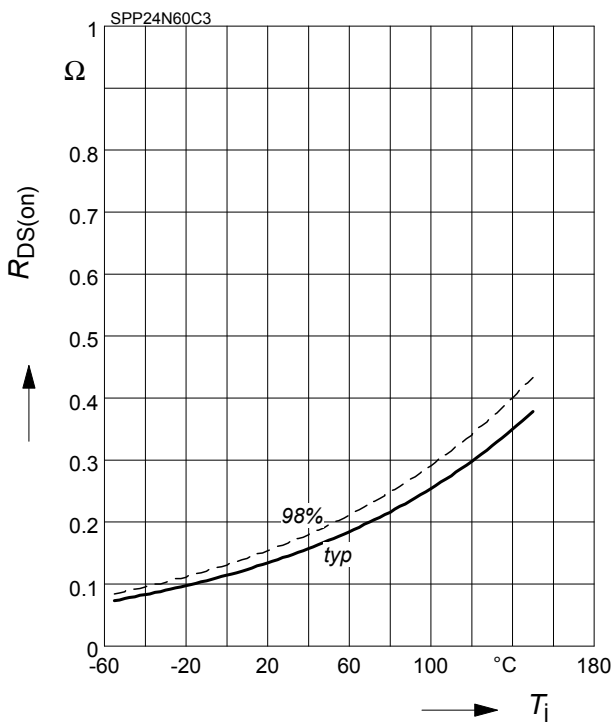
parameter:  $T_j = 150^\circ\text{C}, V_{GS}$



**7 Drain-source on-state resistance**

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

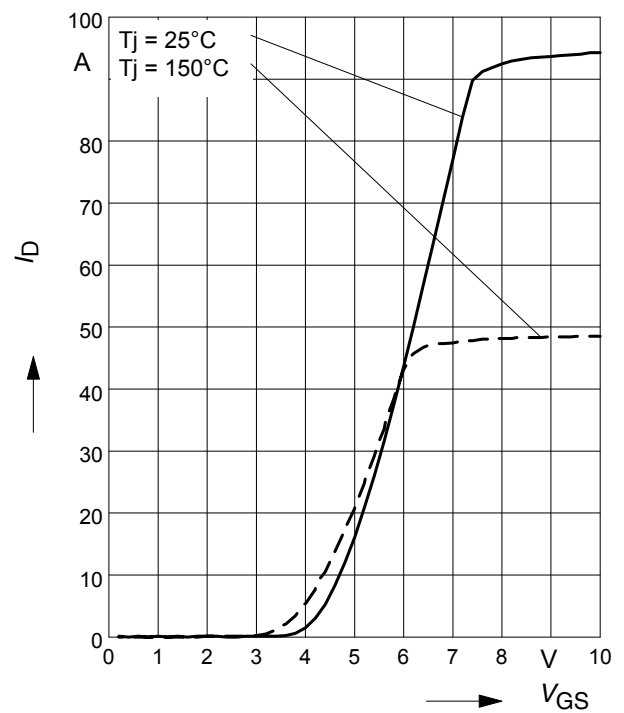
parameter:  $I_D = 15.4 \text{ A}, V_{GS} = 10 \text{ V}$



**8 Typ. transfer characteristics**

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

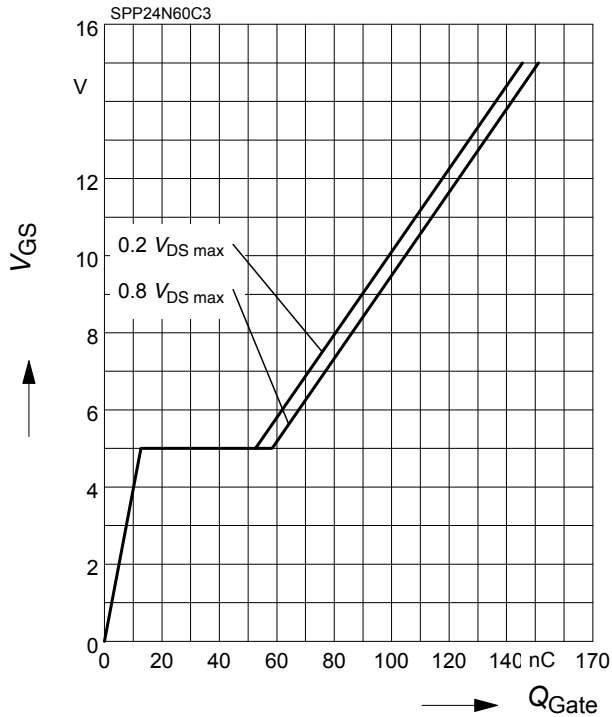
parameter:  $t_p = 10 \mu\text{s}$



**9 Typ. gate charge**

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

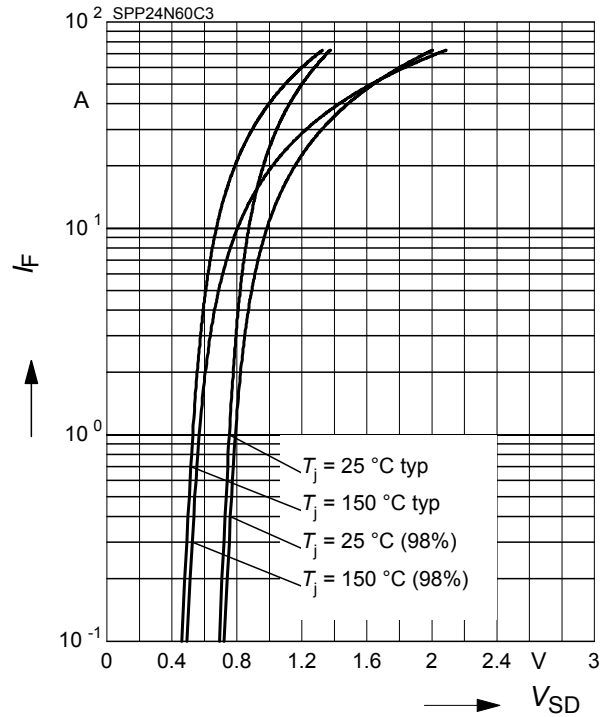
parameter:  $I_D = 24.3 \text{ A}$  pulsed



**10 Forward characteristics of body diode**

$I_F = f(V_{SD})$

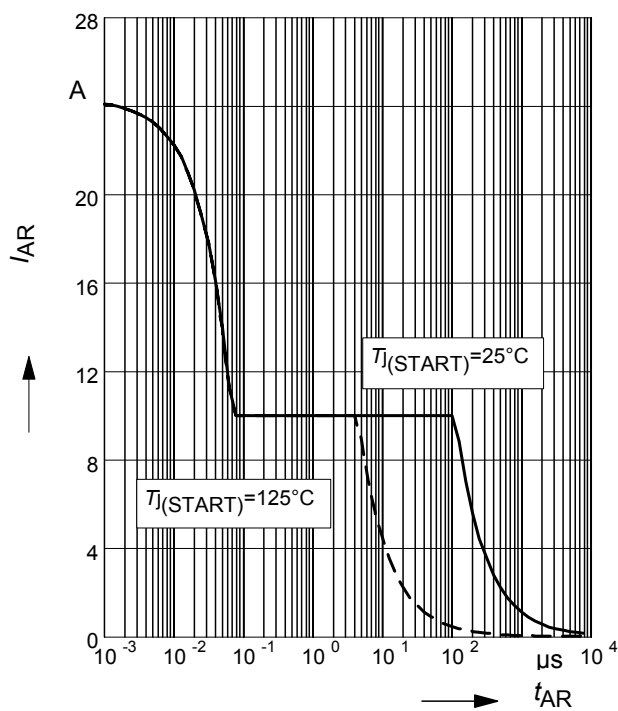
parameter:  $T_j, t_p = 10 \mu\text{s}$



**11 Avalanche SOA**

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

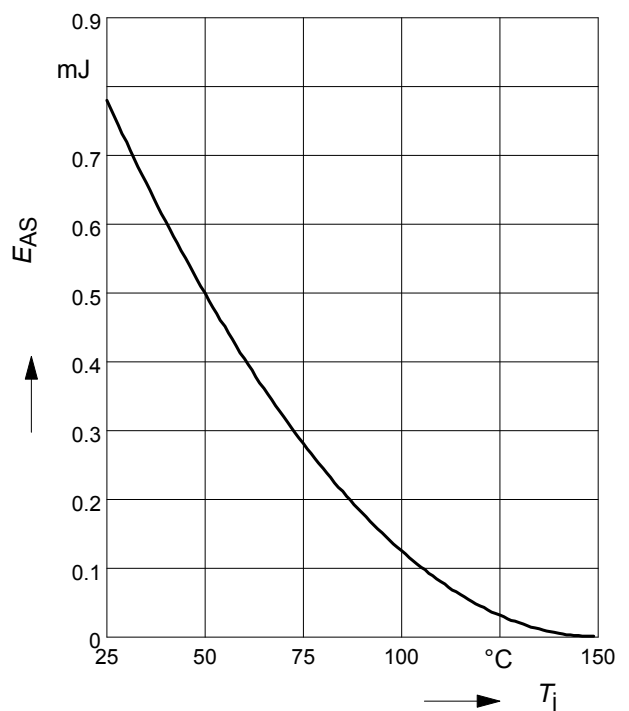
par.:  $T_j \leq 150 \text{ °C}$



**12 Avalanche energy**

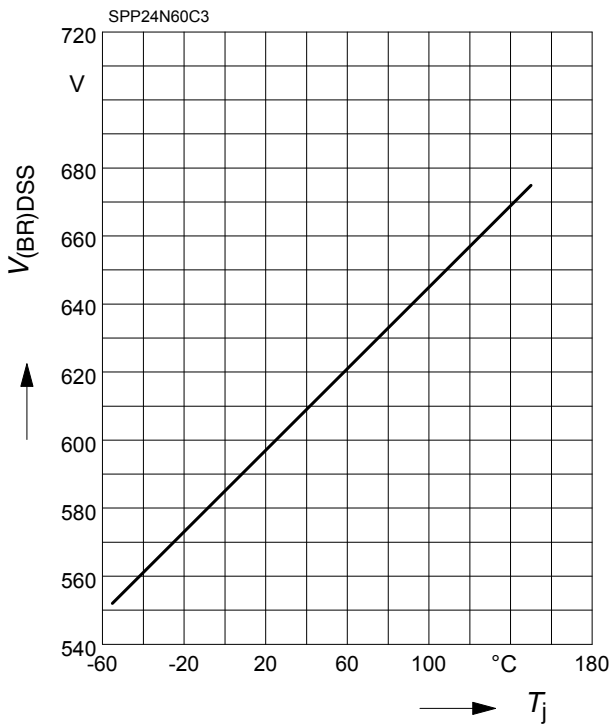
$E_{AS} = f(T_j)$

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



**13 Drain-source breakdown voltage**

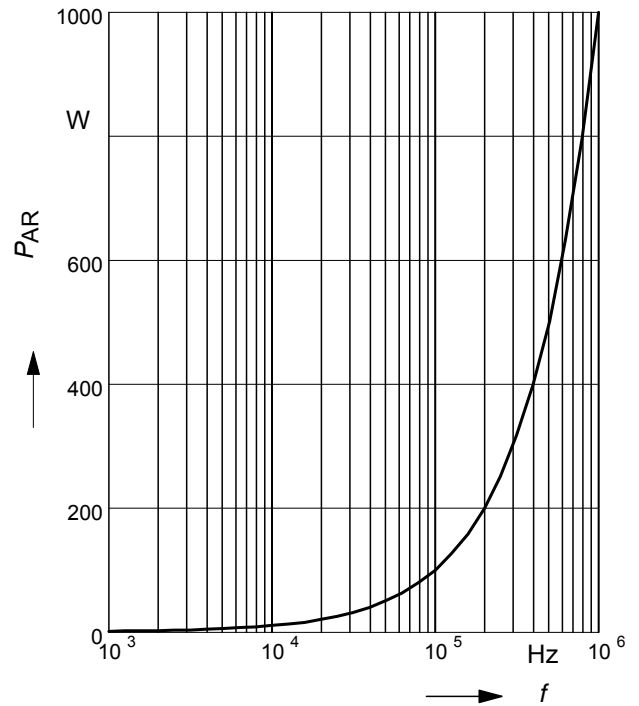
$$V_{(BR)DSS} = f(T_j)$$



**14 Avalanche power losses**

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

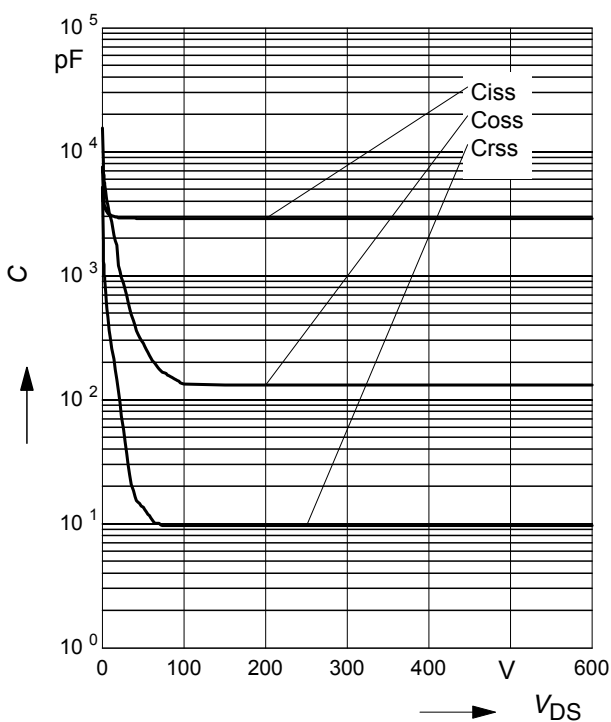
parameter:  $E_{AR}=1mJ$



**15 Typ. capacitances**

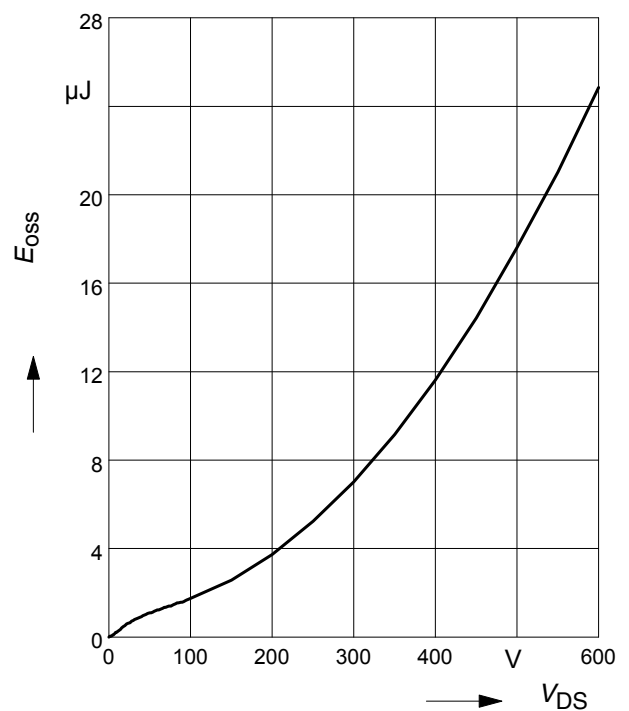
$$C = f(V_{DS})$$

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



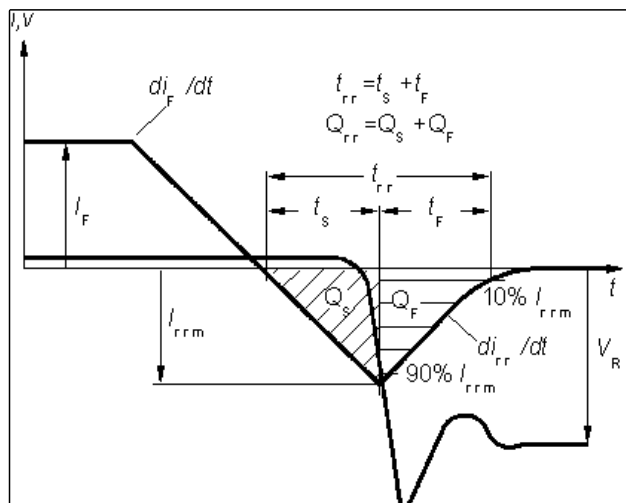
**16 Typ.  $C_{OSS}$  stored energy**

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

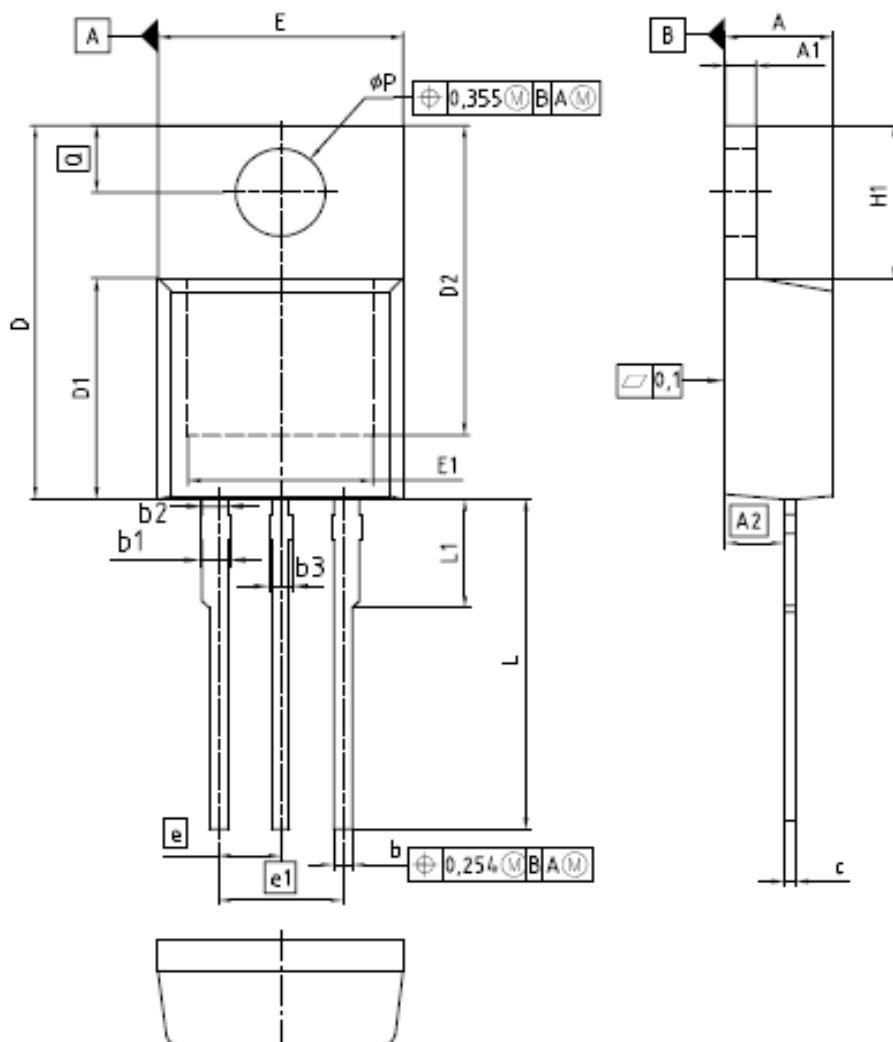




Definition of diodes switching characteristics



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	6,51	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	0,338
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
$\phi P$	3,60	3,89	0,142	0,153
Q	2,60	3,00	0,102	0,118

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