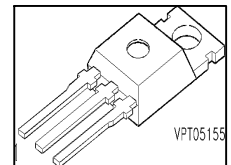


**Cool MOS™ Power Transistor**
**Feature**

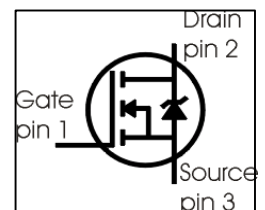
- New revolutionary high voltage technology
- Worldwide best  $R_{DS(on)}$  in TO 220
- Ultra low gate charge
- Periodic avalanche rated
- Extreme  $dv/dt$  rated
- High peak current capability
- Intrinsic fast-recovery body diode
- Extreme low reverse recovery charge
- **Pb-free lead plating; RoHS compliant; Halogen free mold compound**
- **Qualified for industrial grade applications according to JEDEC<sup>0)</sup>**

$V_{DS} @ T_{jmax}$	650	V
$R_{DS(on)}$	0.22	$\Omega$
$I_D$	20.7	A

PG-TO220



Type	Package	Ordering Code	Marking
SPP20N60CFD	PG-TO220	Q67040-S4616	20N60CFD


**Maximum Ratings**

Parameter	Symbol	Value	Unit
Continuous drain current $T_C = 25\text{ °C}$ $T_C = 100\text{ °C}$	$I_D$	20.7 13.1	A
Pulsed drain current, $t_D$ limited by $T_{jmax}$	$I_{D\text{ puls}}$	52	
Avalanche energy, single pulse $I_D = 10\text{ A}$ , $V_{DD} = 50\text{ V}$	$E_{AS}$	690	mJ
Avalanche energy, repetitive $t_{AR}$ limited by $T_{jmax}$ <sup>1)</sup> $I_D = 20\text{ A}$ , $V_{DD} = 50\text{ V}$	$E_{AR}$	1	
Avalanche current, repetitive $t_{AR}$ limited by $T_{jmax}$	$I_{AR}$	20	A
Reverse diode $dv/dt$ $I_S = 20.7\text{ A}$ , $V_{DS} = 480\text{ V}$ , $T_j = 125\text{ °C}$	$dv/dt$	40	V/ns
Gate source voltage	$V_{GS}$	$\pm 20$	V
Gate source voltage AC ( $f > 1\text{ Hz}$ )	$V_{GS}$	$\pm 30$	
Power dissipation, $T_C = 25\text{ °C}$	$P_{tot}$	208	W
Operating and storage temperature	$T_j, T_{sta}$	-55... +150	$\text{°C}$

**Maximum Ratings**

Parameter	Symbol	Value	Unit
Drain Source voltage slope $V_{DS} = 480\text{ V}$ , $I_D = 20.7\text{ A}$ , $T_j = 125\text{ °C}$	$dv/dt$	80	V/ns
Maximum diode commutation speed $V_{DS} = 480\text{ V}$ , $I_D = 20.7\text{ A}$ , $T_j = 125\text{ °C}$	$di_F/dt$	900	A/ $\mu$ s

**Thermal Characteristics**

Parameter	Symbol	Values			Unit
		min.	typ.	max.	
Thermal resistance, junction - case	$R_{thJC}$	-	-	0.6	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  $T_j=25\text{ °C}$  unless otherwise specified**

Parameter	Symbol	Conditions	Values			Unit
			min.	typ.	max.	
Drain-source breakdown voltage	$V_{(BR)DSS}$	$V_{GS}=0\text{ V}$ , $I_D=0.25\text{ mA}$	600	-	-	V
Drain-Source avalanche breakdown voltage	$V_{(BR)DS}$	$V_{GS}=0\text{ V}$ , $I_D=20\text{ A}$	-	700	-	
Gate threshold voltage	$V_{GS(th)}$	$I_D=1000\mu\text{ A}$ , $V_{GS}=V_{DS}$	3	4	5	
Zero gate voltage drain current	$I_{DSS}$	$V_{DS}=600\text{ V}$ , $V_{GS}=0\text{ V}$ , $T_j=25\text{ °C}$ , $T_j=150\text{ °C}$	-	2.1 1700	-	$\mu\text{ A}$
Gate-source leakage current	$I_{GSS}$	$V_{GS}=20\text{ V}$ , $V_{DS}=0\text{ V}$	-	-	100	nA
Drain-source on-state resistance	$R_{DS(on)}$	$V_{GS}=10\text{ V}$ , $I_D=13.1\text{ A}$ , $T_j=25\text{ °C}$ $T_j=150\text{ °C}$	-	0.19 0.51	0.22 -	$\Omega$
Gate input resistance	$R_G$	$f=1\text{ MHz}$ , open Drain	-	0.54	-	

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

Parameter	Symbol	Conditions	Values			Unit
			min.	typ.	max.	
Transconductance	$g_{fs}$	$V_{DS} \geq 2 \cdot I_D \cdot R_{DS(on)max}$ , $I_D = 13.1\text{A}$	-	17.5	-	S
Input capacitance	$C_{iss}$	$V_{GS} = 0\text{V}$ , $V_{DS} = 25\text{V}$ , $f = 1\text{MHz}$	-	2400	-	pF
Output capacitance	$C_{oss}$		-	780	-	
Reverse transfer capacitance	$C_{rss}$		-	50	-	
Effective output capacitance, <sup>2)</sup> energy related	$C_{o(er)}$	$V_{GS} = 0\text{V}$ , $V_{DS} = 0\text{V to } 480\text{V}$	-	83	-	pF
Effective output capacitance, <sup>3)</sup> time related	$C_{o(tr)}$		-	160	-	
Turn-on delay time	$t_{d(on)}$	$V_{DD} = 380\text{V}$ , $V_{GS} = 0/10\text{V}$ , $I_D = 20.7\text{A}$ , $R_G = 3.6\Omega$	-	12	-	ns
Rise time	$t_r$		-	15	-	
Turn-off delay time	$t_{d(off)}$		-	59	-	
Fall time	$t_f$		-	6.4	-	

**Gate Charge Characteristics**

Gate to source charge	$Q_{gs}$	$V_{DD} = 480\text{V}$ , $I_D = 20.7\text{A}$	-	15	-	nC
Gate to drain charge	$Q_{gd}$		-	54	-	
Gate charge total	$Q_g$	$V_{DD} = 480\text{V}$ , $I_D = 20.7\text{A}$ , $V_{GS} = 0\text{ to } 10\text{V}$	-	95	124	
Gate plateau voltage	$V_{(plateau)}$	$V_{DD} = 480\text{V}$ , $I_D = 20.7\text{A}$	-	7	-	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%  $V_{DSS}$ .

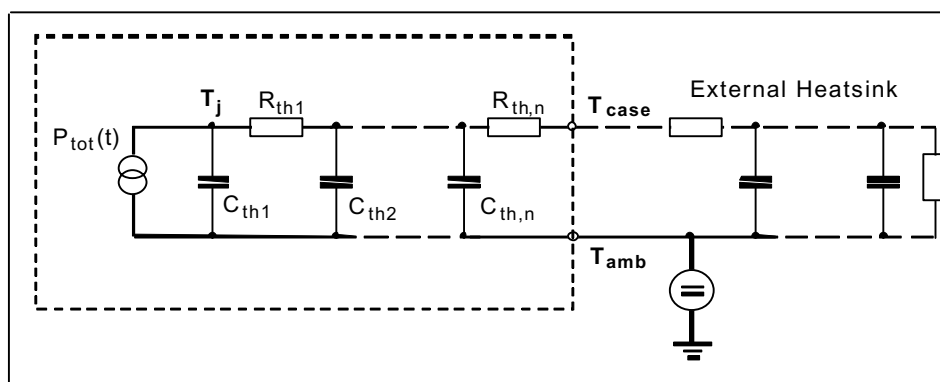
<sup>3</sup> $C_{o(tr)}$  is a fixed capacitance that gives the same charging time as  $C_{oss}$  while  $V_{DS}$  is rising from 0 to 80%  $V_{DSS}$ .

**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	$I_S$	$T_C=25^\circ\text{C}$	-	-	20.7	A
Inverse diode direct current, pulsed	$I_{SM}$		-	-	52	
Inverse diode forward voltage	$V_{SD}$	$V_{GS}=0\text{V}, I_F=I_S$	-	1	1.2	V
Reverse recovery time	$t_{rr}$	$V_R=480\text{V}, I_F=I_S,$	-	150	-	ns
Reverse recovery charge	$Q_{rr}$	$di_F/dt=100\text{A}/\mu\text{s}$	-	1	-	$\mu\text{C}$
Peak reverse recovery current	$I_{rrm}$		-	13	-	A
Peak rate of fall of reverse recovery current	$di_{rr}/dt$		-	1400	-	$\text{A}/\mu\text{s}$

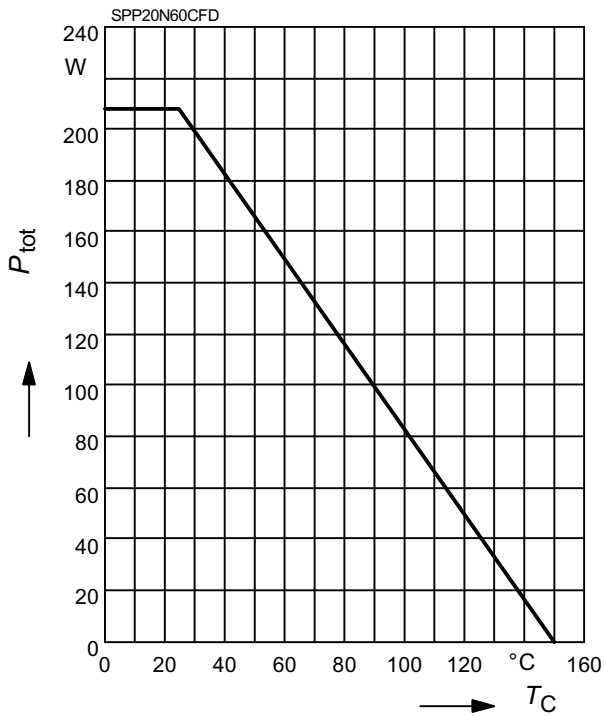
**Typical Transient Thermal Characteristics**

Symbol	Value	Unit	Symbol	Value	Unit
	typ.			typ.	
Thermal resistance			Thermal capacitance		
$R_{th1}$	0.007686	K/W	$C_{th1}$	0.0003764	Ws/K
$R_{th2}$	0.015		$C_{th2}$	0.001412	
$R_{th3}$	0.029		$C_{th3}$	0.001932	
$R_{th4}$	0.114		$C_{th4}$	0.005299	
$R_{th5}$	0.136		$C_{th5}$	0.012	
$R_{th6}$	0.059		$C_{th6}$	0.091	



**1 Power dissipation**

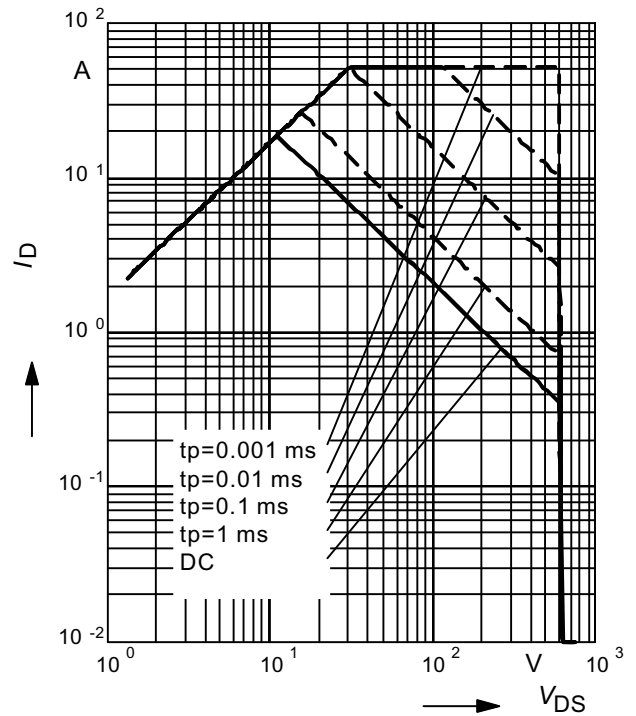
$$P_{tot} = f(T_C)$$



**2 Safe operating area**

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

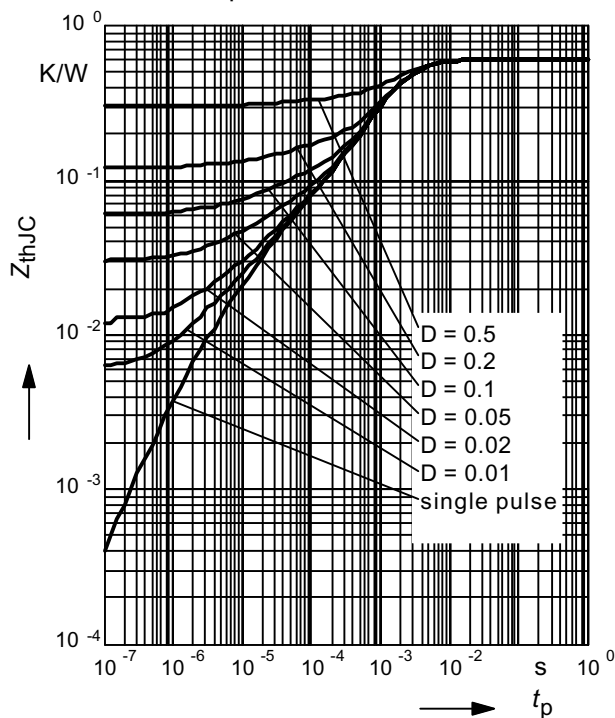
parameter :  $D = 0, T_C = 25^\circ\text{C}$



**3 Transient thermal impedance**

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

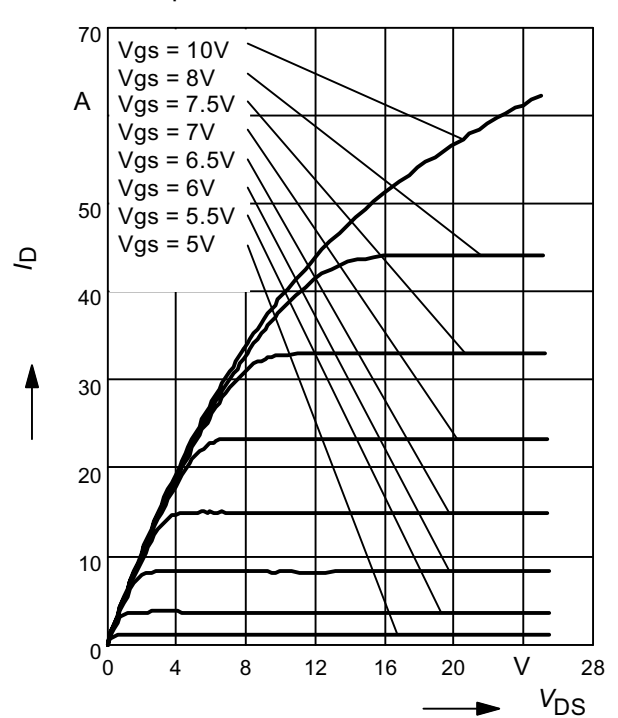
parameter:  $D = t_p/T$



**4 Typ. output characteristic**

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

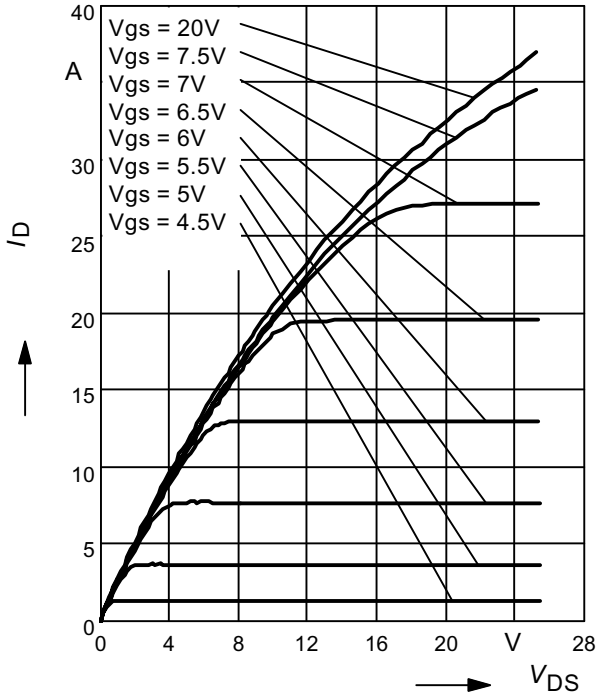
parameter:  $t_p = 10 \mu\text{s}, V_{GS}$



**5 Typ. output characteristic**

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

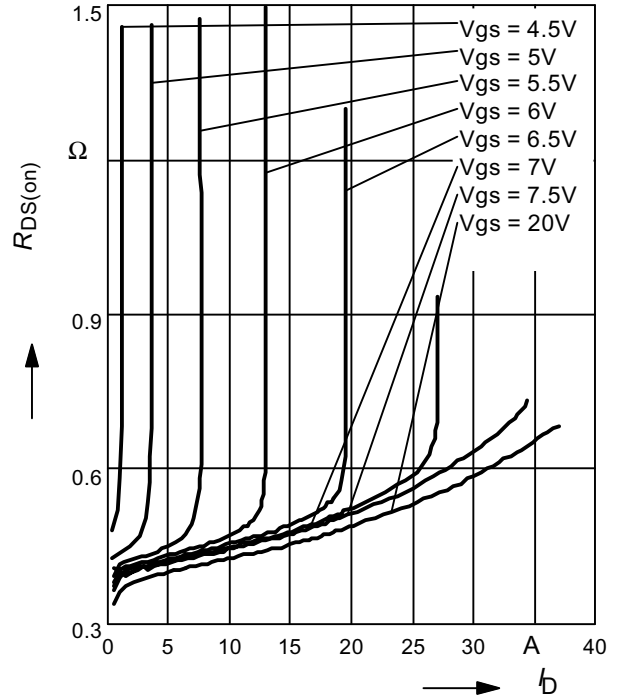
parameter:  $t_p = 10 \mu\text{s}, V_{GS}$



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

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

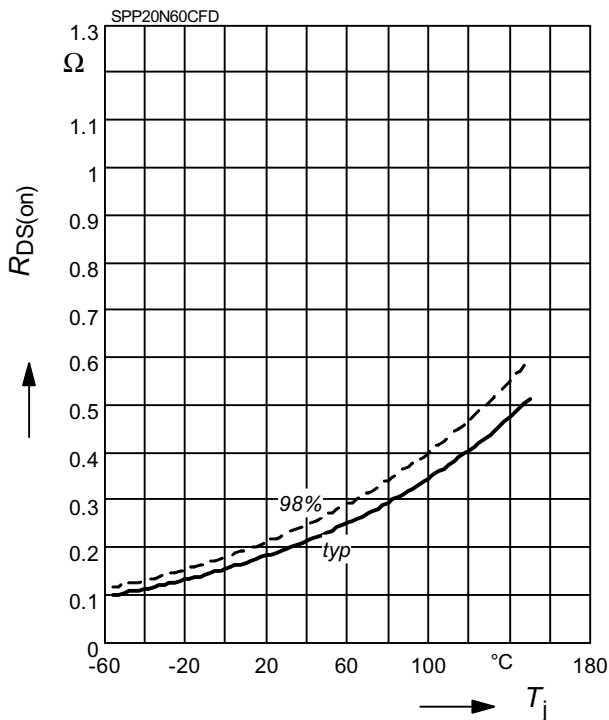
parameter:  $T_j = 150^\circ\text{C}, V_{GS}$



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

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

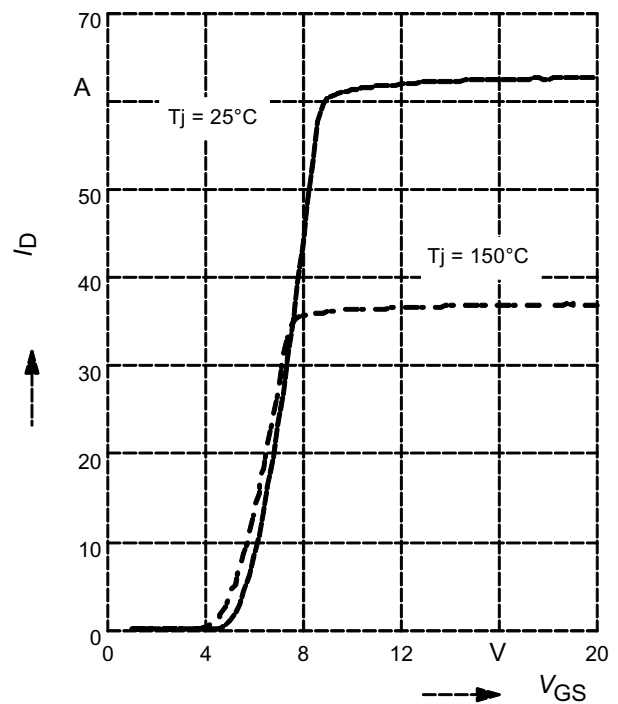
parameter:  $I_D = 13.1 \text{ A}, V_{GS} = 10 \text{ V}$



**8 Typ. transfer characteristics**

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

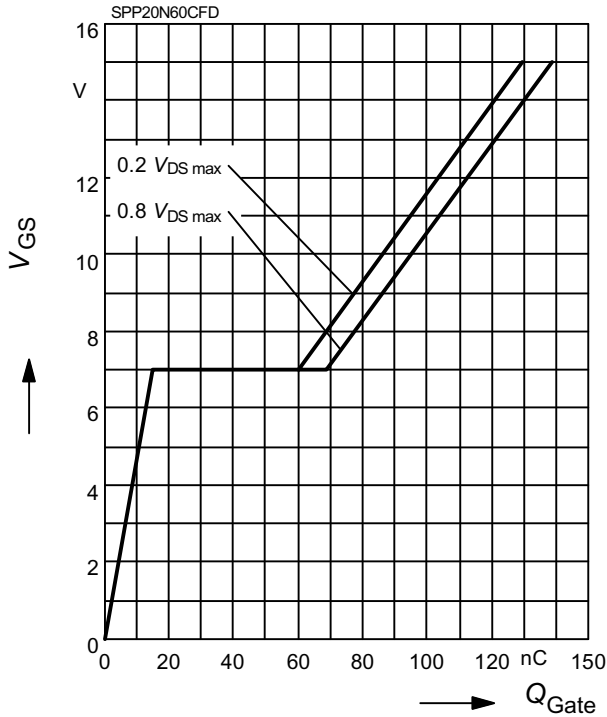
parameter:  $t_p = 10 \mu\text{s}$



**9 Typ. gate charge**

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

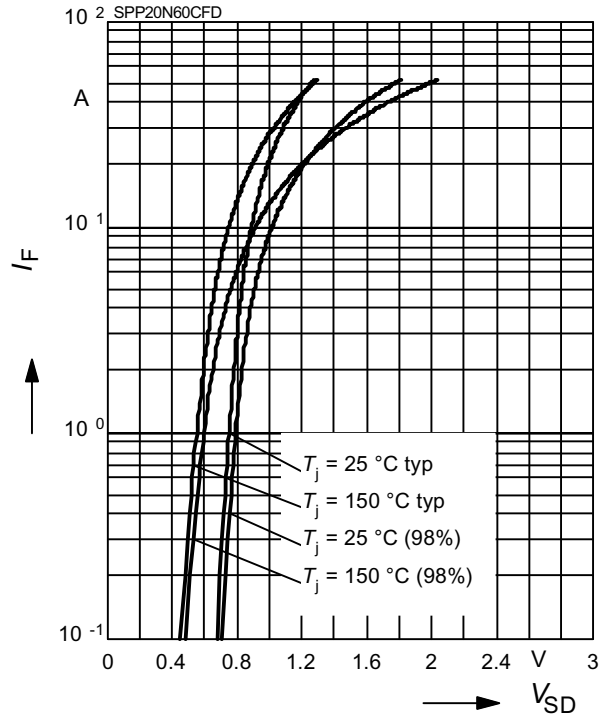
parameter:  $I_D = 20.7 \text{ A}$  pulsed



**10 Forward characteristics of body diode**

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

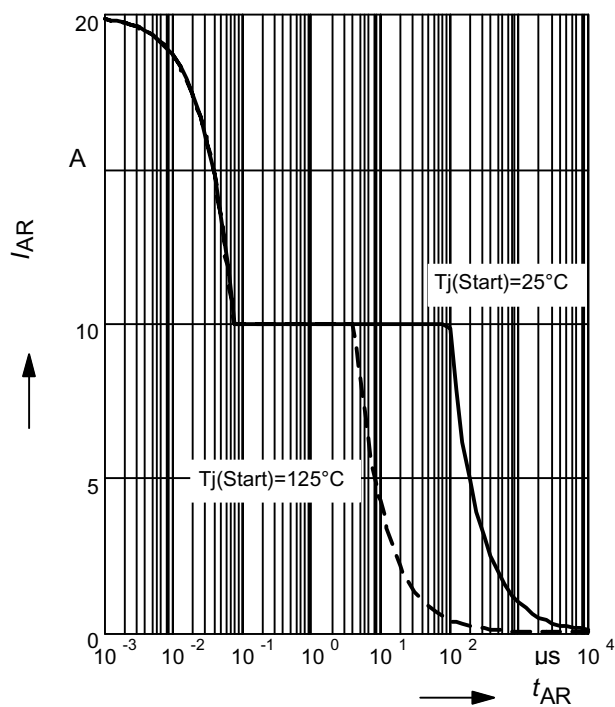
parameter:  $T_j, t_p = 10 \mu\text{s}$



**11 Avalanche SOA**

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

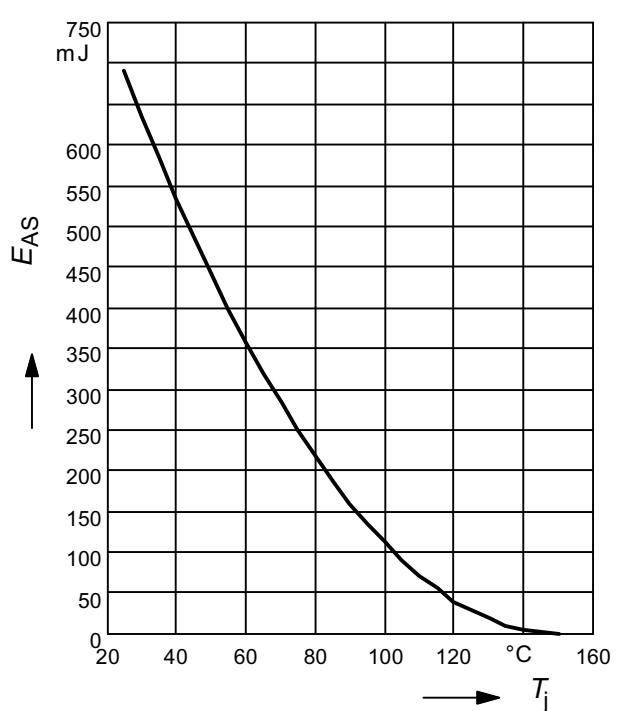
par.:  $T_j \leq 150 \text{ °C}$



**12 Avalanche energy**

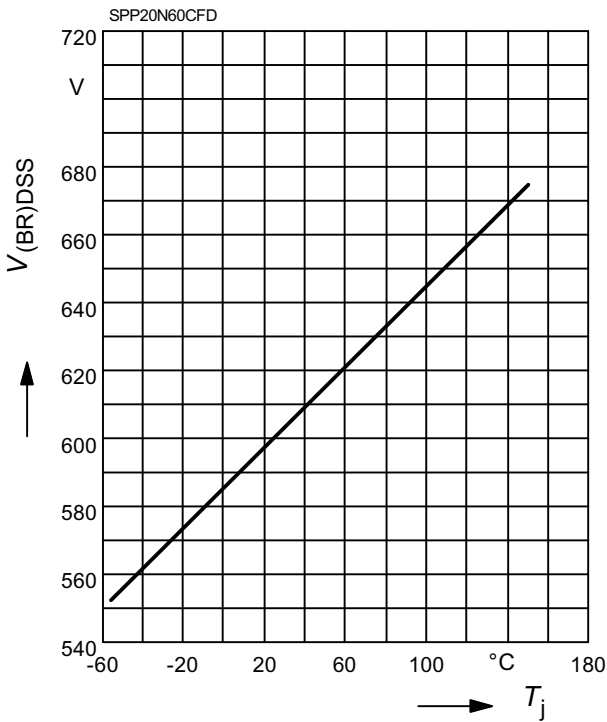
$$E_{AS} = f(T_j)$$

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



**13 Drain-source breakdown voltage**

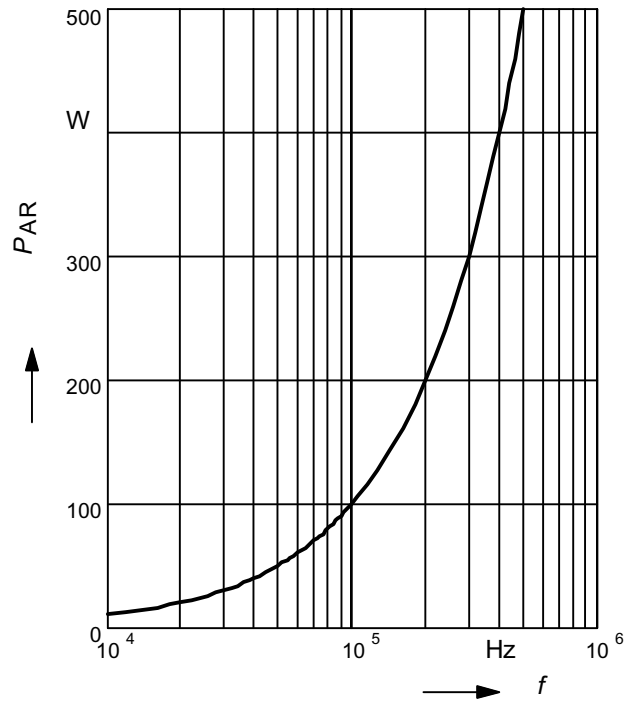
$$V_{(BR)DSS} = f(T_j)$$



**14 Avalanche power losses**

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

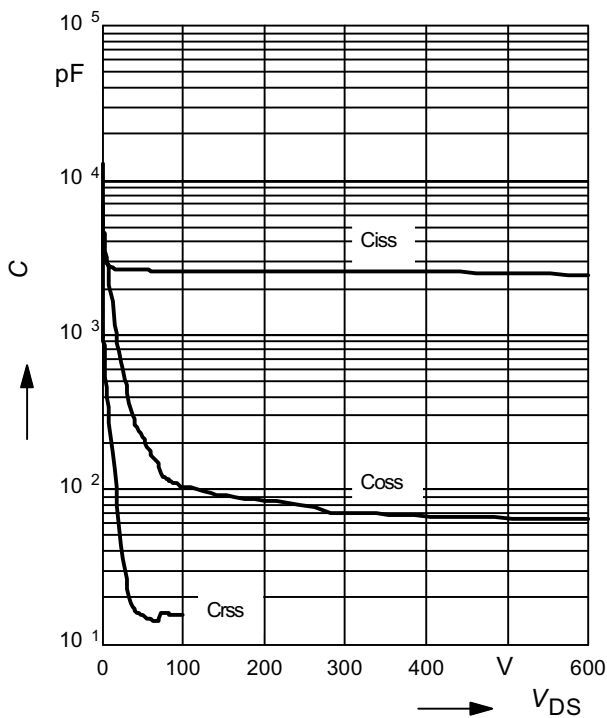
parameter:  $E_{AR}=1mJ$



**15 Typ. capacitances**

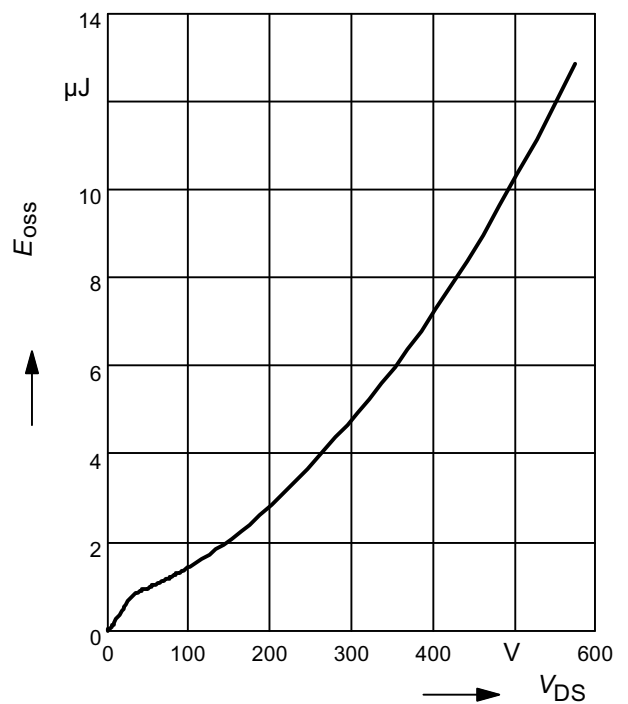
$$C = f(V_{DS})$$

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



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

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

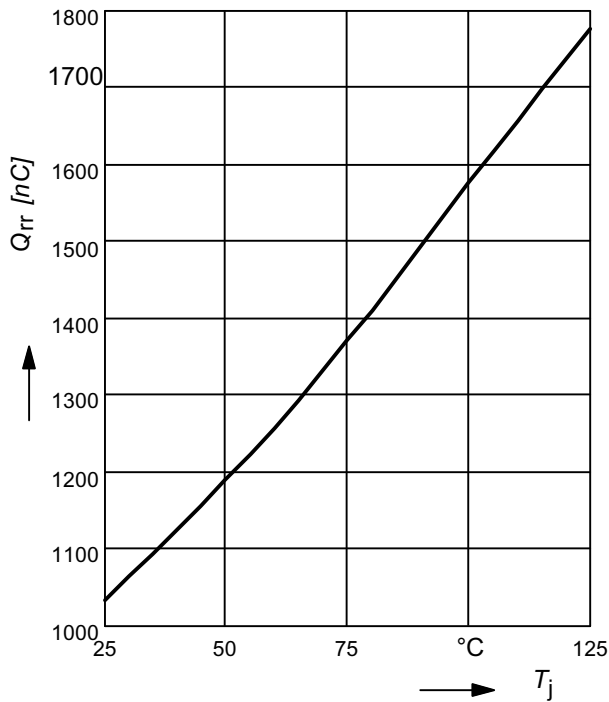




**17 Typ. reverse recovery charge**

$$Q_{rr} = f(T_j)$$

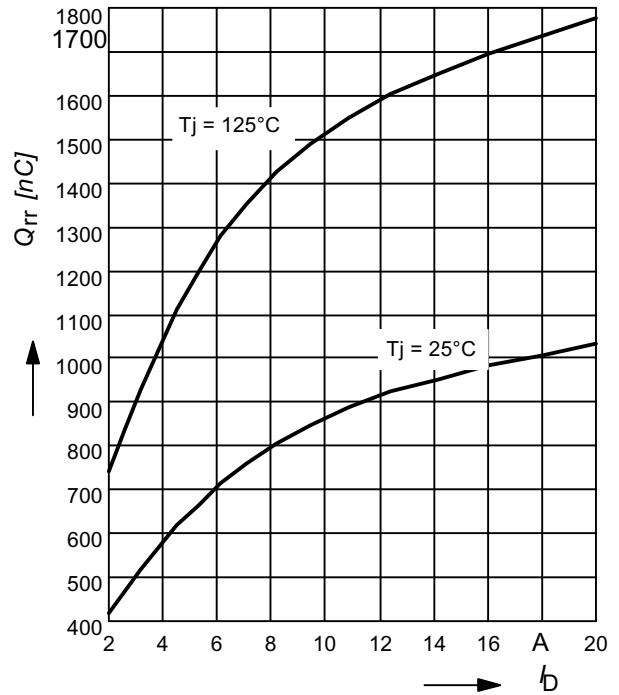
parameter:  $I_D = 20.7A$



**18 Typ. reverse recovery charge**

$$Q_{rr} = f(I_D)$$

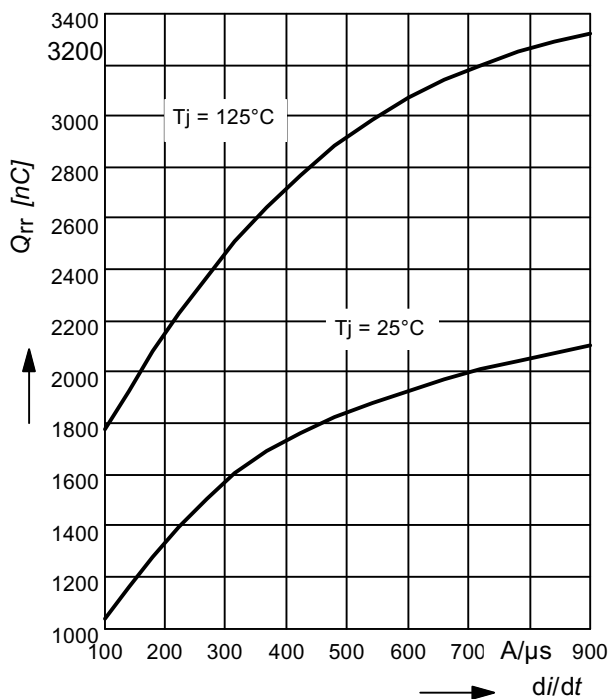
parameter:  $di/dt = 100 A/\mu s$



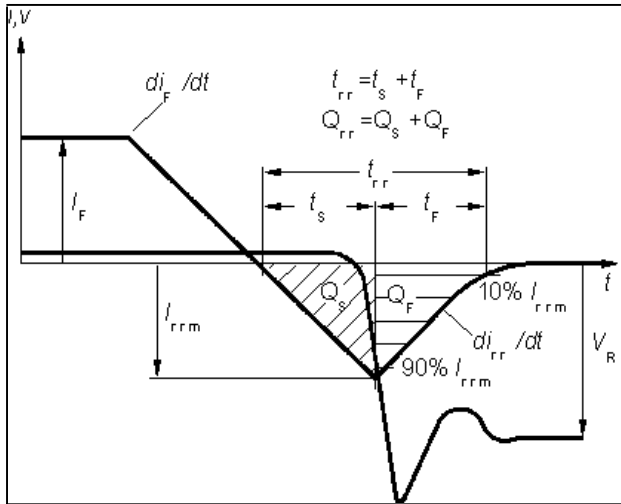
**19 Typ. reverse recovery charge**

$$Q_{rr} = f(di/dt)$$

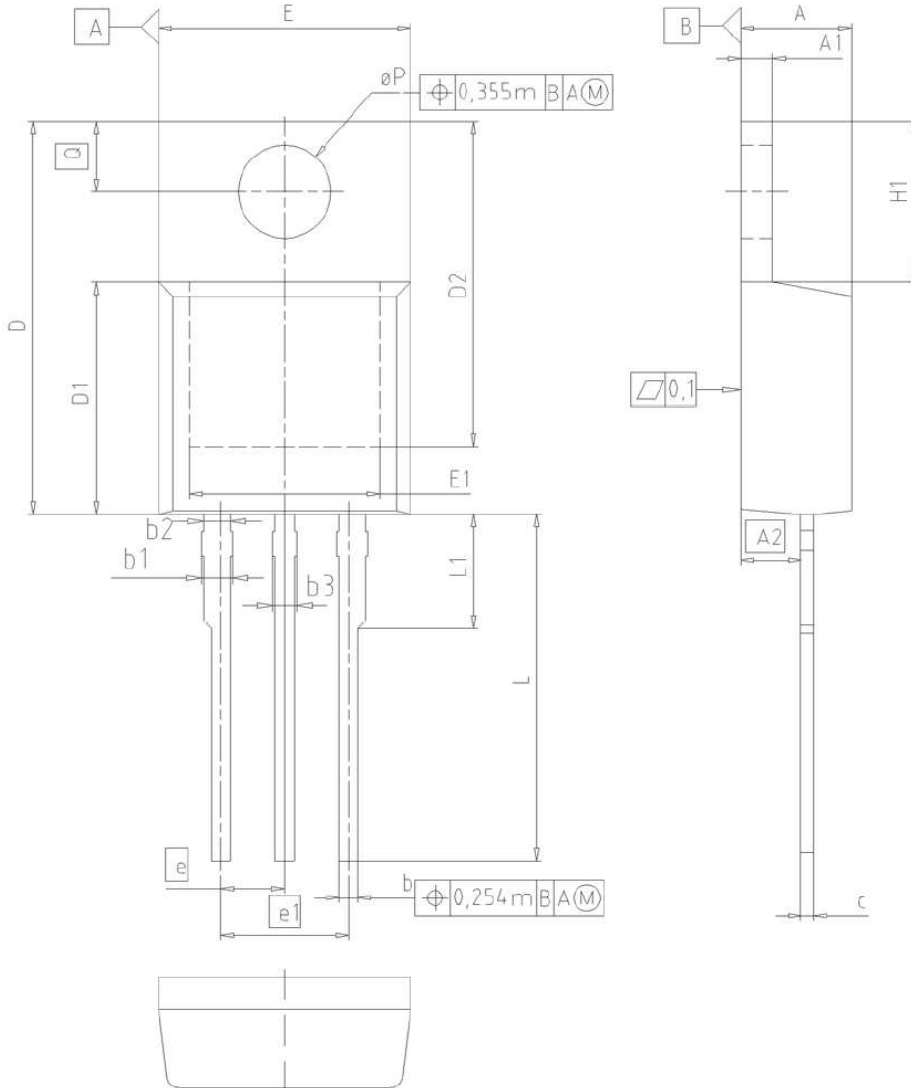
parameter:  $I_D = 20.7 A$



Definition of diodes switching characteristics



PG-TO-220-3-1, PG-TO220-3-21



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
$\phi P$	3.60	3.89	0.142	0.153
Q	2.60	3.00	0.102	0.118

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SCALE

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