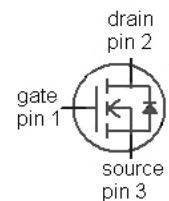
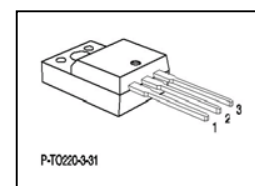


**CoolMOS™ Power Transistor**
**Features**

- New revolutionary high voltage technology
- Intrinsic fast-recovery body diode
- Extremely low reverse recovery charge
- Ultra low gate charge
- Extreme  $dv/dt$  rated
- High peak current capability
- Periodic avalanche rated
- Qualified for industrial grade applications according to JEDEC<sup>0)</sup>
- **Halogen free mold compound**

**Product Summary**

$V_{DS}$	600	V
$R_{DS(on),max}$	0.44	$\Omega$
$I_D^{1)}$	11	A

**PG-TO220-3-31**


Type	Package	Ordering Code	Marking
SPA11N60CFD	TO-220-3-31	SP000216317	11N60CFD

**Maximum ratings, at  $T_j=25\text{ °C}$ , unless otherwise specified**

Parameter	Symbol	Conditions	Value	Unit
Continuous drain current <sup>1)</sup>	$I_D$	$T_C=25\text{ °C}$	11	A
		$T_C=100\text{ °C}$	7	
Pulsed drain current <sup>2)</sup>	$I_{D,pulse}$	$T_C=25\text{ °C}$	28	
Avalanche energy, single pulse	$E_{AS}$	$I_D=5.5\text{ A}$ , $V_{DD}=50\text{ V}$	340	mJ
Avalanche energy, repetitive <sup>2),3)</sup>	$E_{AR}$	$I_D=11\text{ A}$ , $V_{DD}=50\text{ V}$	0.6	
Avalanche current, repetitive <sup>2),3)</sup>	$I_{AR}$		11	A
Drain source voltage slope	$dv/dt$	$I_D=11\text{ A}$ , $V_{DS}=480\text{ V}$ , $T_j=125\text{ °C}$	80	V/ns
Reverse diode $dv/dt$	$dv/dt$	$I_S=11\text{ A}$ , $V_{DS}=480\text{ V}$ , $T_j=125\text{ °C}$	40	V/ns
Maximum diode commutation speed	$di/dt$		600	A/ $\mu$ s
Gate source voltage	$V_{GS}$	static	$\pm 20$	V
		AC ( $f > 1\text{ Hz}$ )	$\pm 30$	
Power dissipation	$P_{tot}$	$T_C=25\text{ °C}$	33	W
Operating and storage temperature	$T_j, T_{stg}$		-55 ... 150	$^{\circ}\text{C}$

Parameter	Symbol	Conditions	Values			Unit
			min.	typ.	max.	

**Thermal characteristics**

Thermal resistance, junction - case	$R_{thJC}$		-	-	3.8	K/W
Thermal resistance, junction - ambient	$R_{thJA}$	leaded	-	-	62	
Soldering temperature, wave soldering	$T_{sold}$	1.6 mm (0.063 in.) from case for 10 s	-	-	260	°C

**Electrical characteristics, at  $T_j=25\text{ °C}$ , unless otherwise specified**
**Static characteristics**

Drain-source breakdown voltage	$V_{(BR)DSS}$	$V_{GS}=0\text{ V}, I_D=250\text{ }\mu\text{A}$	600	-	-	V
Avalanche breakdown voltage	$V_{(BR)DS}$	$V_{GS}=0\text{ V}, I_D=11\text{ A}$	-	700	-	
Gate threshold voltage	$V_{GS(th)}$	$V_{DS}=V_{GS}, I_D=1.9\text{ mA}$	3	4	5	
Zero gate voltage drain current	$I_{DSS}$	$V_{DS}=600\text{ V}, V_{GS}=0\text{ V}, T_j=25\text{ °C}$	-	1.1	-	$\mu\text{A}$
		$V_{DS}=600\text{ V}, V_{GS}=0\text{ V}, T_j=150\text{ °C}$	-	900	-	
Gate-source leakage current	$I_{GSS}$	$V_{GS}=20\text{ V}, V_{DS}=0\text{ V}$	-	-	100	nA
Drain-source on-state resistance	$R_{DS(on)}$	$V_{GS}=10\text{ V}, I_D=7\text{ A}, T_j=25\text{ °C}$	-	0.38	0.44	$\Omega$
		$V_{GS}=10\text{ V}, I_D=7\text{ A}, T_j=150\text{ °C}$	-	1.02	-	
Gate resistance	$R_G$	$f=1\text{ MHz}$ , open drain	-	0.86	-	
Transconductance	$g_{fs}$	$ V_{DS} >2 I_D  R_{DS(on)max}, I_D=7\text{ A}$	-	8.3	-	S

Parameter	Symbol	Conditions	Values			Unit
			min.	typ.	max.	

**Dynamic characteristics**

Input capacitance	$C_{iss}$	$V_{GS}=0\text{ V}, V_{DS}=25\text{ V},$ $f=1\text{ MHz}$	-	1200	-	pF
Output capacitance	$C_{oss}$		-	390	-	
Reverse transfer capacitance	$C_{rss}$		-	30	-	
Effective output capacitance, energy related <sup>4)</sup>	$C_{o(er)}$	$V_{GS}=0\text{ V}, V_{DS}=0\text{ V}$ to 480 V	-	45	-	
Effective output capacitance, time related <sup>5)</sup>	$C_{o(tr)}$		-	85	-	
Turn-on delay time	$t_{d(on)}$	$V_{DD}=480\text{ V},$ $V_{GS}=10\text{ V}, I_D=11\text{ A},$ $R_G=6.8\ \Omega$	-	34	-	ns
Rise time	$t_r$		-	18	-	
Turn-off delay time	$t_{d(off)}$		-	43	-	
Fall time	$t_f$		-	7	-	

**Gate Charge Characteristics**

Gate to source charge	$Q_{gs}$	$V_{DD}=480\text{ V}, I_D=11\text{ A},$ $V_{GS}=0\text{ to }10\text{ V}$	-	9	-	nC
Gate to drain charge	$Q_{gd}$		-	23	-	
Gate charge total	$Q_g$		-	48	64	
Gate plateau voltage	$V_{plateau}$		-	7.5	-	V

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

<sup>1)</sup> Limited only by maximum temperature.

<sup>2)</sup> Pulse width  $t_p$  limited by  $T_{j,max}$ 
<sup>3)</sup> Repetitive avalanche causes additional power losses that can be calculated as  $P_{AV}=E_{AR} \cdot f$ .

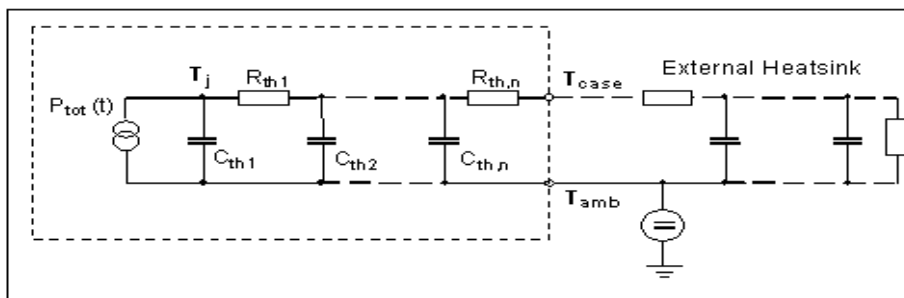
<sup>4)</sup>  $C_{o(er)}$  is a fixed capacitance that gives the same stored energy as  $C_{oss}$  while  $V_{DS}$  is rising from 0 to 80%  $V_{DSS}$ .

<sup>5)</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%  $V_{DSS}$ .

Parameter	Symbol	Conditions	Values			Unit
			min.	typ.	max.	
<b>Reverse Diode</b>						
Diode continuous forward current <sup>1)</sup>	$I_S$	$T_C=25\text{ }^\circ\text{C}$	-	-	11	A
Diode pulse current <sup>2)</sup>	$I_{S,pulse}$		-	-	28	
Diode forward voltage	$V_{SD}$	$V_{GS}=0\text{ V}, I_F=11\text{ A}, T_j=25\text{ }^\circ\text{C}$	-	1.0	1.2	V
Reverse recovery time	$t_{rr}$	$V_R=480\text{ V}, I_F=I_S, di_F/dt=100\text{ A}/\mu\text{s}$	-	140	-	ns
Reverse recovery charge	$Q_{rr}$		-	0.7	-	$\mu\text{C}$
Peak reverse recovery current	$I_{rrm}$		-	11	-	A

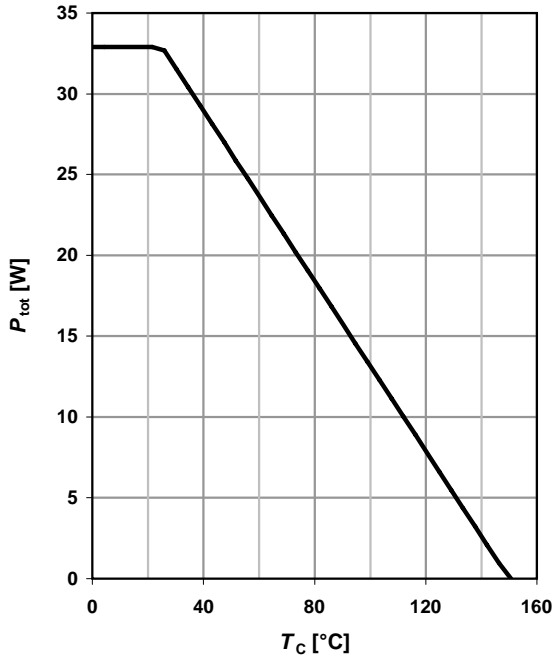
**Typical Transient Thermal Characteristics**

Symbol	Value	Unit	Symbol	Value	Unit
	typ.			typ.	
$R_{th1}$	0.0178	K/W	$C_{th1}$	0.0000989	Ws/K
$R_{th2}$	0.0931		$C_{th2}$	0.000939	
$R_{th3}$	0.228		$C_{th3}$	0.00303	
$R_{th4}$	0.559		$C_{th4}$	0.0245	
$R_{th5}$	1.58		$C_{th5}$	0.951	



**1 Power dissipation**

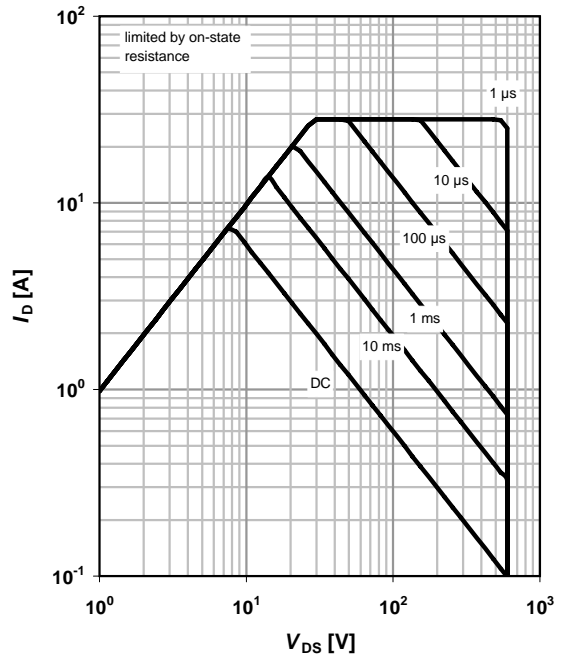
$P_{tot}=f(T_C)$



**2 Safe operating area**

$I_D=f(V_{DS}); T_C=25\text{ °C}; D=0$

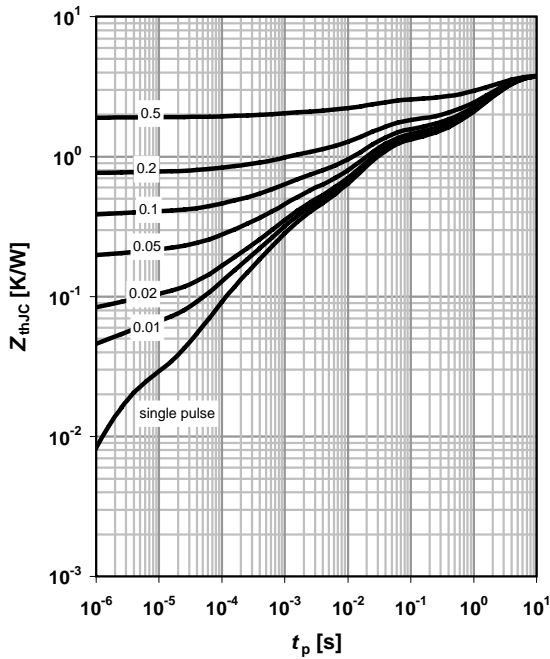
parameter:  $t_p$



**3 Max. transient thermal impedance**

$I_D=f(V_{DS}); T_j=25\text{ °C}$

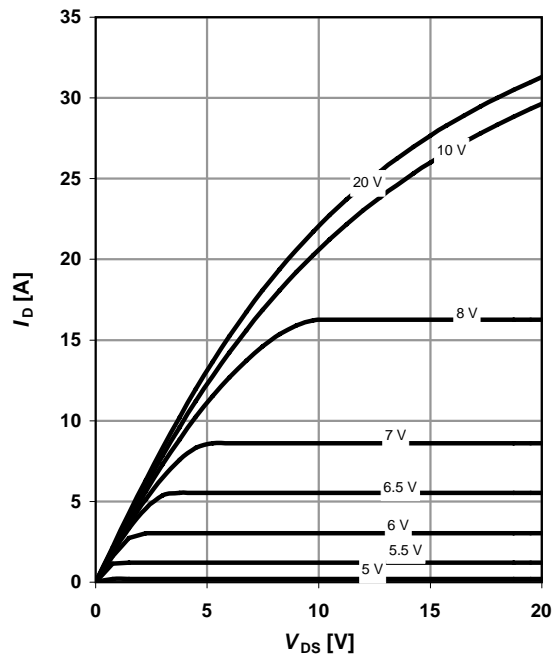
parameter:  $D=t_p/T$



**4 Typ. output characteristics**

$I_D=f(V_{DS}); T_j=25\text{ °C}$

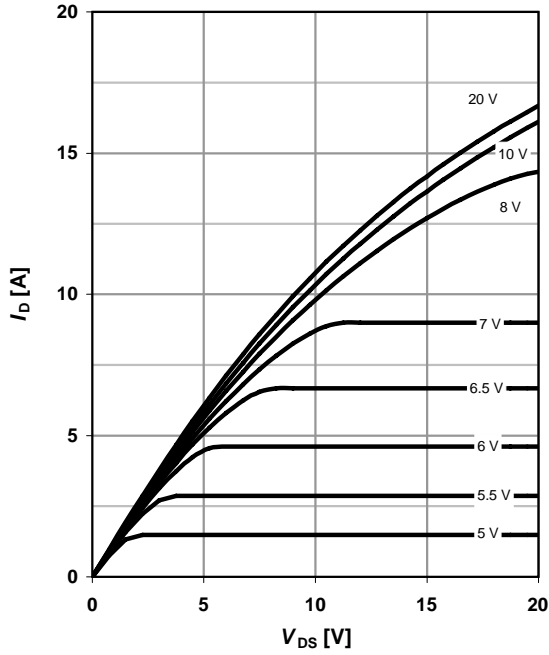
parameter:  $t_p = 10\mu\text{s } V_{GS}$



**5 Typ. output characteristics**

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

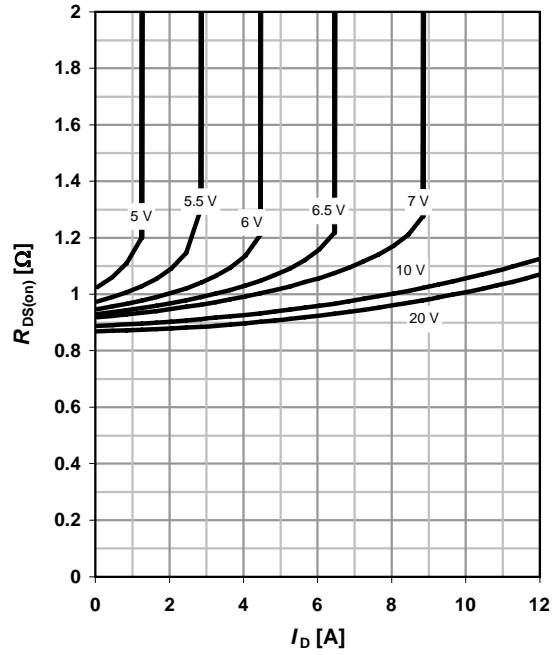
parameter:  $t_p = 10\mu\text{s}$   $V_{GS}$



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

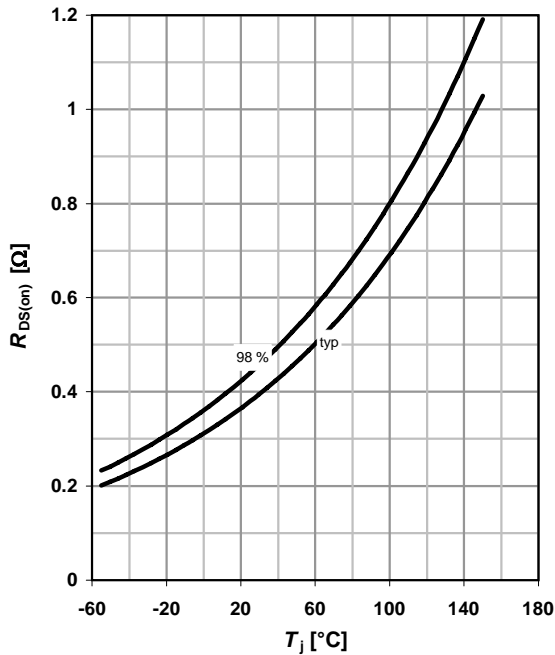
$R_{DS(on)} = f(I_D); T_j = 150\text{ }^\circ\text{C}$

parameter:  $V_{GS}$



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

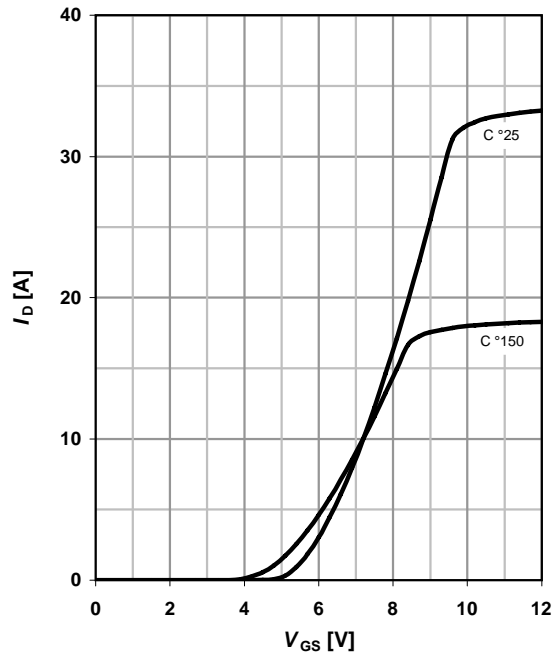
$R_{DS(on)} = f(T_j); I_D = 7\text{ A}; V_{GS} = 10\text{ V}$



**8 Typ. transfer characteristics**

$I_D = f(V_{GS}); |V_{DS}| > 2|I_D|R_{DS(on)max}$

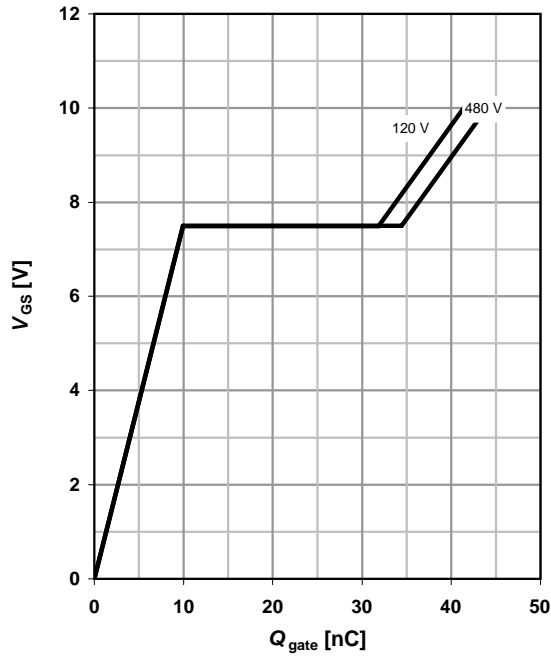
parameter:  $T_j$



**9 Typ. gate charge**

$V_{GS}=f(Q_{gate}); I_D=11 \text{ A pulsed}$

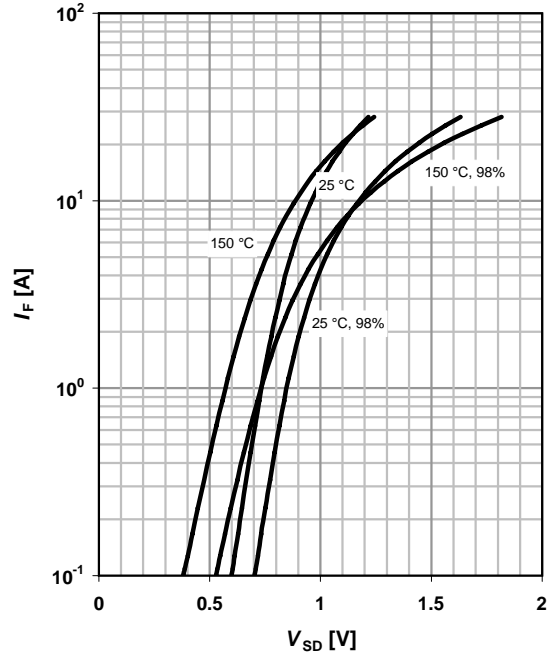
parameter:  $V_{DD}$



**10 Forward characteristics of reverse diode**

$I_F=f(V_{SD})$

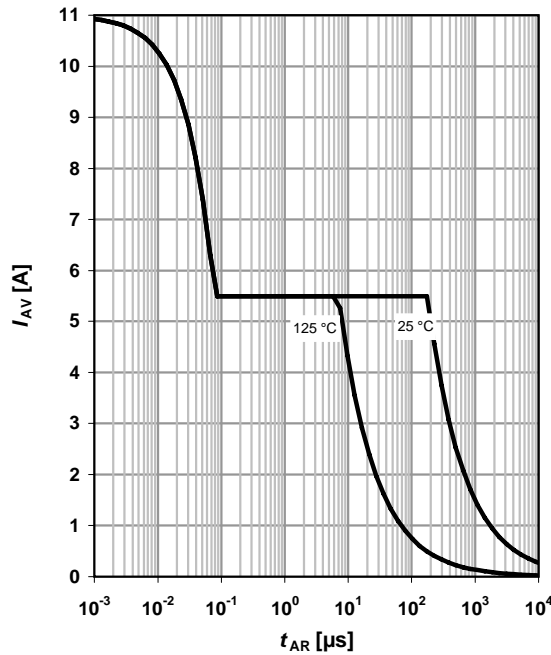
parameter:  $T_j$



**11 Avalanche SOA**

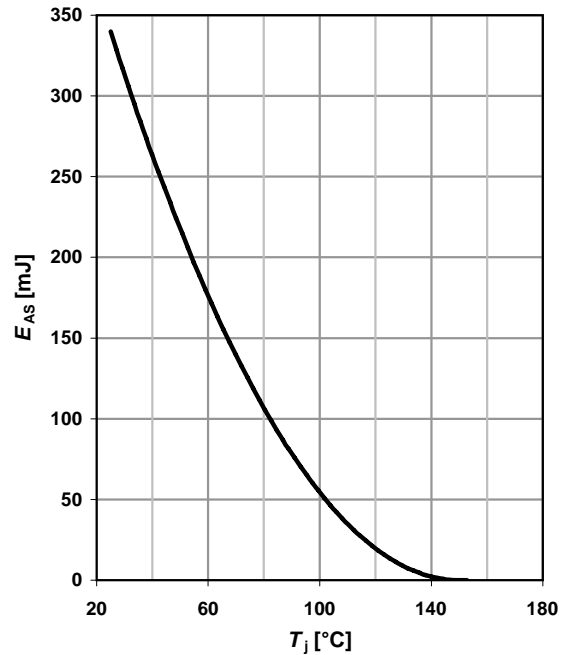
$I_{AR}=f(t_{AR})$

parameter:  $T_{j(start)}$



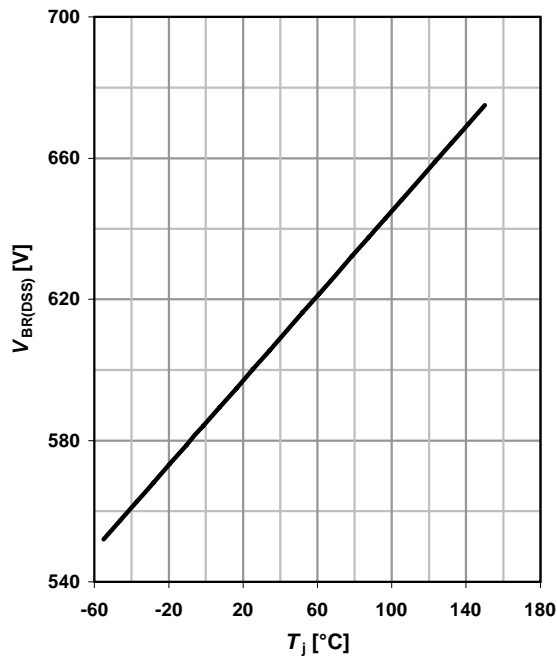
**12 Avalanche energy**

$E_{AS}=f(T_j); I_D=5.5 \text{ A}; V_{DD}=50 \text{ V}$



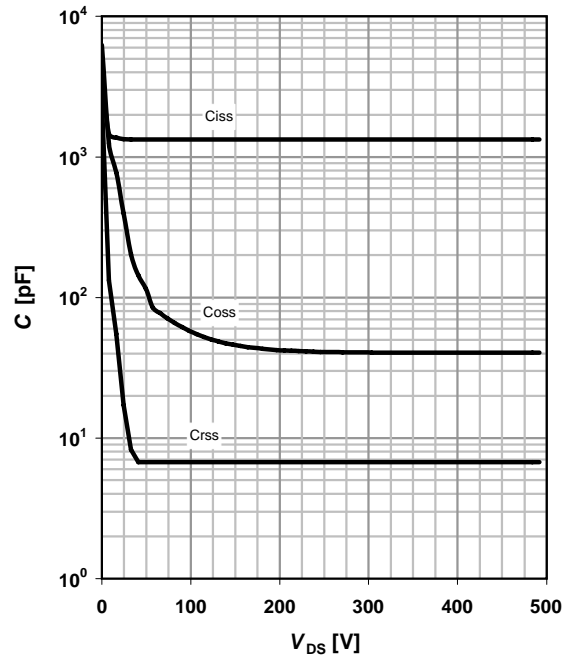
**13 Drain-source breakdown voltage**

$V_{BR(DSS)}=f(T_j); I_D=10\text{ mA}$



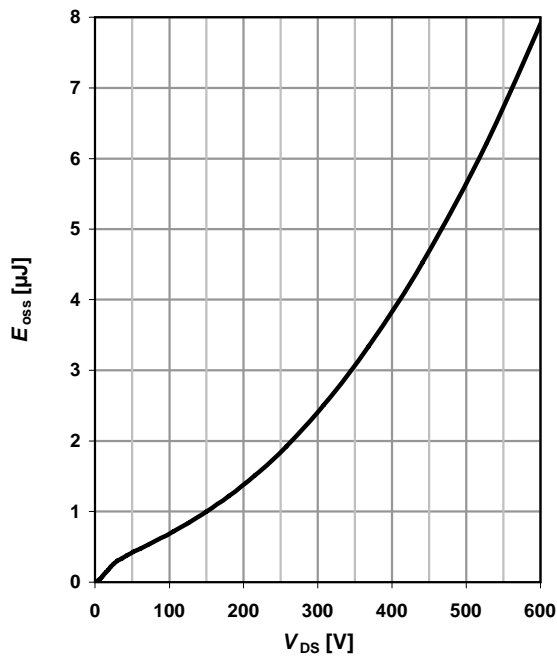
**14 Typ. capacitances**

$C=f(V_{DS}); V_{GS}=0\text{ V}; f=1\text{ MHz}$



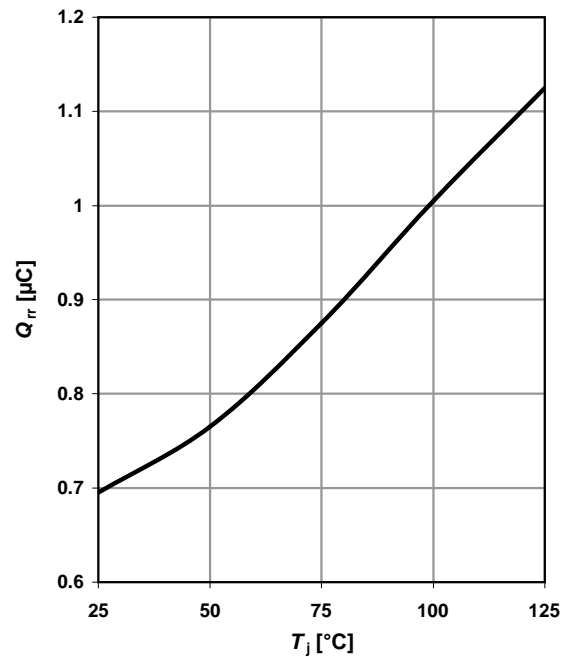
**15 Typ.  $C_{oss}$  stored energy**

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



**16 Typ. reverse recovery charge**

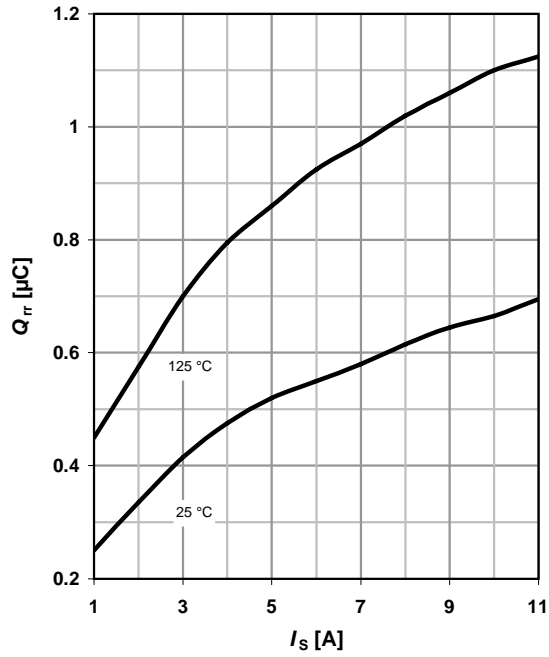
$Q_{rr}=f(T_j); \text{parameter: } I_D=11\text{ A}$





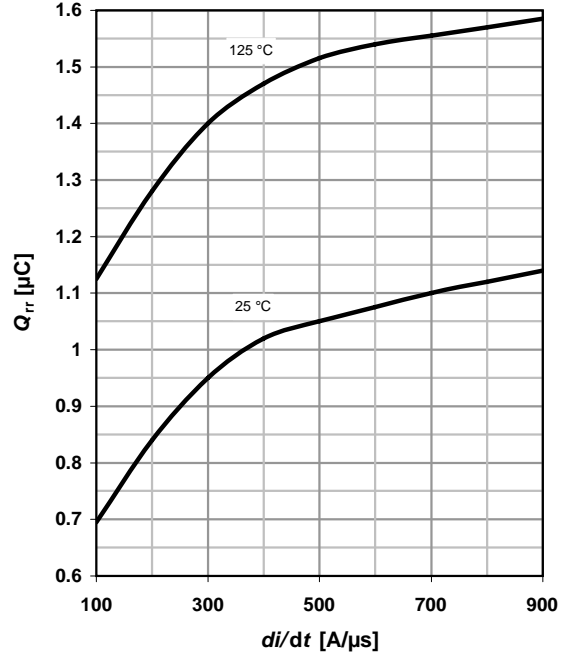
17 Typ. reverse recovery charge

$Q_{rr}=f(I_S)$ ; parameter:  $di/dt=100\text{ A}/\mu\text{s}$

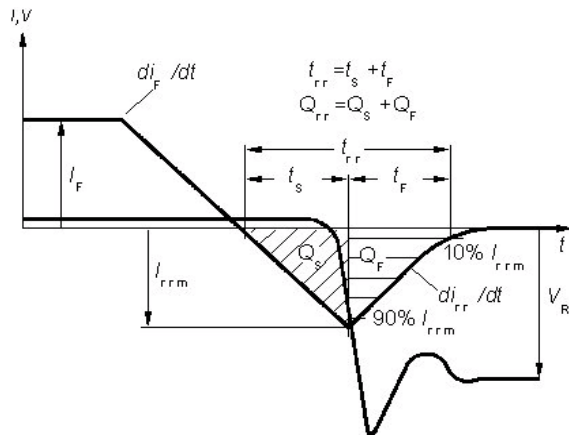


18 Typ. reverse recovery charge

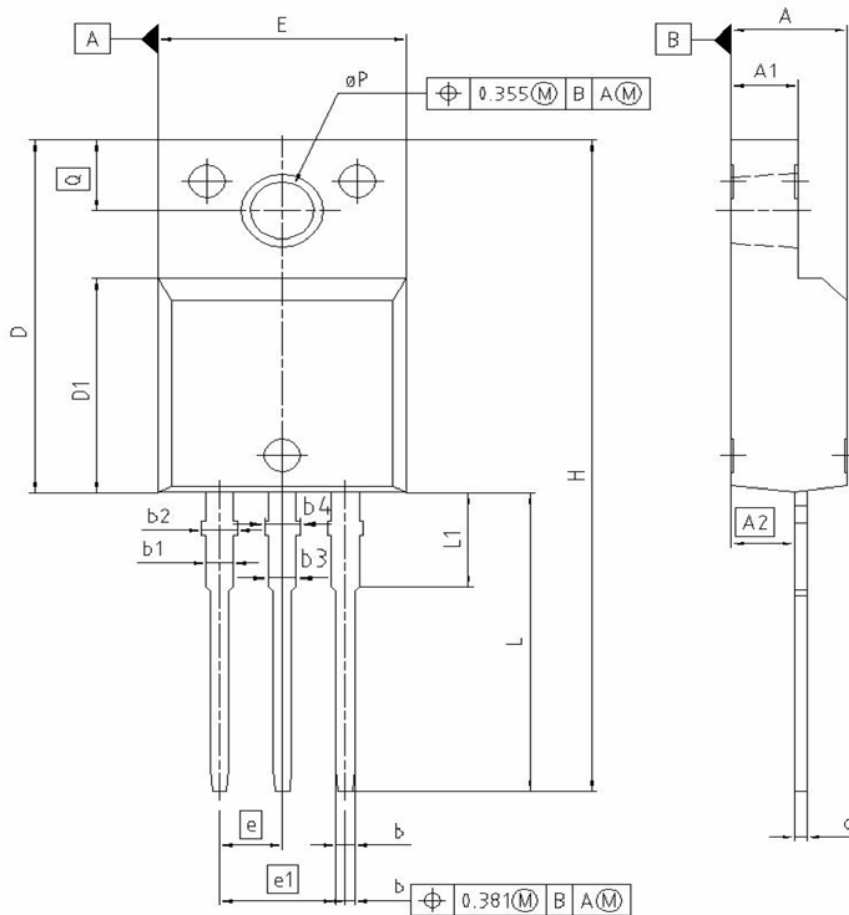
$Q_{rr}=f(di/dt)$ ; parameter:  $I_D=11\ \text{A}$



Definition of diode switching characteristics



PG-TO-220-3-31 (FullPAK)

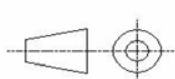


DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.55	4.85	0.179	0.191
A1	2.55	2.85	0.100	0.112
A2	2.42	2.72	0.095	0.107
b	0.65	0.85	0.026	0.033
b1	0.95	1.33	0.037	0.052
b2	0.95	1.51	0.037	0.059
b3	0.65	1.33	0.026	0.052
b4	0.65	1.51	0.026	0.059
c	0.40	0.63	0.016	0.025
D	15.85	16.15	0.624	0.636
D1	9.53	9.83	0.375	0.387
E	10.35	10.65	0.407	0.419
e	2.54		0.100	
e1	5.08		0.200	
N	3		3	
H	29.45	29.75	1.159	1.171
L	13.45	13.75	0.530	0.541
L1	3.15	3.45	0.124	0.136
pP	2.95	3.20	0.116	0.126
Q	3.15	3.50	0.124	0.138

REFERENCE  
..

SCALE  
0 2.5 5mm

EUROPEAN PROJECTION



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FILE  
TO220\_2

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