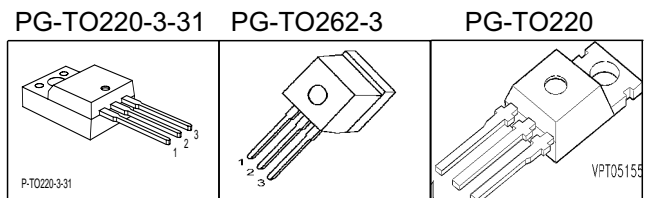


## Cool MOS™ Power Transistor

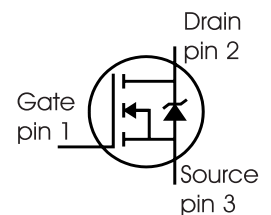
### Feature

- New revolutionary high voltage technology
- Ultra low gate charge
- Periodic avalanche rated
- Extreme  $dv/dt$  rated
- High peak current capability
- Improved transconductance
- PG-TO-220-3-31: Fully isolated package (2500 VAC; 1 minute)
- Pb-free lead plating; RoHS compliant
- Qualified according to JEDEC<sup>0)</sup> for target applications

$V_{DS} @ T_{jmax}$	650	V
$R_{DS(on)}$	0.38	$\Omega$
$I_D$	11	A



Type	Package	Ordering Code	Marking
SPP11N60C3	PG-TO220-3	Q67040-S4395	11N60C3
SPI11N60C3	PG-TO262-3	Q67042-S4403	11N60C3
SPA11N60C3	PG-TO220-3-31	SP000216312	11N60C3



### Maximum Ratings

Parameter	Symbol	Value		Unit
		SPP_I	SPA	
Continuous drain current $T_C = 25\text{ }^\circ\text{C}$ $T_C = 100\text{ }^\circ\text{C}$	$I_D$	11 7	11 <sup>1)</sup> 7 <sup>1)</sup>	A
Pulsed drain current, $t_p$ limited by $T_{jmax}$	$I_{D\text{ puls}}$	33	33	A
Avalanche energy, single pulse $I_D=5.5\text{A}, V_{DD}=50\text{V}$	$E_{AS}$	340	340	mJ
Avalanche energy, repetitive $t_{AR}$ limited by $T_{jmax}$ <sup>2)</sup> $I_D=11\text{A}, V_{DD}=50\text{V}$	$E_{AR}$	0.6	0.6	
Avalanche current, repetitive $t_{AR}$ limited by $T_{jmax}$	$I_{AR}$	11	11	A
Gate source voltage static	$V_{GS}$	$\pm 20$	$\pm 20$	V
Gate source voltage AC ( $f > 1\text{Hz}$ )	$V_{GS}$	$\pm 30$	$\pm 30$	
Power dissipation, $T_C = 25\text{ }^\circ\text{C}$	$P_{tot}$	125	33	W
Operating and storage temperature	$T_j, T_{stg}$	-55...+150		$^\circ\text{C}$
Reverse diode $dv/dt$ <sup>7)</sup>	$dv/dt$	15		V/ns

### Maximum Ratings

Parameter	Symbol	Value	Unit
Drain Source voltage slope $V_{DS} = 480 \text{ V}, I_D = 11 \text{ A}, T_j = 125 \text{ }^\circ\text{C}$	$dv/dt$	50	V/ns

### Thermal Characteristics

Parameter	Symbol	Values			Unit
		min.	typ.	max.	
Thermal resistance, junction - case	$R_{thJC}$	-	-	1	K/W
Thermal resistance, junction - case, FullPAK	$R_{thJC \text{ FP}}$	-	-	3.8	
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 <sup>2</sup> cooling area <sup>3)</sup>	$R_{thJA}$	-	-	62	
Soldering temperature, wavesoldering 1.6 mm (0.063 in.) from case for 10s <sup>4)</sup>	$T_{sold}$	-	-	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	$V_{(BR)DSS}$	$V_{GS}=0\text{V}, I_D=0.25\text{mA}$	600	-	-	V
Drain-Source avalanche breakdown voltage	$V_{(BR)DS}$	$V_{GS}=0\text{V}, I_D=11\text{A}$	-	700	-	
Gate threshold voltage	$V_{GS(th)}$	$I_D=500\mu\text{A}, V_{GS}=V_{DS}$	2.1	3	3.9	
Zero gate voltage drain current	$I_{DSS}$	$V_{DS}=600\text{V}, V_{GS}=0\text{V},$ $T_j=25^\circ\text{C}$ $T_j=150^\circ\text{C}$	-	0.1	1	$\mu\text{A}$
Gate-source leakage current	$I_{GSS}$	$V_{GS}=30\text{V}, V_{DS}=0\text{V}$	-	-	100	
Drain-source on-state resistance	$R_{DS(on)}$	$V_{GS}=10\text{V}, I_D=7\text{A}$ $T_j=25^\circ\text{C}$ $T_j=150^\circ\text{C}$	-	0.34	0.38	$\Omega$
Gate input resistance	$R_G$	$f=1\text{MHz}, \text{open drain}$	-	0.86	-	

### Electrical Characteristics

Parameter	Symbol	Conditions	Values			Unit
			min.	typ.	max.	
Transconductance	$g_{fs}$	$V_{DS} \geq 2 \cdot I_D \cdot R_{DS(on)max}$ , $I_D = 7A$	-	8.3	-	S
Input capacitance	$C_{iss}$	$V_{GS} = 0V$ , $V_{DS} = 25V$ ,	-	1200	-	pF
Output capacitance	$C_{oss}$	$f = 1MHz$	-	390	-	
Reverse transfer capacitance	$C_{rss}$		-	30	-	
Effective output capacitance, <sup>5)</sup> energy related	$C_{o(er)}$	$V_{GS} = 0V$ , $V_{DS} = 0V$ to 480V	-	45	-	
Effective output capacitance, <sup>6)</sup> time related	$C_{o(tr)}$		-	85	-	
Turn-on delay time	$t_{d(on)}$	$V_{DD} = 380V$ , $V_{GS} = 0/10V$ ,	-	10	-	ns
Rise time	$t_r$	$I_D = 11A$ ,	-	5	-	
Turn-off delay time	$t_{d(off)}$	$R_G = 6.8\Omega$	-	44	70	
Fall time	$t_f$		-	5	9	

### Gate Charge Characteristics

Gate to source charge	$Q_{gs}$	$V_{DD} = 480V$ , $I_D = 11A$	-	5.5	-	nC
Gate to drain charge	$Q_{gd}$		-	22	-	
Gate charge total	$Q_g$	$V_{DD} = 480V$ , $I_D = 11A$ , $V_{GS} = 0$ to 10V	-	45	60	
Gate plateau voltage	$V_{(plateau)}$	$V_{DD} = 480V$ , $I_D = 11A$	-	5.5	-	V

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

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

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

<sup>3</sup>Device on 40mm\*40mm\*1.5mm epoxy PCB FR4 with 6cm<sup>2</sup> (one layer, 70 μm thick) copper area for drain connection. PCB is vertical without blown air.

<sup>4</sup>Soldering temperature for TO-263: 220°C, reflow

<sup>5</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>6</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>7</sup> $I_{SD} \leq I_D$ ,  $di/dt \leq 400A/\mu s$ ,  $V_{DClink} = 400V$ ,  $V_{peak} < V_{BR, DSS}$ ,  $T_j < T_{j,max}$ .

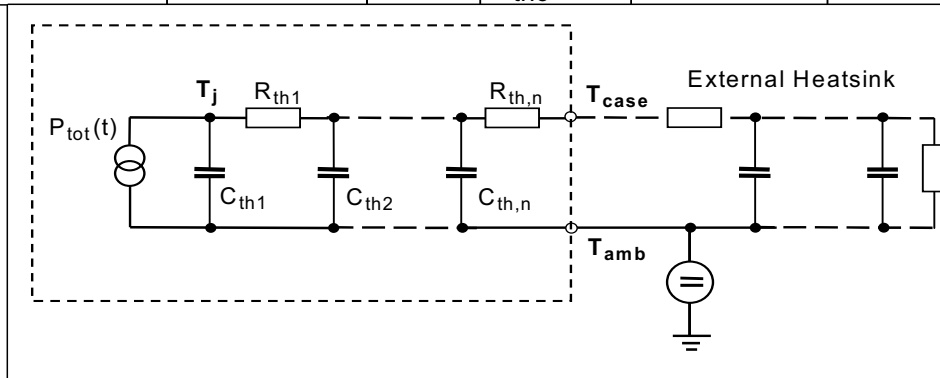
Identical low-side and high-side switch.

**Electrical Characteristics**

Parameter	Symbol	Conditions	Values			Unit
			min.	typ.	max.	
Inverse diode continuous forward current	$I_S$	$T_C=25^\circ\text{C}$	-	-	11	A
Inverse diode direct current, pulsed	$I_{SM}$		-	-	33	
Inverse diode forward voltage	$V_{SD}$	$V_{GS}=0\text{V}, I_F=I_S$	-	1	1.2	V
Reverse recovery time	$t_{rr}$	$V_R=480\text{V}, I_F=I_S,$	-	400	600	ns
Reverse recovery charge	$Q_{rr}$	$di_F/dt=100\text{A}/\mu\text{s}$	-	6	-	$\mu\text{C}$
Peak reverse recovery current	$I_{rrm}$		-	41	-	A
Peak rate of fall of reverse recovery current	$di_{rr}/dt$	$T_j=25^\circ\text{C}$	-	1200	-	$\text{A}/\mu\text{s}$

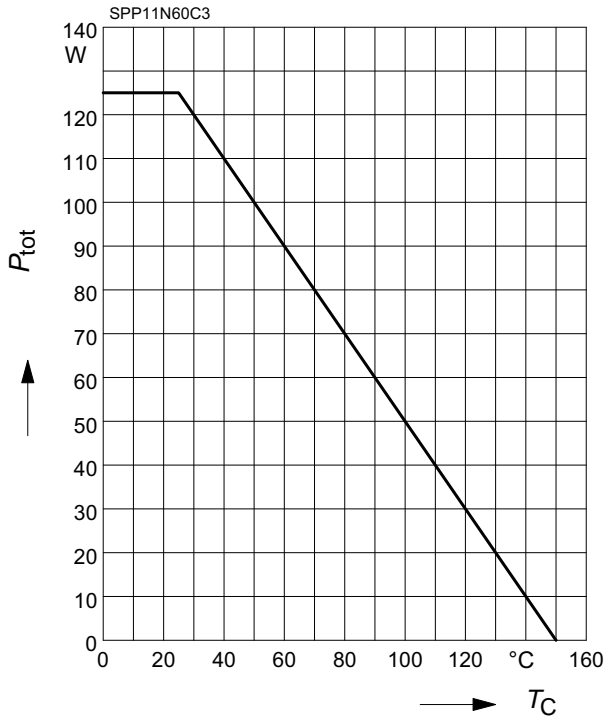
**Typical Transient Thermal Characteristics**

Symbol	Value		Unit	Symbol	Value		Unit
	SPP_I	SPA			SPP_I	SPA	
$R_{th1}$	0.015	0.15	K/W	$C_{th1}$	0.0001878	0.0001878	Ws/K
$R_{th2}$	0.03	0.03		$C_{th2}$	0.0007106	0.0007106	
$R_{th3}$	0.056	0.056		$C_{th3}$	0.000988	0.000988	
$R_{th4}$	0.197	0.194		$C_{th4}$	0.002791	0.002791	
$R_{th5}$	0.216	0.413		$C_{th5}$	0.007285	0.007401	
$R_{th6}$	0.083	2.522		$C_{th6}$	0.063	0.412	



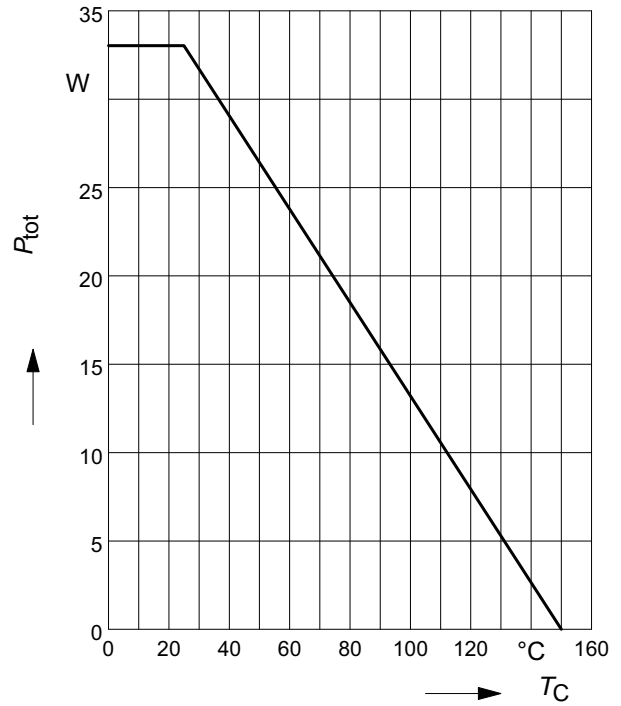
**1 Power dissipation**

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



**2 Power dissipation FullPAK**

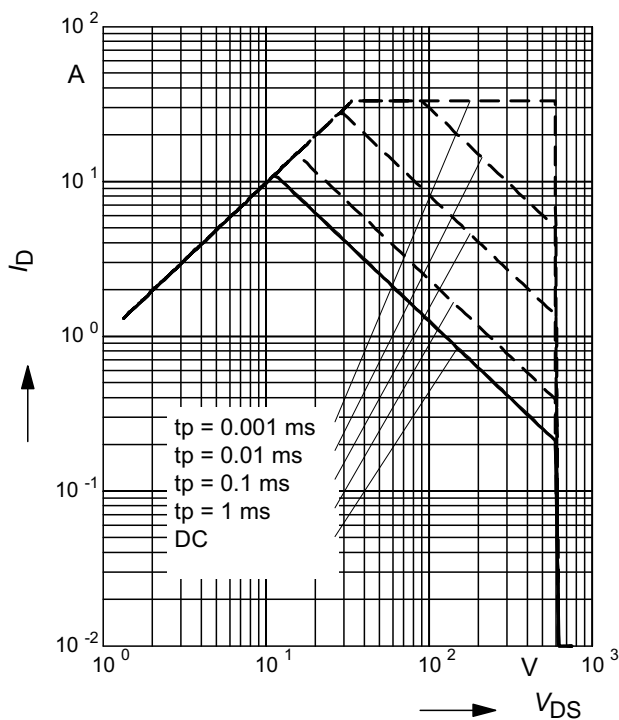
$$P_{tot} = f(T_C)$$



**3 Safe operating area**

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

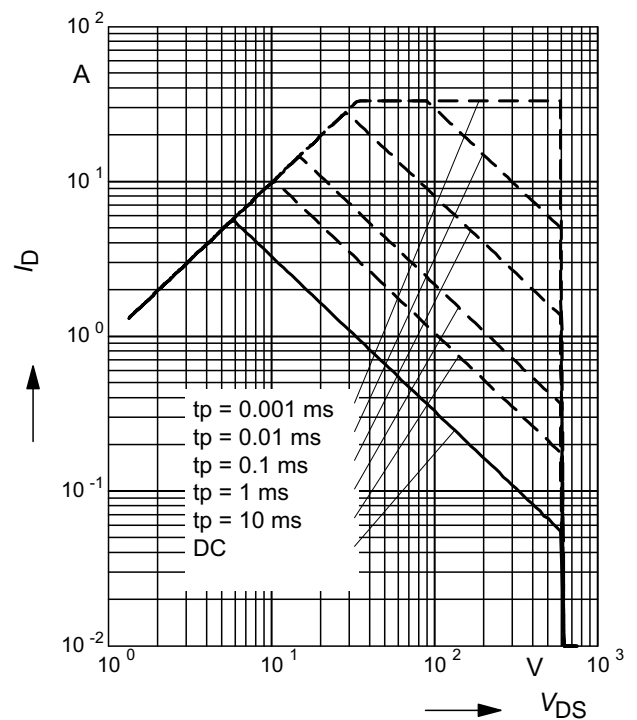
parameter :  $D = 0$  ,  $T_C = 25^\circ\text{C}$



**4 Safe operating area FullPAK**

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

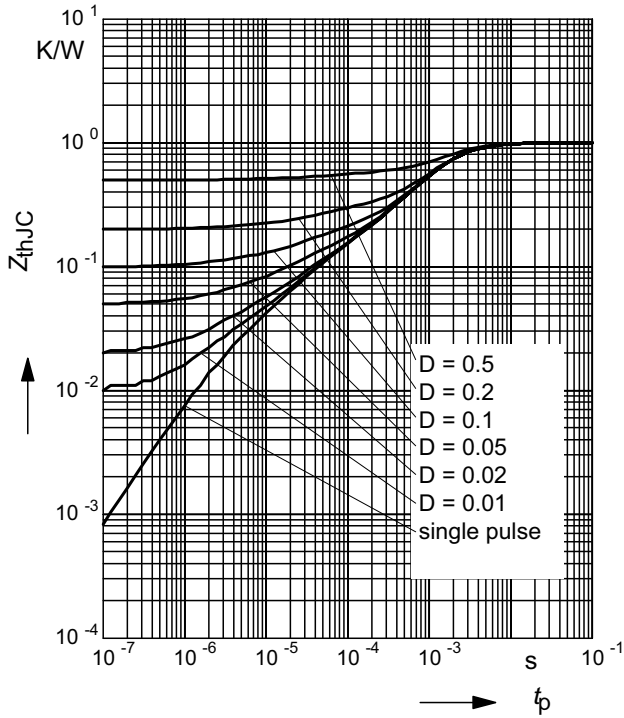
parameter:  $D = 0$  ,  $T_C = 25^\circ\text{C}$



**5 Transient thermal impedance**

$Z_{thJC} = f(t_p)$

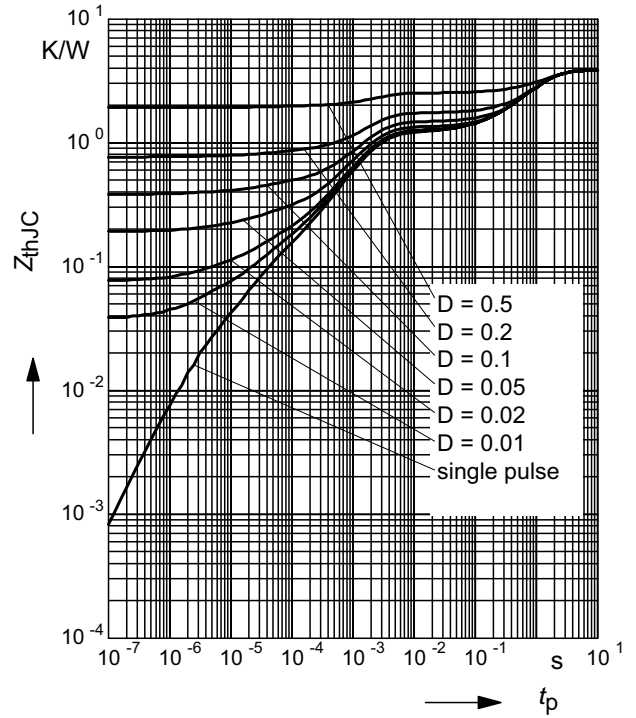
parameter:  $D = t_p/T$



**6 Transient thermal impedance FullPAK**

$Z_{thJC} = f(t_p)$

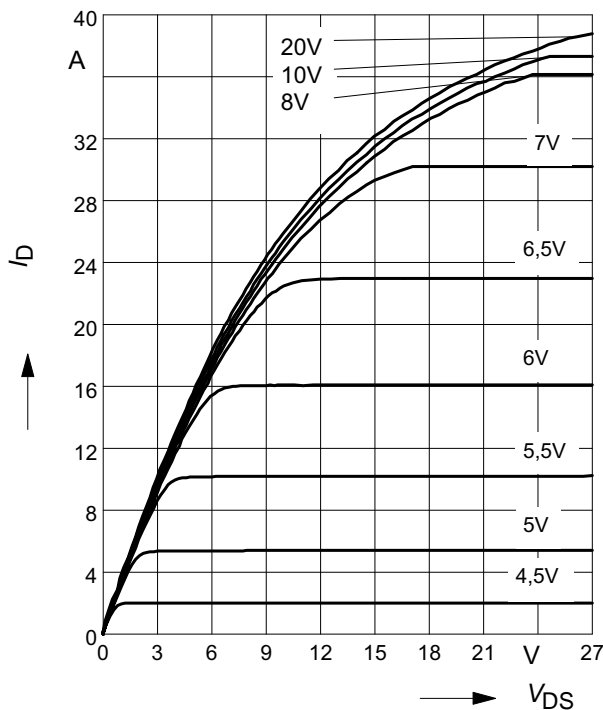
parameter:  $D = t_p/t$



**7 Typ. output characteristic**

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

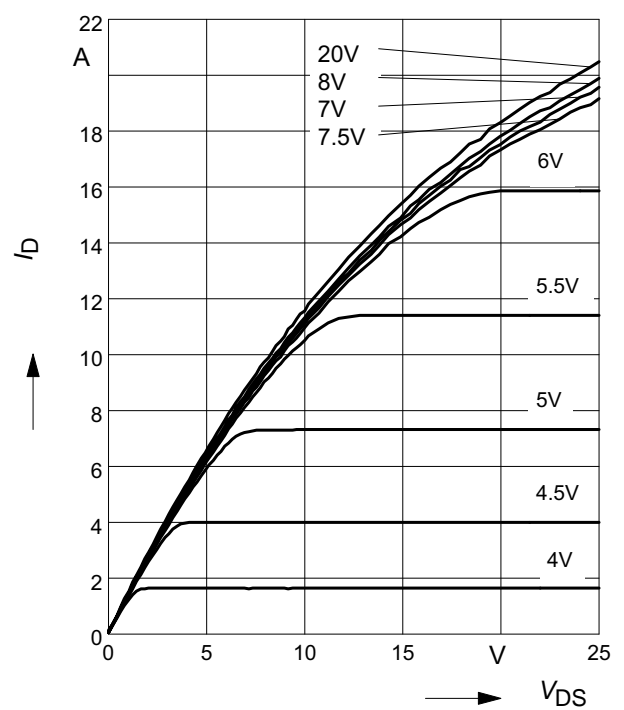
parameter:  $t_p = 10 \mu\text{s}, V_{GS}$



**8 Typ. output characteristic**

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

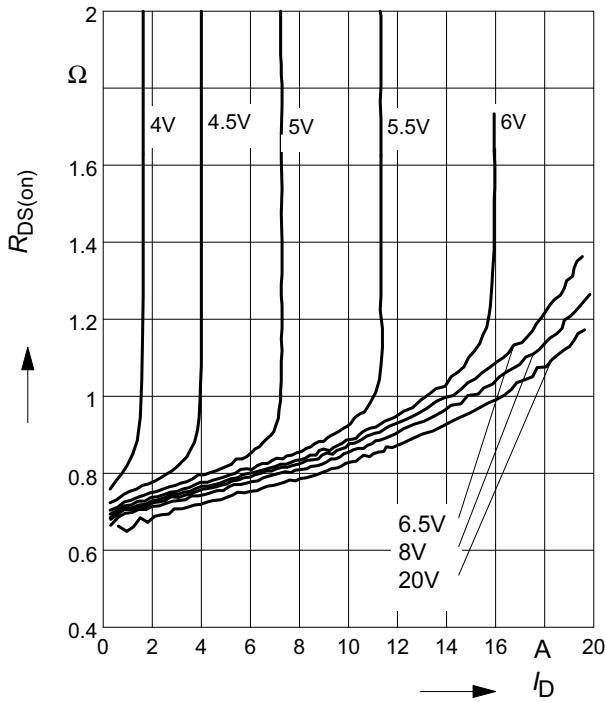
parameter:  $t_p = 10 \mu\text{s}, V_{GS}$



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

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

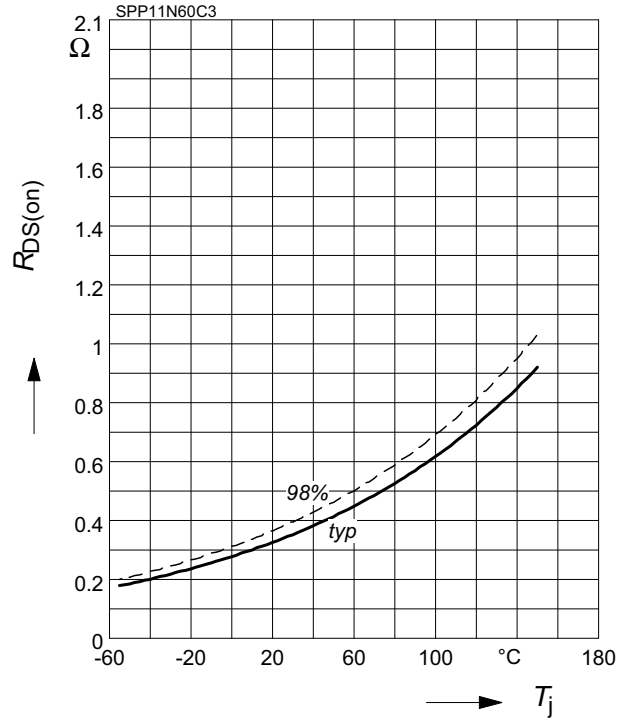
parameter:  $T_j = 150^\circ\text{C}$ ,  $V_{GS}$



**10 Drain-source on-state resistance**

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

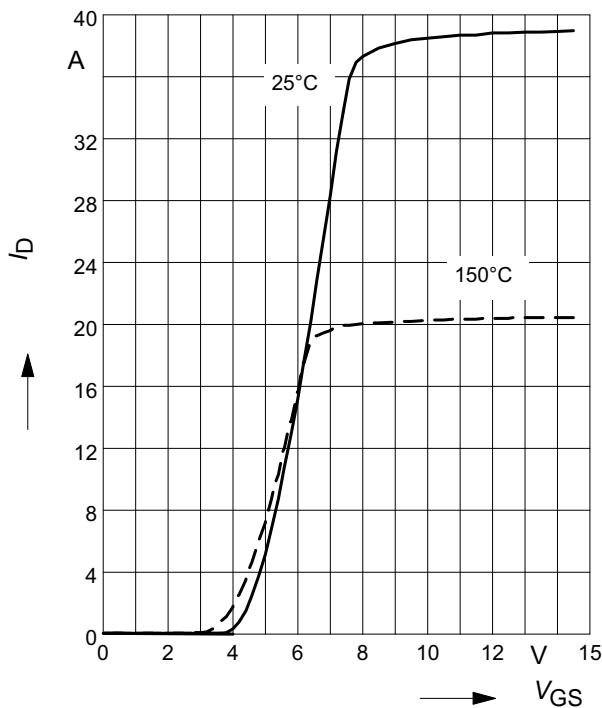
parameter:  $I_D = 7\text{ A}$ ,  $V_{GS} = 10\text{ V}$



**11 Typ. transfer characteristics**

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

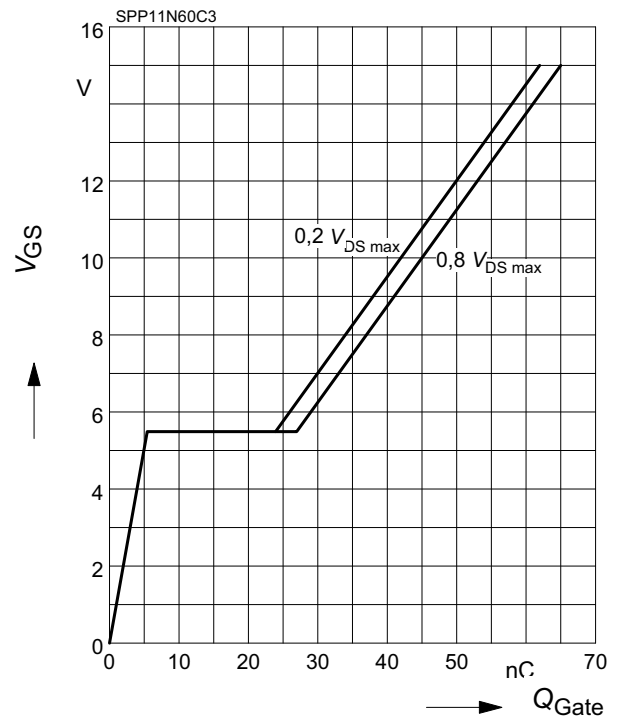
parameter:  $t_p = 10\ \mu\text{s}$



**12 Typ. gate charge**

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

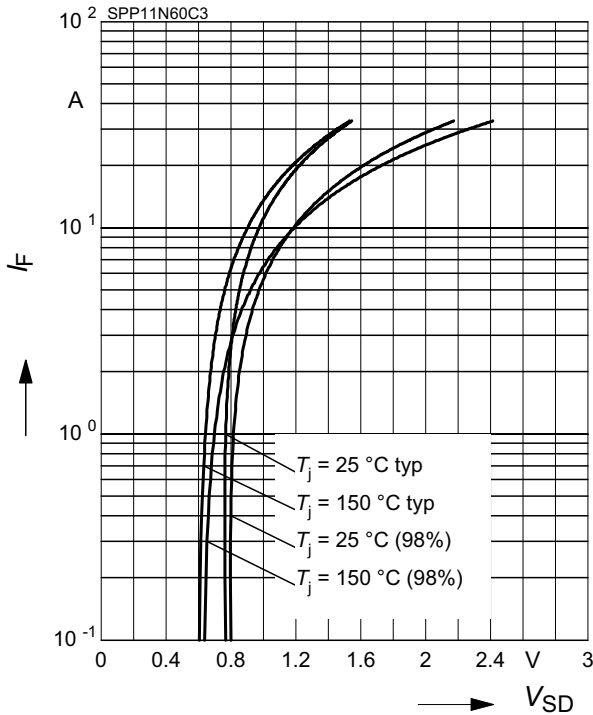
parameter:  $I_D = 11\text{ A pulsed}$



**13 Forward characteristics of body diode**

$I_F = f(V_{SD})$

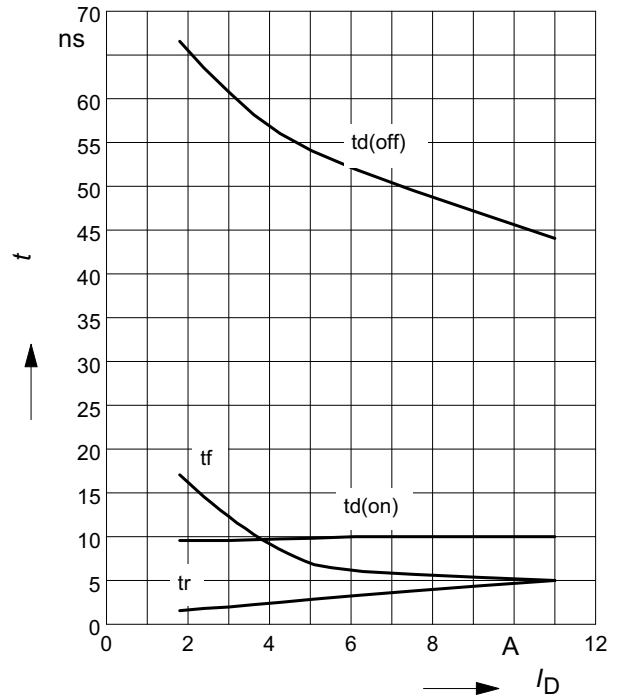
parameter:  $T_j$ ,  $t_p = 10 \mu s$



**14 Typ. switching time**

$t = f(I_D)$ , inductive load,  $T_j = 125^\circ C$

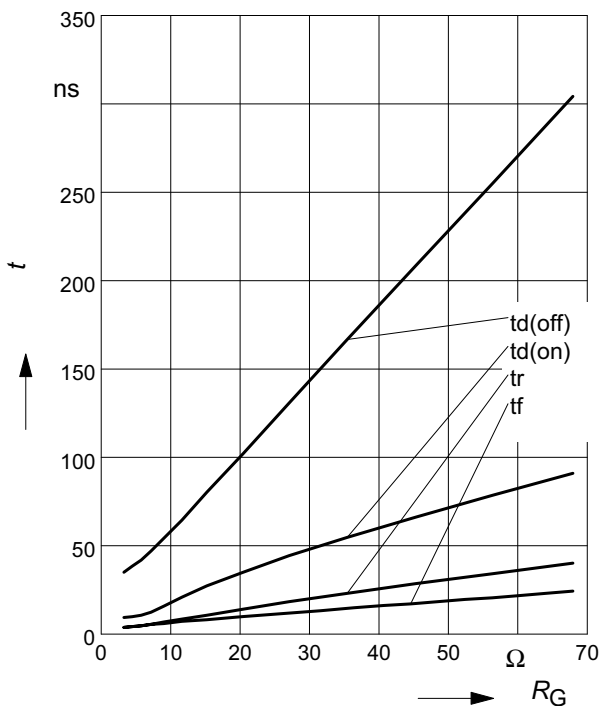
par.:  $V_{DS} = 380V$ ,  $V_{GS} = 0/+13V$ ,  $R_G = 6.8\Omega$



**15 Typ. switching time**

$t = f(R_G)$ , inductive load,  $T_j = 125^\circ C$

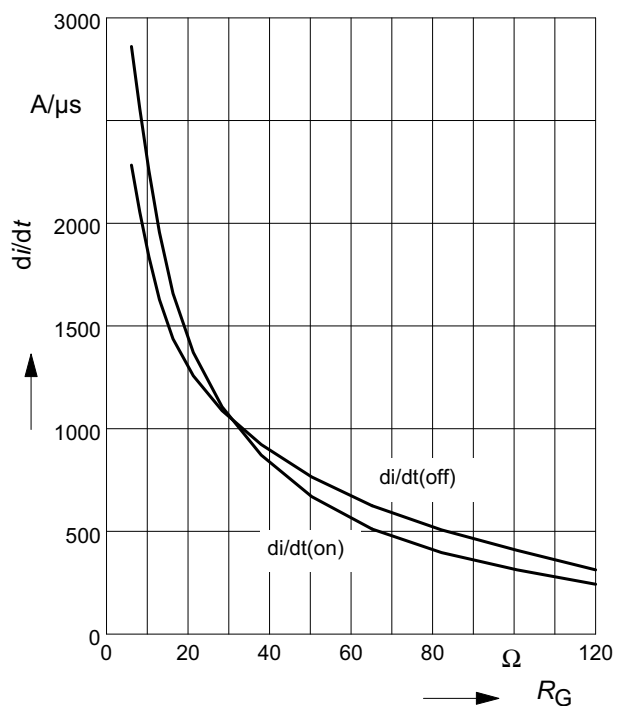
par.:  $V_{DS} = 380V$ ,  $V_{GS} = 0/+13V$ ,  $I_D = 11 A$



**16 Typ. drain current slope**

$di/dt = f(R_G)$ , inductive load,  $T_j = 125^\circ C$

par.:  $V_{DS} = 380V$ ,  $V_{GS} = 0/+13V$ ,  $I_D = 11A$

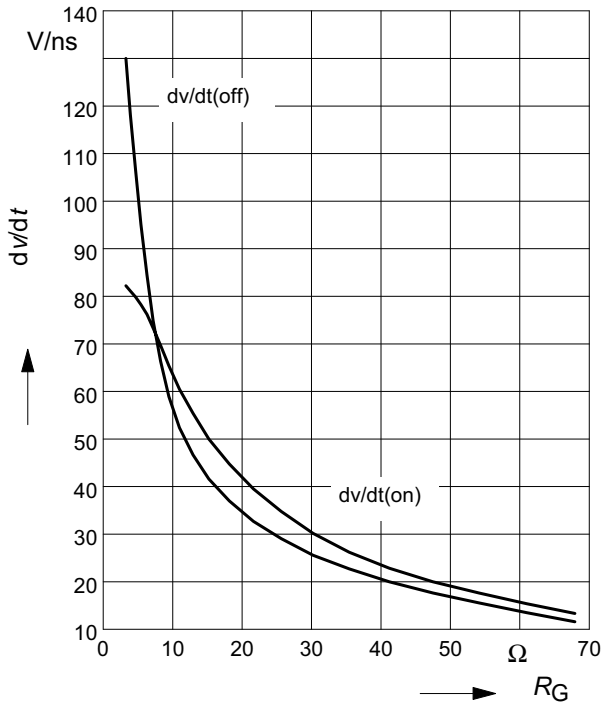




**17 Typ. drain source voltage slope**

$dv/dt = f(R_G)$ , inductive load,  $T_j = 125^\circ\text{C}$

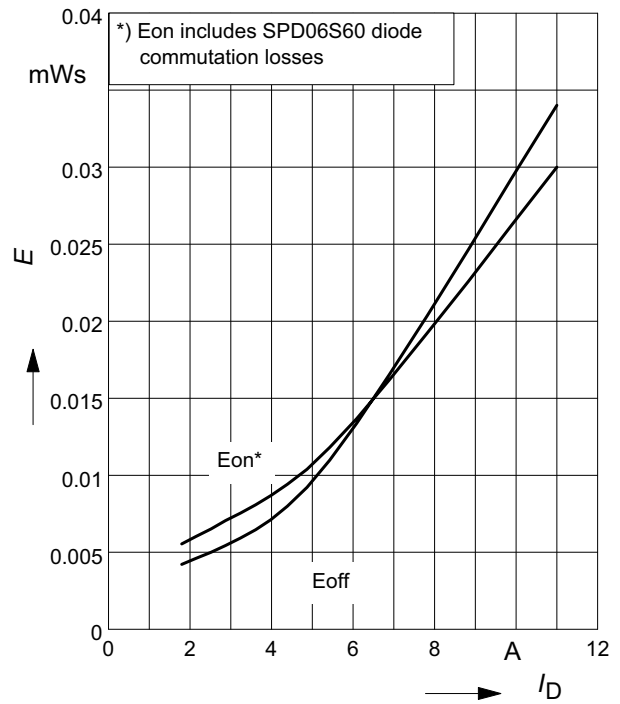
par.:  $V_{DS}=380\text{V}$ ,  $V_{GS}=0/+13\text{V}$ ,  $I_D=11\text{A}$



**18 Typ. switching losses**

$E = f(I_D)$ , inductive load,  $T_j=125^\circ\text{C}$

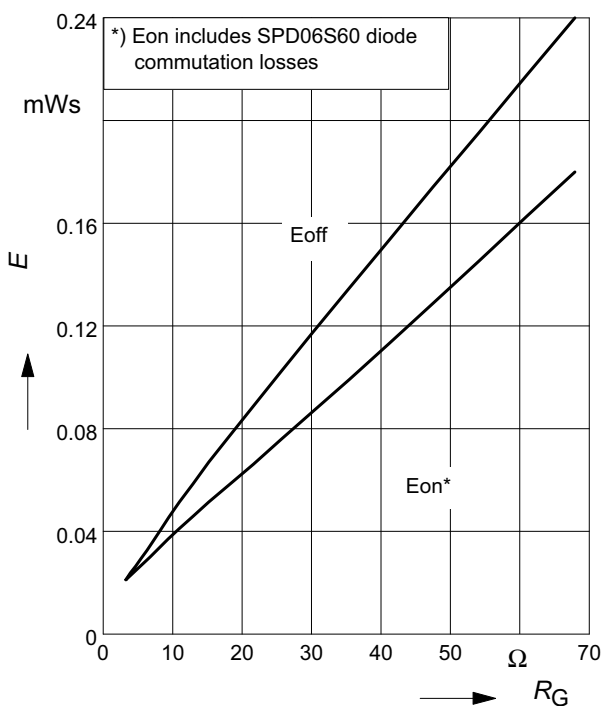
par.:  $V_{DS}=380\text{V}$ ,  $V_{GS}=0/+13\text{V}$ ,  $R_G=6.8\Omega$



**19 Typ. switching losses**

$E = f(R_G)$ , inductive load,  $T_j=125^\circ\text{C}$

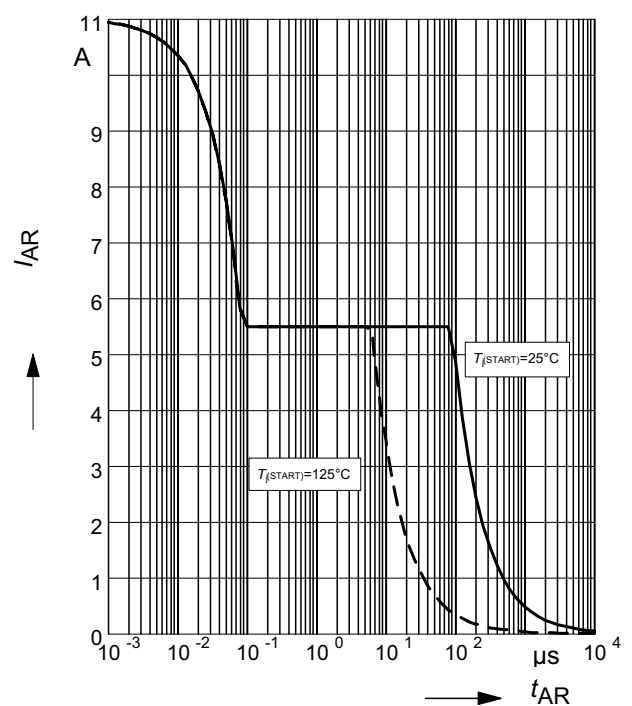
par.:  $V_{DS}=380\text{V}$ ,  $V_{GS}=0/+13\text{V}$ ,  $I_D=11\text{A}$



**20 Avalanche SOA**

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

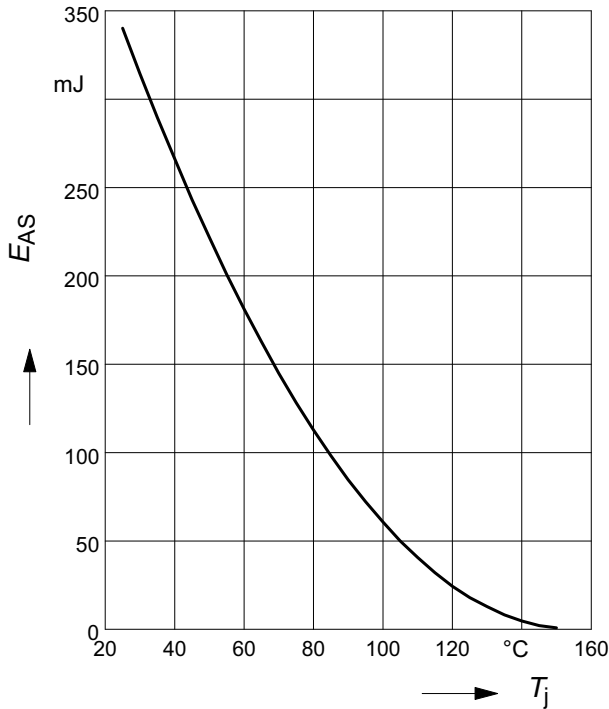
par.:  $T_j \leq 150^\circ\text{C}$



**21 Avalanche energy**

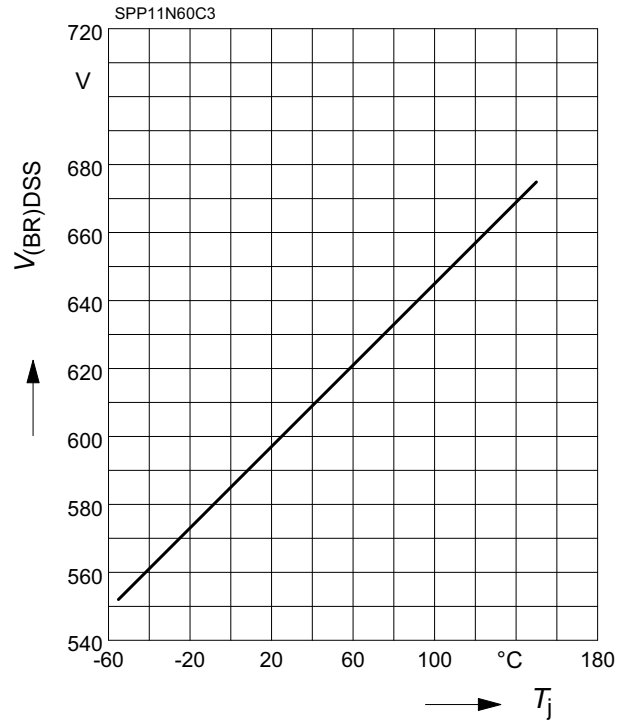
$$E_{AS} = f(T_j)$$

par.:  $I_D = 5.5 \text{ A}$ ,  $V_{DD} = 50 \text{ V}$



**22 Drain-source breakdown voltage**

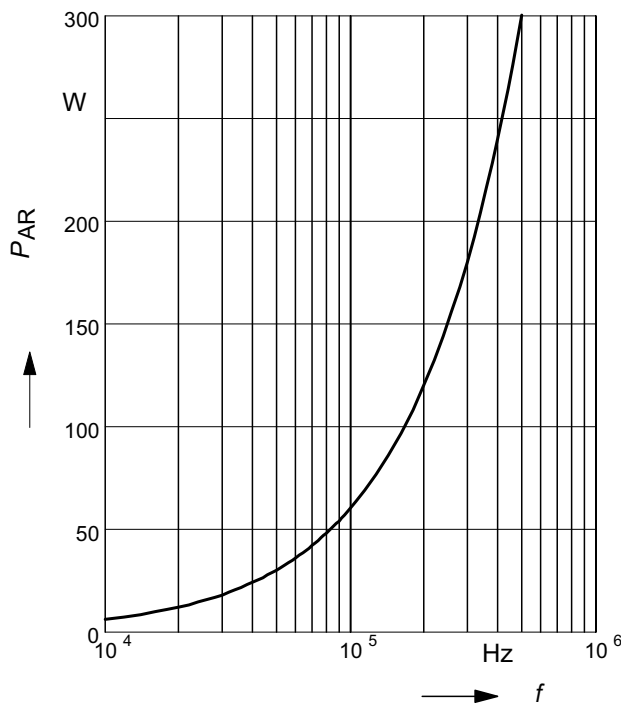
$$V_{(BR)DSS} = f(T_j)$$



**23 Avalanche power losses**

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

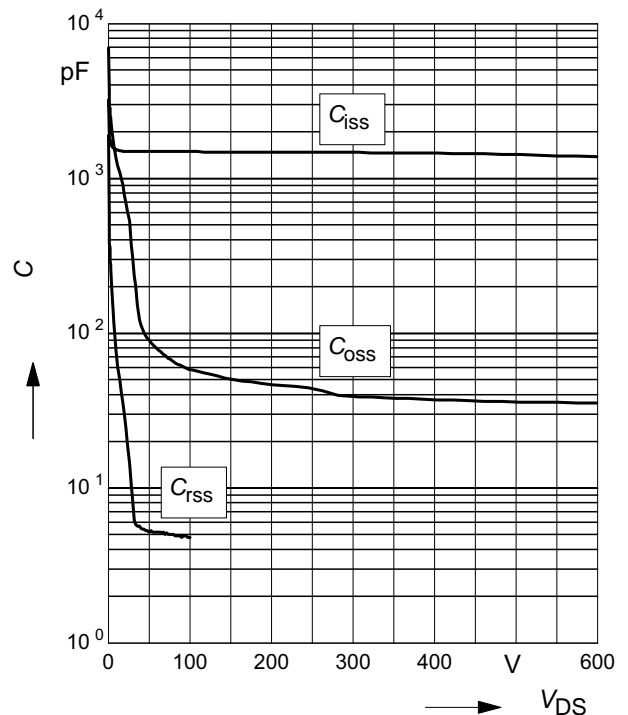
parameter:  $E_{AR} = 0.6 \text{ mJ}$



**24 Typ. capacitances**

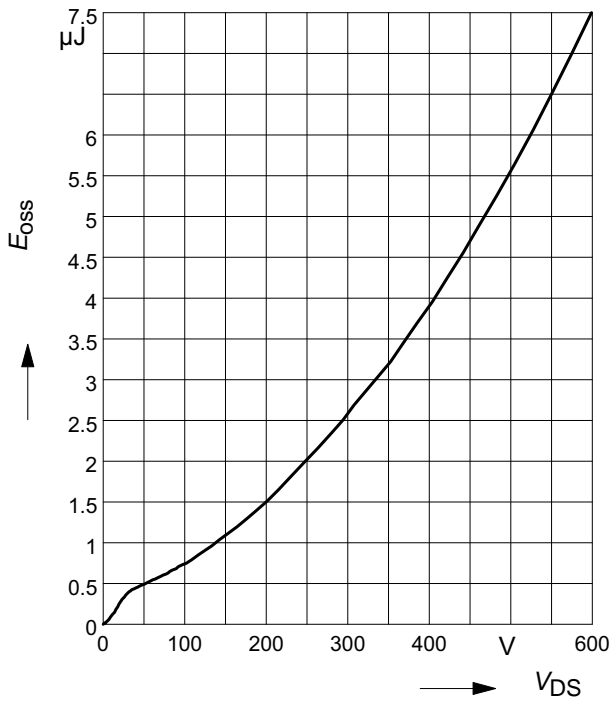
$$C = f(V_{DS})$$

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

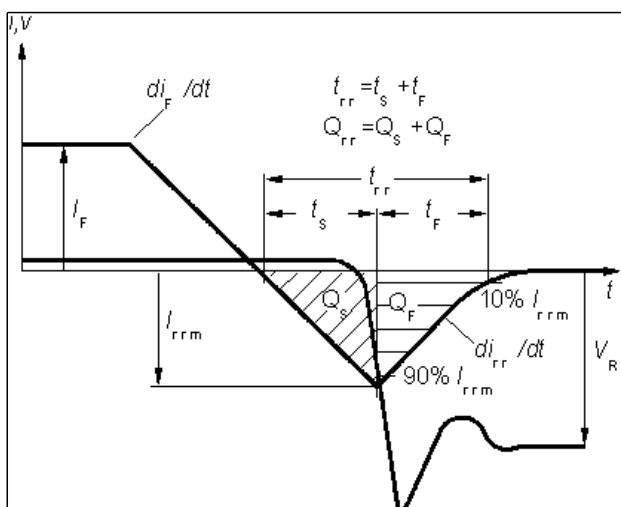


25 Typ.  $C_{OSS}$  stored energy

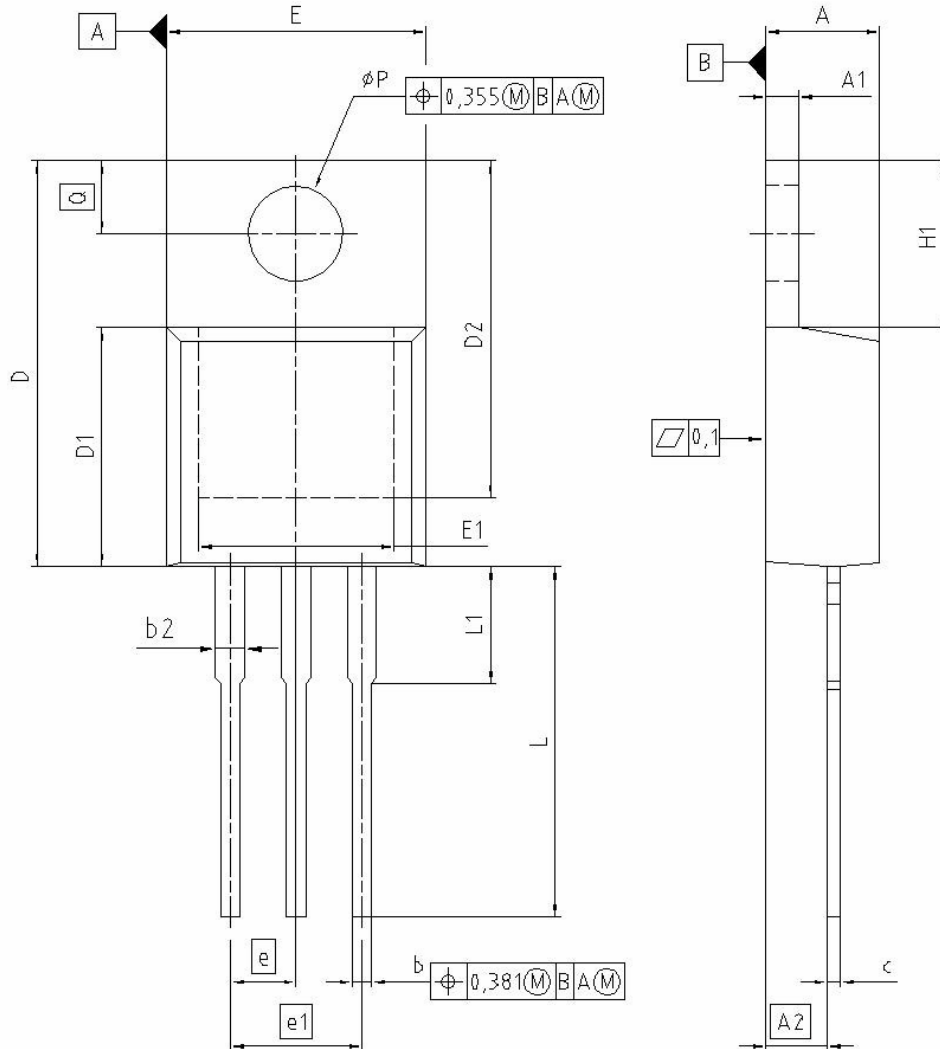
$$E_{OSS} = f(V_{DS})$$



Definition of diodes switching characteristics



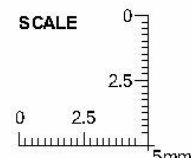
PG-TO220-3-1, PG-TO220-3-21 : Outline



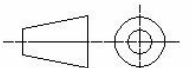
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.300	4.572	0.169	0.180
A1	1.170	1.400	0.046	0.055
A2	2.215	2.718	0.087	0.107
b	0.650	0.864	0.026	0.034
b2	0.635	1.778	0.025	0.070
c	0.330	0.600	0.013	0.024
D	14.808	15.950	0.583	0.628
D1	8.509	9.450	0.335	0.372
D2	12.850	13.100	0.506	0.516
E	9.700	10.363	0.382	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

**SCALE**



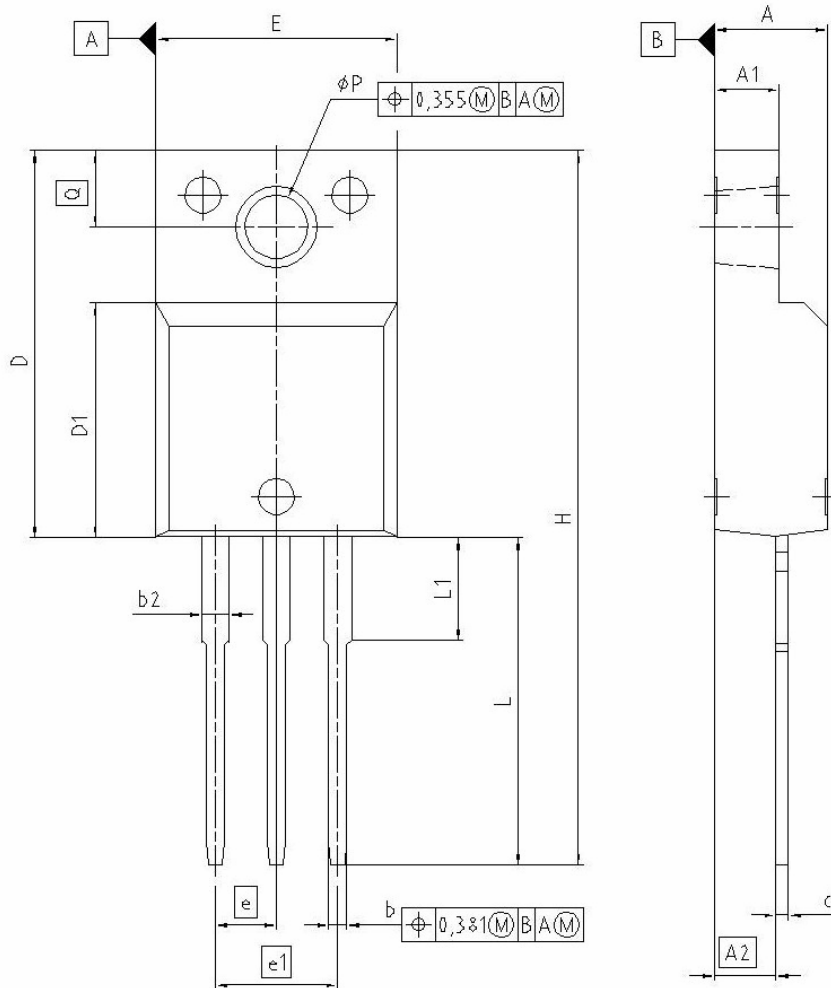
**EUROPEAN PROJECTION**



**ISSUE DATE**  
01-06-2005

**FILE**  
TO220\_1


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**  
 ...

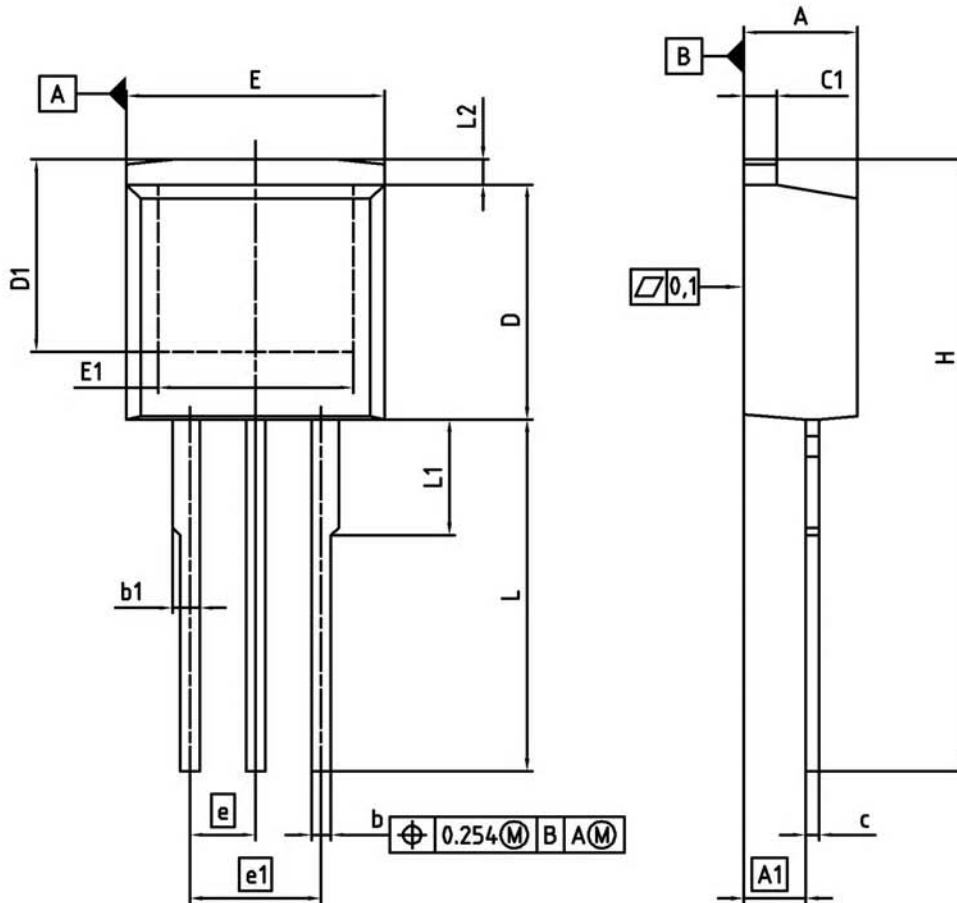
**SCALE**  
 0 2.5 5mm

**EUROPEAN PROJECTION**  


**ISSUE DATE**  
 17-08-2005

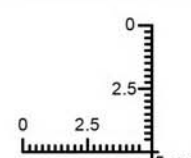
**FILE**  
 TO220\_2

PG-TO262-3-1/PG-TO262-3-21 (I<sup>2</sup>-PAK)




DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.300	4.572	0.169	0.180
A1	2.150	2.718	0.085	0.107
b	0.650	0.864	0.026	0.034
b1	0.635	1.400	0.025	0.055
c	0.330	0.600	0.013	0.024
c1	1.170	1.400	0.046	0.055
D	8.509	9.450	0.335	0.372
D1	6.900	-	0.272	-
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	
L	13.000	14.000	0.512	0.551
L1	-	4.800	-	0.189
L2	-	1.727	-	0.068

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