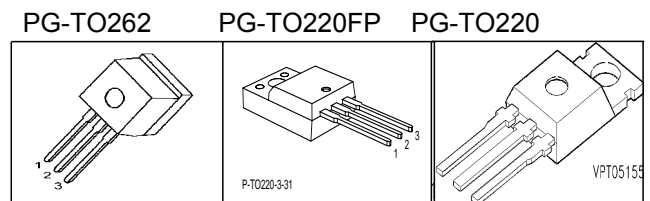


## Cool MOS™ Power Transistor

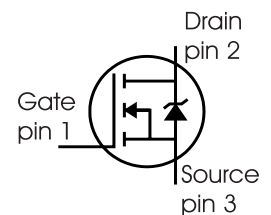
### Feature

- 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
- Improved transconductance
- Pb-free lead plating; RoHS compliant
- Qualified according to JEDEC<sup>0)</sup> for target applications

$V_{DS}$	650	V
$R_{DS(on)}$	0.19	$\Omega$
$I_D$	20.7	A



Type	Package	Ordering Code	Marking
SPP20N65C3	PG-TO220	Q67040-S4556	20N65C3
SPA20N65C3	PG-TO220FP	SP000216362	20N65C3
SPI20N65C3	PG-TO262	Q67040-S4560	20N65C3



### Maximum Ratings

Parameter	Symbol	Value		Unit
		SPP_I	SPA	
Continuous drain current $T_C = 25\text{ }^\circ\text{C}$ $T_C = 100\text{ }^\circ\text{C}$	$I_D$	20.7 13.1	20.7 <sup>1)</sup> 13.1 <sup>1)</sup>	A
Pulsed drain current, $t_p$ limited by $T_{jmax}$	$I_D$ puls	62.1	62.1	A
Avalanche energy, single pulse $I_D=3.5\text{A}$ , $V_{DD}=50\text{V}$	$E_{AS}$	690	690	mJ
Avalanche energy, repetitive $t_{AR}$ limited by $T_{jmax}$ <sup>2)</sup> $I_D=7\text{A}$ , $V_{DD}=50\text{V}$	$E_{AR}$	1	1	
Avalanche current, repetitive $t_{AR}$ limited by $T_{jmax}$	$I_{AR}$	7	7	A
Gate source voltage	$V_{GS}$	$\pm 20$	$\pm 20$	V
Gate source voltage AC ( $f > 1\text{Hz}$ )	$V_{GS}$	$\pm 30$	$\pm 30$	
Power dissipation, $T_C = 25\text{ }^\circ\text{C}$	$P_{tot}$	208	34.5	W
Operating and storage temperature	$T_j$ , $T_{stg}$	-55...+150		$^\circ\text{C}$

### Maximum Ratings

Parameter	Symbol	Value	Unit
Drain Source voltage slope $V_{DS} = 480\text{ V}$ , $I_D = 20.7\text{ A}$ , $T_j = 125\text{ °C}$	$dv/dt$	50	V/ns

### Thermal Characteristics

Parameter	Symbol	Values			Unit
		min.	typ.	max.	
Thermal resistance, junction - case	$R_{thJC}$	-	-	0.6	K/W
Thermal resistance, junction - case, FullPAK	$R_{thJC\text{ FP}}$	-	-	3.6	
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	$T_{sold}$	-	-	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	$V_{(BR)DSS}$	$V_{GS}=0\text{V}$ , $I_D=0.25\text{mA}$	650	-	-	V
Drain-Source avalanche breakdown voltage	$V_{(BR)DS}$	$V_{GS}=0\text{V}$ , $I_D=7\text{A}$	-	730	-	
Gate threshold voltage	$V_{GS(th)}$	$I_D=1000\mu\text{A}$ , $V_{GS}=V_{DS}$	2.1	3	3.9	
Zero gate voltage drain current	$I_{DSS}$	$V_{DS}=600\text{V}$ , $V_{GS}=0\text{V}$ , $T_j=25\text{ °C}$ $T_j=150\text{ °C}$	-	0.1	1	$\mu\text{A}$
Gate-source leakage current	$I_{GSS}$	$V_{GS}=20\text{V}$ , $V_{DS}=0\text{V}$	-	-	100	
Drain-source on-state resistance	$R_{DS(on)}$	$V_{GS}=10\text{V}$ , $I_D=13.1\text{A}$ $T_j=25\text{ °C}$ $T_j=150\text{ °C}$	-	0.16	0.19	$\Omega$
Gate input resistance	$R_G$	$f=1\text{MHz}$ , open drain	-	0.54	-	

**Electrical Characteristics**

Parameter	Symbol	Conditions	Values			Unit
			min.	typ.	max.	
Transconductance	$g_{fs}$	$V_{DS} \geq 2 \cdot I_D \cdot R_{DS(on)max}$ $I_D = 13.1A$	-	17.5	-	S
Input capacitance	$C_{iss}$	$V_{GS} = 0V, V_{DS} = 25V,$	-	2400	-	pF
Output capacitance	$C_{oss}$	$f = 1MHz$	-	780	-	
Reverse transfer capacitance	$C_{rss}$		-	50	-	
Effective output capacitance, <sup>4)</sup> energy related	$C_{o(er)}$	$V_{GS} = 0V,$ $V_{DS} = 0V \text{ to } 480V$	-	83	-	
Effective output capacitance, <sup>5)</sup> time related	$C_{o(tr)}$		-	160	-	
Turn-on delay time	$t_{d(on)}$	$V_{DD} = 380V, V_{GS} = 0/13V,$ $I_D = 20.7A,$ $R_G = 3.6\Omega, T_j = 125$	-	10	-	ns
Rise time	$t_r$	$V_{DD} = 380V, V_{GS} = 0/13V,$	-	5	-	
Turn-off delay time	$t_{d(off)}$	$I_D = 20.7A,$	-	67	100	
Fall time	$t_f$	$R_G = 3.6\Omega$	-	4.5	12	

**Gate Charge Characteristics**

Gate to source charge	$Q_{gs}$	$V_{DD} = 480V, I_D = 20.7A$	-	11	-	nC
Gate to drain charge	$Q_{gd}$		-	33	-	
Gate charge total	$Q_g$	$V_{DD} = 480V, I_D = 20.7A,$ $V_{GS} = 0 \text{ to } 10V$	-	87	114	
Gate plateau voltage	$V_{(plateau)}$	$V_{DD} = 480V, I_D = 20.7A$	-	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> $C_{o(er)}$  is a fixed capacitance that gives the same stored energy as  $C_{oss}$  while  $V_{DS}$  is rising from 0 to 80%  $V_{DSS}$ .

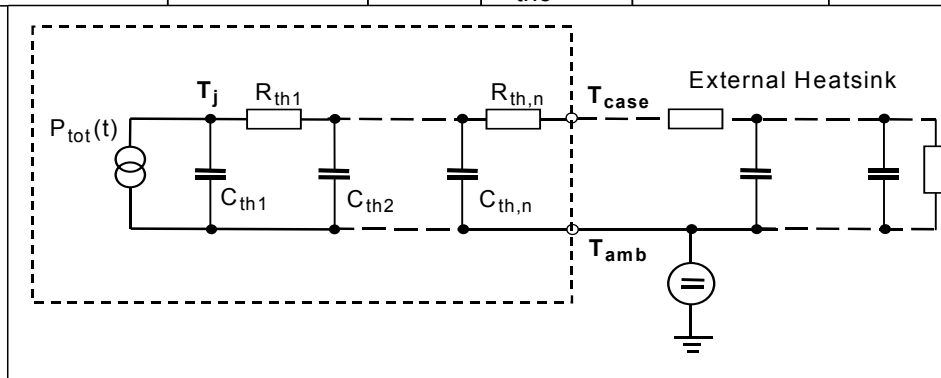
<sup>5</sup> $C_{o(tr)}$  is a fixed capacitance that gives the same charging time as  $C_{oss}$  while  $V_{DS}$  is rising from 0 to 80%  $V_{DSS}$ .

### Electrical Characteristics

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	$I_{SM}$		-	-	62.1	
Inverse diode forward voltage	$V_{SD}$	$V_{GS}=0\text{V}, I_F=I_S$	-	1	1.2	V
Reverse recovery time	$t_{rr}$	$V_R=480\text{V}, I_F=I_S,$	-	500	800	ns
Reverse recovery charge	$Q_{rr}$	$di_F/dt=100\text{A}/\mu\text{s}$	-	11	-	$\mu\text{C}$
Peak reverse recovery current	$I_{rrm}$		-	70	-	A
Peak rate of fall of reverse recovery current	$di_{rr}/dt$	$T_j=25^\circ\text{C}$	-	1400	-	$\text{A}/\mu\text{s}$

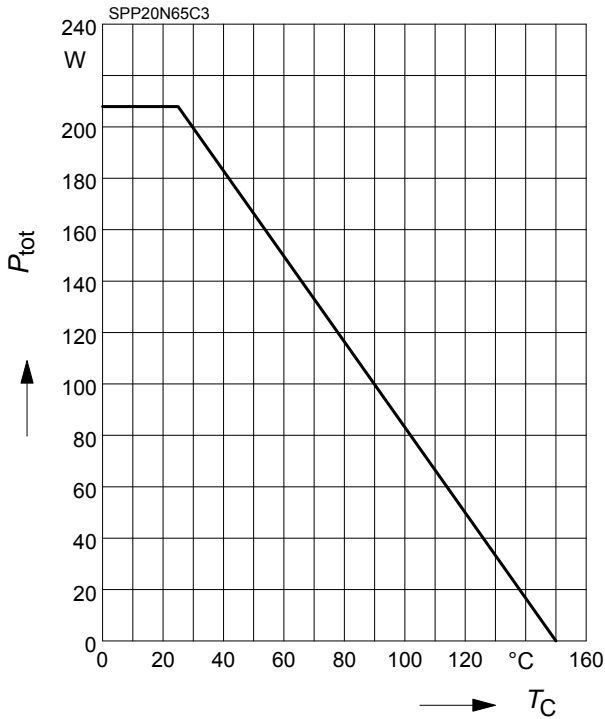
### Typical Transient Thermal Characteristics

Symbol	Value		Unit	Symbol	Value		Unit
	SPP_I	SPA			SPP_I	SPA	
$R_{th1}$	0.00769	0.00769	K/W	$C_{th1}$	0.0003763	0.0003763	Ws/K
$R_{th2}$	0.015	0.015		$C_{th2}$	0.001411	0.001411	
$R_{th3}$	0.029	0.029		$C_{th3}$	0.001931	0.001931	
$R_{th4}$	0.114	0.163		$C_{th4}$	0.005297	0.005297	
$R_{th5}$	0.136	0.323		$C_{th5}$	0.012	0.008453	
$R_{th6}$	0.059	2.526		$C_{th6}$	0.091	0.412	



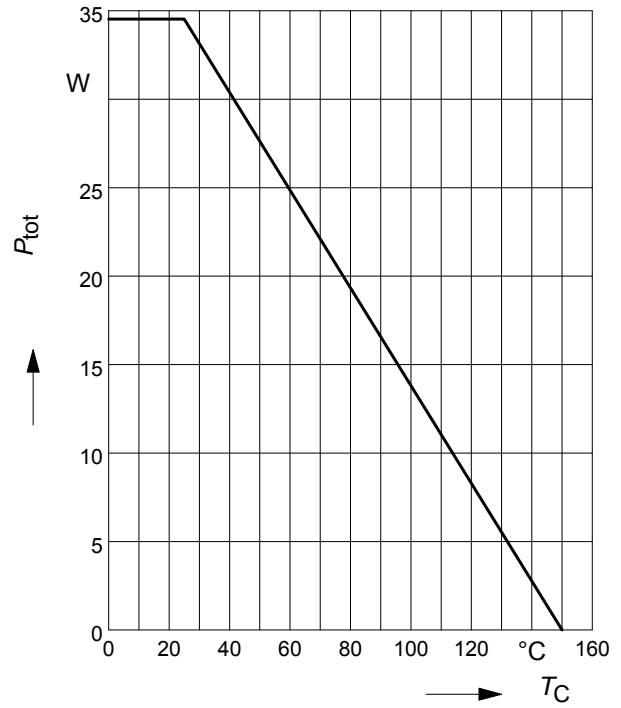
### 1 Power dissipation

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



### 2 Power dissipation FullPAK

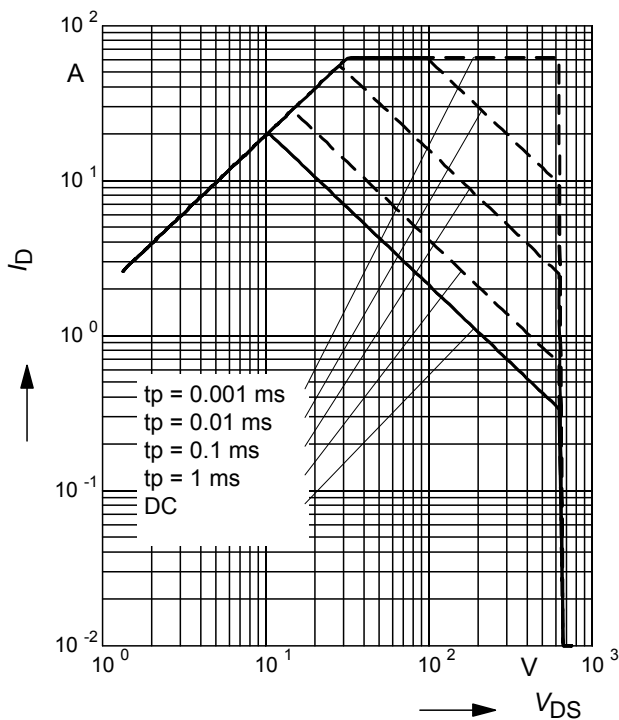
$$P_{tot} = f(T_C)$$



### 3 Safe operating area

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

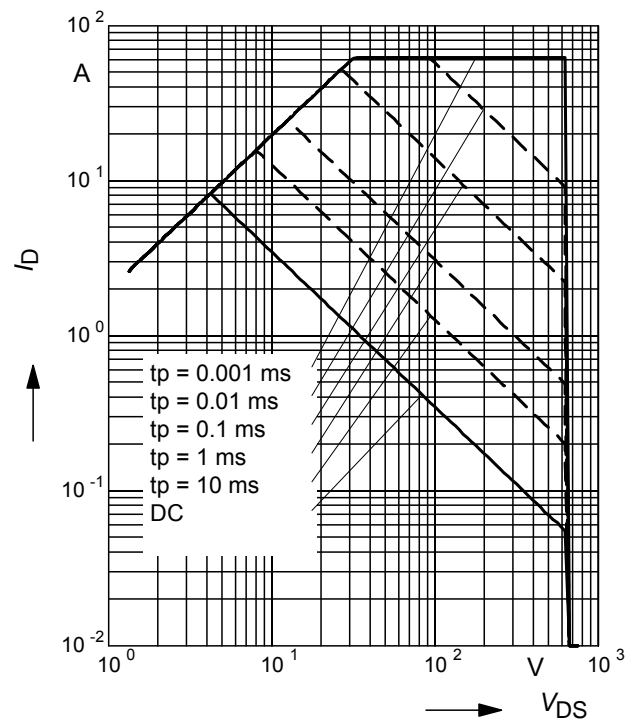
parameter :  $D = 0$  ,  $T_C = 25^\circ\text{C}$



### 4 Safe operating area FullPAK

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

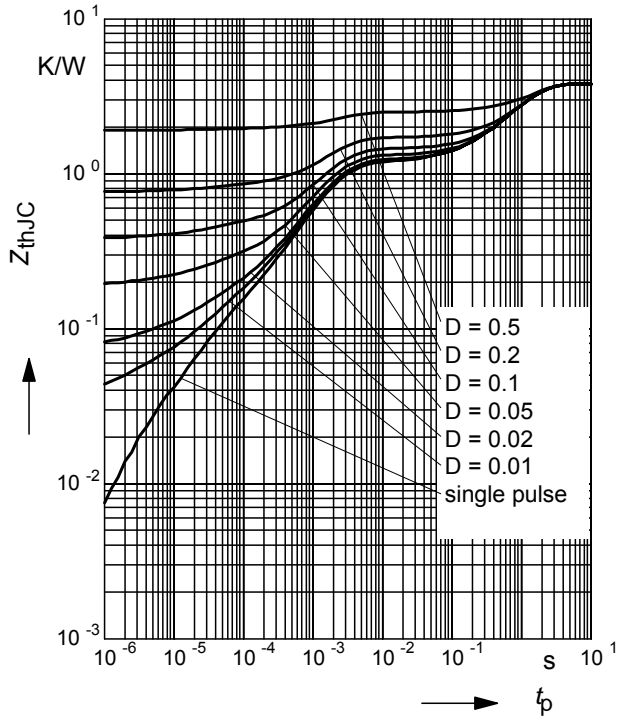
parameter:  $D = 0$  ,  $T_C = 25^\circ\text{C}$



**5 Transient thermal impedance FullPAK**

$Z_{thJC} = f(t_p)$

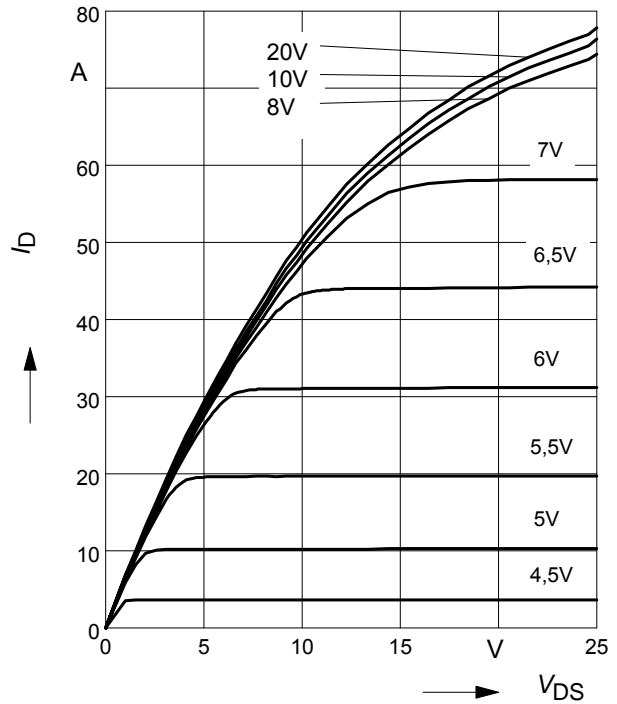
parameter:  $D = t_p/t$



**6 Typ. output characteristic**

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

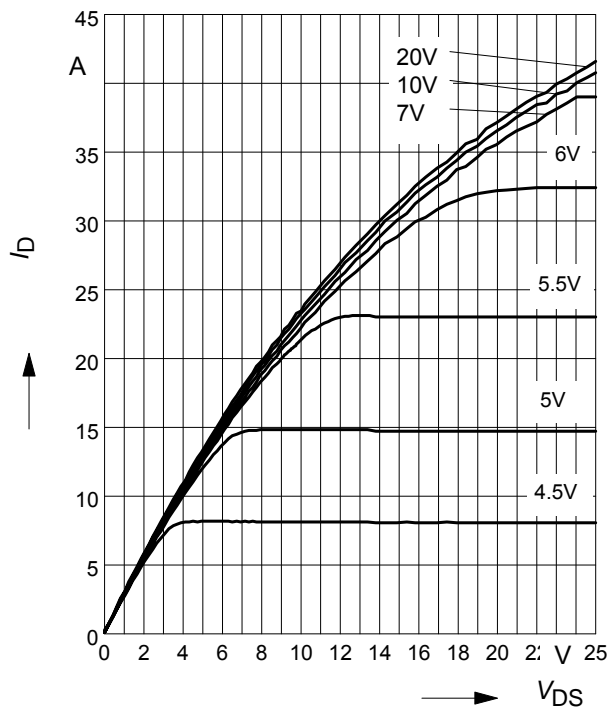
parameter:  $t_p = 10 \mu s, V_{GS}$



**7 Typ. output characteristic**

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

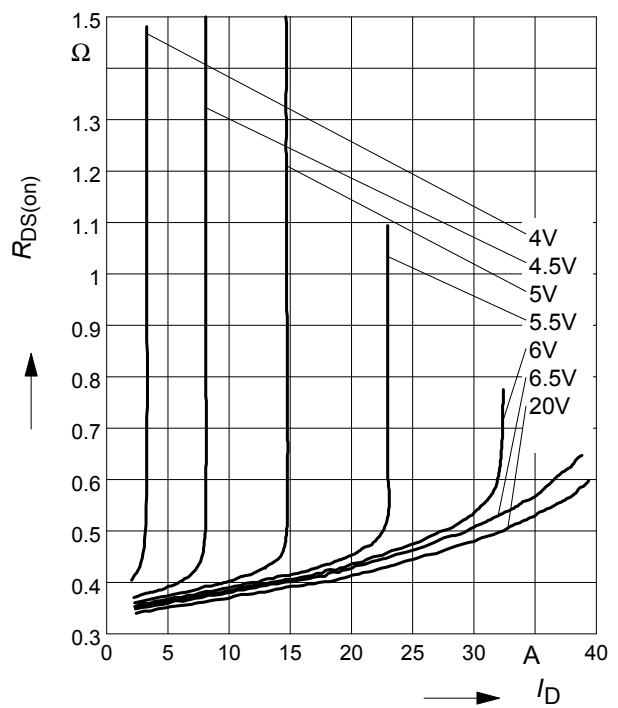
parameter:  $t_p = 10 \mu s, V_{GS}$



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

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

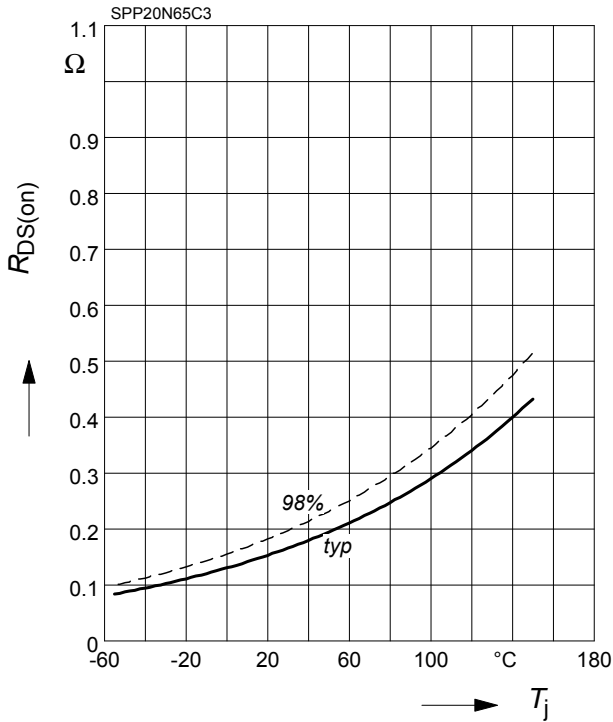
parameter:  $T_j=150^\circ C, V_{GS}$



### 9 Drain-source on-state resistance

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

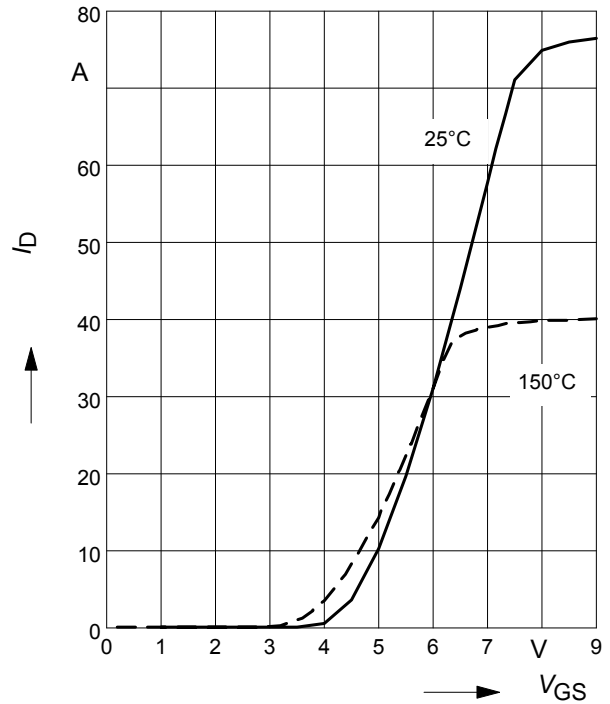
parameter:  $I_D = 13.1 \text{ A}$ ,  $V_{GS} = 10 \text{ V}$



### 10 Typ. transfer characteristics

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

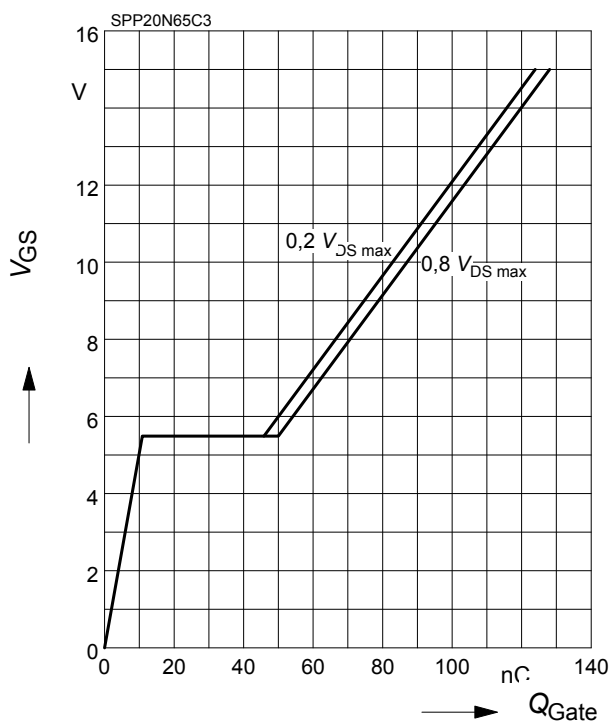
parameter:  $t_p = 10 \mu\text{s}$



### 11 Typ. gate charge

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

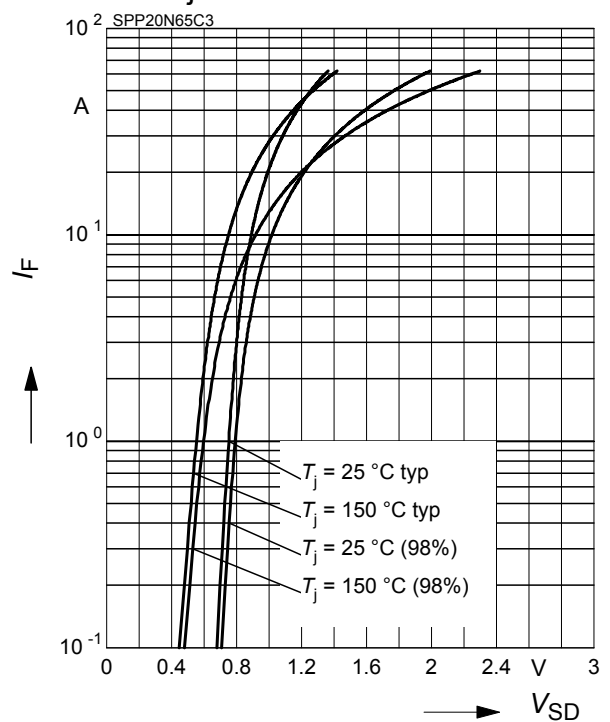
parameter:  $I_D = 20.7 \text{ A}$  pulsed



### 12 Forward characteristics of body diode

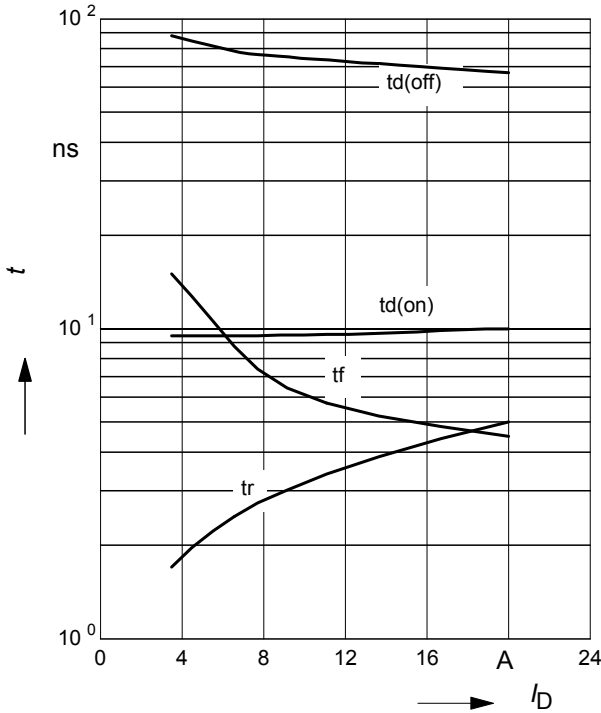
$$I_F = f(V_{SD})$$

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



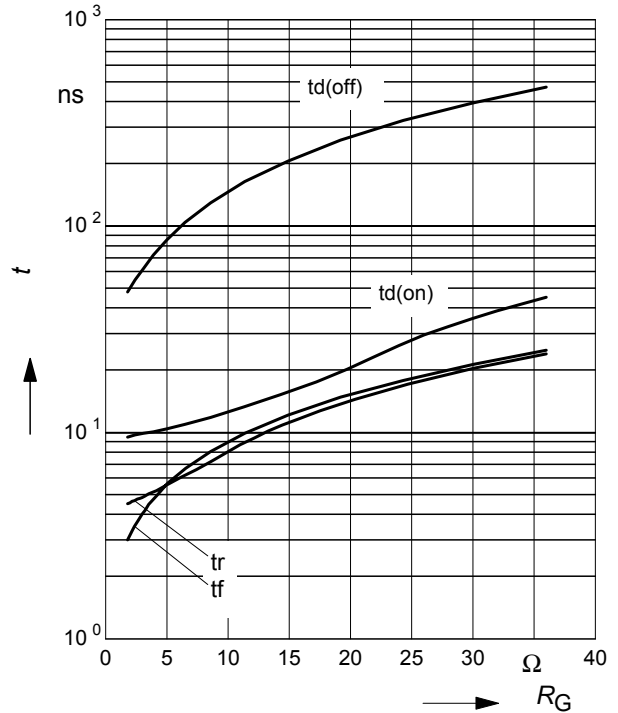
**13 Typ. switching time**

$t = f(I_D)$ , inductive load,  $T_j = 125^\circ\text{C}$   
par.:  $V_{DS} = 380\text{V}$ ,  $V_{GS} = 0/+13\text{V}$ ,  $R_G = 3.6\Omega$



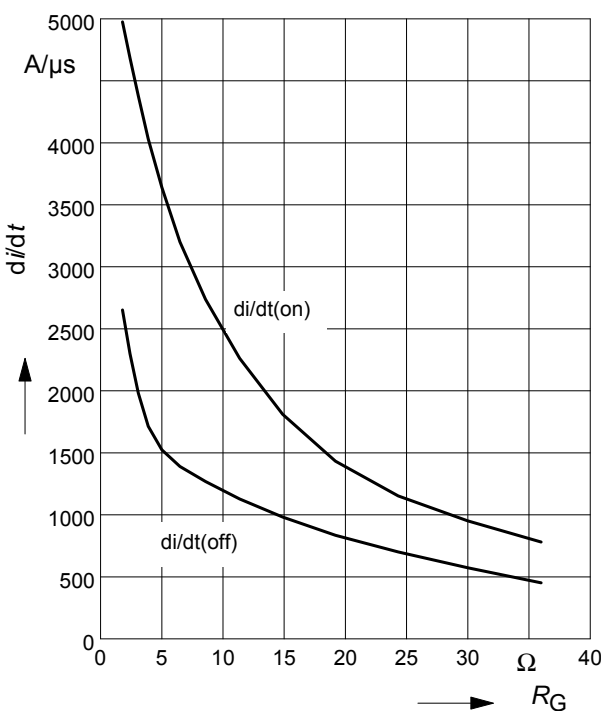
**14 Typ. switching time**

$t = f(R_G)$ , inductive load,  $T_j = 125^\circ\text{C}$   
par.:  $V_{DS} = 380\text{V}$ ,  $V_{GS} = 0/+13\text{V}$ ,  $I_D = 20.7\text{ A}$



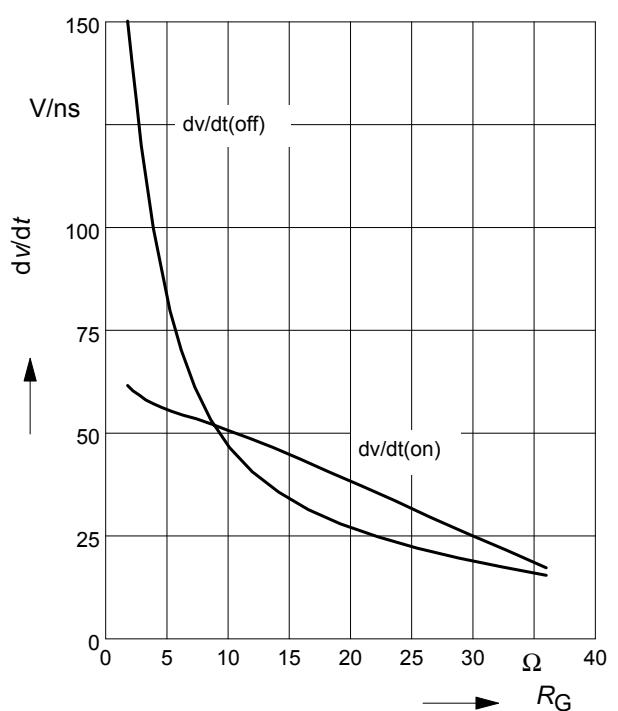
**15 Typ. drain current slope**

$di/dt = f(R_G)$ , inductive load,  $T_j = 125^\circ\text{C}$   
par.:  $V_{DS} = 380\text{V}$ ,  $V_{GS} = 0/+13\text{V}$ ,  $I_D = 20.7\text{A}$



**16 Typ. drain source voltage slope**

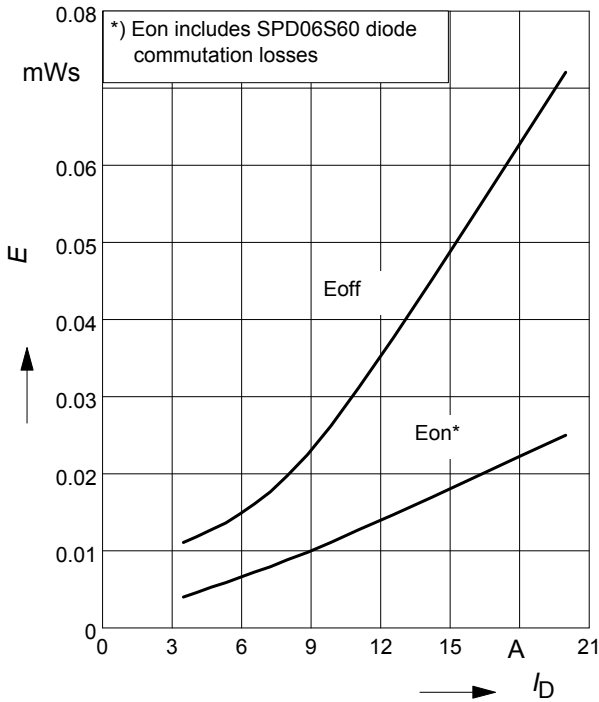
$dv/dt = f(R_G)$ , inductive load,  $T_j = 125^\circ\text{C}$   
par.:  $V_{DS} = 380\text{V}$ ,  $V_{GS} = 0/+13\text{V}$ ,  $I_D = 20.7\text{A}$





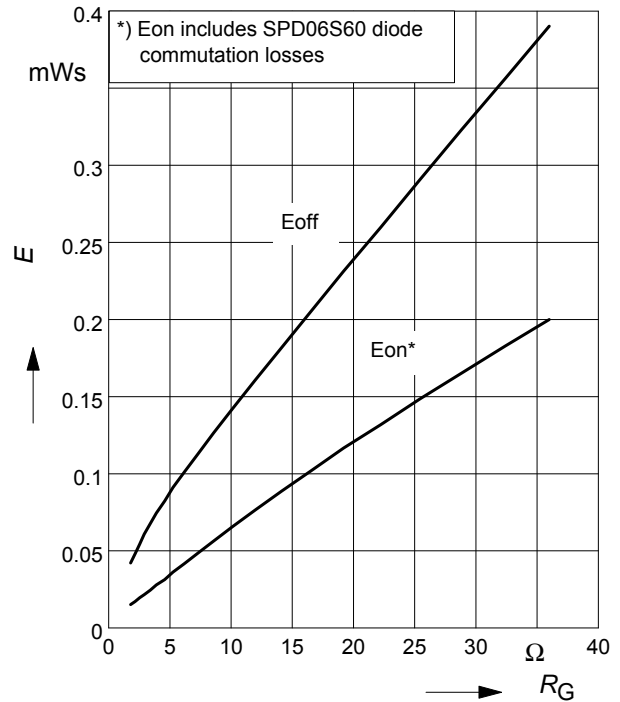
**17 Typ. switching losses**

$E = f(I_D)$ , inductive load,  $T_j=125^\circ\text{C}$   
par.:  $V_{DS}=380\text{V}$ ,  $V_{GS}=0/+13\text{V}$ ,  $R_G=3.6\Omega$



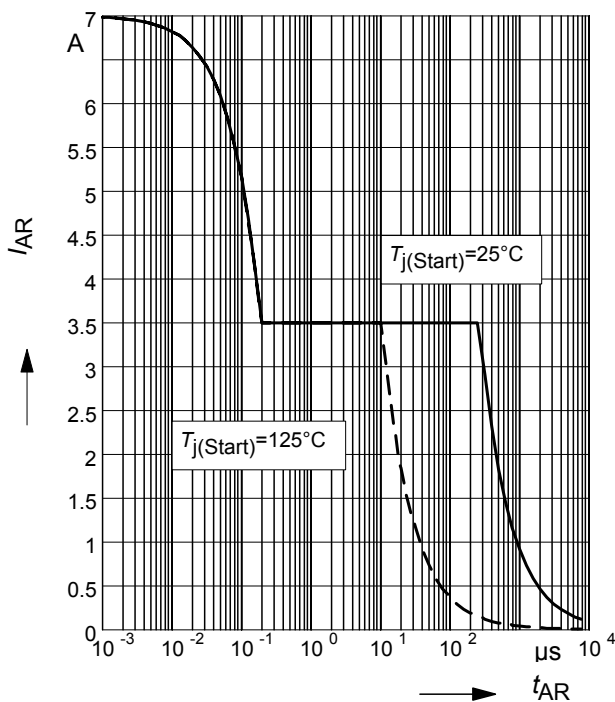
**18 Typ. switching losses**

$E = f(R_G)$ , inductive load,  $T_j=125^\circ\text{C}$   
par.:  $V_{DS}=380\text{V}$ ,  $V_{GS}=0/+13\text{V}$ ,  $I_D=11\text{A}$



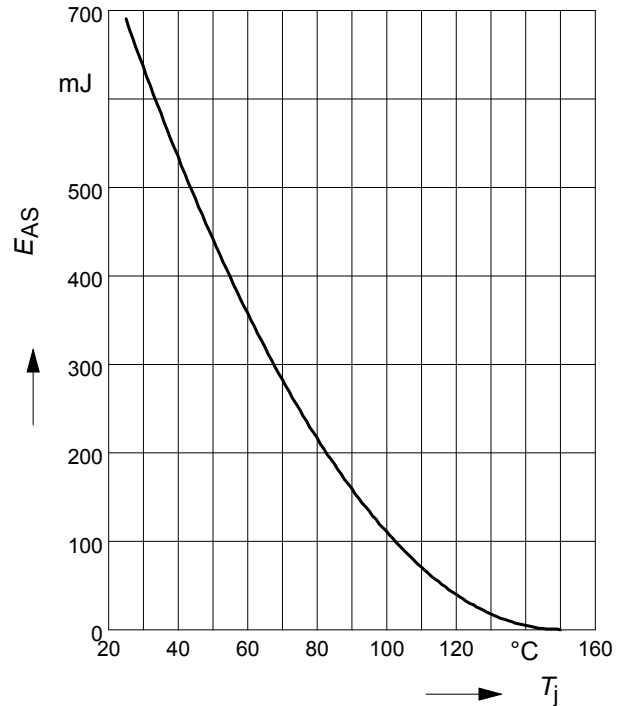
**19 Avalanche SOA**

$I_{AR} = f(t_{AR})$   
par.:  $T_j \leq 150^\circ\text{C}$



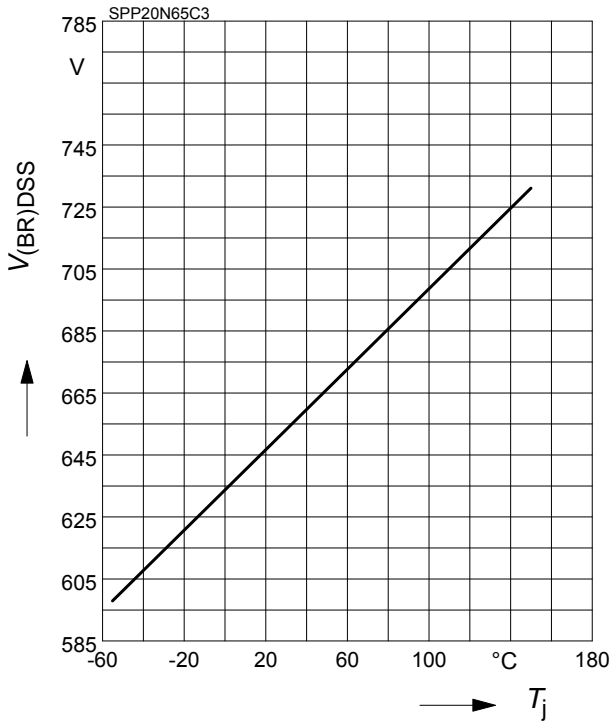
**20 Avalanche energy**

$E_{AS} = f(T_j)$   
par.:  $I_D = 3.5\text{A}$ ,  $V_{DD} = 50\text{V}$



### 21 Drain-source breakdown voltage

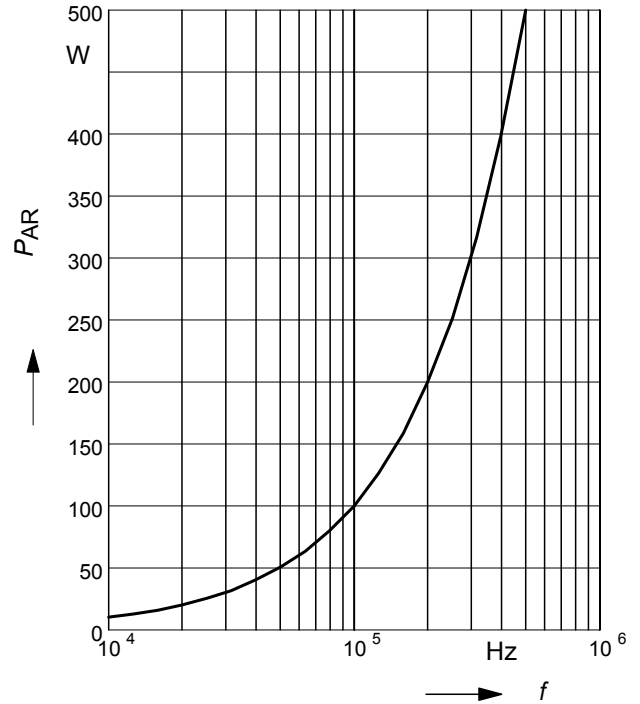
$$V_{(BR)DSS} = f(T_j)$$



### 22 Avalanche power losses

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

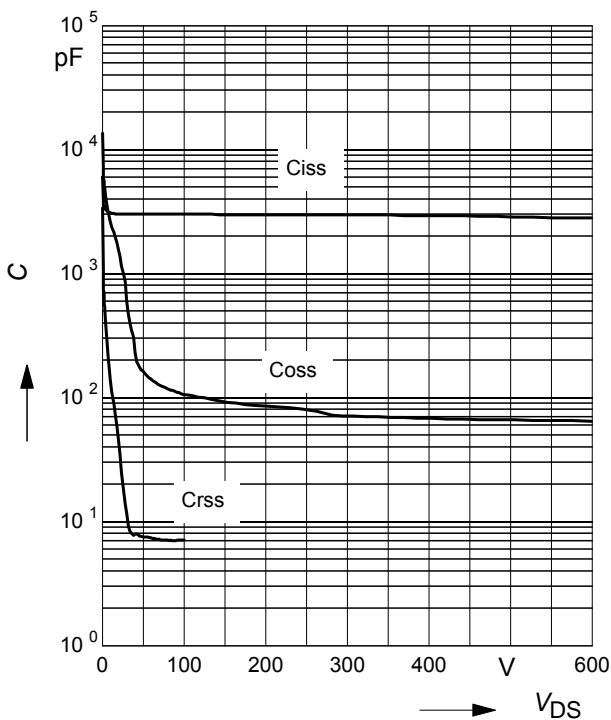
parameter:  $E_{AR}=1mJ$



### 23 Typ. capacitances

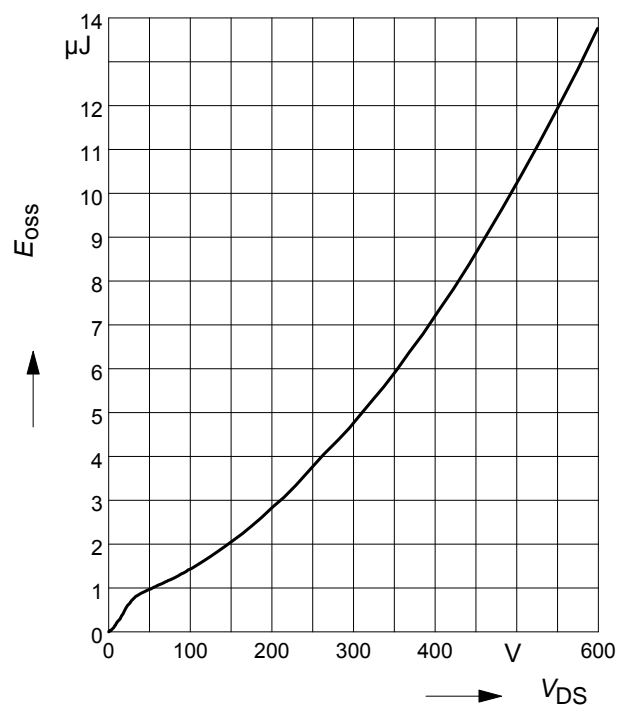
$$C = f(V_{DS})$$

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

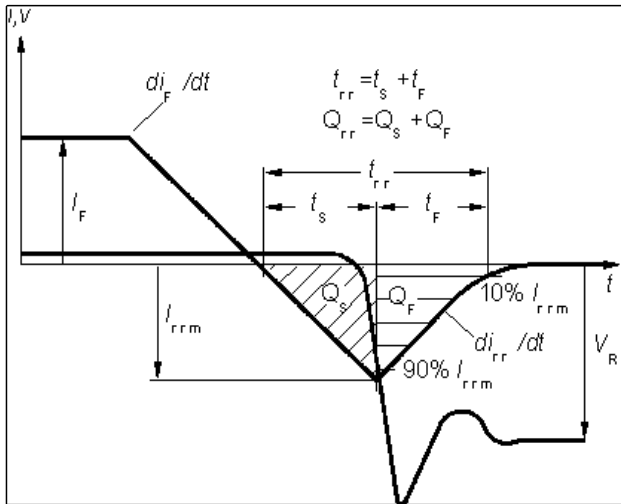


### 24 Typ. Coss stored energy

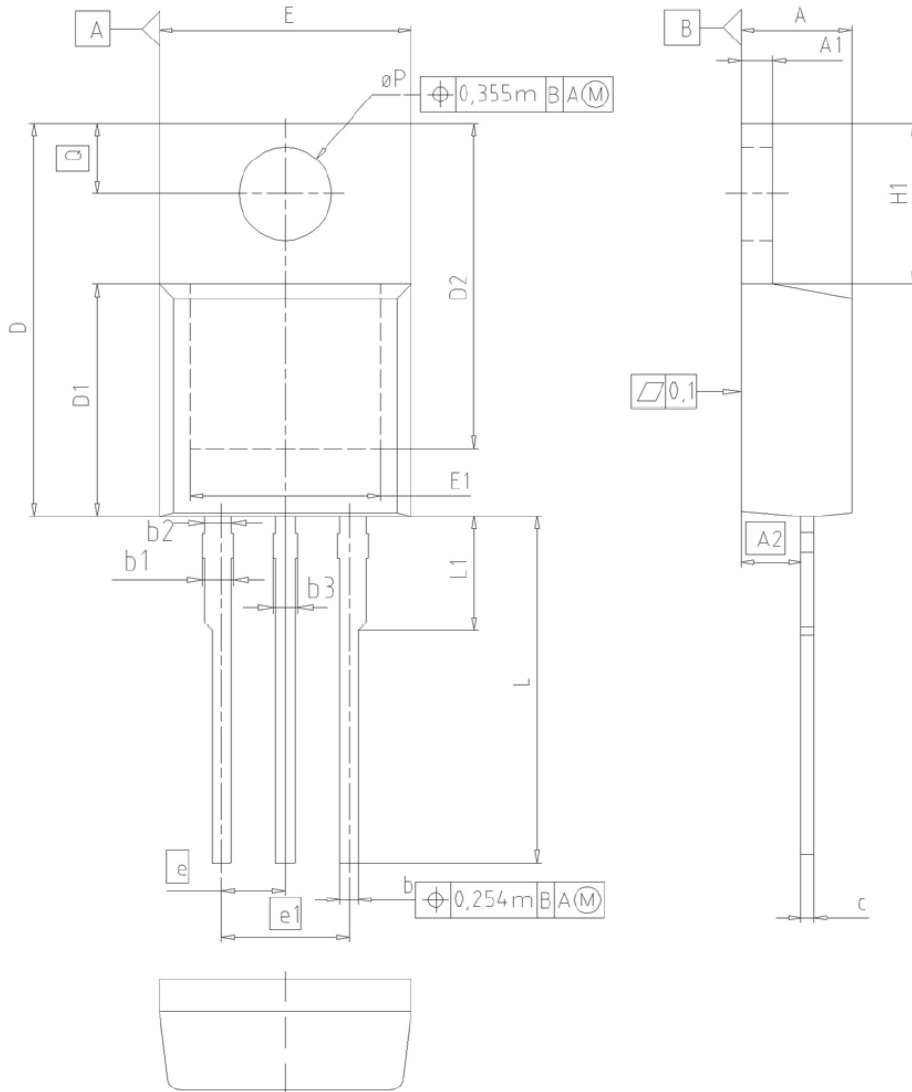
$$E_{Oss} = f(V_{DS})$$



Definition of diodes switching characteristics



PG-TO220-3-1, 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
øP	3.60	3.89	0.142	0.153
Q	2.60	3.00	0.102	0.118

**DOCUMENT NO.**  
Z8B00003318

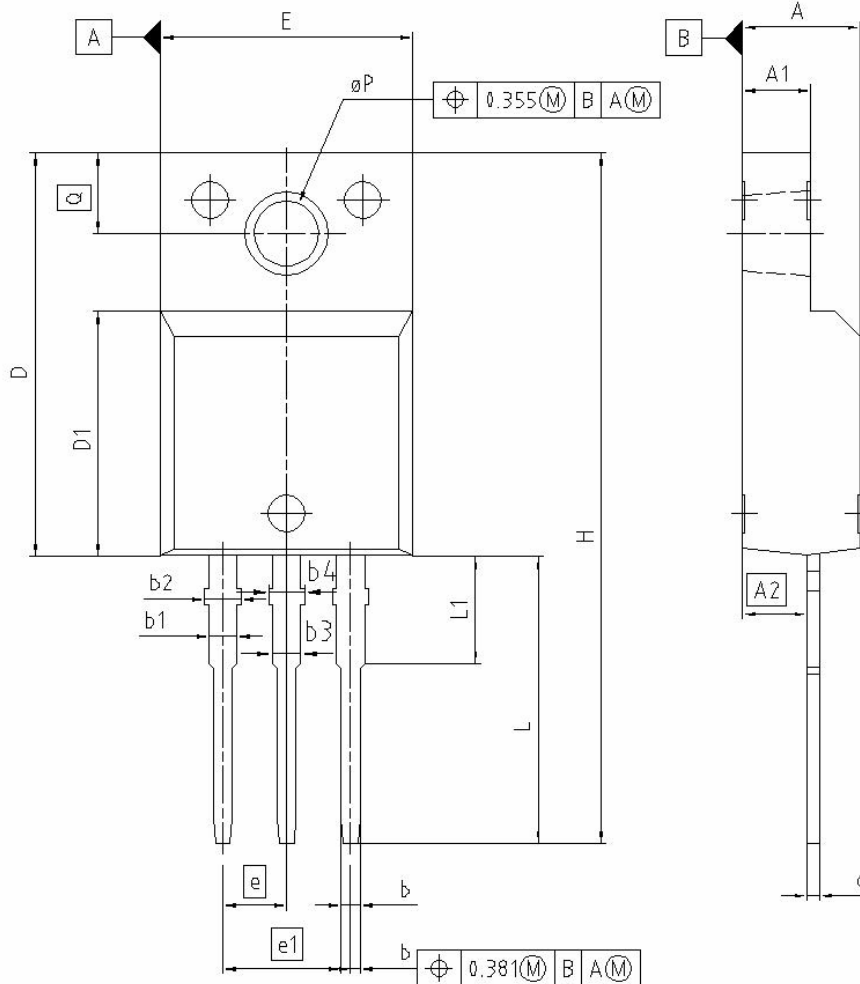
**SCALE**

**EUROPEAN PROJECTION**

**ISSUE DATE**  
23-08-2007

**REVISION**  
05

PG-TO220-3-31/3-111 Fully isolated package ( 2500 VAC; 1 minute )



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
øP	2.95	3.20	0.116	0.126
Q	3.15	3.50	0.124	0.138

REFERENCE  
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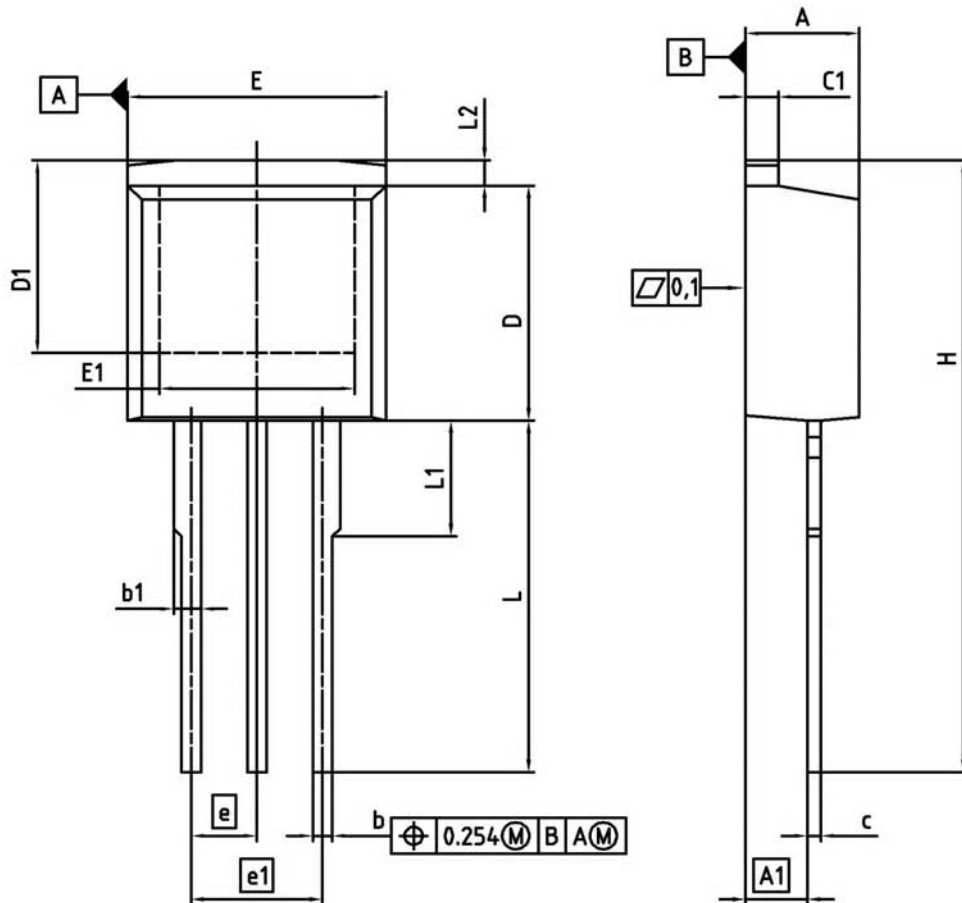
SCALE  
0 2.5 5mm

EUROPEAN PROJECTION

ISSUE DATE  
08-01-2007

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

REFERENCE  
JEDEC TO262

EUROPEAN PROJECTION

ISSUE DATE  
05-05-2006

FILE  
TO262\_1

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Infineon Technologies AG  
81726 Munich, Germany  
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