

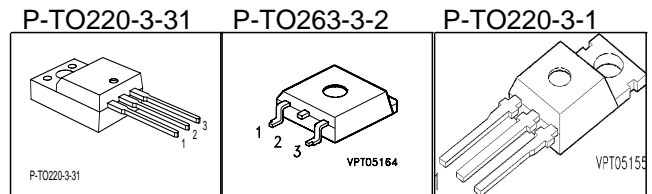
## Cool MOS™ Power Transistor

### Feature

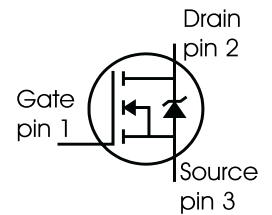
- New revolutionary high voltage technology
- Ultra low gate charge
- Periodic avalanche rated
- Extreme  $dv/dt$  rated
- Ultra low effective capacitances

### Product Summary

$V_{DS} @ T_{jmax}$	650	V
$R_{DS(on)}$	0.95	$\Omega$
$I_D$	4.5	A



Type	Package	Ordering Code	Marking
SPP04N60C2	P-TO220-3-1	Q67040-S4304	04N60C2
SPB04N60C2	P-TO263-3-2	Q67040-S4305	04N60C2
SPA04N60C2	P-TO220-3-31	Q67040-S4330	04N60C2



### Maximum Ratings

Parameter	Symbol	Value		Unit
		SPP_B	SPA	
Continuous drain current $T_C = 25\text{ }^\circ\text{C}$ $T_C = 100\text{ }^\circ\text{C}$	$I_D$	4.5 2.8	4.5 <sup>1)</sup> 2.8 <sup>1)</sup>	A
Pulsed drain current, $t_p$ limited by $T_{jmax}$	$I_{D\text{ puls}}$	9	9	A
Avalanche energy, single pulse $I_D=3.6\text{A}, V_{DD}=50\text{V}$	$E_{AS}$	130	130	mJ
Avalanche energy, repetitive $t_{AR}$ limited by $T_{jmax}$ <sup>2)</sup> $I_D=4.5\text{A}, V_{DD}=50\text{V}$	$E_{AR}$	0.4	0.4	
Avalanche current, repetitive $t_{AR}$ limited by $T_{jmax}$	$I_{AR}$	4.5	4.5	A
Reverse diode $dv/dt$ $I_S = 4.5\text{A}, V_{DS} < V_{DD}, di/dt=100\text{A}/\mu\text{s}, T_{jmax}=150\text{ }^\circ\text{C}$	$dv/dt$	6	6	V/ns
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, $T_C = 25\text{ }^\circ\text{C}$	$P_{tot}$	50	31	W
Operating and storage temperature	$T_j, T_{stg}$	-55...+150		$^\circ\text{C}$

**Thermal Characteristics**

Parameter	Symbol	Values			Unit
		min.	typ.	max.	
<b>Characteristics</b>					
Thermal resistance, junction - case	$R_{thJC}$	-	-	2.5	K/W
Thermal resistance, junction - case, FullPAK	$R_{thJC\_FP}$	-	-	4	
Thermal resistance, junction - ambient, leaded	$R_{thJA}$	-	-	62	
Thermal resistance, junction - ambient, FullPAK	$R_{thJA\_FP}$	-	-	80	
SMD version, device on PCB: @ min. footprint @ 6 cm <sup>2</sup> cooling area <sup>3)</sup>	$R_{thJA}$	-	-	62	
		-	35	-	
Linear derating factor		-	-	0.4	W/K
Linear derating factor, FullPAK		-	-	0.25	
Soldering temperature, 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**

**Static Characteristics**

Drain-source breakdown voltage $V_{GS}=0V, I_D=0.25mA$	$V_{(BR)DSS}$	600	-	-	V
Drain-source avalanche breakdown voltage $V_{GS}=0V, I_D=4.5A$	$V_{(BR)DS}$	-	700	-	
Gate threshold voltage, $V_{GS} = V_{DS}$ $I_D=200\mu A, T_j=25\text{ °C}$	$V_{GS(th)}$	3.5	4.5	5.5	
Zero gate voltage drain current $V_{DS} = 600\text{ V}, V_{GS} = 0\text{ V}, T_j = 25\text{ °C}$ $V_{DS} = 600\text{ V}, V_{GS} = 0\text{ V}, T_j = 150\text{ °C}$	$I_{DSS}$	-	0.5	1	$\mu A$
		-	-	50	
Gate-source leakage current $V_{GS}=20V, V_{DS}=0V$	$I_{GSS}$	-	-	100	nA
Drain-source on-state resistance $V_{GS}=10V, I_D=2.8A, T_j=25\text{ °C}$	$R_{DS(on)}$	-	0.85	0.95	$\Omega$
Gate input resistance $f = 1\text{ MHz}, \text{open drain}$	$R_G$	-	0.95	-	

**Electrical Characteristics**

Parameter	Symbol	Conditions	Values			Unit
			min.	typ.	max.	

**Characteristics**

Transconductance	$g_{fs}$	$V_{DS} \geq 2 \cdot I_D \cdot R_{DS(on)max}$ , $I_D = 2.8A$	-	2.5		S
Input capacitance	$C_{iss}$	$V_{GS} = 0V$ , $V_{DS} = 25V$ ,	-	580	-	pF
Output capacitance	$C_{oss}$	$f = 1MHz$	-	220	-	
Reverse transfer capacitance	$C_{rss}$		-	7	-	
Effective output capacitance, <sup>4)</sup> energy related	$C_{o(er)}$	$V_{GS} = 0V$ , $V_{DS} = 0V$ to 480V	-	20	-	
Effective output capacitance, <sup>5)</sup> time related	$C_{o(tr)}$		-	35	-	
Turn-on delay time	$t_{d(on)}$	$V_{DD} = 380V$ , $V_{GS} = 0/13V$ ,	-	10	-	ns
Rise time	$t_r$	$I_D = 4.5A$ ,	-	31	-	
Turn-off delay time	$t_{d(off)}$	$R_G = 18\Omega$ , $T_j = 125^\circ C$	-	44	66	
Fall time	$t_f$		-	12.5	18.8	

**Gate Charge Characteristics**

Gate to source charge	$Q_{gs}$	$V_{DD} = 350V$ , $I_D = 4.5A$	-	4.5	-	nC
Gate to drain charge	$Q_{gd}$		-	11	-	
Gate charge total	$Q_g$	$V_{DD} = 350V$ , $I_D = 4.5A$ , $V_{GS} = 0$ to 10V	-	17.6	22.9	
Gate plateau voltage	$V_{(plateau)}$	$V_{DD} = 350V$ , $I_D = 4.5A$	-	8	-	V

<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%  $V_{DSS}$ .

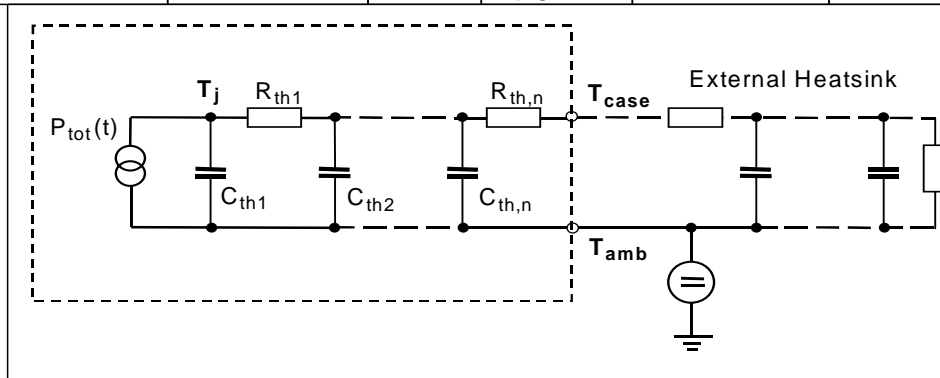
<sup>5</sup> $C_{o(tr)}$  is a fixed capacitance that gives the same charging time as  $C_{oss}$  while  $V_{DS}$  is rising from 0 to 80%  $V_{DSS}$ .

**Electrical Characteristics**

Parameter	Symbol	Conditions	Values			Unit
			min.	typ.	max.	
<b>Characteristics</b>						
Inverse diode continuous forward current	$I_S$	$T_C=25^\circ\text{C}$	-	-	4.5	A
Inverse diode direct current, pulsed	$I_{SM}$		-	-	9	
Inverse diode forward voltage	$V_{SD}$	$V_{GS}=0\text{V}, I_F=I_S$	-	1	1.2	V
Reverse recovery time	$t_{rr}$	$V_R=350\text{V}, I_F=I_S,$	-	900	1530	ns
Reverse recovery charge	$Q_{rr}$	$di_{rr}/dt=100\text{A}/\mu\text{s}$	-	3.2	-	$\mu\text{C}$
Peak reverse recovery current	$I_{rrm}$		-	12	-	A
Peak rate of fall of reverse recovery current	$di_{rr}/dt$	$T_j=25^\circ\text{C}$	-	440	-	$\text{A}/\mu\text{s}$

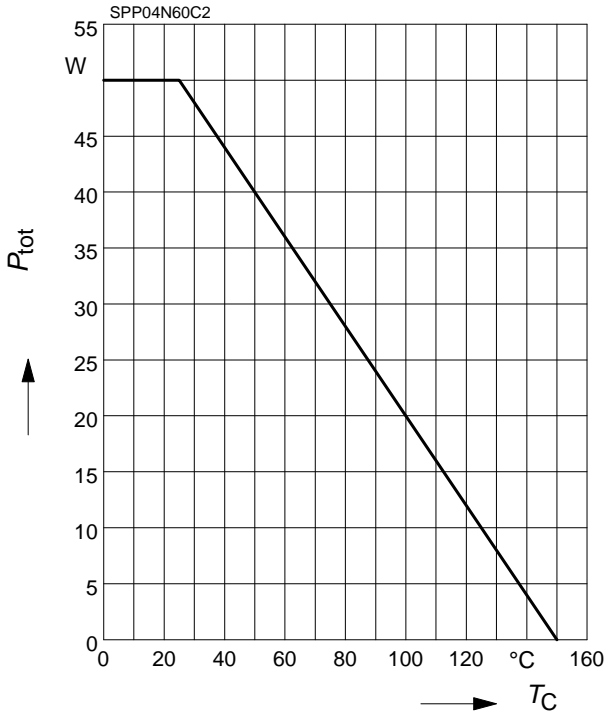
**Typical Transient Thermal Characteristics**

Symbol	Value		Unit	Symbol	Value		Unit
	SPP_B	SPA			SPP_B	SPA	
$R_{th1}$	0.039	0.039	K/W	$C_{th1}$	0.00008293	0.0000734	Ws/K
$R_{th2}$	0.083	0.075		$C_{th2}$	0.000282	0.000282	
$R_{th3}$	0.101	0.102		$C_{th3}$	0.0004859	0.000401	
$R_{th4}$	0.262	0.27		$C_{th4}$	0.0006523	0.000736	
$R_{th5}$	0.294	0.594		$C_{th5}$	0.005017	0.00501	
$R_{th6}$	0.094	2.536		$C_{th6}$	0.052	0.412	



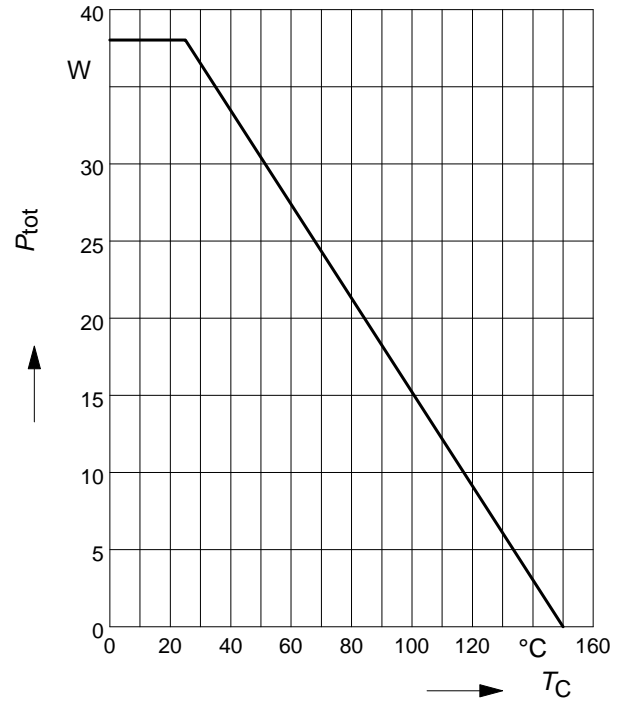
**1 Power dissipation**

$P_{tot} = f(T_C)$



**2 Power dissipation FullPAK**

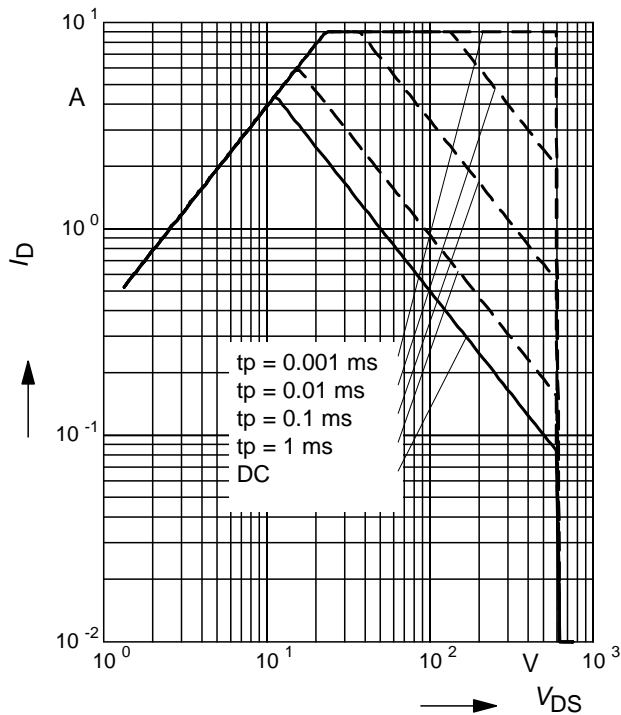
$P_{tot} = f(T_C)$



**3 Safe operating area**

$I_D = f(V_{DS})$

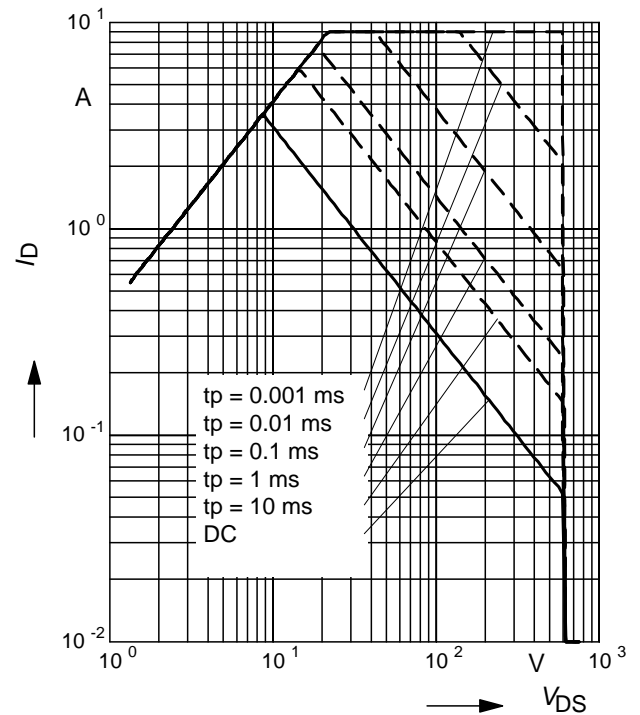
parameter :  $D = 0$  ,  $T_C = 25^\circ\text{C}$



**4 Safe operating area FullPAK**

$I_D = f(V_{DS})$

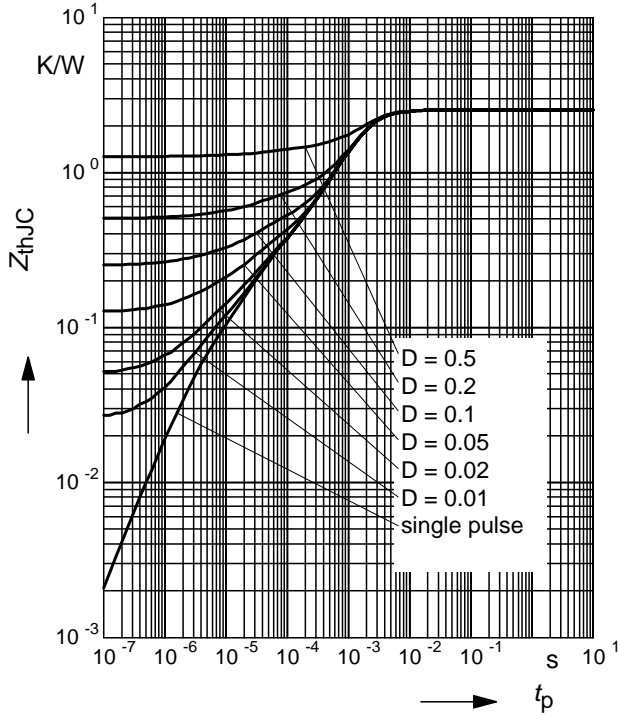
parameter:  $D = 0$  ,  $T_C = 25^\circ\text{C}$



**5 Transient thermal impedance**

$Z_{thJC} = f(t_p)$

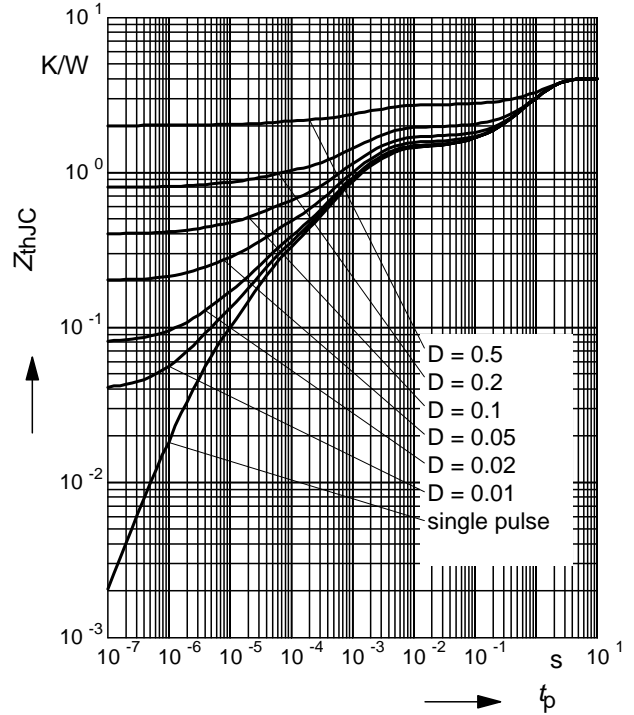
parameter:  $D = t_p/T$



**6 Transient thermal impedance FullPAK**

$Z_{thJC} = f(t_p)$

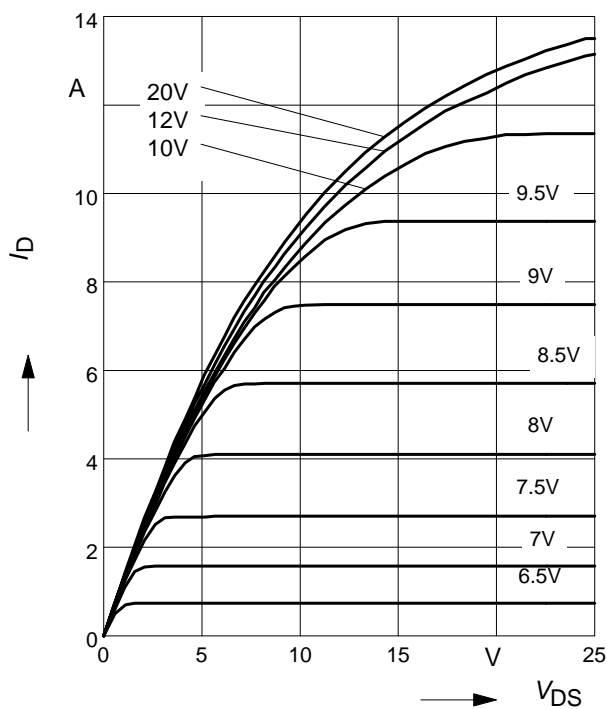
parameter:  $D = t_p/t$



**7 Typ. output characteristic**

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

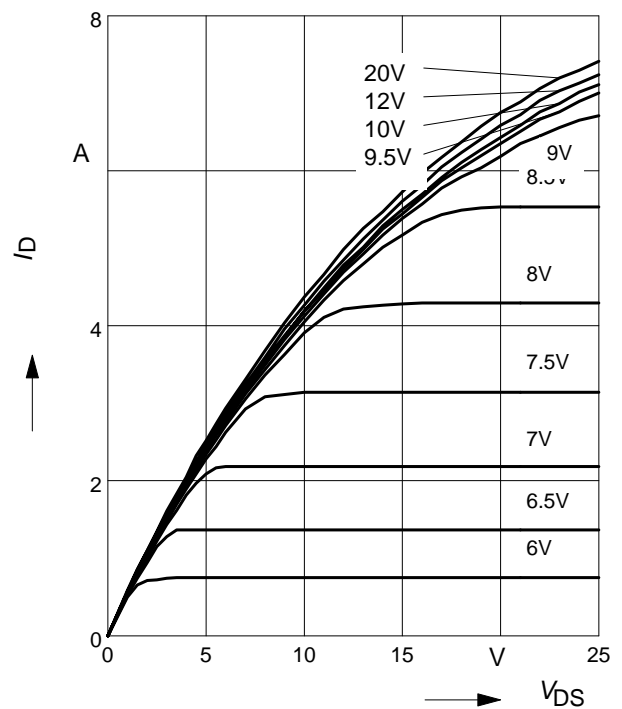
parameter:  $t_p = 10 \mu s, V_{GS}$



**8 Typ. output characteristic**

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

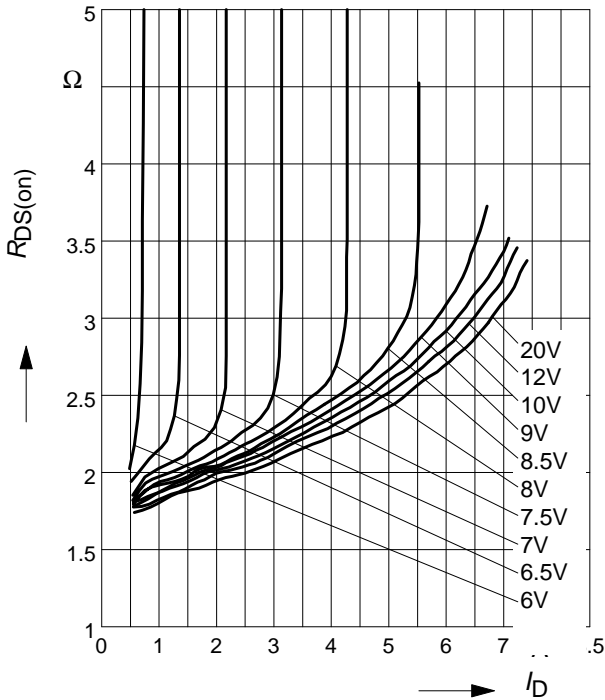
parameter:  $t_p = 10 \mu s, V_{GS}$



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

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

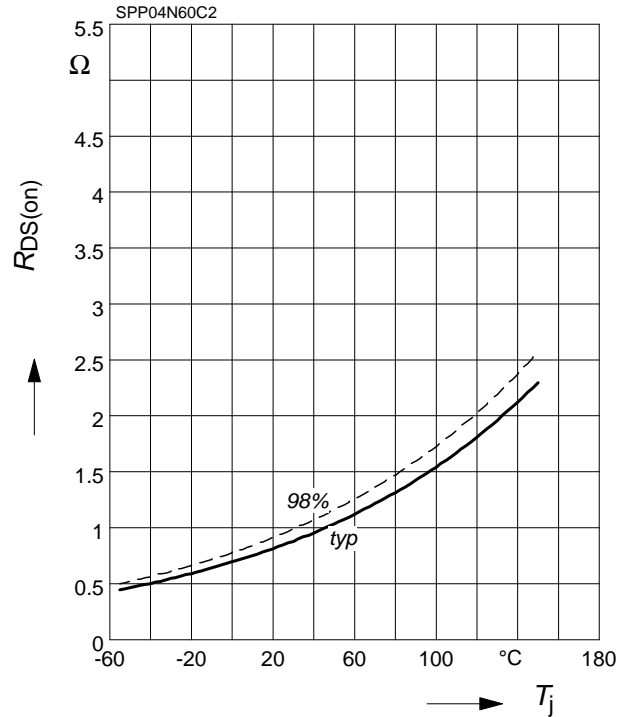
parameter:  $T_j = 150^\circ\text{C}$ ,  $V_{GS}$



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

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

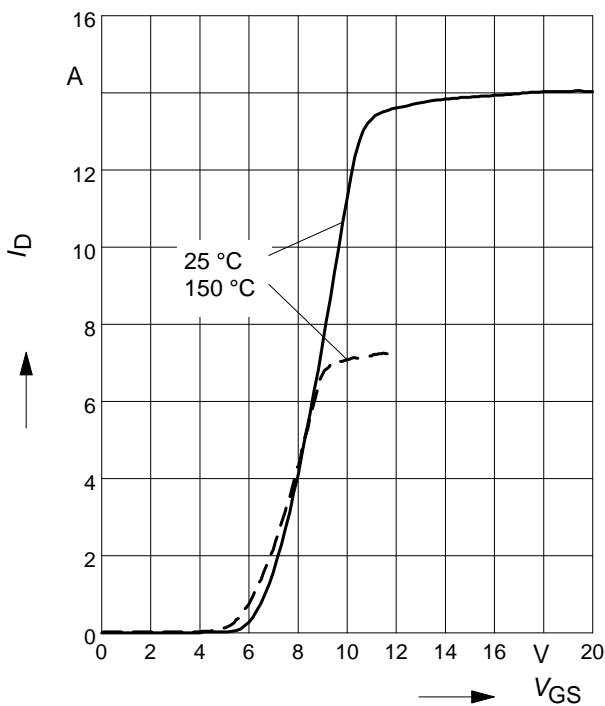
parameter:  $I_D = 2.8 \text{ A}$ ,  $V_{GS} = 10 \text{ V}$



**11 Typ. transfer characteristics**

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

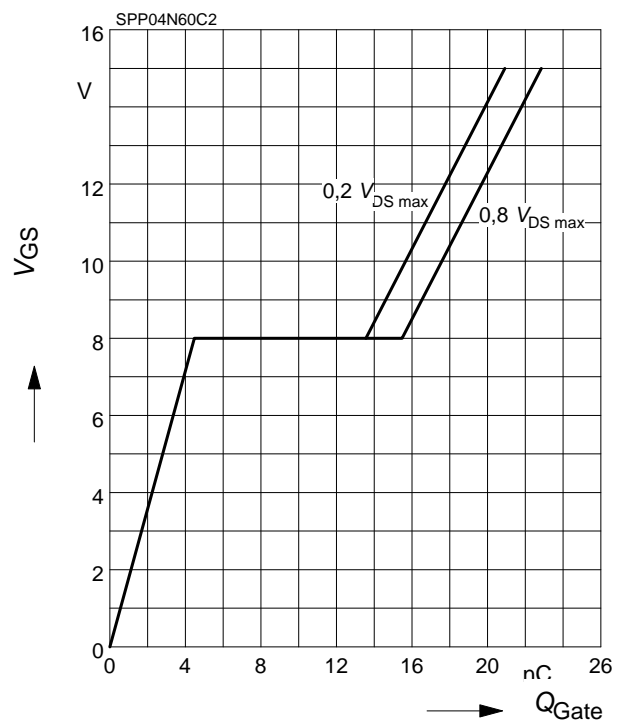
parameter:  $t_p = 10 \mu\text{s}$



**12 Typ. gate charge**

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

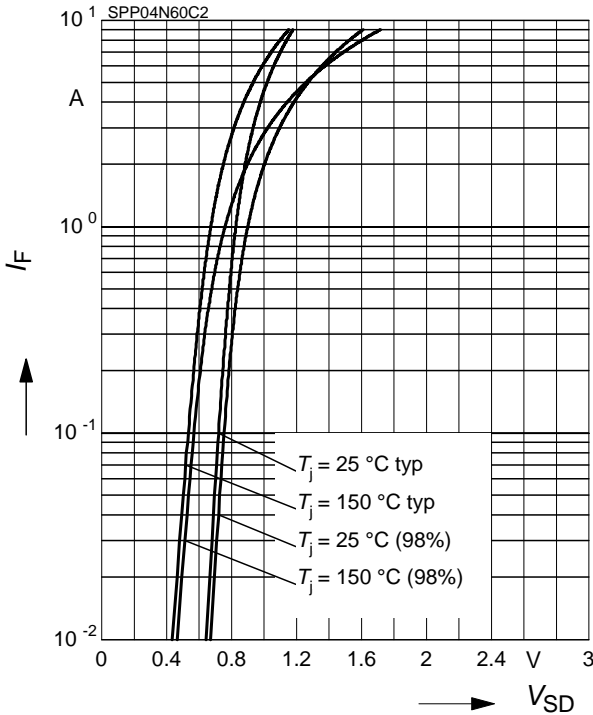
parameter:  $I_D = 4.5 \text{ A pulsed}$



**13 Forward characteristics of body diode**

$I_F = f(V_{SD})$

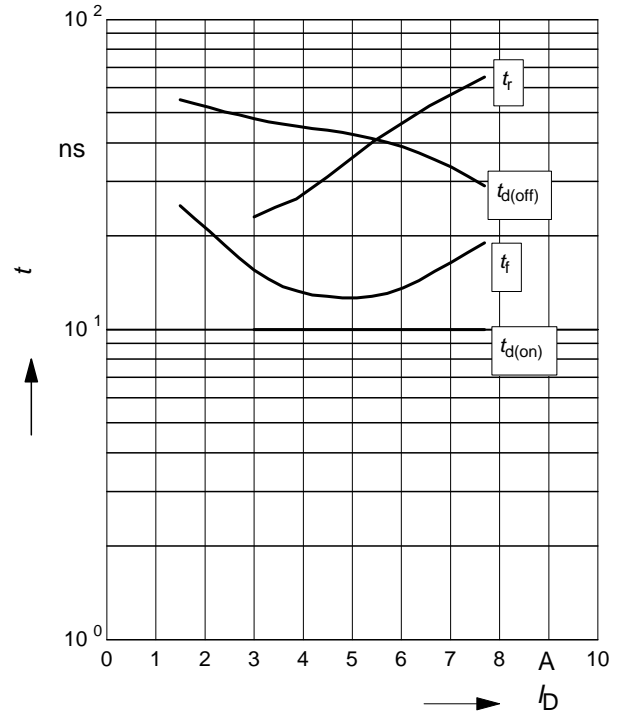
parameter:  $T_j$ ,  $t_p = 10 \mu s$



**14 Typ. switching time**

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

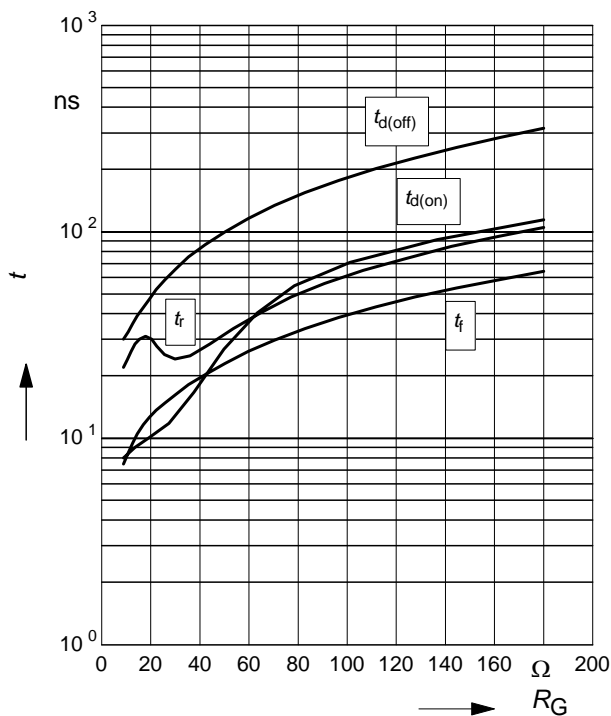
par.:  $V_{DS}=380V$ ,  $V_{GS}=0/+13V$ ,  $R_G=18\Omega$



**15 Typ. switching time**

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

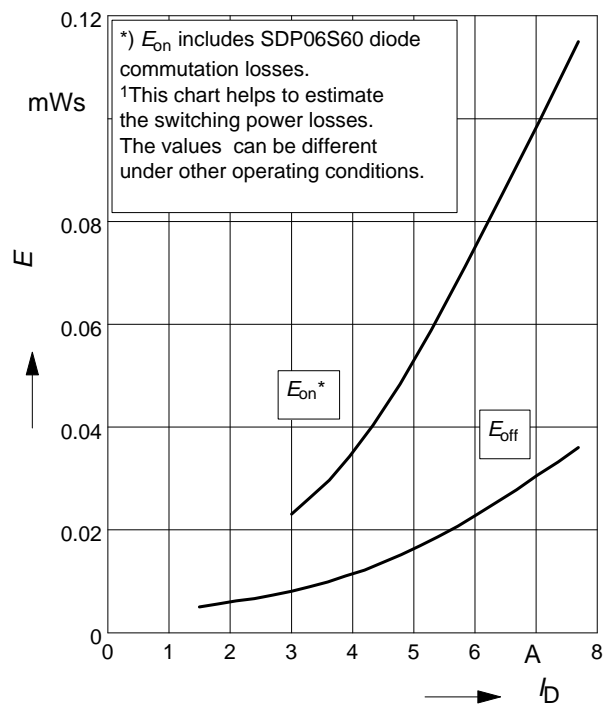
par.:  $V_{DS}=380V$ ,  $V_{GS}=0/+13V$ ,  $I_D=4.5 A$



**16 Typ. switching losses<sup>1)</sup>**

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

par.:  $V_{DS}=380V$ ,  $V_{GS}=0/+13V$ ,  $R_G=18\Omega$

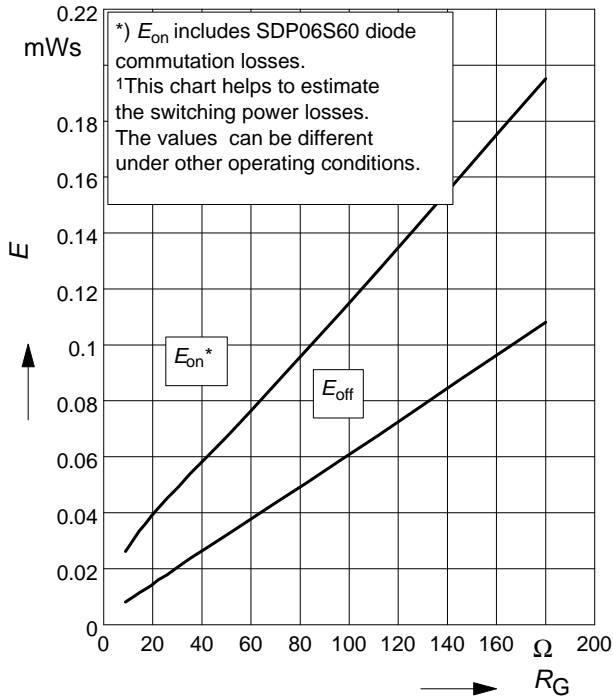




**17 Typ. switching losses<sup>1)</sup>**

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

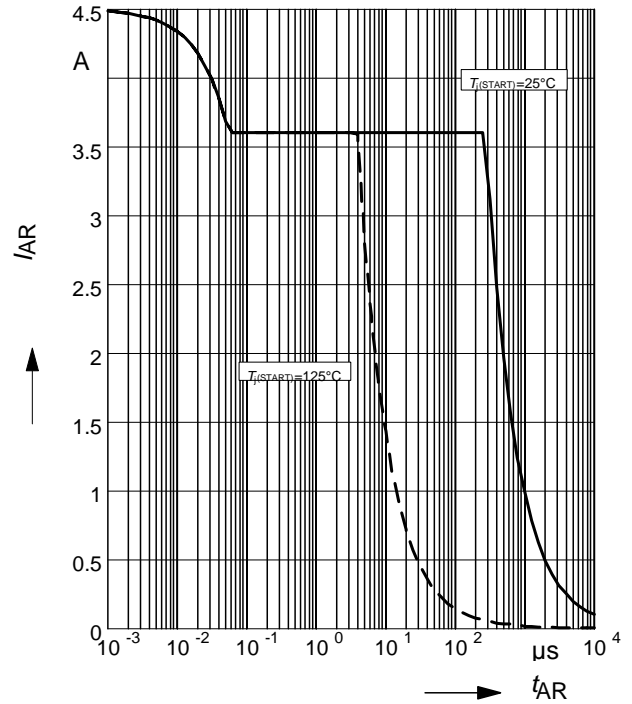
par.:  $V_{DS} = 380\text{V}$ ,  $V_{GS} = 0/+13\text{V}$ ,  $I_D = 4.5\text{A}$



**18 Avalanche SOA**

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

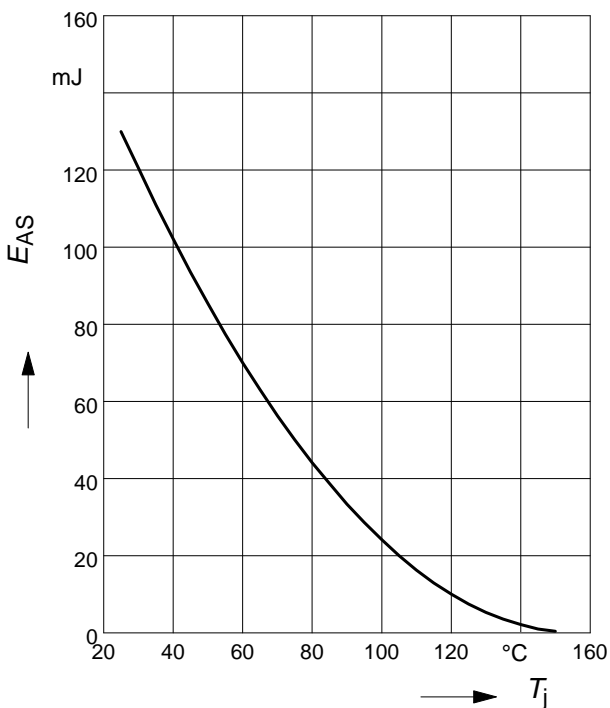
par.:  $T_j \leq 150^\circ\text{C}$



**19 Avalanche energy**

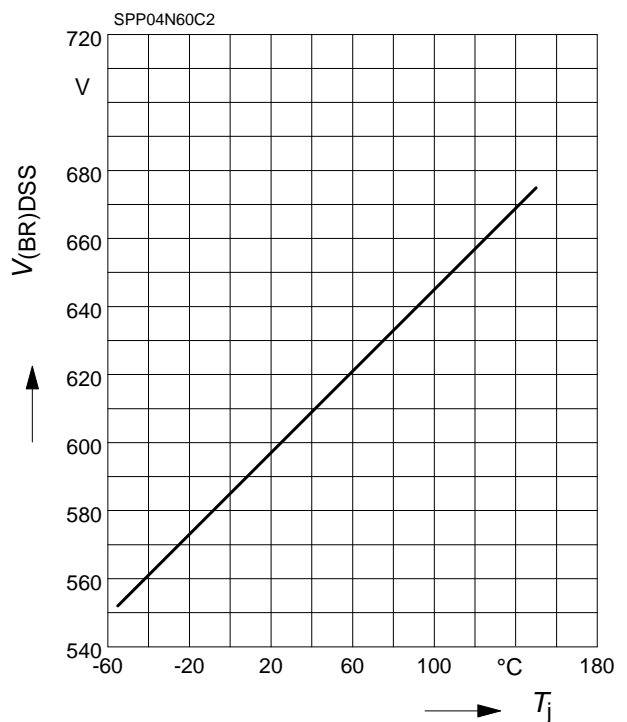
$E_{AS} = f(T_j)$

par.:  $I_D = 3.6\text{A}$ ,  $V_{DD} = 50\text{V}$



**20 Drain-source breakdown voltage**

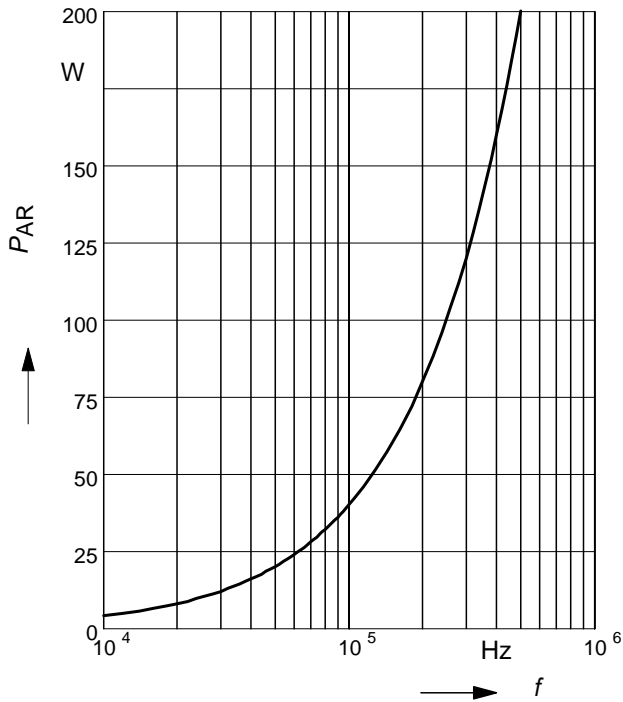
$V_{(BR)DSS} = f(T_j)$



**21 Avalanche power losses**

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

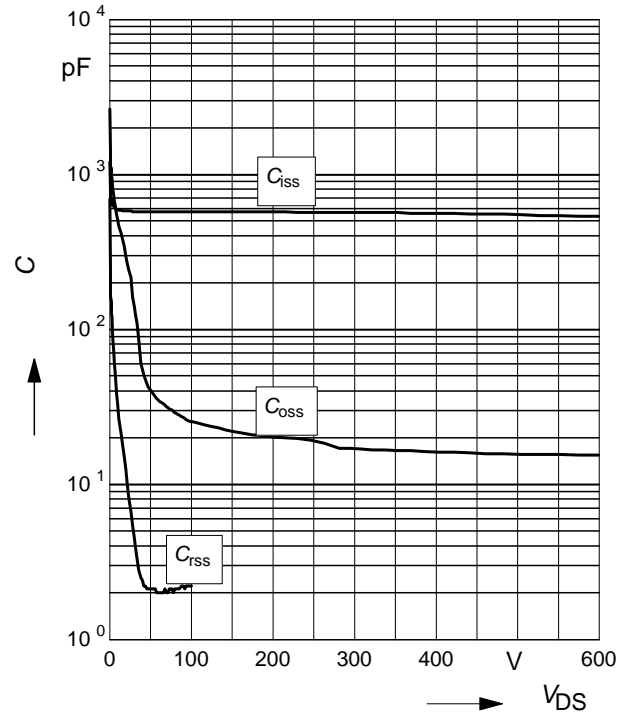
parameter:  $E_{AR}=0.4\text{mJ}$



**22 Typ. capacitances**

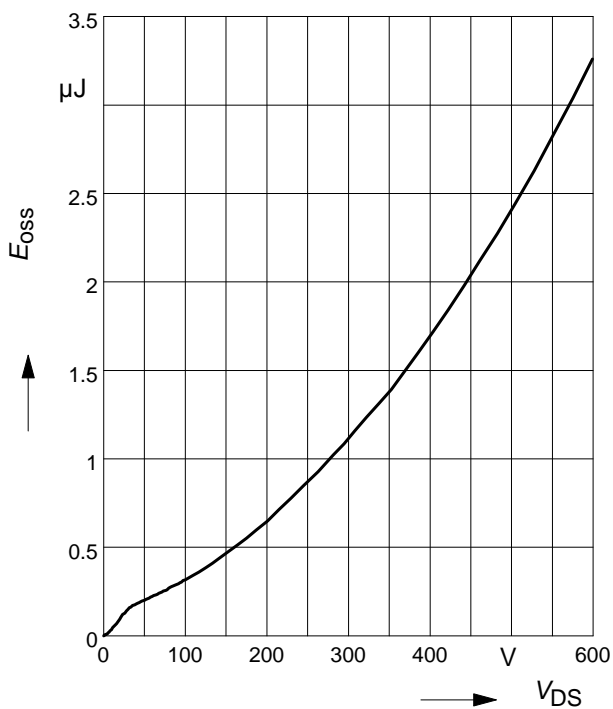
$$C = f(V_{DS})$$

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

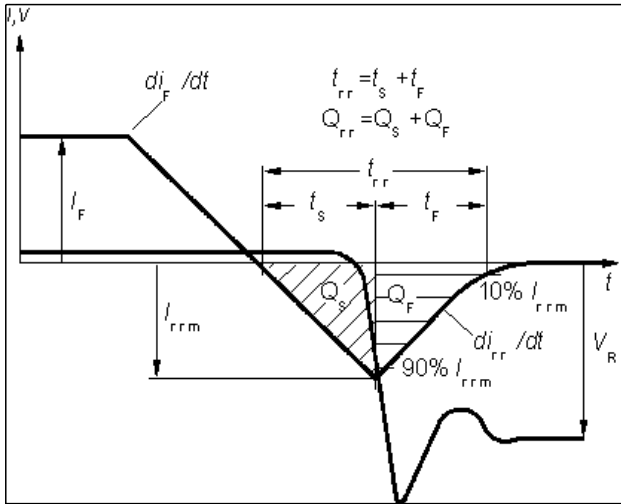


**23 Typ.  $C_{oss}$  stored energy**

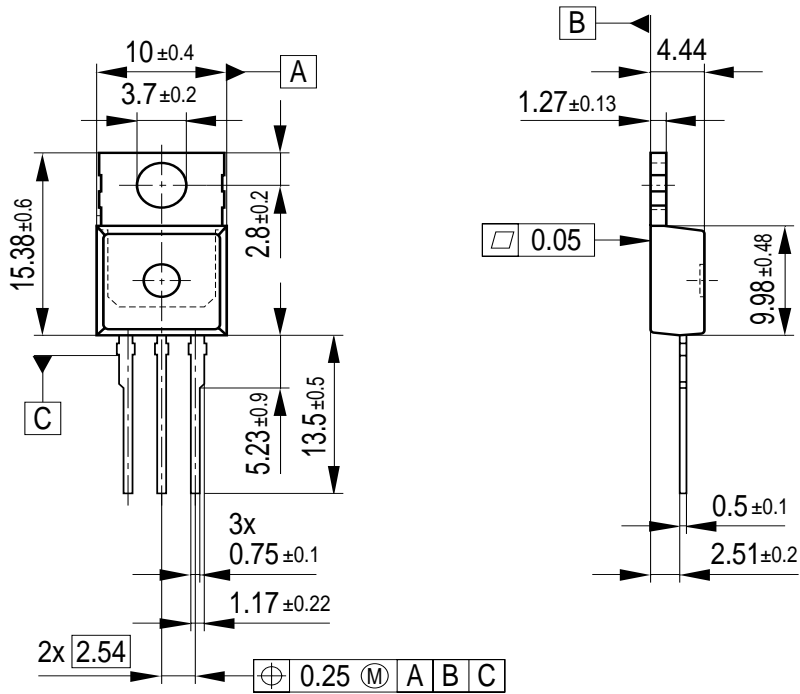
$$E_{oss}=f(V_{DS})$$



Definition of diodes switching characteristics

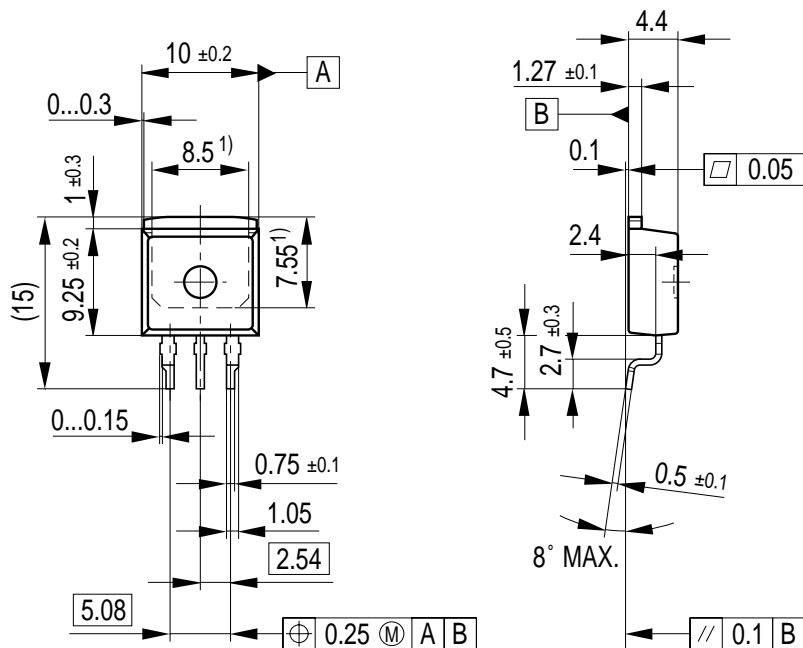


P-TO-220-3-1



All metal surfaces tin plated, except area of cut.  
Metal surface min. x=7.25, y=12.3

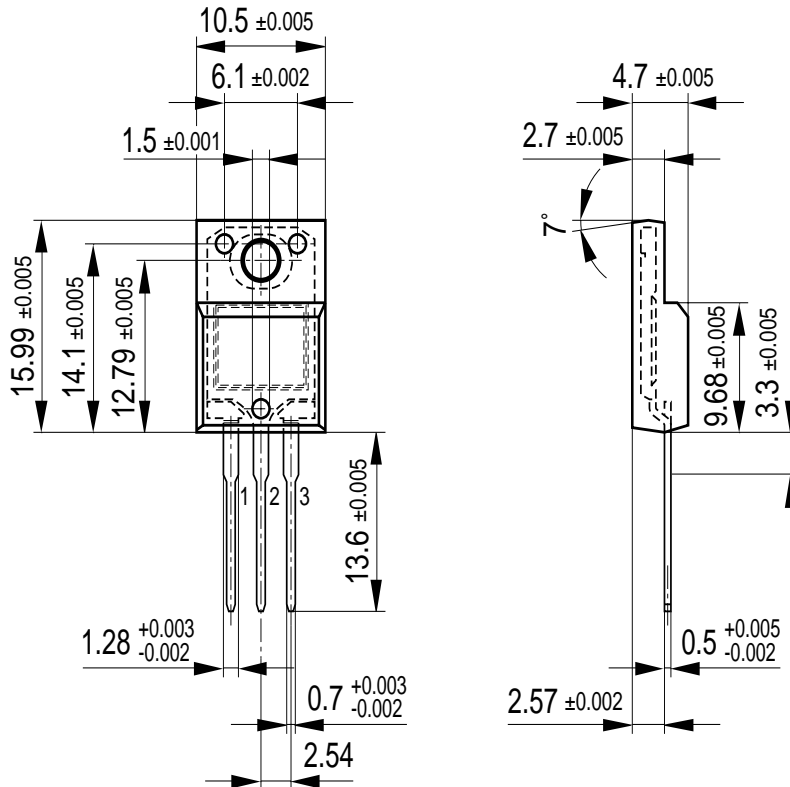
P-TO-263-3-1 (D<sup>2</sup>-PAK)



<sup>1)</sup> Typical

All metal surfaces: tin plated, except area of cut.  
Metal surface min. x=7.25, y=6.9

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



Please refer to mounting instructions (application note AN-TO220-3-31-01)

**Published by**  
**Infineon Technologies AG,**  
**Bereichs Kommunikation**  
**St.-Martin-Strasse 53,**  
**D-81541 München**  
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