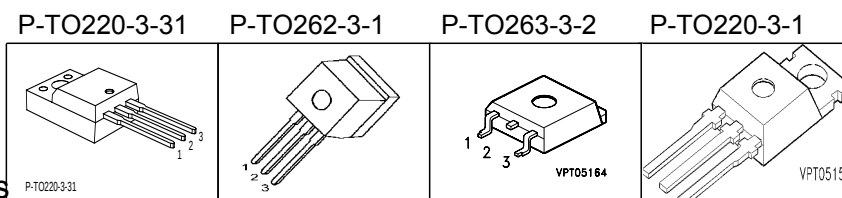


Cool MOS™ Power Transistor

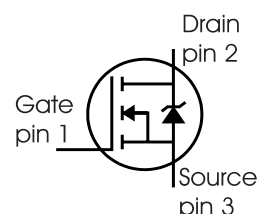
Feature

- New revolutionary high voltage technology
- Worldwide best $R_{DS(on)}$ in TO 220
- Ultra low gate charge
- Periodic avalanche rated
- Extreme dv/dt rated
- Ultra low effective capacitances
- Improved transconductance
- P-TO-220-3-31: Fully isolated package (2500 VAC; 1 minute)



$V_{DS} @ T_{jmax}$	560	V
$R_{DS(on)}$	0.19	Ω
I_D	21	A

Type	Package	Ordering Code	Marking
SPP21N50C3	P-TO220-3-1	Q67040-S4565	21N50C3
SPB21N50C3	P-TO263-3-2	Q67040-S4566	21N50C3
SPI21N50C3	P-TO262-3-1	Q67040-S4564	21N50C3
SPA21N50C3	P-TO220-3-31	Q67040-S4585	21N50C3



Maximum Ratings

Parameter	Symbol	Value		Unit
		SPP21N50C3	SPA	
Continuous drain current $T_C = 25\text{ }^{\circ}\text{C}$ $T_C = 100\text{ }^{\circ}\text{C}$	I_D	21 13.1	21 ¹⁾ 13.1 ¹⁾	A
Pulsed drain current, t_p limited by T_{jmax}	$I_{D\text{ puls}}$	63	63	A
Avalanche energy, single pulse $I_D=10\text{A}$, $V_{DD}=50\text{V}$	E_{AS}	690	690	mJ
Avalanche energy, repetitive t_{AR} limited by T_{jmax} ²⁾ $I_D=21\text{A}$, $V_{DD}=50\text{V}$	E_{AR}	1	1	
Avalanche current, repetitive t_{AR} limited by T_{jmax}	I_{AR}	21	21	A
Gate source voltage	V_{GS}	± 20	± 20	V
Gate source voltage AC ($f > 1\text{Hz}$)	V_{GS}	± 30	± 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 $V_{DS} = 400 \text{ V}$, $I_D = 21 \text{ A}$, $T_j = 125^\circ\text{C}$	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 ² cooling area ³⁾	R_{thJA}	-	-	62	
		-	35	-	
Soldering temperature, 1.6 mm (0.063 in.) from case for 10s ⁴⁾	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	$V_{(BR)DSS}$	$V_{GS}=0\text{V}$, $I_D=0.25\text{mA}$	500	-	-	V
Drain-Source avalanche breakdown voltage	$V_{(BR)DS}$	$V_{GS}=0\text{V}$, $I_D=21\text{A}$	-	600	-	
Gate threshold voltage	$V_{GS(th)}$	$I_D=1000\mu\text{A}$, $V_{GS}=V_D$	2.1	3	3.9	
Zero gate voltage drain current	I_{DSS}	$V_{DS}=500\text{V}$, $V_{GS}=0\text{V}$, $T_j=25^\circ\text{C}$ $T_j=150^\circ\text{C}$	-	0.1	1	μA
			-	-	100	
Gate-source leakage current	I_{GSS}	$V_{GS}=20\text{V}$, $V_{DS}=0\text{V}$	-	-	100	nA
Drain-source on-state resistance	$R_{DS(on)}$	$V_{GS}=10\text{V}$, $I_D=13.1\text{A}$, $T_j=25^\circ\text{C}$ $T_j=150^\circ\text{C}$	-	0.16	0.19	Ω
			-	0.54	-	
Gate input resistance	R_G	$f=1\text{MHz}$, open drain	-	0.53	-	

Electrical Characteristics

Parameter	Symbol	Conditions	Values			Unit
			min.	typ.	max.	
Transconductance	g_{fs}	$V_{DS} \geq 2 \cdot I_D \cdot R_{DS(on)max}$, $I_D = 13.1A$	-	18	-	S
Input capacitance	C_{iss}	$V_{GS} = 0V$, $V_{DS} = 25V$, $f = 1MHz$	-	2400	-	pF
Output capacitance	C_{oss}		-	1200	-	
Reverse transfer capacitance	C_{rss}		-	30	-	
Effective output capacitance, ⁵⁾ energy related	$C_{o(er)}$	$V_{GS} = 0V$, $V_{DS} = 400V$	-	87	-	
Effective output capacitance, ⁶⁾ time related	$C_{o(tr)}$		-	181	-	
Turn-on delay time	$t_{d(on)}$	$V_{DD} = 380V$, $V_{GS} = 0/10V$, $I_D = 21A$, $R_G = 3.6\Omega$	-	10	-	ns
Rise time	t_r		-	5	-	
Turn-off delay time	$t_{d(off)}$		-	67	-	
Fall time	t_f		-	4.5	-	

Gate Charge Characteristics

Gate to source charge	Q_{gs}	$V_{DD} = 380V$, $I_D = 21A$	-	10	-	nC
Gate to drain charge	Q_{gd}		-	50	-	
Gate charge total	Q_g	$V_{DD} = 380V$, $I_D = 21A$, $V_{GS} = 0$ to $10V$	-	95	-	
Gate plateau voltage	$V_{(plateau)}$	$V_{DD} = 380V$, $I_D = 21A$	-	5	-	V

¹Limited only by maximum temperature

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

³Device on 40mm*40mm*1.5mm epoxy PCB FR4 with 6cm² (one layer, 70 µm thick) copper area for drain connection. PCB is vertical without blown air.

⁴Soldering temperature for TO-263: 220°C, reflow

⁵ $C_{o(er)}$ is a fixed capacitance that gives the same stored energy as C_{oss} while V_{DS} is rising from 0 to 80% V_{DSS} .

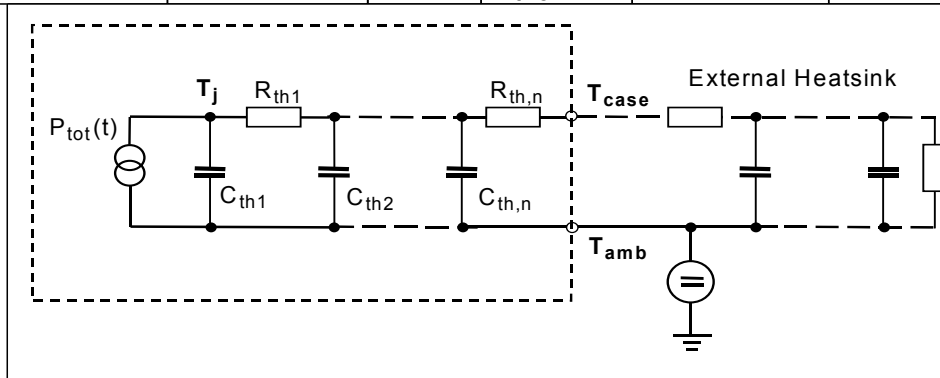
⁶ $C_{o(tr)}$ is a fixed capacitance that gives the same charging time as C_{oss} while V_{DS} is rising from 0 to 80% V_{DSS} .

Electrical Characteristics

Parameter	Symbol	Conditions	Values			Unit
			min.	typ.	max.	
Inverse diode continuous forward current	I_S	$T_C=25^{\circ}\text{C}$	-	-	21	A
Inverse diode direct current, pulsed	I_{SM}		-	-	63	
Inverse diode forward voltage	V_{SD}	$V_{GS}=0\text{V}$, $I_F=I_S$	-	1	1.2	V
Reverse recovery time	t_{rr}	$V_R=380\text{V}$, $I_F=I_S$, $di_F/dt=100\text{A}/\mu\text{s}$	-	450	-	ns
Reverse recovery charge	Q_{rr}		-	9	-	μC
Peak reverse recovery current	I_{rrm}		-	60	-	A
Peak rate of fall of reverse recovery current	di_{rr}/dt	$T_j=25^{\circ}\text{C}$	-	1200	-	$\text{A}/\mu\text{s}$

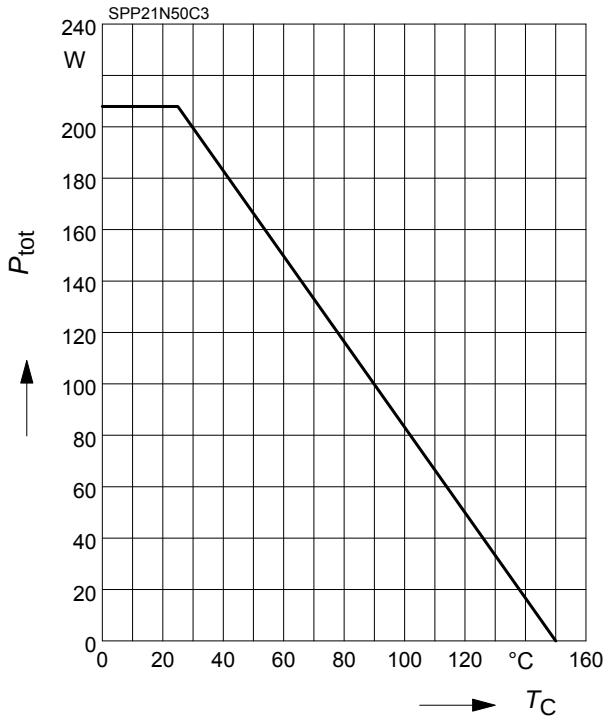
Typical Transient Thermal Characteristics

Symbol	Value		Unit	Symbol	Value		Unit
	SPP_B_I	SPA			SPP_B_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	0.16		C_{th4}	0.005297	0.005297	
R_{th5}	0.136	0.319		C_{th5}	0.012	0.008659	
R_{th6}	0.059	2.523		C_{th6}	0.091	0.412	



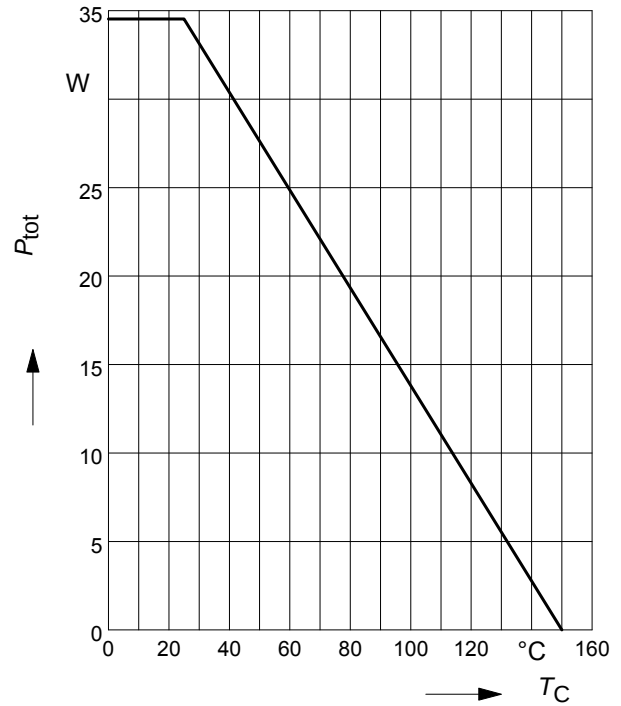
1 Power dissipation

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



2 Power dissipation FullPAK

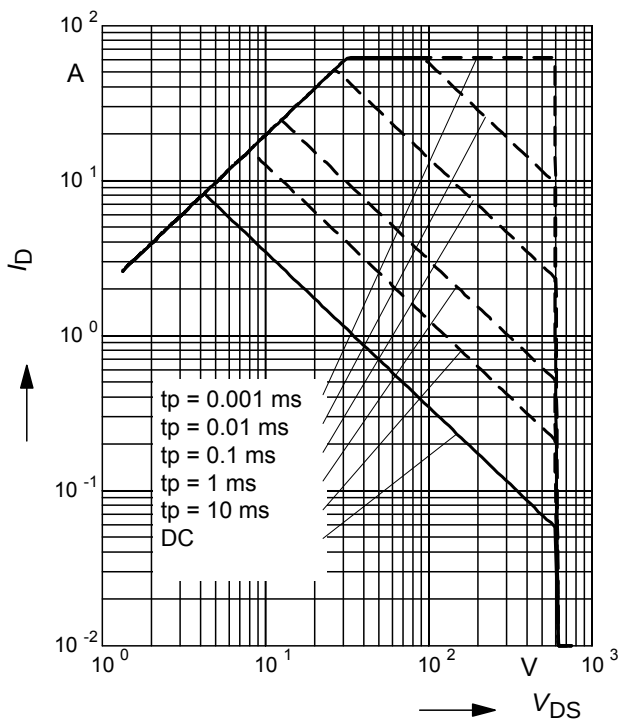
$$P_{\text{tot}} = f(T_C)$$



3 Safe operating area

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

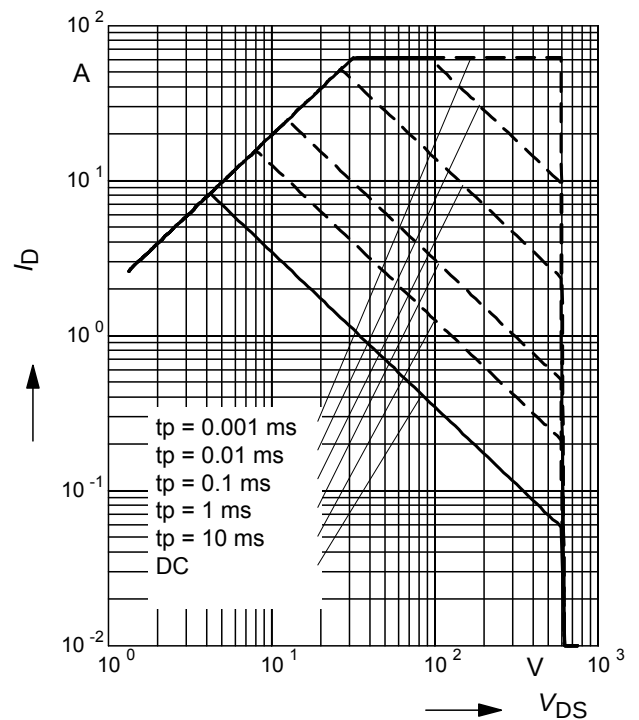
parameter : $D = 0$, $T_C = 25^\circ\text{C}$



4 Safe operating area FullPAK

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

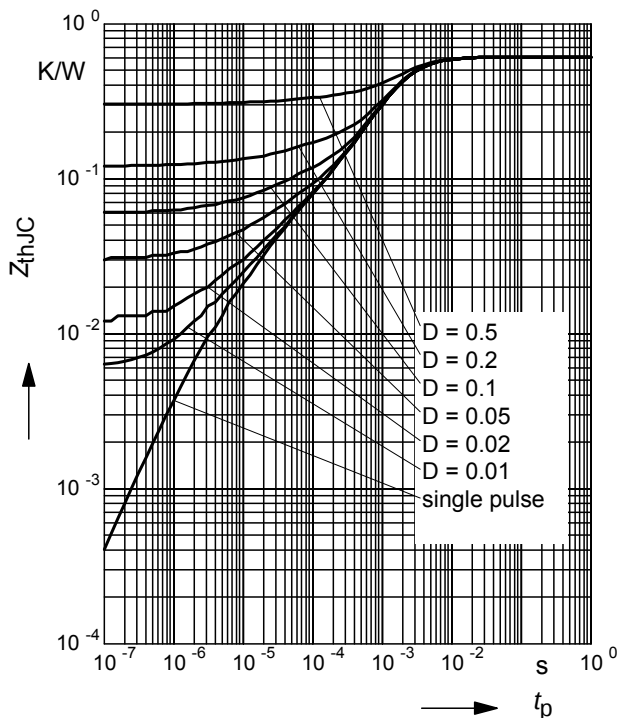
parameter: $D = 0$, $T_C = 25^\circ\text{C}$



5 Transient thermal impedance

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

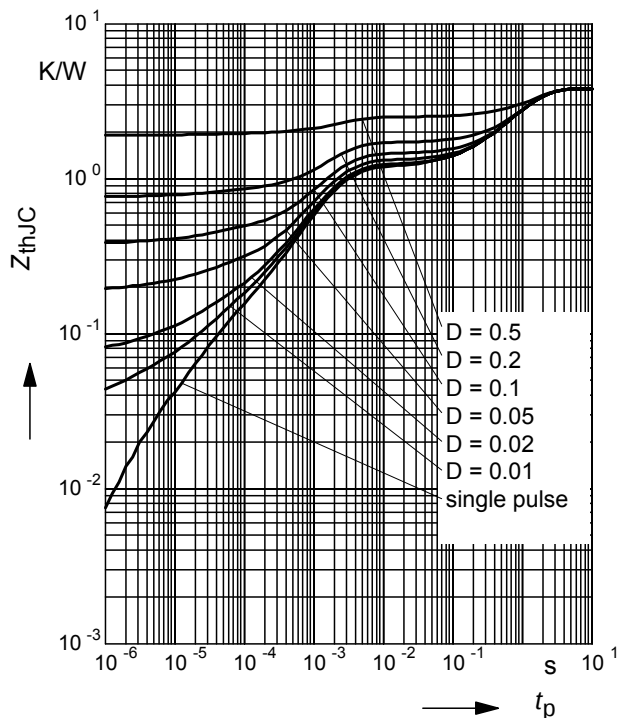
parameter: $D = t_p/T$



6 Transient thermal impedance FullPAK

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

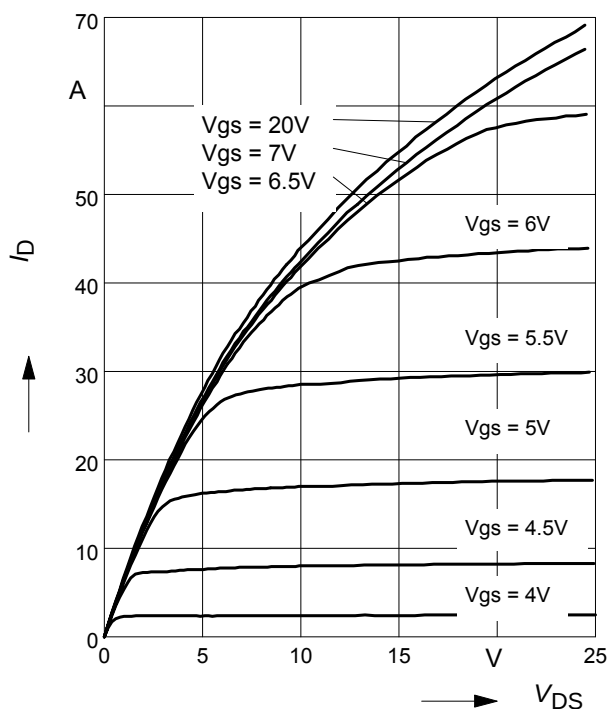
parameter: $D = t_p/t$



7 Typ. output characteristic

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

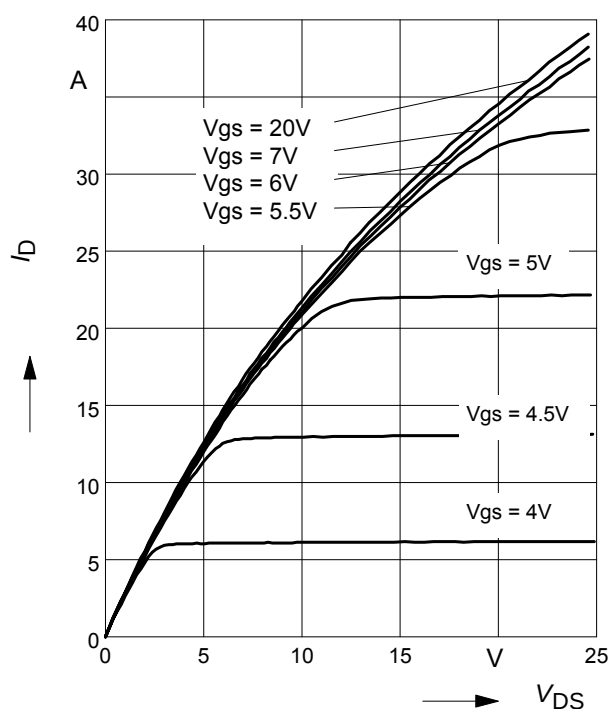
parameter: $t_p = 10 \mu\text{s}, V_{GS}$



8 Typ. output characteristic

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

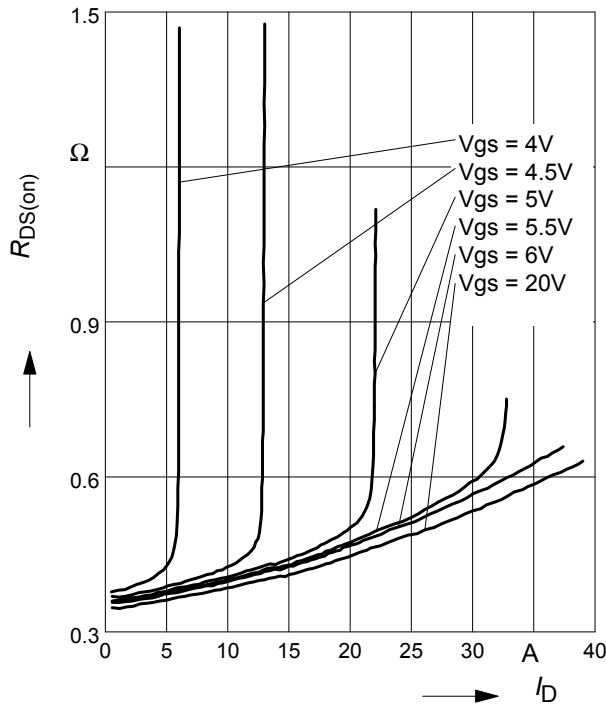
parameter: $t_p = 10 \mu\text{s}, V_{GS}$



9 Typ. drain-source on resistance

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

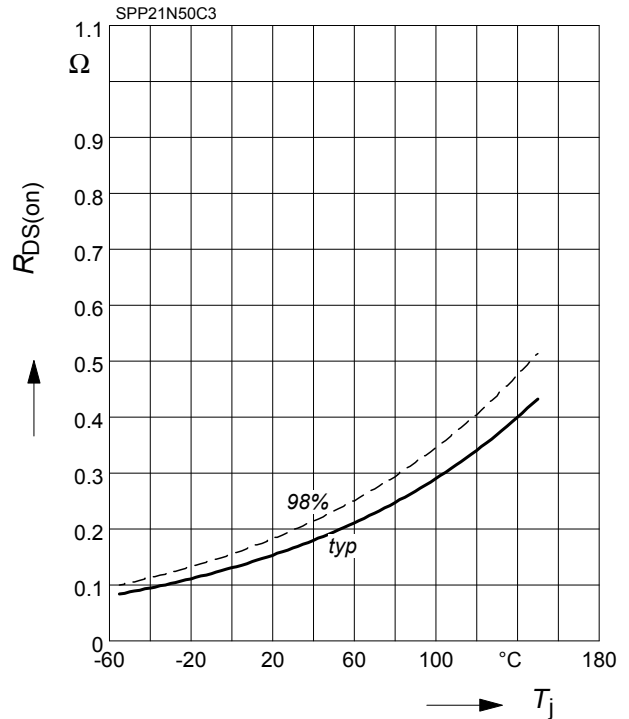
parameter: $T_j = 150^\circ\text{C}$, V_{GS}



10 Drain-source on-state resistance

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

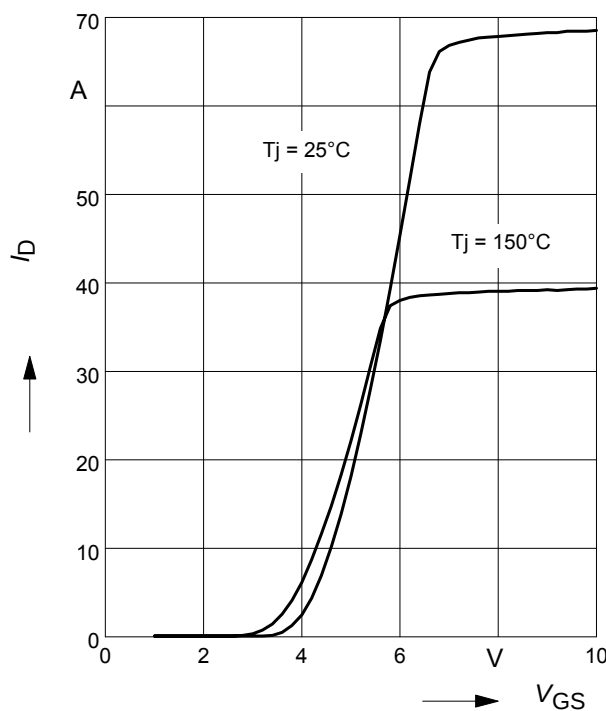
parameter: $I_D = 13.1\text{ A}$, $V_{GS} = 10\text{ V}$



11 Typ. transfer characteristics

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

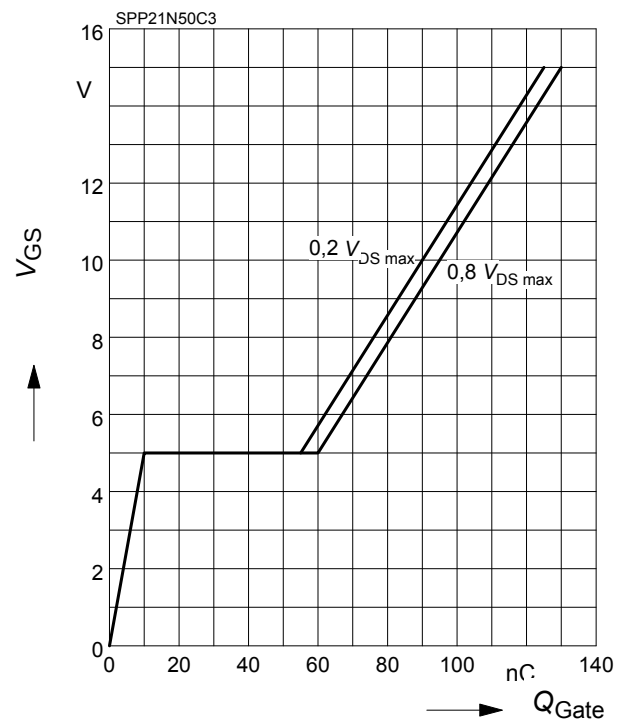
parameter: $t_p = 10\text{ }\mu\text{s}$



12 Typ. gate charge

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

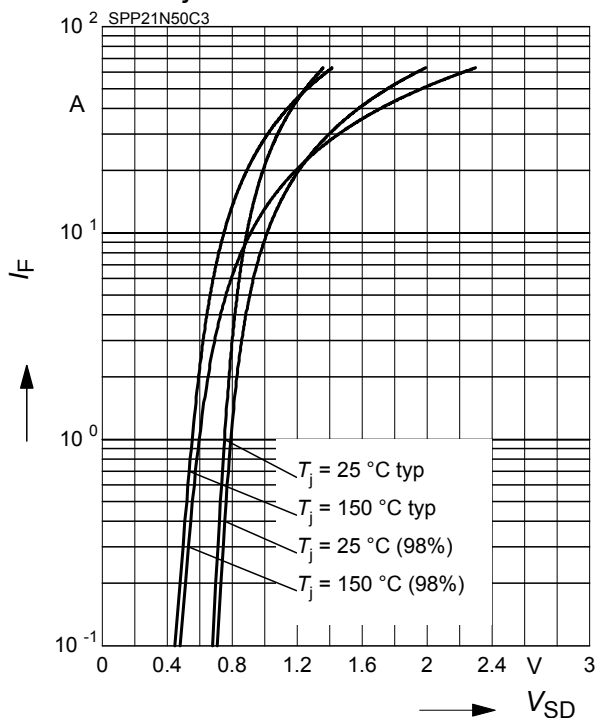
parameter: $I_D = 21\text{ A}$ pulsed



13 Forward characteristics of body diode

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

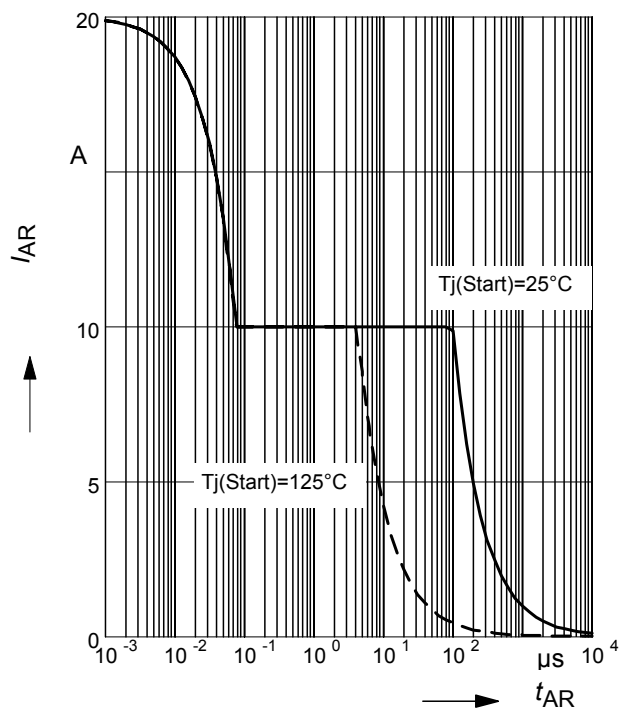
parameter: T_j , $t_p = 10 \mu s$



14 Avalanche SOA

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

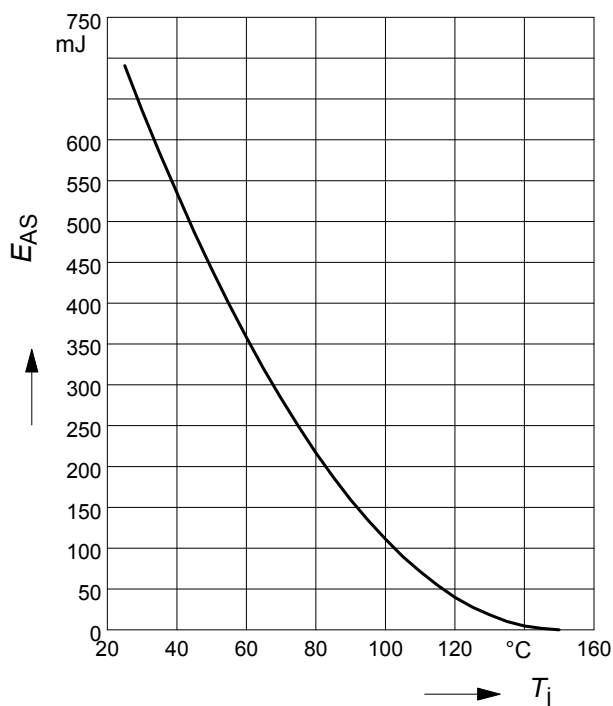
par.: $T_j \leq 150 \text{ } ^\circ\text{C}$



15 Avalanche energy

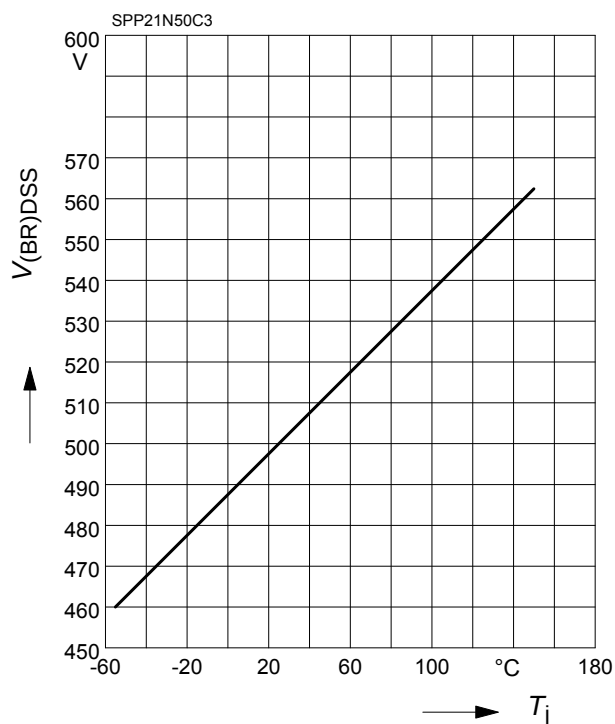
$$E_{AS} = f(T_j)$$

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



16 Drain-source breakdown voltage

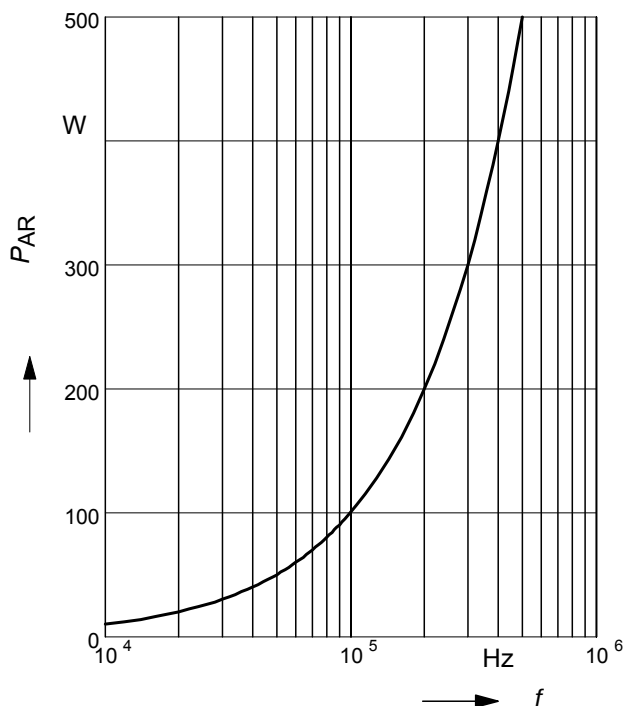
$$V_{(BR)DSS} = f(T_j)$$



17 Avalanche power losses

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

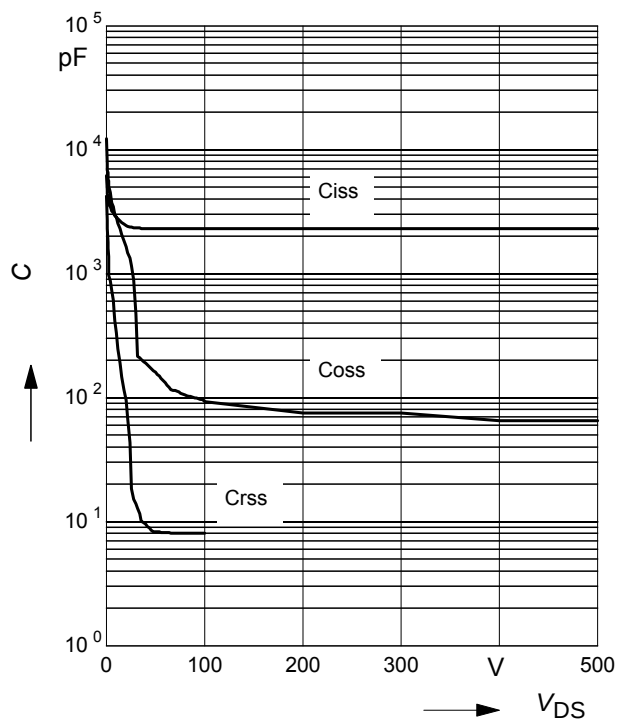
parameter: $E_{AR}=1\text{mJ}$



18 Typ. capacitances

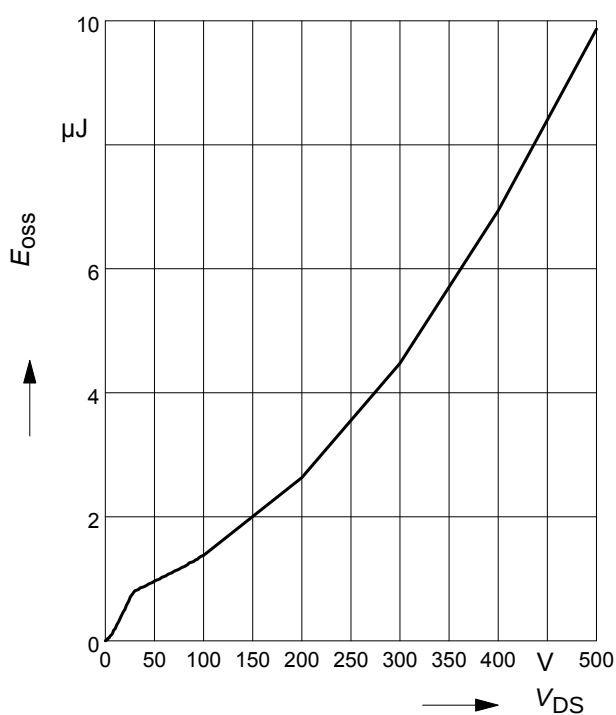
$$C = f(V_{DS})$$

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

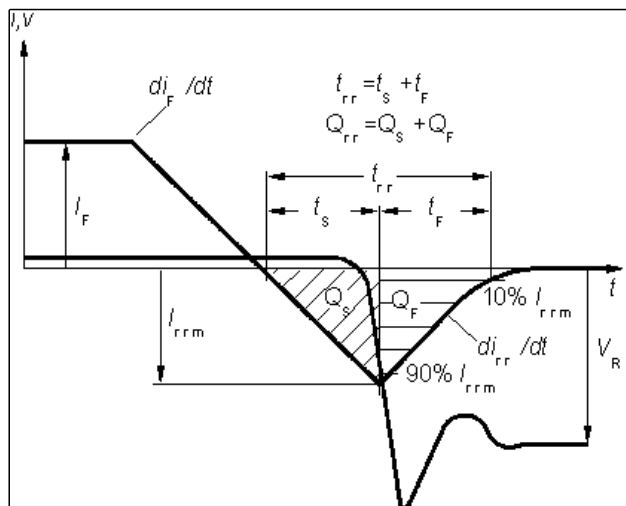


19 Typ. C_{OSS} stored energy

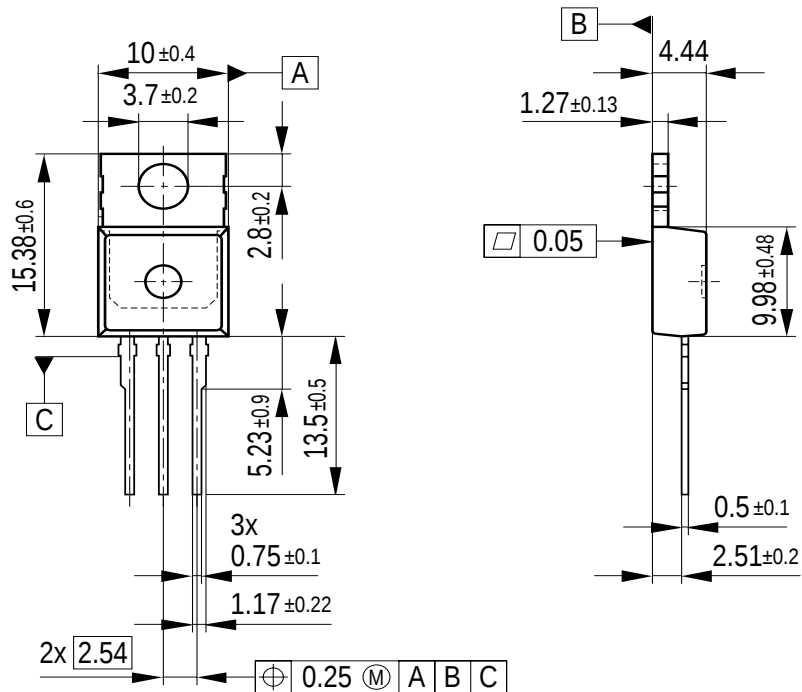
$$E_{OSS}=f(V_{DS})$$



Definition of diodes switching characteristics

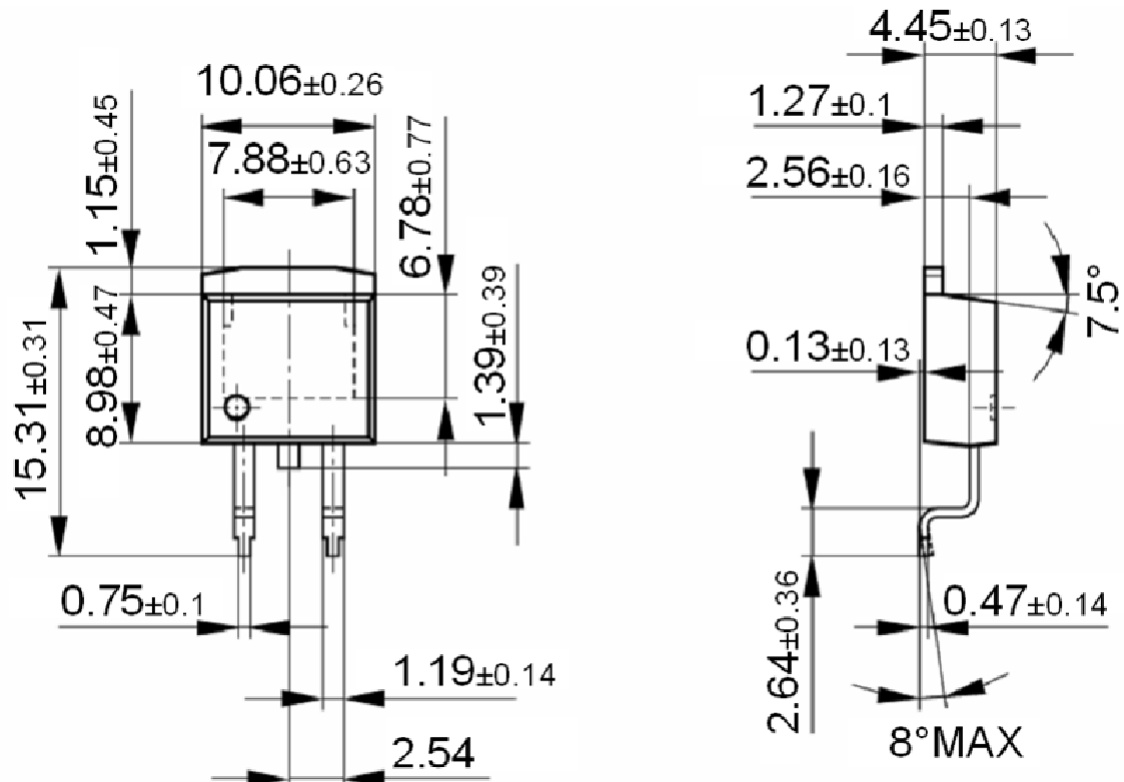


P-TO-220-3-1

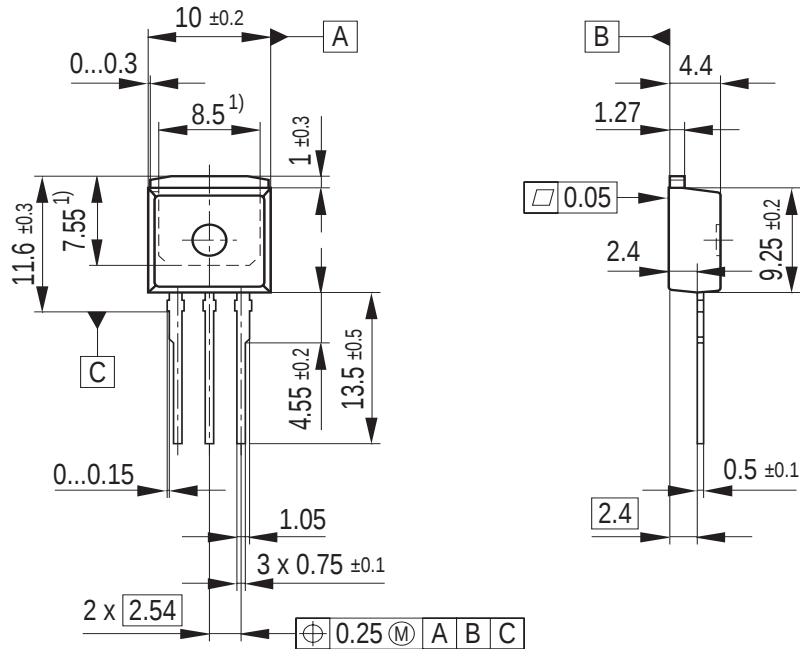


All metal surfaces tin plated, except area of cut.
Metal surface min. x=7.25, y=12.3

P-TO-263-3-2 (D²-PAK)



P-TO-262-3-1 (I²-PAK)

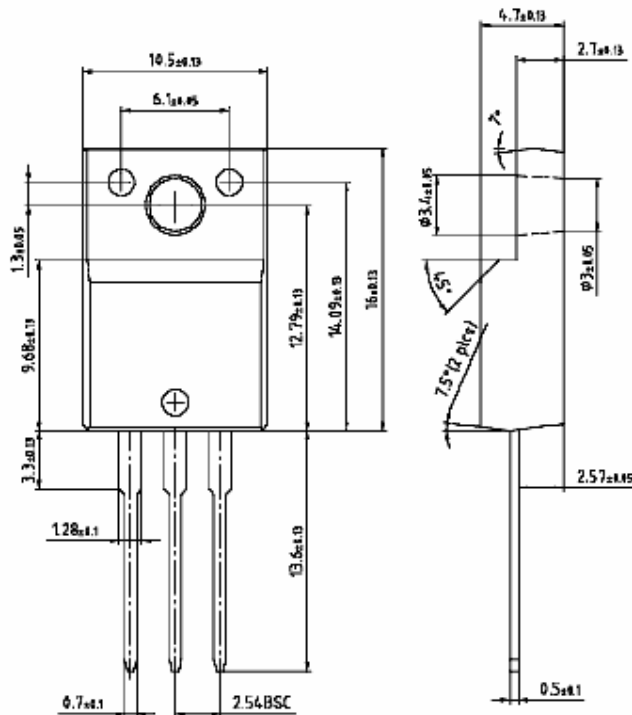


¹⁾ Typical

Metal surface min. X = 7.25, Y = 6.9

All metal surfaces tin plated, except area of cut.

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



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

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