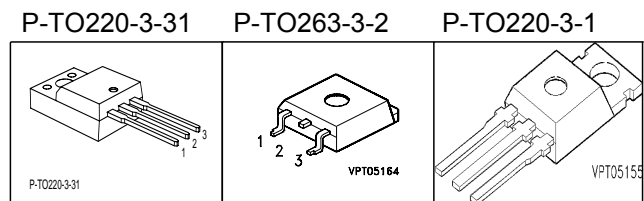


Cool MOS™ Power Transistor

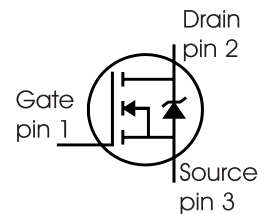
Feature

- New revolutionary high voltage technology
- Ultra low gate charge
- Periodic avalanche rated
- Extreme dv/dt rated
- High peak current capability
- Improved transconductance
- P-TO-220-3-31: Fully isolated package (2500 VAC; 1 minute)

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



Type	Package	Ordering Code	Marking
SPP04N60C3	P-TO220-3-1	Q67040-S4366	04N60C3
SPB04N60C3	P-TO263-3-2	Q67040-S4407	04N60C3
SPA04N60C3	P-TO220-3-31	Q67040-S4413	04N60C3



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 ¹⁾ 2.8 ¹⁾	A
Pulsed drain current, t_p limited by T_{jmax}	$I_D \text{ puls}$	13.5	13.5	A
Avalanche energy, single pulse $I_D=3.4, V_{DD}=50V$	E_{AS}	130	130	mJ
Avalanche energy, repetitive t_{AR} limited by T_{jmax} ²⁾ $I_D=4.5A, V_{DD}=50V$	E_{AR}	0.4	0.4	
Avalanche current, repetitive t_{AR} limited by T_{jmax}	I_{AR}	4.5	4.5	A
Gate source voltage static	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}	50	31	W
Operating and storage temperature	T_j, T_{stg}	-55...+150		$^\circ\text{C}$

Maximum Ratings

Parameter	Symbol	Value	Unit
Drain Source voltage slope $V_{DS} = 480 \text{ V}, I_D = 4.5 \text{ A}, T_j = 125 \text{ }^\circ\text{C}$	dv/dt	50	V/ns

Thermal Characteristics

Parameter	Symbol	Values			Unit
		min.	typ.	max.	
Thermal resistance, junction - case	R_{thJC}	-	-	2.5	K/W
Thermal resistance, junction - case, FullPAK	$R_{thJC \text{ FP}}$	-	-	4	
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	
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	$V_{(BR)DSS}$	$V_{GS}=0\text{V}, I_D=0.25\text{mA}$	600	-	-	V
Drain-Source avalanche breakdown voltage	$V_{(BR)DS}$	$V_{GS}=0\text{V}, I_D=4.5\text{A}$	-	700	-	
Gate threshold voltage	$V_{GS(th)}$	$I_D=200\mu\text{A}, V_{GS}=V_{DS}$	2.1	3	3.9	
Zero gate voltage drain current	I_{DSS}	$V_{DS}=600\text{V}, V_{GS}=0\text{V},$ $T_j=25^\circ\text{C}$ $T_j=150^\circ\text{C}$	-	0.5	1	μA
Gate-source leakage current	I_{GSS}	$V_{GS}=30\text{V}, V_{DS}=0\text{V}$	-	-	100	
Drain-source on-state resistance	$R_{DS(on)}$	$V_{GS}=10\text{V}, I_D=2.8\text{A}$ $T_j=25^\circ\text{C}$ $T_j=150^\circ\text{C}$	-	0.85	0.95	Ω
Gate input resistance	R_G	$f=1\text{MHz}, \text{open drain}$	-	0.95	-	

Electrical Characteristics

Parameter	Symbol	Conditions	Values			Unit
			min.	typ.	max.	
Transconductance	g_{fs}	$V_{DS} \geq 2 \cdot I_D \cdot R_{DS(on)max}$, $I_D = 2.8A$	-	4.4	-	S
Input capacitance	C_{iss}	$V_{GS} = 0V$, $V_{DS} = 25V$, $f = 1MHz$	-	490	-	pF
Output capacitance	C_{oss}		-	160	-	
Reverse transfer capacitance	C_{rss}		-	15	-	
Effective output capacitance, ⁵⁾ energy related	$C_{o(er)}$	$V_{GS} = 0V$, $V_{DS} = 0V$ to 480V	-	20	-	
Effective output capacitance, ⁶⁾ time related	$C_{o(tr)}$		-	35	-	
Turn-on delay time	$t_{d(on)}$	$V_{DD} = 380V$, $V_{GS} = 0/10V$, $I_D = 4.5A$, $R_G = 18\Omega$	-	6	-	ns
Rise time	t_r		-	2.5	-	
Turn-off delay time	$t_{d(off)}$		-	58.5	80	
Fall time	t_f		-	9.5	14	

Gate Charge Characteristics

Gate to source charge	Q_{gs}	$V_{DD} = 480V$, $I_D = 4.5A$	-	2.2	-	nC
Gate to drain charge	Q_{gd}		-	8.8	-	
Gate charge total	Q_g	$V_{DD} = 480V$, $I_D = 4.5A$, $V_{GS} = 0$ to 10V	-	19	25	
Gate plateau voltage	$V_{(plateau)}$	$V_{DD} = 480V$, $I_D = 4.5A$	-	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} .

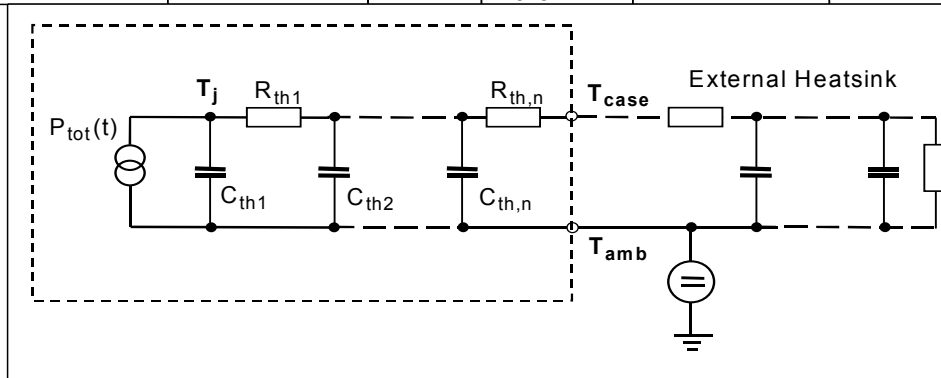
⁶ $C_{o(tr)}$ is a fixed capacitance that gives the same charging time as C_{oss} while V_{DS} is rising from 0 to 80% V_{DSS} .

Electrical Characteristics

Parameter	Symbol	Conditions	Values			Unit
			min.	typ.	max.	
Inverse diode continuous forward current	I_S	$T_C=25^\circ\text{C}$	-	-	4.5	A
Inverse diode direct current, pulsed	I_{SM}		-	-	13.5	
Inverse diode forward voltage	V_{SD}	$V_{GS}=0\text{V}, I_F=I_S$	-	1	1.2	V
Reverse recovery time	t_{rr}	$V_R=480\text{V}, I_F=I_S,$	-	300	500	ns
Reverse recovery charge	Q_{rr}	$di_F/dt=100\text{A}/\mu\text{s}$	-	2.6	-	μC
Peak reverse recovery current	I_{rrm}		-	18	-	A
Peak rate of fall of reverse recovery current	di_{rr}/dt	$T_j=25^\circ\text{C}$	-	900	-	$\text{A}/\mu\text{s}$

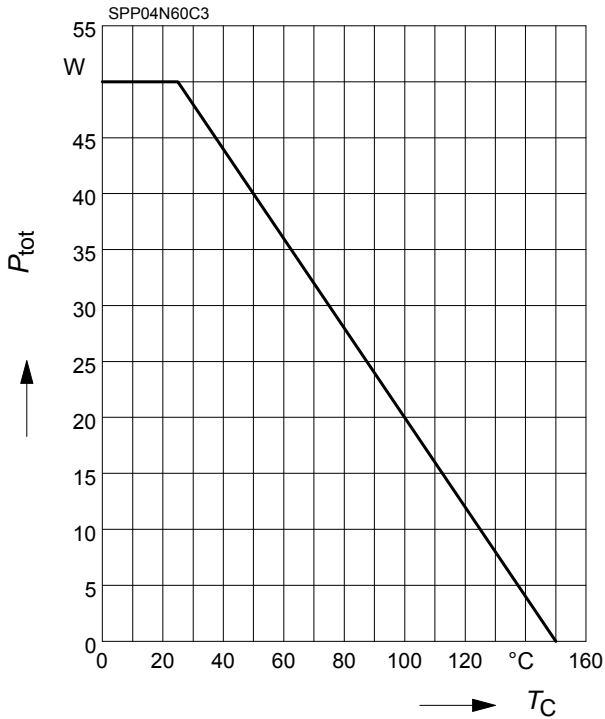
Typical Transient Thermal Characteristics

Symbol	Value		Unit	Symbol	Value		Unit
	SPP_B	SPA			SPP_B	SPA	
R_{th1}	0.039	0.039	K/W	C_{th1}	0.00007347	0.00007347	Ws/K
R_{th2}	0.074	0.074		C_{th2}	0.0002831	0.0002831	
R_{th3}	0.132	0.132		C_{th3}	0.0004062	0.0004062	
R_{th4}	0.555	0.272		C_{th4}	0.001215	0.001215	
R_{th5}	0.529	0.559		C_{th5}	0.00276	0.005633	
R_{th6}	0.169	2.523		C_{th6}	0.029	0.412	



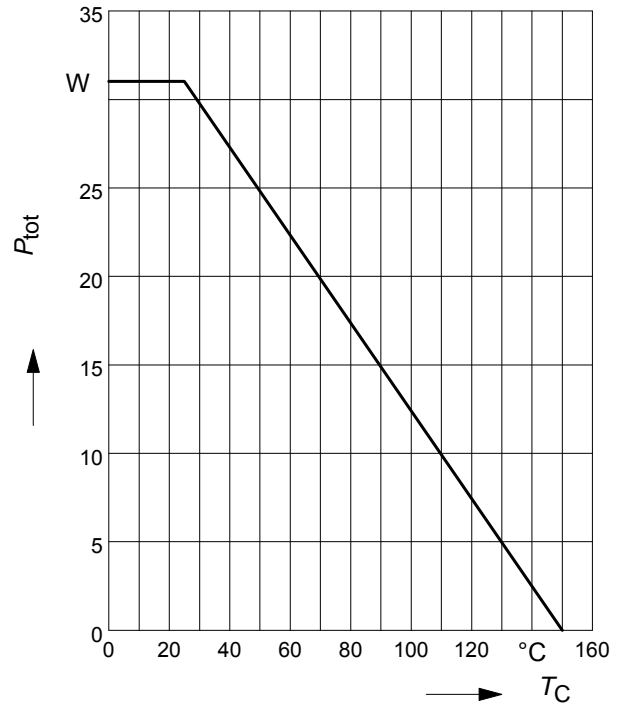
1 Power dissipation

$P_{tot} = f(T_C)$



2 Power dissipation FullPAK

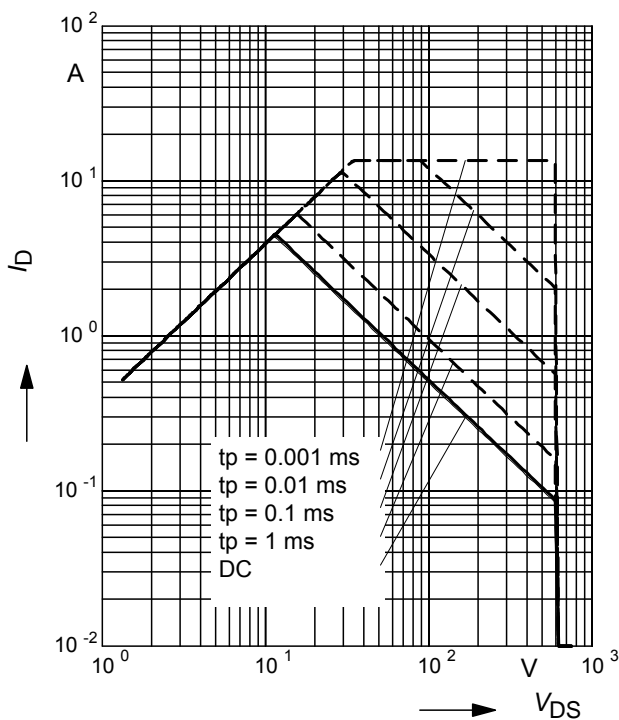
$P_{tot} = f(T_C)$



3 Safe operating area

$I_D = f(V_{DS})$

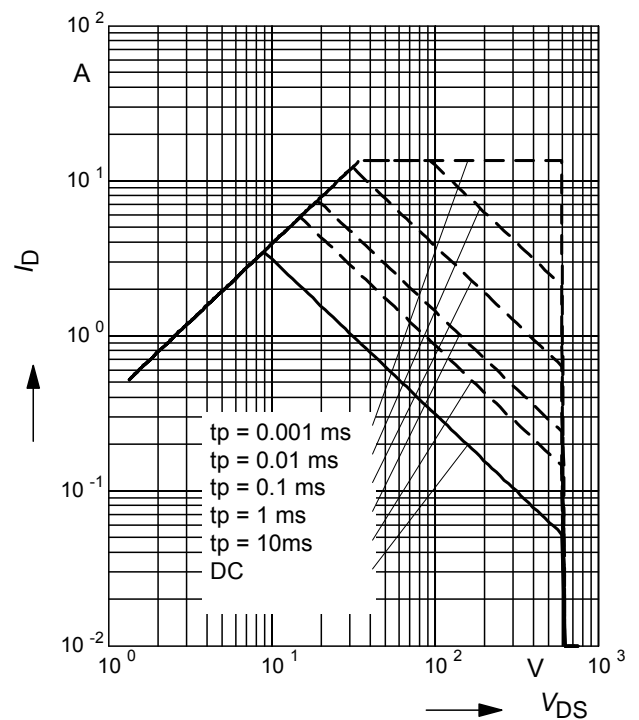
parameter : $D = 0$, $T_C = 25^\circ\text{C}$



4 Safe operating area FullPAK

$I_D = f(V_{DS})$

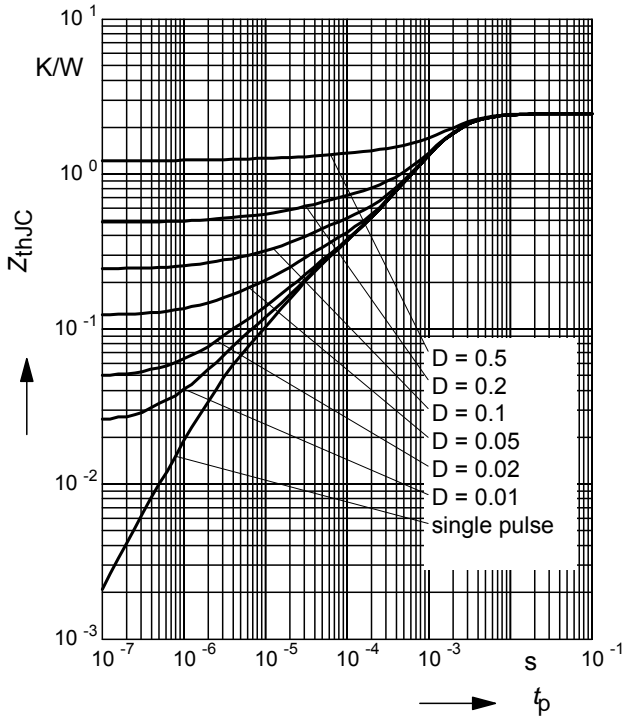
parameter: $D = 0$, $T_C = 25^\circ\text{C}$



5 Transient thermal impedance

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

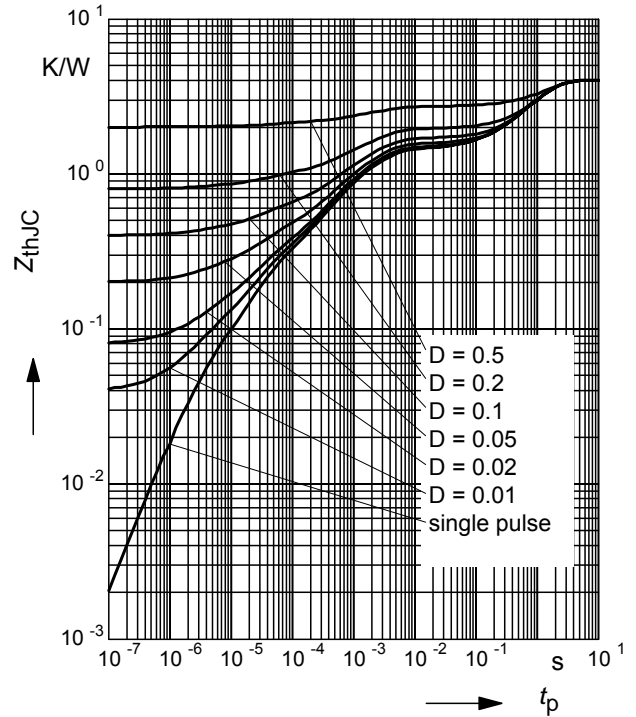
parameter: $D = t_p/T$



6 Transient thermal impedance FullPAK

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

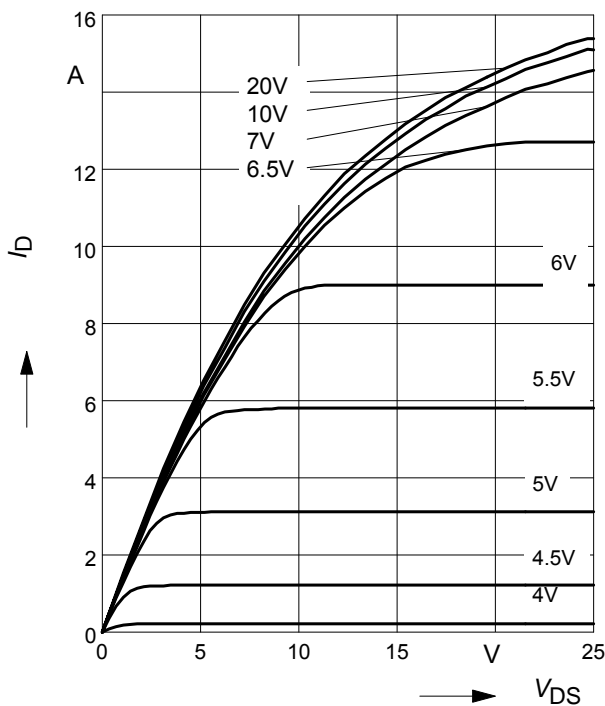
parameter: $D = t_p/t$



7 Typ. output characteristic

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

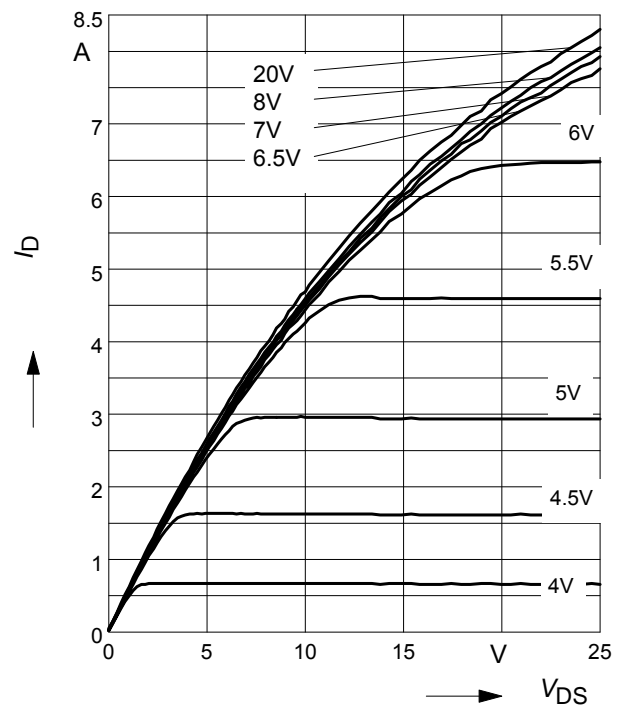
parameter: $t_p = 10 \mu\text{s}, V_{GS}$



8 Typ. output characteristic

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

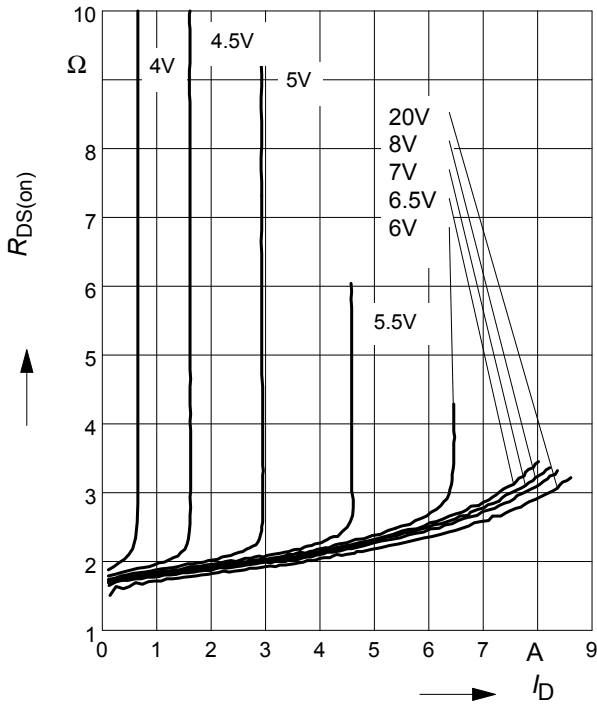
parameter: $t_p = 10 \mu\text{s}, V_{GS}$



9 Typ. drain-source on resistance

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

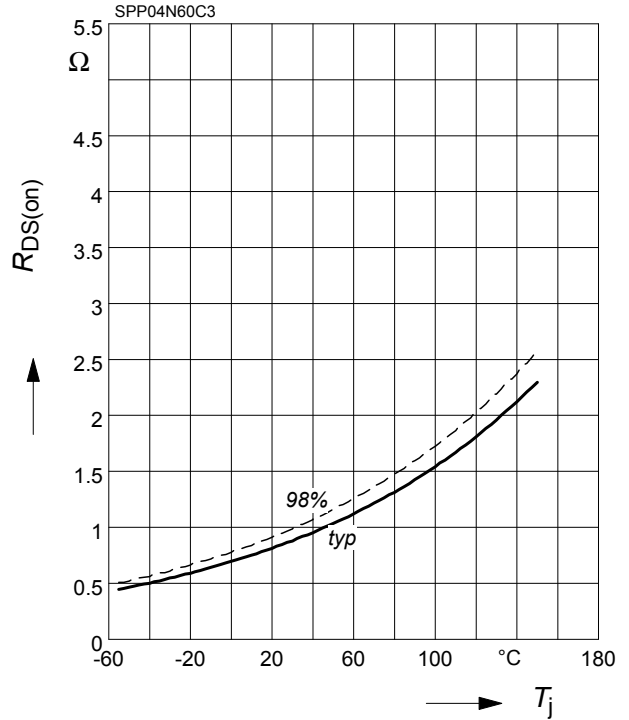
parameter: $T_j = 150^\circ\text{C}$, V_{GS}



10 Drain-source on-state resistance

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

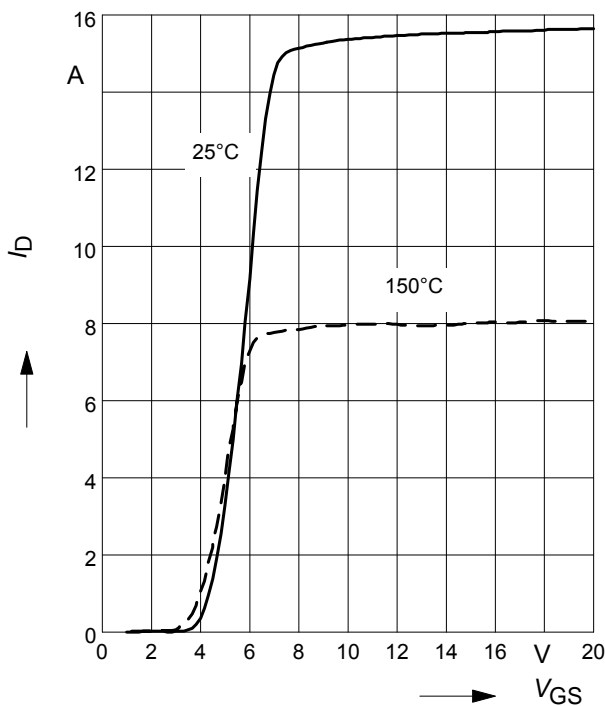
parameter: $I_D = 2.8\text{ A}$, $V_{GS} = 10\text{ V}$



11 Typ. transfer characteristics

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

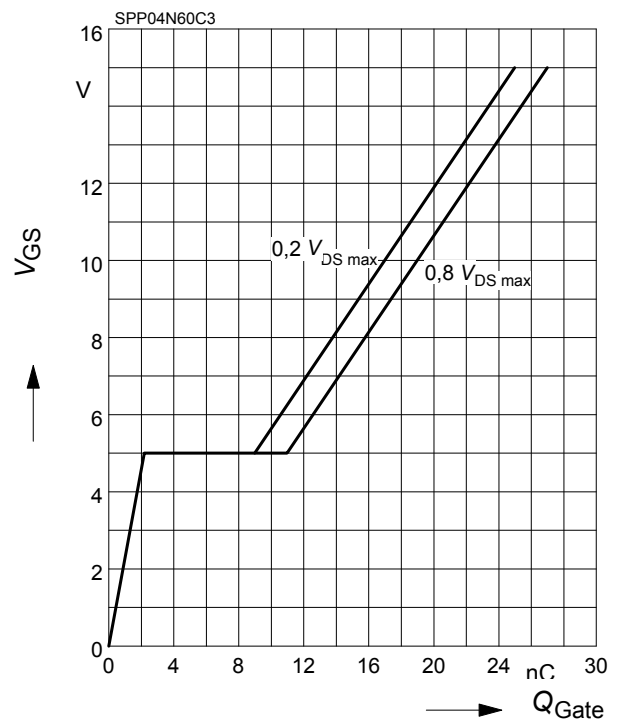
parameter: $t_p = 10\ \mu\text{s}$



12 Typ. gate charge

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

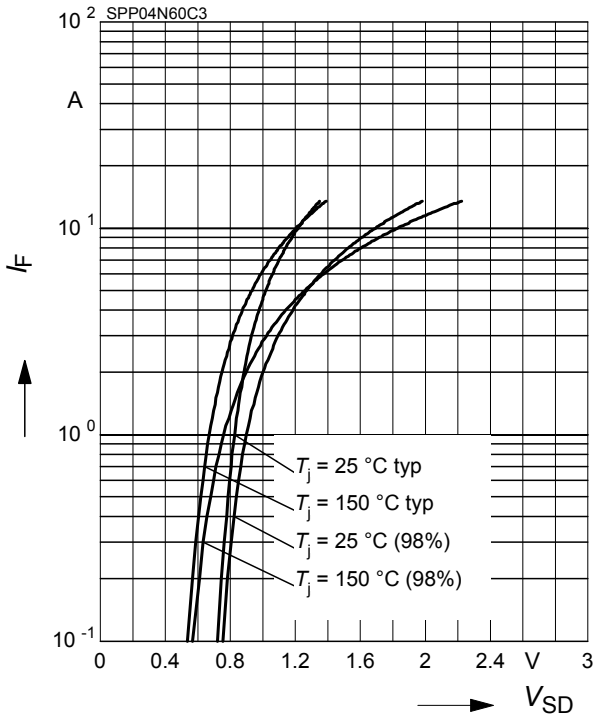
parameter: $I_D = 4.5\text{ A pulsed}$



13 Forward characteristics of body diode

$I_F = f(V_{SD})$

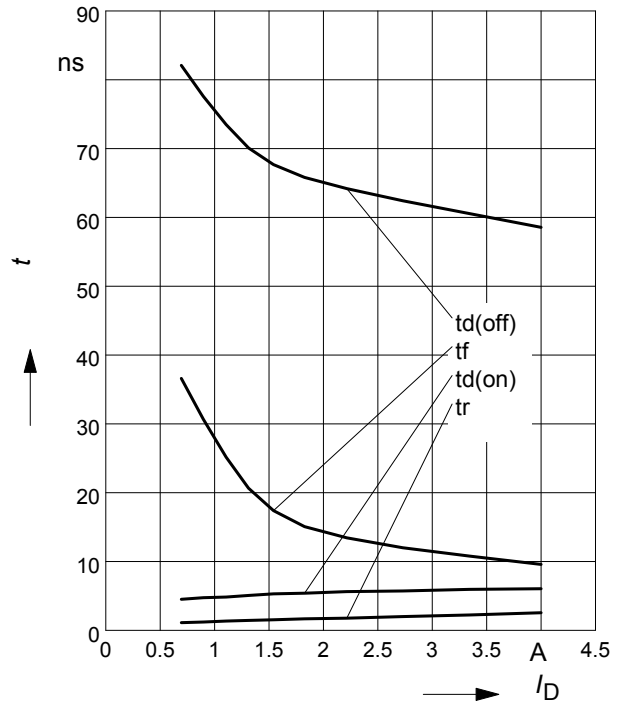
parameter: T_j , $t_p = 10 \mu s$



14 Typ. switching time

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

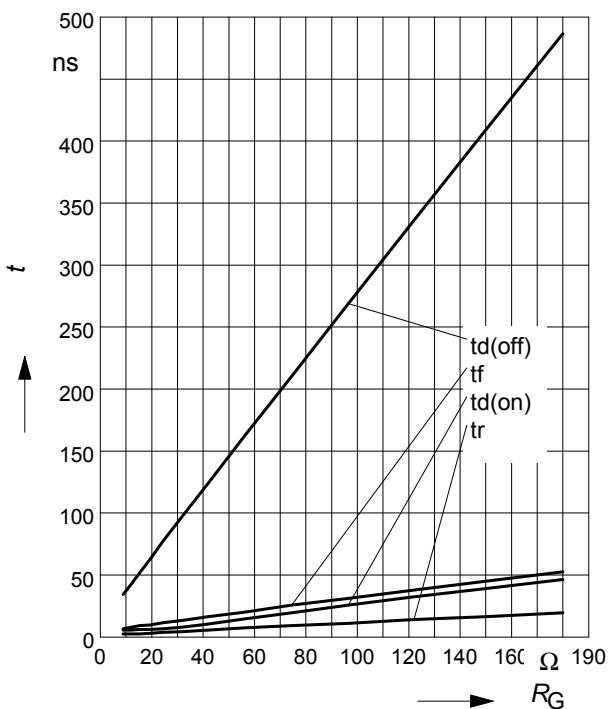
par.: $V_{DS} = 380V$, $V_{GS} = 0/+13V$, $R_G = 18\Omega$



15 Typ. switching time

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

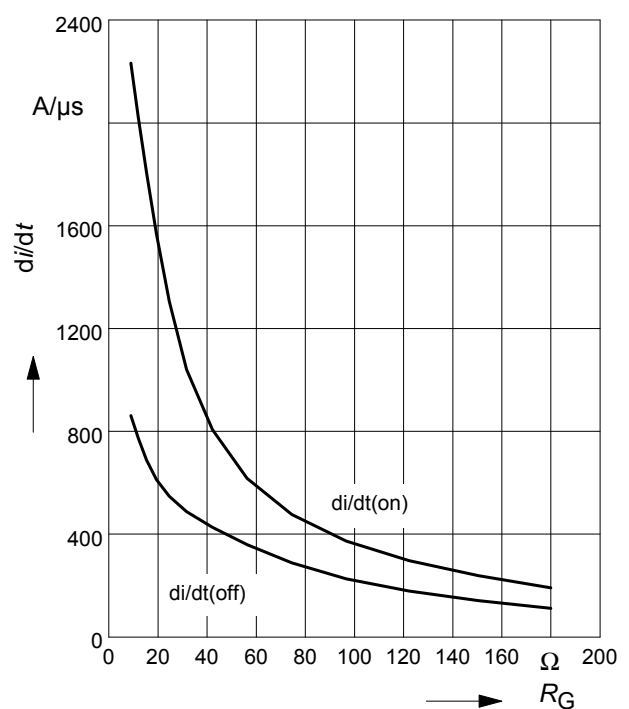
par.: $V_{DS} = 380V$, $V_{GS} = 0/+13V$, $I_D = 4.5 A$



16 Typ. drain current slope

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

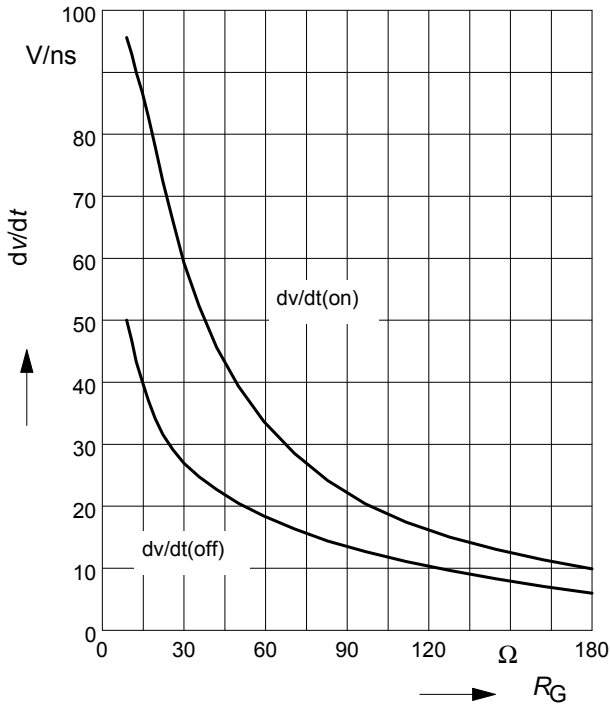
par.: $V_{DS} = 380V$, $V_{GS} = 0/+13V$, $I_D = 4.5A$



17 Typ. drain source voltage slope

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

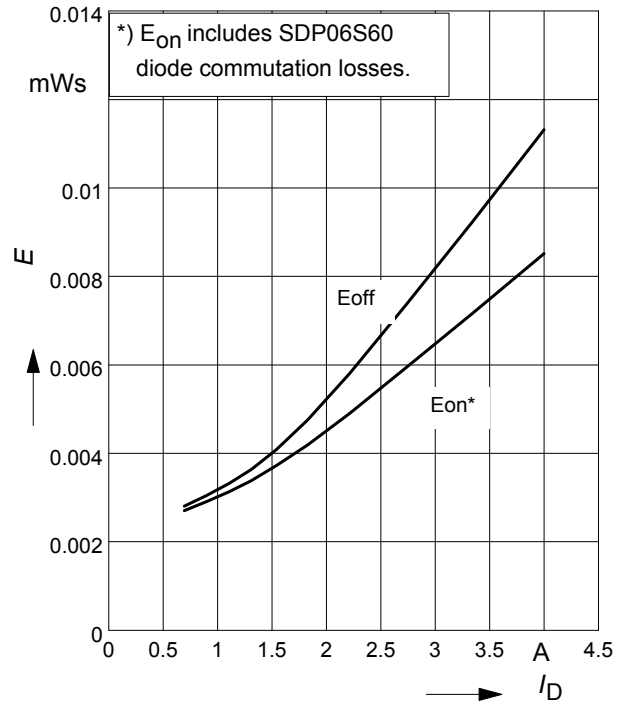
par.: $V_{DS}=380\text{V}$, $V_{GS}=0/+13\text{V}$, $I_D=4.5\text{A}$



18 Typ. switching losses

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

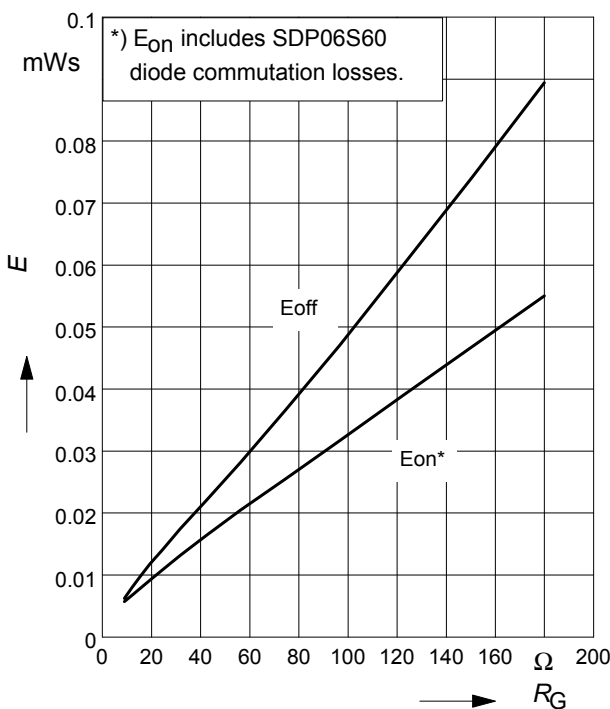
par.: $V_{DS}=380\text{V}$, $V_{GS}=0/+13\text{V}$, $R_G=18\Omega$



19 Typ. switching losses

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

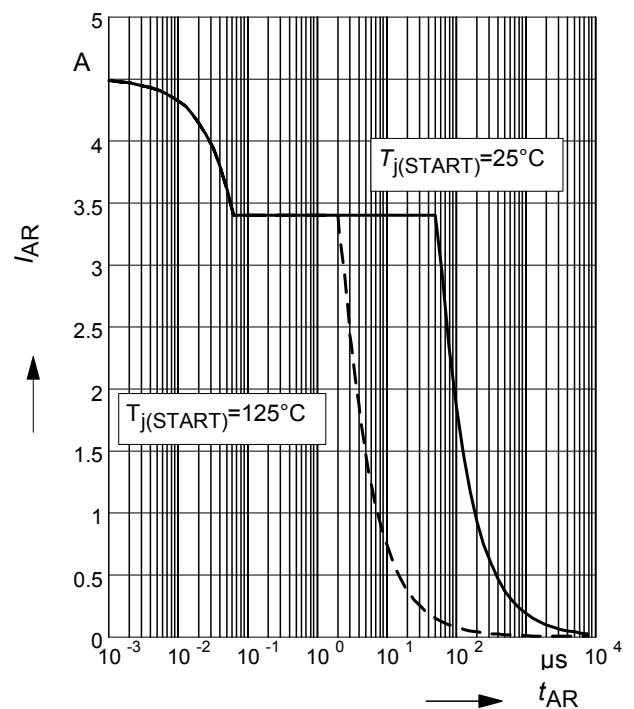
par.: $V_{DS}=380\text{V}$, $V_{GS}=0/+13\text{V}$, $I_D=4.5\text{A}$



20 Avalanche SOA

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

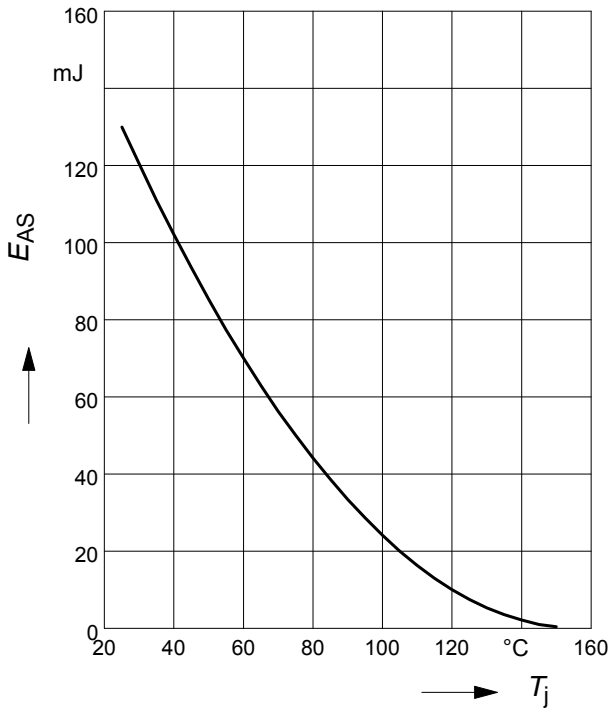
par.: $T_j \leq 150^\circ\text{C}$



21 Avalanche energy

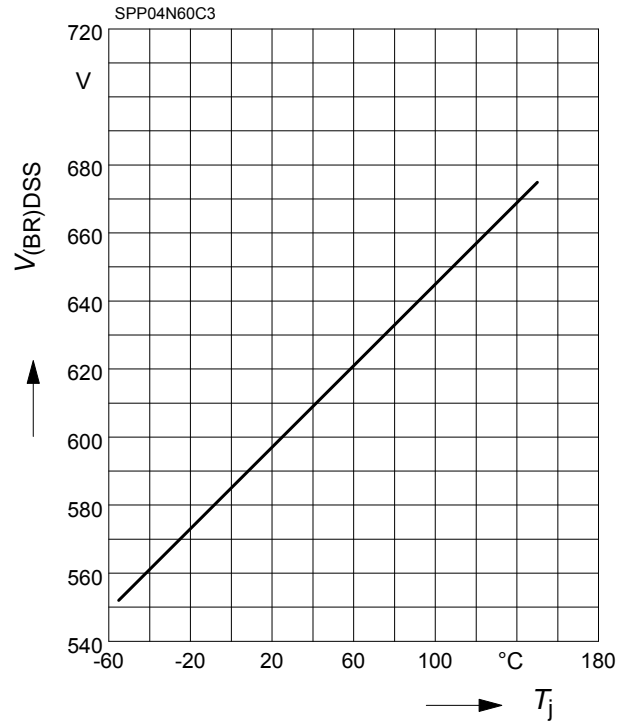
$$E_{AS} = f(T_j)$$

par.: $I_D = 3.4$, $V_{DD} = 50$ V



22 Drain-source breakdown voltage

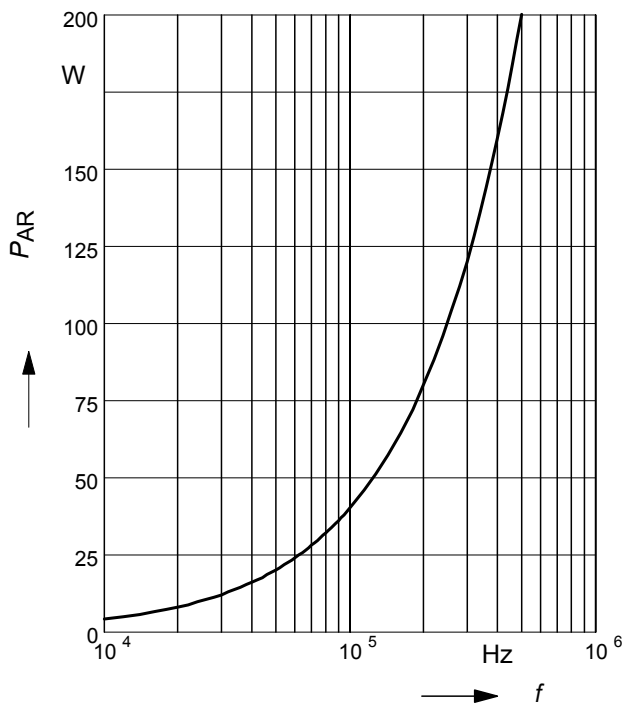
$$V_{(BR)DSS} = f(T_j)$$



23 Avalanche power losses

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

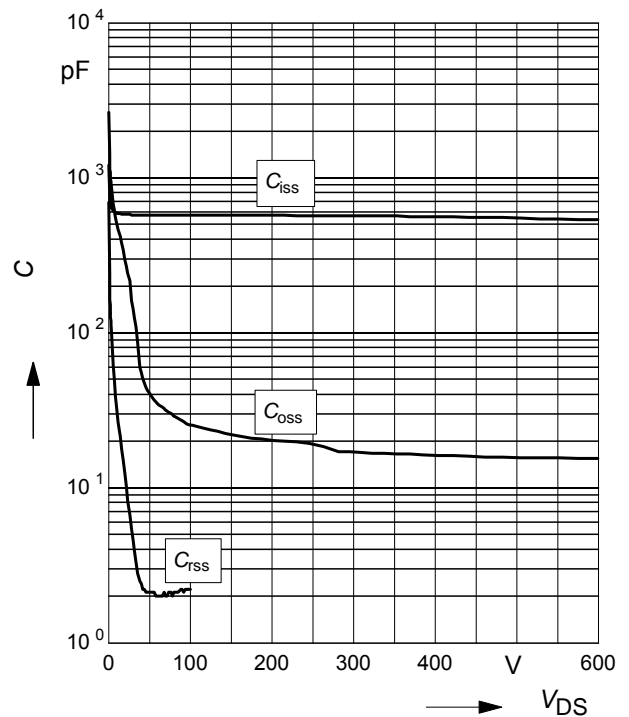
parameter: $E_{AR} = 0.4$ mJ



24 Typ. capacitances

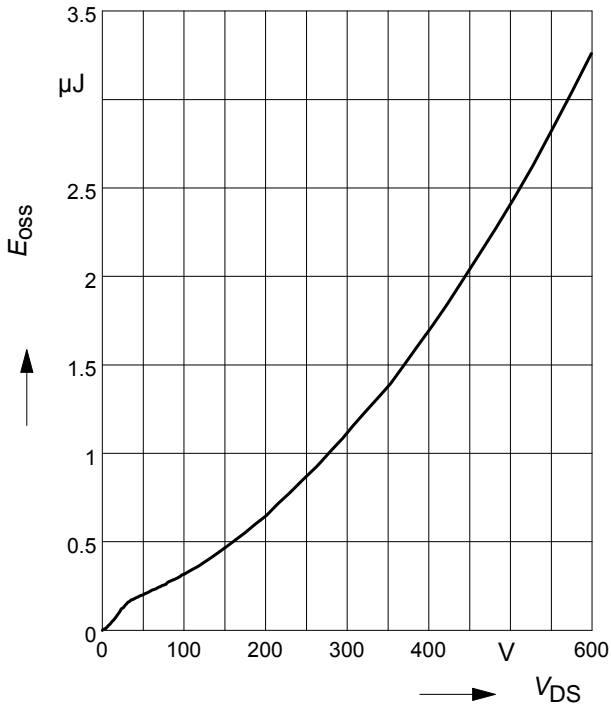
$$C = f(V_{DS})$$

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

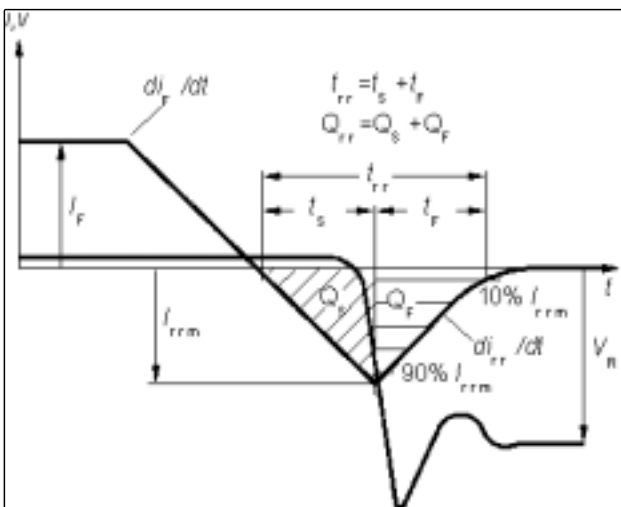


25 Typ. C_{OSS} stored energy

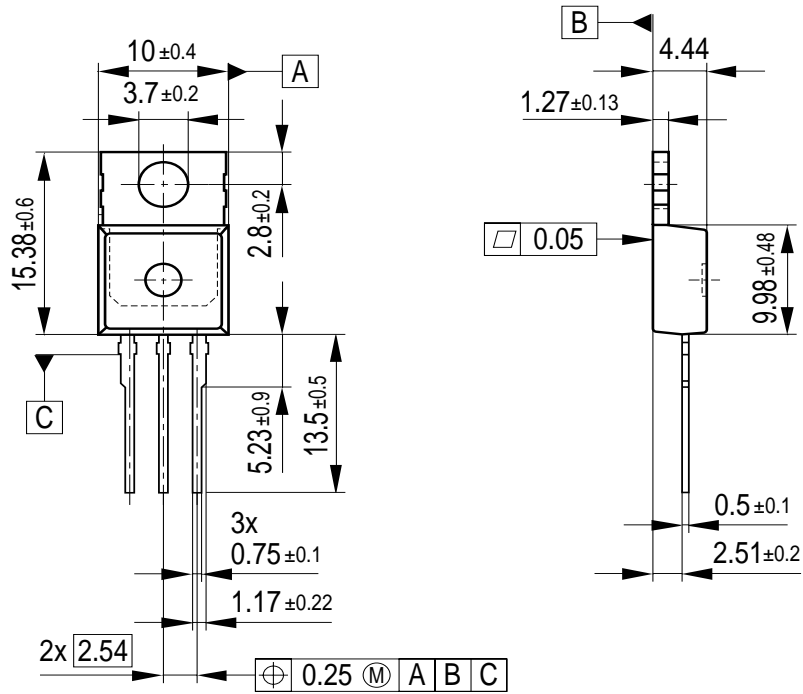
$$E_{OSS} = f(V_{DS})$$



Definition of diodes switching characteristics

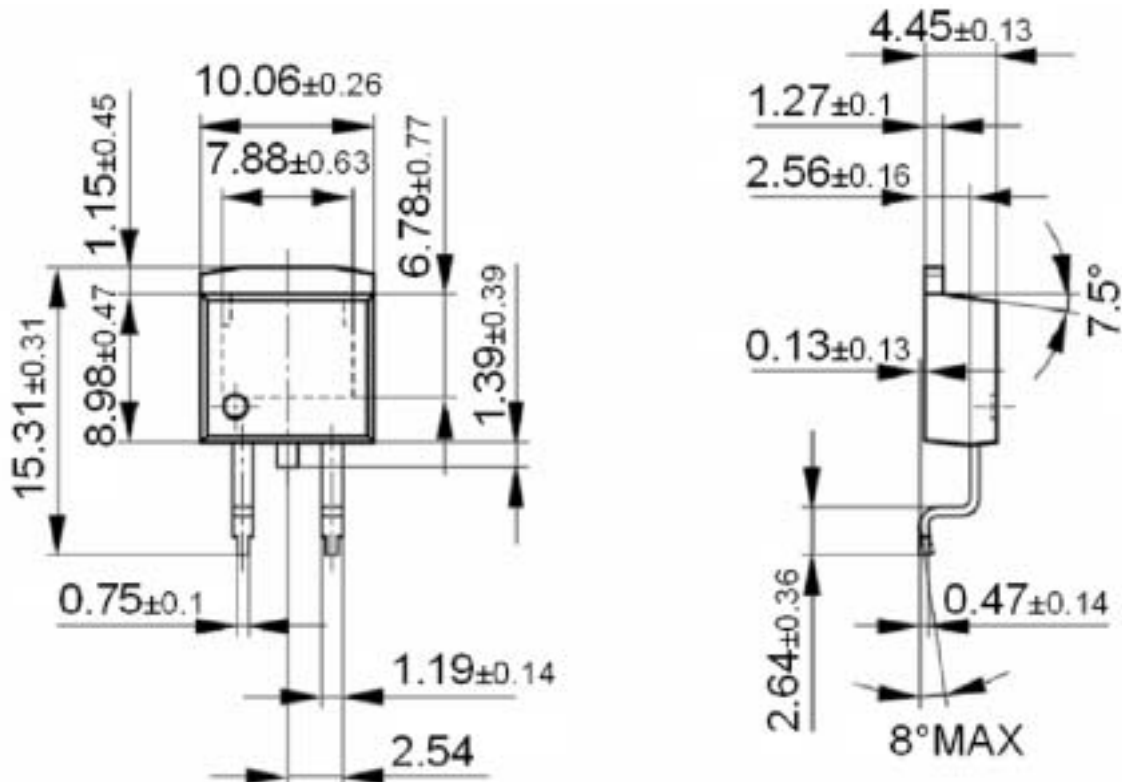


P-TO-220-3-1

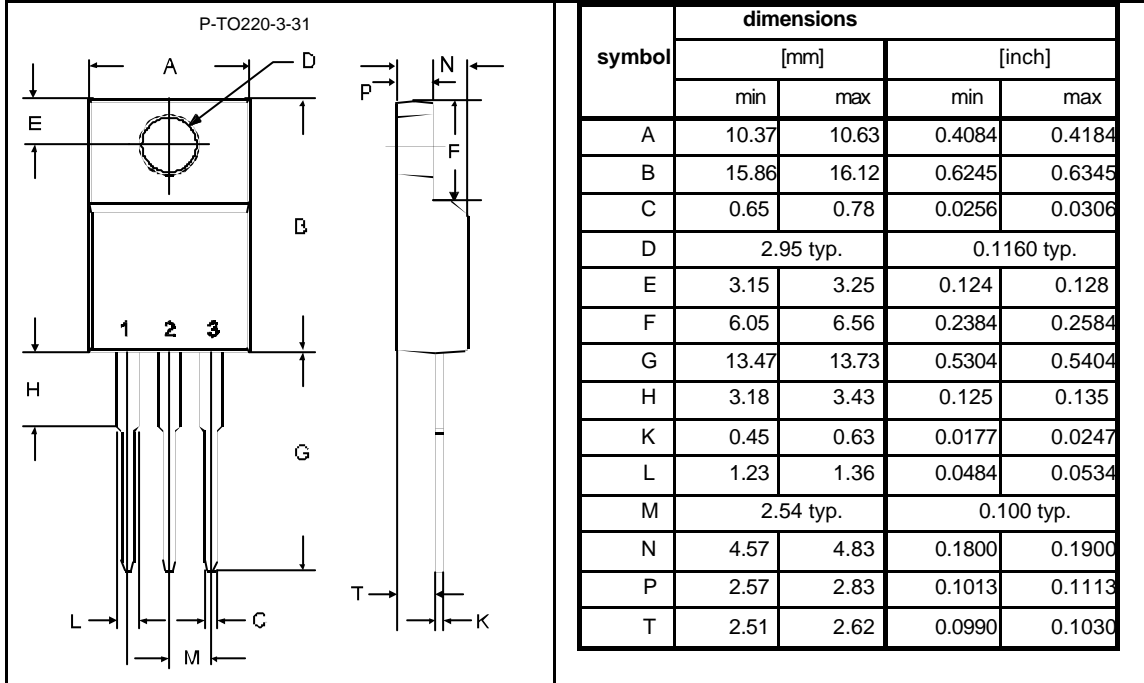


All metal surfaces tin plated, except area of cut.
Metal surface min. $x=7.25$, $y=12.3$

P-TO-263-3-2 (D²-PAK)



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



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