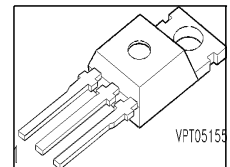


Cool MOS™ Power Transistor
Feature

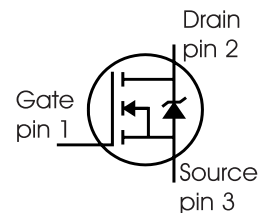
- New revolutionary high voltage technology
- Ultra low gate charge
- Periodic avalanche rated
- Extreme dv/dt rated
- Ultra low effective capacitances
- Pb-free lead plating; RoHS compliant
- Qualified according to JEDEC⁰⁾ for target applications

$V_{DS} @ T_{jmax}$	650	V
$R_{DS(on)}$	3	Ω
I_D	1.8	A

PG-TO220



Type	Package	Ordering Code	Marking
SPP02N60C3	PG-TO220	Q67040-S4392	02N60C3


Maximum Ratings

Parameter	Symbol	Value	Unit
Continuous drain current $T_C = 25\text{ °C}$ $T_C = 100\text{ °C}$	I_D	1.8 1.1	A
Pulsed drain current, t_p limited by T_{jmax}	$I_{D\text{ puls}}$	5.4	
Avalanche energy, single pulse $I_D = 1.35\text{ A}$, $V_{DD} = 50\text{ V}$	E_{AS}	50	mJ
Avalanche energy, repetitive t_{AR} limited by T_{jmax} ¹⁾ $I_D = 1.8\text{ A}$, $V_{DD} = 50\text{ V}$	E_{AR}	0.07	
Avalanche current, repetitive t_{AR} limited by T_{jmax}	I_{AR}	1.8	A
Gate source voltage static	V_{GS}	± 20	V
Gate source voltage AC ($f > 1\text{ Hz}$)	V_{GS}	± 30	
Power dissipation, $T_C = 25\text{ °C}$	P_{tot}	25	W
Operating and storage temperature	T_j, T_{stg}	-55... +150	°C
Reverse diode dv/dt ⁶⁾	dv/dt	15	V/ns

Maximum Ratings

Parameter	Symbol	Value	Unit
Drain Source voltage slope $V_{DS} = 480 \text{ V}$, $I_D = 1.8 \text{ A}$, $T_j = 125 \text{ }^\circ\text{C}$	dv/dt	50	V/ns

Thermal Characteristics

Parameter	Symbol	Values			Unit
		min.	typ.	max.	
Thermal resistance, junction - case	R_{thJC}	-	-	5	K/W
Thermal resistance, junction - ambient, leaded	R_{thJA}	-	-	62	
SMD version, device on PCB: @ min. footprint @ 6 cm ² cooling area ²⁾	R_{thJA}	-	-	62	
Soldering temperature, wavesoldering 1.6 mm (0.063 in.) from case for 10s ³⁾	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	$V_{(BR)DS}$	$V_{GS}=0\text{V}$, $I_D=0.25\text{A}$	-	700	-	
Gate threshold voltage	$V_{GS(th)}$	$I_D=80\mu\text{A}$, $V_{GS}=V_{DS}$	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	$R_{DS(on)}$	$V_{GS}=10\text{V}$, $I_D=1.1\text{A}$, $T_j=25^\circ\text{C}$ $T_j=150^\circ\text{C}$	-	2.7	3	Ω
Gate input resistance	R_G	$f=1\text{MHz}$, open Drain	-	9	-	

Electrical Characteristics , at $T_j = 25\text{ }^\circ\text{C}$, unless otherwise specified

Parameter	Symbol	Conditions	Values			Unit
			min.	typ.	max.	
Transconductance	g_{fs}	$V_{DS} \geq 2 \cdot I_D \cdot R_{DS(on)max}$, $I_D = 1.1\text{A}$	-	1.75	-	S
Input capacitance	C_{iss}	$V_{GS} = 0\text{V}$, $V_{DS} = 25\text{V}$, $f = 1\text{MHz}$	-	200	-	pF
Output capacitance	C_{oss}		-	90	-	
Reverse transfer capacitance	C_{rss}		-	4	-	
Effective output capacitance, ⁴⁾ energy related	$C_{o(er)}$	$V_{GS} = 0\text{V}$, $V_{DS} = 0\text{V to } 480\text{V}$	-	8.1	-	pF
Effective output capacitance, ⁵⁾ time related	$C_{o(tr)}$		-	15.7	-	
Turn-on delay time	$t_{d(on)}$	$V_{DD} = 350\text{V}$, $V_{GS} = 0/10\text{V}$, $I_D = 1.8\text{A}$, $R_G = 50\Omega$	-	6	-	ns
Rise time	t_r		-	3	-	
Turn-off delay time	$t_{d(off)}$		-	68	70	
Fall time	t_f		-	12	30	

Gate Charge Characteristics

Gate to source charge	Q_{gs}	$V_{DD} = 420\text{V}$, $I_D = 1.8\text{A}$	-	1.6	-	nC
Gate to drain charge	Q_{gd}		-	3.8	-	
Gate charge total	Q_g	$V_{DD} = 420\text{V}$, $I_D = 1.8\text{A}$, $V_{GS} = 0\text{ to } 10\text{V}$	-	9.5	12.5	
Gate plateau voltage	$V_{(plateau)}$	$V_{DD} = 420\text{V}$, $I_D = 1.8\text{A}$	-	5.5	-	V

⁰J-STD20 and JESD22

¹Repetitive avalanche causes additional power losses that can be calculated as $P_{AV} = E_{AR} \cdot f$.

²Device 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.

³Soldering temperature for TO-263: 220°C, reflow

⁴ $C_{o(er)}$ is a fixed capacitance that gives the same stored energy as C_{oss} while V_{DS} is rising from 0 to 80% V_{DSS} .

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

⁶ $I_{SD} \leq I_D$, $di/dt \leq 400\text{A/us}$, $V_{DClink} = 400\text{V}$, $V_{peak} < V_{BR, DSS}$, $T_j < T_{j,max}$.

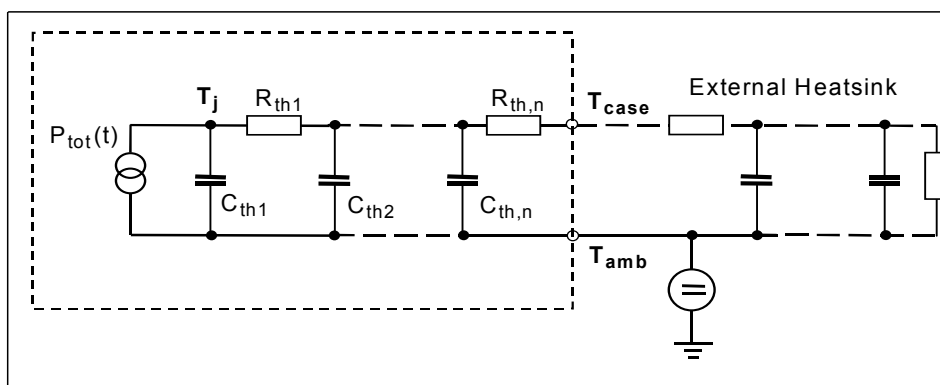
Identical low-side and high-side switch.

Electrical Characteristics, at $T_j = 25\text{ }^\circ\text{C}$, unless otherwise specified

Parameter	Symbol	Conditions	Values			Unit
			min.	typ.	max.	
Inverse diode continuous forward current	I_S	$T_C=25^\circ\text{C}$	-	-	1.8	A
Inverse diode direct current, pulsed	I_{SM}		-	-	5.4	
Inverse diode forward voltage	V_{SD}	$V_{GS}=0\text{V}, I_F=I_S$	-	1	1.2	V
Reverse recovery time	t_{rr}	$V_R=420\text{V}, I_F=I_S,$	-	200	350	ns
Reverse recovery charge	Q_{rr}	$di_F/dt=100\text{A}/\mu\text{s}$	-	1.3	-	μC
Peak reverse recovery current	I_{rrm}		-	9	-	A
Peak rate of fall of reverse recovery current	di_{rr}/dt		-	-	200	$\text{A}/\mu\text{s}$

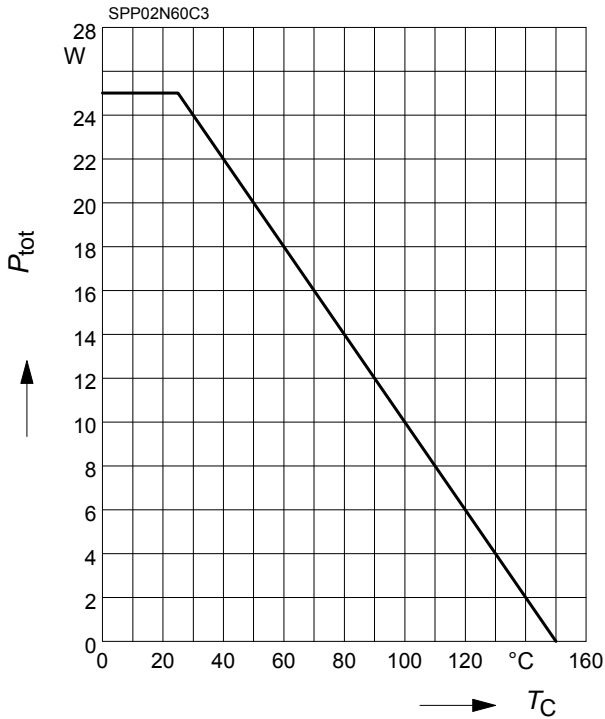
Typical Transient Thermal Characteristics

Symbol	Value	Unit	Symbol	Value	Unit
	typ.			typ.	
Thermal resistance			Thermal capacitance		
R_{th1}	0.1	K/W	C_{th1}	0.00002806	Ws/K
R_{th2}	0.184		C_{th2}	0.0001113	
R_{th3}	0.306		C_{th3}	0.0001679	
R_{th4}	1.207		C_{th4}	0.000547	
R_{th5}	0.974		C_{th5}	0.001388	
R_{th6}	0.251		C_{th6}	0.035	



1 Power dissipation

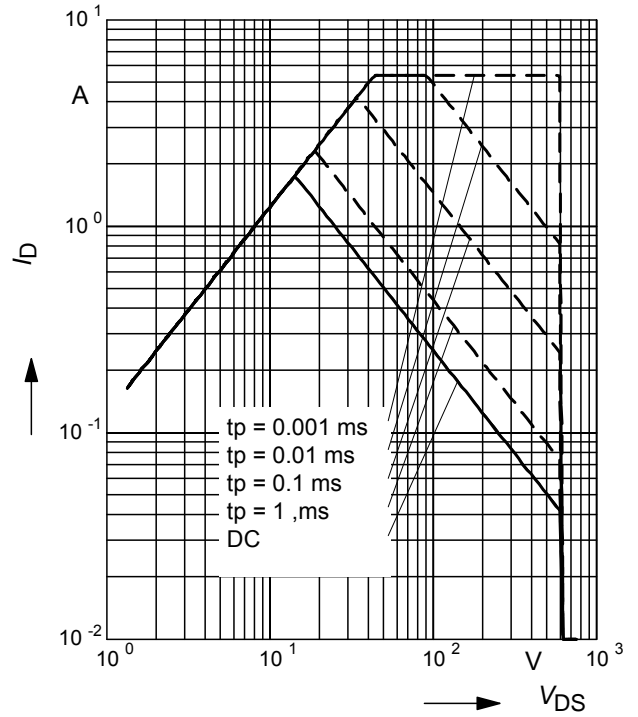
$$P_{tot} = f(T_C)$$



2 Safe operating area

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

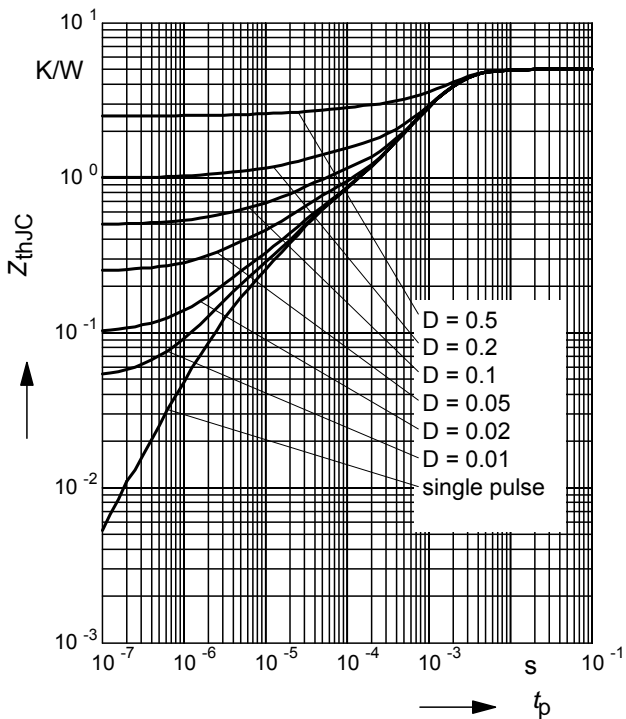
parameter : $D = 0$, $T_C = 25^\circ C$



3 Transient thermal impedance

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

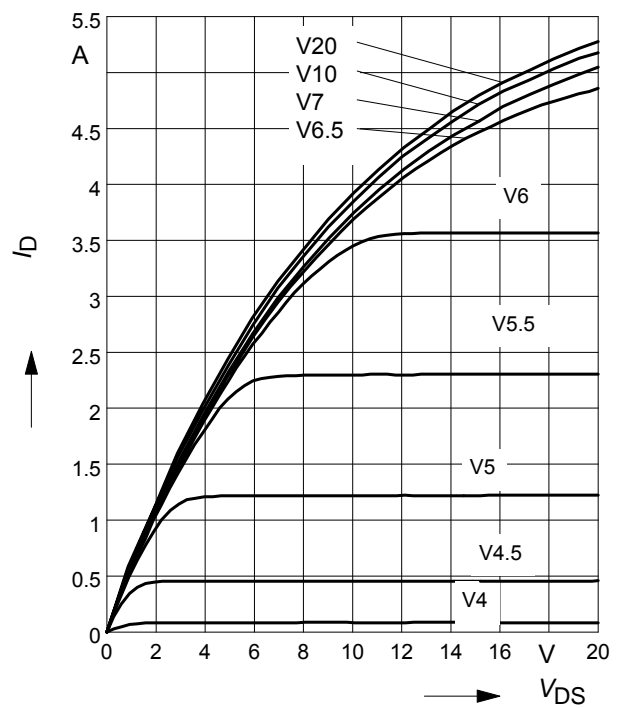
parameter: $D = t_p/T$



4 Typ. output characteristic

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

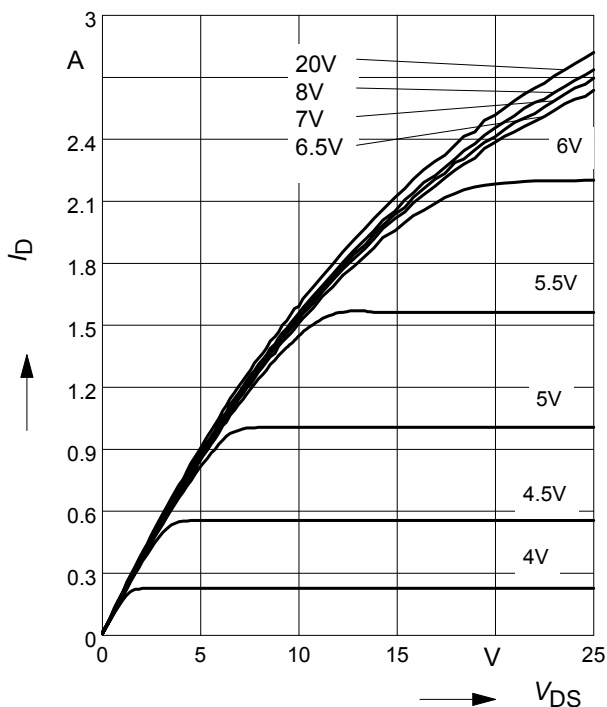
parameter: $t_p = 10 \mu s$, V_{GS}



5 Typ. output characteristic

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

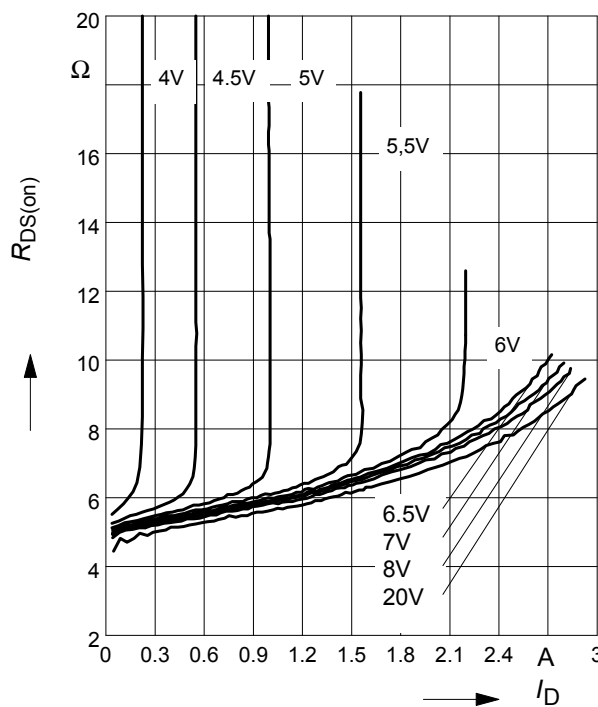
parameter: $t_p = 10 \mu\text{s}, V_{GS}$



6 Typ. drain-source on resistance

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

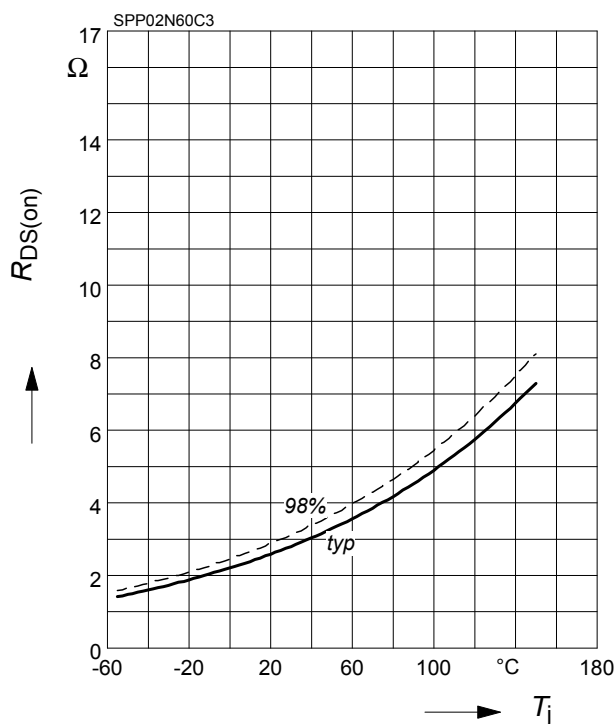
parameter: $T_j = 150^\circ\text{C}, V_{GS}$



7 Drain-source on-state resistance

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

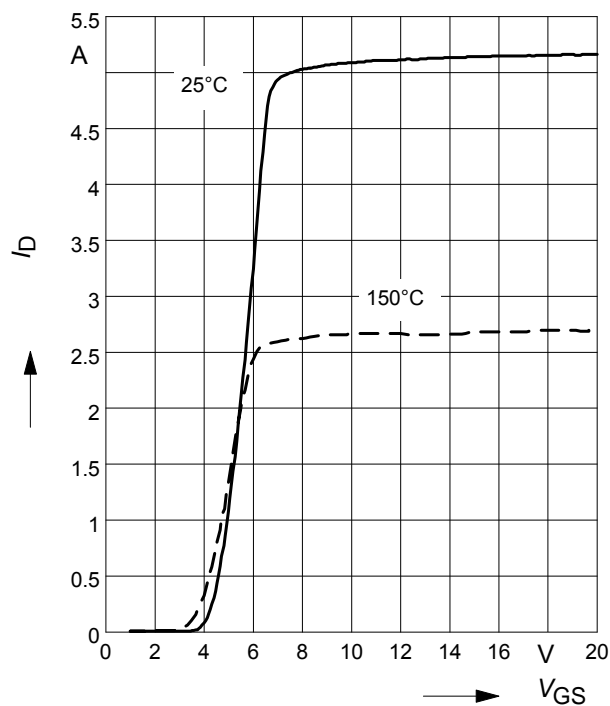
parameter: $I_D = 1.1 \text{ A}, V_{GS} = 10 \text{ V}$



8 Typ. transfer characteristics

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

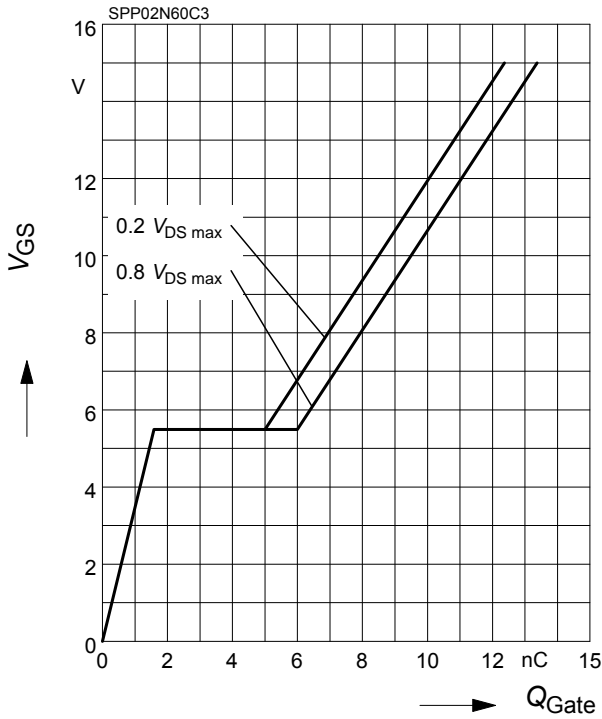
parameter: $t_p = 10 \mu\text{s}$



9 Typ. gate charge

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

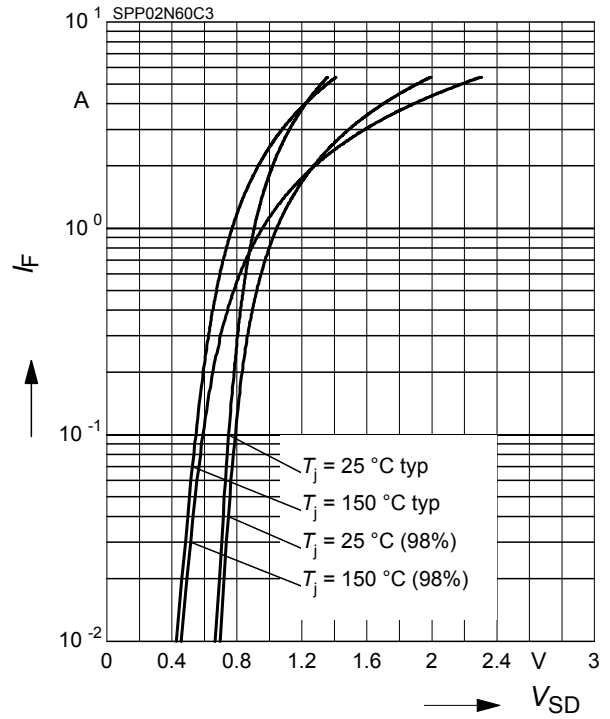
parameter: $I_D = 1.8\text{ A}$ pulsed



10 Forward characteristics of body diode

$I_F = f(V_{SD})$

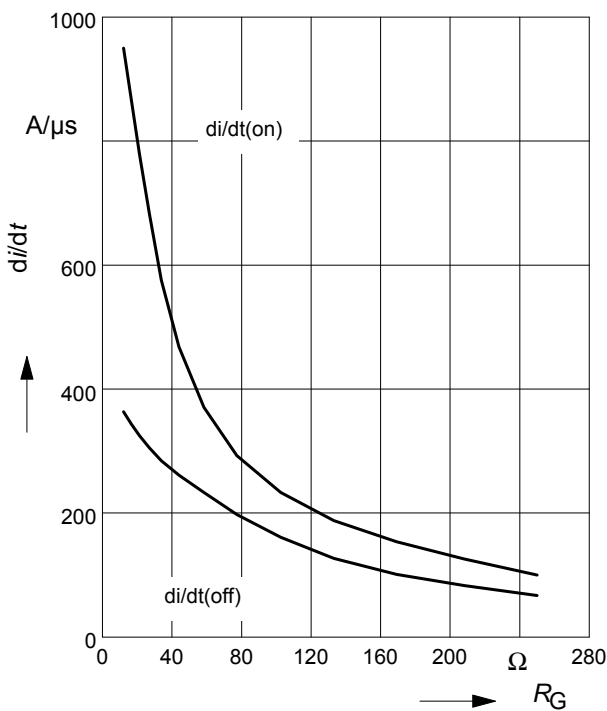
parameter: $T_j, t_p = 10\ \mu\text{s}$



11 Typ. drain current slope

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

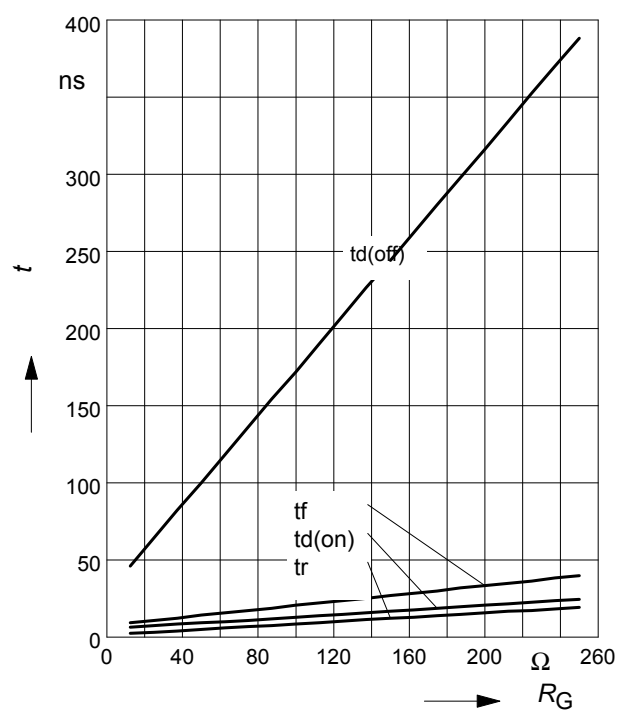
par.: $V_{DS} = 380\text{V}$, $V_{GS} = 0/+13\text{V}$, $I_D = 1.8\text{A}$



12 Typ. switching time

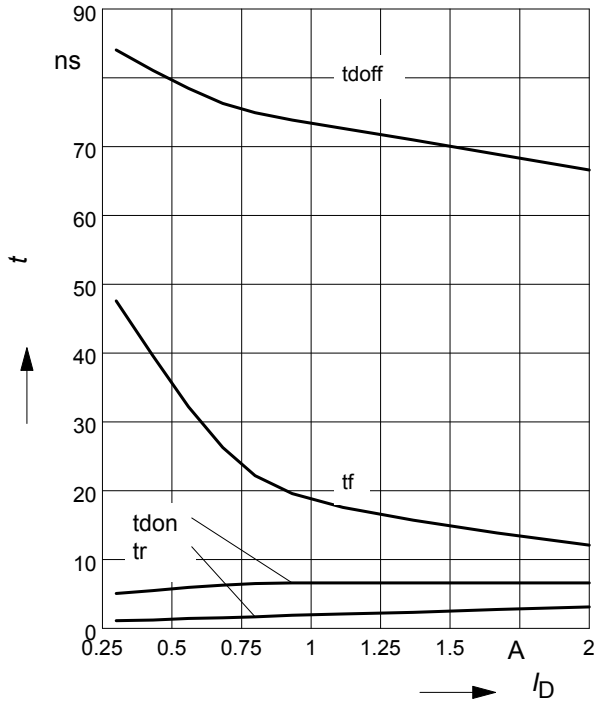
$t = f(R_G)$, inductive load, $T_j = 125^\circ\text{C}$

par.: $V_{DS} = 380\text{V}$, $V_{GS} = 0/+13\text{V}$, $I_D = 1.8\text{A}$



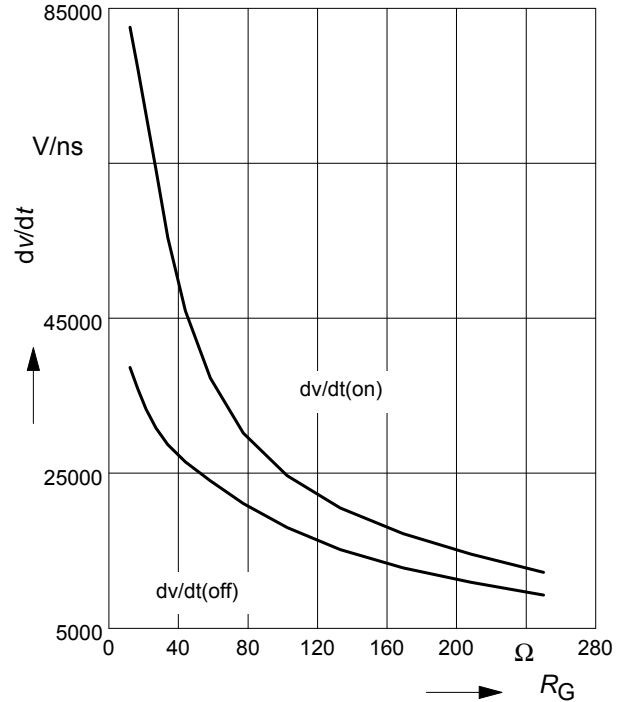
13 Typ. switching time

$t = f(I_D)$, inductive load, $T_j=125^\circ\text{C}$
 par.: $V_{DS}=380\text{V}$, $V_{GS}=0/+13\text{V}$, $R_G=50\Omega$



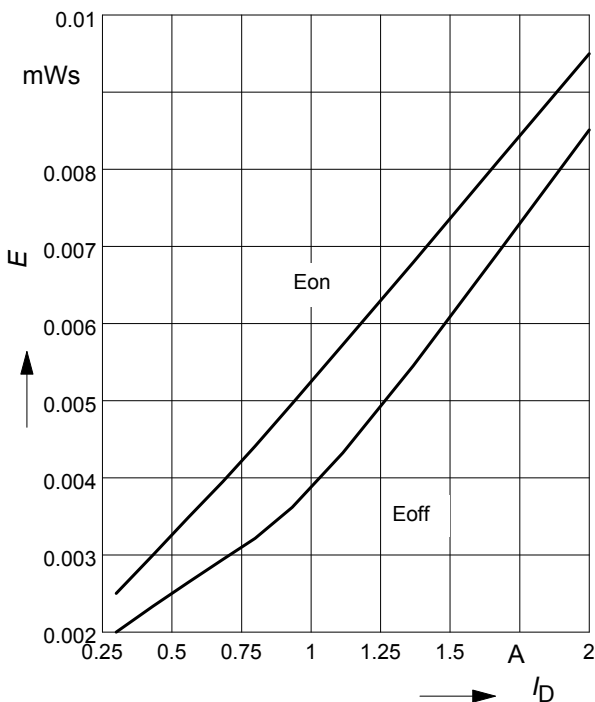
14 Typ. drain source voltage slope

$dv/dt = f(R_G)$, inductive load, $T_j = 125^\circ\text{C}$
 par.: $V_{DS}=380\text{V}$, $V_{GS}=0/+13\text{V}$, $I_D=1.8\text{A}$



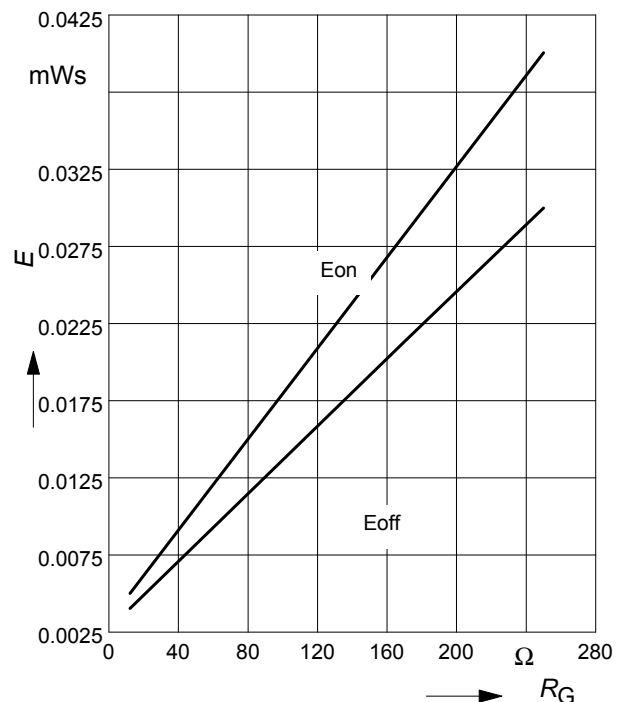
15 Typ. switching losses

$E = f(I_D)$, inductive load, $T_j=125^\circ\text{C}$
 par.: $V_{DS}=380\text{V}$, $V_{GS}=0/+13\text{V}$, $R_G=50\Omega$



16 Typ. switching losses

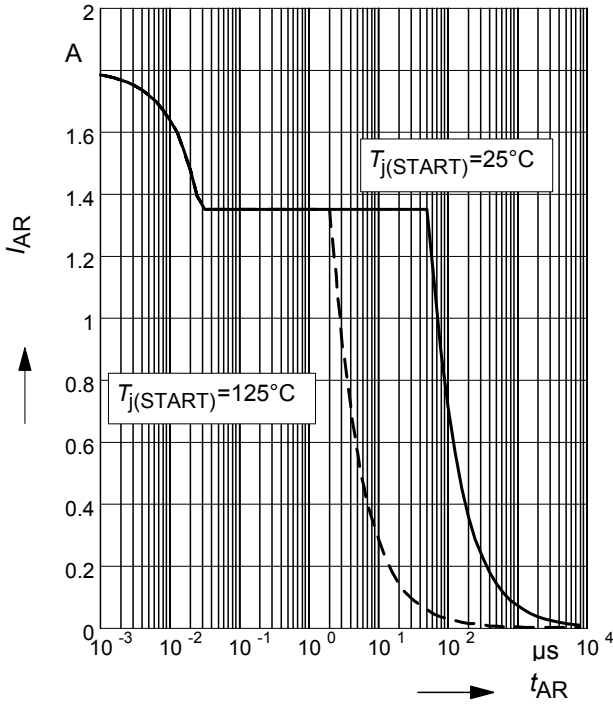
$E = f(R_G)$, inductive load, $T_j=125^\circ\text{C}$
 par.: $V_{DS}=380\text{V}$, $V_{GS}=0/+13\text{V}$, $I_D=1.8\text{A}$



17 Avalanche SOA

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

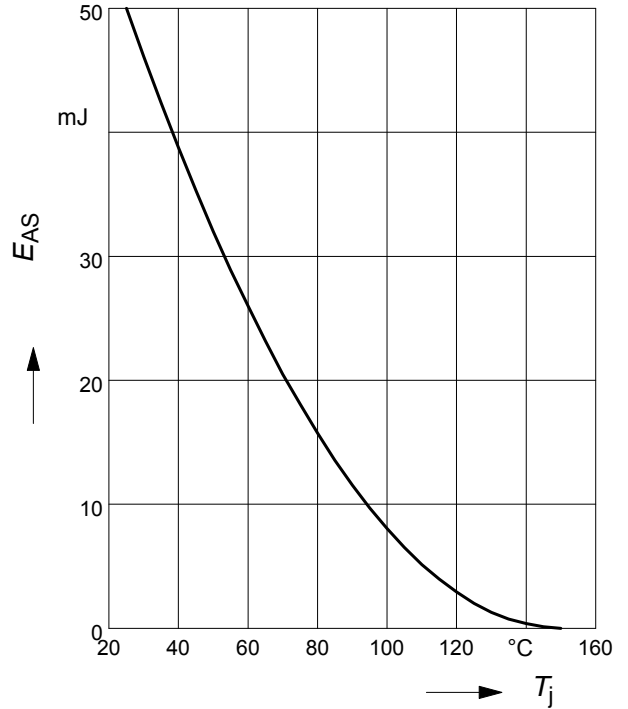
par.: $T_j \leq 150\text{ }^\circ\text{C}$



18 Avalanche energy

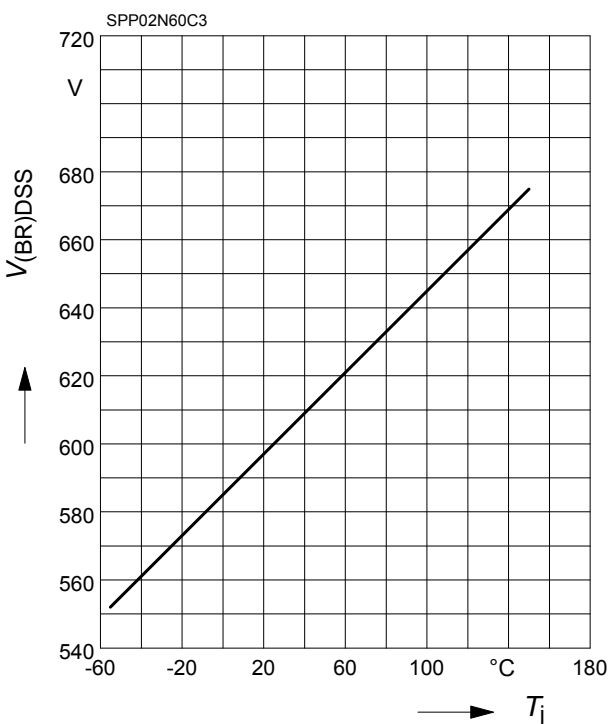
$$E_{AS} = f(T_j)$$

par.: $I_D = 1.35\text{ A}$, $V_{DD} = 50\text{ V}$



19 Drain-source breakdown voltage

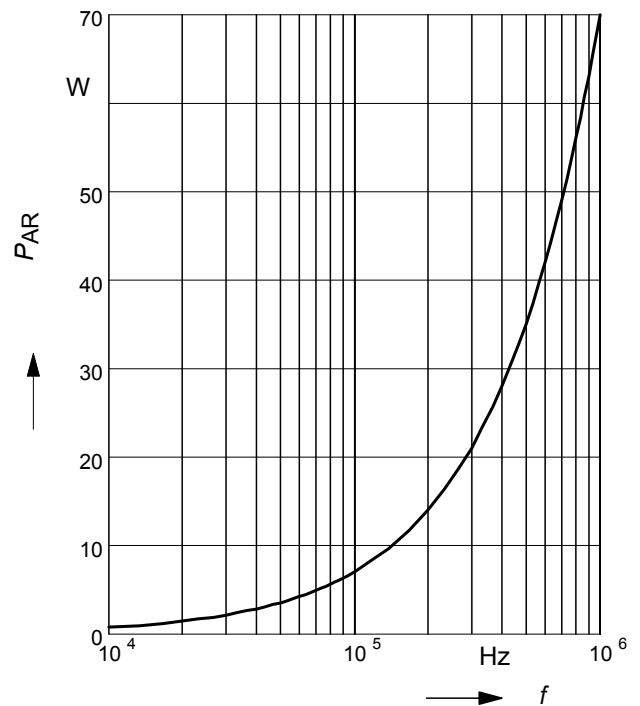
$$V_{(BR)DSS} = f(T_j)$$



20 Avalanche power losses

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

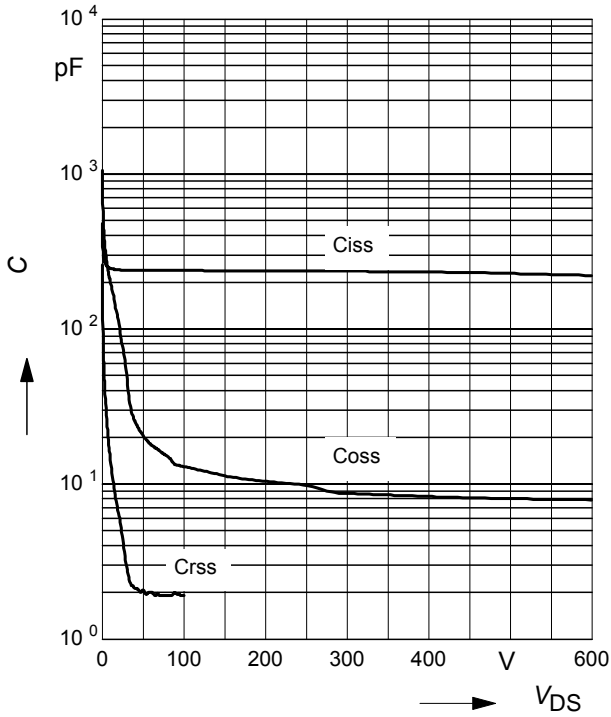
parameter: $E_{AR} = 0.07\text{ mJ}$



21 Typ. capacitances

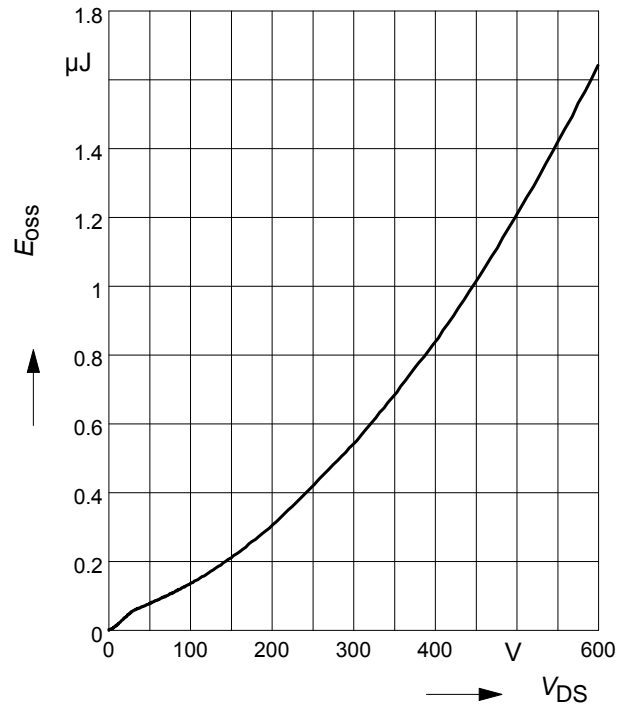
$$C = f(V_{DS})$$

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

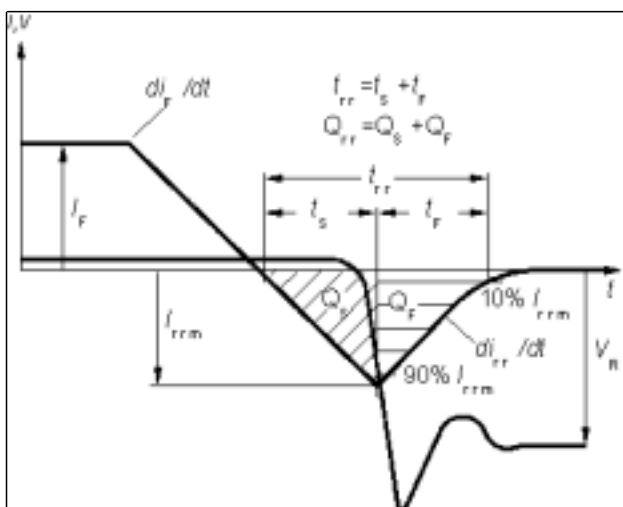


22 Typ. C_{OSS} stored energy

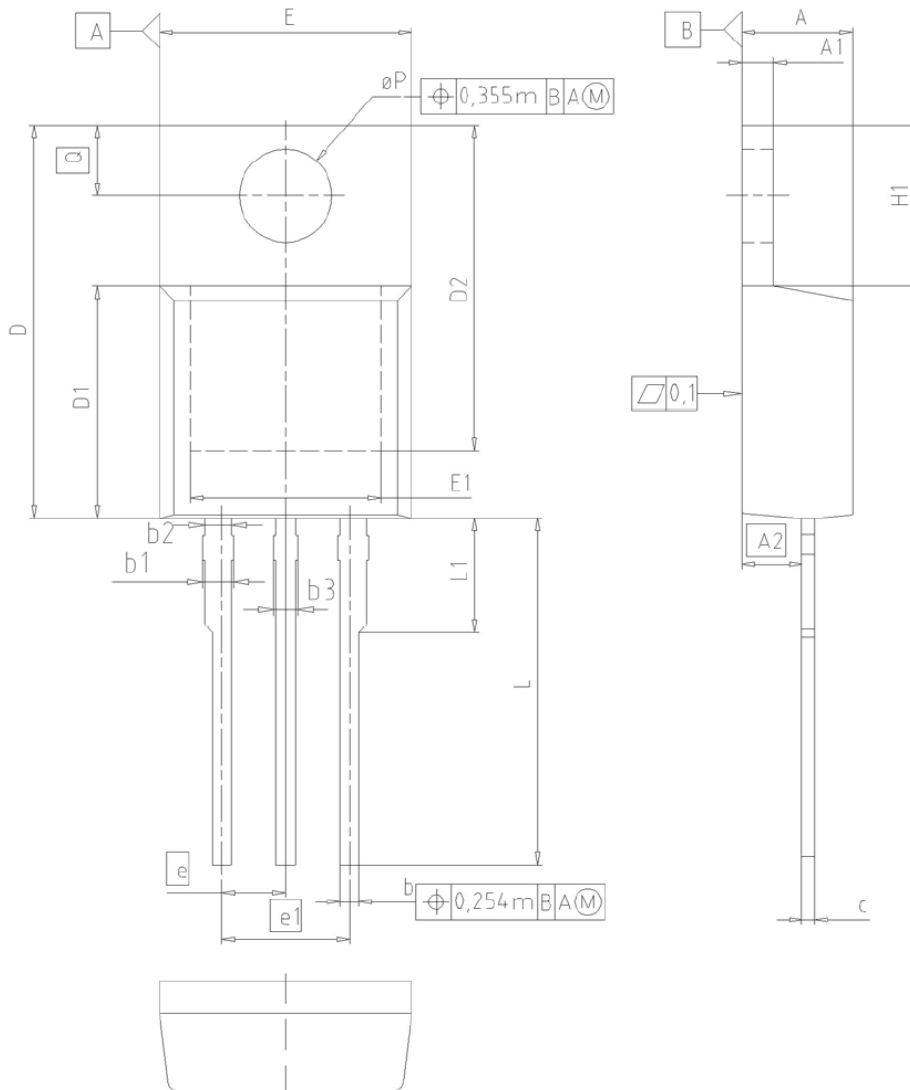
$$E_{Oss} = f(V_{DS})$$



Definition of diodes switching characteristics



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



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.30	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

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SCALE
0 2.5 5mm

EUROPEAN PROJECTION

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05

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