

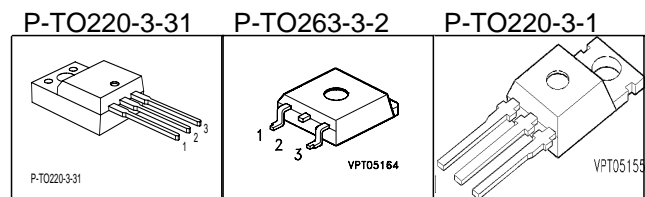
## Cool MOS™ Power Transistor

### Feature

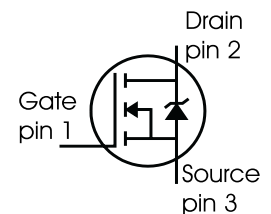
- New revolutionary high voltage technology
- Ultra low gate charge
- Periodic avalanche rated
- Extreme  $dv/dt$  rated
- High peak current capability
- Improved transconductance
- 150 °C operating temperature

### Product Summary

$V_{DS} @ T_{jmax}$	650	V
$R_{DS(on)}$	0.95	$\Omega$
$I_D$	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 $T_C = 25\text{ °C}$ $T_C = 100\text{ °C}$	$I_D$	4.5 2.8	4.5 <sup>1)</sup> 2.8 <sup>1)</sup>	A
Pulsed drain current, $t_p$ limited by $T_{jmax}$	$I_{D\text{ puls}}$	13.5	13.5	A
Avalanche energy, single pulse $I_D=2.3\text{A}, V_{DD}=50\text{V}$	$E_{AS}$	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 $dv/dt$ $I_S = 4.5\text{ A}, V_{DS} < V_{DD}, di/dt=100\text{A}/\mu\text{s}, T_{jmax}=150\text{ °C}$	$dv/dt$	6	6	V/ns
Gate source voltage static	$V_{GS}$	$\pm 20$	$\pm 20$	V
Gate source voltage AC ( $f > 1\text{Hz}$ )	$V_{GS}$	$\pm 30$	$\pm 30$	
Power dissipation, $T_C = 25\text{ °C}$	$P_{tot}$	50	31	W
Operating and storage temperature	$T_j, T_{stg}$	-55...+150		°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, $V_{GS} = V_{DS}$ $I_D = 200\ \mu A$	$V_{GS(th)}$	2.1	3	3.9	
Zero gate voltage drain current $V_{DS} = 600\ V, V_{GS} = 0\ V, T_j = 25\text{ °C}$ $V_{DS} = 600\ V, V_{GS} = 0\ V, T_j = 150\text{ °C}$	$I_{DSS}$	-	0.5	1	$\mu A$
		-	-	50	
Gate-source leakage current $V_{GS}=30V, V_{DS}=0V$	$I_{GSS}$	-	-	100	nA
Drain-source on-state resistance $V_{GS}=10V, I_D=2.8A, T_j=25\text{ °C}$ $V_{GS}=10V, I_D=2.8A, T_j=150\text{ °C}$	$R_{DS(on)}$	-	0.85	0.95	$\Omega$
		-	2.35	2.62	
Gate input resistance $f = 1\text{ MHz, open drain}$	$R_G$	-	0.95	-	

### Electrical Characteristics

Parameter	Symbol	Conditions	Values			Unit
			min.	typ.	max.	
<b>Characteristics</b>						
Transconductance	$g_{fs}$	$V_{DS} \geq 2 \cdot I_D \cdot R_{DS(on)max}$ , $I_D = 2.8A$	-	4.4	-	S
Input capacitance	$C_{iss}$	$V_{GS} = 0V$ , $V_{DS} = 25V$ ,	-	490	-	pF
Output capacitance	$C_{oss}$	$f = 1MHz$	-	160	-	
Reverse transfer capacitance	$C_{rss}$		-	15	-	
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	$t_{d(on)}$	$V_{DD} = 380V$ , $V_{GS} = 0/10V$ ,	-	6	-	ns
Rise time	$t_r$	$I_D = 4.5A$ ,	-	2.5	-	
Turn-off delay time	$t_{d(off)}$	$R_G = 18\Omega$	-	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

<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%  $V_{DSS}$ .

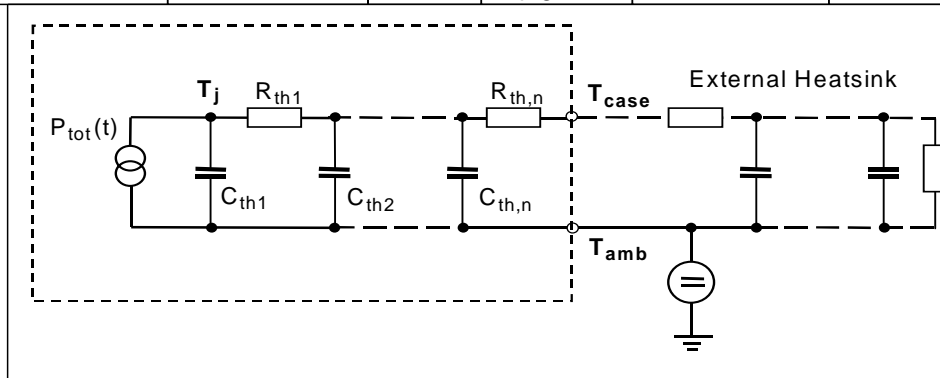
<sup>5</sup> $C_{o(tr)}$  is a fixed capacitance that gives the same charging time as  $C_{oss}$  while  $V_{DS}$  is rising from 0 to 80%  $V_{DSS}$ .

**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	$I_{SM}$		-	-	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	-	$\mu\text{C}$
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	-	$\text{A}/\mu\text{s}$

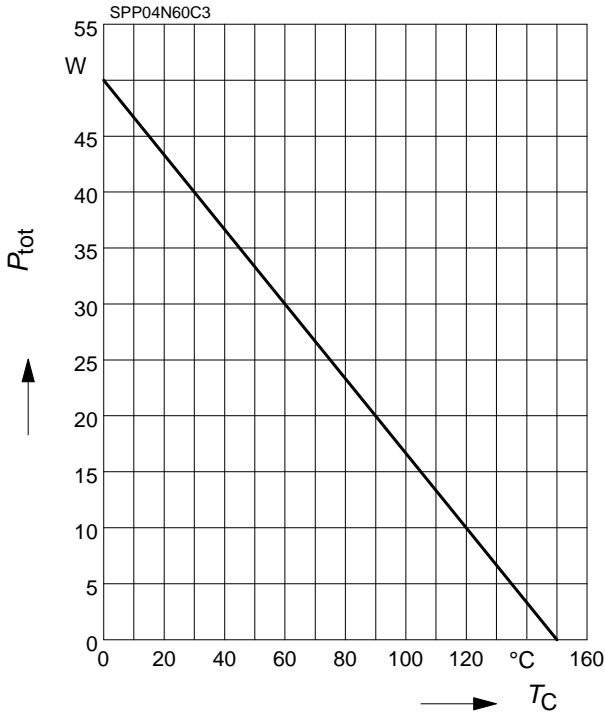
**Typical Transient Thermal Characteristics**

Symbol	Value		Unit	Symbol	Value		Unit
	SPP_B	SPA			SPP_B	SPA	
$R_{th1}$	0.039	0.039	K/W	$C_{th1}$	0.00008293	0.0000734	Ws/K
$R_{th2}$	0.083	0.075		$C_{th2}$	0.000282	0.000282	
$R_{th3}$	0.133	0.102		$C_{th3}$	0.0004859	0.000401	
$R_{th4}$	0.275	0.27		$C_{th4}$	0.0011	0.000736	
$R_{th5}$	0.278	0.594		$C_{th5}$	0.00535	0.00501	
$R_{th6}$	0.093	2.536		$C_{th6}$	0.054	0.412	



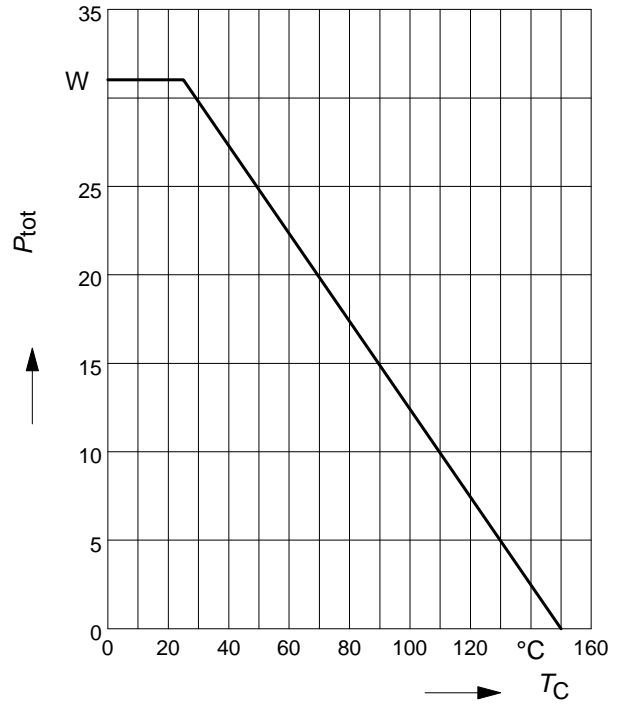
### 1 Power dissipation

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



### 2 Power dissipation FullPAK

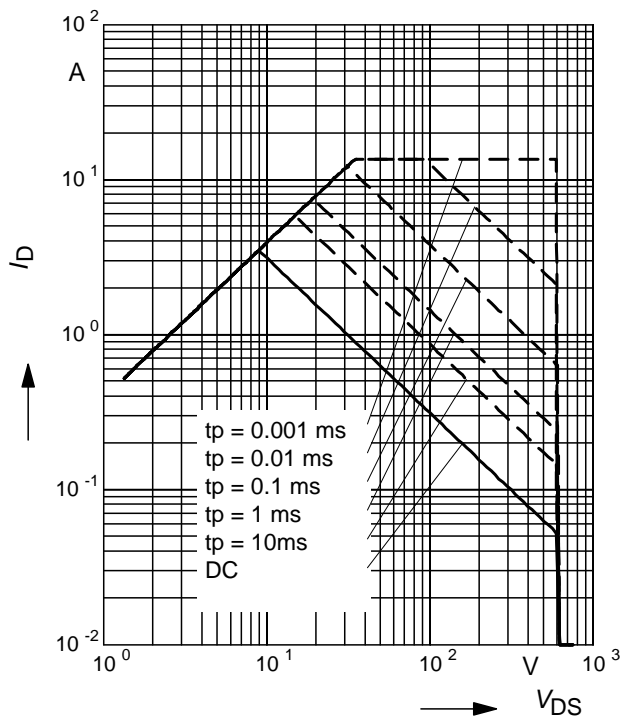
$$P_{tot} = f(T_C)$$



### 3 Safe operating area FullPAK

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

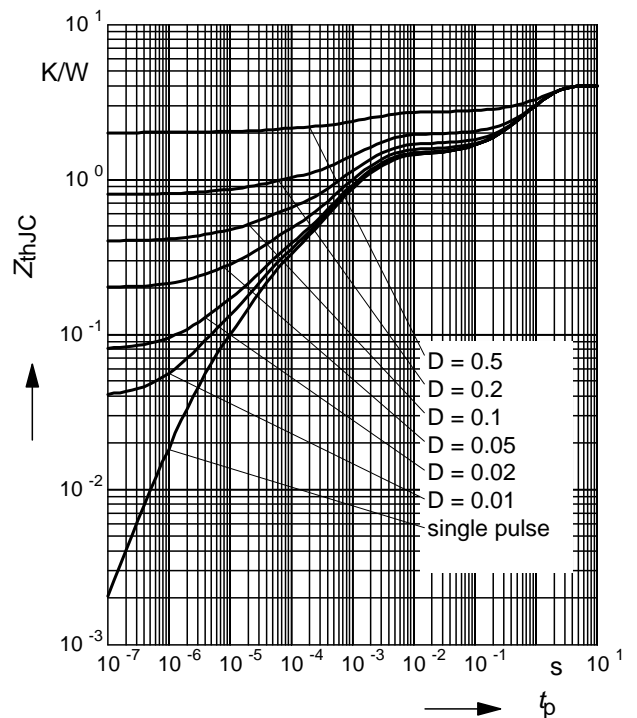
parameter:  $D = 0$ ,  $T_C = 25^\circ\text{C}$



### 4 Transient thermal impedance FullPAK

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

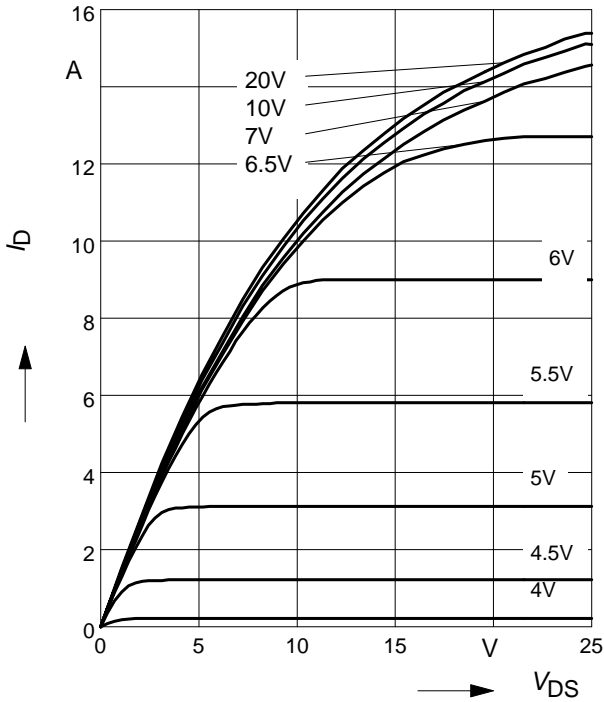
parameter:  $D = t_p/t$



**5 Typ. output characteristic**

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

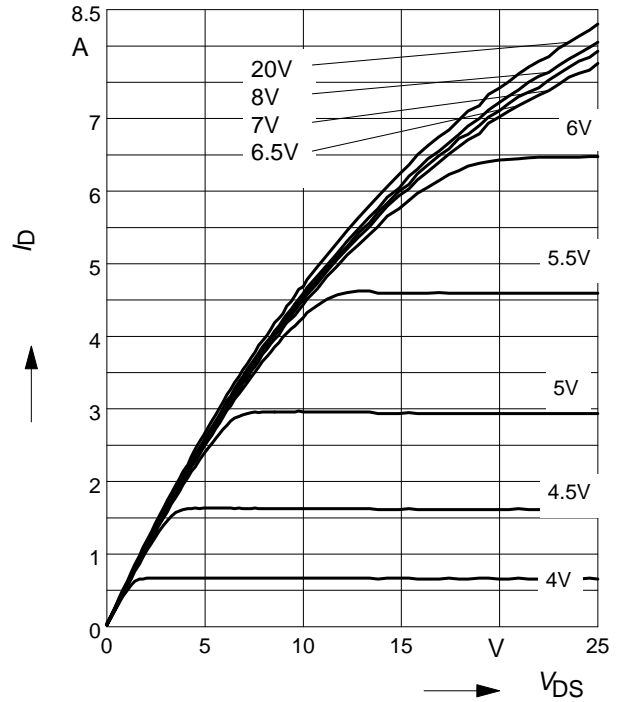
parameter:  $t_p = 10 \mu\text{s}, V_{GS}$



**6 Typ. output characteristic**

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

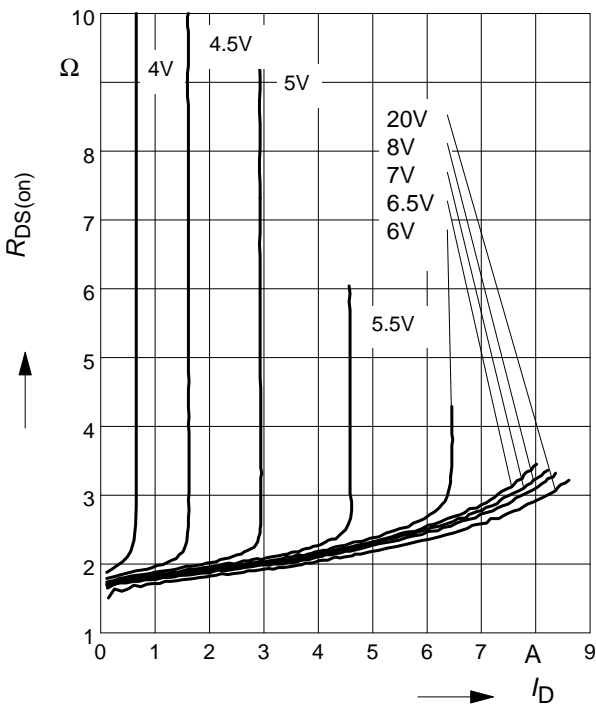
parameter:  $t_p = 10 \mu\text{s}, V_{GS}$



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

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

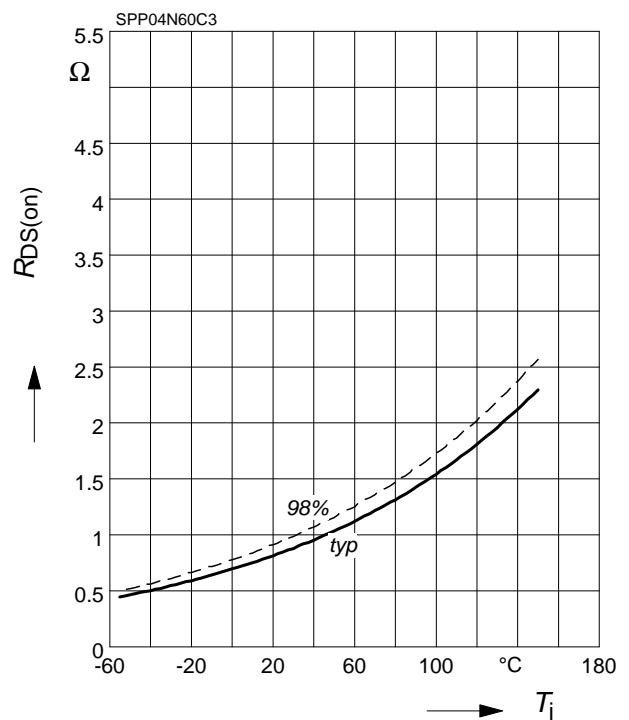
parameter:  $T_j = 150^\circ\text{C}, V_{GS}$



**8 Drain-source on-state resistance**

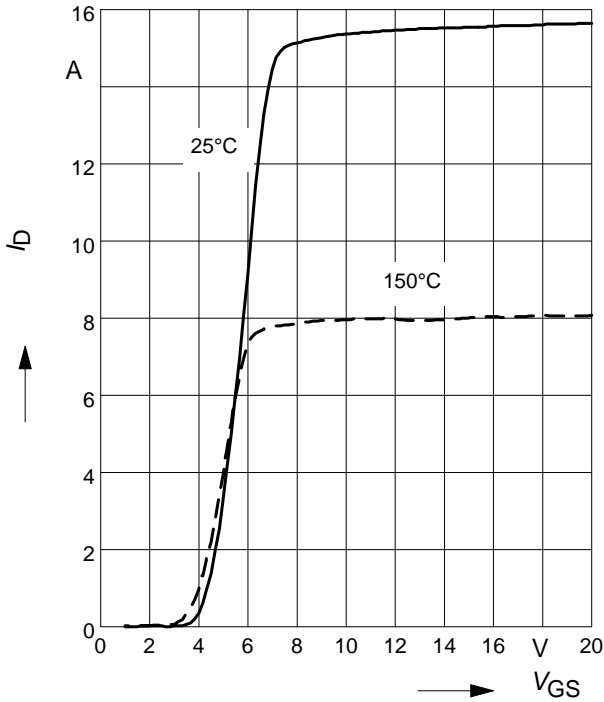
$R_{DS(on)} = f(T_j)$

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



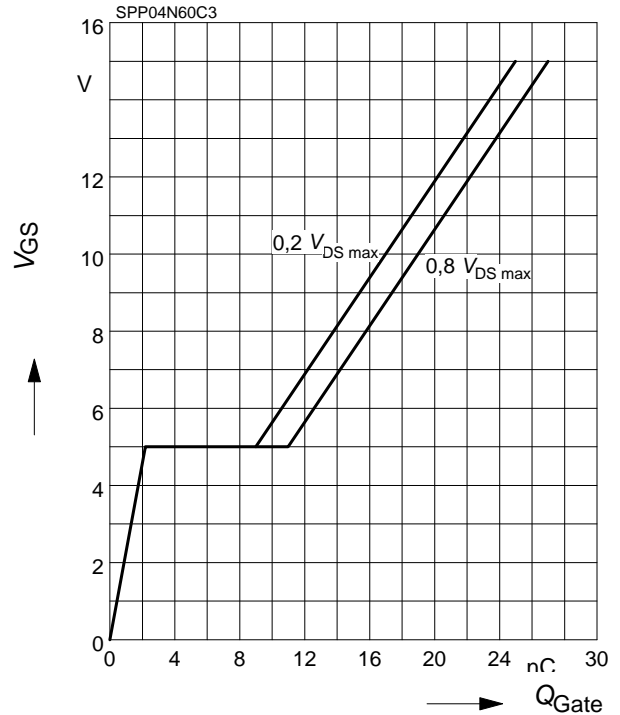
**9 Typ. transfer characteristics**

$I_D = f(V_{GS})$ ;  $V_{DS} \geq 2 \times I_D \times R_{DS(on)max}$   
parameter:  $t_p = 10 \mu s$



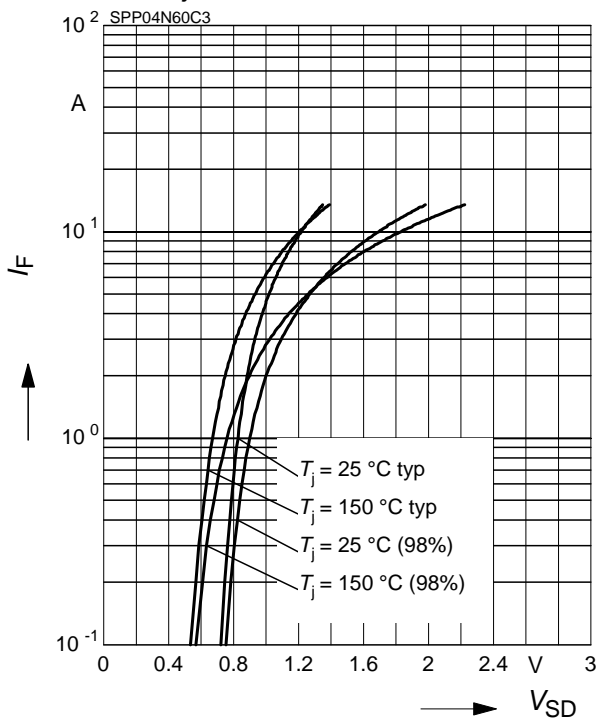
**10 Typ. gate charge**

$V_{GS} = f(Q_{Gate})$   
parameter:  $I_D = 4.5 A$  pulsed



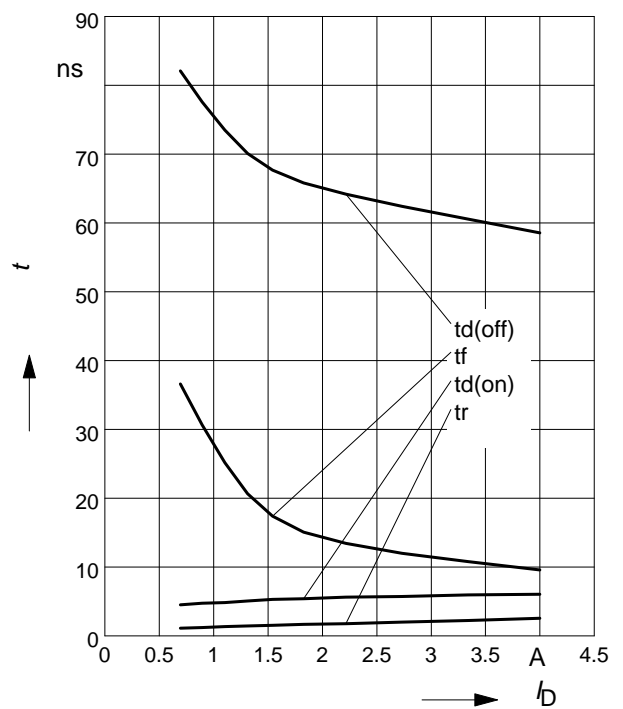
**11 Forward characteristics of body diode**

$I_F = f(V_{SD})$   
parameter:  $T_j$ ,  $t_p = 10 \mu s$



**12 Typ. switching time**

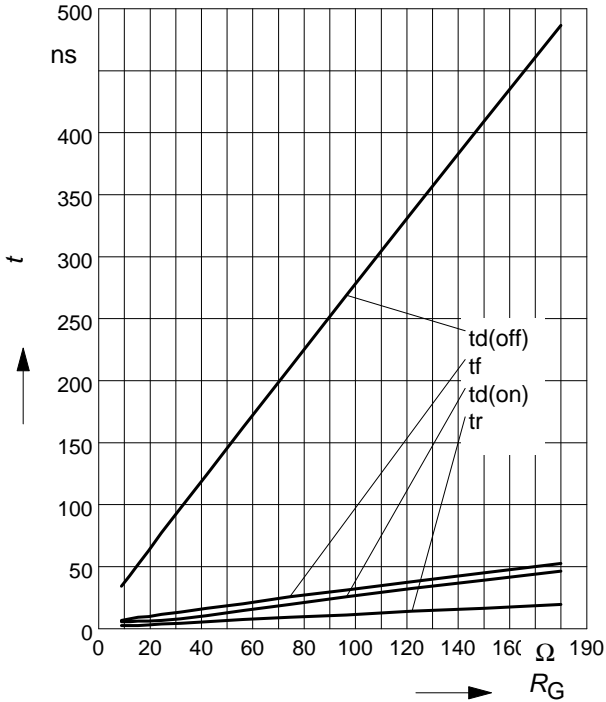
$t = f(I_D)$ , inductive load,  $T_j = 125^\circ C$   
par.:  $V_{DS} = 380V$ ,  $V_{GS} = 0/+13V$ ,  $R_G = 18\Omega$



**13 Typ. switching time**

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

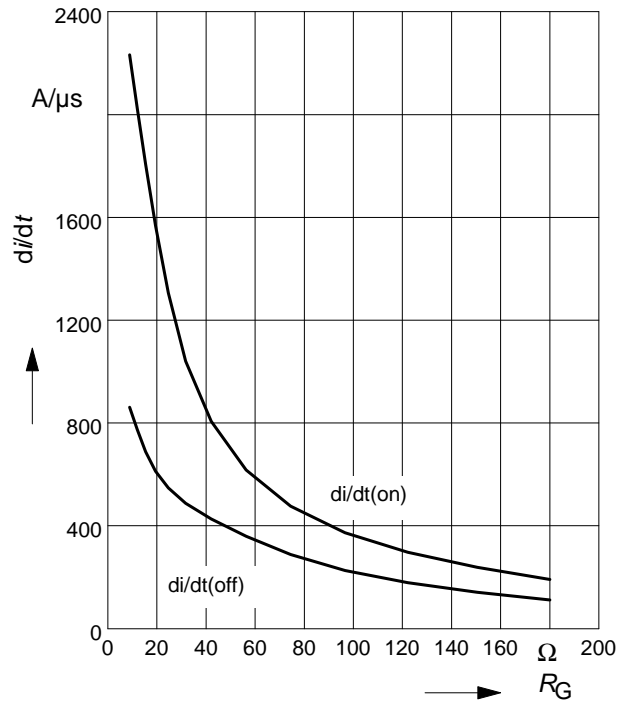
par.:  $V_{DS} = 380\text{V}$ ,  $V_{GS} = 0/+13\text{V}$ ,  $I_D = 4.5\text{A}$



**14 Typ. drain current slope**

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

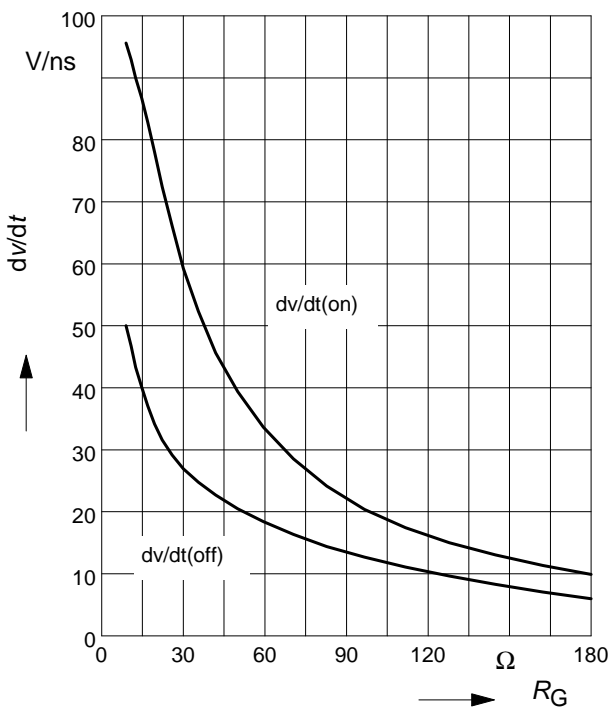
par.:  $V_{DS} = 380\text{V}$ ,  $V_{GS} = 0/+13\text{V}$ ,  $I_D = 4.5\text{A}$



**15 Typ. drain source voltage slope**

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

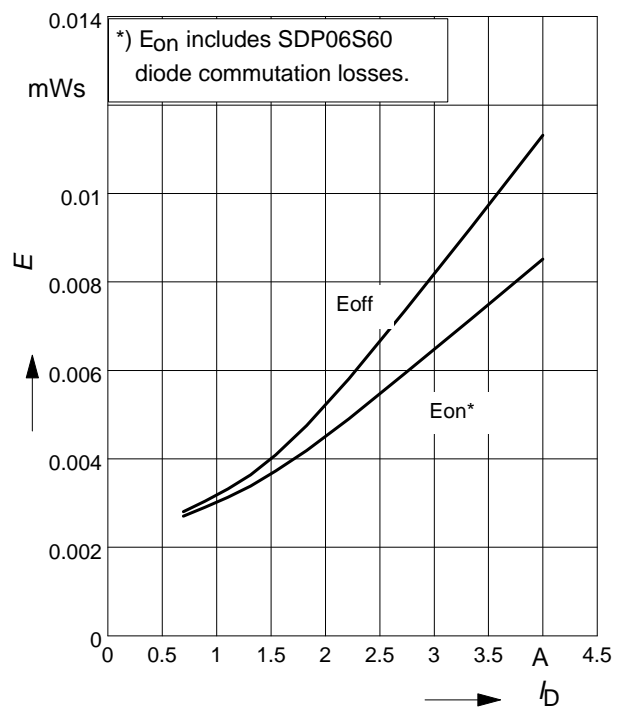
par.:  $V_{DS} = 380\text{V}$ ,  $V_{GS} = 0/+13\text{V}$ ,  $I_D = 4.5\text{A}$



**16 Typ. switching losses**

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

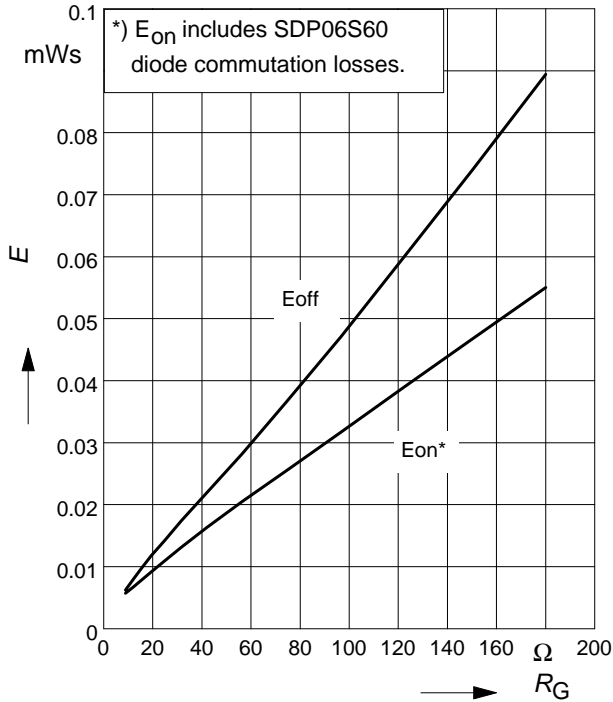
par.:  $V_{DS} = 380\text{V}$ ,  $V_{GS} = 0/+13\text{V}$ ,  $R_G = 18\Omega$





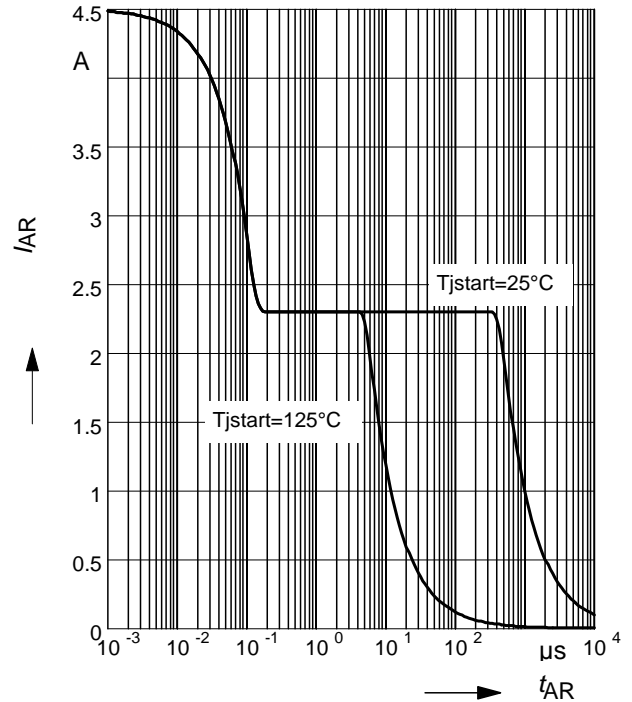
### 17 Typ. switching losses

$E = f(R_G)$ , inductive load,  $T_j = 125^\circ\text{C}$   
par.:  $V_{DS} = 380\text{V}$ ,  $V_{GS} = 0/+13\text{V}$ ,  $I_D = 4.5\text{A}$



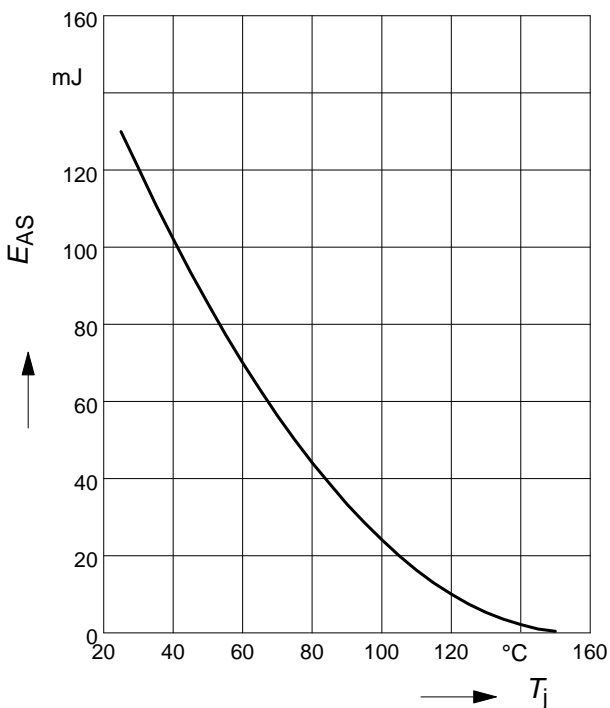
### 18 Avalanche SOA

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



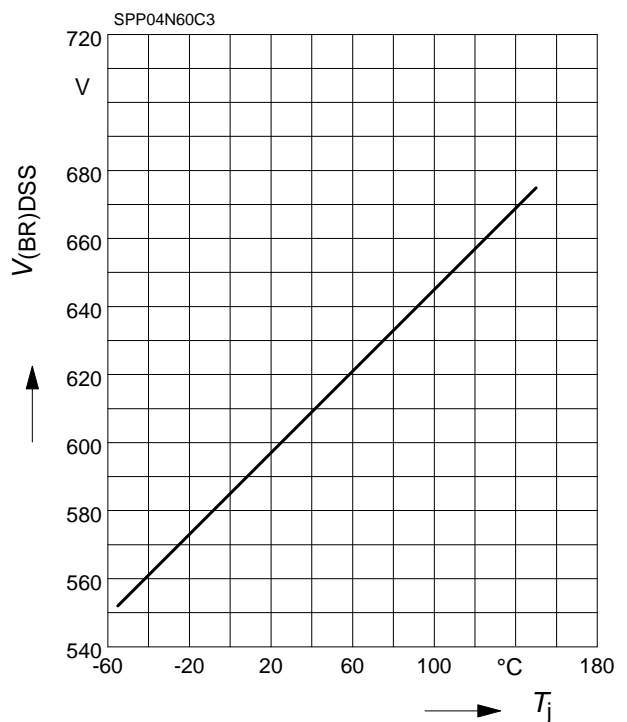
### 19 Avalanche energy

$E_{AS} = f(T_j)$   
par.:  $I_D = 2.3\text{A}$ ,  $V_{DD} = 50\text{V}$



### 20 Drain-source breakdown voltage

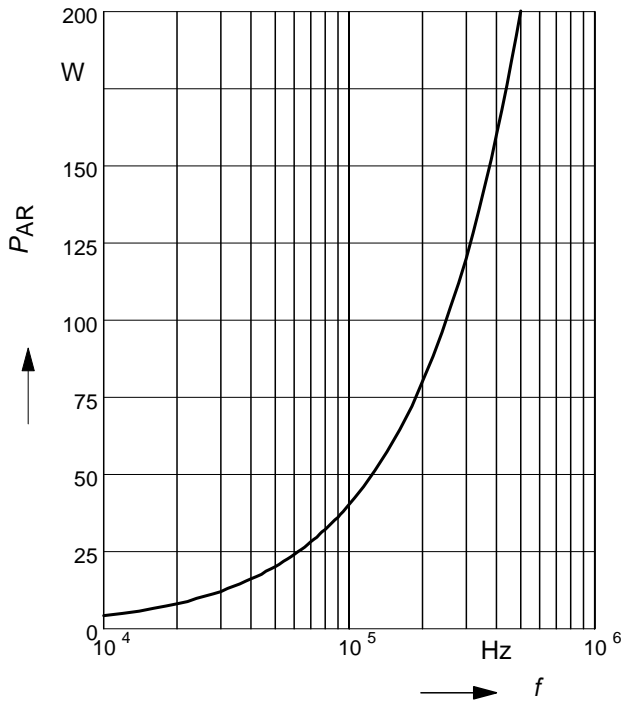
$V_{(BR)DSS} = f(T_j)$



**21 Avalanche power losses**

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

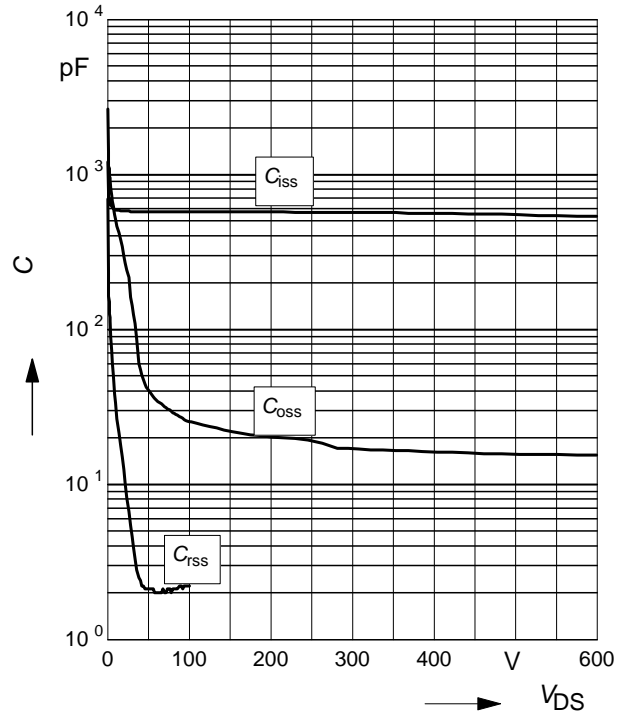
parameter:  $E_{AR}=0.4\text{mJ}$



**22 Typ. capacitances**

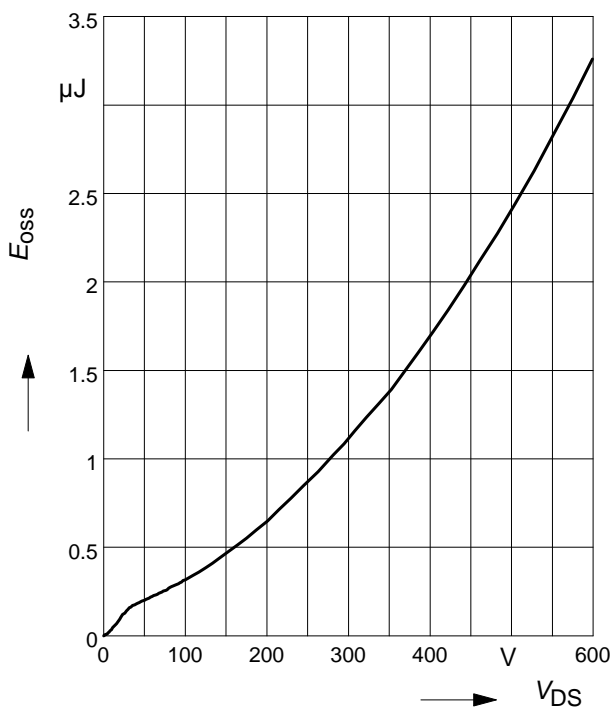
$$C = f(V_{DS})$$

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

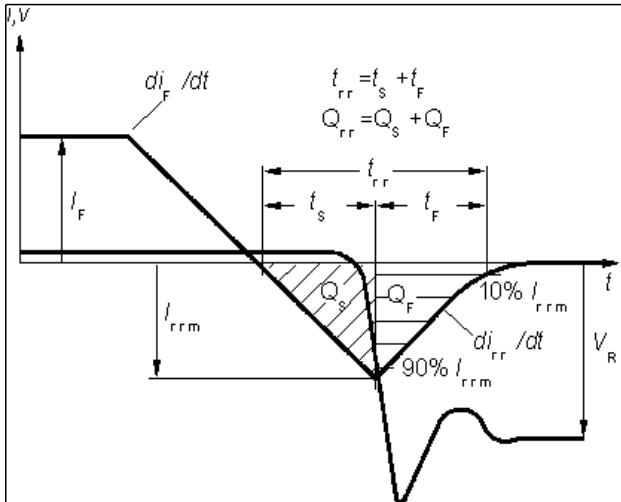


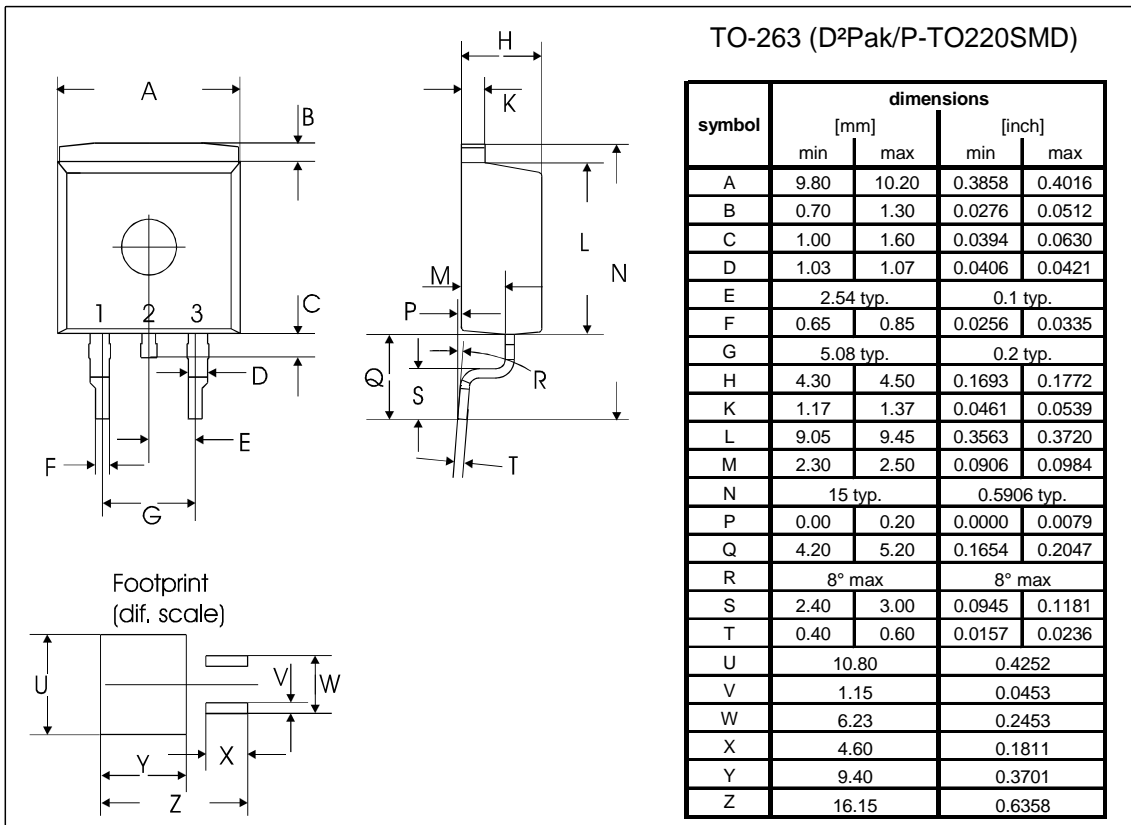
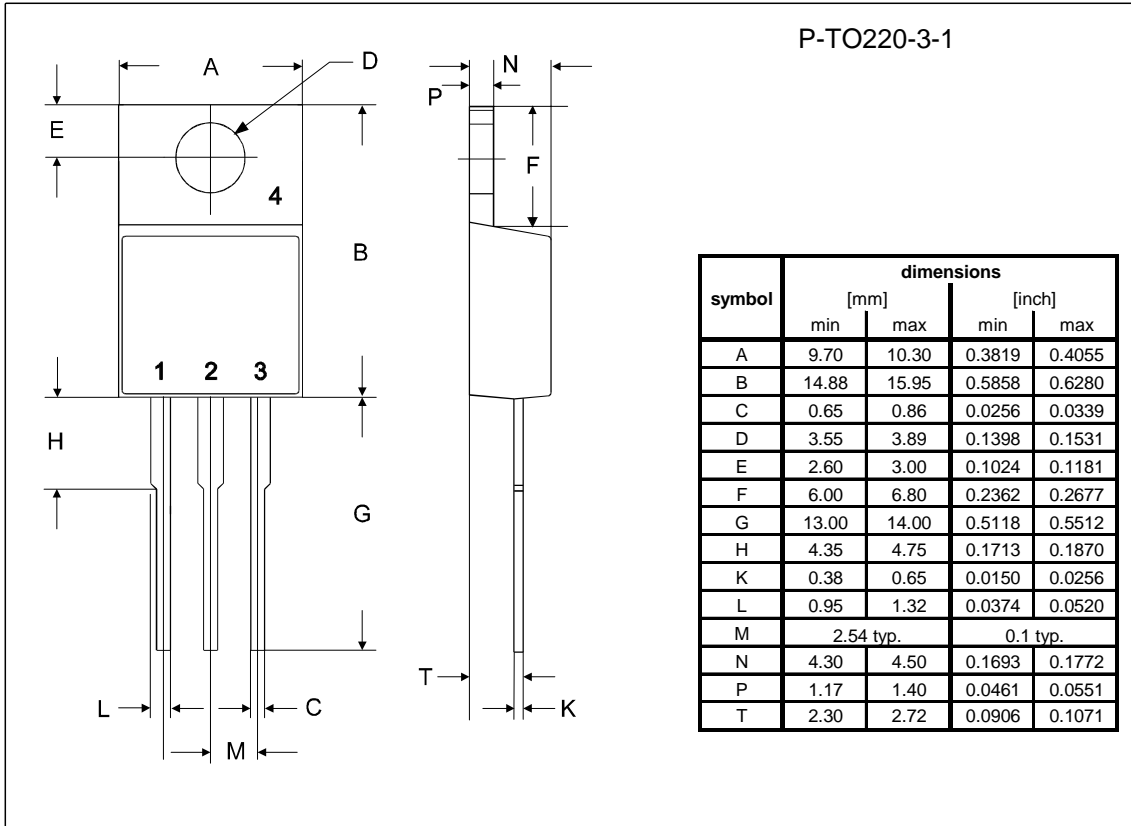
**23 Typ.  $C_{oss}$  stored energy**

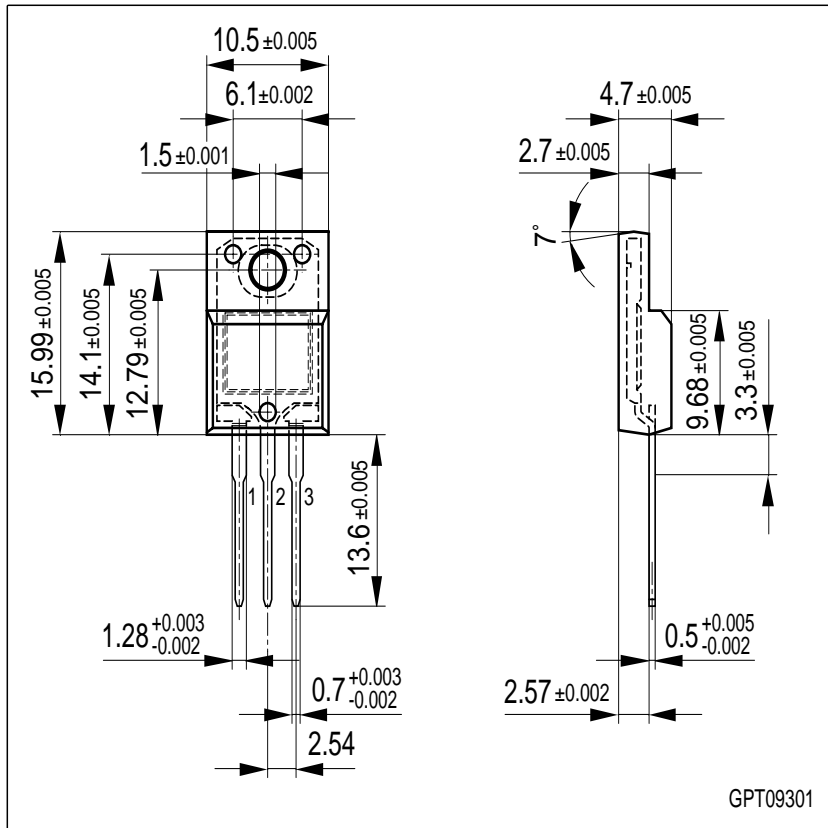
$$E_{oss} = f(V_{DS})$$



Definition of diodes switching characteristics







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



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