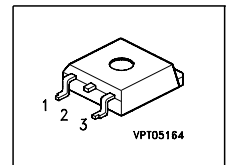


**Cool MOS™ Power Transistor**
**Feature**

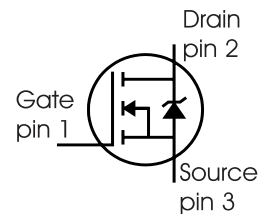
- New revolutionary high voltage technology
- Ultra low gate charge
- Periodic avalanche rated
- Extreme dv/dt rated
- High peak current capability
- Improved transconductance
- Qualified according to JEDEC<sup>0)</sup> for target applications

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

PG-TO263



Type	Package	Ordering Code	Marking
SPB04N60C3	PG-TO263	Q67040-S4407	04N60C3


**Maximum Ratings**

Parameter	Symbol	Value		Unit
		SPB		
Continuous drain current $T_C = 25\text{ }^\circ\text{C}$ $T_C = 100\text{ }^\circ\text{C}$	$I_D$	4.5 2.8		A
Pulsed drain current, $t_p$ limited by $T_{jmax}$	$I_{D\text{ puls}}$	13.5		A
Avalanche energy, single pulse $I_D=3.4, V_{DD}=50\text{V}$	$E_{AS}$	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		
Avalanche current, repetitive $t_{AR}$ limited by $T_{jmax}$	$I_{AR}$	4.5		A
Gate source voltage static	$V_{GS}$	$\pm 20$		V
Gate source voltage AC ( $f > 1\text{Hz}$ )	$V_{GS}$	$\pm 30$		
Power dissipation, $T_C = 25\text{ }^\circ\text{C}$	$P_{tot}$	50		W
Operating and storage temperature	$T_j, T_{stg}$	-55...+150		$^\circ\text{C}$
Reverse diode dv/dt <sup>7)</sup>	dv/dt	15		V/ns

**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 <sup>2</sup> cooling area <sup>3)</sup>	$R_{thJA}$	-	-	62	
Soldering temperature, reflow soldering, MSL1 1.6 mm (0.063 in.) from case for 10s	$T_{sold}$	-	-	260	$^\circ\text{C}$

**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	$\mu\text{A}$
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	$\Omega$
Gate input resistance	$R_G$	$f=1\text{MHz}$ , 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	$C_{iss}$	$V_{GS} = 0V$ , $V_{DS} = 25V$ ,	-	490	-	pF
Output capacitance	$C_{oss}$	$f = 1MHz$	-	160	-	
Reverse transfer capacitance	$C_{rss}$		-	15	-	
Effective output capacitance, <sup>5)</sup> energy related	$C_{o(er)}$	$V_{GS} = 0V$ , $V_{DS} = 0V$ to 480V	-	20	-	
Effective output capacitance, <sup>6)</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>0</sup>J-STD20 and JESD22

<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%  $V_{DSS}$ .

<sup>6</sup> $I_{SD} \leq I_D$ ,  $di/dt \leq 400A/\mu s$ ,  $V_{Dclink} = 400V$ ,  $V_{peak} < V_{BR, DSS}$ ,  $T_j < T_{j,max}$ .

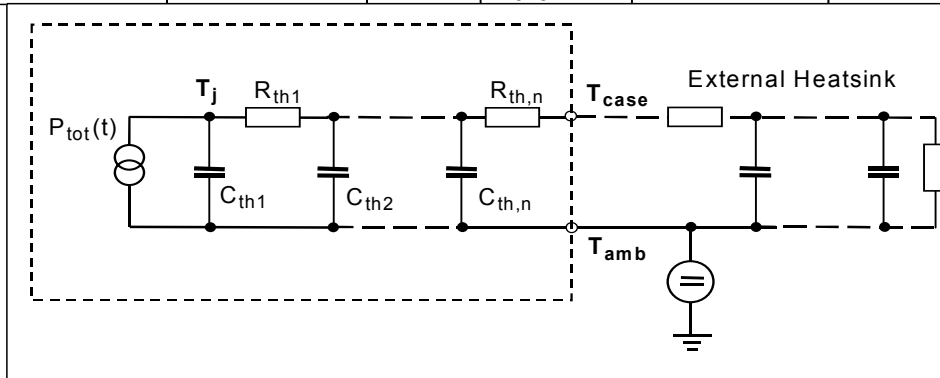
Identical low-side and high-side switch.

**Electrical Characteristics**

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

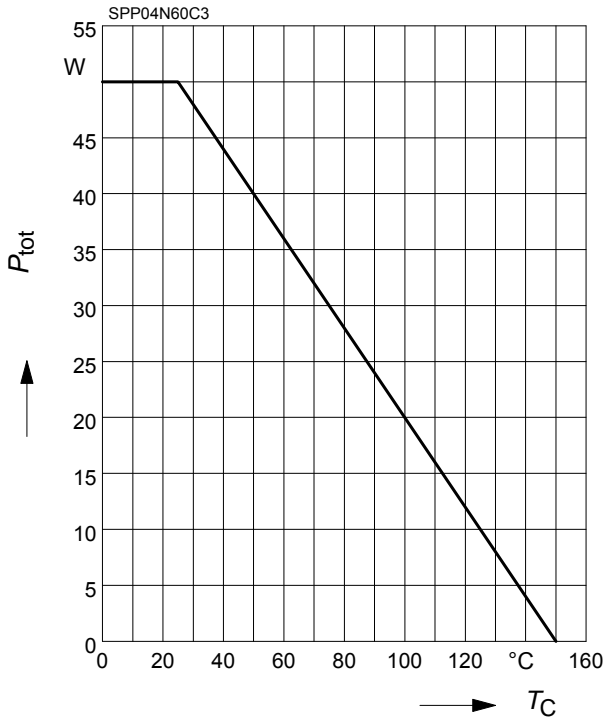
**Typical Transient Thermal Characteristics**

Symbol	Value		Unit	Symbol	Value		Unit
	SPB				SPB		
$R_{th1}$	0.039		K/W	$C_{th1}$	0.00007347		Ws/K
$R_{th2}$	0.074			$C_{th2}$	0.0002831		
$R_{th3}$	0.132			$C_{th3}$	0.0004062		
$R_{th4}$	0.555			$C_{th4}$	0.001215		
$R_{th5}$	0.529			$C_{th5}$	0.00276		
$R_{th6}$	0.169			$C_{th6}$	0.029		



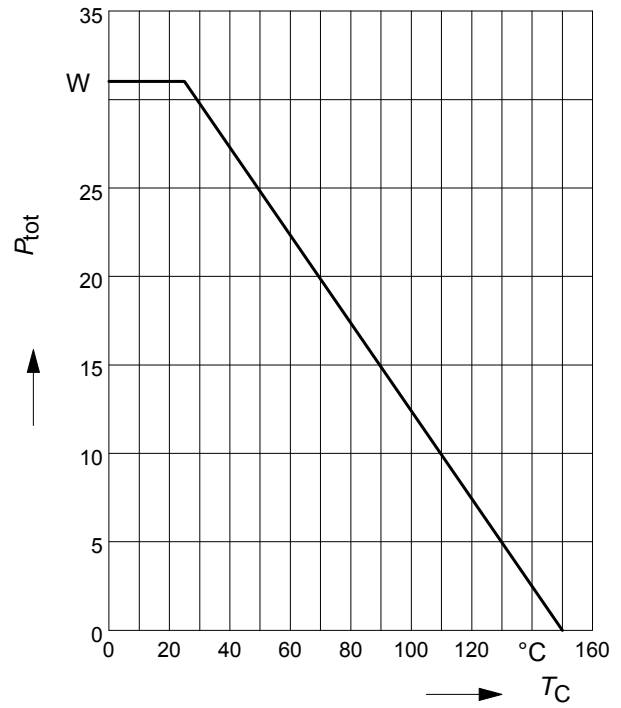
**1 Power dissipation**

$P_{tot} = f(T_C)$



**2 Power dissipation FullPAK**

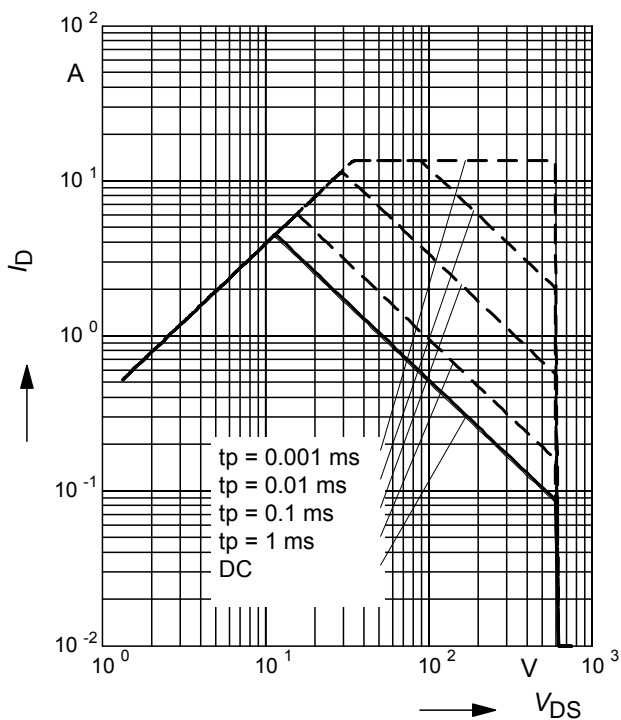
$P_{tot} = f(T_C)$



**3 Safe operating area**

$I_D = f(V_{DS})$

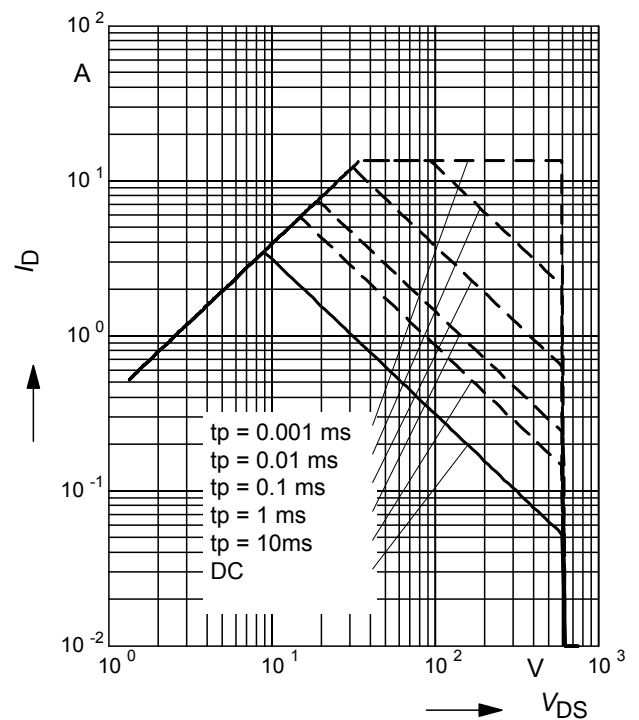
parameter :  $D = 0$  ,  $T_C = 25^\circ\text{C}$



**4 Safe operating area FullPAK**

$I_D = f(V_{DS})$

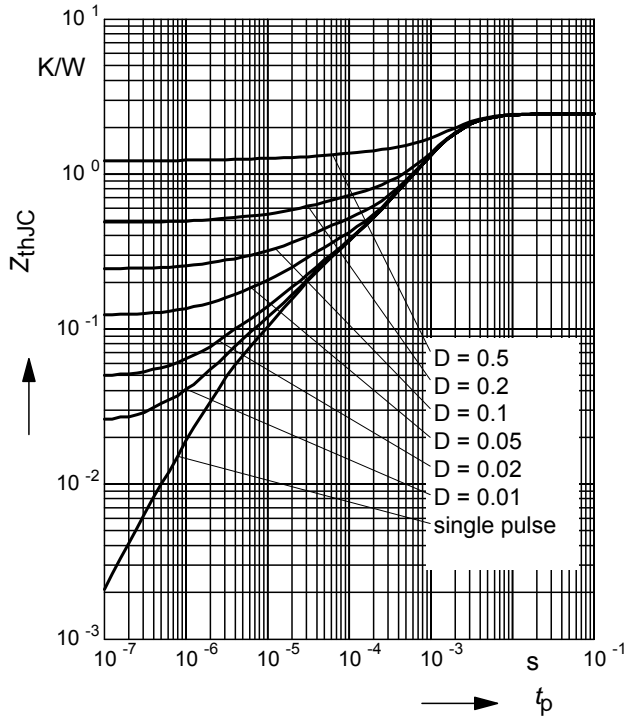
parameter:  $D = 0$  ,  $T_C = 25^\circ\text{C}$



**5 Transient thermal impedance**

$Z_{thJC} = f(t_p)$

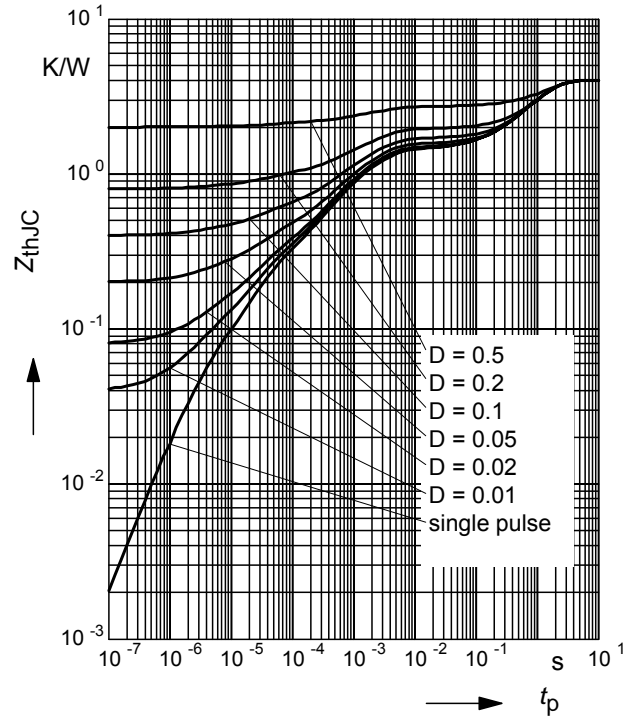
parameter:  $D = t_p/T$



**6 Transient thermal impedance FullPAK**

$Z_{thJC} = f(t_p)$

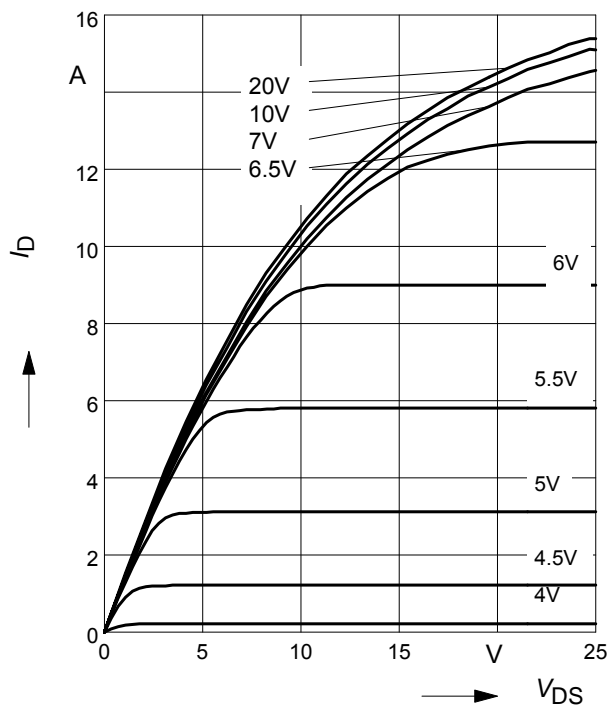
parameter:  $D = t_p/t$



**7 Typ. output characteristic**

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

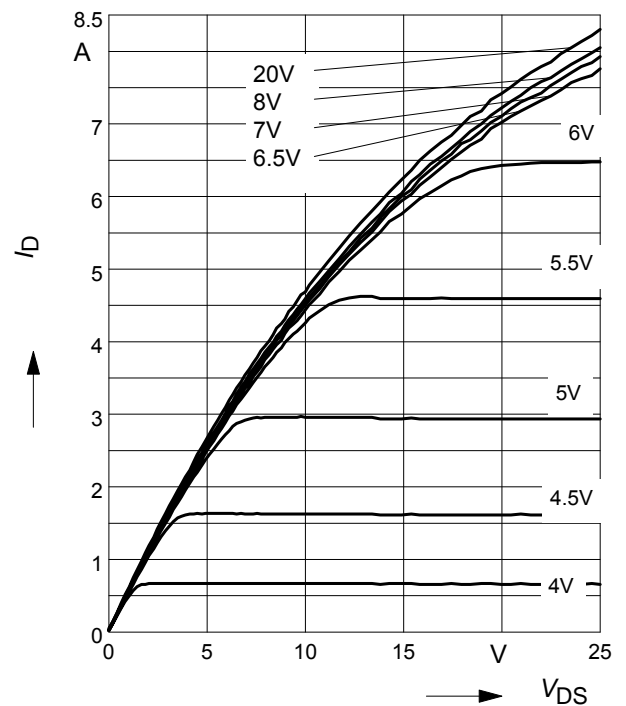
parameter:  $t_p = 10 \mu\text{s}, V_{GS}$



**8 Typ. output characteristic**

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

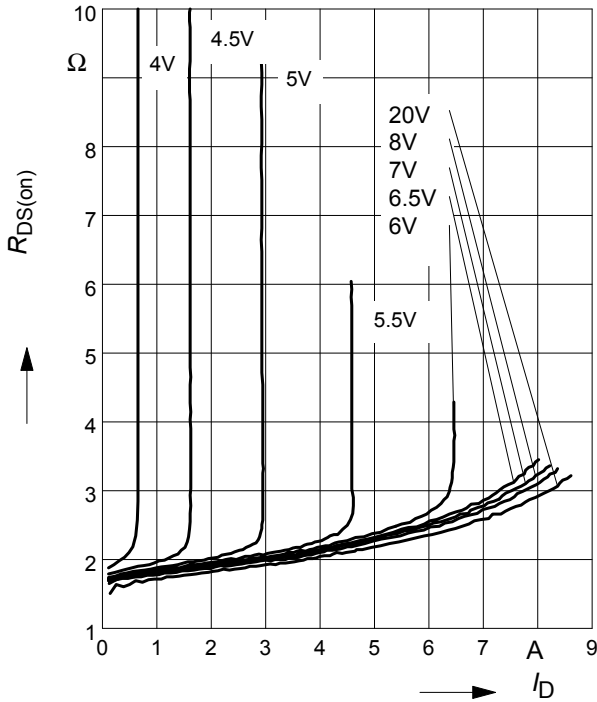
parameter:  $t_p = 10 \mu\text{s}, V_{GS}$



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

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

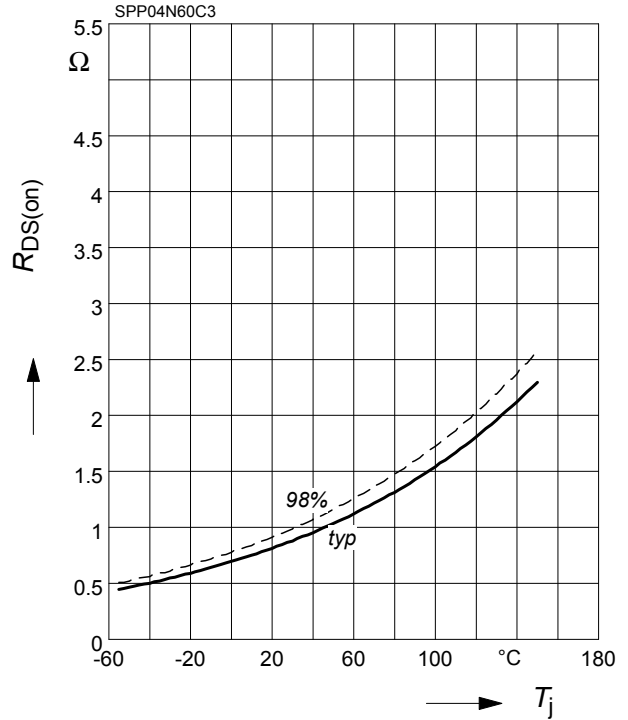
parameter:  $T_j = 150^\circ\text{C}$ ,  $V_{GS}$



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

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

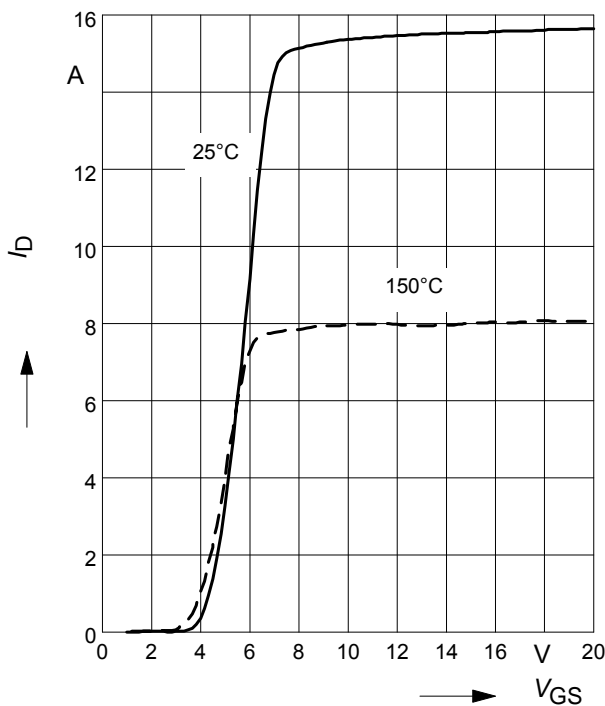
parameter:  $I_D = 2.8 \text{ A}$ ,  $V_{GS} = 10 \text{ V}$



**11 Typ. transfer characteristics**

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

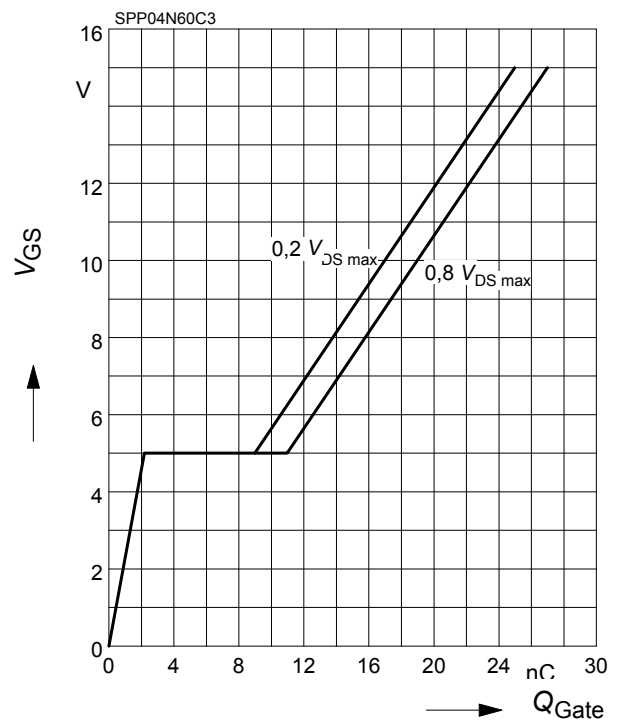
parameter:  $t_p = 10 \mu\text{s}$



**12 Typ. gate charge**

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

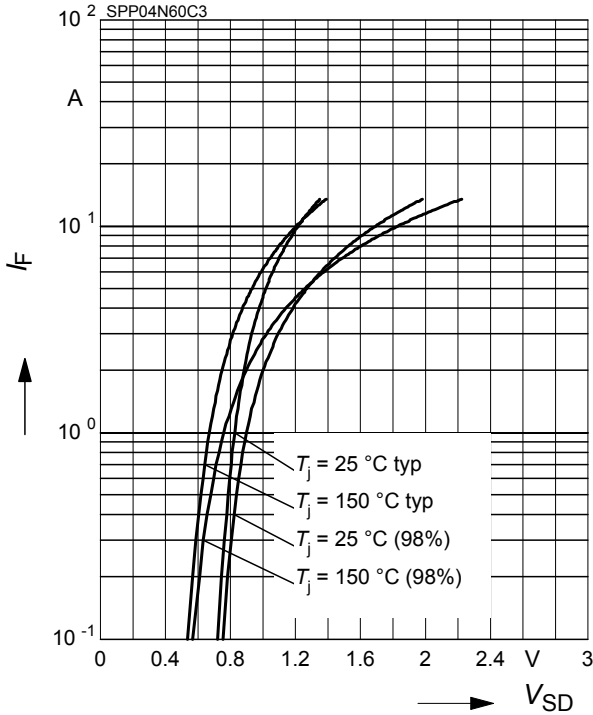
parameter:  $I_D = 4.5 \text{ A}$  pulsed



**13 Forward characteristics of body diode**

$I_F = f(V_{SD})$

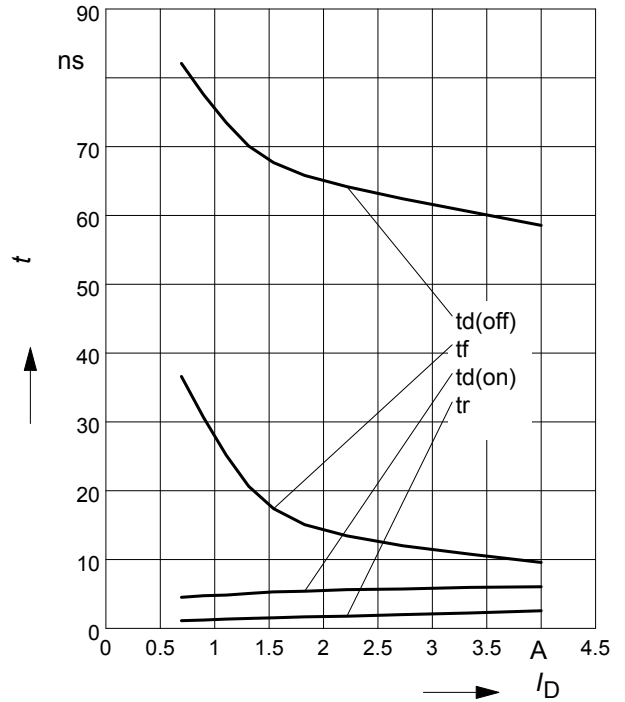
parameter:  $T_j$ ,  $t_p = 10 \mu s$



**14 Typ. switching time**

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

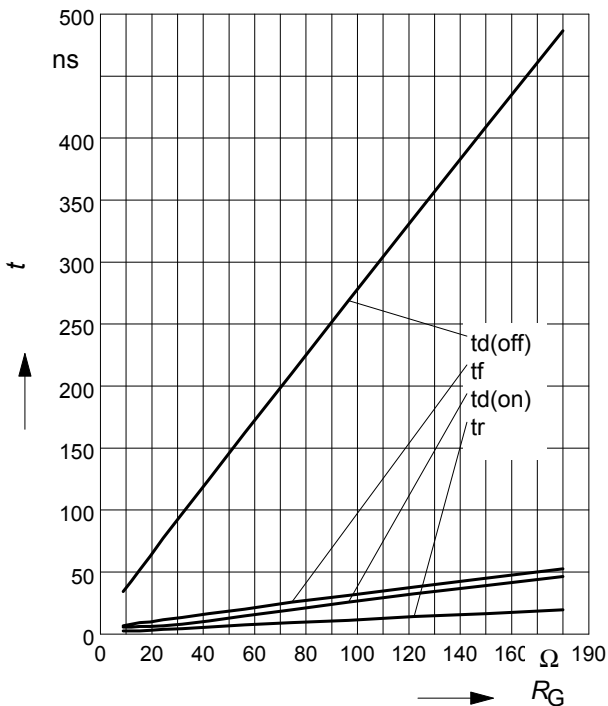
par.:  $V_{DS} = 380V$ ,  $V_{GS} = 0/+13V$ ,  $R_G = 18\Omega$



**15 Typ. switching time**

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

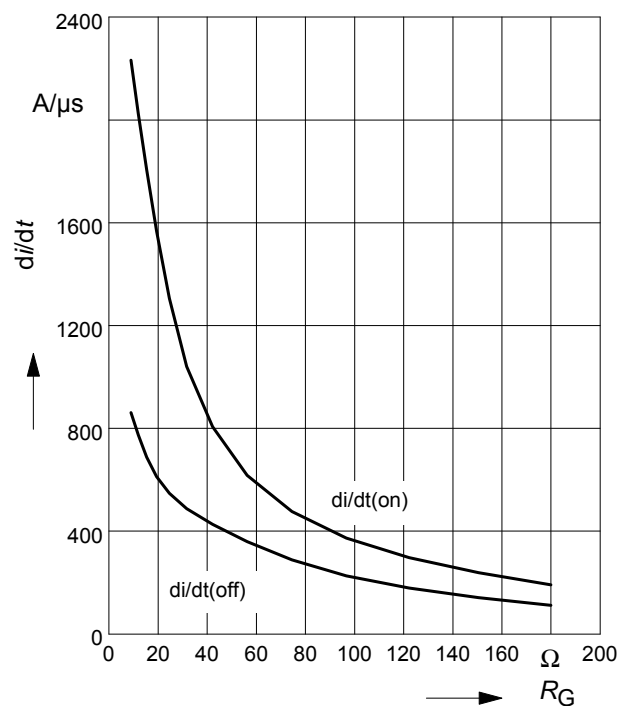
par.:  $V_{DS} = 380V$ ,  $V_{GS} = 0/+13V$ ,  $I_D = 4.5 A$



**16 Typ. drain current slope**

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

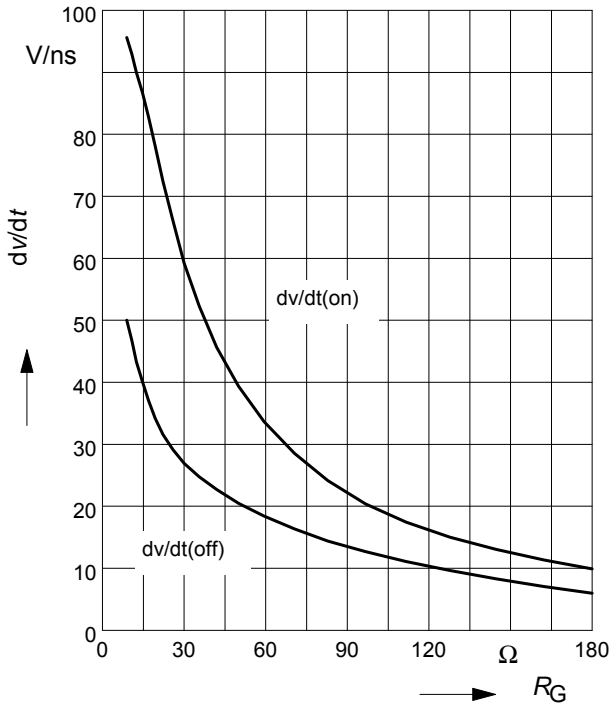
par.:  $V_{DS} = 380V$ ,  $V_{GS} = 0/+13V$ ,  $I_D = 4.5A$





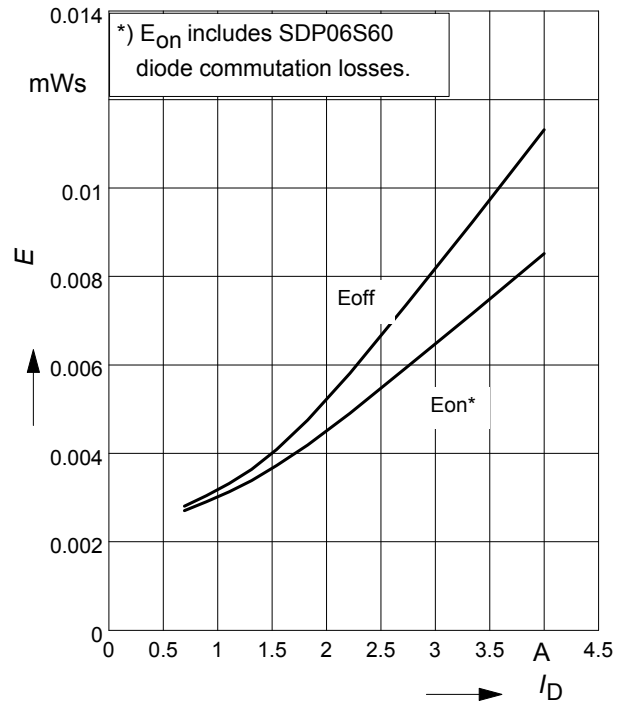
**17 Typ. drain source voltage slope**

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



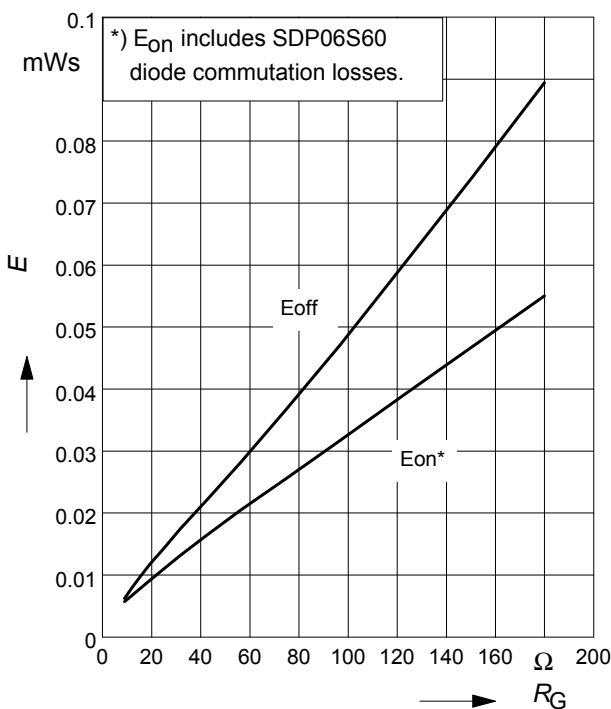
**18 Typ. switching losses**

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



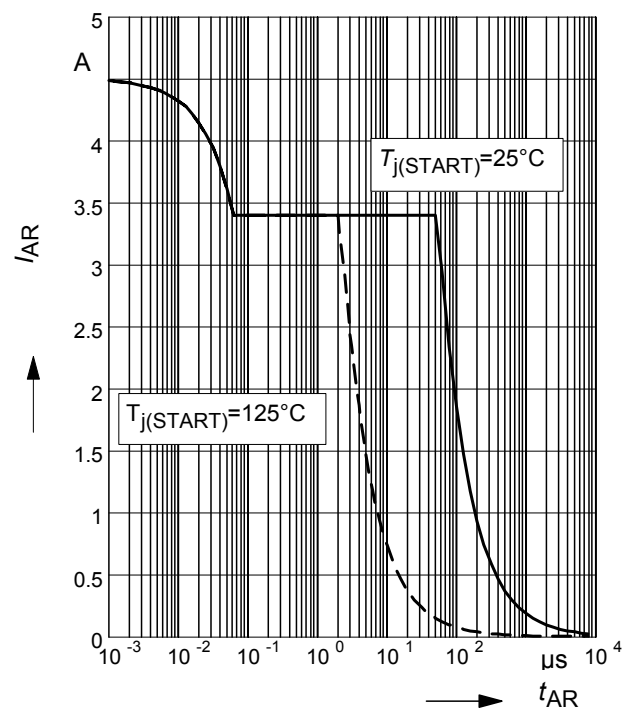
**19 Typ. switching losses**

$E = f(R_G)$ , 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**

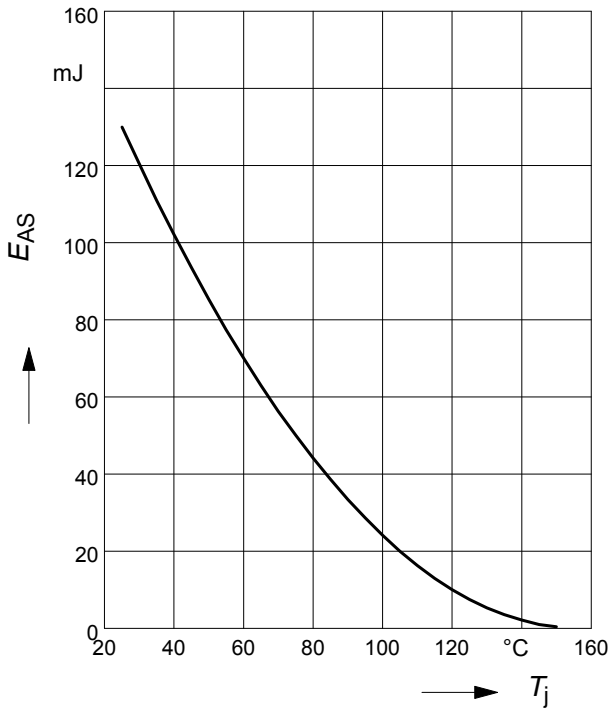
$I_{AR} = f(t_{AR})$   
 par.:  $T_j \leq 150^\circ\text{C}$



**21 Avalanche energy**

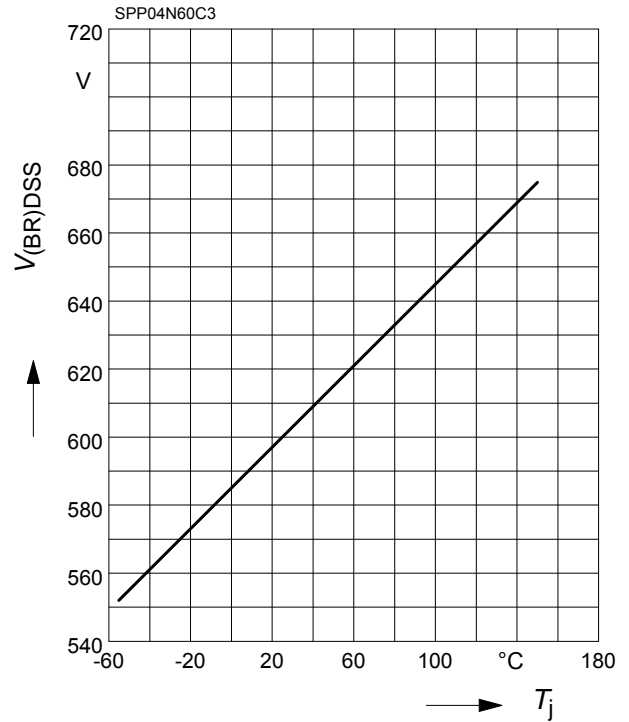
$$E_{AS} = f(T_j)$$

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



**22 Drain-source breakdown voltage**

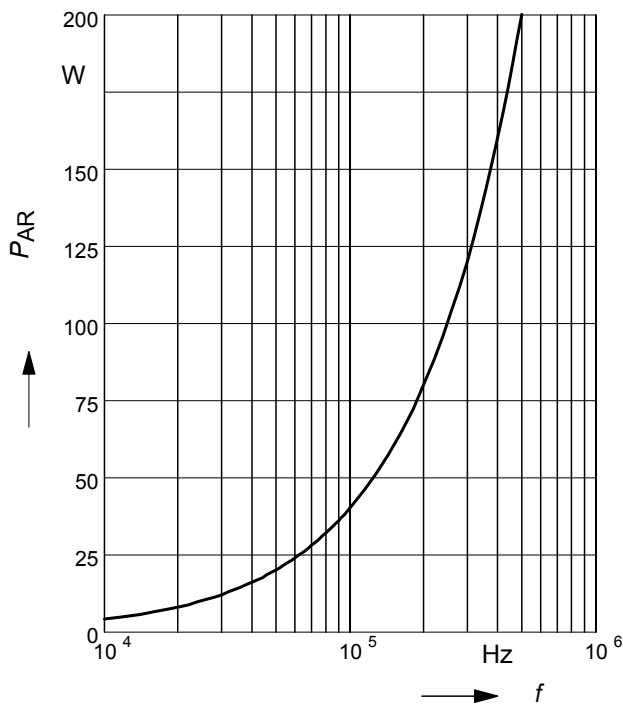
$$V_{(BR)DSS} = f(T_j)$$



**23 Avalanche power losses**

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

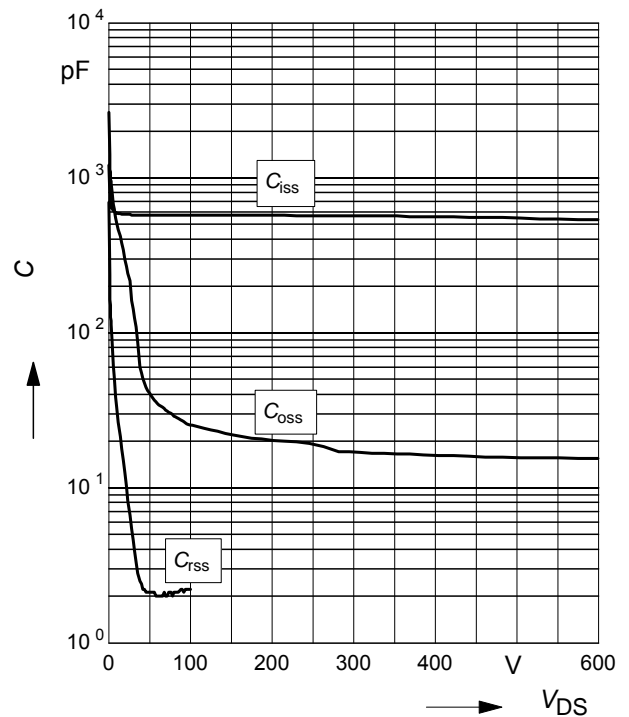
parameter:  $E_{AR}=0.4$ mJ



**24 Typ. capacitances**

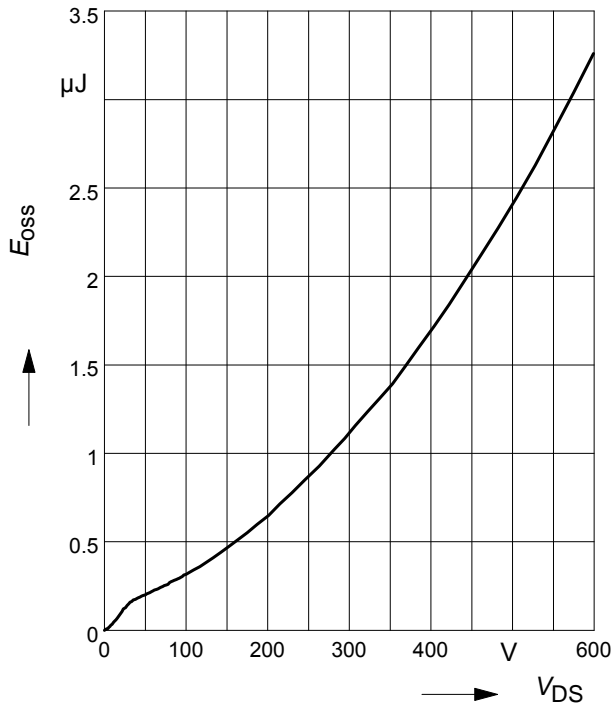
$$C = f(V_{DS})$$

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

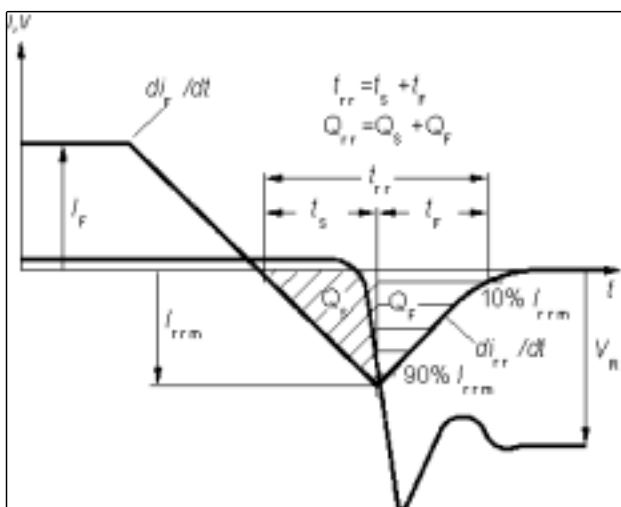


25 Typ.  $C_{OSS}$  stored energy

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



Definition of diodes switching characteristics





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