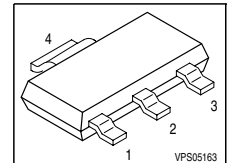


**Cool MOS™ Power Transistor**
**Feature**

- New revolutionary high voltage technology
- Worldwide best  $R_{DS(on)}$  in SOT 223
- Ultra low gate charge
- Extreme  $dv/dt$  rated
- Ultra low effective capacitances
- Improved transconductance
- Qualified according to JEDEC<sup>0)</sup> for target applications

$V_{DS}$	600	V
$R_{DS(on)}$	0.95	$\Omega$
$I_D$	0.8	A

SOT-223



Type	Package	Ordering Code	Marking
SPN04N60S5	SOT-223	Q67040-S4211	04N60S5

drain pins 2, 4



source pin 3

**Maximum Ratings**

Parameter	Symbol	Value	Unit
Continuous drain current $T_A = 25\text{ °C}$ $T_A = 70\text{ °C}$	$I_D$	0.8 0.65	A
Pulsed drain current, $t_p$ limited by $T_{jmax}$ $T_A = 25\text{ °C}$	$I_D$ puls	3	
Gate source voltage	$V_{GS}$	$\pm 20$	V
Gate source voltage AC ( $f > 1\text{ Hz}$ )	$V_{GS}$	$\pm 30$	
Power dissipation, $T_A = 25\text{ °C}$	$P_{tot}$	1.8	W
Operating and storage temperature	$T_j, T_{stg}$	-55... +150	$^{\circ}\text{C}$

**Maximum Ratings**

Parameter	Symbol	Value	Unit
Drain Source voltage slope $V_{DS} = 480\text{ V}$ , $I_D = 4.5\text{ A}$ , $T_j = 125\text{ °C}$	$dv/dt$	20	V/ns

**Thermal Characteristics**

Parameter	Symbol	Values			Unit
		min.	typ.	max.	
Thermal resistance, junction - soldering point	$R_{thJS}$	-	20	-	K/W
SMD version, device on PCB: @ min. footprint @ 6 cm <sup>2</sup> cooling area <sup>1)</sup>	$R_{thJA}$	-	110	-	K/W
		-	-	70	
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**

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	-	μA
Gate threshold voltage	$V_{GS(th)}$	$I_D=200\text{μA}$ , $V_{GS}=V_{DS}$	3.5	4.5	5.5	
Zero gate voltage drain current	$I_{DSS}$	$V_{DS}=600\text{V}$ , $V_{GS}=0\text{V}$ , $T_j=25\text{°C}$ , $T_j=150\text{°C}$	-	0.5	1	
Gate-source leakage current	$I_{GSS}$	$V_{GS}=20\text{V}$ , $V_{DS}=0\text{V}$	-	-	100	nA
Drain-source on-state resistance	$R_{DS(on)}$	$V_{GS}=10\text{V}$ , $I_D=2.8\text{A}$ , $T_j=25\text{°C}$ $T_j=150\text{°C}$	-	0.8	0.95	Ω
			-	2.3	-	
Gate input resistance	$R_G$	$f=1\text{MHz}$ , open Drain	-	20	-	

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

Parameter	Symbol	Conditions	Values			Unit
			min.	typ.	max.	
<b>Characteristics</b>						
Transconductance	$g_{fs}$	$V_{DS} \geq 2 \cdot I_D \cdot R_{DS(on)max}$ , $I_D = 0.65\text{A}$	-	1	-	S
Input capacitance	$C_{iss}$	$V_{GS} = 0\text{V}$ , $V_{DS} = 25\text{V}$ , $f = 1\text{MHz}$	-	600	-	pF
Output capacitance	$C_{oss}$		-	325	-	
Reverse transfer capacitance	$C_{rss}$		-	15	-	
Effective output capacitance, <sup>2)</sup> energy related	$C_{o(er)}$	$V_{GS} = 0\text{V}$ , $V_{DS} = 0\text{V to } 480\text{V}$	-	20	-	pF
Effective output capacitance, <sup>3)</sup> time related	$C_{o(tr)}$		-	35	-	
Turn-on delay time	$t_{d(on)}$	$V_{DD} = 350\text{V}$ , $V_{GS} = 0/10\text{V}$ , $I_D = 0.8\text{A}$ , $R_G = 18\Omega$	-	40	-	ns
Rise time	$t_r$		-	20	-	
Turn-off delay time	$t_{d(off)}$		-	130	-	
Fall time	$t_f$		-	30	-	

**Gate Charge Characteristics**

Gate to source charge	$Q_{gs}$	$V_{DD} = 350\text{V}$ , $I_D = 0.8\text{A}$	-	4.1	-	nC
Gate to drain charge	$Q_{gd}$		-	9.2	-	
Gate charge total	$Q_g$	$V_{DD} = 350\text{V}$ , $I_D = 0.8\text{A}$ , $V_{GS} = 0\text{ to } 10\text{V}$	-	17	-	
Gate plateau voltage	$V_{(plateau)}$	$V_{DD} = 350\text{V}$ , $I_D = 0.8\text{A}$	-	8	-	V

<sup>0</sup>J-STD20 and JESD22

<sup>1</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>2</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%  $V_{DSS}$ .

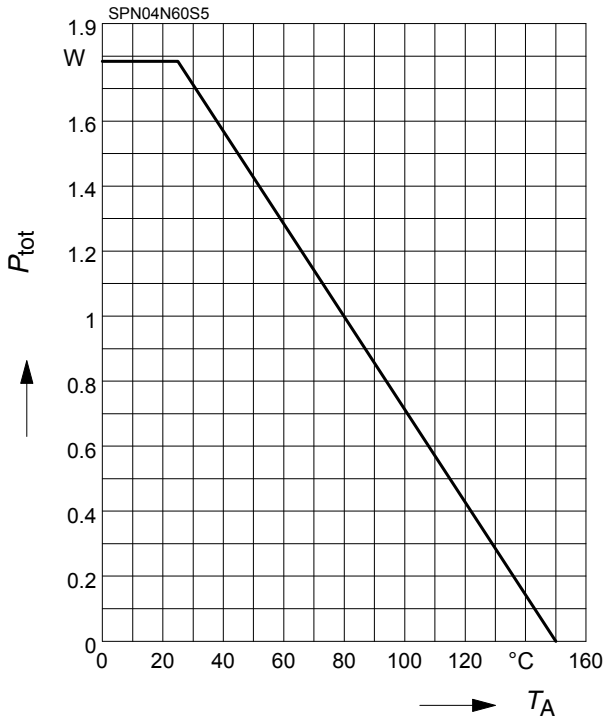
<sup>3</sup> $C_{o(tr)}$  is a fixed capacitance that gives the same charging time as  $C_{oss}$  while  $V_{DS}$  is rising from 0 to 80%  $V_{DSS}$ .

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

Parameter	Symbol	Conditions	Values			Unit
			min.	typ.	max.	
Inverse diode continuous forward current	$I_S$	$T_A=25\text{ °C}$	-	-	0.8	A
Inverse diode direct current, pulsed	$I_{SM}$		-	-	3	
Inverse diode forward voltage	$V_{SD}$	$V_{GS}=0V, I_F=I_S$	-	0.85	1.05	V
Reverse recovery time	$t_{rr}$	$V_R=350V, I_F=I_S,$	-	200	-	ns
Reverse recovery charge	$Q_{rr}$	$di_F/dt=100A/\mu s$	-	1.2	-	$\mu C$

**1 Power dissipation**

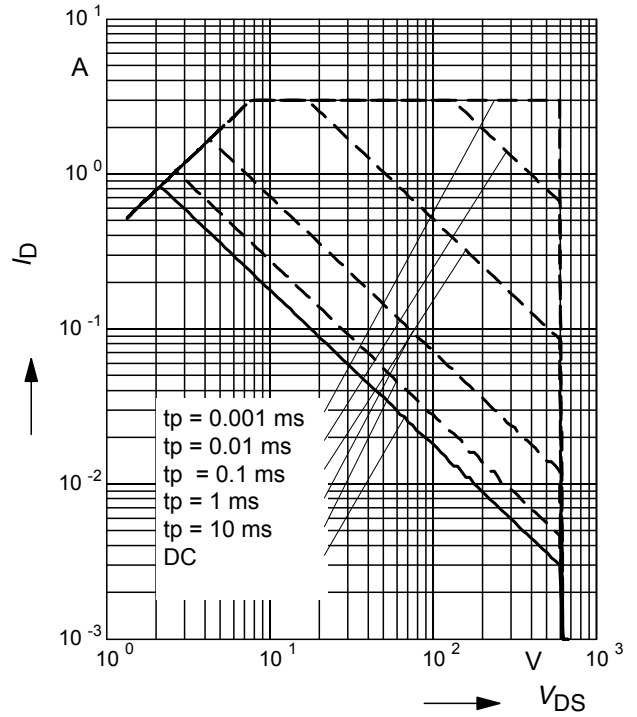
$P_{tot} = f(T_A)$



**2 Safe operating area**

$I_D = f(V_{DS})$

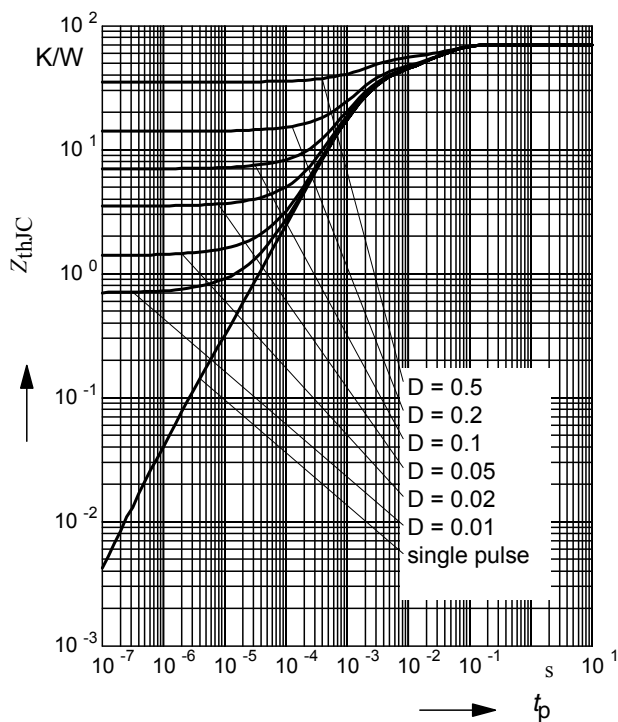
parameter :  $D = 0$  ,  $T_A = 25^\circ\text{C}$



**3 Transient thermal impedance**

$Z_{thJC} = f(t_p)$

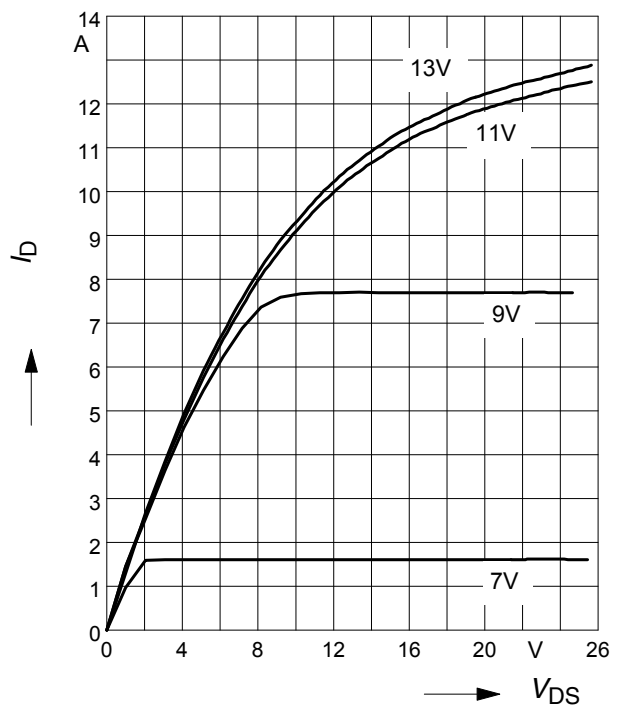
parameter:  $D = t_p/T$



**4 Typ. output characteristic**

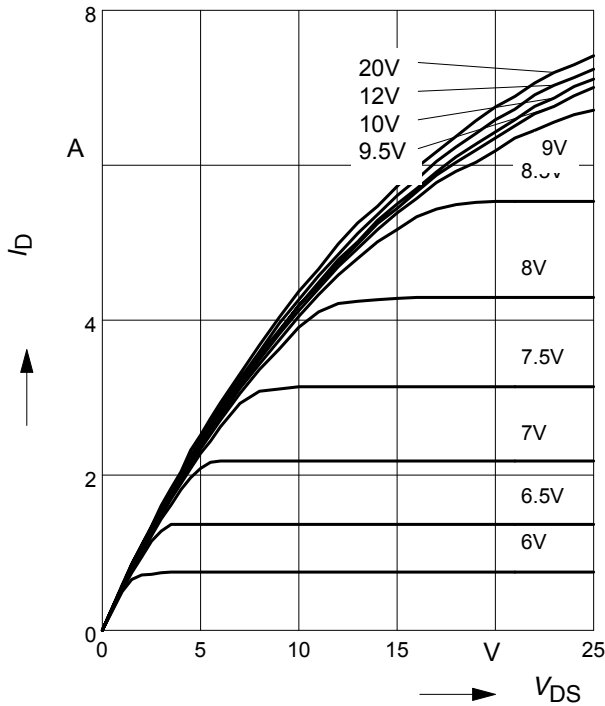
$I_D = f(V_{DS})$ ;  $T_j = 25^\circ\text{C}$

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



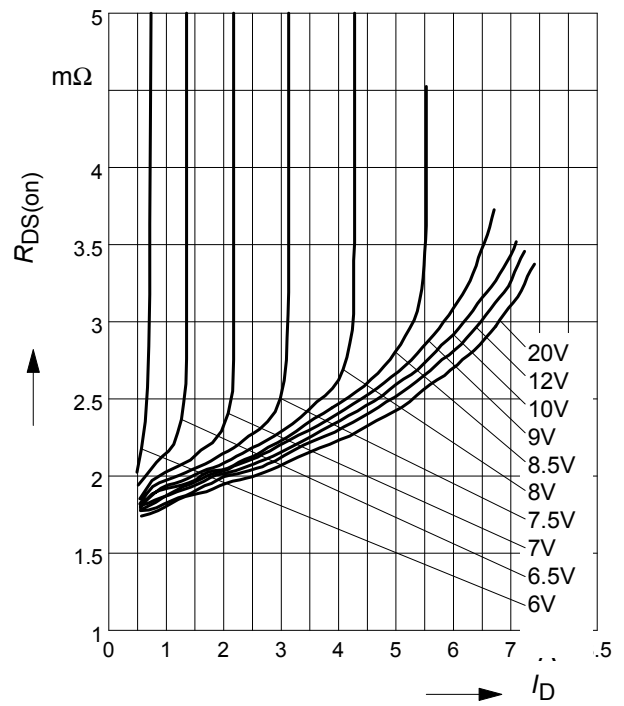
**5 Typ. output characteristic**

$I_D = f(V_{DS}); T_j = 150^\circ\text{C}$   
 parameter:  $t_p = 10 \mu\text{s}, V_{GS}$



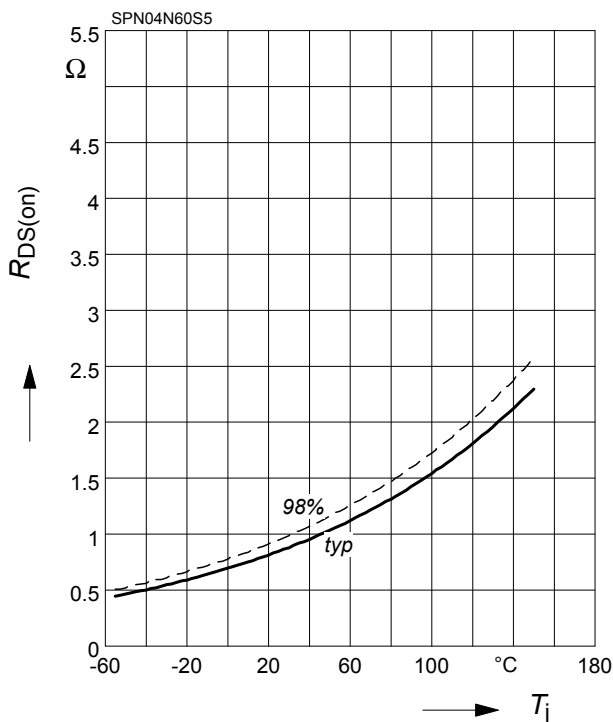
**6 Typ. drain-source on resistance**

$R_{DS(on)} = f(I_D)$   
 parameter:  $T_j = 150^\circ\text{C}, V_{GS}$



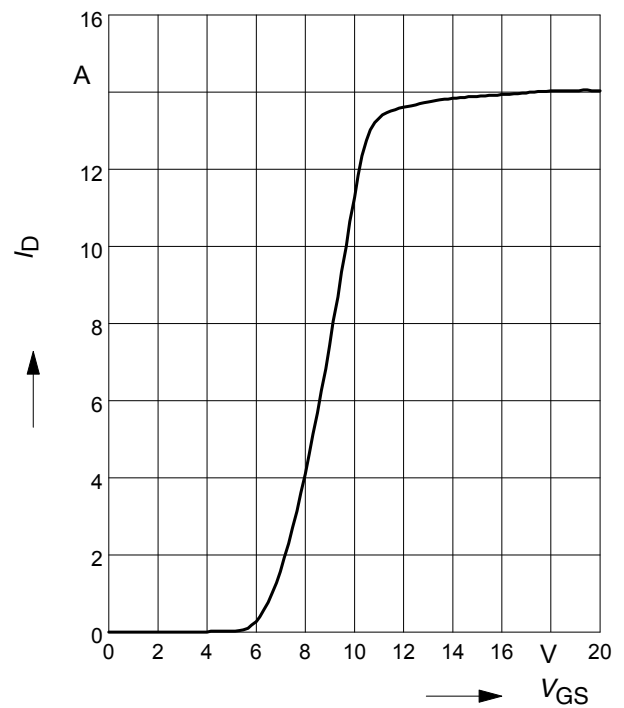
**7 Drain-source on-state resistance**

$R_{DS(on)} = f(T_j)$   
 parameter:  $I_D = 0.65 \text{ A}, V_{GS} = 10 \text{ V}$



**8 Typ. transfer characteristics**

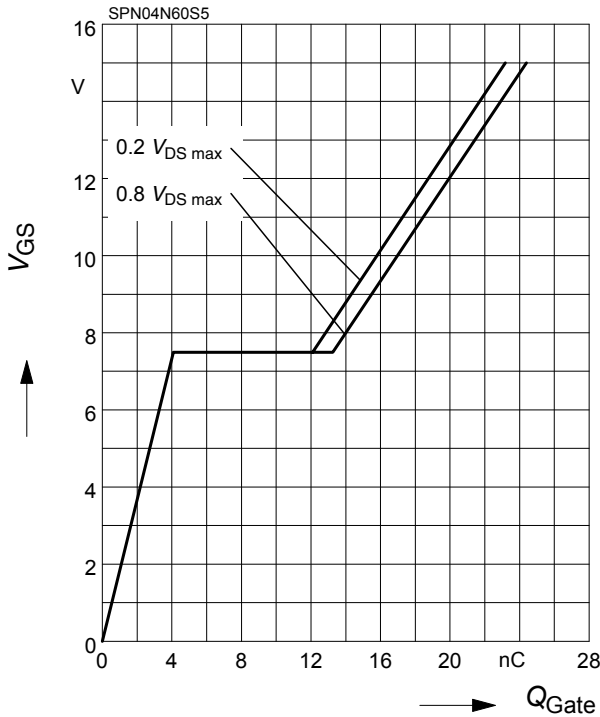
$I_D = f(V_{GS}); V_{DS} \geq 2 \times I_D \times R_{DS(on)max}$   
 parameter:  $t_p = 10 \mu\text{s}$



**9 Typ. gate charge**

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

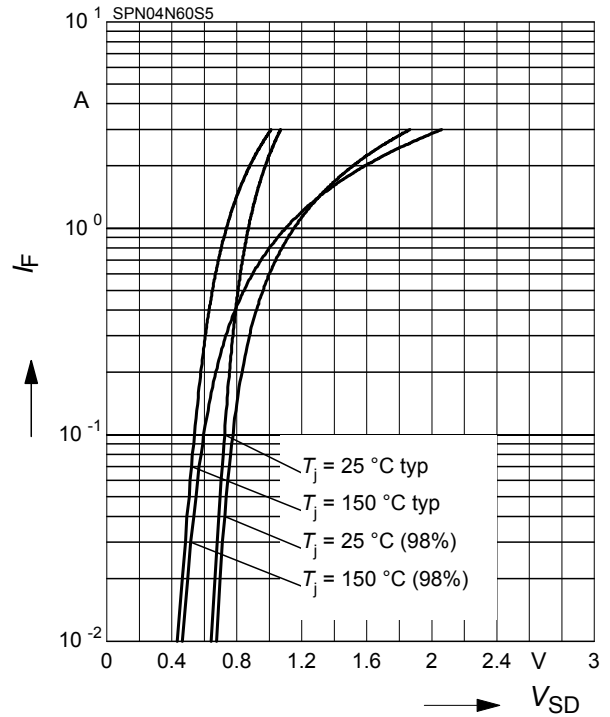
parameter:  $I_D = 0.8 \text{ A}$  pulsed



**10 Forward characteristics of body diode**

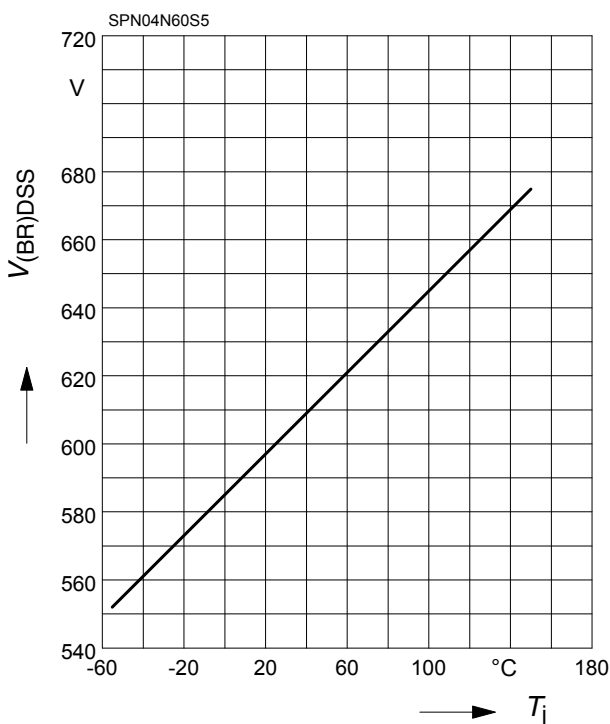
$$I_F = f(V_{SD})$$

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



**11 Drain-source breakdown voltage**

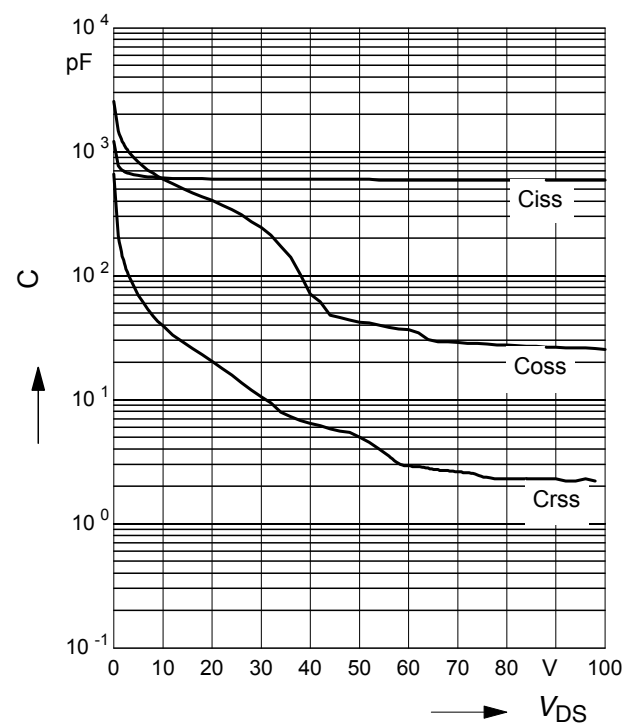
$$V_{(BR)DSS} = f(T_j)$$



**12 Typ. capacitances**

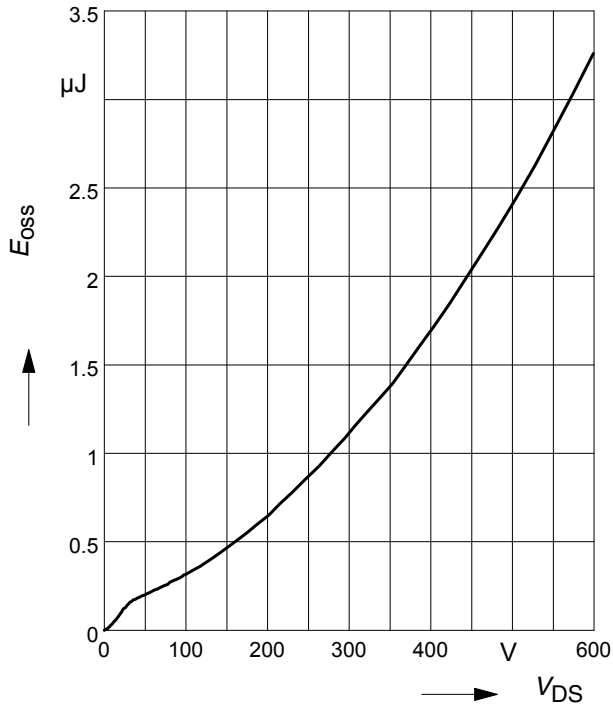
$$C = f(V_{DS})$$

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

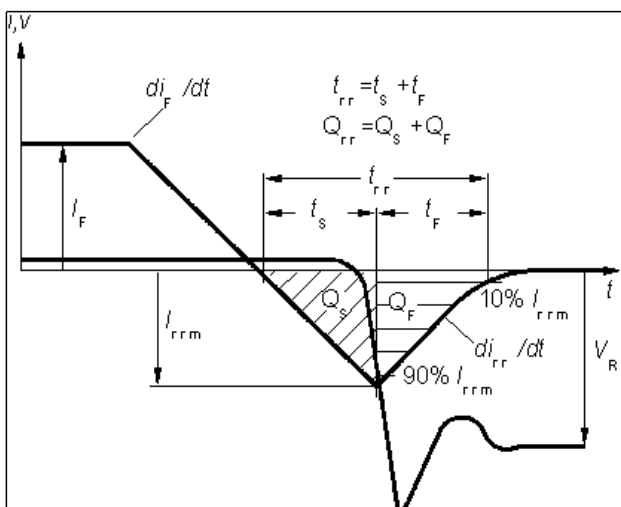


13 Typ.  $C_{OSS}$  stored energy

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

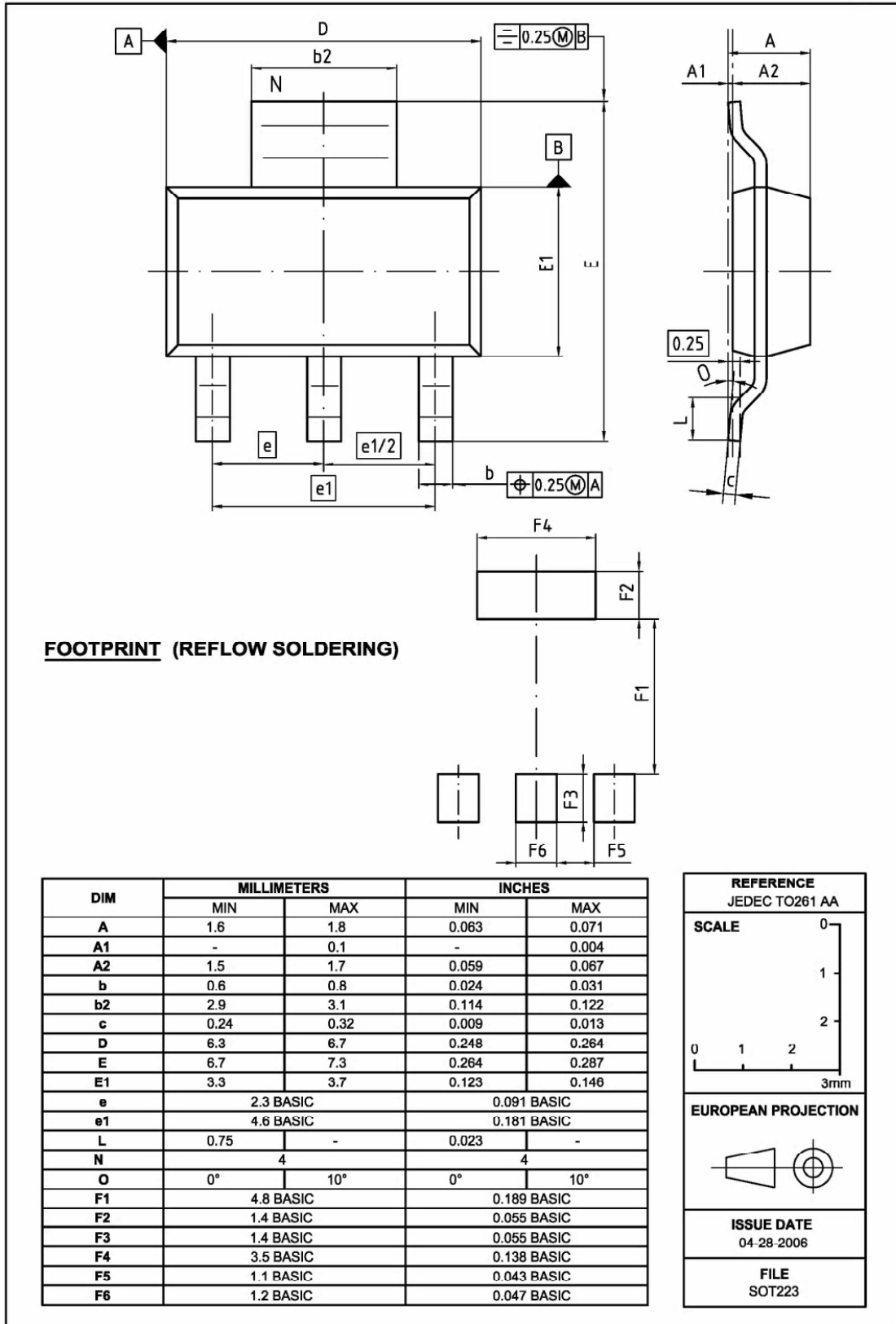


Definition of diodes switching characteristics





SOT223



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