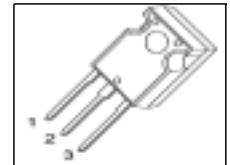


**Cool MOS™ Power Transistor**
**Feature**

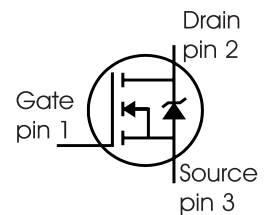
- New revolutionary high voltage technology
- Ultra low gate charge
- Periodic avalanche rated
- Extreme  $dv/dt$  rated
- Ultra low effective capacitances
- Improved transconductance
- Pb-free lead plating; RoHS compliant
- Qualified according to JEDEC<sup>0)</sup> for target applications

$V_{DS} @ T_{jmax}$	560	V
$R_{DS(on)}$	0.19	$\Omega$
$I_D$	21	A

PG-TO247



Type	Package	Ordering Code	Marking
SPW21N50C3	PG-TO247	Q67040-S4586	21N50C3


**Maximum Ratings**

Parameter	Symbol	Value	Unit
Continuous drain current $T_C = 25\text{ °C}$ $T_C = 100\text{ °C}$	$I_D$	21 13.1	A
Pulsed drain current, $t_p$ limited by $T_{jmax}$	$I_{D\text{ puls}}$	63	
Avalanche energy, single pulse $I_D = 10\text{ A}$ , $V_{DD} = 50\text{ V}$	$E_{AS}$	690	mJ
Avalanche energy, repetitive $t_{AR}$ limited by $T_{jmax}$ <sup>1)</sup> $I_D = 21\text{ A}$ , $V_{DD} = 50\text{ V}$	$E_{AR}$	1	
Avalanche current, repetitive $t_{AR}$ limited by $T_{jmax}$	$I_{AR}$	21	A
Reverse diode $dv/dt$ <sup>4)</sup>	$dv/dt$	15	V/ns
Gate source voltage	$V_{GS}$	$\pm 20$	V
Gate source voltage AC ( $f > 1\text{ Hz}$ )	$V_{GS}$	$\pm 30$	
Power dissipation, $T_C = 25\text{ °C}$	$P_{tot}$	208	W
Operating and storage temperature	$T_j, T_{stg}$	-55... +150	$^{\circ}\text{C}$

**Maximum Ratings**

Parameter	Symbol	Value	Unit
Drain Source voltage slope $V_{DS} = 400\text{ V}$ , $I_D = 21\text{ A}$ , $T_j = 125\text{ °C}$	$dv/dt$	50	V/ns

**Thermal Characteristics**

Parameter	Symbol	Values			Unit
		min.	typ.	max.	
Thermal resistance, junction - case	$R_{thJC}$	-	-	0.6	K/W
Thermal resistance, junction - ambient, leaded	$R_{thJA}$	-	-	62	
Soldering temperature, wavesoldering 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	$V_{(BR)DSS}$	$V_{GS}=0V$ , $I_D=0.25mA$	500	-	-	V
Drain-Source avalanche breakdown voltage	$V_{(BR)DS}$	$V_{GS}=0V$ , $I_D=21A$	-	600	-	
Gate threshold voltage	$V_{GS(th)}$	$I_D=1000\mu A$ , $V_{GS}=V_{DS}$	2.1	3	3.9	
Zero gate voltage drain current	$I_{DSS}$	$V_{DS}=500V$ , $V_{GS}=0V$ , $T_j=25\text{ °C}$ , $T_j=150\text{ °C}$	-	0.1	1	$\mu A$
Gate-source leakage current	$I_{GSS}$	$V_{GS}=20V$ , $V_{DS}=0V$	-	-	100	
Drain-source on-state resistance	$R_{DS(on)}$	$V_{GS}=10V$ , $I_D=13.1A$ , $T_j=25\text{ °C}$ $T_j=150\text{ °C}$	-	0.16	0.19	$\Omega$
Gate input resistance	$R_G$	$f=1MHz$ , open Drain	-	0.53	-	

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

Parameter	Symbol	Conditions	Values			Unit
			min.	typ.	max.	
Transconductance	$g_{fs}$	$V_{DS} \geq 2 \cdot I_D \cdot R_{DS(on)max}$ , $I_D = 13.1\text{A}$	-	18	-	S
Input capacitance	$C_{iss}$	$V_{GS} = 0\text{V}$ , $V_{DS} = 25\text{V}$ , $f = 1\text{MHz}$	-	2400	-	pF
Output capacitance	$C_{oss}$		-	1200	-	
Reverse transfer capacitance	$C_{rss}$		-	30	-	
Effective output capacitance, <sup>2)</sup> energy related	$C_{o(er)}$	$V_{GS} = 0\text{V}$ , $V_{DS} = 0\text{V to } 400\text{V}$	-	87	-	pF
Effective output capacitance, <sup>3)</sup> time related	$C_{o(tr)}$		-	tbd	-	
Turn-on delay time	$t_{d(on)}$	$V_{DD} = 380\text{V}$ , $V_{GS} = 0/10\text{V}$ , $I_D = 21\text{A}$ , $R_G = 3.6\Omega$	-	10	-	ns
Rise time	$t_r$		-	5	-	
Turn-off delay time	$t_{d(off)}$		-	67	-	
Fall time	$t_f$		-	4.5	-	

**Gate Charge Characteristics**

Gate to source charge	$Q_{gs}$	$V_{DD} = 380\text{V}$ , $I_D = 21\text{A}$	-	10	-	nC
Gate to drain charge	$Q_{gd}$		-	50	-	
Gate charge total	$Q_g$	$V_{DD} = 380\text{V}$ , $I_D = 21\text{A}$ , $V_{GS} = 0\text{ to } 10\text{V}$	-	95	-	
Gate plateau voltage	$V_{(plateau)}$	$V_{DD} = 380\text{V}$ , $I_D = 21\text{A}$	-	5	-	V

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

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

<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%  $V_{DSS}$ .

<sup>4</sup> $I_{SD} \leq I_D$ ,  $di/dt \leq 200\text{A}/\mu\text{s}$ ,  $V_{DClink} = 400\text{V}$ ,  $V_{peak} < V_{BR, DSS}$ ,  $T_j < T_{j,max}$ .

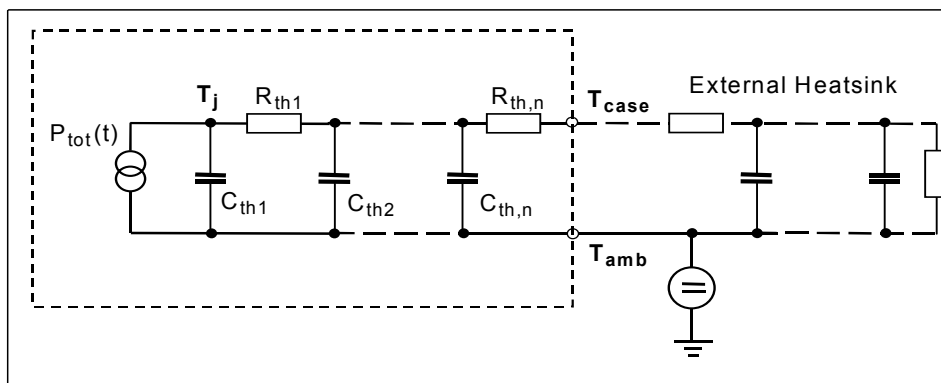
Identical low-side and high-side switch.

**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	$I_S$	$T_C=25^\circ\text{C}$	-	-	21	A
Inverse diode direct current, pulsed	$I_{SM}$		-	-	63	
Inverse diode forward voltage	$V_{SD}$	$V_{GS}=0\text{V}, I_F=I_S$	-	1	1.2	V
Reverse recovery time	$t_{rr}$	$V_R=380\text{V}, I_F=I_S,$	-	450	-	ns
Reverse recovery charge	$Q_{rr}$	$di_F/dt=100\text{A}/\mu\text{s}$	-	9	-	$\mu\text{C}$
Peak reverse recovery current	$I_{rrm}$		-	60	-	A
Peak rate of fall of reverse recovery current	$di_{rr}/dt$		-	1200	-	$\text{A}/\mu\text{s}$

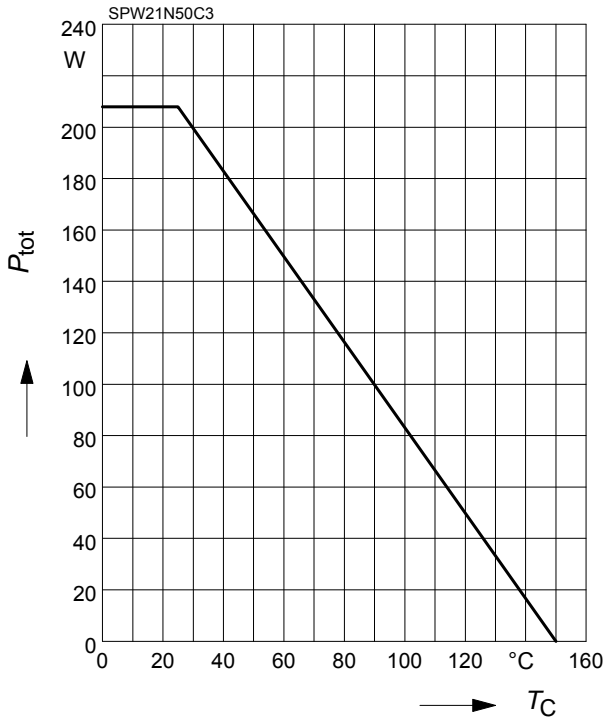
**Typical Transient Thermal Characteristics**

Symbol	Value	Unit	Symbol	Value	Unit
	typ.			typ.	
Thermal resistance			Thermal capacitance		
$R_{th1}$	0.00769	K/W	$C_{th1}$	0.0003763	Ws/K
$R_{th2}$	0.015		$C_{th2}$	0.001411	
$R_{th3}$	0.029		$C_{th3}$	0.001931	
$R_{th4}$	0.114		$C_{th4}$	0.005297	
$R_{th5}$	0.136		$C_{th5}$	0.012	
$R_{th6}$	0.059		$C_{th6}$	0.091	



**1 Power dissipation**

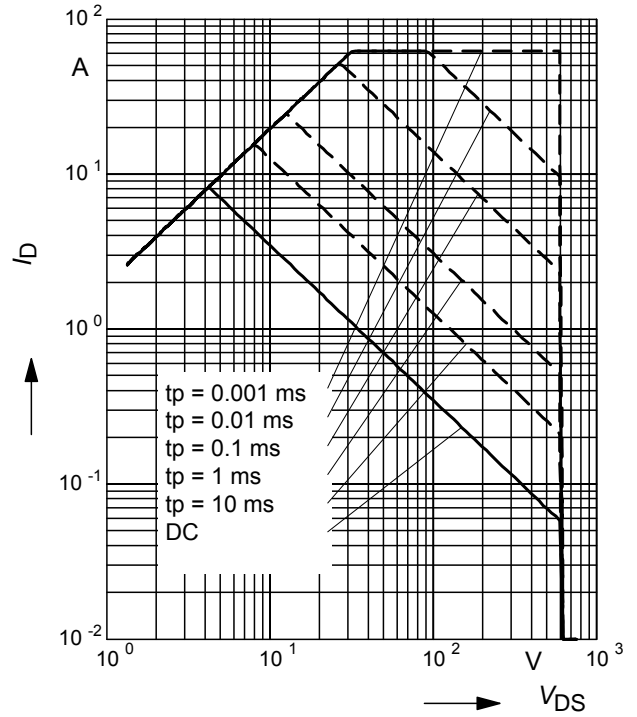
$P_{tot} = f(T_C)$



**2 Safe operating area**

$I_D = f(V_{DS})$

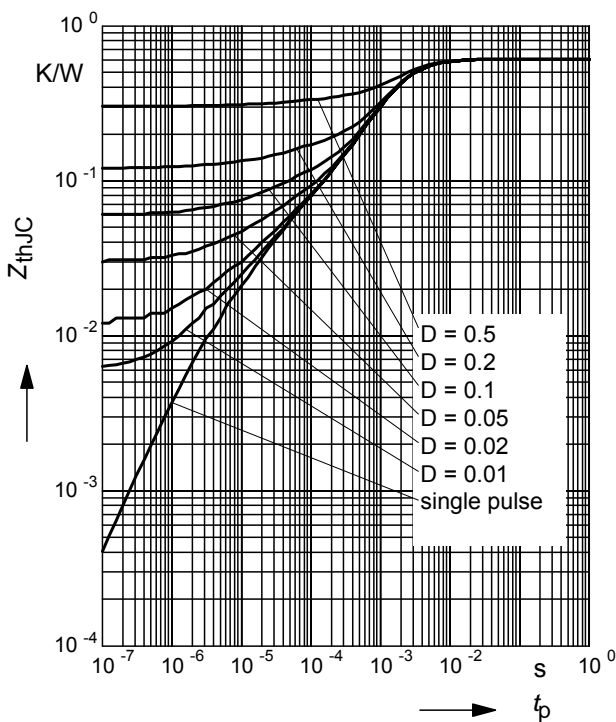
parameter :  $D = 0$  ,  $T_C = 25^\circ C$



**3 Transient thermal impedance**

$Z_{thJC} = f(t_p)$

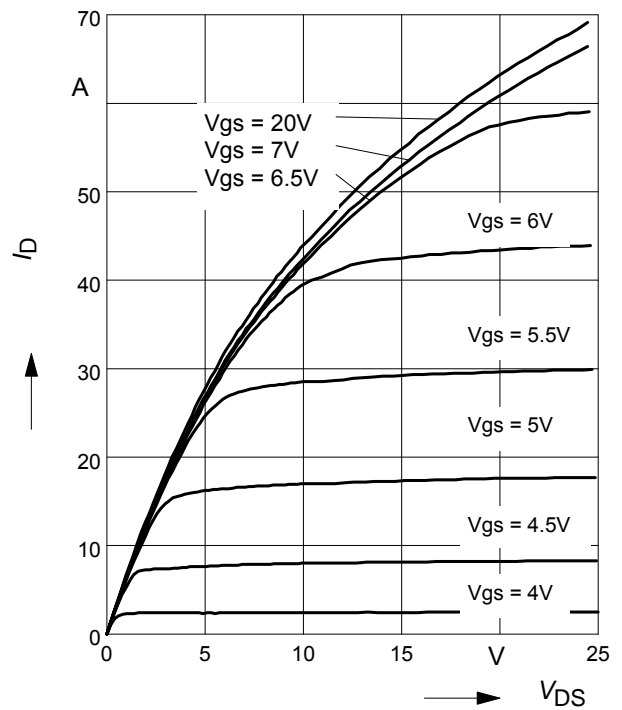
parameter:  $D = t_p/T$



**4 Typ. output characteristic**

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

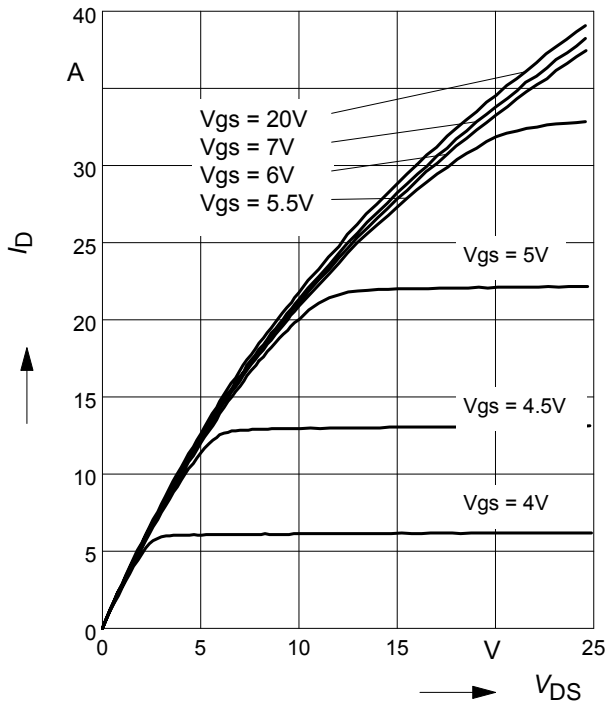
parameter:  $t_p = 10 \mu s$ ,  $V_{GS}$



**5 Typ. output characteristic**

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

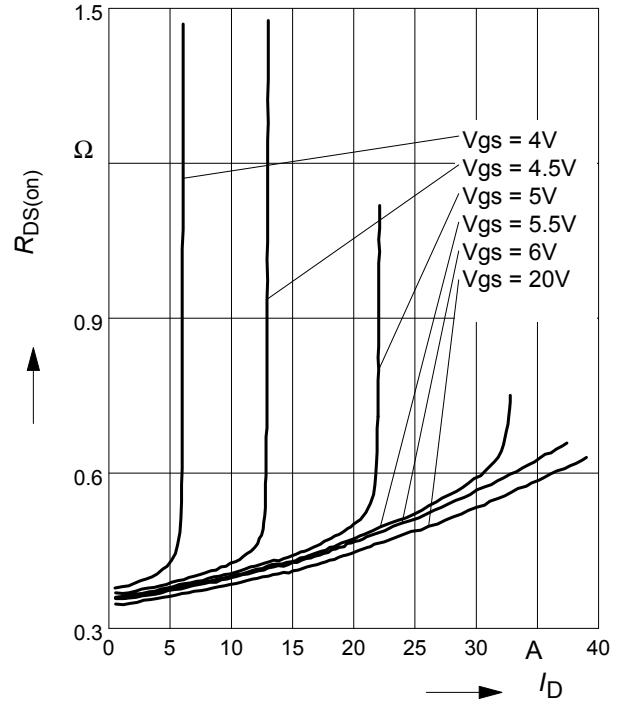
parameter:  $t_p = 10 \mu\text{s}, V_{GS}$



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

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

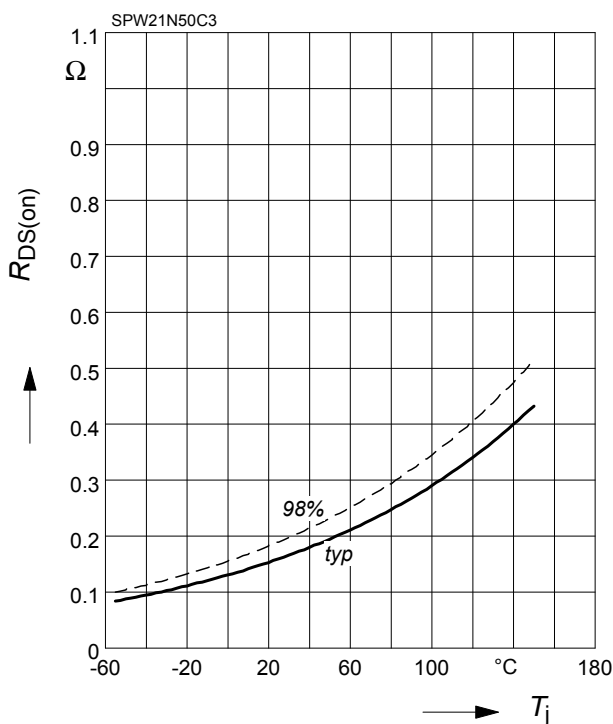
parameter:  $T_j = 150^\circ\text{C}, V_{GS}$



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

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

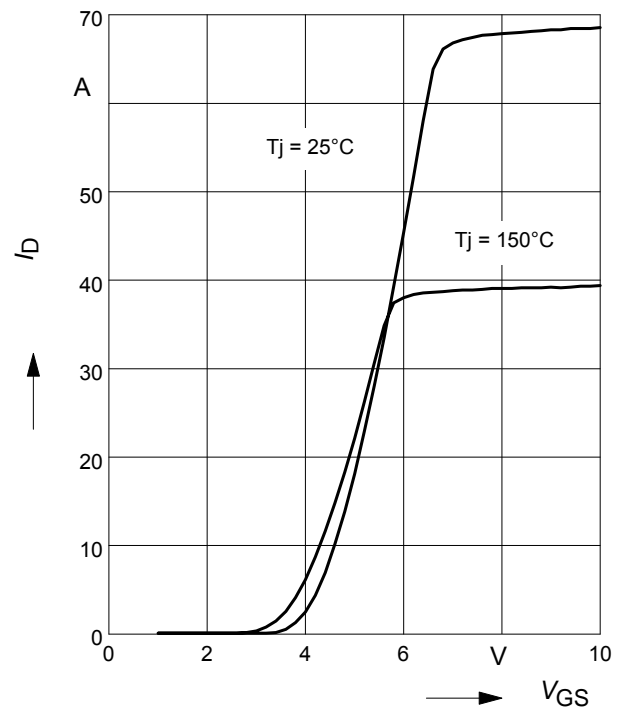
parameter:  $I_D = 13.1 \text{ A}, V_{GS} = 10 \text{ V}$



**8 Typ. transfer characteristics**

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

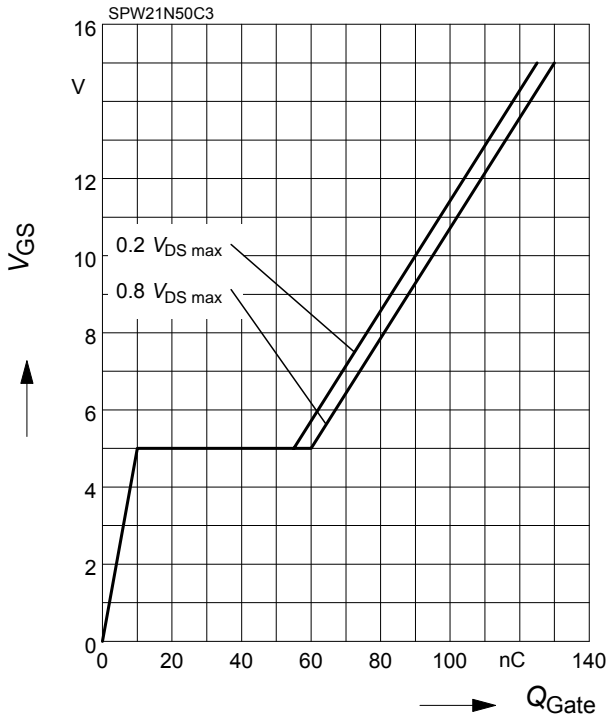
parameter:  $t_p = 10 \mu\text{s}$



**9 Typ. gate charge**

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

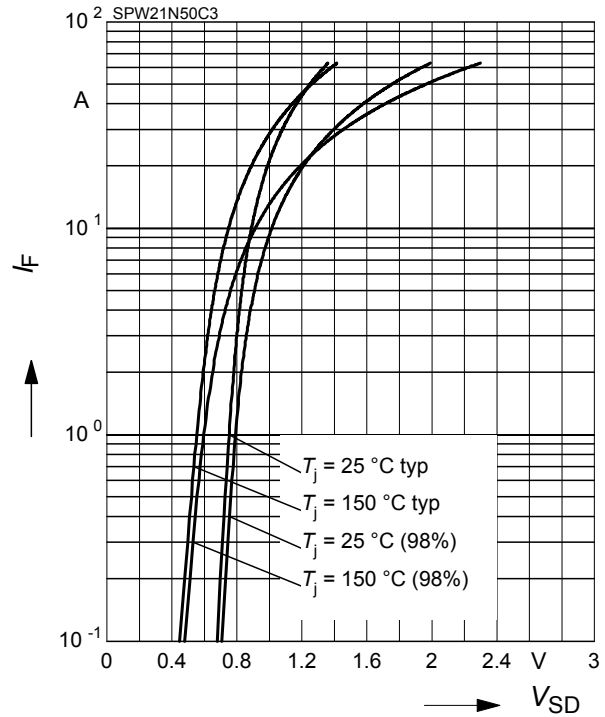
parameter:  $I_D = 21\text{ A}$  pulsed



**10 Forward characteristics of body diode**

$I_F = f(V_{SD})$

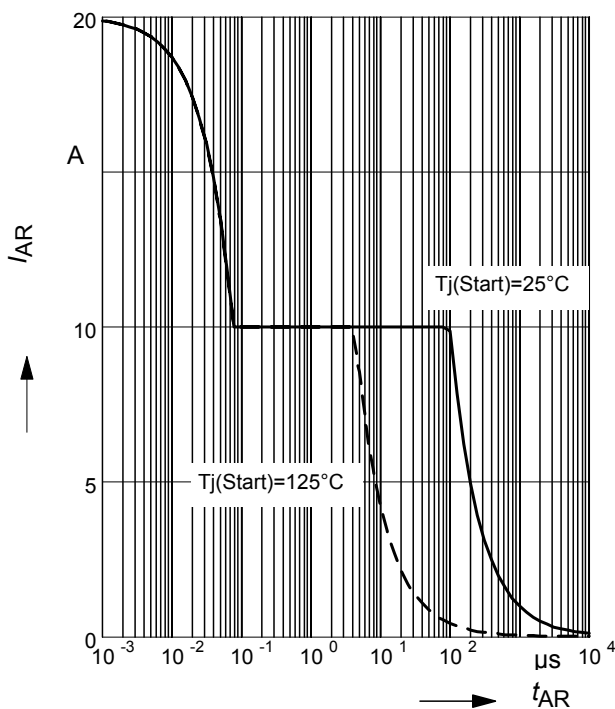
parameter:  $T_j, t_p = 10\ \mu\text{s}$



**11 Avalanche SOA**

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

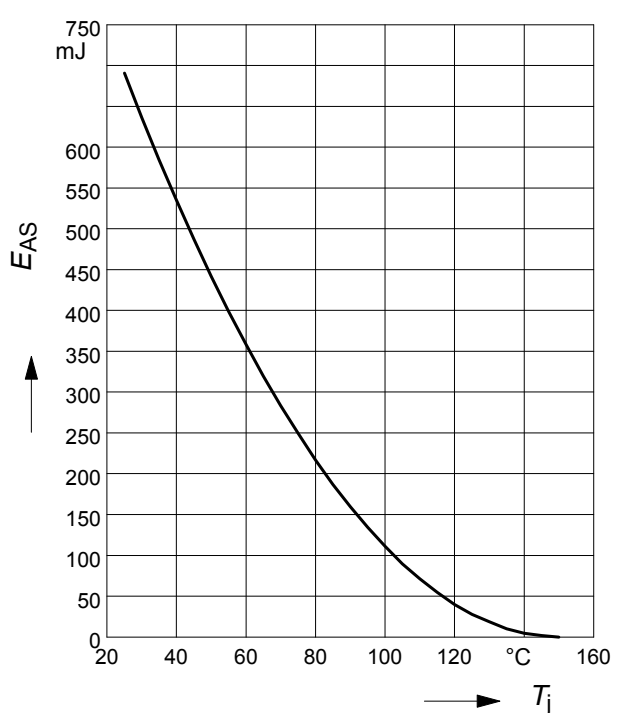
par.:  $T_j \leq 150\text{ °C}$



**12 Avalanche energy**

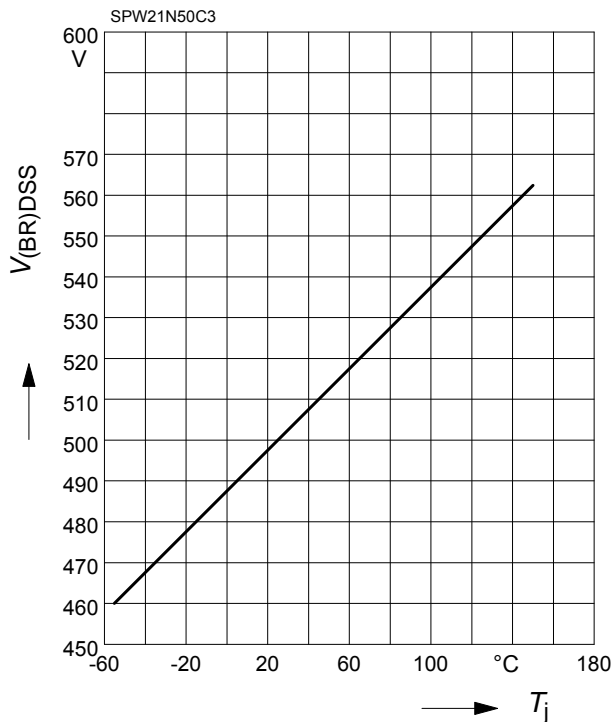
$E_{AS} = f(T_j)$

par.:  $I_D = 10\text{ A}, V_{DD} = 50\text{ V}$



### 13 Drain-source breakdown voltage

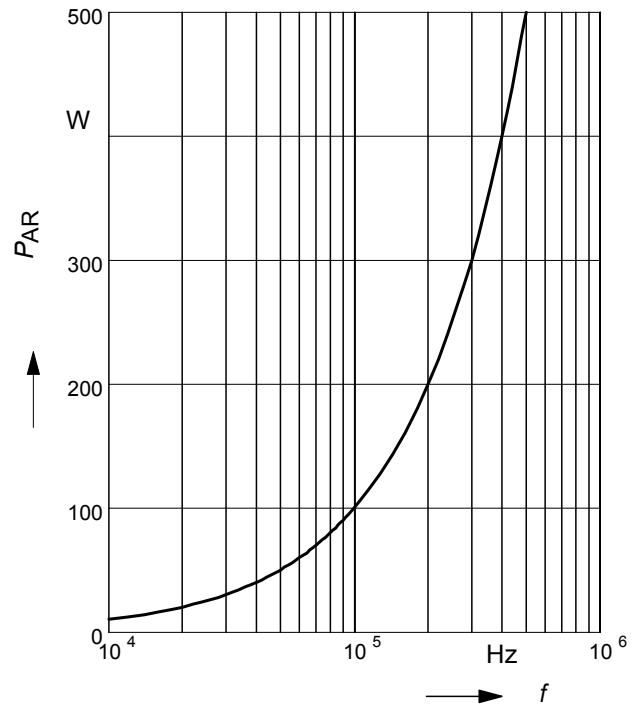
$$V_{(BR)DSS} = f(T_j)$$



### 14 Avalanche power losses

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

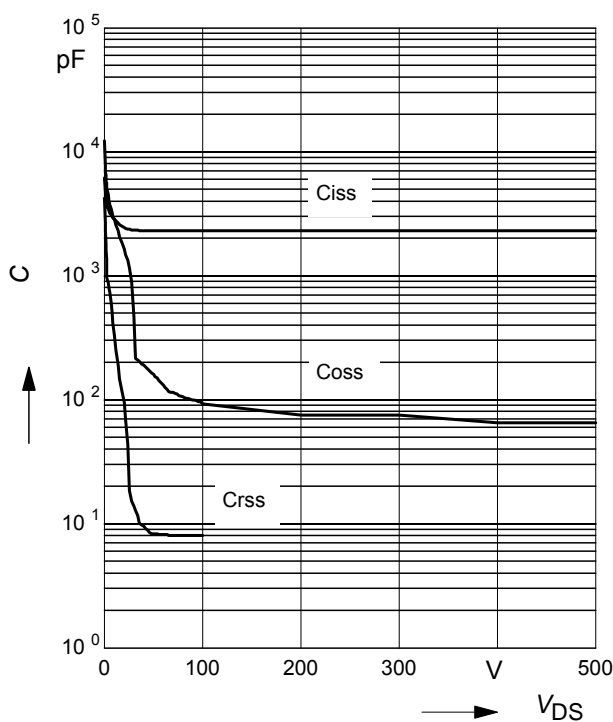
parameter:  $E_{AR}=1mJ$



### 15 Typ. capacitances

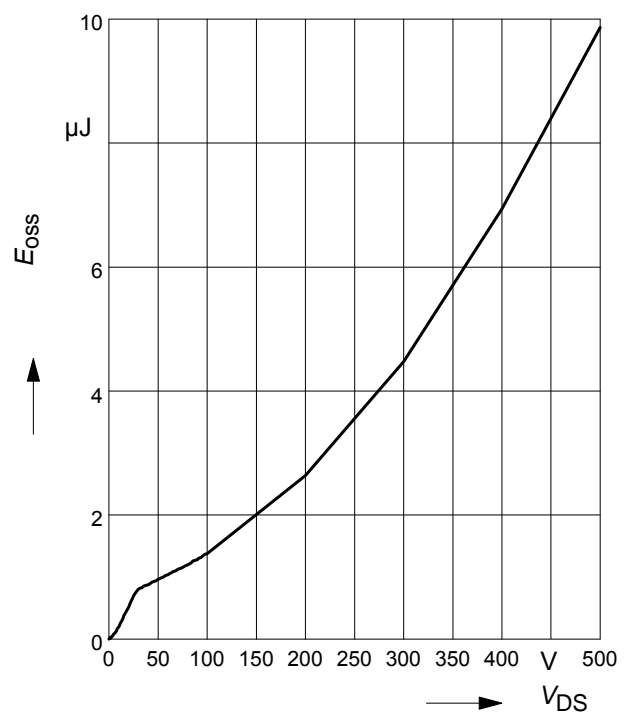
$$C = f(V_{DS})$$

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



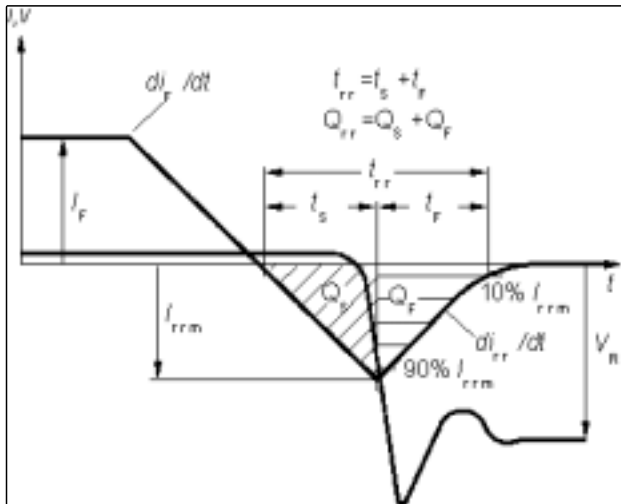
### 16 Typ. $C_{OSS}$ stored energy

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

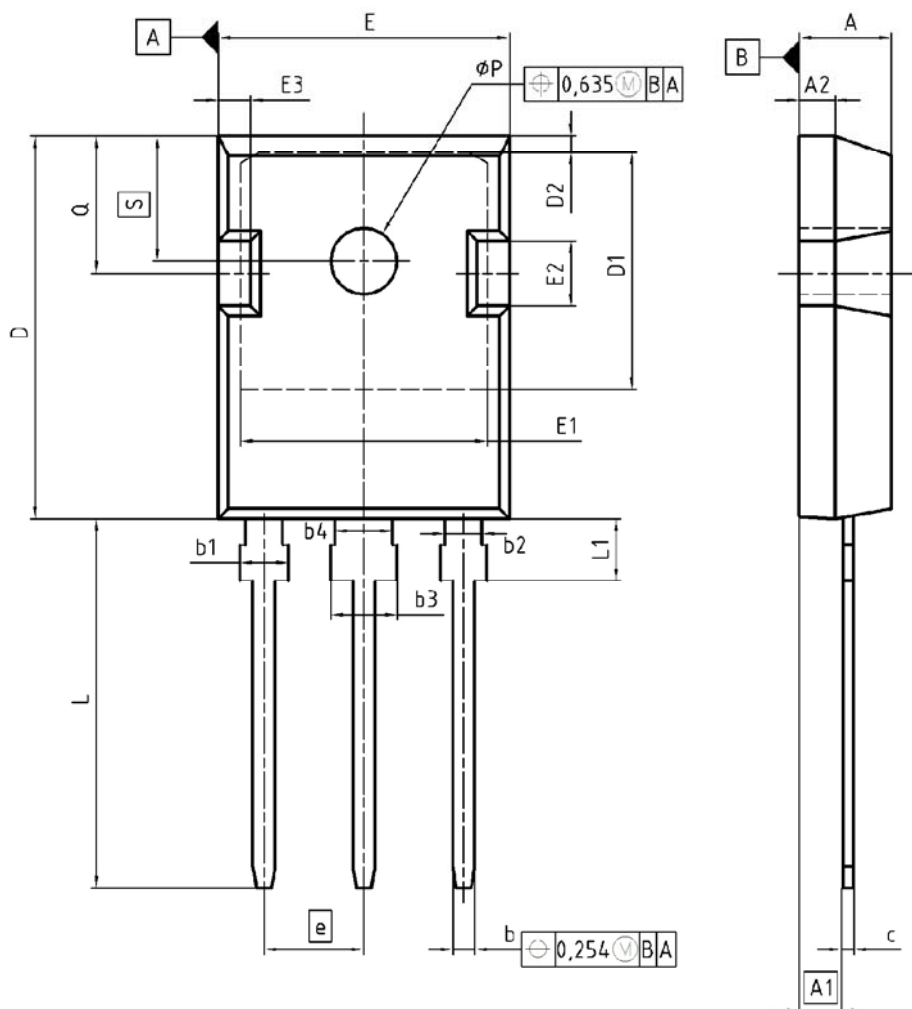




Definition of diodes switching characteristics



PG-TO-247-3-1



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.90	5.16	0.193	0.203
A1	2.27	2.53	0.089	0.099
A2	1.85	2.11	0.073	0.083
b	1.07	1.33	0.042	0.052
b1	1.90	2.41	0.075	0.095
b2	1.90	2.16	0.075	0.085
b3	2.87	3.38	0.113	0.133
b4	2.87	3.13	0.113	0.123
c	0.55	0.68	0.022	0.027
D	20.82	21.10	0.820	0.831
D1	16.25	17.65	0.640	0.695
D2	1.05	1.35	0.041	0.053
E	15.70	16.03	0.618	0.631
E1	13.10	14.15	0.516	0.557
E2	3.68	5.10	0.145	0.201
E3	1.68	2.60	0.066	0.102
e	5.44		0.214	
N	3		3	
L	19.80	20.31	0.780	0.799
L1	4.17	4.47	0.164	0.176
$\phi P$	3.50	3.70	0.138	0.146
Q	5.49	6.00	0.216	0.236
S	6.04	6.30	0.238	0.248

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# 1 New package outlines TO-247

Assembly capacity extension for CoolMOSTM technology products assembled in lead-free package PG-TO247-3 at subcontractor ASE (Weihai) Inc., China (Changes are marked in blue.)

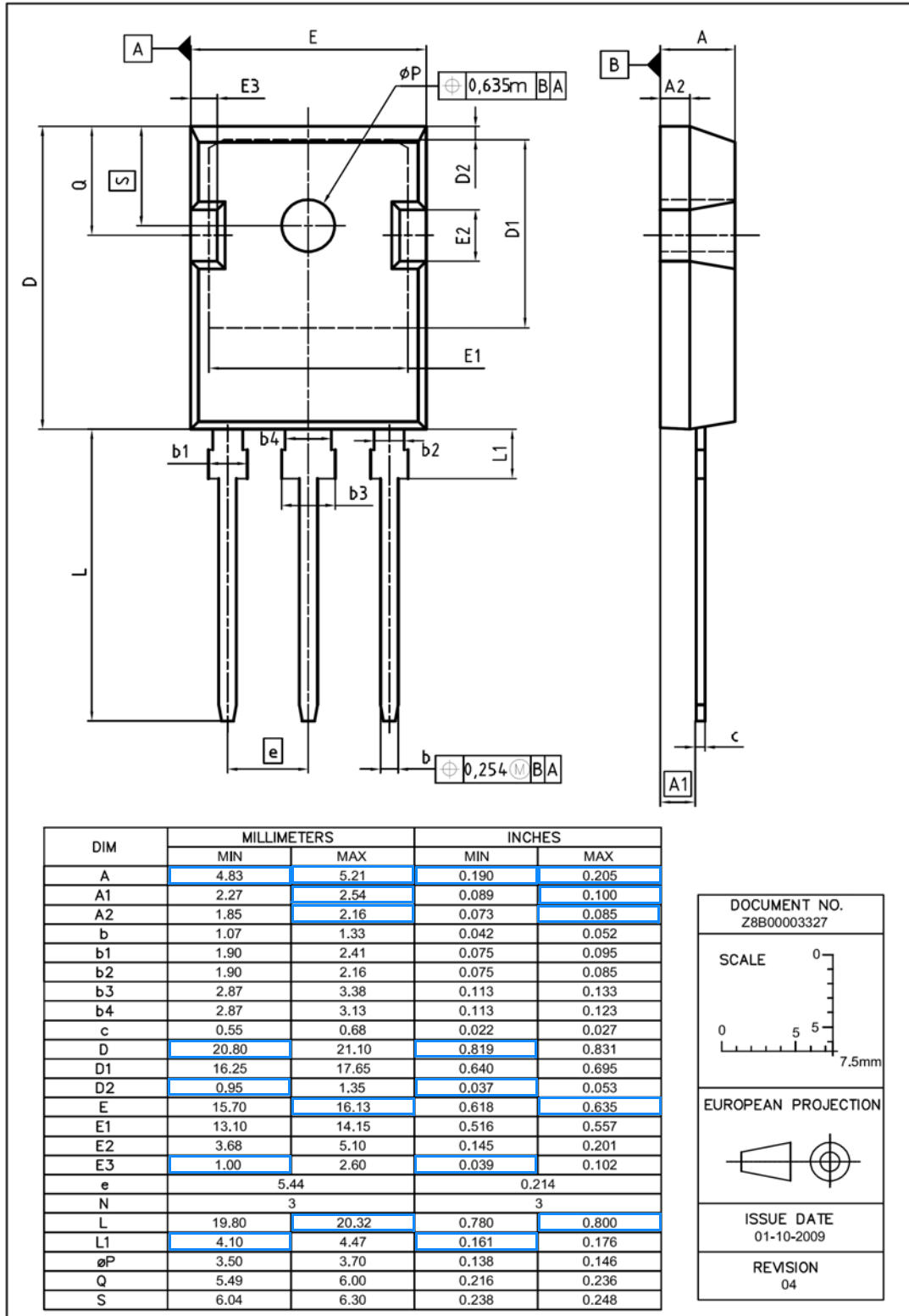


Figure 1 Outlines TO-247, dimensions in mm/inches