

**CoolMOS™ Power Transistor**
**Features**

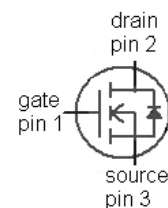
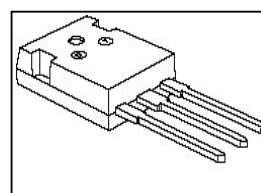
- Intrinsic fast-recovery body diode
- Extremely low reverse recovery charge
- Ultra low gate charge
- Extreme  $dv/dt$  rated
- High peak current capability
- Qualified according to JEDEC<sup>1)</sup> for target applications

**CoolMOS CFD designed for**

- Softswitching PWM Stages
- LCD & CRT TV

**Product Summary**

$V_{DS} @ T_{jmax}$	650	V
$R_{DS(on),max}$	0.185	$\Omega$
$I_D$	21.7	A

**PG-TO247**


Type	Package	Marking
SPW24N60CFD	PG-TO247	24N60CFD

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

Parameter	Symbol	Conditions	Value	Unit
Continuous drain current	$I_D$	$T_C=25^\circ\text{C}$	21.7	A
		$T_C=100^\circ\text{C}$	13.7	
Pulsed drain current <sup>2)</sup>	$I_{D,pulse}$	$T_C=25^\circ\text{C}$	55	
Avalanche energy, single pulse	$E_{AS}$	$I_D=10\text{A}, V_{DD}=50\text{V}$	780	mJ
Avalanche energy, repetitive <sup>2),3)</sup>	$E_{AR}$	$I_D=20\text{A}, V_{DD}=50\text{V}$	1	
Avalanche current, repetitive <sup>2),3)</sup>	$I_{AR}$		20	A
Drain source voltage slope	$dv/dt$	$I_D=21.7\text{A}, V_{DS}=480\text{V}, T_j=125^\circ\text{C}$	80	V/ns
Reverse diode $dv/dt$	$dv/dt$	$I_S=21.7\text{A}, V_{DS}=480\text{V}, T_j=125^\circ\text{C}$	40	V/ns
Maximum diode commutation speed	$di/dt$		600	A/ $\mu\text{s}$
Gate source voltage	$V_{GS}$	static	$\pm 20$	V
		AC ( $f > 1\text{ Hz}$ )	$\pm 30$	
Power dissipation	$P_{tot}$	$T_C=25^\circ\text{C}$	240	W
Operating and storage temperature	$T_j, T_{stg}$		-55 ... 150	$^\circ\text{C}$
Mounting torque		M3 & M3.5 screws	60	Ncm

Parameter	Symbol	Conditions	Values			Unit
			min.	typ.	max.	

**Thermal characteristics**

Thermal resistance, junction - case	$R_{thJC}$		-	-	0.52	K/W
Thermal resistance, junction - ambient	$R_{thJA}$	leaded	-	-	62	
Soldering temperature, wave soldering only allowed at leads	$T_{sold}$	1.6 mm (0.063 in.) from case for 10 s	-	-	260	°C

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

Drain-source breakdown voltage	$V_{(BR)DSS}$	$V_{GS}=0\text{ V}, I_D=250\text{ }\mu\text{A}$	600	-	-	V
Avalanche breakdown voltage	$V_{(BR)DS}$	$V_{GS}=0\text{ V}, I_D=21.7\text{ A}$	-	700	-	
Gate threshold voltage	$V_{GS(th)}$	$V_{DS}=V_{GS}, I_D=1.2\text{ mA}$	3	4	5	
Zero gate voltage drain current	$I_{DSS}$	$V_{DS}=600\text{ V}, V_{GS}=0\text{ V}, T_j=25\text{ °C}$	-	2.5	-	$\mu\text{A}$
		$V_{DS}=600\text{ V}, V_{GS}=0\text{ V}, T_j=150\text{ °C}$	-	2600	-	
Gate-source leakage current	$I_{GSS}$	$V_{GS}=20\text{ V}, V_{DS}=0\text{ V}$	-	-	100	nA
Drain-source on-state resistance	$R_{DS(on)}$	$V_{GS}=10\text{ V}, I_D=15.4\text{ A}, T_j=25\text{ °C}$	-	0.15	0.185	$\Omega$
		$V_{GS}=10\text{ V}, I_D=15.4\text{ A}, T_j=150\text{ °C}$	-	0.42	-	
Gate resistance	$R_G$	$f=1\text{ MHz}$ , open drain	-	0.8	-	
Transconductance	$g_{fs}$	$ V_{DS} >2 I_D R_{DS(on)max}, I_D=15.4\text{ A}$	-	14.0	-	S

Parameter	Symbol	Conditions	Values			Unit
			min.	typ.	max.	

**Dynamic characteristics**

Input capacitance	$C_{iss}$	$V_{GS}=0\text{ V}, V_{DS}=25\text{ V},$ $f=1\text{ MHz}$	-	3160	-	pF
Output capacitance	$C_{oss}$		-	900	-	
Reverse transfer capacitance	$C_{rss}$		-	34	-	
Effective output capacitance, energy related <sup>4)</sup>	$C_{o(er)}$	$V_{GS}=0\text{ V}, V_{DS}=0\text{ V}$ to 480 V	-	103	-	
Effective output capacitance, time related <sup>5)</sup>	$C_{o(tr)}$		-	188	-	
Turn-on delay time	$t_{d(on)}$	$V_{DD}=400\text{ V},$ $V_{GS}=10\text{ V}, I_D=21.7\text{ A},$ $R_G=6.8\ \Omega$	-	50	-	ns
Rise time	$t_r$		-	24	-	
Turn-off delay time	$t_{d(off)}$		-	100	-	
Fall time	$t_f$		-	9	-	

**Gate Charge Characteristics**

Gate to source charge	$Q_{gs}$	$V_{DD}=480\text{ V},$ $I_D=21.7\text{ A},$ $V_{GS}=0\text{ to }10\text{ V}$	-	15	-	nC
Gate to drain charge	$Q_{gd}$		-	67	-	
Gate charge total	$Q_g$		-	110	143	
Gate plateau voltage	$V_{plateau}$		-	7.3	-	V

<sup>1)</sup> J-STD20 and JESD22

<sup>2)</sup> Pulse width  $t_p$  limited by  $T_{j,max}$

<sup>3)</sup> Repetitive avalanche causes additional power losses that can be calculated as  $P_{AV}=E_{AR} \cdot f$ .

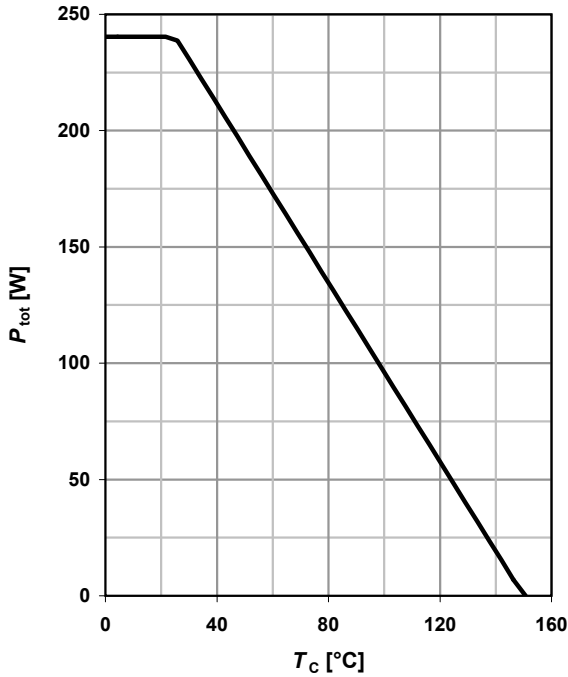
<sup>4)</sup>  $C_{o(er)}$  is a fixed capacitance that gives the same stored energy as  $C_{oss}$  while  $V_{DS}$  is rising from 0 to 80%  $V_{DSS}$ .

<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%  $V_{DSS}$ .

Parameter	Symbol	Conditions	Values			Unit
			min.	typ.	max.	
<b>Reverse Diode</b>						
Diode continuous forward current	$I_S$	$T_C=25\text{ °C}$	-	-	21.7	A
Diode pulse current <sup>2)</sup>	$I_{S,pulse}$		-	-	55	
Diode forward voltage	$V_{SD}$	$V_{GS}=0\text{ V}, I_F=I_S,$ $T_j=25\text{ °C}$	-	1.0	1.2	V
Reverse recovery time	$t_{rr}$	$V_R=480\text{ V}, I_F=I_S,$ $di_F/dt=100\text{ A}/\mu\text{s}$	-	140	-	ns
Reverse recovery charge	$Q_{rr}$		-	0.9	-	$\mu\text{C}$
Peak reverse recovery current	$I_{rrm}$		-	11	-	A
Peak rate of fall of reverse recovery current	$di_{rr}/dt$	$T_j=25\text{ °C}$	-	1400	-	A/ $\mu\text{s}$

**1 Power dissipation**

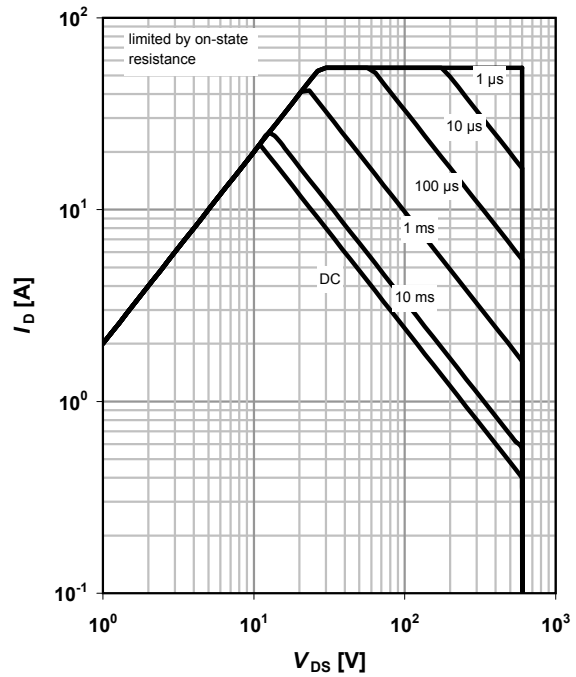
$P_{tot}=f(T_C)$



**2 Safe operating area**

$I_D=f(V_{DS}); T_C=25\text{ °C}; D=0$

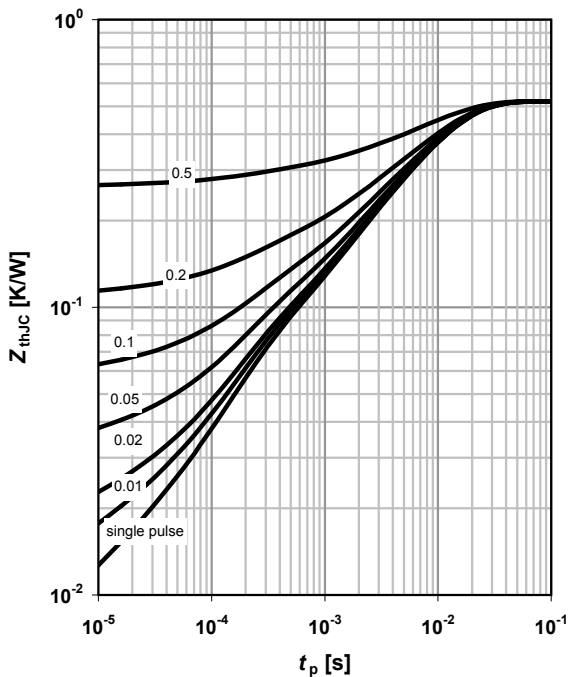
parameter:  $t_p$



**3 Max. transient thermal impedance**

$I_D=f(V_{DS}); T_J=25\text{ °C}$

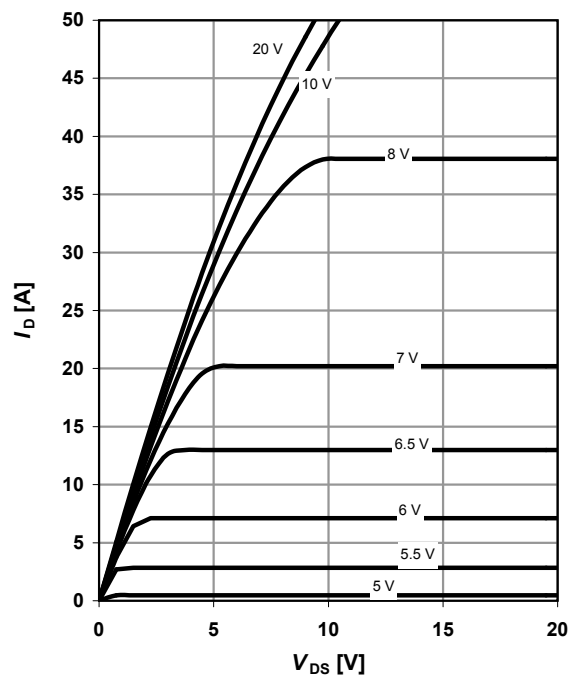
parameter:  $D=t_p/T$



**4 Typ. output characteristics**

$I_D=f(V_{DS}); T_J=25\text{ °C}$

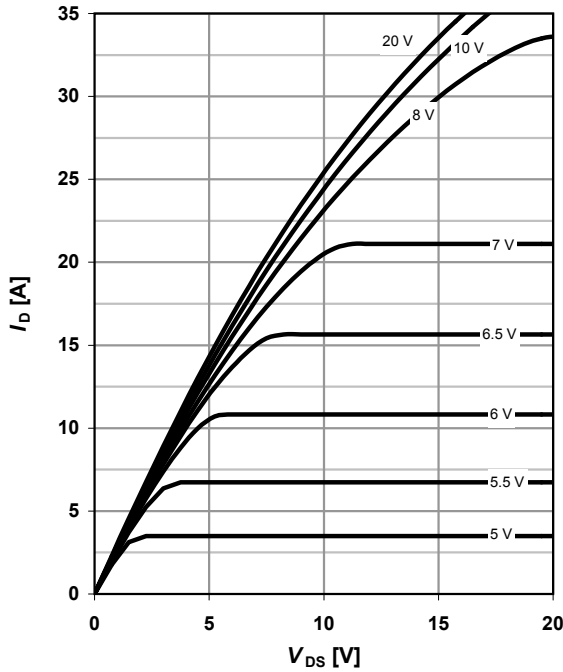
parameter:  $V_{GS}$



**5 Typ. output characteristics**

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

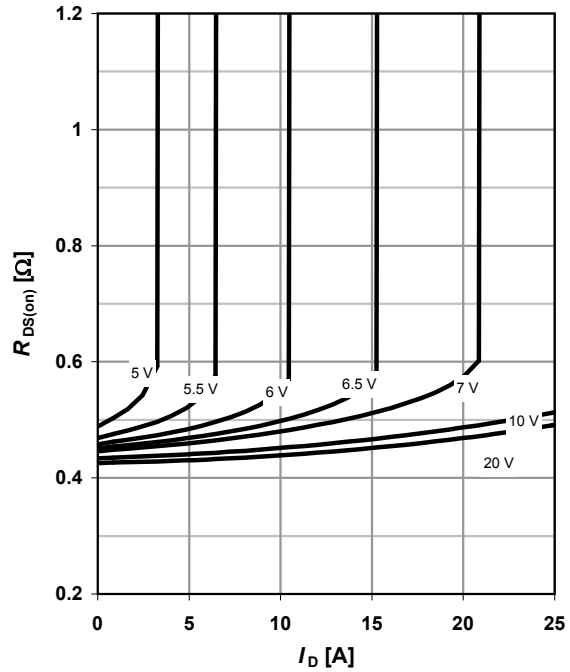
parameter:  $V_{GS}$



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

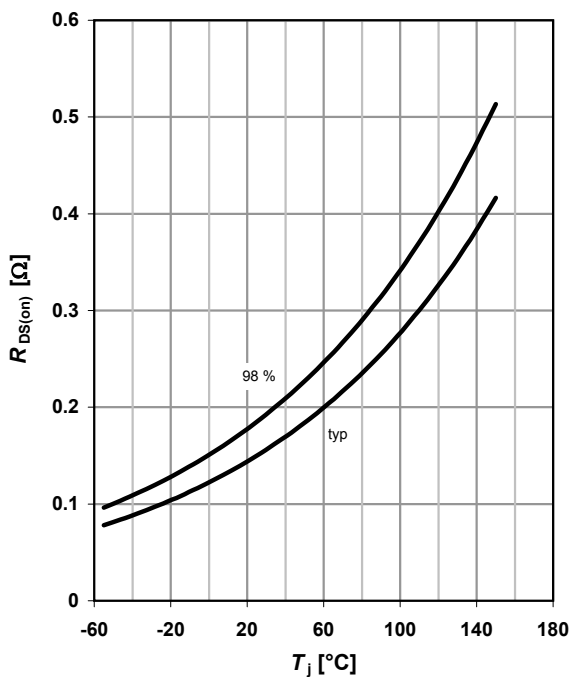
$R_{DS(on)} = f(I_D); T_j = 150\text{ }^\circ\text{C}$

parameter:  $V_{GS}$



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

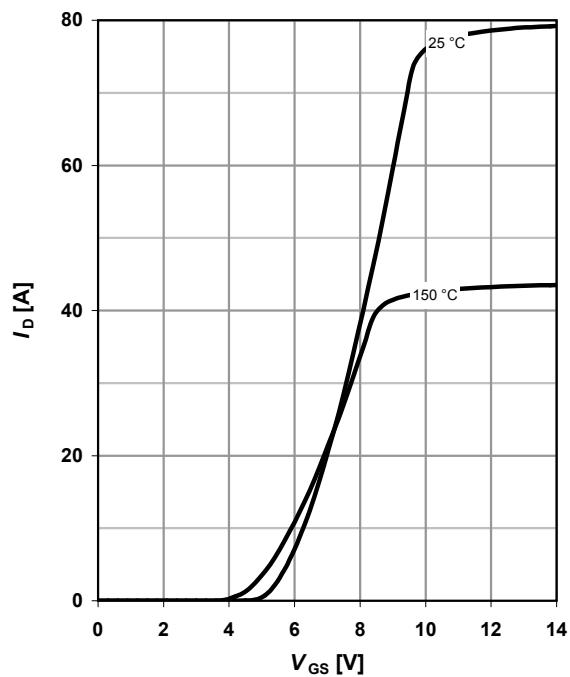
$R_{DS(on)} = f(T_j); I_D = 15.4\text{ A}; V_{GS} = 10\text{ V}$



**8 Typ. transfer characteristics**

$I_D = f(V_{GS}); |V_{DS}| > 2|I_D|R_{DS(on)max}$

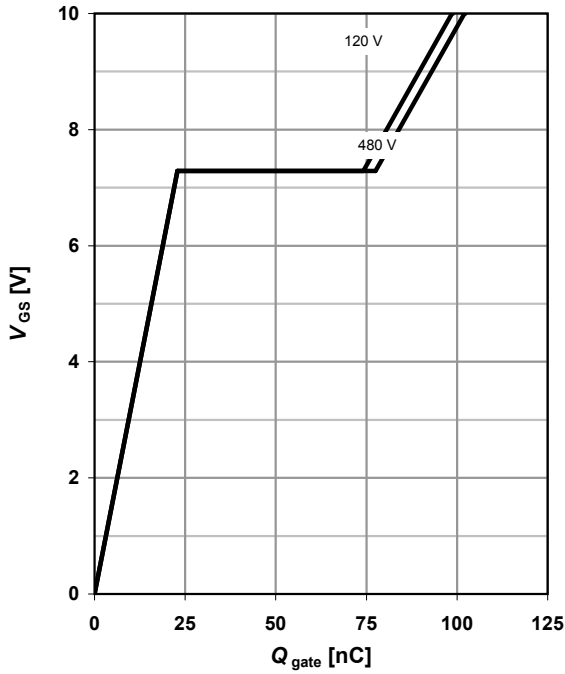
parameter:  $T_j$



**9 Typ. gate charge**

$V_{GS}=f(Q_{gate}); I_D=21.7 \text{ A pulsed}$

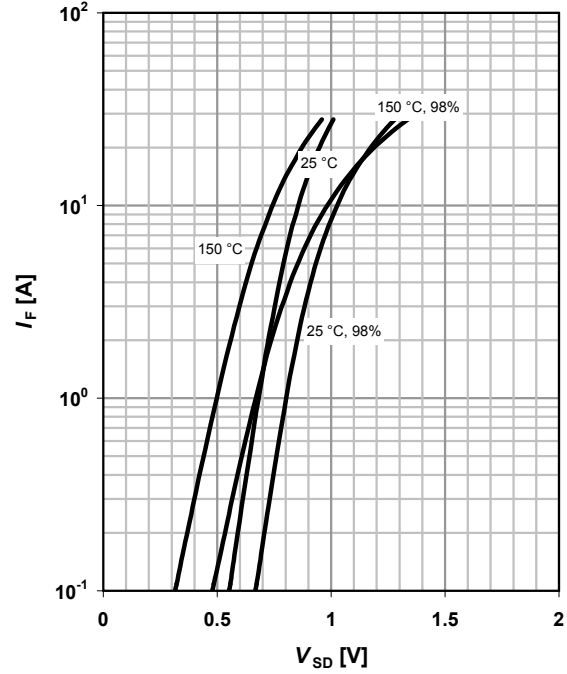
parameter:  $V_{DD}$



**10 Forward characteristics of reverse diode**

$I_F=f(V_{SD})$

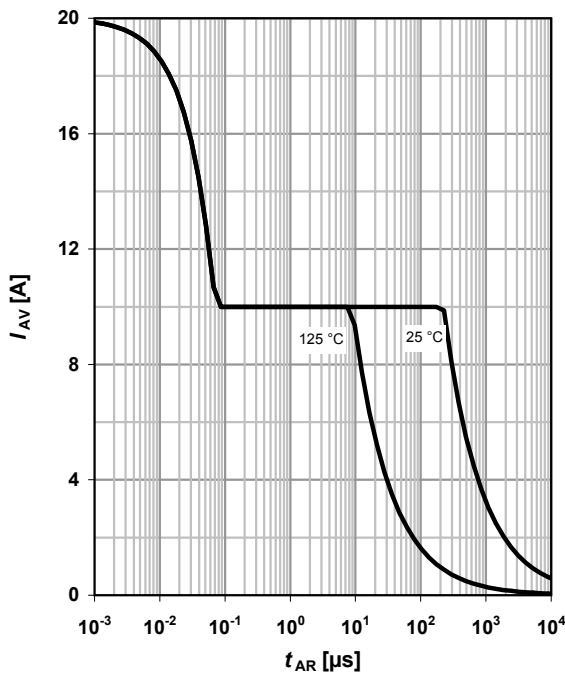
parameter:  $T_j$



**11 Avalanche SOA**

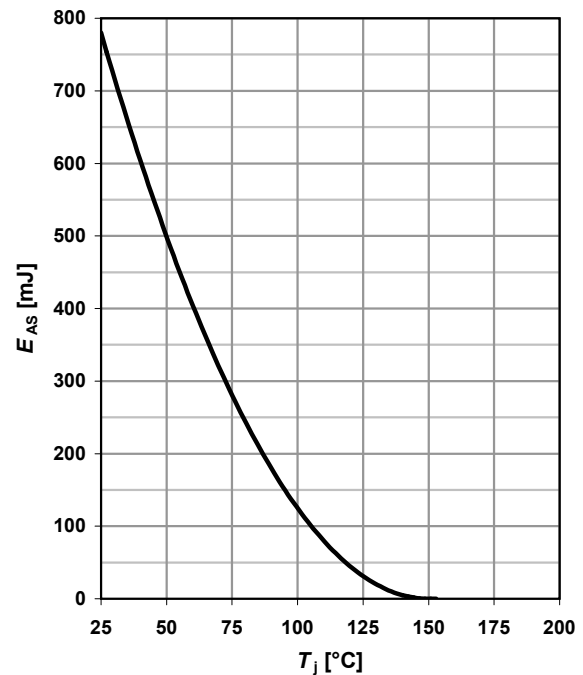
$I_{AR}=f(t_{AR})$

parameter:  $T_{j(start)}$



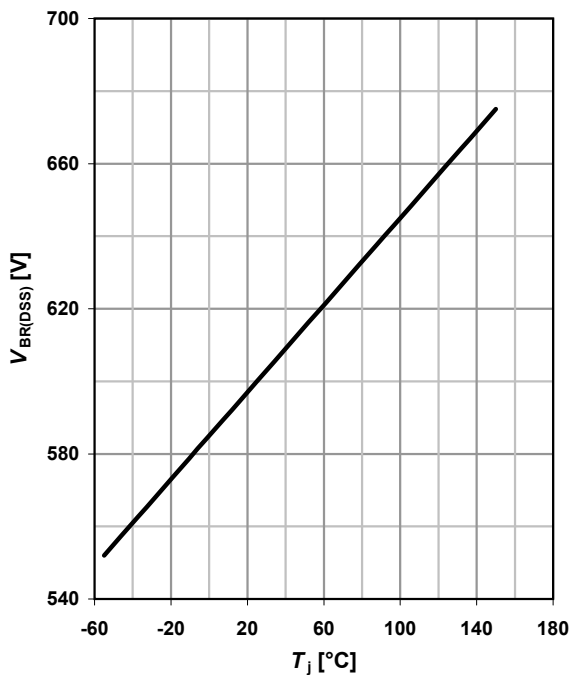
**12 Avalanche energy**

$E_{AS}=f(T_j); I_D=10 \text{ A}; V_{DD}=50 \text{ V}$



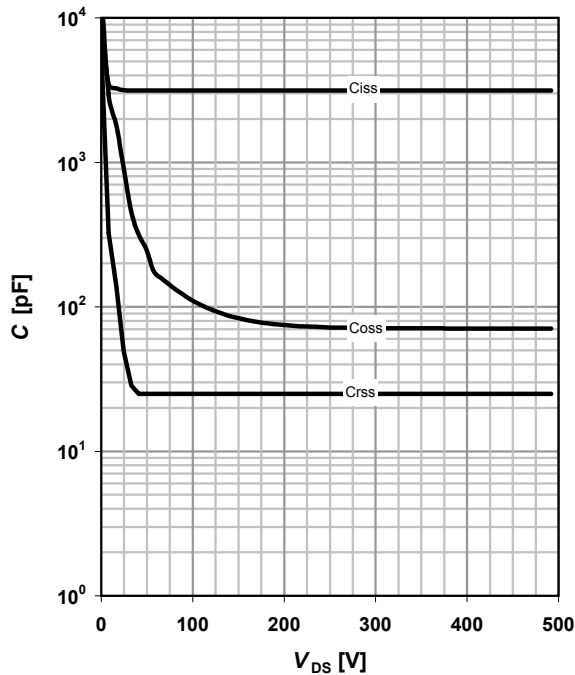
**13 Drain-source breakdown voltage**

$V_{BR(DSS)} = f(T_j); I_D = 10 \text{ mA}$



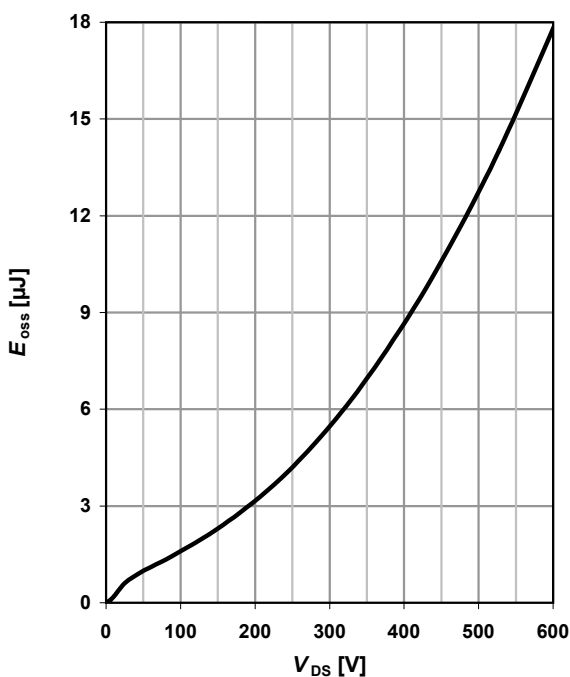
**14 Typ. capacitances**

$C = f(V_{DS}); V_{GS} = 0 \text{ V}; f = 1 \text{ MHz}$



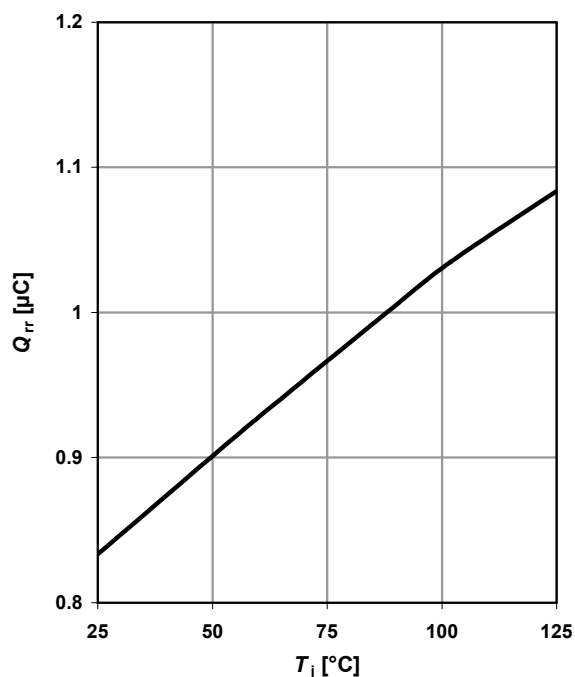
**15 Typ.  $C_{oss}$  stored energy**

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



**16 Typ. reverse recovery charge**

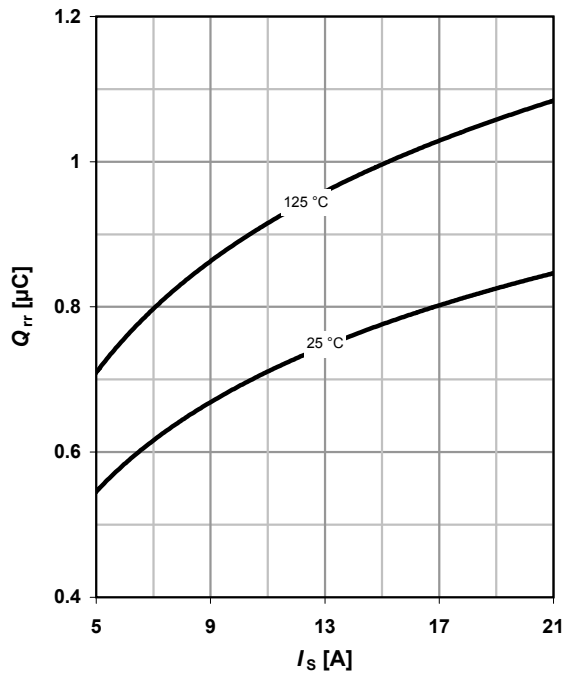
$Q_{rr} = f(T_j); \text{parameter: } I_D = 21.7 \text{ A}$





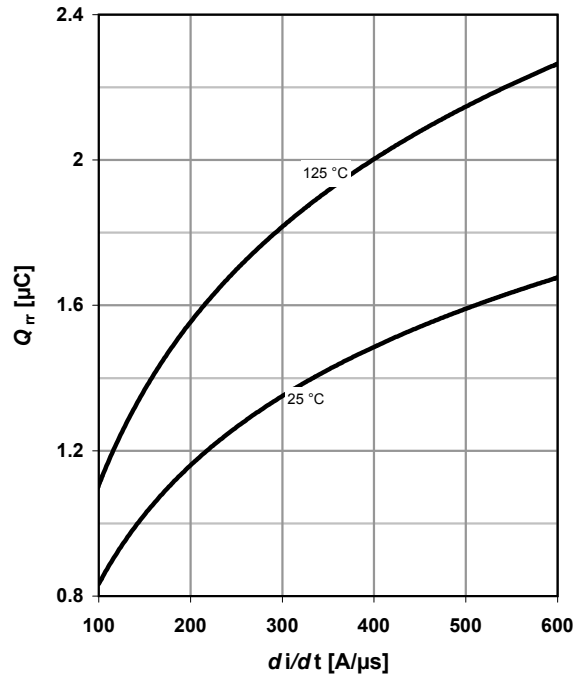
17 Typ. reverse recovery charge

$Q_{rr}=f(I_S)$ ; parameter:  $di/dt=100\text{ A}/\mu\text{s}$

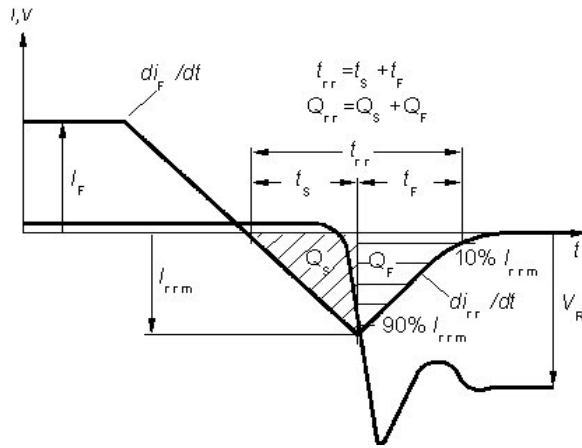


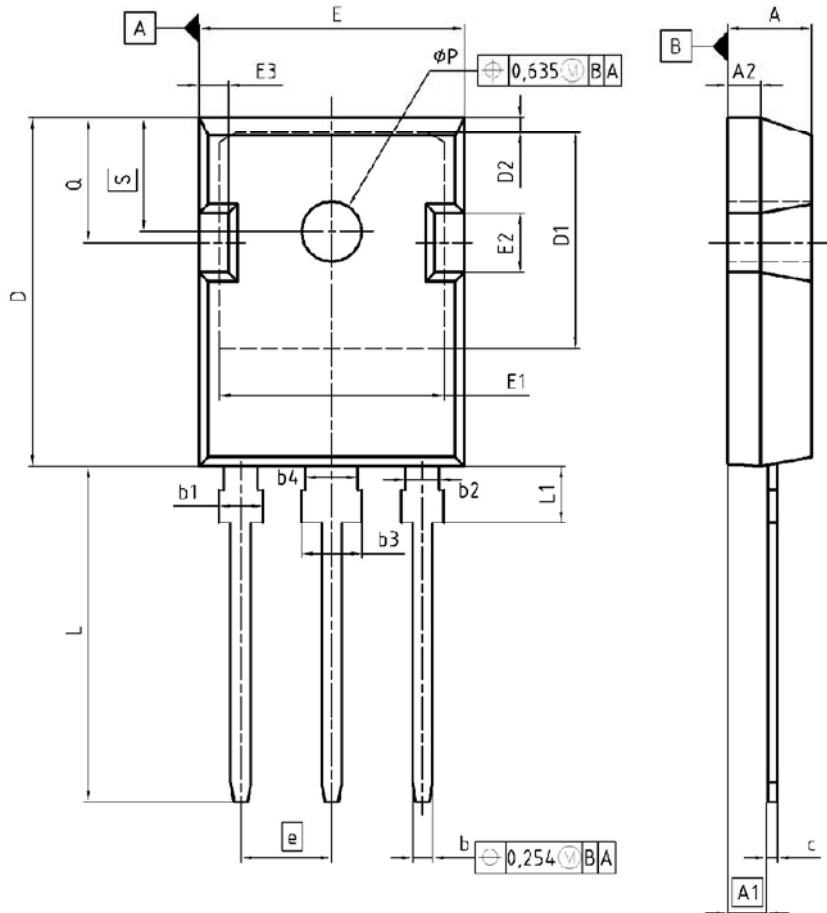
18 Typ. reverse recovery charge

$Q_{rr}=f(di/dt)$ ; parameter:  $I_D=21.7\text{ A}$



Definition of diode switching characteristics





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.)

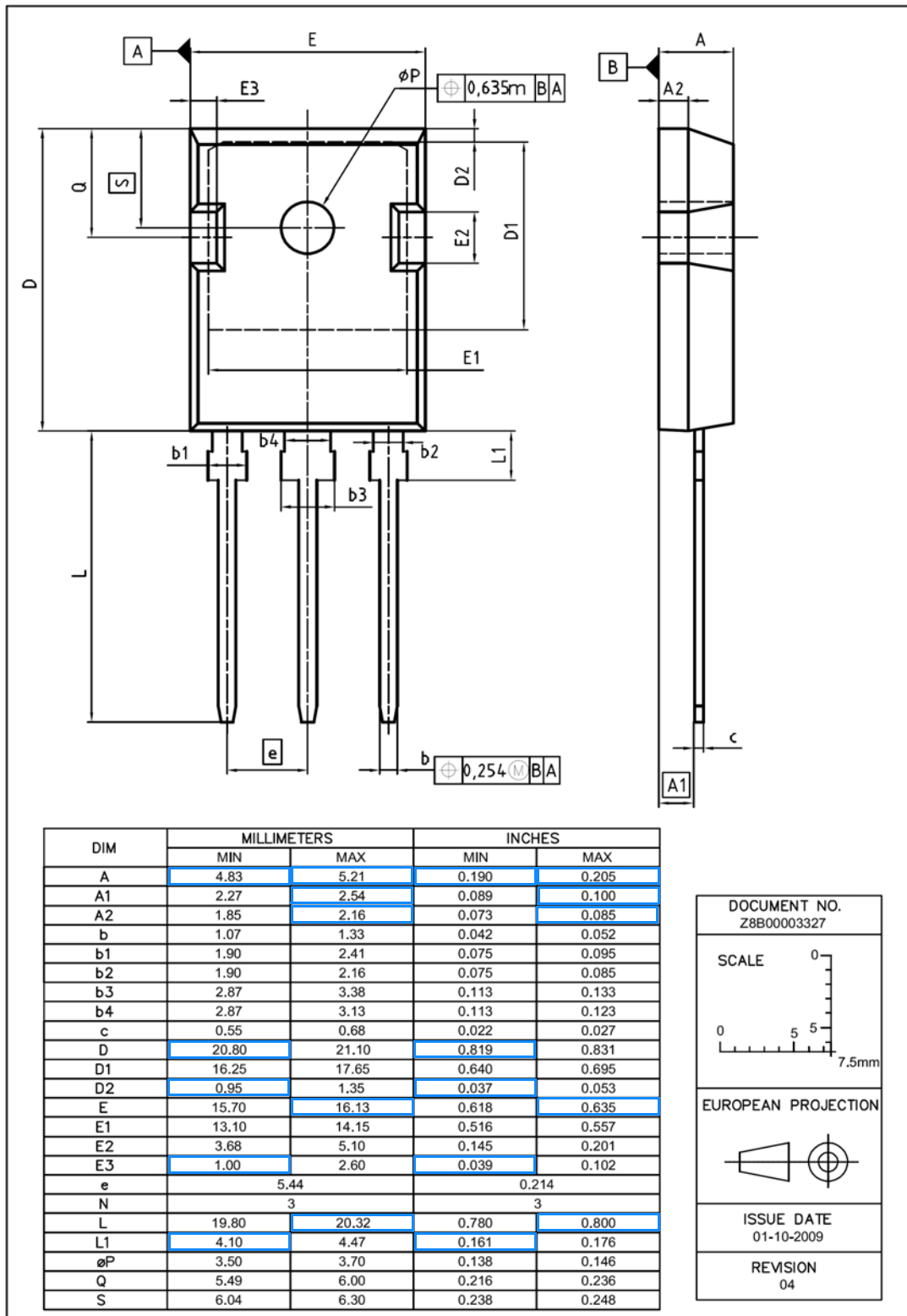


Figure 1 Outlines TO-247, dimensions in mm/inches