

CoolMOS™ Power Transistor
Features

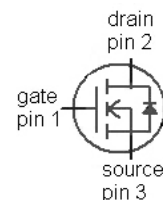
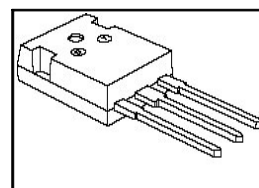
- Intrinsic fast-recovery body diode
- Extremely low reverse recovery charge
- Ultra low gate charge
- Extreme dv/dt rated
- High peak current capability
- Qualified for industrial grade applications according to JEDEC¹⁾

• CoolMOS CFD designed for

- Softswitching PWM Stages
- LCD & CRT TV

Product Summary

$V_{DS} @ T_{jmax}$	650	V
$R_{DS(on),max}$	0.185	Ω
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 ²⁾	$I_{D,pulse}$	$T_C=25^\circ\text{C}$	55	
Avalanche energy, single pulse	E_{AS}	$I_D=10\text{A}$, $V_{DD}=50\text{V}$	780	mJ
Avalanche energy, repetitive ^{2),3)}	E_{AR}	$I_D=20\text{A}$, $V_{DD}=50\text{V}$	1	
Avalanche current, repetitive ^{2),3)}	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/ μs
Gate source voltage	V_{GS}	static	± 20	V
		AC ($f>1\text{Hz}$)	± 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	-	μA
		$V_{DS}=600\text{ V}$, $V_{GS}=0\text{ V}$, $T_j=150\text{ °C}$	-	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	Ω
		$V_{GS}=10\text{ V}$, $I_D=15.4\text{ A}$, $T_j=150\text{ °C}$	-	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 ⁴⁾	$C_{o(er)}$	$V_{GS}=0\text{ V}, V_{DS}=0\text{ V}$ to 480 V	-	103	-	
Effective output capacitance, time related ⁵⁾	$C_{o(tr)}$		-	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

¹⁾ J-STD20 and JESD22

²⁾ Pulse width t_p limited by $T_{j,max}$

³⁾ Repetitive avalanche causes additional power losses that can be calculated as $P_{AV}=E_{AR}*f$.

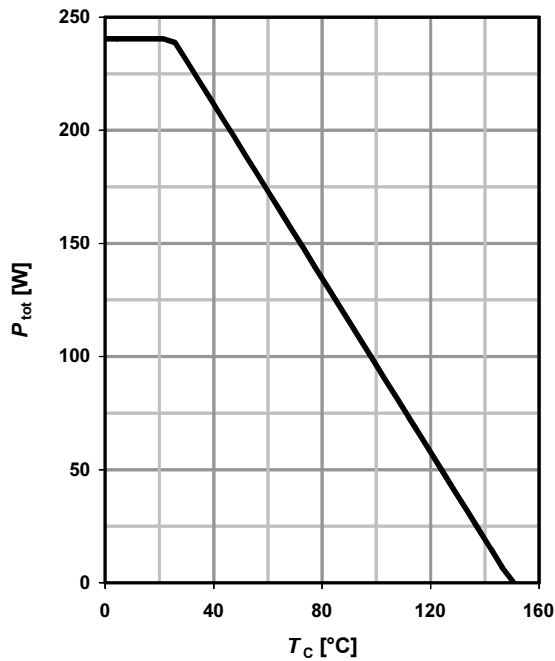
⁴⁾ $C_{o(er)}$ is a fixed capacitance that gives the same stored energy as C_{oss} while V_{DS} is rising from 0 to 80% V_{DSS} .

⁵⁾ $C_{o(tr)}$ 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.	
Reverse Diode						
Diode continuous forward current	I_S	$T_C=25\text{ }^{\circ}\text{C}$	-	-	21.7	A
Diode pulse current ²⁾	$I_{S,pulse}$		-	-	55	
Diode forward voltage	V_{SD}	$V_{GS}=0\text{ V}, I_F=I_S,$ $T_j=25\text{ }^{\circ}\text{C}$	-	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	-	μC
Peak reverse recovery current	I_{rm}		-	11	-	A
Peak rate of fall of reverse recovery current	di_{rr}/dt	$T_j=25\text{ }^{\circ}\text{C}$	-	1400	-	A/ μs

1 Power dissipation

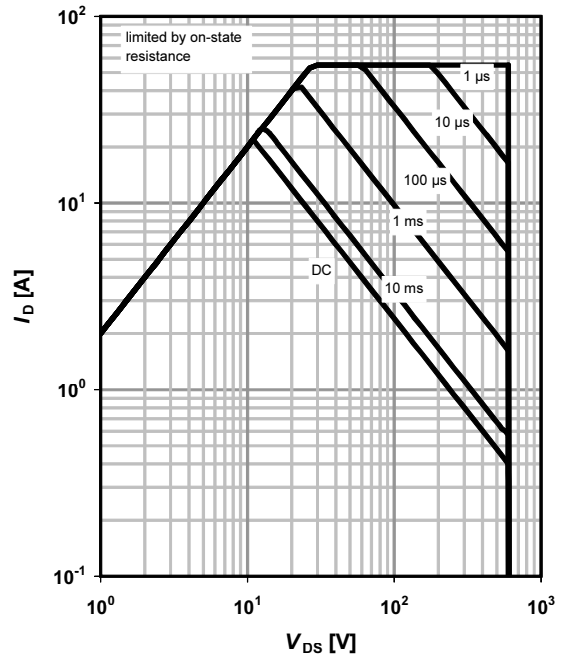
$$P_{\text{tot}} = f(T_C)$$



2 Safe operating area

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

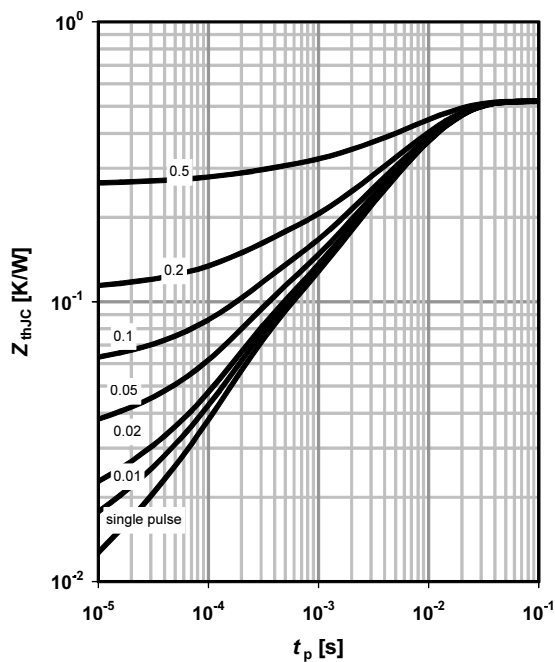
parameter: t_p



3 Max. transient thermal impedance

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

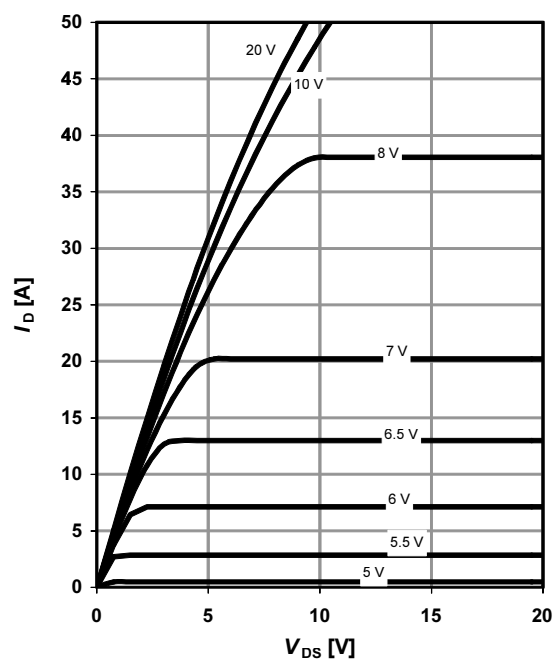
parameter: $D = t_p / T$



4 Typ. output characteristics

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

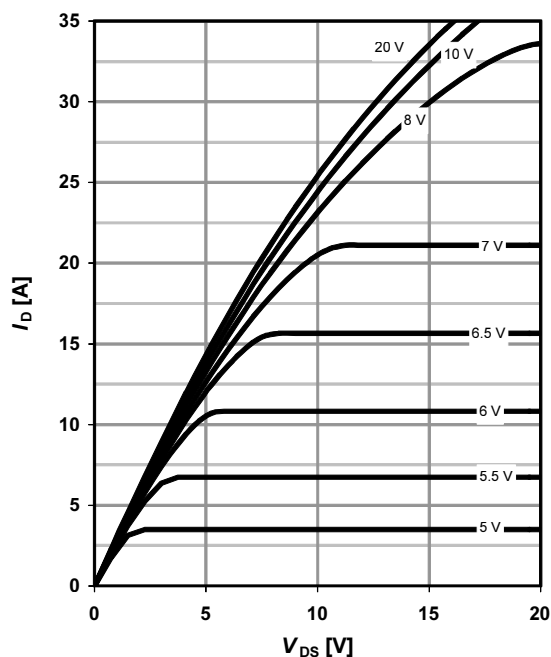
parameter: V_{GS}



5 Typ. output characteristics

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

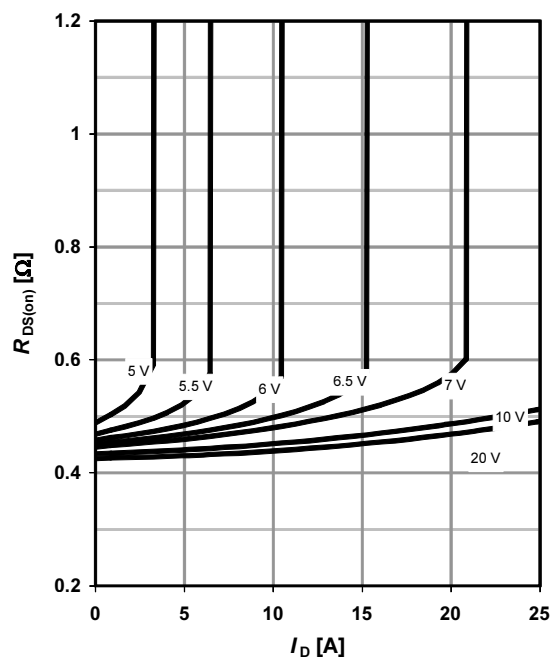
parameter: V_{GS}



6 Typ. drain-source on-state resistance

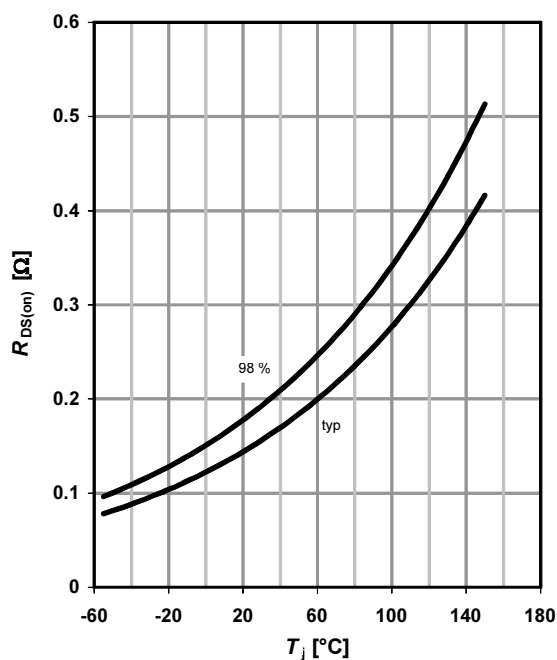
$$R_{DS(on)} = f(I_D); T_J = 150^\circ\text{C}$$

parameter: V_{GS}



7 Drain-source on-state resistance

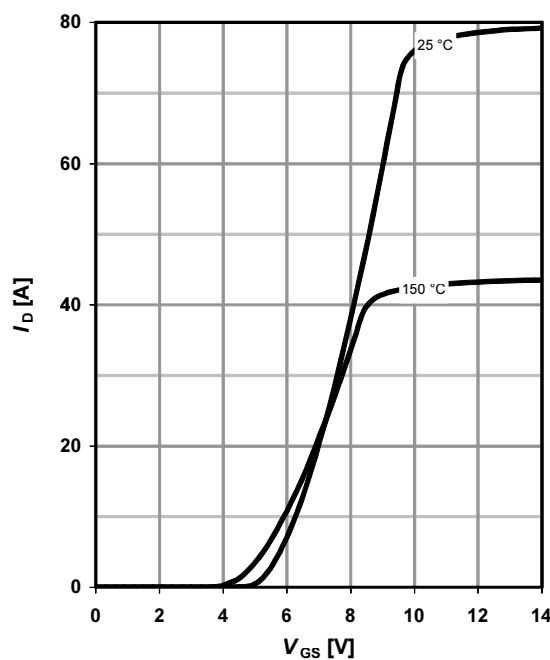
$$R_{DS(on)} = f(T_J); I_D = 15.4\text{ A}; V_{GS} = 10\text{ V}$$



8 Typ. transfer characteristics

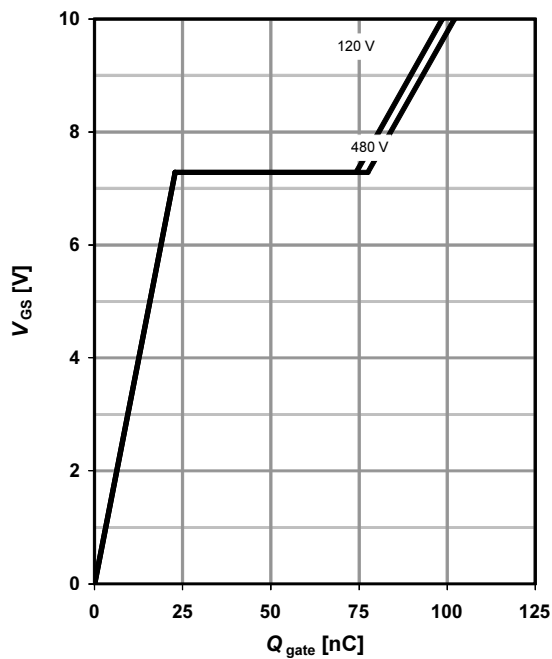
$$I_D = f(V_{GS}); |V_{DS}| > 2|I_D|R_{DS(on)\max}$$

parameter: T_J



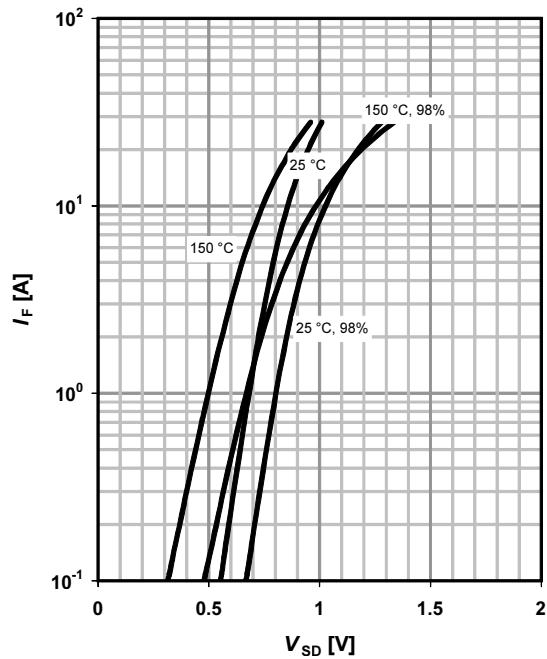
9 Typ. gate charge

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

parameter: V_{DD}


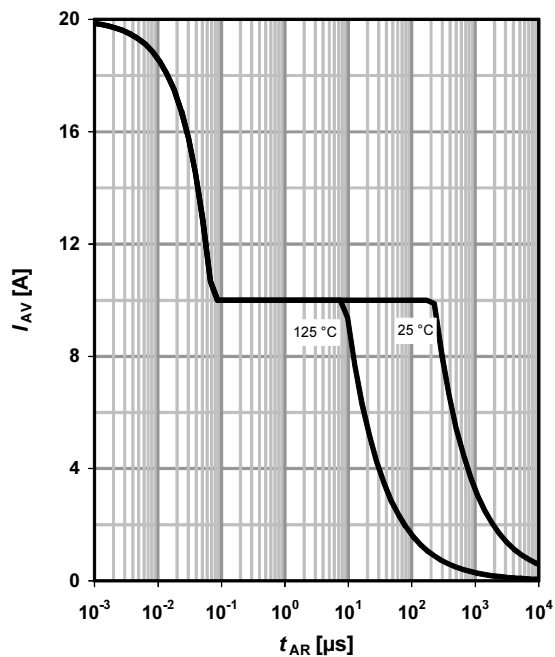
10 Forward characteristics of reverse diode

 $I_F=f(V_{SD})$

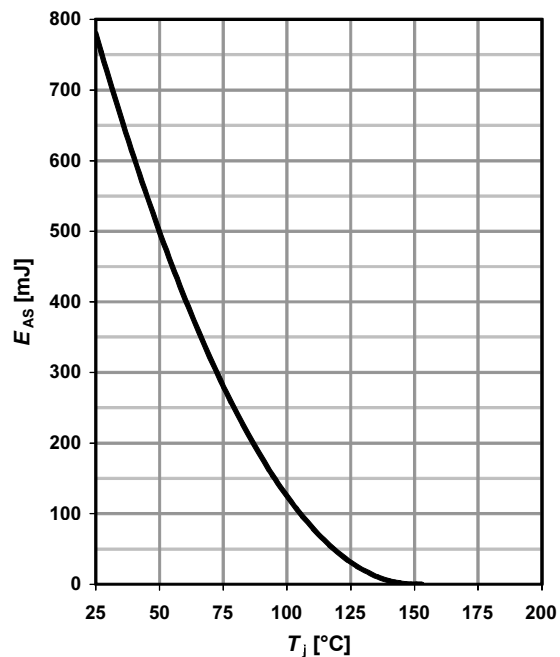
parameter: T_j


11 Avalanche SOA

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

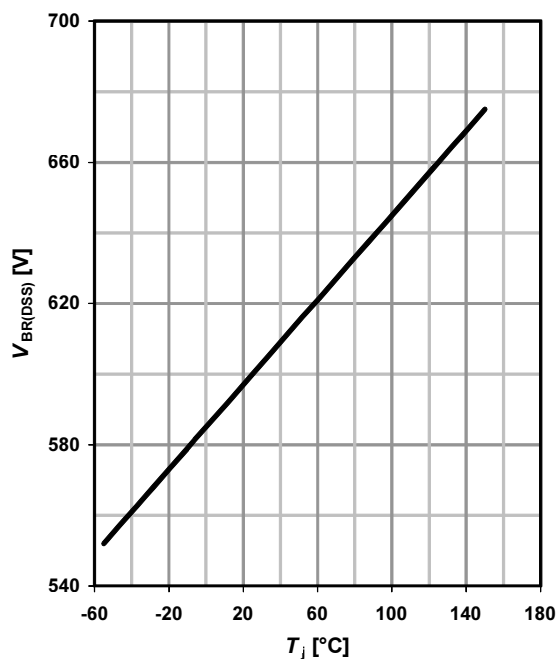
parameter: $T_{j(start)}$


12 Avalanche energy

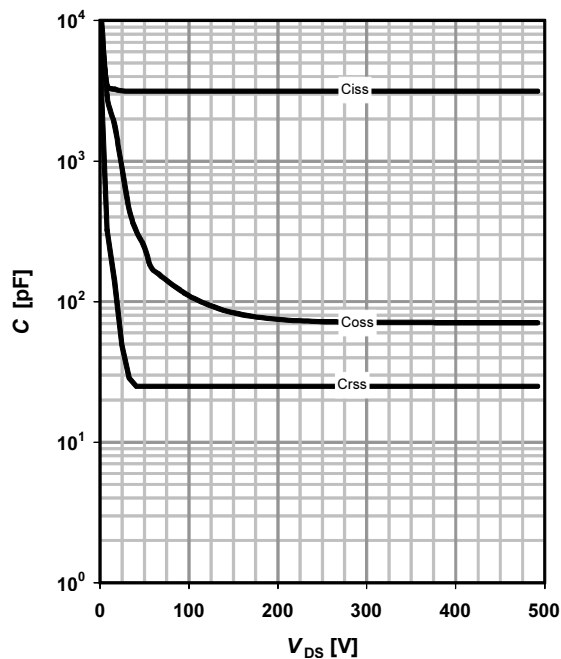
 $E_{AS}=f(T_j); I_D=10 \text{ A}; V_{DD}=50 \text{ V}$


13 Drain-source breakdown voltage

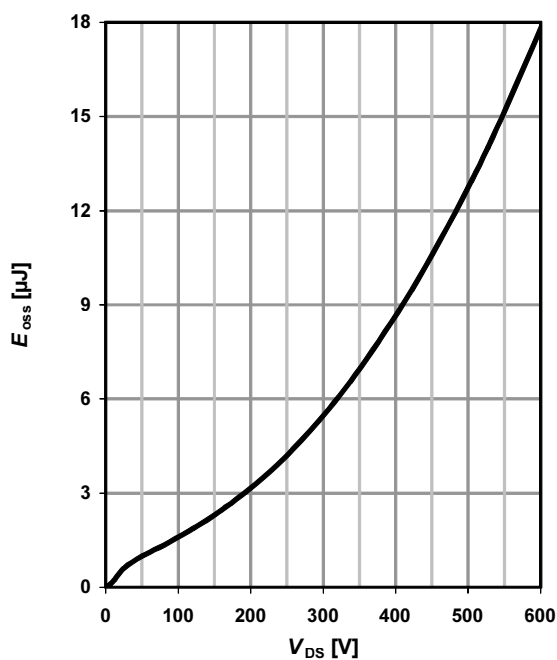
$$V_{BR(DSS)} = f(T_j); I_D = 10 \text{ mA}$$


14 Typ. capacitances

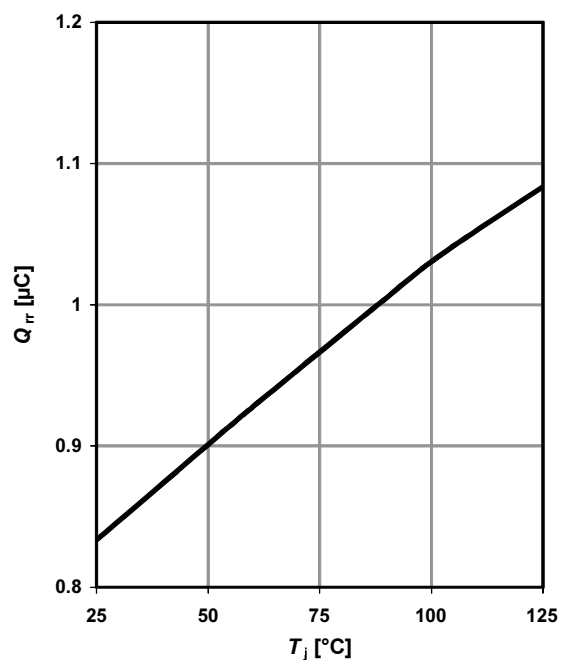
$$C = f(V_{DS}); V_{GS} = 0 \text{ V}; f = 1 \text{ MHz}$$


15 Typ. C_{oss} stored energy

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

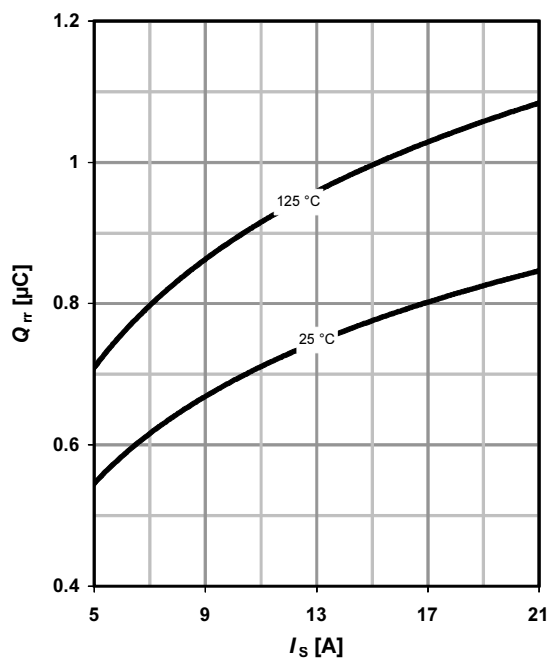

16 Typ. reverse recovery charge

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



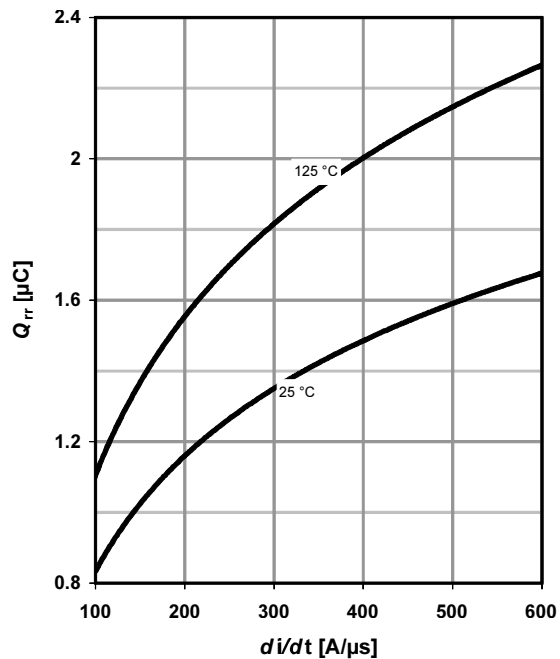
17 Typ. reverse recovery charge

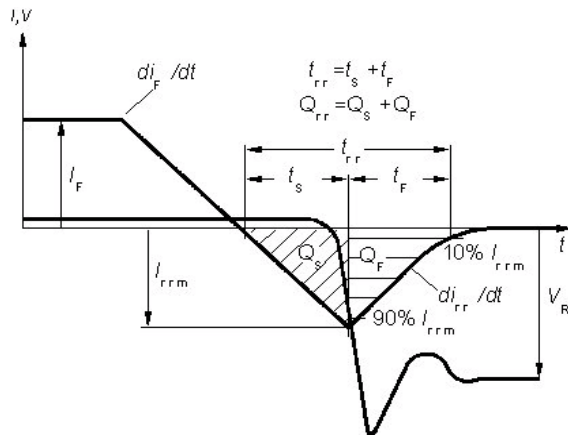
$Q_{rr}=f(I_S)$; parameter: $di/dt=100\text{ A}/\mu\text{s}$

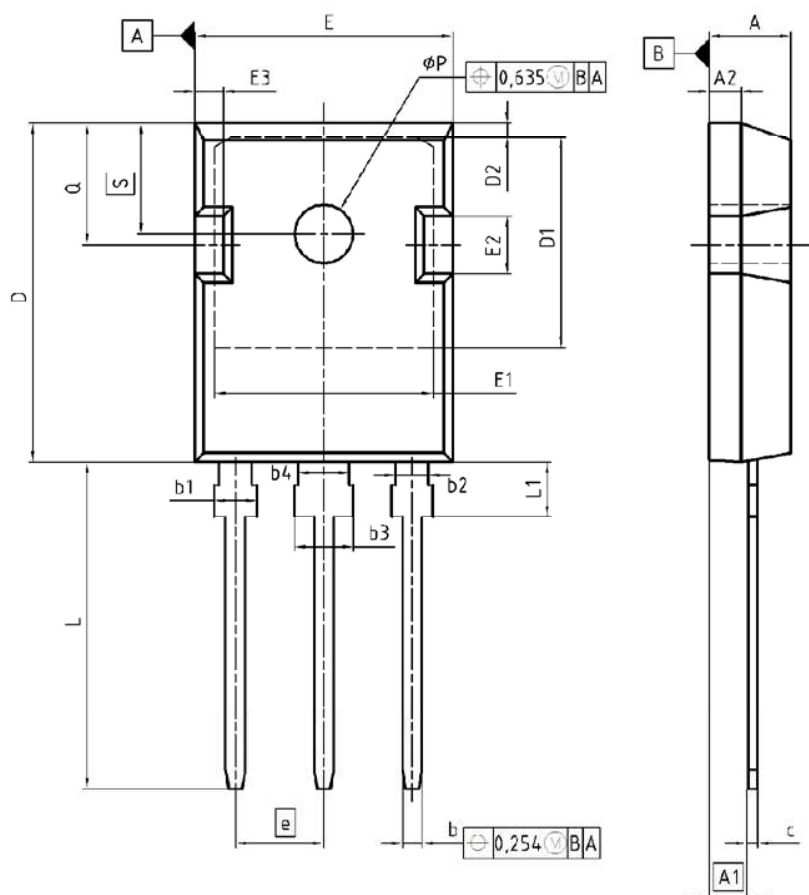


18 Typ. reverse recovery charge

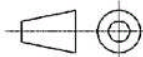
$Q_{rr}=f(di/dt)$; parameter: $I_D=21.7\text{ A}$



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	2.18	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.)

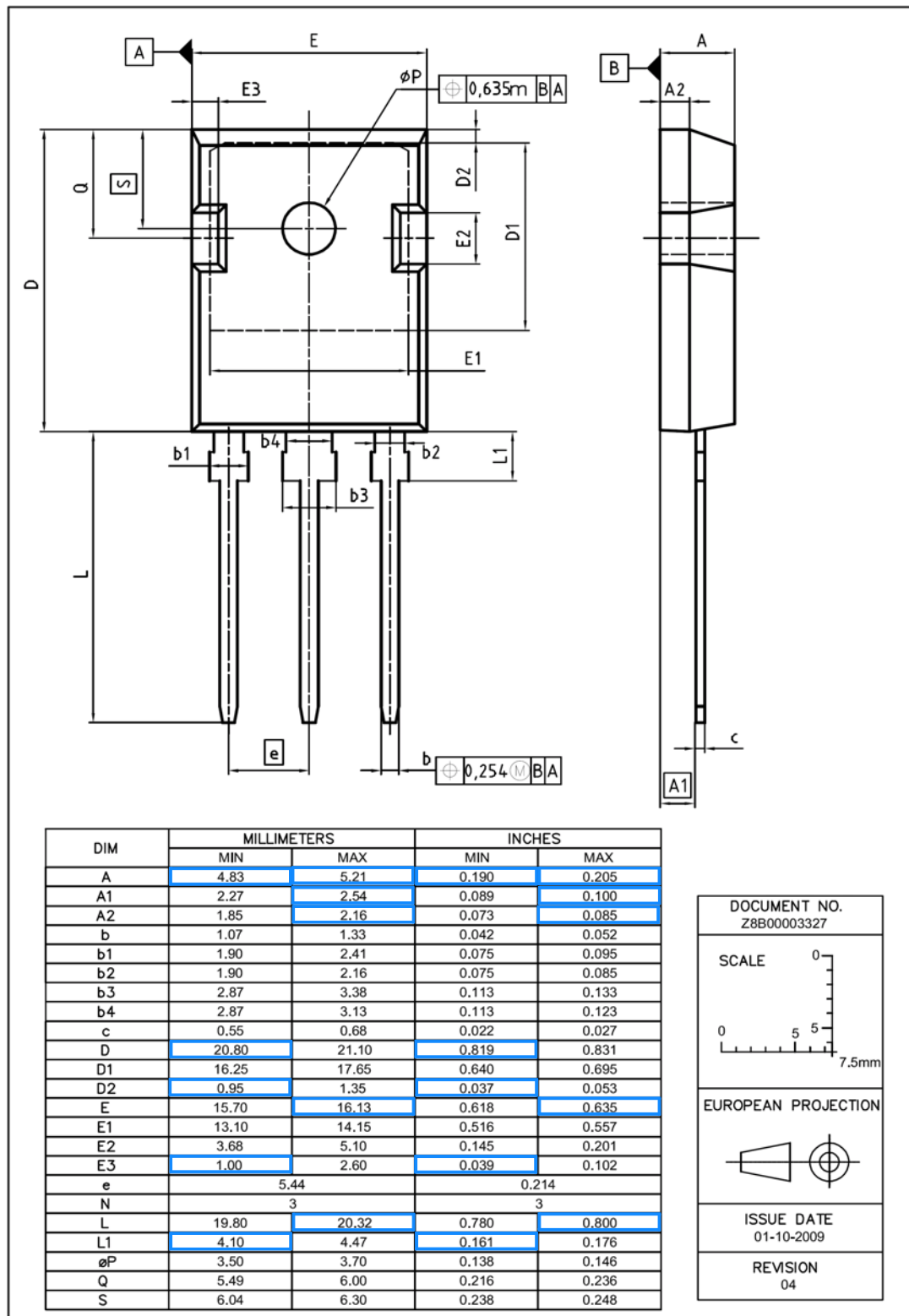


Figure 1 Outlines TO-247, dimensions in mm/inches