

**CoolMOS® Power Transistor**
**Features**

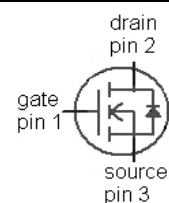
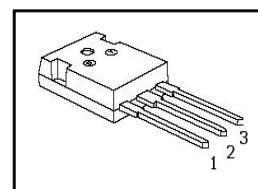
- Lowest figure-of-merit  $R_{ON} \times Q_g$
- Ultra low gate charge
- Extreme dv/dt rated
- High peak current capability
- Qualified for industrial grade applications according to JEDEC<sup>1)</sup>
- Pb-free lead plating; RoHS compliant

**Product Summary**

|                      |       |          |
|----------------------|-------|----------|
| $V_{DS} @ T_{j,max}$ | 650   | V        |
| $R_{DS(on),max}$     | 0.165 | $\Omega$ |
| $Q_{g,typ}$          | 39    | nC       |

**CoolMOS CP is specially designed for:**

- Hard switching topologies, for Server and Telecom

**PG-TO247-3**


| Type        | Package    | Ordering Code | Marking |
|-------------|------------|---------------|---------|
| IPW60R165CP | PG-TO247-3 | SP000095483   | 6R165P  |

**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          | A                |
|                                                |                   | $T_C=100^\circ\text{C}$                   | 13          |                  |
| Pulsed drain current <sup>2)</sup>             | $I_{D,pulse}$     | $T_C=25^\circ\text{C}$                    | 61          |                  |
| Avalanche energy, single pulse                 | $E_{AS}$          | $I_D=7.9\text{ A}$ , $V_{DD}=50\text{ V}$ | 522         | mJ               |
| Avalanche energy, repetitive $t_{AR}^{2),3)}$  | $E_{AR}$          | $I_D=7.9\text{ A}$ , $V_{DD}=50\text{ V}$ | 0.79        |                  |
| Avalanche current, repetitive $t_{AR}^{2),3)}$ | $I_{AR}$          |                                           | 7.9         | A                |
| MOSFET dv/dt ruggedness                        | dv/dt             | $V_{DS}=0\dots480\text{ V}$               | 50          | V/ns             |
| Gate source voltage                            | $V_{GS}$          | static                                    | $\pm 20$    | V                |
|                                                |                   | AC ( $f>1\text{ Hz}$ )                    | $\pm 30$    |                  |
| Power dissipation                              | $P_{tot}$         | $T_C=25^\circ\text{C}$                    | 192         | W                |
| Operating and storage temperature              | $T_j$ , $T_{stg}$ |                                           | -55 ... 150 | $^\circ\text{C}$ |
| Mounting torque                                |                   | M3 and M3.5 screws                        | 60          | Ncm              |

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

| Parameter                           | Symbol        | Conditions         | Value | Unit |
|-------------------------------------|---------------|--------------------|-------|------|
| Continuous diode forward current    | $I_S$         | $T_C=25\text{ °C}$ | 12    | A    |
| Diode pulse current <sup>2)</sup>   | $I_{S,pulse}$ |                    | 61    |      |
| Reverse diode $dv/dt$ <sup>4)</sup> | $dv/dt$       |                    | 15    | V/ns |

| Parameter | Symbol | Conditions | Values |      |      | Unit |
|-----------|--------|------------|--------|------|------|------|
|           |        |            | min.   | typ. | max. |      |

#### Thermal characteristics

|                                                            |              |                                       |   |   |      |     |
|------------------------------------------------------------|--------------|---------------------------------------|---|---|------|-----|
| Thermal resistance, junction - case                        | $R_{thJC}$   |                                       | - | - | 0.65 | K/W |
| Thermal resistance, junction - ambient                     | $R_{thJA}$   | lead                                  | - | - | 62   |     |
| Soldering temperature, wavesoldering only allowed at leads | $T_{solder}$ | 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             |
| Gate threshold voltage           | $V_{GS(th)}$  | $V_{DS}=V_{GS}, I_D=0.79\text{ mA}$                         | 2.5 | 3    | 3.5   |               |
| Zero gate voltage drain current  | $I_{DSS}$     | $V_{DS}=600\text{ V}, V_{GS}=0\text{ V}, T_j=25\text{ °C}$  | -   | -    | 1     | $\mu\text{A}$ |
|                                  |               | $V_{DS}=600\text{ V}, V_{GS}=0\text{ V}, T_j=150\text{ °C}$ | -   | 10   | -     |               |
| Gate-source leakage current      | $I_{GSS}$     | $V_{GS}=20\text{ V}, V_{DS}=0\text{ V}$                     | -   | -    | 100   | nA            |
| Drain-source on-state resistance | $R_{DS(on)}$  | $V_{GS}=10\text{ V}, I_D=12\text{ A}, T_j=25\text{ °C}$     | -   | 0.15 | 0.165 | $\Omega$      |
|                                  |               | $V_{GS}=10\text{ V}, I_D=12\text{ A}, T_j=150\text{ °C}$    | -   | 0.40 | -     |               |
| Gate resistance                  | $R_G$         | $f=1\text{ MHz}$ , open drain                               | -   | 1.9  | -     | $\Omega$      |

| Parameter | Symbol | Conditions | Values |      |      | Unit |
|-----------|--------|------------|--------|------|------|------|
|           |        |            | min.   | typ. | max. |      |

#### Dynamic characteristics

|                                                            |              |                                                                                  |   |      |   |    |
|------------------------------------------------------------|--------------|----------------------------------------------------------------------------------|---|------|---|----|
| Input capacitance                                          | $C_{iss}$    | $V_{GS}=0\text{ V}, V_{DS}=100\text{ V},$<br>$f=1\text{ MHz}$                    | - | 2000 | - | pF |
| Output capacitance                                         | $C_{oss}$    |                                                                                  | - | 100  | - |    |
| Effective output capacitance, energy related <sup>5)</sup> | $C_{o(er)}$  | $V_{GS}=0\text{ V}, V_{DS}=0\text{ V}$<br>to 480 V                               | - | 83   | - |    |
| Effective output capacitance, time related <sup>6)</sup>   | $C_{o(tr)}$  |                                                                                  | - | 220  | - |    |
| Turn-on delay time                                         | $t_{d(on)}$  | $V_{DD}=400\text{ V}, V_{GS}=10\text{ V},$<br>$I_D=12\text{ A}, R_G=3.3\ \Omega$ | - | 12   | - | ns |
| Rise time                                                  | $t_r$        |                                                                                  | - | 5    | - |    |
| Turn-off delay time                                        | $t_{d(off)}$ |                                                                                  | - | 50   | - |    |
| Fall time                                                  | $t_f$        |                                                                                  | - | 5    | - |    |

#### Gate Charge Characteristics

|                       |               |                                                                             |   |      |    |    |
|-----------------------|---------------|-----------------------------------------------------------------------------|---|------|----|----|
| Gate to source charge | $Q_{gs}$      | $V_{DD}=400\text{ V}, I_D=12\text{ A},$<br>$V_{GS}=0\text{ to }10\text{ V}$ | - | 9    | -  | nC |
| Gate to drain charge  | $Q_{gd}$      |                                                                             | - | 13.0 | -  |    |
| Gate charge total     | $Q_g$         |                                                                             | - | 39   | 52 |    |
| Gate plateau voltage  | $V_{plateau}$ |                                                                             | - | 5.0  | -  | V  |

#### Reverse Diode

|                               |           |                                                                         |   |     |     |               |
|-------------------------------|-----------|-------------------------------------------------------------------------|---|-----|-----|---------------|
| Diode forward voltage         | $V_{SD}$  | $V_{GS}=0\text{ V}, I_F=12\text{ A},$<br>$T_j=25\text{ }^\circ\text{C}$ | - | 0.9 | 1.2 | V             |
| Reverse recovery time         | $t_{rr}$  | $V_R=400\text{ V}, I_F=I_S,$<br>$di_F/dt=100\text{ A}/\mu\text{s}$      | - | 390 | -   | ns            |
| Reverse recovery charge       | $Q_{rr}$  |                                                                         | - | 7.5 | -   | $\mu\text{C}$ |
| Peak reverse recovery current | $I_{rrm}$ |                                                                         | - | 38  | -   | A             |

<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  $P_{AV}=E_{AR} \cdot f$ .

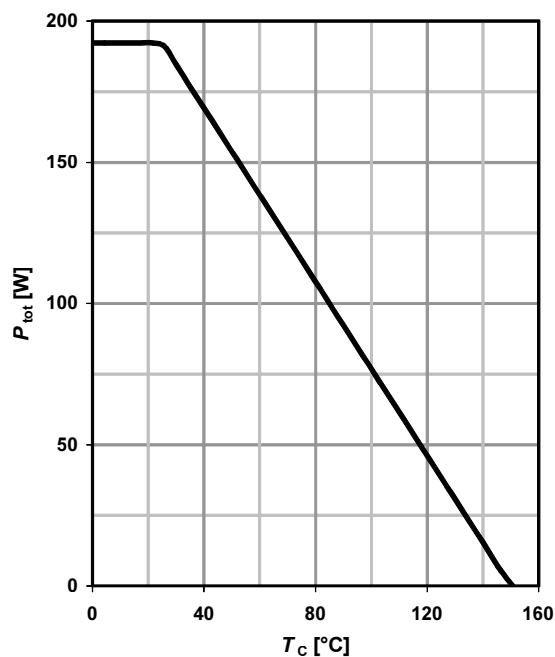
<sup>4)</sup>  $I_{SD} \leq I_D$ ,  $di/dt \leq 200\text{ A}/\mu\text{s}$ ,  $V_{DClk}=400\text{ V}$ ,  $V_{peak} < V_{(BR)DSS}$ ,  $T_j < T_{j,max}$ , identical low side and high side switch

<sup>5)</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>6)</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%  $V_{DSS}$ .

## 1 Power dissipation

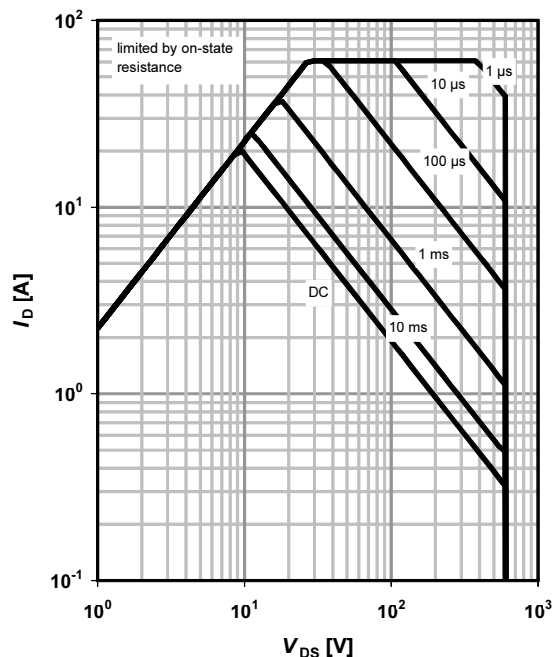
$$P_{\text{tot}} = f(T_C)$$



## 2 Safe operating area

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

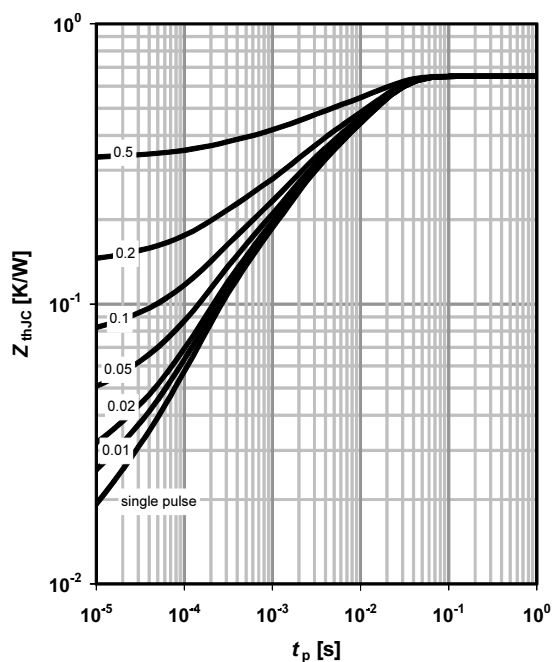
parameter:  $t_p$



## 3 Max. transient thermal impedance

$$Z_{\text{thJC}} = f(t_p)$$

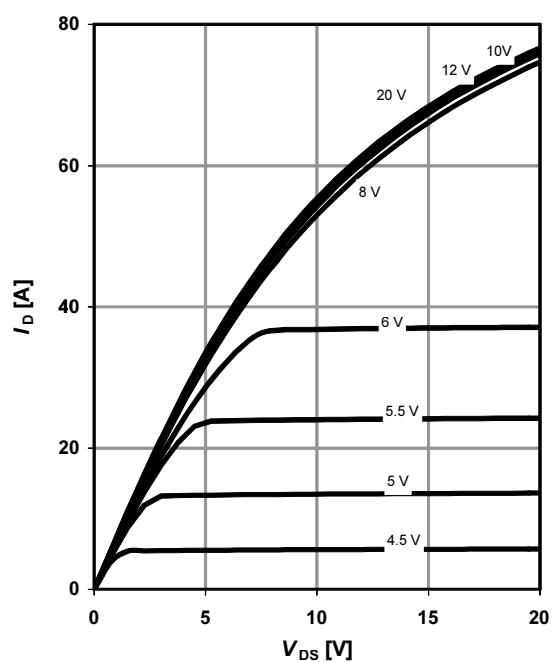
parameter:  $D = t_p / T$



## 4 Typ. output characteristics

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

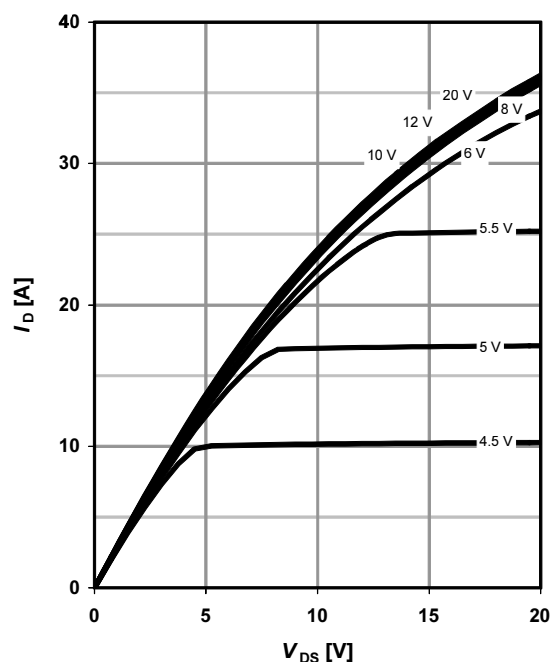
parameter:  $V_{GS}$



## 5 Typ. output characteristics

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

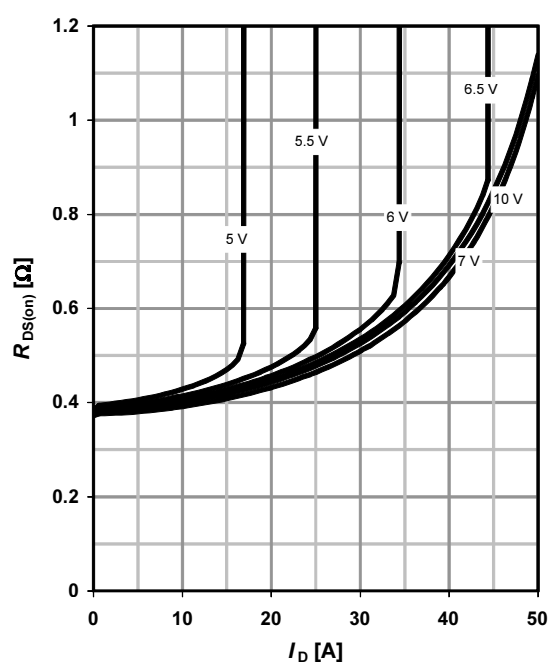
parameter:  $V_{GS}$



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

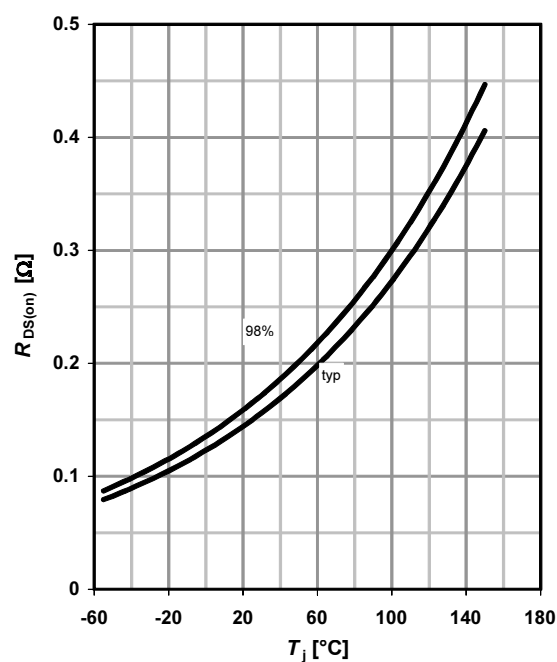
$$R_{DS(on)} = f(I_D); T_j = 150^\circ\text{C}$$

parameter:  $V_{GS}$



## 7 Drain-source on-state resistance

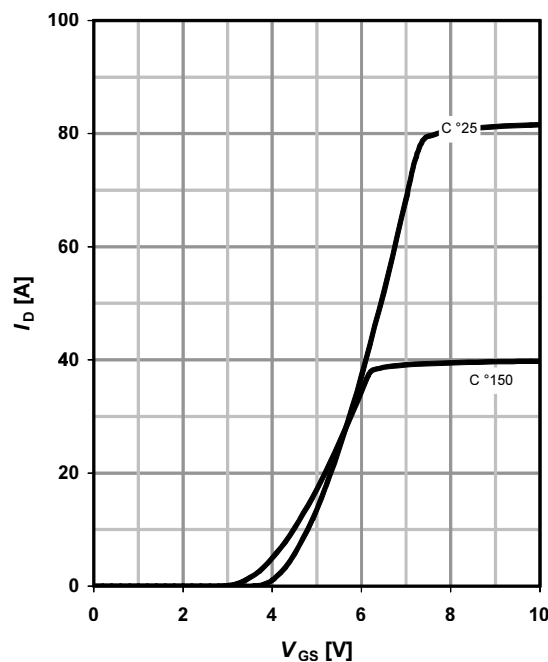
$$R_{DS(on)} = f(T_j); I_D = 12\text{ A}; V_{GS} = 10\text{ V}$$



## 8 Typ. transfer characteristics

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

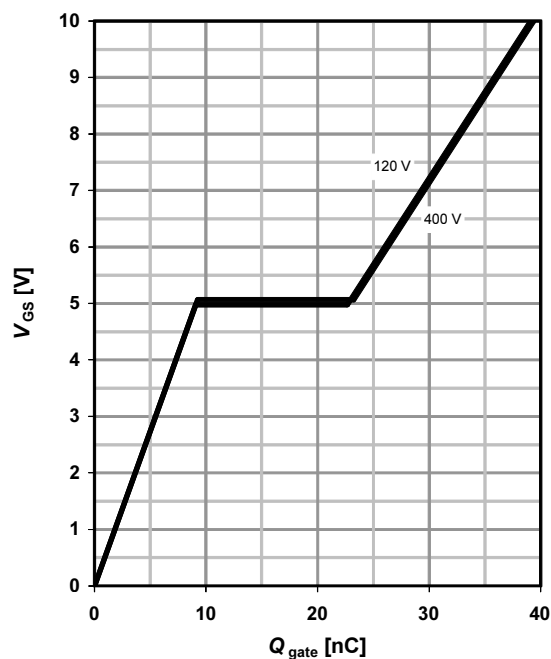
parameter:  $T_j$



## 9 Typ. gate charge

$$V_{GS}=f(Q_{gate}); I_D=12\text{ A pulsed}$$

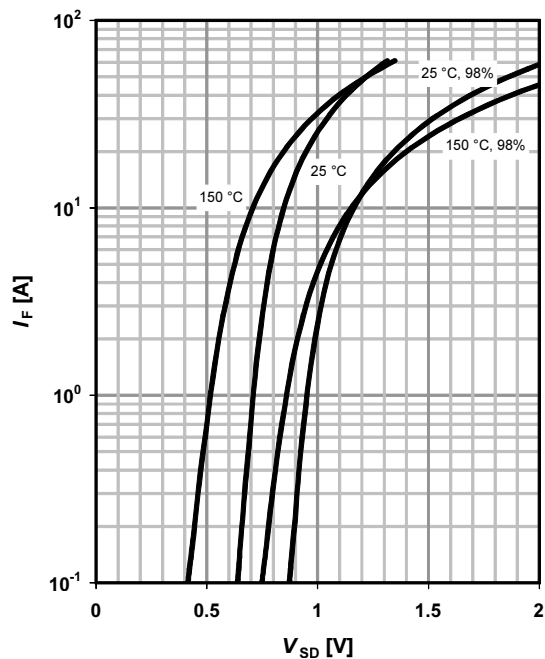
parameter:  $V_{DD}$



## 10 Forward characteristics of reverse diode

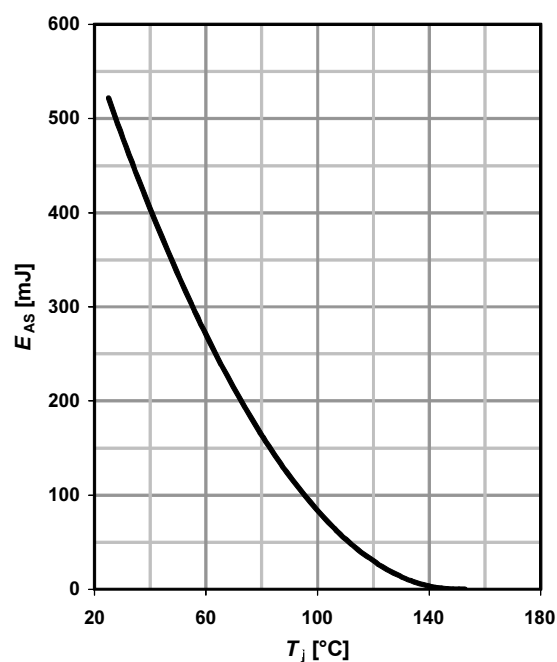
$$I_F=f(V_{SD})$$

parameter:  $T_j$



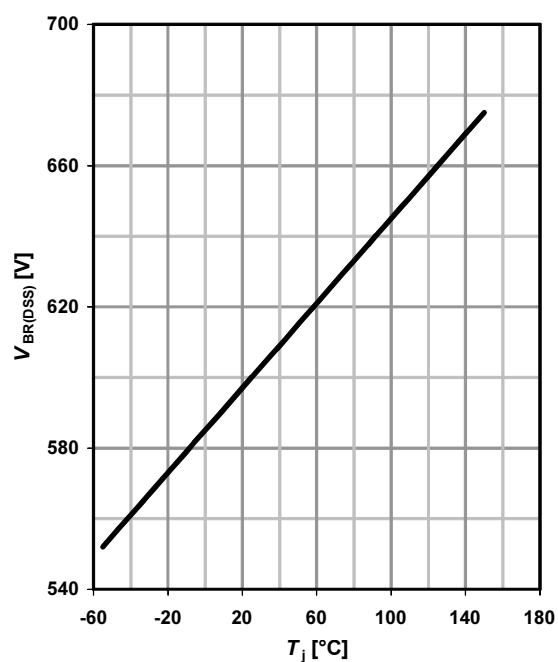
## 11 Avalanche energy

$$E_{AS}=f(T_j); I_D=7.9\text{ A}; V_{DD}=50\text{ V}$$

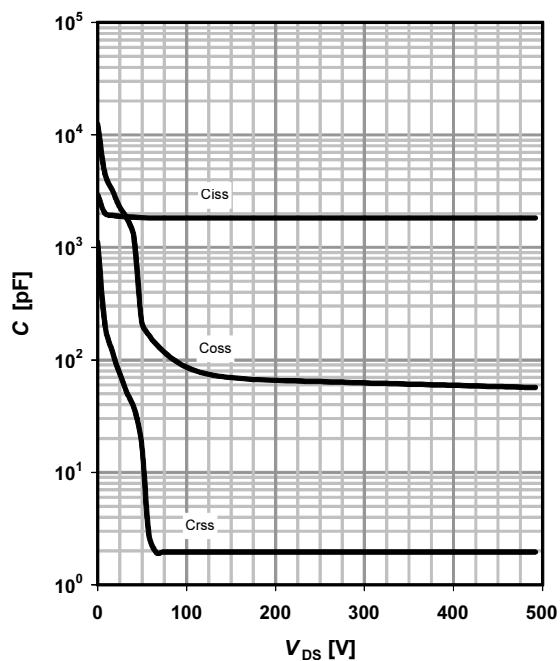


## 12 Drain-source breakdown voltage

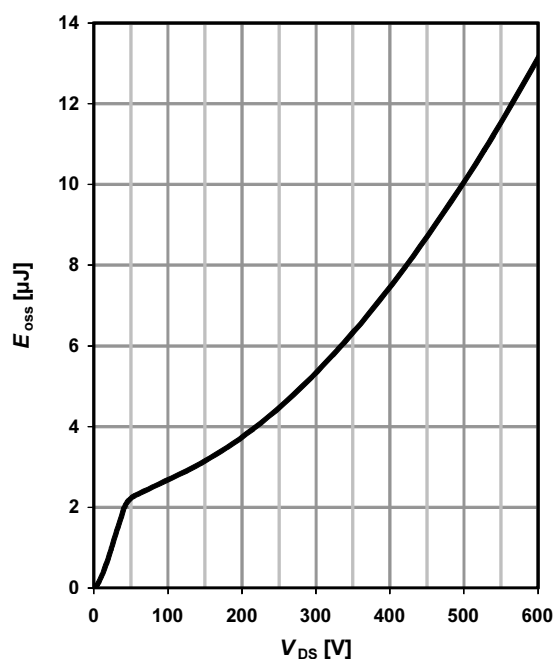
$$V_{BR(DSS)}=f(T_j); I_D=0.25\text{ mA}$$



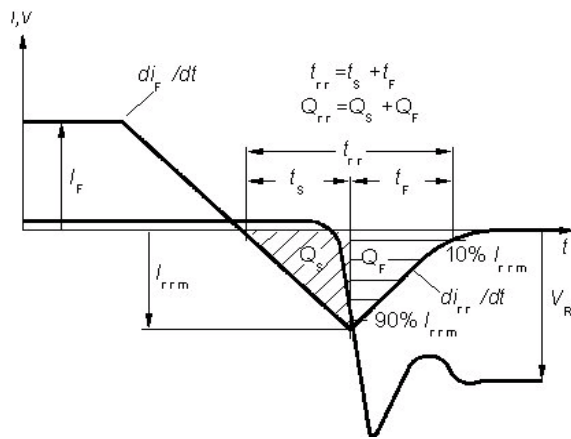
### 13 Typ. capacitances

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


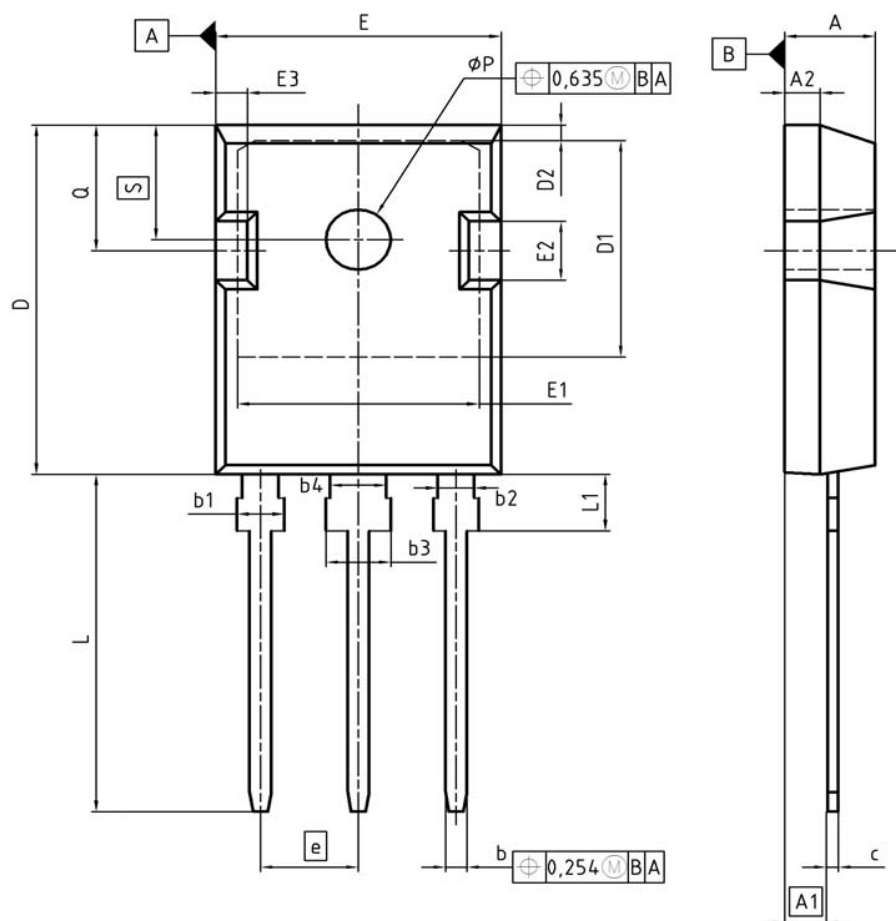
### 14 Typ. Coss stored energy

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


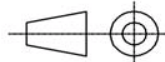
# Definition of diode switching characteristics



## PG-TO247-3: Outline



| 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 |
| ØP  | 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 |

|                                                                                                              |
|--------------------------------------------------------------------------------------------------------------|
| DOCUMENT NO.<br>Z8B00003327                                                                                  |
| SCALE<br>0 5 5 7.5mm                                                                                         |
| EUROPEAN PROJECTION<br> |
| ISSUE DATE<br>17-12-2007                                                                                     |
| REVISION<br>03                                                                                               |

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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.)

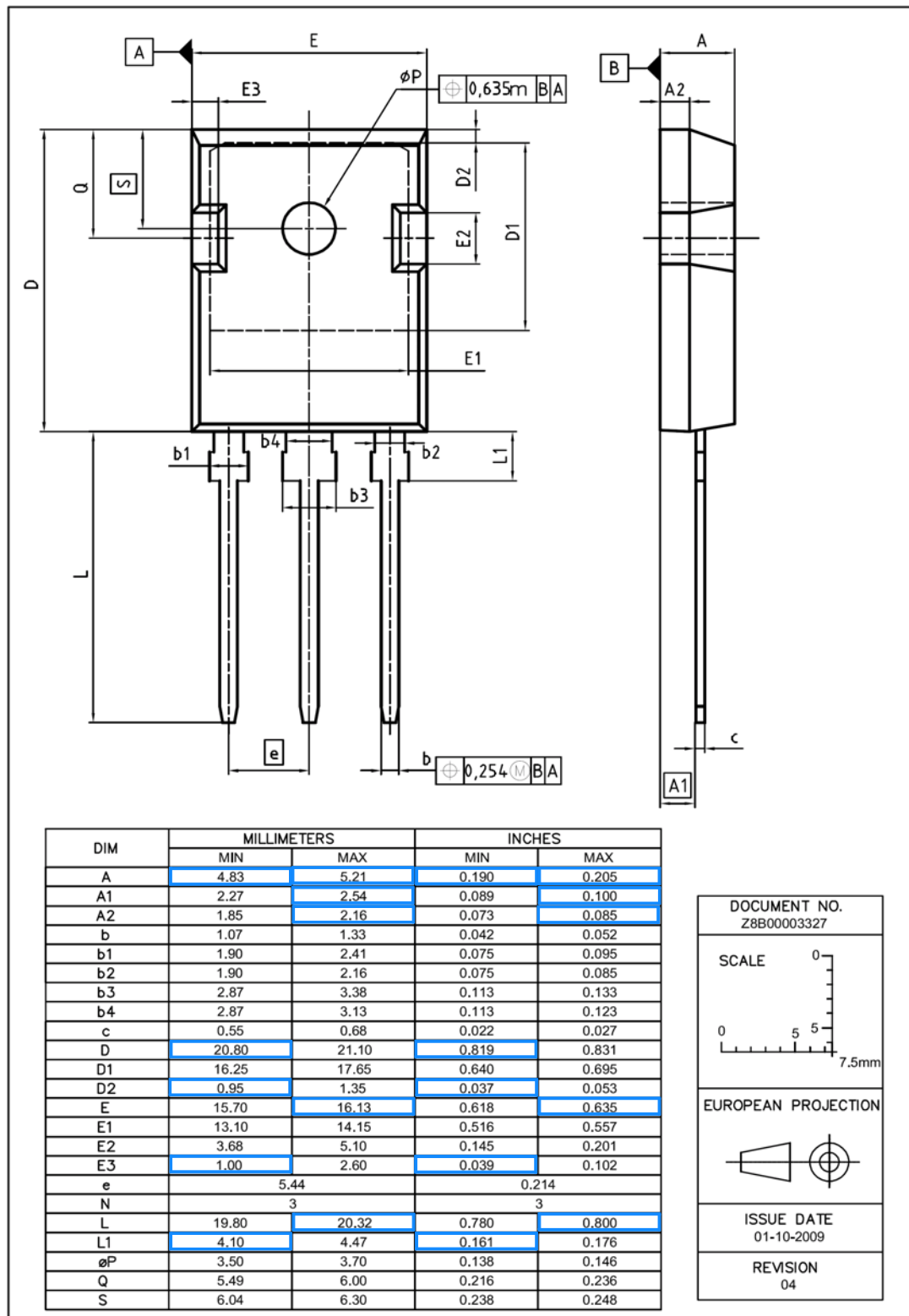


Figure 1 Outlines TO-247, dimensions in mm/inches