

## CoolMOS® Power Transistor

### Features

- Worldwide best  $R_{DS(on)}$  in TO220
- Lowest figure of merit  $R_{ON} \times Q_g$
- Ultra low gate charge
- Extreme dv/dt rated
- High peak current capability
- Pb-free lead plating; RoHS compliant; Halogen free for mold compound
- Qualified for industrial grade applications according to JEDEC<sup>1)</sup>

### CoolMOS CP is designed for:

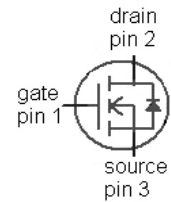
- Hard & soft switching SMPS topologies
- CCM PFC for ATX, Notebookadapter & PDP and LCD TV
- PWM Stages for Server, Adapter

| Type        | Package  | Marking |
|-------------|----------|---------|
| IPI50R140CP | PG-TO220 | 5R140P  |

### Product Summary

|                     |       |          |
|---------------------|-------|----------|
| $V_{DS} @ T_{jmax}$ | 550   | V        |
| $R_{DS(on),max}$    | 0.140 | $\Omega$ |
| $Q_{g,typ}$         | 48    | nC       |

TO-262-3-1



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

| Parameter                                      | Symbol         | Conditions                                | Value       | Unit             |
|------------------------------------------------|----------------|-------------------------------------------|-------------|------------------|
| Continuous drain current                       | $I_D$          | $T_C=25^\circ\text{C}$                    | 23          | A                |
|                                                |                | $T_C=100^\circ\text{C}$                   | 15          |                  |
| Pulsed drain current <sup>2)</sup>             | $I_{D,pulse}$  | $T_C=25^\circ\text{C}$                    | 56          |                  |
| Avalanche energy, single pulse                 | $E_{AS}$       | $I_D=9.3\text{ A}$ , $V_{DD}=50\text{ V}$ | 616         | mJ               |
| Avalanche energy, repetitive $t_{AR}^{2),3)}$  | $E_{AR}$       | $I_D=9.3\text{ A}$ , $V_{DD}=50\text{ V}$ | 0.93        |                  |
| Avalanche current, repetitive $t_{AR}^{2),3)}$ | $I_{AR}$       |                                           | 9.3         | A                |
| MOSFET dv/dt ruggedness                        | dv/dt          | $V_{DS}=0\ldots 400\text{ V}$             | 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     | $I_S$         | $T_C=25\text{ °C}$ | 14    | A    |
| Diode pulse current <sup>(2)</sup>   | $I_{S,pulse}$ |                    | 56    |      |
| 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                     | $R_{thJA}$   | leaded                                | - | - | 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   | $V_{(BR)DSS}$ | $V_{GS}=0\text{ V}$ , $I_D=250\text{ }\mu\text{A}$                | 500 | -    | -    | V             |
| Gate threshold voltage           | $V_{GS(th)}$  | $V_{DS}=V_{GS}$ , $I_D=0.93\text{ mA}$                            | 2.5 | 3    | 3.5  |               |
| Zero gate voltage drain current  | $I_{DSS}$     | $V_{DS}=500\text{ V}$ , $V_{GS}=0\text{ V}$ , $T_j=25\text{ °C}$  | -   | -    | 2    | $\mu\text{A}$ |
|                                  |               | $V_{DS}=500\text{ V}$ , $V_{GS}=0\text{ V}$ , $T_j=150\text{ °C}$ | -   | 20   | -    |               |
| Gate-source leakage current      | $I_{GSS}$     | $V_{GS}=20\text{ V}$ , $V_{DS}=0\text{ V}$                        | -   | -    | 100  | nA            |
| Drain-source on-state resistance | $R_{DS(on)}$  | $V_{GS}=10\text{ V}$ , $I_D=14\text{ A}$ , $T_j=25\text{ °C}$     | -   | 0.13 | 0.14 | $\Omega$      |
|                                  |               | $V_{GS}=10\text{ V}$ , $I_D=14\text{ A}$ , $T_j=150\text{ °C}$    | -   | 0.32 | -    |               |
| Gate resistance                  | $R_G$         | $f=1\text{ MHz}$ , open drain                                     | -   | 2.2  | -    | $\Omega$      |

| 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>$f=1\text{ MHz}$                          | - | 2540 | - | pF |
| Output capacitance                                         | $C_{oss}$    |                                                                                        | - | 110  | - |    |
| Effective output capacitance, energy related <sup>5)</sup> | $C_{o(er)}$  | $V_{GS}=0\text{ V}, V_{DS}=0\text{ V}$<br>to 400 V                                     | - | 110  | - |    |
| Effective output capacitance, time related <sup>6)</sup>   | $C_{o(tr)}$  |                                                                                        | - | 230  | - |    |
| Turn-on delay time                                         | $t_{d(on)}$  | $V_{DD}=400\text{ V},$<br>$V_{GS}=10\text{ V}, I_D=14\text{ A},$<br>$R_G=12.2\ \Omega$ | - | 35   | - | ns |
| Rise time                                                  | $t_r$        |                                                                                        | - | 14   | - |    |
| Turn-off delay time                                        | $t_{d(off)}$ |                                                                                        | - | 80   | - |    |
| Fall time                                                  | $t_f$        |                                                                                        | - | 8    | - |    |

**Gate Charge Characteristics**

|                       |               |                                                                             |   |     |    |    |
|-----------------------|---------------|-----------------------------------------------------------------------------|---|-----|----|----|
| Gate to source charge | $Q_{gs}$      | $V_{DD}=400\text{ V}, I_D=14\text{ A},$<br>$V_{GS}=0\text{ to }10\text{ V}$ | - | 11  | -  | nC |
| Gate to drain charge  | $Q_{gd}$      |                                                                             | - | 15  | -  |    |
| Gate charge total     | $Q_g$         |                                                                             | - | 48  | 64 |    |
| Gate plateau voltage  | $V_{plateau}$ |                                                                             | - | 5.2 | -  | V  |

**Reverse Diode**

|                               |           |                                                                         |   |     |     |               |
|-------------------------------|-----------|-------------------------------------------------------------------------|---|-----|-----|---------------|
| Diode forward voltage         | $V_{SD}$  | $V_{GS}=0\text{ V}, I_F=14\text{ A},$<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>$di_F/dt=100\text{ A}/\mu\text{s}$      | - | 400 | -   | ns            |
| Reverse recovery charge       | $Q_{rr}$  |                                                                         | - | 5.6 | -   | $\mu\text{C}$ |
| Peak reverse recovery current | $I_{rrm}$ |                                                                         | - | 26  | -   | 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  $P_{AV}=E_{AR} \cdot f$ .

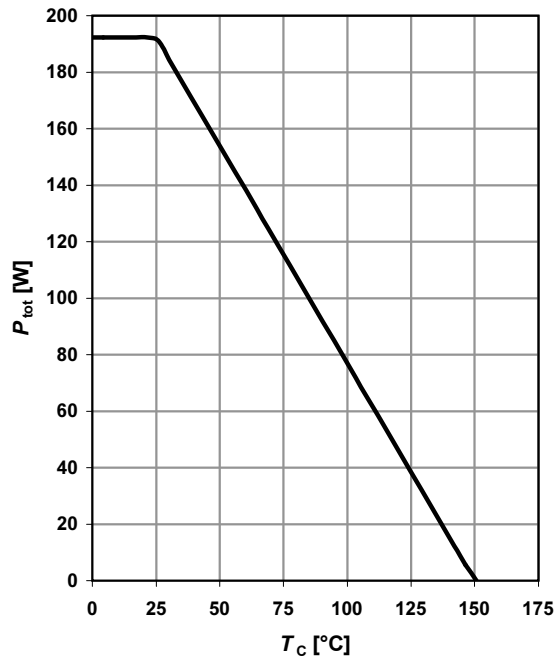
<sup>4)</sup>  $I_{SD} \leq I_D, di/dt \leq 200\text{ A}/\mu\text{s}, V_{DClink}=400\text{ V}, V_{peak} < V_{(BR)DSS}, T_j < T_{j,max}$ , identical low and high side switch

<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

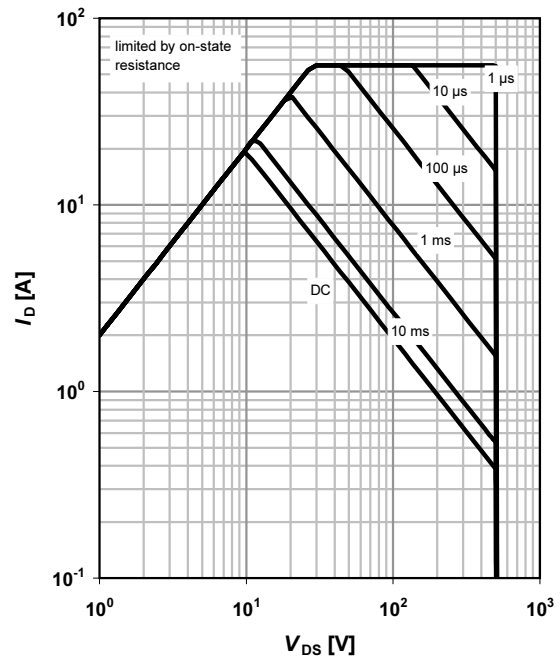
$$P_{\text{tot}} = f(T_C)$$



## 2 Safe operating area

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

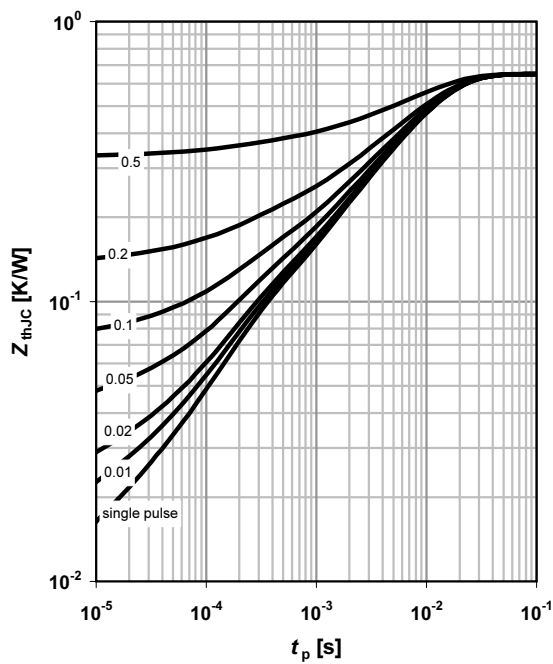
parameter:  $t_p$



## 3 Max. transient thermal impedance

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

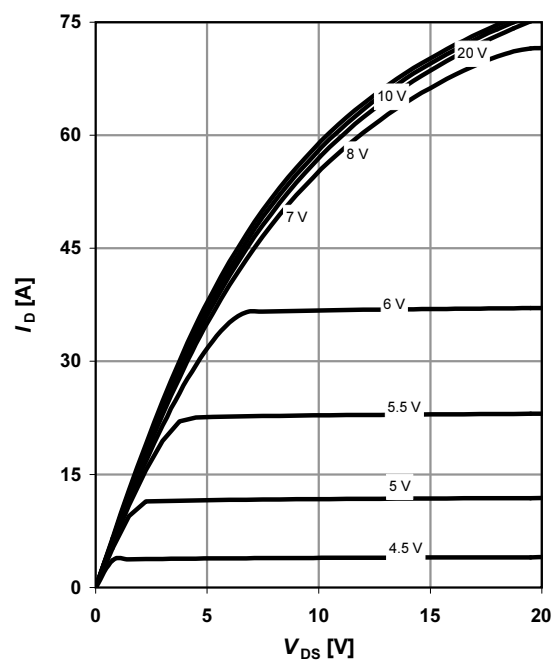
parameter:  $D = t_p / T$



## 4 Typ. output characteristics

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

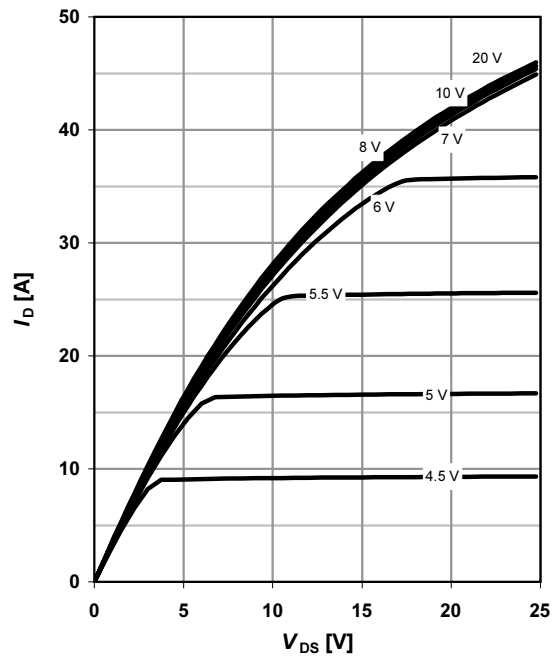
parameter:  $V_{GS}$



### 5 Typ. output characteristics

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

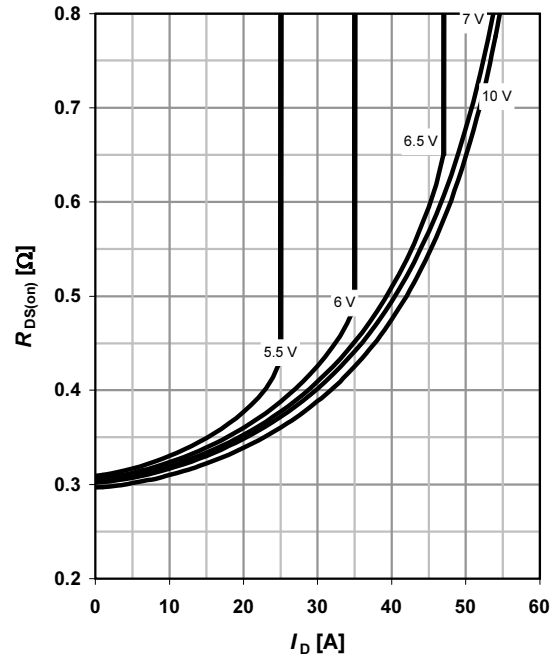
parameter:  $V_{GS}$



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

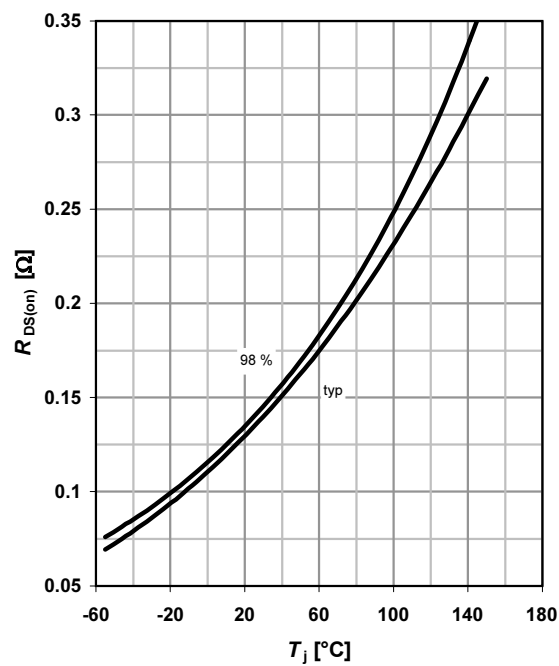
$$R_{DS(on)} = f(I_D); T_J = 150^\circ\text{C}$$

parameter:  $V_{GS}$



### 7 Drain-source on-state resistance

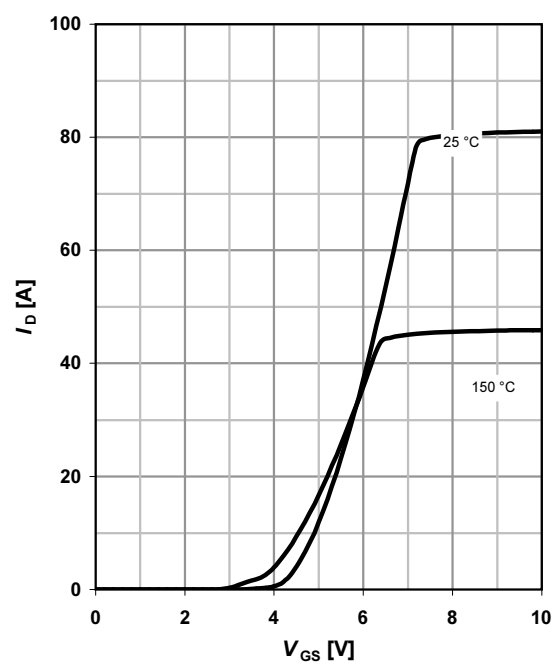
$$R_{DS(on)} = f(T_J); I_D = 14\text{ A}; V_{GS} = 10\text{ V}$$



### 8 Typ. transfer characteristics

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

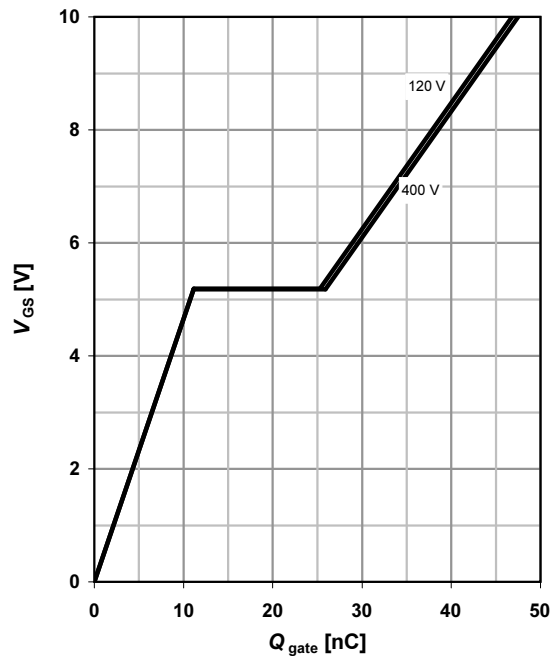
parameter:  $T_J$



### 9 Typ. gate charge

$$V_{GS}=f(Q_{gate}); I_D=14 \text{ A pulsed}$$

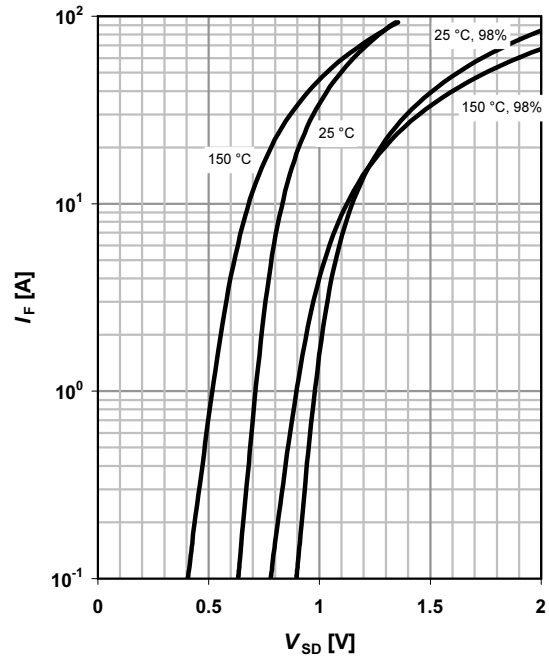
parameter:  $V_{DD}$



### 10 Forward characteristics of reverse diode

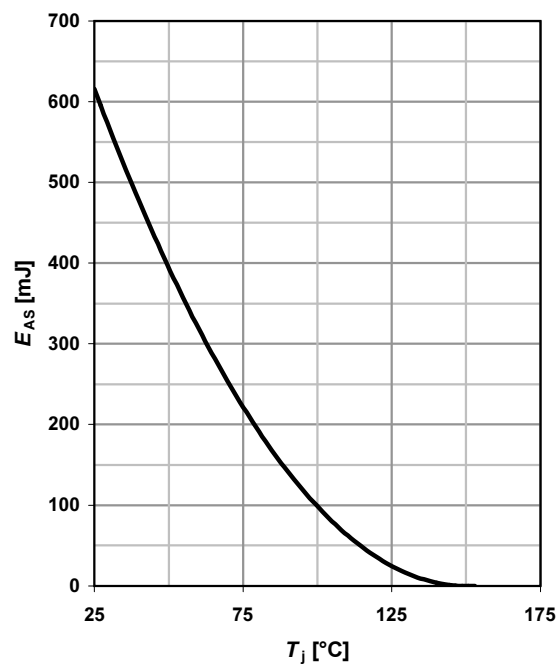
$$I_F=f(V_{SD})$$

parameter:  $T_j$



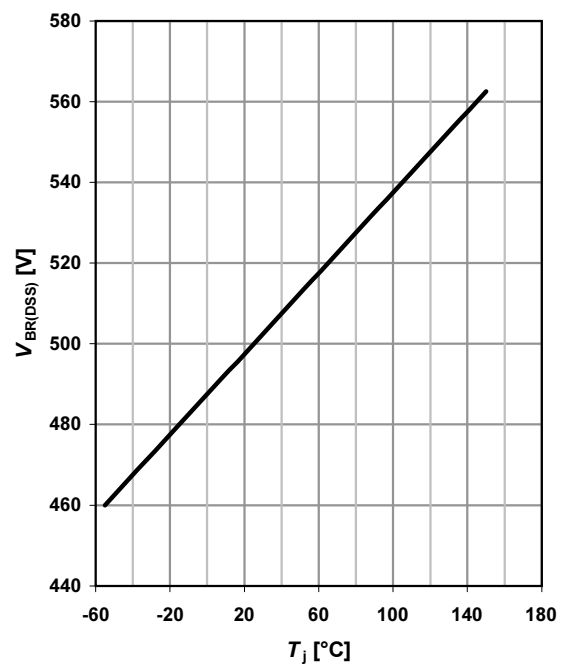
### 11 Avalanche energy

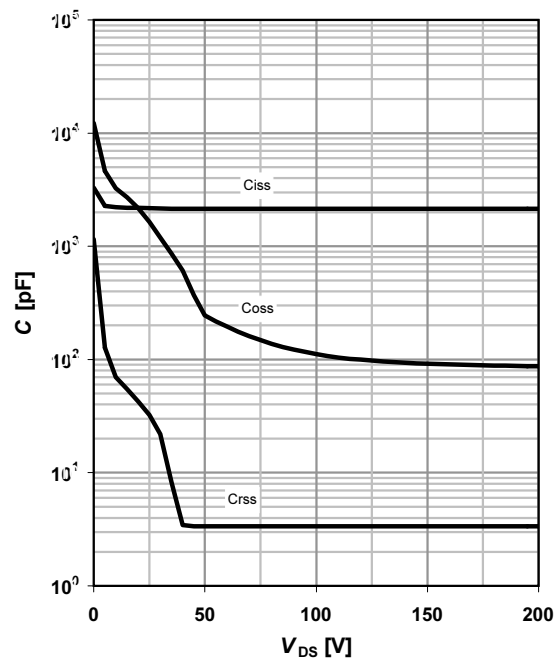
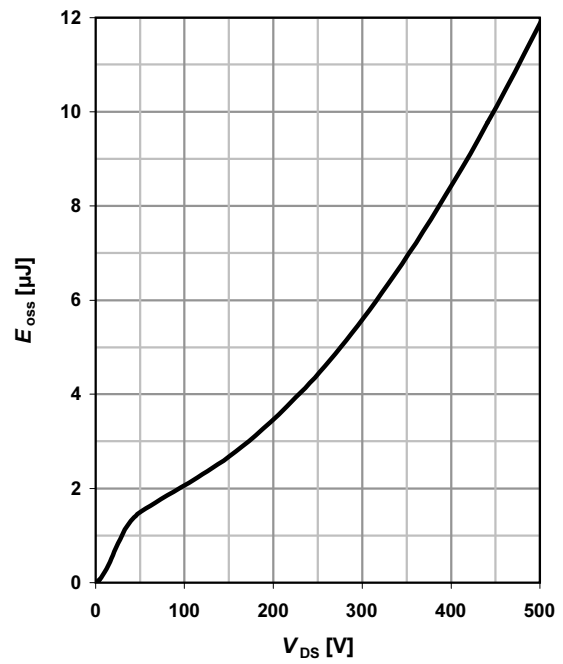
$$E_{AS}=f(T_j); I_D=9.3 \text{ A}; V_{DD}=50 \text{ V}$$

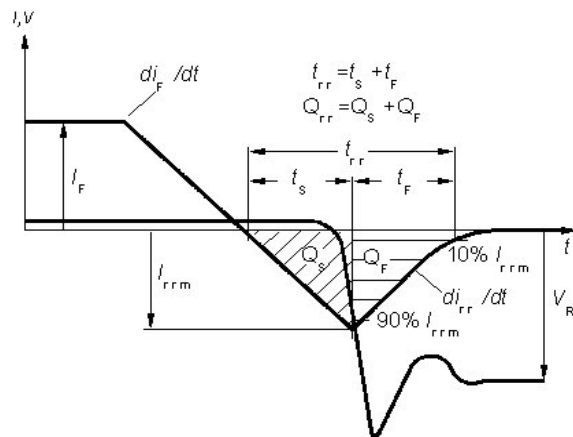


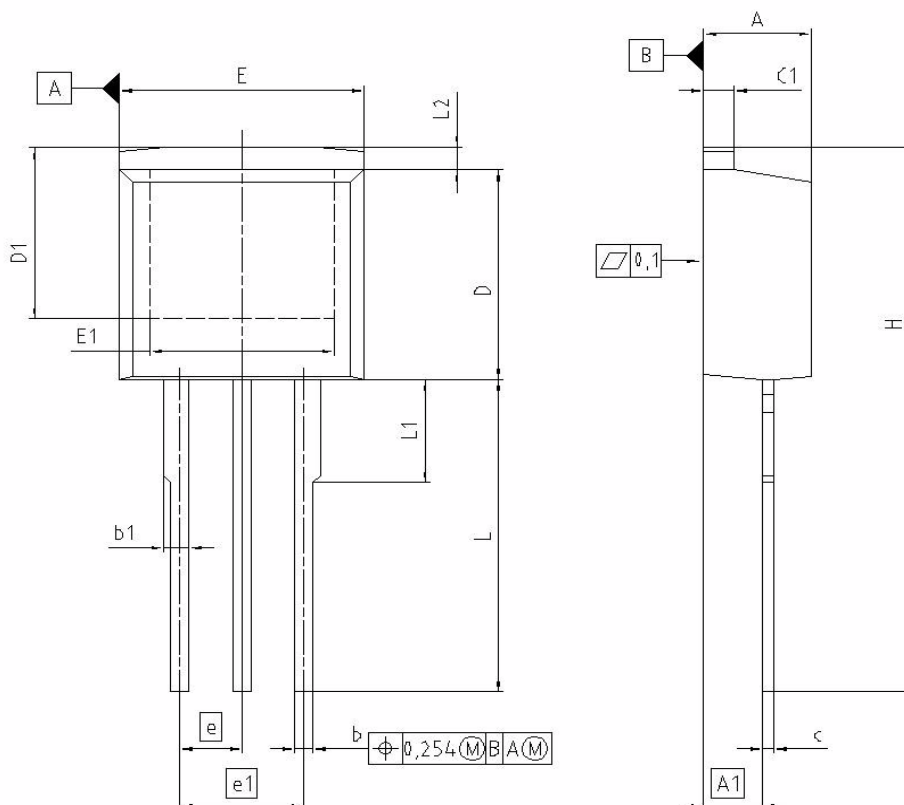
### 12 Drain-source breakdown voltage

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

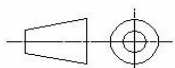


**13 Typ. capacitances**
 $C = f(V_{DS}); V_{GS} = 0 \text{ V}; f = 1 \text{ MHz}$ 

**14 Typ. Coss stored energy**
 $E_{oss} = f(V_{DS})$ 


**Definition of diode switching characteristics**


**PG-TO262-3-1: Outlines**


| DIM       | MILLIMETERS |        | INCHES |       |
|-----------|-------------|--------|--------|-------|
|           | MIN         | MAX    | MIN    | MAX   |
| <b>A</b>  | 4.300       | 4.500  | 0.169  | 0.177 |
| <b>A1</b> | 2.150       | 2.650  | 0.085  | 0.104 |
| <b>b</b>  | 0.650       | 0.850  | 0.026  | 0.033 |
| <b>b1</b> | 0.635       | 1.400  | 0.025  | 0.055 |
| <b>c</b>  | 0.400       | 0.600  | 0.016  | 0.024 |
| <b>c1</b> | 1.170       | 1.370  | 0.046  | 0.054 |
| <b>D</b>  | 9.050       | 9.450  | 0.356  | 0.372 |
| <b>D1</b> | 6.900       | 7.650  | 0.272  | 0.301 |
| <b>E</b>  | 9.800       | 10.200 | 0.386  | 0.402 |
| <b>E1</b> | 7.250       | 8.600  | 0.285  | 0.339 |
| <b>e</b>  | 2.540       |        | 0.100  |       |
| <b>e1</b> | 5.080       |        | 0.200  |       |
| <b>N</b>  | 3           |        | 3      |       |
| <b>L</b>  | 13.000      | 14.000 | 0.512  | 0.551 |
| <b>L1</b> | 4.350       | 4.750  | 0.171  | 0.187 |
| <b>L2</b> | 0.700       | 1.300  | 0.028  | 0.051 |

|                                                                                                                     |
|---------------------------------------------------------------------------------------------------------------------|
| <b>REFERENCE</b><br>JEDEC TO262                                                                                     |
| <b>SCALE</b><br>0 2.5 5mm                                                                                           |
| <b>EUROPEAN PROJECTION</b><br> |
| <b>ISSUE DATE</b><br>01-06-2005                                                                                     |
| <b>FILE</b><br>TO262_1                                                                                              |

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