

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

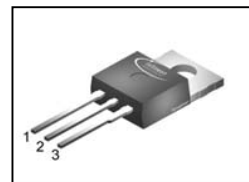
- Lowest figure-of-merit  $R_{ON} \times Q_g$
- Ultra low gate charge
- Extreme dv/dt rated
- High peak current capability
- Qualified for industrial grade applications according to JEDEC<sup>1)</sup>
- Pb-free lead plating; RoHS compliant; Halogen free mold compound

**Product Summary**

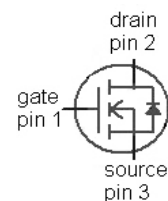
|                      |       |          |
|----------------------|-------|----------|
| $V_{DS} @ T_{j,max}$ | 650   | V        |
| $R_{DS(on),max}$     | 0.385 | $\Omega$ |
| $Q_{g,typ}$          | 17    | nC       |

**CoolMOS CP is specially designed for:**

- Hard switching SMPS topologies

**PG-TO220**


| Type        | Package  | Ordering Code | Marking |
|-------------|----------|---------------|---------|
| IPP60R385CP | PG-TO220 | SP000082281   | 6R385P  |



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

| Parameter                                               | Symbol            | Conditions                                | Value       | Unit             |
|---------------------------------------------------------|-------------------|-------------------------------------------|-------------|------------------|
| Continuous drain current                                | $I_D$             | $T_C=25^\circ\text{C}$                    | 9.0         | A                |
|                                                         |                   | $T_C=100^\circ\text{C}$                   | 5.7         |                  |
| Pulsed drain current <sup>2)</sup>                      | $I_{D,pulse}$     | $T_C=25^\circ\text{C}$                    | 27          |                  |
| Avalanche energy, single pulse                          | $E_{AS}$          | $I_D=3.4\text{ A}$ , $V_{DD}=50\text{ V}$ | 227         | mJ               |
| Avalanche energy, repetitive $t_{AR}$ <sup>2),3)</sup>  | $E_{AR}$          | $I_D=3.4\text{ A}$ , $V_{DD}=50\text{ V}$ | 0.3         |                  |
| Avalanche current, repetitive $t_{AR}$ <sup>2),3)</sup> | $I_{AR}$          |                                           | 3           | 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                                       | $P_{tot}$         | $T_C=25^\circ\text{C}$                    | 83          | 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    | $I_S$         | $T_C=25\text{ °C}$ | 5.2   | A    |
| Diode pulse current <sup>2)</sup>   | $I_{S,pulse}$ |                    | 27    |      |
| 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                        | $R_{thJC}$ |                                       | - | - | 1.5 | K/W |
| Thermal resistance, junction - ambient                     | $R_{thJA}$ | lead                                  | - | - | 62  |     |
| Soldering temperature, wavesoldering 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             |
| Gate threshold voltage           | $V_{GS(th)}$  | $V_{DS}=V_{GS}$ , $I_D=0.34\text{ mA}$                            | 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 | $R_{DS(on)}$  | $V_{GS}=10\text{ V}$ , $I_D=5.2\text{ A}$ , $T_j=25\text{ °C}$    | -   | 0.35 | 0.385 | $\Omega$      |
|                                  |               | $V_{GS}=10\text{ V}$ , $I_D=5.2\text{ A}$ , $T_j=150\text{ °C}$   | -   | 0.94 | -     |               |
| Gate resistance                  | $R_G$         | $f=1\text{ MHz}$ , open drain                                     | -   | 1.8  | -     | $\Omega$      |

| 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>$f=1\text{ MHz}$                          | - | 790 | - | pF |
| Output capacitance                                         | $C_{oss}$    |                                                                                        | - | 38  | - |    |
| 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                                     | - | 36  | - |    |
| Effective output capacitance, time related <sup>6)</sup>   | $C_{o(tr)}$  |                                                                                        | - | 96  | - |    |
| Turn-on delay time                                         | $t_{d(on)}$  | $V_{DD}=400\text{ V},$<br>$V_{GS}=10\text{ V}, I_D=5.2\text{ A},$<br>$R_G=3.3\ \Omega$ | - | 10  | - | ns |
| Rise time                                                  | $t_r$        |                                                                                        | - | 5   | - |    |
| Turn-off delay time                                        | $t_{d(off)}$ |                                                                                        | - | 40  | - |    |
| Fall time                                                  | $t_f$        |                                                                                        | - | 5   | - |    |

**Gate Charge Characteristics**

|                       |               |                                                                              |   |     |    |    |
|-----------------------|---------------|------------------------------------------------------------------------------|---|-----|----|----|
| Gate to source charge | $Q_{gs}$      | $V_{DD}=400\text{ V}, I_D=5.2\text{ A},$<br>$V_{GS}=0\text{ to }10\text{ V}$ | - | 4   | -  | nC |
| Gate to drain charge  | $Q_{gd}$      |                                                                              | - | 6   | -  |    |
| Gate charge total     | $Q_g$         |                                                                              | - | 17  | 22 |    |
| Gate plateau voltage  | $V_{plateau}$ |                                                                              | - | 5.0 | -  | V  |

**Reverse Diode**

|                               |           |                                                                    |   |     |     |               |
|-------------------------------|-----------|--------------------------------------------------------------------|---|-----|-----|---------------|
| Diode forward voltage         | $V_{SD}$  | $V_{GS}=0\text{ V}, I_F=5.2\text{ A},$<br>$T_j=25\text{ °C}$       | - | 0.9 | 1.2 | V             |
| Reverse recovery time         | $t_{rr}$  | $V_R=400\text{ V}, I_F=I_S,$<br>$di_F/dt=100\text{ A}/\mu\text{s}$ | - | 260 | -   | ns            |
| Reverse recovery charge       | $Q_{rr}$  |                                                                    | - | 3.1 | -   | $\mu\text{C}$ |
| Peak reverse recovery current | $I_{rrm}$ |                                                                    | - | 24  | -   | 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  $P_{AV}=E_{AR} \cdot f$ .

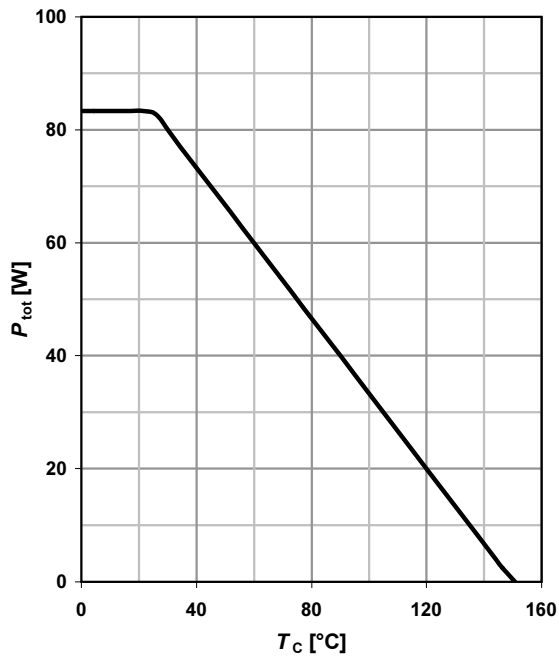
<sup>4)</sup>  $I_{SD}=I_D$ ,  $di/dt \leq 400\text{ A}/\mu\text{s}$ ,  $V_{DClink}=400\text{ V}$ ,  $V_{peak} < V_{(BR)DSS}$ ,  $T_j < T_{j,max}$ , identical low side and high side switch

<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

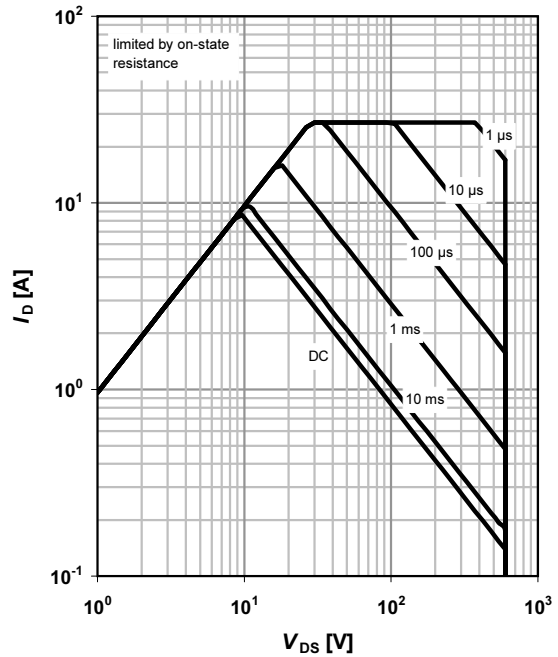
$$P_{\text{tot}} = f(T_C)$$



## 2 Safe operating area

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

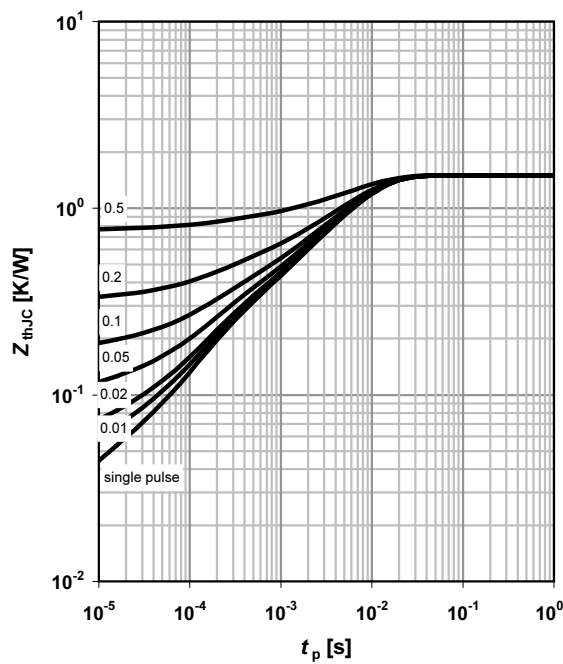
parameter:  $t_p$



## 3 Max. transient thermal impedance

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

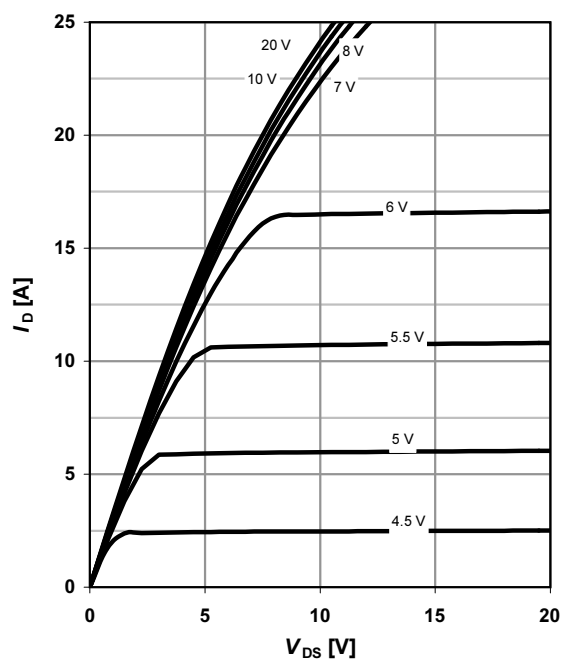
parameter:  $D = t_p / T$



## 4 Typ. output characteristics

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

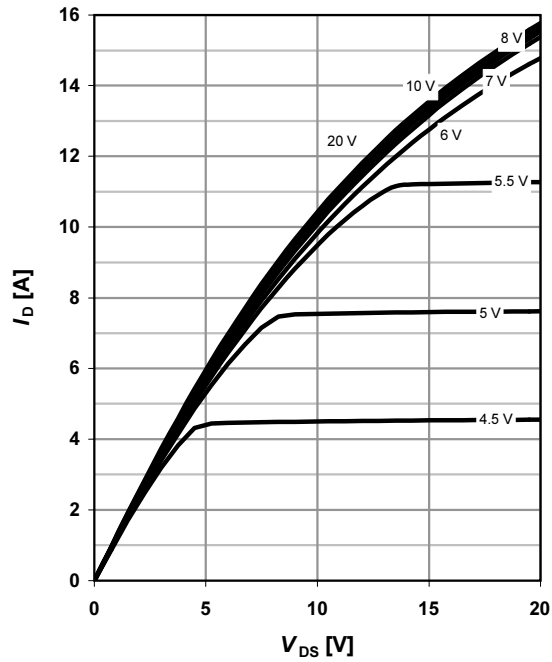
parameter:  $V_{GS}$



**5 Typ. output characteristics**

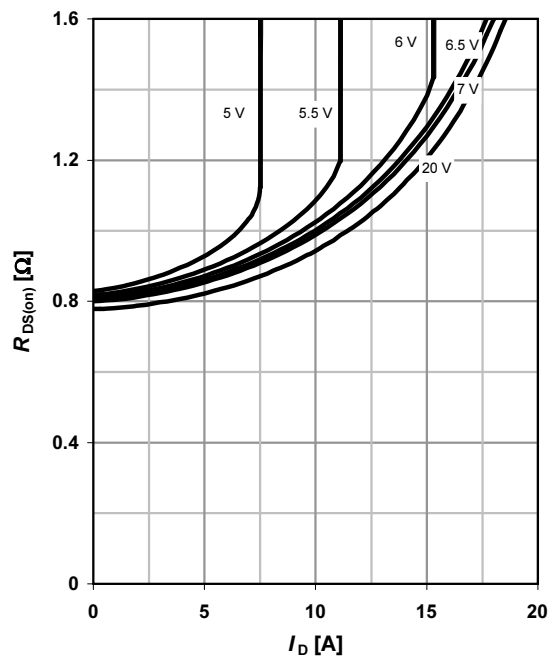
$$I_D = f(V_{DS}); T_j = 150^\circ\text{C}$$

parameter:  $V_{GS}$

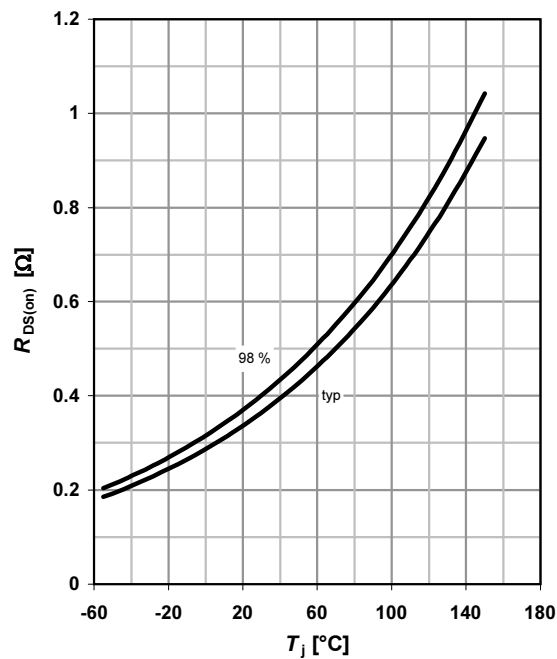

**6 Typ. drain-source on-state resistance**

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

parameter:  $V_{GS}$

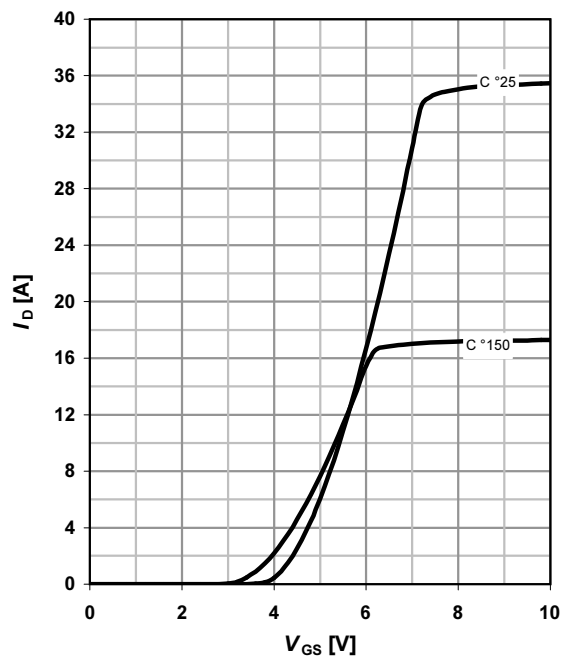

**7 Drain-source on-state resistance**

$$R_{DS(on)} = f(T_j); I_D = 5.2\text{ A}; V_{GS} = 10\text{ V}$$


**8 Typ. transfer characteristics**

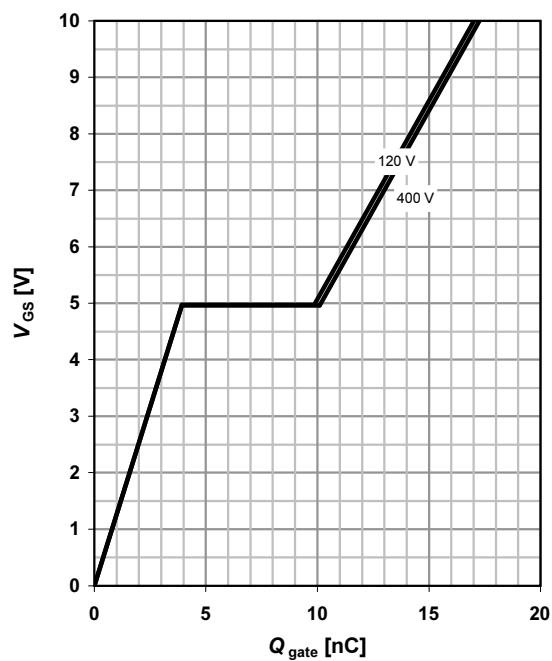
$$I_D = f(V_{GS}); |V_{DS}| > 2|I_D|R_{DS(on)\max}$$

parameter:  $T_j$



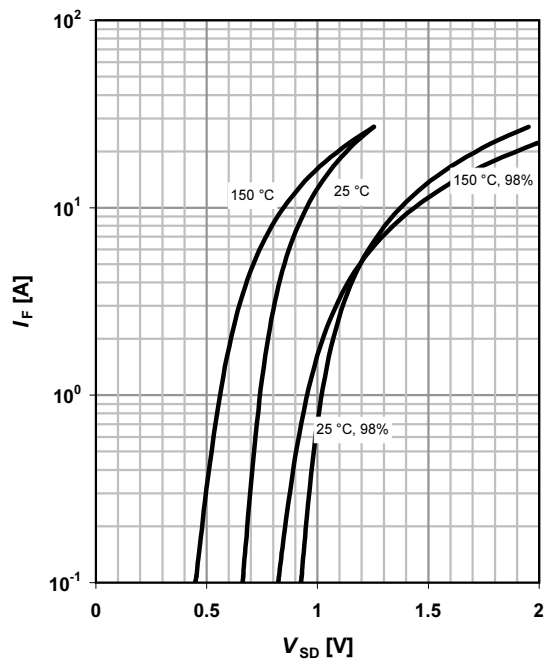
### 9 Typ. gate charge

 $V_{GS}=f(Q_{gate}); I_D=5.2 \text{ A pulsed}$ 

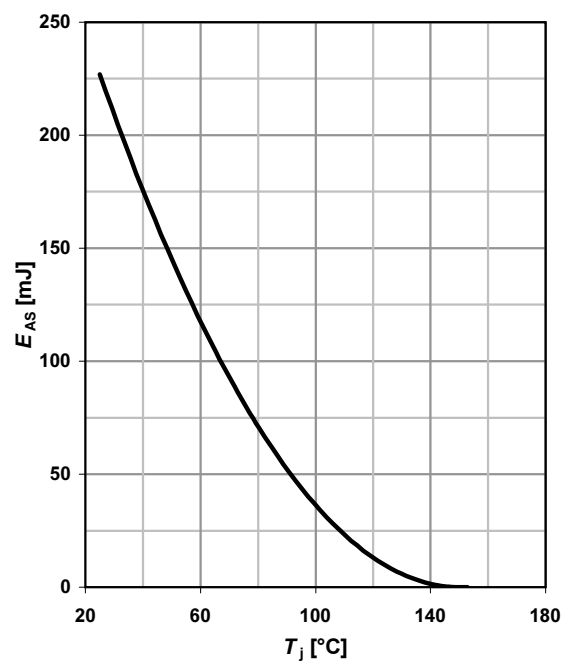
parameter:  $V_{DD}$ 


### 10 Forward characteristics of reverse diode

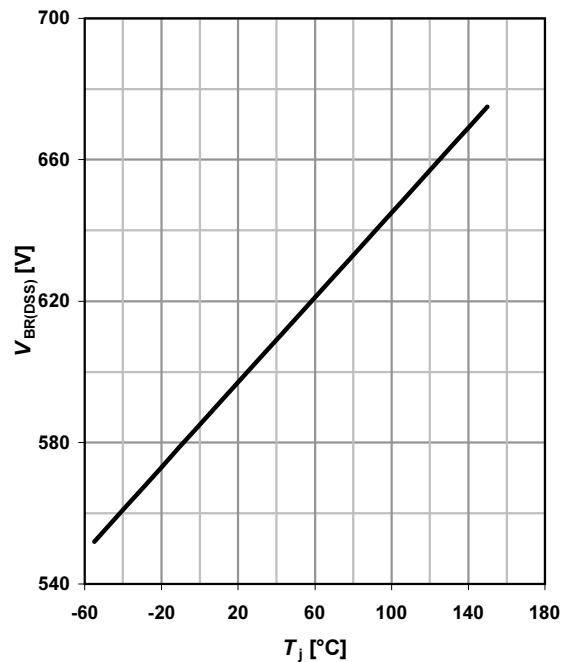
 $I_F=f(V_{SD})$ 

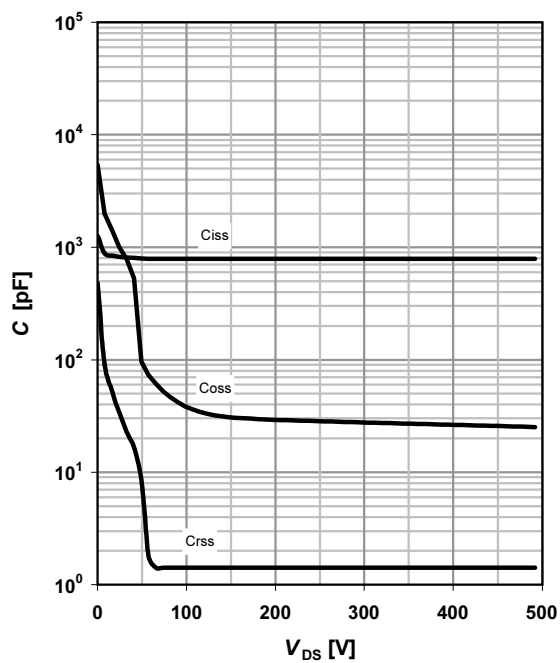
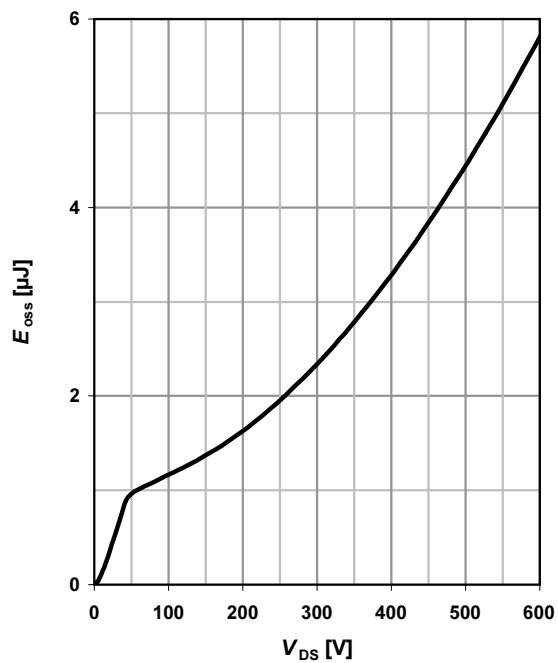
parameter:  $T_j$ 


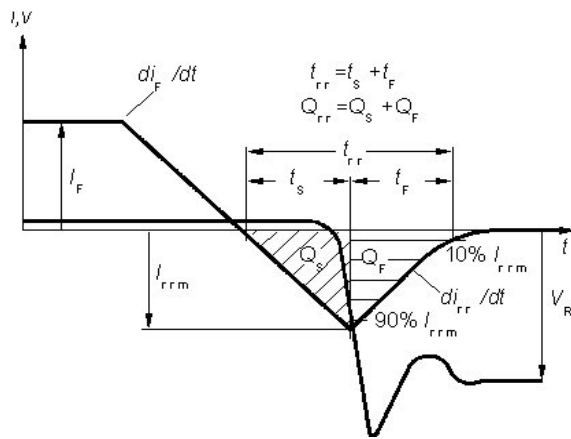
### 11 Avalanche energy

 $E_{AS}=f(T_j); I_D=3.4 \text{ A}; V_{DD}=50 \text{ V}$ 


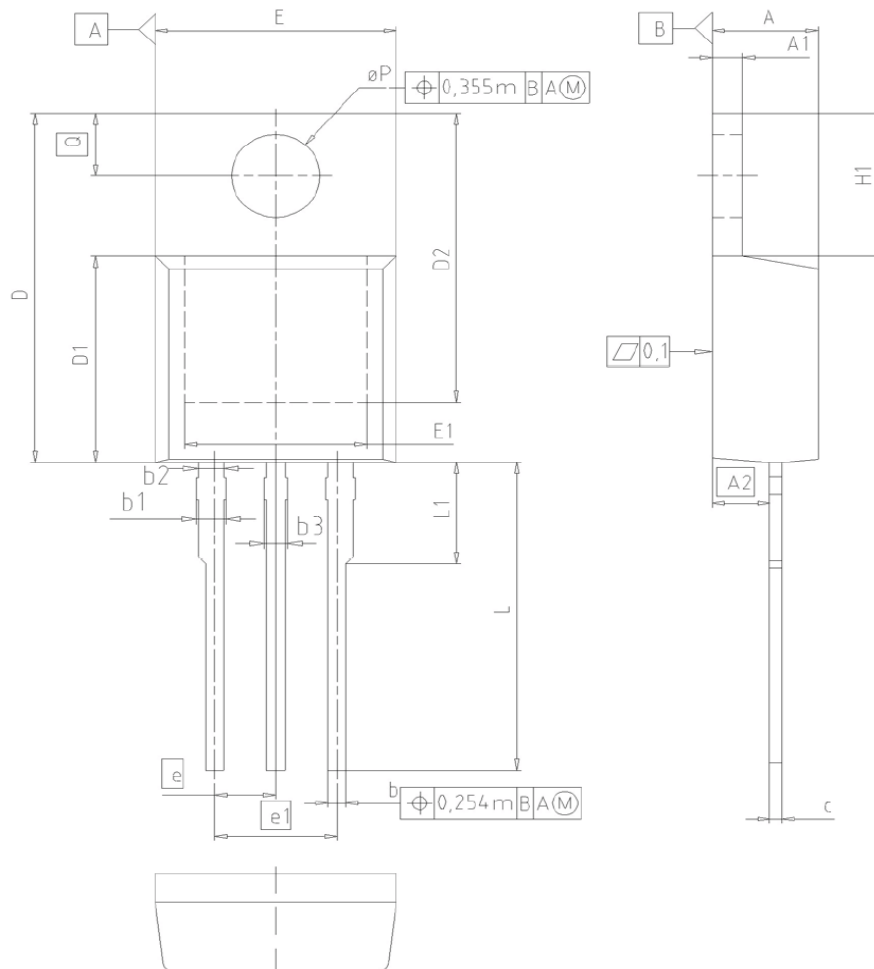
### 12 Drain-source breakdown voltage

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


**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**




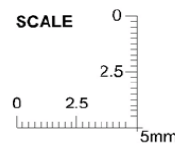
**PG-TO220-3-1/TO220-3-21: Outlines**


| DIM | MILLIMETERS |       | INCHES |       |
|-----|-------------|-------|--------|-------|
|     | MIN         | MAX   | MIN    | MAX   |
| A   | 4.30        | 4.57  | 0.169  | 0.180 |
| A1  | 1.17        | 1.40  | 0.046  | 0.055 |
| A2  | 2.15        | 2.72  | 0.085  | 0.107 |
| b   | 0.65        | 0.86  | 0.026  | 0.034 |
| b1  | 0.95        | 1.40  | 0.037  | 0.055 |
| b2  | 0.95        | 1.15  | 0.037  | 0.045 |
| b3  | 0.65        | 1.15  | 0.026  | 0.045 |
| c   | 0.33        | 0.60  | 0.013  | 0.024 |
| D   | 14.81       | 15.95 | 0.583  | 0.628 |
| D1  | 8.51        | 9.45  | 0.335  | 0.372 |
| D2  | 12.19       | 13.10 | 0.480  | 0.516 |
| E   | 9.70        | 10.36 | 0.382  | 0.408 |
| E1  | 6.50        | 8.60  | 0.256  | 0.339 |
| e   | 2.54        |       | 0.100  |       |
| e1  | 5.08        |       | 0.200  |       |
| N   | 3           |       | 3      |       |
| H1  | 5.90        | 6.90  | 0.232  | 0.272 |
| L   | 13.00       | 14.00 | 0.512  | 0.551 |
| L1  | -           | 4.80  | -      | 0.189 |
| øP  | 3.60        | 3.89  | 0.142  | 0.153 |
| Q   | 2.60        | 3.00  | 0.102  | 0.118 |

Dimensions in mm/inches:

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**SCALE**



**EUROPEAN PROJECTION**



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