

## 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 according to JEDEC<sup>1)</sup> for target applications
- Pb-free lead plating; RoHS compliant

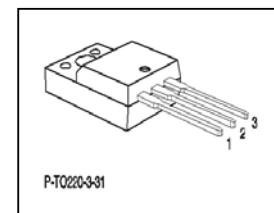
### CoolMOS CP is specially designed for:

- Hard switching SMPS topologies

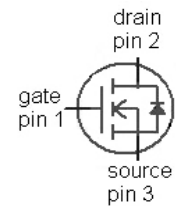
### Product Summary

|                      |       |          |
|----------------------|-------|----------|
| $V_{DS} @ T_{j,max}$ | 650   | V        |
| $R_{DS(on),max}$     | 0.299 | $\Omega$ |
| $Q_{g,typ}$          | 22    | nC       |

PG-TO220-3-31



| Type        | Package       | Ordering Code | Marking |
|-------------|---------------|---------------|---------|
| IPA60R299CP | PG-TO220-3-31 | SP000096438   | 6R299P  |



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

| Parameter                                      | Symbol         | Conditions                                | Value       | Unit |
|------------------------------------------------|----------------|-------------------------------------------|-------------|------|
| Continuous drain current <sup>2)</sup>         | $I_D$          | $T_C=25\text{ °C}$                        | 11          | A    |
|                                                |                | $T_C=100\text{ °C}$                       | 7           |      |
| Pulsed drain current <sup>3)</sup>             | $I_{D,pulse}$  | $T_C=25\text{ °C}$                        | 34          |      |
| Avalanche energy, single pulse                 | $E_{AS}$       | $I_D=4.4\text{ A}$ , $V_{DD}=50\text{ V}$ | 290         | mJ   |
| Avalanche energy, repetitive $t_{AR}^{3),4)}$  | $E_{AR}$       | $I_D=4.4\text{ A}$ , $V_{DD}=50\text{ V}$ | 0.44        |      |
| Avalanche current, repetitive $t_{AR}^{3),4)}$ | $I_{AR}$       |                                           | 4.4         | A    |
| MOSFET $dv/dt$ ruggedness                      | $dv/dt$        | $V_{DS}=0\ldots480\text{ V}$              | 50          | V/ns |
| Gate source voltage                            | $V_{GS}$       | static                                    | $\pm 20$    | V    |
|                                                |                | AC ( $f>1\text{ Hz}$ )                    | $\pm 30$    |      |
| Power dissipation                              | $P_{tot}$      | $T_C=25\text{ °C}$                        | 33          | W    |
| Operating and storage temperature              | $T_j, T_{stg}$ |                                           | -55 ... 150 | °C   |
| Mounting torque                                |                | M2.5 screws                               | 50          | Ncm  |

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

| Parameter                                      | Symbol        | Conditions         | Value | Unit |
|------------------------------------------------|---------------|--------------------|-------|------|
| Continuous diode forward current <sup>2)</sup> | $I_S$         | $T_C=25\text{ °C}$ | 11    | A    |
| Diode pulse current <sup>3)</sup>              | $I_{S,pulse}$ |                    | 34    |      |
| Reverse diode $dv/dt$ <sup>5)</sup>            | $dv/dt$       |                    | 15    | V/ns |

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

#### Thermal characteristics

|                                                            |            |                                       |   |   |     |     |
|------------------------------------------------------------|------------|---------------------------------------|---|---|-----|-----|
| Thermal resistance, junction - case                        | $R_{thJC}$ |                                       | - | - | 3.8 | K/W |
| Thermal resistance, junction - ambient                     | $R_{thJA}$ | leaded                                | - | - | 80  |     |
| 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           | $V_{GS(th)}$  | $V_{DS}=V_{GS}$ , $I_D=0.44\text{ mA}$                            | 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 | $R_{DS(on)}$  | $V_{GS}=10\text{ V}$ , $I_D=6.6\text{ A}$ , $T_j=25\text{ °C}$    | -   | 0.27 | 0.299 | $\Omega$      |
|                                  |               | $V_{GS}=10\text{ V}$ , $I_D=6.6\text{ A}$ , $T_j=150\text{ °C}$   | -   | 0.73 |       |               |
| 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>$f=1\text{ MHz}$                          | - | 1100 | - | pF |
| Output capacitance                                         | $C_{oss}$    |                                                                                        | - | 60   | - |    |
| Effective output capacitance, energy related <sup>6)</sup> | $C_{o(er)}$  | $V_{GS}=0\text{ V}, V_{DS}=0\text{ V}$<br>to 480 V                                     | - | 46   | - |    |
| Effective output capacitance, time related <sup>7)</sup>   | $C_{o(tr)}$  |                                                                                        | - | 120  | - |    |
| Turn-on delay time                                         | $t_{d(on)}$  | $V_{DD}=400\text{ V},$<br>$V_{GS}=10\text{ V}, I_D=6,6\text{ A},$<br>$R_G=4,3\ \Omega$ | - | 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 | $Q_{gs}$      | $V_{DD}=400\text{ V}, I_D=6.6\text{ A},$<br>$V_{GS}=0\text{ to }10\text{ V}$ | - | 5   | -  | nC |
| Gate to drain charge  | $Q_{gd}$      |                                                                              | - | 7.6 | -  |    |
| Gate charge total     | $Q_g$         |                                                                              | - | 22  | 29 |    |
| Gate plateau voltage  | $V_{plateau}$ |                                                                              | - | 5.0 | -  | V  |

**Reverse Diode**

|                               |           |                                                                          |   |     |     |               |
|-------------------------------|-----------|--------------------------------------------------------------------------|---|-----|-----|---------------|
| Diode forward voltage         | $V_{SD}$  | $V_{GS}=0\text{ V}, I_F=6.6\text{ A},$<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>$di_F/dt=100\text{ A}/\mu\text{s}$       | - | 300 | -   | ns            |
| Reverse recovery charge       | $Q_{rr}$  |                                                                          | - | 3.9 | -   | $\mu\text{C}$ |
| Peak reverse recovery current | $I_{rrm}$ |                                                                          | - | 26  | -   | A             |

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

<sup>2)</sup> Limited only by maximum temperature

<sup>3)</sup> Pulse width  $t_p$  limited by  $T_{j,max}$

<sup>4)</sup> Repetitive avalanche causes additional power losses that can be calculated as  $P_{AV}=E_{AR} \cdot f$ .

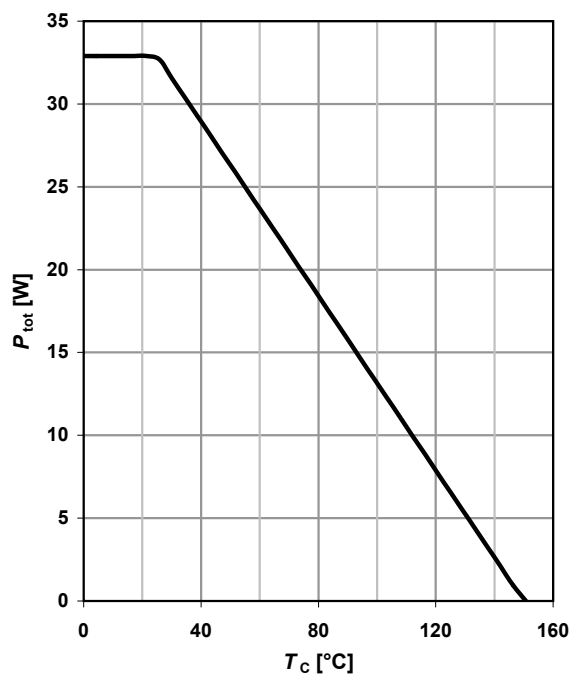
<sup>5)</sup>  $I_{SD} \leq I_D$ ,  $di/dt \leq 200\text{ A}/\mu\text{s}$ ,  $V_{DClk}=400\text{ V}$ ,  $V_{peak} < V_{(BR)DSS}$ ,  $T_j < T_{j,max}$ , identical low side and high side switch.

<sup>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%  $V_{DSS}$ .

<sup>7)</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

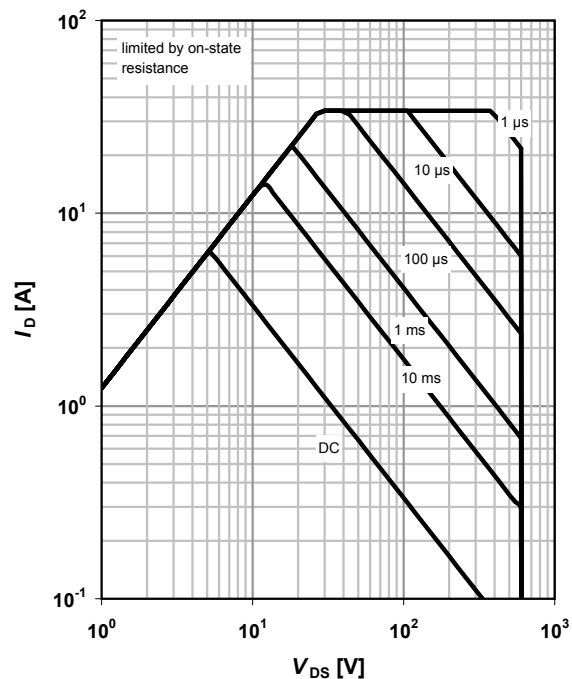
$$P_{\text{tot}} = f(T_c)$$



### 2 Safe operating area

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

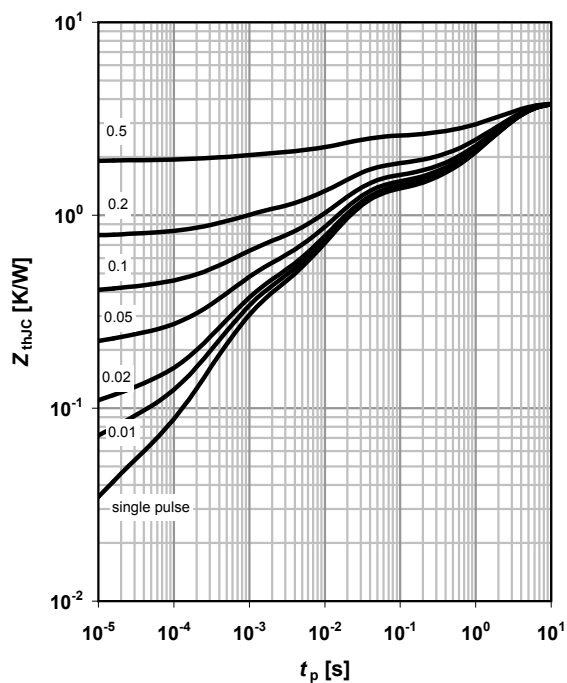
parameter:  $t_p$



### 3 Max. transient thermal impedance

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

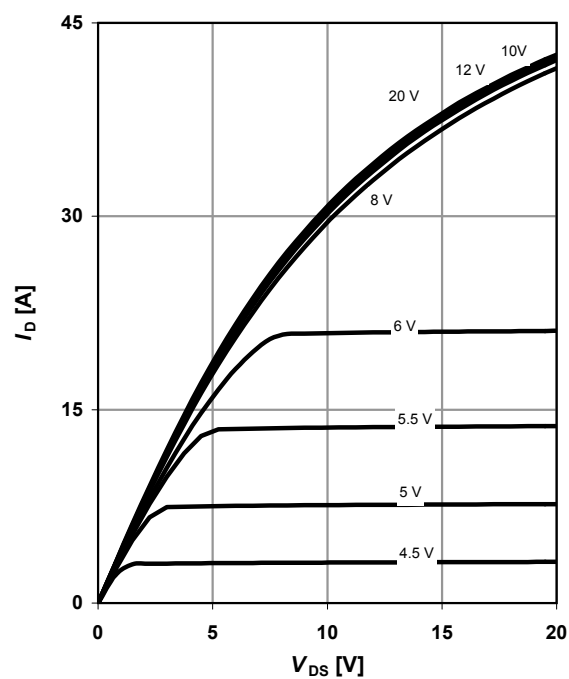
parameter:  $D = t_p / T$



### 4 Typ. output characteristics

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

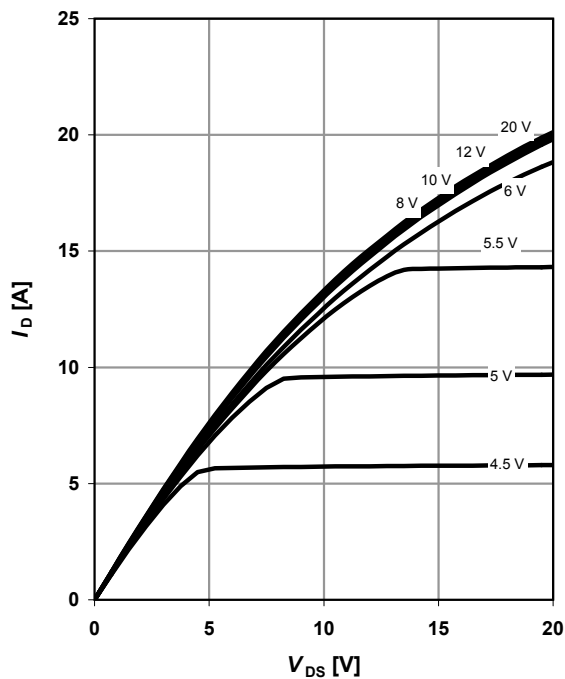
parameter:  $V_{GS}$



### 5 Typ. output characteristics

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

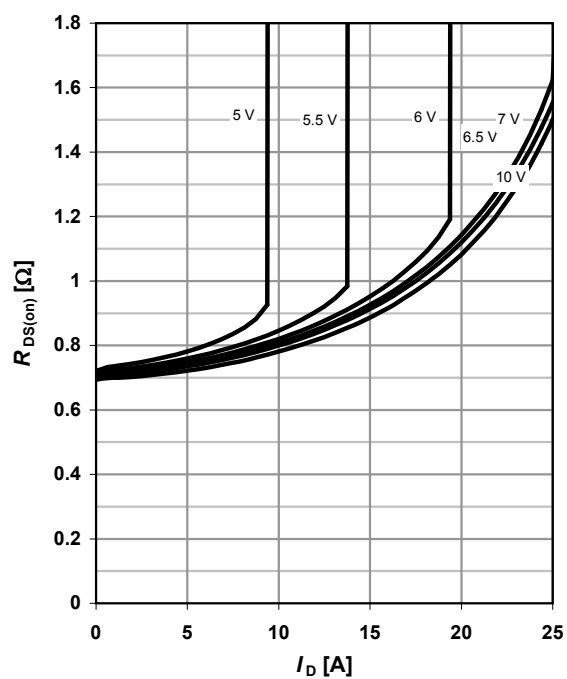
parameter:  $V_{GS}$



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

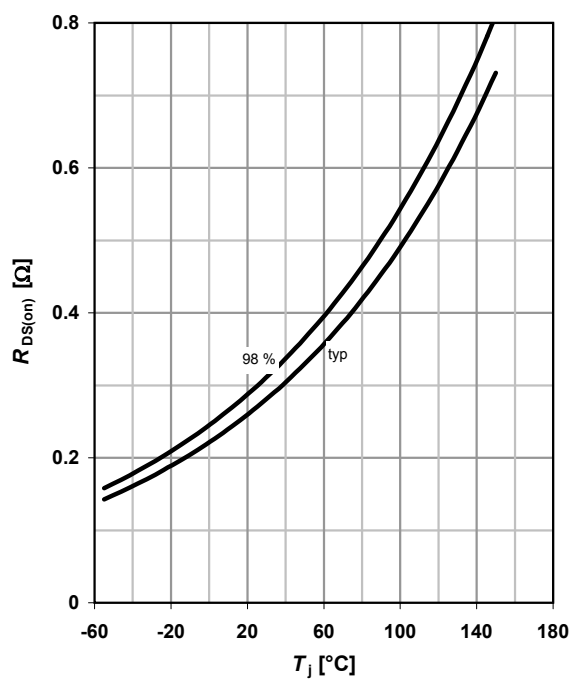
$$R_{DS(on)} = f(I_D); T_j = 150^\circ\text{C}$$

parameter:  $V_{GS}$



### 7 Drain-source on-state resistance

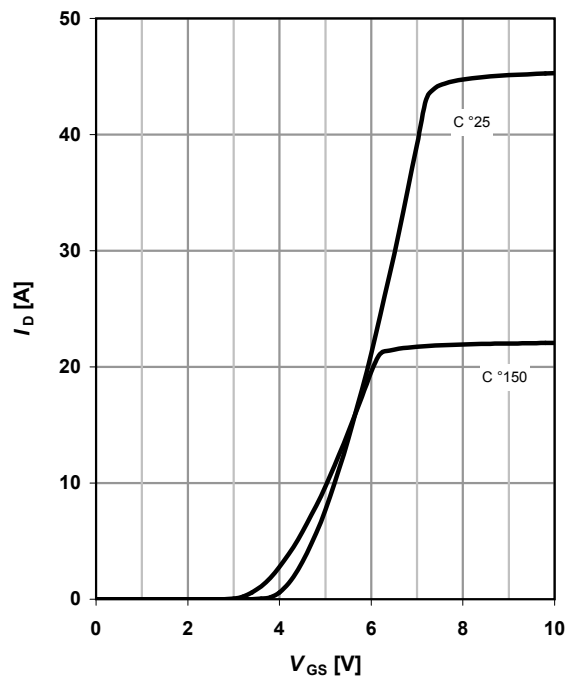
$$R_{DS(on)} = f(T_j); I_D = 6.6\text{ A}; V_{GS} = 10\text{ V}$$



### 8 Typ. transfer characteristics

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

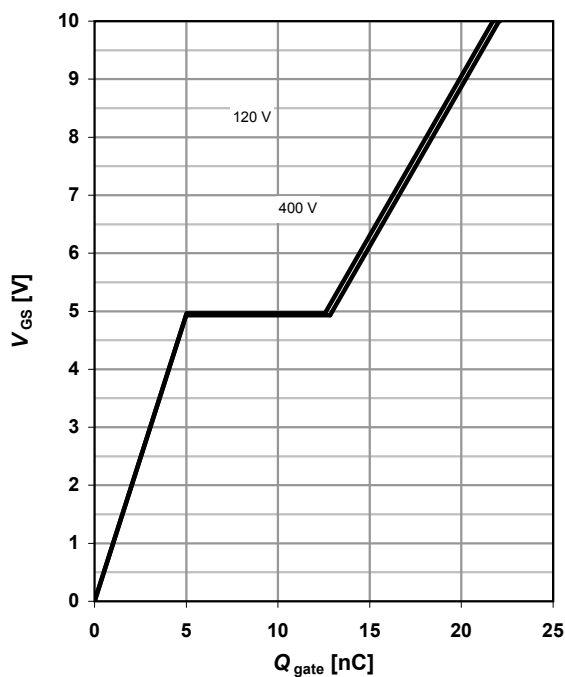
parameter:  $T_j$



### 9 Typ. gate charge

$$V_{GS}=f(Q_{gate}); I_D=6.6 \text{ A pulsed}$$

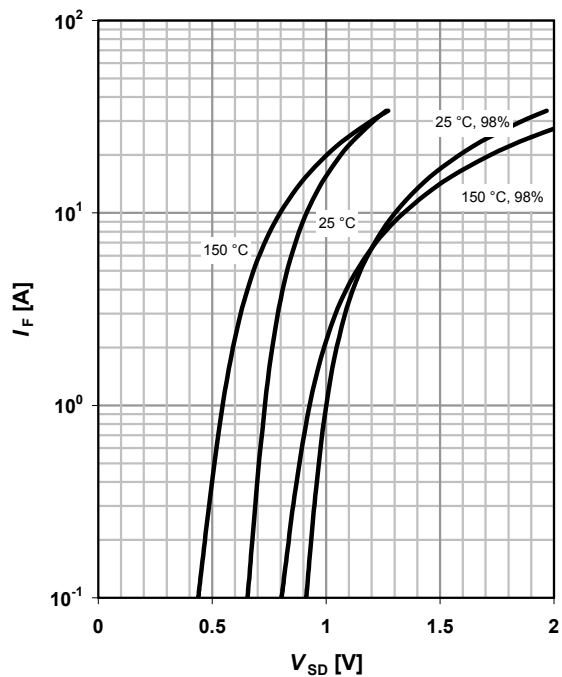
parameter:  $V_{DD}$



### 10 Forward characteristics of reverse diode

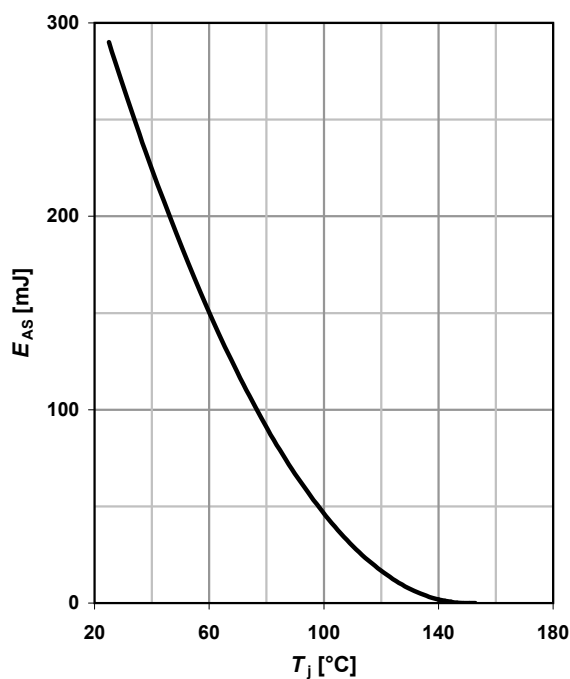
$$I_F=f(V_{SD})$$

parameter:  $T_j$



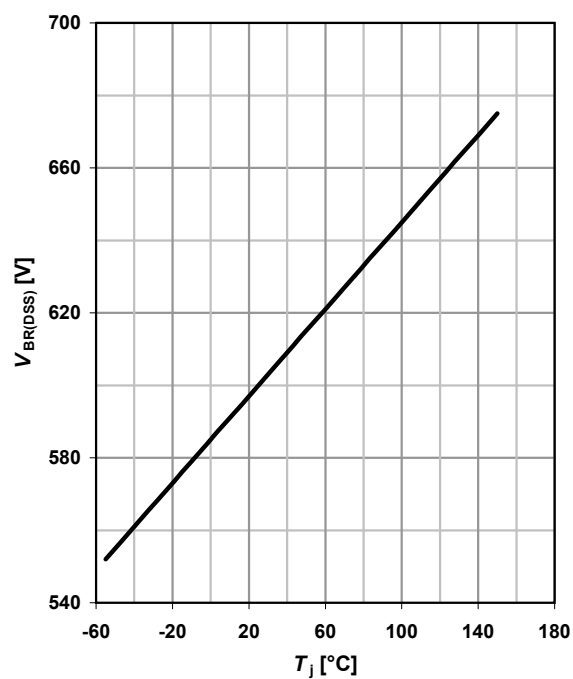
### 11 Avalanche energy

$$E_{AS}=f(T_j); I_D=4.4 \text{ A}; V_{DD}=50 \text{ V}$$



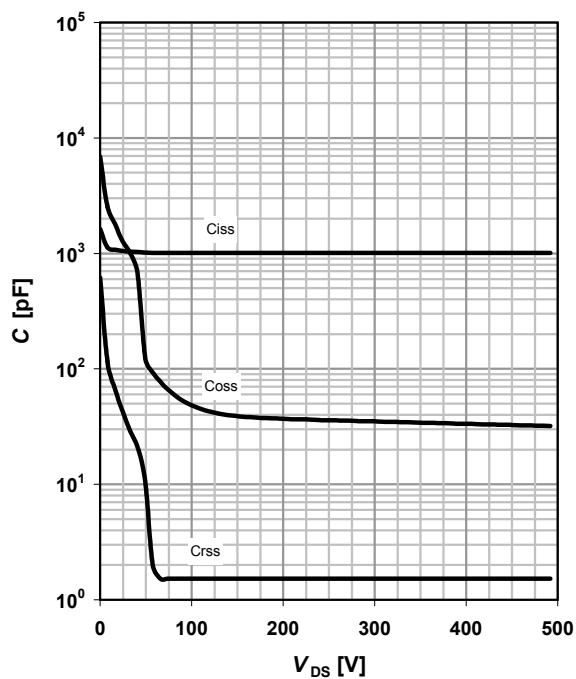
### 12 Drain-source breakdown voltage

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



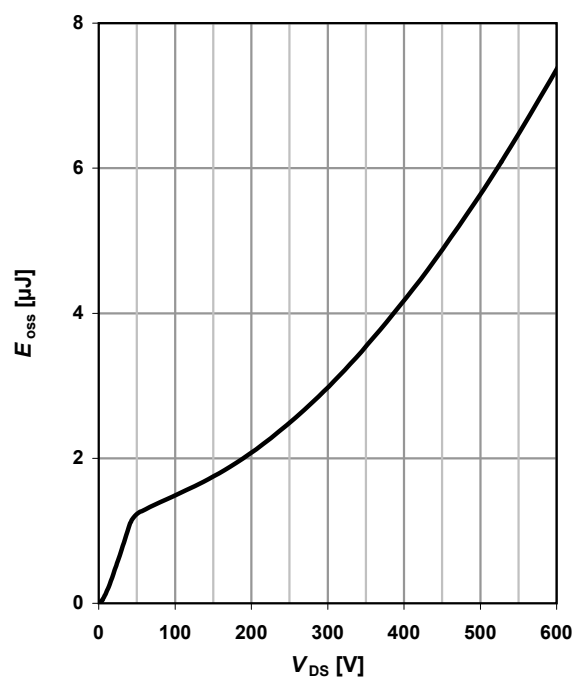
### 13 Typ. capacitances

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



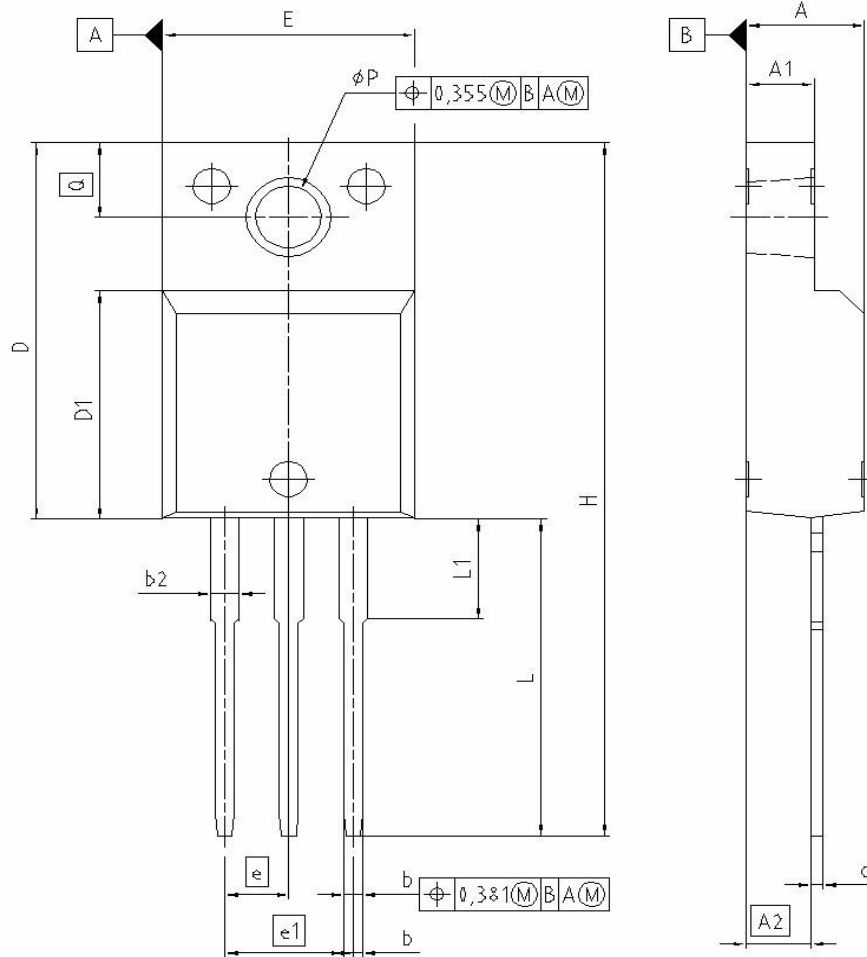
### 14 Typ. Coss stored energy

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

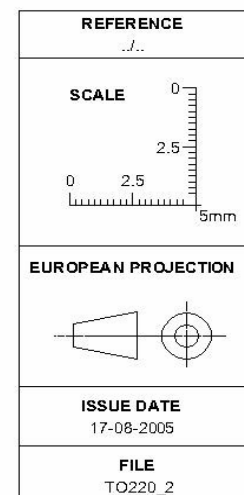


# Definition of diode switching characteristics



**PG-TO220-3-31: Outline/ Fully isolated package (2500VAC; 1 minute)**


| DIM       | MILLIMETERS |        | INCHES |       |
|-----------|-------------|--------|--------|-------|
|           | MIN         | MAX    | MIN    | MAX   |
| <b>A</b>  | 4.572       | 4.826  | 0.180  | 0.190 |
| <b>A1</b> | 2.573       | 2.827  | 0.101  | 0.111 |
| <b>A2</b> | 2.514       | 2.616  | 0.099  | 0.103 |
| <b>b</b>  | 0.649       | 0.776  | 0.025  | 0.030 |
| <b>b2</b> | 1.143       | 1.509  | 0.045  | 0.059 |
| <b>c</b>  | 0.449       | 0.627  | 0.017  | 0.027 |
| <b>D</b>  | 15.863      | 16.117 | 0.624  | 0.634 |
| <b>D1</b> | 9.554       | 9.808  | 0.376  | 0.386 |
| <b>E</b>  | 10.373      | 10.627 | 0.408  | 0.418 |
| <b>e</b>  | 2.540       |        | 0.100  |       |
| <b>e1</b> | 5.080       |        | 0.200  |       |
| <b>N</b>  | 3           |        | 3      |       |
| <b>H</b>  | 29.463      | 29.717 | 1.160  | 1.170 |
| <b>L</b>  | 13.473      | 13.727 | 0.530  | 0.540 |
| <b>L1</b> | 3.175       | 3.429  | 0.125  | 0.135 |
| <b>øP</b> | 2.949       | 3.025  | 0.119  | 0.116 |
| <b>Q</b>  | 3.149       | 3.251  | 0.124  | 0.128 |



Dimensions in mm/inches

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