

## CoolMOS<sup>®</sup> 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

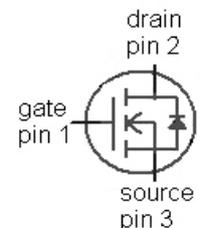
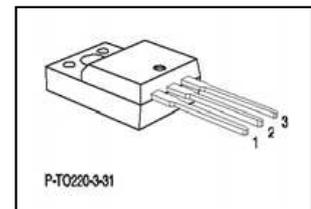
### Product Summary

|                                     |       |          |
|-------------------------------------|-------|----------|
| $V_{DS} @ T_{j,max}$                | 650   | V        |
| $R_{DS(on),max} @ T_j = 25^\circ C$ | 0.165 | $\Omega$ |
| $Q_{g,typ}$                         | 39    | nC       |

### CoolMOS CP is designed for:

- Hard switching SMPS topologies

### PG-TO220



| Type        | Package  | Ordering Code | Marking |
|-------------|----------|---------------|---------|
| IPA60R165CP | PG-TO220 | SP000096437   | 6R165P  |

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

| Parameter   | Symbol         | Conditions                         | Value       | Unit       |
|---|----------------|------------------------------------|-------------|------------|
| Continuous drain current <sup>2)</sup>                  | $I_D$          | $T_C = 25^\circ C$                 | 21          | A          |
|   |                | $T_C = 100^\circ C$                | 13          |            |
| Pulsed drain current <sup>3)</sup>                      | $I_{D,pulse}$  | $T_C = 25^\circ C$                 | 61          |            |
| Avalanche energy, single pulse                          | $E_{AS}$       | $I_D = 7.9 A, V_{DD} = 50 V$       | 522         | mJ         |
| Avalanche energy, repetitive $t_{AR}$ <sup>3),4)</sup>  | $E_{AR}$       | $I_D = 7.9 A, V_{DD} = 50 V$       | 0.79        |            |
| Avalanche current, repetitive $t_{AR}$ <sup>3),4)</sup> | $I_{AR}$       |                                    | 7.9         | A          |
| MOSFET dv/dt ruggedness                                 | dv/dt          | $V_{DS} = 0 \dots 480 V$           | 50          | V/ns       |
| Gate source voltage                                     | $V_{GS}$       | static                             | $\pm 20$    | V          |
|   |                | AC ( $f > 1 Hz$ )                  | $\pm 30$    |            |
| Power dissipation                                       | $P_{tot}$      | $T_C = 25^\circ C$                 | 34          | W          |
| Operating and storage temperature                       | $T_j, T_{stg}$ |                                    | -55 ... 150 | $^\circ C$ |
| Mounting torque   |                | M2.5 screws                        | 50          | Ncm        |
| Insulation withstand voltage                            | $V_{ISO}$      | Vrms, $T_C = 25^\circ C, t = 1min$ | 2500        | V          |

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

| Parameter                                      | Symbol        | Conditions         | Value | Unit |
|--|---------------|--------------------|-------|------|
| Continuous diode forward current <sup>2)</sup> | $I_S$         | $T_C=25\text{ °C}$ | 21    | A    |
| Diode pulse current <sup>3)</sup>              | $I_{S,pulse}$ |                    | 61    |      |
| 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                        | $R_{thJC}$ |                                       | - |   | 3.65 | 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           | $V_{GS(th)}$  | $V_{DS}=V_{GS}, I_D=0.79\text{ mA}$                        | 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     | $\mu\text{A}$ |
|                                  |               | $V_{DS}=25\text{ V}, V_{GS}=0\text{ V}, T_j=150\text{ °C}$ | -   | 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                  | $R_G$         | $f=1\text{ MHz}, \text{open drain}$                        | -   | 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>6)</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>7)</sup>   | $C_{o(tr)}$  |   | - | 220  | - |    |
| Turn-on delay time   | $t_{d(on)}$  | $V_{DD}=400\text{ V},$<br>$V_{GS}=10\text{ V}, I_D=12\text{ A},$<br>$R_G=3.3\ \Omega$ | - | 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> Limited only by maximum temperature

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

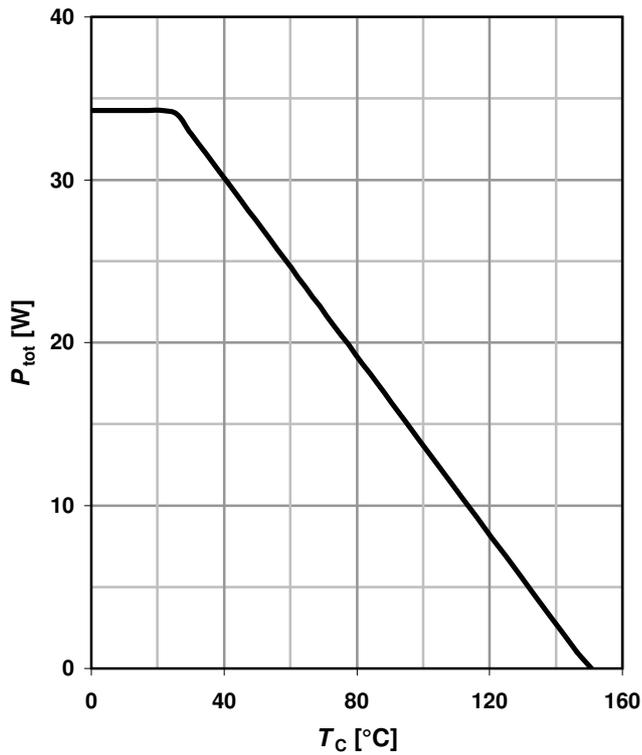
<sup>5)</sup>  $I_{SD} \leq I_D$ ,  $di/dt \leq 200\text{ A}/\mu\text{s}$ ,  $V_{DClink}=400\text{ V}$ ,  $V_{peak} < V_{(BR)DSS}$ ,  $T_j < T_{j,max}$ , identical low side and high side switch.

<sup>6)</sup>  $C_{o(er)}$  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>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

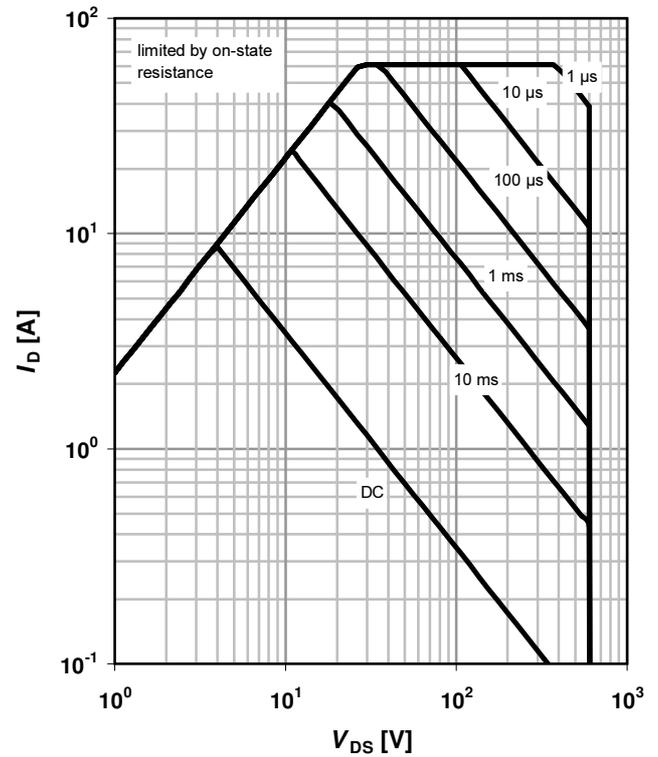
$$P_{tot} = f(T_c)$$



### 2 Safe operating area

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

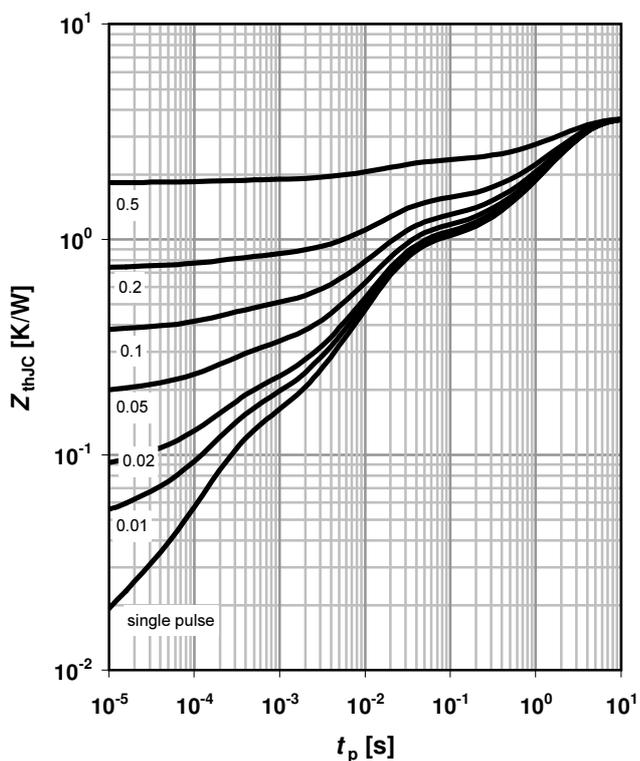
parameter:  $t_p$



### 3 Max. transient thermal impedance

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

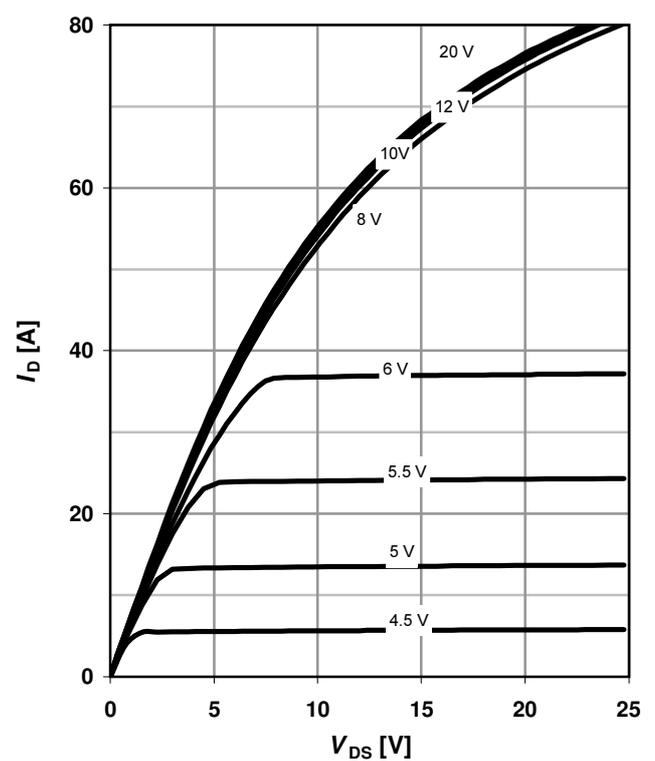
parameter:  $D = t_p / T$



### 4 Typ. output characteristics

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

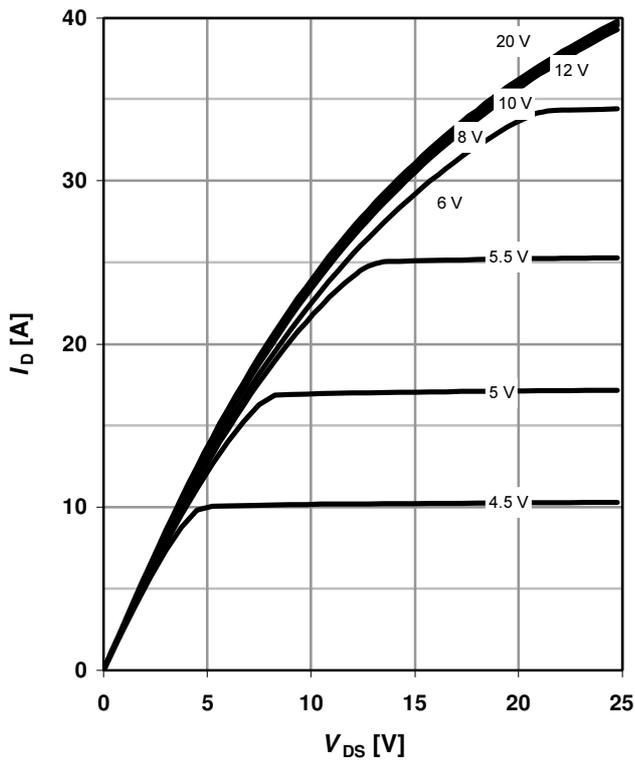
parameter:  $V_{GS}$



**5 Typ. output characteristics**

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

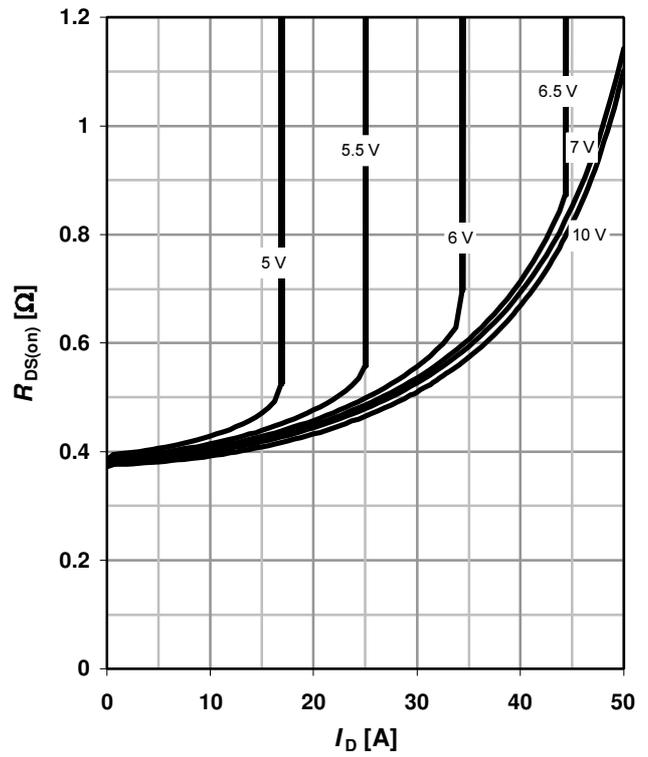
parameter:  $V_{GS}$



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

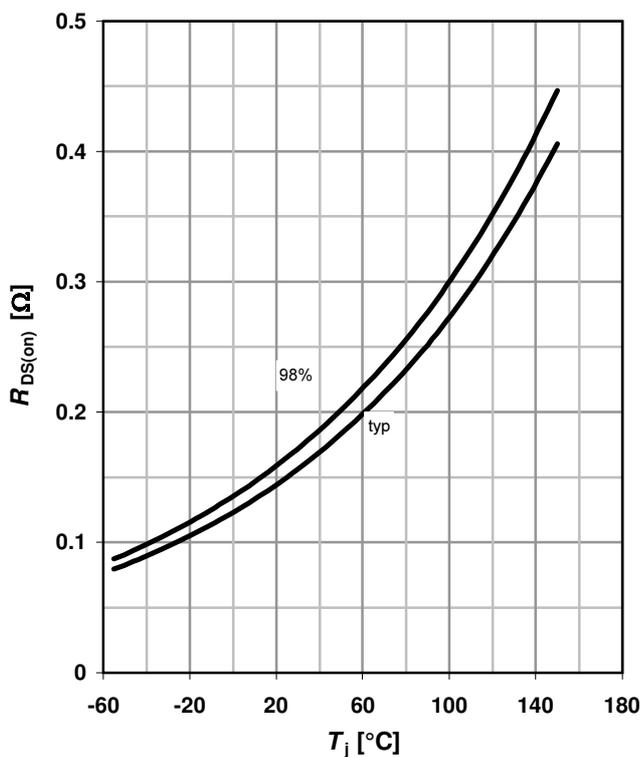
$R_{DS(on)} = f(I_D); T_j = 150\text{ }^\circ\text{C}$

parameter:  $V_{GS}$



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

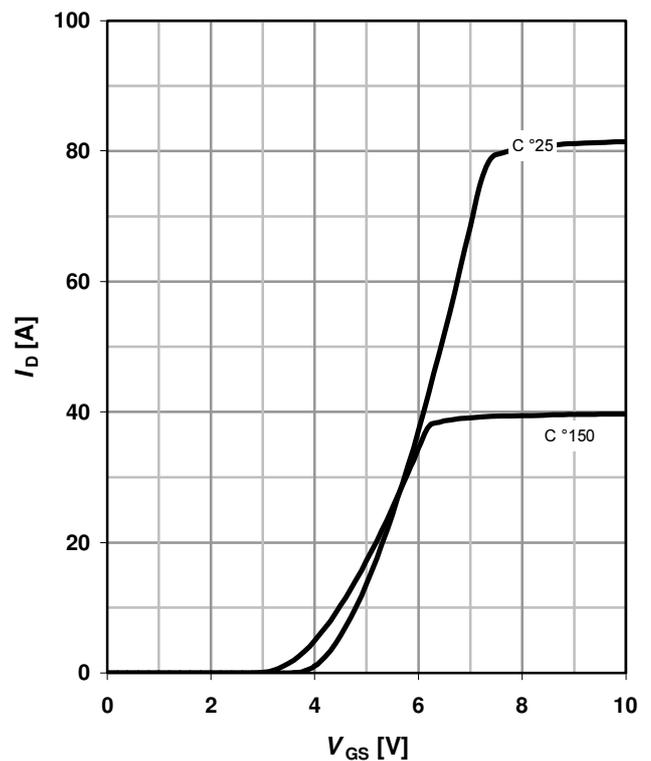
$R_{DS(on)} = f(T_j); I_D = 12\text{ A}; V_{GS} = 10\text{ V}$



**8 Typ. transfer characteristics**

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

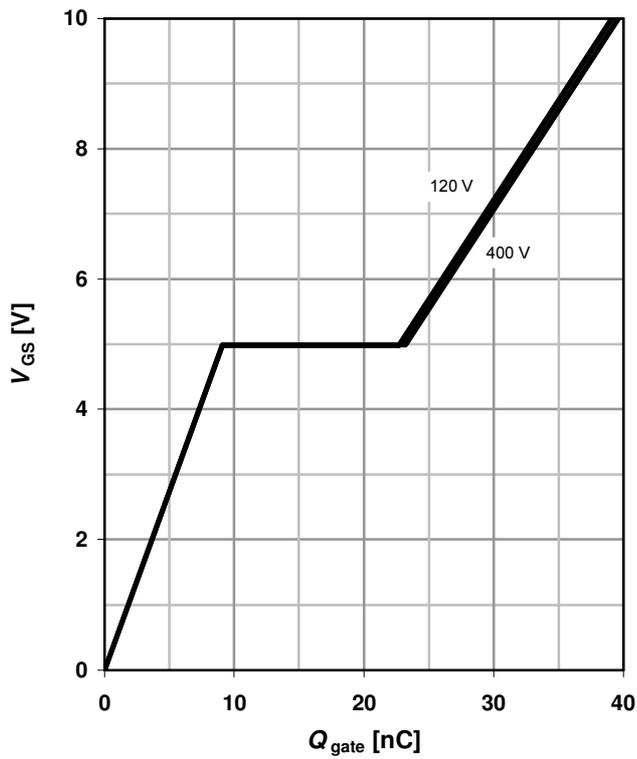
parameter:  $T_j$



**9 Typ. gate charge**

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

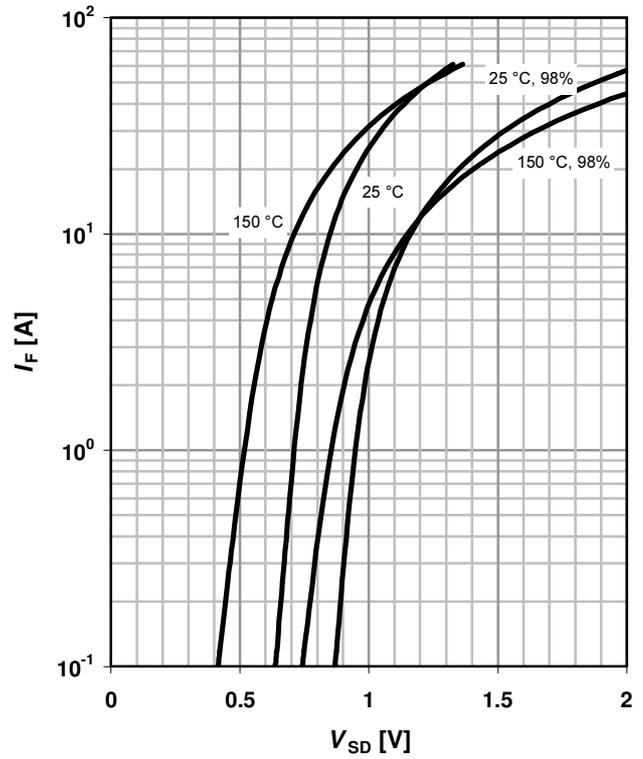
parameter:  $V_{DD}$



**10 Forward characteristics of reverse diode**

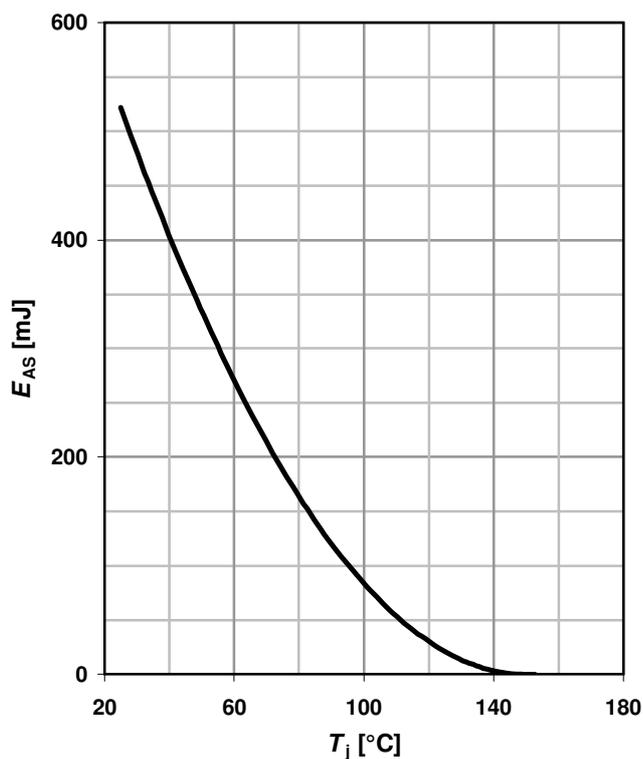
$I_F=f(V_{SD})$

parameter:  $T_j$



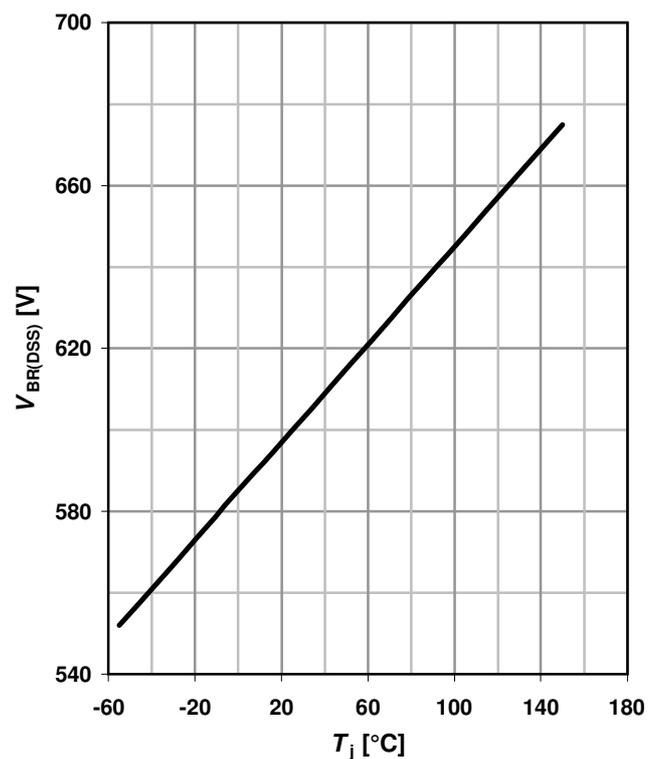
**11 Avalanche energy**

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



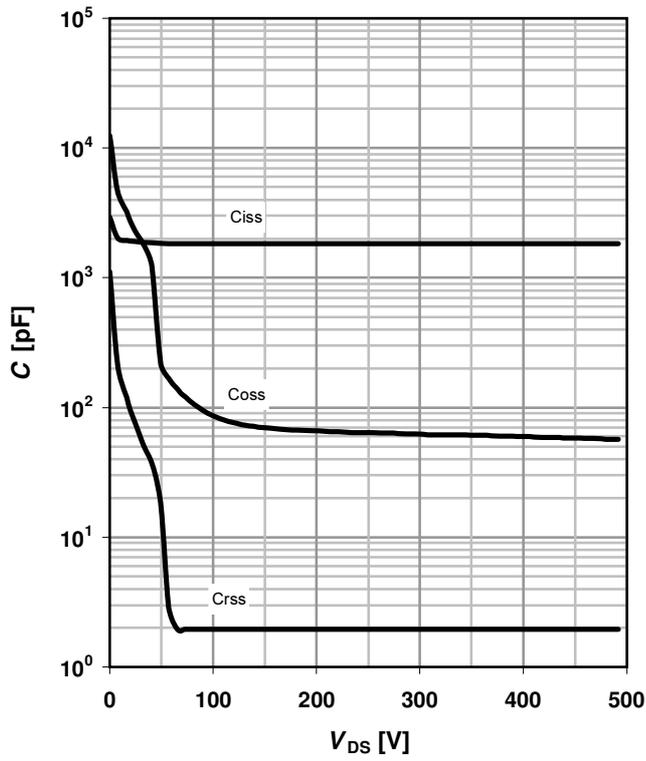
**12 Drain-source breakdown voltage**

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



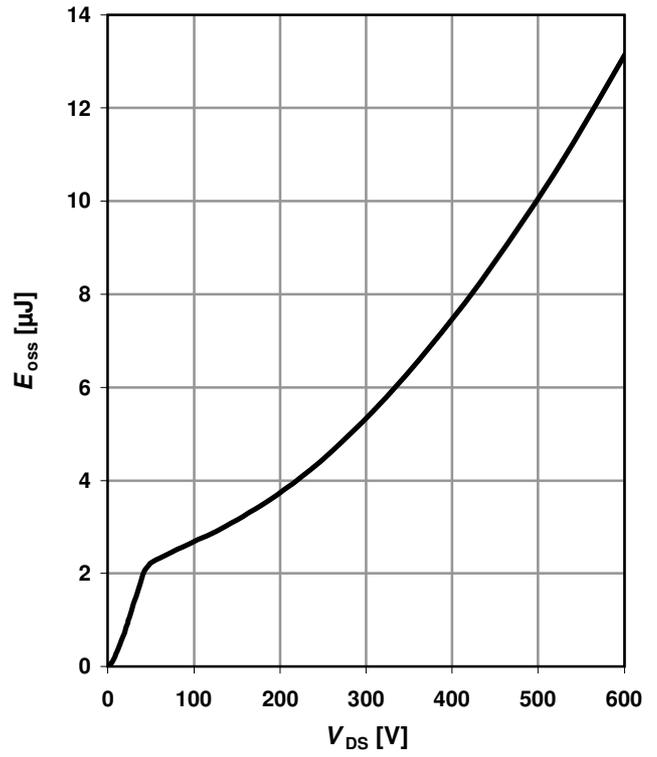
13 Typ. capacitances

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

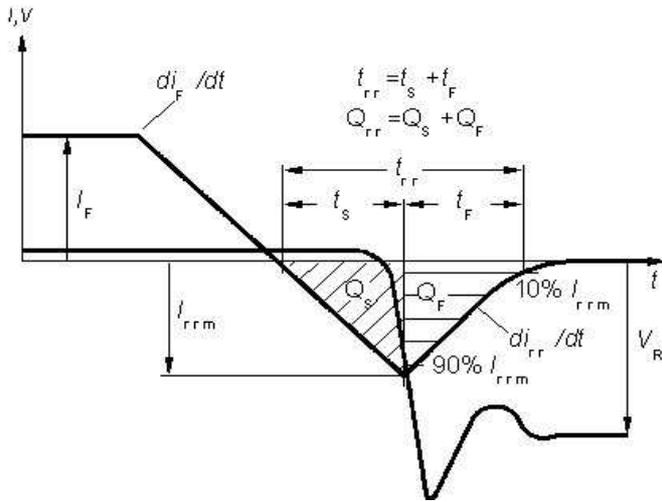


14 Typ. Coss stored energy

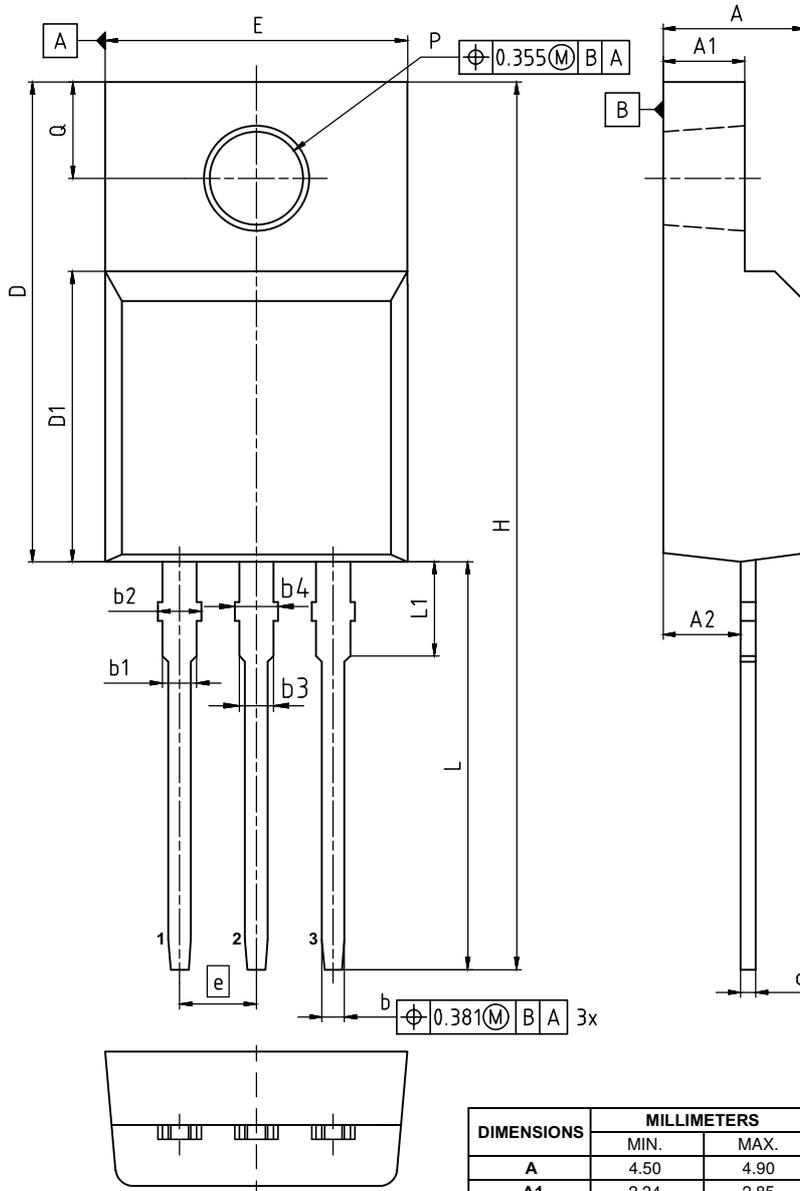
$E_{oss}=f(V_{DS})$



Definition of diode switching characteristics



# Package Outlines



NOTES:  
 ALL DIMENSIONS REFER TO JEDEC STANDARD TO-281  
 AND DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS  
 OR GATE BURRS  
 GATE BURRS ARE LESS THAN 0.5 mm

| DIMENSIONS | MILLIMETERS |       |
|------------|-------------|-------|
|            | MIN.        | MAX.  |
| A          | 4.50        | 4.90  |
| A1         | 2.34        | 2.85  |
| A2         | 2.42        | 2.86  |
| b          | 0.65        | 0.90  |
| b1         | 0.95        | 1.38  |
| b2         | 0.95        | 1.51  |
| b3         | 0.65        | 1.38  |
| b4         | 0.65        | 1.51  |
| c          | 0.40        | 0.63  |
| D          | 15.67       | 16.15 |
| D1         | 8.97        | 9.83  |
| E          | 10.00       | 10.65 |
| e          | 2.54        |       |
| H          | 28.70       | 29.75 |
| L          | 12.78       | 13.75 |
| L1         | 2.83        | 3.45  |
| øP         | 3.00        | 3.30  |
| Q          | 3.15        | 3.50  |

|                             |
|-----------------------------|
| DOCUMENT NO.<br>Z8B00003319 |
| REVISION<br>07              |
| SCALE 5:1<br>0 1 2 3 4 5mm  |
| EUROPEAN PROJECTION<br>     |
| ISSUE DATE<br>27.01.2017    |

Figure 1 Outline PG-TO 220 FullPAK, dimensions in mm/inches

# 600V CoolMOS™ CP Power Transistor

## IPA60R165CP

### Revision History

IPA60R165CP

**Revision: 2018-01-25, Rev. 2.3**

Previous Revision

| Revision | Date       | Subjects (major changes since last revision)                              |
|----------|------------|---|
| 2.3      | 2018-01-25 | Updated Isolation voltage on page 1 and revised package drawing on page 9 |

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- Техническая поддержка проекта;
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