

## MOSFET

Metal Oxide Semiconductor Field Effect Transistor

### CoolMOS™ E6 600V

600V CoolMOS™ E6 Power Transistor  
IPx60R280E6

## Data Sheet

Rev. 2.3  
Final

## 600V CoolMOS™ E6 Power Transistor

IPP60R280E6, IPA60R280E6  
IPW60R280E6

### 1 Description

CoolMOS™ is a revolutionary technology for high voltage power MOSFETs, designed according to the superjunction (SJ) principle and pioneered by Infineon Technologies. CoolMOS™ E6 series combines the experience of the leading SJ MOSFET supplier with high class innovation. The offered devices provide all benefits of a fast switching SJ MOSFET while not sacrificing ease of use. Extremely low switching and conduction losses make switching applications even more efficient, more compact, lighter, and cooler.

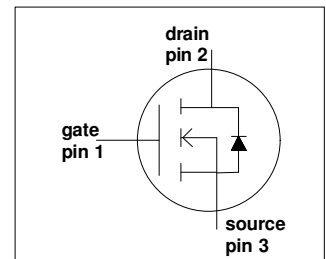
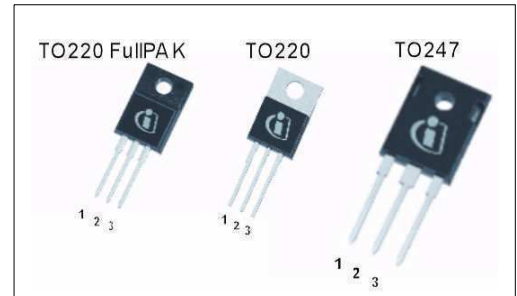
#### Features

- Extremely low losses due to very low FOM  $R_{DS(on)} \cdot Q_g$  and  $E_{oss}$
- Very high commutation ruggedness
- Easy to use/drive
- JEDEC<sup>1)</sup> qualified, Pb-free plating, Halogen free

#### Applications

PFC stages, hard switching PWM stages and resonant switching PWM stages for e.g. PC Silverbox, Adapter, LCD & PDP TV, Lighting, Server, Telecom and UPS.

*Please note: For MOSFET paralleling the use of ferrite beads on the gate or separate totem poles is generally recommended.*



**Table 1 Key Performance Parameters**

| Parameter            | Value | Unit       |
|----------------------|-------|------------|
| $V_{DS} @ T_{j,max}$ | 650   | V          |
| $R_{DS(on),max}$     | 0.28  | $\Omega$   |
| $Q_{g,typ}$          | 43    | nC         |
| $I_{D,pulse}$        | 40    | A          |
| $E_{oss} @ 400V$     | 3.7   | $\mu J$    |
| Body diode $di/dt$   | 500   | A/ $\mu s$ |

| Type / Ordering Code | Package          | Marking | Related Links   |
|----------------------|------------------|---------|---|
| IPW60R280E6          | PG-TO247         | 6R280E6 | <a href="#">IFX CoolMOS Webpage</a><br><a href="#">IFX Design tools</a> |
| IPP60R280E6          | PG-TO220         |         |   |
| IPA60R280E6          | PG-TO220 FullPAK |         |   |

1) J-STD20 and JESD22

## Table of Contents

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## 2 Maximum ratings

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

**Table 2 Maximum ratings**

| Parameter  | Symbol              | Values |      |      | Unit | Note / Test Condition   |
|--|---------------------|--------|------|------|------|---|
|  |                     | Min.   | Typ. | Max. |      |   |
| Continuous drain current <sup>1)</sup>               | $I_D$               | -      | -    | 13.8 | A    | $T_C = 25\text{ °C}$  |
|  |                     |        |      | 8.7  |      | $T_C = 100\text{ °C}$   |
| Pulsed drain current <sup>2)</sup>                   | $I_{D,pulse}$       | -      | -    | 40   | A    | $T_C = 25\text{ °C}$  |
| Avalanche energy, single pulse                       | $E_{AS}$            | -      | -    | 284  | mJ   | $I_D = 2.4\text{ A}, V_{DD} = 50\text{ V}$<br>(see table 21)              |
| Avalanche energy, repetitive                         | $E_{AR}$            | -      | -    | 0.43 |      | $I_D = 2.4\text{ A}, V_{DD} = 50\text{ V}$                                |
| Avalanche current, repetitive                        | $I_{AR}$            | -      | -    | 2.4  | A    |   |
| MOSFET dv/dt ruggedness                              | dv/dt               | -      | -    | 50   | V/ns | $V_{DS} = 0 \dots 480\text{ V}$   |
| Gate source voltage                                  | $V_{GS}$            | -20    | -    | 20   | V    | static  |
|  |                     | -30    |      | 30   |      | AC ( $f > 1\text{ Hz}$ )  |
| Power dissipation for TO-220, TO-247, TO-262, TO-263 | $P_{tot}$           | -      | -    | 104  | W    | $T_C = 25\text{ °C}$  |
| Power dissipation for TO-220 FullPAK                 | $P_{tot}$           | -      | -    | 32   |      |   |
| Operating and storage temperature                    | $T_j, T_{stg}$      | -55    | -    | 150  | °C   |   |
| Mounting torque TO-220, TO-247                       |                     | -      | -    | 60   | Ncm  | M3 and M3.5 screws  |
| Mounting torque TO-220 FullPAK                       |                     |        |      | 50   |      | M2.5 screws   |
| Continuous diode forward current                     | $I_S$               | -      | -    | 12   | A    | $T_C = 25\text{ °C}$  |
| Diode pulse current <sup>2)</sup>                    | $I_{S,pulse}$       | -      | -    | 40   | A    | $T_C = 25\text{ °C}$  |
| Reverse diode dv/dt <sup>3)</sup>                    | dv/dt               | -      | -    | 15   | V/ns | $V_{DS} = 0 \dots 400\text{ V}, I_{SD} \leq I_D,$<br>$T_j = 25\text{ °C}$ |
| Maximum diode commutation speed <sup>3)</sup>        | di <sub>r</sub> /dt |        |      | 500  | A/μs | (see table 22)  |

1) Limited by  $T_{j,max}$ . Maximum duty cycle  $D = 0.75$

2) Pulse width  $t_p$  limited by  $T_{j,max}$

3) Identical low side and high side switch with identical  $R_G$

### 3 Thermal characteristics

**Table 3 Thermal characteristics TO-220 (IPP60R280E6), TO-247 (IPW60R280E6)**

| Parameter  | Symbol     | Values |      |      | Unit | Note / Test Condition                 |
|--|------------|--------|------|------|------|---------------------------------------|
|  |            | Min.   | Typ. | Max. |      |                                       |
| Thermal resistance, junction - case                        | $R_{thJC}$ | -      | -    | 1.2  | °C/W | leaded                                |
| Thermal resistance, junction - ambient                     | $R_{thJA}$ | -      | -    | 62   |      |                                       |
| Soldering temperature, wavesoldering only allowed at leads | $T_{sold}$ | -      | -    | 260  | °C   | 1.6 mm (0.063 in.) from case for 10 s |

**Table 4 Thermal characteristics TO-220FullPAK (IPA60R280E6)**

| Parameter  | Symbol     | Values |      |      | Unit | Note / Test Condition                 |
|--|------------|--------|------|------|------|---------------------------------------|
|  |            | Min.   | Typ. | Max. |      |                                       |
| Thermal resistance, junction - case                        | $R_{thJC}$ | -      | -    | 3.9  | °C/W | leaded                                |
| Thermal resistance, junction - ambient                     | $R_{thJA}$ | -      | -    | 80   |      |                                       |
| Soldering temperature, wavesoldering only allowed at leads | $T_{sold}$ | -      | -    | 260  | °C   | 1.6 mm (0.063 in.) from case for 10 s |

## 4 Electrical characteristics

Electrical characteristics, at  $T_J=25\text{ °C}$ , unless otherwise specified.

**Table 5 Static characteristics**

| Parameter                        | Symbol        | Values |      |      | Unit          | Note / Test Condition  |
|----------------------------------|---------------|--------|------|------|---------------|--|
|                                  |               | Min.   | Typ. | Max. |               |  |
| Drain-source breakdown voltage   | $V_{(BR)DSS}$ | 600    | -    | -    | V             | $V_{GS}=0\text{ V}$ , $I_D=0.25\text{ mA}$                           |
| Gate threshold voltage           | $V_{GS(th)}$  | 2.5    | 3    | 3.5  |               | $V_{DS}=V_{GS}$ , $I_D=0.43\text{ mA}$                               |
| Zero gate voltage drain current  | $I_{DSS}$     | -      | -    | 1    | $\mu\text{A}$ | $V_{DS}=600\text{ V}$ , $V_{GS}=0\text{ V}$ ,<br>$T_J=25\text{ °C}$  |
|                                  |               | -      | 10   | -    |               | $V_{DS}=600\text{ V}$ , $V_{GS}=0\text{ V}$ ,<br>$T_J=150\text{ °C}$ |
| Gate-source leakage current      | $I_{GSS}$     | -      | -    | 100  | nA            | $V_{GS}=20\text{ V}$ , $V_{DS}=0\text{ V}$                           |
| Drain-source on-state resistance | $R_{DS(on)}$  | -      | 0.25 | 0.28 | $\Omega$      | $V_{GS}=10\text{ V}$ , $I_D=6.5\text{ A}$ ,<br>$T_J=25\text{ °C}$    |
|                                  |               | -      | 0.66 | -    |               | $V_{GS}=10\text{ V}$ , $I_D=6.5\text{ A}$ ,<br>$T_J=150\text{ °C}$   |
| Gate resistance                  | $R_G$         | -      | 7    | -    | $\Omega$      | $f=1\text{ MHz}$ , open drain  |

**Table 6 Dynamic characteristics**

| Parameter  | Symbol       | Values |      |      | Unit | Note / Test Condition   |
|--|--------------|--------|------|------|------|---|
|  |              | Min.   | Typ. | Max. |      |   |
| Input capacitance  | $C_{iss}$    | -      | 950  | -    | pF   | $V_{GS}=0\text{ V}$ , $V_{DS}=100\text{ V}$ ,<br>$f=1\text{ MHz}$   |
| Output capacitance   | $C_{oss}$    | -      | 60   | -    |      |   |
| Effective output capacitance, energy related <sup>1)</sup> | $C_{o(er)}$  | -      | 40   | -    |      |   |
| Effective output capacitance, time related <sup>2)</sup>   | $C_{o(tr)}$  | -      | 183  | -    |      | $I_D=\text{constant}$ , $V_{GS}=0\text{ V}$<br>$V_{DS}=0\dots480\text{ V}$  |
| Turn-on delay time   | $t_{d(on)}$  | -      | 11   | -    | ns   | $V_{DD}=400\text{ V}$ ,<br>$V_{GS}=13\text{ V}$ , $I_D=6.5\text{ A}$ ,<br>$R_G=3.4\text{ }\Omega$<br>(see table 20) |
| Rise time  | $t_r$        | -      | 9    | -    |      |   |
| Turn-off delay time  | $t_{d(off)}$ | -      | 71   | -    |      |   |
| Fall time  | $t_f$        | -      | 9    | -    |      |   |

1)  $C_{o(er)}$  is a fixed capacitance that gives the same stored energy as  $C_{oss}$  while  $V_{DS}$  is rising from 0 to 80%  $V_{(BR)DSS}$

2)  $C_{o(tr)}$  is a fixed capacitance that gives the same charging time as  $C_{oss}$  while  $V_{DS}$  is rising from 0 to 80%  $V_{(BR)DSS}$

**Table 7 Gate charge characteristics**

| Parameter             | Symbol               | Values |      |      | Unit | Note /<br>Test Condition   |
|-----------------------|----------------------|--------|------|------|------|--|
|                       |                      | Min.   | Typ. | Max. |      |  |
| Gate to source charge | $Q_{gs}$             | -      | 5    | -    | nC   | $V_{DD}=480\text{ V}$ , $I_D=6.5\text{ A}$ ,<br>$V_{GS}=0\text{ to }10\text{ V}$ |
| Gate to drain charge  | $Q_{gd}$             | -      | 22   | -    |      |  |
| Gate charge total     | $Q_g$                | -      | 43   | -    |      |  |
| Gate plateau voltage  | $V_{\text{plateau}}$ | -      | 5.4  | -    | V    |  |

**Table 8 Reverse diode characteristics**

| Parameter                     | Symbol    | Values |      |      | Unit          | Note /<br>Test Condition  |
|-------------------------------|-----------|--------|------|------|---------------|---|
|                               |           | Min.   | Typ. | Max. |               |   |
| Diode forward voltage         | $V_{SD}$  | -      | 0.9  | -    | V             | $V_{GS}=0\text{ V}$ , $I_F=6.5\text{ A}$ ,<br>$T_j=25\text{ °C}$                                  |
| Reverse recovery time         | $t_{rr}$  | -      | 345  | -    | ns            | $V_R=400\text{ V}$ , $I_F=6.5\text{ A}$ ,<br>$di_F/dt=100\text{ A}/\mu\text{s}$<br>(see table 22) |
| Reverse recovery charge       | $Q_{rr}$  | -      | 4.5  | -    | $\mu\text{C}$ |   |
| Peak reverse recovery current | $I_{rrm}$ | -      | 24   | -    | A             |   |

5 Electrical characteristics diagrams

Table 9

|  |  |
|--|--|
| <p><b>Power dissipation</b><br/>TO-220, TO-247, TO-262, TO-263</p> | <p><b>Power dissipation</b><br/>TO-220 FullPAK</p> |
|  |  |
| <p><math>P_{tot} = f(T_C)</math></p>                               | <p><math>P_{tot} = f(T_C)</math></p>               |

Table 10

|   |  |
|---|--|
| <p><b>Max. transient thermal impedance</b><br/>TO-220, TO-247, TO-262, TO-263</p> | <p><b>Max. transient thermal impedance</b><br/>TO-220 FullPAK</p>            |
|   |  |
| <p><math>Z_{(thJC)} = f(t_p)</math>; parameter: <math>D = t_p / T</math></p>      | <p><math>Z_{(thJC)} = f(t_p)</math>; parameter: <math>D = t_p / T</math></p> |



Table 11

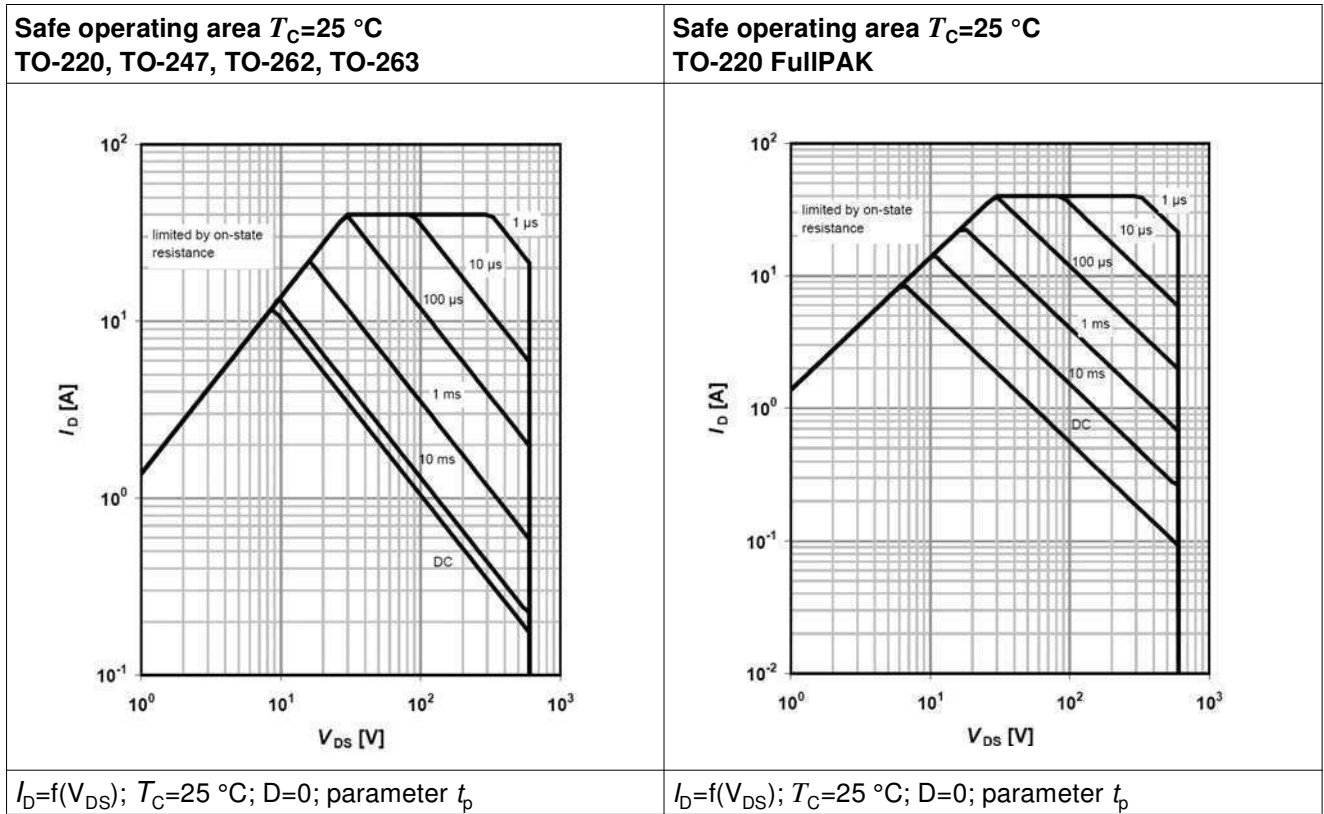


Table 12

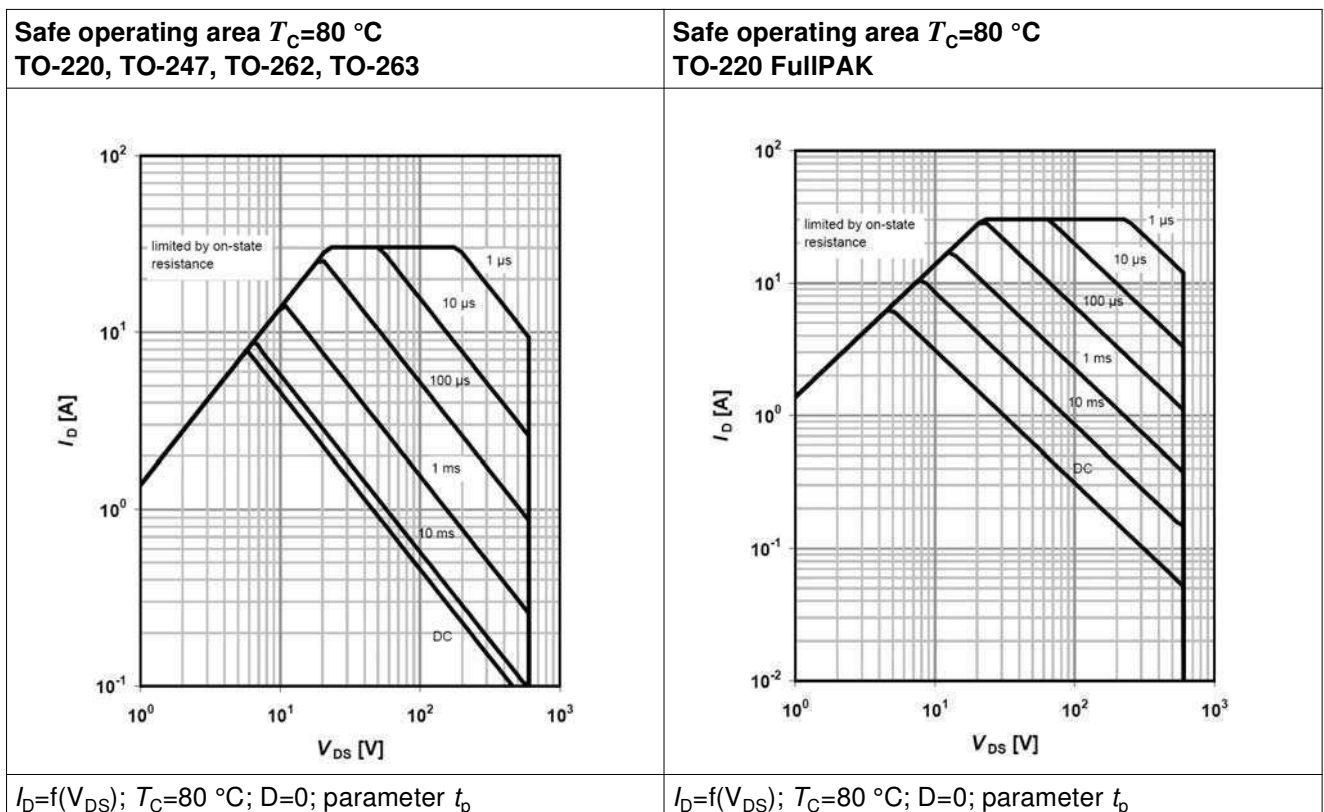


Table 13

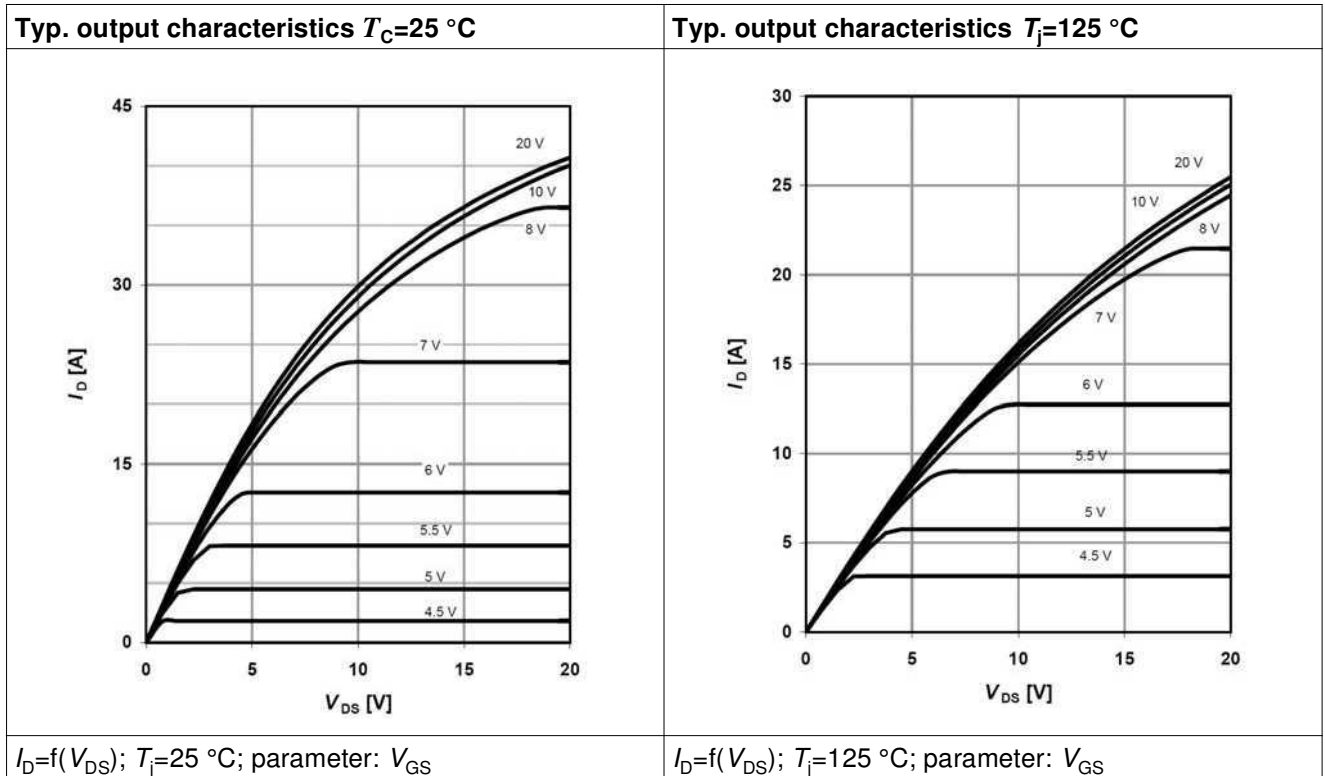


Table 14

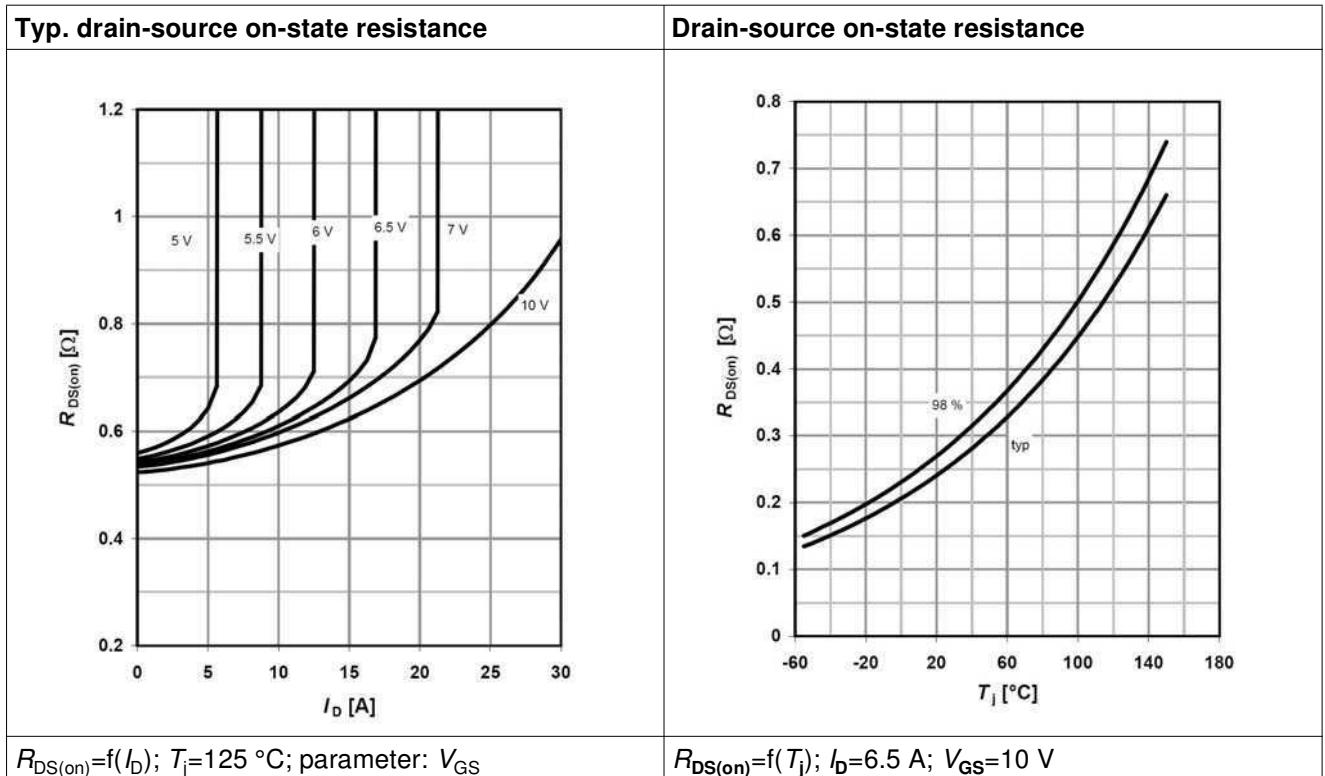


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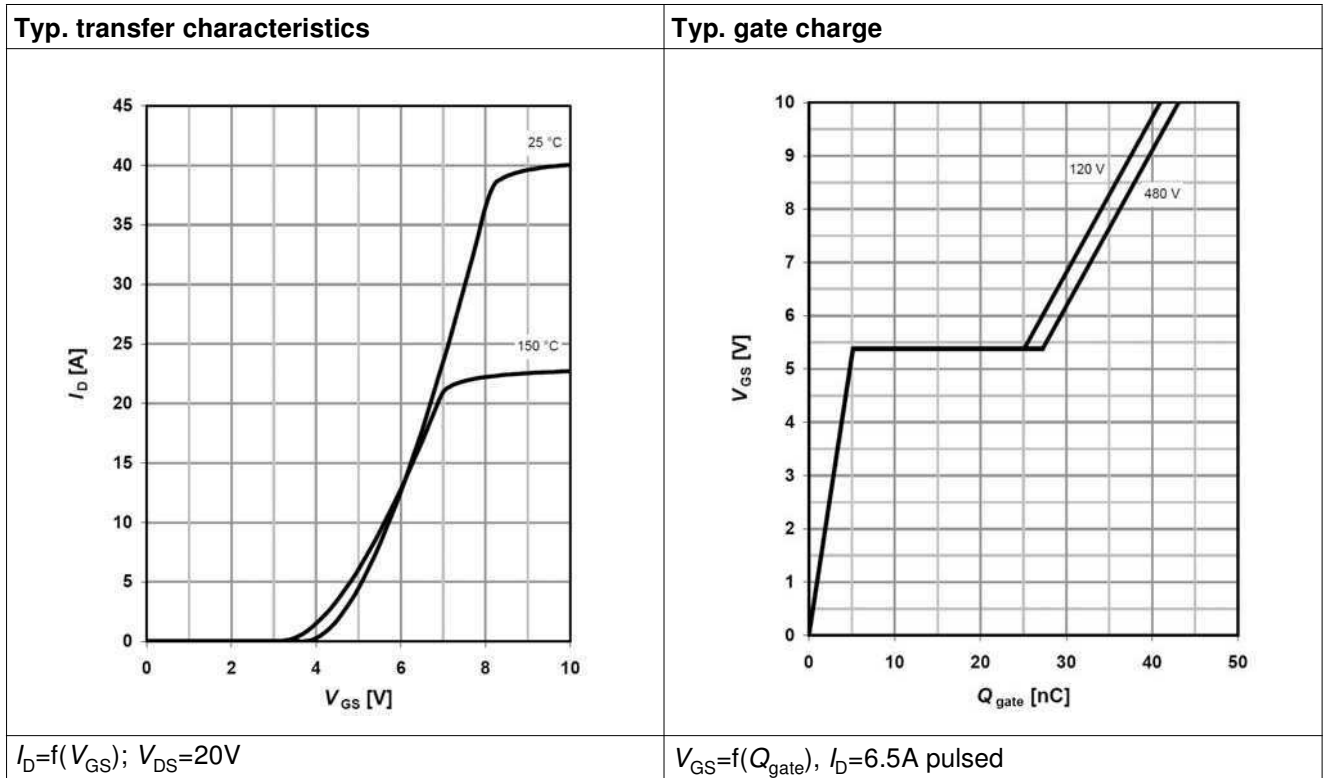


Table 16

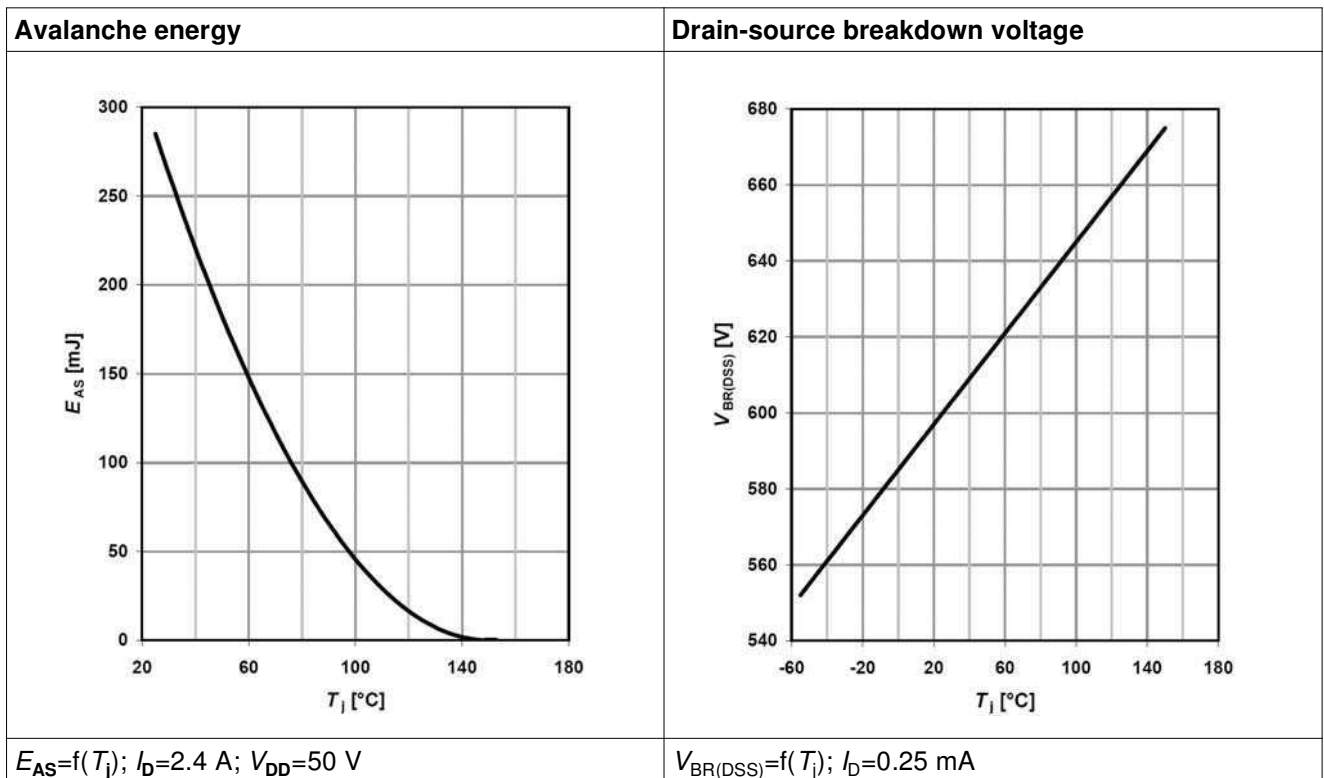


Table 17

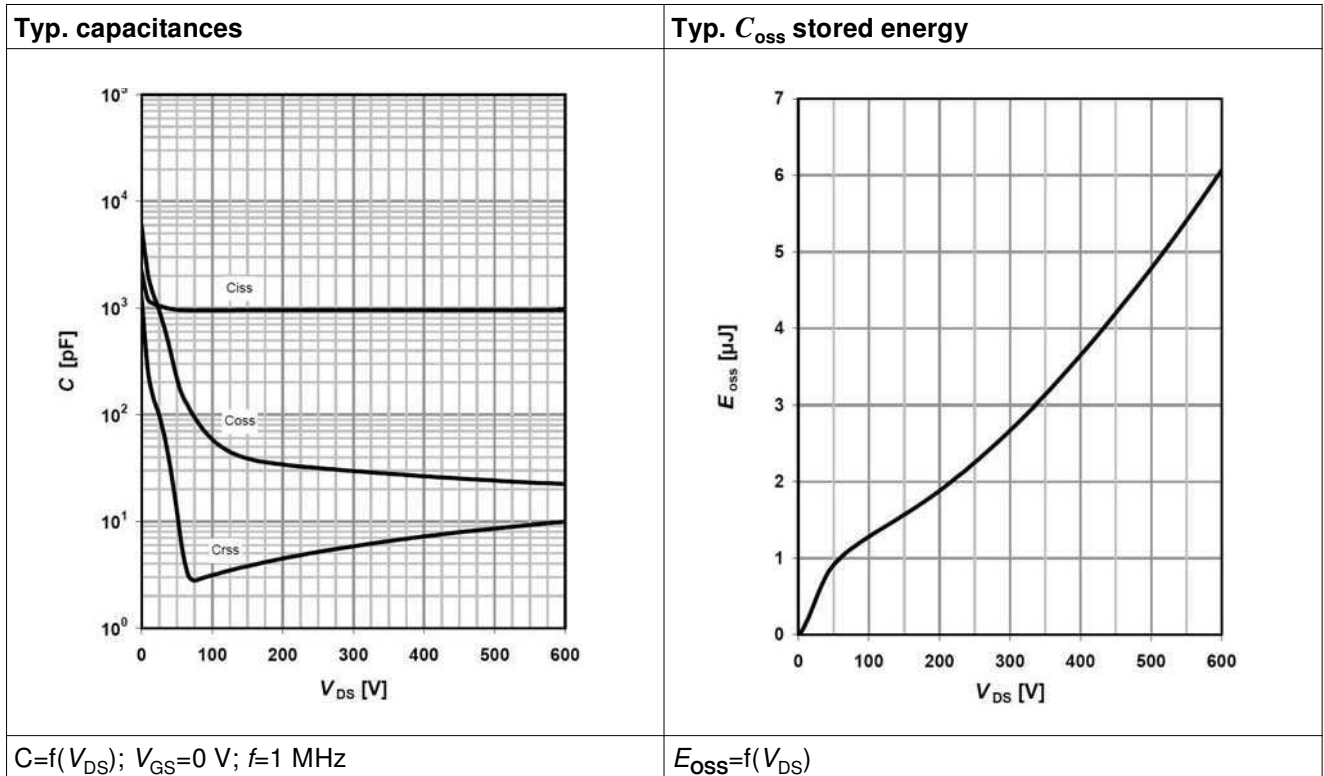
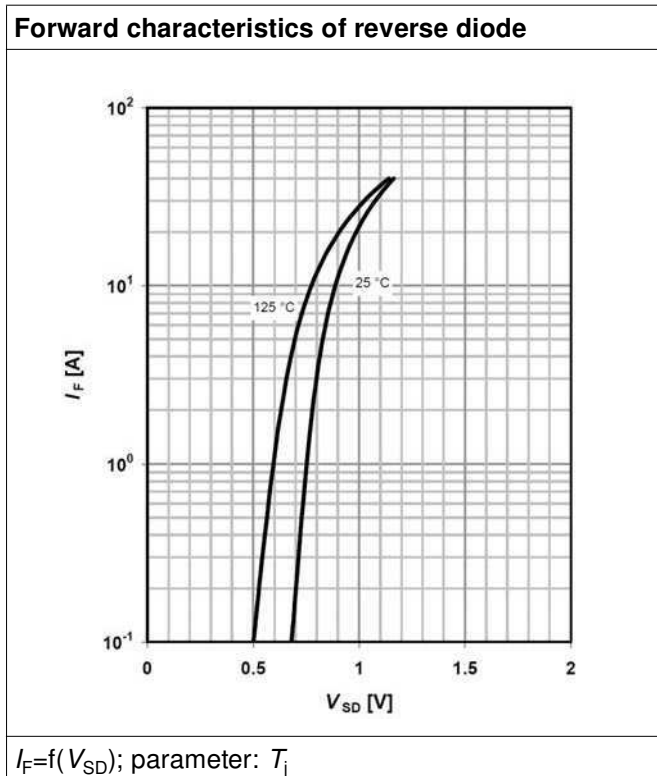


Table 18



## 6 Test circuits

**Table 19** Switching times test circuit and waveform for inductive load

| Switching times test circuit for inductive load | Switching time waveform |
|---|-------------------------|
|   |                         |

**Table 20** Unclamped inductive load test circuit and waveform

| Unclamped inductive load test circuit | Unclamped inductive waveform |
|---------------------------------------|------------------------------|
|                                       |                              |

**Table 21** Test circuit and waveform for diode characteristics

| Test circuit for diode characteristics | Diode recovery waveform |
|--|-------------------------|
|  |                         |

7 Package outlines

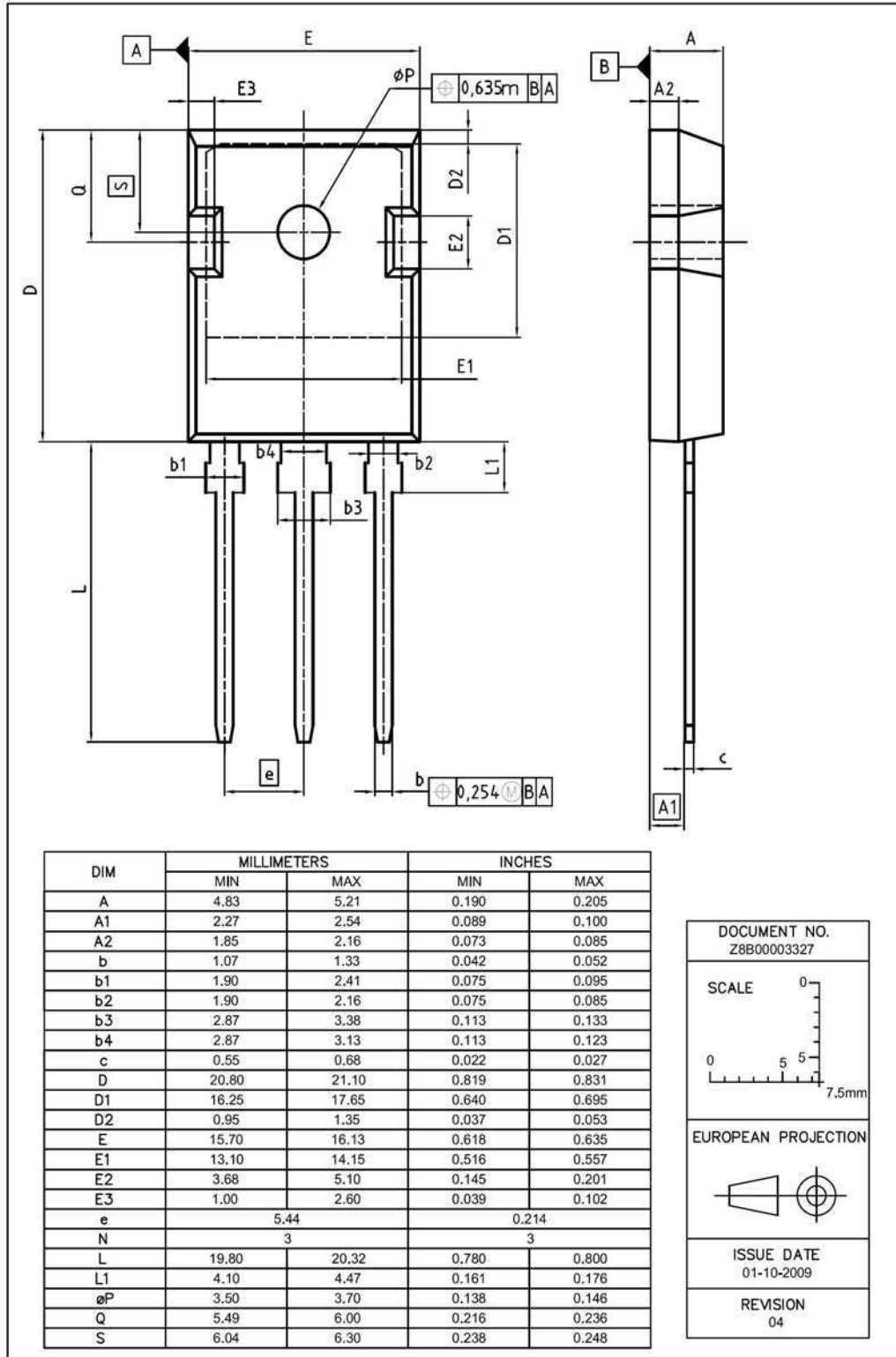
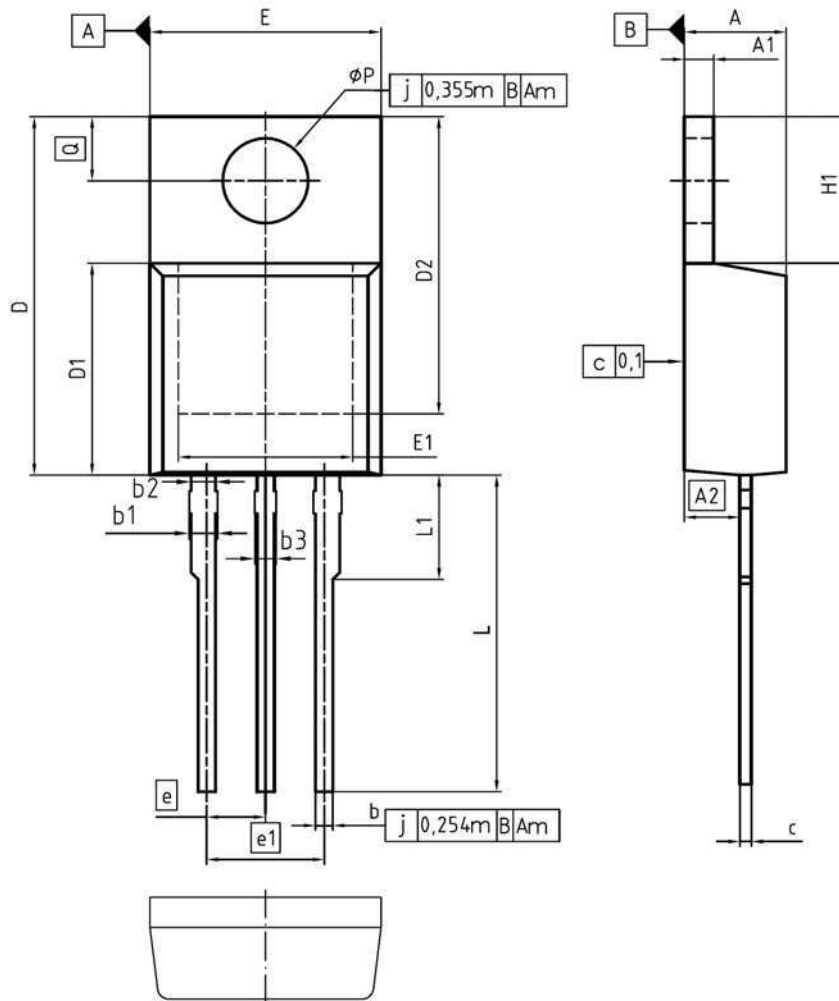


Figure 1 Outlines TO-247, dimensions in mm/inches





| 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 |

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Figure 2 Outlines TO-220, dimensions in mm/inches

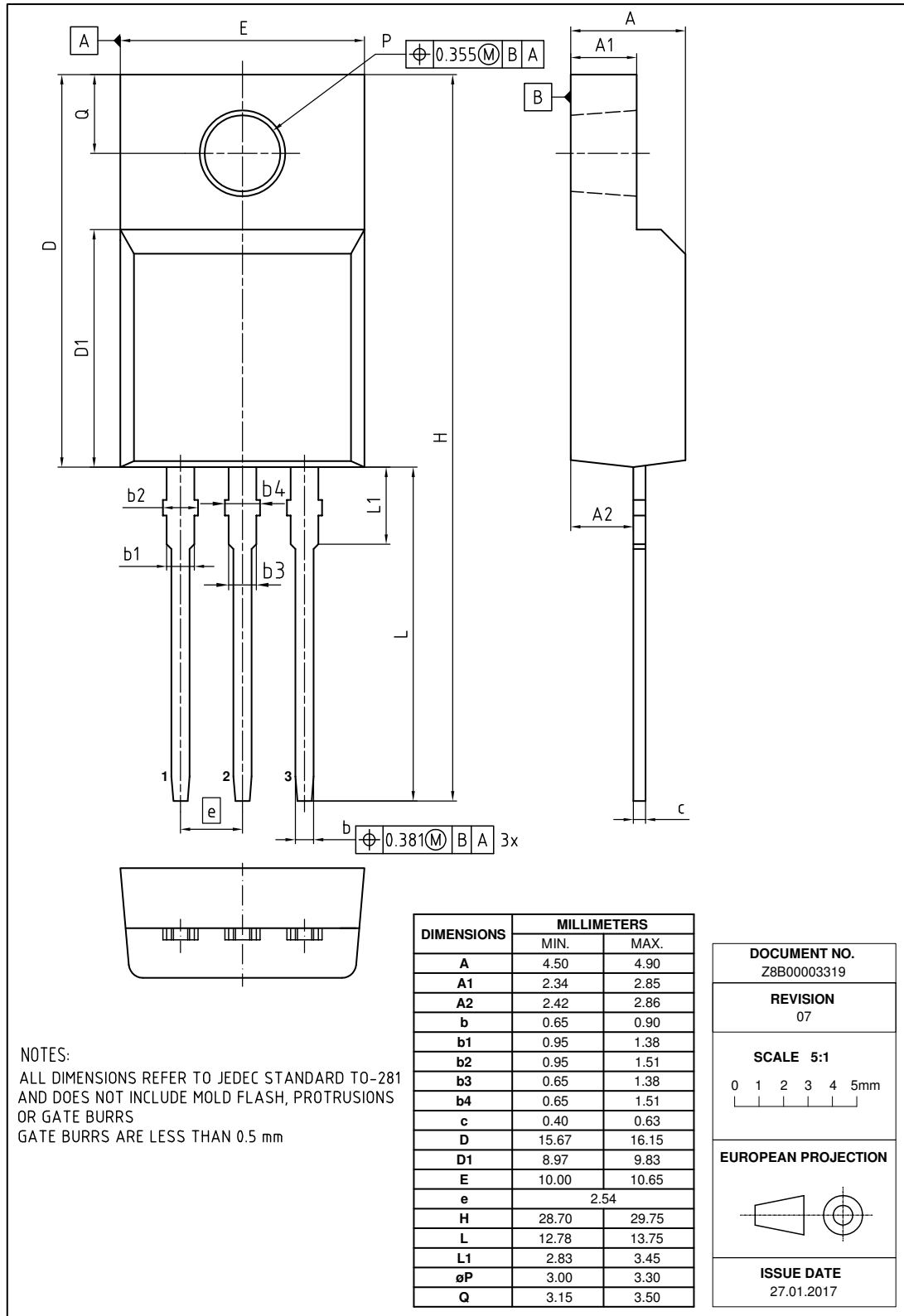


Figure 3 Outline PG-TO 220 FullPAK, dimensions in mm



## Revision History

IPx60R280E6

**Revision: 2018-03-04, Rev. 2.3**

Previous Revision

| Revision | Date       | Subjects (major changes since last revision)                  |
|----------|------------|---|
| 2.0      | 2011-06-08 | Release final data sheet                                      |
| 2.1      | 2011-09-14 | -   |
| 2.2      | 2015-02-09 | PG-TO220 FullPAK package outline update (creation:2014-12-09) |
| 2.3      | 2018-03-04 | Outline PG-TO-220 FullPAK update                              |

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