

# MOSFET

Metal Oxide Semiconductor Field Effect Transistor

## CoolMOS™ CFD2 650V

650V CoolMOS™ CFD2 Power Transistor  
IPx65R420CFD

## Data Sheet

Rev. 2.6  
Final

### 1 Description

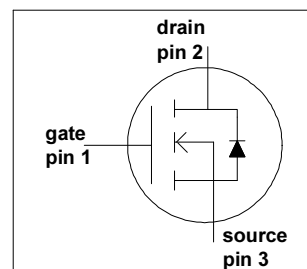
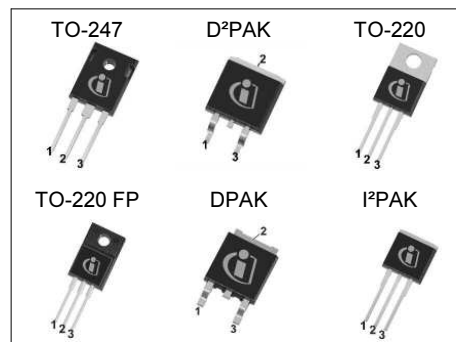
CoolMOS™ is a revolutionary technology for high voltage power MOSFETs, designed according to the superjunction (SJ) principle and pioneered by Infineon Technologies. 650V CoolMOS™ CFD2 series combines the experience of the leading SJ MOSFET supplier with high class innovation. The resulting devices provide all benefits of a fast switching SJ MOSFET while offering an extremely fast and robust body diode. This combination of extremely low switching, commutation and conduction losses together with highest robustness make especially resonant switching applications more reliable, more efficient, lighter and cooler.

### Features

- Ultra-fast body diode
- Very high commutation ruggedness
- Extremely low losses due to very low FOM  $R_{ds(on)} \cdot Q_g$  and  $E_{oss}$
- Easy to use/drive
- Qualified for industrial grade applications according to JEDEC (J-STD20 and JESD22)
- Pb-free plating, Halogen free mold compound

### Applications

650V CoolMOS™ CFD2 is especially suitable for resonant switching PWM stages for e.g. PC Silverbox, LCD TV, Lighting, Server and Telecom



**Table 1 Key Performance Parameters**

| Parameter             | Value | Unit       |
|-----------------------|-------|------------|
| $V_{DS} @ T_{j \max}$ | 700   | V          |
| $R_{DS(on), \max}$    | 0.42  | $\Omega$   |
| $Q_g, \text{typ}$     | 31.5  | nC         |
| $I_D, \text{pulse}$   | 27    | A          |
| $E_{oss} @ 400V$      | 2.8   | $\mu J$    |
| Body diode $di/dt$    | 900   | A/ $\mu s$ |
| $Q_{rr}$              | 0.3   | $\mu C$    |
| $t_{rr}$              | 90    | ns         |
| $I_{rrm}$             | 6.2   | A          |

| Type / Ordering Code | Package           | Marking | Related Links  |
|----------------------|-------------------|---------|----------------|
| IPW65R420CFD         | PG-TO 247         | 65F6420 | see Appendix A |
| IPB65R420CFD         | PG-TO 263         |         |                |
| IPP65R420CFD         | PG-TO 220         |         |                |
| IPA65R420CFD         | PG-TO 220 FullPAK |         |                |
| IPD65R420CFD         | PG-TO 252         |         |                |
| IPI65R420CFD         | PG-TO 262         |         |                |

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## 2 Maximum ratings

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

**Table 2 Maximum ratings**

| Parameter                                                             | Symbol              | Values |      |      | Unit             | Note / Test Condition                                                                              |
|-----------------------------------------------------------------------|---------------------|--------|------|------|------------------|----------------------------------------------------------------------------------------------------|
|                                                                       |                     | Min.   | Typ. | Max. |                  |                                                                                                    |
| Continuous drain current <sup>1)</sup>                                | $I_D$               |        |      | 8.7  | A                | $T_C = 25^\circ\text{C}$                                                                           |
|                                                                       |                     |        |      | 5.5  |                  | $T_C = 100^\circ\text{C}$                                                                          |
| Pulsed drain current <sup>2)</sup>                                    | $I_{D,pulse}$       |        |      | 27   | A                | $T_C = 25^\circ\text{C}$                                                                           |
| Avalanche energy, single pulse                                        | $E_{AS}$            |        |      | 227  | mJ               | $I_D = 1.8\text{A}$ , $V_{DD} = 50\text{V}$<br>(see table 22)                                      |
| Avalanche energy, repetitive                                          | $E_{AR}$            |        |      | 0.34 | mJ               | $I_D = 1.8\text{A}$ , $V_{DD} = 50\text{V}$                                                        |
| Avalanche current, repetitive                                         | $I_{AR}$            |        |      | 1.8  | A                |                                                                                                    |
| MOSFET dv/dt ruggedness                                               | dv/dt               |        |      | 50   | V/ns             | $V_{DS} = 0 \dots 400\text{V}$                                                                     |
| Gate source voltage                                                   | $V_{GS}$            | -20    |      | 20   | V                | static                                                                                             |
|                                                                       |                     | -30    |      | 30   |                  | AC ( $f > 1\text{Hz}$ )                                                                            |
| Power dissipation (non FullPAK)<br>TO-247, TO-220, I <sup>2</sup> PAK | $P_{tot}$           |        |      | 83.3 | W                | $T_C = 25^\circ\text{C}$                                                                           |
| Power dissipation (FullPAK)<br>TO-220 FP                              | $P_{tot}$           |        |      | 31.2 | W                | $T_C = 25^\circ\text{C}$                                                                           |
| Operating and storage temperature                                     | $T_j, T_{stg}$      | -55    |      | 150  | $^\circ\text{C}$ |                                                                                                    |
| Mounting torque (non FullPAK)<br>TO-247, TO-220, I <sup>2</sup> PAK   |                     |        |      | 60   | Ncm              | M3 and M3.5 screws                                                                                 |
| Mounting torque (FullPAK)<br>TO-220 FP                                |                     |        |      | 50   | Ncm              | M2.5 screws                                                                                        |
| Continuous diode forward current                                      | $I_S$               |        |      | 8.7  | A                | $T_C = 25^\circ\text{C}$                                                                           |
| Diode pulse current                                                   | $I_{S,pulse}$       |        |      | 27   | A                | $T_C = 25^\circ\text{C}$                                                                           |
| Reverse diode dv/dt <sup>3)</sup>                                     | dv/dt               |        |      | 50   | V/ns             | $V_{DS} = 0 \dots 400\text{V}$ , $I_{SD} \leq I_D$ ,<br>$T_j = 25^\circ\text{C}$<br>(see table 20) |
| Maximum diode commutation speed                                       | di <sub>r</sub> /dt |        |      | 900  | A/ $\mu\text{s}$ |                                                                                                    |
| Insulation withstand voltage<br>for TO-220FP                          | V <sub>ISO</sub>    |        |      | 2500 | V                | $V_{rms}$ , $T_C=25^\circ\text{C}$ , $t=1\text{min}$                                               |

<sup>1)</sup> Limited by  $T_{j\text{ max}}$ .

<sup>2)</sup> Pulse width  $t_p$  limited by  $T_{j\text{ max}}$

<sup>3)</sup>  $V_{peak} < V_{(BR)DSS}$ ,  $T_j < T_{j\text{ max}}$ , identical low side and high side switch with same R<sub>g</sub>

### 3 Thermal characteristics

**Table 3 Thermal characteristics TO-247, TO-220, I<sup>2</sup>PAK**

| Parameter                                                  | Symbol     | Values |      |      | Unit | Note / Test Condition                |
|------------------------------------------------------------|------------|--------|------|------|------|--------------------------------------|
|                                                            |            | Min.   | Typ. | Max. |      |                                      |
| Thermal resistance, junction - case                        | $R_{thJC}$ |        |      | 1.5  | °C/W |                                      |
| Thermal resistance, junction - ambient                     | $R_{thJA}$ |        |      | 62   | °C/W | leaded                               |
| Soldering temperature, wavesoldering only allowed at leads | $T_{sold}$ |        |      | 260  | °C   | 1.6 mm (0.063 in.) from case for 10s |

**Table 4 Thermal characteristics TO-220 FP**

| Parameter                                                  | Symbol     | Values |      |      | Unit | Note / Test Condition                |
|------------------------------------------------------------|------------|--------|------|------|------|--------------------------------------|
|                                                            |            | Min.   | Typ. | Max. |      |                                      |
| Thermal resistance, junction - case                        | $R_{thJC}$ |        |      | 4    | °C/W |                                      |
| Thermal resistance, junction - ambient                     | $R_{thJA}$ |        |      | 80   | °C/W | leaded                               |
| Soldering temperature, wavesoldering only allowed at leads | $T_{sold}$ |        |      | 260  | °C   | 1.6 mm (0.063 in.) from case for 10s |

**Table 5 Thermal characteristics D<sup>2</sup>PAK, DPAK**

| Parameter                                              | Symbol     | Values |      |      | Unit | Note / Test Condition                                     |
|--------------------------------------------------------|------------|--------|------|------|------|-----------------------------------------------------------|
|                                                        |            | Min.   | Typ. | Max. |      |                                                           |
| Thermal resistance, junction - case                    | $R_{thJC}$ |        |      | 1.5  | °C/W |                                                           |
| Thermal resistance, junction - ambient <sup>1)</sup>   | $R_{thJA}$ |        |      | 62   | °C/W | SMD version, device on PCB, minimal footprint             |
|                                                        |            |        | 35   |      |      | SMD version, device on PCB, 6cm <sup>2</sup> cooling area |
| Soldering temperature, wave- & reflowsoldering allowed | $T_{sold}$ |        |      | 260  | °C   | reflow MSL1                                               |

<sup>1)</sup> Device on 40mm\*40mm\*1.5mm one layer epoxy PCB FR4 with 6cm<sup>2</sup> copper area (thickness 70µm) for drain connection. PCB is vertical without air stream cooling.

## 4 Electrical characteristics

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

**Table 6 Static characteristics**

| Parameter                        | Symbol        | Values |       |      | Unit     | Note / Test Condition                                       |
|----------------------------------|---------------|--------|-------|------|----------|-------------------------------------------------------------|
|                                  |               | Min.   | Typ.  | Max. |          |                                                             |
| Drain-source breakdown voltage   | $V_{(BR)DSS}$ | 650    |       |      | V        | $V_{GS} = 0V$ , $I_D = 1mA$                                 |
| Gate threshold voltage           | $V_{GS(th)}$  | 3.5    | 4     | 4.5  | V        | $V_{DS} = V_{GS}$ , $I_D = 0.3mA$                           |
| Zero gate voltage drain current  | $I_{DSS}$     |        |       | 1    | $\mu A$  | $V_{DS} = 650V$ , $V_{GS} = 0V$ , $T_j = 25^\circ\text{C}$  |
|                                  |               |        | 100   |      |          | $V_{DS} = 650V$ , $V_{GS} = 0V$ , $T_j = 150^\circ\text{C}$ |
| Gate-source leakage current      | $I_{GSS}$     |        |       | 100  | nA       | $V_{GS} = 20V$ , $V_{DS} = 0V$                              |
| Drain-source on-state resistance | $R_{DS(on)}$  |        | 0.378 | 0.42 | $\Omega$ | $V_{GS} = 10V$ , $I_D = 3.4A$ , $T_j = 25^\circ\text{C}$    |
|                                  |               |        | 0.983 |      |          | $V_{GS} = 10V$ , $I_D = 3.4A$ , $T_j = 150^\circ\text{C}$   |
| Gate resistance                  | $R_G$         |        | 4     |      | $\Omega$ | $f = 1MHz$ , open drain                                     |

**Table 7 Dynamic characteristics**

| Parameter                                                  | Symbol       | Values |      |      | Unit | Note / Test Condition                                                                    |
|------------------------------------------------------------|--------------|--------|------|------|------|------------------------------------------------------------------------------------------|
|                                                            |              | Min.   | Typ. | Max. |      |                                                                                          |
| Input capacitance                                          | $C_{iss}$    |        | 870  |      | pF   | $V_{GS} = 0V$ , $V_{DS} = 100V$ , $f = 1MHz$                                             |
| Output capacitance                                         | $C_{oss}$    |        | 45   |      | pF   |                                                                                          |
| Effective output capacitance, energy related <sup>1)</sup> | $C_{o(er)}$  |        | 36   |      | pF   | $V_{GS} = 0V$ , $V_{DS} = 0 \dots 400V$                                                  |
| Effective output capacitance, time related <sup>2)</sup>   | $C_{o(tr)}$  |        | 161  |      | pF   | $I_D = \text{constant}$ , $V_{GS} = 0V$ , $V_{DS} = 0 \dots 400V$                        |
| Turn-on delay time                                         | $t_{d(on)}$  |        | 10   |      | ns   | $V_{DD} = 480V$ , $V_{GS} = 13V$ ,<br>$I_D = 5.2A$ , $R_G = 3.4\Omega$<br>(see table 21) |
| Rise time                                                  | $t_r$        |        | 7    |      | ns   |                                                                                          |
| Turn-off delay time                                        | $t_{d(off)}$ |        | 38   |      | ns   |                                                                                          |
| Fall time                                                  | $t_f$        |        | 8    |      | ns   |                                                                                          |

**Table 8 Gate charge characteristics**

| Parameter             | Symbol        | Values |      |      | Unit | Note / Test Condition                                            |
|-----------------------|---------------|--------|------|------|------|------------------------------------------------------------------|
|                       |               | Min.   | Typ. | Max. |      |                                                                  |
| Gate to source charge | $Q_{gs}$      |        | 6.4  |      | nC   | $V_{DD} = 480V$ , $I_D = 5.2A$ ,<br>$V_{GS} = 0 \text{ to } 10V$ |
| Gate to drain charge  | $Q_{gd}$      |        | 18.6 |      | nC   |                                                                  |
| Gate charge total     | $Q_g$         |        | 31.5 |      | nC   |                                                                  |
| Gate plateau voltage  | $V_{plateau}$ |        | 6.4  |      | V    |                                                                  |

<sup>1)</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 400V

<sup>2)</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 400V

**Table 9 Reverse diode characteristics**

| Parameter                     | Symbol    | Values |      |      | Unit    | Note / Test Condition                                                 |
|-------------------------------|-----------|--------|------|------|---------|-----------------------------------------------------------------------|
|                               |           | Min.   | Typ. | Max. |         |                                                                       |
| Diode forward voltage         | $V_{SD}$  |        | 0.9  |      | V       | $V_{GS} = 0V, I_F = 5.2A, T_j = 25^{\circ}C$                          |
| Reverse recovery time         | $t_{rr}$  |        | 90   |      | ns      | $V_R = 400V, I_F = 5.2A,$<br>$di_F/dt = 100A/\mu s$<br>(see table 20) |
| Reverse recovery charge       | $Q_{rr}$  |        | 0.3  |      | $\mu C$ |                                                                       |
| Peak reverse recovery current | $I_{rrm}$ |        | 6.2  |      | A       |                                                                       |

## 5 Electrical characteristics diagrams

Table 10

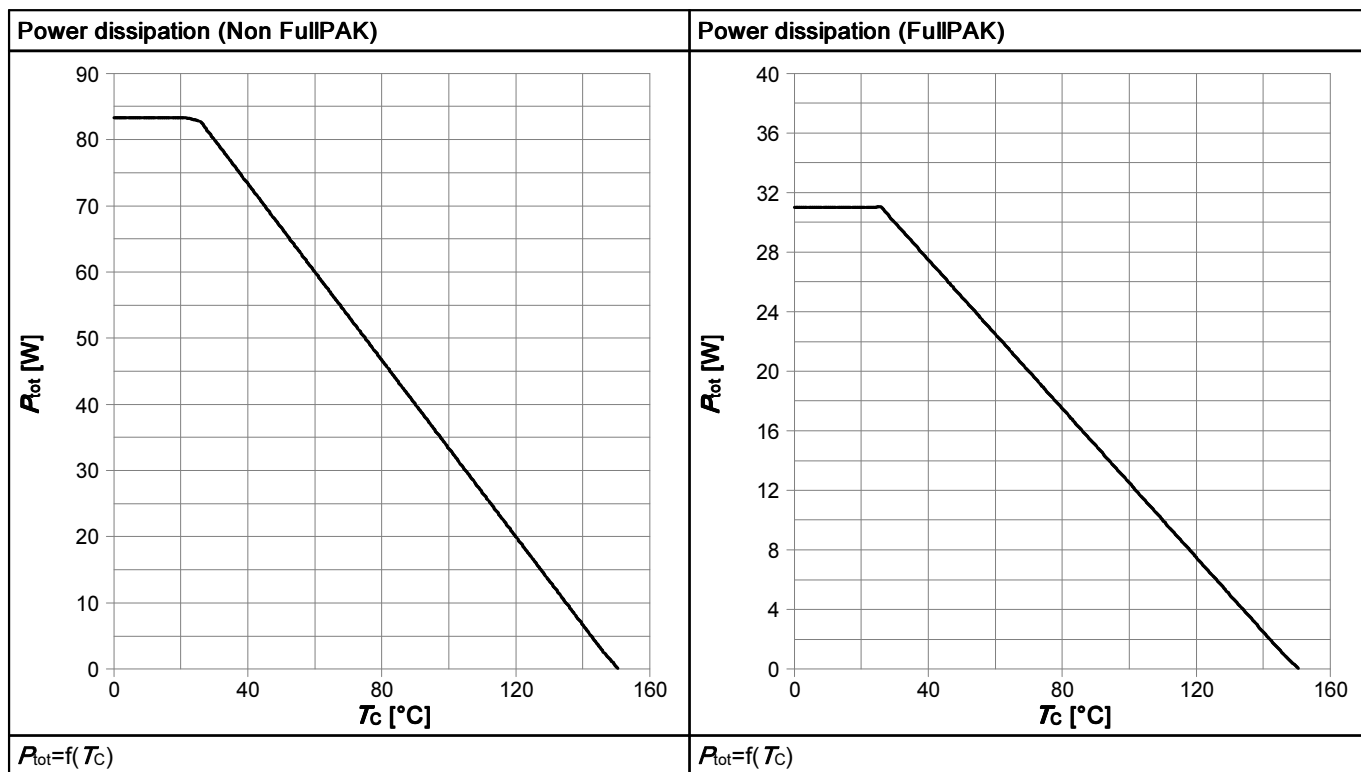


Table 11

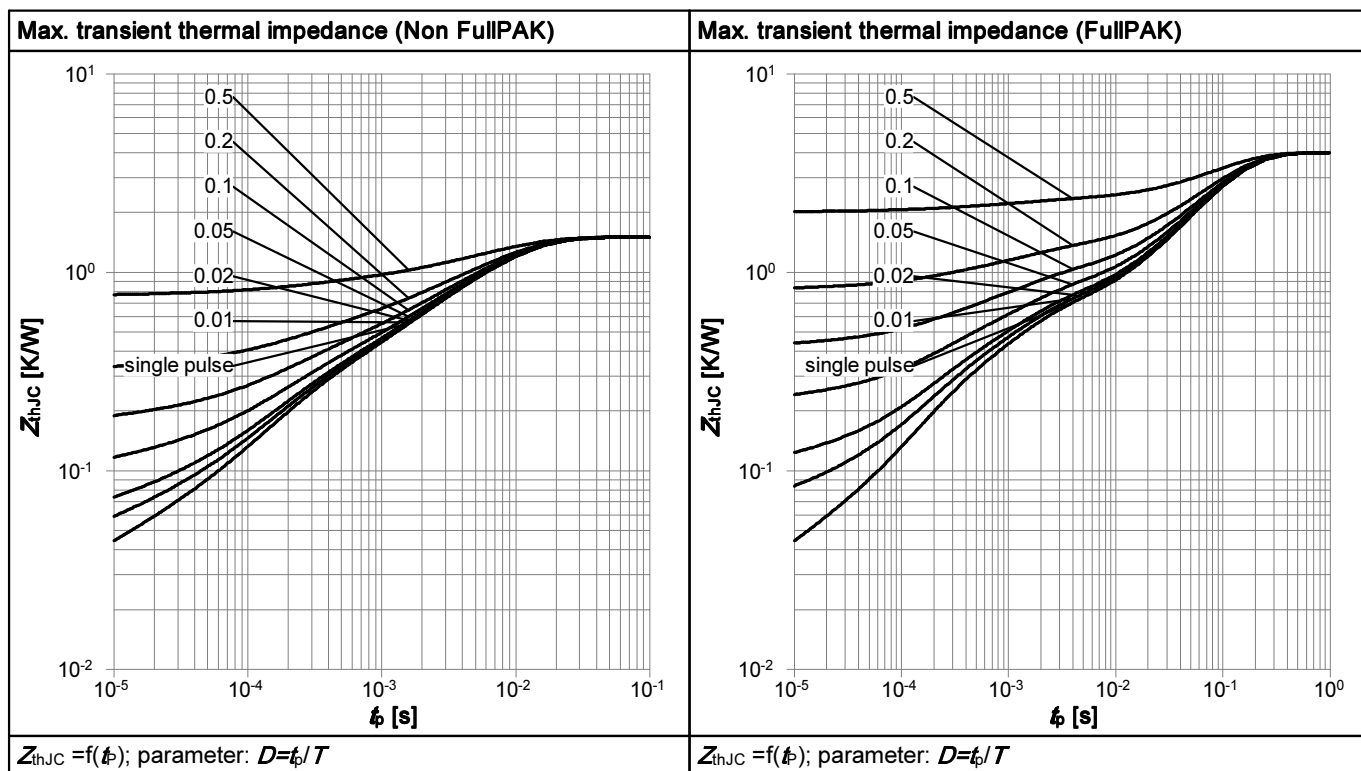


Table 12

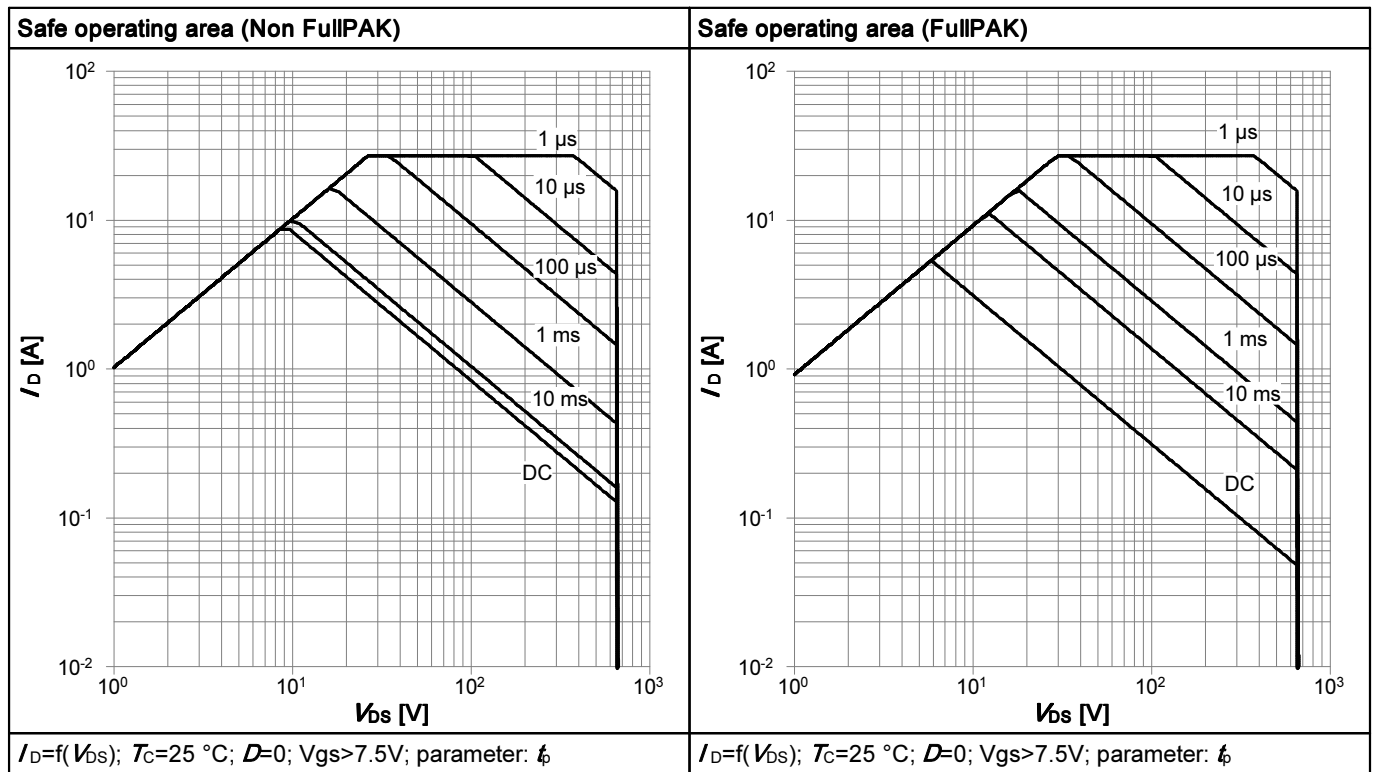


Table 13

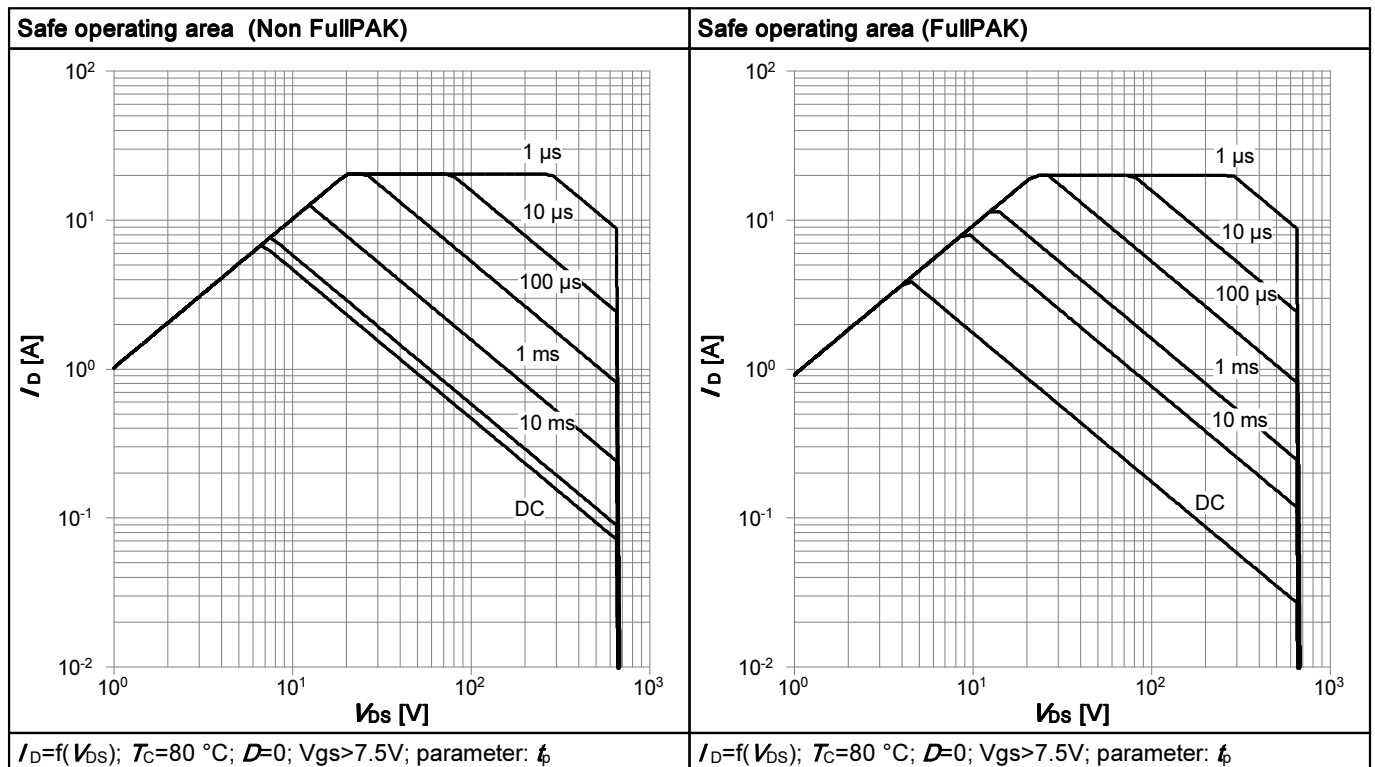


Table 14

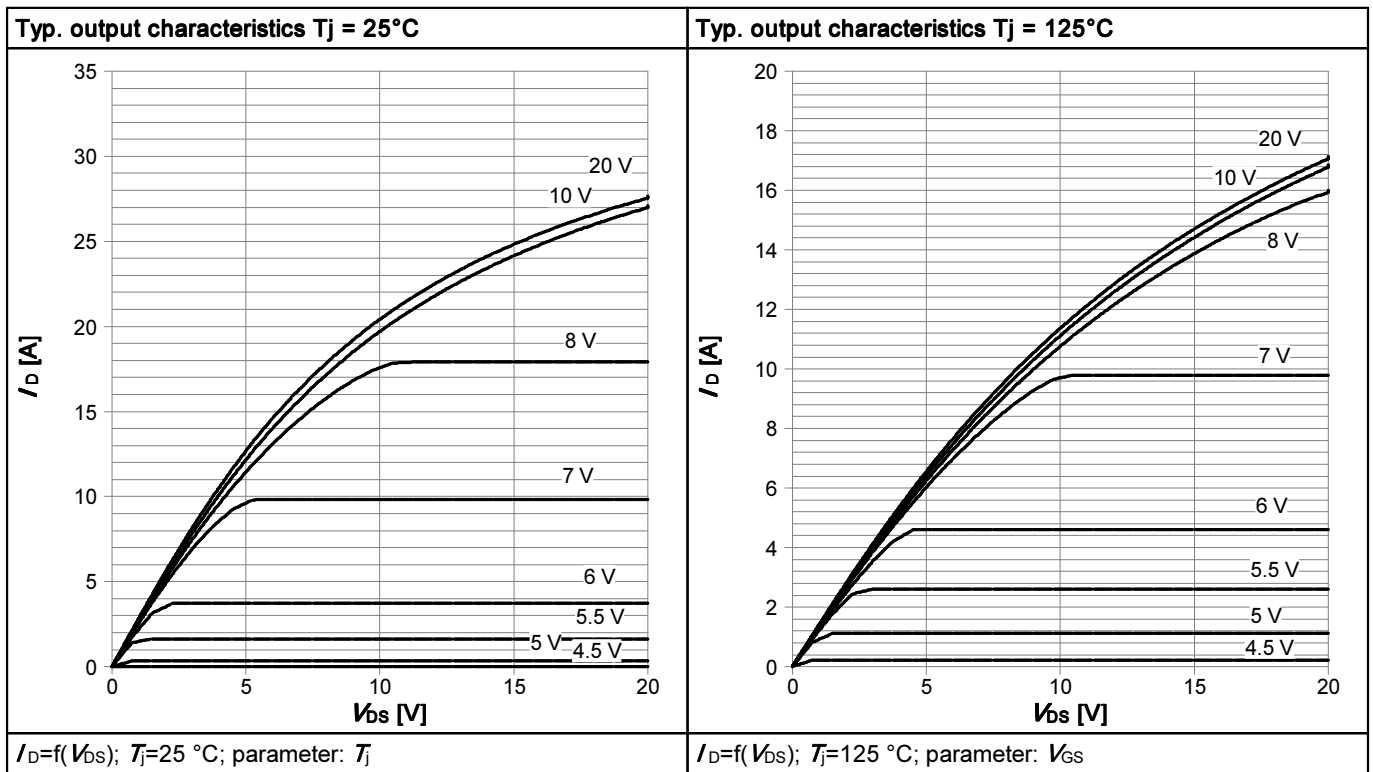


Table 15

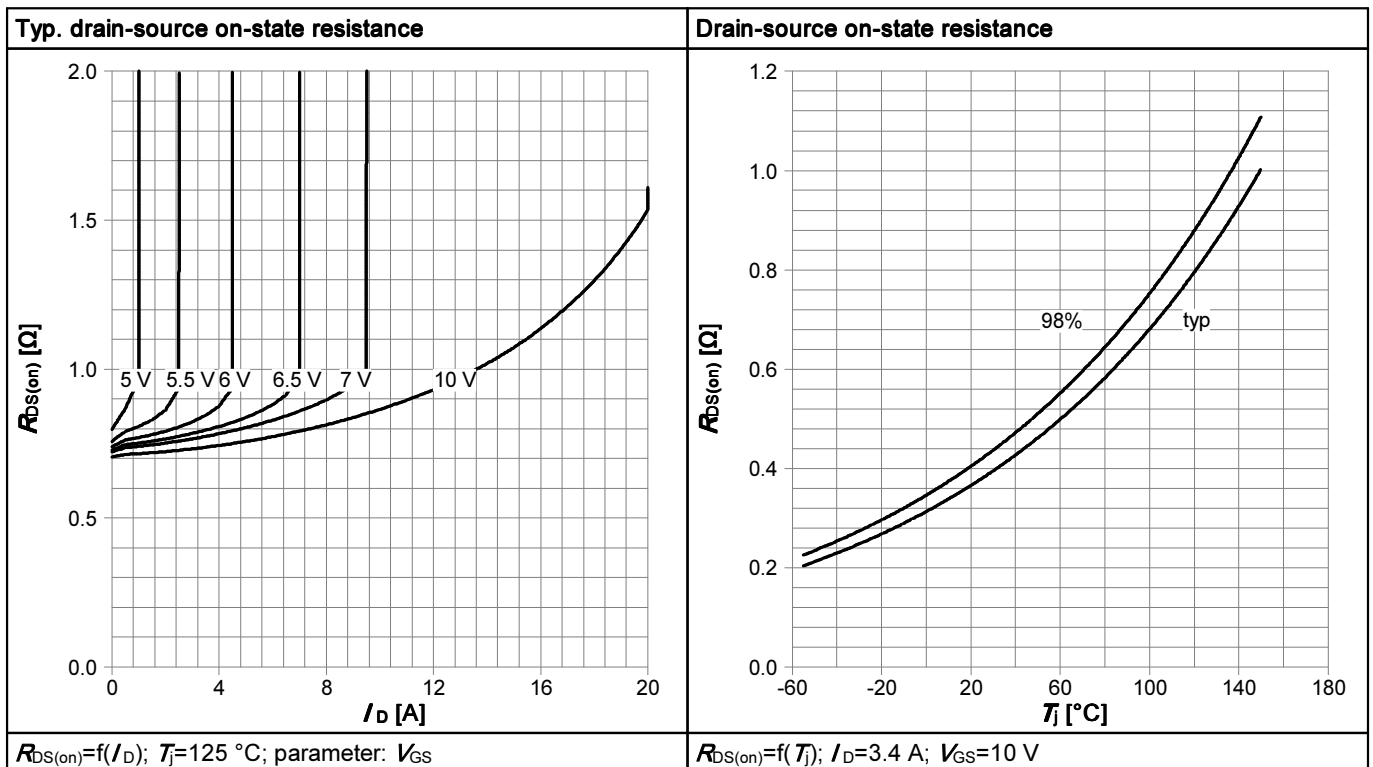


Table 16

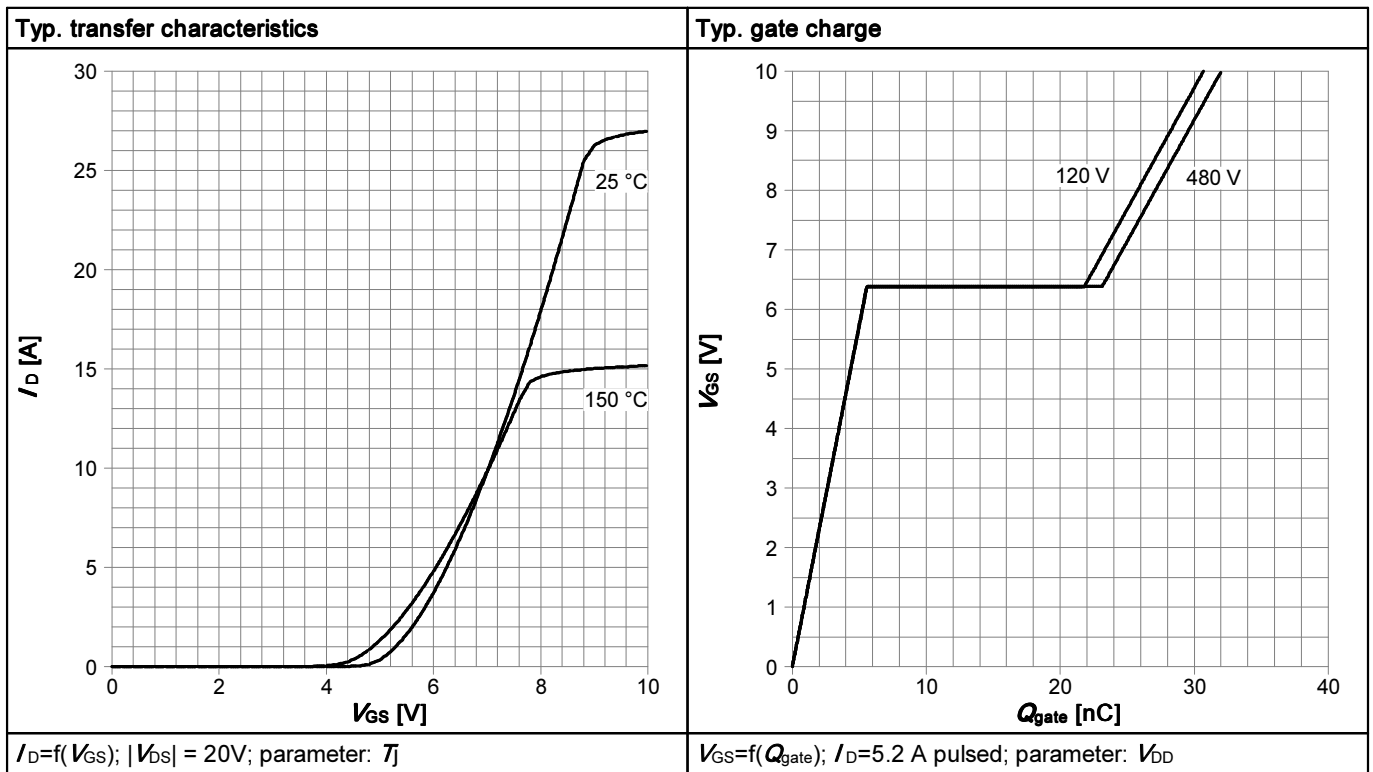


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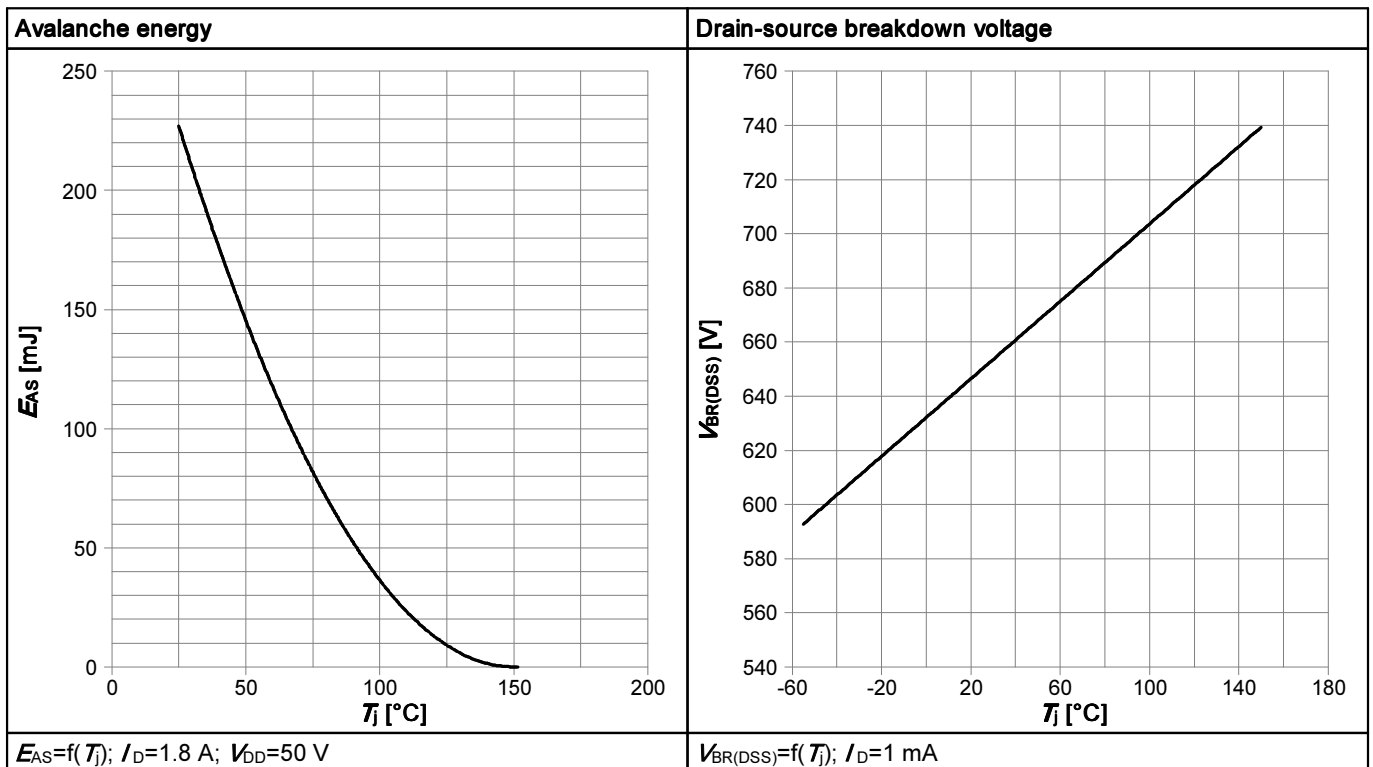


Table 18

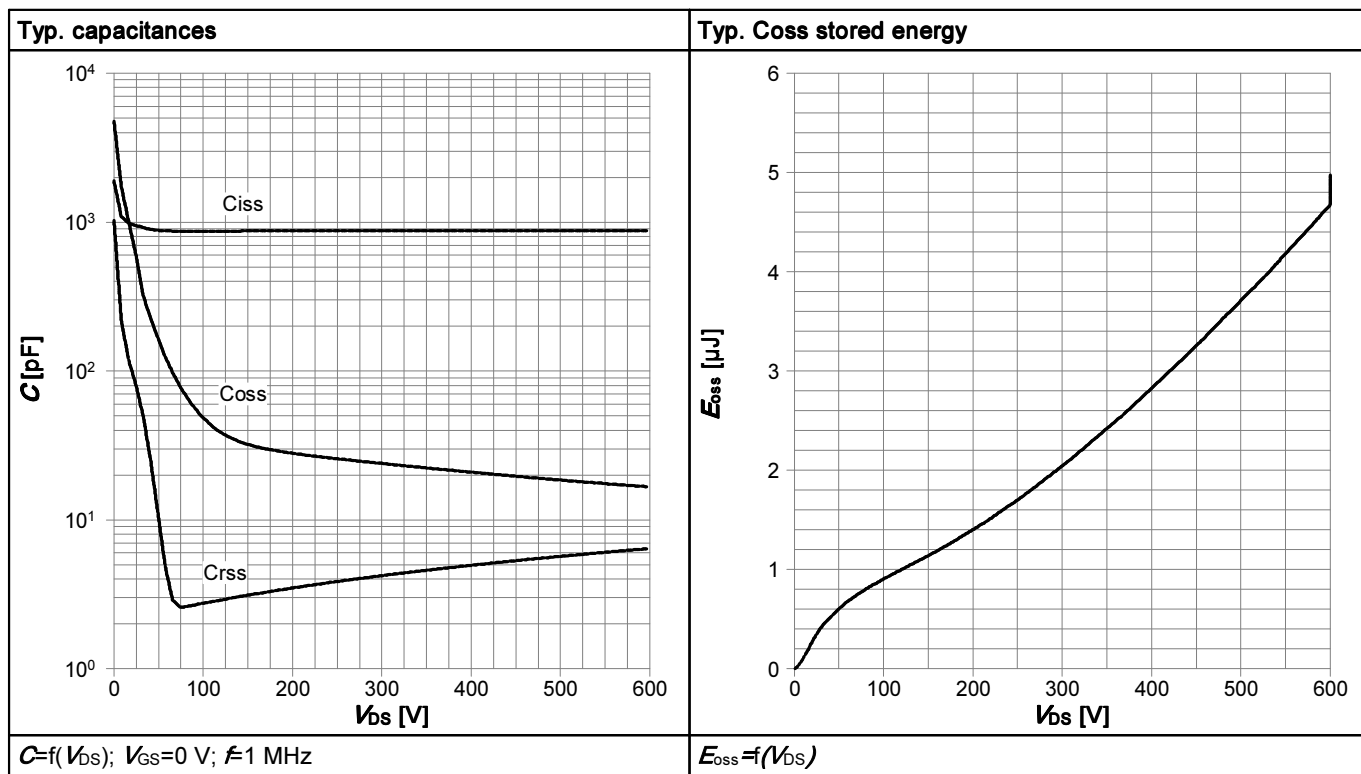
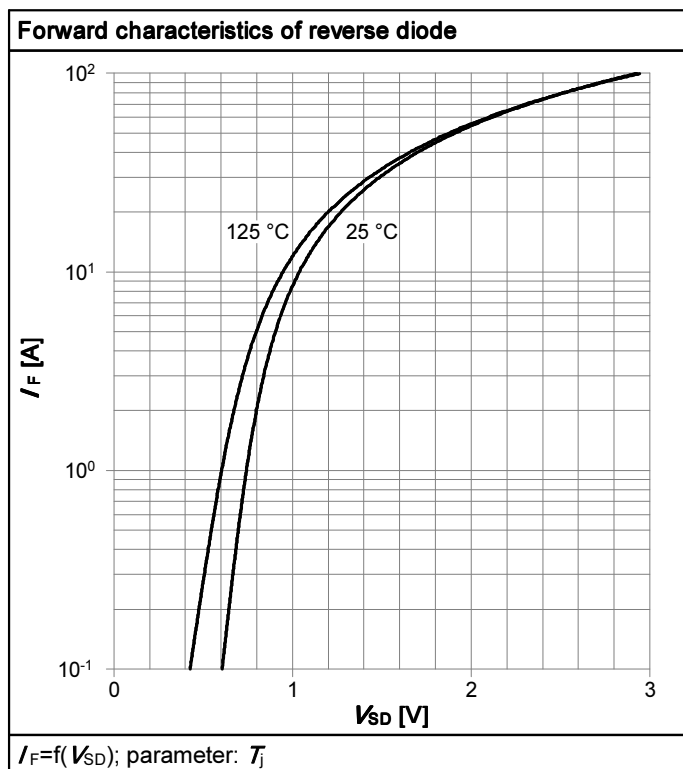
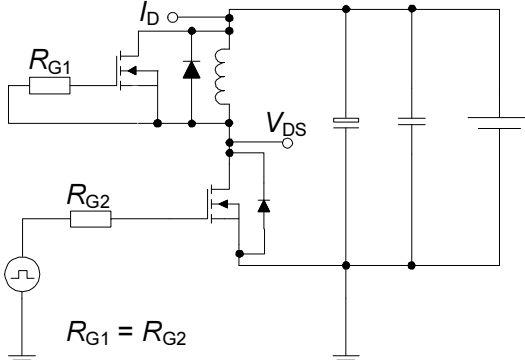
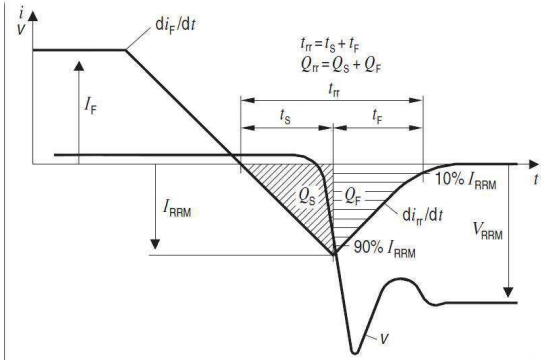


Table 19

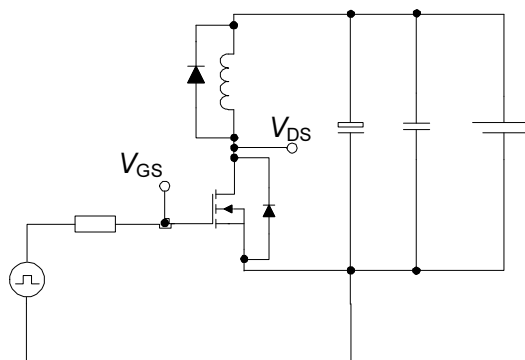
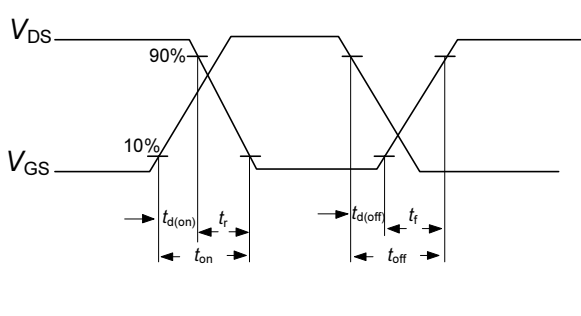


## 6 Test Circuits

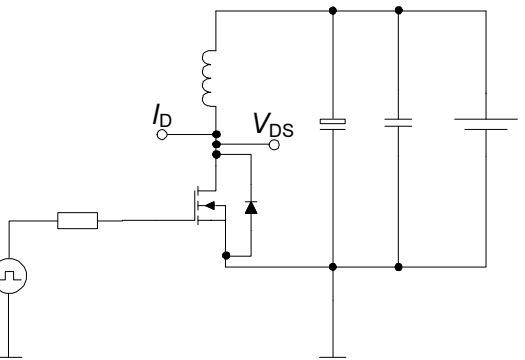
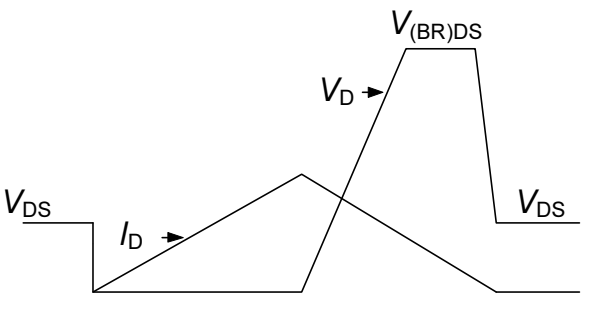
**Table 20 Diode characteristics**

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

**Table 21 Switching times**

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

**Table 22 Unclamped inductive**

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

## 7 Package Outlines

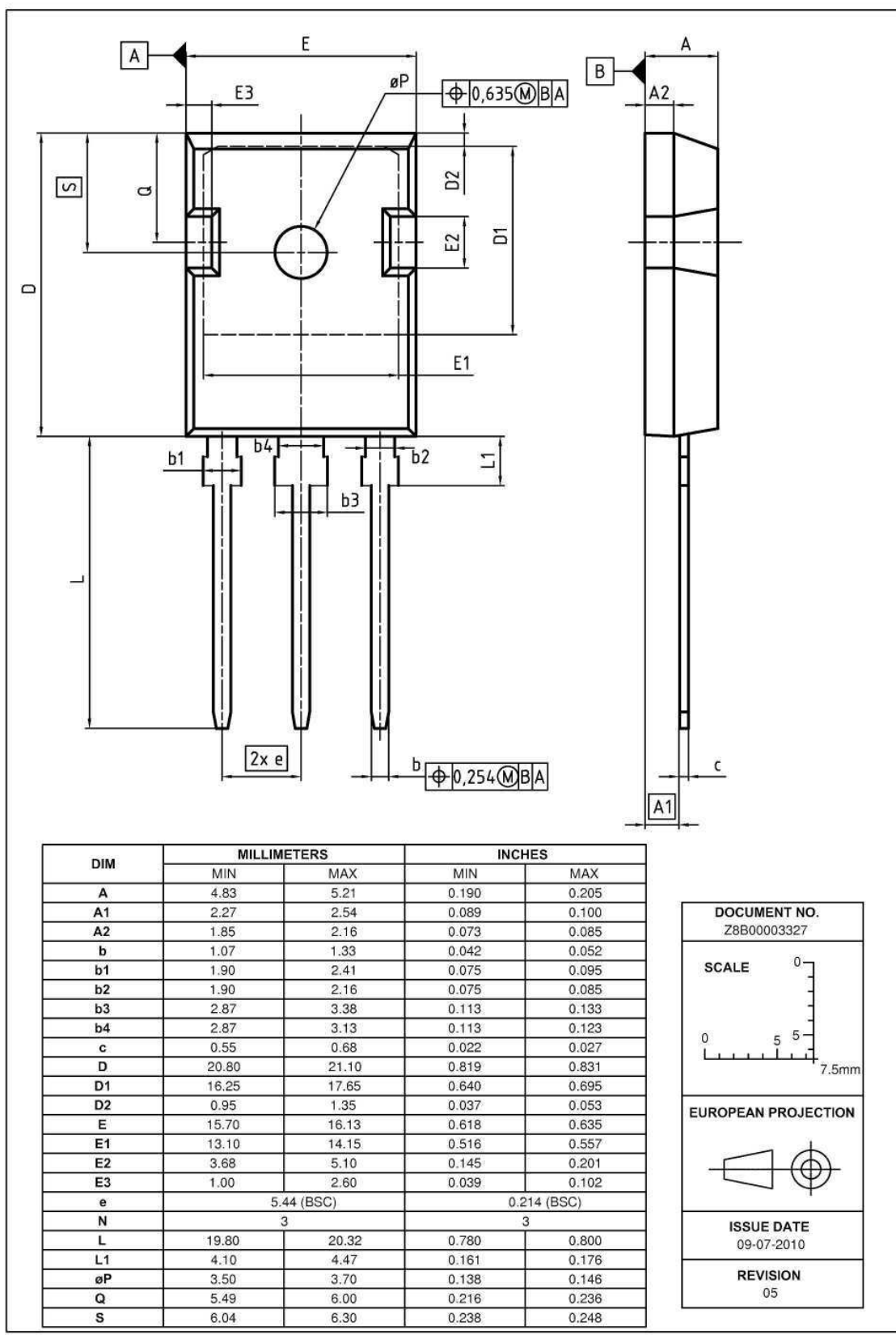
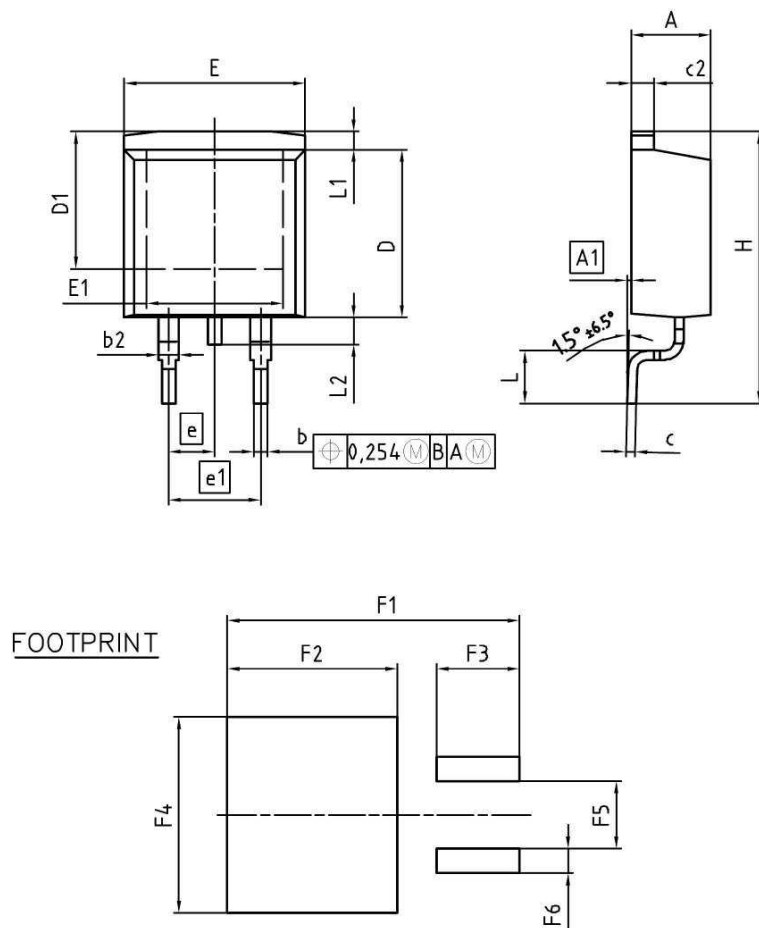


Figure 1 Outline PG-TO 247, dimensions in mm/inches



| DIM | MILLIMETERS |       | INCHES |       |
|-----|-------------|-------|--------|-------|
|     | MIN         | MAX   | MIN    | MAX   |
| A   | 4.30        | 4.57  | 0.169  | 0.180 |
| A1  | 0.00        | 0.25  | 0.000  | 0.010 |
| b   | 0.65        | 0.85  | 0.026  | 0.033 |
| b2  | 0.95        | 1.15  | 0.037  | 0.045 |
| c   | 0.33        | 0.65  | 0.013  | 0.026 |
| c2  | 1.17        | 1.40  | 0.046  | 0.055 |
| D   | 8.51        | 9.45  | 0.335  | 0.372 |
| D1  | 7.10        | 7.90  | 0.280  | 0.311 |
| E   | 9.80        | 10.31 | 0.386  | 0.406 |
| E1  | 6.50        | 8.60  | 0.256  | 0.339 |
| e   | 2.54        |       | 0.100  |       |
| e1  | 5.08        |       | 0.200  |       |
| N   | 2           |       | 2      |       |
| H   | 14.61       | 15.88 | 0.575  | 0.625 |
| L   | 2.29        | 3.00  | 0.090  | 0.118 |
| L1  | 0.70        | 1.60  | 0.028  | 0.063 |
| L2  | 1.00        | 1.78  | 0.039  | 0.070 |
| F1  | 16.05       | 16.25 | 0.632  | 0.640 |
| F2  | 9.30        | 9.50  | 0.366  | 0.374 |
| F3  | 4.50        | 4.70  | 0.177  | 0.185 |
| F4  | 10.70       | 10.90 | 0.421  | 0.429 |
| F5  | 3.65        | 3.85  | 0.144  | 0.152 |
| F6  | 1.25        | 1.45  | 0.049  | 0.057 |

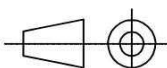
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| EUROPEAN PROJECTION<br> |
| ISSUE DATE<br>30-08-2007                                                                                     |
| REVISION<br>01                                                                                               |

Figure 2 Outline PG-TO 263, dimensions in mm/inches

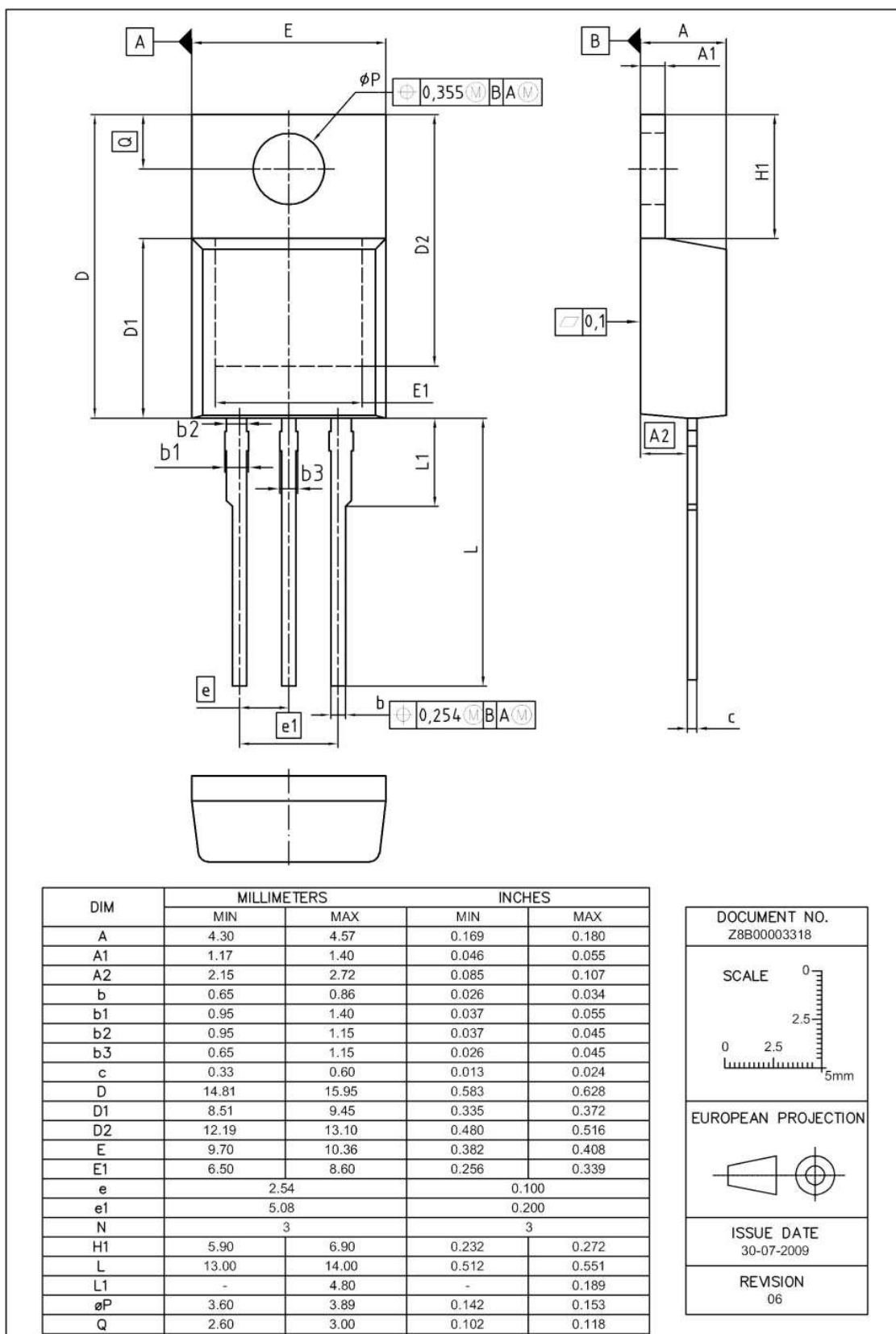


Figure 3 Outline PG-TO 220, dimensions in mm/inches

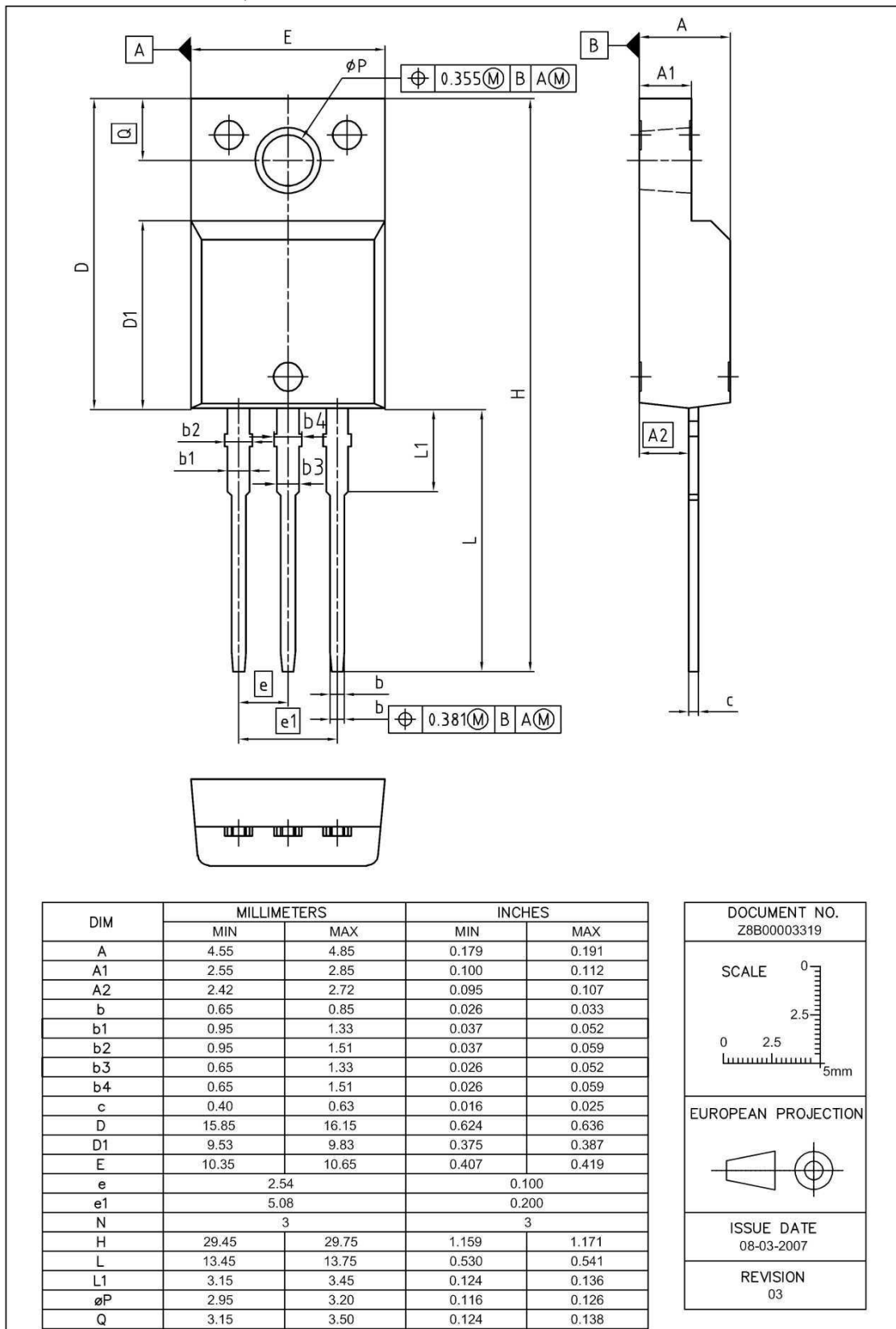


Figure 4 Outline PG-TO 220 FullPAK, dimensions in mm/inches

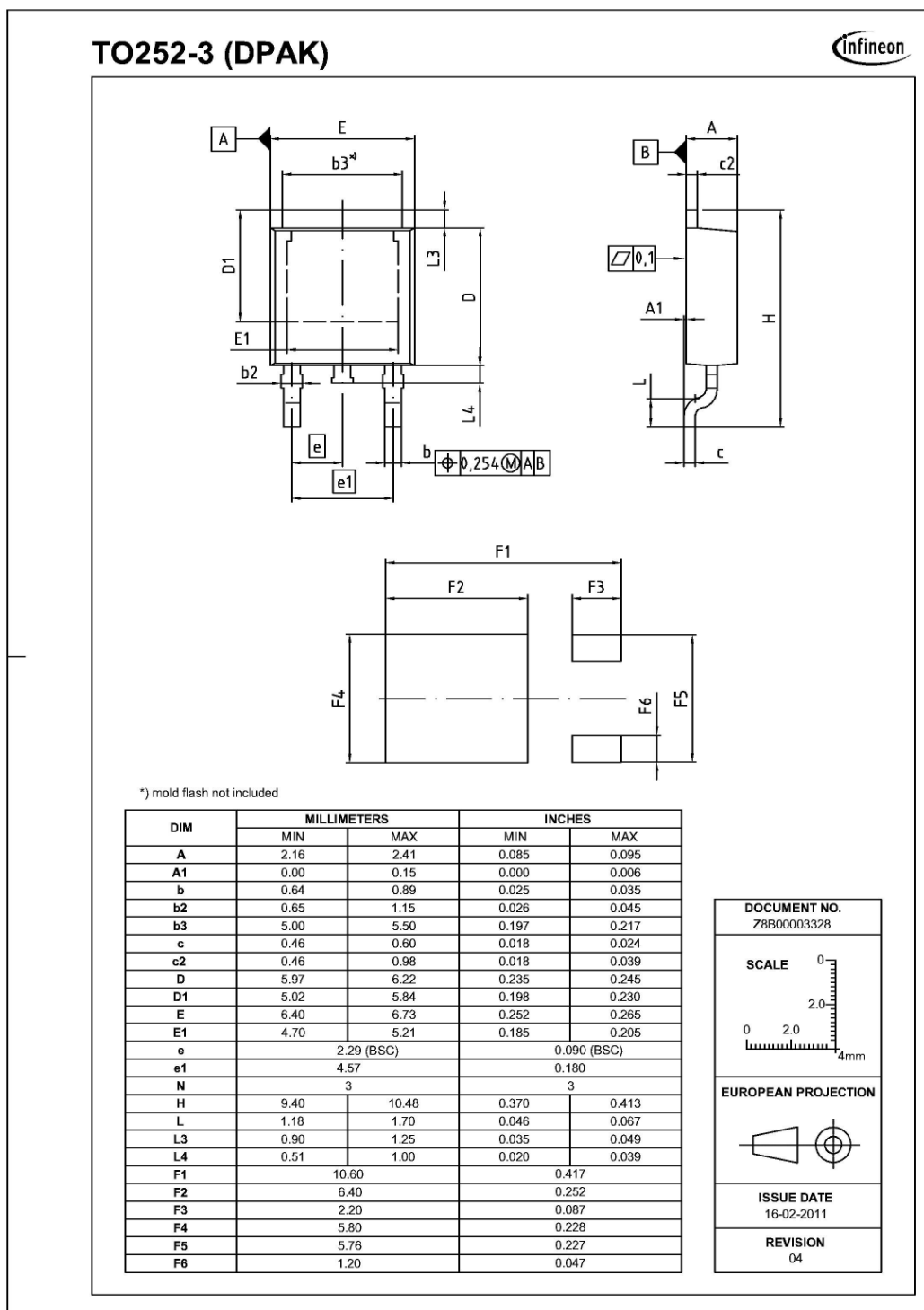


Figure 5 Outline PG-TO 252, dimensions in mm/inches

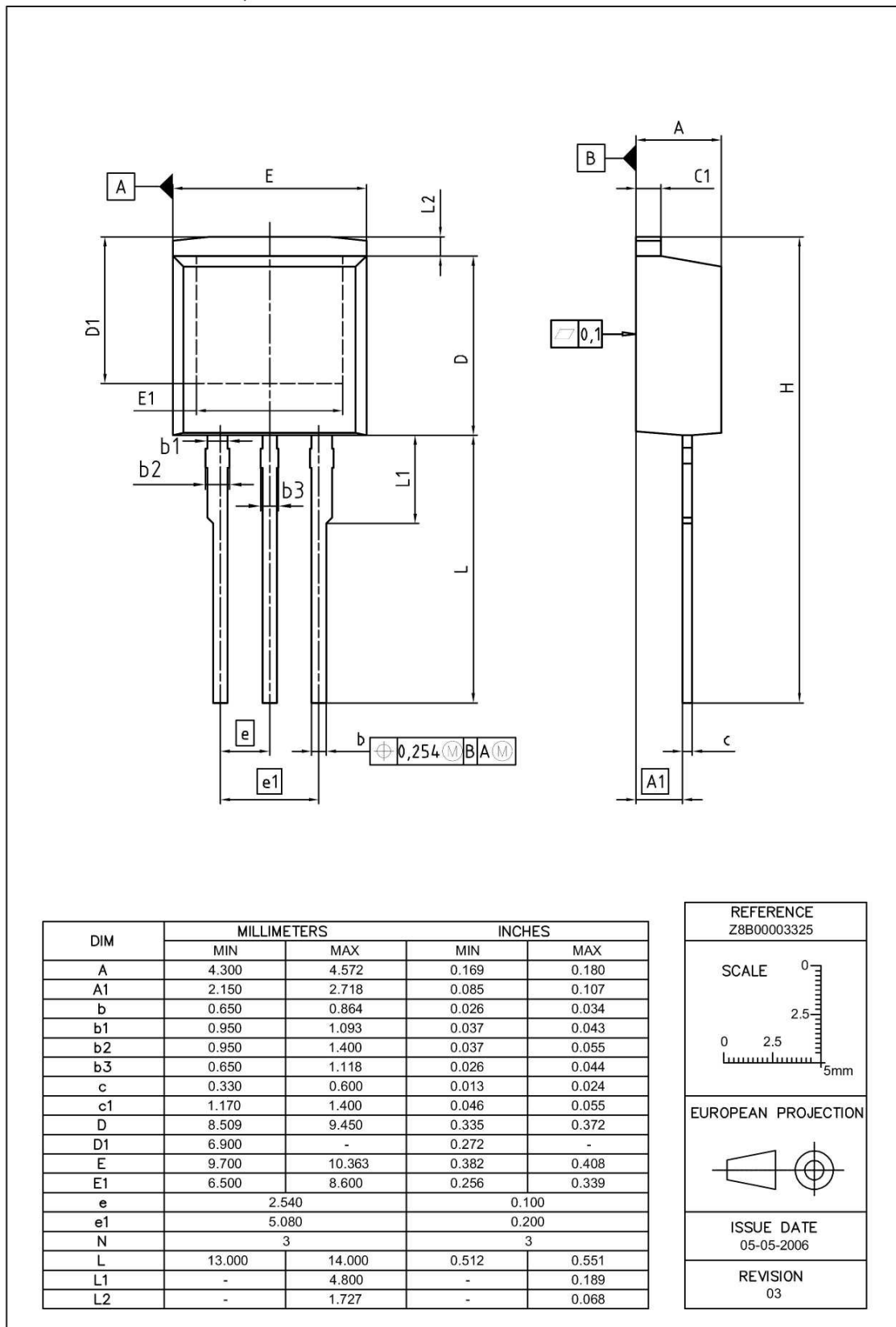


Figure 6 Outline PG-TO 262, dimensions in mm/inches

## 8 Appendix A

### Table 23 Related Links

- **IFX Design Tools:**  
<http://www.infineon.com/cms/en/product/promopages/designtools/index.html>
- **IFX CoolMOS Webpage:**  
<http://www.infineon.com/cms/en/product/channel.html?channel=ff80808112ab681d0112ab6a628704d8>

## Revision History

IPW65R420CFD , IPB65R420CFD , IPP65R420CFD , IPA65R420CFD , IPD65R420CFD , IPI65R420CFD

### Revision History: 2016-08-24, Rev. 2.6

Previous Revision: 2.5

| Revision | Date       | Subjects (major changes since last revision)                           |
|----------|------------|------------------------------------------------------------------------|
| 2.0      | 2011-05-04 | Release of final datasheet                                             |
| 2.1      | 2011-05-05 | release of final datasheet                                             |
| 2.2      | 2011-06-07 | Update $V_{DS} @ T_{j \max}$                                           |
| 2.3      | 2011-08-29 | update $Q_{gd}$                                                        |
| 2.4      | 2012-06-01 | update SOA, AE, Typ. Gate Charge                                       |
| 2.5      | 2013-07-31 | Update halogen free mold compound status of PG-TO 252 package          |
| 2.6      | 2016-08-24 | PG-TO 252 non-halogen free version discontinued (creation: 2016.08.24) |
|          |            |                                                                        |

### We Listen to Your Comments

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## Revision History

IPD65R420CFD

**Revision: 2016-08-26, Rev. 2.6**

Previous Revision

| Revision | Date       | Subjects (major changes since last revision)                              |
|----------|------------|---------------------------------------------------------------------------|
| 2.6      | 2016-08-26 | PG-TO 252 non-halogen free version discontinued (DS creation: 2016.08.24) |

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