

# MOSFET

Metal Oxide Semiconductor Field Effect Transistor

## CoolMOS™ CFD2 650V

650V CoolMOS™ CFD2 Power Transistor  
IPx65R660CFD

## Data Sheet

Rev. 2.7  
Final

Industrial & Multimarket

## 1 Description

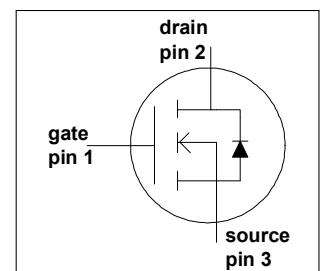
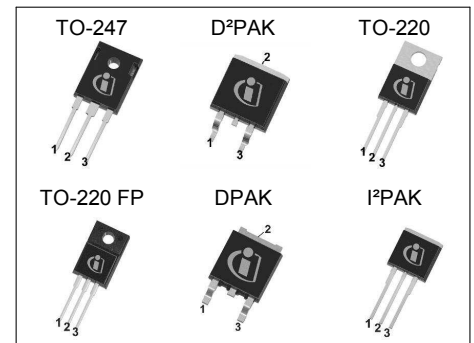
CoolMOS™ is a revolutionary technology for high voltage power MOSFETs, designed according to the superjunction (SJ) principle and pioneered by Infineon Technologies. 650V CoolMOS™ CFD2 series combines the experience of the leading SJ MOSFET supplier with high class innovation. The resulting devices provide 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
- Fully qualified according to JEDEC for Industrial Applications
- Pb-free plating, available in Halogen free mold compound<sup>a)</sup>

## Applications

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



**Table 1 Key Performance Parameters**

| Parameter             | Value | Unit       |
|-----------------------|-------|------------|
| $V_{DS} @ T_{j \max}$ | 700   | V          |
| $R_{DS(on), \max}$    | 0.66  | $\Omega$   |
| $Q_g, \text{typ}$     | 22    | nC         |
| $I_D, \text{pulse}$   | 17    | A          |
| $E_{oss} @ 400V$      | 1.8   | $\mu J$    |
| Body diode $di/dt$    | 900   | A/ $\mu s$ |
| $Q_{rr}$              | 0.2   | $\mu C$    |
| $t_{rr}$              | 65    | ns         |
| $I_{rrm}$             | 4.5   | A          |

| Type / Ordering Code | Package           | Marking | Related Links  |
|----------------------|-------------------|---------|----------------|
| IPW65R660CFD         | PG-TO 247         | 65F6660 | see Appendix A |
| IPB65R660CFD         | PG-TO 263         |         |                |
| IPP65R660CFD         | PG-TO 220         |         |                |
| IPA65R660CFD         | PG-TO 220 FullPAK |         |                |
| IPD65R660CFD         | PG-TO 252         |         |                |
| IPI65R660CFD         | PG-TO 262         |         |                |



## Table of Contents

|                                           |    |
|-------------------------------------------|----|
| Description .....                         | 2  |
| Table of Contents .....                   | 3  |
| Maximum ratings .....                     | 4  |
| Thermal characteristics .....             | 5  |
| Electrical characteristics .....          | 6  |
| Electrical characteristics diagrams ..... | 8  |
| Test Circuits .....                       | 13 |
| Package Outlines .....                    | 14 |
| Appendix A .....                          | 20 |
| Revision History .....                    | 21 |
| Disclaimer .....                          | 21 |

## 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>                                | $I_D$               |        |      | 6.0  | A                | $T_C = 25^\circ\text{C}$                                                         |
|                                                                       |                     |        |      | 3.8  |                  | $T_C = 100^\circ\text{C}$                                                        |
| Pulsed drain current <sup>2)</sup>                                    | $I_{D,pulse}$       |        |      | 17   | A                | $T_C = 25^\circ\text{C}$                                                         |
| Avalanche energy, single pulse                                        | $E_{AS}$            |        |      | 115  | mJ               | $I_b = 1.2\text{A}$ , $V_{DS} = 50\text{V}$                                      |
| Avalanche energy, repetitive                                          | $E_{AR}$            |        |      | 0.21 | mJ               | $I_b = 1.2\text{A}$ , $V_{DS} = 50\text{V}$                                      |
| Avalanche current, repetitive                                         | $I_{AR}$            |        |      | 1.2  | 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 | $P_{tot}$           |        |      | 62.5 | W                | $T_C = 25^\circ\text{C}$                                                         |
| Power dissipation (FullPAK)<br>TO-220 FP                              | $P_{tot}$           |        |      | 27.8 | 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                                      | $I_S$               |        |      | 6.0  | A                | $T_C = 25^\circ\text{C}$                                                         |
| Diode pulse current                                                   | $I_{S,pulse}$       |        |      | 17   | A                | $T_C = 25^\circ\text{C}$                                                         |
| Reverse diode dv/dt <sup>3)</sup>                                     | dv/dt               |        |      | 50   | V/ns             | $V_{DS} = 0 \dots 400\text{V}$ , $I_{SD} \leq I_b$ ,<br>$T_j = 25^\circ\text{C}$ |
| Maximum diode commutation speed                                       | di <sub>f</sub> /dt |        |      | 900  | A/ $\mu\text{s}$ |                                                                                  |

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

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

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

### 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                        | $R_{thJC}$ |        |      | 2    | °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                        | $R_{thJC}$ |        |      | 4.5  | °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                    | $R_{thJC}$ |        |      | 2    | °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 MSL                                                |

<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        | $V_{DS} = V_{GS}, I_D = 0.2mA$                        |
| 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 | $R_{DS(on)}$  |        | 0.594 | 0.66 | $\Omega$ | $V_{GS} = 10V, I_D = 2.1A, T_j = 25^\circ\text{C}$    |
|                                  |               |        | 1.544 |      |          | $V_{GS} = 10V, I_D = 2.1A, T_j = 150^\circ\text{C}$   |
| Gate resistance                  | $R_G$         |        | 6.5   |      | $\Omega$ | $f = 1MHz, \text{open drain}$                         |

**Table 7 Dynamic characteristics**

| Parameter                                                  | Symbol       | Values |      |      | Unit | Note / Test Condition                                       |
|------------------------------------------------------------|--------------|--------|------|------|------|-------------------------------------------------------------|
|                                                            |              | Min.   | Typ. | Max. |      |                                                             |
| Input capacitance                                          | $C_{iss}$    |        | 615  |      | pF   | $V_{GS} = 0V, V_{DS} = 100V, f = 1MHz$                      |
| Output capacitance                                         | $C_{oss}$    |        | 33   |      | pF   |                                                             |
| Effective output capacitance, energy related <sup>1)</sup> | $C_{o(er)}$  |        | 21   |      | pF   | $V_{GS} = 0V, V_{DS} = 0 \dots 400V$                        |
| Effective output capacitance, time related <sup>2)</sup>   | $C_{o(tr)}$  |        | 88   |      | pF   | $I_D = \text{constant}, V_{GS} = 0V, V_{DS} = 0 \dots 400V$ |
| Turn-on delay time                                         | $t_{d(on)}$  |        | 9    |      | ns   | $V_{DD} = 400V, V_{GS} = 13V, I_D = 3.2A, R_G = 6.8\Omega$  |
| Rise time                                                  | $t_r$        |        | 8    |      | ns   |                                                             |
| Turn-off delay time                                        | $t_{d(off)}$ |        | 40   |      | ns   |                                                             |
| Fall time                                                  | $t_f$        |        | 10   |      | ns   |                                                             |

**Table 8 Gate charge characteristics**

| Parameter             | Symbol        | Values |      |      | Unit | Note / Test Condition                                   |
|-----------------------|---------------|--------|------|------|------|---------------------------------------------------------|
|                       |               | Min.   | Typ. | Max. |      |                                                         |
| Gate to source charge | $Q_{gs}$      |        | 3.5  |      | nC   | $V_{DD} = 480V, I_D = 3.2A, V_{GS} = 0 \text{ to } 10V$ |
| Gate to drain charge  | $Q_{gd}$      |        | 12   |      | nC   |                                                         |
| Gate charge total     | $Q_g$         |        | 22   |      | 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       | $V_{GS} = 0V$ , $I_F = 3.2A$ , $T_J = 25^\circ C$       |
| Reverse recovery time         | $t_{rr}$  |        | 65   |      | ns      | $V_R = 400V$ , $I_F = 3.2A$ ,<br>$dI_F/dt = 100A/\mu s$ |
| Reverse recovery charge       | $Q_{rr}$  |        | 0.2  |      | $\mu C$ |                                                         |
| Peak reverse recovery current | $I_{rrm}$ |        | 4.5  |      | A       |                                                         |

## 5 Electrical characteristics diagrams

Table 10

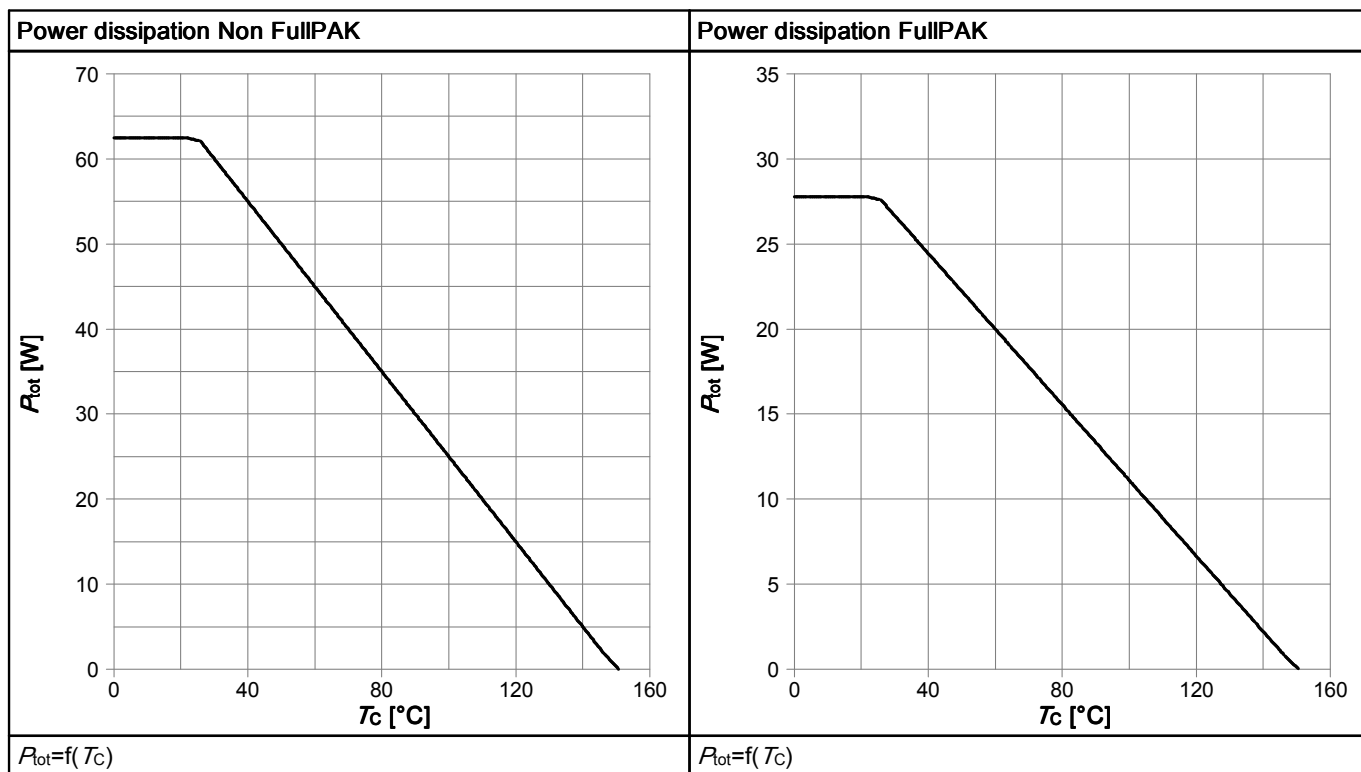


Table 11

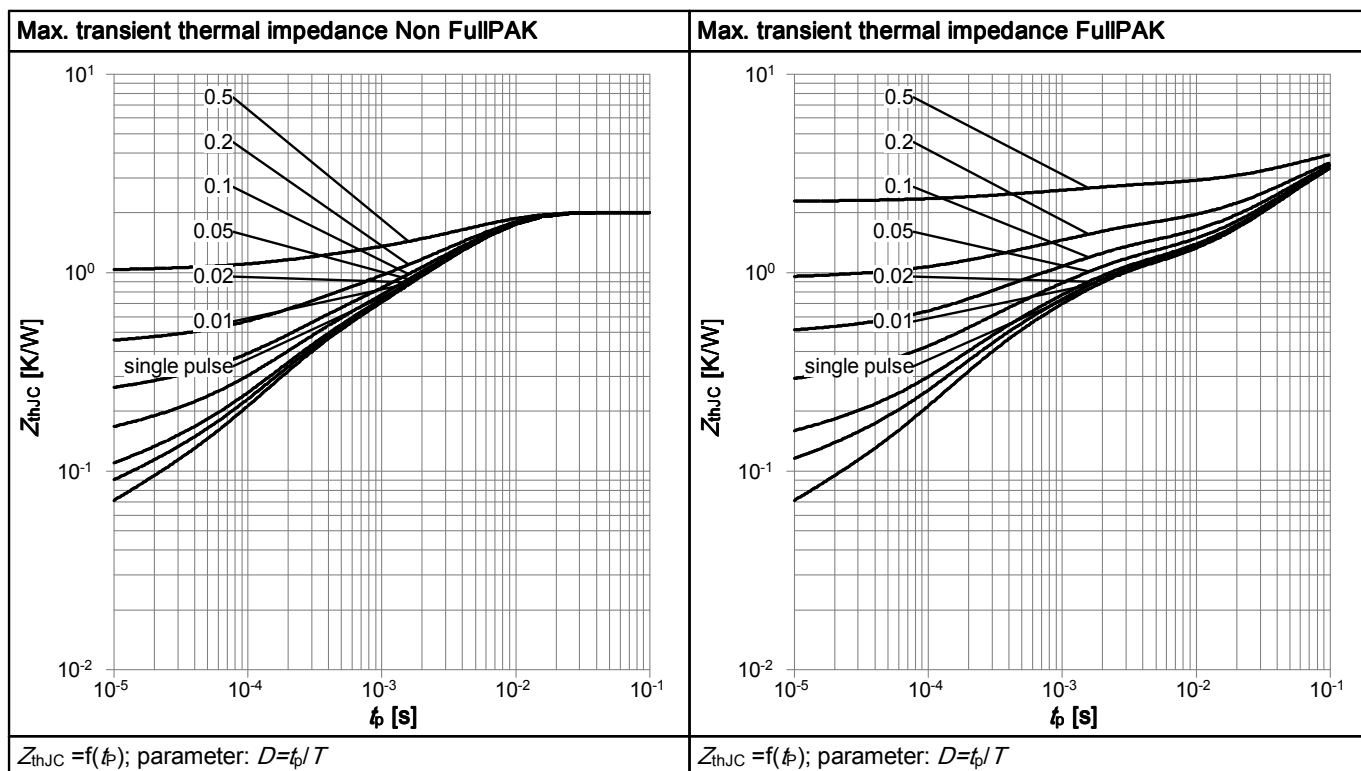


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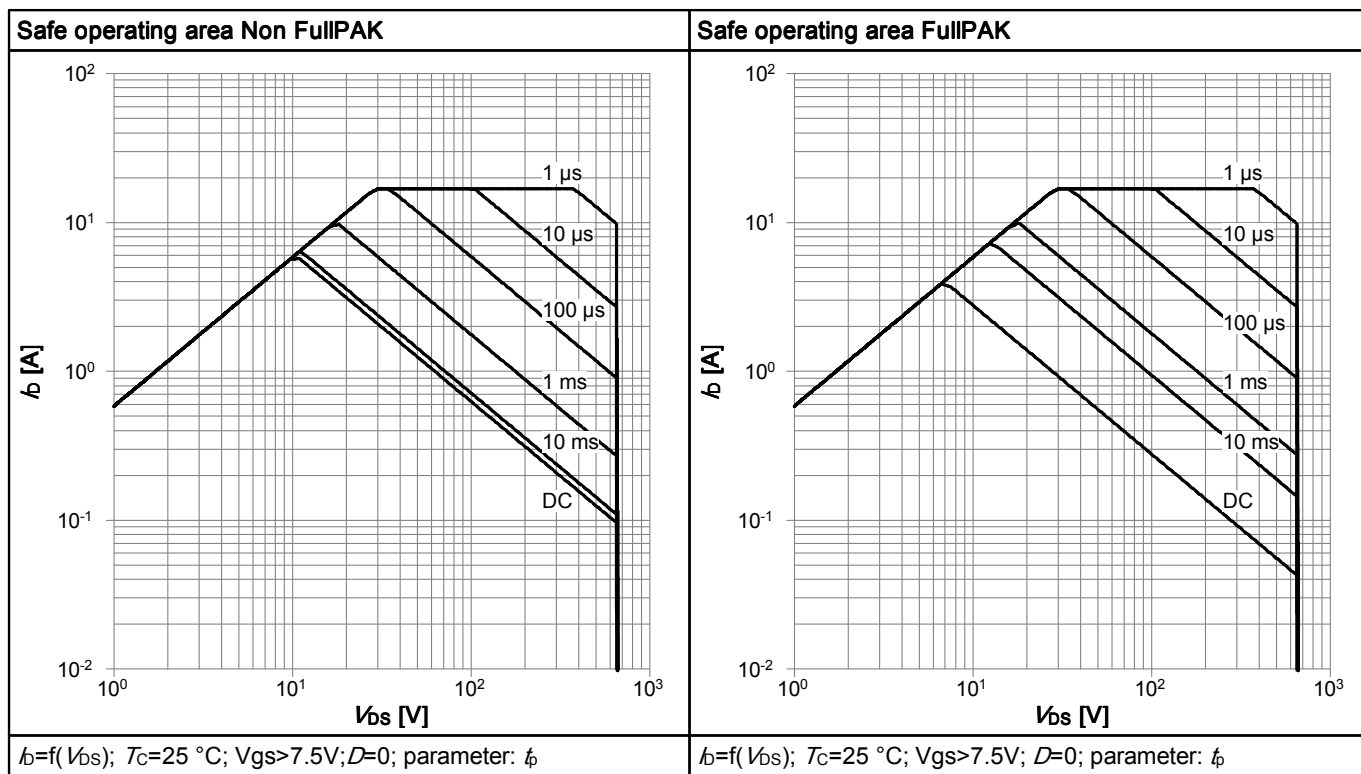


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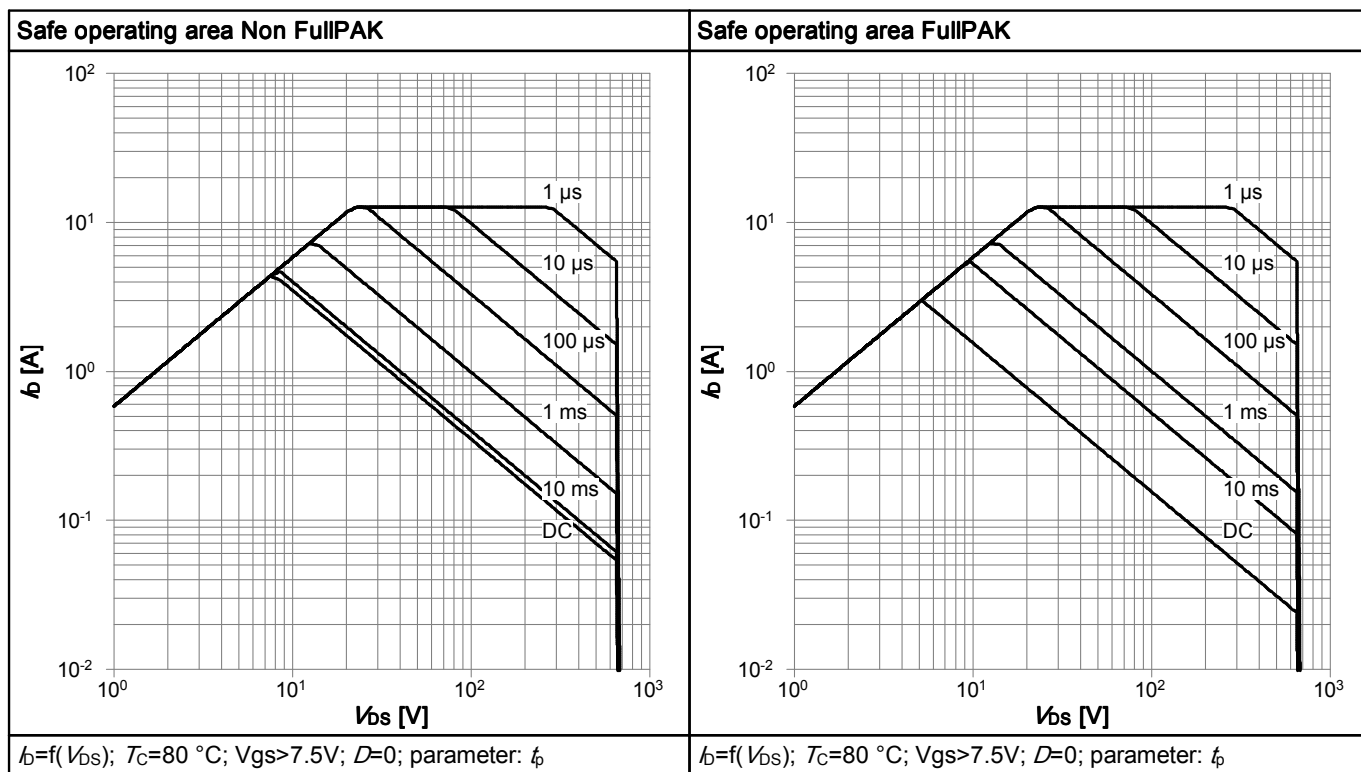


Table 14

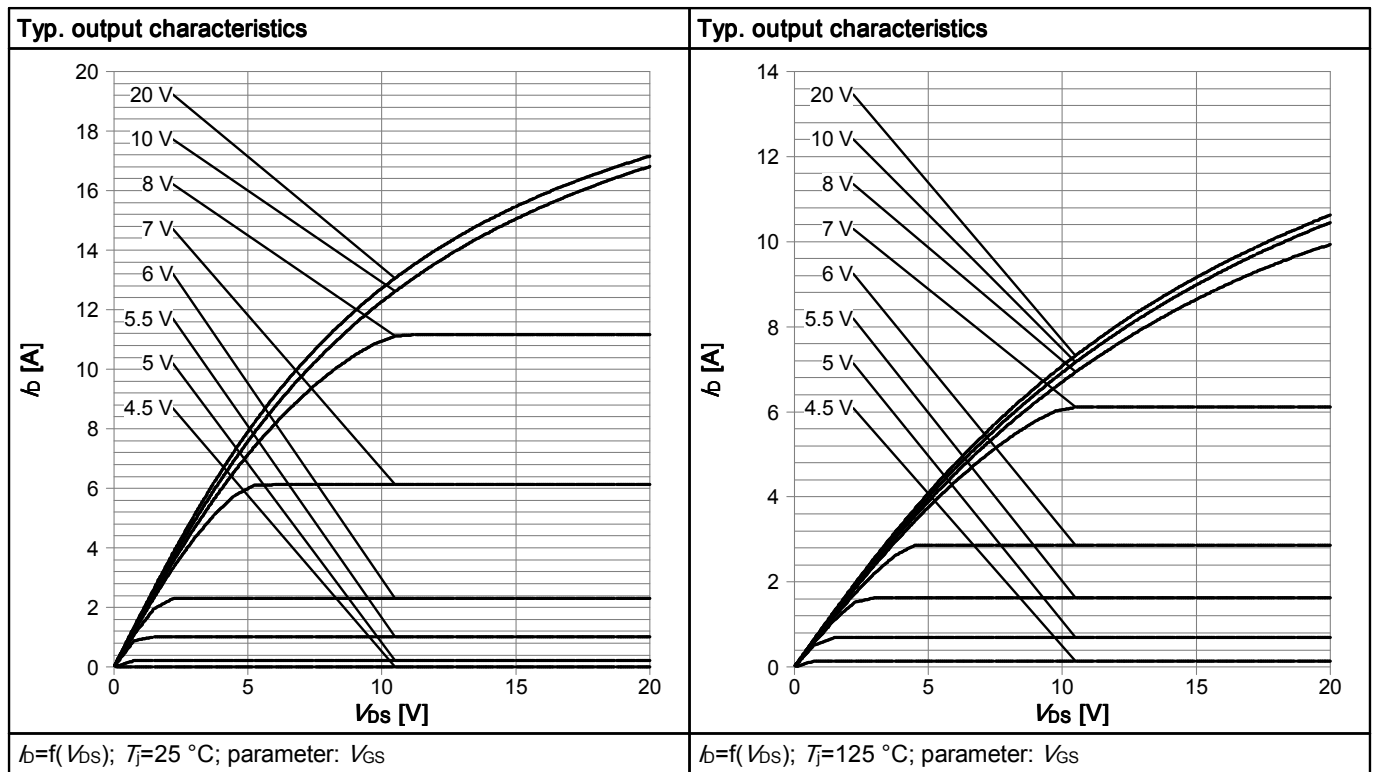


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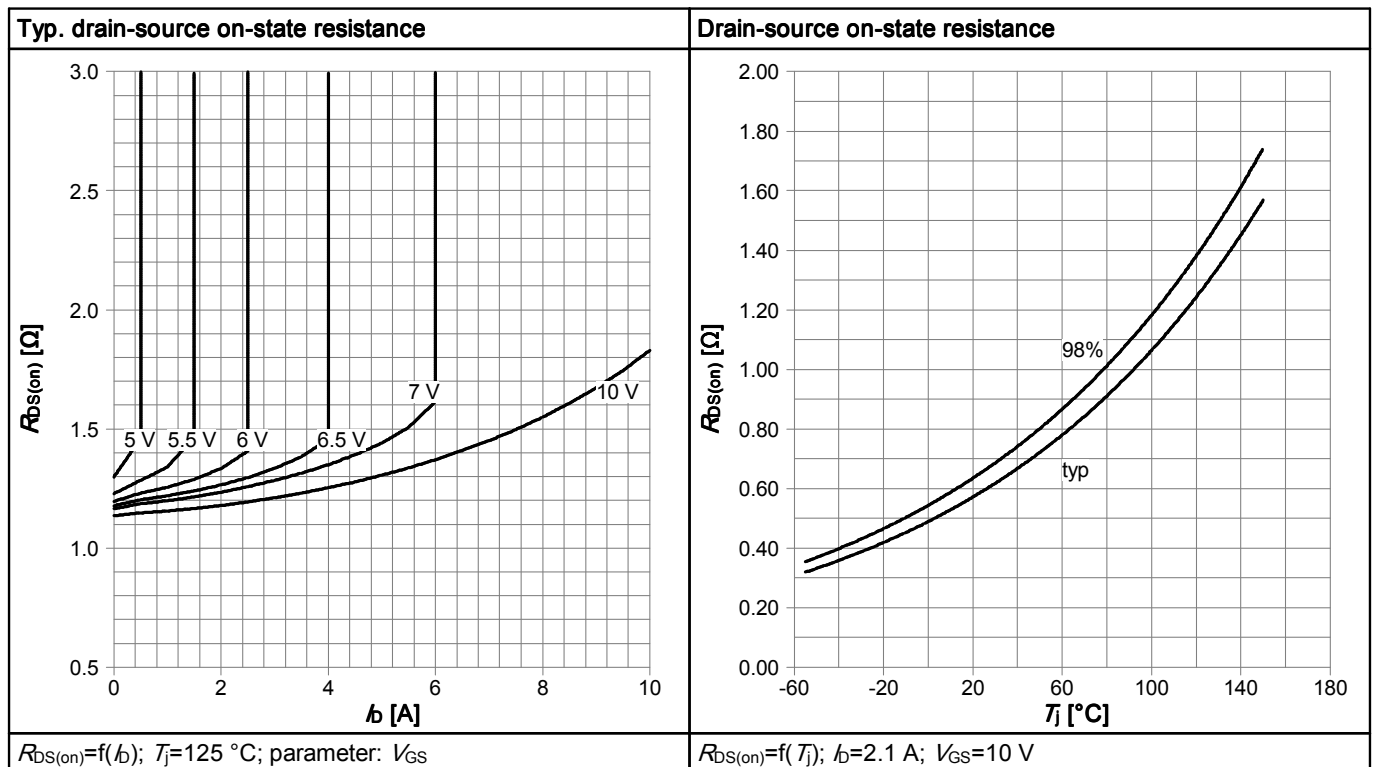


Table 16

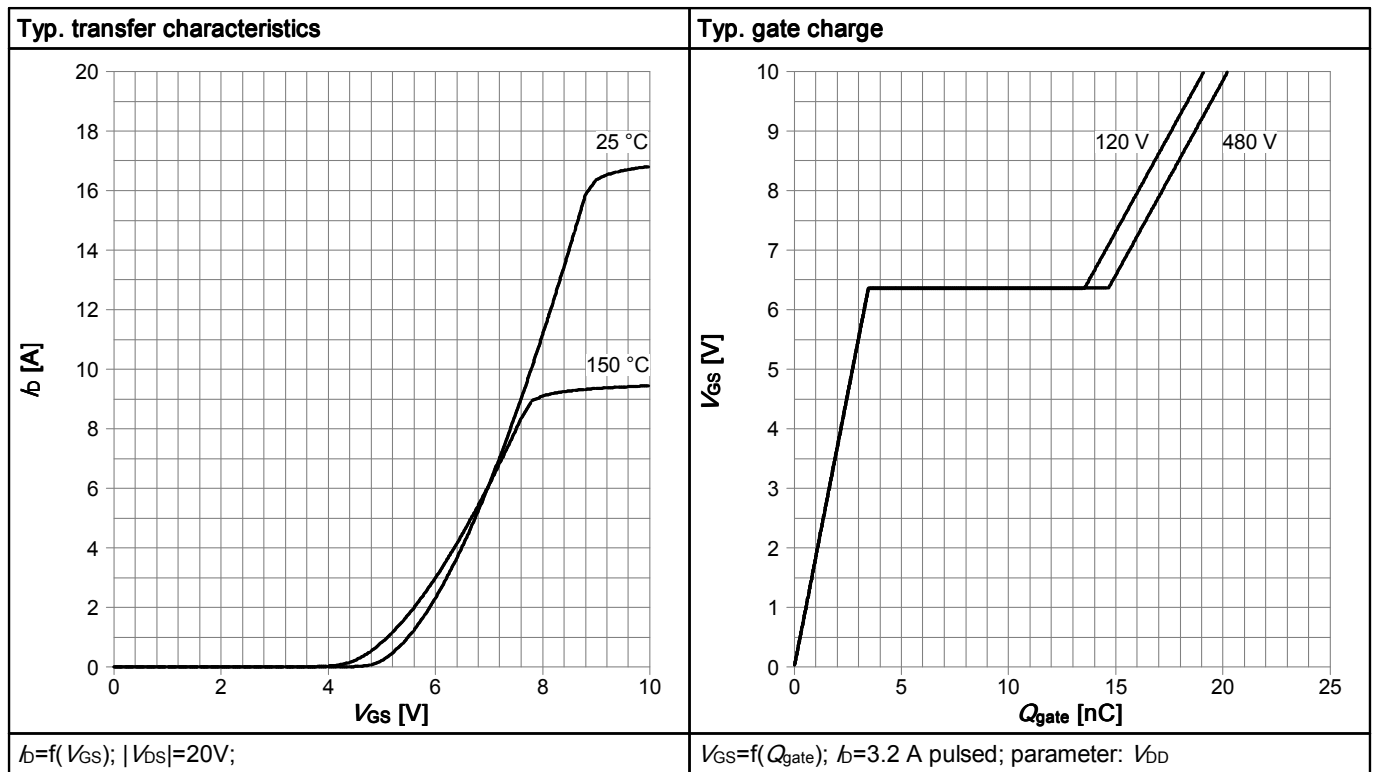


Table 17

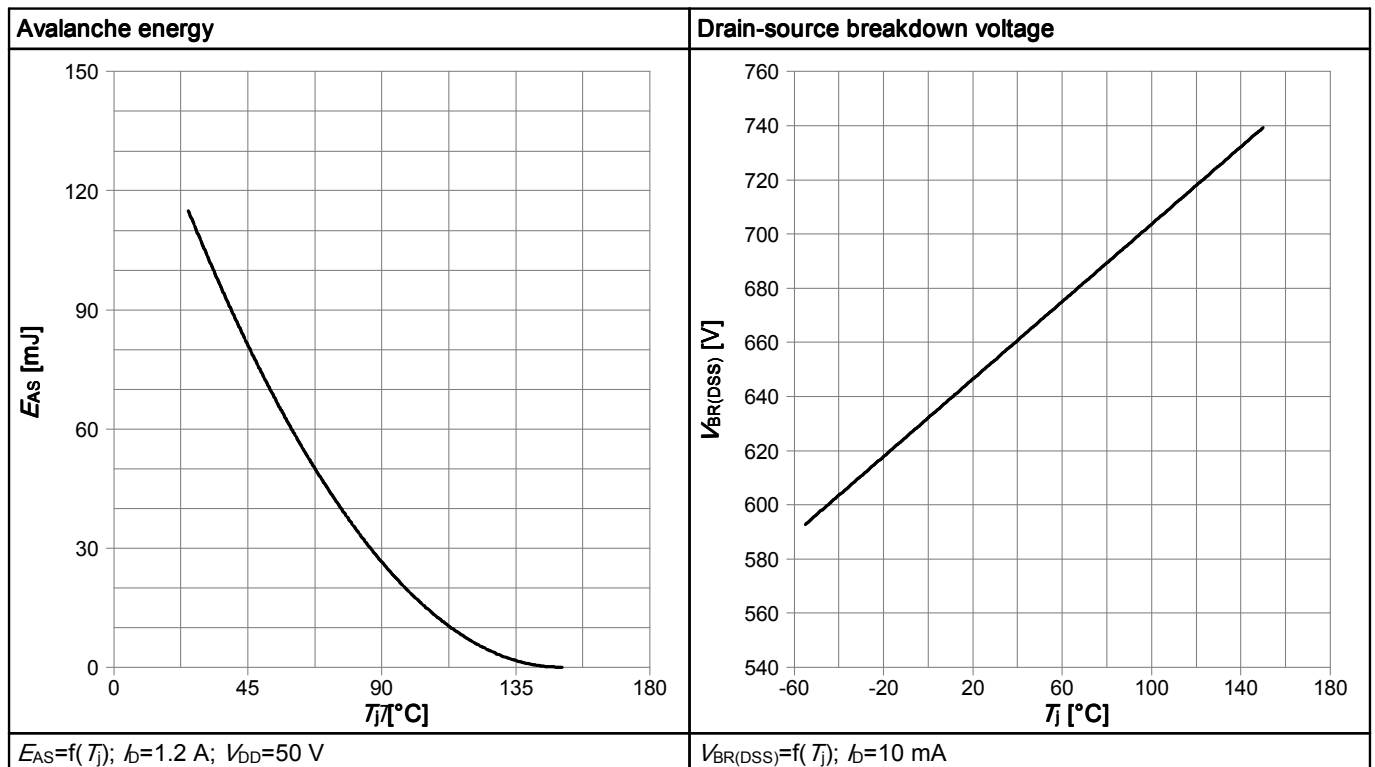


Table 18

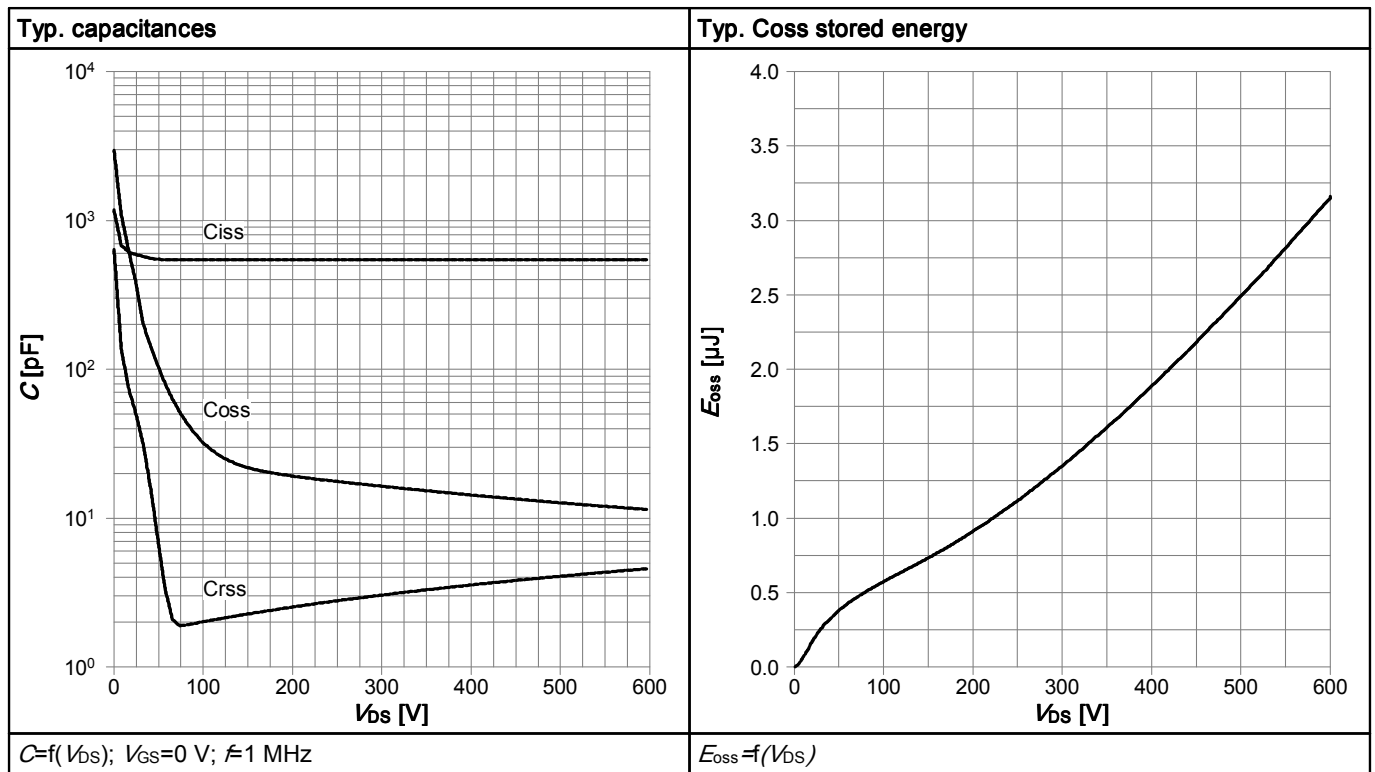
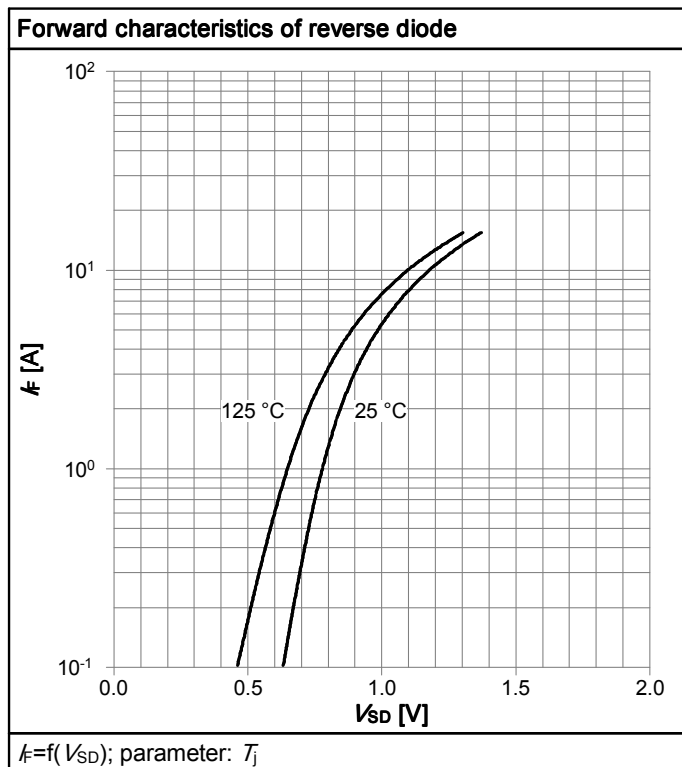
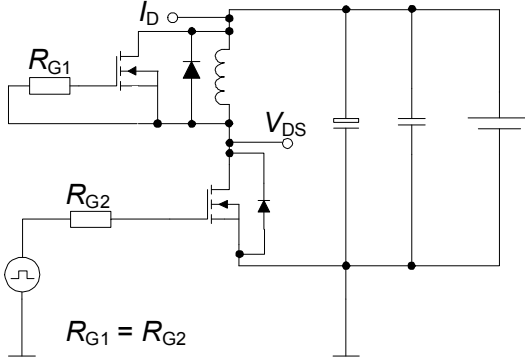
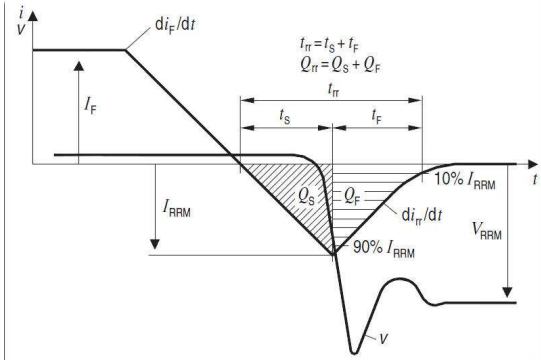


Table 19

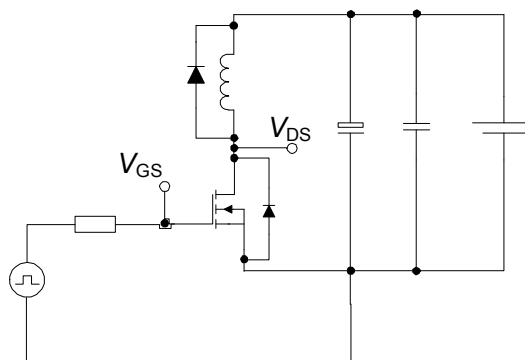
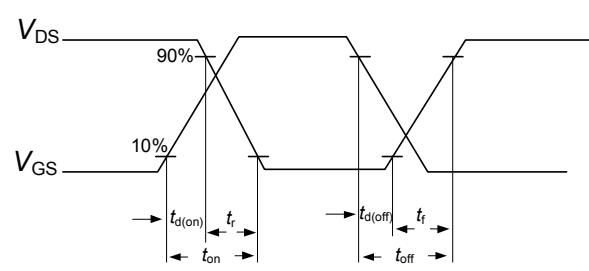


## 6 Test Circuits

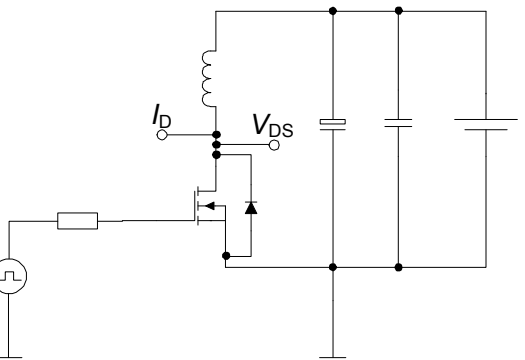
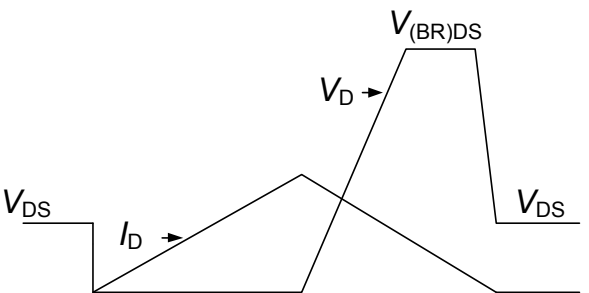
**Table 20 Diode\_characteristics**

| 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

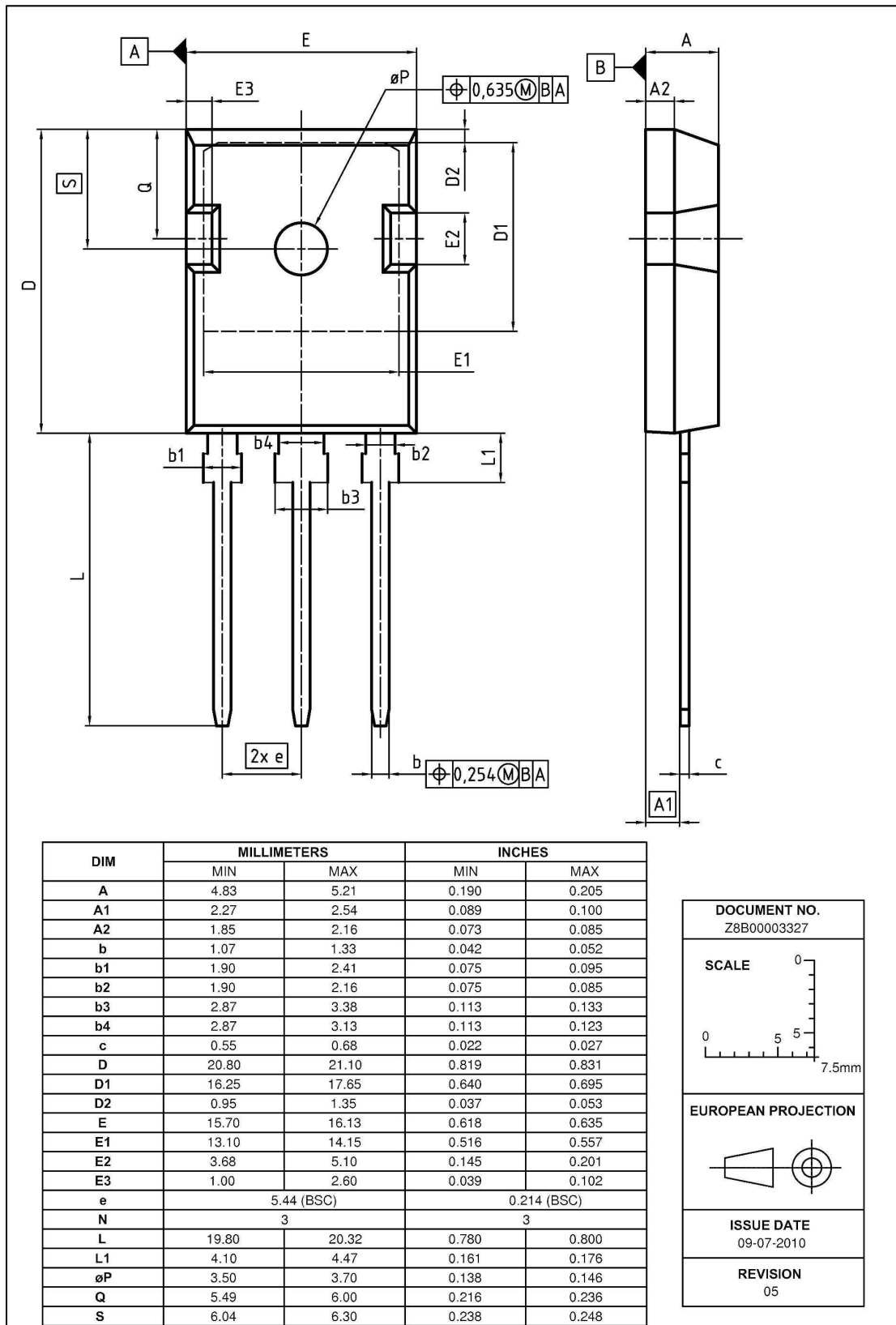
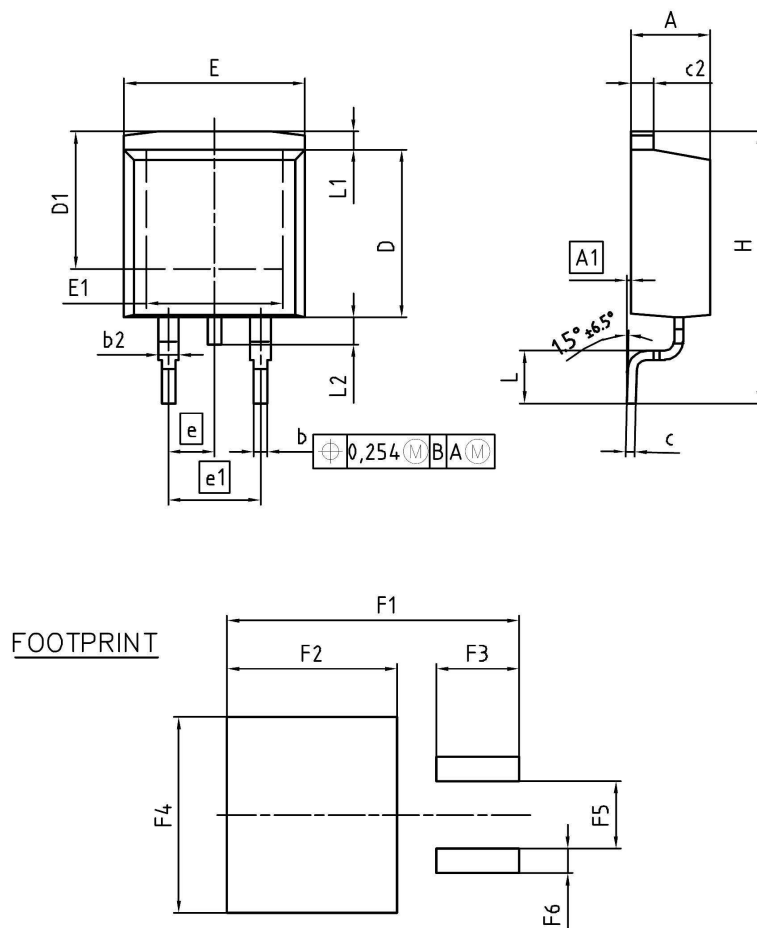


Figure 1 Outline PG-TO 247, dimensions in mm/inches



| 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 |

|                                                                                                              |
|--------------------------------------------------------------------------------------------------------------|
| DOCUMENT NO.<br>Z8B00003324                                                                                  |
| SCALE<br>0 5 5 7.5mm                                                                                         |
| EUROPEAN PROJECTION<br> |
| ISSUE DATE<br>30-08-2007                                                                                     |
| REVISION<br>01                                                                                               |

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

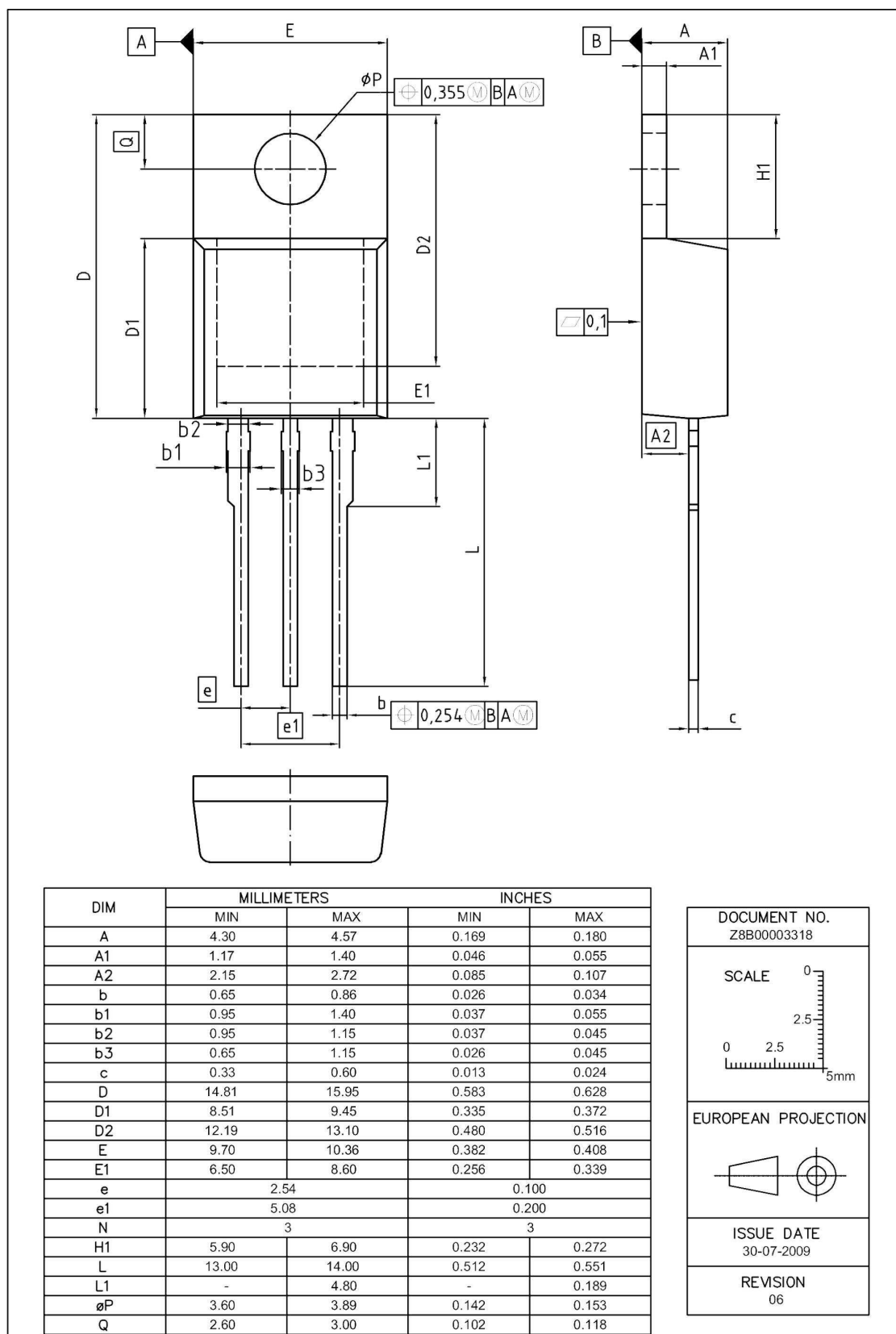


Figure 3 Outline PG-TO 220, dimensions in mm/inches

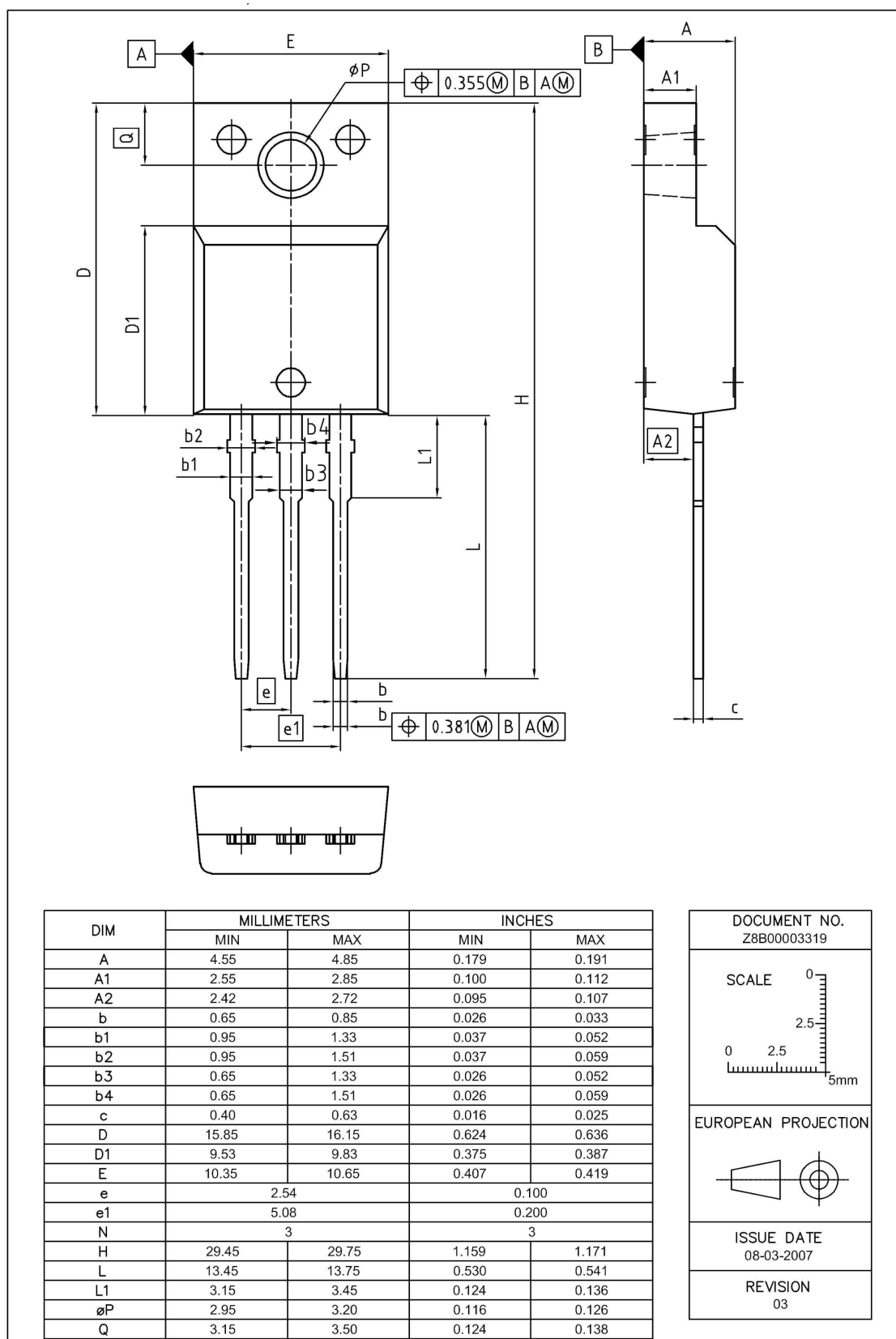
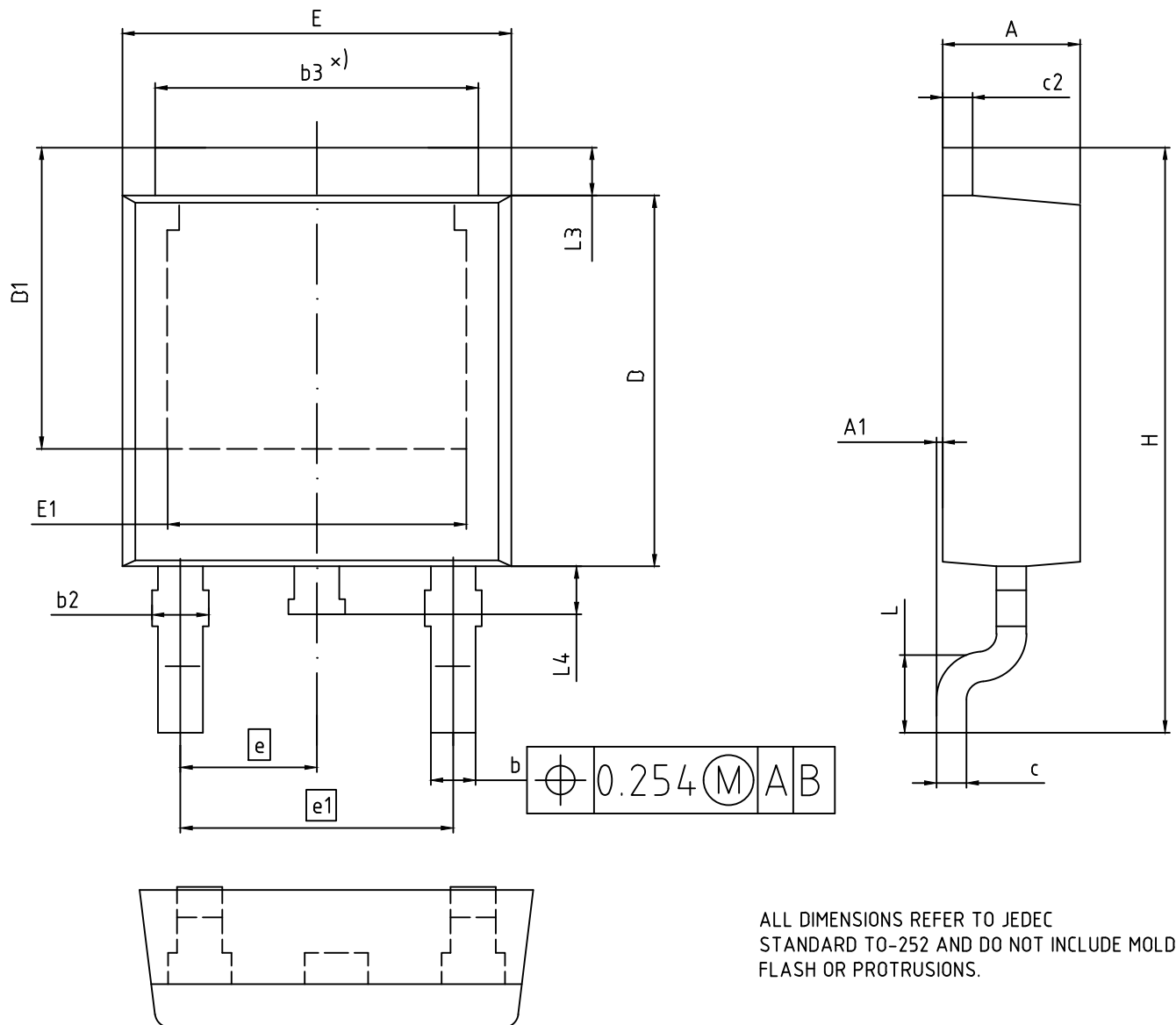


Figure 4 Outline PG-TO 220 FullPAK, dimensions in mm/inches

## 7 Package Outlines



| DIMENSION | MILLIMETERS |       |
|-----------|-------------|-------|
|           | MIN.        | MAX.  |
| A         | 2.16        | 2.41  |
| A1        | 0.00        | 0.15  |
| b         | 0.64        | 0.89  |
| b2        | 0.65        | 1.15  |
| b3        | 4.95        | 5.50  |
| c         | 0.46        | 0.61  |
| c2        | 0.40        | 0.98  |
| D         | 5.97        | 6.22  |
| D1        | 5.02        | 5.84  |
| E         | 6.35        | 6.73  |
| E1        | 4.32        | 5.50  |
| e         | 2.29        |       |
| e1        | 4.57        |       |
| N         | 3           |       |
| H         | 9.40        | 10.48 |
| L         | 1.18        | 1.78  |
| L3        | 0.89        | 1.27  |
| L4        | 0.51        | 1.02  |

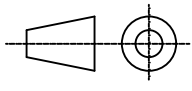
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| <b>REVISION</b><br>07                                                                                                     |
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| <b>EUROPEAN PROJECTION</b><br>       |
| <b>ISSUE DATE</b><br>01.04.2020                                                                                           |

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

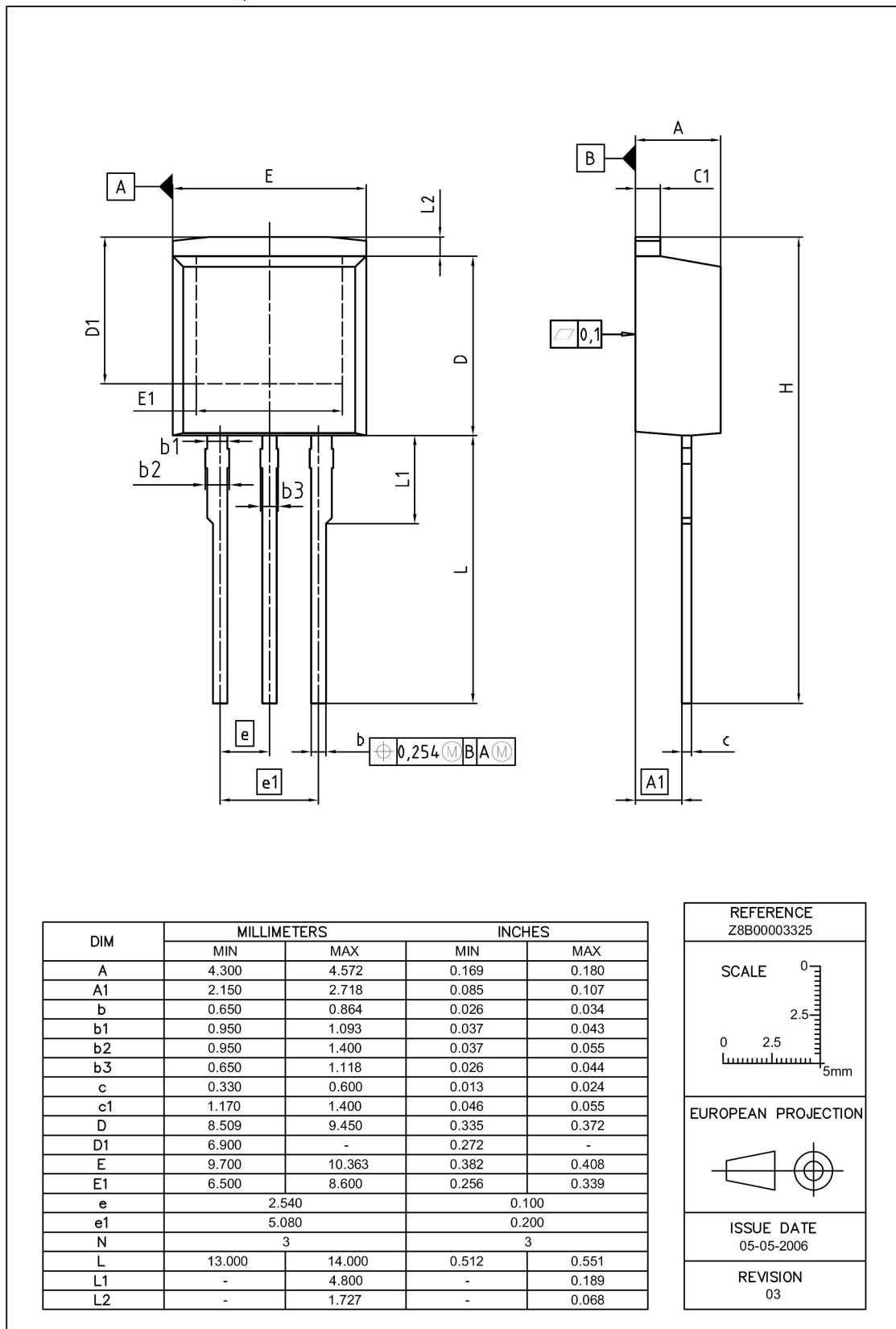


Figure 6 Outline PG-TO 262, dimensions in mm/inches

## 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

IPx65R660CFD

**Revision: 2020-05-26, Rev. 2.7**

Previous Revision

| Revision | Date       | Subjects (major changes since last revision) |
|----------|------------|----------------------------------------------|
| 2.1      | 2011-08-29 | update to CFD2 standard                      |
| 2.2      | 2011-09-15 | update pin naming                            |
| 2.3      | 2011-09-15 | update pin naming                            |
| 2.4      | 2011-09-15 | release of new pin naming                    |
| 2.5      | 2011-09-27 | update Igss test condition                   |
| 2.7      | 2020-05-26 | Update package outline                       |

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