

# MOSFET

Metal Oxide Semiconductor Field Effect Transistor

## CoolMOS C6

650V CoolMOS™ C6 Power Transistor  
IPx65R190C6

## Data Sheet

Rev. 2.0, 2011-05-09  
Final

Industrial & Multimarket

## 650V CoolMOS™ C6 Power Transistor

IPA65R190C6, IPB65R190C6  
 IPI65R190C6, IPP65R190C6  
 IPW65R190C6

### 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™ C6 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.

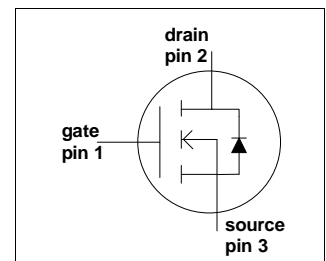
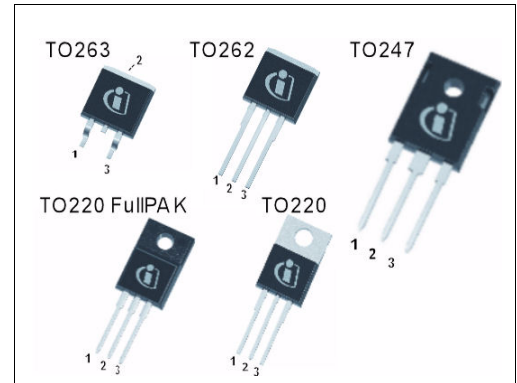
#### Features

- 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       |
|----------------------|-------|------------|
| $V_{DS} @ T_{j,max}$ | 700   | V          |
| $R_{DS(on),max}$     | 0.19  | $\Omega$   |
| $Q_{g,typ}$          | 73    | nC         |
| $I_{D,pulse}$        | 66    | A          |
| $E_{oss} @ 400V$     | 5.9   | $\mu J$    |
| Body diode $di/dt$   | 500   | A/ $\mu s$ |

| Type / Ordering Code | Package           | Marking | Related Links   |
|----------------------|-------------------|---------|---|
| IPW65R190C6          | PG-TO247          | 65C6190 | <a href="#">IFX CoolMOS Webpage</a><br><a href="#">IFX Design tools</a> |
| IPB65R190C6          | PG-TO263          |         |   |
| IPI65R190C6          | PG-TO262          |         |   |
| IPP65R190C6          | PG-TO220          |         |   |
| IPA65R190C6          | PG-TO220 FullIPAK |         |   |

1) J-STD20 and JESD22

## Table of Contents

|   |   |    |
|---|---|----|
| 1 | Description .....                         | 2  |
|   | Table of Contents .....                   | 3  |
| 2 | Maximum ratings .....                     | 4  |
| 3 | Thermal characteristics .....             | 5  |
| 4 | Electrical characteristics .....          | 6  |
| 5 | Electrical characteristics diagrams ..... | 8  |
| 6 | Test circuits .....                       | 13 |
| 7 | Package outlines .....                    | 14 |
| 8 | Revision History .....                    | 19 |

## 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>               | $I_D$          | -      | -    | 20.2 | A    | $T_C = 25\text{ °C}$  |
|  |                |        |      | 12.8 |      | $T_C = 100\text{ °C}$   |
| Pulsed drain current <sup>2)</sup>                   | $I_{D,pulse}$  | -      | -    | 66   | A    | $T_C = 25\text{ °C}$  |
| Avalanche energy, single pulse                       | $E_{AS}$       | -      | -    | 485  | mJ   | $I_D = 3.5\text{ A}, V_{DD} = 50\text{ V}$                                |
| Avalanche energy, repetitive                         | $E_{AR}$       | -      | -    | 0.73 |      | $I_D = 3.5\text{ A}, V_{DD} = 50\text{ V}$                                |
| Avalanche current, repetitive                        | $I_{AR}$       | -      | -    | 3.5  | 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 | $P_{tot}$      | -      | -    | 151  | W    | $T_C = 25\text{ °C}$  |
| Power dissipation for TO-220 FullPAK                 | $P_{tot}$      | -      | -    | 34   |      |   |
| 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                     | $I_S$          | -      | -    | 17.5 | A    | $T_C = 25\text{ °C}$  |
| Diode pulse current <sup>2)</sup>                    | $I_{S,pulse}$  | -      | -    | 66   | 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/dt          |        |      | 500  | A/μs |   |

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 non FullPAK**

| Parameter  | Symbol     | Values |      |      | Unit | Note / Test Condition                 |
|--|------------|--------|------|------|------|---------------------------------------|
|  |            | Min.   | Typ. | Max. |      |                                       |
| Thermal resistance, junction - case                        | $R_{thJC}$ | -      | -    | 0.83 | °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 FullPAK**

| Parameter  | Symbol     | Values |      |      | Unit | Note / Test Condition                 |
|--|------------|--------|------|------|------|---------------------------------------|
|  |            | Min.   | Typ. | Max. |      |                                       |
| Thermal resistance, junction - case                        | $R_{thJC}$ | -      | -    | 3.7  | °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 |

**Table 5 Thermal characteristics SMD**

| Parameter   | Symbol     | Values |      |      | Unit | Note / Test Condition                         |
|---|------------|--------|------|------|------|---|
|   |            | Min.   | Typ. | Max. |      |   |
| Thermal resistance, junction - case                     | $R_{thJC}$ | -      | -    | 0.83 | °C/W | SMD version, device on PCB, minimal footprint |
| Thermal resistance, junction - ambient                  | $R_{thJA}$ | -      | -    | 62   |      |   |
|   |            | -      | 35   | -    |      |   |
| Soldering temperature, wave- & reflow soldering allowed | $T_{sold}$ | -      | -    | 260  | °C   | reflow MSL1                                   |

1) 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

Electrical characteristics, at  $T_J=25\text{ °C}$ , 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             | $V_{GS}=0\text{ V}$ , $I_D=1.0\text{ mA}$                            |
| Gate threshold voltage           | $V_{GS(th)}$  | 2.5    | 3    | 3.5  |               | $V_{DS}=V_{GS}$ , $I_D=0.73\text{ mA}$                               |
| Zero gate voltage drain current  | $I_{DSS}$     | -      | -    | 1    | $\mu\text{A}$ | $V_{DS}=650\text{ V}$ , $V_{GS}=0\text{ V}$ ,<br>$T_J=25\text{ °C}$  |
|                                  |               | -      | 10   | -    |               | $V_{DS}=650\text{ V}$ , $V_{GS}=0\text{ V}$ ,<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 | $R_{DS(on)}$  | -      | 0.17 | 0.19 | $\Omega$      | $V_{GS}=10\text{ V}$ , $I_D=7.3\text{ A}$ ,<br>$T_J=25\text{ °C}$    |
|                                  |               | -      | 0.44 | -    |               | $V_{GS}=10\text{ V}$ , $I_D=7.3\text{ A}$ ,<br>$T_J=150\text{ °C}$   |
| Gate resistance                  | $R_G$         | -      | 8.5  | -    | $\Omega$      | $f=1\text{ MHz}$ , open drain  |

**Table 7 Dynamic characteristics**

| Parameter  | Symbol       | Values |      |      | Unit | Note / Test Condition  |
|--|--------------|--------|------|------|------|--|
|  |              | Min.   | Typ. | Max. |      |  |
| Input capacitance  | $C_{iss}$    | -      | 1620 | -    | pF   | $V_{GS}=0\text{ V}$ , $V_{DS}=100\text{ V}$ ,<br>$f=1\text{ MHz}$                                |
| Output capacitance   | $C_{oss}$    | -      | 98   | -    |      |  |
| Effective output capacitance, energy related <sup>1)</sup> | $C_{o(er)}$  | -      | 65   | -    |      |  |
| Effective output capacitance, time related <sup>2)</sup>   | $C_{o(tr)}$  | -      | 308  | -    |      | $I_D=\text{constant}$ , $V_{GS}=0\text{ V}$<br>$V_{DS}=0\dots480\text{ V}$                       |
| Turn-on delay time   | $t_{d(on)}$  | -      | 13   | -    | ns   | $V_{DD}=400\text{ V}$ ,<br>$V_{GS}=13\text{ V}$ , $I_D=11\text{ A}$ ,<br>$R_G=3.4\text{ }\Omega$ |
| Rise time  | $t_r$        | -      | 12   | -    |      |  |
| Turn-off delay time  | $t_{d(off)}$ | -      | 133  | -    |      |  |
| Fall time  | $t_f$        | -      | 10   | -    |      |  |

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 8 Gate charge characteristics**

| Parameter             | Symbol        | Values |      |      | Unit | Note / Test Condition   |
|-----------------------|---------------|--------|------|------|------|---|
|                       |               | Min.   | Typ. | Max. |      |   |
| Gate to source charge | $Q_{gs}$      | -      | 8.9  | -    | nC   | $V_{DD}=480\text{ V}$ , $I_D=11\text{ A}$ ,<br>$V_{GS}=0\text{ to }10\text{ V}$ |
| Gate to drain charge  | $Q_{gd}$      | -      | 38   | -    |      |   |
| Gate charge total     | $Q_g$         | -      | 73   | -    |      |   |
| Gate plateau voltage  | $V_{plateau}$ | -      | 5.5  | -    | V    |   |

**Table 9 Reverse diode characteristics**

| Parameter                     | Symbol    | Values |      |      | Unit          | Note / Test Condition  |
|-------------------------------|-----------|--------|------|------|---------------|--|
|                               |           | Min.   | Typ. | Max. |               |  |
| Diode forward voltage         | $V_{SD}$  | -      | 0.9  | -    | V             | $V_{GS}=0\text{ V}$ , $I_F=11\text{ A}$ ,<br>$T_j=25\text{ °C}$                |
| Reverse recovery time         | $t_{rr}$  | -      | 410  | -    | ns            | $V_R=400\text{ V}$ , $I_F=11\text{ A}$ ,<br>$di_F/dt=100\text{ A}/\mu\text{s}$ |
| Reverse recovery charge       | $Q_{rr}$  | -      | 6.1  | -    | $\mu\text{C}$ |  |
| Peak reverse recovery current | $I_{rrm}$ | -      | 28   | -    | A             |  |

5 Electrical characteristics diagrams

Table 10

| Power dissipation<br>Non FullPAK | Power dissipation<br>FullPAK |
|----------------------------------|------------------------------|
|                                  |                              |
| $P_{tot} = f(T_C)$               | $P_{tot} = f(T_C)$           |

Table 11

| Max. transient thermal impedance<br>Non FullPAK  | Max. transient thermal impedance<br>FullPAK      |
|--|--|
|  |  |
| $Z_{(thJC)} = f(t_p)$ ; parameter: $D = t_p / T$ | $Z_{(thJC)} = f(t_p)$ ; parameter: $D = t_p / T$ |



Electrical characteristics diagrams

Table 12

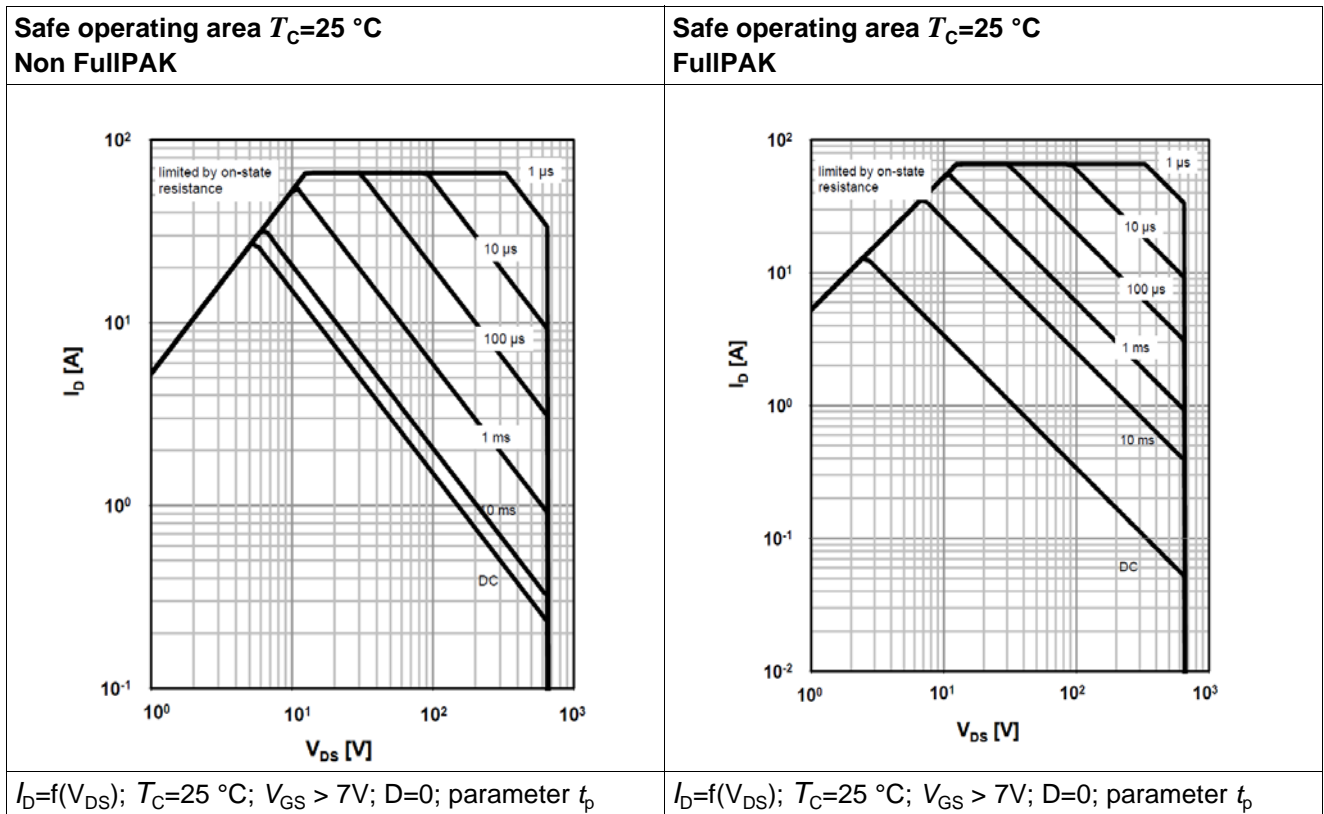


Table 13

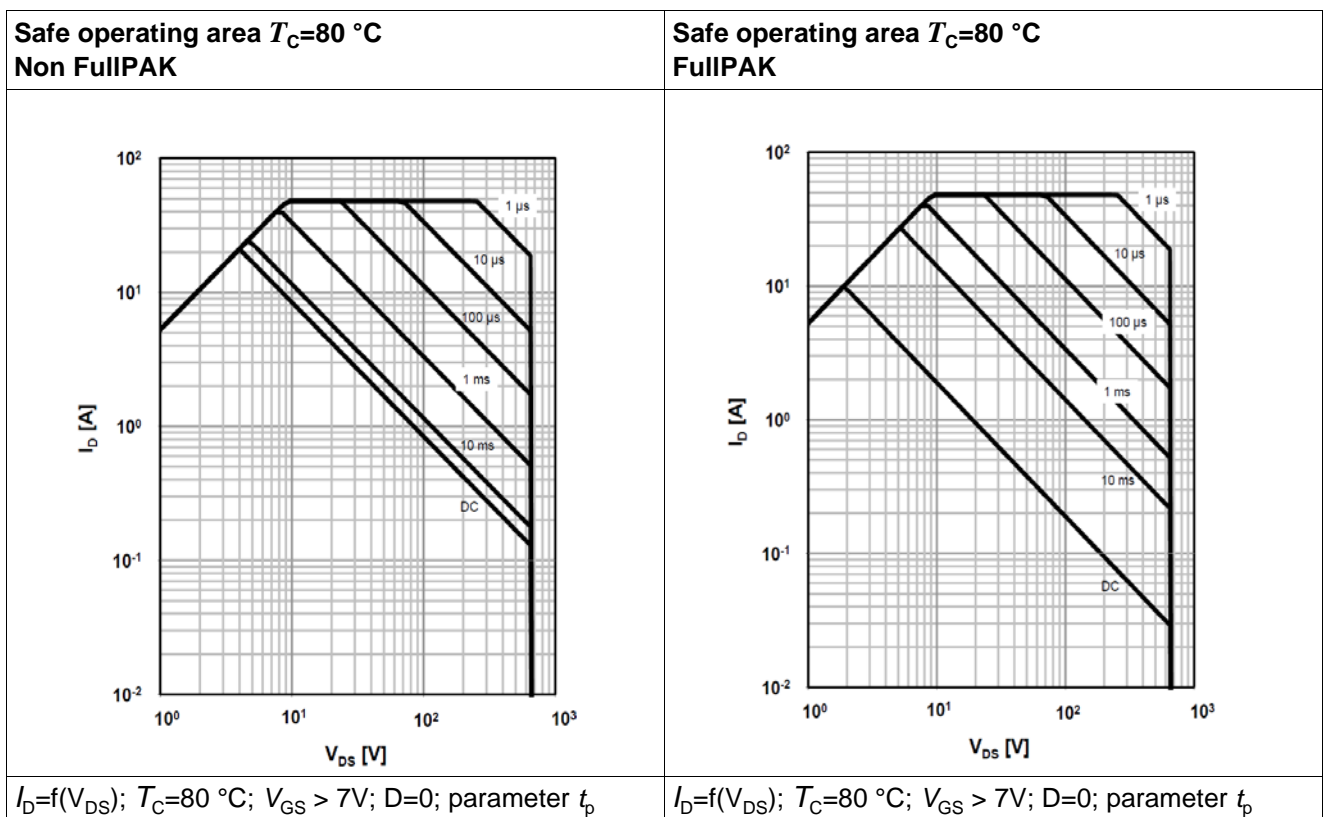


Table 14

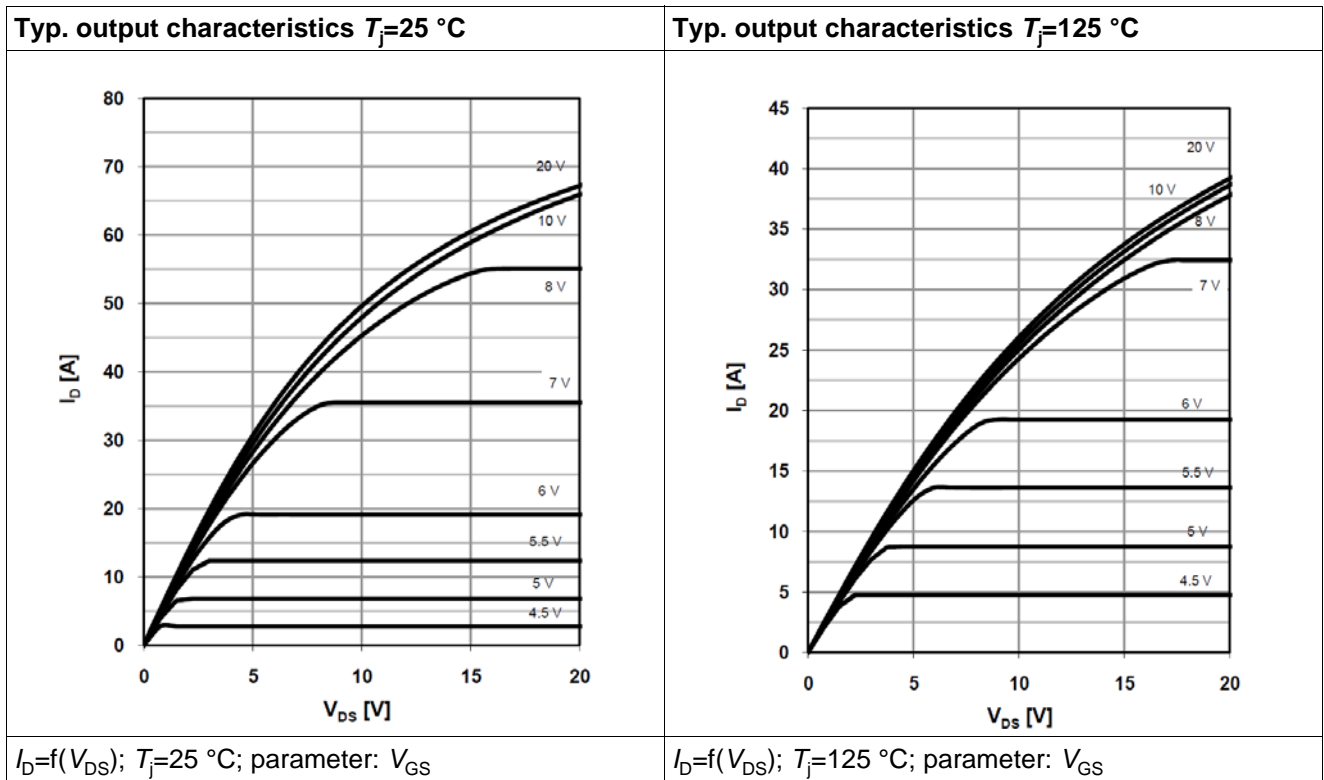


Table 15

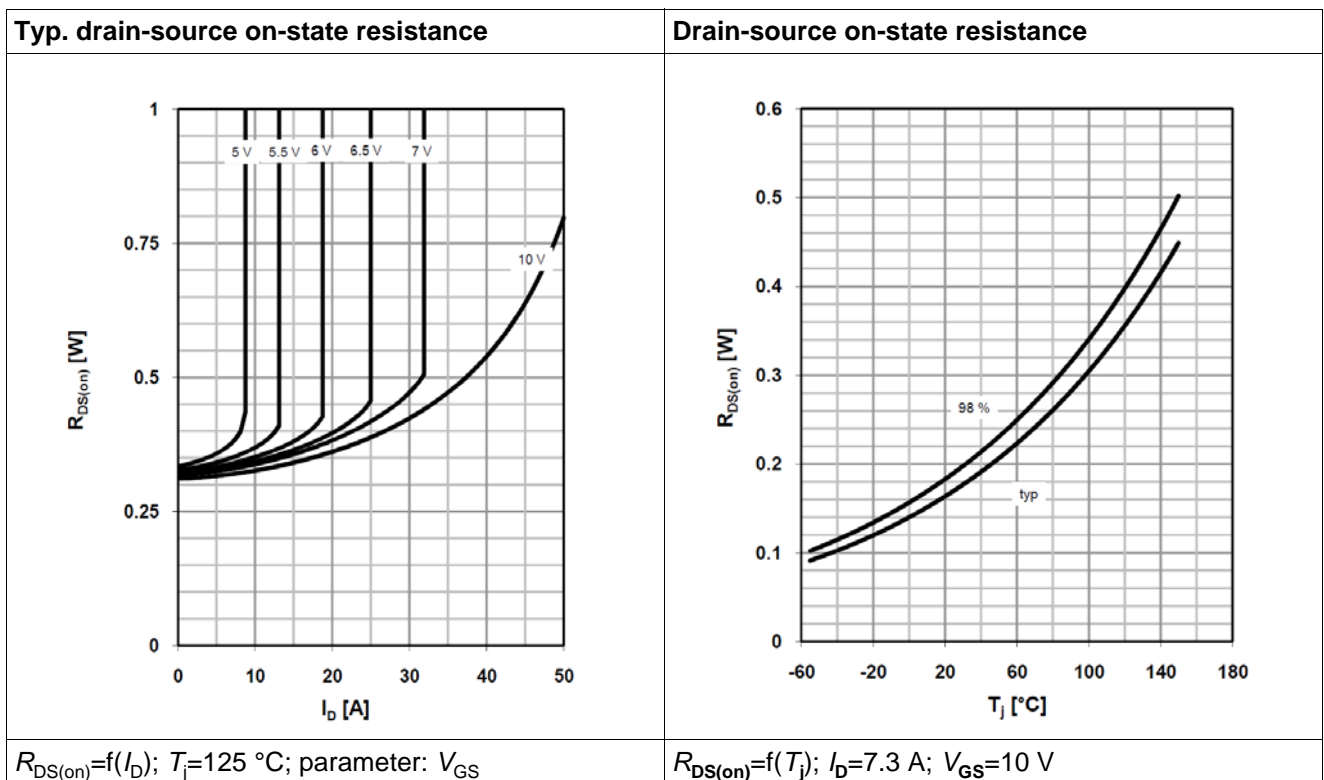


Table 16

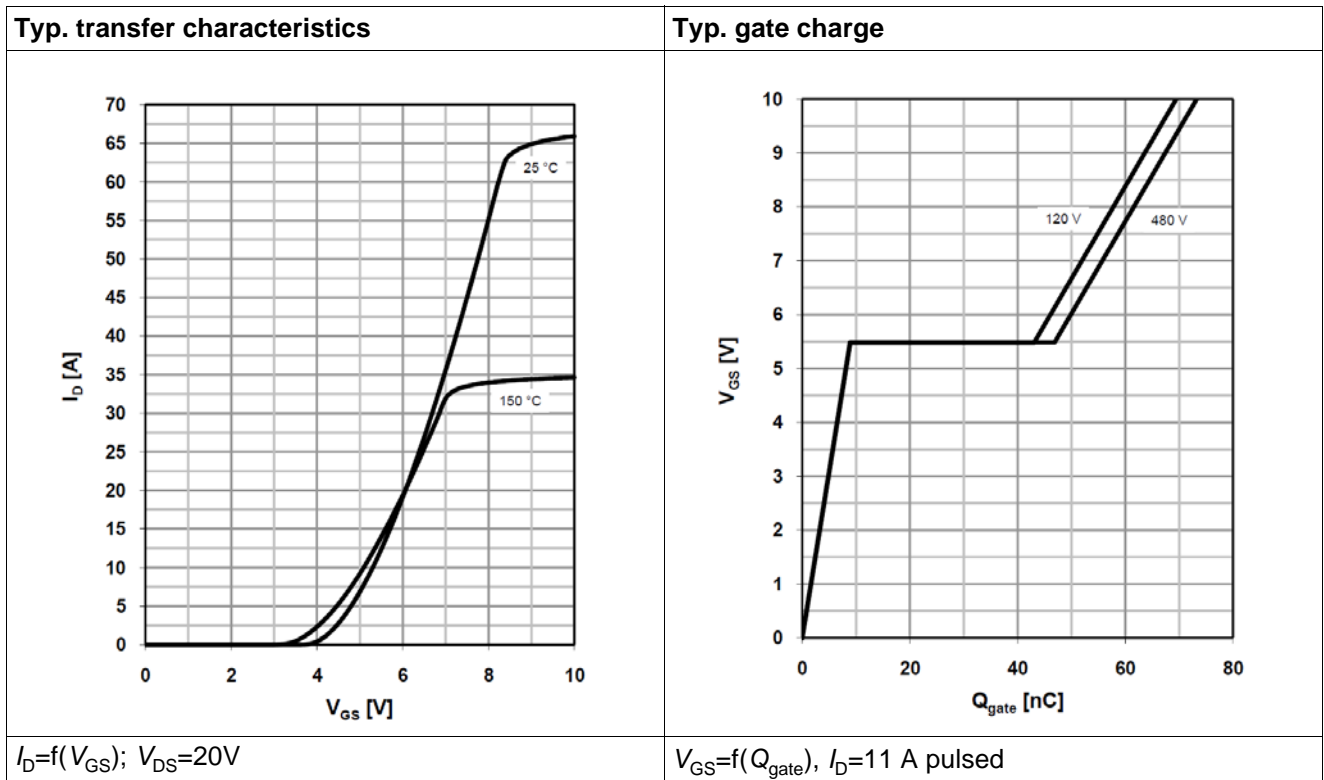


Table 17

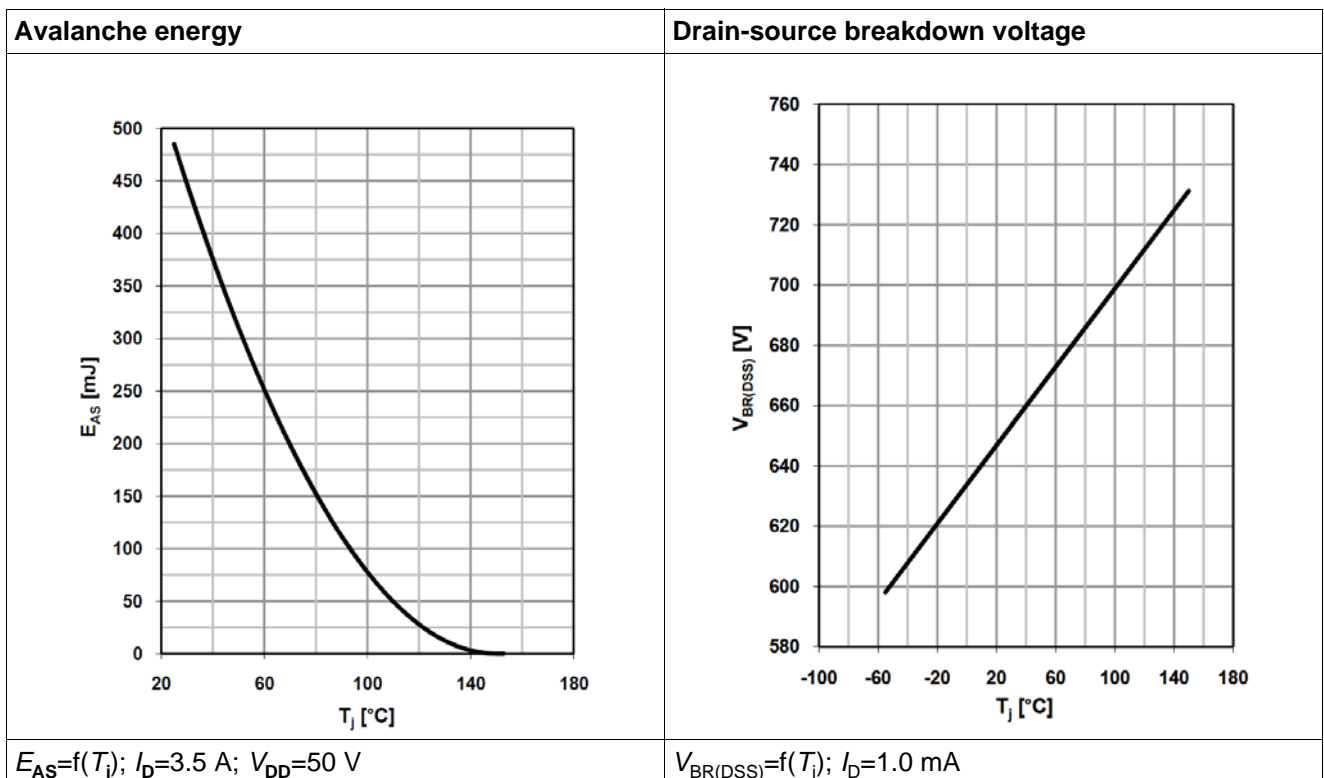


Table 18

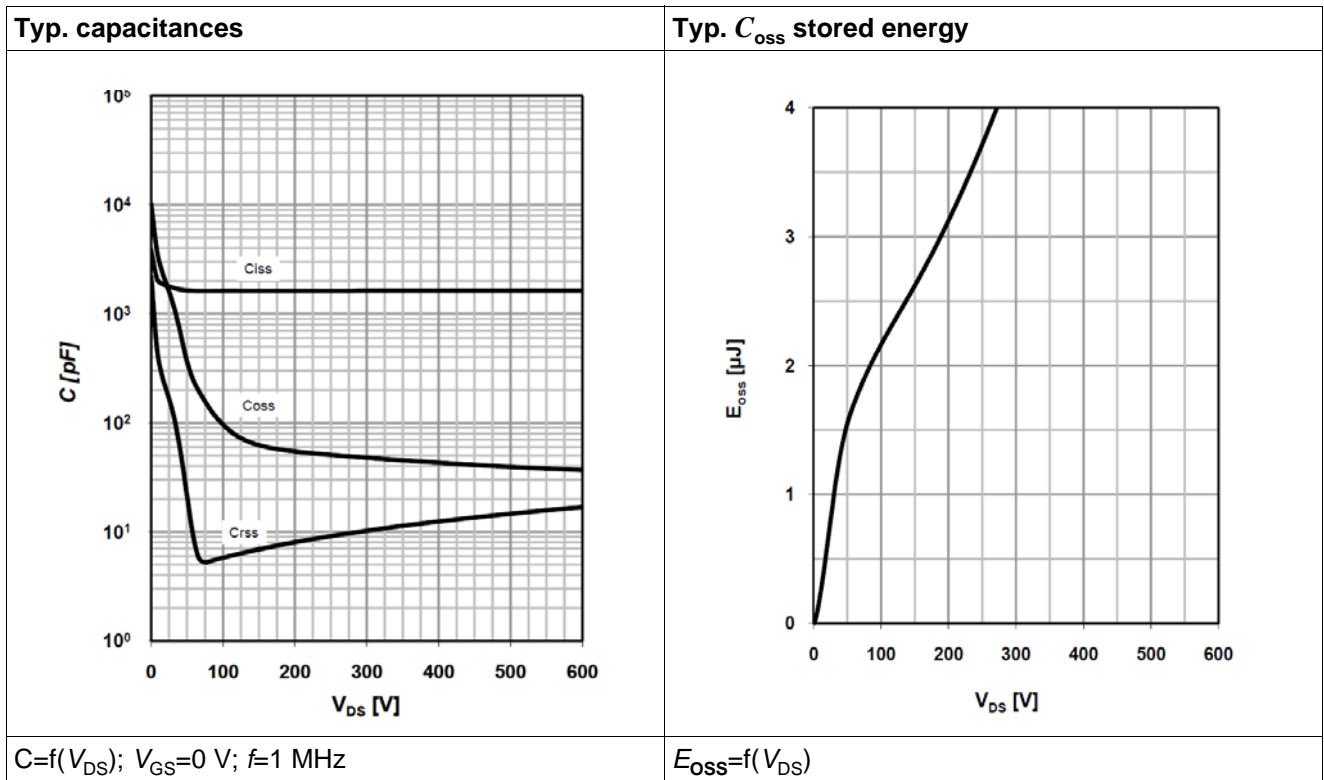
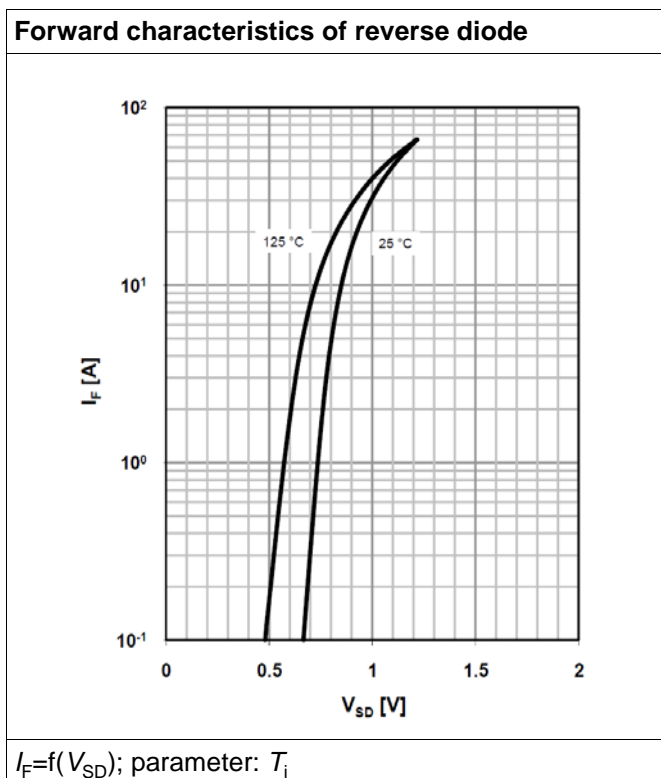


Table 19



## 6 Test circuits

Table 20 Switching times test circuit and waveform for inductive load

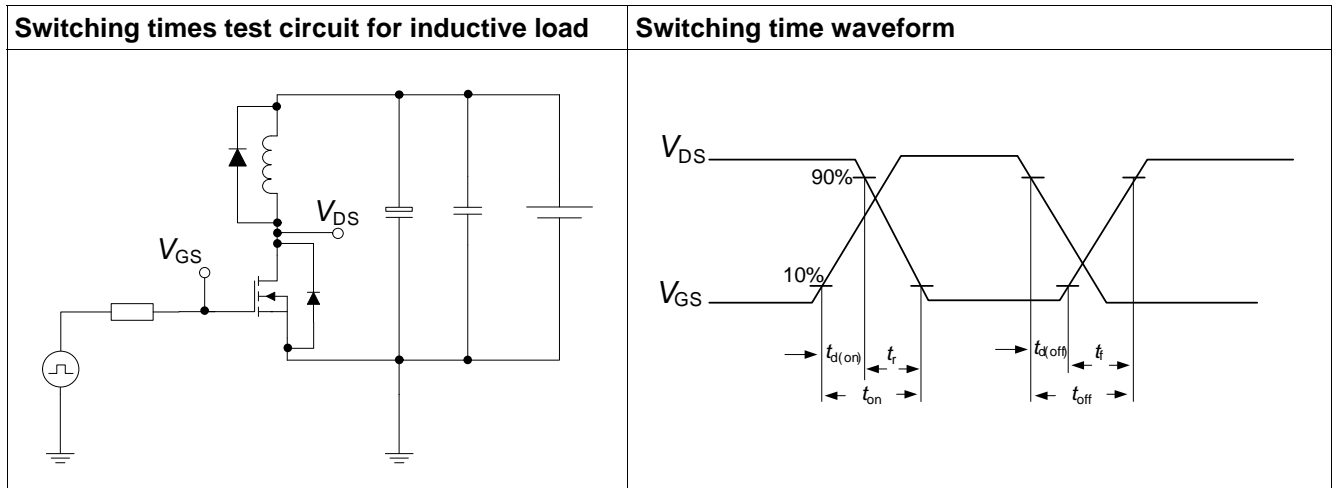


Table 21 Unclamped inductive load test circuit and waveform

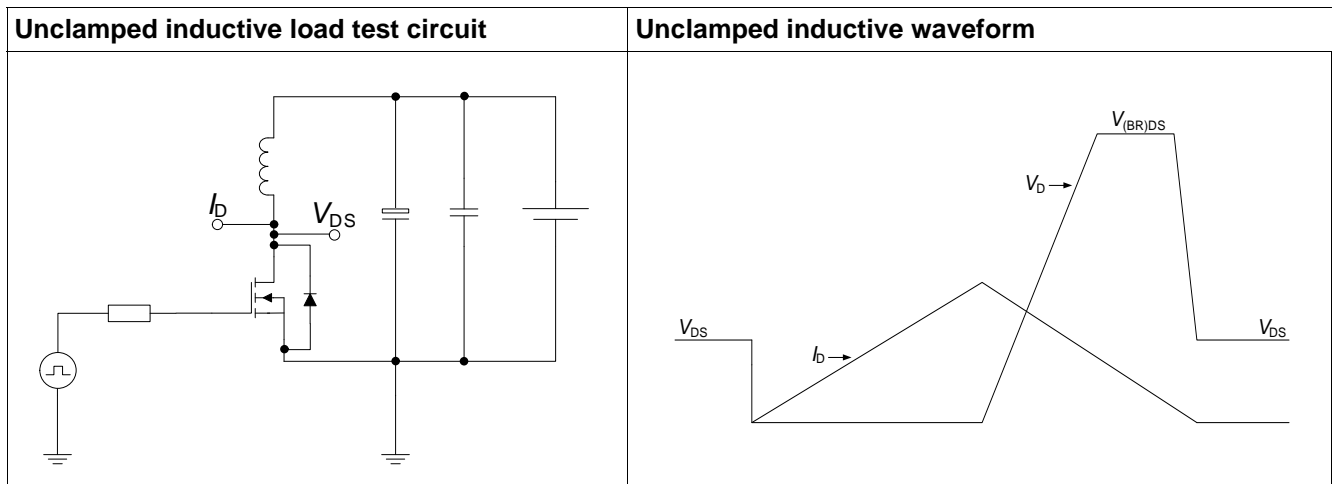
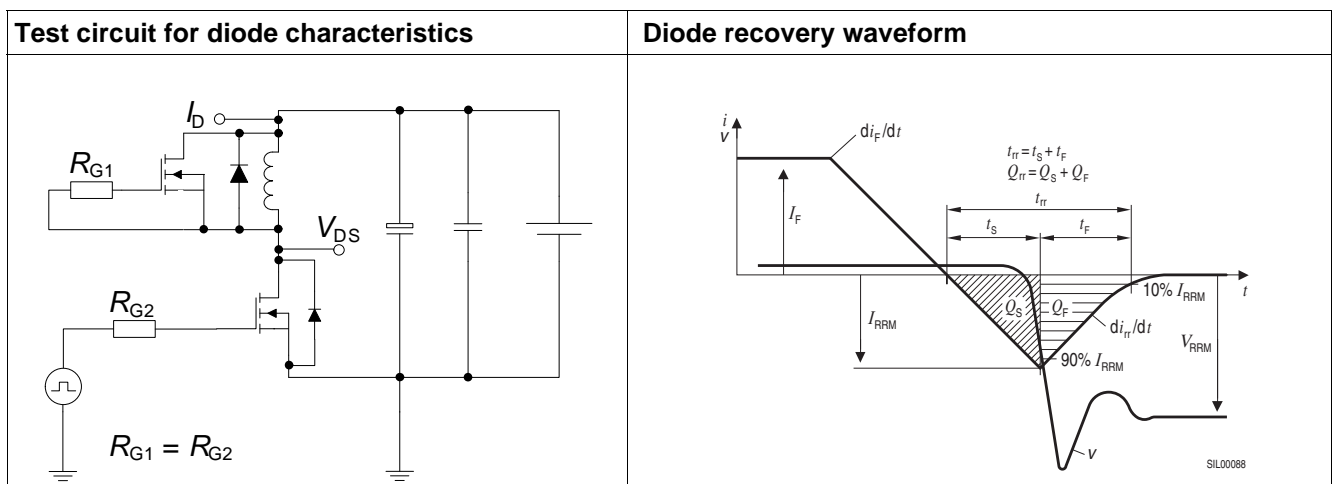


Table 22 Test circuit and waveform for diode characteristics



7 Package outlines

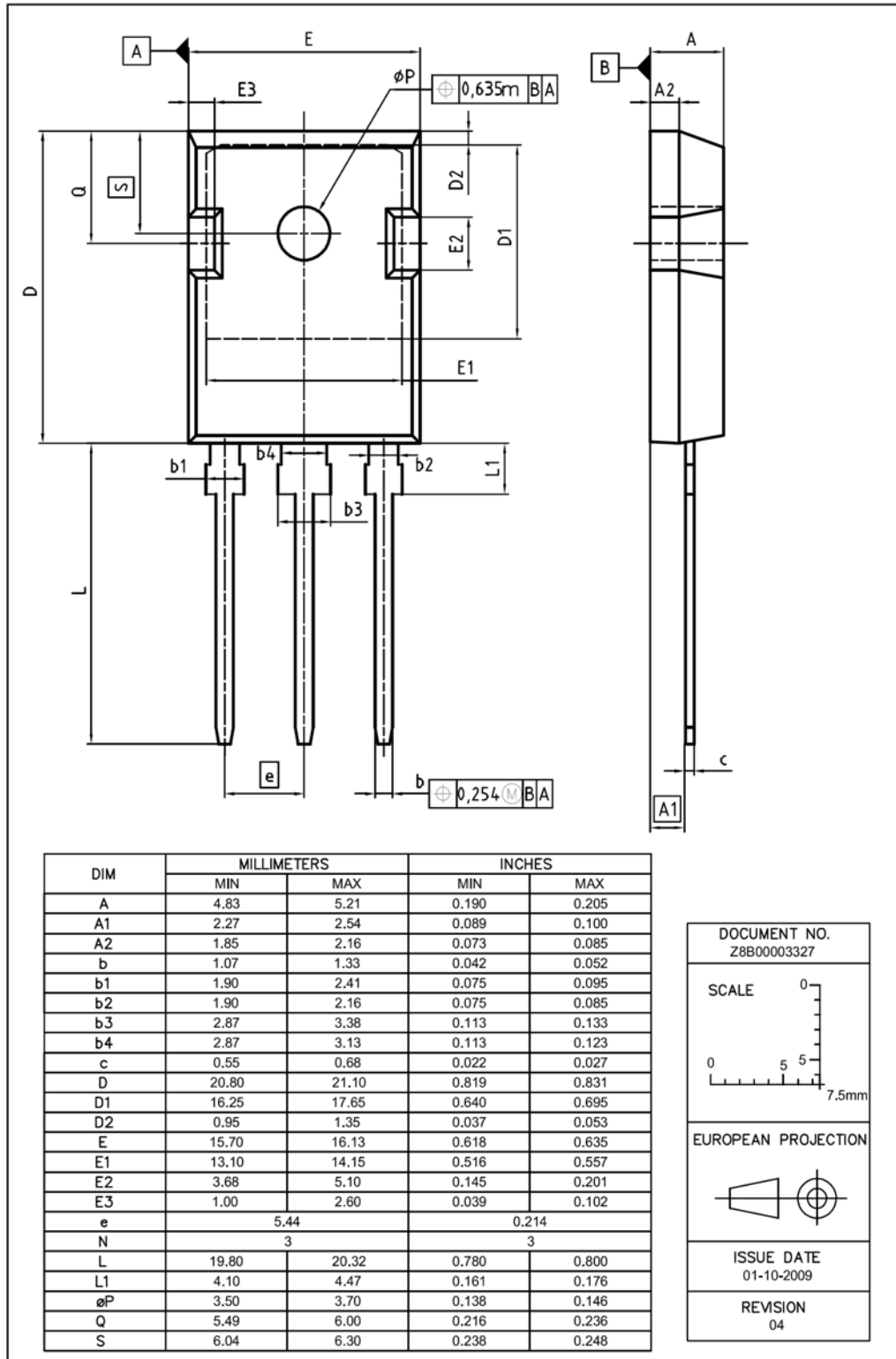
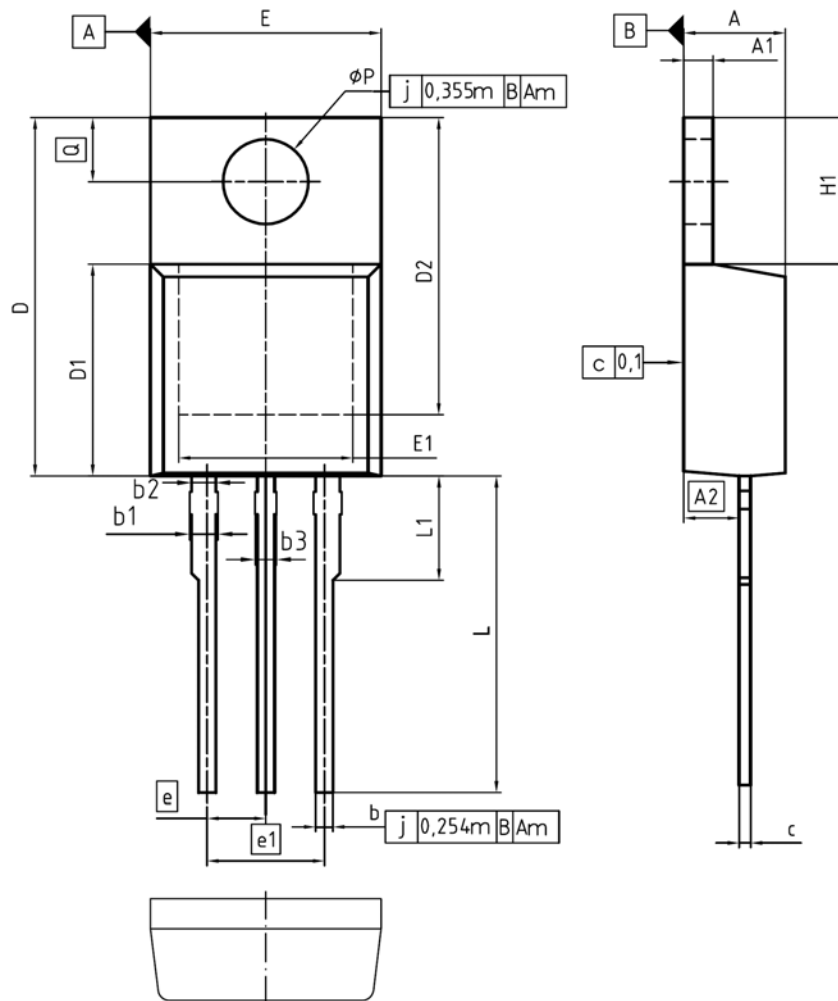


Figure 1 Outlines TO-247, dimensions in mm/inches



| 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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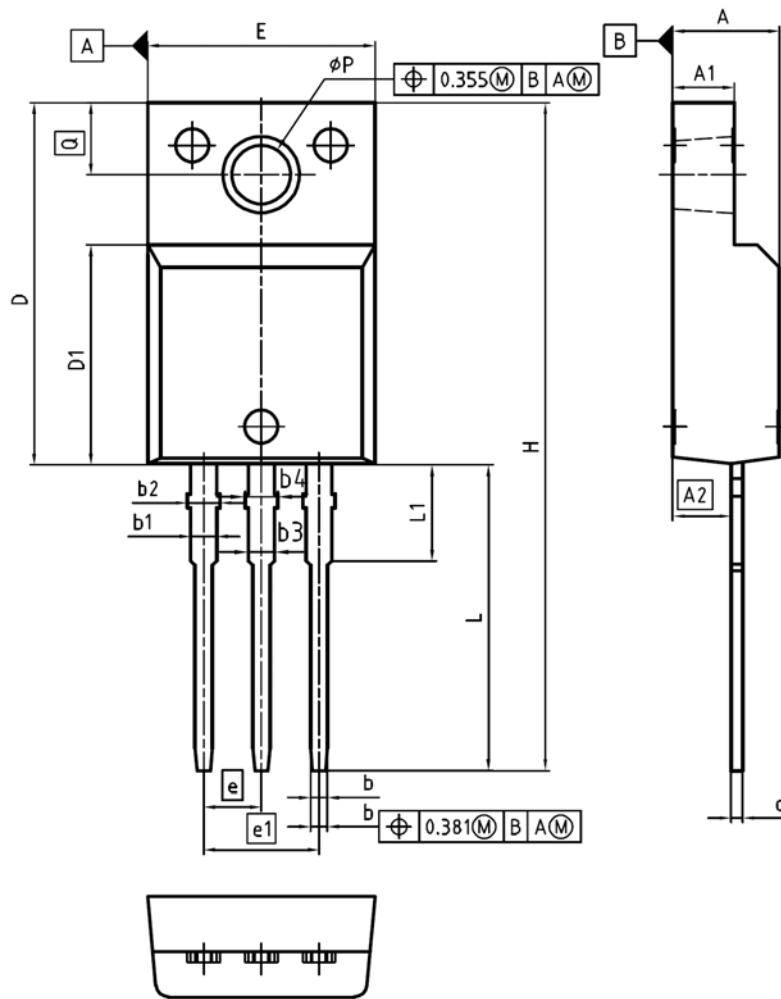
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23-08-2007

REVISION  
05

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



| DIM | MILLIMETERS |       | INCHES |       |
|-----|-------------|-------|--------|-------|
|     | MIN         | MAX   | MIN    | MAX   |
| A   | 4.55        | 4.85  | 0.179  | 0.191 |
| A1  | 2.55        | 2.85  | 0.100  | 0.112 |
| A2  | 2.42        | 2.72  | 0.095  | 0.107 |
| b   | 0.65        | 0.85  | 0.026  | 0.033 |
| b1  | 0.95        | 1.33  | 0.037  | 0.052 |
| b2  | 0.95        | 1.51  | 0.037  | 0.059 |
| b3  | 0.65        | 1.33  | 0.026  | 0.052 |
| b4  | 0.65        | 1.51  | 0.026  | 0.059 |
| c   | 0.40        | 0.63  | 0.016  | 0.025 |
| D   | 15.85       | 16.15 | 0.624  | 0.636 |
| D1  | 9.53        | 9.83  | 0.375  | 0.387 |
| E   | 10.35       | 10.65 | 0.407  | 0.419 |
| e   | 2.54        |       | 0.100  |       |
| e1  | 5.08        |       | 0.200  |       |
| N   | 3           |       | 3      |       |
| H   | 29.45       | 29.75 | 1.159  | 1.171 |
| L   | 13.45       | 13.75 | 0.530  | 0.541 |
| L1  | 3.15        | 3.45  | 0.124  | 0.136 |
| øP  | 2.95        | 3.20  | 0.116  | 0.126 |
| Q   | 3.15        | 3.50  | 0.124  | 0.138 |

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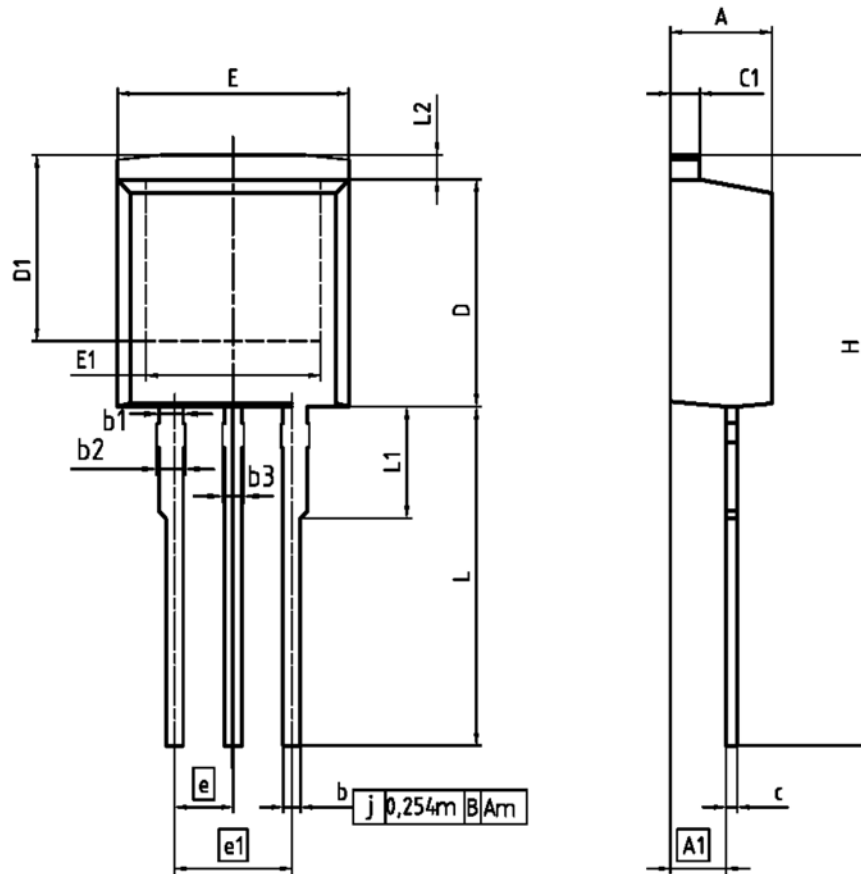
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03

Figure 3 Outlines TO-220 FullPAK, dimensions in mm/inches





| DIM | MILLIMETERS |        | INCHES |       |
|-----|-------------|--------|--------|-------|
|     | MIN         | MAX    | MIN    | MAX   |
| A   | 4.300       | 4.572  | 0.169  | 0.180 |
| A1  | 2.150       | 2.718  | 0.085  | 0.107 |
| b   | 0.650       | 0.864  | 0.026  | 0.034 |
| b1  | 0.950       | 1.093  | 0.037  | 0.043 |
| b2  | 0.950       | 1.400  | 0.037  | 0.055 |
| b3  | 0.850       | 1.118  | 0.026  | 0.044 |
| c   | 0.330       | 0.600  | 0.013  | 0.024 |
| c1  | 1.170       | 1.400  | 0.046  | 0.055 |
| D   | 8.509       | 9.450  | 0.335  | 0.372 |
| D1  | 6.900       | -      | 0.272  | -     |
| E   | 9.700       | 10.383 | 0.382  | 0.408 |
| E1  | 6.500       | 8.600  | 0.256  | 0.339 |
| e   | 2.540       |        | 0.100  |       |
| e1  | 5.080       |        | 0.200  |       |
| N   | 3           |        | 3      |       |
| L   | 13.000      | 14.000 | 0.512  | 0.551 |
| L1  | -           | 4.800  | -      | 0.189 |
| L2  | -           | 1.727  | -      | 0.068 |

REFERENCE  
JEDEC TO262

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05-05-2006

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TO262\_1

Figure 4 Outlines TO-262, dimensions in mm/inches

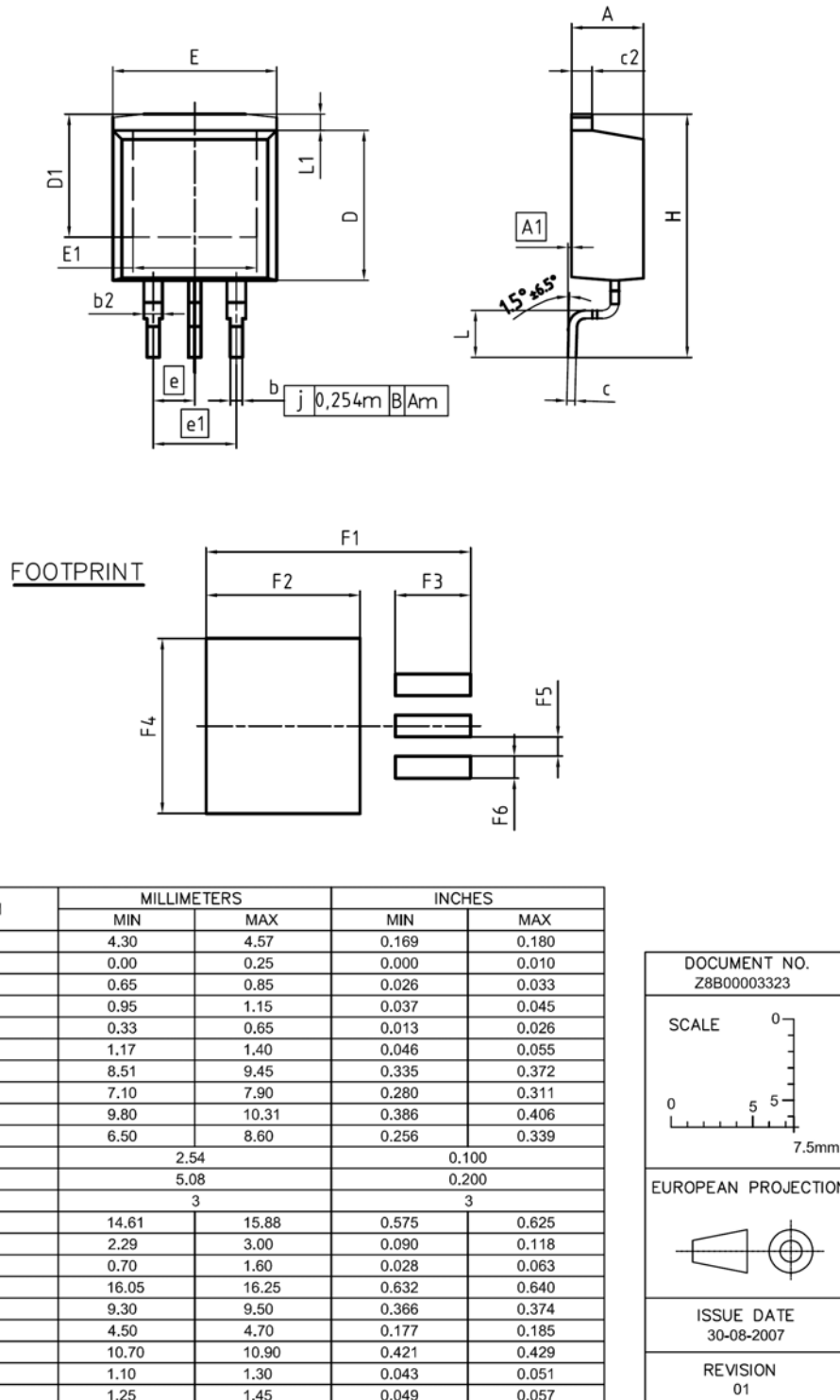


Figure 5 Outlines TO-263, dimensions in mm/inches

## 8 Revision History

Revision History: 2011-05-09, Rev. 2.0

Previous Revision:

| Revision | Subjects (major changes since last revision) |
|----------|--|
| 2.0      | Release of final data sheet                  |
|          |  |
|          |  |
|          |  |

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### Warnings

Due to technical requirements, components may contain dangerous substances. For information on the types in question, please contact the nearest Infineon Technologies Office.

The Infineon Technologies component described in this Data Sheet may be used in life-support devices or systems and/or automotive, aviation and aerospace applications or systems only with the express written approval of Infineon Technologies, if a failure of such components can reasonably be expected to cause the failure of that life-support, automotive, aviation and aerospace device or system or to affect the safety or effectiveness of that device or system. Life support devices or systems are intended to be implanted in the human body or to support and/or maintain and sustain and/or protect human life. If they fail, it is reasonable to assume that the health of the user or other persons may be endangered.