

# MOSFET

Metal Oxide Semiconductor Field Effect Transistor

## CFDA Automotive

650V CoolMOS™ CFDA Power Transistor  
IPx65R310CFDA

## Data Sheet

Rev. 2.0  
Final

Automotive

## 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™ CFDA 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 according to AEC Q101
- Green package (RoHS compliant), Pb-free plating, halogen free for mold compound

### Applications

650V CoolMOS™ CFDA is designed for switching applications.

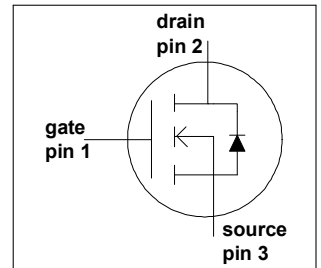
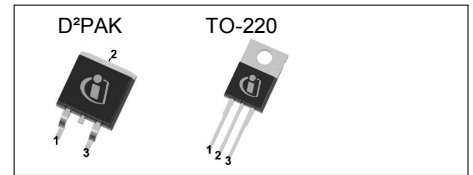


**Table 1 Key Performance Parameters**

| Parameter          | Value | Unit       |
|--------------------|-------|------------|
| $V_{DS}$           | 650   | V          |
| $R_{DS(on),max}$   | 0.31  | $\Omega$   |
| $Q_g,typ$          | 41    | nC         |
| $I_D,pulse$        | 34.4  | A          |
| $E_{oss} @ 400V$   | 3.5   | $\mu J$    |
| Body diode $di/dt$ | 900   | A/ $\mu s$ |
| $Q_{rr}$           | 0.35  | $\mu C$    |
| $t_{rr}$           | 95    | ns         |
| $I_{rrm}$          | 6.5   | A          |

| Type / Ordering Code | Package   | Marking  | Related Links |
|----------------------|-----------|----------|---------------|
| IPB65R310CFDA        | PG-TO 263 | 65F6310A | -             |
| IPP65R310CFDA        | PG-TO 220 |          |               |

**Table of Contents**

|                                           |    |
|-------------------------------------------|----|
| Description .....                         | 2  |
| Table of Contents .....                   | 3  |
| Maximum ratings .....                     | 4  |
| Thermal characteristics .....             | 5  |
| Electrical characteristics .....          | 6  |
| Electrical characteristics diagrams ..... | 8  |
| Test Circuits .....                       | 12 |
| Package Outlines .....                    | 13 |
| Revision History .....                    | 15 |
| Disclaimer .....                          | 15 |

## 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>                             | $I_D$               |        |      | 11.4  | A                | $T_C = 25^\circ\text{C}$                                                                           |
|                                                                    |                     |        |      | 7.2   |                  | $T_C = 100^\circ\text{C}$                                                                          |
| Pulsed drain current <sup>2)</sup>                                 | $I_{D,pulse}$       |        |      | 34.4  | A                | $T_C = 25^\circ\text{C}$                                                                           |
| Avalanche energy, single pulse                                     | $E_{AS}$            |        |      | 290   | mJ               | $I_D = 2.3\text{A}$ , $V_{DD} = 50\text{V}$<br>(see table 19)                                      |
| Avalanche energy, repetitive                                       | $E_{AR}$            |        |      | 0.43  | mJ               | $I_D = 2.3\text{A}$ , $V_{DD} = 50\text{V}$                                                        |
| Avalanche current, repetitive                                      | $I_{AR}$            |        |      | 2.3   | 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, SMD)<br>TO-220, D <sup>2</sup> PAK | $P_{tot}$           |        |      | 104.2 | W                | $T_C = 25^\circ\text{C}$                                                                           |
| Operating and storage temperature                                  | $T_j, T_{stg}$      | -40    |      | 150   | $^\circ\text{C}$ |                                                                                                    |
| Mounting torque (non FullPAK)<br>TO-220                            |                     |        |      | 60    | Ncm              | M3 and M3.5 screws                                                                                 |
| Continuous diode forward current                                   | $I_S$               |        |      | 11.4  | A                | $T_C = 25^\circ\text{C}$                                                                           |
| Diode pulse current                                                | $I_{S,pulse}$       |        |      | 34.4  | 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 17) |
| 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> Identical low side and high side switch with identical  $R_G$

### 3 Thermal characteristics

**Table 3 Thermal characteristics TO-220**

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

**Table 4 Thermal characteristics D<sup>2</sup>PAK**

| Parameter                                              | Symbol     | Values |      |      | Unit | Note / Test Condition                                     |
|--------------------------------------------------------|------------|--------|------|------|------|-----------------------------------------------------------|
|                                                        |            | Min.   | Typ. | Max. |      |                                                           |
| Thermal resistance, junction - case                    | $R_{thJC}$ |        |      | 1.2  | K/W  |                                                           |
| Thermal resistance, junction - ambient <sup>1)</sup>   | $R_{thJA}$ |        |      | 62   | K/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 | $T_{sld}$  |        |      | 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 5 Static characteristics**

| Parameter                                    | Symbol        | Values |       |      | Unit     | Note / Test Condition                                       |
|----------------------------------------------|---------------|--------|-------|------|----------|-------------------------------------------------------------|
|                                              |               | Min.   | Typ.  | Max. |          |                                                             |
| Drain-source breakdown voltage <sup>1)</sup> | $V_{(BR)DSS}$ | 650    |       |      | V        | $V_{GS} = 0V$ , $I_D = 1mA$                                 |
| Gate threshold voltage                       | $V_{GS(th)}$  | 3.5    | 4     | 4.5  | V        | $V_{DS} = V_{GS}$ , $I_D = 0.44mA$                          |
| Zero gate voltage drain current              | $I_{DSS}$     |        |       | 1    | $\mu A$  | $V_{DS} = 650V$ , $V_{GS} = 0V$ , $T_j = 25^\circ\text{C}$  |
|                                              |               |        | 150   |      |          | $V_{DS} = 650V$ , $V_{GS} = 0V$ , $T_j = 150^\circ\text{C}$ |
| Gate-source leakage current                  | $I_{GSS}$     |        |       | 100  | nA       | $V_{GS} = 20V$ , $V_{DS} = 0V$                              |
| Drain-source on-state resistance             | $R_{DS(on)}$  |        | 0.28  | 0.31 | $\Omega$ | $V_{GS} = 10V$ , $I_D = 4.4A$ , $T_j = 25^\circ\text{C}$    |
|                                              |               |        | 0.725 |      |          | $V_{GS} = 10V$ , $I_D = 4.4A$ , $T_j = 150^\circ\text{C}$   |
| Gate resistance                              | $R_G$         |        | 4.5   |      | $\Omega$ | $f = 1MHz$ , open drain                                     |

**Table 6 Dynamic characteristics**

| Parameter                                                  | Symbol       | Values |      |      | Unit | Note / Test Condition                                                              |
|------------------------------------------------------------|--------------|--------|------|------|------|------------------------------------------------------------------------------------|
|                                                            |              | Min.   | Typ. | Max. |      |                                                                                    |
| Input capacitance                                          | $C_{iss}$    |        | 1110 |      | pF   | $V_{GS} = 0V$ , $V_{DS} = 100V$ , $f = 1MHz$                                       |
| Output capacitance                                         | $C_{oss}$    |        | 55   |      | pF   |                                                                                    |
| Effective output capacitance, energy related <sup>2)</sup> | $C_{o(er)}$  |        | 44   |      | pF   | $V_{GS} = 0V$ , $V_{DS} = 0 \dots 400V$                                            |
| Effective output capacitance, time related <sup>3)</sup>   | $C_{o(tr)}$  |        | 204  |      | pF   | $I_D = \text{constant}$ , $V_{GS} = 0V$ , $V_{DS} = 0 \dots 400V$                  |
| Turn-on delay time                                         | $t_{d(on)}$  |        | 11   |      | ns   | $V_{DD} = 480V$ , $V_{GS} = 13V$ , $I_D = 6.6A$ , $R_G = 3.4\Omega$ (see table 18) |
| Rise time                                                  | $t_r$        |        | 7.5  |      | ns   |                                                                                    |
| Turn-off delay time                                        | $t_{d(off)}$ |        | 45   |      | ns   |                                                                                    |
| Fall time                                                  | $t_f$        |        | 7    |      | ns   |                                                                                    |

**Table 7 Gate charge characteristics**

| Parameter             | Symbol        | Values |      |      | Unit | Note / Test Condition                                         |
|-----------------------|---------------|--------|------|------|------|---------------------------------------------------------------|
|                       |               | Min.   | Typ. | Max. |      |                                                               |
| Gate to source charge | $Q_{gs}$      |        | 7    |      | nC   | $V_{DD} = 480V$ , $I_D = 6.6A$ , $V_{GS} = 0 \text{ to } 10V$ |
| Gate to drain charge  | $Q_{gd}$      |        | 22   |      | nC   |                                                               |
| Gate charge total     | $Q_g$         |        | 41   |      | nC   |                                                               |
| Gate plateau voltage  | $V_{plateau}$ |        | 6.4  |      | V    |                                                               |

<sup>1)</sup> For applications with applied blocking voltage > 65% of the specified blocking voltage, we recommend to evaluate the impact of the cosmic radiation effect in early design phase. For assessment please contact local Infineon sales office.

<sup>2)</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>3)</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 8 Reverse diode characteristics**

| Parameter                     | Symbol    | Values |      |      | Unit    | Note / Test Condition                                                 |
|-------------------------------|-----------|--------|------|------|---------|-----------------------------------------------------------------------|
|                               |           | Min.   | Typ. | Max. |         |                                                                       |
| Diode forward voltage         | $V_{SD}$  |        | 0.9  |      | V       | $V_{GS} = 0V, I_F = 6.6A, T_j = 25^{\circ}C$                          |
| Reverse recovery time         | $t_{rr}$  |        | 95   |      | ns      | $V_R = 400V, I_F = 6.6A,$<br>$di_F/dt = 100A/\mu s$<br>(see table 17) |
| Reverse recovery charge       | $Q_{rr}$  |        | 0.35 |      | $\mu C$ |                                                                       |
| Peak reverse recovery current | $I_{rrm}$ |        | 6.5  |      | A       |                                                                       |

## 5 Electrical characteristics diagrams

Table 9

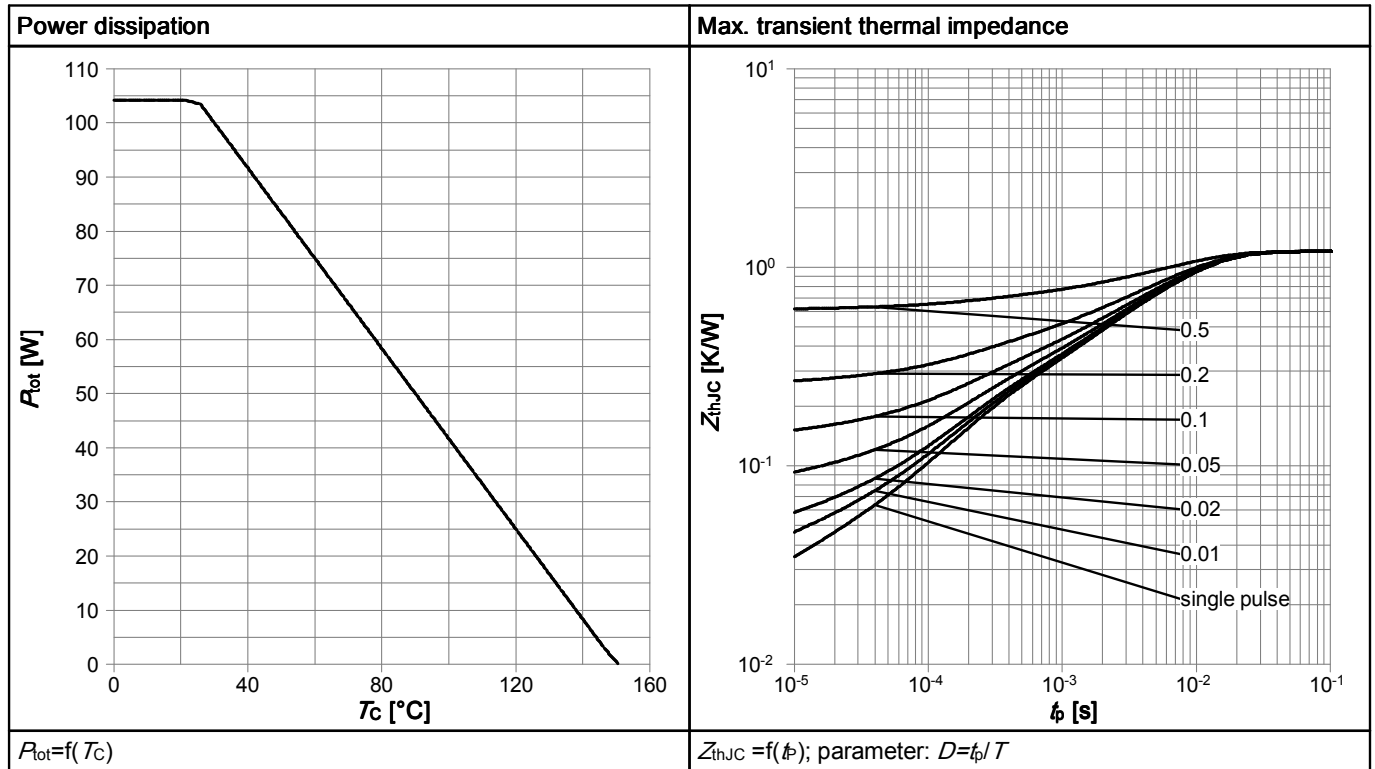


Table 10

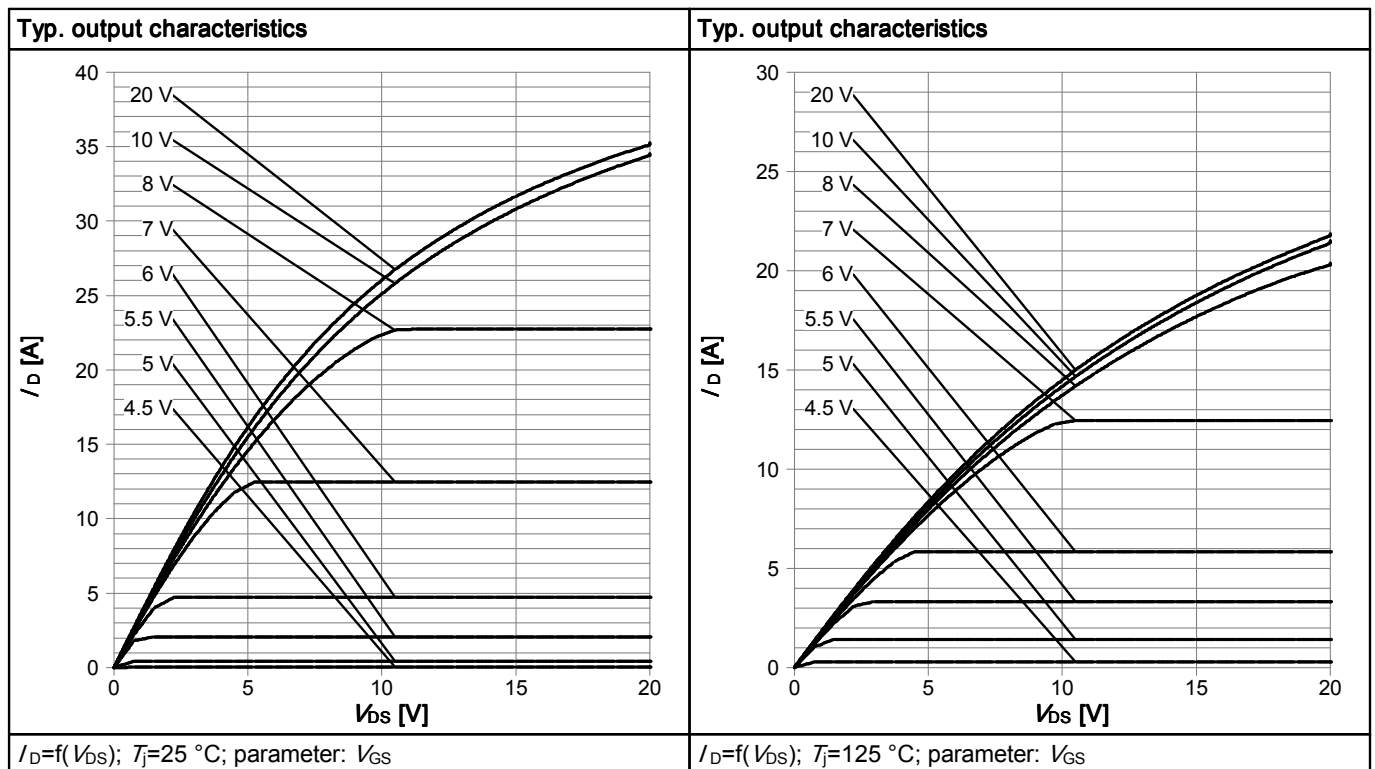


Table 11

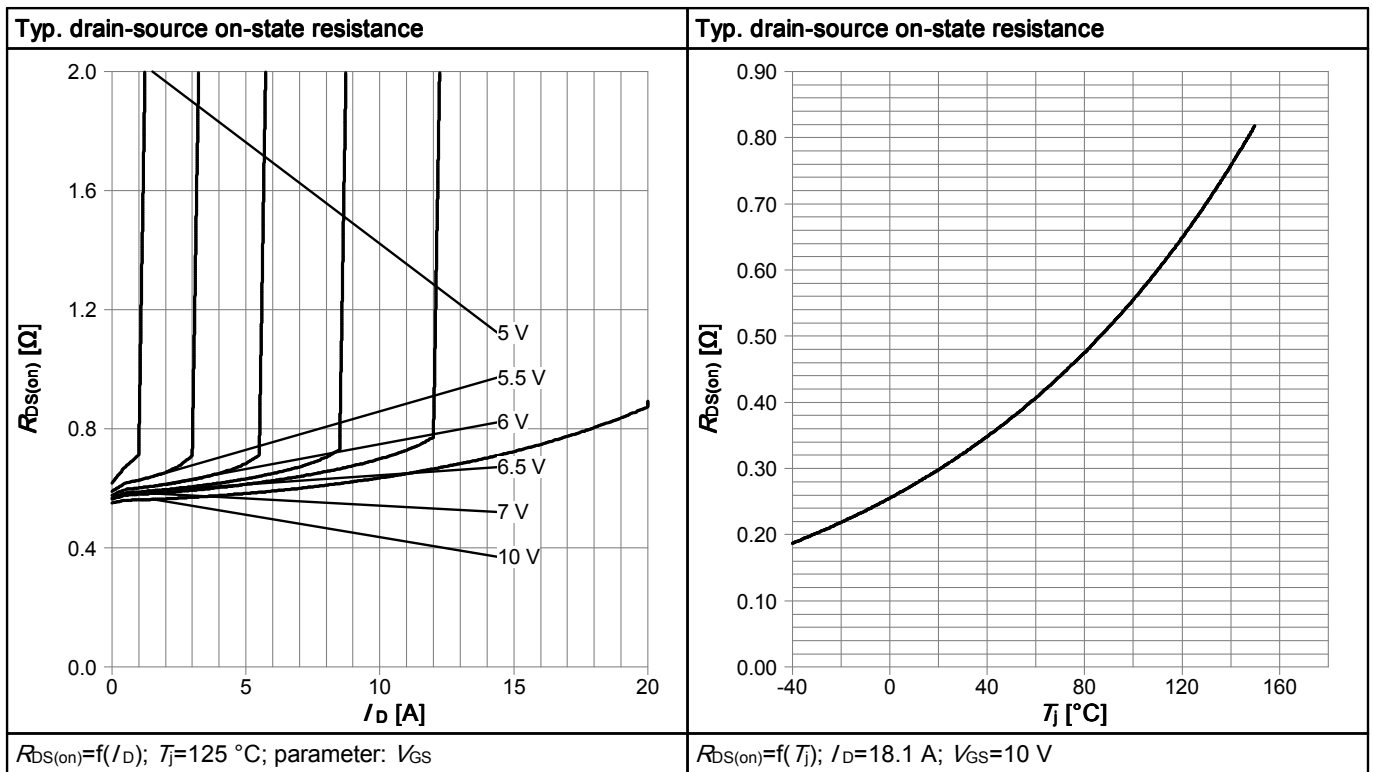


Table 12

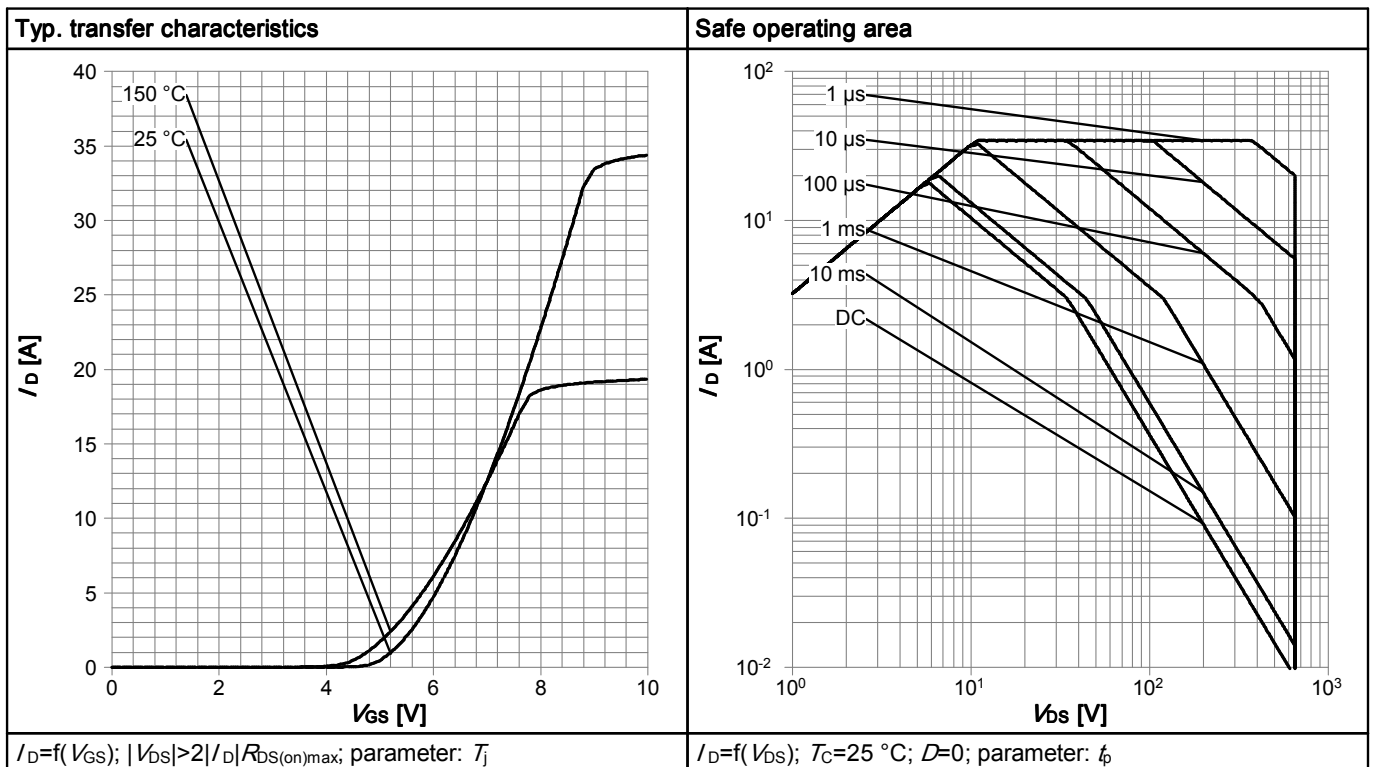


Table 13

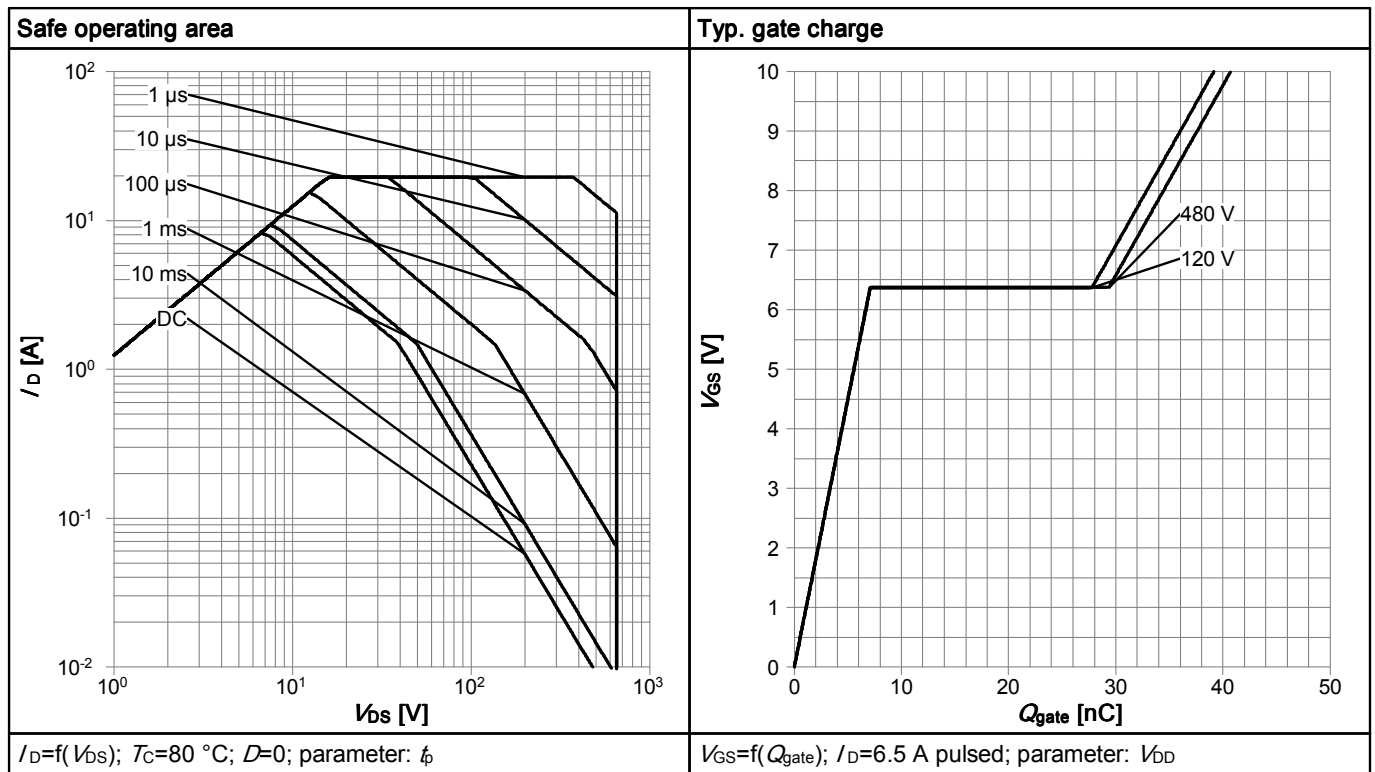


Table 14

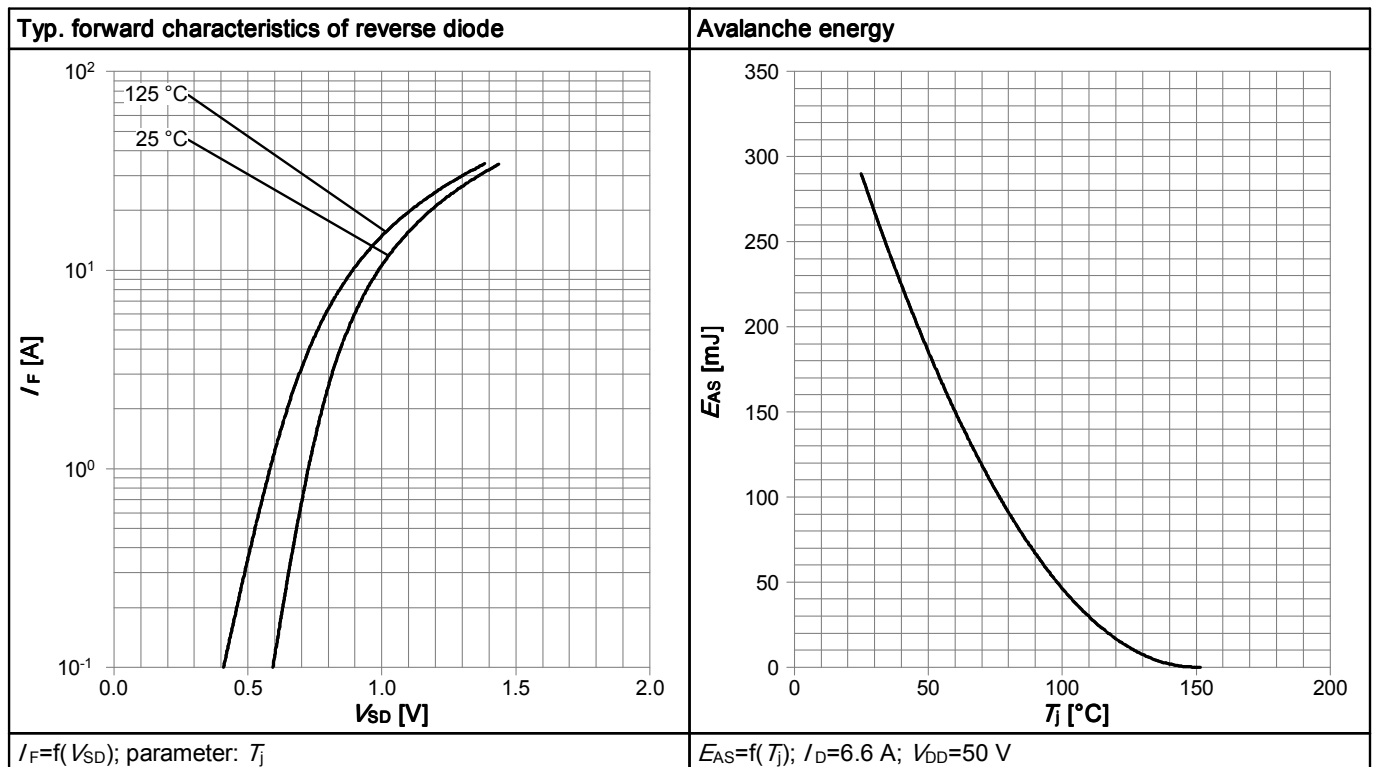


Table 15

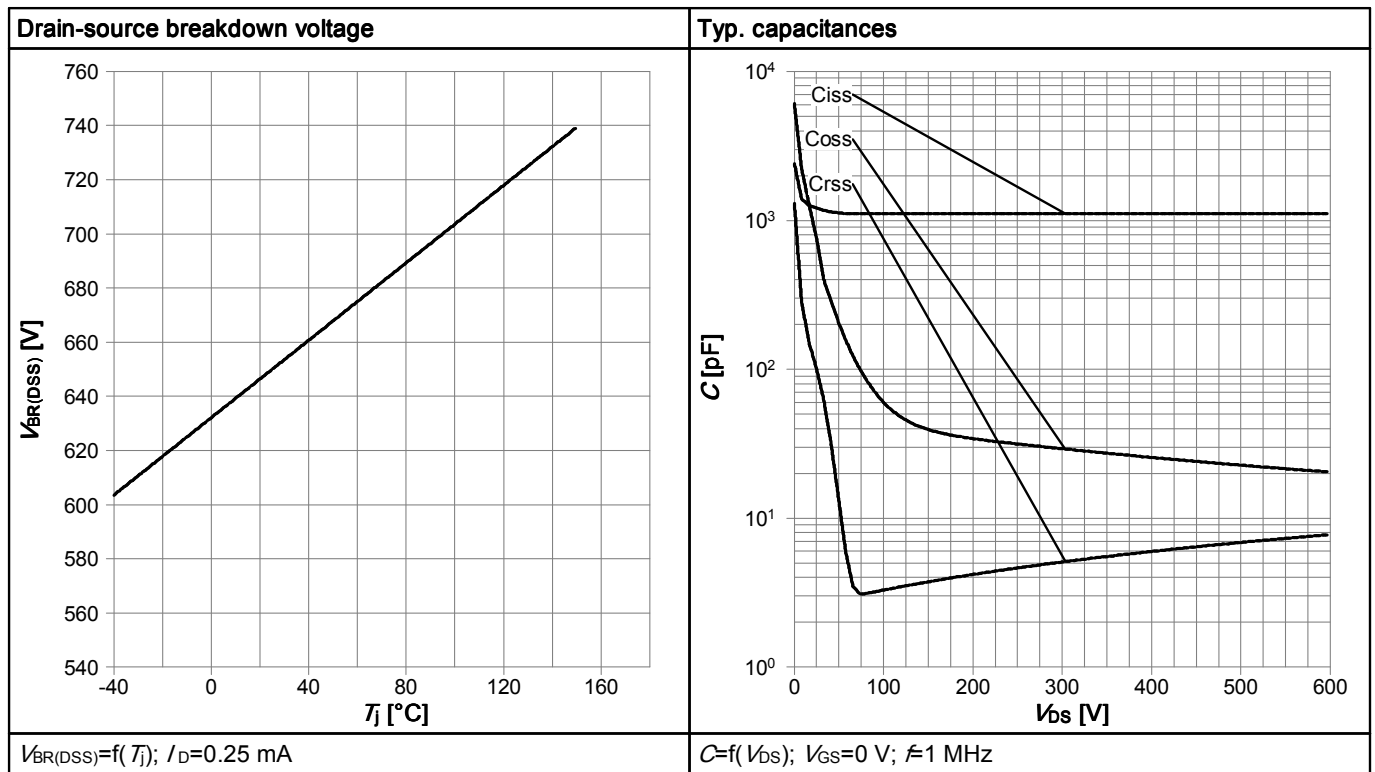
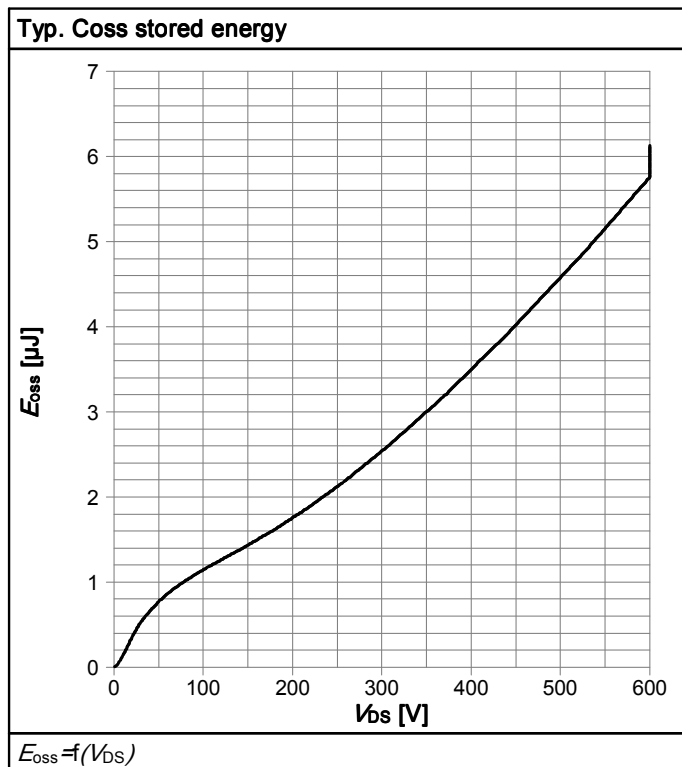


Table 16



## 6 Test Circuits

**Table 17 Diode characteristics**

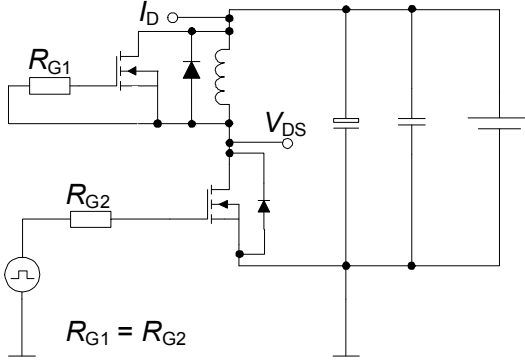
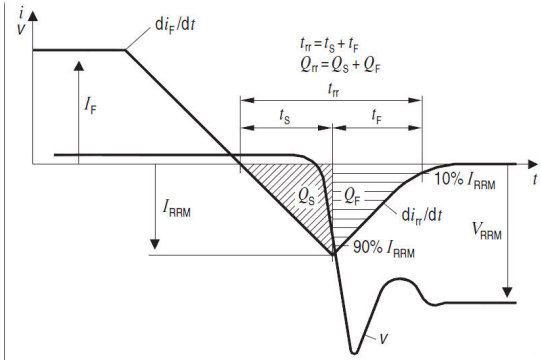
| Test circuit for diode characteristics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Diode recovery waveform                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  <p>The test circuit for diode characteristics shows a MOSFET switching an inductive load. The MOSFET gate is driven by a pulse generator through a resistor <math>R_{G1}</math>. The drain is connected to the inductive load and a DC supply <math>V_{DS}</math>. The MOSFET source is connected to ground through a resistor <math>R_{G2}</math>. The condition <math>R_{G1} = R_{G2}</math> is specified. The diode current <math>I_D</math> and drain-source voltage <math>V_{DS}</math> are indicated.</p> |  <p>The diode recovery waveform shows the current <math>i</math> and voltage <math>V</math> over time <math>t</math>. It illustrates the forward current <math>I_F</math>, the reverse current <math>I_{RRM}</math>, and the reverse recovery voltage <math>V_{RRM}</math>. Key parameters include the reverse recovery time <math>t_{rr}</math>, the reverse recovery charge <math>Q_{rr}</math>, and the reverse recovery current <math>I_{RRM}</math>. The waveform also shows the forward current <math>I_F</math> and the forward voltage <math>V_F</math>. The reverse recovery time <math>t_{rr}</math> is defined as the time from the zero-crossing of the current to the point where the current reaches 10% of <math>I_{RRM}</math>. The reverse recovery charge <math>Q_{rr}</math> is the area under the reverse current curve. The reverse recovery current <math>I_{RRM}</math> is the peak value of the reverse current. The reverse recovery voltage <math>V_{RRM}</math> is the peak value of the reverse voltage. The reverse recovery time <math>t_{rr}</math> is also defined as the time from the zero-crossing of the current to the point where the current reaches 90% of <math>I_{RRM}</math>. The reverse recovery charge <math>Q_{rr}</math> is also defined as the area under the reverse current curve. The reverse recovery current <math>I_{RRM}</math> is also defined as the peak value of the reverse current. The reverse recovery voltage <math>V_{RRM}</math> is also defined as the peak value of the reverse voltage.</p> |

**Table 18 Switching times**

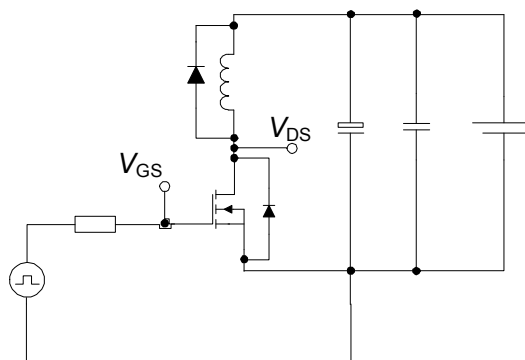
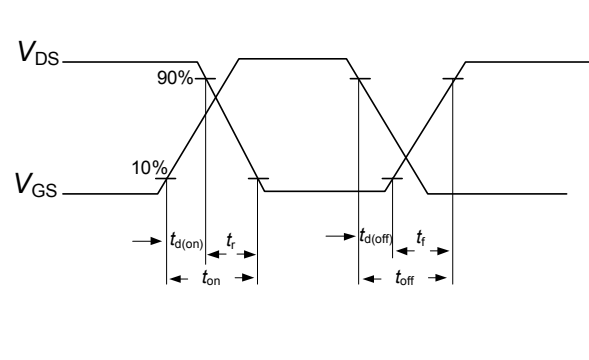
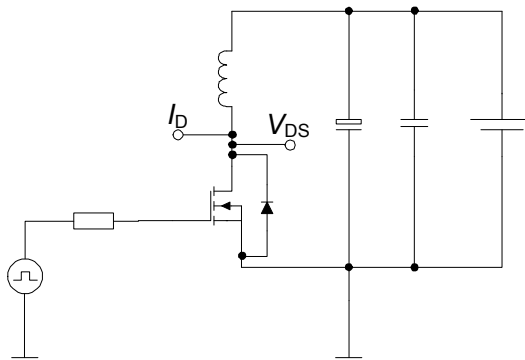
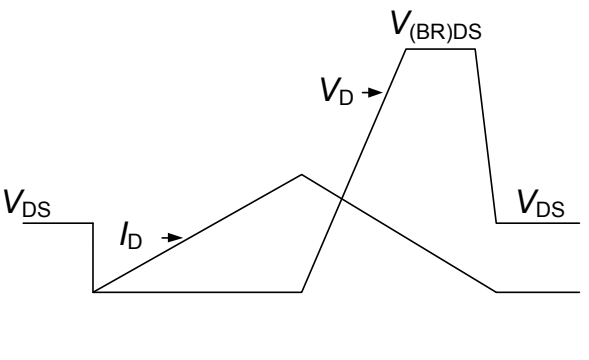
| Switching times test circuit for inductive load                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Switching times waveform                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  <p>The switching times test circuit for inductive load shows a MOSFET switching an inductive load. The MOSFET gate is driven by a pulse generator through a resistor. The drain is connected to the inductive load and a DC supply <math>V_{DS}</math>. The MOSFET source is connected to ground. The gate-source voltage <math>V_{GS}</math> and drain-source voltage <math>V_{DS}</math> are indicated.</p> |  <p>The switching times waveform shows the gate-source voltage <math>V_{GS}</math> and drain-source voltage <math>V_{DS}</math> over time. It illustrates the turn-on time <math>t_{d(on)}</math>, the rise time <math>t_r</math>, the fall time <math>t_f</math>, and the turn-off time <math>t_{d(off)}</math>. The turn-on time <math>t_{d(on)}</math> is the time from the 10% level of <math>V_{GS}</math> to the 90% level of <math>V_{DS}</math>. The rise time <math>t_r</math> is the time from the 10% level of <math>V_{GS}</math> to the 90% level of <math>V_{GS}</math>. The fall time <math>t_f</math> is the time from the 90% level of <math>V_{GS}</math> to the 10% level of <math>V_{GS}</math>. The turn-off time <math>t_{d(off)}</math> is the time from the 90% level of <math>V_{GS}</math> to the 10% level of <math>V_{DS}</math>.</p> |

**Table 19 Unclamped inductive**

| Unclamped inductive load test circuit                                                                                                                                                                                                                                                                                                                                                                                                                                          | Unclamped inductive waveform                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  <p>The unclamped inductive load test circuit shows a MOSFET switching an inductive load. The MOSFET gate is driven by a pulse generator through a resistor. The drain is connected to the inductive load and a DC supply <math>V_{DS}</math>. The MOSFET source is connected to ground. The diode current <math>I_D</math> and drain-source voltage <math>V_{DS}</math> are indicated.</p> |  <p>The unclamped inductive waveform shows the drain-source voltage <math>V_{DS}</math> and diode current <math>I_D</math> over time. It illustrates the unclamped inductive voltage <math>V_{(BR)DS}</math> and the diode current <math>I_D</math>. The unclamped inductive voltage <math>V_{(BR)DS}</math> is the peak value of the drain-source voltage during the switching transient. The diode current <math>I_D</math> is the current flowing through the diode during the switching transient.</p> |

## 7 Package Outlines

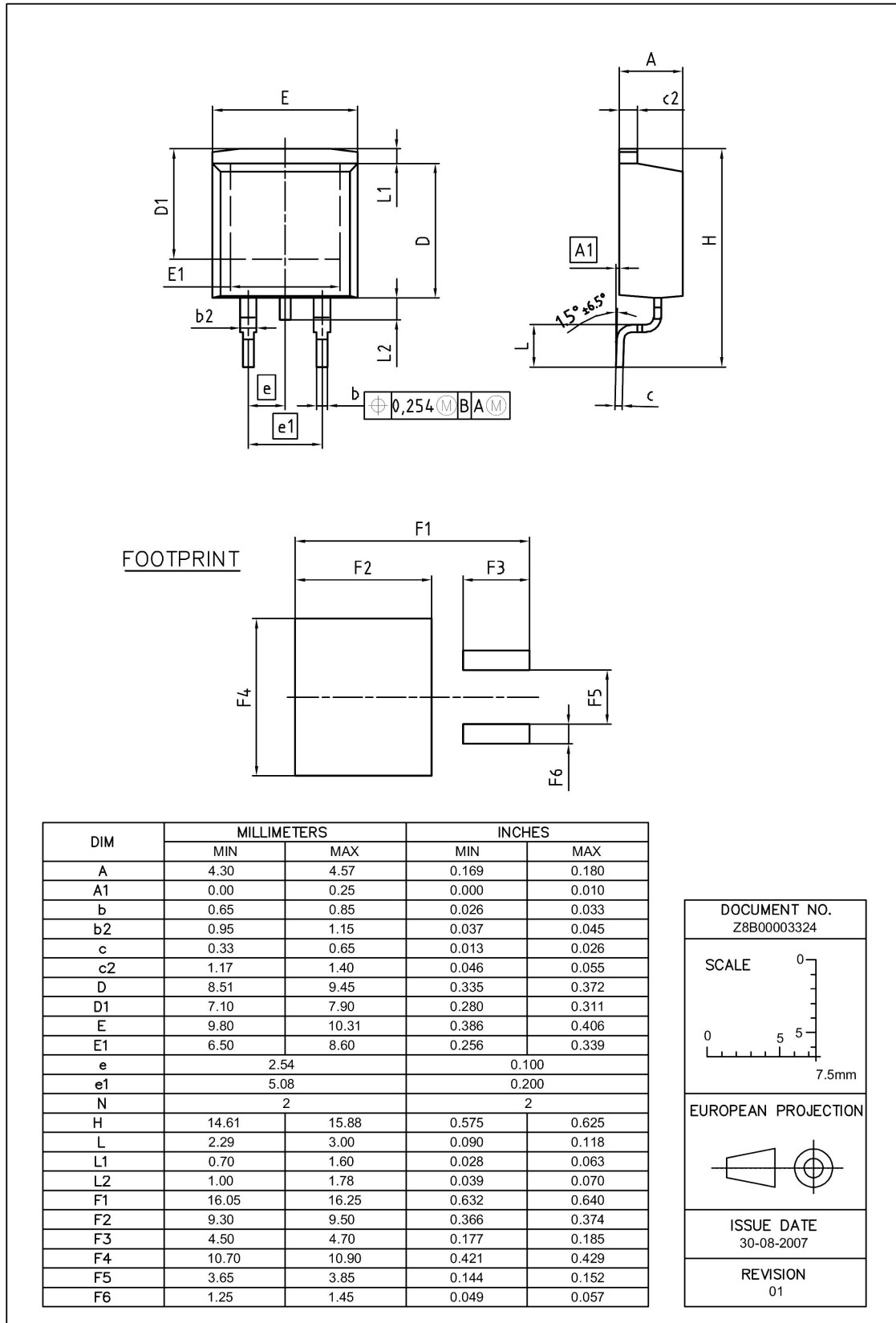


**Figure 1 Outline PG-TO 263, dimensions in mm/inches**

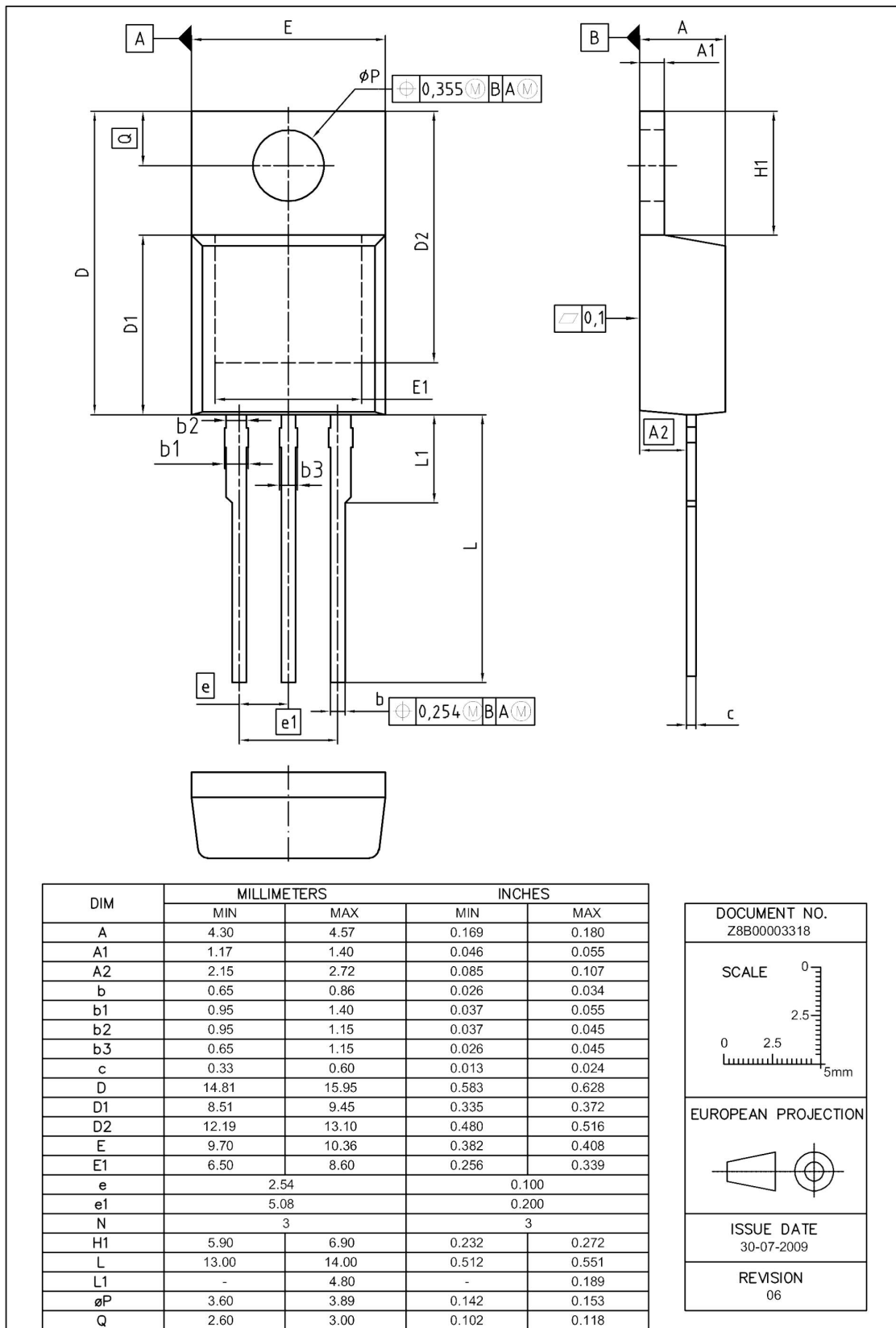


**Figure 2 Outline PG-TO 220, dimensions in mm/inches**

## Revision History

---

IPB65R310CFDA, IPP65R310CFDA

**Revision: 2012-03-28, Rev. 2.0**

---

Previous Revision

| Revision | Date       | Subjects (major changes since last revision) |
|----------|------------|----------------------------------------------|
| 2.0      | 2012-03-28 | Final datasheet                              |

## Disclaimer ATV

### We Listen to Your Comments

Any information within this document that you feel is wrong, unclear or missing at all? Your feedback will help us to continuously improve the quality of this document. Please send your proposal (including a reference to this document) to: [erratum@infineon.com](mailto:erratum@infineon.com)

**Edition 2011-09-30**

**Published by**

**Infineon Technologies AG**

**81726 München, Germany**

**© 2011 Infineon Technologies AG**

**All Rights Reserved.**

### Legal Disclaimer

The information given in this document shall in no event be regarded as a guarantee of conditions or characteristics ("Beschaffenheitsgarantie"). With respect to any examples or hints given herein, any typical values stated herein and/or any information regarding the application of the device, Infineon Technologies hereby disclaims any and all warranties and liabilities of any kind, including without limitation warranties of non-infringement of intellectual property rights of any third party.

### Information

For further information on technology, delivery terms and conditions and prices please contact your nearest Infineon Technologies Office ([www.infineon.com](http://www.infineon.com)).

### Warnings

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

Infineon Technologies Components may only be used in life-support devices or systems 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 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.