

# MOSFET

Metal Oxide Semiconductor Field Effect Transistor

## CoolMOS™ CFD2 650V

650V CoolMOS™ CFD2 Power Transistor  
IPD65R1K4CFD

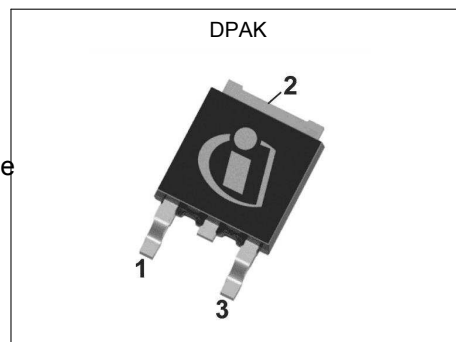
## Data Sheet

Rev. 2.2  
Final

Industrial & Multimarket

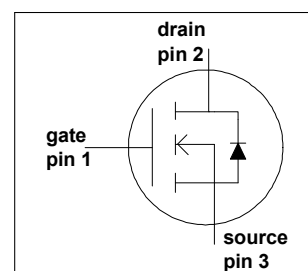
## 1 Description

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
- Easy to use/drive
- Very high commutation ruggedness
- Pb-free plating, available in Halogen free mold compound<sup>a)</sup>
- Extremely low losses due to very low FOM  $R_{ds(on)} \cdot Q_g$  and  $E_{oss}$
- Fully qualified according to JEDEC for Industrial Applications



## Applications

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



**Table 1 Key Performance Parameters**

| Parameter             | Value | Unit       |
|-----------------------|-------|------------|
| $V_{DS} @ T_{j \max}$ | 700   | V          |
| $R_{DS(on), \max}$    | 1.4   | $\Omega$   |
| $Q_g, \text{typ}$     | 10    | nC         |
| $I_D, \text{pulse}$   | 8.2   | A          |
| $E_{oss} @ 400V$      | 1     | $\mu J$    |
| Body diode $di/dt$    | 900   | A/ $\mu s$ |
| $Q_{rr}$              | 0.1   | $\mu C$    |
| $t_{rr}$              | 50    | ns         |
| $I_{rrm}$             | 3.2   | A          |

| Type / Ordering Code | Package   | Marking | Related Links  |
|----------------------|-----------|---------|----------------|
| IPD65R1K4CFD         | PG-TO 252 | 65F61K4 | see Appendix A |

## Table of Contents

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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> | $I_D$          |        |      | 2.8  | A                | $T_C = 25^\circ\text{C}$                                                                           |
|                                        |                |        |      | 1.8  |                  | $T_C = 100^\circ\text{C}$                                                                          |
| Pulsed drain current <sup>2)</sup>     | $I_{D,pulse}$  |        |      | 8.2  | A                | $T_C = 25^\circ\text{C}$                                                                           |
| Avalanche energy, single pulse         | $E_{AS}$       |        |      | 26   | mJ               | $I_D = 0.6\text{A}$ , $V_{DD} = 50\text{V}$<br>(see table 18)                                      |
| Avalanche energy, repetitive           | $E_{AR}$       |        |      | 0.10 | mJ               | $I_D = 0.6\text{A}$ , $V_{DD} = 50\text{V}$                                                        |
| Avalanche current, repetitive          | $I_{AR}$       |        |      | 0.6  | 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 ( $f > 1\text{ Hz}$ )                                                                           |
| Operating and storage temperature      | $T_j, T_{stg}$ | -55    |      | 150  | $^\circ\text{C}$ |                                                                                                    |
| Continuous diode forward current       | $I_S$          |        |      | 2.8  | A                | $T_C = 25^\circ\text{C}$                                                                           |
| Diode pulse current                    | $I_{S,pulse}$  |        |      | 8.2  | 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 16) |
| Maximum diode commutation speed        | di/dt          |        |      | 900  | A/ $\mu\text{s}$ |                                                                                                    |
| Power dissipation                      | $P_{tot}$      |        |      | 28.4 | W                | $T_C = 25^\circ\text{C}$                                                                           |

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

<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 and high side switch with same  $R_g$

### 3 Thermal characteristics

**Table 3 Thermal characteristics DPAK**

| Parameter                                              | Symbol     | Values |      |      | Unit | Note / Test Condition                                     |
|--------------------------------------------------------|------------|--------|------|------|------|-----------------------------------------------------------|
|                                                        |            | Min.   | Typ. | Max. |      |                                                           |
| Thermal resistance, junction - case                    | $R_{thJC}$ |        |      | 4.4  | °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 4 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        | $V_{DS} = V_{GS}$ , $I_D = 0.1mA$                           |
| 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 | $R_{DS(on)}$  |        | 1.260 | 1.4  | $\Omega$ | $V_{GS} = 10V$ , $I_D = 1.0A$ , $T_j = 25^\circ\text{C}$    |
|                                  |               |        | 3.276 |      |          | $V_{GS} = 10V$ , $I_D = 1A$ , $T_j = 150^\circ\text{C}$     |
| Gate resistance                  | $R_G$         |        | 9.5   |      | $\Omega$ | $f = 1MHz$ , open drain                                     |

**Table 5 Dynamic characteristics**

| Parameter                                                  | Symbol       | Values |      |      | Unit | Note / Test Condition                                                                     |
|------------------------------------------------------------|--------------|--------|------|------|------|-------------------------------------------------------------------------------------------|
|                                                            |              | Min.   | Typ. | Max. |      |                                                                                           |
| Input capacitance                                          | $C_{iss}$    |        | 262  |      | pF   | $V_{GS} = 0V$ , $V_{DS} = 100V$ , $f = 1MHz$                                              |
| Output capacitance                                         | $C_{oss}$    |        | 18   |      | pF   |                                                                                           |
| Effective output capacitance, energy related <sup>1)</sup> | $C_{o(er)}$  |        | 12   |      | pF   | $V_{GS} = 0V$ , $V_{DS} = 0 \dots 400V$                                                   |
| Effective output capacitance, time related <sup>2)</sup>   | $C_{o(tr)}$  |        | 49   |      | pF   | $I_D = \text{constant}$ , $V_{GS} = 0V$ , $V_{DS} = 0 \dots 400V$                         |
| Turn-on delay time                                         | $t_{d(on)}$  |        | 8    |      | ns   | $V_{DD} = 400V$ , $V_{GS} = 13V$ , $I_D = 1.5A$ ,<br>$R_G = 10.2\Omega$<br>(see table 17) |
| Rise time                                                  | $t_r$        |        | 6    |      | ns   |                                                                                           |
| Turn-off delay time                                        | $t_{d(off)}$ |        | 33   |      | ns   |                                                                                           |
| Fall time                                                  | $t_f$        |        | 18.2 |      | ns   |                                                                                           |

**Table 6 Gate charge characteristics**

| Parameter             | Symbol        | Values |      |      | Unit | Note / Test Condition                                            |
|-----------------------|---------------|--------|------|------|------|------------------------------------------------------------------|
|                       |               | Min.   | Typ. | Max. |      |                                                                  |
| Gate to source charge | $Q_{gs}$      |        | 1.78 |      | nC   | $V_{DD} = 480V$ , $I_D = 1.5A$ ,<br>$V_{GS} = 0 \text{ to } 10V$ |
| Gate to drain charge  | $Q_{gd}$      |        | 5.5  |      | nC   |                                                                  |
| Gate charge total     | $Q_g$         |        | 10   |      | 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 7 Reverse diode characteristics**

| Parameter                     | Symbol    | Values |      |      | Unit    | Note / Test Condition                                                 |
|-------------------------------|-----------|--------|------|------|---------|-----------------------------------------------------------------------|
|                               |           | Min.   | Typ. | Max. |         |                                                                       |
| Diode forward voltage         | $V_{SD}$  |        | 0.9  |      | V       | $V_{GS} = 0V, I_F = 1.5A, T_j = 25^{\circ}C$                          |
| Reverse recovery time         | $t_{rr}$  |        | 50   |      | ns      | $V_R = 400V, I_F = 1.5A,$<br>$di_F/dt = 100A/\mu s$<br>(see table 16) |
| Reverse recovery charge       | $Q_{rr}$  |        | 0.1  |      | $\mu C$ |                                                                       |
| Peak reverse recovery current | $I_{rrm}$ |        | 3.2  |      | A       |                                                                       |

## 5 Electrical characteristics diagrams

Table 8

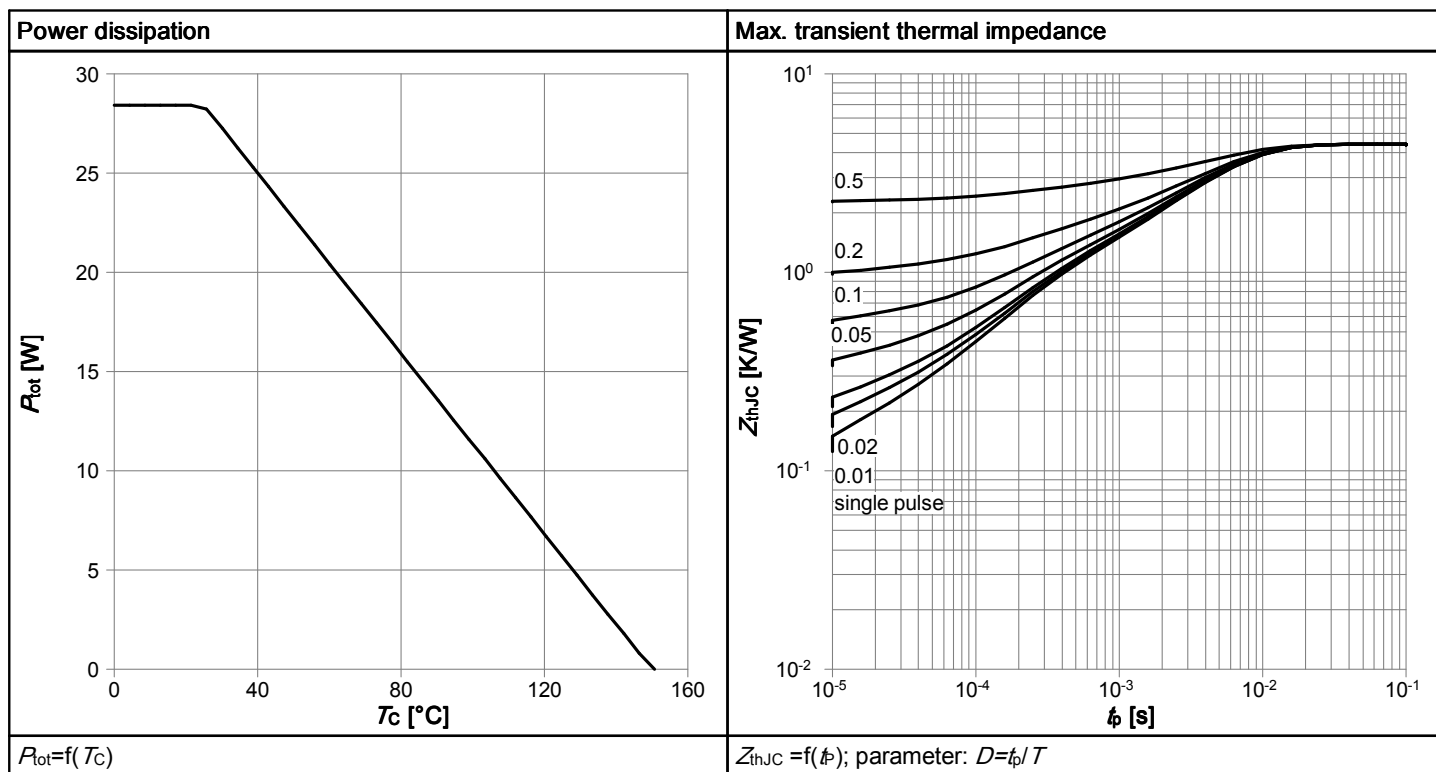


Table 9

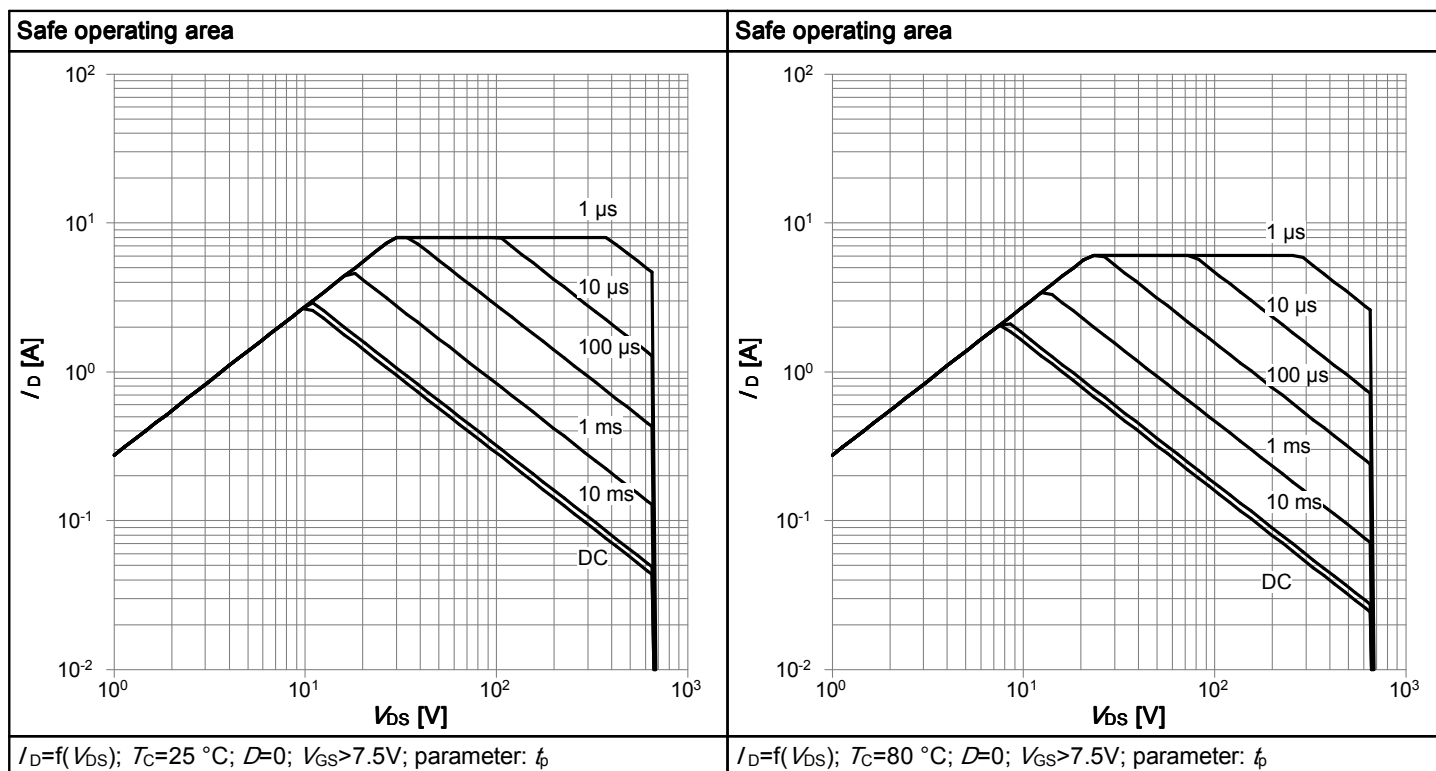


Table 10

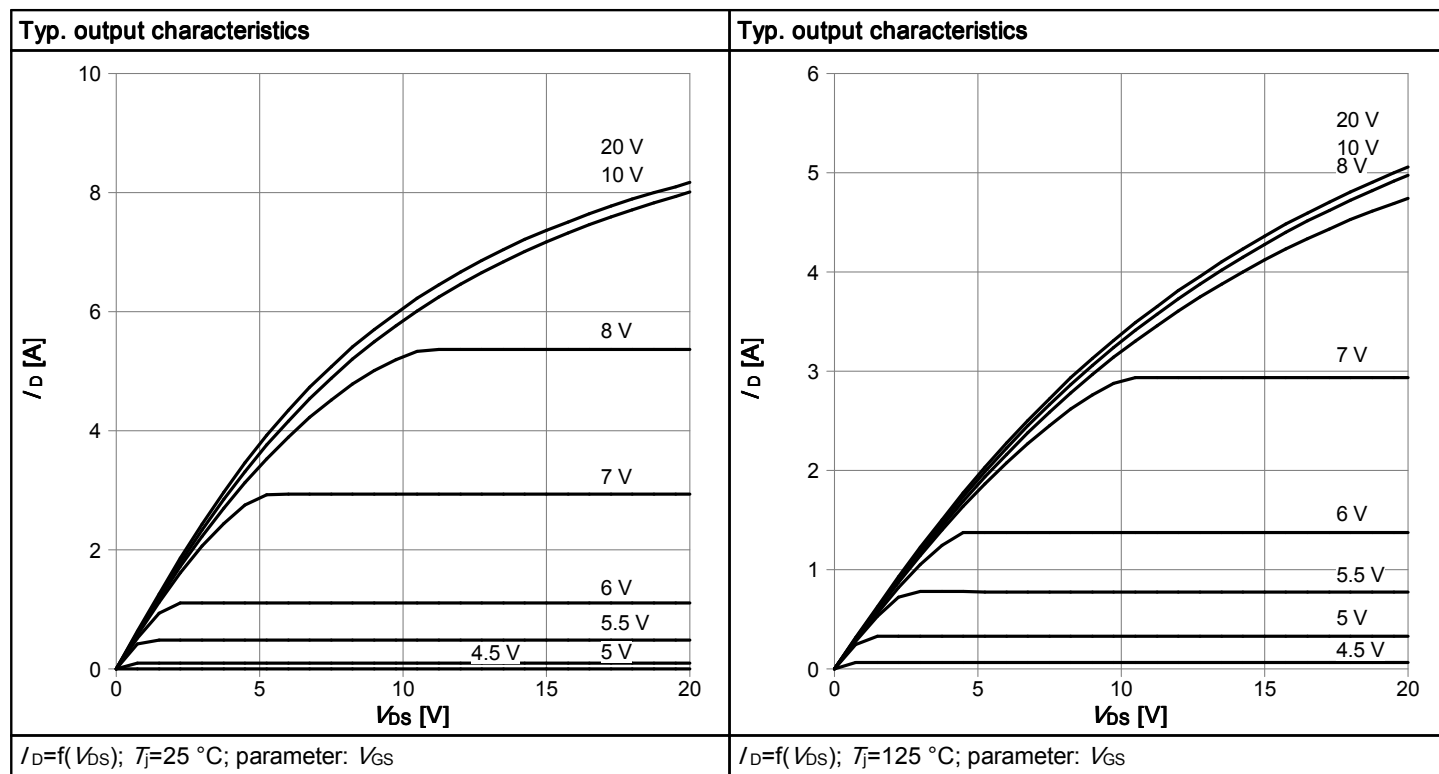


Table 11

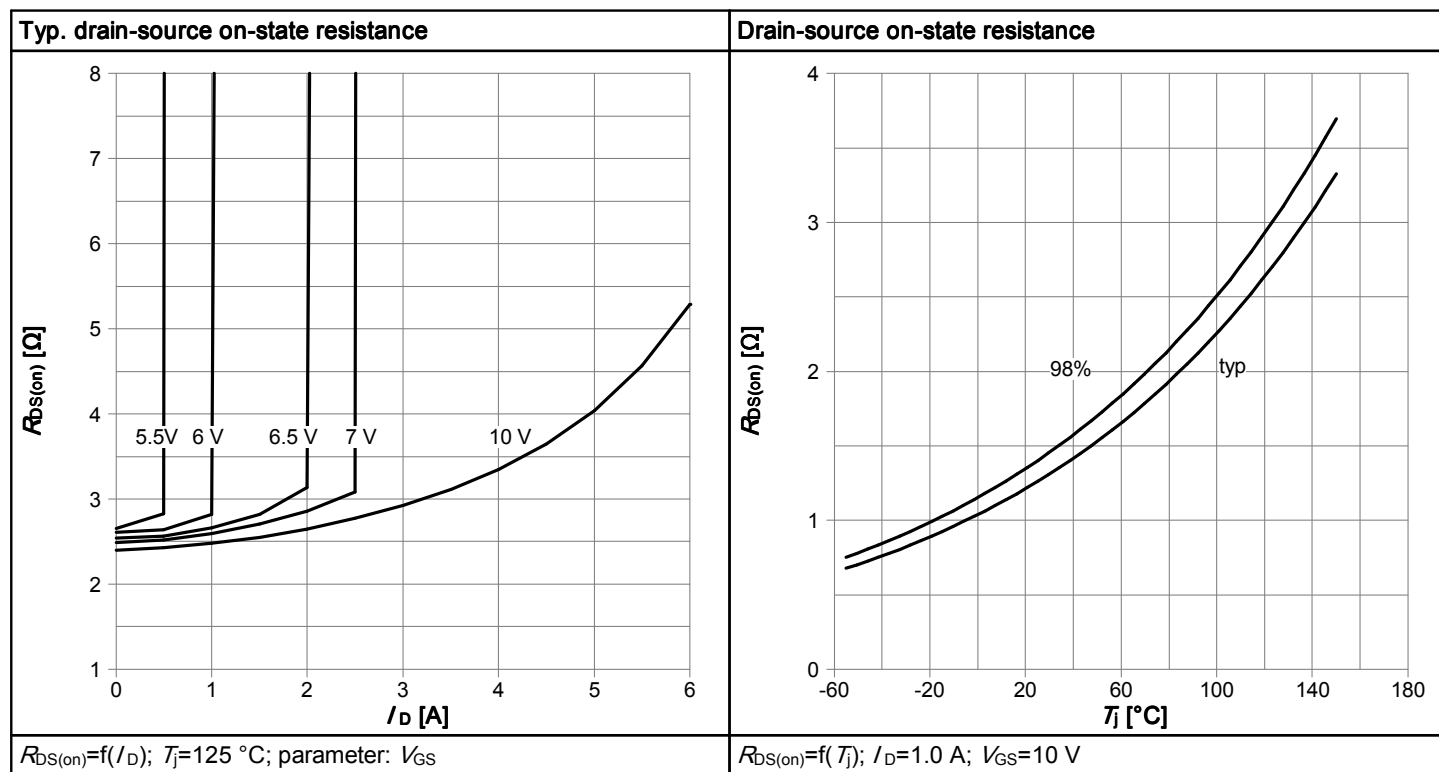


Table 12

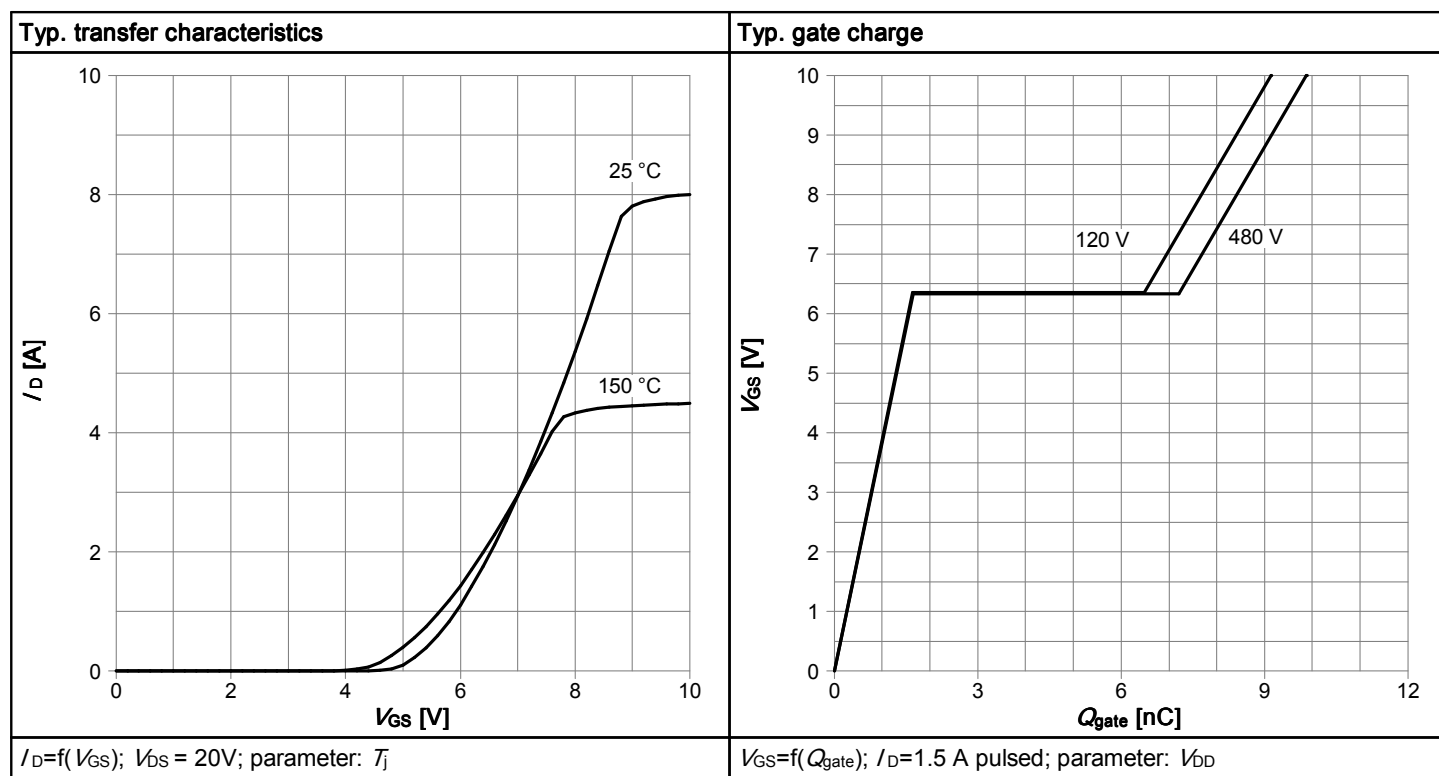


Table 13

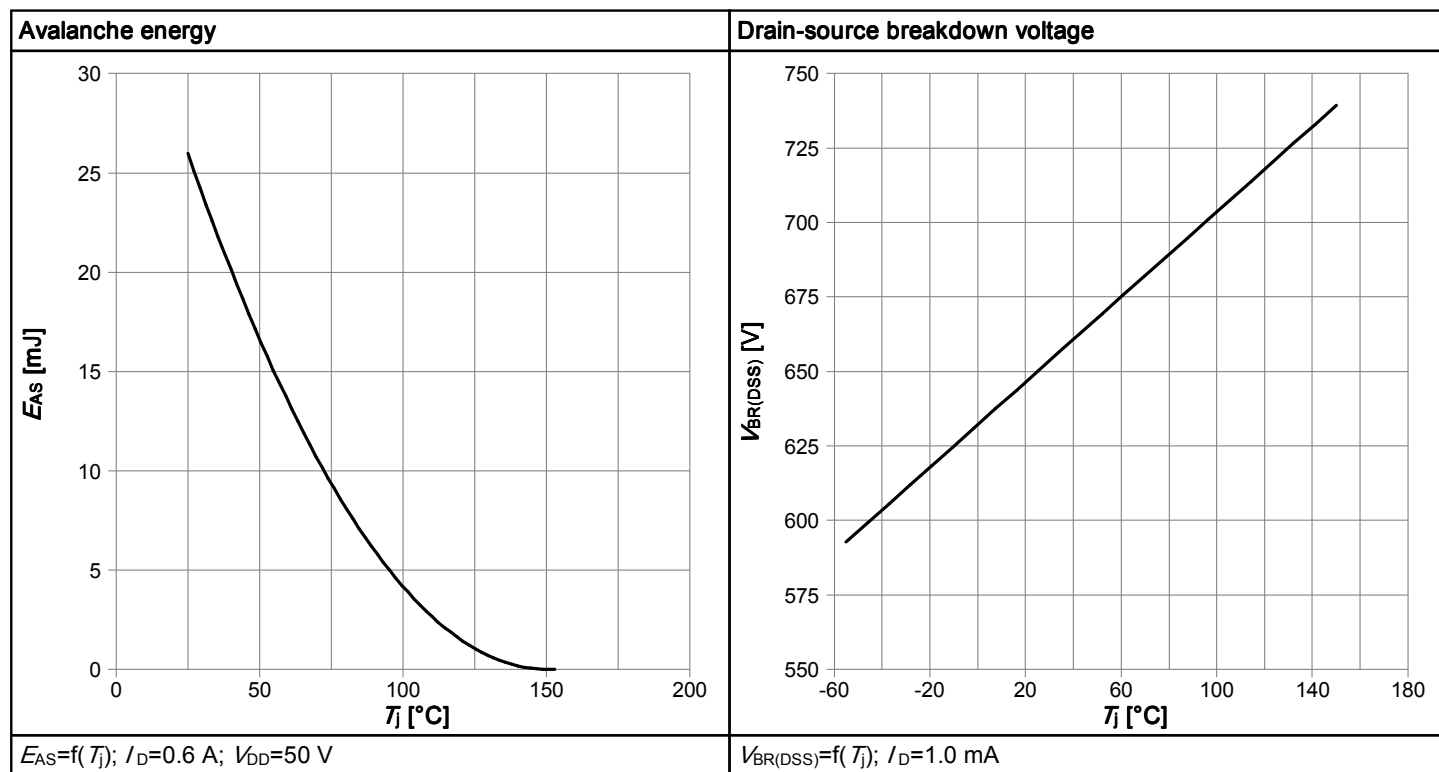


Table 14

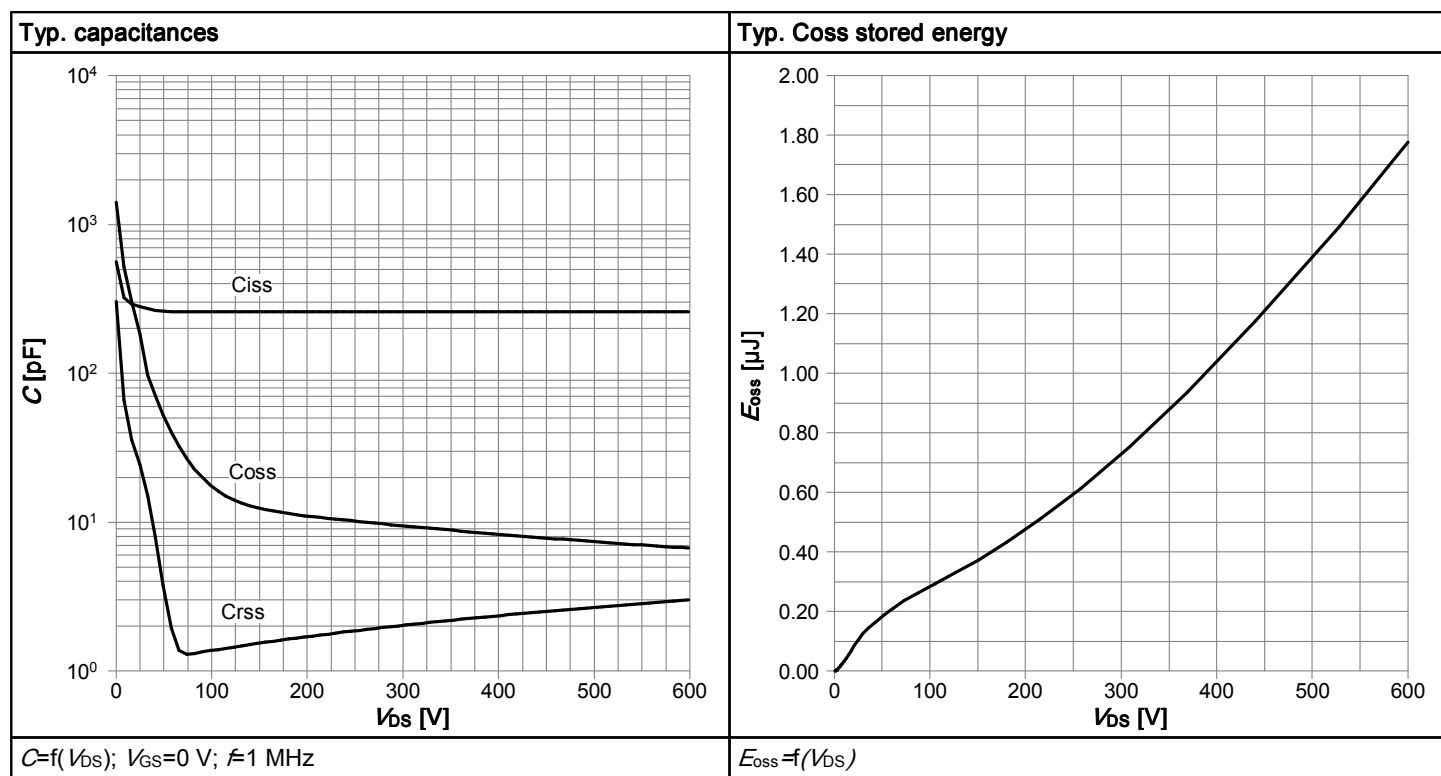
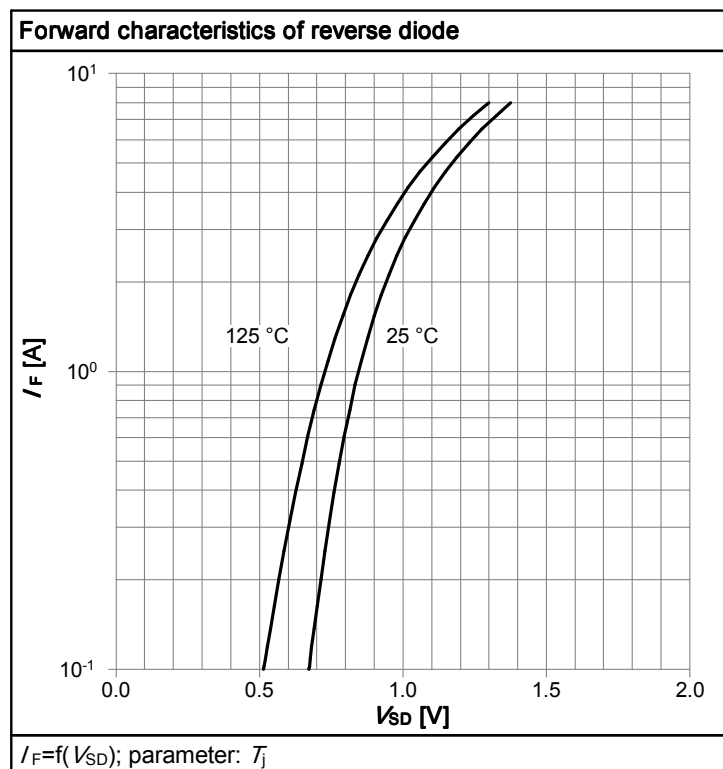
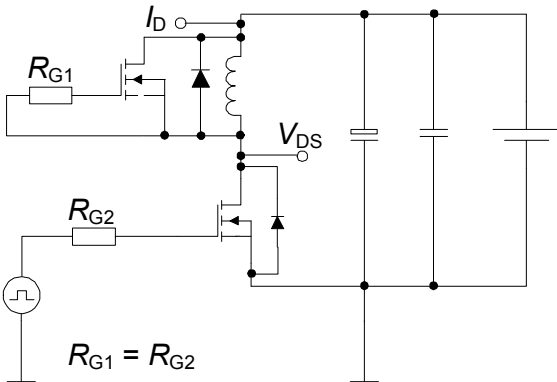
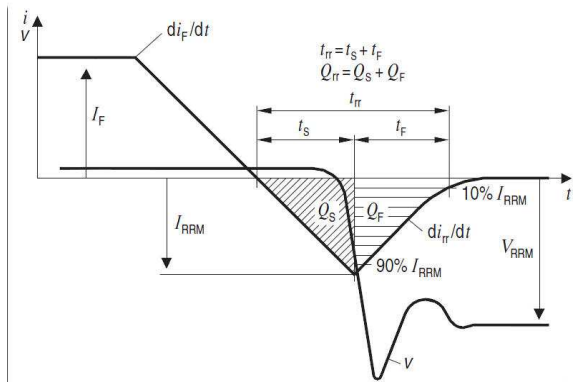


Table 15

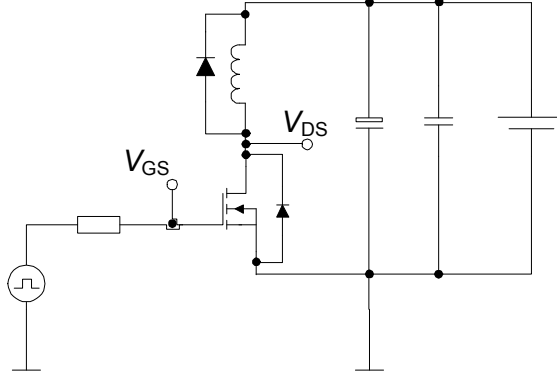
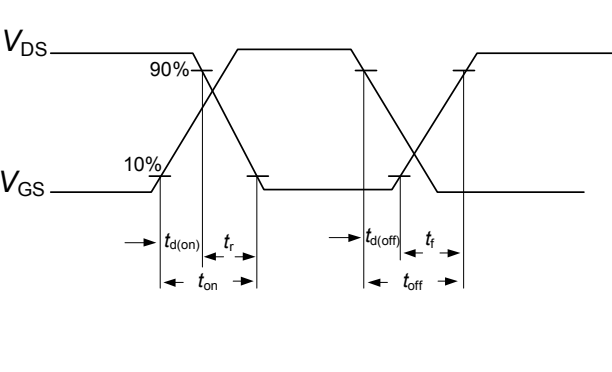


## 6 Test Circuits

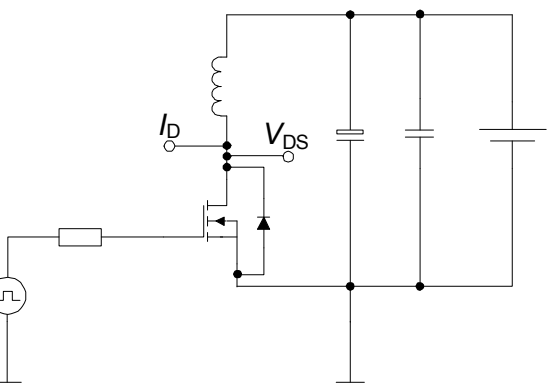
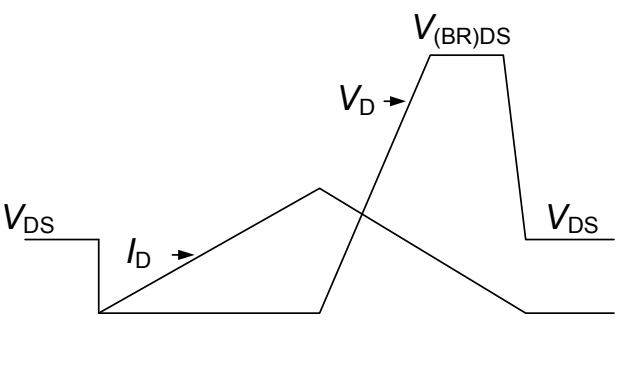
**Table 16 Diode characteristics**

| Test circuit for diode characteristics                                                                                | Diode recovery waveform                                                            |
|-----------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------|
|  <p><math>R_{G1} = R_{G2}</math></p> |  |

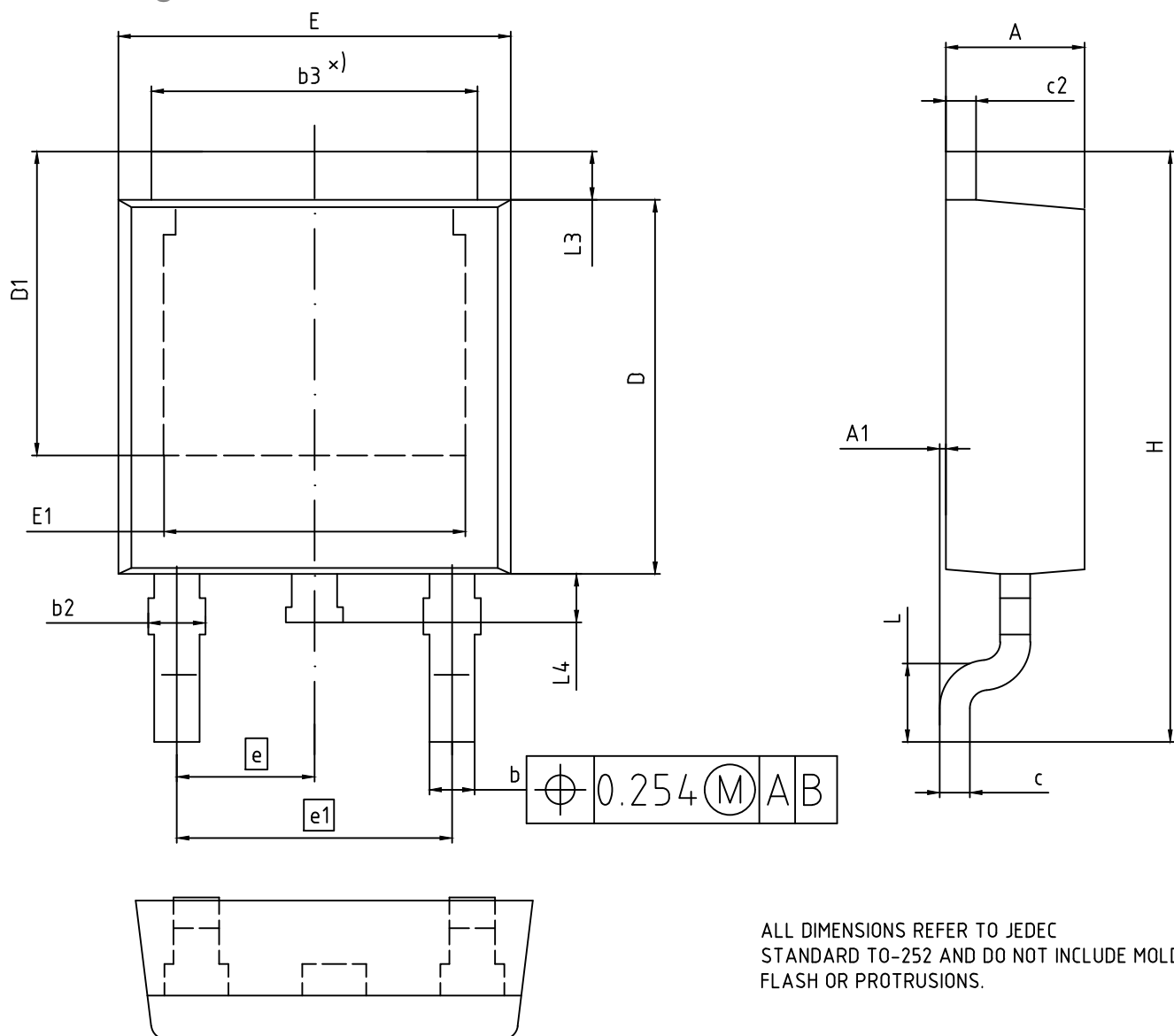
**Table 17 Switching times**

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

**Table 18 Unclamped inductive**

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

## 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  |

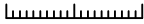
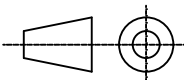
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| <b>DOCUMENT NO.</b><br>Z8B00003328                                                                                        |
| <b>REVISION</b><br>07                                                                                                     |
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| <b>EUROPEAN PROJECTION</b><br>       |
| <b>ISSUE DATE</b><br>01.04.2020                                                                                           |

Figure 1 Outline PG-TO 252, dimensions in mm/inches

## 8 Appendix A

### Table 19 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

IPD65R1K4CFD

**Revision: 2020-05-26, Rev. 2.2**

Previous Revision

| Revision | Date       | Subjects (major changes since last revision) |
|----------|------------|----------------------------------------------|
| 2.0      | 2012-07-17 | Release of final version                     |
| 2.2      | 2020-05-26 | Update package outline                       |

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