

# MOSFET

## 500V CoolMOS™ CE Power Transistor

CoolMOS™ is a revolutionary technology for high voltage power MOSFETs, designed according to the superjunction (SJ) principle and pioneered by Infineon Technologies. CoolMOS™ CE is a price-performance optimized platform enabling to target cost sensitive applications in Consumer and Lighting markets by still meeting highest efficiency standards. The new series provides all benefits of a fast switching Superjunction MOSFET while not sacrificing ease of use and offering the best cost down performance ratio available on the market.

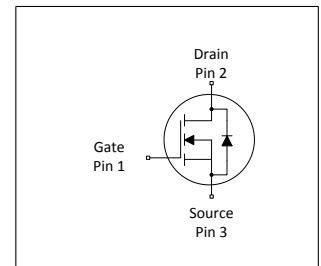
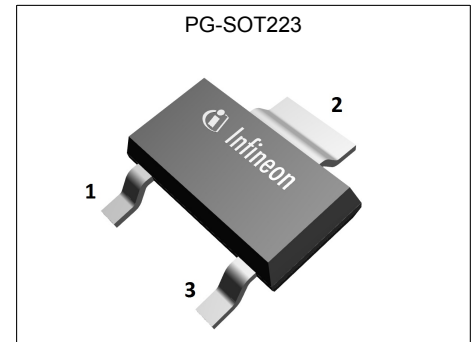
### Features

- 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
- Pb-free plating, Halogen free mold compound
- Qualified for standard grade applications

### Applications

Adapter, Charger and Lighting

*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     |
|----------------------|-------|----------|
| $V_{DS} @ T_{j,max}$ | 550   | V        |
| $R_{DS(on),max}$     | 0.65  | $\Omega$ |
| $I_D$                | 9     | A        |
| $Q_{g,typ}$          | 15    | nC       |
| $I_{D,pulse}$        | 19    | A        |
| $E_{oss} @ 400V$     | 1.69  | $\mu J$  |

| Type / Ordering Code | Package   | Marking | Related Links  |
|----------------------|-----------|---------|----------------|
| IPN50R650CE          | PG-SOT223 | 50S650  | see Appendix A |

## Table of Contents

|                                           |    |
|-------------------------------------------|----|
| Description .....                         | 1  |
| Maximum ratings .....                     | 3  |
| Thermal characteristics .....             | 3  |
| Electrical characteristics .....          | 4  |
| Electrical characteristics diagrams ..... | 6  |
| Test Circuits .....                       | 10 |
| Package Outlines .....                    | 11 |
| Appendix A .....                          | 12 |
| Revision History .....                    | 13 |
| Trademarks .....                          | 13 |
| Disclaimer .....                          | 13 |

## 1 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>        | $I_D$          | -          | -    | 9<br>5.7 | A                | $T_C = 25^\circ\text{C}$<br>$T_C = 100^\circ\text{C}$                                                        |
| Pulsed drain current <sup>2)</sup>            | $I_{D,pulse}$  | -          | -    | 19       | A                | $T_C = 25^\circ\text{C}$                                                                                     |
| Avalanche energy, single pulse                | $E_{AS}$       | -          | -    | 102      | mJ               | $I_D = 2.3\text{A}$ ; $V_{DD} = 50\text{V}$                                                                  |
| Avalanche energy, repetitive                  | $E_{AR}$       | -          | -    | 0.15     | 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<br>-30 | -    | 20<br>30 | V                | static;<br>AC ( $f > 1\text{ Hz}$ )                                                                          |
| Power dissipation                             | $P_{tot}$      | -          | -    | 5.0      | W                | $T_C = 25^\circ\text{C}$                                                                                     |
| Operating and storage temperature             | $T_j, T_{stg}$ | -40        | -    | 150      | $^\circ\text{C}$ | -                                                                                                            |
| Continuous diode forward current              | $I_S$          | -          | -    | 1.8      | A                | $T_C = 25^\circ\text{C}$                                                                                     |
| Diode pulse current <sup>2)</sup>             | $I_{S,pulse}$  | -          | -    | 19.0     | A                | $T_C = 25^\circ\text{C}$                                                                                     |
| Reverse diode dv/dt <sup>3)</sup>             | dv/dt          | -          | -    | 15       | V/ns             | $V_{DS} = 0 \dots 400\text{V}$ , $I_{SD} \leq I_S$ , $T_j = 25^\circ\text{C}$ ,<br>$t_{cond} < 2\mu\text{s}$ |
| Maximum diode commutation speed <sup>3)</sup> | di/dt          | -          | -    | 500      | A/ $\mu\text{s}$ | $V_{DS} = 0 \dots 400\text{V}$ , $I_{SD} \leq I_S$ , $T_j = 25^\circ\text{C}$ ,<br>$t_{cond} < 2\mu\text{s}$ |

## 2 Thermal characteristics

**Table 3 Thermal characteristics**

| Parameter                                                      | Symbol     | Values |      |      | Unit               | Note / Test Condition                                                                                                                                                           |
|----------------------------------------------------------------|------------|--------|------|------|--------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                                |            | Min.   | Typ. | Max. |                    |                                                                                                                                                                                 |
| Thermal resistance, junction - solder point                    | $R_{thJS}$ | -      | -    | 22.5 | $^\circ\text{C/W}$ | -                                                                                                                                                                               |
| Thermal resistance, junction - ambient for minimal footprint   | $R_{thJA}$ | -      | -    | 160  | $^\circ\text{C/W}$ | minimal footprint                                                                                                                                                               |
| Thermal resistance, junction - ambient soldered on copper area | $R_{thJA}$ | -      | -    | 75   | $^\circ\text{C/W}$ | Device on 40mm*40mm*1.5 epoxy PCB FR4 with 6cm <sup>2</sup> (one layer 70 $\mu\text{m}$ thick) copper area for drain connection and cooling. PCB is vertical without blown air. |
| Soldering temperature, wavesoldering only allowed at leads     | $T_{sold}$ | -      | -    | 260  | $^\circ\text{C}$   | reflow MSL3                                                                                                                                                                     |

<sup>1)</sup> DPAK equivalent. Limited by  $T_{j,max}$ . Maximum duty cycle  $D=0.5$

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

<sup>3)</sup>  $V_{DClamp}=400\text{V}$ ;  $V_{DS,peak} < V_{(BR)DSS}$ ; identical low side and high side switch with identical  $R_G$

### 3 Electrical characteristics

**Table 4 Static characteristics**

| Parameter                        | Symbol        | Values |      |      | Unit     | Note / Test Condition                                                                             |
|----------------------------------|---------------|--------|------|------|----------|---------------------------------------------------------------------------------------------------|
|                                  |               | Min.   | Typ. | Max. |          |                                                                                                   |
| Drain-source breakdown voltage   | $V_{(BR)DSS}$ | 500    | -    | -    | V        | $V_{GS}=0V$ , $I_D=1mA$                                                                           |
| Gate threshold voltage           | $V_{GS(th)}$  | 2.50   | 3    | 3.50 | V        | $V_{DS}=V_{GS}$ , $I_D=0.15mA$                                                                    |
| Zero gate voltage drain current  | $I_{DSS}$     | -      | -    | 1    | $\mu A$  | $V_{DS}=500V$ , $V_{GS}=0V$ , $T_j=25^\circ C$<br>$V_{DS}=500V$ , $V_{GS}=0V$ , $T_j=150^\circ C$ |
| Gate-source leakage current      | $I_{GSS}$     | -      | -    | 100  | nA       | $V_{GS}=20V$ , $V_{DS}=0V$                                                                        |
| Drain-source on-state resistance | $R_{DS(on)}$  | -      | 0.59 | 0.65 | $\Omega$ | $V_{GS}=13V$ , $I_D=1.8A$ , $T_j=25^\circ C$<br>$V_{GS}=13V$ , $I_D=1.8A$ , $T_j=150^\circ C$     |
| Gate resistance                  | $R_G$         | -      | 3    | -    | $\Omega$ | $f=1\text{ MHz}$ , open drain                                                                     |

**Table 5 Dynamic characteristics**

| Parameter                                                  | Symbol       | Values |      |      | Unit | Note / Test Condition                                          |
|------------------------------------------------------------|--------------|--------|------|------|------|----------------------------------------------------------------|
|                                                            |              | Min.   | Typ. | Max. |      |                                                                |
| Input capacitance                                          | $C_{iss}$    | -      | 342  | -    | pF   | $V_{GS}=0V$ , $V_{DS}=100V$ , $f=1\text{ MHz}$                 |
| Output capacitance                                         | $C_{oss}$    | -      | 26   | -    | pF   | $V_{GS}=0V$ , $V_{DS}=100V$ , $f=1\text{ MHz}$                 |
| Effective output capacitance, energy related <sup>1)</sup> | $C_{o(er)}$  | -      | 21   | -    | pF   | $V_{GS}=0V$ , $V_{DS}=0...400V$                                |
| Effective output capacitance, time related <sup>2)</sup>   | $C_{o(tr)}$  | -      | 80   | -    | pF   | $I_D=\text{constant}$ , $V_{GS}=0V$ , $V_{DS}=0...400V$        |
| Turn-on delay time                                         | $t_{d(on)}$  | -      | 6    | -    | ns   | $V_{DD}=400V$ , $V_{GS}=13V$ , $I_D=2.3A$ ,<br>$R_G=5.3\Omega$ |
| Rise time                                                  | $t_r$        | -      | 5    | -    | ns   | $V_{DD}=400V$ , $V_{GS}=13V$ , $I_D=2.3A$ ,<br>$R_G=5.3\Omega$ |
| Turn-off delay time                                        | $t_{d(off)}$ | -      | 27   | -    | ns   | $V_{DD}=400V$ , $V_{GS}=13V$ , $I_D=2.3A$ ,<br>$R_G=5.3\Omega$ |
| Fall time                                                  | $t_f$        | -      | 13   | -    | ns   | $V_{DD}=400V$ , $V_{GS}=13V$ , $I_D=2.3A$ ,<br>$R_G=5.3\Omega$ |

**Table 6 Gate charge characteristics**

| Parameter             | Symbol        | Values |      |      | Unit | Note / Test Condition                            |
|-----------------------|---------------|--------|------|------|------|--------------------------------------------------|
|                       |               | Min.   | Typ. | Max. |      |                                                  |
| Gate to source charge | $Q_{gs}$      | -      | 1.8  | -    | nC   | $V_{DD}=400V$ , $I_D=2.3A$ , $V_{GS}=0$ to $10V$ |
| Gate to drain charge  | $Q_{gd}$      | -      | 8.1  | -    | nC   | $V_{DD}=400V$ , $I_D=2.3A$ , $V_{GS}=0$ to $10V$ |
| Gate charge total     | $Q_g$         | -      | 15   | -    | nC   | $V_{DD}=400V$ , $I_D=2.3A$ , $V_{GS}=0$ to $10V$ |
| Gate plateau voltage  | $V_{plateau}$ | -      | 5.3  | -    | V    | $V_{DD}=400V$ , $I_D=2.3A$ , $V_{GS}=0$ to $10V$ |

<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         | $V_{SD}$  | -      | 0.84 | -    | V       | $V_{GS}=0V, I_F=2.3A, T_f=25^{\circ}C$   |
| Reverse recovery time         | $t_{rr}$  | -      | 162  | -    | ns      | $V_R=400V, I_F=2.3A, di_F/dt=100A/\mu s$ |
| Reverse recovery charge       | $Q_{rr}$  | -      | 1    | -    | $\mu C$ | $V_R=400V, I_F=2.3A, di_F/dt=100A/\mu s$ |
| Peak reverse recovery current | $I_{rrm}$ | -      | 11.1 | -    | A       | $V_R=400V, I_F=2.3A, di_F/dt=100A/\mu s$ |

## 4 Electrical characteristics diagrams

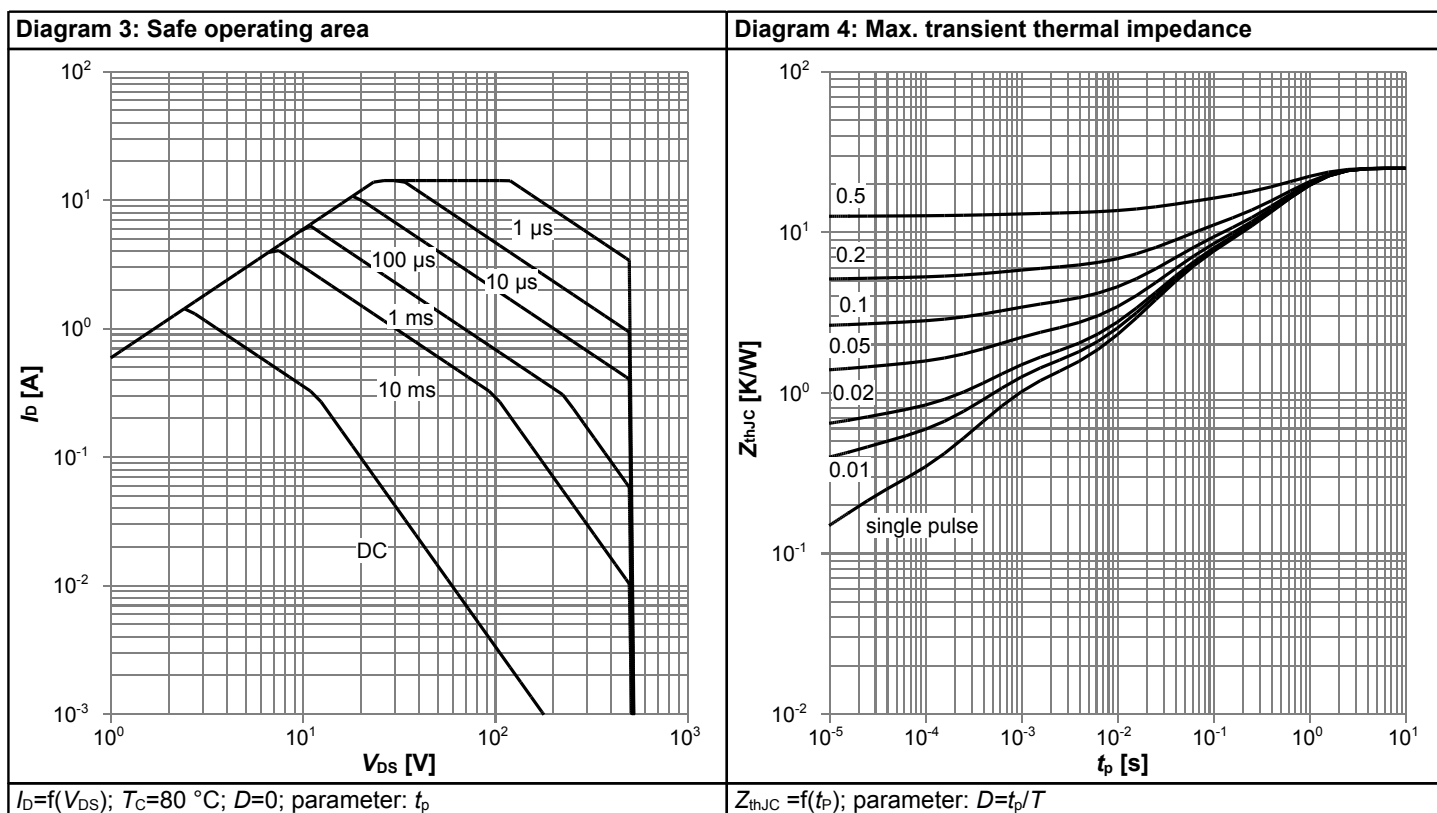
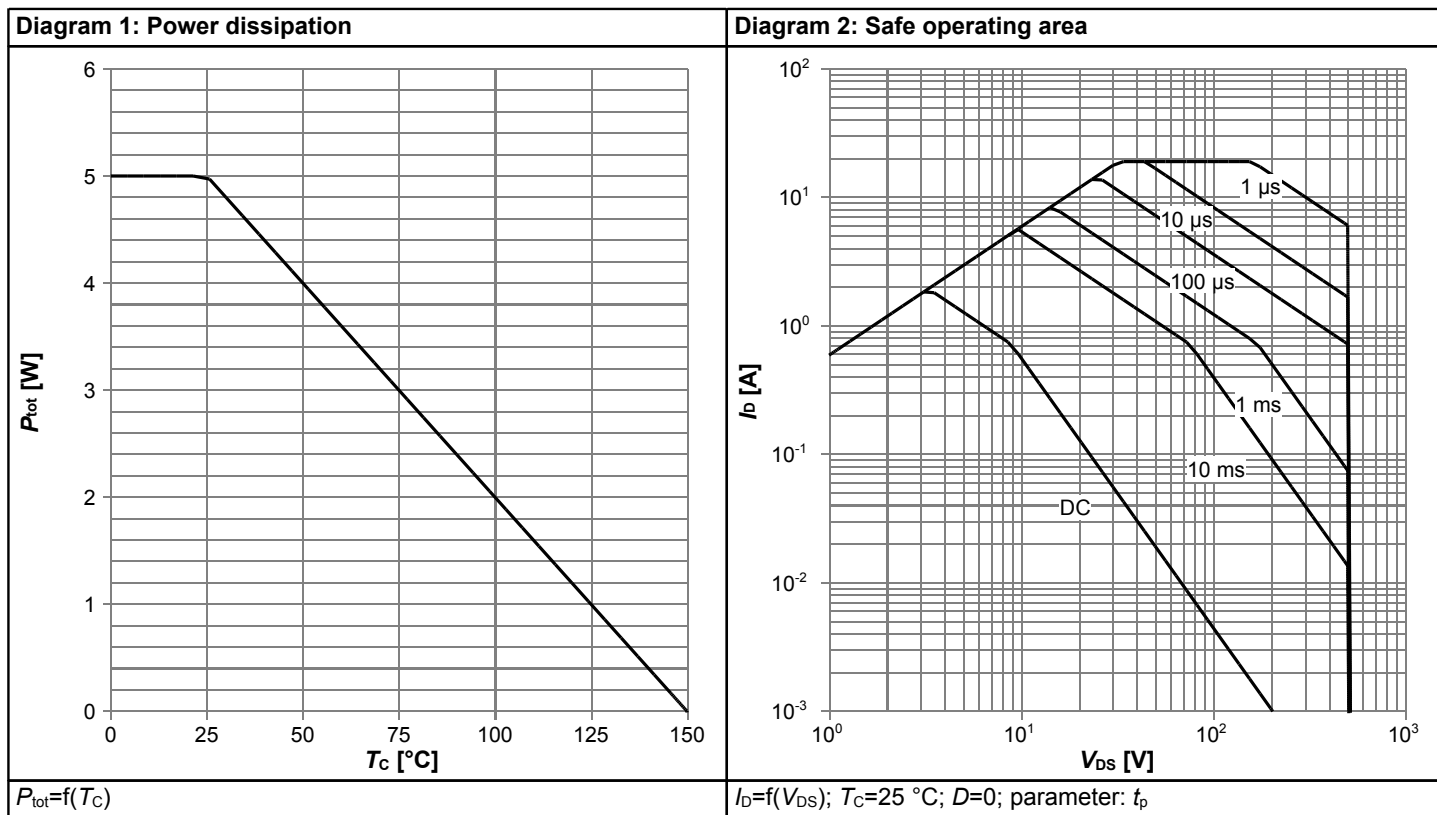
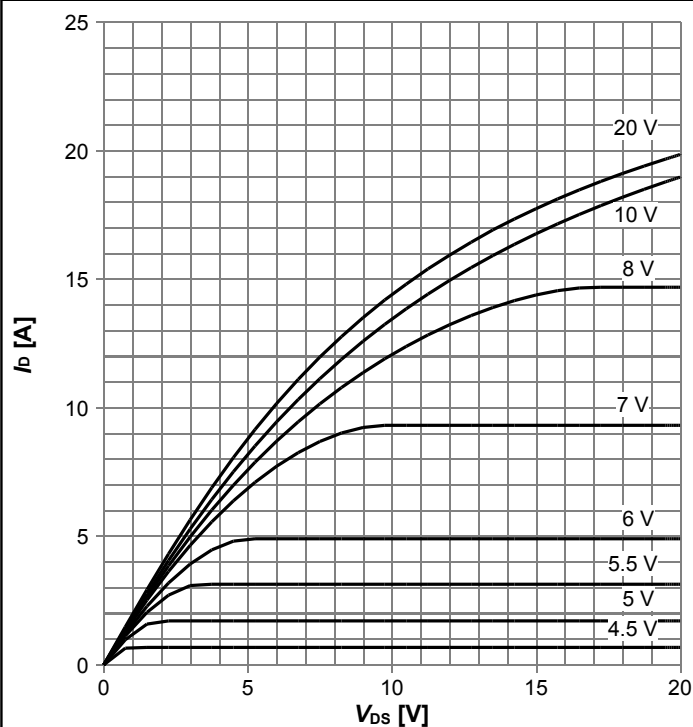
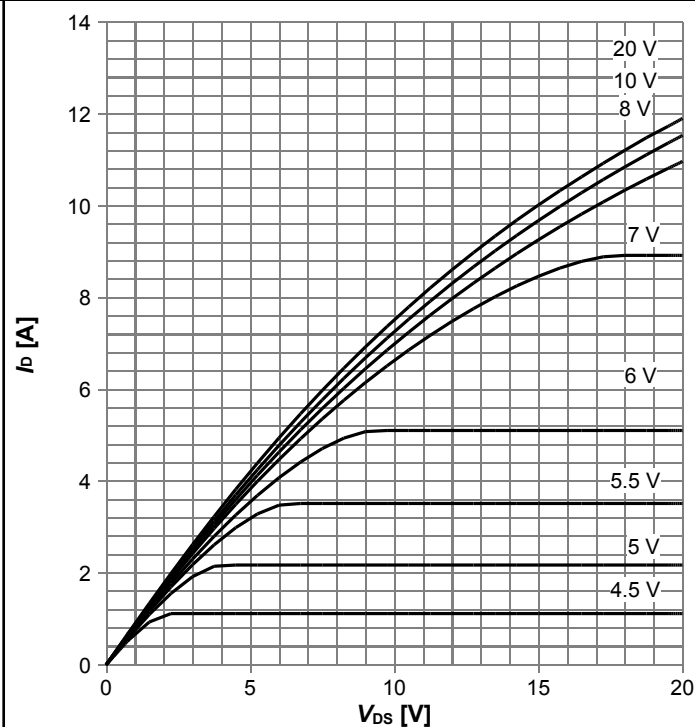


Diagram 5: Typ. output characteristics



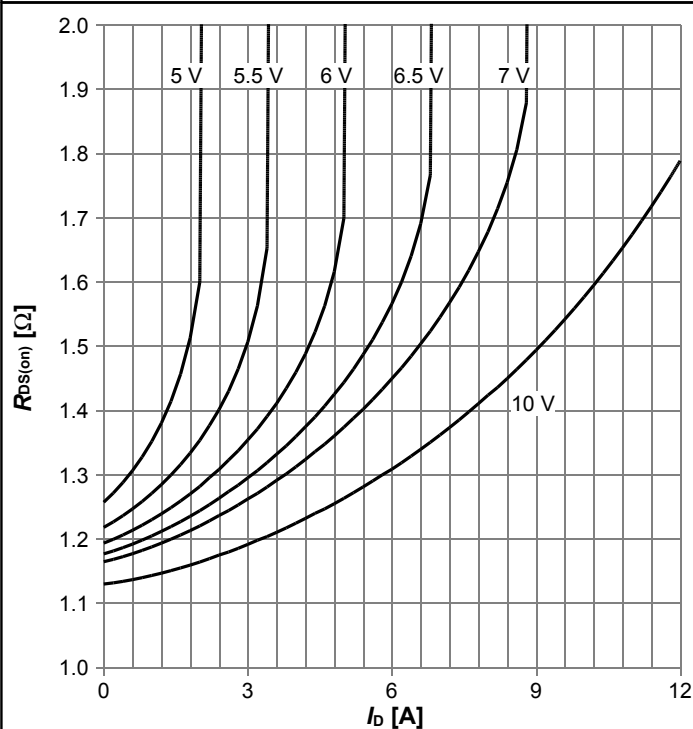
$I_D = f(V_{DS})$ ;  $T_j = 25\text{ °C}$ ; parameter:  $V_{GS}$

Diagram 6: Typ. output characteristics



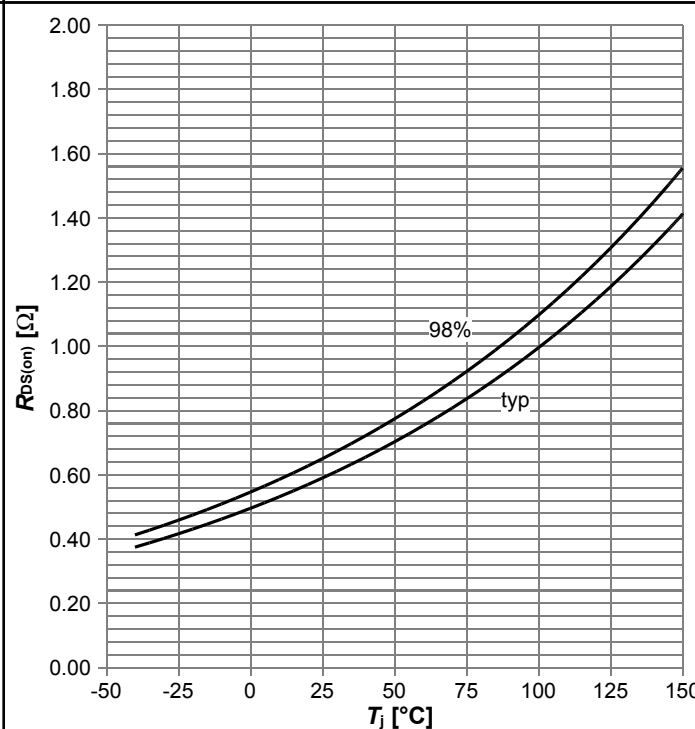
$I_D = f(V_{DS})$ ;  $T_j = 125\text{ °C}$ ; parameter:  $V_{GS}$

Diagram 7: Typ. drain-source on-state resistance



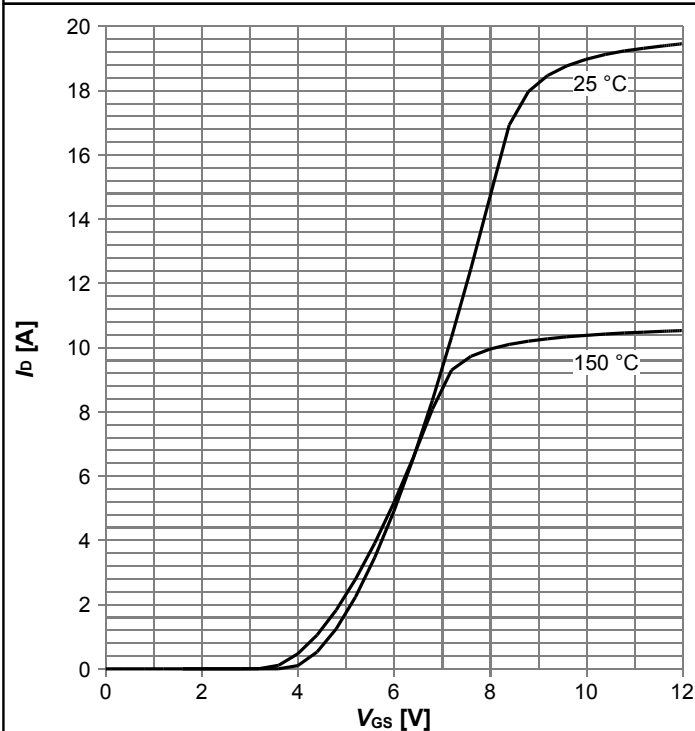
$R_{DS(on)} = f(I_D)$ ;  $T_j = 125\text{ °C}$ ; parameter:  $V_{GS}$

Diagram 8: Drain-source on-state resistance



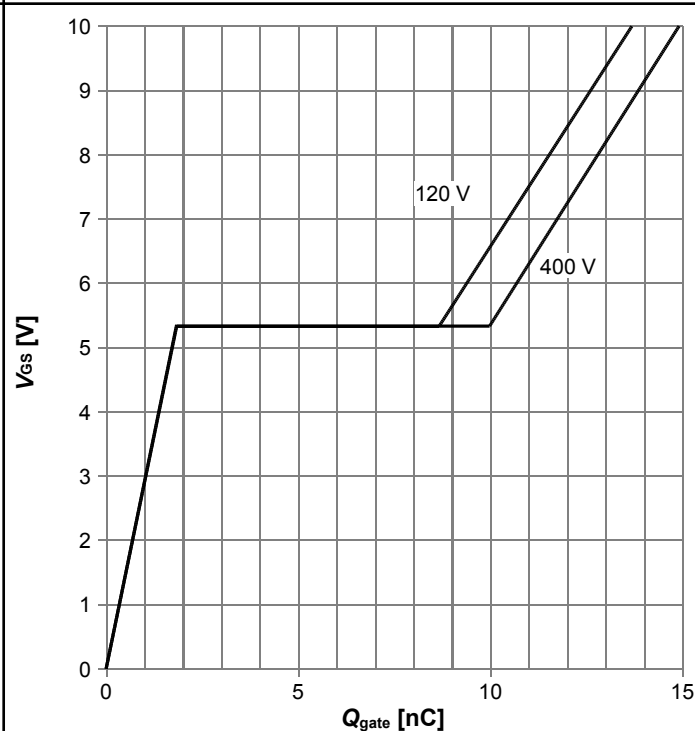
$R_{DS(on)} = f(T_j)$ ;  $I_D = 1.8\text{ A}$ ;  $V_{GS} = 13\text{ V}$

**Diagram 9: Typ. transfer characteristics**



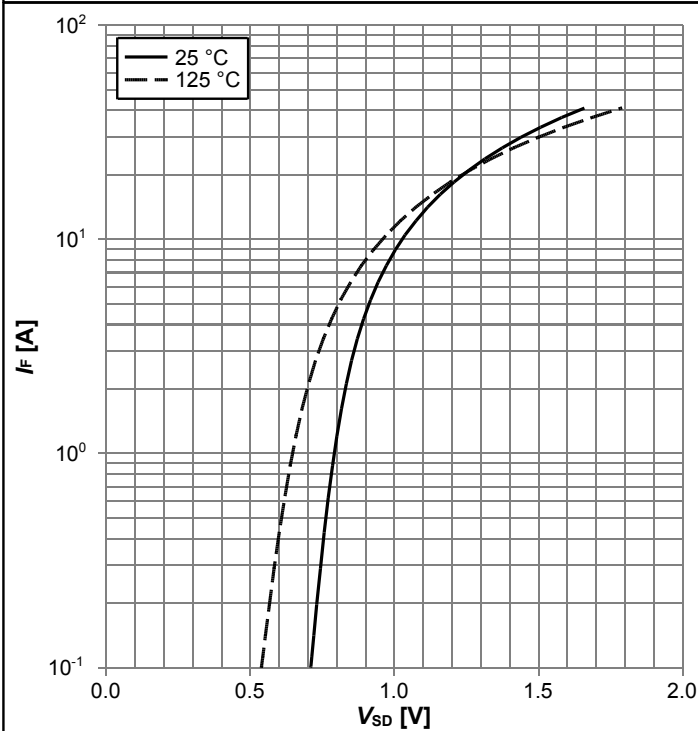
$I_D = f(V_{GS})$ ;  $V_{DS} = 20V$ ; parameter:  $T_j$

**Diagram 10: Typ. gate charge**



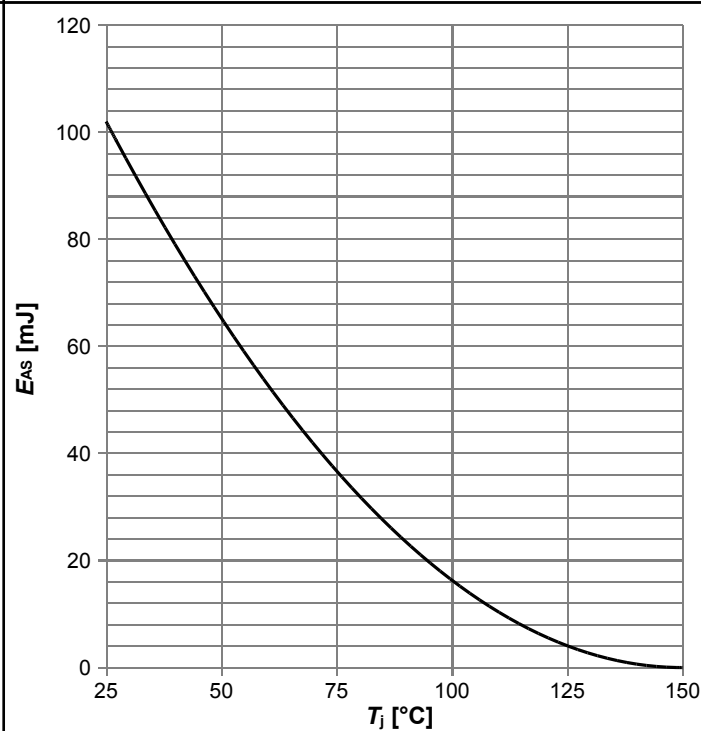
$V_{GS} = f(Q_{gate})$ ;  $I_D = 2.3$  A pulsed; parameter:  $V_{DD}$

**Diagram 11: Forward characteristics of reverse diode**



$I_F = f(V_{SD})$ ; parameter:  $T_j$

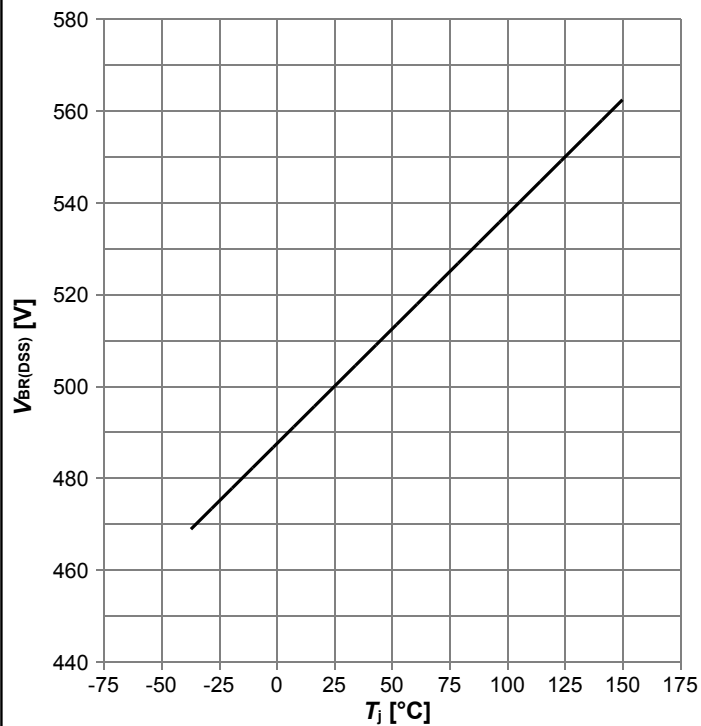
**Diagram 12: Avalanche energy**



$E_{AS} = f(T_j)$ ;  $I_D = 0.8$  A;  $V_{DD} = 50$  V

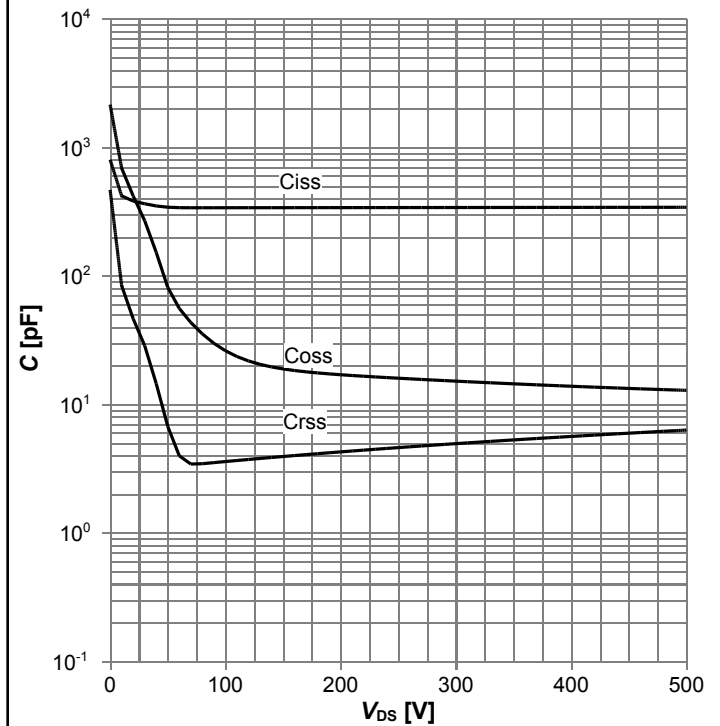


**Diagram 13: Drain-source breakdown voltage**



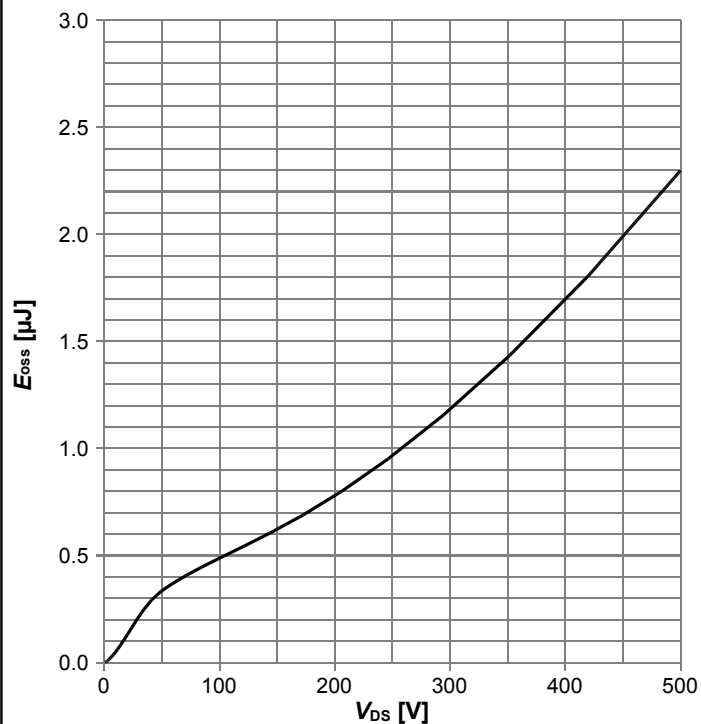
$V_{BR(DSS)} = f(T_J); I_D = 1 \text{ mA}$

**Diagram 14: Typ. capacitances**



$C = f(V_{DS}); V_{GS} = 0 \text{ V}; f = 1 \text{ MHz}$

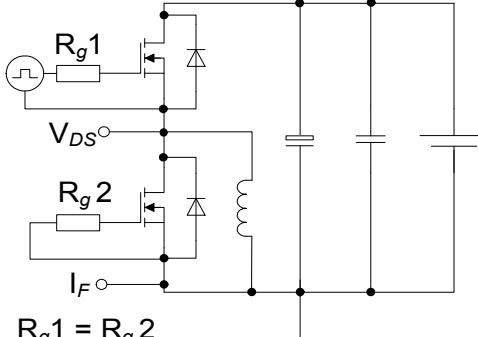
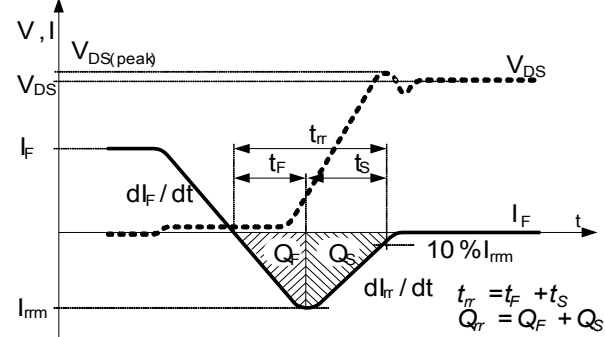
**Diagram 15: Typ. Coss stored energy**



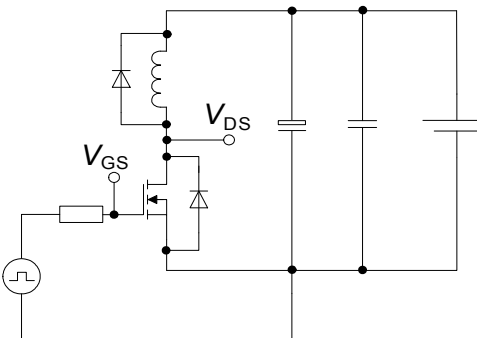
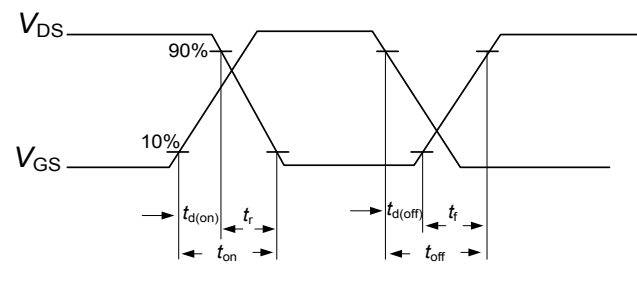
$E_{oss} = f(V_{DS})$

## 5 Test Circuits

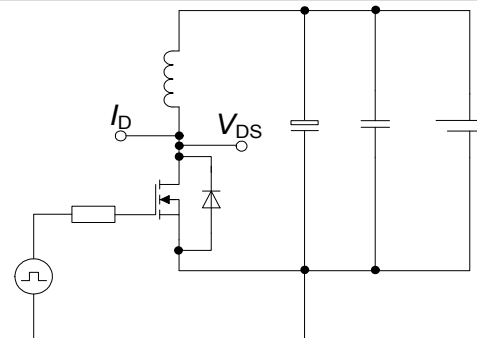
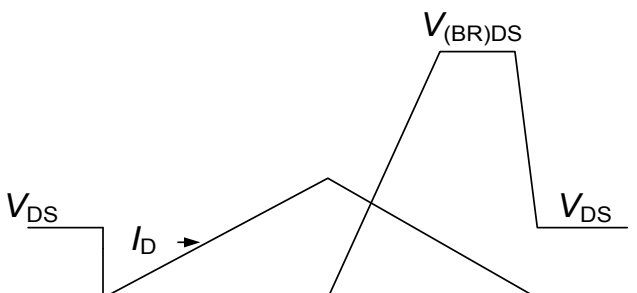
**Table 8 Diode characteristics**

| Test circuit for diode characteristics                                                                                | Diode recovery waveform                                                                                                                                             |
|-----------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  <p><math>R_{g1} = R_{g2}</math></p> |  <p><math>t_{rr} = t_{fr} + t_s</math><br/><math>Q_{rr} = Q_{fr} + Q_s</math></p> |

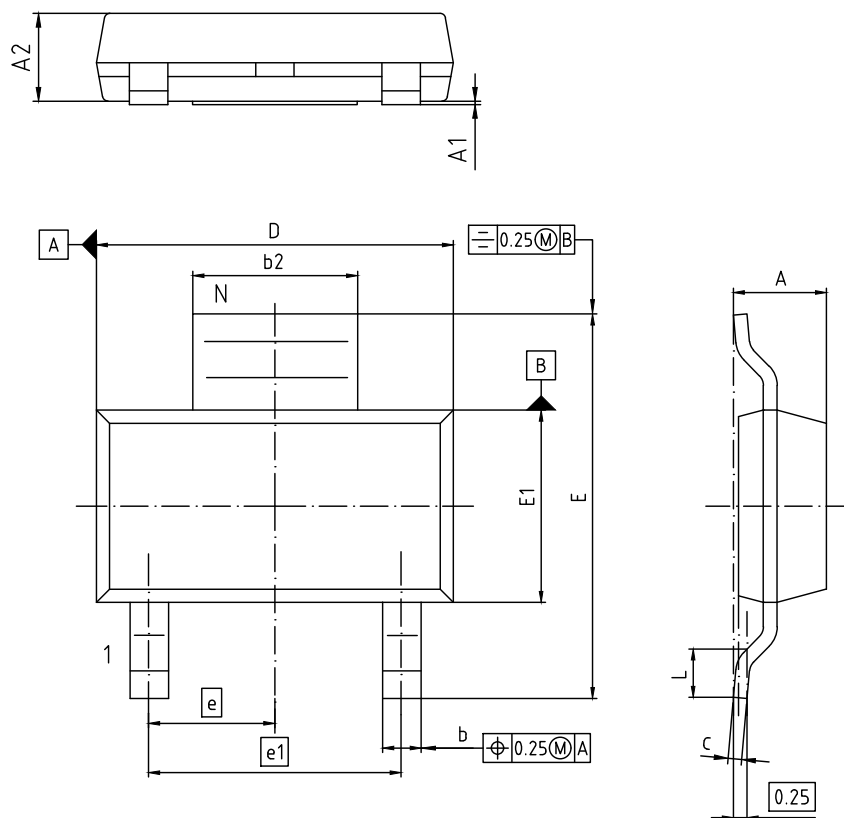
**Table 9 Switching times**

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

**Table 10 Unclamped inductive load**

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

## 6 Package Outlines



### NOTES:

1. ALL DIMENSIONS REFER TO JEDEC STANDARD TO-261

| DIM | MILLIMETERS |      | INCHES      |       |
|-----|-------------|------|-------------|-------|
|     | MIN         | MAX  | MIN         | MAX   |
| A   | 1.52        | 1.80 | 0.060       | 0.071 |
| A1  | -           | 0.10 | -           | 0.004 |
| A2  | 1.50        | 1.70 | 0.059       | 0.067 |
| b   | 0.60        | 0.80 | 0.024       | 0.031 |
| b2  | 2.95        | 3.10 | 0.116       | 0.122 |
| c   | 0.24        | 0.32 | 0.009       | 0.013 |
| D   | 6.30        | 6.70 | 0.248       | 0.264 |
| E   | 6.70        | 7.30 | 0.264       | 0.287 |
| E1  | 3.30        | 3.70 | 0.130       | 0.146 |
| e   | 2.3 BASIC   |      | 0.091 BASIC |       |
| e1  | 4.6 BASIC   |      | 0.181 BASIC |       |
| L   | 0.75        | 1.10 | 0.030       | 0.043 |
| N   | 3           |      | 3           |       |
| O   | 0°          | 10°  | 0°          | 10°   |

|                             |
|-----------------------------|
| DOCUMENT NO.<br>Z8B00180553 |
| SCALE<br>0 2.5 5mm          |
| EUROPEAN PROJECTION<br>     |
| ISSUE DATE<br>24-02-2016    |
| REVISION<br>01              |

Figure 1 Outline PG-SOT223, dimensions in mm/inches

## **7 Appendix A**

### **Table 11 Related Links**

- **IFX CoolMOS Webpage:** [www.infineon.com](http://www.infineon.com)
- **IFX Design tools:** [www.infineon.com](http://www.infineon.com)

## Revision History

IPN50R650CE

**Revision: 2016-06-13, Rev. 2.1**

Previous Revision

| Revision | Date       | Subjects (major changes since last revision) |
|----------|------------|----------------------------------------------|
| 2.0      | 2016-04-29 | Release of final version                     |
| 2.1      | 2016-06-13 | Updated ID ratings                           |

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