

# MOSFET

Metal Oxide Semiconductor Field Effect Transistor

## CoolMOS C6

600V CoolMOS™ C6 Power Transistor  
IPD60R3K3C6

## Data Sheet

Rev. 2.0, 2010-07-21  
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. CoolMOS™ C6 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 not sacrificing ease of use. Extremely low switching and conduction losses make switching applications even more efficient, more compact, lighter, and cooler.

### Features

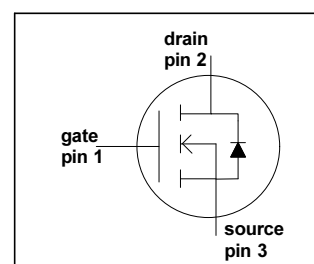
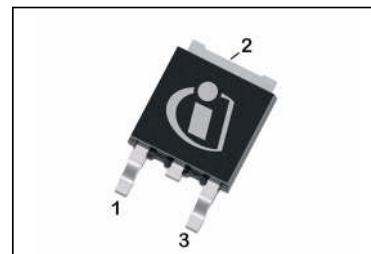
- Extremely low losses due to very low FOM  $R_{DS(on)} \cdot Q_g$  and  $E_{oss}$
- Very high commutation ruggedness
- Easy to use/drive
- JEDEC<sup>1)</sup> qualified, Pb-free plating

### 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       |
|----------------------|-------|------------|
| $V_{DS} @ T_{j,max}$ | 650   | V          |
| $R_{DS(on),max}$     | 3.3   | $\Omega$   |
| $Q_{g,typ}$          | 4.6   | nC         |
| $I_{D,pulse}$        | 4     | A          |
| $E_{oss} @ 400V$     | 0.57  | $\mu J$    |
| Body diode $di/dt$   | 500   | A/ $\mu s$ |

| Type / Ordering Code | Package  | Marking | Related Links                                                                                                                                       |
|----------------------|----------|---------|-----------------------------------------------------------------------------------------------------------------------------------------------------|
| IPD60R3K3C6          | PG-TO252 | 6R3K3C6 | <a href="#">IFX C6 Product Brief</a><br><a href="#">IFX C6 Portfolio</a><br><a href="#">IFX CoolMOS Webpage</a><br><a href="#">IFX Design tools</a> |

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 .....                       | 12 |
| 7 | Package outlines .....                    | 13 |
| 8 | Revision History .....                    | 14 |

## 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>        | $I_D$          | -      | -    | 1.7  | A    | $T_C = 25\text{ °C}$                                                       |
|                                               |                |        |      | 1.1  |      | $T_C = 100\text{ °C}$                                                      |
| Pulsed drain current <sup>2)</sup>            | $I_{D,pulse}$  | -      | -    | 4    | A    | $T_C = 25\text{ °C}$                                                       |
| Avalanche energy, single pulse                | $E_{AS}$       | -      | -    | 6    | mJ   | $I_D = 0.3\text{ A}, V_{DD} = 50\text{ V}$<br>(see table 17)               |
| Avalanche energy, repetitive                  | $E_{AR}$       | -      | -    | 0.04 |      | $I_D = 0.3\text{ A}, V_{DD} = 50\text{ V}$                                 |
| Avalanche current, repetitive                 | $I_{AR}$       | -      | -    | 0.3  | 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                             | $P_{tot}$      | -      | -    | 18.1 | W    | $T_C = 25\text{ °C}$                                                       |
| Operating and storage temperature             | $T_j, T_{stg}$ | -55    | -    | 150  | °C   |                                                                            |
| Continuous diode forward current              | $I_S$          | -      | -    | 1.5  | A    | $T_C = 25\text{ °C}$                                                       |
| Diode pulse current <sup>2)</sup>             | $I_{S,pulse}$  | -      | -    | 4    | A    | $T_C = 25\text{ °C}$                                                       |
| Reverse diode dv/dt <sup>3)</sup>             | dv/dt          | -      | -    | 15   | V/ns | $V_{DS} = 0 \dots 480\text{ V}, I_{SD} \leq I_D,$<br>$T_j = 125\text{ °C}$ |
| Maximum diode commutation speed <sup>3)</sup> | di/dt          |        |      | 500  | A/μs | (see table 18)                                                             |

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**

| Parameter                                              | Symbol     | Values |      |      | Unit | Note / Test Condition                                                   |
|--------------------------------------------------------|------------|--------|------|------|------|-------------------------------------------------------------------------|
|                                                        |            | Min.   | Typ. | Max. |      |                                                                         |
| Thermal resistance, junction - case                    | $R_{thJC}$ | -      | -    | 6.9  | °C/W |                                                                         |
| Thermal resistance, junction - ambient                 | $R_{thJA}$ | -      | -    | 62   |      | SMD version, device on PCB, minimal footprint                           |
|                                                        |            |        | 35   |      |      | SMD version, device on PCB, 6cm <sup>2</sup> cooling area <sup>1)</sup> |
| Soldering temperature, wave- & reflowsoldering allowed | $T_{sold}$ | -      | -    | 260  | °C   | reflow MSL1                                                             |

1) Device on 40mm\*40mm\*1.5 epoxy PCB FR4 with 6cm<sup>2</sup> (one layer, 70µm thick) copper area 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 4 Static characteristics**

| Parameter                        | Symbol        | Values |      |      | Unit          | Note / Test Condition                                                |
|----------------------------------|---------------|--------|------|------|---------------|----------------------------------------------------------------------|
|                                  |               | Min.   | Typ. | Max. |               |                                                                      |
| Drain-source breakdown voltage   | $V_{(BR)DSS}$ | 600    | -    | -    | V             | $V_{GS}=0\text{ V}$ , $I_D=0.25\text{ mA}$                           |
| Gate threshold voltage           | $V_{GS(th)}$  | 2.5    | 3    | 3.5  |               | $V_{DS}=V_{GS}$ , $I_D=0.04\text{ mA}$                               |
| Zero gate voltage drain current  | $I_{DSS}$     | -      | -    | 1    | $\mu\text{A}$ | $V_{DS}=600\text{ V}$ , $V_{GS}=0\text{ V}$ ,<br>$T_j=25\text{ °C}$  |
|                                  |               | -      | 10   | -    |               | $V_{DS}=600\text{ V}$ , $V_{GS}=0\text{ V}$ ,<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 | $R_{DS(on)}$  | -      | 2.97 | 3.3  | $\Omega$      | $V_{GS}=10\text{ V}$ , $I_D=0.5\text{ A}$ ,<br>$T_j=25\text{ °C}$    |
|                                  |               | -      | 7.72 | -    |               | $V_{GS}=10\text{ V}$ , $I_D=0.5\text{ A}$ ,<br>$T_j=150\text{ °C}$   |
| Gate resistance                  | $R_G$         | -      | 15   | -    | $\Omega$      | $f=1\text{ MHz}$ , open drain                                        |

**Table 5 Dynamic characteristics**

| Parameter                                                  | Symbol       | Values |      |      | Unit | Note / Test Condition                                                                                              |
|------------------------------------------------------------|--------------|--------|------|------|------|--------------------------------------------------------------------------------------------------------------------|
|                                                            |              | Min.   | Typ. | Max. |      |                                                                                                                    |
| Input capacitance                                          | $C_{iss}$    | -      | 93   | -    | pF   | $V_{GS}=0\text{ V}$ , $V_{DS}=100\text{ V}$ ,<br>$f=1\text{ MHz}$                                                  |
| Output capacitance                                         | $C_{oss}$    | -      | 9    | -    |      |                                                                                                                    |
| Effective output capacitance, energy related <sup>1)</sup> | $C_{o(er)}$  | -      | 6.4  | -    |      | $V_{GS}=0\text{ V}$ ,<br>$V_{DS}=0\dots480\text{ V}$                                                               |
| Effective output capacitance, time related <sup>2)</sup>   | $C_{o(tr)}$  | -      | 21   | -    |      | $I_D=\text{constant}$ , $V_{GS}=0\text{ V}$<br>$V_{DS}=0\dots480\text{ V}$                                         |
| Turn-on delay time                                         | $t_{d(on)}$  | -      | 8    | -    | ns   | $V_{DD}=400\text{ V}$ ,<br>$V_{GS}=10\text{ V}$ , $I_D=0.6\text{ A}$ ,<br>$R_G=20\text{ }\Omega$<br>(see table 16) |
| Rise time                                                  | $t_r$        | -      | 10   | -    |      |                                                                                                                    |
| Turn-off delay time                                        | $t_{d(off)}$ | -      | 40   | -    |      |                                                                                                                    |
| Fall time                                                  | $t_f$        | -      | 60   | -    |      |                                                                                                                    |

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 6 Gate charge characteristics**

| Parameter             | Symbol        | Values |      |      | Unit | Note / Test Condition                                                            |
|-----------------------|---------------|--------|------|------|------|----------------------------------------------------------------------------------|
|                       |               | Min.   | Typ. | Max. |      |                                                                                  |
| Gate to source charge | $Q_{gs}$      | -      | 0.5  | -    | nC   | $V_{DD}=480\text{ V}$ , $I_D=0.6\text{ A}$ ,<br>$V_{GS}=0\text{ to }10\text{ V}$ |
| Gate to drain charge  | $Q_{gd}$      | -      | 2.6  | -    |      |                                                                                  |
| Gate charge total     | $Q_g$         | -      | 4.6  | -    |      |                                                                                  |
| Gate plateau voltage  | $V_{plateau}$ | -      | 5.4  | -    | V    |                                                                                  |

**Table 7 Reverse diode characteristics**

| Parameter                     | Symbol    | Values |      |      | Unit          | Note / Test Condition                                                                             |
|-------------------------------|-----------|--------|------|------|---------------|---------------------------------------------------------------------------------------------------|
|                               |           | Min.   | Typ. | Max. |               |                                                                                                   |
| Diode forward voltage         | $V_{SD}$  | -      | 0.9  | -    | V             | $V_{GS}=0\text{ V}$ , $I_F=0.6\text{ A}$ ,<br>$T_j=25\text{ °C}$                                  |
| Reverse recovery time         | $t_{rr}$  | -      | 160  | -    | ns            | $V_R=400\text{ V}$ , $I_F=0.6\text{ A}$ ,<br>$di_F/dt=100\text{ A}/\mu\text{s}$<br>(see table 18) |
| Reverse recovery charge       | $Q_{rr}$  | -      | 0.42 | -    | $\mu\text{C}$ |                                                                                                   |
| Peak reverse recovery current | $I_{rrm}$ | -      | 5.1  | -    | A             |                                                                                                   |

## 5 Electrical characteristics diagrams

Table 8

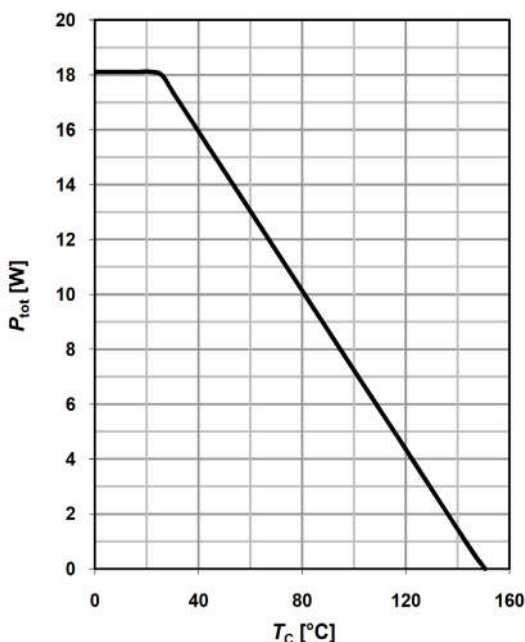
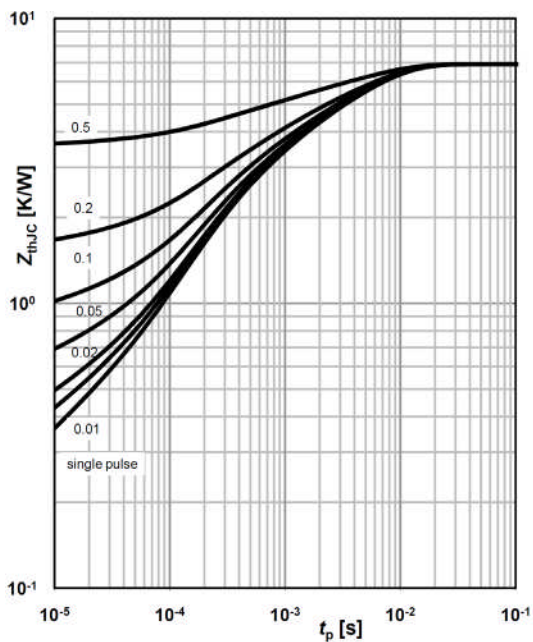
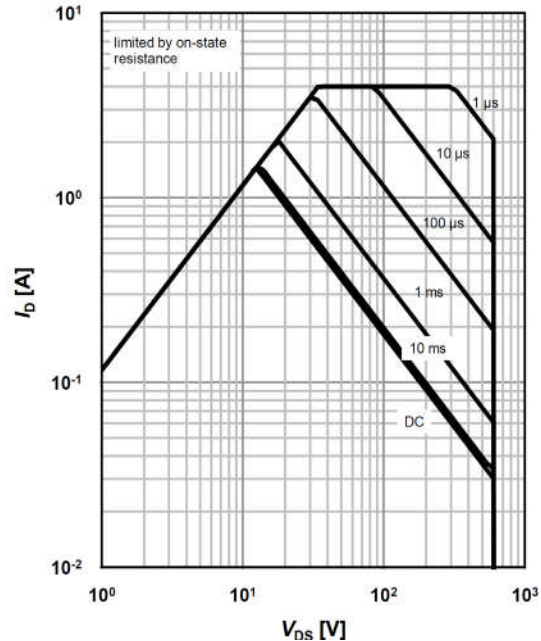
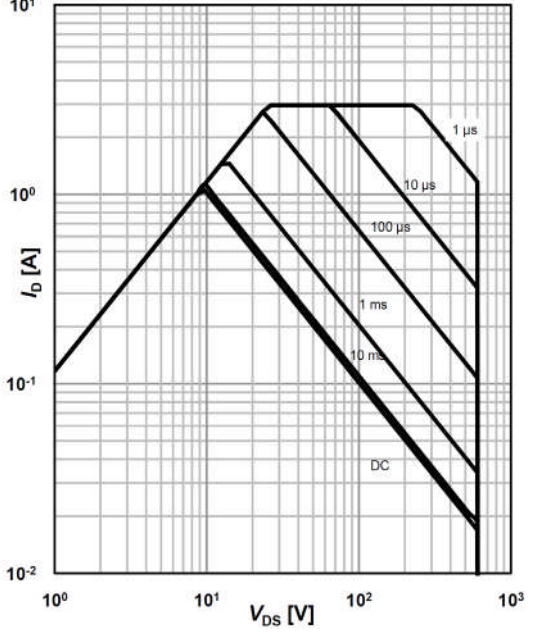
| Power dissipation                                                                                                              | Max. transient thermal impedance                                                                                                                                      |
|--------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  <p><math>P_{\text{tot}} = f(T_c)</math></p> |  <p><math>Z_{\text{thJC}} = f(t_p)</math>; parameter: <math>D = t_p / T</math></p> |

Table 9

| Safe operating area $T_c = 25^\circ\text{C}$                                                                                                                                              | Safe operating area $T_c = 80^\circ\text{C}$                                                                                                                                               |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  <p><math>I_D = f(V_{\text{DS}}); T_c = 25^\circ\text{C}; D = 0</math>; parameter <math>t_p</math></p> |  <p><math>I_D = f(V_{\text{DS}}); T_c = 80^\circ\text{C}; D = 0</math>; parameter <math>t_p</math></p> |

Electrical characteristics diagrams

Table 10

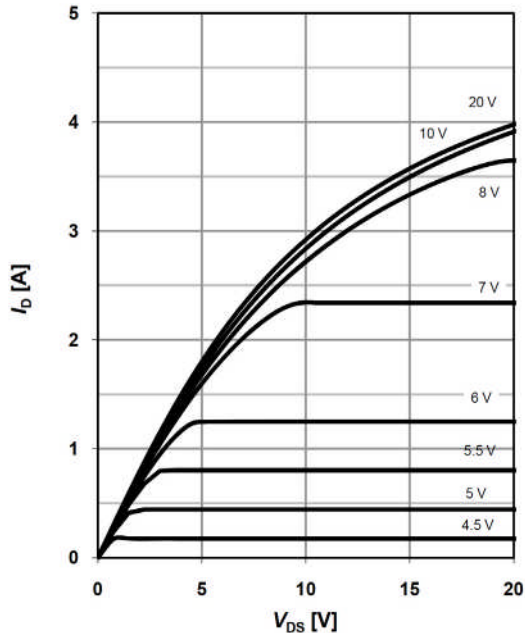
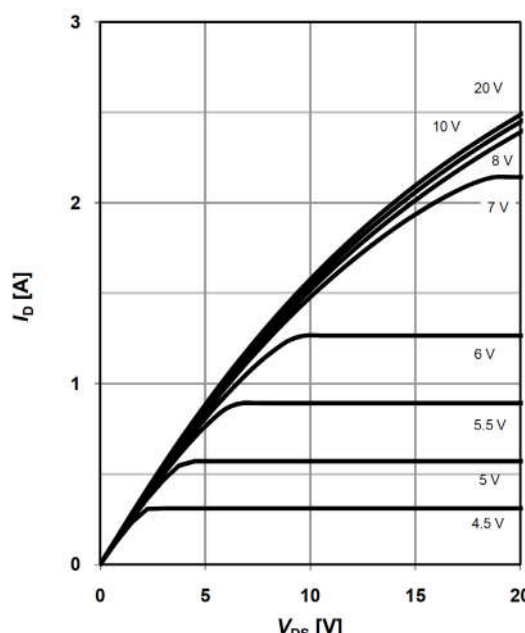
| Typ. output characteristics $T_j=25\text{ °C}$                                     | Typ. output characteristics $T_j=125\text{ °C}$                                     |
|------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
|  |  |
| $I_D=f(V_{DS}); T_j=25\text{ °C}; \text{parameter: } V_{GS}$                       | $I_D=f(V_{DS}); T_j=125\text{ °C}; \text{parameter: } V_{GS}$                       |

Table 11

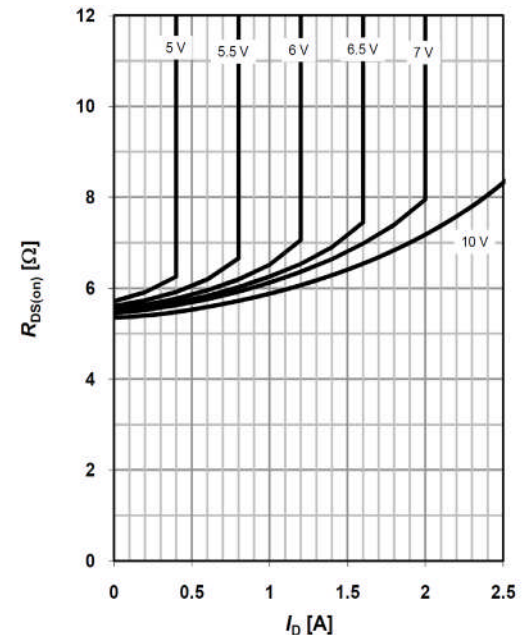
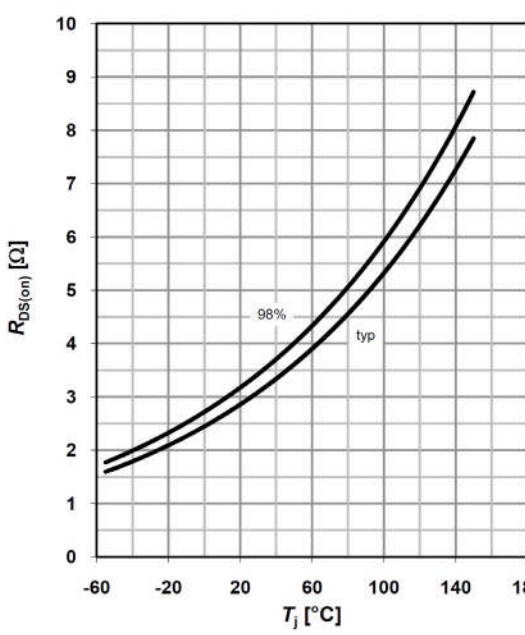
| Typ. drain-source on-state resistance                                               | Drain-source on-state resistance                                                     |
|-------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|
|  |  |
| $R_{DS(on)}=f(I_D); T_j=125\text{ °C}; \text{parameter: } V_{GS}$                   | $R_{DS(on)}=f(T_j); I_D=0.5\text{ A}; V_{GS}=10\text{ V}$                            |

Table 12

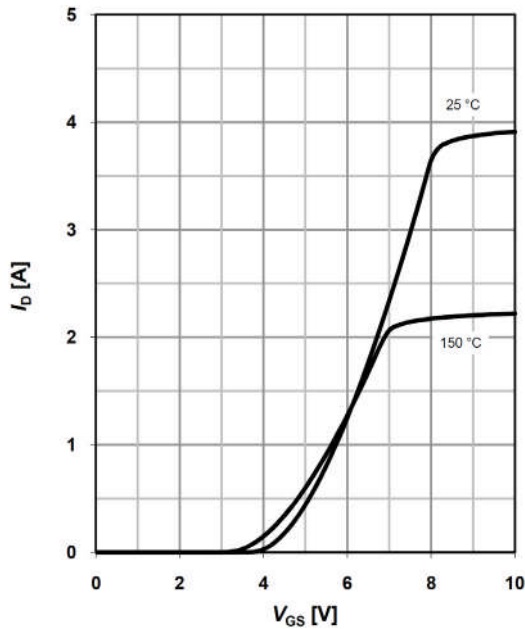
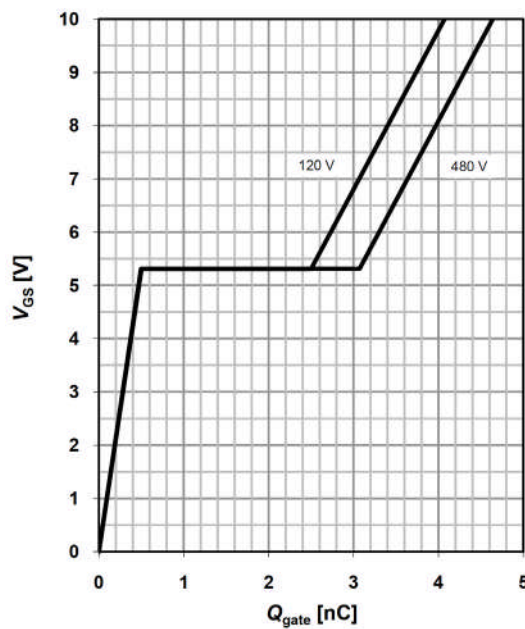
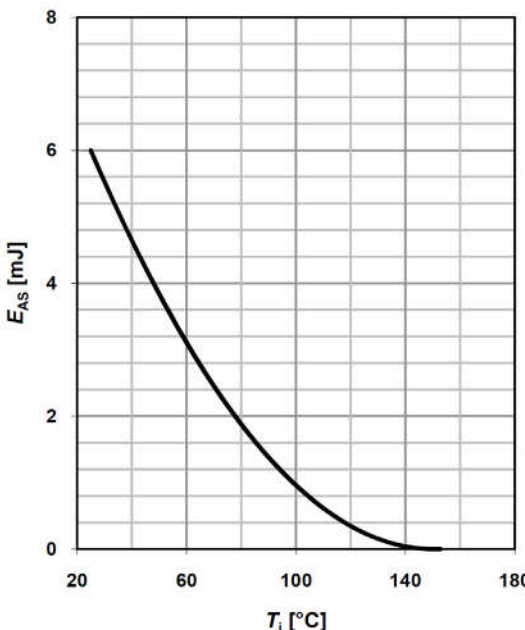
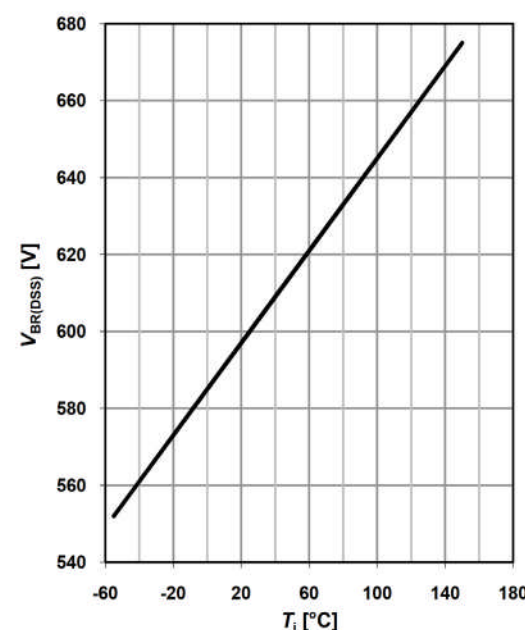
| Typ. transfer characteristics                                                      | Typ. gate charge                                                                    |
|------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
|  |  |
| $I_D = f(V_{GS}); V_{DS} = 20V$                                                    | $V_{GS} = f(Q_{gate}), I_D = 0.6 \text{ A pulsed}$                                  |

Table 13

| Avalanche energy                                                                    | Drain-source breakdown voltage                                                       |
|-------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|
|  |  |
| $E_{AS} = f(T_j); I_D = 0.3 \text{ A}; V_{DD} = 50 \text{ V}$                       | $V_{BR(DSS)} = f(T_j); I_D = 0.25 \text{ mA}$                                        |

Electrical characteristics diagrams

Table 14

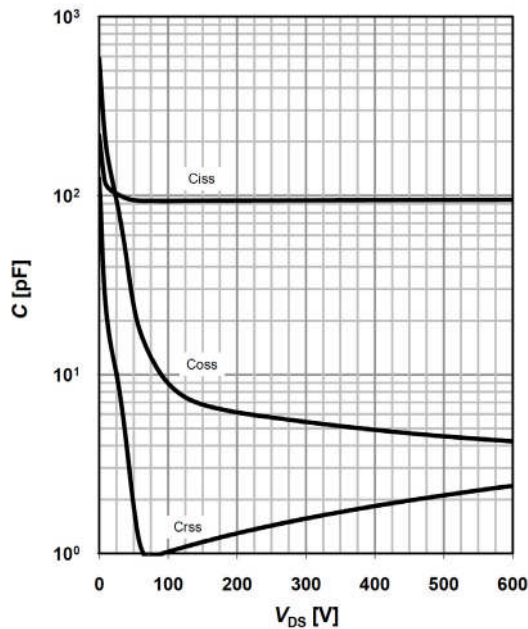
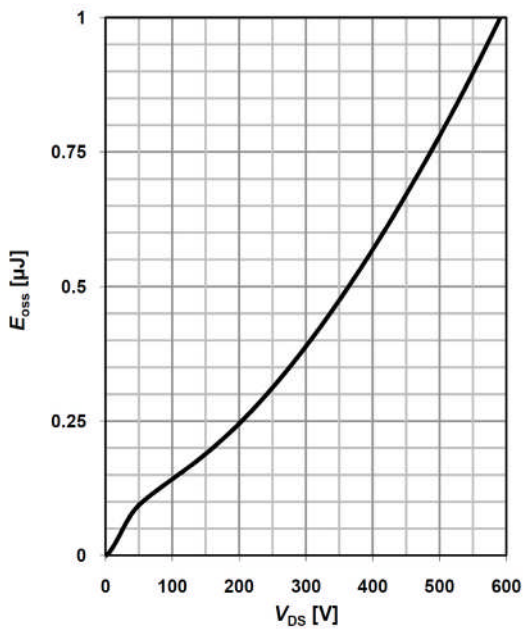
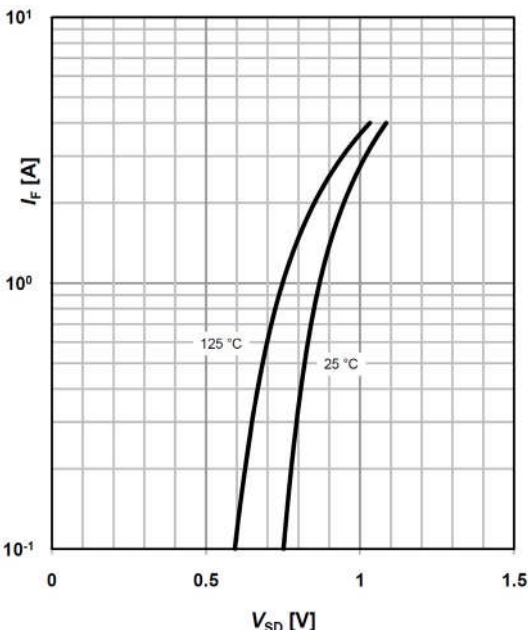
| Typ. capacitances                                                                                                                                             | Typ. $C_{oss}$ stored energy                                                                                                |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------|
|  <p><math>C = f(V_{DS}); V_{GS} = 0 \text{ V}; f = 1 \text{ MHz}</math></p> |  <p><math>E_{oss} = f(V_{DS})</math></p> |

Table 15

| Forward characteristics of reverse diode                                                                                                        |
|-------------------------------------------------------------------------------------------------------------------------------------------------|
|  <p><math>I_F = f(V_{SD}); \text{parameter: } T_j</math></p> |

## 6 Test circuits

Table 16 Switching times test circuit and waveform for inductive load

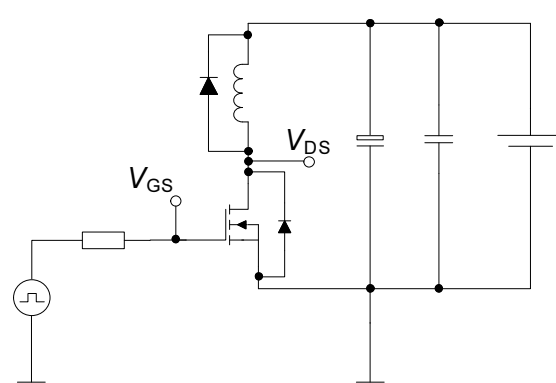
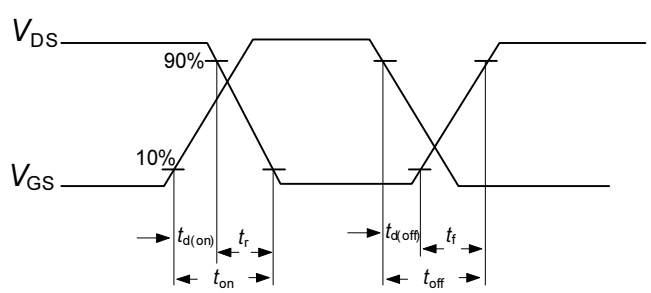
| Switching times test circuit for inductive load                                   | Switching time waveform                                                            |
|-----------------------------------------------------------------------------------|------------------------------------------------------------------------------------|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

Table 17 Unclamped inductive load test circuit and waveform

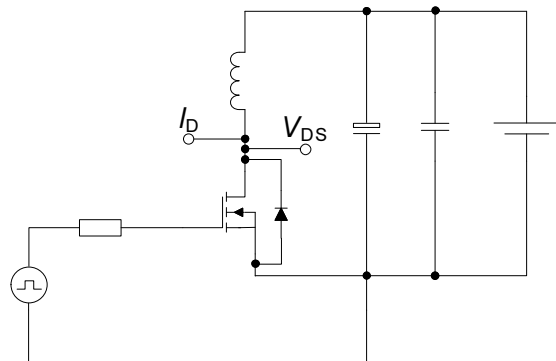
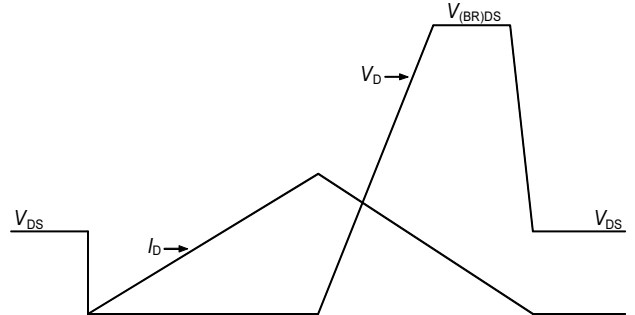
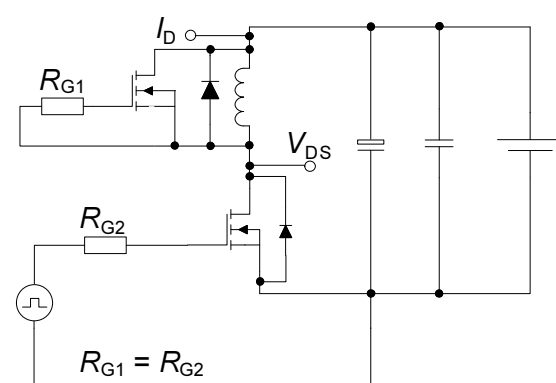
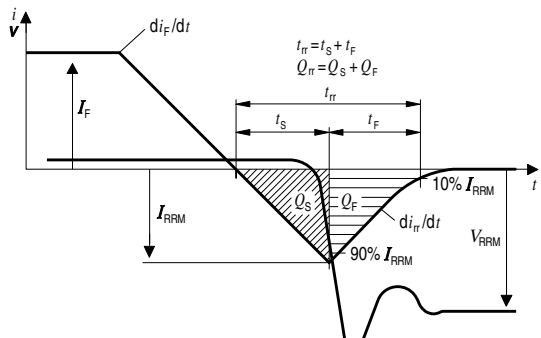
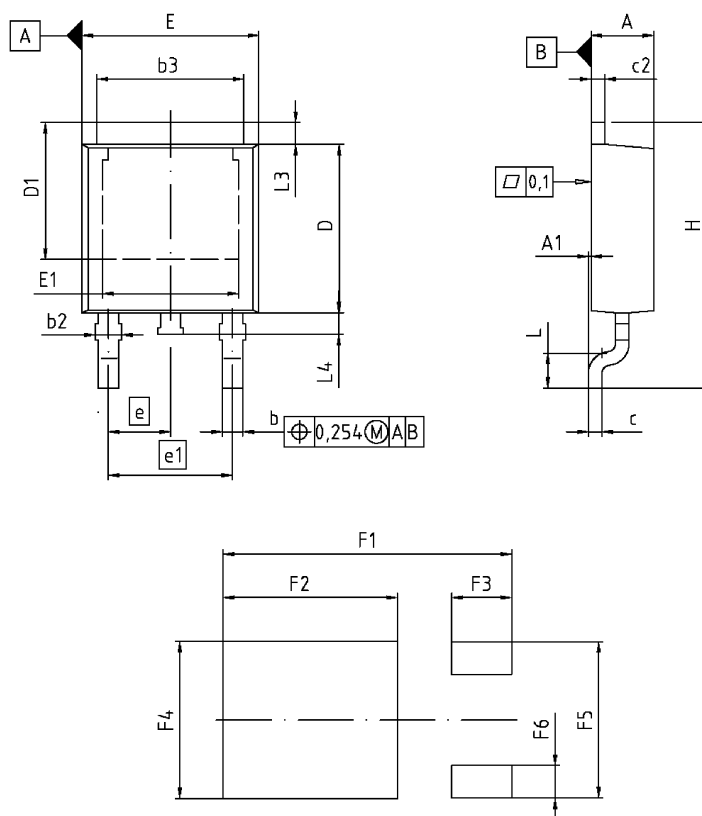
| Unclamped inductive load test circuit                                               | Unclamped inductive waveform                                                         |
|-------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|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

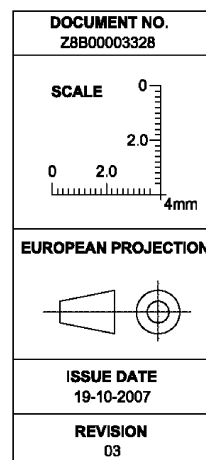
Table 18 Test circuit and waveform for diode characteristics

| Test circuit for diode characteristics                                                                                  | Diode recovery waveform                                                                              |
|-------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------|
|  <p><math>R_{G1} = R_{G2}</math></p> |  <p>SIL00088</p> |

## 7 Package outlines



| DIM | MILLIMETERS |       | INCHES |       |
|-----|-------------|-------|--------|-------|
|     | MIN         | MAX   | MIN    | MAX   |
| A   | 2.16        | 2.41  | 0.085  | 0.095 |
| A1  | 0.00        | 0.15  | 0.000  | 0.006 |
| b   | 0.64        | 0.89  | 0.025  | 0.035 |
| b2  | 0.65        | 1.15  | 0.026  | 0.045 |
| b3  | 5.00        | 5.50  | 0.197  | 0.217 |
| c   | 0.46        | 0.80  | 0.018  | 0.024 |
| c2  | 0.46        | 0.98  | 0.018  | 0.039 |
| D   | 5.97        | 6.22  | 0.235  | 0.245 |
| D1  | 5.02        | 5.84  | 0.198  | 0.230 |
| E   | 6.40        | 6.73  | 0.252  | 0.265 |
| E1  | 4.70        | 5.21  | 0.185  | 0.205 |
| e   | 2.29        |       | 0.090  |       |
| e1  | 4.57        |       | 0.180  |       |
| N   | 3           |       | 3      |       |
| H   | 9.40        | 10.48 | 0.370  | 0.413 |
| L   | 1.18        | 1.70  | 0.046  | 0.067 |
| L3  | 0.90        | 1.25  | 0.035  | 0.049 |
| L4  | 0.51        | 1.00  | 0.020  | 0.039 |
| F1  | 10.50       | 10.70 | 0.413  | 0.421 |
| F2  | 6.30        | 6.50  | 0.248  | 0.256 |
| F3  | 2.10        | 2.30  | 0.083  | 0.091 |
| F4  | 5.70        | 5.90  | 0.224  | 0.232 |
| F5  | 5.66        | 5.86  | 0.223  | 0.231 |
| F6  | 1.10        | 1.30  | 0.043  | 0.051 |



**Figure 1** Outlines TO-252, dimensions in mm/inches

## 8 Revision History

### CoolMOS C6 600V CoolMOS™ C6 Power Transistor

Revision History: 2010-07-21, 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.

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.