

## MOSFET

Metal Oxide Semiconductor Field Effect Transistor

## CoolMOS™ E6

650V CoolMOS™ E6 Power Transistor  
IPS65R600E6

## Data Sheet

Rev. 2.0  
Final

## 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™ E6 series combines the experience of the leading SJ MOSFET supplier with high class innovation. The resulting devices provide all benefits of a fast switching Superjunction MOSFET while not sacrificing ease of use. Extremely low switching and conduction losses make switching applications even more efficient, more compact, lighter and cooler.

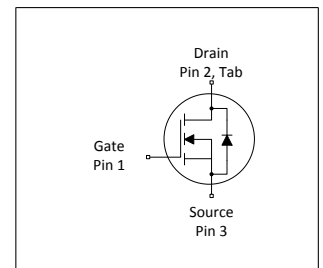
## Features

- 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
- Pb-free plating, Halogen free mold compound
- Qualified for industrial grade applications according to JEDEC (J-STD20 and JESD22)

## Applications

PFC stages, hard switching PWM stages and resonant switching stages for e.g. PC Silverbox, Adapter, LCD & PDP TV and Lighting, Server, Telecom and UPS

*Please note: For MOSFET paralleling the use of ferrite beads on the gate or separate totem poles is generally recommended.*



**Table 1 Key Performance Parameters**

| Parameter            | Value | Unit |
|----------------------|-------|------|
| $V_{DS} @ T_{j,max}$ | 700   | V    |
| $R_{DS(on),max}$     | 600   | mΩ   |
| $Q_{g,typ}$          | 23    | nC   |
| $I_{D,pulse}$        | 18    | A    |
| $E_{oss@400V}$       | 2     | μJ   |
| Body diode di/dt     | 500   | A/μs |

| Type / Ordering Code | Package   | Marking | Related Links  |
|----------------------|-----------|---------|----------------|
| IPS65R600E6          | PG-TO 251 | 65E6600 | see Appendix A |

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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> | $I_D$         | -      | -    | 7.3<br>4.6 | A                | $T_C=25^\circ\text{C}$<br>$T_C=100^\circ\text{C}$                                     |
| Pulsed drain current <sup>2)</sup>     | $I_{D,pulse}$ | -      | -    | 18         | A                | $T_C=25^\circ\text{C}$  |
| Avalanche energy, single pulse         | $E_{AS}$      | -      | -    | 142        | mJ               | $I_D=1.3\text{A}$ ; $V_{DD}=50\text{V}$ ; see table 10                                |
| Avalanche energy, repetitive           | $E_{AR}$      | -      | -    | 0.21       | mJ               | $I_D=1.3\text{A}$ ; $V_{DD}=50\text{V}$ ; see table 10                                |
| Avalanche current, repetitive          | $I_{AR}$      | -      | -    | 1.3        | A                | -   |
| MOSFET dv/dt ruggedness                | dv/dt         | -      | -    | 50         | V/ns             | $V_{DS}=0\dots480\text{V}$  |
| Gate source voltage (static)           | $V_{GS}$      | -20    | -    | 20         | V                | static;   |
| Gate source voltage (dynamic)          | $V_{GS}$      | -30    | -    | 30         | V                | AC ( $f>1\text{ Hz}$ )  |
| Power dissipation                      | $P_{tot}$     | -      | -    | 63         | W                | $T_C=25^\circ\text{C}$  |
| Storage temperature                    | $T_{stg}$     | -55    | -    | 150        | $^\circ\text{C}$ | -   |
| Operating junction temperature         | $T_j$         | -55    | -    | 150        | $^\circ\text{C}$ | -   |
| Continuous diode forward current       | $I_S$         | -      | -    | 6.3        | A                | $T_C=25^\circ\text{C}$  |
| Diode pulse current <sup>2)</sup>      | $I_{S,pulse}$ | -      | -    | 18         | A                | $T_C=25^\circ\text{C}$  |
| Reverse diode dv/dt <sup>3)</sup>      | dv/dt         | -      | -    | 15         | V/ns             | $V_{DS}=0\dots400\text{V}$ , $I_{SD}\leq I_S$ , $T_j=25^\circ\text{C}$<br>see table 8 |
| Maximum diode commutation speed        | di/dt         | -      | -    | 500        | A/ $\mu\text{s}$ | $V_{DS}=0\dots400\text{V}$ , $I_{SD}\leq I_S$ , $T_j=25^\circ\text{C}$<br>see table 8 |

<sup>1)</sup> Limited by  $T_{j,max}$ . Maximum duty cycle  $D=0.75$

<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**

| Parameter  | Symbol     | Values |      |      | Unit | Note / Test Condition               |
|--|------------|--------|------|------|------|-------------------------------------|
|  |            | Min.   | Typ. | Max. |      |                                     |
| Thermal resistance, junction - case                        | $R_{thJC}$ | -      | -    | 2    | °C/W | -                                   |
| Thermal resistance, junction - ambient                     | $R_{thJA}$ | -      | -    | 62   | °C/W | leaded                              |
| Soldering temperature, wavesoldering only allowed at leads | $T_{sold}$ | -      | -    | 260  | °C   | 1.6mm (0.063 in.) from case for 10s |

## 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             | $V_{GS}=0\text{V}$ , $I_D=1\text{mA}$   |
| Gate threshold voltage           | $V_{(GS)th}$  | 2.5    | 3.0  | 3.5  | V             | $V_{DS}=V_{GS}$ , $I_D=0.21\text{mA}$   |
| Zero gate voltage drain current  | $I_{DSS}$     | -      | -    | 1    | $\mu\text{A}$ | $V_{DS}=650$ , $V_{GS}=0\text{V}$ , $T_j=25^\circ\text{C}$<br>$V_{DS}=650$ , $V_{GS}=0\text{V}$ , $T_j=150^\circ\text{C}$             |
| Gate-source leakage current      | $I_{GSS}$     | -      | -    | 100  | nA            | $V_{GS}=20\text{V}$ , $V_{DS}=0\text{V}$  |
| Drain-source on-state resistance | $R_{DS(on)}$  | -      | 0.54 | 0.60 | $\Omega$      | $V_{GS}=10\text{V}$ , $I_D=2.1\text{A}$ , $T_j=25^\circ\text{C}$<br>$V_{GS}=10\text{V}$ , $I_D=2.1\text{A}$ , $T_j=150^\circ\text{C}$ |
| Gate resistance                  | $R_G$         | -      | 10.5 | -    | $\Omega$      | $f=1\text{MHz}$ , open drain  |

**Table 5 Dynamic characteristics**

| Parameter  | Symbol       | Values |      |      | Unit | Note / Test Condition   |
|--|--------------|--------|------|------|------|---|
|  |              | Min.   | Typ. | Max. |      |   |
| Input capacitance  | $C_{iss}$    | -      | 440  | -    | pF   | $V_{GS}=0\text{V}$ , $V_{DS}=100\text{V}$ , $f=1\text{MHz}$                                       |
| Output capacitance   | $C_{oss}$    | -      | 30   | -    | pF   | $V_{GS}=0\text{V}$ , $V_{DS}=100\text{V}$ , $f=1\text{MHz}$                                       |
| Effective output capacitance, energy related <sup>1)</sup> | $C_{o(er)}$  | -      | 21   | -    | pF   | $V_{GS}=0\text{V}$ , $V_{DS}=0\dots480\text{V}$   |
| Effective output capacitance, time related <sup>2)</sup>   | $C_{o(tr)}$  | -      | 88   | -    | pF   | $I_D=\text{constant}$ , $V_{GS}=0\text{V}$ , $V_{DS}=0\dots480\text{V}$                           |
| Turn-on delay time   | $t_{d(on)}$  | -      | 10   | -    | ns   | $V_{DD}=400\text{V}$ , $V_{GS}=13\text{V}$ , $I_D=3.2\text{A}$ ,<br>$R_G=6.8\Omega$ ; see table 9 |
| Rise time  | $t_r$        | -      | 8    | -    | ns   | $V_{DD}=400\text{V}$ , $V_{GS}=13\text{V}$ , $I_D=3.2\text{A}$ ,<br>$R_G=6.8\Omega$ ; see table 9 |
| Turn-off delay time  | $t_{d(off)}$ | -      | 64   | -    | ns   | $V_{DD}=400\text{V}$ , $V_{GS}=13\text{V}$ , $I_D=3.2\text{A}$ ,<br>$R_G=6.8\Omega$ ; see table 9 |
| Fall time  | $t_f$        | -      | 11   | -    | ns   | $V_{DD}=400\text{V}$ , $V_{GS}=13\text{V}$ , $I_D=3.2\text{A}$ ,<br>$R_G=6.8\Omega$ ; see table 9 |

**Table 6 Gate charge characteristics**

| Parameter             | Symbol        | Values |      |      | Unit | Note / Test Condition   |
|-----------------------|---------------|--------|------|------|------|---|
|                       |               | Min.   | Typ. | Max. |      |   |
| Gate to source charge | $Q_{gs}$      | -      | 2.75 | -    | nC   | $V_{DD}=480\text{V}$ , $I_D=3.2\text{A}$ , $V_{GS}=0$ to $10\text{V}$ |
| Gate to drain charge  | $Q_{gd}$      | -      | 12   | -    | nC   | $V_{DD}=480\text{V}$ , $I_D=3.2\text{A}$ , $V_{GS}=0$ to $10\text{V}$ |
| Gate charge total     | $Q_g$         | -      | 23   | -    | nC   | $V_{DD}=480\text{V}$ , $I_D=3.2\text{A}$ , $V_{GS}=0$ to $10\text{V}$ |
| Gate plateau voltage  | $V_{plateau}$ | -      | 5.5  | -    | V    | $V_{DD}=480\text{V}$ , $I_D=3.2\text{A}$ , $V_{GS}=0$ to $10\text{V}$ |

<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 480V

<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 480V

**Table 7 Reverse diode characteristics**

| Parameter                     | Symbol    | Values |      |      | Unit    | Note / Test Condition                                  |
|-------------------------------|-----------|--------|------|------|---------|--|
|                               |           | Min.   | Typ. | Max. |         |  |
| Diode forward voltage         | $V_{SD}$  | -      | 0.9  | -    | V       | $V_{GS}=0V, I_F=3.2A, T_j=25^\circ C$                  |
| Reverse recovery time         | $t_{rr}$  | -      | 270  | -    | ns      | $V_R=400V, I_F=3.2A, di_F/dt=100A/\mu s$ ; see table 8 |
| Reverse recovery charge       | $Q_{rr}$  | -      | 2    | -    | $\mu C$ | $V_R=400V, I_F=3.2A, di_F/dt=100A/\mu s$ ; see table 8 |
| Peak reverse recovery current | $I_{rrm}$ | -      | 13   | -    | A       | $V_R=400V, I_F=3.2A, di_F/dt=100A/\mu s$ ; see table 8 |

## 5 Electrical characteristics diagrams

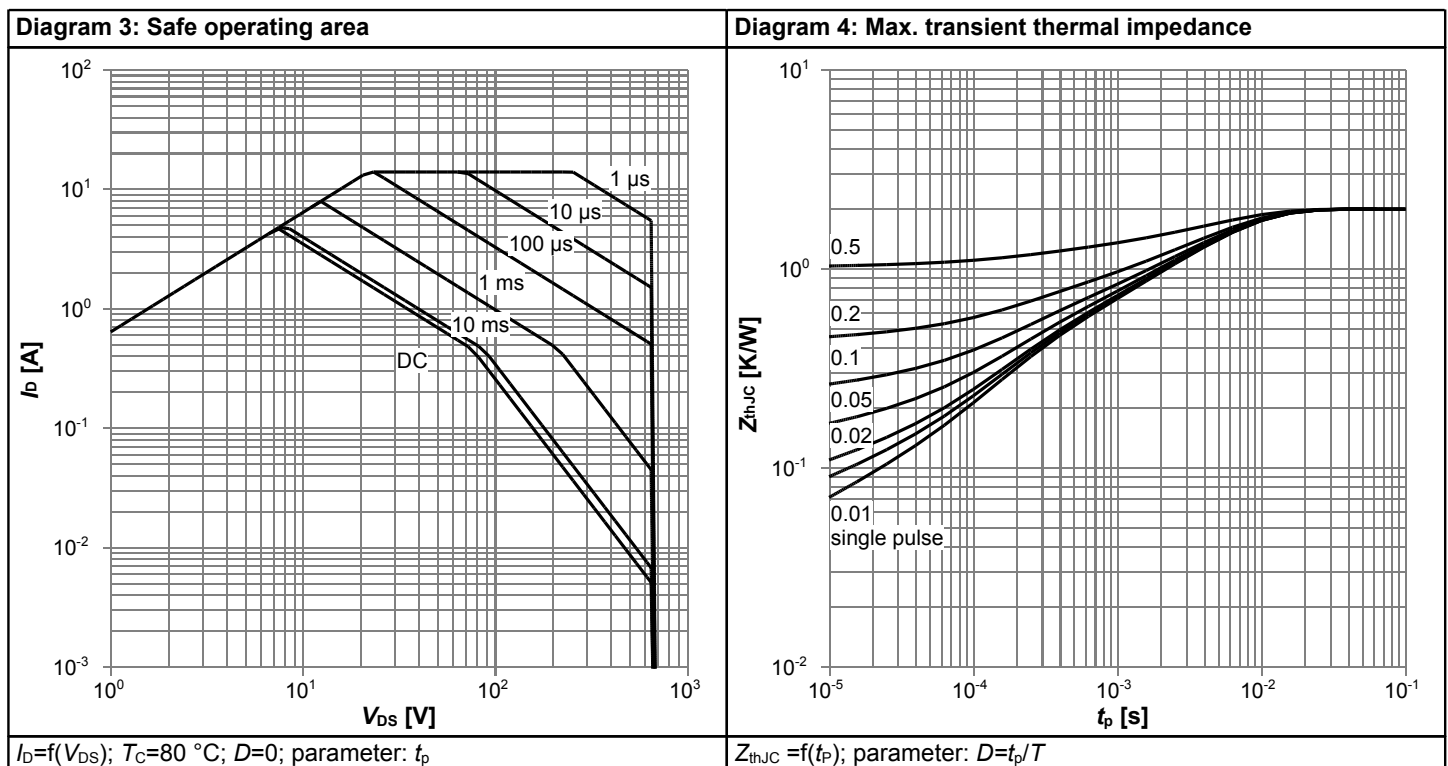
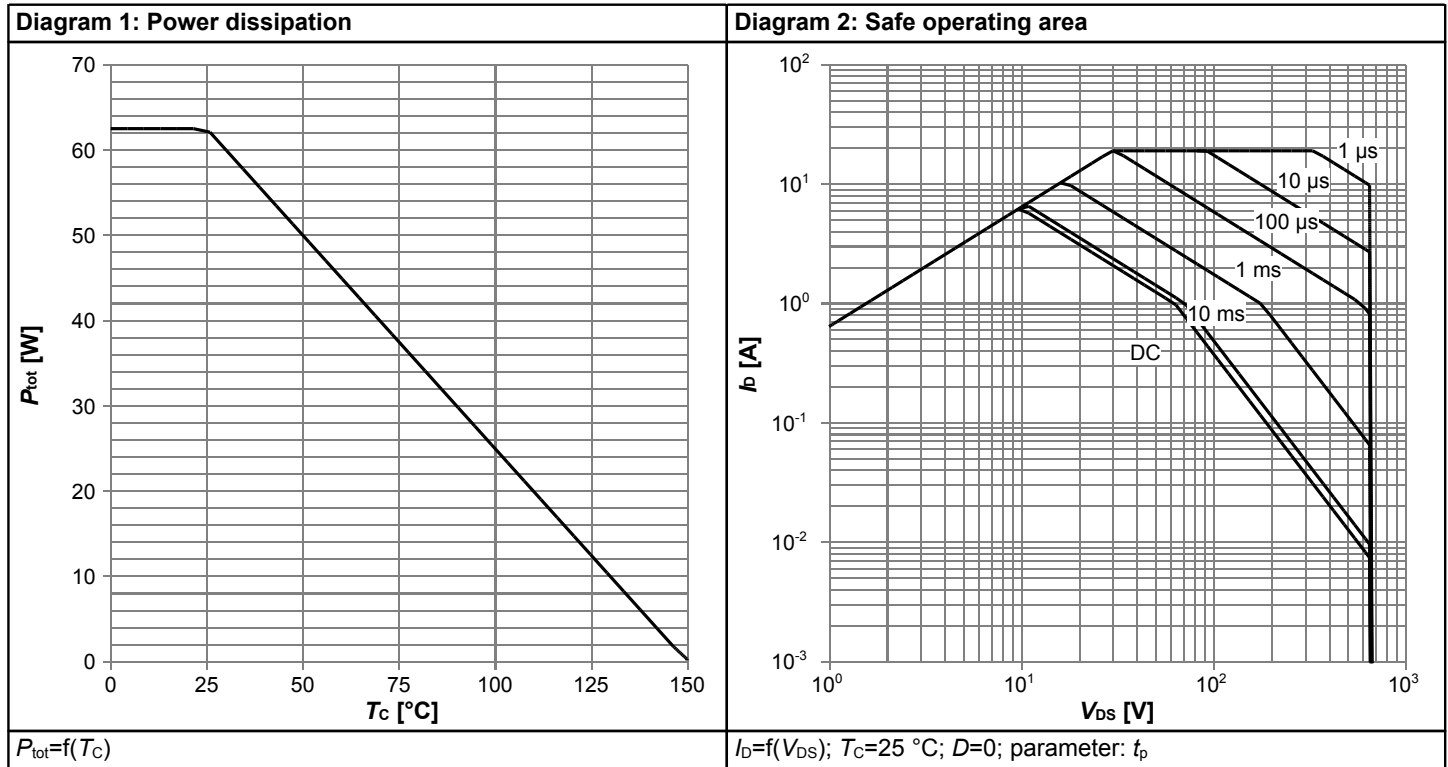
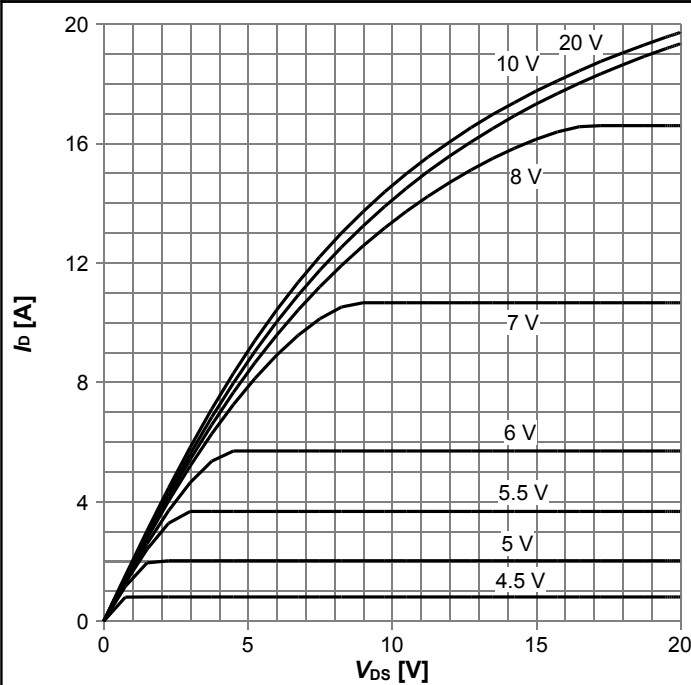


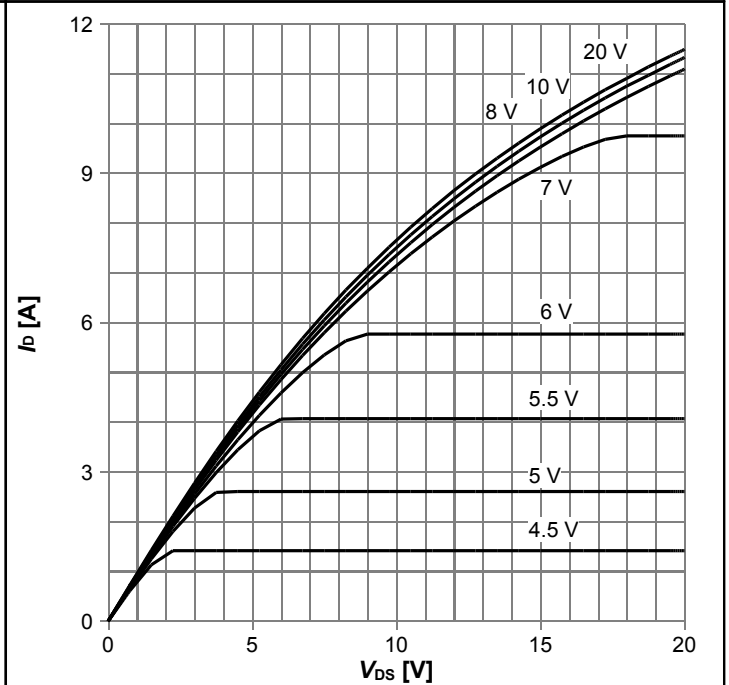


Diagram 5: Typ. output characteristics



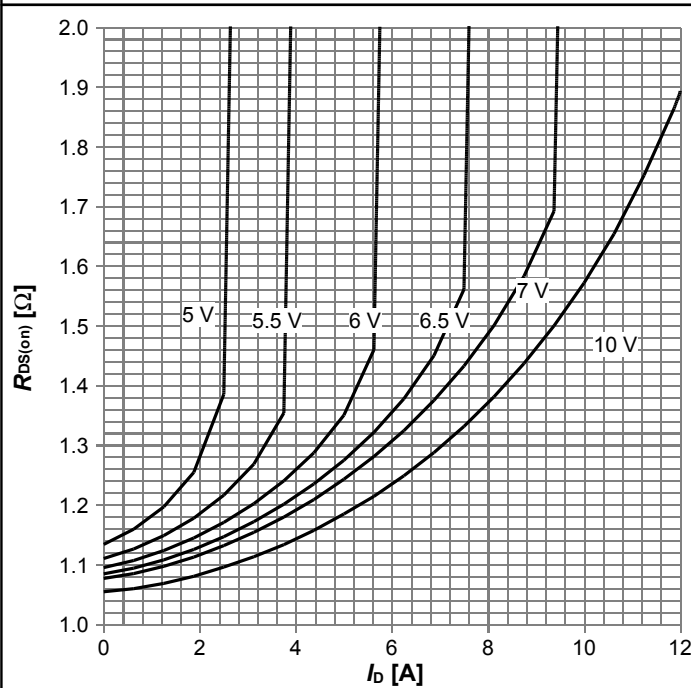
$I_D=f(V_{DS})$ ;  $T_j=25\text{ }^\circ\text{C}$ ; parameter:  $V_{GS}$

Diagram 6: Typ. output characteristics



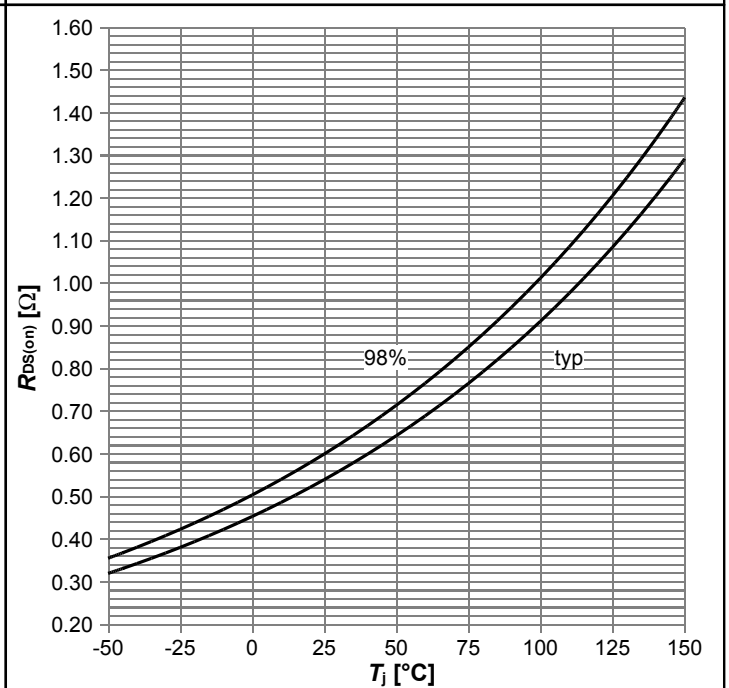
$I_D=f(V_{DS})$ ;  $T_j=125\text{ }^\circ\text{C}$ ; parameter:  $V_{GS}$

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



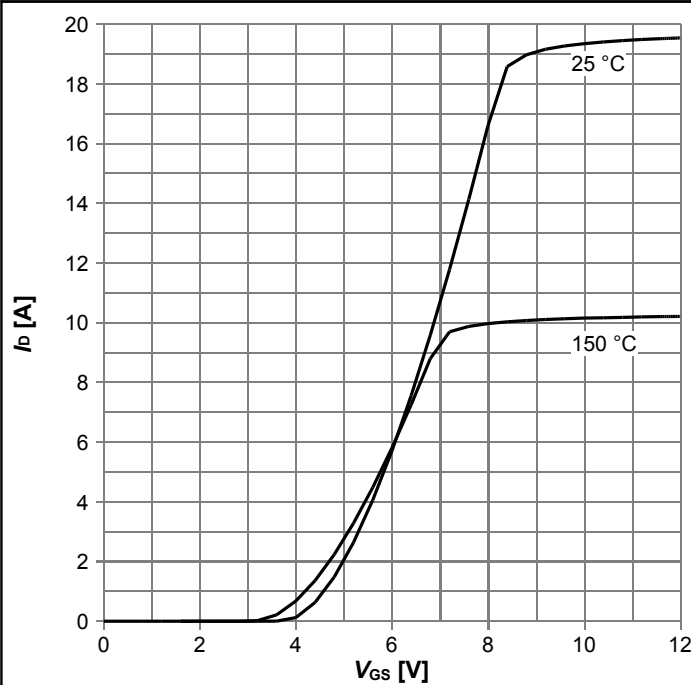
$R_{DS(on)}=f(I_D)$ ;  $T_j=125\text{ }^\circ\text{C}$ ; parameter:  $V_{GS}$

Diagram 8: Drain-source on-state resistance



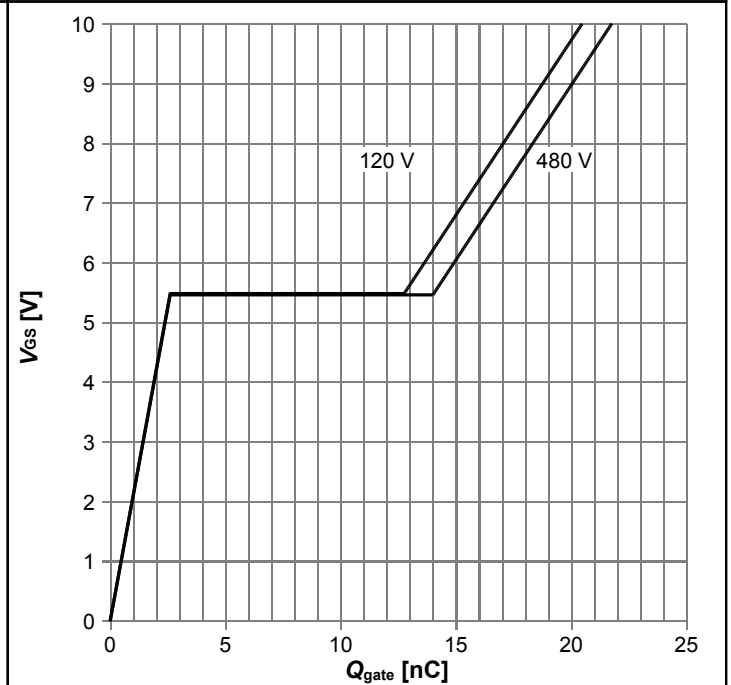
$R_{DS(on)}=f(T_j)$ ;  $I_D=2.1\text{ A}$ ;  $V_{GS}=10\text{ V}$

Diagram 9: Typ. transfer characteristics



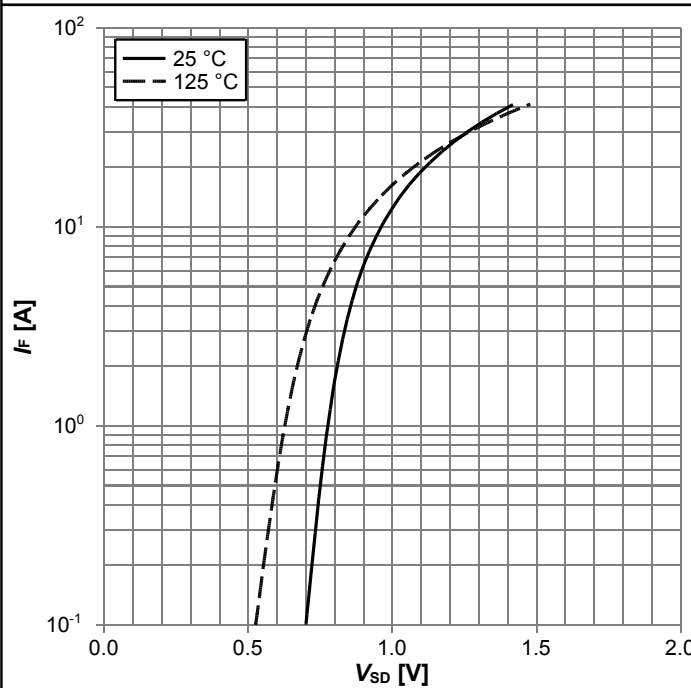
$I_D=f(V_{GS}); V_{DS}=20V; \text{parameter: } T_j$

Diagram 10: Typ. gate charge



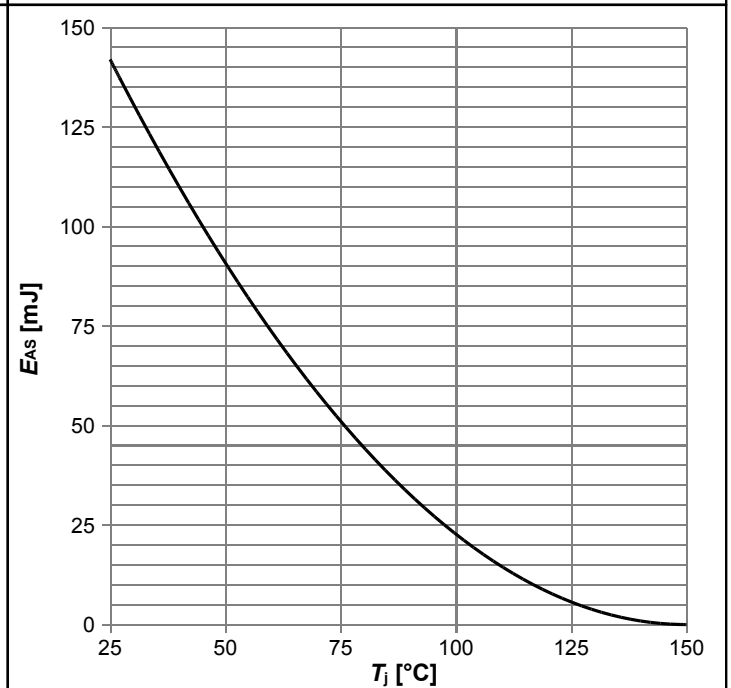
$V_{GS}=f(Q_{gate}); I_D=3.2 \text{ A pulsed}; \text{parameter: } V_{DD}$

Diagram 11: Forward characteristics of reverse diode



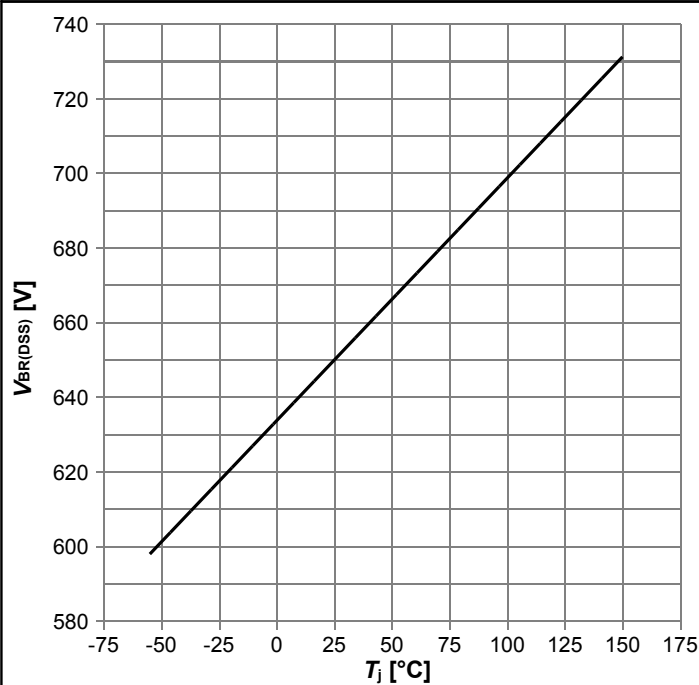
$I_F=f(V_{SD}); \text{parameter: } T_j$

Diagram 12: Avalanche energy



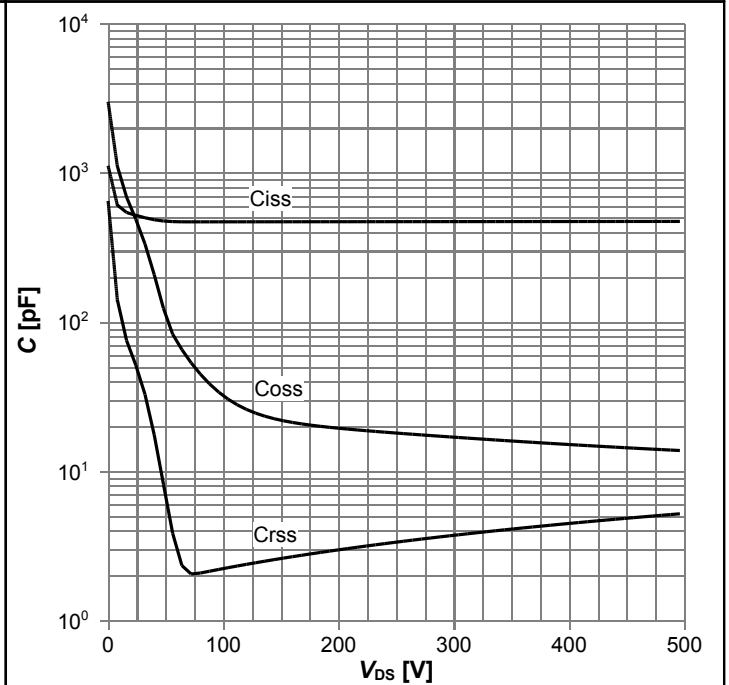
$E_{AS}=f(T_j); I_D=1.3 \text{ A}; V_{DD}=50 \text{ V}$

Diagram 13: Drain-source breakdown voltage



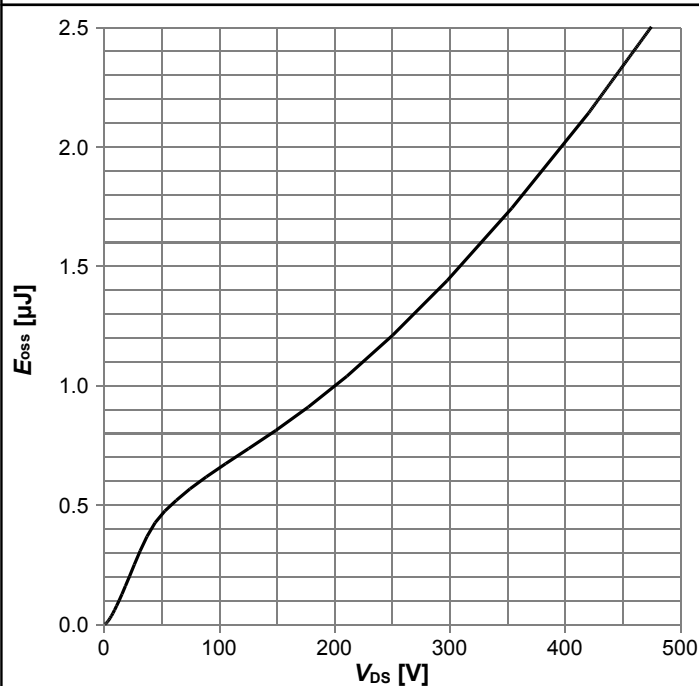
$V_{BR(DSS)}=f(T_j); I_D=1.0 \text{ mA}$

Diagram 14: Typ. capacitances



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

Diagram 15: Typ. Coss stored energy



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

## 6 Test Circuits

**Table 8 Diode characteristics**

| Test circuit for diode characteristics | Diode recovery waveform |
|--|-------------------------|
|  |                         |

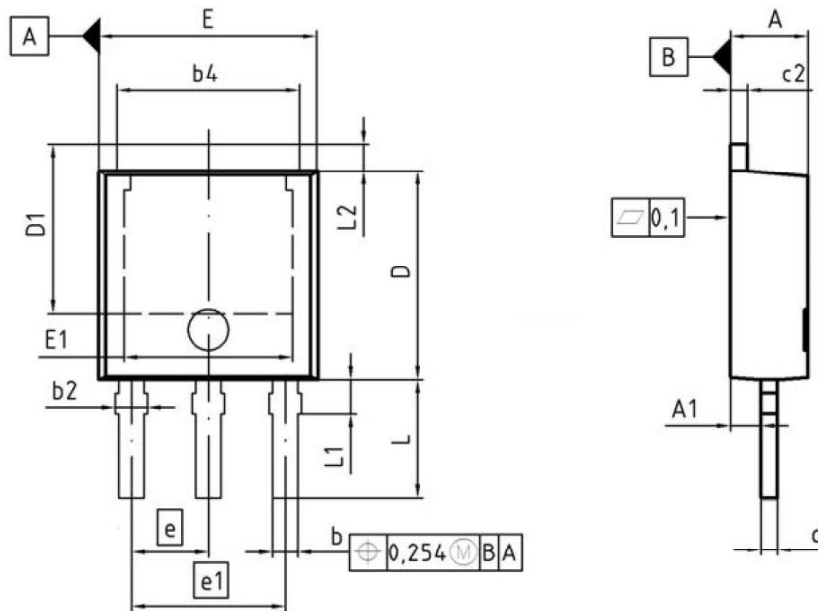
**Table 9 Switching times**

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

**Table 10 Unclamped inductive load**

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

## 7 Package Outlines



| DIM | MILLIMETERS |      | INCHES |       |
|-----|-------------|------|--------|-------|
|     | MIN         | MAX  | MIN    | MAX   |
| A   | 2.18        | 2.39 | 0.086  | 0.094 |
| A1  | 0.80        | 1.14 | 0.031  | 0.045 |
| b   | 0.64        | 0.89 | 0.025  | 0.035 |
| b2  | 0.65        | 1.15 | 0.026  | 0.045 |
| b4  | 4.95        | 5.50 | 0.195  | 0.217 |
| c   | 0.46        | 0.58 | 0.018  | 0.023 |
| c2  | 0.46        | 0.89 | 0.018  | 0.035 |
| D   | 5.97        | 6.22 | 0.235  | 0.245 |
| D1  | 5.04        | 5.44 | 0.198  | 0.214 |
| E   | 6.35        | 6.73 | 0.250  | 0.265 |
| E1  | 4.90        | 5.10 | 0.193  | 0.201 |
| e   | 2.29        |      | 0.090  |       |
| e1  | 4.57        |      | 0.180  |       |
| N   | 3           |      | 3      |       |
| L   | 3.30        | 3.50 | 0.130  | 0.138 |
| L1  | 0.90        | 1.10 | 0.035  | 0.043 |
| L2  | 0.90        | 1.10 | 0.035  | 0.043 |

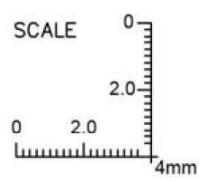
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|--|
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| SCALE<br>0<br>2.0<br>4mm   |
| EUROPEAN PROJECTION<br> |
| ISSUE DATE<br>05-07-2012   |
| REVISION<br>04   |

Figure 1 Outline PG-TO 251, dimensions in mm/inches

## 8 Appendix A

### Table 11 Related Links

- IFX CoolMOS™ E6 Webpage: [www.infineon.com](http://www.infineon.com)
- IFX CoolMOS™ E6 application note: [www.infineon.com](http://www.infineon.com)
- IFX CoolMOS™ E6 simulation model: [www.infineon.com](http://www.infineon.com)
- IFX Design tools: [www.infineon.com](http://www.infineon.com)

## Revision History

IPS65R600E6

**Revision: 2015-04-23, Rev. 2.0**

Previous Revision

| Revision | Date       | Subjects (major changes since last revision) |
|----------|------------|--|
| 2.0      | 2015-04-23 | Release of final version                     |

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