

# MOSFET

## 600V CoolMOS™ P6 Power Transistor

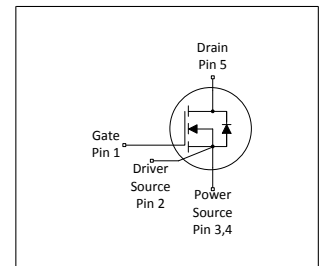
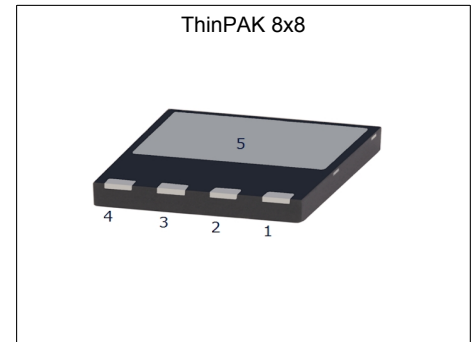
CoolMOS™ is a revolutionary technology for high voltage power MOSFETs, designed according to the superjunction (SJ) principle and pioneered by Infineon Technologies. CoolMOS™ P6 series combines the experience of the leading SJ MOSFET supplier with high class innovation. The offered devices provide all 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

- Increased MOSFET  $dv/dt$  ruggedness
- 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)

### Potential applications

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



**Table 1 Key Performance Parameters**

| Parameter            | Value | Unit       |
|----------------------|-------|------------|
| $V_{DS} @ T_{j,max}$ | 650   | V          |
| $R_{DS(on),max}$     | 180   | $m\Omega$  |
| $Q_{g,typ}$          | 44    | nC         |
| $I_{D,pulse}$        | 62    | A          |
| $E_{oss} @ 400V$     | 5.7   | $\mu J$    |
| Body diode $di_F/dt$ | 500   | A/ $\mu s$ |

| Type / Ordering Code | Package   | Marking | Related Links  |
|----------------------|-----------|---------|----------------|
| IPL60R180P6          | PG-VSON-4 | 6R180P6 | see Appendix A |

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## 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> | $I_D$         | -      | -    | 22.4<br>14.1 | A                | $T_C=25^\circ\text{C}$<br>$T_C=100^\circ\text{C}$                                     |
| Pulsed drain current <sup>2)</sup>     | $I_{D,pulse}$ | -      | -    | 62           | A                | $T_C=25^\circ\text{C}$                                                                |
| Avalanche energy, single pulse         | $E_{AS}$      | -      | -    | 497          | mJ               | $I_D=3.9\text{A}$ ; $V_{DD}=50\text{V}$ ; see table 10                                |
| Avalanche energy, repetitive           | $E_{AR}$      | -      | -    | 0.75         | mJ               | $I_D=3.9\text{A}$ ; $V_{DD}=50\text{V}$ ; see table 10                                |
| Avalanche current, repetitive          | $I_{AR}$      | -      | -    | 3.9          | A                | -                                                                                     |
| MOSFET dv/dt ruggedness                | dv/dt         | -      | -    | 100          | V/ns             | $V_{DS}=0\dots400\text{V}$                                                            |
| 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                      | $P_{tot}$     | -      | -    | 176          | W                | $T_C=25^\circ\text{C}$                                                                |
| Storage temperature                    | $T_{stg}$     | -40    | -    | 150          | $^\circ\text{C}$ | -                                                                                     |
| Operating junction temperature         | $T_j$         | -40    | -    | 150          | $^\circ\text{C}$ | -                                                                                     |
| Continuous diode forward current       | $I_S$         | -      | -    | 19.4         | A                | $T_C=25^\circ\text{C}$                                                                |
| Diode pulse current <sup>2)</sup>      | $I_{S,pulse}$ | -      | -    | 62           | 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  $R_G$

## 2 Thermal characteristics

**Table 3 Thermal characteristics**

| Parameter                                              | Symbol     | Values |      |      | Unit | Note / Test Condition                                                                                                                                                               |
|--------------------------------------------------------|------------|--------|------|------|------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                        |            | Min.   | Typ. | Max. |      |                                                                                                                                                                                     |
| Thermal resistance, junction - case                    | $R_{thJC}$ | -      | -    | 0.71 | °C/W | -                                                                                                                                                                                   |
| Thermal resistance, junction - ambient                 | $R_{thJA}$ | -      | -    | 62   | °C/W | device on PCB, minimal footprint                                                                                                                                                    |
| Thermal resistance, junction - ambient for SMD version | $R_{thJA}$ | -      | -    | 45   | °C/W | Device on 40mm*40mm*1.5mm epoxy PCB FR4 with 6cm <sup>2</sup> (one layer, 70µm thickness) copper area for drain connection and cooling. PCB is vertical without air stream cooling. |
| Soldering temperature, wave & reflow soldering allowed | $T_{sold}$ | -      | -    | 260  | °C   | reflow MSL2a                                                                                                                                                                        |

### 3 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   | $V_{(BR)DSS}$ | 600    | -              | -          | V        | $V_{GS}=0V$ , $I_D=1mA$                                                                                     |
| Gate threshold voltage           | $V_{(GS)th}$  | 3.5    | 4.0            | 4.5        | V        | $V_{DS}=V_{GS}$ , $I_D=0.75mA$                                                                              |
| Zero gate voltage drain current  | $I_{DSS}$     | -      | -              | 1          | $\mu A$  | $V_{DS}=600$ , $V_{GS}=0V$ , $T_j=25^\circ\text{C}$<br>$V_{DS}=600$ , $V_{GS}=0V$ , $T_j=150^\circ\text{C}$ |
| Gate-source leakage current      | $I_{GSS}$     | -      | -              | 100        | nA       | $V_{GS}=20V$ , $V_{DS}=0V$                                                                                  |
| Drain-source on-state resistance | $R_{DS(on)}$  | -      | 0.162<br>0.421 | 0.180<br>- | $\Omega$ | $V_{GS}=10V$ , $I_D=9A$ , $T_j=25^\circ\text{C}$<br>$V_{GS}=10V$ , $I_D=9A$ , $T_j=150^\circ\text{C}$       |
| Gate resistance                  | $R_G$         | -      | 1.6            | -          | $\Omega$ | $f=1MHz$ , open drain                                                                                       |

**Table 5 Dynamic characteristics**

| Parameter                                                  | Symbol       | Values |      |      | Unit | Note / Test Condition                                                         |
|------------------------------------------------------------|--------------|--------|------|------|------|-------------------------------------------------------------------------------|
|                                                            |              | Min.   | Typ. | Max. |      |                                                                               |
| Input capacitance                                          | $C_{iss}$    | -      | 2080 | -    | pF   | $V_{GS}=0V$ , $V_{DS}=100V$ , $f=1MHz$                                        |
| Output capacitance                                         | $C_{oss}$    | -      | 89   | -    | pF   | $V_{GS}=0V$ , $V_{DS}=100V$ , $f=1MHz$                                        |
| Effective output capacitance, energy related <sup>1)</sup> | $C_{o(er)}$  | -      | 72   | -    | pF   | $V_{GS}=0V$ , $V_{DS}=0...400V$                                               |
| Effective output capacitance, time related <sup>2)</sup>   | $C_{o(tr)}$  | -      | 313  | -    | pF   | $I_D=\text{constant}$ , $V_{GS}=0V$ , $V_{DS}=0...400V$                       |
| Turn-on delay time                                         | $t_{d(on)}$  | -      | 12.5 | -    | ns   | $V_{DD}=400V$ , $V_{GS}=13V$ , $I_D=11.3A$ ,<br>$R_G=1.7\Omega$ ; see table 9 |
| Rise time                                                  | $t_r$        | -      | 7.6  | -    | ns   | $V_{DD}=400V$ , $V_{GS}=13V$ , $I_D=11.3A$ ,<br>$R_G=1.7\Omega$ ; see table 9 |
| Turn-off delay time                                        | $t_{d(off)}$ | -      | 40   | -    | ns   | $V_{DD}=400V$ , $V_{GS}=13V$ , $I_D=11.3A$ ,<br>$R_G=1.7\Omega$ ; see table 9 |
| Fall time                                                  | $t_f$        | -      | 5.8  | -    | ns   | $V_{DD}=400V$ , $V_{GS}=13V$ , $I_D=11.3A$ ,<br>$R_G=1.7\Omega$ ; see table 9 |

**Table 6 Gate charge characteristics**

| Parameter             | Symbol        | Values |      |      | Unit | Note / Test Condition                             |
|-----------------------|---------------|--------|------|------|------|---------------------------------------------------|
|                       |               | Min.   | Typ. | Max. |      |                                                   |
| Gate to source charge | $Q_{gs}$      | -      | 13   | -    | nC   | $V_{DD}=400V$ , $I_D=11.3A$ , $V_{GS}=0$ to $10V$ |
| Gate to drain charge  | $Q_{gd}$      | -      | 15   | -    | nC   | $V_{DD}=400V$ , $I_D=11.3A$ , $V_{GS}=0$ to $10V$ |
| Gate charge total     | $Q_g$         | -      | 44   | -    | nC   | $V_{DD}=400V$ , $I_D=11.3A$ , $V_{GS}=0$ to $10V$ |
| Gate plateau voltage  | $V_{plateau}$ | -      | 6.1  | -    | V    | $V_{DD}=400V$ , $I_D=11.3A$ , $V_{GS}=0$ 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         | $V_{SD}$  | -      | 0.9  | -    | V       | $V_{GS}=0V$ , $I_F=11.3A$ , $T_J=25^{\circ}C$                 |
| Reverse recovery time         | $t_{rr}$  | -      | 350  | -    | ns      | $V_R=400V$ , $I_F=11.3A$ , $di_F/dt=100A/\mu s$ ; see table 8 |
| Reverse recovery charge       | $Q_{rr}$  | -      | 5.3  | -    | $\mu C$ | $V_R=400V$ , $I_F=11.3A$ , $di_F/dt=100A/\mu s$ ; see table 8 |
| Peak reverse recovery current | $I_{rrm}$ | -      | 28   | -    | A       | $V_R=400V$ , $I_F=11.3A$ , $di_F/dt=100A/\mu s$ ; see table 8 |

## 4 Electrical characteristics diagrams

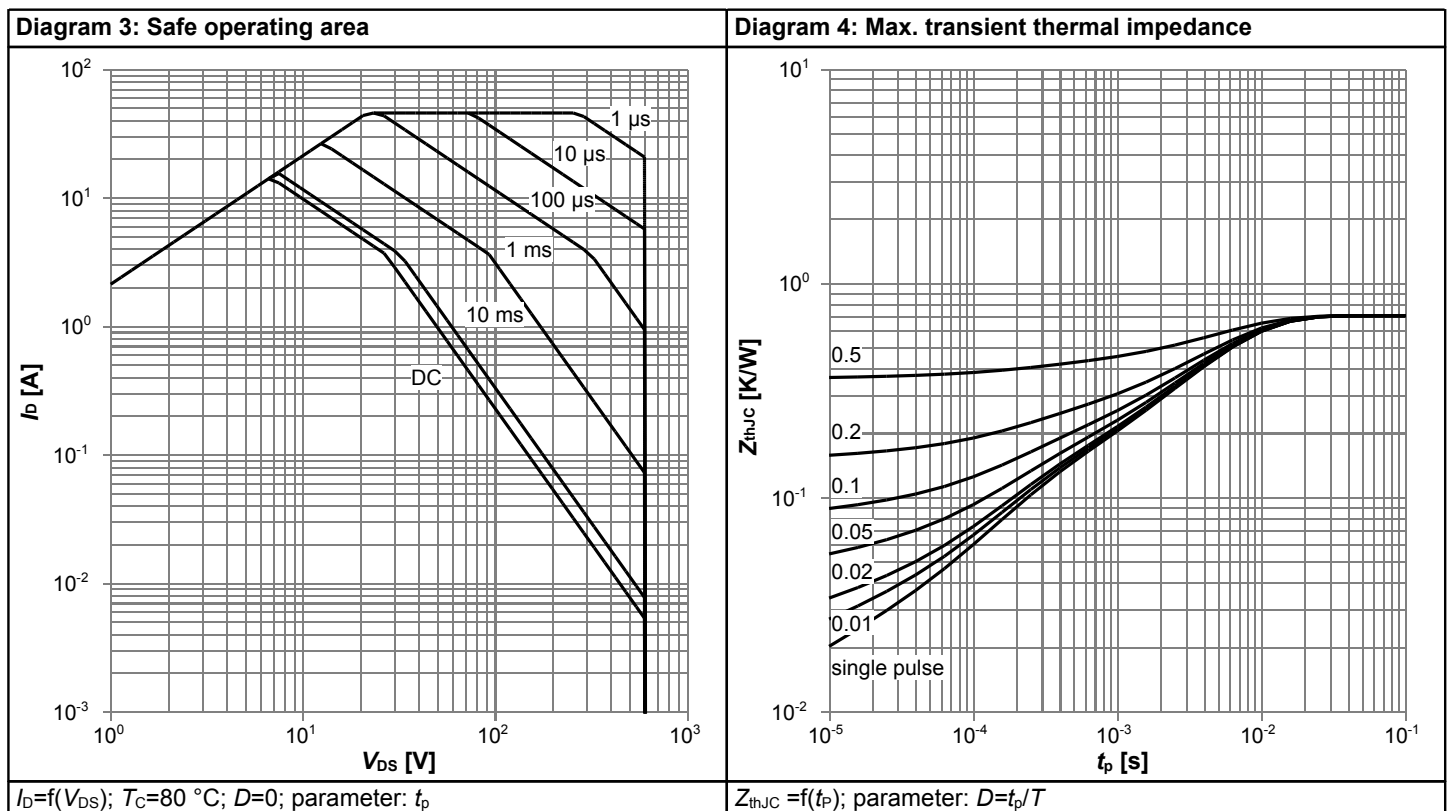
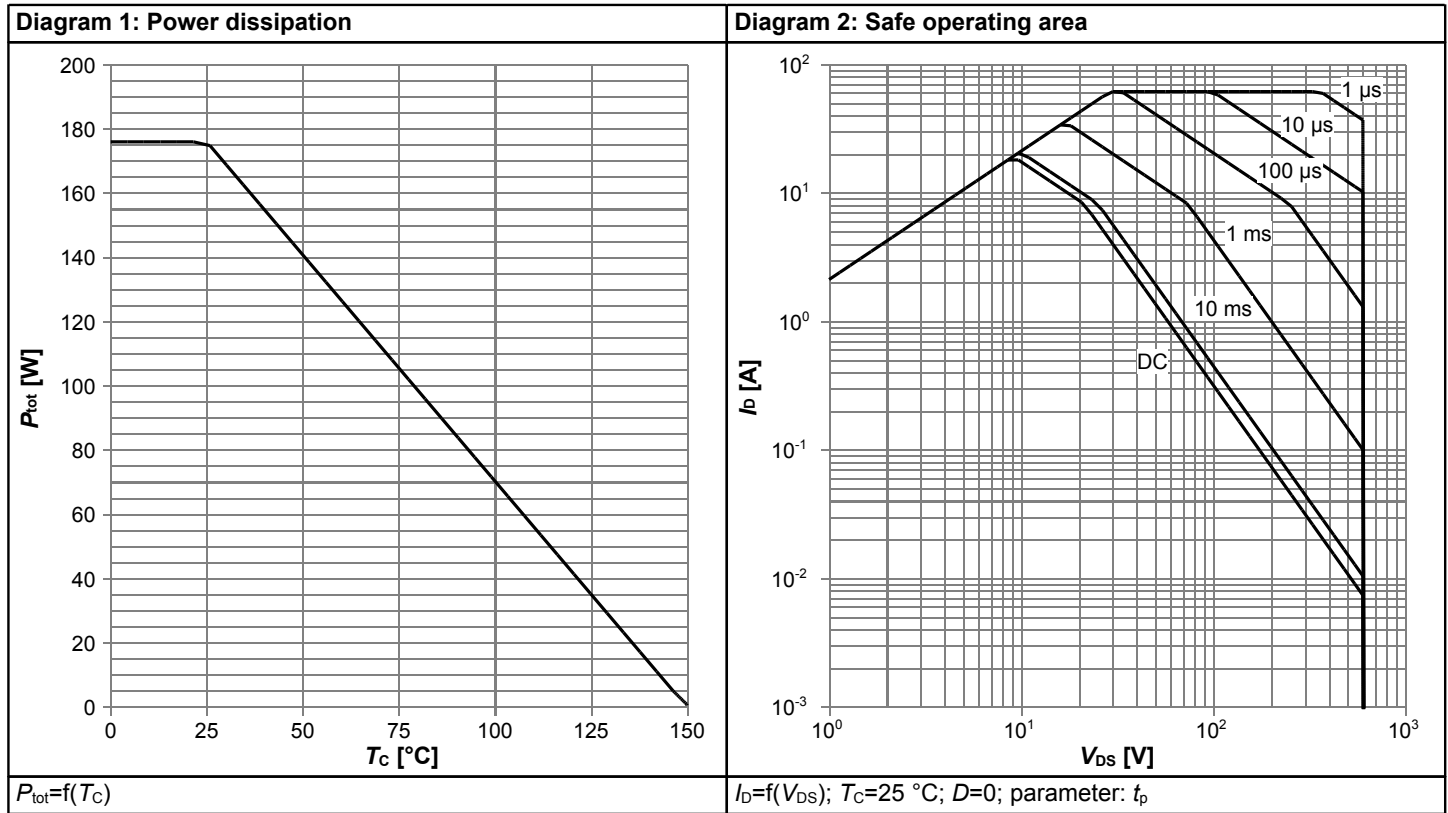
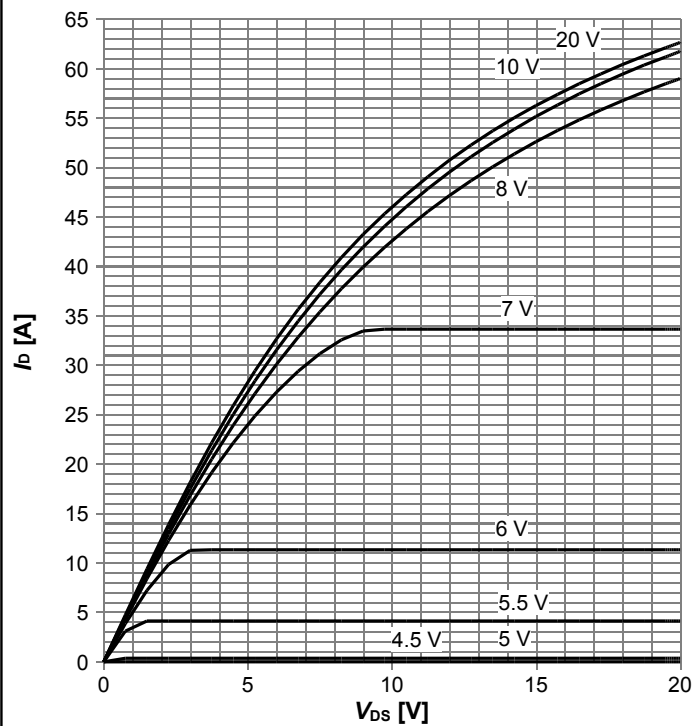
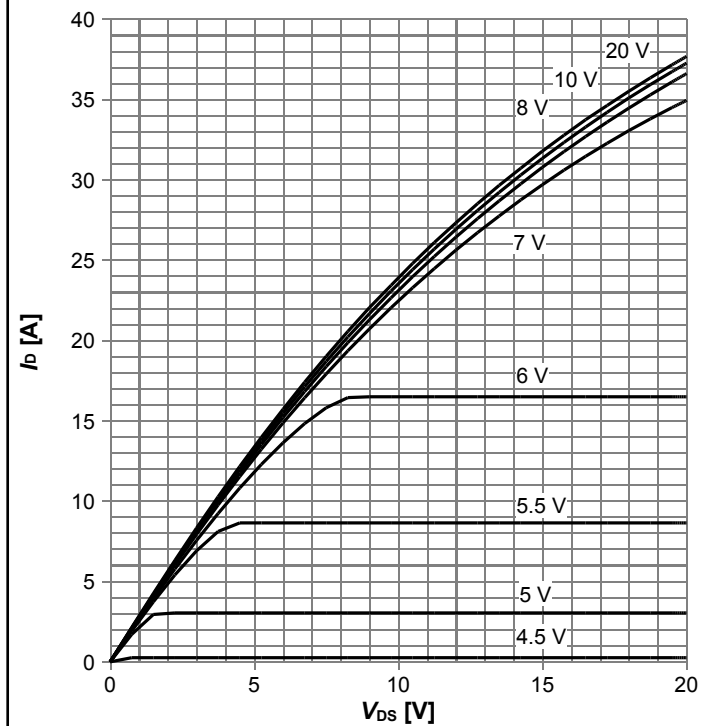


Diagram 5: Typ. output characteristics



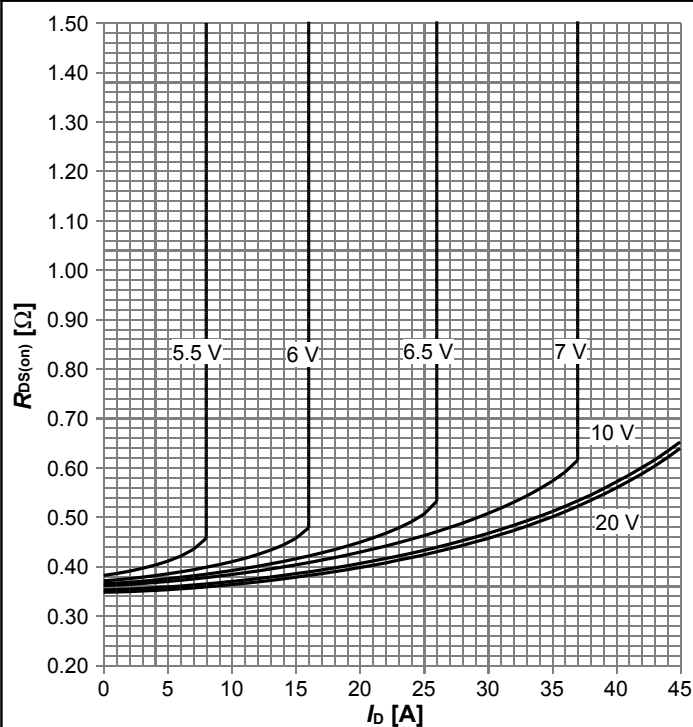
$I_D = f(V_{DS})$ ;  $T_J = 25^\circ\text{C}$ ; parameter:  $V_{GS}$

Diagram 6: Typ. output characteristics



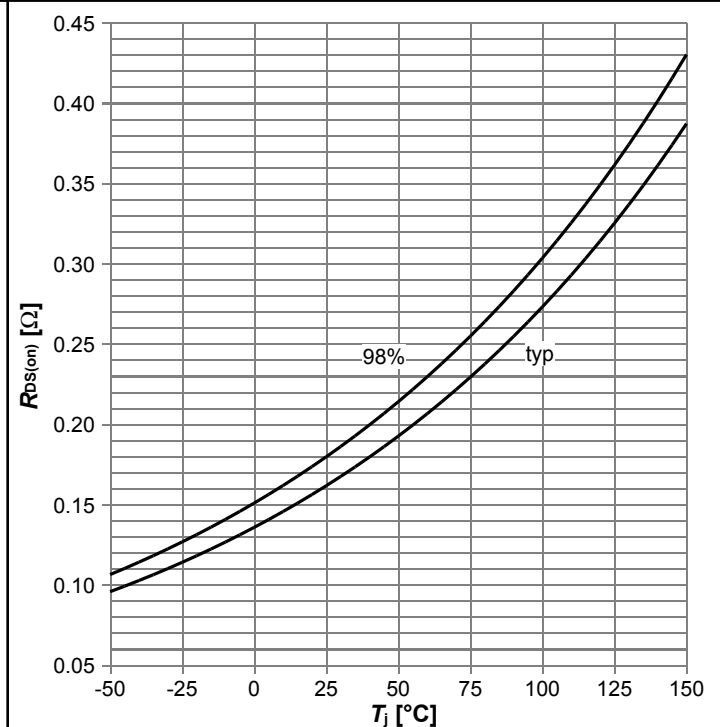
$I_D = f(V_{DS})$ ;  $T_J = 125^\circ\text{C}$ ; parameter:  $V_{GS}$

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



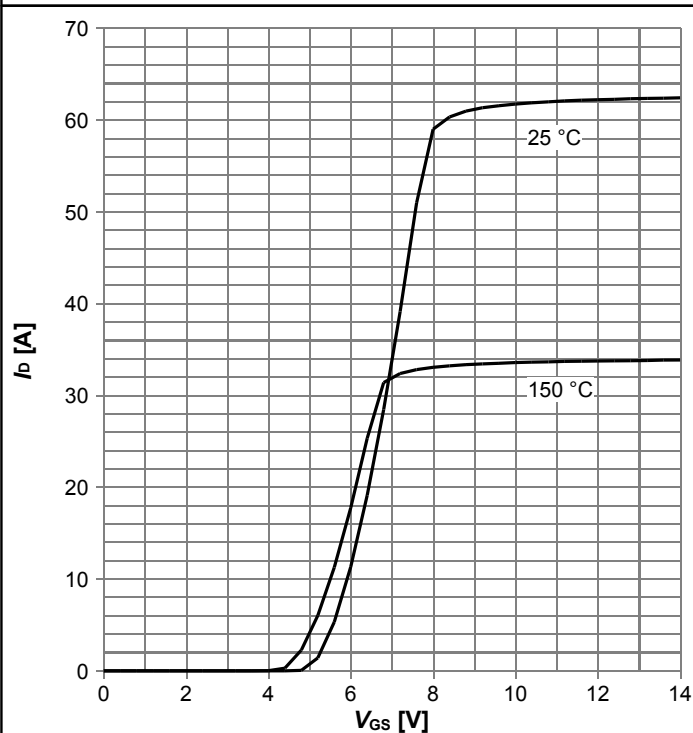
$R_{DS(on)} = f(I_D)$ ;  $T_J = 125^\circ\text{C}$ ; parameter:  $V_{GS}$

Diagram 8: Drain-source on-state resistance



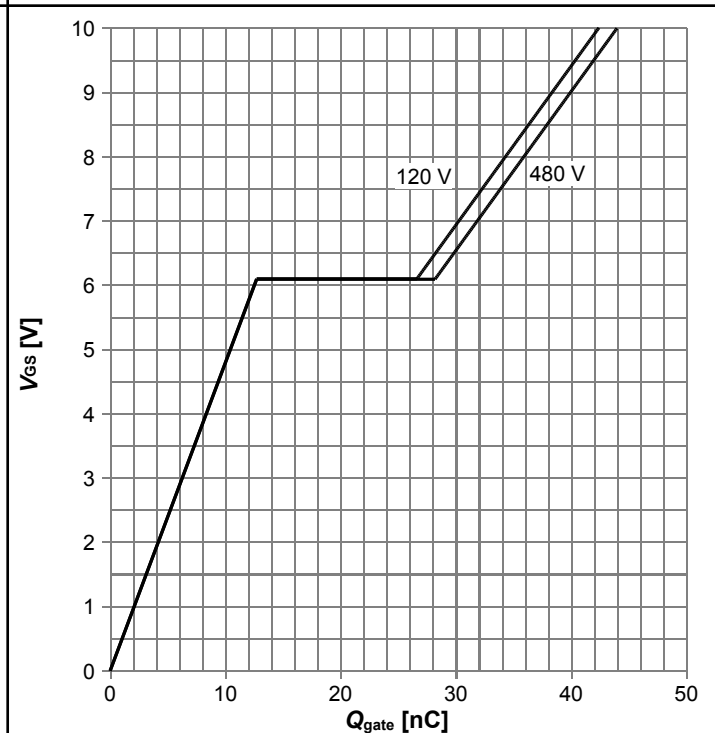
$R_{DS(on)} = f(T_J)$ ;  $I_D = 9.0\text{ A}$ ;  $V_{GS} = 10\text{ V}$

Diagram 9: Typ. transfer characteristics



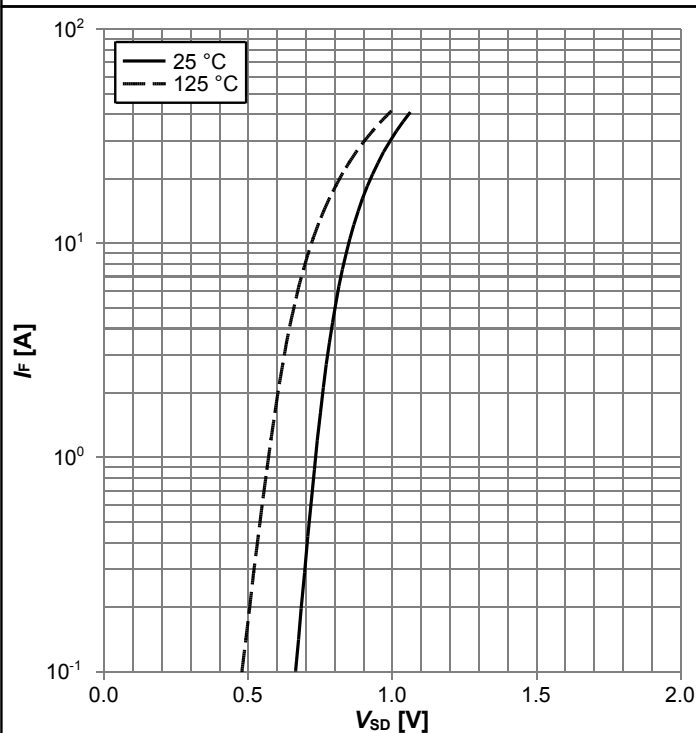
$I_D = f(V_{GS})$ ;  $V_{DS} = 20V$ ; parameter:  $T_j$

Diagram 10: Typ. gate charge



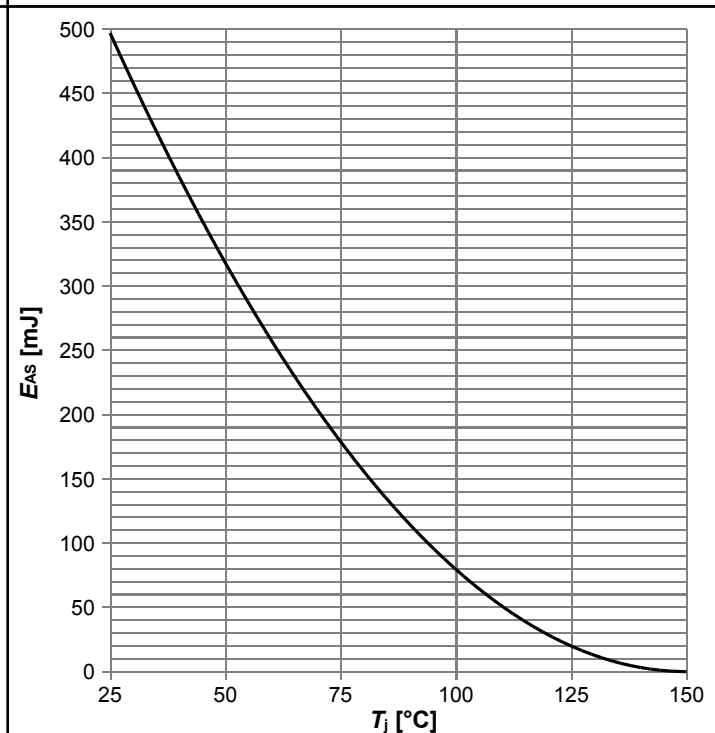
$V_{GS} = f(Q_{gate})$ ;  $I_D = 11.3$  A pulsed; parameter:  $V_{DD}$

Diagram 11: Forward characteristics of reverse diode



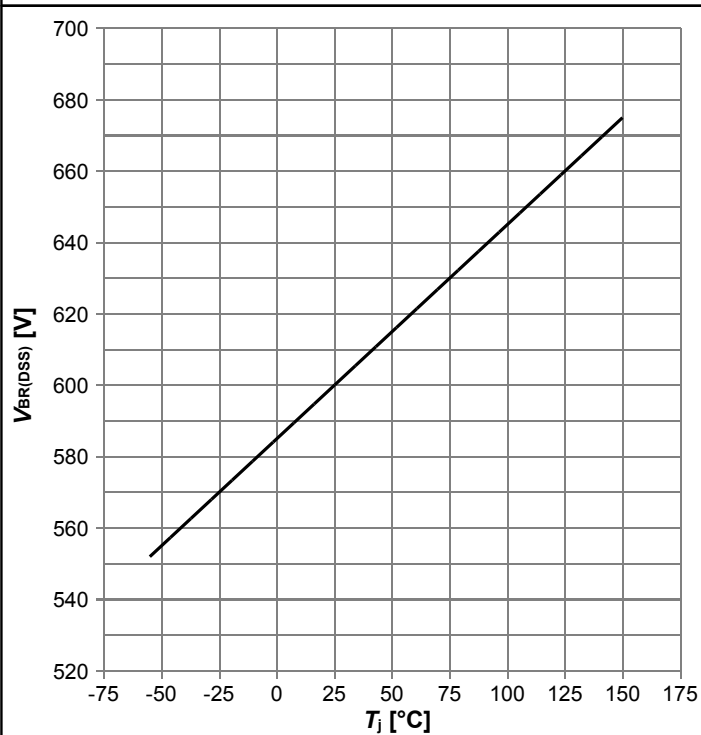
$I_F = f(V_{SD})$ ; parameter:  $T_j$

Diagram 12: Avalanche energy



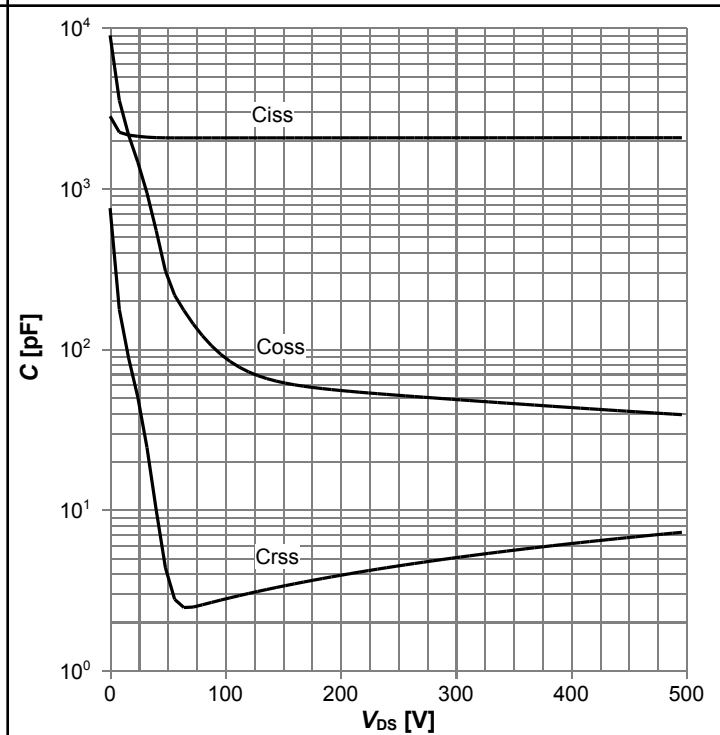
$E_{AS} = f(T_j)$ ;  $I_D = 3.9$  A;  $V_{DD} = 50$  V

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



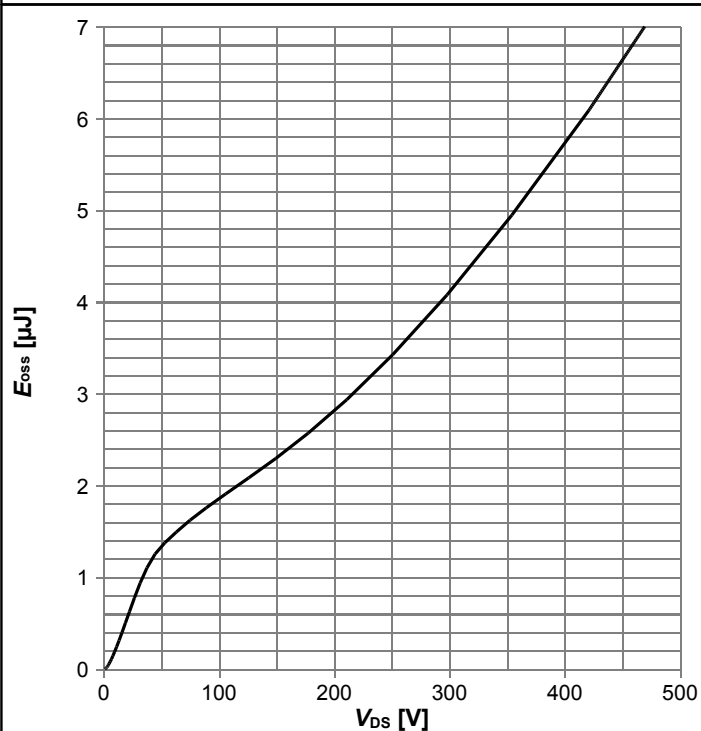
$V_{BR(DSS)} = f(T_J); I_D = 1 \text{ mA}$

**Diagram 14: Typ. capacitances**



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

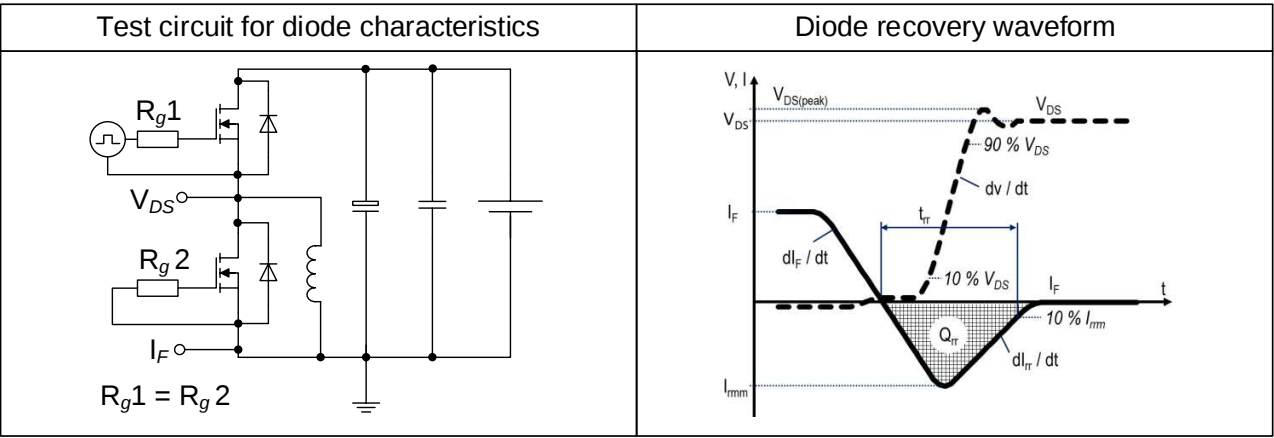
**Diagram 15: Typ. Coss stored energy**



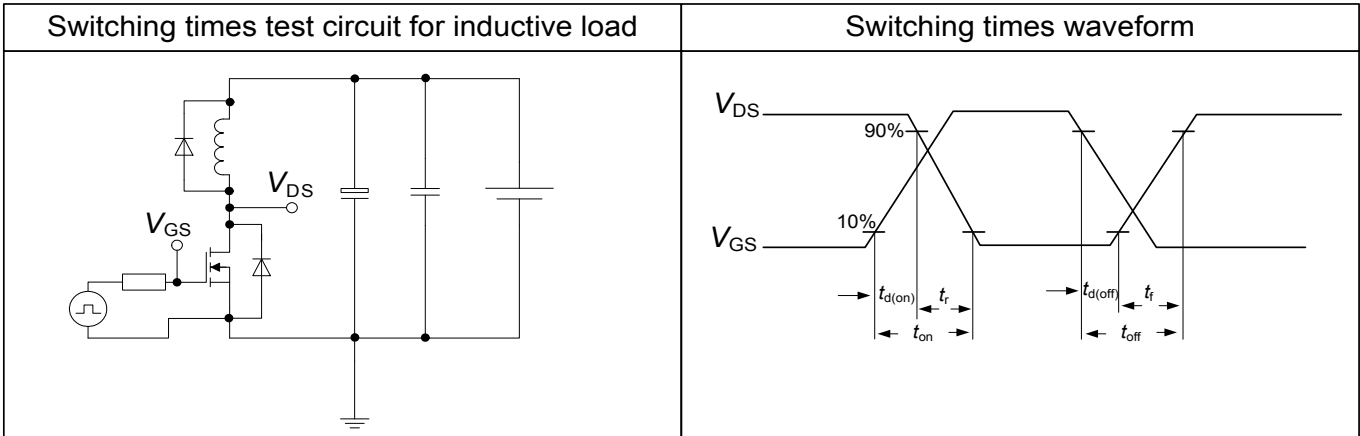
$E_{oss} = f(V_{DS})$

## 5 Test Circuits

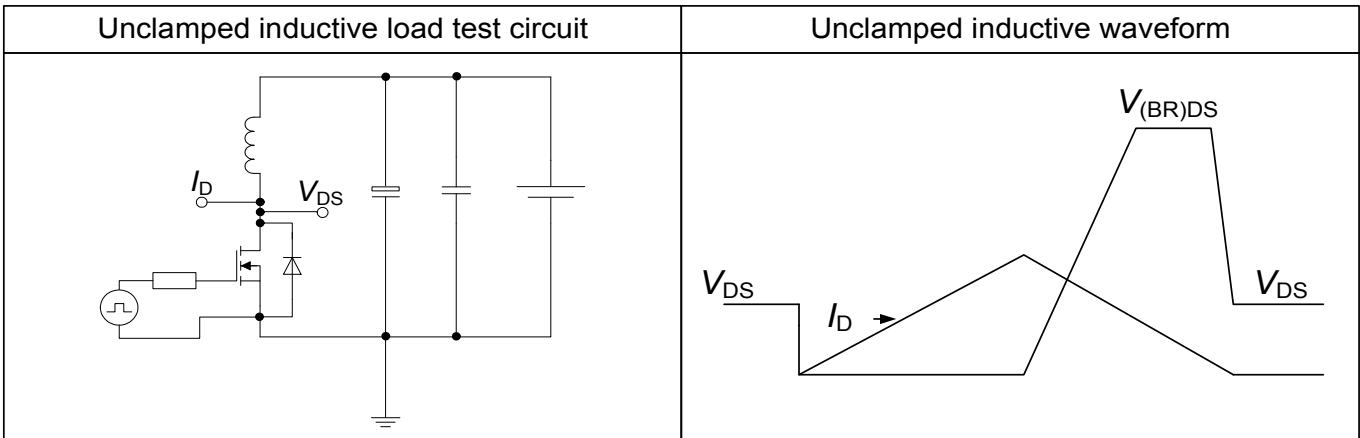
**Table 8 Diode characteristics**



**Table 9 switching times (ss)**



**Table 10 Unclamped inductive load (ss)**



## 6 Package Outlines



Figure 1 Outline PG-VSON-4, dimensions in mm/inches

## **7 Appendix A**

### **Table 11 Related Links**

- IFX CoolMOS™ P6 Webpage: [www.infineon.com](http://www.infineon.com)
- IFX CoolMOS™ P6 application note: [www.infineon.com](http://www.infineon.com)
- IFX CoolMOS™ P6 simulation model: [www.infineon.com](http://www.infineon.com)
- IFX Design tools: [www.infineon.com](http://www.infineon.com)

## Revision History

IPL60R180P6

**Revision: 2017-08-30, Rev. 2.1**

Previous Revision

| Revision | Date       | Subjects (major changes since last revision) |
|----------|------------|----------------------------------------------|
| 2.0      | 2014-05-16 | Release of final version                     |
| 2.1      | 2017-08-30 | Updated MSL; style updated                   |

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