

# MOSFET

Metal Oxide Semiconductor Field Effect Transistor

## CoolMOS™ C7

600V CoolMOS™ C7 Power Transistor  
IPA60R060C7

## Data Sheet

Rev. 2.0  
Final

## 1 Description

CoolMOS™ C7 is a revolutionary technology for high voltage power MOSFETs, designed according to the superjunction (SJ) principle and pioneered by Infineon Technologies.

600V CoolMOS™ C7 series combines the experience of the leading SJ MOSFET supplier with high class innovation.

The 600V C7 is the first technology ever with  $R_{DS(on)} \cdot A$  below  $10\text{m}\Omega \cdot \text{mm}^2$ .

## Features

- Suitable for hard and soft switching (PFC and high performance LLC)
- Increased MOSFET dv/dt ruggedness to 120V/ns
- Increased efficiency due to best in class FOM  $R_{DS(on)} \cdot E_{oss}$  and  $R_{DS(on)} \cdot Q_g$
- Best in class  $R_{DS(on)}$  /package
- Qualified for industrial grade applications according to JEDEC (J-STD20 and JESD22)

## Benefits

- Increased economies of scale by use in PFC and PWM topologies in the application
- Higher dv/dt limit enables faster switching leading to higher efficiency
- Enabling higher system efficiency by lower switching losses
- Increased power density solutions due to smaller packages
- Suitable for applications such as server, telecom and solar
- Higher switching frequencies possible without loss in efficiency due to low  $E_{oss}$  and  $Q_g$

## Applications

PFC stages and PWM stages (TTF, LLC) for high power/performance SMPS e.g. Computing, Server, Telecom, UPS and Solar.

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

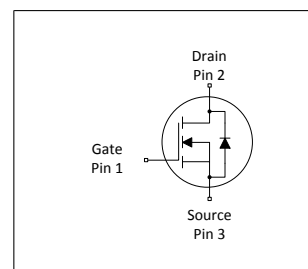


**Table 1 Key Performance Parameters**

| Parameter                                    | Value | Unit                   |
|----------------------------------------------|-------|------------------------|
| $V_{DS} @ T_{j,max}$                         | 650   | V                      |
| $R_{DS(on),max}$                             | 60    | $\text{m}\Omega$       |
| $Q_{g,typ}$                                  | 68    | nC                     |
| $I_{D,pulse}$                                | 135   | A                      |
| $I_{D,continuous} @ T_j < 150^\circ\text{C}$ | 54    | A                      |
| $E_{oss}@400\text{V}$                        | 8.1   | $\mu\text{J}$          |
| Body diode di/dt                             | 420   | $\text{A}/\mu\text{s}$ |

| Type / Ordering Code | Package           | Marking | Related Links  |
|----------------------|-------------------|---------|----------------|
| IPA60R060C7          | PG-TO 220 FullPAK | 60C7060 | 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> | $I_D$         | -      | -    | 16<br>10 | A                | $T_C=25^\circ\text{C}$<br>$T_C=100^\circ\text{C}$                                             |
| Pulsed drain current <sup>2)</sup>     | $I_{D,pulse}$ | -      | -    | 135      | A                | $T_C=25^\circ\text{C}$                                                                        |
| Avalanche energy, single pulse         | $E_{AS}$      | -      | -    | 159      | mJ               | $I_D=6.4\text{A}$ ; $V_{DD}=50\text{V}$ ; see table 10                                        |
| Avalanche energy, repetitive           | $E_{AR}$      | -      | -    | 0.80     | mJ               | $I_D=6.4\text{A}$ ; $V_{DD}=50\text{V}$ ; see table 10                                        |
| Avalanche current, single pulse        | $I_{AS}$      | -      | -    | 6.4      | A                | -                                                                                             |
| MOSFET dv/dt ruggedness                | dv/dt         | -      | -    | 120      | 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                      | $P_{tot}$     | -      | -    | 34       | W                | $T_C=25^\circ\text{C}$                                                                        |
| Storage temperature                    | $T_{stg}$     | -55    | -    | 150      | $^\circ\text{C}$ | -                                                                                             |
| Operating junction temperature         | $T_j$         | -55    | -    | 150      | $^\circ\text{C}$ | -                                                                                             |
| Mounting torque                        | -             | -      | -    | 50       | Ncm              | M2.5 screws                                                                                   |
| Continuous diode forward current       | $I_S$         | -      | -    | 16       | A                | $T_C=25^\circ\text{C}$                                                                        |
| Diode pulse current <sup>2)</sup>      | $I_{S,pulse}$ | -      | -    | 135      | A                | $T_C=25^\circ\text{C}$                                                                        |
| Reverse diode dv/dt <sup>3)</sup>      | dv/dt         | -      | -    | 20       | V/ns             | $V_{DS}=0\dots400\text{V}$ , $I_{SD}\leq 9.9\text{A}$ , $T_j=25^\circ\text{C}$<br>see table 8 |
| Maximum diode commutation speed        | di/dt         | -      | -    | 420      | A/ $\mu\text{s}$ | $V_{DS}=0\dots400\text{V}$ , $I_{SD}\leq 9.9\text{A}$ , $T_j=25^\circ\text{C}$<br>see table 8 |
| Insulation withstand voltage           | $V_{ISO}$     | -      | -    | 2500     | V                | $V_{rms}$ , $T_C=25^\circ\text{C}$ , $t=1\text{min}$                                          |

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

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

<sup>3)</sup> Identical low side and high side switch

### 3 Thermal characteristics

**Table 3 Thermal characteristics**

| Parameter                                                  | Symbol     | Values |      |      | Unit | Note / Test Condition               |
|------------------------------------------------------------|------------|--------|------|------|------|-------------------------------------|
|                                                            |            | Min.   | Typ. | Max. |      |                                     |
| Thermal resistance, junction - case                        | $R_{thJC}$ | -      | -    | 3.69 | °C/W | -                                   |
| Thermal resistance, junction - ambient                     | $R_{thJA}$ | -      | -    | 80   | °C/W | leaded                              |
| Thermal resistance, junction - ambient for SMD version     | $R_{thJA}$ | -      | -    | -    | °C/W | n.a.                                |
| 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   | $V_{(BR)DSS}$ | 600    | -              | -          | V        | $V_{GS}=0V$ , $I_D=1mA$                                                                                     |
| Gate threshold voltage           | $V_{(GS)th}$  | 3      | 3.5            | 4          | V        | $V_{DS}=V_{GS}$ , $I_D=0.8mA$                                                                               |
| 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 | $R_{DS(on)}$  | -      | 0.052<br>0.115 | 0.060<br>- | $\Omega$ | $V_{GS}=10V$ , $I_D=15.9A$ , $T_j=25^\circ\text{C}$<br>$V_{GS}=10V$ , $I_D=15.9A$ , $T_j=150^\circ\text{C}$ |
| Gate resistance                  | $R_G$         | -      | 0.8            | -          | $\Omega$ | $f=1MHz$ , open drain                                                                                       |

**Table 5 Dynamic characteristics**

| Parameter                                                  | Symbol       | Values |      |      | Unit | Note / Test Condition                                                      |
|------------------------------------------------------------|--------------|--------|------|------|------|----------------------------------------------------------------------------|
|                                                            |              | Min.   | Typ. | Max. |      |                                                                            |
| Input capacitance                                          | $C_{iss}$    | -      | 2850 | -    | pF   | $V_{GS}=0V$ , $V_{DS}=400V$ , $f=250kHz$                                   |
| Output capacitance                                         | $C_{oss}$    | -      | 54   | -    | pF   | $V_{GS}=0V$ , $V_{DS}=400V$ , $f=250kHz$                                   |
| Effective output capacitance, energy related <sup>1)</sup> | $C_{o(er)}$  | -      | 101  | -    | pF   | $V_{GS}=0V$ , $V_{DS}=0...400V$                                            |
| Effective output capacitance, time related <sup>2)</sup>   | $C_{o(tr)}$  | -      | 1050 | -    | pF   | $I_D=\text{constant}$ , $V_{GS}=0V$ , $V_{DS}=0...400V$                    |
| Turn-on delay time                                         | $t_{d(on)}$  | -      | 15.5 | -    | ns   | $V_{DD}=400V$ , $V_{GS}=13V$ , $I_D=15.9A$ , $R_G=3.3\Omega$ ; see table 9 |
| Rise time                                                  | $t_r$        | -      | 11   | -    | ns   | $V_{DD}=400V$ , $V_{GS}=13V$ , $I_D=15.9A$ , $R_G=3.3\Omega$ ; see table 9 |
| Turn-off delay time                                        | $t_{d(off)}$ | -      | 79   | -    | ns   | $V_{DD}=400V$ , $V_{GS}=13V$ , $I_D=15.9A$ , $R_G=3.3\Omega$ ; see table 9 |
| Fall time                                                  | $t_f$        | -      | 4    | -    | ns   | $V_{DD}=400V$ , $V_{GS}=13V$ , $I_D=15.9A$ , $R_G=3.3\Omega$ ; see table 9 |

**Table 6 Gate charge characteristics**

| Parameter             | Symbol        | Values |      |      | Unit | Note / Test Condition                             |
|-----------------------|---------------|--------|------|------|------|---------------------------------------------------|
|                       |               | Min.   | Typ. | Max. |      |                                                   |
| Gate to source charge | $Q_{gs}$      | -      | 14   | -    | nC   | $V_{DD}=400V$ , $I_D=15.9A$ , $V_{GS}=0$ to $10V$ |
| Gate to drain charge  | $Q_{gd}$      | -      | 23   | -    | nC   | $V_{DD}=400V$ , $I_D=15.9A$ , $V_{GS}=0$ to $10V$ |
| Gate charge total     | $Q_g$         | -      | 68   | -    | nC   | $V_{DD}=400V$ , $I_D=15.9A$ , $V_{GS}=0$ to $10V$ |
| Gate plateau voltage  | $V_{plateau}$ | -      | 5.0  | -    | V    | $V_{DD}=400V$ , $I_D=15.9A$ , $V_{GS}=0$ to $10V$ |

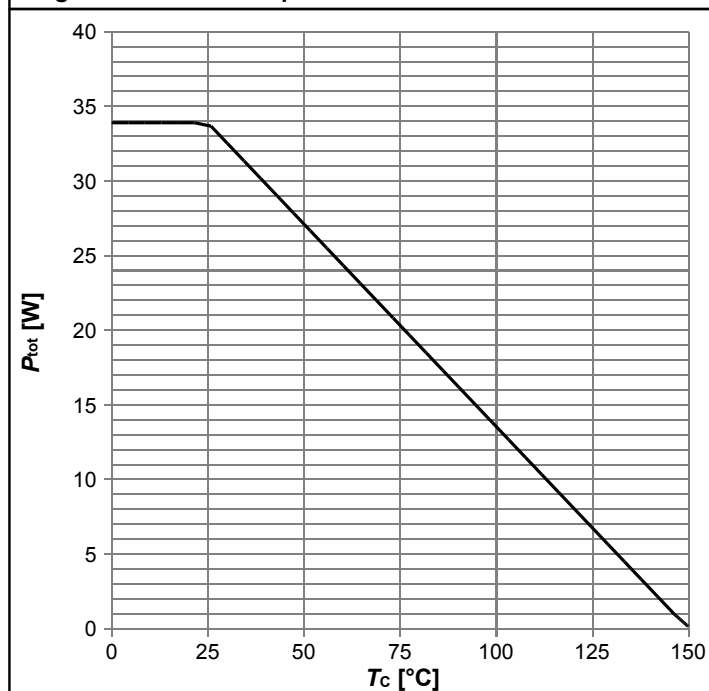
<sup>1)</sup>  $C_{o(er)}$  is a fixed capacitance that gives the same stored energy as  $C_{oss}$  while  $V_{DS}$  is rising from 0 to 400V

<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

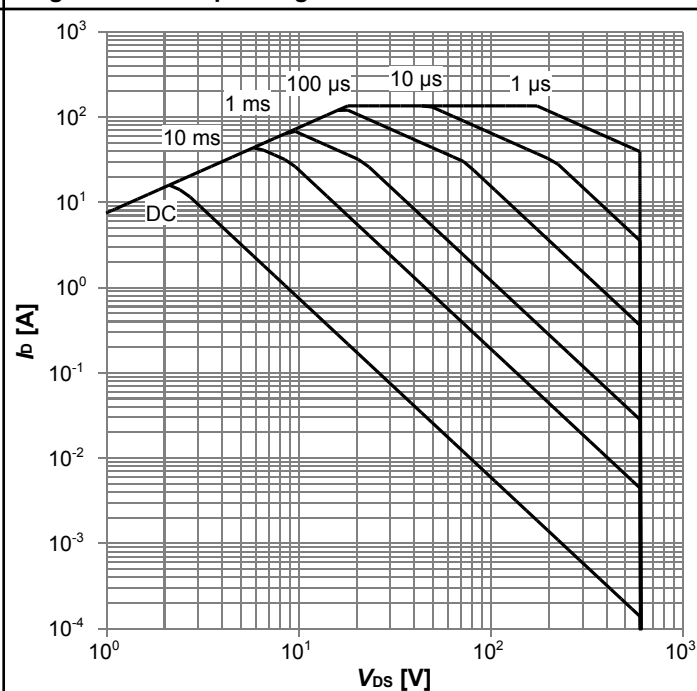
**Table 7 Reverse diode characteristics**

| Parameter                     | Symbol    | Values |      |      | Unit    | Note / Test Condition                                         |
|-------------------------------|-----------|--------|------|------|---------|---------------------------------------------------------------|
|                               |           | Min.   | Typ. | Max. |         |                                                               |
| Diode forward voltage         | $V_{SD}$  | -      | 0.9  | -    | V       | $V_{GS}=0V$ , $I_F=15.9A$ , $T_J=25^{\circ}C$                 |
| Reverse recovery time         | $t_{rr}$  | -      | 390  | -    | ns      | $V_R=400V$ , $I_F=15.9A$ , $di_F/dt=100A/\mu s$ ; see table 8 |
| Reverse recovery charge       | $Q_{rr}$  | -      | 6    | -    | $\mu C$ | $V_R=400V$ , $I_F=15.9A$ , $di_F/dt=100A/\mu s$ ; see table 8 |
| Peak reverse recovery current | $I_{rrm}$ | -      | 32   | -    | A       | $V_R=400V$ , $I_F=15.9A$ , $di_F/dt=100A/\mu s$ ; see table 8 |

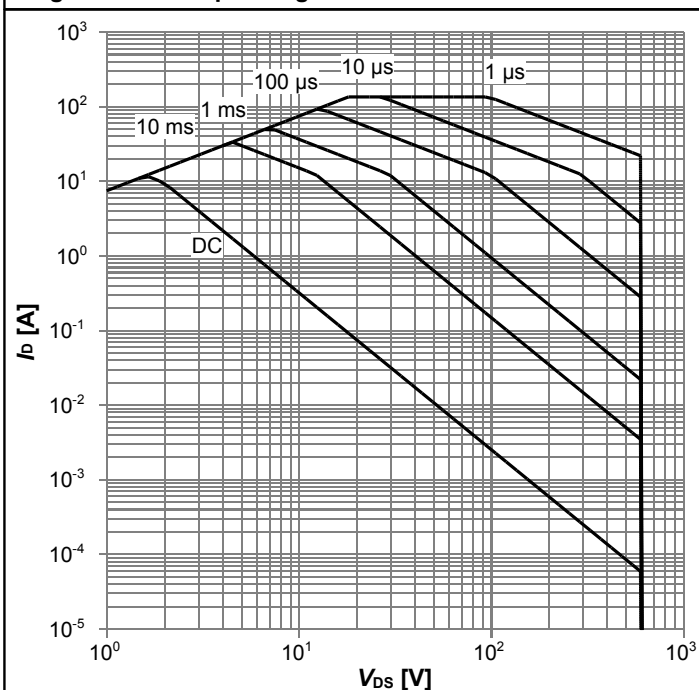
## 5 Electrical characteristics diagrams

**Diagram 1: Power dissipation**


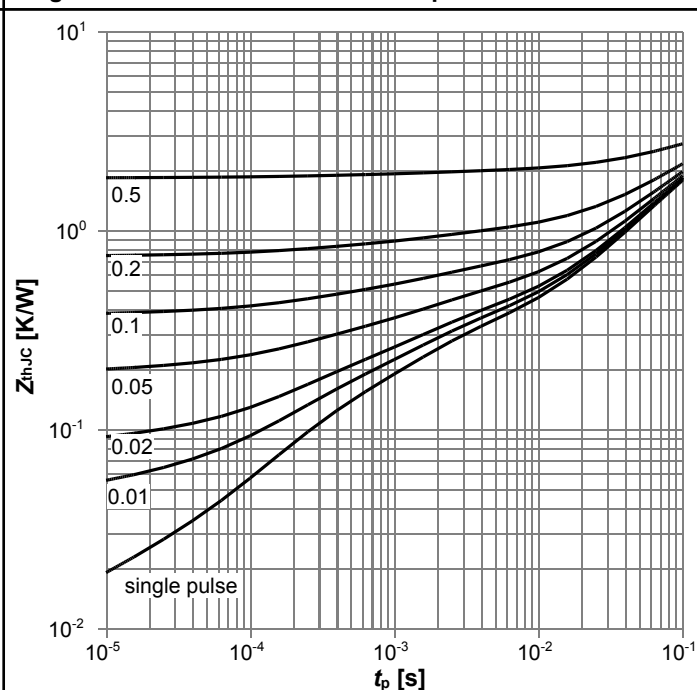
$$P_{\text{tot}} = f(T_c)$$

**Diagram 2: Safe operating area**


$$I_D = f(V_{DS}); T_c = 25^\circ\text{C}; D = 0; \text{parameter: } t_p$$

**Diagram 3: Safe operating area**


$$I_D = f(V_{DS}); T_c = 80^\circ\text{C}; D = 0; \text{parameter: } t_p$$

**Diagram 4: Max. transient thermal impedance**


$$Z_{thJC} = f(t_p); \text{parameter: } D = t_p / T$$

Diagram 5: Typ. output characteristics

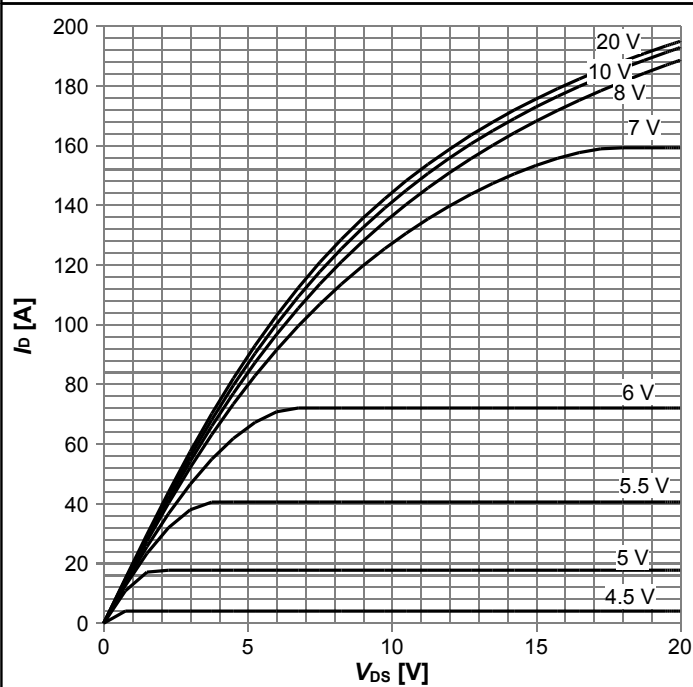

 $I_D = f(V_{DS}); T_J = 25^\circ\text{C}; \text{parameter: } V_{GS}$ 

Diagram 6: Typ. output characteristics

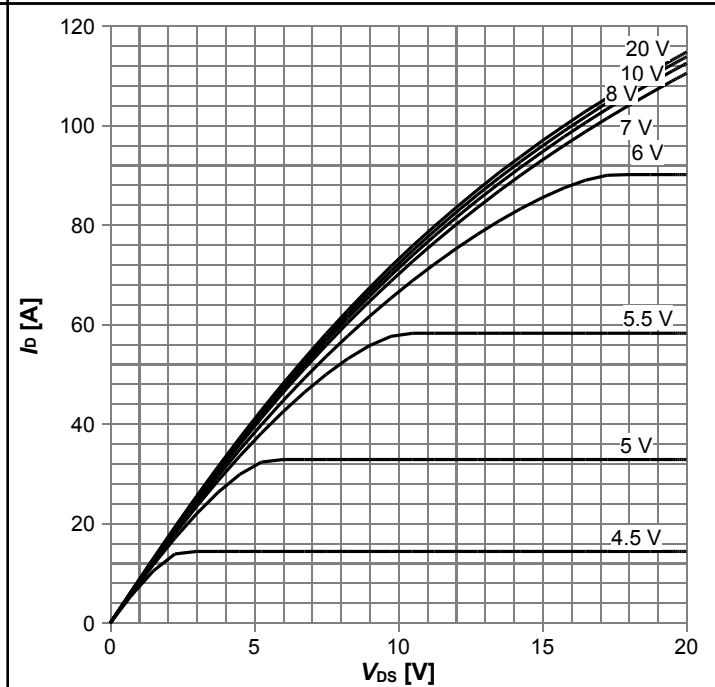

 $I_D = f(V_{DS}); T_J = 125^\circ\text{C}; \text{parameter: } V_{GS}$ 

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

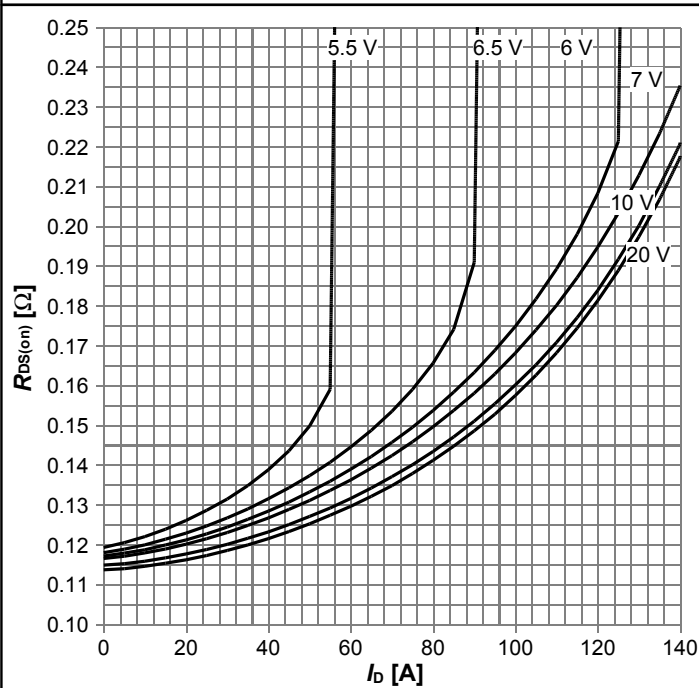

 $R_{DS(on)} = f(I_D); T_J = 125^\circ\text{C}; \text{parameter: } V_{GS}$ 

Diagram 8: Drain-source on-state resistance

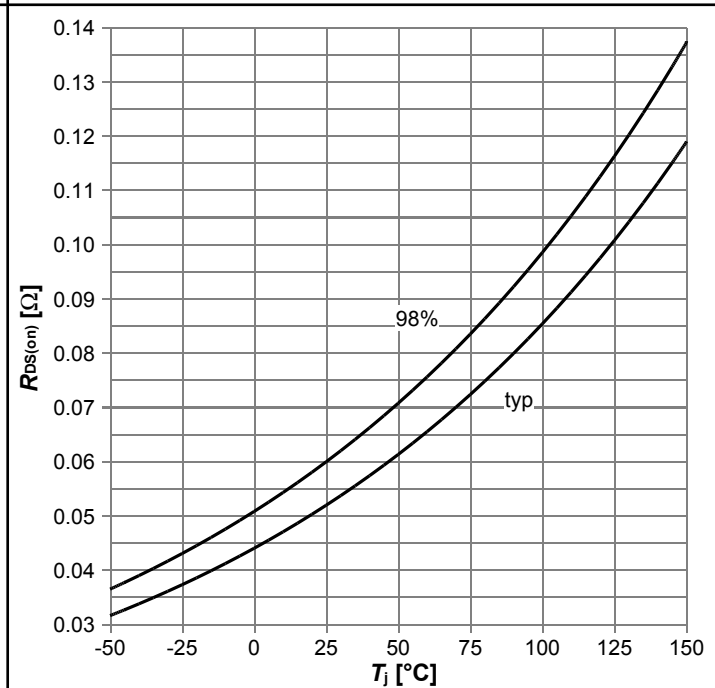

 $R_{DS(on)} = f(T_J); I_D = 15.9\text{ A}; V_{GS} = 10\text{ V}$

Diagram 9: Typ. transfer characteristics

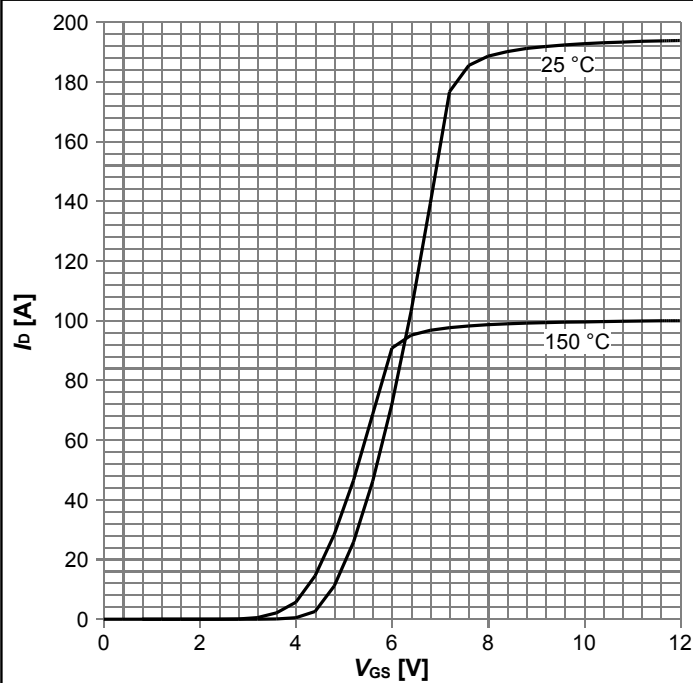

 $I_D = f(V_{GS})$ ;  $V_{DS} = 20V$ ; parameter:  $T_j$ 

Diagram 10: Typ. gate charge

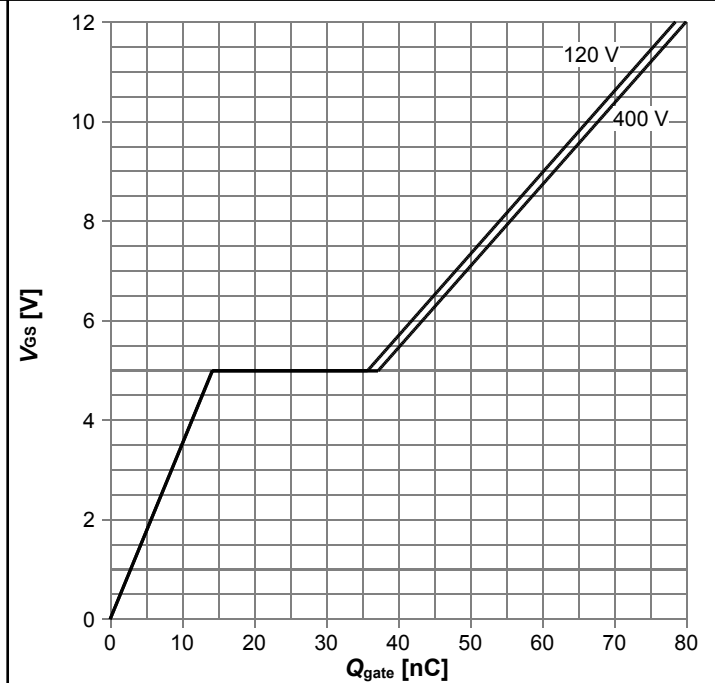

 $V_{GS} = f(Q_{gate})$ ;  $I_D = 15.9$  A pulsed; parameter:  $V_{DD}$ 

Diagram 11: Forward characteristics of reverse diode

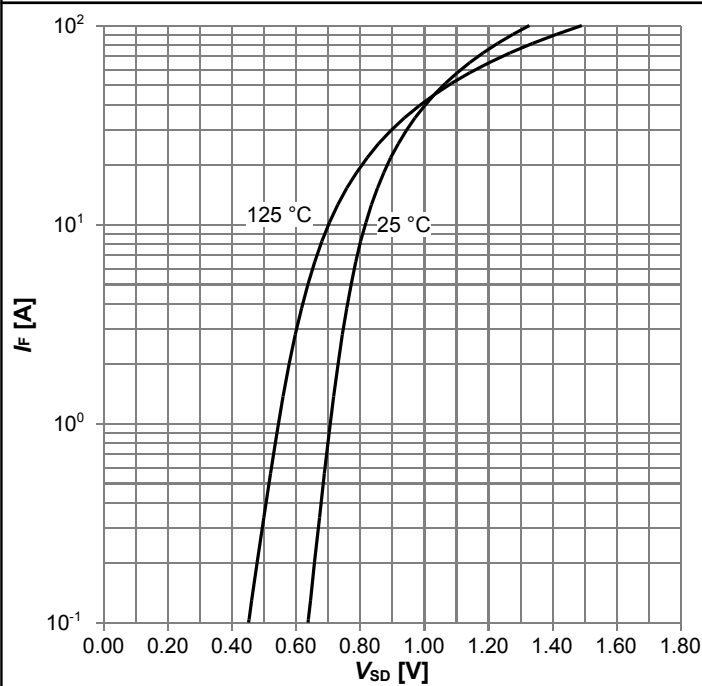

 $I_F = f(V_{SD})$ ; parameter:  $T_j$ 

Diagram 12: Avalanche energy

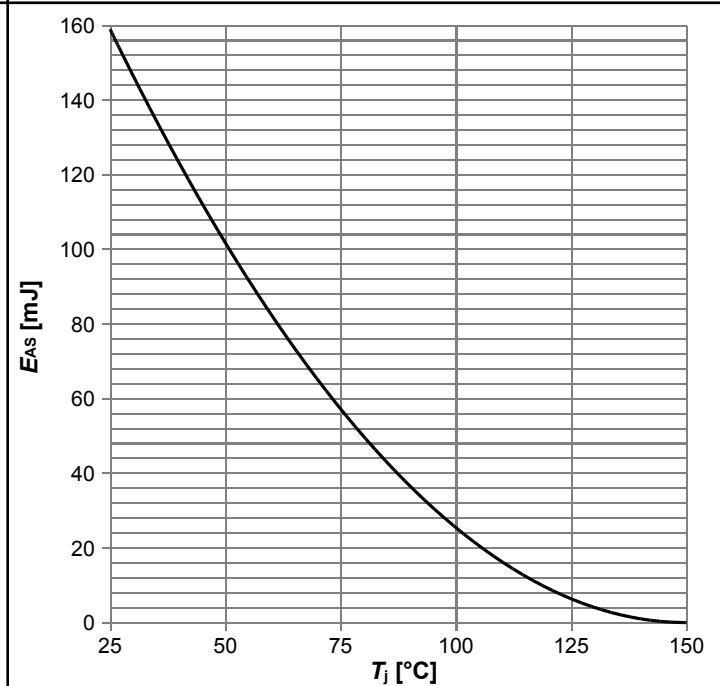
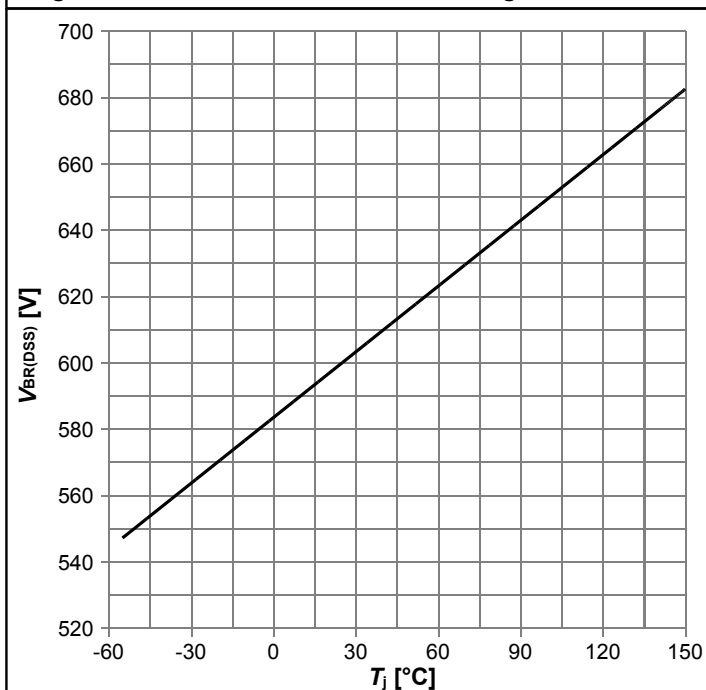
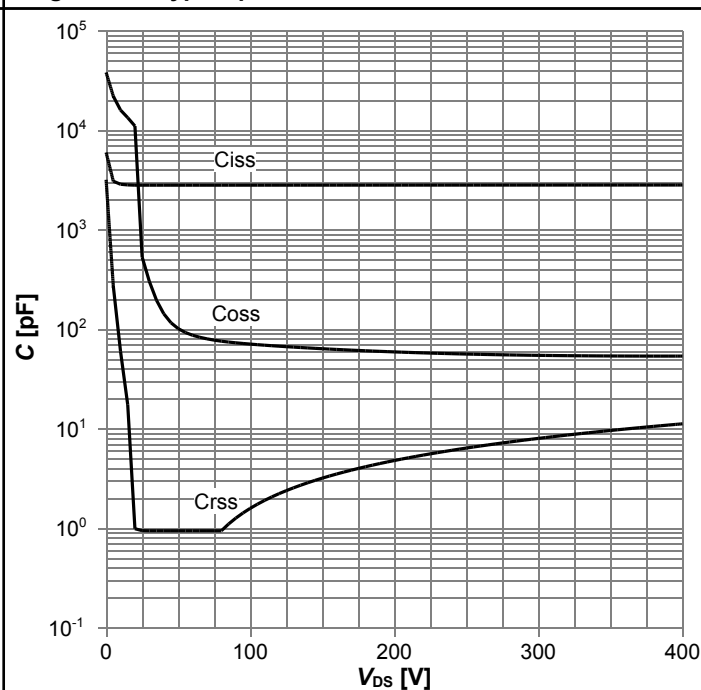

 $E_{AS} = f(T_j)$ ;  $I_D = 6.4$  A;  $V_{DD} = 50$  V

Diagram 13: Drain-source breakdown voltage



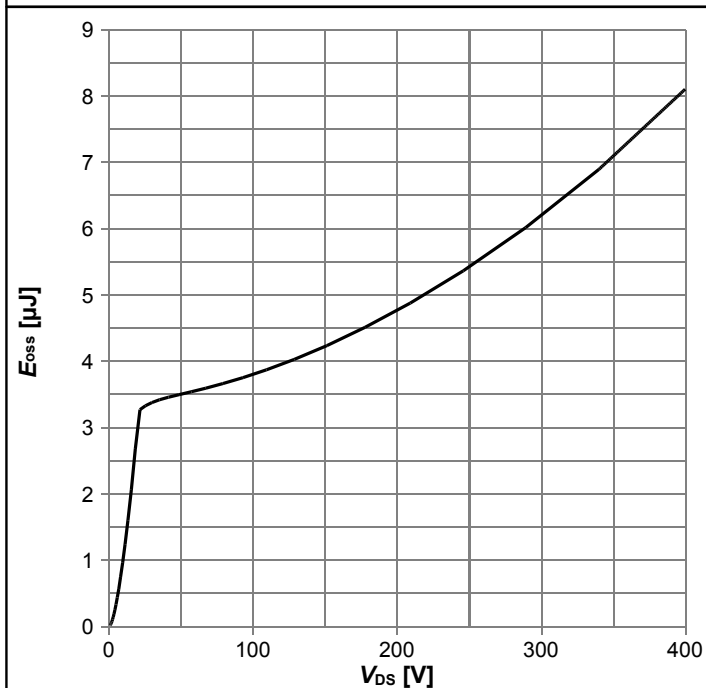
$$V_{BR(DSS)} = f(T_j); I_D = 1 \text{ mA}$$

Diagram 14: Typ. capacitances



$$C = f(V_{DS}); V_{GS} = 0 \text{ V}; f = 250 \text{ kHz}$$

Diagram 15: Typ. Coss stored energy



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

## 6 Test Circuits

**Table 8 Diode characteristics**

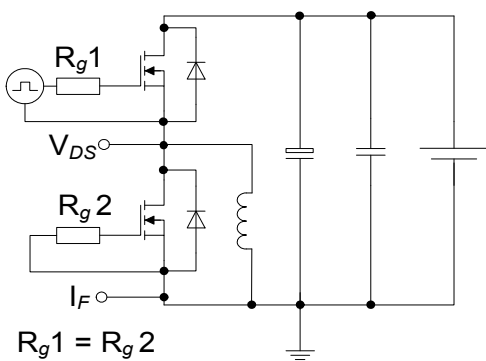
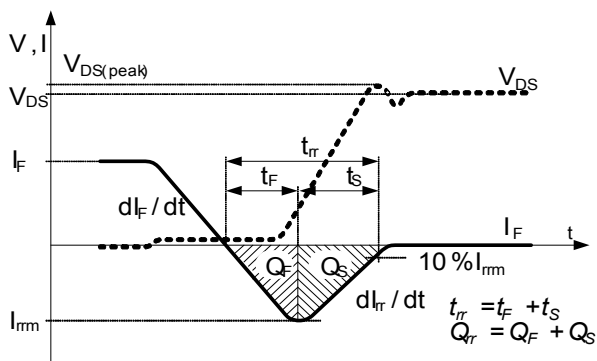
| Test circuit for diode characteristics                                                                                | Diode recovery waveform                                                                                                                                           |
|-----------------------------------------------------------------------------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

**Table 9 Switching times**

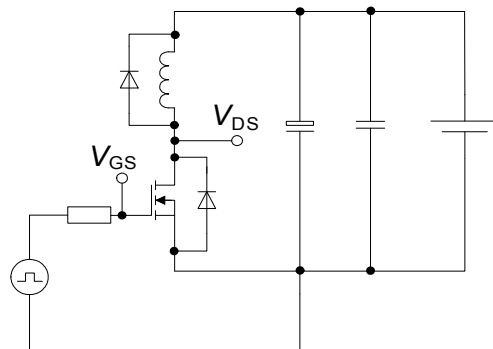
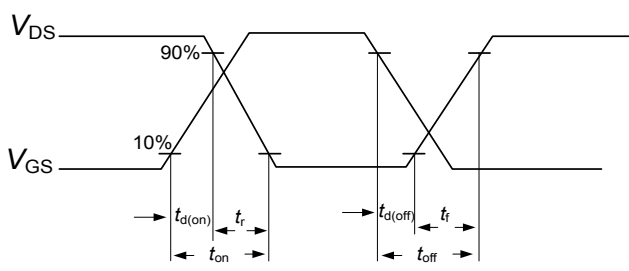
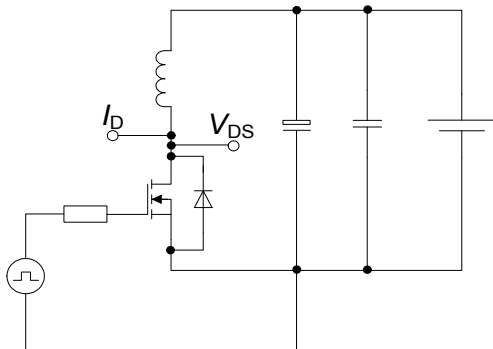
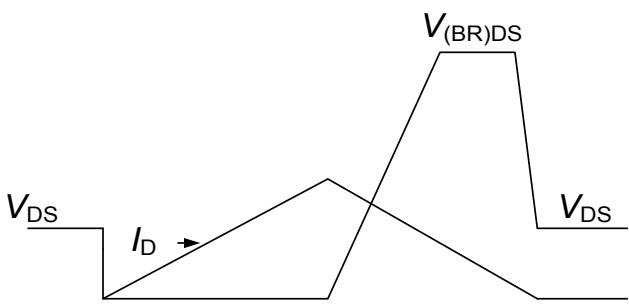
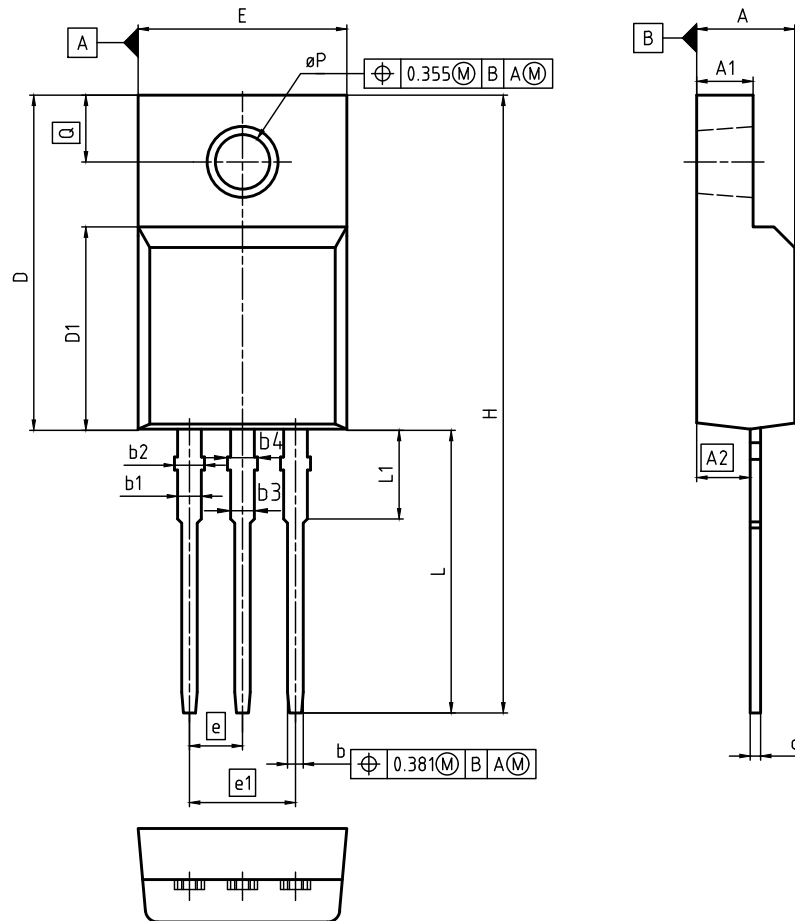
| Switching times test circuit for inductive load                                     | Switching times waveform                                                             |
|-------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|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

**Table 10 Unclamped inductive load**

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

## 7 Package Outlines



DIMENSIONS DO NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS.

| DIM | MILLIMETERS |       | INCHES      |       |
|-----|-------------|-------|-------------|-------|
|     | MIN         | MAX   | MIN         | MAX   |
| A   | 4.50        | 4.90  | 0.177       | 0.193 |
| A1  | 2.34        | 2.85  | 0.092       | 0.112 |
| A2  | 2.42        | 2.86  | 0.095       | 0.113 |
| b   | 0.65        | 0.90  | 0.026       | 0.035 |
| b1  | 0.95        | 1.38  | 0.037       | 0.054 |
| b2  | 0.95        | 1.51  | 0.037       | 0.059 |
| b3  | 0.65        | 1.38  | 0.026       | 0.054 |
| b4  | 0.65        | 1.51  | 0.026       | 0.059 |
| c   | 0.40        | 0.63  | 0.016       | 0.025 |
| D   | 15.67       | 16.15 | 0.617       | 0.636 |
| D1  | 8.97        | 9.83  | 0.353       | 0.387 |
| E   | 10.00       | 10.65 | 0.394       | 0.419 |
| e   | 2.54 (BSC)  |       | 0.100 (BSC) |       |
| e1  | 5.08        |       | 0.200       |       |
| N   | 3           |       | 3           |       |
| H   | 28.70       | 29.75 | 1.130       | 1.171 |
| L   | 12.78       | 13.75 | 0.503       | 0.541 |
| L1  | 2.83        | 3.45  | 0.111       | 0.136 |
| øP  | 2.95        | 3.38  | 0.116       | 0.133 |
| Q   | 3.15        | 3.50  | 0.124       | 0.138 |

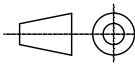
|                                                                                                              |
|--------------------------------------------------------------------------------------------------------------|
| DOCUMENT NO.<br>Z8B00003319                                                                                  |
| SCALE<br>0 2.5 5mm                                                                                           |
| EUROPEAN PROJECTION<br> |
| ISSUE DATE<br>24-10-2014                                                                                     |
| REVISION<br>05                                                                                               |

Figure 1 Outline PG-TO 220 FullPAK, dimensions in mm/inches

## 8 Appendix A

### Table 11 Related Links

- IFX CoolMOS™ C7 Webpage: [www.infineon.com](http://www.infineon.com)
- IFX CoolMOS™ C7 application note: [www.infineon.com](http://www.infineon.com)
- IFX CoolMOS™ C7 simulation model: [www.infineon.com](http://www.infineon.com)
- IFX Design tools: [www.infineon.com](http://www.infineon.com)

## Revision History

IPA60R060C7

**Revision: 2015-12-01, Rev. 2.0**

Previous Revision

| Revision | Date       | Subjects (major changes since last revision) |
|----------|------------|----------------------------------------------|
| 2.0      | 2015-12-01 | Release of final version                     |

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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.

The 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.