

# MOSFET

Metal Oxide Semiconductor Field Effect Transistor

## CoolMOS™ C7

600V CoolMOS™ C7 Power Transistor  
IPW60R060C7

## 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  $10\text{Ohm} \cdot \text{mm}^2$ .

## Features

- Suitable for hard and soft switching (PFC and high performance LLC)
- Increased MOSFET  $dv/dt$  ruggedness to  $120\text{V/ns}$
- 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)

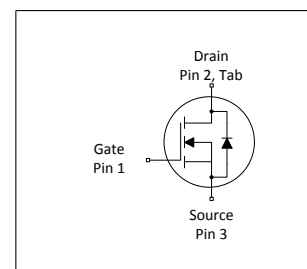
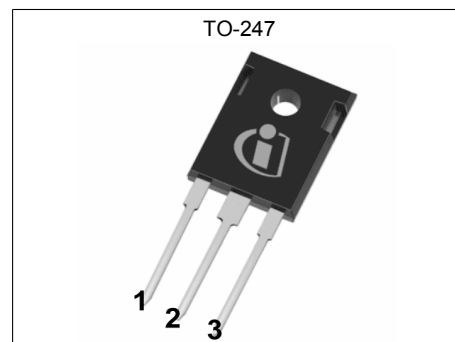
## Benefits

- 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    | $m\Omega$              |
| $Q_{g,typ}$                                  | 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  |
|----------------------|-----------|---------|----------------|
| IPW60R060C7          | PG-TO 247 | 60C7060 | see Appendix A |

## Table of Contents

|                                           |    |
|-------------------------------------------|----|
| Description .....                         | 2  |
| Maximum ratings .....                     | 4  |
| Thermal characteristics .....             | 5  |
| Electrical characteristics .....          | 6  |
| Electrical characteristics diagrams ..... | 8  |
| Test Circuits .....                       | 12 |
| Package Outlines .....                    | 13 |
| Appendix A .....                          | 14 |
| Revision History .....                    | 15 |
| Disclaimer .....                          | 15 |

## 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> | $I_D$         | -      | -    | 35<br>22 | 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                      | $P_{tot}$     | -      | -    | 162      | 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                        | -             | -      | -    | 60       | Ncm              | M3 and M3.5 screws                                                                            |
| Continuous diode forward current       | $I_S$         | -      | -    | 35       | 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           | $V_{ISO}$     | -      | -    | n.a.     | 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                        | $R_{thJC}$ | -      | -    | 0.772 | °C/W | -                                   |
| Thermal resistance, junction - ambient                     | $R_{thJA}$ | -      | -    | 62    | °C/W | lead                                |
| Thermal resistance, junction - ambient for SMD version     | $R_{thJA}$ | -      | -    | -     | °C/W | n.a.                                |
| Soldering temperature, wavesoldering only allowed at leads | $T_{sld}$  | -      | -    | 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   | $V_{DD}=400V$ , $V_{GS}=13V$ , $I_D=15.9A$ ,<br>$R_G=3.3\Omega$ ; see table 9 |
| Rise time                                                  | $t_r$        | -      | 11   | -    | ns   | $V_{DD}=400V$ , $V_{GS}=13V$ , $I_D=15.9A$ ,<br>$R_G=3.3\Omega$ ; see table 9 |
| Turn-off delay time                                        | $t_{d(off)}$ | -      | 79   | -    | ns   | $V_{DD}=400V$ , $V_{GS}=13V$ , $I_D=15.9A$ ,<br>$R_G=3.3\Omega$ ; see table 9 |
| Fall time                                                  | $t_f$        | -      | 4    | -    | ns   | $V_{DD}=400V$ , $V_{GS}=13V$ , $I_D=15.9A$ ,<br>$R_G=3.3\Omega$ ; 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

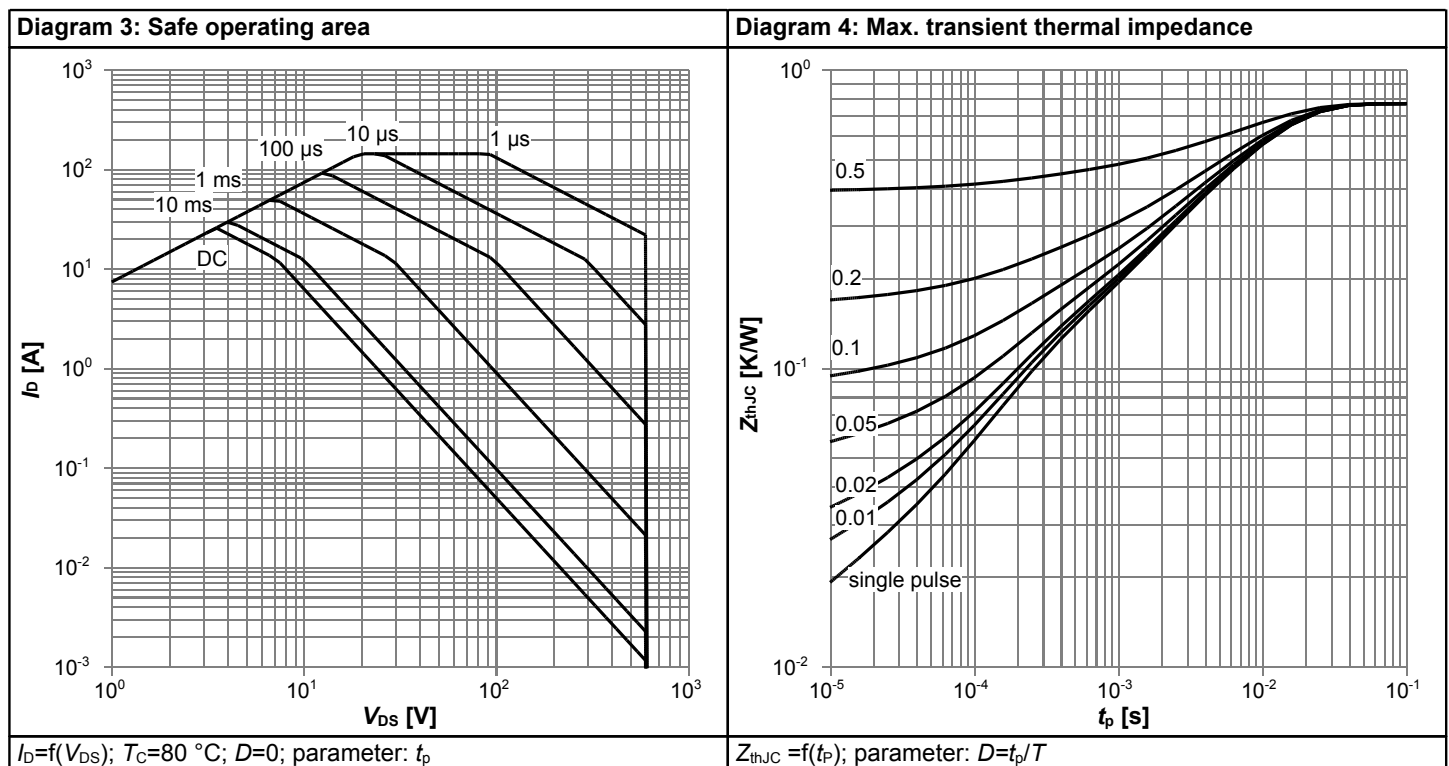
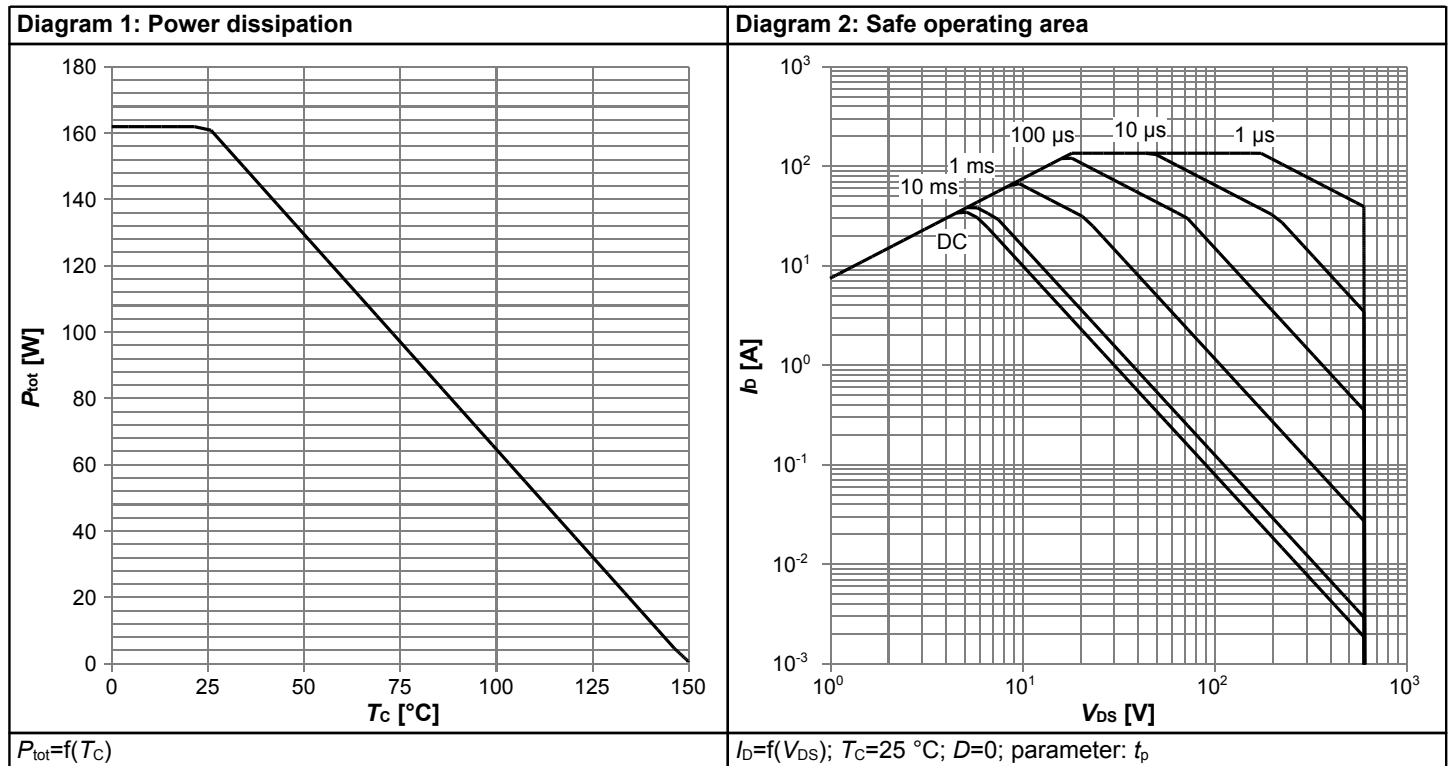


Diagram 5: Typ. output characteristics

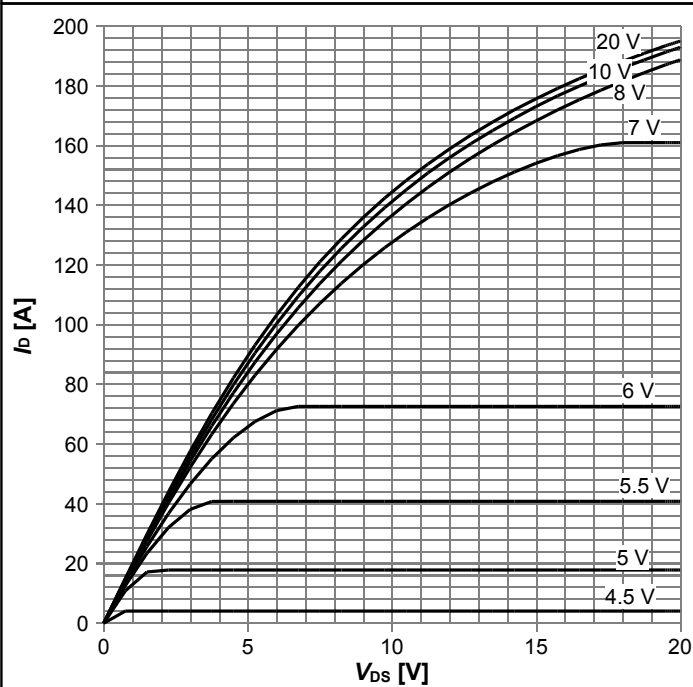

 $I_D = f(V_{DS}); T_J = 25^\circ\text{C}; \text{parameter: } V_{GS}$ 

Diagram 6: Typ. output characteristics

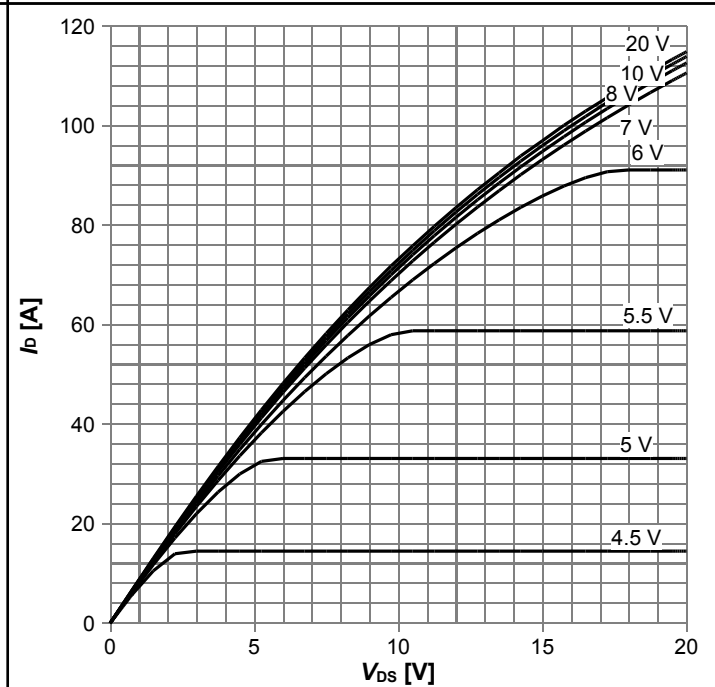

 $I_D = f(V_{DS}); T_J = 125^\circ\text{C}; \text{parameter: } V_{GS}$ 

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

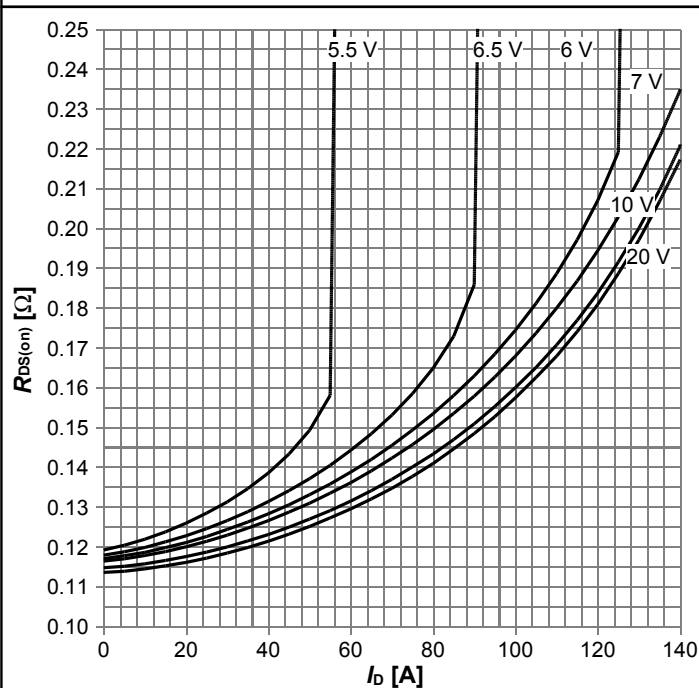

 $R_{DS(on)} = f(I_D); T_J = 125^\circ\text{C}; \text{parameter: } V_{GS}$ 

Diagram 8: Drain-source on-state resistance

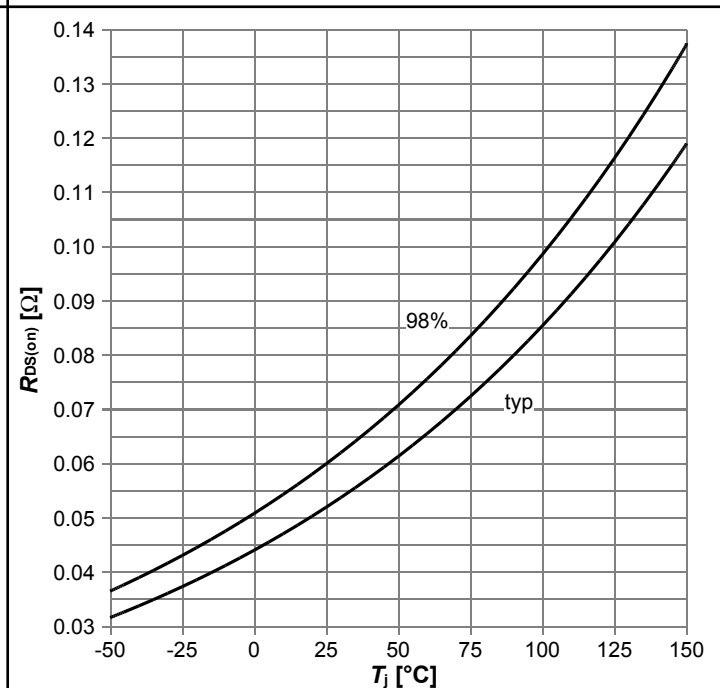

 $R_{DS(on)} = f(T_J); I_D = 15.9\text{ A}; V_{GS} = 10\text{ V}$

Diagram 9: Typ. transfer characteristics

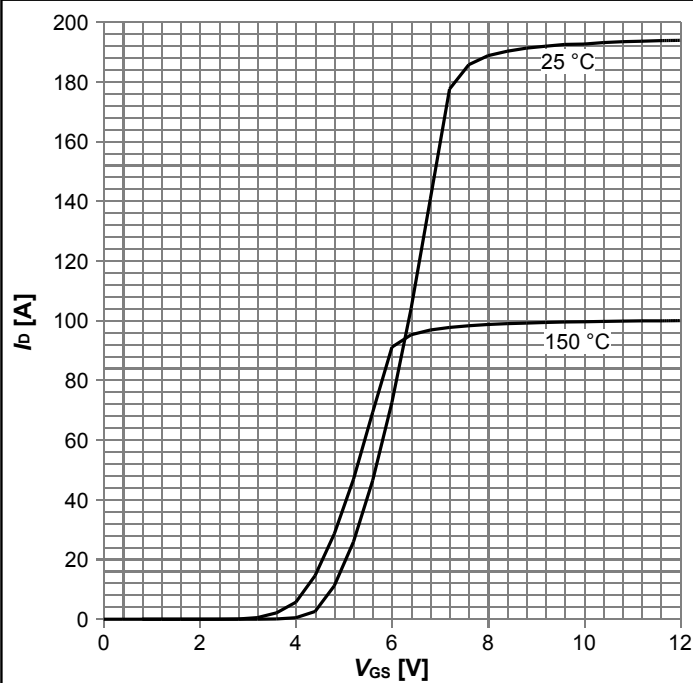

 $I_D = f(V_{GS}); V_{DS} = 20V; \text{parameter: } T_j$ 

Diagram 10: Typ. gate charge

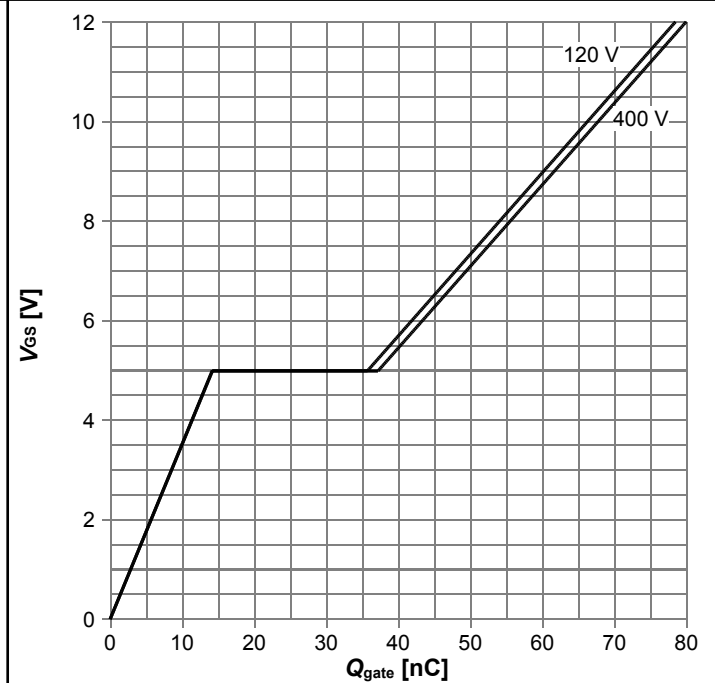

 $V_{GS} = f(Q_{gate}); I_D = 15.9 \text{ A pulsed}; \text{parameter: } V_{DD}$ 

Diagram 11: Forward characteristics of reverse diode

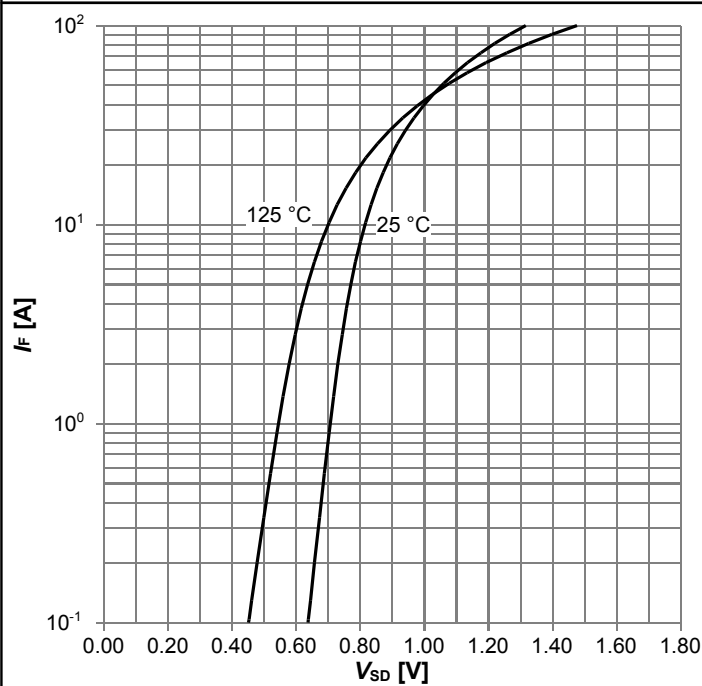

 $I_F = f(V_{SD}); \text{parameter: } T_j$ 

Diagram 12: Avalanche energy

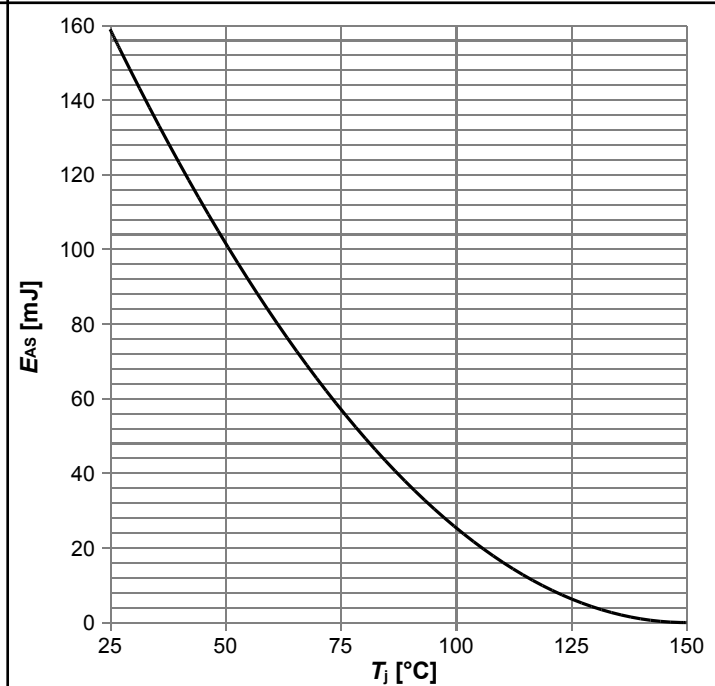
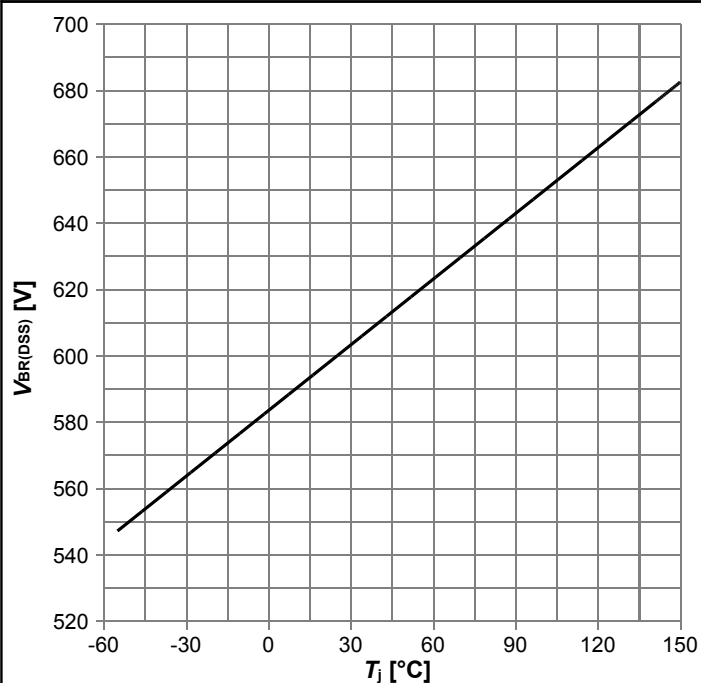
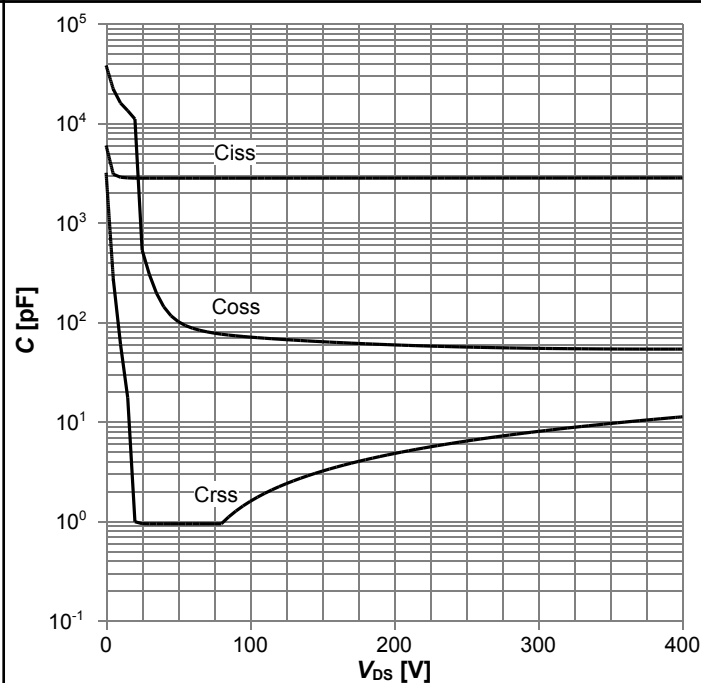

 $E_{AS} = f(T_j); I_D = 6.4 \text{ A}; V_{DD} = 50 \text{ V}$

Diagram 13: Drain-source breakdown voltage



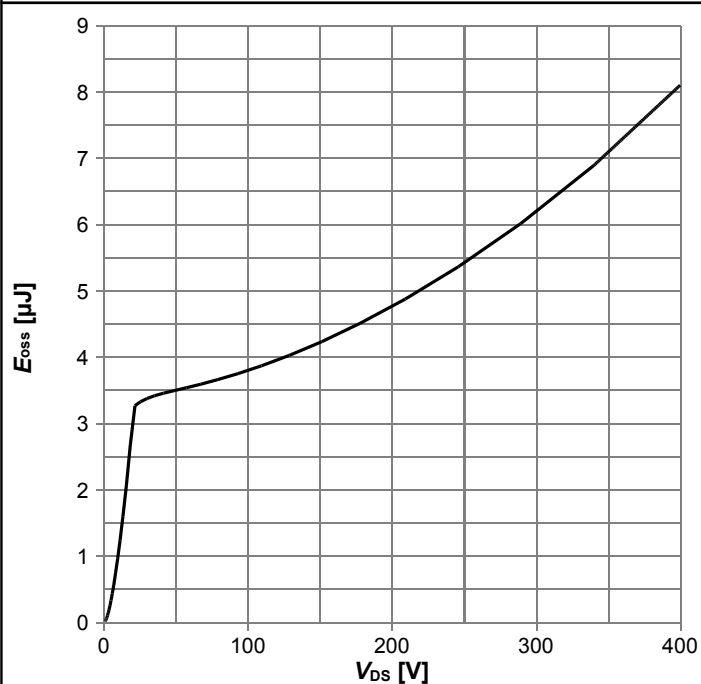
$$V_{BR(DSS)} = f(T_j); I_D = 1 \text{ mA}$$

Diagram 14: Typ. capacitances



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

Diagram 15: Typ. Coss stored energy



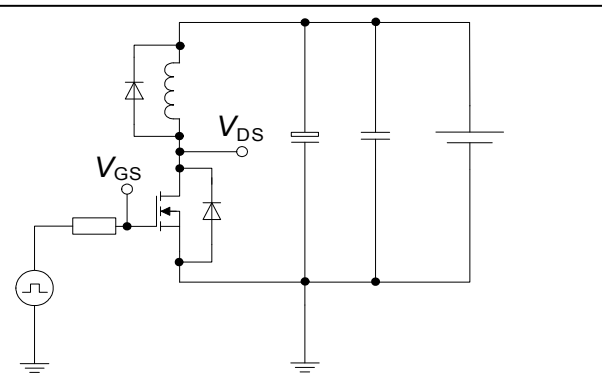
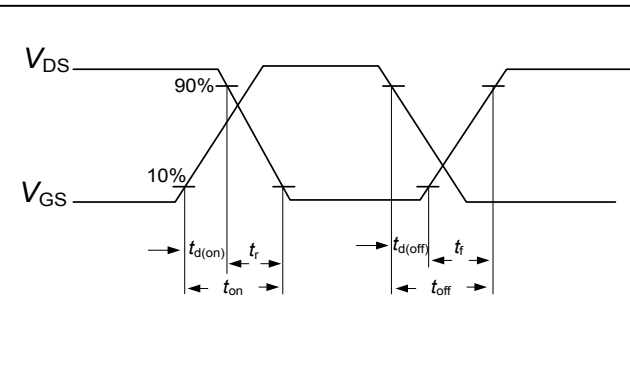
$$E_{oss} = f(V_{DS})$$

## 6 Test Circuits

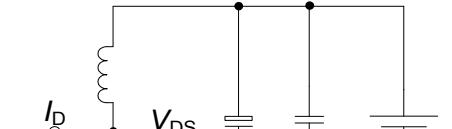
### Table 8 Diode characteristics

|                                                                                   |                                                                                                            |
|-----------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------|
| <p>Test circuit for diode characteristics</p> <p><math>R_{g1} = R_{g2}</math></p> | <p>Diode recovery waveform</p> <p><math>t_{rr} = t_F + t_S</math><br/> <math>Q_{rr} = Q_F + Q_S</math></p> |
|-----------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------|

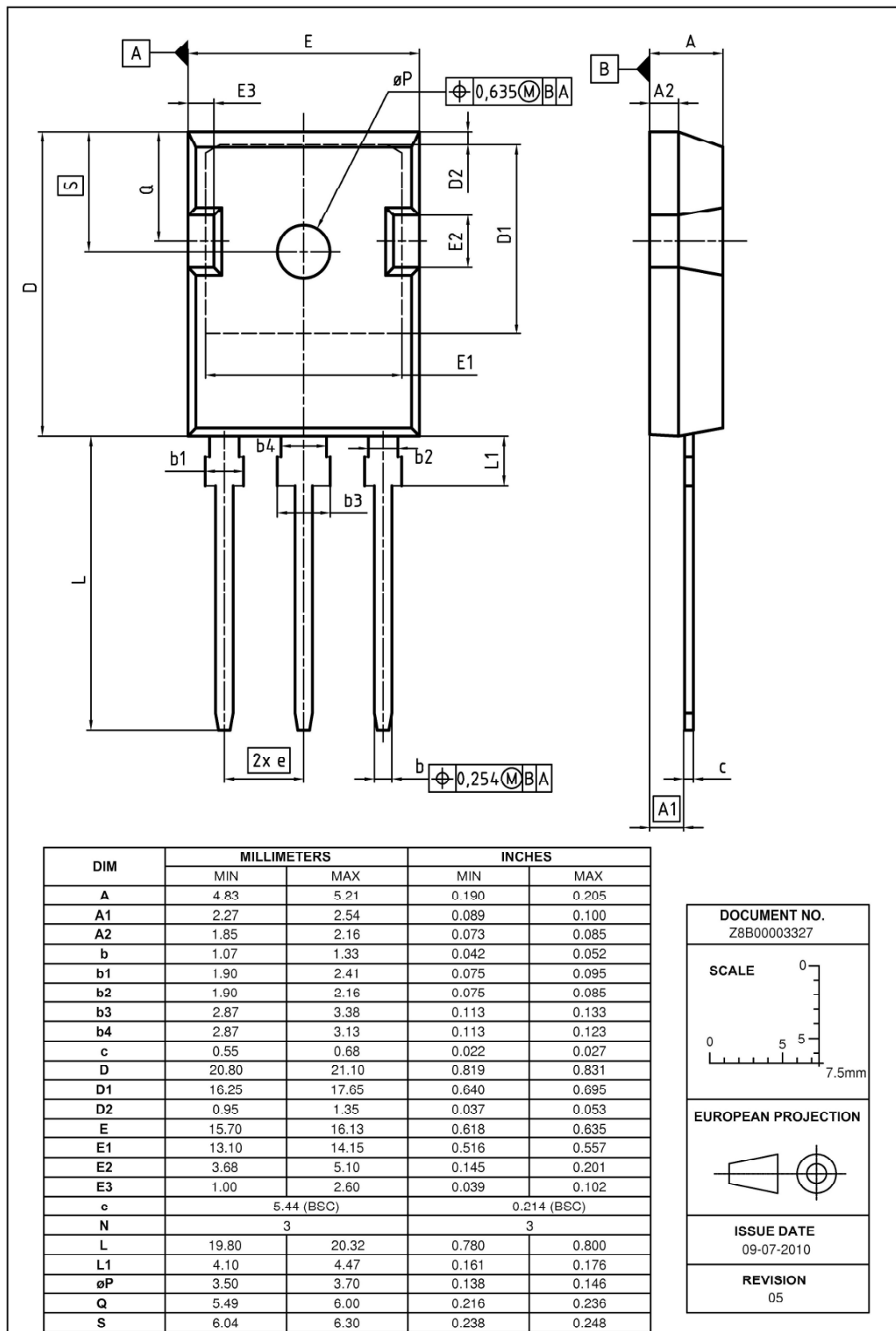
### Table 9 Switching times

| Switching times test circuit for inductive load                                                                                                                                                                                                                                                                                                                                                                                                                                            | Switching times waveform                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  <p>The circuit diagram illustrates a MOSFET switching an inductive load. A pulse generator is connected to the gate of the MOSFET through a resistor. The drain of the MOSFET is connected to a DC source and an inductive load (represented by an inductor and a diode in parallel). The voltage across the load is labeled <math>V_{DS}</math>. The gate voltage is labeled <math>V_{GS}</math>.</p> |  <p>The timing diagram shows the switching waveforms for <math>V_{DS}</math> and <math>V_{GS}</math>. The diagram defines the following switching times:</p> <ul style="list-style-type: none"> <li><math>t_{d(on)}</math>: Delay time from 10% <math>V_{GS}</math> to 90% <math>V_{DS}</math>.</li> <li><math>t_r</math>: Rise time from 90% <math>V_{DS}</math> to 100% <math>V_{DS}</math>.</li> <li><math>t_{on}</math>: Total on-time from 10% <math>V_{GS}</math> to 100% <math>V_{DS}</math>.</li> <li><math>t_{d(off)}</math>: Delay time from 10% <math>V_{GS}</math> to 90% <math>V_{DS}</math>.</li> <li><math>t_f</math>: Fall time from 90% <math>V_{DS}</math> to 100% <math>V_{DS}</math>.</li> <li><math>t_{off}</math>: Total off-time from 10% <math>V_{GS}</math> to 100% <math>V_{DS}</math>.</li> </ul> |

### Table 10 Unclamped inductive load

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

## 7 Package Outlines



**Figure 1 Outline PG-TO 247, 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

IPW60R060C7

**Revision: 2015-11-30, Rev. 2.0**

Previous Revision

| Revision | Date       | Subjects (major changes since last revision) |
|----------|------------|----------------------------------------------|
| 2.0      | 2015-11-30 | Release of final version                     |

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### Published by

**Infineon Technologies AG**

**81726 München, Germany**

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