

MOSFET

Metal Oxide Semiconductor Field Effect Transistor

CoolMOS™ C7

600V CoolMOS™ C7 Power Transistor
IPW60R040C7

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 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.

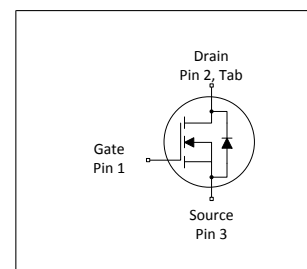
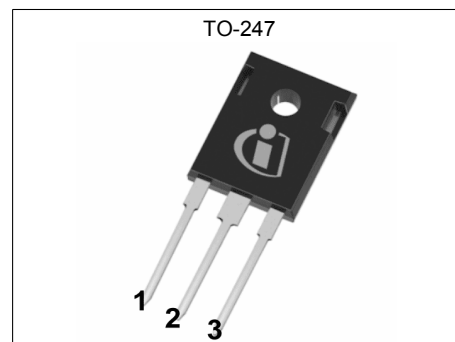


Table 1 Key Performance Parameters

| Parameter | Value | Unit |
|--|-------|------------------------|
| $V_{DS} @ T_{j,max}$ | 650 | V |
| $R_{DS(on),max}$ | 40 | $m\Omega$ |
| $Q_{g,typ}$ | 107 | nC |
| $I_{D,pulse}$ | 211 | A |
| $I_{D,continuous} @ T_j < 150^\circ\text{C}$ | 73 | A |
| $E_{oss}@400\text{V}$ | 12.6 | μJ |
| Body diode di/dt | 450 | $\text{A}/\mu\text{s}$ |

| Type / Ordering Code | Package | Marking | Related Links |
|----------------------|-----------|---------|----------------|
| IPW60R040C7 | PG-TO 247 | 60C7040 | 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 ¹⁾ | I_D | - | - | 50 32 | A | $T_C=25^\circ\text{C}$ $T_C=100^\circ\text{C}$ |
| Pulsed drain current ²⁾ | $I_{D,pulse}$ | - | - | 211 | A | $T_C=25^\circ\text{C}$ |
| Avalanche energy, single pulse | E_{AS} | - | - | 249 | mJ | $I_D=7.4\text{A}$; $V_{DD}=50\text{V}$; see table 10 |
| Avalanche energy, repetitive | E_{AR} | - | - | 1.24 | mJ | $I_D=7.4\text{A}$; $V_{DD}=50\text{V}$; see table 10 |
| Avalanche current, single pulse | I_{AS} | - | - | 7.4 | 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} | - | - | 227 | 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 | - | - | 50 | A | $T_C=25^\circ\text{C}$ |
| Diode pulse current ²⁾ | $I_{S,pulse}$ | - | - | 211 | A | $T_C=25^\circ\text{C}$ |
| Reverse diode dv/dt ³⁾ | dv/dt | - | - | 20 | V/ns | $V_{DS}=0\dots400\text{V}$, $I_{SD}\leq 11.4\text{A}$, $T_j=25^\circ\text{C}$ see table 8 |
| Maximum diode commutation speed | di/dt | - | - | 450 | A/ μs | $V_{DS}=0\dots400\text{V}$, $I_{SD}\leq 11.4\text{A}$, $T_j=25^\circ\text{C}$ see table 8 |
| Insulation withstand voltage | V_{ISO} | - | - | n.a. | V | V_{rms} , $T_C=25^\circ\text{C}$, $t=1\text{min}$ |

¹⁾ Limited by $T_{j,max}$.

²⁾ Pulse width t_p limited by $T_{j,max}$

³⁾ 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} | - | - | 0.55 | °C/W | - |
| Thermal resistance, junction - ambient | R_{thJA} | - | - | 62 | °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 | $V_{DS}=V_{GS}$, $I_D=1.24mA$ |
| Zero gate voltage drain current | I_{DSS} | - | - | 1 | μA | $V_{DS}=600$, $V_{GS}=0V$, $T_j=25^\circ\text{C}$ $V_{DS}=600$, $V_{GS}=0V$, $T_j=150^\circ\text{C}$ |
| Gate-source leakage current | I_{GSS} | - | - | 100 | nA | $V_{GS}=20V$, $V_{DS}=0V$ |
| Drain-source on-state resistance | $R_{DS(on)}$ | - | 0.034 0.077 | 0.040 - | Ω | $V_{GS}=10V$, $I_D=24.9A$, $T_j=25^\circ\text{C}$ $V_{GS}=10V$, $I_D=24.9A$, $T_j=150^\circ\text{C}$ |
| Gate resistance | R_G | - | 0.77 | - | Ω | $f=1MHz$, open drain |

Table 5 Dynamic characteristics

| Parameter | Symbol | Values | | | Unit | Note / Test Condition |
|--|--------------|--------|------|------|------|--|
| | | Min. | Typ. | Max. | | |
| Input capacitance | C_{iss} | - | 4340 | - | pF | $V_{GS}=0V$, $V_{DS}=400V$, $f=250kHz$ |
| Output capacitance | C_{oss} | - | 85 | - | pF | $V_{GS}=0V$, $V_{DS}=400V$, $f=250kHz$ |
| Effective output capacitance, energy related ¹⁾ | $C_{o(er)}$ | - | 158 | - | pF | $V_{GS}=0V$, $V_{DS}=0...400V$ |
| Effective output capacitance, time related ²⁾ | $C_{o(tr)}$ | - | 1640 | - | pF | $I_D=\text{constant}$, $V_{GS}=0V$, $V_{DS}=0...400V$ |
| Turn-on delay time | $t_{d(on)}$ | - | 18.5 | - | ns | $V_{DD}=400V$, $V_{GS}=13V$, $I_D=24.9A$, $R_G=3.3\Omega$; see table 9 |
| Rise time | t_r | - | 11 | - | ns | $V_{DD}=400V$, $V_{GS}=13V$, $I_D=24.9A$, $R_G=3.3\Omega$; see table 9 |
| Turn-off delay time | $t_{d(off)}$ | - | 81 | - | ns | $V_{DD}=400V$, $V_{GS}=13V$, $I_D=24.9A$, $R_G=3.3\Omega$; see table 9 |
| Fall time | t_f | - | 3.2 | - | ns | $V_{DD}=400V$, $V_{GS}=13V$, $I_D=24.9A$, $R_G=3.3\Omega$; see table 9 |

Table 6 Gate charge characteristics

| Parameter | Symbol | Values | | | Unit | Note / Test Condition |
|-----------------------|---------------|--------|------|------|------|---|
| | | Min. | Typ. | Max. | | |
| Gate to source charge | Q_{gs} | - | 22 | - | nC | $V_{DD}=400V$, $I_D=24.9A$, $V_{GS}=0$ to $10V$ |
| Gate to drain charge | Q_{gd} | - | 36 | - | nC | $V_{DD}=400V$, $I_D=24.9A$, $V_{GS}=0$ to $10V$ |
| Gate charge total | Q_g | - | 107 | - | nC | $V_{DD}=400V$, $I_D=24.9A$, $V_{GS}=0$ to $10V$ |
| Gate plateau voltage | $V_{plateau}$ | - | 5.0 | - | V | $V_{DD}=400V$, $I_D=24.9A$, $V_{GS}=0$ to $10V$ |

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 400V

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 400V

Table 7 Reverse diode characteristics

| Parameter | Symbol | Values | | | Unit | Note / Test Condition |
|-------------------------------|-----------|--------|------|------|---------|---|
| | | Min. | Typ. | Max. | | |
| Diode forward voltage | V_{SD} | - | 0.9 | - | V | $V_{GS}=0V$, $I_F=24.9A$, $T_J=25^{\circ}C$ |
| Reverse recovery time | t_{rr} | - | 460 | - | ns | $V_R=400V$, $I_F=24.9A$, $di_F/dt=100A/\mu s$; see table 8 |
| Reverse recovery charge | Q_{rr} | - | 9.2 | - | μC | $V_R=400V$, $I_F=24.9A$, $di_F/dt=100A/\mu s$; see table 8 |
| Peak reverse recovery current | I_{rrm} | - | 40 | - | A | $V_R=400V$, $I_F=24.9A$, $di_F/dt=100A/\mu s$; see table 8 |

5 Electrical characteristics diagrams

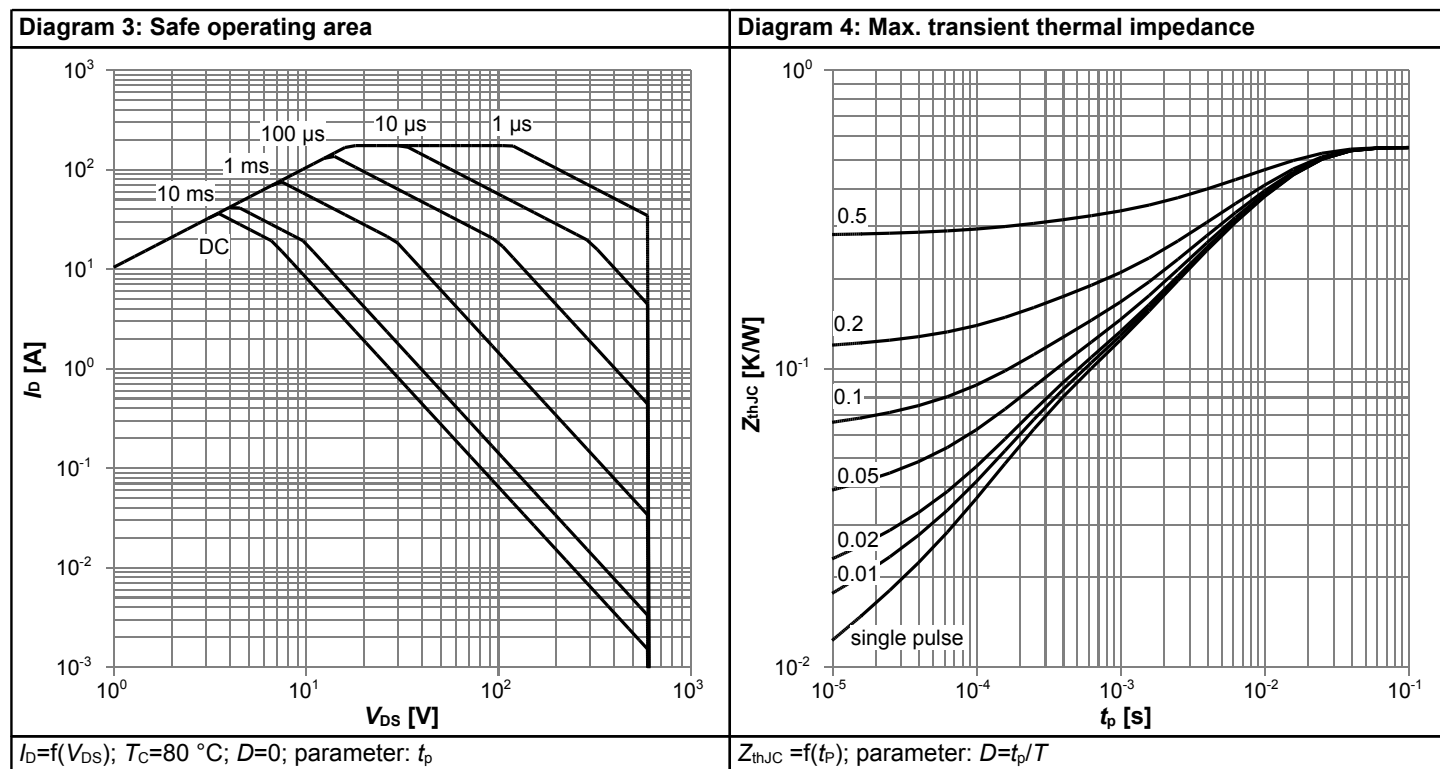
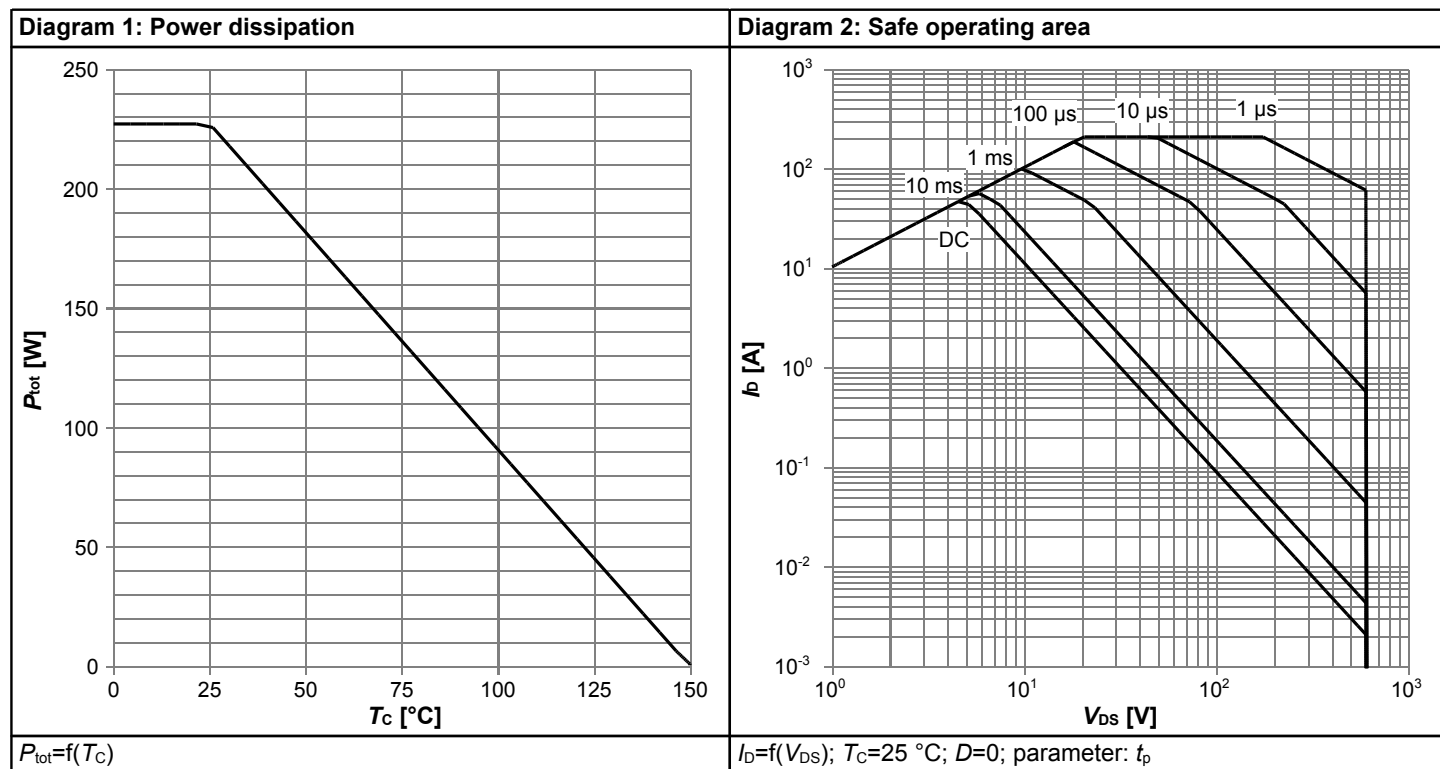


Diagram 5: Typ. output characteristics

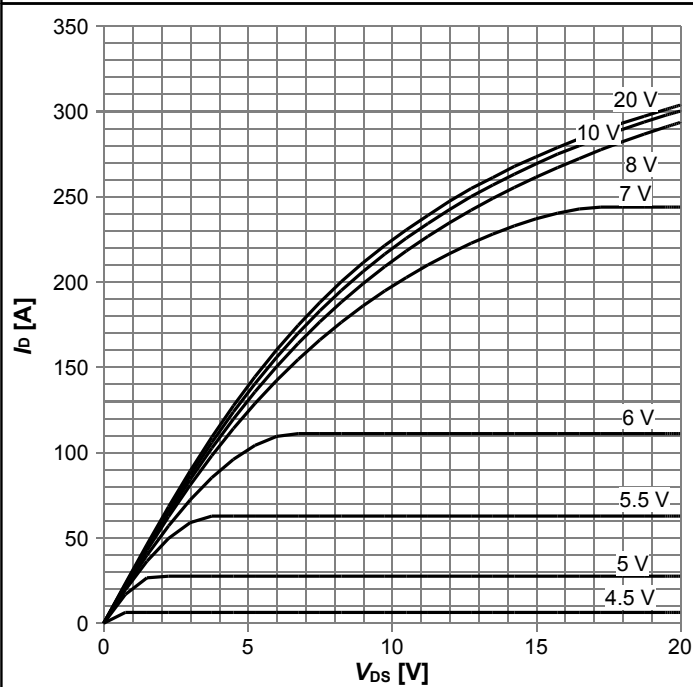

 $I_D = f(V_{DS}); T_J = 25^\circ\text{C}; \text{parameter: } V_{GS}$

Diagram 6: Typ. output characteristics

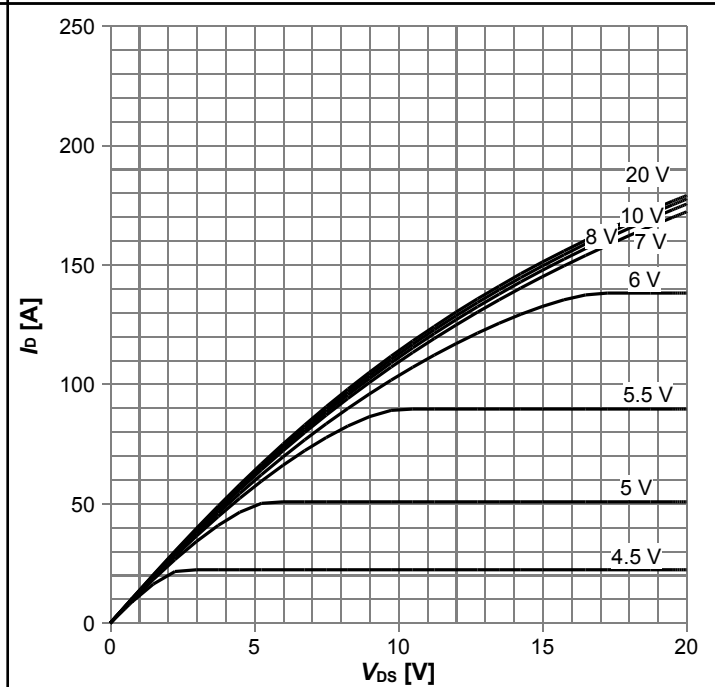

 $I_D = f(V_{DS}); T_J = 125^\circ\text{C}; \text{parameter: } V_{GS}$

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

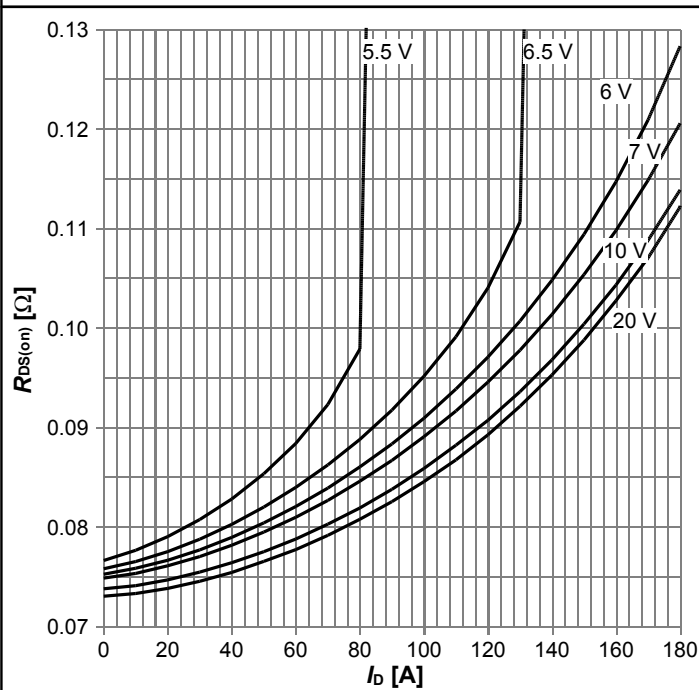

 $R_{DS(on)} = f(I_D); T_J = 125^\circ\text{C}; \text{parameter: } V_{GS}$

Diagram 8: Drain-source on-state resistance

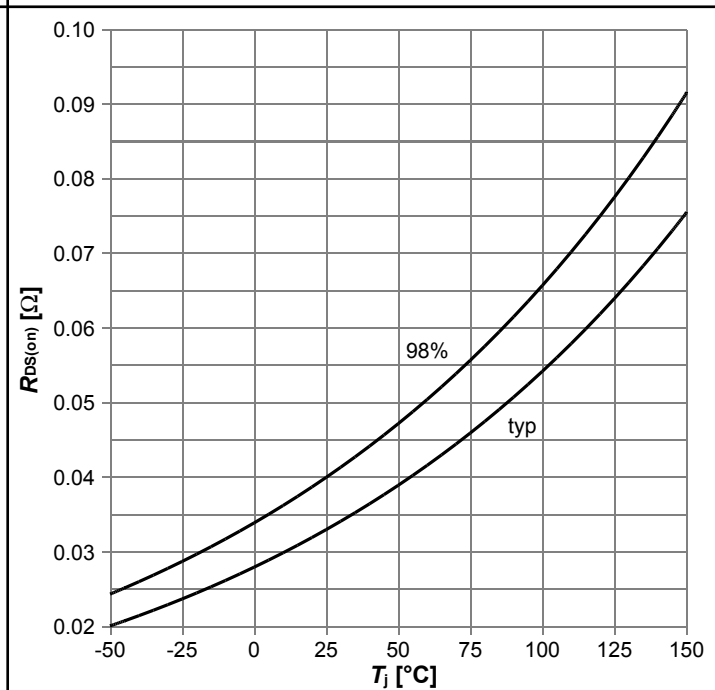

 $R_{DS(on)} = f(T_J); I_D = 24.9\text{ A}; V_{GS} = 10\text{ V}$

Diagram 9: Typ. transfer characteristics

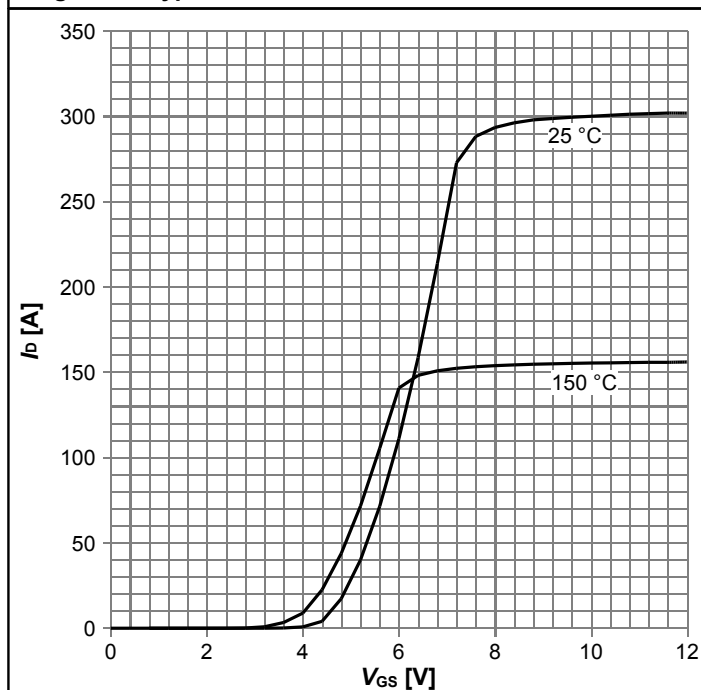

 $I_D = f(V_{GS}); V_{DS} = 20V; \text{parameter: } T_j$

Diagram 10: Typ. gate charge

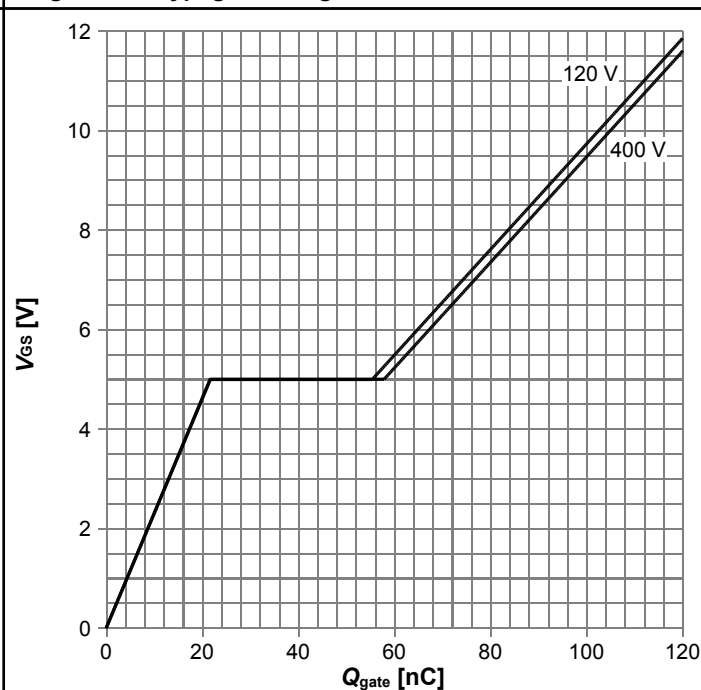

 $V_{GS} = f(Q_{gate}); I_D = 24.9 \text{ A pulsed}; \text{parameter: } V_{DD}$

Diagram 11: Forward characteristics of reverse diode

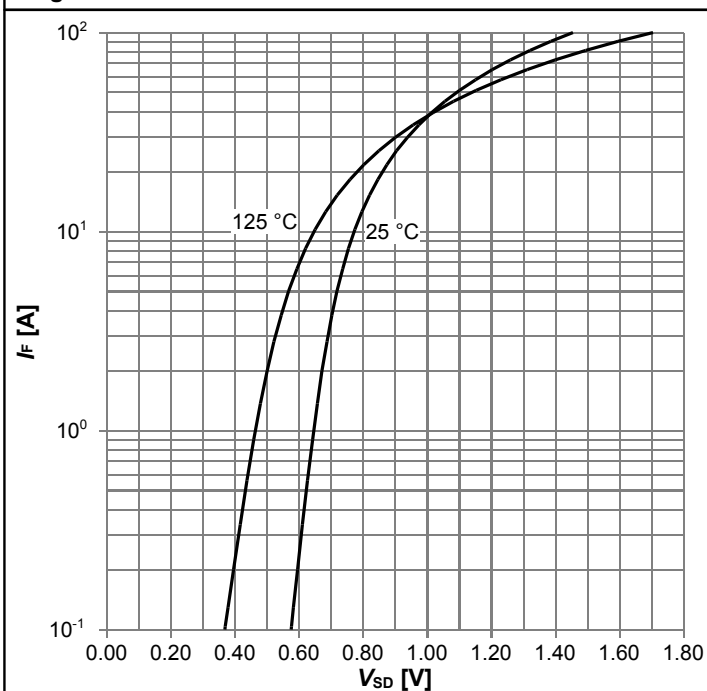

 $I_F = f(V_{SD}); \text{parameter: } T_j$

Diagram 12: Avalanche energy

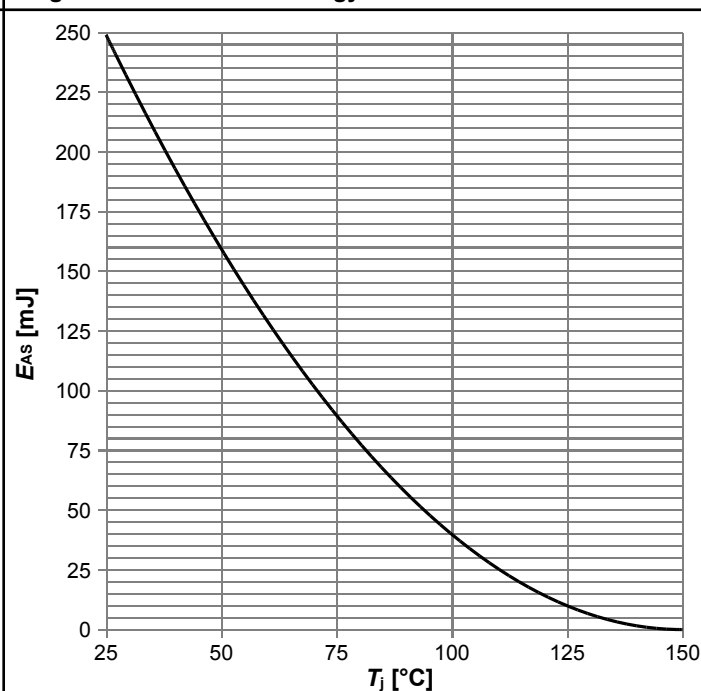
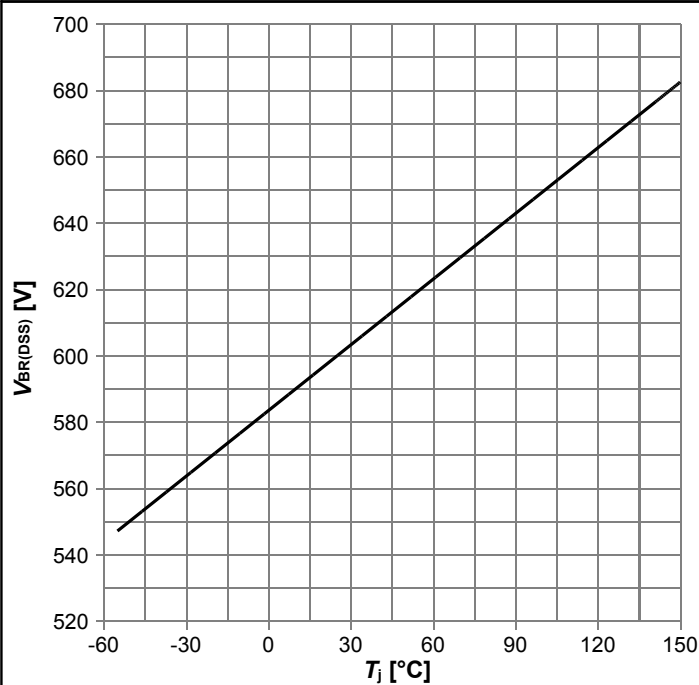
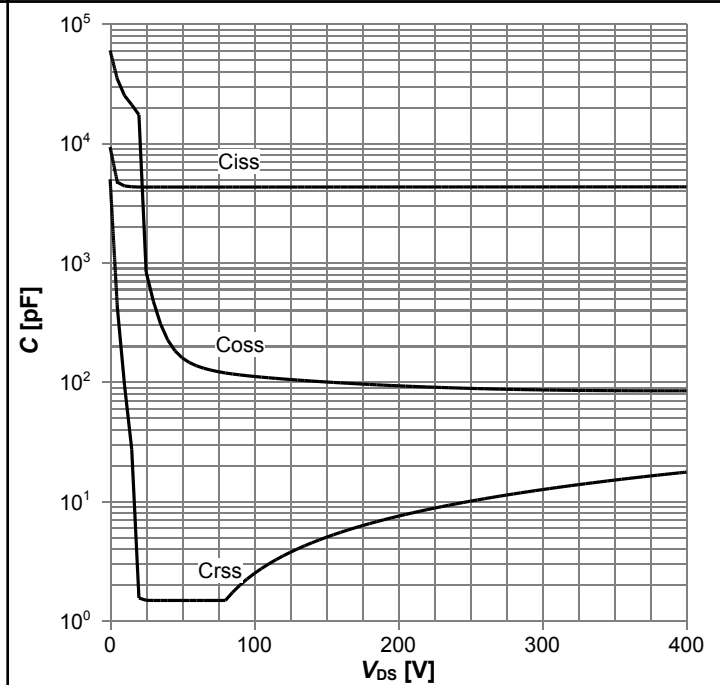

 $E_{AS} = f(T_j); I_D = 7.4 \text{ A}; V_{DD} = 50 \text{ V}$

Diagram 13: Drain-source breakdown voltage



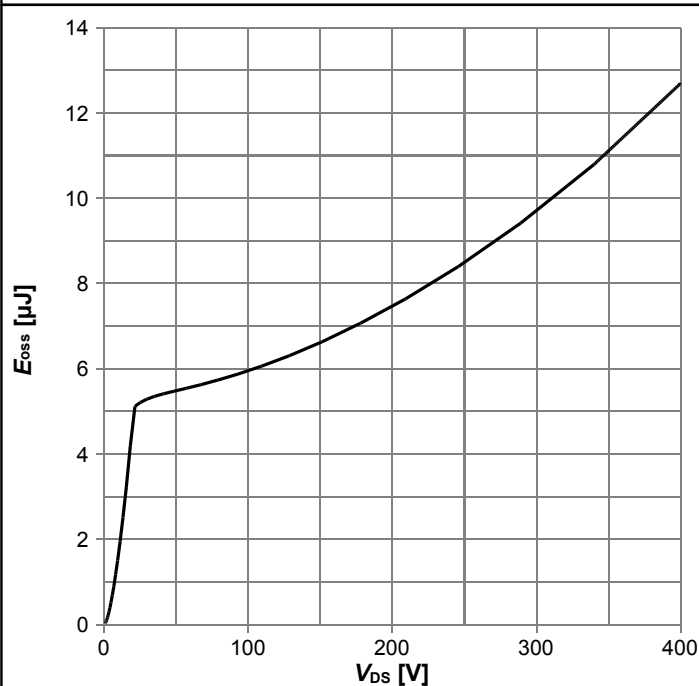
$$V_{BR(DSS)} = f(T_j); I_D = 1 \text{ mA}$$

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

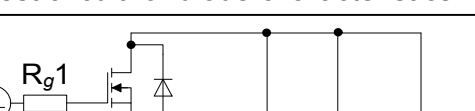
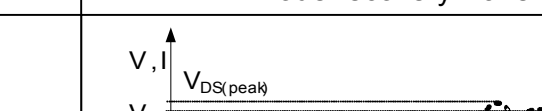
| | |
|---|---|
| <p>Test circuit for diode characteristics</p>  <p>$R_{g1} = R_{g2}$</p> | <p>Diode recovery waveform</p>  <p> $t_{tr} = t_F + t_S$ $Q_{tr} = Q_F + Q_S$ </p> |
|---|---|

Table 9 Switching times

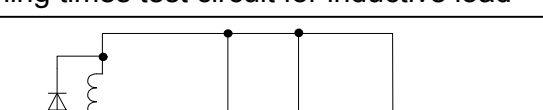
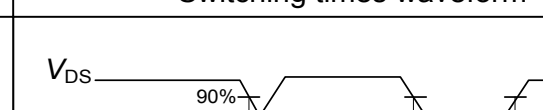
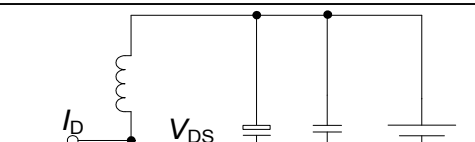

| | |
|--|--|
| <p>Switching times test circuit for inductive load</p>  | <p>Switching times waveform</p>  |
|--|--|

Table 10 **Unclamped inductive load**

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

7 Package Outlines

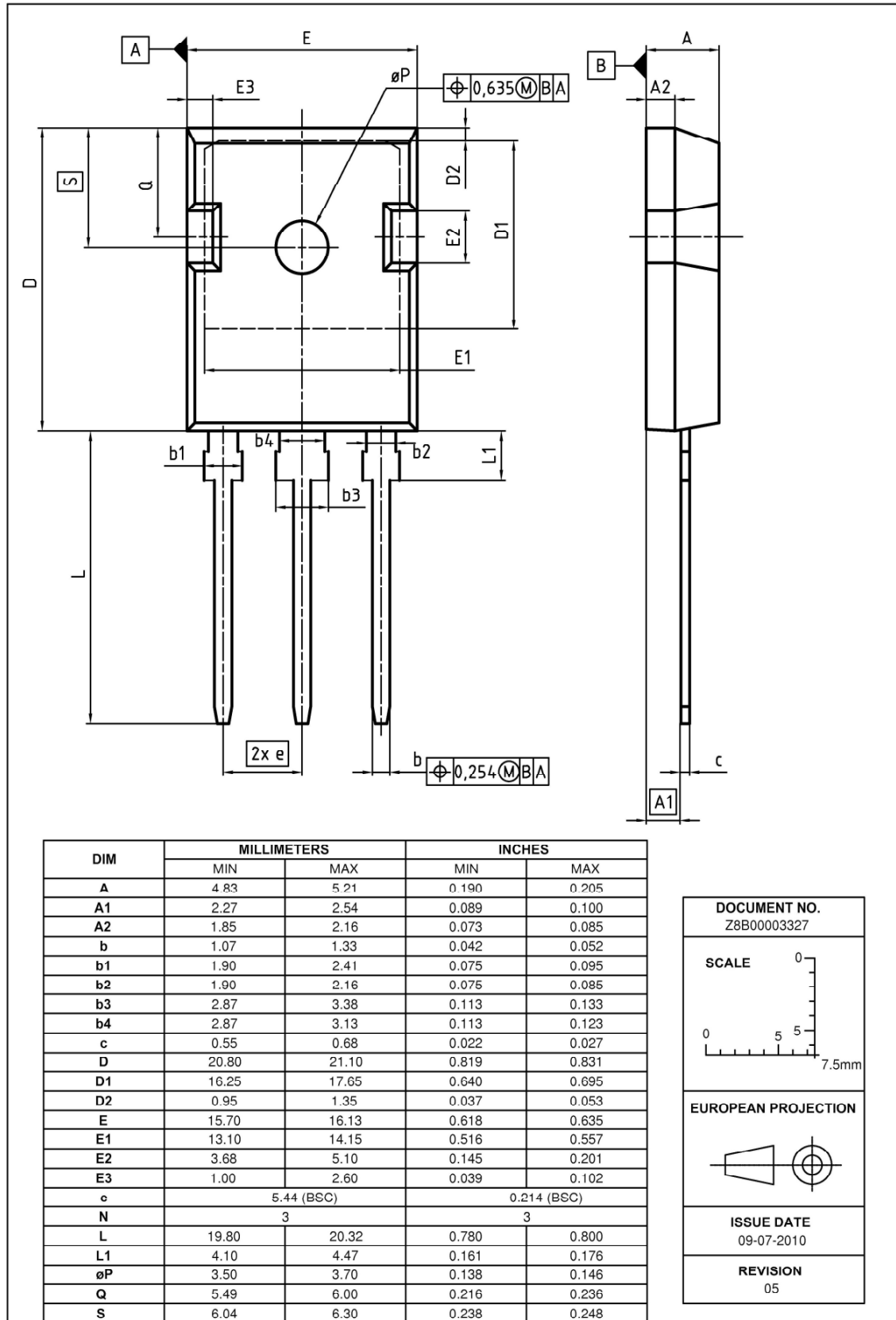


Figure 1 Outline PG-TO 247, dimensions in mm/inches

8 Appendix A

Table 11 Related Links

- IFX CoolMOS™ C7 Webpage: www.infineon.com
- IFX CoolMOS™ C7 application note: www.infineon.com
- IFX CoolMOS™ C7 simulation model: www.infineon.com
- IFX Design tools: www.infineon.com

Revision History

IPW60R040C7

Revision: 2015-05-08, Rev. 2.0

Previous Revision

| Revision | Date | Subjects (major changes since last revision) |
|----------|------------|--|
| 2.0 | 2015-05-08 | Release of final version |

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Published by

Infineon Technologies AG

81726 München, Germany

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