# MOSFET

Metal Oxide Semiconductor Field Effect Transistor

# CoolMOS™ C7

600V CoolMOS™ C7 Power Transistor
IPA60R060C7

## Data Sheet

Rev. 2.0
Final

Power Management & Multimarket

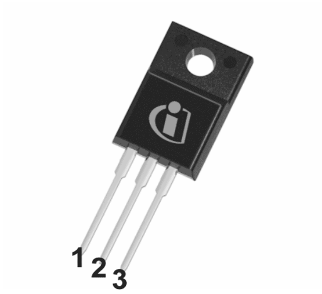
# 1 Description

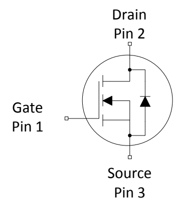
CoolMOS™ C7 is a revolutionary technology for high voltage power MOSFETs, designed according to the superjunction (SJ) principle and pioneered by Infineon Technologies.

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 $R_{DS(on)}$*A below 1Ohm*mm².

TO-220 FP




## 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 $R_{DS(on)}$*$E_{oss}$ and $R_{DS(on)}$*$Q_g$
- 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 Eoss and Qg

## 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 | mΩ |
| $Q_{g.typ}$ | 68 | nC |
| $I_{D,pulse}$ | 135 | A |
| $I_{D,continuous}$ @ $T_j$<150°C | 54 | A |
| $E_{oss}$@400V | 8.1 | µJ |
| Body diode di/dt | 420 | A/µs |

| Type / Ordering Code | Package | Marking | Related Links |
|---|---|---|---|
| IPA60R060C7 | PG-TO 220 FullPAK | 60C7060 | see Appendix A |

## Table of Contents

## 2 Maximum ratings

at $T_j$ = 25°C, unless otherwise specified

### Table 2 Maximum ratings

| Parameter | Symbol | Values | | | Unit | Note / Test Condition |
|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | |
| Continuous drain current[1] | $I_D$ | -<br>- | -<br>- | 16<br>10 | A | $T_C$=25°C<br>$T_C$=100°C |
| Pulsed drain current[2] | $I_{D,pulse}$ | - | - | 135 | A | $T_C$=25°C |
| Avalanche energy, single pulse | $E_{AS}$ | - | - | 159 | mJ | $I_D$=6.4A; $V_{DD}$=50V; see table 10 |
| Avalanche energy, repetitive | $E_{AR}$ | - | - | 0.80 | mJ | $I_D$=6.4A; $V_{DD}$=50V; see table 10 |
| Avalanche current, single pulse | $I_{AS}$ | - | - | 6.4 | A | - |
| MOSFET dv/dt ruggedness | dv/dt | - | - | 120 | V/ns | $V_{DS}$=0...400V |
| Gate source voltage (static) | $V_{GS}$ | -20 | - | 20 | V | static; |
| Gate source voltage (dynamic) | $V_{GS}$ | -30 | - | 30 | V | AC (f>1 Hz) |
| Power dissipation | $P_{tot}$ | - | - | 34 | W | $T_C$=25°C |
| Storage temperature | $T_{stg}$ | -55 | - | 150 | °C | - |
| Operating junction temperature | $T_j$ | -55 | - | 150 | °C | - |
| Mounting torque | - | - | - | 50 | Ncm | M2.5 screws |
| Continuous diode forward current | $I_S$ | - | - | 16 | A | $T_C$=25°C |
| Diode pulse current[2] | $I_{S,pulse}$ | - | - | 135 | A | $T_C$=25°C |
| Reverse diode dv/dt[3] | dv/dt | - | - | 20 | V/ns | $V_{DS}$=0...400V, $I_{SD}$<=9.9A, $T_j$=25°C see table 8 |
| Maximum diode commutation speed | $di_f/dt$ | - | - | 420 | A/µs | $V_{DS}$=0...400V, $I_{SD}$<=9.9A, $T_j$=25°C see table 8 |
| Insulation withstand voltage | $V_{ISO}$ | - | - | 2500 | V | $V_{rms}$, $T_C$=25°C, $t$=1min |

[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 | $R_{thJC}$ | - | - | 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°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 | $I_{DSS}$ | -<br>- | -<br>10 | 1<br>- | µA | $V_{DS}$=600, $V_{GS}$=0V, $T_j$=25°C<br>$V_{DS}$=600, $V_{GS}$=0V, $T_j$=150°C |
| Gate-source leakage current | $I_{GSS}$ | - | - | 100 | nA | $V_{GS}$=20V, $V_{DS}$=0V |
| Drain-source on-state resistance | $R_{DS(on)}$ | -<br>- | 0.052<br>0.115 | 0.060<br>- | Ω | $V_{GS}$=10V, $I_D$=15.9A, $T_j$=25°C<br>$V_{GS}$=10V, $I_D$=15.9A, $T_j$=150°C |
| Gate resistance | $R_G$ | - | 0.8 | - | Ω | $f$=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[1)] | $C_{o(er)}$ | - | 101 | - | pF | $V_{GS}$=0V, $V_{DS}$=0...400V |
| Effective output capacitance, time related[2)] | $C_{o(tr)}$ | - | 1050 | - | pF | $I_D$=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, $R_G$=3.3Ω; see table 9 |
| Rise time | $t_r$ | - | 11 | - | ns | $V_{DD}$=400V, $V_{GS}$=13V, $I_D$=15.9A, $R_G$=3.3Ω; see table 9 |
| Turn-off delay time | $t_{d(off)}$ | - | 79 | - | ns | $V_{DD}$=400V, $V_{GS}$=13V, $I_D$=15.9A, $R_G$=3.3Ω; see table 9 |
| Fall time | $t_f$ | - | 4 | - | ns | $V_{DD}$=400V, $V_{GS}$=13V, $I_D$=15.9A, $R_G$=3.3Ω; see table 9 |

## Table 6 Gate charge characteristics

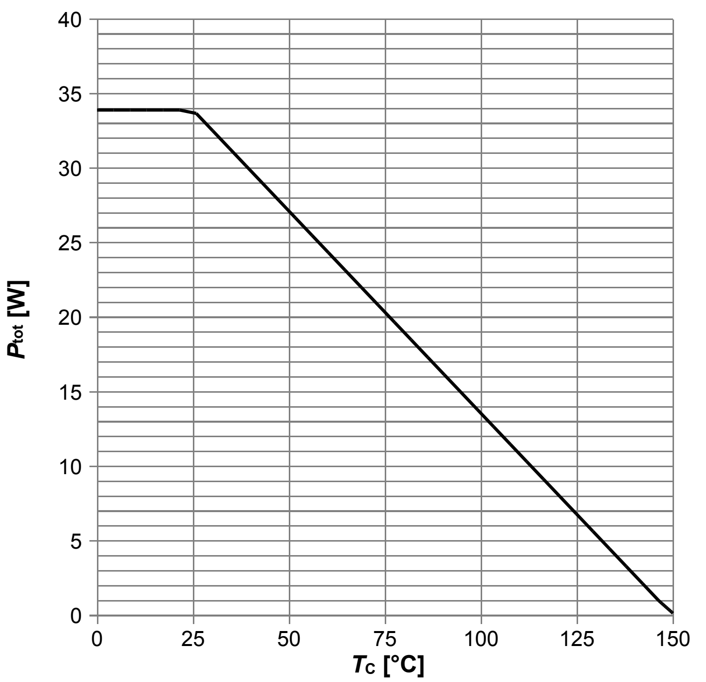
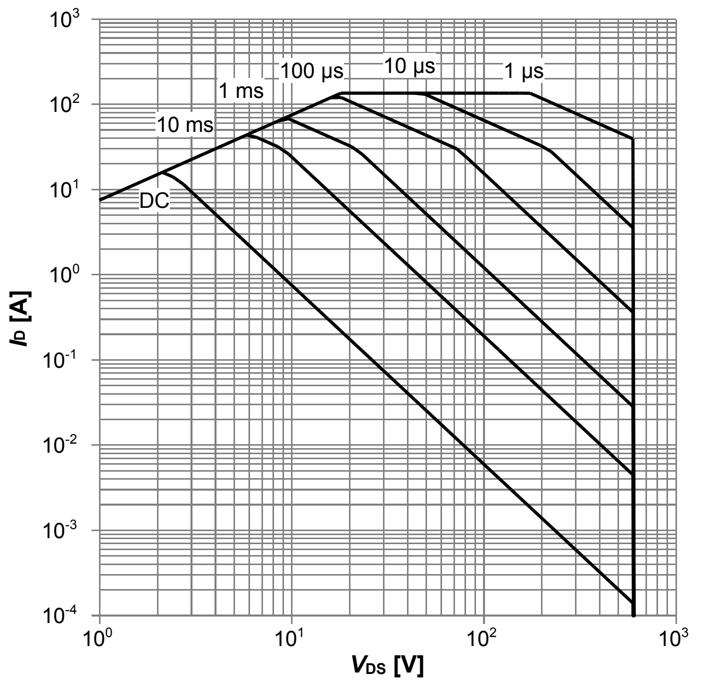
| Parameter | Symbol | Values | | | Unit | Note / Test Condition |
|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | |
| Gate to source charge | $Q_{gs}$ | - | 14 | - | nC | $V_{DD}$=400V, $I_D$=15.9A, $V_{GS}$=0 to 10V |
| Gate to drain charge | $Q_{gd}$ | - | 23 | - | nC | $V_{DD}$=400V, $I_D$=15.9A,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

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, $I_F$=15.9A, $T_j$=25°C |
| Reverse recovery time | $t_{rr}$ | - | 390 | - | ns | $V_R$=400V, $I_F$=15.9A, $di_F/dt$=100A/µs; see table 8 |
| Reverse recovery charge | $Q_{rr}$ | - | 6 | - | µC | $V_R$=400V, $I_F$=15.9A, $di_F/dt$=100A/µs; see table 8 |
| Peak reverse recovery current | $I_{rrm}$ | - | 32 | - | A | $V_R$=400V, $I_F$=15.9A, $di_F/dt$=100A/µs; see table 8 |

# 5 Electrical characteristics diagrams

| **Diagram 1: Power dissipation** | **Diagram 2: Safe operating area** |
|---|---|
|  |  |
| $P_{tot}$=f($T_C$) | $I_D$=f($V_{DS}$); $T_C$=25 °C; $D$=0; parameter: $t_p$ |

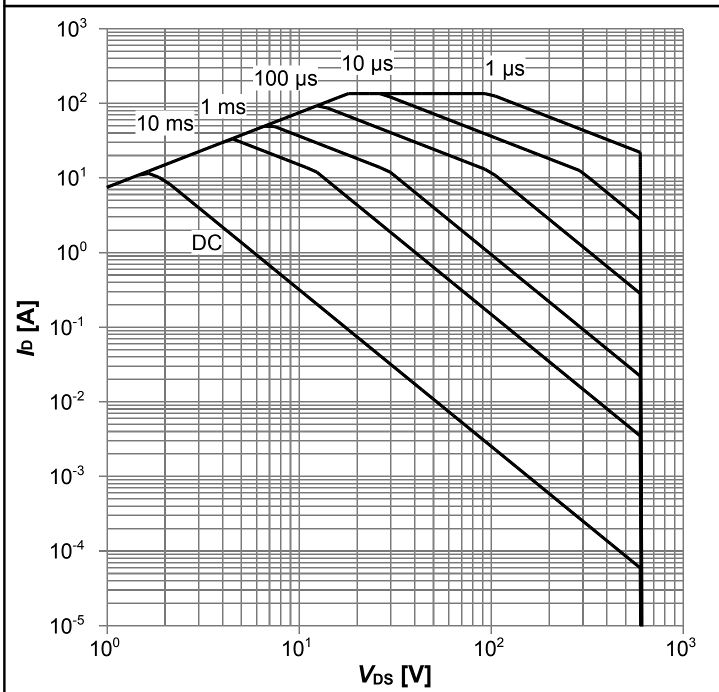
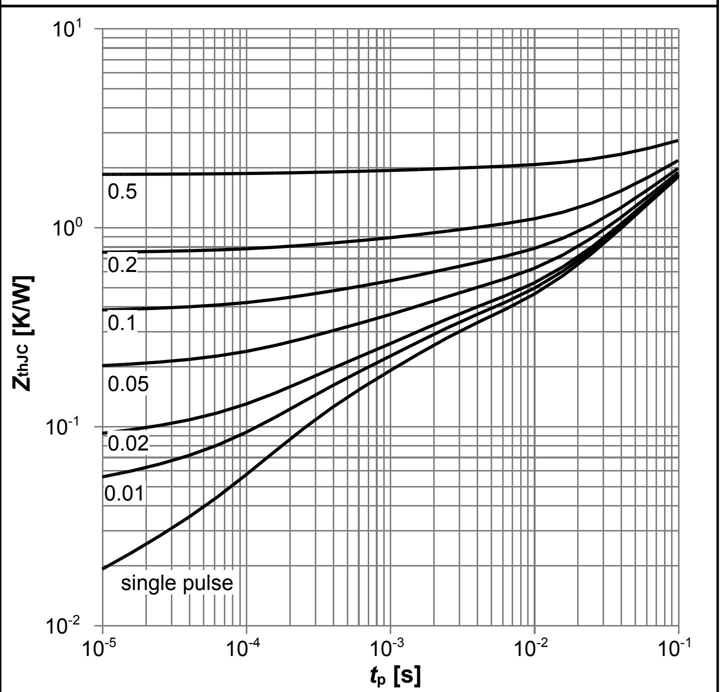
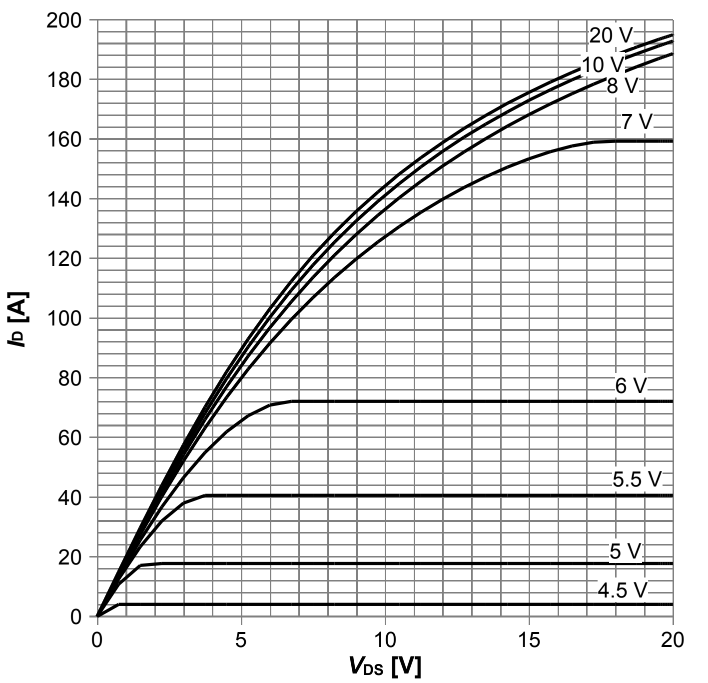
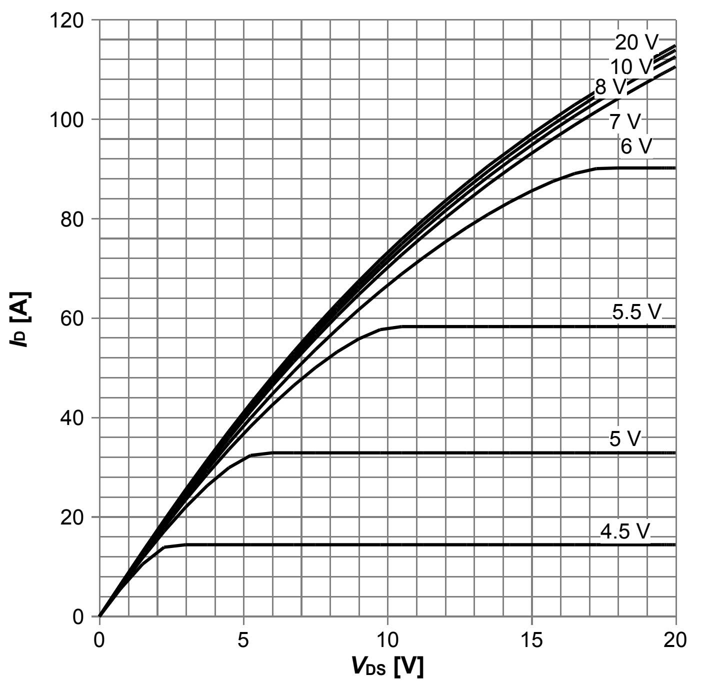
| **Diagram 3: Safe operating area** | **Diagram 4: Max. transient thermal impedance** |
|---|---|
|  |  |
| $I_D$=f($V_{DS}$); $T_C$=80 °C; $D$=0; parameter: $t_p$ | $Z_{thJC}$ =f($t_P$); parameter: $D$=$t_p$/$T$ |

**Diagram 5: Typ. output characteristics**



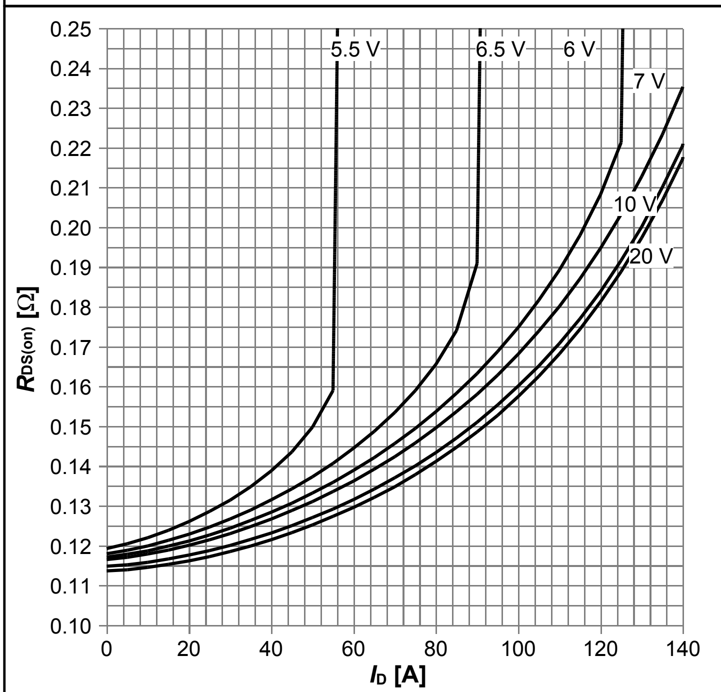

$I_D$=f($V_{DS}$); $T_j$=25 °C; parameter: $V_{GS}$

**Diagram 6: Typ. output characteristics**



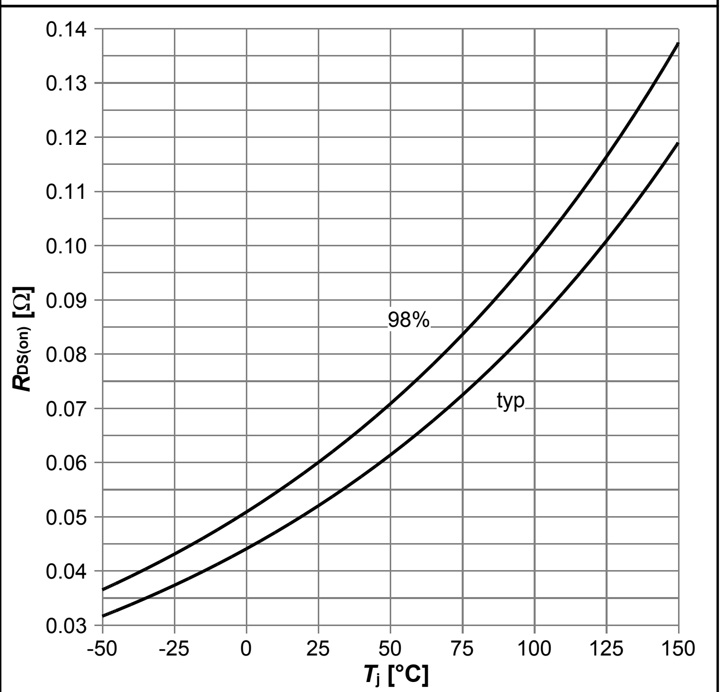

$I_D$=f($V_{DS}$); $T_j$=125 °C; parameter: $V_{GS}$

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



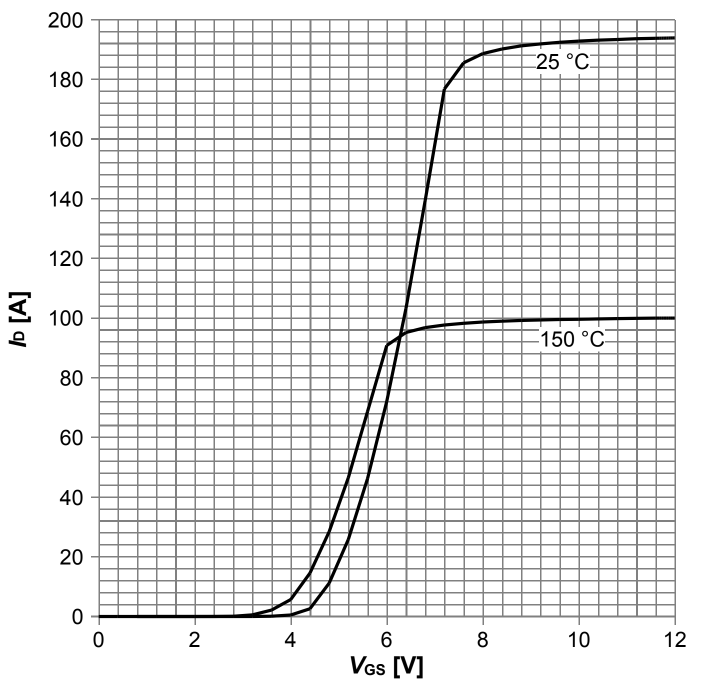

$R_{DS(on)}$=f($I_D$); $T_j$=125 °C; parameter: $V_{GS}$

**Diagram 8: Drain-source on-state resistance**



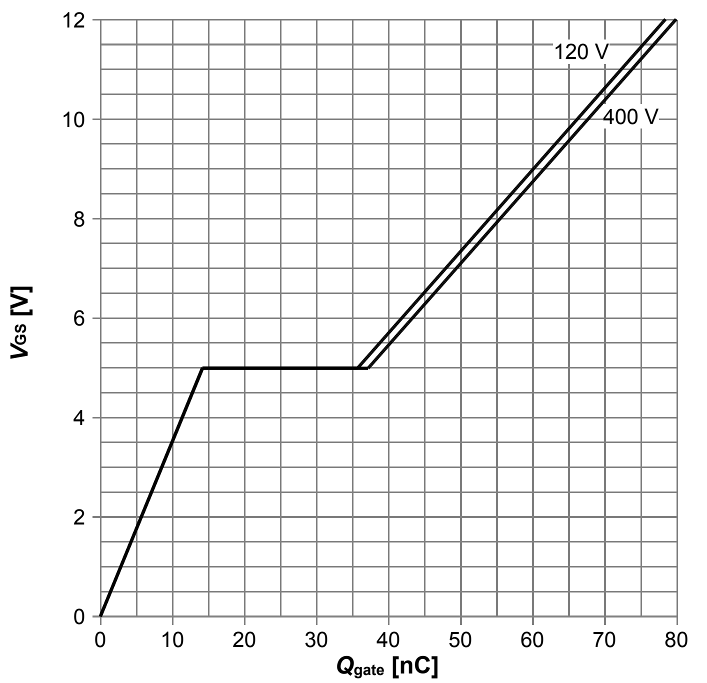

$R_{DS(on)}$=f($T_j$); $I_D$=15.9 A; $V_{GS}$=10 V

**Diagram 9: Typ. transfer characteristics**



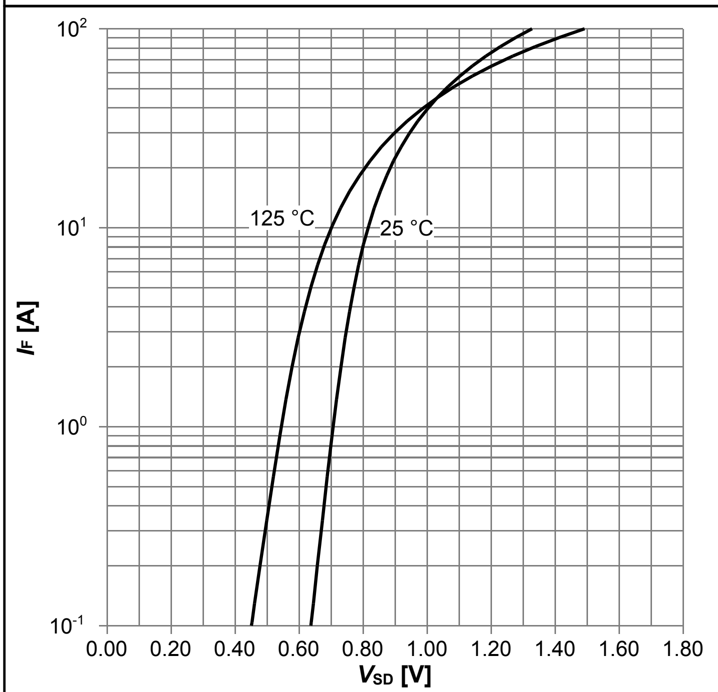

$I_D$=f($V_{GS}$); $V_{DS}$=20V; parameter: $T_j$

**Diagram 10: Typ. gate charge**



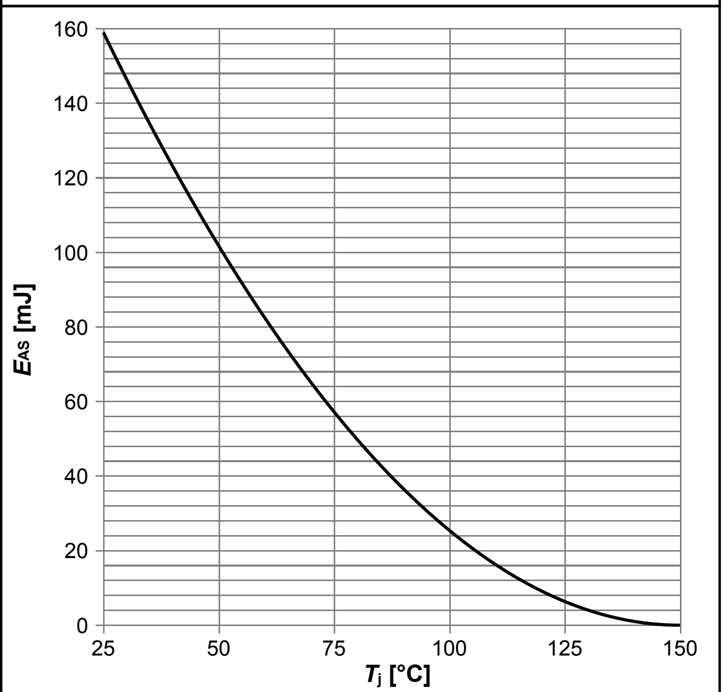

$V_{GS}$=f($Q_{gate}$); $I_D$=15.9 A pulsed; parameter: $V_{DD}$

**Diagram 11: Forward characteristics of reverse diode**



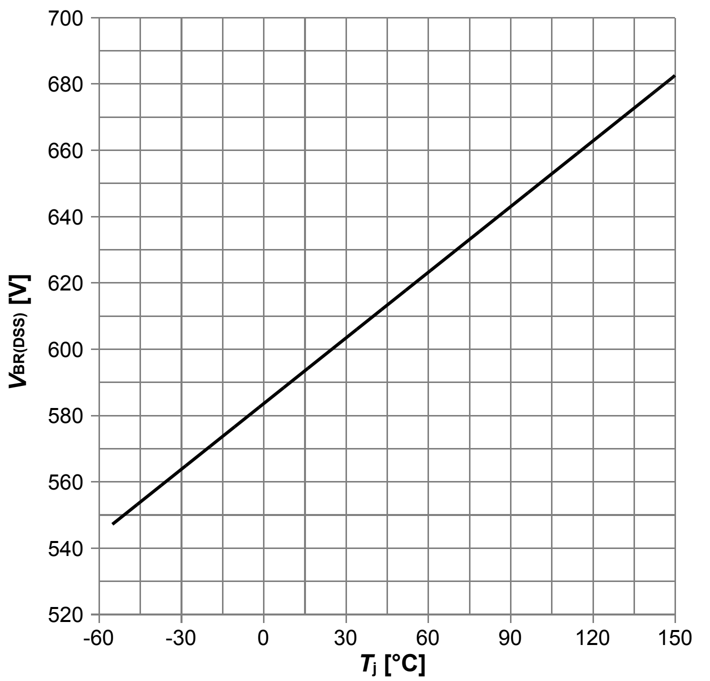

$I_F$=f($V_{SD}$); parameter: $T_j$

**Diagram 12: Avalanche energy**



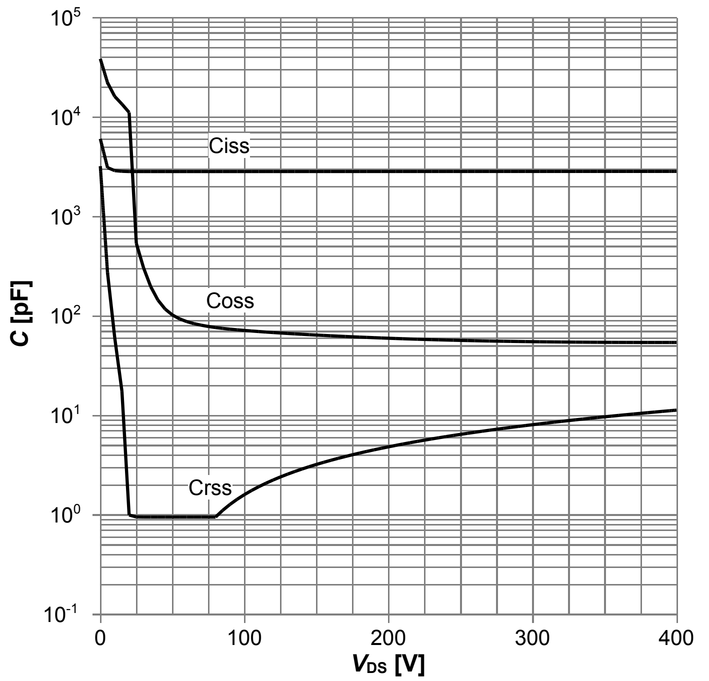

$E_{AS}$=f($T_j$); $I_D$=6.4 A; $V_{DD}$=50 V

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



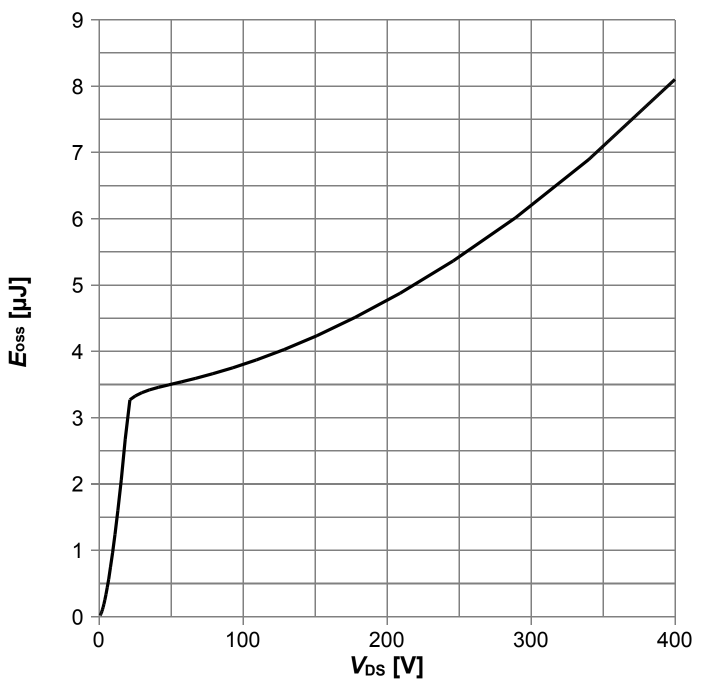

$V_{BR(DSS)}$=f($T_j$); $I_D$=1 mA

**Diagram 14: Typ. capacitances**




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

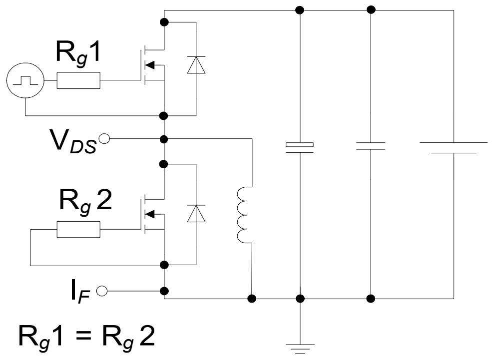
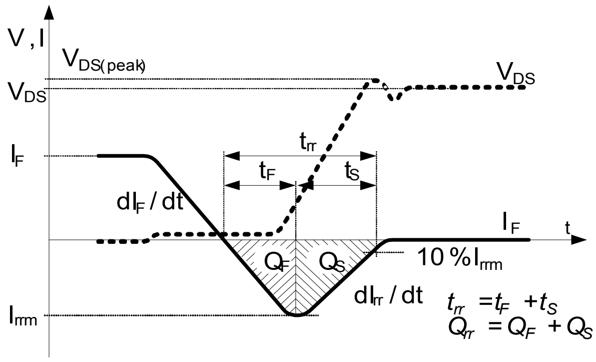
**Diagram 15: Typ. Coss stored energy**



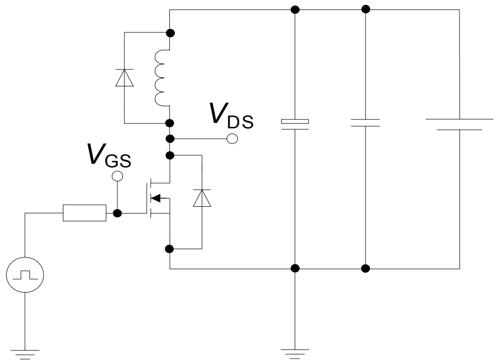
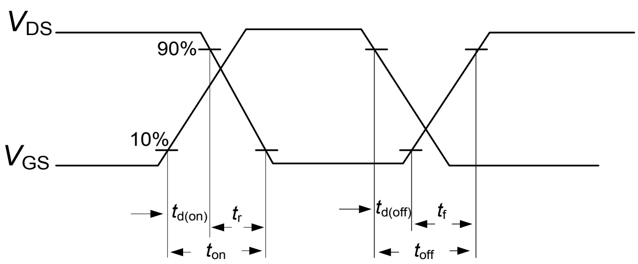

$E_{oss}$=f($V_{DS}$)

# 6 Test Circuits

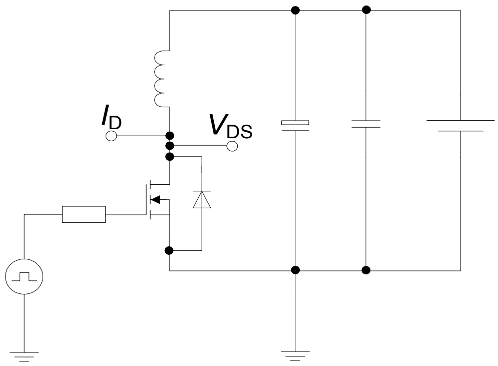
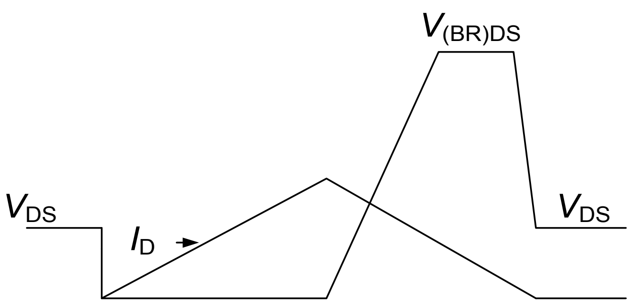
## Table 8 Diode characteristics

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

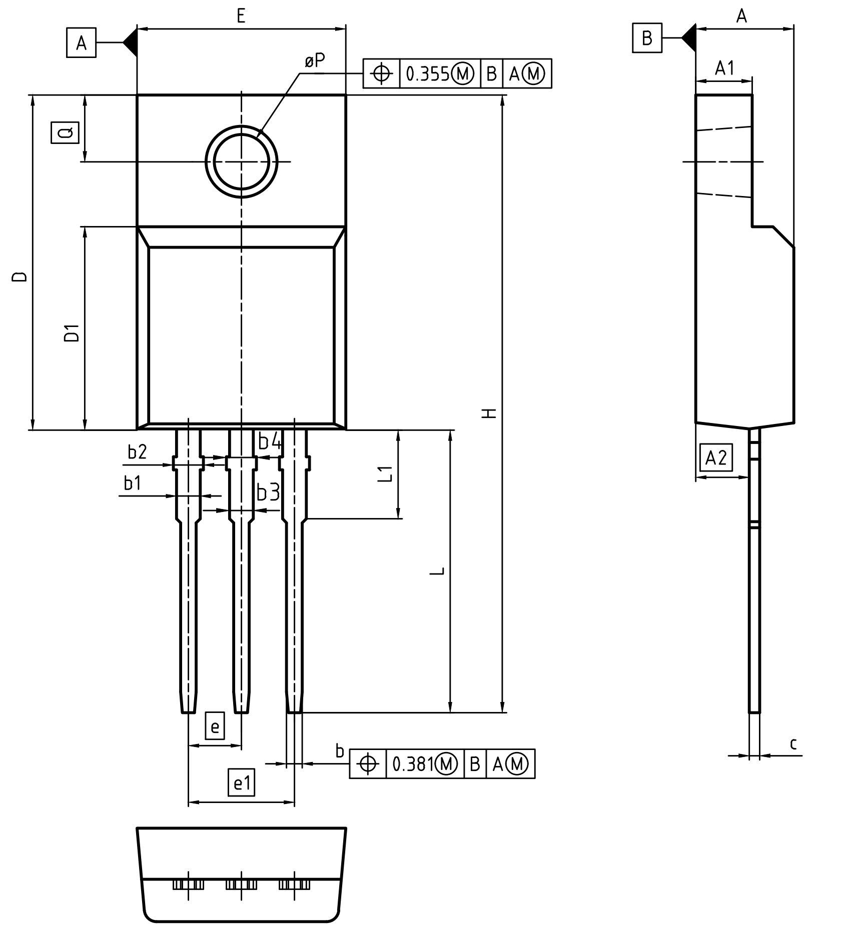
## Table 9 Switching times

| 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 |

| | |
|---|---|
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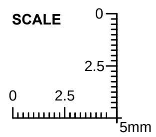
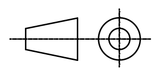
| SCALE |  |
| EUROPEAN PROJECTION |  |
| ISSUE DATE | 24-10-2014 |
| REVISION | 05 |



**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
- **IFX CoolMOS™ C7 application note:** www.infineon.com
- **IFX CoolMOS™ C7 simulation model:** www.infineon.com
- **IFX Design tools:** 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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**Вы можете приобрести в компании MosChip.**

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http://moschip.ru/get-element

Вы можете разместить у нас заказ для любого Вашего проекта, будь то серийное производство или разработка единичного прибора.

В нашем ассортименте представлены ведущие мировые производители активных и пассивных электронных компонентов.

Нашей специализацией является поставка электронной компонентной базы двойного назначения, продукции таких производителей как XILINX, Intel (ex.ALTERA), Vicor, Microchip, Texas Instruments, Analog Devices, Mini-Circuits, Amphenol, Glenair.

Сотрудничество с глобальными дистрибьюторами электронных компонентов, предоставляет возможность заказывать и получать с международных складов практически любой перечень компонентов в оптимальные для Вас сроки.

На всех этапах разработки и производства наши партнеры могут получить квалифицированную поддержку опытных инженеров.

Система менеджмента качества компании отвечает требованиям в соответствии с ГОСТ Р ИСО 9001, ГОСТ РВ 0015-002 и ЭС РД 009

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