# MOSFET
Metal Oxide Semiconductor Field Effect Transistor

# CoolMOS™ P6
600V CoolMOS™ P6 Power Transistor
IPx60R125P6

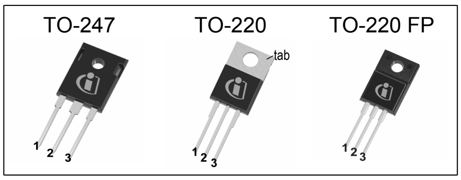
## Data Sheet

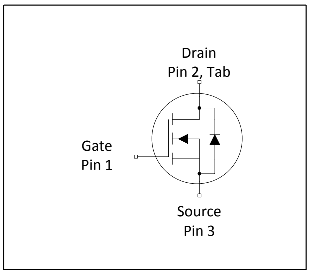
Rev. 2.0
Final

Power Management & Multimarket

# 1 Description

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 Rdson*Qg and Eoss
- 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)

## 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.

*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 |
| $R_{DS(on),max}$ | 125 | mΩ |
| $Q_{g.typ}$ | 56 | nC |
| $I_{D,pulse}$ | 87 | A |
| $E_{oss}$@400V | 7.2 | µJ |
| Body diode di/dt | 300 | A/µs |

| Type / Ordering Code | Package | Marking | Related Links |
|---|---|---|---|
| IPW60R125P6 | PG-TO 247 | 6R125P6 | see Appendix A |
| IPP60R125P6 | PG-TO 220 | | |
| IPA60R125P6 | PG-TO 220 FullPAK | | |

## 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>- | 30.0<br>19.0 | A | $T_C$=25°C<br>$T_C$=100°C |
| Pulsed drain current [2] | $I_{D,pulse}$ | - | - | 87 | A | $T_C$=25°C |
| Avalanche energy, single pulse | $E_{AS}$ | - | - | 636 | mJ | $I_D$=5.2A; $V_{DD}$=50V; see table 10 |
| Avalanche energy, repetitive | $E_{AR}$ | - | - | 0.96 | mJ | $I_D$=5.2A; $V_{DD}$=50V; see table 10 |
| Avalanche current, repetitive | $I_{AR}$ | - | - | 5.2 | A | - |
| MOSFET dv/dt ruggedness | dv/dt | - | - | 100 | 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 (Non FullPAK)<br>TO-220, TO-247 | $P_{tot}$ | - | - | 219 | W | $T_C$=25°C |
| Power dissipation (FullPAK)<br>TO-220FP | $P_{tot}$ | - | - | 34 | W | $T_C$=25°C |
| Storage temperature | $T_{stg}$ | -55 | - | 150 | °C | - |
| Operating junction temperature | $T_j$ | -55 | - | 150 | °C | - |
| Mounting torque (Non FullPAK)<br>TO-220, TO-247 | - | - | - | 60 | Ncm | M3 and M3.5 screws |
| Mounting torque (FullPAK)<br>TO-220FP | - | - | - | 50 | Ncm | M2.5 screws |
| Continuous diode forward current | $I_S$ | - | - | 26.0 | A | $T_C$=25°C |
| Diode pulse current [2] | $I_{S,pulse}$ | - | - | 87 | A | $T_C$=25°C |
| Reverse diode dv/dt [3] | dv/dt | - | - | 15 | V/ns | $V_{DS}$=0...400V, $I_{SD}$<=$I_S$, $T_j$=25°C<br>see table 8 |
| Maximum diode commutation speed | $di_f/dt$ | - | - | 300 | A/µs | $V_{DS}$=0...400V, $I_{SD}$<=$I_S$, $T_j$=25°C<br>see table 8 |
| Insulation withstand voltage for<br>TO-220FP | $V_{ISO}$ | - | - | 2500 | V | $V_{rms}$, $T_C$=25°C, $t$=1min |

[1] Limited by $T_{j\,max}$. Maximum duty cycle D=0.75
[2] Pulse width $t_p$ limited by $T_{j,max}$
[3] Identical low side and high side switch with identical $R_G$

## 3 Thermal characteristics

**Table 3 Thermal characteristics (Non FullPAK) TO-220, TO-247**

| Parameter | Symbol | Values | | | Unit | Note / Test Condition |
|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | |
| Thermal resistance, junction - case | $R_{thJC}$ | - | - | 0.57 | °C/W | - |
| Thermal resistance, junction - ambient | $R_{thJA}$ | - | - | 62 | °C/W | leaded |
| Soldering temperature, wavesoldering only allowed at leads | $T_{sold}$ | - | - | 260 | °C | 1.6mm (0.063 in.) from case for 10s |

**Table 4 Thermal characteristics (FullPAK) TO-220FP**

| Parameter | Symbol | Values | | | Unit | Note / Test Condition |
|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | |
| Thermal resistance, junction - case | $R_{thJC}$ | - | - | 3.65 | °C/W | - |
| Thermal resistance, junction - ambient | $R_{thJA}$ | - | - | 80 | °C/W | leaded |
| 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 5 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 | $V_{DS}$=$V_{GS}$, $I_D$=0.96mA |
| Zero gate voltage drain current | $I_{DSS}$ | -<br>- | -<br>10 | 2<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>- | 0.113<br>0.293 | 0.125<br>- | Ω | $V_{GS}$=10V, $I_D$=11.6A, $T_j$=25°C<br>$V_{GS}$=10V, $I_D$=11.6A, $T_j$=150°C |
| Gate resistance | $R_G$ | - | 1.7 | - | Ω | $f$=1MHz, open drain |

## Table 6 Dynamic characteristics

| Parameter | Symbol | Values | | | Unit | Note / Test Condition |
|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | |
| Input capacitance | $C_{iss}$ | - | 2660 | - | pF | $V_{GS}$=0V, $V_{DS}$=100V, $f$=1MHz |
| Output capacitance | $C_{oss}$ | - | 110 | - | pF | $V_{GS}$=0V, $V_{DS}$=100V, $f$=1MHz |
| Effective output capacitance, energy related [1] | $C_{o(er)}$ | - | 90 | - | pF | $V_{GS}$=0V, $V_{DS}$=0...400V |
| Effective output capacitance, time related [2] | $C_{o(tr)}$ | - | 398 | - | pF | $I_D$=constant, $V_{GS}$=0V, $V_{DS}$=0...400V |
| Turn-on delay time | $t_{d(on)}$ | - | 14 | - | ns | $V_{DD}$=400V, $V_{GS}$=13V, $I_D$=14.5A, $R_G$=1.7Ω; see table 9 |
| Rise time | $t_r$ | - | 9 | - | ns | $V_{DD}$=400V, $V_{GS}$=13V, $I_D$=14.5A, $R_G$=1.7Ω; see table 9 |
| Turn-off delay time | $t_{d(off)}$ | - | 44 | - | ns | $V_{DD}$=400V, $V_{GS}$=13V, $I_D$=14.5A, $R_G$=1.7Ω; see table 9 |
| Fall time | $t_f$ | - | 5 | - | ns | $V_{DD}$=400V, $V_{GS}$=13 V, $I_D$=14.5A, $R_G$=1.7Ω; see table 9 |

## Table 7 Gate charge characteristics

| Parameter | Symbol | Values | | | Unit | Note / Test Condition |
|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | |
| Gate to source charge | $Q_{gs}$ | - | 16 | - | nC | $V_{DD}$=400V, $I_D$=14.5A, $V_{GS}$=0 to 10V |
| Gate to drain charge | $Q_{gd}$ | - | 20 | - | nC | $V_{DD}$=400V, $I_D$=14.5A, $V_{GS}$=0 to 10V |
| Gate charge total | $Q_g$ | - | 56 | - | nC | $V_{DD}$=400V, $I_D$=14.5A, $V_{GS}$=0 to 10V |
| Gate plateau voltage | $V_{plateau}$ | - | 6.1 | - | V | $V_{DD}$=400V, $I_D$=14.5A, $V_{GS}$=0 to 10V |

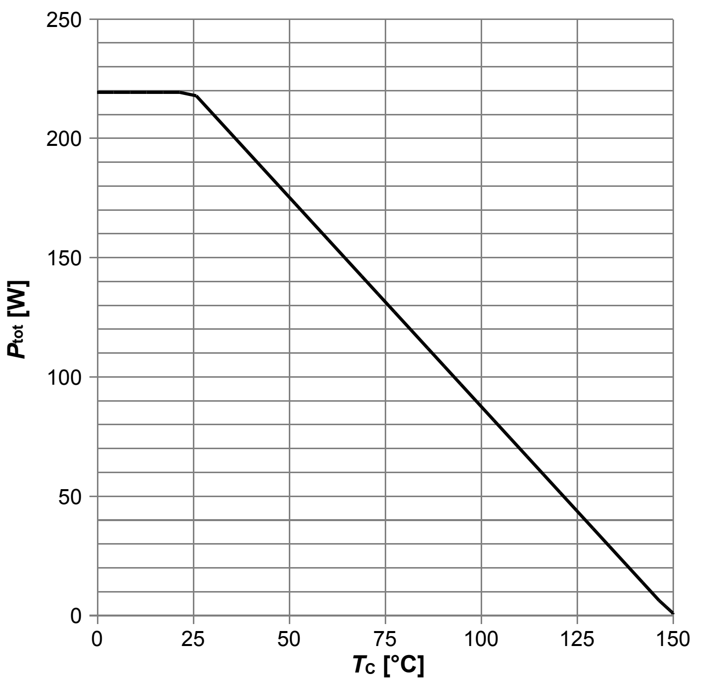
[1] $C_{o(er)}$ is a fixed capacitance that gives the same stored energy as $C_{oss}$ while $V_{DS}$ is rising from 0 to 400V
[2] $C_{o(tr)}$ is a fixed capacitance that gives the same charging time as $C_{oss}$ while $V_{DS}$ is rising from 0 to 400V

**Table 8 Reverse diode characteristics**

| Parameter | Symbol | Values | | | Unit | Note / Test Condition |
|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | |
| Diode forward voltage | $V_{SD}$ | - | 0.9 | - | V | $V_{GS}$=0V, $I_F$=14.5A, $T_j$=25°C |
| Reverse recovery time | $t_{rr}$ | - | 385 | - | ns | $V_R$=400V, $I_F$=14.5A, $di_F/dt$=100A/µs; see table 8 |
| Reverse recovery charge | $Q_{rr}$ | - | 7 | - | µC | $V_R$=400V, $I_F$=14.5A, $di_F/dt$=100A/µs; see table 8 |
| Peak reverse recovery current | $I_{rrm}$ | - | 32 | - | A | $V_R$=400V, $I_F$=14.5A, $di_F/dt$=100A/µs; see table 8 |

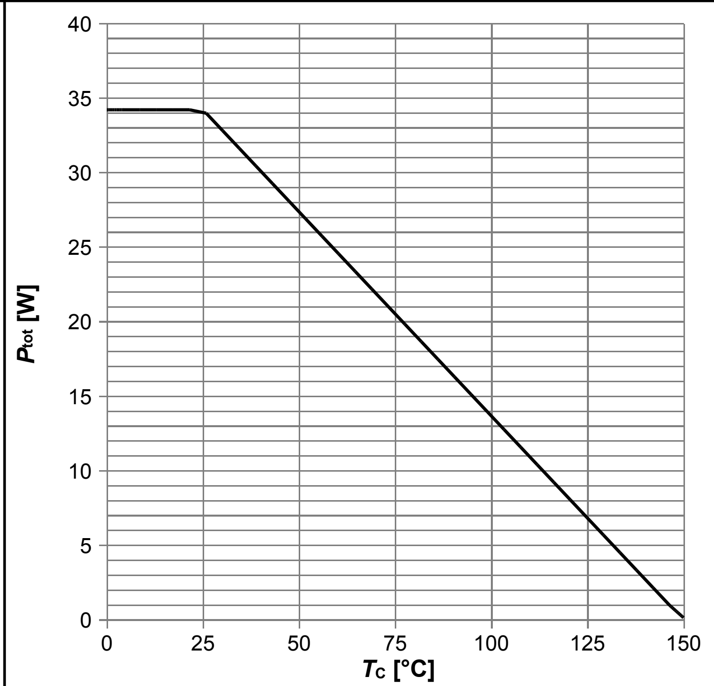
# 5 Electrical characteristics diagrams

**Diagram 1: Power dissipation (Non FullPAK)**



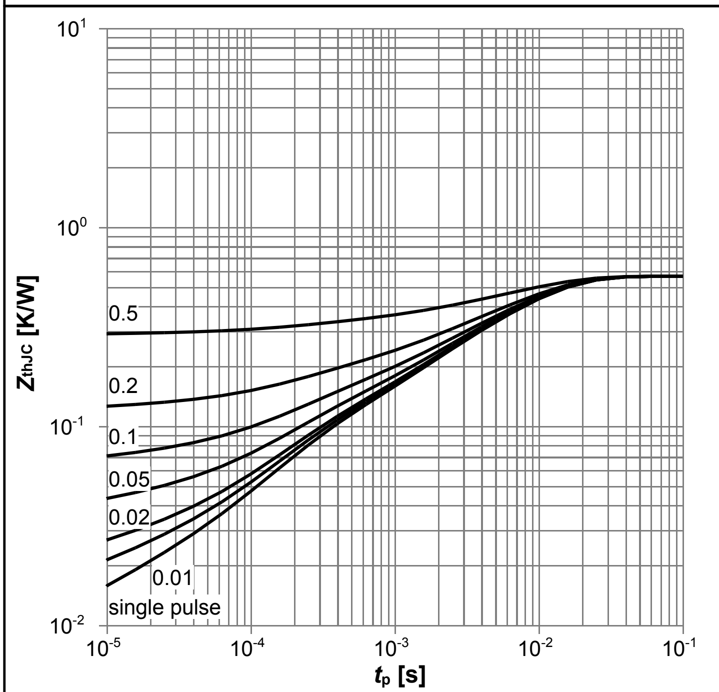

$P_{tot}$=f($T_C$)

**Diagram 2: Power dissipation (FullPAK)**



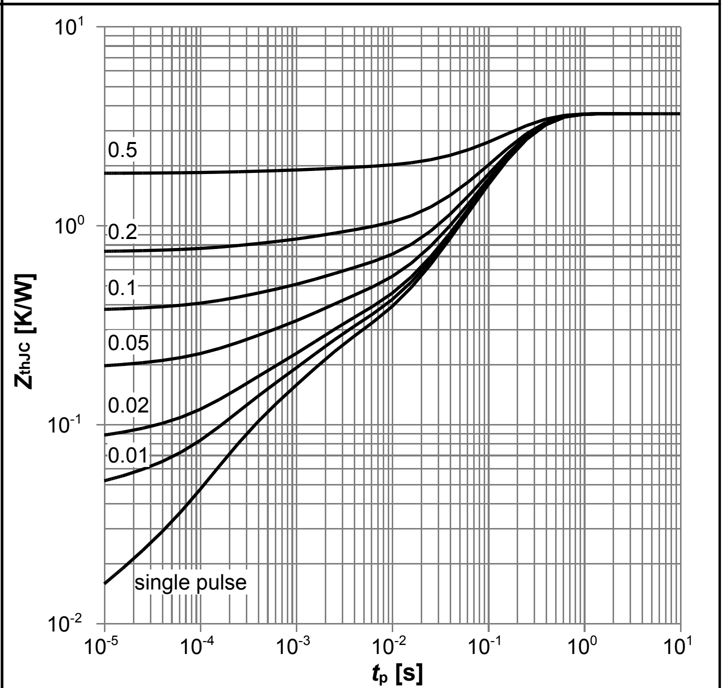

$P_{tot}$=f($T_C$)

**Diagram 3: Max. transient thermal impedance (Non FullPAK)**



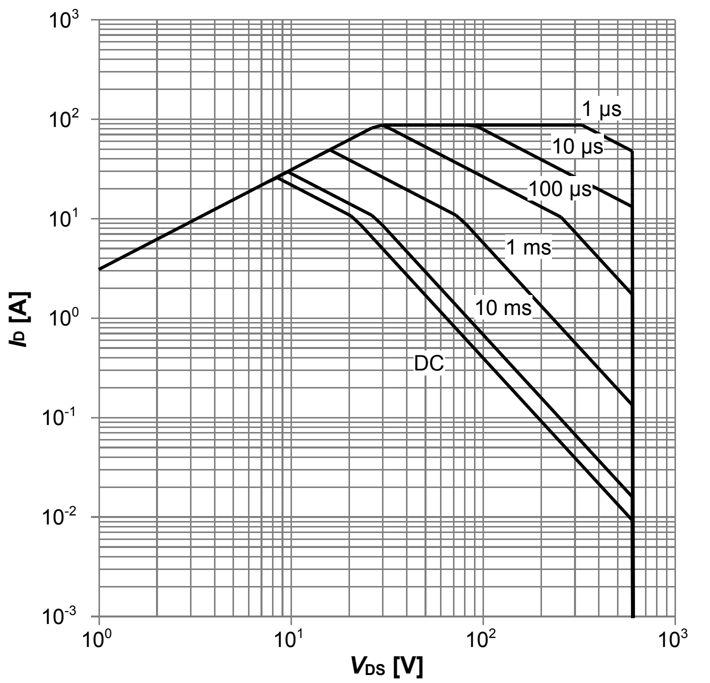

$Z_{thJC}$ =f($t_P$); parameter: $D$=$t_p$/$T$

**Diagram 4: Max. transient thermal impedance (FullPAK)**



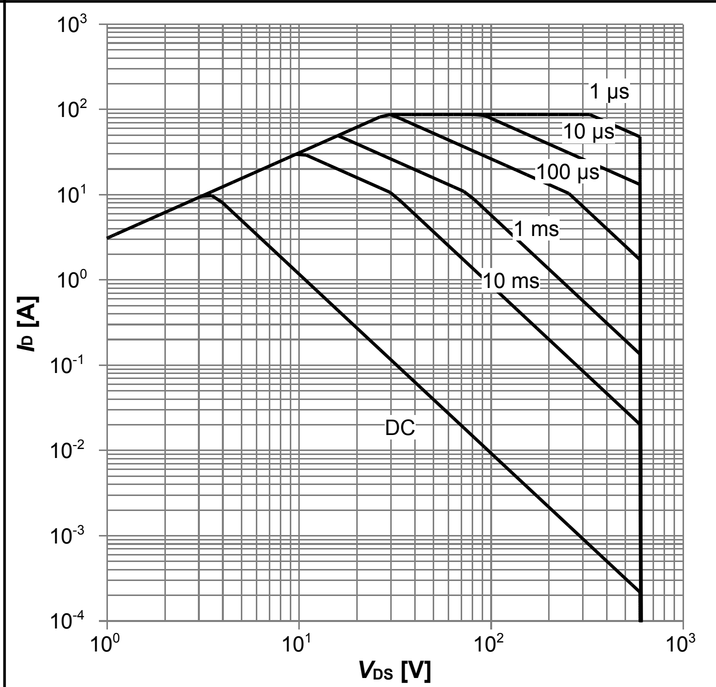

$Z_{thJC}$ =f($t_P$); parameter: $D$=$t_p$/$T$

**Diagram 5: Safe operating area (Non FullPAK)**



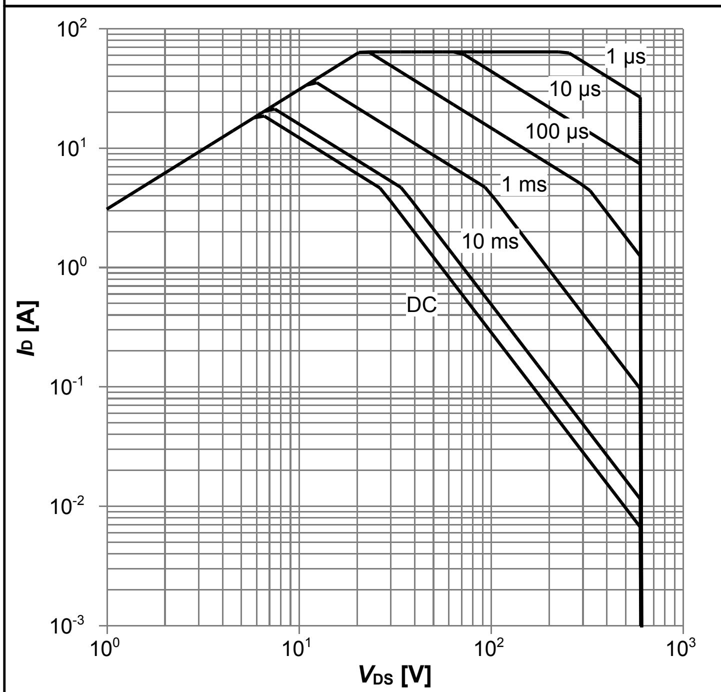

$I_D$=f($V_{DS}$); $T_C$=25 °C; $D$=0; parameter: $t_p$

**Diagram 6: Safe operating area (FullPAK)**



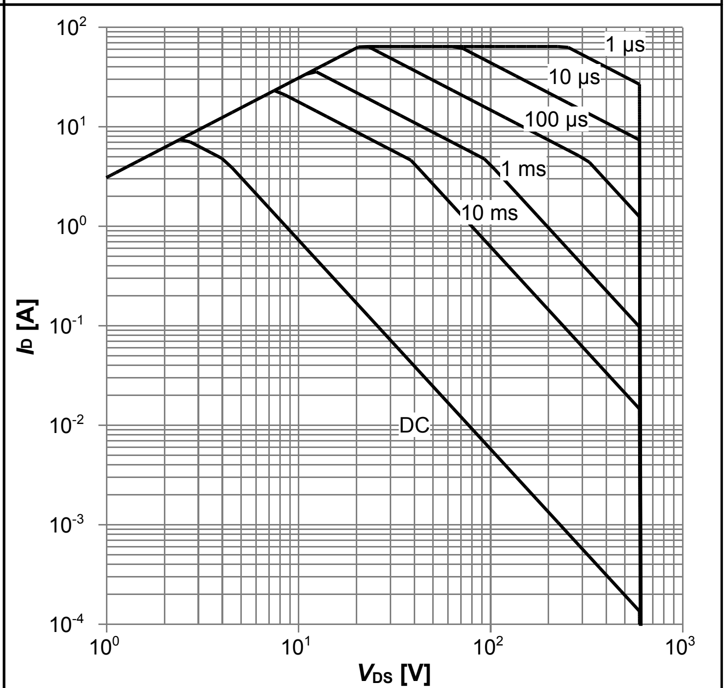

$I_D$=f($V_{DS}$); $T_C$=25 °C; $D$=0; parameter: $t_p$

**Diagram 7: Safe operating area (Non FullPAK)**



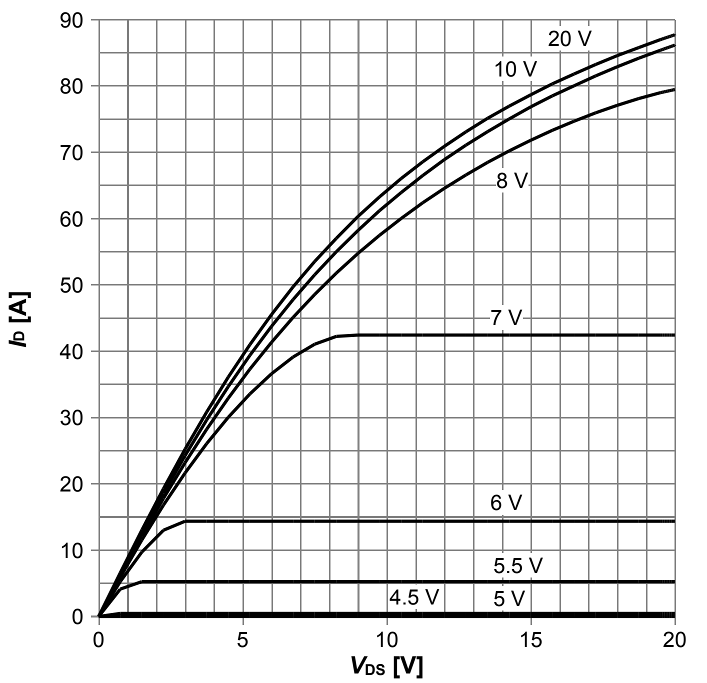

$I_D$=f($V_{DS}$); $T_C$=80 °C; $D$=0; parameter: $t_p$

**Diagram 8: Safe operating area (FullPAK)**



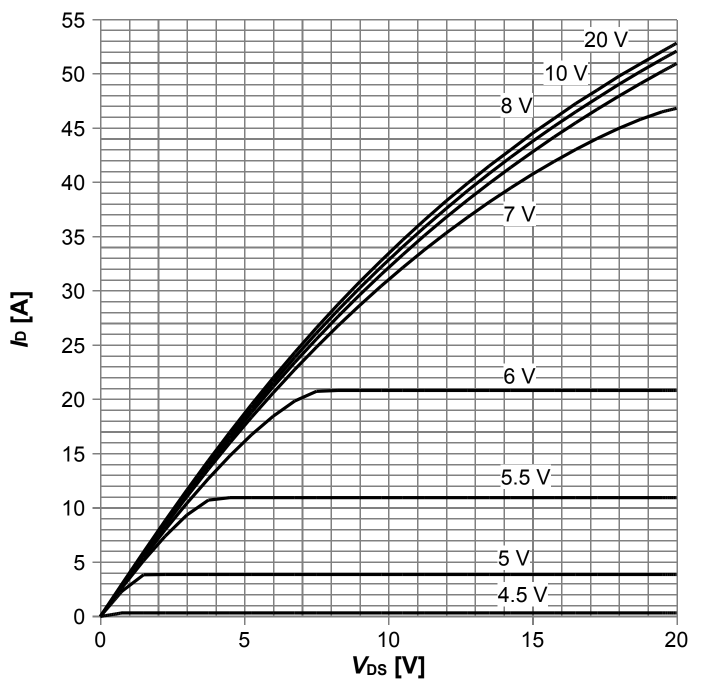

$I_D$=f($V_{DS}$); $T_C$=80 °C; $D$=0; parameter: $t_p$

**Diagram 9: Typ. output characteristics**



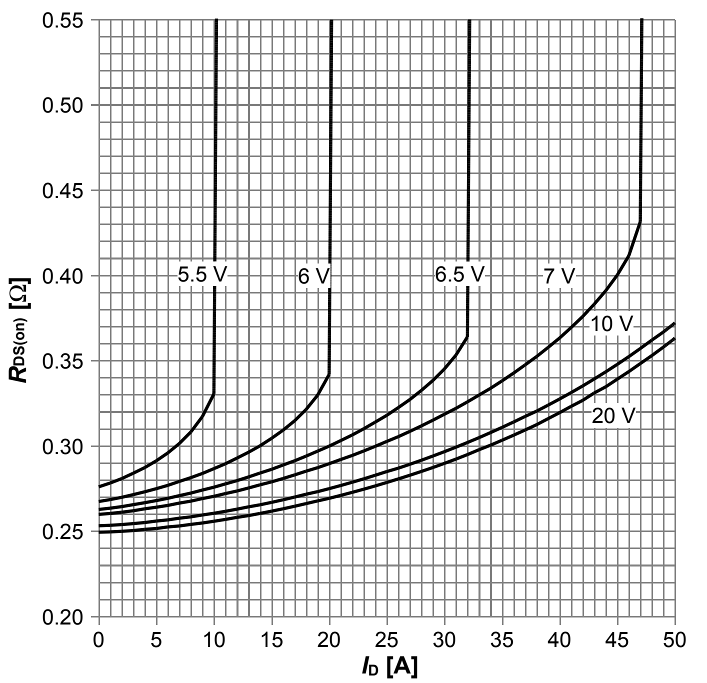

$I_D$=f($V_{DS}$); $T_j$=25 °C; parameter: $V_{GS}$

**Diagram 10: Typ. output characteristics**



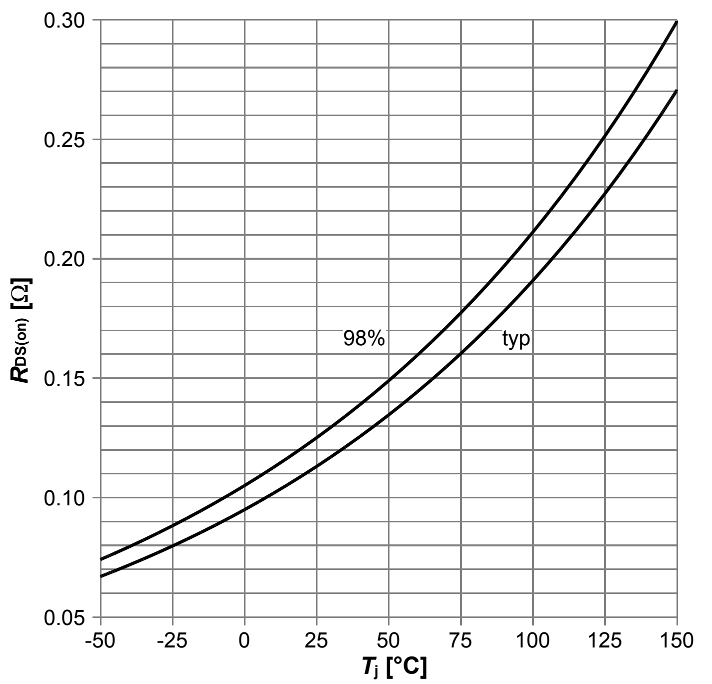

$I_D$=f($V_{DS}$); $T_j$=125 °C; parameter: $V_{GS}$

**Diagram 11: Typ. drain-source on-state resistance**



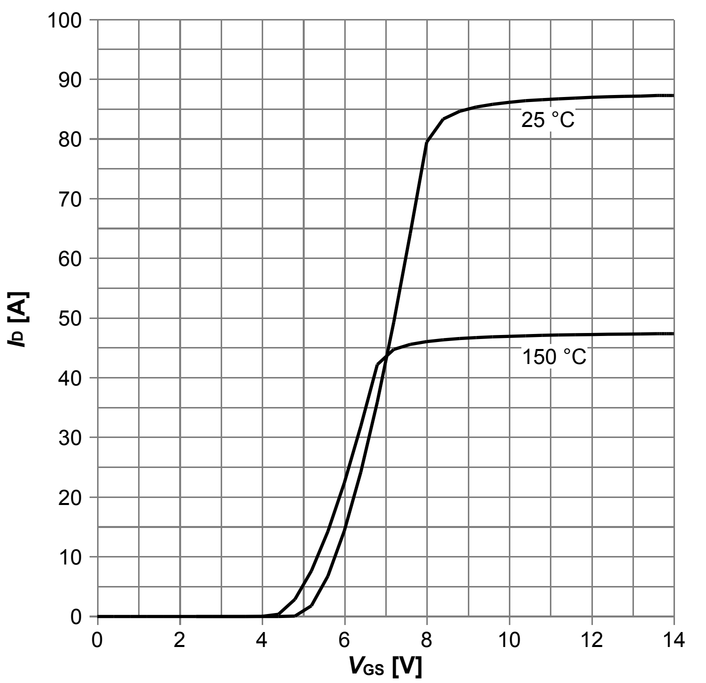

$R_{DS(on)}$=f($I_D$); $T_j$=125 °C; parameter: $V_{GS}$

**Diagram 12: Drain-source on-state resistance**



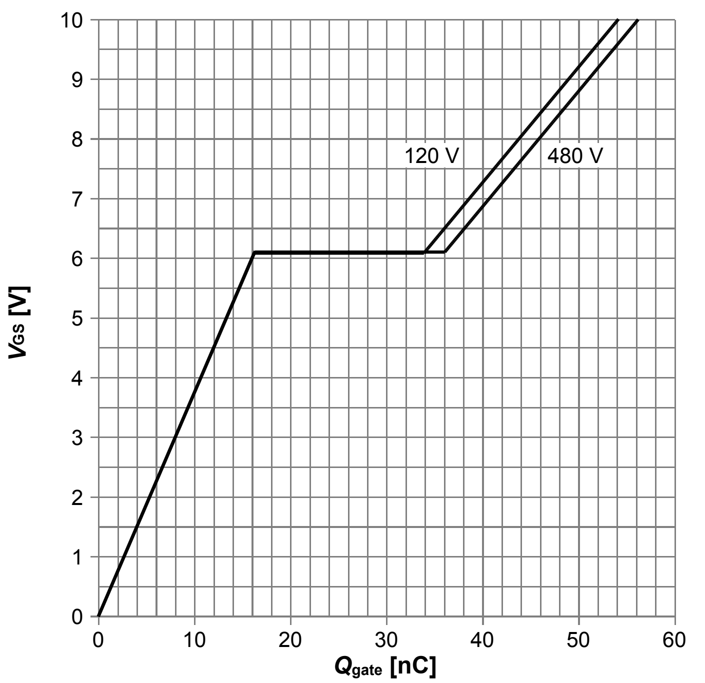

$R_{DS(on)}$=f($T_j$); $I_D$=11.6 A; $V_{GS}$=10 V

**Diagram 13: Typ. transfer characteristics**



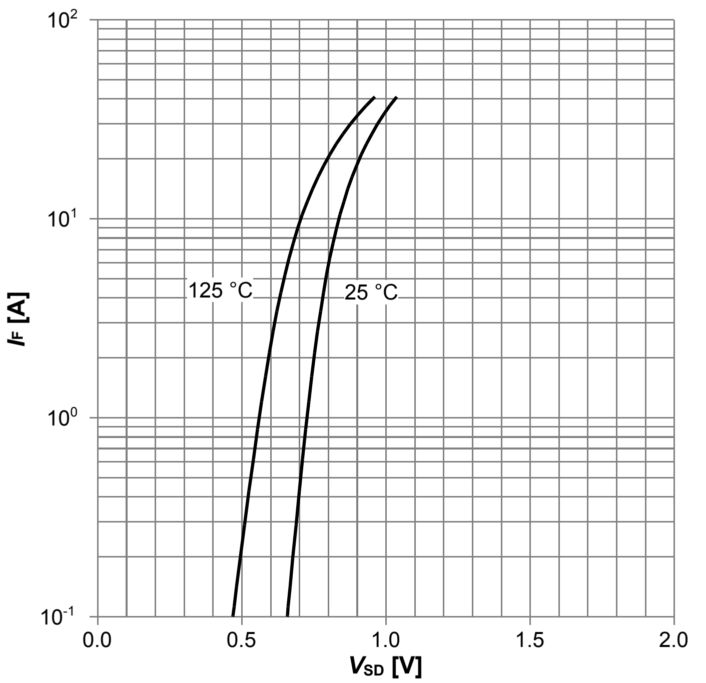

$I_D$=f($V_{GS}$); $V_{DS}$=20V; parameter: $T_j$

**Diagram 14: Typ. gate charge**



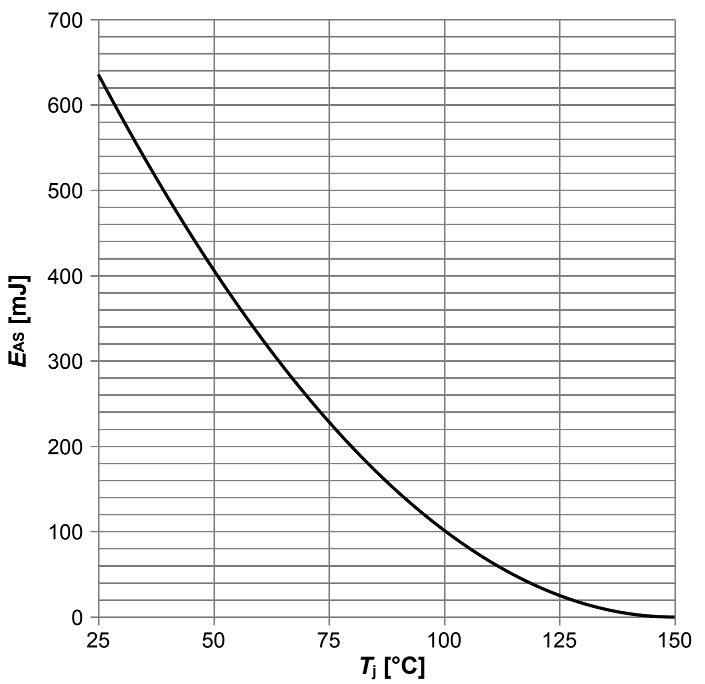

$V_{GS}$=f($Q_{gate}$); $I_D$=14.5 A pulsed; parameter: $V_{DD}$

**Diagram 15: Forward characteristics of reverse diode**



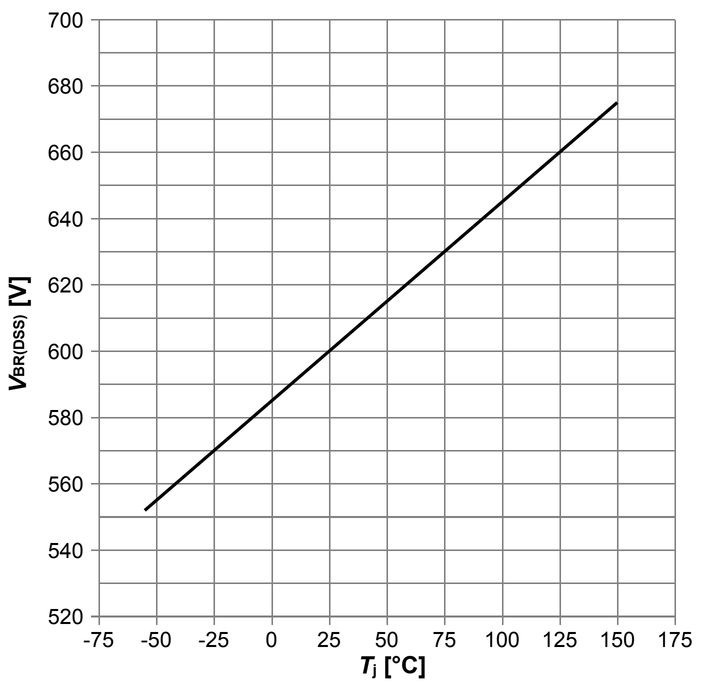

$I_F$=f($V_{SD}$); parameter: $T_j$

**Diagram 16: Avalanche energy**



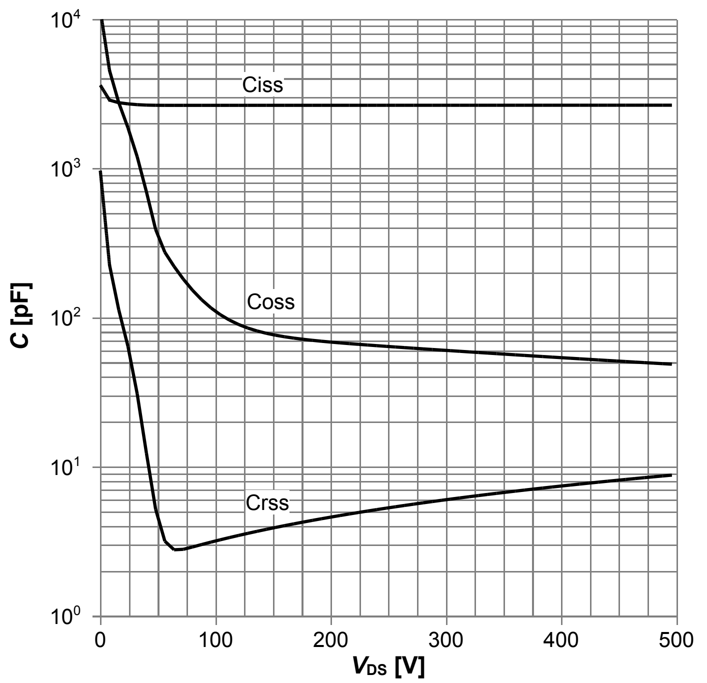

$E_{AS}$=f($T_j$); $I_D$=5.2 A; $V_{DD}$=50 V

**Diagram 17: Drain-source breakdown voltage**



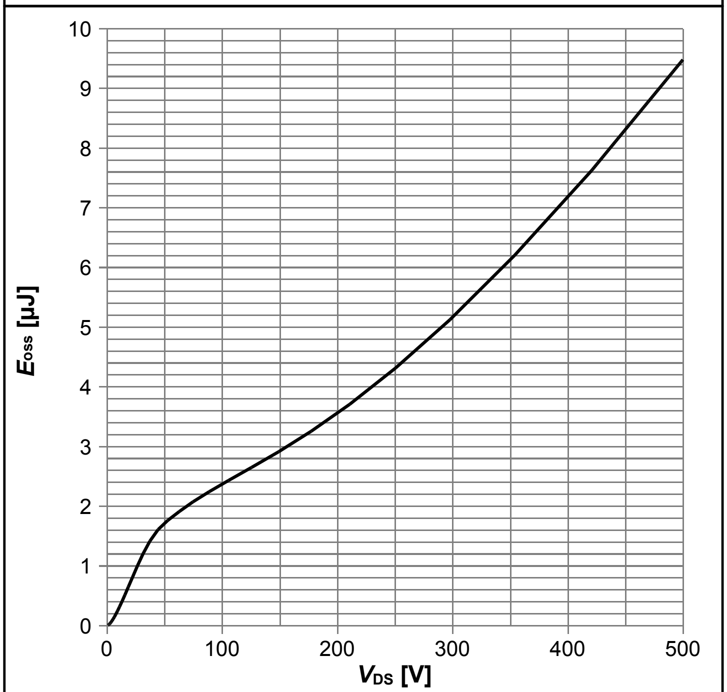

$V_{BR(DSS)}$=f($T_j$); $I_D$=1 mA

**Diagram 18: Typ. capacitances**




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

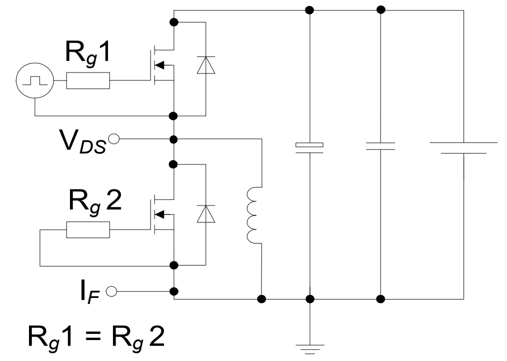
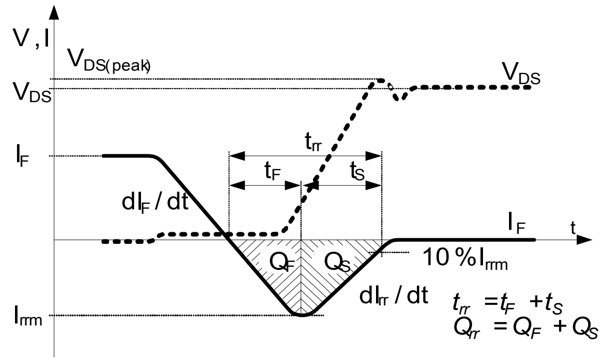
**Diagram 19: Typ. Coss stored energy**



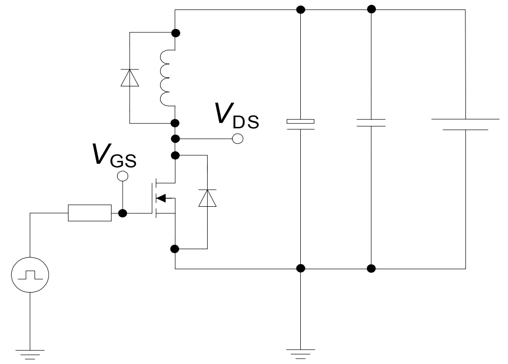
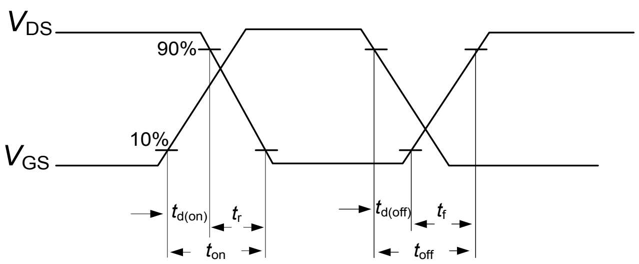

$E_{oss}$=f($V_{DS}$)

# 6 Test Circuits

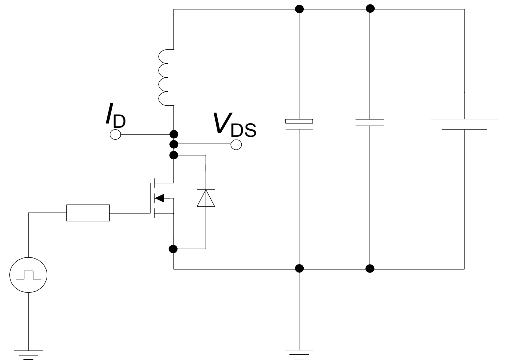
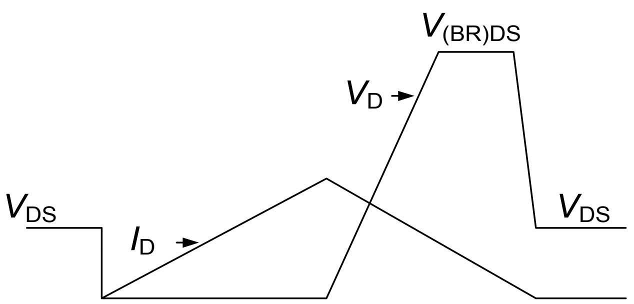
### Table 9 Diodecharacteristics

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

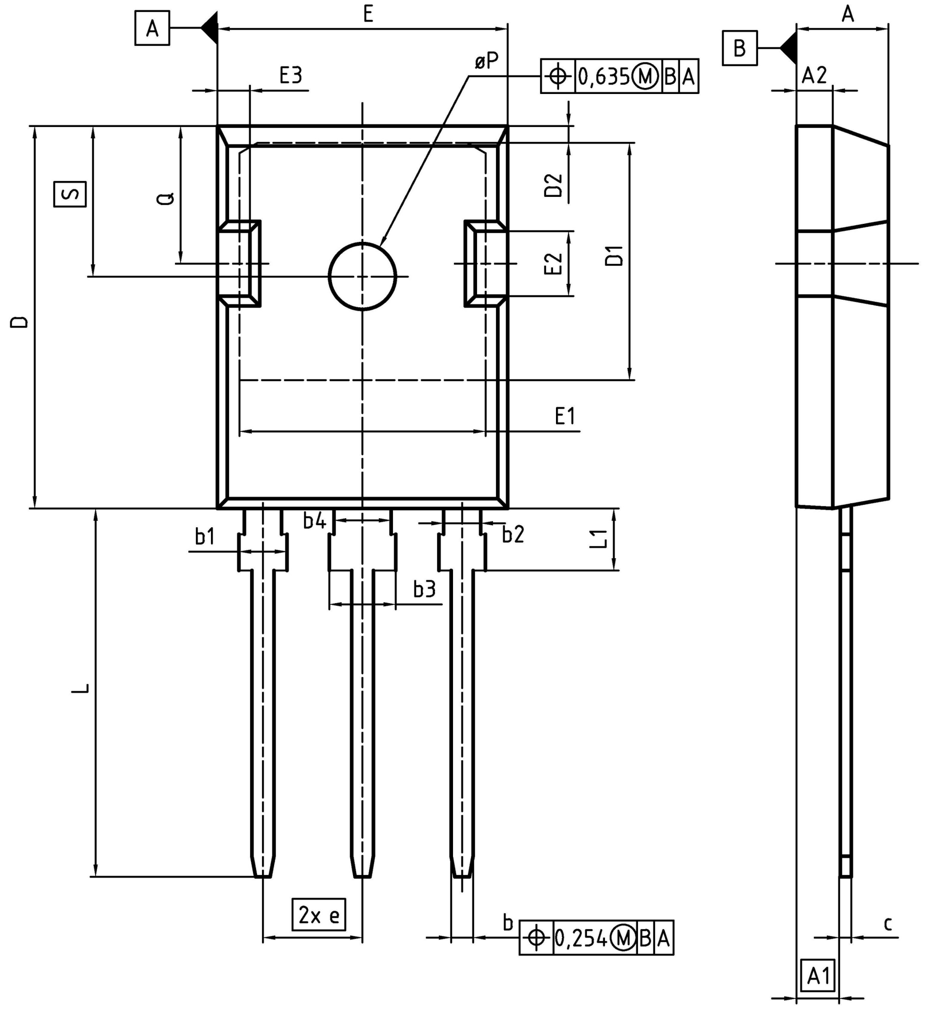
### Table 10 Switching times

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

### Table 11 Unclamped inductive load

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

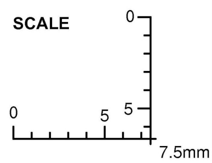
# 7 Package Outlines



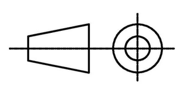

| DIM | MILLIMETERS | | INCHES | |
|---|---|---|---|---|
| | MIN | MAX | MIN | MAX |
| A | 4.83 | 5.21 | 0.190 | 0.205 |
| A1 | 2.27 | 2.54 | 0.089 | 0.100 |
| A2 | 1.85 | 2.16 | 0.073 | 0.085 |
| b | 1.07 | 1.33 | 0.042 | 0.052 |
| b1 | 1.90 | 2.41 | 0.075 | 0.095 |
| b2 | 1.90 | 2.16 | 0.075 | 0.085 |
| b3 | 2.87 | 3.38 | 0.113 | 0.133 |
| b4 | 2.87 | 3.13 | 0.113 | 0.123 |
| c | 0.55 | 0.68 | 0.022 | 0.027 |
| D | 20.80 | 21.10 | 0.819 | 0.831 |
| D1 | 16.25 | 17.65 | 0.640 | 0.695 |
| D2 | 0.95 | 1.35 | 0.037 | 0.053 |
| E | 15.70 | 16.13 | 0.618 | 0.635 |
| E1 | 13.10 | 14.15 | 0.516 | 0.557 |
| E2 | 3.68 | 5.10 | 0.145 | 0.201 |
| E3 | 1.00 | 2.60 | 0.039 | 0.102 |
| e | 5.44 (BSC) | | 0.214 (BSC) | |
| N | 3 | | 3 | |
| L | 19.80 | 20.32 | 0.780 | 0.800 |
| L1 | 4.10 | 4.47 | 0.161 | 0.176 |
| øP | 3.50 | 3.70 | 0.138 | 0.146 |
| Q | 5.49 | 6.00 | 0.216 | 0.236 |
| S | 6.04 | 6.30 | 0.238 | 0.248 |

DOCUMENT NO.
Z8B00003327

SCALE



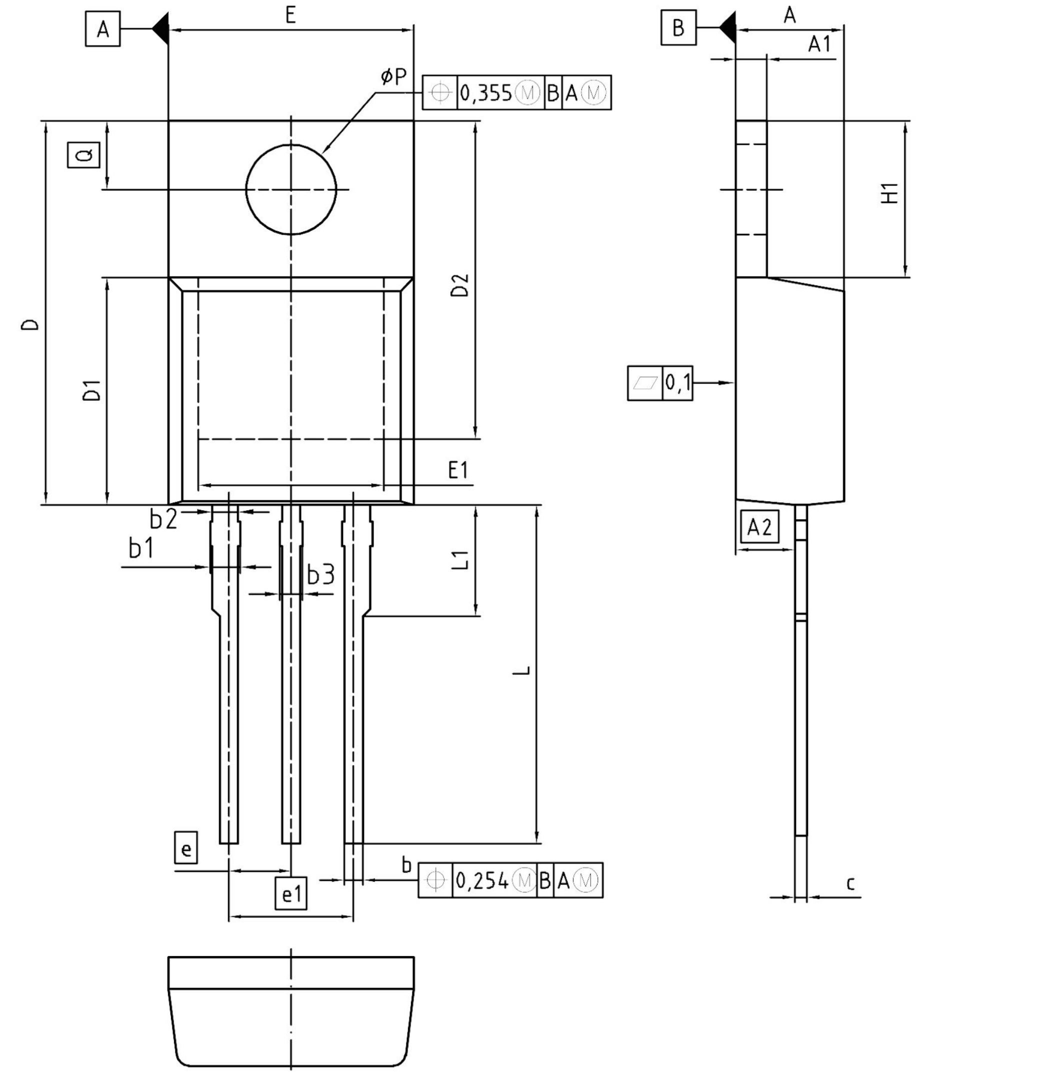

EUROPEAN PROJECTION



ISSUE DATE
09-07-2010

REVISION
05

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




| DIM | MILLIMETERS | | INCHES | |
|---|---|---|---|---|
| | MIN | MAX | MIN | MAX |
| A | 4.30 | 4.57 | 0.169 | 0.180 |
| A1 | 1.17 | 1.40 | 0.046 | 0.055 |
| A2 | 2.15 | 2.72 | 0.085 | 0.107 |
| b | 0.65 | 0.86 | 0.026 | 0.034 |
| b1 | 0.95 | 1.40 | 0.037 | 0.055 |
| b2 | 0.95 | 1.15 | 0.037 | 0.045 |
| b3 | 0.65 | 1.15 | 0.026 | 0.045 |
| c | 0.33 | 0.60 | 0.013 | 0.024 |
| D | 14.81 | 15.95 | 0.583 | 0.628 |
| D1 | 8.51 | 9.45 | 0.335 | 0.372 |
| D2 | 12.19 | 13.10 | 0.480 | 0.516 |
| E | 9.70 | 10.36 | 0.382 | 0.408 |
| E1 | 6.50 | 8.60 | 0.256 | 0.339 |
| e | 2.54 | | 0.100 | |
| e1 | 5.08 | | 0.200 | |
| N | 3 | | 3 | |
| H1 | 5.90 | 6.90 | 0.232 | 0.272 |
| L | 13.00 | 14.00 | 0.512 | 0.551 |
| L1 | - | 4.80 | - | 0.189 |
| øP | 3.60 | 3.89 | 0.142 | 0.153 |
| Q | 2.60 | 3.00 | 0.102 | 0.118 |

DOCUMENT NO.
Z8B00003318

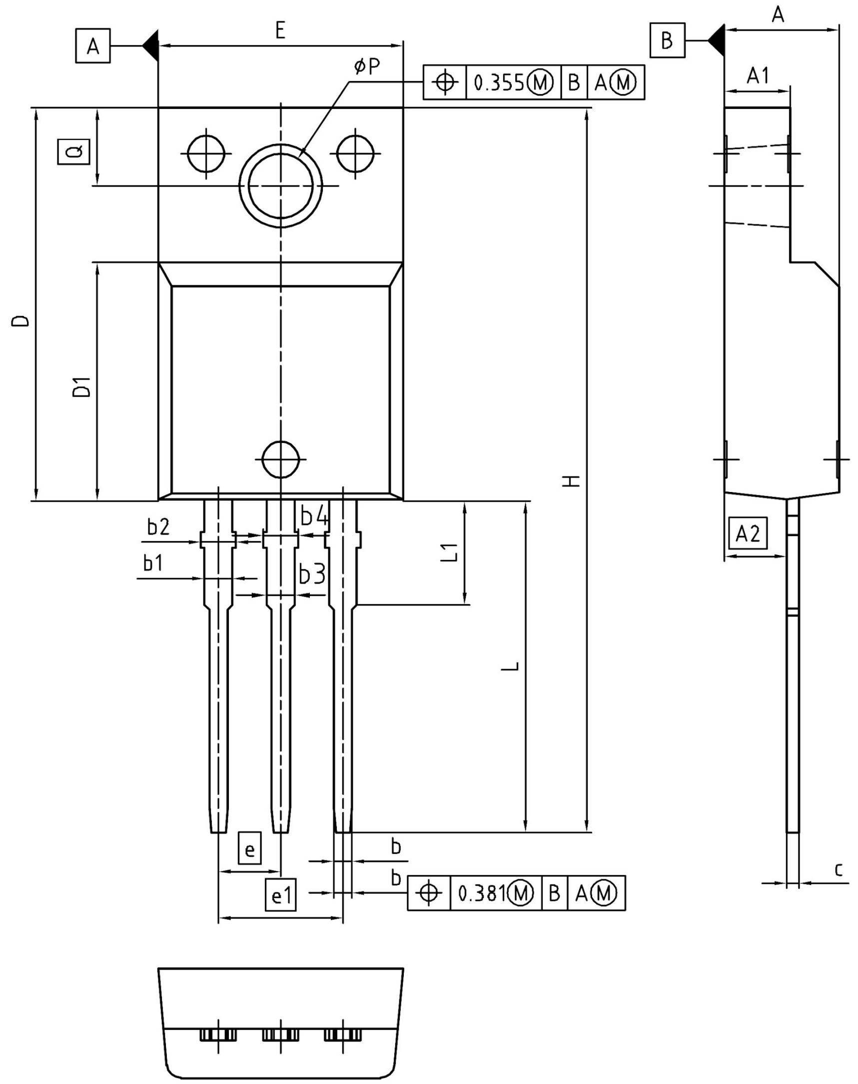
SCALE 0 2.5 5mm

EUROPEAN PROJECTION

ISSUE DATE
30-07-2009

REVISION
06

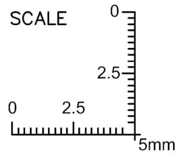
**Figure 2 Outline PG-TO 220, dimensions in mm/inches**



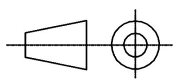

| DIM | MILLIMETERS | | INCHES | |
|---|---|---|---|---|
| | MIN | MAX | MIN | MAX |
| A | 4.55 | 4.85 | 0.179 | 0.191 |
| A1 | 2.55 | 2.85 | 0.100 | 0.112 |
| A2 | 2.42 | 2.72 | 0.095 | 0.107 |
| b | 0.65 | 0.85 | 0.026 | 0.033 |
| b1 | 0.95 | 1.33 | 0.037 | 0.052 |
| b2 | 0.95 | 1.51 | 0.037 | 0.059 |
| b3 | 0.65 | 1.33 | 0.026 | 0.052 |
| b4 | 0.65 | 1.51 | 0.026 | 0.059 |
| c | 0.40 | 0.63 | 0.016 | 0.025 |
| D | 15.85 | 16.15 | 0.624 | 0.636 |
| D1 | 9.53 | 9.83 | 0.375 | 0.387 |
| E | 10.35 | 10.65 | 0.407 | 0.419 |
| e | 2.54 | | 0.100 | |
| e1 | 5.08 | | 0.200 | |
| N | 3 | | 3 | |
| H | 29.45 | 29.75 | 1.159 | 1.171 |
| L | 13.45 | 13.75 | 0.530 | 0.541 |
| L1 | 3.15 | 3.45 | 0.124 | 0.136 |
| øP | 2.95 | 3.20 | 0.116 | 0.126 |
| Q | 3.15 | 3.50 | 0.124 | 0.138 |

DOCUMENT NO.
Z8B00003319

SCALE




EUROPEAN PROJECTION



ISSUE DATE
08-03-2007

REVISION
03

**Figure 3 Outline PG-TO 220 FullPAK, dimensions in mm/inches**

# 8 Appendix A

## Table 12 Related Links

- **IFX CoolMOS™ P6 Webpage:** www.infineon.com
- **IFX CoolMOS™ P6 application note:** www.infineon.com
- **IFX CoolMOS™ P6 simulation model:** www.infineon.com
- **IFX Design tools:** www.infineon.com

## Revision History

IPW60R125P6, IPP60R125P6, IPA60R125P6

**Revision: 2014-03-07, Rev. 2.0**

Previous Revision

| Revision | Date | Subjects (major changes since last revision) |
|---|---|---|
| 2.0 | 2014-03-07 | Release of final version |

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