# MOSFET

Metal Oxide Semiconductor Field Effect Transistor

# CoolMOS™ C6

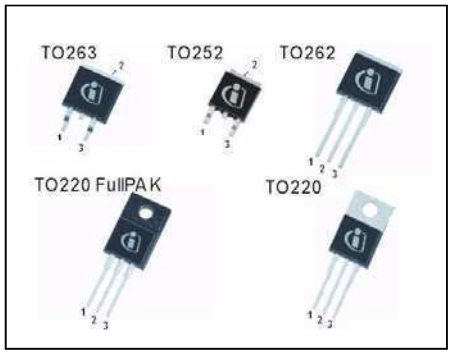
650V CoolMOS™ C6 Power Transistor
IPx65R380C6

## Data Sheet

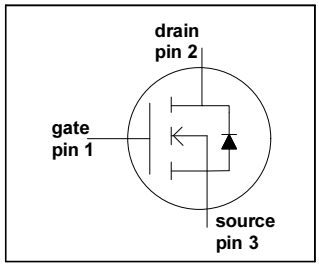
Rev. 2.2
Final

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™ C6 series combines the experience of the leading SJ MOSFET supplier with high class innovation. The resulting 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

- Extremely low losses due to very low FOM $R_{dson}$*$Q_g$ and $E_{oss}$
- Very high commutation ruggedness
- Easy to use/drive, Pb-free plating, Halogen free
- Fully qualified according to JEDEC for Industrial Applications

### Applications

PFC stages, hard switching PWM stages and resonant switching PWM 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 |
|---|---|---|
| $V_{DS}$ @ $T_{j,max}$ | 700 | V |
| $R_{DS(on),max}$ | 0.38 | Ω |
| $Q_{g,typ}$ | 39 | nC |
| $I_{D,pulse}$ | 29 | A |
| $E_{oss}$ @ 400V | 2.8 | µJ |
| Body diode d$i$/d$t$ | 500 | A/µs |

| Type / Ordering Code | Package | Marking | Related Links |
|---|---|---|---|
| IPD65R380C6 | PG-TO252 | 65C6380 | IFX CoolMOS Webpage |
| IPI65R380C6 | PG-TO262 | | IFX Design tools |
| IPB65R380C6 | PG-TO263 | | |
| IPP65R380C6 | PG-TO220 | | |
| IPA65R380C6 | PG-TO220 FullPAK | | |

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## 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] | $I_D$ | - | - | 10.6 | A | $T_C$= 25 °C |
| | | | | 6.7 | | $T_C$= 100°C |
| Pulsed drain current[2] | $I_{D,pulse}$ | - | - | 29 | A | $T_C$=25 °C |
| Avalanche energy, single pulse | $E_{AS}$ | - | - | 215 | mJ | $I_D$=1.8 A, $V_{DD}$=50 V (see table 21) |
| Avalanche energy, repetitive | $E_{AR}$ | - | - | 0.32 | | $I_D$=1.8 A, $V_{DD}$=50 V |
| Avalanche current, repetitive | $I_{AR}$ | - | - | 1.8 | A | |
| MOSFET dv/dt ruggedness | dv/dt | - | - | 50 | V/ns | $V_{DS}$=0...480 V |
| Gate source voltage | $V_{GS}$ | -20 | - | 20 | V | static |
| | | -30 | | 30 | | AC (f>1 Hz) |
| Power dissipation for TO-220, TO-252, TO-262, TO-263 | $P_{tot}$ | - | - | 83 | W | $T_C$=25 °C |
| Power dissipation for TO-220 FullPAK | $P_{tot}$ | - | - | 31 | W | $T_C$=25 °C |
| Operating and storage temperature | $T_j$, $T_{stg}$ | -55 | - | 150 | °C | |
| Mounting torque TO-220 | | - | - | 60 | Ncm | M3 and M3.5 screws |
| Mounting torque TO-220 FullPAK | | | | 50 | | M2.5 screws |
| Continuous diode forward current | $I_S$ | - | - | 9.2 | A | $T_C$=25 °C |
| Diode pulse current[2] | $I_{S,pulse}$ | - | - | 29 | A | $T_C$=25 °C |
| Reverse diode dv/dt[3] | dv/dt | - | - | 15 | V/ns | $V_{DS}$=0...480 V, $I_{SD} \leq I_D$, $T_j$=125 °C |
| Maximum diode commutation speed[3] | $di_f/dt$ | | | 500 | A/µs | |

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 TO-220 & TO-262**

| Parameter | Symbol | Values | | | Unit | Note / Test Condition |
|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | |
| Thermal resistance, junction - case | $R_{thJC}$ | - | - | 1.5 | °C/W | |
| Thermal resistance, junction - ambient | $R_{thJA}$ | - | - | 62 | | leaded |
| Soldering temperature, wavesoldering only allowed at leads | $T_{sold}$ | - | - | 260 | °C | 1.6 mm (0.063 in.) from case for 10 s |

**Table 4 Thermal characteristics TO-220FullPAK**

| Parameter | Symbol | Values | | | Unit | Note / Test Condition |
|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | |
| Thermal resistance, junction - case | $R_{thJC}$ | - | - | 4.0 | °C/W | |
| Thermal resistance, junction - ambient | $R_{thJA}$ | - | - | 80 | | leaded |
| Soldering temperature, wavesoldering only allowed at leads | $T_{sold}$ | - | - | 260 | °C | 1.6 mm (0.063 in.) from case for 10 s |

**Table 5 Thermal characteristics TO-263 & TO-252**

| Parameter | Symbol | Values | | | Unit | Note / Test Condition |
|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | |
| Thermal resistance, junction - case | $R_{thJC}$ | - | - | 1.5 | °C/W | |
| Thermal resistance, junction - ambient | $R_{thJA}$ | - | - | 62 | | SMD version, device on PCB, minimal footprint |
| | | | 35 | | | SMD version, device on PCB, 6cm$^2$ cooling area[1)] |
| Soldering temperature, wave- & reflowsoldering allowed | $T_{sold}$ | - | - | 260 | °C | reflow MSL1 |

1) Device on 40mm*40mm*1.5 epoxy PCB FR4 with 6cm$^2$ (one layer, 70µm thick) copper area for drain connection. PCB is vertical without air stream cooling.

# 4 Electrical characteristics

Electrical characteristics, at $T$j=25 °C, unless otherwise specified

**Table 6 Static characteristics**

| Parameter | Symbol | Values | | | Unit | Note / Test Condition |
|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | |
| Drain-source breakdown voltage | $V_{(BR)DSS}$ | 650 | - | - | V | $V_{GS}$=0 V, $I_D$=1.0 mA |
| Gate threshold voltage | $V_{GS(th)}$ | 2.5 | 3 | 3.5 | | $V_{DS}$=$V_{GS}$, $I_D$=0.32 mA |
| Zero gate voltage drain current | $I_{DSS}$ | - | - | 1 | µA | $V_{DS}$=600 V, $V_{GS}$=0 V, $T_j$=25 °C |
| | | - | 10 | - | | $V_{DS}$=600 V, $V_{GS}$=0 V, $T_j$=150 °C |
| Gate-source leakage current | $I_{GSS}$ | - | - | 100 | nA | $V_{GS}$=20 V, $V_{DS}$=0 V |
| Drain-source on-state resistance | $R_{DS(on)}$ | - | 0.34 | 0.38 | Ω | $V_{GS}$=10 V, $I_D$=3.2 A, $T_j$=25 °C |
| | | - | 0.89 | - | | $V_{GS}$=10 V, $I_D$=3.2 A, $T_j$=150 °C |
| Gate resistance | $R_G$ | - | 17 | - | Ω | $f$=1 MHz, open drain |

**Table 7 Dynamic characteristics**

| Parameter | Symbol | Values | | | Unit | Note / Test Condition |
|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | |
| Input capacitance | $C_{iss}$ | - | 710 | - | pF | $V_{GS}$=0 V, $V_{DS}$=100 V, $f$=1 MHz |
| Output capacitance | $C_{oss}$ | - | 41 | - | | |
| Effective output capacitance, energy related[1)] | $C_{o(er)}$ | - | 32 | - | | $V_{GS}$=0 V, $V_{DS}$=0...480 V |
| Effective output capacitance, time related[2)] | $C_{o(tr)}$ | - | 140 | - | | $I_D$=constant, $V_{GS}$=0 V $V_{DS}$=0...480V |
| Turn-on delay time | $t_{d(on)}$ | - | 12 | - | ns | $V_{DD}$=400 V, $V_{GS}$=13 V, $I_D$=4.9A, $R_G$= 3.4 Ω (see table 20) |
| Rise time | $t_r$ | - | 12 | - | | |
| Turn-off delay time | $t_{d(off)}$ | - | 110 | - | | |
| Fall time | $t_f$ | - | 11 | - | | |

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 80% $V_{(BR)DSS}$

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 80% $V_{(BR)DSS}$

**Table 8 Gate charge characteristics**

| Parameter | Symbol | Values | | | Unit | Note / Test Condition |
|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | |
| IGate to source charge | $Q_{gs}$ | - | 4 | - | nC | $V_{DD}$=480 V, $I_D$=4.9 A, $V_{GS}$=0 to 10 V |
| Gate to drain charge | $Q_{gd}$ | - | 20 | - | | |
| Gate charge total | $Q_g$ | - | 39 | - | | |
| Gate plateau voltage | $V_{plateau}$ | - | 5.5 | - | V | |

**Table 9 Reverse diode characteristics**

| Parameter | Symbol | Values | | | Unit | Note / Test Condition |
|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | |
| Diode forward voltage | $V_{SD}$ | - | 0.9 | - | V | $V_{GS}$=0 V, $I_F$=4.9A, $T_j$=25 °C |
| Reverse recovery time | $t_{rr}$ | - | 280 | - | ns | $V_R$=400 V, $I_F$=4.9 A, d$i_F$/d$t$=100 A/µs (see table 22) |
| Reverse recovery charge | $Q_{rr}$ | - | 2.8 | - | µC | |
| Peak reverse recovery current | $I_{rrm}$ | - | 17 | - | A | |

# 5 Electrical characteristics diagrams

**Table 10**

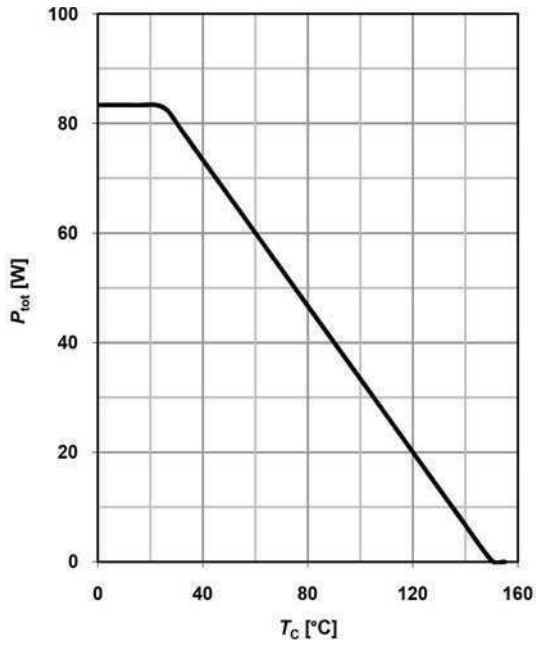
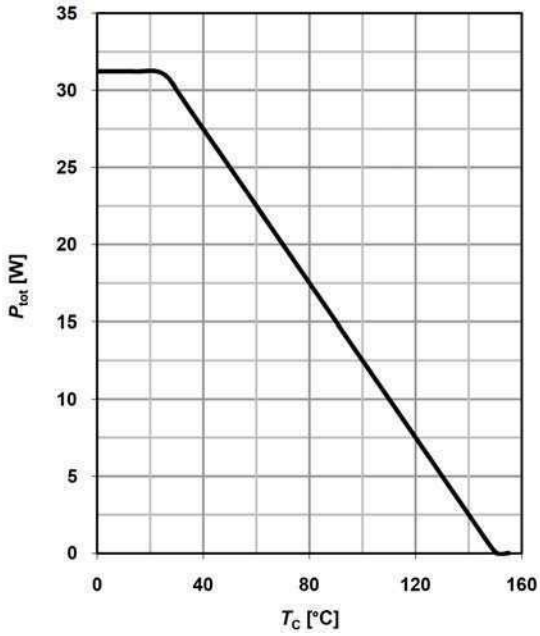
| Power dissipation<br>Non FullPAK | Power dissipation<br>FullPAK |
|---|---|
|  |  |
| $P_{tot} = f(T_C)$ | $P_{tot} = f(T_C)$ |

**Table 11**

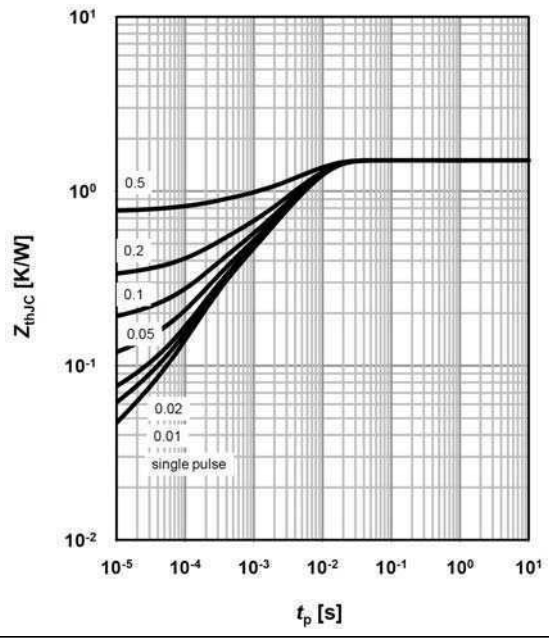
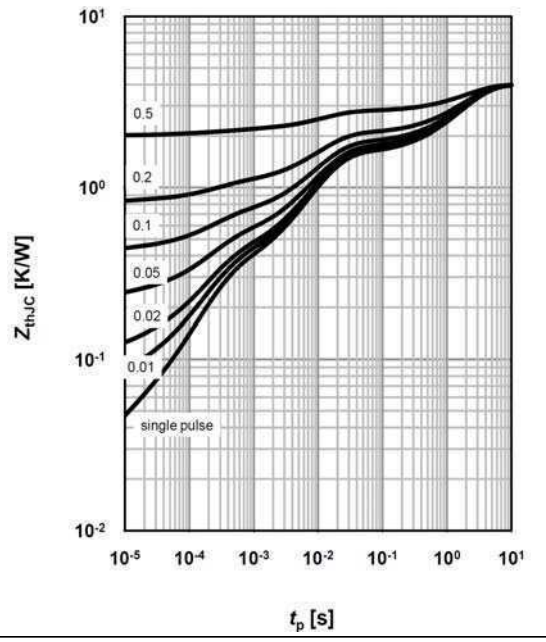
| Max. transient thermal impedance<br>Non FullPAK | Max. transient thermal impedance<br>FullPAK |
|---|---|
|  |  |
| $Z_{(thJC)}$=f(tp); parameter: D=$t_p$/T | $Z_{(thJC)}$=f(tp); parameter: D=$t_p$/T |

**Table 12**

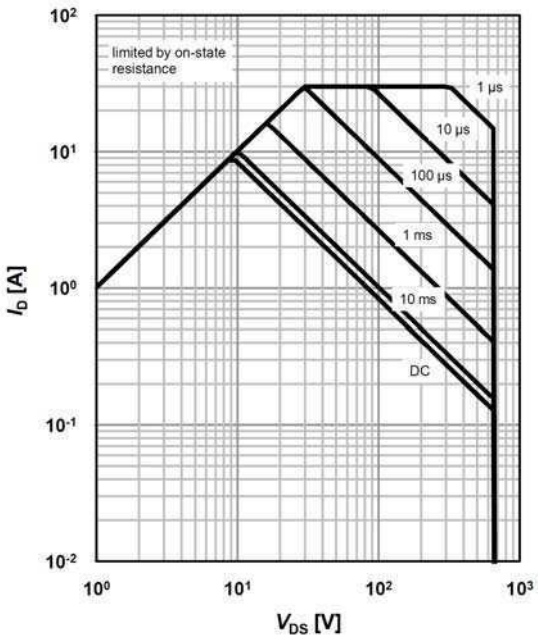
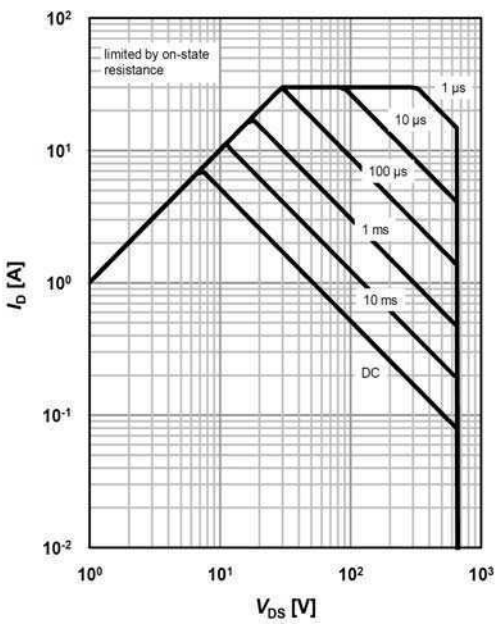
| Safe operating area $T_C$=25 °C<br>Non FullPAK | Safe operating area $T_C$=25 °C<br>FullPAK |
|---|---|
|  |  |
| $I_D$=f($V_{DS}$); $T_C$=25 °C; $V_{GS}$ > 7V; D=0; parameter $t_p$ | $I_D$=f($V_{DS}$); $T_C$=25 °C; $V_{GS}$ > 7V; D=0; parameter $t_p$ |

**Table 13**

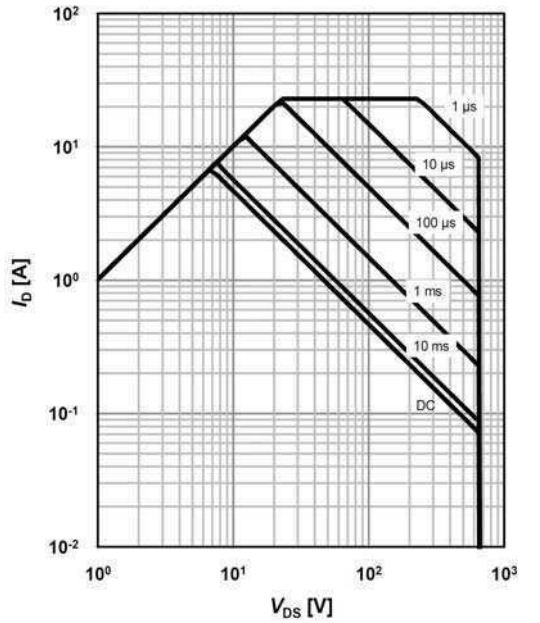
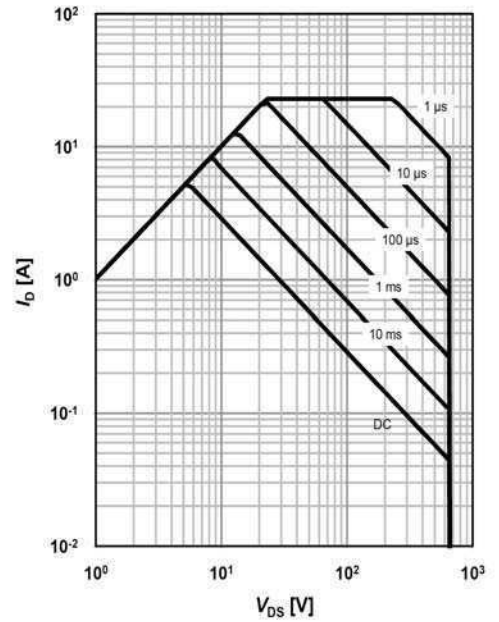
| Safe operating area $T_C$=80 °C<br>Non FullPAK | Safe operating area $T_C$=80 °C<br>FullPAK |
|---|---|
|  |  |
| $I_D$=f($V_{DS}$); $T_C$=80 °C; $V_{GS}$ > 7V; D=0; parameter $t_p$ | $I_D$=f($V_{DS}$); $T_C$=80 °C; $V_{GS}$ > 7V; D=0; parameter $t_p$ |

**Table 14**

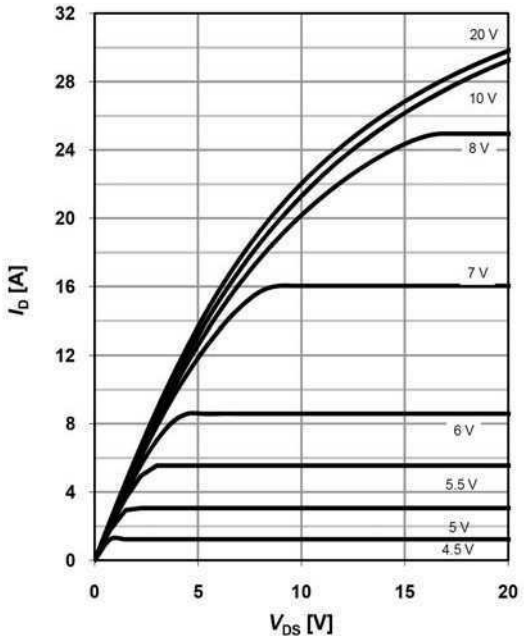
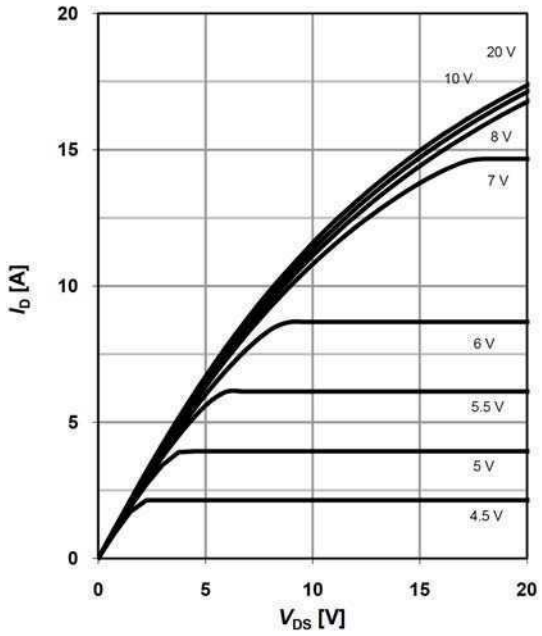
| Typ. output characteristics $T_C$=25 °C | Typ. output characteristics $T_j$=125 °C |
|---|---|
|  |  |
| $I_D$=f($V_{DS}$); $T_j$=25 °C; parameter: $V_{GS}$ | $I_D$=f($V_{DS}$); $T_j$=125 °C; parameter: $V_{GS}$ |

**Table 15**

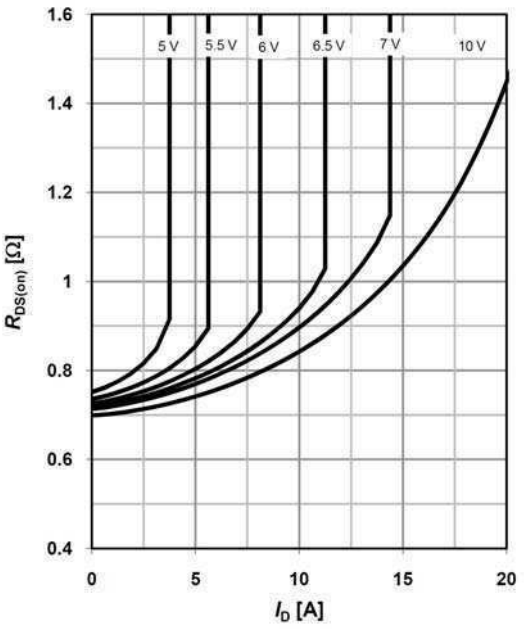
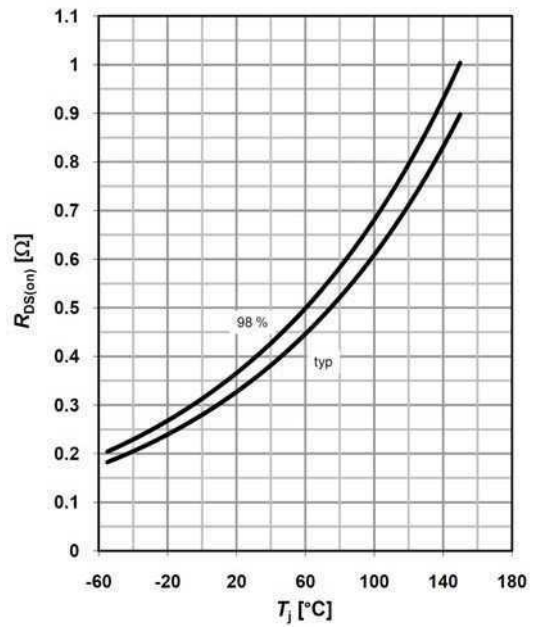
| Typ. drain-source on-state resistance | Drain-source on-state resistance |
|---|---|
|  |  |
| $R_{DS(on)}$=f($I_D$); $T_j$=125 °C; parameter: $V_{GS}$ | $R_{DS(on)}$=f($T_j$); $I_D$=4.9 A; $V_{GS}$=10 V |

**Table 16**

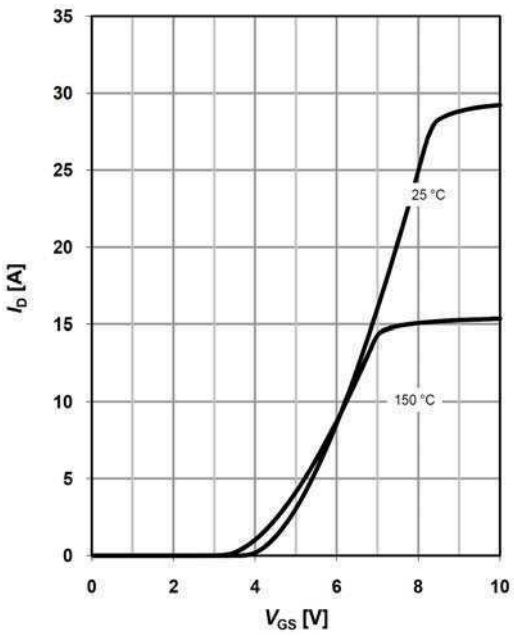
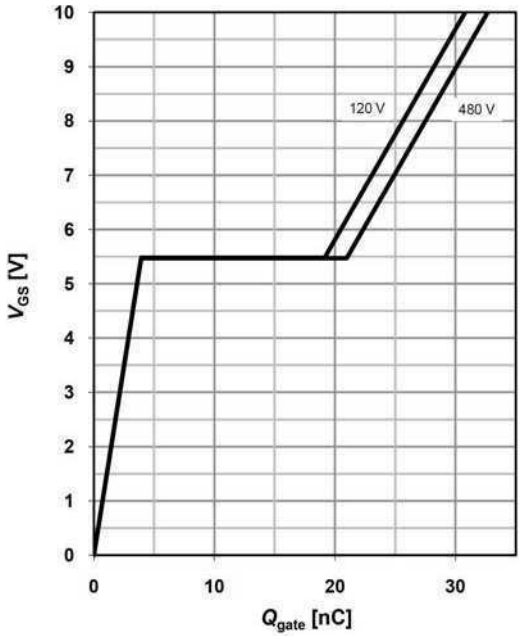
| Typ. transfer characteristics | Typ. gate charge |
|---|---|
|  |  |
| $I_D$=f($V_{GS}$); $V_{DS}$=20V | $V_{GS}$=f($Q_{gate}$), $I_D$=4.9 A pulsed |

**Table 17**

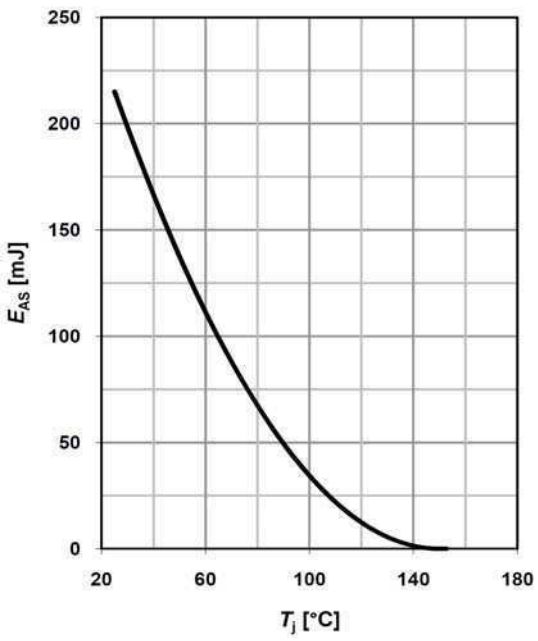
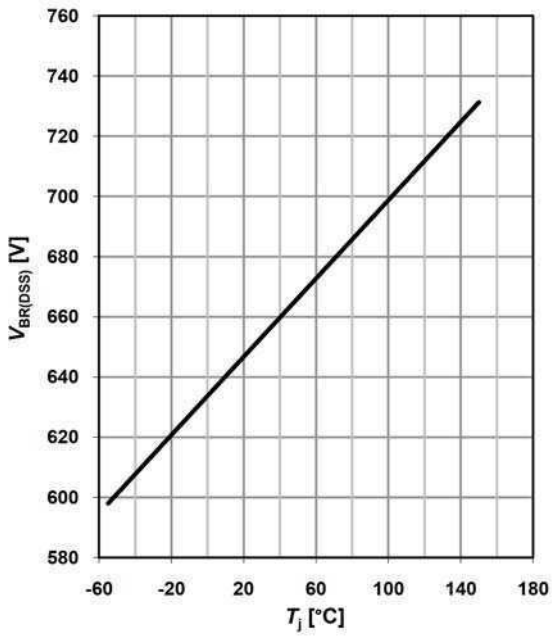
| Avalanche energy | Drain-source breakdown voltage |
|---|---|
|  |  |
| $E_{AS}$=f($T_j$); $I_D$=1.8 A; $V_{DD}$=50 V | $V_{BR(DSS)}$=f($T_j$); $I_D$=1.0 mA |

**Table 18**

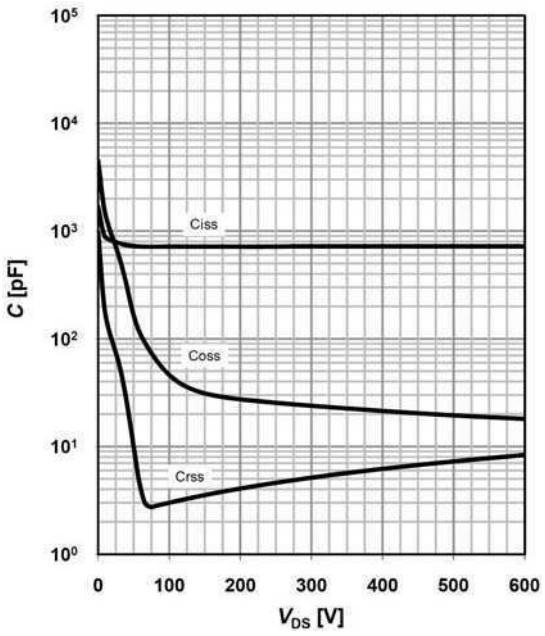
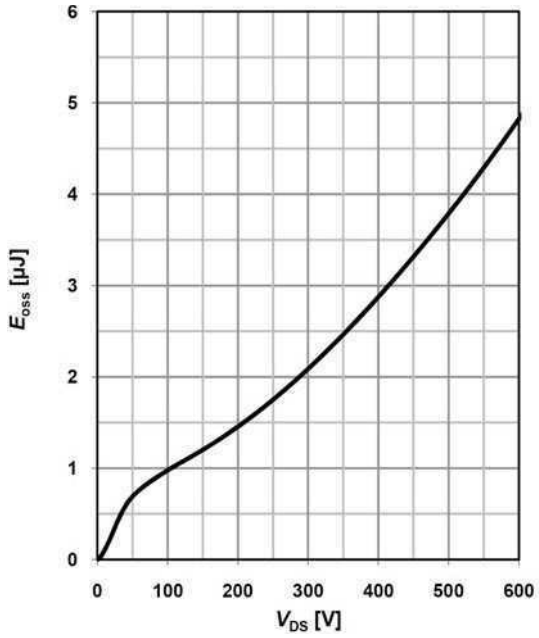
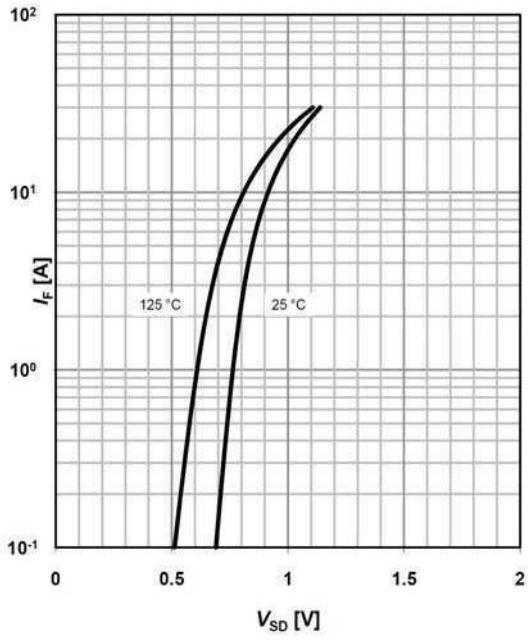
| Typ. capacitances | Typ. $C_{oss}$ stored energy |
|---|---|
|  |  |
| C=f($V_{DS}$); $V_{GS}$=0 V; $f$=1 MHz | $E_{oss}$=f($V_{DS}$) |

**Table 19**

| Forward characteristics of reverse diode |
|---|
|  |
| $I_F$=f($V_{SD}$); parameter: $T_j$ |

# 6 Test circuits

**Table 20 Switching times test circuit and waveform for inductive load**

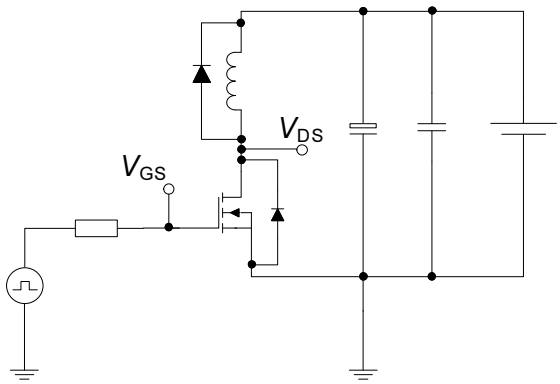
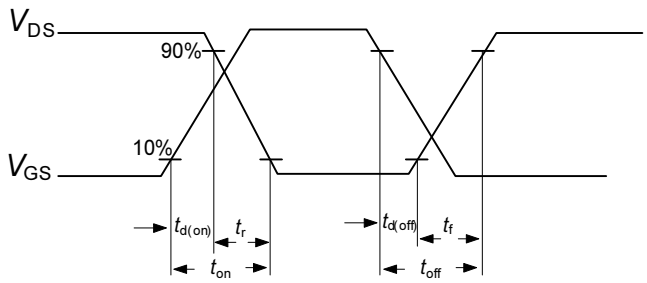
| Switching times test circuit for inductive load | Switching time waveform |
|---|---|
|  |  |



**Table 21 Unclamped inductive load test circuit and waveform**

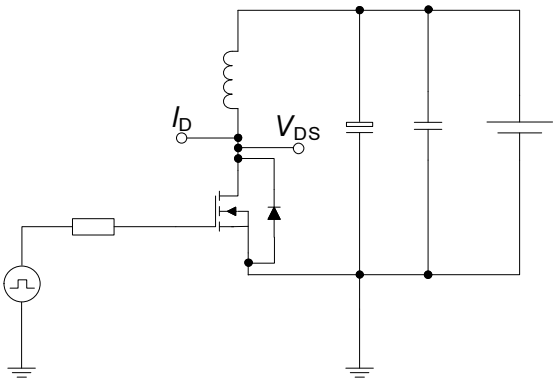
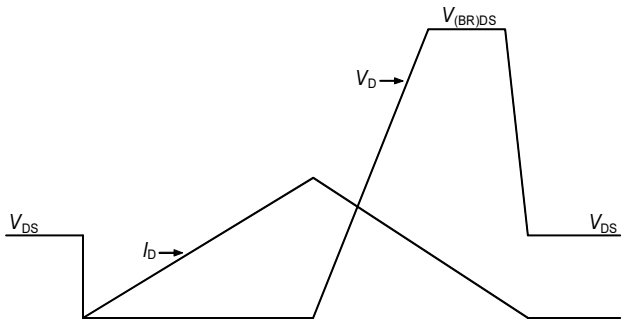
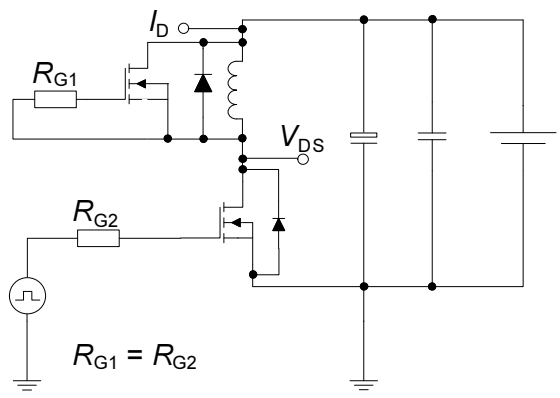
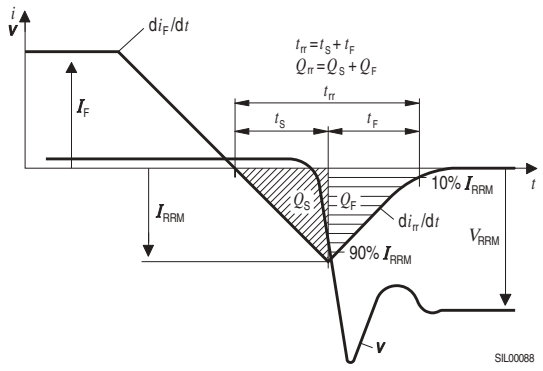
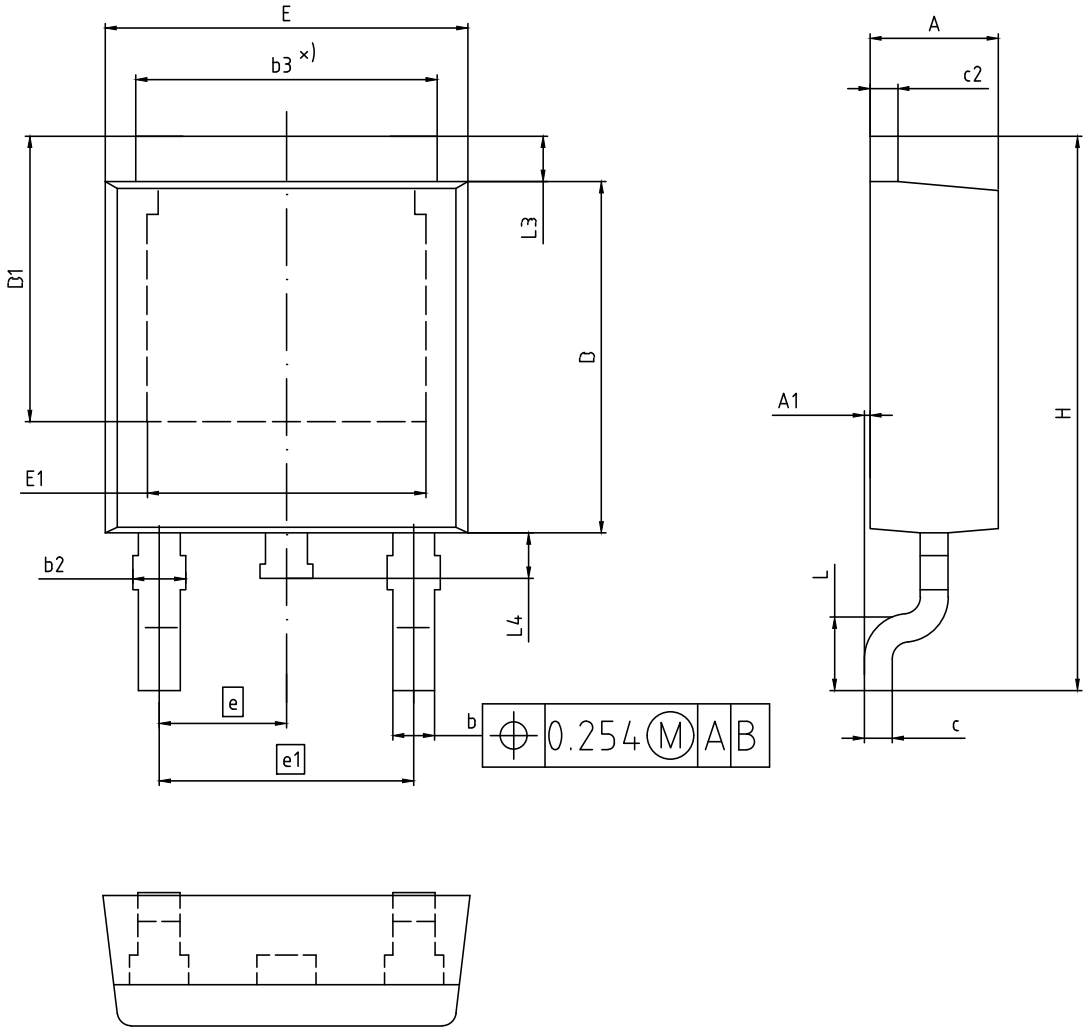
| Unclamped inductive load test circuit | Unclamped inductive waveform |
|---|---|
|  |  |



**Table 22 Test circuit and waveform for diode characteristics**

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

# 7 Package outlines

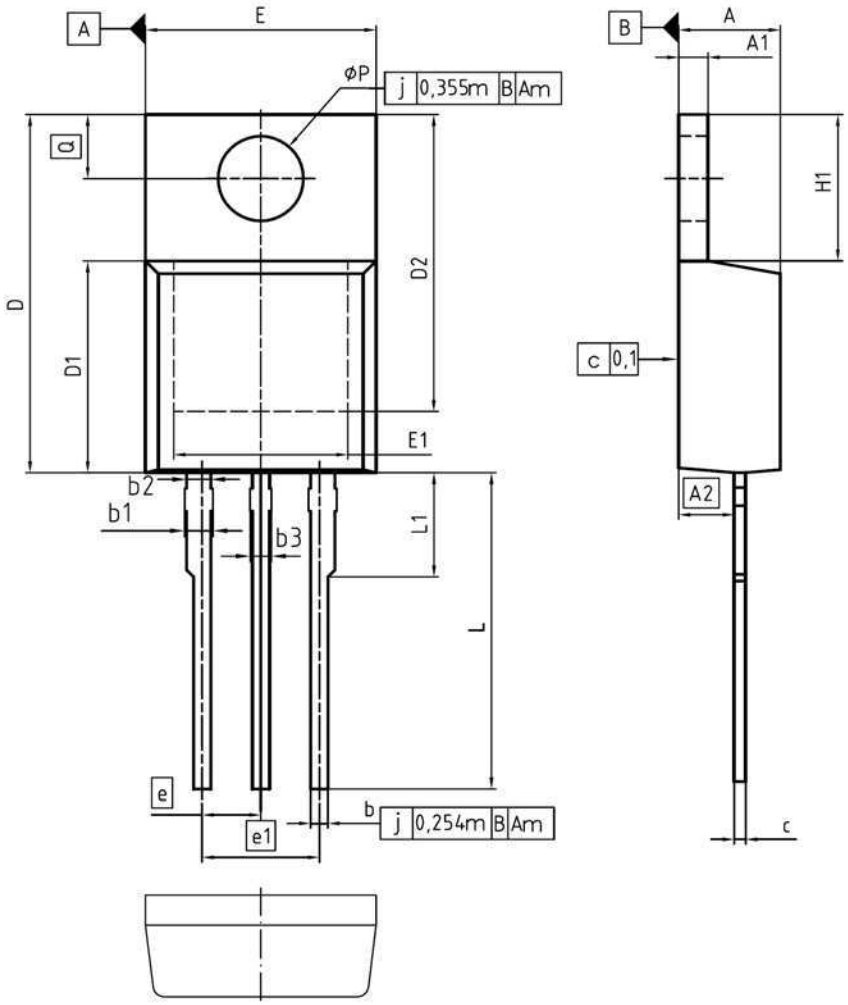



ALL DIMENSIONS REFER TO JEDEC
STANDARD TO-252 AND DO NOT INCLUDE MOLD
FLASH OR PROTRUSIONS.

| DIMENSION | MILLIMETERS | |
|---|---|---|
| | MIN. | MAX. |
| **A** | 2.16 | 2.41 |
| **A1** | 0.00 | 0.15 |
| **b** | 0.64 | 0.89 |
| **b2** | 0.65 | 1.15 |
| **b3** | 4,95 | 5.50 |
| **c** | 0.46 | 0.61 |
| **c2** | 0.40 | 0.98 |
| **D** | 5.97 | 6.22 |
| **D1** | 5.02 | 5.84 |
| **E** | 6.35 | 6.73 |
| **E1** | 4.32 | 5.50 |
| **e** | 2.29 | |
| **e1** | 4.57 | |
| **N** | 3 | |
| **H** | 9.40 | 10.48 |
| **L** | 1.18 | 1.78 |
| **L3** | 0.89 | 1.27 |
| **L4** | 0.51 | 1.02 |

| | |
|---|---|
| **DOCUMENT NO.** | Z8B00003328 |
| **REVISION** | 07 |
| **SCALE:** | 10:1 |
| | 0 1 2mm |
| **EUROPEAN PROJECTION** | |
| **ISSUE DATE** | 01.04.2020 |

**Figure 1 Outlines TO-252, dimensions in mm**




| 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 |

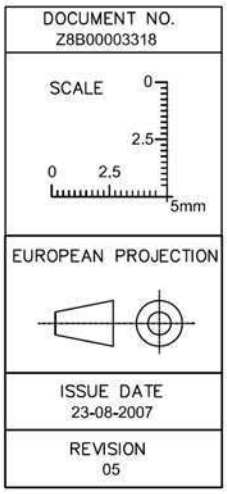
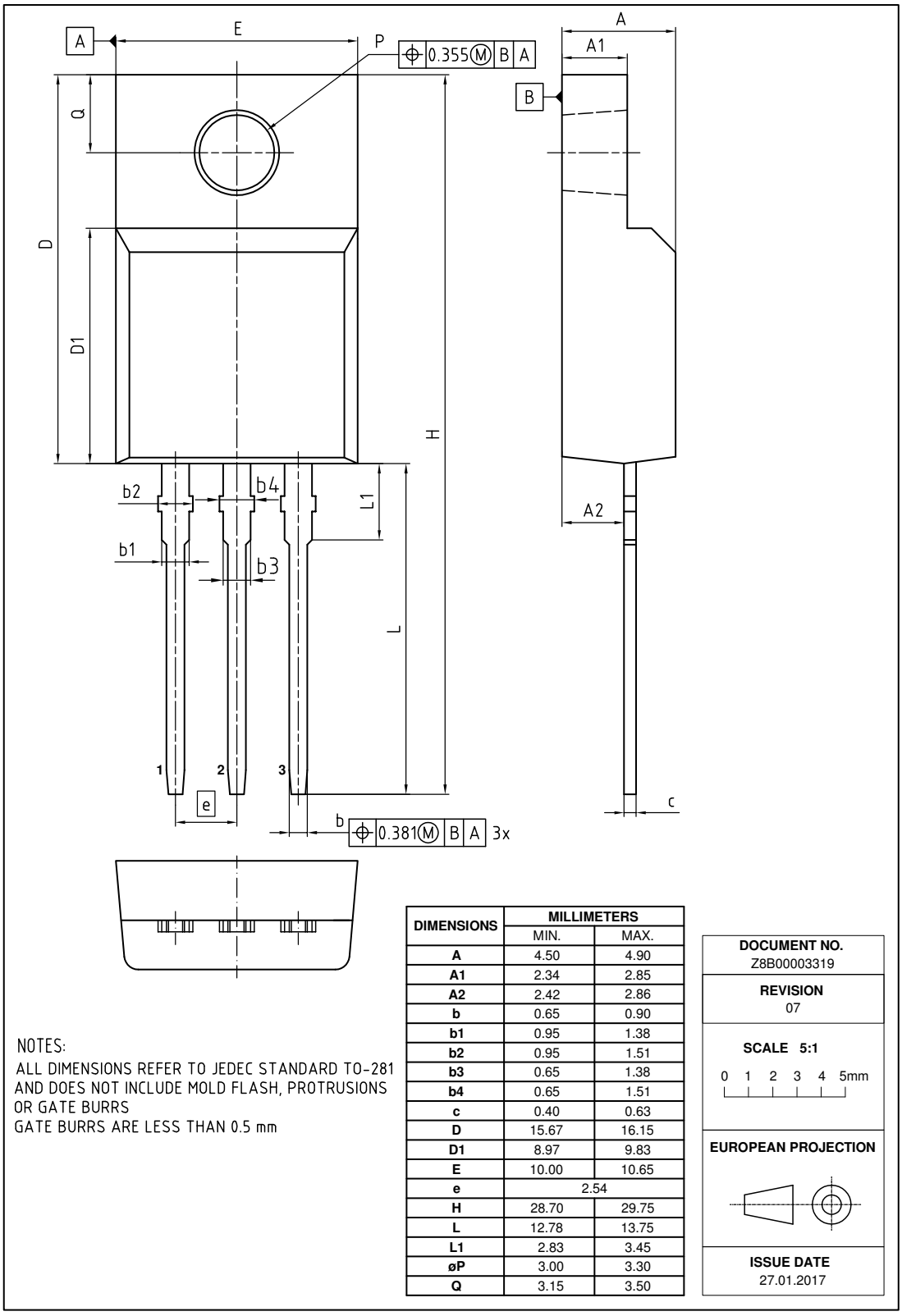



**Figure 2 Outlines TO-220, dimensions in mm/inches**




| DIMENSIONS | MILLIMETERS | |
|---|---|---|
| | MIN. | MAX. |
| A | 4.50 | 4.90 |
| A1 | 2.34 | 2.85 |
| A2 | 2.42 | 2.86 |
| b | 0.65 | 0.90 |
| b1 | 0.95 | 1.38 |
| b2 | 0.95 | 1.51 |
| b3 | 0.65 | 1.38 |
| b4 | 0.65 | 1.51 |
| c | 0.40 | 0.63 |
| D | 15.67 | 16.15 |
| D1 | 8.97 | 9.83 |
| E | 10.00 | 10.65 |
| e | 2.54 | |
| H | 28.70 | 29.75 |
| L | 12.78 | 13.75 |
| L1 | 2.83 | 3.45 |
| øP | 3.00 | 3.30 |
| Q | 3.15 | 3.50 |

NOTES:
ALL DIMENSIONS REFER TO JEDEC STANDARD TO-281 AND DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS
GATE BURRS ARE LESS THAN 0.5 mm

**DOCUMENT NO.**
Z8B00003319

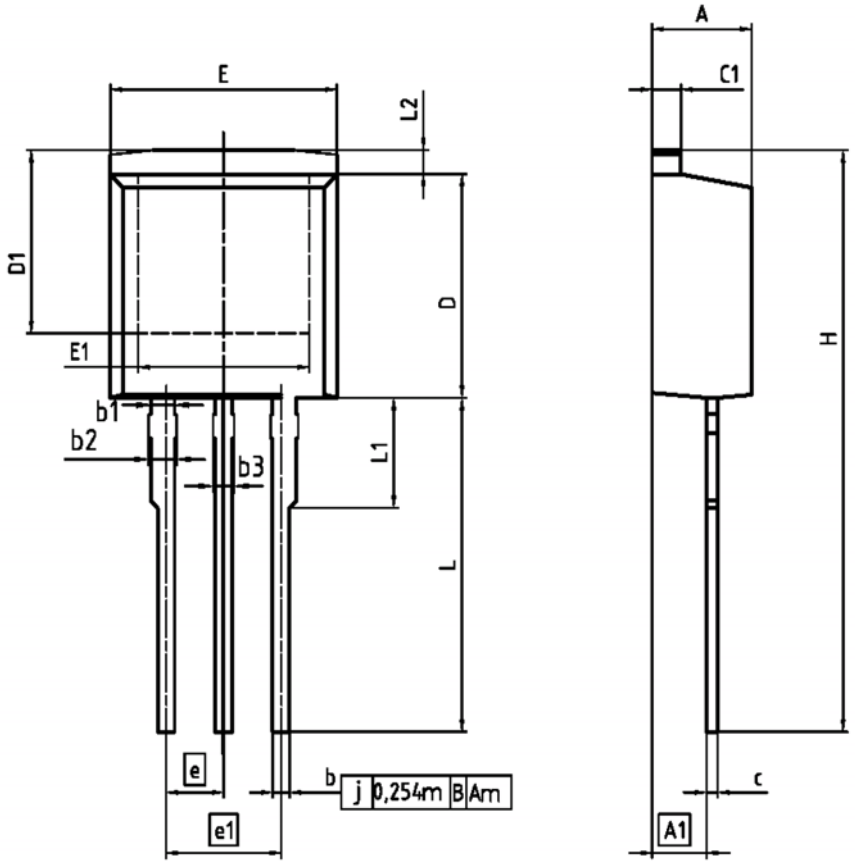
**REVISION**
07

**SCALE 5:1**
0 1 2 3 4 5mm

**EUROPEAN PROJECTION**

**ISSUE DATE**
27.01.2017

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




| DIM | MILLIMETERS | | INCHES | |
|---|---|---|---|---|
| | MIN | MAX | MIN | MAX |
| A | 4.300 | 4.572 | 0.169 | 0.180 |
| A1 | 2.150 | 2.718 | 0.085 | 0.107 |
| b | 0.650 | 0.864 | 0.026 | 0.034 |
| b1 | 0.950 | 1.093 | 0.037 | 0.043 |
| b2 | 0.950 | 1.400 | 0.037 | 0.055 |
| b3 | 0.650 | 1.118 | 0.026 | 0.044 |
| c | 0.330 | 0.600 | 0.013 | 0.024 |
| c1 | 1.170 | 1.400 | 0.046 | 0.055 |
| D | 8.509 | 9.450 | 0.335 | 0.372 |
| D1 | 6.900 | - | 0.272 | - |
| E | 9.700 | 10.363 | 0.382 | 0.408 |
| E1 | 6.500 | 8.600 | 0.256 | 0.339 |
| e | 2.540 | | 0.100 | |
| e1 | 5.080 | | 0.200 | |
| N | 3 | | 3 | |
| L | 13.000 | 14.000 | 0.512 | 0.551 |
| L1 | - | 4.800 | - | 0.189 |
| L2 | - | 1.727 | - | 0.068 |

REFERENCE
JEDEC TO262

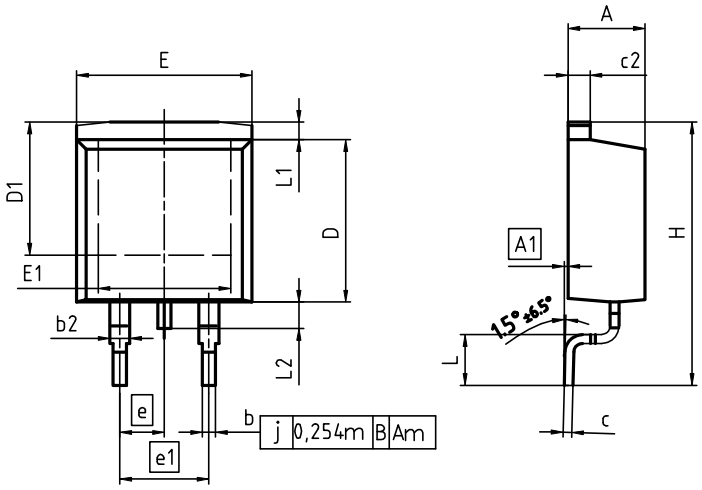
SCALE 0 2.5 0 2.5 5mm

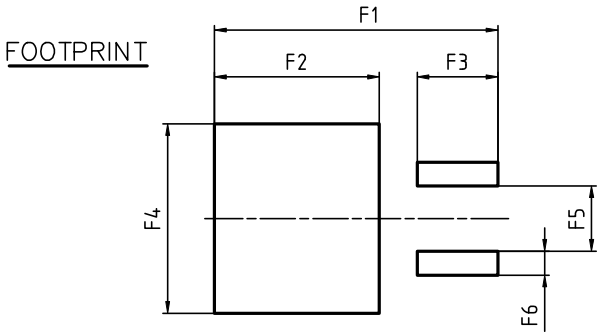
EUROPEAN PROJECTION

ISSUE DATE
05-05-2006

FILE
TO262_1

**Figure 4 Outlines TO-262, dimensions in mm/inches**




| DIM | MILLIMETERS | | INCHES | |
|---|---|---|---|---|
| | MIN | MAX | MIN | MAX |
| A | 4.30 | 4.57 | 0.169 | 0.180 |
| A1 | 0.00 | 0.25 | 0.000 | 0.010 |
| b | 0.65 | 0.85 | 0.026 | 0.033 |
| b2 | 0.95 | 1.15 | 0.037 | 0.045 |
| c | 0.33 | 0.65 | 0.013 | 0.026 |
| c2 | 1.17 | 1.40 | 0.046 | 0.055 |
| D | 8.51 | 9.45 | 0.335 | 0.372 |
| D1 | 7.10 | 7.90 | 0.280 | 0.311 |
| E | 9.80 | 10.31 | 0.386 | 0.406 |
| E1 | 6.50 | 8.60 | 0.256 | 0.339 |
| e | 2.54 | | 0.100 | |
| e1 | 5.08 | | 0.200 | |
| N | 2 | | 2 | |
| H | 14.61 | 15.88 | 0.575 | 0.625 |
| L | 2.29 | 3.00 | 0.090 | 0.118 |
| L1 | 0.70 | 1.60 | 0.028 | 0.063 |
| L2 | 1.00 | 1.78 | 0.039 | 0.070 |
| F1 | 16.05 | 16.25 | 0.632 | 0.640 |
| F2 | 9.30 | 9.50 | 0.366 | 0.374 |
| F3 | 4.50 | 4.70 | 0.177 | 0.185 |
| F4 | 10.70 | 10.90 | 0.421 | 0.429 |
| F5 | 3.65 | 3.85 | 0.144 | 0.152 |
| F6 | 1.25 | 1.45 | 0.049 | 0.057 |

DOCUMENT NO.
Z8B00003324

SCALE 0 5 5 7.5mm

EUROPEAN PROJECTION

ISSUE DATE
30-08-2007

REVISION
01

**Figure 5 Outlines TO-263, dimensions in mm/inches**

## Revision History

IPx65R380C6

**Revision: 2020-05-20, Rev. 2.2**

| Previous Revision | | |
|---|---|---|
| Revision | Date | Subjects (major changes since last revision) |
| 2.1 | 2018-03-05 | Outline PG-TO220 FullPAK update |
| 2.2 | 2020-05-20 | Update of the package outlines TO-252 |



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