**MOSFET**

Metal Oxide Semiconductor Field Effect Transistor

**CoolMOS™ C6 600V**

600V CoolMOS™ C6 Power Transistor
IPx60R190C6

**Data Sheet**

Rev. 2.3
Final

**Power Management & Multimarket**

**600V CoolMOS™ C6 Power Transistor**

**IPA60R190C6, IPB60R190C6**
**IPI60R190C6, IPP60R190C6**
**IPW60R190C6**

# 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 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

- Extremely low losses due to very low FOM $R_{dson}*Q_g$ and $E_{oss}$
- Very high commutation ruggedness
- Easy to use/drive
- JEDEC[1] qualified, Pb-free plating, Halogen free

### 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.*
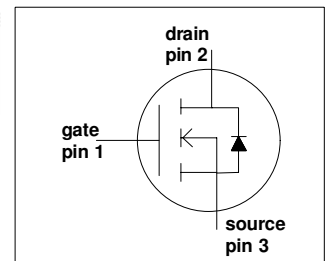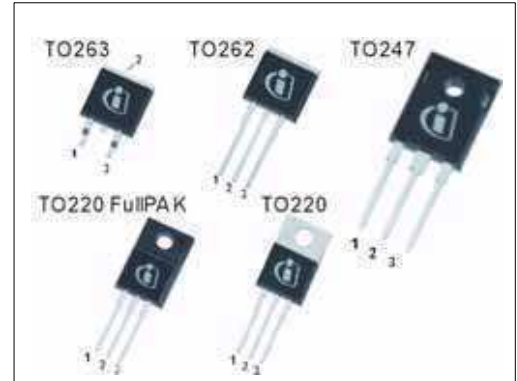
**Table 1      Key Performance Parameters**

| Parameter | Value | Unit |
|---|---|---|
| $V_{DS}$ @ $T_{j,max}$ | 650 | V |
| $R_{DS(on),max}$ | 0.19 | Ω |
| $Q_{g,typ}$ | 63 | nC |
| $I_{D,pulse}$ | 59 | A |
| $E_{oss}$ @ 400V | 5.2 | μJ |
| Body diode d$i$/d$t$ | 500 | A/μs |

| Type / Ordering Code | Package | Marking | Related Links |
|---|---|---|---|
| IPW60R190C6 | PG-TO247 | | [IFX C6 Product Brief](#) |
| IPB60R190C6 | PG-TO263 | | [IFX C6 Portfolio](#) |
| IPI60R190C6 | PG-TO262 | 6R190C6 | [IFX CoolMOS Webpage](#) |
| IPP60R190C6 | PG-TO220 | | [IFX Design tools](#) |
| IPA60R190C6 | PG-TO220 FullPAK | | |

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1)   J-STD20 and JESD22

# 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] | $I_D$ | - | - | 20.2 | A | $T_C$= 25 °C |
| | | | | 12.8 | | $T_C$= 100°C |
| Pulsed drain current[2] | $I_{D,pulse}$ | - | - | 59 | A | $T_C$=25 °C |
| Avalanche energy, single pulse | $E_{AS}$ | - | - | 418 | mJ | $I_D$=3.4 A, $V_{DD}$=50 V (see table 21) |
| Avalanche energy, repetitive | $E_{AR}$ | - | - | 0.63 | | $I_D$=3.4 A, $V_{DD}$=50 V |
| Avalanche current, repetitive | $I_{AR}$ | - | - | 3.4 | 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-247, TO-262, TO-263 | $P_{tot}$ | - | - | 151 | W | $T_C$=25 °C |
| Power dissipation for TO-220 FullPAK | $P_{tot}$ | - | - | 34 | | |
| Operating and storage temperature | $T_j$, $T_{stg}$ | - 55 | - | 150 | °C | |
| Mounting torque TO-220, TO-247 | | - | - | 60 | Ncm | M3 and M3.5 screws |
| Mounting torque TO-220 FullPAK | | | | 50 | | M2.5 screws |
| Continuous diode forward current | $I_S$ | - | - | 17.5 | A | $T_C$=25 °C |
| Diode pulse current[2] | $I_{S,pulse}$ | - | - | 59 | A | $T_C$=25 °C |
| Reverse diode dv/dt[3] | dv/dt | - | - | 15 | V/ns | $V_{DS}$=0...400 V, $I_{SD}$~ $I_D$, |
| Maximum diode commutation speed[3] | $di_f/dt$ | - | - | 500 | A/µs | $T_j$=25 °C (see table 22) |
| Insulation withstand voltage TO-220 FullPAK | $V_{ISO}$ | - | - | 2500 | V | $V_{RMS}$, $T_C$=25 °C, $t$ = 1 min |

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 (IPP60R190C6),TO-247 (IPW60R190C6),TO-262 (IPI60R190C6)**

| Parameter | Symbol | Values | | | Unit | Note / Test Condition |
|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | |
| Thermal resistance, junction - case | $R_{thJC}$ | - | - | 0.83 | °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-220 FullPAK (IPA60R190C6)**

| Parameter | Symbol | Values | | | Unit | Note / Test Condition |
|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | |
| Thermal resistance, junction - case | $R_{thJC}$ | - | - | 3.7 | °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 (IPB60R190C6)**

| Parameter | Symbol | Values | | | Unit | Note / Test Condition |
|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | |
| Thermal resistance, junction - case | $R_{thJC}$ | - | - | 0.83 | °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- & reflow soldering allowed | $T_{sold}$ | - | - | 260 | °C | reflow MSL1 |

1)   Device on 40mm*40mm*1.5mm one layer epoxy PCB FR4 with 6cm$^2$ copper area (thickness 70µm) 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 | $V_{(BR)DSS}$ | 600 | - | - | V | $V_{GS}$=0 V, $I_D$=0.25 mA |
| Gate threshold voltage | $V_{GS(th)}$ | 2.5 | 3 | 3.5 | | $V_{DS}$=$V_{GS}$, $I_D$=0.63mA |
| 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 | $R_{DS(on)}$ | - | 0.17 | 0.19 | Ω | $V_{GS}$=10 V, $I_D$=9.5 A, $T_j$=25 °C |
| | | - | 0.44 | - | | $V_{GS}$=10 V, $I_D$=9.5 A, $T_j$=150 °C |
| Gate resistance | $R_G$ | - | 8.5 | - | Ω | $f$=1 MHz, open drain |

**Table 7    Dynamic characteristics**

| Parameter | Symbol | Values | | | Unit | Note / Test Condition |
|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | |
| Input capacitance | $C_{iss}$ | - | 1400 | - | pF | $V_{GS}$=0 V, $V_{DS}$=100 V, $f$=1 MHz |
| Output capacitance | $C_{oss}$ | - | 85 | - | | |
| Effective output capacitance, energy related[1] | $C_{o(er)}$ | - | 56 | - | | $V_{GS}$=0 V, $V_{DS}$=0...480 V |
| Effective output capacitance, time related[2] | $C_{o(tr)}$ | - | 266 | - | | $I_D$=constant, $V_{GS}$=0 V $V_{DS}$=0...480V |
| Turn-on delay time | $t_{d(on)}$ | - | 15 | - | ns | $V_{DD}$=400 V, $V_{GS}$=13 V, $I_D$=9.5A, $R_G$= 3.4Ω (see table 20) |
| Rise time | $t_r$ | - | 11 | - | | |
| Turn-off delay time | $t_{d(off)}$ | - | 110 | - | | |
| Fall time | $t_f$ | - | 9 | - | | |

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. | | |
| Gate to source charge | $Q_{gs}$ | - | 7.6 | - | nC | $V_{DD}$=480 V, $I_D$=9.5A, $V_{GS}$=0 to 10 V |
| Gate to drain charge | $Q_{gd}$ | - | 32 | - | | |
| Gate charge total | $Q_g$ | - | 63 | - | | |
| Gate plateau voltage | $V_{plateau}$ | - | 5.4 | - | 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, $I_F$=9.5A, $T_j$=25 °C |
| Reverse recovery time | $t_{rr}$ | - | 430 | - | ns | $V_R$=400 V, $I_F$=9.5A, $di_F/dt$=100 A/µs (see table 22) |
| Reverse recovery charge | $Q_{rr}$ | - | 6.9 | - | µC | |
| Peak reverse recovery current | $I_{rrm}$ | - | 30 | - | A | |

# 5 Electrical characteristics diagrams

**Table 10**

| Power dissipation<br>TO-220, TO-247, TO-262, TO-263 | Power dissipation<br>TO-220 FullPAK |
|---|---|
|  |  |
| $P_{tot} = f(T_C)$ | $P_{tot} = f(T_C)$ |

**Table 11**

| Max. transient thermal impedance<br>TO-220, TO-247, TO-262, TO-263 | Max. transient thermal impedance<br>TO-220 FullPAK |
|---|---|
|  |  |
| $Z_{(thJC)}=f(tp)$; parameter: $D=t_p/T$ | $Z_{(thJC)}=f(tp)$; parameter: $D=t_p/T$ |

**Table 12**

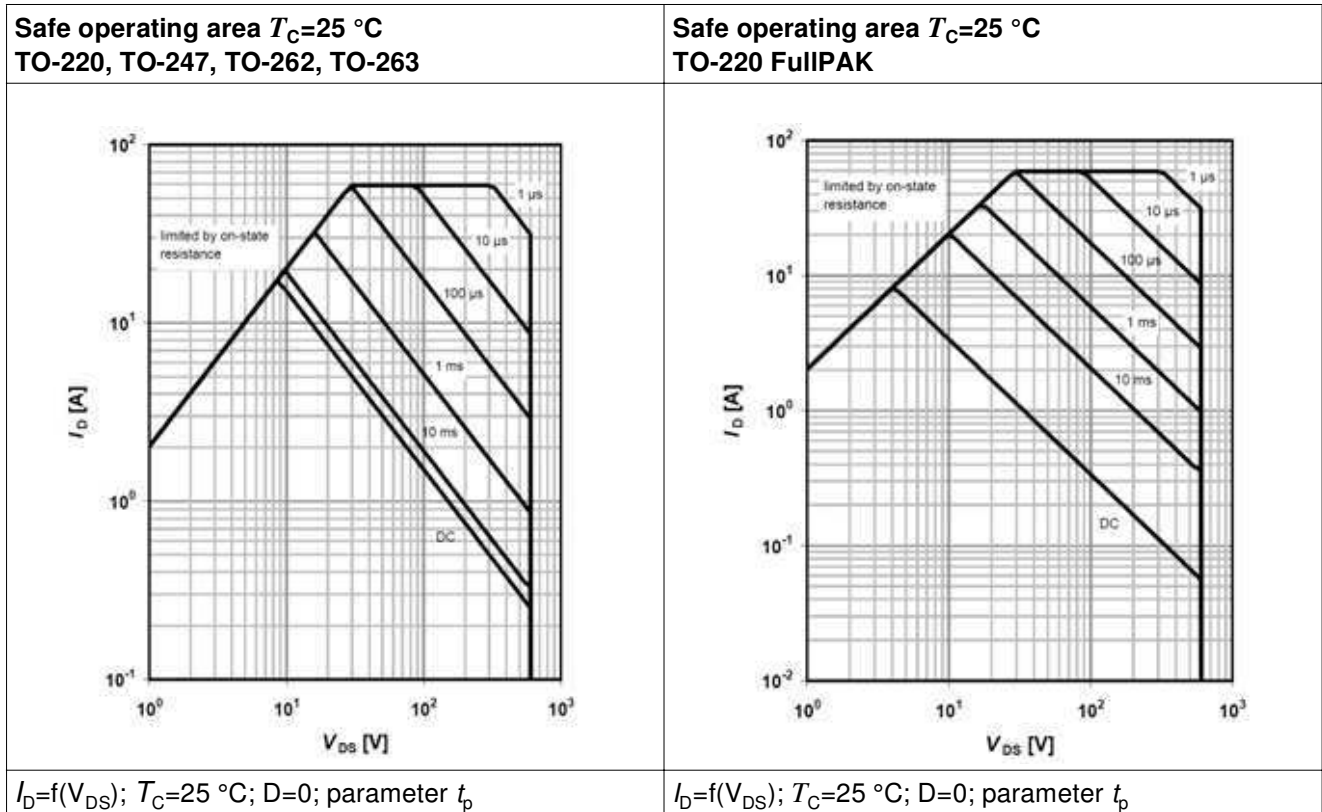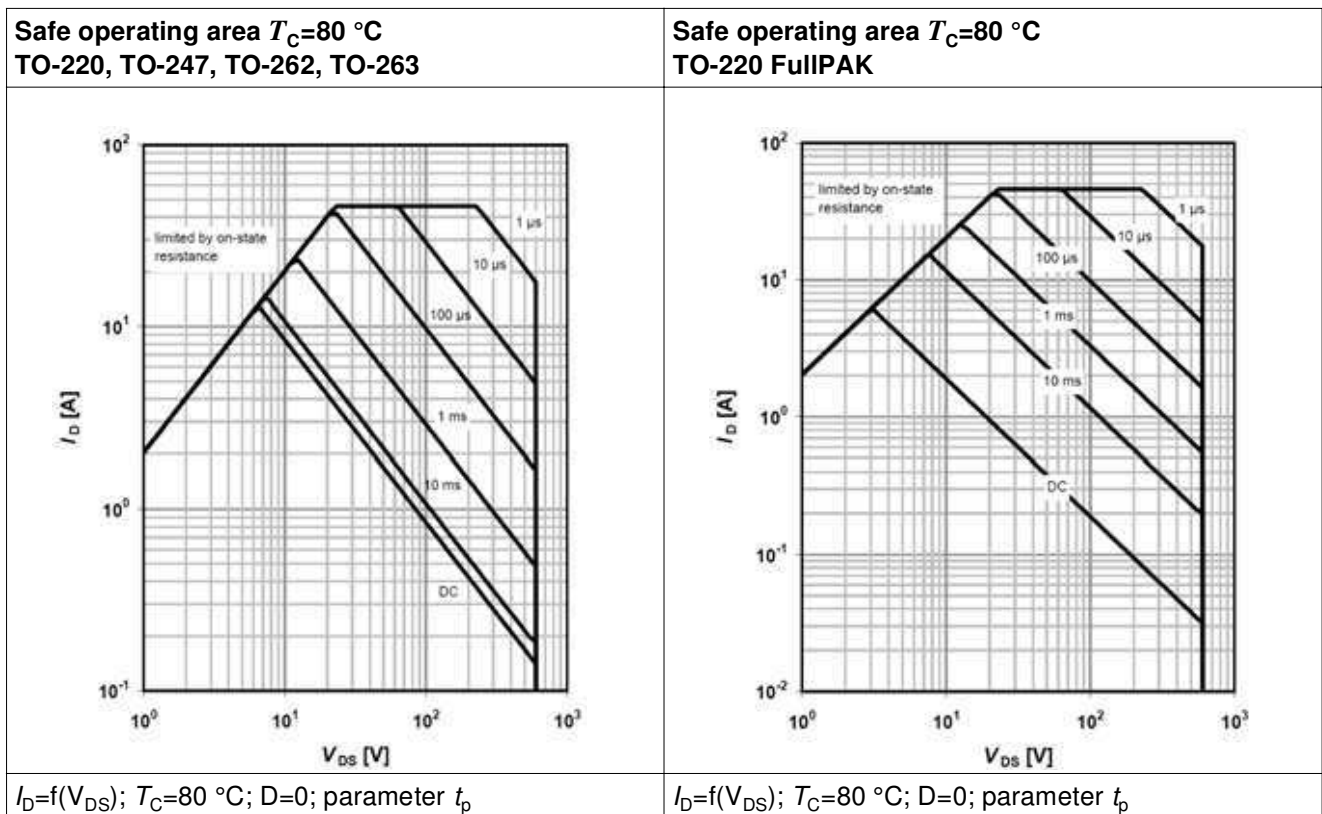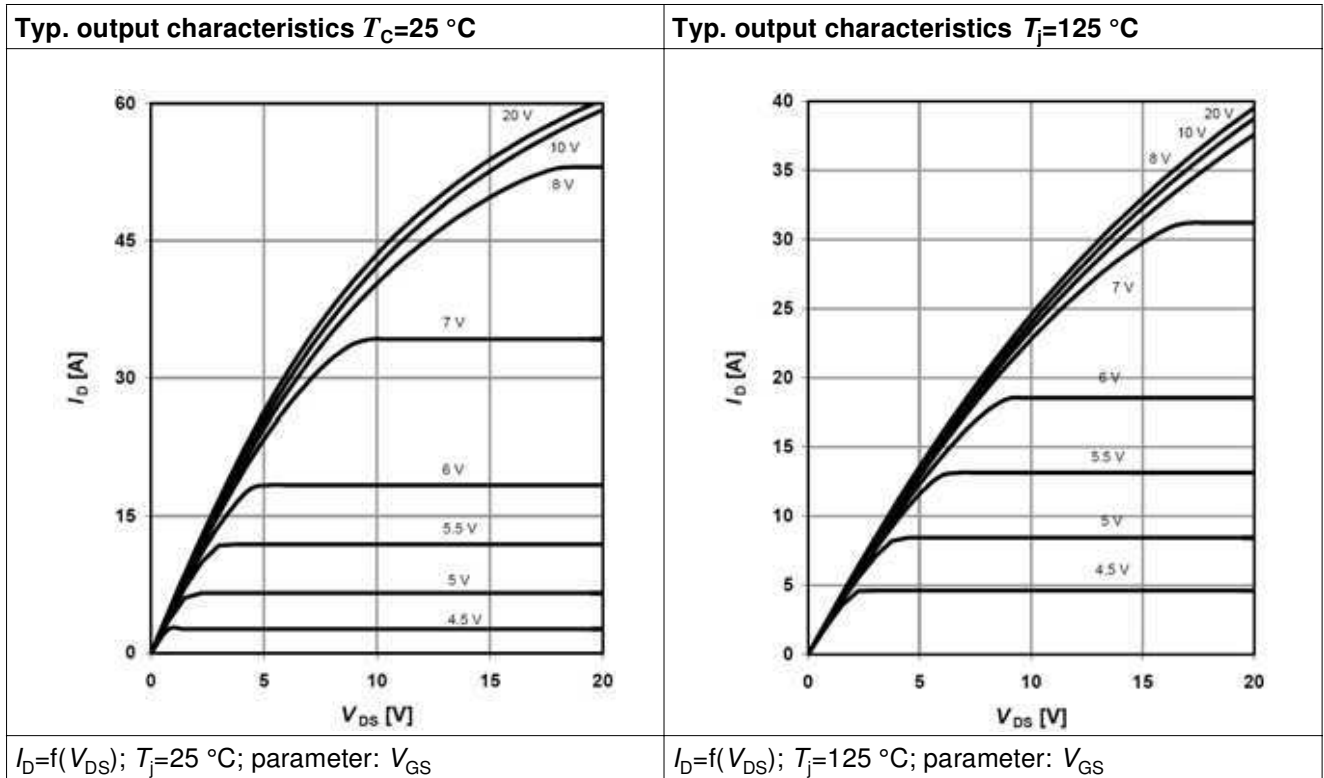| Safe operating area $T_C$=25 °C<br>TO-220, TO-247, TO-262, TO-263 | Safe operating area $T_C$=25 °C<br>TO-220 FullPAK |
|---|---|
|  |  |
| $I_D$=f($V_{DS}$); $T_C$=25 °C; D=0; parameter $t_p$ | $I_D$=f($V_{DS}$); $T_C$=25 °C; D=0; parameter $t_p$ |

**Table 13**

| Safe operating area $T_C$=80 °C<br>TO-220, TO-247, TO-262, TO-263 | Safe operating area $T_C$=80 °C<br>TO-220 FullPAK |
|---|---|
|  |  |
| $I_D$=f($V_{DS}$); $T_C$=80 °C; D=0; parameter $t_p$ | $I_D$=f($V_{DS}$); $T_C$=80 °C; 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($T_j$); $I_D$=9.5 A; $V_{GS}$=10 V |

**Table 16**

| Typ. transfer characteristics | Typ. gate charge |
|---|---|
|  |  |
| $I_D$=f($V_{GS}$); $V_{DS}$=20V | $V_{GS}$=f($Q_{gate}$), $I_D$=9.5A pulsed |

**Table 17**

| Avalanche energy | Drain-source breakdown voltage |
|---|---|
|  |  |
| $E_{AS}$=f($T_j$); $I_D$=3.4 A; $V_{DD}$=50 V | $V_{BR(DSS)}$=f($T_j$); $I_D$=0.25 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**

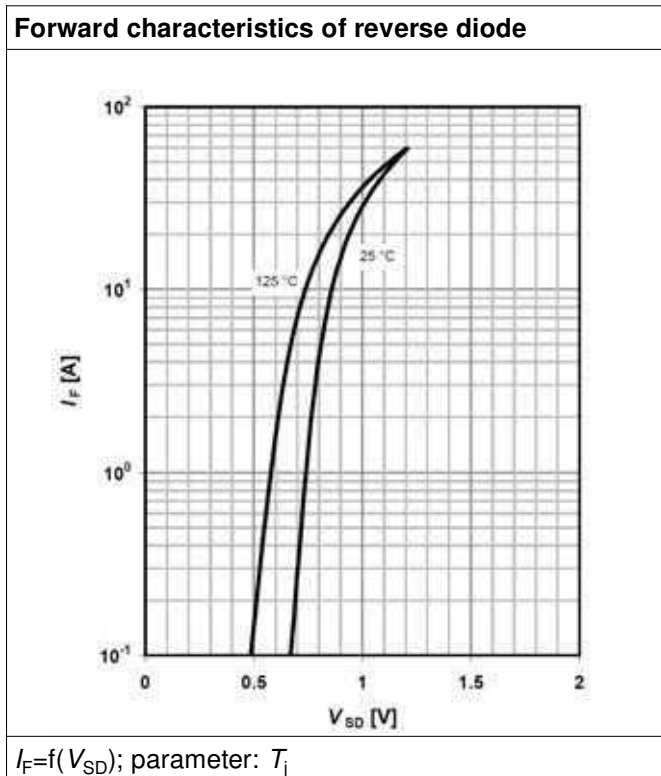| Forward characteristics of reverse diode |
|---|
|  |
| $I_F$=f($V_{SD}$); parameter: $T_j$ |
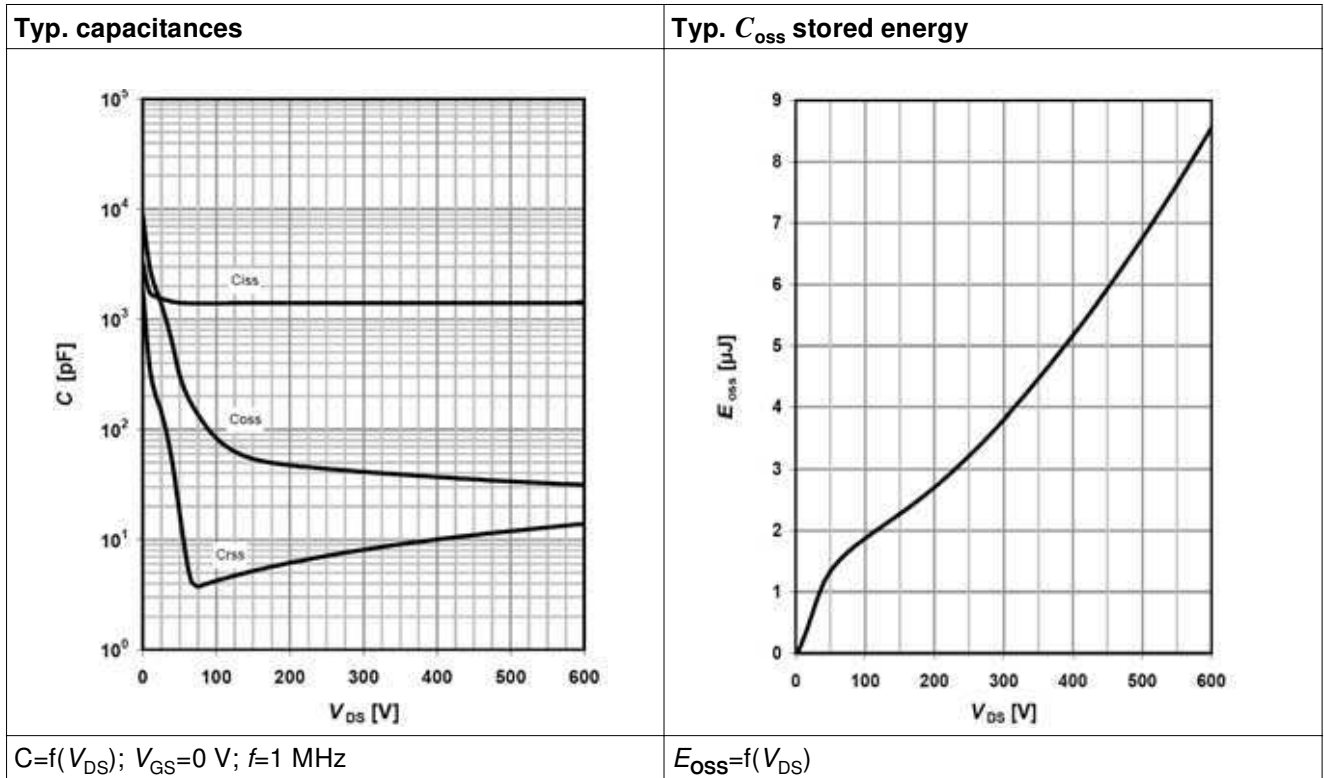
# 6 Test circuits

**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**

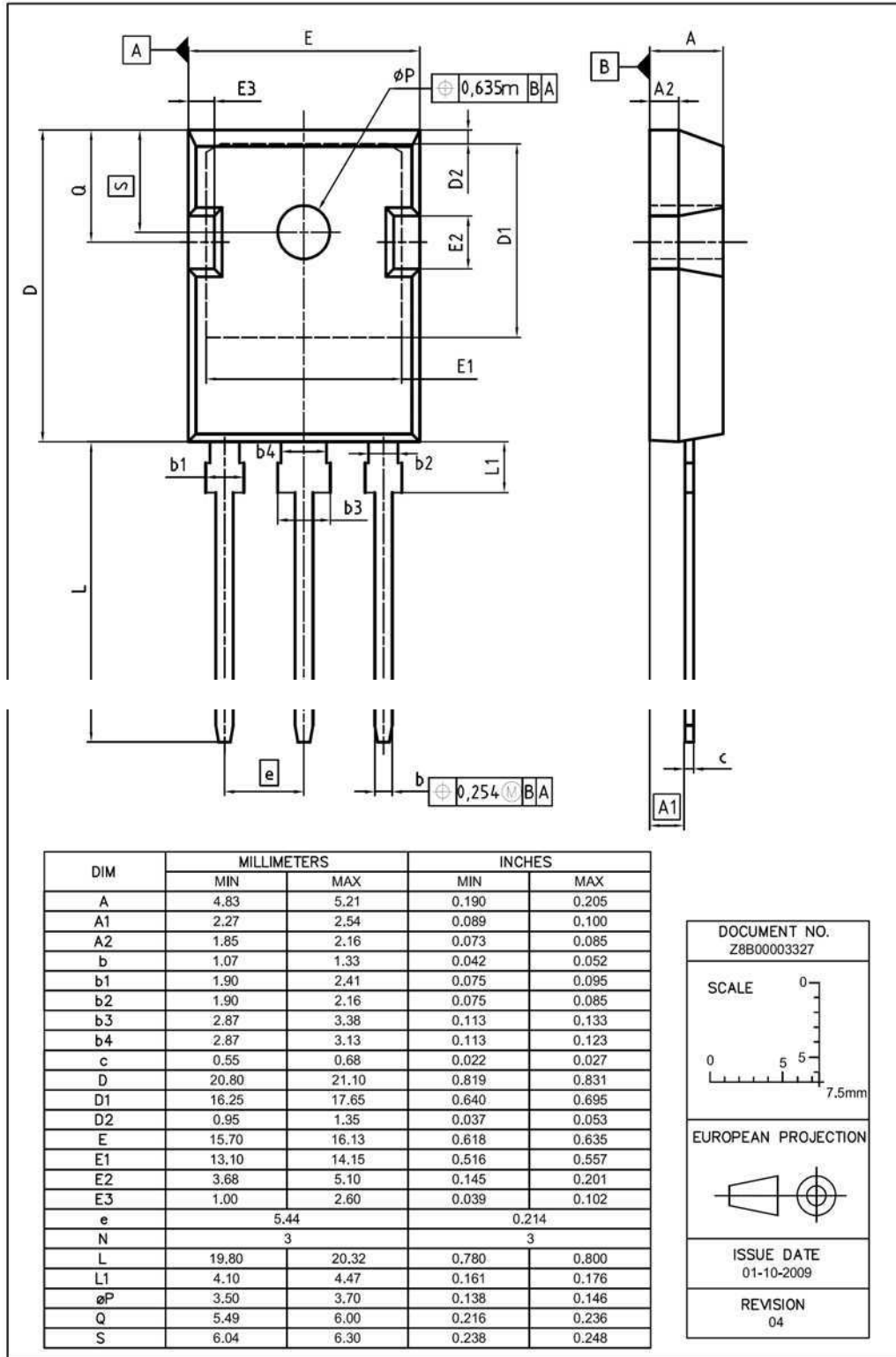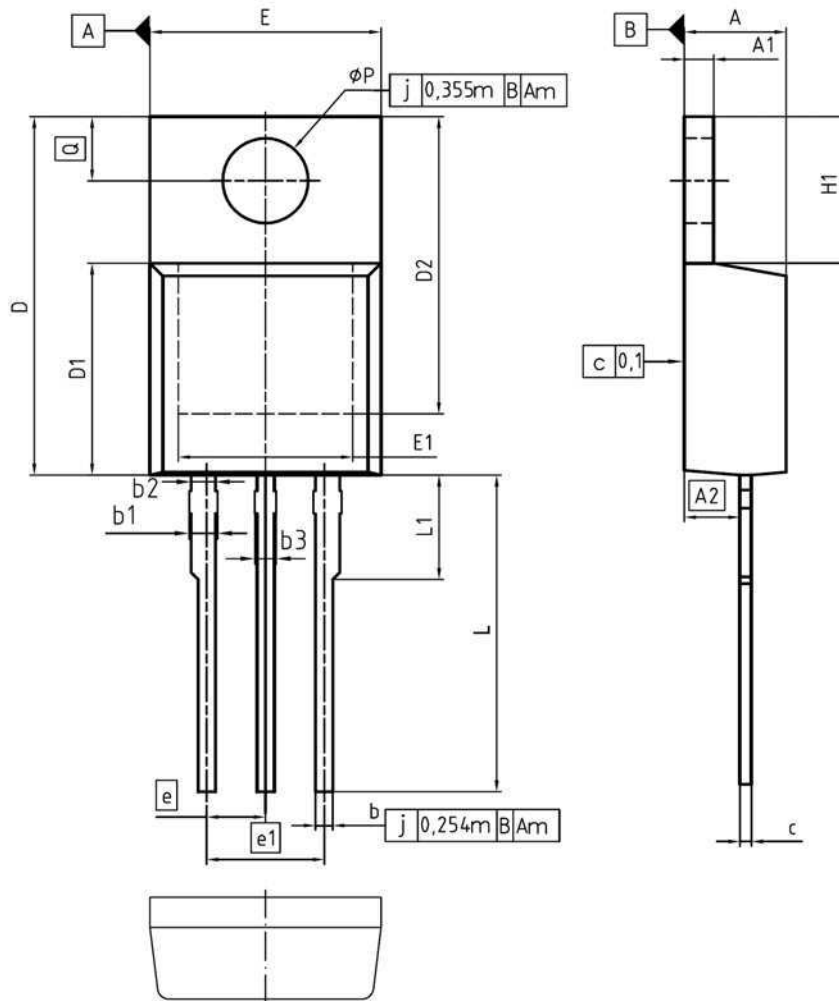| Test circuit for diode characteristics | Diode recovery waveform |
|---|---|
|  |  |

# 7 Package outlines



| 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 | | 0.214 | |
| 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

7.5mm

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ISSUE DATE
01-10-2009

REVISION
04

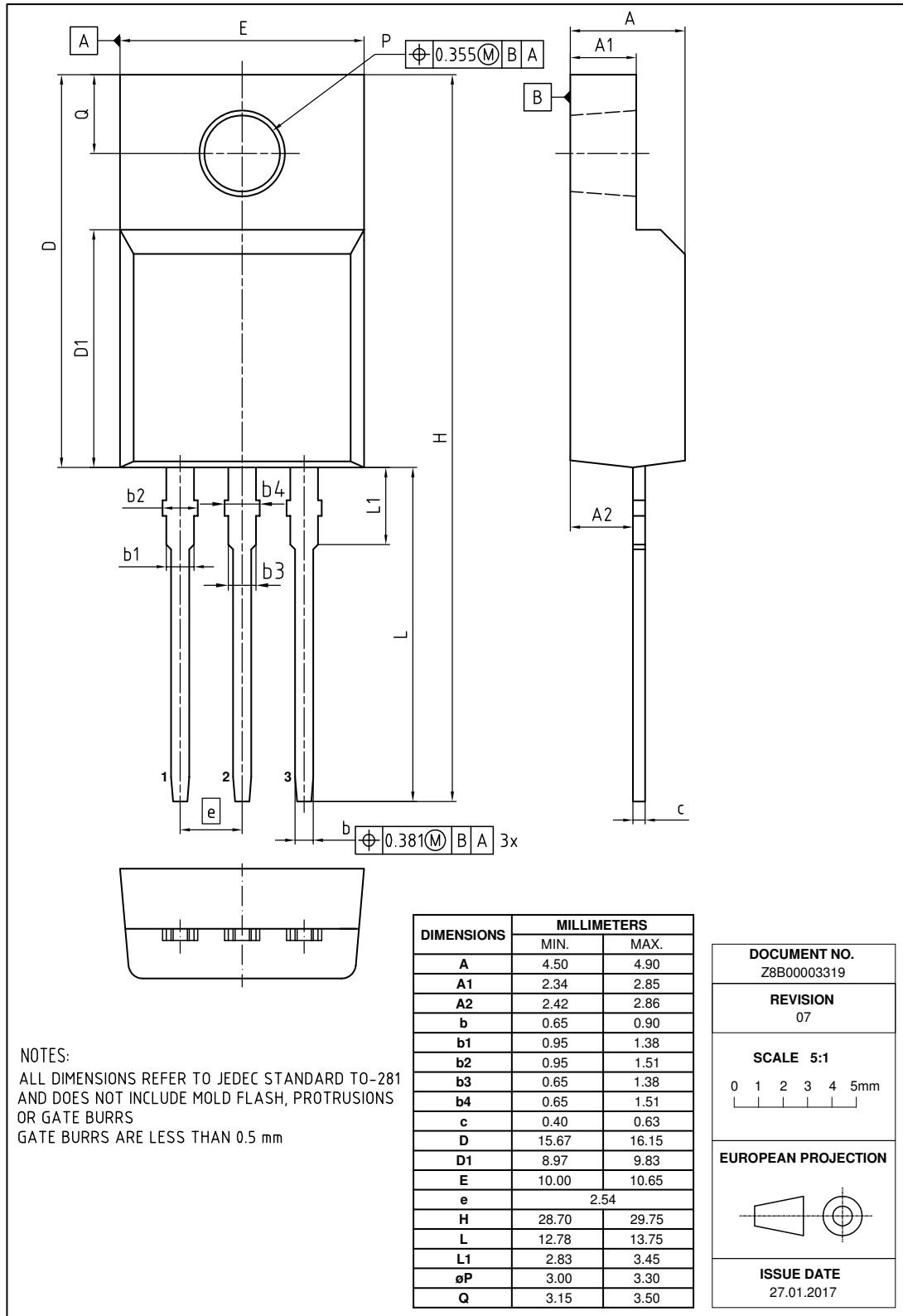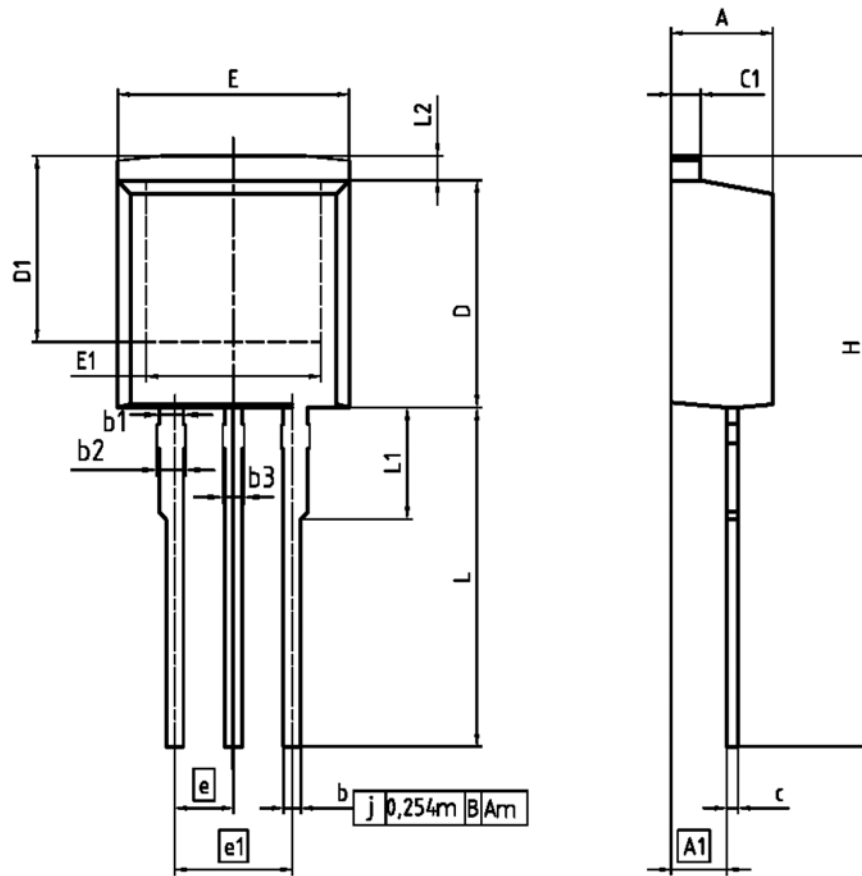**Figure 1      Outlines TO-247, dimensions in mm/inches**

| DIM | MILLIMETERS | | INCHES | | | DOCUMENT NO. |
|-----|-----|-----|-----|-----|---|---|
| | MIN | MAX | MIN | MAX | | Z8B00003318 |
| A | 4.30 | 4.57 | 0.169 | 0.180 | | |
| A1 | 1.17 | 1.40 | 0.046 | 0.055 | | SCALE |
| 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 | | EUROPEAN PROJECTION |
| 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 | | ISSUE DATE |
| L | 13.00 | 14.00 | 0.512 | 0.551 | | 23-08-2007 |
| L1 | - | 4.80 | - | 0.189 | | REVISION |
| øP | 3.60 | 3.89 | 0.142 | 0.153 | | 05 |
| 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 |

DOCUMENT NO.
Z8B00003319

REVISION
07

SCALE 5:1

0 1 2 3 4 5mm

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27.01.2017

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

**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

EUROPEAN PROJECTION

ISSUE DATE
05-05-2006

FILE
TO262_1

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

FOOTPRINT
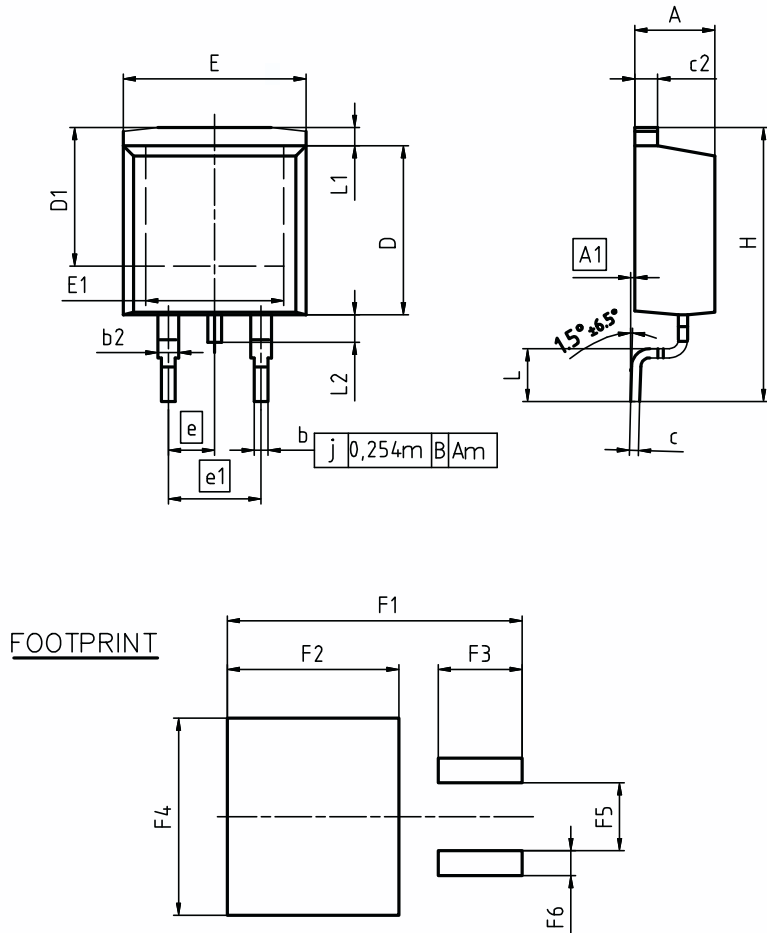
| DIM | MILLIMETERS | | INCHES | |
|-----|-----|-----|-----|-----|
| | **MIN** | **MAX** | **MIN** | **MAX** |
| A | 4.30 | 4.57 | 0.169 | 0.180 |
| A1 | 0.00 | 0.25 | 0.000 | 0.010 |
| b | 0.65 | 0.85 | 0.026 | 0.033 |
| b2 | 0.95 | 1.15 | 0.037 | 0.045 |
| c | 0.33 | 0.65 | 0.013 | 0.026 |
| c2 | 1.17 | 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

7.5mm

EUROPEAN PROJECTION

ISSUE DATE
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REVISION
01

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

## Revision History

IPx60R190C6

**Revision: 2018-03-04, Rev. 2.3**

Previous Revision

| Revision | Date | Subjects (major changes since last revision) |
|---|---|---|
| 2.0 | 2011-06-08 | Release of final data sheet |
| 2.1 | 2011-09-14 | - |
| 2.2 | 2015-02-09 | PG-TO220 FullPAK package outline update (creation:2014-12-02) |
| 2.3 | 2018-03-04 | Outline PG-TO220 FullPAK update |

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