

MOSFET

Metal Oxide Semiconductor Field Effect Transistor

CoolMOS™ C6

650V CoolMOS™ C6 Power Transistor
IPx65R380C6

Data Sheet

Rev. 2.1
Final

650V CoolMOS™ C6 Power Transistor

IPD65R380C6, IPI65R380C6
IPB65R380C6, IPP65R380C6
IPA65R380C6

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 $R_{DS(on)} \cdot Q_g$ and E_{oss}
- Very high commutation ruggedness
- Easy to use/drive
- JEDEC¹⁾ qualified, Pb-free plating, Halogen free²⁾

Applications

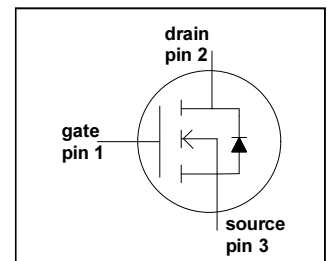
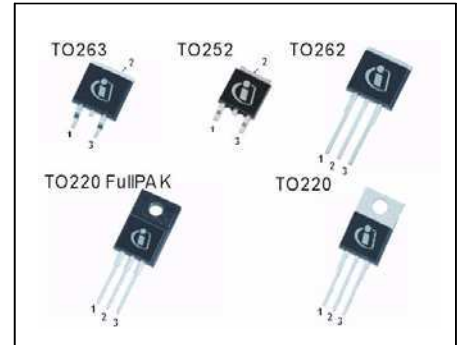
PFC stages, hard switching PWM stages and resonant switching PWM stages for e.g. PC Silverbox, Adapter, LCD & PDP TV, Lighting, Server, Telecom and UPS.

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 di/dt | 500 | $A/\mu s$ |

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



1) J-STD20 and JESD22
2) no PG-To252

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2 Maximum ratings

at $T_j = 25\text{ °C}$, unless otherwise specified.

Table 2 Maximum ratings

| Parameter | Symbol | Values | | | Unit | Note / Test Condition |
|--|----------------|--------|------|------|------|--|
| | | Min. | Typ. | Max. | | |
| Continuous drain current ¹⁾ | I_D | - | - | 10.6 | A | $T_C = 25\text{ °C}$ |
| | | | | 6.7 | | $T_C = 100\text{ °C}$ |
| Pulsed drain current ²⁾ | $I_{D,pulse}$ | - | - | 29 | A | $T_C = 25\text{ °C}$ |
| Avalanche energy, single pulse | E_{AS} | - | - | 215 | mJ | $I_D = 1.8\text{ A}, V_{DD} = 50\text{ V}$ (see table 21) |
| Avalanche energy, repetitive | E_{AR} | - | - | 0.32 | | $I_D = 1.8\text{ A}, V_{DD} = 50\text{ V}$ |
| Avalanche current, repetitive | I_{AR} | - | - | 1.8 | A | |
| MOSFET dv/dt ruggedness | dv/dt | - | - | 50 | V/ns | $V_{DS} = 0 \dots 480\text{ V}$ |
| Gate source voltage | V_{GS} | -20 | - | 20 | V | static |
| | | -30 | | 30 | | AC ($f > 1\text{ Hz}$) |
| Power dissipation for TO-220, TO-252, TO-262, TO-263 | P_{tot} | - | - | 83 | W | $T_C = 25\text{ °C}$ |
| Power dissipation for TO-220 FullPAK | P_{tot} | - | - | 31 | W | $T_C = 25\text{ °C}$ |
| 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 | $T_C = 25\text{ °C}$ |
| Diode pulse current ²⁾ | $I_{S,pulse}$ | - | - | 29 | A | $T_C = 25\text{ °C}$ |
| Reverse diode dv/dt ³⁾ | dv/dt | - | - | 15 | V/ns | $V_{DS} = 0 \dots 480\text{ V}, I_{SD} \leq I_D,$ $T_j = 125\text{ °C}$ |
| Maximum diode commutation speed ³⁾ | di/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 | leaded |
| Thermal resistance, junction - ambient | R_{thJA} | - | - | 62 | | |
| 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 | leaded |
| Thermal resistance, junction - ambient | R_{thJA} | - | - | 80 | | |
| 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 | SMD version, device on PCB, minimal footprint |
| Thermal resistance, junction - ambient | R_{thJA} | - | - | 62 | | |
| | | | | 35 | | |
| Soldering temperature, wave- & reflowsoldering allowed | T_{sold} | - | - | 260 | °C | reflow MSL1 |

1) Device on 40mm*40mm*1.5 epoxy PCB FR4 with 6cm² (one layer, 70µm thick) copper area for drain connection. PCB is vertical without air stream cooling.

4 Electrical characteristics

Electrical characteristics, at $T_J=25\text{ °C}$, 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 | $V_{GS}=0\text{ V}, I_D=1.0\text{ mA}$ |
| Gate threshold voltage | $V_{GS(th)}$ | 2.5 | 3 | 3.5 | | $V_{DS}=V_{GS}, I_D=0.32\text{ mA}$ |
| Zero gate voltage drain current | I_{DSS} | - | - | 1 | μA | $V_{DS}=600\text{ V}, V_{GS}=0\text{ V}, T_J=25\text{ °C}$ |
| | | - | 10 | - | | $V_{DS}=600\text{ V}, V_{GS}=0\text{ V}, T_J=150\text{ °C}$ |
| Gate-source leakage current | I_{GSS} | - | - | 100 | nA | $V_{GS}=20\text{ V}, V_{DS}=0\text{ V}$ |
| Drain-source on-state resistance | $R_{DS(on)}$ | - | 0.34 | 0.38 | Ω | $V_{GS}=10\text{ V}, I_D=3.2\text{ A}, T_J=25\text{ °C}$ |
| | | - | 0.89 | - | | $V_{GS}=10\text{ V}, I_D=3.2\text{ A}, T_J=150\text{ °C}$ |
| Gate resistance | R_G | - | 17 | - | Ω | $f=1\text{ MHz}, \text{open drain}$ |

Table 7 Dynamic characteristics

| Parameter | Symbol | Values | | | Unit | Note / Test Condition | |
|--|--------------|--------|------|------|------|--|---|
| | | Min. | Typ. | Max. | | | |
| Input capacitance | C_{iss} | - | 710 | - | pF | $V_{GS}=0\text{ V}, V_{DS}=100\text{ V}, f=1\text{ MHz}$ | |
| Output capacitance | C_{oss} | - | 41 | - | | | |
| Effective output capacitance, energy related ¹⁾ | $C_{o(er)}$ | - | 32 | - | | | $V_{GS}=0\text{ V}, V_{DS}=0\dots480\text{ V}$ |
| Effective output capacitance, time related ²⁾ | $C_{o(tr)}$ | - | 140 | - | | | $I_D=\text{constant}, V_{GS}=0\text{ V}, V_{DS}=0\dots480\text{ V}$ |
| Turn-on delay time | $t_{d(on)}$ | - | 12 | - | ns | $V_{DD}=400\text{ V}, V_{GS}=13\text{ V}, I_D=4.9\text{ A}, R_G=3.4\text{ }\Omega$ (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. | | |
| Gate to source charge | Q_{gs} | - | 4 | - | nC | $V_{DD}=480\text{ V}$, $I_D=4.9\text{ A}$, $V_{GS}=0\text{ to }10\text{ V}$ |
| 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 | $V_{GS}=0\text{ V}$, $I_F=4.9\text{ A}$, $T_j=25\text{ °C}$ |
| Reverse recovery time | t_{rr} | - | 280 | - | ns | $V_R=400\text{ V}$, $I_F=4.9\text{ A}$, $di_F/dt=100\text{ A}/\mu\text{s}$ (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 Non FullPAK | Power dissipation FullPAK |
|----------------------------------|------------------------------|
| | |
| $P_{tot} = f(T_C)$ | $P_{tot} = f(T_C)$ |

Table 11

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

Table 12

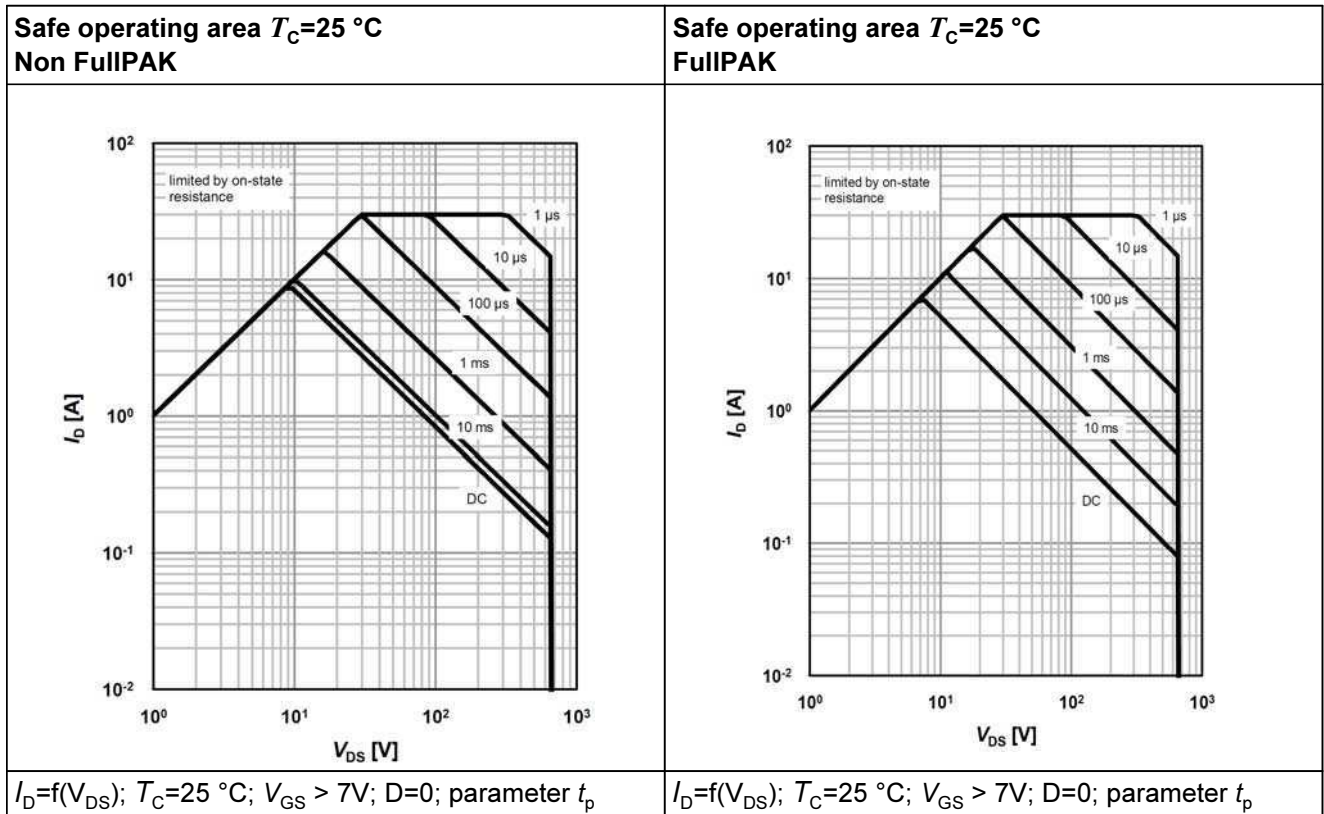


Table 13

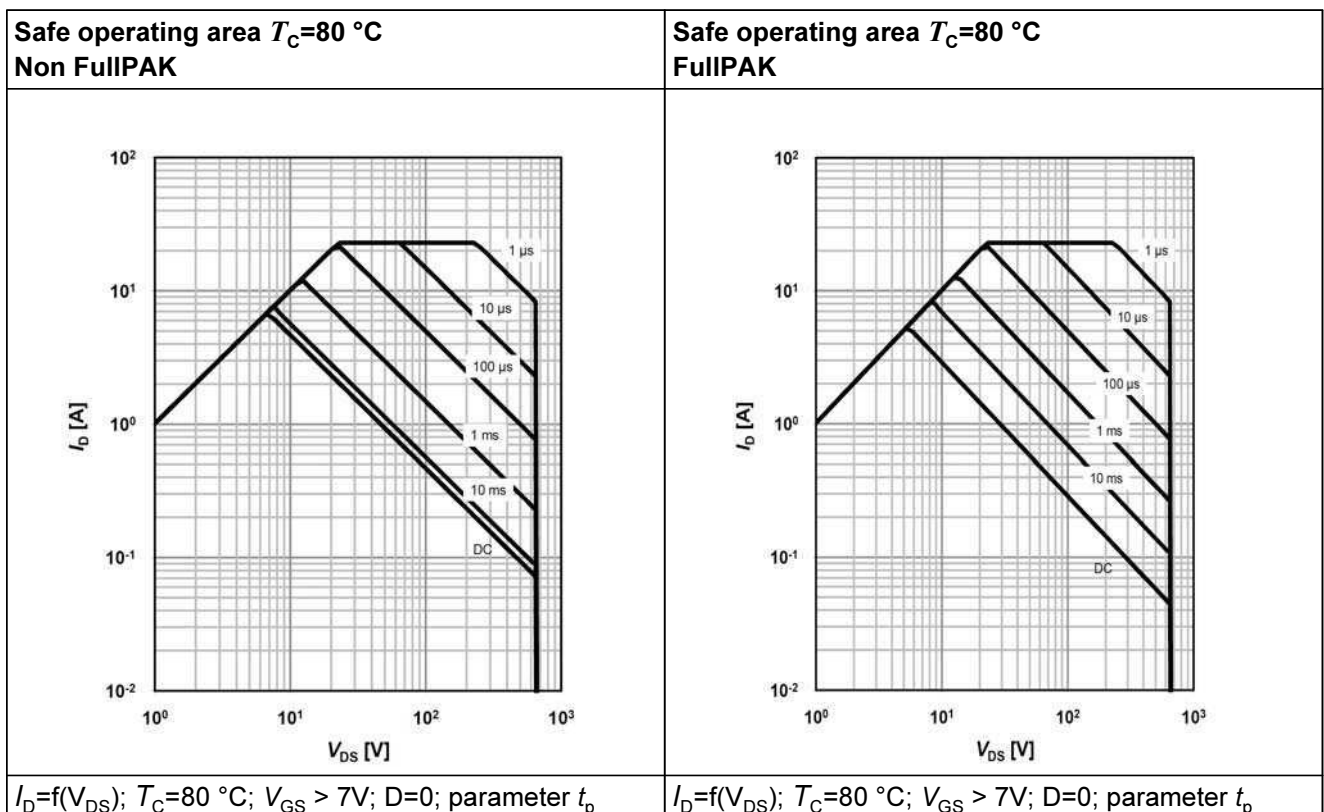


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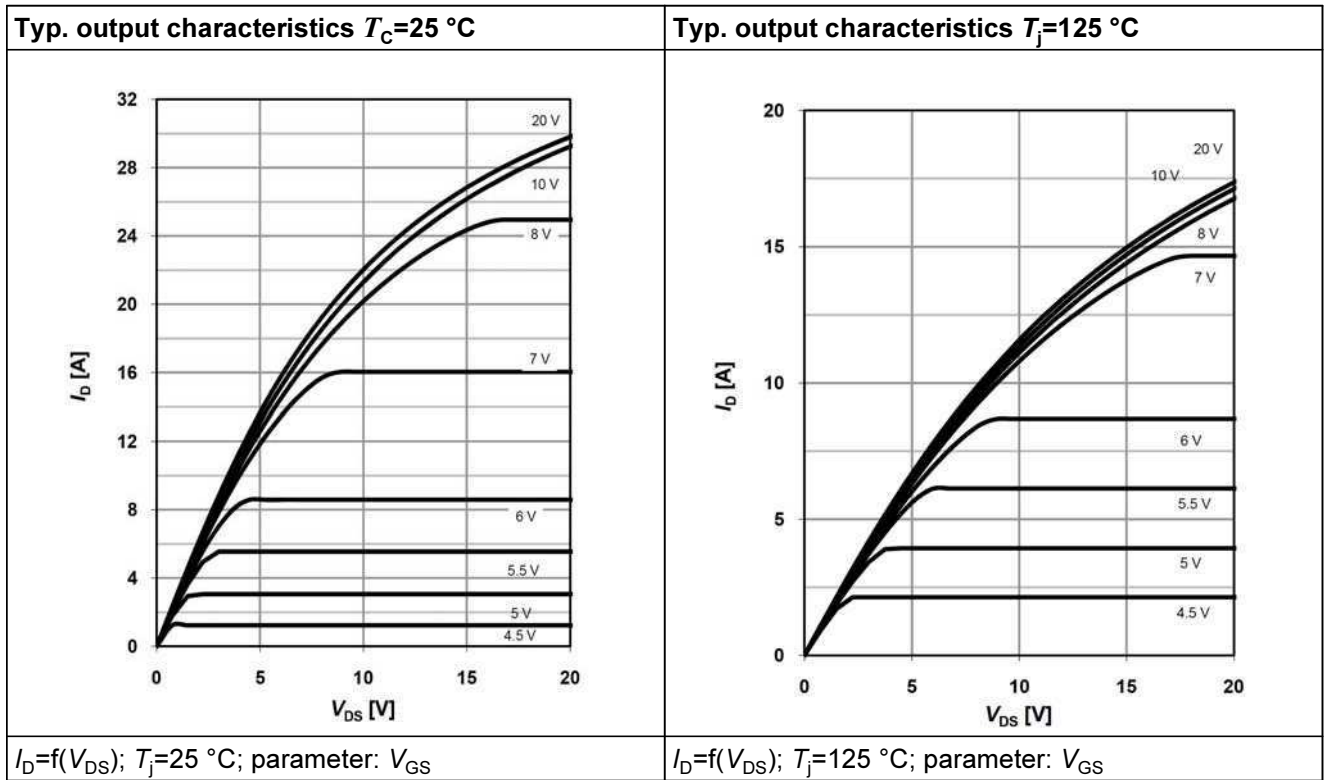


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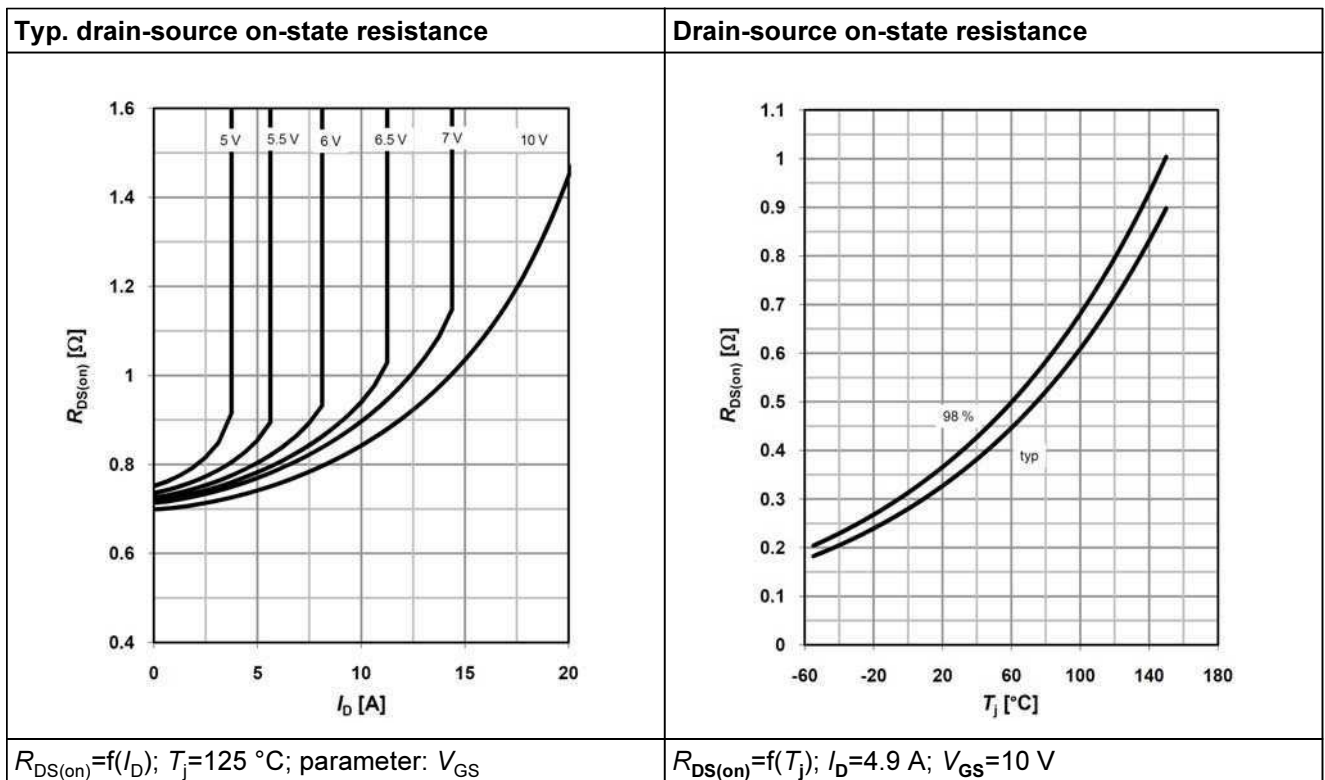


Table 16

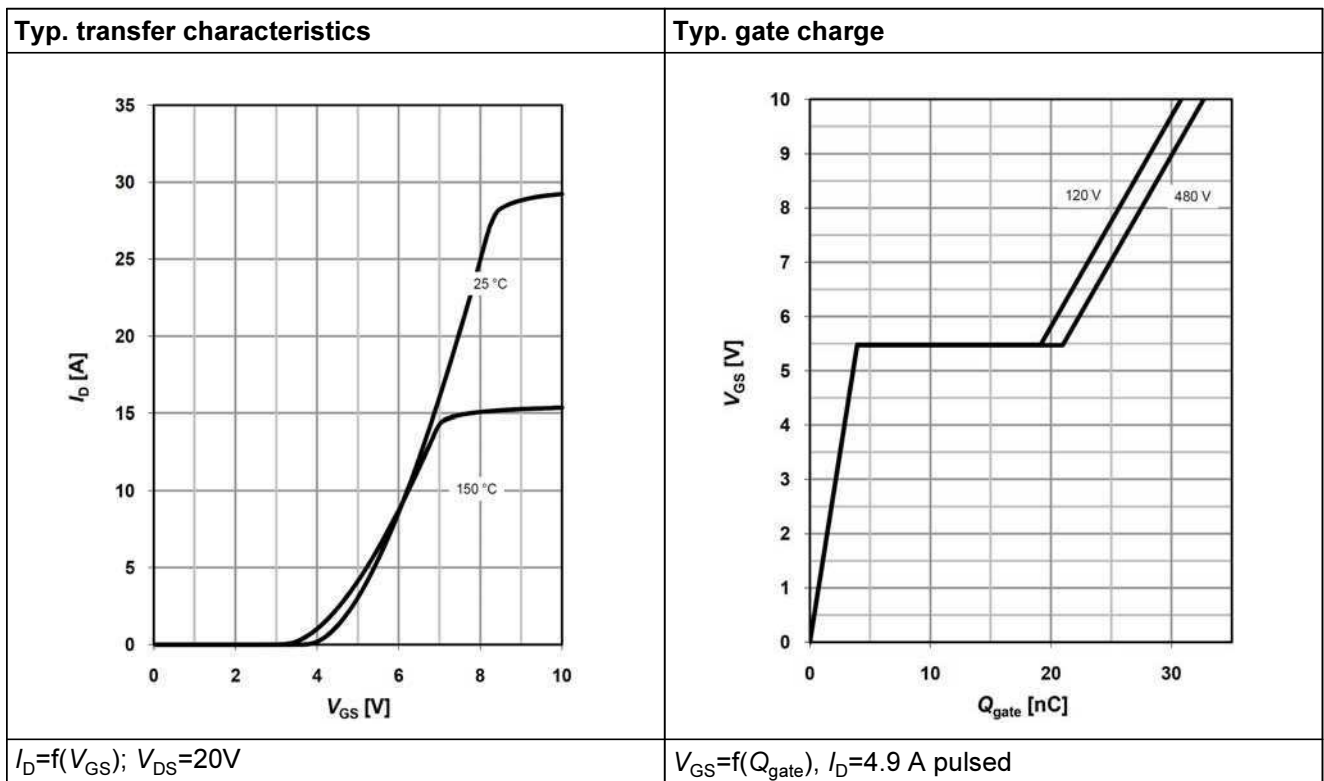


Table 17

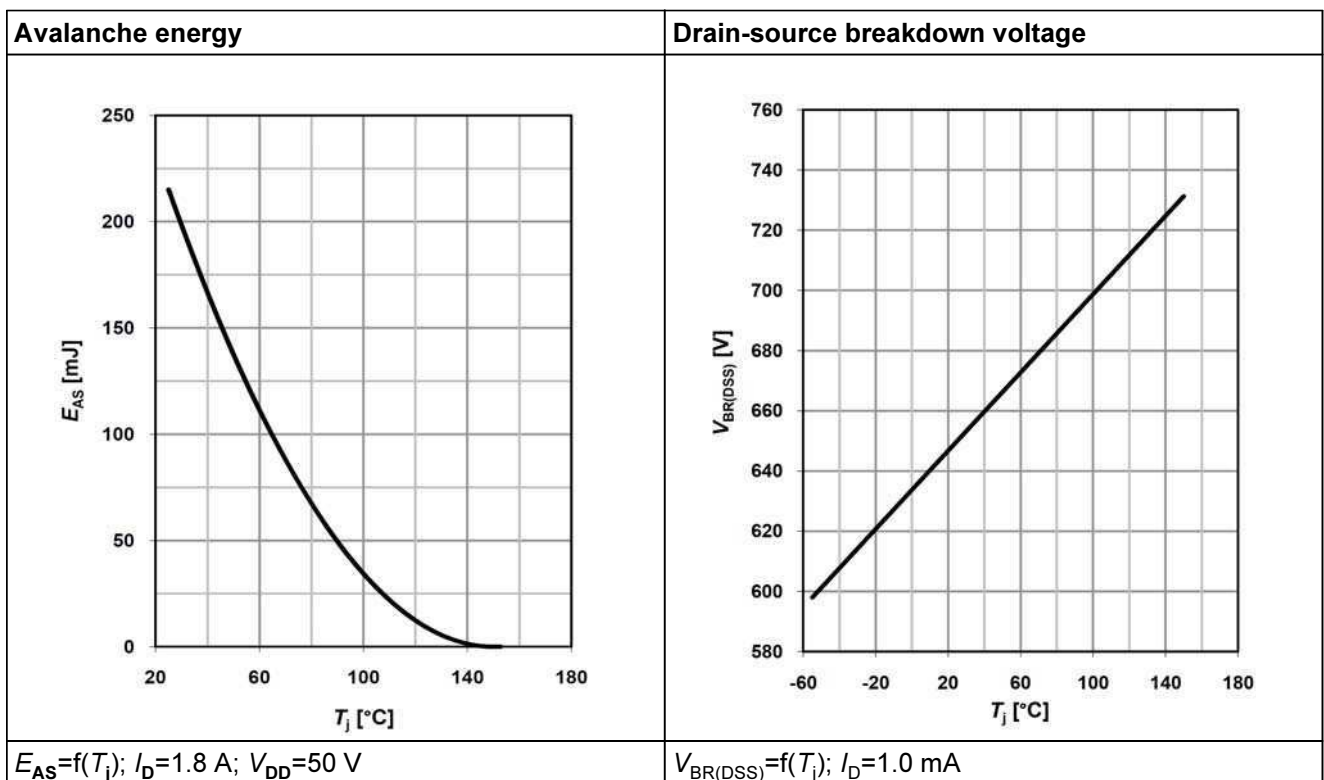


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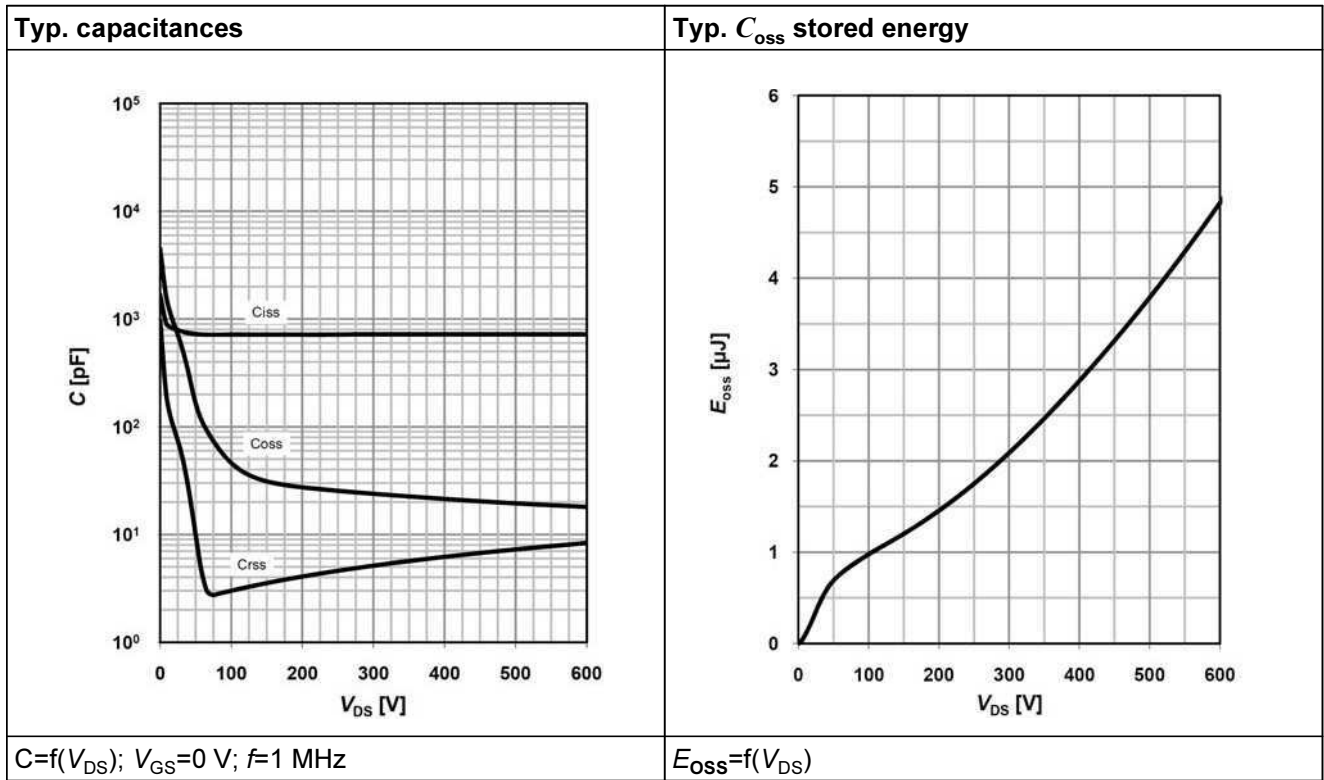
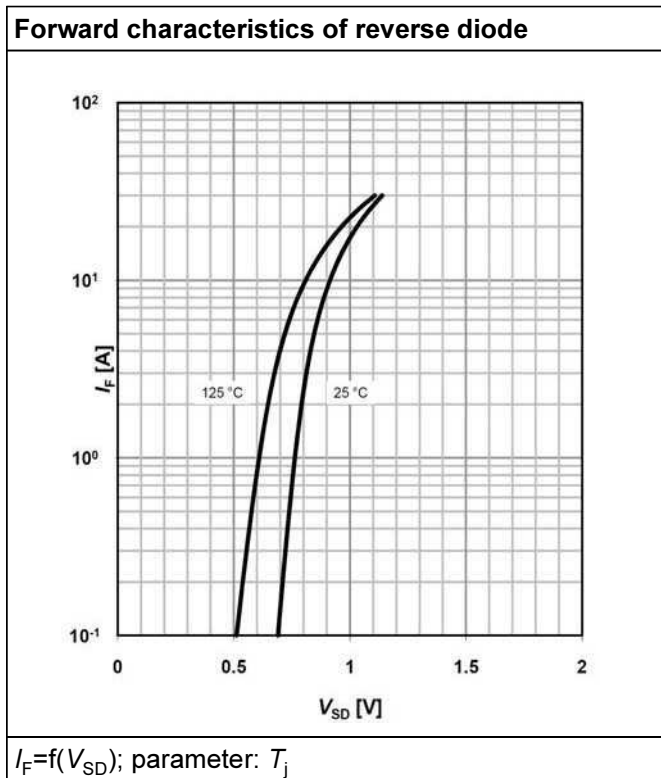


Table 19



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 |
|---------------------------------------|------------------------------|
| | |

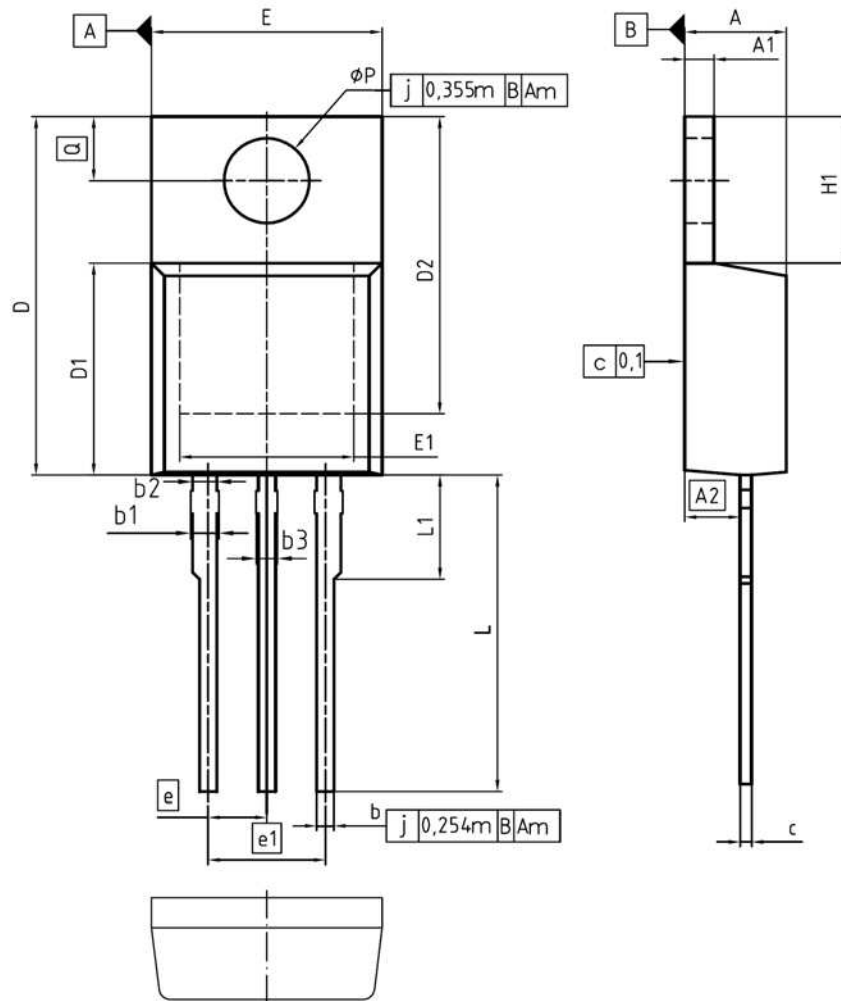
Table 22 Test circuit and waveform for diode characteristics

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

7 Package outlines



Figure 1 Outlines TO-252, 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 |

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

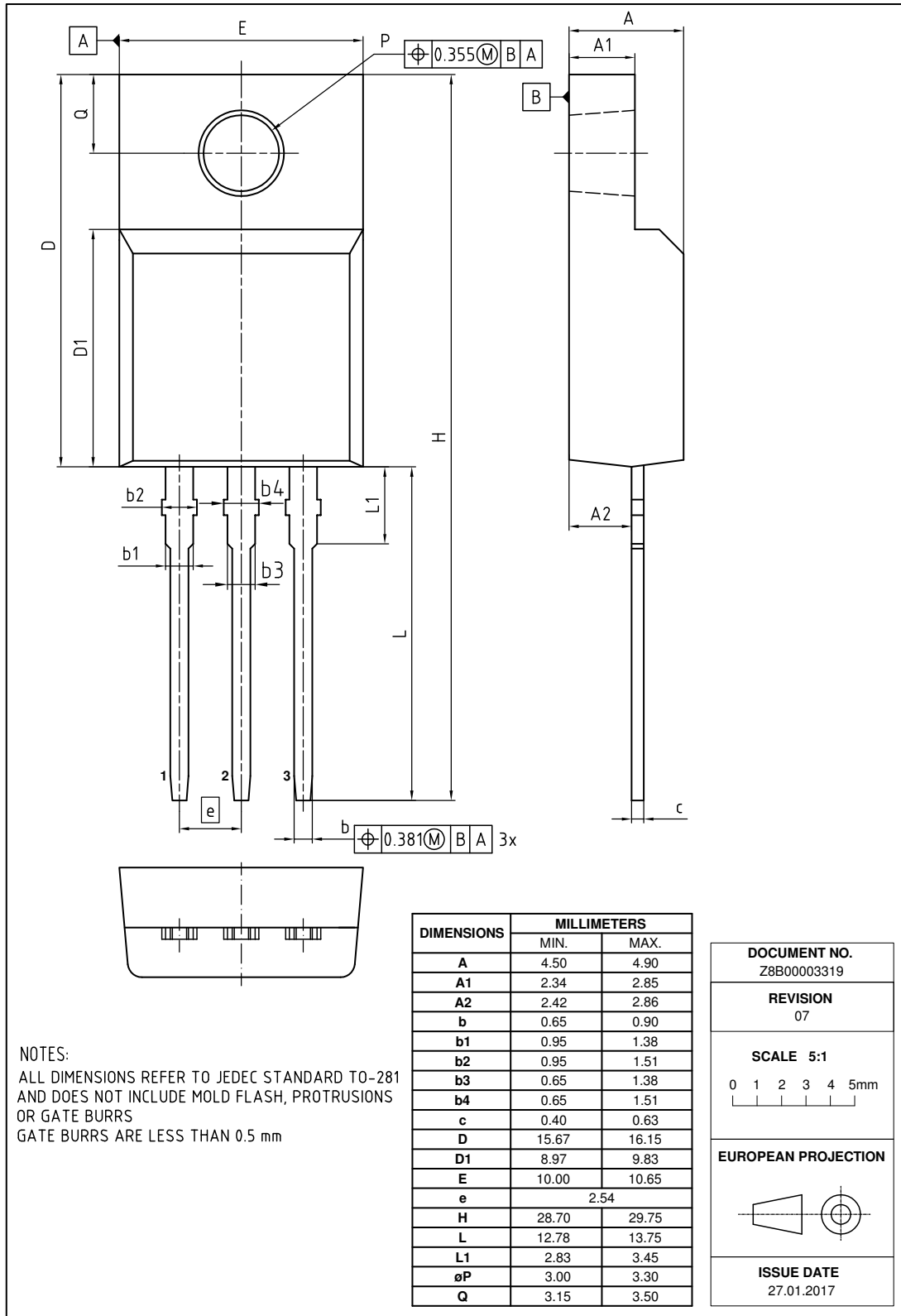
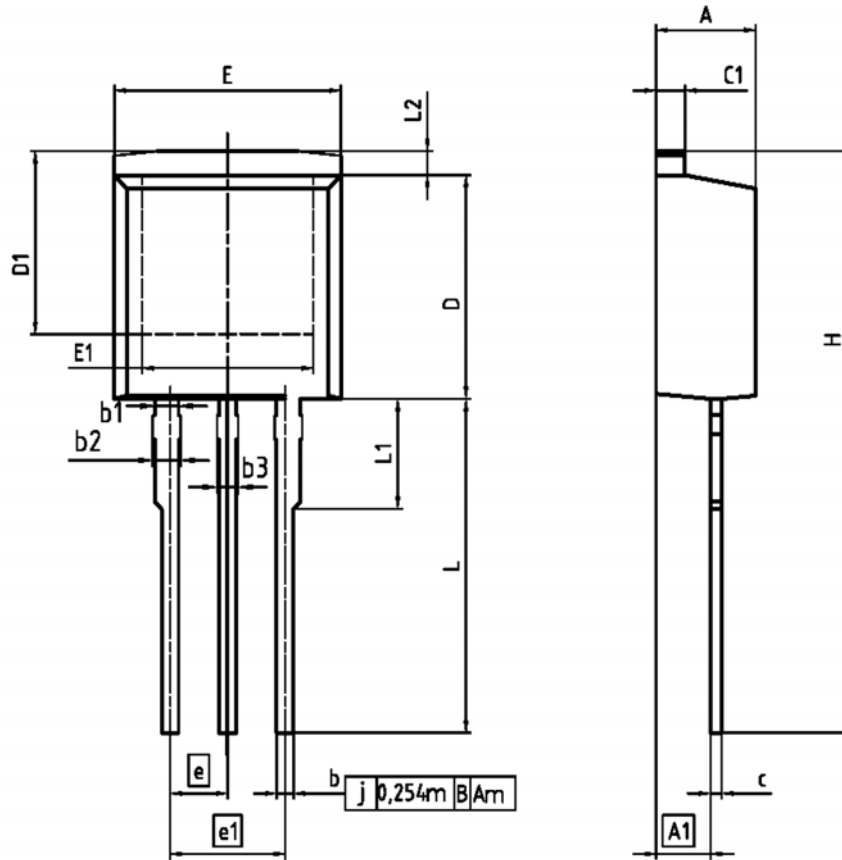


Figure 3 Outline PG-TO-220 FullPAK dimensions in mm



| 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 | 8.450 | 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

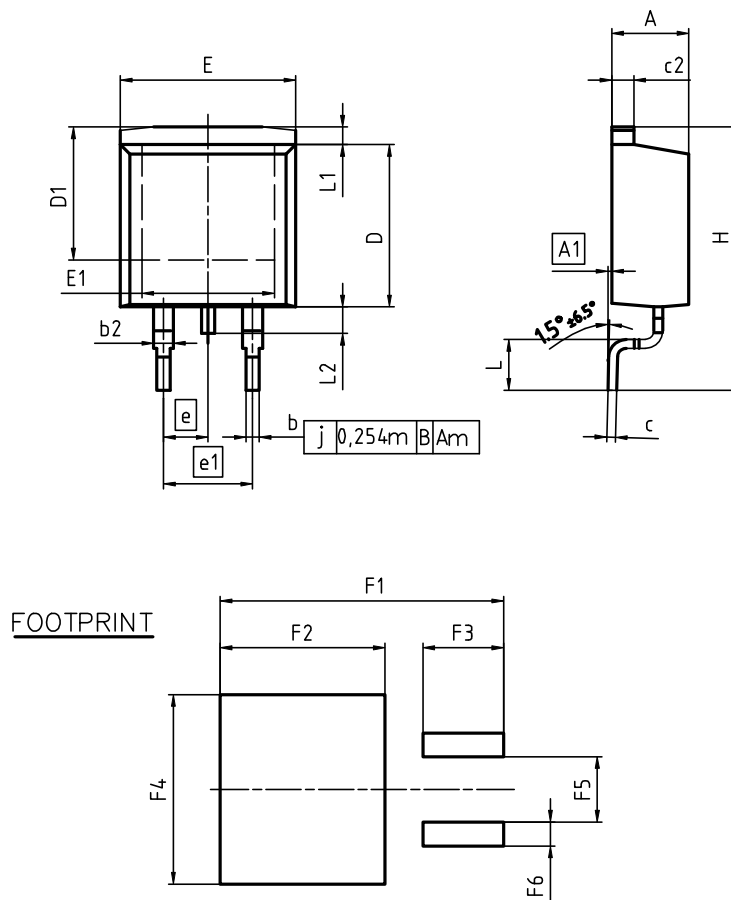
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Figure 4 Outlines TO-262, dimensions in mm/inches



| 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 |

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

650V CoolMOS™ C6 Power Transistor

IPx65R380C6

Revision History

IPx65R380C6

Revision: 2018-03-05, Rev. 2.1

Previous Revision

| Revision | Date | Subjects (major changes since last revision) |
|----------|------------|--|
| 2.1 | 2018-03-05 | Outline PG-TO220 FullPAK update |

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