

MOSFET

Metal Oxide Semiconductor Field Effect Transistor

CoolMOS™ P6

600V CoolMOS™ P6 Power Transistor
IPx60R380P6

Data Sheet

Rev. 2.2
Final

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 $R_{DS(on)} \cdot Q_g$ and E_{oss}
- 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.

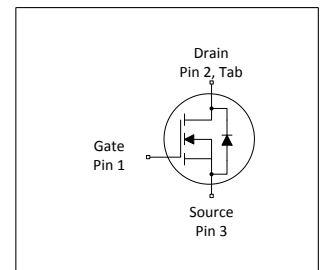
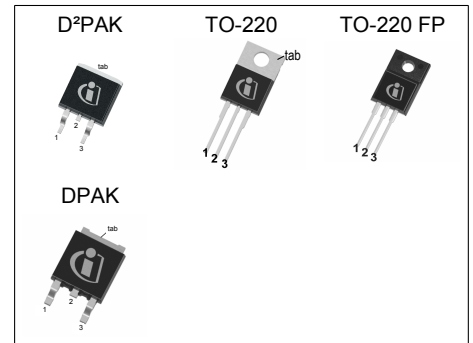


Table 1 Key Performance Parameters

| Parameter | Value | Unit |
|----------------------|-------|------|
| $V_{DS} @ T_{j,max}$ | 650 | V |
| $R_{DS(on),max}$ | 380 | mΩ |
| $Q_{g,typ}$ | 19 | nC |
| $I_{D,pulse}$ | 29 | A |
| $E_{oss@400V}$ | 2.7 | μJ |
| Body diode di/dt | 500 | A/μs |

| Type / Ordering Code | Package | Marking | Related Links |
|----------------------|-------------------|---------|----------------|
| IPB60R380P6 | PG-TO 263 | 6R380P6 | see Appendix A |
| IPP60R380P6 | PG-TO 220 | | |
| IPA60R380P6 | PG-TO 220 FullPAK | | |
| IPD60R380P6 | PG-TO 252 | | |



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2 Maximum ratings

at $T_j = 25^\circ\text{C}$, 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 6.7 | A | $T_C=25^\circ\text{C}$ $T_C=100^\circ\text{C}$ |
| Pulsed drain current ²⁾ | $I_{D,pulse}$ | - | - | 29 | A | $T_C=25^\circ\text{C}$ |
| Avalanche energy, single pulse | E_{AS} | - | - | 210 | mJ | $I_D=1.8\text{A}$; $V_{DD}=50\text{V}$; see table 12 |
| Avalanche energy, repetitive | E_{AR} | - | - | 0.32 | mJ | $I_D=1.8\text{A}$; $V_{DD}=50\text{V}$; see table 12 |
| Avalanche current, repetitive | I_{AR} | - | - | 1.8 | A | - |
| MOSFET dv/dt ruggedness | dv/dt | - | - | 100 | V/ns | $V_{DS}=0\dots400\text{V}$ |
| Gate source voltage (static) | V_{GS} | -20 | - | 20 | V | static; |
| Gate source voltage (dynamic) | V_{GS} | -30 | - | 30 | V | AC ($f>1\text{ Hz}$) |
| Power dissipation (Non FullPAK) TO-220, TO-252, TO-263 | P_{tot} | - | - | 83 | W | $T_C=25^\circ\text{C}$ |
| Power dissipation (FullPAK) TO-220FP | P_{tot} | - | - | 31 | W | $T_C=25^\circ\text{C}$ |
| Storage temperature | T_{stg} | -55 | - | 150 | $^\circ\text{C}$ | - |
| Operating junction temperature | T_j | -55 | - | 150 | $^\circ\text{C}$ | - |
| Mounting torque (Non FullPAK) TO-220 | - | - | - | 60 | Ncm | M3 and M3.5 screws |
| Mounting torque (FullPAK) TO-220FP | - | - | - | 50 | Ncm | M2.5 screws |
| Continuous diode forward current | I_S | - | - | 9.2 | A | $T_C=25^\circ\text{C}$ |
| Diode pulse current ²⁾ | $I_{S,pulse}$ | - | - | 29 | A | $T_C=25^\circ\text{C}$ |
| Reverse diode dv/dt ³⁾ | dv/dt | - | - | 15 | V/ns | $V_{DS}=0\dots400\text{V}$, $I_{SD}\leq I_S$, $T_j=25^\circ\text{C}$ see table 10 |
| Maximum diode commutation speed | di/dt | - | - | 500 | A/ μs | $V_{DS}=0\dots400\text{V}$, $I_{SD}\leq I_S$, $T_j=25^\circ\text{C}$ see table 10 |
| Insulation withstand voltage for TO-220FP | V_{ISO} | - | - | 2500 | V | V_{rms} , $T_C=25^\circ\text{C}$, $t=1\text{min}$ |

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 (Non FullPAK) TO-220

| 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 | °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} | - | - | 4 | °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 |

Table 5 Thermal characteristics TO-252, TO-263

| 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 | °C/W | device on PCB, minimal footprint |
| Thermal resistance, junction - ambient for SMD version | R_{thJA} | - | 35 | 45 | °C/W | Device on 40mm*40mm*1.5mm epoxy PCB FR4 with 6cm ² (one layer, 70µm thickness) copper area for drain connection and cooling. PCB is vertical without air stream cooling. |
| Soldering temperature, wave & reflow soldering allowed | T_{sold} | - | - | 260 | °C | reflow MSL1 |

4 Electrical characteristics

at $T_j=25^\circ\text{C}$, unless otherwise specified

Table 6 Static characteristics

| Parameter | Symbol | Values | | | Unit | Note / Test Condition |
|----------------------------------|---------------|--------|----------------|------------|---------------|---|
| | | Min. | Typ. | Max. | | |
| Drain-source breakdown voltage | $V_{(BR)DSS}$ | 600 | - | - | V | $V_{GS}=0\text{V}$, $I_D=1\text{mA}$ |
| Gate threshold voltage | $V_{(GS)th}$ | 3.5 | 4.0 | 4.5 | V | $V_{DS}=V_{GS}$, $I_D=0.32\text{mA}$ |
| Zero gate voltage drain current | I_{DSS} | - | - | 1 | μA | $V_{DS}=600$, $V_{GS}=0\text{V}$, $T_j=25^\circ\text{C}$ $V_{DS}=600$, $V_{GS}=0\text{V}$, $T_j=150^\circ\text{C}$ |
| Gate-source leakage current | I_{GSS} | - | - | 100 | nA | $V_{GS}=20\text{V}$, $V_{DS}=0\text{V}$ |
| Drain-source on-state resistance | $R_{DS(on)}$ | - | 0.342 0.889 | 0.380 - | Ω | $V_{GS}=10\text{V}$, $I_D=3.8\text{A}$, $T_j=25^\circ\text{C}$ $V_{GS}=10\text{V}$, $I_D=3.8\text{A}$, $T_j=150^\circ\text{C}$ |
| Gate resistance | R_G | - | 7.8 | - | Ω | $f=1\text{MHz}$, open drain |

Table 7 Dynamic characteristics

| Parameter | Symbol | Values | | | Unit | Note / Test Condition |
|--|--------------|--------|------|------|------|--|
| | | Min. | Typ. | Max. | | |
| Input capacitance | C_{iss} | - | 877 | - | pF | $V_{GS}=0\text{V}$, $V_{DS}=100\text{V}$, $f=1\text{MHz}$ |
| Output capacitance | C_{oss} | - | 42 | - | pF | $V_{GS}=0\text{V}$, $V_{DS}=100\text{V}$, $f=1\text{MHz}$ |
| Effective output capacitance, energy related ¹⁾ | $C_{o(er)}$ | - | 33 | - | pF | $V_{GS}=0\text{V}$, $V_{DS}=0\dots400\text{V}$ |
| Effective output capacitance, time related ²⁾ | $C_{o(tr)}$ | - | 135 | - | pF | $I_D=\text{constant}$, $V_{GS}=0\text{V}$, $V_{DS}=0\dots400\text{V}$ |
| Turn-on delay time | $t_{d(on)}$ | - | 12 | - | ns | $V_{DD}=400\text{V}$, $V_{GS}=13\text{V}$, $I_D=4.8\text{A}$, $R_G=3.4\Omega$; see table 11 |
| Rise time | t_r | - | 6 | - | ns | $V_{DD}=400\text{V}$, $V_{GS}=13\text{V}$, $I_D=4.8\text{A}$, $R_G=3.4\Omega$; see table 11 |
| Turn-off delay time | $t_{d(off)}$ | - | 33 | - | ns | $V_{DD}=400\text{V}$, $V_{GS}=13\text{V}$, $I_D=4.8\text{A}$, $R_G=3.4\Omega$; see table 11 |
| Fall time | t_f | - | 7 | - | ns | $V_{DD}=400\text{V}$, $V_{GS}=13\text{V}$, $I_D=4.8\text{A}$, $R_G=3.4\Omega$; see table 11 |

Table 8 Gate charge characteristics

| Parameter | Symbol | Values | | | Unit | Note / Test Condition |
|-----------------------|---------------|--------|------|------|------|---|
| | | Min. | Typ. | Max. | | |
| Gate to source charge | Q_{gs} | - | 5.4 | - | nC | $V_{DD}=400\text{V}$, $I_D=4.8\text{A}$, $V_{GS}=0$ to 10V |
| Gate to drain charge | Q_{gd} | - | 7 | - | nC | $V_{DD}=400\text{V}$, $I_D=4.8\text{A}$, $V_{GS}=0$ to 10V |
| Gate charge total | Q_g | - | 19 | - | nC | $V_{DD}=400\text{V}$, $I_D=4.8\text{A}$, $V_{GS}=0$ to 10V |
| Gate plateau voltage | $V_{plateau}$ | - | 6.1 | - | V | $V_{DD}=400\text{V}$, $I_D=4.8\text{A}$, $V_{GS}=0$ 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 9 Reverse diode characteristics

| Parameter | Symbol | Values | | | Unit | Note / Test Condition |
|-------------------------------|-----------|--------|------|------|---------|--|
| | | Min. | Typ. | Max. | | |
| Diode forward voltage | V_{SD} | - | 0.9 | - | V | $V_{GS}=0V, I_F=4.8A, T_j=25^\circ C$ |
| Reverse recovery time | t_{rr} | - | 232 | - | ns | $V_R=400V, I_F=4.8A, di_F/dt=100A/\mu s$; see table 10 |
| Reverse recovery charge | Q_{rr} | - | 2.1 | - | μC | $V_R=400V, I_F=4.8A, di_F/dt=100A/\mu s$; see table 10 |
| Peak reverse recovery current | I_{rrm} | - | 17 | - | A | $V_R=400V, I_F=4.8A, di_F/dt=100A/\mu s$; see table 10 |

5 Electrical characteristics diagrams

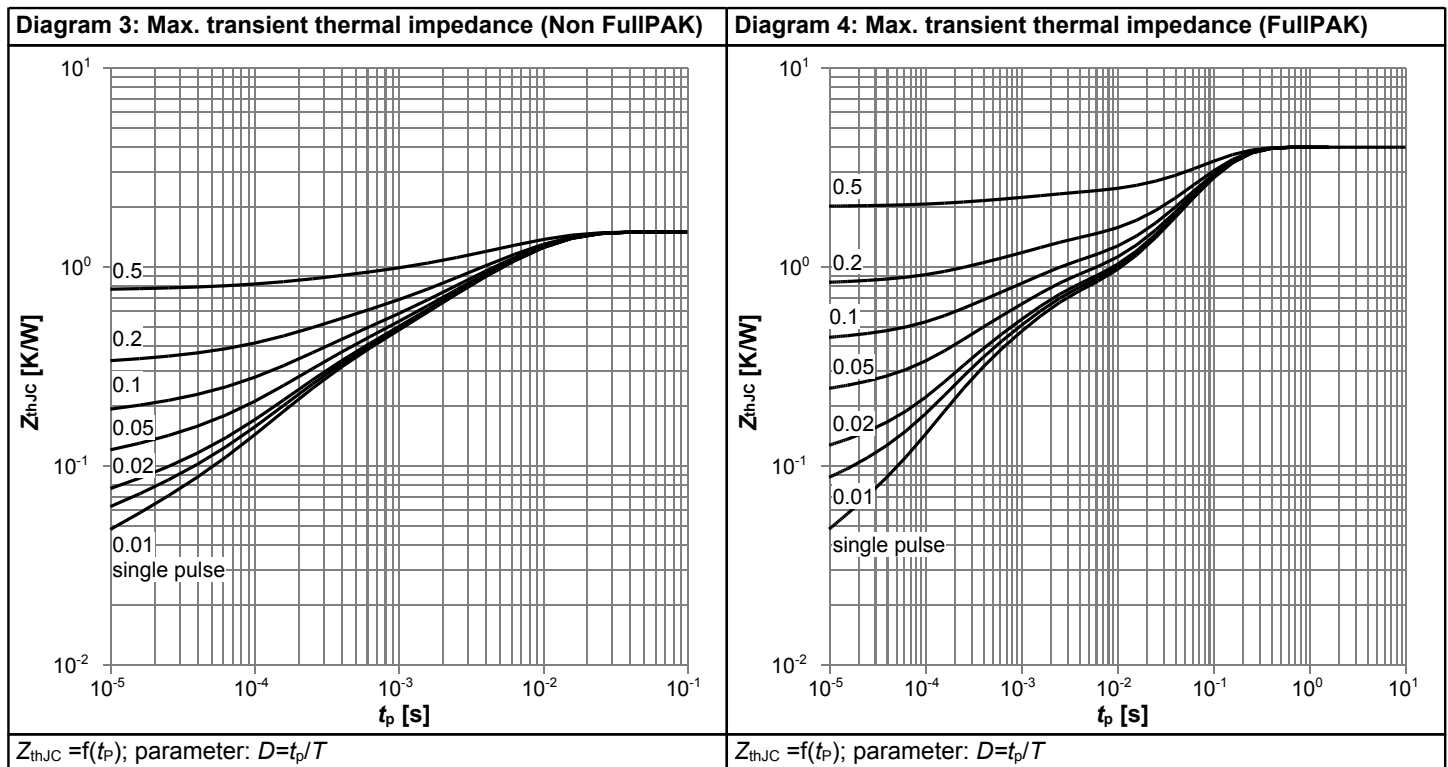
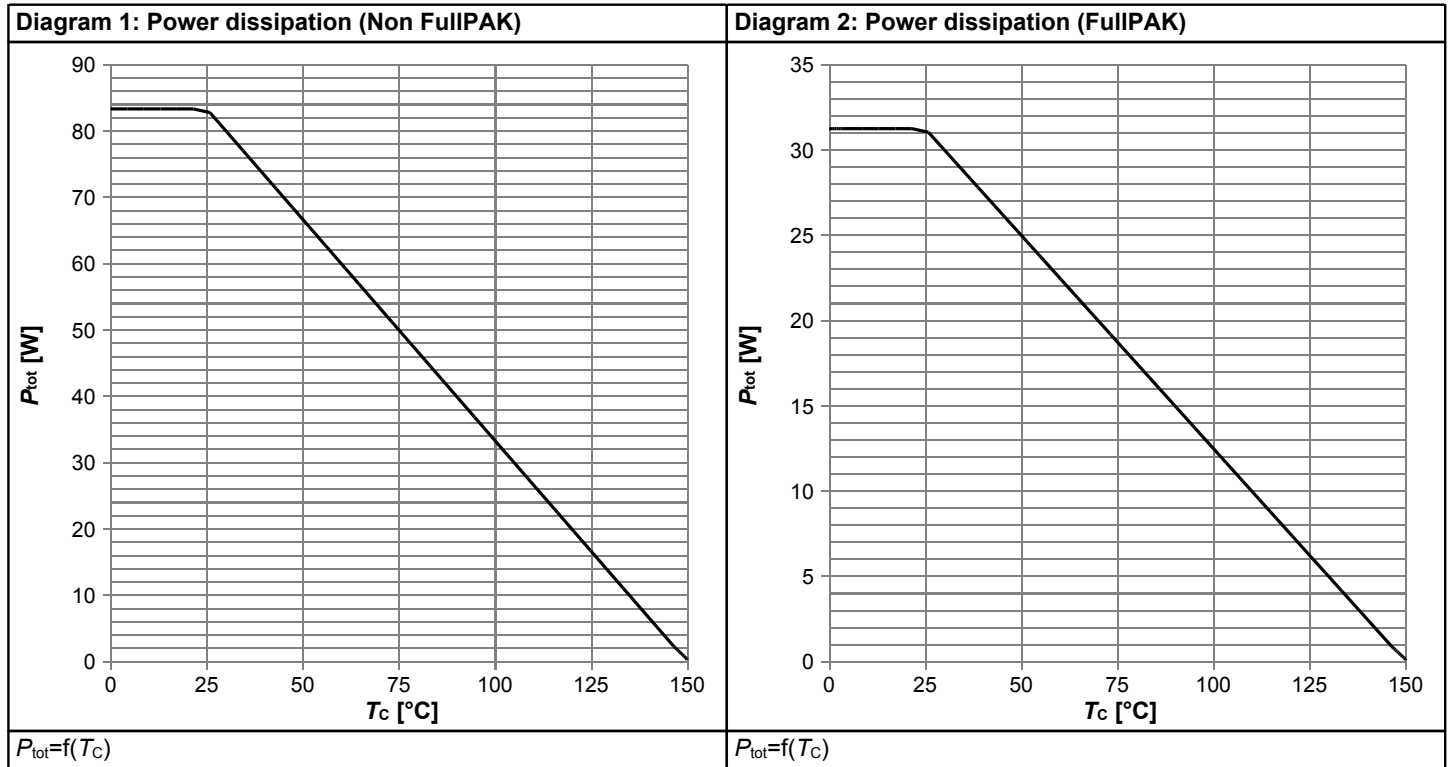
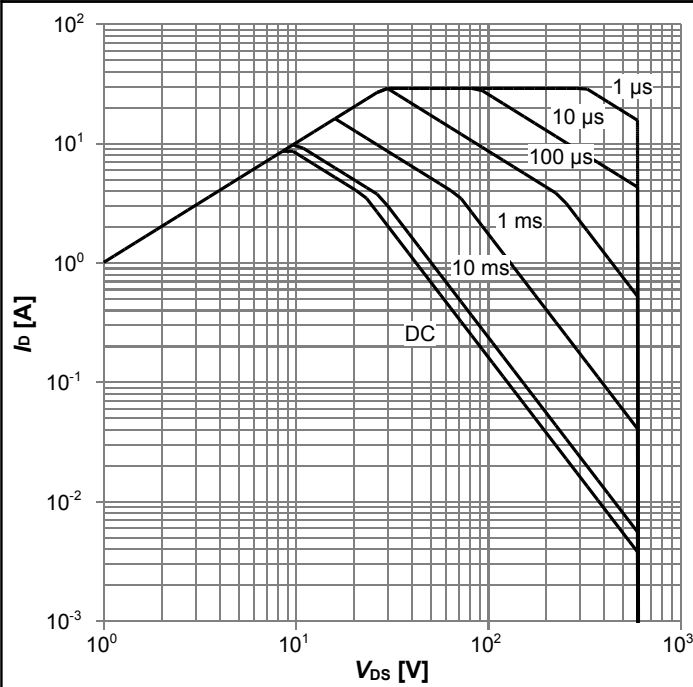
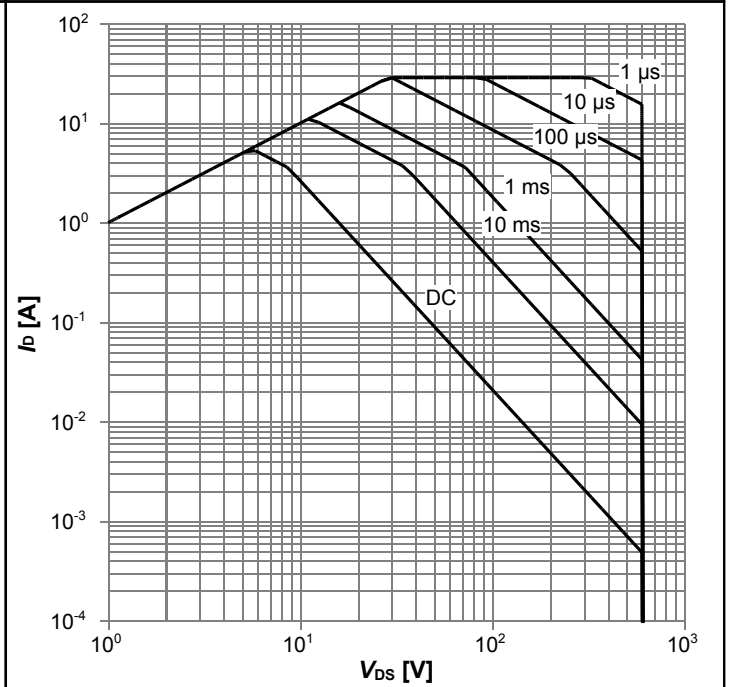


Diagram 5: Safe operating area (Non FullPAK)



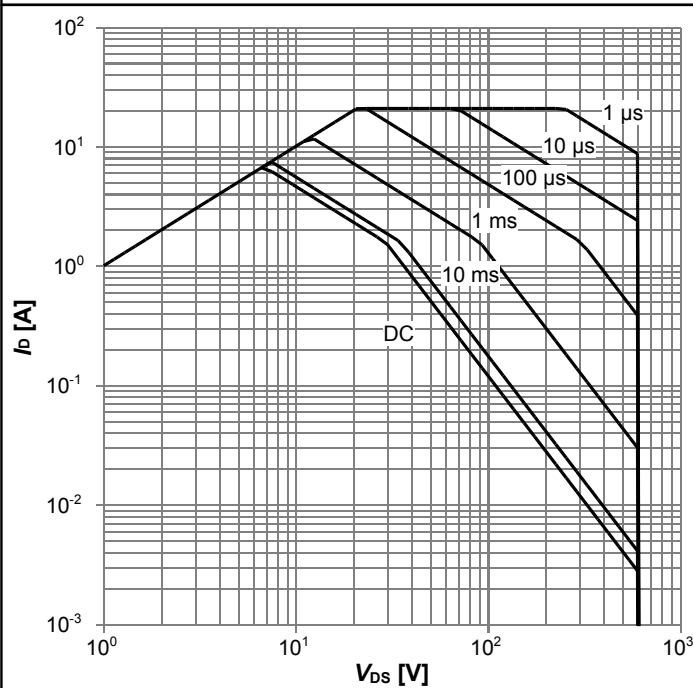
$I_D=f(V_{DS}); T_C=25\text{ °C}; D=0$; parameter: t_p

Diagram 6: Safe operating area (FullPAK)



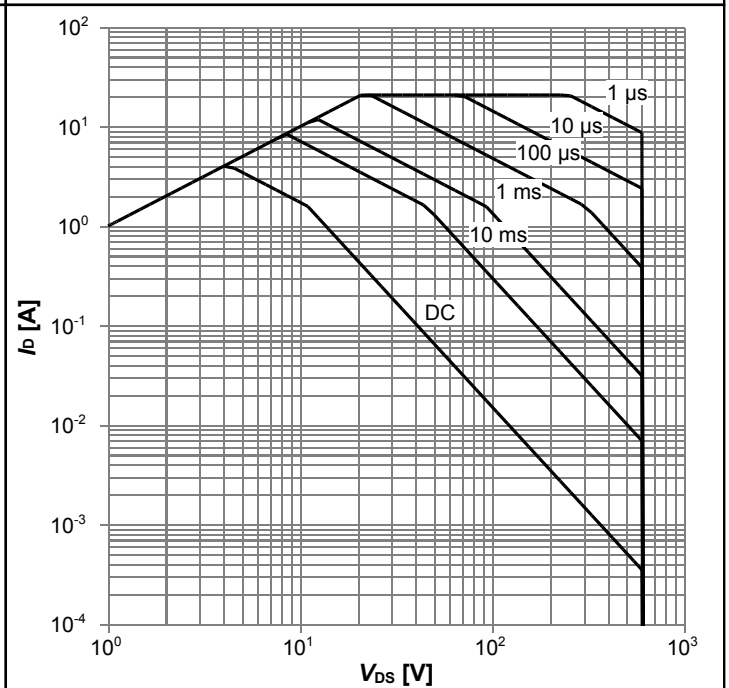
$I_D=f(V_{DS}); T_C=25\text{ °C}; D=0$; parameter: t_p

Diagram 7: Safe operating area (Non FullPAK)



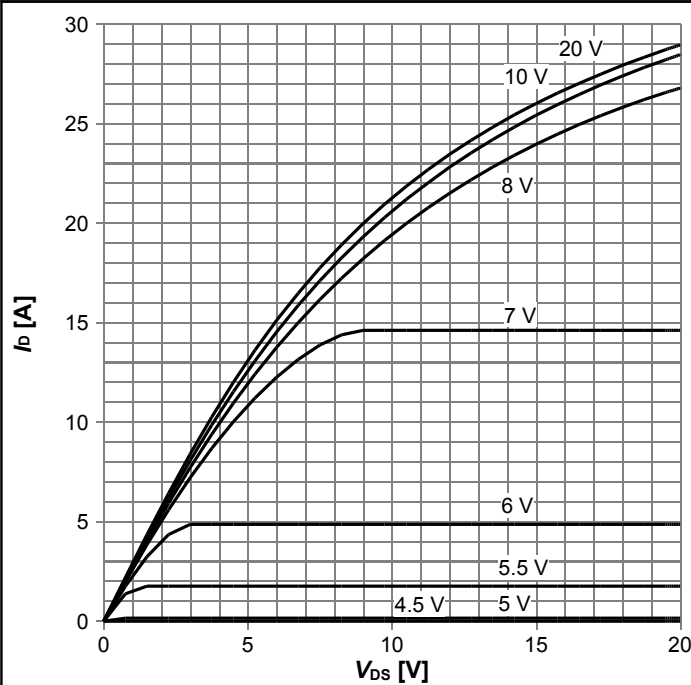
$I_D=f(V_{DS}); T_C=80\text{ °C}; D=0$; parameter: t_p

Diagram 8: Safe operating area (FullPAK)



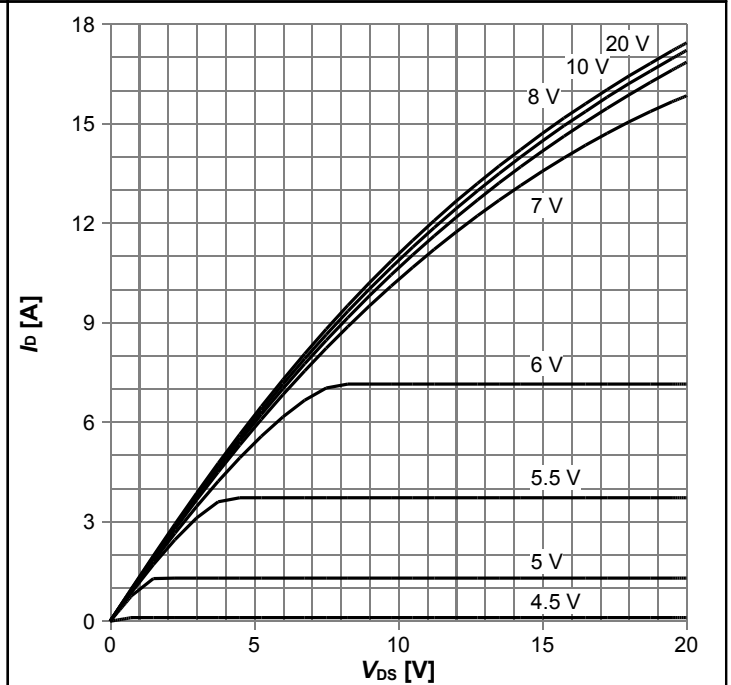
$I_D=f(V_{DS}); T_C=80\text{ °C}; D=0$; parameter: t_p

Diagram 9: Typ. output characteristics



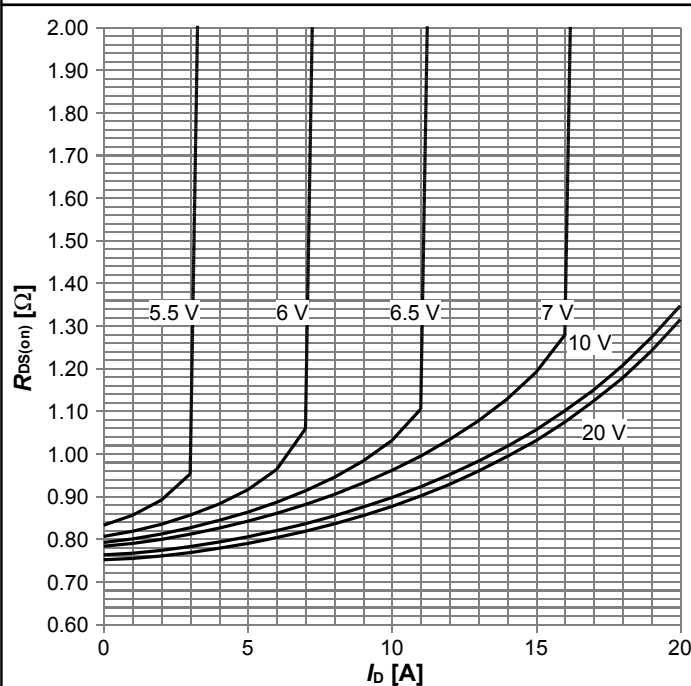
$I_D=f(V_{DS})$; $T_j=25\text{ °C}$; parameter: V_{GS}

Diagram 10: Typ. output characteristics



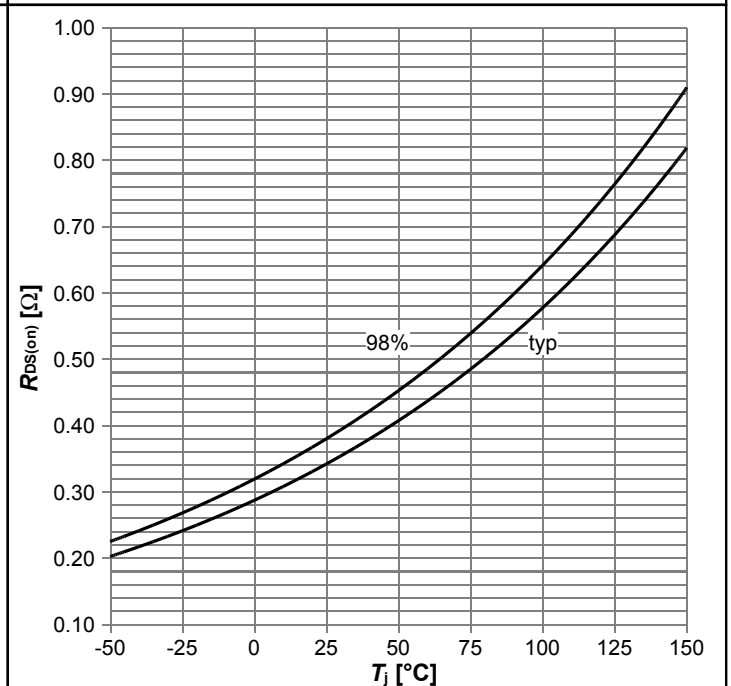
$I_D=f(V_{DS})$; $T_j=125\text{ °C}$; parameter: V_{GS}

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



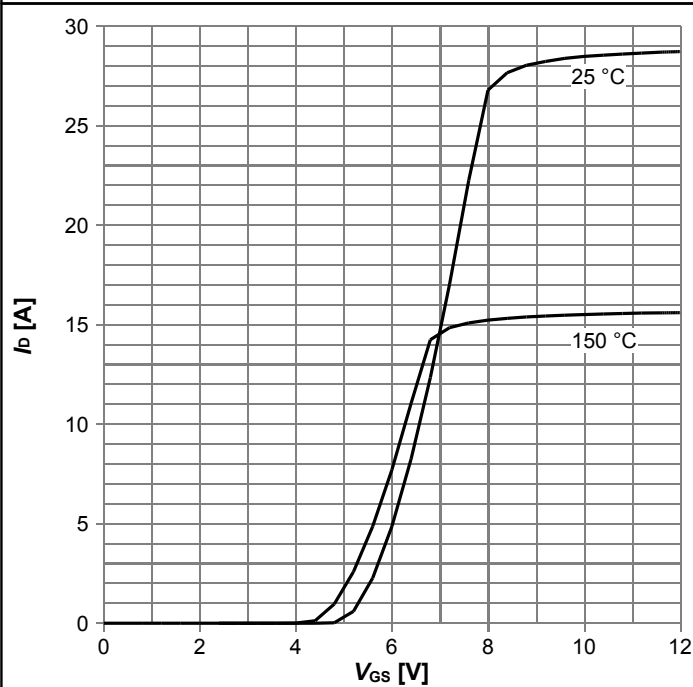
$R_{DS(on)}=f(I_D)$; $T_j=125\text{ °C}$; parameter: V_{GS}

Diagram 12: Drain-source on-state resistance



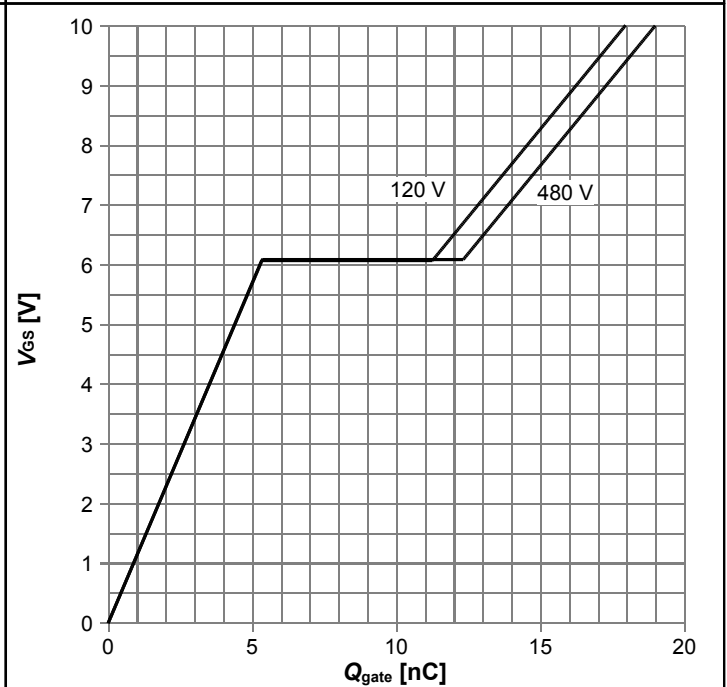
$R_{DS(on)}=f(T_j)$; $I_D=3.8\text{ A}$; $V_{GS}=10\text{ V}$

Diagram 13: Typ. transfer characteristics



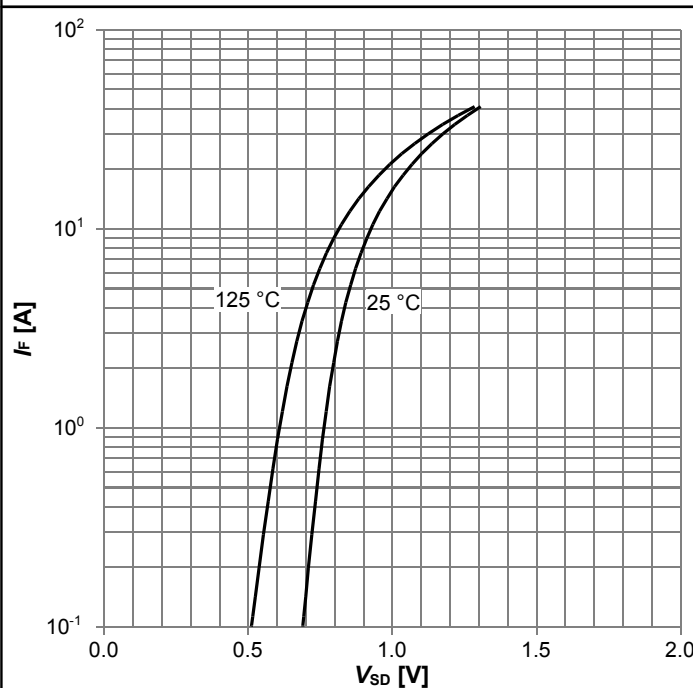
$I_D=f(V_{GS}); V_{DS}=20V$; parameter: T_j

Diagram 14: Typ. gate charge



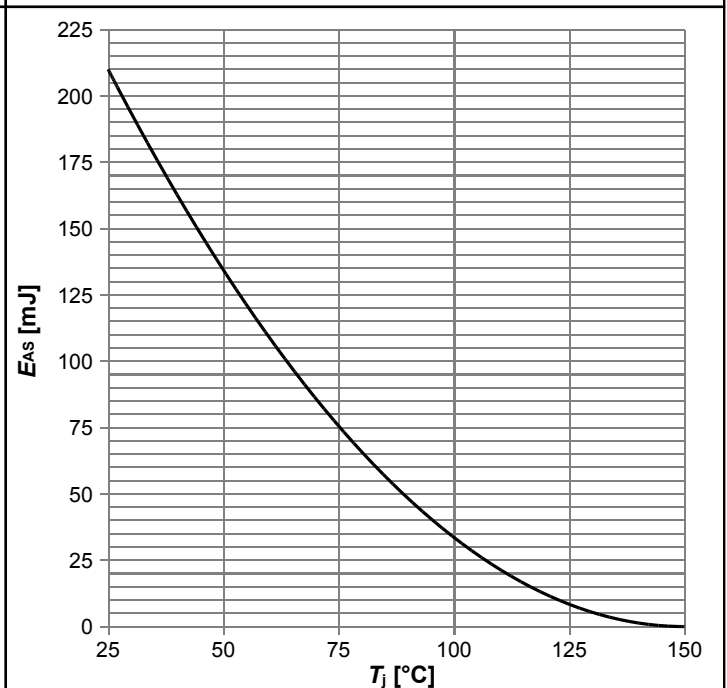
$V_{GS}=f(Q_{gate}); I_D=4.8$ A pulsed; parameter: V_{DD}

Diagram 15: Forward characteristics of reverse diode



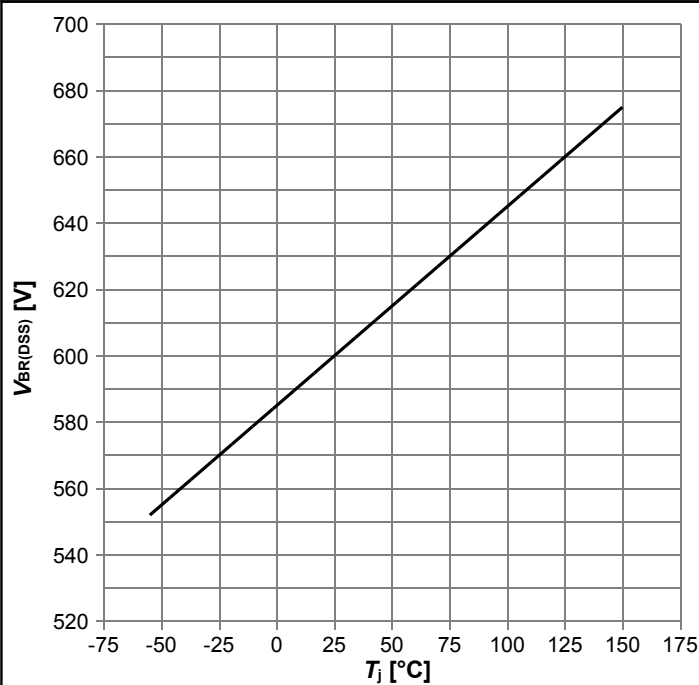
$I_F=f(V_{SD})$; parameter: T_j

Diagram 16: Avalanche energy



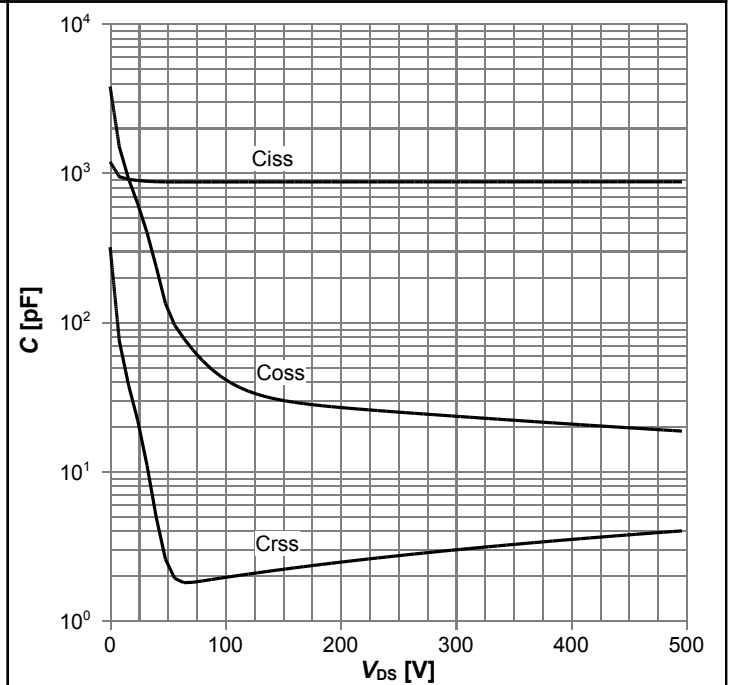
$E_{AS}=f(T_j); I_D=1.8$ A; $V_{DD}=50$ V

Diagram 17: Drain-source breakdown voltage



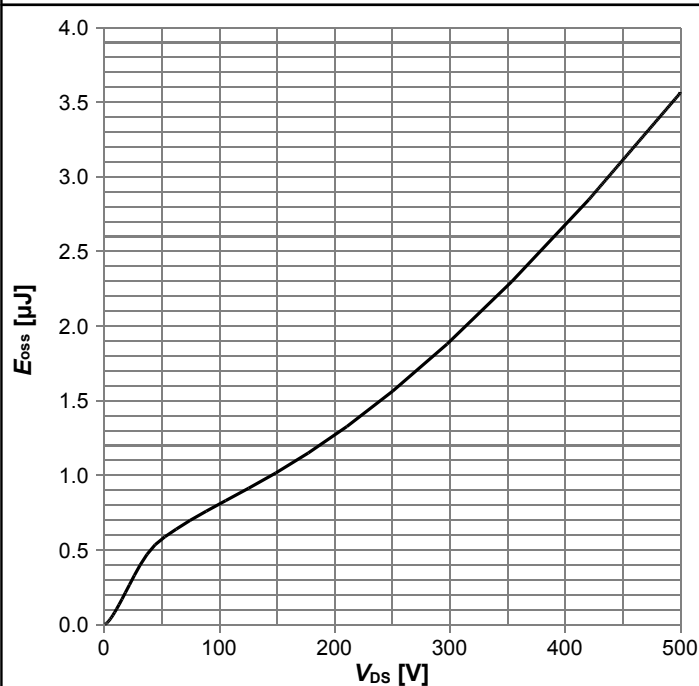
$V_{BR(DSS)}=f(T_j); I_D=1 \text{ mA}$

Diagram 18: Typ. capacitances



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

Diagram 19: Typ. Coss stored energy



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

6 Test Circuits

Table 10 Diode characteristics

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

Table 11 Switching times

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

Table 12 Unclamped inductive load

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

7 Package Outlines

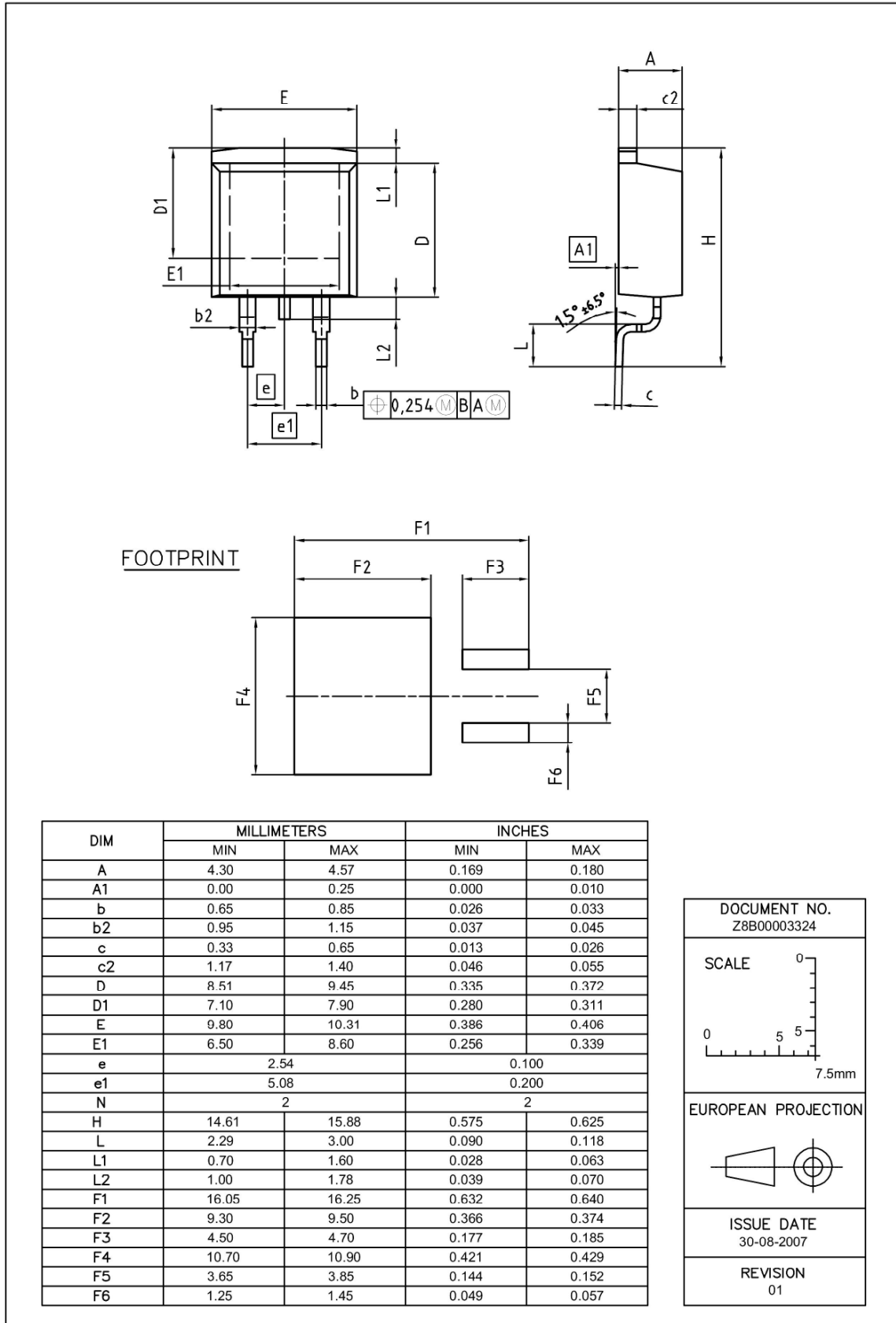


Figure 1 Outline PG-TO 263, dimensions in mm/inches

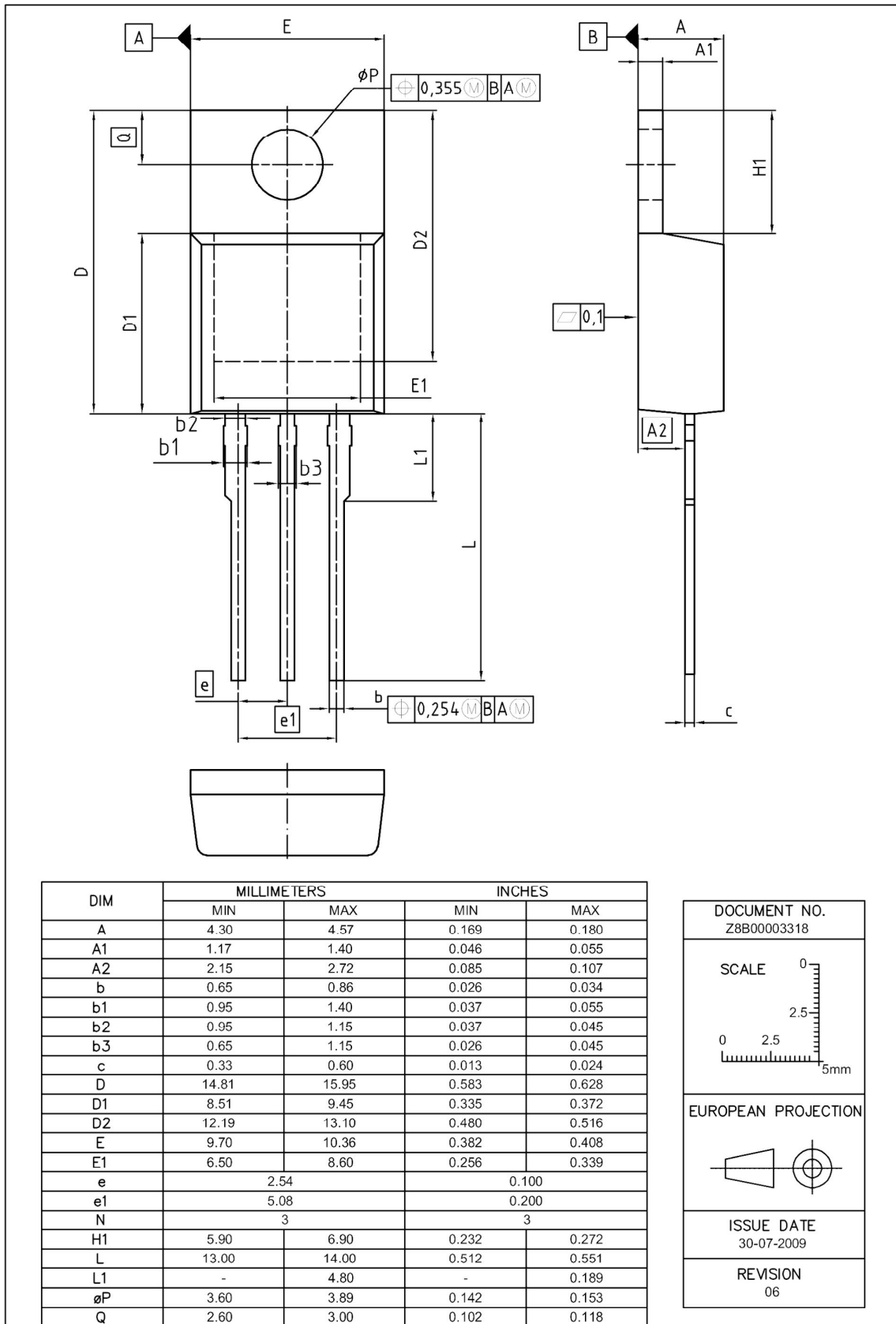
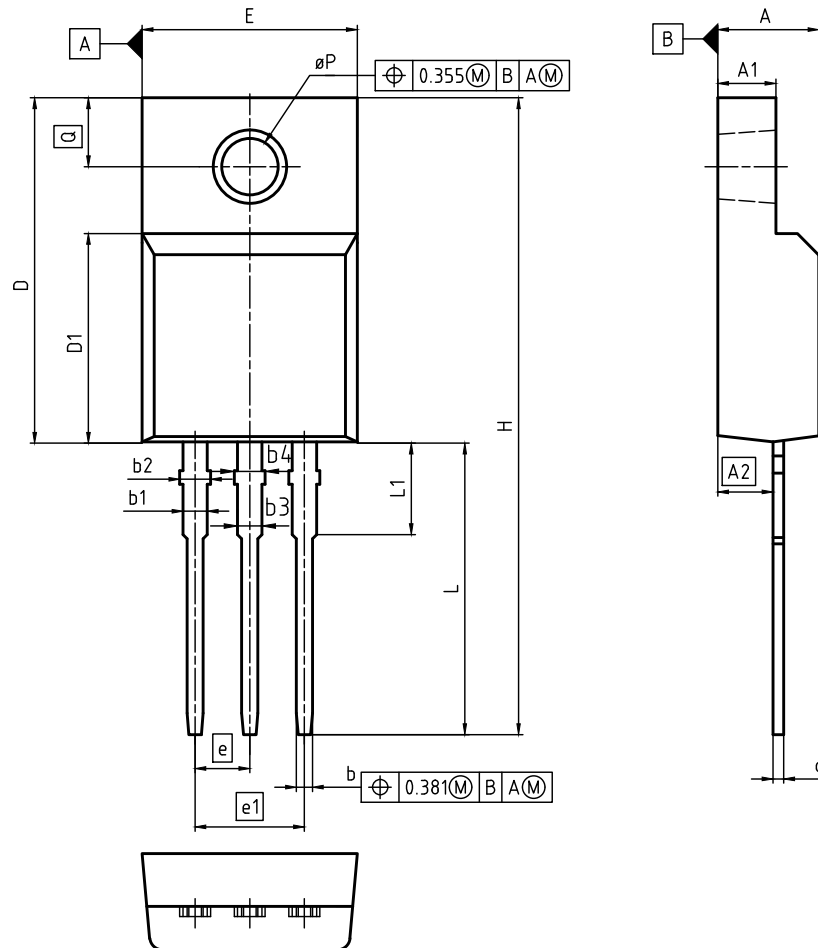


Figure 2 Outline PG-TO 220, dimensions in mm/inches



| 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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EUROPEAN PROJECTION

ISSUE DATE
05-05-2014

REVISION
04

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

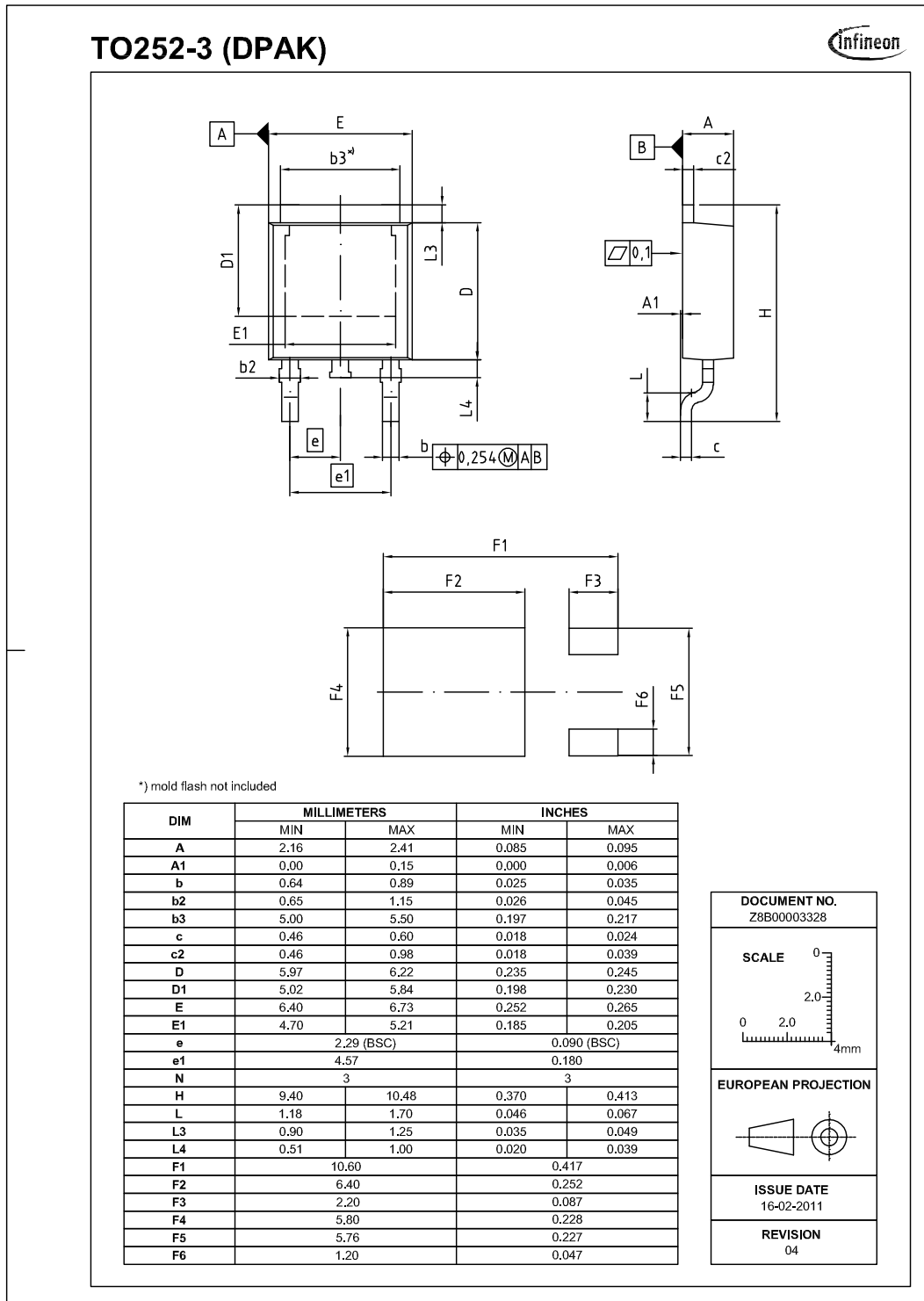


Figure 4 Outline PG-TO 252, dimensions in mm/inches

8 Appendix A

Table 13 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

IPB60R380P6, IPP60R380P6, IPA60R380P6, IPD60R380P6

Revision: 2015-07-10, Rev. 2.2

Previous Revision

| Revision | Date | Subjects (major changes since last revision) |
|----------|------------|--|
| 2.0 | 2013-12-05 | Release of final version |
| 2.1 | 2013-12-05 | Release of multi-package datasheet |
| 2.2 | 2015-07-10 | PG-TO 263 package added |

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