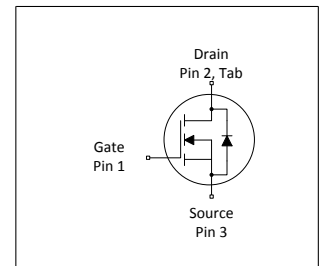
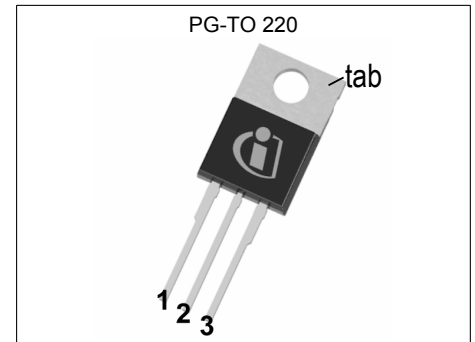


# MOSFET

## 600V CoolMOS™ CFD7 Power Transistor

CoolMOS™ is a revolutionary technology for high voltage power MOSFETs, designed according to the superjunction (SJ) principle and pioneered by Infineon Technologies. The latest CoolMOS™ CFD7 is the successor to the CoolMOS™ CFD2 series and is an optimized platform tailored to target soft switching applications such as phase-shift full-bridge (ZVS) and LLC. Resulting from reduced gate charge ( $Q_g$ ), best-in-class reverse recovery charge ( $Q_{rr}$ ) and improved turn off behavior CoolMOS™ CFD7 offers highest efficiency in resonant topologies. As part of Infineon's fast body diode portfolio, this new product series blends all advantages of a fast switching technology together with superior hard commutation robustness, without sacrificing easy implementation in the design-in process. The CoolMOS™ CFD7 technology meets highest efficiency and reliability standards and furthermore supports high power density solutions. Altogether, CoolMOS™ CFD7 makes resonant switching topologies more efficient, more reliable, lighter and cooler.



## Features

- Ultra-fast body diode
- Low gate charge
- Best-in-class reverse recovery charge ( $Q_{rr}$ )
- Improved MOSFET reverse diode  $dv/dt$  and  $di_F/dt$  ruggedness
- Lowest FOM  $R_{DS(on)} \cdot Q_g$  and  $R_{DS(on)} \cdot E_{oss}$
- Best-in-class  $R_{DS(on)}$  in SMD and THD packages

## Benefits

- Excellent hard commutation ruggedness
- Highest reliability for resonant topologies
- Highest efficiency with outstanding ease-of-use / performance tradeoff
- Enabling increased power density solutions

## Potential applications

Suitable for Soft Switching topologies  
Optimized for phase-shift full-bridge (ZVS), LLC Applications – Server, Telecom, EV Charging

**Product Validation:** Fully qualified according to JEDEC for Industrial Applications

*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    |
| $R_{DS(on),max}$     | 210   | mΩ   |
| $Q_{g,typ}$          | 23    | nC   |
| $I_{D,pulse}$        | 42    | A    |
| $E_{oss} @ 400V$     | 2.6   | μJ   |
| Body diode $di_F/dt$ | 1300  | A/μs |

| Type / Ordering Code | Package     | Marking  | Related Links  |
|----------------------|-------------|----------|----------------|
| IPP60R210CFD7        | PG-TO 220-3 | 60R210F7 | see Appendix A |

**Table of Contents**

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## 1 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 <sup>1)</sup> | $I_D$         | -      | -    | 12<br>7.0 | A                | $T_C=25^\circ\text{C}$<br>$T_C=100^\circ\text{C}$                                            |
| Pulsed drain current <sup>2)</sup>     | $I_{D,pulse}$ | -      | -    | 42        | A                | $T_C=25^\circ\text{C}$                                                                       |
| Avalanche energy, single pulse         | $E_{AS}$      | -      | -    | 49        | mJ               | $I_D=3.2\text{A}$ ; $V_{DD}=50\text{V}$ ; see table 10                                       |
| Avalanche energy, repetitive           | $E_{AR}$      | -      | -    | 0.24      | mJ               | $I_D=3.2\text{A}$ ; $V_{DD}=50\text{V}$ ; see table 10                                       |
| Avalanche current, single pulse        | $I_{AS}$      | -      | -    | 3.2       | A                | -                                                                                            |
| MOSFET dv/dt ruggedness                | dv/dt         | -      | -    | 120       | 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                      | $P_{tot}$     | -      | -    | 64        | 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                        | -             | -      | -    | 60        | Ncm              | M3 and M3.5 screws                                                                           |
| Continuous diode forward current       | $I_S$         | -      | -    | 12        | A                | $T_C=25^\circ\text{C}$                                                                       |
| Diode pulse current <sup>2)</sup>      | $I_{S,pulse}$ | -      | -    | 42        | A                | $T_C=25^\circ\text{C}$                                                                       |
| Reverse diode dv/dt <sup>3)</sup>      | dv/dt         | -      | -    | 70        | V/ns             | $V_{DS}=0\dots400\text{V}$ , $I_{SD}\leq 12\text{A}$ , $T_j=25^\circ\text{C}$<br>see table 8 |
| Maximum diode commutation speed        | di/dt         | -      | -    | 1300      | A/ $\mu\text{s}$ | $V_{DS}=0\dots400\text{V}$ , $I_{SD}\leq 12\text{A}$ , $T_j=25^\circ\text{C}$<br>see table 8 |
| Insulation withstand voltage           | $V_{ISO}$     | -      | -    | n.a.      | V                | $V_{rms}$ , $T_C=25^\circ\text{C}$ , $t=1\text{min}$                                         |

<sup>1)</sup> Limited by  $T_{j,max}$ .

<sup>2)</sup> Pulse width  $t_p$  limited by  $T_{j,max}$ .

<sup>3)</sup> Identical low side and high side switch with identical  $R_\theta$ .

## 2 Thermal characteristics

**Table 3 Thermal characteristics**

| Parameter                                               | Symbol     | Values |      |      | Unit | Note / Test Condition               |
|---------------------------------------------------------|------------|--------|------|------|------|-------------------------------------|
|                                                         |            | Min.   | Typ. | Max. |      |                                     |
| Thermal resistance, junction - case                     | $R_{thJC}$ | -      | -    | 1.94 | °C/W | -                                   |
| Thermal resistance, junction - ambient                  | $R_{thJA}$ | -      | -    | 62   | °C/W | lead                                |
| Thermal resistance, junction - ambient for SMD version  | $R_{thJA}$ | -      | -    | -    | °C/W | n.a.                                |
| Soldering temperature, wave- & reflow soldering allowed | $T_{sld}$  | -      | -    | 260  | °C   | 1.6mm (0.063 in.) from case for 10s |

### 3 Electrical characteristics

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

**Table 4 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             | 4.5       | V        | $V_{DS}=V_{GS}$ , $I_D=0.24mA$                                                                                |
| Zero gate voltage drain current <sup>1)</sup> | $I_{DSS}$     | -      | -             | 1         | $\mu A$  | $V_{DS}=600V$ , $V_{GS}=0V$ , $T_j=25^\circ\text{C}$<br>$V_{DS}=600V$ , $V_{GS}=0V$ , $T_j=125^\circ\text{C}$ |
| Gate-source leakage current                   | $I_{GSS}$     | -      | -             | 100       | nA       | $V_{GS}=20V$ , $V_{DS}=0V$                                                                                    |
| Drain-source on-state resistance              | $R_{DS(on)}$  | -      | 0.171<br>0.39 | 0.21<br>- | $\Omega$ | $V_{GS}=10V$ , $I_D=4.9A$ , $T_j=25^\circ\text{C}$<br>$V_{GS}=10V$ , $I_D=4.9A$ , $T_j=150^\circ\text{C}$     |
| Gate resistance                               | $R_G$         | -      | 11            | -         | $\Omega$ | $f=1MHz$ , open drain                                                                                         |

**Table 5 Dynamic characteristics**

| Parameter                                                  | Symbol       | Values |      |      | Unit | Note / Test Condition                                                         |
|------------------------------------------------------------|--------------|--------|------|------|------|-------------------------------------------------------------------------------|
|                                                            |              | Min.   | Typ. | Max. |      |                                                                               |
| Input capacitance                                          | $C_{iss}$    | -      | 1015 | -    | pF   | $V_{GS}=0V$ , $V_{DS}=400V$ , $f=250kHz$                                      |
| Output capacitance                                         | $C_{oss}$    | -      | 18   | -    | pF   | $V_{GS}=0V$ , $V_{DS}=400V$ , $f=250kHz$                                      |
| Effective output capacitance, energy related <sup>2)</sup> | $C_{o(er)}$  | -      | 33   | -    | pF   | $V_{GS}=0V$ , $V_{DS}=0...400V$                                               |
| Effective output capacitance, time related <sup>3)</sup>   | $C_{o(tr)}$  | -      | 330  | -    | pF   | $I_D=\text{constant}$ , $V_{GS}=0V$ , $V_{DS}=0...400V$                       |
| Turn-on delay time                                         | $t_{d(on)}$  | -      | 22   | -    | ns   | $V_{DD}=400V$ , $V_{GS}=10V$ , $I_D=6.0A$ ,<br>$R_G=10.2\Omega$ ; see table 9 |
| Rise time                                                  | $t_r$        | -      | 16.5 | -    | ns   | $V_{DD}=400V$ , $V_{GS}=10V$ , $I_D=6.0A$ ,<br>$R_G=10.2\Omega$ ; see table 9 |
| Turn-off delay time                                        | $t_{d(off)}$ | -      | 54   | -    | ns   | $V_{DD}=400V$ , $V_{GS}=10V$ , $I_D=6.0A$ ,<br>$R_G=10.2\Omega$ ; see table 9 |
| Fall time                                                  | $t_f$        | -      | 7.5  | -    | ns   | $V_{DD}=400V$ , $V_{GS}=10V$ , $I_D=6.0A$ ,<br>$R_G=10.2\Omega$ ; see table 9 |

**Table 6 Gate charge characteristics**

| Parameter             | Symbol        | Values |      |      | Unit | Note / Test Condition                            |
|-----------------------|---------------|--------|------|------|------|--------------------------------------------------|
|                       |               | Min.   | Typ. | Max. |      |                                                  |
| Gate to source charge | $Q_{gs}$      | -      | 6    | -    | nC   | $V_{DD}=400V$ , $I_D=6.0A$ , $V_{GS}=0$ to $10V$ |
| Gate to drain charge  | $Q_{gd}$      | -      | 7    | -    | nC   | $V_{DD}=400V$ , $I_D=6.0A$ , $V_{GS}=0$ to $10V$ |
| Gate charge total     | $Q_g$         | -      | 23   | -    | nC   | $V_{DD}=400V$ , $I_D=6.0A$ , $V_{GS}=0$ to $10V$ |
| Gate plateau voltage  | $V_{plateau}$ | -      | 5.7  | -    | V    | $V_{DD}=400V$ , $I_D=6.0A$ , $V_{GS}=0$ to $10V$ |

<sup>1)</sup> Maximum specification is defined by calculated six sigma upper confidence bound

<sup>2)</sup>  $C_{o(er)}$  is a fixed capacitance that gives the same stored energy as  $C_{oss}$  while  $V_{DS}$  is rising from 0 to 400V

<sup>3)</sup>  $C_{o(tr)}$  is a fixed capacitance that gives the same charging time as  $C_{oss}$  while  $V_{DS}$  is rising from 0 to 400V

**Table 7 Reverse diode characteristics**

| Parameter                     | Symbol    | Values |       |      | Unit    | Note / Test Condition                                        |
|-------------------------------|-----------|--------|-------|------|---------|--------------------------------------------------------------|
|                               |           | Min.   | Typ.  | Max. |         |                                                              |
| Diode forward voltage         | $V_{SD}$  | -      | 1.0   | -    | V       | $V_{GS}=0V$ , $I_F=4.9A$ , $T_J=25^{\circ}C$                 |
| Reverse recovery time         | $t_{rr}$  | -      | 92    | 138  | ns      | $V_R=400V$ , $I_F=6.0A$ , $di_F/dt=100A/\mu s$ ; see table 8 |
| Reverse recovery charge       | $Q_{rr}$  | -      | 0.385 | 0.77 | $\mu C$ | $V_R=400V$ , $I_F=6.0A$ , $di_F/dt=100A/\mu s$ ; see table 8 |
| Peak reverse recovery current | $I_{rrm}$ | -      | 7.5   | -    | A       | $V_R=400V$ , $I_F=6.0A$ , $di_F/dt=100A/\mu s$ ; see table 8 |

## 4 Electrical characteristics diagrams

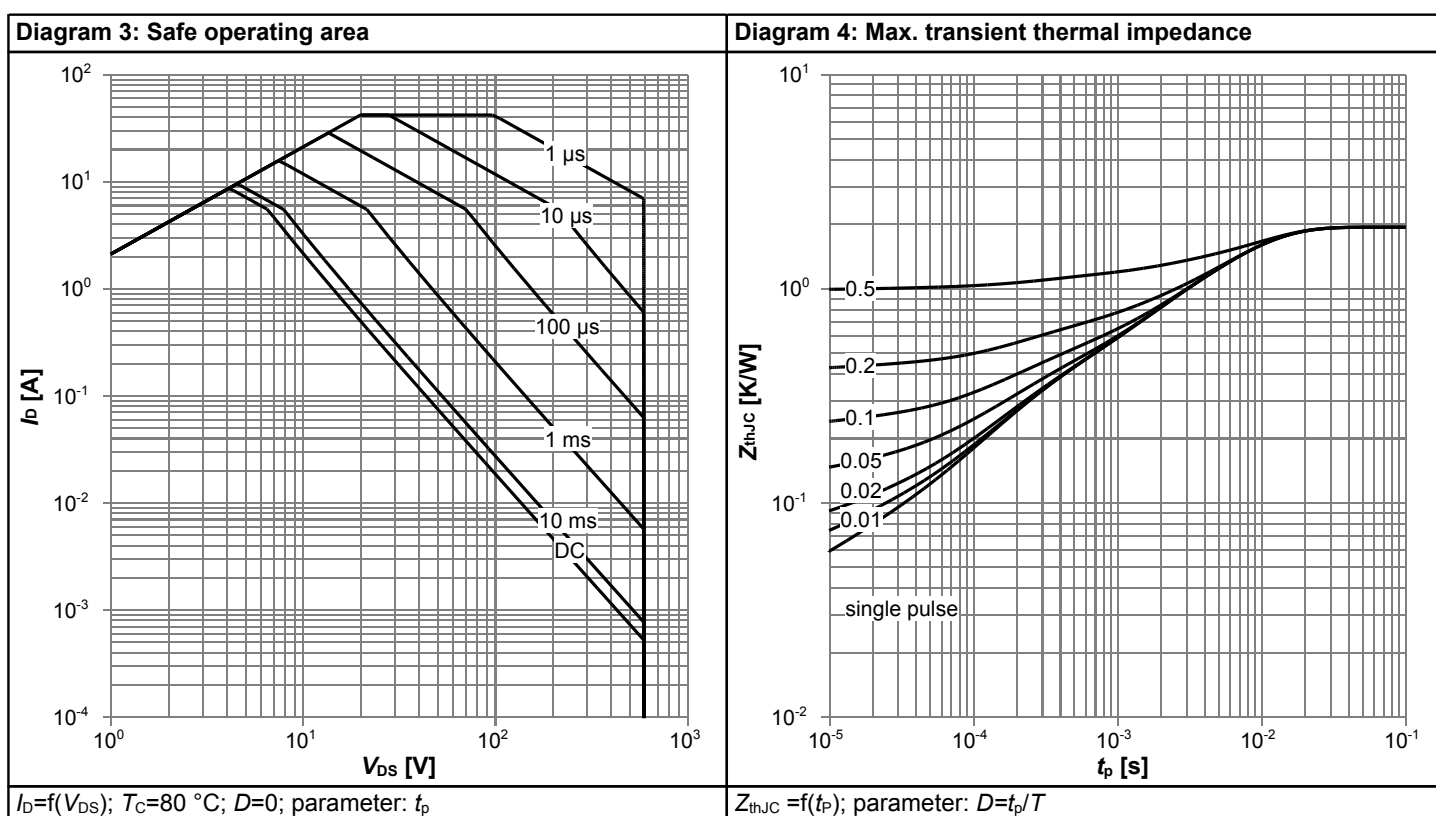
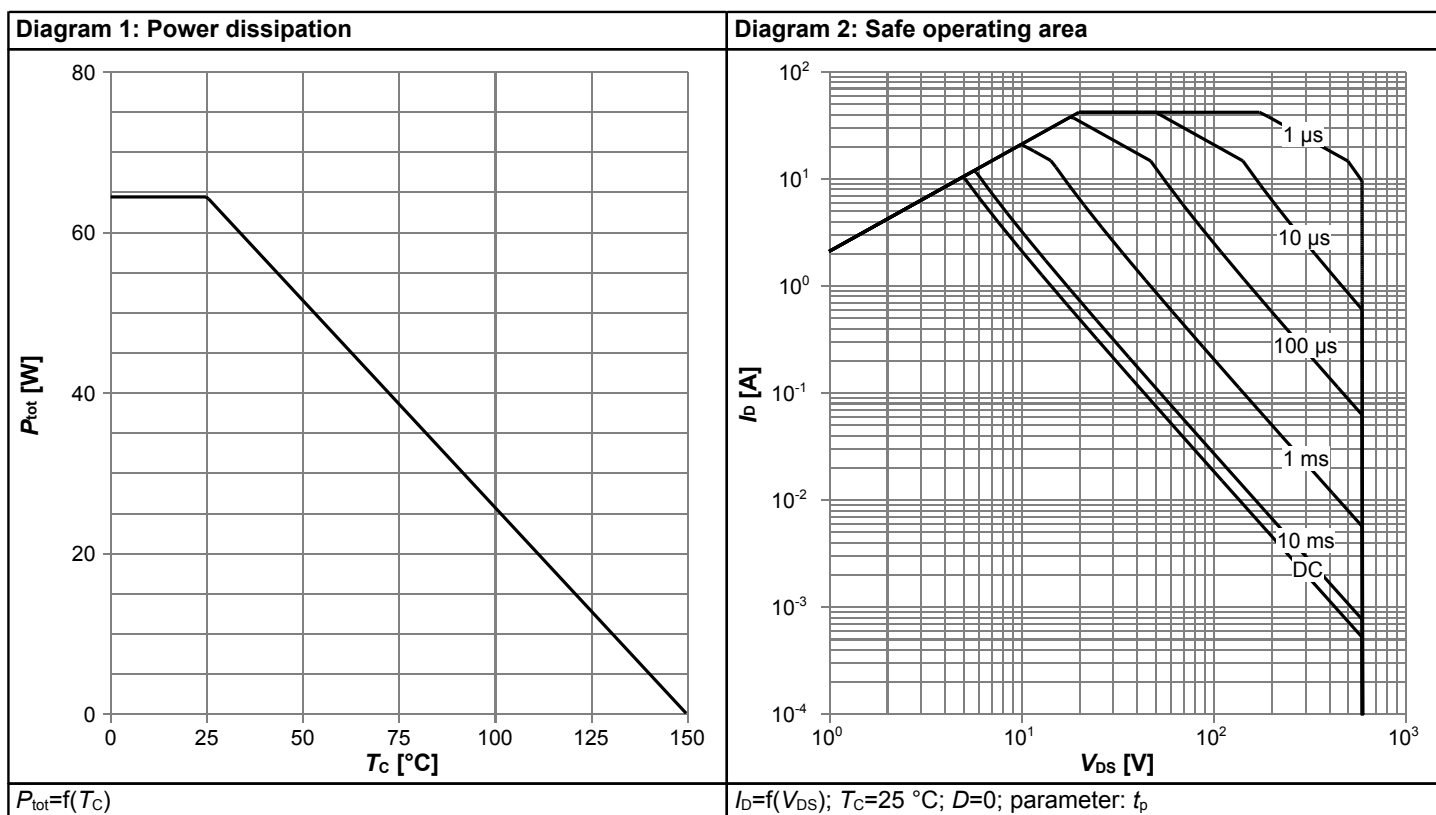
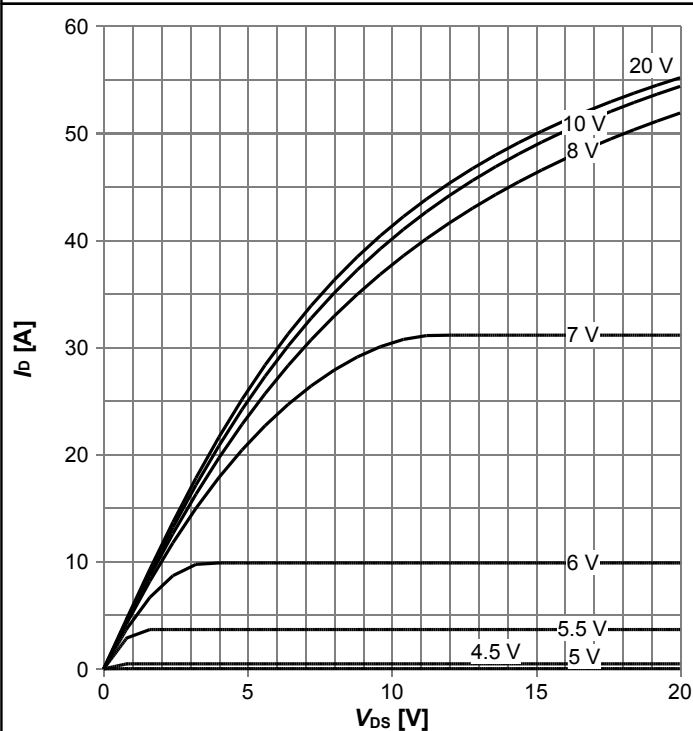
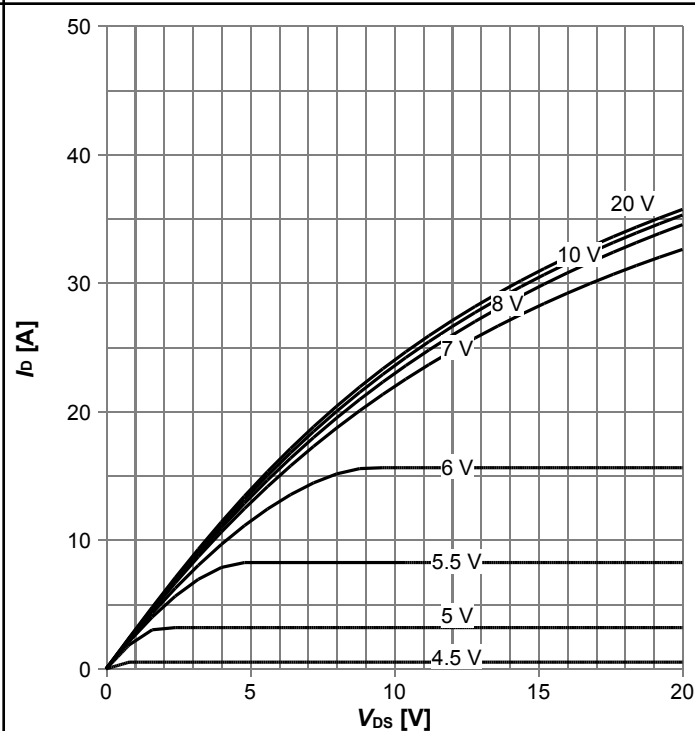


Diagram 5: Typ. output characteristics



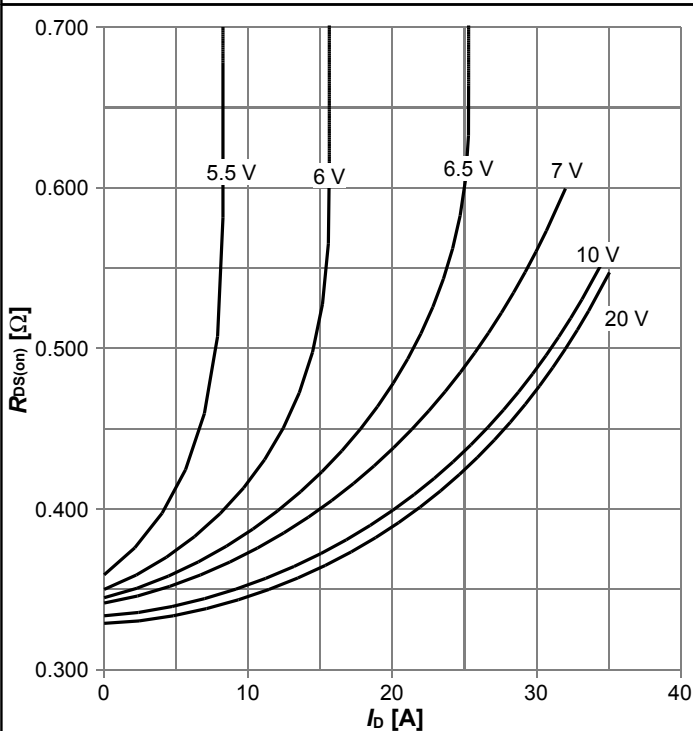
$I_D = f(V_{DS})$ ;  $T_j = 25\text{ °C}$ ; parameter:  $V_{GS}$

Diagram 6: Typ. output characteristics



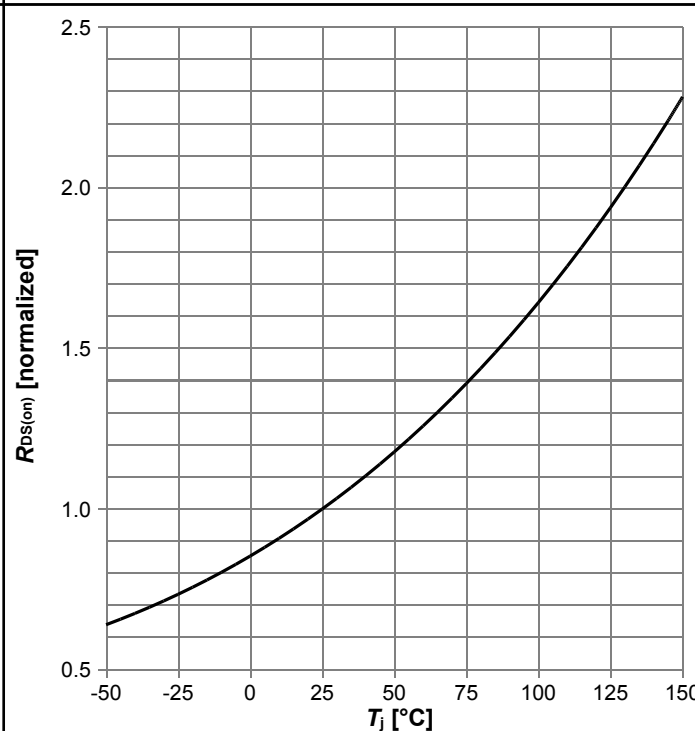
$I_D = f(V_{DS})$ ;  $T_j = 125\text{ °C}$ ; parameter:  $V_{GS}$

Diagram 7: Typ. drain-source on-state resistance



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

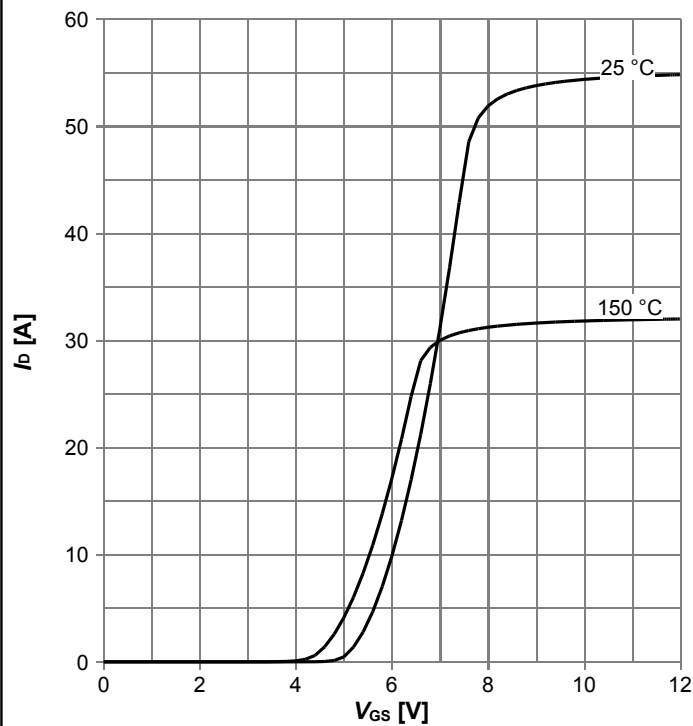
Diagram 8: Drain-source on-state resistance



$R_{DS(on)} = f(T_j)$ ;  $I_D = 4.9\text{ A}$ ;  $V_{GS} = 10\text{ V}$

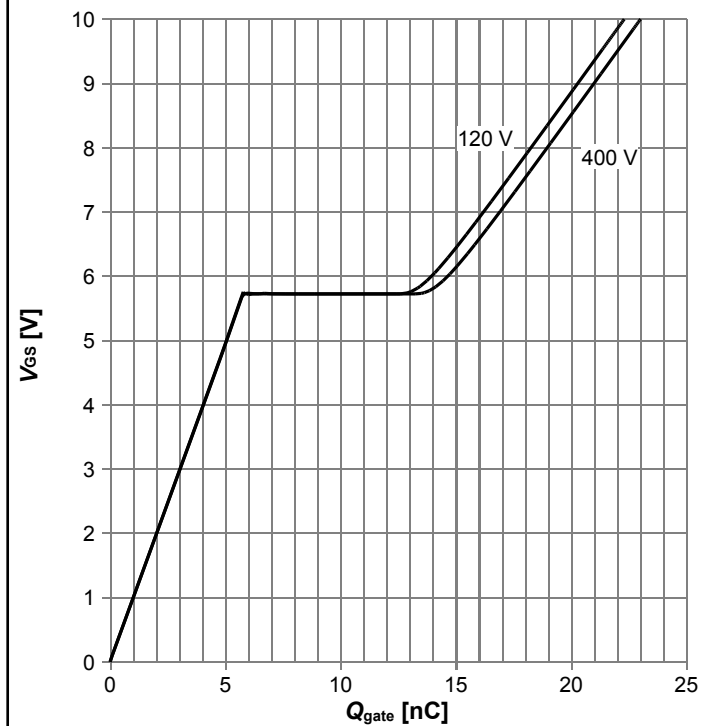


**Diagram 9: Typ. transfer characteristics**



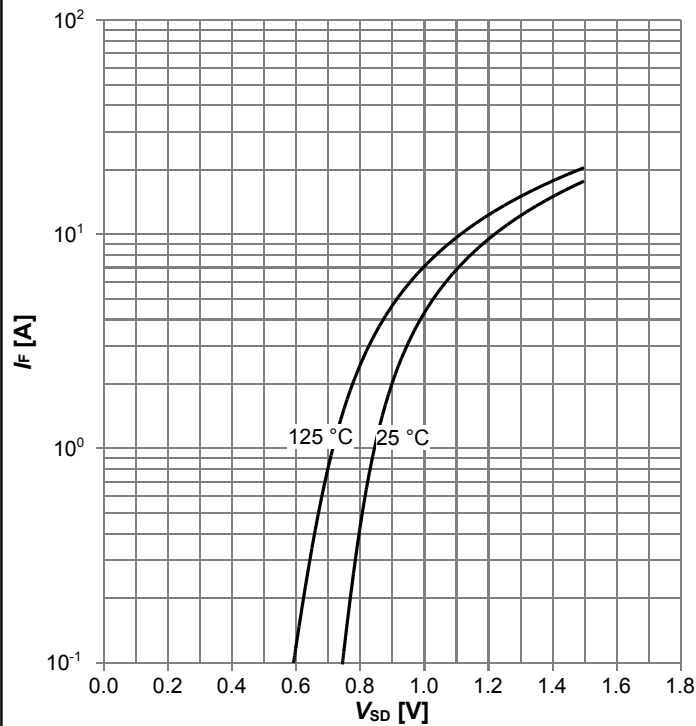
$I_D = f(V_{GS})$ ;  $V_{DS} = 20V$ ; parameter:  $T_j$

**Diagram 10: Typ. gate charge**



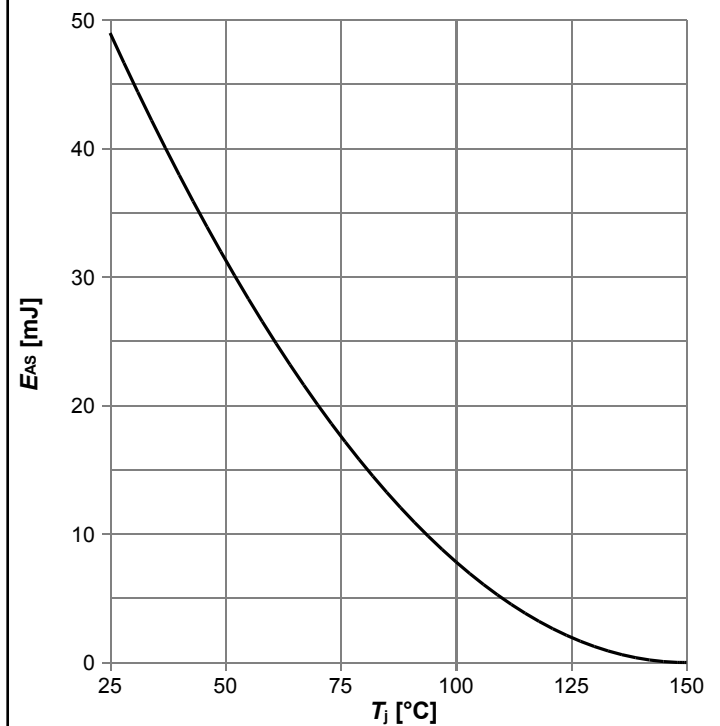
$V_{GS} = f(Q_{gate})$ ;  $I_D = 6.0$  A pulsed; parameter:  $V_{DD}$

**Diagram 11: Forward characteristics of reverse diode**



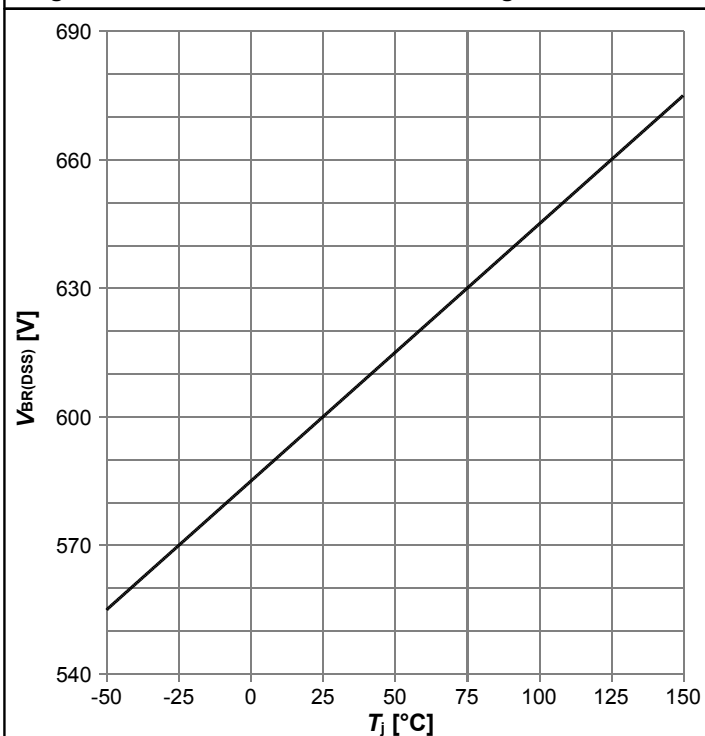
$I_F = f(V_{SD})$ ; parameter:  $T_j$

**Diagram 12: Avalanche energy**



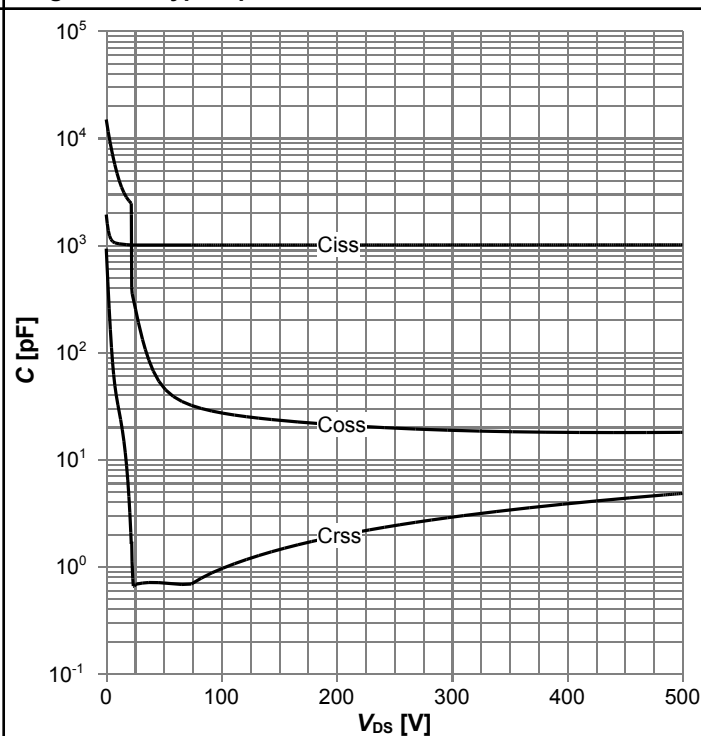
$E_{AS} = f(T_j)$ ;  $I_D = 3.2$  A;  $V_{DD} = 50$  V

Diagram 13: Drain-source breakdown voltage



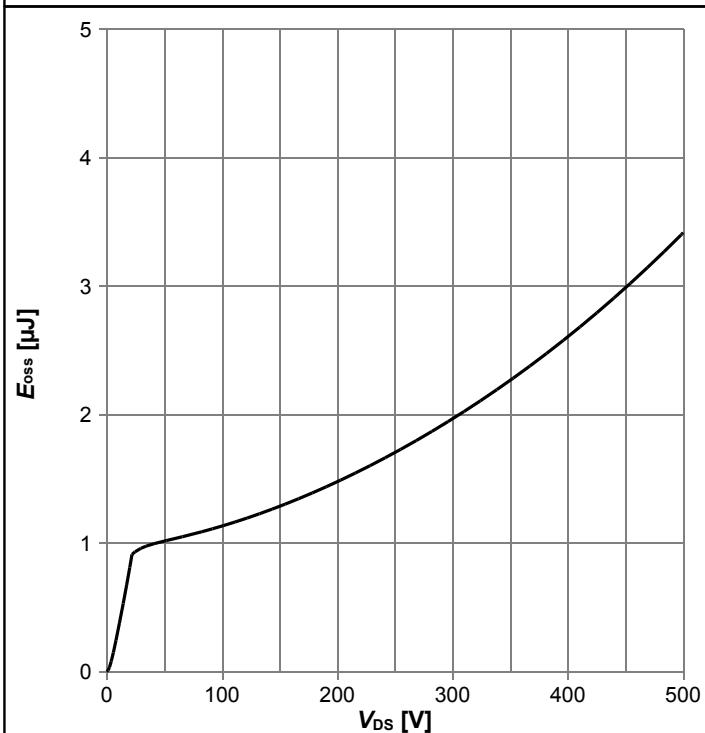
$$V_{BR(DSS)} = f(T_j); I_D = 1 \text{ mA}$$

Diagram 14: Typ. capacitances



$$C = f(V_{DS}); V_{GS} = 0 \text{ V}; f = 250 \text{ kHz}$$

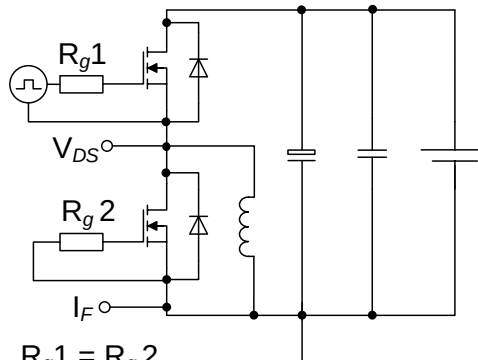
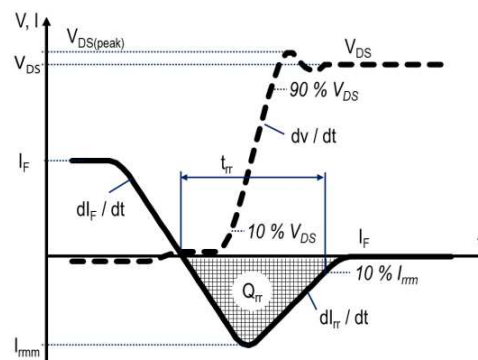
Diagram 15: Typ.  $C_{oss}$  stored energy



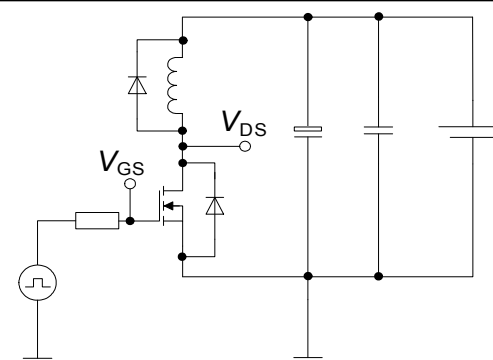
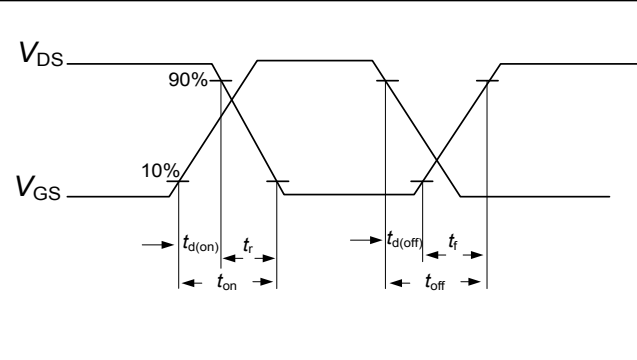
$$E_{oss} = f(V_{DS})$$

## 5 Test Circuits

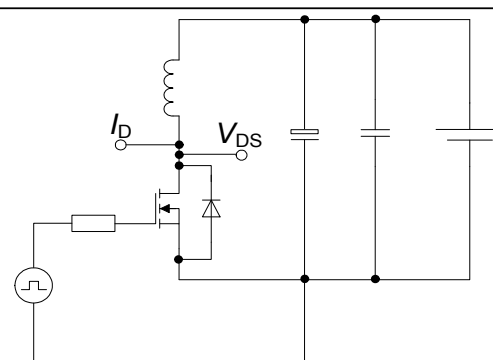
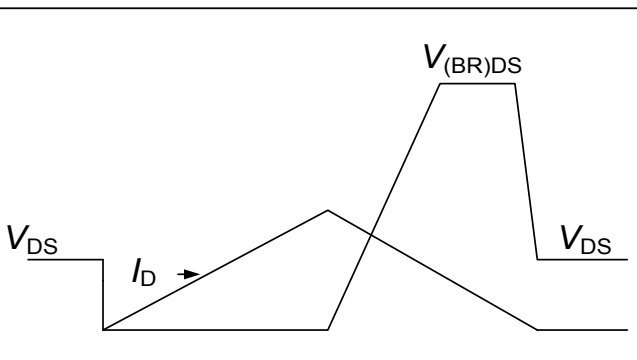
**Table 8 Diode characteristics**

| Test circuit for diode characteristics                                                                                | Diode recovery waveform                                                            |
|-----------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------|
|  <p><math>R_{g1} = R_{g2}</math></p> |  |

**Table 9 Switching times**

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

**Table 10 Unclamped inductive load**

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

## 6 Package Outlines

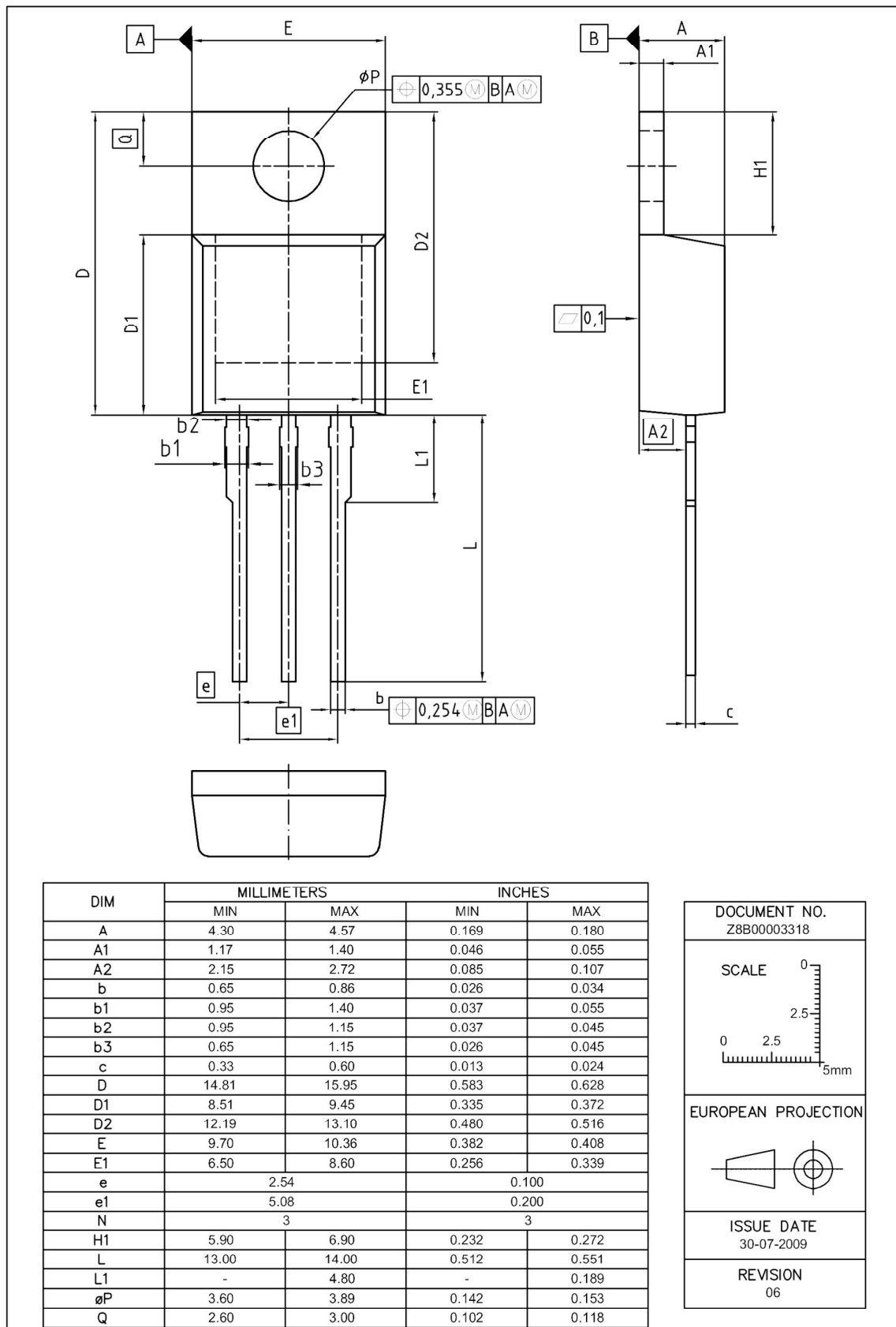


Figure 1 Outline PG-TO 220-3, dimensions in mm/inches

## **7 Appendix A**

### **Table 11 Related Links**

- **IFX CoolMOS CFD7 Webpage:** [www.infineon.com](http://www.infineon.com)
- **IFX CoolMOS CFD7 application note:** [www.infineon.com](http://www.infineon.com)
- **IFX CoolMOS CFD7 simulation model:** [www.infineon.com](http://www.infineon.com)
- **IFX Design tools:** [www.infineon.com](http://www.infineon.com)

## Revision History

IPP60R210CFD7

**Revision: 2018-11-05, Rev. 2.1**

Previous Revision

| Revision | Date       | Subjects (major changes since last revision)                               |
|----------|------------|----------------------------------------------------------------------------|
| 2.0      | 2018-04-20 | Release of final version                                                   |
| 2.1      | 2018-11-05 | Table 7: Reduced trr,max value; Change of qualification grade nomenclature |

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