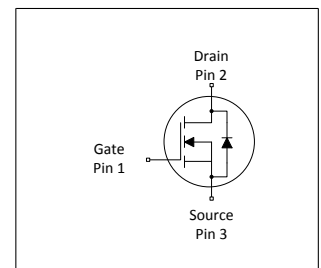


# MOSFET

## 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  $R_{DS(on)} * Q_g$  and  $R_{DS(on)} * E_{oss}$
- 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          |
| $R_{DS(on),max}$     | 24    | m $\Omega$ |
| $Q_{g,typ}$          | 183   | nC         |
| $I_{D,pulse}$        | 360   | A          |
| $E_{oss} @ 400V$     | 21.1  | $\mu$ J    |
| Body diode $di_f/dt$ | 1300  | A/ $\mu$ s |

| Type / Ordering Code | Package     | Marking  | Related Links  |
|----------------------|-------------|----------|----------------|
| IPW60R024CFD7        | PG-TO 247-3 | 60R024F7 | see Appendix A |

## Table of Contents

|   |    |
|---|----|
| Description .....                         | 1  |
| Maximum ratings .....                     | 3  |
| Thermal characteristics .....             | 4  |
| Electrical characteristics .....          | 5  |
| Electrical characteristics diagrams ..... | 7  |
| Test Circuits .....                       | 11 |
| Package Outlines .....                    | 12 |
| Appendix A .....                          | 13 |
| Revision History .....                    | 14 |
| Trademarks .....                          | 14 |
| Disclaimer .....                          | 14 |

## 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> | $I_D$               | -      | -    | 77<br>49 | A                | $T_C=25^\circ\text{C}$<br>$T_C=100^\circ\text{C}$  |
| Pulsed drain current <sup>2)</sup>     | $I_{D,pulse}$       | -      | -    | 360      | A                | $T_C=25^\circ\text{C}$   |
| Avalanche energy, single pulse         | $E_{AS}$            | -      | -    | 424      | mJ               | $I_D=8.6\text{A}$ ; $V_{DD}=50\text{V}$ ; see table 10                                       |
| Avalanche energy, repetitive           | $E_{AR}$            | -      | -    | 2.12     | mJ               | $I_D=8.6\text{A}$ ; $V_{DD}=50\text{V}$ ; see table 10                                       |
| Avalanche current, single pulse        | $I_{AS}$            | -      | -    | 8.6      | 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                      | $P_{tot}$           | -      | -    | 320      | 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       | $I_S$               | -      | -    | 77       | A                | $T_C=25^\circ\text{C}$   |
| Diode pulse current <sup>2)</sup>      | $I_{S,pulse}$       | -      | -    | 360      | A                | $T_C=25^\circ\text{C}$   |
| Reverse diode dv/dt <sup>3)</sup>      | dv/dt               | -      | -    | 70       | V/ns             | $V_{DS}=0\dots400\text{V}$ , $I_{SD}\leq 77\text{A}$ , $T_j=25^\circ\text{C}$<br>see table 8 |
| Maximum diode commutation speed        | di <sub>F</sub> /dt | -      | -    | 1300     | A/ $\mu\text{s}$ | $V_{DS}=0\dots400\text{V}$ , $I_{SD}\leq 77\text{A}$ , $T_j=25^\circ\text{C}$<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                        | $R_{thJC}$ | -      | -    | 0.39 | °C/W | -                                   |
| Thermal resistance, junction - ambient                     | $R_{thJA}$ | -      | -    | 62   | °C/W | leaded                              |
| Thermal resistance, junction - ambient for SMD version     | $R_{thJA}$ | -      | -    | -    | °C/W | n.a.                                |
| Soldering temperature, wavesoldering only allowed at leads | $T_{sold}$ | -      | -    | 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             | $V_{DS}=V_{GS}, I_D=2.12mA$   |
| Zero gate voltage drain current <sup>1)</sup> | $I_{DSS}$     | -      | -     | 1     | $\mu\text{A}$ | $V_{DS}=600V, V_{GS}=0V, T_j=25^\circ\text{C}$<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              | $R_{DS(on)}$  | -      | 0.019 | 0.024 | $\Omega$      | $V_{GS}=10V, I_D=42.4A, T_j=25^\circ\text{C}$<br>$V_{GS}=10V, I_D=42.4A, T_j=150^\circ\text{C}$   |
| Gate resistance                               | $R_G$         | -      | 3.1   | -     | $\Omega$      | $f=1\text{MHz}$ , open drain  |

**Table 5 Dynamic characteristics**

| Parameter  | Symbol       | Values |       |      | Unit | Note / Test Condition  |
|--|--------------|--------|-------|------|------|--|
|  |              | Min.   | Typ.  | Max. |      |  |
| Input capacitance  | $C_{iss}$    | -      | 7268  | -    | pF   | $V_{GS}=0V, V_{DS}=400V, f=250\text{kHz}$                              |
| Output capacitance   | $C_{oss}$    | -      | 143   | -    | pF   | $V_{GS}=0V, V_{DS}=400V, f=250\text{kHz}$                              |
| Effective output capacitance, energy related <sup>2)</sup> | $C_{o(er)}$  | -      | 264   | -    | pF   | $V_{GS}=0V, V_{DS}=0\dots400V$   |
| Effective output capacitance, time related <sup>3)</sup>   | $C_{o(tr)}$  | -      | 2729  | -    | pF   | $I_D=\text{constant}, V_{GS}=0V, V_{DS}=0\dots400V$                    |
| Turn-on delay time   | $t_{d(on)}$  | -      | 59    | -    | ns   | $V_{DD}=400V, V_{GS}=10V, I_D=19.0A,$<br>$R_G=1.8\Omega$ ; see table 9 |
| Rise time  | $t_r$        | -      | 32    | -    | ns   | $V_{DD}=400V, V_{GS}=10V, I_D=19.0A,$<br>$R_G=1.8\Omega$ ; see table 9 |
| Turn-off delay time  | $t_{d(off)}$ | -      | 170.6 | -    | ns   | $V_{DD}=400V, V_{GS}=10V, I_D=19.0A,$<br>$R_G=1.8\Omega$ ; see table 9 |
| Fall time  | $t_f$        | -      | 9.6   | -    | ns   | $V_{DD}=400V, V_{GS}=10V, I_D=19.0A,$<br>$R_G=1.8\Omega$ ; see table 9 |

**Table 6 Gate charge characteristics**

| Parameter             | Symbol        | Values |      |      | Unit | Note / Test Condition                     |
|-----------------------|---------------|--------|------|------|------|---|
|                       |               | Min.   | Typ. | Max. |      |   |
| Gate to source charge | $Q_{gs}$      | -      | 39   | -    | nC   | $V_{DD}=400V, I_D=19.0A, V_{GS}=0$ to 10V |
| Gate to drain charge  | $Q_{gd}$      | -      | 66   | -    | nC   | $V_{DD}=400V, I_D=19.0A, V_{GS}=0$ to 10V |
| Gate charge total     | $Q_g$         | -      | 183  | -    | nC   | $V_{DD}=400V, I_D=19.0A, V_{GS}=0$ to 10V |
| Gate plateau voltage  | $V_{plateau}$ | -      | 5.3  | -    | V    | $V_{DD}=400V, I_D=19.0A, V_{GS}=0$ to 10V |

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

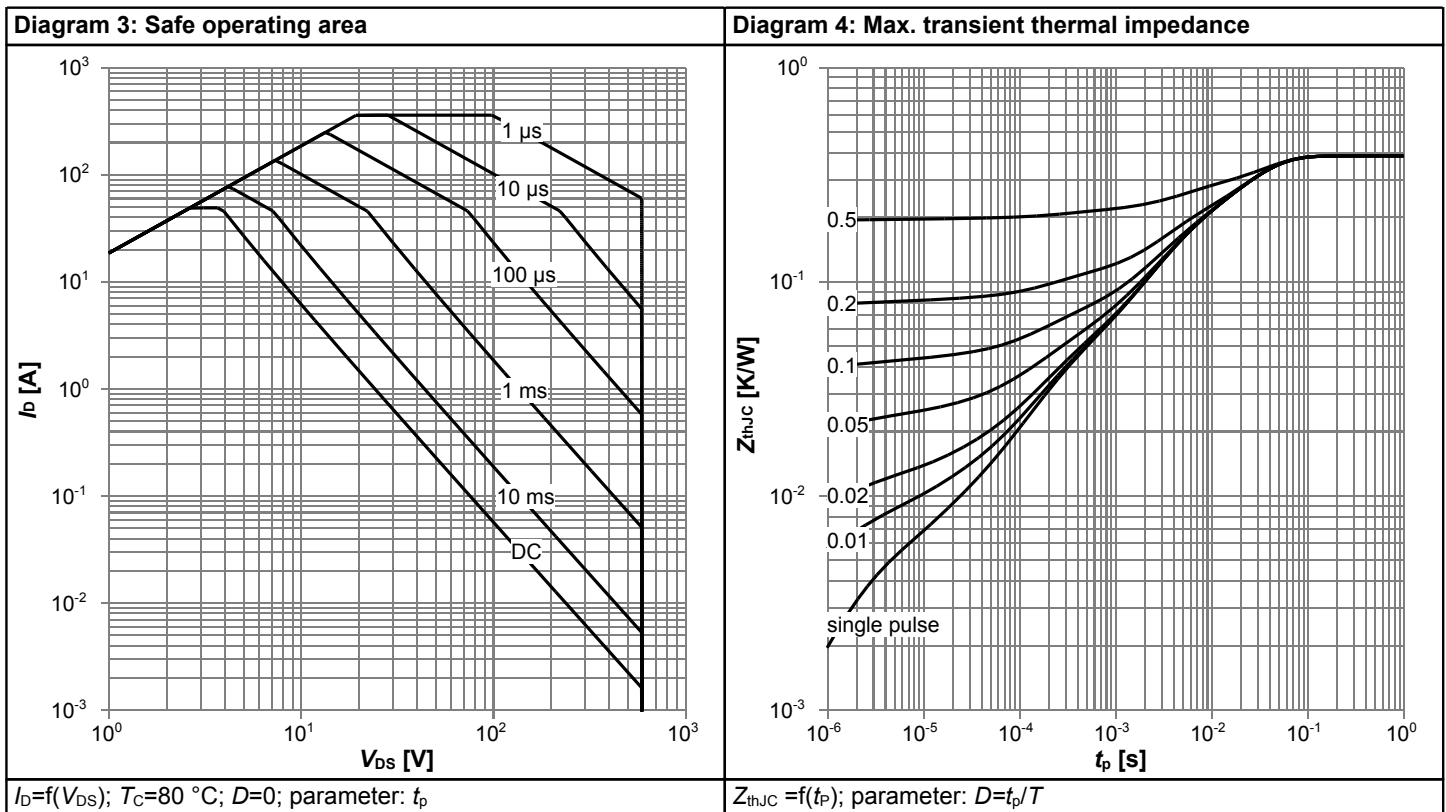
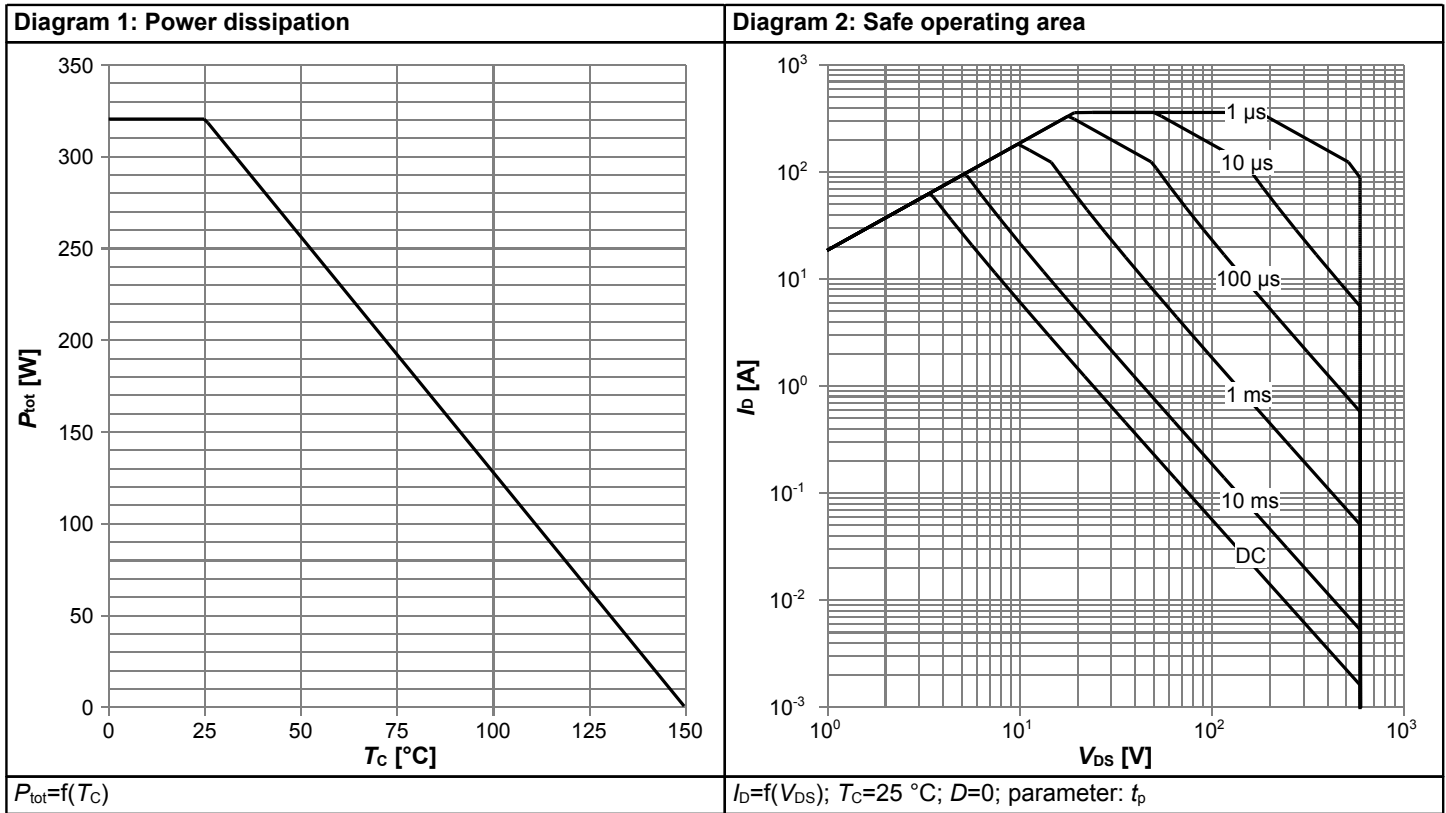
<sup>2)</sup>  $C_{o(er)}$  is a fixed capacitance that gives the same stored energy as  $C_{oss}$  while  $V_{DS}$  is rising from 0 to 400V

<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       | $V_{GS}=0V, I_F=42.4A, T_j=25^{\circ}C$                    |
| Reverse recovery time         | $t_{rr}$  | -      | 175.3 | 263  | ns      | $V_R=400V, I_F=19.0A, di_F/dt=100A/\mu s$ ;<br>see table 8 |
| Reverse recovery charge       | $Q_{rr}$  | -      | 1.3   | 2.6  | $\mu C$ | $V_R=400V, I_F=19.0A, di_F/dt=100A/\mu s$ ;<br>see table 8 |
| Peak reverse recovery current | $I_{rrm}$ | -      | 11.57 | -    | A       | $V_R=400V, I_F=19.0A, di_F/dt=100A/\mu s$ ;<br>see table 8 |

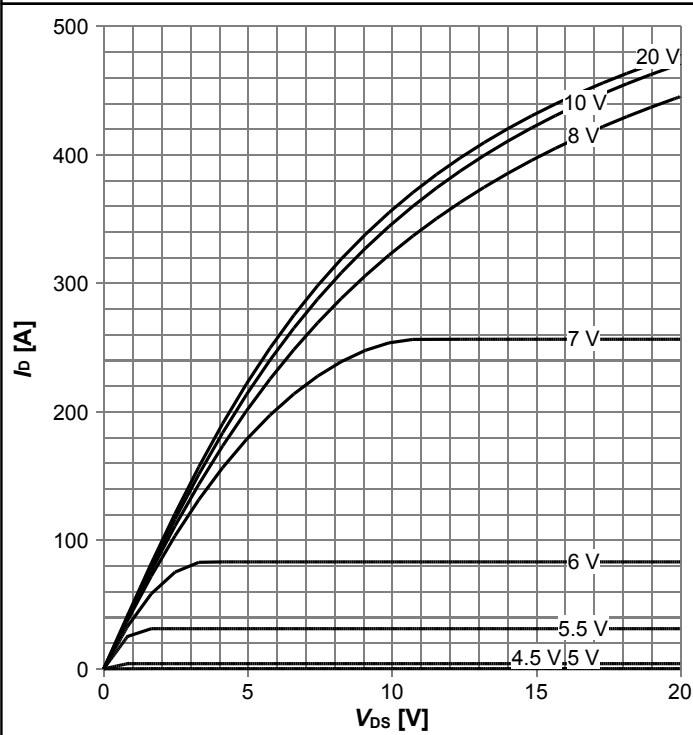
### 4 Electrical characteristics diagrams



# 600V CoolMOS™ CFD7 Power Transistor

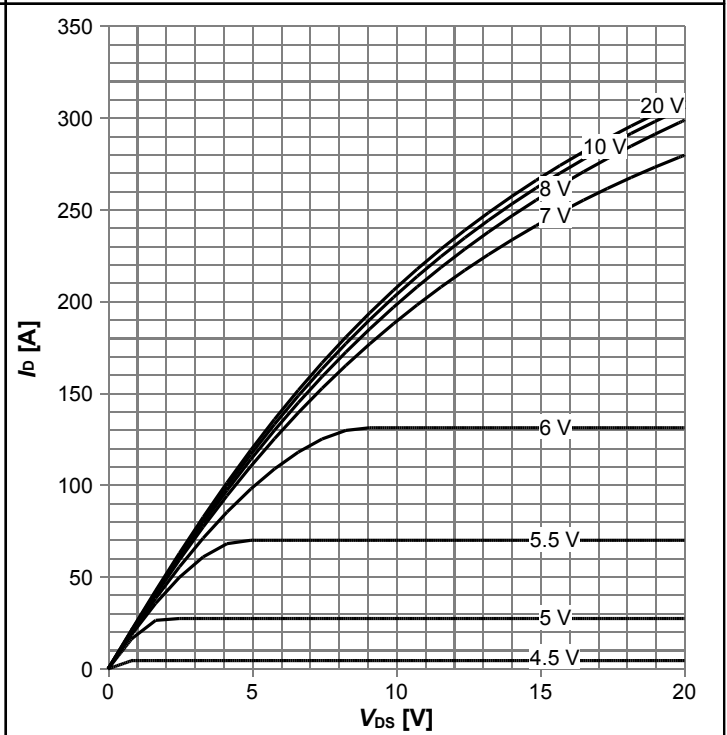
## IPW60R024CFD7

**Diagram 5: Typ. output characteristics**



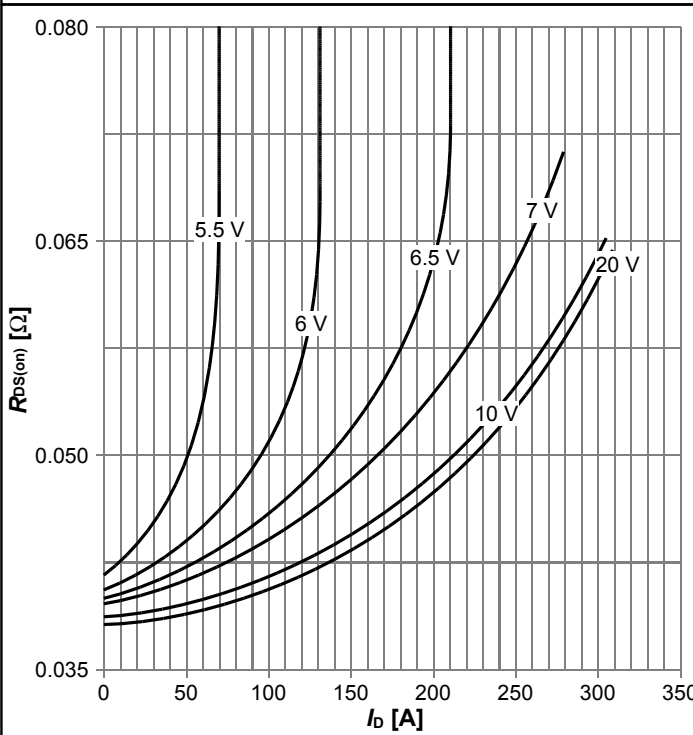
$I_D=f(V_{DS})$ ;  $T_j=25\text{ °C}$ ; parameter:  $V_{GS}$

**Diagram 6: Typ. output characteristics**



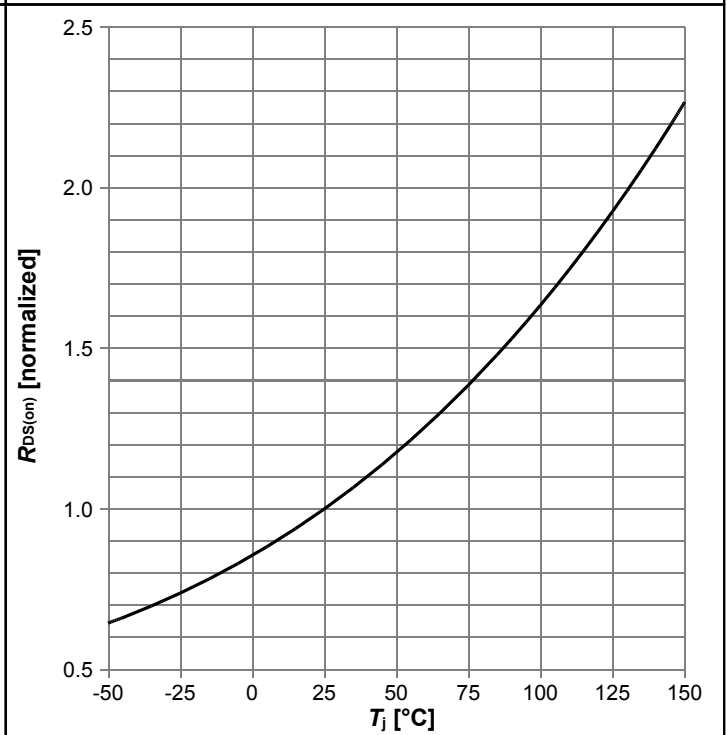
$I_D=f(V_{DS})$ ;  $T_j=125\text{ °C}$ ; parameter:  $V_{GS}$

**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**



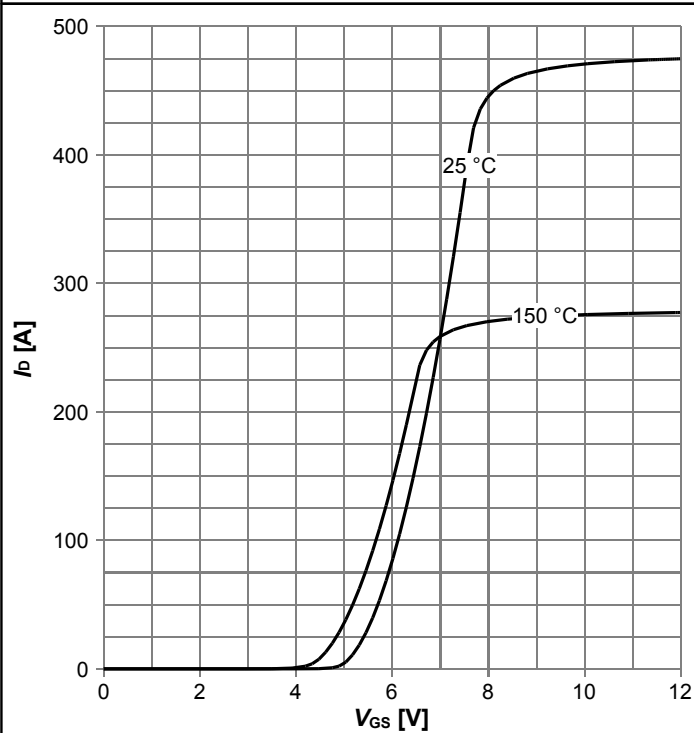
$R_{DS(on)}=f(T_j)$ ;  $I_D=42.4\text{ A}$ ;  $V_{GS}=10\text{ V}$



# 600V CoolMOS™ CFD7 Power Transistor

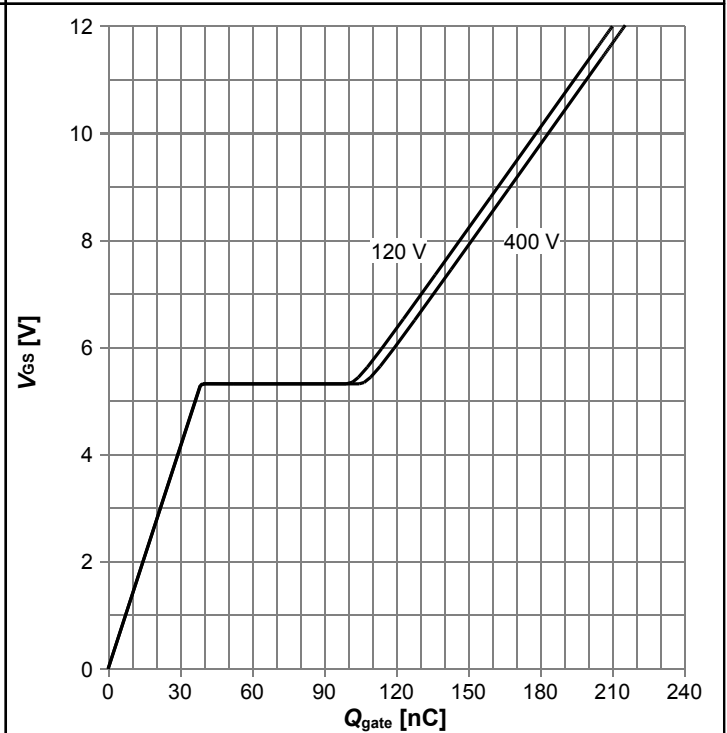
## IPW60R024CFD7

**Diagram 9: Typ. transfer characteristics**



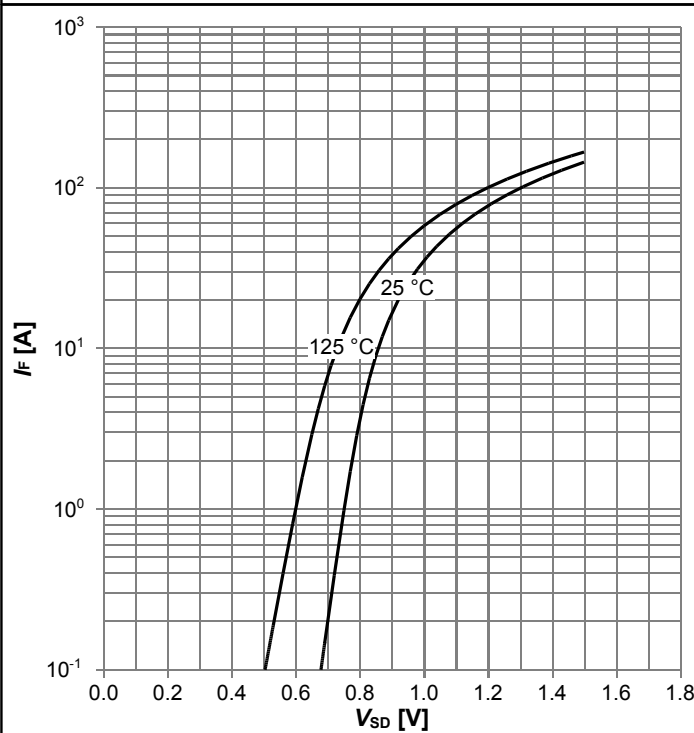
$I_D = f(V_{GS})$ ;  $V_{DS} = 20V$ ; parameter:  $T_j$

**Diagram 10: Typ. gate charge**



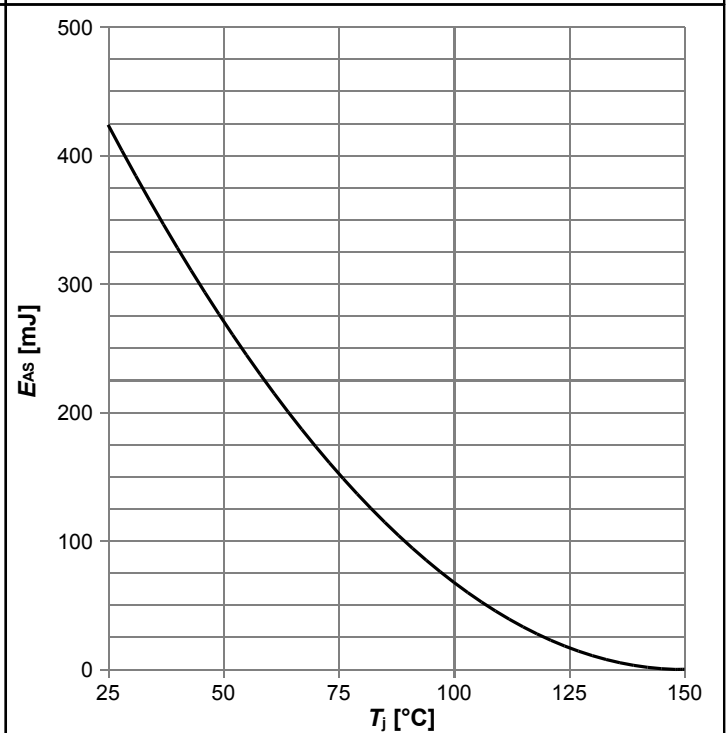
$V_{GS} = f(Q_{gate})$ ;  $I_D = 19.0$  A pulsed; parameter:  $V_{DD}$

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



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

**Diagram 12: Avalanche energy**

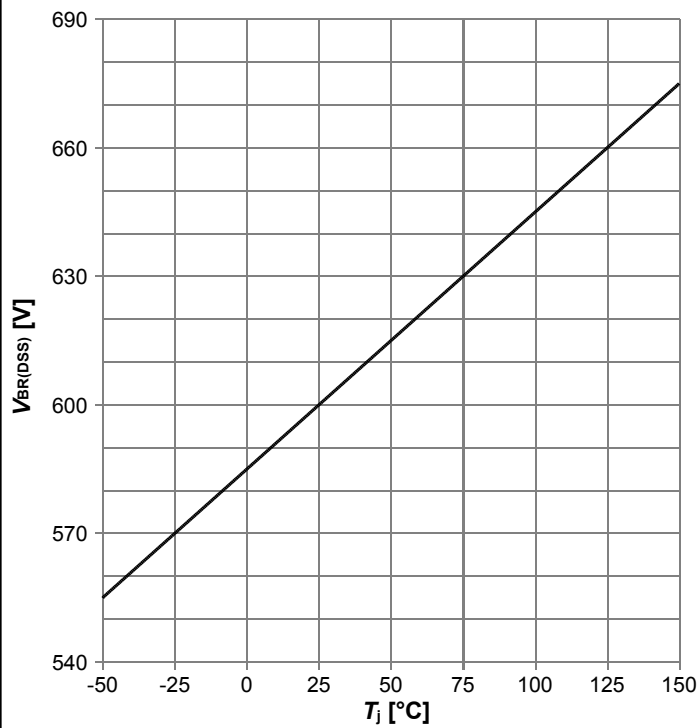


$E_{AS} = f(T_j)$ ;  $I_D = 8.6$  A;  $V_{DD} = 50$  V

# 600V CoolMOS™ CFD7 Power Transistor

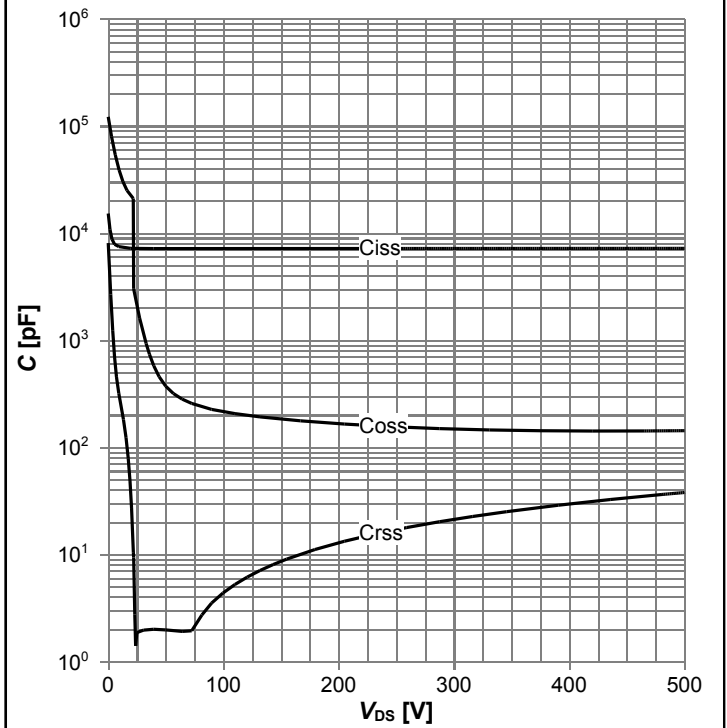
## IPW60R024CFD7

Diagram 13: Drain-source breakdown voltage



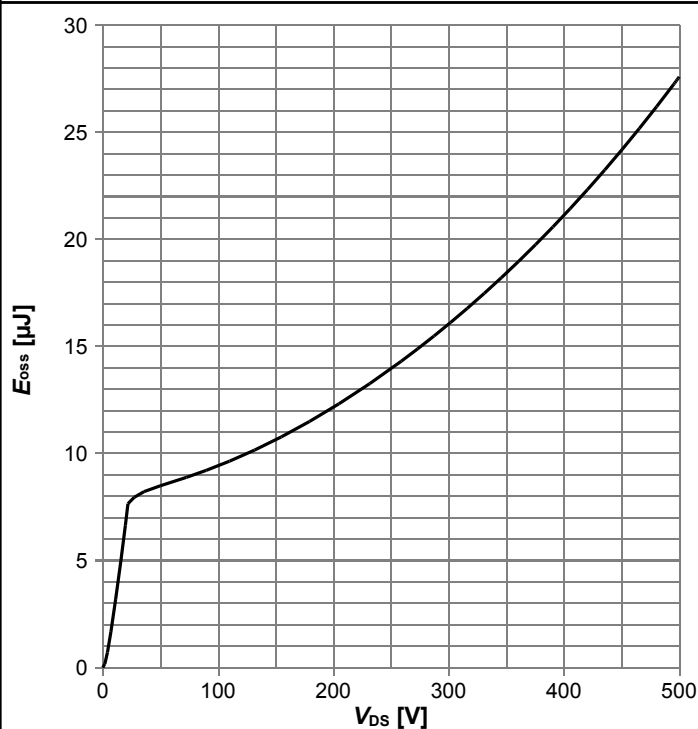
$V_{BR(DSS)}=f(T_j); I_D=1\text{ mA}$

Diagram 14: Typ. capacitances



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

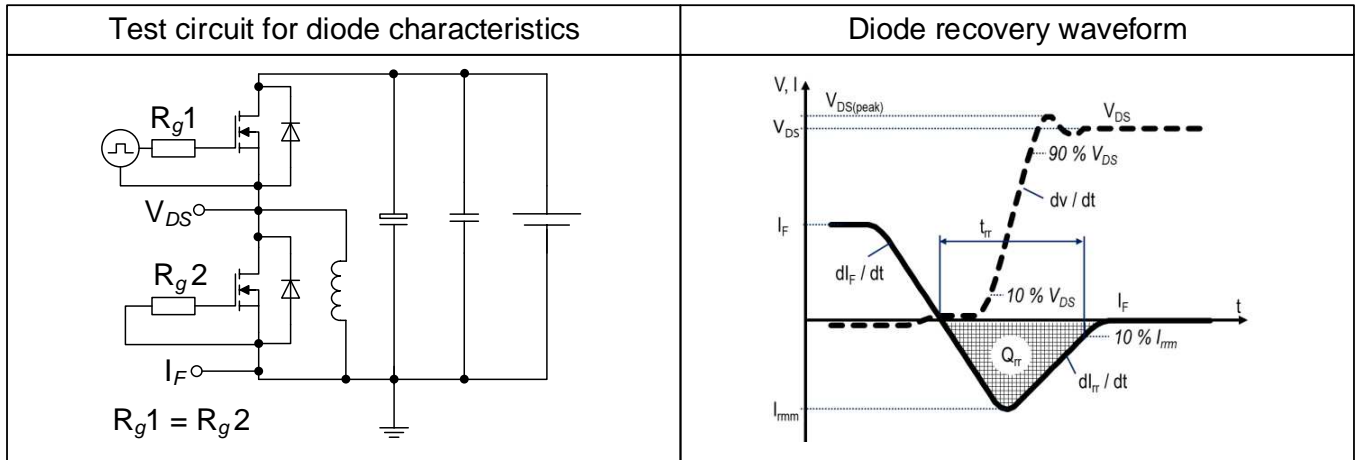
Diagram 15: Typ. Coss stored energy



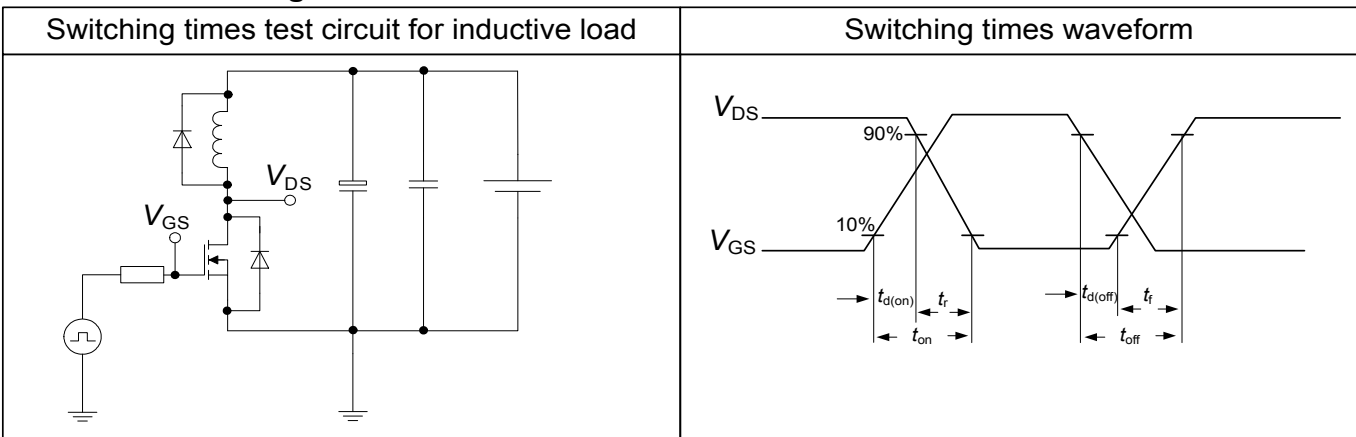
$E_{oss}=f(V_{DS})$

## 5 Test Circuits

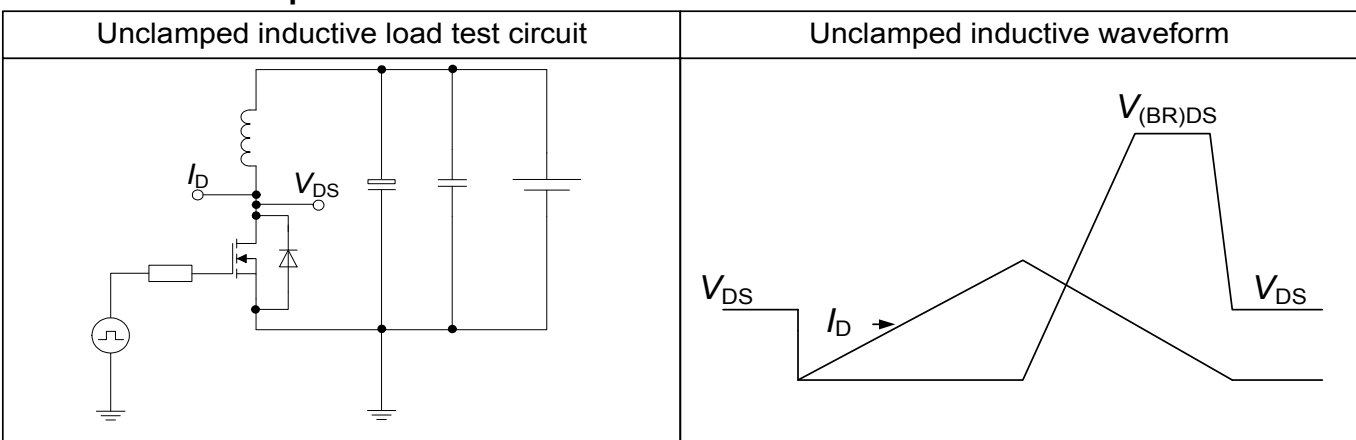
**Table 8 Diode characteristics**



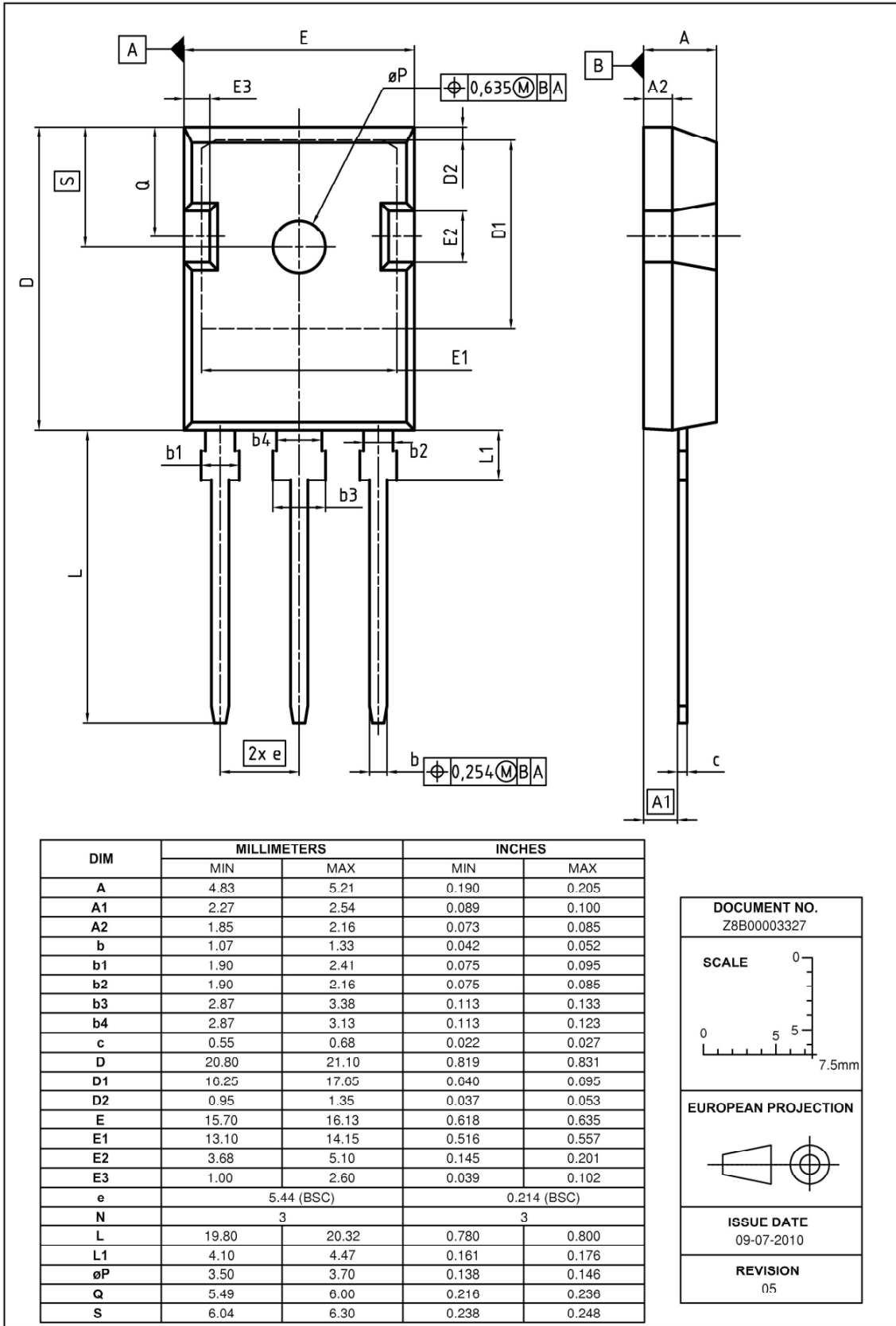
**Table 9 Switching times**



**Table 10 Unclamped inductive load**



**6 Package Outlines**



**Figure 1 Outline PG-TO 247-3, 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

IPW60R024CFD7

**Revision: 2019-02-28, Rev. 2.0**

Previous Revision

| Revision | Date       | Subjects (major changes since last revision) |
|----------|------------|--|
| 2.0      | 2019-02-28 | Release of final version                     |

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