

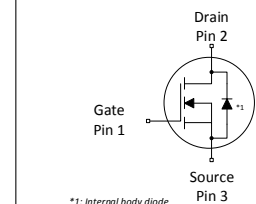
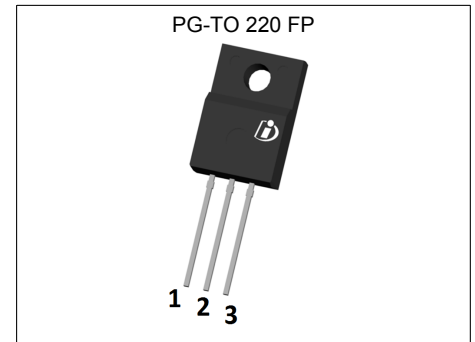
## MOSFET

### 600V CoolMOS™ PFD7 SJ Power Device

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™ PFD7 is an optimized platform tailored to target cost sensitive applications in consumer markets such as charger, adapter, motor drive, lighting, etc.

The new series provides all the benefits of a fast switching Superjunction MOSFET, combined with an excellent price/performance ratio and state of the art ease-of-use level. The technology meets highest efficiency standards and supports high power density, enabling customers going towards very slim designs.



### Features

- Extremely low losses due to very low FOM  $R_{DS(on)} \cdot Q_g$  and  $R_{DS(on)} \cdot E_{oss}$
- Low switching losses  $E_{oss}$ , excellent thermal behavior
- Fast body diode
- Wide range portfolio of  $R_{DS(on)}$  and package variations

### Benefits

- Enables high power density designs and small form factors
- Enables efficiency gains at higher switching frequencies
- Excellent commutation ruggedness
- Easy to select right parts and optimize the design

### Potential applications

Recommended for ZVS topologies used in high density chargers, adapters, lighting and motor drives applications, etc.

### Product validation

Qualified according to JEDEC Standard

*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 |
| ESD Class (HBM)      | 1C    | -    |

| Type / Ordering Code | Package                         | Marking  | Related Links  |
|----------------------|---------------------------------|----------|----------------|
| IPAN60R210PFD7S      | PG-TO 220 FullPAK - Narrow Lead | 60S210D7 | see Appendix A |

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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>         | $I_D$               | -      | -    | 16<br>10 | 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                              | $P_{tot}$           | -      | -    | 25       | W                | $T_C=25^\circ\text{C}$                                                                       |
| Storage temperature                            | $T_{stg}$           | -40    | -    | 150      | $^\circ\text{C}$ | -                                                                                            |
| Operating junction temperature                 | $T_j$               | -40    | -    | 150      | $^\circ\text{C}$ | -                                                                                            |
| Mounting torque                                | -                   | -      | -    | 50       | Ncm              | M2.5 screws                                                                                  |
| Continuous diode forward current <sup>1)</sup> | $I_S$               | -      | -    | 16       | 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 <sub>F</sub> /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                   | $V_{ISO}$           | -      | -    | 2500     | V                | $V_{rms}$ , $T_C=25^\circ\text{C}$ , $t=1\text{min}$                                         |

<sup>1)</sup> Limited by  $T_{j,max}$ . Maximum Duty Cycle  $D = 0.50$ ; DPAK / IPAK equivalent

<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                        | $R_{thJC}$ | -      | -    | 5.0  | °C/W | -                                   |
| Thermal resistance, junction - ambient                     | $R_{thJA}$ | -      | -    | 80   | °C/W | lead                                |
| Thermal resistance, junction - ambient for SMD version     | $R_{thJA}$ | -      | -    | -    | °C/W | n.a.                                |
| Soldering temperature, wavesoldering only allowed at leads | $T_{sld}$  | -      | -    | 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>0.386 | 0.210<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                               | $R_G$         | -      | 11.0           | -          | $\Omega$ | $f=1MHz$ , 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                                         | $t_{d(on)}$  | -      | 20   | -    | ns   | $V_{DD}=400V$ , $V_{GS}=10V$ , $I_D=4.9A$ ,<br>$R_G=10.2\Omega$ ; see table 9 |
| Rise time                                                  | $t_r$        | -      | 16   | -    | ns   | $V_{DD}=400V$ , $V_{GS}=10V$ , $I_D=4.9A$ ,<br>$R_G=10.2\Omega$ ; see table 9 |
| Turn-off delay time                                        | $t_{d(off)}$ | -      | 57   | -    | ns   | $V_{DD}=400V$ , $V_{GS}=10V$ , $I_D=4.9A$ ,<br>$R_G=10.2\Omega$ ; see table 9 |
| Fall time                                                  | $t_f$        | -      | 7    | -    | ns   | $V_{DD}=400V$ , $V_{GS}=10V$ , $I_D=4.9A$ ,<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   | $V_{DD}=400V$ , $I_D=4.9A$ , $V_{GS}=0$ to $10V$ |
| Gate to drain charge  | $Q_{gd}$      | -      | 7    | -    | nC   | $V_{DD}=400V$ , $I_D=4.9A$ , $V_{GS}=0$ to $10V$ |
| Gate charge total     | $Q_g$         | -      | 23   | -    | nC   | $V_{DD}=400V$ , $I_D=4.9A$ , $V_{GS}=0$ to $10V$ |
| Gate plateau voltage  | $V_{plateau}$ | -      | 5.7  | -    | V    | $V_{DD}=400V$ , $I_D=4.9A$ , $V_{GS}=0$ to $10V$ |

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

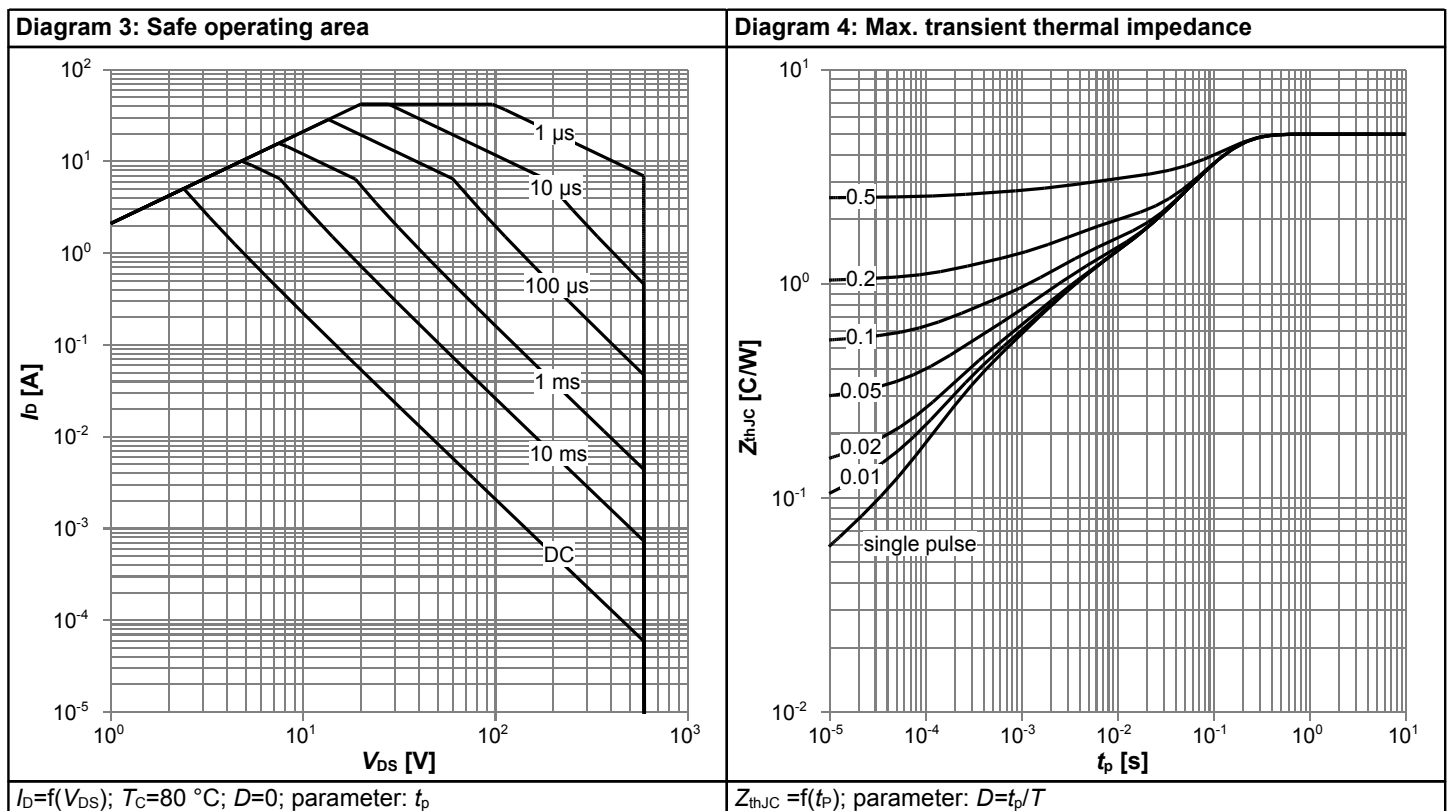
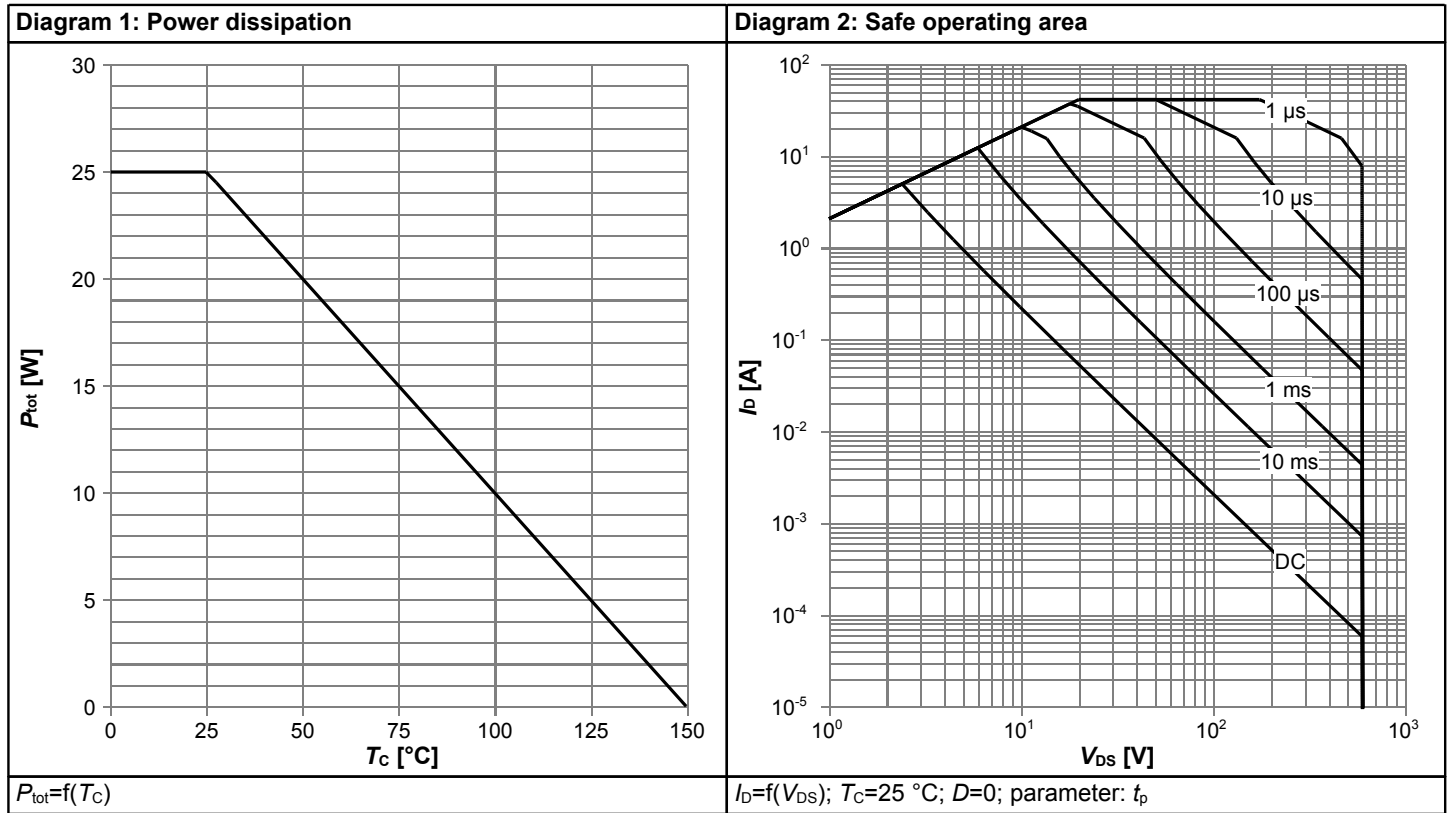
<sup>2)</sup>  $C_{o(er)}$  is a fixed capacitance that gives the same stored energy as  $C_{oss}$  while  $V_{DS}$  is rising from 0 to 400V

<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

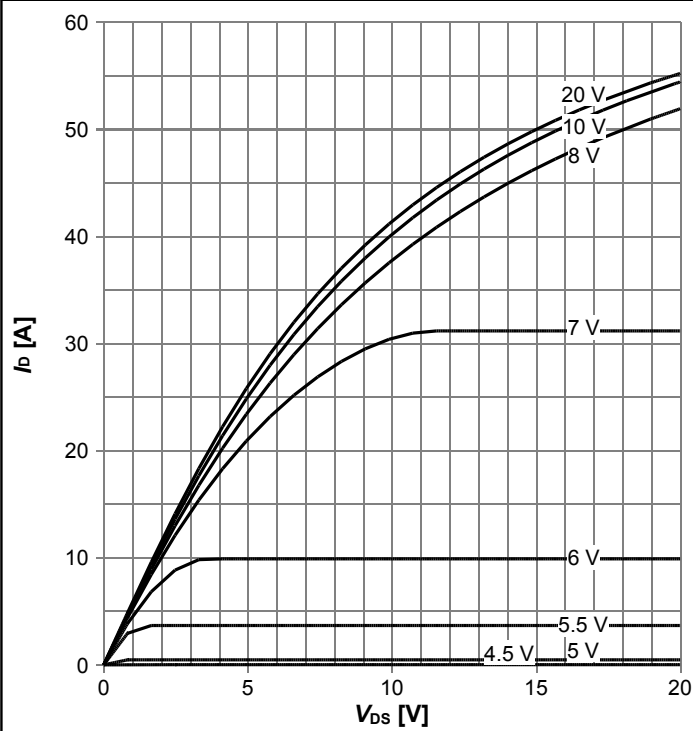
**Table 7 Reverse diode characteristics**

| 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         | $t_{rr}$  | -      | 87   | 174  | ns      | $V_R=400V$ , $I_F=4.9A$ , $di_F/dt=100A/\mu s$ ; see table 8 |
| Reverse recovery charge       | $Q_{rr}$  | -      | 0.34 | 0.68 | $\mu C$ | $V_R=400V$ , $I_F=4.9A$ , $di_F/dt=100A/\mu s$ ; see table 8 |
| Peak reverse recovery current | $I_{rrm}$ | -      | 6.8  | -    | A       | $V_R=400V$ , $I_F=4.9A$ , $di_F/dt=100A/\mu s$ ; see table 8 |

## 4 Electrical characteristics diagrams

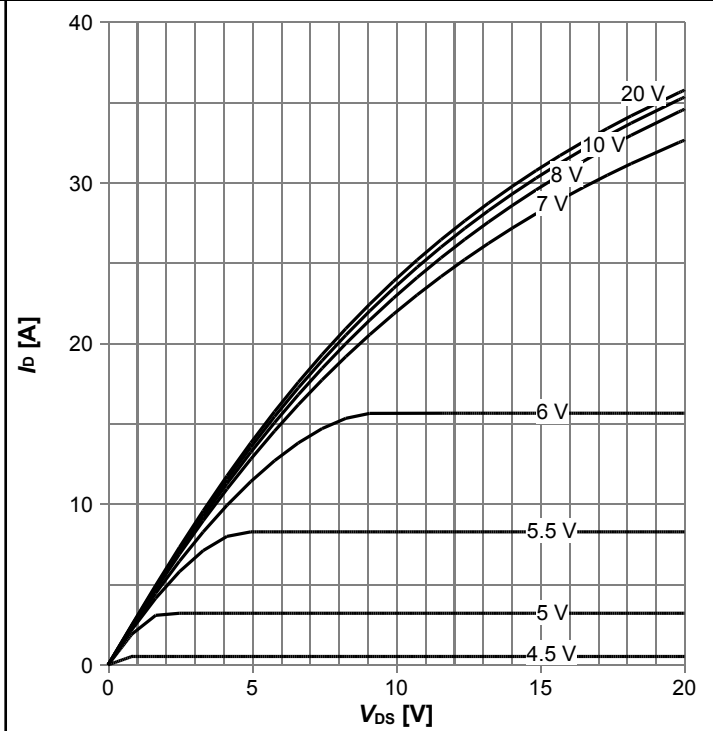


**Diagram 5: Typ. output characteristics**



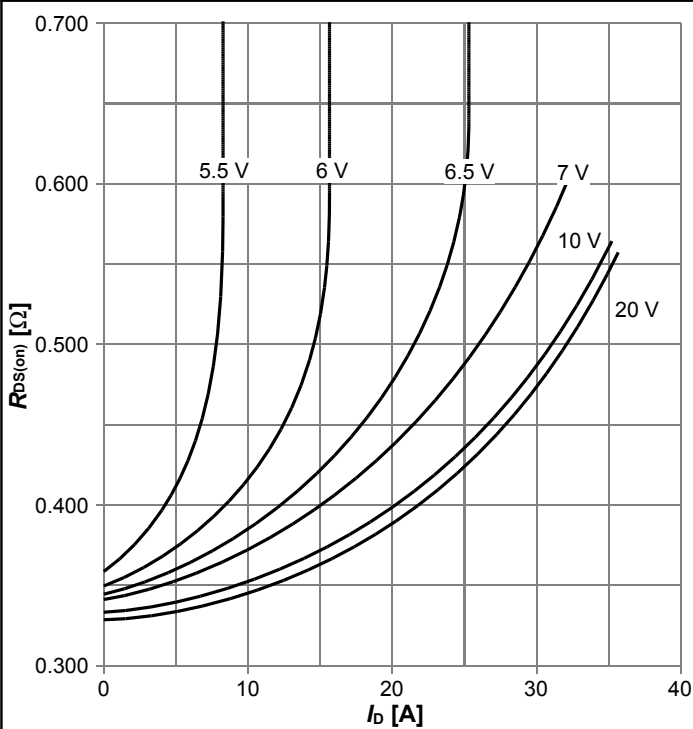
$I_D = f(V_{DS})$ ;  $T_J = 25\text{ °C}$ ; parameter:  $V_{GS}$

**Diagram 6: Typ. output characteristics**



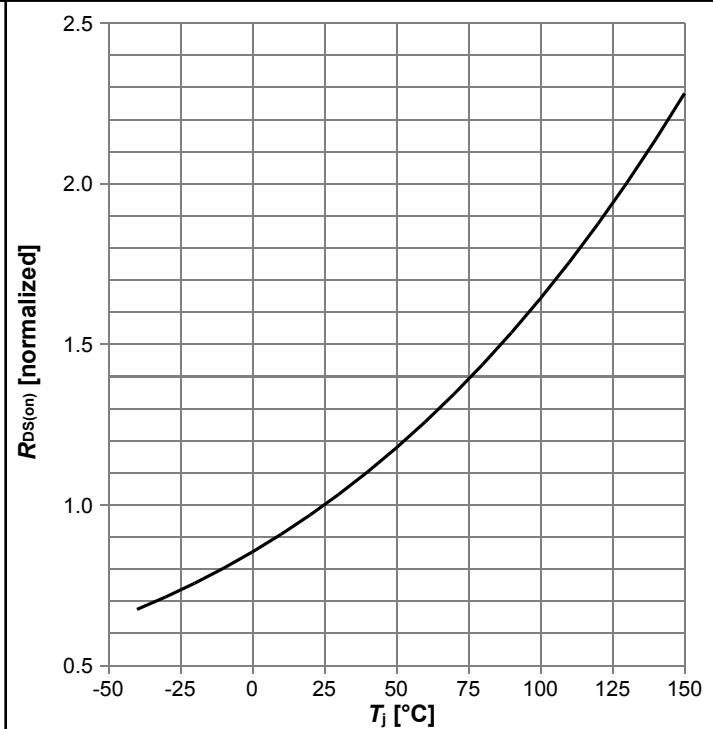
$I_D = f(V_{DS})$ ;  $T_J = 125\text{ °C}$ ; parameter:  $V_{GS}$

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



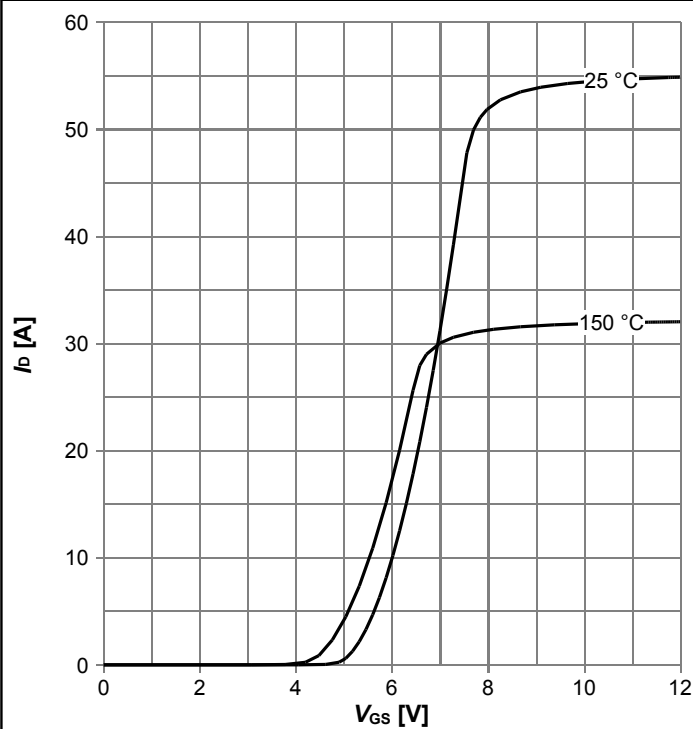
$R_{DS(on)} = f(I_D)$ ;  $T_J = 125\text{ °C}$ ; parameter:  $V_{GS}$

**Diagram 8: Drain-source on-state resistance**



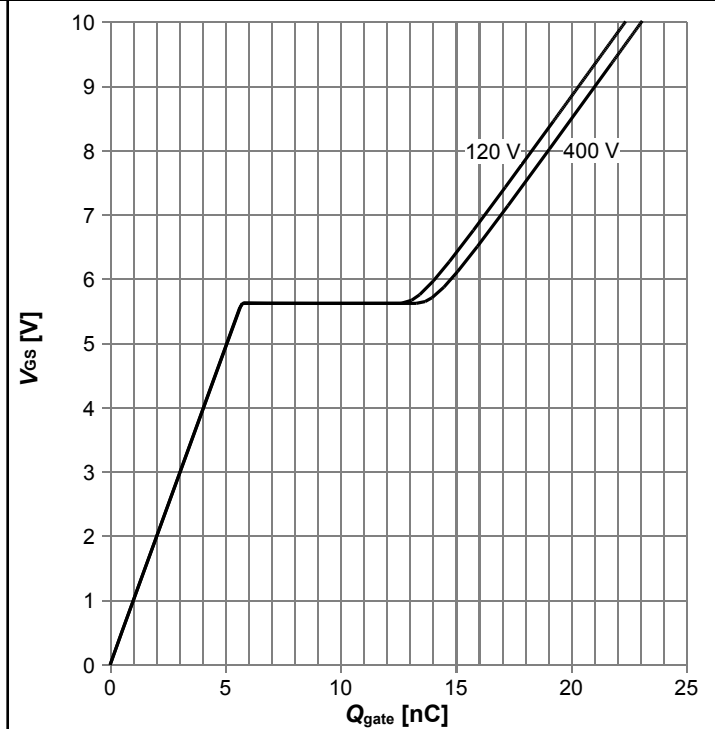
$R_{DS(on)} = f(T_J)$ ;  $I_D = 4.9\text{ A}$ ;  $V_{GS} = 10\text{ V}$

**Diagram 9: Typ. transfer characteristics**



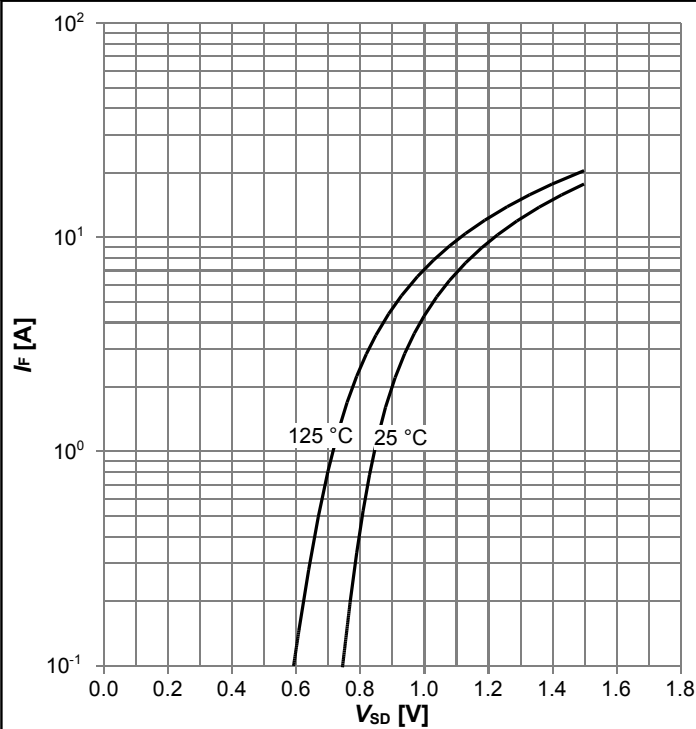
$I_D = f(V_{GS})$ ;  $V_{DS} = 20$  V; parameter:  $T_j$

**Diagram 10: Typ. gate charge**



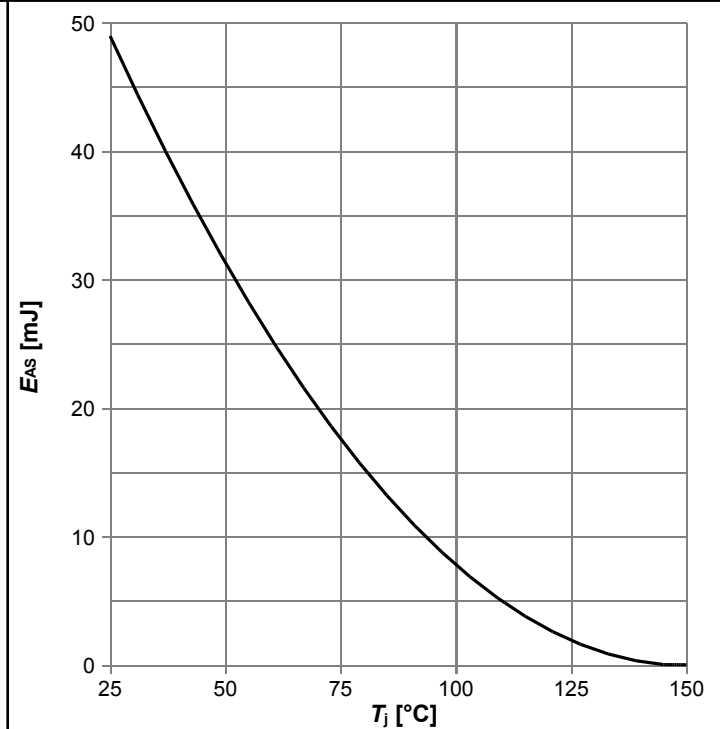
$V_{GS} = f(Q_{gate})$ ;  $I_D = 4.9$  A pulsed; parameter:  $V_{DD}$

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



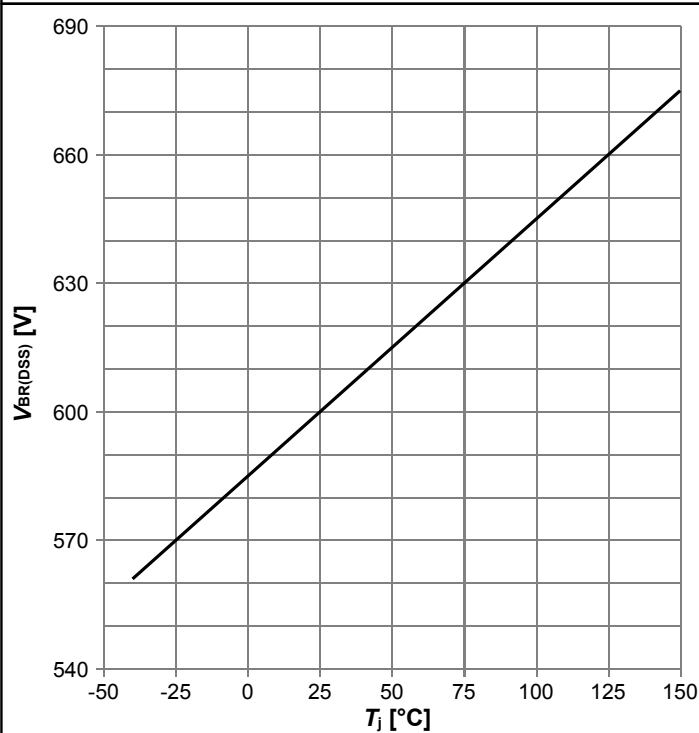
$I_F = f(V_{SD})$ ; parameter:  $T_j$

**Diagram 12: Avalanche energy**



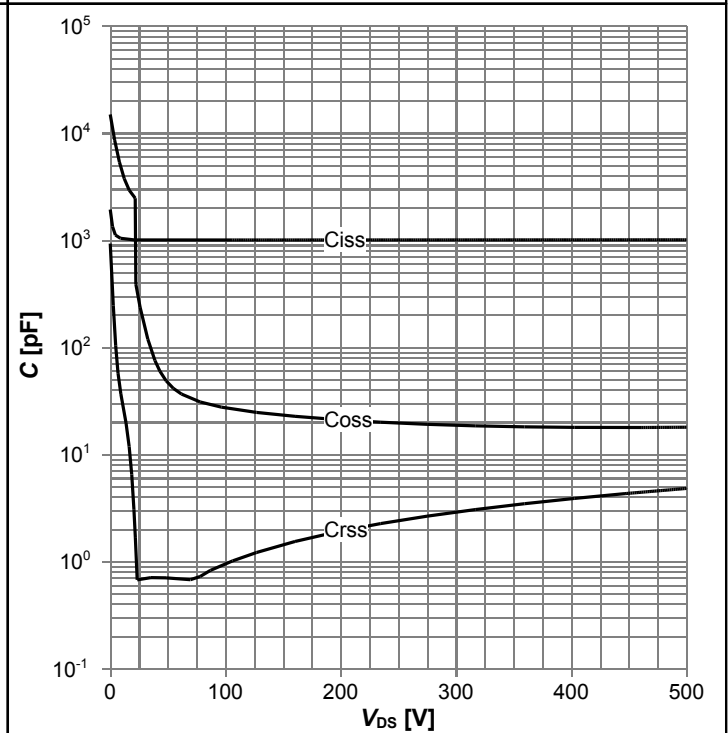
$E_{AS} = f(T_j)$ ;  $I_D = 3.2$  A;  $V_{DD} = 50$  V

Diagram 13: Drain-source breakdown voltage



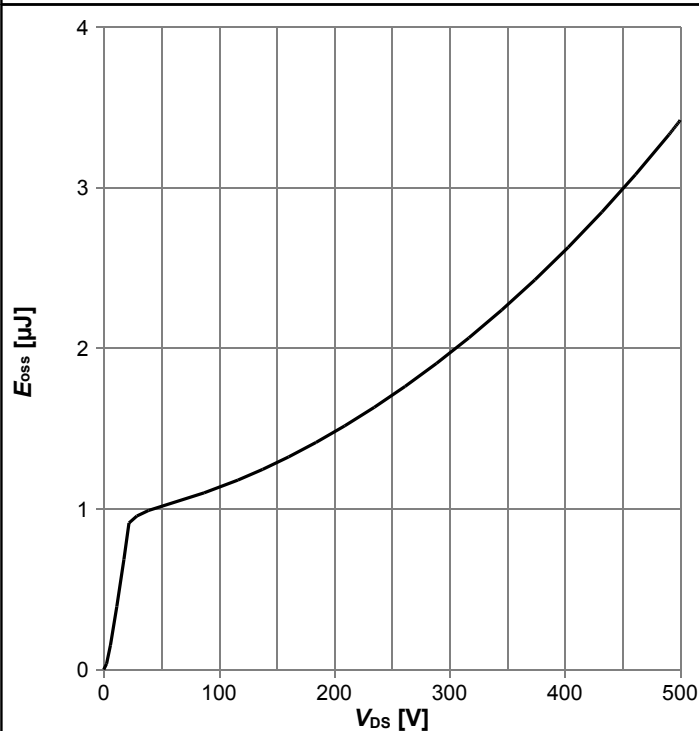
$V_{BR(DSS)} = f(T_J); I_D = 1 \text{ mA}$

Diagram 14: Typ. capacitances



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

Diagram 15: Typ. Coss 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> |  |

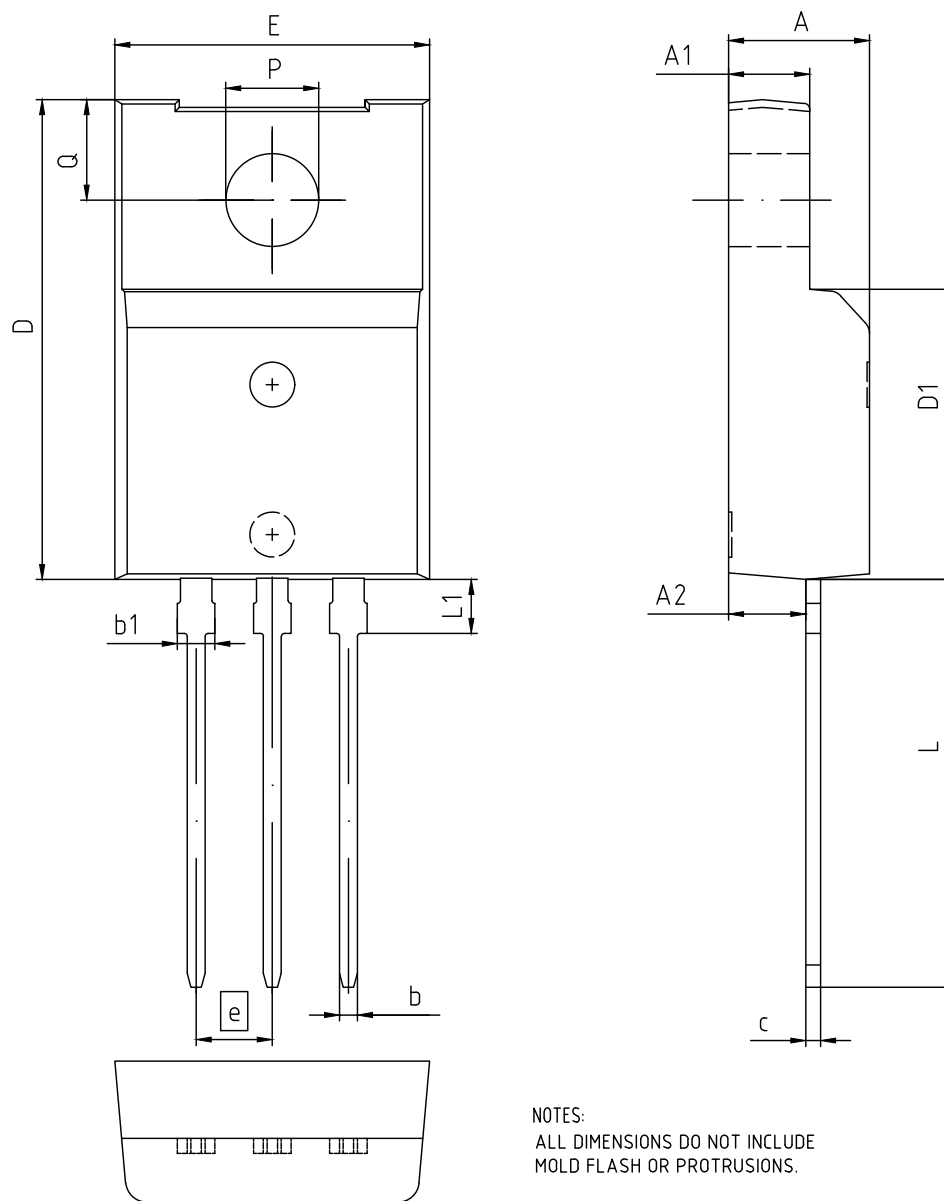
**Table 9 Switching times**

| 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



NOTES:  
ALL DIMENSIONS DO NOT INCLUDE  
MOLD FLASH OR PROTRUSIONS.

| DIMENSIONS | MILLIMETERS |       |
|------------|-------------|-------|
|            | MIN.        | MAX.  |
| A          | 4.60        | 4.80  |
| A1         | 2.60        | 2.80  |
| A2         | 2.47        | 2.67  |
| b          | 0.56        | 0.69  |
| b1         | 1.01        | 1.15  |
| c          | 0.46        | 0.59  |
| D          | 15.90       | 16.10 |
| D1         | 9.58        | 9.78  |
| E          | 10.40       | 10.60 |
| e          | 2.54        |       |
| N          | 3           |       |
| L          | 13.45       | 13.75 |
| L1         | 1.70        | 1.91  |
| øP         | 3.00        | 3.20  |
| Q          | 3.25        | 3.45  |

|                             |
|-----------------------------|
| DOCUMENT NO.<br>Z8B00188573 |
| REVISION<br>02              |
| SCALE 5:1<br>0 1 2 3 4 5mm  |
| EUROPEAN PROJECTION<br>     |
| ISSUE DATE<br>21.03.2019    |

Figure 1 Outline PG-TO 220 FullPAK - Narrow Lead, dimensions in mm

## **7 Appendix A**

**Table 11 Related Links**

- IFX CoolMOS PFD7 Webpage: [www.infineon.com](http://www.infineon.com)
- IFX CoolMOS PFD7 application note: [www.infineon.com](http://www.infineon.com)
- IFX CoolMOS PFD7 simulation model: [www.infineon.com](http://www.infineon.com)
- IFX Design tools: [www.infineon.com](http://www.infineon.com)

## Revision History

IPAN60R210PFD7S

**Revision: 2019-11-29, Rev. 2.1**

Previous Revision

| Revision | Date       | Subjects (major changes since last revision) |
|----------|------------|----------------------------------------------|
| 2.0      | 2019-04-09 | Release of final version                     |
| 2.1      | 2019-11-29 | Modified current Id and Is ratings           |

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