

## 1 Description

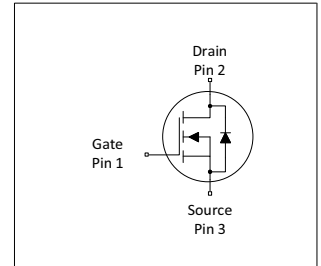
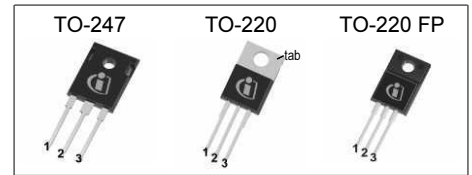
CoolMOS™ is a revolutionary technology for high voltage power MOSFETs, designed according to the superjunction (SJ) principle and pioneered by Infineon Technologies. CoolMOS™ E6 series combines the experience of the leading SJ MOSFET supplier with high class innovation. The resulting devices provide 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
- 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 PWM stages for e.g. PC Silverbox, Adapter, LCD & PDP TV, Lighting, Server, Telecom and UPS.



**Table 1 Key Performance Parameters**

| Parameter            | Value | Unit       |
|----------------------|-------|------------|
| $V_{DS} @ T_{j,max}$ | 650   | V          |
| $R_{DS(on),max}$     | 0.19  | $\Omega$   |
| $Q_g,typ$            | 63    | nC         |
| $I_D,pulse$          | 59    | A          |
| $E_{oss} @ 400V$     | 5.2   | $\mu J$    |
| Body diode $di/dt$   | 500   | A/ $\mu s$ |

| Type / Ordering Code | Package           | Marking | Related Links  |
|----------------------|-------------------|---------|----------------|
| IPW60R190E6          | PG-TO 247         | 6R190E6 | see Appendix A |
| IPP60R190E6          | PG-TO 220         |         |                |
| IPA60R190E6          | PG-TO 220 FullPAK |         |                |

**Table of Contents**

|                                           |    |
|-------------------------------------------|----|
| Description .....                         | 2  |
| Table of Contents .....                   | 3  |
| Maximum ratings .....                     | 4  |
| Thermal characteristics .....             | 5  |
| Electrical characteristics .....          | 6  |
| Electrical characteristics diagrams ..... | 8  |
| Test Circuits .....                       | 13 |
| Package Outlines .....                    | 14 |
| Appendix A .....                          | 17 |
| Revision History .....                    | 18 |
| Disclaimer .....                          | 18 |

## 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 <sup>1)</sup>            | $I_D$          |        |      | 20.2  | A                | $T_C = 25^\circ\text{C}$                                                                          |
|                                                   |                |        |      | 12.8  |                  | $T_C = 100^\circ\text{C}$                                                                         |
| Pulsed drain current <sup>2)</sup>                | $I_{D,pulse}$  |        |      | 59    | A                | $T_C = 25^\circ\text{C}$                                                                          |
| Avalanche energy, single pulse                    | $E_{AS}$       |        |      | 418   | mJ               | $I_D = 3.4\text{A}$ , $V_{DD} = 50\text{V}$<br>(see table 11)                                     |
| Avalanche energy, repetitive                      | $E_{AR}$       |        |      | 0.63  | mJ               | $I_D = 3.4\text{A}$ , $V_{DD} = 50\text{V}$                                                       |
| Avalanche current, repetitive                     | $I_{AR}$       |        |      | 3.4   | 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 (non FullPAK)<br>TO-247, TO-220 | $P_{tot}$      |        |      | 151.0 | W                | $T_C = 25^\circ\text{C}$                                                                          |
| Power dissipation (FullPAK)<br>TO-220 FP          | $P_{tot}$      |        |      | 34.0  | W                | $T_C = 25^\circ\text{C}$                                                                          |
| Operating and storage temperature                 | $T_j, T_{stg}$ | -55    |      | 150   | $^\circ\text{C}$ |                                                                                                   |
| Mounting torque (non FullPAK)<br>TO-247, TO-220   |                |        |      | 60    | Ncm              | M3 and M3.5 screws                                                                                |
| Mounting torque (FullPAK)<br>TO-220 FP            |                |        |      | 50    | Ncm              | M2.5 screws                                                                                       |
| Continuous diode forward current                  | $I_S$          |        |      | 17.5  | A                | $T_C = 25^\circ\text{C}$                                                                          |
| Diode pulse current                               | $I_{S,pulse}$  |        |      | 59    | A                | $T_C = 25^\circ\text{C}$                                                                          |
| Reverse diode dv/dt <sup>3)</sup>                 | dv/dt          |        |      | 15    | V/ns             | $V_{DS} = 0 \dots 400\text{V}$ , $I_{SD} \leq I_D$ ,<br>$T_j = 25^\circ\text{C}$<br>(see table 9) |
| Maximum diode commutation speed                   | di/dt          |        |      | 500   | A/ $\mu\text{s}$ |                                                                                                   |
| Insulation withstand voltage for<br>TO-220FP      | $V_{ISO}$      | -      | -    | 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  $D=0.75$

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

<sup>3)</sup> Identical low side and high side switch with identical  $R_G$

### 3 Thermal characteristics

**Table 3 Thermal characteristics TO-247, TO-220**

| Parameter                                                  | Symbol     | Values |      |      | Unit | Note / Test Condition                |
|------------------------------------------------------------|------------|--------|------|------|------|--------------------------------------|
|                                                            |            | Min.   | Typ. | Max. |      |                                      |
| Thermal resistance, junction - case                        | $R_{thJC}$ |        |      | 0.83 | °C/W |                                      |
| Thermal resistance, junction - ambient                     | $R_{thJA}$ |        |      | 62   | °C/W | leaded                               |
| Soldering temperature, wavesoldering only allowed at leads | $T_{sold}$ |        |      | 260  | °C   | 1.6 mm (0.063 in.) from case for 10s |

**Table 4 Thermal characteristics TO-220 FP**

| Parameter                                                  | Symbol     | Values |      |      | Unit | Note / Test Condition                |
|------------------------------------------------------------|------------|--------|------|------|------|--------------------------------------|
|                                                            |            | Min.   | Typ. | Max. |      |                                      |
| Thermal resistance, junction - case                        | $R_{thJC}$ |        |      | 3.7  | °C/W |                                      |
| Thermal resistance, junction - ambient                     | $R_{thJA}$ |        |      | 80   | °C/W | leaded                               |
| Soldering temperature, wavesoldering only allowed at leads | $T_{sold}$ |        |      | 260  | °C   | 1.6 mm (0.063 in.) from case for 10s |

## 4 Electrical characteristics

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

**Table 5 Static characteristics**

| Parameter                        | Symbol        | Values |       |      | Unit     | Note / Test Condition                           |
|----------------------------------|---------------|--------|-------|------|----------|-------------------------------------------------|
|                                  |               | Min.   | Typ.  | Max. |          |                                                 |
| Drain-source breakdown voltage   | $V_{(BR)DSS}$ | 600    |       |      | V        | $V_{GS} = 0V, I_D = 0.25mA$                     |
| Gate threshold voltage           | $V_{GS(th)}$  | 2.5    | 3     | 3.5  | V        | $V_{DS} = V_{GS}, I_D = 0.63mA$                 |
| Zero gate voltage drain current  | $I_{DSS}$     |        |       | 1    | $\mu A$  | $V_{DS} = 600V, V_{GS} = 0V, T_j = 25^\circ C$  |
|                                  |               |        | 10    |      |          | $V_{DS} = 600V, V_{GS} = 0V, T_j = 150^\circ C$ |
| Gate-source leakage current      | $I_{GSS}$     |        |       | 100  | nA       | $V_{GS} = 20V, V_{DS} = 0V$                     |
| Drain-source on-state resistance | $R_{DS(on)}$  |        | 0.170 | 0.19 | $\Omega$ | $V_{GS} = 10V, I_D = 9.5A, T_j = 25^\circ C$    |
|                                  |               |        | 0.440 |      |          | $V_{GS} = 10V, I_D = 9.5A, T_j = 150^\circ C$   |
| Gate resistance                  | $R_G$         |        | 6     |      | $\Omega$ | $f = 1MHz, \text{open drain}$                   |

**Table 6 Dynamic characteristics**

| Parameter                                                  | Symbol       | Values |      |      | Unit | Note / Test Condition                                                        |
|------------------------------------------------------------|--------------|--------|------|------|------|------------------------------------------------------------------------------|
|                                                            |              | Min.   | Typ. | Max. |      |                                                                              |
| Input capacitance                                          | $C_{iss}$    |        | 1400 |      | pF   | $V_{GS} = 0V, V_{DS} = 100V, f = 1MHz$                                       |
| Output capacitance                                         | $C_{oss}$    |        | 85   |      | pF   |                                                                              |
| Effective output capacitance, energy related <sup>1)</sup> | $C_{o(er)}$  |        | 56   |      | pF   | $V_{GS} = 0V, V_{DS} = 0 \dots 480V$                                         |
| Effective output capacitance, time related <sup>2)</sup>   | $C_{o(tr)}$  |        | 266  |      | pF   | $I_D = \text{constant}, V_{GS} = 0V, V_{DS} = 0 \dots 480V$                  |
| Turn-on delay time                                         | $t_{d(on)}$  |        | 12   |      | ns   | $V_{DD} = 400V, V_{GS} = 13V, I_D = 9.5A, R_G = 3.4\Omega$<br>(see table 10) |
| Rise time                                                  | $t_r$        |        | 10   |      | ns   |                                                                              |
| Turn-off delay time                                        | $t_{d(off)}$ |        | 90   |      | ns   |                                                                              |
| Fall time                                                  | $t_f$        |        | 8    |      | ns   |                                                                              |

**Table 7 Gate charge characteristics**

| Parameter             | Symbol        | Values |      |      | Unit | Note / Test Condition                                   |
|-----------------------|---------------|--------|------|------|------|---------------------------------------------------------|
|                       |               | Min.   | Typ. | Max. |      |                                                         |
| Gate to source charge | $Q_{gs}$      |        | 7.6  |      | nC   | $V_{DD} = 480V, I_D = 9.5A, V_{GS} = 0 \text{ to } 10V$ |
| Gate to drain charge  | $Q_{gd}$      |        | 32   |      | nC   |                                                         |
| Gate charge total     | $Q_g$         |        | 63   |      | nC   |                                                         |
| Gate plateau voltage  | $V_{plateau}$ |        | 5.4  |      | V    |                                                         |

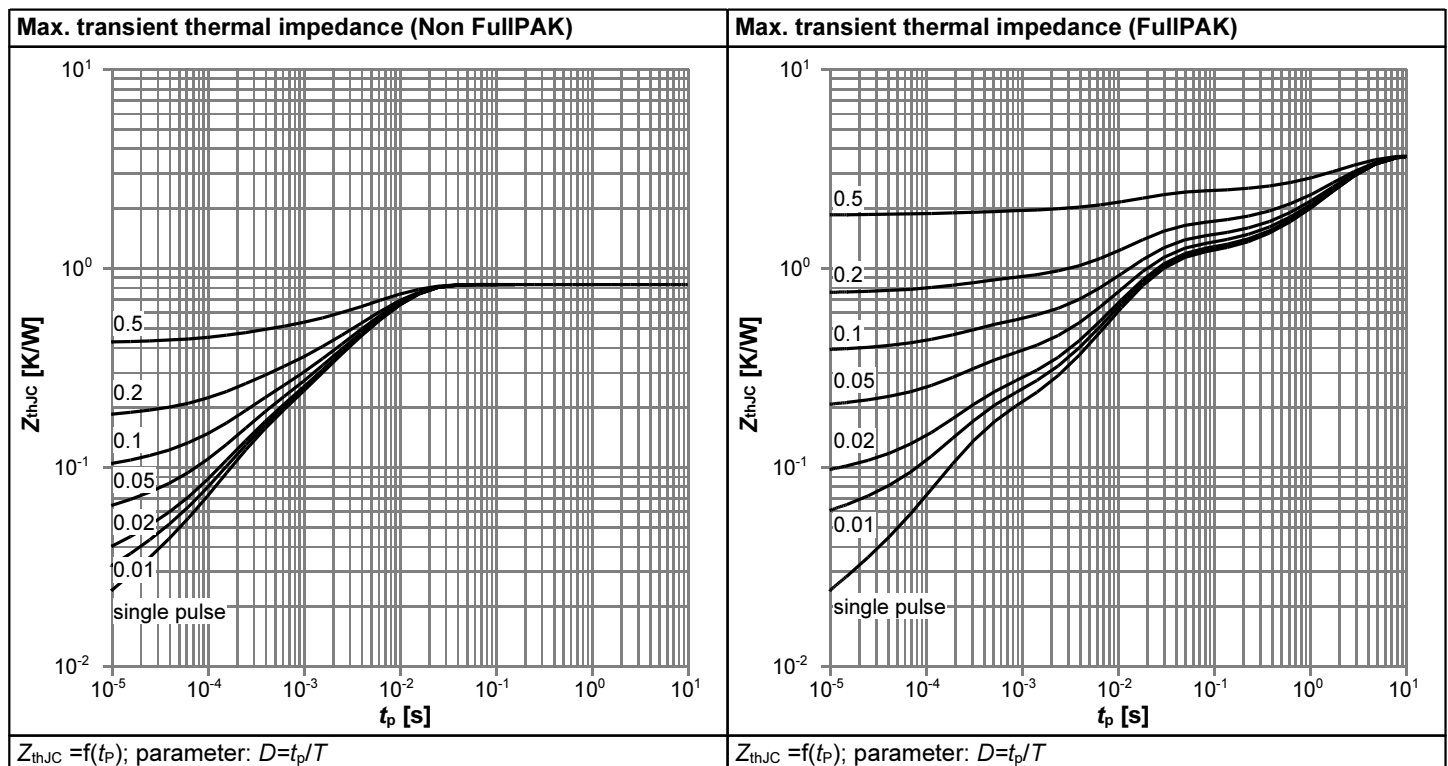
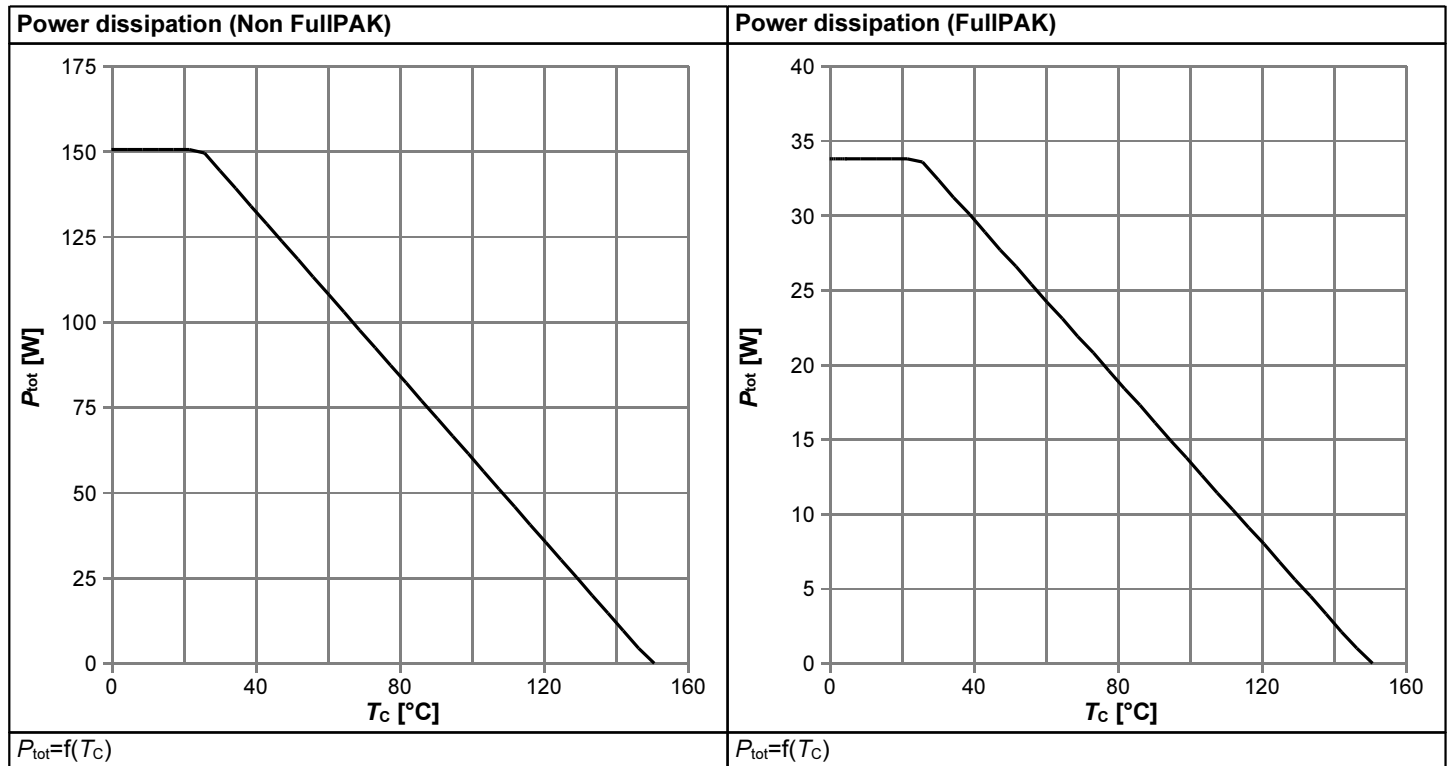
<sup>1)</sup>  $C_{o(er)}$  is a fixed capacitance that gives the same stored energy as  $C_{oss}$  while  $V_{DS}$  is rising from 0 to 80%  $V_{(BR)DSS}$

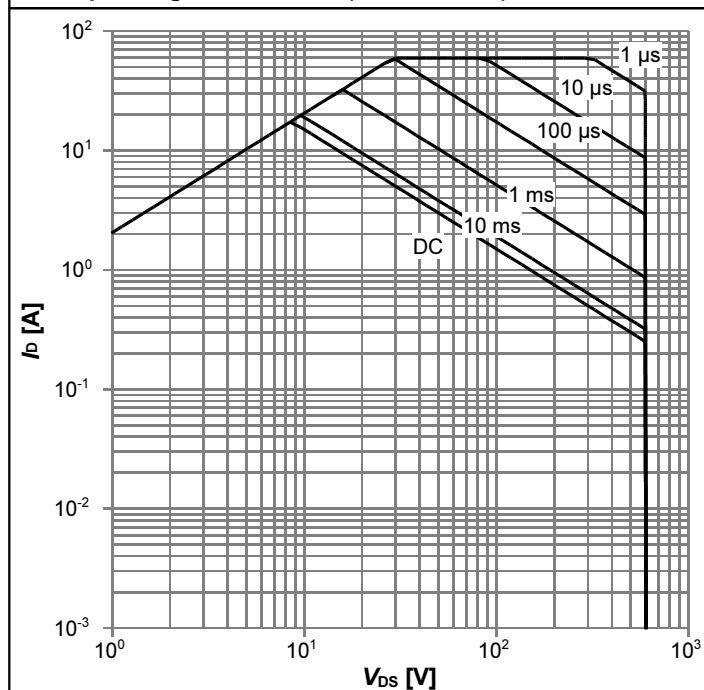
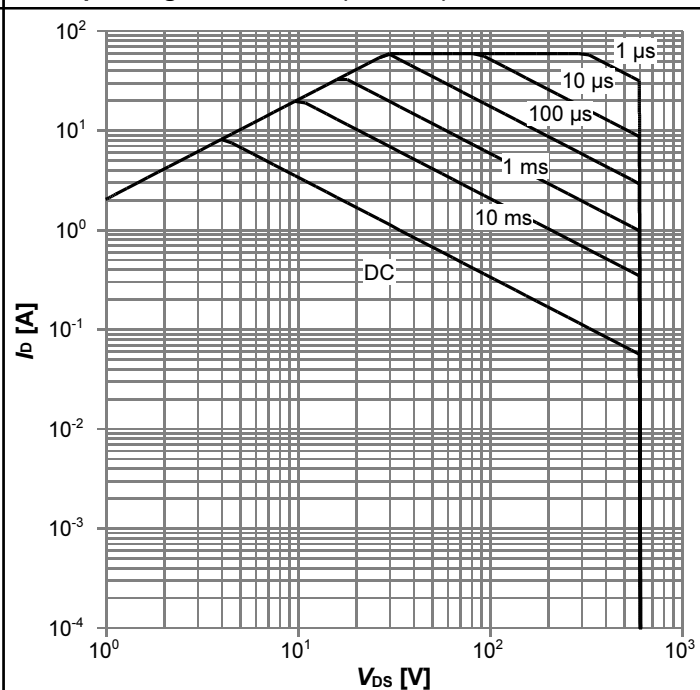
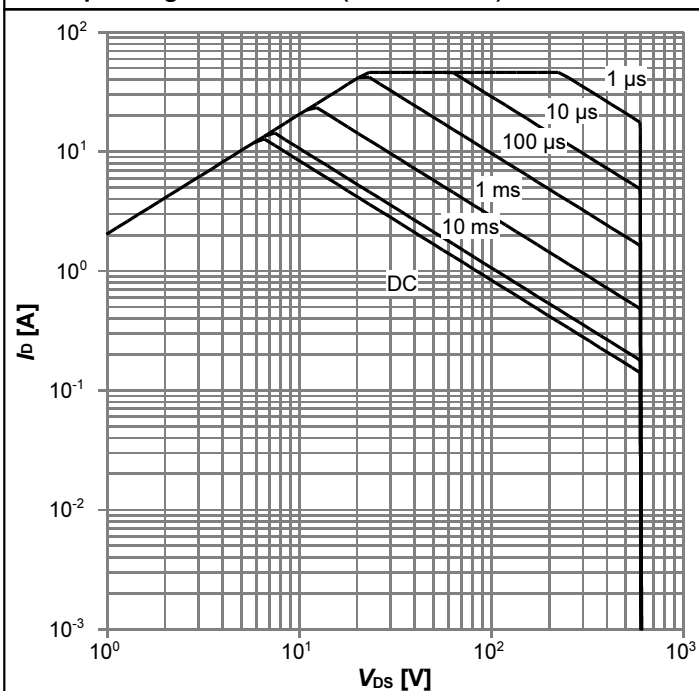
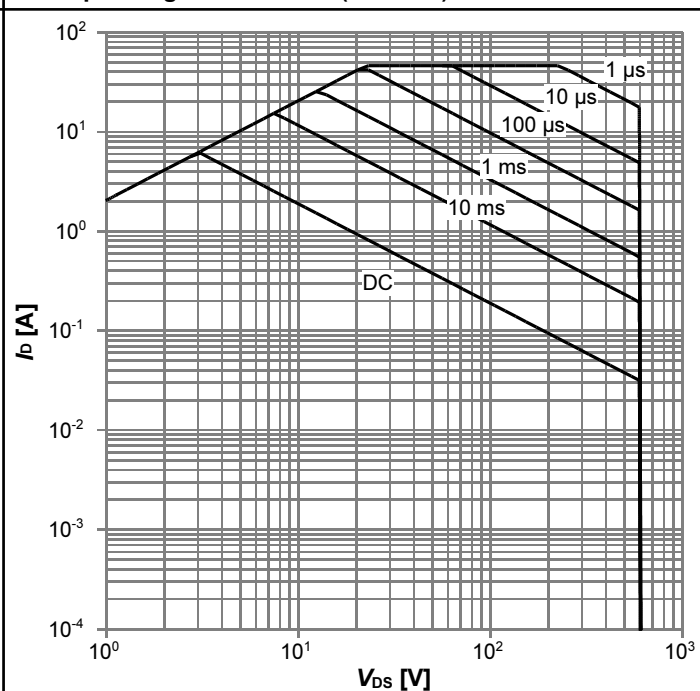
<sup>2)</sup>  $C_{o(tr)}$  is a fixed capacitance that gives the same charging time as  $C_{oss}$  while  $V_{DS}$  is rising from 0 to 80%  $V_{(BR)DSS}$

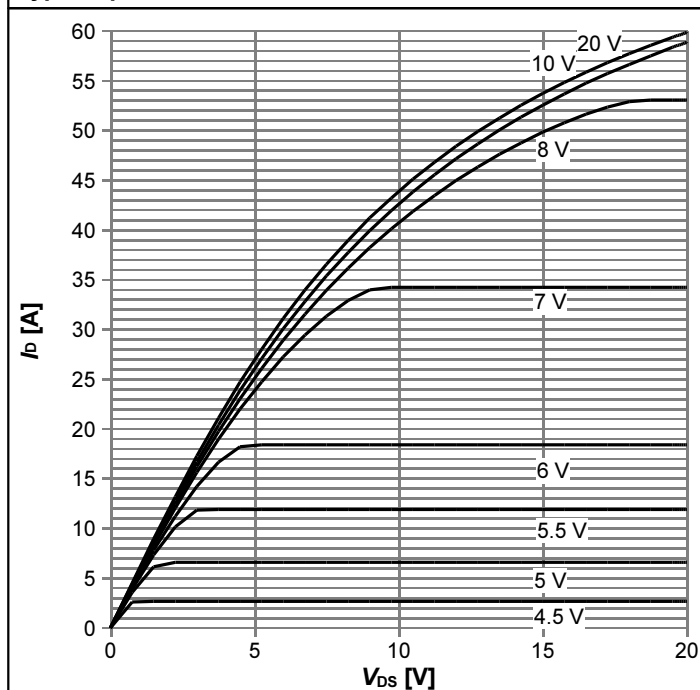
**Table 8 Reverse diode characteristics**

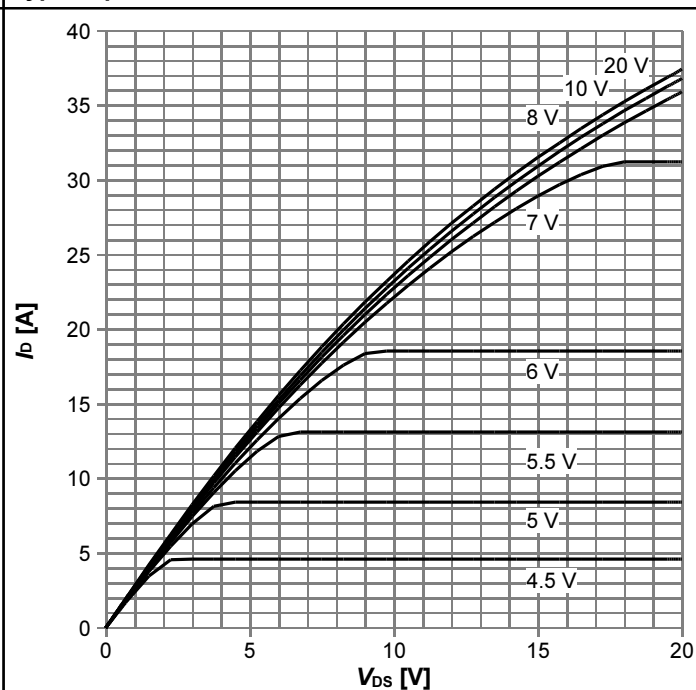
| Parameter                     | Symbol    | Values |      |      | Unit    | Note / Test Condition                                                |
|-------------------------------|-----------|--------|------|------|---------|----------------------------------------------------------------------|
|                               |           | Min.   | Typ. | Max. |         |                                                                      |
| Diode forward voltage         | $V_{SD}$  |        | 0.9  |      | V       | $V_{GS} = 0V, I_F = 9.5A, T_J = 25^{\circ}C$                         |
| Reverse recovery time         | $t_{rr}$  |        | 430  |      | ns      | $V_R = 400V, I_F = 9.5A,$<br>$di_F/dt = 100A/\mu s$<br>(see table 9) |
| Reverse recovery charge       | $Q_{rr}$  |        | 6.9  |      | $\mu C$ |                                                                      |
| Peak reverse recovery current | $I_{rrm}$ |        | 30   |      | A       |                                                                      |

## 5 Electrical characteristics diagrams

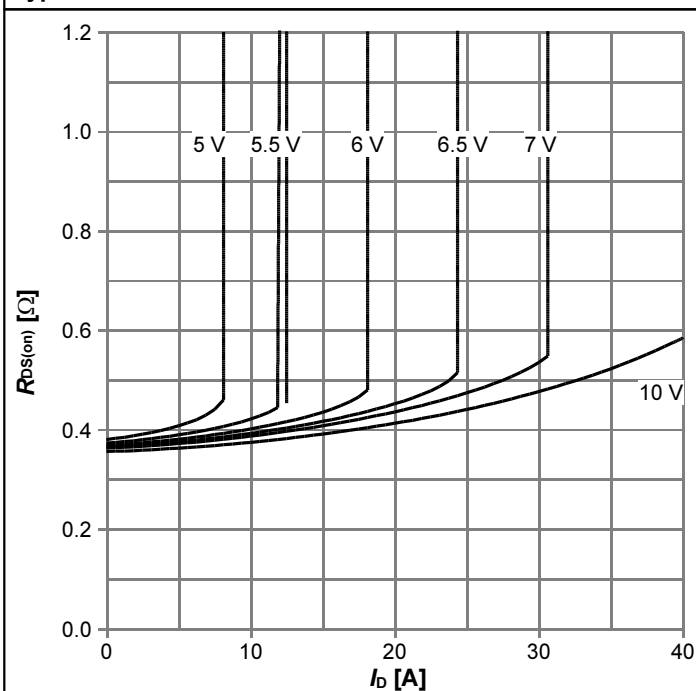


**Safe operating area  $T_c=25^\circ\text{C}$  (Non FullPAK)**

 $I_D=f(V_{DS}); T_c=25^\circ\text{C}; D=0; \text{parameter: } t_p$ 
**Safe operating area  $T_c=25^\circ\text{C}$  (FullPAK)**

 $I_D=f(V_{DS}); T_c=25^\circ\text{C}; D=0; \text{parameter: } t_p$ 
**Safe operating area  $T_c=80^\circ\text{C}$  (Non FullPAK)**

 $I_D=f(V_{DS}); T_c=80^\circ\text{C}; D=0; \text{parameter: } t_p$ 
**Safe operating area  $T_c=80^\circ\text{C}$  (FullPAK)**

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

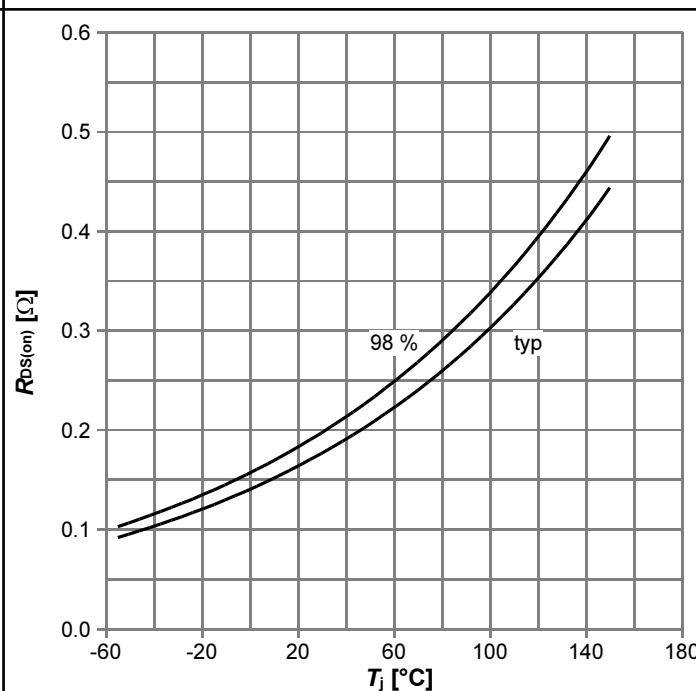
Typ. output characteristics  $T_c=25^\circ\text{C}$ 

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

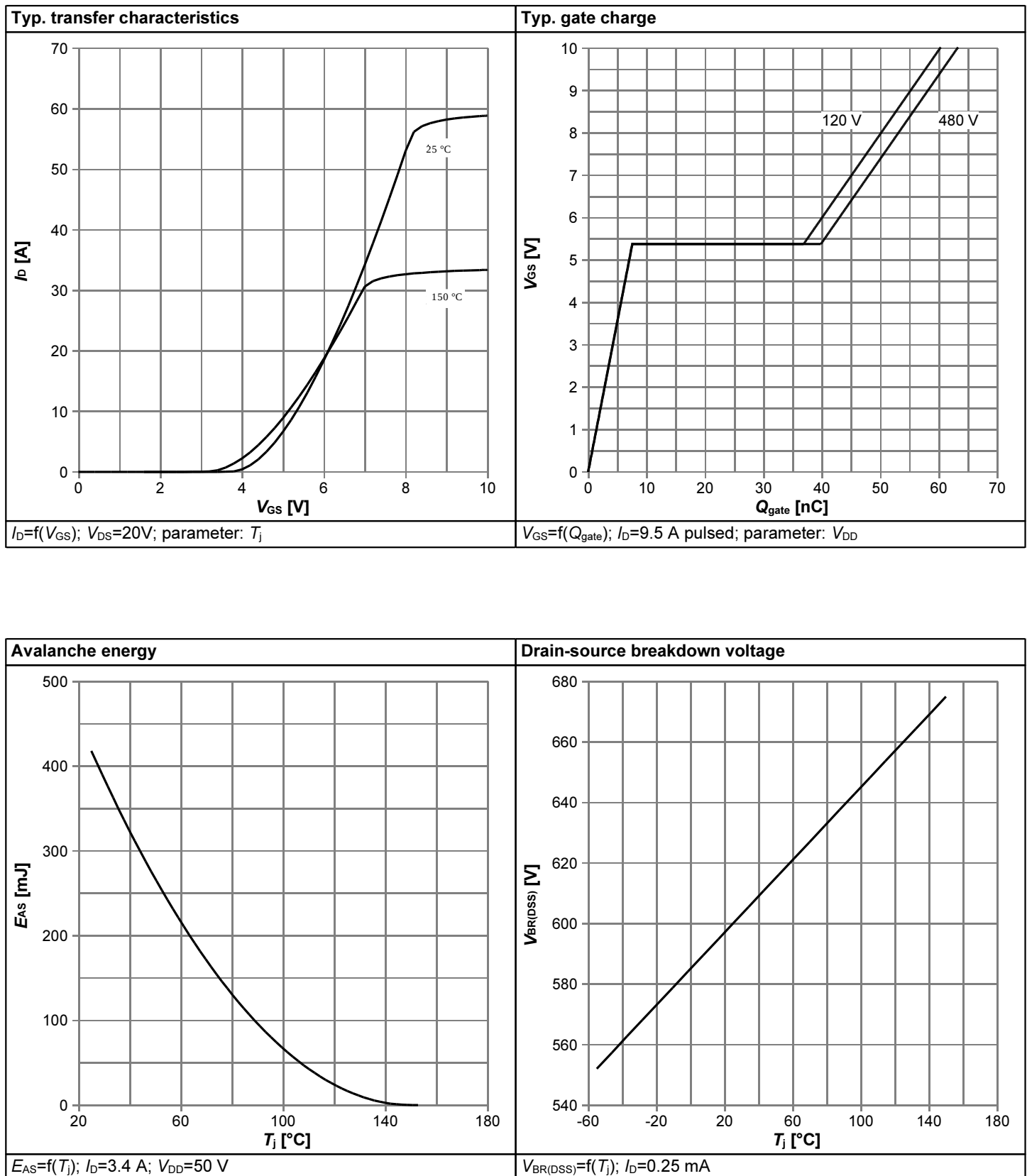
Typ. output characteristics  $T_c=125^\circ\text{C}$ 

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

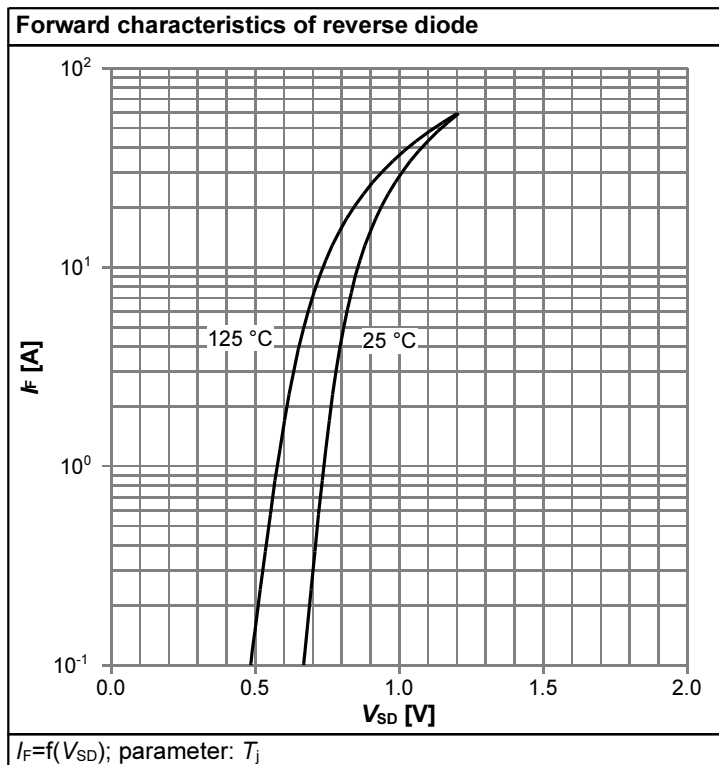
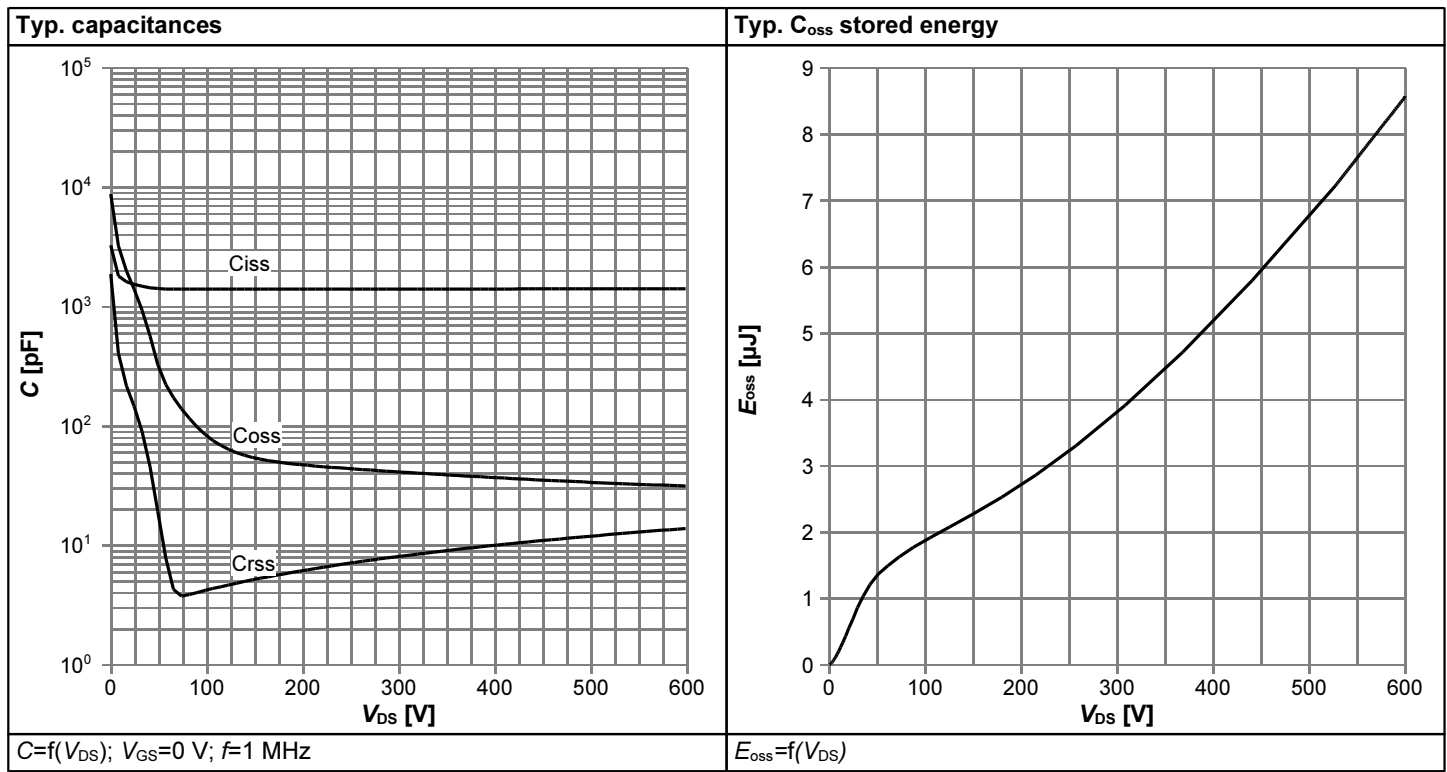
Typ. drain-source on-state resistance


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

Drain-source on-state resistance

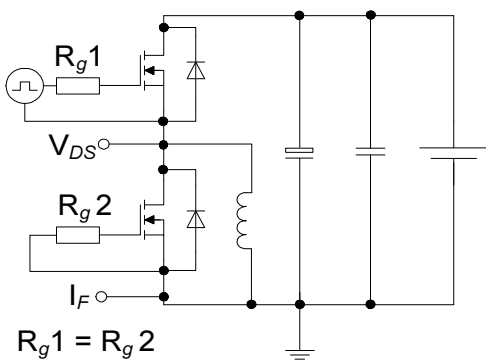
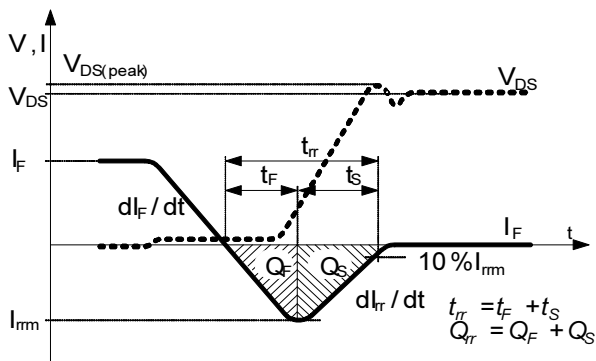

 $R_{DS(on)}=f(T_j); I_D=9.5\text{ A}; V_{GS}=10\text{ V}$



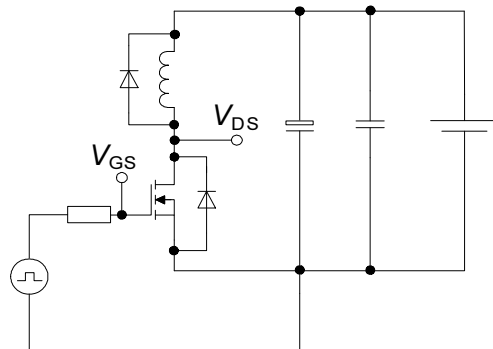
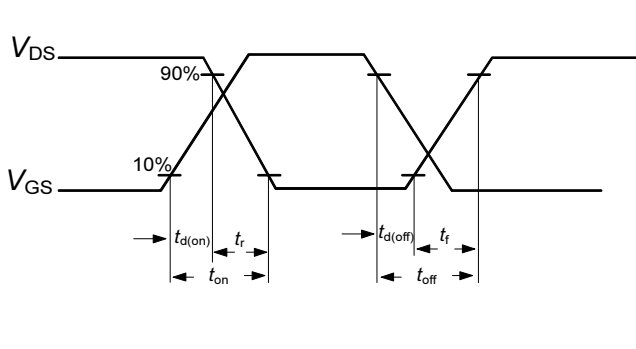


## 6 Test Circuits

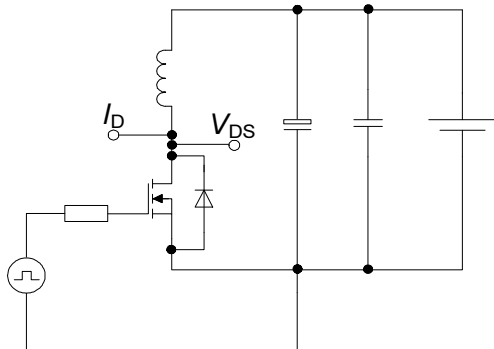
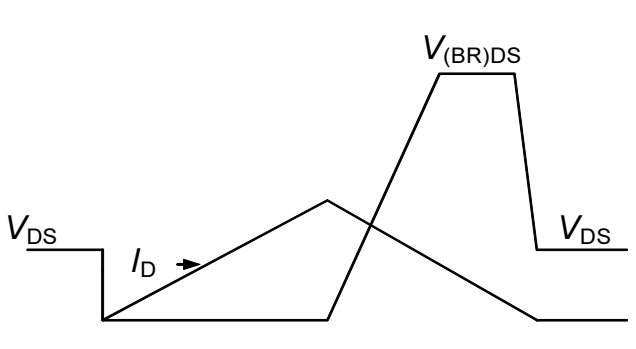
**Table 9 Diode characteristics**

| Test circuit for diode characteristics                                                                                | Diode recovery waveform                                                                                                                                          |
|-----------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  <p><math>R_{g1} = R_{g2}</math></p> |  <p> <math>t_{rr} = t_F + t_S</math><br/> <math>Q_{rr} = Q_F + Q_S</math> </p> |

**Table 10 Switching times**

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

**Table 11 Unclamped inductive load**

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

## 7 Package Outlines

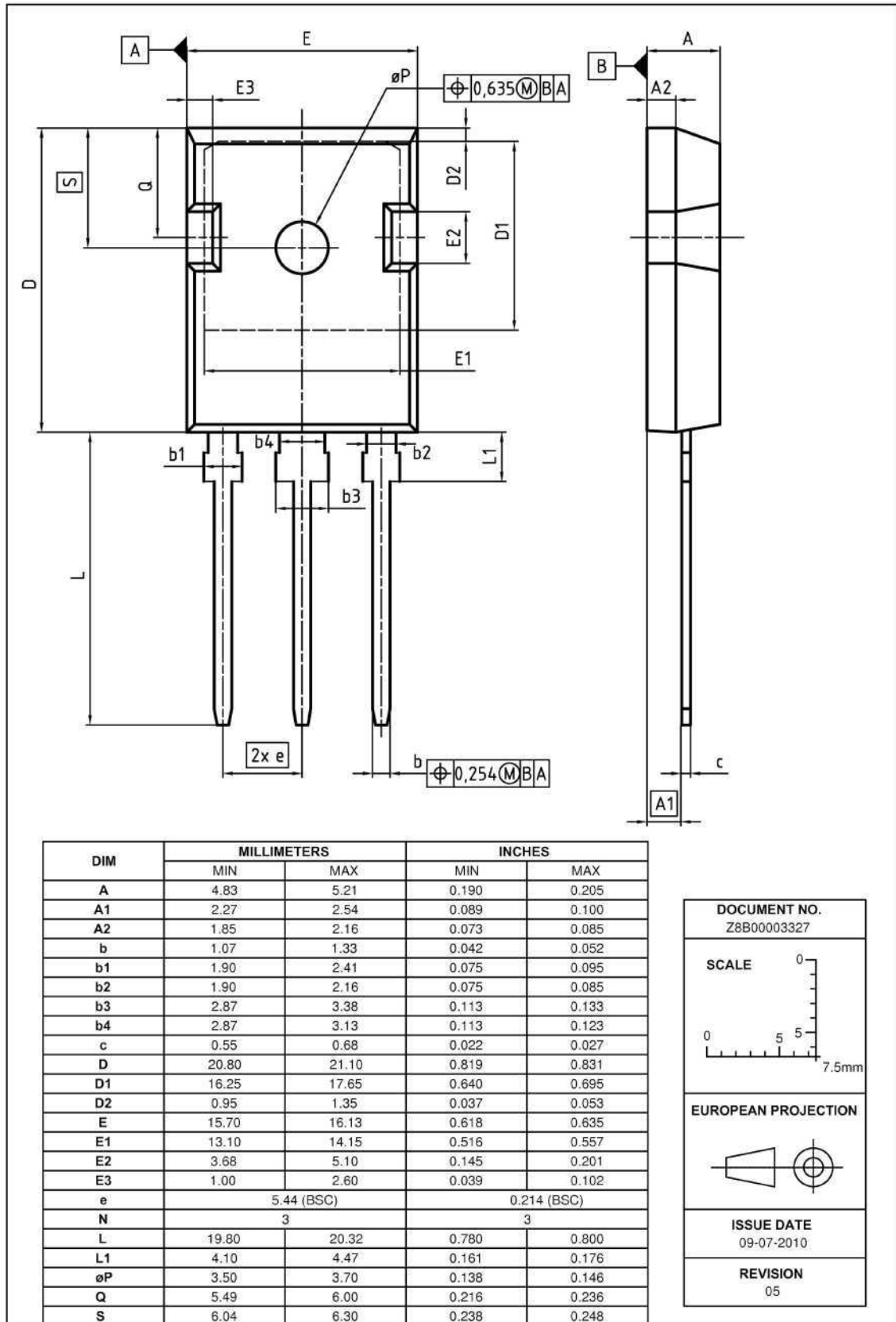


Figure 1 Outline PG-TO 247, dimensions in mm/inches

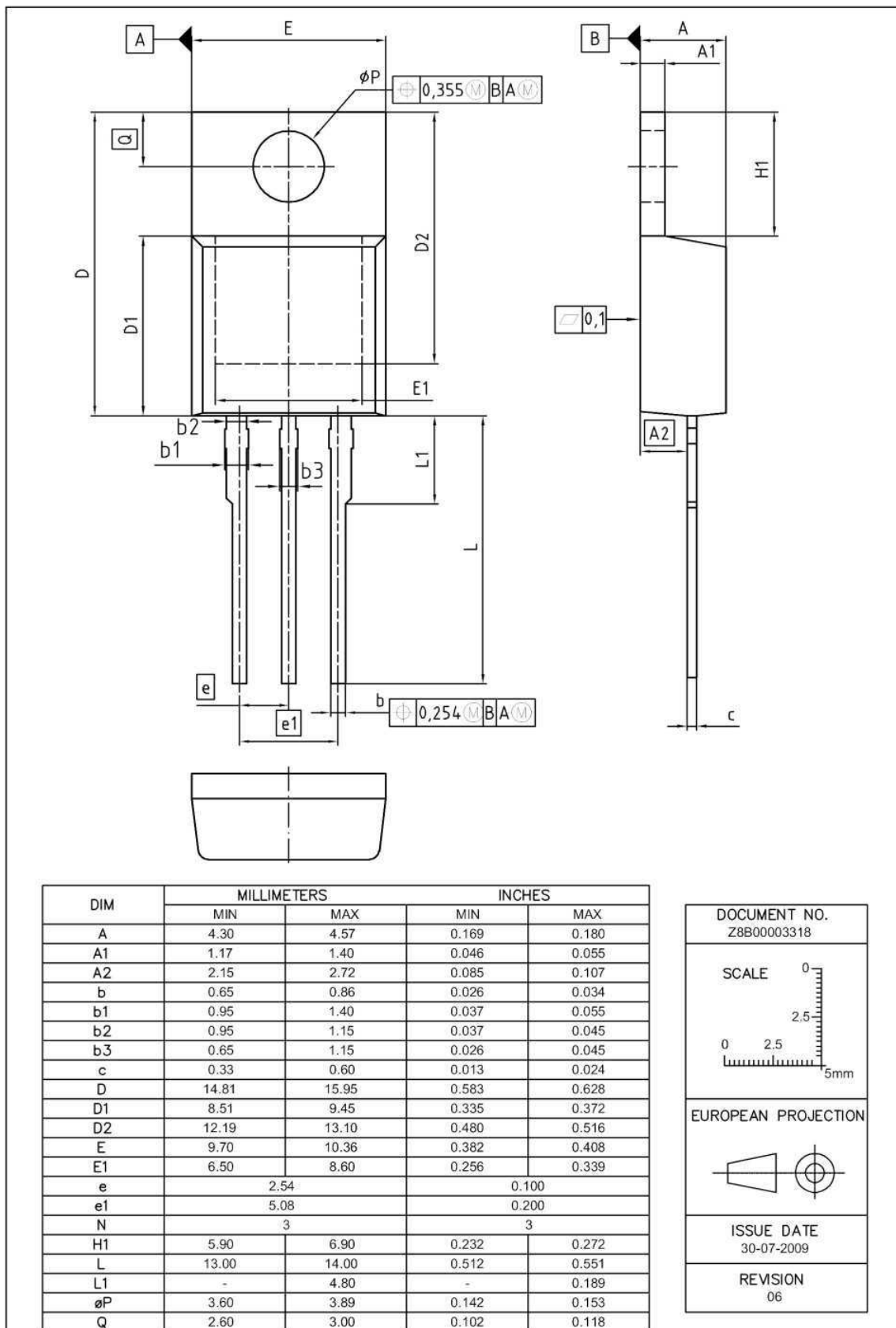
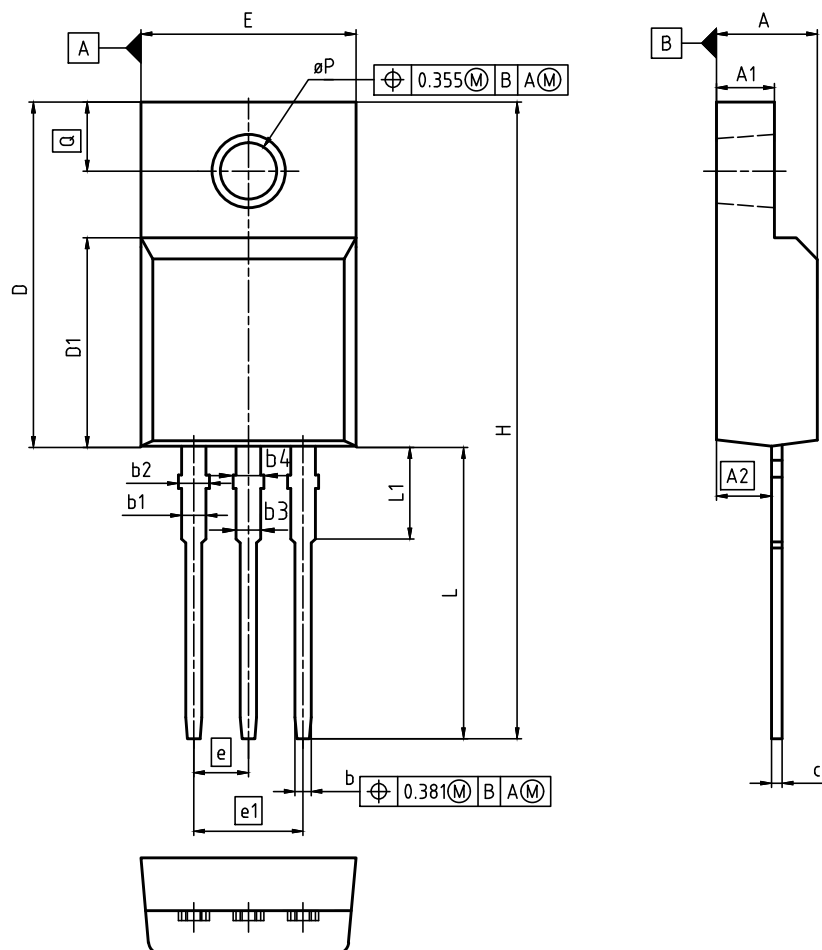


Figure 2 Outline PG-TO 220, dimensions in mm/inches



| 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 |

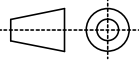
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| DOCUMENT NO.<br>Z8B00003319                                                                                  |
| SCALE<br>0 2.5 5mm                                                                                           |
| EUROPEAN PROJECTION<br> |
| ISSUE DATE<br>05-05-2014                                                                                     |
| REVISION<br>04                                                                                               |

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

## 8 Appendix A

### Table 12 Related Links

- IFX CoolMOS Webpage: [www.infineon.com](http://www.infineon.com)
- IFX Design Tools: [www.infineon.com](http://www.infineon.com)

## Revision History

IPX60R190E6

**Revision: 2017-10-17, Rev. 2.4**

Previous Revision

| Revision | Date       | Subjects (major changes since last revision)                                                                                                                                    |
|----------|------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 2.4      | 2017-10-17 | Rev. 2.1 to Rev. 2.3: Package drawing modifications. Rev. 2.4: Added Full PAK insulation voltage rating in Table 2 on page 3. Revised transfer characteristics graph on Page 10 |

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**Infineon Technologies AG**  
**81726 München, Germany**  
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For further information on technology, delivery terms and conditions and prices please contact your nearest Infineon Technologies Office ([www.infineon.com](http://www.infineon.com)).

### Warnings

Due to technical requirements, components may contain dangerous substances. For information on the types in question, please contact the nearest Infineon Technologies Office.

The Infineon Technologies component described in this Data Sheet may be used in life-support devices or systems and/or automotive, aviation and aerospace applications or systems only with the express written approval of Infineon Technologies, if a failure of such components can reasonably be expected to cause the failure of that life-support, automotive, aviation and aerospace device or system or to affect the safety or effectiveness of that device or system. Life support devices or systems are intended to be implanted in the human body or to support and/or maintain and sustain and/or protect human life. If they fail, it is reasonable to assume that the health of the user or other persons may be endangered.

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