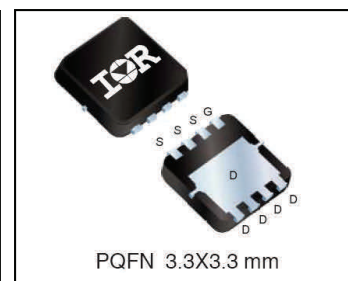
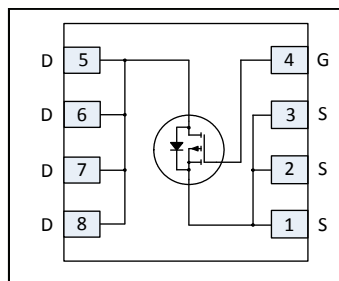


**HEXFET® Power MOSFET**

|                                                             |             |           |
|-------------------------------------------------------------|-------------|-----------|
| <b>V<sub>DSS</sub></b>                                      | <b>-30</b>  | <b>V</b>  |
| <b>R<sub>DS(on)</sub> max</b><br>(@ V <sub>GS</sub> = -10V) | <b>14.6</b> | <b>mΩ</b> |
| (@ V <sub>GS</sub> = -4.5V)                                 | <b>22.5</b> |           |
| <b>Qg</b> (typical)                                         | <b>32</b>   | <b>nC</b> |
| <b>I<sub>D</sub></b><br>(@T <sub>A</sub> = 25°C)            | <b>-11</b>  | <b>A</b>  |


**Applications**

- System/load switch,
- Charge or discharge switch for battery protection

**Features**

|                                                   |
|---------------------------------------------------|
| Low Thermal Resistance to PCB (<3.8°C/W)          |
| Low Profile (<1.05 mm)                            |
| Industry-Standard Pinout                          |
| Compatible with Existing Surface Mount Techniques |
| RoHS Compliant, Halogen-Free                      |
| MSL1, Consumer Qualification                      |

**Benefits**

|                                   |
|-----------------------------------|
| Enable better Thermal Dissipation |
| Increased Power Density           |
| Multi-Vendor Compatibility        |
| Easier Manufacturing              |
| Environmentally Friendlier        |
| Increased Reliability             |

results in  
⇒

| Base part number | Package Type       | Standard Pack |          | Orderable Part Number |
|------------------|--------------------|---------------|----------|-----------------------|
|                  |                    | Form          | Quantity |                       |
| IRFHM9391PbF     | PQFN 3.3mm x 3.3mm | Tape and Reel | 4000     | IRFHM9391TRPbF        |

**Absolute Maximum Ratings**

|                                                 | Parameter                                                                              | Max.              | Units |
|-------------------------------------------------|----------------------------------------------------------------------------------------|-------------------|-------|
| V <sub>GS</sub>                                 | Gate-to-Source Voltage                                                                 | ± 25              | V     |
| I <sub>D</sub> @ T <sub>A</sub> = 25°C          | Continuous Drain Current, V <sub>GS</sub> @ 10V                                        | -11               | A     |
| I <sub>D</sub> @ T <sub>A</sub> = 70°C          | Continuous Drain Current, V <sub>GS</sub> @ 10V                                        | -9.0              |       |
| I <sub>DM</sub>                                 | Pulsed Drain Current                                                                   | -90               |       |
| I <sub>D</sub> @ T <sub>C(Bottom)</sub> = 25°C  | Continuous Drain Current, V <sub>GS</sub> @ 10V                                        | -38 <sup>⑤⑥</sup> |       |
| I <sub>D</sub> @ T <sub>C(Bottom)</sub> = 100°C | Continuous Drain Current, V <sub>GS</sub> @ 10V                                        | -24 <sup>⑤⑥</sup> |       |
| I <sub>D</sub> @ T <sub>C</sub> = 25°C          | Continuous Drain Current, V <sub>GS</sub> @ 10V<br>(Source Bonding Technology Limited) | -24 <sup>⑥</sup>  | W     |
| P <sub>D</sub> @ T <sub>A</sub> = 25°C          | Power Dissipation <sup>④</sup>                                                         | 2.6               |       |
| P <sub>D</sub> @ T <sub>C(Bottom)</sub> = 25°C  | Power Dissipation <sup>④</sup>                                                         | 33                |       |
|                                                 | Linear Derating Factor <sup>④</sup>                                                    | 0.021             | W/°C  |
| T <sub>J</sub><br>T <sub>STG</sub>              | Operating Junction and<br>Storage Temperature Range                                    | -55 to + 150      | °C    |

Notes ① through ⑥ are on page 9

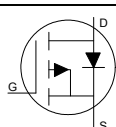
**Static @ T<sub>J</sub> = 25°C (unless otherwise specified)**

|                                     | Parameter                                           | Min. | Typ. | Max. | Units | Conditions                                                                                           |
|-------------------------------------|-----------------------------------------------------|------|------|------|-------|------------------------------------------------------------------------------------------------------|
| BV <sub>DSS</sub>                   | Drain-to-Source Breakdown Voltage                   | -30  | —    | —    | V     | V <sub>GS</sub> = 0V, I <sub>D</sub> = -250μA                                                        |
| ΔBV <sub>DSS</sub> /ΔT <sub>J</sub> | Breakdown Voltage Temp. Coefficient                 | —    | 0.02 | —    | V/°C  | Reference to 25°C, I <sub>D</sub> = -1mA                                                             |
| R <sub>DS(on)</sub>                 | Static Drain-to-Source On-Resistance                | —    | 10   | —    | mΩ    | V <sub>GS</sub> = -20V, I <sub>D</sub> = -11A ②                                                      |
|                                     |                                                     | —    | 11.7 | 14.6 |       | V <sub>GS</sub> = -10V, I <sub>D</sub> = -11A ②                                                      |
|                                     |                                                     | —    | 18   | 22.5 |       | V <sub>GS</sub> = -4.5V, I <sub>D</sub> = -11A ②                                                     |
| V <sub>GS(th)</sub>                 | Gate Threshold Voltage                              | -1.3 | -1.8 | -2.4 | V     | V <sub>DS</sub> = V <sub>GS</sub> , I <sub>D</sub> = -25μA                                           |
| ΔV <sub>GS(th)</sub>                | Gate Threshold Voltage Coefficient                  | —    | -5.1 | —    | mV/°C |                                                                                                      |
| I <sub>DSS</sub>                    | Drain-to-Source Leakage Current                     | —    | —    | -1.0 | μA    | V <sub>DS</sub> = -24V, V <sub>GS</sub> = 0V                                                         |
|                                     |                                                     | —    | —    | -150 |       | V <sub>DS</sub> = -24V, V <sub>GS</sub> = 0V, T <sub>J</sub> = 125°C                                 |
| I <sub>GSS</sub>                    | Gate-to-Source Forward Leakage                      | —    | —    | -10  | μA    | V <sub>GS</sub> = -25V                                                                               |
|                                     | Gate-to-Source Reverse Leakage                      | —    | —    | 10   |       | V <sub>GS</sub> = 25V                                                                                |
| g <sub>fs</sub>                     | Forward Transconductance                            | 16   | —    | —    | S     | V <sub>DS</sub> = -10V, I <sub>D</sub> = -9.0A                                                       |
| Q <sub>g</sub>                      | Total Gate Charge                                   | —    | 16   | —    | nC    | V <sub>GS</sub> = -4.5V, V <sub>DS</sub> = -15V, I <sub>D</sub> = -9.0A                              |
| Q <sub>g</sub>                      | Total Gate Charge                                   | —    | 32   | 48   | nC    | V <sub>DS</sub> = -15V<br>V <sub>GS</sub> = -10V<br>I <sub>D</sub> = -9.0A                           |
| Q <sub>gs1</sub>                    | Pre-V <sub>th</sub> Gate-to-Source Charge           | —    | 3.0  | —    |       |                                                                                                      |
| Q <sub>gs2</sub>                    | Post-V <sub>th</sub> Gate-to-Source Charge          | —    | 1.4  | —    |       |                                                                                                      |
| Q <sub>gd</sub>                     | Gate-to-Drain Charge                                | —    | 8.0  | —    |       |                                                                                                      |
| Q <sub>godr</sub>                   | Gate Charge Overdrive                               | —    | 19.6 | —    |       |                                                                                                      |
| Q <sub>sw</sub>                     | Switch Charge (Q <sub>gs2</sub> + Q <sub>gd</sub> ) | —    | 9.4  | —    | nC    | V <sub>DS</sub> = -16V, V <sub>GS</sub> = 0V                                                         |
| Q <sub>oss</sub>                    | Output Charge                                       | —    | 9.0  | —    |       |                                                                                                      |
| R <sub>G</sub>                      | Gate Resistance                                     | —    | 16   | —    | Ω     |                                                                                                      |
| t <sub>d(on)</sub>                  | Turn-On Delay Time                                  | —    | 11   | —    | ns    | V <sub>DD</sub> = -15V, V <sub>GS</sub> = -4.5V ②<br>I <sub>D</sub> = -1.0A<br>R <sub>G</sub> = 6.8Ω |
| t <sub>r</sub>                      | Rise Time                                           | —    | 27   | —    |       |                                                                                                      |
| t <sub>d(off)</sub>                 | Turn-Off Delay Time                                 | —    | 72   | —    |       |                                                                                                      |
| t <sub>f</sub>                      | Fall Time                                           | —    | 60   | —    |       |                                                                                                      |
| C <sub>iss</sub>                    | Input Capacitance                                   | —    | 1543 | —    | pF    | V <sub>GS</sub> = 0V<br>V <sub>DS</sub> = -25V<br>f = 1.0KHz                                         |
| C <sub>oss</sub>                    | Output Capacitance                                  | —    | 310  | —    |       |                                                                                                      |
| C <sub>rss</sub>                    | Reverse Transfer Capacitance                        | —    | 208  | —    |       |                                                                                                      |

**Avalanche Characteristics**

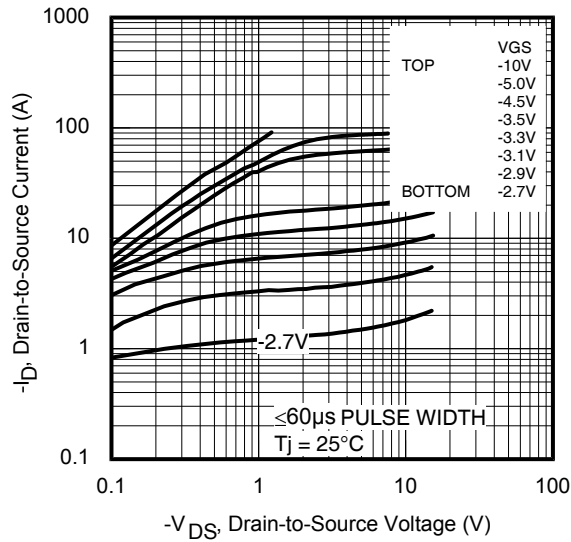
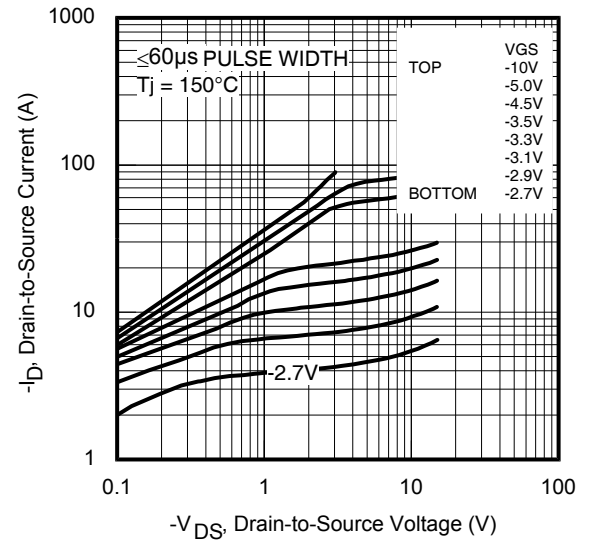
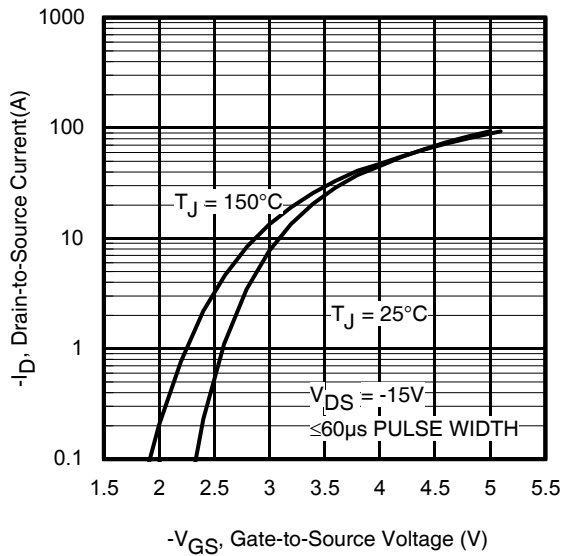
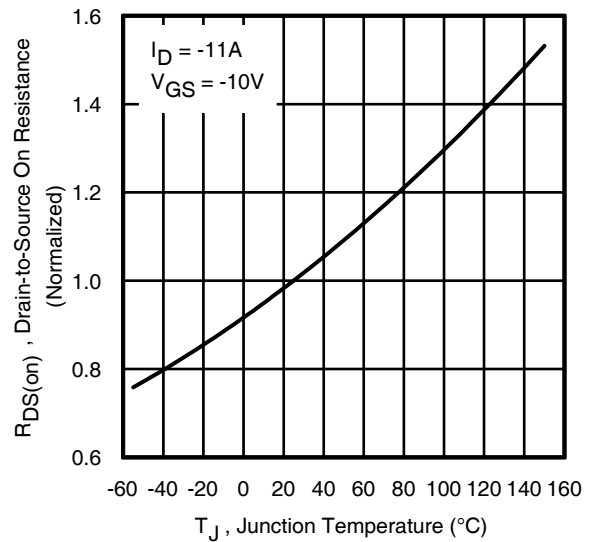
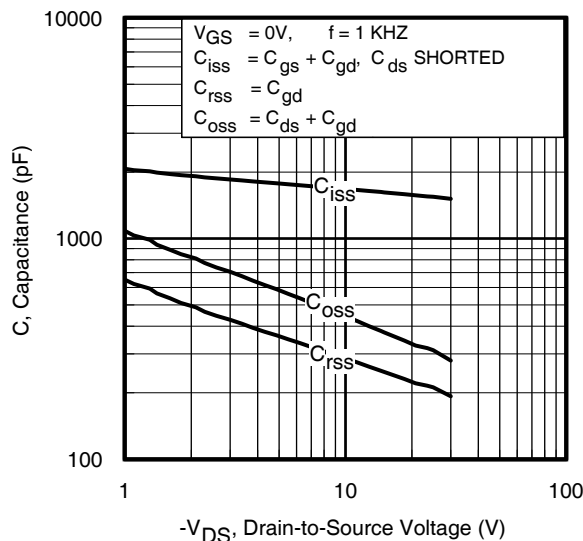
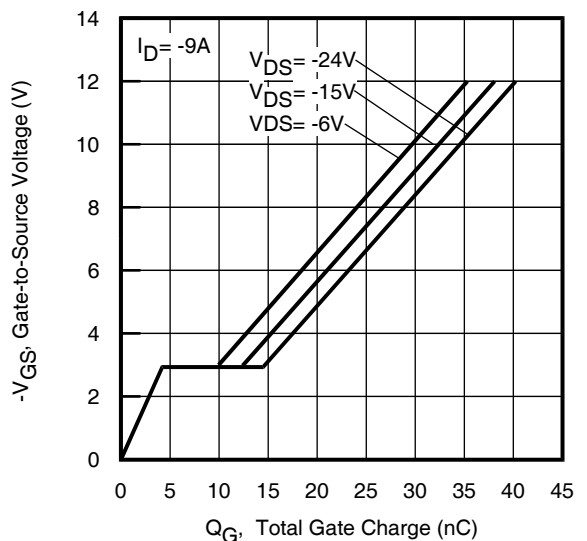
|                 | Parameter                       | Typ. | Max. | Units |
|-----------------|---------------------------------|------|------|-------|
| E <sub>AS</sub> | Single Pulse Avalanche Energy ① | —    | 75   | mJ    |

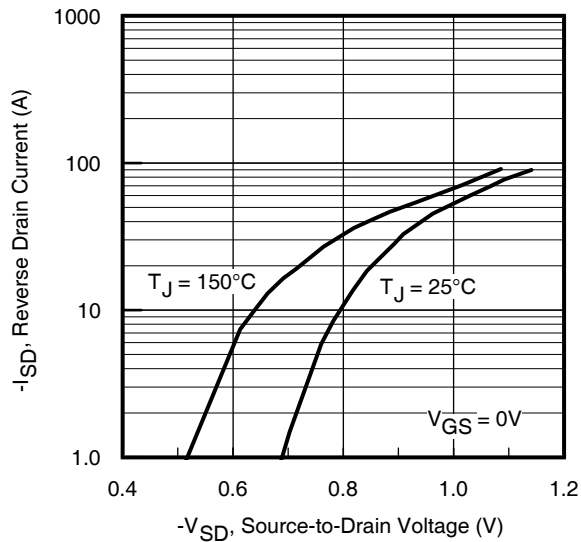
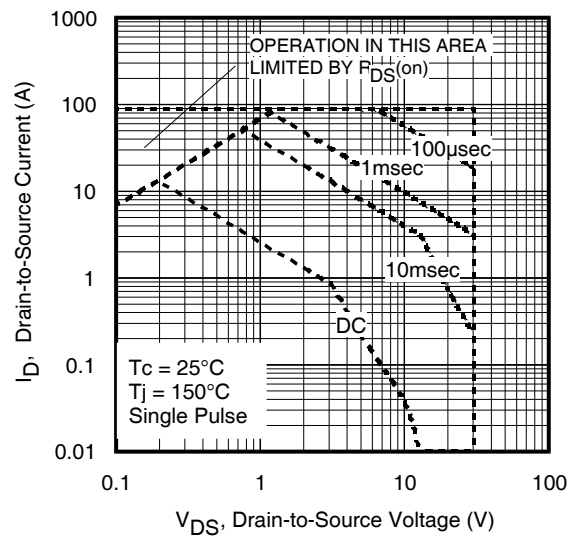
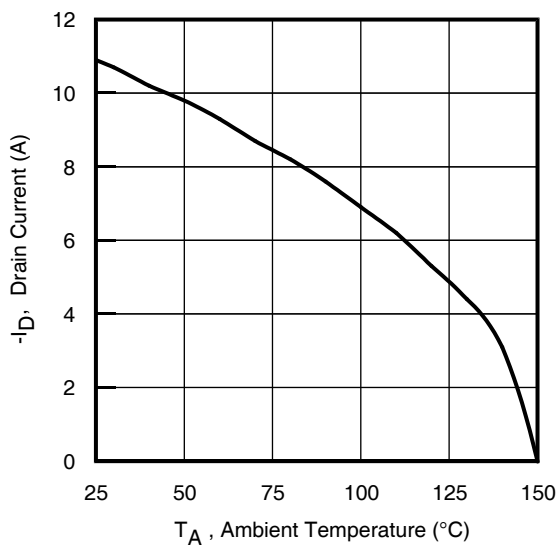
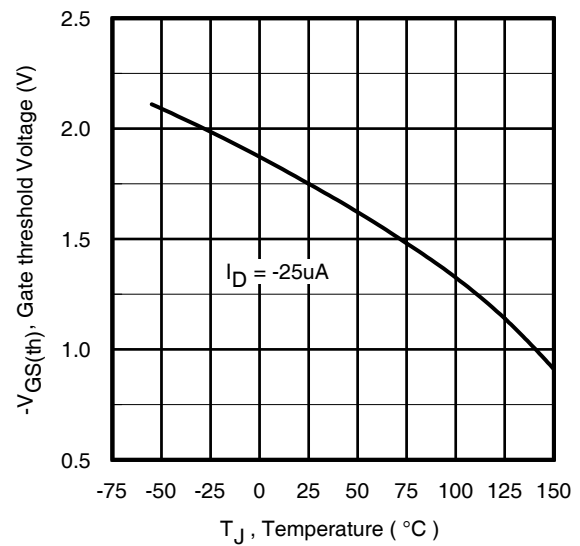
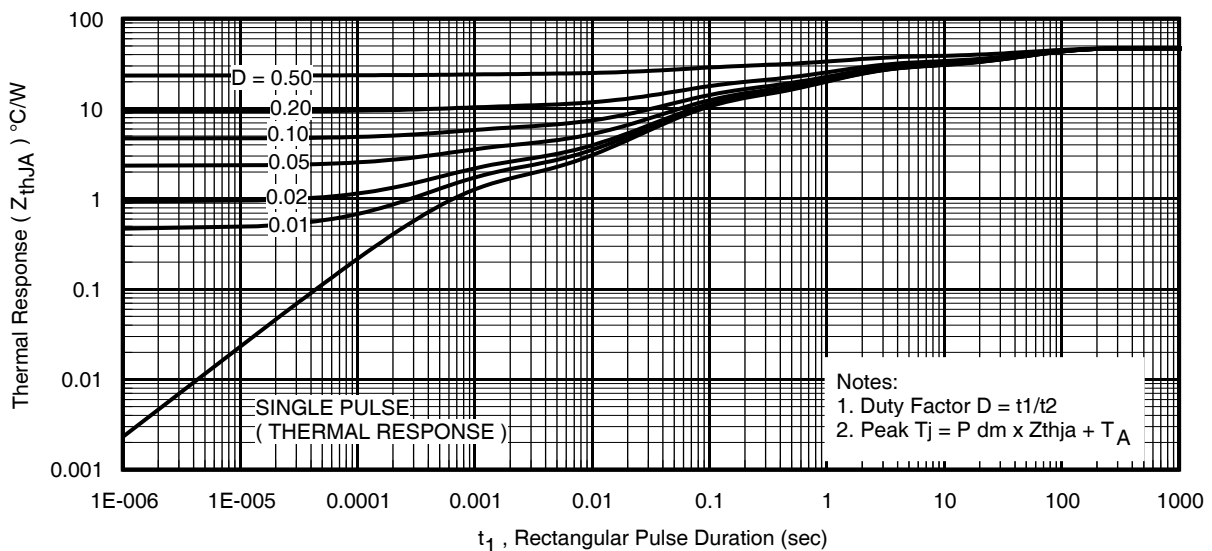
**Diode Characteristics**

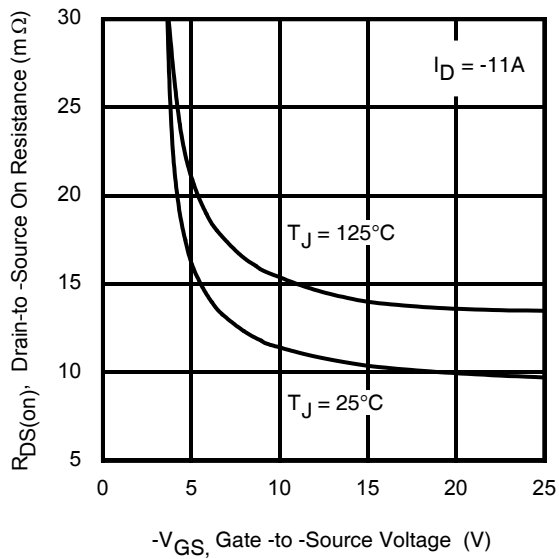
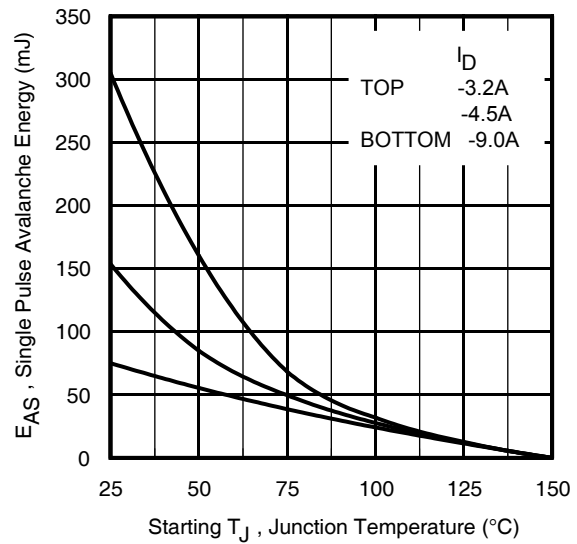
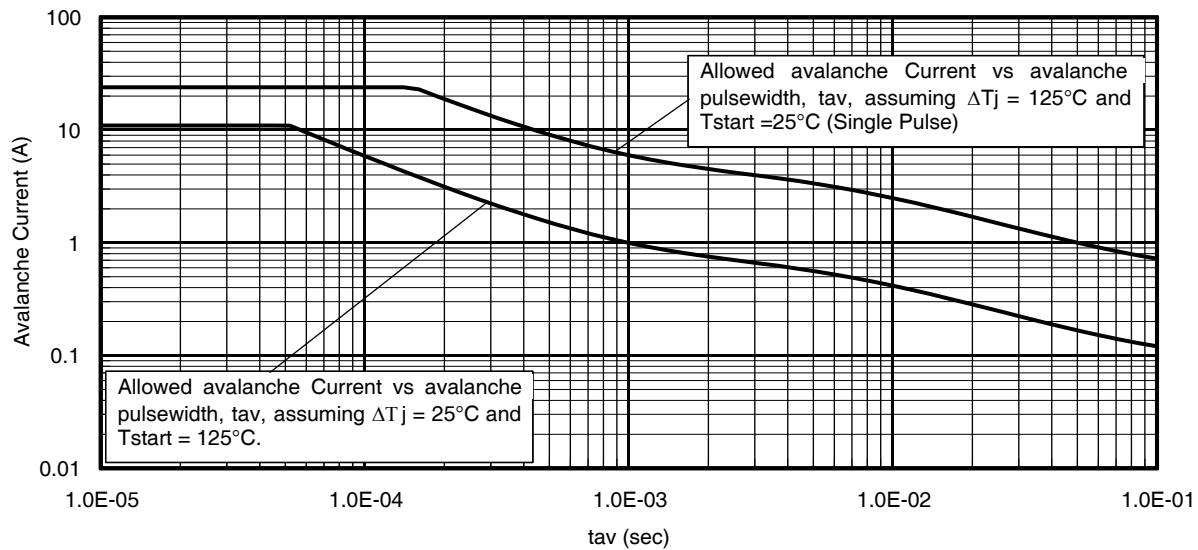
|                 | Parameter                              | Min. | Typ. | Max. | Units | Conditions                                                                                                                                           |
|-----------------|----------------------------------------|------|------|------|-------|------------------------------------------------------------------------------------------------------------------------------------------------------|
| I <sub>S</sub>  | Continuous Source Current (Body Diode) | —    | —    | -2.8 | A     | MOSFET symbol showing the integral reverse p-n junction diode.  |
| I <sub>SM</sub> | Pulsed Source Current (Body Diode) ①   | —    | —    | -90  |       |                                                                                                                                                      |
| V <sub>SD</sub> | Diode Forward Voltage                  | —    | —    | -1.2 | V     | T <sub>J</sub> = 25°C, I <sub>S</sub> = -2.8A, V <sub>GS</sub> = 0V ②                                                                                |
| t <sub>rr</sub> | Reverse Recovery Time                  | —    | 64   | 96   | ns    | T <sub>J</sub> = 25°C, I <sub>F</sub> = -2.8A, V <sub>DD</sub> = -24V<br>di/dt = 100A/μs ②                                                           |
| Q <sub>rr</sub> | Reverse Recovery Charge                | —    | 25   | 38   | nC    |                                                                                                                                                      |

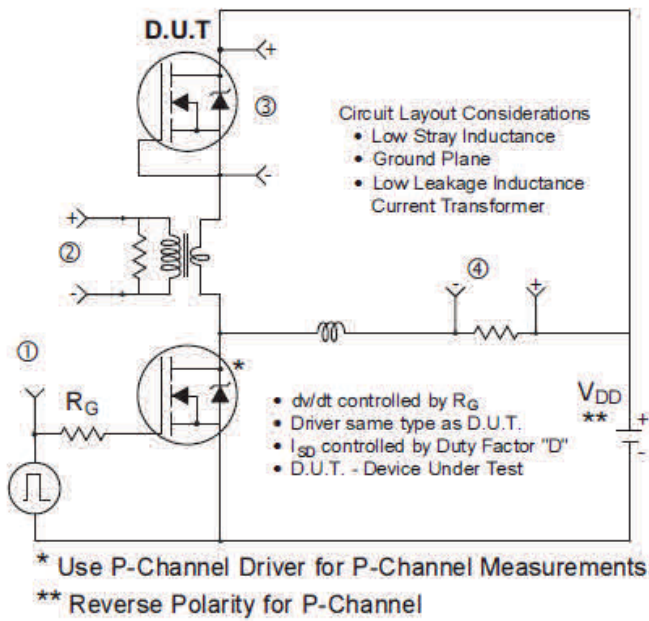
**Thermal Resistance**

|                           | Parameter             | Typ. | Max. | Units |
|---------------------------|-----------------------|------|------|-------|
| R <sub>θJC</sub> (Bottom) | Junction-to-Case ③    | —    | 3.8  | °C/W  |
| R <sub>θJC</sub> (Top)    | Junction-to-Case ③    | —    | 42   |       |
| R <sub>θJA</sub>          | Junction-to-Ambient ④ | —    | 47   |       |
| R <sub>θJA</sub> (<10s)   | Junction-to-Ambient ④ | —    | 32   |       |

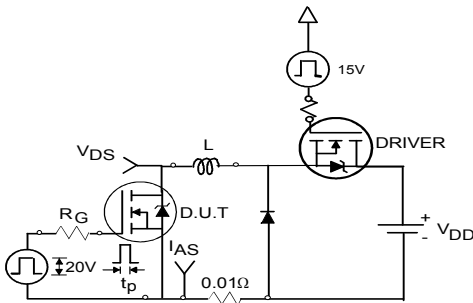
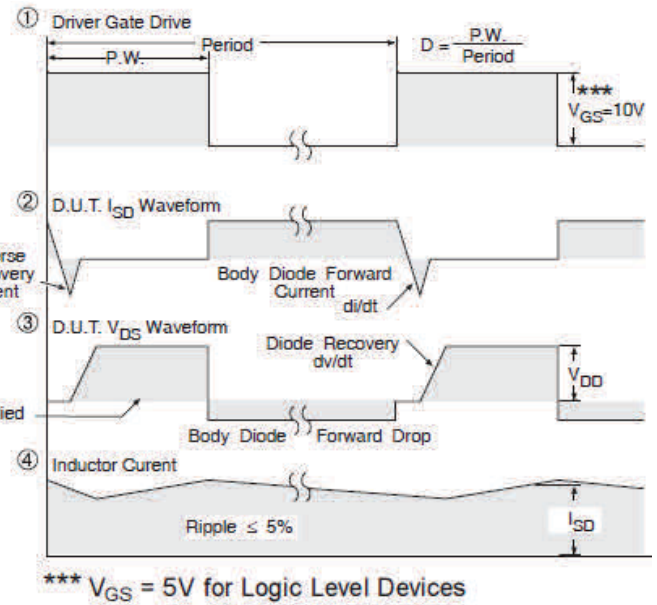

**Fig 1.** Typical Output Characteristics

**Fig 2.** Typical Output Characteristics

**Fig 3.** Typical Transfer Characteristics

**Fig 4.** Normalized On-Resistance vs. Temperature

**Fig 5.** Typical Capacitance vs. Drain-to-Source Voltage

**Fig 6.** Typical Gate Charge vs. Gate-to-Source Voltage


**Fig 7.** Typical Source-Drain Diode Forward Voltage

**Fig 8.** Maximum Safe Operating Area

**Fig 9.** Maximum Drain Current vs. Case Temperature

**Fig 10.** Threshold Voltage Vs. Temperature

**Fig 11.** Maximum Effective Transient Thermal Impedance, Junction-to-Case

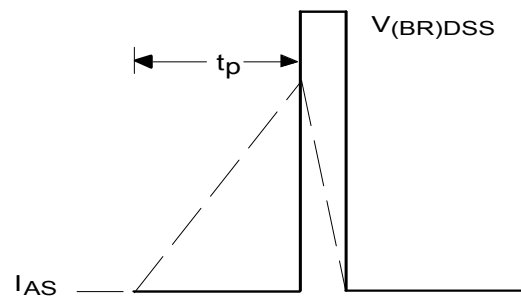

**Fig 12.** On-Resistance vs. Gate Voltage

**Fig 13.** Maximum Avalanche Energy vs. Drain Current

**Fig 14.** Typical Avalanche Current vs. Pulsewidth



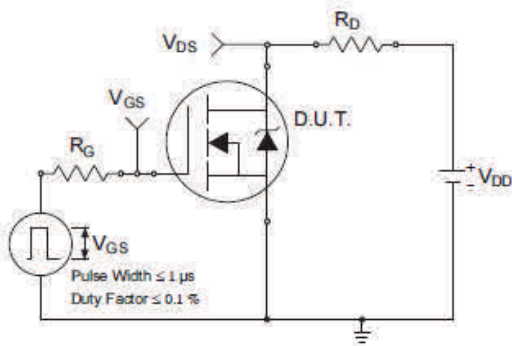
**Fig 15. Peak Diode Recovery  $dv/dt$  Test Circuit for N-Channel HEXFET® Power MOSFETs**



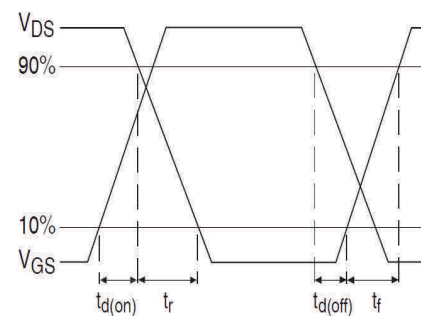
**Fig 16a. Unclamped Inductive Test Circuit**



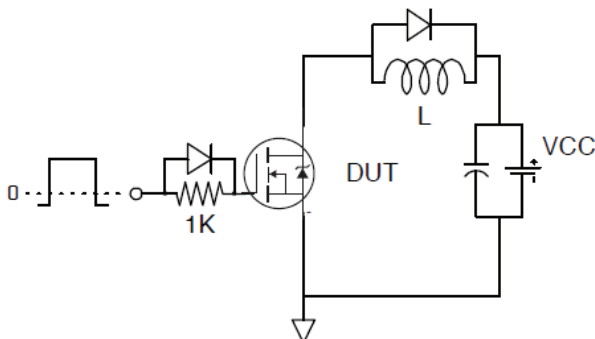
**Fig 16b. Unclamped Inductive Waveforms**



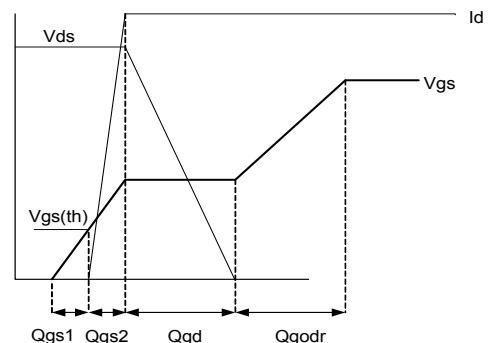
**Fig 17a. Switching Time Test Circuit**



**Fig 17b. Switching Time Waveforms**

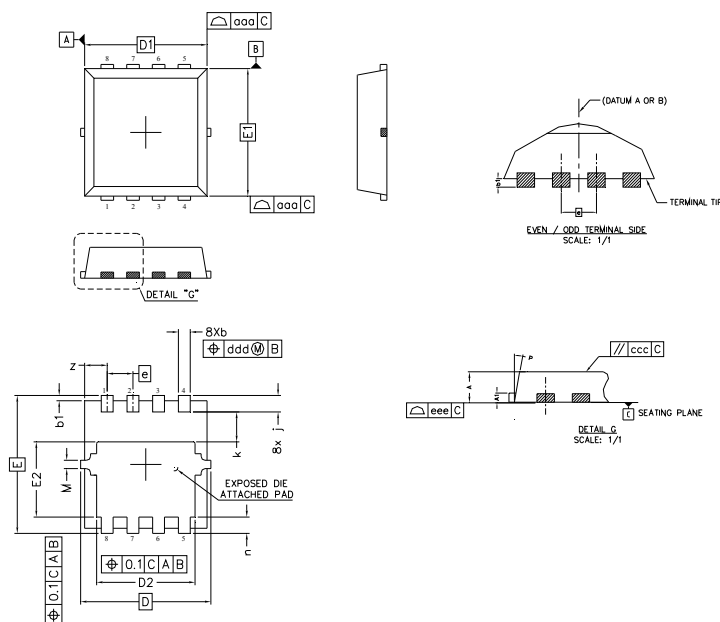


**Fig 18. Gate Charge Test Circuit**



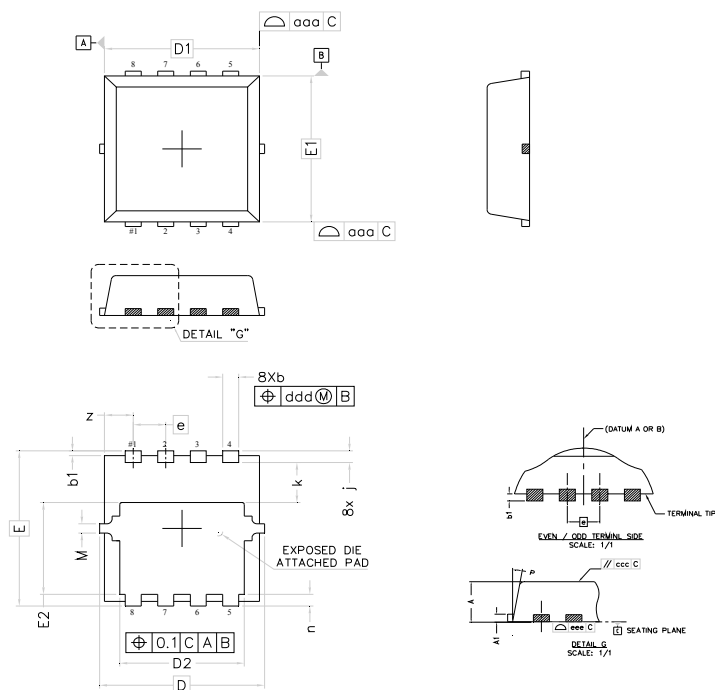
**Fig 19. Gate Charge Waveform**

## PQFN 3.3 x 3.3 Outline “C” Package Details



| DIM | MILLIMETERS |      | INCHES    |       |
|-----|-------------|------|-----------|-------|
|     | MIN         | MAX  | MIN       | MAX   |
| A   | 0.70        | 0.80 | .0276     | .0315 |
| A1  | 0.10        | 0.25 | .0039     | .0098 |
| b   | 0.25        | 0.35 | .0098     | .0138 |
| b1  | 0.05        | 0.15 | .0020     | .0059 |
| D   | 3.20        | 3.40 | .1260     | .1339 |
| D1  | 3.00        | 3.20 | .1181     | .1260 |
| D2  | 2.39        | 2.59 | .0941     | .1020 |
| E   | 3.25        | 3.45 | .1280     | .1358 |
| E1  | 3.00        | 3.20 | .1181     | .1260 |
| E2  | 1.78        | 1.98 | .0701     | .0780 |
| e   | 0.65 BSC    |      | .0255 BSC |       |
| j   | 0.30        | 0.50 | .0118     | .0197 |
| k   | 0.59        | 0.79 | .0232     | .0311 |
| n   | 0.30        | 0.50 | .0118     | .0197 |
| M   | 0.03        | 0.23 | .0012     | .0091 |
| P   | 10°         | 12°  | 10°       | 12°   |
| z   | 0.50        | 0.70 | .0197     | .0276 |

## PQFN 3.3 x 3.3 Outline “G” Package Details

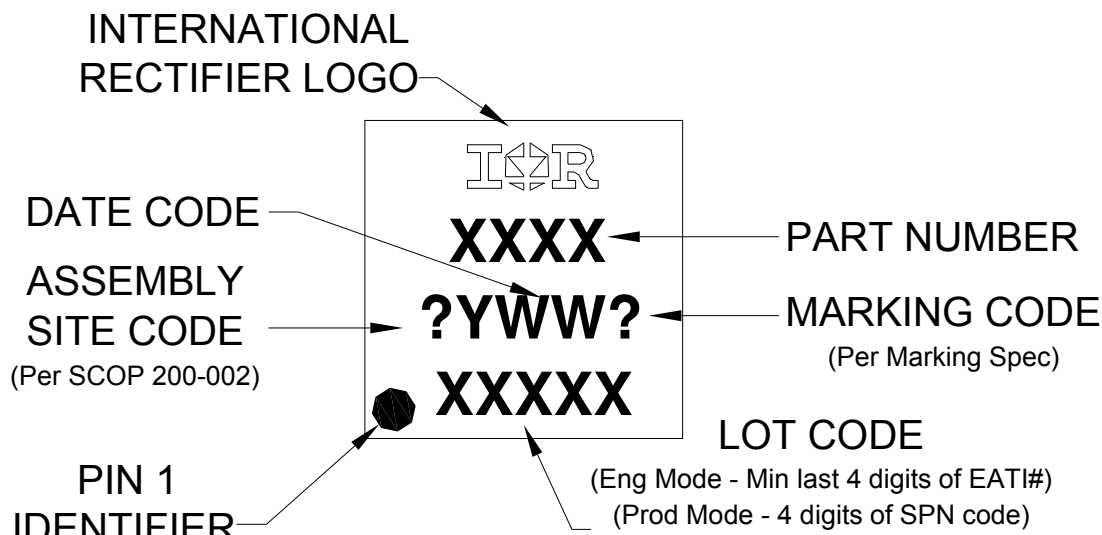


| DIM | MILLIMETERS |      | INCHES    |       |
|-----|-------------|------|-----------|-------|
|     | MIN         | MAX  | MIN       | MAX   |
| A   | 0.80        | 0.90 | .0315     | .0354 |
| A1  | 0.12        | 0.22 | .0047     | .0086 |
| b   | 0.22        | 0.42 | .0087     | .0165 |
| b1  | 0.05        | 0.15 | .0020     | .0059 |
| D   | 3.30 BSC    |      | .1299 BSC |       |
| D1  | 3.10 BSC    |      | .1220 BSC |       |
| D2  | 2.29        | 2.69 | .0902     | .1059 |
| E   | 3.30 BSC    |      | .1299 BSC |       |
| E1  | 3.10 BSC    |      | .1220 BSC |       |
| E2  | 1.85        | 2.05 | .0728     | .0807 |
| e   | 0.65 BSC    |      | .0255 BSC |       |
| j   | 0.15        | 0.35 | .0059     | .0137 |
| k   | 0.75        | 0.95 | .0295     | .0374 |
| n   | 0.15        | 0.35 | .0059     | .0137 |
| M   | NOM.        | 0.20 | NOM.      | .0078 |
| P   | 9°          | 11°  | 9°        | 11°   |

For more information on board mounting, including footprint and stencil recommendation, please refer to application note AN-1136: <http://www.irf.com/technical-info/appnotes/an-1136.pdf>

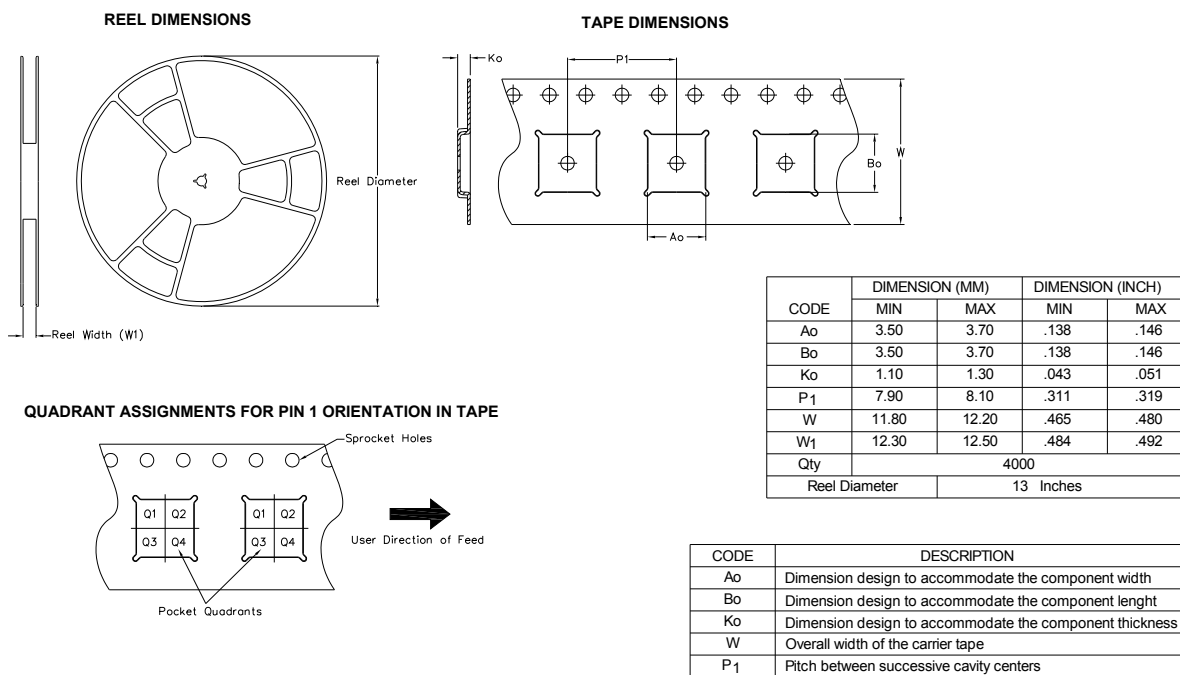
For more information on package inspection techniques, please refer to application note AN-1154: <http://www.irf.com/technical-info/appnotes/an-1154.pdf>

## PQFN 3.3 x 3.3 Part Marking



Note: For the most current drawing please refer to IR website at <http://www.irf.com/package/>

## PQFN 3.3 x 3.3 Tape and Reel



Note: For the most current drawing please refer to IR website at <http://www.irf.com/package/>

**Qualification Information<sup>†</sup>**

|                                   |                                                          |                                               |
|-----------------------------------|----------------------------------------------------------|-----------------------------------------------|
| <b>Qualification Level</b>        | Consumer <sup>††</sup><br>(per JEDEC JESD47F guidelines) |                                               |
| <b>Moisture Sensitivity Level</b> | PQFN 3.3mm x 3.3mm                                       | MSL1<br>(per JEDEC J-STD-020D <sup>††</sup> ) |
| <b>RoHS Compliant</b>             | Yes                                                      |                                               |

† Qualification standards can be found at International Rectifier's web site: <http://www.irf.com/product-info/reliability/>

†† Applicable version of JEDEC standard at the time of product release.

**Notes:**

- ① Starting  $T_J = 25^{\circ}\text{C}$ ,  $L = 1.872\text{mH}$ ,  $R_G = 50\Omega$ ,  $I_{AS} = -9\text{A}$ .
- ② Pulse width  $\leq 400\mu\text{s}$ ; duty cycle  $\leq 2\%$ .
- ③  $R_{\theta}$  is measured at  $T_J$  of approximately  $90^{\circ}\text{C}$ .
- ④ When mounted on 1 inch square PCB (FR-4). Please refer to AN-994 for more details:  
<http://www.irf.com/technical-info/appnotes/an-994.pdf>
- ⑤ Calculated continuous current based on maximum allowable junction temperature.
- ⑥ Current is limited by source bonding technology.

## Revision History

| Date      | Comments                                                                                                                                                                                                      |
|-----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7/1/2014  | <ul style="list-style-type: none"> <li>Remove "SAWN" package outline on page 7.</li> <li>Updated part marking on page 7.</li> <li>Updated tape and reel on page 8.</li> </ul>                                 |
| 2/23/2016 | <ul style="list-style-type: none"> <li>Updated datasheet with corporate template</li> <li>Updated package outline to reflect the PCN # (241-PCN30-Public) for "Option C" and "Option G" on page 7.</li> </ul> |

**Published by**  
**Infineon Technologies AG**  
**81726 München, Germany**  
**© Infineon Technologies AG 2015**  
**All Rights Reserved.**

## IMPORTANT NOTICE

The information given in this document shall in no event be regarded as a guarantee of conditions or characteristics ("Beschaffenheitsgarantie"). With respect to any examples, hints or any typical values stated herein and/or any information regarding the application of the product, Infineon Technologies hereby disclaims any and all warranties and liabilities of any kind, including without limitation warranties of non-infringement of intellectual property rights of any third party.

In addition, any information given in this document is subject to customer's compliance with its obligations stated in this document and any applicable legal requirements, norms and standards concerning customer's products and any use of the product of Infineon Technologies in customer's applications.

The data contained in this document is exclusively intended for technically trained staff. It is the responsibility of customer's technical departments to evaluate the suitability of the product for the intended application and the completeness of the product information given in this document with respect to such application.

For further information on the product, 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 products may contain dangerous substances. For information on the types in question please contact your nearest Infineon Technologies office.

Except as otherwise explicitly approved by Infineon Technologies in a written document signed by authorized representatives of Infineon Technologies, Infineon Technologies' products may not be used in any applications where a failure of the product or any consequences of the use thereof can reasonably be expected to result in personal injury.