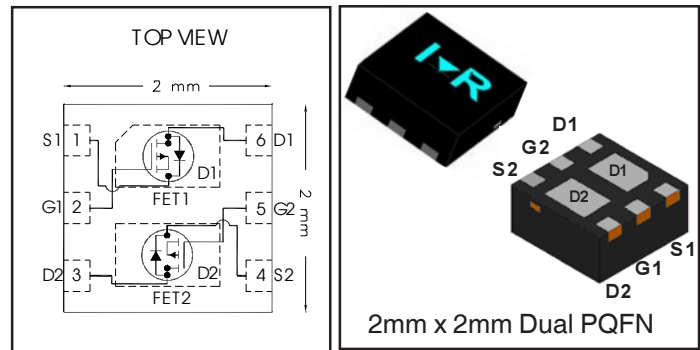


|   |               |           |
|---|---------------|-----------|
| $V_{DS}$                                  | <b>-30</b>    | <b>V</b>  |
| $V_{GS\ max}$                             | <b>±20</b>    | <b>V</b>  |
| $R_{DS(on)\ max}$<br>(@ $V_{GS} = -10V$ ) | <b>170</b>    | <b>mΩ</b> |
| $I_D$<br>(@ $T_C = 25^\circ C$ )          | <b>-3.4</b> ② | <b>A</b>  |



### Applications

- Charge and Discharge Switch for Battery Application
- System/load switch

### Features and Benefits

#### Features

|  |
|--|
| Low $R_{DS(on)}$ ( $\leq 170m\Omega$ )                       |
| Low Thermal Resistance to PCB ( $\leq 19^\circ C/W$ )        |
| Low Profile ( $\leq 1.0\ mm$ )                               |
| Compatible with Existing Surface Mount Techniques            |
| RoHS Compliant Containing no Lead, no Bromide and no Halogen |
| MSL1, Industrial Qualification                               |

results in

#### Benefits

|                                   |
|-----------------------------------|
| Lower Conduction Losses           |
| Enable better thermal dissipation |
| Increased Power Density           |
| Easier Manufacturing              |
| Environmentally Friendlier        |
| Increased Reliability             |

| Orderable part number | Package Type   | Standard Pack |          | Note             |
|-----------------------|----------------|---------------|----------|------------------|
|                       |                | Form          | Quantity |                  |
| IRFHS9351TRPBF        | PQFN 2mm x 2mm | Tape and Reel | 4000     |                  |
| IRFHS9351TR2PBF       | PQFN 2mm x 2mm | Tape and Reel | 400      | EOL notice # 259 |

### Absolute Maximum Ratings

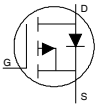
|                            | Parameter  | Max.         | Units |
|----------------------------|--|--------------|-------|
| $V_{DS}$                   | Drain-to-Source Voltage                                    | -30          | V     |
| $V_{GS}$                   | Gate-to-Source Voltage                                     | ± 20         |       |
| $I_D$ @ $T_A = 25^\circ C$ | Continuous Drain Current, $V_{GS}$ @ -10V                  | -2.3         | A     |
| $I_D$ @ $T_A = 70^\circ C$ | Continuous Drain Current, $V_{GS}$ @ -10V                  | -1.5         |       |
| $I_D$ @ $T_C = 25^\circ C$ | Continuous Drain Current, $V_{GS}$ @ -10V                  | -5.1 ②       |       |
| $I_D$ @ $T_C = 70^\circ C$ | Continuous Drain Current, $V_{GS}$ @ -10V                  | -4.1 ②       |       |
| $I_D$ @ $T_C = 25^\circ C$ | Continuous Drain Current, $V_{GS}$ @ 10V (Package Limited) | -3.4 ②       |       |
| $I_{DM}$                   | Pulsed Drain Current ①                                     | -20          |       |
| $P_D$ @ $T_A = 25^\circ C$ | Power Dissipation ④  | 1.4          | W     |
| $P_D$ @ $T_A = 70^\circ C$ | Power Dissipation ④  | 0.9          |       |
|                            | Linear Derating Factor                                     | 0.01         | W/°C  |
| $T_J$<br>$T_{STG}$         | Operating Junction and Storage Temperature Range           | -55 to + 150 | °C    |

Notes ① through ⑥ are on page 2

**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                           |
| V <sub>DSS</sub> / T <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 | —    | 135  | 170  | m     | V <sub>GS</sub> = -10V, I <sub>D</sub> = -3.1A ③                        |
|                                   |                                      | —    | 235  | 290  |       | V <sub>GS</sub> = -4.5V, I <sub>D</sub> = -2.5A ③                       |
| 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> = -10μA              |
| V <sub>GS(th)</sub>               | Gate Threshold Voltage Coefficient   | —    | -4.6 | —    | 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       | —    | —    | -100 | nA    | V <sub>GS</sub> = -20V  |
|                                   | Gate-to-Source Reverse Leakage       | —    | —    | 100  |       | V <sub>GS</sub> = 20V   |
| g <sub>fs</sub>                   | Forward Transconductance             | 2.4  | —    | —    | S     | V <sub>DS</sub> = -10V, I <sub>D</sub> = -3.1A                          |
| Q <sub>g</sub>                    | Total Gate Charge ⑥                  | —    | 1.9  | —    | nC    | V <sub>DS</sub> = -15V, V <sub>GS</sub> = -4.5V, I <sub>D</sub> = -3.1A |
| Q <sub>g</sub>                    | Total Gate Charge ⑥                  | —    | 3.7  | —    | nC    | V <sub>GS</sub> = -10V  |
| Q <sub>gs</sub>                   | Gate-to-Source Charge ⑥              | —    | 0.6  | —    |       | V <sub>DS</sub> = -15V  |
| Q <sub>gd</sub>                   | Gate-to-Drain Charge ⑥               | —    | 1.1  | —    |       | I <sub>D</sub> = -3.1A  |
| R <sub>G</sub>                    | Gate Resistance ⑥                    | —    | 17   | —    |       |   |
| t <sub>d(on)</sub>                | Turn-On Delay Time                   | —    | 8.3  | —    | ns    | V <sub>DD</sub> = -15V, V <sub>GS</sub> = -4.5V ③                       |
| t <sub>r</sub>                    | Rise Time                            | —    | 30   | —    |       | I <sub>D</sub> = -3.1A  |
| t <sub>d(off)</sub>               | Turn-Off Delay Time                  | —    | 6.3  | —    |       | R <sub>G</sub> = 1.8  |
| t <sub>f</sub>                    | Fall Time                            | —    | 7.9  | —    |       | See Figs. 19a & 19b   |
| C <sub>iss</sub>                  | Input Capacitance                    | —    | 160  | —    | pF    | V <sub>GS</sub> = 0V  |
| C <sub>oss</sub>                  | Output Capacitance                   | —    | 39   | —    |       | V <sub>DS</sub> = -25V  |
| C <sub>rss</sub>                  | Reverse Transfer Capacitance         | —    | 26   | —    |       | f = 1.0KHz  |

**Diode Characteristics**

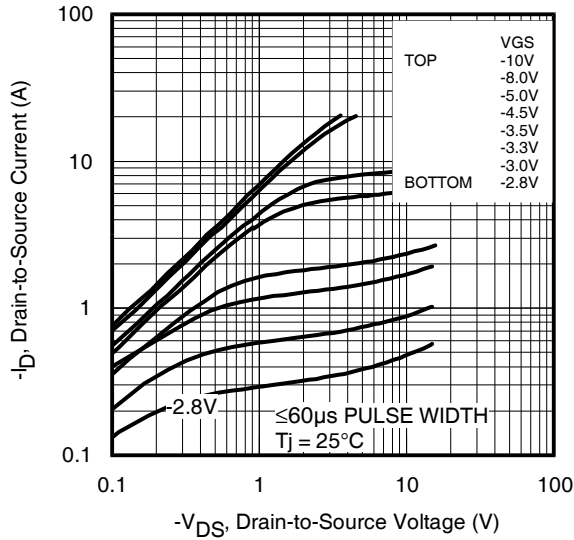
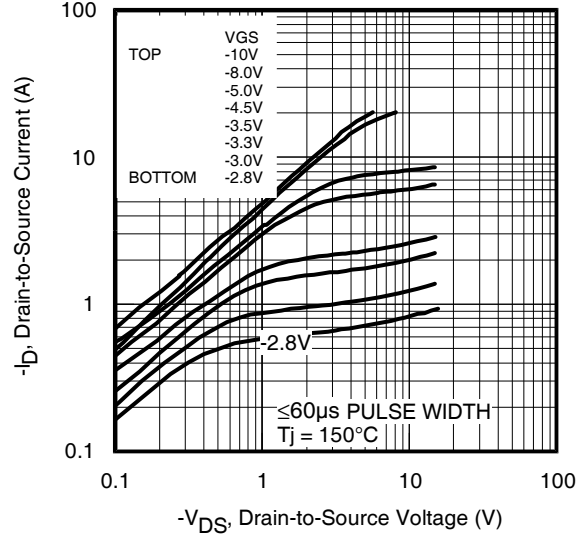
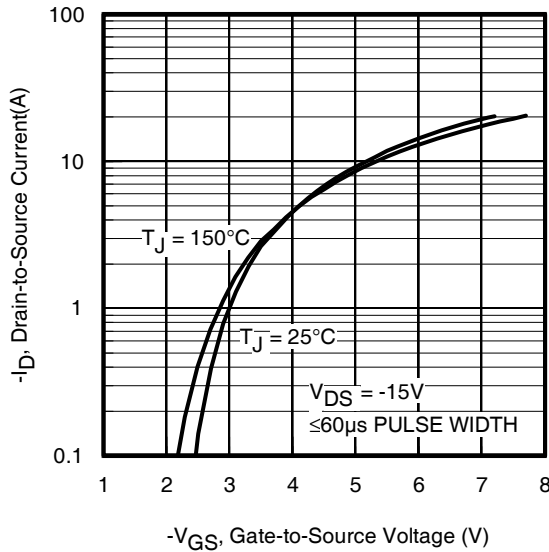
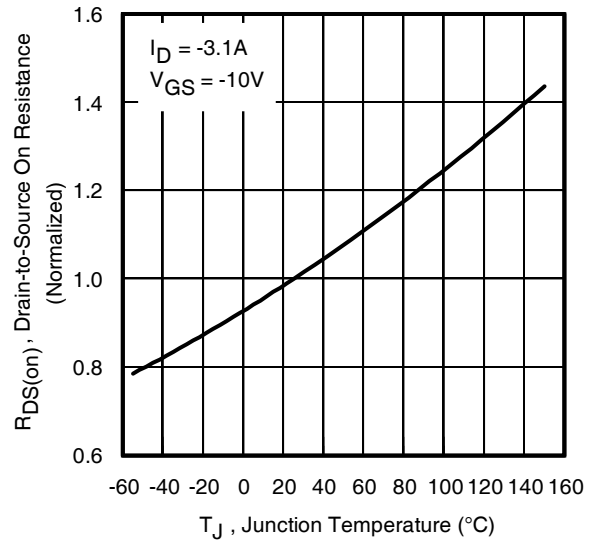
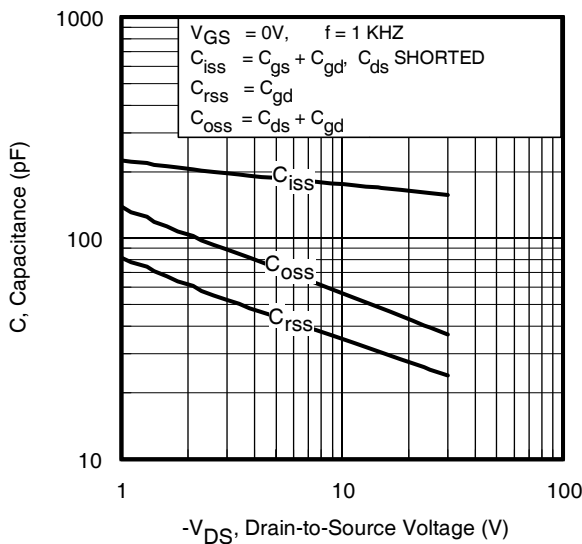
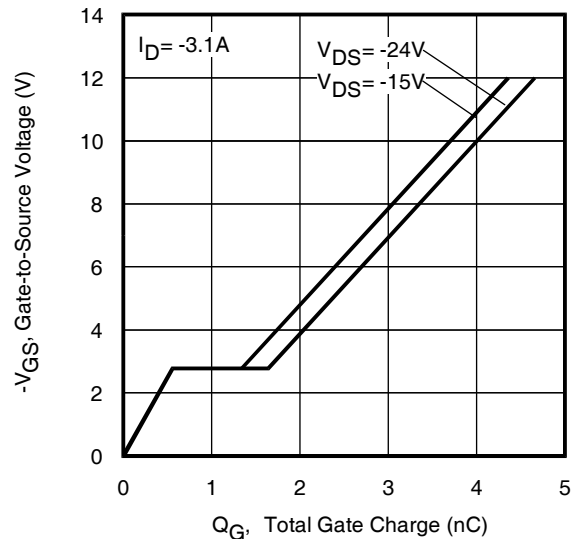
|                 | Parameter                                 | Min. | Typ. | Max. | Units | Conditions   |
|-----------------|---|------|------|------|-------|--|
| I <sub>S</sub>  | Continuous Source Current<br>(Body Diode) | —    | —    | -5.1 | A     | MOSFET symbol showing the integral reverse p-n junction diode.  |
| I <sub>SM</sub> | Pulsed Source Current<br>(Body Diode) ①   | —    | —    | -20  |       |  |
| V <sub>SD</sub> | Diode Forward Voltage                     | —    | —    | -1.2 | V     | T <sub>J</sub> = 25°C, I <sub>S</sub> = -3.1A, V <sub>GS</sub> = 0V ③  |
| t <sub>rr</sub> | Reverse Recovery Time                     | —    | 20   | 30   | ns    | T <sub>J</sub> = 25°C, I <sub>F</sub> = -3.1A, V <sub>DD</sub> = -15V  |
| Q <sub>rr</sub> | Reverse Recovery Charge                   | —    | 42   | 63   | nC    | di/dt = 370/μs ③   |

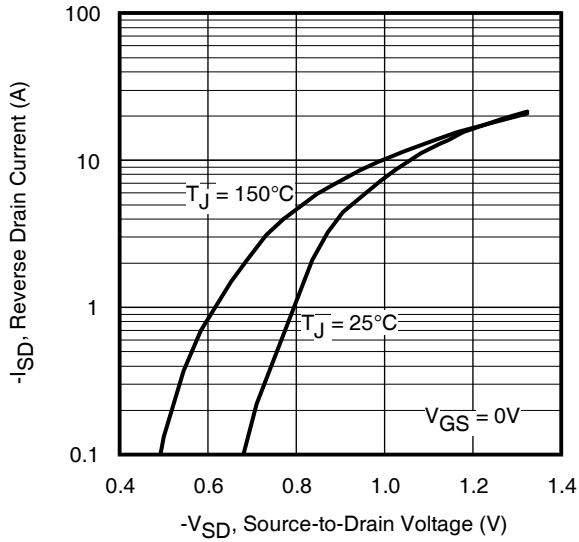
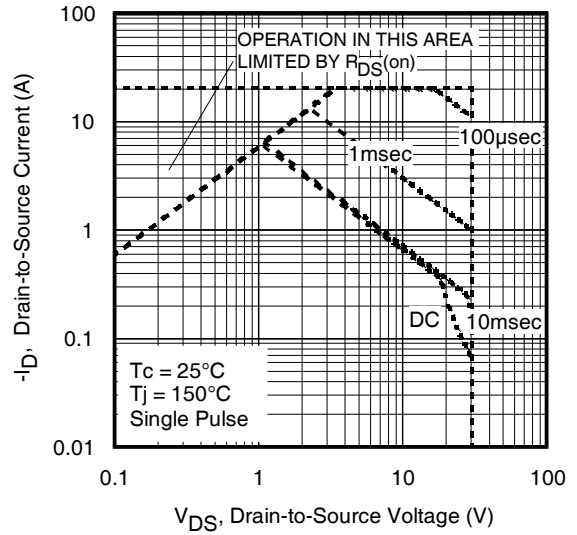
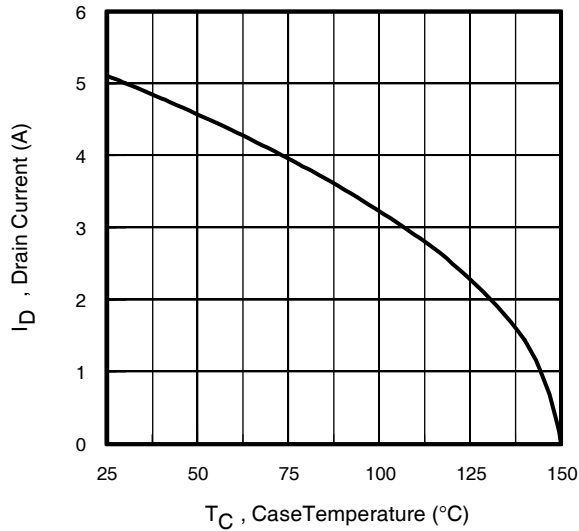
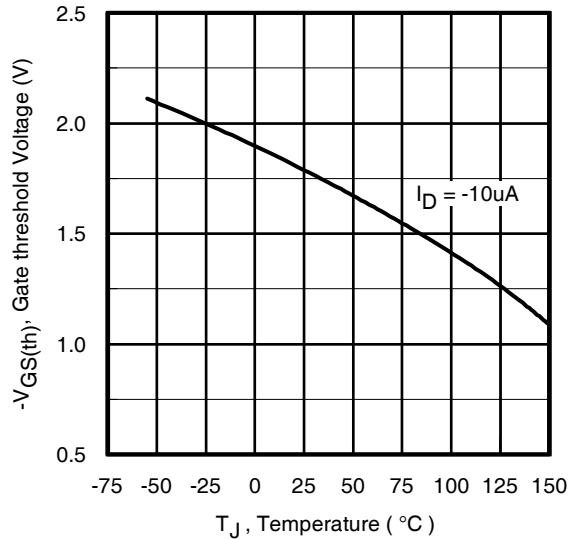
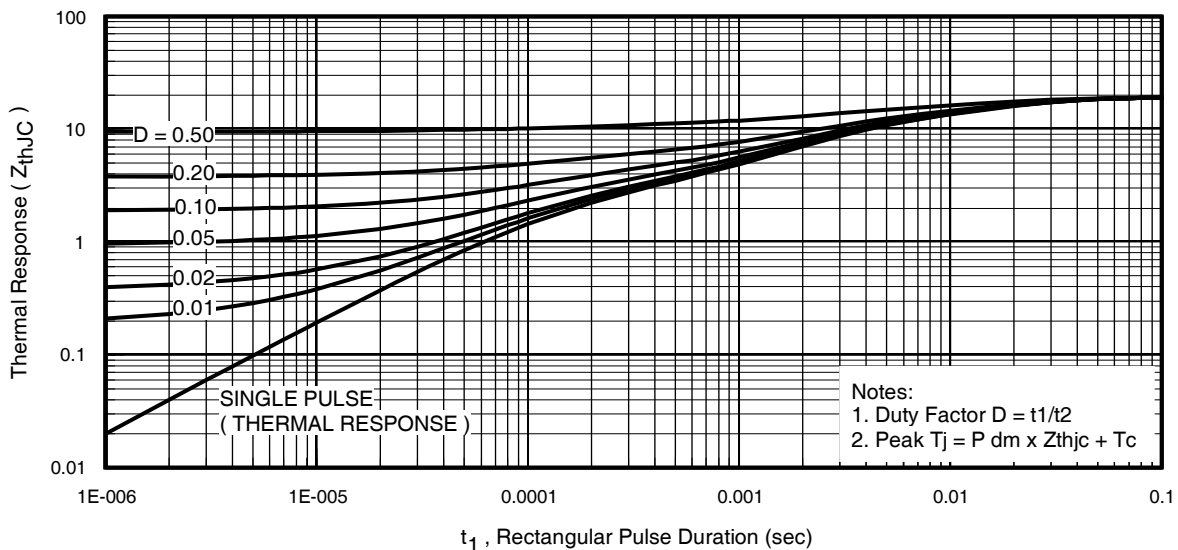
**Thermal Resistance**

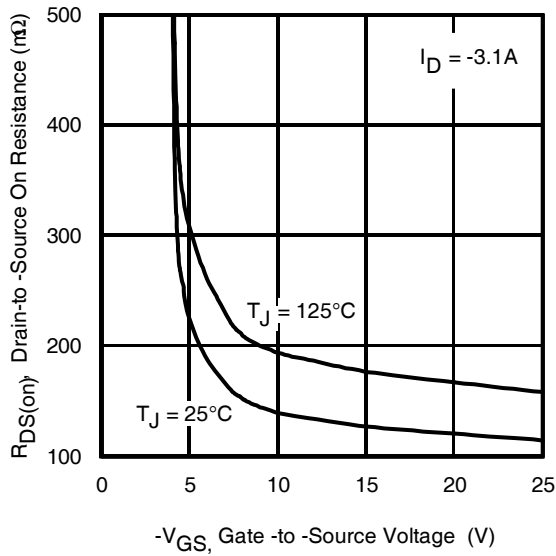
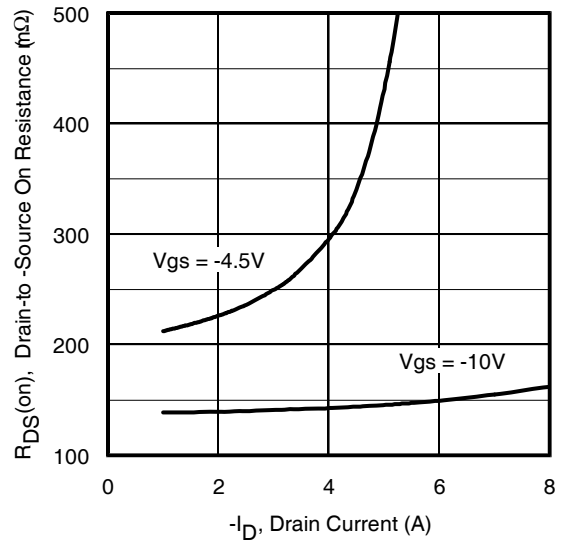
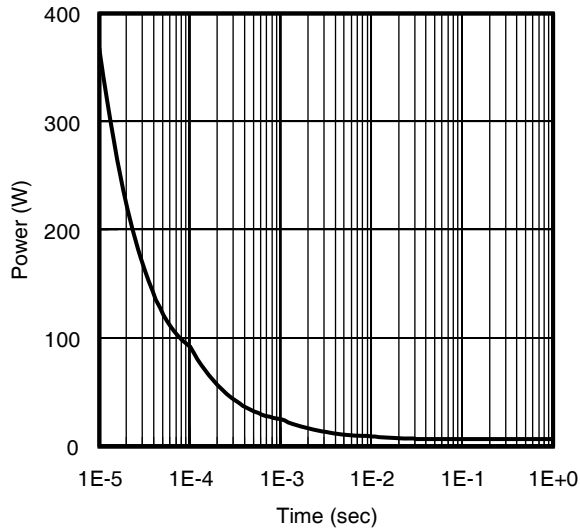
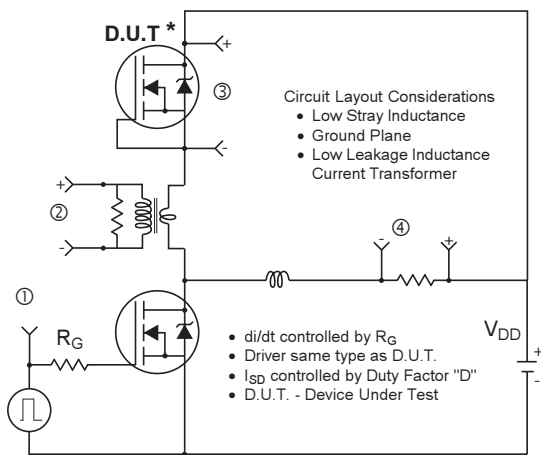
|                          | Parameter                     | Typ. | Max. | Units |
|--------------------------|-------------------------------|------|------|-------|
| R <sub>JC</sub> (Bottom) | Junction-to-Case ②            | —    | 19   | °C/W  |
| R <sub>JC</sub> (Top)    | Junction-to-Case ②            | —    | 170  |       |
| R <sub>JA</sub>          | Junction-to-Ambient ④         | —    | 90   |       |
| R <sub>JA</sub>          | Junction-to-Ambient (t<10s) ④ | —    | 75   |       |

**Notes:**

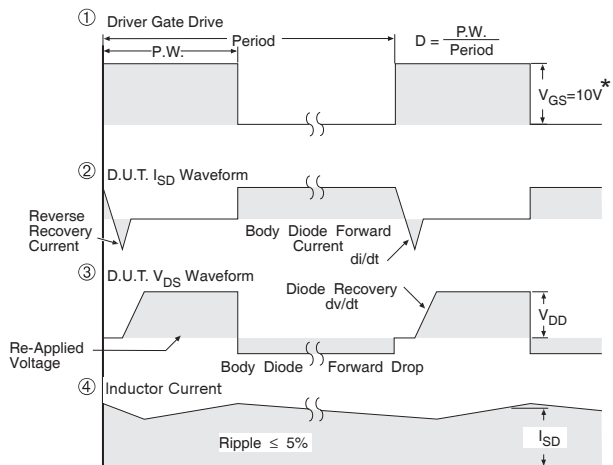
- ① Repetitive rating; pulse width limited by max. junction temperature.
- ② Current limited by package. .
- ③ Pulse width ≤ 400μs; duty cycle ≤ 2%.
- ④ When mounted on 1 inch square copper board.
- ⑤ R<sub>θ</sub> is measured at T<sub>J</sub> of approximately 90°C.
- ⑥ For DESIGN AID ONLY, not subject to production testing.


**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

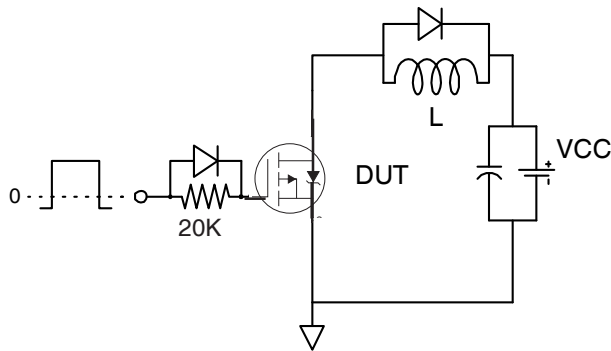
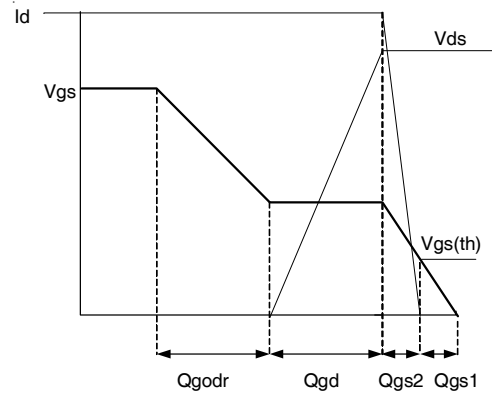
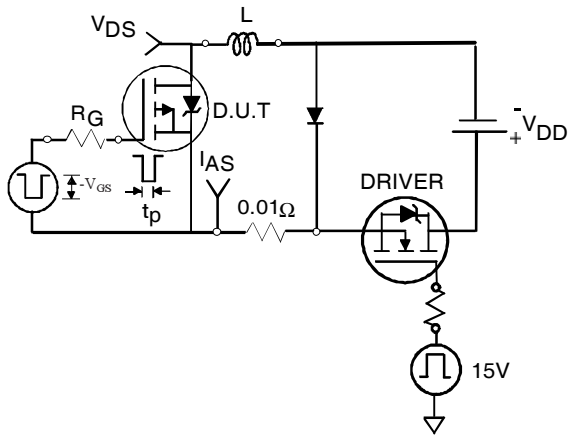

**Fig 12. On-Resistance vs. Gate Voltage**

**Fig 13. Typical On-Resistance vs. Drain Current**

**Fig 14. Typical Power vs. Time**


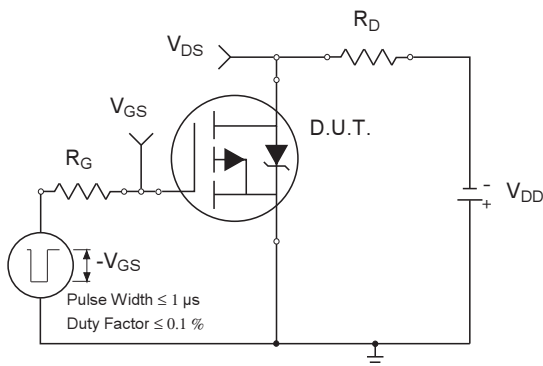
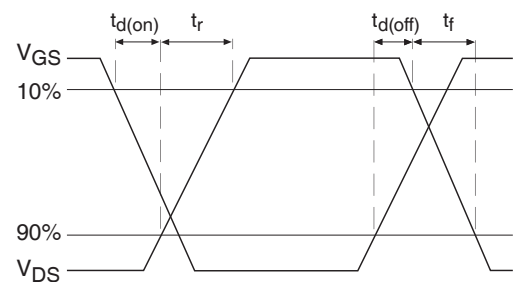
\* Reverse Polarity of D.U.T for P-Channel



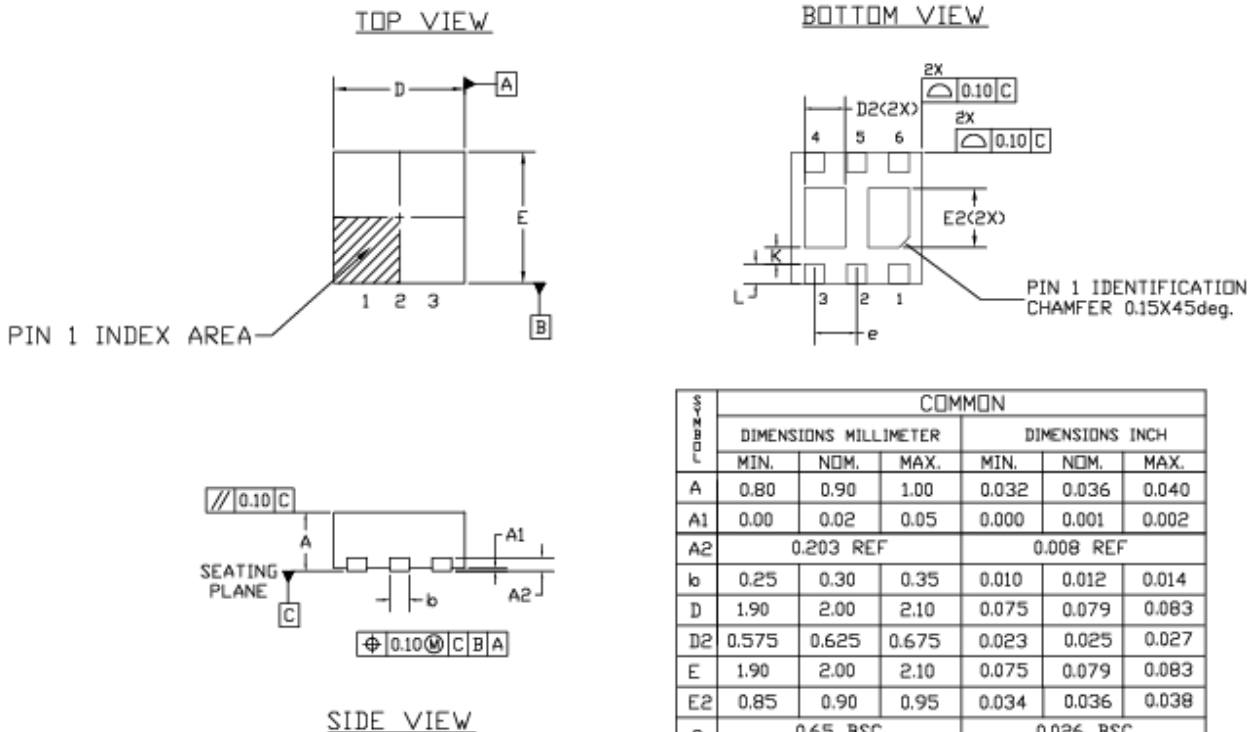
\*  $V_{GS} = 5V$  for Logic Level Devices

**Fig 15. Diode Reverse Recovery Test Circuit for P-Channel HEXFET® Power MOSFETs**


**Fig 16a. Gate Charge Test Circuit**

**Fig 16b. Gate Charge Waveform**

**Fig 17a. Unclamped Inductive Test Circuit**

**Fig 17b. Unclamped Inductive Waveforms**

**Fig 18a. Switching Time Test Circuit**

**Fig 18b. Switching Time Waveforms**

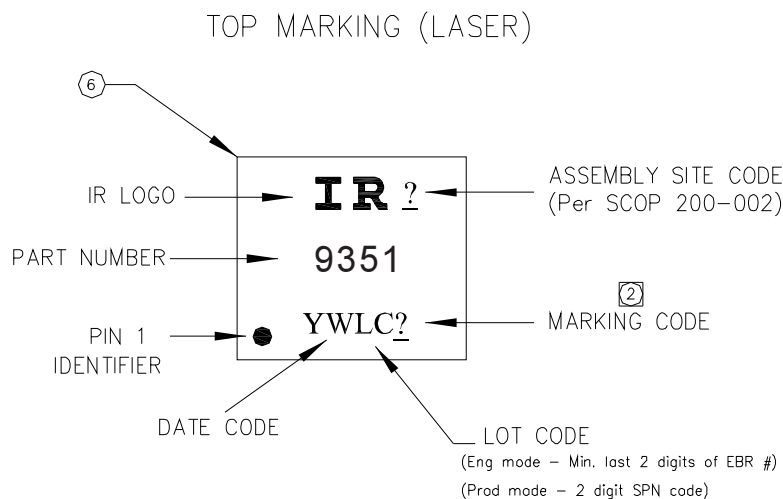
## PQFN Package Details



**NOTES :**

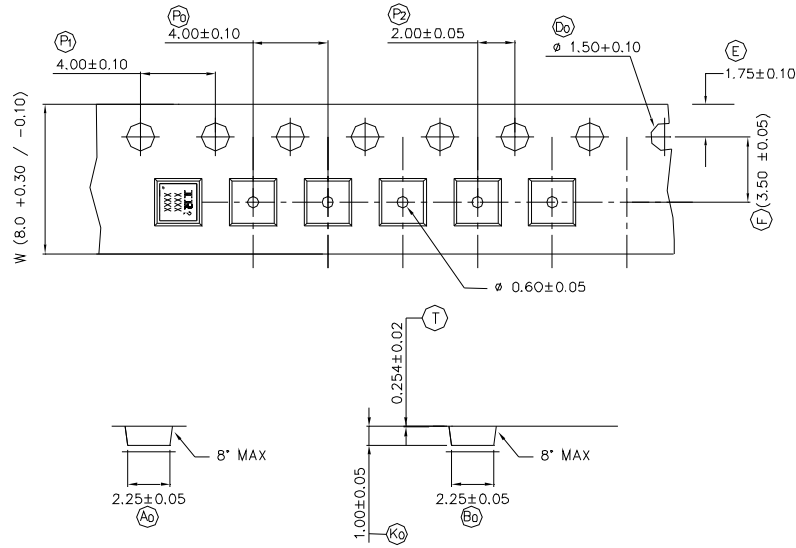
1. DIMENSION AND TOLERANCING CONFORM TO ASME Y14.5M-1994.
2. CONTROLLING DIMENSIONS : MILLIMETER. CONVERTED INCH DIMENSION ARE NOT NECESSARILY EXACT.

## PQFN Part Marking

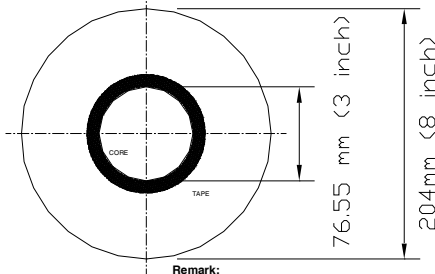
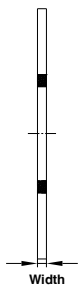


Note: For the most current drawing please refer to IR website at: <http://www.irf.com/package/>

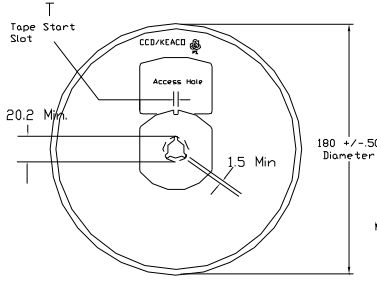
# PQFN Tape and Reel



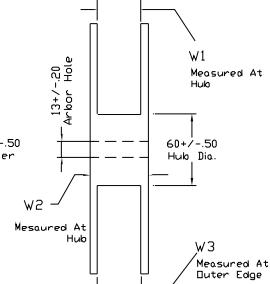
NOTE: The Surface Resistivity is  $10^4 - 10^8$  OHM/SQ



**Remark:**  
 - Dimension above are typical dimensions.  
 - Cover tape thickness is  $0.043\text{mm} \pm 0.005\text{mm}$ .  
 - Surface resistivity  $10E5 < R_s < 10E8$ .



FRONT VIEW



SIDE VIEW

| COVER TAPE (WIDTH) | TOLERANCE  |
|--------------------|------------|
| 5.4 mm             | +/- 0.1 mm |
| 9.5 mm             | +/- 0.1 mm |

| TAPE WIDTH | T        | W1                                   | W2       | W3                   | PART NO |
|------------|----------|--------------------------------------|----------|----------------------|---------|
| 8 MM       | 3 ± 0.50 | 8.4 <sup>+1.5</sup> <sub>-0.0</sub>  | 14.4 Max | 7.90 Min<br>10.9 Max | 91586-1 |
| 12 MM      | 3 ± 0.50 | 12.4 <sup>+2.0</sup> <sub>-0.0</sub> | 18.4 Max | 11.9 Min<br>15.4 Max | 91586-2 |

Note: Surface resistivity is  $\geq 1 \times 10^5$  but  $< 1 \times 10^{12}$  ohm/sq.

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



**Qualification information<sup>†</sup>**

|                            |  |  |
|----------------------------|--|--|
| Qualification level        | Industrial <sup>††</sup><br>(per JEDEC JESD47F <sup>†††</sup> guidelines ) |  |
| Moisture Sensitivity Level | PQFN 2mm x 2mm   | MSL1<br>(per IPC/JEDEC J-STD-020D <sup>†††</sup> ) |
| RoHS compliant             | Yes  |  |

† Qualification standards can be found at International Rectifier's web site

<http://www.irf.com/product-info/reliability>

†† Higher qualification ratings may be available should the user have such requirements.

Please contact your International Rectifier sales representative for further information:

<http://www.irf.com/whoto-call/salesrep/>

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

**Revision History**

| Date      | Comment  |
|-----------|--|
| 5/13/2014 | <ul style="list-style-type: none"> <li>Updated ordering information to reflect the End-Of-life (EOL) of the mini-reel option (EOL notice #259)</li> <li>Updated data sheet based on corporate template.</li> </ul> |
| 5/21/2014 | <ul style="list-style-type: none"> <li>Updated qual level from "Consumer" to "Industrial" on page 1 &amp; 9.</li> </ul>  |

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[MIC4420CM-TR](#) [VN1206L](#) [614234A](#) [715780A](#) [NTNS3166NZT5G](#) [SSM6J414TU,LF\(T](#) [751625C](#) [BUK954R8-60E](#) [GROUP A 5962-](#)  
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[NTE2967](#) [NTE2969](#) [NTE2976](#) [NTE6400A](#) [NTE2910](#) [NTE2916](#) [NTE2956](#) [NTE2911](#) [DMN2080UCB4-7](#) [TK10A80W,S4X\(S](#)  
[SSM6P54TU,LF](#) [SSM6P69NU,LF](#) [DMP22D4UFO-7B](#)