HEXFET® Power MOSFET

IRFR2905Z
IRFU2905Z

Features
- Advanced Process Technology
- Ultra Low On-Resistance
- 175°C Operating Temperature
- Fast Switching
- Repetitive Avalanche Allowed up to Tjmax

Description
Specifically designed for Automotive applications, this HEXFET® Power MOSFET utilizes the latest processing techniques to achieve extremely low on-resistance per silicon area. Additional features of this design are a 175°C junction operating temperature, fast switching speed and improved repetitive avalanche rating. These features combine to make this design an extremely efficient and reliable device for use in Automotive applications and a wide variety of other applications.

Absolute Maximum Ratings

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Max.</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>ID @ Tc = 25°C</td>
<td>59</td>
<td>A</td>
</tr>
<tr>
<td>ID @ Tc = 100°C</td>
<td>42</td>
<td>A</td>
</tr>
<tr>
<td>ID @ Tc = 25°C (Package Limited)</td>
<td>42</td>
<td>A</td>
</tr>
<tr>
<td>IDM</td>
<td>240</td>
<td></td>
</tr>
<tr>
<td>PD @ Tc = 25°C</td>
<td>110</td>
<td>W</td>
</tr>
<tr>
<td>VGS (Silicon Limited)</td>
<td>0.72</td>
<td>W/°C</td>
</tr>
<tr>
<td>VGS (Thermally limited)</td>
<td>± 20</td>
<td>V</td>
</tr>
<tr>
<td>EAS (Tested)</td>
<td>55</td>
<td>mJ</td>
</tr>
<tr>
<td>EAS (Tested)</td>
<td>82</td>
<td></td>
</tr>
<tr>
<td>IAR</td>
<td>See Fig.12a, 12b, 15, 16</td>
<td>A</td>
</tr>
<tr>
<td>EAR</td>
<td></td>
<td>mJ</td>
</tr>
<tr>
<td>TJ</td>
<td>-55 to +175</td>
<td>°C</td>
</tr>
<tr>
<td>TJSTG</td>
<td>300 (1.6mm from case)</td>
<td></td>
</tr>
<tr>
<td>Mounting Torque, 6-32 or M3 screw</td>
<td>10 lbf<em>in (1.1N</em>m)</td>
<td></td>
</tr>
</tbody>
</table>

Thermal Resistance

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Typ.</th>
<th>Max.</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>θJC</td>
<td>1.38</td>
<td>W/°C</td>
<td></td>
</tr>
<tr>
<td>θJA</td>
<td>40</td>
<td></td>
<td></td>
</tr>
<tr>
<td>θJA</td>
<td>110</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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11/24/03
## Electrical Characteristics @ T<sub>J</sub> = 25°C (unless otherwise specified)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Units</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>V&lt;sub&gt;(BR)DSS&lt;/sub&gt;</td>
<td>55</td>
<td>—</td>
<td>—</td>
<td>V</td>
<td>V&lt;sub&gt;DS&lt;/sub&gt; = 0V, I&lt;sub&gt;D&lt;/sub&gt; = 250µA</td>
</tr>
<tr>
<td>∆V&lt;sub&gt;(BR)DSS&lt;/sub&gt;/∆T&lt;sub&gt;J&lt;/sub&gt;</td>
<td>—</td>
<td>—</td>
<td>0.053</td>
<td>mV/°C</td>
<td>Reference to 25°C, I&lt;sub&gt;D&lt;/sub&gt; = 1mA</td>
</tr>
<tr>
<td>R&lt;sub&gt;DS(on)&lt;/sub&gt;</td>
<td>—</td>
<td>—</td>
<td>11.1</td>
<td>mΩ</td>
<td>V&lt;sub&gt;DS&lt;/sub&gt; = 10V, I&lt;sub&gt;D&lt;/sub&gt; = 36A (Ω)</td>
</tr>
<tr>
<td>V&lt;sub&gt;GS(th)&lt;/sub&gt;</td>
<td>—</td>
<td>—</td>
<td>2.0</td>
<td>V</td>
<td>V&lt;sub&gt;DS&lt;/sub&gt; = V&lt;sub&gt;GS&lt;/sub&gt;, I&lt;sub&gt;D&lt;/sub&gt; = 250µA</td>
</tr>
<tr>
<td>g&lt;sub&gt;f&lt;/sub&gt;</td>
<td>—</td>
<td>—</td>
<td>20</td>
<td>S</td>
<td>V&lt;sub&gt;DS&lt;/sub&gt; = 25V, I&lt;sub&gt;D&lt;/sub&gt; = 36A</td>
</tr>
<tr>
<td>I&lt;sub&gt;DS&lt;/sub&gt;</td>
<td>—</td>
<td>—</td>
<td>20</td>
<td>µA</td>
<td>V&lt;sub&gt;DS&lt;/sub&gt; = 55V, V&lt;sub&gt;GS&lt;/sub&gt; = 0V</td>
</tr>
<tr>
<td>I&lt;sub&gt;G&lt;/sub&gt;</td>
<td>—</td>
<td>—</td>
<td>200</td>
<td>nA</td>
<td>V&lt;sub&gt;DS&lt;/sub&gt; = 20V</td>
</tr>
<tr>
<td>Q&lt;sub&gt;g&lt;/sub&gt;</td>
<td>—</td>
<td>29</td>
<td>44</td>
<td>nC</td>
<td>I&lt;sub&gt;D&lt;/sub&gt; = 36A</td>
</tr>
<tr>
<td>Q&lt;sub&gt;gs&lt;/sub&gt;</td>
<td>—</td>
<td>—</td>
<td>7.7</td>
<td>nC</td>
<td>V&lt;sub&gt;DS&lt;/sub&gt; = 44V</td>
</tr>
<tr>
<td>Q&lt;sub&gt;gd&lt;/sub&gt;</td>
<td>—</td>
<td>—</td>
<td>12</td>
<td>nC</td>
<td>V&lt;sub&gt;DS&lt;/sub&gt; = 10V (Ω)</td>
</tr>
<tr>
<td>R&lt;sub&gt;G&lt;/sub&gt;</td>
<td>—</td>
<td>1.3</td>
<td>—</td>
<td>Ω</td>
<td>f = 1MHz, open drain</td>
</tr>
<tr>
<td>t&lt;sub&gt;on&lt;/sub&gt;</td>
<td>—</td>
<td>14</td>
<td>—</td>
<td>ns</td>
<td>V&lt;sub&gt;DD&lt;/sub&gt; = 28V</td>
</tr>
<tr>
<td>L&lt;sub&gt;D&lt;/sub&gt;</td>
<td>—</td>
<td>4.5</td>
<td>—</td>
<td>nH</td>
<td>Between lead, 6mm (0.25in.) from package and center of die contact</td>
</tr>
<tr>
<td>C&lt;sub&gt;iss&lt;/sub&gt;</td>
<td>—</td>
<td>1380</td>
<td>—</td>
<td>pF</td>
<td>V&lt;sub&gt;DS&lt;/sub&gt; = 0V</td>
</tr>
<tr>
<td>C&lt;sub&gt;oss&lt;/sub&gt;</td>
<td>—</td>
<td>240</td>
<td>—</td>
<td>pF</td>
<td>V&lt;sub&gt;DS&lt;/sub&gt; = 25V</td>
</tr>
<tr>
<td>C&lt;sub&gt;rss&lt;/sub&gt;</td>
<td>—</td>
<td>120</td>
<td>—</td>
<td>pF</td>
<td>f = 1.0MHz</td>
</tr>
<tr>
<td>t&lt;sub&gt;off&lt;/sub&gt;</td>
<td>—</td>
<td>31</td>
<td>—</td>
<td>ns</td>
<td>V&lt;sub&gt;DS&lt;/sub&gt; = 44V, f = 1.0MHz</td>
</tr>
<tr>
<td>Q&lt;sub&gt;rr&lt;/sub&gt;</td>
<td>—</td>
<td>820</td>
<td>—</td>
<td>nC</td>
<td>V&lt;sub&gt;DS&lt;/sub&gt; = 0V, V&lt;sub&gt;GS&lt;/sub&gt; = 0V</td>
</tr>
<tr>
<td>t&lt;sub&gt;r&lt;/sub&gt;</td>
<td>—</td>
<td>190</td>
<td>—</td>
<td>pF</td>
<td>f = 1.0MHz</td>
</tr>
<tr>
<td>C&lt;sub&gt;oss&lt;/sub&gt; eff.</td>
<td>—</td>
<td>300</td>
<td>—</td>
<td>pF</td>
<td>V&lt;sub&gt;DS&lt;/sub&gt; = 0V, V&lt;sub&gt;DS&lt;/sub&gt; = 0V to 44V (Ω)</td>
</tr>
</tbody>
</table>

### Source-Drain Ratings and Characteristics

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Units</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>I&lt;sub&gt;G&lt;/sub&gt;</td>
<td>—</td>
<td>—</td>
<td>36</td>
<td>A</td>
<td>MOSFET symbol showing the integral reverse p-n junction diode.</td>
</tr>
<tr>
<td>I&lt;sub&gt;SM&lt;/sub&gt;</td>
<td>—</td>
<td>—</td>
<td>240</td>
<td>A</td>
<td>p-n junction diode.</td>
</tr>
<tr>
<td>V&lt;sub&gt;SD&lt;/sub&gt;</td>
<td>1.3</td>
<td>—</td>
<td>—</td>
<td>V</td>
<td>V&lt;sub&gt;DS&lt;/sub&gt; = 1.0V, f = 1.0MHz</td>
</tr>
<tr>
<td>t&lt;sub&gt;r&lt;/sub&gt;</td>
<td>23</td>
<td>35</td>
<td>—</td>
<td>ns</td>
<td>T&lt;sub&gt;J&lt;/sub&gt; = 25°C, I&lt;sub&gt;D&lt;/sub&gt; = 36A</td>
</tr>
<tr>
<td>Q&lt;sub&gt;r&lt;/sub&gt;</td>
<td>—</td>
<td>16</td>
<td>24</td>
<td>nC</td>
<td>di/dt = 100A/µs (Ω)</td>
</tr>
<tr>
<td>I&lt;sub&gt;on&lt;/sub&gt;</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>A</td>
<td>Intrinsic turn-on time is negligible (turn-on is dominated by LS+LD)</td>
</tr>
</tbody>
</table>
Fig 1. Typical Output Characteristics

Fig 2. Typical Output Characteristics

Fig 3. Typical Transfer Characteristics

Fig 4. Typical Forward Transconductance Vs. Drain Current
Fig 5. Typical Capacitance Vs. Drain-to-Source Voltage

\[ V_{GS} = 0V, \quad f = 1 \text{ MHz} \]

\[ C_{iss} = C_{ds} + C_{gd} \quad C_{oss} = C_{ds} + C_{gd} \]

\[ C_{iss} = C_{gs} \quad C_{oss} = C_{gd} \]

\[ C_{rss} = C_{gd} \]

Fig 6. Typical Gate Charge Vs. Gate-to-Source Voltage

\[ V_{DS} = 44V \]

\[ V_{DS} = 28V \]

\[ V_{DS} = 11V \]

\[ I_D = 36A \]

FOR TEST CIRCUIT SEE FIGURE 13

Fig 7. Typical Source-Drain Diode Forward Voltage

\[ V_{GS} = 0V \]

\[ T_J = 25^\circ C \]

\[ T_J = 175^\circ C \]

\[ I_{SD} \quad \text{Reverse Drain Current (A)} \]

\[ V_{SD} \quad \text{Source-to-Drain Voltage (V)} \]

\[ 0.2 \quad 0.6 \quad 1.0 \quad 1.4 \quad 1.8 \quad 2.2 \]

\[ 0.1 \quad 1 \quad 10 \quad 100 \quad 1000 \]

Fig 8. Maximum Safe Operating Area

\[ V_{DS} \quad \text{Drain-to-Source Voltage (V)} \]

\[ 1 \quad 10 \quad 100 \quad 1000 \]

\[ 0.1 \quad 1 \quad 10 \quad 100 \quad 1000 \]

OPERATION IN THIS AREA LIMITED BY \( R_{DS(on)} \)

\[ T_c = 25^\circ C \]

\[ T_j = 175^\circ C \]

Single Pulse

\[ 100\mu s \quad 1m s \quad 100m s \]
**Fig 9.** Maximum Drain Current Vs. Case Temperature

**Fig 10.** Normalized On-Resistance Vs. Temperature

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

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**Notes:**
1. Duty Factor \( D = \frac{t_1}{t_2} \)
2. Peak \( T_J = P_{dm} \times Z_{thJC} + T_c \)
Fig 12a. Unclamped Inductive Test Circuit

Fig 12b. Unclamped Inductive Waveforms

Fig 12c. Maximum Avalanche Energy Vs. Drain Current

Fig 13a. Basic Gate Charge Waveform

Fig 13b. Gate Charge Test Circuit

Fig 14. Threshold Voltage Vs. Temperature

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Notes on Repetitive Avalanche Curves, Figures 15, 16:
(For further info, see AN-1005 at www.irf.com)

1. Avalanche failures assumption:
   - Purely a thermal phenomenon and failure occurs at a temperature far in excess of $T_{j\text{max}}$. This is validated for every part type.
2. Safe operation in Avalanche is allowed as long as $T_{j\text{max}}$ is not exceeded.
3. Equation below based on circuit and waveforms shown in Figures 12a, 12b.
4. $P_{D\text{(ave)}} = \text{Average power dissipation per single avalanche pulse.}$
5. $BV = \text{Rated breakdown voltage (1.3 factor accounts for voltage increase during avalanche).}$
6. $I_{av} = \text{Allowable avalanche current.}$
7. $\Delta T = \text{Allowable rise in junction temperature, not to exceed}$ $T_{j\text{max}}$ (assumed as 25°C in Figure 15, 16).
8. $t_{av} = \text{Average time in avalanche.}$
9. $D = \text{Duty cycle in avalanche = } t_{av} \cdot f$
10. $Z_{thJC}(D, t_{av}) = \text{Transient thermal resistance, see figure 11)}$

$$P_{D\text{(ave)}} = \frac{1}{2} \left( 1.3 \cdot BV \cdot I_{av} \right) = \frac{\Delta T}{Z_{thJC}}$$

$$I_{av} = 2 \cdot \frac{\Delta T}{[1.3 \cdot BV \cdot Z_{th}]}$$

$$E_{AS\left(AR\right)} = P_{D\text{(ave)}} t_{av}$$
Fig 17. Peak Diode Recovery dv/dt Test Circuit for N-Channel HEXFET® Power MOSFETs

- Circuit Layout Considerations
  - Low Stray Inductance
  - Ground Plane
  - Low Leakage Inductance Current Transformer
- dv/dt controlled by R0
- Driver same type as D.U.T.
- IDQ controlled by Duty Factor “D”
- D.U.T. - Device Under Test

*VGS = 5V for Logic Level Devices

Fig 18a. Switching Time Test Circuit

Fig 18b. Switching Time Waveforms
D-Pak (TO-252AA) Package Outline

Dimensions are shown in millimeters (inches)

D-Pak (TO-252AA) Part Marking Information

Notes: This part marking information applies to devices produced before 02/26/2001

EXAMPLE: THIS IS AN IRFR120 WITH ASSEMBLY LOT CODE 9U1P

INTERNATIONAL RECTIFIER LOGO

ASSEMBLY LOT CODE

DATE CODE

YEAR = 0
WEEK = 16

Notes: This part marking information applies to devices produced after 02/26/2001

EXAMPLE: THIS IS AN IRFR120 WITH ASSEMBLY LOT CODE 1234 ASSEMBLED ON WW 16, 1999 IN THE ASSEMBLY LINE "A"

INTERNATIONAL RECTIFIER LOGO

ASSEMBLY LOT CODE

PART NUMBER

DATE CODE

YEAR 9 = 1999
WEEK 16
LINE A

www.irf.com
IRFR/U2905Z

I-Pak (TO-251AA) Package Outline

Dimensions are shown in millimeters (inches)

LEAD ASSIGNMENTS
1 - GATE
2 - DRAIN
3 - SOURCE
4 - DRAIN

NOTES:
1 DIMENSIONING & TOLERANCING PER ANSI Y14.5M, 1982.
2 CONTROLLING DIMENSION : INCH.
3 CONFORMS TO JEDEC OUTLINE TO-252AA.
4 DIMENSIONS SHOWN ARE BEFORE SOLDER DIP.
   SOLDER DIP MAX. +0.16 (.006).

I-Pak (TO-251AA) Part Marking Information

Notes: This part marking information applies to devices produced before 02/26/2001

EXAMPLE: THIS IS AN IRFR120 WITH ASSEMBLY LOT CODE 9U1P

INTERNATIONAL RECIFIER LOGO
DATE CODE
YEAR = 0
WEEK = 16

ASSEMBLY LOT CODE

Notes: This part marking information applies to devices produced after 02/26/2001

EXAMPLE: THIS IS AN IRFR120 WITH ASSEMBLY LOT CODE 5678
ASSEMBLED ON WW 19, 1999 IN THE ASSEMBLY LINE "A"

INTERNATIONAL RECIFIER LOGO

PART NUMBER
DATE CODE
YEAR 9 = 1999
WEEK 19
LINE A

ASSEMBLY LOT CODE

www.irf.com
D-Pak (TO-252AA) Tape & Reel Information

Dimensions are shown in millimeters (inches)

NOTES:
1. CONTROLLING DIMENSION: MILLIMETER.
2. ALL DIMENSIONS ARE SHOWN IN MILLIMETERS (INCHES).
3. OUTLINE CONFORMS TO EIA-481 & EIA-541.

Notes:
1. Repetitive rating; pulse width limited by max. junction temperature. (See fig. 11).
2. Limited by $T_{\text{J,max}}$, starting $T_J = 25^\circ C$, $L = 0.08\text{mH}$
   $R_D = 25\Omega$, $I_{\text{AS}} = 36\text{A}$, $V_{\text{GS}} = 10\text{V}$. Part not recommended for use above this value.
3. Pulse width $\leq 1.0\text{ms}$; duty cycle $\leq 2\%$.
4. $C_{oss}$ eff. is a fixed capacitance that gives the same charging time as $C_{oss}$ while $V_{DS}$ is rising from 0 to 80\% $V_{DSS}$.
5. Limited by $T_{\text{J,max}}$, see Fig.12a, 12b, 15, 16 for typical repetitive avalanche performance.
6. This value determined from sample failure population. 100\% tested to this value in production.
7. When mounted on 1\" square PCB (FR-4 or G-10 Material).
   For recommended footprint and soldering techniques refer to application note #AN-994.
8. $R_{ij}$ is measured at $T_J$ approximately 90\°C

Data and specifications subject to change without notice.

This product has been designed and qualified for the Automotive [Q101] market.
Qualification Standards can be found on IR’s Web site.

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Visit us at www.irf.com for sales contact information. 11/03
Note: For the most current drawings please refer to the IR website at:
http://www.irf.com/package/