Power MOSFET

FEATURES
- Dynamic dV/dt rating
- Repetitive avalanche rated
- 175 °C operating temperature
- Fast switching
- Ease of paralleling
- Simple drive requirements
- Material categorization: for definitions of compliance please see www.vishay.com/doc?99912

Note
* This datasheet provides information about parts that are RoHS-compliant and / or parts that are non RoHS-compliant. For example, parts with lead (Pb) terminations are not RoHS-compliant. Please see the information / tables in this datasheet for details

DESCRIPTION
Third generation power MOSFETs from Vishay provide the designer with the best combination of fast switching, ruggedized device design, low on-resistance and cost-effectiveness.

The TO-220AB package is universally preferred for all commercial-industrial applications at power dissipation levels to approximately 50 W. The low thermal resistance and low package cost of the TO-220AB contribute to its wide acceptance throughout the industry.

PRODUCT SUMMARY

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Limit</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drain-source voltage</td>
<td>V_DS</td>
<td>100</td>
<td>V</td>
</tr>
<tr>
<td>Gate-source voltage</td>
<td>V_GS</td>
<td>± 20</td>
<td></td>
</tr>
<tr>
<td>Continuous drain current</td>
<td>I_D</td>
<td>5.6</td>
<td>A</td>
</tr>
<tr>
<td>Pulsed drain current</td>
<td>I_Dm</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Linear derating factor</td>
<td></td>
<td>0.29</td>
<td>W/°C</td>
</tr>
<tr>
<td>Single pulse avalanche energy</td>
<td>E_AS</td>
<td>75</td>
<td>mJ</td>
</tr>
<tr>
<td>Repetitive avalanche current</td>
<td>I_AR</td>
<td>5.6</td>
<td>A</td>
</tr>
<tr>
<td>Repetitive avalanche energy</td>
<td>E_AR</td>
<td>4.3</td>
<td>mJ</td>
</tr>
<tr>
<td>Maximum power dissipation</td>
<td>P_D</td>
<td>43</td>
<td>W</td>
</tr>
<tr>
<td>Peak diode recovery dV/dt</td>
<td></td>
<td>5.5</td>
<td>V/ns</td>
</tr>
<tr>
<td>Operating junction and storage temperature range</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soldering recommendations (peak temperature)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mounting torque</td>
<td></td>
<td>10</td>
<td>lbf · in</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.1</td>
<td>N · m</td>
</tr>
</tbody>
</table>

Notes
a. Repetitive rating; pulse width limited by maximum junction temperature (see fig. 11)
b. V_DD = 25 V, starting T_J = 25 °C, L = 4.8 mH, R_g = 25 Ω, I_DS = 5.6 A (see fig. 12)
c. I_DS ≤ 5.6 A, dI/dt ≤ 75 A/µs, V_DD ≤ V_DS, T_J ≤ 175 °C

ORDERING INFORMATION

<table>
<thead>
<tr>
<th>Package Options</th>
<th>Package Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>TO-220AB</td>
<td>TO-220AB</td>
</tr>
<tr>
<td>Lead (Pb)-free</td>
<td>IRF510PbF</td>
</tr>
<tr>
<td>Lead (Pb)-free and halogen-free</td>
<td>IRF510PbF-BE3</td>
</tr>
</tbody>
</table>

ABSOLUTE MAXIMUM RATINGS (T_C = 25 °C, unless otherwise noted)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Limit</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drain-source voltage</td>
<td>V_DS</td>
<td>100</td>
<td>V</td>
</tr>
<tr>
<td>Gate-source voltage</td>
<td>V_GS</td>
<td>± 20</td>
<td></td>
</tr>
<tr>
<td>Continuous drain current at 10 V</td>
<td>I_D</td>
<td>5.6</td>
<td>A</td>
</tr>
<tr>
<td>Continuous drain current at 100 °C</td>
<td>I_Dm</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Linear derating factor</td>
<td></td>
<td>0.29</td>
<td>W/°C</td>
</tr>
<tr>
<td>Repetitive avalanche energy</td>
<td>E_AS</td>
<td>75</td>
<td>mJ</td>
</tr>
<tr>
<td>Repetitive avalanche energy</td>
<td>E_AR</td>
<td>4.3</td>
<td>mJ</td>
</tr>
<tr>
<td>Maximum power dissipation</td>
<td>P_D</td>
<td>43</td>
<td>W</td>
</tr>
<tr>
<td>Peak diode recovery dV/dt</td>
<td></td>
<td>5.5</td>
<td>V/ns</td>
</tr>
<tr>
<td>Operating junction and storage temperature range</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soldering recommendations (peak temperature)</td>
<td>For 10 s</td>
<td>300</td>
<td></td>
</tr>
<tr>
<td>Mounting torque</td>
<td></td>
<td>10</td>
<td>lbf · in</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.1</td>
<td>N · m</td>
</tr>
</tbody>
</table>
THERMAL RESISTANCE RATINGS

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>SYMBOL</th>
<th>TYP.</th>
<th>MAX.</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum junction-to-ambient</td>
<td>$R_{thJA}$</td>
<td>-</td>
<td>62</td>
<td>°C/W</td>
</tr>
<tr>
<td>Case-to-sink, flat, greased surface</td>
<td>$R_{thCS}$</td>
<td>0.50</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Maximum junction-to-case (drain)</td>
<td>$R_{thJC}$</td>
<td>-</td>
<td>3.5</td>
<td></td>
</tr>
</tbody>
</table>

SPECIFICATIONS ($T_J = 25$ °C, unless otherwise noted)

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>SYMBOL</th>
<th>TEST CONDITIONS</th>
<th>MIN.</th>
<th>TYP.</th>
<th>MAX.</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Static</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drain-source breakdown voltage</td>
<td>$V_{DS}$</td>
<td>$V_{GS} = 0$ V, $I_D = 250$ μA</td>
<td>100</td>
<td>-</td>
<td>-</td>
<td>V</td>
</tr>
<tr>
<td>$V_{DS}$ temperature coefficient</td>
<td>$\Delta V_{DS}/T_J$</td>
<td>Reference to $25$ °C, $I_D = 1$ mA</td>
<td>-</td>
<td>0.12</td>
<td>-</td>
<td>V/°C</td>
</tr>
<tr>
<td>Gate-source threshold voltage</td>
<td>$V_{GS(th)}$</td>
<td>$V_{DS} = V_{GS}, I_D = 250$ μA</td>
<td>2.0</td>
<td>-</td>
<td>4.0</td>
<td>V</td>
</tr>
<tr>
<td>Gate-source leakage</td>
<td>$I_{GSS}$</td>
<td>$V_{GS} = \pm 20$ V</td>
<td>-</td>
<td>-</td>
<td>$\pm 100$</td>
<td>nA</td>
</tr>
<tr>
<td>Zero gate voltage drain current</td>
<td>$I_{DS}$</td>
<td>$V_{DS} = 100$ V, $V_{GS} = 0$ V</td>
<td>-</td>
<td>-</td>
<td>25</td>
<td>μA</td>
</tr>
<tr>
<td>Drain-source on-state resistance</td>
<td>$R_{DS(on)}$</td>
<td>$V_{GS} = 10$ V, $I_D = 3.4$ A</td>
<td>-</td>
<td>-</td>
<td>0.54</td>
<td>Ω</td>
</tr>
<tr>
<td>Forward transconductance</td>
<td>$g_{fs}$</td>
<td>$V_{DS} = 50$ V, $I_D = 3.4$ A</td>
<td>1.3</td>
<td>-</td>
<td>-</td>
<td>S</td>
</tr>
<tr>
<td>Dynamic</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input capacitance</td>
<td>$C_{iss}$</td>
<td>$V_{GS} = 0$ V, $f = 1.0$ MHz, see fig. 5</td>
<td>-</td>
<td>180</td>
<td>-</td>
<td>pF</td>
</tr>
<tr>
<td>Output capacitance</td>
<td>$C_{oss}$</td>
<td>$V_{DS} = 25$ V, $f = 1.0$ MHz, see fig. 5</td>
<td>-</td>
<td>81</td>
<td>-</td>
<td>pF</td>
</tr>
<tr>
<td>Reverse transfer capacitance</td>
<td>$C_{oss}$</td>
<td>$V_{GS} = 10$ V</td>
<td>-</td>
<td>15</td>
<td>-</td>
<td>nC</td>
</tr>
<tr>
<td>Total gate charge</td>
<td>$Q_g$</td>
<td>$I_D = 5.6$ A, $V_{DS} = 80$ V</td>
<td>-</td>
<td>-</td>
<td>8.3</td>
<td></td>
</tr>
<tr>
<td>Gate-source charge</td>
<td>$Q_{gs}$</td>
<td>$V_{DS} = 10$ V, see fig. 6 and fig. 13 b</td>
<td>-</td>
<td>-</td>
<td>2.3</td>
<td></td>
</tr>
<tr>
<td>Gate-Drain charge</td>
<td>$Q_{gd}$</td>
<td>$V_{GS} = 10$ V</td>
<td>-</td>
<td>-</td>
<td>3.8</td>
<td></td>
</tr>
<tr>
<td>Turn-on delay time</td>
<td>$t_{d(on)}$</td>
<td>$V_{DS} = 50$ V, $I_D = 5.6$ A</td>
<td>-</td>
<td>6.9</td>
<td>-</td>
<td>ns</td>
</tr>
<tr>
<td>Rise time</td>
<td>$t_r$</td>
<td>$R_D = 24$ Ω, $R_O = 8.4$ Ω, see fig. 10 b</td>
<td>-</td>
<td>16</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Turn-off delay time</td>
<td>$t_{d(off)}$</td>
<td>$V_{GS} = 0$ V</td>
<td>-</td>
<td>15</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Fall time</td>
<td>$t_f$</td>
<td>$f = 1$ MHz, open drain</td>
<td>-</td>
<td>9.4</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Gate input resistance</td>
<td>$R_g$</td>
<td>$f = 1$ MHz, open drain</td>
<td>2.5</td>
<td>-</td>
<td>11.6</td>
<td>Ω</td>
</tr>
<tr>
<td>Internal drain inductance</td>
<td>$L_D$</td>
<td>Between lead, 6 mm (0.25&quot;) from package and center of die contact</td>
<td>-</td>
<td>4.5</td>
<td>-</td>
<td>nH</td>
</tr>
<tr>
<td>Internal source inductance</td>
<td>$L_S$</td>
<td>-</td>
<td>7.5</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drain-Source Body Diode Characteristics</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Continuous source-drain diode current</td>
<td>$I_S$</td>
<td>MOSFET symbol showing the integral reverse p - n junction diode</td>
<td>-</td>
<td>-</td>
<td>5.6</td>
<td>A</td>
</tr>
<tr>
<td>Pulsed diode forward current</td>
<td>$I_{SM}$</td>
<td>-</td>
<td>-</td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Body diode voltage</td>
<td>$V_{SD}$</td>
<td>$T_J = 25$ °C, $I_S = 5.6$ A, $V_{GS} = 0$ V b</td>
<td>-</td>
<td>-</td>
<td>2.5</td>
<td>V</td>
</tr>
<tr>
<td>Body diode reverse recovery time</td>
<td>$t_r$</td>
<td>$T_J = 25$ °C, $I_F = 5.6$ A, $dI/dt = 100$ A/μs b</td>
<td>-</td>
<td>100</td>
<td>200</td>
<td>ns</td>
</tr>
<tr>
<td>Body diode reverse recovery charge</td>
<td>$Q_r$</td>
<td>$0.44$</td>
<td>0.88</td>
<td>μC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forward turn-on time</td>
<td>$t_{on}$</td>
<td>Intrinsic turn-on time is negligible (turn-on is dominated by $L_S$ and $L_D$)</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes
a. Repetitive rating; pulse width limited by maximum junction temperature (see fig. 11)
b. Pulse width ≤ 300 μs; duty cycle ≤ 2 %
TYPICAL CHARACTERISTICS (25 °C, unless otherwise noted)

Fig. 1 - Typical Output Characteristics, T_C = 25 °C

Fig. 2 - Typical Output Characteristics, T_C = 175 °C

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. 10a - Switching Time Test Circuit

Fig. 10b - Switching Time Waveforms

Fig. 11 - Maximum Effective Transient Thermal Impedance, Junction-to-Case
**Fig. 12a - Unclamped Inductive Test Circuit**

Vary $t_p$ to obtain required $I_{AS}$.

**Fig. 12b - Unclamped Inductive Waveforms**

**Fig. 12c - Maximum Avalanche Energy vs. Drain Current**

![Graph of $E_A$ vs. $I_D$ and Starting $T_J$, Junction Temperature (°C)]

**Fig. 13a - Basic Gate Charge Waveform**

**Fig. 13b - Gate Charge Test Circuit**

Current regulator
Same type as D.U.T.

Current sampling resistors
Fig. 14 - For N-Channel

Peak Diode Recovery dV/dt Test Circuit

Circuit layout considerations
- Low stray inductance
- Ground plane
- Low leakage inductance current transformer

- dV/dt controlled by \( R_g \)
- Driver same type as D.U.T.
- \( I_{SD} \) controlled by duty factor “D”
- D.U.T. - device under test

Note
a. \( V_{GS} = 5 \text{ V} \) for logic level devices

Driver gate drive
Driver gate drive
D.U.T. \( I_{SD} \) waveform
Reverse recovery current
D.U.T. \( V_{DS} \) waveform
Re-applied voltage
Inductor current
Body diode forward drop
Ripple \( \leq 5 \% \)

\( \text{D} = \frac{\text{P.W.}}{\text{Period}} \)

\( V_{DD} \)

\( \text{VDD} \)

\( \frac{\text{d}V}{\text{d}t} \text{ controlled by } R_g \)
\( \frac{\text{d}V}{\text{d}t} \text{ same type as D.U.T.} \)
\( \frac{\text{d}I}{\text{d}t} \text{ controlled by duty factor “D”} \)
\( \text{D.U.T.} - \text{device under test} \)

\( V_{GS} = 10 \text{ V} \)

\( V_{DD} \)
Disclaimer

ALL PRODUCT, PRODUCT SPECIFICATIONS AND DATA ARE SUBJECT TO CHANGE WITHOUT NOTICE TO IMPROVE RELIABILITY, FUNCTION OR DESIGN OR OTHERWISE.

Vishay Intertechnology, Inc., its affiliates, agents, and employees, and all persons acting on its or their behalf (collectively, “Vishay”), disclaim any and all liability for any errors, inaccuracies or incompleteness contained in any datasheet or in any other disclosure relating to any product.

Vishay makes no warranty, representation or guarantee regarding the suitability of the products for any particular purpose or the continuing production of any product. To the maximum extent permitted by applicable law, Vishay disclaims (i) any and all liability arising out of the application or use of any product, (ii) any and all liability, including without limitation special, consequential or incidental damages, and (iii) any and all implied warranties, including warranties of fitness for particular purpose, non-infringement and merchantability.

Statements regarding the suitability of products for certain types of applications are based on Vishay’s knowledge of typical requirements that are often placed on Vishay products in generic applications. Such statements are not binding statements about the suitability of products for a particular application. It is the customer’s responsibility to validate that a particular product with the properties described in the product specification is suitable for use in a particular application. Parameters provided in datasheets and / or specifications may vary in different applications and performance may vary over time. All operating parameters, including typical parameters, must be validated for each customer application by the customer’s technical experts. Product specifications do not expand or otherwise modify Vishay’s terms and conditions of purchase, including but not limited to the warranty expressed therein.

Hyperlinks included in this datasheet may direct users to third-party websites. These links are provided as a convenience and for informational purposes only. Inclusion of these hyperlinks does not constitute an endorsement or an approval by Vishay of any of the products, services or opinions of the corporation, organization or individual associated with the third-party website. Vishay disclaims any and all liability and bears no responsibility for the accuracy, legality or content of the third-party website or for that of subsequent links.

Except as expressly indicated in writing, Vishay products are not designed for use in medical, life-saving, or life-sustaining applications or for any other application in which the failure of the Vishay product could result in personal injury or death. Customers using or selling Vishay products not expressly indicated for use in such applications do so at their own risk. Please contact authorized Vishay personnel to obtain written terms and conditions regarding products designed for such applications.

No license, express or implied, by estoppel or otherwise, to any intellectual property rights is granted by this document or by any conduct of Vishay. Product names and markings noted herein may be trademarks of their respective owners.