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Power MOSFET

**FEATURES**
- Dynamic dv/dt Rating
- Repetitive Avalanche Rated
- Fast Switching
- Ease of Paralleling
- Simple Drive Requirements
- Compliant to RoHS Directive 2002/95/EC

**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>200 V</td>
<td>V</td>
</tr>
<tr>
<td>Gate-Source Voltage</td>
<td>V_{GS}</td>
<td>± 20 V</td>
<td>V</td>
</tr>
<tr>
<td>Continuous Drain Current</td>
<td>V_{GS} at 10 V</td>
<td>I_D</td>
<td>5.2</td>
</tr>
<tr>
<td></td>
<td>T_C = 25 °C</td>
<td>3.3</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>T_C = 100 °C</td>
<td>18</td>
<td>A</td>
</tr>
<tr>
<td>Pulsed Drain Current^a</td>
<td>I_{DM}</td>
<td>18</td>
<td>A</td>
</tr>
<tr>
<td>Linear Derating Factor</td>
<td></td>
<td>0.40</td>
<td>W/°C</td>
</tr>
<tr>
<td>Single Pulse Avalanche Energy^b</td>
<td>E_{AS}</td>
<td>110</td>
<td>mJ</td>
</tr>
<tr>
<td>Repetitive Avalanche Current^a</td>
<td>I_{AR}</td>
<td>5.2</td>
<td>A</td>
</tr>
<tr>
<td>Repetitive Avalanche Energy^a</td>
<td>E_{AR}</td>
<td>5.0</td>
<td>mJ</td>
</tr>
<tr>
<td>Maximum Power Dissipation</td>
<td>T_C = 25 °C</td>
<td>P_D</td>
<td>50</td>
</tr>
<tr>
<td>Peak Diode Recovery dV/dt^c</td>
<td></td>
<td>5.0</td>
<td>V/ns</td>
</tr>
<tr>
<td>Operating Junction and Storage Temperature Range</td>
<td>T_J, T_{stg}</td>
<td>- 55 to + 150</td>
<td>°C</td>
</tr>
<tr>
<td>Soldering Recommendations (Peak Temperature) for 10 s</td>
<td></td>
<td>300^2</td>
<td>°C</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} = 50 V, starting T_J = 25 °C, L = 6.1 mH, R_S = 25 Ω, I_{AS} = 5.2 A (see fig. 12).

c. I_{DD} ≤ 5.2 A, dI/dt ≤ 95 A/µs, V_{OD} ≤ V_{DS}. T_J ≤ 150 °C.

d. 1.6 mm from case.

* Pb containing terminations are not RoHS compliant, exemptions may apply

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**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>2.5</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>200</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>0.29</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_{GS}</td>
<td>V_GS = ± 20 V</td>
<td>-</td>
<td>-</td>
<td>± 100</td>
<td>nA</td>
</tr>
<tr>
<td>Zero Gate Voltage Drain Current</td>
<td>I_{DSS}</td>
<td>V_{DS} = 200 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</td>
<td>I_D = 3.1 A</td>
<td>-</td>
<td>-</td>
<td>0.80</td>
</tr>
<tr>
<td>Forward Transconductance</td>
<td>g_m</td>
<td>V_{DS} = 50 V, I_D = 3.1 A</td>
<td>1.5</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>260</td>
<td>-</td>
<td>pF</td>
</tr>
<tr>
<td>Output Capacitance</td>
<td>C_{oss}</td>
<td>V_{DS} = 25 V</td>
<td>-</td>
<td>100</td>
<td>-</td>
<td>pF</td>
</tr>
<tr>
<td>Reverse Transfer Capacitance</td>
<td>C_{rss}</td>
<td>V_GS = 10 V</td>
<td>I_D = 4.8 A, V_{DS} = 160 V, see fig. 6 and 13a</td>
<td>-</td>
<td>30</td>
<td>-</td>
</tr>
<tr>
<td>Total Gate Charge</td>
<td>Q_g</td>
<td>V_GS = 10 V</td>
<td>I_D = 4.8 A, V_{DS} = 160 V, see fig. 6 and 13a</td>
<td>-</td>
<td>-</td>
<td>14</td>
</tr>
<tr>
<td>Gate-Source Charge</td>
<td>Q_{gs}</td>
<td>-</td>
<td>-</td>
<td>3.0</td>
<td>-</td>
<td>nC</td>
</tr>
<tr>
<td>Gate-Drain Charge</td>
<td>Q_{gd}</td>
<td>-</td>
<td>-</td>
<td>7.9</td>
<td>-</td>
<td>nC</td>
</tr>
<tr>
<td>Turn-On Delay Time</td>
<td>t_{on}</td>
<td>V_{DD} = 100 V, I_D = 4.8 A, R_g = 18 Ω, R_D = 20 Ω, see fig. 10b</td>
<td>-</td>
<td>7.2</td>
<td>-</td>
<td>ns</td>
</tr>
<tr>
<td>Rise Time</td>
<td>t_r</td>
<td>-</td>
<td>-</td>
<td>22</td>
<td>-</td>
<td>ns</td>
</tr>
<tr>
<td>Turn-Off Delay Time</td>
<td>t_{off}</td>
<td>-</td>
<td>-</td>
<td>19</td>
<td>-</td>
<td>ns</td>
</tr>
<tr>
<td>Fall Time</td>
<td>t_f</td>
<td>-</td>
<td>-</td>
<td>13</td>
<td>-</td>
<td>ns</td>
</tr>
<tr>
<td>Internal Drain Inductance</td>
<td>L_D</td>
<td>Between lead, 6 mm (0.25”) 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>nH</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>5.2</td>
<td>A</td>
</tr>
<tr>
<td>Pulsed Diode Forward Currenta</td>
<td>I_{SM}</td>
<td>-</td>
<td>-</td>
<td>18</td>
<td>-</td>
<td>A</td>
</tr>
<tr>
<td>Body Diode Voltage</td>
<td>V_{SD}</td>
<td>T_J = 25 °C, I_F = 5.2 A, V_{GS} = 0 V</td>
<td>-</td>
<td>-</td>
<td>1.8</td>
<td>V</td>
</tr>
<tr>
<td>Body Diode Reverse Recovery Time</td>
<td>t_r</td>
<td>T_J = 25 °C, I_F = 4.8 A, dI/dt = 100 A/μs</td>
<td>-</td>
<td>150</td>
<td>300</td>
<td>ns</td>
</tr>
<tr>
<td>Body Diode Reverse Recovery Charge</td>
<td>Q_r</td>
<td>-</td>
<td>0.91</td>
<td>1.8</td>
<td>μC</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_G 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, TC = 25 °C](image1)

![Fig. 2 - Typical Output Characteristics, TC = 150 °C](image2)

![Fig. 3 - Typical Transfer Characteristics](image3)

![Fig. 4 - Normalized On-Resistance vs. Temperature](image4)
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**Fig. 5 - Typical Capacitance vs. Drain-to-Source Voltage**

![Capacitance vs. Drain-to-Source Voltage](image1)

- $V_{GS} = 0 \text{ V, } f = 1 \text{ MHz}$
- $C_{iss} = C_{gs} + C_{gd}$, $C_{rss} = C_{gd}$
- $C_{oss} = C_{ds} + C_{gd}$

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

![Gate Charge vs. Gate-to-Source Voltage](image2)

- $Q_{G}$, Total Gate Charge (nC)
- $V_{GS}$, Gate-to-Source Voltage (V)

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

![Source-Drain Diode Forward Voltage](image3)

- $V_{SD}$, Source-to-Drain Voltage (V)
- $I_{SD}$, Reverse Drain Current (A)

**Fig. 8 - Maximum Safe Operating Area**

![Maximum Safe Operating Area](image4)

- $V_{DS}$, Drain-to-Source Voltage (V)
- $I_D$, Drain Current (A)

---

For test circuit, see figure 13

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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

Fig. 12b - Unclamped Inductive Waveforms
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**Fig. 12c - Maximum Avalanche Energy vs. Drain Current**

![Graph showing maximum avalanche energy vs. drain current.](image)

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

![Diagram of basic gate charge waveform.](image)

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

![Diagram of gate charge test circuit.](image)
Peak Diode Recovery dV/dt Test Circuit

D.U.T.

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

D.U.T.

- dV/dt controlled by Rg
- Driver same type as D.U.T.
- ISD controlled by duty factor “D”
- D.U.T. - device under test

Driver gate drive

Period

D = P.W. / Period

VGS = 10 V

D.U.T. I_SD waveform

Reverse recovery current

Body diode forward current

di/dt

D.U.T. VGS waveform

Diode recovery dV/dt

Re-applied voltage

Inductor current

Body diode forward drop

Ripple ≤ 5 %

Note
a. VGS = 5 V for logic level devices

Fig. 14 - For N-Channel
**TO-220-1**

**Notes**
- $M^* = 0.052$ inches to 0.064 inches (dimension including protrusion), heatsink hole for HVM
- Outline conforms to JEDEC® outline TO-220AB with exception of dimension F

<table>
<thead>
<tr>
<th>DIM.</th>
<th>MILLIMETERS</th>
<th>INCHES</th>
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<tbody>
<tr>
<td>A</td>
<td>4.14</td>
<td>0.163</td>
</tr>
<tr>
<td>b</td>
<td>0.69</td>
<td>0.027</td>
</tr>
<tr>
<td>b(1)</td>
<td>1.14</td>
<td>0.045</td>
</tr>
<tr>
<td>c</td>
<td>0.36</td>
<td>0.014</td>
</tr>
<tr>
<td>D</td>
<td>14.33</td>
<td>0.564</td>
</tr>
<tr>
<td>E</td>
<td>9.96</td>
<td>0.392</td>
</tr>
<tr>
<td>e</td>
<td>2.41</td>
<td>0.095</td>
</tr>
<tr>
<td>e(1)</td>
<td>4.88</td>
<td>0.192</td>
</tr>
<tr>
<td>F</td>
<td>0.43</td>
<td>0.017</td>
</tr>
<tr>
<td>H(1)</td>
<td>6.10</td>
<td>0.240</td>
</tr>
<tr>
<td>J(1)</td>
<td>2.41</td>
<td>0.095</td>
</tr>
<tr>
<td>L</td>
<td>13.36</td>
<td>0.526</td>
</tr>
<tr>
<td>L(1)</td>
<td>3.33</td>
<td>0.131</td>
</tr>
<tr>
<td>ØP</td>
<td>3.53</td>
<td>0.139</td>
</tr>
<tr>
<td>Q</td>
<td>2.59</td>
<td>0.102</td>
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</tbody>
</table>

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