N-Channel Enhancement Mode Field Effect Transistor
2N7000, 2N7002, NDS7002A

Description
These N-channel enhancement mode field effect transistors are produced using onsemi's proprietary, high cell density, DMOS technology. These products have been designed to minimize on-state resistance while providing rugged, reliable, and fast switching performance. They can be used in most applications requiring up to 400 mA
dc and can deliver pulsed currents up to 2 A. These products are particularly suited for low-voltage, low-current applications, such as small servo motor control, power MOSFET gate drivers, and other switching applications.

Features
- High Density Cell Design for Low $R_{DS(on)}$
- Voltage Controlled Small Signal Switch
- Rugged and Reliable
- High Saturation Current Capability
- This Device is Pb-Free and Halogen Free

MARKING DIAGRAM

TO-92 CASE 135AN

MARKING DIAGRAM

TO-92 CASE 135AR

MARKING DIAGRAM

SOT-23 CASE 318-08

ORDERING INFORMATION
See detailed ordering and shipping information on page 7 of this data sheet.
### ABSOLUTE MAXIMUM RATINGS

Values are at $T_C = 25^\circ$C unless otherwise noted.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{DSS}$</td>
<td>Drain–to–Source Voltage</td>
<td>60 V</td>
</tr>
<tr>
<td>$V_{GSS}$</td>
<td>Gate–Source Voltage – Continuous</td>
<td>$\pm$20 V</td>
</tr>
<tr>
<td>$I_D$</td>
<td>Maximum Drain Current – Continuous</td>
<td>200 mA</td>
</tr>
<tr>
<td>$P_D$</td>
<td>Maximum Power Dissipation Derated above 25$^\circ$C</td>
<td>400 mW</td>
</tr>
<tr>
<td>$T_J$, $T_{STG}$</td>
<td>Operating and Storage Temperature Range</td>
<td>–55 to 150°C</td>
</tr>
<tr>
<td>$T_L$</td>
<td>Maximum Lead Temperature for Soldering Purposes, 1/16–inch from Case for 10 s</td>
<td>300°C</td>
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</table>

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

### THERMAL CHARACTERISTICS

Values are at $T_C = 25^\circ$C unless otherwise noted.

<table>
<thead>
<tr>
<th>Symbol</th>
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<th>Value</th>
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<tbody>
<tr>
<td>$R_{\theta,JA}$</td>
<td>Thermal Resistance, Junction to Ambient</td>
<td>312.5°C/W</td>
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### ELECTRICAL CHARACTERISTICS

Values are at $T_C = 25^\circ$C unless otherwise noted.

#### OFF CHARACTERISTICS

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Type</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
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<tbody>
<tr>
<td>$B_{V_{DSS}}$</td>
<td>Drain–Source Breakdown Voltage</td>
<td>$V_{GS} = 0$ V, $I_D = 10 \mu$A</td>
<td>All</td>
<td>60</td>
<td>–</td>
<td>–</td>
<td>V</td>
</tr>
<tr>
<td>$I_{DSS}$</td>
<td>Zero Gate Voltage Drain Current</td>
<td>$V_{DS} = 48$ V, $V_{GS} = 0$ V</td>
<td>2N7000</td>
<td>–</td>
<td>–</td>
<td>1</td>
<td>μA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$V_{DS} = 48$ V, $V_{GS} = 0$ V, $T_C = 125^\circ$C</td>
<td>2N7000</td>
<td>–</td>
<td>–</td>
<td>1</td>
<td>mA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$V_{DS} = 60$ V, $V_{GS} = 0$ V</td>
<td>2N7002 NDS7002A</td>
<td>–</td>
<td>–</td>
<td>1</td>
<td>μA</td>
</tr>
<tr>
<td></td>
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<td>$V_{DS} = 60$ V, $V_{GS} = 0$ V, $T_C = 125^\circ$C</td>
<td>2N7002 NDS7002A</td>
<td>–</td>
<td>–</td>
<td>0.5</td>
<td>mA</td>
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<tr>
<td>$I_{GSSF}$</td>
<td>Gate – Body Leakage, Forward</td>
<td>$V_{GS} = 15$ V, $V_{DS} = 0$ V</td>
<td>2N7000</td>
<td>–</td>
<td>–</td>
<td>10</td>
<td>nA</td>
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<tr>
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<td>$V_{GS} = 20$ V, $V_{DS} = 0$ V</td>
<td>2N7002 NDS7002A</td>
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<td>100</td>
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<td>$I_{GSSR}$</td>
<td>Gate – Body Leakage, Reverse</td>
<td>$V_{GS} = –15$ V, $V_{DS} = 0$ V</td>
<td>2N7000</td>
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<td>–</td>
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<td>nA</td>
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<td>$V_{GS} = –20$ V, $V_{DS} = 0$ V</td>
<td>2N7002 NDS7002A</td>
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<td>–100</td>
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#### ON CHARACTERISTICS

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<th>Typ</th>
<th>Max</th>
<th>Unit</th>
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<tbody>
<tr>
<td>$V_{GSS(ON)}$</td>
<td>Gate Threshold Voltage</td>
<td>$V_{DS} = V_{GS}$, $I_D = 1$ mA</td>
<td>2N7000</td>
<td>0.8</td>
<td>2.1</td>
<td>3</td>
<td>V</td>
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<td>$V_{DS} = V_{GS}$, $I_D = 250$ μA</td>
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<td>2.1</td>
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ELECTRICAL CHARACTERISTICS (continued)
Values are at TC = 25°C unless otherwise noted.

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<th>Typ</th>
<th>Max</th>
<th>Unit</th>
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<td>R&lt;sub&gt;DS(on)&lt;/sub&gt;</td>
<td>Static Drain–Source On–Resistance</td>
<td>V&lt;sub&gt;GS&lt;/sub&gt; = 10 V, I&lt;sub&gt;D&lt;/sub&gt; = 500 mA</td>
<td>2N7000</td>
<td>–</td>
<td>1.2</td>
<td>5</td>
<td>Ω</td>
</tr>
<tr>
<td></td>
<td></td>
<td>V&lt;sub&gt;GS&lt;/sub&gt; = 10 V, I&lt;sub&gt;D&lt;/sub&gt; = 500 mA, T&lt;sub&gt;C&lt;/sub&gt; = 125°C</td>
<td></td>
<td>–</td>
<td>1.9</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>V&lt;sub&gt;GS&lt;/sub&gt; = 4.5 V, I&lt;sub&gt;D&lt;/sub&gt; = 75 mA</td>
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<td>–</td>
<td>1.8</td>
<td>5.3</td>
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<td></td>
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<td>2N7002</td>
<td>–</td>
<td>1.2</td>
<td>7.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>V&lt;sub&gt;GS&lt;/sub&gt; = 10 V, I&lt;sub&gt;D&lt;/sub&gt; = 500 mA, T&lt;sub&gt;C&lt;/sub&gt; = 100°C</td>
<td></td>
<td>–</td>
<td>1.7</td>
<td>13.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>V&lt;sub&gt;GS&lt;/sub&gt; = 5 V, I&lt;sub&gt;D&lt;/sub&gt; = 50 mA</td>
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<td>–</td>
<td>1.7</td>
<td>7.5</td>
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<td>V&lt;sub&gt;GS&lt;/sub&gt; = 5 V, I&lt;sub&gt;D&lt;/sub&gt; = 50 mA, T&lt;sub&gt;C&lt;/sub&gt; = 100°C</td>
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<td>–</td>
<td>2.4</td>
<td>13.5</td>
<td></td>
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<td>V&lt;sub&gt;GS&lt;/sub&gt; = 10 V, I&lt;sub&gt;D&lt;/sub&gt; = 500 mA</td>
<td>NDS7002A</td>
<td>–</td>
<td>1.2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>V&lt;sub&gt;GS&lt;/sub&gt; = 10 V, I&lt;sub&gt;D&lt;/sub&gt; = 500 mA, T&lt;sub&gt;C&lt;/sub&gt; = 125°C</td>
<td></td>
<td>–</td>
<td>2</td>
<td>3.5</td>
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</tr>
<tr>
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<td>V&lt;sub&gt;GS&lt;/sub&gt; = 5 V, I&lt;sub&gt;D&lt;/sub&gt; = 50 mA</td>
<td></td>
<td>–</td>
<td>1.7</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td></td>
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<td>V&lt;sub&gt;GS&lt;/sub&gt; = 5 V, I&lt;sub&gt;D&lt;/sub&gt; = 50 mA, T&lt;sub&gt;C&lt;/sub&gt; = 125°C</td>
<td></td>
<td>–</td>
<td>2.8</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>V&lt;sub&gt;DS(on)&lt;/sub&gt;</td>
<td>Drain–Source On–Voltage</td>
<td>V&lt;sub&gt;GS&lt;/sub&gt; = 10 V, I&lt;sub&gt;D&lt;/sub&gt; = 500 mA</td>
<td>2N7000</td>
<td>–</td>
<td>0.6</td>
<td>2.5</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>V&lt;sub&gt;GS&lt;/sub&gt; = 4.5 V, I&lt;sub&gt;D&lt;/sub&gt; = 75 mA</td>
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<td>–</td>
<td>0.14</td>
<td>0.4</td>
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<tr>
<td></td>
<td></td>
<td>V&lt;sub&gt;GS&lt;/sub&gt; = 10 V, I&lt;sub&gt;D&lt;/sub&gt; = 500 mA</td>
<td>2N7002</td>
<td>–</td>
<td>0.6</td>
<td>3.75</td>
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<tr>
<td></td>
<td></td>
<td>V&lt;sub&gt;GS&lt;/sub&gt; = 5.0 V, I&lt;sub&gt;D&lt;/sub&gt; = 50 mA</td>
<td></td>
<td>–</td>
<td>0.09</td>
<td>1.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>V&lt;sub&gt;GS&lt;/sub&gt; = 10 V, I&lt;sub&gt;D&lt;/sub&gt; = 500 mA</td>
<td>NDS7002A</td>
<td>–</td>
<td>0.6</td>
<td>1</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>V&lt;sub&gt;GS&lt;/sub&gt; = 5.0 V, I&lt;sub&gt;D&lt;/sub&gt; = 50 mA</td>
<td></td>
<td>–</td>
<td>0.09</td>
<td>0.15</td>
<td></td>
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<tr>
<td>I&lt;sub&gt;D(on)&lt;/sub&gt;</td>
<td>On–State Drain Current</td>
<td>V&lt;sub&gt;GS&lt;/sub&gt; = 4.5 V, V&lt;sub&gt;DS&lt;/sub&gt; = 10 V</td>
<td>2N7000</td>
<td>75</td>
<td>600</td>
<td>–</td>
<td>mA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>V&lt;sub&gt;GS&lt;/sub&gt; = 10 V, V&lt;sub&gt;DS&lt;/sub&gt; ≥ 2 V&lt;sub&gt;DS(on)&lt;/sub&gt;</td>
<td>2N7002</td>
<td>500</td>
<td>2700</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>V&lt;sub&gt;GS&lt;/sub&gt; = 10 V, V&lt;sub&gt;DS&lt;/sub&gt; ≥ 2 V&lt;sub&gt;DS(on)&lt;/sub&gt;</td>
<td>NDS7002A</td>
<td>500</td>
<td>2700</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>g&lt;sub&gt;f&lt;/sub&gt;</td>
<td>Forward Transconductance</td>
<td>V&lt;sub&gt;DS&lt;/sub&gt; = 10 V, I&lt;sub&gt;D&lt;/sub&gt; = 200 mA</td>
<td>2N7000</td>
<td>100</td>
<td>320</td>
<td>–</td>
<td>mS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>V&lt;sub&gt;DS&lt;/sub&gt; ≥ 2 V&lt;sub&gt;DS(on)&lt;/sub&gt;, I&lt;sub&gt;D&lt;/sub&gt; = 200 mA</td>
<td>2N7002</td>
<td>80</td>
<td>320</td>
<td>–</td>
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<td>V&lt;sub&gt;DS&lt;/sub&gt; ≥ 2 V&lt;sub&gt;DS(on)&lt;/sub&gt;</td>
<td>NDS7002A</td>
<td>80</td>
<td>320</td>
<td>–</td>
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**DYNAMIC CHARACTERISTICS**

<table>
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<th>Parameter</th>
<th>Conditions</th>
<th>Type</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>C&lt;sub&gt;iss&lt;/sub&gt;</td>
<td>Input Capacitance</td>
<td>V&lt;sub&gt;DS&lt;/sub&gt; = 25 V, V&lt;sub&gt;GS&lt;/sub&gt; = 0 V, f = 1.0 MHz</td>
<td>All</td>
<td>–</td>
<td>20</td>
<td>50</td>
<td>pF</td>
</tr>
<tr>
<td>C&lt;sub&gt;oss&lt;/sub&gt;</td>
<td>Output Capacitance</td>
<td></td>
<td>All</td>
<td>–</td>
<td>11</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>C&lt;sub&gt;rss&lt;/sub&gt;</td>
<td>Reverse Transfer Capacitance</td>
<td></td>
<td>All</td>
<td>–</td>
<td>4</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>t&lt;sub&gt;on&lt;/sub&gt;</td>
<td>Turn–On Time</td>
<td>V&lt;sub&gt;DD&lt;/sub&gt; = 15 V, R&lt;sub&gt;L&lt;/sub&gt; = 25 Ω, I&lt;sub&gt;D&lt;/sub&gt; = 500 mA, V&lt;sub&gt;GS&lt;/sub&gt; = 10 V, R&lt;sub&gt;GEN&lt;/sub&gt; = 25 Ω</td>
<td>2N7000</td>
<td>–</td>
<td>–</td>
<td>10</td>
<td>ns</td>
</tr>
<tr>
<td></td>
<td></td>
<td>V&lt;sub&gt;DD&lt;/sub&gt; = 30 V, R&lt;sub&gt;L&lt;/sub&gt; = 150 Ω, I&lt;sub&gt;D&lt;/sub&gt; = 200 mA, V&lt;sub&gt;GS&lt;/sub&gt; = 10 V, R&lt;sub&gt;GEN&lt;/sub&gt; = 25 Ω</td>
<td>2N7002</td>
<td>–</td>
<td>–</td>
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<tr>
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<td></td>
<td>NDS7002A</td>
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<td>t&lt;sub&gt;off&lt;/sub&gt;</td>
<td>Turn–Off Time</td>
<td>V&lt;sub&gt;DD&lt;/sub&gt; = 15 V, R&lt;sub&gt;L&lt;/sub&gt; = 25 Ω, I&lt;sub&gt;D&lt;/sub&gt; = 500 mA, V&lt;sub&gt;GS&lt;/sub&gt; = 10 V, R&lt;sub&gt;GEN&lt;/sub&gt; = 25 Ω</td>
<td>2N7000</td>
<td>–</td>
<td>–</td>
<td>10</td>
<td>ns</td>
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<tr>
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<td>V&lt;sub&gt;DD&lt;/sub&gt; = 30 V, R&lt;sub&gt;L&lt;/sub&gt; = 150 Ω, I&lt;sub&gt;D&lt;/sub&gt; = 200 mA, V&lt;sub&gt;GS&lt;/sub&gt; = 10 V, R&lt;sub&gt;GEN&lt;/sub&gt; = 25 Ω</td>
<td>2N7002</td>
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<td>–</td>
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<td>NDS7002A</td>
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ELECTRICAL CHARACTERISTICS (continued)
Values are at \( T_C = 25^\circ \text{C} \) unless otherwise noted.

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<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
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<td>( I_S )</td>
<td>Maximum Continuous Drain–Source Diode Forward Current</td>
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<td>2N7002</td>
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<td>–</td>
<td>115</td>
<td>mA</td>
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<td>NDS7002A</td>
<td>–</td>
<td>–</td>
<td>280</td>
<td></td>
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<tr>
<td>( I_{SM} )</td>
<td>Maximum Pulsed Drain–Source Diode Forward Current</td>
<td></td>
<td>2N7002</td>
<td>–</td>
<td>–</td>
<td>0.8</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>NDS7002A</td>
<td>–</td>
<td>–</td>
<td>1.5</td>
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</table>

\( V_{SD} \) Drain–Source Diode Forward Voltage

\begin{align*}
V_{GS} & = 0 \text{ V}, \; I_S = 115 \text{ mA} \\
& \quad \text{(Note 1)} \\
V_{GS} & = 0 \text{ V}, \; I_S = 400 \text{ mA} \\
& \quad \text{Note 1)}
\end{align*}

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<thead>
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<th>Max</th>
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<td>2N7002</td>
<td>–</td>
<td>0.88</td>
<td>1.5</td>
<td>V</td>
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<td>NDS7002A</td>
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<td>0.88</td>
<td>1.2</td>
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Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

1. Pulse test: Pulse Width ≤ 300 \( \mu \text{s} \), Duty Cycle ≤ 2 %

TYPICAL PERFORMANCE CHARACTERISTICS

- **Figure 1.** On–Region Characteristics
- **Figure 2.** On–Resistance Variation with Gate Voltage and Drain Current
- **Figure 3.** On–Resistance Variation with Temperature
- **Figure 4.** On–Resistance Variation with Drain Current and Temperature
TYPICAL PERFORMANCE CHARACTERISTICS

Figure 5. Transfer Characteristics

Figure 6. Gate Threshold Variation with Temperature

Figure 7. Breakdown Voltage Variation with Temperature

Figure 8. Body Diode Forward Voltage Variation with

Figure 9. Capacitance Characteristics

Figure 10. Gate Charge Characteristics
Figure 11. Switching Test Circuit

Figure 12. Switching Waveforms

Figure 13. 2N7000 Maximum Safe Operating Area

Figure 14. 2N7002 Maximum Safe Operating Area

Figure 15. NDS7002A Maximum Safe Operating Area
TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

Figure 16. TO−92, 2N7000 Transient Thermal Response Curve

Figure 17. SOT−23, 2N7002 / NDS7002A Transient Thermal Response Curve

ORDERING INFORMATION

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Marking</th>
<th>Package</th>
<th>Packing Method†</th>
<th>Min Order Qty / Immediate Pack Qty</th>
</tr>
</thead>
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<tr>
<td>2N7000</td>
<td>2N7000</td>
<td>TO−92 3L (Pb−Free)</td>
<td>Bulk</td>
<td>10000 / 1000</td>
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<tr>
<td>2N7000−D74Z</td>
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<td></td>
<td>Ammo</td>
<td>2000 / 2000</td>
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<tr>
<td>2N7000−D75Z</td>
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<td></td>
<td>Tape and Reel</td>
<td>2000 / 2000</td>
</tr>
<tr>
<td>2N7000−D26Z</td>
<td></td>
<td></td>
<td></td>
<td>2000 / 2000</td>
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<tr>
<td>2N7002</td>
<td>702</td>
<td>SOT−23 3L (Pb−Free)</td>
<td>Tape and Reel</td>
<td>3000 / 3000</td>
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<td>NDS7002A</td>
<td>712</td>
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<td>3000 / 3000</td>
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†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.
TO-92 3 4.825x4.76
CASE 135AN
ISSUE 0

DATE 31 JUL 2016

NOTES: UNLESS OTHERWISE SPECIFIED
A) DRAWING WITH REFERENCE TO JEDEC TO-92 RECOMMENDATIONS.
B) ALL DIMENSIONS ARE IN MILLIMETERS.
C) DRAWING CONFORMS TO ASME Y14.5M-2009.
TO-92 3 4.83x4.76 LEADFORMED
CASE 135AR
ISSUE 0

DATE 30 SEP 2016

NOTES: UNLESS OTHERWISE SPECIFIED
A) DRAWING WITH REFERENCE TO JEDEC TO-92 RECOMMENDATIONS.
B) ALL DIMENSIONS ARE IN MILLIMETERS.
C) DRAWING CONFORMS TO ASME Y14.5M-1994
MECHANICAL CASE OUTLINE
PACKAGING DIMENSIONS

SOT–23 (TO–236)
CASE 318–08
ISSUE AS

DATE 30 JAN 2018

NOTES:
2. CONTROLLING DIMENSION: MILLIMETERS.
3. MAXIMUM LEAD THICKNESS INCLUDES LEAD FINISH.
4. MINIMUM LEAD THICKNESS IS THE MINIMUM THICKNESS OF THE BASE MATERIAL.
5. DIMENSIONS D AND E DO NOT INCLUDE MOLD FLASH, PROTRUSIONS, OR GATE BURRS.

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