2N7002K, 2V7002K

Small Signal MOSFET
60 V, 380 mA, Single, N–Channel, SOT–23

Features
- ESD Protected
- Low RDS(on)
- Surface Mount Package
- 2V Prefix for Automotive and Other Applications Requiring Unique Site and Control Change Requirements; AEC–Q101 Qualified and PPAP Capable
- These Devices are Pb–Free, Halogen Free/BFR Free and are RoHS Compliant

Applications
- Low Side Load Switch
- Level Shift Circuits
- DC–DC Converter
- Portable Applications i.e. DSC, PDA, Cell Phone, etc.

MAXIMUM RATINGS (TJ = 25°C unless otherwise stated)

<table>
<thead>
<tr>
<th>Rating</th>
<th>Symbol</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drain–to–Source Voltage</td>
<td>VDSS</td>
<td>60</td>
<td>V</td>
</tr>
<tr>
<td>Gate–to–Source Voltage</td>
<td>VGSS</td>
<td>±20</td>
<td>V</td>
</tr>
<tr>
<td>Drain Current (Note 1) Steady State 1 sq in Pad</td>
<td>ID</td>
<td>380</td>
<td>mA</td>
</tr>
<tr>
<td>Steady State Minimum Pad</td>
<td></td>
<td>270</td>
<td>mA</td>
</tr>
<tr>
<td>Drain Current (Note 2) Steady State Minimum Pad</td>
<td>ID</td>
<td>320</td>
<td>mA</td>
</tr>
<tr>
<td>Steady State Minimum Pad</td>
<td></td>
<td>230</td>
<td>mA</td>
</tr>
<tr>
<td>Power Dissipation</td>
<td>PD</td>
<td>420</td>
<td>mW</td>
</tr>
<tr>
<td>Source Current (Body Diode)</td>
<td>IS</td>
<td>300</td>
<td>mA</td>
</tr>
<tr>
<td>Lead Temperature for Soldering Purposes (1/8&quot; from case for 10 s)</td>
<td>TL</td>
<td>260</td>
<td>°C</td>
</tr>
<tr>
<td>Gate–Source ESD Rating (HBM, Method 3015)</td>
<td>ESD</td>
<td>2000</td>
<td>V</td>
</tr>
</tbody>
</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.

1. Surface–mounted on FR4 board using 1 sq in pad size with 1 oz Cu.
2. Surface–mounted on FR4 board using 0.08 sq in pad size with 1 oz Cu.

ORDERING INFORMATION

<table>
<thead>
<tr>
<th>Device</th>
<th>Package</th>
<th>Shipping†</th>
</tr>
</thead>
<tbody>
<tr>
<td>2N7002KT1G, 2V7002KT1G</td>
<td>SOT–23 (Pb–Free)</td>
<td>3000 / Tape &amp; Reel</td>
</tr>
<tr>
<td>2N7002KT7G</td>
<td>SOT–23  (Pb–Free)</td>
<td>3500 / Tape &amp; Reel</td>
</tr>
</tbody>
</table>

†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.
### THERMAL CHARACTERISTICS

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Symbol</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Junction-to-Ambient – Steady State (Note 3)</td>
<td>$R_{JUA}$</td>
<td>300</td>
<td>°C/W</td>
</tr>
<tr>
<td>Junction-to-Ambient – $t \leq 5$ s (Note 3)</td>
<td></td>
<td>92</td>
<td></td>
</tr>
<tr>
<td>Junction-to-Ambient – Steady State (Note 4)</td>
<td></td>
<td>417</td>
<td></td>
</tr>
<tr>
<td>Junction-to-Ambient – $t \leq 5$ s (Note 4)</td>
<td></td>
<td>154</td>
<td></td>
</tr>
</tbody>
</table>

3. Surface–mounted on FR4 board using 1 sq in pad size with 1 oz Cu.
4. Surface–mounted on FR4 board using 0.08 sq in pad size with 1 oz Cu.

### ELECTRICAL CHARACTERISTICS (TJ = 25°C unless otherwise specified)

#### OFF CHARACTERISTICS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Test Condition</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drain–Source Breakdown Voltage</td>
<td>$V_{(BR)DSS}$</td>
<td>$V_{GS} = 0$ V, $I_D = 250$ µA</td>
<td>60</td>
<td></td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>Drain–Source Breakdown Voltage Temperature Coefficient</td>
<td>$V_{(BR)DSS/TJ}$</td>
<td></td>
<td>71</td>
<td></td>
<td></td>
<td>mV/°C</td>
</tr>
<tr>
<td>Zero Gate Voltage Drain Current</td>
<td>$I_DSS$</td>
<td>$V_{GS} = 0$ V, $V_{DS} = 60$ V</td>
<td>1</td>
<td></td>
<td></td>
<td>µA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$T_J = 125$ °C</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$V_{GS} = 0$ V, $V_{DS} = 50$ V</td>
<td>100</td>
<td></td>
<td></td>
<td>nA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$T_J = 25$ °C</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gate–Source Leakage Current</td>
<td>$I_{GSS}$</td>
<td>$V_{DS} = 0$ V, $V_{GS} = \pm 20$ V</td>
<td></td>
<td></td>
<td>±10</td>
<td>µA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$V_{DS} = 0$ V, $V_{GS} = \pm 10$ V</td>
<td></td>
<td></td>
<td>450</td>
<td>nA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$V_{DS} = 0$ V, $V_{GS} = \pm 5.0$ V</td>
<td></td>
<td></td>
<td>150</td>
<td>nA</td>
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</table>

#### ON CHARACTERISTICS (Note 5)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Test Condition</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gate Threshold Voltage</td>
<td>$V_{G}(TH)$</td>
<td>$V_{GS} = V_{DS}$, $I_D = 250$ µA</td>
<td>1.0</td>
<td></td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>Negative Threshold Temperature Coefficient</td>
<td>$V_{G}(TH)/T_J$</td>
<td></td>
<td>4.0</td>
<td></td>
<td></td>
<td>mV/°C</td>
</tr>
<tr>
<td>Drain–Source On Resistance</td>
<td>$R_{D(on)}$</td>
<td>$V_{GS} = 10$ V, $I_D = 500$ mA</td>
<td>1.19</td>
<td>1.6</td>
<td></td>
<td>Ω</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$V_{GS} = 4.5$ V, $I_D = 200$ mA</td>
<td>1.33</td>
<td>2.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forward Transconductance</td>
<td>$g_F$</td>
<td>$V_{DS} = 5$ V, $I_D = 200$ mA</td>
<td></td>
<td></td>
<td>530</td>
<td>mS</td>
</tr>
</tbody>
</table>

#### CHARGES AND CAPACITANCES

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Test Condition</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Capacitance</td>
<td>$C_{ISS}$</td>
<td>$V_{GS} = 0$ V, $f = 1$ MHz, $V_{DS} = 20$ V</td>
<td>24.5</td>
<td>45</td>
<td></td>
<td>pF</td>
</tr>
<tr>
<td>Output Capacitance</td>
<td>$C_{OSS}$</td>
<td></td>
<td>4.2</td>
<td>8.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reverse Transfer Capacitance</td>
<td>$C_{RSS}$</td>
<td></td>
<td>2.2</td>
<td>5.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Gate Charge</td>
<td>$Q_{G(TOT)}$</td>
<td>$V_{GS} = 4.5$ V, $V_{DS} = 10$ V; $I_D = 200$ mA</td>
<td>0.7</td>
<td></td>
<td></td>
<td>nC</td>
</tr>
<tr>
<td>Threshold Gate Charge</td>
<td>$Q_{G(TH)}$</td>
<td></td>
<td>0.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gate–Source Charge</td>
<td>$Q_{GS}$</td>
<td></td>
<td>0.3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gate–Drain Charge</td>
<td>$Q_{GD}$</td>
<td></td>
<td>0.1</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### SWITCHING CHARACTERISTICS, $V_{GS} = V$ (Note 6)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Test Condition</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turn–On Delay Time</td>
<td>$t_{d(ON)}$</td>
<td>$V_{GS} = 10$ V, $V_{DD} = 25$ V, $I_D = 500$ mA, $R_G = 25$ Ω</td>
<td>12.2</td>
<td></td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td>Rise Time</td>
<td>$t_r$</td>
<td></td>
<td>9.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turn–Off Delay Time</td>
<td>$t_{d(OFF)}$</td>
<td></td>
<td>55.8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fall Time</td>
<td>$t_f$</td>
<td></td>
<td>29</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### DRAIN–SOURCE DIODE CHARACTERISTICS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Test Condition</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forward Diode Voltage</td>
<td>$V_{SD}$</td>
<td>$V_{GS} = 0$ V, $I_S = 200$ mA</td>
<td>0.8</td>
<td>1.2</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$T_J = 25$ °C</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$T_J = 85$ °C</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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.

5. Pulse Test: pulse width ≤ 300 µs, duty cycle ≤ 2%
6. Switching characteristics are independent of operating junction temperatures
TYPICAL CHARACTERISTICS

Figure 1. On−Region Characteristics

Figure 2. Transfer Characteristics

Figure 3. On−Resistance vs. Drain Current and Temperature

Figure 4. On−Resistance vs. Drain Current and Temperature

Figure 5. On−Resistance vs. Gate−to−Source Voltage

Figure 6. On−Resistance Variation with Temperature
TYPICAL CHARACTERISTICS

Figure 7. Capacitance Variation

Figure 8. Gate-to-Source and Drain-to-Source Voltage vs. Total Charge

Figure 9. Diode Forward Voltage vs. Current

Figure 10. Threshold Voltage with Temperature

GATE-TO-SOURCE OR DRAIN-TO-SOURCE VOLTAGE (V)

VGS, GATE-TO-SOURCE VOLTAGE (V)

IS, SOURCE CURRENT (A)

VSD, SOURCE-TO-DRAIN VOLTAGE (V)

Qg, TOTAL GATE CHARGE (nC)

VGS(TH), THRESHOLD VOLTAGE (V)

TJ, JUNCTION TEMPERATURE (°C)

C, CAPACITANCE (pF)

TJ = 25°C
VGS = 0 V

TJ = 85°C
TJ = 25°C

VGS = 0 V

TJ = 25°C
Ig = 0.2 A

TJ = 25°C
ID = 250 µA
Figure 11. Thermal Response – 1 sq in pad

Figure 12. Thermal Response – minimum pad
**PACKAGE DIMENSIONS**

**SOT-23 (TO-236)**

**CASE 318-08**

**ISSUE AS**

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

**RECOMMENDED SOLDERING FOOTPRINT**

**DIMENSIONS: MILLIMETERS**

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