Small Signal MOSFET
60 V, 380 mA, Single, N–Channel, SOT–23
2N7002K, 2V7002K

Features
- ESD Protected
- Low $R_{DS(on)}$
- 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 (T_J = 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>$V_{DSS}$</td>
<td>60</td>
<td>V</td>
</tr>
<tr>
<td>Gate–to–Source Voltage</td>
<td>$V_{GS}$</td>
<td>±20</td>
<td>V</td>
</tr>
<tr>
<td>Drain Current (Note 1)</td>
<td>$I_{D}$</td>
<td>380</td>
<td>mA</td>
</tr>
<tr>
<td>Steady State 1 sq in Pad</td>
<td>$T_A = 25^\circ$C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Steady State 1 sq in Pad</td>
<td>$T_A = 85^\circ$C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drain Current (Note 2)</td>
<td>$I_{D}$</td>
<td>320</td>
<td>mA</td>
</tr>
<tr>
<td>Steady State Minimum Pad</td>
<td>$T_A = 25^\circ$C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Steady State Minimum Pad</td>
<td>$T_A = 85^\circ$C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power Dissipation</td>
<td>$P_D$</td>
<td>420</td>
<td>mW</td>
</tr>
<tr>
<td>Steady State 1 sq in Pad</td>
<td></td>
<td>300</td>
<td></td>
</tr>
<tr>
<td>Steady State Minimum Pad</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pulsed Drain Current (t_b = 10 ms)</td>
<td>$I_{DM}$</td>
<td>5.0</td>
<td>A</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>Source Current (Body Diode)</td>
<td>$I_S$</td>
<td>300</td>
<td>mA</td>
</tr>
<tr>
<td>Lead Temperature for Soldering Purposes</td>
<td>$T_L$</td>
<td>260</td>
<td>°C</td>
</tr>
<tr>
<td>(1/8&quot; from case for 10 s)</td>
<td></td>
<td></td>
<td></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.

SOT–23 CASE 318

MARKING DIAGRAM

ORDERING INFORMATION

<table>
<thead>
<tr>
<th>Device</th>
<th>Package</th>
<th>Shipping¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>2N7002KT1G,</td>
<td>SOT–23</td>
<td>3000 / Tape &amp; Reel</td>
</tr>
<tr>
<td>2N7002KT1G</td>
<td>(Pb–Free)</td>
<td></td>
</tr>
<tr>
<td>2N7002KT7G</td>
<td>SOT–23</td>
<td>3500 / Tape &amp; Reel</td>
</tr>
<tr>
<td></td>
<td>(Pb–Free)</td>
<td></td>
</tr>
</tbody>
</table>

¹For 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>$R_{JA}$</td>
<td>300</td>
<td>°C/W</td>
</tr>
<tr>
<td>Junction-to-Ambient – t ≤ 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 ≤ 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  \( (T_J = 25°C \text{ unless otherwise specified}) \)

#### 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–to–Source Breakdown Voltage</td>
<td>$V_{(BR)DS}$</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–to–Source Breakdown Voltage</td>
<td>$V_{BRDS}/T_J$</td>
<td></td>
<td>71</td>
<td></td>
<td></td>
<td>mV/°C</td>
</tr>
<tr>
<td>Zero Gate Voltage Drain Current</td>
<td>$I_{DS}$</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>$T_J = 25°C$</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–to–Source Leakage Current</td>
<td>$I_{GS}$</td>
<td>$V_{DS} = 0$ V, $V_{GS} = ±0.20$ V</td>
<td>±10</td>
<td></td>
<td></td>
<td>µA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$V_{GS} = 0$ V, $V_{GS} = ±0.10$ V</td>
<td>450</td>
<td></td>
<td></td>
<td>nA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$V_{DS} = 0$ V, $V_{GS} = ±0.50$ V</td>
<td>150</td>
<td></td>
<td></td>
<td>nA</td>
</tr>
</tbody>
</table>

#### ON CHARACTERISTICS  \( \text{(Note 5)} \)

<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>$V_{GS(TH)}$</td>
<td>$V_{GS} = V_{DS}$, $I_D = 250$ µA</td>
<td>1.0</td>
<td></td>
<td>2.3</td>
<td>V</td>
</tr>
<tr>
<td>Negative Threshold Temperature Coefficient</td>
<td>$V_{GS(TH)}/T_J$</td>
<td></td>
<td>4.0</td>
<td></td>
<td>8.0</td>
<td>mV/°C</td>
</tr>
<tr>
<td>Drain–to–Source On Resistance</td>
<td>$R_{DS(on)}$</td>
<td>$V_{GS} = 10$ V, $I_D = 500$ mA</td>
<td>1.19</td>
<td></td>
<td>1.6</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></td>
<td>2.5</td>
<td></td>
</tr>
<tr>
<td>Forward Transconductance</td>
<td>$g_{FS}$</td>
<td>$V_{DS} = 5$ V, $I_D = 200$ mA</td>
<td>530</td>
<td></td>
<td></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></td>
<td>45</td>
<td>pF</td>
</tr>
<tr>
<td>Output Capacitance</td>
<td>$C_{oss}$</td>
<td></td>
<td>4.2</td>
<td></td>
<td>8.0</td>
<td></td>
</tr>
<tr>
<td>Reverse Transfer Capacitance</td>
<td>$C_{rss}$</td>
<td></td>
<td>2.2</td>
<td></td>
<td>5.0</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–to–Source Charge</td>
<td>$Q_{GS}$</td>
<td></td>
<td>0.3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gate–to–Drain Charge</td>
<td>$Q_{GD}$</td>
<td></td>
<td>0.1</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

<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>$t_{ON}$</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>$t_{OFF}$</td>
<td></td>
<td>55.8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fail 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></td>
<td>1.2</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>0.7</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


Figure 11. Thermal Response – 1 sq in pad

Figure 12. Thermal Response – minimum pad
SOT–23 (TO–236)
CASE 318
ISSUE AT DATE 01 MAR 2023

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.

<table>
<thead>
<tr>
<th>DIM</th>
<th>MILLIMETERS</th>
<th>INCHES</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>MIN. 0.89</td>
<td>NOM. 1.00</td>
</tr>
<tr>
<td>A1</td>
<td>MIN. 0.01</td>
<td>NOM. 0.06</td>
</tr>
<tr>
<td>b</td>
<td>MIN. 0.37</td>
<td>NOM. 0.44</td>
</tr>
<tr>
<td>c</td>
<td>MIN. 0.08</td>
<td>NOM. 0.14</td>
</tr>
<tr>
<td>D</td>
<td>MIN. 2.80</td>
<td>NOM. 2.90</td>
</tr>
<tr>
<td>e</td>
<td>MIN. 1.78</td>
<td>NOM. 1.90</td>
</tr>
<tr>
<td>L</td>
<td>MIN. 0.30</td>
<td>NOM. 0.43</td>
</tr>
<tr>
<td>L1</td>
<td>MIN. 0.35</td>
<td>NOM. 0.54</td>
</tr>
<tr>
<td>H</td>
<td>MIN. 2.10</td>
<td>NOM. 2.40</td>
</tr>
<tr>
<td>T</td>
<td>MIN. 0°</td>
<td>NOM. 10°</td>
</tr>
</tbody>
</table>

**RECOMMENDED MOUNTING FOOTPRINT**

- For additional information on our Pb-Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDMTM/3.

**GENERIC MARKING DIAGRAM**

XXX = Specific Device Code
M = Date Code
= Pb-Free Package

*This information is generic. Please refer to device data sheet for actual part marking. Pb-Free indicator, "G" or microdot ",", may or may not be present. Some products may not follow the Generic Marking.

STYLES ON PAGE 2

DOCUMENT NUMBER: 98ASB42226B
DESCRIPTION: SOT–23 (TO–236)

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<table>
<thead>
<tr>
<th>Style</th>
<th>Pin 1</th>
<th>Pin 2</th>
<th>Pin 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ANODE</td>
<td>ANODE</td>
<td>CATHODE</td>
</tr>
<tr>
<td>2</td>
<td>CATHODE</td>
<td>CATHODE</td>
<td>CATHODE</td>
</tr>
<tr>
<td>3</td>
<td>GATE</td>
<td>GATE</td>
<td>GATE</td>
</tr>
</tbody>
</table>

**Style 2:**
- Pin 1: GATE
- Pin 2: SOURCE
- Pin 3: OUTPUT

**Style 3:**
- Pin 1: CATHODE
- Pin 2: ANODE
- Pin 3: CATHODE

**Style 4:**
- Pin 1: CATHODE
- Pin 2: CATHODE
- Pin 3: CATHODE

**Style 5:**
- Pin 1: CATHODE
- Pin 2: CATHODE
- Pin 3: CATHODE

**Style 6:**
- Pin 1: BASE
- Pin 2: EMITTER
- Pin 3: COLLECTOR

**Style 7:**
- Pin 1: EMITTER
- Pin 2: BASE
- Pin 3: NO CONNECTION

**Style 8:**
- Pin 1: ANODE
- Pin 2: CATHODE
- Pin 3: COLLECTOR

**Style 9:**
- Pin 1: ANODE
- Pin 2: ANODE
- Pin 3: CATHODE

**Style 10:**
- Pin 1: DRAIN
- Pin 2: SOURCE
- Pin 3: GATE

**Style 11:**
- Pin 1: ANODE
- Pin 2: CATHODE
- Pin 3: COLLECTOR

**Style 12:**
- Pin 1: CATHODE
- Pin 2: CATHODE
- Pin 3: ANODE

**Style 13:**
- Pin 1: ANODE
- Pin 2: CATHODE
- Pin 3: CATHODE

**Style 14:**
- Pin 1: ANODE
- Pin 2: CATHODE
- Pin 3: CATHODE

**Style 15:**
- Pin 1: GATE
- Pin 2: SOURCE
- Pin 3: DRAIN

**Style 16:**
- Pin 1: ANODE
- Pin 2: CATHODE
- Pin 3: ANODE

**Style 17:**
- Pin 1: GATE
- Pin 2: SOURCE
- Pin 3: DRAIN

**Style 18:**
- Pin 1: ANODE
- Pin 2: CATHODE
- Pin 3: CATHODE

**Style 19:**
- Pin 1: CATHODE
- Pin 2: ANODE
- Pin 3: CATHODE

**Style 20:**
- Pin 1: CATHODE
- Pin 2: GATE
- Pin 3: ANODE

**Style 21:**
- Pin 1: GATE
- Pin 2: SOURCE
- Pin 3: DRAM

**Style 22:**
- Pin 1: RETURN
- Pin 2: OUTPUT
- Pin 3: INPUT

**Style 23:**
- Pin 1: ANODE
- Pin 2: ANODE
- Pin 3: CATHODE

**Style 24:**
- Pin 1: GATE
- Pin 2: DRAIN
- Pin 3: SOURCE

**Style 25:**
- Pin 1: ANODE
- Pin 2: CATHODE
- Pin 3: GATE

**Style 26:**
- Pin 1: ANODE
- Pin 2: NO CONNECTION

**Style 27:**
- Pin 1: CATHODE
- Pin 2: CATHODE
- Pin 3: CATHODE

**Style 28:**
- Pin 1: ANODE
- Pin 2: ANODE
- Pin 3: ANODE

**Style 1 Through 5:**
- CANCELLED

**Style 6:**
- PIN 1: BASE
- PIN 2: EMITTER
- PIN 3: COLLECTOR

**Style 7:**
- PIN 1: EMITTER
- PIN 2: BASE
- PIN 3: NO CONNECTION

**Style 8:**
- PIN 1: ANODE
- PIN 2: CATHODE
- PIN 3: COLLECTOR

**Style 9:**
- PIN 1: ANODE
- PIN 2: ANODE
- PIN 3: CATHODE

**Style 10:**
- PIN 1: DRAIN
- PIN 2: SOURCE
- PIN 3: GATE

**Style 11:**
- PIN 1: ANODE
- PIN 2: CATHODE
- PIN 3: COLLECTOR

**Style 12:**
- PIN 1: CATHODE
- PIN 2: CATHODE
- PIN 3: ANODE

**Style 13:**
- PIN 1: ANODE
- PIN 2: CATHODE
- PIN 3: CATHODE

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- PIN 2: CATHODE
- PIN 3: CATHODE

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- PIN 3: DRAIN

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- PIN 2: CATHODE
- PIN 3: ANODE

**Style 17:**
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- PIN 2: SOURCE
- PIN 3: DRAIN

**Style 18:**
- PIN 1: ANODE
- PIN 2: CATHODE
- PIN 3: CATHODE

**Style 19:**
- PIN 1: CATHODE
- PIN 2: ANODE
- PIN 3: CATHODE

**Style 20:**
- PIN 1: CATHODE
- PIN 2: GATE
- PIN 3: ANODE

**Style 21:**
- PIN 1: GATE
- Pin 2: SOURCE
- Pin 3: DRAM

**Style 22:**
- PIN 1: RETURN
- PIN 2: OUTPUT
- PIN 3: INPUT

**Style 23:**
- PIN 1: ANODE
- PIN 2: ANODE
- PIN 3: CATHODE

**Style 24:**
- PIN 1: GATE
- PIN 2: DRAIN
- PIN 3: SOURCE

**Style 25:**
- PIN 1: ANODE
- PIN 2: CATHODE
- PIN 3: GATE

**Style 26:**
- PIN 1: ANODE
- PIN 2: NO CONNECTION

**Style 27:**
- PIN 1: CATHODE
- PIN 2: CATHODE
- PIN 3: CATHODE

**Style 28:**
- PIN 1: ANODE
- PIN 2: ANODE
- PIN 3: ANODE