

2N7002

N-channel enhancement mode field-effect transistor

Rev. 03 — 27 July 2000

Product specification

1. Description

N-channel enhancement mode field-effect transistor in a plastic package using TrenchMOS™¹ technology.

Product availability:

2N7002 in SOT23.

2. Features

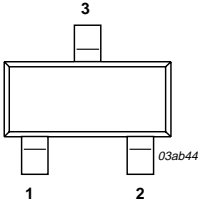
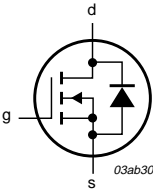
- TrenchMOS™ technology
- Very fast switching
- Logic level compatible
- Subminiature surface mount package.

3. Applications

- Relay driver
- High speed line driver
- Logic level translator.

4. Pinning information

Table 1: Pinning - SOT23, simplified outline and symbol

| Pin | Description | Simplified outline | Symbol |
|-----|-------------|---|---|
| 1 | gate (g) |  |  |
| 2 | source (s) | | |
| 3 | drain (d) | | |
| | | SOT23 | N-channel MOSFET |

1. TrenchMOS is a trademark of Royal Philips Electronics.

5. Quick reference data

Table 2: Quick reference data

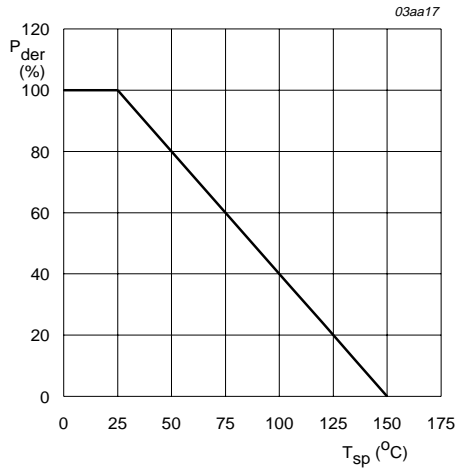
| Symbol | Parameter | Conditions | Typ | Max | Unit |
|--------------|----------------------------------|-----------------------------------|-----|------|----------|
| V_{DS} | drain-source voltage (DC) | $T_j = 25$ to 150 °C | – | 60 | V |
| I_D | drain current (DC) | $T_{sp} = 25$ °C; $V_{GS} = 10$ V | – | 300 | mA |
| P_{tot} | total power dissipation | $T_{sp} = 25$ °C | – | 0.83 | W |
| T_j | junction temperature | | – | 150 | °C |
| $R_{DS(on)}$ | drain-source on-state resistance | $V_{GS} = 10$ V; $I_D = 500$ mA | 2.8 | 5 | Ω |
| | | $V_{GS} = 4.5$ V; $I_D = 75$ mA | 3.8 | 5.3 | Ω |

6. Limiting values

Table 3: Limiting values

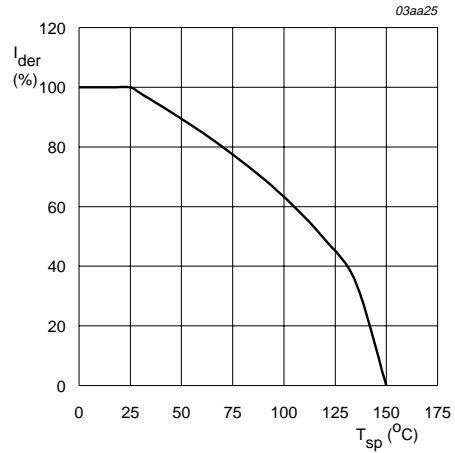
In accordance with the Absolute Maximum Rating System (IEC 60134).

| Symbol | Parameter | Conditions | Min | Max | Unit |
|---------------------------|-------------------------------------|--|-----|----------|------|
| V_{DS} | drain-source voltage (DC) | $T_j = 25$ to 150 °C | – | 60 | V |
| V_{DGR} | drain-gate voltage (DC) | $T_j = 25$ to 150 °C; $R_{GS} = 20$ k Ω | – | 60 | V |
| V_{GS} | gate-source voltage (DC) | | – | ± 30 | V |
| V_{GSM} | peak gate-source voltage | $t_p \leq 50$ μ s; pulsed; duty cycle = 25% | – | ± 40 | V |
| I_D | drain current (DC) | $T_{sp} = 25$ °C; $V_{GS} = 10$ V; Figure 2 and 3 | – | 300 | mA |
| | | $T_{sp} = 100$ °C; $V_{GS} = 10$ V; Figure 2 | – | 190 | mA |
| I_{DM} | peak drain current | $T_{sp} = 25$ °C; pulsed; $t_p \leq 10$ μ s; Figure 3 | – | 1.2 | A |
| P_{tot} | total power dissipation | $T_{sp} = 25$ °C; Figure 1 | – | 0.83 | W |
| T_{stg} | storage temperature | | –65 | +150 | °C |
| T_j | operating junction temperature | | –65 | +150 | °C |
| Source-drain diode | | | | | |
| I_S | source (diode forward) current (DC) | $T_{sp} = 25$ °C | – | 300 | mA |
| I_{SM} | peak source (diode forward) current | $T_{sp} = 25$ °C; pulsed; $t_p \leq 10$ μ s | – | 1.2 | A |



$$P_{der} = \frac{P_{tot}}{P_{tot(25^{\circ}C)}} \times 100\%$$

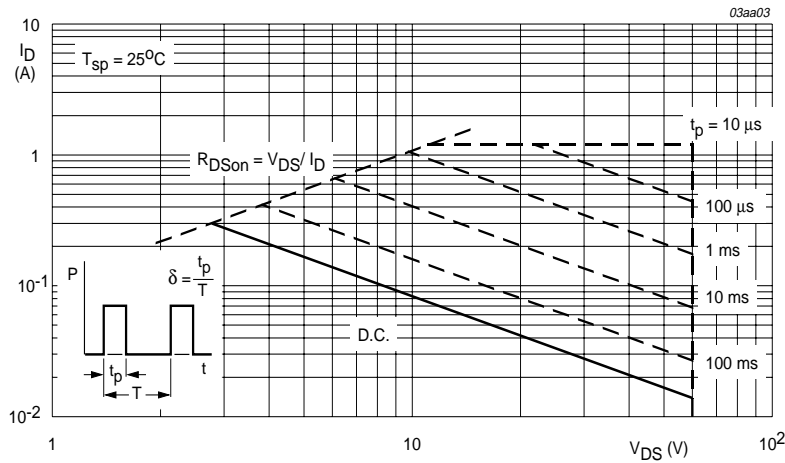
Fig 1. Normalized total power dissipation as a function of solder point temperature.



$$V_{GS} \geq 4.5 \text{ V}$$

$$I_{der} = \frac{I_D}{I_{D(25^{\circ}C)}} \times 100\%$$

Fig 2. Normalized continuous drain current as a function of solder point temperature.



$T_{sp} = 25^{\circ}C$; I_{DM} is single pulse.

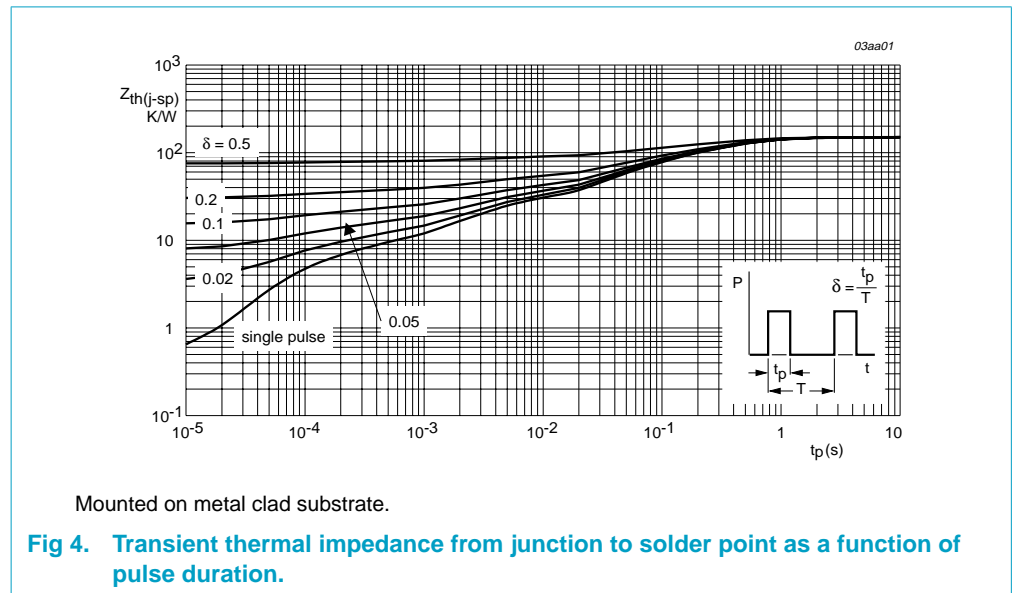
Fig 3. Safe operating area; continuous and peak drain currents as a function of drain-source voltage.

7. Thermal characteristics

Table 4: Thermal characteristics

| Symbol | Parameter | Conditions | Value | Unit |
|----------------|--|--|-------|------|
| $R_{th(j-sp)}$ | thermal resistance from junction to solder point | mounted on a metal clad substrate; Figure 4 | 150 | K/W |
| $R_{th(j-a)}$ | thermal resistance from junction to ambient | mounted on a printed circuit board; minimum footprint | 350 | K/W |

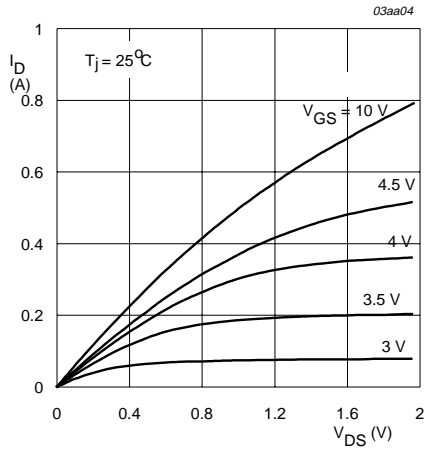
7.1 Transient thermal impedance



8. Characteristics

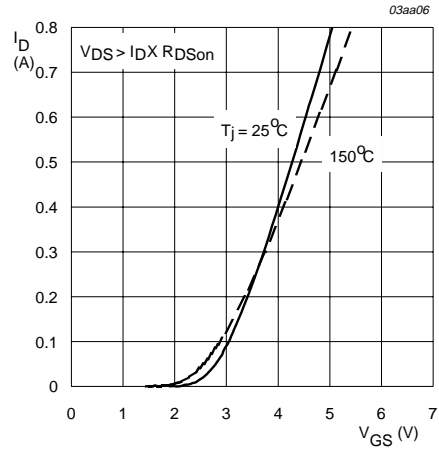
Table 5: Characteristics
 $T_j = 25\text{ °C}$ unless otherwise specified

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|--------------------------------|--------------------------------------|--|-----|------|------|---------------|
| Static characteristics | | | | | | |
| $V_{(BR)DSS}$ | drain-source breakdown voltage | $I_D = 10\ \mu\text{A}; V_{GS} = 0\ \text{V}$ $T_j = 25\text{ °C}$ | 60 | 75 | – | V |
| | | $T_j = -55\text{ °C}$ | 55 | – | – | V |
| $V_{GS(th)}$ | gate-source threshold voltage | $I_D = 1\ \text{mA}; V_{DS} = V_{GS};$ Figure 9 | | | | |
| | | $T_j = 25\text{ °C}$ | 1 | 2 | – | V |
| | | $T_j = 150\text{ °C}$ | 0.6 | – | – | V |
| | | $T_j = -55\text{ °C}$ | – | – | 3.5 | V |
| I_{DSS} | drain-source leakage current | $V_{DS} = 48\ \text{V}; V_{GS} = 0\ \text{V}$ $T_j = 25\text{ °C}$ | – | 0.01 | 1.0 | μA |
| | | $T_j = 150\text{ °C}$ | – | – | 10 | μA |
| | | | | | | |
| I_{GSS} | gate-source leakage current | $V_{GS} = \pm 15\ \text{V}; V_{DS} = 0\ \text{V}$ | – | 10 | 100 | nA |
| R_{Dson} | drain-source on-state resistance | $V_{GS} = 10\ \text{V}; I_D = 500\ \text{mA};$ Figure 7 and 8 | | | | |
| | | $T_j = 25\text{ °C}$ | – | 2.8 | 5 | Ω |
| | | $T_j = 150\text{ °C}$ | – | – | 9.25 | Ω |
| | | $V_{GS} = 4.5\ \text{V}; I_D = 75\ \text{mA};$ Figure 7 and 8 | | | | |
| | | $T_j = 25\text{ °C}$ | – | 3.8 | 5.3 | Ω |
| Dynamic characteristics | | | | | | |
| g_{fs} | forward transconductance | $V_{DS} = 10\ \text{V}; I_D = 200\ \text{mA};$ Figure 11 | 100 | 300 | – | mS |
| C_{iss} | input capacitance | $V_{GS} = 0\ \text{V}; V_{DS} = 10\ \text{V};$ $f = 1\ \text{MHz};$ Figure 12 | – | 25 | 40 | pF |
| C_{oss} | output capacitance | | – | 18 | 30 | pF |
| C_{rss} | reverse transfer capacitance | | – | 7.5 | 10 | pF |
| t_{on} | turn-on time | $V_{DD} = 50\ \text{V}; R_D = 250\ \Omega;$ | – | 3 | 10 | ns |
| t_{off} | turn-off time | $V_{GS} = 10\ \text{V}; R_G = 50\ \Omega;$ $R_{GS} = 50\ \Omega$ | – | 12 | 15 | ns |
| Source-drain diode | | | | | | |
| V_{SD} | source-drain (diode forward) voltage | $I_S = 300\ \text{mA}; V_{GS} = 0\ \text{V};$ Figure 13 | – | 0.85 | 1.5 | V |
| t_{rr} | reverse recovery time | $I_S = 300\ \text{mA};$ | – | 30 | – | ns |
| Q_r | recovered charge | $di_S/dt = -100\ \text{A}/\mu\text{s};$ $V_{GS} = 0\ \text{V}; V_{DS} = 25\ \text{V}$ | – | 30 | – | nC |



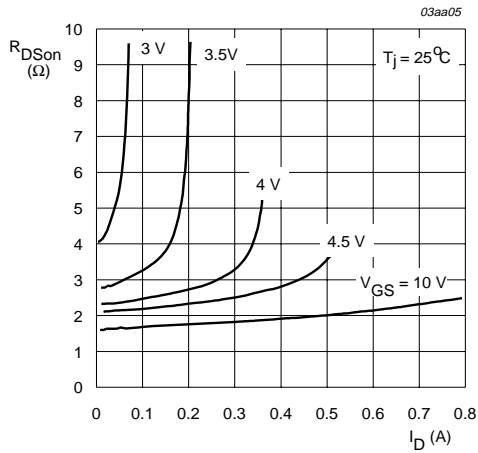
$T_j = 25^\circ\text{C}$

Fig 5. Output characteristics: drain current as a function of drain-source voltage; typical values.



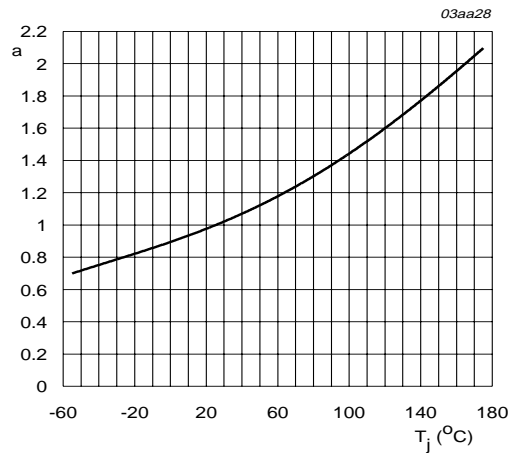
$T_j = 25^\circ\text{C}$ and 150°C ; $V_{DS} > I_D \times R_{DSon}$

Fig 6. Transfer characteristics: drain current as a function of gate-source voltage; typical values.



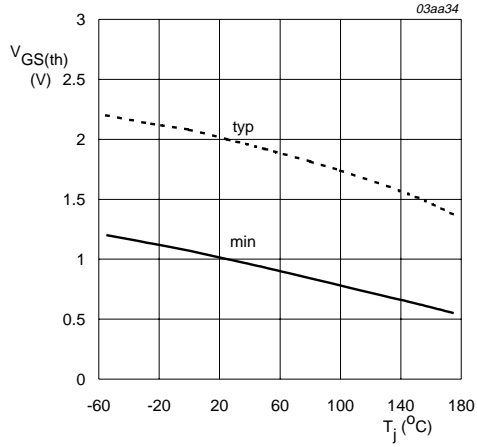
$T_j = 25^\circ\text{C}$

Fig 7. Drain-source on-state resistance as a function of drain current; typical values.



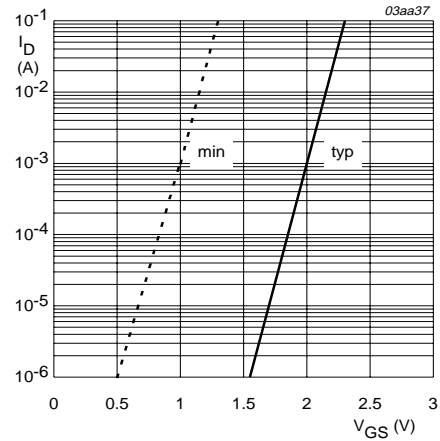
$$a = \frac{R_{DSon}}{R_{DSon}(25^\circ\text{C})}$$

Fig 8. Normalized drain-source on-state resistance factor as a function of junction temperature.



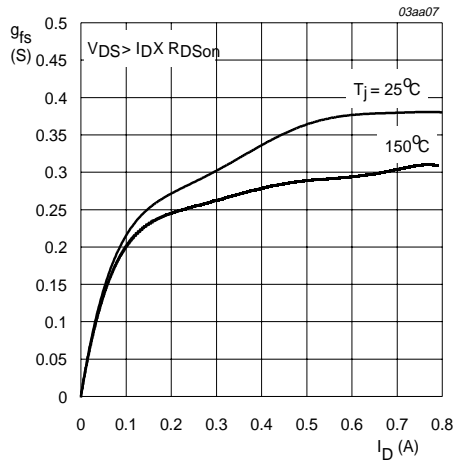
$I_D = 1 \text{ mA}; V_{DS} = V_{GS}$

Fig 9. Gate-source threshold voltage as a function of junction temperature.



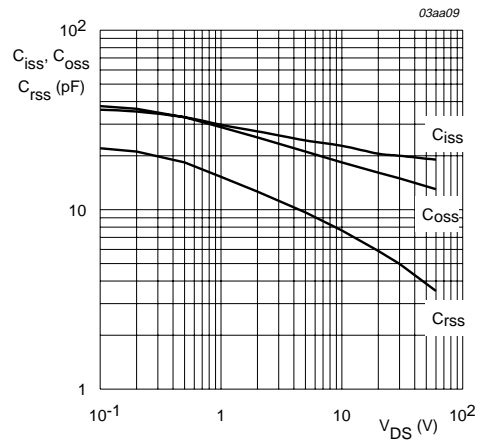
$T_j = 25 \text{ }^{\circ}C; V_{DS} = 5 \text{ V}$

Fig 10. Sub-threshold drain current as a function of gate-source voltage.



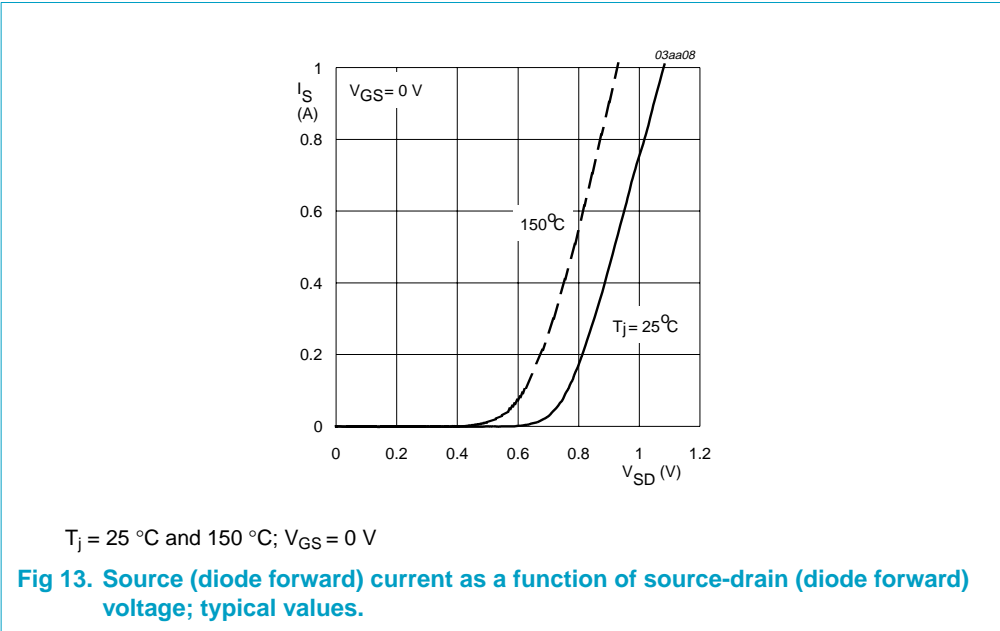
$T_j = 25 \text{ }^{\circ}C \text{ and } 150 \text{ }^{\circ}C; V_{DS} > I_D \times R_{DS(on)}$

Fig 11. Forward transconductance as a function of drain current; typical values.



$V_{GS} = 0 \text{ V}; f = 1 \text{ MHz}$

Fig 12. Input, output and reverse transfer capacitances as a function of drain-source voltage; typical values.



9. Package outline

Plastic surface mounted package; 3 leads

SOT23

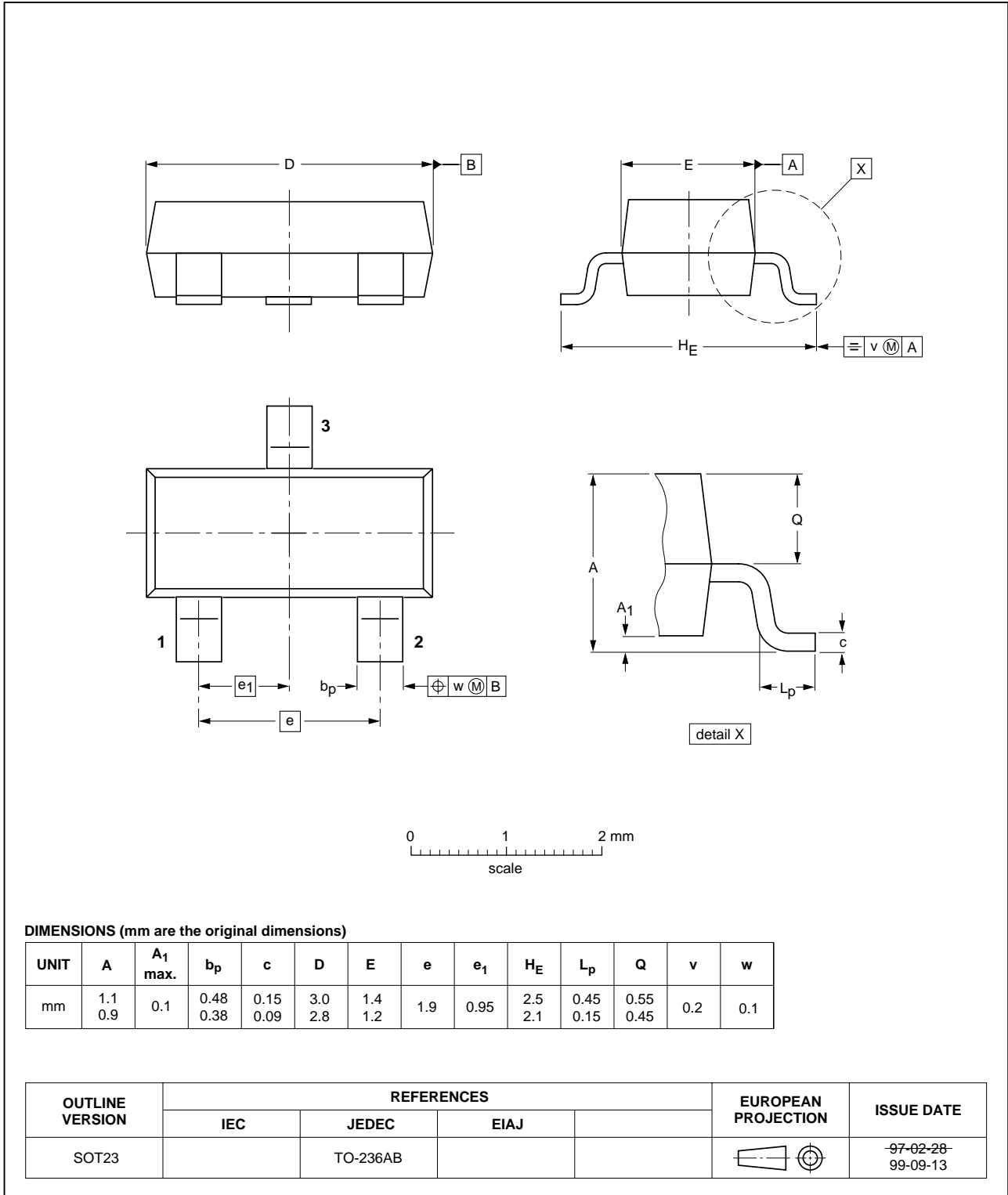


Fig 14. SOT23.

10. Revision history

Table 6: Revision history

| Rev | Date | CPCN | Description |
|-----|----------|--------|--|
| 03 | 20000727 | HZG336 | Product specification; third version; supersedes 2N7002_CNV_2 of 970617. Converted from VDMOS (Nijmegen) to TrenchMOS™ (Hazel Grove) technology. |
| 02 | 19970617 | - | Product specification; second version. |
| 01 | 19901031 | - | Product specification; initial version. |

11. Data sheet status

| Datasheet status | Product status | Definition ^[1] |
|---------------------------|----------------|--|
| Objective specification | Development | This data sheet contains the design target or goal specifications for product development. Specification may change in any manner without notice. |
| Preliminary specification | Qualification | This data sheet contains preliminary data, and supplementary data will be published at a later date. Philips Semiconductors reserves the right to make changes at any time without notice in order to improve design and supply the best possible product. |
| Product specification | Production | This data sheet contains final specifications. Philips Semiconductors reserves the right to make changes at any time without notice in order to improve design and supply the best possible product. |

[1] Please consult the most recently issued data sheet before initiating or completing a design.

12. Definitions

Short-form specification — The data in a short-form specification is extracted from a full data sheet with the same type number and title. For detailed information see the relevant data sheet or data handbook.

Limiting values definition — Limiting values given are in accordance with the Absolute Maximum Rating System (IEC 60134). Stress above one or more of the limiting values may cause permanent damage to the device. These are stress ratings only and operation of the device at these or at any other conditions above those given in the Characteristics sections of the specification is not implied. Exposure to limiting values for extended periods may affect device reliability.

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Argentina: see South America

Australia: Tel. +61 2 9704 8141, Fax. +61 2 9704 8139

Austria: Tel. +43 160 101, Fax. +43 160 101 1210

Belarus: Tel. +375 17 220 0733, Fax. +375 17 220 0773

Belgium: see The Netherlands

Brazil: see South America

Bulgaria: Tel. +359 268 9211, Fax. +359 268 9102

Canada: Tel. +1 800 234 7381

China/Hong Kong: Tel. +852 2 319 7888, Fax. +852 2 319 7700

Colombia: see South America

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Denmark: Tel. +45 3 288 2636, Fax. +45 3 157 0044

Finland: Tel. +358 961 5800, Fax. +358 96 158 0920

France: Tel. +33 14 099 6161, Fax. +33 14 099 6427

Germany: Tel. +49 40 23 5360, Fax. +49 402 353 6300

Hungary: see Austria

India: Tel. +91 22 493 8541, Fax. +91 22 493 8722

Indonesia: see Singapore

Ireland: Tel. +353 17 64 0000, Fax. +353 17 64 0200

Israel: Tel. +972 36 45 0444, Fax. +972 36 49 1007

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Japan: Tel. +81 33 740 5130, Fax. +81 3 3740 5057

Korea: Tel. +82 27 09 1412, Fax. +82 27 09 1415

Malaysia: Tel. +60 37 50 5214, Fax. +60 37 57 4880

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For all other countries apply to: Philips Semiconductors,
Marketing Communications,
Building BE, P.O. Box 218, 5600 MD EINDHOVEN,
The Netherlands, Fax. +31 40 272 4825

Netherlands: Tel. +31 40 278 2785, Fax. +31 40 278 8399

New Zealand: Tel. +64 98 49 4160, Fax. +64 98 49 7811

Norway: Tel. +47 22 74 8000, Fax. +47 22 74 8341

Philippines: Tel. +63 28 16 6380, Fax. +63 28 17 3474

Poland: Tel. +48 22 5710 000, Fax. +48 22 5710 001

Portugal: see Spain

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Russia: Tel. +7 095 755 6918, Fax. +7 095 755 6919

Singapore: Tel. +65 350 2538, Fax. +65 251 6500

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Sweden: Tel. +46 86 32 2000, Fax. +46 86 32 2745

Switzerland: Tel. +41 14 88 2686, Fax. +41 14 81 7730

Taiwan: Tel. +886 22 134 2451, Fax. +886 22 134 2874

Thailand: Tel. +66 23 61 7910, Fax. +66 23 98 3447

Turkey: Tel. +90 216 522 1500, Fax. +90 216 522 1813

Ukraine: Tel. +380 44 264 2776, Fax. +380 44 268 0461

United Kingdom: Tel. +44 208 730 5000, Fax. +44 208 754 8421

United States: Tel. +1 800 234 7381

Uruguay: see South America

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Yugoslavia: Tel. +381 11 3341 299, Fax. +381 11 3342 553

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Contents

| | | |
|-----|---------------------------------------|----|
| 1 | Description | 1 |
| 2 | Features | 1 |
| 3 | Applications | 1 |
| 4 | Pinning information | 1 |
| 5 | Quick reference data | 2 |
| 6 | Limiting values | 2 |
| 7 | Thermal characteristics | 4 |
| 7.1 | Transient thermal impedance | 4 |
| 8 | Characteristics | 5 |
| 9 | Package outline | 9 |
| 10 | Revision history | 10 |
| 11 | Data sheet status | 11 |
| 12 | Definitions | 11 |
| 13 | Disclaimers | 11 |



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