

# 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™<sup>1</sup> technology.

Product availability:

2N7002 in SOT23.

## 2. Features

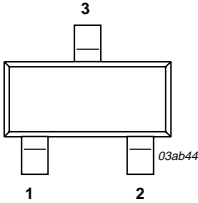
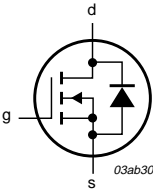
- TrenchMOS™ technology
- Very fast switching
- Logic level compatible
- Subminiature surface mount package.

## 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**

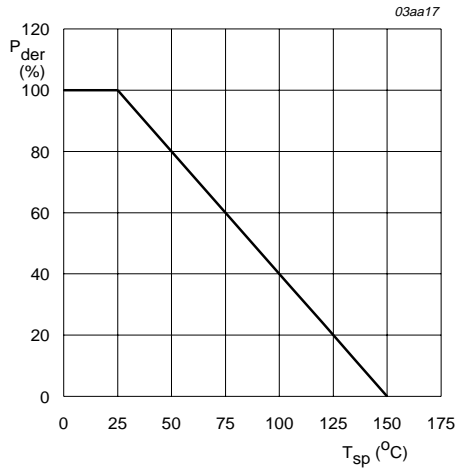
Symbol	Parameter	Conditions	Typ	Max	Unit
$V_{DS}$	drain-source voltage (DC)	$T_j = 25$ to $150$ °C	–	60	V
$I_D$	drain current (DC)	$T_{sp} = 25$ °C; $V_{GS} = 10$ V	–	300	mA
$P_{tot}$	total power dissipation	$T_{sp} = 25$ °C	–	0.83	W
$T_j$	junction temperature		–	150	°C
$R_{DS(on)}$	drain-source on-state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

## 6. Limiting values

**Table 3: Limiting values**

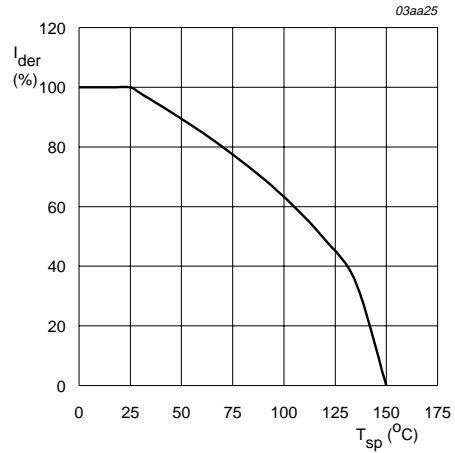
In accordance with the Absolute Maximum Rating System (IEC 60134).

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 $\Omega$	–	60	V
$V_{GS}$	gate-source voltage (DC)		–	$\pm 30$	V
$V_{GSM}$	peak gate-source voltage	$t_p \leq 50$ $\mu$ s; pulsed; duty cycle = 25%	–	$\pm 40$	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; $t_p \leq 10$ $\mu$ 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
<b>Source-drain diode</b>					
$I_S$	source (diode forward) current (DC)	$T_{sp} = 25$ °C	–	300	mA
$I_{SM}$	peak source (diode forward) current	$T_{sp} = 25$ °C; pulsed; $t_p \leq 10$ $\mu$ s	–	1.2	A



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

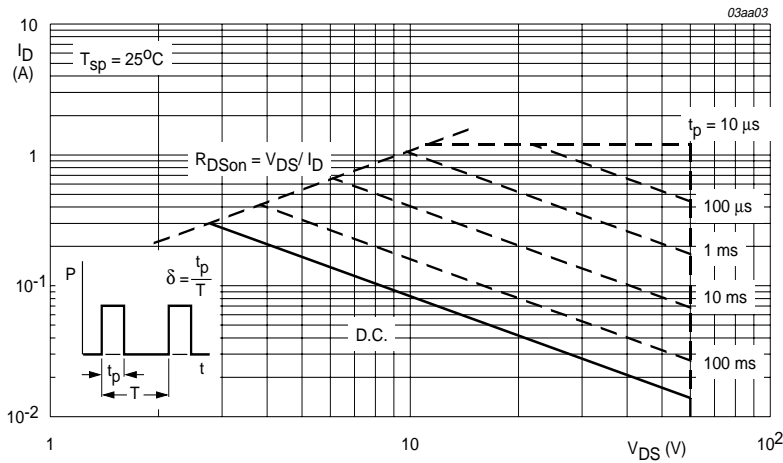
Fig 1. Normalized total power dissipation as a function of solder point temperature.



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

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

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



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

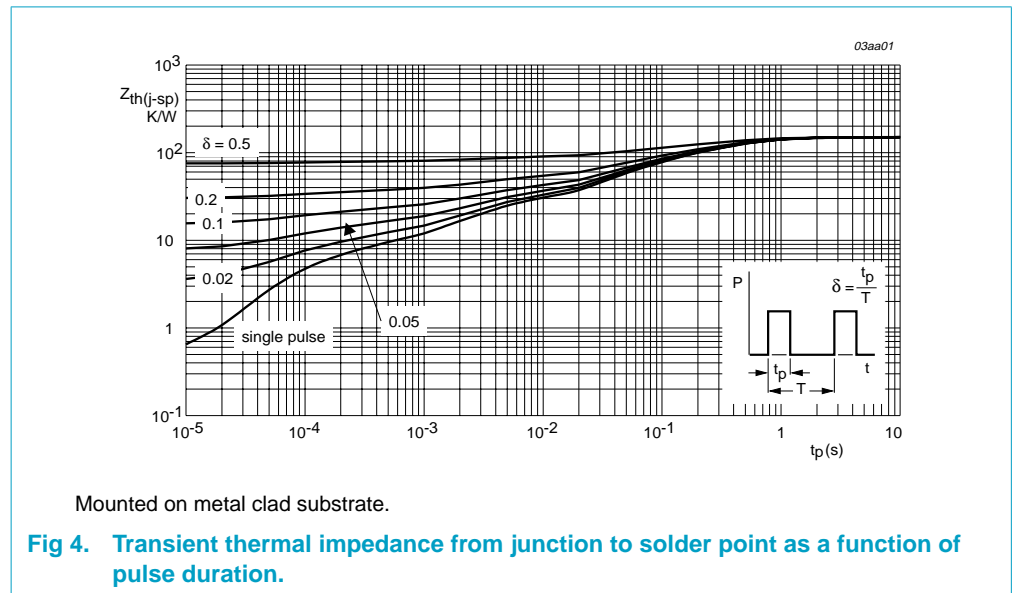
Fig 3. Safe operating area; continuous and peak drain currents as a function of drain-source voltage.

## 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

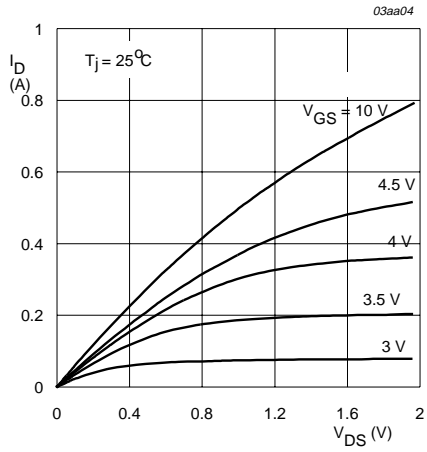


## 8. Characteristics

**Table 5: Characteristics**

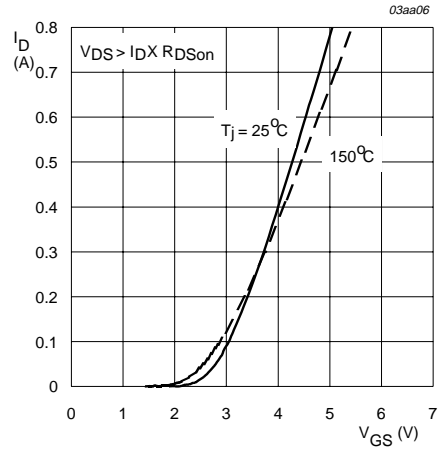
$T_j = 25\text{ °C}$  unless otherwise specified

Symbol	Parameter	Conditions	Min	Typ	Max	Unit	
<b>Static characteristics</b>							
$V_{(BR)DSS}$	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	$I_D = 1\ \text{mA}; V_{DS} = V_{GS};$ <b>Figure 9</b>					
		$T_j = 25\text{ °C}$	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	$\mu\text{A}$	
		$T_j = 150\text{ °C}$	–	–	10	$\mu\text{A}$	
$I_{GSS}$	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	$V_{GS} = 10\ \text{V}; I_D = 500\ \text{mA};$ <b>Figure 7 and 8</b>					
		$T_j = 25\text{ °C}$	–	2.8	5	$\Omega$	
		$T_j = 150\text{ °C}$	–	–	9.25	$\Omega$	
		$V_{GS} = 4.5\ \text{V}; I_D = 75\ \text{mA};$ <b>Figure 7 and 8</b>					
		$T_j = 25\text{ °C}$	–	3.8	5.3	$\Omega$	
<b>Dynamic characteristics</b>							
$g_{fs}$	forward transconductance	$V_{DS} = 10\ \text{V}; I_D = 200\ \text{mA};$ <b>Figure 11</b>	100	300	–	mS	
$C_{iss}$	input capacitance	$V_{GS} = 0\ \text{V}; V_{DS} = 10\ \text{V};$ $f = 1\ \text{MHz};$ <b>Figure 12</b>	–	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	
<b>Source-drain diode</b>							
$V_{SD}$	source-drain (diode forward) voltage	$I_S = 300\ \text{mA}; V_{GS} = 0\ \text{V};$ <b>Figure 13</b>	–	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	



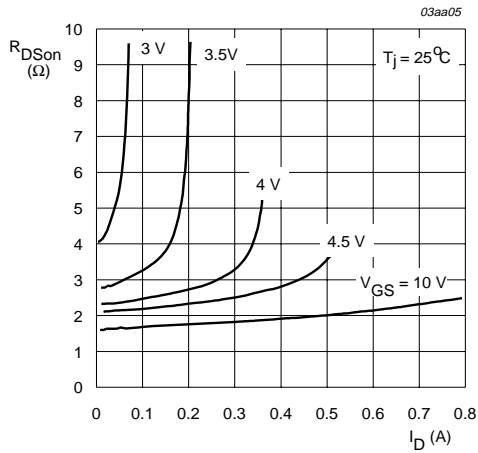
$T_j = 25^\circ\text{C}$

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



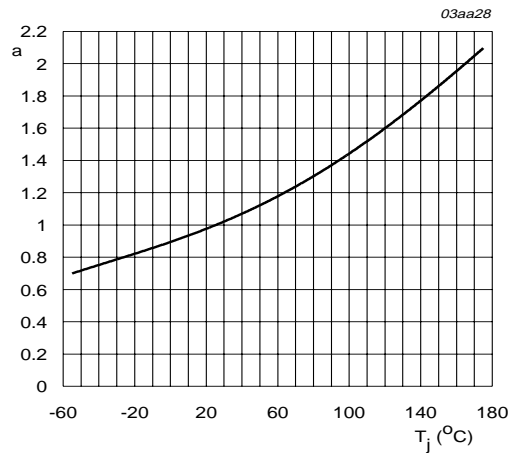
$T_j = 25^\circ\text{C}$  and  $150^\circ\text{C}$ ;  $V_{DS} > I_D \times R_{DSon}$

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



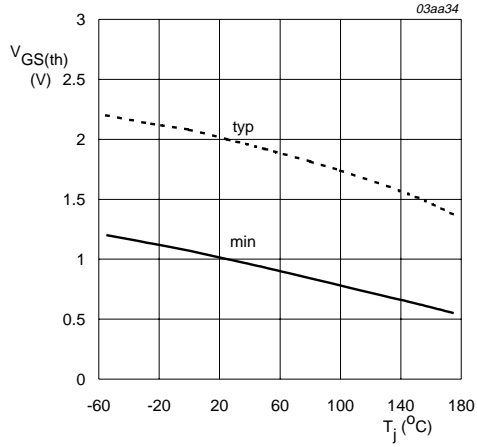
$T_j = 25^\circ\text{C}$

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



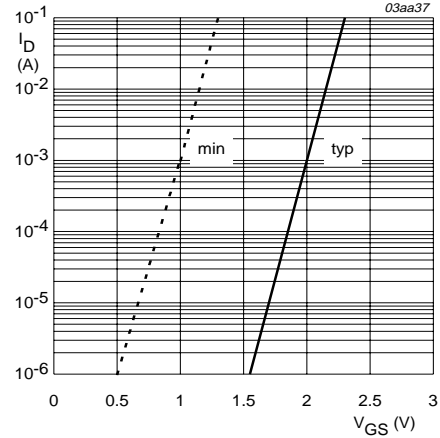
$$a = \frac{R_{DSon}}{R_{DSon}(25^\circ\text{C})}$$

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



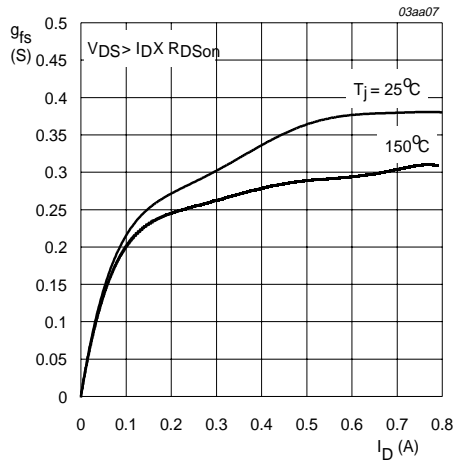
$I_D = 1 \text{ mA}; V_{DS} = V_{GS}$

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



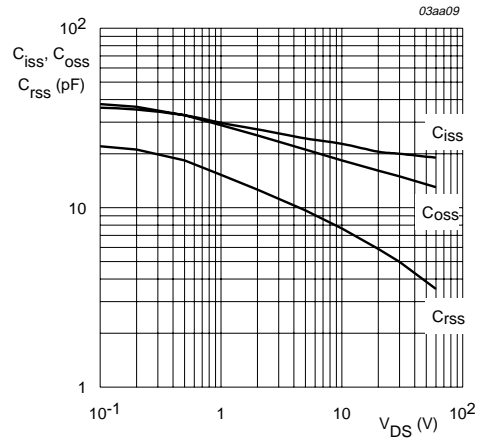
$T_j = 25 \text{ }^{\circ}C; V_{DS} = 5 \text{ V}$

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



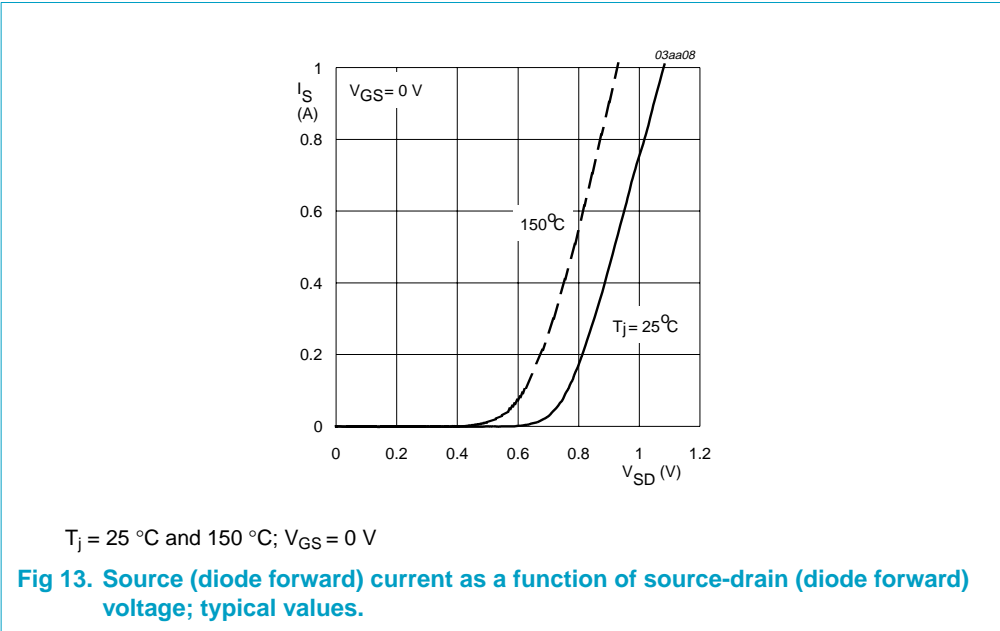
$T_j = 25 \text{ }^{\circ}C \text{ and } 150 \text{ }^{\circ}C; V_{DS} > I_D \times R_{DS(on)}$

**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

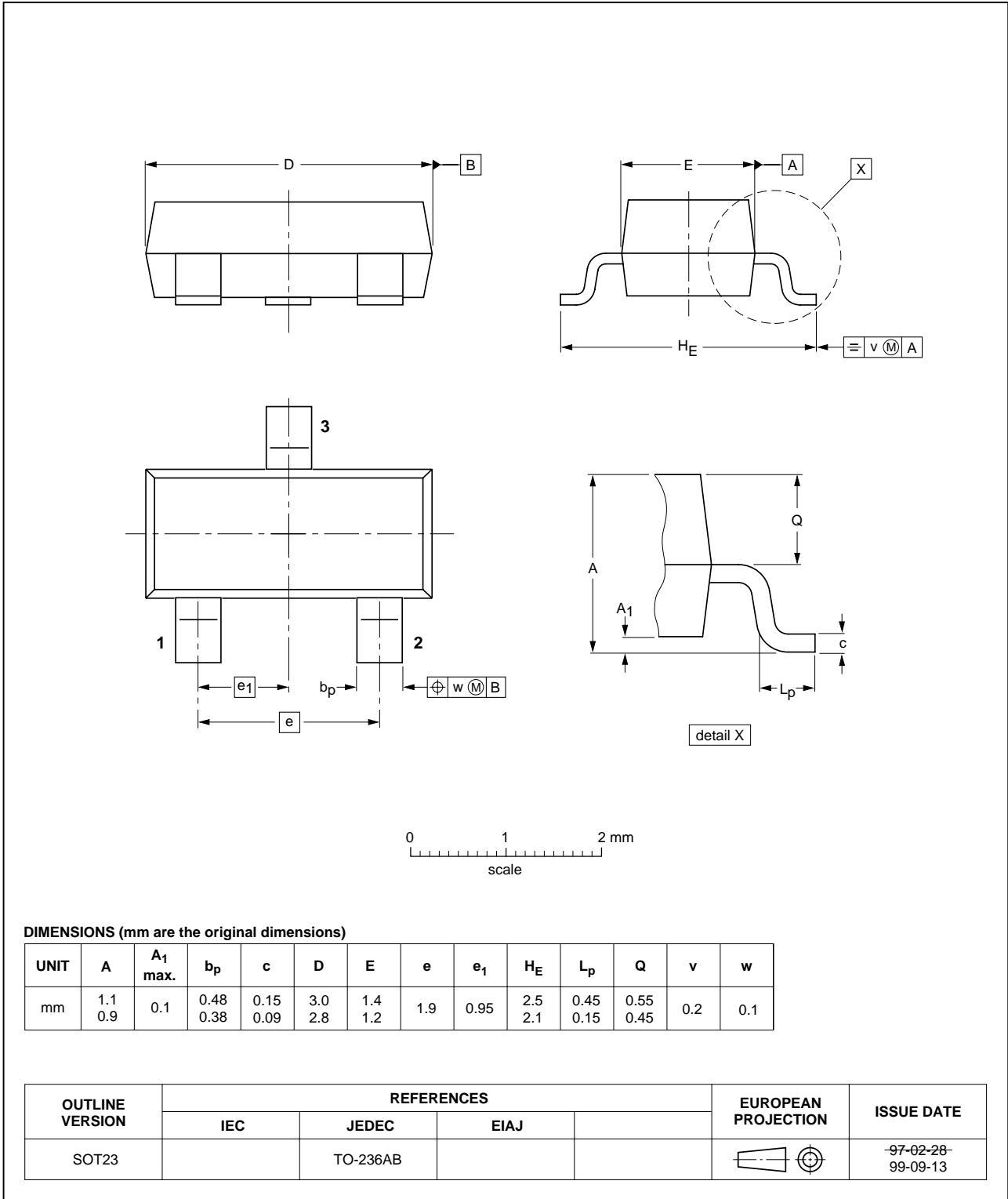


Fig 14. SOT23.

## 10. Revision history

Table 6: Revision history

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

## 11. Data sheet status

Datasheet status	Product status	Definition <sup>[1]</sup>
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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