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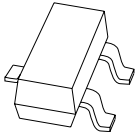
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Kind regards,

Team Nexperia



# 2N7002E

## N-channel TrenchMOS FET

Rev. 03 — 28 April 2006

Product data sheet

## 1. Product profile

### 1.1 General description

N-channel enhancement mode Field-Effect Transistor (FET) in a plastic package using TrenchMOS technology.

### 1.2 Features

- Logic level threshold compatible
- Surface-mounted package
- Very fast switching
- TrenchMOS technology

### 1.3 Applications

- Logic level translator
- High-speed line driver

### 1.4 Quick reference data

- $V_{DS} \leq 60 \text{ V}$
- $R_{DSon} \leq 3 \Omega$
- $I_D \leq 385 \text{ mA}$
- $P_{tot} \leq 0.83 \text{ W}$

## 2. Pinning information

Table 1: Pinning

Pin	Description	Simplified outline	Symbol
1	gate (G)	<p>SOT23</p>	<p>mbb076</p>
2	source (S)		
3	drain (D)		

# PHILIPS

### 3. Ordering information

**Table 2: Ordering information**

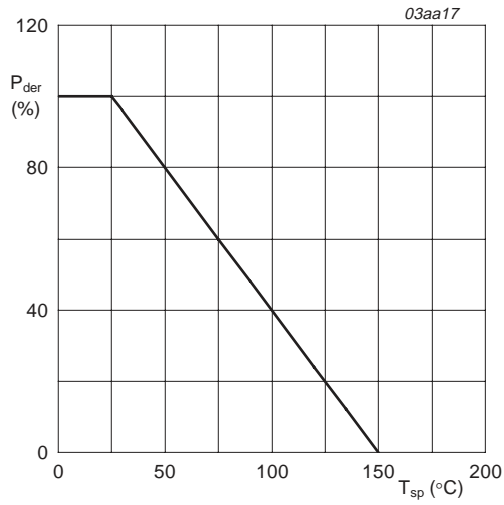
Type number	Package		
	Name	Description	Version
2N7002E	TO-236AB	plastic surface-mounted package; 3 leads	SOT23

### 4. Limiting values

**Table 3: Limiting values**

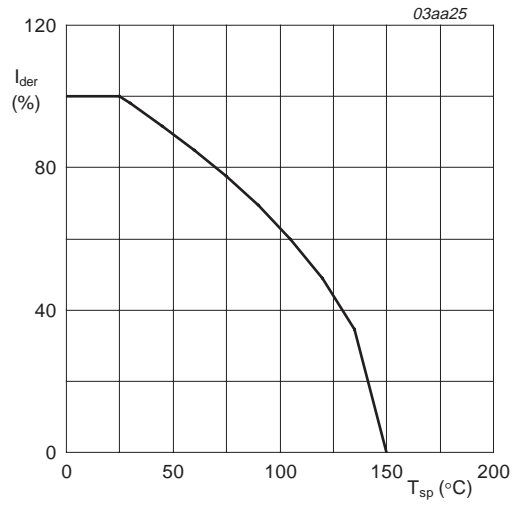
In accordance with the Absolute Maximum Rating System (IEC 60134).

Symbol	Parameter	Conditions	Min	Max	Unit
$V_{DS}$	drain-source voltage	$25\text{ °C} \leq T_j \leq 150\text{ °C}$	-	60	V
$V_{DGR}$	drain-gate voltage (DC)	$25\text{ °C} \leq T_j \leq 150\text{ °C}$ ; $R_{GS} = 20\text{ k}\Omega$	-	60	V
$V_{GS}$	gate-source voltage		-	$\pm 30$	V
$V_{GSM}$	peak gate-source voltage	$t_p \leq 50\text{ }\mu\text{s}$ ; pulsed; duty cycle = 25 %	-	$\pm 40$	V
$I_D$	drain current	$T_{sp} = 25\text{ °C}$ ; $V_{GS} = 10\text{ V}$ ; see <a href="#">Figure 2</a> and <a href="#">3</a>	-	385	mA
		$T_{sp} = 100\text{ °C}$ ; $V_{GS} = 10\text{ V}$ ; see <a href="#">Figure 2</a>	-	245	mA
$I_{DM}$	peak drain current	$T_{sp} = 25\text{ °C}$ ; pulsed; $t_p \leq 10\text{ }\mu\text{s}$ ; see <a href="#">Figure 3</a>	-	1.5	A
$P_{tot}$	total power dissipation	$T_{sp} = 25\text{ °C}$ ; see <a href="#">Figure 1</a>	-	0.83	W
$T_{stg}$	storage temperature		-65	+150	°C
$T_j$	junction temperature		-65	+150	°C
<b>Source-drain diode</b>					
$I_S$	source current	$T_{sp} = 25\text{ °C}$	-	385	mA
$I_{SM}$	peak source current	$T_{sp} = 25\text{ °C}$ ; pulsed; $t_p \leq 10\text{ }\mu\text{s}$	-	1.5	mA



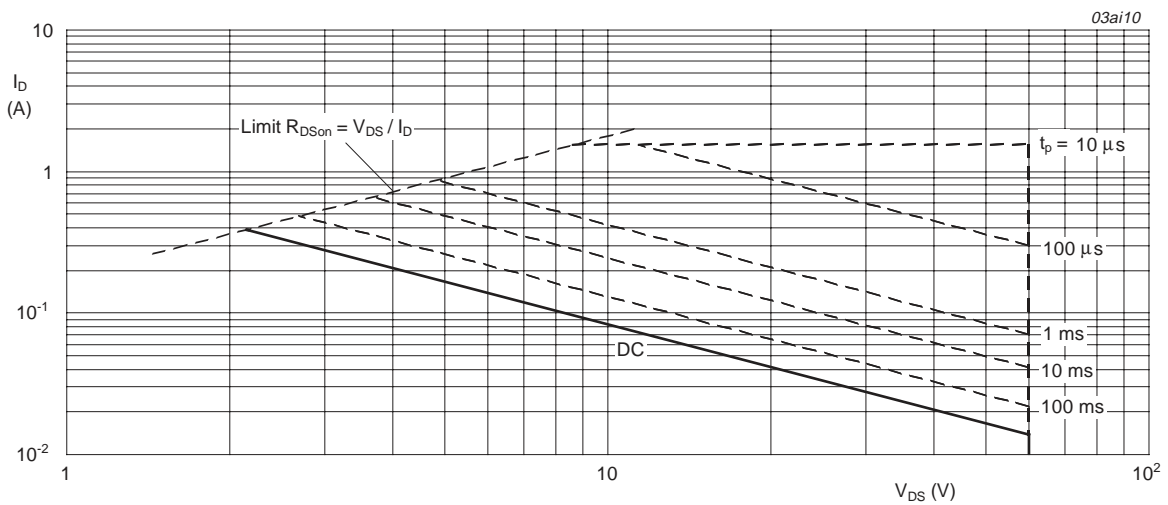
$$P_{der} = \frac{P_{tot}}{P_{tot(25^\circ C)}} \times 100\%$$

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



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

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



T<sub>sp</sub> = 25 °C; I<sub>DM</sub> is single pulse

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

## 5. Thermal characteristics

Table 4: Thermal characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$R_{th(j-sp)}$	thermal resistance from junction to solder point	see <a href="#">Figure 4</a>	-	-	150	K/W
$R_{th(j-a)}$	thermal resistance from junction to ambient		[1]	-	350	K/W

[1] Mounted on a printed-circuit board; minimum footprint; vertical in still air

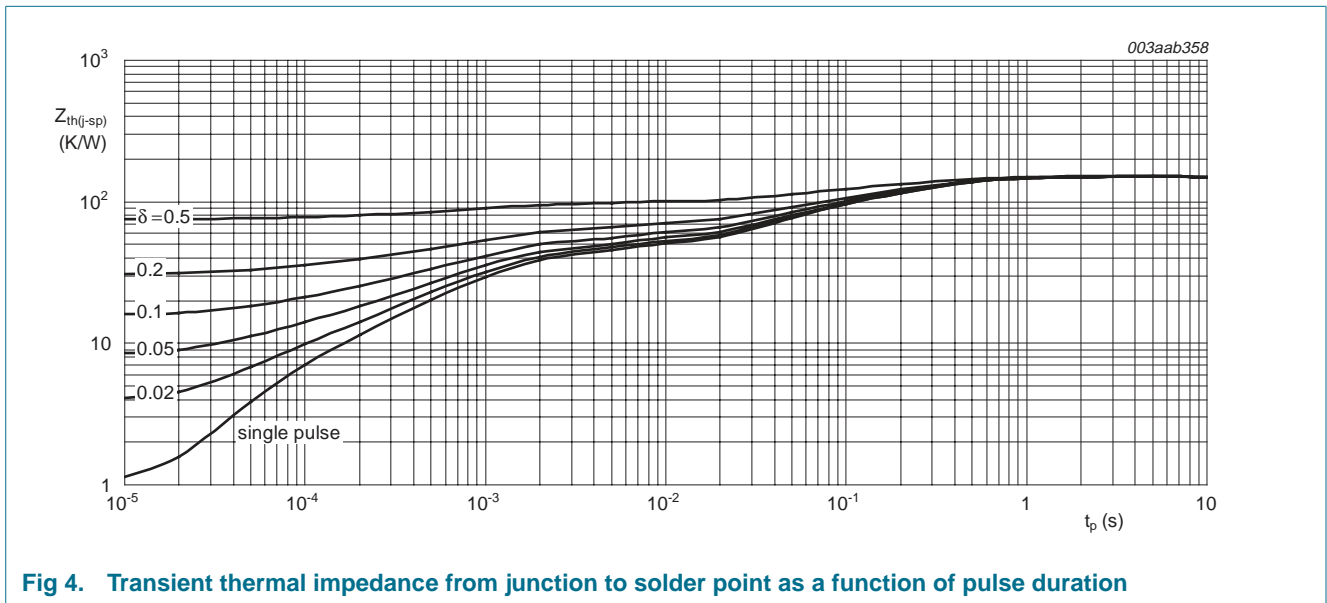


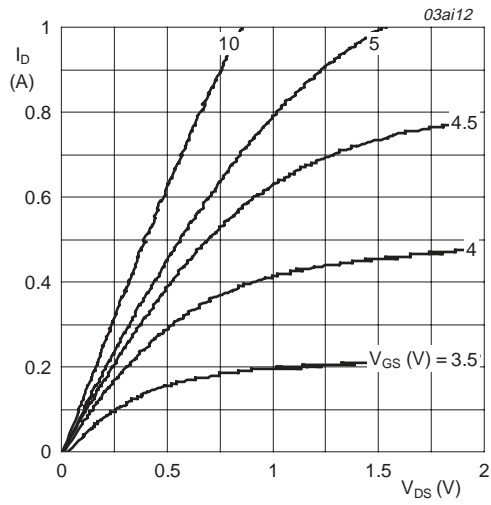
Fig 4. Transient thermal impedance from junction to solder point as a function of pulse duration

## 6. Characteristics

**Table 5: Characteristics**

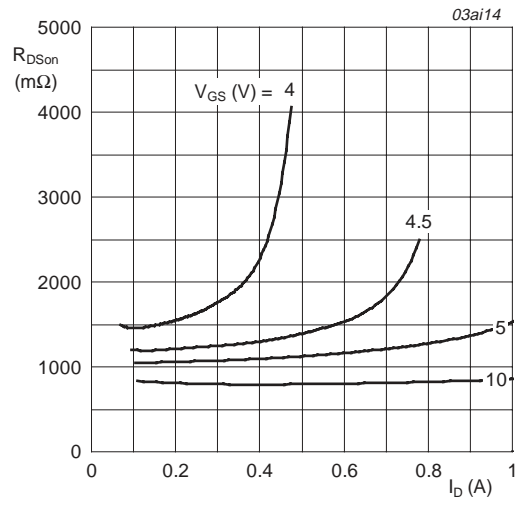
$T_j = 25\text{ }^\circ\text{C}$  unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
<b>Static characteristics</b>						
$V_{(BR)DSS}$	drain-source breakdown voltage	$I_D = 10\text{ }\mu\text{A}$ ; $V_{GS} = 0\text{ V}$				
		$T_j = 25\text{ }^\circ\text{C}$	60	-	-	V
		$T_j = -55\text{ }^\circ\text{C}$	55	-	-	V
$V_{GS(th)}$	gate-source threshold voltage	$I_D = 0.25\text{ mA}$ ; $V_{DS} = V_{GS}$ ; see <a href="#">Figure 9</a> and <a href="#">10</a>				
		$T_j = 25\text{ }^\circ\text{C}$	1	2	2.5	V
		$T_j = 150\text{ }^\circ\text{C}$	0.6	-	-	V
		$T_j = -55\text{ }^\circ\text{C}$	-	-	2.75	V
$I_{DSS}$	drain leakage current	$V_{DS} = 48\text{ V}$ ; $V_{GS} = 0\text{ V}$				
		$T_j = 25\text{ }^\circ\text{C}$	-	-	1	$\mu\text{A}$
		$T_j = 150\text{ }^\circ\text{C}$	-	-	10	$\mu\text{A}$
$I_{GSS}$	gate leakage current	$V_{GS} = \pm 15\text{ V}$ ; $V_{DS} = 0\text{ V}$	-	10	100	nA
$R_{DS(on)}$	drain-source on-state resistance	$V_{GS} = 10\text{ V}$ ; $I_D = 500\text{ mA}$ ; see <a href="#">Figure 6</a> and <a href="#">8</a>				
		$T_j = 25\text{ }^\circ\text{C}$	-	0.78	3	$\Omega$
		$T_j = 150\text{ }^\circ\text{C}$	-	1.45	5.5	$\Omega$
		$V_{GS} = 4.5\text{ V}$ ; $I_D = 75\text{ mA}$ ; see <a href="#">Figure 6</a> and <a href="#">8</a>	-	1.2	4	$\Omega$
<b>Dynamic characteristics</b>						
$Q_{G(tot)}$	total gate charge	$I_D = 300\text{ mA}$ ; $V_{DS} = 30\text{ V}$ ; $V_{GS} = 10\text{ V}$ ; see <a href="#">Figure 11</a> and <a href="#">12</a>	-	0.69	-	nC
$Q_{GS}$	gate-source charge		-	0.1	-	nC
$Q_{GD}$	gate-drain charge		-	0.27	-	nC
$C_{iss}$	input capacitance	$V_{GS} = 0\text{ V}$ ; $V_{DS} = 10\text{ V}$ ; $f = 1\text{ MHz}$ ; see <a href="#">Figure 14</a>	-	31	50	pF
$C_{oss}$	output capacitance		-	6.8	30	pF
$C_{rss}$	reverse transfer capacitance		-	3.5	10	pF
$t_{on}$	turn-on time	$V_{DS} = 50\text{ V}$ ; $R_L = 250\text{ }\Omega$ ; $V_{GS} = 10\text{ V}$ ; $R_G = 50\text{ }\Omega$ ; $R_{GS} = 50\text{ }\Omega$	-	2.5	10	ns
$t_{off}$	turn-off time		-	11	15	ns
<b>Source-drain diode</b>						
$V_{SD}$	source-drain voltage	$I_S = 300\text{ mA}$ ; $V_{GS} = 0\text{ V}$ ; see <a href="#">Figure 13</a>	-	0.85	1.5	V
$t_{rr}$	reverse recovery time	$I_S = 300\text{ mA}$ ; $di_S/dt = -100\text{ A}/\mu\text{s}$ ; $V_{GS} = 0\text{ V}$	-	30	-	ns
$Q_r$	recovered charge		-	30	-	nC



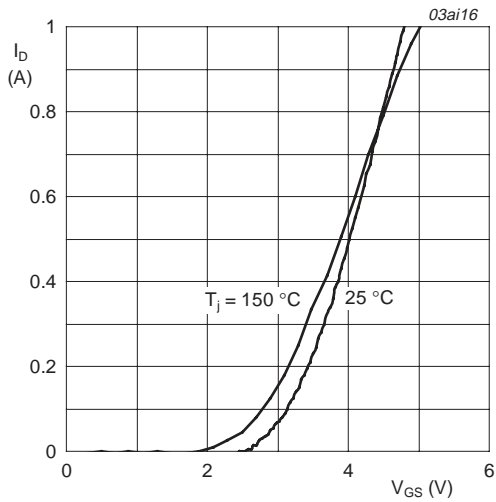
$T_j = 25\text{ }^\circ\text{C}$

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



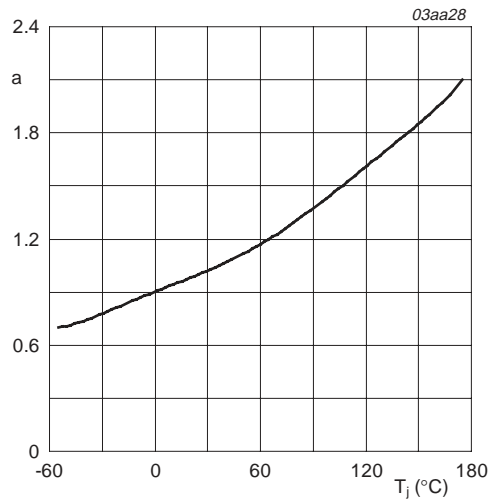
$T_j = 25\text{ }^\circ\text{C}$

**Fig 6. Drain-source on-state resistance as a function of drain current; typical values**



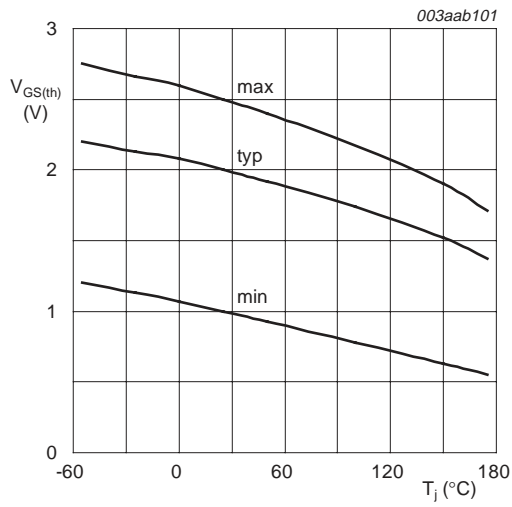
$T_j = 25\text{ }^\circ\text{C}$  and  $150\text{ }^\circ\text{C}$ ;  $V_{DS} > I_D \times R_{DS(on)}$

**Fig 7. Transfer characteristics: drain current as a function of gate-source voltage; typical values**



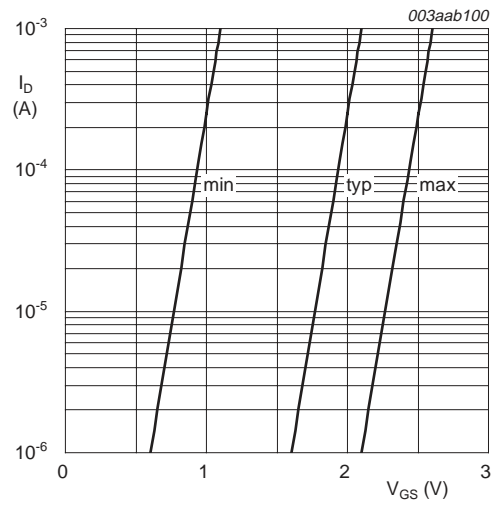
$$a = \frac{R_{DS(on)}}{R_{DS(on)(25\text{ }^\circ\text{C})}}$$

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



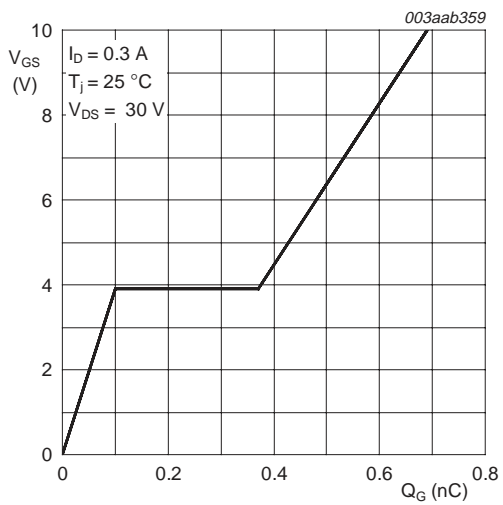
$I_D = 0.25 \text{ mA}; V_{DS} = V_{GS}$

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



$I_D = 0.3 \text{ A}; V_{DS} = 30 \text{ V}$

Fig 11. Gate-source voltage as a function of gate charge; typical values

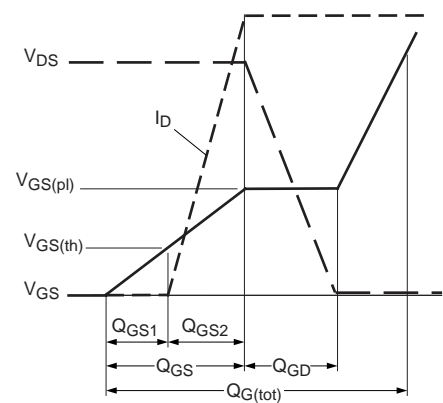
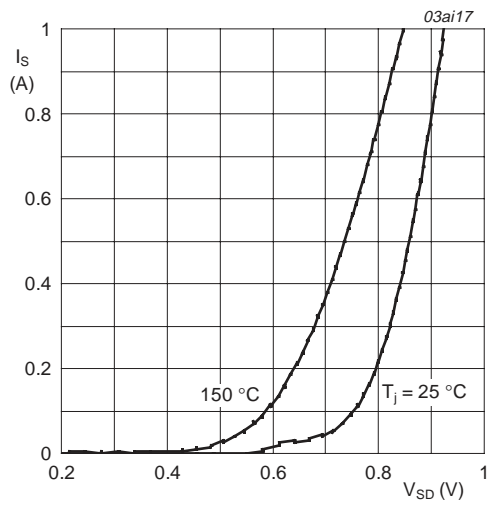


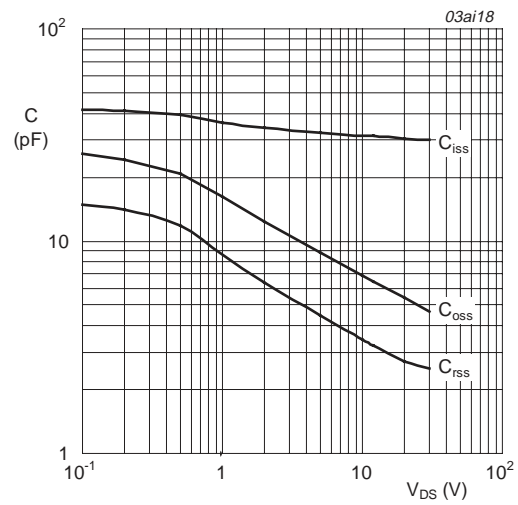
Fig 12. Gate charge waveform definitions





$T_j = 25\text{ }^\circ\text{C}$  and  $150\text{ }^\circ\text{C}$ ;  $V_{GS} = 0\text{ V}$

**Fig 13. Source current as a function of source-drain voltage; typical values**



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

**Fig 14. Input, output and reverse transfer capacitances as a function of drain-source voltage; typical values**

7. Package outline

Plastic surface-mounted package; 3 leads

SOT23

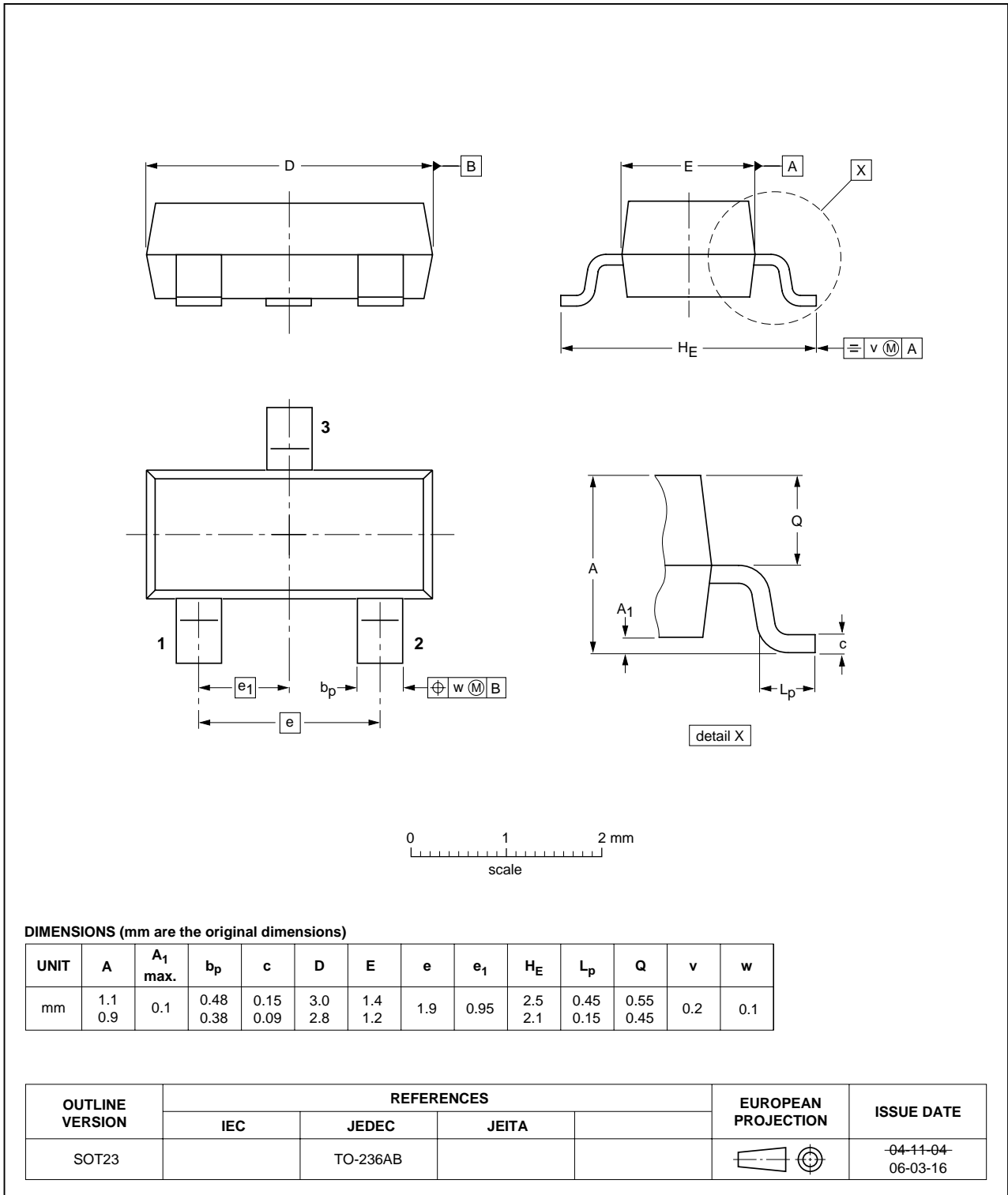


Fig 15. Package outline SOT23

## 8. Revision history

**Table 6: Revision history**

Document ID	Release date	Data sheet status	Change notice	Doc. number	Supersedes
2N7002E_3	20060428	Product data sheet	-	-	2N7002E_2
Modifications:	<ul style="list-style-type: none"> <li>• <a href="#">Table 5 “Characteristics”</a>: <math>V_{GS(th)}</math> <math>I_D</math> condition modified</li> <li>• <a href="#">Table 5 “Characteristics”</a>: <math>V_{GS(th)}</math> maximum limits modified</li> <li>• <a href="#">Table 5 “Characteristics”</a>: <math>R_{DS(on)}</math> typical values modified</li> <li>• <a href="#">Table 5 “Characteristics”</a>: <math>g_{fs}</math> removed</li> <li>• <a href="#">Table 5 “Characteristics”</a>: Addition of <math>Q_{G(tot)}</math>, <math>Q_{GS}</math> and <math>Q_{GD}</math></li> <li>• <a href="#">Table 5 “Characteristics”</a>: <math>C_{iss}</math>, <math>C_{oss}</math> and <math>C_{rss}</math> values modified</li> <li>• <a href="#">Table 5 “Characteristics”</a>: <math>t_{on}</math> and <math>t_{off}</math> typical values modified</li> <li>• <a href="#">Figure 3</a>, <a href="#">4</a>, <a href="#">5</a>, <a href="#">6</a>, <a href="#">7</a>, <a href="#">9</a>, <a href="#">10</a>, <a href="#">13</a> and <a href="#">14</a>: modified</li> <li>• <a href="#">Figure 11</a>: added</li> </ul>				
2N7002E_2	20050426	Product data sheet	-	9397 750 14944	2N7002E-01
2N7002E-01	20020211	Product data	-	9397 750 09095	-

## 9. Data sheet status

Level	Data sheet status <sup>[1]</sup>	Product status <sup>[2]</sup> <sup>[3]</sup>	Definition
I	Objective data	Development	This data sheet contains data from the objective specification for product development. Philips Semiconductors reserves the right to change the specification in any manner without notice.
II	Preliminary data	Qualification	This data sheet contains data from the preliminary specification. Supplementary data will be published at a later date. Philips Semiconductors reserves the right to change the specification without notice, in order to improve the design and supply the best possible product.
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[3] For data sheets describing multiple type numbers, the highest-level product status determines the data sheet status.

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**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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