



# 2N7002F

## 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

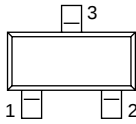
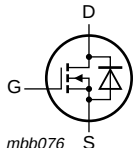
- Logic level translator
- High-speed line driver

### 1.4 Quick reference data

- $V_{DS} \leq 60 \text{ V}$
- $R_{DS(on)} \leq 2 \Omega$
- $I_D \leq 475 \text{ mA}$
- $P_{tot} \leq 0.83 \text{ W}$

## 2. Pinning information

Table 1: Pinning

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

# PHILIPS

### 3. Ordering information

Table 2: Ordering information

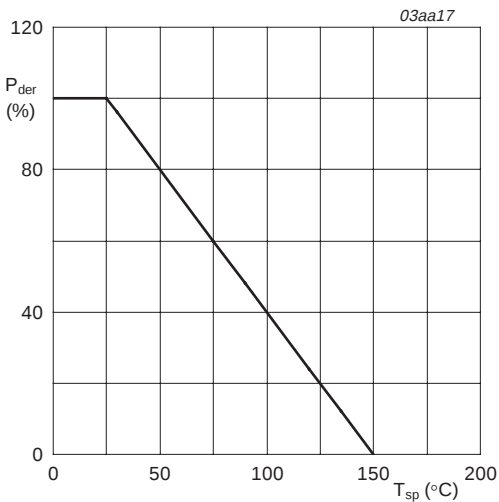
| Type number | Package  |                                          |         |
|-------------|----------|------------------------------------------|---------|
|             | Name     | Description                              | Version |
| 2N7002F     | TO-236AB | plastic surface-mounted package; 3 leads | SOT23   |

### 4. Limiting values

Table 3: Limiting values

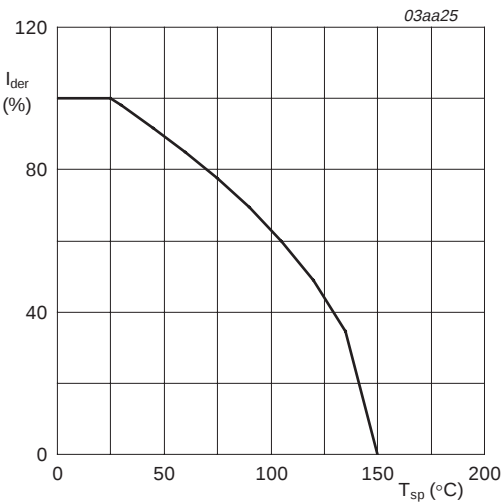
In accordance with the Absolute Maximum Rating System (IEC 60134).

| 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> | -   | 475      | mA   |
|                           |                          | $T_{sp} = 100\text{ °C}$ ; $V_{GS} = 10\text{ V}$ ; see <a href="#">Figure 2</a>                      | -   | 300      | 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>     | -   | 1.9      | 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           | $T_{sp} = 25\text{ °C}$                                                                               | -   | 475      | mA   |
| $I_{SM}$                  | peak source current      | $T_{sp} = 25\text{ °C}$ ; pulsed; $t_p \leq 10\text{ }\mu\text{s}$                                    | -   | 1.9      | A    |



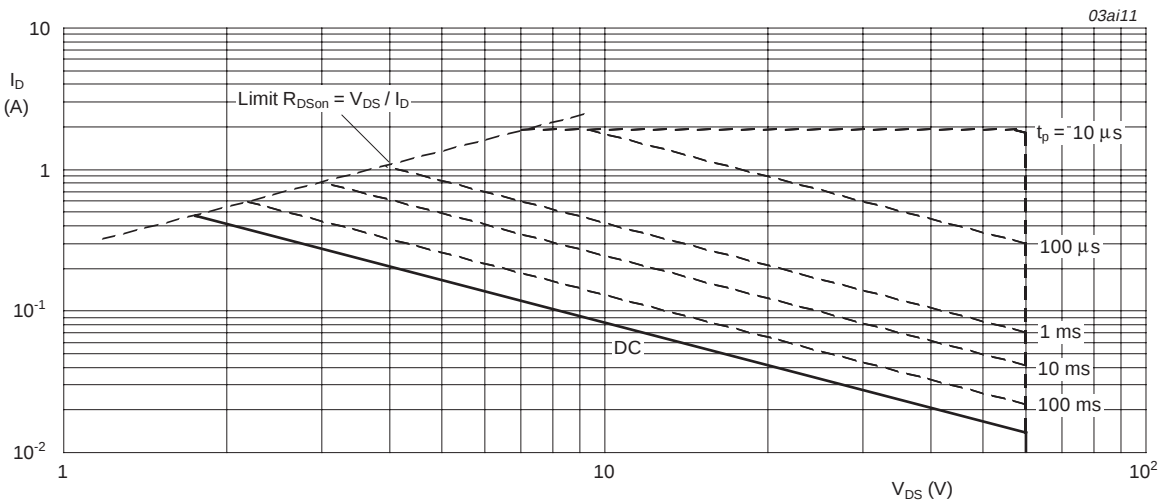
$$P_{der} = \frac{P_{tot}}{P_{tot(25\text{ }^{\circ}\text{C})}} \times 100\%$$

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



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

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

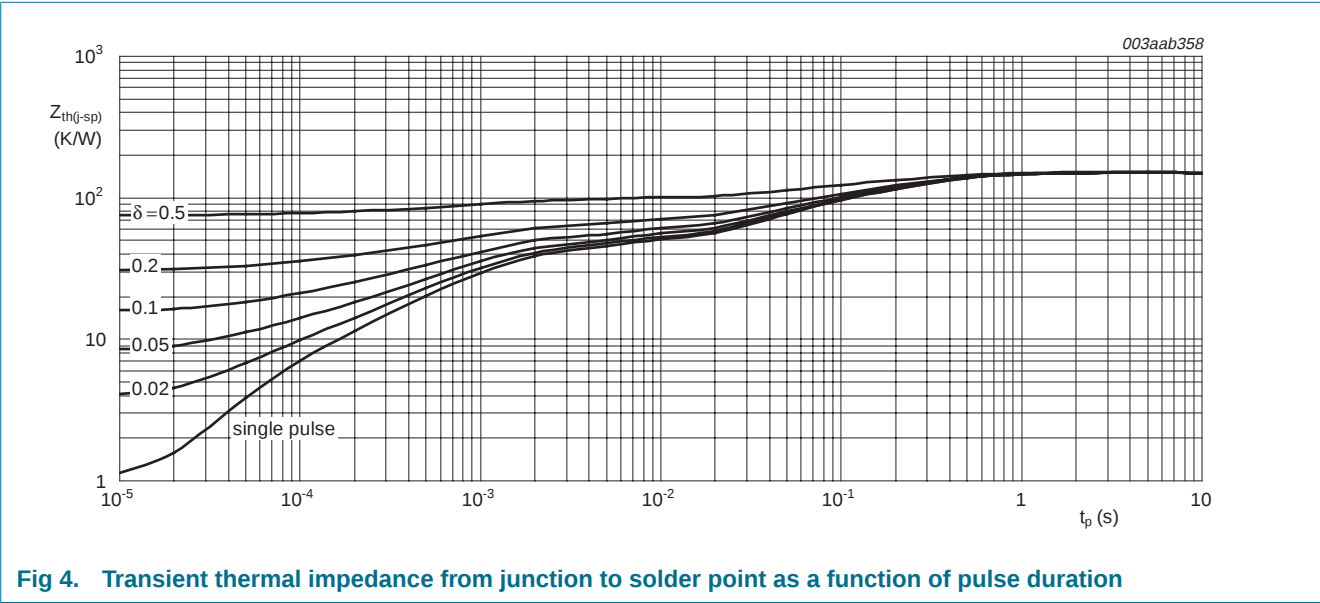
Fig 3. Safe operating area; continuous and peak drain currents as a function of drain-source voltage

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

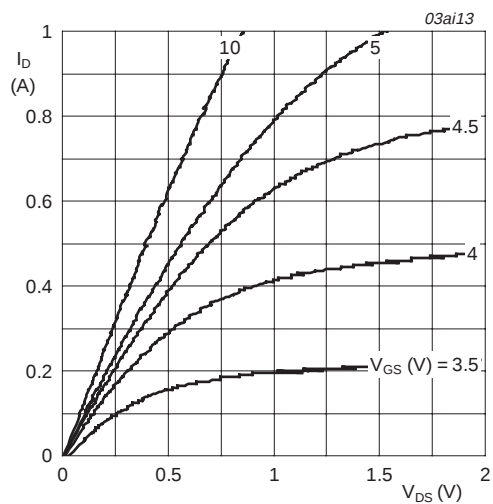


## 6. Characteristics

**Table 5: Characteristics**

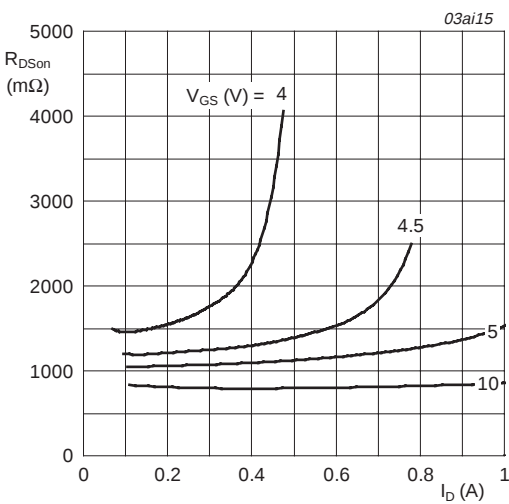
$T_j = 25\text{ }^{\circ}\text{C}$  unless otherwise specified.

| Symbol                         | Parameter                        | Conditions                                                                                                                                | Min | Typ  | Max  | Unit          |
|--------------------------------|----------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|-----|------|------|---------------|
| <b>Static characteristics</b>  |                                  |                                                                                                                                           |     |      |      |               |
| $V_{(BR)DSS}$                  | drain-source breakdown voltage   | $I_D = 10\text{ }\mu\text{A}$ ; $V_{GS} = 0\text{ V}$<br>$T_j = 25\text{ }^{\circ}\text{C}$                                               | 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><br>$T_j = 25\text{ }^{\circ}\text{C}$    | 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            | $V_{DS} = 48\text{ V}$ ; $V_{GS} = 0\text{ V}$<br>$T_j = 25\text{ }^{\circ}\text{C}$                                                      | -   | 0.01 | 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><br>$T_j = 25\text{ }^{\circ}\text{C}$ | -   | 0.78 | 2    | $\Omega$      |
|                                |                                  | $T_j = 150\text{ }^{\circ}\text{C}$                                                                                                       | -   | 1.45 | 3.7  | $\Omega$      |
|                                |                                  | $V_{GS} = 4.5\text{ V}$ ; $I_D = 75\text{ mA}$ ; 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            |



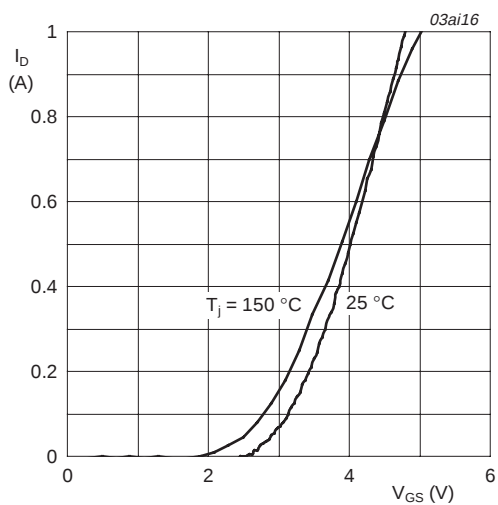
T<sub>j</sub> = 25 °C

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



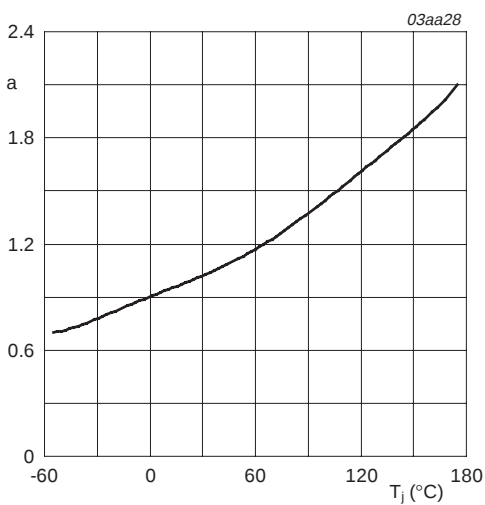
T<sub>j</sub> = 25 °C

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



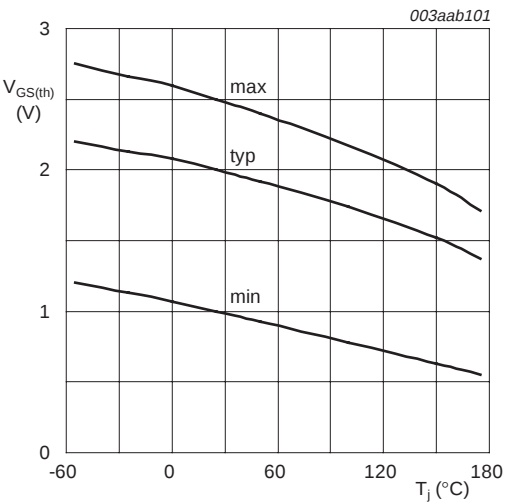
T<sub>j</sub> = 25 °C and 150 °C; V<sub>DS</sub> > I<sub>D</sub> × R<sub>DSon</sub>

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



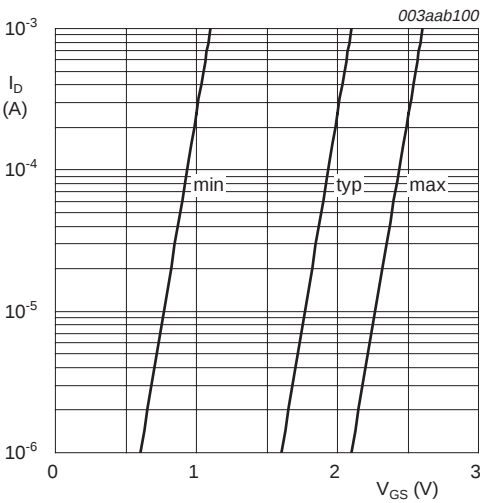
$$a = \frac{R_{DSon}}{R_{DSon(25\text{ °C})}}$$

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



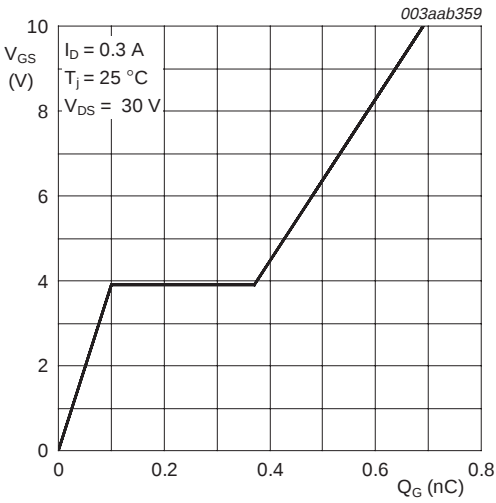
$I_D = 0.25 \text{ mA}$ ;  $V_{DS} = V_{GS}$

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



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

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



$I_D = 300 \text{ mA}$ ;  $V_{DS} = 30 \text{ V}$

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

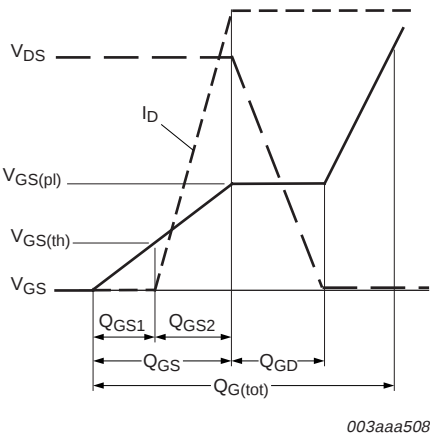
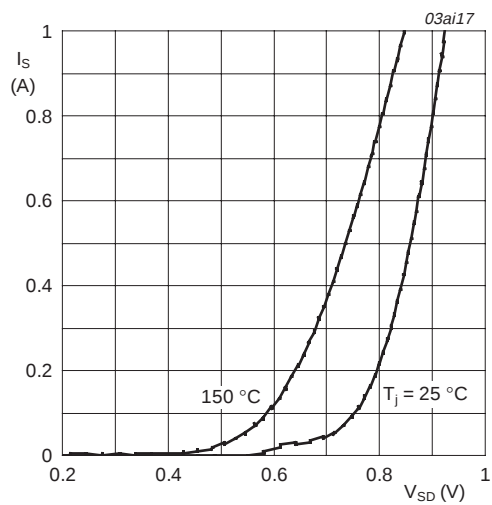
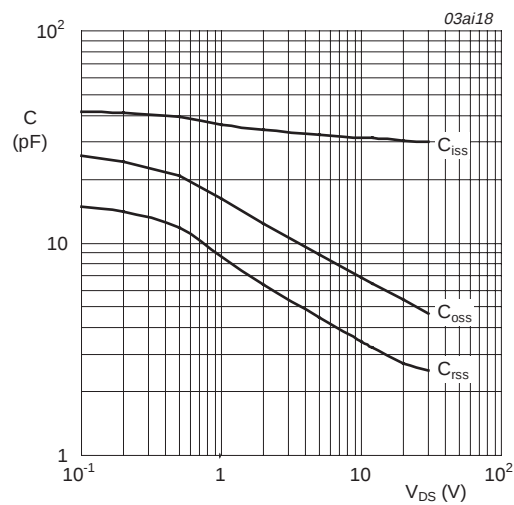


Fig 12. Gate charge waveform definitions



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

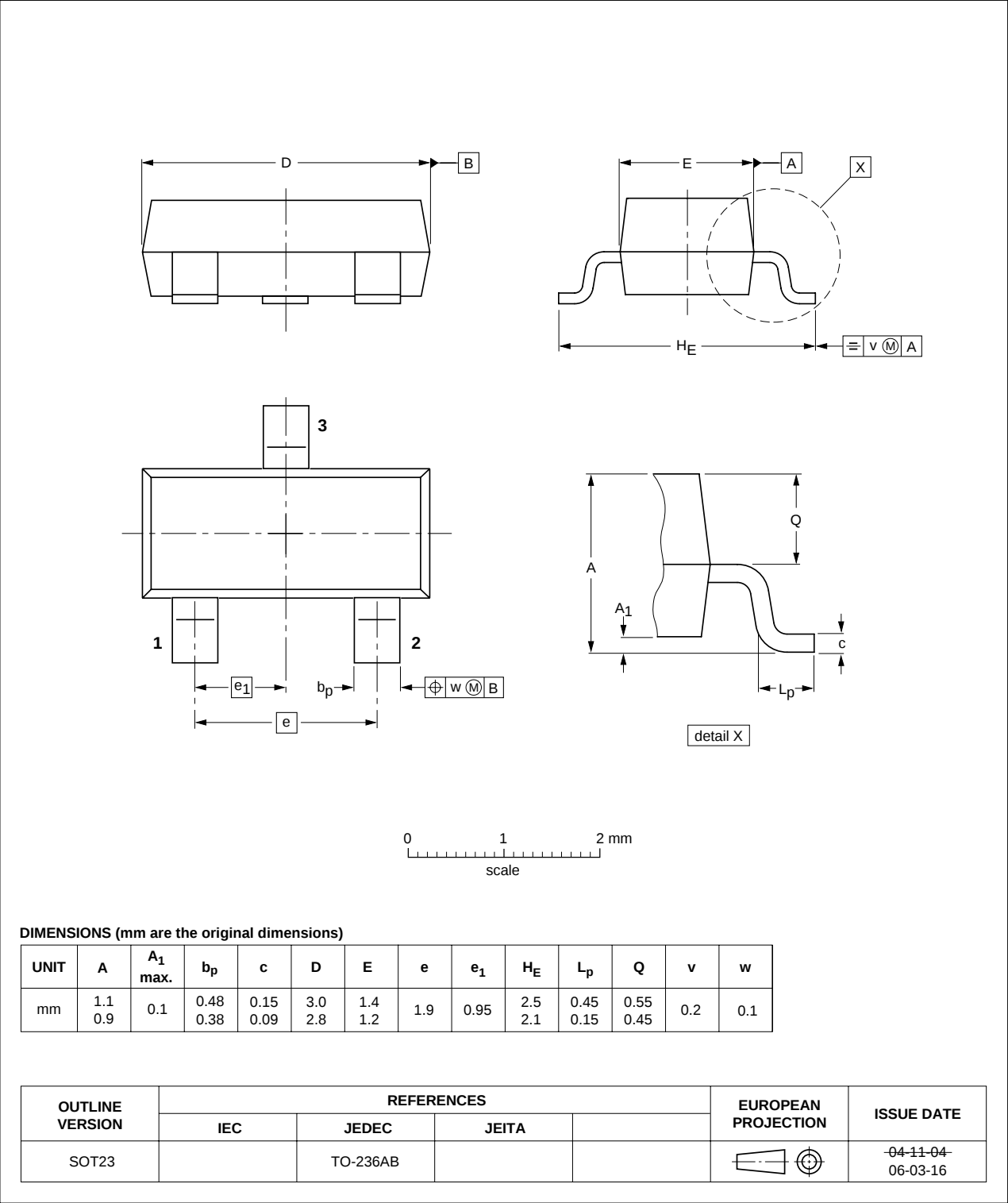


Fig 15. Package outline SOT23

8. Revision history

Table 6: Revision history

| Document ID    | Release date                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Data sheet status  | Change notice | Doc. number    | Supersedes |
|----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|---------------|----------------|------------|
| 2N7002F_3      | 20060428                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Product data sheet | -             | -              | 2N7002F_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> |                    |               |                |            |
| 2N7002F_2      | 20050509                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Product data sheet | -             | 9397 750 14945 | 2N7002F-01 |
| 2N7002F-01     | 20020211                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Product data       | -             | 9397 750 09096 | -          |

## 9. Data sheet status

| Level | Data sheet status <sup>[1]</sup> | Product status <sup>[2] [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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[1] Please consult the most recently issued data sheet before initiating or completing a design.

[2] The product status of the device(s) described in this data sheet may have changed since this data sheet was published. The latest information is available on the Internet at URL <http://www.semiconductors.philips.com>.

[3] For data sheets describing multiple type numbers, the highest-level product status determines the data sheet status.

## 10. 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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14. Contents

1 Product profile ..... 1

1.1 General description..... 1

1.2 Features ..... 1

1.3 Applications ..... 1

1.4 Quick reference data..... 1

2 Pinning information..... 1

3 Ordering information..... 2

4 Limiting values..... 2

5 Thermal characteristics..... 4

6 Characteristics..... 5

7 Package outline ..... 9

8 Revision history..... 10

9 Data sheet status ..... 11

10 Definitions ..... 11

11 Disclaimers..... 11

12 Trademarks..... 11

13 Contact information ..... 11



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