

# 2N7000

N-channel enhancement mode field-effect transistor

Rev. 03 — 19 May 2000

Product specification

## 1. Description

N-channel enhancement mode field-effect transistor in a plastic package using TrenchMOS<sup>TM1</sup> technology.

Product availability:

2N7000 in SOT54 (TO-92 variant).

## 2. Features

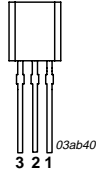
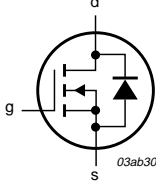
- TrenchMOS<sup>TM</sup> technology
- Very fast switching
- Logic level compatible.

## 3. Applications

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

## 4. Pinning information

Table 1: Pinning - SOT54, simplified outline and symbol

| Pin | Description | Simplified outline  | Symbol  |
|-----|-------------|---|---|
| 1   | drain (d)   |  |  |
| 2   | gate (g)    |   |   |
| 3   | source (s)  |   |   |
|     |             | SOT54 (TO-92 variant)   | N-channel MOSFET  |

1. TrenchMOS is a trademark of Royal Philips Electronics.

## 5. Quick reference data

Table 2: Quick reference data

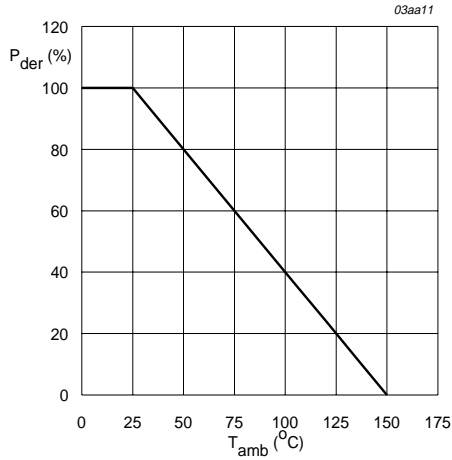
| Symbol       | Parameter                        | Conditions                         | Typ | Max  | Unit     |
|--------------|----------------------------------|------------------------------------|-----|------|----------|
| $V_{DS}$     | drain-source voltage (DC)        | $T_j = 25$ to $150$ °C             | –   | 60   | V        |
| $I_D$        | drain current (DC)               | $T_{amb} = 25$ °C; $V_{GS} = 10$ V | –   | 300  | mA       |
| $P_{tot}$    | total power dissipation          | $T_{amb} = 25$ °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

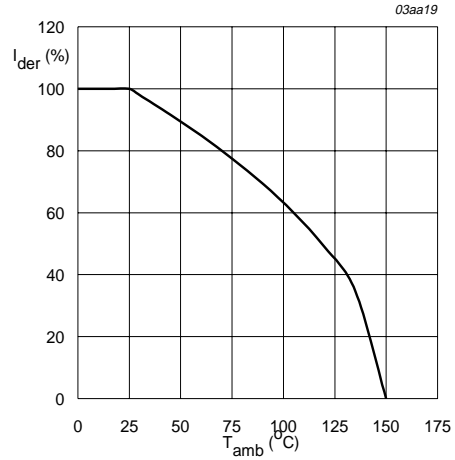
In accordance with the Absolute Maximum Rating System (IEC 60134).

| 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)                  | $T_{amb} = 25$ °C; $V_{GS} = 10$ V;<br>Figure 2 and 3         | –   | 300      | mA   |
|                           |                                     | $T_{amb} = 100$ °C; $V_{GS} = 10$ V; Figure 2                 | –   | 190      | mA   |
| $I_{DM}$                  | peak drain current                  | $T_{amb} = 25$ °C; pulsed; $t_p \leq 10$ $\mu$ s;<br>Figure 3 | –   | 1.3      | A    |
| $P_{tot}$                 | total power dissipation             | $T_{amb} = 25$ °C; Figure 1                                   | –   | 0.83     | W    |
| $T_{stg}$                 | storage temperature                 |   | –55 | +150     | °C   |
| $T_j$                     | operating junction temperature      |   | –55 | +150     | °C   |
| <b>Source-drain diode</b> |                                     |   |     |          |      |
| $I_S$                     | source (diode forward) current (DC) | $T_{amb} = 25$ °C   | –   | 300      | mA   |
| $I_{SM}$                  | peak source (diode forward) current | $T_{amb} = 25$ °C; pulsed; $t_p \leq 10$ $\mu$ s              | –   | 1.3      | A    |



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

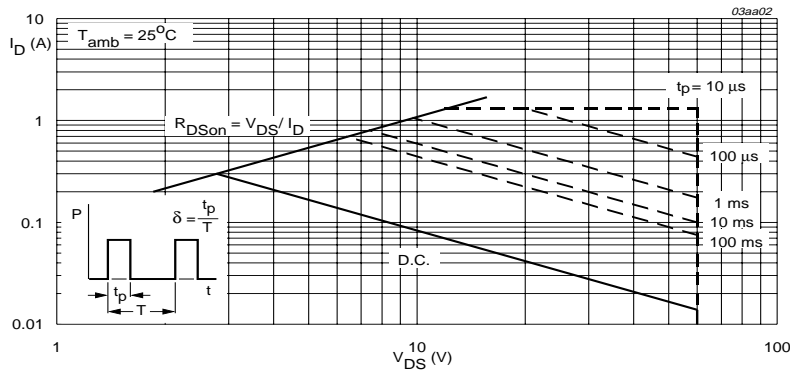
**Fig 1. Normalized total power dissipation as a function of ambient temperature.**



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

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

**Fig 2. Normalized continuous drain current as a function of ambient temperature.**



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

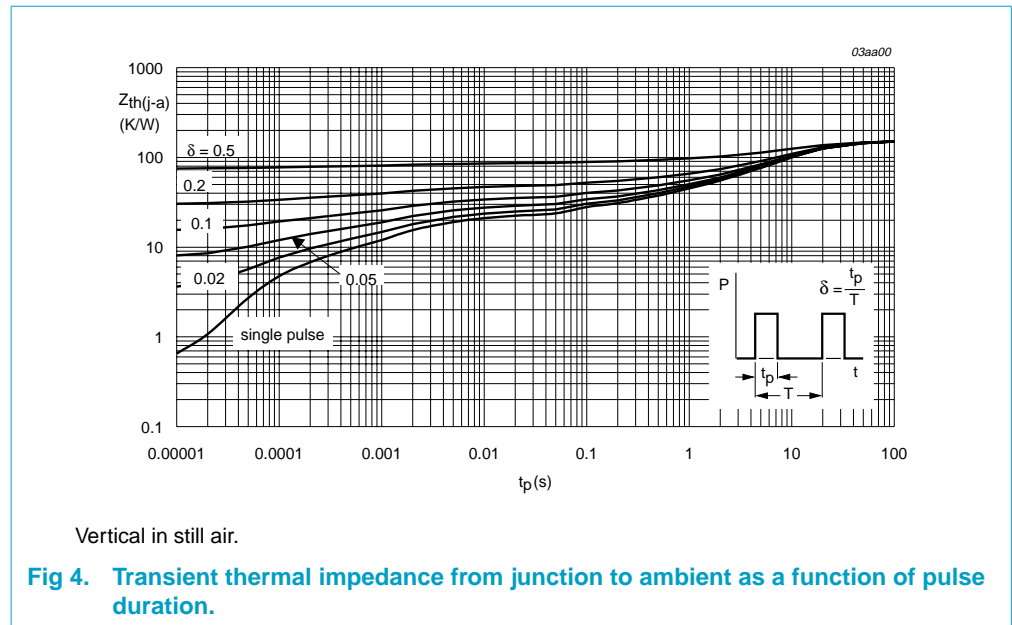
**Fig 3. Safe operating area; continuous and peak drain currents as a function of drain-source voltage.**

## 7. Thermal characteristics

Table 4: Thermal characteristics

| Symbol        | Parameter                                   | Conditions   | Value | Unit |
|---------------|---|--|-------|------|
| $R_{th(j-a)}$ | thermal resistance from junction to ambient | vertical in still air;<br>lead length $\leq 5$ mm; <b>Figure 4</b> | 150   | K/W  |

### 7.1 Transient thermal impedance

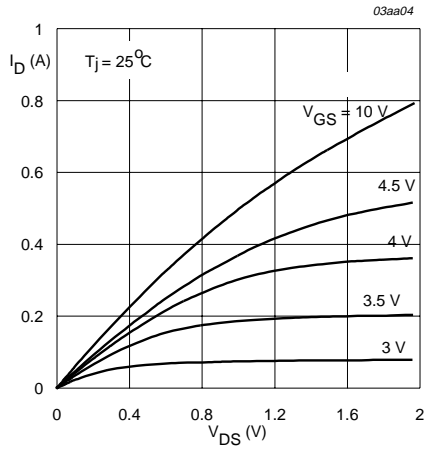


## 8. Characteristics

**Table 5: Characteristics**

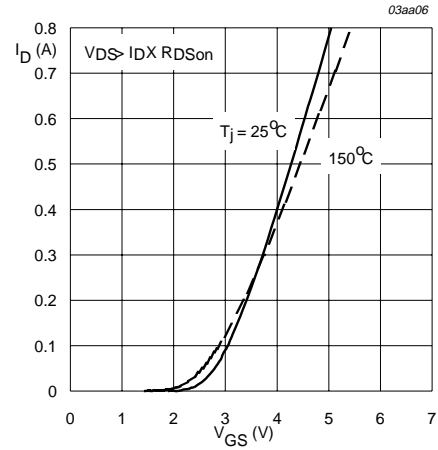
$T_j = 25\text{ °C}$  unless otherwise specified

| 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        | $I_D = 1\ \text{mA}; V_{DS} = V_{GS};$<br><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            |
| $R_{DS(on)}$                   | drain-source on-state resistance     | $V_{GS} = 10\ \text{V}; I_D = 500\ \text{mA};$<br><b>Figure 7 and 8</b>                  |     |      |      |               |
|                                |                                      | $T_j = 25\text{ °C}$   | –   | 2.8  | 5    | $\Omega$      |
|                                |                                      | $T_j = 150\text{ °C}$  | –   | –    | 9.25 | $\Omega$      |
|                                |                                      | $V_{GS} = 4.5\ \text{V}; I_D = 75\ \text{mA};$<br><b>Figure 7 and 8</b>                  |     |      |      |               |
|                                |                                      | $T_j = 25\text{ °C}$   | –   | 3.8  | 5.3  | $\Omega$      |
| <b>Dynamic characteristics</b> |                                      |  |     |      |      |               |
| $g_{fs}$                       | forward transconductance             | $V_{DS} = 10\ \text{V}; I_D = 200\ \text{mA};$<br><b>Figure 11</b>                       | 100 | 300  | –    | mS            |
| $C_{iss}$                      | input capacitance                    | $V_{GS} = 0\ \text{V}; V_{DS} = 10\ \text{V};$<br>$f = 1\ \text{MHz};$ <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                        | $V_{GS} = 10\ \text{V}; R_G = 50\ \Omega;$<br>$R_{GS} = 50\ \Omega$                      | –   | 12   | 15   | ns            |
| <b>Source-drain diode</b>      |                                      |  |     |      |      |               |
| $V_{SD}$                       | source-drain (diode forward) voltage | $I_S = 300\ \text{mA}; V_{GS} = 0\ \text{V};$<br><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                     | $di_S/dt = -100\ \text{A}/\mu\text{s};$<br>$V_{GS} = 0\ \text{V}; V_{DS} = 25\ \text{V}$ | –   | 30   | –    | nC            |



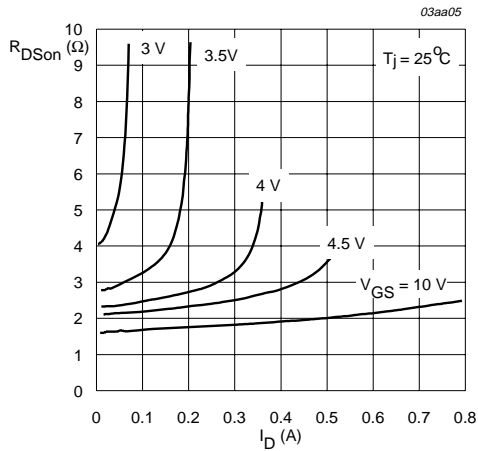
$T_j = 25^\circ\text{C}$

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



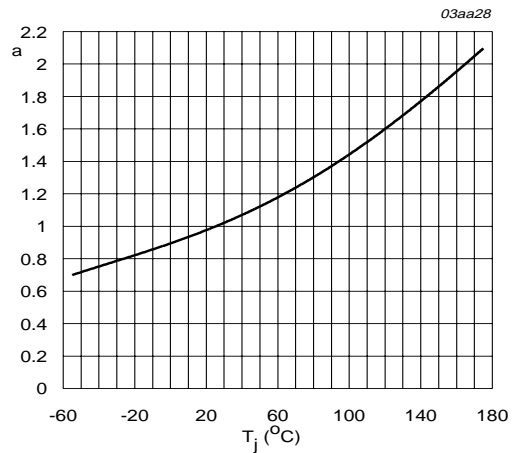
$T_j = 25^\circ\text{C}$  and  $150^\circ\text{C}$ ;  $V_{DS} \geq I_D \times R_{DSon}$

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



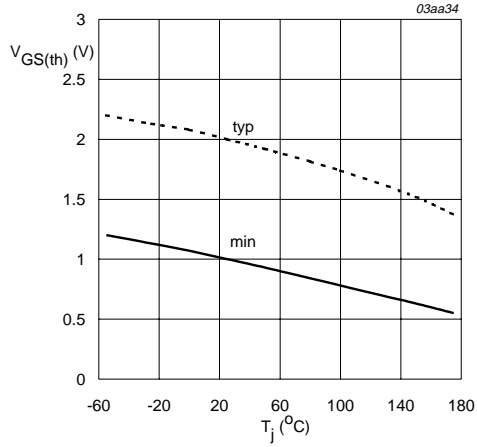
$T_j = 25^\circ\text{C}$

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



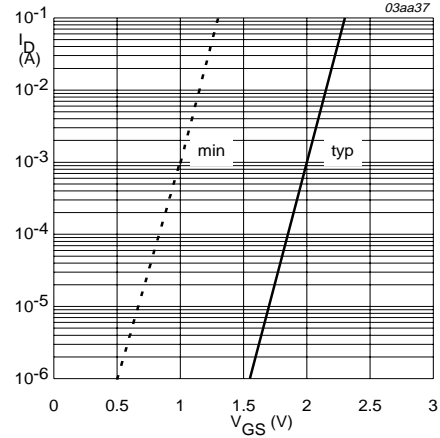
$$a = \frac{R_{DSon}}{R_{DSon}(25^\circ\text{C})}$$

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



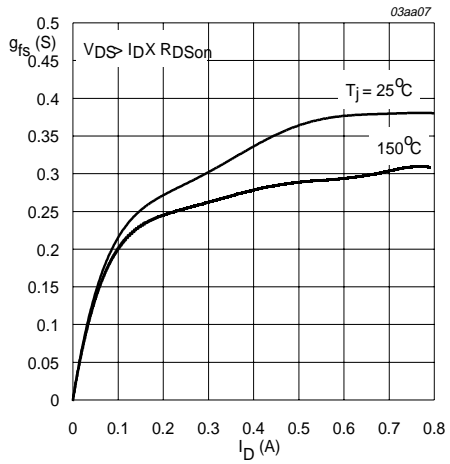
$I_D = 1 \text{ mA}; V_{DS} = V_{GS}$

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



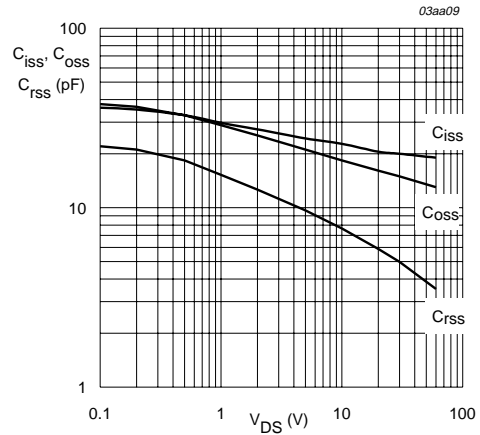
$T_j = 25 \text{ }^{\circ}$ C;  $V_{DS} = 5 \text{ V}$

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



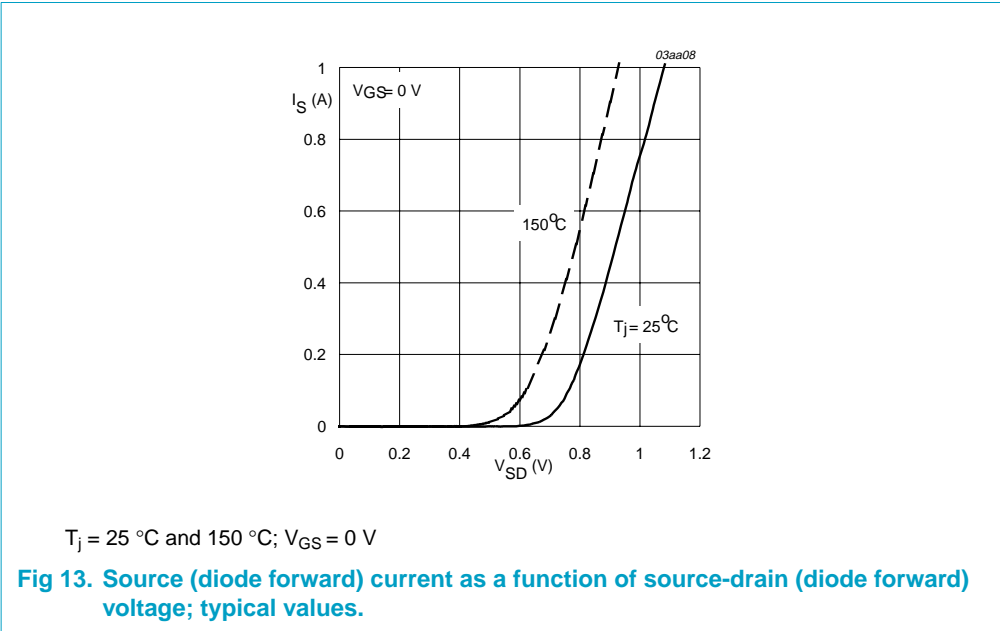
$T_j = 25 \text{ }^{\circ}$ C and  $150 \text{ }^{\circ}$ C;  $V_{DS} \geq I_D \times R_{DS(on)}$

**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 single-ended leaded (through hole) package; 3 leads

SOT54

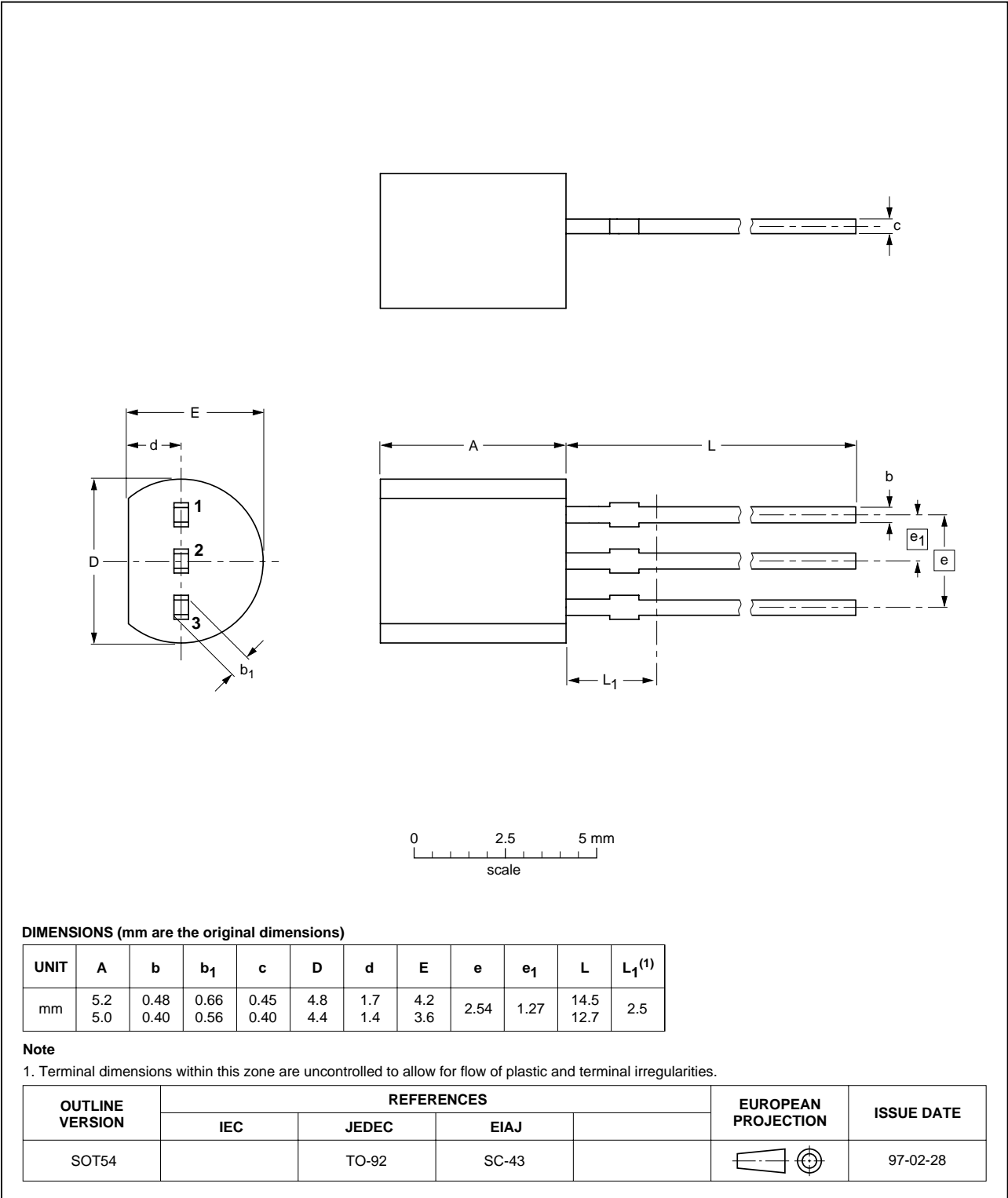


Fig 14. SOT54 (TO-92 variant).

## 10. Revision history

Table 6: Revision history

| Rev | Date     | CPCN   | Description   |
|-----|----------|--------|---|
| 03  | 20000519 | HZG336 | <b>Product specification; third version.</b><br>Converted to TrenchMOS™ 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.

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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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(SCA69)

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