

# BUT12AX

Silicon diffused power transistor

Rev. 01 — 16 June 2004

Product data

## 1. Product profile

### 1.1 Description

High voltage, high speed, NPN power transistor in a plastic package.

### 1.2 Features

- Isolated package
- Fast switching.

### 1.3 Applications

- Inverters
- Motor control systems
- Switching regulators
- DC-to-DC converters.

### 1.4 Quick reference data

- $V_{CESM} \leq 1000 \text{ V}$
- $P_{tot} \leq 23 \text{ W}$
- $I_C \leq 8 \text{ A}$
- $t_f \leq 0.8 \text{ } \mu\text{s}$ .

## 2. Pinning information

Table 1: Pinning - SOT186A (TO-220F), simplified outline and symbol

| Pin | Description                | Simplified outline | Symbol |
|-----|----------------------------|--------------------|--------|
| 1   | base (b)                   |                    |        |
| 2   | collector (c)              |                    |        |
| 3   | emitter (e)                |                    |        |
| mb  | mounting base;<br>isolated |                    |        |



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### 3. Ordering information

Table 2: Ordering information

| Type number | Package |                                                                                    |         |
|-------------|---------|------------------------------------------------------------------------------------|---------|
|             | Name    | Description                                                                        | Version |
| BUT12AX     | TO-220F | Plastic single-ended package; isolated heatsink mounted; 1 mounting hole; 3 leads. | SOT186A |

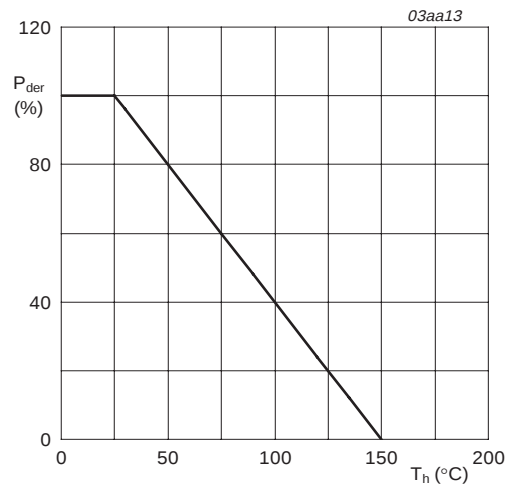
### 4. Limiting values

Table 3: Limiting values

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

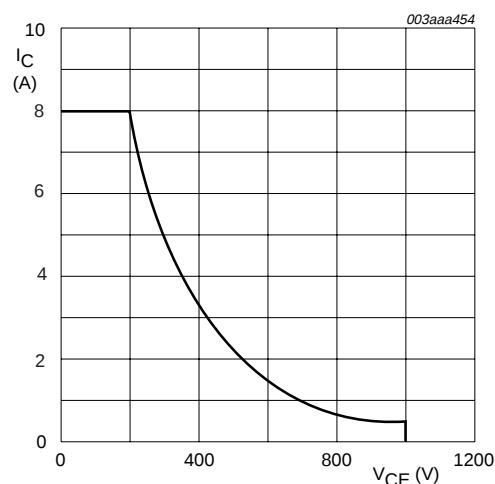
| Symbol     | Parameter                      | Conditions                      | Min   | Max  | Unit |
|------------|--------------------------------|---------------------------------|-------|------|------|
| $V_{CESM}$ | peak collector-emitter voltage | $V_{BE} = 0\text{ V}$           | -     | 1000 | V    |
| $V_{CEO}$  | collector-emitter voltage      | base open circuit               | -     | 450  | V    |
| $I_C$      | collector current              | Figure 2 and 3                  | -     | 8    | A    |
| $I_{Csat}$ | collector saturation current   |                                 | -     | 5    | A    |
| $I_{CM}$   | peak collector current         | Figure 3                        | -     | 20   | A    |
| $I_B$      | base current (DC)              |                                 | -     | 4    | A    |
| $I_{BM}$   | peak base current              |                                 | -     | 6    | A    |
| $P_{tot}$  | total power dissipation        | $T_h = 25\text{ °C}$ ; Figure 1 | [1] - | 23   | W    |
| $T_{stg}$  | storage temperature            |                                 | -65   | +150 | °C   |
| $T_j$      | junction temperature           |                                 | -     | +150 | °C   |

[1] Mounted without heatsink compound.



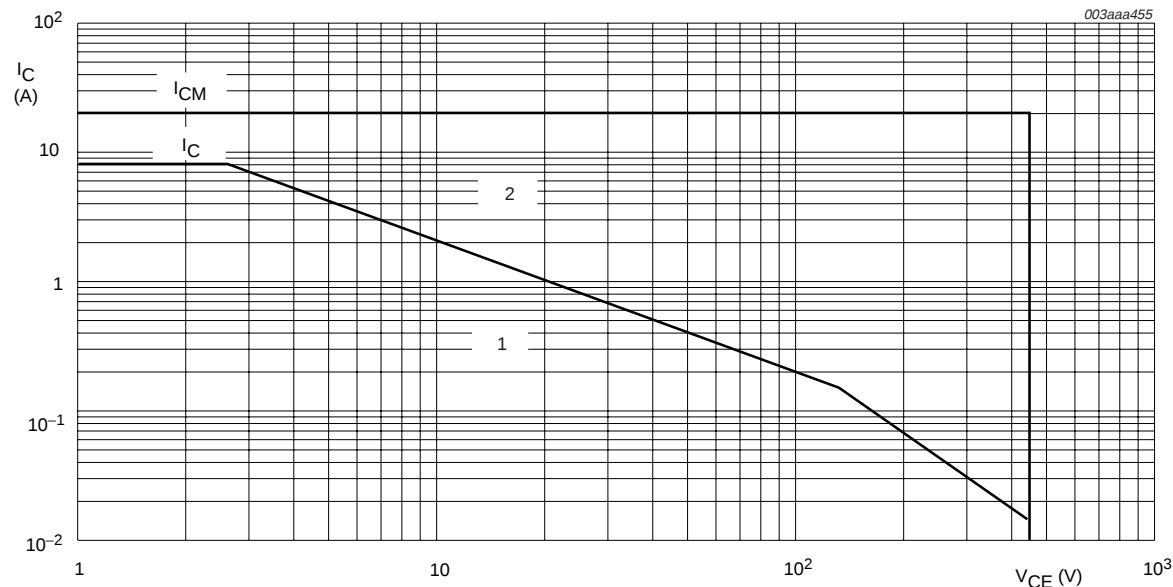
$$P_{der} = \frac{P_{tot}}{P_{tot(25^{\circ}C)}} \times 100\%$$

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



$V_{BE} = -1$  V to  $-5$  V;  $T_h = 100$  °C.

Fig 2. Reverse bias safe operating area; continuous collector current as a function of collector-emitter voltage.



$T_h = 25$  °C

- 1 - Region of permissible DC operation.
- 2 - Permissible extension for repetitive operation.

Fig 3. Forward bias safe operating area; continuous and peak collector currents as a function of collector-emitter voltage.

## 5. Thermal characteristics

**Table 4: Thermal characteristics**

| Symbol        | Parameter                                    | Conditions                        | Min | Typ | Max | Unit    |
|---------------|----------------------------------------------|-----------------------------------|-----|-----|-----|---------|
| $R_{th(j-h)}$ | thermal resistance from junction to heatsink | Mounted without heatsink compound | [1] | -   | -   | 5.5 K/W |
|               |                                              | Mounted with heatsink compound    | [1] | -   | -   | 3.9 K/W |
| $R_{th(j-a)}$ | thermal resistance from junction to ambient  |                                   | -   | 55  | -   | K/W     |

[1] External heatsink connected to mounting base.

## 6. Characteristics

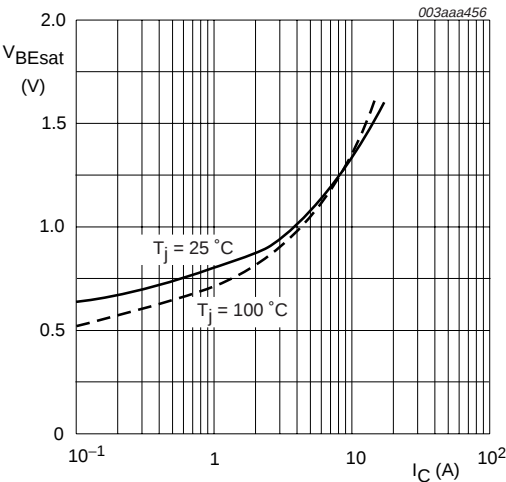
**Table 5: Characteristics**

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

| Symbol                  | Parameter                            | Conditions                                                                                                                                | Min | Typ | Max | Unit |    |
|-------------------------|--------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|-----|-----|-----|------|----|
| Static characteristics  |                                      |                                                                                                                                           |     |     |     |      |    |
| V <sub>CEOsus</sub>     | collector-emitter sustaining voltage | I <sub>C</sub> = 100 mA; I <sub>Boff</sub> = 0 A; L = 25 mH;<br>Figure 9 and 10                                                           | 400 | -   | -   | V    |    |
| V <sub>CEsat</sub>      | collector-emitter saturation voltage | I <sub>C</sub> = 5 A; I <sub>B</sub> = 1 A; Figure 5                                                                                      | -   | -   | 1.5 | V    |    |
| V <sub>BEsat</sub>      | base-emitter saturation voltage      | I <sub>C</sub> = 5 A; I <sub>B</sub> = 1 A; Figure 4                                                                                      | -   | -   | 1.5 | V    |    |
| I <sub>CES</sub>        | collector-emitter cut-off current    | V <sub>CE</sub> = V <sub>CESM</sub> ; V <sub>BE</sub> = 0 V                                                                               |     |     |     |      |    |
|                         |                                      | T <sub>j</sub> = 25 °C                                                                                                                    | [1] | -   | -   | 1    | mA |
|                         |                                      | T <sub>j</sub> = 125 °C                                                                                                                   | [1] | -   | -   | 3    | mA |
| h <sub>FE</sub>         | DC current gain                      | V <sub>CE</sub> = 5 V; Figure 8                                                                                                           |     |     |     |      |    |
|                         |                                      | I <sub>C</sub> = 10 mA                                                                                                                    | 10  | 18  | 35  |      |    |
|                         |                                      | I <sub>C</sub> = 1 A                                                                                                                      | 10  | 20  | 35  |      |    |
| Dynamic characteristics |                                      |                                                                                                                                           |     |     |     |      |    |
| t <sub>on</sub>         | turn-on time                         | I <sub>Con</sub> = 5 A; I <sub>Bon</sub> = I <sub>Boff</sub> = 1 A;<br>resistive load; Figure 11 and 12                                   | -   | -   | 1   | μs   |    |
| t <sub>s</sub>          | carrier storage time                 | I <sub>Con</sub> = 5 A; I <sub>Bon</sub> = I <sub>Boff</sub> = 1 A;<br>resistive load; Figure 11 and 12                                   | [2] | -   | 4   | μs   |    |
|                         |                                      | I <sub>Con</sub> = 5 A; I <sub>Bon</sub> = 1 A;<br>V <sub>CL</sub> = 250 V; T <sub>mb</sub> = 100 °C;<br>inductive load; Figure 13 and 14 | -   | 1.9 | 2.5 | μs   |    |
| t <sub>f</sub>          | fall time                            | I <sub>Con</sub> = 5 A; I <sub>Bon</sub> = I <sub>Boff</sub> = 1 A;<br>resistive load; Figure 11 and 12                                   | -   | -   | 0.8 | μs   |    |
|                         |                                      | I <sub>Con</sub> = 5 A; I <sub>Bon</sub> = 1 A; V <sub>CL</sub> = 300 V;<br>T <sub>mb</sub> = 100 °C; inductive load;<br>Figure 13 and 14 | -   | 200 | 300 | ns   |    |

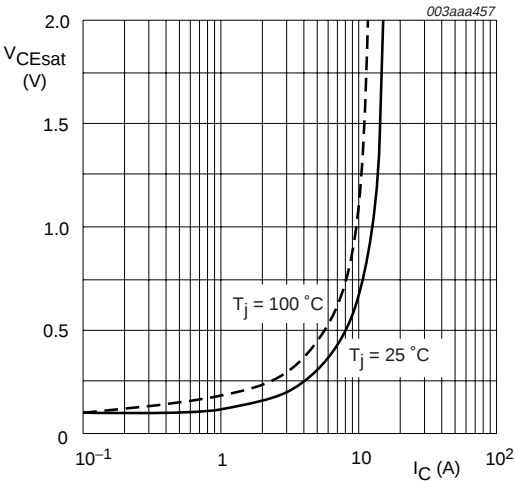
[1] Measured with a half-sinewave voltage.

[2] turn-off storage time



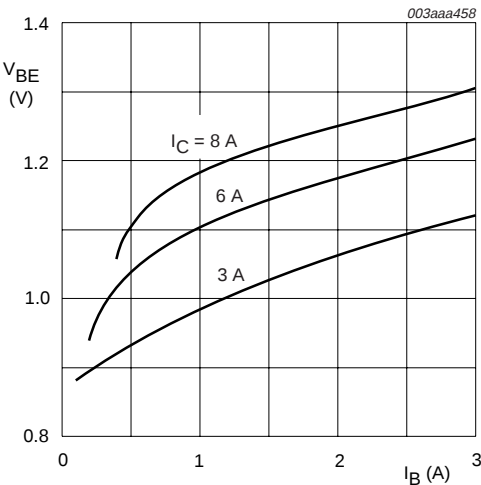
$T_j = 25\text{ }^{\circ}\text{C}$  and  $100\text{ }^{\circ}\text{C}$

Fig 4. Base-emitter saturation voltage as a function of collector current; typical values.



$T_j = 25\text{ }^{\circ}\text{C}$  and  $100\text{ }^{\circ}\text{C}$

Fig 5. Collector-emitter saturation voltage as a function of collector current; typical values.



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

Fig 6. Base-emitter voltage as a function of base current; typical values.

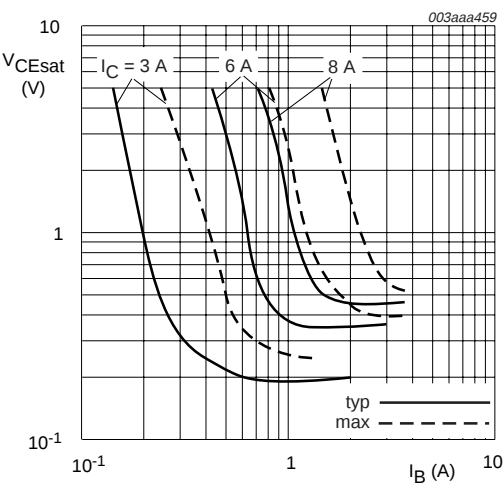
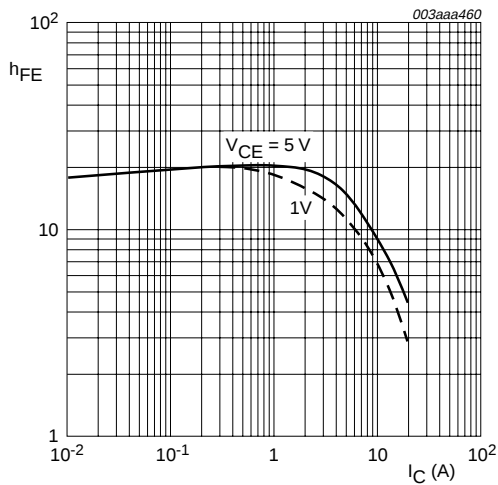


Fig 7. Collector-emitter saturation voltage as a function base current; typical and maximum values.



$V_{CE} = 5\text{ V}$  and  $1\text{ V}$

Fig 8. DC current gain as a function of collector current; typical values.

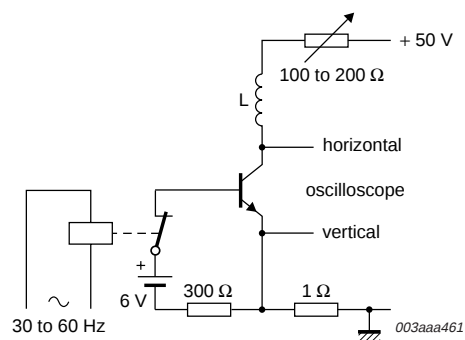


Fig 9. Test circuit for collector-emitter sustaining voltage.

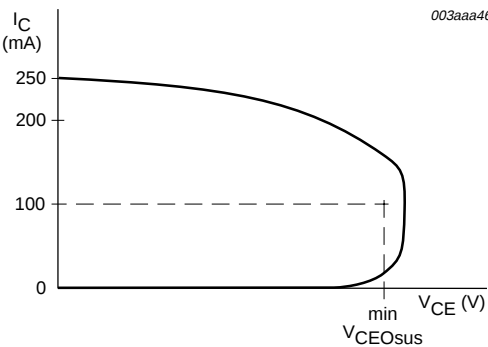
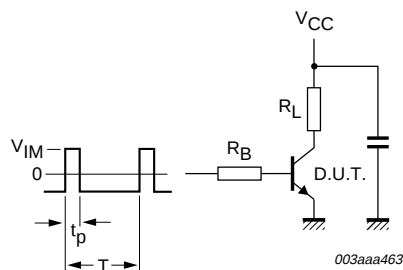


Fig 10. Oscilloscope display for collector-emitter sustaining voltage.



$V_{CC} = 250\text{ V}$ ;  $t_p = 20\text{ }\mu\text{s}$ ;  $V_{IM} = -6\text{ V to }8\text{ V}$ ;  $t_p/T = 0.01$ .  
The values of  $R_B$  and  $R_L$  are selected in accordance with  $I_{Con}$  and  $I_{Bon}$  requirements.

Fig 11. Test circuit for resistive load switching times

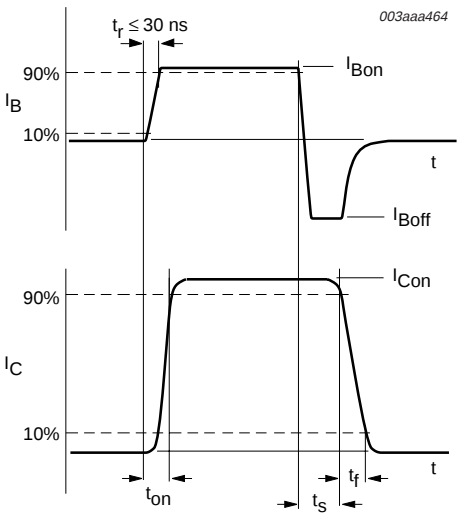
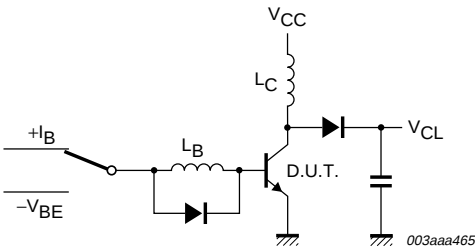


Fig 12. Switching time waveforms with resistive load.



$V_{CL} \leq 1000 \text{ V}$ ;  $V_{CC} = 30 \text{ V}$ ;  $V_{BE} = -1 \text{ V to } -5 \text{ V}$ ;  
 $L_B = 1 \mu\text{H}$ ;  $L_C = 200 \mu\text{H}$

Fig 13. Test circuit for inductive load switching and reverse bias safe operating area.

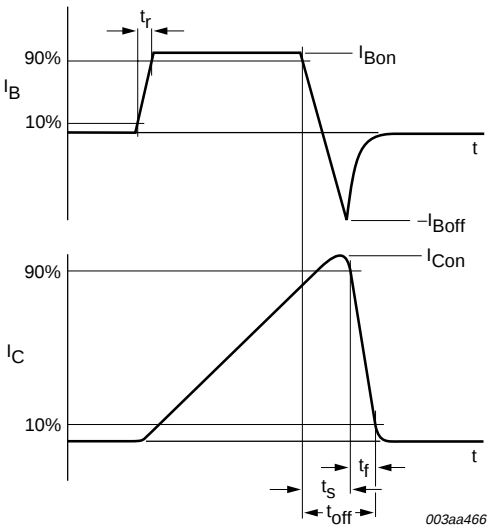


Fig 14. Switching time waveforms with inductive load.

7. Isolation characteristics

Table 6: Isolation characteristics

| Symbol           | Parameter                                                                 | Conditions                                                                                         | Min. | Typ. | Max. | Unit |
|------------------|---------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------|------|------|------|------|
| $V_{isol(RMS)M}$ | Peak RMS isolation voltage from all three terminals to external heatsink. | $f = 50 \text{ to } 60 \text{ Hz}$ ; sinusoidal waveform;<br>$RH \leq 65\%$ ; clean and dust-free. | -    | -    | 2500 | V    |
| $C_{C-h}$        | Capacitance from collector to external heatsink.                          |                                                                                                    | -    | 12   | -    | pF   |

8. Package outline

Plastic single-ended package; isolated heatsink mounted;  
1 mounting hole; 3 lead TO-220 'full pack'

SOT186A

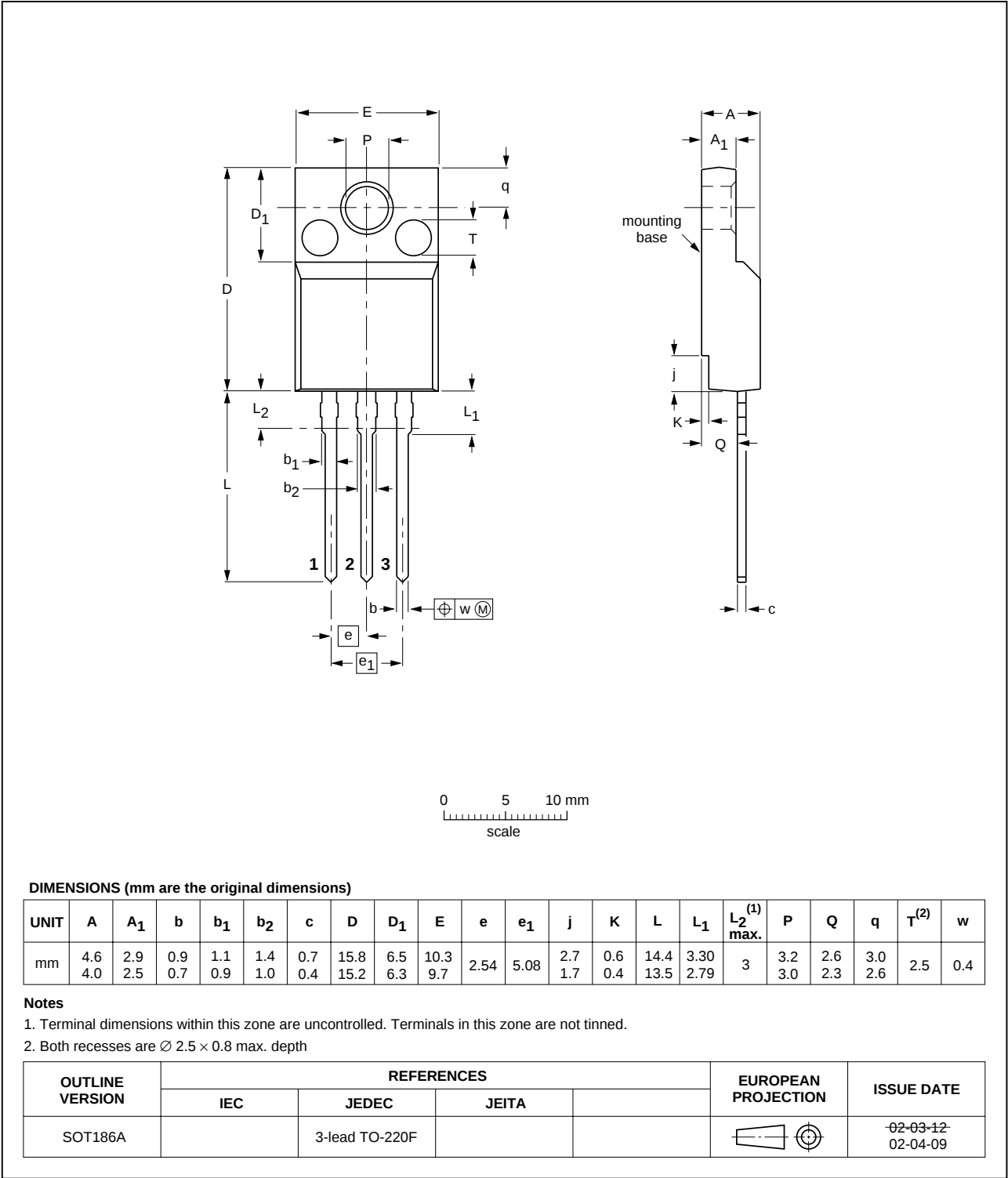


Fig 15. SOT186A (TO-220F).

9. Revision history

Table 7: Revision history

| Rev | Date     | CPCN | Description                   |
|-----|----------|------|-------------------------------|
| 01  | 20040616 | -    | Product data (9397 750 13442) |

## 10. 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.             |
| III   | Product data                     | Production                       | This data sheet contains data from the product specification. Philips Semiconductors reserves the right to make changes at any time in order to improve the design, manufacturing and supply. Relevant changes will be communicated via a Customer Product/Process Change Notification (CPCN). |

[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.

## 11. 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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For sales office addresses, send e-mail to: [sales.addresses@www.semiconductors.philips.com](mailto:sales.addresses@www.semiconductors.philips.com).

Fax: +31 40 27 24825

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