

## 1. Description

N-channel enhancement mode field-effect power transistor in a plastic package using TrenchMOS™ technology, featuring very low on-state resistance.

Product availability:

BUK9509-75A in SOT78 (TO-220AB)

BUK9609-75A in SOT404 (D<sup>2</sup>-PAK).

## 2. Features

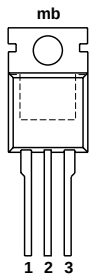
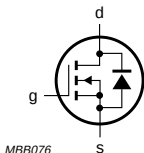
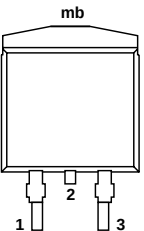
- TrenchMOS™ technology
- Q101 compliant
- 175 °C rated
- Logic level compatible.

## 3. Applications

- Automotive and general purpose power switching:
  - ◆ 12 V, 24 V and 42 V loads
  - ◆ Motors, lamps and solenoids.

## 4. Pinning information

Table 1: Pinning - SOT78 and SOT404, simplified outline and symbol

| Pin | Description                              | Simplified outline                                                                                 | Symbol                                                                                              |
|-----|------------------------------------------|----------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------|
| 1   | gate (g)                                 |  <p>MBK106</p>  |  <p>MBB076</p> |
| 2   | drain (d)                                |                                                                                                    |                                                                                                     |
| 3   | source (s)                               |                                                                                                    |                                                                                                     |
| mb  | mounting base;<br>connected to drain (d) |                                                                                                    |                                                                                                     |
|     |                                          |  <p>MBK116</p> |                                                                                                     |
|     |                                          | SOT78 (TO-220AB)                                                                                   | SOT404 (D <sup>2</sup> -PAK)                                                                        |

## 5. Quick reference data

Table 2: Quick reference data

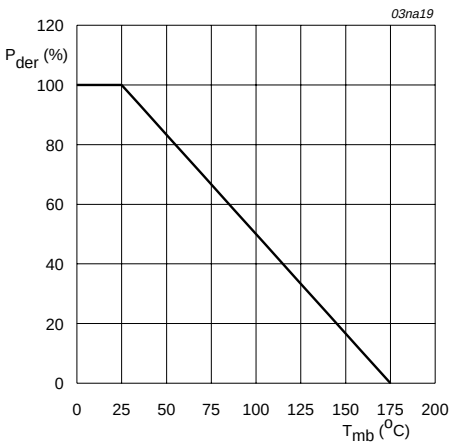
| Symbol       | Parameter                        | Conditions                                      | Typ | Max  | Unit |
|--------------|----------------------------------|-------------------------------------------------|-----|------|------|
| $V_{DS}$     | drain-source voltage (DC)        |                                                 | –   | 75   | V    |
| $I_D$        | drain current (DC)               | $T_{mb} = 25\text{ °C}$ ; $V_{GS} = 5\text{ V}$ | –   | 75   | A    |
| $P_{tot}$    | total power dissipation          | $T_{mb} = 25\text{ °C}$                         | –   | 230  | W    |
| $T_j$        | junction temperature             |                                                 | –   | 175  | °C   |
| $R_{DS(on)}$ | drain-source on-state resistance | $V_{GS} = 5\text{ V}$ ; $I_D = 25\text{ A}$     | 7.6 | 9    | mΩ   |
|              |                                  | $V_{GS} = 4.5\text{ V}$ ; $I_D = 25\text{ A}$   | –   | 9.95 | mΩ   |

## 6. Limiting values

Table 3: Limiting values

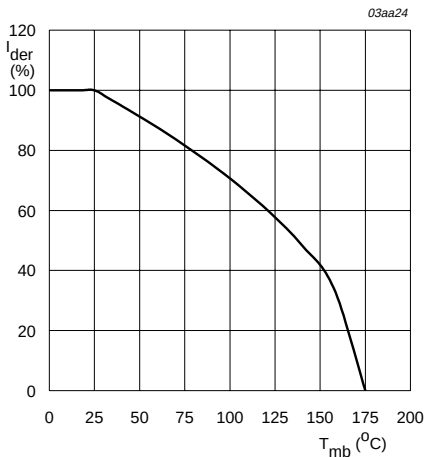
In accordance with the Absolute Maximum Rating System (IEC 60134).

| Symbol                      | Parameter                          | Conditions                                                                                                                                                               | Min | Max  | Unit |
|-----------------------------|------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|------|------|
| $V_{DS}$                    | drain-source voltage (DC)          |                                                                                                                                                                          | –   | 75   | V    |
| $V_{DGR}$                   | drain-gate voltage (DC)            | $R_{GS} = 20\text{ k}\Omega$                                                                                                                                             | –   | 75   | V    |
| $V_{GS}$                    | gate-source voltage (DC)           |                                                                                                                                                                          | –   | ±10  | V    |
| $V_{GSM}$                   | non-repetitive gate-source voltage | $t_p \leq 50\text{ }\mu\text{s}$                                                                                                                                         | –   | ±15  | V    |
| $I_D$                       | drain current (DC)                 | $T_{mb} = 25\text{ °C}$ ; $V_{GS} = 5\text{ V}$ ;<br>Figure 2 and 3                                                                                                      | –   | 75   | A    |
|                             |                                    | $T_{mb} = 100\text{ °C}$ ; $V_{GS} = 5\text{ V}$ ; Figure 2                                                                                                              | –   | 65   | A    |
| $I_{DM}$                    | peak drain current                 | $T_{mb} = 25\text{ °C}$ ; pulsed; $t_p \leq 10\text{ }\mu\text{s}$ ;<br>Figure 3                                                                                         | –   | 440  | A    |
| $P_{tot}$                   | total power dissipation            | $T_{mb} = 25\text{ °C}$ ; Figure 1                                                                                                                                       | –   | 230  | W    |
| $T_{stg}$                   | storage temperature                |                                                                                                                                                                          | –55 | +175 | °C   |
| $T_j$                       | operating junction temperature     |                                                                                                                                                                          | –55 | +175 | °C   |
| <b>Source-drain diode</b>   |                                    |                                                                                                                                                                          |     |      |      |
| $I_{DR}$                    | reverse drain current (DC)         | $T_{mb} = 25\text{ °C}$                                                                                                                                                  | –   | 75   | A    |
| $I_{DRM}$                   | pulsed reverse drain current       | $T_{mb} = 25\text{ °C}$ ; pulsed; $t_p \leq 10\text{ }\mu\text{s}$                                                                                                       | –   | 440  | A    |
| <b>Avalanche ruggedness</b> |                                    |                                                                                                                                                                          |     |      |      |
| $W_{DSS}$                   | non-repetitive avalanche energy    | unclamped inductive load; $I_D = 75\text{ A}$ ;<br>$V_{DS} \leq 75\text{ V}$ ; $V_{GS} = 5\text{ V}$ ; $R_{GS} = 50\text{ }\Omega$ ;<br>starting $T_{mb} = 25\text{ °C}$ | –   | 562  | mJ   |



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

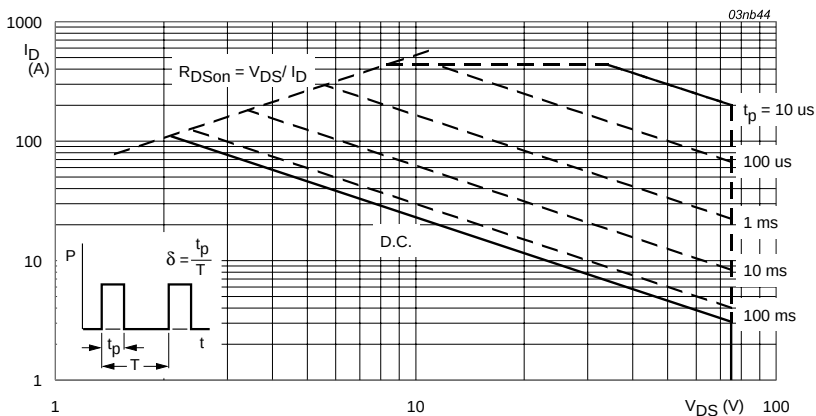
Fig 1. Normalized total power dissipation as a function of mounting base temperature.



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

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

Fig 2. Normalized continuous drain current as a function of mounting base temperature.



$T_{mb} = 25^{\circ}C$ ;  $I_{DM}$  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; SOT78 package                                | 60    | K/W  |
|                |                                                   | mounted on printed circuit board; minimum footprint; SOT404 package | 50    | K/W  |
| $R_{th(j-mb)}$ | thermal resistance from junction to mounting base | Figure 4                                                            | 0.65  | K/W  |

7.1 Transient thermal impedance

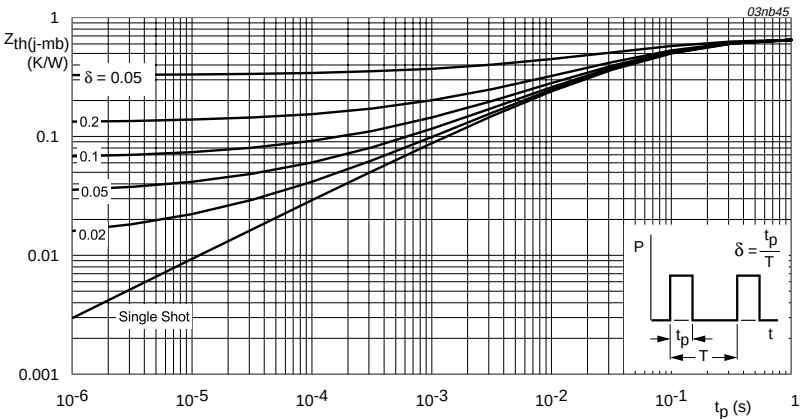


Fig 4. Transient thermal impedance from junction to mounting base as a function of pulse duration.

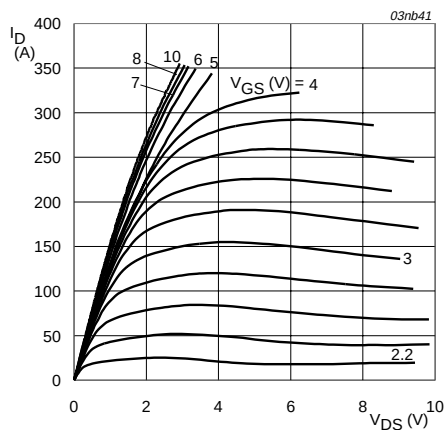
## 8. Characteristics

**Table 5: Characteristics**
 $T_j = 25\text{ °C}$  unless otherwise specified

| Symbol                  | Parameter                        | Conditions                                                             | Min | Typ  | Max  | Unit |
|-------------------------|----------------------------------|------------------------------------------------------------------------|-----|------|------|------|
| Static characteristics  |                                  |                                                                        |     |      |      |      |
| V <sub>(BR)DSS</sub>    | drain-source breakdown voltage   | I <sub>D</sub> = 0.25 mA; V <sub>GS</sub> = 0 V                        |     |      |      |      |
|                         |                                  | T <sub>J</sub> = 25 °C                                                 | 75  | –    | –    | V    |
|                         |                                  | T <sub>J</sub> = –55 °C                                                | 70  | –    | –    | V    |
| V <sub>GS(th)</sub>     | gate-source threshold voltage    | I <sub>D</sub> = 1 mA; V <sub>DS</sub> = V <sub>GS</sub> ;<br>Figure 9 |     |      |      |      |
|                         |                                  | T <sub>J</sub> = 25 °C                                                 | 1   | 1.5  | 2    | V    |
|                         |                                  | T <sub>J</sub> = 175 °C                                                | 0.5 | –    | –    | V    |
|                         |                                  | T <sub>J</sub> = –55 °C                                                | –   | –    | 2.3  | V    |
| I <sub>DSS</sub>        | drain-source leakage current     | V <sub>DS</sub> = 75 V; V <sub>GS</sub> = 0 V                          |     |      |      |      |
|                         |                                  | T <sub>J</sub> = 25 °C                                                 | –   | 0.05 | 10   | μA   |
|                         |                                  | T <sub>J</sub> = 175 °C                                                | –   | –    | 500  | μA   |
| I <sub>GSS</sub>        | gate-source leakage current      | V <sub>GS</sub> = ±10 V; V <sub>DS</sub> = 0 V                         | –   | 2    | 100  | nA   |
| R <sub>DSon</sub>       | drain-source on-state resistance | V <sub>GS</sub> = 5 V; I <sub>D</sub> = 25 A;<br>Figure 7 and 8        |     |      |      |      |
|                         |                                  | T <sub>J</sub> = 25 °C                                                 | –   | 7.6  | 9    | mΩ   |
|                         |                                  | T <sub>J</sub> = 175 °C                                                | –   | –    | 18.9 | mΩ   |
|                         |                                  | V <sub>GS</sub> = 4.5 V; I <sub>D</sub> = 25 A                         | –   | –    | 9.95 | mΩ   |
|                         |                                  | V <sub>GS</sub> = 10 V; I <sub>D</sub> = 25 A                          | –   | 7.23 | 8.5  | mΩ   |
| Dynamic characteristics |                                  |                                                                        |     |      |      |      |
| C <sub>iss</sub>        | input capacitance                | V <sub>GS</sub> = 0 V; V <sub>DS</sub> = 25 V;                         | –   | 6631 | 8840 | pF   |
| C <sub>oss</sub>        | output capacitance               | f = 1 MHz; Figure 12                                                   | –   | 905  | 1090 | pF   |
| C <sub>rss</sub>        | reverse transfer capacitance     |                                                                        | –   | 610  | 840  | pF   |
| t <sub>d(on)</sub>      | turn-on delay time               | V <sub>DD</sub> = 30 V; R <sub>L</sub> = 1.2 Ω;                        | –   | 47   | –    | ns   |
| t <sub>r</sub>          | rise time                        | V <sub>GS</sub> = 5 V; R <sub>G</sub> = 10 Ω                           | –   | 185  | –    | ns   |
| t <sub>d(off)</sub>     | turn-off delay time              |                                                                        | –   | 424  | –    | ns   |
| t <sub>f</sub>          | fall time                        |                                                                        | –   | 226  | –    | ns   |
| L <sub>d</sub>          | internal drain inductance        | from drain lead 6 mm from package to centre of die                     | –   | 4.5  | –    | nH   |
|                         |                                  | from contact screw on mounting base to centre of die SOT78             | –   | 3.5  | –    | nH   |
|                         |                                  | from upper edge of drain mounting base to centre of die SOT404         | –   | 2.5  | –    | nH   |
| L <sub>s</sub>          | internal source inductance       | from source lead to source bond pad                                    | –   | 7.5  | –    | nH   |

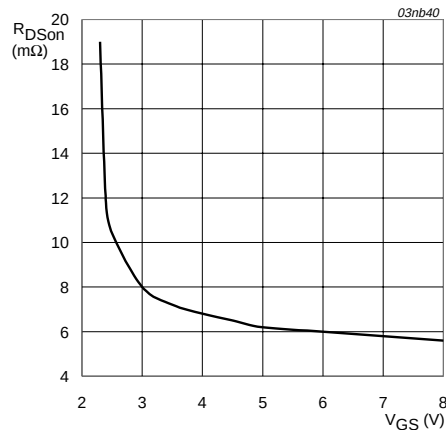
Table 5: Characteristics...continued  
 $T_j = 25\text{ }^{\circ}\text{C}$  unless otherwise specified

| Symbol             | Parameter                            | Conditions                                                  | Min | Typ  | Max | Unit |
|--------------------|--------------------------------------|-------------------------------------------------------------|-----|------|-----|------|
| Source-drain diode |                                      |                                                             |     |      |     |      |
| $V_{SD}$           | source-drain (diode forward) voltage | $I_S = 25\text{ A}$ ; $V_{GS} = 0\text{ V}$ ;<br>Figure 15  | —   | 0.85 | 1.2 | V    |
| $t_{rr}$           | reverse recovery time                | $I_S = 20\text{ A}$ ; $dI_S/dt = -100\text{ A}/\mu\text{s}$ | —   | 70.3 | —   | ns   |
| $Q_r$              | recovered charge                     | $V_{GS} = -10\text{ V}$ ; $V_{DS} = 30\text{ V}$            | —   | 213  | —   | nC   |



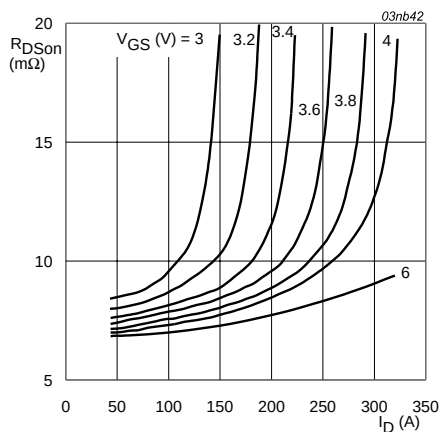
$T_j = 25\text{ }^{\circ}\text{C}$ ;  $t_p = 300\text{ }\mu\text{s}$

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



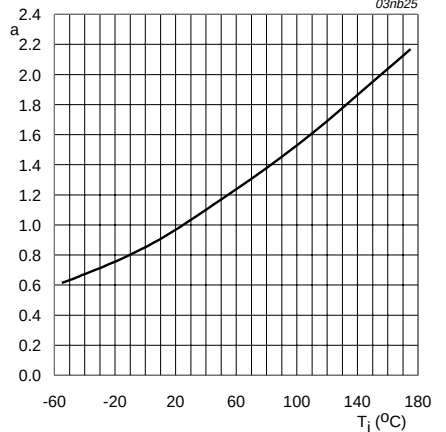
$T_j = 25\text{ }^{\circ}\text{C}$ ;  $I_D = 25\text{ A}$

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



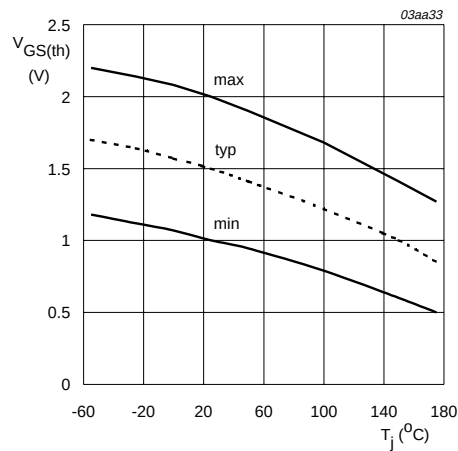
$T_j = 25\text{ }^{\circ}\text{C}$

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



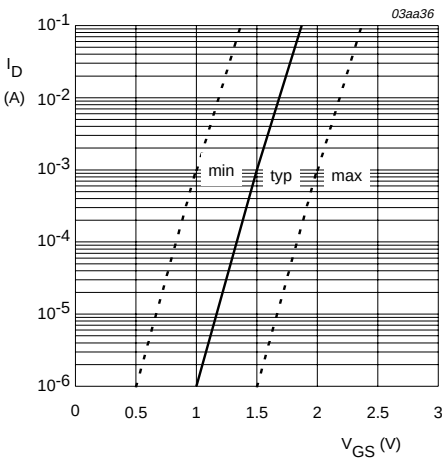
$$a = \frac{R_{DSon}}{R_{DSon(25^{\circ}\text{C})}}$$

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



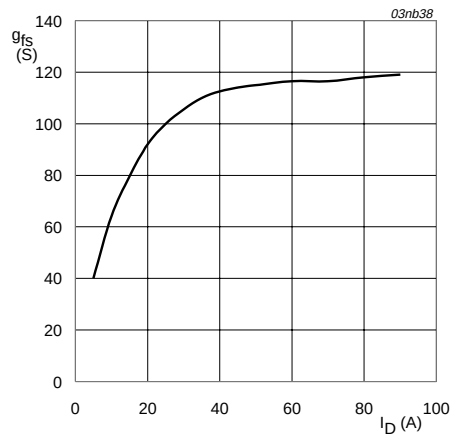
$I_D = 1 \text{ mA}$ ;  $V_{DS} = V_{GS}$

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



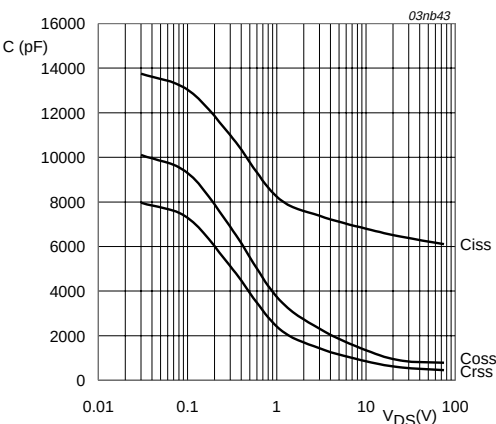
$T_j = 25 \text{ °C}$ ;  $V_{DS} = V_{GS}$

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



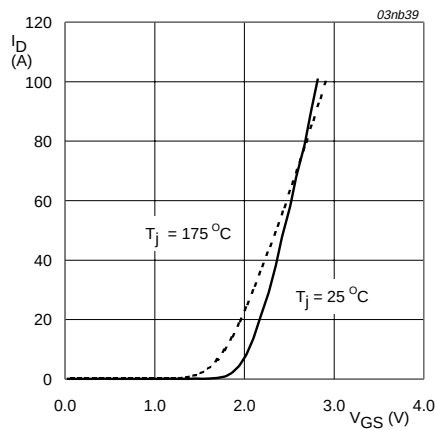
$T_j = 25 \text{ °C}$ ;  $V_{DS} = 25 \text{ V}$

Fig 11. Forward transconductance as a function of drain current; typical values.



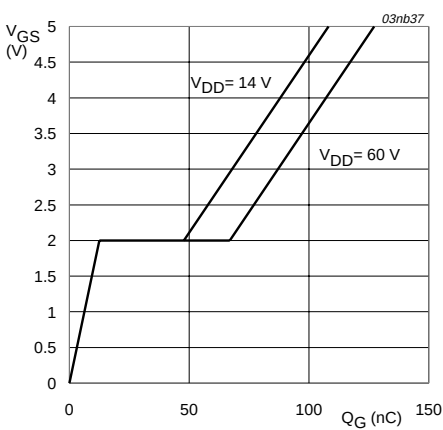
$V_{GS} = 0 \text{ V}$ ;  $f = 1 \text{ MHz}$

Fig 12. Input, output and reverse transfer capacitances as a function of drain-source voltage; typical values.



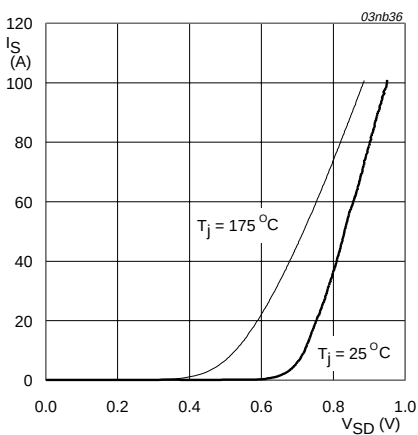
$V_{DS} = 25\text{ V}$

Fig 13. Transfer characteristics: drain current as a function of gate-source voltage; typical values.



$T_J = 25\text{ }^{\circ}\text{C}; I_D = 25\text{ A}$

Fig 14. Gate-source voltage as a function of turn-on gate charge; typical values.



$V_{GS} = 0\text{ V}$

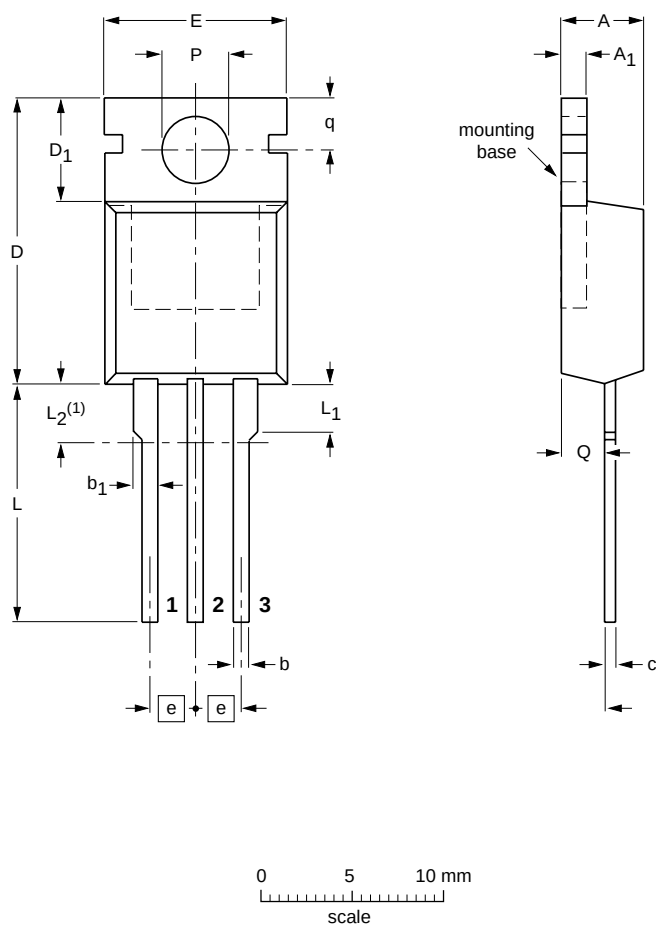
Fig 15. Reverse diode current as a function of reverse diode voltage; typical values.



9. Package outline

Plastic single-ended package; heatsink mounted; 1 mounting hole; 3-lead TO-220AB

SOT78



DIMENSIONS (mm are the original dimensions)

| UNIT | A          | A <sub>1</sub> | b          | b <sub>1</sub> | c          | D            | D <sub>1</sub> | E           | e    | L            | L <sub>1</sub> | L <sub>2</sub> <sup>(1)</sup><br>max. | P          | q          | Q          |
|------|------------|----------------|------------|----------------|------------|--------------|----------------|-------------|------|--------------|----------------|---------------------------------------|------------|------------|------------|
| mm   | 4.5<br>4.1 | 1.39<br>1.27   | 0.9<br>0.7 | 1.3<br>1.0     | 0.7<br>0.4 | 15.8<br>15.2 | 6.4<br>5.9     | 10.3<br>9.7 | 2.54 | 15.0<br>13.5 | 3.30<br>2.79   | 3.0                                   | 3.8<br>3.6 | 3.0<br>2.7 | 2.6<br>2.2 |

Note

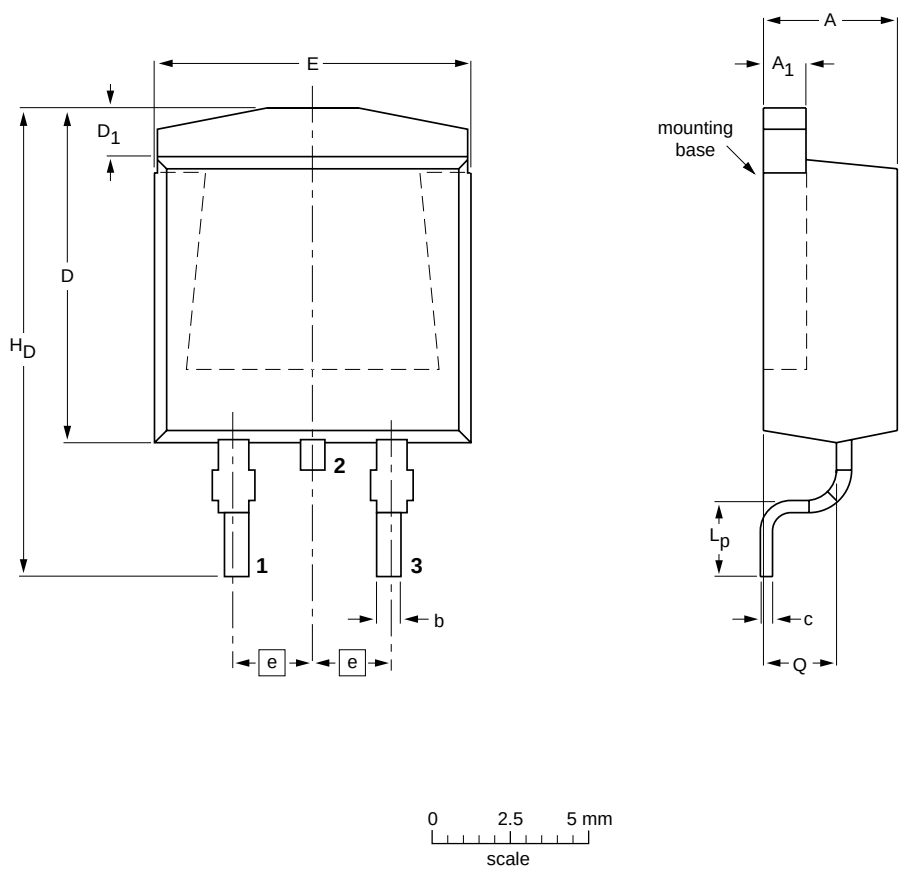
1. Terminals in this zone are not tinned.

| OUTLINE<br>VERSION | REFERENCES |                 |       |  | EUROPEAN<br>PROJECTION                                                                | ISSUE DATE           |
|--------------------|------------|-----------------|-------|--|---------------------------------------------------------------------------------------|----------------------|
|                    | IEC        | JEDEC           | EIAJ  |  |                                                                                       |                      |
| SOT78              |            | 3-lead TO-220AB | SC-46 |  |  | 99-09-13<br>00-09-07 |

Fig 16. SOT78 (TO-220AB).

Plastic single-ended surface mounted package (Philips version of D<sup>2</sup>-PAK); 3 leads  
(one lead cropped)

SOT404



DIMENSIONS (mm are the original dimensions)

| UNIT | A            | A <sub>1</sub> | b            | c            | D <sub>max.</sub> | D <sub>1</sub> | E             | e    | L <sub>p</sub> | H <sub>D</sub> | Q            |
|------|--------------|----------------|--------------|--------------|-------------------|----------------|---------------|------|----------------|----------------|--------------|
| mm   | 4.50<br>4.10 | 1.40<br>1.27   | 0.85<br>0.60 | 0.64<br>0.46 | 11                | 1.60<br>1.20   | 10.30<br>9.70 | 2.54 | 2.90<br>2.10   | 15.40<br>14.80 | 2.60<br>2.20 |

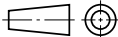
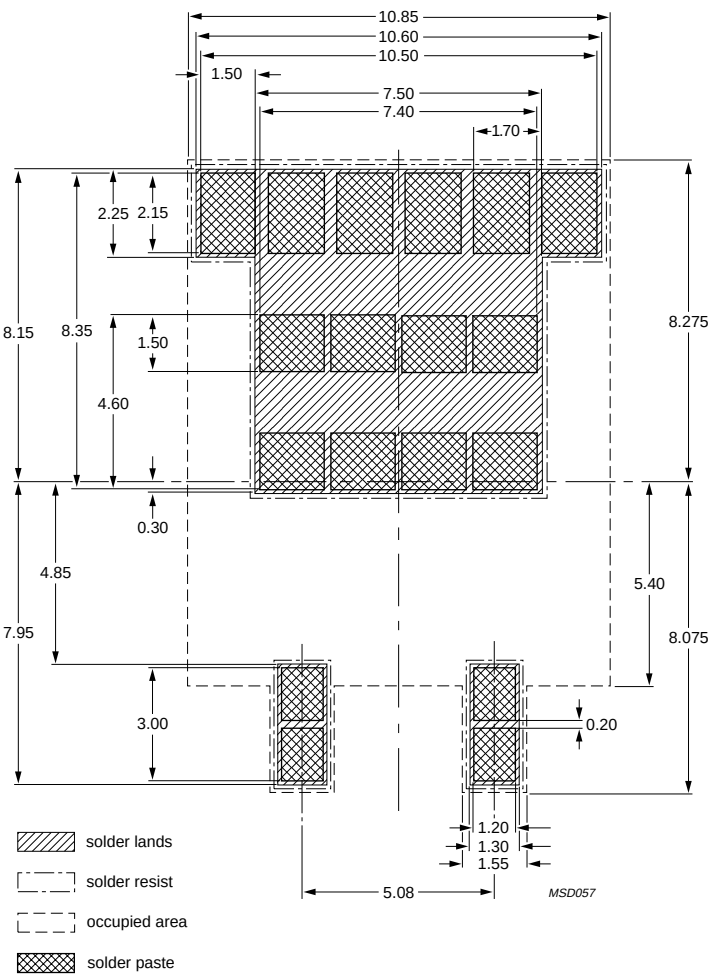
| OUTLINE<br>VERSION | REFERENCES |       |      |  | EUROPEAN<br>PROJECTION                                                                | ISSUE DATE           |
|--------------------|------------|-------|------|--|---------------------------------------------------------------------------------------|----------------------|
|                    | IEC        | JEDEC | EIAJ |  |                                                                                       |                      |
| SOT404             |            |       |      |  |  | 98-12-14<br>99-06-25 |

Fig 17. SOT404 (D<sup>2</sup>-PAK).

10. Soldering



## 11. Revision history

Table 6: Revision history

| Rev | Date     | CPCN | Description                                                                                                                                                                                                                                                                                         |
|-----|----------|------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 02  | 20001106 | -    | <b>Product specification; second version; supersedes Rev. 01 of 20001010.</b> <ul style="list-style-type: none"><li>Value of 'I<sub>S</sub>' changed from '46 A' to '20 A' in the 'Conditions' column of 't<sub>rr</sub>'; see section "Source-drain diode" of Table 5 "Characteristics".</li></ul> |
| 01  | 20001010 | -    | <b>Product specification; initial version.</b>                                                                                                                                                                                                                                                      |

## 12. 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.

## 13. 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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