



# BUK9504-40A

## N-channel TrenchMOS logic level FET

Rev. 2 — 7 February 2011

Product data sheet

## 1. Product profile

### 1.1 General description

Logic level N-channel enhancement mode Field-Effect Transistor (FET) in a plastic package using TrenchMOS technology. This product has been designed and qualified to the appropriate AEC standard for use in automotive critical applications.

### 1.2 Features and benefits

- AEC Q101 compliant
- Low conduction losses due to low on-state resistance
- Suitable for logic level gate drive sources
- Suitable for thermally demanding environments due to 175 °C rating

### 1.3 Applications

- 12 V loads
- Automotive and general purpose power switching
- Motors, lamps and solenoids

### 1.4 Quick reference data

Table 1. Quick reference data

| Symbol    | Parameter               | Conditions  | Min                 | Typ | Max | Unit |
|-----------|-------------------------|---|---------------------|-----|-----|------|
| $V_{DS}$  | drain-source voltage    | $T_j \geq 25\text{ °C}$ ; $T_j \leq 175\text{ °C}$  | -                   | -   | 40  | V    |
| $I_D$     | drain current           | $V_{GS} = 5\text{ V}$ ; $T_{mb} = 25\text{ °C}$ ; see <a href="#">Figure 1</a> ; see <a href="#">Figure 3</a> | <a href="#">[1]</a> | -   | 75  | A    |
| $P_{tot}$ | total power dissipation | $T_{mb} = 25\text{ °C}$ ; see <a href="#">Figure 2</a>  | -                   | -   | 300 | W    |

#### Static characteristics

|              |                                  |  |   |     |     |            |
|--------------|----------------------------------|--|---|-----|-----|------------|
| $R_{DS(on)}$ | drain-source on-state resistance | $V_{GS} = 4.3\text{ V}$ ; $I_D = 25\text{ A}$ ; $T_j = 25\text{ °C}$   | - | 3.7 | 5.9 | m $\Omega$ |
|              |                                  | $V_{GS} = 10\text{ V}$ ; $I_D = 25\text{ A}$ ; $T_j = 25\text{ °C}$  | - | 2.9 | 4   | m $\Omega$ |
|              |                                  | $V_{GS} = 5\text{ V}$ ; $I_D = 25\text{ A}$ ; $T_j = 25\text{ °C}$ ; see <a href="#">Figure 11</a> ; see <a href="#">Figure 12</a> | - | 3.5 | 4.4 | m $\Omega$ |



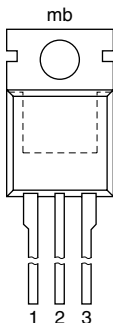
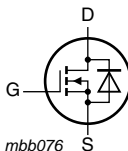
**Table 1. Quick reference data ...continued**

| Symbol                         | Parameter                                    | Conditions   | Min | Typ | Max | Unit |
|--------------------------------|--|--|-----|-----|-----|------|
| <b>Avalanche ruggedness</b>    |  |  |     |     |     |      |
| $E_{DS(AL)S}$                  | non-repetitive drain-source avalanche energy | $I_D = 75\text{ A}$ ; $V_{sup} \leq 40\text{ V}$ ;<br>$R_{GS} = 50\ \Omega$ ; $V_{GS} = 5\text{ V}$ ;<br>$T_{j(\text{init})} = 25\text{ }^\circ\text{C}$ ; unclamped | -   | -   | 1.6 | J    |
| <b>Dynamic characteristics</b> |  |  |     |     |     |      |
| $Q_{GD}$                       | gate-drain charge                            | $V_{GS} = 5\text{ V}$ ; $I_D = 25\text{ A}$ ;<br>$V_{DS} = 32\text{ V}$ ; $T_j = 25\text{ }^\circ\text{C}$ ;<br>see <a href="#">Figure 13</a>                        | -   | 56  | -   | nC   |

[1] Continuous current is limited by package.

## 2. Pinning information

**Table 2. Pinning information**

| Pin | Symbol | Description                       | Simplified outline   | Graphic symbol   |
|-----|--------|-----------------------------------|--|--|
| 1   | G      | gate                              |  |  |
| 2   | D      | drain                             |  |  |
| 3   | S      | source                            |  |  |
| mb  | D      | mounting base; connected to drain |  |  |

**SOT78A (TO-220AB)**

## 3. Ordering information

**Table 3. Ordering information**

| Type number | Package  |  | Version |
|-------------|----------|--|---------|
|             | Name     | Description  |         |
| BUK9504-40A | TO-220AB | plastic single-ended package; heatsink mounted; 1 mounting hole; 3-lead TO-220AB | SOT78A  |

## 4. Limiting values

**Table 4. Limiting values**

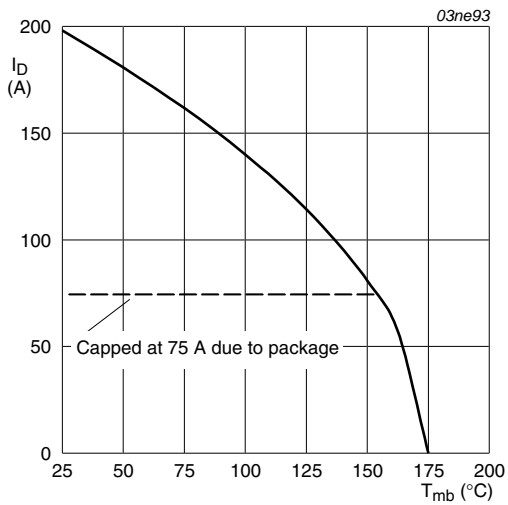
In accordance with the Absolute Maximum Rating System (IEC 60134).

| Symbol                      | Parameter                                    | Conditions  | Min | Max | Unit |   |
|-----------------------------|--|---|-----|-----|------|---|
| $V_{DS}$                    | drain-source voltage                         | $T_j \geq 25\text{ °C}$ ; $T_j \leq 175\text{ °C}$  | -   | 40  | V    |   |
| $V_{DGR}$                   | drain-gate voltage                           | $R_{GS} = 20\text{ k}\Omega$  | -   | 40  | V    |   |
| $V_{GS}$                    | gate-source voltage                          |   | -15 | 15  | V    |   |
| $I_D$                       | drain current                                | $T_{mb} = 100\text{ °C}$ ; $V_{GS} = 5\text{ V}$ ; see <a href="#">Figure 1</a>   | [1] | -   | 75   | A |
|                             |  | $T_{mb} = 25\text{ °C}$ ; $V_{GS} = 5\text{ V}$ ; see <a href="#">Figure 1</a> ; see <a href="#">Figure 3</a>                                     | [1] | -   | 75   | A |
|                             |  |   | [2] | -   | 198  | A |
| $I_{DM}$                    | peak drain current                           | $T_{mb} = 25\text{ °C}$ ; pulsed; $t_p \leq 10\text{ }\mu\text{s}$ ; see <a href="#">Figure 3</a>   | -   | 794 | A    |   |
| $P_{tot}$                   | total power dissipation                      | $T_{mb} = 25\text{ °C}$ ; see <a href="#">Figure 2</a>  | -   | 300 | W    |   |
| $T_{stg}$                   | storage temperature                          |   | -55 | 175 | °C   |   |
| $T_j$                       | junction temperature                         |   | -55 | 175 | °C   |   |
| <b>Source-drain diode</b>   |  |   |     |     |      |   |
| $I_S$                       | source current                               | $T_{mb} = 25\text{ °C}$   | [3] | -   | 198  | A |
|                             |  |   | [1] | -   | 75   | A |
| $I_{SM}$                    | peak source current                          | pulsed; $t_p \leq 10\text{ }\mu\text{s}$ ; $T_{mb} = 25\text{ °C}$  | -   | 794 | A    |   |
| <b>Avalanche ruggedness</b> |  |   |     |     |      |   |
| $E_{DS(AL)S}$               | non-repetitive drain-source avalanche energy | $I_D = 75\text{ A}$ ; $V_{sup} \leq 40\text{ V}$ ; $R_{GS} = 50\text{ }\Omega$ ; $V_{GS} = 5\text{ V}$ ; $T_{j(init)} = 25\text{ °C}$ ; unclamped | -   | 1.6 | J    |   |

[1] Continuous current is limited by package.

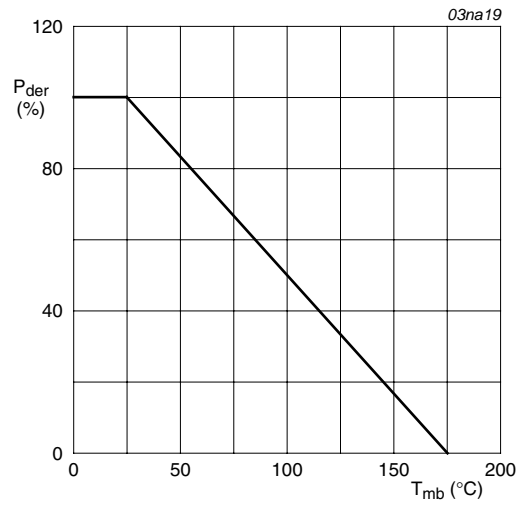
[2] Current is limited by power dissipation chip rating.

[3] Current is limited by power dissipation chip rating



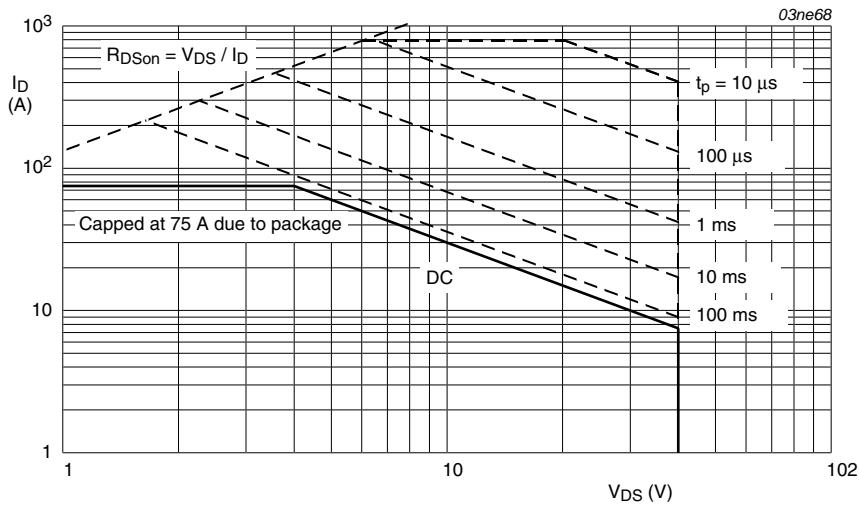
$$V_{GS} \geq 5V$$

**Fig 1. Normalized continuous drain current as a function of mounting base temperature**



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

**Fig 2. Normalized total power dissipation as a function of mounting base temperature**



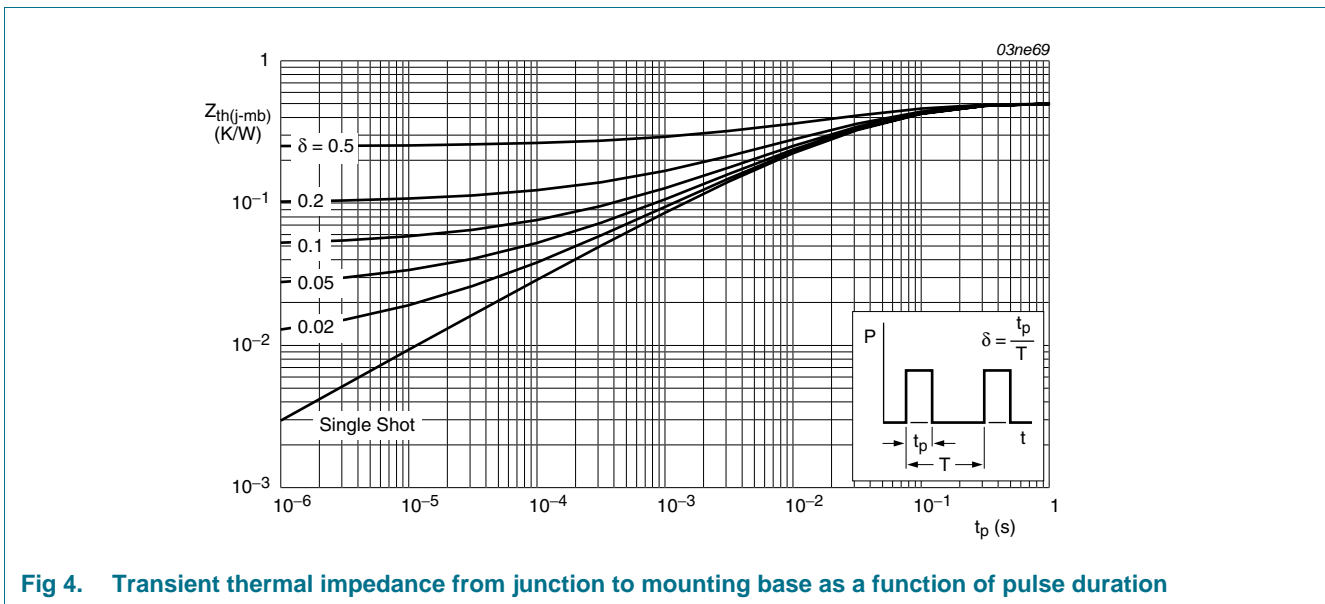
$$T_{mb} = 25^{\circ}C; I_{DM} \text{ is single pulse}$$

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

## 5. Thermal characteristics

**Table 5. Thermal characteristics**

| Symbol         | Parameter   | Conditions                   | Min | Typ | Max | Unit |
|----------------|---|------------------------------|-----|-----|-----|------|
| $R_{th(j-mb)}$ | thermal resistance from junction to mounting base | see <a href="#">Figure 4</a> | -   | -   | 0.5 | K/W  |
| $R_{th(j-a)}$  | thermal resistance from junction to ambient       | vertical in still air        | -   | 60  | -   | K/W  |



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

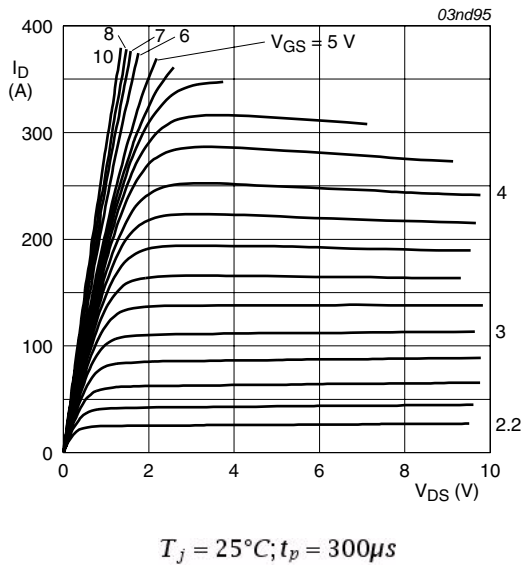
## 6. Characteristics

**Table 6. Characteristics**

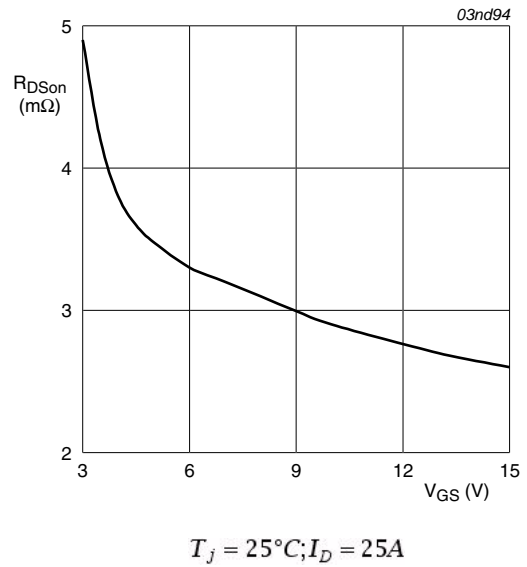
| Symbol                         | Parameter                        | Conditions  | Min | Typ  | Max  | Unit          |
|--------------------------------|----------------------------------|---|-----|------|------|---------------|
| <b>Static characteristics</b>  |                                  |   |     |      |      |               |
| $V_{(BR)DSS}$                  | drain-source breakdown voltage   | $I_D = 0.25 \text{ mA}; V_{GS} = 0 \text{ V}; T_j = 25 \text{ }^\circ\text{C}$  | 40  | -    | -    | V             |
|                                |                                  | $I_D = 0.25 \text{ mA}; V_{GS} = 0 \text{ V}; T_j = -55 \text{ }^\circ\text{C}$   | 36  | -    | -    | V             |
| $V_{GS(th)}$                   | gate-source threshold voltage    | $I_D = 1 \text{ mA}; V_{DS} = V_{GS}; T_j = 25 \text{ }^\circ\text{C};$<br>see <a href="#">Figure 10</a>  | 1   | 1.5  | 2    | V             |
|                                |                                  | $I_D = 1 \text{ mA}; V_{DS} = V_{GS}; T_j = 175 \text{ }^\circ\text{C};$<br>see <a href="#">Figure 10</a>                                       | 0.5 | -    | -    | V             |
|                                |                                  | $I_D = 1 \text{ mA}; V_{DS} = V_{GS}; T_j = -55 \text{ }^\circ\text{C};$<br>see <a href="#">Figure 10</a>                                       | -   | -    | 2.3  | V             |
| $I_{DSS}$                      | drain leakage current            | $V_{DS} = 40 \text{ V}; V_{GS} = 0 \text{ V}; T_j = 25 \text{ }^\circ\text{C}$  | -   | 0.05 | 10   | $\mu\text{A}$ |
|                                |                                  | $V_{DS} = 40 \text{ V}; V_{GS} = 0 \text{ V}; T_j = 175 \text{ }^\circ\text{C}$   | -   | -    | 500  | $\mu\text{A}$ |
| $I_{GSS}$                      | gate leakage current             | $V_{GS} = 10 \text{ V}; V_{DS} = 0 \text{ V}; T_j = 25 \text{ }^\circ\text{C}$  | -   | 2    | 100  | nA            |
|                                |                                  | $V_{GS} = -10 \text{ V}; V_{DS} = 0 \text{ V}; T_j = 25 \text{ }^\circ\text{C}$   | -   | 2    | 100  | nA            |
| $R_{DS(on)}$                   | drain-source on-state resistance | $V_{GS} = 4.3 \text{ V}; I_D = 25 \text{ A}; T_j = 25 \text{ }^\circ\text{C}$   | -   | 3.7  | 5.9  | m $\Omega$    |
|                                |                                  | $V_{GS} = 10 \text{ V}; I_D = 25 \text{ A}; T_j = 25 \text{ }^\circ\text{C}$  | -   | 2.9  | 4    | m $\Omega$    |
|                                |                                  | $V_{GS} = 5 \text{ V}; I_D = 25 \text{ A}; T_j = 175 \text{ }^\circ\text{C};$<br>see <a href="#">Figure 11</a> ; see <a href="#">Figure 12</a>  | -   | -    | 8.3  | m $\Omega$    |
|                                |                                  | $V_{GS} = 5 \text{ V}; I_D = 25 \text{ A}; T_j = 25 \text{ }^\circ\text{C};$<br>see <a href="#">Figure 11</a> ; see <a href="#">Figure 12</a>   | -   | 3.5  | 4.4  | m $\Omega$    |
| <b>Dynamic characteristics</b> |                                  |   |     |      |      |               |
| $Q_{G(tot)}$                   | total gate charge                | $I_D = 25 \text{ A}; V_{DS} = 32 \text{ V}; V_{GS} = 5 \text{ V};$<br>$T_j = 25 \text{ }^\circ\text{C};$ see <a href="#">Figure 13</a>          | -   | 128  | -    | nC            |
| $Q_{GS}$                       | gate-source charge               |   | -   | 13   | -    | nC            |
| $Q_{GD}$                       | gate-drain charge                |   | -   | 56   | -    | nC            |
| $C_{iss}$                      | input capacitance                | $V_{GS} = 0 \text{ V}; V_{DS} = 25 \text{ V}; f = 1 \text{ MHz};$<br>$T_j = 25 \text{ }^\circ\text{C};$ see <a href="#">Figure 14</a>           | -   | 6200 | 8260 | pF            |
| $C_{oss}$                      | output capacitance               |   | -   | 1040 | 1250 | pF            |
| $C_{rss}$                      | reverse transfer capacitance     |   | -   | 680  | 940  | pF            |
| $t_{d(on)}$                    | turn-on delay time               | $V_{DS} = 30 \text{ V}; R_L = 1.2 \text{ } \Omega; V_{GS} = 5 \text{ V};$<br>$R_{G(ext)} = 10 \text{ } \Omega; T_j = 25 \text{ }^\circ\text{C}$ | -   | 62   | -    | ns            |
| $t_r$                          | rise time                        |   | -   | 309  | -    | ns            |
| $t_{d(off)}$                   | turn-off delay time              |   | -   | 365  | -    | ns            |
| $t_f$                          | fall time                        |   | -   | 306  | -    | ns            |
| $L_D$                          | internal drain inductance        | from contact screw on mounting base to centre of die SOT78 ; $T_j = 25 \text{ }^\circ\text{C}$  | -   | 3.5  | -    | nH            |
|                                |                                  | from drain lead 6 mm from package to centre of die ; $T_j = 25 \text{ }^\circ\text{C}$  | -   | 4.5  | -    | nH            |
| $L_S$                          | internal source inductance       | from source lead to source bond pad ; $T_j = 25 \text{ }^\circ\text{C}$   | -   | 7.5  | -    | nH            |

**Table 6. Characteristics ...continued**

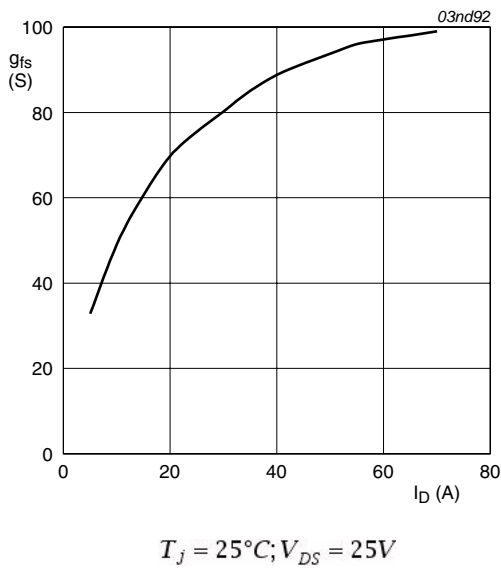
| Symbol                    | Parameter             | Conditions   | Min | Typ  | Max | Unit |
|---------------------------|-----------------------|--|-----|------|-----|------|
| <b>Source-drain diode</b> |                       |  |     |      |     |      |
| $V_{SD}$                  | source-drain voltage  | $I_S = 40\text{ A}$ ; $V_{GS} = 0\text{ V}$ ; $T_j = 25\text{ }^\circ\text{C}$ ; see <a href="#">Figure 15</a> | -   | 0.85 | 1.2 | V    |
| $t_{rr}$                  | reverse recovery time | $I_S = 20\text{ A}$ ; $dI_S/dt = -100\text{ A}/\mu\text{s}$ ;  | -   | 260  | -   | ns   |
| $Q_r$                     | recovered charge      | $V_{GS} = -10\text{ V}$ ; $V_{DS} = 30\text{ V}$ ; $T_j = 25\text{ }^\circ\text{C}$                            | -   | 531  | -   | nC   |



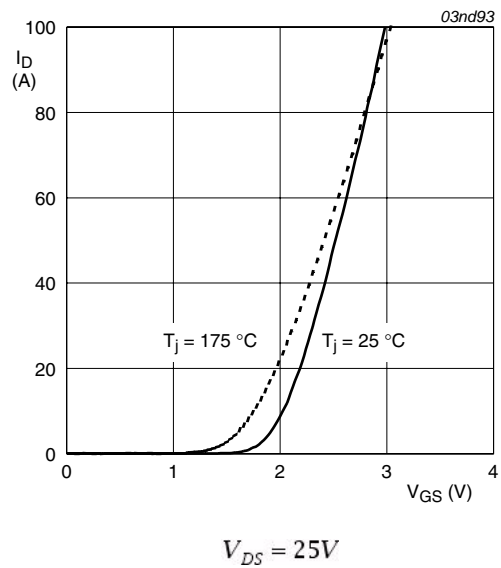
**Fig 5. Output characteristics: drain current as a function of drain-source voltage; typical values**



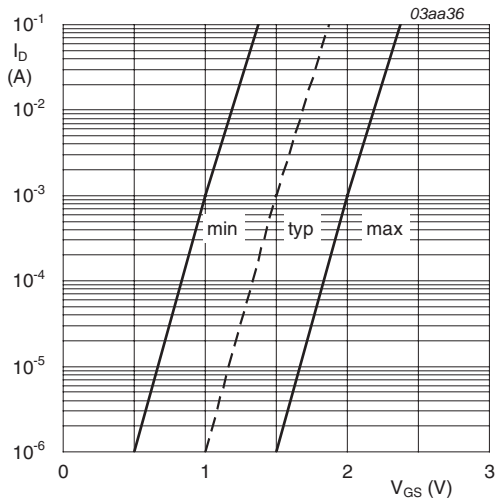
**Fig 6. Drain-source on-state resistance as a function of gate-source voltage; typical values**



**Fig 7. Forward transconductance as a function of drain current; typical values**

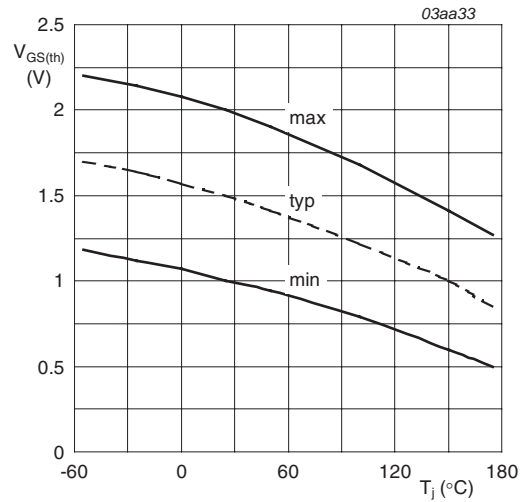


**Fig 8. Transfer characteristics: drain current as a function of gate-source voltage; typical values**



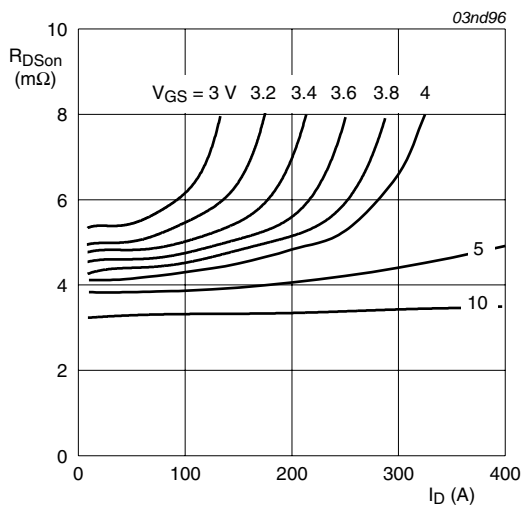
$T_j = 25\text{ }^\circ\text{C}; V_{DS} = 5\text{ V}$

**Fig 9. Sub-threshold drain current as a function of gate-source voltage**



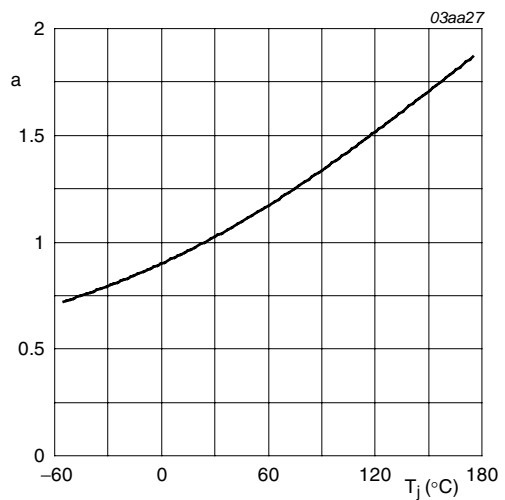
$I_D = 1\text{ mA}; V_{DS} = V_{GS}$

**Fig 10. Gate-source threshold voltage as a function of junction temperature**



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

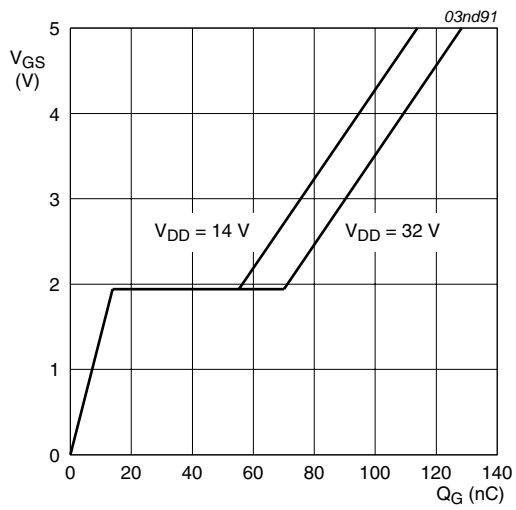
**Fig 11. Drain-source on-state resistance as a function of drain current; typical values**



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

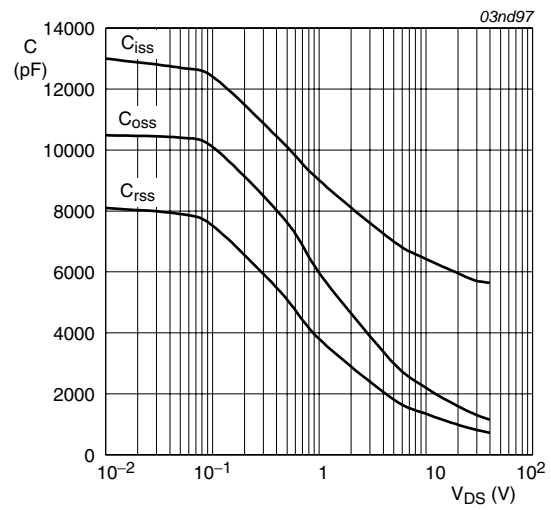
**Fig 12. Normalized drain-source on-state resistance factor as a function of junction temperature**





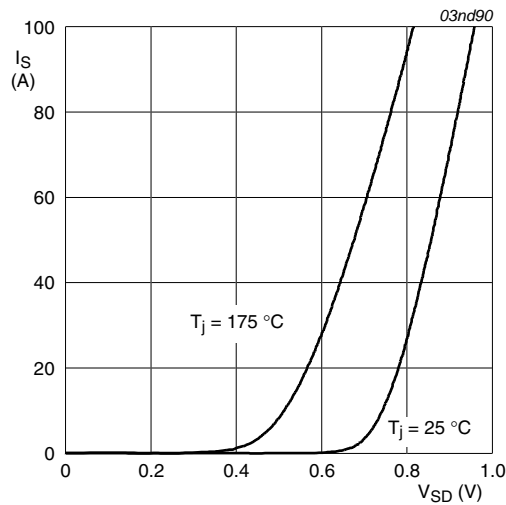
$T_j = 25^\circ\text{C}; I_D = 25\text{A}$

**Fig 13. Gate-source voltage as a function of turn-on gate charge; 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**



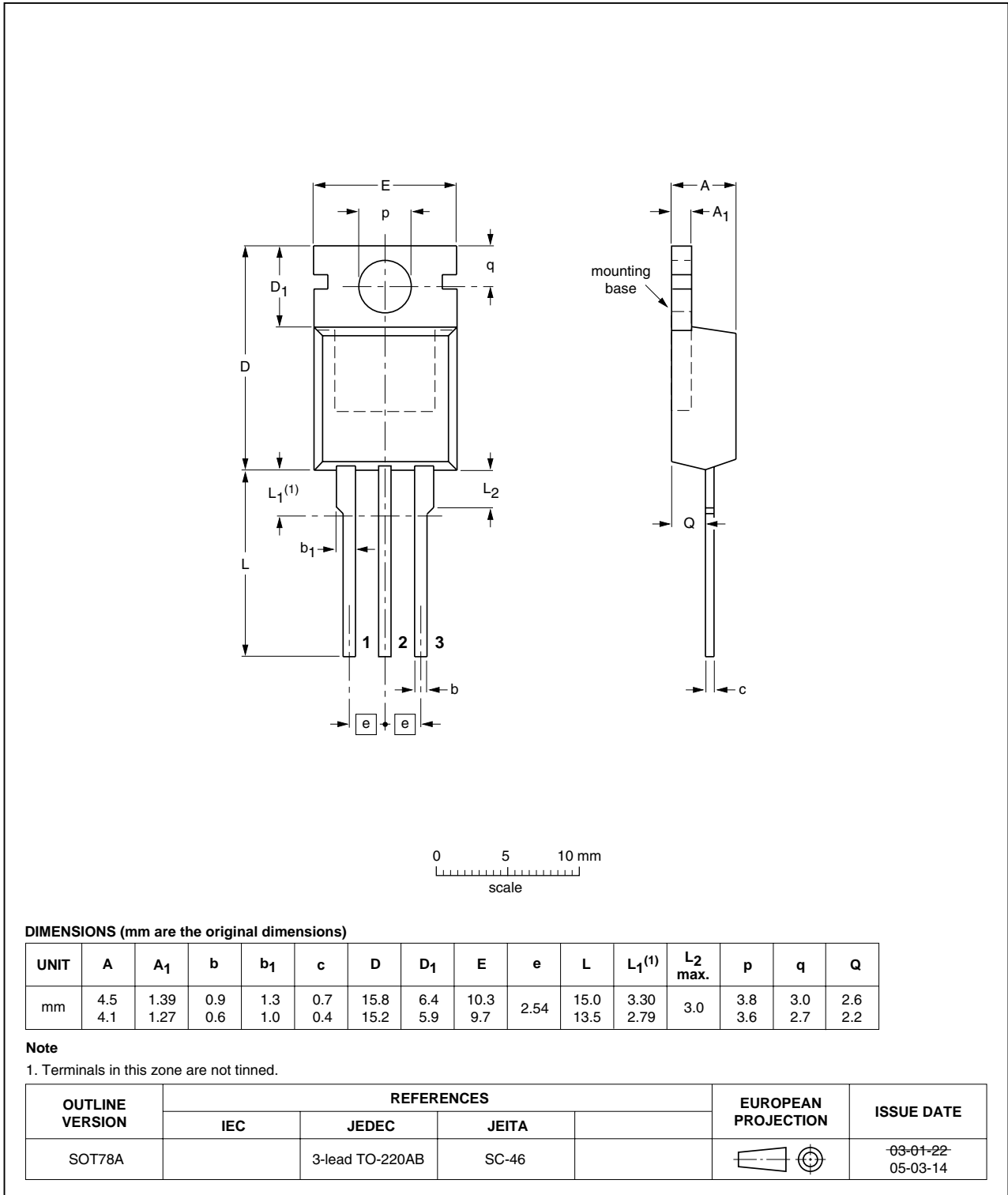
$V_{GS} = 0\text{V}$

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

**7. Package outline**

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

SOT78A



**Fig 16. Package outline SOT78A (TO-220AB)**

## 8. Revision history

Table 7. Revision history

| Document ID          | Release date | Data sheet status  | Change notice | Supersedes           |
|----------------------|--------------|--|---------------|----------------------|
| BUK9604-40A v.2      | 20110207     | Product data sheet   | -             | BUK95_96_9E04_40A-01 |
| Modifications:       |              | <ul style="list-style-type: none"><li>• The format of this data sheet has been redesigned to comply with the new identity guidelines of NXP Semiconductors.</li><li>• Legal texts have been adapted to the new company name where appropriate.</li><li>• Type number BUK9604-40A separated from data sheet BUK95_96_9E04_40A-01.</li></ul> |               |                      |
| BUK95_96_9E04_40A-01 | 20011024     | Product specification  | -             | -                    |

## 9. Legal information

### 9.1 Data sheet status

| Document status <sup>[1][2]</sup> | Product status <sup>[3]</sup> | Definition  |
|-----------------------------------|-------------------------------|---|
| Objective [short] data sheet      | Development                   | This document contains data from the objective specification for product development. |
| Preliminary [short] data sheet    | Qualification                 | This document contains data from the preliminary specification.                       |
| Product [short] data sheet        | Production                    | This document contains the product specification.                                     |

[1] Please consult the most recently issued document before initiating or completing a design.

[2] The term 'short data sheet' is explained in section "Definitions".

[3] The product status of device(s) described in this document may have changed since this document was published and may differ in case of multiple devices. The latest product status information is available on the Internet at URL <http://www.nxp.com>.

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**Limiting values** — Stress above one or more limiting values (as defined in the Absolute Maximum Ratings System of IEC 60134) will cause permanent damage to the device. Limiting values are stress ratings only and (proper) operation of the device at these or any other conditions above those given in the Recommended operating conditions section (if present) or the Characteristics sections of this document is not warranted. Constant or repeated exposure to limiting values will permanently and irreversibly affect the quality and reliability of the device.

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