

# BUK654R8-40C

N-channel TrenchMOS intermediate level FET

Rev. 03 — 12 October 2010

Product data sheet

## 1. Product profile

### 1.1 General description

Intermediate level gate drive N-channel enhancement mode Field-Effect Transistor (FET) in a plastic package using advanced TrenchMOS technology. This product has been designed and qualified to the appropriate AEC Q101 standard for use in high performance automotive applications.

### 1.2 Features and benefits

- AEC Q101 compliant
- Suitable for standard and logic level gate drive sources
- Suitable for thermally demanding environments due to 175 °C rating

### 1.3 Applications

- 12 V Automotive systems
- Electric and electro-hydraulic power steering
- Motors, lamps and solenoid control
- Start-Stop micro-hybrid applications
- Transmission control
- Ultra high performance power switching

### 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                    | $V_{GS} = 10\text{ V}; T_{mb} = 25\text{ °C};$<br>see <a href="#">Figure 1</a>                    | <a href="#">(1)</a> | -    | 100 | A    |
| $P_{tot}$                     | total power dissipation          | $T_{mb} = 25\text{ °C};$ see <a href="#">Figure 2</a>   | -                   | -    | 158 | W    |
| <b>Static characteristics</b> |                                  |   |                     |      |     |      |
| $R_{DS(on)}$                  | drain-source on-state resistance | $V_{GS} = 10\text{ V}; I_D = 25\text{ A};$<br>$T_j = 25\text{ °C};$ see <a href="#">Figure 11</a> | -                   | 3.84 | 4.8 | mΩ   |



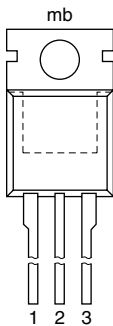
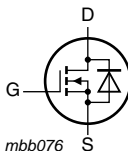
**Table 1. Quick reference data ...continued**

| Symbol                         | Parameter                                    | Conditions  | Min | Typ  | Max | Unit |
|--------------------------------|--|---|-----|------|-----|------|
| <b>Avalanche ruggedness</b>    |  |   |     |      |     |      |
| $E_{DS(AL)S}$                  | non-repetitive drain-source avalanche energy | $I_D = 100\text{ A}$ ; $V_{sup} \leq 40\text{ V}$ ;<br>$R_{GS} = 50\ \Omega$ ; $V_{GS} = 10\text{ V}$ ;<br>$T_{j(init)} = 25\text{ }^\circ\text{C}$ ; unclamped | -   | -    | 179 | mJ   |
| <b>Dynamic characteristics</b> |  |   |     |      |     |      |
| $Q_{GD}$                       | gate-drain charge                            | $I_D = 25\text{ A}$ ; $V_{DS} = 32\text{ V}$ ;<br>$V_{GS} = 10\text{ V}$ ; see <a href="#">Figure 13</a> ;<br>see <a href="#">Figure 14</a>                     | -   | 25.9 | -   | 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  |         |
| BUK654R8-40C | 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    |    |
| $V_{GS}$                    | gate-source voltage                          | DC  | [1]       | -16 | 16   | V  |
|                             |  | Pulsed  | [2]       | -20 | 20   | V  |
| $I_D$                       | drain current                                | $T_{mb} = 25\text{ °C}; V_{GS} = 10\text{ V};$ see <a href="#">Figure 1</a>   | [3]       | -   | 100  | A  |
|                             |  | $T_{mb} = 100\text{ °C}; V_{GS} = 10\text{ V};$ see <a href="#">Figure 1</a>  |           | -   | 88   | A  |
| $I_{DM}$                    | peak drain current                           | $T_{mb} = 25\text{ °C}; t_p \leq 10\text{ }\mu\text{s};$ pulsed;<br>see <a href="#">Figure 3</a>  |           | -   | 500  | A  |
| $P_{tot}$                   | total power dissipation                      | $T_{mb} = 25\text{ °C};$ see <a href="#">Figure 2</a>   |           | -   | 158  | 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]       | -   | 100  | A  |
| $I_{SM}$                    | peak source current                          | $t_p \leq 10\text{ }\mu\text{s};$ pulsed; $T_{mb} = 25\text{ °C}$   |           | -   | 500  | A  |
| <b>Avalanche ruggedness</b> |  |   |           |     |      |    |
| $E_{DS(AL)S}$               | non-repetitive drain-source avalanche energy | $I_D = 100\text{ A}; V_{sup} \leq 40\text{ V}; R_{GS} = 50\text{ }\Omega;$<br>$V_{GS} = 10\text{ V}; T_{j(init)} = 25\text{ °C};$ unclamped |           | -   | 179  | mJ |
| $E_{DS(AL)R}$               | repetitive drain-source avalanche energy     |   | [4][5][6] | -   | -    | J  |

[1] -16V accumulated duration not to exceed 168 hrs.

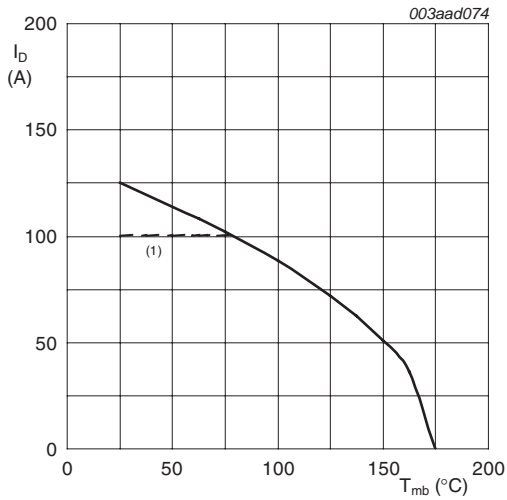
[2] Accumulated pulse duration not to exceed 5mins.

[3] Continuous current is limited by package.

[4] Single-pulse avalanche rating limited by maximum junction temperature of 175 °C.

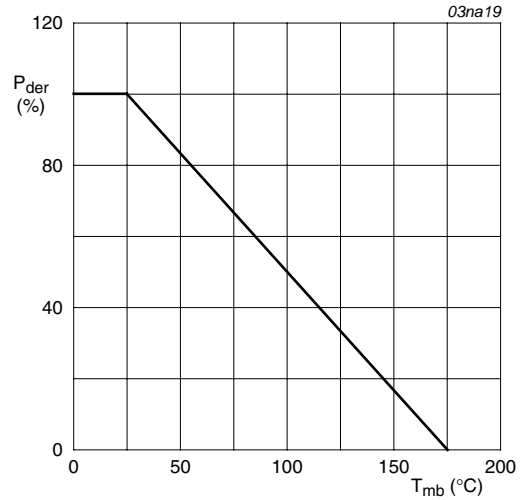
[5] Repetitive avalanche rating limited by an average junction temperature of 170 °C.

[6] Refer to application note AN10273 for further information.



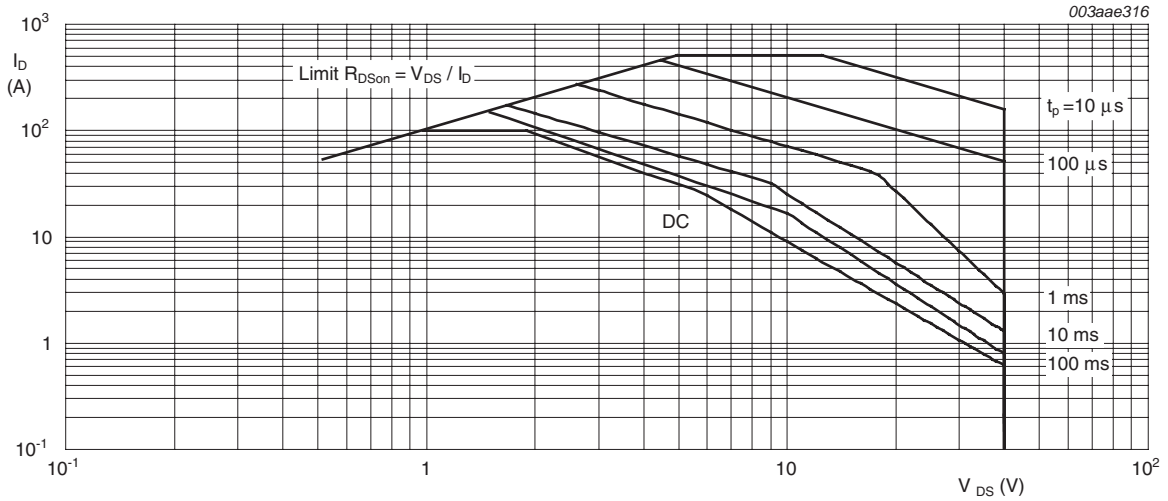
$V_{GS} \geq 10\text{ V}$   
 (1) Capped at 100 A due to package.

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



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

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



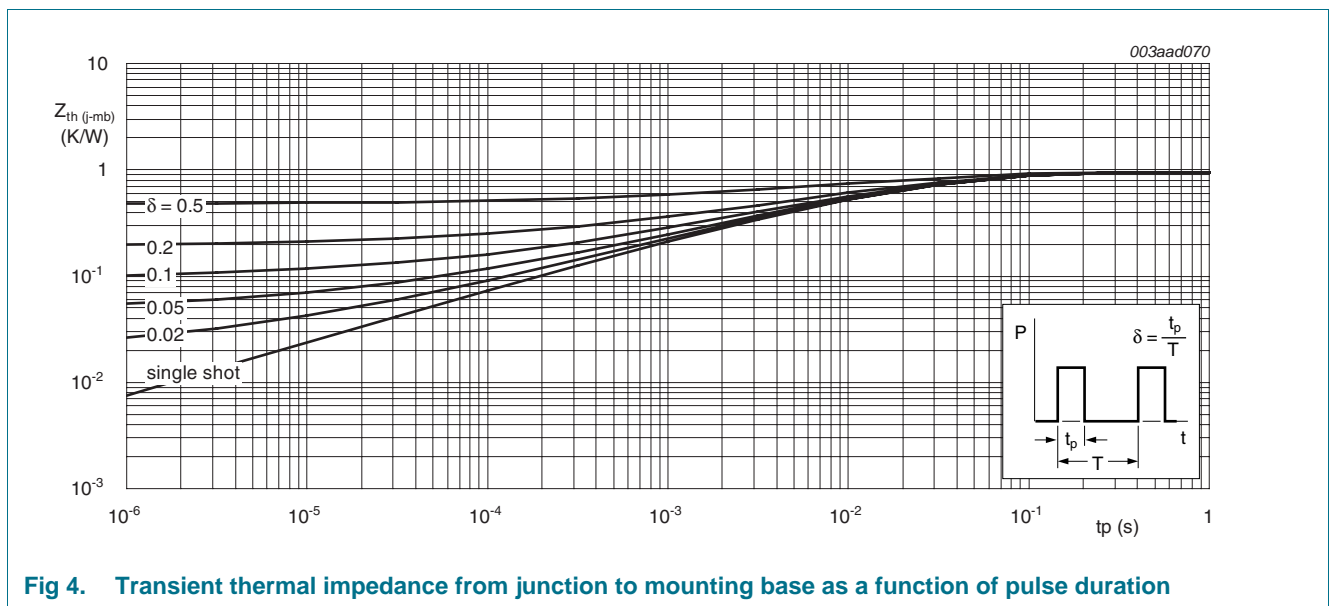
$T_{mb} = 25\text{ }^\circ\text{C}; I_{DM}$  is a single pulse

**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> | -   | -   | 0.95 | K/W  |
| $R_{th(j-a)}$  | thermal resistance from junction to ambient       | vertical in free air         | -   | 60  | -    | K/W  |



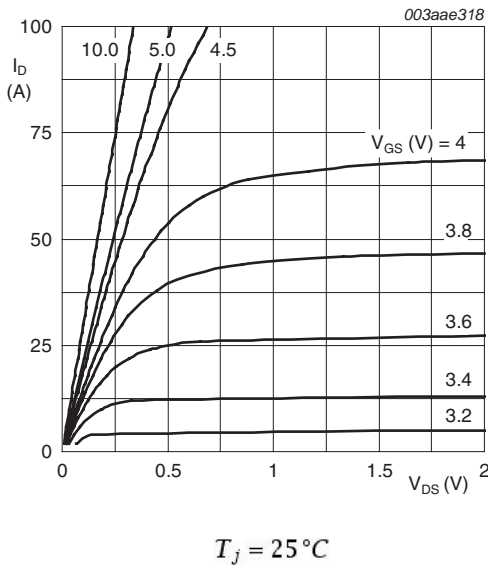
## 6. Characteristics

Table 6. Characteristics

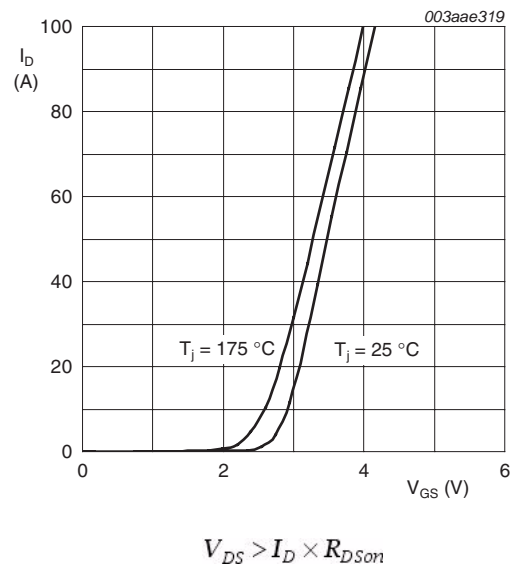
| Symbol                         | Parameter                        | Conditions  | Min | Typ  | Max  | Unit       |
|--------------------------------|----------------------------------|---|-----|------|------|------------|
| <b>Static characteristics</b>  |                                  |   |     |      |      |            |
| $V_{(BR)DSS}$                  | drain-source breakdown voltage   | $I_D = 250 \mu A; V_{GS} = 0 V; T_j = 25 \text{ }^\circ C$  | 40  | -    | -    | V          |
|                                |                                  | $I_D = 250 \mu A; V_{GS} = 0 V; T_j = -55 \text{ }^\circ C$   | 36  | -    | -    | V          |
| $V_{GS(th)}$                   | gate-source threshold voltage    | $I_D = 1 \text{ mA}; V_{DS} = V_{GS}; T_j = 25 \text{ }^\circ C$ ; see <a href="#">Figure 9</a> ; see <a href="#">Figure 10</a> | 1.8 | 2.3  | 2.8  | V          |
|                                |                                  | $I_D = 1 \text{ mA}; V_{DS} = V_{GS}; T_j = -55 \text{ }^\circ C$ ; see <a href="#">Figure 9</a>                                | -   | -    | 3.3  | V          |
|                                |                                  | $I_D = 1 \text{ mA}; V_{DS} = V_{GS}; T_j = 175 \text{ }^\circ C$ ; see <a href="#">Figure 9</a>                                | 0.8 | -    | -    | V          |
| $I_{DSS}$                      | drain leakage current            | $V_{DS} = 40 V; V_{GS} = 0 V; T_j = 25 \text{ }^\circ C$  | -   | 0.02 | 1    | $\mu A$    |
|                                |                                  | $V_{DS} = 40 V; V_{GS} = 0 V; T_j = 175 \text{ }^\circ C$   | -   | -    | 500  | $\mu A$    |
| $I_{GSS}$                      | gate leakage current             | $V_{DS} = 0 V; V_{GS} = 20 V; T_j = 25 \text{ }^\circ C$  | -   | 2    | 100  | nA         |
|                                |                                  | $V_{DS} = 0 V; V_{GS} = -20 V; T_j = 25 \text{ }^\circ C$   | -   | 2    | 100  | nA         |
| $R_{DS(on)}$                   | drain-source on-state resistance | $V_{GS} = 10 V; I_D = 25 A; T_j = 25 \text{ }^\circ C$ ; see <a href="#">Figure 11</a>  | -   | 3.84 | 4.8  | m $\Omega$ |
|                                |                                  | $V_{GS} = 5 V; I_D = 25 A; T_j = 25 \text{ }^\circ C$ ; see <a href="#">Figure 11</a>   | -   | 5.2  | 6.5  | m $\Omega$ |
|                                |                                  | $V_{GS} = 4.5 V; I_D = 25 A; T_j = 25 \text{ }^\circ C$ ; see <a href="#">Figure 11</a>   | -   | 5.9  | 7.9  | m $\Omega$ |
|                                |                                  | $V_{GS} = 10 V; I_D = 25 A; T_j = 175 \text{ }^\circ C$ ; see <a href="#">Figure 12</a> ; see <a href="#">Figure 11</a>         | -   | -    | 10.1 | m $\Omega$ |
| <b>Dynamic characteristics</b> |                                  |   |     |      |      |            |
| $Q_{G(tot)}$                   | total gate charge                | $I_D = 25 A; V_{DS} = 32 V; V_{GS} = 10 V$ ; see <a href="#">Figure 13</a> ; see <a href="#">Figure 14</a>                      | -   | 88   | -    | nC         |
|                                |                                  | $I_D = 25 A; V_{DS} = 32 V; V_{GS} = 5 V$ ; see <a href="#">Figure 13</a> ; see <a href="#">Figure 14</a>                       | -   | 50.5 | -    | nC         |
| $Q_{GS}$                       | gate-source charge               | $I_D = 25 A; V_{DS} = 32 V; V_{GS} = 10 V$ ; see <a href="#">Figure 13</a> ; see <a href="#">Figure 14</a>                      | -   | 14.6 | -    | nC         |
| $Q_{GD}$                       | gate-drain charge                | $I_D = 25 A; V_{DS} = 32 V; V_{GS} = 10 V$ ; see <a href="#">Figure 13</a> ; see <a href="#">Figure 14</a>                      | -   | 25.9 | -    | nC         |
| $C_{iss}$                      | input capacitance                | $V_{GS} = 0 V; V_{DS} = 25 V; f = 1 \text{ MHz}; T_j = 25 \text{ }^\circ C$ ; see <a href="#">Figure 15</a>                     | -   | 3900 | 5200 | pF         |
| $C_{oss}$                      | output capacitance               | $T_j = 25 \text{ }^\circ C$ ; see <a href="#">Figure 15</a>   | -   | 512  | 614  | pF         |
| $C_{rss}$                      | reverse transfer capacitance     |   | -   | 350  | 480  | pF         |
| $t_{d(on)}$                    | turn-on delay time               | $V_{DS} = 30 V; R_L = 1.2 \text{ } \Omega; V_{GS} = 10 V; R_{G(ext)} = 10 \text{ } \Omega$                                      | -   | 23   | -    | ns         |
| $t_r$                          | rise time                        |   | -   | 52   | -    | ns         |
| $t_{d(off)}$                   | turn-off delay time              |   | -   | 164  | -    | ns         |
| $t_f$                          | fall time                        |   | -   | 77   | -    | ns         |
| $L_D$                          | internal drain inductance        | from drain lead 6 mm from package to centre of die ; $T_j = 25 \text{ }^\circ C$  | -   | 4.5  | -    | nH         |
| $L_S$                          | internal source inductance       | from source lead to source bond pad ; $T_j = 25 \text{ }^\circ C$   | -   | 7.5  | -    | nH         |

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

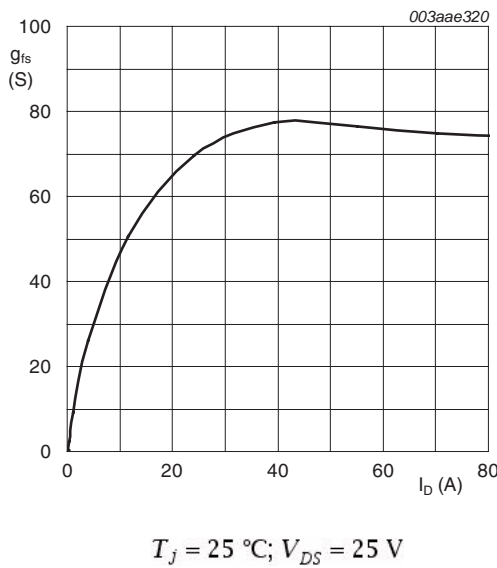
| Symbol                    | Parameter             | Conditions  | Min | Typ  | Max | Unit |
|---------------------------|-----------------------|---|-----|------|-----|------|
| <b>Source-drain diode</b> |                       |   |     |      |     |      |
| $V_{SD}$                  | source-drain voltage  | $I_S = 25\text{ A}$ ; $V_{GS} = 0\text{ V}$ ; $T_j = 25\text{ °C}$ ;<br>see <a href="#">Figure 16</a> | -   | 0.85 | 1.2 | V    |
| $t_{rr}$                  | reverse recovery time | $I_S = 20\text{ A}$ ; $di_S/dt = -100\text{ A}/\mu\text{s}$ ;   | -   | 42   | -   | ns   |
| $Q_r$                     | recovered charge      | $V_{GS} = 0\text{ V}$ ; $V_{DS} = 25\text{ V}$  | -   | 65   | -   | nC   |



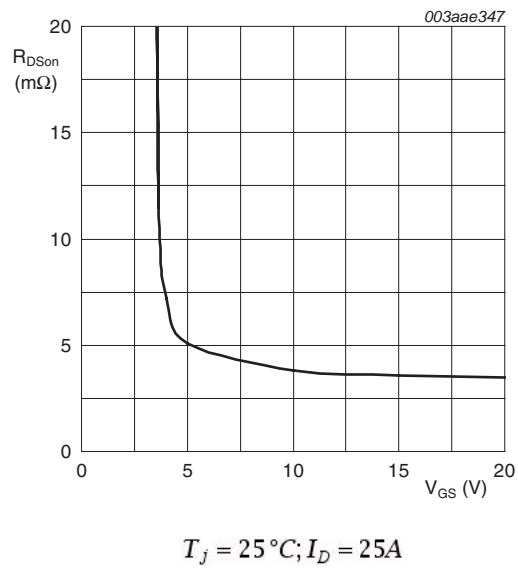
**Fig 5. Output characteristics: drain current as a function of drain-source voltage; typical values**



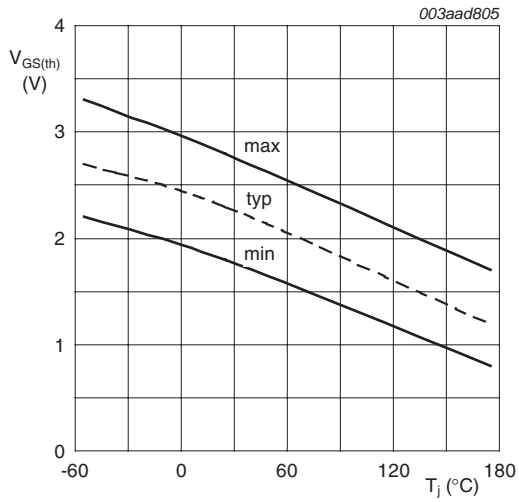
**Fig 6. Transfer characteristics: drain current as a function of gate-source voltage; typical values**



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

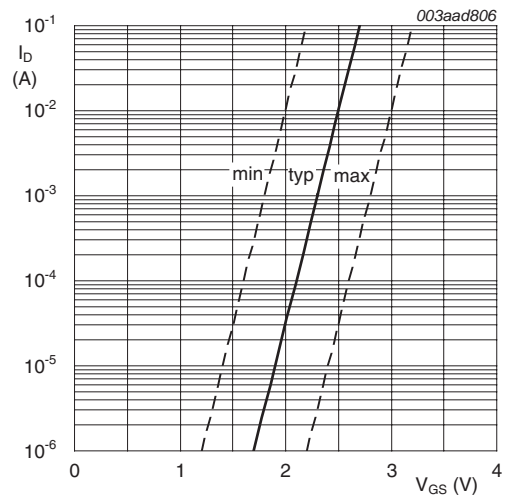


**Fig 8. Drain-source on-state resistance as a function of gate-source voltage; typical values.**



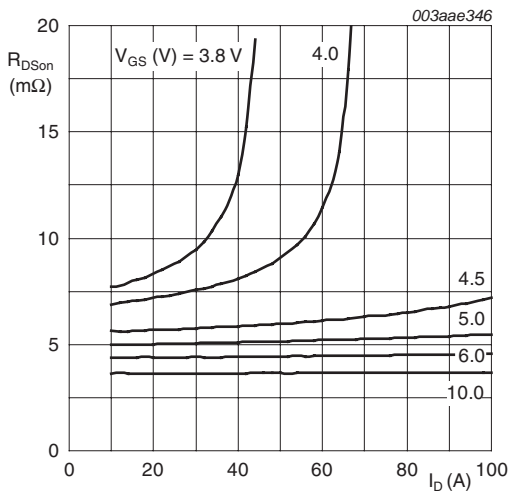
$$I_D = 1\text{mA}; V_{DS} = V_{GS}$$

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



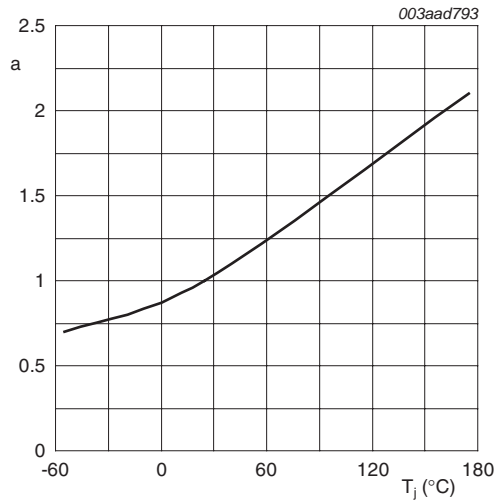
$$T_j = 25\text{ }^\circ\text{C}; V_{DS} = 5\text{V}$$

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



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

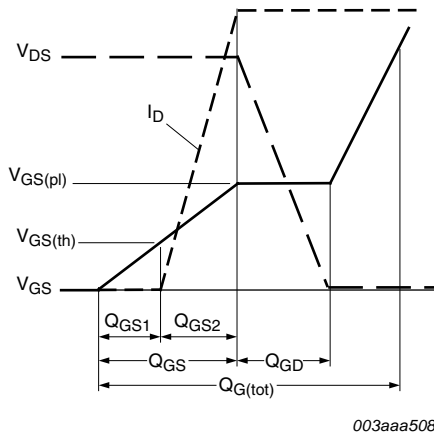
**Fig 11. Drain-source on-state resistance as a function of drain current; typical values**



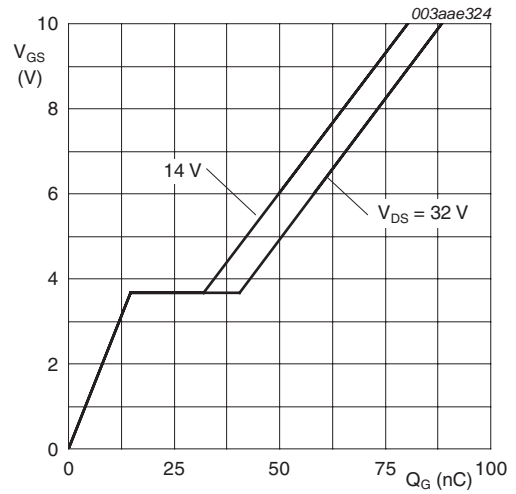
$$a = \frac{R_{DS(on)}}{R_{DS(on)25\text{ }^\circ\text{C}}}$$

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



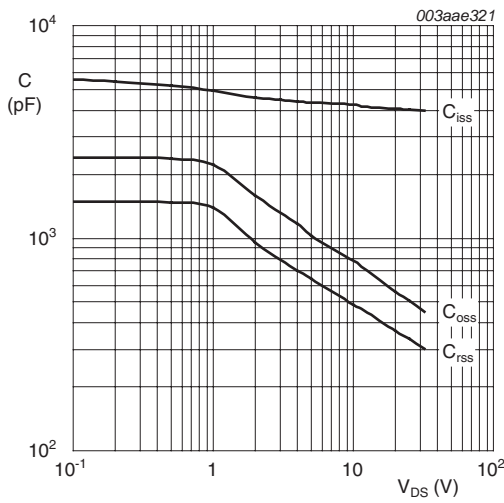


**Fig 13. Gate charge waveform definitions**



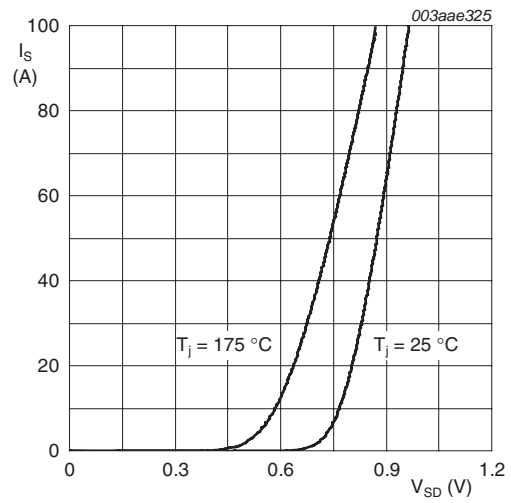
$T_j = 25^\circ C; I_D = 25A$

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



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

**Fig 15. Input, output and reverse transfer capacitances as a function of drain-source voltage; typical values**



$V_{GS} = 0V$

**Fig 16. Source current as a function of source-drain voltage; typical values**

**7. Package outline**

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

SOT78A

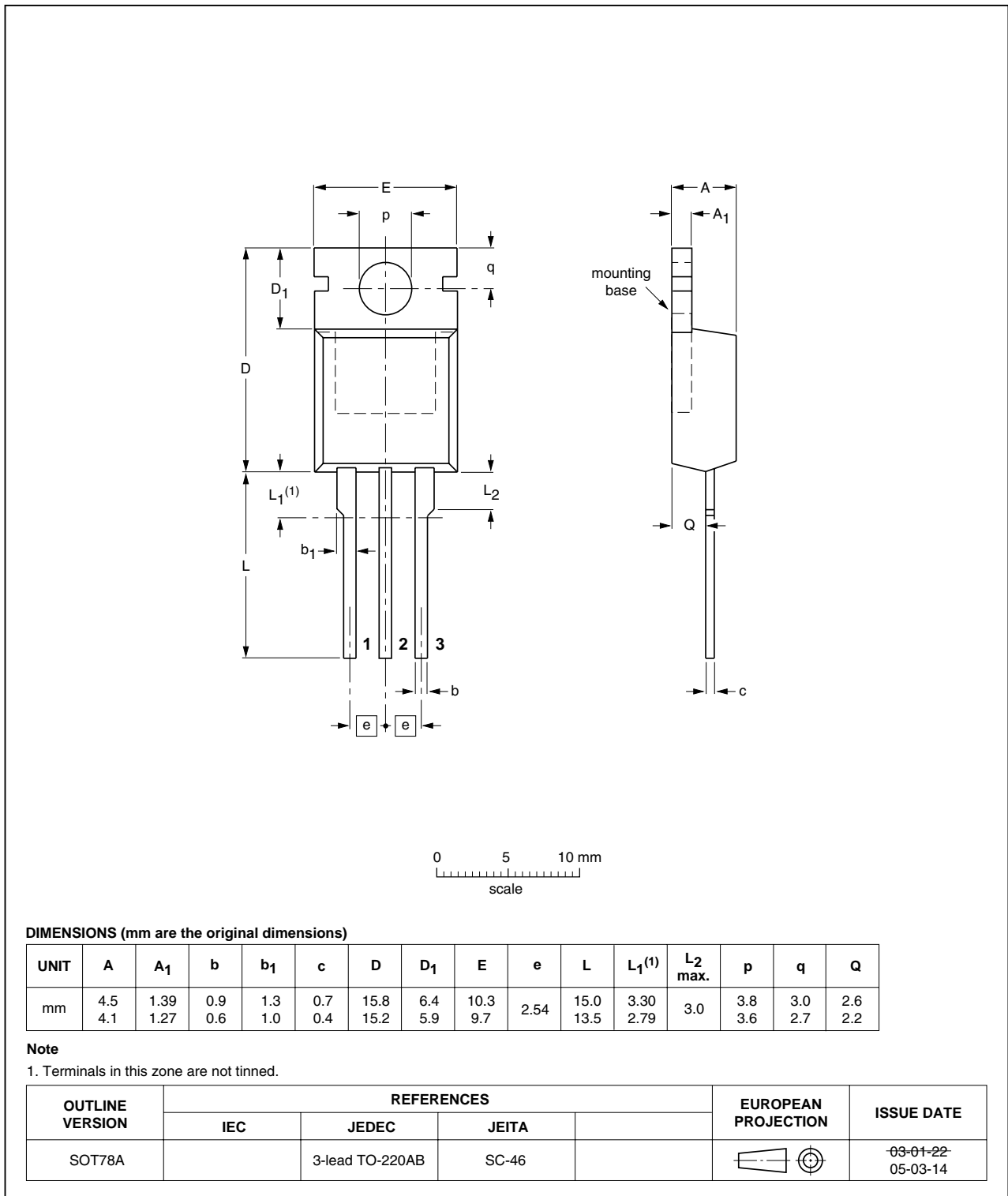


Fig 17. Package outline SOT78A (TO-220AB)

## 8. Revision history

Table 7. Revision history

| Document ID      | Release date  | Data sheet status    | Change notice | Supersedes       |
|------------------|---|----------------------|---------------|------------------|
| BUK654R8-40C v.3 | 20101012  | Product data sheet   | -             | BUK654R8-40C v.2 |
| Modifications:   | <ul style="list-style-type: none"><li>• Status changed from objective to product.</li><li>• Various changes to content.</li></ul> |                      |               |                  |
| BUK654R8-40C v.2 | 20100521  | Objective data sheet | -             | BUK654R8-40C v.1 |

## 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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