# 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 | $T_j \geq 25$ °C; $T_j \leq 175$ °C | | - | - | 40 | V |
| $I_D$ | drain current | $V_{GS}$ = 10 V; $T_{mb}$ = 25 °C; see Figure 1 | [1] | - | - | 100 | A |
| $P_{tot}$ | total power dissipation | $T_{mb}$ = 25 °C; see Figure 2 | | - | - | 158 | W |
| **Static characteristics** | | | | | | | |
| $R_{DSon}$ | drain-source on-state resistance | $V_{GS}$ = 10 V; $I_D$ = 25 A; $T_j$ = 25 °C; see Figure 11 | | - | 3.84 | 4.8 | mΩ |

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

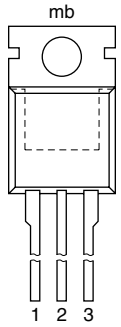
| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| **Avalanche ruggedness** | | | | | | |
| $E_{DS(AL)S}$ | non-repetitive drain-source avalanche energy | $I_D$ = 100 A; $V_{sup}$ ≤ 40 V; $R_{GS}$ = 50 Ω; $V_{GS}$ = 10 V; $T_{j(init)}$ = 25 °C; unclamped | - | - | 179 | mJ |
| **Dynamic characteristics** | | | | | | |
| $Q_{GD}$ | gate-drain charge | $I_D$ = 25 A; $V_{DS}$ = 32 V; $V_{GS}$ = 10 V; see Figure 13; see Figure 14 | - | 25.9 | - | nC |

[1] Continuous current is limited by package.

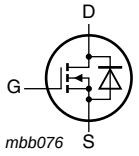
## 2. Pinning information

**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 | | |
|---|---|---|---|
| | Name | Description | Version |
| 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 | $T_j \geq 25$ °C; $T_j \leq 175$ °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 °C; $V_{GS}$ = 10 V; see Figure 1 | [3] | - | 100 | A |
| | | $T_{mb}$ = 100 °C; $V_{GS}$ = 10 V; see Figure 1 | | - | 88 | A |
| $I_{DM}$ | peak drain current | $T_{mb}$ = 25 °C; $t_p \leq 10$ µs; pulsed; see Figure 3 | | - | 500 | A |
| $P_{tot}$ | total power dissipation | $T_{mb}$ = 25 °C; see Figure 2 | | - | 158 | W |
| $T_{stg}$ | storage temperature | | | -55 | 175 | °C |
| $T_j$ | junction temperature | | | -55 | 175 | °C |
| **Source-drain diode** | | | | | | |
| $I_S$ | source current | $T_{mb}$ = 25 °C | [3] | - | 100 | A |
| $I_{SM}$ | peak source current | $t_p \leq 10$ µs; pulsed; $T_{mb}$ = 25 °C | | - | 500 | A |
| **Avalanche ruggedness** | | | | | | |
| $E_{DS(AL)S}$ | non-repetitive drain-source avalanche energy | $I_D$ = 100 A; $V_{sup} \leq 40$ V; $R_{GS}$ = 50 Ω; $V_{GS}$ = 10 V; $T_{j(init)}$ = 25 °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.

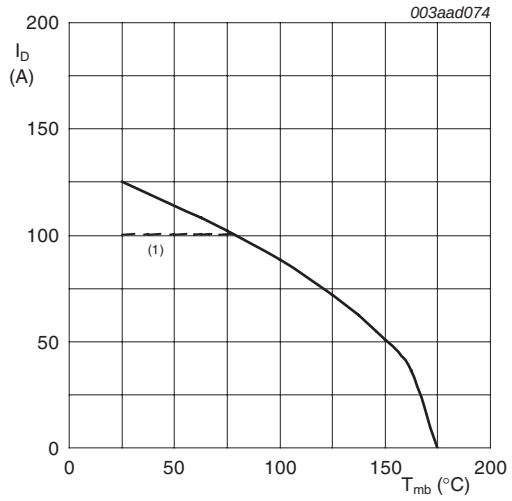
[2] Accumulated pulse duration not to exceed 5mins.

[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.

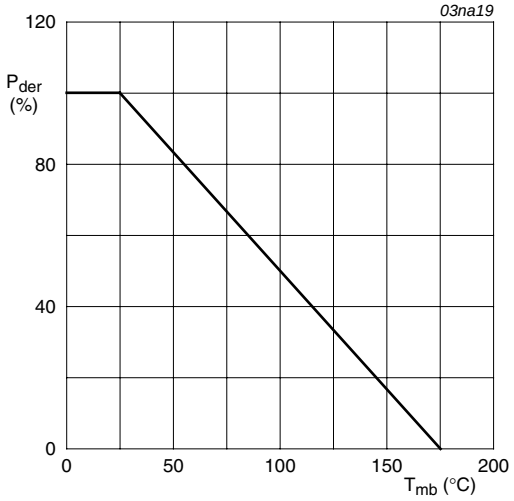
[6] Refer to application note AN10273 for further information.




$V_{GS} \geq 10\ V$

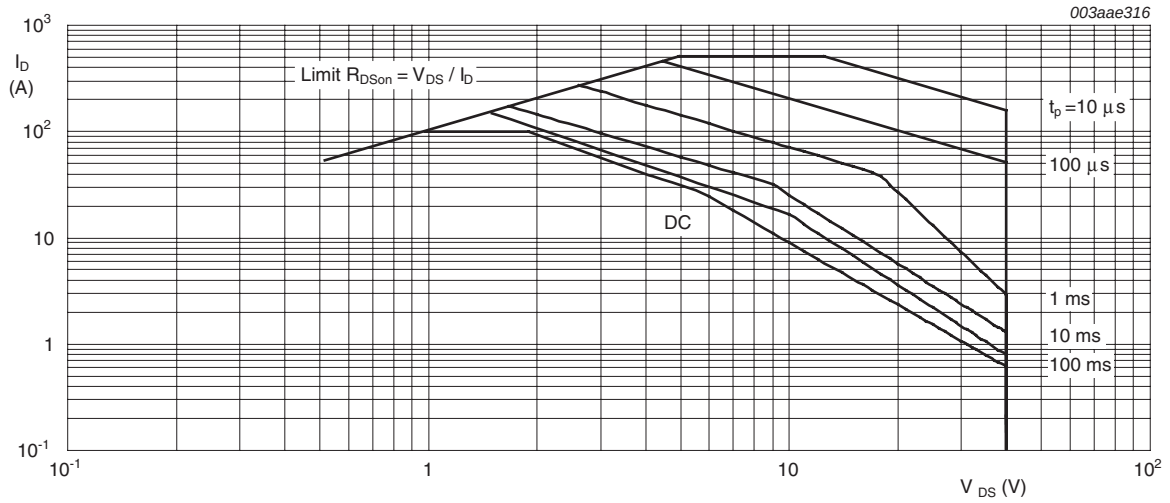
(1) Capped at 100 A due to package.

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




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

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




$T_{mb} = 25\ °C$; $I_{DM}$ 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 Figure 4 | - | - | 0.95 | K/W |
| $R_{th(j-a)}$ | thermal resistance from junction to ambient | vertical in free air | - | 60 | - | K/W |

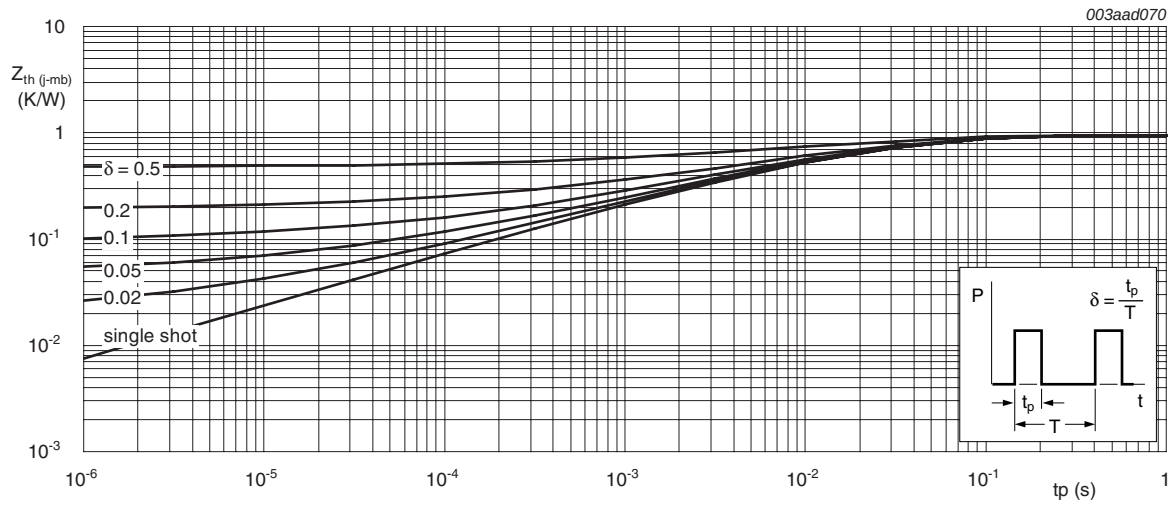



**Fig 4. Transient thermal impedance from junction to mounting base as a function of pulse duration**

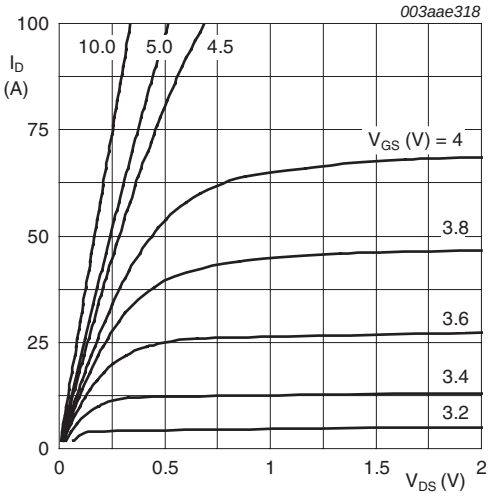
# 6. Characteristics

**Table 6. Characteristics**

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| **Static characteristics** | | | | | | |
| $V_{(BR)DSS}$ | drain-source breakdown voltage | $I_D$ = 250 µA; $V_{GS}$ = 0 V; $T_j$ = 25 °C | 40 | - | - | V |
| | | $I_D$ = 250 µA; $V_{GS}$ = 0 V; $T_j$ = -55 °C | 36 | - | - | V |
| $V_{GS(th)}$ | gate-source threshold voltage | $I_D$ = 1 mA; $V_{DS}$ = $V_{GS}$; $T_j$ = 25 °C; see Figure 9; see Figure 10 | 1.8 | 2.3 | 2.8 | V |
| | | $I_D$ = 1 mA; $V_{DS}$ = $V_{GS}$; $T_j$ = -55 °C; see Figure 9 | - | - | 3.3 | V |
| | | $I_D$ = 1 mA; $V_{DS}$ = $V_{GS}$; $T_j$ = 175 °C; see Figure 9 | 0.8 | - | - | V |
| $I_{DSS}$ | drain leakage current | $V_{DS}$ = 40 V; $V_{GS}$ = 0 V; $T_j$ = 25 °C | - | 0.02 | 1 | µA |
| | | $V_{DS}$ = 40 V; $V_{GS}$ = 0 V; $T_j$ = 175 °C | - | - | 500 | µA |
| $I_{GSS}$ | gate leakage current | $V_{DS}$ = 0 V; $V_{GS}$ = 20 V; $T_j$ = 25 °C | - | 2 | 100 | nA |
| | | $V_{DS}$ = 0 V; $V_{GS}$ = -20 V; $T_j$ = 25 °C | - | 2 | 100 | nA |
| $R_{DSon}$ | drain-source on-state resistance | $V_{GS}$ = 10 V; $I_D$ = 25 A; $T_j$ = 25 °C; see Figure 11 | - | 3.84 | 4.8 | mΩ |
| | | $V_{GS}$ = 5 V; $I_D$ = 25 A; $T_j$ = 25 °C; see Figure 11 | - | 5.2 | 6.5 | mΩ |
| | | $V_{GS}$ = 4.5 V; $I_D$ = 25 A; $T_j$ = 25 °C; see Figure 11 | - | 5.9 | 7.9 | mΩ |
| | | $V_{GS}$ = 10 V; $I_D$ = 25 A; $T_j$ = 175 °C; see Figure 12; see Figure 11 | - | - | 10.1 | mΩ |
| **Dynamic characteristics** | | | | | | |
| $Q_{G(tot)}$ | total gate charge | $I_D$ = 25 A; $V_{DS}$ = 32 V; $V_{GS}$ = 10 V; see Figure 13; see Figure 14 | - | 88 | - | nC |
| | | $I_D$ = 25 A; $V_{DS}$ = 32 V; $V_{GS}$ = 5 V; see Figure 13; see Figure 14 | - | 50.5 | - | nC |
| $Q_{GS}$ | gate-source charge | $I_D$ = 25 A; $V_{DS}$ = 32 V; $V_{GS}$ = 10 V; see Figure 13; see Figure 14 | - | 14.6 | - | nC |
| $Q_{GD}$ | gate-drain charge | | - | 25.9 | - | nC |
| $C_{iss}$ | input capacitance | $V_{GS}$ = 0 V; $V_{DS}$ = 25 V; f = 1 MHz; $T_j$ = 25 °C; see Figure 15 | - | 3900 | 5200 | pF |
| $C_{oss}$ | output capacitance | | - | 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 Ω; $V_{GS}$ = 10 V; $R_{G(ext)}$ = 10 Ω | - | 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 °C | - | 4.5 | - | nH |
| $L_S$ | internal source inductance | from source lead to source bond pad ; $T_j$ = 25 °C | - | 7.5 | - | nH |

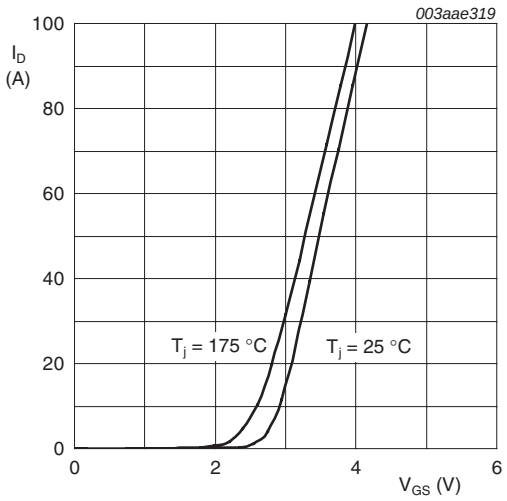
**Table 6. Characteristics** *...continued*

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| **Source-drain diode** | | | | | | |
| $V_{SD}$ | source-drain voltage | $I_S$ = 25 A; $V_{GS}$ = 0 V; $T_j$ = 25 °C; see Figure 16 | - | 0.85 | 1.2 | V |
| $t_{rr}$ | reverse recovery time | $I_S$ = 20 A; $dI_S/dt$ = -100 A/µs; $V_{GS}$ = 0 V; $V_{DS}$ = 25 V | - | 42 | - | ns |
| $Q_r$ | recovered charge | | - | 65 | - | nC |



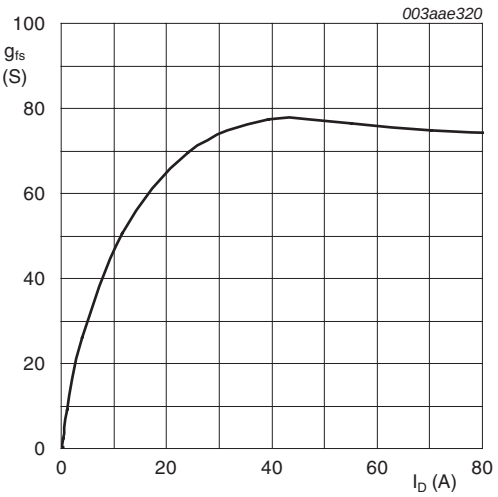

$T_j = 25\,°C$

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



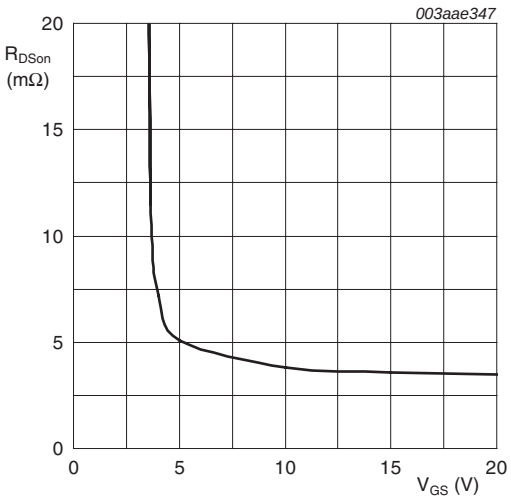

$V_{DS} > I_D \times R_{DSon}$

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



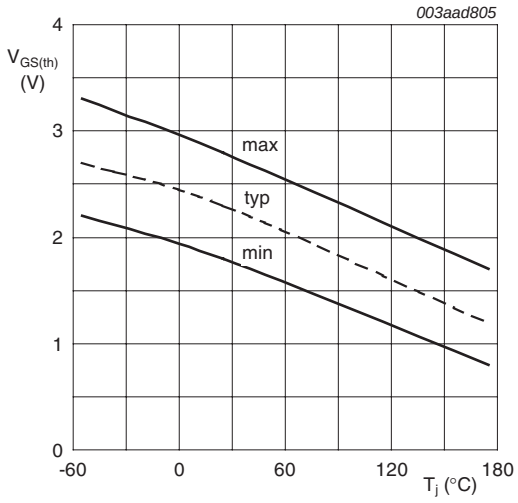

$T_j = 25\,°C;\ V_{DS} = 25\,V$

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



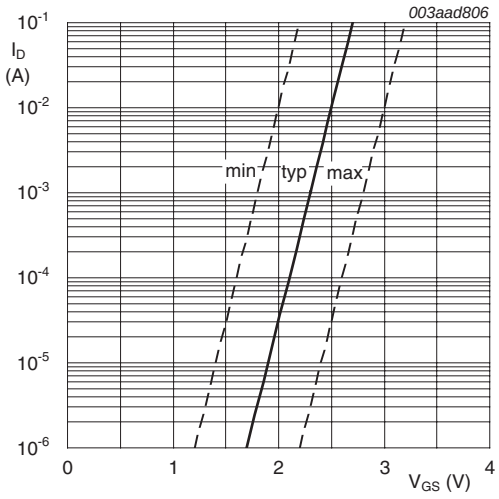

$T_j = 25\,°C;\ I_D = 25A$

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



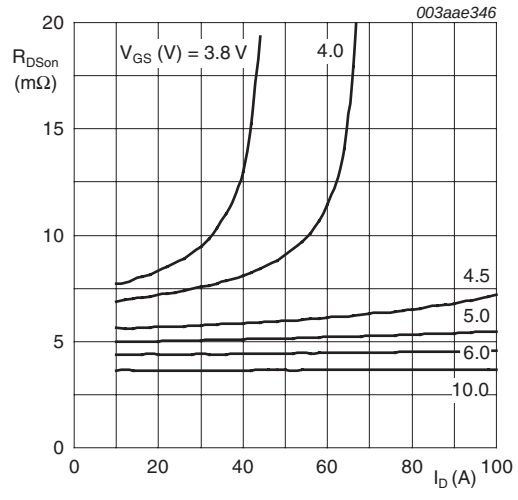

$I_D = 1mA; V_{DS} = V_{GS}$

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



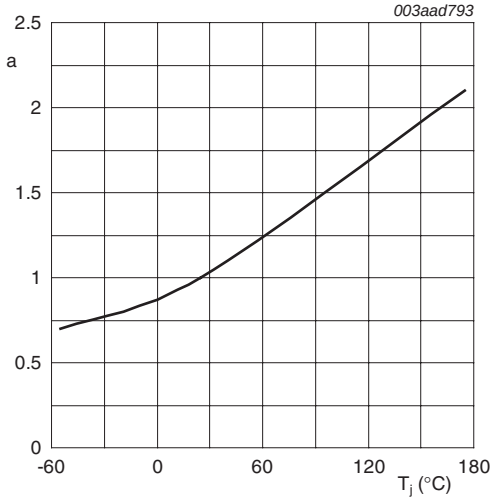

$T_j = 25\,°C; V_{DS} = 5V$

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




$T_j = 25\,°C$

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




$$a = \frac{R_{DSon}}{R_{DSon(25\,°C)}}$$

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

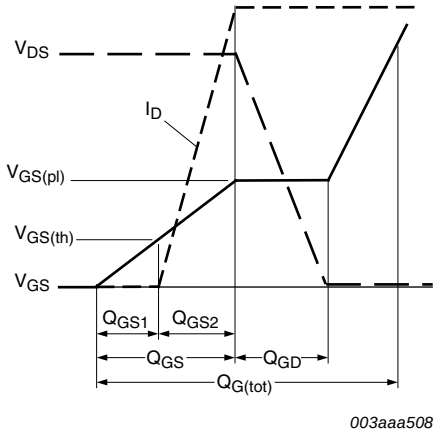
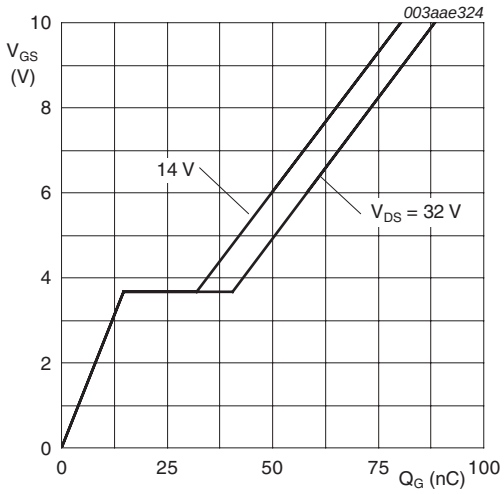
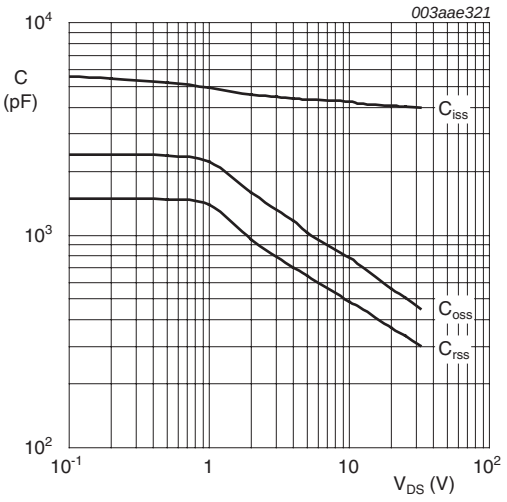



Fig 13. Gate charge waveform definitions



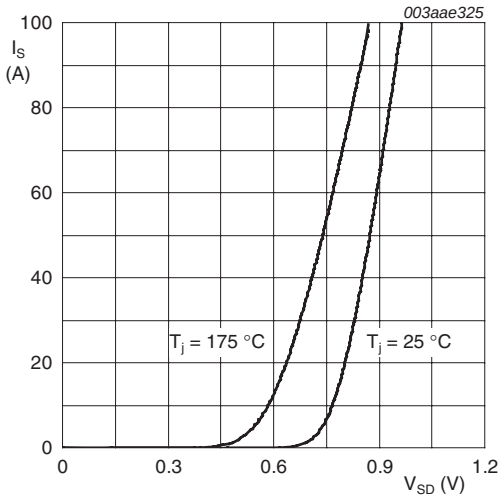

$T_j = 25\,°C; I_D = 25A$

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

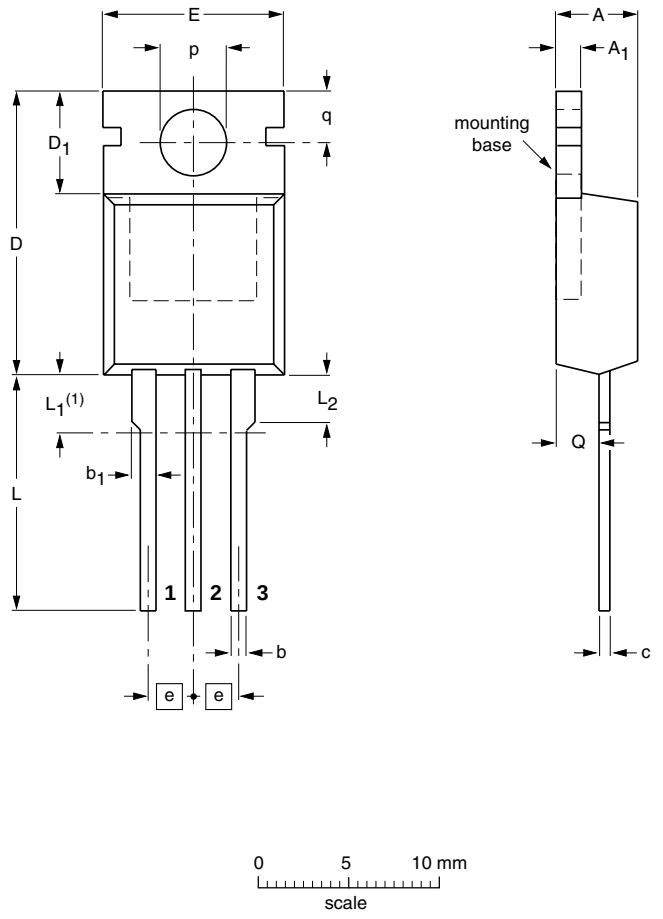



$V_{GS} = 0V$

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**




**DIMENSIONS (mm are the original dimensions)**

| UNIT | A | $A_1$ | b | $b_1$ | c | D | $D_1$ | E | e | L | $L_1$(1) | $L_2$ max. | p | q | Q |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| mm | 4.5<br>4.1 | 1.39<br>1.27 | 0.9<br>0.6 | 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 VERSION | REFERENCES | | | | EUROPEAN PROJECTION | ISSUE DATE |
|---|---|---|---|---|---|---|
| | IEC | JEDEC | JEITA | | | |
| SOT78A | | 3-lead TO-220AB | SC-46 | | | ~~03-01-22~~<br>05-03-14 |

**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: | • Status changed from objective to product.<br>• Various changes to content. | | | |
| BUK654R8-40C v.2 | 20100521 | Objective data sheet | - | BUK654R8-40C v.1 |

# 9. Legal information

## 9.1 Data sheet status

| Document status[1][2] | Product status[3] | 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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