

## 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 intermediate 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	$T_j \geq 25^\circ\text{C}$ ; $T_j \leq 175^\circ\text{C}$	-	-	40	V
$I_D$	drain current	$V_{GS} = 10\text{ V}$ ; $T_{mb} = 25^\circ\text{C}$ ; see <a href="#">Figure 1</a>	[1]	-	-	A
$P_{tot}$	total power dissipation	$T_{mb} = 25^\circ\text{C}$ ; see <a href="#">Figure 2</a>	-	-	306	W
<b>Static characteristics</b>						
$R_{DSon}$	drain-source on-state resistance	$V_{GS} = 10\text{ V}$ ; $I_D = 25\text{ A}$ ; $T_j = 25^\circ\text{C}$ ; see <a href="#">Figure 11</a>	-	2	2.3	$\text{m}\Omega$



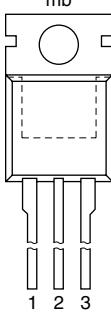
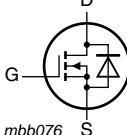
Table 1. Quick reference data ...continued

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
<b>Avalanche ruggedness</b>						
$E_{DS(AL)S}$	non-repetitive drain-source avalanche energy	$I_D = 120 \text{ A}$ ; $V_{sup} \leq 40 \text{ V}$ ; $R_{GS} = 50 \Omega$ ; $V_{GS} = 10 \text{ V}$ ; $T_{j(init)} = 25 \text{ }^\circ\text{C}$ ; unclamped	-	-	1.02	J
<b>Dynamic characteristics</b>						
$Q_{GD}$	gate-drain charge	$I_D = 25 \text{ A}$ ; $V_{DS} = 32 \text{ V}$ ; $V_{GS} = 10 \text{ V}$ ; see <a href="#">Figure 13</a> ; see <a href="#">Figure 14</a>	-	72	-	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		
BUK652R3-40C	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	$T_j \geq 25^\circ\text{C}; T_j \leq 175^\circ\text{C}$	-	40	V
$V_{GS}$	gate-source voltage	DC	[1]	-16	V
		Pulsed		-20	V
$I_D$	drain current	$T_{mb} = 25^\circ\text{C}; V_{GS} = 10\text{ V}$ ; see <a href="#">Figure 1</a>	[3]	-	120 A
		$T_{mb} = 100^\circ\text{C}; V_{GS} = 10\text{ V}$ ; see <a href="#">Figure 1</a>		-	120 A
$I_{DM}$	peak drain current	$T_{mb} = 25^\circ\text{C}; t_p \leq 10\ \mu\text{s}$ ; pulsed; see <a href="#">Figure 3</a>	-	1006	A
$P_{tot}$	total power dissipation	$T_{mb} = 25^\circ\text{C}$ ; see <a href="#">Figure 2</a>	-	306	W
$T_{stg}$	storage temperature		-55	175	°C
$T_j$	junction temperature		-55	175	°C
<b>Source-drain diode</b>					
$I_S$	source current	$T_{mb} = 25^\circ\text{C}$	[3]	-	120 A
$I_{SM}$	peak source current	$t_p \leq 10\ \mu\text{s}$ ; pulsed; $T_{mb} = 25^\circ\text{C}$		-	1006 A
<b>Avalanche ruggedness</b>					
$E_{DS(AL)S}$	non-repetitive drain-source avalanche energy	$I_D = 120\text{ A}; V_{sup} \leq 40\text{ V}; R_{GS} = 50\ \Omega$ ; $V_{GS} = 10\text{ V}; T_{j(init)} = 25^\circ\text{C}$ ; unclamped	-	1.02	J
$E_{DS(AL)R}$	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.

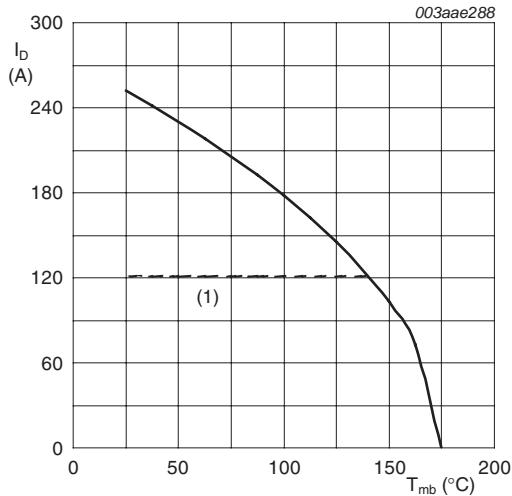
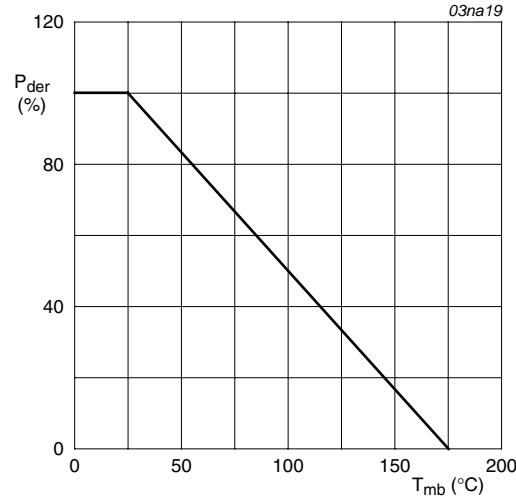
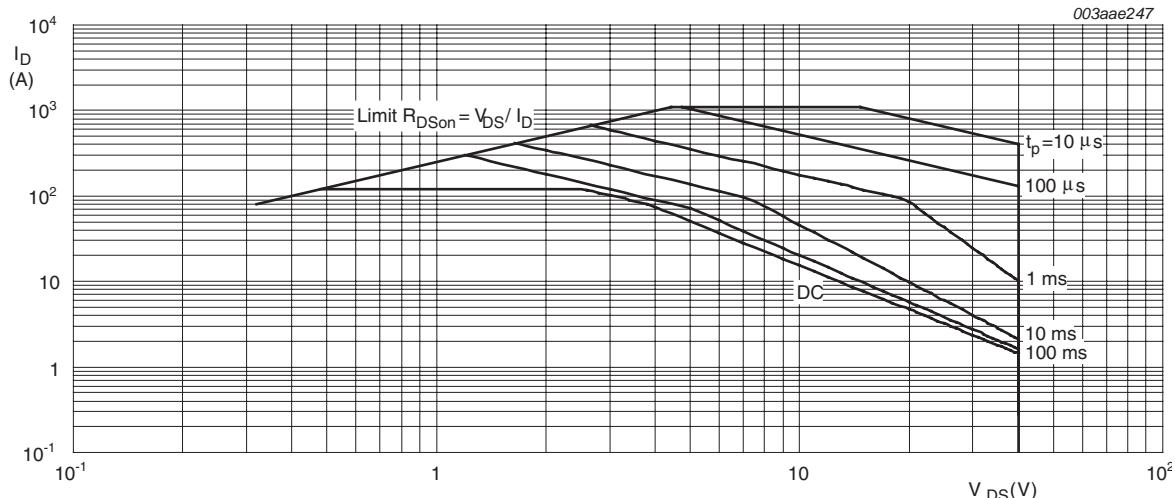


Fig 1. Continuous drain current as a function of mounting base temperature



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

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



$T_{mb} = 25^{\circ}\text{C}$ ;  $I_{DM}$  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
$R_{th(j\text{-}mb)}$	thermal resistance from junction to mounting base	see <a href="#">Figure 4</a>	-	-	0.49	K/W
$R_{th(j\text{-}a)}$	thermal resistance from junction to ambient	vertical in free air	-	60	-	K/W

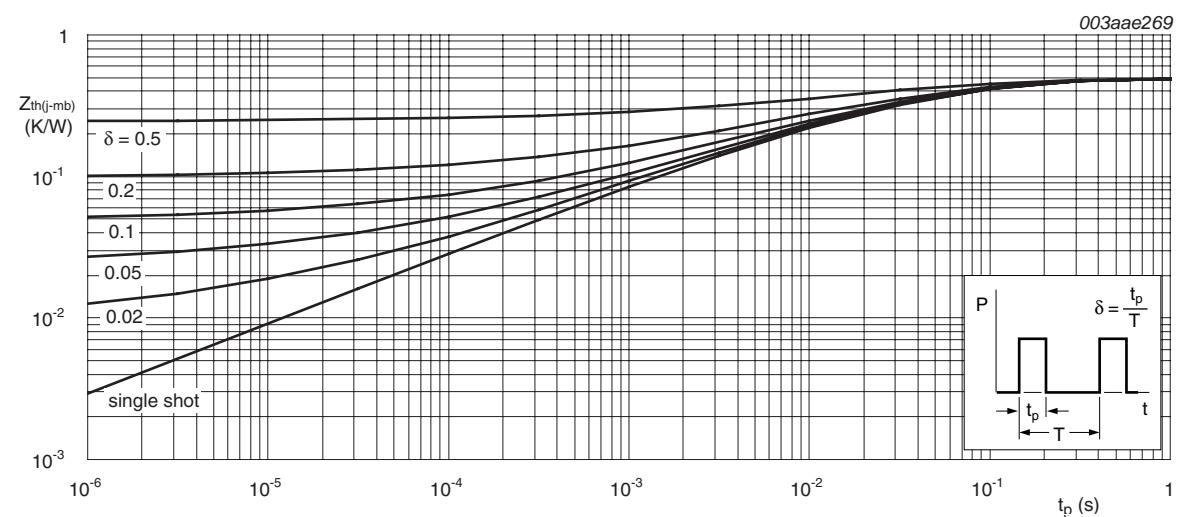


Fig 4. Transient thermal impedance from junction to mounting base as a function of pulse duration

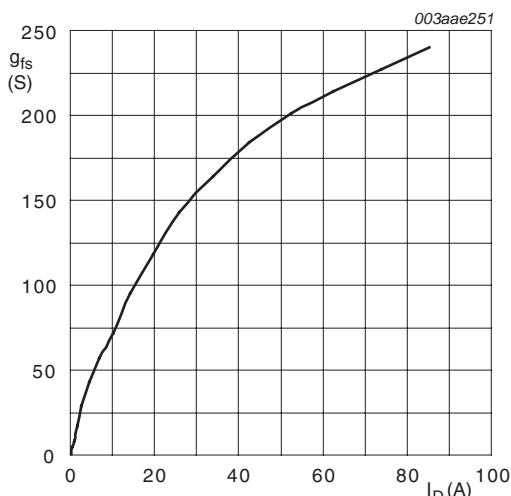
## 6. Characteristics

Table 6. Characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
<b>Static characteristics</b>						
$V_{(BR)DSS}$	drain-source breakdown voltage	$I_D = 250 \mu A; V_{GS} = 0 V; T_j = 25^\circ C$ $I_D = 250 \mu A; V_{GS} = 0 V; T_j = -55^\circ C$	40	-	-	V
$V_{GS(th)}$	gate-source threshold voltage	$I_D = 1 \text{ mA}; V_{DS} = V_{GS}; T_j = 25^\circ C$ ; see <a href="#">Figure 9</a> ; see <a href="#">Figure 10</a> $I_D = 1 \text{ mA}; V_{DS} = V_{GS}; T_j = -55^\circ C$ ; see <a href="#">Figure 10</a> $I_D = 2.5 \text{ mA}; V_{DS} = V_{GS}; T_j = 175^\circ C$ ; see <a href="#">Figure 10</a>	1.8	2.3	2.8	V
$I_{DSS}$	drain leakage current	$V_{DS} = 40 V; V_{GS} = 0 V; T_j = 175^\circ C$ $V_{DS} = 40 V; V_{GS} = 0 V; T_j = 25^\circ C$	-	-	500	$\mu A$
$I_{GSS}$	gate leakage current	$V_{DS} = 0 V; V_{GS} = 20 V; T_j = 25^\circ C$ $V_{DS} = 0 V; V_{GS} = -20 V; T_j = 25^\circ C$	-	2	100	nA
$R_{DSon}$	drain-source on-state resistance	$V_{GS} = 10 V; I_D = 25 A; T_j = 25^\circ C$ ; see <a href="#">Figure 11</a> $V_{GS} = 5 V; I_D = 25 A; T_j = 25^\circ C$ ; see <a href="#">Figure 11</a> $V_{GS} = 4.5 V; I_D = 25 A; T_j = 25^\circ C$ ; see <a href="#">Figure 11</a> $V_{GS} = 10 V; I_D = 25 A; T_j = 175^\circ C$ ; see <a href="#">Figure 12</a> ; see <a href="#">Figure 11</a>	-	2	2.3	$m\Omega$
<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> $I_D = 25 A; V_{DS} = 32 V; V_{GS} = 5 V$ ; see <a href="#">Figure 13</a> ; see <a href="#">Figure 14</a>	-	260	-	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>	-	38	-	nC
$Q_{GD}$	gate-drain charge	see <a href="#">Figure 13</a> ; see <a href="#">Figure 14</a>	-	72	-	nC
$C_{iss}$	input capacitance	$V_{GS} = 0 V; V_{DS} = 25 V; f = 1 \text{ MHz}$	-	11.3	15.1	nF
$C_{oss}$	output capacitance	$T_j = 25^\circ C$ ; see <a href="#">Figure 16</a>	-	1447	1750	pF
$C_{rss}$	reverse transfer capacitance		-	1014	1390	pF
$t_{d(on)}$	turn-on delay time	$V_{DS} = 30 V; R_L = 1.2 \Omega; V_{GS} = 10 V$	-	60	-	ns
$t_r$	rise time	$R_{G(ext)} = 10 \Omega$	-	140	-	ns
$t_{d(off)}$	turn-off delay time		-	234	-	ns
$t_f$	fall time		-	416	-	ns
$L_D$	internal drain inductance	from drain lead 6 mm from package to centre of die; $T_j = 25^\circ C$	-	4.5	-	nH
$L_S$	internal source inductance	from source lead to source bond pad; $T_j = 25^\circ C$	-	7.5	-	nH

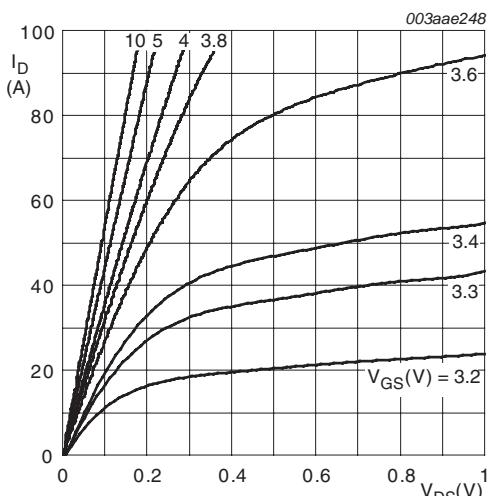
Table 6. Characteristics ...continued

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
<b>Source-drain diode</b>						
$V_{SD}$	source-drain voltage	$I_S = 25 \text{ A}$ ; $V_{GS} = 0 \text{ V}$ ; $T_j = 25 \text{ }^\circ\text{C}$ ; see <a href="#">Figure 15</a>	-	0.8	1.2	V
$t_{rr}$	reverse recovery time	$I_S = 20 \text{ A}$ ; $dI_S/dt = -100 \text{ A}/\mu\text{s}$ ; $V_{GS} = 0 \text{ V}$	-	63	-	ns
$Q_r$	recovered charge	$V_{DS} = 25 \text{ V}$	-	127	-	nC



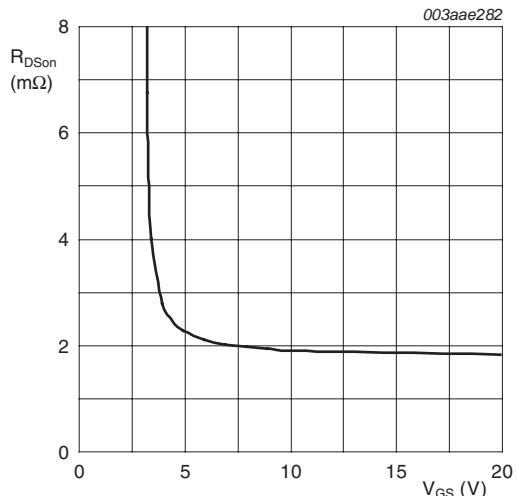
$T_j = 25 \text{ }^\circ\text{C}$ ;  $V_{DS} = 10 \text{ V}$

Fig 5. Forward transconductance as a function of drain current; typical values



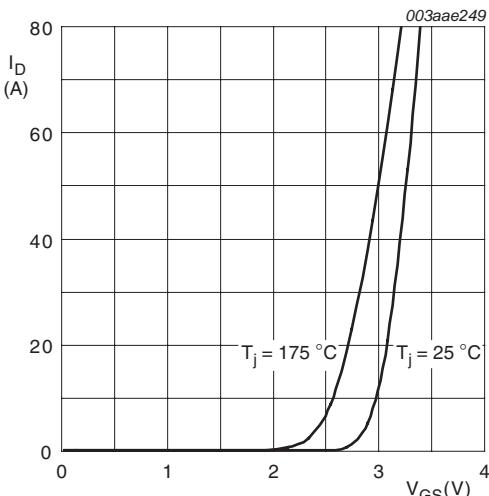
$T_j = 25 \text{ }^\circ\text{C}$

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



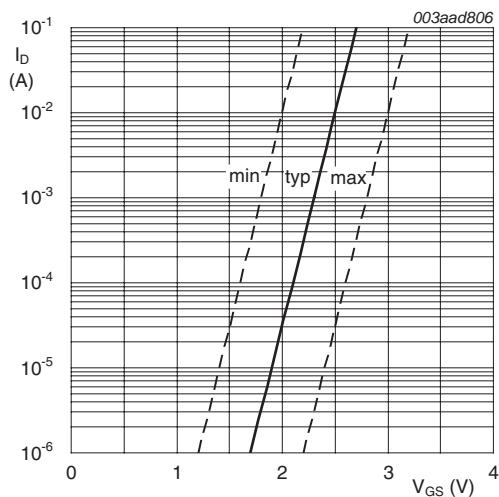
$T_j = 25 \text{ }^\circ\text{C}$ ;  $I_D = 25 \text{ A}$

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



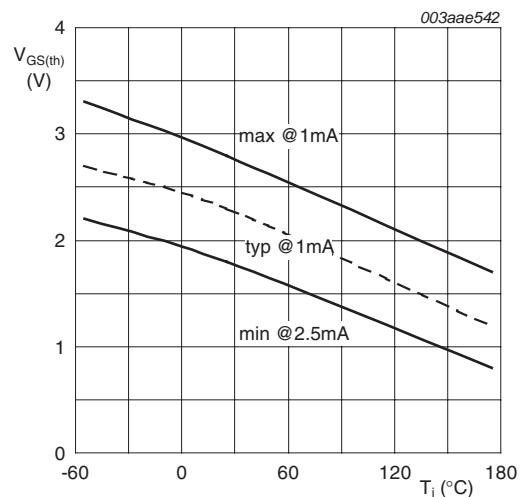
$V_{DS} > I_D \times R_{DSon}$

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



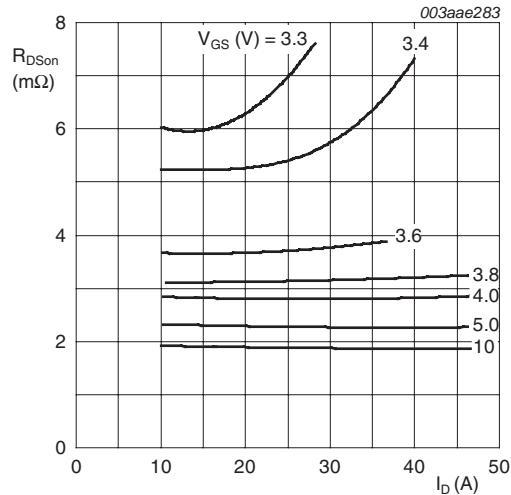
$T_j = 25^\circ\text{C}; V_{DS} = 5\text{V}$

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



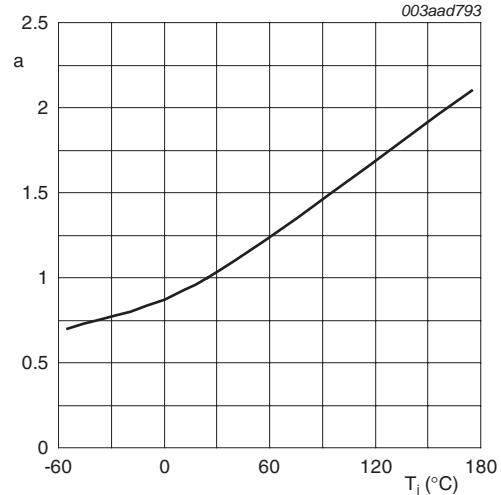
$I_D = 1\text{mA}; V_{DS} = V_{GS}$

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



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

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



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

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

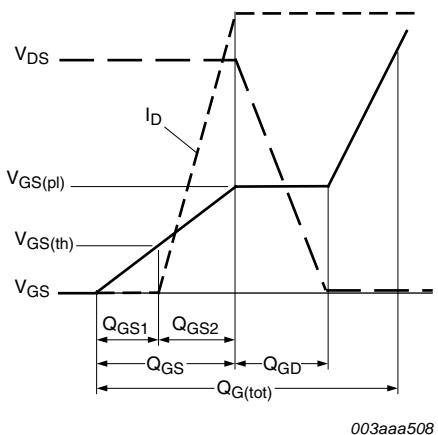
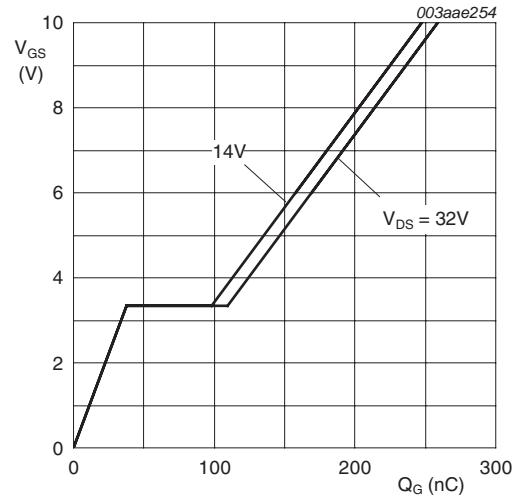


Fig 13. Gate charge waveform definitions



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

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

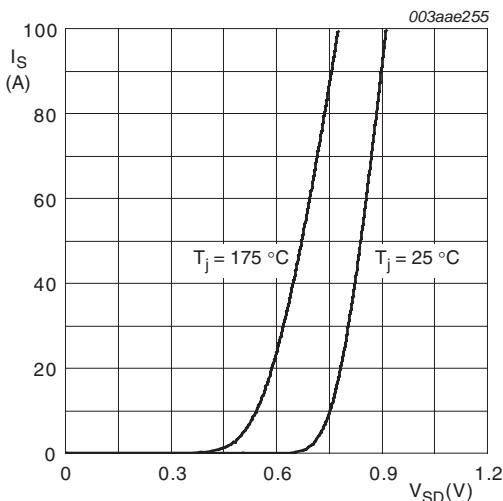
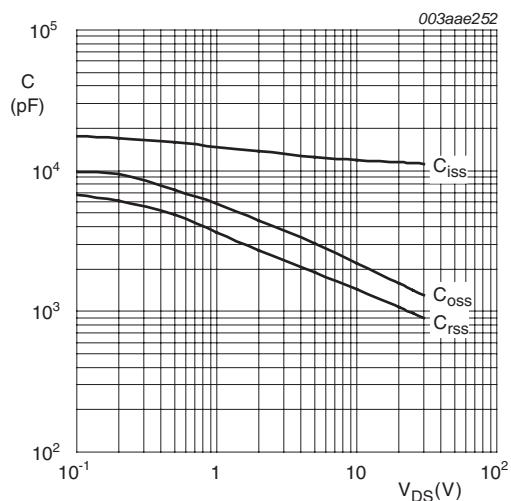


Fig 15. Source current as a function of source-drain voltage; typical values



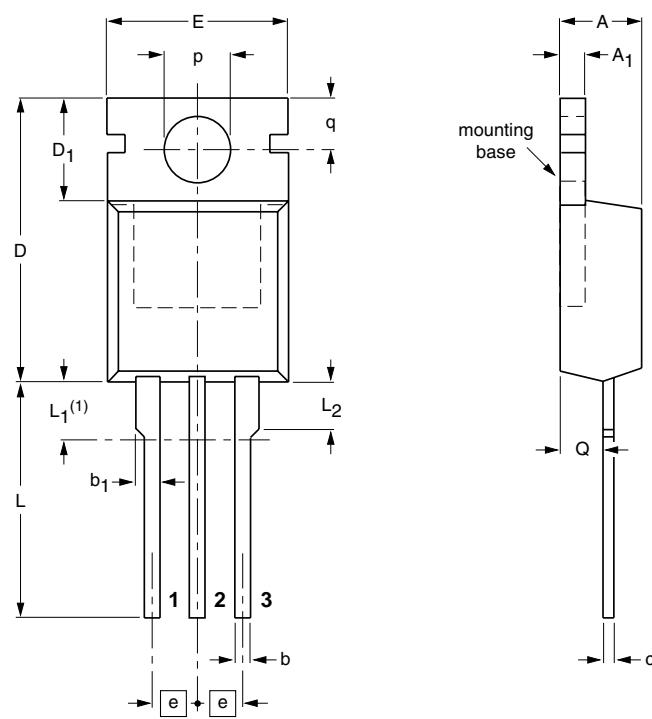
$$V_{GS} = 0 \text{ V}; f = 1 \text{ MHz}$$

**Fig 16. Input, output and reverse transfer capacitances as a function of drain-source voltage; typical values**

## 7. Package outline

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

SOT78A



0 5 10 mm  
scale

### 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> (1)	L <sub>2</sub> max.	p	q	Q
mm	4.5	1.39	0.9	1.3	0.7	15.8	6.4	10.3	2.54	15.0	3.30	3.0	3.8	3.0	2.6
	4.1	1.27	0.6	1.0	0.4	15.2	5.9	9.7		13.5	2.79	3.0	3.6	2.7	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- 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
BUK652R3-40C v.2	20100818	Product data sheet	-	BUK652R3-40C v.1
Modifications:		• Status changed from objective to product.		
BUK652R3-40C v.1	20100520	Objective data sheet	-	-

## 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".

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