



# 2N7002BK

60 V, 350 mA N-channel Trench MOSFET

Rev. 1 — 17 June 2010

Product data sheet

## 1. Product profile

### 1.1 General description

N-channel enhancement mode Field-Effect Transistor (FET) in a small SOT23 (TO-236AB) Surface-Mounted Device (SMD) plastic package using Trench MOSFET technology.

### 1.2 Features and benefits

- Logic-level compatible
- Very fast switching
- Trench MOSFET technology
- ESD protection up to 2 kV
- AEC-Q101 qualified

### 1.3 Applications

- Relay driver
- High-speed line driver
- Low-side loadswitch
- Switching circuits

### 1.4 Quick reference data

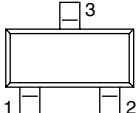
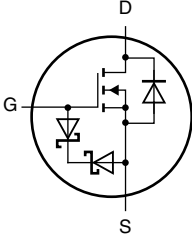
Table 1. Quick reference data

| Symbol       | Parameter                        | Conditions                                                                              | Min                   | Typ | Max      | Unit     |
|--------------|----------------------------------|-----------------------------------------------------------------------------------------|-----------------------|-----|----------|----------|
| $V_{DS}$     | drain-source voltage             | $T_{amb} = 25\text{ }^{\circ}\text{C}$                                                  | -                     | -   | 60       | V        |
| $V_{GS}$     | gate-source voltage              | $T_{amb} = 25\text{ }^{\circ}\text{C}$                                                  | -                     | -   | $\pm 20$ | V        |
| $I_D$        | drain current                    | $T_{amb} = 25\text{ }^{\circ}\text{C};$<br>$V_{GS} = 10\text{ V}$                       | <a href="#">[1]</a> - | -   | 350      | mA       |
| $R_{DS(on)}$ | drain-source on-state resistance | $T_j = 25\text{ }^{\circ}\text{C};$<br>$V_{GS} = 10\text{ V};$<br>$I_D = 500\text{ mA}$ | -                     | 1   | 1.6      | $\Omega$ |

[1] Device mounted on an FR4 PCB, single-sided copper, tin-plated, mounting pad for drain 1 cm<sup>2</sup>.

## 2. Pinning information

Table 2. Pinning

| Pin | Symbol | Description | Simplified outline                                                                  | Graphic symbol                                                                      |
|-----|--------|-------------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
| 1   | G      | gate        |  |  |
| 2   | S      | source      |                                                                                     |                                                                                     |
| 3   | D      | drain       |                                                                                     |                                                                                     |

017aaa000

## 3. Ordering information

Table 3. Ordering information

| Type number | Package  |                                          |         |
|-------------|----------|------------------------------------------|---------|
|             | Name     | Description                              | Version |
| 2N7002BK    | TO-236AB | plastic surface-mounted package; 3 leads | SOT23   |

## 4. Marking

Table 4. Marking codes

| Type number | Marking code <sup>[1]</sup> |
|-------------|-----------------------------|
| 2N7002BK    | LN*                         |

- [1] \* = -: made in Hong Kong  
 \* = p: made in Hong Kong  
 \* = t: made in Malaysia  
 \* = W: made in China

## 5. Limiting values

Table 5. Limiting values

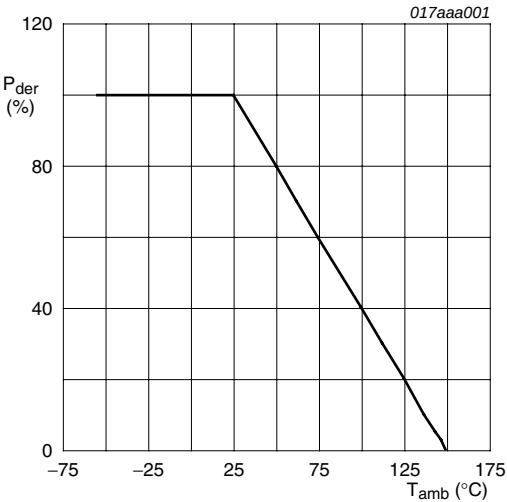
In accordance with the Absolute Maximum Rating System (IEC 60134).

| Symbol   | Parameter            | Conditions                                                                   | Min            | Max | Unit |
|----------|----------------------|------------------------------------------------------------------------------|----------------|-----|------|
| $V_{DS}$ | drain-source voltage | $T_{amb} = 25\text{ °C}$                                                     | -              | 60  | V    |
| $V_{GS}$ | gate-source voltage  | $T_{amb} = 25\text{ °C}$                                                     | -              | ±20 | V    |
| $I_D$    | drain current        | $V_{GS} = 10\text{ V}$                                                       | <sup>[1]</sup> |     |      |
|          |                      | $T_{amb} = 25\text{ °C}$                                                     | -              | 350 | mA   |
|          |                      | $T_{amb} = 100\text{ °C}$                                                    | -              | 245 | mA   |
| $I_{DM}$ | peak drain current   | $T_{amb} = 25\text{ °C}$ ;<br>single pulse; $t_p \leq 10\text{ }\mu\text{s}$ | -              | 1.2 | A    |

Table 5. Limiting values ...continued  
In accordance with the Absolute Maximum Rating System (IEC 60134).

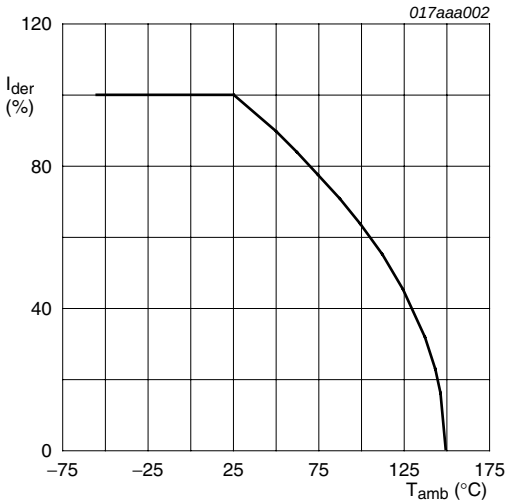
| Symbol             | Parameter                       | Conditions               | Min   | Max  | Unit |
|--------------------|---------------------------------|--------------------------|-------|------|------|
| P <sub>tot</sub>   | total power dissipation         | T <sub>amb</sub> = 25 °C | [2] - | 370  | mW   |
|                    |                                 |                          | [1] - | 440  | mW   |
|                    |                                 | T <sub>sp</sub> = 25 °C  | -     | 1.2  | W    |
| T <sub>j</sub>     | junction temperature            |                          |       | 150  | °C   |
| T <sub>amb</sub>   | ambient temperature             |                          | -55   | +150 | °C   |
| T <sub>stg</sub>   | storage temperature             |                          | -65   | +150 | °C   |
| Source-drain diode |                                 |                          |       |      |      |
| I <sub>S</sub>     | source current                  | T <sub>amb</sub> = 25 °C | [1] - | 350  | mA   |
| ESD maximum rating |                                 |                          |       |      |      |
| V <sub>ESD</sub>   | electrostatic discharge voltage | human body model         | [3] - | 2000 | V    |

- [1] Device mounted on an FR4 PCB, single-sided copper, tin-plated, mounting pad for drain 1 cm<sup>2</sup>.  
[2] Device mounted on an FR4 Printed-Circuit Board (PCB), single-sided copper, tin-plated and standard footprint.  
[3] Measured between all pins.



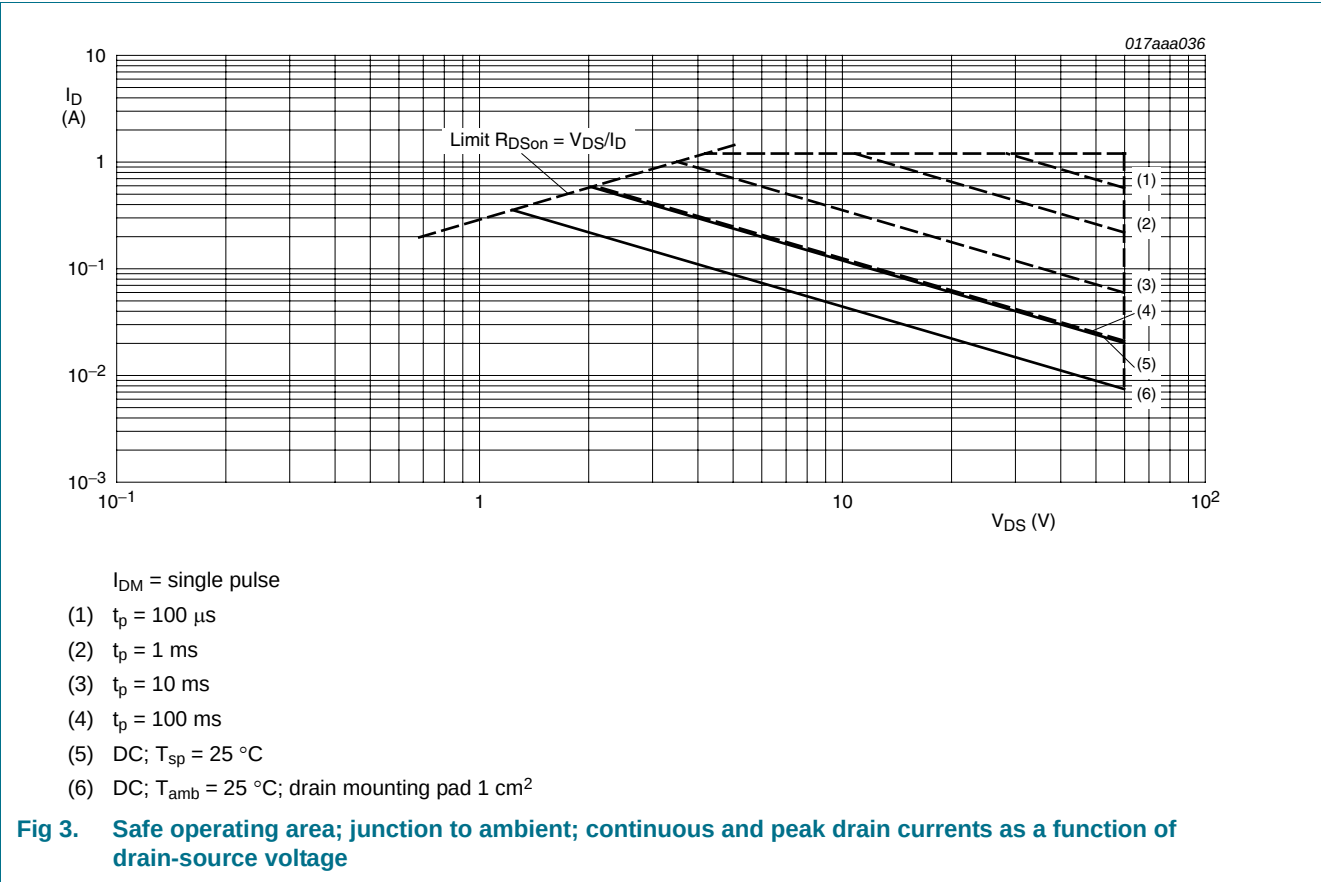
$$P_{der} = \frac{P_{tot}}{P_{tot(25^{\circ}C)}} \times 100 \%$$

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



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

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



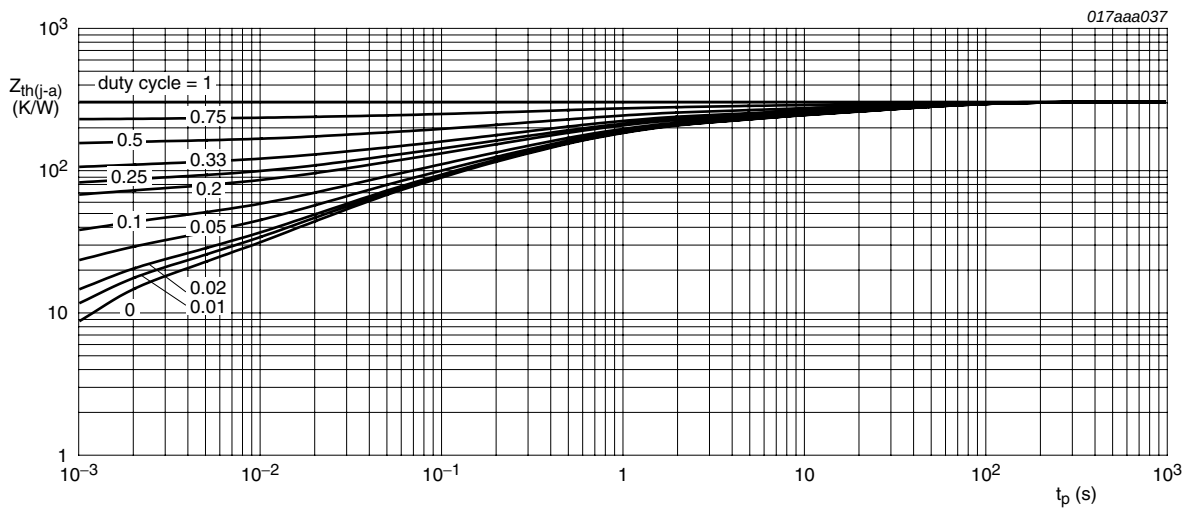
## 6. Thermal characteristics

Table 6. Thermal characteristics

| Symbol         | Parameter                                        | Conditions  | Min   | Typ | Max | Unit |
|----------------|--------------------------------------------------|-------------|-------|-----|-----|------|
| $R_{th(j-a)}$  | thermal resistance from junction to ambient      | in free air | [1] - | 295 | 340 | K/W  |
|                |                                                  |             | [2] - | 250 | 285 | K/W  |
| $R_{th(j-sp)}$ | thermal resistance from junction to solder point |             | -     | -   | 105 | K/W  |

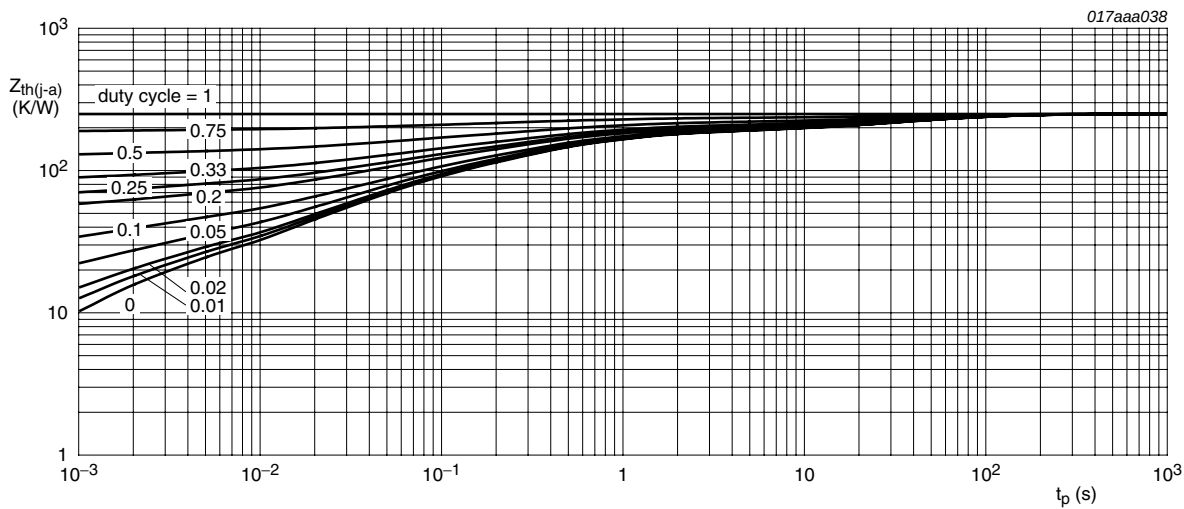
[1] Device mounted on an FR4 PCB, single-sided copper, tin-plated and standard footprint.

[2] Device mounted on an FR4 PCB, single-sided copper, tin-plated, mounting pad for drain  $1 cm^2$ .



FR4 PCB, standard footprint

Fig. 4. Transient thermal impedance from junction to ambient as a function of pulse duration; typical values



FR4 PCB, mounting pad for drain 1 cm<sup>2</sup>

Fig. 5. Transient thermal impedance from junction to ambient as a function of pulse duration; typical values

## 7. Characteristics

**Table 7. Characteristics**

$T_j = 25\text{ }^{\circ}\text{C}$  unless otherwise specified.

| Symbol                         | Parameter                        | Conditions                                            | Min  | Typ  | Max | Unit          |
|--------------------------------|----------------------------------|-------------------------------------------------------|------|------|-----|---------------|
| <b>Static characteristics</b>  |                                  |                                                       |      |      |     |               |
| $V_{(BR)DSS}$                  | drain-source breakdown voltage   | $I_D = 10\text{ }\mu\text{A}$ ; $V_{GS} = 0\text{ V}$ | 60   | -    | -   | V             |
| $V_{GS(th)}$                   | gate-source threshold voltage    | $I_D = 250\text{ }\mu\text{A}$ ; $V_{DS} = V_{GS}$    | 1.1  | 1.6  | 2.1 | V             |
| $I_{DSS}$                      | drain leakage current            | $V_{DS} = 60\text{ V}$ ; $V_{GS} = 0\text{ V}$        |      |      |     |               |
|                                |                                  | $T_j = 25\text{ }^{\circ}\text{C}$                    | -    | -    | 1   | $\mu\text{A}$ |
|                                |                                  | $T_j = 150\text{ }^{\circ}\text{C}$                   | -    | -    | 10  | $\mu\text{A}$ |
| $I_{GSS}$                      | gate leakage current             | $V_{GS} = \pm 20\text{ V}$ ; $V_{DS} = 0\text{ V}$    | -    | -    | 10  | $\mu\text{A}$ |
| $R_{DS(on)}$                   | drain-source on-state resistance |                                                       | [1]  |      |     |               |
|                                |                                  | $V_{GS} = 5\text{ V}$ ; $I_D = 50\text{ mA}$          | -    | 1.3  | 2   | $\Omega$      |
|                                |                                  | $V_{GS} = 10\text{ V}$ ; $I_D = 500\text{ mA}$        | -    | 1    | 1.6 | $\Omega$      |
| $g_{fs}$                       | forward transconductance         | $V_{DS} = 10\text{ V}$ ; $I_D = 200\text{ mA}$        | [1]  | 550  | -   | mS            |
| <b>Dynamic characteristics</b> |                                  |                                                       |      |      |     |               |
| $Q_{G(tot)}$                   | total gate charge                | $I_D = 300\text{ mA}$ ;                               | -    | 0.5  | 0.6 | nC            |
| $Q_{GS}$                       | gate-source charge               | $V_{DS} = 30\text{ V}$ ;                              | -    | 0.2  | -   | nC            |
| $Q_{GD}$                       | gate-drain charge                | $V_{GS} = 4.5\text{ V}$                               | -    | 0.1  | -   | nC            |
| $C_{iss}$                      | input capacitance                | $V_{GS} = 0\text{ V}$ ; $V_{DS} = 10\text{ V}$ ;      | -    | 33   | 50  | pF            |
| $C_{oss}$                      | output capacitance               | $f = 1\text{ MHz}$                                    | -    | 7    | -   | pF            |
| $C_{rss}$                      | reverse transfer capacitance     |                                                       | -    | 4    | -   | pF            |
| $t_{d(on)}$                    | turn-on delay time               | $V_{DD} = 50\text{ V}$ ;                              | -    | 5    | 10  | ns            |
| $t_r$                          | rise time                        | $R_L = 250\text{ }\Omega$ ;                           | -    | 6    | -   | ns            |
| $t_{d(off)}$                   | turn-off delay time              | $V_{GS} = 10\text{ V}$ ;                              | -    | 12   | 24  | ns            |
| $t_f$                          | fall time                        | $R_G = 6\text{ }\Omega$                               | -    | 7    | -   | ns            |
| <b>Source-drain diode</b>      |                                  |                                                       |      |      |     |               |
| $V_{SD}$                       | source-drain voltage             | $I_S = 115\text{ mA}$ ; $V_{GS} = 0\text{ V}$         | 0.47 | 0.75 | 1.1 | V             |

[1] Pulse test:  $t_p \leq 300\text{ }\mu\text{s}$ ;  $\delta \leq 0.01$ .

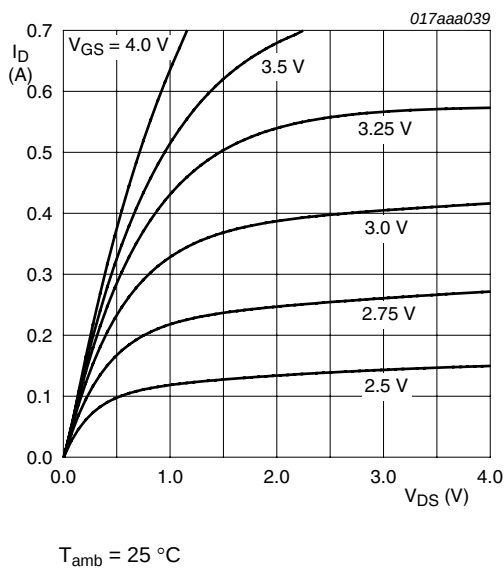


Fig 6. Output characteristics: drain current as a function of drain-source voltage; typical values

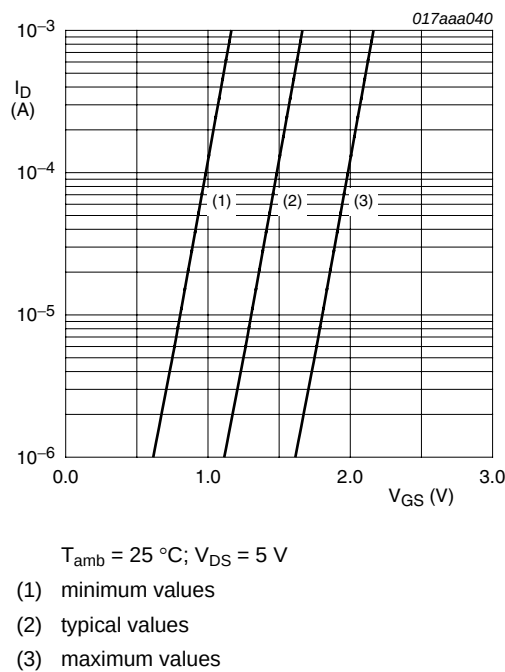


Fig 7. Sub-threshold drain current as a function of gate-source voltage

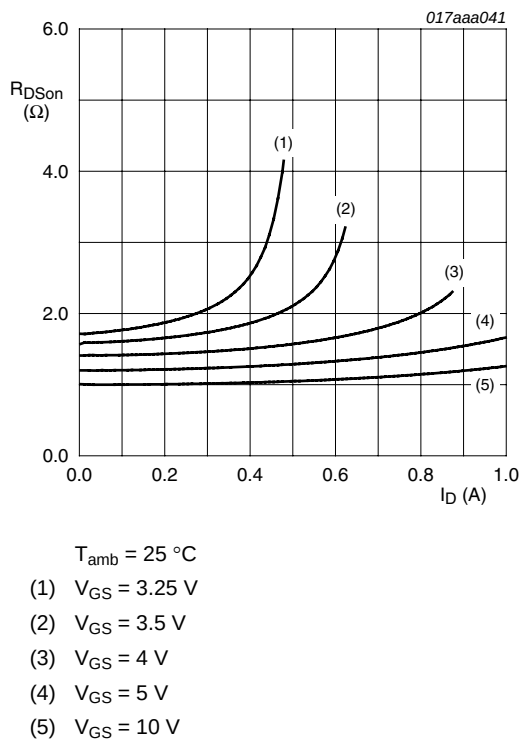


Fig 8. Drain-source on-state resistance as a function of drain current; typical values

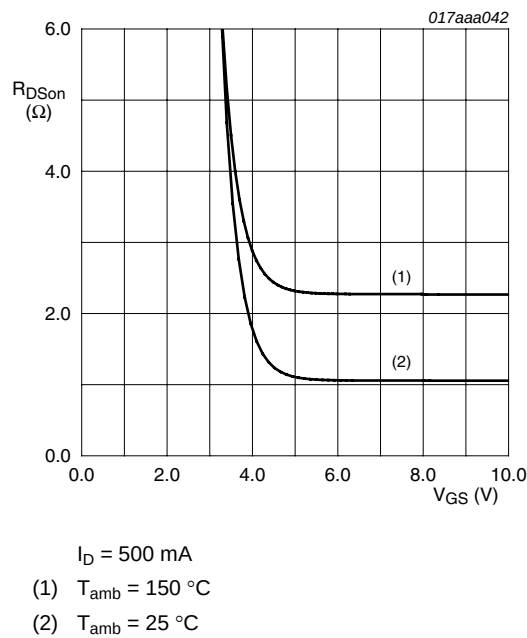
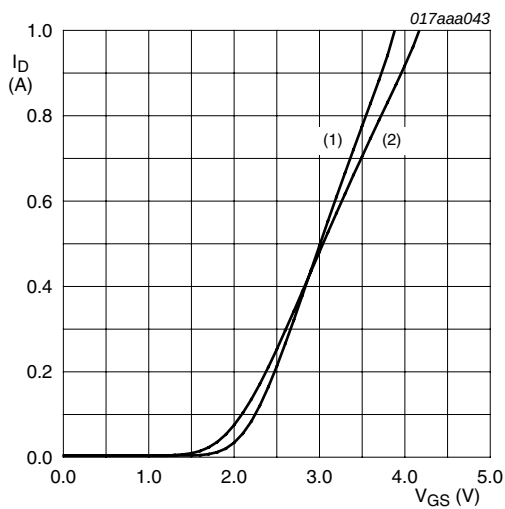
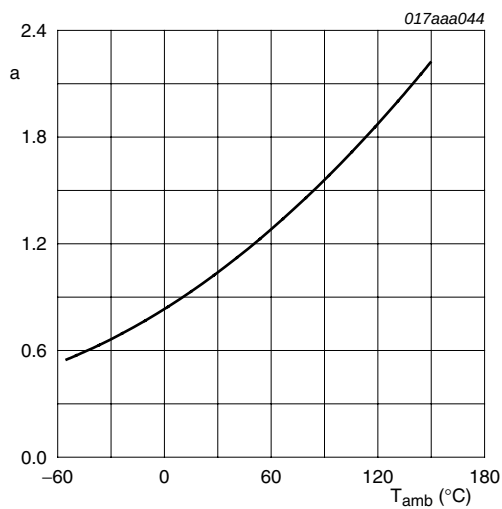


Fig 9. Drain-source on-state resistance as a function of gate-source voltage; typical values



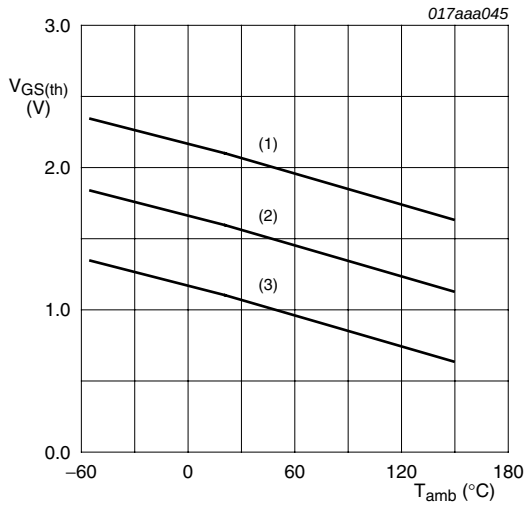
- $V_{DS} > I_D \times R_{DSon}$
- (1)  $T_{amb} = 25\text{ °C}$
  - (2)  $T_{amb} = 150\text{ °C}$

Fig 10. Transfer characteristics: drain current as a function of gate-source voltage; typical values



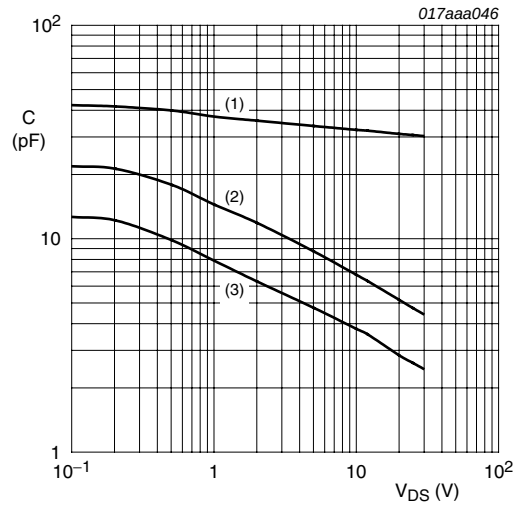
$$a = \frac{R_{DSon}}{R_{DSon}(25^{\circ}C)}$$

Fig 11. Normalized drain-source on-state resistance as a function of ambient temperature; typical values



- $I_D = 0.25\text{ mA}; V_{DS} = V_{GS}$
- (1) maximum values
  - (2) typical values
  - (3) minimum values

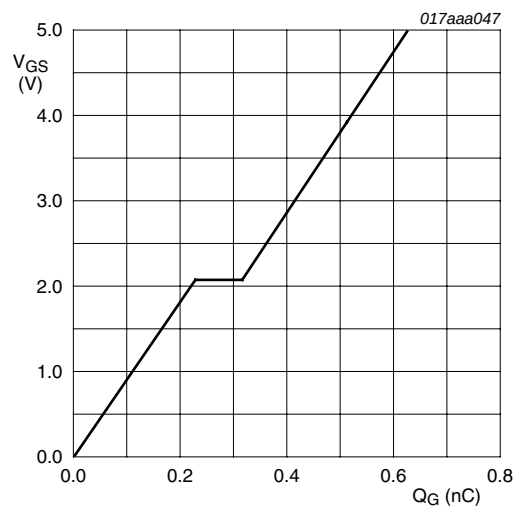
Fig 12. Gate-source threshold voltage as a function of ambient temperature



- $f = 1\text{ MHz}; V_{GS} = 0\text{ V}$
- (1)  $C_{iss}$
  - (2)  $C_{oss}$
  - (3)  $C_{rss}$

Fig 13. Input, output and reverse transfer capacitances as a function of drain-source voltage; typical values





$I_D = 300\text{ mA}$ ;  $V_{DD} = 6\text{ V}$ ;  $T_{amb} = 25\text{ }^{\circ}\text{C}$

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

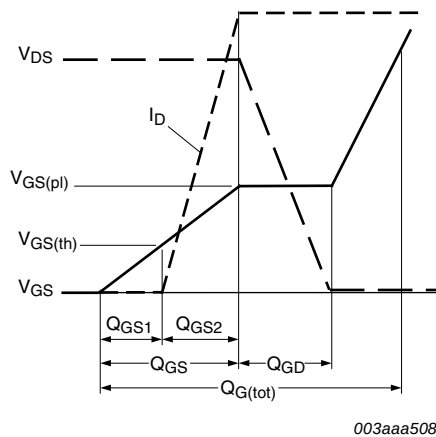
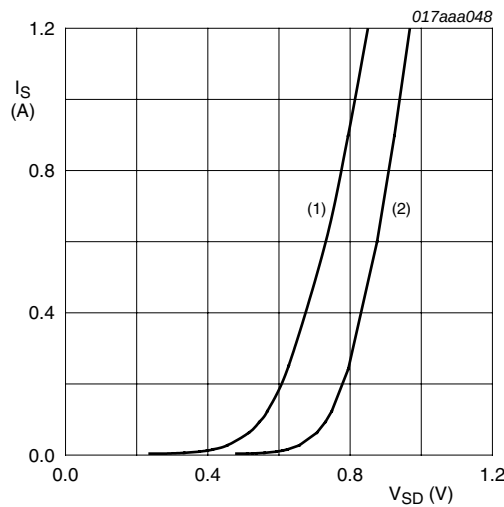


Fig 15. Gate charge waveform definitions



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

- (1)  $T_{amb} = 150\text{ }^{\circ}\text{C}$
- (2)  $T_{amb} = 25\text{ }^{\circ}\text{C}$

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

## 8. Test information

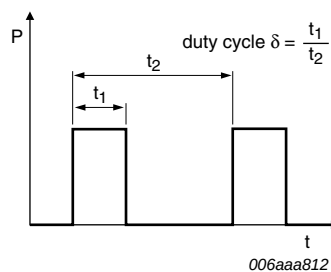


Fig 17. Duty cycle definition

9. Package outline

Plastic surface-mounted package; 3 leads

SOT23

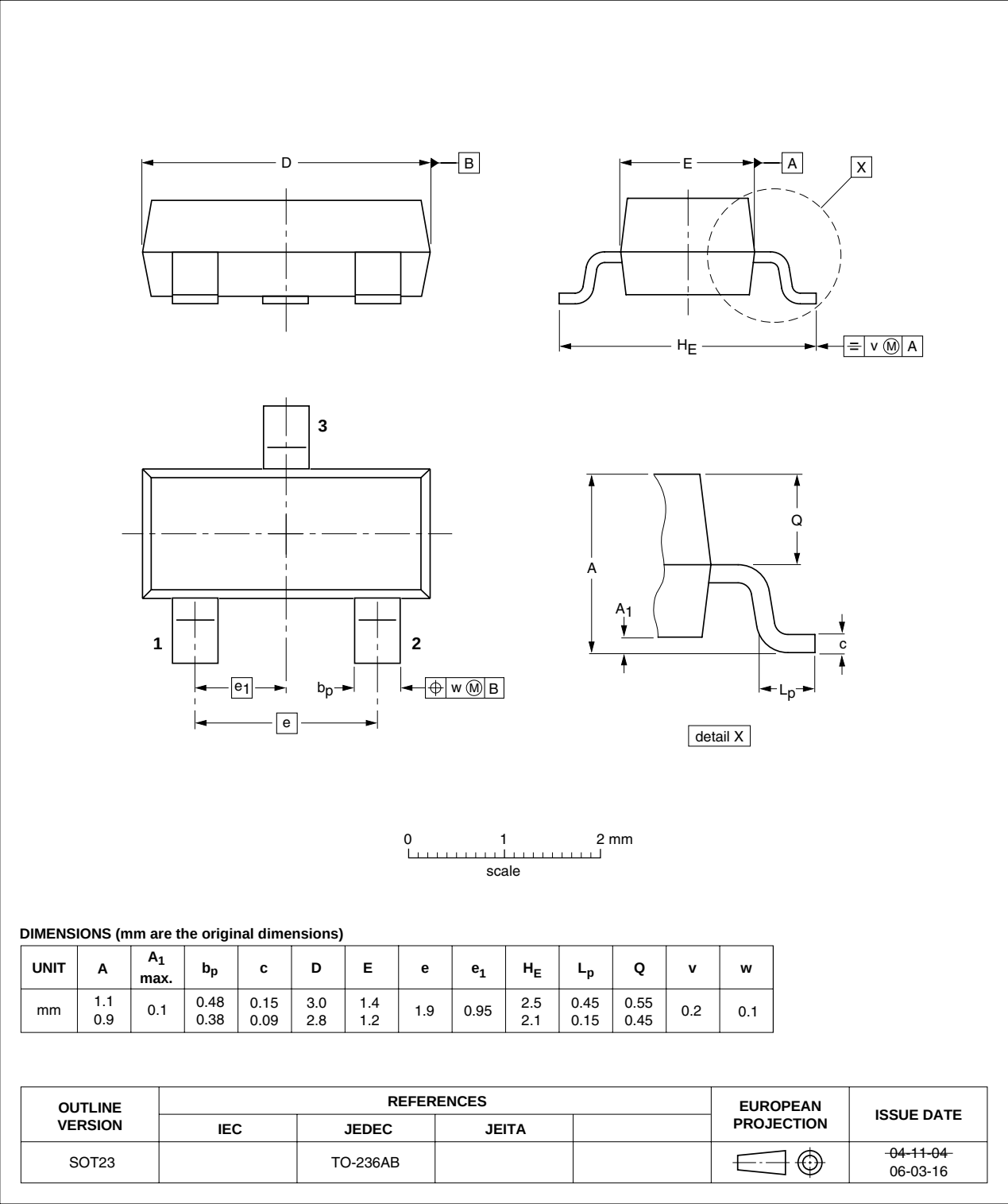


Fig 18. Package outline SOT23 (TO-236AB)



11. Revision history

Table 8. Revision history

| Document ID  | Release date | Data sheet status  | Change notice | Supersedes |
|--------------|--------------|--------------------|---------------|------------|
| 2N7002BK v.1 | 20100617     | Product data sheet | -             | -          |

## 12. Legal information

### 12.1 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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Нашей специализацией является поставка электронной компонентной базы двойного назначения, продукции таких производителей как XILINX, Intel (ex.ALTERA), Vicor, Microchip, Texas Instruments, Analog Devices, Mini-Circuits, Amphenol, Glenair.

Сотрудничество с глобальными дистрибьюторами электронных компонентов, предоставляет возможность заказывать и получать с международных складов практически любой перечень компонентов в оптимальные для Вас сроки.

На всех этапах разработки и производства наши партнеры могут получить квалифицированную поддержку опытных инженеров.

Система менеджмента качества компании отвечает требованиям в соответствии с ГОСТ Р ИСО 9001, ГОСТ РВ 0015-002 и ЭС РД 009

### Офис по работе с юридическими лицами:

105318, г.Москва, ул.Щербаковская д.3, офис 1107, 1118, ДЦ «Щербаковский»

Телефон: +7 495 668-12-70 (многоканальный)

Факс: +7 495 668-12-70 (доб.304)

E-mail: [info@moschip.ru](mailto:info@moschip.ru)

Skype отдела продаж:

moschip.ru

moschip.ru\_4

moschip.ru\_6

moschip.ru\_9