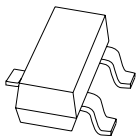


# 2N7002CK

## 60 V, 0.3 A N-channel Trench MOSFET

Rev. 01 — 11 September 2009 Product data sheet

## 1. Product profile

### 1.1 General description

ESD protected 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

- Logic-level compatible
- Very fast switching
- Trench MOSFET technology
- ESD protection up to 3 kV

### 1.3 Applications

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

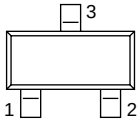
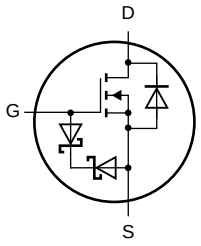
### 1.4 Quick reference data

Table 1. Quick reference data

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| $V_{DS}$ | drain-source voltage | | - | - | 60 | V |
| $I_D$ | drain current | | - | - | 300 | mA |
| $I_{DM}$ | peak drain current | single pulse; $t_p \leq 10\ \mu s$ | - | - | 1.2 | A |
| $R_{DSon}$ | drain-source on-state resistance | $V_{GS}$ = 10 V; $I_D$ = 500 mA | - | 1.1 | 1.6 | Ω |

## 2. Pinning information

Table 2. Pinning

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



## 3. Ordering information

Table 3. Ordering information

| Type number | Package | | |
|---|---|---|---|
| | Name | Description | Version |
| 2N7002CK | TO-236AB | plastic surface-mounted package; 3 leads | SOT23 |

## 4. Marking

Table 4. Marking codes

| Type number | Marking code[1] |
|---|---|
| 2N7002CK | LP* |

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

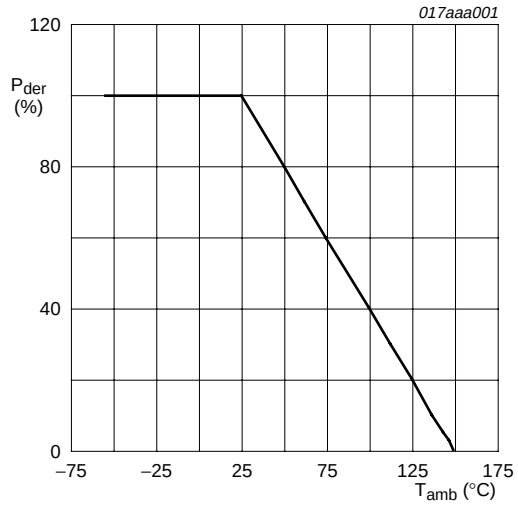
## 5. Limiting values

**Table 5. Limiting values**

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

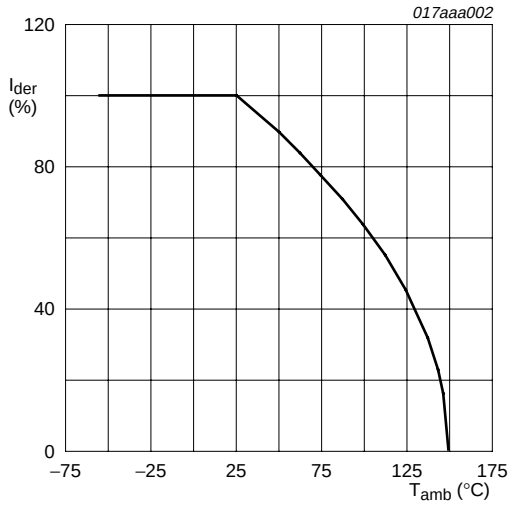
| Symbol | Parameter | Conditions | | Min | Max | Unit |
|---|---|---|---|---|---|---|
| $V_{DS}$ | drain-source voltage | 25 °C ≤ $T_j$ ≤ 150 °C | | - | 60 | V |
| $V_{GS}$ | gate-source voltage | | | - | ±20 | V |
| $I_D$ | drain current | $V_{GS}$ = 10 V | | | | |
| | | $T_{amb}$ = 25 °C | | - | 300 | mA |
| | | $T_{amb}$ = 100 °C | | - | 190 | mA |
| $I_{DM}$ | peak drain current | $T_{amb}$ = 25 °C; $t_p$ ≤ 10 µs | | - | 1.2 | A |
| $P_{tot}$ | total power dissipation | $T_{amb}$ = 25 °C | [1] | - | 350 | mW |
| $T_j$ | junction temperature | | | | 150 | °C |
| $T_{amb}$ | ambient temperature | | | –55 | +150 | °C |
| $T_{stg}$ | storage temperature | | | –65 | +150 | °C |
| **Source-drain diode** | | | | | | |
| $I_S$ | source current | $T_{amb}$ = 25 °C | | - | 200 | mA |
| $I_{SM}$ | peak source current | $T_{amb}$ = 25 °C; $t_p$ ≤ 10 µs | | - | 1.2 | A |
| **ElectroStatic Discharge (ESD)** | | | | | | |
| $V_{ESD}$ | electrostatic discharge voltage | all pins; human body model; C = 100 pF; R = 1.5 kΩ | | - | 3 | kV |

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



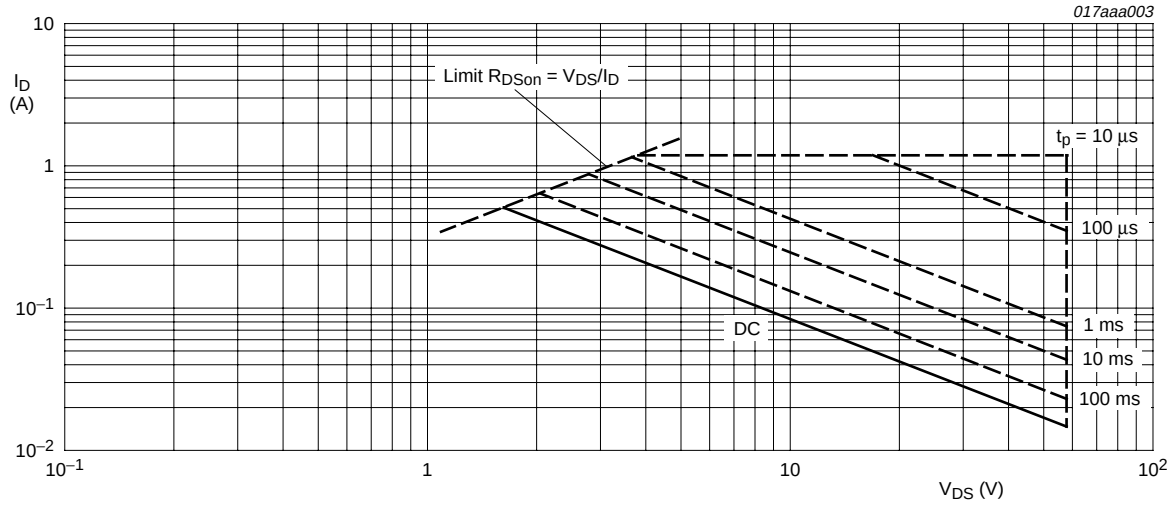

$$P_{der} = \frac{P_{tot}}{P_{tot(25°C)}} \times 100\ \%$$

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



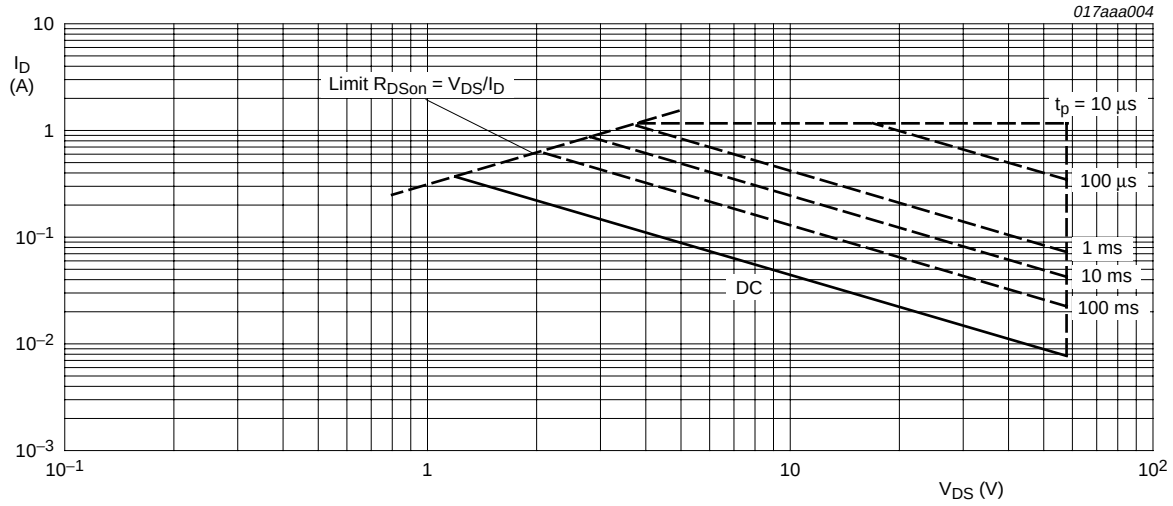

$$I_{der} = \frac{I_D}{I_{D(25°C)}} \times 100\ \%$$

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




$T_{sp}$ = 25 °C; $I_{DM}$ = single pulse; $V_{GS}$ = 10 V

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




$T_{amb}$ = 25 °C; $I_{DM}$ = single pulse; $V_{GS}$ = 10 V

**Fig 4. Safe operating area; junction to ambient; continuous and peak drain currents as a function of drain-source voltage**

# 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] | - | 350 | 500 | K/W |

**Table 6. Thermal characteristics** *...continued*

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| $R_{th(j-sp)}$ | thermal resistance from junction to solder point | | - | - | 150 | K/W |

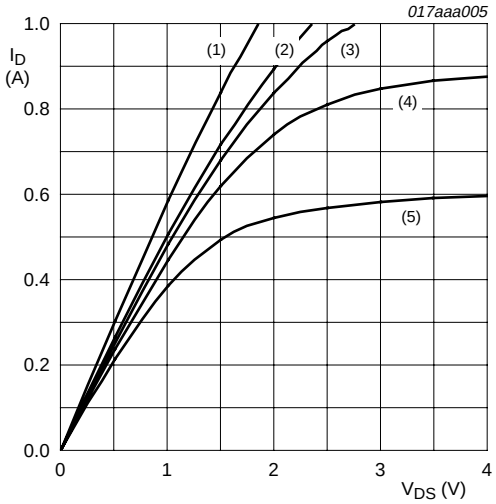
[1] Device mounted on an FR4 PCB, single-sided copper, tin-plated and standard footprint.

# 7. Characteristics

**Table 7. Characteristics**

*$T_{amb}$ = 25 °C unless otherwise specified.*

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| **Static characteristics** | | | | | | |
| $V_{(BR)DSS}$ | drain-source breakdown voltage | $I_D$ = 10 µA; $V_{GS}$ = 0 V | | | | |
| | | $T_j$ = 25 °C | 60 | - | - | V |
| | | $T_j$ = −55 °C | 55 | - | - | V |
| $V_{GS(th)}$ | gate-source threshold voltage | $I_D$ = 250 µA; $V_{DS}$ = $V_{GS}$; $T_j$ = 25 °C | 1 | 1.75 | 2.5 | V |
| $I_{DSS}$ | drain leakage current | $V_{DS}$ = 60 V; $V_{GS}$ = 0 V | | | | |
| | | $T_j$ = 25 °C | - | - | 100 | nA |
| | | $T_j$ = 150 °C | - | - | 1 | µA |
| $I_{GSS}$ | gate leakage current | $V_{GS}$ = ±20 V; $V_{DS}$ = 0 V | - | - | 5 | µA |
| | | $V_{GS}$ = ±10 V; $V_{DS}$ = 0 V | - | 50 | 450 | nA |
| | | $V_{GS}$ = ±5 V; $V_{DS}$ = 0 V | - | - | 100 | nA |
| $R_{DSon}$ | drain-source on-state resistance | $V_{GS}$ = 4.5 V; $I_D$ = 200 mA | | | | |
| | | $T_j$ = 25 °C | - | 1.3 | 3 | Ω |
| | | $T_j$ = 150 °C | - | 2.8 | 4.4 | Ω |
| | | $V_{GS}$ = 10 V; $I_D$ = 500 mA | - | 1.1 | 1.6 | Ω |
| **Dynamic characteristics** | | | | | | |
| $Q_{G(tot)}$ | total gate charge | $I_D$ = 200 mA; $V_{DS}$ = 10 V; $V_{GS}$ = 4.5 V | - | 1.09 | 1.3 | nC |
| $Q_{GS}$ | gate-source charge | | - | 0.22 | - | nC |
| $Q_{GD}$ | gate-drain charge | | - | 0.23 | - | nC |
| $C_{iss}$ | input capacitance | $V_{GS}$ = 0 V; $V_{DS}$ = 25 V; f = 1 MHz | - | 47.2 | 55 | pF |
| $C_{oss}$ | output capacitance | | - | 11 | 20 | pF |
| $C_{rss}$ | reverse transfer capacitance | | - | 5 | 7.5 | pF |
| $t_{d(on)}$ | turn-on delay time | $V_{DS}$ = 15 V; $R_L$ = 15 Ω; $V_{GS}$ = 10 V; $R_G$ = 6 Ω | - | 8 | 15 | ns |
| $t_r$ | rise time | | - | 8 | 15 | ns |
| $t_{d(off)}$ | turn-off delay time | | - | 38 | 50 | ns |
| $t_f$ | fall time | | - | 22 | 35 | ns |
| **Source-drain diode** | | | | | | |
| $V_{SD}$ | source-drain voltage | $I_S$ = 200 mA; $V_{GS}$ = 0 V | 0.47 | 0.79 | 1.1 | V |




$T_j$ = 25 °C

(1) $V_{GS}$ = 10 V

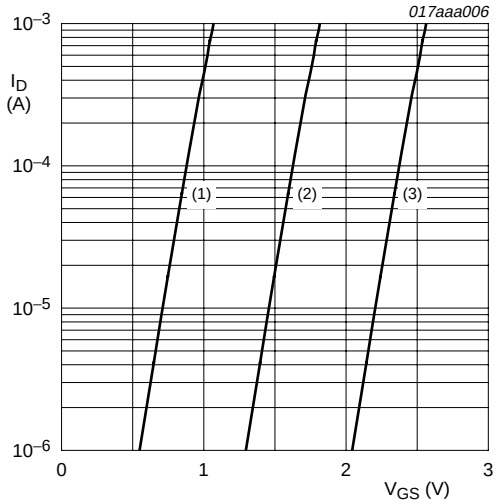
(2) $V_{GS}$ = 5 V

(3) $V_{GS}$ = 4.5 V

(4) $V_{GS}$ = 4 V

(5) $V_{GS}$ = 3.5 V

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



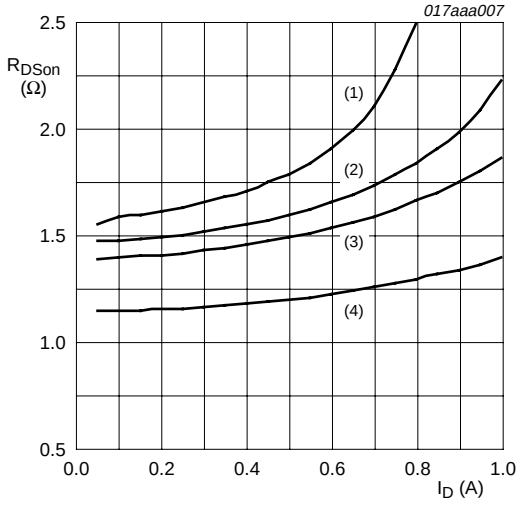

$T_j$ = 25 °C; $V_{DS}$ = 5 V

(1) minimum values

(2) typical values

(3) maximum values

**Fig 6. Sub-threshold drain current as a function of gate-source voltage**




$T_j$ = 25 °C

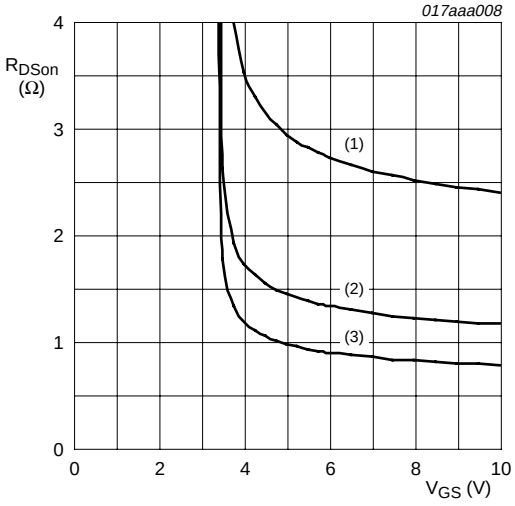
(1) $V_{GS}$ = 4 V

(2) $V_{GS}$ = 4.5 V

(3) $V_{GS}$ = 5 V

(4) $V_{GS}$ = 10 V

**Fig 7. Drain-source on-state resistance as a function of drain current; typical values**



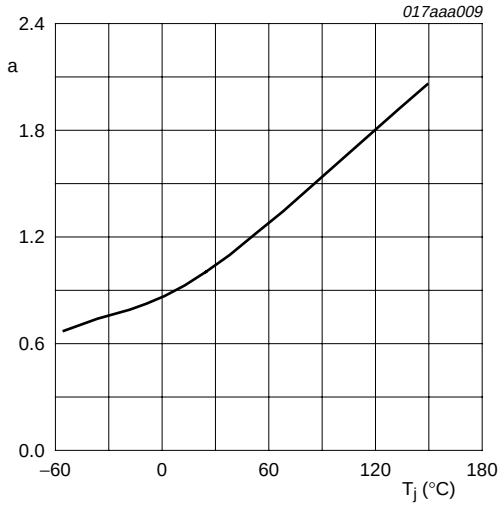

$I_D$ = 500 mA

(1) $T_j$ = 150 °C

(2) $T_j$ = 25 °C

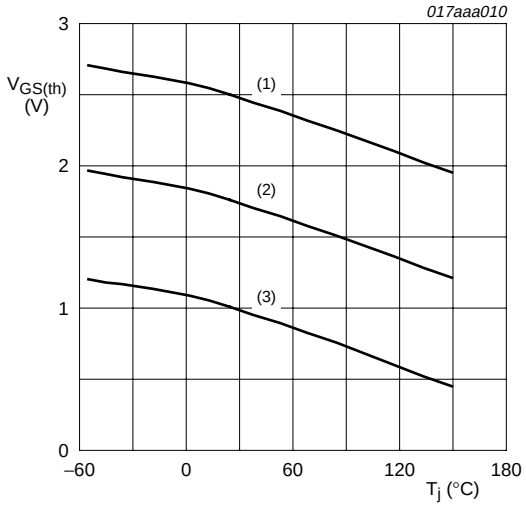
(3) $T_j$ = –55 °C

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




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

**Fig 9. Normalized drain-source on-state resistance factor as a function of junction temperature**



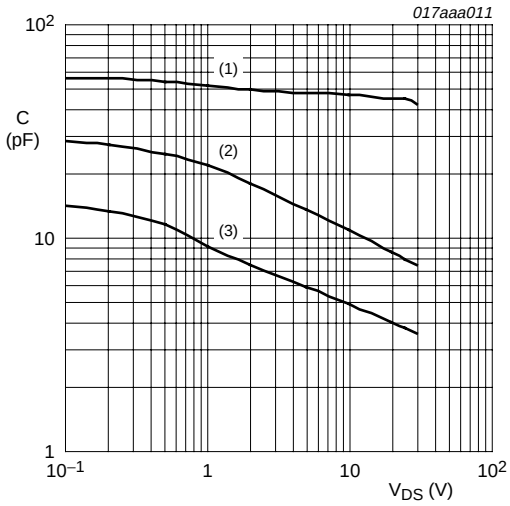

$I_D$ = 0.25 mA; $V_{DS}$ = $V_{GS}$

(1) maximum values

(2) typical values

(3) minimum values

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



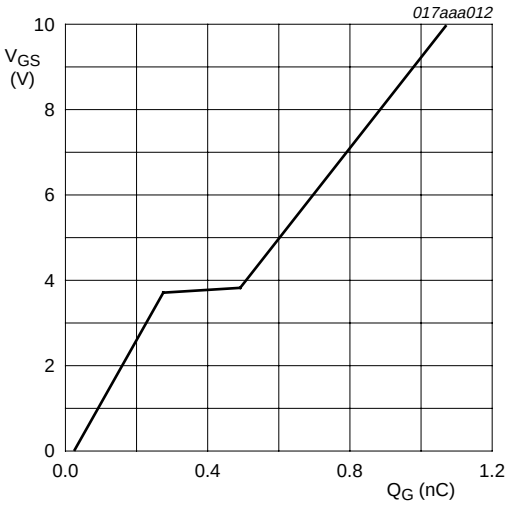

$V_{GS}$ = 0 V; f = 1 MHz

(1) $C_{iss}$

(2) $C_{oss}$

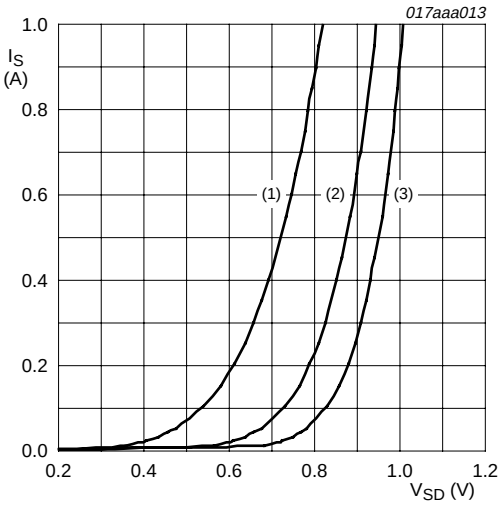
(3) $C_{rss}$

**Fig 11. Input, output and reverse transfer capacitances as a function of drain-source voltage; typical values**




$I_D$ = 200 mA; $V_{DD}$ = 30 V; $T_j$ = 25 °C

**Fig 12. Gate-source voltage as a function of gate charge; typical values**




$V_{GS}$ = 0 V

(1) $T_j$ = 150 °C

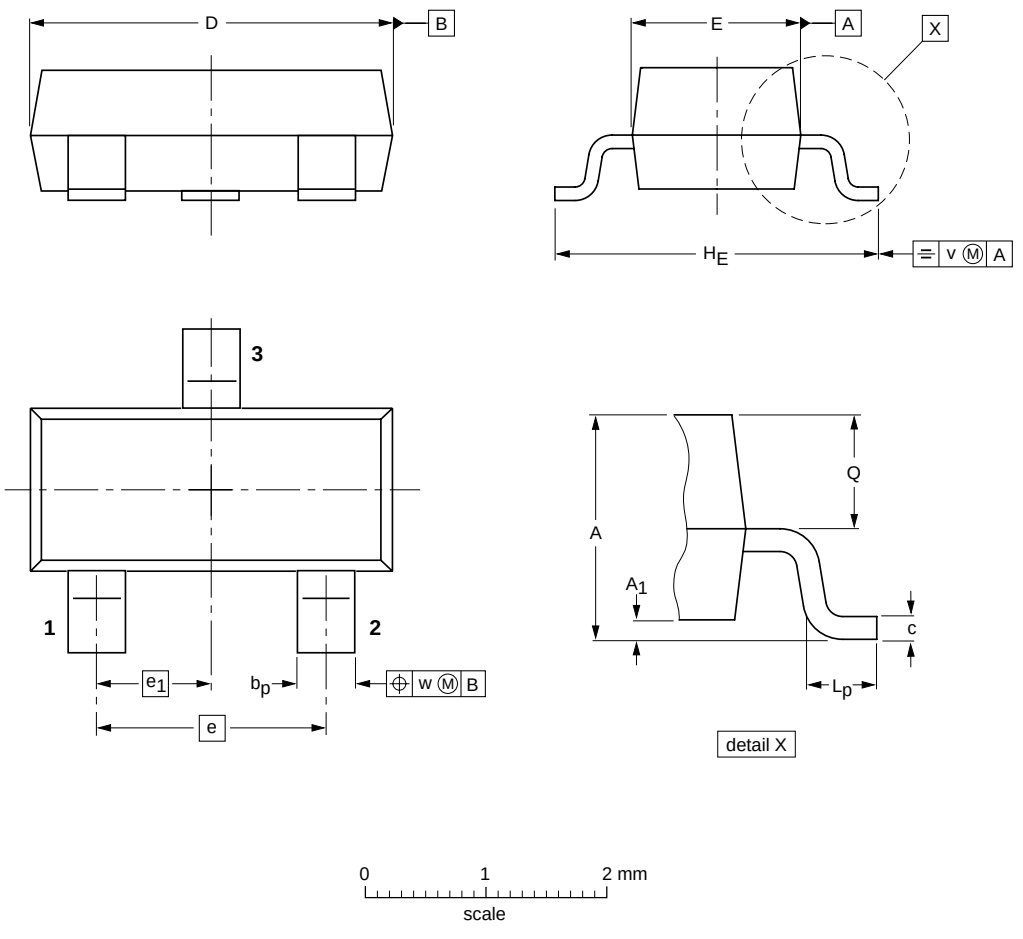
(2) $T_j$ = 25 °C

(3) $T_j$ = –55 °C

**Fig 13. Source current as a function of source-drain voltage; typical values**

## 8. Package outline

**Plastic surface-mounted package; 3 leads** **SOT23**




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

| UNIT | A | $A_1$ max. | $b_p$ | c | D | E | e | $e_1$ | $H_E$ | $L_p$ | Q | v | w |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| mm | 1.1<br>0.9 | 0.1 | 0.48<br>0.38 | 0.15<br>0.09 | 3.0<br>2.8 | 1.4<br>1.2 | 1.9 | 0.95 | 2.5<br>2.1 | 0.45<br>0.15 | 0.55<br>0.45 | 0.2 | 0.1 |

| OUTLINE VERSION | REFERENCES | | | | EUROPEAN PROJECTION | ISSUE DATE |
|---|---|---|---|---|---|---|
| | IEC | JEDEC | JEITA | | | |
| SOT23 | | TO-236AB | | | | ~~04-11-04~~<br>06-03-16 |

**Fig 14. Package outline SOT23 (TO-236AB)**

## 9. Soldering

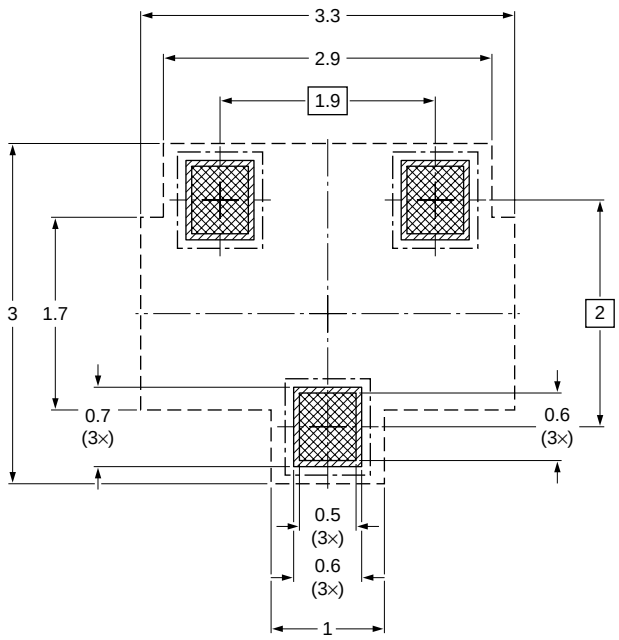



Fig 15. Reflow soldering footprint SOT23 (TO-236AB)

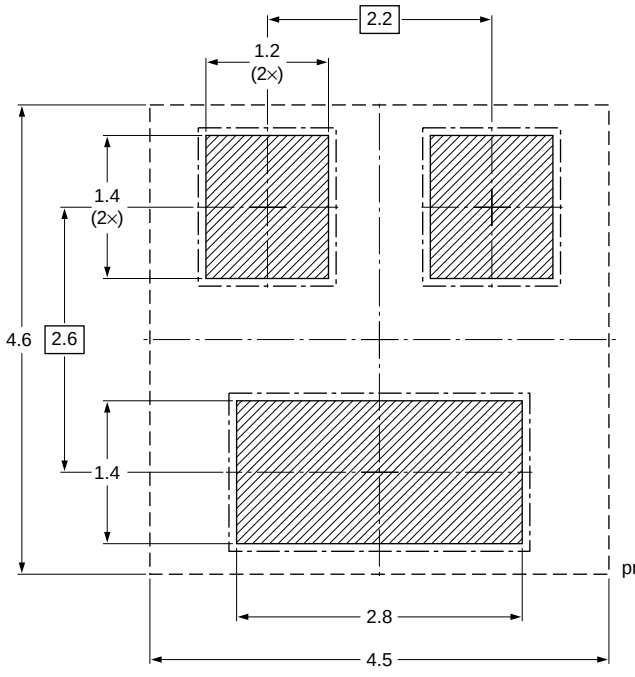



Fig 16. Wave soldering footprint SOT23 (TO-236AB)

## 10. Revision history

**Table 8. Revision history**

| Document ID | Release date | Data sheet status | Change notice | Supersedes |
|---|---|---|---|---|
| 2N7002CK_1 | 20090911 | Product data sheet | - | - |

# 11. Legal information

## 11.1 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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