

2N7002BK

60 V, 350 mA N-channel Trench MOSFET

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

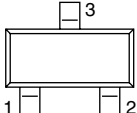
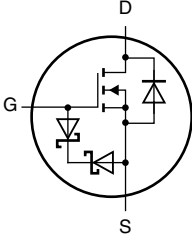
Table 1. Quick reference data

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{DS}	drain-source voltage	$T_{amb} = 25\text{ °C}$	-	-	60	V
V_{GS}	gate-source voltage	$T_{amb} = 25\text{ °C}$	-	-	±20	V
I_D	drain current	$T_{amb} = 25\text{ °C};$ $V_{GS} = 10\text{ V}$	[1] -	-	350	mA
$R_{DS(on)}$	drain-source on-state resistance	$T_j = 25\text{ °C};$ $V_{GS} = 10\text{ V};$ $I_D = 500\text{ mA}$	-	1	1.6	Ω

[1] Device mounted on an FR4 PCB, single-sided copper, tin-plated, mounting pad for drain 1 cm².

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 ^[1]
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	$V_{GS} = 10\text{ V}$	[1]		
		$T_{amb} = 25\text{ °C}$	-	350	mA
		$T_{amb} = 100\text{ °C}$	-	245	mA
I_{DM}	peak drain current	$T_{amb} = 25\text{ °C}$; single pulse; $t_p \leq 10\text{ }\mu\text{s}$	-	1.2	A

Table 5. Limiting values ...continued

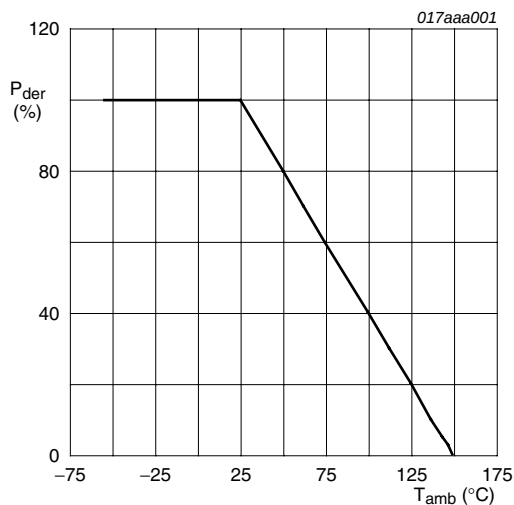
In accordance with the Absolute Maximum Rating System (IEC 60134).

Symbol	Parameter	Conditions	Min	Max	Unit
P_{tot}	total power dissipation	$T_{amb} = 25\text{ °C}$	[2] -	370	mW
			[1] -	440	mW
		$T_{sp} = 25\text{ °C}$	-	1.2	W
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	$T_{amb} = 25\text{ °C}$	[1] -	350	mA
ESD maximum rating					
V_{ESD}	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 cm².

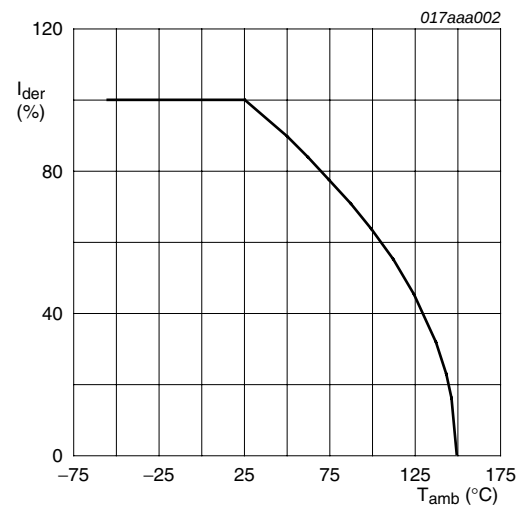
[2] Device mounted on an FR4 Printed-Circuit Board (PCB), single-sided copper, tin-plated and standard footprint.

[3] Measured between all pins.



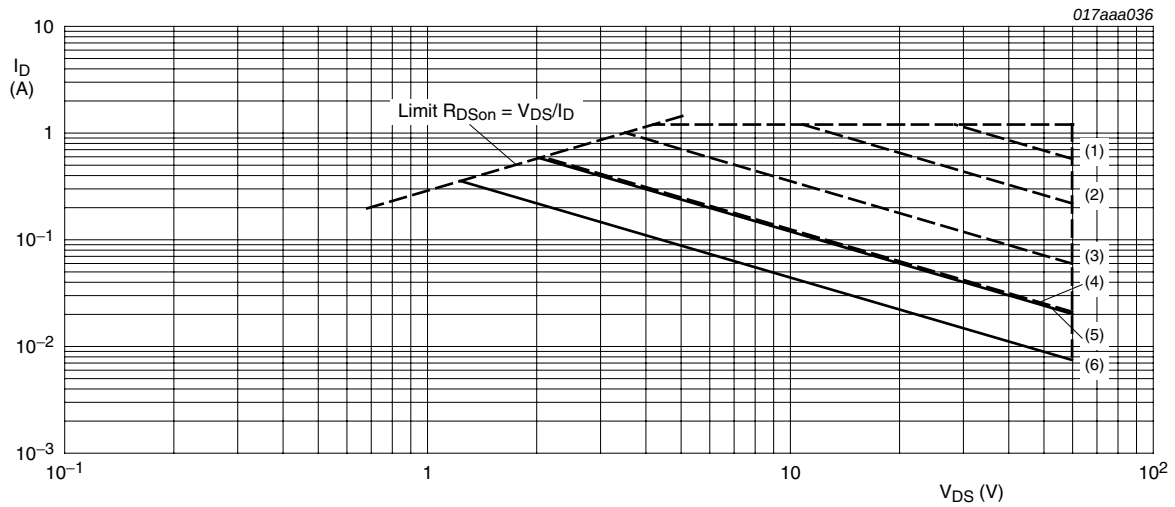
$$P_{der} = \frac{P_{tot}}{P_{tot(25^{\circ}\text{C})}} \times 100\%$$

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



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

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



- I_{DM} = single pulse
- (1) $t_p = 100 \mu s$
 - (2) $t_p = 1 ms$
 - (3) $t_p = 10 ms$
 - (4) $t_p = 100 ms$
 - (5) DC; $T_{sp} = 25^\circ C$
 - (6) DC; $T_{amb} = 25^\circ C$; drain mounting pad $1 cm^2$

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

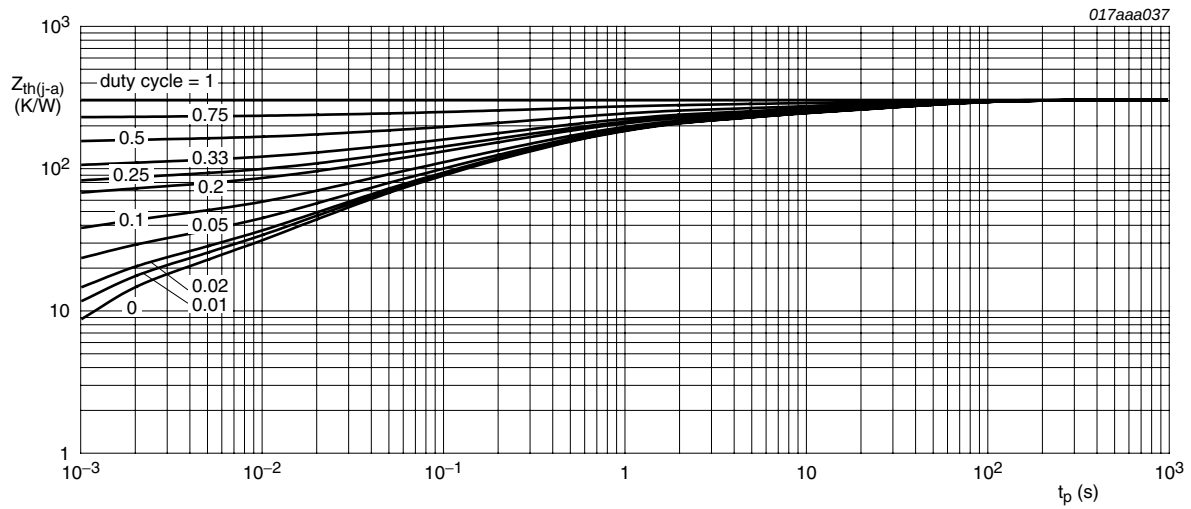
6. Thermal characteristics

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] -	295	340	K/W
			[2] -	250	285	K/W
$R_{th(j-sp)}$	thermal resistance from junction to solder point		-	-	105	K/W

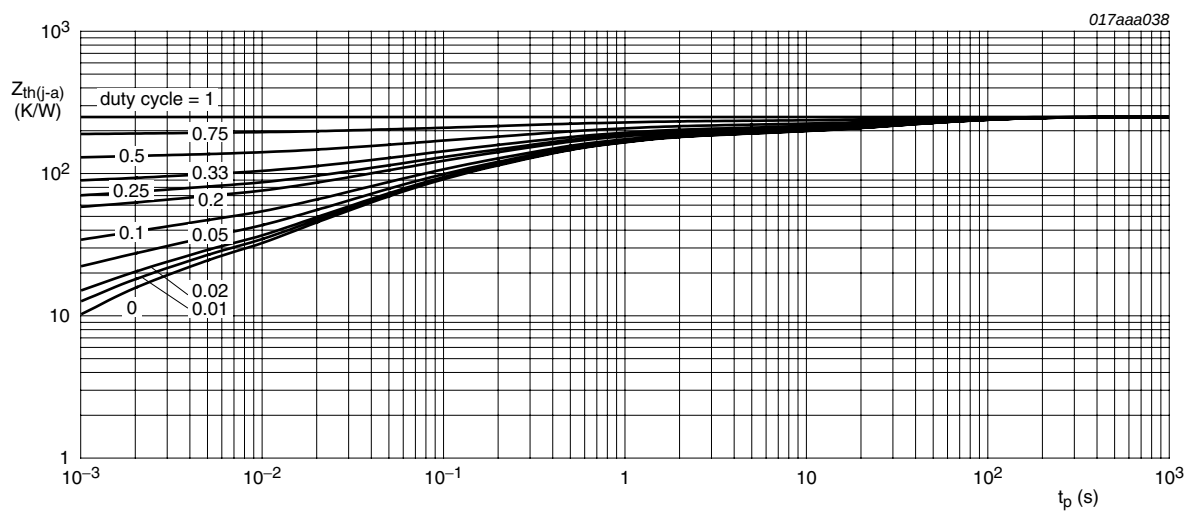
[1] Device mounted on an FR4 PCB, single-sided copper, tin-plated and standard footprint.

[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^2

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

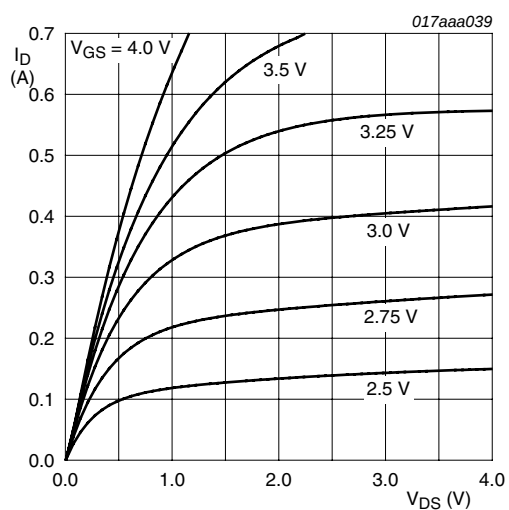
7. Characteristics

Table 7. Characteristics

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

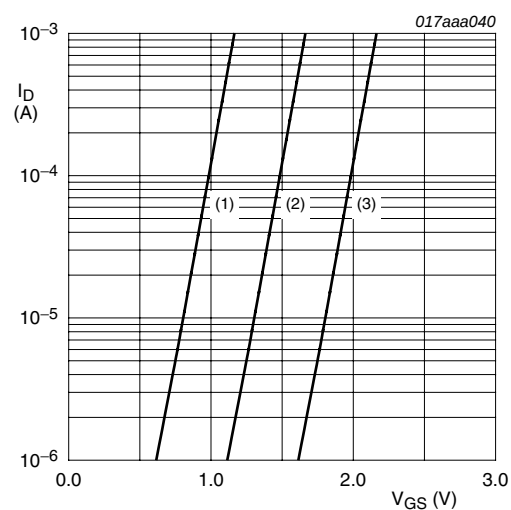
Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Static characteristics						
$V_{(BR)DSS}$	drain-source breakdown voltage	$I_D = 10\text{ }\mu\text{A}$; $V_{GS} = 0\text{ V}$	60	-	-	V
$V_{GS(th)}$	gate-source threshold voltage	$I_D = 250\text{ }\mu\text{A}$; $V_{DS} = V_{GS}$	1.1	1.6	2.1	V
I_{DSS}	drain leakage current	$V_{DS} = 60\text{ V}$; $V_{GS} = 0\text{ V}$				
		$T_j = 25\text{ }^{\circ}\text{C}$	-	-	1	μA
		$T_j = 150\text{ }^{\circ}\text{C}$	-	-	10	μA
I_{GSS}	gate leakage current	$V_{GS} = \pm 20\text{ V}$; $V_{DS} = 0\text{ V}$	-	-	10	μA
$R_{DS(on)}$	drain-source on-state resistance		[1]			
		$V_{GS} = 5\text{ V}$; $I_D = 50\text{ mA}$	-	1.3	2	Ω
		$V_{GS} = 10\text{ V}$; $I_D = 500\text{ mA}$	-	1	1.6	Ω
g_{fs}	forward transconductance	$V_{DS} = 10\text{ V}$; $I_D = 200\text{ mA}$	[1]	550	-	mS
Dynamic characteristics						
$Q_{G(tot)}$	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
Source-drain diode						
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: $t_p \leq 300\text{ }\mu\text{s}$; $\delta \leq 0.01$.



$T_{amb} = 25\text{ }^{\circ}\text{C}$

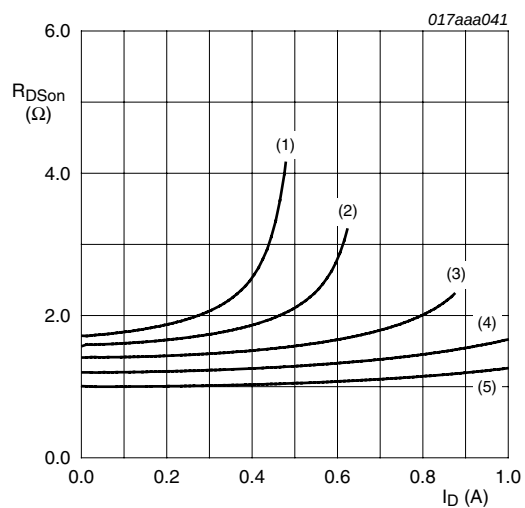
Fig 6. Output characteristics: drain current as a function of drain-source voltage; typical values



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

- (1) minimum values
- (2) typical values
- (3) maximum values

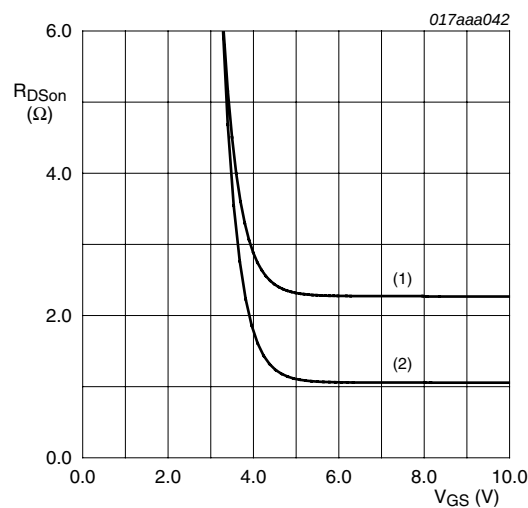
Fig 7. Sub-threshold drain current as a function of gate-source voltage



$T_{amb} = 25\text{ }^{\circ}\text{C}$

- (1) $V_{GS} = 3.25\text{ V}$
- (2) $V_{GS} = 3.5\text{ V}$
- (3) $V_{GS} = 4\text{ V}$
- (4) $V_{GS} = 5\text{ V}$
- (5) $V_{GS} = 10\text{ V}$

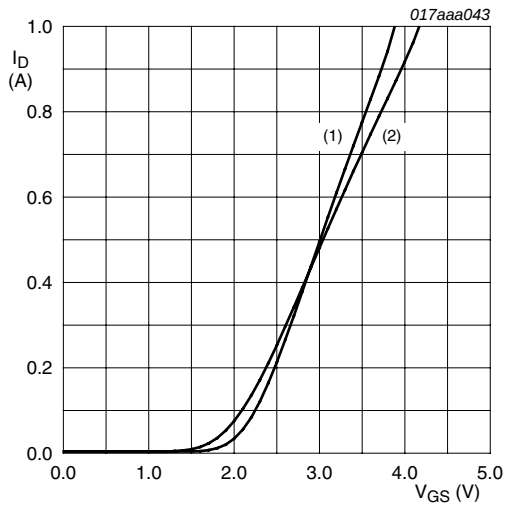
Fig 8. Drain-source on-state resistance as a function of drain current; typical values



$I_D = 500\text{ mA}$

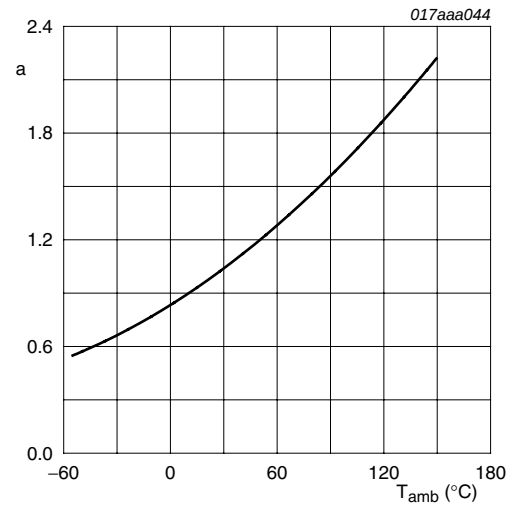
- (1) $T_{amb} = 150\text{ }^{\circ}\text{C}$
- (2) $T_{amb} = 25\text{ }^{\circ}\text{C}$

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



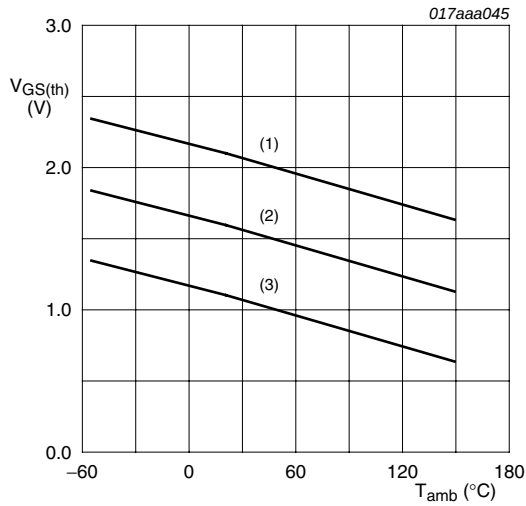
- $V_{DS} > I_D \times R_{DSon}$
- (1) $T_{amb} = 25\text{ °C}$
 - (2) $T_{amb} = 150\text{ °C}$

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



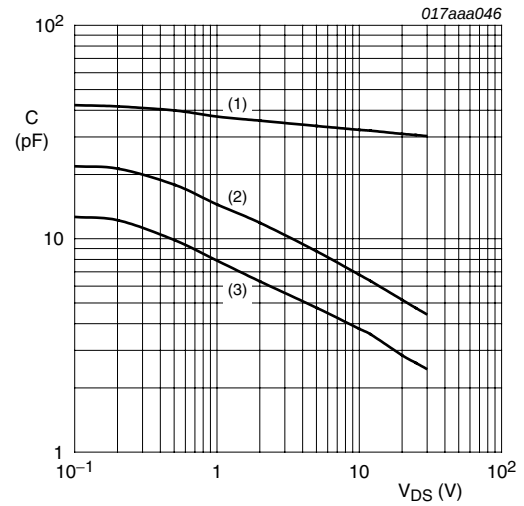
$$a = \frac{R_{DSon}}{R_{DSon(25^{\circ}C)}}$$

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



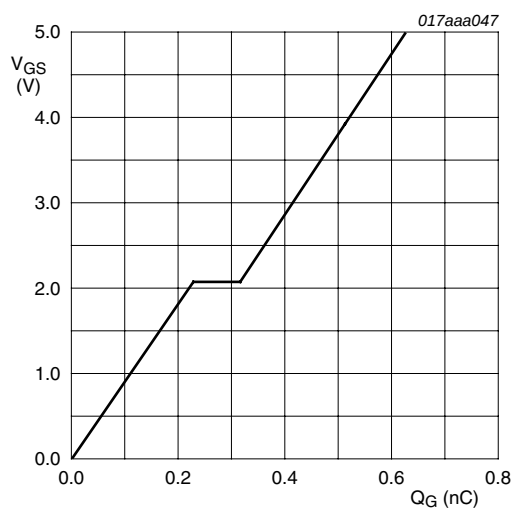
- $I_D = 0.25\text{ mA}; V_{DS} = V_{GS}$
- (1) maximum values
 - (2) typical values
 - (3) minimum values

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

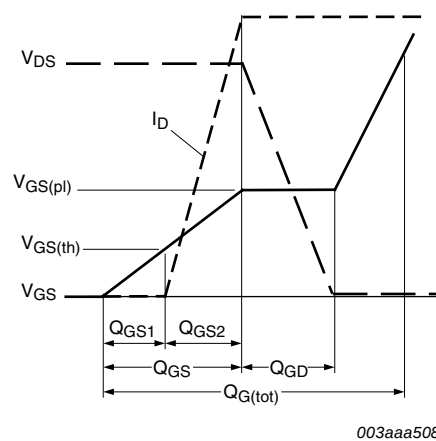
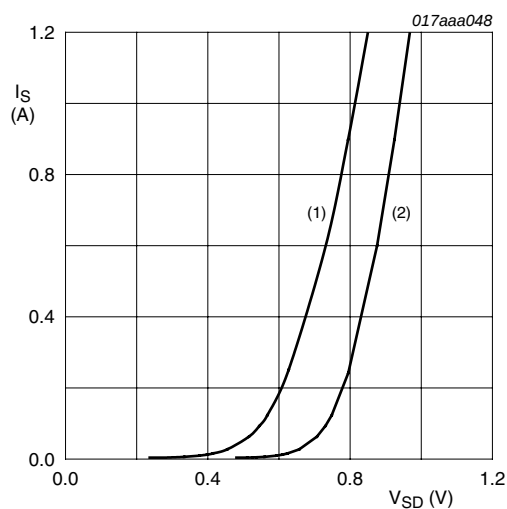


Fig 15. Gate charge waveform definitions



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

- (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

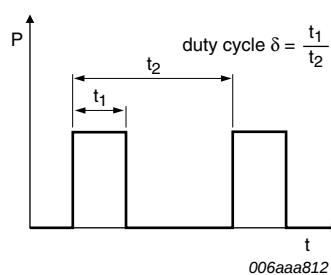


Fig 17. Duty cycle definition

9. Package outline

Plastic surface-mounted package; 3 leads

SOT23

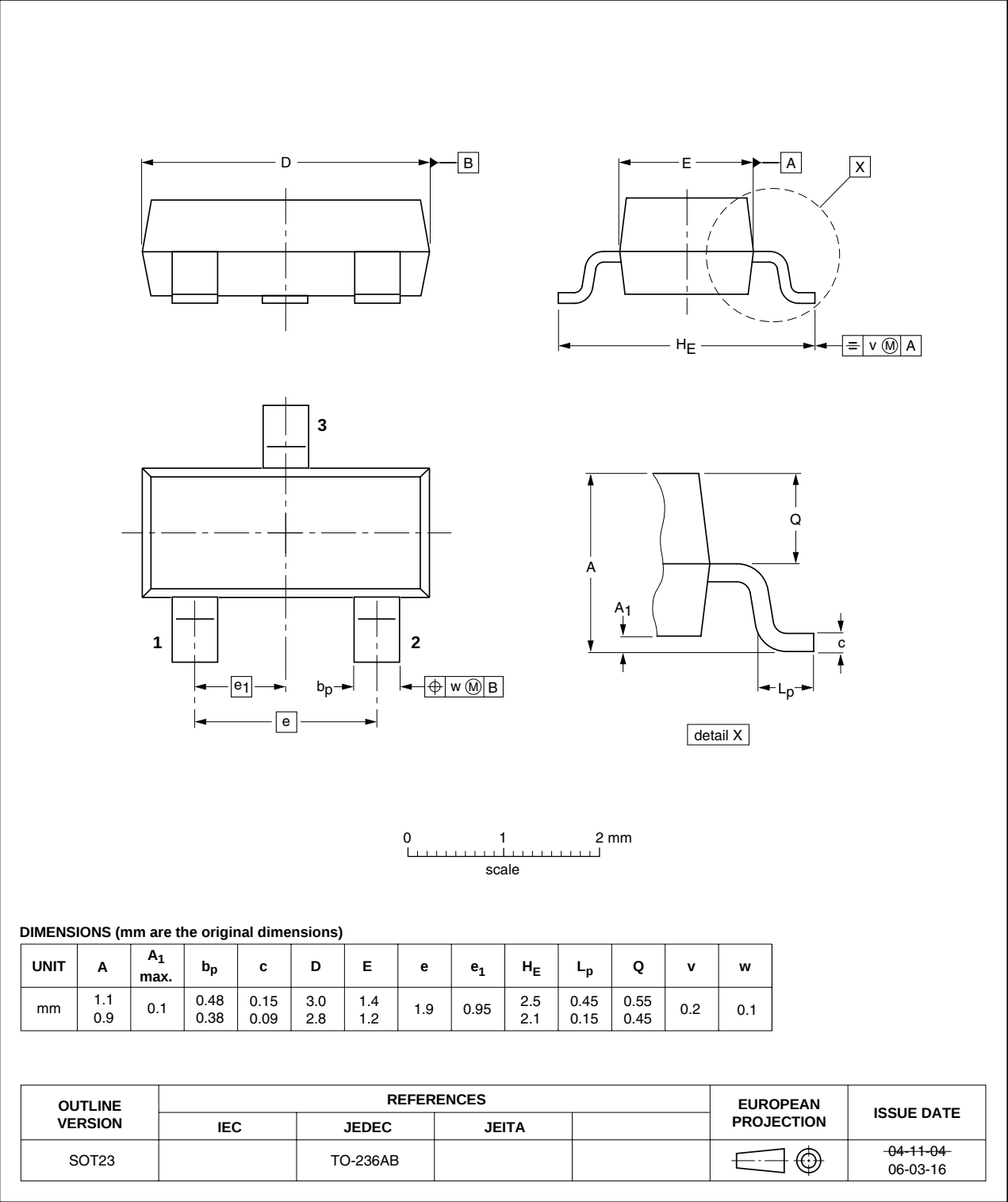


Fig 18. Package outline SOT23 (TO-236AB)

10. Soldering

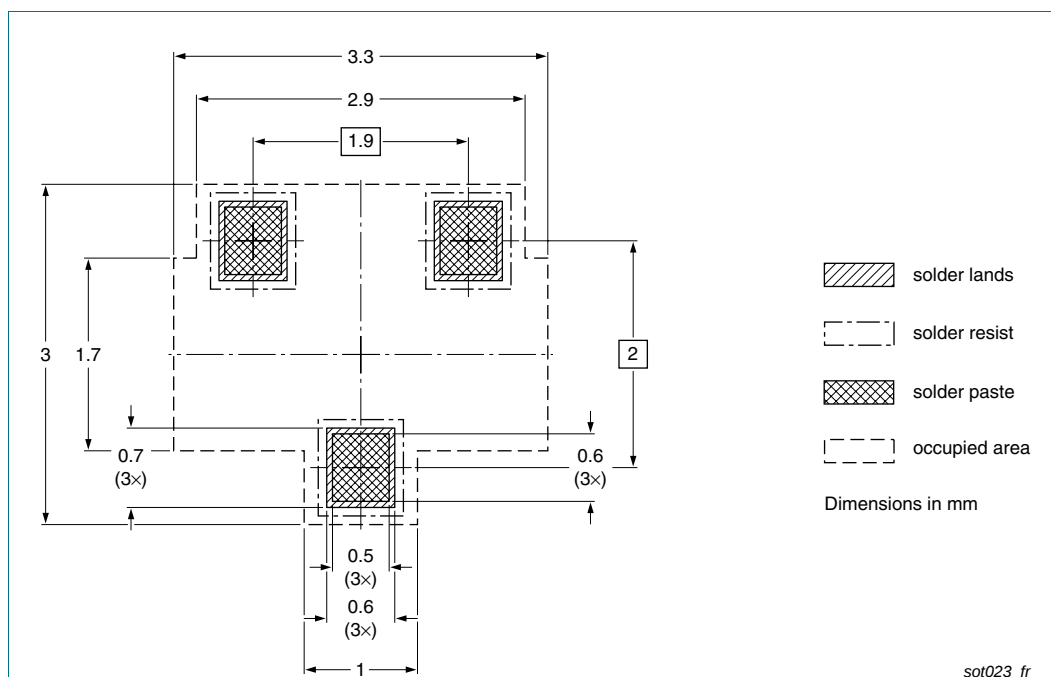


Fig 19. Reflow soldering footprint SOT23 (TO-236AB)

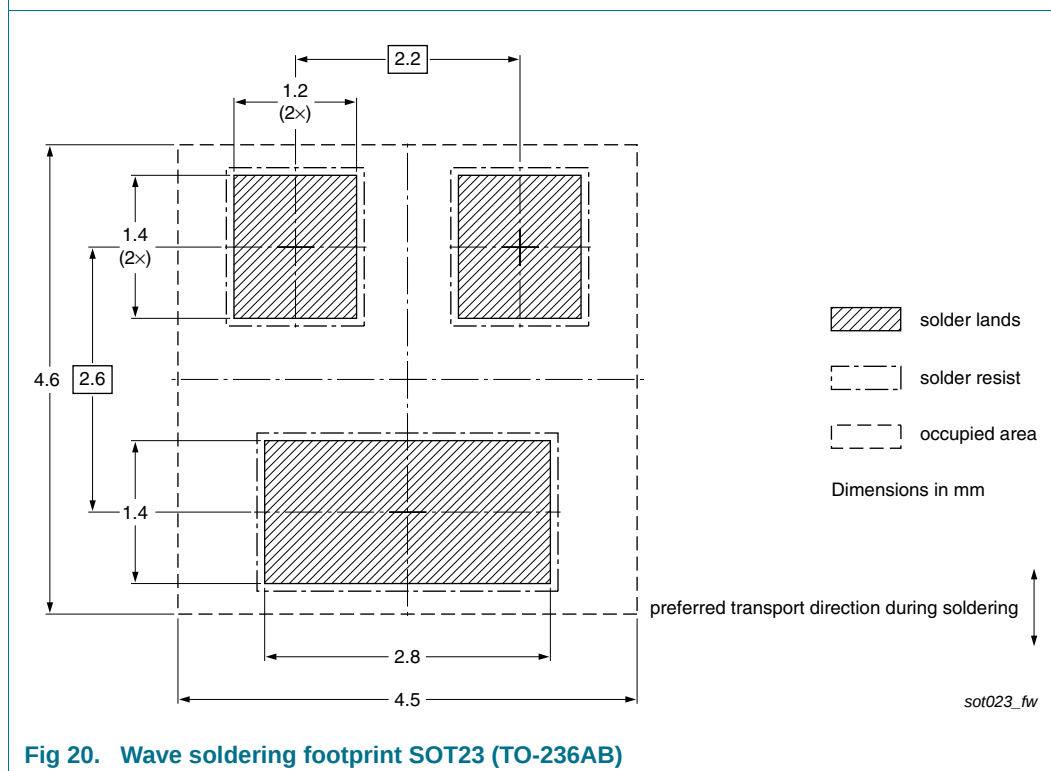


Fig 20. Wave soldering footprint SOT23 (TO-236AB)

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 ^{[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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13. Contact information

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