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

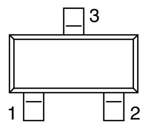
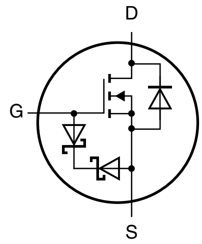
Table 1. Quick reference data

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

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

2. Pinning information

Table 2. Pinning

Pin	Symbol	Description	Simplified outline	Graphic symbol
1	G	gate		 017aaa000
2	S	source		
3	D	drain		

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 °C	-	60	V
V_{GS}	gate-source voltage	T_{amb} = 25 °C	-	±20	V
I_D	drain current	V_{GS} = 10 V [1]			
		T_{amb} = 25 °C	-	350	mA
		T_{amb} = 100 °C	-	245	mA
I_{DM}	peak drain current	T_{amb} = 25 °C; single pulse; $t_p \leq 10$ µs	-	1.2	A

Table 5. Limiting values *...continued*

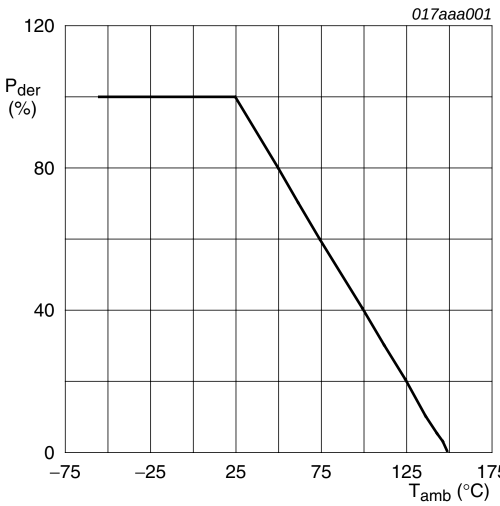
In accordance with the Absolute Maximum Rating System (IEC 60134).

Symbol	Parameter	Conditions		Min	Max	Unit
P_{tot}	total power dissipation	T_{amb} = 25 °C	[2]	-	370	mW
			[1]	-	440	mW
		T_{sp} = 25 °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 °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 cm^2.

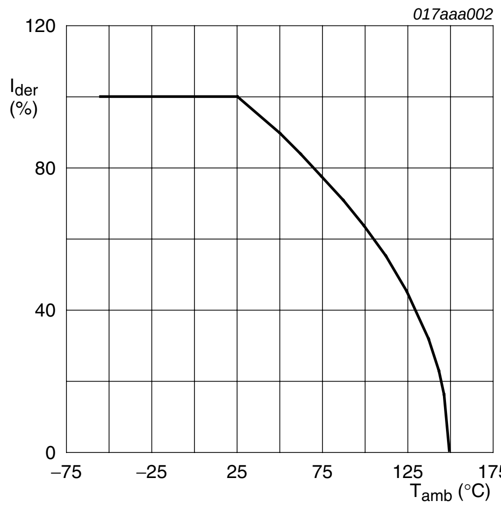
[2] Device mounted on an FR4 Printed-Circuit Board (PCB), single-sided copper, tin-plated and standard footprint.

[3] Measured between all pins.



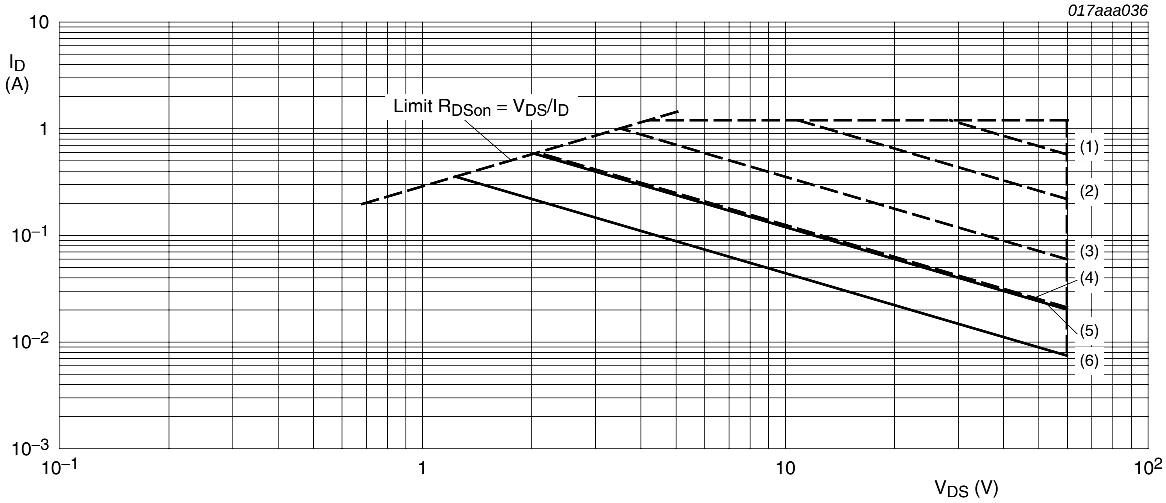
$$P_{der} = \frac{P_{tot}}{P_{tot(25°C)}} \times 100\ \%$$

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



I_{DM} = single pulse

(1) t_p = 100 µs

(2) t_p = 1 ms

(3) t_p = 10 ms

(4) t_p = 100 ms

(5) DC; T_{sp} = 25 °C

(6) DC; T_{amb} = 25 °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

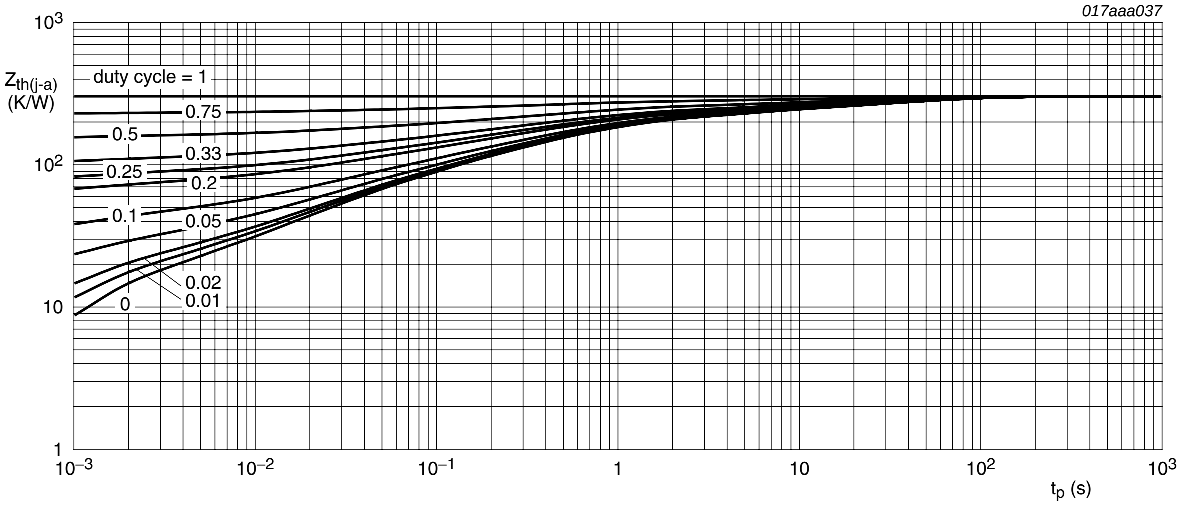
6. Thermal characteristics

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

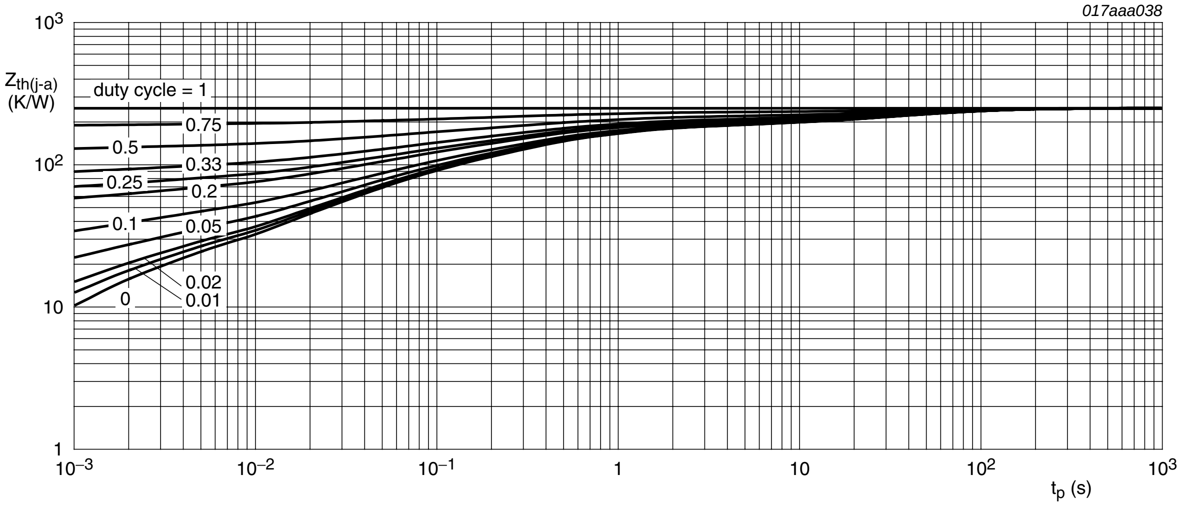
[1] Device mounted on an FR4 PCB, single-sided copper, tin-plated and standard footprint.

[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

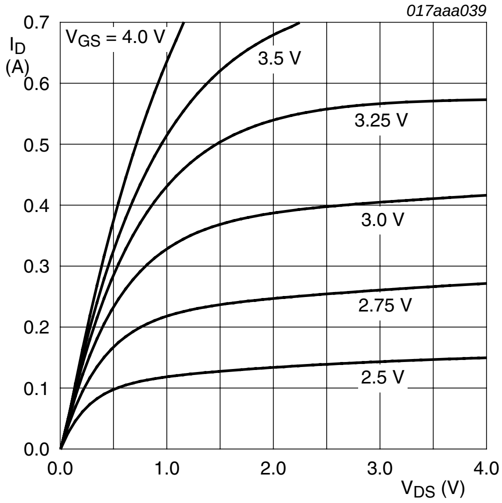
7. Characteristics

Table 7. Characteristics

T_j = 25 °C unless otherwise specified.

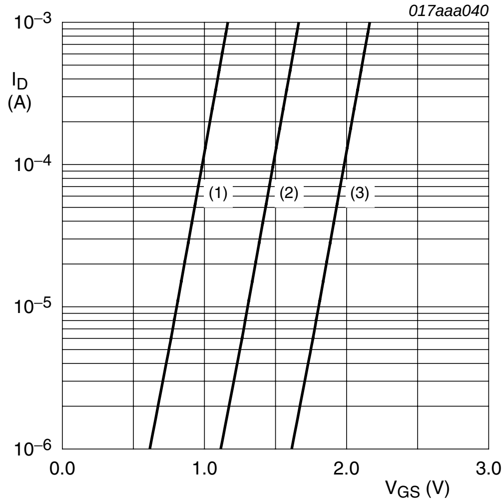
Symbol	Parameter	Conditions		Min	Typ	Max	Unit
Static characteristics							
$V_{(BR)DSS}$	drain-source breakdown voltage	I_D = 10 µA; V_{GS} = 0 V		60	-	-	V
$V_{GS(th)}$	gate-source threshold voltage	I_D = 250 µA; V_{DS} = V_{GS}		1.1	1.6	2.1	V
I_{DSS}	drain leakage current	V_{DS} = 60 V; V_{GS} = 0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

[1] Pulse test: $t_p \leq 300$ µs; $\delta \leq 0.01$.



T_{amb} = 25 °C

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



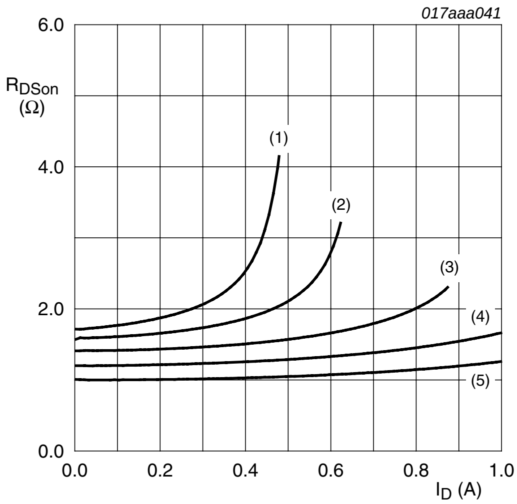
T_{amb} = 25 °C; V_{DS} = 5 V

(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 °C

(1) V_{GS} = 3.25 V

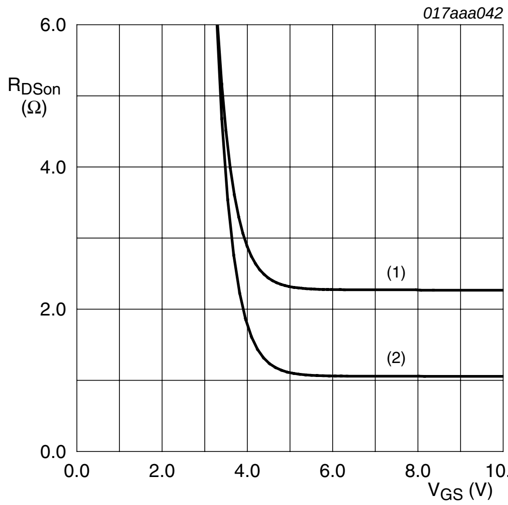
(2) V_{GS} = 3.5 V

(3) V_{GS} = 4 V

(4) V_{GS} = 5 V

(5) V_{GS} = 10 V

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

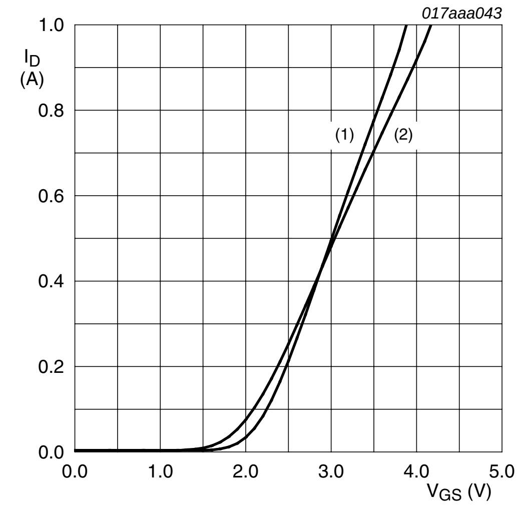


I_D = 500 mA

(1) T_{amb} = 150 °C

(2) T_{amb} = 25 °C

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

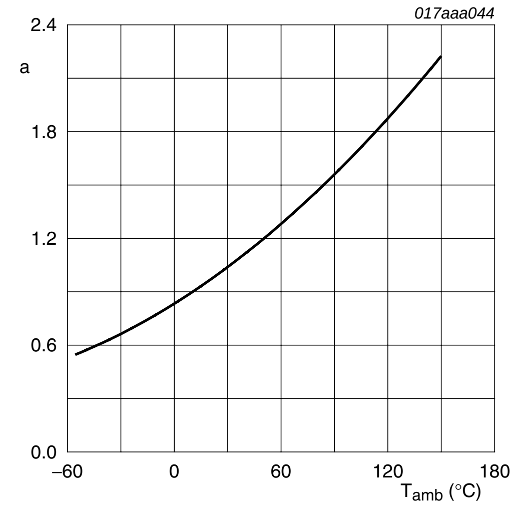


$V_{DS} > I_D \times R_{DSon}$

(1) T_{amb} = 25 °C

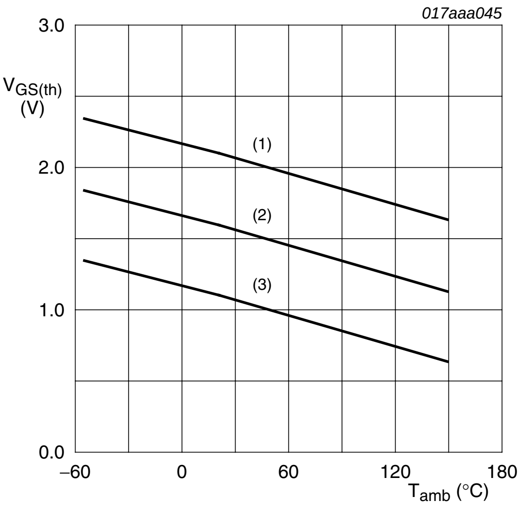
(2) T_{amb} = 150 °C

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



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

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



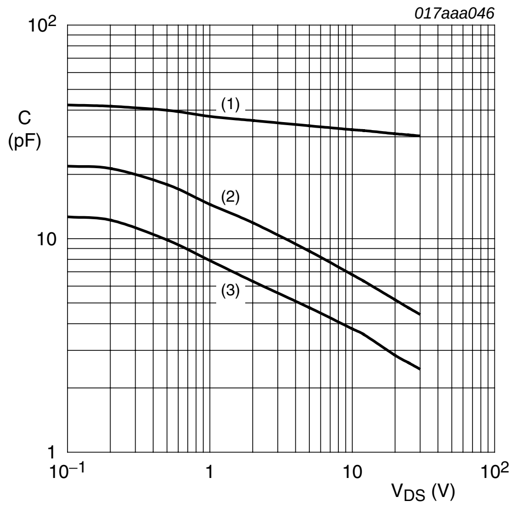
I_D = 0.25 mA; $V_{DS} = V_{GS}$

(1) maximum values

(2) typical values

(3) minimum values

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



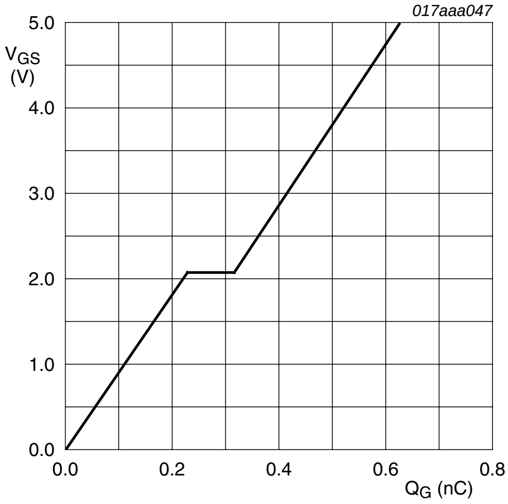
f = 1 MHz; V_{GS} = 0 V

(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 mA; V_{DD} = 6 V; T_{amb} = 25 °C

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

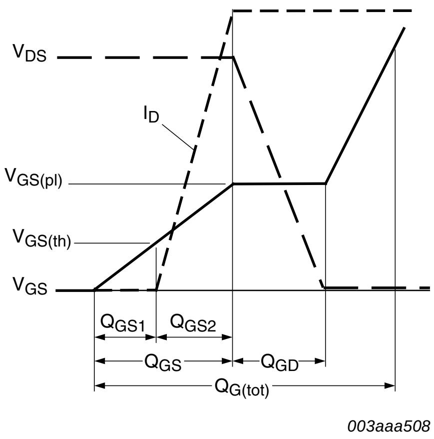
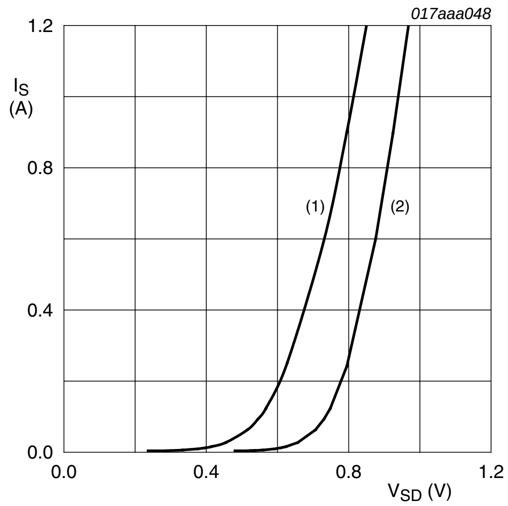


Fig 15. Gate charge waveform definitions



V_{GS} = 0 V

(1) T_{amb} = 150 °C

(2) T_{amb} = 25 °C

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

8. Test information

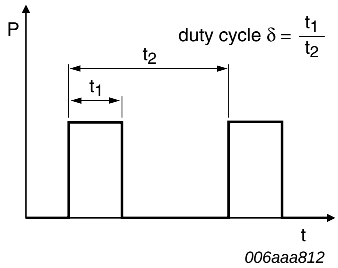
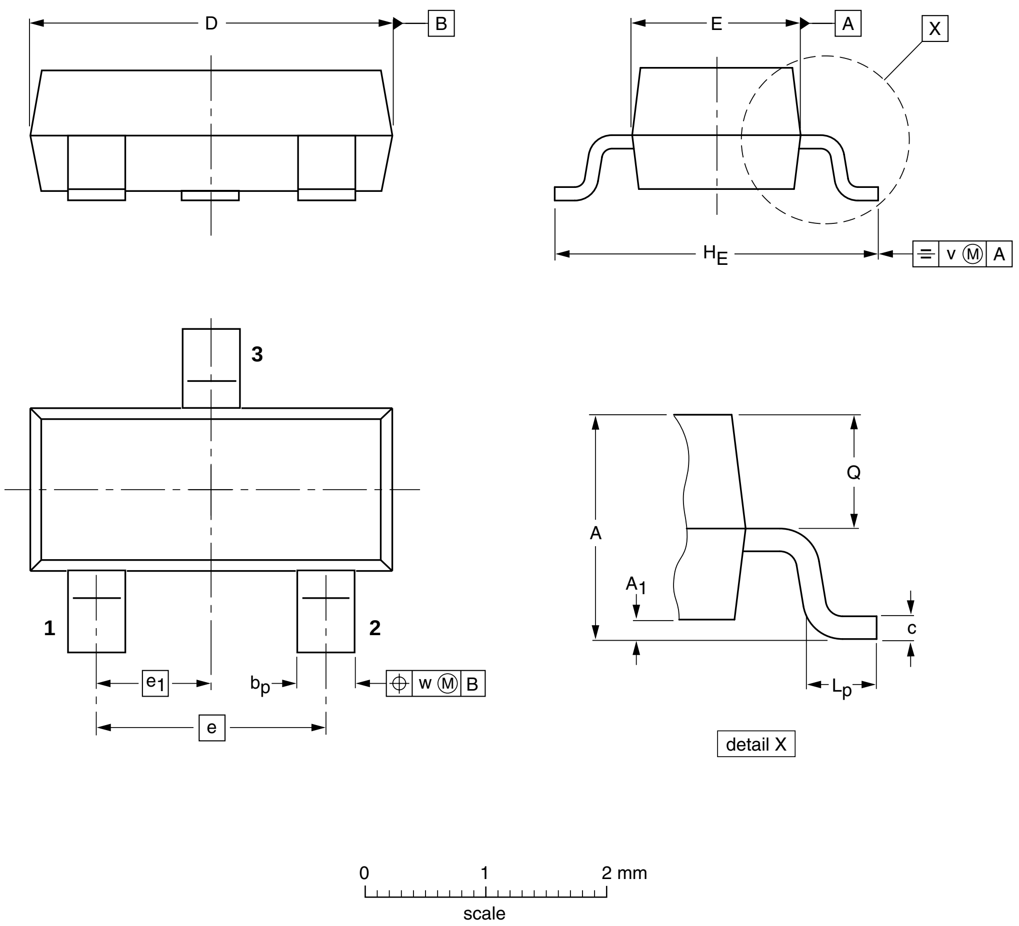


Fig 17. Duty cycle definition

9. Package outline

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



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 0.9	0.1	0.48 0.38	0.15 0.09	3.0 2.8	1.4 1.2	1.9	0.95	2.5 2.1	0.45 0.15	0.55 0.45	0.2	0.1

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

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

10. Soldering

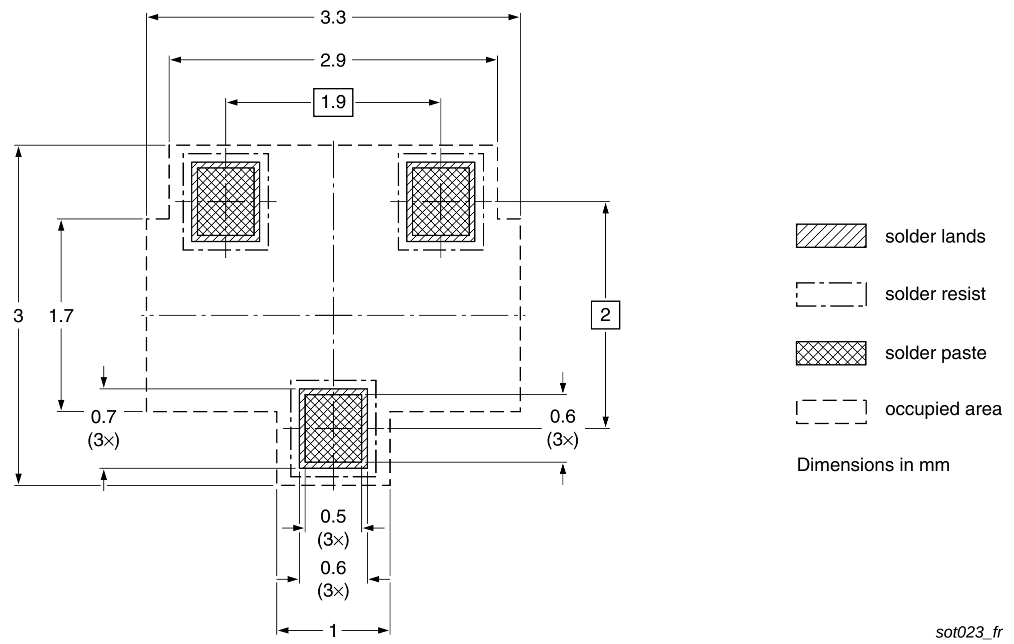


Fig 19. Reflow soldering footprint SOT23 (TO-236AB)

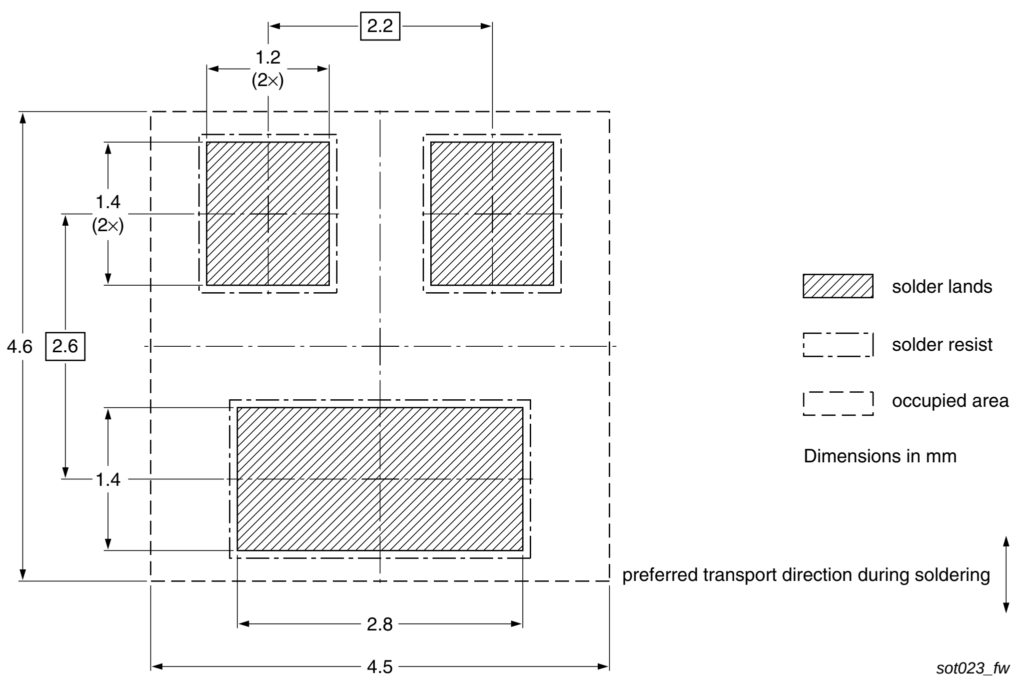


Fig 20. Wave soldering footprint SOT23 (TO-236AB)

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.nexperia.com.

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13. Contact information

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14. Contents

Date of release: 17 June 2010

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