
# NX138BK

## 60 V, single N-channel Trench MOSFET

29 January 2016 — Product data sheet

## 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.

## 2. Features and benefits

- Low threshold voltage
- Very fast switching
- Trench MOSFET technology
- ElectroStatic Discharge (ESD) protection > 2 kV HBM

## 3. Applications

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

## 4. Quick reference data

**Table 1. Quick reference data**

| Symbol | Parameter | Conditions | | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|---|
| $V_{DS}$ | drain-source voltage | $T_j$ = 25 °C | | - | - | 60 | V |
| $V_{GS}$ | gate-source voltage | | | -20 | - | 20 | V |
| $I_D$ | drain current | $V_{GS}$ = 10 V; $T_{amb}$ = 25 °C | [1] | - | - | 265 | mA |
| **Static characteristics** | | | | | | | |
| $R_{DSon}$ | drain-source on-state resistance | $V_{GS}$ = 10 V; $I_D$ = 200 mA; $T_j$ = 25 °C | | - | 2.1 | 3.5 | Ω |

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

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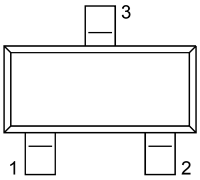
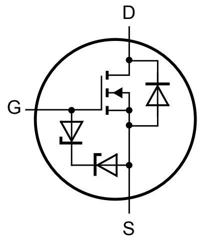
## 5. Pinning information

**Table 2. Pinning information**

| Pin | Symbol | Description | Simplified outline | Graphic symbol |
|---|---|---|---|---|
| 1 | G | gate |   TO-236AB (SOT23) |   017aaa255 |
| 2 | S | source | | |
| 3 | D | drain | | |

## 6. Ordering information

**Table 3. Ordering information**

| Type number | Package | | |
|---|---|---|---|
| | Name | Description | Version |
| NX138BK | TO-236AB | plastic surface-mounted package; 3 leads | SOT23 |

## 7. Marking

**Table 4. Marking codes**

| Type number | Marking code [1] |
|---|---|
| NX138BK | BX% |

[1] % = placeholder for manufacturing site code

# 8. 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 | $T_j$ = 25 °C | | - | 60 | V |
| $V_{GS}$ | gate-source voltage | | | -20 | 20 | V |
| $I_D$ | drain current | $V_{GS}$ = 10 V; $T_{amb}$ = 25 °C | [1] | - | 265 | mA |
| | | $V_{GS}$ = 10 V; $T_{amb}$ = 100 °C | [1] | - | 170 | mA |
| | | $V_{GS}$ = 10 V; $T_{sp}$ = 25 °C | | - | 330 | mA |
| $I_{DM}$ | peak drain current | $T_{amb}$ = 25 °C; single pulse; $t_p$ ≤ 10 µs | | - | 0.9 | A |
| $P_{tot}$ | total power dissipation | $T_{amb}$ = 25 °C | [2] | - | 310 | mW |
| | | | [1] | - | 400 | mW |
| | | $T_{sp}$ = 25 °C | | - | 1.67 | W |
| $T_j$ | junction temperature | | | -55 | 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] | - | 200 | mA |

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

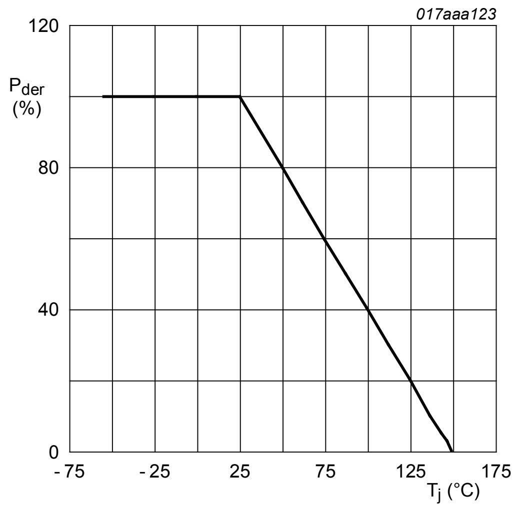



Fig. 1. Normalized total power dissipation as a function of junction temperature

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

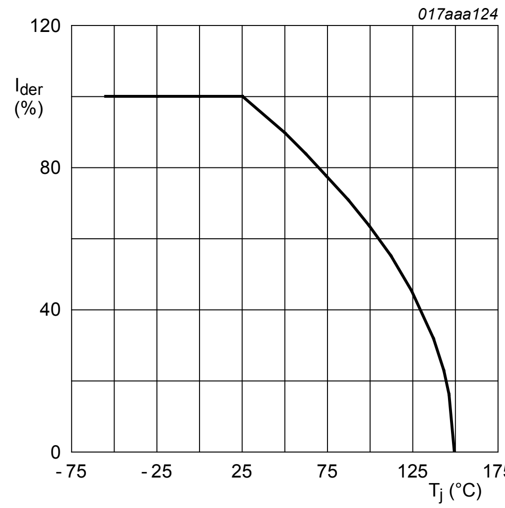
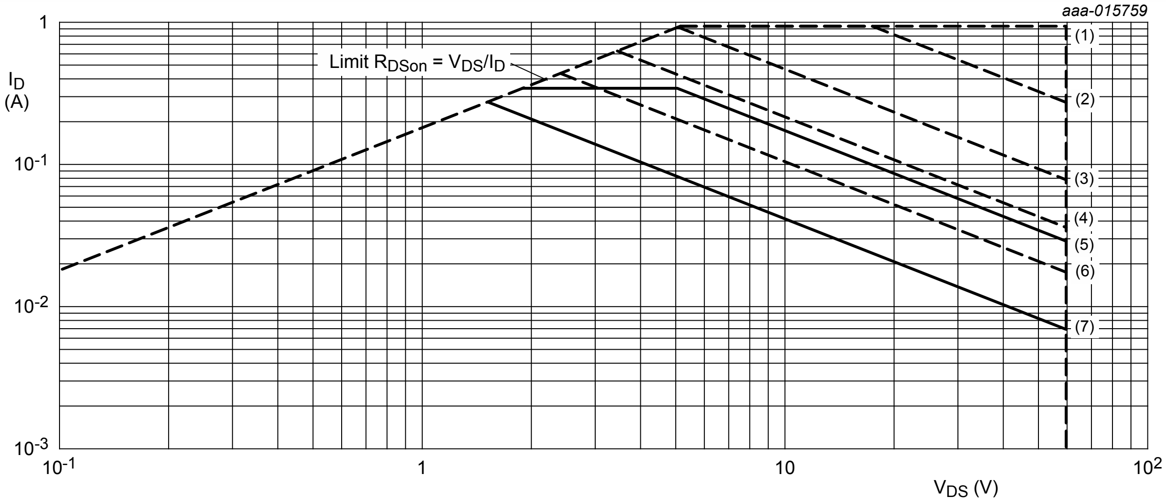



Fig. 2. Normalized continuous drain current as a function of junction temperature

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




$I_{DM}$ = single pulse

(1) $t_p$ = 10 µs

(2) $t_p$ = 100 µs

(3) $t_p$ = 1 ms

(4) $t_p$ = 10 ms

(5) DC; $T_{sp}$ = 25 °C

(6) $t_p$ = 100 ms

(7) DC; $T_{amb}$ = 25 °C; drain mounting pad 1 $cm^2$

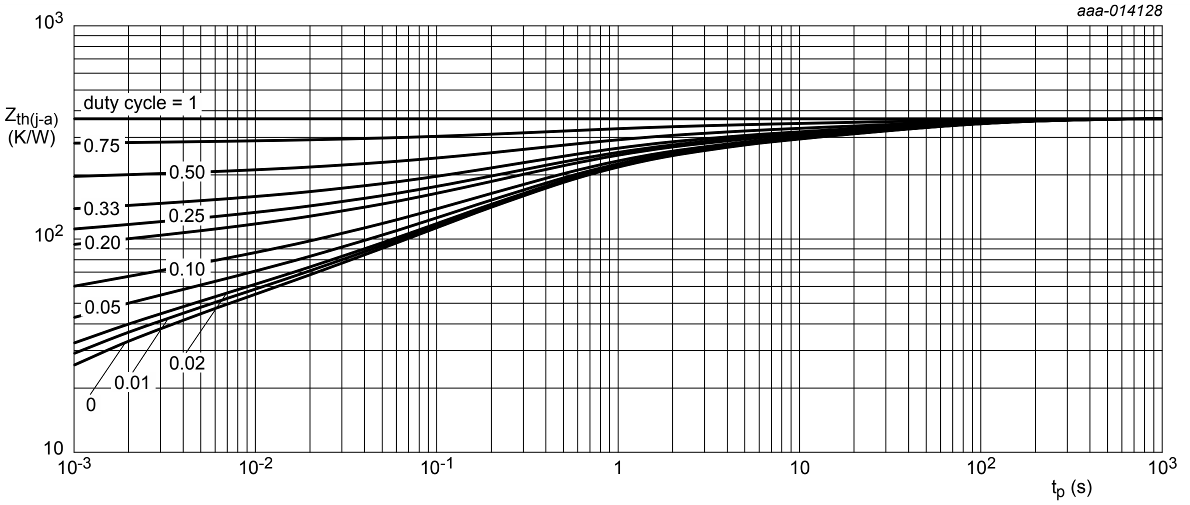
**Fig. 3. Safe operating area; junction to ambient; continuous and peak drain currents as a function of drain-source voltage**

# 9. Thermal characteristics

**Table 6. Thermal characteristics**

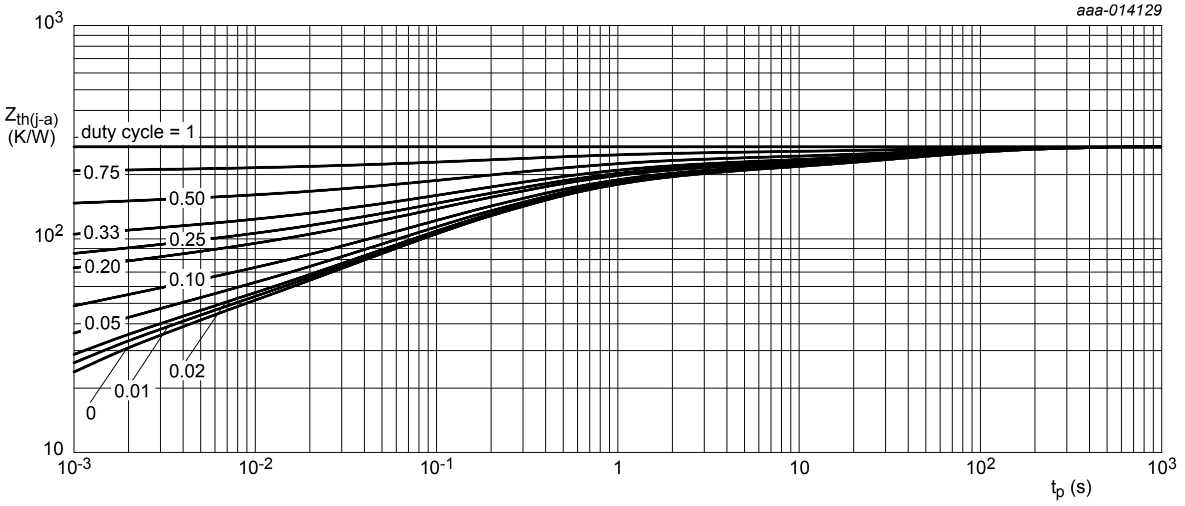
| Symbol | Parameter | Conditions | | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|---|
| $R_{th(j-a)}$ | thermal resistance from junction to ambient | in free air | [1] | - | 350 | 400 | K/W |
| | | | [2] | - | 270 | 310 | K/W |
| $R_{th(j-sp)}$ | thermal resistance from junction to solder point | | | - | 65 | 75 | 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 and 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**



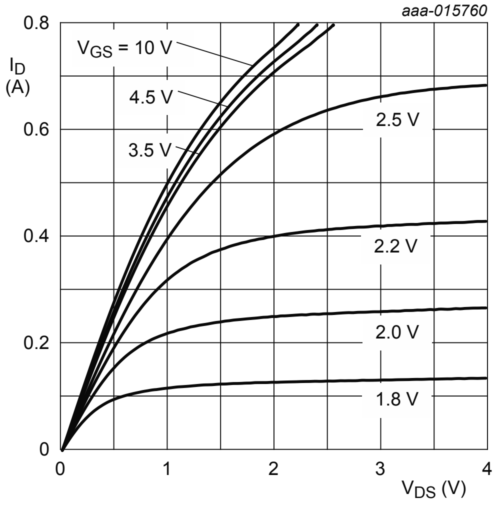

FR4 PCB, mounting pad for drain 1 $cm^2$

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

## 10. Characteristics

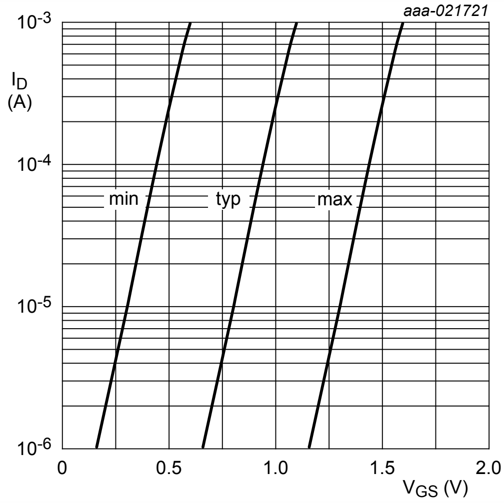
Table 7. Characteristics

| Symbol | Parameter | Conditions | | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|---|
| **Static characteristics** | | | | | | | |
| $V_{(BR)DSS}$ | drain-source breakdown voltage | $I_D$ = 250 µA; $V_{GS}$ = 0 V; $T_j$ = 25 °C | | 60 | - | - | V |
| $V_{GSth}$ | gate-source threshold voltage | $I_D$ = 250 µA; $V_{DS}$=$V_{GS}$; $T_j$ = 25 °C | | 0.5 | 1 | 1.5 | V |
| $I_{DSS}$ | drain leakage current | $V_{DS}$ = 60 V; $V_{GS}$ = 0 V; $T_j$ = 25 °C | | - | - | 1 | µA |
| $I_{GSS}$ | gate leakage current | $V_{GS}$ = 20 V; $V_{DS}$ = 0 V; $T_j$ = 25 °C | | - | - | 10 | µA |
| | | $V_{GS}$ = -20 V; $V_{DS}$ = 0 V; $T_j$ = 25 °C | | - | - | -10 | µA |
| | | $V_{GS}$ = 10 V; $V_{DS}$ = 0 V; $T_j$ = 25 °C | | - | - | 1 | µA |
| | | $V_{GS}$ = -10 V; $V_{DS}$ = 0 V; $T_j$ = 25 °C | | - | - | -1 | µA |
| | | $V_{GS}$ = 5 V; $V_{DS}$ = 0 V; $T_j$ = 25 °C | | - | - | 0.3 | µA |
| | | $V_{GS}$ = -5 V; $V_{DS}$ = 0 V; $T_j$ = 25 °C | | - | - | -0.3 | µA |
| $R_{DSon}$ | drain-source on-state resistance | $V_{GS}$ = 10 V; $I_D$ = 200 mA; $T_j$ = 25 °C | | - | 2.1 | 3.5 | Ω |
| | | $V_{GS}$ = 10 V; $I_D$ = 200 mA; $T_j$ = 150 °C | | - | 4.3 | 7.2 | Ω |
| | | $V_{GS}$ = 5 V; $I_D$ = 200 mA; $T_j$ = 25 °C | | - | 2.2 | 3.8 | Ω |
| | | $V_{GS}$ = 2.5 V; $I_D$ = 75 mA; $T_j$ = 25 °C | | - | 2.6 | 5 | Ω |
| $g_{fs}$ | forward transconductance | $V_{DS}$ = 10 V; $I_D$ = 200 mA; $T_j$ = 25 °C | | - | 0.71 | - | S |
| **Dynamic characteristics** | | | | | | | |
| $Q_{G(tot)}$ | total gate charge | $V_{DS}$ = 30 V; $I_D$ = 200 mA; $V_{GS}$ = 4.5 V; $T_j$ = 25 °C | | - | 0.49 | - | nC |
| $Q_{GS}$ | gate-source charge | | | - | 0.12 | - | nC |
| $Q_{GD}$ | gate-drain charge | | | - | 0.12 | - | nC |
| $C_{iss}$ | input capacitance | $V_{DS}$ = 30 V; f = 1 MHz; $V_{GS}$ = 0 V; $T_j$ = 25 °C | | - | 20.2 | - | pF |
| $C_{oss}$ | output capacitance | | | - | 3.1 | - | pF |
| $C_{rss}$ | reverse transfer capacitance | | | - | 2 | - | pF |
| $t_{d(on)}$ | turn-on delay time | $V_{DS}$ = 30 V; $I_D$ = 200 mA; $V_{GS}$ = 4.5 V; $R_{G(ext)}$ = 6 Ω; $T_j$ = 25 °C | | - | 7.9 | - | ns |
| $t_r$ | rise time | | | - | 8.4 | - | ns |
| $t_{d(off)}$ | turn-off delay time | | | - | 12.5 | - | ns |
| $t_f$ | fall time | | | - | 5.1 | - | ns |
| **Source-drain diode** | | | | | | | |
| $V_{SD}$ | source-drain voltage | $I_S$ = 200 mA; $V_{GS}$ = 0 V; $T_j$ = 25 °C | | - | 0.86 | 1.2 | V |



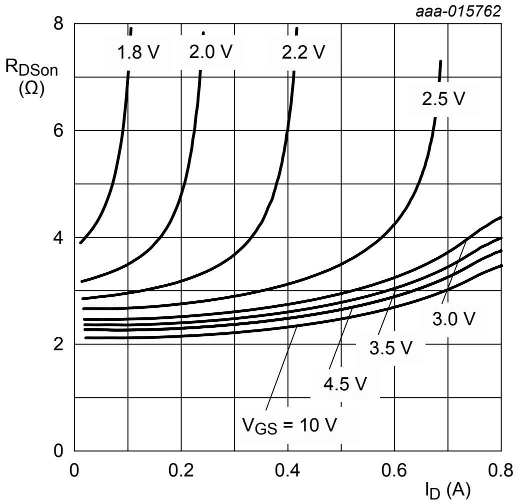

$T_j$ = 25 °C

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



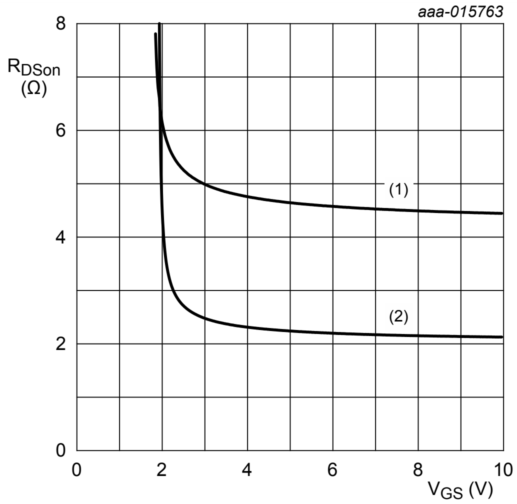

$T_j$ = 25 °C; $V_{DS}$ = 5 V

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




$T_j$ = 25 °C

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

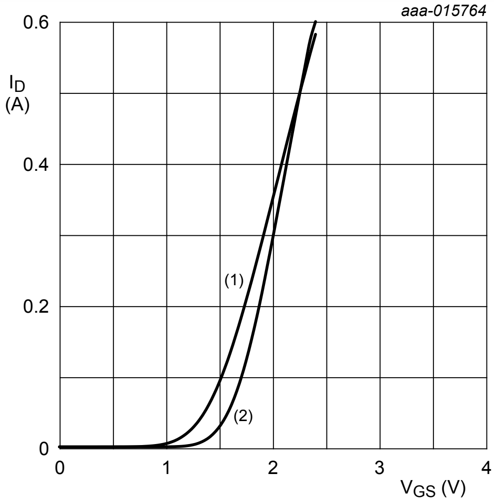



$I_D$ = 0.2 A

(1) $T_j$ = 150 °C

(2) $T_j$ = 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) $T_j$ = 150 °C

(2) $T_j$ = 25 °C

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

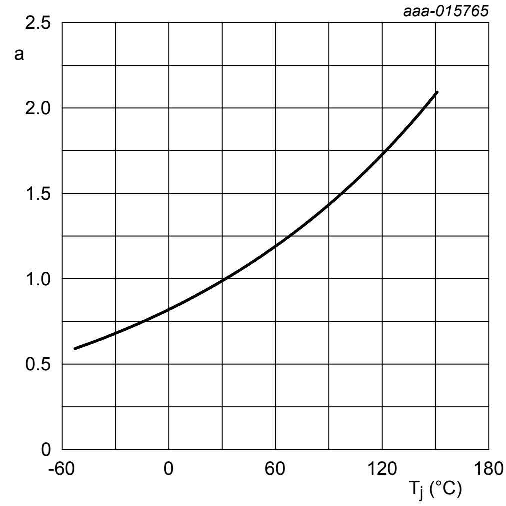
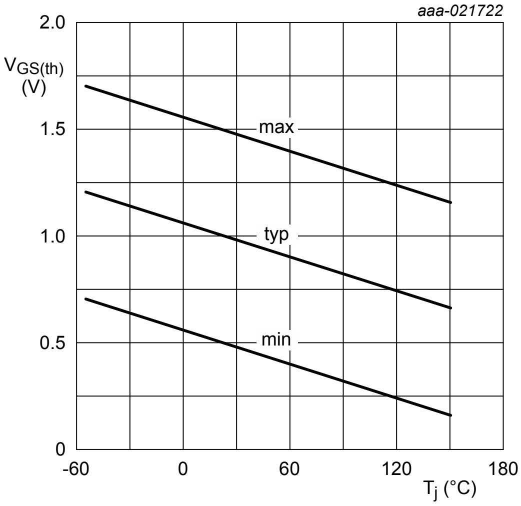


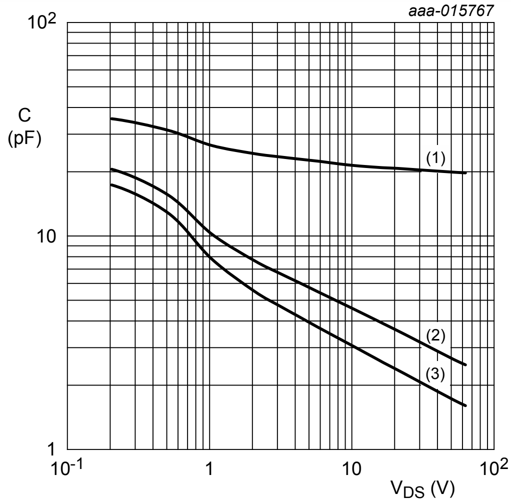

**Fig. 11. Normalized drain-source on-state resistance as a function of junction temperature; typical values**

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




$I_D$ = 250 μA; $V_{DS} = V_{GS}$

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



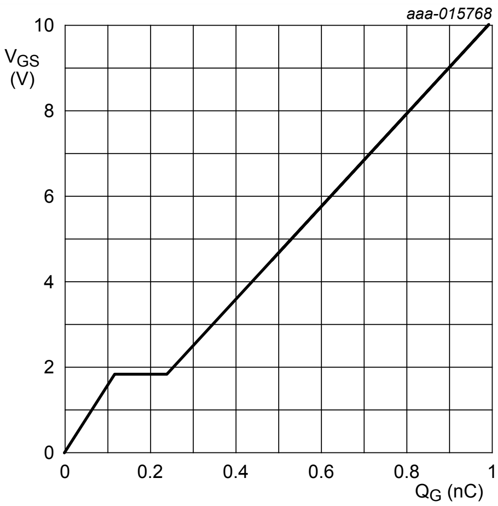

f = 1 MHz; $V_{GS}$ = 0 V

(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**




$I_D$ = 0.2 A; $V_{DS}$ = 30 V; $T_{amb}$ = 25 °C

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

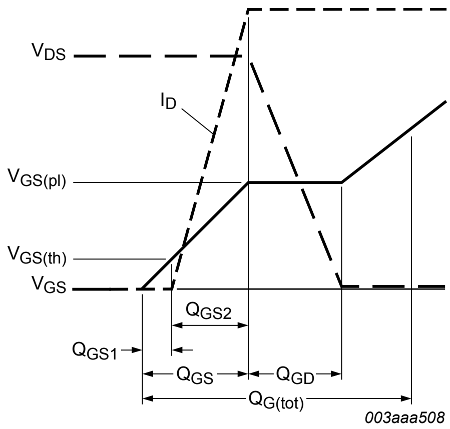
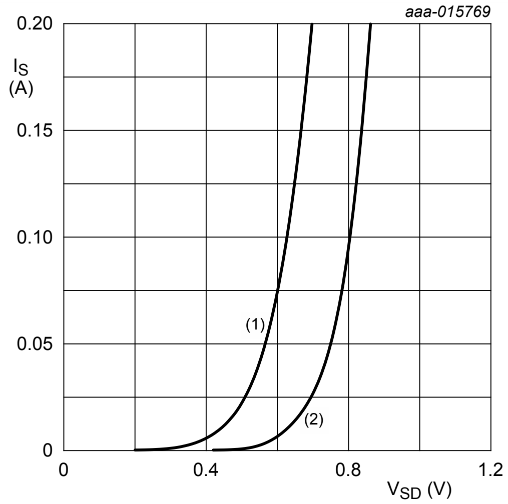



**Fig. 15. MOSFET transistor: Gate charge waveform definitions**




$V_{GS}$ = 0 V

(1) $T_j$ = 150 °C

(2) $T_j$ = 25 °C

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

# 11. Test information

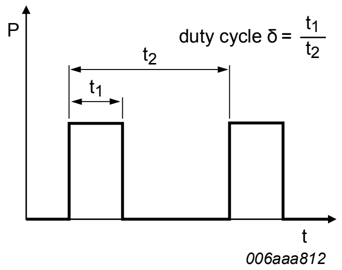



**Fig. 17. Duty cycle definition**

# 12. Package outline

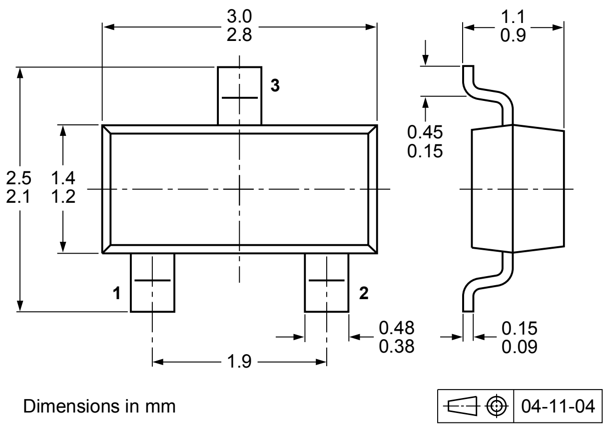



**Fig. 18. Package outline TO-236AB (SOT23)**

## 13. Soldering

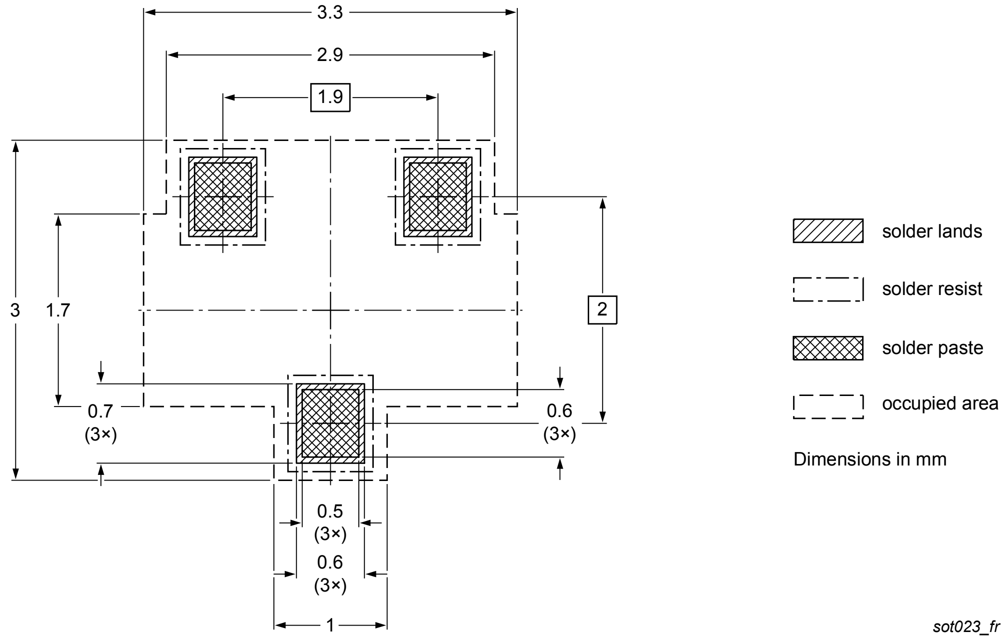



**Fig. 19. Reflow soldering footprint for TO-236AB (SOT23)**

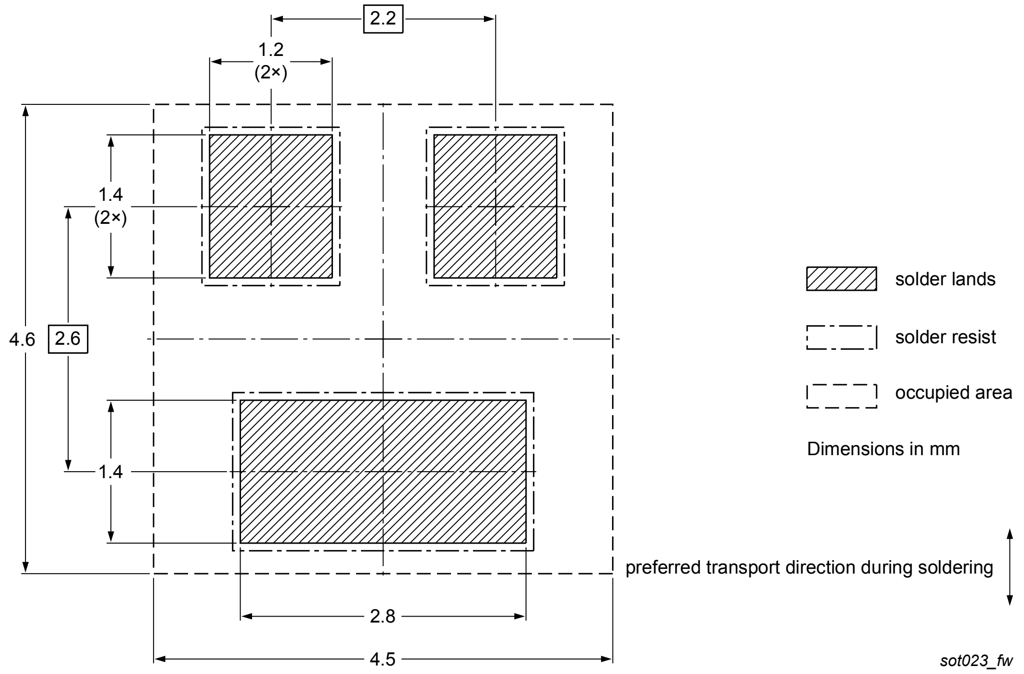



**Fig. 20. Wave soldering footprint for TO-236AB (SOT23)**

# 14. Revision history

**Table 8. Revision history**

| Data sheet ID | Release date | Data sheet status | Change notice | Supersedes |
|---|---|---|---|---|
| NX138BK v.1 | 20160129 | Product data sheet | - | - |

# 15. Legal information

## 15.1 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".
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# 16. Contents




**Date of release: 29 January 2016**