



# 2N7002HW

60 V, N-channel Trench MOSFET

1 December 2021

Product data sheet

## 1. General description

N-channel enhancement mode Field-Effect Transistor (FET) in a very small SOT323 (SC-70) Surface-Mounted Device (SMD) plastic package using Trench MOSFET technology.

## 2. Features and benefits

- Logic-level compatible
- Very fast switching
- Trench MOSFET technology
- AEC-Q101 qualified

## 3. Applications

- Relay driver
- High-speed line driver
- Low-side load switch
- Switching circuits

## 4. Quick reference data

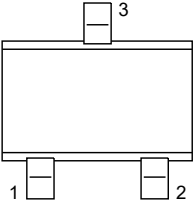
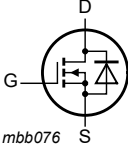
Table 1. Quick reference data

| Symbol                        | Parameter                        | Conditions                                                      |     | Min | Typ | Max | Unit     |
|-------------------------------|----------------------------------|-----------------------------------------------------------------|-----|-----|-----|-----|----------|
| $V_{DS}$                      | drain-source voltage             | $T_{amb} = 25\text{ °C}$                                        |     | -   | -   | 60  | V        |
| $V_{GS}$                      | gate-source voltage              |                                                                 |     | -20 | -   | 20  | V        |
| $I_D$                         | drain current                    | $V_{GS} = 10\text{ V}; T_{amb} = 25\text{ °C}$                  | [1] | -   | -   | 310 | mA       |
| <b>Static characteristics</b> |                                  |                                                                 |     |     |     |     |          |
| $R_{DS(on)}$                  | drain-source on-state resistance | $V_{GS} = 10\text{ V}; I_D = 500\text{ mA}; T_j = 25\text{ °C}$ |     | -   | 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>.

5. Pinning information

Table 2. Pinning information

| Pin | Symbol | Description | Simplified outline                                                                                  | Graphic symbol                                                                                |
|-----|--------|-------------|-----------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|
| 1   | G      | gate        | <br>SC-70 (SOT323) | <br>mbb076 |
| 2   | S      | source      |                                                                                                     |                                                                                               |
| 3   | D      | drain       |                                                                                                     |                                                                                               |

6. Ordering information

Table 3. Ordering information

| Type number | Package |                                                                                        |         |
|-------------|---------|----------------------------------------------------------------------------------------|---------|
|             | Name    | Description                                                                            | Version |
| 2N7002HW    | SC-70   | plastic, surface-mounted package; 3 leads; 1.3 mm pitch; 2 mm x 1.25 mm x 0.95 mm body | SOT323  |

7. Marking

Table 4. Marking codes

| Type number | Marking code[1] |
|-------------|-----------------|
| 2N7002HW    | 2N%             |

[1] % = placeholder for manufacturing site code

## 8. Limiting values

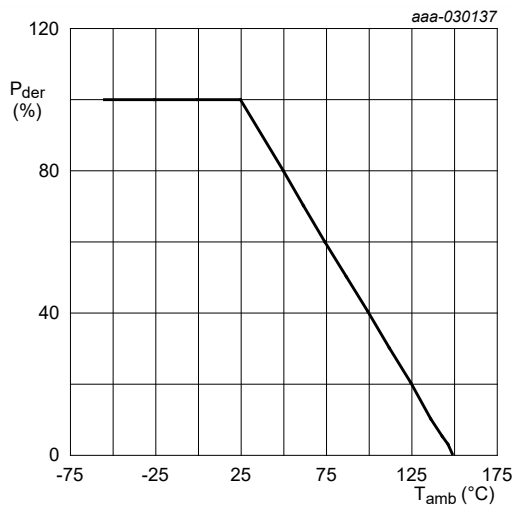
**Table 5. Limiting values**

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

| Symbol                    | Parameter               | Conditions                                                     |     | Min | Max | Unit |
|---------------------------|-------------------------|----------------------------------------------------------------|-----|-----|-----|------|
| V <sub>DS</sub>           | drain-source voltage    | T <sub>amb</sub> = 25 °C                                       |     | -   | 60  | V    |
| V <sub>GS</sub>           | gate-source voltage     |                                                                |     | -20 | 20  | V    |
| I <sub>D</sub>            | drain current           | V <sub>GS</sub> = 10 V; T <sub>amb</sub> = 25 °C               | [1] | -   | 310 | mA   |
|                           |                         | V <sub>GS</sub> = 10 V; T <sub>amb</sub> = 100 °C              | [1] | -   | 200 | mA   |
| I <sub>DM</sub>           | peak drain current      | T <sub>amb</sub> = 25 °C; single pulse; t <sub>p</sub> ≤ 10 μs |     | -   | 1.2 | A    |
| P <sub>tot</sub>          | total power dissipation | T <sub>amb</sub> = 25 °C                                       | [2] | -   | 260 | mW   |
|                           |                         |                                                                | [1] | -   | 310 | mW   |
|                           |                         | T <sub>sp</sub> = 25 °C                                        |     | -   | 830 | mW   |
| T <sub>j</sub>            | junction temperature    |                                                                |     | -55 | 150 | °C   |
| T <sub>amb</sub>          | ambient temperature     |                                                                |     | -55 | 150 | °C   |
| T <sub>stg</sub>          | storage temperature     |                                                                |     | -65 | 150 | °C   |
| <b>Source-drain diode</b> |                         |                                                                |     |     |     |      |
| I <sub>S</sub>            | source current          | T <sub>amb</sub> = 25 °C                                       | [1] | -   | 310 | mA   |

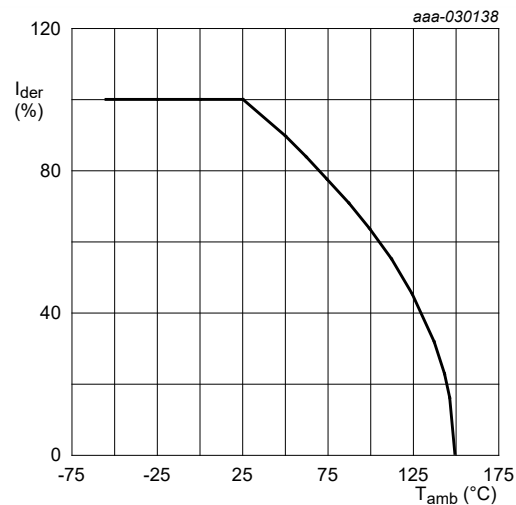
[1] Device mounted on an FR4 PCB, single-sided copper, tin-plated, mounting pad for drain 1 cm<sup>2</sup>.

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



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

**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**

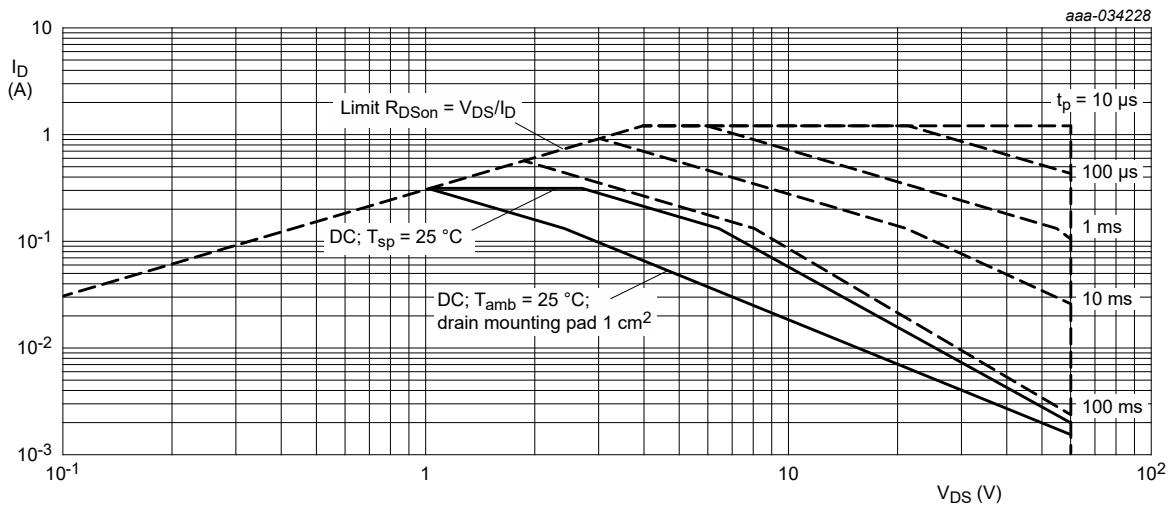


Fig. 3. Safe operating area; junction to ambient; continuous and peak drain currents as a function of drain-source voltage

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] | -   | 415 | 480 | K/W  |
|                |                                                  |             | [2] | -   | 350 | 400 | K/W  |
| $R_{th(j-sp)}$ | 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.
- [2] Device mounted on an FR4 PCB, single-sided copper, tin-plated, mounting pad for drain 1 cm<sup>2</sup>.

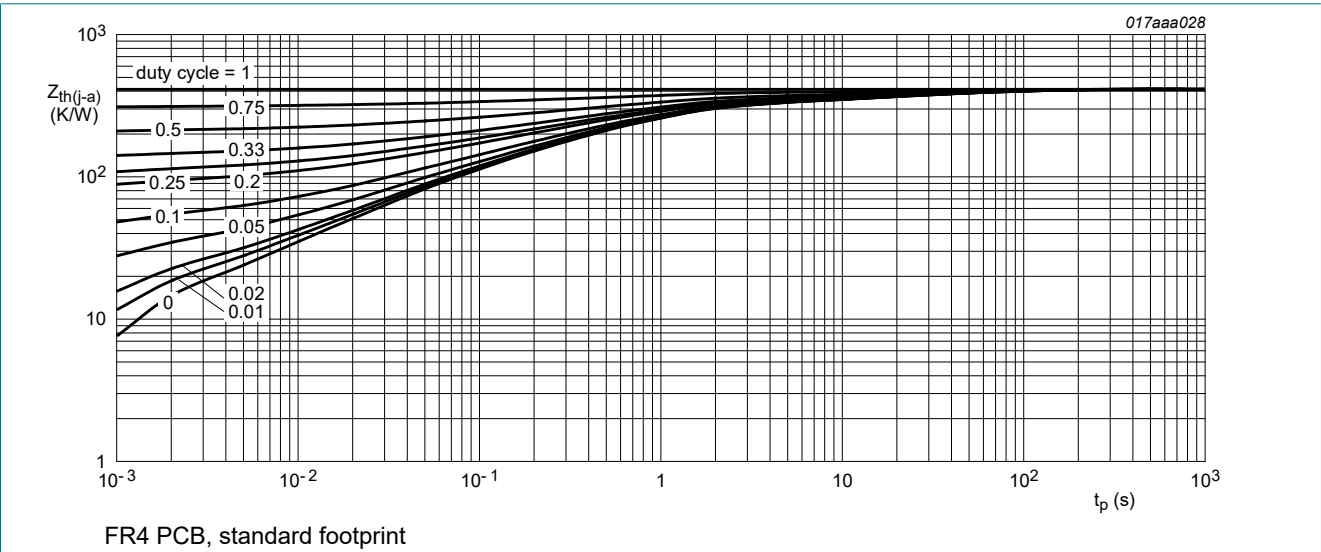


Fig. 4. Transient thermal impedance from junction to ambient as a function of pulse duration; typical values

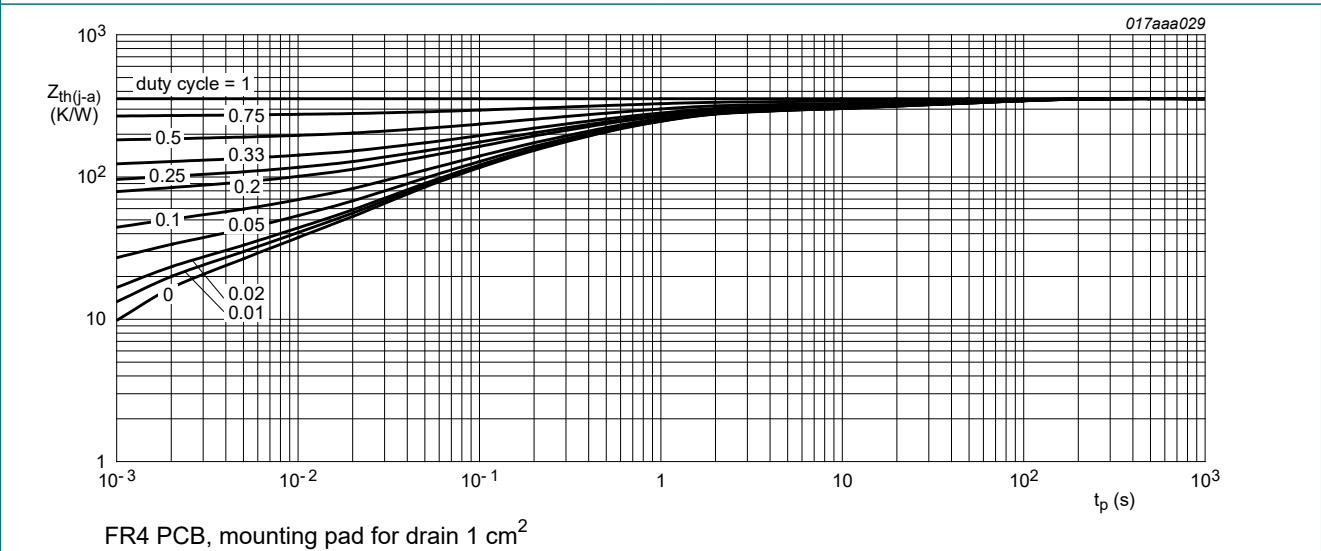


Fig. 5. Transient thermal impedance from junction to ambient as a function of pulse duration; typical values

## 10. Characteristics

Table 7. Characteristics

| Symbol                  | Parameter                        | Conditions                                                                                                                |  | Min  | Typ  | Max  | Unit |
|-------------------------|----------------------------------|---------------------------------------------------------------------------------------------------------------------------|--|------|------|------|------|
| Static characteristics  |                                  |                                                                                                                           |  |      |      |      |      |
| V <sub>(BR)DSS</sub>    | drain-source breakdown voltage   | I <sub>D</sub> = 10 μA; V <sub>GS</sub> = 0 V; T <sub>j</sub> = 25 °C                                                     |  | 60   | -    | -    | V    |
| V <sub>GSth</sub>       | gate-source threshold voltage    | I <sub>D</sub> = 250 μA; V <sub>DS</sub> =V <sub>GS</sub> ; T <sub>j</sub> = 25 °C                                        |  | 1.1  | 1.75 | 2.4  | V    |
| I <sub>DSS</sub>        | drain leakage current            | V <sub>DS</sub> = 60 V; V <sub>GS</sub> = 0 V; T <sub>j</sub> = 25 °C                                                     |  | -    | -    | 1    | μA   |
|                         |                                  | V <sub>DS</sub> = 60 V; V <sub>GS</sub> = 0 V; T <sub>j</sub> = 150 °C                                                    |  | -    | -    | 10   | μA   |
| I <sub>GSS</sub>        | gate leakage current             | V <sub>GS</sub> = 20 V; V <sub>DS</sub> = 0 V; T <sub>j</sub> = 25 °C                                                     |  | -    | -    | 100  | nA   |
|                         |                                  | V <sub>GS</sub> = -20 V; V <sub>DS</sub> = 0 V; T <sub>j</sub> = 25 °C                                                    |  | -    | -    | -100 | nA   |
| R <sub>DSon</sub>       | drain-source on-state resistance | V <sub>GS</sub> = 10 V; I <sub>D</sub> = 500 mA; T <sub>j</sub> = 25 °C                                                   |  | -    | 1    | 1.6  | Ω    |
|                         |                                  | V <sub>GS</sub> = 10 V; I <sub>D</sub> = 500 mA; T <sub>j</sub> = 150 °C                                                  |  | -    | 2.1  | 3.3  | Ω    |
|                         |                                  | V <sub>GS</sub> = 5 V; I <sub>D</sub> = 50 mA; T <sub>j</sub> = 25 °C                                                     |  | -    | 1.3  | 2    | Ω    |
| g <sub>fs</sub>         | forward transconductance         | V <sub>DS</sub> = 10 V; I <sub>D</sub> = 200 mA; T <sub>j</sub> = 25 °C                                                   |  | -    | 400  | -    | mS   |
| Dynamic characteristics |                                  |                                                                                                                           |  |      |      |      |      |
| Q <sub>G(tot)</sub>     | total gate charge                | V <sub>DS</sub> = 30 V; I <sub>D</sub> = 300 mA; V <sub>GS</sub> = 4.5 V; T <sub>j</sub> = 25 °C                          |  | -    | 0.3  | 0.5  | nC   |
| Q <sub>GS</sub>         | gate-source charge               |                                                                                                                           |  | -    | 0.1  | -    | nC   |
| Q <sub>GD</sub>         | gate-drain charge                |                                                                                                                           |  | -    | 0.1  | -    | nC   |
| C <sub>iss</sub>        | input capacitance                | V <sub>DS</sub> = 10 V; f = 1 MHz; V <sub>GS</sub> = 0 V; T <sub>j</sub> = 25 °C                                          |  | -    | 34   | -    | pF   |
| C <sub>oss</sub>        | output capacitance               |                                                                                                                           |  | -    | 7    | -    | pF   |
| C <sub>rss</sub>        | reverse transfer capacitance     |                                                                                                                           |  | -    | 4    | -    | pF   |
| t <sub>d(on)</sub>      | turn-on delay time               | V <sub>DS</sub> = 50 V; R <sub>L</sub> = 250 Ω; V <sub>GS</sub> = 10 V; R <sub>G(ext)</sub> = 6 Ω; T <sub>j</sub> = 25 °C |  | -    | 2    | -    | ns   |
| t <sub>r</sub>          | rise time                        |                                                                                                                           |  | -    | 3    | -    | ns   |
| t <sub>d(off)</sub>     | turn-off delay time              |                                                                                                                           |  | -    | 6    | -    | ns   |
| t <sub>f</sub>          | fall time                        |                                                                                                                           |  | -    | 4    | -    | ns   |
| Source-drain diode      |                                  |                                                                                                                           |  |      |      |      |      |
| V <sub>SD</sub>         | source-drain voltage             | I <sub>S</sub> = 115 mA; V <sub>GS</sub> = 0 V; T <sub>j</sub> = 25 °C                                                    |  | 0.47 | 0.75 | 1.1  | V    |

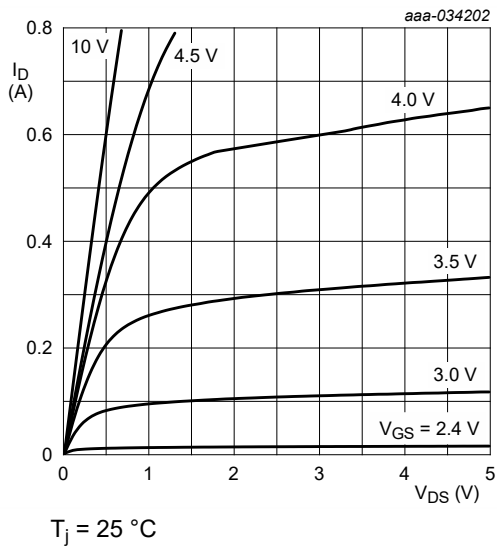


Fig. 6. Output characteristics: drain current as a function of drain-source voltage; typical values

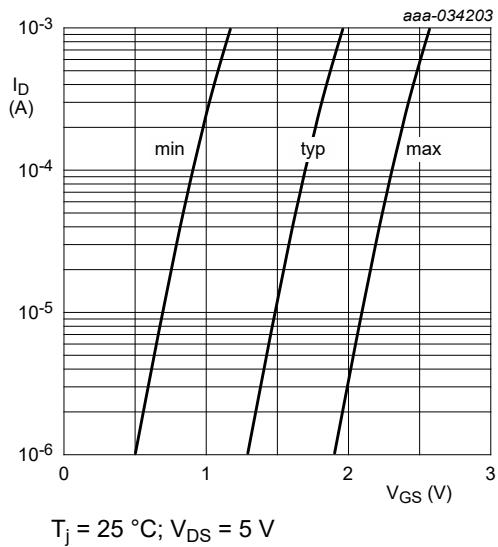


Fig. 7. Sub-threshold drain current as a function of gate-source voltage

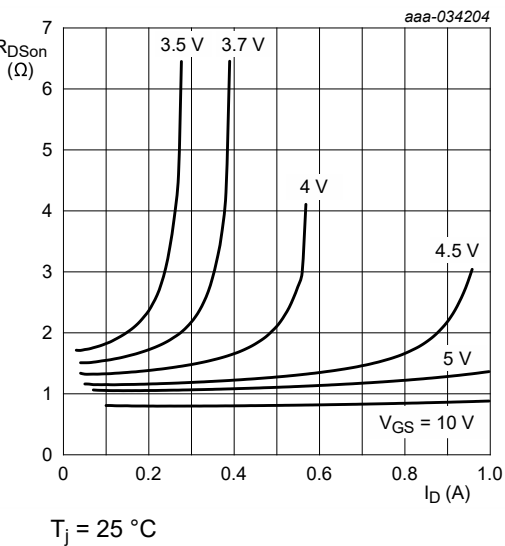


Fig. 8. Drain-source on-state resistance as a function of drain current; typical values

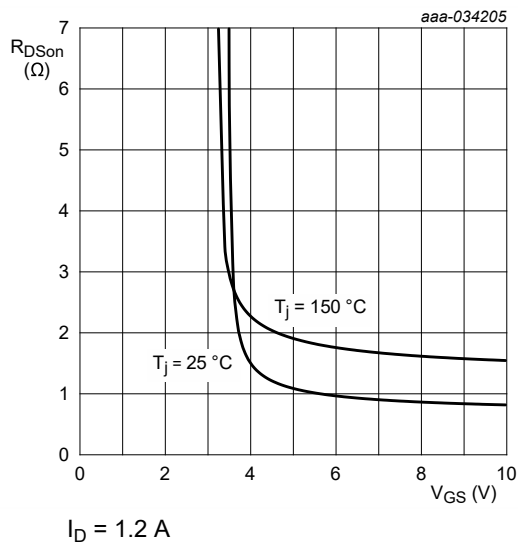


Fig. 9. Drain-source on-state resistance as a function of gate-source voltage; typical values

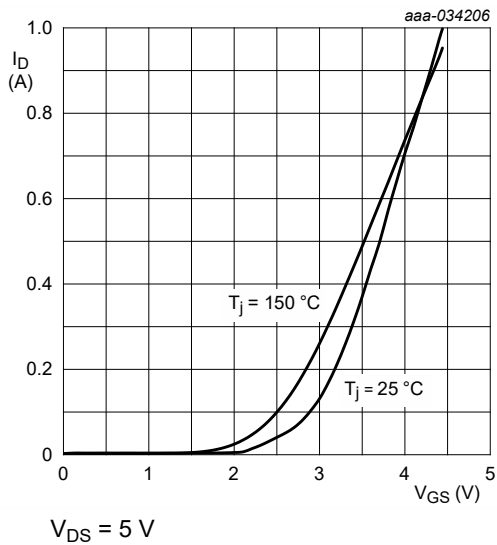


Fig. 10. Transfer characteristics: drain current as a function of gate-source voltage; typical values

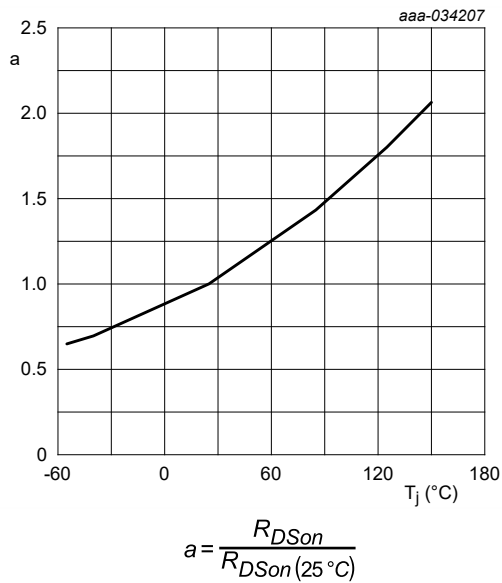


Fig. 11. Normalized drain-source on-state resistance as a function of junction temperature; typical values

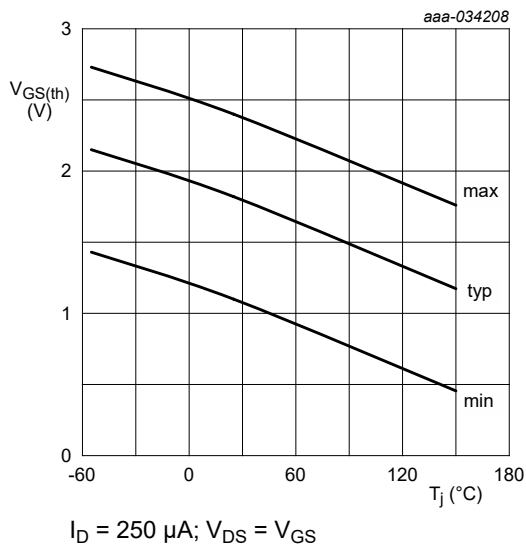


Fig. 12. Gate-source threshold voltage as a function of junction temperature

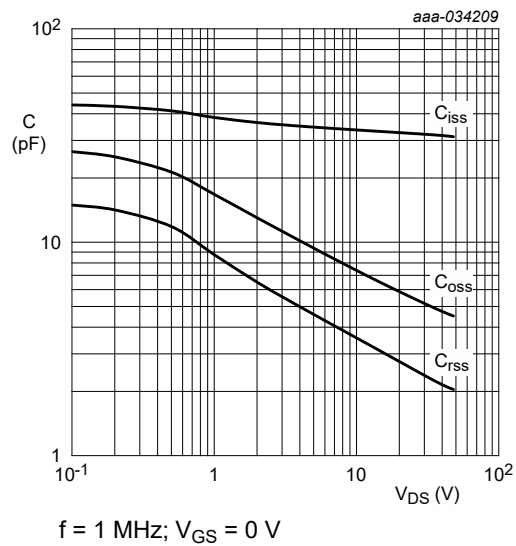


Fig. 13. Input, output and reverse transfer capacitances as a function of drain-source voltage; typical values

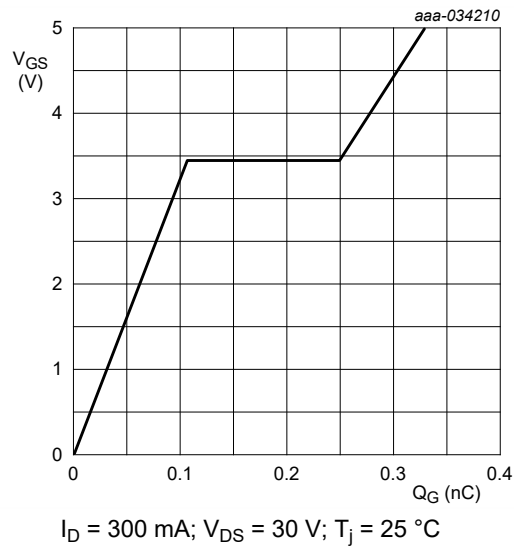


Fig. 14. Gate-source voltage as a function of gate charge; typical values

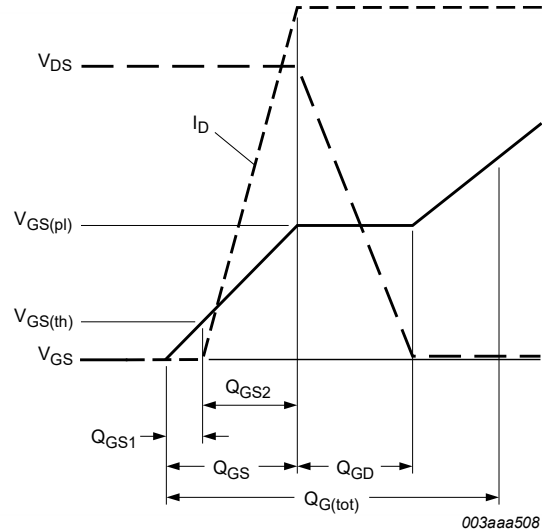


Fig. 15. Gate charge waveform definitions

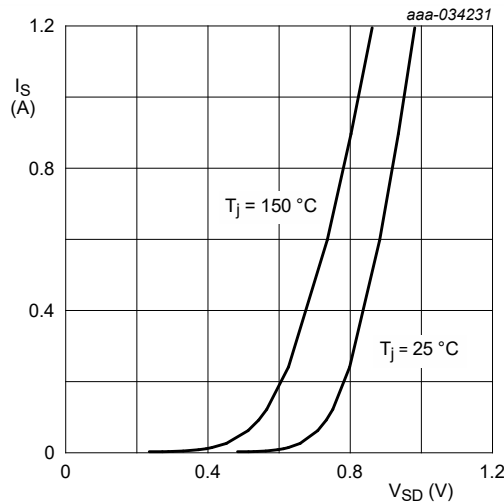


Fig. 16. Source current as a function of source-drain voltage; typical values

## 11. Test information

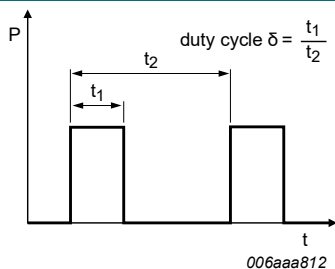


Fig. 17. Duty cycle definition

### Quality information

This product has been qualified in accordance with the Automotive Electronics Council (AEC) standard *Q101 - Stress test qualification for discrete semiconductors*, and is suitable for use in automotive applications.

12. Package outline

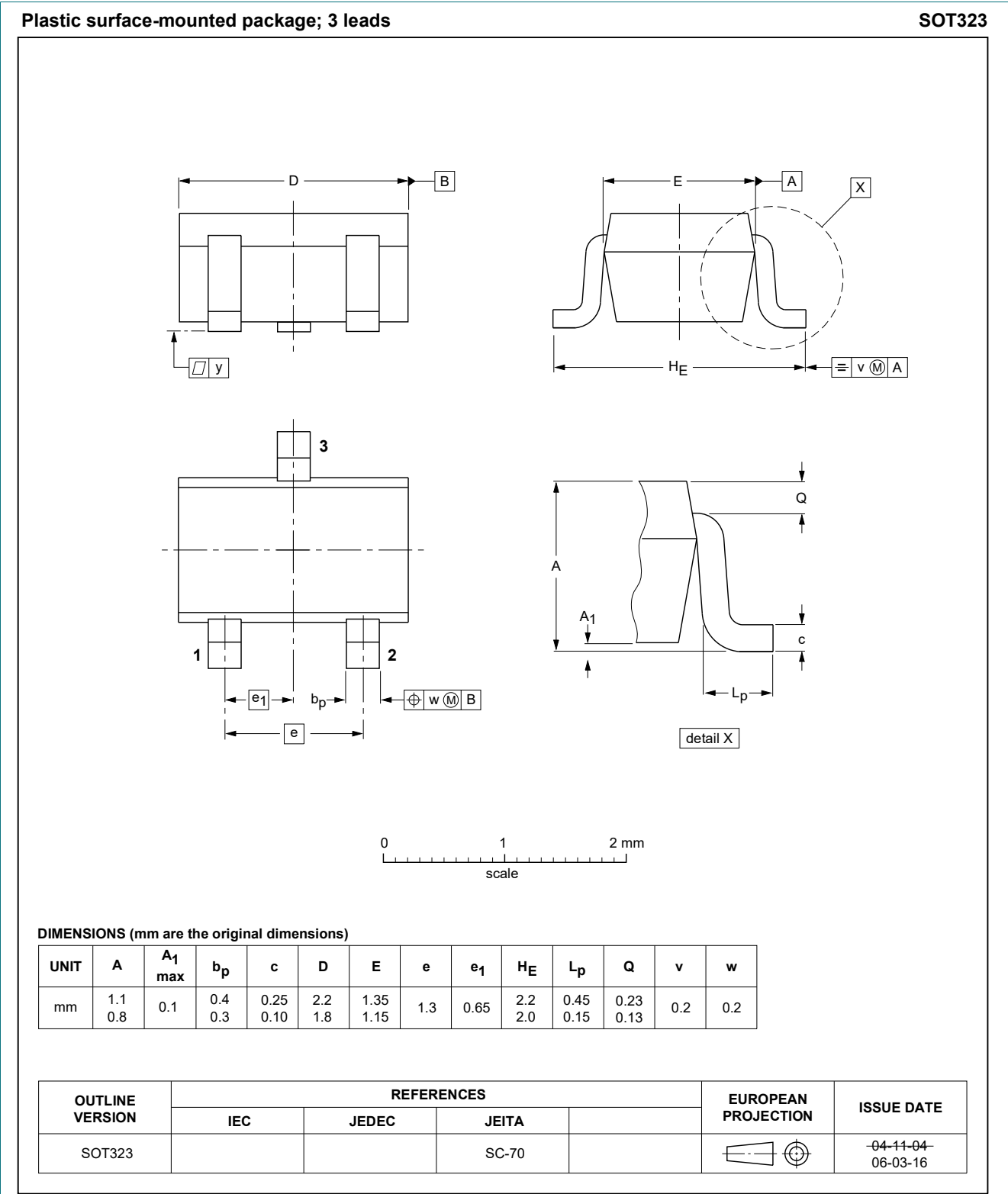


Fig. 18. Package outline SC-70 (SOT323)

13. Soldering

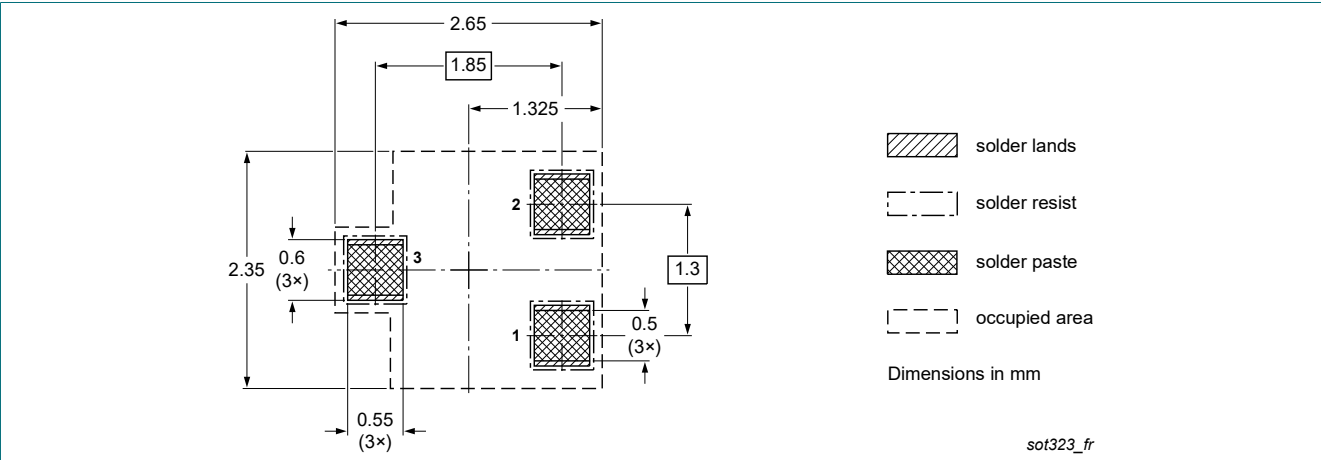


Fig. 19. Reflow soldering footprint for SC-70 (SOT323)

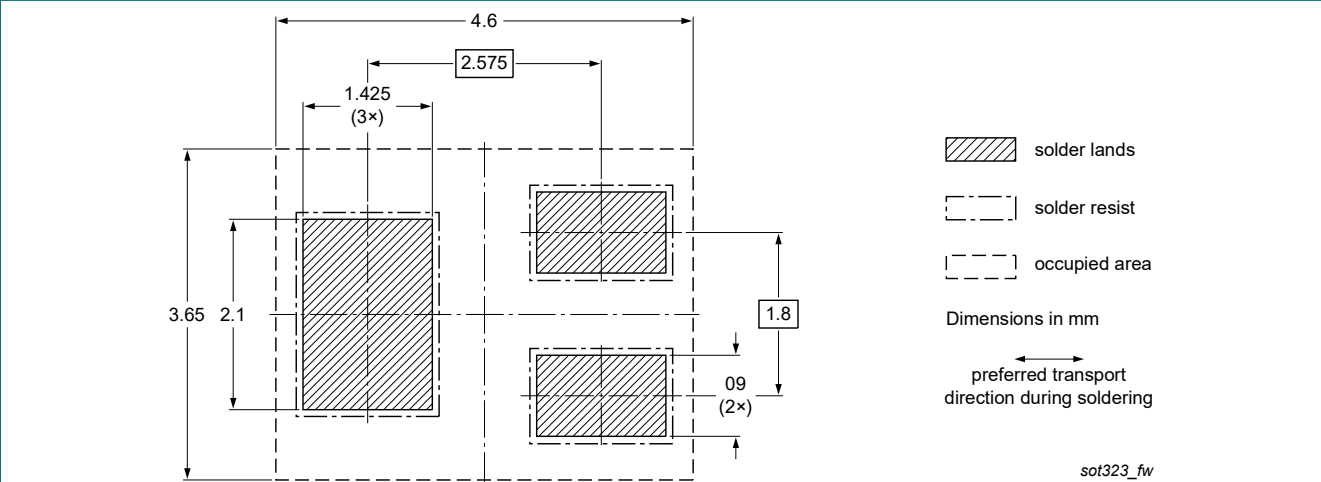


Fig. 20. Wave soldering footprint for SC-70 (SOT323)

## 14. Revision history

**Table 8. Revision history**

| Data sheet ID  | Release date                                                                                    | Data sheet status      | Change notice | Supersedes   |
|----------------|-------------------------------------------------------------------------------------------------|------------------------|---------------|--------------|
| 2N7002HW v.2   | 20211201                                                                                        | Product data sheet     | -             | 2N7002HW v.1 |
| Modifications: | <ul style="list-style-type: none"><li>Changed document status to "Product data sheet"</li></ul> |                        |               |              |
| 2N7002HW v.1   | 20211119                                                                                        | Preliminary data sheet | -             | -            |

## 15. Legal information

### Data sheet status

| Document status<br>[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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Contents

1. General description..... 1

2. Features and benefits..... 1

3. Applications..... 1

4. Quick reference data..... 1

5. Pinning information.....2

6. Ordering information.....2

7. Marking.....2

8. Limiting values..... 3

9. Thermal characteristics..... 5

10. Characteristics.....6

11. Test information..... 10

12. Package outline..... 11

13. Soldering..... 12

14. Revision history.....13

15. Legal information.....14

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