



# BUK9D23-40E

40 V, N-channel Trench MOSFET

13 December 2017

Product data sheet

## 1. General description

N-channel enhancement mode Field-Effect Transistor (FET) in a medium power DFN2020MD-6 (SOT1220) Surface-Mounted Device (SMD) plastic package using Trench MOSFET technology.

## 2. Features and benefits

- Extended temperature range  $T_j = 175\text{ °C}$
- Side wettable flanks for optical solder inspection
- Small and leadless ultra thin SMD plastic package: 2 x 2 x 0.65 mm
- Trench MOSFET technology
- AEC-Q101 qualified

## 3. Applications

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

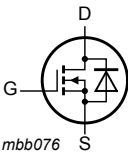
## 4. Quick reference data

Table 1. Quick reference data

| Symbol                        | Parameter                        | Conditions                                                   |  | Min | Typ | Max | Unit |
|-------------------------------|----------------------------------|--------------------------------------------------------------|--|-----|-----|-----|------|
| $V_{DS}$                      | drain-source voltage             | $T_j = 25\text{ °C}$                                         |  | -   | -   | 40  | V    |
| $V_{GS}$                      | gate-source voltage              |                                                              |  | -15 | -   | 15  | V    |
| $I_D$                         | drain current                    | $V_{GS} = 10\text{ V}; T_{sp} = 25\text{ °C}$                |  | -   | -   | 19  | A    |
| $P_{tot}$                     | total power dissipation          | $T_{sp} = 25\text{ °C}$                                      |  | -   | -   | 15  | W    |
| <b>Static characteristics</b> |                                  |                                                              |  |     |     |     |      |
| $R_{DSon}$                    | drain-source on-state resistance | $V_{GS} = 10\text{ V}; I_D = 8\text{ A}; T_j = 25\text{ °C}$ |  | -   | 18  | 23  | mΩ   |

5. Pinning information

Table 2. Pinning information

| Pin | Symbol | Description | Simplified outline                                                                                                                             | Graphic symbol                                                                                    |
|-----|--------|-------------|------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------|
| 1   | D      | drain       |  <p>Transparent top view<br/><b>DFN2020MD-6 (SOT1220)</b></p> |  <p>mbb076</p> |
| 2   | D      | drain       |                                                                                                                                                |                                                                                                   |
| 3   | G      | gate        |                                                                                                                                                |                                                                                                   |
| 4   | S      | source      |                                                                                                                                                |                                                                                                   |
| 5   | D      | drain       |                                                                                                                                                |                                                                                                   |
| 6   | D      | drain       |                                                                                                                                                |                                                                                                   |
| 7   | D      | drain       |                                                                                                                                                |                                                                                                   |
| 8   | S      | source      |                                                                                                                                                |                                                                                                   |

6. Ordering information

Table 3. Ordering information

| Type number | Package     |                                                                                               |         |
|-------------|-------------|-----------------------------------------------------------------------------------------------|---------|
|             | Name        | Description                                                                                   | Version |
| BUK9D23-40E | DFN2020MD-6 | DFN2020MD-6: plastic thermal enhanced ultra thin small outline package; no leads; 6 terminals | SOT1220 |

7. Marking

Table 4. Marking codes

| Type number | Marking code <sup>[1]</sup> |
|-------------|-----------------------------|
| BUK9D23-40E | %4B                         |

[1] % = placeholder for manufacturing site code

## 8. Limiting values

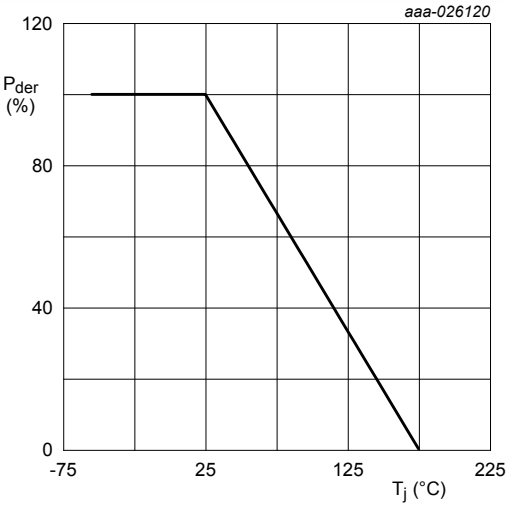
**Table 5. Limiting values**

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

| Symbol                      | Parameter                                    | Conditions                                                                                               |     | Min | Max  | Unit               |
|-----------------------------|----------------------------------------------|----------------------------------------------------------------------------------------------------------|-----|-----|------|--------------------|
| $V_{DS}$                    | drain-source voltage                         | $T_j = 25\text{ }^{\circ}\text{C}$                                                                       |     | -   | 40   | V                  |
| $V_{GS}$                    | gate-source voltage                          |                                                                                                          |     | -15 | 15   | V                  |
| $I_D$                       | drain current                                | $V_{GS} = 10\text{ V}; T_{sp} = 25\text{ }^{\circ}\text{C}$                                              |     | -   | 19   | A                  |
|                             |                                              | $V_{GS} = 10\text{ V}; T_{sp} = 100\text{ }^{\circ}\text{C}$                                             |     | -   | 12   | A                  |
|                             |                                              | $V_{GS} = 10\text{ V}; T_{amb} = 25\text{ }^{\circ}\text{C}$                                             | [1] | -   | 8    | A                  |
| $I_{DM}$                    | peak drain current                           | $T_{sp} = 25\text{ }^{\circ}\text{C}$ ; single pulse; $t_p \leq 10\text{ }\mu\text{s}$                   |     | -   | 76   | A                  |
| $P_{tot}$                   | total power dissipation                      | $T_{sp} = 25\text{ }^{\circ}\text{C}$                                                                    |     | -   | 15   | W                  |
|                             |                                              | $T_{amb} = 25\text{ }^{\circ}\text{C}$                                                                   | [1] | -   | 2.3  | W                  |
| $T_j$                       | junction temperature                         |                                                                                                          |     | -55 | 175  | $^{\circ}\text{C}$ |
| $T_{amb}$                   | ambient temperature                          |                                                                                                          |     | -55 | 175  | $^{\circ}\text{C}$ |
| $T_{stg}$                   | storage temperature                          |                                                                                                          |     | -65 | 175  | $^{\circ}\text{C}$ |
| <b>Source-drain diode</b>   |                                              |                                                                                                          |     |     |      |                    |
| $I_S$                       | source current                               | $T_{sp} = 25\text{ }^{\circ}\text{C}$                                                                    |     | -   | 15   | A                  |
|                             |                                              | $T_{amb} = 25\text{ }^{\circ}\text{C}$                                                                   | [1] | -   | 2.3  | A                  |
| $I_{SM}$                    | peak source current                          | single pulse; $t_p \leq 10\text{ }\mu\text{s}$ ; $T_{sp} = 25\text{ }^{\circ}\text{C}$                   |     | -   | 62   | A                  |
| <b>ESD maximum rating</b>   |                                              |                                                                                                          |     |     |      |                    |
| $V_{ESD}$                   | electrostatic discharge voltage              | HBM                                                                                                      | [2] | -   | 500  | V                  |
| <b>Avalanche ruggedness</b> |                                              |                                                                                                          |     |     |      |                    |
| $E_{DS(AL)S}$               | non-repetitive drain-source avalanche energy | $T_{j(\text{init})} = 25\text{ }^{\circ}\text{C}$ ; $I_D = 1.35\text{ A}$ ; DUT in avalanche (unclamped) |     | -   | 28.4 | mJ                 |

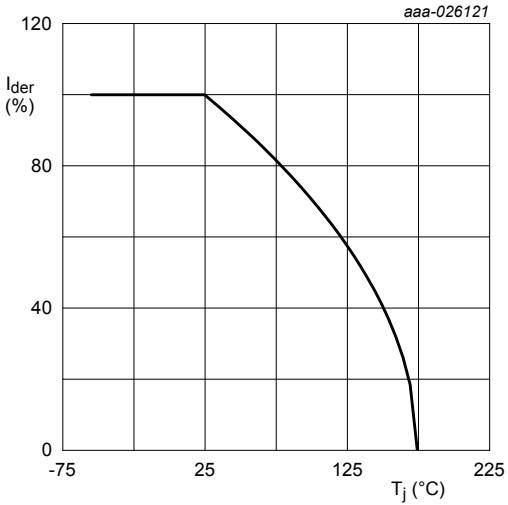
[1] Device mounted on an FR4 Printed-Circuit Board (PCB), single-sided copper, tin-plated, mounting pad for drain  $6\text{ cm}^2$ .

[2] Measured between all pins.



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

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



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

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

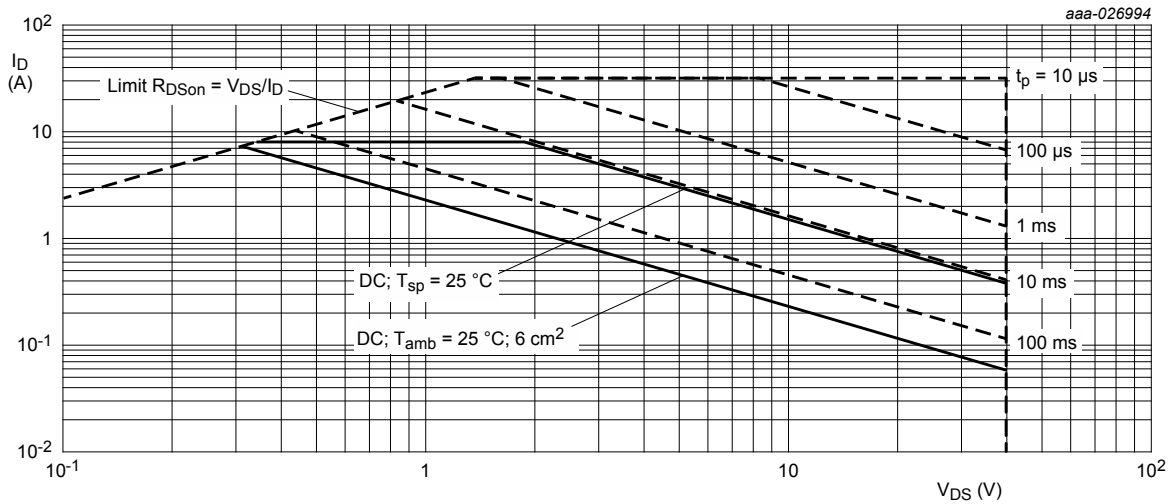


Fig. 3. Safe operating area; junction to ambient; continuous and peak drain currents as a function of drain-source voltage

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] | -   | 57  | 66  | K/W  |
| $R_{th(j-sp)}$ | thermal resistance from junction to solder point |             |     | -   | 6   | 10  | K/W  |

[1] Device mounted on an FR4 PCB, single-sided copper, tin-plated, mounting pad for drain 6 cm<sup>2</sup>.

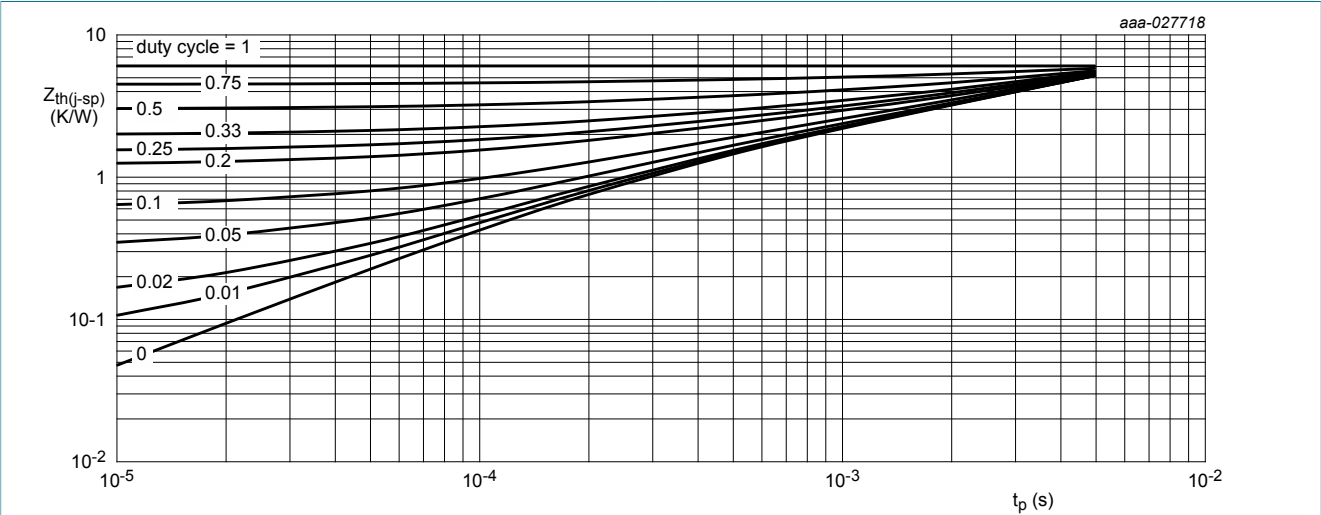
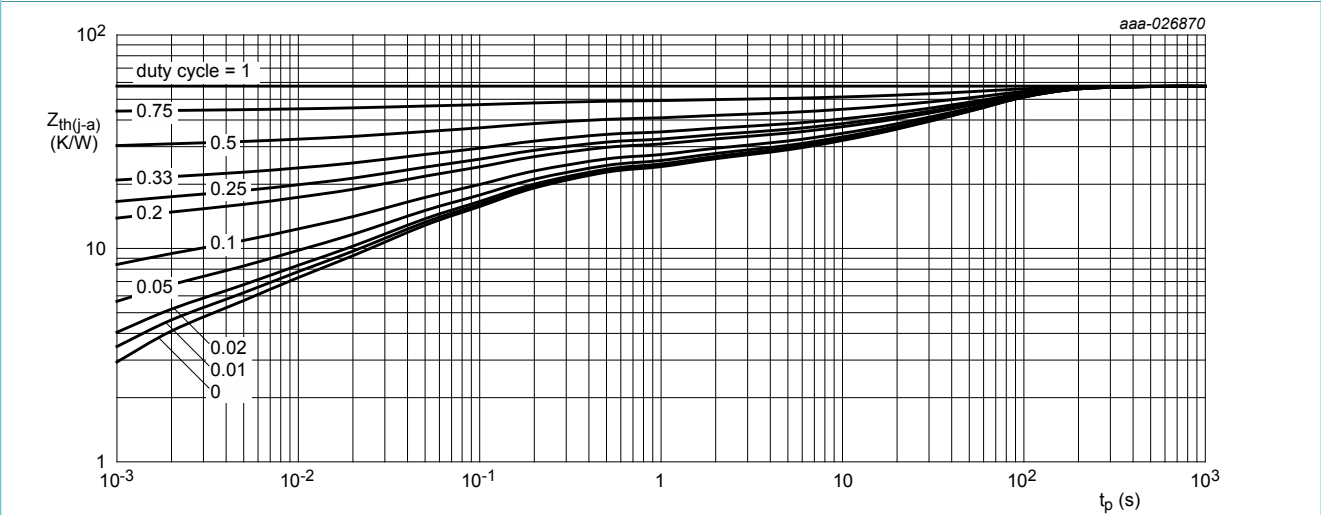


Fig. 4. Transient thermal impedance from junction to solder point as a function of pulse duration; typical values



FR4 PCB, mounting pad for drain 6 cm<sup>2</sup>

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> = 250 μA; V <sub>GS</sub> = 0 V; T <sub>j</sub> = 25 °C                                                         |  | 40  | -    | -    | 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                                            |  | 1.4 | 1.7  | 2.1  | V    |
| I <sub>DSS</sub>        | drain leakage current            | V <sub>DS</sub> = 40 V; V <sub>GS</sub> = 0 V; T <sub>j</sub> = 25 °C                                                          |  | -   | -    | 1    | μA   |
|                         |                                  | V <sub>DS</sub> = 40 V; V <sub>GS</sub> = 0 V; T <sub>j</sub> = 175 °C                                                         |  | -   | -    | 500  | μA   |
| I <sub>GSS</sub>        | gate leakage current             | V <sub>GS</sub> = 15 V; V <sub>DS</sub> = 0 V; T <sub>j</sub> = 25 °C                                                          |  | -   | -    | 100  | nA   |
|                         |                                  | V <sub>GS</sub> = -15 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> = 8 A; T <sub>j</sub> = 25 °C                                                           |  | -   | 18   | 23   | mΩ   |
|                         |                                  | V <sub>GS</sub> = 10 V; I <sub>D</sub> = 8 A; T <sub>j</sub> = 175 °C                                                          |  | -   | 33   | 43   | mΩ   |
|                         |                                  | V <sub>GS</sub> = 4.5 V; I <sub>D</sub> = 6.4 A; T <sub>j</sub> = 25 °C                                                        |  | -   | 22   | 30   | mΩ   |
| g <sub>fs</sub>         | forward transconductance         | V <sub>DS</sub> = 10 V; I <sub>D</sub> = 8 A; T <sub>j</sub> = 25 °C                                                           |  | -   | 39   | -    | S    |
| R <sub>G</sub>          | gate resistance                  | f = 1 MHz                                                                                                                      |  | -   | 1.8  | -    | Ω    |
| Dynamic characteristics |                                  |                                                                                                                                |  |     |      |      |      |
| Q <sub>G(tot)</sub>     | total gate charge                | V <sub>DS</sub> = 20 V; I <sub>D</sub> = 8 A; V <sub>GS</sub> = 10 V; T <sub>j</sub> = 25 °C                                   |  | -   | 11.5 | 17   | nC   |
| Q <sub>GS</sub>         | gate-source charge               |                                                                                                                                |  | -   | 1.7  | -    | nC   |
| Q <sub>GD</sub>         | gate-drain charge                |                                                                                                                                |  | -   | 2.1  | -    | nC   |
| C <sub>iss</sub>        | input capacitance                | V <sub>DS</sub> = 20 V; f = 1 MHz; V <sub>GS</sub> = 0 V; T <sub>j</sub> = 25 °C                                               |  | -   | 637  | -    | pF   |
| C <sub>oss</sub>        | output capacitance               |                                                                                                                                |  | -   | 102  | -    | pF   |
| C <sub>rss</sub>        | reverse transfer capacitance     |                                                                                                                                |  | -   | 52   | -    | pF   |
| t <sub>d(on)</sub>      | turn-on delay time               | V <sub>DS</sub> = 20 V; I <sub>D</sub> = 8 A; 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                        |                                                                                                                                |  | -   | 6    | -    | ns   |
| t <sub>d(off)</sub>     | turn-off delay time              |                                                                                                                                |  | -   | 12   | -    | ns   |
| t <sub>f</sub>          | fall time                        |                                                                                                                                |  | -   | 4    | -    | ns   |
| Source-drain diode      |                                  |                                                                                                                                |  |     |      |      |      |
| V <sub>SD</sub>         | source-drain voltage             | I <sub>S</sub> = 2.3 A; V <sub>GS</sub> = 0 V; T <sub>j</sub> = 25 °C                                                          |  | -   | 0.8  | 1.2  | V    |
| t <sub>rr</sub>         | reverse recovery time            | I <sub>S</sub> = 2.3 A; dI <sub>S</sub> /dt = -100 A/μs; V <sub>GS</sub> = 0 V; V <sub>DS</sub> = 20 V; T <sub>j</sub> = 25 °C |  | -   | 12.9 | -    | ns   |
| Q <sub>r</sub>          | recovered charge                 |                                                                                                                                |  | -   | 5.3  | -    | nC   |

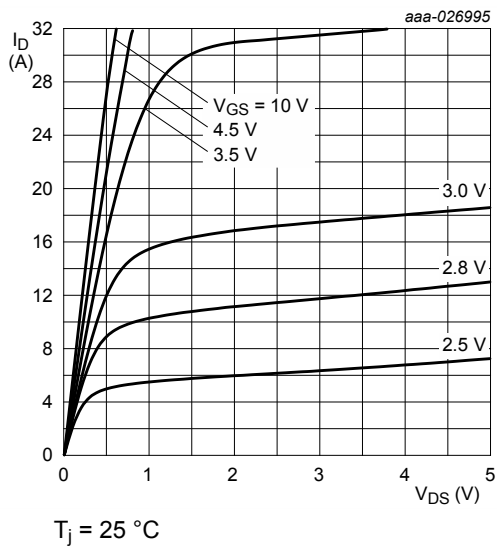


Fig. 6. Output characteristics: drain current as a function of drain-source voltage; typical values

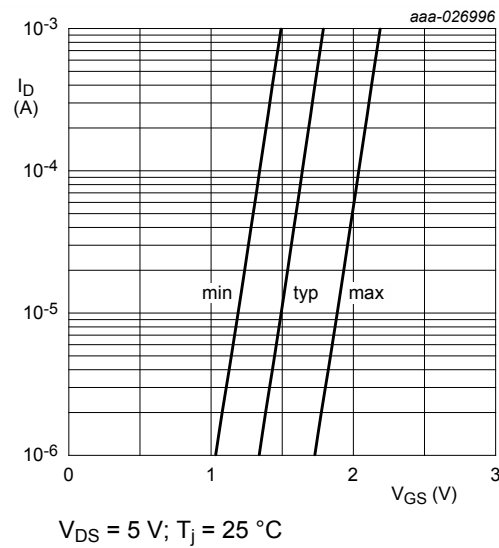


Fig. 7. Sub-threshold drain current as a function of gate-source voltage

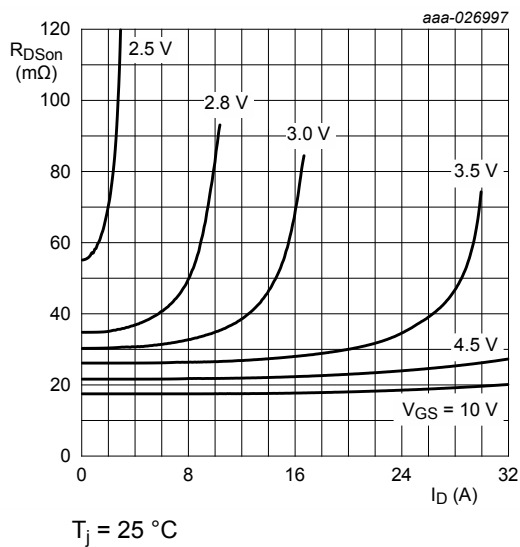


Fig. 8. Drain-source on-state resistance as a function of drain current; typical values

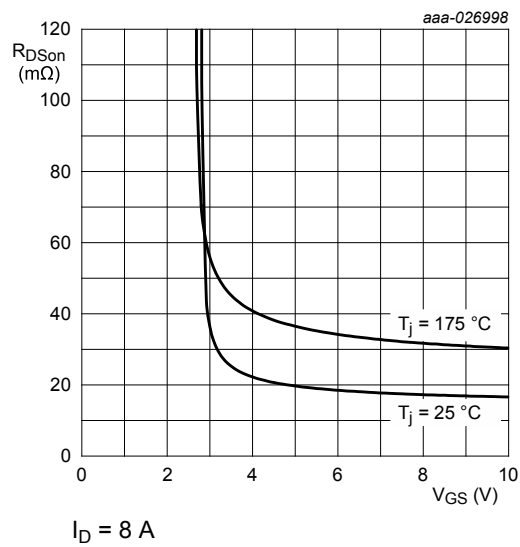


Fig. 9. Drain-source on-state resistance as a function of gate-source voltage; typical values

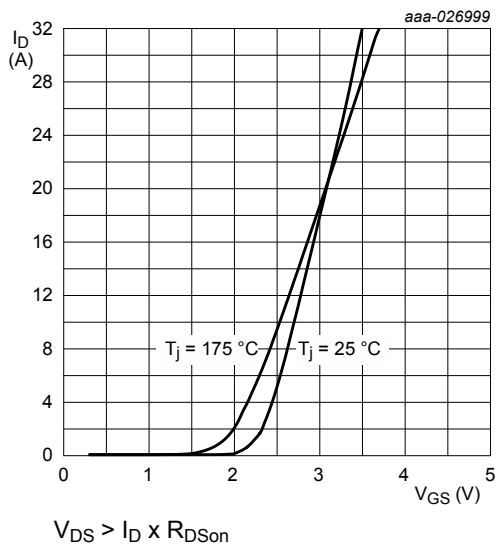


Fig. 10. Transfer characteristics: drain current as a function of gate-source voltage; typical values

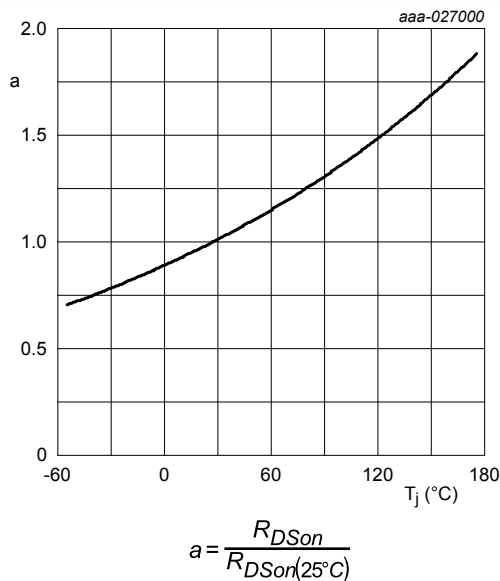


Fig. 11. Normalized drain-source on-state resistance as a function of junction temperature; typical values

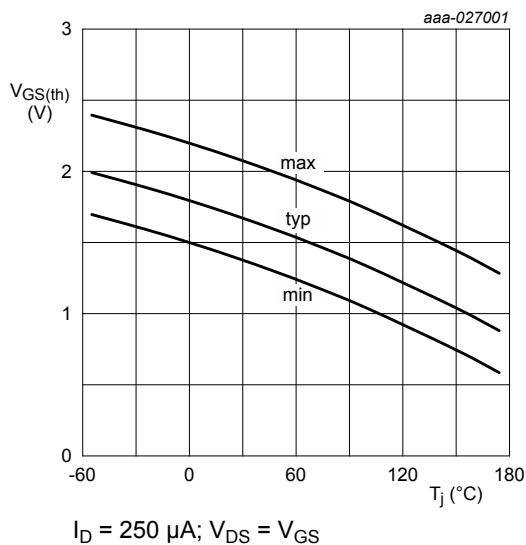


Fig. 12. Gate-source threshold voltage as a function of junction temperature

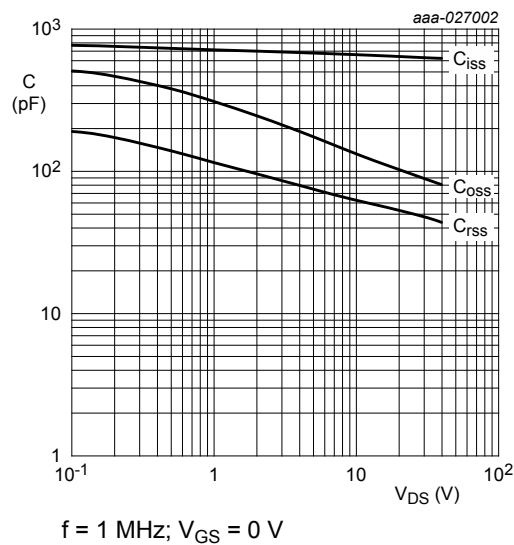
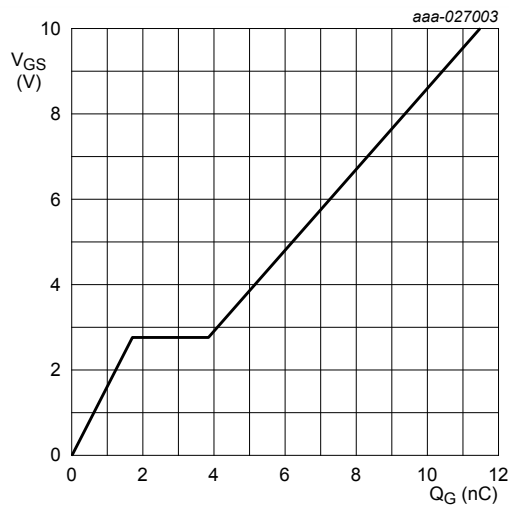


Fig. 13. Input, output and reverse transfer capacitances as a function of drain-source voltage; typical values



$V_{DS} = 20\text{ V}; I_D = 8\text{ A}; T_{amb} = 25\text{ }^{\circ}\text{C}$

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

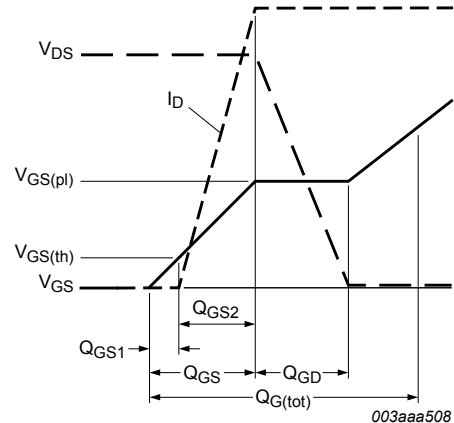
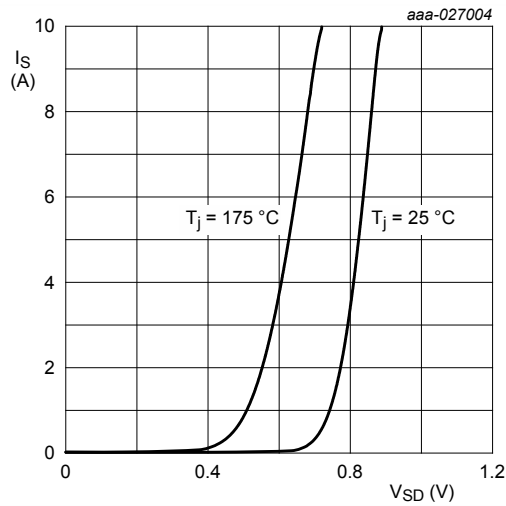


Fig. 15. Gate charge waveform definitions



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

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

## 11. Test information

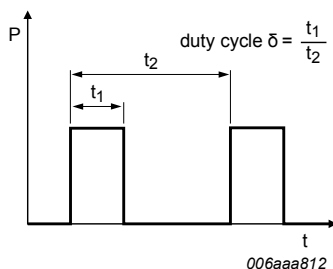


Fig. 17. Duty cycle definition

### 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

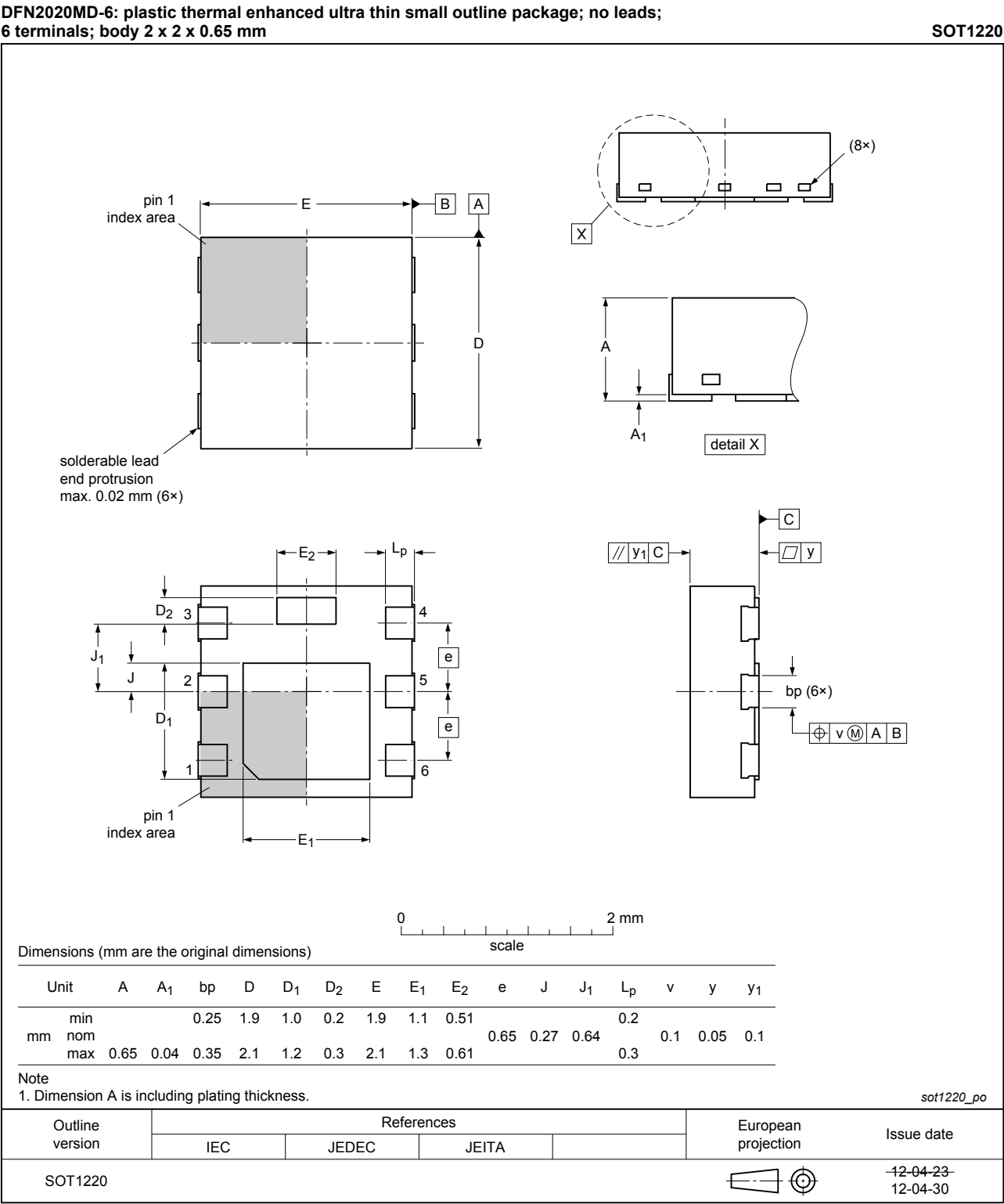
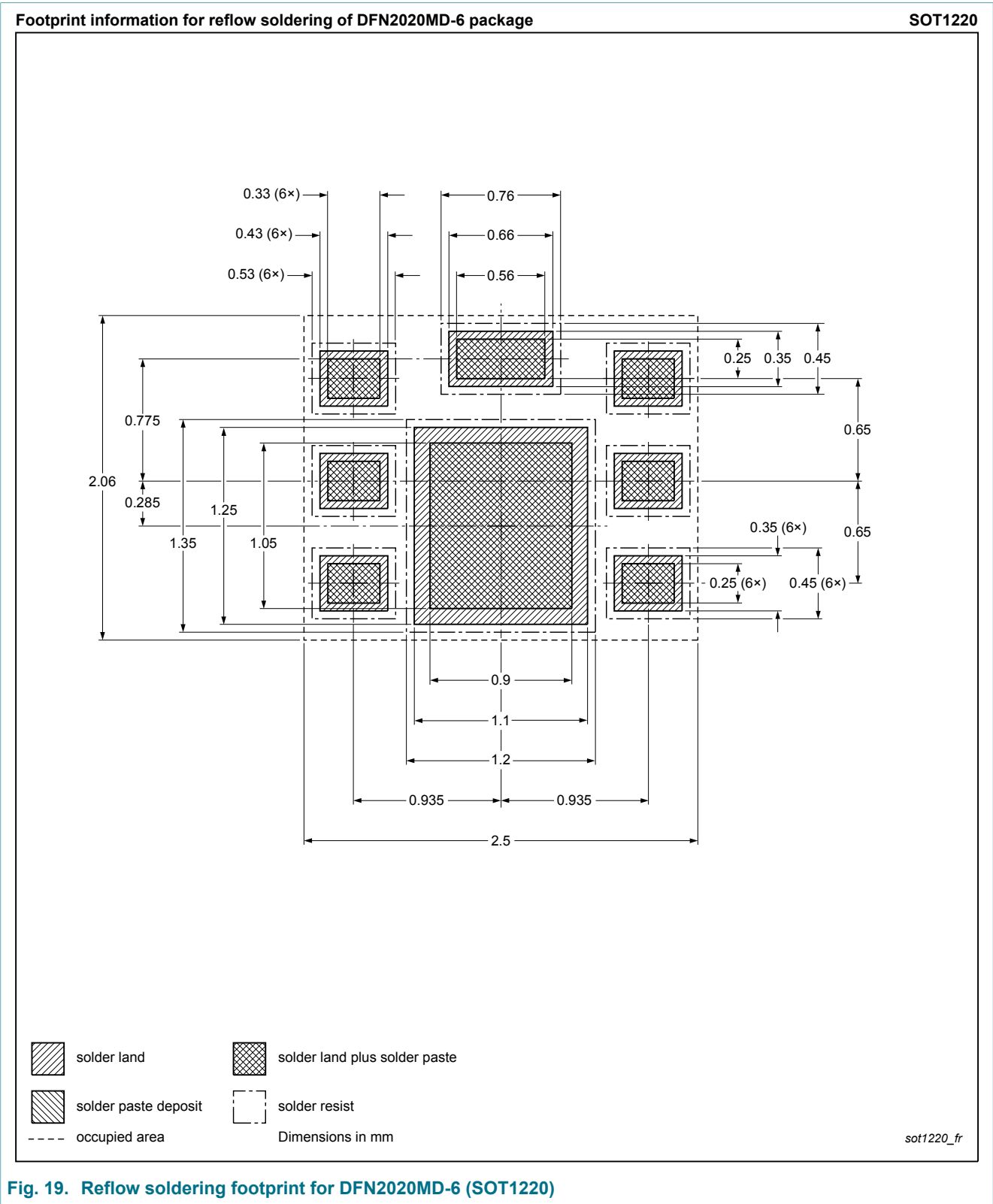


Fig. 18. Package outline DFN2020MD-6 (SOT1220)

13. Soldering



14. Revision history

Table 8. Revision history

| Data sheet ID   | Release date | Data sheet status  | Change notice | Supersedes |
|-----------------|--------------|--------------------|---------------|------------|
| BUK9D23-40E v.1 | 20171213     | Product data sheet | -             | -          |

## 15. Legal information

### 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.
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