



# BUK9614-60E

N-channel TrenchMOS logic level FET

28 July 2016

Product data sheet

## 1. General description

Logic level N-channel MOSFET in a SOT404 package using TrenchMOS technology. This product has been designed and qualified to AEC Q101 standard for use in high performance automotive applications.

## 2. Features and benefits

- AEC Q101 compliant
- Repetitive avalanche rated
- Suitable for thermally demanding environments due to 175 °C rating
- True logic level gate with VGS(th) rating of greater than 0.5V at 175 °C

## 3. Applications

- 12 V Automotive systems
- Motors, lamps and solenoid control
- Start-Stop micro-hybrid applications
- Transmission control
- Ultra high performance power switching

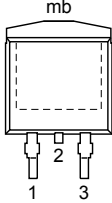
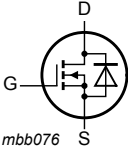
## 4. Quick reference data

Table 1. Quick reference data

| Symbol                         | Parameter                        | Conditions                                                                                                              | Min | Typ  | Max | Unit |
|--------------------------------|----------------------------------|-------------------------------------------------------------------------------------------------------------------------|-----|------|-----|------|
| V <sub>DS</sub>                | drain-source voltage             | T <sub>j</sub> ≥ 25 °C; T <sub>j</sub> ≤ 175 °C                                                                         | -   | -    | 60  | V    |
| I <sub>D</sub>                 | drain current                    | V <sub>GS</sub> = 5 V; T <sub>mb</sub> = 25 °C; <a href="#">Fig. 2</a>                                                  | -   | -    | 56  | A    |
| P <sub>tot</sub>               | total power dissipation          | T <sub>mb</sub> = 25 °C; <a href="#">Fig. 1</a>                                                                         | -   | -    | 96  | W    |
| <b>Static characteristics</b>  |                                  |                                                                                                                         |     |      |     |      |
| R <sub>DSon</sub>              | drain-source on-state resistance | V <sub>GS</sub> = 5 V; I <sub>D</sub> = 15 A; T <sub>j</sub> = 25 °C; <a href="#">Fig. 11</a>                           | -   | 11.5 | 14  | mΩ   |
| <b>Dynamic characteristics</b> |                                  |                                                                                                                         |     |      |     |      |
| Q <sub>GD</sub>                | gate-drain charge                | V <sub>GS</sub> = 5 V; I <sub>D</sub> = 15 A; V <sub>DS</sub> = 48 V; <a href="#">Fig. 13</a> ; <a href="#">Fig. 14</a> | -   | 6.7  | -   | nC   |

5. Pinning information

Table 2. Pinning information

| Pin | Symbol | Description                       | Simplified outline                                                                                  | Graphic symbol                                                                                |
|-----|--------|-----------------------------------|-----------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|
| 1   | G      | gate                              | <br>D2PAK (SOT404) | <br>mbb076 |
| 2   | D      | drain                             |                                                                                                     |                                                                                               |
| 3   | S      | source                            |                                                                                                     |                                                                                               |
| mb  | D      | mounting base; connected to drain |                                                                                                     |                                                                                               |

6. Ordering information

Table 3. Ordering information

| Type number | Package |                                                                                  |         |
|-------------|---------|----------------------------------------------------------------------------------|---------|
|             | Name    | Description                                                                      | Version |
| BUK9614-60E | D2PAK   | plastic single-ended surface-mounted package (D2PAK); 3 leads (one lead cropped) | SOT404  |

7. Marking

Table 4. Marking codes

| Type number | Marking code |
|-------------|--------------|
| BUK9614-60E | BUK9614-60E  |

8. Limiting values

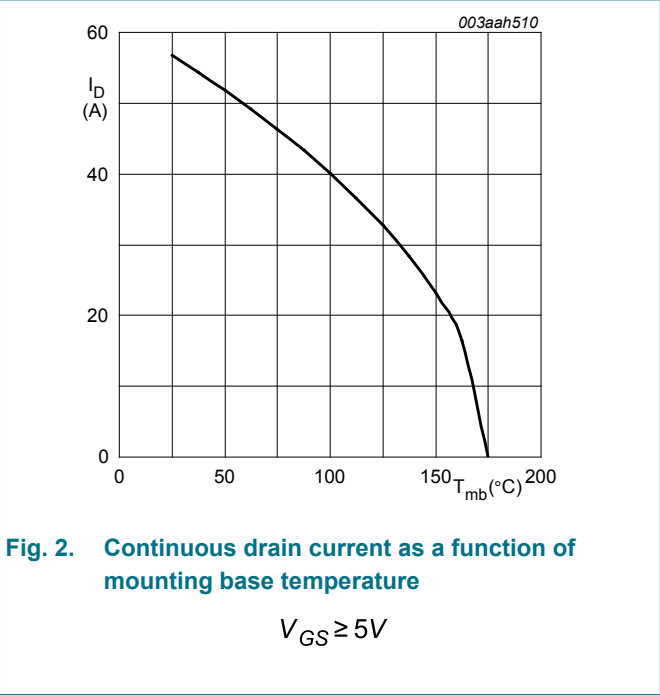
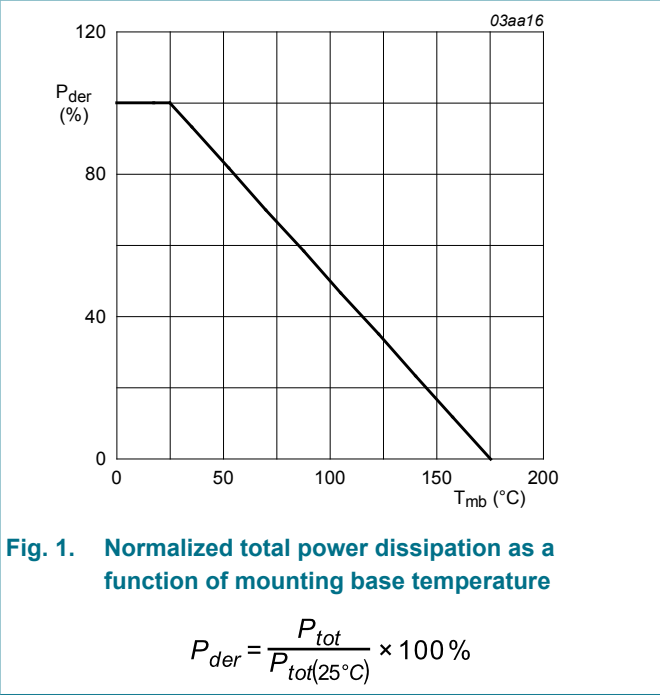
Table 5. Limiting values

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

| Symbol    | Parameter               | Conditions                                                                                |        | Min | Max | Unit               |
|-----------|-------------------------|-------------------------------------------------------------------------------------------|--------|-----|-----|--------------------|
| $V_{DS}$  | drain-source voltage    | $T_j \geq 25\text{ }^{\circ}\text{C}$ ; $T_j \leq 175\text{ }^{\circ}\text{C}$            |        | -   | 60  | V                  |
| $V_{DGR}$ | drain-gate voltage      | $R_{GS} = 20\text{ k}\Omega$                                                              |        | -   | 60  | V                  |
| $V_{GS}$  | gate-source voltage     | $T_j \leq 175\text{ }^{\circ}\text{C}$ ; DC                                               |        | -10 | 10  | V                  |
|           |                         | $T_j \leq 175\text{ }^{\circ}\text{C}$ ; Pulsed                                           | [1][2] | -15 | 15  | V                  |
| $P_{tot}$ | total power dissipation | $T_{mb} = 25\text{ }^{\circ}\text{C}$ ; Fig. 1                                            |        | -   | 96  | W                  |
| $I_D$     | drain current           | $T_{mb} = 25\text{ }^{\circ}\text{C}$ ; $V_{GS} = 5\text{ V}$ ; Fig. 2                    |        | -   | 56  | A                  |
|           |                         | $T_{mb} = 100\text{ }^{\circ}\text{C}$ ; $V_{GS} = 5\text{ V}$ ; Fig. 2                   |        | -   | 40  | A                  |
| $I_{DM}$  | peak drain current      | $T_{mb} = 25\text{ }^{\circ}\text{C}$ ; pulsed; $t_p \leq 10\text{ }\mu\text{s}$ ; Fig. 3 |        | -   | 224 | A                  |
| $T_{stg}$ | storage temperature     |                                                                                           |        | -55 | 175 | $^{\circ}\text{C}$ |

| Symbol               | Parameter                                    | Conditions                                                                                                                                                           |        | Min | Max | Unit |
|----------------------|----------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|-----|-----|------|
| T <sub>j</sub>       | junction temperature                         |                                                                                                                                                                      |        | -55 | 175 | °C   |
| Source-drain diode   |                                              |                                                                                                                                                                      |        |     |     |      |
| I <sub>S</sub>       | source current                               | T <sub>mb</sub> = 25 °C                                                                                                                                              | [3]    | -   | 56  | A    |
| I <sub>SM</sub>      | peak source current                          | pulsed; t <sub>p</sub> ≤ 10 μs; T <sub>mb</sub> = 25 °C                                                                                                              |        | -   | 224 | A    |
| Avalanche ruggedness |                                              |                                                                                                                                                                      |        |     |     |      |
| E <sub>DS(AL)S</sub> | non-repetitive drain-source avalanche energy | I <sub>D</sub> = 56 A; V <sub>sup</sub> ≤ 60 V; R <sub>GS</sub> = 50 Ω;<br>V <sub>GS</sub> = 5 V; T <sub>j(init)</sub> = 25 °C; unclamped;<br><a href="#">Fig. 4</a> | [4][5] | -   | 39  | mJ   |

- [1] Accumulated pulse duration up to 50 hours delivers zero defect ppm
- [2] Significantly longer life times are achieved by lowering T<sub>j</sub> and or V<sub>GS</sub>
- [3] Continuous current is limited by package.
- [4] Single-pulse avalanche rating limited by maximum junction temperature of 175 °C.
- [5] Refer to application note AN10273 for further information.



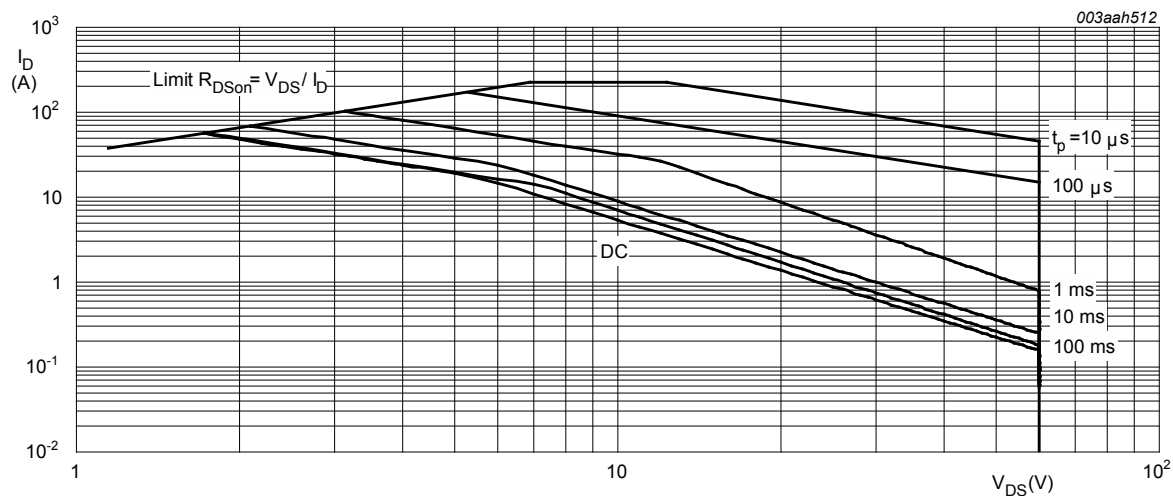


Fig. 3. Safe operating area; continuous and peak drain currents as a function of drain-source voltage

$T_{mb} = 25^{\circ}\text{C}$ ;  $I_{DM}$  is a single pulse

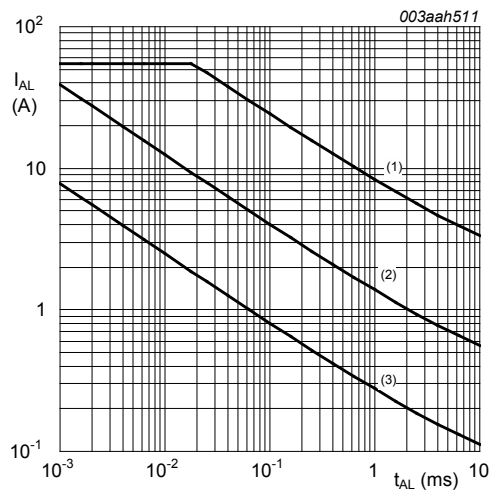


Fig. 4. Single pulse avalanche rating; avalanche current as a function of avalanche time

(1)  $T_{j(init)} = 25^{\circ}\text{C}$ ; (2)  $T_{j(init)} = 150^{\circ}\text{C}$ ; (3) Repetitive Avalanche

## 9. Thermal characteristics

Table 6. Thermal characteristics

| Symbol         | Parameter                                         | Conditions                                             | Min | Typ | Max  | Unit |
|----------------|---------------------------------------------------|--------------------------------------------------------|-----|-----|------|------|
| $R_{th(j-mb)}$ | thermal resistance from junction to mounting base | <a href="#">Fig. 5</a>                                 | -   | -   | 1.56 | K/W  |
| $R_{th(j-a)}$  | thermal resistance from junction to ambient       | minimum footprint ; mounted on a printed-circuit board | -   | 50  | -    | K/W  |

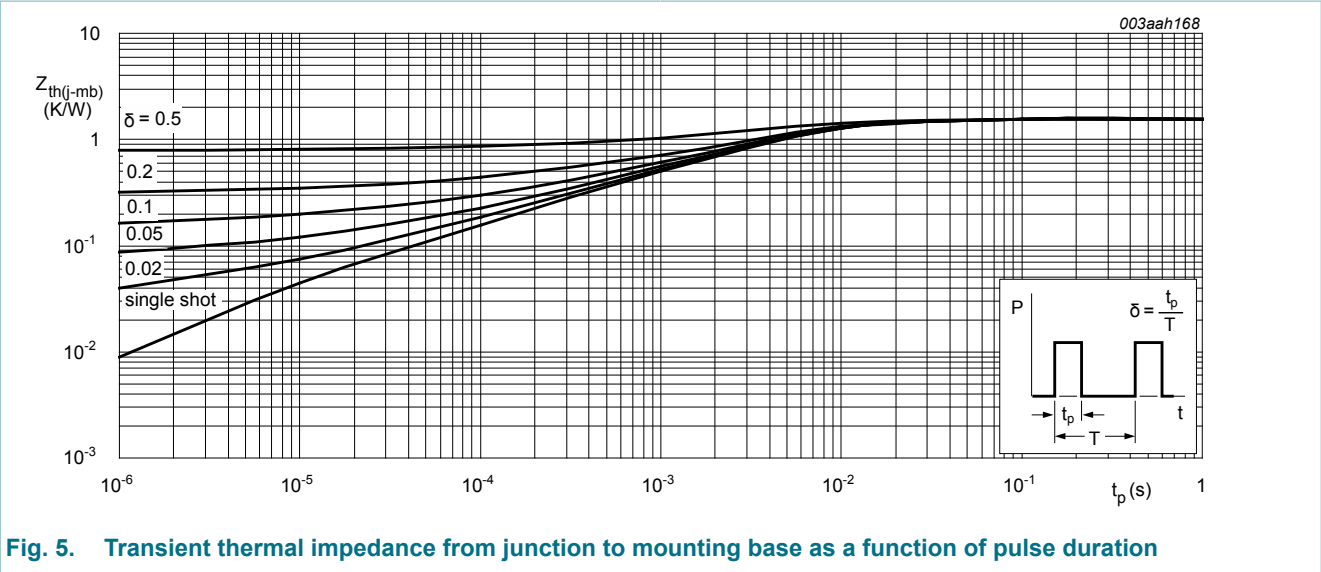


Fig. 5. Transient thermal impedance from junction to mounting base as a function of pulse duration

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                                                              |  | 60  | -    | -    | V    |
|                         |                                  | I <sub>D</sub> = 250 μA; V <sub>GS</sub> = 0 V; T <sub>J</sub> = -55 °C                                                             |  | 54  | -    | -    | V    |
| V <sub>GS(th)</sub>     | gate-source threshold voltage    | I <sub>D</sub> = 1 mA; V <sub>DS</sub> = V <sub>GS</sub> ; T <sub>J</sub> = 25 °C; <a href="#">Fig. 9</a> ; <a href="#">Fig. 10</a> |  | 1.4 | 1.7  | 2.1  | V    |
|                         |                                  | I <sub>D</sub> = 1 mA; V <sub>DS</sub> = V <sub>GS</sub> ; T <sub>J</sub> = -55 °C; <a href="#">Fig. 9</a>                          |  | -   | -    | 2.45 | V    |
|                         |                                  | I <sub>D</sub> = 1 mA; V <sub>DS</sub> = V <sub>GS</sub> ; T <sub>J</sub> = 175 °C; <a href="#">Fig. 9</a>                          |  | 0.5 | -    | -    | 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                                                               |  | -   | 0.02 | 1    | μA   |
|                         |                                  | V <sub>DS</sub> = 60 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> = 10 V; V <sub>DS</sub> = 0 V; T <sub>J</sub> = 25 °C                                                               |  | -   | 2    | 100  | nA   |
|                         |                                  | V <sub>GS</sub> = -10 V; V <sub>DS</sub> = 0 V; T <sub>J</sub> = 25 °C                                                              |  | -   | 2    | 100  | nA   |
| R <sub>DSon</sub>       | drain-source on-state resistance | V <sub>GS</sub> = 5 V; I <sub>D</sub> = 15 A; T <sub>J</sub> = 25 °C; <a href="#">Fig. 11</a>                                       |  | -   | 11.5 | 14   | mΩ   |
|                         |                                  | V <sub>GS</sub> = 10 V; I <sub>D</sub> = 15 A; T <sub>J</sub> = 25 °C; <a href="#">Fig. 11</a>                                      |  | -   | 10.3 | 12.8 | mΩ   |
|                         |                                  | V <sub>GS</sub> = 5 V; I <sub>D</sub> = 15 A; T <sub>J</sub> = 175 °C; <a href="#">Fig. 12</a> ; <a href="#">Fig. 11</a>            |  | -   | -    | 31   | mΩ   |
| Dynamic characteristics |                                  |                                                                                                                                     |  |     |      |      |      |
| Q <sub>G(tot)</sub>     | total gate charge                | I <sub>D</sub> = 15 A; V <sub>DS</sub> = 48 V; V <sub>GS</sub> = 5 V; <a href="#">Fig. 13</a> ; <a href="#">Fig. 14</a>             |  | -   | 20.5 | -    | nC   |
| Q <sub>GS</sub>         | gate-source charge               |                                                                                                                                     |  | -   | 4    | -    | nC   |

| Symbol       | Parameter                    | Conditions                                                                                                                    |  | Min | Typ  | Max  | Unit |
|--------------|------------------------------|-------------------------------------------------------------------------------------------------------------------------------|--|-----|------|------|------|
| $Q_{GD}$     | gate-drain charge            |                                                                                                                               |  | -   | 6.7  | -    | nC   |
| $C_{iss}$    | input capacitance            | $V_{GS} = 0\text{ V}; V_{DS} = 25\text{ V}; f = 1\text{ MHz};$<br>$T_j = 25\text{ }^{\circ}\text{C};$ <a href="#">Fig. 15</a> |  | -   | 1988 | 2651 | pF   |
| $C_{oss}$    | output capacitance           |                                                                                                                               |  | -   | 196  | 235  | pF   |
| $C_{rss}$    | reverse transfer capacitance |                                                                                                                               |  | -   | 114  | 156  | pF   |
| $t_{d(on)}$  | turn-on delay time           | $V_{DS} = 45\text{ V}; R_L = 3\text{ }\Omega; V_{GS} = 5\text{ V};$<br>$R_{G(ext)} = 5\text{ }\Omega$                         |  | -   | 16.9 | -    | ns   |
| $t_r$        | rise time                    |                                                                                                                               |  | -   | 22.4 | -    | ns   |
| $t_{d(off)}$ | turn-off delay time          |                                                                                                                               |  | -   | 35.7 | -    | ns   |
| $t_f$        | fall time                    |                                                                                                                               |  | -   | 22.9 | -    | ns   |
| $L_D$        | internal drain inductance    | from upper edge of drain mounting base to center of die                                                                       |  | -   | 2.5  | -    | nH   |
| $L_S$        | internal source inductance   | from source lead to source bonding pad                                                                                        |  | -   | 7.5  | -    | nH   |

Source-drain diode

|          |                       |                                                                                                          |  |   |      |     |    |
|----------|-----------------------|----------------------------------------------------------------------------------------------------------|--|---|------|-----|----|
| $V_{SD}$ | source-drain voltage  | $I_S = 15\text{ A}; V_{GS} = 0\text{ V}; T_j = 25\text{ }^{\circ}\text{C};$ <a href="#">Fig. 16</a>      |  | - | 0.83 | 1.2 | V  |
| $t_{rr}$ | reverse recovery time | $I_S = 15\text{ A}; dI_S/dt = -100\text{ A}/\mu\text{s}; V_{GS} = 0\text{ V};$<br>$V_{DS} = 25\text{ V}$ |  | - | 22.3 | -   | ns |
| $Q_r$    | recovered charge      |                                                                                                          |  | - | 20.9 | -   | nC |

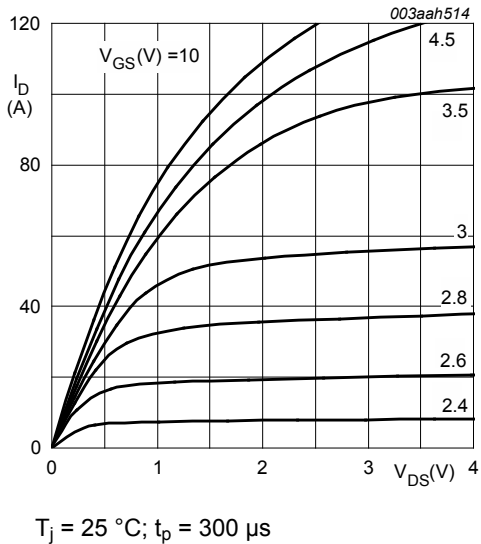


Fig. 6. Output characteristics; drain current as a function of drain-source voltage; typical values

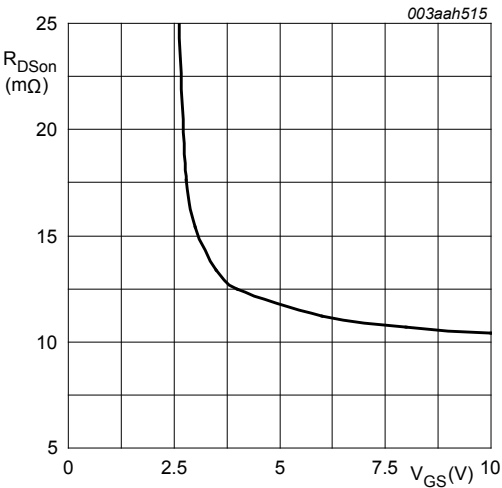


Fig. 7. Drain-source on-state resistance as a function of gate-source voltage; typical values

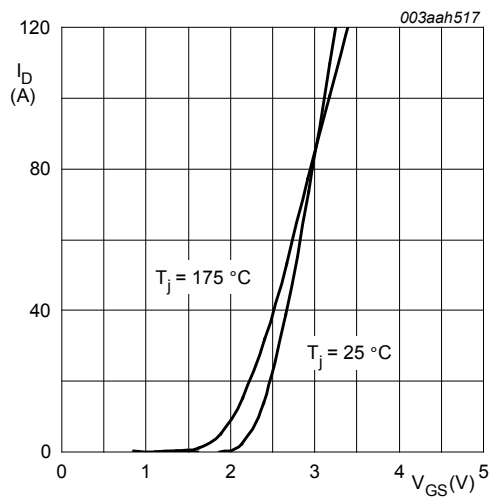


Fig. 8. Transfer characteristics; drain current as a function of gate-source voltage; typical values

$V_{DS} = 10V$

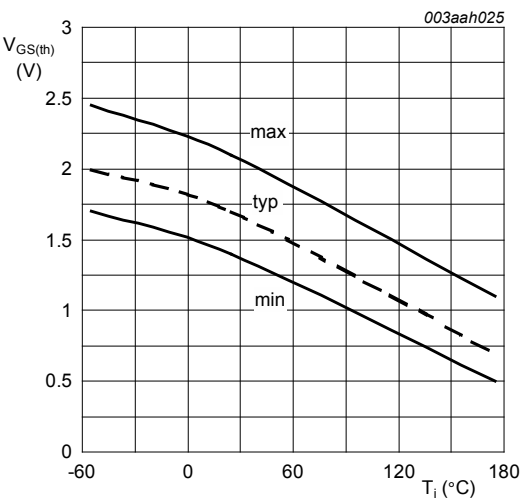


Fig. 9. Gate-source threshold voltage as a function of junction temperature

$I_D = 1 \text{ mA}; V_{DS} = V_{GS}$

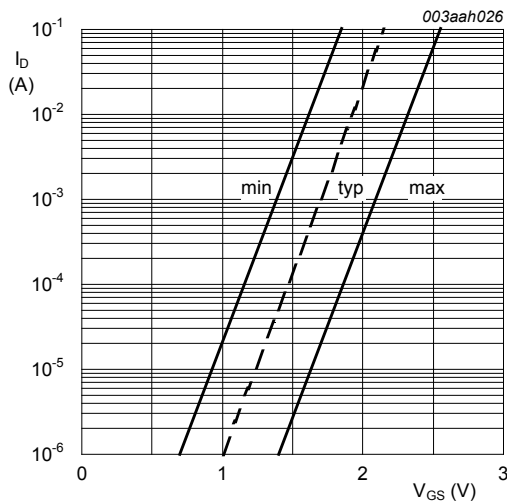


Fig. 10. Sub-threshold drain current as a function of gate-source voltage

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

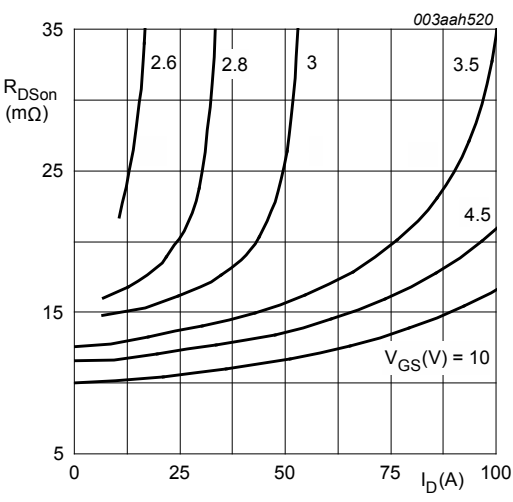


Fig. 11. Drain-source on-state resistance as a function of drain current; typical values

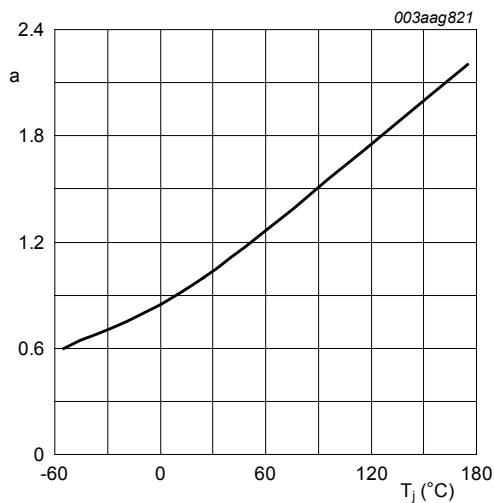


Fig. 12. Normalized drain-source on-state resistance factor as a function of junction temperature

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

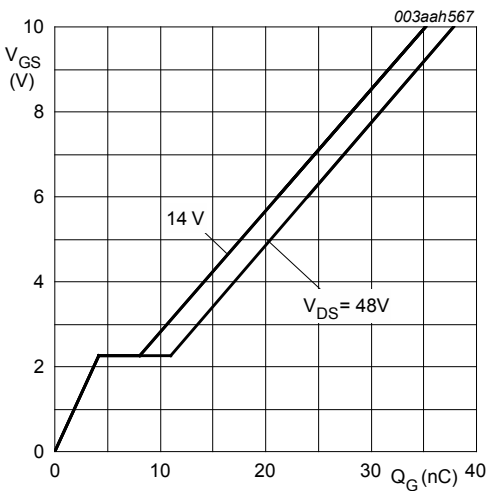


Fig. 14. Gate-source voltage as a function of gate charge; typical values

$$T_j = 25^{\circ}\text{C}; I_D = 15\text{ A}$$

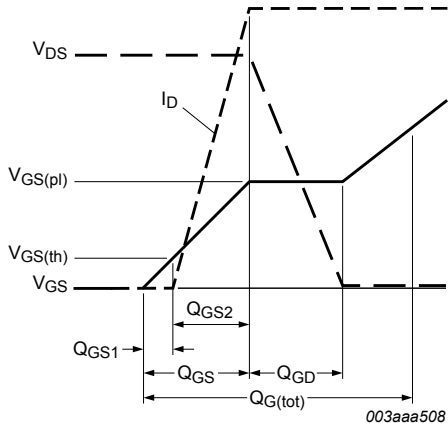


Fig. 13. Gate charge waveform definitions

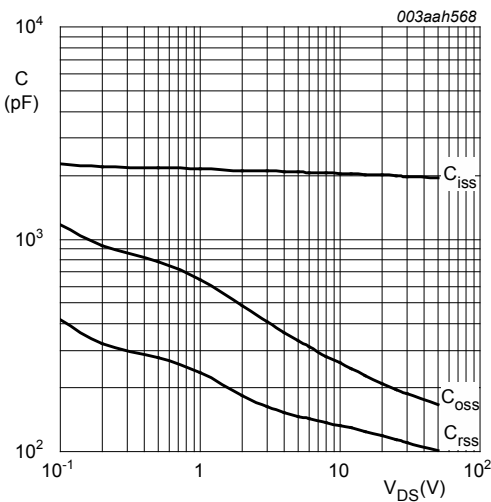


Fig. 15. Input, output and reverse transfer capacitances as a function of drain-source voltage; typical values

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



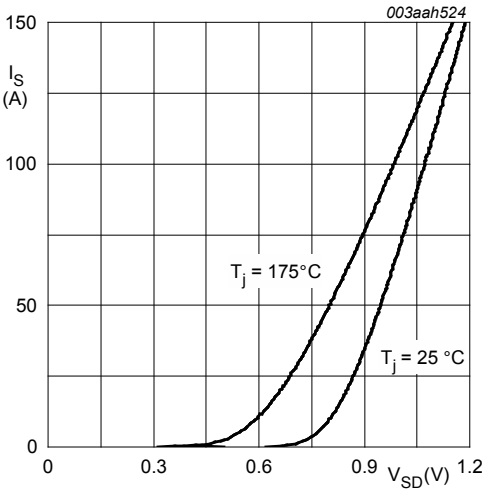


Fig. 16. Source (diode forward) current as a function of source-drain (diode forward) voltage; typical values  
 $V_{GS} = 0\text{V}$

11. Package outline

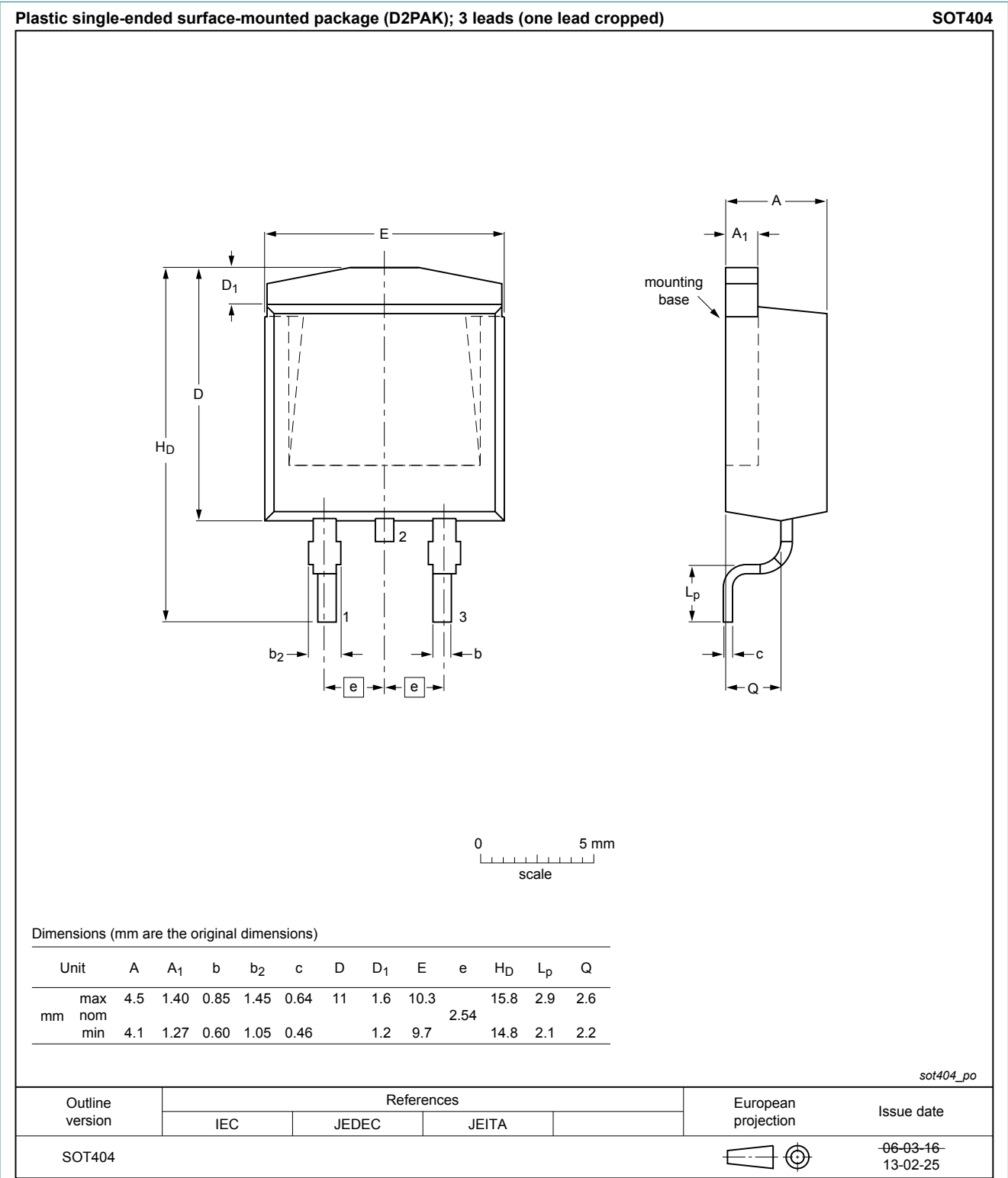


Fig. 17. Package outline D2PAK (SOT404)

## 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".
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13. 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 ..... 2

9 Thermal characteristics ..... 4

10 Characteristics ..... 5

11 Package outline ..... 10

12 Legal information ..... 11

12.1 Data sheet status ..... 11

12.2 Definitions ..... 11

12.3 Disclaimers ..... 11

12.4 Trademarks ..... 12

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