

# BUK9K6R2-40E

Dual N-channel TrenchMOS logic level FET

19 July 2012

Product data sheet

## 1. Product profile

### 1.1 General description

Dual logic level N-channel MOSFET in a LFPAK56D package using TrenchMOS technology. This product has been designed and qualified to AEC Q101 standard for use in high performance automotive applications.

### 1.2 Features and benefits

- Q101 compliant
- Repetitive avalanche rated
- Suitable for thermally demanding environments due to 175 °C rating
- True logic level gate with  $V_{GS(th)} > 0.5 \text{ V @ } 175 \text{ °C}$

### 1.3 Applications

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

### 1.4 Quick reference data

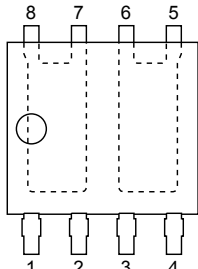
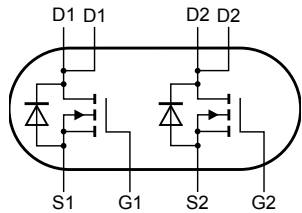
Table 1. Quick reference data

| Symbol                                       | Parameter                        | Conditions                                                                                                              | Min | Typ  | Max | Unit       |
|----------------------------------------------|----------------------------------|-------------------------------------------------------------------------------------------------------------------------|-----|------|-----|------------|
| $V_{DS}$                                     | drain-source voltage             | $T_j \geq 25 \text{ °C}; T_j \leq 175 \text{ °C}$                                                                       | -   | -    | 40  | V          |
| $I_D$                                        | drain current                    | $V_{GS} = 5 \text{ V}; T_{mb} = 25 \text{ °C}; \text{Fig. 1}$                                                           | -   | -    | 40  | A          |
| $P_{tot}$                                    | total power dissipation          | $T_{mb} = 25 \text{ °C}; \text{Fig. 2}$                                                                                 | -   | -    | 68  | W          |
| <b>Static characteristics FET1 and FET2</b>  |                                  |                                                                                                                         |     |      |     |            |
| $R_{DSon}$                                   | drain-source on-state resistance | $V_{GS} = 5 \text{ V}; I_D = 25 \text{ A}; T_j = 25 \text{ °C}; \text{Fig. 12}$                                         | -   | 5.27 | 6.2 | m $\Omega$ |
| <b>Dynamic characteristics FET1 and FET2</b> |                                  |                                                                                                                         |     |      |     |            |
| $Q_{GD}$                                     | gate-drain charge                | $I_D = 10 \text{ A}; V_{DS} = 32 \text{ V}; V_{GS} = 10 \text{ V}; T_j = 25 \text{ °C}; \text{Fig. 14}; \text{Fig. 15}$ | -   | 5.8  | -   | nC         |



## 2. Pinning information

Table 2. Pinning information

| Pin | Symbol | Description | Simplified outline                                                                                                 | Graphic symbol                                                                                                                      |
|-----|--------|-------------|--------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------|
| 1   | S1     | source1     |  <p><b>LFPAK56D (SOT1205)</b></p> |  <p style="text-align: right;"><i>mbk725</i></p> |
| 2   | G1     | gate1       |                                                                                                                    |                                                                                                                                     |
| 3   | S2     | source2     |                                                                                                                    |                                                                                                                                     |
| 4   | G2     | gate2       |                                                                                                                    |                                                                                                                                     |
| 5   | D2     | drain2      |                                                                                                                    |                                                                                                                                     |
| 6   | D2     | drain2      |                                                                                                                    |                                                                                                                                     |
| 7   | D1     | drain1      |                                                                                                                    |                                                                                                                                     |
| 8   | D1     | drain1      |                                                                                                                    |                                                                                                                                     |

## 3. Ordering information

Table 3. Ordering information

| Type number  | Package  |                                                                  | Version |
|--------------|----------|------------------------------------------------------------------|---------|
|              | Name     | Description                                                      |         |
| BUK9K6R2-40E | LFPAK56D | Plastic single ended surface mounted package (LFPAK56D); 8 leads | SOT1205 |

## 4. Limiting values

Table 4. Limiting values

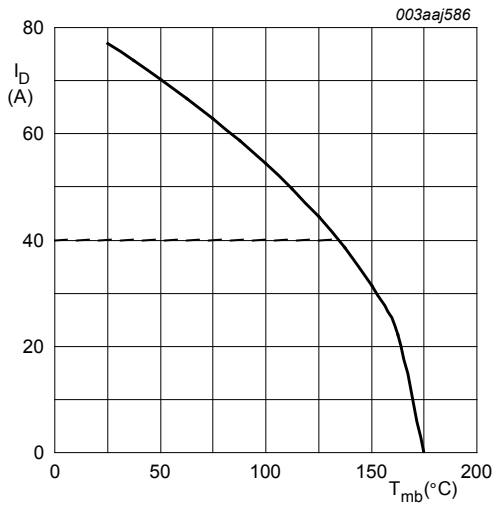
In accordance with the Absolute Maximum Rating System (IEC 60134).

| Symbol                                  | Parameter                  | Conditions                                                                                  | Min | Max | Unit |
|-----------------------------------------|----------------------------|---------------------------------------------------------------------------------------------|-----|-----|------|
| $V_{DS}$                                | drain-source voltage       | $T_j \geq 25\text{ °C}$ ; $T_j \leq 175\text{ °C}$                                          | -   | 40  | V    |
| $V_{DGR}$                               | drain-gate voltage         | $R_{GS} = 20\text{ k}\Omega$ ; $T_j \geq 25\text{ °C}$ ; $T_j \leq 175\text{ °C}$           | -   | 40  | V    |
| $V_{GS}$                                | gate-source voltage        |                                                                                             | -10 | 10  | V    |
| $I_D$                                   | drain current              | $T_{mb} = 25\text{ °C}$ ; $V_{GS} = 5\text{ V}$ ; <a href="#">Fig. 1</a>                    | -   | 40  | A    |
|                                         |                            | $T_{mb} = 100\text{ °C}$ ; $V_{GS} = 5\text{ V}$ ; <a href="#">Fig. 1</a>                   | -   | 40  | A    |
| $I_{DM}$                                | peak drain current         | $T_{mb} = 25\text{ °C}$ ; pulsed; $t_p \leq 10\text{ }\mu\text{s}$ ; <a href="#">Fig. 4</a> | -   | 309 | A    |
| $P_{tot}$                               | total power dissipation    | $T_{mb} = 25\text{ °C}$ ; <a href="#">Fig. 2</a>                                            | -   | 68  | W    |
| $T_{stg}$                               | storage temperature        |                                                                                             | -55 | 175 | °C   |
| $T_j$                                   | junction temperature       |                                                                                             | -55 | 175 | °C   |
| $T_{sld(M)}$                            | peak soldering temperature |                                                                                             | -   | 260 | °C   |
| <b>Source-drain diode FET1 and FET2</b> |                            |                                                                                             |     |     |      |
| $I_S$                                   | source current             | $T_{mb} = 25\text{ °C}$                                                                     | -   | 40  | A    |

| Symbol                                    | Parameter                                    | Conditions                                                                                                                      | Min    | Max | Unit |
|-------------------------------------------|----------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------|--------|-----|------|
| I <sub>SM</sub>                           | peak source current                          | pulsed; t <sub>p</sub> ≤ 10 μs; T <sub>mb</sub> = 25 °C                                                                         | -      | 309 | A    |
| <b>Avalanche Ruggedness FET1 and FET2</b> |                                              |                                                                                                                                 |        |     |      |
| E <sub>DS(AL)S</sub>                      | non-repetitive drain-source avalanche energy | I <sub>D</sub> = 40 A; V <sub>sup</sub> ≤ 40 V; V <sub>GS</sub> = 10 V;<br>T <sub>j(init)</sub> = 25 °C; <a href="#">Fig. 3</a> | [1][2] | 166 | mJ   |

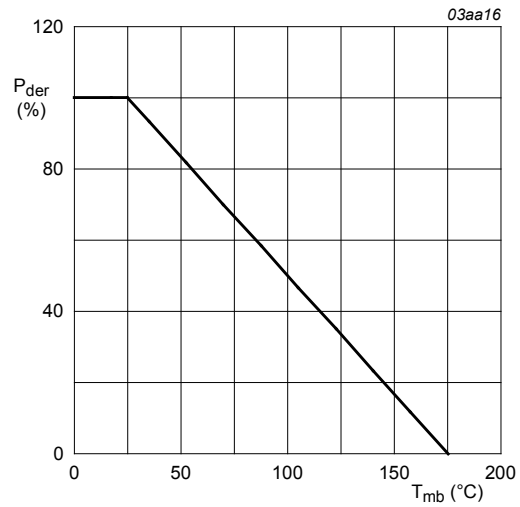
[1] Refer to application note AN10273 for further information

[2] Single-pulse avalanche rating limited by maximum junction temperature of 175 °C



**Fig. 1. Continuous drain current as a function of mounting base temperature**

V<sub>GS</sub> ≥ 10 V; (1) capped at 40 A due to package.



**Fig. 2. Normalized total power dissipation as a function of mounting base temperature**

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

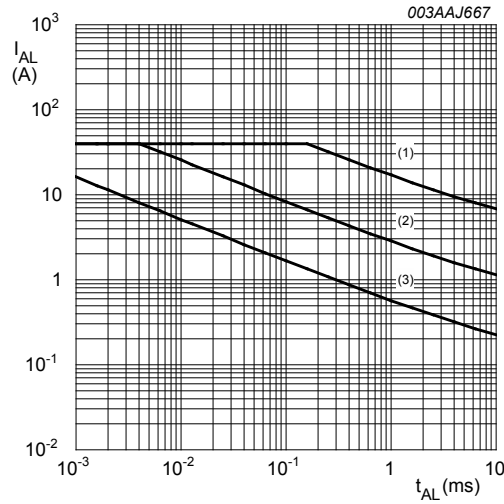


Fig. 3. Single-pulse and repetitive avalanche rating; avalanche current as a function of avalanche time, FET1 and FET2

- (1) Single-pulse;  $T_j = 25\text{ }^\circ\text{C}$ .
- (2) Single-pulse;  $T_j = 175\text{ }^\circ\text{C}$ .
- (3) Repetitive.

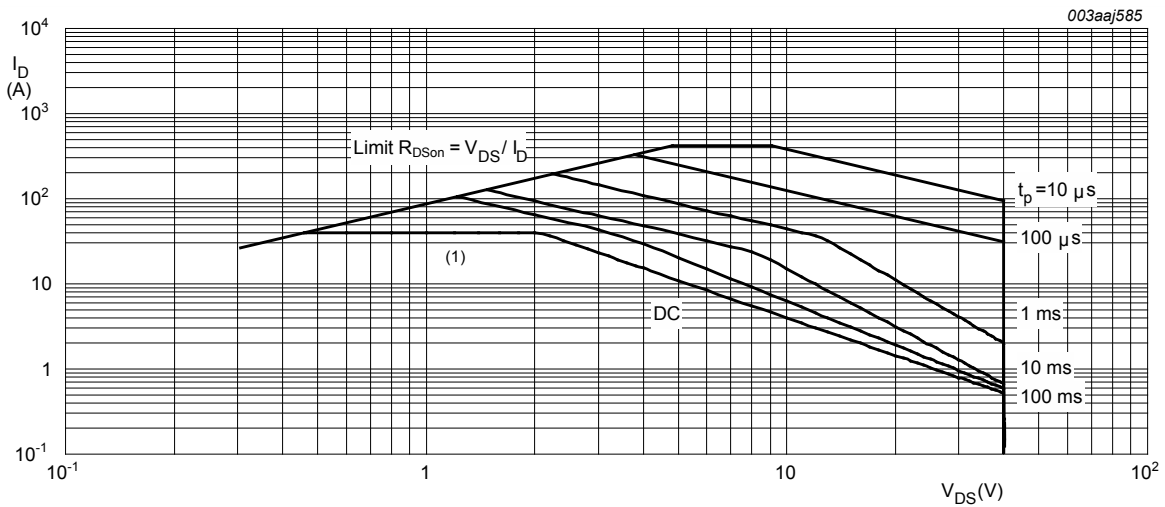


Fig. 4. Safe operating area; continuous and peak drain currents as a function of drain-source voltage

$T_{mb} = 25\text{ }^\circ\text{C}$ ;  $I_{DM}$  is a single pulse; (1) Capped at 40 A due to package

## 5. Thermal characteristics

Table 5. Thermal characteristics

| Symbol         | Parameter                                         | Conditions | Min | Typ | Max | Unit |
|----------------|---------------------------------------------------|------------|-----|-----|-----|------|
| $R_{th(j-mb)}$ | thermal resistance from junction to mounting base | Fig. 5     | -   | -   | 2.1 | K/W  |

| Symbol        | Parameter                                   | Conditions                                            | Min | Typ | Max | Unit |
|---------------|---------------------------------------------|-------------------------------------------------------|-----|-----|-----|------|
| $R_{th(j-a)}$ | thermal resistance from junction to ambient | Minimum footprint; mounted on a printed circuit board | -   | 95  | -   | K/W  |

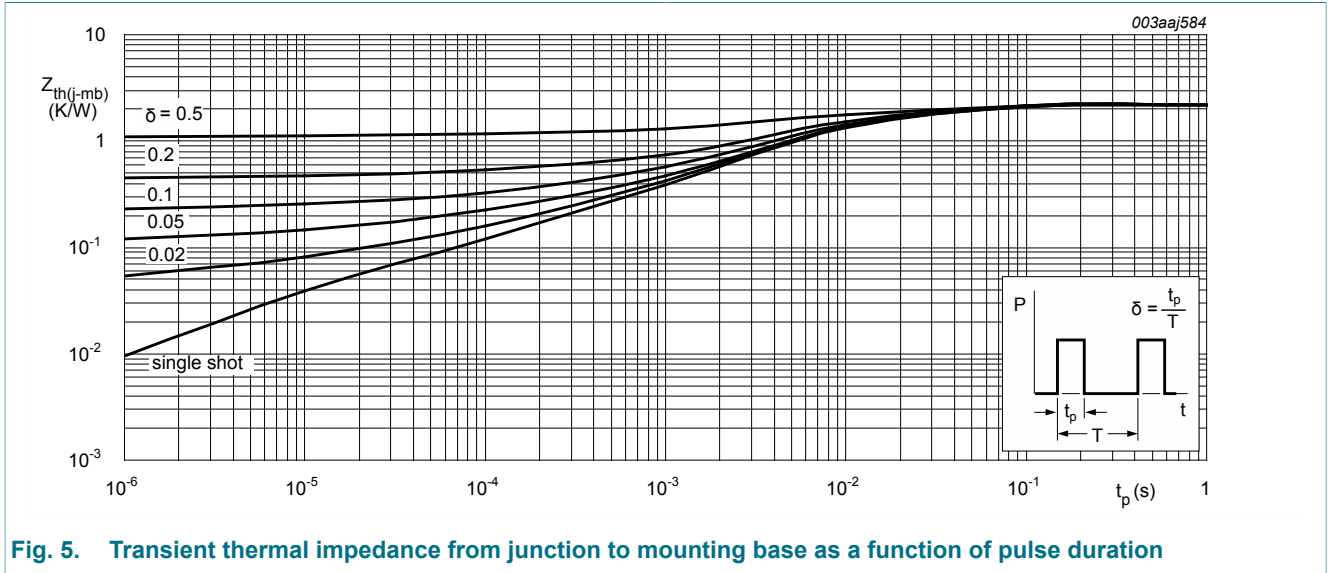


Fig. 5. Transient thermal impedance from junction to mounting base as a function of pulse duration

## 6. Characteristics

Table 6. Characteristics

| Symbol                                      | Parameter                        | Conditions                                                                                                  | Min | Typ  | Max  | Unit       |
|---------------------------------------------|----------------------------------|-------------------------------------------------------------------------------------------------------------|-----|------|------|------------|
| <b>Static characteristics FET1 and FET2</b> |                                  |                                                                                                             |     |      |      |            |
| $V_{(BR)DSS}$                               | drain-source breakdown voltage   | $I_D = 250 \mu A; V_{GS} = 0 V; T_j = -55 \text{ }^\circ C$                                                 | 36  | -    | -    | V          |
|                                             |                                  | $I_D = 250 \mu A; V_{GS} = 0 V; T_j = 25 \text{ }^\circ C$                                                  | 40  | -    | -    | V          |
| $V_{GS(th)}$                                | gate-source threshold voltage    | $I_D = 1 \text{ mA}; V_{DS} = V_{GS}; T_j = 25 \text{ }^\circ C;$<br><a href="#">Fig. 10; Fig. 11</a>       | 1.4 | 1.7  | 2.1  | V          |
|                                             |                                  | $I_D = 1 \text{ mA}; V_{DS} = V_{GS}; T_j = 175 \text{ }^\circ C;$<br><a href="#">Fig. 10; Fig. 11</a>      | 0.5 | -    | -    | V          |
|                                             |                                  | $I_D = 1 \text{ mA}; V_{DS} = V_{GS}; T_j = -55 \text{ }^\circ C;$<br><a href="#">Fig. 10; Fig. 11</a>      | -   | -    | 2.45 | V          |
| $I_{DSS}$                                   | drain leakage current            | $V_{DS} = 40 \text{ V}; V_{GS} = 0 \text{ V}; T_j = 175 \text{ }^\circ C$                                   | -   | -    | 500  | $\mu A$    |
|                                             |                                  | $V_{DS} = 40 \text{ V}; V_{GS} = 0 \text{ V}; T_j = 25 \text{ }^\circ C$                                    | -   | 0.02 | 1    | $\mu A$    |
| $I_{GSS}$                                   | gate leakage current             | $V_{GS} = -10 \text{ V}; V_{DS} = 0 \text{ V}; T_j = 25 \text{ }^\circ C$                                   | -   | 2    | 100  | nA         |
|                                             |                                  | $V_{GS} = 10 \text{ V}; V_{DS} = 0 \text{ V}; T_j = 25 \text{ }^\circ C$                                    | -   | 2    | 100  | nA         |
| $R_{DSon}$                                  | drain-source on-state resistance | $V_{GS} = 5 \text{ V}; I_D = 25 \text{ A}; T_j = 25 \text{ }^\circ C;$ <a href="#">Fig. 12</a>              | -   | 5.27 | 6.2  | m $\Omega$ |
|                                             |                                  | $V_{GS} = 5 \text{ V}; I_D = 25 \text{ A}; T_j = 175 \text{ }^\circ C;$<br><a href="#">Fig. 12; Fig. 13</a> | -   | 9.75 | 11.5 | m $\Omega$ |

| Symbol                                       | Parameter                         | Conditions                                                                                                                                                           | Min | Typ  | Max  | Unit |
|----------------------------------------------|-----------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|------|------|------|
|                                              |                                   | $V_{GS} = 10\text{ V}; I_D = 25\text{ A}; T_j = 25\text{ }^\circ\text{C};$<br><a href="#">Fig. 12</a>                                                                | -   | 4.84 | 6    | mΩ   |
| <b>Dynamic characteristics FET1 and FET2</b> |                                   |                                                                                                                                                                      |     |      |      |      |
| $Q_{G(\text{tot})}$                          | total gate charge                 | $I_D = 10\text{ A}; V_{DS} = 32\text{ V}; V_{GS} = 10\text{ V};$<br>$T_j = 25\text{ }^\circ\text{C};$ <a href="#">Fig. 14</a> ; <a href="#">Fig. 15</a>              | -   | 35.4 | -    | nC   |
| $Q_{GS}$                                     | gate-source charge                |                                                                                                                                                                      | -   | 4.4  | -    | nC   |
| $Q_{GD}$                                     | gate-drain charge                 |                                                                                                                                                                      | -   | 5.8  | -    | nC   |
| $Q_{GS(\text{th})}$                          | pre-threshold gate-source charge  | $I_D = 10\text{ A}; V_{DS} = 32\text{ V}; V_{GS} = 10\text{ V};$<br>$T_j = 25\text{ }^\circ\text{C};$ <a href="#">Fig. 14</a> ; <a href="#">Fig. 15</a>              | -   | 3.4  | -    | nC   |
| $Q_{GS(\text{th-pl})}$                       | post-threshold gate-source charge |                                                                                                                                                                      | -   | 1.1  | -    | nC   |
| $V_{GS(\text{pl})}$                          | gate-source plateau voltage       | $I_D = 10\text{ A}; V_{DS} = 32\text{ V}; T_j = 25\text{ }^\circ\text{C};$<br><a href="#">Fig. 14</a> ; <a href="#">Fig. 15</a>                                      | -   | 2.3  | -    | V    |
| $C_{iss}$                                    | 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. 16</a>                                          | -   | 2461 | 3281 | pF   |
| $C_{oss}$                                    | output capacitance                |                                                                                                                                                                      | -   | 345  | 414  | pF   |
| $C_{rss}$                                    | reverse transfer capacitance      |                                                                                                                                                                      | -   | 162  | 222  | pF   |
| $t_{d(\text{on})}$                           | turn-on delay time                | $V_{DS} = 32\text{ V}; R_L = 3.3\text{ }^\Omega; V_{GS} = 10\text{ V};$<br>$R_{G(\text{ext})} = 5\text{ }^\Omega; T_j = 25\text{ }^\circ\text{C}; I_D = 10\text{ A}$ | -   | 6    | -    | ns   |
| $t_r$                                        | rise time                         |                                                                                                                                                                      | -   | 7.1  | -    | ns   |
| $t_{d(\text{off})}$                          | turn-off delay time               |                                                                                                                                                                      | -   | 44.4 | -    | ns   |
| $t_f$                                        | fall time                         |                                                                                                                                                                      | -   | 19.8 | -    | ns   |
| <b>Source-drain diode FET1 and FET2</b>      |                                   |                                                                                                                                                                      |     |      |      |      |
| $V_{SD}$                                     | source-drain voltage              | $I_S = 25\text{ A}; V_{GS} = 0\text{ V}; T_j = 25\text{ }^\circ\text{C};$ <a href="#">Fig. 17</a>                                                                    | -   | 0.78 | 1.2  | V    |
| $t_{rr}$                                     | reverse recovery time             | $I_S = 25\text{ A}; dI_S/dt = -100\text{ A}/\mu\text{s}; V_{GS} = 0\text{ V};$                                                                                       | -   | 23.7 | -    | ns   |
| $Q_r$                                        | recovered charge                  | $V_{DS} = 20\text{ V}; T_j = 25\text{ }^\circ\text{C}$                                                                                                               | -   | 16.8 | -    | nC   |

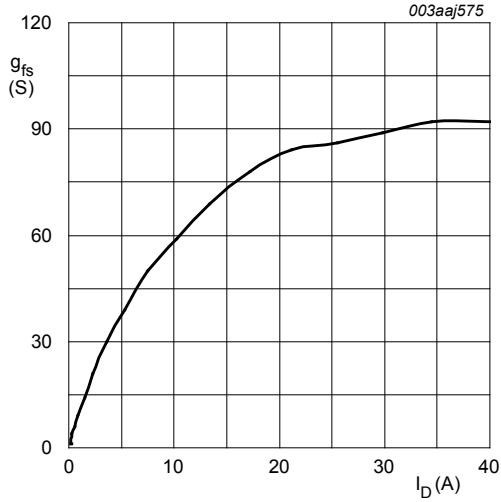


Fig. 6. Forward transconductance as a function of drain current; typical values

$$T_j = 25^\circ\text{C}; V_{DS} = 15\text{ V}$$

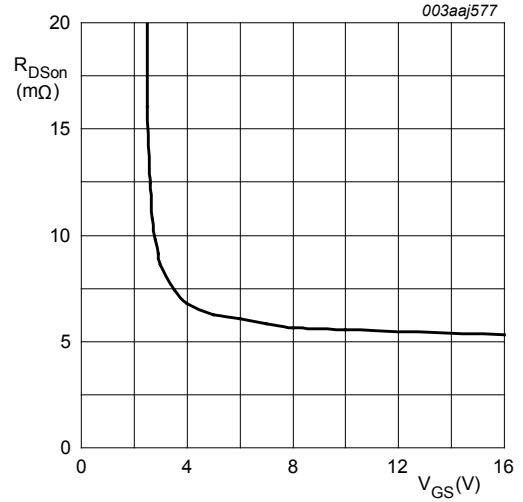


Fig. 7. Drain-source on-state resistance as a function of gate-source voltage; typical values

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

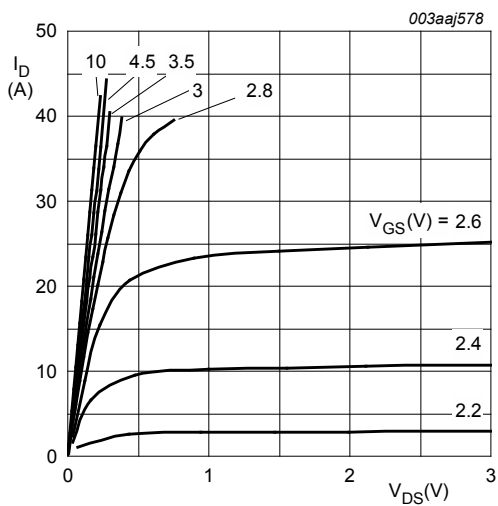


Fig. 8. Output characteristics: drain current as a function of drain-source voltage; typical values

$$T_j = 25^\circ\text{C}$$

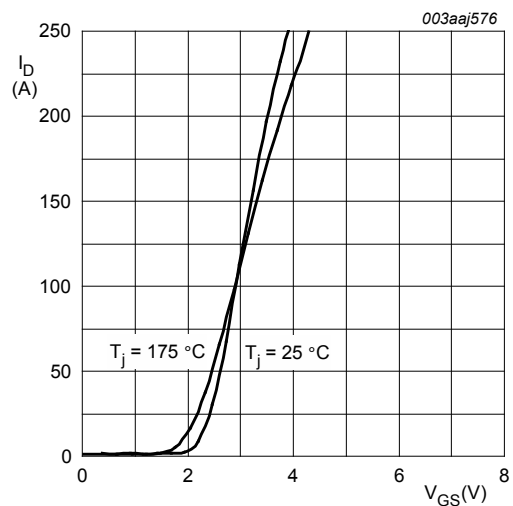
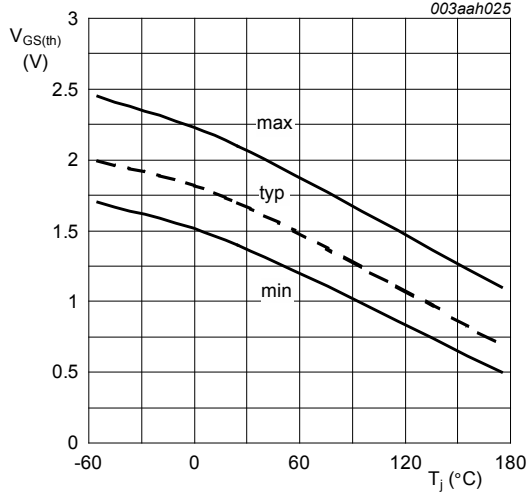


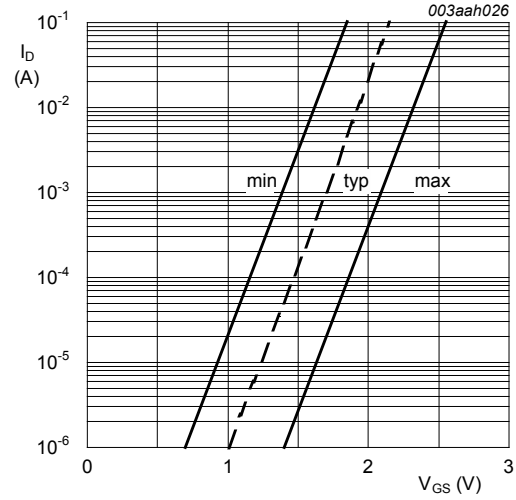
Fig. 9. Transfer characteristics: drain current as a function of gate-source voltage; typical values

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



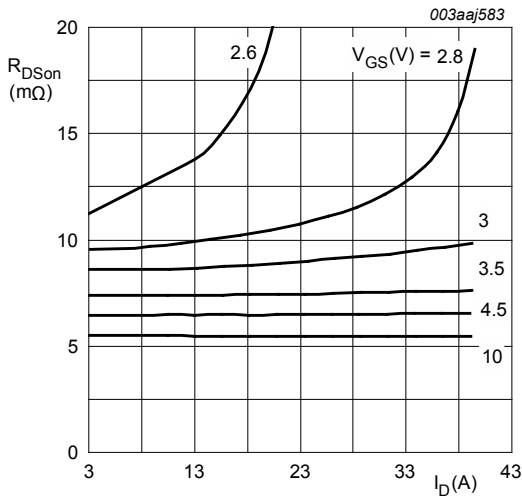
**Fig. 10. Gate-source threshold voltage as a function of junction temperature**

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



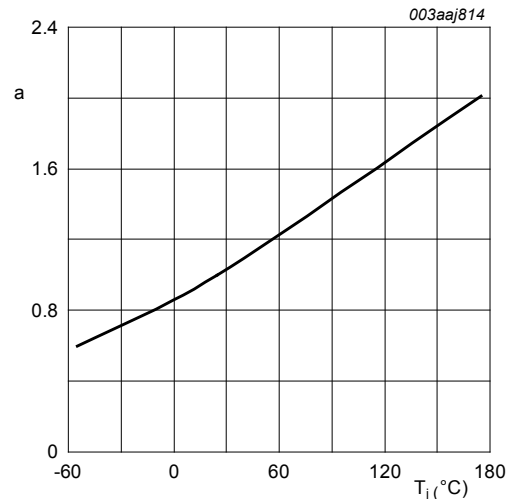
**Fig. 11. Sub-threshold drain current as a function of gate-source voltage**

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



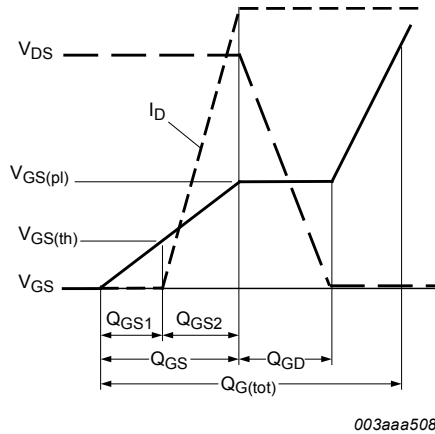
**Fig. 12. Drain-source on-state resistance as a function of drain current; typical values**

$$T_j = 25^\circ\text{C}$$



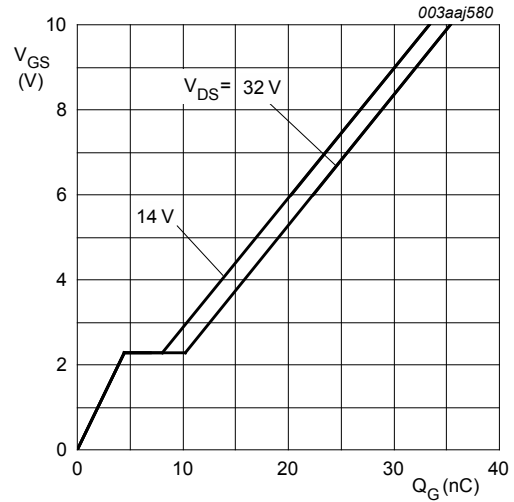
**Fig. 13. Normalized drain-source on-state resistance factor as a function of junction temperature**

$$\alpha = \frac{R_{DS(on)}}{R_{DS(on)}(25^\circ\text{C})}$$



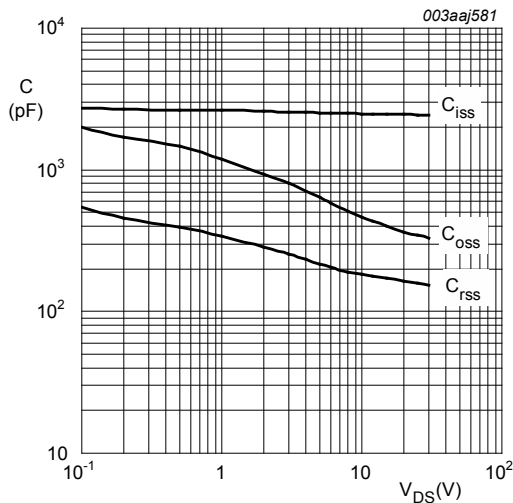
**Fig. 14. Gate charge waveform definitions**

003aaa508



**Fig. 15. Gate-source voltage as a function of gate charge; typical values**

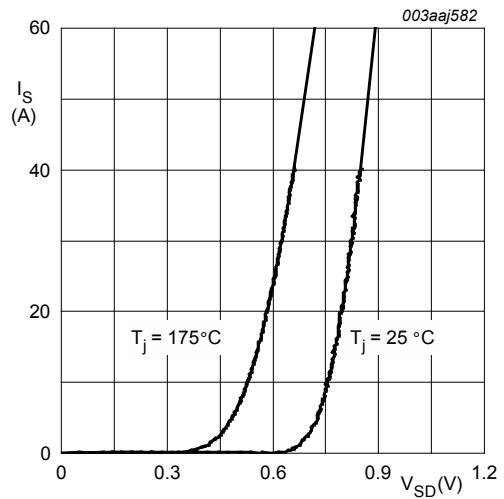
$T_j = 25^\circ\text{C}; I_D = 10\text{A}$



**Fig. 16. Input, output and reverse transfer capacitances as a function of drain-source voltage; typical values**

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

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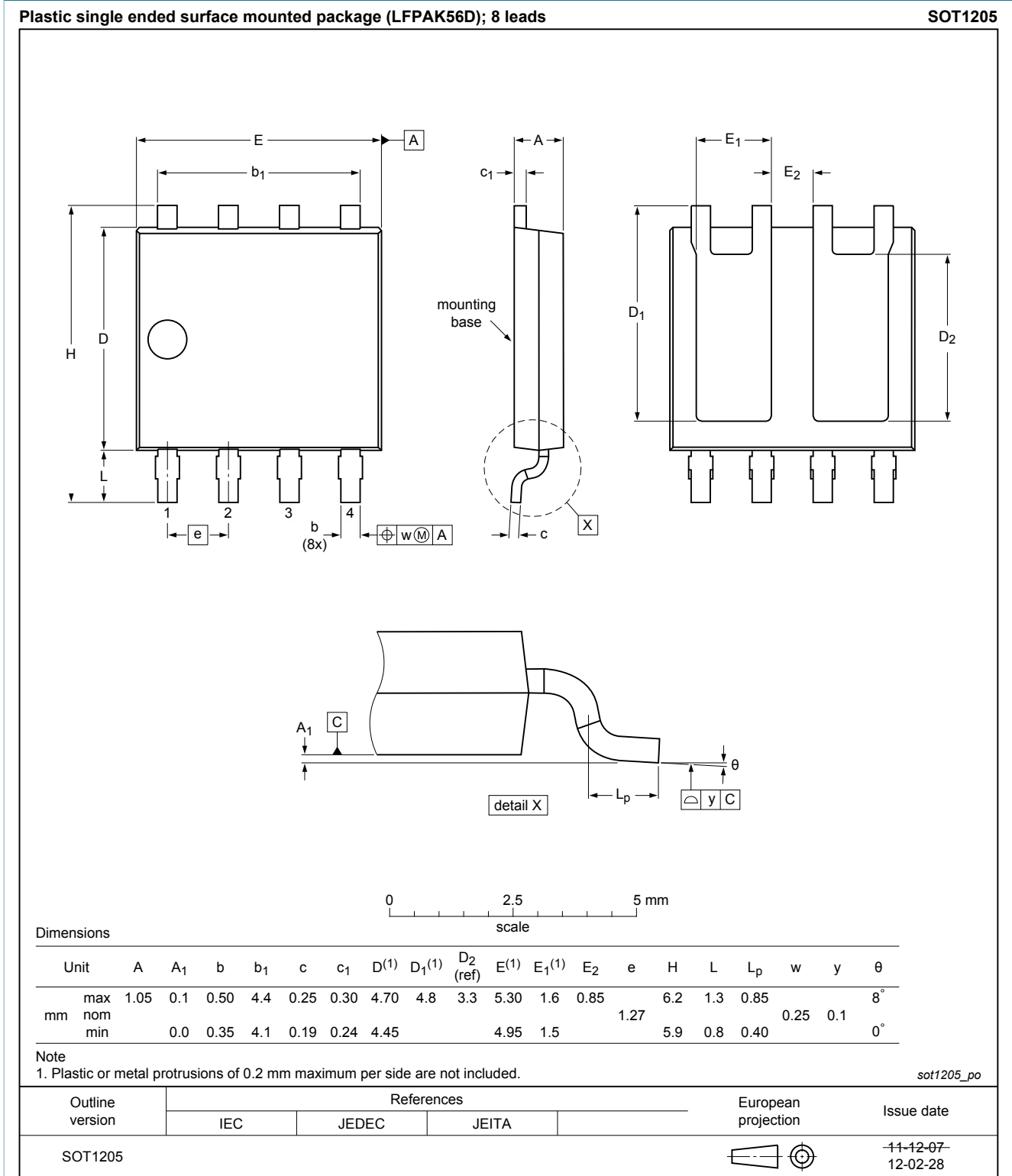


**Fig. 17. Source (diode forward) current as a function of source-drain (diode forward) voltage; typical values**

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

003aaaj582

**7. Package outline**



**Fig. 18. LPAK56D (SOT1205)**

## 8. Legal information

### 8.1 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.nxp.com>.

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