
# BUK9M9R1-40E

**N-channel 40 V, 9.1 mΩ logic level MOSFET in LFPAK33**

**19 September 2016** **Product data sheet**

## 1. General description

Logic level N-channel MOSFET in an LFPAK33 (Power33) 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

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

## 3. Applications

- 12 V automotive systems
- Motors, lamps and solenoid control
- Transmission control
- Ultra high performance power switching

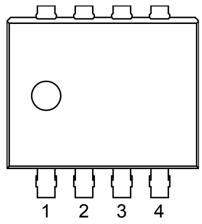
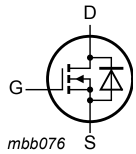
## 4. Quick reference data

**Table 1. Quick reference data**

| Symbol | Parameter | Conditions | | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|---|
| $V_{DS}$ | drain-source voltage | 25 °C ≤ $T_j$ ≤ 175 °C | | - | - | 40 | V |
| $I_D$ | drain current | $V_{GS}$ = 5 V; $T_{mb}$ = 25 °C; Fig. 2 | | - | - | 64 | A |
| $P_{tot}$ | total power dissipation | $T_{mb}$ = 25 °C; Fig. 1 | | - | - | 75 | W |
| **Static characteristics** | | | | | | | |
| $R_{DSon}$ | drain-source on-state resistance | $V_{GS}$ = 5 V; $I_D$ = 20 A; $T_j$ = 25 °C; Fig. 11 | | - | 7.5 | 9.1 | mΩ |
| **Dynamic characteristics** | | | | | | | |
| $Q_{GD}$ | gate-drain charge | $I_D$ = 20 A; $V_{DS}$ = 32 V; $V_{GS}$ = 5 V; $T_j$ = 25 °C; Fig. 13; Fig. 14 | | - | 6.3 | - | nC |

# 5. Pinning information

**Table 2. Pinning information**

| Pin | Symbol | Description | Simplified outline | Graphic symbol |
|---|---|---|---|---|
| 1 | S | Source |  LFPAK33 (SOT1210) |  |
| 2 | S | Source | | |
| 3 | S | Source | | |
| 4 | G | Gate | | |
| mb | D | Mounting base; connected to drain | | |

# 6. Ordering information

**Table 3. Ordering information**

| Type number | Package | | |
|---|---|---|---|
| | Name | Description | Version |
| BUK9M9R1-40E | LFPAK33 | Plastic single ended surface mounted package (LFPAK33); 8 leads | SOT1210 |

# 7. Marking

**Table 4. Marking codes**

| Type number | Marking code |
|---|---|
| BUK9M9R1-40E | 99E140 |

# 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 | 25 °C ≤ $T_j$ ≤ 175 °C | | - | 40 | V |
| $V_{DGR}$ | drain-gate voltage | $R_{GS}$ = 20 kΩ | | - | 40 | V |
| $V_{GS}$ | gate-source voltage | DC; $T_j$ ≤ 175 °C | | -10 | 10 | V |
| | | Pulsed; $T_j$ ≤ 175 °C | [1][2] | -15 | 15 | V |
| $P_{tot}$ | total power dissipation | $T_{mb}$ = 25 °C; Fig. 1 | | - | 75 | W |
| $I_D$ | drain current | $V_{GS}$ = 5 V; $T_{mb}$ = 25 °C; Fig. 2 | | - | 64 | A |
| | | $V_{GS}$ = 5 V; $T_{mb}$ = 100 °C; Fig. 2 | | - | 45.5 | A |
| $I_{DM}$ | peak drain current | pulsed; $t_p$ ≤ 10 µs; $T_{mb}$ = 25 °C; Fig. 3 | | - | 258 | A |

| Symbol | Parameter | Conditions | | Min | Max | Unit |
|---|---|---|---|---|---|---|
| $T_{stg}$ | storage temperature | | | -55 | 175 | °C |
| $T_j$ | junction temperature | | | -55 | 175 | °C |
| **Source-drain diode** | | | | | | |
| $I_S$ | source current | $T_{mb}$ = 25 °C | | - | 63 | A |
| $I_{SM}$ | peak source current | pulsed; $t_p \leq$ 10 µs; $T_{mb}$ = 25 °C | | - | 258 | A |
| **Avalanche ruggedness** | | | | | | |
| $E_{DS(AL)S}$ | non-repetitive drain-source avalanche energy | $I_D$ = 64 A; $V_{sup} \leq$ 40 V; $R_{GS}$ = 50 Ω; $V_{GS}$ = 5 V; $T_{j(init)}$ = 25 °C; unclamped; Fig. 4 | [3][4] | - | 42.8 | mJ |

[1] Accumulated pulse duration up to 50 hours delivers zero defect ppm.
[2] Significantly longer life times are achieved by lowering $T_j$ and or $V_{GS}$
[3] Single-pulse avalanche rating limited by maximum junction temperature of 175 °C.
[4] Refer to application note AN10273 for further information.

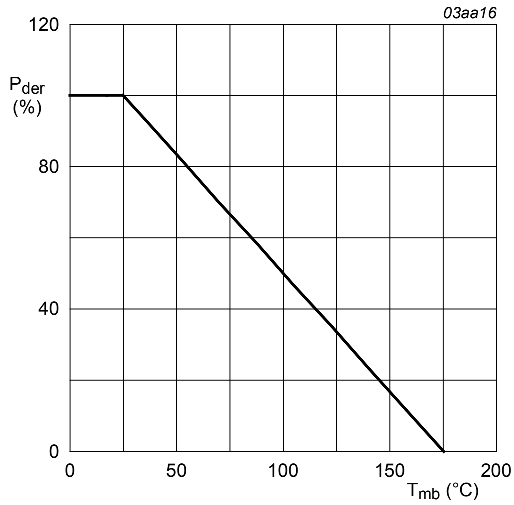
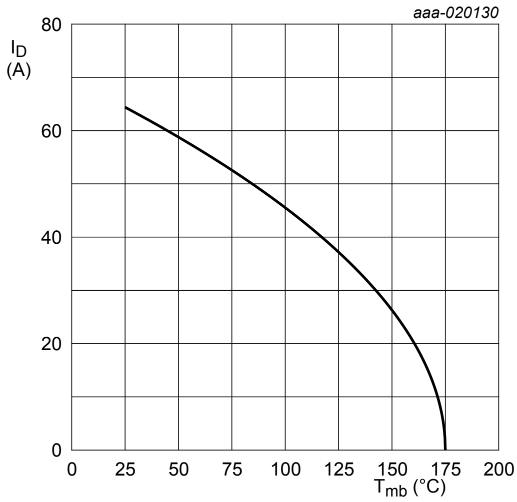



**Fig. 1. Normalized total power dissipation as a function of mounting base temperature**

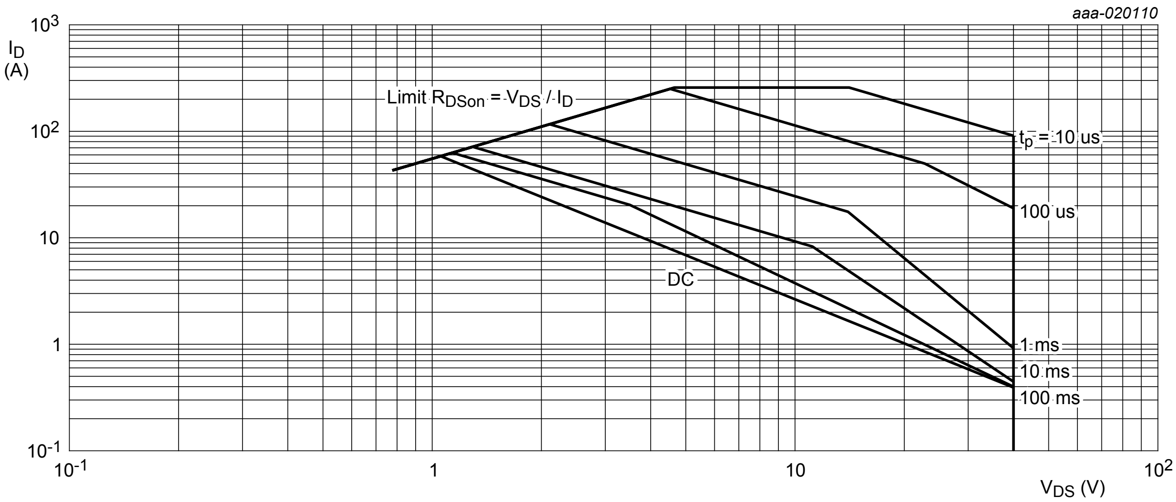
$$P_{der} = \frac{P_{tot}}{P_{tot(25°C)}} \times 100\,\%$$




$V_{GS} \geq 5$ V

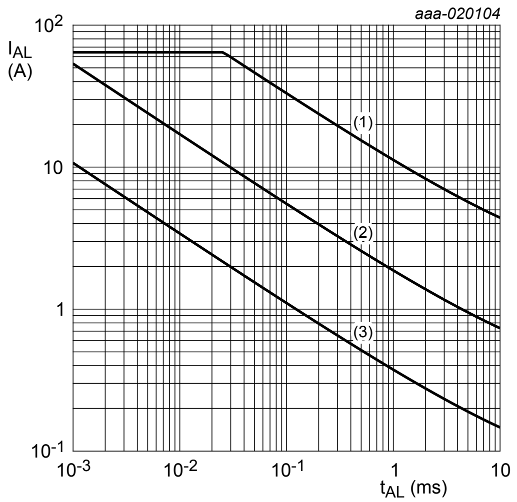
**Fig. 2. Continuous drain current as a function of mounting base temperature**

$$I_D = 64A \times \sqrt{\frac{175°C - T_{mb}}{150°C}} \text{ for } T_{mb} \geq 25°C$$




$T_{mb}$ = 25 °C; $I_{DM}$ is a single pulse

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




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

**Fig. 4. Avalanche rating; avalanche current as a function of avalanche time**

## 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 | Fig. 5 | | - | 1.82 | 2 | K/W |

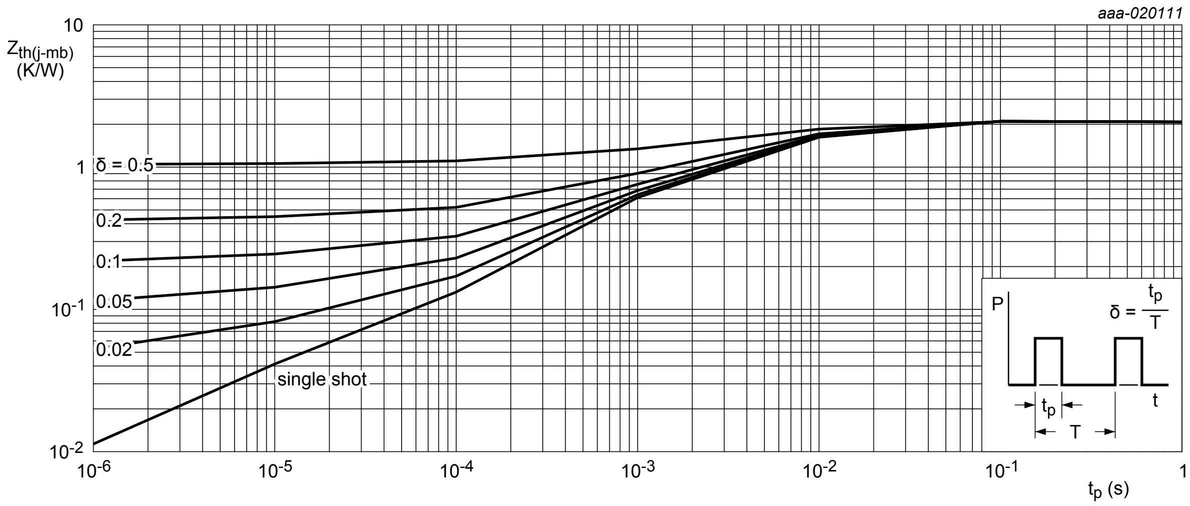


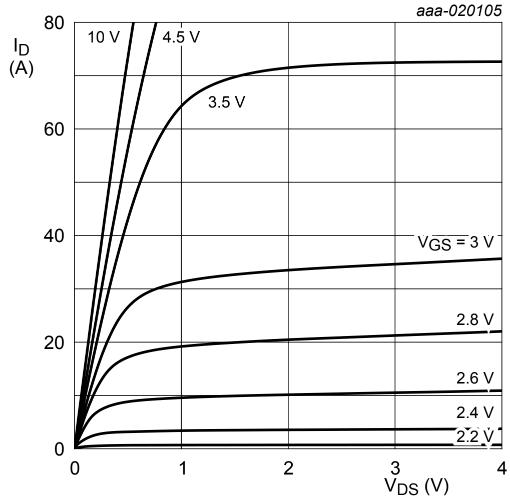

**Fig. 5. Transient thermal impedance from junction to mounting base as a function of pulse duration**

## 10. Characteristics

**Table 7. Characteristics**

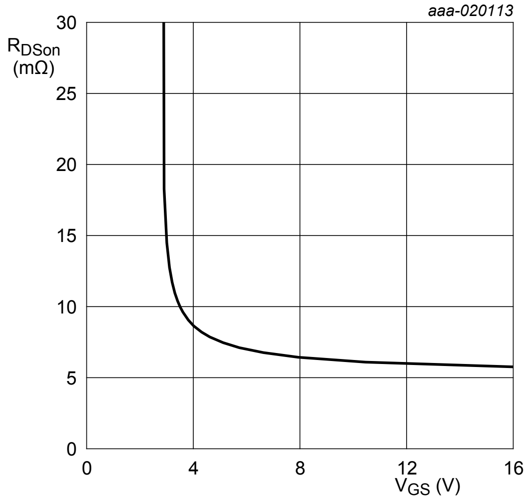
| Symbol | Parameter | Conditions | | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|---|
| **Static characteristics** | | | | | | | |
| $V_{(BR)DSS}$ | drain-source breakdown voltage | $I_D$ = 250 µA; $V_{GS}$ = 0 V; $T_j$ = 25 °C | | 40 | - | - | V |
| | | $I_D$ = 250 µA; $V_{GS}$ = 0 V; $T_j$ = -55 °C | | 36 | - | - | V |
| $V_{GS(th)}$ | gate-source threshold voltage | $I_D$ = 1 mA; $V_{DS}$ = $V_{GS}$; $T_j$ = 25 °C; Fig. 9; Fig. 10 | | 1.4 | 1.7 | 2.1 | V |
| | | $I_D$ = 1 mA; $V_{DS}$ = $V_{GS}$; $T_j$ = -55 °C | | - | - | 2.45 | V |
| | | $I_D$ = 1 mA; $V_{DS}$ = $V_{GS}$; $T_j$ = 175 °C | | 0.5 | - | - | V |
| $I_{DSS}$ | drain leakage current | $V_{DS}$ = 40 V; $V_{GS}$ = 0 V; $T_j$ = 25 °C | | - | 0.01 | 1 | µA |
| | | $V_{DS}$ = 40 V; $V_{GS}$ = 0 V; $T_j$ = 175 °C | | - | - | 500 | µA |
| $I_{GSS}$ | gate leakage current | $V_{GS}$ = 10 V; $V_{DS}$ = 0 V; $T_j$ = 25 °C | | - | 2 | 100 | nA |
| | | $V_{GS}$ = -10 V; $V_{DS}$ = 0 V; $T_j$ = 25 °C | | - | 2 | 100 | nA |
| $R_{DSon}$ | drain-source on-state resistance | $V_{GS}$ = 5 V; $I_D$ = 20 A; $T_j$ = 25 °C; Fig. 11 | | - | 7.5 | 9.1 | mΩ |
| | | $V_{GS}$ = 10 V; $I_D$ = 20 A; $T_j$ = 25 °C; Fig. 11 | | - | 6.2 | 7.3 | mΩ |
| | | $V_{GS}$ = 5 V; $I_D$ = 20 A; $T_j$ = 175 °C; Fig. 12 | | - | - | 18.1 | mΩ |
| **Dynamic characteristics** | | | | | | | |
| $Q_{G(tot)}$ | total gate charge | $I_D$ = 20 A; $V_{DS}$ = 32 V; $V_{GS}$ = 5 V; $T_j$ = 25 °C; Fig. 13; Fig. 14 | | - | 16.2 | - | nC |
| $Q_{GS}$ | gate-source charge | | | - | 4.2 | - | nC |
| $Q_{GD}$ | gate-drain charge | | | - | 6.3 | - | nC |

| Symbol | Parameter | Conditions | | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|---|
| $C_{iss}$ | input capacitance | $V_{DS}$ = 25 V; $V_{GS}$ = 0 V; f = 1 MHz; $T_j$ = 25 °C; Fig. 15 | | - | 1540 | 2048 | pF |
| $C_{oss}$ | output capacitance | | | - | 216 | 259 | pF |
| $C_{rss}$ | reverse transfer capacitance | | | - | 114 | 156 | pF |
| $t_{d(on)}$ | turn-on delay time | $V_{DS}$ = 30 V; $R_L$ = 1.5 Ω; $V_{GS}$ = 5 V; $R_{G(ext)}$ = 5 Ω; $T_j$ = 25 °C | | - | 11.9 | - | ns |
| $t_r$ | rise time | | | - | 25 | - | ns |
| $t_{d(off)}$ | turn-off delay time | | | - | 24.2 | - | ns |
| $t_f$ | fall time | | | - | 18.7 | - | ns |
| **Source-drain diode** | | | | | | | |
| $V_{SD}$ | source-drain voltage | $I_S$ = 20 A; $V_{GS}$ = 0 V; $T_j$ = 25 °C; Fig. 16 | | - | 0.86 | 1.2 | V |
| $t_{rr}$ | reverse recovery time | $I_S$ = 20 A; $dI_S/dt$ = -100 A/µs; $V_{GS}$ = 0 V; $V_{DS}$ = 25 V; $T_j$ = 25 °C | | - | 21 | - | ns |
| $Q_r$ | recovered charge | | | - | 13.4 | - | nC |



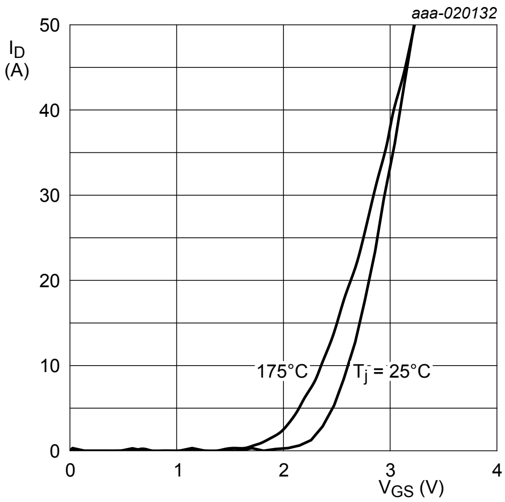

$T_j$ = 25 °C

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



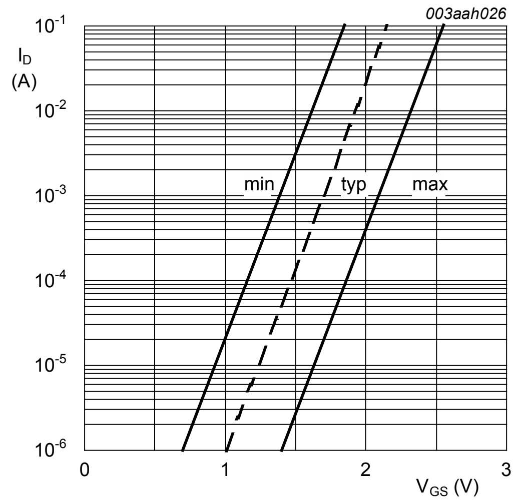

$T_j$ = 25 °C; $I_D$ = 20 A

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



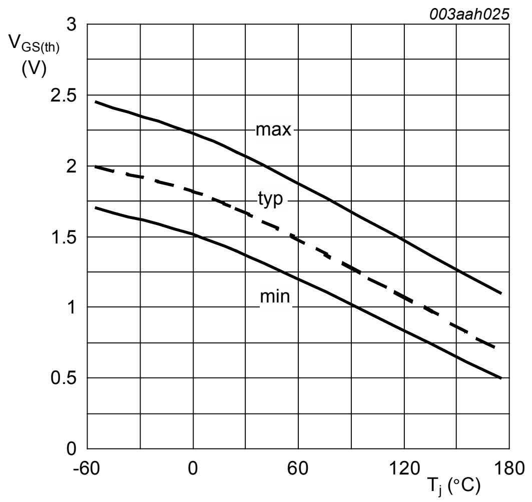

$V_{DS}$ = 12 V

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



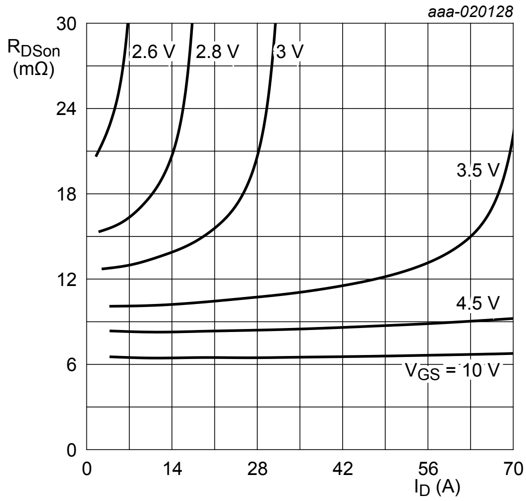

$T_j$ = 25 °C; $V_{DS}$ = 5 V

**Fig. 9. Sub-threshold drain current as a function of gate-source voltage**




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

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




$T_j$ = 25 °C

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

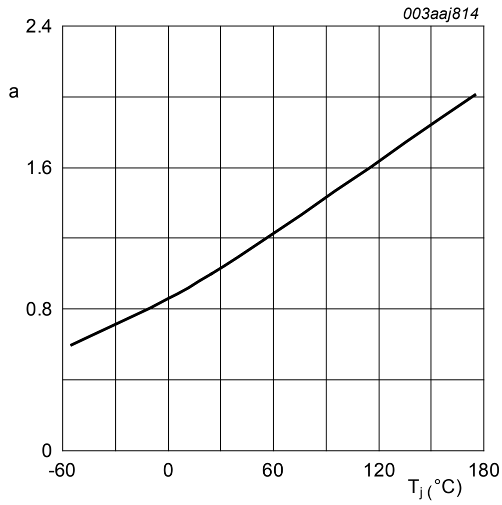
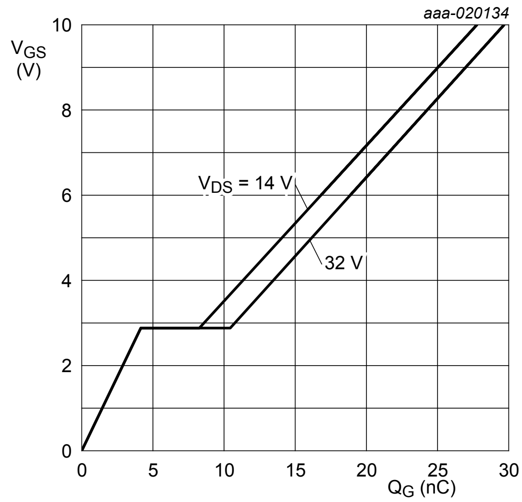



Fig. 12. Normalized drain-source on-state resistance factor as a function of junction temperature

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




$T_j$ = 25 °C; $I_D$ = 20 A

Fig. 13. Gate-source voltage as a function of gate charge; typical values

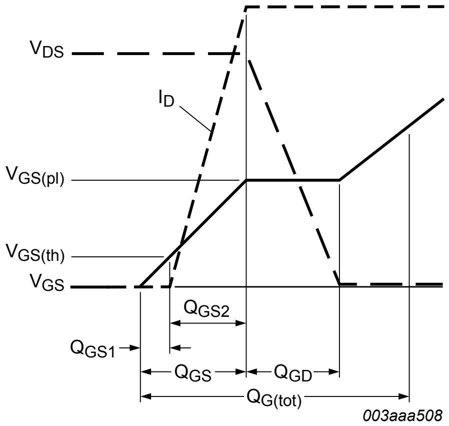
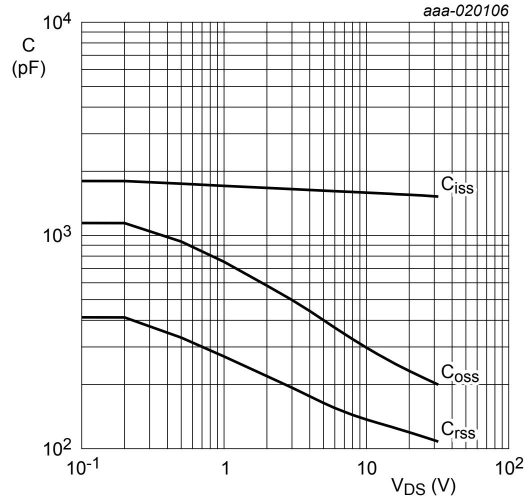
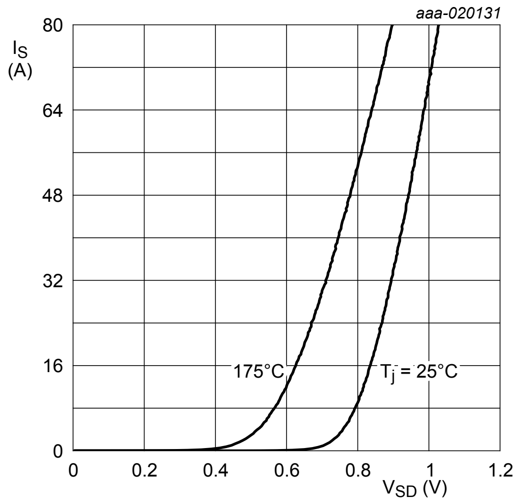



Fig. 14. Gate charge waveform definitions




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

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




$V_{GS}$ = 0 V

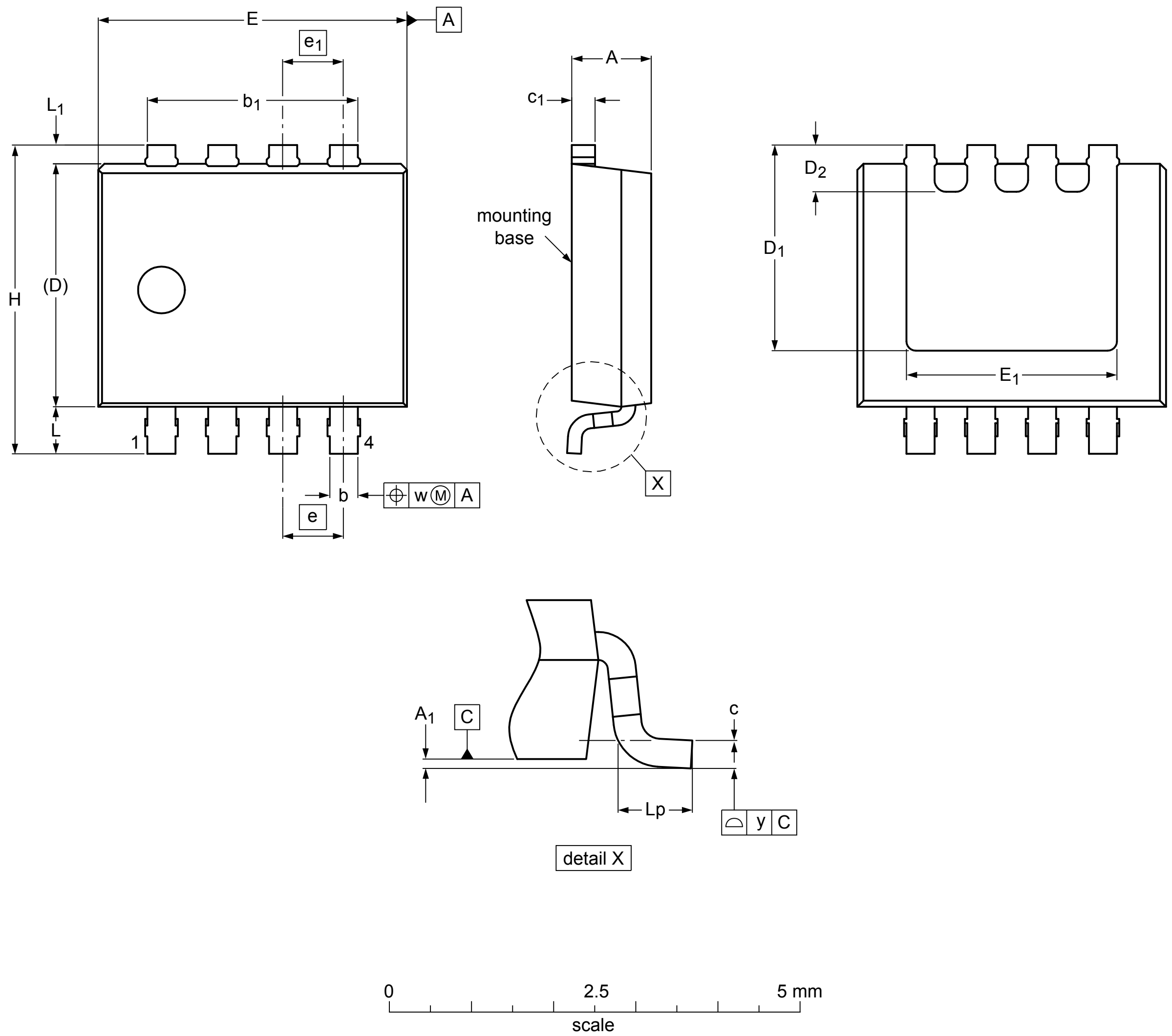
**Fig. 16. Source-drain (diode forward) current as a function of source-drain (diode forward) voltage; typical values**

## 11. Application information

For guidance on how to use and understand this datasheet, please refer to application note AN11158 "Understanding power MOSFET datasheet parameters".

## 12. Package outline

**Plastic single ended surface mounted package (LFPAK33); 8 leads** **SOT1210**




Dimensions

| Unit(1) | | A | $A_1$ | b(1) | $b_1$(1) | c | $c_1$ | D ref | $D_1$ | $D_2$ | E(1) | $E_1$ | e | $e_1$ | H | L | $L_1$ | $L_p$ | w | y |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| mm | max | 0.90 | 0.10 | 0.35 | 2.4 | 0.20 | 0.30 | | 2.35 | | 3.40 | 2.45 | | | 3.40 | 0.65 | 0.25 | 0.50 | | |
| | nom | | | | | | | 2.60 | | 0.50 | | | 0.65 | 0.65 | | | | | 0.20 | 0.10 |
| | min | 0.80 | 0.00 | 0.25 | 2.2 | 0.10 | 0.20 | | 1.90 | | 3.20 | 2.00 | | | 3.20 | 0.45 | 0.13 | 0.30 | | |

Note
1. Plastic or metal protrusions of 0.15 mm per side are not included.

*sot1210_po*

| Outline version | References | | | | European projection | Issue date |
|---|---|---|---|---|---|---|
| | IEC | JEDEC | JEITA | | | |
| SOT1210 | | | | | | ~~14-04-25~~<br>16-08-09 |

**Fig. 17. Package outline LFPAK33 (SOT1210)**

# 13. Legal information

## 13.1 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.
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**Date of release: 19 September 2016**