



# BUK9M24-60E

N-channel 60 V, 24 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

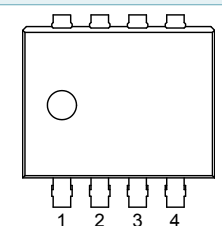
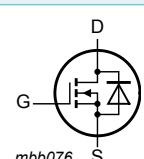
## 4. Quick reference data

Table 1. Quick reference data

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$V_{DS}$	drain-source voltage	$25\text{ °C} \leq T_j \leq 175\text{ °C}$	-	-	60	V
$I_D$	drain current	$V_{GS} = 5\text{ V}$ ; $T_{mb} = 25\text{ °C}$ ; <a href="#">Fig. 2</a>	-	-	32	A
$P_{tot}$	total power dissipation	$T_{mb} = 25\text{ °C}$ ; <a href="#">Fig. 1</a>	-	-	55	W
<b>Static characteristics</b>						
$R_{DS(on)}$	drain-source on-state resistance	$V_{GS} = 5\text{ V}$ ; $I_D = 10\text{ A}$ ; $T_j = 25\text{ °C}$ ; <a href="#">Fig. 11</a>	-	19	24	mΩ
<b>Dynamic characteristics</b>						
$Q_{GD}$	gate-drain charge	$I_D = 10\text{ A}$ ; $V_{DS} = 48\text{ V}$ ; $V_{GS} = 5\text{ V}$ ; $T_j = 25\text{ °C}$ ; <a href="#">Fig. 13</a> ; <a href="#">Fig. 14</a>	-	4.9	-	nC

## 5. Pinning information

Table 2. Pinning information

Pin	Symbol	Description	Simplified outline	Graphic symbol
1	S	Source	 <p>LFAK33 (SOT1210)</p>	 <p>mbb076</p>
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
BUK9M24-60E	LFAK33	Plastic single ended surface mounted package (LFAK33); 8 leads	SOT1210

## 7. Marking

Table 4. Marking codes

Type number	Marking code
BUK9M24-60E	92460E

## 8. Limiting values

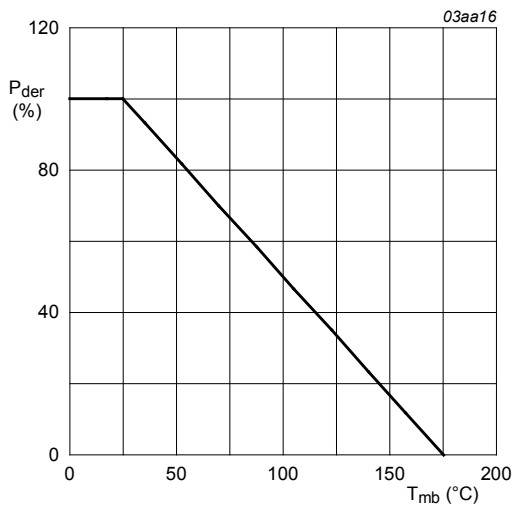
Table 5. Limiting values

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

Symbol	Parameter	Conditions	Min	Max	Unit
$V_{DS}$	drain-source voltage	$25\text{ °C} \leq T_j \leq 175\text{ °C}$	-	60	V
$V_{DGR}$	drain-gate voltage	$R_{GS} = 20\text{ k}\Omega$	-	60	V
$V_{GS}$	gate-source voltage	DC; $T_j \leq 175\text{ °C}$	-10	10	V
		Pulsed; $T_j \leq 175\text{ °C}$	[1][2]	15	V
$P_{tot}$	total power dissipation	$T_{mb} = 25\text{ °C}$ ; Fig. 1	-	55	W
$I_D$	drain current	$V_{GS} = 5\text{ V}$ ; $T_{mb} = 25\text{ °C}$ ; Fig. 2	-	32	A
		$V_{GS} = 5\text{ V}$ ; $T_{mb} = 100\text{ °C}$ ; Fig. 2	-	22.4	A
$I_{DM}$	peak drain current	pulsed; $t_p \leq 10\text{ }\mu\text{s}$ ; $T_{mb} = 25\text{ °C}$ ; Fig. 3	-	127	A

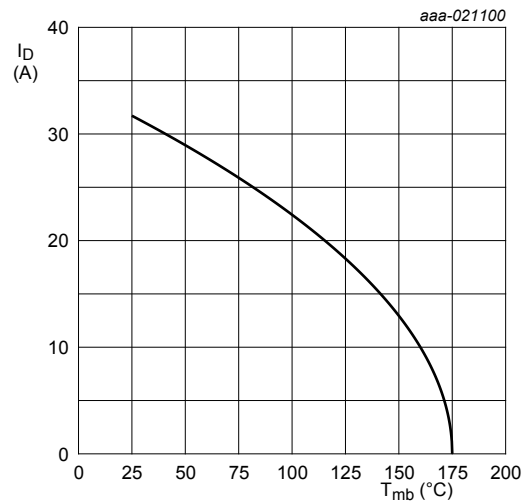
Symbol	Parameter	Conditions	Min	Max	Unit
T <sub>stg</sub>	storage temperature		-55	175	°C
T <sub>j</sub>	junction temperature		-55	175	°C
<b>Source-drain diode</b>					
I <sub>S</sub>	source current	T <sub>mb</sub> = 25 °C	-	32	A
I <sub>SM</sub>	peak source current	pulsed; t <sub>p</sub> ≤ 10 μs; T <sub>mb</sub> = 25 °C	-	127	A
<b>Avalanche ruggedness</b>					
E <sub>DS(AL)S</sub>	non-repetitive drain-source avalanche energy	I <sub>D</sub> = 32 A; V <sub>sup</sub> ≤ 60 V; R <sub>GS</sub> = 50 Ω; V <sub>GS</sub> = 5 V; T <sub>j(init)</sub> = 25 °C; unclamped; <a href="#">Fig. 4</a>	[3][4]	-	23.9 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] 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**

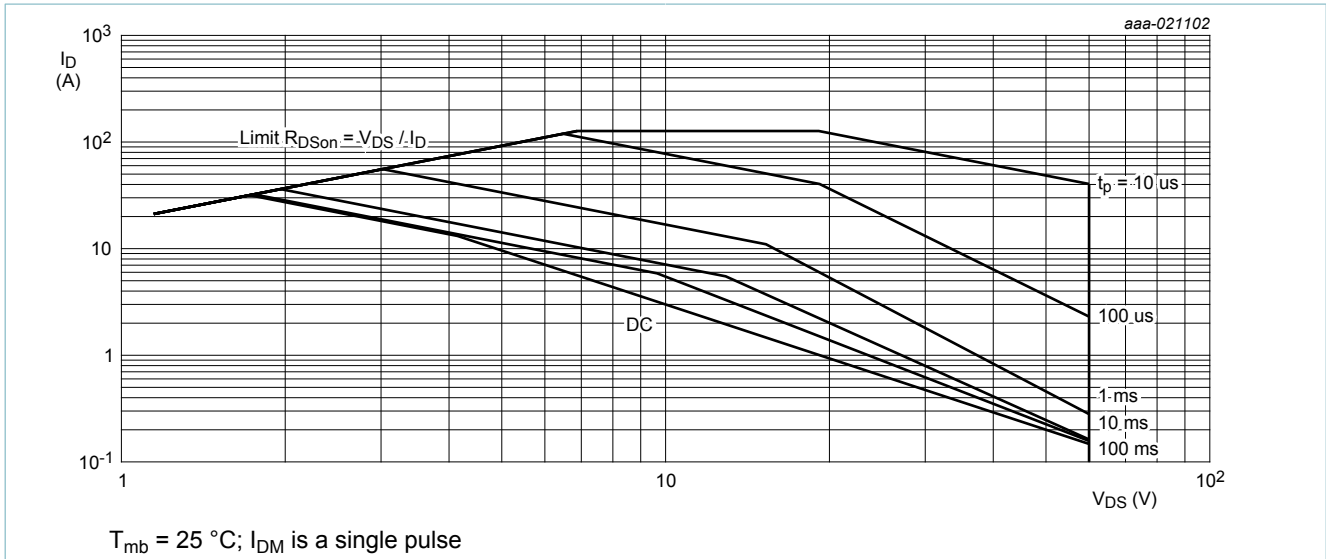
$$P_{der} = \frac{P_{tot}}{P_{tot(25^\circ C)}} \times 100\%$$



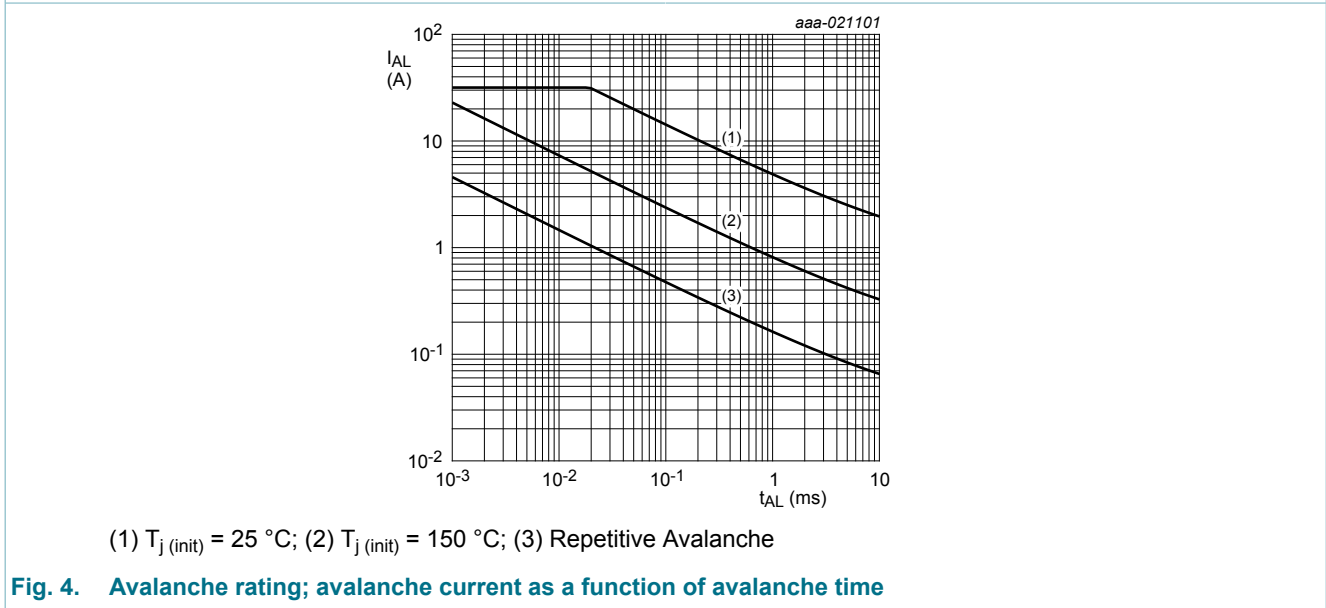
V<sub>GS</sub> ≥ 5 V

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

$$I_D = 32A \times \sqrt{\frac{175^\circ C - T_{mb}}{150^\circ C}} \text{ for } T_{mb} \geq 25^\circ C$$



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



**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	<a href="#">Fig. 5</a>	-	2.46	2.75	K/W

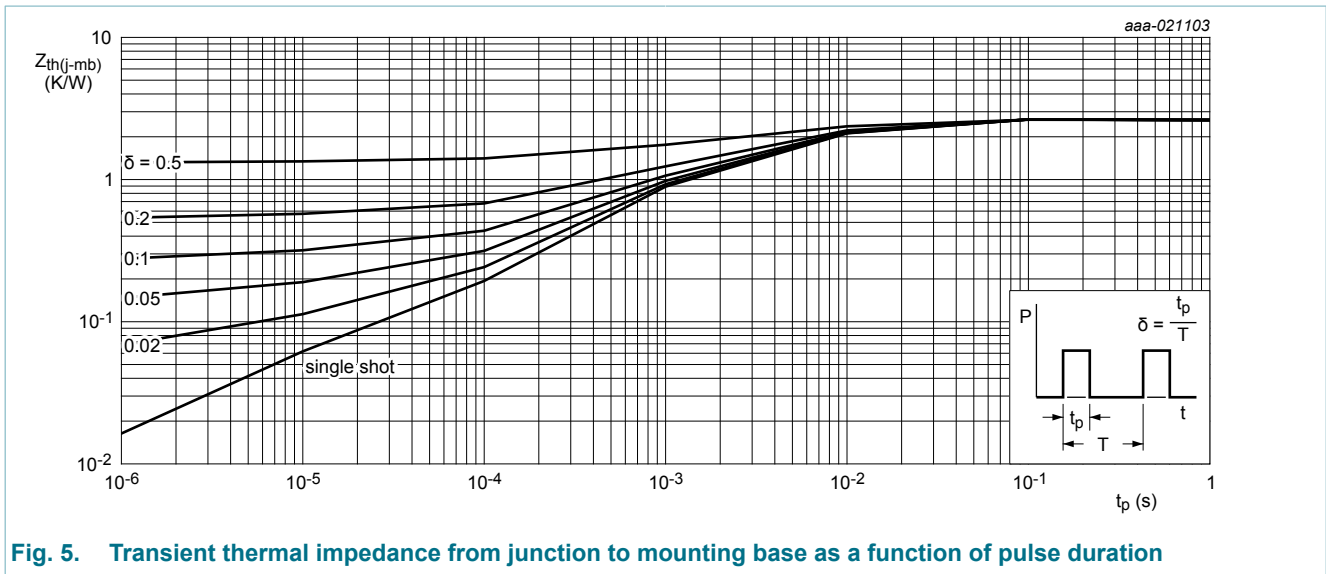


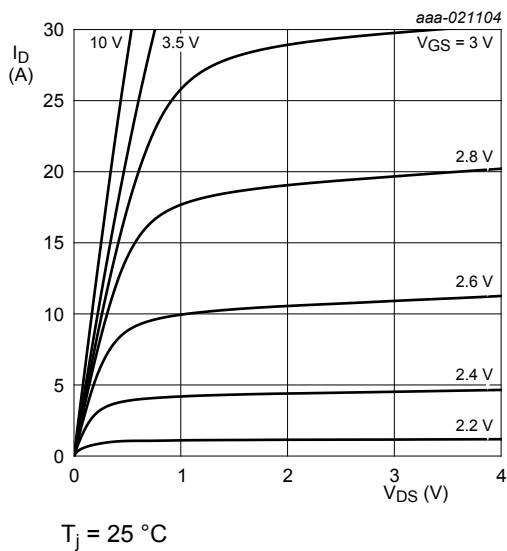
Fig. 5. Transient thermal impedance from junction to mounting base as a function of pulse duration

## 10. Characteristics

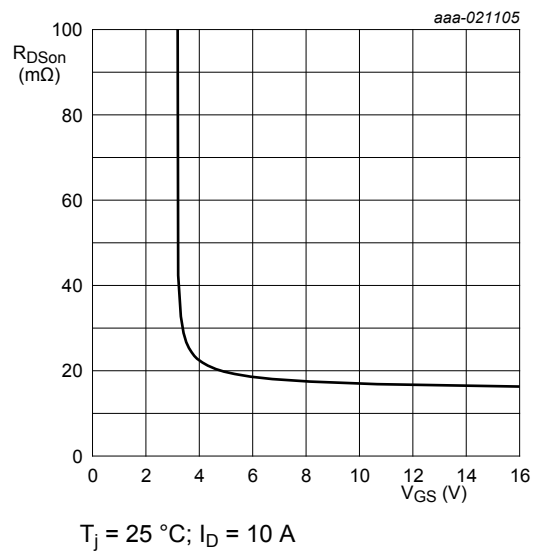
Table 7. Characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
<b>Static characteristics</b>						
$V_{(BR)DSS}$	drain-source breakdown voltage	$I_D = 250 \mu A; V_{GS} = 0 V; T_j = 25 \text{ }^\circ C$	60	-	-	V
		$I_D = 250 \mu A; V_{GS} = 0 V; T_j = -55 \text{ }^\circ C$	54	-	-	V
$V_{GS(th)}$	gate-source threshold voltage	$I_D = 1 \text{ mA}; V_{DS} = V_{GS}; T_j = 25 \text{ }^\circ C;$ <a href="#">Fig. 9; Fig. 10</a>	1.4	1.7	2.1	V
		$I_D = 1 \text{ mA}; V_{DS} = V_{GS}; T_j = -55 \text{ }^\circ C;$ <a href="#">Fig. 10</a>	-	-	2.45	V
		$I_D = 1 \text{ mA}; V_{DS} = V_{GS}; T_j = 175 \text{ }^\circ C;$ <a href="#">Fig. 10</a>	0.5	-	-	V
$I_{DSS}$	drain leakage current	$V_{DS} = 60 V; V_{GS} = 0 V; T_j = 25 \text{ }^\circ C$	-	0.01	1	$\mu A$
		$V_{DS} = 60 V; V_{GS} = 0 V; T_j = 175 \text{ }^\circ C$	-	-	500	$\mu A$
$I_{GSS}$	gate leakage current	$V_{GS} = 10 V; V_{DS} = 0 V; T_j = 25 \text{ }^\circ C$	-	2	100	nA
		$V_{GS} = -10 V; V_{DS} = 0 V; T_j = 25 \text{ }^\circ C$	-	2	100	nA
$R_{DSon}$	drain-source on-state resistance	$V_{GS} = 5 V; I_D = 10 A; T_j = 25 \text{ }^\circ C;$ <a href="#">Fig. 11</a>	-	19	24	mΩ
		$V_{GS} = 10 V; I_D = 10 A; T_j = 25 \text{ }^\circ C;$ <a href="#">Fig. 11</a>	-	17	21	mΩ
		$V_{GS} = 5 V; I_D = 10 A; T_j = 175 \text{ }^\circ C;$ <a href="#">Fig. 12</a>	-	-	54	mΩ
<b>Dynamic characteristics</b>						
$Q_{G(tot)}$	total gate charge	$I_D = 10 A; V_{DS} = 48 V; V_{GS} = 5 V;$ $T_j = 25 \text{ }^\circ C;$ <a href="#">Fig. 13; Fig. 14</a>	-	12.4	-	nC
$Q_{GS}$	gate-source charge		-	2.7	-	nC

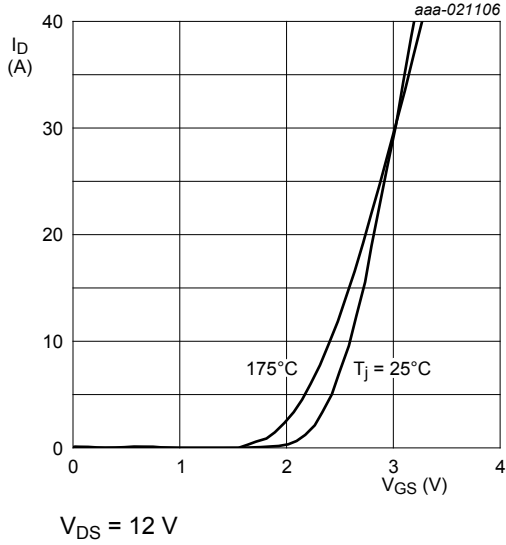
Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$Q_{GD}$	gate-drain charge		-	4.9	-	nC
$C_{iss}$	input capacitance	$V_{DS} = 25\text{ V}; V_{GS} = 0\text{ V}; f = 1\text{ MHz}; T_j = 25\text{ }^\circ\text{C}; \text{Fig. 15}$	-	1104	1469	pF
$C_{oss}$	output capacitance		-	116	139	pF
$C_{rss}$	reverse transfer capacitance		-	67	92	pF
$t_{d(on)}$	turn-on delay time	$V_{DS} = 45\text{ V}; R_L = 4\text{ }\Omega; V_{GS} = 5\text{ V}; R_{G(ext)} = 5\text{ }\Omega; T_j = 25\text{ }^\circ\text{C}$	-	7.8	-	ns
$t_r$	rise time		-	11.9	-	ns
$t_{d(off)}$	turn-off delay time		-	17.5	-	ns
$t_f$	fall time		-	11.4	-	ns
<b>Source-drain diode</b>						
$V_{SD}$	source-drain voltage	$I_S = 10\text{ A}; V_{GS} = 0\text{ V}; T_j = 25\text{ }^\circ\text{C}; \text{Fig. 16}$	-	0.83	1.2	V
$t_{rr}$	reverse recovery time	$I_S = 10\text{ A}; di_S/dt = -100\text{ A}/\mu\text{s}; V_{GS} = 0\text{ V}; V_{DS} = 25\text{ V}; T_j = 25\text{ }^\circ\text{C}$	-	16.6	-	ns
$Q_r$	recovered charge		-	12.3	-	nC



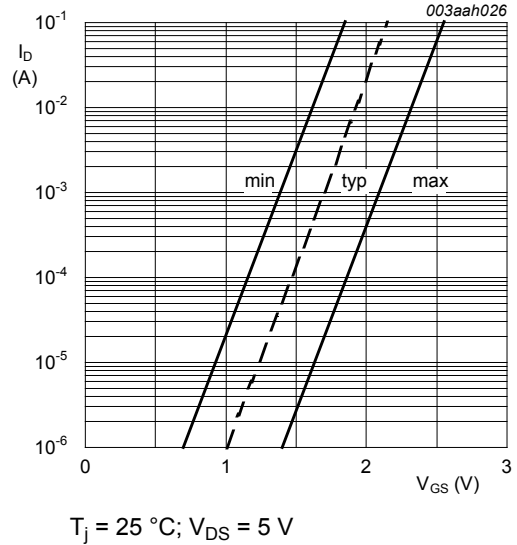
**Fig. 6. Output characteristics; drain current as a function of drain-source voltage; typical values**



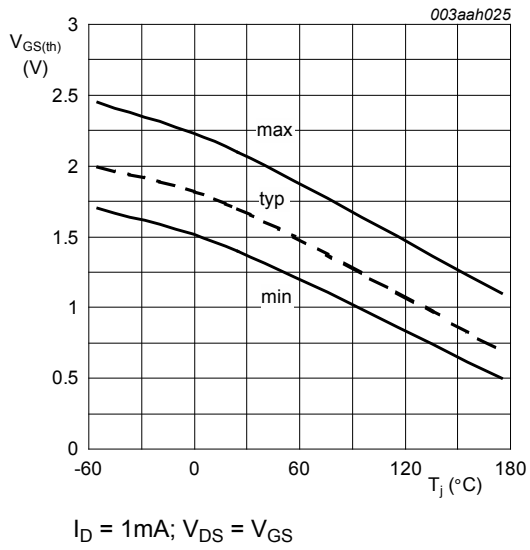
**Fig. 7. Drain-source on-state resistance as a function of gate-source voltage; typical values**



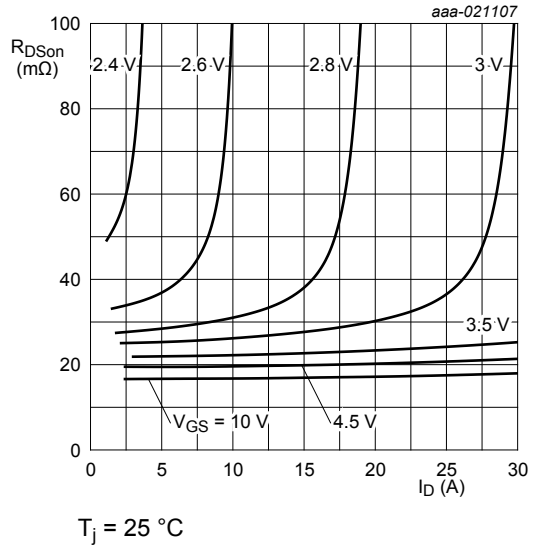
**Fig. 8. Transfer characteristics; drain current as a function of gate-source voltage; typical values**



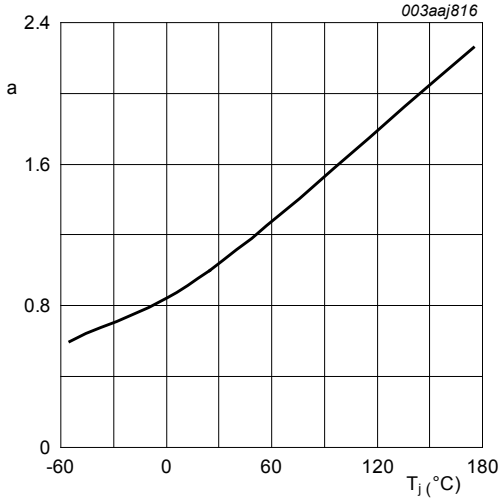
**Fig. 9. Sub-threshold drain current as a function of gate-source voltage**



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

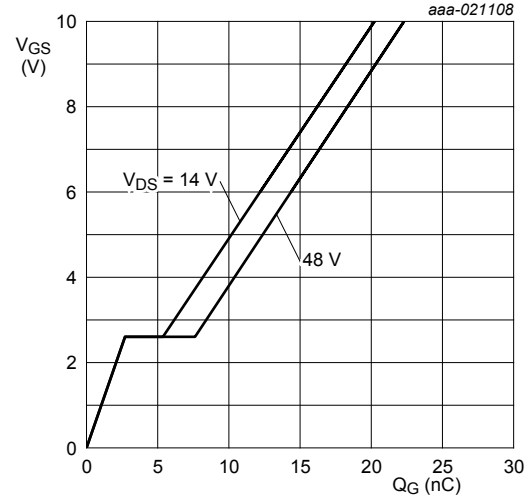


**Fig. 11. Drain-source on-state resistance as a function of drain current; typical values**



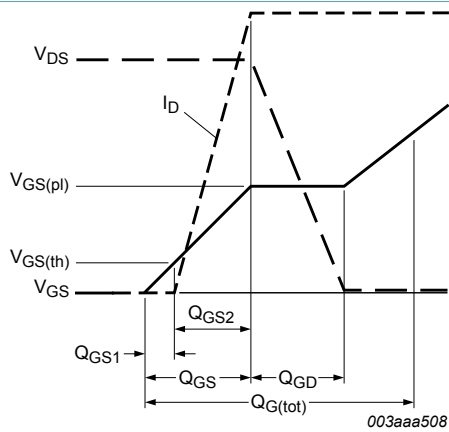
**Fig. 12. Normalized drain-source on-state resistance factor as a function of junction temperature**

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

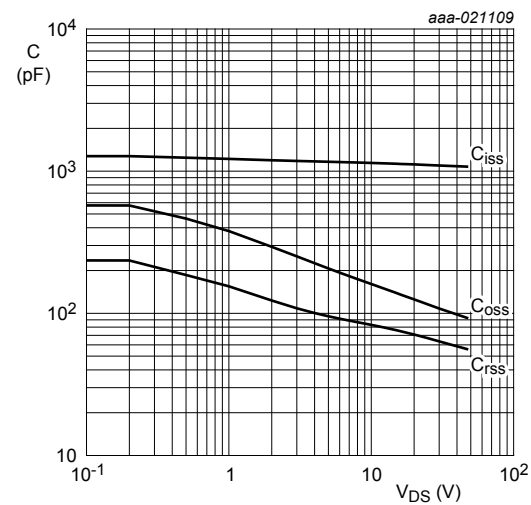


$T_j = 25^{\circ}C; I_D = 10 A$

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



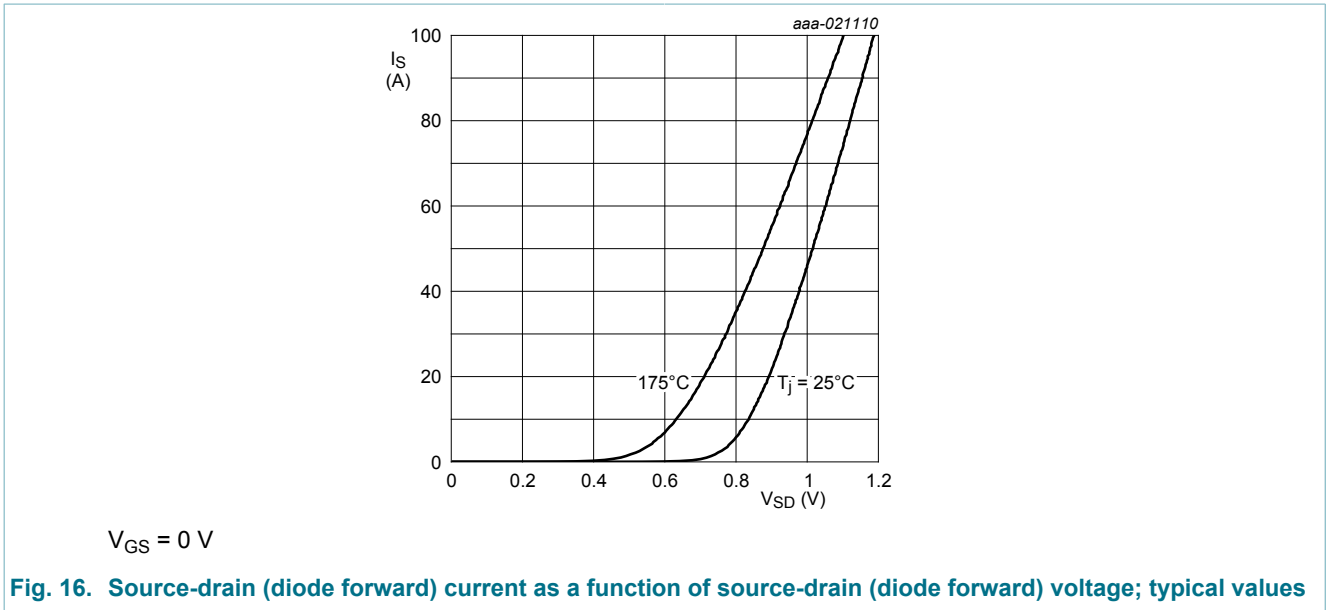
**Fig. 14. Gate charge waveform definitions**



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

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

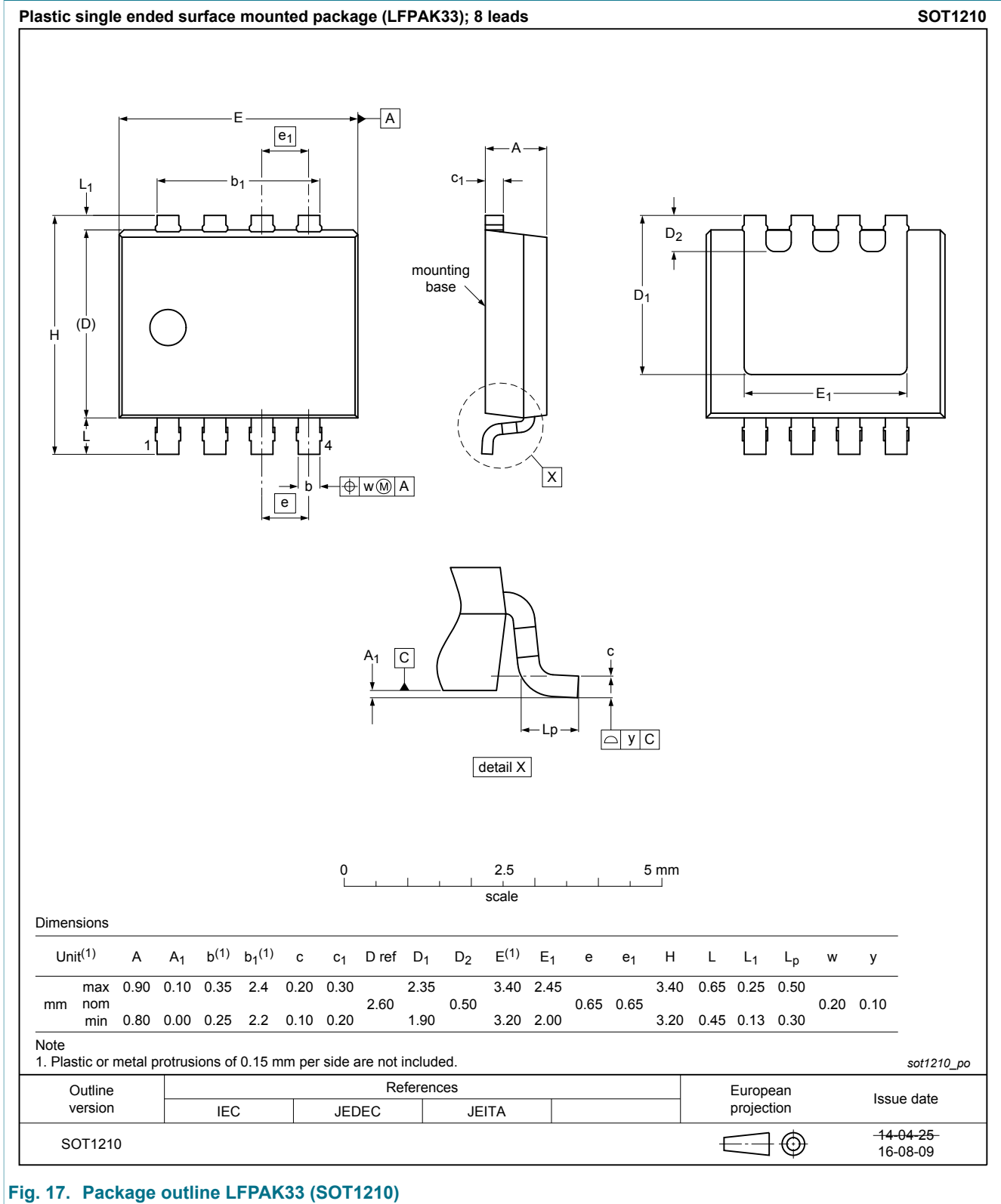




## 11. Application information

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

## 12. Package outline



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

## 13. Legal information

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Document status [1][2]	Product status [3]	Definition
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Preliminary [short] data sheet	Qualification	This document contains data from the preliminary specification.
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