



# BUK9K35-60RA

Dual N-channel 60 V, 35 mOhm logic level MOSFET in LFPAK56D using Repetitive Avalanche technology

2 December 2020

Product data sheet

## 1. General description

Dual, logic level N-channel MOSFET in an LFPAK56D package, using Application Specific (ASFET) repetitive avalanche silicon technology. This product has been designed and qualified to AEC-Q101 for use in repetitive avalanche applications.

## 2. Features and benefits

- Fully automotive qualified to AEC-Q101 at 175 °C
- Repetitive Avalanche rated to 30 °C  $T_j$  rise:
  - Tested to 1 Bn avalanche events
- LFPAK copper clip package technology:
  - High robustness and reliability
  - Gull wing leads for high manufacturability and AOI

## 3. Applications

- 12 V, 24 V and 48 V automotive systems
- Repetitive avalanche topologies
- Engine control
- Transmission control
- Actuator and auxiliary loads

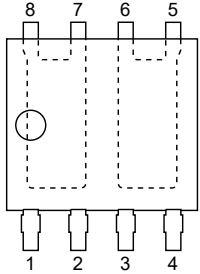
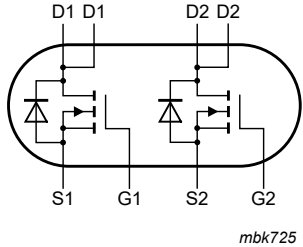
## 4. Quick reference data

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>	-	-	22	A
$P_{tot}$	total power dissipation	$T_{mb} = 25\text{ °C}$ ; <a href="#">Fig. 1</a>	-	-	38	W
<b>Static characteristics FET1 and FET2</b>						
$R_{DSon}$	drain-source on-state resistance	$V_{GS} = 5\text{ V}$ ; $I_D = 5\text{ A}$ ; $T_j = 25\text{ °C}$ ; <a href="#">Fig. 15</a>	17	30.5	35	mΩ
<b>Dynamic characteristics FET1 and FET2</b>						
$Q_{GD}$	gate-drain charge	$I_D = 5\text{ A}$ ; $V_{DS} = 48\text{ V}$ ; $V_{GS} = 5\text{ V}$ ; $T_j = 25\text{ °C}$ ; <a href="#">Fig. 17</a> ; <a href="#">Fig. 18</a>	-	3	-	nC

## 5. Pinning information

Table 2. Pinning information

Pin	Symbol	Description	Simplified outline	Graphic symbol
1	S1	source1	 <p>LFAK56D; Dual LFAK (SOT1205)</p>	 <p>mbk725</p>
2	G1	gate1		
3	S2	source2		
4	G2	gate2		
5	D2	drain2		
6	D2	drain2		
7	D1	drain1		
8	D1	drain1		

## 6. Ordering information

Table 3. Ordering information

Type number	Package		Version
	Name	Description	
BUK9K35-60RA	LFAK56D; Dual LFAK	plastic, single ended surface mounted package (LFAK56D); 8 leads	SOT1205

## 7. Marking

Table 4. Marking codes

Type number	Marking code
BUK9K35-60RA	93560RA

## 8. Limiting values

Table 5. Limiting values

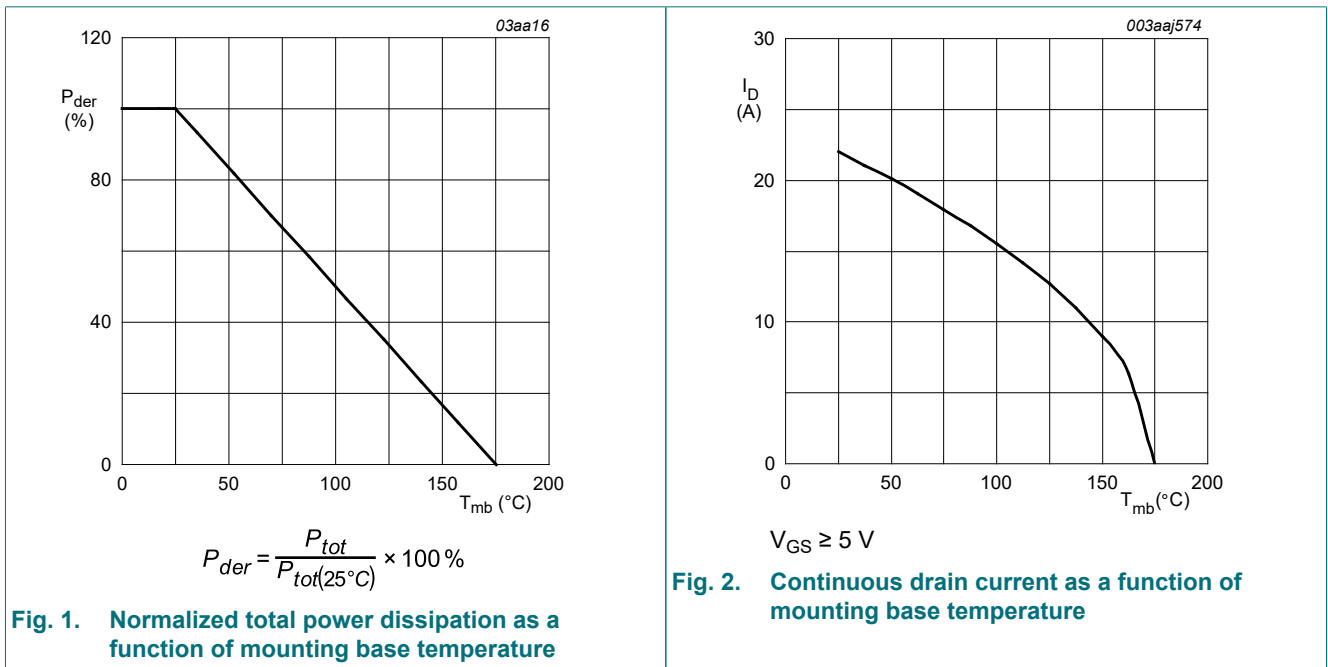
In accordance with the Absolute Maximum Rating System (IEC 60134).

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	$25\text{ °C} \leq T_j \leq 175\text{ °C}$ ; $R_{GS} = 20\text{ k}\Omega$	-	60	V
$V_{GS}$	gate-source voltage	DC; $T_j \leq 175\text{ °C}$	-10	10	V
		$T_j \leq 175\text{ °C}$	[1] [2] -15	15	V
$P_{tot}$	total power dissipation	$T_{mb} = 25\text{ °C}$ ; Fig. 1	-	38	W
$I_D$	drain current	$V_{GS} = 5\text{ V}$ ; $T_{mb} = 25\text{ °C}$ ; Fig. 2	-	22	A
		$V_{GS} = 5\text{ V}$ ; $T_{mb} = 100\text{ °C}$ ; Fig. 2	-	16	A
$I_{DM}$	peak drain current	pulsed; $t_p \leq 10\text{ }\mu\text{s}$ ; $T_{mb} = 25\text{ °C}$ ; Fig. 3	-	90	A
$T_{stg}$	storage temperature		-55	175	°C
$T_j$	junction temperature		-55	175	°C
$T_{sld(M)}$	peak soldering temperature		-	260	°C

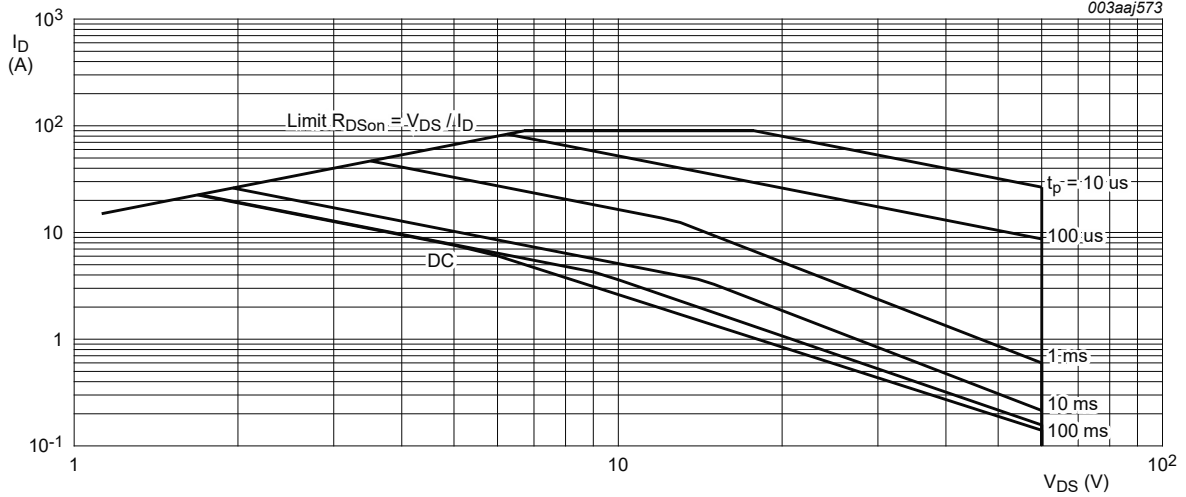
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Symbol	Parameter	Conditions	Min	Max	Unit
<b>Source-drain diode FET1 and FET2</b>					
$I_S$	source current	$T_{mb} = 25\text{ °C}$	-	22	A
$I_{SM}$	peak source current	pulsed; $t_p \leq 10\text{ }\mu\text{s}$ ; $T_{mb} = 25\text{ °C}$	-	90	A
<b>Avalanche ruggedness</b>					
$E_{DS(AL)R}$	repetitive drain-source avalanche energy	$I_D = 0.73\text{ A}$ ; $V_{sup} \leq 60\text{ V}$ ; $R_{GS} = 10\text{ }\Omega$ ; $V_{GS} = 10\text{ V}$ ; $T_{j(\text{rise})} \leq 30\text{ °C}$ ; unclamped; Fig. 4; Fig. 5; Fig. 6	[3] [4] [5]	-	28.6 mJ
<b>Avalanche ruggedness FET1 and FET2</b>					
$E_{DS(AL)S}$	non-repetitive drain-source avalanche energy	$I_D = 22\text{ A}$ ; $V_{sup} \leq 60\text{ V}$ ; $V_{GS} = 5\text{ V}$ ; $T_{j(\text{init})} = 25\text{ °C}$ ; Fig. 7	[6] [7]	-	19.5 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] Repetitive avalanche rating is limited by maximum junction temperature of 175 °C and junction rise of 30 °C
- [4] Refer to Fig. 5 for the limiting number of avalanche events
- [5] Refer to Fig. 6  $R_{dson}$  at  $V_{gs}=5V$  will increase as a function of repetitive avalanche cycles
- [6] Refer to application note AN10273 for further information
- [7] Single-pulse avalanche rating limited by maximum junction temperature of 175 °C

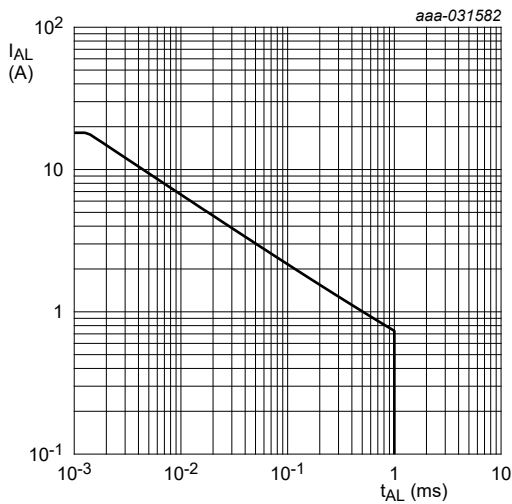


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$T_{mb} = 25\text{ }^{\circ}\text{C}$ ;  $I_{DM}$  is single pulse

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



$T_j$  is limited to  $175\text{ }^{\circ}\text{C}$  and  $T_{j(\text{rise})}$  is limited to  $30\text{ }^{\circ}\text{C}$

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

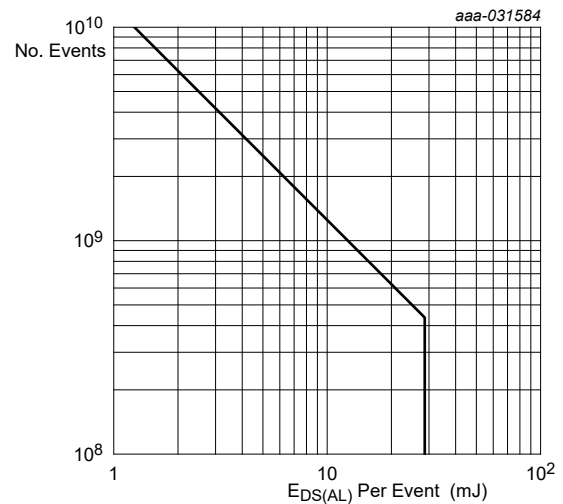


Fig. 5. Repetitive avalanche rating; maximum number of avalanche events as a function of avalanche energy

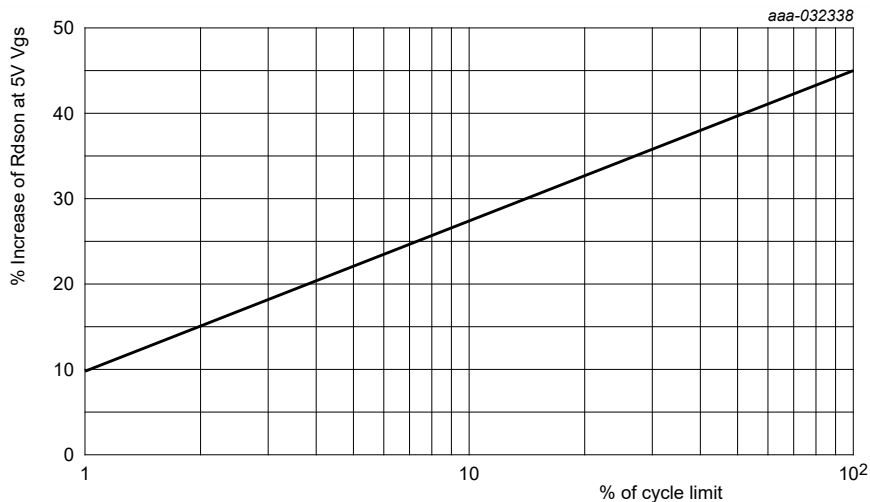


Fig. 6. Percentage  $R_{dson}$  at 5V increase as a function of avalanche cycles

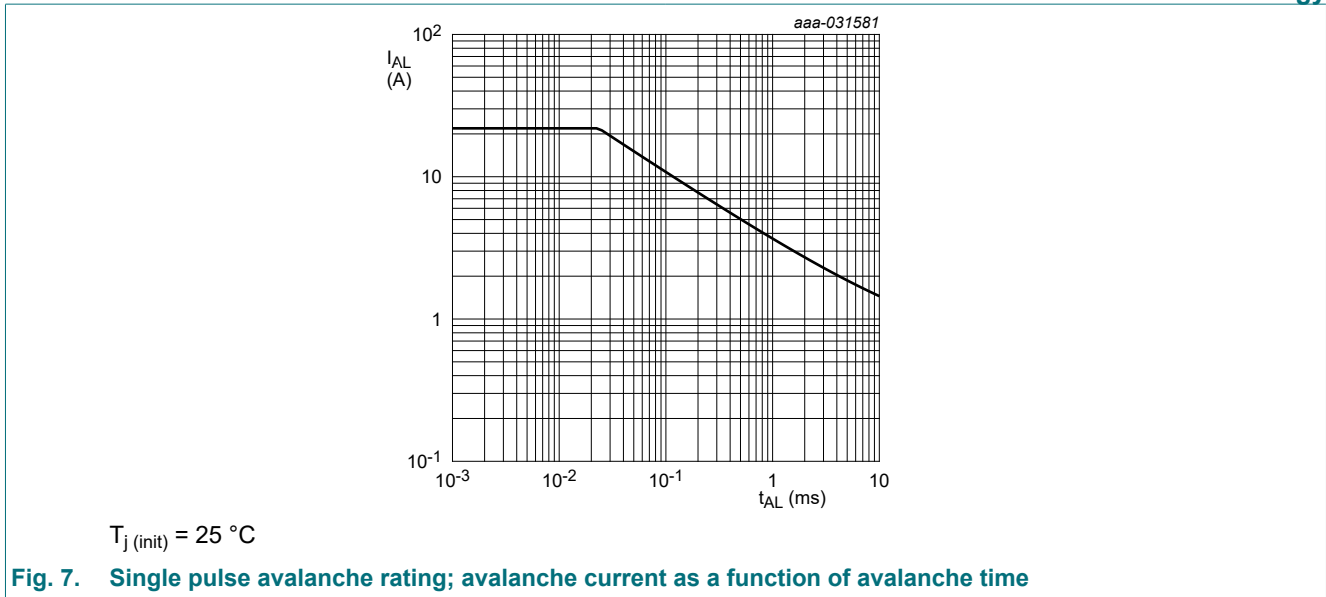


Fig. 7. Single pulse avalanche rating; avalanche current as a function of avalanche time

## 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. 8	-	-	3.96	K/W
$R_{th(j-a)}$	thermal resistance from junction to ambient	Minimum footprint; mounted on a printed circuit board	-	95	-	K/W

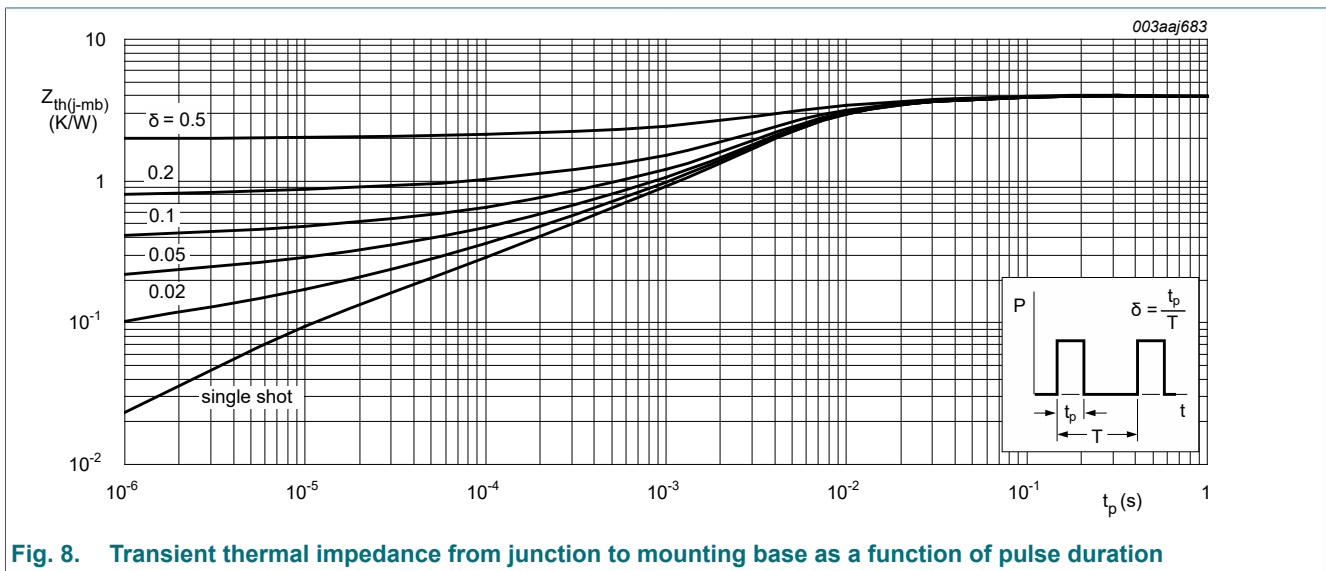


Fig. 8. Transient thermal impedance from junction to mounting base as a function of pulse duration

## 10. Characteristics

Table 7. Characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
<b>Static characteristics FET1 and FET2</b>						
$V_{(BR)DSS}$	drain-source breakdown voltage	$I_D = 250 \mu\text{A}; V_{GS} = 0 \text{ V}; T_j = -55 \text{ }^\circ\text{C}$	54	-	-	V
		$I_D = 250 \mu\text{A}; V_{GS} = 0 \text{ V}; T_j = 25 \text{ }^\circ\text{C}$	60	-	-	V
$V_{GS(th)}$	gate-source threshold voltage	$I_D = 1 \text{ mA}; V_{DS}=V_{GS}; T_j = 25 \text{ }^\circ\text{C};$ <a href="#">Fig. 13</a> ; <a href="#">Fig. 14</a>	1.4	1.7	2.1	V
		$I_D = 1 \text{ mA}; V_{DS}=V_{GS}; T_j = 175 \text{ }^\circ\text{C};$ <a href="#">Fig. 13</a> ; <a href="#">Fig. 14</a>	0.5	-	-	V
		$I_D = 1 \text{ mA}; V_{DS}=V_{GS}; T_j = -55 \text{ }^\circ\text{C};$ <a href="#">Fig. 13</a> ; <a href="#">Fig. 14</a>	-	-	2.45	V
$I_{DSS}$	drain leakage current	$V_{DS} = 60 \text{ V}; V_{GS} = 0 \text{ V}; T_j = 175 \text{ }^\circ\text{C}$	-	-	500	$\mu\text{A}$
		$V_{DS} = 60 \text{ V}; V_{GS} = 0 \text{ V}; T_j = 25 \text{ }^\circ\text{C}$	-	0.02	1	$\mu\text{A}$
$I_{GSS}$	gate leakage current	$V_{GS} = -10 \text{ V}; V_{DS} = 0 \text{ V}; T_j = 25 \text{ }^\circ\text{C}$	-	2	100	nA
		$V_{GS} = 10 \text{ V}; V_{DS} = 0 \text{ V}; T_j = 25 \text{ }^\circ\text{C}$	-	2	100	nA
$R_{DS(on)}$	drain-source on-state resistance	$V_{GS} = 5 \text{ V}; I_D = 5 \text{ A}; T_j = 25 \text{ }^\circ\text{C};$ <a href="#">Fig. 15</a>	17	30.5	35	m $\Omega$
		$V_{GS} = 5 \text{ V}; I_D = 5 \text{ A}; T_j = 175 \text{ }^\circ\text{C};$ <a href="#">Fig. 15</a> ; <a href="#">Fig. 16</a>	-	65.27	79	m $\Omega$
		$V_{GS} = 10 \text{ V}; I_D = 5 \text{ A}; T_j = 25 \text{ }^\circ\text{C};$ <a href="#">Fig. 15</a>	15.5	26.8	32	m $\Omega$
<b>Dynamic characteristics FET1 and FET2</b>						
$Q_{G(tot)}$	total gate charge	$I_D = 5 \text{ A}; V_{DS} = 48 \text{ V}; V_{GS} = 5 \text{ V};$ $T_j = 25 \text{ }^\circ\text{C};$ <a href="#">Fig. 17</a> ; <a href="#">Fig. 18</a>	-	7.8	-	nC
$Q_{GS}$	gate-source charge		-	1.2	-	nC
$Q_{GD}$	gate-drain charge		-	3	-	nC
$C_{iss}$	input capacitance	$V_{DS} = 25 \text{ V}; V_{GS} = 0 \text{ V}; f = 1 \text{ MHz};$ $T_j = 25 \text{ }^\circ\text{C};$ <a href="#">Fig. 19</a>	-	811	1081	pF
$C_{oss}$	output capacitance		-	98	118	pF
$C_{rss}$	reverse transfer capacitance		-	51	70	pF
$t_{d(on)}$	turn-on delay time	$V_{DS} = 48 \text{ V}; R_L = 10 \text{ }^\circ\Omega; V_{GS} = 5 \text{ V};$ $R_{G(ext)} = 5 \text{ }^\circ\Omega; T_j = 25 \text{ }^\circ\text{C}$	-	7.1	-	ns
$t_r$	rise time		-	11.3	-	ns
$t_{d(off)}$	turn-off delay time		-	14.9	-	ns
$t_f$	fall time		-	10.6	-	ns
<b>Source-drain diode FET1 and FET2</b>						
$V_{SD}$	source-drain voltage	$I_S = 5 \text{ A}; V_{GS} = 0 \text{ V}; T_j = 25 \text{ }^\circ\text{C};$ <a href="#">Fig. 20</a>	-	0.78	1.2	V
$t_{rr}$	reverse recovery time	$I_S = 5 \text{ A}; dI_S/dt = -100 \text{ A}/\mu\text{s}; V_{GS} = 0 \text{ V};$ $V_{DS} = 30 \text{ V}; T_j = 25 \text{ }^\circ\text{C}$	-	17.6	-	ns
$Q_r$	recovered charge		-	12.1	-	nC

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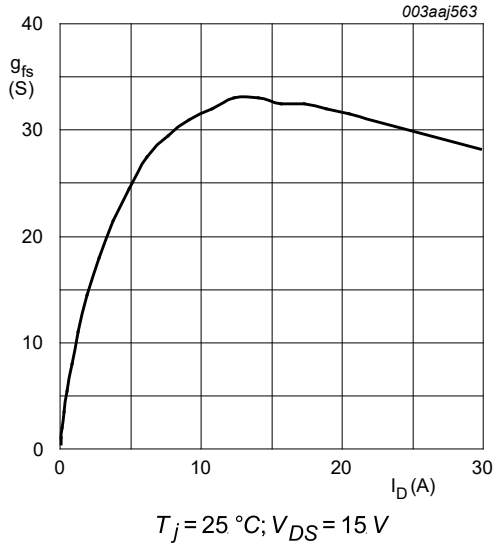


Fig. 9. Forward transconductance as a function of drain current; typical values

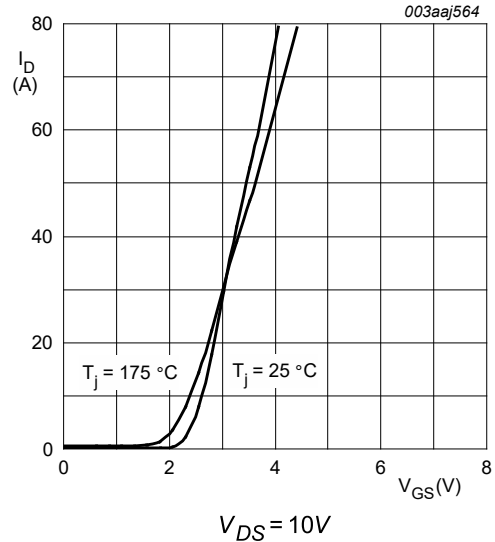


Fig. 10. Transfer Characteristic: drain current as a function of gate-source voltage; typical values

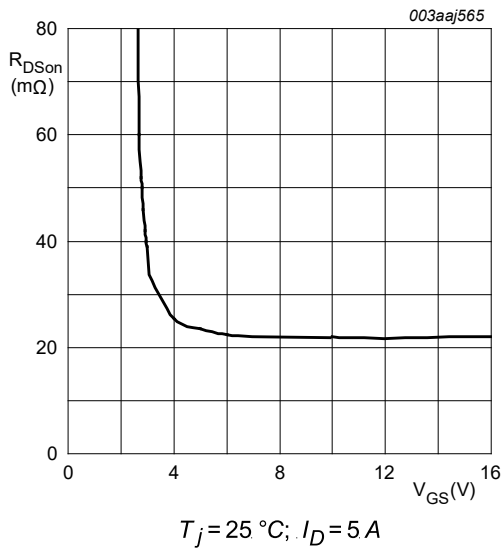


Fig. 11. Drain-source on-state resistance as a function of gate-source voltage; typical values

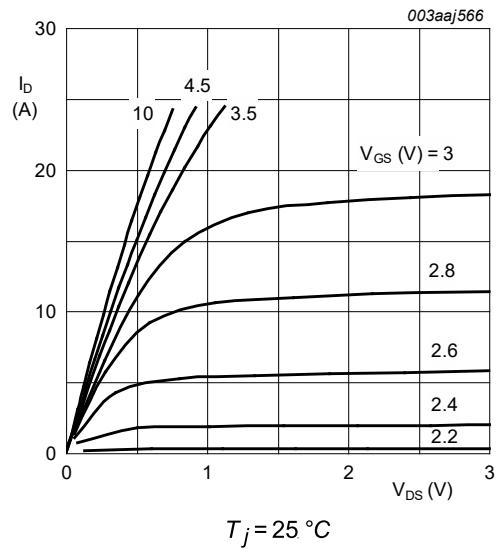


Fig. 12. Output characteristics: drain current as a function of drain-source voltage; typical values

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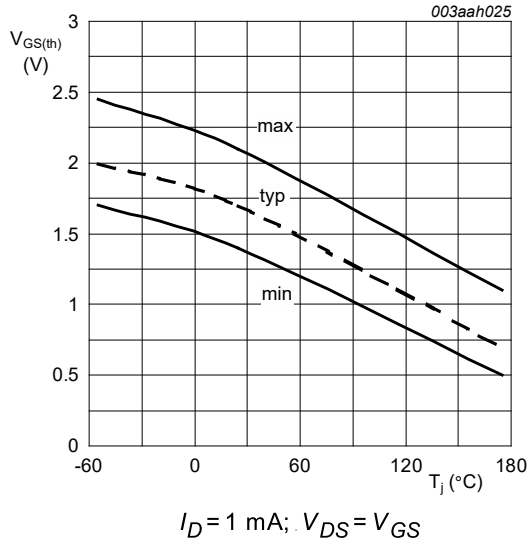


Fig. 13. Gate-source threshold voltage as a function of junction temperature

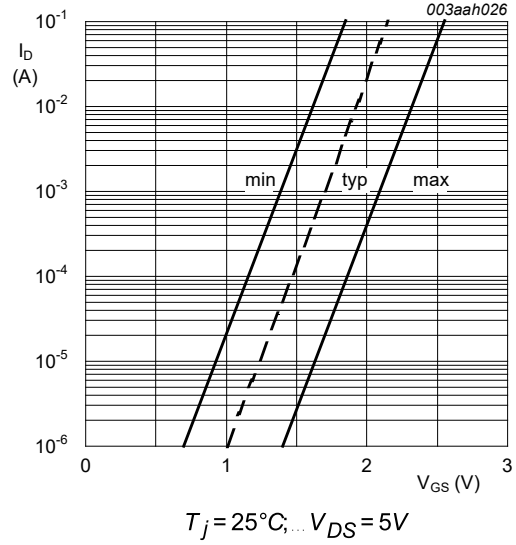


Fig. 14. Sub-threshold drain current as a function of gate-source voltage

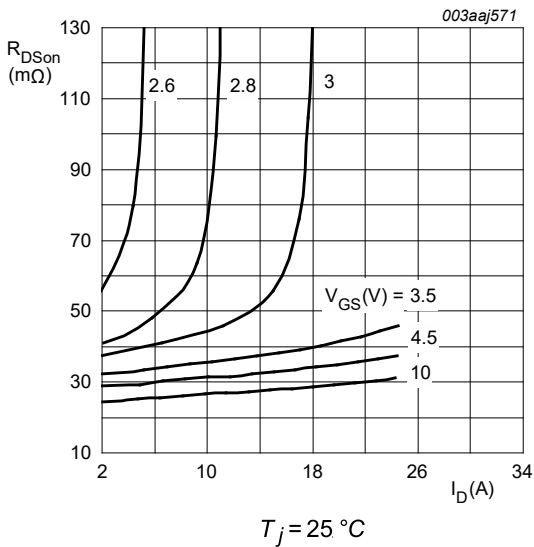


Fig. 15. Drain-source on-state resistance as a function of drain current; typical values

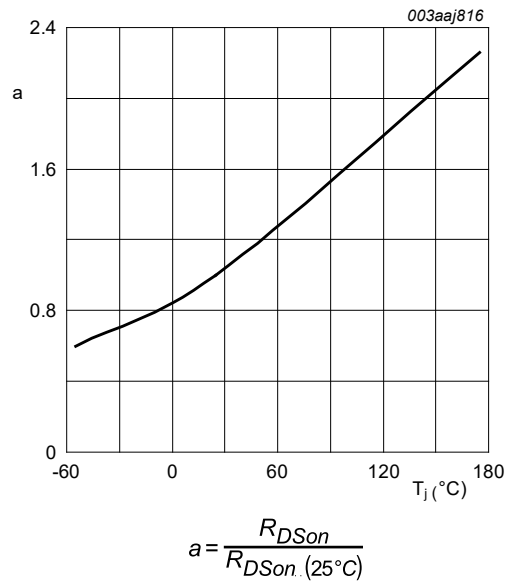


Fig. 16. Normalized drain-source on-state resistance factor as a function of junction temperature



Dual N-channel 60 V, 35 mOhm logic level MOSFET in LPAK56D using Repetitive Avalanche technology

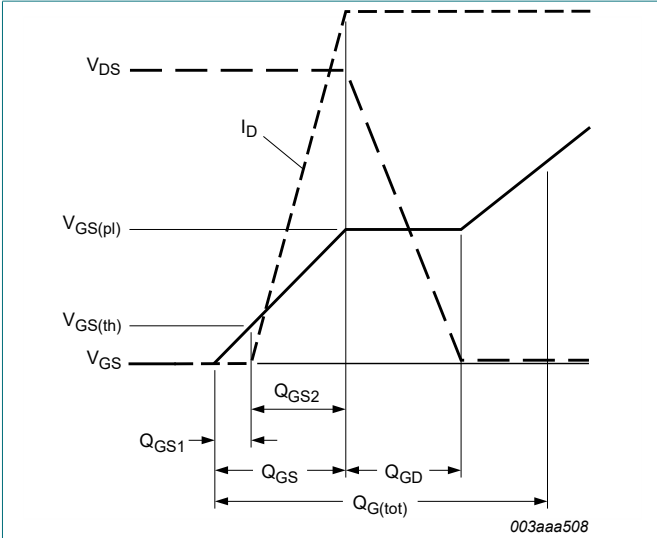


Fig. 17. Gate charge waveform definitions

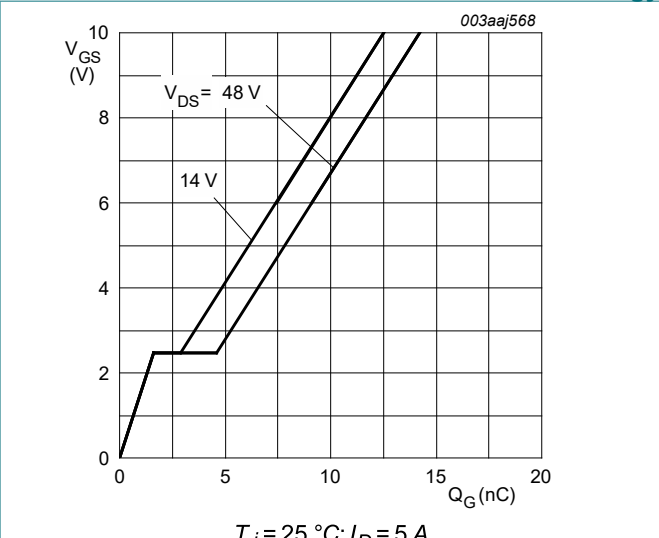


Fig. 18. Gate-source voltage as a function of gate charge; typical values

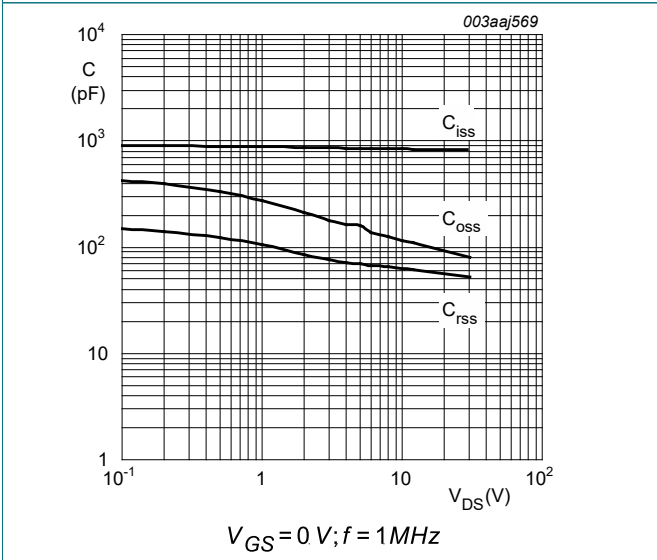


Fig. 19. Input, output and reverse transfer capacitances as a function of drain-source voltage; typical values

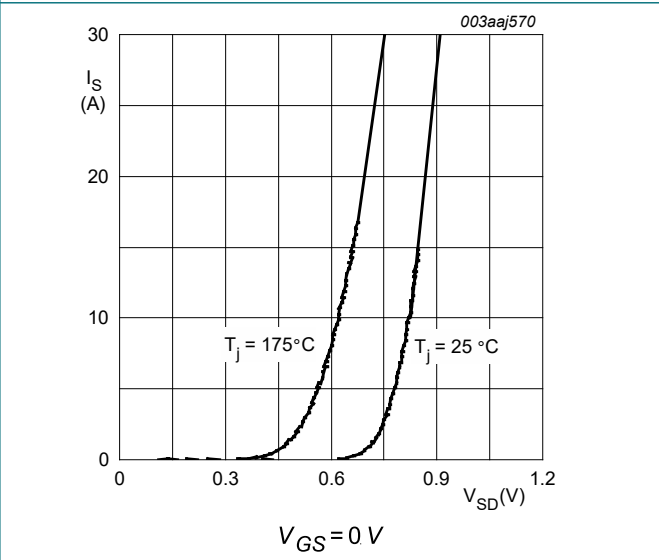


Fig. 20. Source current as a function of source-drain voltage; typical values

11. Package outline

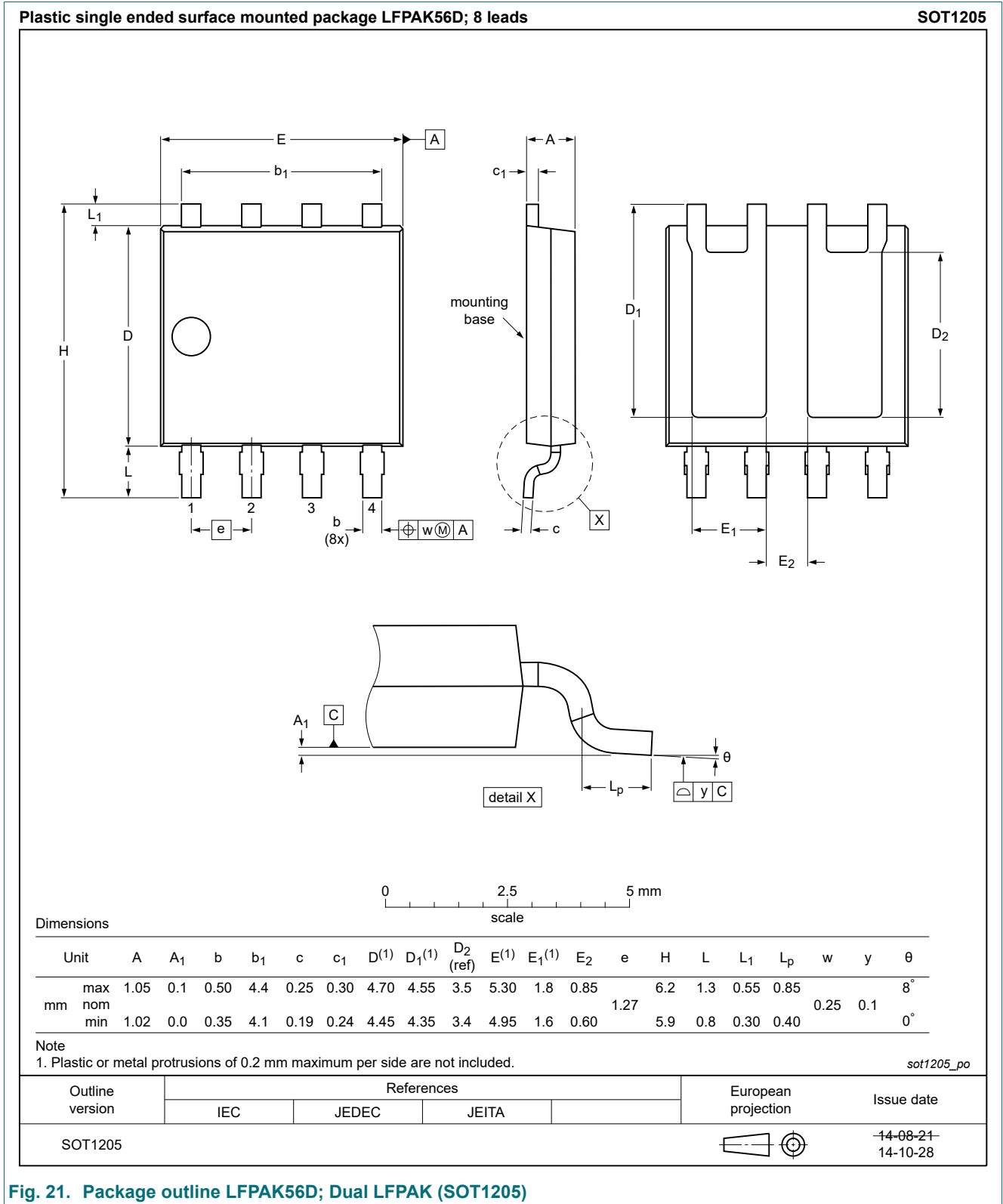
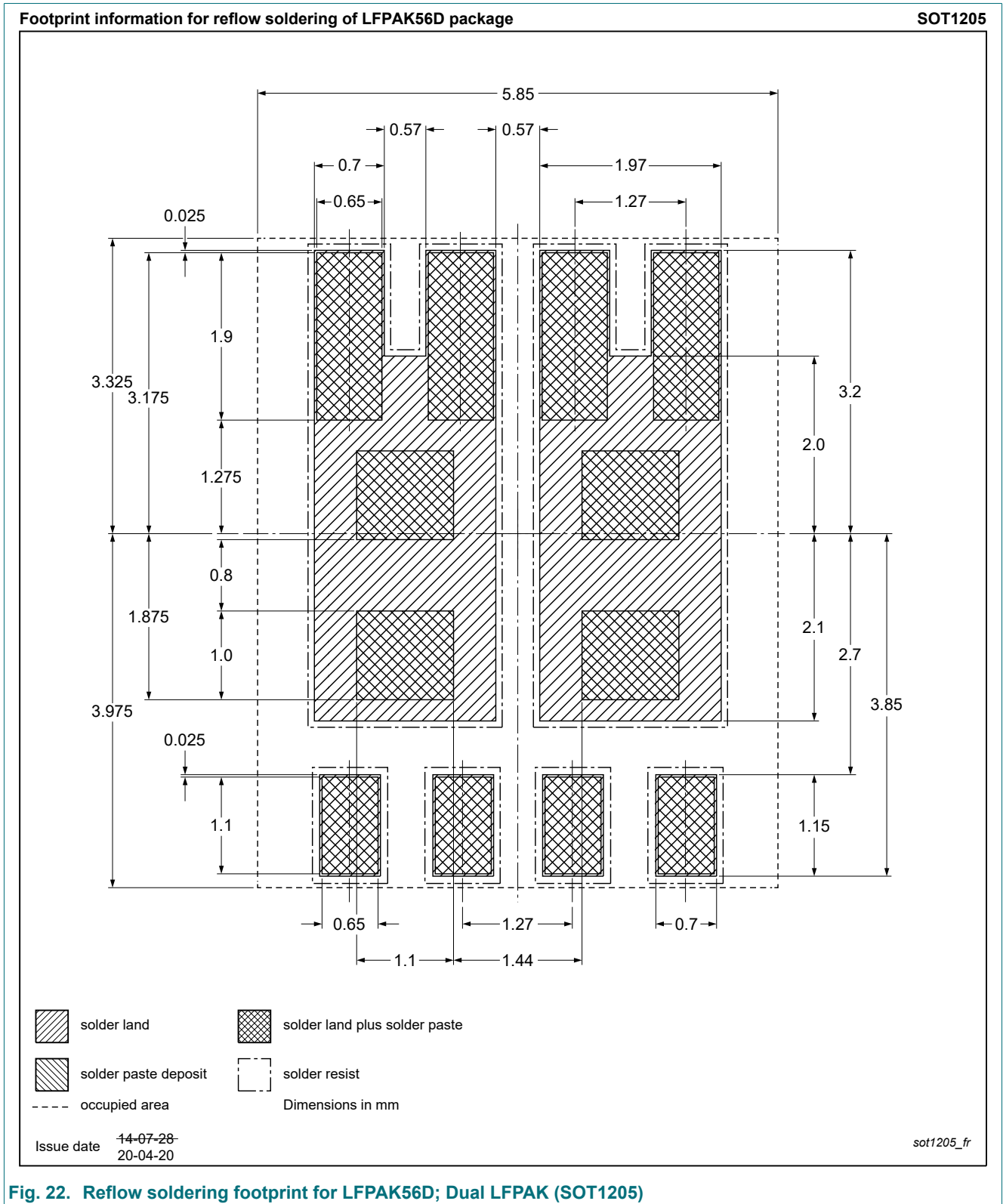


Fig. 21. Package outline LPAK56D; Dual LPAK (SOT1205)

## 12. Soldering



**Fig. 22. Reflow soldering footprint for LPAK56D; Dual LPAK (SOT1205)**

## Dual N-channel 60 V, 35 mOhm logic level MOSFET in LPAK56D using Repetitive Avalanche technology

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Document status [1][2]	Product status [3]	Definition
Objective [short] data sheet	Development	This document contains data from the objective specification for product development.
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Product [short] data sheet	Production	This document contains the product specification.

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## Contents

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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.....	5
10. Characteristics.....	6
11. Package outline.....	10
12. Soldering.....	11
13. Legal information.....	12

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