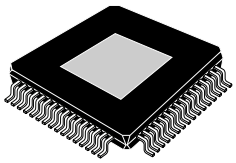
FDA901

Data brief

4 x 50 W class-D digital input automotive power amplifier with load current monitoring and low voltage operation



LQFP64 (exposed pad up)

Product status link
FDA901

Device summary		
Order code	**Package**	**Packing**
FDA901-VYY	LQFP64 (exposed pad up)	Tray
FDA901-VYT		Tape & Reel

Features

- AEC-Q100 qualified
- Integrated 110 dB D/A conversion
- I^2S and TDM digital input (3.3/1.8 V)
- Input sampling frequency: 44.1 kHz, 48 kHz, 96 kHz and 192 kHz
- Class-D channels with 93% efficiency
- CISPR25 - Class V (Fourth Edition)
- Low radiation function (LRF)
- Idle tones free DAC
- Output lowpass filter included in the feedback allowing superior audio performance
- High output power capability
  - 28 W/4 Ω 10% THD, V_d = 14.4 V
  - Max. output power: 4 x 50 W/4 Ω @ 15.2 V, 1 kHz
- Full I^2C bus driving (3.3/1.8 V):
  - Channel independent Eco-Mode
  - Channel independent soft play/mute
  - I^2C bus diagnostics, including DC and AC load detection and load value recognition
- Integrated fault protection
- Input and output offset detector
- Clipping detector
- Real time load current monitoring (on I^2C and TDM data lines)
- ESD protection
- 6 V operation ("Start - Stop" engines compatibility)
- 2 and 1 Ω load driving capability

Description

FDA901 is a new BCD technology Quad Bridge class D amplifier, specially intended for car radio automotive applications.

Thanks to the technology used, it is possible to integrate a high performance D/A converter together with powerful MOSFET outputs in class D, to get an outstanding efficiency compared to the standard class AB.

The integrated D/A converter allows to reach outstanding performances (115 dB S/N ratio with 110 dB of dynamic range). The feedback loop includes the output L-C low-pass filter, allowing superior frequency response linearity and lower distortion independently from the inductor and capacitor quality.

FDA901 is fully configurable through I^2C bus, moreover it includes not only the most complete load diagnostic matrix but also a unique real time load current acquisition on I^2C and I^2S data lines, enabling sophisticated speaker monitoring functions.

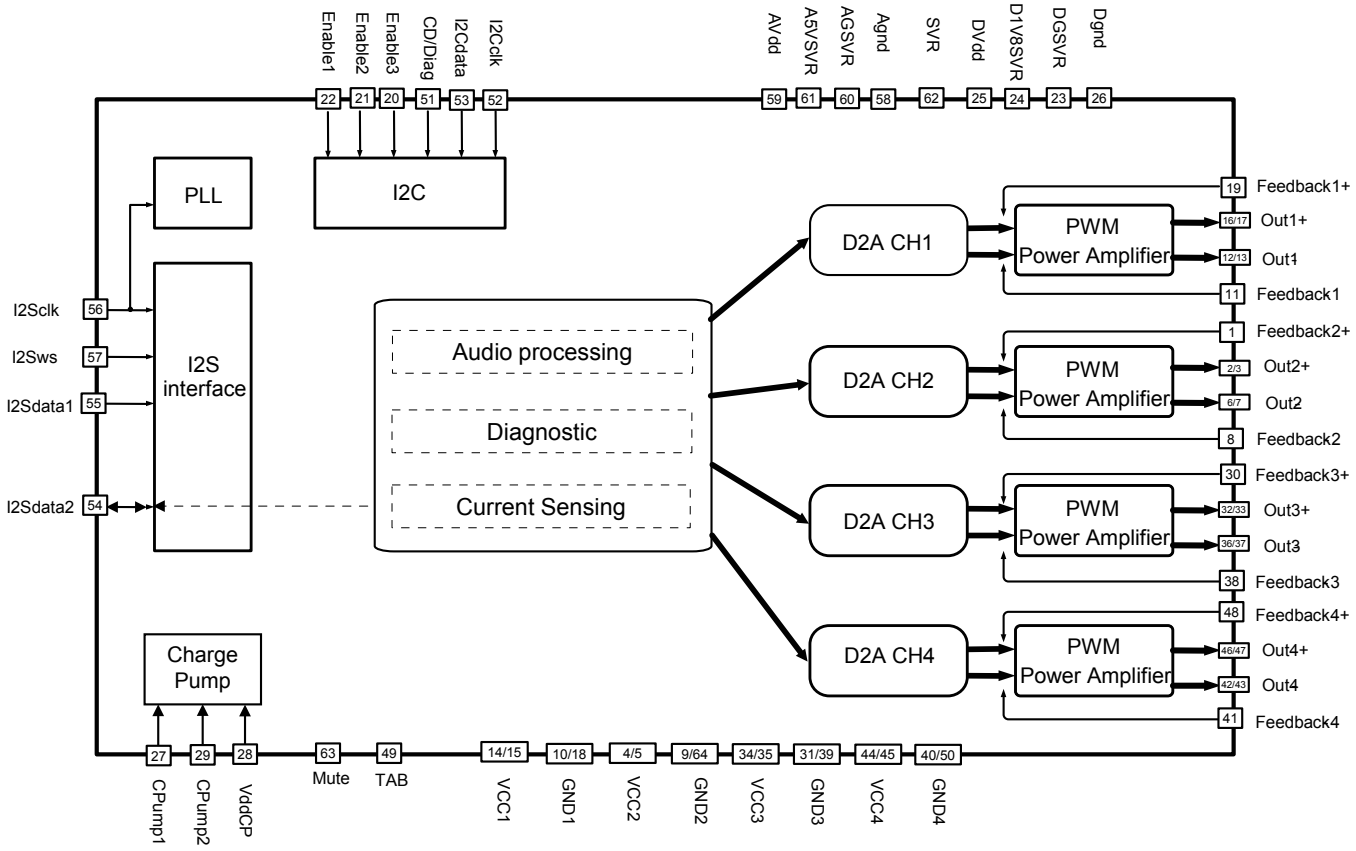
Thanks to the solutions implemented to contain EMI emissions, the device is intended to be used in the standard single DIN car-radio box together with the tuner.

Moreover the FDA901 is able to work with power supply as low as 6 V, thus supporting the most recent low voltage ('start-stop') car-makers specification.

1 Block diagram and pins description

1.1 Block diagram

Figure 1. Block diagram



1.2 Pins description

Figure 2. **Pins connection diagram (top view)**

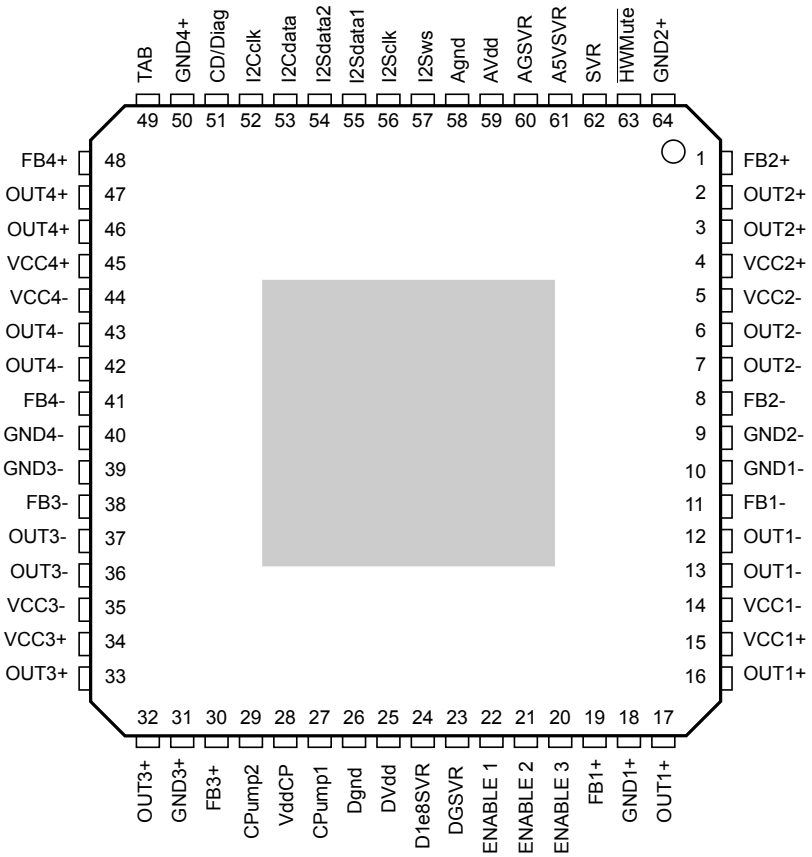


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Table 1. **Pins list description**

N#	Pin	Function
1	FB2+	Channel 2, half bridge plus, Feedback
2	OUT2+	Channel 2, half bridge plus, Output
3	OUT2+	Channel 2, half bridge plus, Output
4	VCC2+	Channel 2, half bridge plus, Power Supply
5	VCC2-	Channel 2, half bridge minus, Power Supply
6	OUT2-	Channel 2, half bridge minus, Output
7	OUT2-	Channel 2, half bridge minus, Output
8	FB2-	Channel 2, half bridge minus, Feedback
9	GND2-	Channel 2, half bridge minus, Power Ground
10	GND1-	Channel 1, half bridge minus, Power Ground
11	FB1-	Channel 1, half bridge minus, Feedback
12	OUT1-	Channel 1, half bridge minus, Output
13	OUT1-	Channel 1, half bridge minus, Output
14	VCC1-	Channel 1, half bridge minus, Power Supply

N#	Pin	Function
15	VCC1+	Channel 1, half bridge plus, Power Supply
16	OUT1+	Channel 1, half bridge plus, Output
17	OUT1+	Channel 1, half bridge plus, Output
18	GND1+	Channel 1, half bridge plus, Power Ground
19	FB1+	Channel 2, half bridge plus, Feedback
20	ENABLE 3	Enable 3
21	ENABLE 2	Enable 2
22	ENABLE 1	Enable 1
23	DGSVR	Negative Analog Supply V(SVR)-0.9V (Internally generated)
24	D1e8SVR	Positive Digital Supply V(SVR)+0.9V (Internally generated)
25	DVdd	Digital supply
26	Dgnd	Digital ground
27	CPump1	Charge Pump pin1
28	VddCP	Charge Pump output voltage
29	CPump2	Charge Pump pin2
30	FB3+	Channel 3, half bridge plus, Feedback
31	GND3+	Channel 3, half bridge plus, Power Ground
32	OUT3+	Channel 3, half bridge plus, Output
33	OUT3+	Channel 3, half bridge plus, Output
34	VCC3+	Channel 3, half bridge plus, Power Supply
35	VCC3-	Channel 3, half bridge minus, Power Supply
36	OUT3-	Channel 3, half bridge minus, Output
37	OUT3-	Channel 3, half bridge minus, Output
38	FB3-	Channel 3, half bridge minus, Feedback
39	GND3-	Channel 3, half bridge minus, Power Ground
40	GND4-	Channel 4, half bridge minus, Power Ground
41	FB4-	Channel 4, half bridge minus, Feedback
42	OUT4-	Channel 4, half bridge minus, Output
43	OUT4-	Channel 4, half bridge minus, Output
44	VCC4-	Channel 4, half bridge minus, Power Supply
45	VCC4+	Channel 4, half bridge plus, Power Supply
46	OUT4+	Channel 4, half bridge plus, Output
47	OUT4+	Channel 4, half bridge plus, Output
48	FB4+	Channel 4, half bridge plus, Feedback
49	TAB	Device slug connection
50	GND4+	Channel 4, half bridge plus, Power Ground
51	CD/Diag	Clipping detector and diagnostic output pin: – Overcurrent protection intervention – Thermal warning – Offset detection

N#	Pin	Function
52	I2Cclk	I^2C Clock (SCL)
53	I2Cdata	I^2C Data (SDA)
54	I2Sdata2	I2S/TDM Data input 2
55	I2Sdata1	I2S/TDM Data input 1
56	I2Sclk	I2S/TDM Clock input
57	I2Sws	I2S/TDM Sinc input
58	Agnd	Analog ground
59	AVdd	Analog supply
60	AGSVR	Negative Analog Supply V(SVR)-2.5V (Internally generated)
61	A5VSVR	Positive Analog Supply V(SVR)+2.5V (Internally generated)
62	SVR	Supply Voltage Ripple Rejection Capacitor
63	$\overline{\text{HWMute}}$	Hardware mute pin
64	GND2+	Channel 2, half bridge plus, Power Ground

2 Electrical specifications

2.1 Absolute maximum ratings

Table 2. Absolute maximum ratings

Symbol	Parameter	Value	Unit
FB(x)+, FB(x)-	Feedback pin	-0.3 to 28	V
OUT(x)+, OUT(x)-	Output pin	-0.3 to 28	V
GND_{max}[GND(x)+, GND(x)-, A_{GND}, D_{GND}]	Ground pin voltage difference	-0.3 to 0.3	V
I^2C_{data}, I^2C_{clk}	I^2C bus pins voltage	-0.3 to 5.5	V
I^2S_{data1}, I^2S_{data2}, I^2S_{clk}, I^2S_{WS}	I^2S bus pins voltage	-0.3 to 5.5	V
$Enable_{1,2,3}$	Enables	-0.3 to 5.5	V
HWMute	Hardware mute	-0.3 to 7	V
CD/Diag	Clip Detection/Diagnostic pin	-0.3 to 5.5	V
I_O	Output current (repetitive f > 10 Hz)	internally limited	A
T_{amb}	Ambient operating temperature	-40 to 105	°C
T_{stg},T_j	Storage and junction temperature	-55 to 150	°C
ESDHBM	ESD protection HBM(1)	2000	V
ESDCDM	ESD protection CDM(1)	500	V

1. *Conform to ESD standard.*

2.2 Thermal data

Table 3. Thermal data

Symbol	Parameter	Typ	Max	Unit
$R_{th\ j\text{-}case}$	Thermal resistance junction-to-case	1.15	1.6	°C/W

3 General information

FDA901 is a fully digital single chip class D amplifier with high immunity to the demodulation filter effects. The high integration level and the on-board signal processing allow excellent audio performance to be achieved.

Thanks to the digital input and to the feedback strategy in the power stage that make the amplifier immune from the output filter components non-linearity, the number and size of the external components are minimized.

A number of features is included to reduce EMI and the fully digital approach provides a strong GSM immunity.

FDA901 includes: digital I^2C and I^2S interfaces, internal 24 bits DAC conversion, digital signal processing for interpolation and noise shaping, innovative self-diagnostic functions and automatic detection of wrong load connections or variation of the load, internal PLL for a clock generation.

3.1 New feedback topology

FDA901 adopts an innovative feedback topology, where the LC filter is included in the feedback loop making the amplifier highly insensitive to the characteristics of such a demodulation circuit. This solution optimizes the system performance in terms of THD and frequency response in any load conditions.

Regardless of the big phase shifting introduced by the output filter the device shows an adequate phase margin for any load condition. The system stability has been tested taking into account:

- PWM switching variation (from 300 to 440 kHz)
- Silicon temperature variation (from -40 to 150 °C)
- Load variation (both inductive and capacitive considered)
- LC demodulator filter variation and tolerance
- Voltage supply variation (from 6 to 25 V)

The system has been designed to guarantee a phase margin > 45 deg for any working condition.

The new feedback topology assures a strong control of voltage and current across the load making the diagnostic load detection reliable. Moreover this topology allows to reach exceptionally good values of output damping factor.

3.2 LC filter design

The audio performance of a Class D amplifier is heavily influenced by the characteristics of the output LC filter. The choice of its components is quite critical because a lot of constraints have to be fulfilled at the same time: size, cost, EMI filtering and efficiency. In particular, both the inductor and the capacitor exhibit a non linear behavior: the value of the inductance is a function of the instantaneous current in it and similarly the value of the capacitor is a function of the voltage across it.

In the classical approach, where the feedback loop is closed right at the output of the power stage, the LC filter is placed outside the loop and these nonlinearities cause the Total Harmonic Distortion (THD) to increase. The only way to avoid this phenomenon would be to use components which are highly linear, but this means they are also bigger and/or more expensive.

Furthermore, when the LC filter is outside the loop, its frequency response heavily depends on the impedance of the loudspeaker; this is one of the most critical aspects of Class D amplifiers. In standard Class D this can be mitigated, but not solved, by increasing cost, volume and power dissipation. FDA901, instead, provides a very flat frequency response over audio-band which cannot be achieved by standard class D without feedback after LC filter.

Since the demodulator group is now in the feedback path, some constraints regarding the inductor and capacitor choice are still present but of course less stringent than in the case of a typical switching application.

3.3 Load possibilities

FDA901 supports several load possibilities and configurations. The default configuration is suitable for a 4-channel application (front/rear - left/right). By means of I^2C register settings it is possible to choose a 2-channel solution with parallel outputs (left/right) or a 2.1 configuration for sub-woofer application.

Possible channel configurations:

- 4 x 4 ohm (up to 25 V);
- 4 x 2 ohm (up to 18 V);

- 2 x 1 ohm (through channels connected in parallel; limited to 18 V);
- 2 x 4 ohm + 1 x 2 ohm (through parallelized channels).

4 Package information

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK® packages, depending on their level of environmental compliance. ECOPACK® specifications, grade definitions and product status are available at: www.st.com. ECOPACK® is an ST trademark.

4.1 LQFP64 (10x10x1.4 mm exp. pad up) package information

Figure 3. LQFP64 (10x10x1.4 mm exp. pad up) package outline

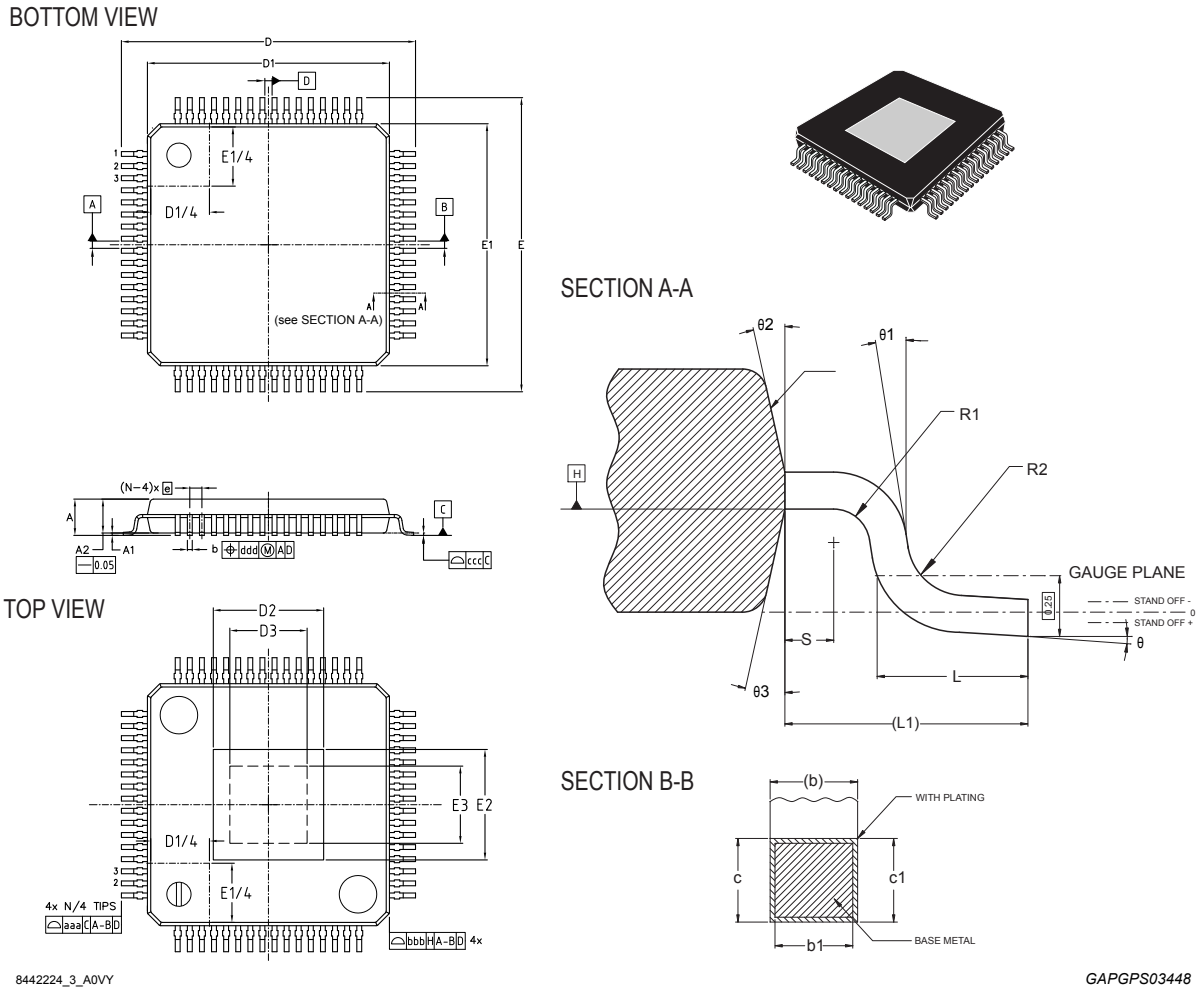


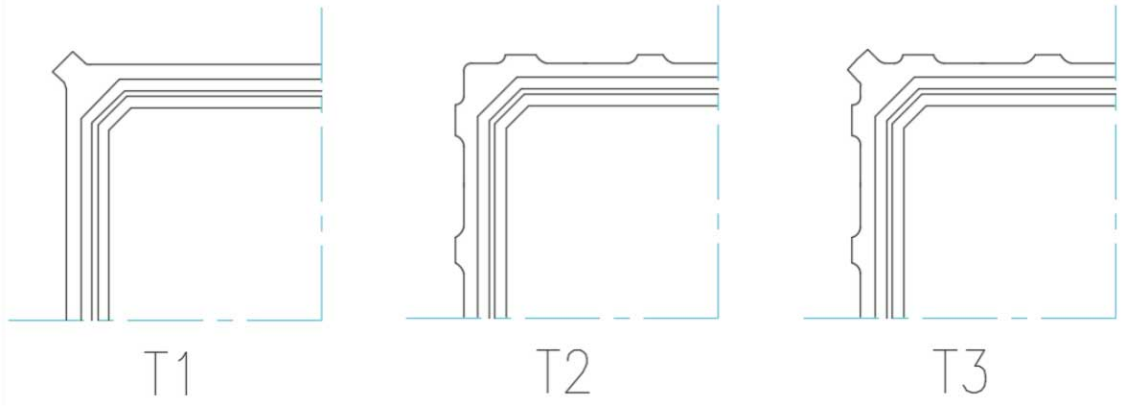
Table 4. LQFP64 (10x10x1.4 mm exp. pad up) package mechanical data

Symbol	Dimensions in mm		
	Min.	Typ.	Max.
Θ	0°	3.5°	6°
Θ1	0°	-	-
Θ2	11°	12°	14°

Symbol	Dimensions in mm		
	Min.	Typ.	Max.
Θ3	11°	12°	13°
A	-	-	1.49
A1	-0.04	-	0.04
A2	1.35	1.40	1.45
b	0.17	0.22	0.27
b1	0.17	0.20	0.23
c	0.09	-	0.20
c1	0.09	0.127	0.16
D	12.00 BSC		
D1(1) (2)	10.00 BSC		
D2	See **VARIATIONS**		
D3	See **VARIATIONS**		
e	0.50 BSC		
E	12.00 BSC		
E1(1)(2)	10.00 BSC		
E2	See **VARIATIONS**		
E3	See **VARIATIONS**		
L	0.45	0.60	0.75
L1	1.00 REF		
N	64		
R1	0.08	-	-
R2	0.08	-	0.20
S	0.20	-	-
Tolerance of form and position			
aaa	0.20		
bbb	0.20		
ccc	0.08		
ddd	0.08		
VARIATIONS			
Pad option 6.0x6.0 (T1-T3)(3)			
D2	-	-	6.61
E2	-	-	6.61
D3	4.8	-	-
E3	4.8	-	-

1. *Dimensions D1 and E1 do not include mold flash or protrusions. Allowable mold flash or protrusion is “0.25 mm” per side.*
2. *The Top package body size may be smaller than the bottom package size by much as 0.15 mm.*
3. *Number, dimensions and position of groves shown in Figure 4 are for reference only.*

Figure 4. **Exposed-pad groove's shapes**



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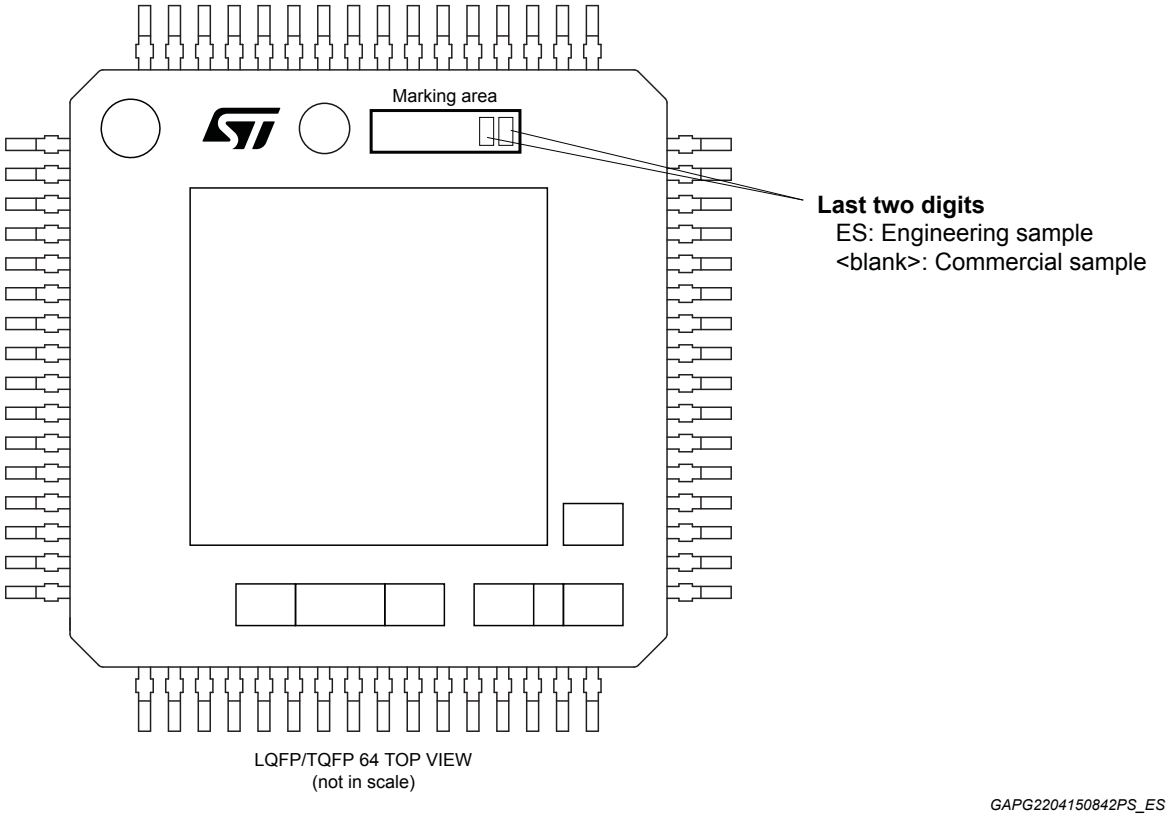
4.2 LQFP64 (10x10x1.4 mm exp. pad up) marking information

Figure 5. **LQFP64 (10x10x1.4 mm exp. pad up) marking information**



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Parts marked as ‘ES’ are not yet qualified and therefore not approved for use in production. ST is not responsible for any consequences resulting from such use. In no event will ST be liable for the customer using any of these engineering samples in production. ST’s Quality department must be contacted prior to any decision to use these engineering samples to run a qualification activity.

Revision history

Table 5. **Document revision history**

Date	Version	Changes
01-Mar-2019	1	Initial release.

Contents

List of tables

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