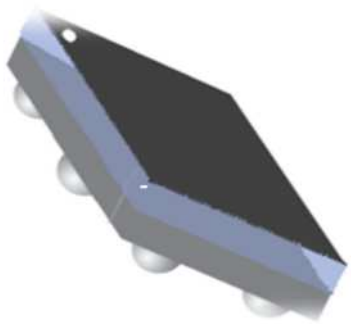
BALFHB-WL-04D3

Datasheet

50 Ω nominal input / conjugate matched balun to BGA-4L STM32WL in low power mode, 862-928 MHz with integrated harmonic filter



Chip scale package on glass 8 bumps

Product status link
BALFHB-WL-04D3

Features

- BGA STM32WL sub-GHz wireless microcontrollers impedance matched balun and Tx harmonics filter
- Optimized for BGA STM32WL sub-GHz wireless microcontrollers in low power mode and dedicated to 4-layer PCB
- 50 Ω nominal input / conjugate matched balun to BGA STM32WL
- 50 Ω nominal impedance on antenna side Tx and Rx
- Deep Tx rejection harmonic filter
- Low insertion loss
- Small footprint
- Low profile ≤ 630 µm after reflow
- High RF performance
- RF BOM and area reduction
- ECOPACK2 compliant component

Applications

- STM32WL sub-GHz wireless microcontrollers
- LPWAN-compliant radio solution, enabling the following modulations: LoRa®, (G)FSK, (G)MSK, and BPSK

Description

STMicroelectronics BALFHB-WL-04D3 is an ultra-miniature balun. This device integrates a matching network, balun, and harmonics filter. Matching impedance has been customized for the STM32WL sub-GHz wireless microcontrollers.

It is using STMicroelectronics IPD technology on a nonconductive glass substrate, which optimizes RF performances.

1 Characteristics

Table 1. Absolute maximum ratings (T_{amb} = 25 °C)

Symbol	Parameter	Value	Unit
P_{IN}	Input power RF_{IN}	27	dBm
V_{ESD}	ESD ratings human body model (JESD22-A114), all I/O one at a time while others connected to GND	2000	V
	ESD ratings machine model, all I/O	200	
T_{OP}	Operating temperature	-40 to +105	°C

Table 2. Impedances (T_{amb} = 25 °C)

Symbol	Parameter	Value			Unit
		Min.	Typ.	Max.	
Z_{RX}	Nominal differential Rx balun impedance	-	Matched to STM32WL	-	Ω
Z_{TX}	Nominal Tx filter impedance	-	Matched to STM32WL	-	
Z_{RX-ANT}	Nominal Rx balun antenna impedance	-	50	-	
Z_{TX-ANT}	Nominal Tx filter antenna impedance	-	50	-	

Table 3. Electrical characteristics and RF performances (T_{amb} = 25 °C)

Symbol	Parameter	Test condition	Value			Unit
			Min.	Typ.	Max.	
f	Frequency range		862	868	928	MHz
IL_{RX}	Rx balun insertion loss differential mode $\|S_{DS}\|$ without mismatch loss	Typical value given at 868 MHz		1.30	1.50	dB
IL_{TX}	LP Tx filter insertion loss $\|S_{21}\|$ without mismatch loss	Typical value given at 868 MHz		0.75	1.00	dB
RL_{RX-ANT}	Rx balun input return loss differential mode $\|S_{DD}\|$ on antenna	Typical value given at 868 MHz	15	18		dB
RL_{TX-ANT}	Tx filter output return loss $\|S_{11}\|$ on antenna	Typical value given at 868 MHz	14	20		dB
ϕ_{imb}	RX balun phase imbalance		-1.8		1.8	°
A_{imb}	RX balun amplitude imbalance		-1.0		1.0	dB
Att_{TX}	Tx filter harmonic rejection levels $\|S_{21}\|$	Attenuation at 2fo	31	34		dB
		Attenuation at 3fo	49	63		
		Attenuation at 4fo	43	56		
		Attenuation at 5fo	31	51		
		Attenuation at 6fo	32	54		
		Attenuation at 7fo	20	43		
		Attenuation at 8fo	27	37		
		Attenuation at 9fo	17	32		
		Attenuation at 10fo	20	27		

1.1 RF measurements (Rx balun)

Figure 1. Insertion loss (dB)

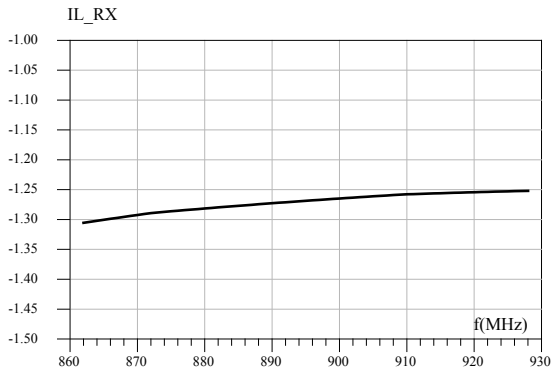


Figure 2. Return loss on antenna (dB)

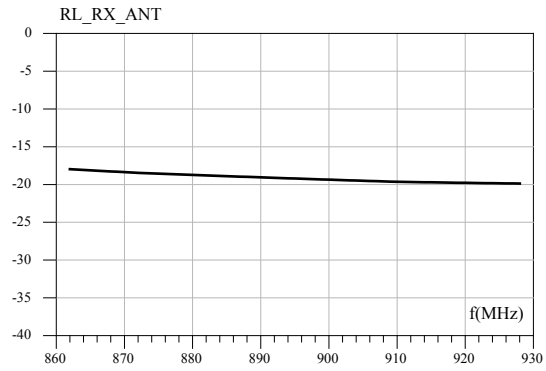


Figure 3. Amplitude imbalance (dB)

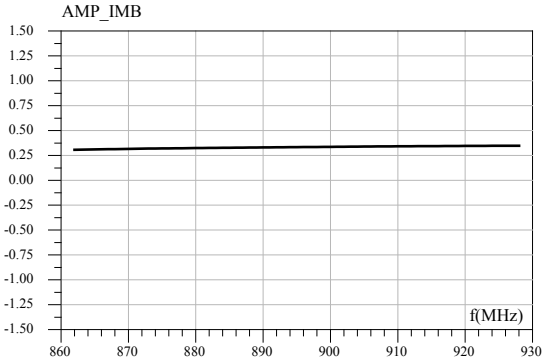
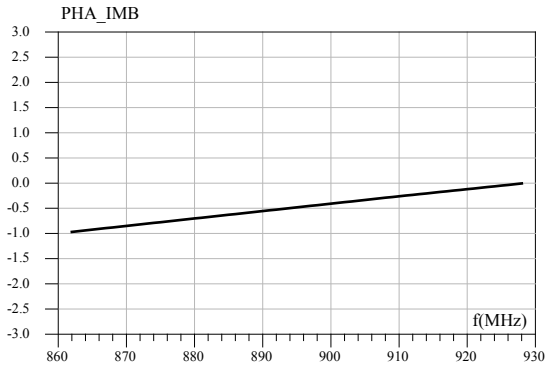


Figure 4. Phase imbalance (°)



1.2 RF measurements (Tx filter)

Figure 5. Transmission wide band with harmonics attenuation (dB)

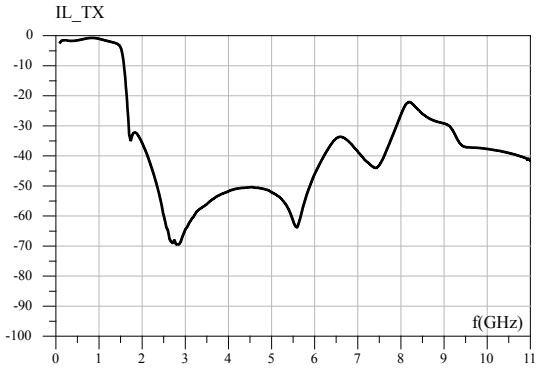


Figure 6. Insertion loss (dB)

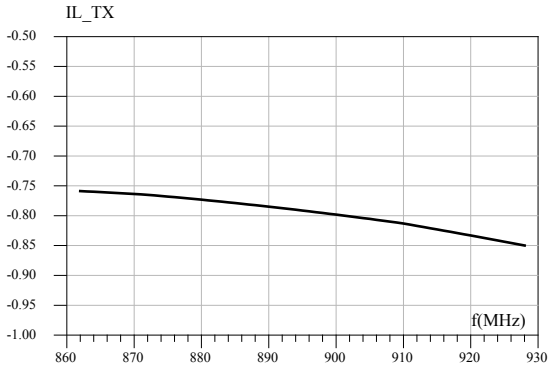
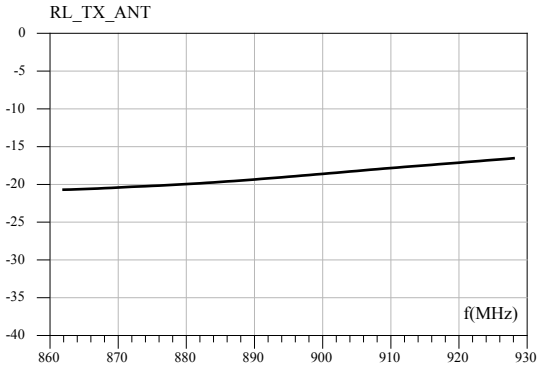


Figure 7. Return loss on antenna (dB)



2 Package information

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.

2.1 CSPG package information

Figure 8. CSPG 8 bumps package outline (bottom view - bumps up)

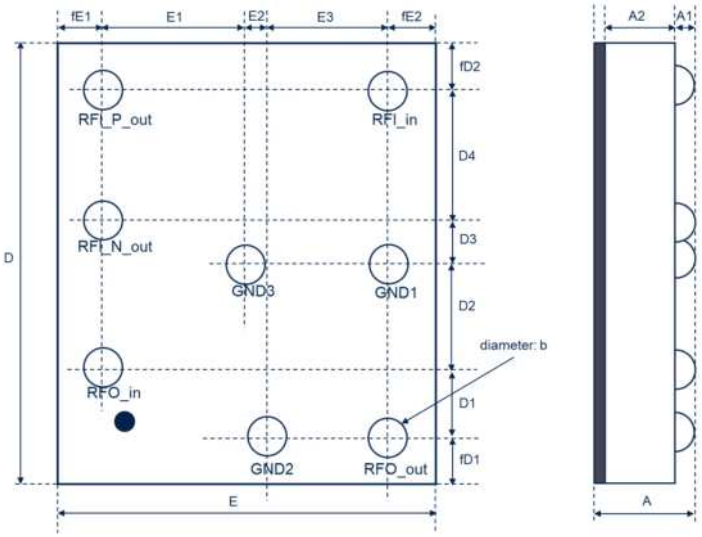


Table 4. CSPG 8 bumps mechanical data

Ref.	Dimensions		
	Millimeters		
	Min.	Typ.	Max.
A	0.580	0.630	0.680
A1	0.180	0.205	0.230
A2	0.380	0.400	0.420
b	0.230	0.255	0.280
D	2.100	2.150	2.200
D1		0.340	
D2		0.500	
D3		0.210	
D4		0.630	
E	1.800	1.850	1.900
E1		0.690	
E2		0.085	
E3		0.605	
fD1		0.235	
fD2		0.235	
fE1		0.235	
fE2		0.235	

2.2 CSPG 8 bumps packing information

Figure 9. **Marking**



Figure 10. **Top view**

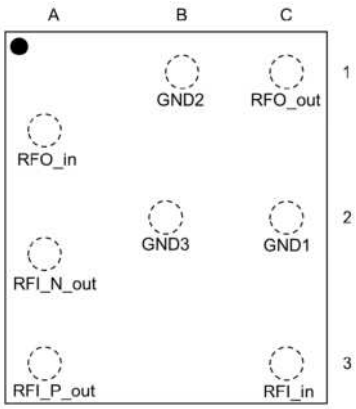


Table 5. **Pads description top view (pads down)**

Pad ref.	Pad name	Description
A1	RFO_in	Tx filter input
A2	RFI_N_out	Differential-N Rx balun output
A3	RFI_P_out	Differential-P Rx balun output
B1	GND2	Ground #2
B2	GND3	Ground #3
C1	RFO_out	Tx filter output
C2	GND1	Ground #1
C3	RFI_in	Single ended Rx balun input

Figure 11. **Tape and reel outline**

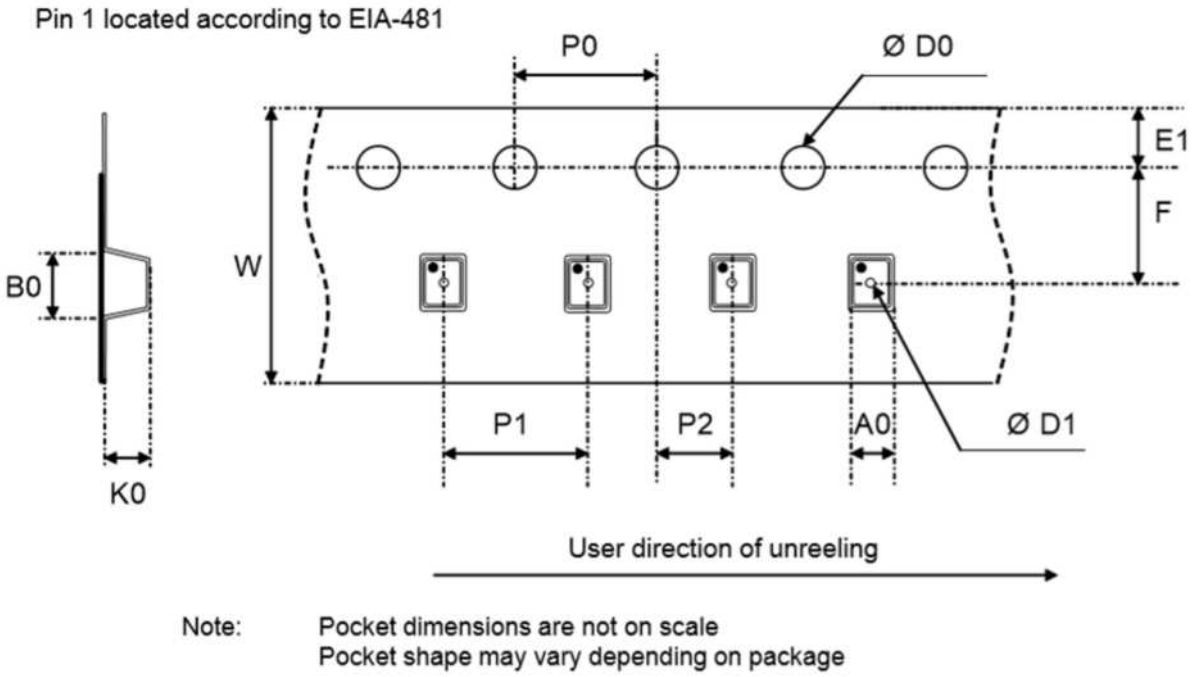


Table 6. **Tape and reel mechanical data**

Ref	Dimensions		
	Millimeters		
	Min	Typ	Max
A0	1.89	1.94	1.99
B0	2.19	2.24	2.29
Ø D0	1.40	1.50	1.60
Ø D1	0.95	1.00	1.05
E1	1.65	1.75	1.85
F	3.45	3.50	3.55
K0	0.70	0.75	0.80
P0	3.90	4.00	4.10
P1	3.90	4.00	4.10
P2	1.95	2.00	2.05
W	7.90	8.00	8.30

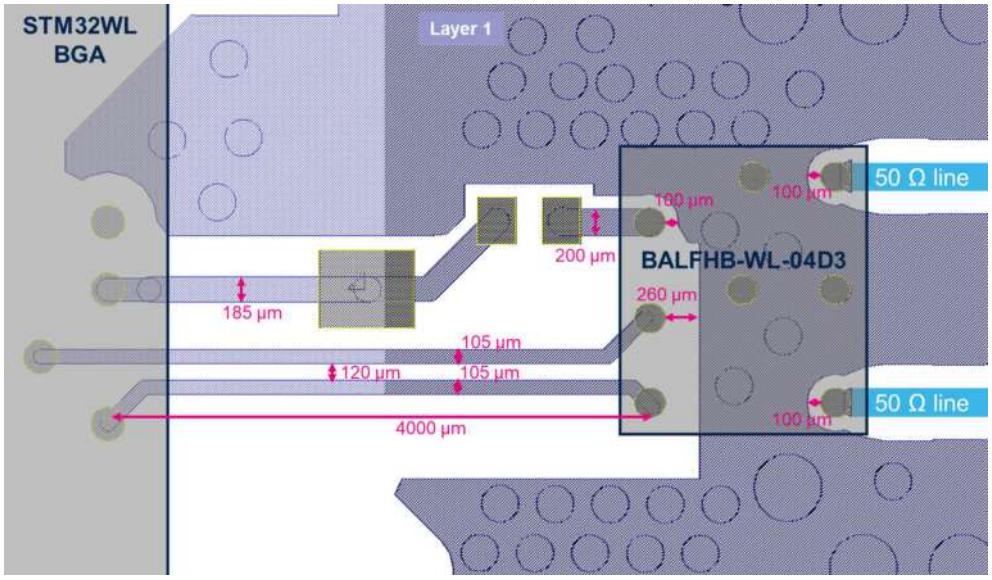
Note: More packing information is available in the application note:

- *AN2348 Flip-Chip: "Package description and recommendations for use"*

3 PCB assembly recommendations

3.1 Land pattern

Figure 12. BGA-4L PCB land pattern recommendation



The land pattern on layer 1 must be respected as described in Figure 12.

The ground plane on layer 1 is mandatory under the BALF, with its shape and definition optimized to achieve the best possible equipotentiality.

The density of vias and drills must be maximized near the BALF area to ensure optimal RF performance.

The layout around the IPD must be followed as closely as possible.

Table 7. Characteristic impedances of RF transmission lines for a BGA package with a 4-layer PCB in low power mode

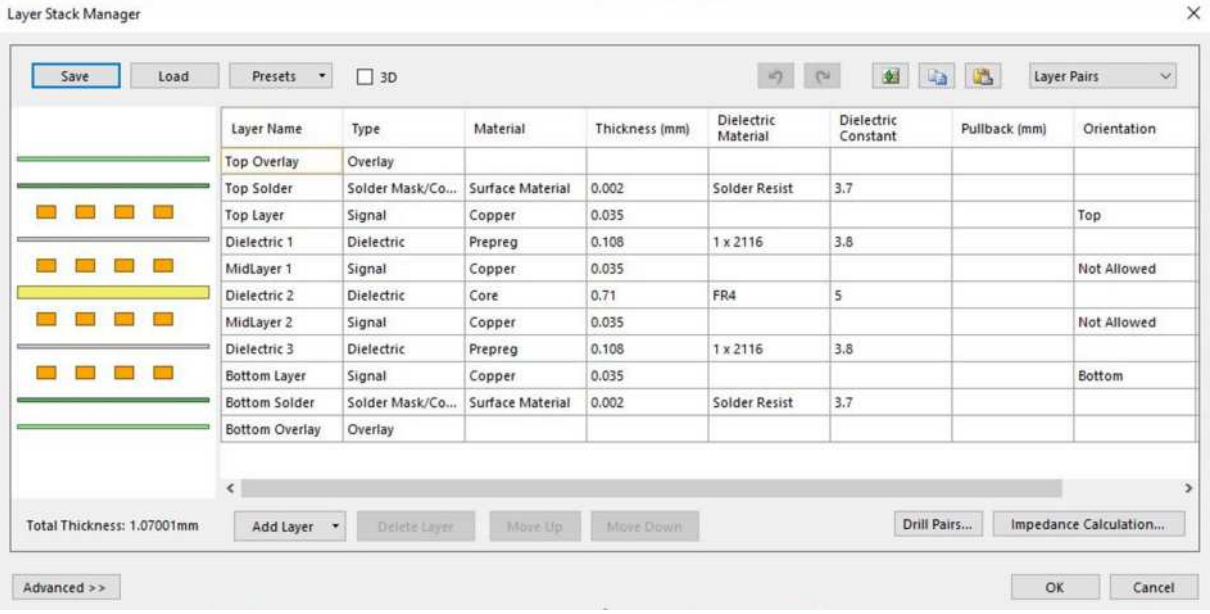
RF transmission line	Type	Value	Unit	Description
RFO_out Antenna	Z_0	50	Ω	Line between the BALF RFO_out pin and the Tx antenna
RFI_in Antenna	Z_0	50	Ω	Line between the BALF RFI_in pin and the Rx antenna
RFO_LP	Z_0	53	Ω	Line between the BALF RFO pin and the STM32 RFO_LP pin
RFI_out	Z_0	64	Ω	Differential lines between the BALF RFI_x_out pins and the STM32 RFI_x_out pins
	Z_{odd}	53	Ω	
	Z_{even}	78	Ω	

The characteristic impedances and lengths of the transmission lines must also be followed as precisely as possible.

Moreover, the physical dimensions of the lines must be adjusted according to the specific PCB stack-up, if it differs from the one presented in the datasheet, to maintain the expected characteristic impedance values.

The dimensions of the lines were calculated considering the ground plane on layer 2.

Figure 13. **Stack-up recommendation for a BGA-4L PCB**

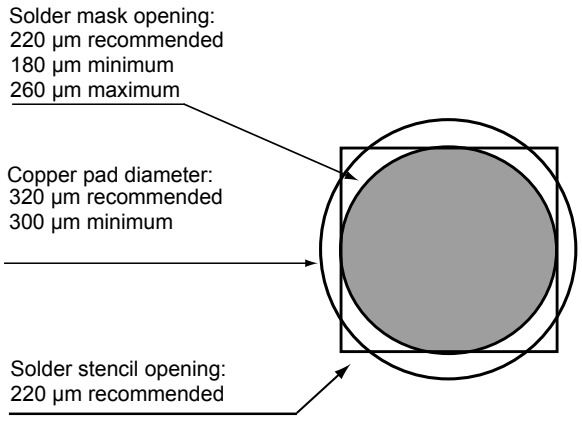


The PCB stack-up presented above is the one used to validate the product. The PCB dimensions should closely follow the recommendations, particularly the thickness of the dielectric between layer 1 and layer 2, which must remain within ±30 % of the specified values (that is, between 80 and 140 µm for a 4-layer PCB dedicated to the BGA package).

Other dimensions may vary without significantly impacting the overall functionality of the product.

3.2 Stencil opening design

Figure 14. **Footprint - 3 mils stencil - solder mask defined**



3.3 Solder paste

1. Halide-free flux qualification ROL0 according to ANSI/J-STD-004.
2. “No clean” solder paste is recommended.
3. Offers a high tack force to resist component movement during high speed.
4. Use solder paste with fine particles: powder particle size 20-38 µm.

3.4 Placement

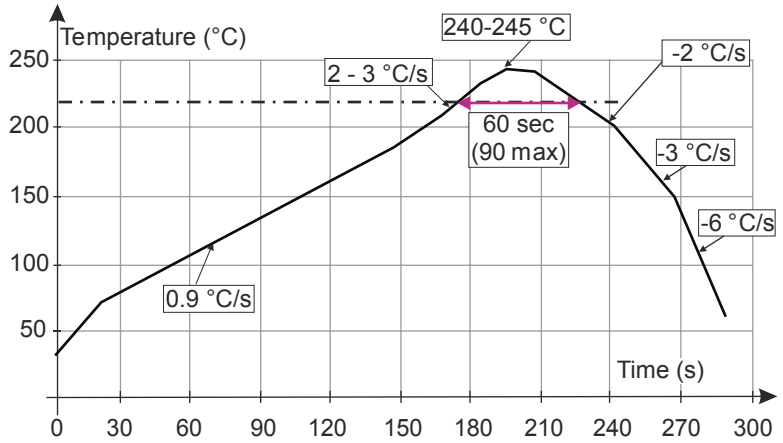
1. Manual positioning is not recommended.
2. It is recommended to use the lead recognition capabilities of the placement system, not the outline centering
3. Standard tolerance of ±0.05 mm is recommended.
4. 1.0 N placement force is recommended. Too much placement force can lead to squeezed out solder paste and cause solder joints to short. Too low placement force can lead to insufficient contact between package and solder paste that could cause open solder joints or badly centered packages.
5. To improve the package placement accuracy, a bottom side optical control should be performed with a high resolution tool.
6. For assembly, a perfect supporting of the PCB (all the more on flexible PCB) is recommended during solder paste printing, pick and place and reflow soldering by using optimized tools.

3.5 PCB design preference

1. To control the solder paste amount, the closed via is recommended instead of open vias.
2. The position of tracks and open vias in the solder area should be well balanced. A symmetrical layout is recommended, to avoid any tilt phenomena caused by asymmetrical solder paste due to solder flow away.

3.6 Reflow profile

Figure 15. ST ECOPACK® recommended soldering reflow profile for PCB mounting



Note: Minimize air convection currents in the reflow oven to avoid component movement.

Note: More information is available in the application note:

- *AN2348 Flip-Chip: "Package description and recommendations for use"*

4 Ordering information

Table 8. **Ordering information**

Order code	Marking	Package	Weight	Base qty.	Delivery mode
BALFHB-WL-04D3	W4	CSPG	3.9 mg	5000	Tape and reel

Revision history

Table 9. **Document revision history**

Date	Revision	Changes
14-Oct-2022	1	Initial release.
21-Dec-2022	2	Updated *Table 1. Absolute maximum ratings (T_{amb} = 25 °C)*.
15-Jul-2025	3	Updated Section 3.1: Land pattern, and Section 3.2: Stencil opening design.

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