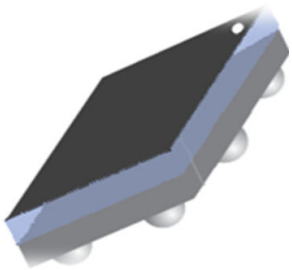
BALF-WL-00D3

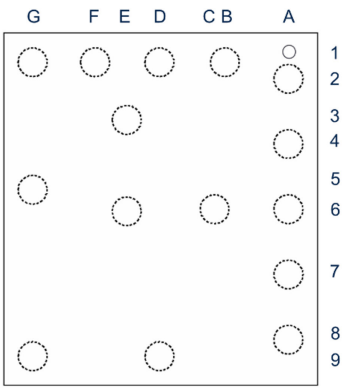
Datasheet

50 Ω nominal input / conjugate match balun to module STM32WL in high and low power modes, 862-928 MHz with integrated harmonic filter



Chip scale package on glass
15 bumps - 2.4 x 2.7 mm²

Pin-out top diagram (top view - bumps down)



Product status
BALF-WL-00D3

Features

- Module STM32WL sub-GHz wireless microcontrollers impedance matched balun and Tx harmonics filter
- Optimized for module STM32WL sub-GHz wireless microcontrollers in high and low power modes and dedicated to module package
- 50 Ω nominal input / conjugate match balun to module 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 BALF-WL-00D3 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_HP}	Input power RF_{IN} high power TX filter	27	dBm
P_{IN_LP}	Input power RF_{IN} low power TX filter	22	
V_{ESD}	ESD ratings human body model (JESD22-A114-C), all I/O one at a time while others connected to GND	200	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_HP}	Nominal HP TX filter impedance	-	Matched to STM32WL	-	
Z_{TX_LP}	Nominal LP TX filter impedance	-	Matched to STM32WL		
Z_{RX_ANT}	Nominal RX balun antenna impedance	-	50	-	
$Z_{TX\_HP\_ANT}$	Nominal HP TX filter antenna impedance	-	50	-	
$Z_{TX\_LP\_ANT}$	Nominal LP 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_{RX}	Frequency range		862	895	928	MHz
f_{TX_HP}	Frequency range for the high power TX filter		862	915	928	
f_{TX_LP}	Frequency range for the low power TX filter		862	868	928	
IL_{RX}	RX balun insertion loss differential mode $\|S_{DS}\|$ without mismatch loss	f_{RX}		0.95	1.15	dB
IL_{TX_HP}	HP TX filter insertion loss $\|S_{21}\|$ without mismatch loss	f_{TX_HP}		0.9	1.25	dB
IL_{TX_LP}	LP TX filter insertion loss $\|S_{21}\|$ without mismatch loss	f_{TX_LP}		0.95	1.25	
$RL_{RX\text{-}ANT}$	RX balun input return loss differential mode $\|S_{DD}$ on antenna	f_{RX}	14	17		dB
$RL_{TX\text{-}HP\_ANT}$	HP TX filter output return loss $\|S_{11}\|$ on antenna	f_{TX_HP}	19	22		
$RL_{TX\text{-}LP\_ANT}$	LP TX filter output return loss $\|S_{11}\|$ on antenna	f_{TX_LP}	14	17		dB
ϕ_{imb}	RX balun phase imbalance	f_{RX}	-4		4	°
A_{imb}	RX balun amplitude imbalance	f_{RX}	-3		3	dB
Att_{TX_HP}	HP TX filter harmonic rejection levels $\|S_{21}\|$	Attenuation at $2f_{TX\_HP}$	25	30		dB
		Attenuation at $3f_{TX\_HP}$	48	53		
		Attenuation at $4f_{TX\_HP}$	45	52		
		Attenuation at $5f_{TX\_HP}$	51	53		
		Attenuation at $6f_{TX\_HP}$	40	50		
		Attenuation at $7f_{TX\_HP}$	40	43		
		Attenuation at $8f_{TX\_HP}$	51	60		
		Attenuation at $9f_{TX\_HP}$	63	70		
		Attenuation at $10f_{TX\_HP}$	40	76		
Att_{TX_LP}	LP TX filter harmonic rejection levels $\|S_{21}\|$	Attenuation at $2f_{TX\_LP}$	23	27		dB
		Attenuation at $3f_{TX\_LP}$	45	51		
		Attenuation at $4f_{TX\_LP}$	47	51		
		Attenuation at $5f_{TX\_LP}$	42	47		
		Attenuation at $6f_{TX\_LP}$	30	41		
		Attenuation at $7f_{TX\_LP}$	34	46		
		Attenuation at $8f_{TX\_LP}$	56	59		
		Attenuation at $9f_{TX\_LP}$	67	75		
		Attenuation at $10f_{TX\_LP}$	43	74		

1.1 RF measurements (RX balun)

Figure 1. Amplitude imbalance (dB)

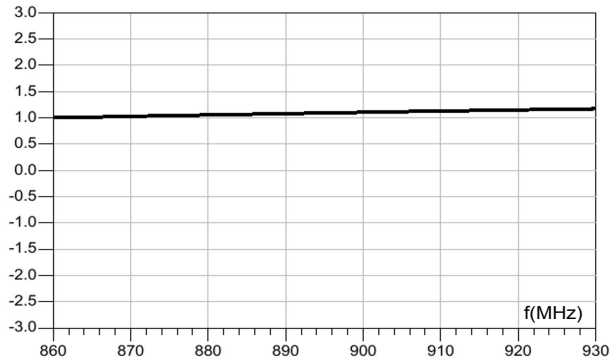


Figure 2. Phase imbalance (°)

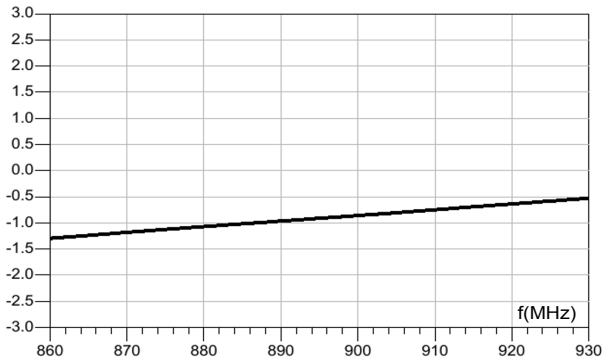


Figure 3. Insertion loss (dB)

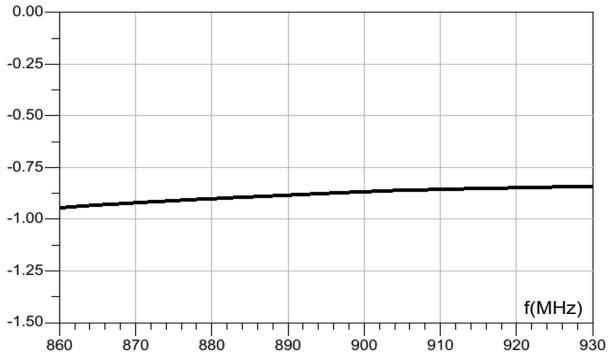
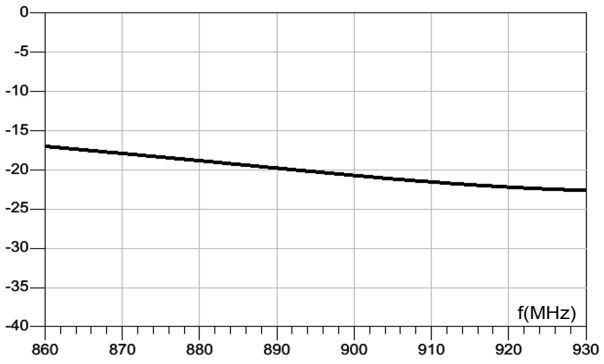


Figure 4. Return loss on antenna (dB)



1.2 RF measurements (HP TX filter)

Figure 5. Transmission (dB)

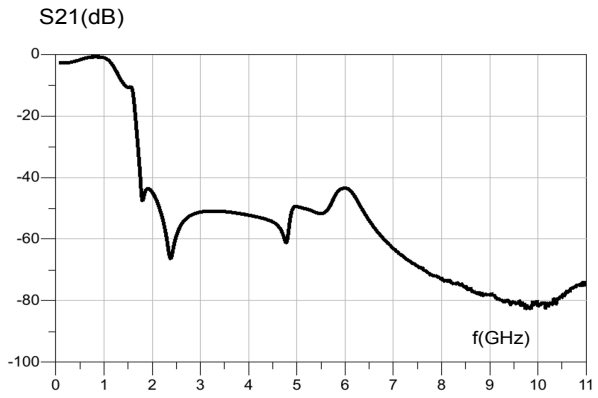


Figure 6. Insertion loss (dB)

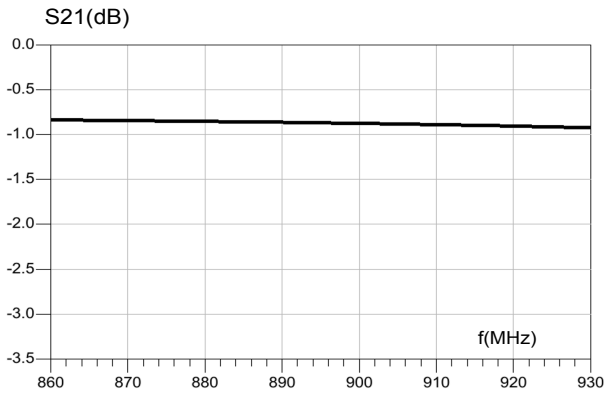


Figure 7. H2 attenuation (dB)

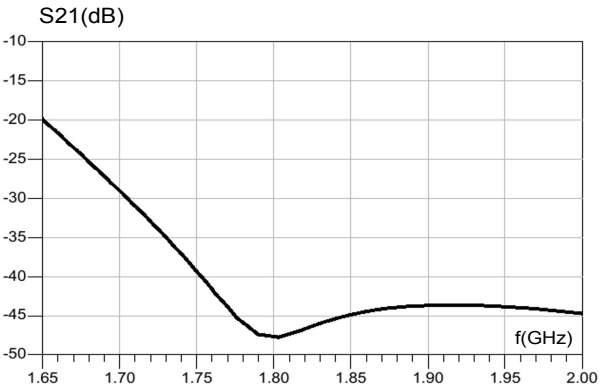


Figure 8. H3 attenuation (dB)

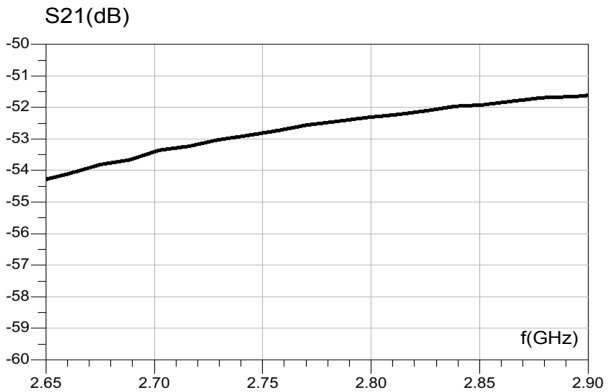


Figure 9. Output return loss (dB)

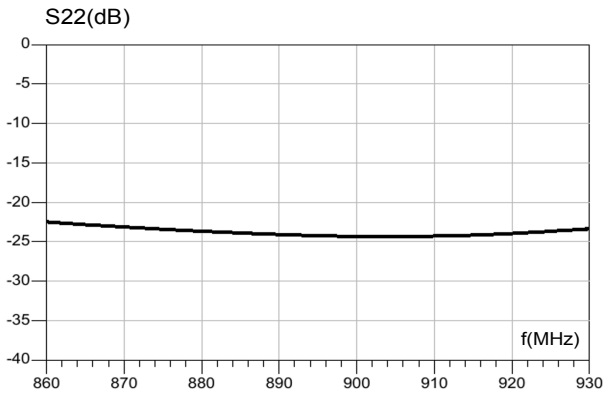
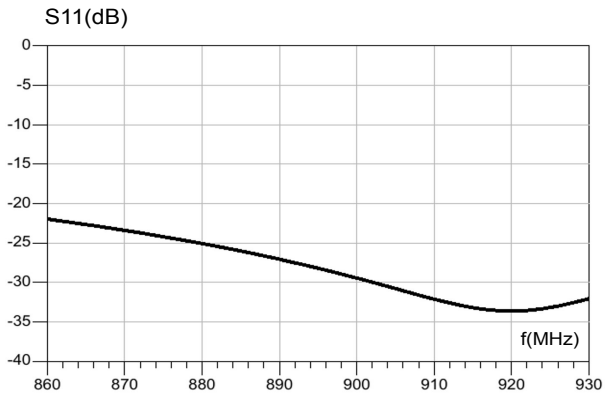


Figure 10. Input return loss (dB)



1.3 RF measurements (LP TX filter)

Figure 11. Transmission (dB)

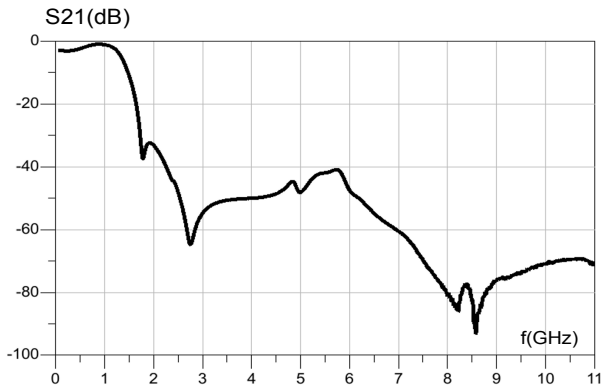


Figure 12. Insertion loss (dB)

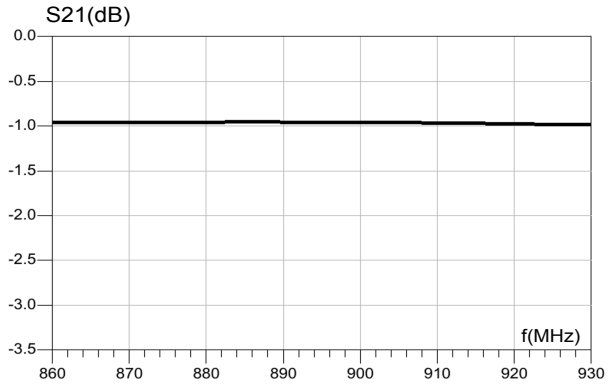


Figure 13. H2 attenuation (dB)

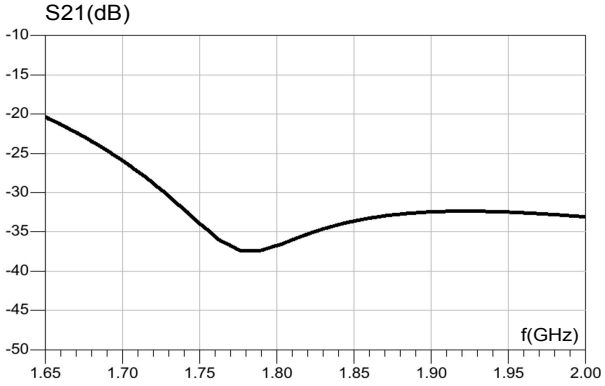


Figure 14. H3 attenuation (dB)

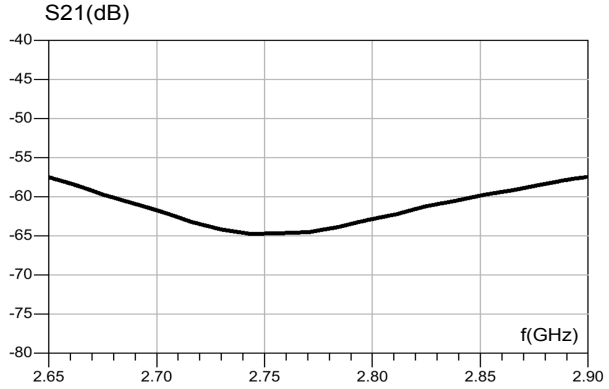


Figure 15. Output return loss (dB)

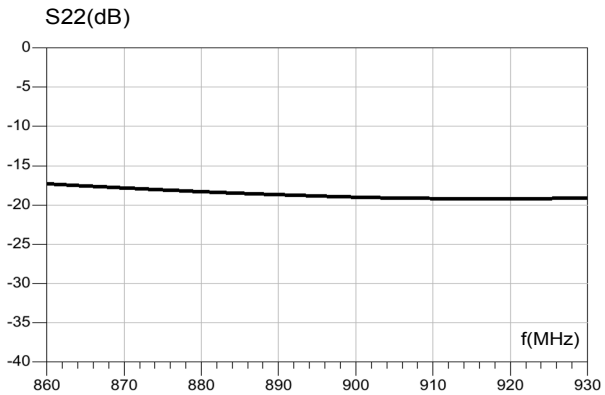
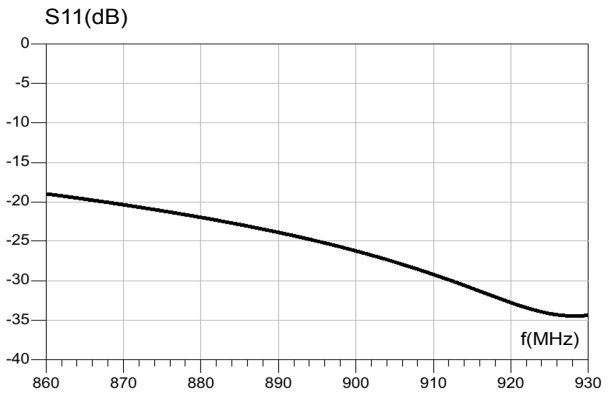


Figure 16. Input return loss (dB)



2 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.

2.1 CSPG 15 bumps package information

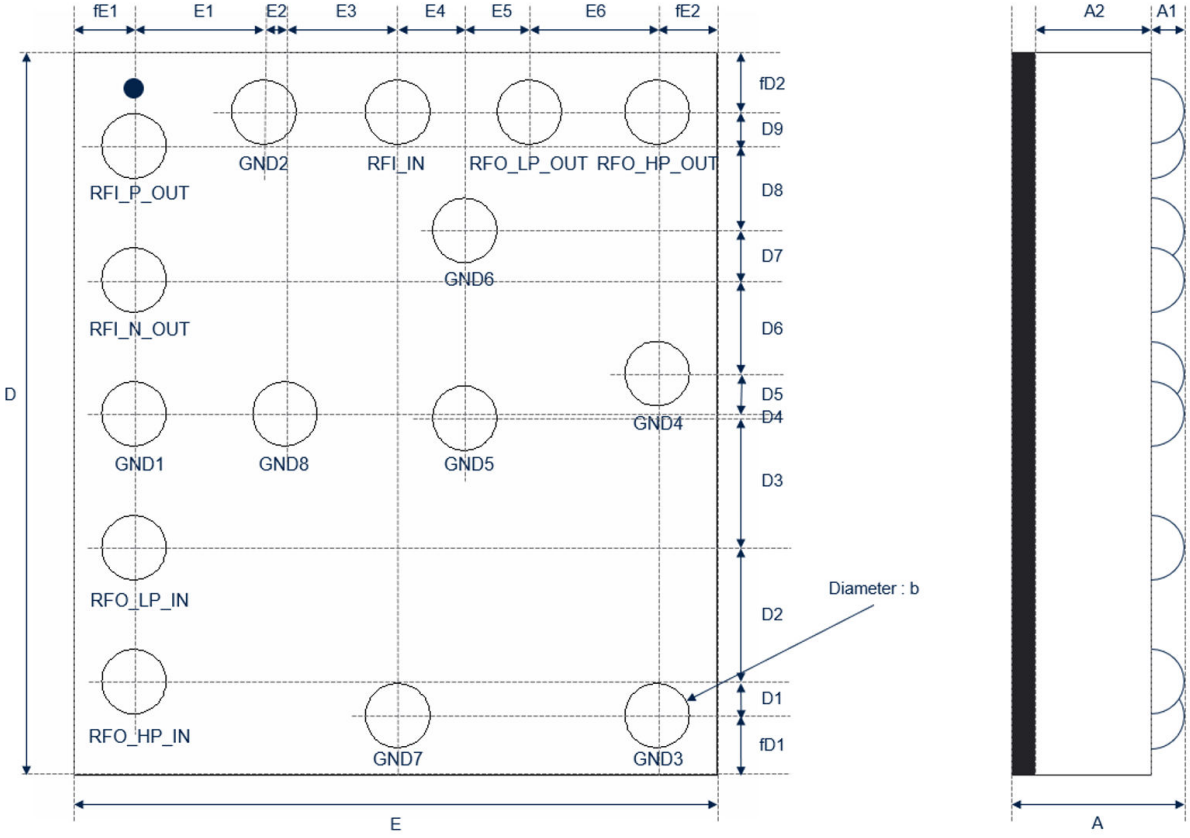


Table 4. **CSPG 15 bumps dimensions (in mm)**

Parameter	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	2.650	2.700	2.750
D1		0.127	
D2		0.500	
D3		0.484	
D4		0.016	
D5		0.150	
D6		0.350	
D7		0.185	
D8		0.315	
D9		0.127	
E	2.350	2.400	2.450
E1		0.485	
E2		0.079	
E3		0.421	
E4		0.250	
E5		0.242	
E6		0.477	
fD1		0.223	
fD2		0.223	
fE1		0.223	
fE2		0.223	

2.2 CSPG 15 bumps packing information

Figure 17. **Marking**

Figure 18. **Top view**

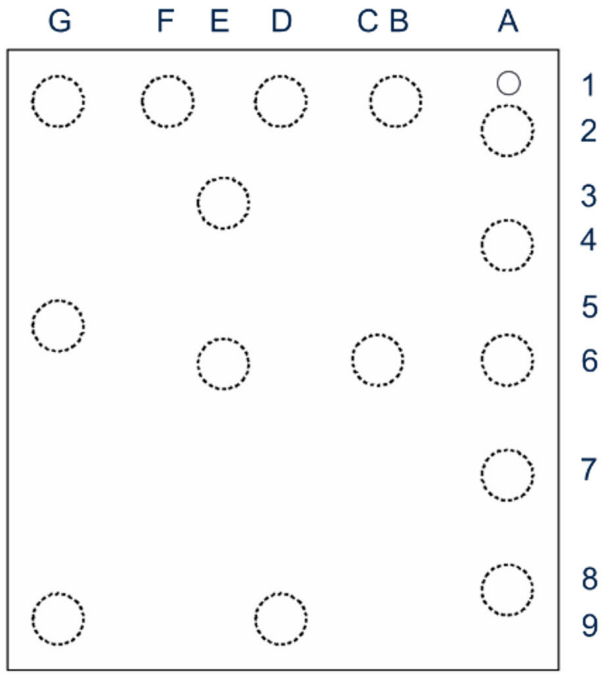
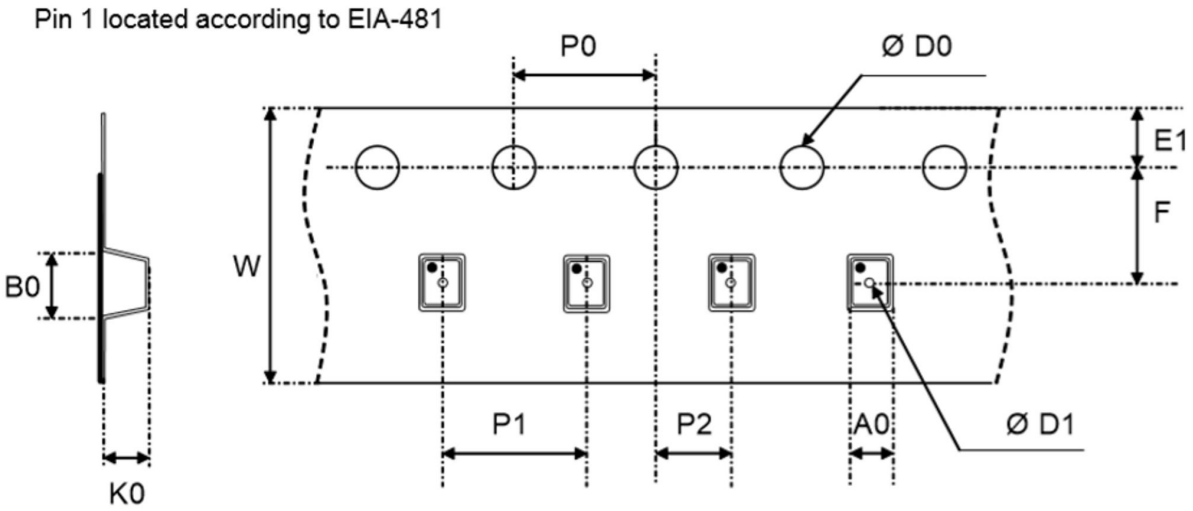


Table 5. **Pads description top view (pads down)**

Pad ref.	Pad name	Description
A2	RFI P OUT	Differential-P Rx balun output
A4	RFI N OUT	Differential-N Rx balun output
A6	GND1	Ground #1
A7	RFO_LP_IN	Tx low power filter input
A8	RFO_HP_IN	Tx high power filter input
B1	GND2	Ground #2
C6	GND8	Ground #8
D1	RFI_IN	Single ended Rx balun input
D9	GND7	Ground #7
E3	GND6	Ground #6
E6	GND5	Ground #5
F1	RFO LP OUT	Tx low power filter output
G1	RFO HP OUT	Tx high power filter output
G5	GND4	Ground #4
G9	GND3	Ground #3

Figure 19. **Tape and reel outline**



Note: Pocket dimensions are not on scale
Pocket shape may vary depending on package

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

Ref	Dimensions		
	Millimeters		
	Min	Typ	Max
A0	2.44	2.49	2.54
B0	2.64	2.79	2.84
Ø D0	1.40	1.50	1.60
Ø D1	0.55	0.60	0.65
E1	1.65	1.75	1.85
F	3.45	3.50	3.55
K0	0.67	0.72	0.77
P0	1.95	2.00	2.05
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:

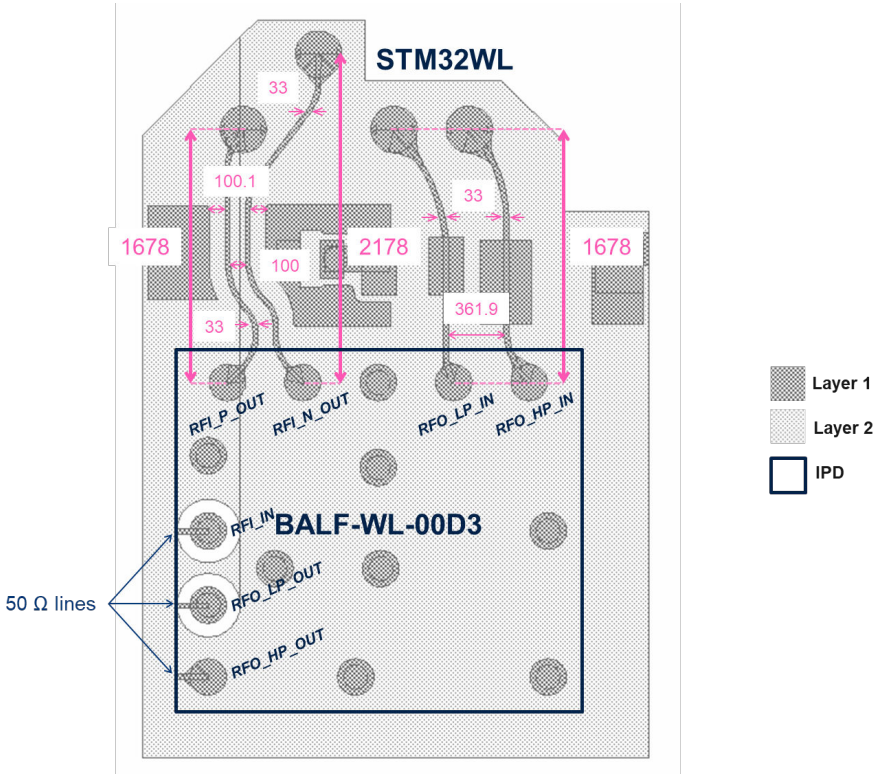
- *AN2348 Flip-Chip: "Package description and recommendations for use"*

3 PCB assembly recommendations

3.1 Land pattern

Layout example using module STM32WL / 4 layers PCB: layer 1 (dark grey) / ground plane in layer 2 (light grey).

Figure 20. PCB land pattern recommendation



Transmission Line between BALF-WL-00D3 and Antenna is dimensioned to 50 ohms characteristics impedance.

Transmission Line between STM32 and BALF-WL-00D3 RFI_P_OUT and RFI_N_OUT pins are a differential line dimensioned to 64 omhs characteristic impedance.

Transmission Line between STM32 and BALF-WL-00D3 RFO_LP_IN pin is dimensioned to 25 ohms characteristics impedance including the transmission line itself and the print of the CMS component.

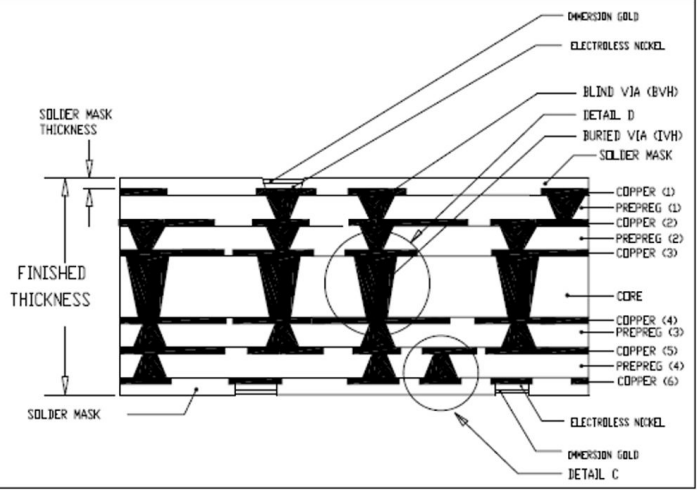
Transmission Line between STM32 and BALF-WL-00D3 RFO_HP_IN pin is dimensioned to 21 ohms characteristics impedance including the transmission line itself and the print of the CMS component.

These transmission line characteristics impedance have to be followed as close as possible.

Moreover, lines physical dimensions will have to be tuned according to specific PCB stack up if different from the one presented in datasheet to keep expected characteristic impedance values.

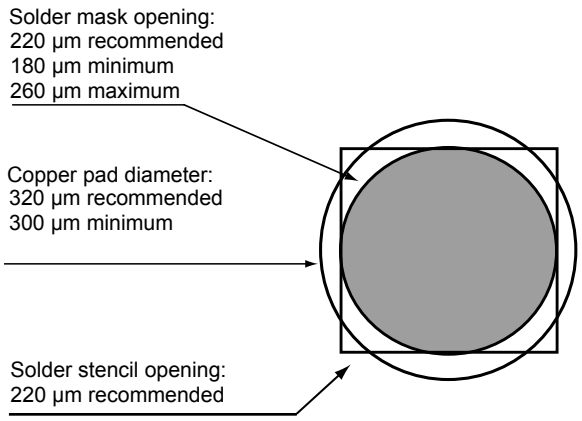
Figure 21. **PCB stack-up recommendation**

DESCRIPTION		MATERIAL	THICKNESS	FIGURE
FINISHED THICKNESS			248+/-40	
METAL FINISH	BUMP PAD	ENIG		
	BALL PAD	ENIG		
	OTHERS	ENIG		
NICLEL PLATING		Electroless NI	3-8	
GOLD PLATING		Inversion Au	0.03-0.12	
SOLDER MASK		PSR4000 AUS308	18+/-10 (ON CU)	
PREPREG(1)(2)(3)(4)		GEA-770G	25+/-10	
CORE		MCL-E-770G(R)	40+/-10	
COPPER THICKNESS (1)(2)(3)(4)(5)(6)		12+/-6		
COPPER THICKNESS IN IVH		FILLED		
COPPER THICKNESS IN BVH		FILLED		
IVH BARREL COPPER		10 MIN.		
DIMPLE DEPTH		10 MAX.		



3.2 Stencil opening design

Figure 22. **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

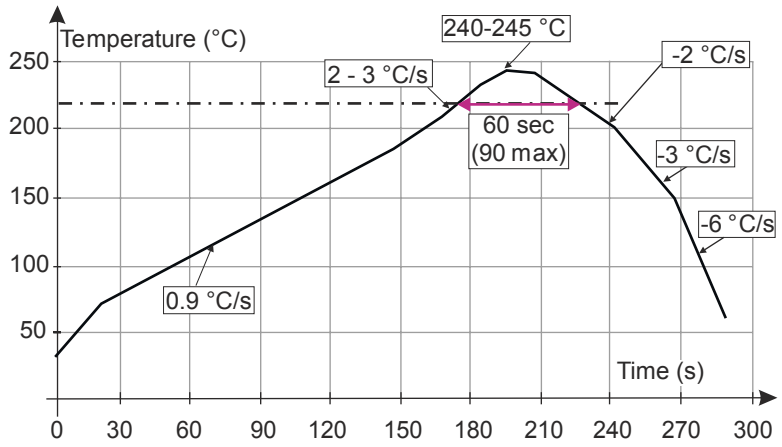
1. Manual positioning is not recommended.
2. It is recommended to use the lead recognition capabilities of the placement system, not the outline centering
3. Standard tolerance of ±0.05 mm is recommended.
4. 1.0 N placement force is recommended. Too much placement force can lead to squeezed out solder 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 23. 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 7. **Ordering information**

Order code	Marking	Package	Weight	Base qty.	Delivery mode
BALF-WL-00D3	TV	CSPG	6.9 mg	5000	Tape and reel

Revision history

Table 8. **Document revision history**

Date	Revision	Changes
15-Dec-2023	1	Initial release.

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