

## RUN mXTEND™ (FR01-S4-224) – AN for Clearance Length and Ground Plane Length Experiments 824-960 MHz and 1710-2690MHz

Fractus Antennas specializes in enabling effective mobile communications. Using Fractus Antennas technology, we design and manufacture optimized antennas to make your wireless devices more competitive. Our mission is to help our clients develop innovative products and accelerate their time to market through our expertise in antenna design, testing and manufacturing.



RUN mXTEND™ Antenna Booster

FR01-S4-224

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Fractus Antennas is an ISO 9001:2008 certified company. All our antennas are lead-free and RoHS compliant.

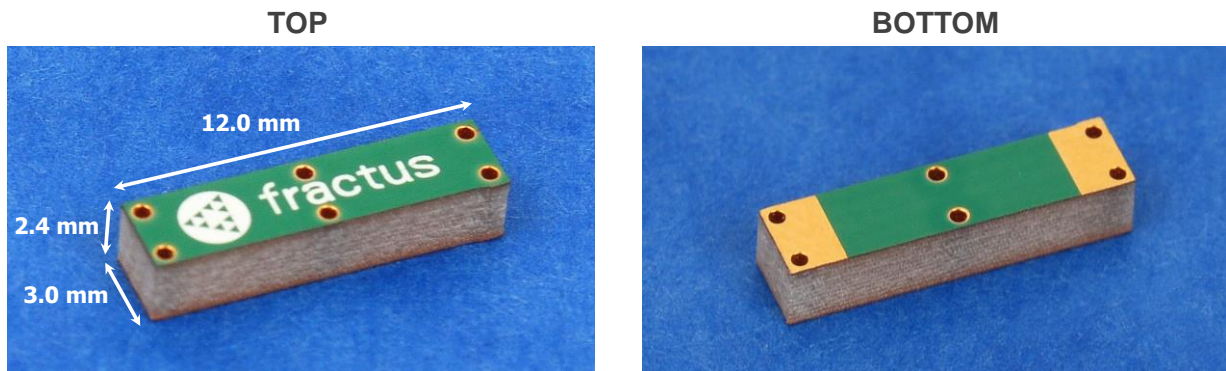


## TABLE OF CONTENTS

1. PRODUCT DESCRIPTION FR01-S4-224 .....	3
2. CLEARANCE LENGTH EXPERIMENTS .....	4
2.1. EVALUATION BOARD.....	4
2.2. VSWR AND EFFICIENCY .....	4
2.3. MATCHING NETWORK.....	5
3. GROUND PLANE LENGTH EXPERIMENTS .....	7
3.1. EVALUATION BOARD.....	7
3.2. VSWR AND EFFICIENCY .....	7
3.3. MATCHING NETWORK.....	8

## 1. PRODUCT DESCRIPTION FR01-S4-224

The RUN mXTEND™ Antenna Booster (FR01-S4-224) has been specifically designed for providing multiband performance in wireless devices, enabling worldwide coverage by allowing operation in the communication standards 2G, 3G, 4G, ISM, Zigbee, RFID, GPS, GLONASS, Bluetooth, WIFI, and WLAN.



**Material:** The RUN mXTEND™ Antenna Booster is built on glass epoxy substrate.

### APPLICATIONS

- Handsets and Smartphones
- Tablets and PCs
- Modules
- Routers
- Headsets
- USB Dongles
- Navigators
- Digital Cameras and Smart Watches
- Metering (Gas, Electricity, Water...)
- RFID
- Sensors (Parking, Speed Control, Optics...)

### BENEFITS

- High efficiency
- Small size
- Cost-effective
- Easy-to-use (pick and place)
- Multiband behaviour (worldwide standards)
- Off-the-Shelf Standard Product (no customization is required)

The RUN mXTEND™ Antenna Booster belongs to a new generation of antenna solutions based on the Virtual Antenna™ technology developed by Fractus. The technology is mainly focused on replacing conventional antenna solutions by miniature and standard components.

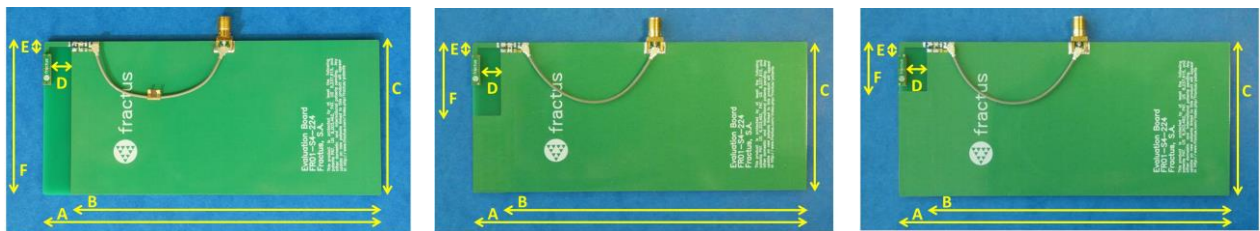
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## 2. CLEARANCE LENGTH EXPERIMENTS

### 2.1. EVALUATION BOARD

This Evaluation Board EB\_FR01-S4-224-1B-2RJ-1P integrates a UFL cable to connect the RUN mXTEND™ Antenna Booster with the SMA connector. The experiment consists of reducing the clearance length, going from 60mm (original case) to 20mm.



Clearance Length: 60 mm

Clearance Length: 30 mm

Clearance Length: 20 mm

Measure	mm
A	131
B	120
C	60
D	8
E	5
F	60-20

**Tolerance:** ±0.2 mm

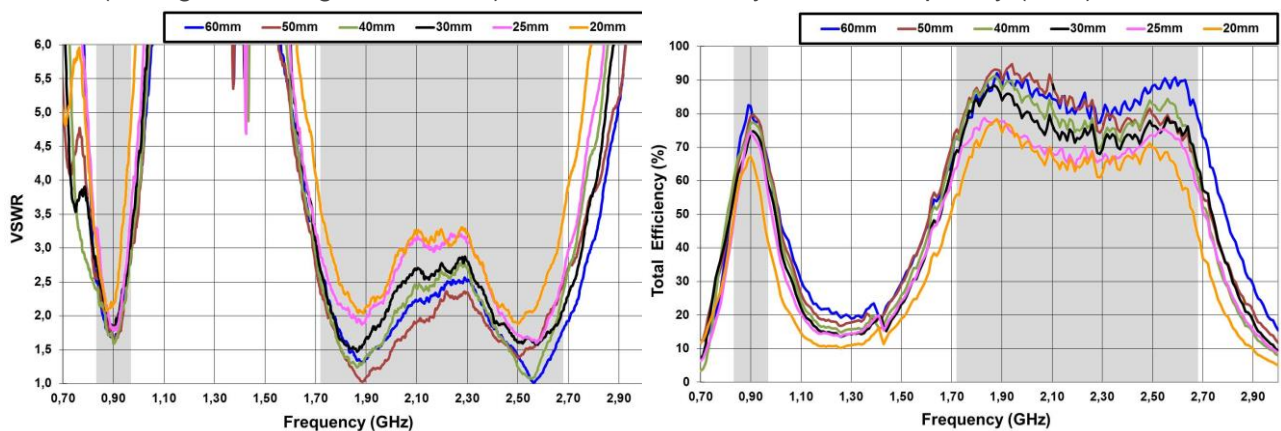
**D:** Distance between the RUN mXTEND™ Antenna Booster and the ground plane.

**Material:** The evaluation board is built on FR4 substrate. Thickness is 1 mm.

**Figure 1** – Evaluation boards with different clearance lengths that provide operation from 824 MHz to 960 MHz and from 1710 MHz to 2690 MHz.

### 2.2. VSWR AND EFFICIENCY

VSWR (Voltage Standing Wave Ratio) and Total Efficiency versus Frequency (GHz).



**Figure 2** – VSWR and Total Efficiency for the 824 – 960 MHz frequency range and for the 1710 – 2690 MHz frequency range from the evaluation board (Figure 1).

F	LFR (824 – 960MHz)					HFR (1710 – 2690MHz)				
	$\eta_a$ 824MHz	$\eta_a$ 960MHz	Min	Max	Av. $\eta_a$	$\eta_a$ 1710MHz	$\eta_a$ 2690MHz	Min	Max	Av. $\eta_a$
60mm	54.3	68.2	54.3	84.6	73.5	74.5	74.7	71.1	94.7	84.5
50mm	54.7	66.5	54.7	80.3	71.8	76.6	57.6	57.6	95.7	82.0
40mm	58.8	64.5	58.8	78.2	71.1	74.3	53.7	53.7	92.1	79.6
30mm	53.6	60.9	53.6	75.5	67.6	69.9	59.9	59.9	89.1	76.3
25mm	46.3	55.6	46.3	74.6	64.5	64.6	47.5	47.5	79.4	70.8
20mm	47.7	43.5	43.5	68.2	58.7	56.7	39.1	39.1	78.6	66.4

Table 1 – Antenna efficiency (%) comparison considering the different clearance lengths.

### 2.3. MATCHING NETWORK

The specs of a Fractus Antennas standard product are measured in their evaluation board, which is an ideal case. In a real design, components nearby the antenna, LCD's, batteries, covers, connectors, etc. affect the antenna performance. This is the reason why it is highly recommended placing pads compatible with 0402 and 0603 SMD components for a matching network as close as possible to the feeding point. Do it in the ground plane area, not in the clearance area. This provides a degree of freedom to tune the RUN mXTEND™ Antenna Booster once the design is finished and taking into account all elements of the series (batteries, displays, covers, etc.).

Please notice that different devices with different ground planes and different components nearby the RUN mXTEND™ Antenna Booster may need a different matching network. To ensure optimal results, the use of high Q and tight tolerance components is highly recommended (Murata components). Please, if you need assistance contact [info@fractusantennas.com](mailto:info@fractusantennas.com) for more information related to the antenna booster matching service.

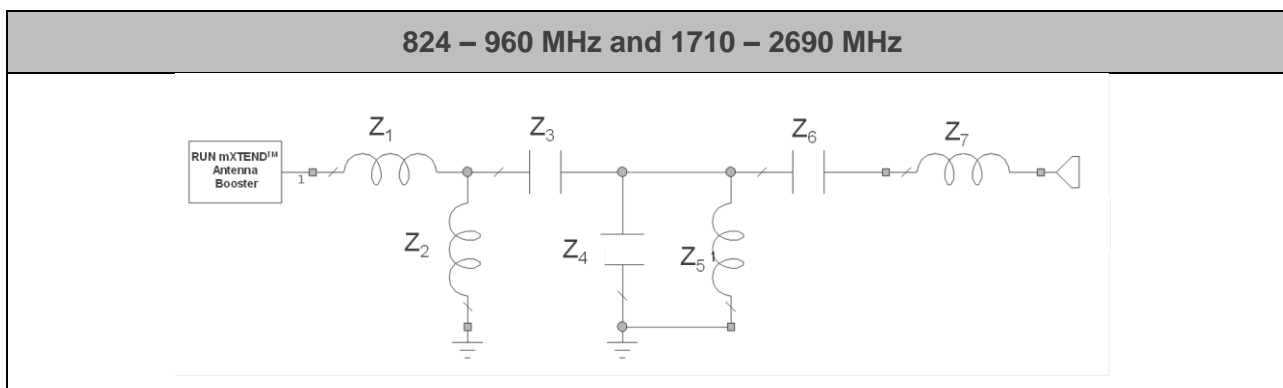


Figure 3 – Topology of matching network mounted at the different solutions.

F	Z <sub>1</sub>	Z <sub>2</sub>	Z <sub>3</sub>	Z <sub>4</sub>	Z <sub>5</sub>	Z <sub>6</sub>	Z <sub>7</sub>
60mm	4.3nH	18nH	0.9pF	1pF	13nH	2pF	4.5nH
50mm	6.5nH	18nH	0.8pF	1pF	11nH	1.8pF	4.5nH
40mm	6.5nH	18nH	0.7pF	1pF	10nH	1.6pF	5.1nH
30mm	6.5nH	18nH	0.7pF	0.9pF	11nH	1.6pF	4.9nH
25mm	6.1nH	17nH	0.8pF	1pF	11nH	2pF	4.5nH
20mm	4.9nH	18nH	0.8pF	1pF	11nH	1.8pF	4.5nH

**Table 2** – Values of the components for each clearance length.

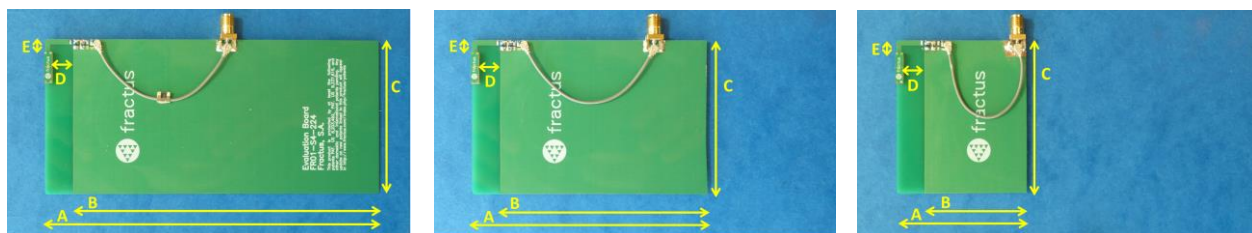
Value		Part Number
Z1	4.3 nH	LQW15AN4N3B80
	6.5 nH	LQW15AN6N5G80D
	6.1 nH	LQW15AN6N1B80D
	4.9 nH	LQW15AN4N9B80
Z2	18 nH	LQW18AN18NG10
	17 nH	LQW18AN17NG80D
Z3	0.9 pF	GJM1555C1HR90WB01
	0.8 pF	GJM1555C1HR80WB01D
	0.7 pF	GJM1555C1HR70WB01D
Z4	1 pF	GJM1555C1H1R0WB01
	0.9 pF	GJM1555C1HR90WB01
Z5	13 nH	LQW15AN13NG00
	11 nH	LQW15AN11NG80
	10 nH	LQW15AN10NG80D
Z6	2.0 pF	GJM1555C1H2R0WB01
	1.8 pF	GJM1555C1H1R8WB01
	1.6 pF	GJM1555C1H1R6WB01
Z7	4.5 nH	LQW15AN4N5B80
	5.1 nH	LQW15AN5N1B80D
	4.9 nH	LQW15AN4N9B80

**Table 3** – Values and part numbers of the components used for the matching networks for the cases with clearance length equal to 60 mm, 50 mm, 40 mm, 30 mm, 25 mm and 20 mm.

### 3. GROUND PLANE LENGTH EXPERIMENTS

#### 3.1. EVALUATION BOARD

This Evaluation Board EB\_FR01-S4-224-1B-2RJ-1P integrates a UFL cable to connect the RUN mXTEND™ Antenna Booster with the SMA connector. The experiment consists of reducing the ground plane length, going from 120mm (original case) to 40mm.



Ground plane Length: 120 mm

Ground plane Length: 80 mm

Ground plane Length: 40 mm

Measure	mm
A	131 – 51
B	120 – 40
C	60
D	8
E	5

**Tolerance:** ±0.2 mm

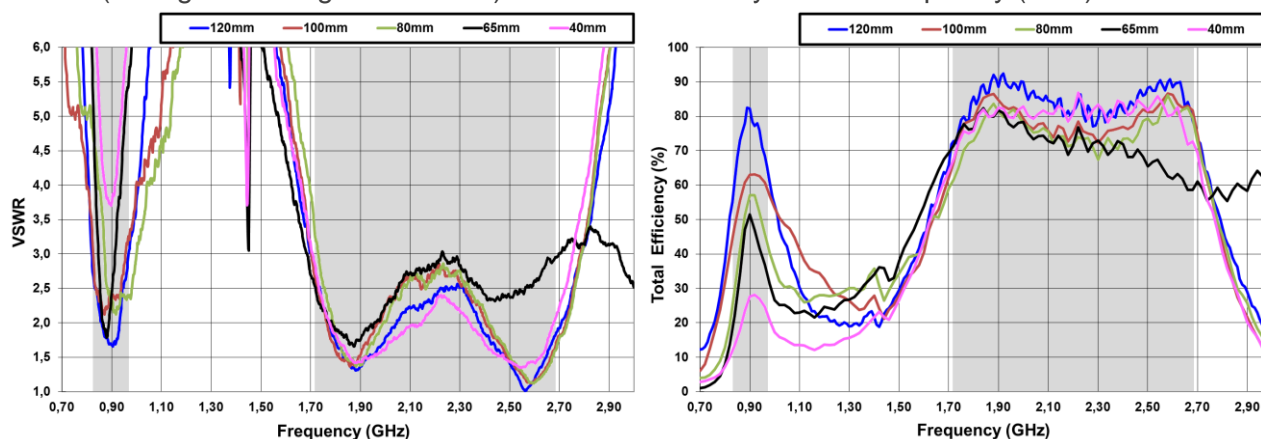
**D:** Distance between the RUN mXTEND™ Antenna Booster and the ground plane.

**Material:** The evaluation board is built on FR4 substrate. Thickness is 1 mm.

**Figure 4** – Evaluation boards with different ground plane lengths that provide operation from 824 MHz to 960 MHz and from 1710 MHz to 2690 MHz.

#### 3.2. VSWR AND EFFICIENCY

VSWR (Voltage Standing Wave Ratio) and Total Efficiency versus Frequency (GHz).



**Figure 5** – VSWR and Total Efficiency for the 824 – 960 MHz frequency range and for the 1710 – 2690 MHz frequency range from the evaluation board (Figure 4).

B	LFR (824 – 960MHz)					HFR (1710 – 2690MHz)				
	$\eta_a$ 824MHz	$\eta_a$ 960MHz	Min	Max	Av. $\eta_a$	$\eta_a$ 1710MHz	$\eta_a$ 2690MHz	Min	Max	Av. $\eta_a$
120mm	54.3	68.2	54.3	84.6	73.5	74.5	74.7	71.1	94.7	84.5
100mm	45.9	59.3	45.9	63.4	59.5	66.7	74.5	66.7	88.4	79.1
80mm	25.7	43.0	25.7	58.8	48.2	61.6	72.3	61.6	87.0	76.0
65mm	18.9	34.4	18.9	53.0	40.5	71.5	61.2	57.1	83.9	71.9
40mm	12.2	22.8	12.2	28.7	23.4	67.5	68.9	67.5	89.2	80.4

Table 4 – Antenna efficiency comparison considering the different ground plane lengths.

### 3.3. MATCHING NETWORK

The specs of a Fractus Antennas standard product are measured in their evaluation board, which is an ideal case. In a real design, components nearby the antenna, LCD's, batteries, covers, connectors, etc. affect the antenna performance. This is the reason why it is highly recommended placing pads compatible with 0402 and 0603 SMD components for a matching network as close as possible to the feeding point. Do it in the ground plane area, not in the clearance area. This provides a degree of freedom to tune the RUN mXTEND™ Antenna Booster once the design is finished and taking into account all elements of the series (batteries, displays, covers, etc.).

Please notice that different devices with different ground planes and different components nearby the RUN mXTEND™ Antenna Booster may need a different matching network. To ensure optimal results, the use of high Q and tight tolerance components is highly recommended (Murata components). Please, if you need assistance contact [info@fractusantennas.com](mailto:info@fractusantennas.com) for more information related to the antenna booster matching service.

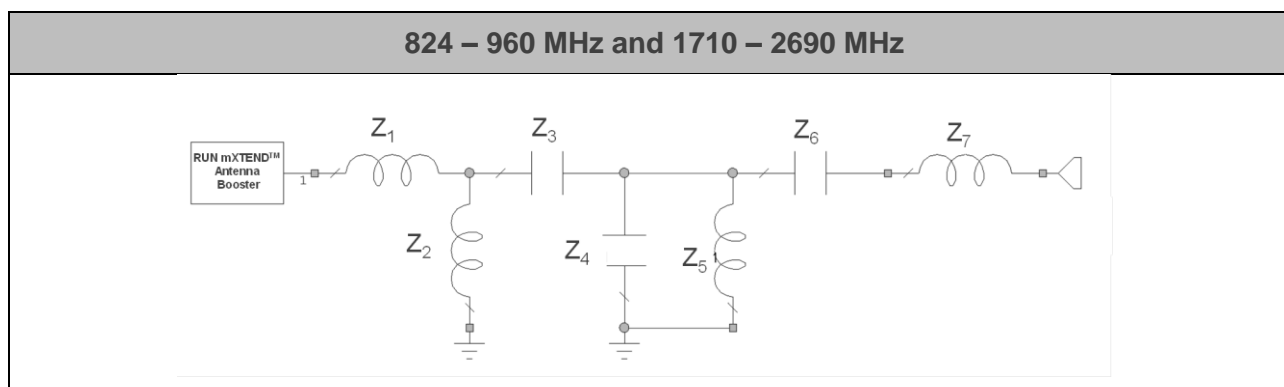


Figure 6 – Topology of matching network mounted at the different solutions.



B	Z <sub>1</sub>	Z <sub>2</sub>	Z <sub>3</sub>	Z <sub>4</sub>	Z <sub>5</sub>	Z <sub>6</sub>	Z <sub>7</sub>
120mm	4.3nH	18nH	0.9pF	1pF	13nH	2pF	4.5nH
100mm	5.1nH	18nH	0.8pF	1pF	10nH	2pF	4.7nH
80mm	4.5nH	18nH	0.8pF	0.9pF	14nH	2pF	4.9nH
65mm	3.6nH	18nH	0.6pF	0.4pF	-	-	3.3 nH-
40mm	4.3nH	18nH	0.9pF	1pF	13nH	2pF	4.5nH

**Table 5** – Values of the components for each ground plane length.

Value		Part Number
Z1	4.3 nH	LQW15AN4N3B80
	5.1 nH	LQW15AN5N1B80D
	4.5 nH	LQW15AN4N5B80D
	3.6 nH	LQW15AN3N6B80D
Z2	18 nH	LQW18AN18NG10
Z3	0.9 pF	GJM1555C1HR90WB01
	0.8 pF	GJM1555C1HR80WB01
	0.6 pF	GJM1555C1HR60WB01
Z4	1 pF	GJM1555C1H1R0WB01
	0.9 pF	GJM1555C1HR90WB01
	0.4 pF	GJM1555C1HR40WB01
Z5	13 nH	LQW15AN13NG00
	10 nH	LQW15AN10NG00
	14 nH	LQW15AN14NG00
Z6	2.0 pF	GJM1555C1H2R0WB01
Z7	3.3 nH	LQW15AN3N3B80D
	4.5 nH	LQW15AN4N5B80
	4.7 nH	LQW15AN4N7B80
	4.9 nH	LQW15AN4N9B80

**Table 6** – Values and part numbers of the components used for the matching networks for the cases with ground plane length equal to 120 mm, 100 mm, 80 mm, 65 mm and 40 mm.