Document:	LTE BACK-UP & WLAN ANTENNA GAIN MEASUREMENT REPORT
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1. Abstract and main results

1.1 Objective

This report presents the BSRF-EA product antenna gain measurement results.

This document includes the description of the antenna gain measurement done by Continental. Facility measurement site, procedure, test equipment, test setup, used for BSRF-EA product antenna radiation characterization are also detailed according to the FCC requirements.

1.2 Main results

Worst case maximum gain value has been reported in 1 for WLAN antenna.

1.2.1 WLAN Antenna

Antenna Name	Wi-Fi antenna
Antenna Type	PCB antenna
Antenna Location	BSRF integrated antenna
Antenna Operating Hemisphere	Inside of vehicle
Antenna Peak Gain [dBi] **(uncertainty ±1dB)**	2400 - 2483.5 MHz: +2.0 5150 – 5250 MHz: +6.0 (*) 5725 - 5850 MHz: +6.0 (**)

Table 1: Worst case maximum gain value for WLAN antenna

(*) the measured maximum gain of the sample presented in §3.1.1 is +4.40dBi.

(**) the measured maximum gain of the sample presented in §3.1.1 is +3.01dBi.

Nevertheless Continental has declared a maximum gain of +6.0dBi for these both channels in order to take into account the design margin for this specific high frequency.

1.3 Attached documents

The following documents are attached to the present report.

Document name	*Description*
DRH10.pdf	DRH10-RF Spin antenna **datasheet** and factory **calibration**

2. Measurement procedure

2.1 Facility description

Continental has performed the measurement in a anechoic chamber provided by *SIEPEL* company. A picture is shown in Figure 1.

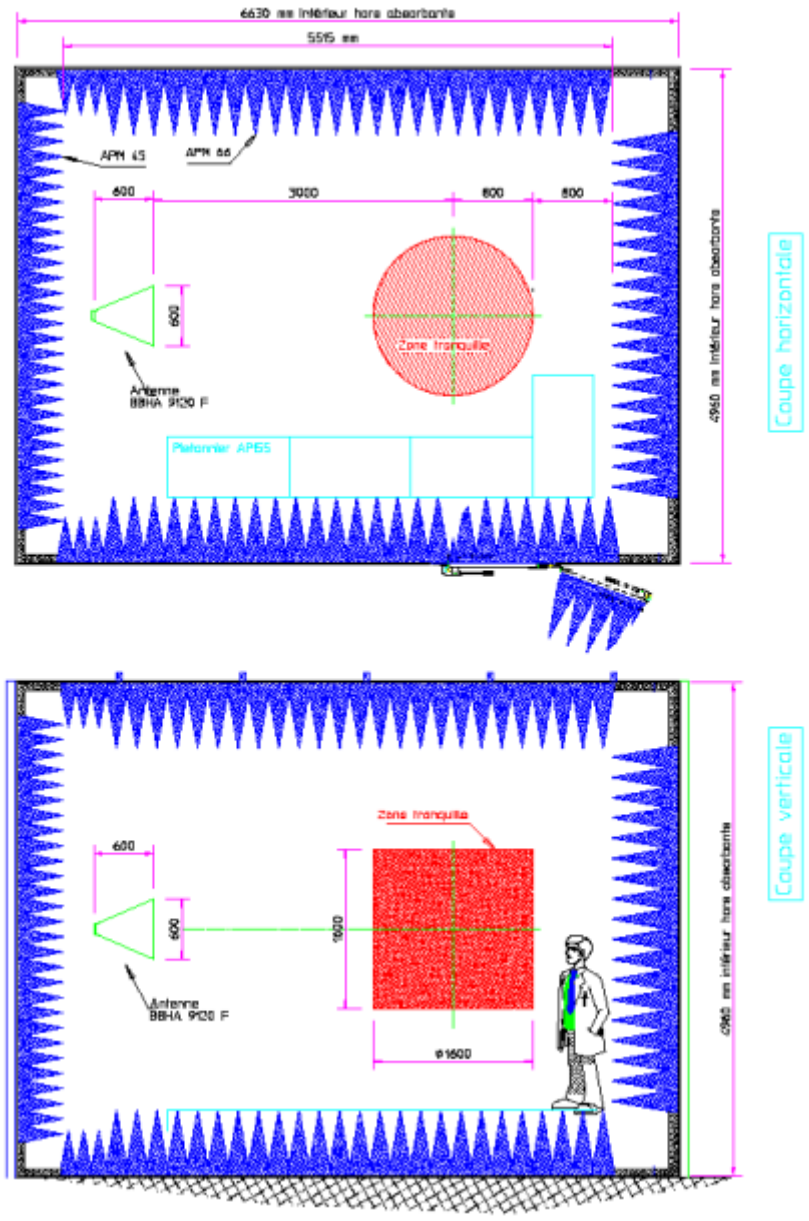


Figure 1: Schematic Top and Side views of the Continental anechoic chamber

2.2 Test equipment

2.2.1 Horn antenna

The “Doubled Ridged Broadband Horn Antenna” named “DRH10” provided by *RFspin* company is used as the measurement antenna from 740 MHz to 10 GHz. Datasheet is available in reference [1].

This antenna is used for the directivity in the direction of the DUT.

As example, some antenna gain values for relevant frequencies according the BSRF-EA product are reportred in Table 2.

Frequency	Gain
800 MHz	5.3 dBi
2000MHz	10.7dBi
5500 MHz	13.1 dBi

Table 2: Antenna gain of the DRH10 antenna

2.2.2 Network Analyzer

The “ZND” network analyzer [2] provided by *Rohde&Schwarz* company updated with the frequency range extension to 8 GHz, is used for these measurements.

2.2.3 DUT Positioners

The “DE3800 positioner” [3] from *Innco systems GmbH* is used to control the DUT orientation toward the measurement antenna. This kind of support allows nearly free space around the DUT.

Figure 2: Innco DE3800 positioner

2.2.4 Remote controller

The “Remote Controller CO3000” [4] is also provided by *Innco systems GmbH* company to monitor the DUT positioners DE3800.

2.3 Test Setup

The Figure 3 and Figure 4 shows the used setup for the measurement data acquisition and the product placement on test support.

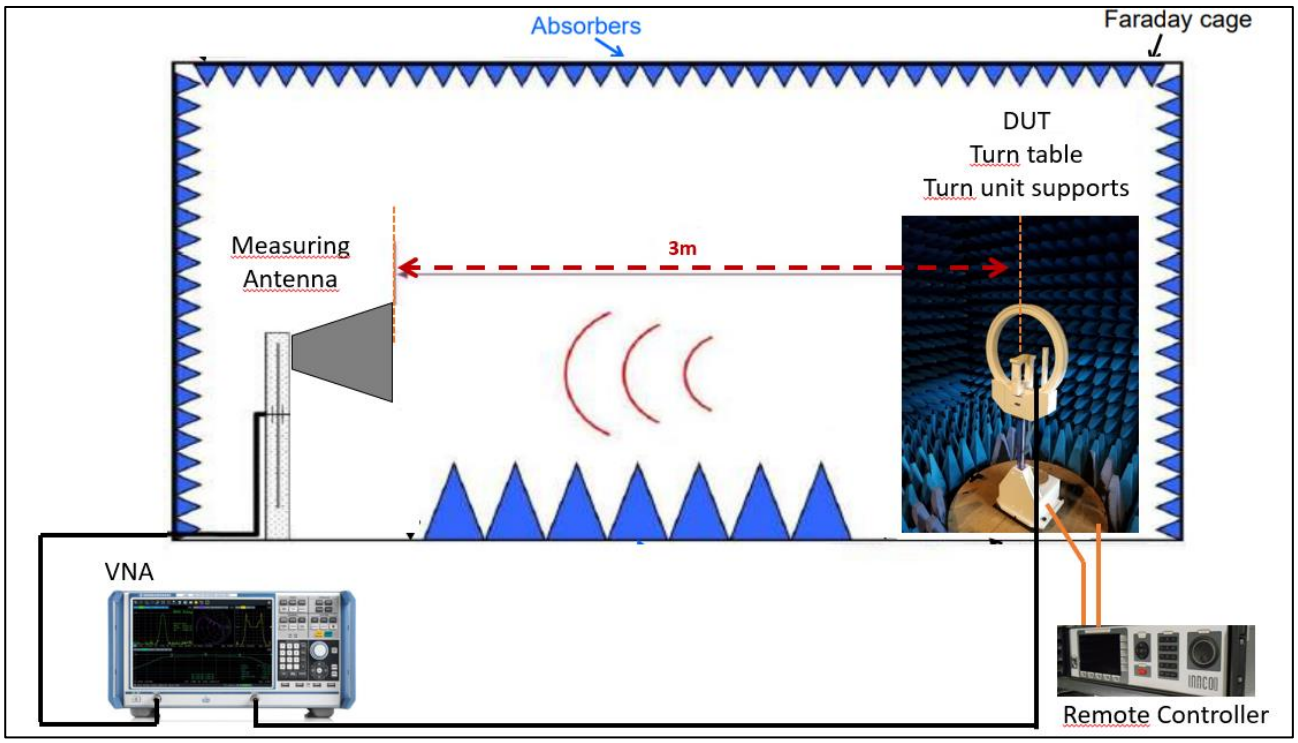


Figure 3: Anechoic Chamber Setup for antenna gain measurement

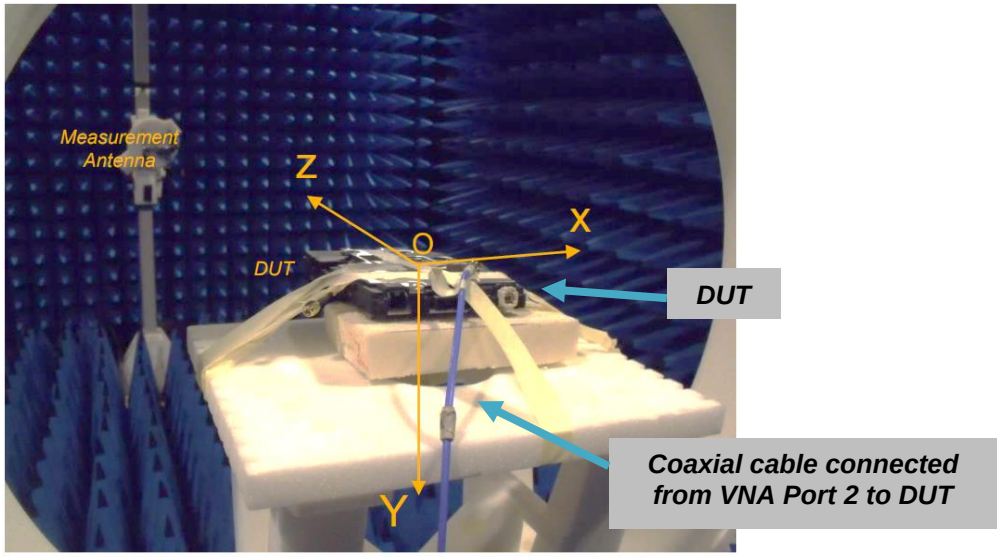


Figure 4: BSRF-EA product on DUT positioner

2.4 Calibration

2.4.1 Measurement Antenna

The measurement antenna gain has been specifically characterized by the manufacturer [§1.3] for the delivered antenna. These data are substracted to the S21 measurement to estimate the DUT gain.

2.4.2 VNA

A pass through two ports calibration has been done for the VNA thanks calibration kit ZV-Z135 [5] from *Rohde & Schwarz* company. All the coxial cables used for the measurement are considered in this calibration.

2.5 Samples description

A short coaxial cable (≈5cm) is soldered to the DUT pcb for antenna measurement with matching network.

Insertion losses of this cable are within 0.1dB to 0.2dB. For BSRF-EA product, this coax is maintained in an opposite direction of the DUT antennas. According to the product metallized parts size and the electrically large ground plane of the electronic board (vs wavelength), it is assumed that the coaxial cable will not influence significatively the DUT antenna radiations.

2.6 Measurement process

Continental is using a home developed S21 acquisition and post treatment software. This has been developed according to the theory explained in [6] and [7].

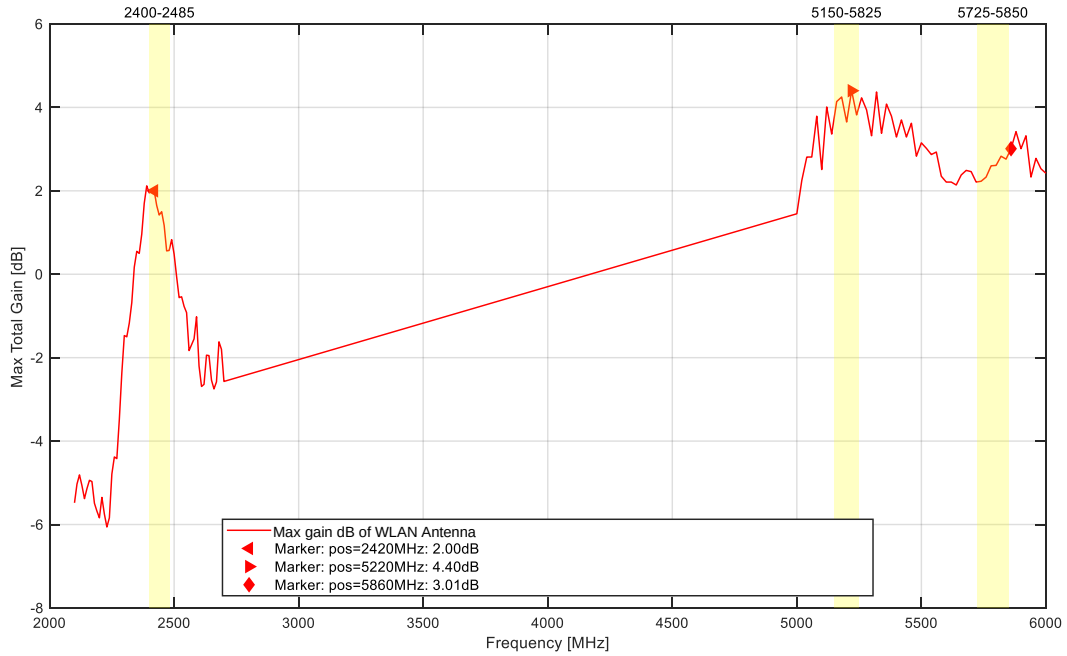
Measurement antenna gain and free space losses calculation are removed from the S21 data. Precise distance from DUT to measurement antenna is achieved with a lasermeter.

3. Measurement results

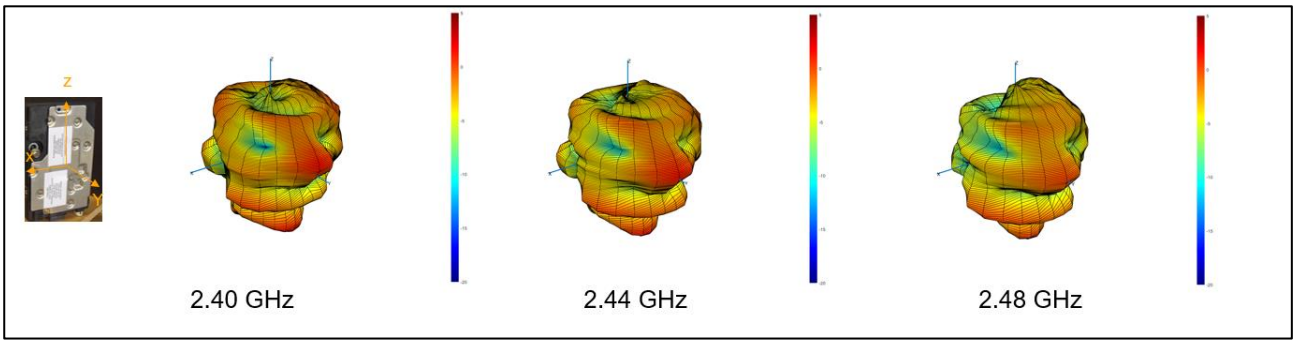
The measurements has been done with a typical sample and presented here below for three relevant frequency values of the applicative frequency bands.

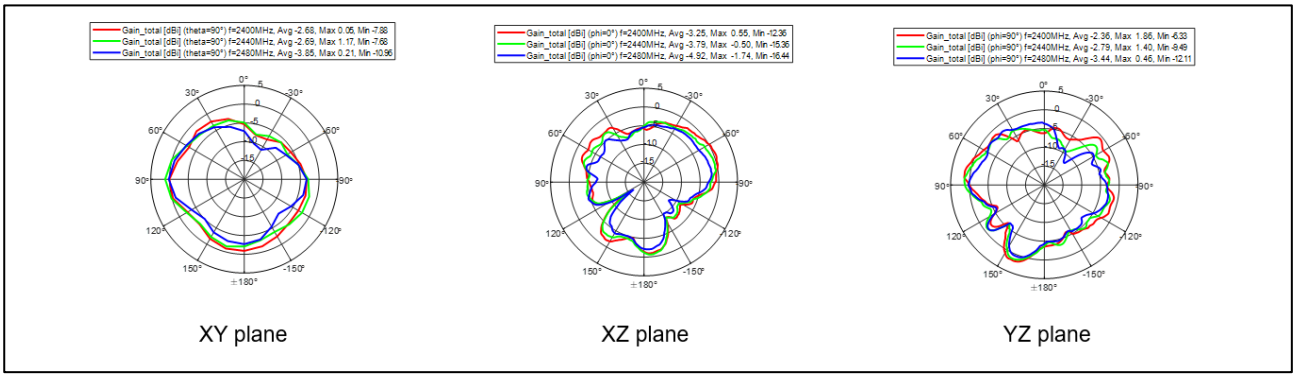
3.1 WLAN antenna

3.1.1 Maximum Gain data vs frequency



3.1.2 *Radiation pattern for WLAN low band (2400 MHz, 2440 MHz, 2480 MHz)*

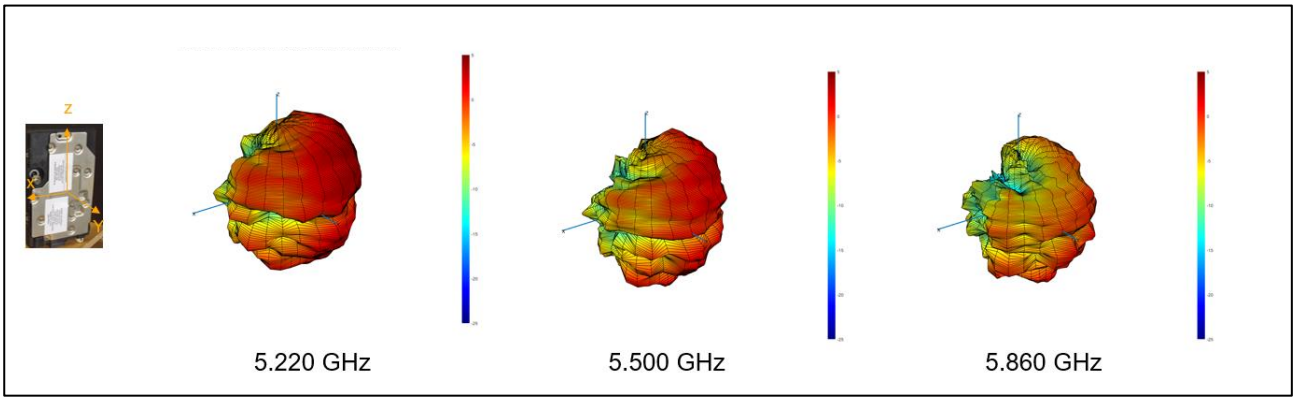


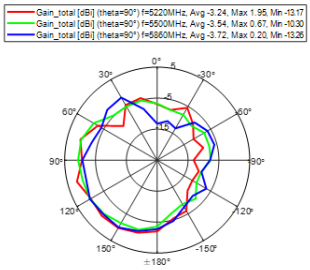


NB: The maximum gain value reported for the 2.4GHz band in §1.2.1 equals to + 2.0 dBi. This value is not visible in the 2D cut planes patterns. Comparing the patterns over three frequencies is usual but does not necessary include the maximum gain data. In this case +2.0 dBi is not reached neither on XY, XZ or YZ cut planes.

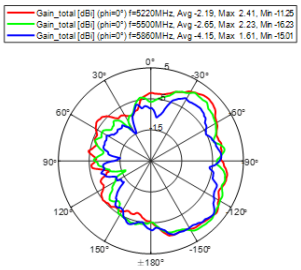
The graph presented in §3.1.1 shows maximum gain data overall 3D direction vs frequency; this maximum is not necessary in the same direction for each frequency.

3.1.3 *Radiation pattern for WLAN high band (5220 MHz, 5500 MHz, 5860 MHz)*

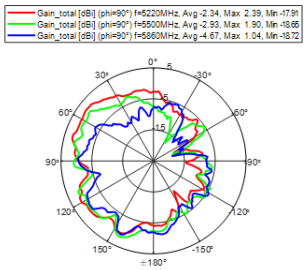




XY plane



XZ plane



YZ plane

4. Conclusion

This reports has presented the radiation characterization of the BSRF-EA product done internally by Continental for the cellular back-up antenna and the WLAN antenna.

5. References

[1] *https://www.rfspin.com/wp-content/uploads/2022/04/DRH10-%E2%80%93-RF-SPIN.pdf*

[2] *https://www.rohde-schwarz.com/us/products/test-and-measurement/network-analyzers/rs-znd-vector-network-analyzers_63493-65409.html*

[3] *https://www.innco-systems.de/de/produkte/id-3d-messsysteme/de3800-turn-device*

[4] *https://www.innco-systems.de/de/produkte/controller/co3000-1d-controller*

[5] *https://scdn.rohde-schwarz.com/ur/pws/dl_downloads/dl_common_library/dl_manuals/gb_1/z/zvx_1/ZV-Z170_Z135_Z129_TechnicalInformation_04.pdf*

[6] C.A. Balanis. Antenna Theory: Analysis and Design, 3rd ed. Wiley Interscience, 2005

[7] 149-2021 - IEEE Recommended Practice for Antenna Measurements