



Heartbeam BLE - Antenna Gain **and Verificiation Report**

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Last modified by:

Scott Vance

Date:

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Approved by:

Jonas Brorsson

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1 Summary

This document is prepared for the Heartbeam project to report antenna design and gain in accordance with the FCC Part 15 submission. In addition to the free space information, this report also contains reference data of measurements performed on a standard chest phantom. Maximum EIRP figures are summarized in [Tabell 1. Tabell 1 - Maximum EIRP](#)

Tabell 1 - Maximum EIRP

Test Position	Maximum EIRP	Frequency
Sensors Extended (Free Space)	10,7 dBm	2440
Sensors Retracted (Free Space)	12,1 dBm	2440
Sensors Extended (Phantom)	1,7 dBm	2402

Note that the figures above show the peak EIRP for the full 3D pattern whereas the 2-D cuts in section 5 including only the three primary reference planes.

2 Antenna Description

2.1 Antenna

The antenna is a bent meandered monopole as shown in the figure below:

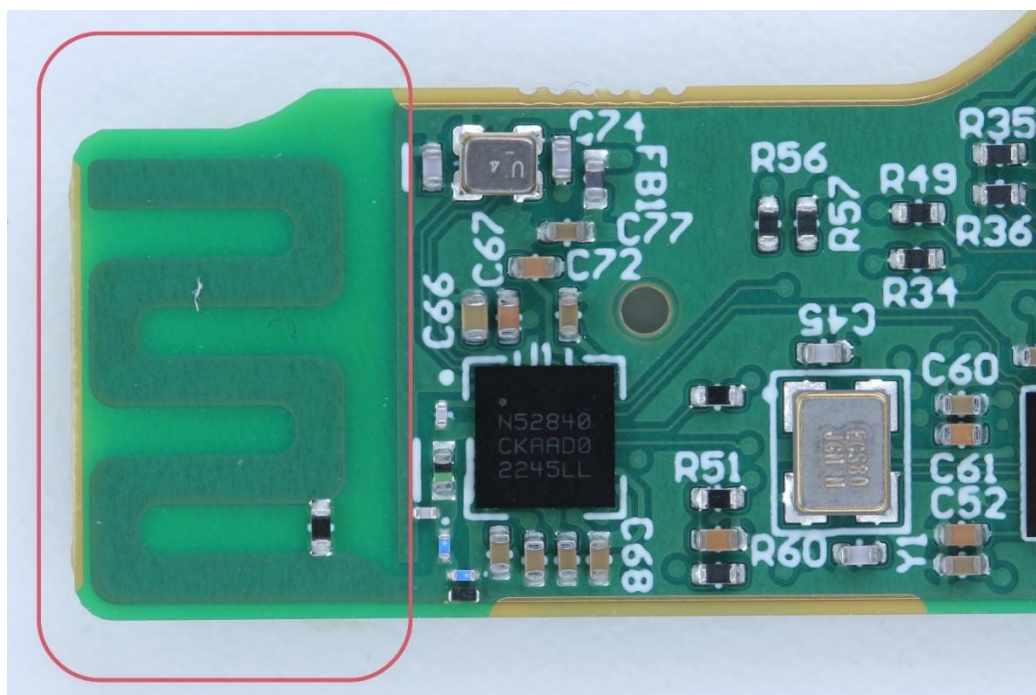


Figure 1 - Heartbeam Antenna (Bent Meandered Monopole)

The antenna is a custom design and is integrated into the main PCB. The antenna is designed to function in the ISM band (2.4 – 2.485 GHz) in both free space and various body-loaded conditions.

2.2 Antenna Matching

The antenna has the following matching:

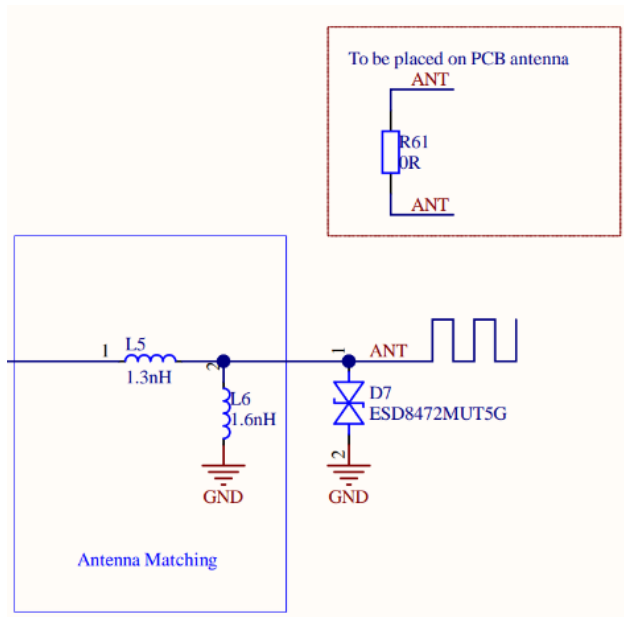


Figure 2 – Antenna Matching

3 Measurement States

The product has multiple physical configurations: the sensors at the end of the product can be opened or closed. Depending on the configuration, the radiated performance may vary. Because each state represents a potential usage case, each was measured and reported.

Test or usage states include:

- 1) Freespace, sensors extended
- 2) Freespace, sensors retracted
- 3) On phantom, sensors extended

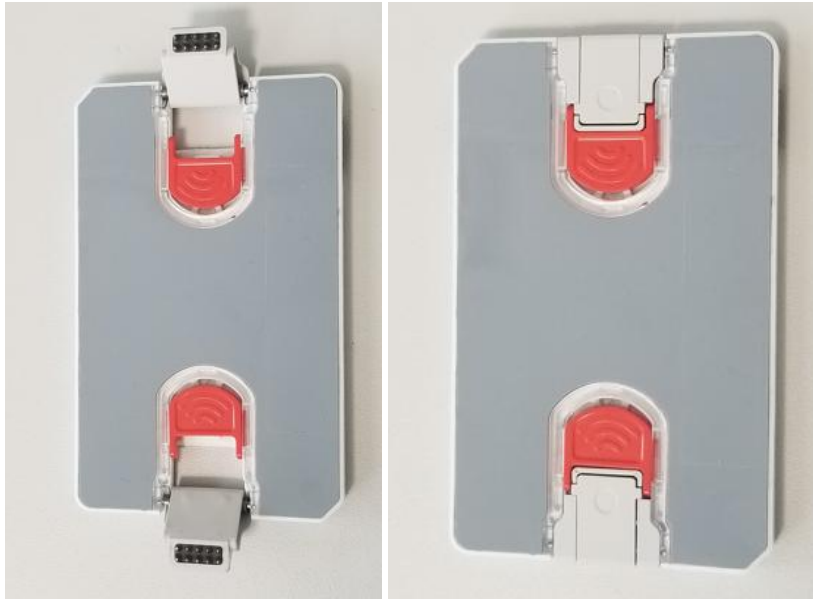


Figure 3 - Sensors extended (left) and sensors retracted (right)



Figure 4 - DUT positioned on test phantom

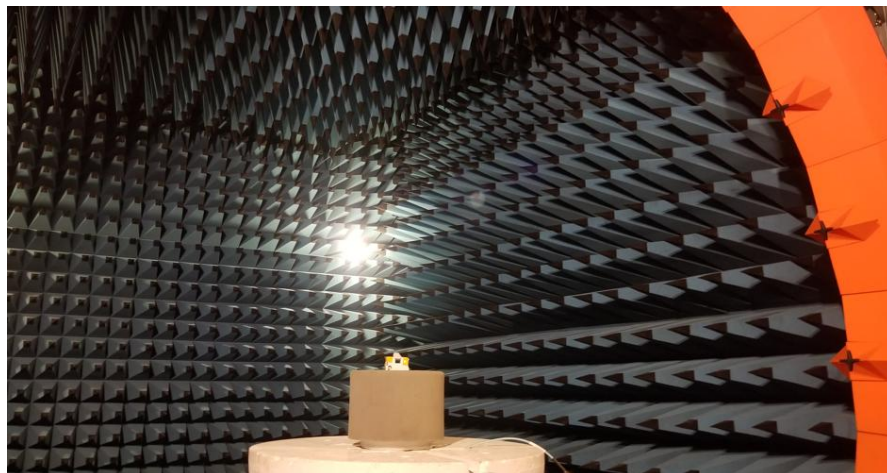


Figure 5 - Freespace test setup

4 TX performance

4.1 Freespace

Using test software to create a CW signal, the following radiated values were measured:

	Frequency (Mhz)		
	2402	2440	2480
TRP (dBm)	5,3	6,4	6,6
Peak EIRP (dBm)	9,8	10,7	10,5
Min EIRP (dBm)	-15,8	-11,0	-10,7
Conducted Power (dBm)	8,2	8,3	8,2
Antenna Gain (dBi)	1,6	2,4	2,3

Figure 6 - Freespace radiated performance, sensors extended

	Frequency (Mhz)		
	2402	2440	2480
TRP (dBm)	7,0	7,2	7,3
Peak EIRP (dBm)	11,6	12,1	11,0
Min EIRP (dBm)	-9,9	-9,1	-4,2
Conducted Power (dBm)	8,2	8,3	8,2
Antenna Gain (dBi)	3,4	3,8	2,8

Figure 7 - Freespace radiated performance, sensors retracted

The peak antenna gain for all free space test cases is 3.8 dBi. Note that the first three row are measured values from the test chamber, the 4th row was measured conducted, and the 5th row is a calculated value based on rows 2 and 5.

4.2 Phantom testing

Testing using the Speag GXPC-V1 phantom was performed to mimic the performance on an actual test subject. This information may not be required by the FCC and is supplied but is provided for informational purposes.

Measurement results on the chest phantom are as follows:

	Frequency (Mhz)		
	2402	2440	2480
TRP (dBm)	-5,0	-5,6	-4,6
Peak EIRP (dBm)	1,7	1,0	1,0
Min EIRP (dBm)	-23,0	-29,7	-24,0
Conducted Power (dBm)	8,2	8,3	8,2
Antenna Gain (dBi)	-6,5	-7,3	-7,2

Figure 8 - Radiated performance on the both phantom in the usage position.

5 Radiation patterns

5.1 Measurement Coordinate System

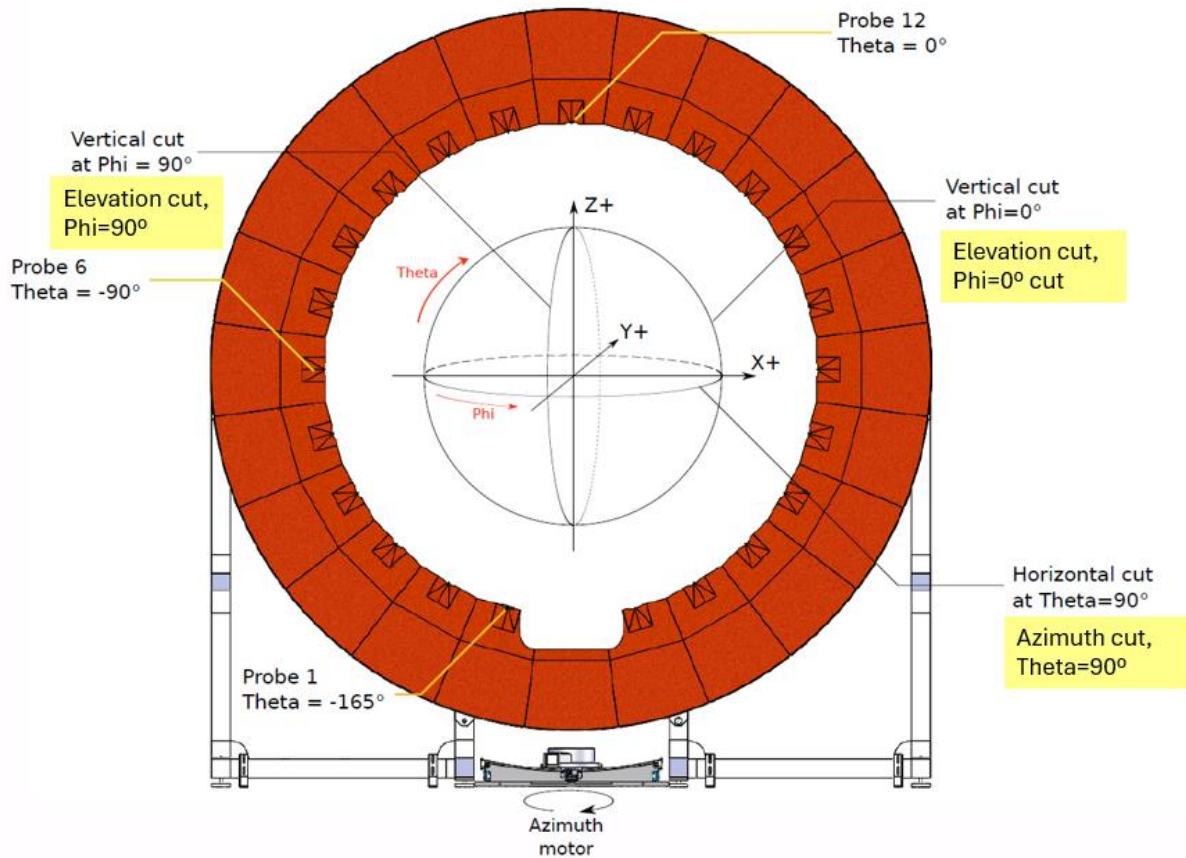


Figure 9: SG24 coordinate system

Coordinate system is given for a fixed antenna under test (AUT) i.e. it is the measurement system which moves around the AUT. The azimuth scan (Phi) and the elevation scan (Theta) are done by rotating of the AUT (goniometer and mast rotation). The direction of rotation of the mast is reversed compared the coordinate system.

$\Phi \in [0^\circ, 180^\circ)$ and $\Theta \in [-180^\circ, 180^\circ]$.

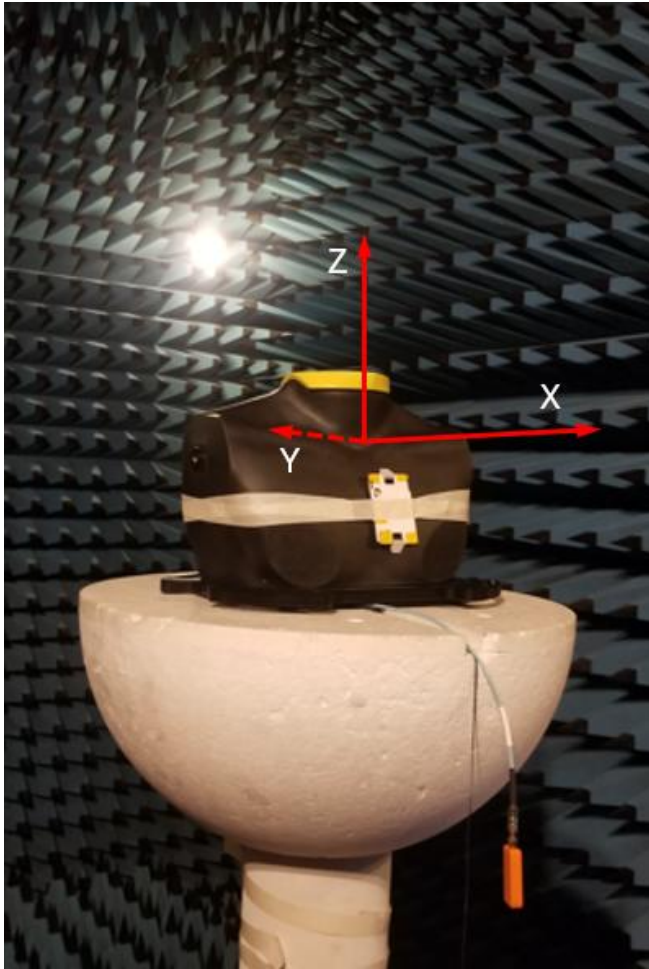


Figure 10 - Test setup with GXPC-V1 showing axis orientation

5.2 Radiation Patterns

Radiation patterns for all test cases are included for reference (mid-band: 2440 MHz).

5.2.1 Sensors extended (open), Free Space

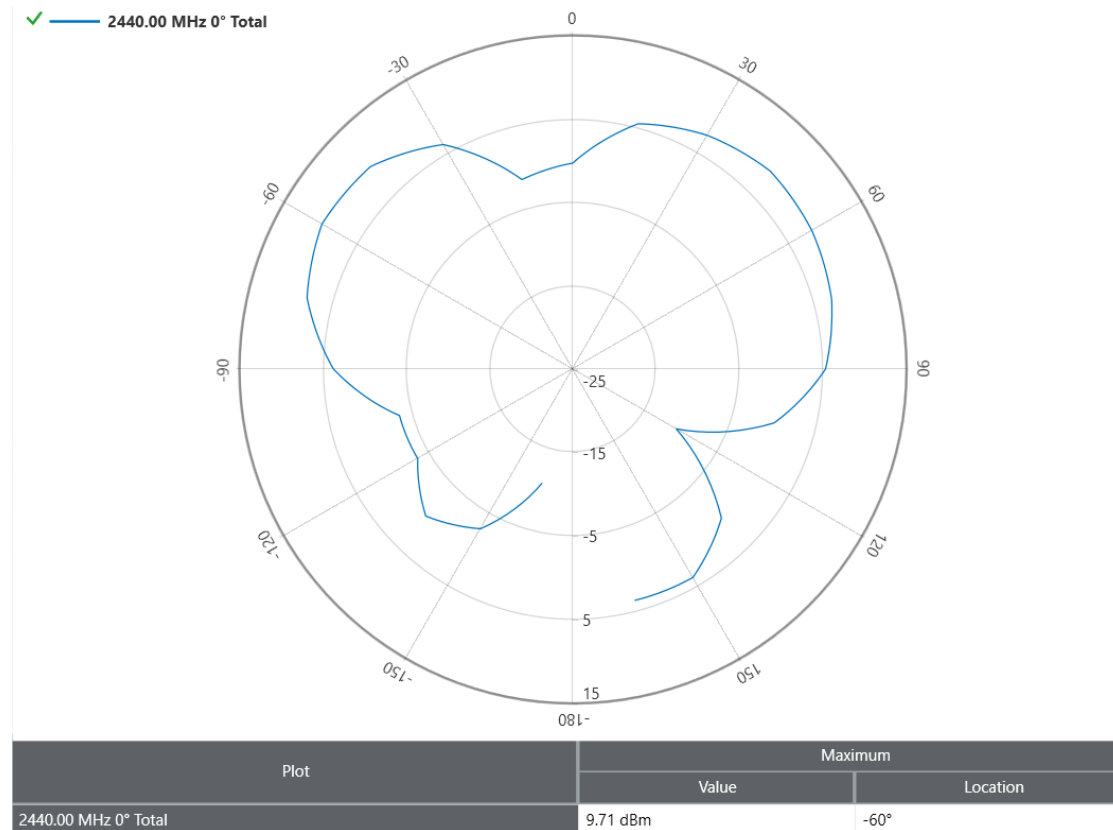
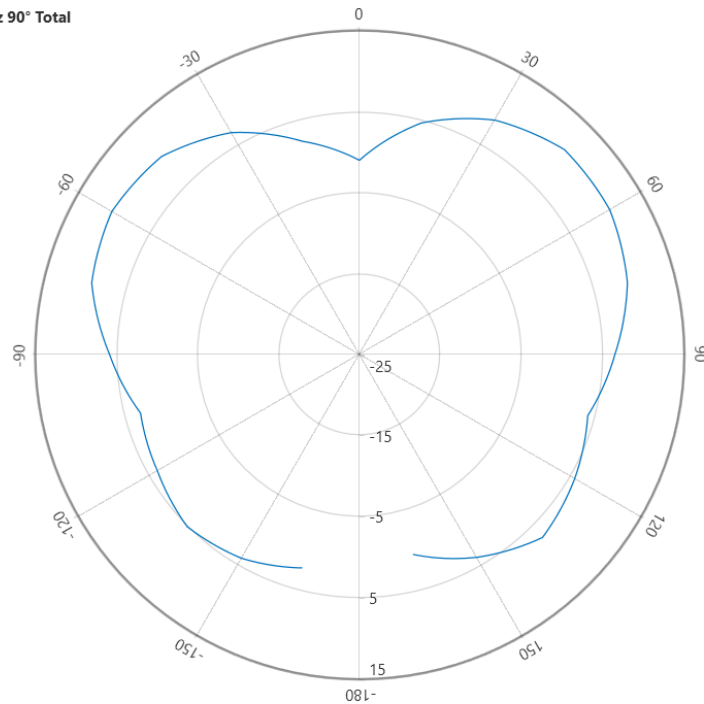


Figure 11 - Elevation Cut, $\Phi = 0$

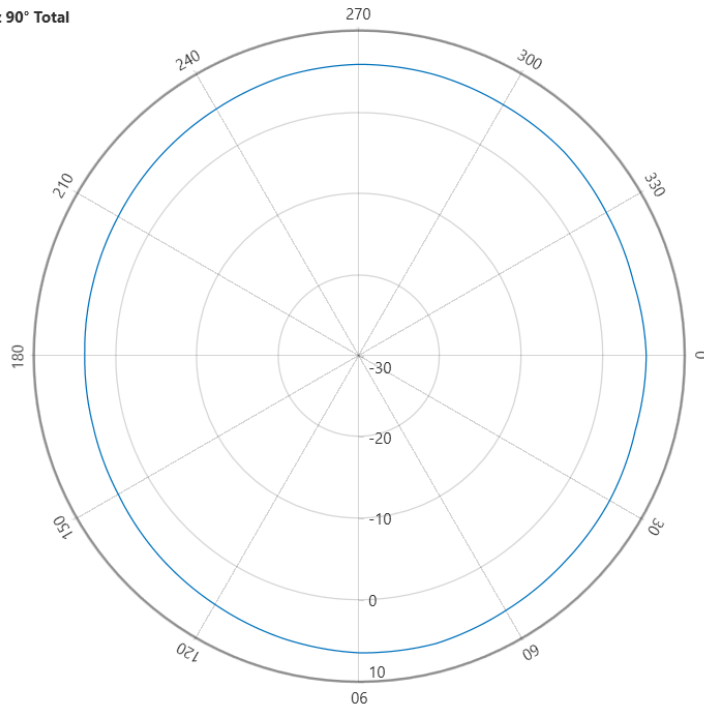
✓ — 2440.00 MHz 90° Total



Plot	Maximum	
	Value	Location
2440.00 MHz 90° Total	10.72 dBm	45°

Figure 12 - Elevation cut, PHI = 90

✓ — 2440.00 MHz 90° Total

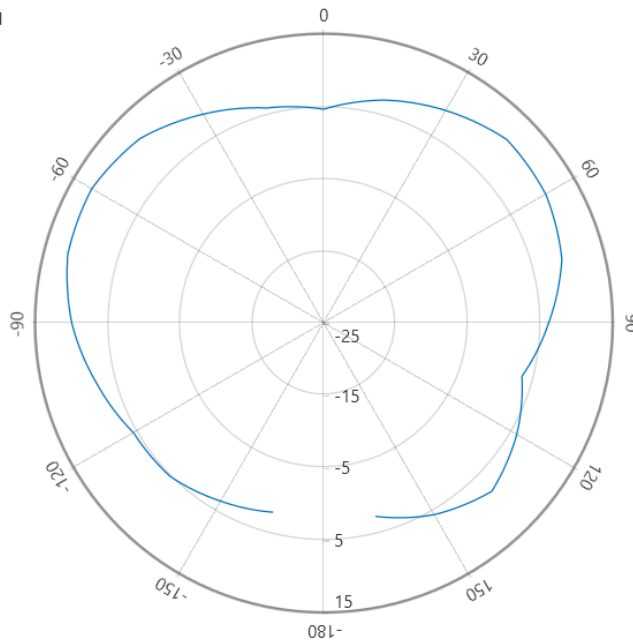


Plot	Maximum	
	Value	Location
2440.00 MHz 90° Total	6.59 dBm	75°

Figure 13 - Azimuth Cut, Theta = 90

5.2.2 Sensors Retracted (Closed) position, Free Space

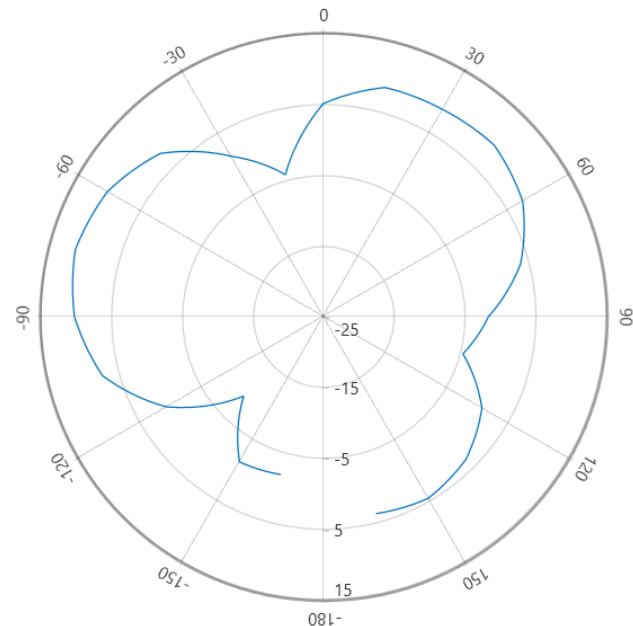
✓ — 2440.00 MHz 90° Total



Plot	Maximum	
	Value	Location
2440.00 MHz 90° Total	12.09 dBm	-60°

Figure 14 - Elevation Cut (PHI = 90)

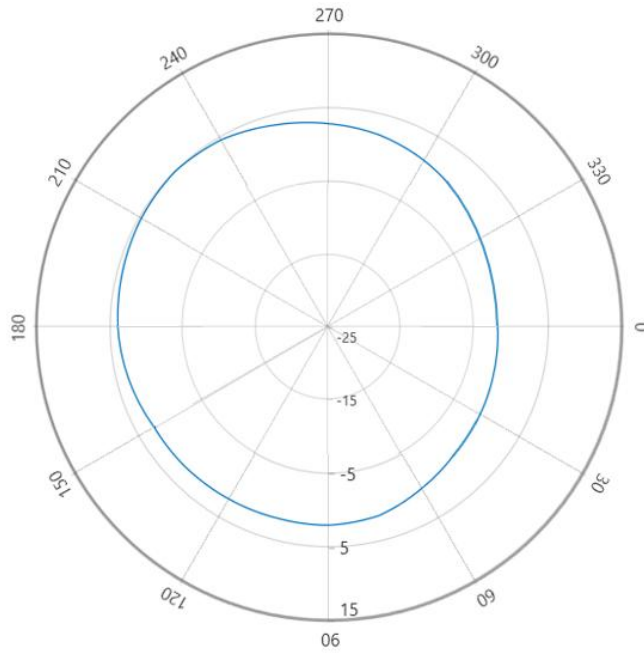
✓ — 2440.00 MHz 0° Total



Plot	Maximum	
	Value	Location
2440.00 MHz 0° Total	11.23 dBm	-75°

Figure 15 - Elevation Cut (PHI = 0)

✓ 2440.00 MHz 90° Total

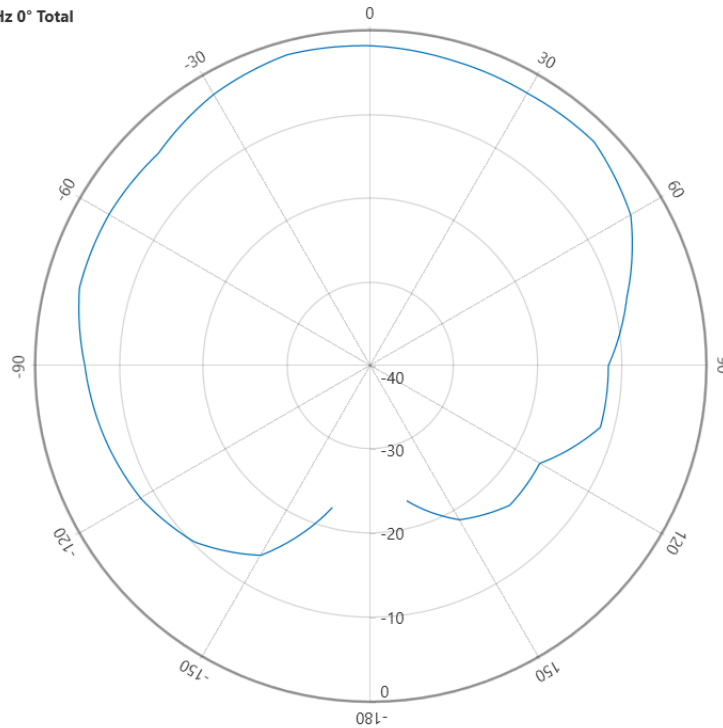


Plot	Maximum	
	Value	Location
2440.00 MHz -165° Total	4.80 dBm	225°

Figure 16 - Azimuth Cut (Theta = 90)

5.2.3 Patterns on chest phantom

✓ 2440.00 MHz 0° Total



Plot	Maximum	
	Value	Location
2440.00 MHz 0° Total	-1.68 dBm	-15°

Figure 17 - Elevation Cut, $\Phi = 0$

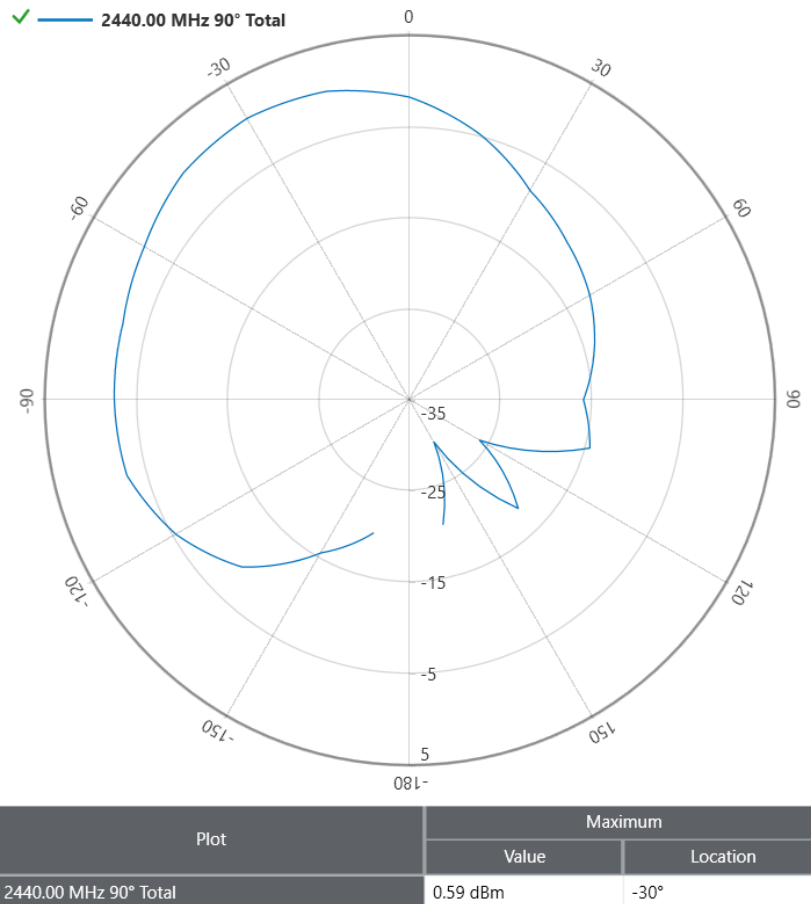


Figure 18 - Elevation Cut, Phi = 90

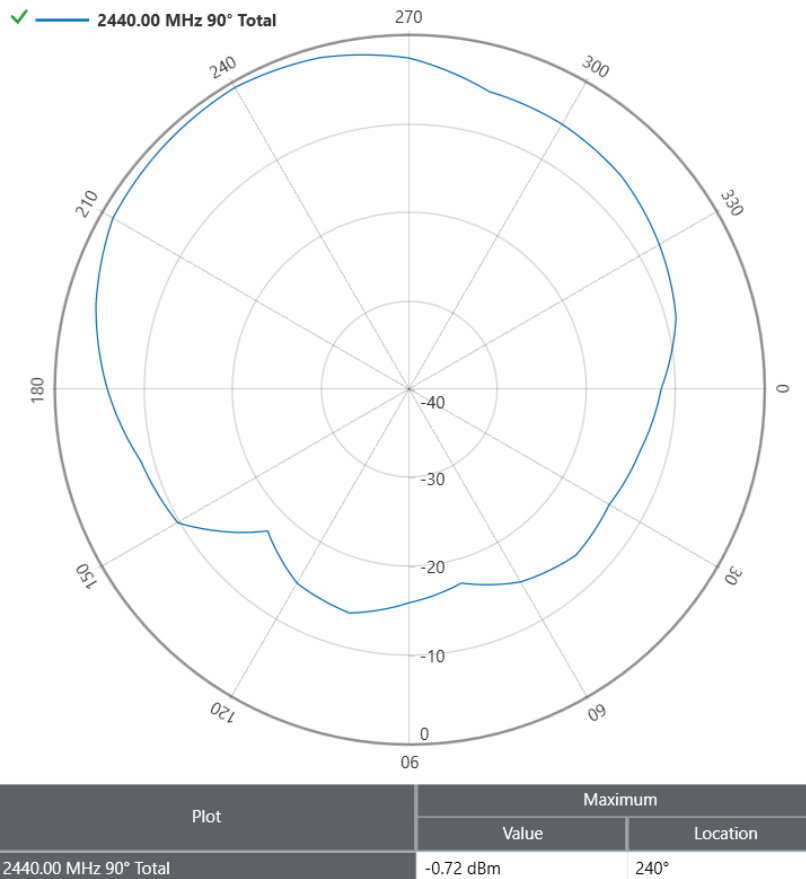


Figure 19 - Azimuth Cut, Theta = 90

6 Testing and Equipment Details

6.1 Equipment & tools

The following equipment was used for verification:

- 1) Active measurements: MVG SG-24L chamber. Application SW version 24.3.2. Annual calibration performed 2024.06.17.
- 2) CTIA approved chest phantom [GCPC-V1, Speag]
- 3) Standard cables and other lab equipment as required.

Calibration and labeling requirements of all instruments at Sigma Connectivity AB are defined in “Calibration Procedure for Electronic and Mechanical Instruments” and “Calibration Procedure for Measurement Systems” as defined in Sigma Connectivity Management System.

6.2 Premises

Verification was performed at the main site of Sigma Connectivity:

Mobilvägen 10, in Lund Sweden

Antenna lab (Floor: 3, Wing: 1A, Left)

Verification was conducted between Apr 14th and Apr 25th, 2025.

6.3 Responsibilities & personnel involved

Role	Name
Tester [Area]	Scott Vance [Antenna]
Project Manager	Tobias Weisel
Engineering Manager [Area]	Jonas Brorson [HW, Radio, and Antenna]
Quality Assurance	Johan Hellfalk [Quality Manager]

Review and Approval of documents according to Sigma internal process “Review and approval process”.

7 Protocols for design verification

The following test protocols were used in verification:

Test Protocol No	Test Protocol
SCDC-1715298472-2316	Wavestudio User Manual [SG24L Chamber measurements]

8 Additional information

8.1 Definitions and abbreviations

DUT: Device under test

GXPC-V1: Generic Chest Phantom CTIA Version 1. A fully compliant phantom for testing devices meant to be worn or used on the chest of a user or on a large, flat section of the human body. Manufactured by Schmid & Partner Engineering AG (Speag, Switzerland).

MVG SG-24 Chamber: An anechoic chamber used for RF antenna verification. This is a multi-probe system which allows for relatively quick measurements of 3D radiation patterns.