RXTX-3033_R1 Antenna Performance Measurement

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2. Document revision history

Revision	Date	Author	Description
0.1	February 14th, 2024	Jan ten Thije	Initial setup & release
1.0	February 20th, 2024	M. Vlas	Review and Release 1.0
1.1	February 23rd,2024	J. ten Thije	Antenna Drawing added

3. Client

Tyro Products B.V.
Bedrijvenpark Twente 299
7602 KK Almelo
Contact person: Mr. John Nijkrake

3. Preface

Tyro Products has integrated a Feasycom Bluetooth Low Energy module onto an adapter printed circuit board that fits into the existing Libra Remote Control. The trace antenna that is initially tuned for 868MHz, has been trimmed by Leap Development to operate in a higher resonance mode on 2.4GHz.
The purpose of this measurement is to measure the antenna Peak Gain , directivity and efficiency.

4. Description of measurement

4.1. Equipment used

- Spectrum analyzer Rigol DSA875TG [9kHz~7.5GHz with tracking Generator] with EMC package
- Spectrum analyzer Rigol DSA830TG [9kHz~3.0GHz with tracking Generator]
- Vector Network Analyzer (VNA) Copper Mountain Planar R54]85MHz ~5.4GHz]
- Molex Dipole Antenna type 146186 [Gain 3.0dBi @2.4GHz]
- ASTRO 18S Horn Antenna
- Low Noise Amplifier [40dB]
- Full Anechoic chamber with Rotation platform synchronized with analyzer sweep
- Devices Under Test (DUT) TX-3032-B PCB : RXTX-3033_R1

4.2. Measurement / execution

First we perform a S11 parameter measurement. This gives us insight in the Return Loss, Voltage Standing Wave Ratio and Impedance. Because of the size of the remote control, using the “Wheeler cap method” to measure the antenna’s efficiency will be difficult. Therefore we will also calculate the efficiency from the radiated power measured from the DUT and the reference antenna. We will do this only in the horizontal plane. The result will be more of an indication than it is an actual figure.

Following we will perform Radiated measurements to measure the gain and directivity. This will be done in a full anechoic chamber.

4.3. S11 Parameters Test Setup

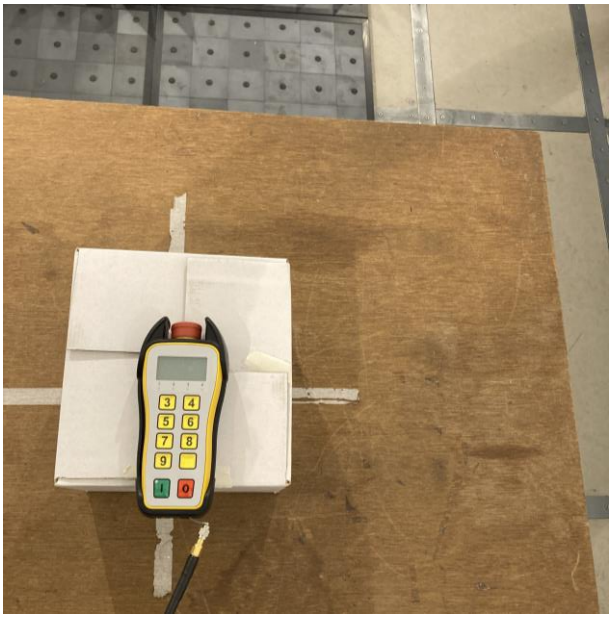
FIGURE 1

View of the test setup used to measure the S11 parameters.

4.4. Radiated Measurements Test Setup

FIGURE 2

View of the **Radiated Emissions** test setup in the anechoic chamber. The DUT is placed on the table that is placed on the rotating platform. The rotation of the platform is synchronized with the analyzer's sweep. The floor is covered with ferrite tiles and absorbing cones to minimize reflections.
Measurements were performed with the DUT and Horn Antenna in the horizontal and vertical polarization.
(Picture left; Horn in Horizontal polarization)

 FIGURE 3	DUT in horizontal position on the rotating platform. The DUT' antenna is placed onto the table' center.
 FIGURE 4	DUT in vertical position on the rotating platform.

5. Measurements

5.1. S11 Parameters Results

Final Result after tuning the Antenna. S-parameters measured at antenna connecting point.

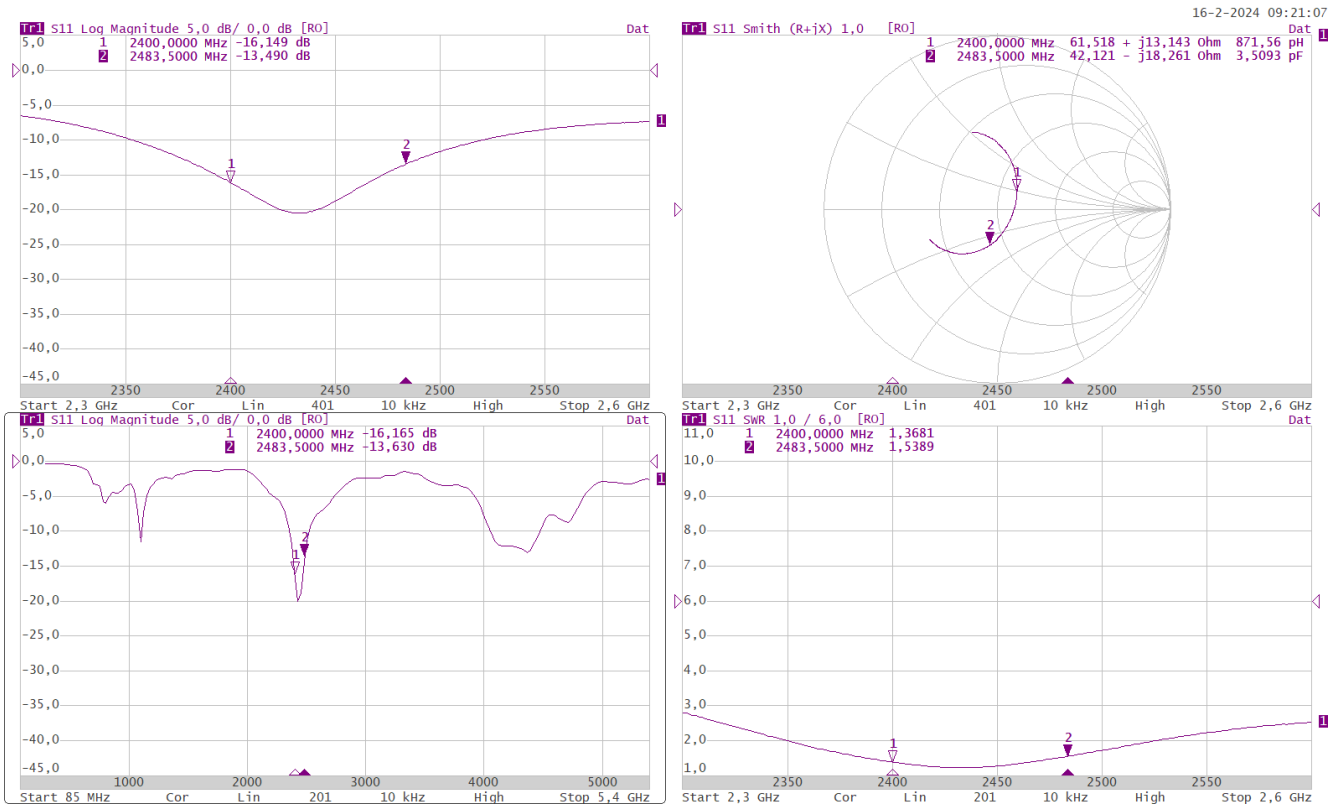


FIGURE 5

5.2. Radiated Results

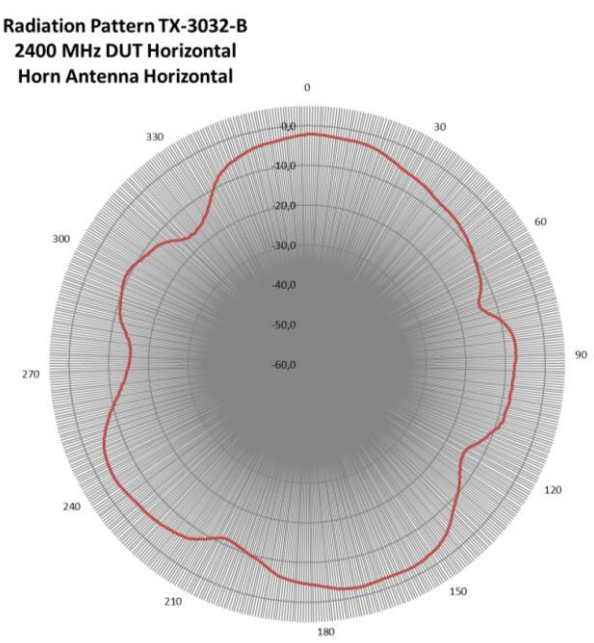


FIGURE 6

Peak Gain is -2.1dBi

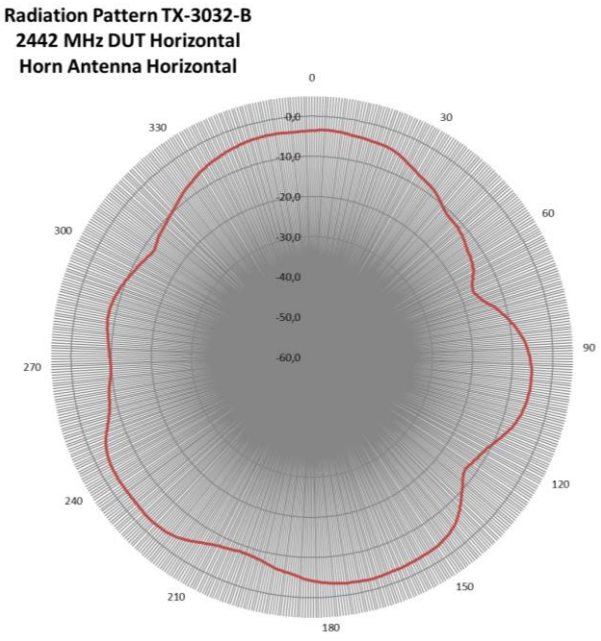
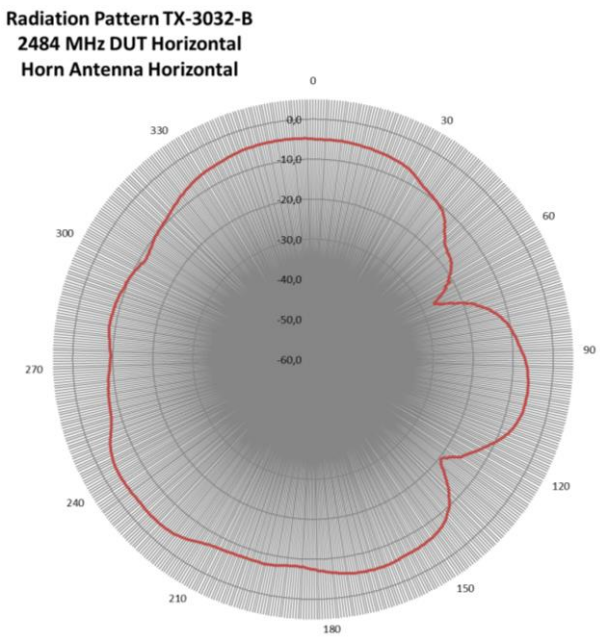
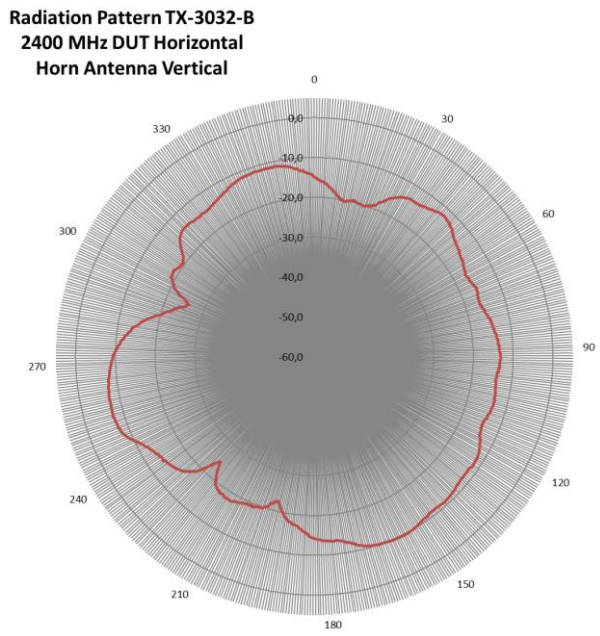
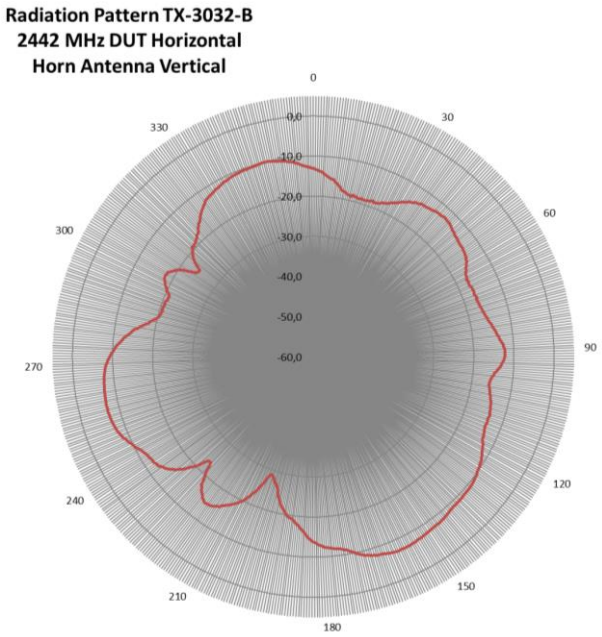
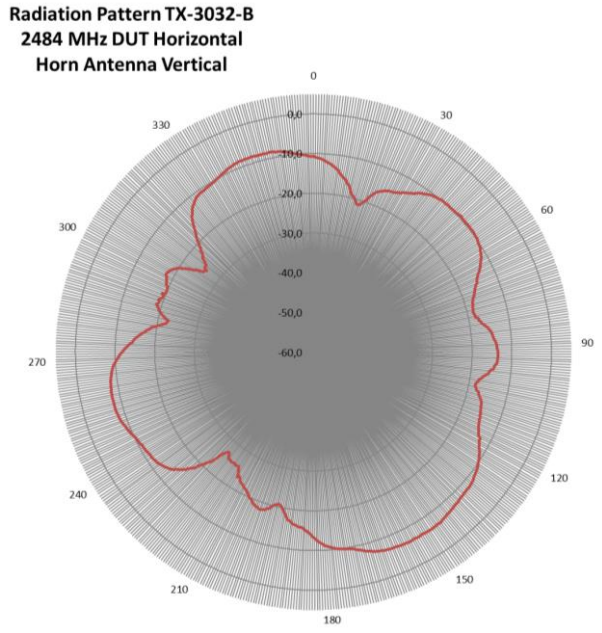
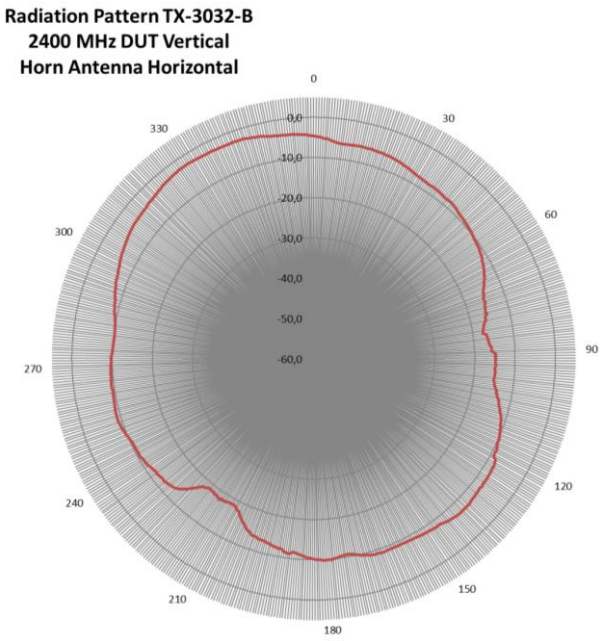
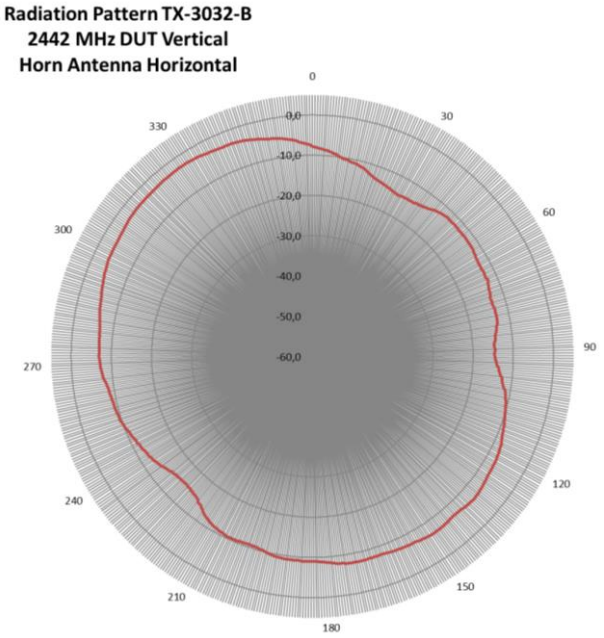


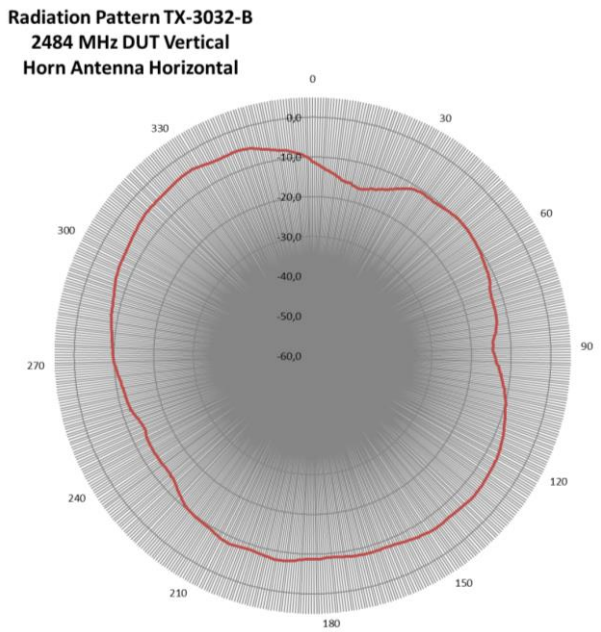
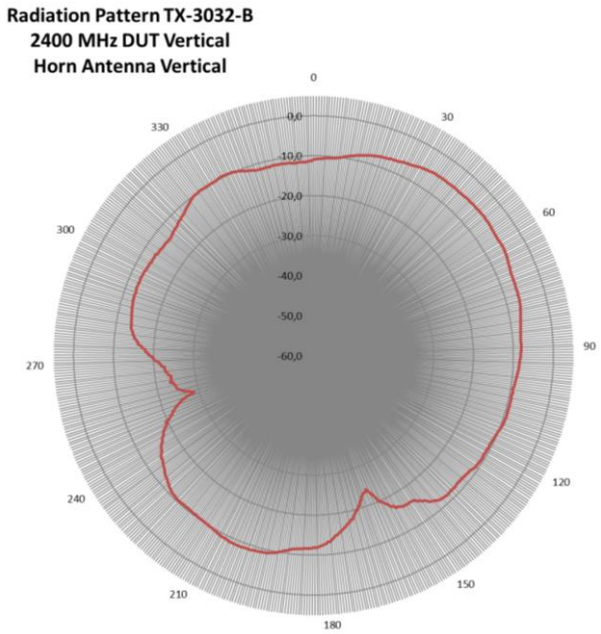
FIGURE 7

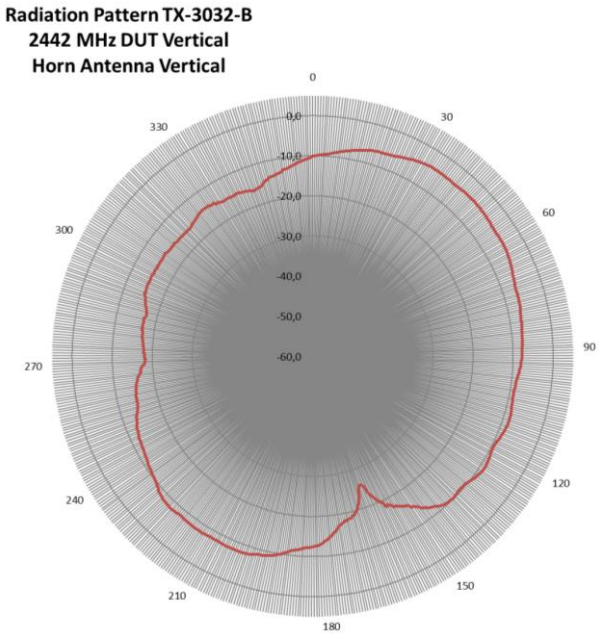
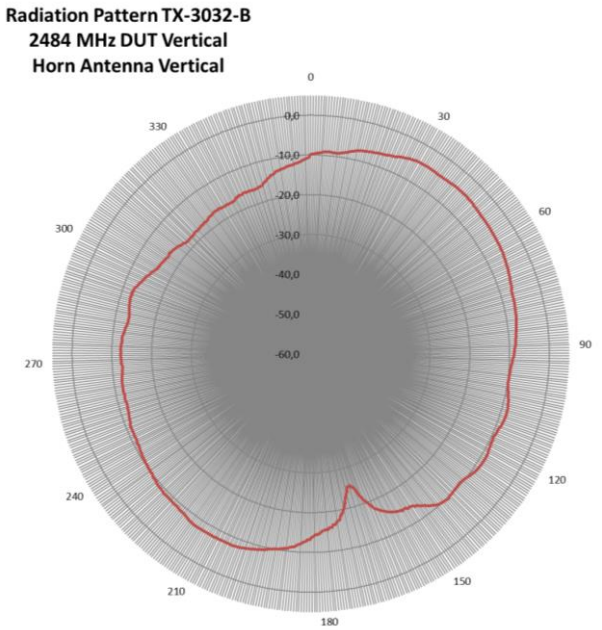
Peak Gain is -2.7dBi

 FIGURE 8	Peak Gain is -3.7dBi
 FIGURE 9	Peak Gain is -7.2dBi (Cross Pol)

 FIGURE 10	Peak Gain is -7.0dBi (Cross Pol)
 FIGURE 11	Peak Gain is -6.3dBi (Cross Pol)

 FIGURE 12	Peak Gain is -2.4dBi (Cross Pol)
 FIGURE 13	Peak Gain is -2.6dBi (Cross Pol)

 FIGURE 14	Peak Gain is -4.2dBi (Cross Pol)
 FIGURE 15	Peak Gain is -5.0dBi

 FIGURE 16	Peak Gain is -4.2dBi
 FIGURE 17	Peak Gain is -4.3dBi

5.3. Efficiency Determination using Radiated Power

The radiation patterns are buildup of 601 sweep points resulting in 601 circle segments.
The enclosed power in a radiation pattern can be approached by summing all segments using the formula below.
This calculation will only give an idea of the efficiency of the DUT antenna, in comparison to a reference antenna, in the horizontal plane.

$$P = \sum_{n=1}^{n=601} \frac{\left(\left(10^{\frac{Signal\ Level[dBm]}{10}}\right)^2\right) * \tan(\alpha)}{2}$$

α=360°/601
tan(α)=Y(segment)/X(segment)
Power volume of one segment is (X*Y)/2

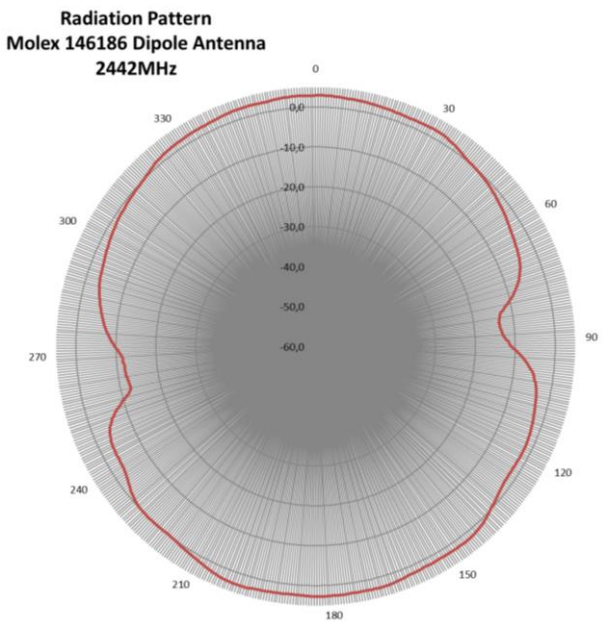


FIGURE 18

Reference signal

Power enclosed, using formula above, is 4.5 (linear)

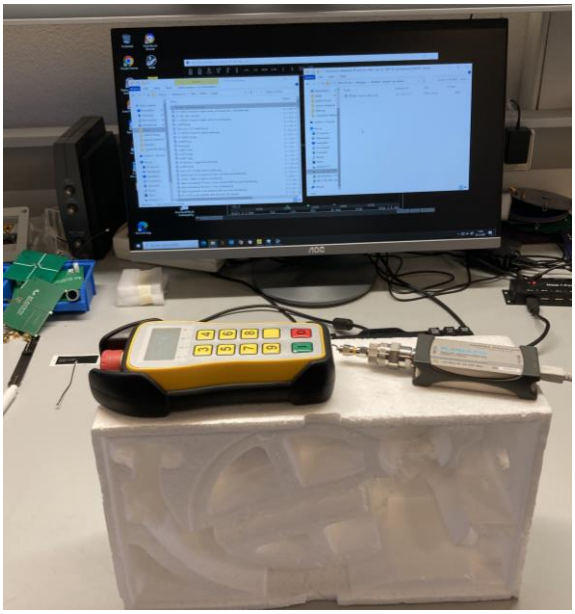
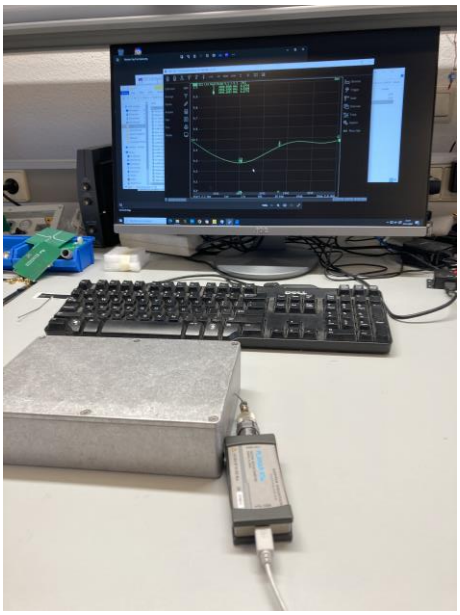
$$Efficiency(\eta) = \frac{Pradiated}{Pin}$$

Efficiency of the Reference Antenna is specified to be >70% i.e. 0.7 or -1.55dB
Reference Antenna Pradiated measured =4.5 -> Pin_antenna >6.43

DUT Antenna Pradiated Measured =0.3 (Total power in radiation pattern of figure 7)
Efficiency DUT Antenna is greater than 0.3/6.43 = 0.047 i.e. 4.7% or -13.3dB

5.4. Efficiency Determination using Wheeler Cap Method

The Wheeler Cap method is an accurate method to measure the Antenna Efficiency. The condition is that the antenna is completely enclosed within a sphere with a radius $r = \lambda/2\pi$ and is in this case (2.442GHz) radius r =19.5mm.
The handheld is too big to fulfill the wheeler cap criteria with a spherical enclosure.
But wrapping the handheld in aluminum foil completely and putting it in an RF enclosure so it can't radiate, comes close to the Wheeler Cap criteria.

 FIGURE 19	Measuring reflection coefficient in free space.
 FIGURE 20	Measuring the reflection coefficient using the Wheeler Cap method. The DUT inside the RF-enclosure is completely wrapped in aluminum foil.

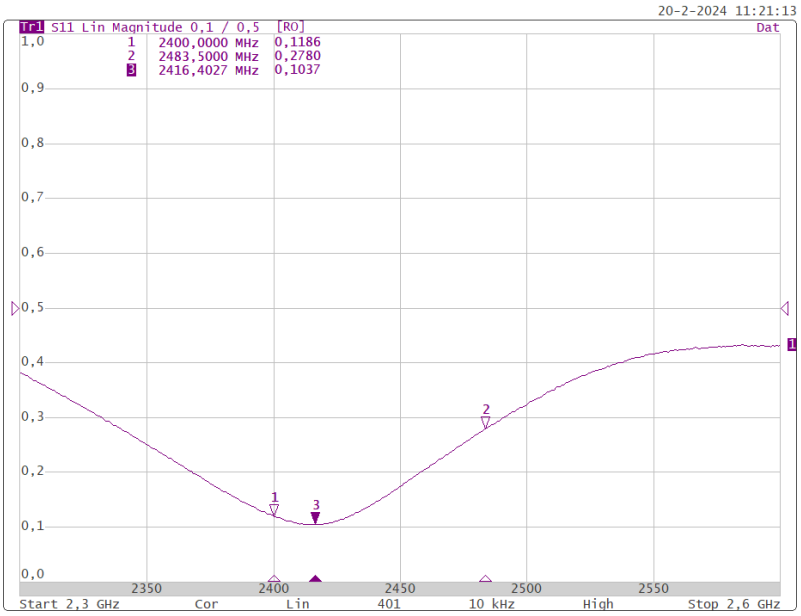


FIGURE 21

DUT in free space
Reflection coefficient Γ_1=0.1037

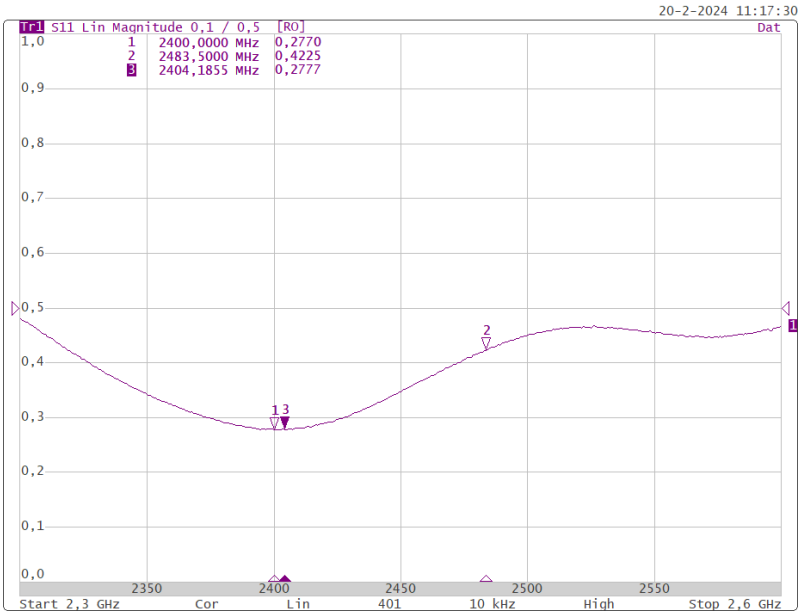


FIGURE 22

DUT in Wheeler Cap.
Reflection coefficient Γ_2=0.2777

$$Efficiency(\eta) = \frac{\Gamma 2^2 - \Gamma 1^2}{1 - \Gamma 1^2} = (0.07711729 - 0.01075369) / (1\text{-}0.01075369) = 0.067 \triangleq 6.7\%$$

6. Test results

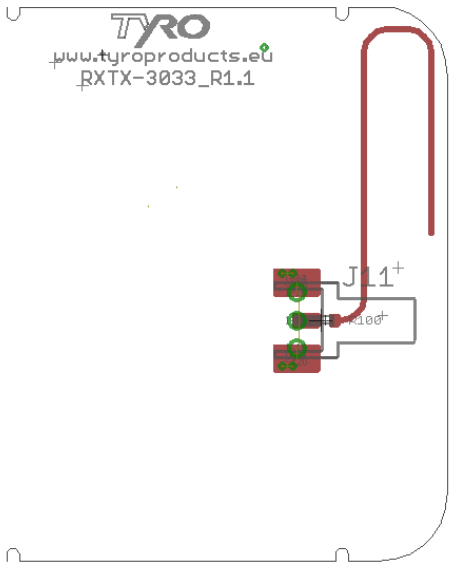
- The Antenna Peak Gain is -2.1dBi
- Efficiency calculated using Wheeler Cap method is 6.7%
- Efficiency calculated using the radiated power measurement in horizontal plane >4.7%

7. Conclusion

The results are in line with the expectation.
Surprisingly the radiation patterns do not show deep black spots. The cross polarization is poor, which actually might be a good thing in practice for remote controls.
The efficiency is not so good. The main reason for that is that the antenna is loaded by the display on one side and a battery pack and emergency switch on the other side.

8. Appendum Antenna Drawing

The pcb trace antenne



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