TRX-3033 (Cetus 2S)
Antenna Performance Measurement

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Company:	Leap Development B.V.
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1. Contents

2. Document revision history

Revision	Date	Author	Description
0.1	February 4, 2025	Jan ten Thije	Initial setup & release
1.0	February 5, 2025	Doy Lubbers	Review and Release

3. Client

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Contact person: Mr. Rob Smit

3. Preface

Tyro Products has modified the firmware of the TRX-3033 (Cetus 2S) remote control to make it suitable for Northern America and Canada. This device uses a Tyro design pcb-trace antenna. Leap Development tuned the antenna for optimum performance.
The purpose of this measurement is to measure the antenna Peak Gain , directivity and efficiency. The antenna tuning process is not described here because it's beyond the scope of this document.

4. Description of measurement

4.1. Equipment used

- Spectrum analyzer Rigol DSA875TG [9kHz~7.5GHz with tracking Generator] with EMC package
- Vector Network Analyzer (VNA) Copper Mountain Planar R54 [85MHz ~5.4GHz]
- Aaronia 30100 Biconical Antenna. (Reference Antenna)
- Molex Antenna 105263 (Reference Antenna)
- Signal Generator Agilent E2245B
- Eaton Log periodic Antenna 96005
- Low Noise Amplifier [40dB]
- Full Anechoic chamber with Rotation platform synchronized with analyzer sweep
- Device Under Test (DUT): TRX-3033 (Cetus 2S), pcb serial# 21160144 (QR code sticker)

4.2. Measurement / execution

First we perform a S11 parameters measurement. This gives insight in the Return Loss, Voltage Standing Wave Ratio and Impedance. If needed we will tune the antenna for optimum performance.
To determine the antenna's efficiency there are two common methods.
The "Wheeler cap method" and the radiated power measurement method.
The Wheeler Cap Method is intended for mechanical small antennas. The actual antenna is small, but the overall enclosure is relatively large, making the radiated power method the preferred option.
We will perform the Radiated Power measurements rotating the DUT over 360 degrees. Measurement will be performed with the DUT in vertical, horizontal and on-the-side orientation. Measurements will be performed at the edge and center frequencies of the Region-2 (USA) ISM band resp. 902.75, 915.00 and 927.25MHz.

4.3. S11 Parameters Test Setup

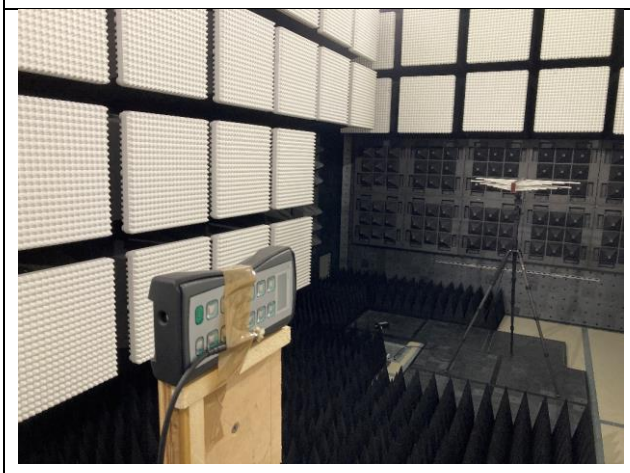
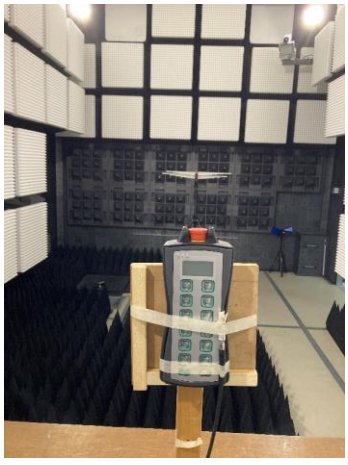
FIGURE 1

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

4.4. Radiated Measurements Test Setup

90-degrees in the plots, is the DUT facing the emergency button in the direction of the receiving antenna.

 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 logperiodic antenna in the horizontal polarisation. The DUT was placed in three different orientations. Here it is in the horizontal position at 90 degrees CW rotation.
 FIGURE 3	Calibration measurement with the Aaronia BicoLOG 30100 antenna.

 FIGURE 4	DUT in horizontal position
 FIGURE 5	DUT on the side
 FIGURE 6	DUT vertical

5. Measurements

5.1. S11 Parameters Results

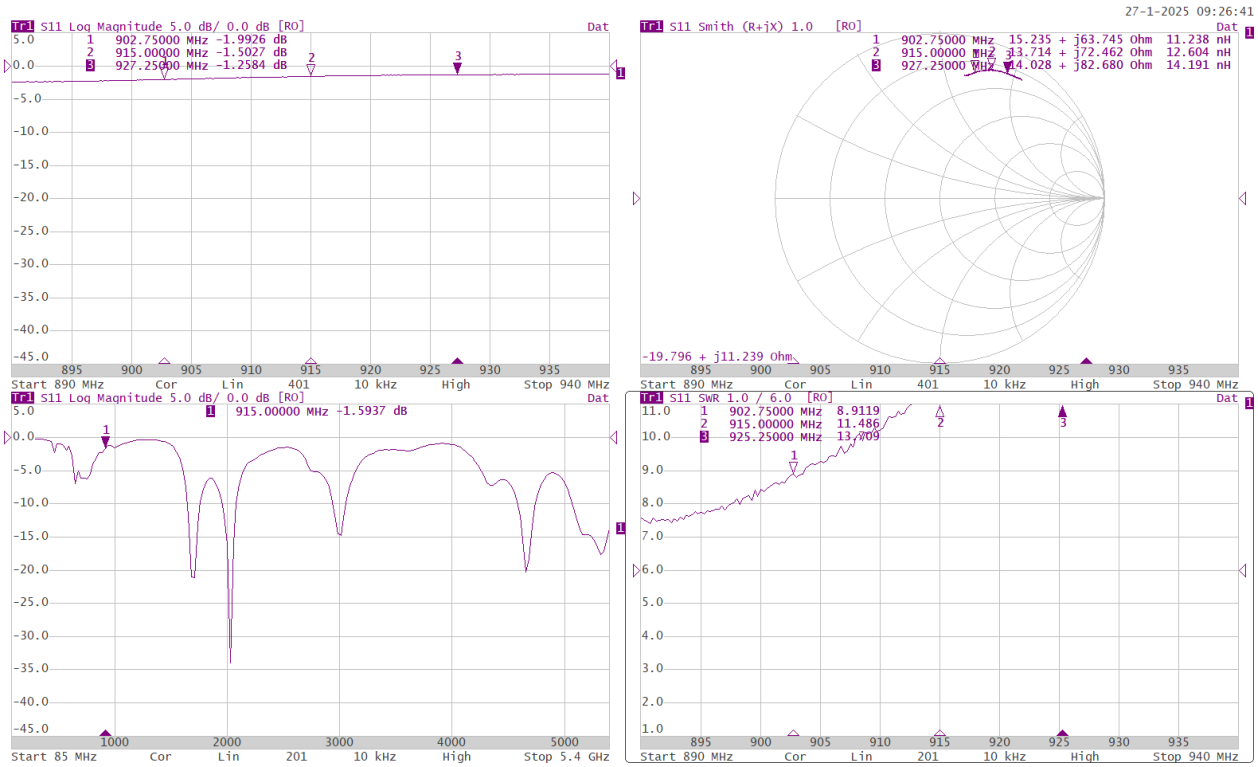


FIGURE 7 INITIAL S11 PARAMETERS

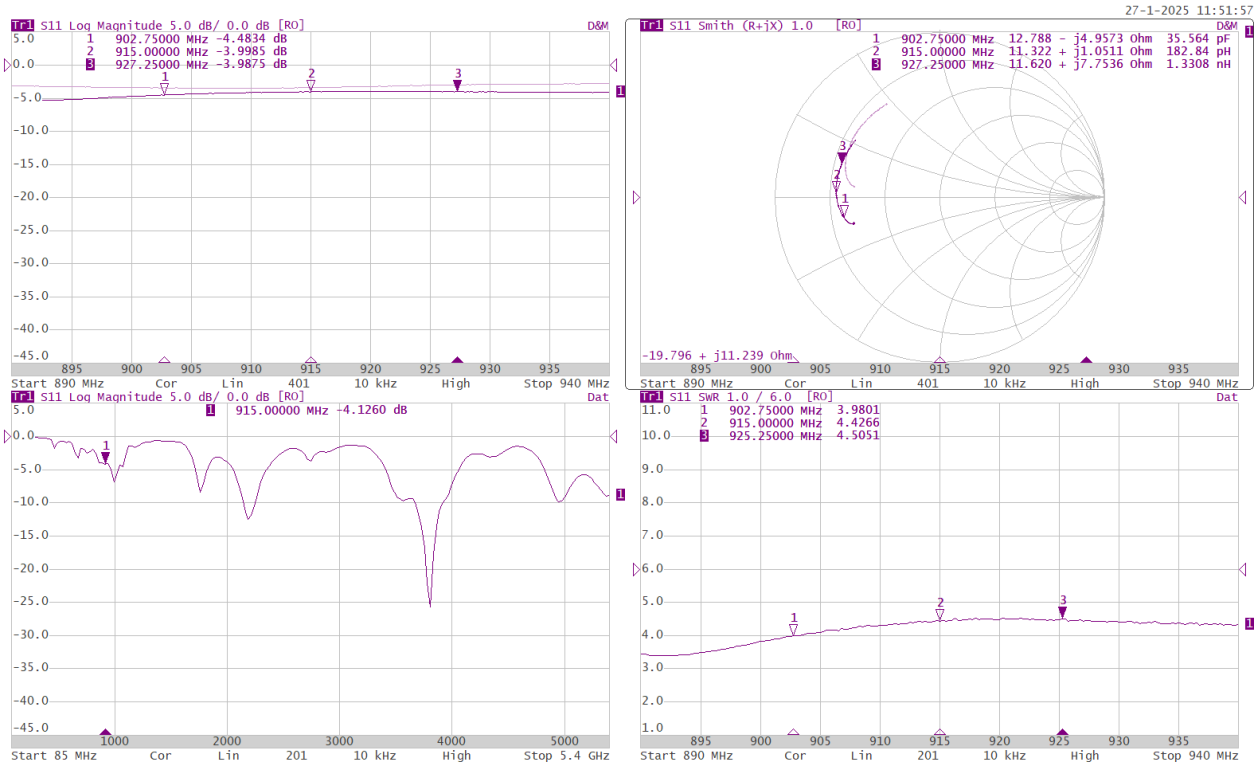


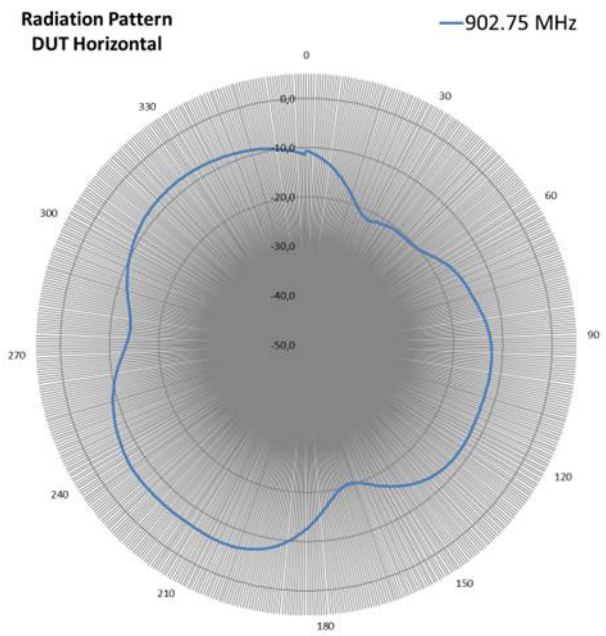
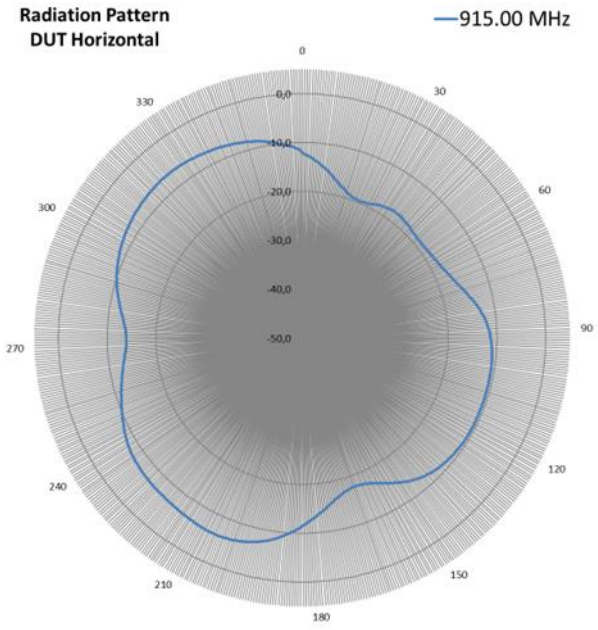
FIGURE 8 FINAL RESULT AFTER TUNING THE ANTENNA

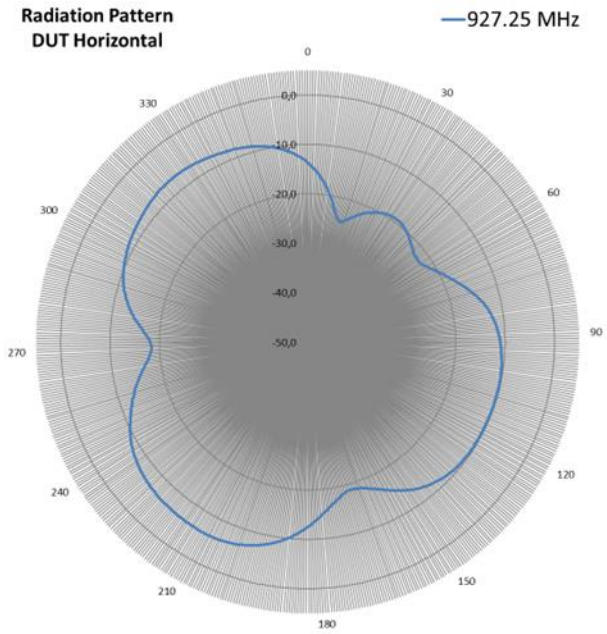
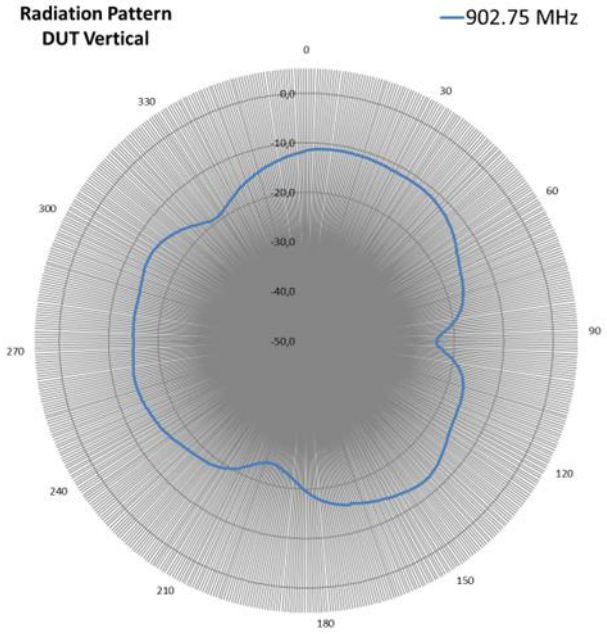
Figure 6 represent the S11 parameters with the antenna trace cut 13mm shorter.
In the pcb design there is no provision for a LC matching network. Therefore the antenna can't be tuned to exactly 50 Ohms.
Figure 8 shows that the VSWR <= 1:4.5, meaning that appr. 60% of the RF power will go into the antenna, the rest will be reflected back to the transceiver.

Please note: Reflections can cause distortion of the radiation patterns.

During the measurements we found that the display and the emergency button load the antenna heavily. As a result, holding the DUT in hand or in free space has minimum influence.

5.2. Radiated Results

 FIGURE 9	Peak Gain is –6.3dBi Enclosed power is 0.04039mW ≡ 10*Log(0.04039) = -13.9dBm
 FIGURE 10	Peak Gain is -6.0dBi Enclosed power is 0.04513mW ≡ 10*Log(0.04513) = -13.5dBm

 FIGURE 11	Peak Gain is -5.9dBi Enclosed power is 0.04093mW ≡ 10*Log(0.04093) = -13.9dBm
 FIGURE 12	Peak Gain is -11dBi Enclosed power is 0.00468mW ≡ 10*Log(0.00468) = -23.3dBm

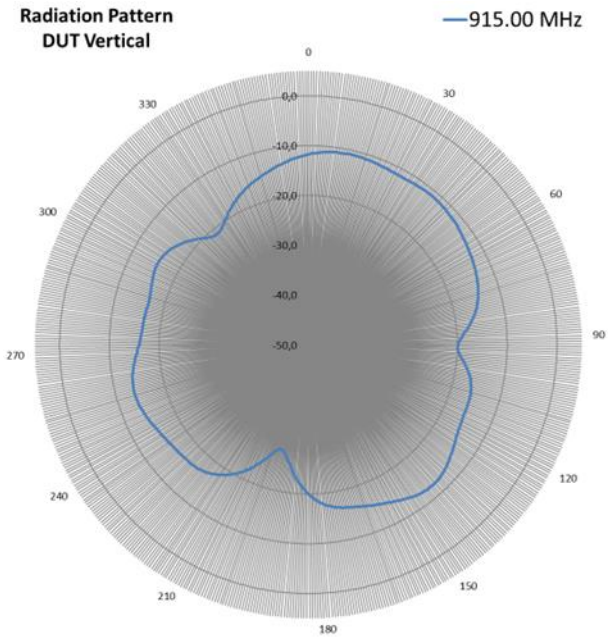


FIGURE 13

Peak Gain is -10.9dBi
Enclosed power is 0.00520mW
≡ 10*Log(0.00520) = -22.8dBm

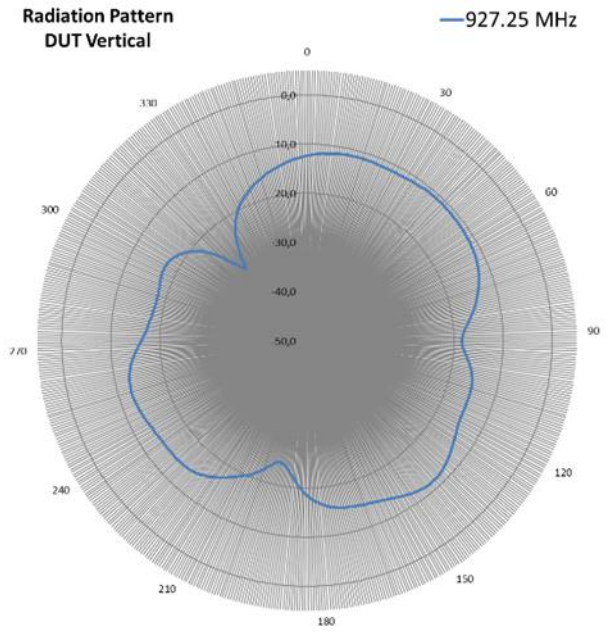
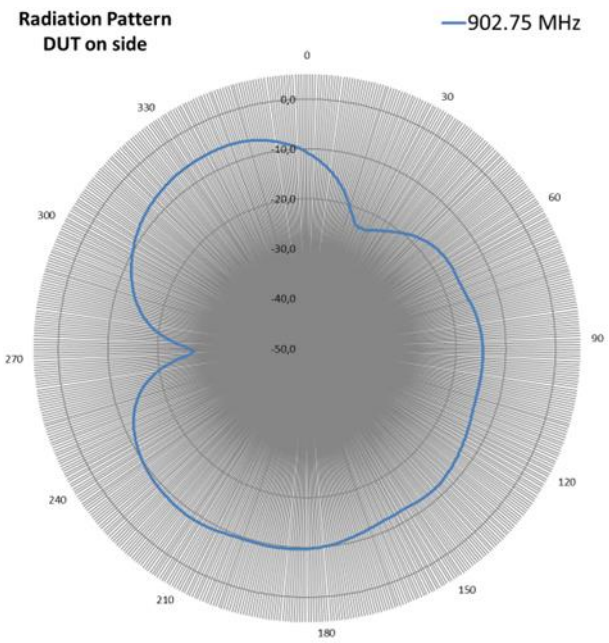
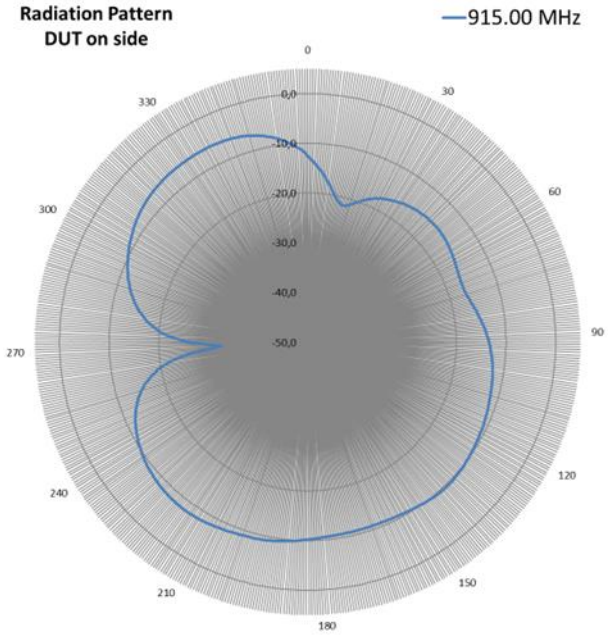


FIGURE 14

Peak Gain is -10.8dBi
Enclosed power is 0.00611mW
≡ 10*Log(0.00611) = -22.1dBm

 FIGURE 15	Peak Gain is -6.2dBi Enclosed power is 0.03150mW ≡ 10*Log(0.03150) = -15dBm
 FIGURE 16	Peak Gain is -6.0dBi Enclosed power is 0.03887mW ≡ 10*Log(0.03887) = -14.1dBm

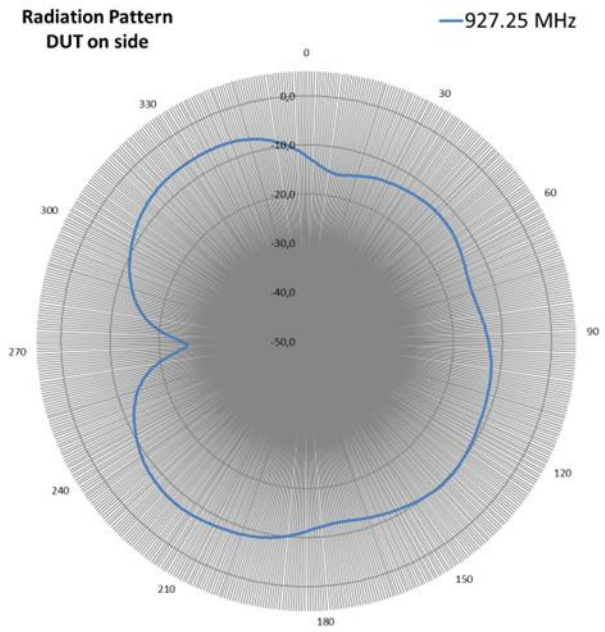


FIGURE 17

Peak Gain is -6.3dBi
Enclosed power is 0.03787mW
≡ 10*Log(0.03787) = -14.2dBm

5.3. Efficiency Determination using Radiated Power

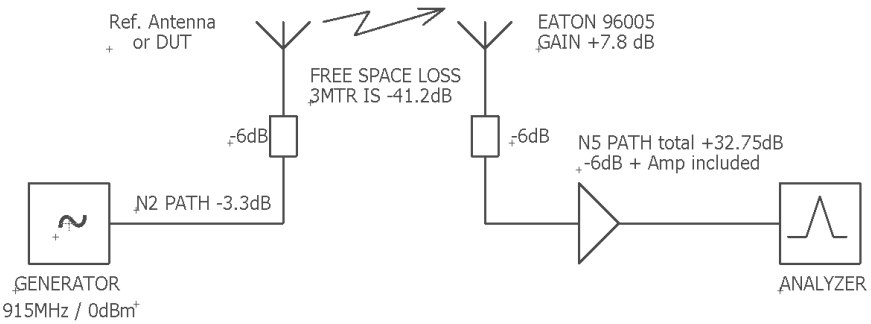
The radiation patterns are buildup of 601 sweep points resulting in 601 circle segments.
The enclosed power in a radiation pattern can be approached by summing all segments using the formula below.
Using this calculation also on a reference antenna with a known efficiency, and comparing both results will give an idea of the efficiency of the DUT antenna.

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

α=360°/601
tan(α)=Y(segment)/X(segment)
Power volume of one segment is (X*Y)/2.
X(segment) is power read from analyzer at 601 angle positions.

Formula 1

5.3.1 Test setup for efficiency measurements



This is the antenna test setup.
Unfortunately we can't measure the spherical radiated power with our setup.
Alternatively we compare the DUT radiated power to the radiated power of a reference antenna with known efficiency.
The radiated power is measured at the low band, mid band and high band frequencies. Than this is done with the DUT in all three orientations.

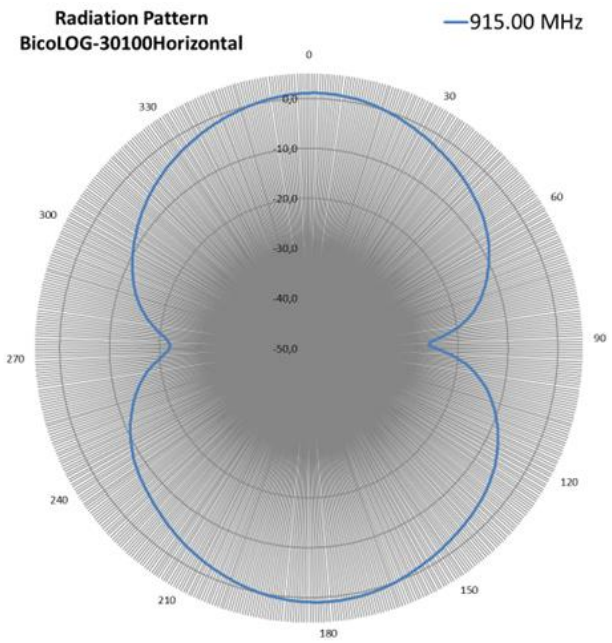


FIGURE 18

Radiation pattern of the Aaronia BicoLOG 30100
Gain max. is 1.1dBi

This is used as a gain reference for all measurements.

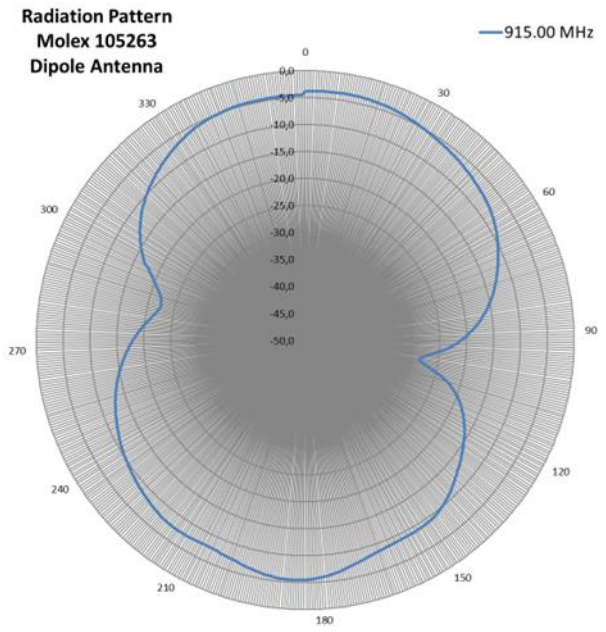


FIGURE 19

Reference Antenna: Molex 105263

Peak gain level is -3.7dBi @915MHz

Total radiated power, using formula 1,
is 0.11910 mW
i.e. 10*Log(0.11910) = -9.2dBm

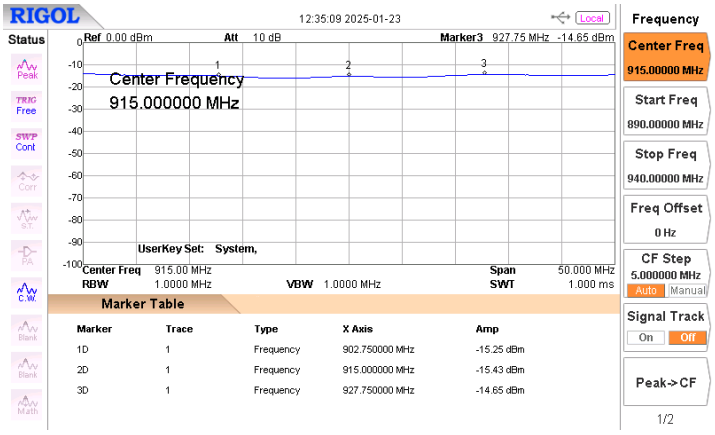


FIGURE 20

Reference Antenna: Molex 105263

Flatness within 915MHz frequency band.

5.3.2. Efficiency Determination

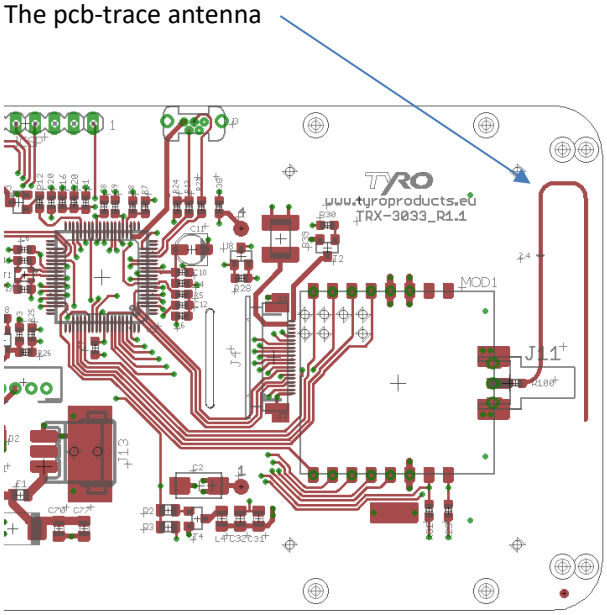
$$Efficiency(\eta) = \frac{Pradiated}{Pin}$$

Efficiency of the Molex Reference Antenna is specified to be > -1.7dB i.e 0.676 i.e. 67.6%
Reference Antenna Pradiated measured = 0.11910 mW -> Pin_antenna = (0.11910 mW/0.676) = 0.17618mW

DUT Antenna Pradiated Measured =0.027853 (Total average linear power in radiation patterns of figure 9 to 17)
Efficiency DUT Antenna is than (0.027853/0.17618) = 0.158 i.e. 15.8% or -8.0dB

6. Antenna Drawing

The pcb-trace antenna



Final layout of the trace antenna after cutting of 13mm. total trace length is now 63.1mm

7. Test results

We determined the efficiency using the average radiated power using the results from the plots in figure 9 to 17.

- The maximum gain of the antenna is -5.9dBi (from figure 11)
- The efficiency is 15.8% (please note that this is an indicative value)

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