RF Report

Reelables, Inc.
Model: N-Label

Antenna Gain Measurements

Prepared for: Reelables, Inc.
113 Cherry St. 76660,
Seattle,
Washington
United States 98104

COMMERCIAL-IN-CONFIDENCE

Document 75961990-07 Issue 01

SIGNATURE			
			
NAME	**JOB TITLE**	**RESPONSIBLE FOR**	**ISSUE DATE**
Matthew Russell	Chief Engineer	Authorised Signatory	06 January 2025

Signatures in this approval box have checked this document in line with the requirements of TÜV SÜD document control rules.

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Contents

1 Report Summary

1.1 Report Modification Record

Alterations and additions to this report will be issued to the holders of each copy in the form of a complete document.

Issue	Description of Change	Date of Issue
1	First Issue	06-Jan-2025

Table 1

1.2 Introduction

Applicant	Reelables, Inc.
Manufacturer	Reelables Europe, Ltd.
Model Number(s)	N-Label
Serial Number(s)	RAD 1 CON 1
Hardware Version(s)	5.61
Software Version(s)	1.11
Number of Samples Tested	2
Order Number	15018
Date	11-July-2024
Date of Receipt of EUT	10-September-2024
Start of Test	10-September-2024
Finish of Test	28-November-2024
Name of Engineer(s)	Thomas Biddlecombe, George Williams and Ahmad Javid

1.3 Brief Summary of Results

A brief summary of the tests carried out are shown below.

Section	Specification Clause	Test Description	Result	Comments/Base Standard
Configuration and Mode: LTE FDD B5				
2.1	-	Antenna Gain Measurements	-	For information only.
Configuration and Mode: LTE FDD B12				
2.1	-	Antenna Gain Measurements	-	For information only.
Configuration and Mode: BLE				
2.1	-	Antenna Gain Measurements	-	For information only.

Table 2

1.4 Application Form

Equipment Description

Technical Description: *(Please provide a brief description of the intended use of the equipment including the technologies the product supports)*	The N-Label from Reelables is an NB-IoT cellular device in the form factor of a thin 4x8" shipping label. It tracks the location of parcels and cargo using cell tower positioning and WiFi SSID scanning only. The intended use is a stickable label to corrugated paper cartons or other shippable containers. The N-Label comprises the following wireless technologies: NB-IoT, Bluetooth, WiFi (RX scan only) and NFC (passive).		
Manufacturer:	Reelables Europe, Ltd		
Model:	N-Label		
Part Number:	N0001		
Hardware Version:	5.61		
Software Version:	1.11		
FCC ID of the product under test – see guidance here		2A7TQ RN0001	
IC ID of the product under test – see guidance here			
Device Category	Mobile ☒	Portable ☐	Fixed ☐
Equipment is fitted with an Audio Low Pass Filter		Yes ☐	No ☒

Table 3

Intentional Radiators

Technology	NB-IoT	Bluetooth Low Energy				
Frequency Range (MHz to MHz)	699MHz-894MHz	2400MHz-2483.5MHz				
Conducted Declared Output Power (dBm)	20dBm	2.5dBm				
Antenna Gain (dBi)	0	0				
Supported Bandwidth(s) (MHz) (e.g. 1 MHz, 20 MHz, 40 MHz)	200KHz	1, 2				
Modulation Scheme(s) (e.g. GFSK, QPSK etc)	QPSK BPSK	GFSK				
ITU Emission Designator (see guidance here) (not mandatory for Part 15 devices)		1M00GXW, 2M00GXW				
Bottom Frequency (MHz)	699MHz	2402				
Middle Frequency (MHz)	746MHz	2440				
Top Frequency (MHz)	894MHz	2480				

Table 4

Un-intentional Radiators

Highest frequency generated or used in the device or on which the device operates or tunes	2483.5MHz
Lowest frequency generated or used in the device or on which the device operates or tunes	699MHz
Class A Digital Device (Use in commercial, industrial or business environment) ☒ Class B Digital Device (Use in residential environment only) ☐	

Table 5

AC Power Source

AC supply frequency:	NA	Hz
Voltage	NA	V
Max current:	NA	A
Single Phase ☐ Three Phase ☐		

Table 6

DC Power Source

Nominal voltage:	NA	V
Extreme upper voltage:	NA	V
Extreme lower voltage:	NA	V
Max current:	NA	A

Table 7

Battery Power Source

Voltage:	6	V
End-point voltage:	2.2	V *(Point at which the battery will terminate)*
Alkaline ☐ Leclanche ☐ Lithium ☐ Nickel Cadmium ☐ Lead Acid* ☐ **(Vehicle regulated)*		
Other ☒ Zinc-carbon Please detail:	Zn-MnO2 coated battery	

Table 8

Charging

Can the EUT transmit whilst being charged	Yes ☐ No ☒

Table 9

Temperature

Minimum temperature:	-20	°C
Maximum temperature:	50	°C

Table 10

Cable Loss

Adapter Cable Loss (Conducted sample)	0.9	dB

Table 11

Antenna Characteristics

Antenna connector ☐			State impedance		Ohm
Temporary antenna connector ☐			State impedance		Ohm
Integral antenna ☒	Type:	PIFA	Gain	0	dBi
External antenna ☐	Type:		Gain		dBi
For external antenna only: Standard Antenna Jack ☐ If yes, describe how user is prohibited from changing antenna (if not professional installed): Equipment is only ever professionally installed ☐ Non-standard Antenna Jack ☐ All part 15 applications will need to show how the antenna gain was derived either from a manufacturer data sheet or a measurement. Where the gain of the antenna is inherently accounted for as a result of the measurement, such as field strength measurements on a part 15.249 or 15.231 device, so the gain does not necessarily need to be verified. However, enough information regarding the construction of the antenna shall be provided. Such information maybe photographs, length of wire antenna etc.					

Table 12

Ancillaries (if applicable)

Manufacturer:		Part Number:	
Model:		Country of Origin:	

Table 13

I hereby declare that the information supplied is correct and complete.

Name: Brian Krejcarek
Position held: CEO
Date: September 11, 2024

1.5 Product Information

1.5.1 Technical Description

The N-Label from Reelables is an NB-IoT cellular device in the form factor of a thin 4x8” shipping label. It tracks the location of parcels and cargo using cell tower positioning and WiFi SSID scanning only. The intended use is a stickable label to corrugated paper cartons or other shippable containers. The N-Label comprises the following wireless technologies: NB-IoT, Bluetooth, WiFi (RX scan only) and NFC (passive).

1.6 EUT Modification Record

The table below details modifications made to the EUT during the test programme.

The modifications incorporated during each test are recorded on the appropriate test pages.

Modification State	Description of Modification still fitted to EUT	Modification Fitted By	Date Modification Fitted
Model: N-Label, Serial Number: CON 1			
0	As supplied by the customer	Not Applicable	Not Applicable
Model: N-Label, Serial Number: RAD 1			
0	As supplied by the customer	Not Applicable	Not Applicable

Table 14

1.7 Test Location

TÜV SÜD conducted the following tests at our Octagon House Test Laboratory.

Test Name	Name of Engineer(s)	Accreditation
Configuration and Mode: LTE FDD B5		
Antenna Gain Measurements	Thomas Biddlecombe and Ahmad Javid	None
Configuration and Mode: LTE FDD B5		
Antenna Gain Measurements	Thomas Biddlecombe and Ahmad Javid	None
Configuration and Mode: LTE FDD B5		
Antenna Gain Measurements	Thomas Biddlecombe and Ahmad Javid	None

Table 15

Office Address:

TÜV SÜD
Octagon House
Concorde Way
Fareham
Hampshire
PO15 5RL
United Kingdom

2 Test Details

2.1 Antenna Gain Measurements

2.1.1 Equipment Under Test and Modification State

N-Label, S/N CON 1: - Modification State 0 (Conducted)
N-Label, S/N RAD 1: - Modification State 0 (Radiated)

2.1.2 Date of Test

10-September-2024 to 11-October-2024

2.1.3 Test Method

The manufacturer provided a modified sample with a temporary 50 ohm SMA connector in place of the antenna which was used to perform a conducted power measurement in accordance with ANSI C63.10 clause 11.9.1.1.

The non-modified sample was then placed in a fully anechoic chamber on a turntable at 1.5m height at a measurement distance of 1m. The equipment under test (EUT) was placed in 3 orientations (X, Y, Z) to establish which plane provided the maximum EIRP.

The chamber is calibrated to make EIRP measurements thus for each frequency point the total loss from the centre of the turntable is determined using the substitution method and set as a correction factor on the measuring equipment. The EUT was oriented for maximum EIRP and rotated in azimuth in 15 degree steps and the EIRP recorded as shown on the polar plots in the test result section below.

2.1.4 Environmental Conditions

Ambient Temperature	19.4 – 22.7 °C
Relative Humidity	33.2 – 56.2 %

2.1.5 Test Equipment Diagram

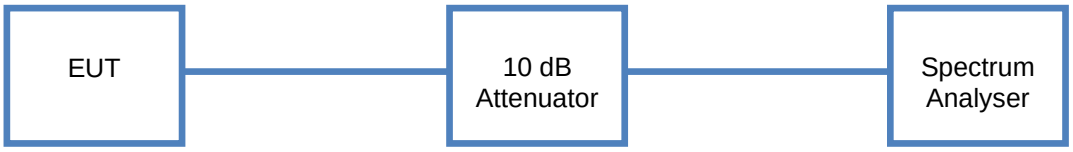

Figure 1 – Conducted Test Setup

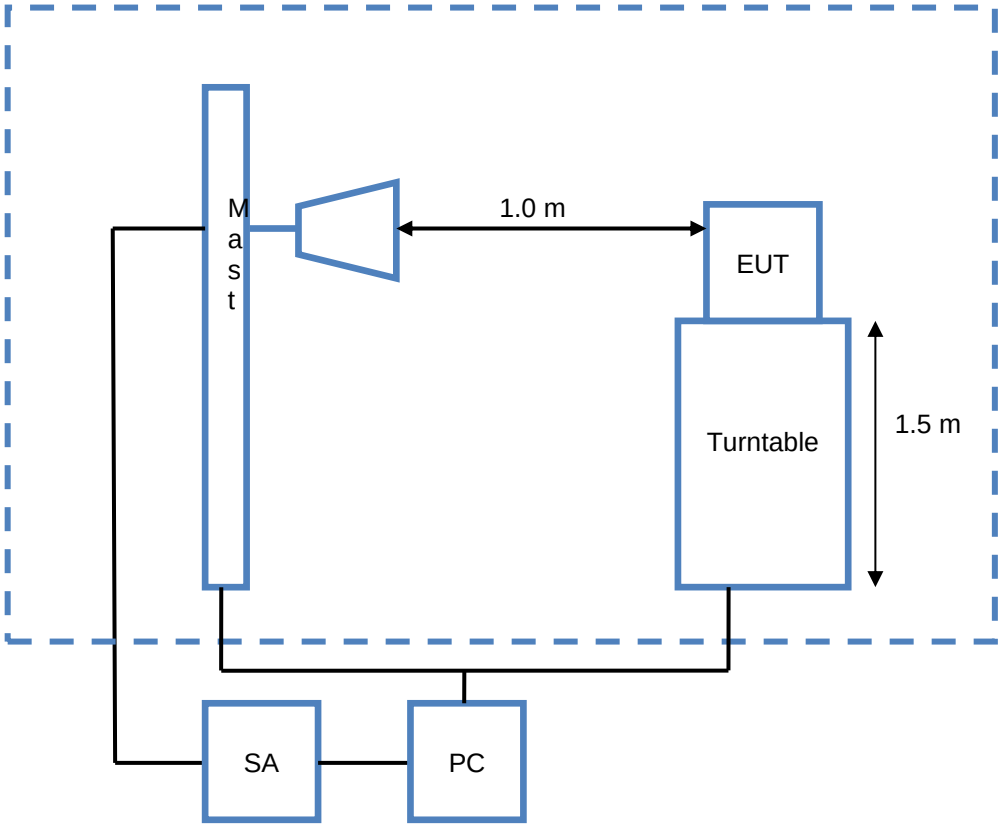

Figure 2 – Radiated Test Setup BLE

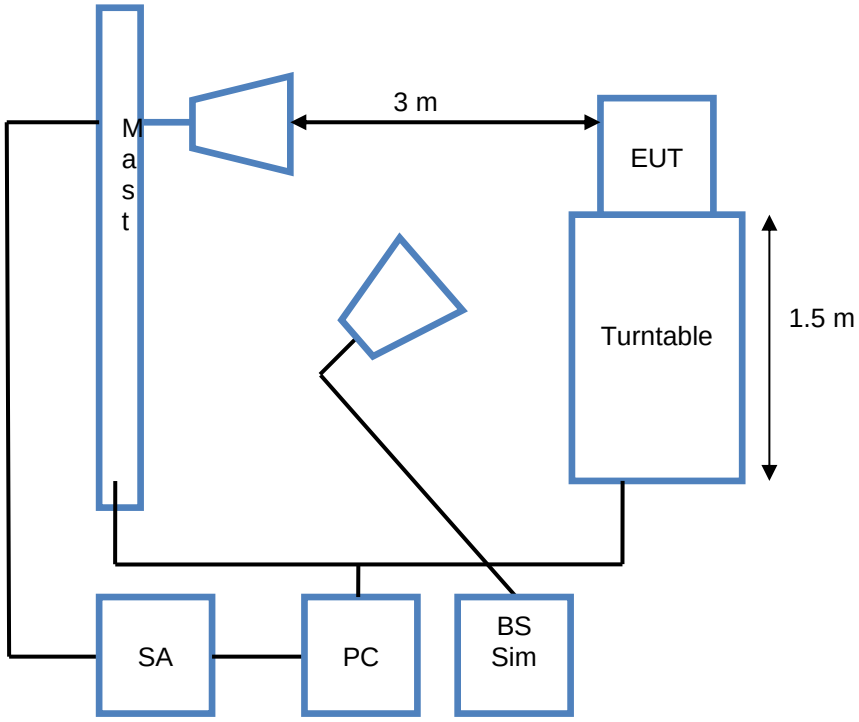

Figure 3 – Radiated Test Setup LTE

2.1.6 Test Results

BLE

Summary of Results

Frequency (MHz)	Antenna Gain (dBi)
2402	2.14
2426	1.72
2480	0.08

Table 16 – Antenna Gain Results

Conducted Results

Frequency (MHz)	Result (dBm)
2402	2.75
2426	2.97
2480	3.19

Table 17 – Maximum Conducted Output Power Results

Radiated Results

Frequency (MHz)	Result (dBm EIRP)
2402	4.89
2426	4.69
2480	3.27

Table 18 – Maximum Radiated Output Power Results

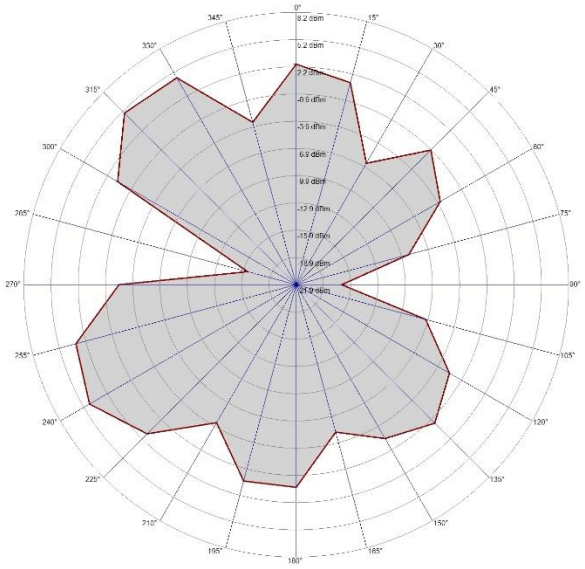

Figure 3 – 2402 MHz, Horizontal

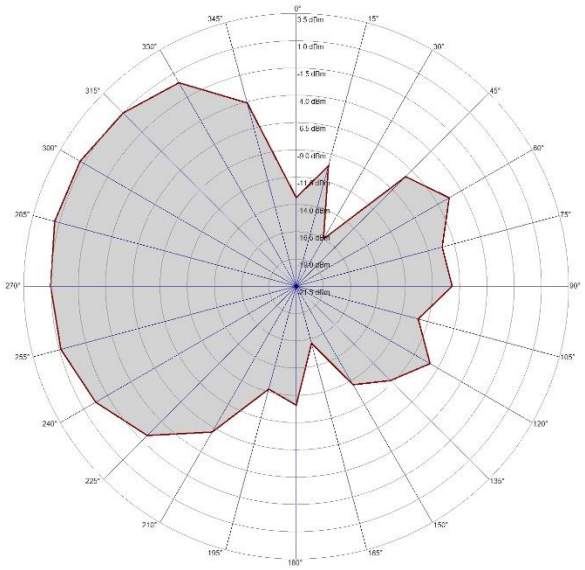

Figure 4 – 2402 MHz, Vertical

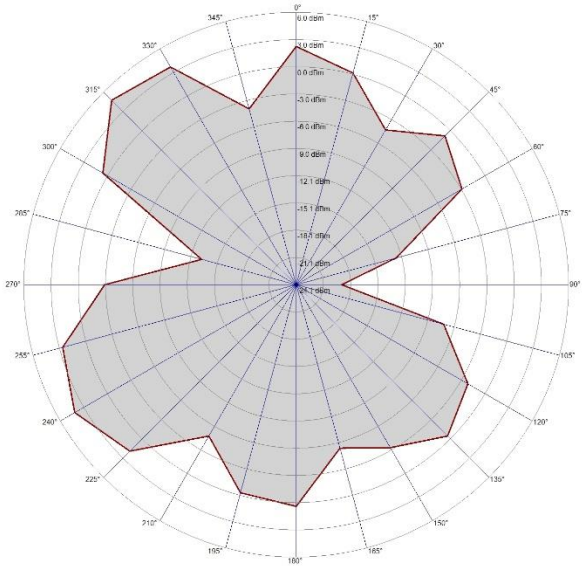

Figure 5 – 2426 MHz, Horizontal

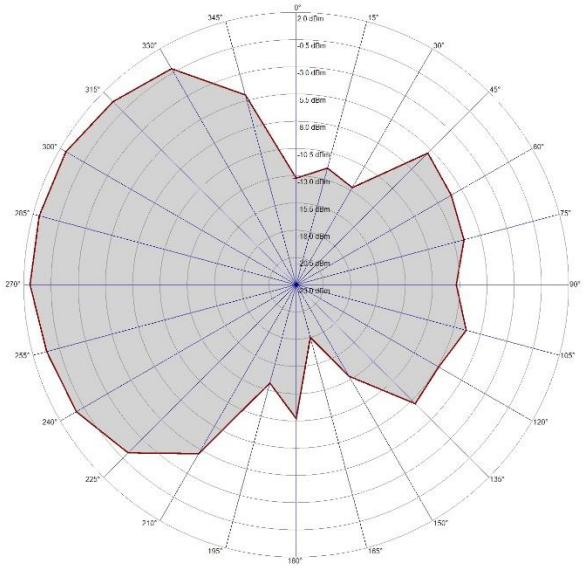

Figure 6 – 2426 MHz, Vertical

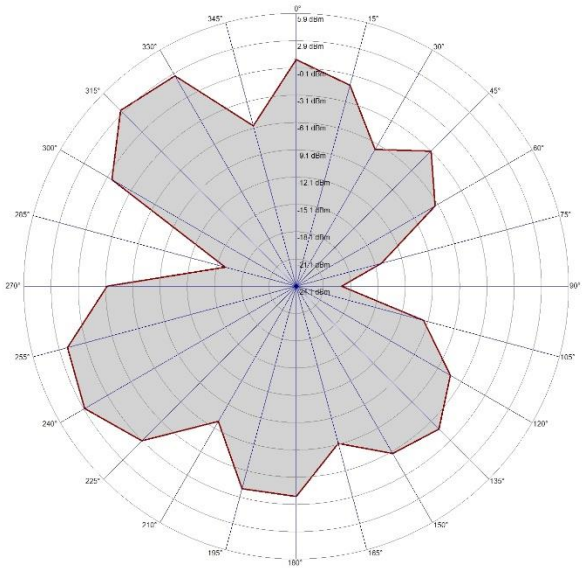

Figure 7 – 2480 MHz, Horizontal

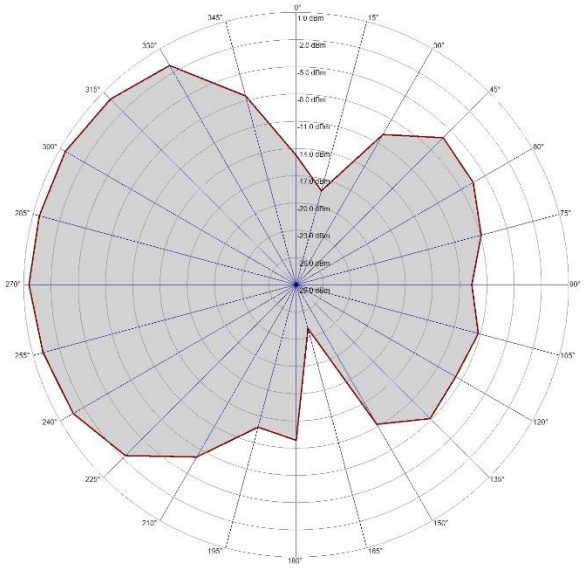

Figure 8 – 2480 MHz, Vertical

LTE FDD B5

Summary of Results

Frequency (MHz)	UARFCN	Modulation	SCS (kHz)	Tone Number	Start Sub-Carrier	MCS
826.5	20425	QPSK	15	6	0	5
836.5	20525	QPSK	15	6	6	5
846.5	20625	QPSK	15	6	6	5

Table 19 – LTE NB IoT Carrier Configuration

Frequency (MHz)	Antenna Gain (dBi)
826.5	-2.44
836.5	-2.57
846.5	-2.07

Table 20 – Antenna Gain Results

Conducted Results

Frequency (MHz)	Result (dBm)
826.5	24.27
836.5	24.52
846.5	24.32

Table 21 – Maximum Conducted Output Power Results

Radiated Results

Frequency (MHz)	Result (dBm EIRP)
826.5	21.83
836.5	21.95
846.5	22.25

Table 22 – Maximum Radiated Output Power Results

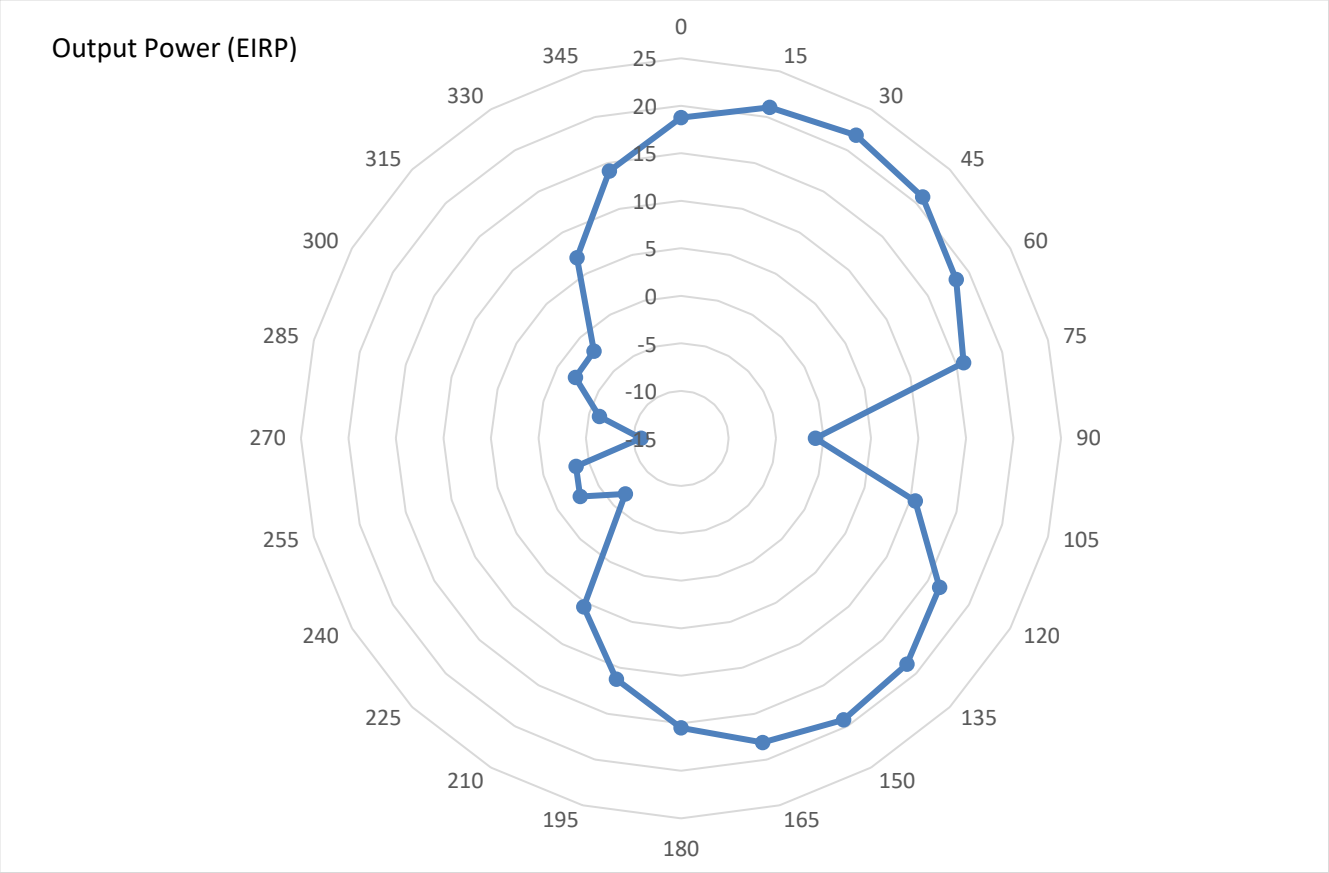

Figure 9 – 826.5 MHz, Horizontal

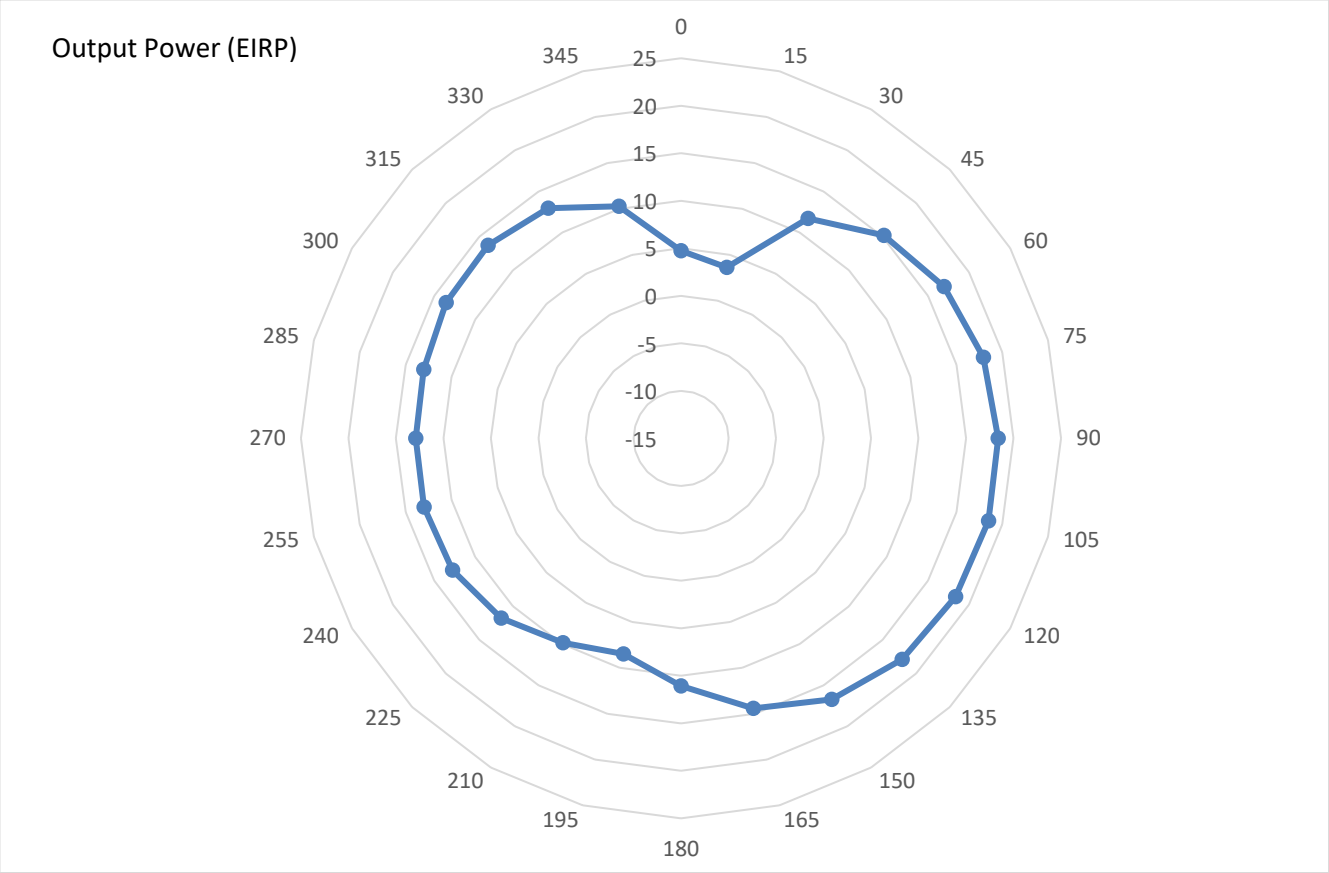

Figure 10 – 826.5 MHz, Vertical

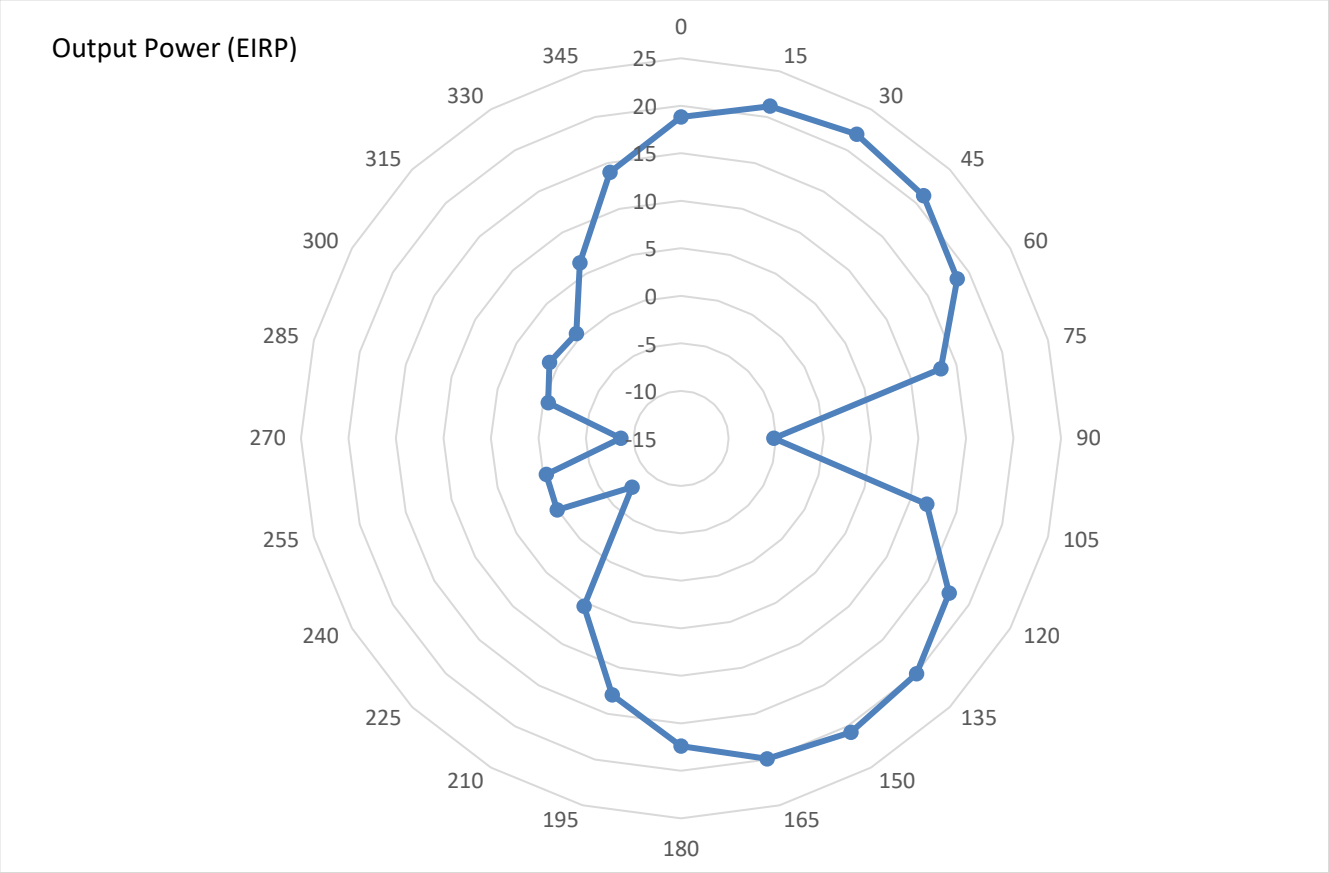

Figure 11 – 836.5 MHz, Horizontal

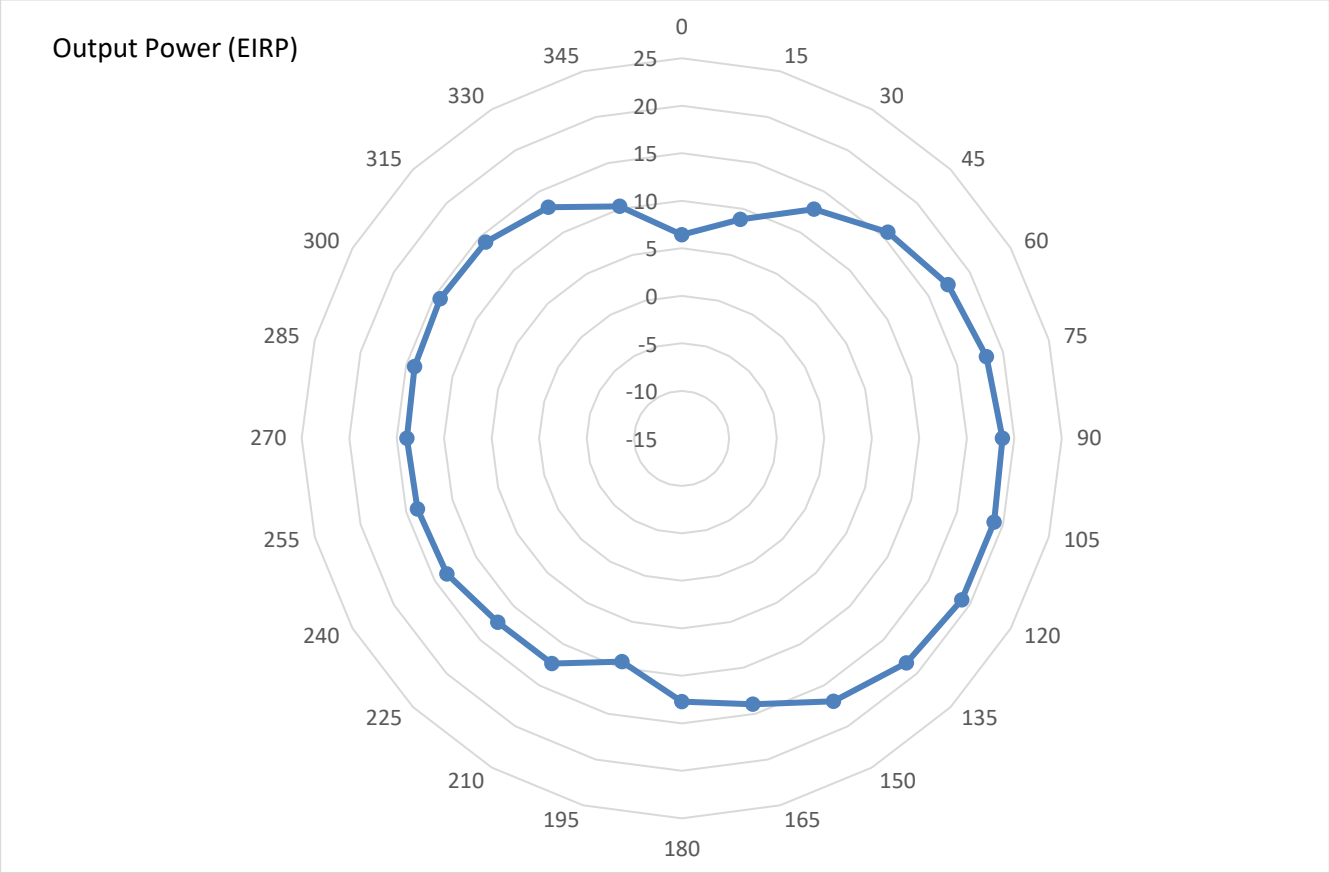

Figure 12 – 836.5 MHz, Vertical

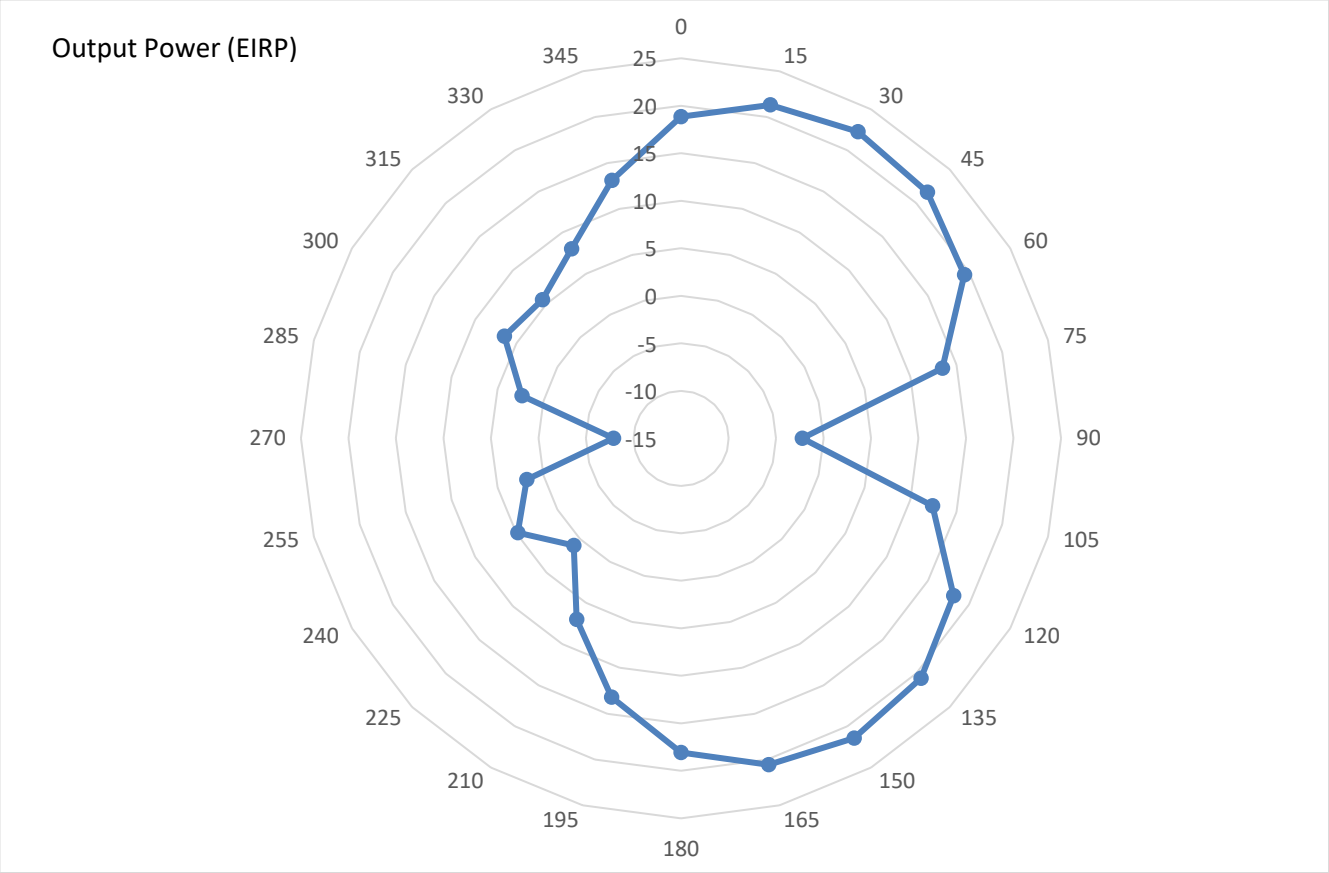

Figure 13 – 846.5 MHz, Horizontal

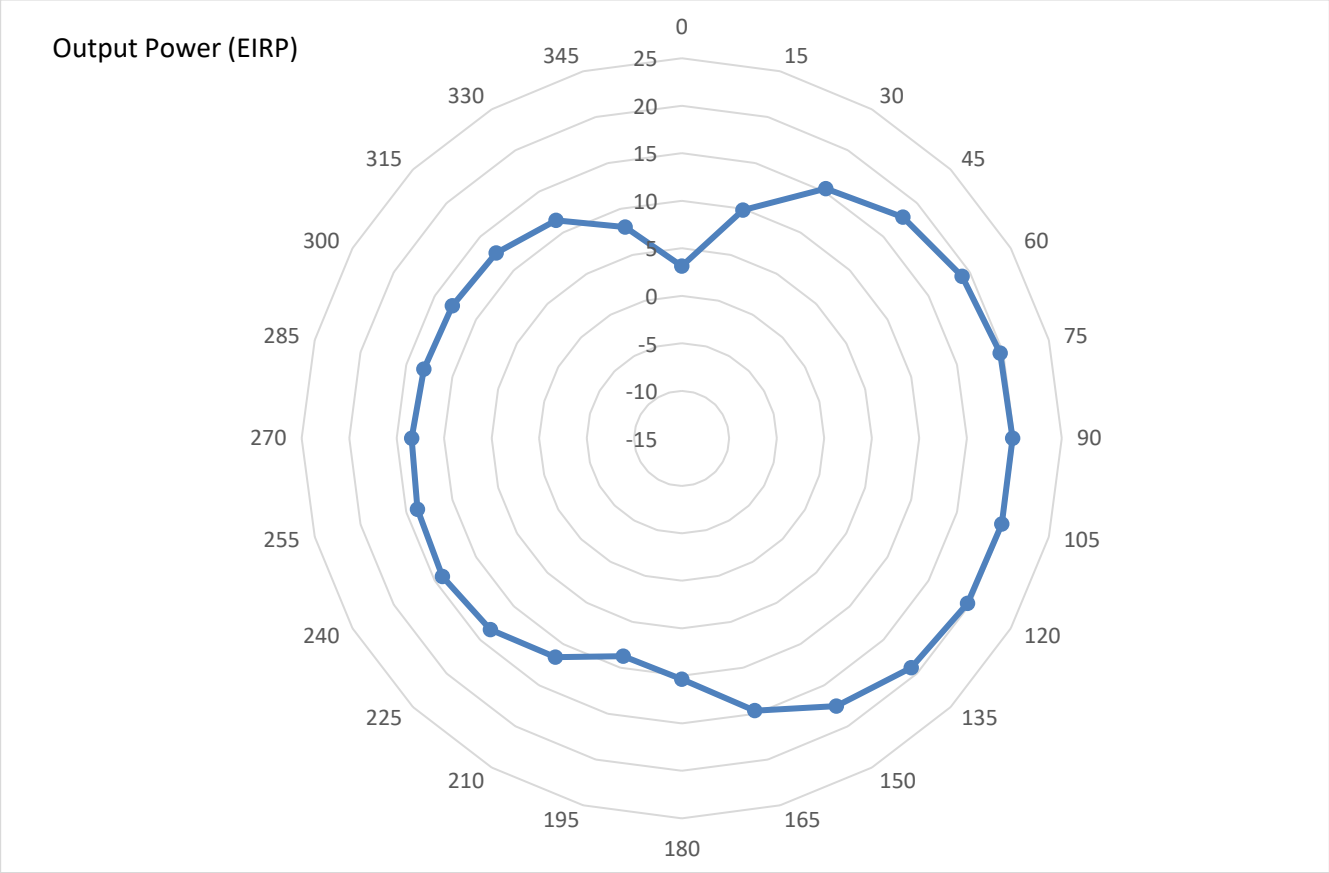

Figure 14 – 846.5 MHz, Vertical

LTE FDD B12

Summary of Results

Frequency (MHz)	UARFCN	Modulation	SCS (kHz)	Tone Number	Start Sub-Carrier	MCS
701.5	23035	QPSK	15	6	0	5
707.5	23095	QPSK	15	6	6	5
713.5	231	QPSK	15	12	0	5

Table 23 – LTE NB IoT Carrier Configuration

Frequency (MHz)	Antenna Gain (dBi)
701.5	-1.57
707.5	-0.43
713.5	-1.45

Table 24 – Antenna Gain Results

Conducted Results

Frequency (MHz)	Result (dBm)
701.5	20.78
707.5	19.08
713.5	19.44

Table 25 – Maximum Conducted Output Power Results

Radiated Results

Frequency (MHz)	Result (dBm EIRP)
701.5	19.21
707.5	18.65
713.5	17.99

Table 26 – Maximum Radiated Output Power Results

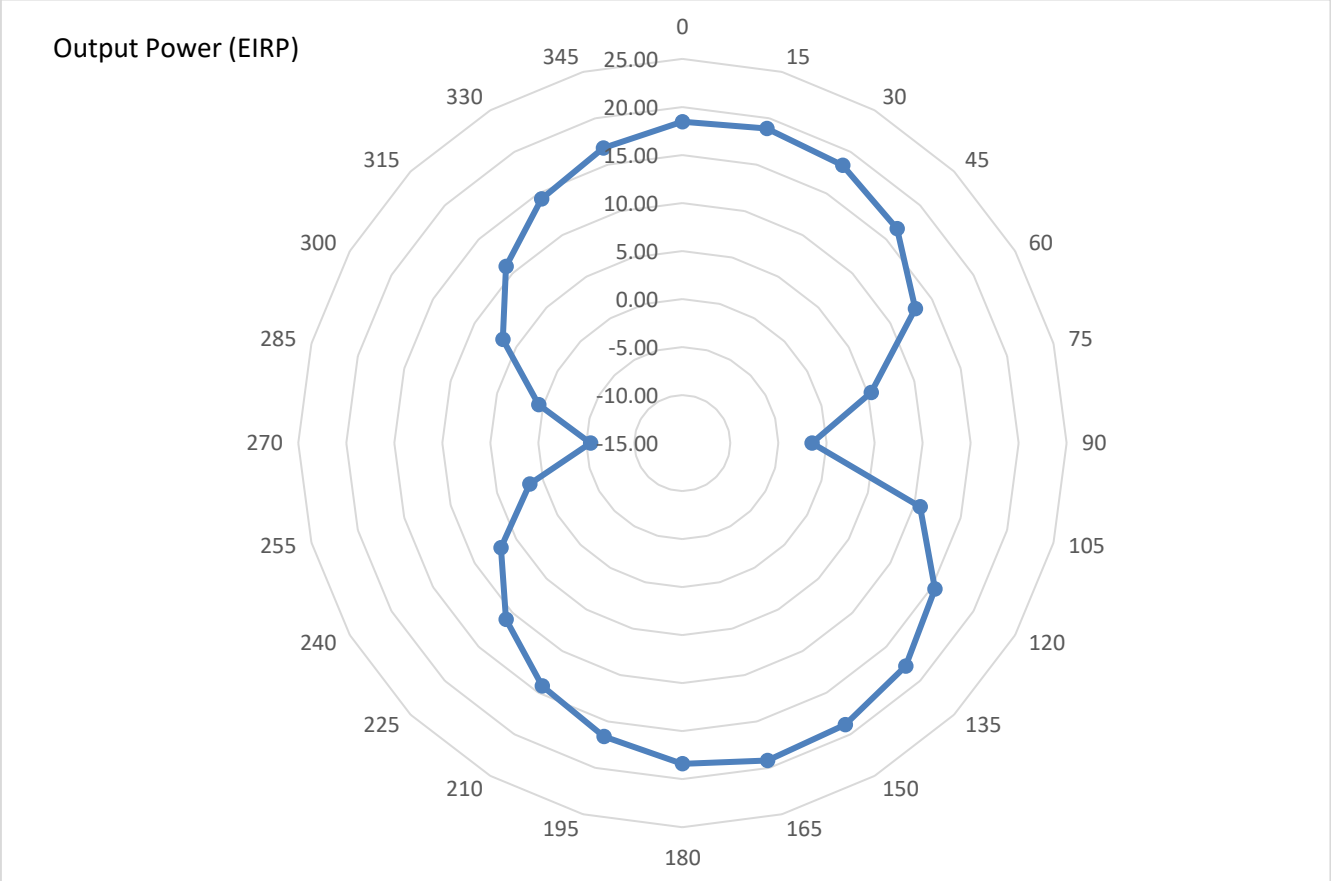

Figure 15 – 701.5 MHz, Horizontal

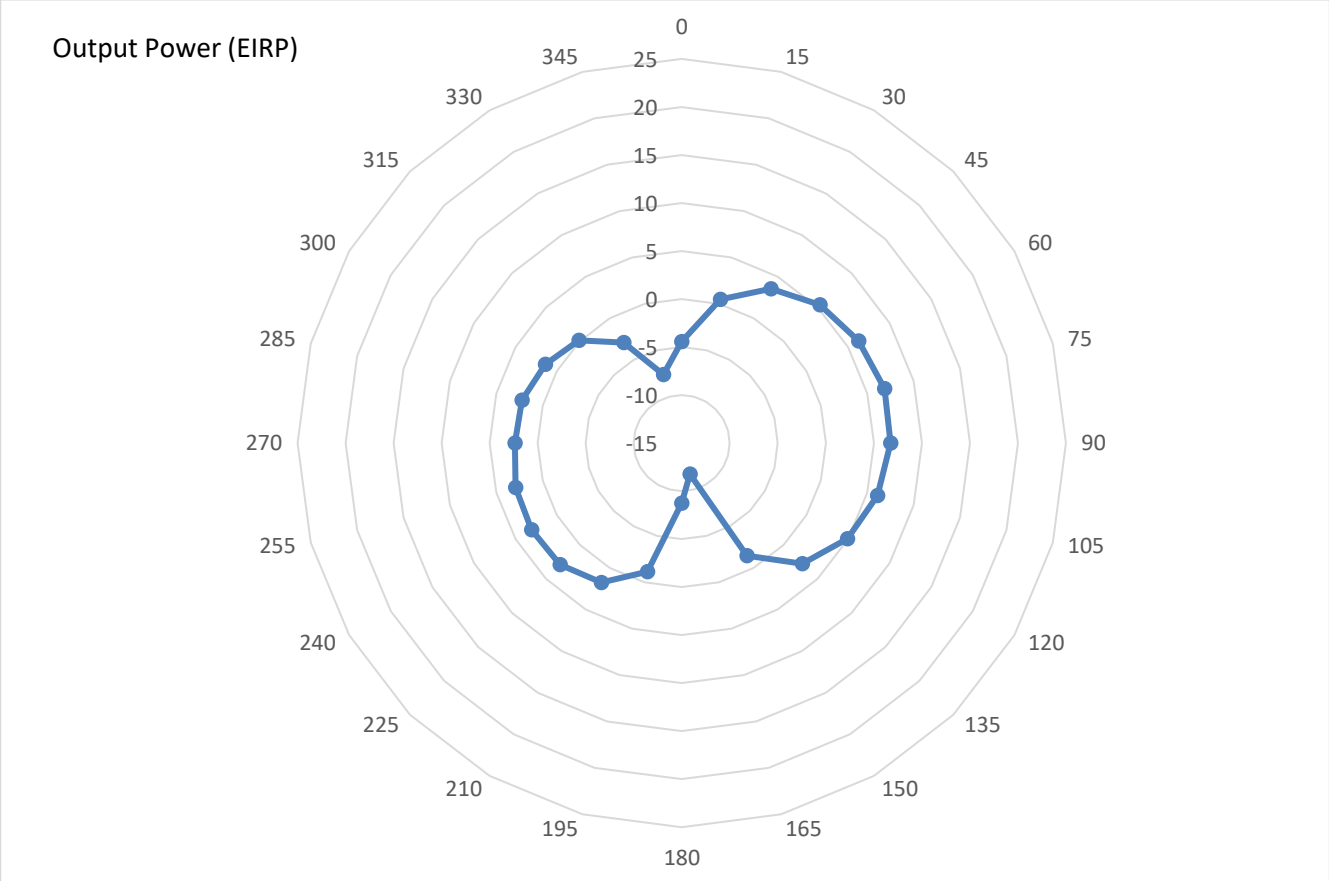

Figure 16 – 701.5 MHz, Vertical

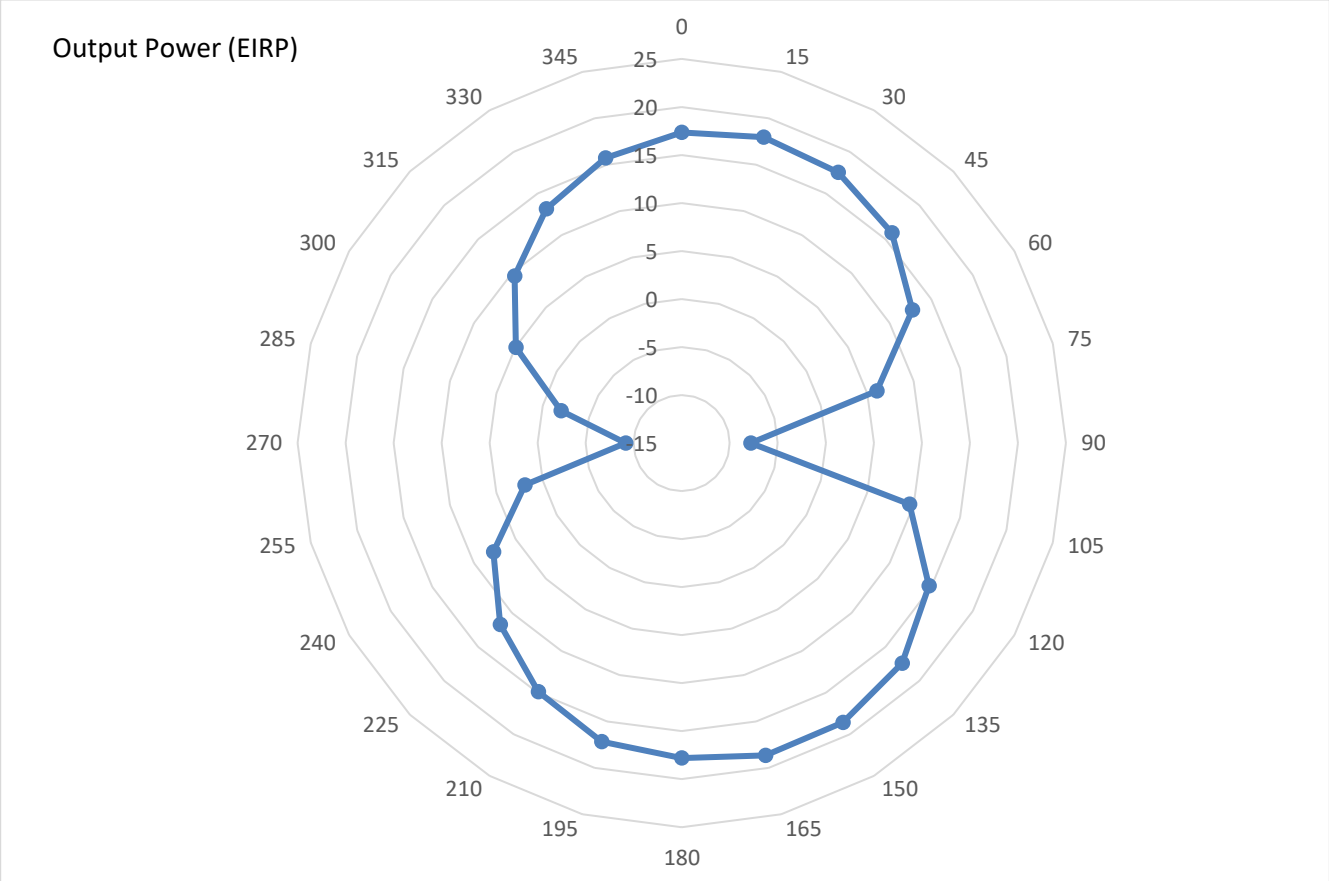

Figure 17 – 707.5 MHz, Horizontal

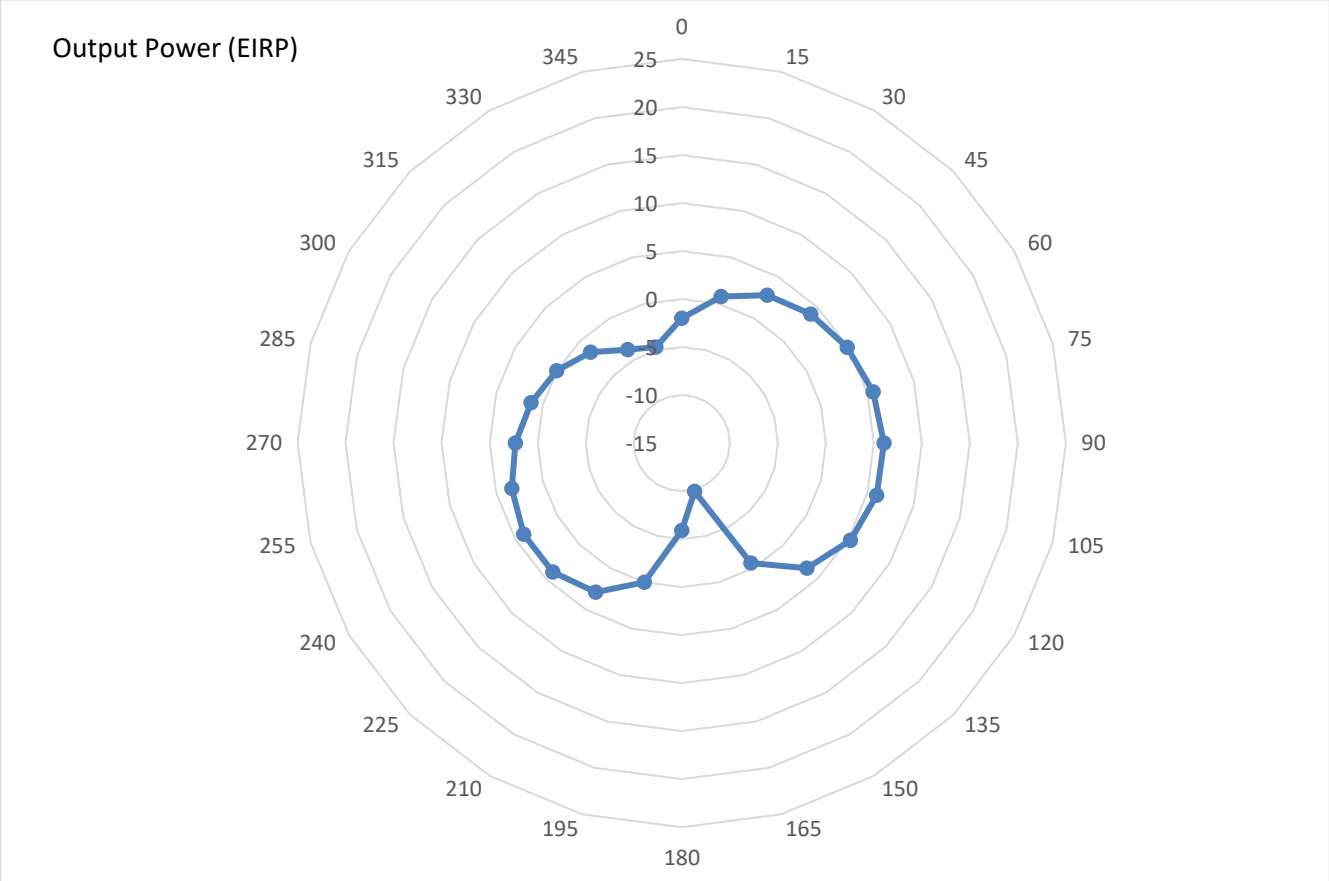

Figure 18 – 707.5 MHz, Vertical

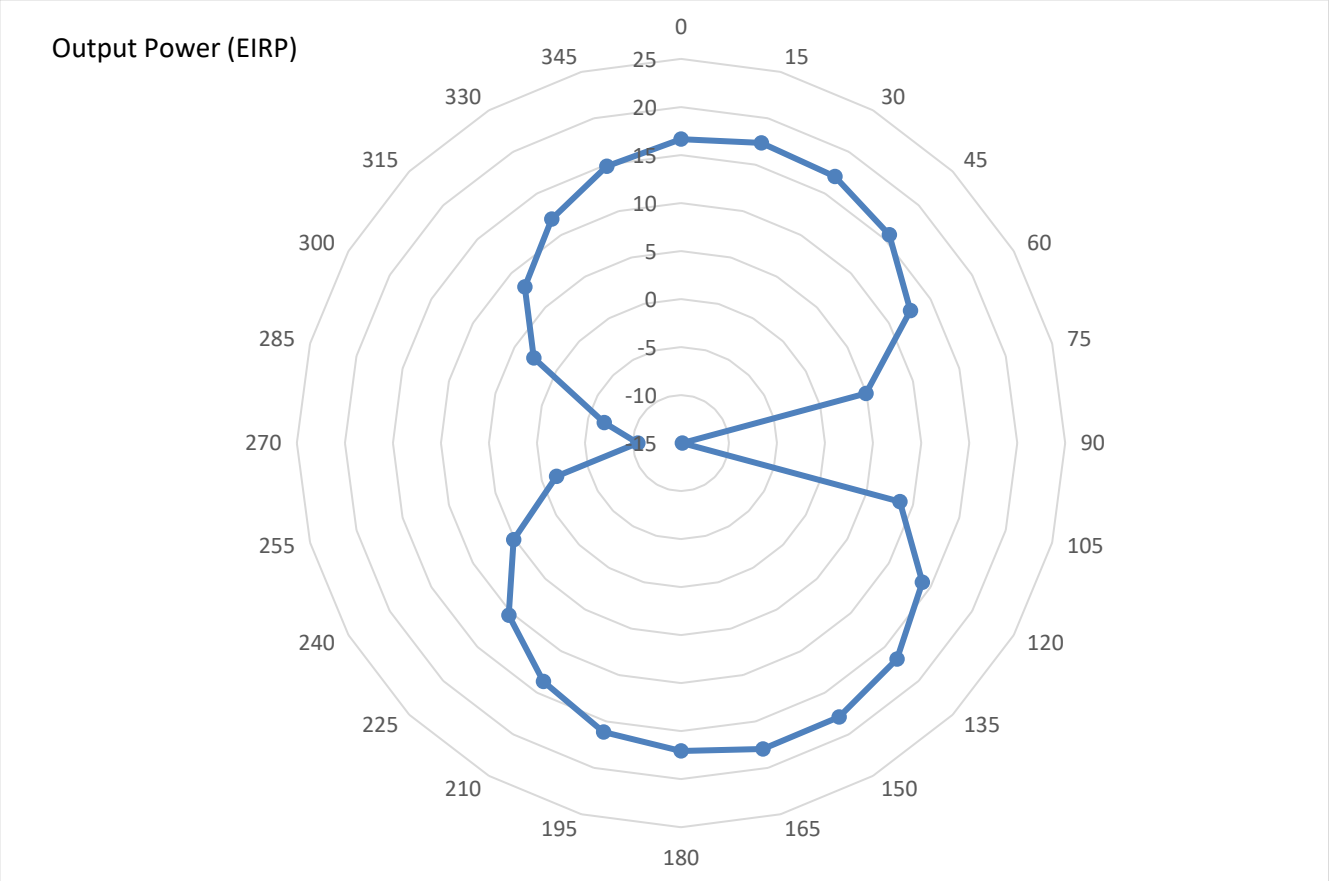

Figure 19 – 713.5 MHz, Horizontal

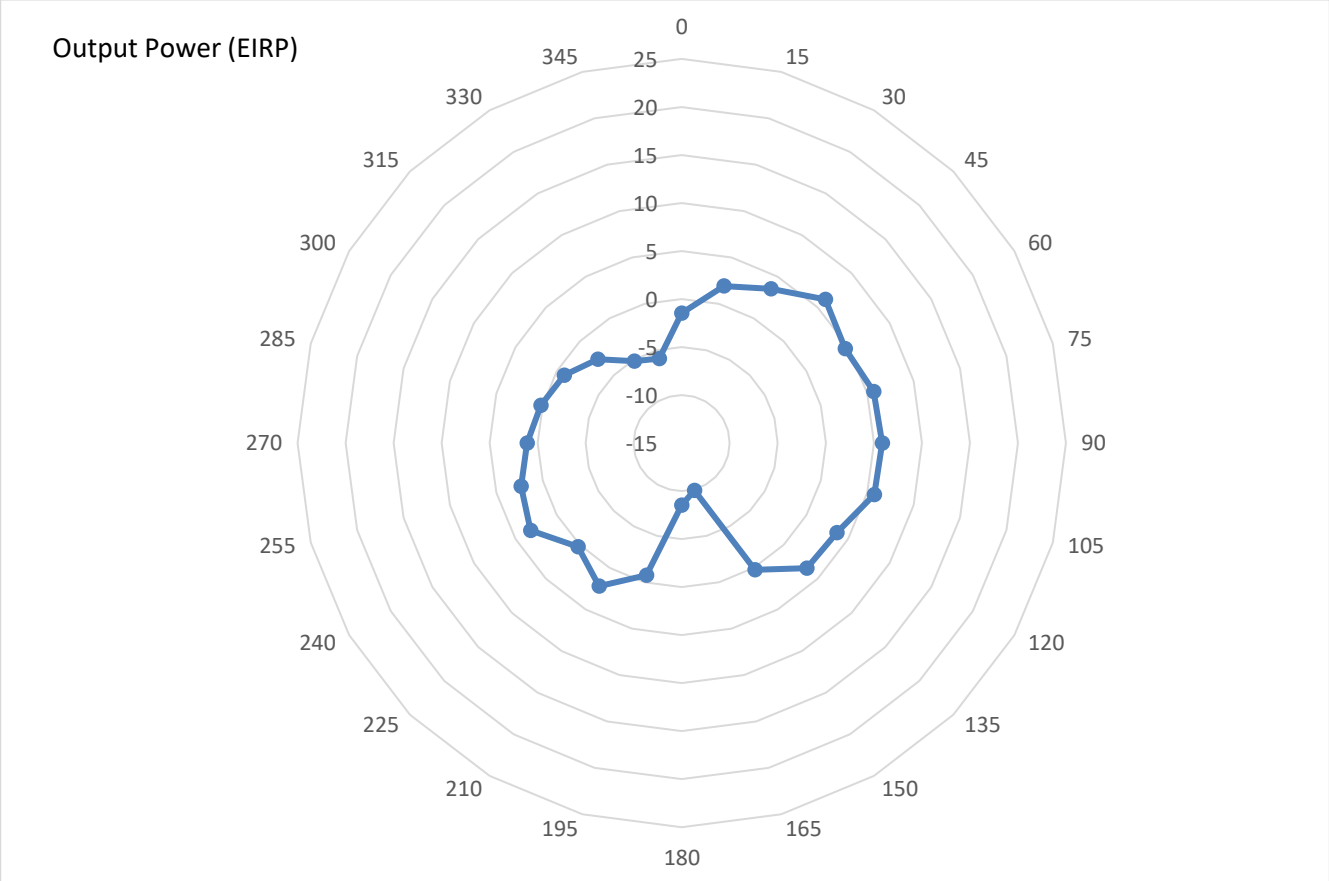

Figure 20 – 713.5 MHz, Vertical

2.1.7 Test Location and Test Equipment Used

This test was carried out in RF Chamber 5.

Instrument	Manufacturer	Type No.	TE No.	Calibration Period (months)	Calibration Expiry Date
Directional Coupler	Kryter	1850	58	0	TU
True RMS Multimeter	Fluke	79 Series III	411	12	12-Jan-2025
Attenuator Switch Driver	Hewlett Packard	11713A	1083	0	TU
3m Semi-Anechoic chamber	Rainford	3115	1545	36	23-Apr-2027
Turntable Controller	Inn-Co GmbH	Rainford	1606	0	TU
Attenuator (11dB, 1W)	Hewlett Packard	8494H	2785	0	O/P Mon
Attenuator (110dB, 1W)	Hewlett Packard	8496H	2786	0	O/P Mon
Hygrometer	Rotronic	I-1000	3220	12	28-Nov-2024
True RMS Multimeter	Fuke	179	4006	12	22-Mar-2025
GPSDR Frequency Standard	Spectracom	SecureSync 1200-0408-0601	4393	6	09-Mar-2025
Mast Controller	Maturo GmbH	ZVA 40	4810	0	TU
Tilt Antenna Mast	Maturo GmbH	NPS-2303-2000-NPS	4811	0	TU
4dB Attenuator	Pasterneck	ZV-Z54	4935	12	31-Jul-2025
Emission software	TUV SUD	SecureSync 1200-0408-0601	5125	0	Software
Thermo-Hygro-Barometer	PCE Instruments	PCE-THB-40	5481	12	13-May-2025
Cable (SMA to SMA, 2m)	Junshoka	IDM93N	5517	12	23-May-2025
EMI Test Reciever	Rhode & Schwarz	NMS-235SP-78.8-NMS	5527	12	26-Jul-2025
MXA Signal Analyser	Keysight	N9020B	5528	24	18-Sep-2025
1m K-Type Cable	Junkosha	MWX221/B	5908	12	10-Jun-2025
Cable (N to N 8m)	Junkosha	HMP4040	6331	12	17-Feb-2025
2m Coaxial Cable Assy	Junkosha	MWX221-02000AMSAMS/A	6357	12	14-May-2025
Spectrum Analyser	Anritsu	MT8821C	6542	12	28-Jun-2025
Attenuator 5W 20dB DC-18GHz	Aaren	AT40A-4041-D18-20	6557	12	18-Jun-2025
Trilog Super Broadband Test Antenna	Schwarzbeck	LU1-001-1000	6635	24	13-Jun-2025
Cable N to N 1m	Junkosha	MWX221-01000NMSN/B	6776	12	15-Apr-2025

PXA Signal Analyser	Keysight Technologies	N9030A	4654	12	23-Jan-2025
Coaxial Fixed Attenuator DC-18GHz 5W 10dB	RF-Lambda	RFS5G18B10SMP	6181	12	16-Aug-2025
Cable (SMA to SMA 3m)	Junkosha	MWX221-03000AMSAMS/B	6023	12	06-Jun-2025
3.5 mm 2m cable	Junkosha	MWX221-02000DMS	5423	12	18-Feb-2025
Power Splitter	Mini-Circuits	ZN2PD2-63-S+	5237	-	O/P Mon
Thermo-Hygro-Barometer	PCE Instruments	PCE-THB-40	5471	12	07-May-2025

Table 27 – Test Equipment

TU - Traceability Unscheduled

3 Photographs

3.1 Test Setup Photographs

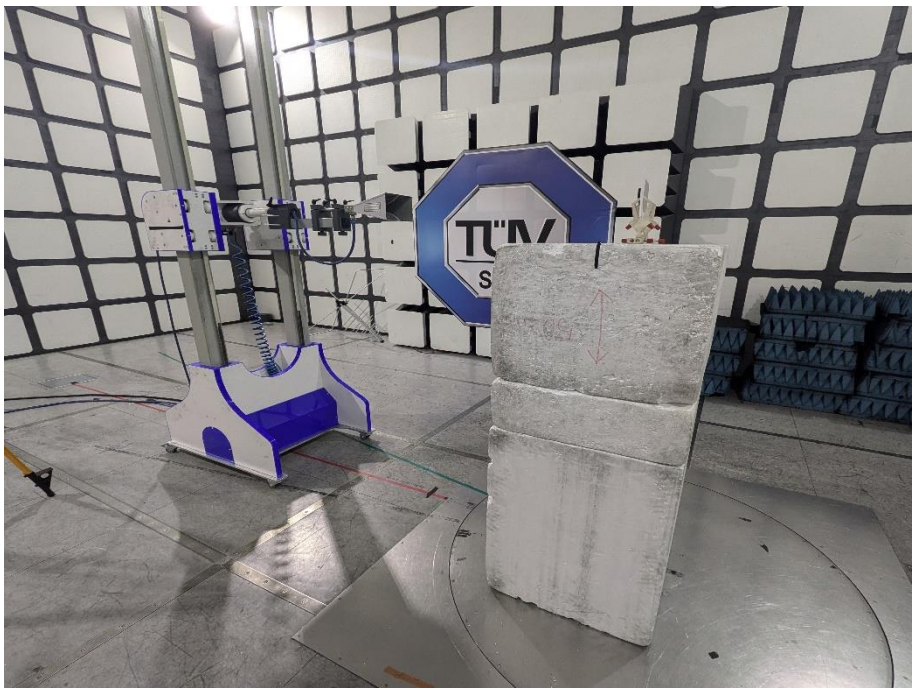

Figure 21 – Test Setup Photo BLE (Radiated)

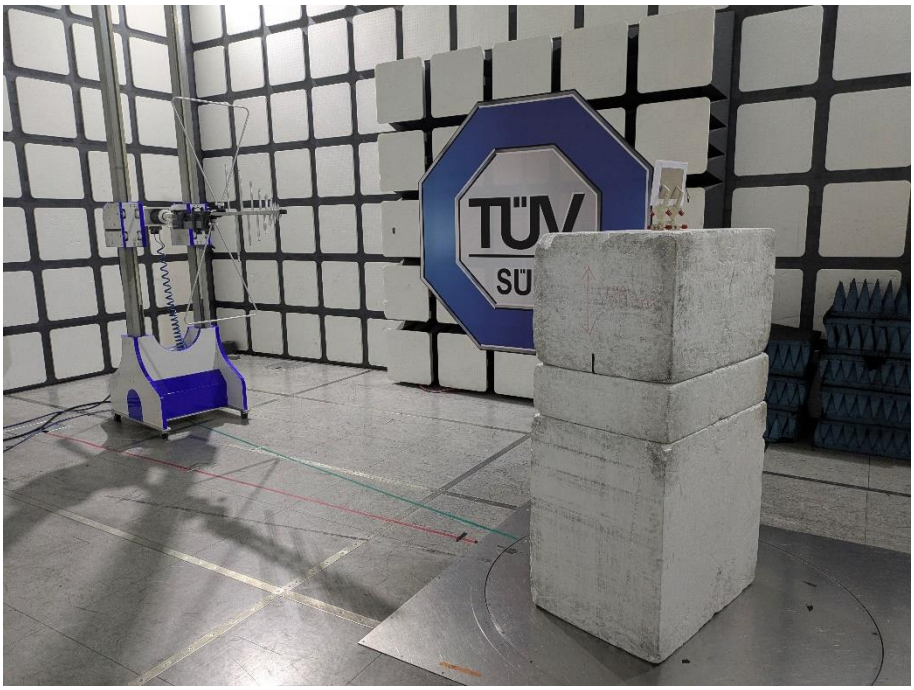

Figure 22 – Test Setup Photo LTE (Radiated)

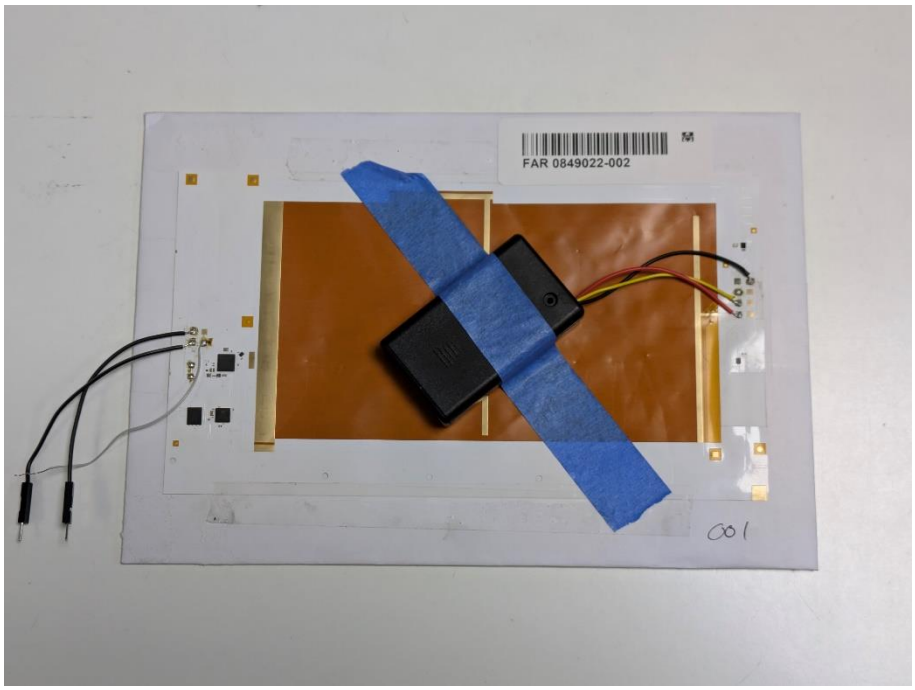

Figure 23 – Sample (Radiated)

4 Measurement Uncertainty

For a 95% confidence level, the measurement uncertainties for defined systems are:

Test Name	Measurement Uncertainty
Antenna Gain Measurements	Conducted: ±0.96 dB Radiated: ±3.08 dB

Table 28

Measurement Uncertainty Decision Rule – Accuracy Method

Determination of conformity with the specification limits is based on the decision rule according to IEC Guide 115:2021, Clause 4.4.3 (Procedure 2). The measurement results are directly compared with the test limit to determine conformance with the requirements of the standard.

Risk: The uncertainty of measurement about the measured result is negligible with regard to the final pass/fail decision. The measurement result can be directly compared with the test limit to determine conformance with the requirement (compare IEC Guide 115). The level of risk to falsely accept and falsely reject items is further described in ILAC-G8.