

LoRa OTA RF Performance Measurement Report for GWF RCM®-H200



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Test Laboratory:

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Deutsche
Akkreditierungsstelle
D-PL-12140-01-01
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D-PL-12140-01-03

Note:

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1 Project and Result Summary

EUT	RCM®-H200	Device (EUI)	EUT1 (861 MHz): 70B3D53878000064 EUT2 (915 MHz): 450030000650344D EUT3 (915 MHz): 70B3D53878000064
		HW version	v11
		Firmware version	v1
Test lab	7layers GmbH Borsigstr. 11 40880 Ratingen Germany	Set up	free space (CW mode)
		LoRaWAN spec. version	1.0.4
		Test start	22.01.2023
Customer	GWF MessSysteme AG Obergrundstrasse 119 Luzern, Luzern, 6002 Switzerland	Report date	13.02.2023
		Temperature (°C)	22.2
		Humidity (%)	31.0
		Report by	Dieter Sütthoff
		Approved by	Robert Machulec



Fig. 1: Photo of test setup free space.

	Frequency (MHz)	EU 865.1	902.3	US 908.5	914.9	AU 922.2
Tx, CW	Polarization	Total	Total	Total	Total	Total
	Ant. Port Input Pwr. (dBm)	14.0	20.0	20.0	20.0	14.0
	Tot. Rad. Pwr. (dBm)	2.0	9.0	8.7	8.6	-3.9
	Peak EIRP (dBm)	5.7	12.0	12.6	12.1	-1.1
	Directivity (dBi)	3.8	3.0	3.9	3.5	2.9
	Efficiency (dB)	-12.0	-11.0	-11.3	-11.4	-17.9
	Efficiency (%)	6.3	7.9	7.5	7.2	1.6
Rx, SF12	Gain (dBi)	-8.3	-8.0	-7.4	-7.9	-15.1
	Frequency (MHz)	865.1	923.3	925.1	927.5	923.2
	Tot. Rad. Sens. (dBm)	-124.0	-122.0	-122.0	-122.0	-120.1
Rx, SF7	Peak EIS (dBm)	-127.7	-125.5	-125.5	-125.5	-123.0
	Tot. Rad. Sens. (dBm)	-110.4	-110.5	-109.5	-110.0	-109.1
	Peak EIS (dBm)	-114.2	-114.0	-113.0	-113.5	-112.0

Tab. 1: Summary measurement results.



Test Lab Declaration

All test results stated relate only to the device tested.

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- in the resulting document it's status (being an excerpt) is clearly stated and
- in minimum chapter 1 is completely included.

2 Signatures

Responsible for
Accreditation Scope:


Dieter Sütthoff

Responsible
for Test Report:


Robert Machulec

3 Description of the test environment and the test procedure

3.1 Equipment

The LoRa radiated RF performance is measurements in the 7 layers OTA **Antenna Fully Anechoic Room (AFAR)** which is CTIA Authorized Test Lab according to CTIA [2].

Ref.No.	Device Name	Description	Manufacturer	Serial Number	Last Calibration	Calibration Due
1.1	AFAR	Dimension: 6,7m x 3,4m x 3m	Albatross Projects		2020.11	2022.11
1.2	EMQuest	Measurement SW version 1.15	ETS	1179		
1.3	ETS3164-03	Dual polarized horn	ETS	00052619		
1.4	FSP3	spectrum analyser	R&S	838164/004	2021.02	2023.02
1.5	FSP3	spectrum analyser	R&S	836722/011	2021.04	2023.04
1.6	E5071B	Network Analyzer	Agilent	MY42200813	2021.03	2023.03
1.7	RSP3	Step Attenuator	R&S	833695/001		
1.8	RWC5020B	LoRa teste	Redwood	0x1930017		
1.9	LORA Gateway	IOT SX301 Starter Kit	Semtech			

Measurement distance: $d_0 = 2.05$ m (horn antenna edge to center of turn table)

Nominal measurement distance: $d = 2.25$ m (antenna phase center mark to turn table)

Measurement Antenna: ETS 3164-03

Horn taper length: $a = 0.50$ m

Horn antenna aperture: $d_1 = 0.33$ m

3.2 Test procedure

The method of measurement for radiated RF power and receiver performance are according “LoRa Alliance End-Device Certification Radiated RF Performance for EU 868 MHz ISM Band Devices” [1].

End-device transmitter performance set up:

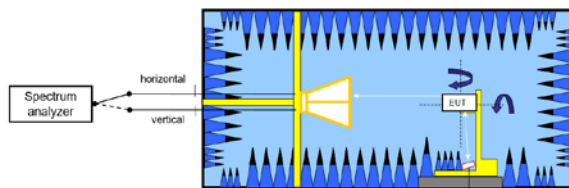


Fig. 1: Block diagram for TRP measurement

Measurement settings:

- Step width: 15°
- 3D radiation power pattern (both φ and θ directions)
- Antenna polarization: vertical and horizontal
- Receiver Detector: RMS
- Trace: Maxhold
- Resolution Bandwidth (RBW): 300 kHz
- Video Bandwidth (VBW): 300 kHz
- Sweep Time: 100 ms
- Span: Zero
- Selected Data Rate: CW mode

The EUT was placed at the turning device inside a fully anechoic chamber. The EUT was set in a Test mode and set to a CW transmission mode to the specified frequency and power. It was set to the. The transmitter pattern was measured on the frequencies of interest.

The EIRP values are reported and the total radiated power (TRP) value was calculated.

The $EIRP(\phi, \theta)$ was measured on different frequencies. This is done at one point, test setup position and measurement antenna polarization. The measurement point was chosen based on the transmitter pattern measurement, where the maximum power was found (boresight position)

End-device receiver performance set up

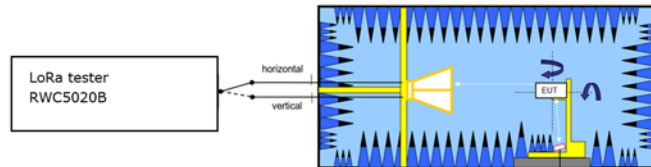


Fig. 2: Block diagram for TRS measurement

Receiver performance set up system parameters:

Path loss at 868.5 MHz for theta polarization: 34.1 dB

Path loss at 868.5 MHz for phi polarization: 34.4 dB

The Effective Isotropic Sensitivity $EIS(\phi, \theta)$ was measured. This is done at one point, test setup position and measurement antenna polarization. The measurement point was chosen based on the transmitter pattern measurement, where the maximum power was found (boresight position). At this point the down link power from the LoRa tester was decreased up to the point where a PER of 10 % was measured. At least 60 downlink frames were measured.

The $EIS(\phi, \theta)$ (at boresight position ϕ, θ and polarization) value was calculated using following Equal:

$$EIS(\phi, \theta) = P_{\text{down link}} - \text{Path loss} + 10 \text{ dB} \quad (1)$$

The Path loss values are determined during OTA Range Calibration according to CTIA [2] described in document "7layers OTA Germany Range Calibration" [4]. The path loss is the sum of NSA, cable attentions and Reference antenna gain between AP X22 and EUT

$$\text{Path loss} = (\text{NSA} + L_{\text{cable}} - G_{\text{ref}}) \quad (2)$$

L_{cable} : Cables from AP X22 to OTA Measurement Antenna ETS3164-03

G_{ref} : Gain of the measurement- and reference antenna

The final EIS value was calculated using relative antenna directivity (ϕ, θ) measured at boresight position and polarization during $EIRP(\phi, \theta)$ pattern measured in transmitter performance test ant using the Total EIRP value:

$$EIS = EIS(\phi_0, \theta_0) + EIRP(\phi, \theta) - EIRP(\phi_0, \theta_0) \quad (3)$$

The total isotropic sensitivity (TIS) was calculated by using following equals:

$$EIS(\phi, \theta) = EIS(\phi_0, \theta_0) - (EIRP(\phi, \theta) - EIRP(\phi_0, \theta_0))$$

$$TIS = \frac{4\pi}{\oint \left(\frac{1}{EIS_{\phi}(\Omega, f)} + \frac{1}{EIS_{\theta}(\Omega, f)} \right)} \quad (4)$$

Definitions:

CTIA	Cellular Telecommunications & Internet Association
PER	Packet error rate
BS	Base station
EUT	Equipment under test
FS	Free space
CW	Continuous Wave
NSA	Normalized Site Attenuation
TP	Talk position (phone is situated at SAM = human head phantom)
TRP	Total Radiated Power
TIS	Total Isotropic Sensitivity
TRS	Total Radiated Sensitivity (same as TIS in CTIA)
EIRP	Equivalent Isotropic Radiated Power
ERP	Effective radiated power
EIS	Effective Isotropic Sensitivity
SPO	Single Point Offset

3.3 References and Standards Used

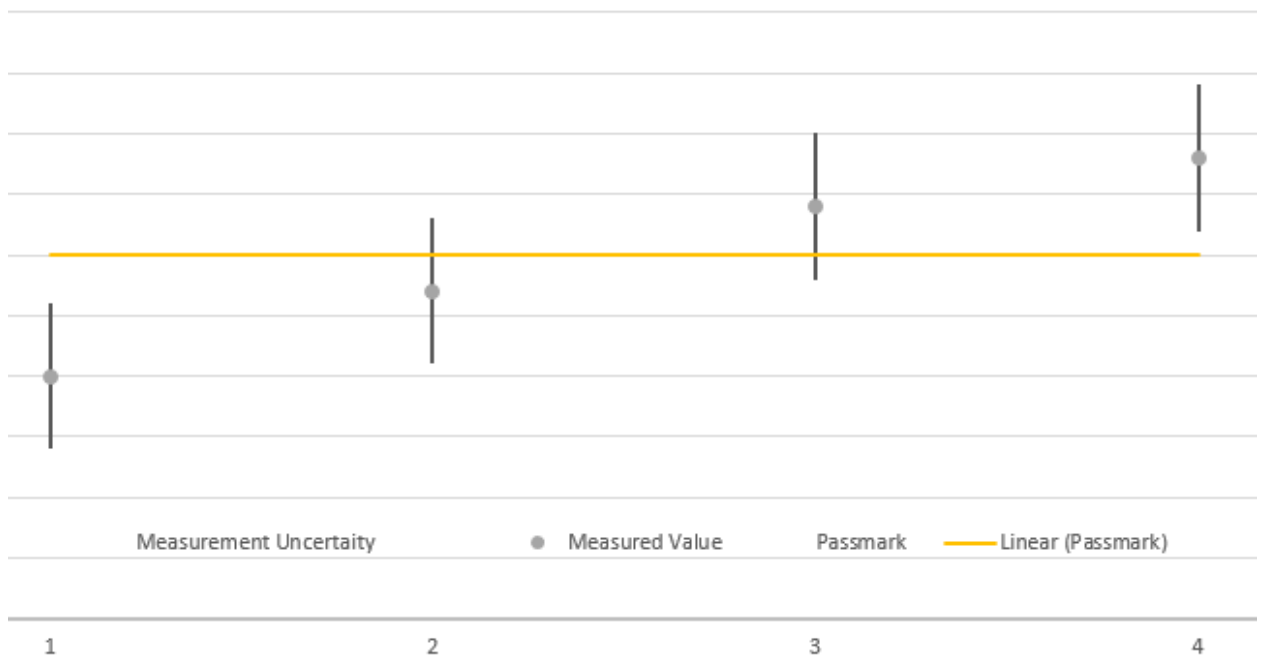
- [1] LoRa Alliance End-Device Certification Radiated RF Performance for EU 868 MHz ISM Band Devices V1.2 (2019).
- [2] CTIA: "Test Plan for Wireless Device Over the Air Performance", Revision 3.9.4, 02/2022
- [3] 7 layers document: "7 layers Germany OTA Measurement Uncertainties", Version January 2021.
- [4] 7 layers document: "7 layers OTA Germany Range Calibration", Version November 2020.

3.4 Measurement uncertainties

Maxim Values	OTA lab at 7layers Germany [3]
TRP Free space	±1.7 dB
TRS (EIS) Free space	±1.9 dB

Standard specific table with the measurement uncertainties of the used parameters

The measurement uncertainties for all parameters are calculated with an expansion factor (coverage factor) $k = 1.96$. This means, that the true value is in the corresponding interval with a probability of 95 %.



The verdicts in this test report are given according the above diagram:

Case	Measured Value	Uncertainty Range	Verdict
1	below pass mark	below pass mark	Passed
2	below pass mark	within pass mark	Passed
3	above pass mark	within pass mark	Failed
4	above pass mark	above pass mark	Failed

That means, the laboratory applies, as decision rule (see ISO/IEC 17025:2017), the so called shared risk principle.

3.5 Orientation of EUT compared to a standard device

For orientation of the EUT in the result pictures below the following photos illustrate the used orientation compared to a standard device:

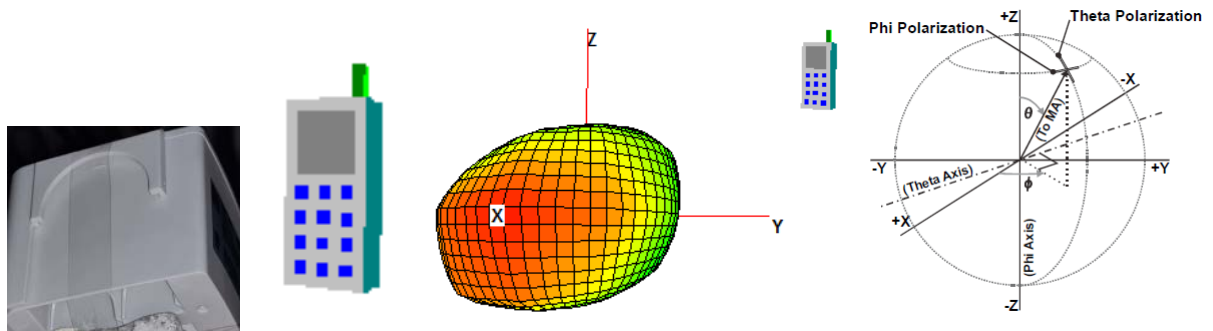


Fig. 2: Photo orientation of EUT compared to a phone.

4 Results and antenna pattern

4.1 End-device transmitter performance at (EU) 865.1 MHz, EUT1

LoRa CW mode, 14 dBm power:

Polarization	Theta	Phi	Total
Nominal Ant. Port Input Pwr. (dBm)	14.0	14.0	14.0
Tot. Rad. Pwr. (dBm)	0.7	-3.9	2.0
Peak EIRP (dBm)	5.5	2.5	5.7
Peak ERP (dBm)	3.4	0.4	3.6
Directivity (dBi)	4.8	6.4	3.8
Efficiency 14dBm (dB)	-13.3	-17.9	-12.0
Efficiency 14dBm (%)	4.7	1.6	6.3
Gain 14dBm (dBi)	-8.5	-11.5	-8.3
NHPRP $\pm\pi/4$ (dBm)	-0.2	-5.9	0.9
NHPRP $\pm\pi/6$ (dBm)	-1.3	-7.7	-0.4
Boresight Phi ($^{\circ}$)	120.0	60.0	120.0
Boresight Th. ($^{\circ}$)	105.0	15.0	105.0

Tab. 2: Summary Tx measurement results at 865.1 MHz.

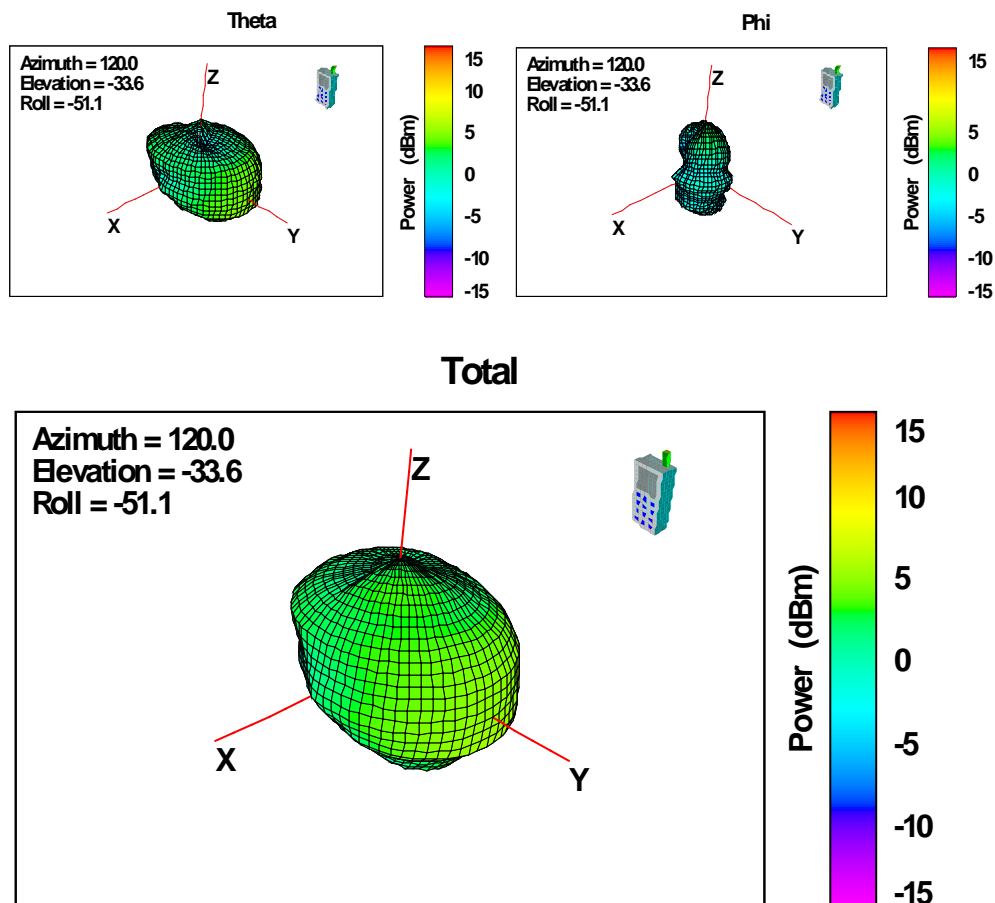


Fig. 3: 3D Pattern at 865.1 MHz.

Th 90° Phi (°)	FSP reading (dBm)	path loss (dB)	EIRP (dBm)	FSP reading (dBm)	path loss (dB)	EIRP (dBm)	EIRP (dBm)
	Polarisation Theta			Polarisation Phi			Total
360	-35.3	35.5	0.2	-40.8	35.7	-5.1	1.3
345	-38.3	35.5	-2.8	-42.2	35.7	-6.5	-1.2
330	-37.9	35.5	-2.4	-43.8	35.7	-8.1	-1.4
315	-37.2	35.5	-1.7	-47.0	35.7	-11.3	-1.3
300	-36.6	35.5	-1.1	-50.7	35.7	-15.0	-0.9
285	-36.2	35.5	-0.7	-49.8	35.7	-14.1	-0.5
270	-36.0	35.5	-0.6	-45.7	35.7	-9.9	-0.1
255	-36.0	35.5	-0.5	-42.5	35.7	-6.8	0.4
240	-35.8	35.5	-0.3	-40.5	35.7	-4.7	1.0
225	-35.3	35.5	0.2	-39.3	35.7	-3.6	1.7
210	-34.7	35.5	0.8	-38.7	35.7	-3.0	2.3
195	-33.9	35.5	1.6	-38.8	35.7	-3.1	2.9
180	-33.1	35.5	2.4	-39.5	35.7	-3.8	3.3
165	-32.5	35.5	3.0	-40.9	35.7	-5.2	3.6
150	-31.9	35.5	3.5	-42.3	35.7	-6.6	3.9
135	-31.6	35.5	3.9	-43.1	35.7	-7.4	4.2
120	-31.3	35.5	4.2	-42.4	35.7	-6.7	4.5
105	-31.2	35.5	4.3	-41.0	35.7	-5.3	4.8
90	-31.2	35.5	4.3	-39.5	35.7	-3.8	4.9
75	-31.4	35.5	4.0	-38.6	35.7	-2.9	4.8
60	-31.8	35.5	3.6	-38.2	35.7	-2.4	4.6
45	-32.6	35.5	2.9	-38.0	35.7	-2.2	4.1
30	-33.5	35.5	2.0	-38.4	35.7	-2.7	3.3
15	-34.4	35.5	1.1	-39.3	35.7	-3.6	2.3
0	-35.3	35.5	0.2	-40.8	35.7	-5.1	1.3

Tab. 3: Summary measurement results EIRP at 865.1 MHz X-Y plane.

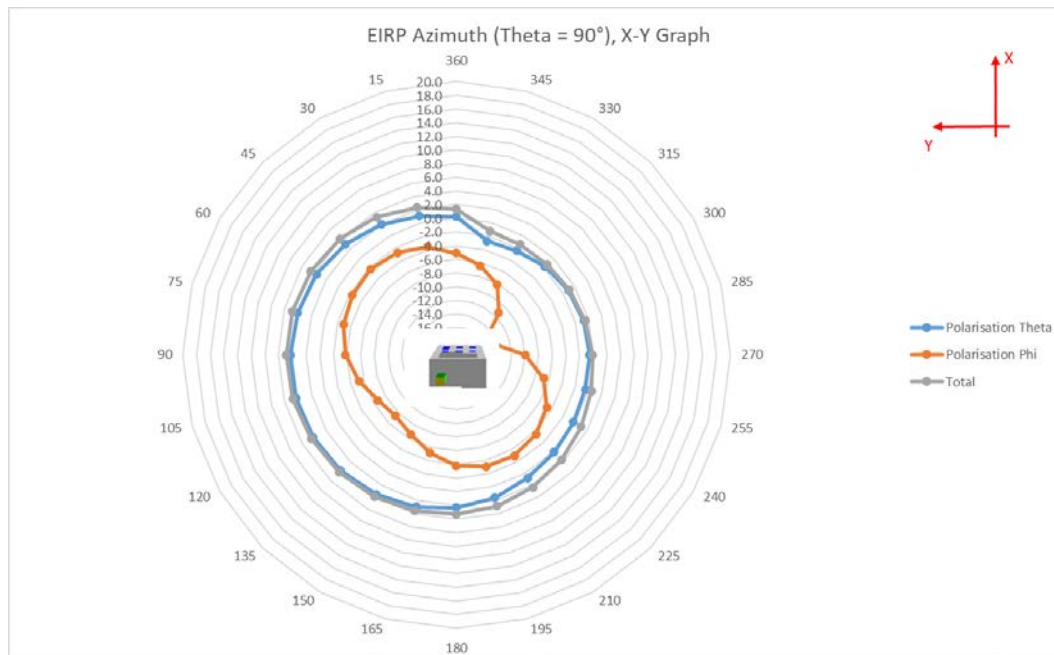


Fig. 4: 2D Pattern, X-Y plant at 865.1 MHz.

Phi = 0°	FSP reading (dBm NSA + Cable (dB)	EIRP (dBm)	FSP reading (dBm)	path loss (dB)	EIRP (dBm)	EIRP (dBm)	
Theta	Pol Theta		Polarisation Phi		Total		
0	-36.6	35.5	-1.1	-37.2	35.7	-1.5	1.7
15	-36.1	35.5	-0.6	-36.8	35.7	-1.1	2.2
30	-35.0	35.5	0.5	-37.1	35.7	-1.4	2.7
45	-34.2	35.5	1.3	-39.9	35.7	-4.2	2.4
60	-34.2	35.5	1.3	-41.8	35.7	-6.1	2.1
75	-36.7	35.5	-1.3	-38.2	35.7	-2.5	1.2
90	-35.3	35.5	0.2	-40.8	35.7	-5.1	1.3
105	-39.0	35.5	-3.6	-40.7	35.7	-4.9	-1.2
120	-45.4	35.5	-9.9	-39.4	35.7	-3.7	-2.8
135	-47.9	35.5	-12.4	-41.6	35.7	-5.9	-5.0
150	-42.9	35.5	-7.5	-44.5	35.7	-8.8	-5.1
165	-37.3	35.5	-1.8	-39.8	35.7	-4.0	0.2
180	-38.2	35.5	-2.8	-39.3	35.7	-3.6	-0.1
195	-40.9	35.5	-5.4	-40.6	35.7	-4.9	-2.1
210	-37.4	35.5	-1.9	-38.4	35.7	-2.7	0.7
225	-34.0	35.5	1.5	-40.1	35.7	-4.4	2.5
240	-34.8	35.5	0.7	-40.1	35.7	-4.3	1.9
255	-32.0	35.5	3.5	-39.2	35.7	-3.5	4.3
270	-33.1	35.5	2.4	-39.5	35.7	-3.8	3.3
285	-32.9	35.5	2.6	-39.6	35.7	-3.9	3.4
300	-33.9	35.5	1.6	-37.8	35.7	-2.1	3.2
315	-35.3	35.5	0.2	-38.1	35.7	-2.3	2.1
330	-35.6	35.5	-0.2	-39.4	35.7	-3.7	1.4
345	-36.1	35.5	-0.6	-41.3	35.7	-5.6	0.6
360	-36.6	35.5	-1.1	-37.2	35.7	-1.5	1.7

Tab. 4: Summary measurement results EIRP at 865.1 MHz Z-X plane.

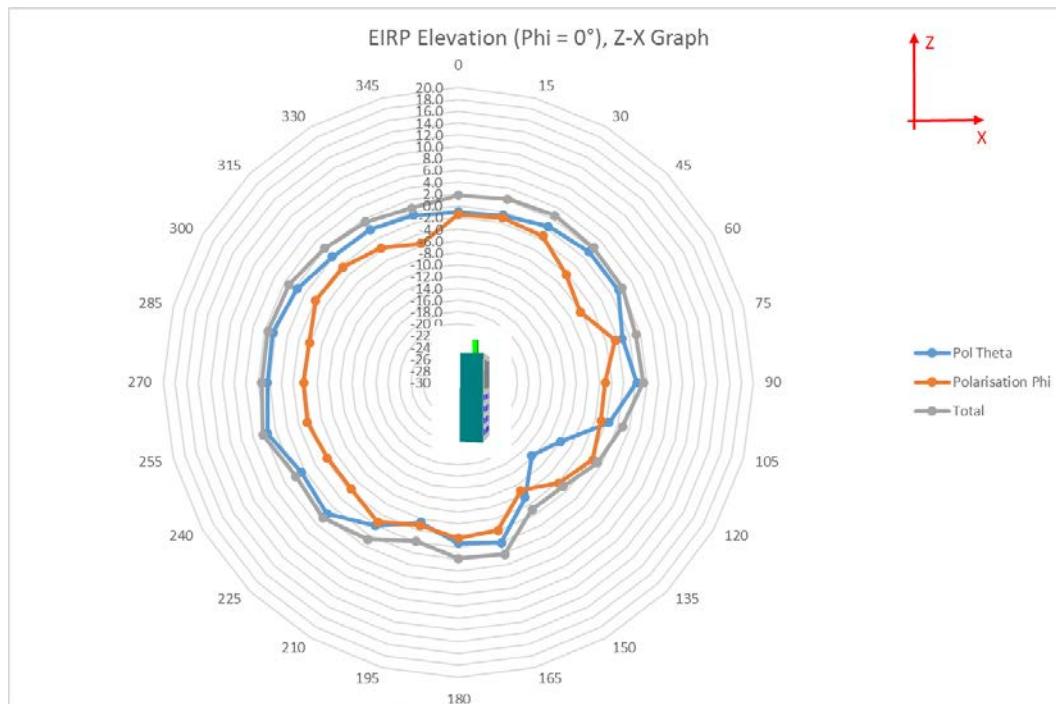


Fig. 5: 2D Pattern, Z-X plant at 865.1 MHz.

Phi 90° Theta	FSP reading (dBm)	path loss (dB)	EIRP (dBm)	FSP reading (dBm)	path loss (dB)	EIRP (dBm)	EIRP (dBm)
	Pollaridation Theta			Polarisation Phi			Total
0	-37.0	35.5	-1.5	-36.8	35.7	-1.1	1.7
15	-39.8	35.5	-4.3	-34.6	35.7	1.1	2.2
30	-37.4	35.5	-1.9	-35.0	35.7	0.8	2.6
45	-35.3	35.5	0.2	-36.8	35.7	-1.1	2.6
60	-32.0	35.5	3.5	-40.7	35.7	-5.0	4.0
75	-31.5	35.5	4.0	-38.7	35.7	-3.0	4.8
90	-31.2	35.5	4.3	-39.5	35.7	-3.8	4.9
105	-30.4	35.5	5.1	-41.0	35.7	-5.3	5.5
120	-33.4	35.5	2.1	-40.7	35.7	-5.0	2.9
135	-33.4	35.5	2.0	-38.0	35.7	-2.2	3.4
150	-38.1	35.5	-2.7	-40.1	35.7	-4.4	-0.4
165	-42.8	35.5	-7.3	-41.9	35.7	-6.2	-3.7
180	-39.1	35.5	-3.6	-38.5	35.7	-2.8	-0.1
195	-39.2	35.5	-3.7	-39.0	35.7	-3.3	-0.5
210	-41.9	35.5	-6.4	-40.6	35.7	-4.8	-2.5
225	-59.3	35.5	-23.8	-42.5	35.7	-6.8	-6.7
240	-45.9	35.5	-10.4	-41.7	35.7	-5.9	-4.6
255	-38.1	35.5	-2.6	-42.7	35.7	-6.9	-1.2
270	-36.0	35.5	-0.6	-45.7	35.7	-9.9	-0.1
285	-35.8	35.5	-0.4	-43.3	35.7	-7.6	0.4
300	-33.4	35.5	2.1	-40.2	35.7	-4.4	3.0
315	-35.2	35.5	0.3	-37.6	35.7	-1.9	2.3
330	-36.3	35.5	-0.8	-38.3	35.7	-2.6	1.4
345	-37.4	35.5	-1.9	-38.3	35.7	-2.6	0.8
360	-37.0	35.5	-1.5	-36.8	35.7	-1.1	1.7

Tab. 5: Summary measurement results EIRP at 865.1 MHz Z-Y plane.

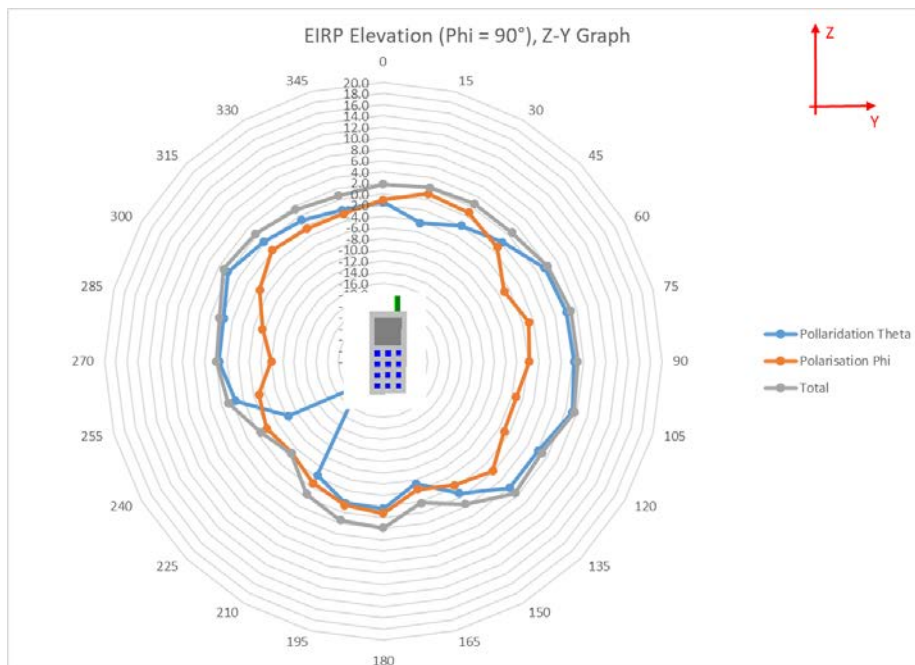


Fig. 6: 2D Pattern, Z-Y plant at 865.1 MHz.

4.2 End-device transmitter performance at (US) 902.3 MHz, EUT2

LoRa CW mode, 20 dBm power:

Polarization	Theta	Phi	Total
Ant. Port Input Pwr. (dBm)	20.0	20.0	20.0
Tot. Rad. Pwr. (dBm)	7.4	3.8	9.0
Peak EIRP (dBm)	11.3	10.3	12.0
Peak ERP (dBm)	9.1	8.2	9.8
Directivity (dBi)	3.9	6.5	3.0
Efficiency (dB)	-12.6	-16.2	-11.0
Efficiency (%)	5.5	2.4	7.9
Gain (dBi)	-8.7	-9.7	-8.0
Boresight Phi (°)	90.0	60.0	60.0
Boresight Th. (°)	105.0	15.0	75.0
Maximum Power (dBm)	11.3	10.3	12.0

Tab. 6: Summary Tx measurement results at 902.3 MHz.

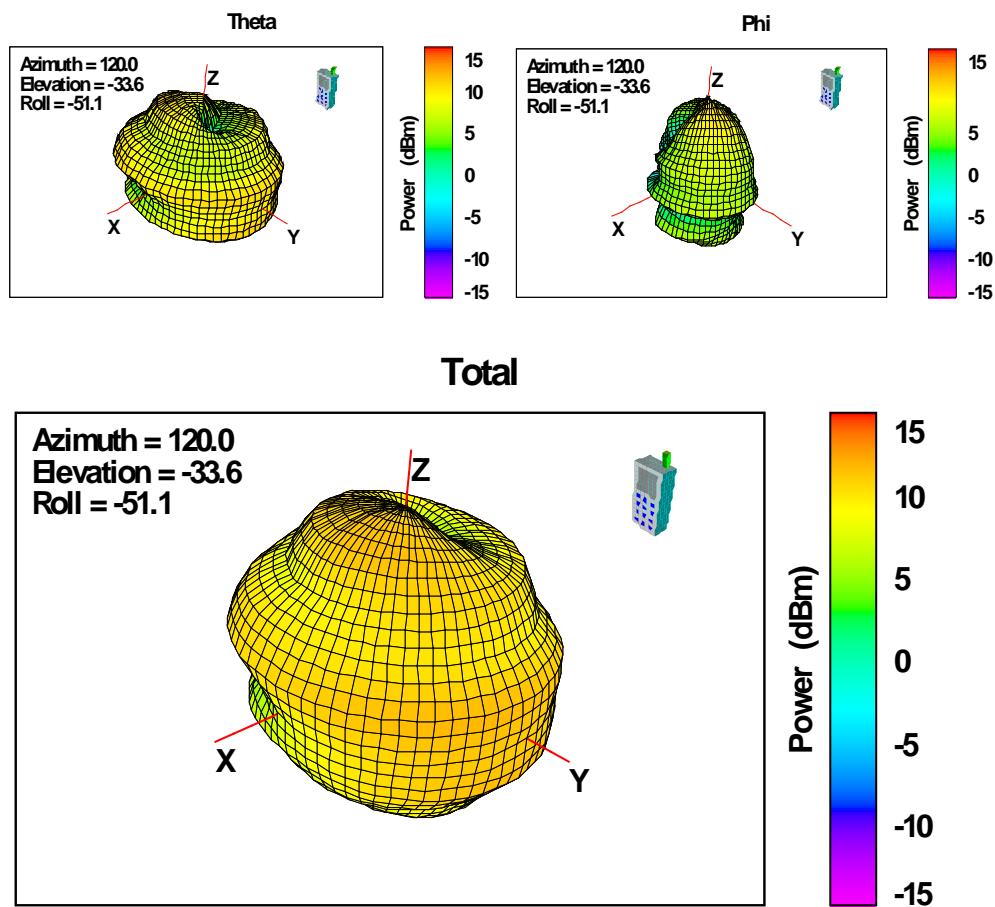


Fig. 7: 3D Pattern at 902.3 MHz.

Th 90° Phi (°)	FSP reading (dBm)	path loss (dB)	EIRP (dBm)	FSP reading (dBm)	path loss (dB)	EIRP (dBm)	EIRP (dBm)
	Polarisation Theta			Polarisation Phi			Total
360	-30.9	35.1	4.3	-31.4	35.8	4.3	7.3
345	-35.4	35.1	-0.2	-32.9	35.8	2.8	4.6
330	-35.5	35.1	-0.4	-34.6	35.8	1.1	3.5
315	-34.7	35.1	0.4	-37.9	35.8	-2.2	2.3
300	-33.8	35.1	1.4	-43.5	35.8	-7.8	1.9
285	-33.1	35.1	2.0	-50.3	35.8	-14.5	2.1
270	-32.8	35.1	2.4	-42.1	35.8	-6.3	2.9
255	-32.7	35.1	2.5	-37.6	35.8	-1.8	3.9
240	-32.4	35.1	2.8	-35.0	35.8	0.8	4.9
225	-31.9	35.1	3.2	-33.7	35.8	2.1	5.7
210	-31.0	35.1	4.1	-33.4	35.8	2.4	6.4
195	-29.8	35.1	5.3	-34.1	35.8	1.7	6.9
180	-28.6	35.1	6.5	-36.0	35.8	-0.2	7.4
165	-27.6	35.1	7.6	-39.5	35.8	-3.7	7.9
150	-26.7	35.1	8.5	-42.5	35.8	-6.7	8.6
135	-26.1	35.1	9.1	-39.1	35.8	-3.4	9.3
120	-25.7	35.1	9.5	-35.0	35.8	0.8	10.0
105	-25.5	35.1	9.7	-32.3	35.8	3.5	10.6
90	-25.5	35.1	9.7	-30.4	35.8	5.4	11.1
75	-25.7	35.1	9.5	-29.3	35.8	6.5	11.2
60	-26.1	35.1	9.1	-28.9	35.8	6.9	11.1
45	-26.8	35.1	8.3	-28.8	35.8	7.0	10.7
30	-27.9	35.1	7.2	-29.2	35.8	6.6	9.9
15	-29.3	35.1	5.9	-30.1	35.8	5.7	8.8
0	-30.9	35.1	4.3	-31.4	35.8	4.3	7.3

Tab. 7: Summary measurement results EIRP at 902.3 MHz X-Y plane.

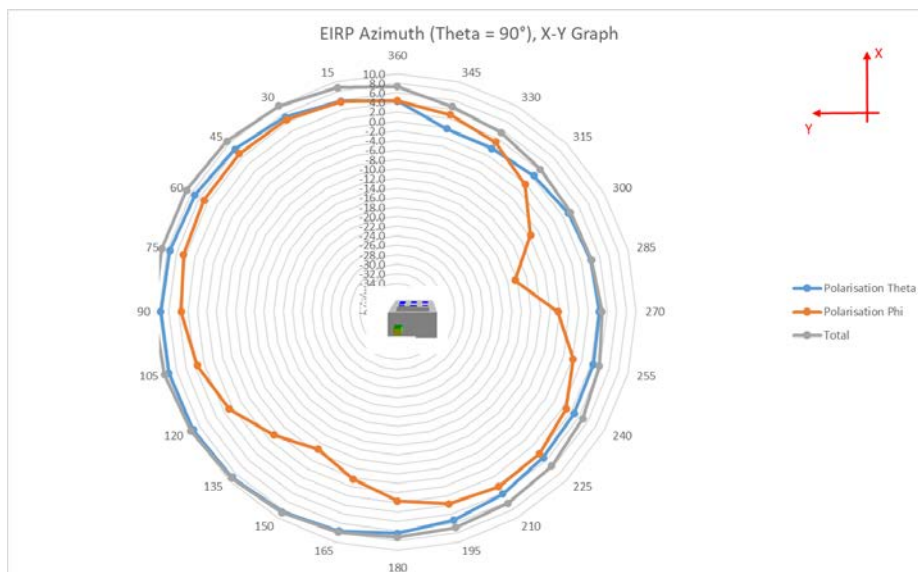


Fig. 8: 2D Pattern, X-Y plant at 902.3 MHz.

Phi = 0°	FSP reading (dBm)	path loss (dB)	EIRP (dBm)	FSP reading (dBm)	path loss (dB)	EIRP (dBm)	EIRP (dBm)
Theta	Pol Theta			Polarisation Phi			Total
0	-28.3	35.1	6.8	-29.0	35.8	6.7	9.8
15	-25.7	35.1	9.4	-28.9	35.8	6.9	11.4
30	-25.2	35.1	9.9	-29.8	35.8	6.0	11.4
45	-28.0	35.1	7.2	-31.8	35.8	4.0	8.9
60	-27.2	35.1	8.0	-31.0	35.8	4.8	9.7
75	-25.0	35.1	10.2	-33.3	35.8	2.4	10.9
90	-30.9	35.1	4.3	-31.4	35.8	4.3	7.3
105	-27.9	35.1	7.3	-38.1	35.8	-2.3	7.7
120	-38.4	35.1	-3.3	-30.2	35.8	5.6	6.1
135	-47.9	35.1	-12.7	-33.3	35.8	2.4	2.6
150	-34.9	35.1	0.2	-36.4	35.8	-0.6	2.8
165	-30.9	35.1	4.3	-31.4	35.8	4.4	7.4
180	-34.4	35.1	0.8	-32.2	35.8	3.6	5.4
195	-34.9	35.1	0.3	-35.8	35.8	-0.1	3.1
210	-30.2	35.1	5.0	-31.1	35.8	4.7	7.8
225	-29.9	35.1	5.3	-31.8	35.8	4.0	7.7
240	-28.8	35.1	6.3	-35.4	35.8	0.4	7.3
255	-26.6	35.1	8.5	-29.9	35.8	5.9	10.4
270	-28.6	35.1	6.5	-36.0	35.8	-0.2	7.4
285	-26.2	35.1	8.9	-31.6	35.8	4.2	10.2
300	-29.4	35.1	5.8	-31.0	35.8	4.8	8.3
315	-25.9	35.1	9.3	-30.5	35.8	5.3	10.7
330	-28.7	35.1	6.4	-32.1	35.8	3.6	8.2
345	-32.0	35.1	3.1	-35.0	35.8	0.8	5.1
360	-28.3	35.1	6.8	-29.0	35.8	6.7	9.8

Tab. 8: Summary measurement results EIRP at 902.3 MHz Z-X plane.

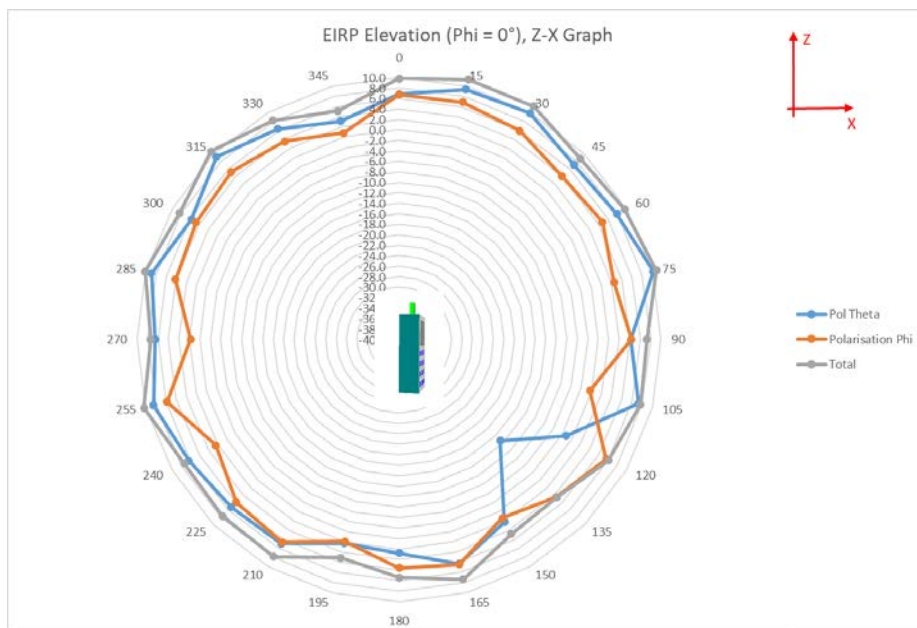


Fig. 9: 2D Pattern, Z-X plant at 902.3 MHz.

Phi 90° Theta	FSP reading (dBm)	path loss (dB)	EIRP (dBm)	FSP reading (dBm)	path loss (dB)	EIRP (dBm)	EIRP (dBm)
	Pollaridation Theta			Polarisation Phi			Total
0	-28.4	35.1	6.7	-28.9	35.8	6.8	9.8
15	-37.6	35.1	-2.5	-26.7	35.8	9.1	9.4
30	-30.0	35.1	5.1	-27.4	35.8	8.4	10.1
45	-26.7	35.1	8.5	-29.3	35.8	6.5	10.6
60	-27.6	35.1	7.5	-30.4	35.8	5.4	9.6
75	-24.3	35.1	10.9	-31.6	35.8	4.2	11.7
90	-25.5	35.1	9.7	-30.4	35.8	5.4	11.1
105	-23.9	35.1	11.3	-33.7	35.8	2.0	11.8
120	-26.8	35.1	8.4	-34.0	35.8	1.8	9.2
135	-28.0	35.1	7.2	-28.8	35.8	6.9	10.1
150	-31.3	35.1	3.8	-36.7	35.8	-1.0	5.1
165	-36.1	35.1	-1.0	-34.4	35.8	1.3	3.3
180	-31.5	35.1	3.6	-35.0	35.8	0.8	5.4
195	-32.0	35.1	3.1	-32.9	35.8	2.9	6.0
210	-33.6	35.1	1.5	-31.3	35.8	4.4	6.2
225	-54.6	35.1	-19.4	-35.4	35.8	0.3	0.4
240	-43.7	35.1	-8.5	-37.0	35.8	-1.3	-0.5
255	-27.6	35.1	7.5	-32.8	35.8	3.0	8.8
270	-32.8	35.1	2.4	-42.1	35.8	-6.3	2.9
285	-24.7	35.1	10.4	-33.0	35.8	2.8	11.1
300	-26.5	35.1	8.7	-33.5	35.8	2.3	9.6
315	-27.9	35.1	7.3	-30.7	35.8	5.0	9.3
330	-25.5	35.1	9.7	-31.3	35.8	4.4	10.8
345	-26.9	35.1	8.3	-31.7	35.8	4.1	9.7
360	-28.4	35.1	6.7	-28.9	35.8	6.8	9.8

Tab. 9: Summary measurement results EIRP at 902.3 MHz Z-Y plane.

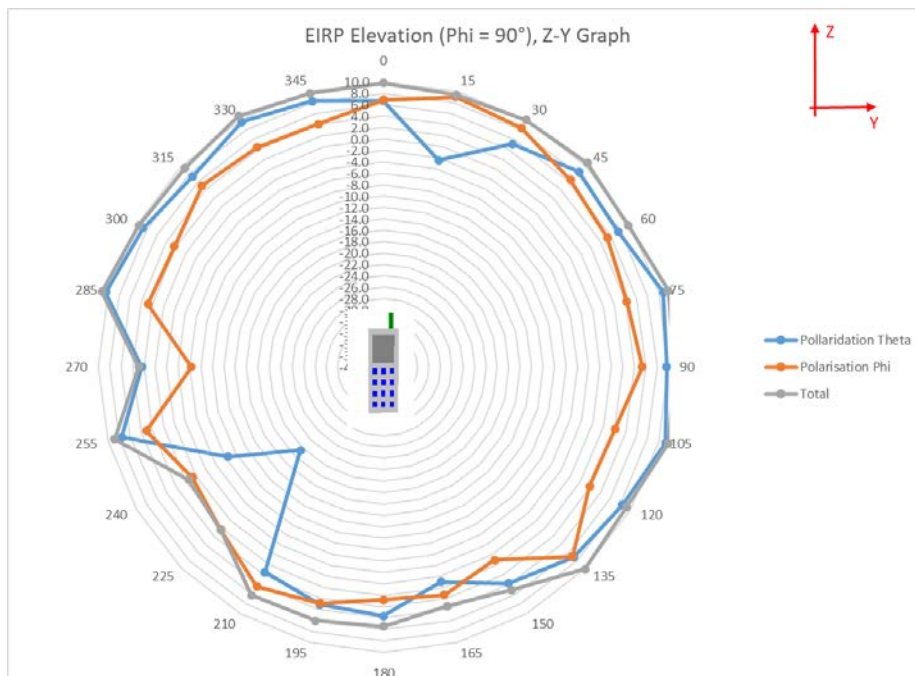


Fig. 10: 2D Pattern, Z-Y plant at 902.3 MHz.

4.3 End-device transmitter performance at (US) 908.5 MHz, EUT2

LoRa CW mode, 20 dBm power:

Polarization	Theta	Phi	Total
Ant. Port Input Pwr. (dBm)	20.0	20.0	20.0
Tot. Rad. Pwr. (dBm)	7.0	3.9	8.7
Peak EIRP (dBm)	11.1	11.2	12.6
Peak ERP (dBm)	8.9	9.0	10.5
Directivity (dBi)	4.0	7.3	3.9
Efficiency (dB)	-13.0	-16.1	-11.3
Efficiency (%)	5.0	2.4	7.5
Gain (dBi)	-8.9	-8.8	-7.4
NHPRP $\pm\pi/4$ (dBm)	6.0	1.8	7.4
NHPRP $\pm\pi/6$ (dBm)	4.9	-0.1	6.1
Boresight Phi (°)	90.0	60.0	30.0
Boresight Th. (°)	105.0	30.0	30.0

Tab. 10: Summary Tx measurement results at 908.5 MHz.

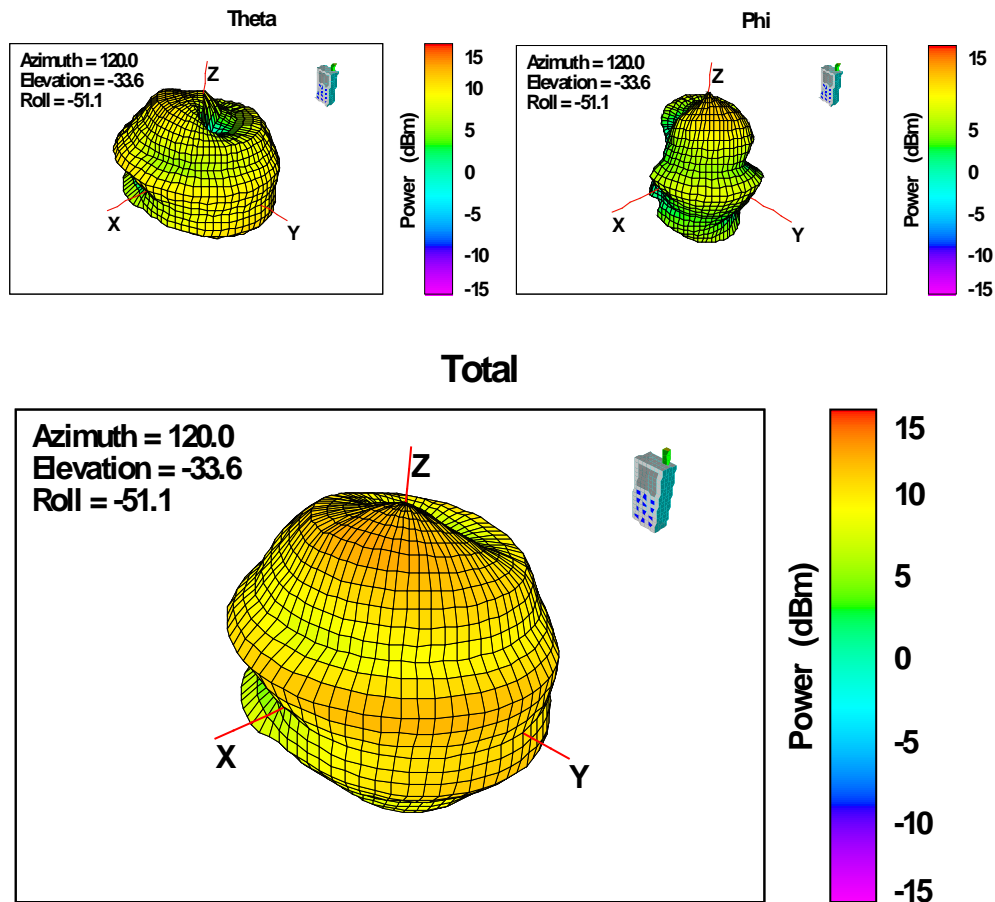


Fig. 11: 3D Pattern at 908.5 MHz.

Th 90° Phi (°)	FSP reading (dBm)	path loss (dB)	EIRP (dBm)	FSP reading (dBm)	path loss (dB)	EIRP (dBm)	EIRP (dBm)
	Polarisation Theta			Polarisation Phi			Total
360	-31.2	35.5	4.3	-35.0	35.7	0.7	5.9
345	-38.7	35.5	-3.3	-36.2	35.7	-0.6	1.3
330	-39.3	35.5	-3.8	-38.6	35.7	-2.9	-0.3
315	-37.6	35.5	-2.1	-43.9	35.7	-8.3	-1.2
300	-35.7	35.5	-0.3	-64.8	35.7	-29.2	-0.3
285	-34.6	35.5	0.9	-43.9	35.7	-8.2	1.4
270	-34.0	35.5	1.5	-37.8	35.7	-2.2	3.1
255	-33.6	35.5	1.9	-34.8	35.7	0.9	4.5
240	-33.3	35.5	2.1	-32.7	35.7	3.0	5.6
225	-33.0	35.5	2.5	-31.6	35.7	4.0	6.4
210	-32.1	35.5	3.3	-31.3	35.7	4.4	6.9
195	-31.2	35.5	4.3	-31.6	35.7	4.0	7.2
180	-30.0	35.5	5.5	-32.9	35.7	2.7	7.4
165	-28.8	35.5	6.6	-35.3	35.7	0.4	7.6
150	-28.0	35.5	7.5	-38.7	35.7	-3.0	7.9
135	-27.3	35.5	8.2	-39.8	35.7	-4.1	8.5
120	-26.7	35.5	8.7	-36.5	35.7	-0.9	9.2
105	-26.5	35.5	9.0	-33.7	35.7	1.9	9.8
90	-26.4	35.5	9.1	-31.8	35.7	3.9	10.2
75	-26.5	35.5	9.0	-30.7	35.7	5.0	10.4
60	-26.8	35.5	8.7	-30.3	35.7	5.4	10.4
45	-27.3	35.5	8.2	-30.4	35.7	5.3	10.0
30	-28.1	35.5	7.3	-31.1	35.7	4.6	9.2
15	-29.4	35.5	6.1	-32.7	35.7	3.0	7.8
0	-31.2	35.5	4.3	-35.0	35.7	0.7	5.9

Tab. 11: Summary measurement results EIRP at 908.5 MHz X-Y plane.

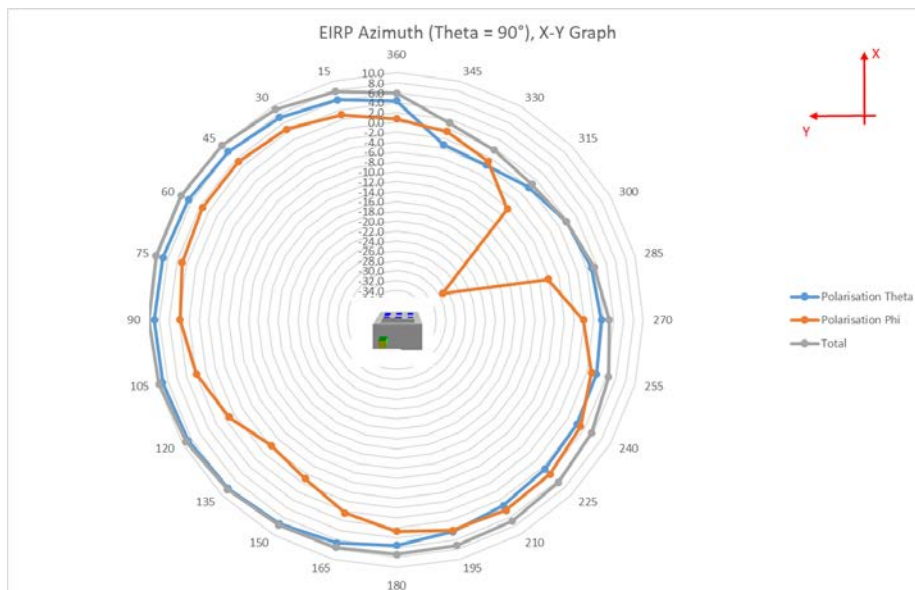


Fig. 12: 2D Pattern, X-Y plant at 908.5 MHz.

Phi = 0°	FSP reading (dBm NSA + Cable (dB)	EIRP (dBm)	FSP reading (dBm)	path loss (dB)	EIRP (dBm)	EIRP (dBm)	
Theta	Pol Theta		Polarisation Phi		Total		
0	-29.1	35.5	6.4	-28.1	35.7	7.6	10.0
15	-26.4	35.5	9.0	-27.5	35.7	8.1	11.6
30	-25.1	35.5	10.4	-27.5	35.7	8.1	12.4
45	-27.1	35.5	8.4	-31.9	35.7	3.8	9.7
60	-30.1	35.5	5.4	-32.9	35.7	2.8	7.3
75	-25.2	35.5	10.3	-29.2	35.7	6.4	11.8
90	-31.2	35.5	4.3	-35.0	35.7	0.7	5.9
105	-28.8	35.5	6.7	-34.5	35.7	1.1	7.7
120	-37.2	35.5	-1.7	-31.5	35.7	4.2	5.2
135	-46.8	35.5	-11.3	-32.5	35.7	3.2	3.3
150	-35.4	35.5	0.1	-39.8	35.7	-4.1	1.5
165	-31.4	35.5	4.1	-32.8	35.7	2.9	6.5
180	-34.4	35.5	1.1	-31.8	35.7	3.9	5.7
195	-35.1	35.5	0.4	-33.7	35.7	2.0	4.3
210	-30.2	35.5	5.3	-31.1	35.7	4.5	8.0
225	-31.9	35.5	3.6	-35.5	35.7	0.2	5.2
240	-29.1	35.5	6.4	-32.2	35.7	3.5	8.2
255	-27.1	35.5	8.4	-31.9	35.7	3.8	9.7
270	-30.0	35.5	5.5	-32.9	35.7	2.7	7.4
285	-28.0	35.5	7.5	-35.2	35.7	0.5	8.2
300	-29.2	35.5	6.3	-29.5	35.7	6.1	9.2
315	-27.0	35.5	8.5	-29.3	35.7	6.4	10.6
330	-31.4	35.5	4.1	-34.4	35.7	1.3	5.9
345	-31.8	35.5	3.7	-38.1	35.7	-2.4	4.6
360	-29.1	35.5	6.4	-28.1	35.7	7.6	10.0

Tab. 12: Summary measurement results EIRP at 908.5 MHz Z-X plane.

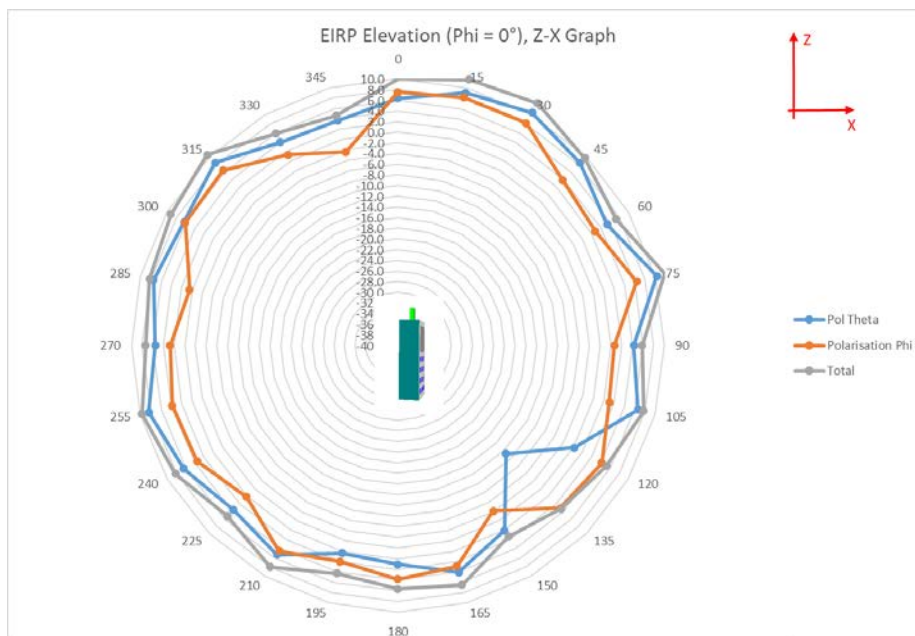


Fig. 13: 2D Pattern, Z-X plant at 908.5 MHz.

Phi 90°	FSP reading (dBm)	path loss (dB)	EIRP (dBm)	FSP reading (dBm)	path loss (dB)	EIRP (dBm)	EIRP (dBm)
Theta	Pollaridation Theta			Polarisation Phi			Total
0	-27.9	35.5	7.6	-29.3	35.7	6.4	10.0
15	-41.7	35.5	-6.2	-25.7	35.7	9.9	10.0
30	-33.4	35.5	2.1	-25.5	35.7	10.1	10.8
45	-27.0	35.5	8.5	-28.5	35.7	7.2	10.9
60	-27.4	35.5	8.1	-33.6	35.7	2.1	9.1
75	-25.7	35.5	9.8	-28.8	35.7	6.9	11.6
90	-26.4	35.5	9.1	-31.8	35.7	3.9	10.2
105	-24.4	35.5	11.1	-33.2	35.7	2.5	11.6
120	-26.9	35.5	8.5	-36.8	35.7	-1.2	9.0
135	-29.6	35.5	5.9	-29.2	35.7	6.4	9.2
150	-31.3	35.5	4.2	-33.6	35.7	2.1	6.3
165	-41.1	35.5	-5.7	-37.1	35.7	-1.5	-0.1
180	-31.6	35.5	3.9	-34.6	35.7	1.1	5.7
195	-31.1	35.5	4.4	-32.0	35.7	3.7	7.1
210	-34.8	35.5	0.7	-32.6	35.7	3.0	5.0
225	-42.4	35.5	-7.0	-38.7	35.7	-3.0	-1.5
240	-42.0	35.5	-6.5	-33.7	35.7	2.0	2.6
255	-27.6	35.5	7.8	-35.3	35.7	0.4	8.6
270	-34.0	35.5	1.5	-37.8	35.7	-2.2	3.1
285	-25.5	35.5	10.0	-35.9	35.7	-0.3	10.4
300	-28.2	35.5	7.3	-32.3	35.7	3.4	8.8
315	-27.2	35.5	8.3	-28.8	35.7	6.8	10.7
330	-26.1	35.5	9.4	-32.5	35.7	3.1	10.3
345	-29.0	35.5	6.5	-33.5	35.7	2.2	7.9
360	-27.9	35.5	7.6	-29.3	35.7	6.4	10.0

Tab. 13: Summary measurement results EIRP at 908.5 MHz Z-Y plane.

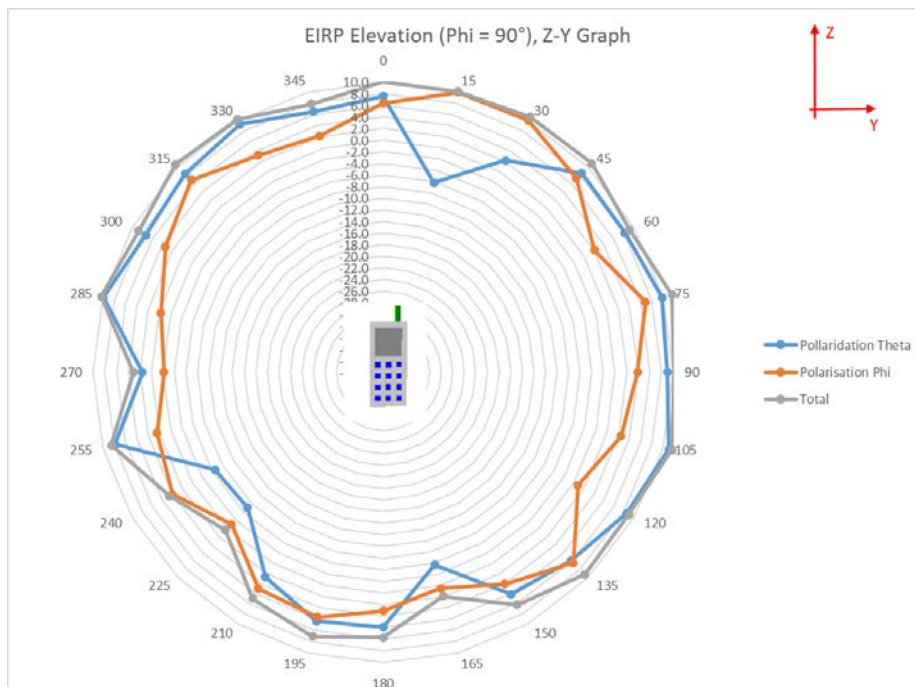


Fig. 14: 2D Pattern, Z-Y plant at 908.5 MHz.

4.4 End-device transmitter performance at (US) 914.9 MHz, EUT2

LoRa CW mode, 20 dBm power:

Polarization	Theta	Phi	Total
Ant. Port Input Pwr. (dBm)	20.0	20.0	20.0
Tot. Rad. Pwr. (dBm)	6.6	4.2	8.6
Peak EIRP (dBm)	11.1	10.0	12.1
Peak ERP (dBm)	8.9	7.8	9.9
Directivity (dBi)	4.5	5.7	3.5
Efficiency (dB)	-13.4	-15.8	-11.4
Efficiency (%)	4.6	2.7	7.2
Gain (dBi)	-8.9	-10.0	-7.9
Boresight Phi (°)	90.0	60.0	90.0
Boresight Th. (°)	105.0	45.0	105.0

Tab. 14: Summary Tx measurement results at 914.9 MHz.

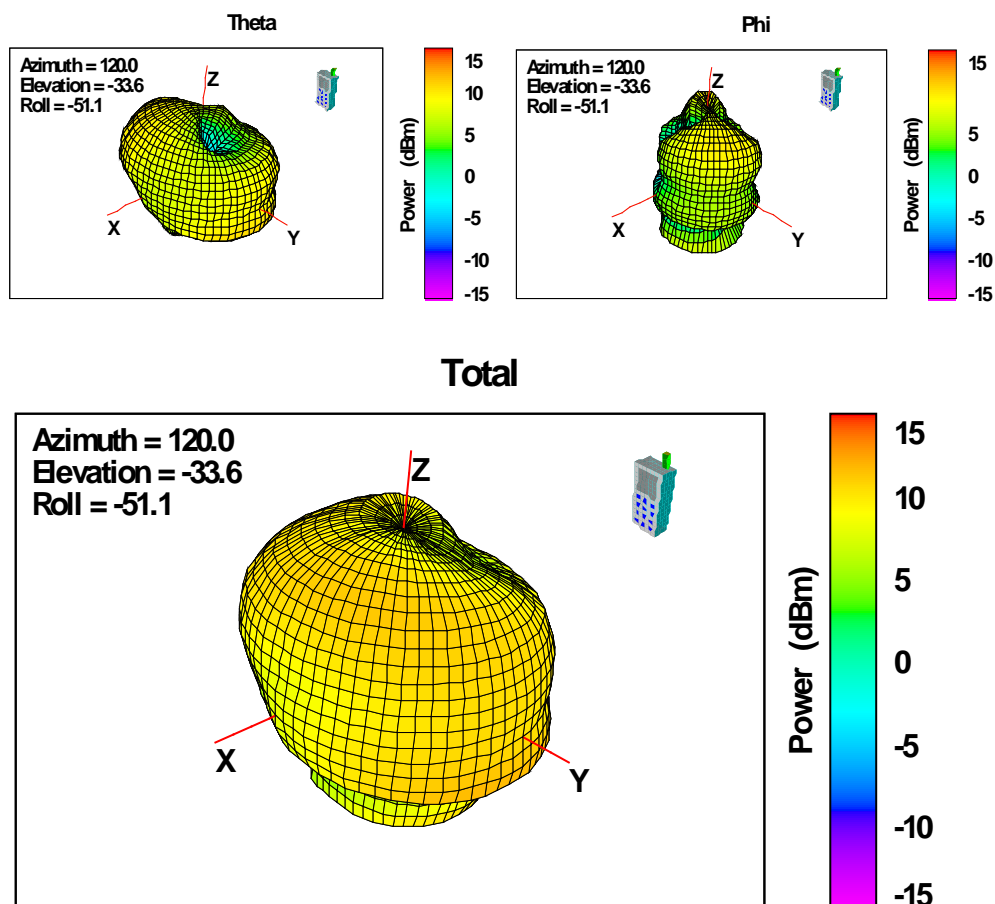


Fig. 15: 3D Pattern at 914.9 MHz.

Th 90° Phi (°)	FSP reading (dBm)	path loss (dB)	EIRP (dBm)	FSP reading (dBm)	path loss (dB)	EIRP (dBm)	EIRP (dBm)
	Polarisation Theta			Polarisation Phi			Total
360	-29.4	35.7	6.3	-32.6	35.7	3.1	8.0
345	-31.1	35.7	4.6	-34.9	35.7	0.8	6.1
330	-31.2	35.7	4.5	-36.6	35.7	-0.9	5.6
315	-30.7	35.7	5.0	-39.7	35.7	-4.0	5.5
300	-30.0	35.7	5.7	-45.2	35.7	-9.5	5.8
285	-29.5	35.7	6.2	-65.4	35.7	-29.8	6.2
270	-29.4	35.7	6.3	-45.7	35.7	-10.0	6.4
255	-29.5	35.7	6.2	-39.8	35.7	-4.1	6.6
240	-30.0	35.7	5.7	-36.8	35.7	-1.1	6.5
225	-30.7	35.7	5.0	-35.3	35.7	0.3	6.3
210	-31.5	35.7	4.2	-35.0	35.7	0.7	5.8
195	-31.7	35.7	4.0	-35.8	35.7	-0.1	5.4
180	-31.3	35.7	4.4	-38.2	35.7	-2.6	5.2
165	-30.2	35.7	5.5	-43.9	35.7	-8.2	5.7
150	-29.3	35.7	6.4	-50.3	35.7	-14.6	6.5
135	-28.2	35.7	7.5	-40.5	35.7	-4.9	7.8
120	-27.4	35.7	8.3	-35.5	35.7	0.2	8.9
105	-27.0	35.7	8.7	-32.6	35.7	3.1	9.7
90	-26.8	35.7	8.9	-30.8	35.7	4.9	10.3
75	-26.8	35.7	8.9	-29.8	35.7	5.9	10.7
60	-27.0	35.7	8.7	-29.4	35.7	6.3	10.7
45	-27.4	35.7	8.3	-29.4	35.7	6.3	10.4
30	-28.0	35.7	7.7	-30.0	35.7	5.7	9.8
15	-28.7	35.7	7.0	-31.0	35.7	4.6	9.0
0	-29.4	35.7	6.3	-32.6	35.7	3.1	8.0

Tab. 15: Summary measurement results EIRP at 914.9 MHz X-Y plane.

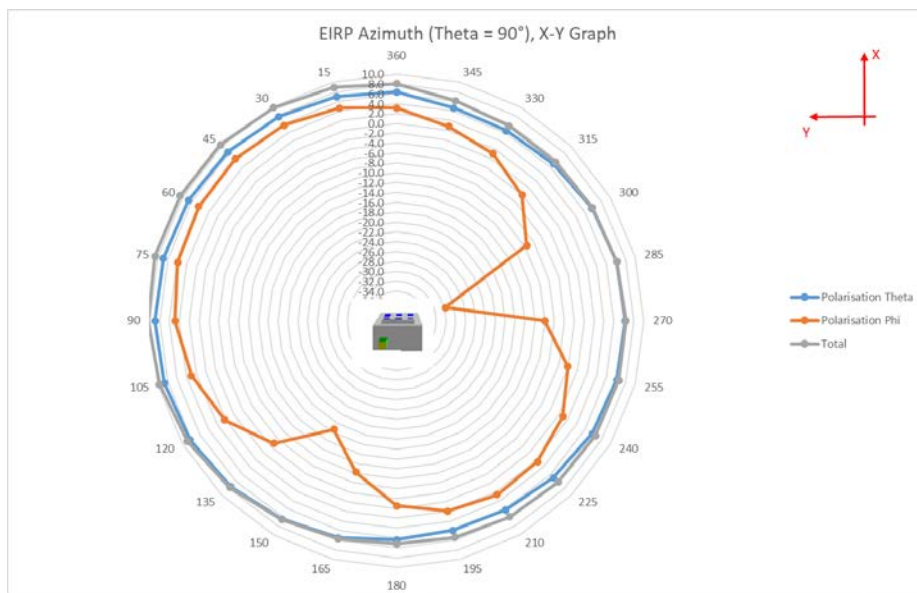


Fig. 16: 2D Pattern, X-Y plant at 914.9 MHz.

Phi = 0°	FSP reading (dBm)	path loss (dB)	EIRP (dBm)	FSP reading (dBm)	path loss (dB)	EIRP (dBm)	EIRP (dBm)
Theta	Pol Theta			Polarisation Phi			Total
0	-29.9	35.7	5.8	-36.1	35.7	-0.4	6.7
15	-28.2	35.7	7.5	-33.5	35.7	2.2	8.6
30	-26.9	35.7	8.8	-29.8	35.7	5.8	10.6
45	-26.6	35.7	9.1	-28.7	35.7	7.0	11.2
60	-27.5	35.7	8.2	-31.2	35.7	4.4	9.7
75	-28.5	35.7	7.2	-34.3	35.7	1.4	8.2
90	-29.4	35.7	6.3	-32.6	35.7	3.1	8.0
105	-30.8	35.7	4.9	-32.7	35.7	3.0	7.0
120	-43.3	35.7	-7.6	-35.5	35.7	0.2	0.9
135	-43.6	35.7	-8.0	-29.2	35.7	6.5	6.6
150	-32.7	35.7	3.0	-38.3	35.7	-2.6	4.1
165	-28.7	35.7	7.0	-33.9	35.7	1.8	8.1
180	-30.5	35.7	5.2	-30.1	35.7	5.6	8.4
195	-34.3	35.7	1.4	-29.7	35.7	6.0	7.3
210	-29.4	35.7	6.3	-28.4	35.7	7.3	9.8
225	-30.9	35.7	4.8	-37.8	35.7	-2.1	5.6
240	-30.8	35.7	4.9	-30.9	35.7	4.7	7.8
255	-27.7	35.7	8.0	-31.0	35.7	4.6	9.6
270	-31.3	35.7	4.4	-38.2	35.7	-2.6	5.2
285	-28.9	35.7	6.8	-31.3	35.7	4.3	8.8
300	-29.1	35.7	6.6	-30.5	35.7	5.2	8.9
315	-32.0	35.7	3.7	-35.8	35.7	-0.1	5.2
330	-33.1	35.7	2.6	-31.8	35.7	3.9	6.3
345	-30.2	35.7	5.5	-29.3	35.7	6.4	9.0
360	-29.9	35.7	5.8	-36.1	35.7	-0.4	6.7

Tab. 16: Summary measurement results EIRP at 914.9 MHz Z-X plane.

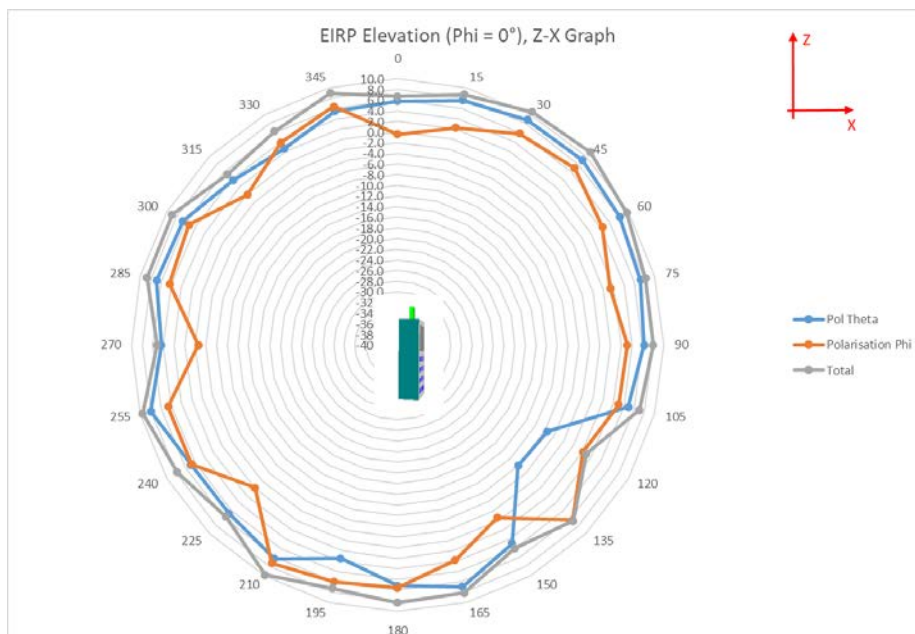


Fig. 17: 2D Pattern, Z-X plant at 914.9 MHz.

Phi 90° Theta	FSP reading (dBm)	path loss (dB)	EIRP (dBm)	FSP reading (dBm)	path loss (dB)	EIRP (dBm)	EIRP (dBm) Total
	Polarisation Theta			Polarisation Phi			
0	-36.1	35.7	-0.4	-29.9	35.7	5.8	6.7
15	-36.3	35.7	-0.6	-30.1	35.7	5.5	6.5
30	-39.1	35.7	-3.4	-28.2	35.7	7.5	7.8
45	-32.9	35.7	2.8	-26.5	35.7	9.2	10.1
60	-27.6	35.7	8.1	-28.5	35.7	7.2	10.7
75	-26.4	35.7	9.3	-32.0	35.7	3.7	10.4
90	-26.8	35.7	8.9	-30.8	35.7	4.9	10.3
105	-24.6	35.7	11.1	-30.3	35.7	5.3	12.1
120	-28.1	35.7	7.6	-50.9	35.7	-15.2	7.6
135	-28.7	35.7	7.0	-27.6	35.7	8.0	10.6
150	-29.7	35.7	6.0	-28.4	35.7	7.3	9.7
165	-42.3	35.7	-6.6	-51.0	35.7	-15.4	-6.0
180	-30.1	35.7	5.6	-30.5	35.7	5.2	8.4
195	-29.8	35.7	5.9	-27.3	35.7	8.3	10.3
210	-32.4	35.7	3.3	-29.9	35.7	5.7	7.7
225	-52.0	35.7	-16.3	-50.3	35.7	-14.7	-12.4
240	-43.3	35.7	-7.6	-31.7	35.7	4.0	4.3
255	-31.0	35.7	4.7	-33.3	35.7	2.3	6.7
270	-29.4	35.7	6.3	-45.7	35.7	-10.0	6.4
285	-27.7	35.7	8.0	-33.4	35.7	2.2	9.0
300	-26.3	35.7	9.4	-31.5	35.7	4.2	10.5
315	-26.4	35.7	9.3	-34.2	35.7	1.4	10.0
330	-27.4	35.7	8.3	-31.5	35.7	4.1	9.7
345	-30.2	35.7	5.5	-27.5	35.7	8.2	10.0
360	-36.1	35.7	-0.4	-29.9	35.7	5.8	6.7

Tab. 17: Summary measurement results EIRP at 914.9 MHz Z-Y plane.

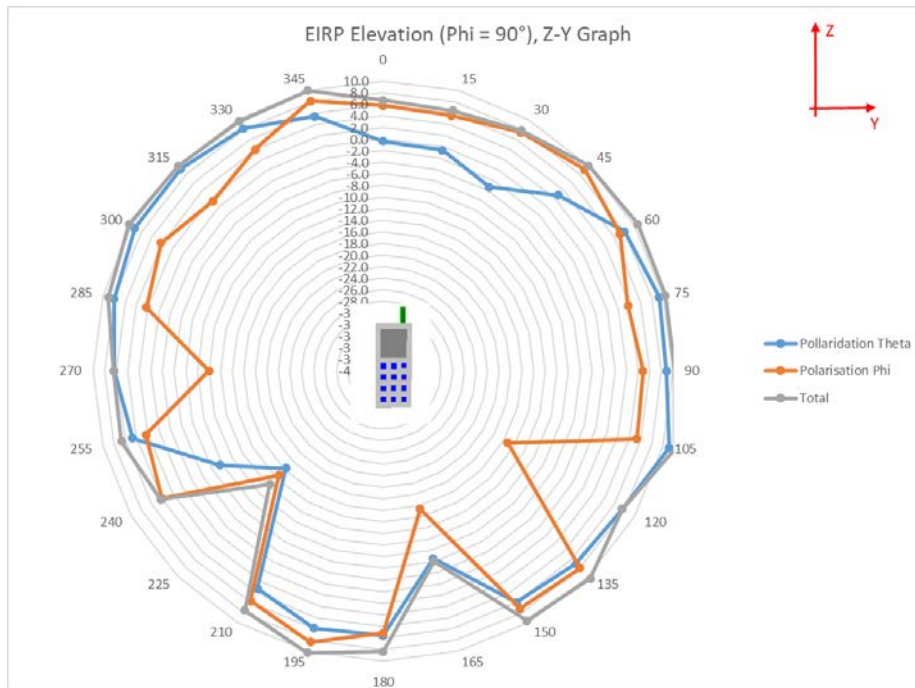


Fig. 18: 2D Pattern, Z-Y plant at 914.9 MHz.

4.5 End-device transmitter performance at (AU) 922.2 MHz, EUT3

LoRa CW mode, 14 dBm power:

Polarization	Theta	Phi	Total
Ant. Port Input Pwr. (dBm)	14.0	14.0	14.0
Tot. Rad. Pwr. (dBm)	-6.3	-7.8	-3.9
Peak EIRP (dBm)	-2.4	-1.9	-1.1
Peak ERP (dBm)	-4.5	-4.0	-3.2
Efficiency (dB)	-20.3	-21.8	-17.9
Efficiency (%)	0.9	0.7	1.6
Gain (dBi)	-16.4	-15.9	-15.1
Boresight Phi (°)	0.0	60.0	30.0
Boresight Th. (°)	165.0	30.0	60.0

Tab. 18: Summary Tx measurement results at 922.2 MHz.

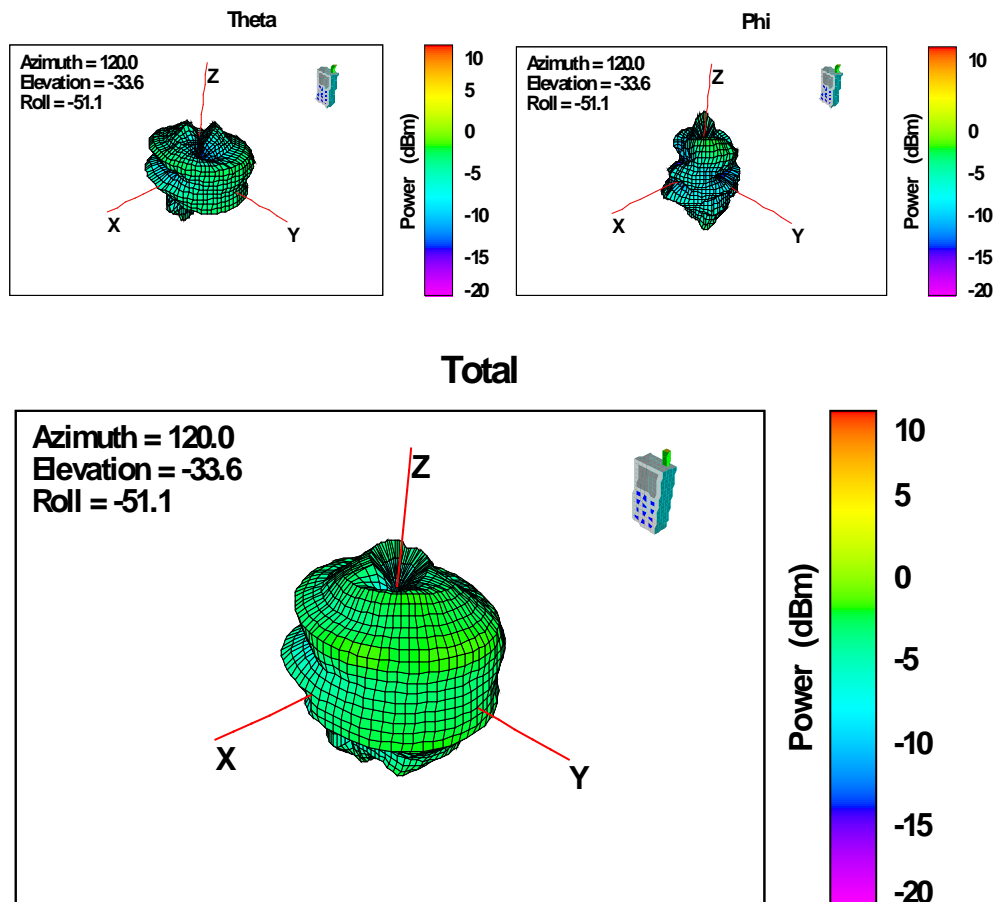


Fig. 19: 3D Pattern at 922.2 MHz.

Th 90° Phi (°)	FSP reading (dBm)	path loss (dB)	EIRP (dBm)	FSP reading (dBm)	path loss (dB)	EIRP (dBm)	EIRP (dBm)
	Polarisation Theta			Polarisation Phi			Total
360	-40.0	35.7	-4.3	-49.1	35.7	-13.5	-3.8
345	-40.6	35.7	-4.9	-45.7	35.7	-10.0	-3.8
330	-40.3	35.7	-4.6	-45.9	35.7	-10.3	-3.6
315	-40.1	35.7	-4.4	-46.2	35.7	-10.6	-3.5
300	-40.1	35.7	-4.4	-46.8	35.7	-11.1	-3.5
285	-40.1	35.7	-4.4	-47.5	35.7	-11.9	-3.7
270	-40.3	35.7	-4.6	-47.6	35.7	-11.9	-3.9
255	-40.5	35.7	-4.9	-46.2	35.7	-10.5	-3.8
240	-41.0	35.7	-5.3	-44.4	35.7	-8.8	-3.7
225	-41.9	35.7	-6.2	-43.0	35.7	-7.4	-3.7
210	-42.9	35.7	-7.2	-42.5	35.7	-6.9	-4.0
195	-43.7	35.7	-8.0	-42.7	35.7	-7.1	-4.5
180	-44.1	35.7	-8.4	-42.8	35.7	-7.2	-4.8
165	-43.9	35.7	-8.2	-43.1	35.7	-7.4	-4.8
150	-43.1	35.7	-7.4	-43.4	35.7	-7.7	-4.6
135	-42.0	35.7	-6.3	-43.8	35.7	-8.1	-4.1
120	-41.0	35.7	-5.3	-45.4	35.7	-9.7	-4.0
105	-40.6	35.7	-5.0	-44.3	35.7	-8.6	-3.4
90	-40.3	35.7	-4.6	-43.3	35.7	-7.6	-2.8
75	-40.2	35.7	-4.5	-43.0	35.7	-7.3	-2.7
60	-40.2	35.7	-4.5	-43.6	35.7	-7.9	-2.9
45	-39.8	35.7	-4.1	-43.8	35.7	-8.1	-2.7
30	-39.9	35.7	-4.2	-44.3	35.7	-8.7	-2.9
15	-40.4	35.7	-4.7	-47.0	35.7	-11.3	-3.9
0	-40.0	35.7	-4.3	-49.1	35.7	-13.5	-3.8

Tab. 19: Summary measurement results EIRP at 922.2 MHz X-Y plane.

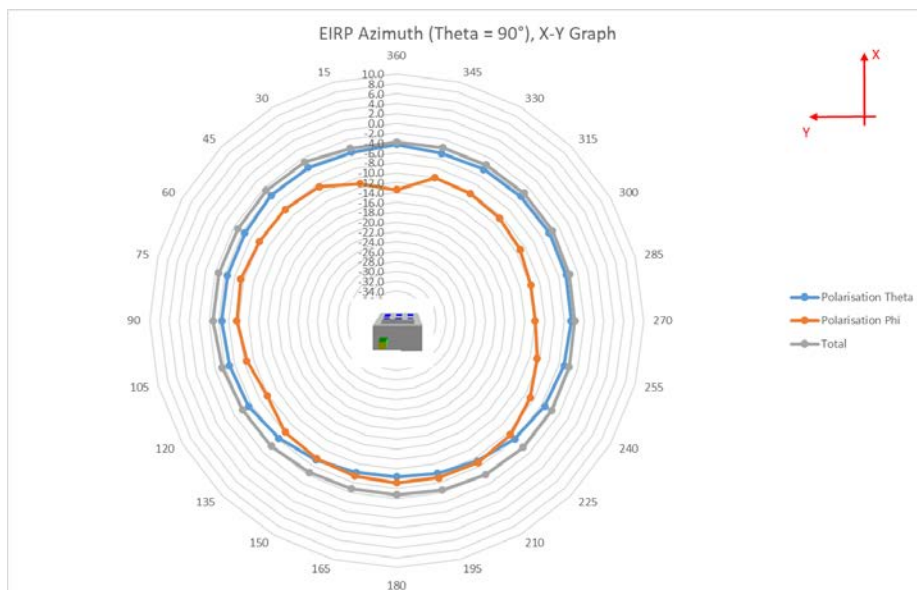


Fig. 20: 2D Pattern, X-Y plant at 922.2 MHz.

Phi = 0°	FSP reading (dBm)	path loss (dB)	EIRP (dBm)	FSP reading (dBm)	path loss (dB)	EIRP (dBm)	EIRP (dBm)
Theta	Pol Theta			Polarisation Phi			Total
0	-46.4	35.7	-10.7	-51.5	35.7	-15.9	-9.5
15	-44.5	35.7	-8.8	-48.7	35.7	-13.0	-7.4
30	-42.1	35.7	-6.4	-41.1	35.7	-5.5	-2.9
45	-40.4	35.7	-4.7	-49.7	35.7	-14.0	-4.2
60	-38.5	35.7	-2.8	-43.9	35.7	-8.3	-1.7
75	-46.7	35.7	-11.0	-42.4	35.7	-6.7	-5.4
90	-40.0	35.7	-4.3	-49.1	35.7	-13.5	-3.8
105	-44.1	35.7	-8.5	-41.4	35.7	-5.7	-3.9
120	-57.5	35.7	-21.8	-44.4	35.7	-8.7	-8.5
135	-54.9	35.7	-19.2	-44.9	35.7	-9.3	-8.8
150	-44.3	35.7	-8.7	-44.6	35.7	-8.9	-5.8
165	-38.1	35.7	-2.4	-47.1	35.7	-11.5	-1.9
180	-42.1	35.7	-6.5	-42.8	35.7	-7.2	-3.8
195	-51.0	35.7	-15.3	-47.3	35.7	-11.6	-10.1
210	-44.1	35.7	-8.4	-43.4	35.7	-7.8	-5.1
225	-41.4	35.7	-5.7	-42.2	35.7	-6.6	-3.1
240	-45.0	35.7	-9.3	-43.2	35.7	-7.5	-5.3
255	-44.2	35.7	-8.5	-39.6	35.7	-3.9	-2.6
270	-44.1	35.7	-8.4	-42.8	35.7	-7.2	-4.8
285	-40.3	35.7	-4.6	-44.2	35.7	-8.6	-3.1
300	-40.9	35.7	-5.3	-41.6	35.7	-5.9	-2.6
315	-42.6	35.7	-7.0	-46.9	35.7	-11.2	-5.6
330	-44.1	35.7	-8.4	-46.4	35.7	-10.7	-6.4
345	-42.1	35.7	-6.4	-40.9	35.7	-5.2	-2.8
360	-46.4	35.7	-10.7	-51.5	35.7	-15.9	-9.5

Tab. 20: Summary measurement results EIRP at 922.2 MHz Z-X plane.

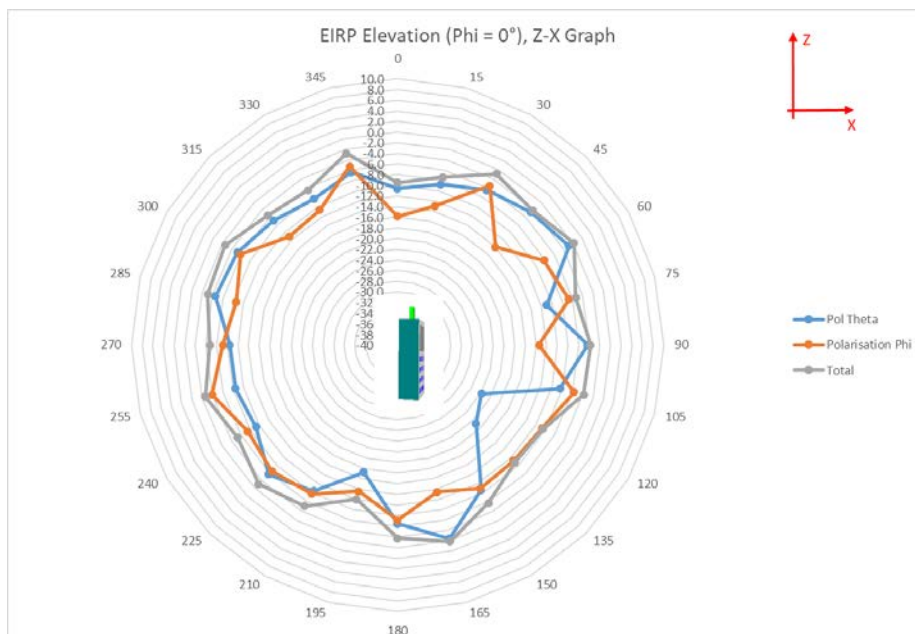


Fig. 21: 2D Pattern, Z-X plant at 922.2 MHz.

Phi 90° Theta	FSP reading (dBm)	path loss (dB)	EIRP (dBm)	FSP reading (dBm)	path loss (dB)	EIRP (dBm)	EIRP (dBm)
	Polarisation Theta			Polarisation Phi			Total
0	-51.6	35.7	-15.9	-46.3	35.7	-10.7	-9.5
15	-43.8	35.7	-8.1	-43.5	35.7	-7.9	-5.0
30	-43.7	35.7	-8.0	-39.7	35.7	-4.0	-2.6
45	-45.1	35.7	-9.4	-39.1	35.7	-3.5	-2.5
60	-38.3	35.7	-2.6	-43.4	35.7	-7.8	-1.5
75	-39.2	35.7	-3.5	-50.8	35.7	-15.1	-3.3
90	-40.3	35.7	-4.6	-43.3	35.7	-7.6	-2.8
105	-38.5	35.7	-2.8	-45.4	35.7	-9.8	-2.0
120	-44.3	35.7	-8.6	-42.9	35.7	-7.3	-4.9
135	-41.4	35.7	-5.7	-41.7	35.7	-6.0	-2.8
150	-44.2	35.7	-8.5	-39.6	35.7	-3.9	-2.6
165	-45.9	35.7	-10.3	-46.3	35.7	-10.6	-7.4
180	-42.8	35.7	-7.2	-42.1	35.7	-6.5	-3.8
195	-41.9	35.7	-6.2	-42.0	35.7	-6.4	-3.3
210	-41.1	35.7	-5.4	-41.4	35.7	-5.7	-2.6
225	-45.1	35.7	-9.4	-42.4	35.7	-6.8	-4.9
240	-46.0	35.7	-10.4	-60.0	35.7	-24.3	-10.2
255	-54.6	35.7	-18.9	-44.2	35.7	-8.6	-8.2
270	-40.3	35.7	-4.6	-47.6	35.7	-11.9	-3.9
285	-44.4	35.7	-8.7	-45.7	35.7	-10.1	-6.3
300	-39.4	35.7	-3.7	-42.2	35.7	-6.6	-1.9
315	-42.1	35.7	-6.4	-45.0	35.7	-9.3	-4.6
330	-42.5	35.7	-6.8	-45.7	35.7	-10.1	-5.1
345	-41.5	35.7	-5.8	-40.8	35.7	-5.1	-2.4
360	-51.6	35.7	-15.9	-46.3	35.7	-10.7	-9.5

Tab. 21: Summary measurement results EIRP at 922.2 MHz Z-Y plane.

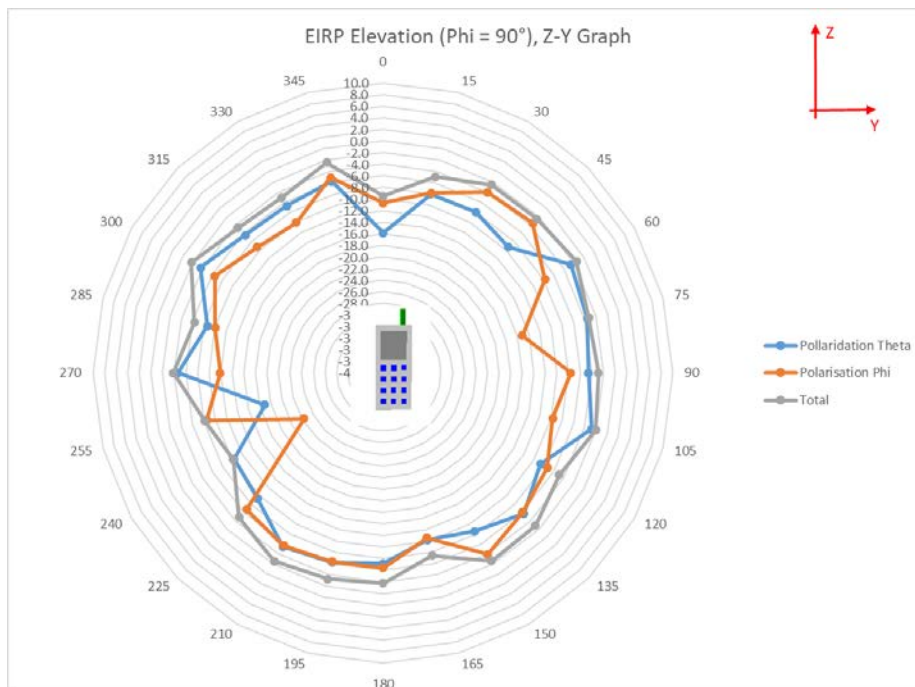


Fig. 22: 2D Pattern, Z-Y plant at 922.2 MHz.

4.6 End-device receiver performance EIS, 865.1 MHz (EU), Rx1, Datarate SF12, EUT1

End-device receiver performance	Result	Reference (according to chapter 3.2)
EIS(ϕ_0, θ_0)	-127.5	(1)
EIS (dB)	-127.7	(3)
TIS Tot. Rad. Sensitivity. (dBm)	-124.0	(4)
Boresight Phi ($^\circ$), ϕ_0	120.0	Chosen Phi Direction
Boresight Th. ($^\circ$), θ_0	105.0	Chosen Theta Direction
Boresight Polarisation	Theta	Chosen Polarisation
NSA (including Lcable and Gref) (path loss dB)	35.5	(2)

Tab. 22: Summary measurement results EIS, 865.1 MHz, Rx1, Datarate SF12.

4.7 End-device receiver performance EIS, 865.1 MHz (EU), Rx1, Datarate SF7, EUT1

End-device receiver performance	Result	Reference (according to chapter 3.2)
EIS(ϕ_0, θ_0)	-114.0	(1)
EIS (dB)	-114.2	(3)
TIS Tot. Rad. Sensitivity. (dBm)	-110.4	(4)
Boresight Phi ($^\circ$), ϕ_0	120.0	Chosen Phi Direction
Boresight Th. ($^\circ$), θ_0	105.0	Chosen Theta Direction
Boresight Polarisation	Theta	Chosen Polarisation
NSA (including Lcable and Gref) (path loss dB)	35.5	(2)
Gateway Tx power (dBm)	8.7	Measured value

Tab. 23: Summary measurement results EIS, 865.1 MHz, Rx1, Datarate SF7.

4.8 End-device receiver performance EIS, 923.3 MHz (US), Rx2, Datarate SF12, EUT2

End-device receiver performance	Result	Reference (according to chapter 3.2)
EIS(ϕ_0, θ_0)	-124.5	(1)
EIS (dB)	-125.5	(3)
TIS Tot. Rad. Sensitivity. (dBm)	-122.0	(4)
Boresight Phi ($^\circ$), ϕ_0	90.0	Chosen Phi Direction
Boresight Th. ($^\circ$), θ_0	105.0	Chosen Theta Direction
Boresight Polarisation	Theta	Chosen Polarisation
NSA (including Lcable and Gref) (path loss dB)	37.5	(2)

Tab. 24: Summary measurement results EIS, 923.3 MHz, Rx2, Datarate SF12.

4.9 End-device receiver performance EIS, 923.3 MHz (US), Rx2, Datarate SF7, EUT2

End-device receiver performance	Result	Reference (according to chapter 3.2)
EIS(ϕ_0, θ_0)	-113.0	(1)
EIS (dB)	-114.0	(3)
TIS Tot. Rad. Sensitivity. (dBm)	-110.5	(4)
Boresight Phi ($^\circ$), ϕ_0	90.0	Chosen Phi Direction
Boresight Th. ($^\circ$), θ_0	105.0	Chosen Theta Direction
Boresight Polarisation	Theta	Chosen Polarisation
NSA (including Lcable and Gref) (path loss dB)	37,5	(2)

Tab. 25: Summary measurement results EIS, 923.3 MHz, Rx2, Datarate SF7.

4.10 End-device receiver performance EIS, 925.1 MHz (US), Rx2, Datarate SF12, EUT2

End-device receiver performance	Result	Reference (according to chapter 3.2)
EIS(ϕ_0, θ_0)	-124.5	(1)
EIS (dB)	-125.5	(3)
TIS Tot. Rad. Sensitivity. (dBm)	-122.0	(4)
Boresight Phi ($^\circ$), ϕ_0	90.0	Chosen Phi Direction
Boresight Th. ($^\circ$), θ_0	105.0	Chosen Theta Direction
Boresight Polarisation	Theta	Chosen Polarisation
NSA (including Lcable and Gref) (path loss dB)	37.5	(2)

Tab. 26: Summary measurement results EIS, 925.1 MHz, Rx2, Datarate SF12.

4.11 End-device receiver performance EIS, 925.1 MHz (US), Rx2, Datarate SF7, EUT2

End-device receiver performance	Result	Reference (according to chapter 3.2)
EIS(ϕ_0, θ_0)	-112.0	(1)
EIS (dB)	-113.0	(3)
TIS Tot. Rad. Sensitivity. (dBm)	-109.5	(4)
Boresight Phi ($^\circ$), ϕ_0	90.0	Chosen Phi Direction
Boresight Th. ($^\circ$), θ_0	105.0	Chosen Theta Direction
Boresight Polarisation	Theta	Chosen Polarisation
NSA (including Lcable and Gref) (path loss dB)	37,5	(2)

Tab. 27: Summary measurement results EIS, 925.1 MHz, Rx2, Datarate SF7.

4.12 End-device receiver performance EIS, 927.5 MHz (US), Rx2, Datarate SF12, EUT2

End-device receiver performance	Result	Reference (according to chapter 3.2)
EIS(ϕ_0, θ_0)	-124.5	(1)
EIS (dB)	-125.5	(3)
TIS Tot. Rad. Sensitivity. (dBm)	-122.0	(4)
Boresight Phi ($^\circ$), ϕ_0	90.0	Chosen Phi Direction
Boresight Th. ($^\circ$), θ_0	105.0	Chosen Theta Direction
Boresight Polarisation	Theta	Chosen Polarisation
NSA (including Lcable and Gref) (path loss dB)	37.5	(2)

Tab. 28: Summary measurement results EIS, 927.5 MHz, Rx2, Datarate SF12.

4.13 End-device receiver performance EIS, 927.5 MHz (US), Rx2, Datarate SF7, EUT2

End-device receiver performance	Result	Reference (according to chapter 3.2)
EIS(ϕ_0, θ_0)	-112.5	(1)
EIS (dB)	-113.5	(3)
TIS Tot. Rad. Sensitivity. (dBm)	-110.0	(4)
Boresight Phi ($^\circ$), ϕ_0	90.0	Chosen Phi Direction
Boresight Th. ($^\circ$), θ_0	105.0	Chosen Theta Direction
Boresight Polarisation	Theta	Chosen Polarisation
NSA (including Lcable and Gref) (path loss dB)	37,5	(2)

Tab. 29: Summary measurement results EIS, 927.5 MHz, Rx2, Datarate SF7.

4.14 End-device receiver performance EIS, 923.3 MHz (AU), Rx1, Datarate SF12

End-device receiver performance	Result	Reference (according to chapter 3.2)
EIS(ϕ_0, θ_0)	-122.2	(1)
EIS (dB)	-123.0	(3)
TIS Tot. Rad. Sensitivity. (dBm)	-120.1	(4)
Boresight Phi ($^\circ$), ϕ_0	60.0	Chosen Phi Direction
Boresight Th. ($^\circ$), θ_0	30.0	Chosen Theta Direction
Boresight Polarisation	Phi	Chosen Polarisation
NSA (including Lcable and Gref) (path loss dB)	37.5	(2)

Tab. 30: Summary measurement results EIS, 923.3 MHz, Rx1, Datarate SF12.

4.15 End-device receiver performance EIS, 923.3 MHz (AU), Rx1, Datarate SF7

End-device receiver performance	Result	Reference (according to chapter 3.2)
EIS(ϕ_0, θ_0)	-111.2	(1)
EIS (dB)	-112.0	(3)
TIS Tot. Rad. Sensitivity. (dBm)	-109.1	(4)
Boresight Phi ($^\circ$), ϕ_0	60.0	Chosen Phi Direction
Boresight Th. ($^\circ$), θ_0	30.0	Chosen Theta Direction
Boresight Polarisation	Phi	Chosen Polarisation
NSA (including Lcable and Gref) (path loss dB)	37.5	(2)

Tab. 31: Summary measurement results EIS, 923.3 MHz, Rx1, Datarate SF7.