LoRa Alliance End-Device Certification Radiated RF Performance test report

Test report #:	12092019_001	Date of report:	12.09.2019
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Testing has been carried out in accordance with:	End-Device RF Performance EU Version 1.0
Device type:	EU 868 MHz
EUT tested by:	Timo Pentikäinen, Sandro von Brandenburg and Jukka Vesterinen
Reported by:	Timo Pentikäinen

Date and signatures:

Digitally signed by Ismo Kaastinen DN: cn=Ismo Kaastinen, o=Etteplan Oyj, ou, email=ismo.kaastinen@etteplan.com, c=FI Date: 2019.09.13 12:51:04 +03'00'	Digitally signed by Timo Pentikäinen DN: cn=Timo Pentikäinen, email=timo.pentikainen@etteplan.com, c=FI Date: 2019.09.13 09:55:30 +03'00'
Ismo Kaastinen	Timo Pentikäinen
Laboratory Manager	Sr. RF Engineer

Test environment

Temperature:	+22 ˚C (±2 °C) HVAC system
Humidity:	45 % (±5 %) HVAC system
Date of tests started :	6th of September 2019
Date of tests ended:	11th of September 2019

Equipment under test (EUT)

EUT type:	LORA device
EUT ID:	-
DUT 1:	AXIOMA QALCOSONIC E3
HW Version:	V05
SW Version:	V2.05
Auxiliary equipment 4:	Battery: EVE ER14505 AA 3.6V, LR03, Made in China, 2 pcs

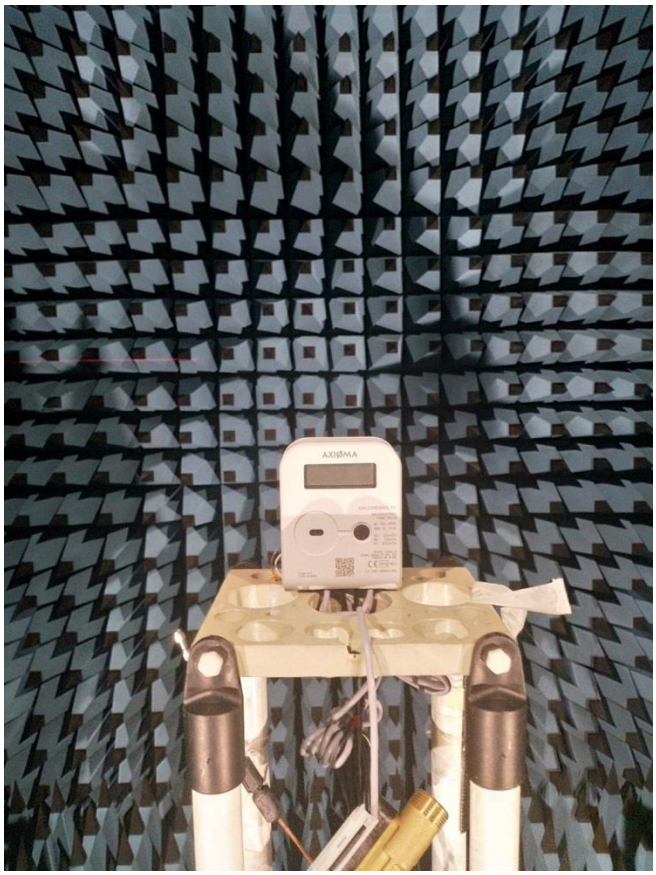


Image 1 – Equipment under test

Test information

Product description:	LoRa End-devices for EU 868 MHz ISM Band External Dipole antenna
Test mode / software operating condition:	Firmware version: NOT Supports TxCW commands Test Software Version: 1.1.11 Gateway Model: IMST Lite Gateway Gateway Software Version: 5.0.1 Packet Forwarder Software Version: 4.0.1
Monitoring methods:	We have measured passive antenna performance in SATIMO, because the software did not support TXCW commands. From SATIMO we get antenna results, Efficiency and GAIN. Then we have measured conducted power and sensitivity and from those values we have calculated the results, TRP, TIS, EIRP and EIS. The transmitter and receiver radiated RF performance measurements are carried out in Satimo Stargate 64 fast antenna measurement system.

Additional notes

The test results and statements apply only to the tested items. This test report shall not be reproduced, except in full, without written approval of the test laboratory.

Table of Contents

Abbreviations & Acronyms

CW	Continuous Wave
GAIN	Antenna Gain or Power Gain
DR	Data Rate
EIS	Effective Isotropic Sensitivity (dBm)
ERP	Effective Radiated Power compared to a dipole antenna (dBm)
EIRP	Equivalent Isotropically Radiated Power (dBm)
EUT	Equipment Under Test
PER	Packet Error Rate
NSA	Normalize Site Attenuation
OTA	Over The Air
TIS	Total Isotropic Sensitivity (dBm)
TRP	Total Radiated Power (dBm)

1 Efficiency

The efficiency of an antenna is the relation between the power delivered to the antenna and the power radiated from the antenna. A high efficiency antenna radiates most of the input power away. A low efficiency antenna absorbs most of the input power as losses within the antenna, or reflects it away due to impedance mismatch.

2 Test Environment

All tests described in this report are performed within Satimo SG64 fast antenna measurement system represented in Figure 1. Measurement equipment including calibration information are listed in Annex A. The test site is a shielded room equipped with RF absorbers on all walls, ceiling and floor to simulate free-space conditions. Uncertainty of the measurement system is presented in Table 1 and Table 2.

The direction of radiation is described with angles of ϕ and θ. The relation of these angles to a Cartesian (xyz-) coordinate system is presented in Figure 1.

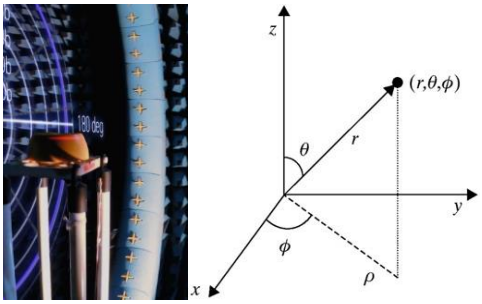


Figure 1 – Satimo Stargate 64 fast antenna measurement system and spherical coordinate system of the measurement.

Table 1 – Total radiated power measurement uncertainty

TRP uncertainty calculation TRP 3GPP TS 34.114 , Stage 1, DUT measurement					Calculated	SUM	
22	Combined standard Uncertainty	dB			0.875	0.766	
23	**Expanded uncertainty**	dB	k=	1.96	**1.72**	**dB**	1.9dB max allowed in 3GPP TS 34.114

Table 2 – Total isotropic sensitivity measurement uncertainty

TIS uncertainty calculation TRS 3GPP TS 34.114 , Stage 1, DUT measurement					Calculated	SUM	
25	Combined standard Uncertainty	dB			1.095	0.0294295	
26	**Expanded uncertainty**	dB	k=	1.96	**2.15**	**dB**	2.3dB max allowed in 3GPP TS 34.114

2.1 End-device transmitter performance

The continuous wave (CW) mode is enabled through the certification test application by Over the Air (OTA) commands. Tx power is set to 14 dBm.

The equivalent isotropically radiated power (EIRP) is measured in 5.54°-steps over the elevation (theta) plane and 5°-steps over the azimuth (phi) plane, for evaluating the complete radiation pattern. The measurement setup is presented in Figure 2.

Measured channels:

- 863.1 MHz (low channel)
- 868.3 MHz (default channel, needed for RX1 window TIS calculation)
- 869.525 MHz (high channel, needed for RX2 window TIS calculation)

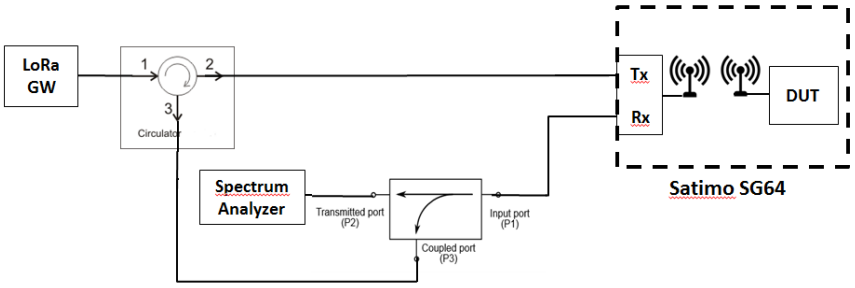


Figure 2 – Measurement setup for radiated power measurement

2.2 End-device receiver performance

The effective isotopic sensitivity (EIS) is measured into the direction of maximum $EIRP$. Measurement setup is presented in Figure 3.

Total isotropic sensitivity (TIS) calculation is based on normalized antenna gain from EIRP pattern measured at the same frequency. This is an estimation of the actual TIS assuming that the transmission radiated performance pattern is equivalent to the reception radiated performance pattern (reciprocity theorem).

The $EIS(\phi, \theta)$ is measured for RX1 and RX2 receive windows for the following channels:

- 868.3 MHz (RX1 window)
- 869.525 MHz (RX2 window)

The measurement was performed using LoRa modulation with the highest and the lowest datarate (SF7&SF12) for 125 MHz bandwidth.

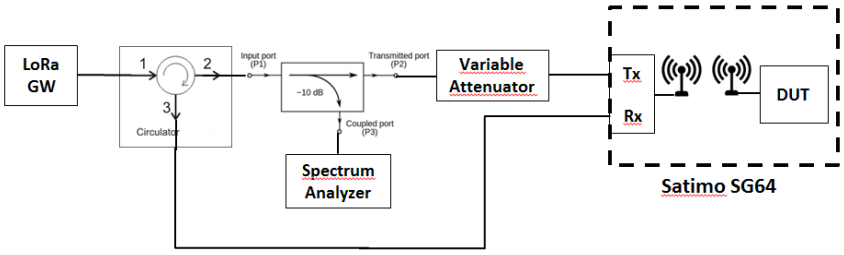


Figure 3 – Measurement setup for radiated sensitivity measurement.

3 Summary of test results – Passive

3.1 Test results – Free Space – Efficiency

Channel	Frequency [MHz]	Efficiency [dBm]	Efficiency [%]
Low Channel	863.1 MHz	-6.5	47.32
Default Channel	868.3 MHz	-6.32	48.31
High Channel	869.525 MHz	-6.33	48.25

3.2 Test results – Free Space – GAIN

Channel	Frequency [MHz]	VERTICAL EIRP [dBm]	HORIZONTAL EIRP [dBm]	TOTAL EIRP [dBm]	Direction of maximum Radiation Azimuth / Elevation [deg]
Low Channel	863.1 MHz	-7.90	-3.72	-3.69	236.25 / 56.26
Default Channel	868.3 MHz	-7.87	-3.92	-3.27	236.25 / 56.26
High Channel	869.525 MHz	-7.80	-3.89	-3.16	236.25 / 56.26

4 Summary of test results

4.1 Test result – Conductive Power

Channel	Frequency [MHz]	POWER [dBm]
Low Channel	863.1 MHz	13.8
Default Channel	868.3 MHz	
High Channel	869.525 MHz	

4.2 Test results – Free Space – TRP

Channel	Frequency [MHz]	TRP [dBm]
Low Channel	863.1 MHz	7.30
Default Channel	868.3 MHz	7.48
High Channel	869.525 MHz	7.47

4.3 Test results – Free Space – EIRP

Channel	Frequency [MHz]	VERTICAL EIRP [dBm]	HORIZONTAL EIRP [dBm]	TOTAL EIRP [dBm]	Direction of maximum Radiation Azimuth / Elevation [deg]
Low Channel	863.1 MHz	5.89	10.07	10.11	236.25 / 56.26
Default Channel	868.3 MHz	5.99	9.90	10.64	236.25 / 56.26
High Channel	869.525 MHz	5.99	9.90	10.63	236.25 / 56.26

4.4 Test results – Free Space – Measurement data

Frequency [MHz]	Receive window	Spreading factor	Forward path Attenuation [dBm]	RF Step Attenuator [dBm]	Normalized Site Attenuation [dBm]	Gateway TX power [dBm]	Effective Isotropic Sensitivity [dBm]
868.3 MHz	RX1	SF12	9.41	89.5	43.57	13.15	-129.33
869.525 MHz	RX2	SF12	9.41	89.5	43.71	13.15	-129.47
868.3 MHz	RX1	SF7	9.41	71	43.57	13.42	-110.56
869.525 MHz	RX2	SF7	9.41	71	43.71	13.42	-110.70

4.5 Test results – Free Space – EIS

Frequency [MHz]	Receive window	Spreading factor	PER limit	PER in Sensitivity threshold	VERTICAL EIS [dBm]	HORIZONTAL EIS [dBm]	TOTAL EIS [dBm]
868.3 MHz	RX1	SF12	10 %	OK*	-121.49	-125.67	-125.71
869.525 MHz	RX2	SF12	10 %	OK*	-121.53	-125.48	-126.13
868.3 MHz	RX1	SF7	10 %	OK*	-102.70	-106.87	-106.91
869.525 MHz	RX2	SF7	10 %	OK*	-102.73	-106.68	-107.33

* Because of the software version, we were not able to see the package threshold. Results are interpreted as if the communication to the device has been “on” or “off”

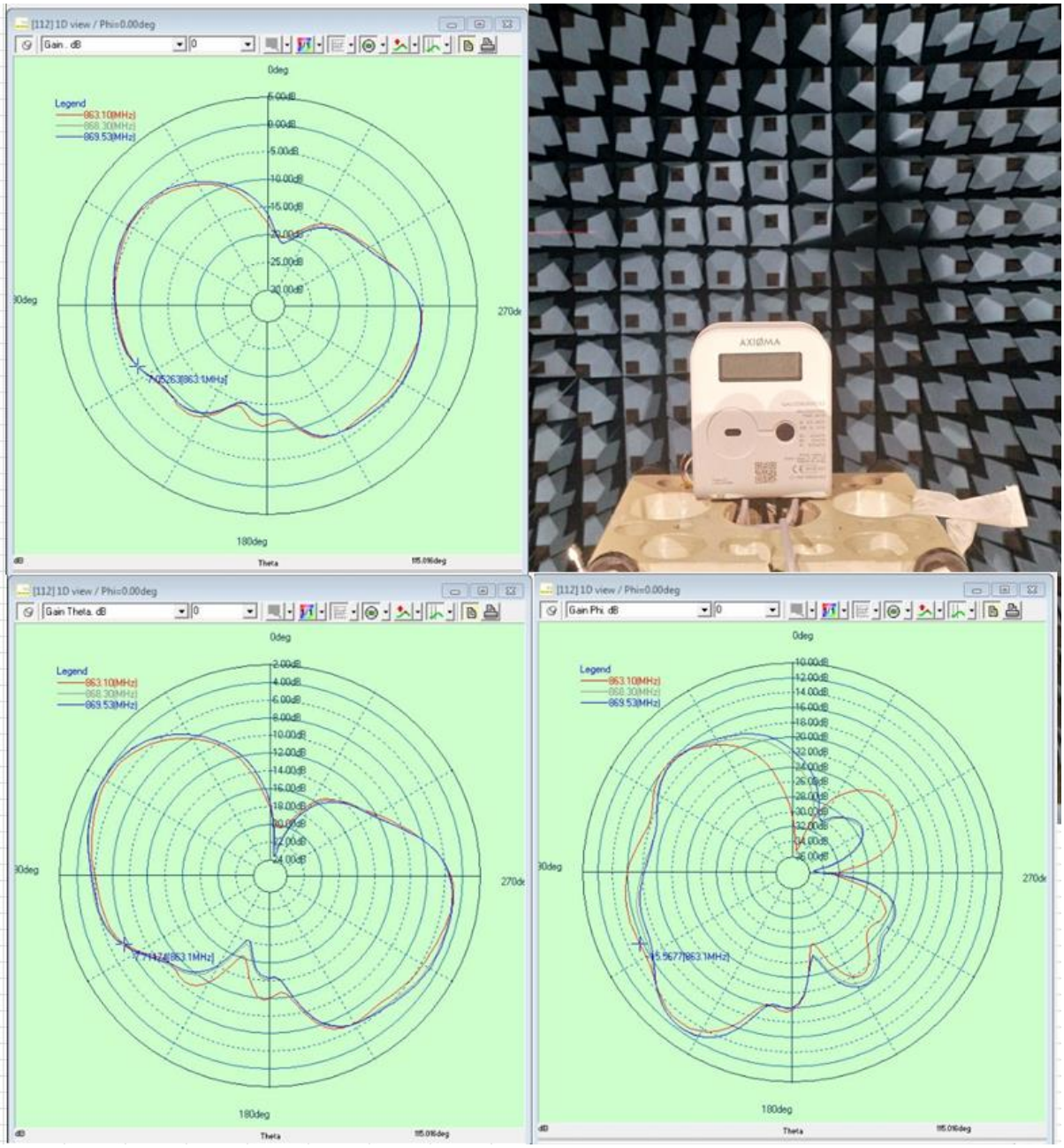
4.6 Test results – Free Space – TIS

Frequency [MHz]	Receive window	Spreading factor	TIS [dBm]
868.3 MHz	RX1	12	-122.83
869.525 MHz	RX2	12	-122.97
868.3 MHz	RX1	7	-104,06
869.525 MHz	RX2	7	-104.20

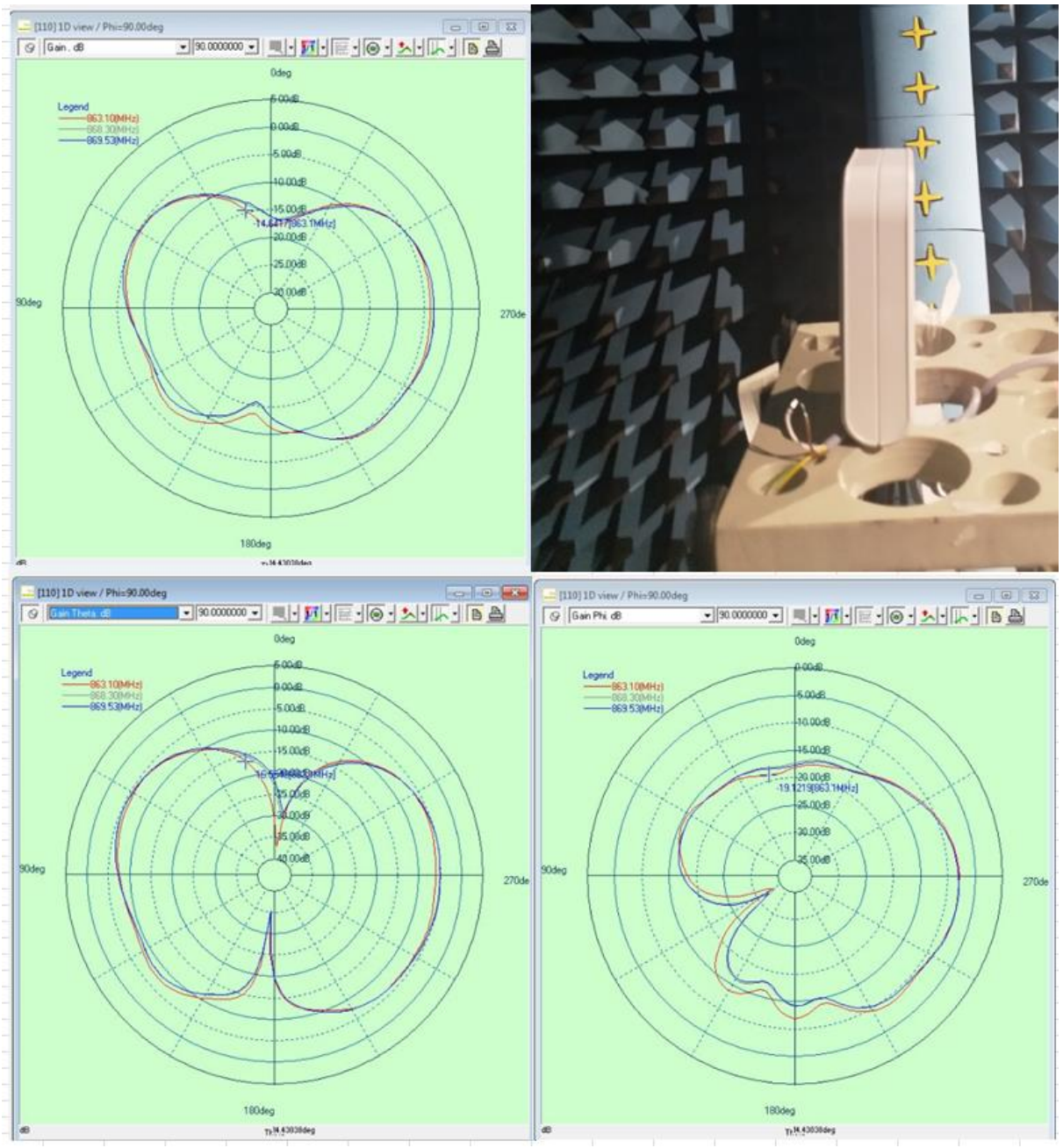
5 Test result of GAIN antenna radiation pattern

5.1 Measurement results – FS

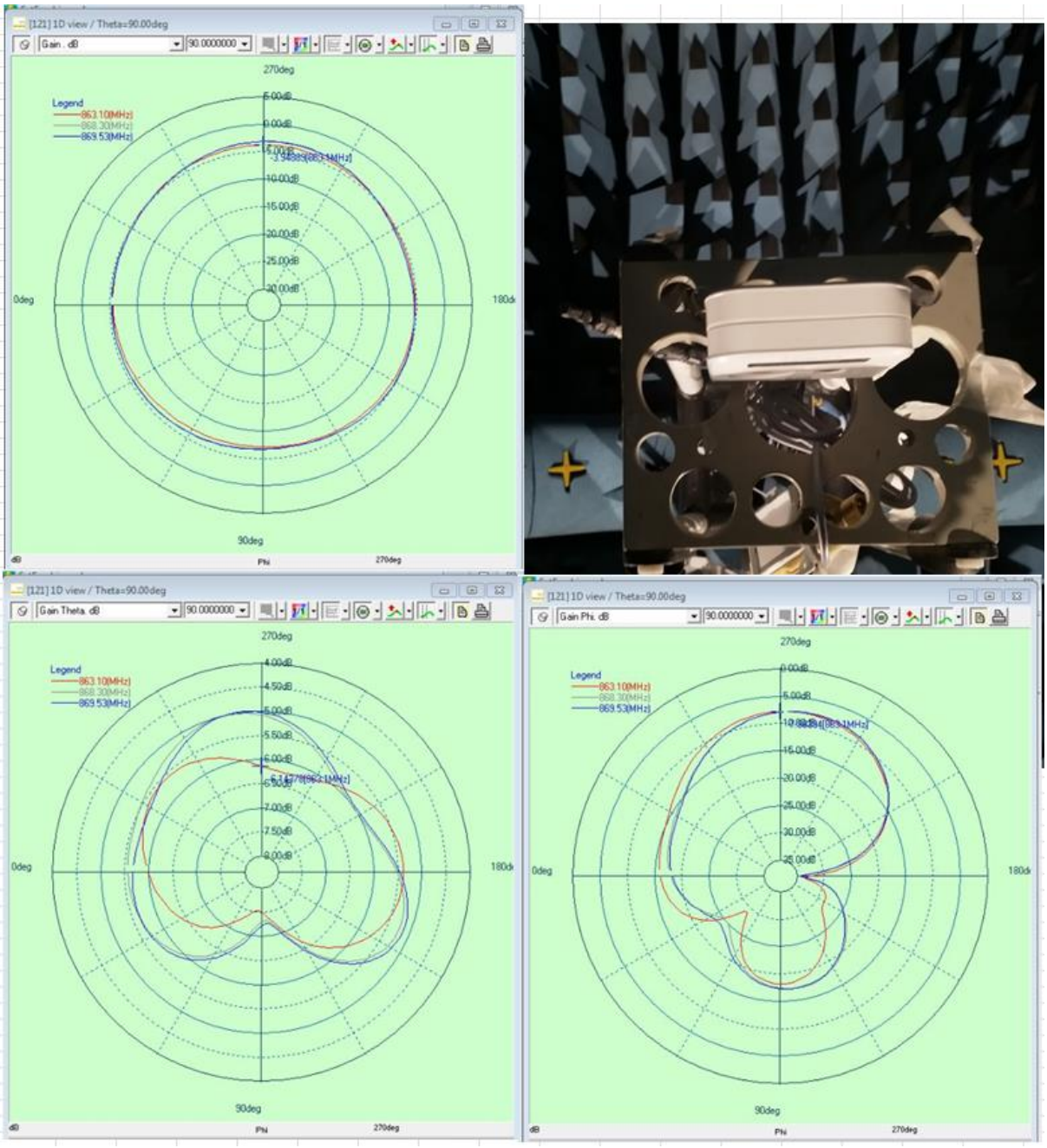
5.1.1 Antenna pattern (E1, XY)



5.1.2 Antenna pattern (E2, XZ)



5.1.3 Antenna pattern (H, YZ)



Annex A, Test equipment listing

Mfg and model/type	Description	Calibrated on	Serial	Note
Satimo Stargate 64	Antenna Chamber	07.03.2019	-	Meas. device 1
Rohde & Schwarz RSP	RF Step Attenuator	04.06.2017	826266	Meas. device 2
Rohde & Schwarz FSP	Signal Analyzer	17.04.2018	100177	Meas. device 3
Rohde & Schwarz ZVA 40	Vector Network Analyzer	20.04.2018	100143	Meas. device 4
UIYCC4550A 0.7G – 1GHz	Circulator	-	-	*
Narda 4226-10 0.5G- 18GHz	Directional Coupler	-	03654	*
Sucoflex 104	RF cables	-	-	*

* Attenuation calibrated with measurement device 4