Preliminary Note !

Viloc Tag - IMST Antenna performance test

June 2018

This document contains two separate test reports, one test was performed on June 14th 2018, the other on June 15th 2018. During this test on the 14th of June 2018 we realized that our test-firmware was not yet optimized for receiving sensitivity. We updated the firmware consequently and IMST performed a new test on the 15th of June 2018. You can find both reports below in chronological order.

Note on test set-up: Since our standard product does not support to have both a test-firmware and operational-firmware in its memory and since our built-in battery is not made for continuous wave mode and the transmission of a large amount of consequent messages, the test required us to develop specific test-firmware and hardware. The tag was modified with external wiring so we could easily reprogram and debug and also connect to an external battery. In this case we could not use a naked device (which would have been a lot simpler) since the resin we use is optimized to tune the antenna performance and thus this would have had a negative effect on the test results.

Effect of test set-up on results: Since the external wiring can have a negative effect on the antenna depending on the relative orientation to the device, we had to tweak the orientation of the wiring untill we got the least influence on the antenna. In the test of 14th of june 2018, Viloc was at IMST to overview and support in the tests and we made sure the wiring influenced the results as little as possible. In the test of 15th of june 2018, Viloc was not at IMST to assist in the measurements resulting in +-5 dBm less antenna performance. Since both TRP and TIS are important we merged the two reports into one, we expect the real TRP to be around +14 dBm and real TIS to be around -134 dBm.

LoRa Measurement Report

Report #

6180593

Characterisation of

Viloc Tag

ordered by

Viloc

performed at

IMST GMBH
LoRa Alliance Authorized Test House
Carl-Friedrich-Gauss-Str. 2-4
D-47475 Kamp-Lintfort
GERMANY

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1. Preface

The objective of the investigations was to perform Radio Performance tests of the device **Viloc Tag** for the customer **Viloc** in accordance to the relevant requirements from the latest End-Device Certification Radiated RF Performance Specification for EU 868 MHz ISM Band Devices. The measurements described in this report cover all tests necessary for the device. **The test results only relate to the items tested. This report shall not be reproduced except in full without the written approval of the IMST GmbH.**

2. Administrative Summary

Location: IMST GmbH, Test Centre, Kamp-Lintfort, Germany

Responsible Test Engineer: Yavuz Turan, Markus Ridder

Chief Test Engineer: Markus Ridder (Dept. Test Center)

Subject: Test of Radio Performance against End-Device Certification Radiated RF Performance Specification for EU 868 MHz ISM Band Devices

Customer and Contact Information: Viloc

Tested Device: Viloc Tag

Measurement Date: 14.06.2018

Firmware Version: V8.0

Hardware Version: V8.0

End-device Identifier: N/A

LoRa Device Class: A

LoRaWAN Specification Version: V1.0.2

Certification Requirements: End-Device Certification Radiated RF Performance Specification for EU 868 MHz ISM Band Devices V1.0

Frequency Band(s) tested: 863.1 MHz, 868.3 MHz, 869.525 MHz

Signatures:

Yavuz Turan
(Test Engineer)

Markus Ridder
(Chief Test Engineer)

3. Measurement and Calibration Setup

3.1. Measurement Environment

The measurements have been performed in the air conditioned and completely shielded anechoic chamber (Range II) B83117-A1431-T161 of IMST GmbH. This minimizes measurement errors caused by variations in temperature, disturbing signals and reflections. Movement of the DUT has been done by a "Roll over Azimuth" positioner. The mast that carries the roll axis is made from Kevlar. The accuracy of the azimuth positioner is 0.03°. During measurement the azimuth positioner is covered with absorbers. The distance between the measurement antenna and the rotation centre of the DUT was ca. 2.23 m during measurement (far field conditions).

Figure 3.1: IMST Anechoic Chamber (Range II) B83117-A1431-T161

3.2. Measurement Devices

All calibrations and measurements have been done with the devices that are stated in the following table. The date of the last calibration is shown in the column "Cal. Date".

Type & Manufacturer	Device	Ser. No.	Cal. Date
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Dual Ridged Horn (Measurement) Satimo	SH800 (0.8 - 12 GHz)	0077	Dec. 2013
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Dual Ridged Horn (Reference) Satimo	SH800 (0.8 - 12 GHz)	00157	Dec. 2013
Anechoic chamber Siemens Matsushita	B83117-A1431-T161	Proj. No. 007-A34-089/99A	N/A
Roll/Azimuth positioner ORBIT/FR	AL-DBDR-3G/AL-560	434	N/A
Controller ORBIT/FR	AL-4164-MC	25	N/A
Control and measurement software IMST	Daric 2.0	N/A	N/A
Rohacell Bracket	Free space mounting	N/A	N/A
LoRa Gateway Semtech	IOT SX1301 Software Version: 3.1.0	N/A	N/A
USB Programmable Step Attenuator Mini-Circuits	Rudat-6000-90 (0 - 90 dB, 0.25 dB step)	11512160027	N/A
USB Programmable RF Switch IMST	4 x 2 way RF-Switch	N/A	N/A

Table 3.1: Devices used for calibration and measurement

3.3. Calibration Setup

3.3.1. Normalized Site Attenuation

The distance between calibration and measurement antenna is ca. 2.23 m. The S_{21} of the measurement range has been measured with a calibrated network analyser. The network analyser was SOLT calibrated between Port 1 and Port 2. The normalized site attenuation (NSA) which was present during the measurement was evaluated with the following formula:

$$D_{\text{NSA}} = S_{21} - G_{\text{gain ref. ant}} \tag{1}$$

Figure 3.2 shows the calibration setup in a simplified drawing. The reference antenna is a so called "well known device" (cf. table 3.1).

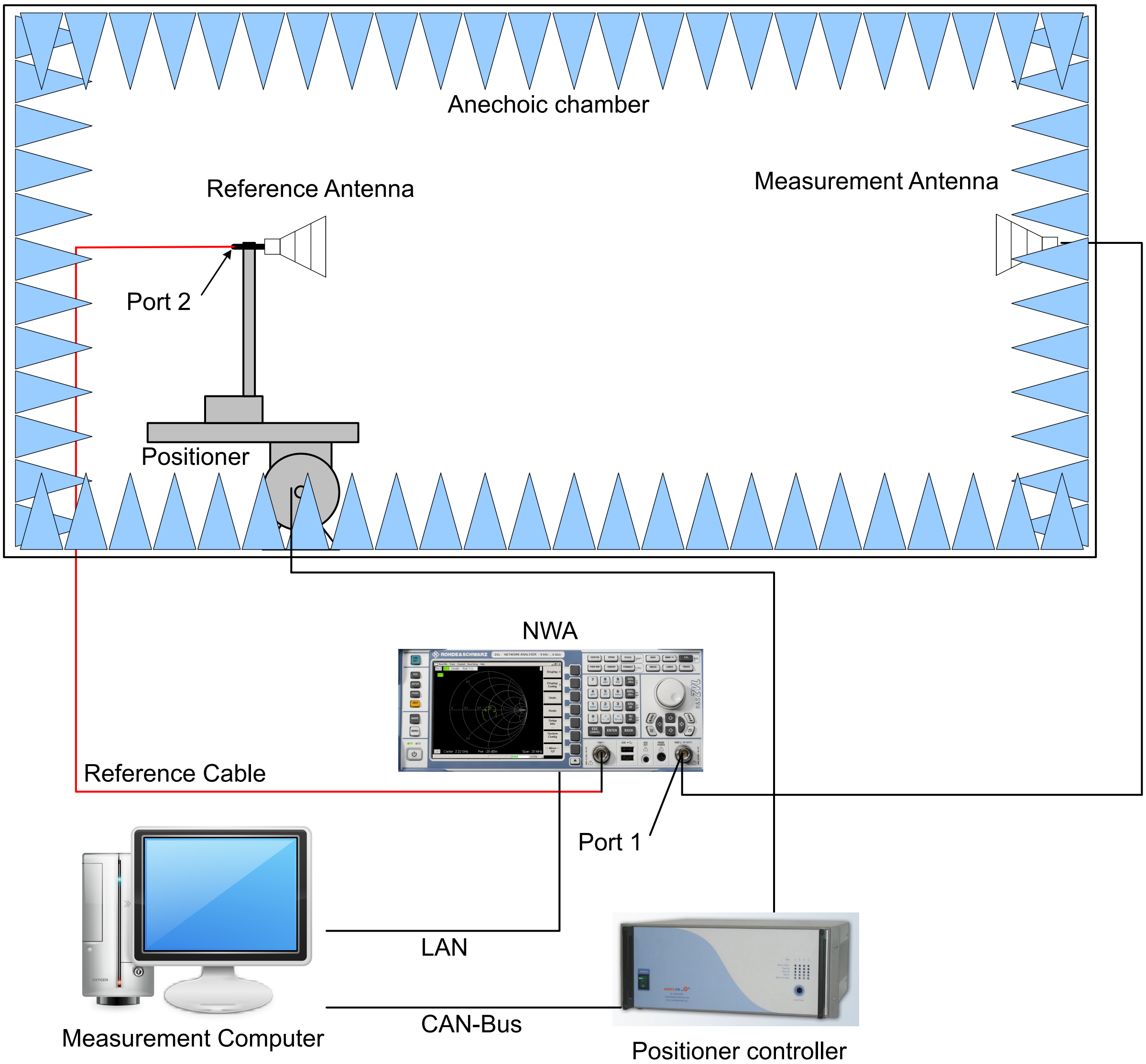


Figure 3.2: Calibrtation Setup

3.3.2. LoRa Command and Tx/Rx Switch Box

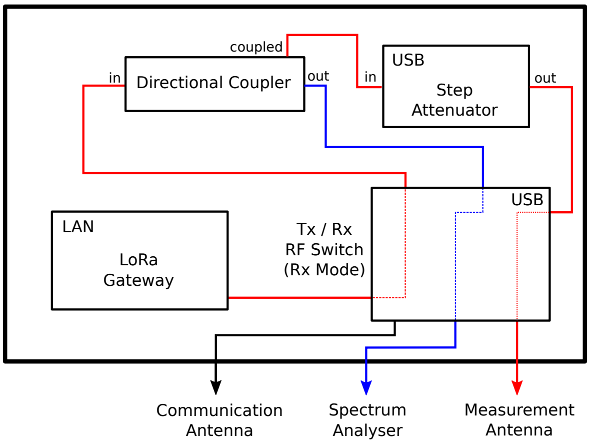
The LoRa Command and Tx/Rx Switch Box is used to switch between transmission (Tx) and receiver (Rx) performance measurement (cf. figure 3.3).

For the transmitter performance test the switch box is placed in the RF path between the Spectrum Analyser and port 1 as shown in figure 3.2. Therefore the insertion loss [$D_{\text{switch box}}$, red path in figure 3(b)] needs to be determined for calibration by using the spectrum analyser and a calibrated signal generator. A CW signal is generated with a known RF power (usually 0 dBm) and recorded as the insertion loss by the spectrum analyser. The final path loss can thus calculated to be:

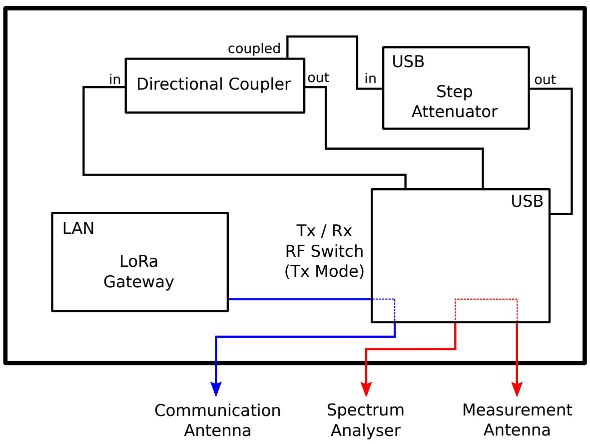
$$D_{\text{tx path loss}} = D_{\text{NSA}} + D_{\text{switch box}} \tag{2}$$

For the receiver performance measurement calibration, the builtin LoRa Gateway [cf. figure 3(b)] is set to transmit a CW signal and the spectrum analyser is used to record both the output power toward the measurment antenna (red path) with the step attenuator set to zero ($D_{\text{step attenuator}} = 0$ dB) and the spectrum analyser measurment path (blue path). The difference ($D_{\text{GW ref power}}$) is recorded and can be used to determine the RF receiver power at the DUT as follows:

$$P_{\text{DUT}} = P_{\text{measured}} + D_{\text{GW ref power}} - D_{\text{NSA}} - D_{\text{step attenuator}} \tag{3}$$



(a) **Rx** RF Switch Setting



(b) **Tx** RF Switch Setting

Figure 3.3: LoRa Command and Tx/Rx Switch Box

3.4. Measurement Setup

3.4.1. Transmitter Performance Test Setup and Calibration Results

The continuous wave mode for a specific uplink (UL) frequency is enabled by the measurement software. The EIRP has been measured as a full 3D radiation power pattern with a grid segmentation on the sphere of 15.0 ° in azimuth (theta, Θ) and 5.0 ° in roll (phi, Φ) direction.

This has been done with two polarizations (E_Θ and E_Φ) of the measurement antenna and the LoRa Switch Box set to Tx configuration. Details for the LoRa Switch Box are depictured in figure 3(b). Figure 3.4 shows the measurement setup in a simplified drawing. For all measurements the end device output power level was configured to 14 dBm. The insertion loss of the LoRa Switch Box in Tx configuration was calibrated to $D_{\text{switch box}} = 1.5$ dB. The normalized site attenuation (D_{NSA}) was calibrated for the different channels as shown in table 3.2.

Channel	Freq. (MHz)	Theta-Pol. (dB)	Phi-Pol. (dB)
LOW	863.1	35.2	35.4
MID	868.3	35.3	35.4
HIGH	869.5	35.3	35.4

Table 3.2: Normalized Site Attenuation for Transmitter Performance Measurement

The TRP/EIRP result summary can be found in table 4.1.

The TRP/EIRP uncertainty of the measurement has been specified with ± 1.5 dB.

3.4.2. Receiver Performance Test Setup and Calibration Results

The effective isotropic sensitivity (EIS) was measured for each channel at a single point in the direction of the maximum EIRP. The end device receiver performance was measured with a measurement setup as depicted in figure 3.4. For this test the LoRa Switch Box is set to Rx configuration [cf. 3(a)] and the packet error rate (PER) limit of 10 % was determined with 60 packets sent from the gateway. The gateway reference power difference was calibrated to $D_{\text{GW ref power}} = -25.2$ dB. The normalized site attenuation (D_{NSA}) was calibrated for the different channels (MID for RX1 and HIGH for RX2) as shown in table 3.2.

The TIS/EIS result summary can be found in table 4.2.

The TIS/EIS uncertainty of the measurement has been specified with ± 2 dB.

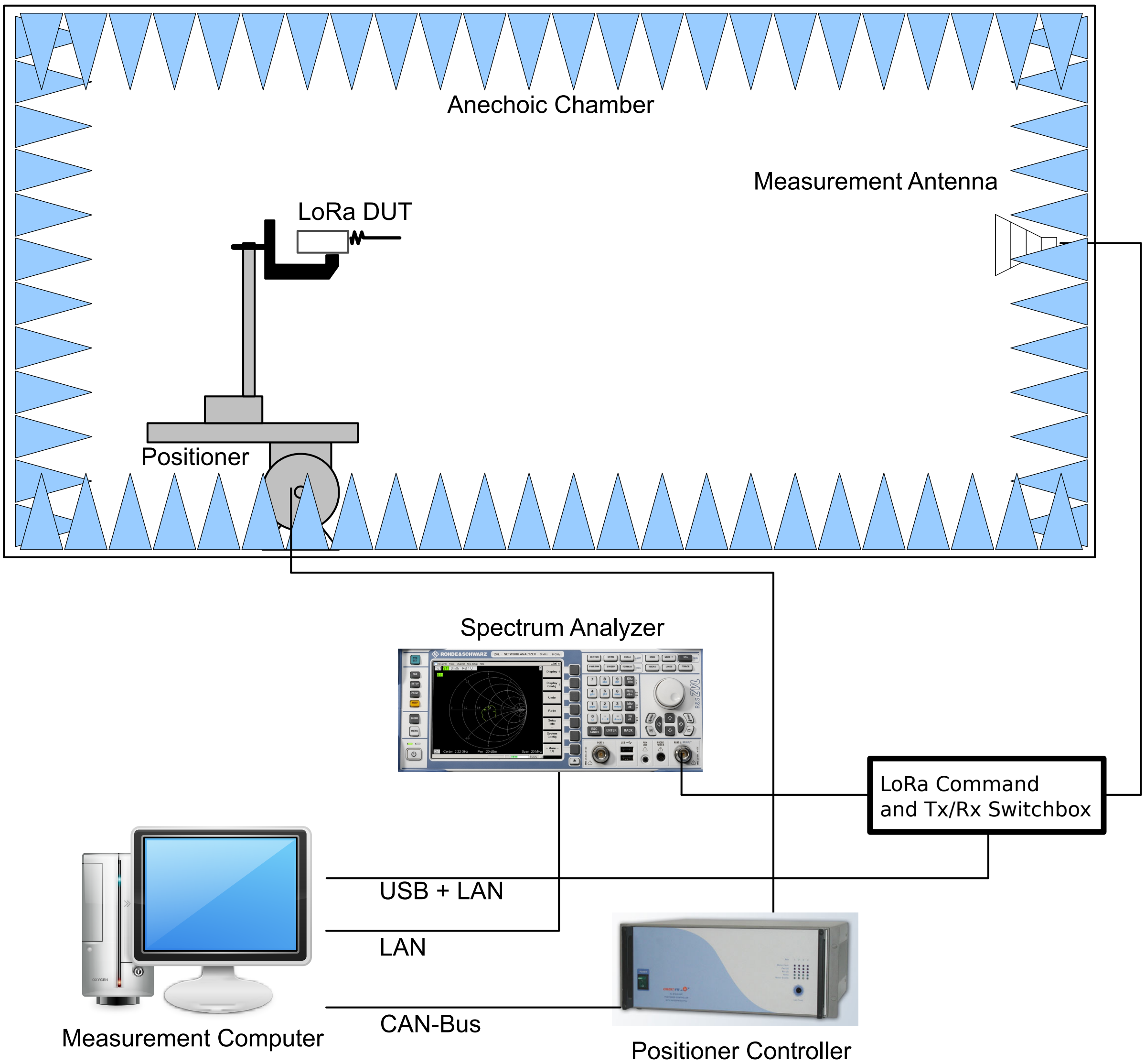


Figure 3.4: LoRa Measurement Setup

4. Measurement Results

4.1. Summary

Channel	max. EIRP (dBm) P(E^{Θ})	P(E^{Φ})	P($\|E\|$)	TRP (dBm)
LOW	18.2	8.2	18.5	15.9
MID	17.4	7.7	17.7	15.0
HIGH	17.2	7.5	17.5	14.8

Table 4.1: Tx Power Measurement Result Summary

Channel	max. EIS (dBm) S^{Θ}	S^{Φ}	S^{eff}	TIS (dBm)
RX1-SF7BW125	-91.7	-82.0	-92.0	-89.3
RX1-SF12BW125	-105.3	-95.6	-105.6	-102.9
RX2-SF7BW125	-92.1	-82.4	-92.4	-89.7
RX2-SF12BW125	-105.7	-96.0	-106.0	-103.3

Table 4.2: Rx Sensitivity Result Summary

4.2. Tx-Power for Channel: LOW

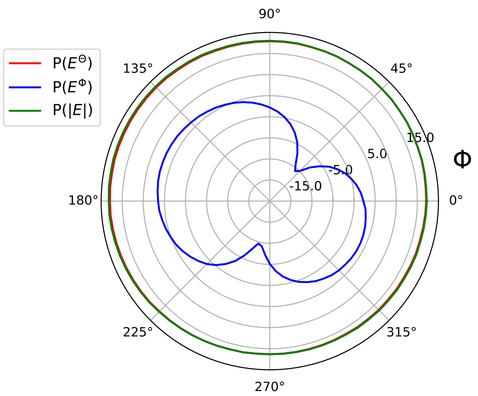
UL-Frequency: 863093070 Hz

TRP: 15.9 dBm

max. EIRP (Θ): 18.2 dBm at (Θ=105.0°, Φ=-175.0°)

max. EIRP (Φ): 8.2 dBm at (Θ=180.0°, Φ=-50.0°)

max. EIRP (abs): 18.5 dBm at (Θ=105.0°, Φ=-195.0°)



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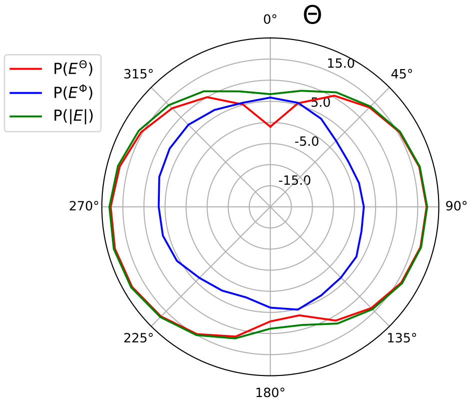

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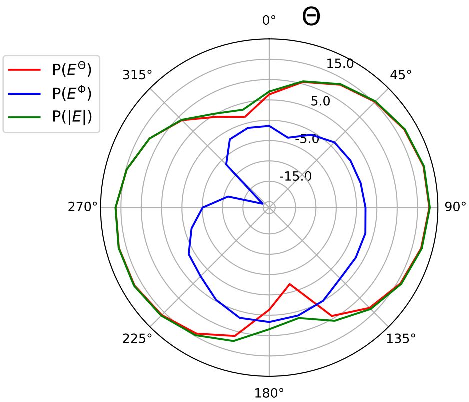


(c) yz-plane

Figure 4.1: Tx Power Measurement Results for Channel: LOW

4.3. Tx-Power for Channel: MID

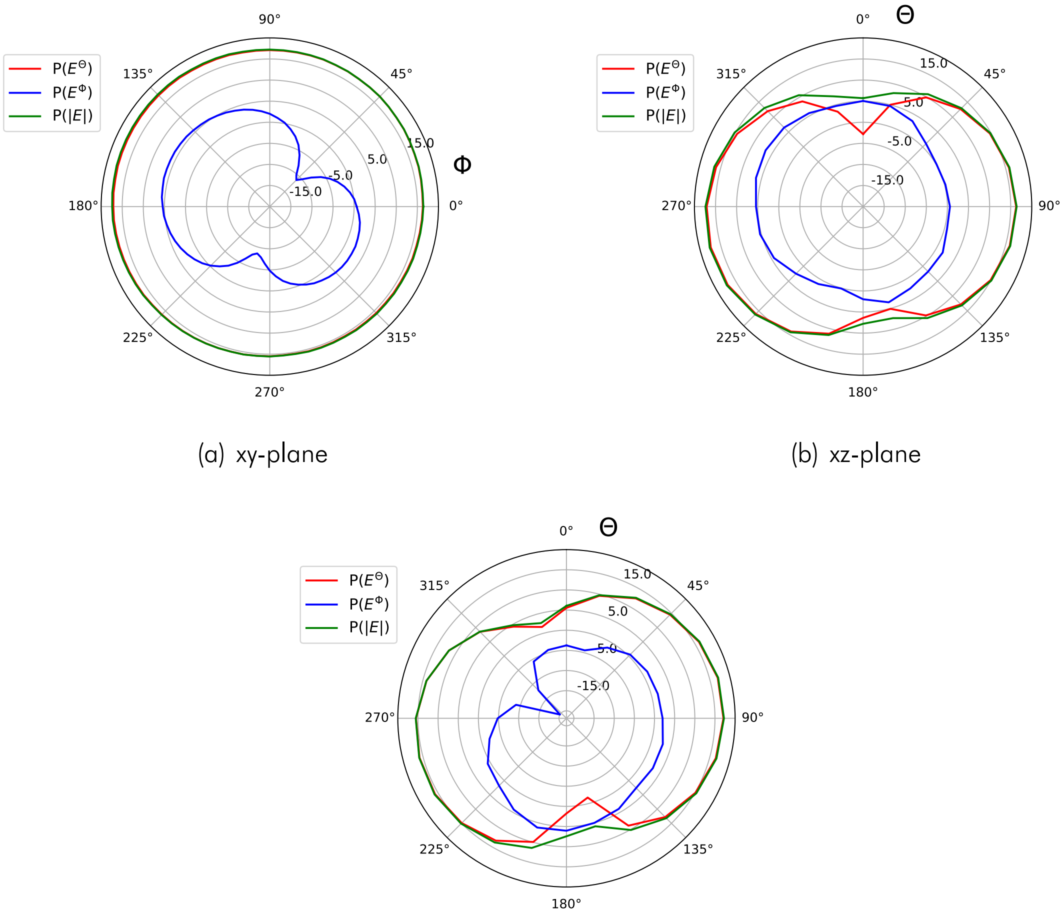
UL-Frequency: 868292740 Hz

TRP: 15.0 dBm

max. EIRP (Θ): 17.4 dBm at (Θ=105.0°, Φ=-170.0°)

max. EIRP (Φ): 7.7 dBm at (Θ=180.0°, Φ=-55.0°)

max. EIRP (abs): 17.7 dBm at (Θ=105.0°, Φ=-205.0°)



(a) xy-plane

(b) xz-plane

(c) yz-plane

Figure 4.2: Tx Power Measurement Results for Channel: MID

4.4. Tx-Power for Channel: HIGH

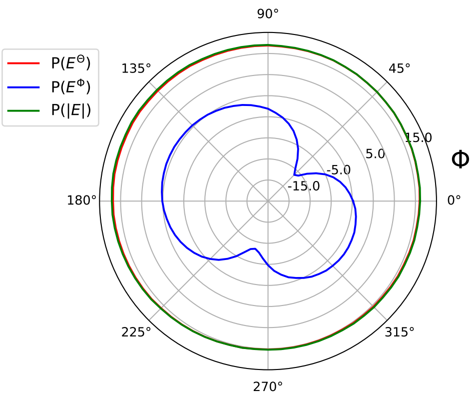
UL-Frequency: 869517740 Hz

TRP: 14.8 dBm

max. EIRP (Θ): 17.2 dBm at (Θ=105.0°, Φ=-180.0°)

max. EIRP (Φ): 7.5 dBm at (Θ=180.0°, Φ=-55.0°)

max. EIRP (abs): 17.5 dBm at (Θ=105.0°, Φ=-200.0°)



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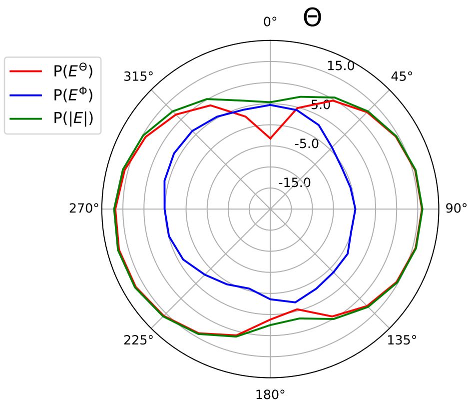

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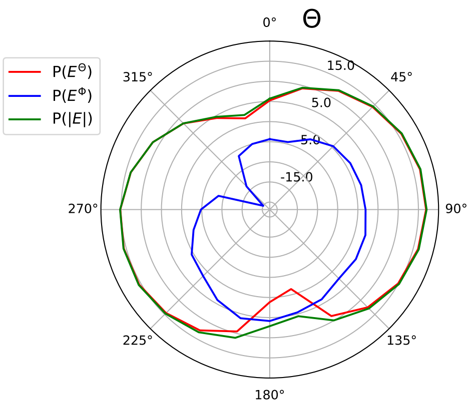


(c) yz-plane

Figure 4.3: Tx Power Measurement Results for Channel: HIGH

4.5. Sensitivity for Channel: RX1-SF7BW125

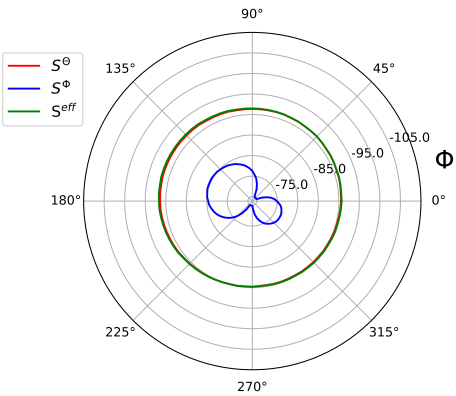
DL-Frequency: 868300000 Hz

TIS: -89.3 dBm

max. EIS (Θ): -91.7 dBm at (Θ=105.0°, Φ=-170.0°)

max. EIS (Φ): -82.0 dBm at (Θ=180.0°, Φ=-55.0°)

max. EIS (eff.): -92.0 dBm at (Θ=105.0°, Φ=-205.0°)



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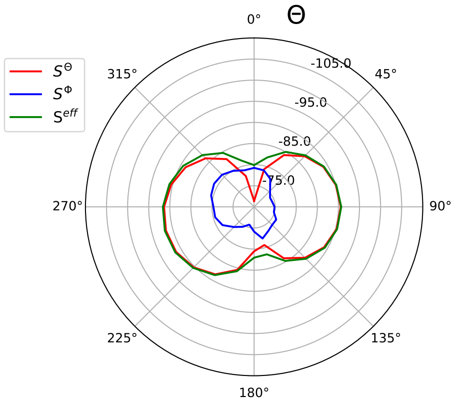

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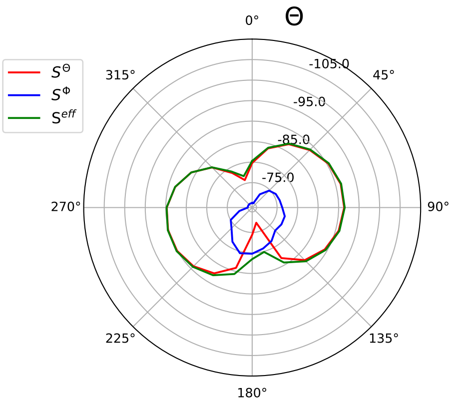


(c) yz-plane

Figure 4.4: Rx Sensitivity Results for Channel: RX1-SF7BW125

4.6. Sensitivity for Channel: RX1-SF12BW125

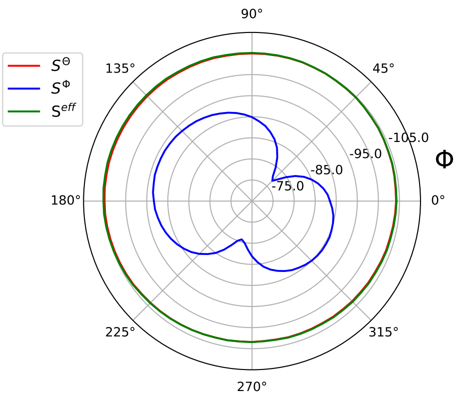
DL-Frequency: 868300000 Hz

TIS: -102.9 dBm

max. EIS (Θ): -105.3 dBm at (Θ=105.0 °, Φ=-170.0 °)

max. EIS (Φ): -95.6 dBm at (Θ=180.0 °, Φ=-55.0 °)

max. EIS (eff.): -105.6 dBm at (Θ=105.0 °, Φ=-205.0 °)



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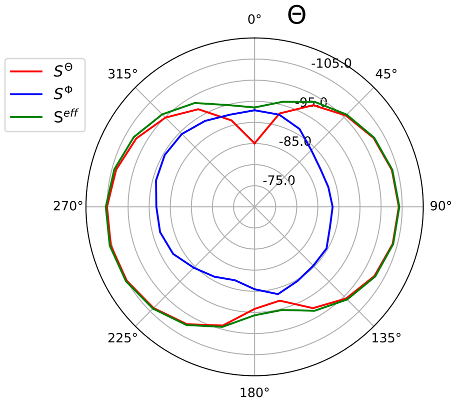

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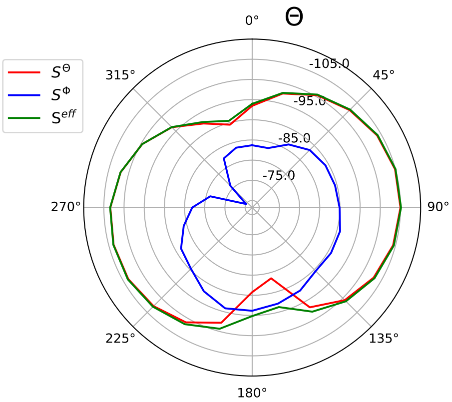


(c) yz-plane

Figure 4.5: Rx Sensitivity Results for Channel: RX1-SF12BW125

4.7. Sensitivity for Channel: RX2-SF7BW125

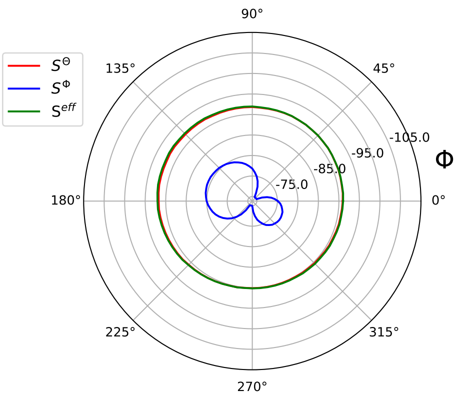
DL-Frequency: 869535000 Hz

TIS: -89.7 dBm

max. EIS (Θ): -92.1 dBm at (Θ=105.0°, Φ=-180.0°)

max. EIS (Φ): -82.4 dBm at (Θ=180.0°, Φ=-55.0°)

max. EIS (eff.): -92.4 dBm at (Θ=105.0°, Φ=-200.0°)



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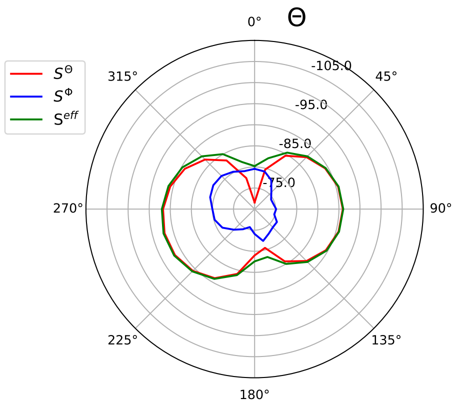

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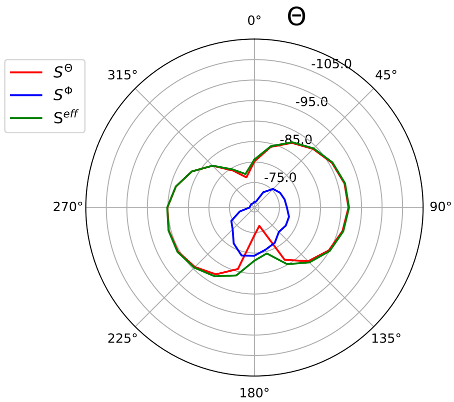


(c) yz-plane

Figure 4.6: Rx Sensitivity Results for Channel: RX2-SF7BW125

4.8. Sensitivity for Channel: RX2-SF12BW125

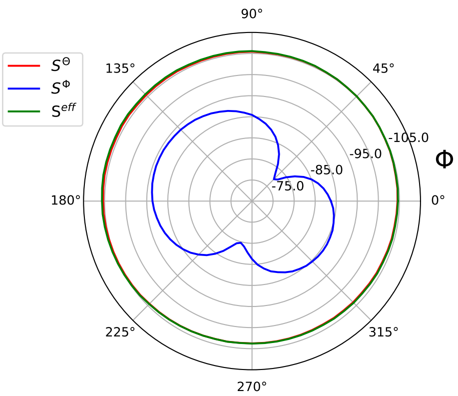
DL-Frequency: 869535000 Hz

TIS: -103.3 dBm

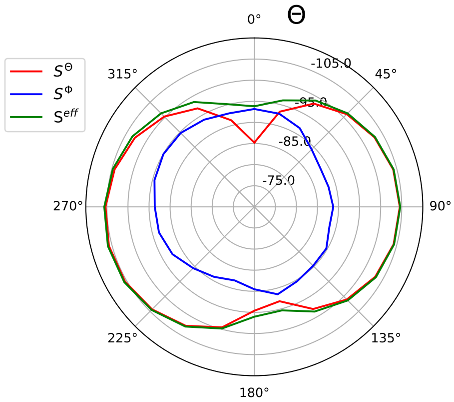
max. EIS (Θ): -105.7 dBm at (Θ=105.0°, Φ=-180.0°)

max. EIS (Φ): -96.0 dBm at (Θ=180.0°, Φ=-55.0°)

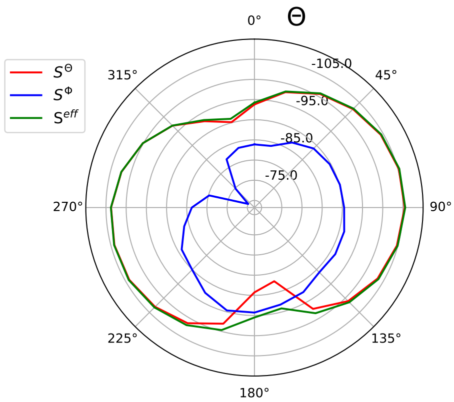
max. EIS (eff.): -106.0 dBm at (Θ=105.0°, Φ=-200.0°)



(a) xy-plane



(b) xz-plane



(c) yz-plane

Figure 4.7: Rx Sensitivity Results for Channel: RX2-SF12BW125

A. Abbreviations

EIRP	Equivalent Isotropic Radiated Power
EIS	Equivalent Isotropic Sensitivity
TRP	Total Radiated Power
TIS	Total Isotropic Sensitivity
CW	Continous Wave
NSA	Normalized Site Attenuation
RF	Radio Frequency
Rx	Receiver (Mode)
Tx	Transmitter (Mode)
UL	Uplink
DL	Downlink
SF	Spreading Factor
BW	Bandwidth

LoRa Measurement Report

Report #

6180592

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Chief Test Engineer: Markus Ridder (Dept. Test Center)

Subject: Test of Radio Performance against End-Device Certification Radiated RF Performance Specification for EU 868 MHz ISM Band Devices

Customer and Contact Information: Viloc

Tested Device: Viloc Tag

Measurement Date: 15.06.2018

Firmware Version: V8.0

Hardware Version: V8.0

End-device Identifier: N/A

LoRa Device Class: A

LoRaWAN Specification Version: V1.0.2

Certification Requirements: End-Device Certification Radiated RF Performance Specification for EU 868 MHz ISM Band Devices V1.0

Frequency Band(s) tested: 863.1 MHz, 868.3 MHz, 869.525 MHz

Signatures:

Yavuz Turan
(Test Engineer)

Markus Ridder
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Figure 3.1: IMST Anechoic Chamber (Range II) B83117-A1431-T161

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Anechoic chamber Siemens Matsushita	B83117-A1431-T161	Proj. No. 007-A34-089/99A	N/A
Roll/Azimuth positioner ORBIT/FR	AL-DBDR-3G/AL-560	434	N/A
Controller ORBIT/FR	AL-4164-MC	25	N/A
Control and measurement software IMST	Daric 2.0	N/A	N/A
Rohacell Bracket	Free space mounting	N/A	N/A
LoRa Gateway Semtech	IOT SX1301 Software Version: 3.1.0	N/A	N/A
USB Programmable Step Attenuator Mini-Circuits	Rudat-6000-90 (0 - 90 dB, 0.25 dB step)	11512160027	N/A
USB Programmable RF Switch IMST	4 x 2 way RF-Switch	N/A	N/A

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$$D_{\text{NSA}} = S_{21} - G_{\text{gain ref. ant}} \tag{1}$$

Figure 3.2 shows the calibration setup in a simplified drawing. The reference antenna is a so called "well known device" (cf. table 3.1).

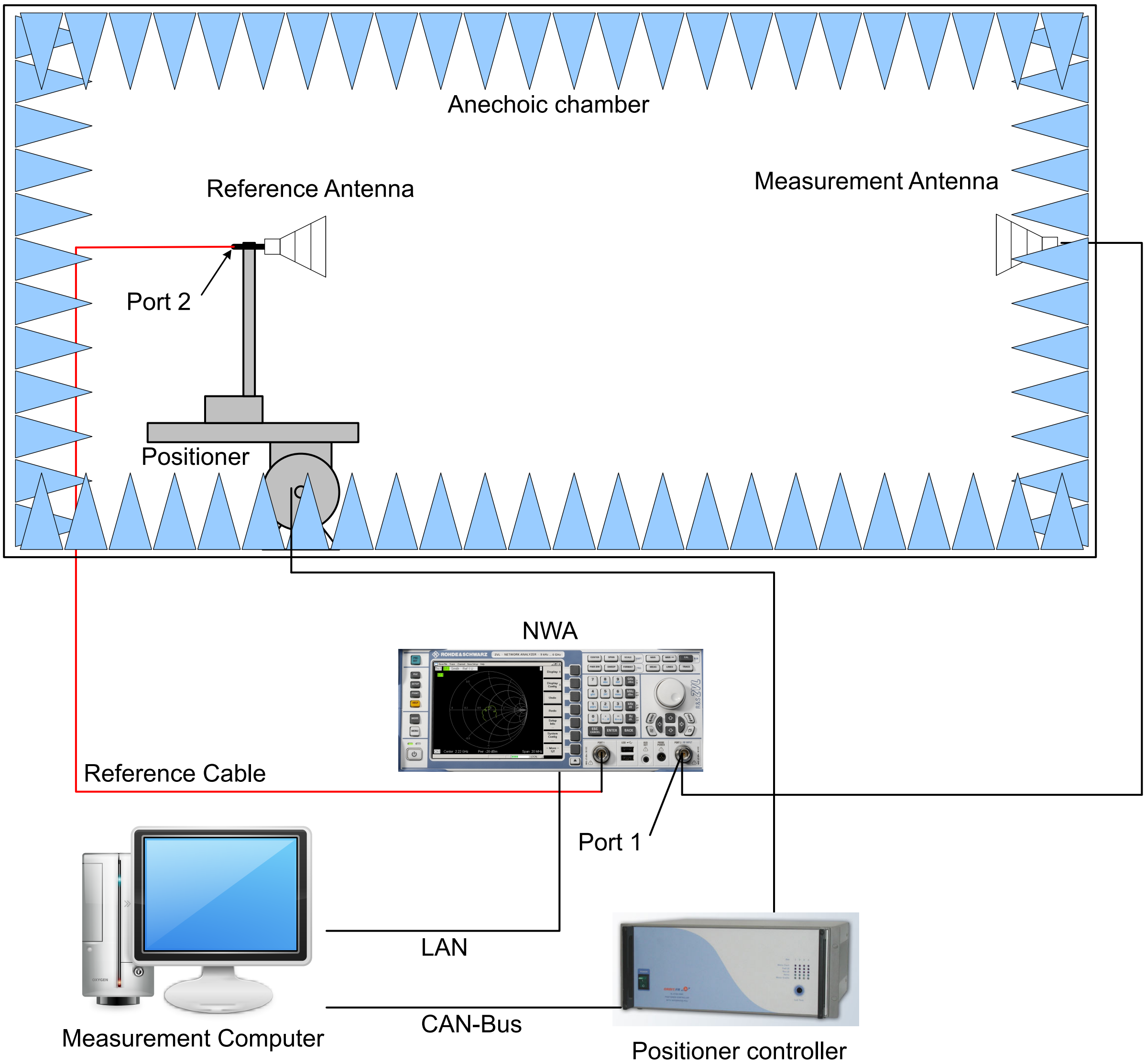


Figure 3.2: Calibrtation Setup

3.3.2. LoRa Command and Tx/Rx Switch Box

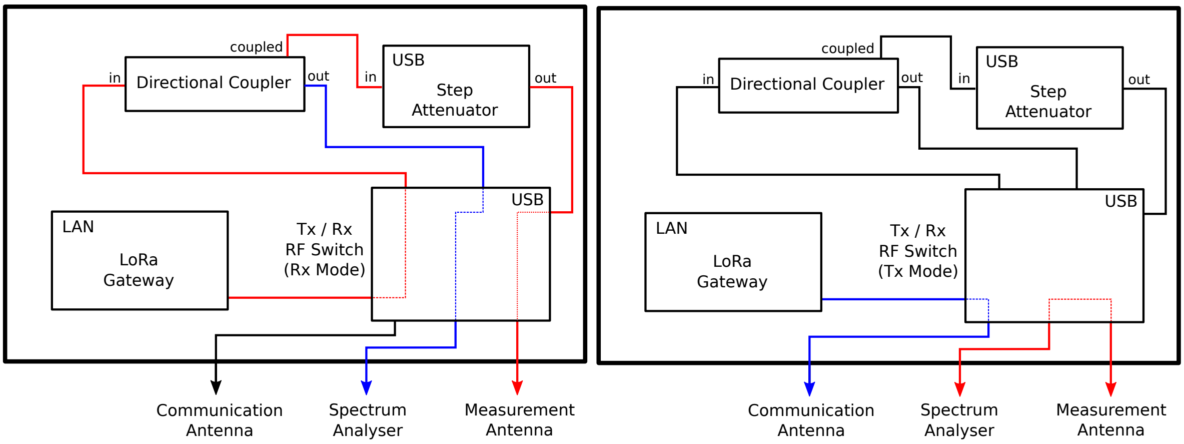
The LoRa Command and Tx/Rx Switch Box is used to switch between transmission (Tx) and receiver (Rx) performance measurement (cf. figure 3.3).

For the transmitter performance test the switch box is placed in the RF path between the Spectrum Analyser and port 1 as shown in figure 3.2. Therefore the insertion loss [$D_{\text{switch box}}$, red path in figure 3(b)] needs to be determined for calibration by using the spectrum analyser and a calibrated signal generator. A CW signal is generated with a known RF power (usually 0 dBm) and recorded as the insertion loss by the spectrum analyser. The final path loss can thus calculated to be:

$$D_{\text{tx path loss}} = D_{\text{NSA}} + D_{\text{switch box}} \tag{2}$$

For the receiver performance measurement calibration, the builtin LoRa Gateway [cf. figure 3(b)] is set to transmit a CW signal and the spectrum analyser is used to record both the output power toward the measurment antenna (red path) with the step attenuator set to zero ($D_{\text{step attenuator}} = 0$ dB) and the spectrum analyser measurment path (blue path). The difference ($D_{\text{GW ref power}}$) is recorded and can be used to determine the RF receiver power at the DUT as follows:

$$P_{\text{DUT}} = P_{\text{measured}} + D_{\text{GW ref power}} - D_{\text{NSA}} - D_{\text{step attenuator}} \tag{3}$$



(a) **Rx** RF Switch Setting (b) **Tx** RF Switch Setting

Figure 3.3: LoRa Command and Tx/Rx Switch Box

3.4. Measurement Setup

3.4.1. Transmitter Performance Test Setup and Calibration Results

The continuous wave mode for a specific uplink (UL) frequency is enabled by the measurement software. The EIRP has been measured as a full 3D radiation power pattern with a grid segmentation on the sphere of 15.0° in azimuth (theta, Θ) and 5.0° in roll (phi, Φ) direction.

This has been done with two polarizations (E_Θ and E_Φ) of the measurement antenna and the LoRa Switch Box set to Tx configuration. Details for the LoRa Switch Box are depictured in figure 3(b). Figure 3.4 shows the measurement setup in a simplified drawing. For all measurements the end device output power level was configured to 14 dBm. The insertion loss of the LoRa Switch Box in Tx configuration was calibrated to $D_{\text{switch box}} = 1.5$ dB. The normalized site attenuation (D_{NSA}) was calibrated for the different channels as shown in table 3.2.

Channel	Freq. (MHz)	Theta-Pol. (dB)	Phi-Pol. (dB)
LOW	863.1	35.2	35.4
MID	868.3	35.3	35.4
HIGH	869.5	35.3	35.4

Table 3.2: Normalized Site Attenuation for Transmitter Performance Measurement

The TRP/EIRP result summary can be found in table 4.1.

The TRP/EIRP uncertainty of the measurement has been specified with ± 1.5 dB.

3.4.2. Receiver Performance Test Setup and Calibration Results

The effective isotropic sensitivity (EIS) was measured for each channel at a single point in the direction of the maximum EIRP. The end device receiver performance was measured with a measurement setup as depicted in figure 3.4. For this test the LoRa Switch Box is set to Rx configuration [cf. 3(a)] and the packet error rate (PER) limit of 10 % was determined with 60 packets sent from the gateway. The gateway reference power difference was calibrated to $D_{\text{GW ref power}} = -25.2$ dB. The normalized site attenuation (D_{NSA}) was calibrated for the different channels (MID for RX1 and HIGH for RX2) as shown in table 3.2.

The TIS/EIS result summary can be found in table 4.2.

The TIS/EIS uncertainty of the measurement has been specified with ± 2 dB.

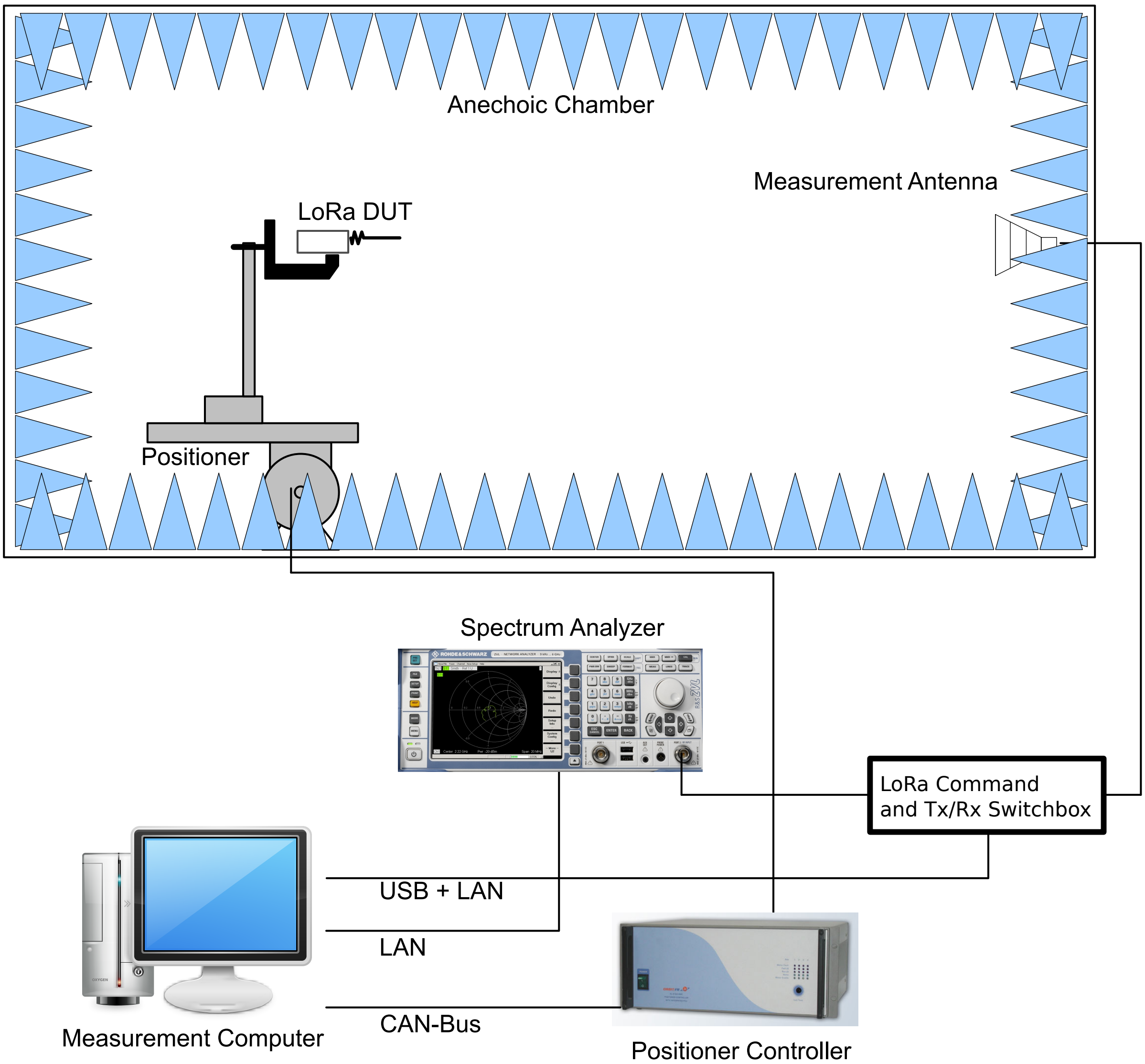


Figure 3.4: LoRa Measurement Setup

4. Measurement Results

4.1. Summary

Channel	max. EIRP (dBm)			TRP (dBm)
	P(E^{Θ})	P(E^{Φ})	P($\lvert E \rvert$)	
LOW	12.3	11.4	13.5	10.5
MID	11.3	10.5	12.7	9.6
HIGH	10.8	10.0	12.2	9.1

Table 4.1: Tx Power Measurement Result Summary

Channel	max. EIS (dBm)			TIS (dBm)
	S^{Θ}	S^{Φ}	S^{eff}	
RX1-SF7BW125	-117.2	-116.4	-118.6	-115.5
RX1-SF12BW125	-131.5	-130.7	-132.9	-129.8
RX2-SF12BW125	-131.0	-130.2	-132.3	-129.3

Table 4.2: Rx Sensitivity Result Summary

4.2. Tx-Power for Channel: LOW

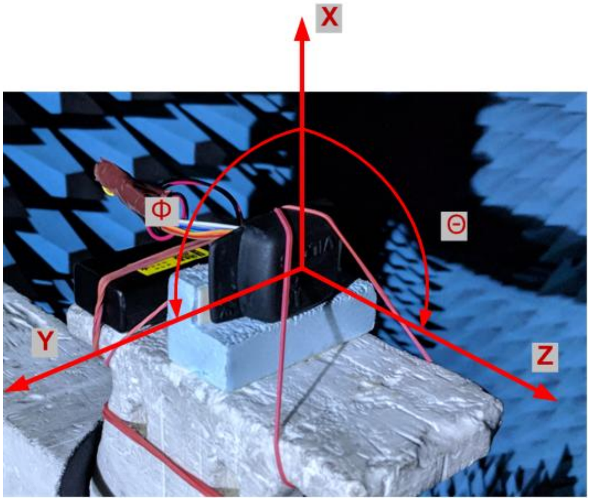
UL-Frequency: 863092740 Hz

TRP: 10.5 dBm

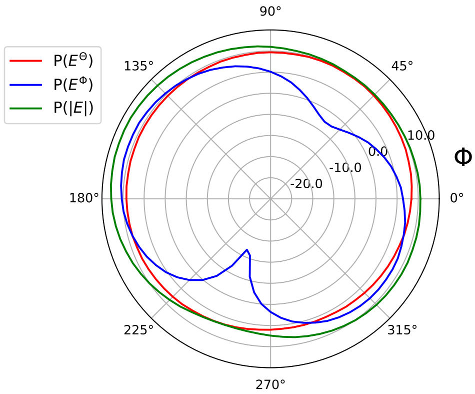
max. EIRP (Θ): 12.3 dBm at (Θ=150.0°, Φ=-105.0°)

max. EIRP (Φ): 11.4 dBm at (Θ=60.0°, Φ=-190.0°)

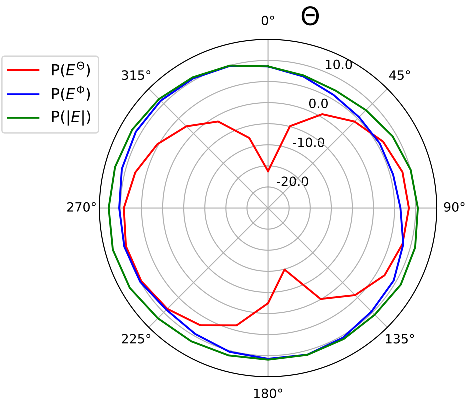
max. EIRP (abs): 13.5 dBm at (Θ=75.0°, Φ=-210.0°)



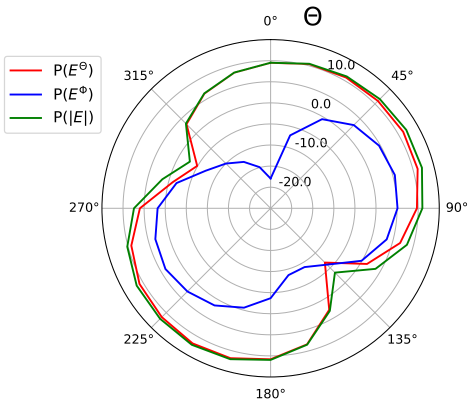
(a) Device under Test



(b) xy-plane



(c) xz-plane



(d) yz-plane

Figure 4.1: Tx Power Measurement Results for Channel: LOW

4.3. Tx-Power for Channel: MID

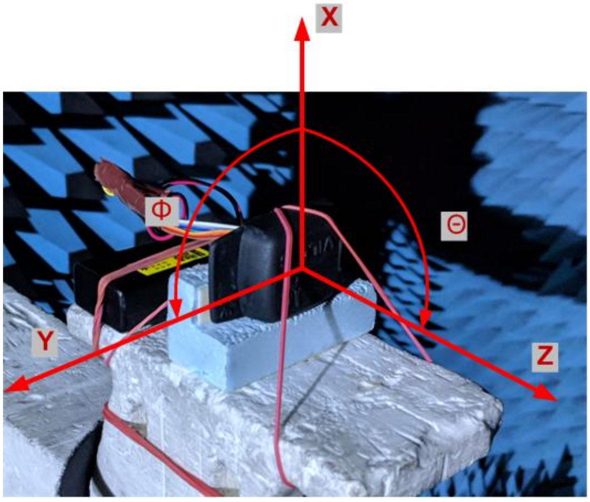
UL-Frequency: 868292410 Hz

TRP: 9.6 dBm

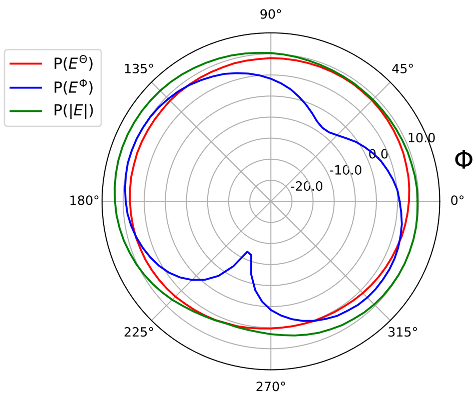
max. EIRP (Θ): 11.3 dBm at (Θ=150.0°, Φ=-105.0°)

max. EIRP (Φ): 10.5 dBm at (Θ=60.0°, Φ=-195.0°)

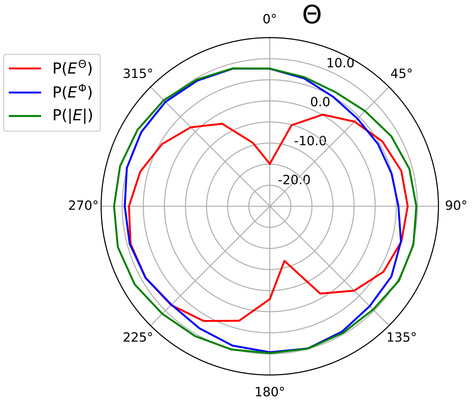
max. EIRP (abs): 12.7 dBm at (Θ=75.0°, Φ=-215.0°)



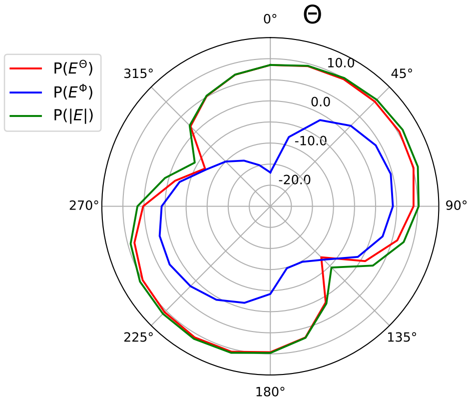
(a) Device under Test



(b) xy-plane



(c) xz-plane



(d) yz-plane

Figure 4.2: Tx Power Measurement Results for Channel: MID

4.4. Tx-Power for Channel: HIGH

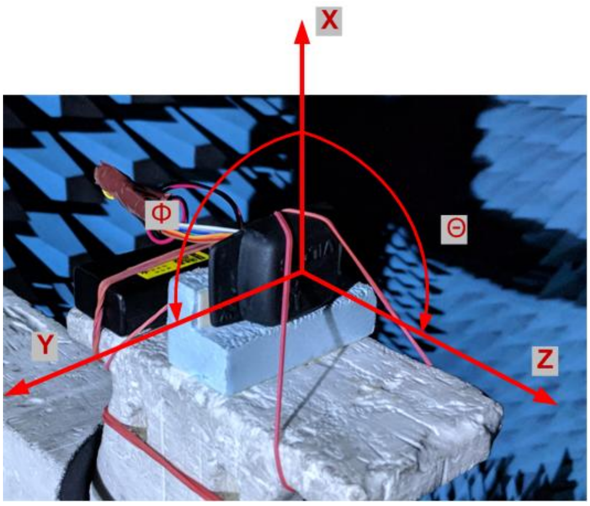
UL-Frequency: 869517300 Hz

TRP: 9.1 dBm

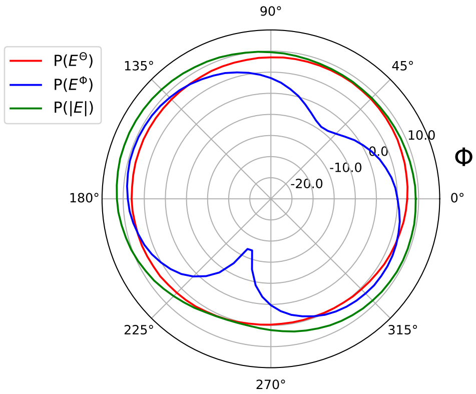
max. EIRP (Θ): 10.8 dBm at (Θ=150.0 °, Φ=-105.0 °)

max. EIRP (Φ): 10.0 dBm at (Θ=60.0 °, Φ=-195.0 °)

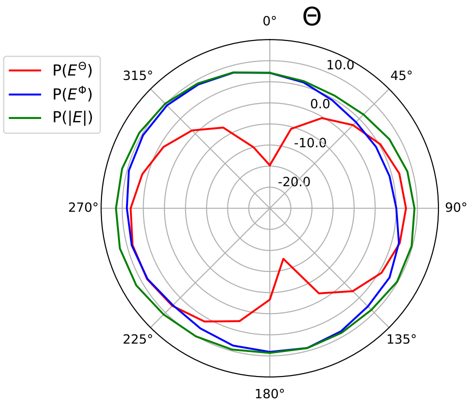
max. EIRP (abs): 12.2 dBm at (Θ=75.0 °, Φ=-215.0 °)



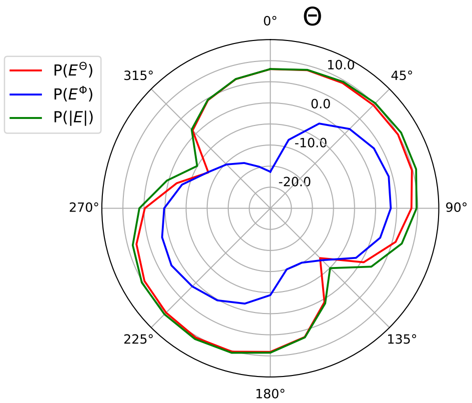
(a) Device under Test



(b) xy-plane



(c) xz-plane



(d) yz-plane

Figure 4.3: Tx Power Measurement Results for Channel: HIGH

4.5. Sensitivity for Channel: RX1-SF7BW125

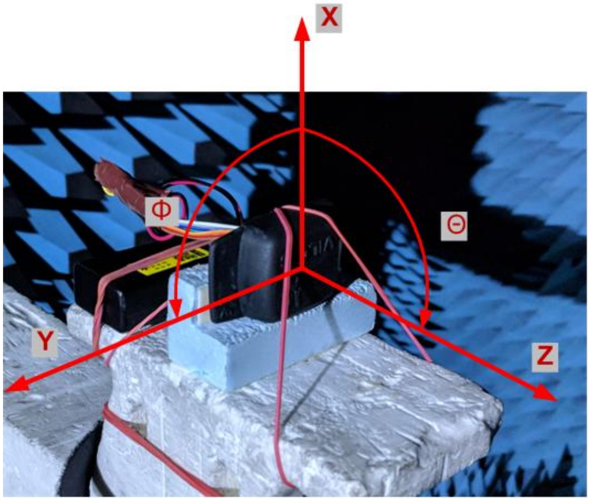
DL-Frequency: 868300000 Hz

TIS: -115.5 dBm

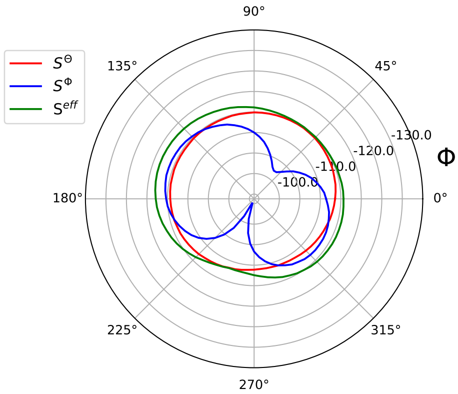
max. EIS (Θ): -117.2 dBm at (Θ=150.0°, Φ=-105.0°)

max. EIS (Φ): -116.4 dBm at (Θ=60.0°, Φ=-195.0°)

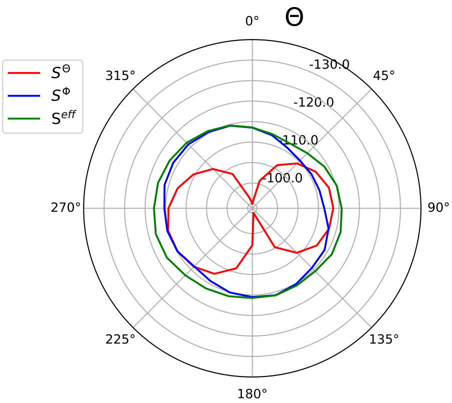
max. EIS (eff.): -118.6 dBm at (Θ=75.0°, Φ=-215.0°)



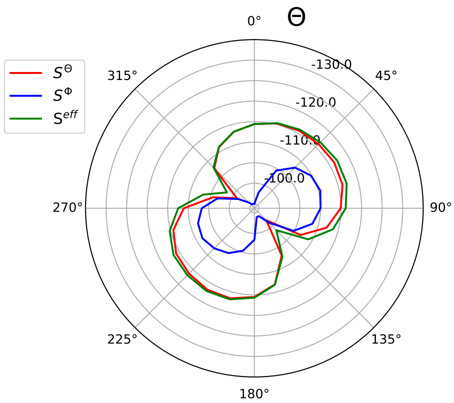
(a) Device under Test



(b) xy-plane



(c) xz-plane



(d) yz-plane

Figure 4.4: Rx Sensitivity Results for Channel: RX1-SF7BW125

4.6. Sensitivity for Channel: RX1-SF12BW125

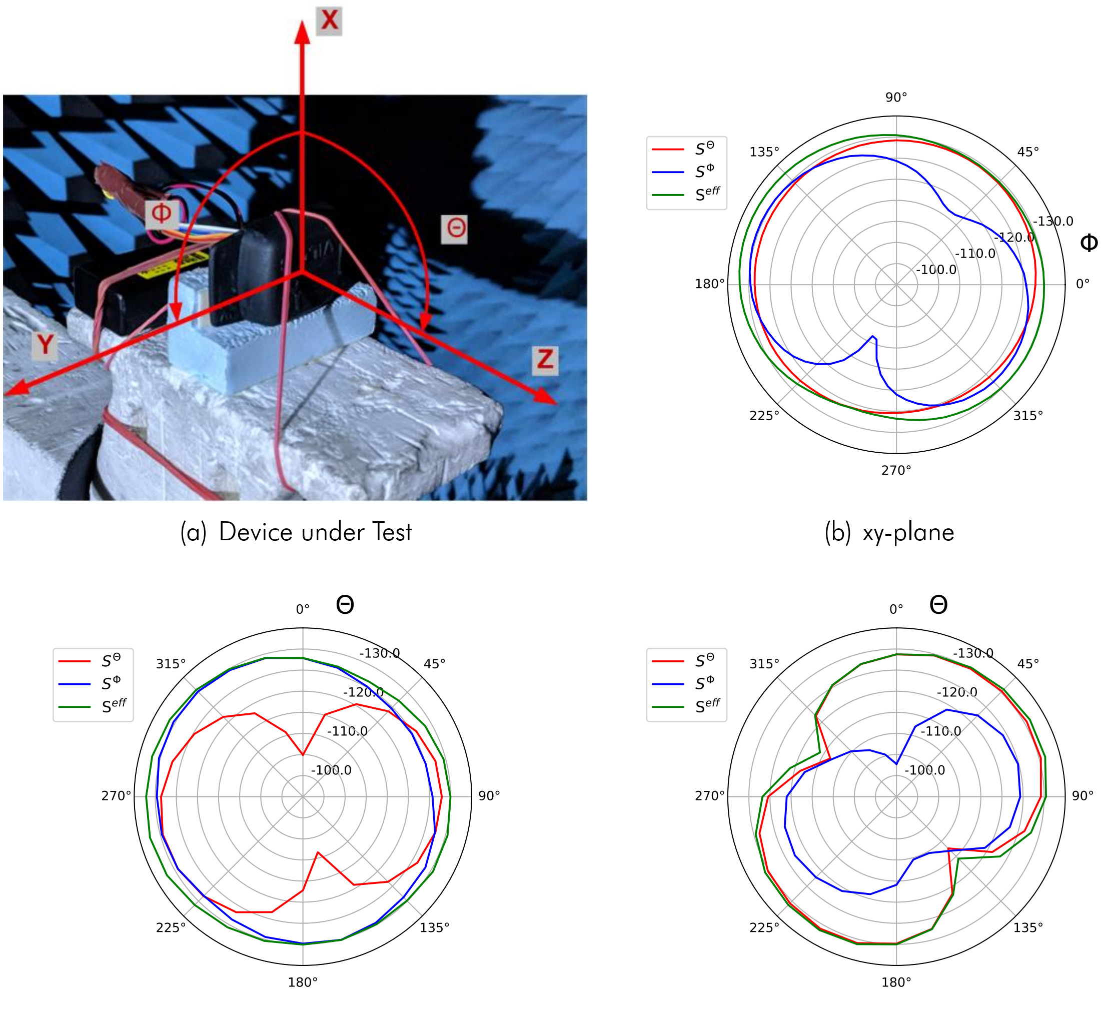
DL-Frequency: 868300000 Hz

TIS: -129.8 dBm

max. EIS (Θ): -131.5 dBm at (Θ=150.0°, Φ=-105.0°)

max. EIS (Φ): -130.7 dBm at (Θ=60.0°, Φ=-195.0°)

max. EIS (eff.): -132.9 dBm at (Θ=75.0°, Φ=-215.0°)



(a) Device under Test

(b) xy-plane

(c) xz-plane

(d) yz-plane

Figure 4.5: Rx Sensitivity Results for Channel: RX1-SF12BW125

4.7. Sensitivity for Channel: RX2-SF12BW125

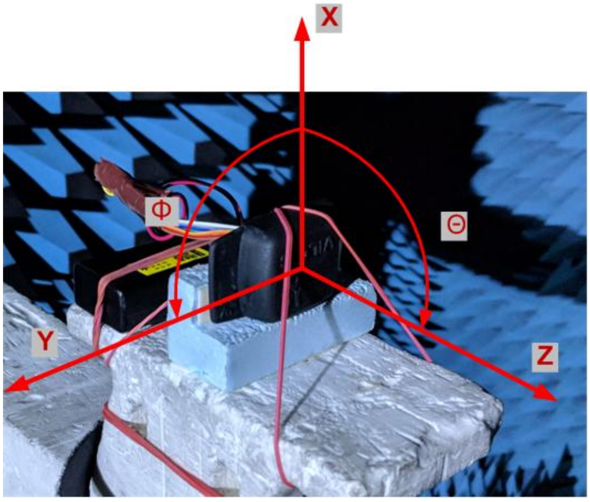
DL-Frequency: 869535000 Hz

TIS: -129.3 dBm

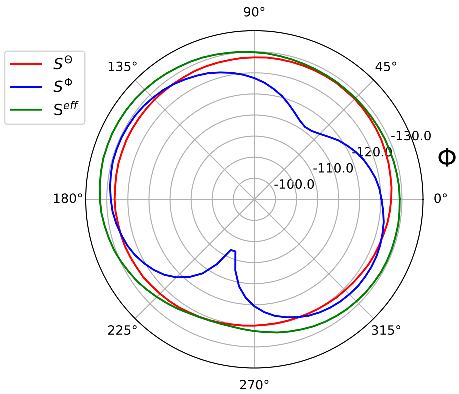
max. EIS (Θ): -131.0 dBm at (Θ=150.0°, Φ=-105.0°)

max. EIS (Φ): -130.2 dBm at (Θ=60.0°, Φ=-195.0°)

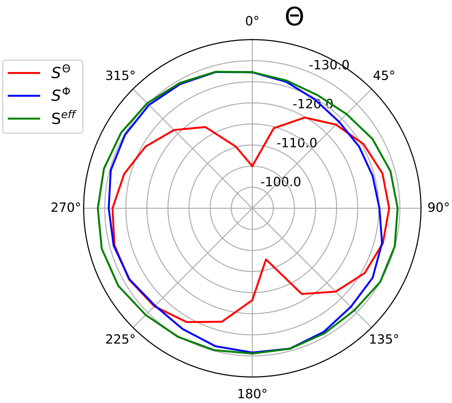
max. EIS (eff.): -132.3 dBm at (Θ=75.0°, Φ=-215.0°)



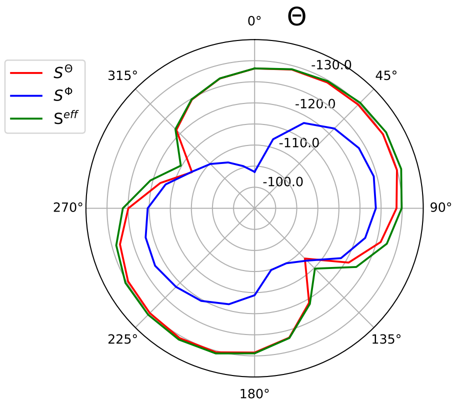
(a) Device under Test



(b) xy-plane



(c) xz-plane



(d) yz-plane

Figure 4.6: Rx Sensitivity Results for Channel: RX2-SF12BW125

A. Abbreviations

EIRP	Equivalent Isotropic Radiated Power
EIS	Equivalent Isotropic Sensitivity
TRP	Total Radiated Power
TIS	Total Isotropic Sensitivity
CW	Continous Wave
NSA	Normalized Site Attenuation
RF	Radio Frequency
Rx	Receiver (Mode)
Tx	Transmitter (Mode)
UL	Uplink
DL	Downlink
SF	Spreading Factor
BW	Bandwidth