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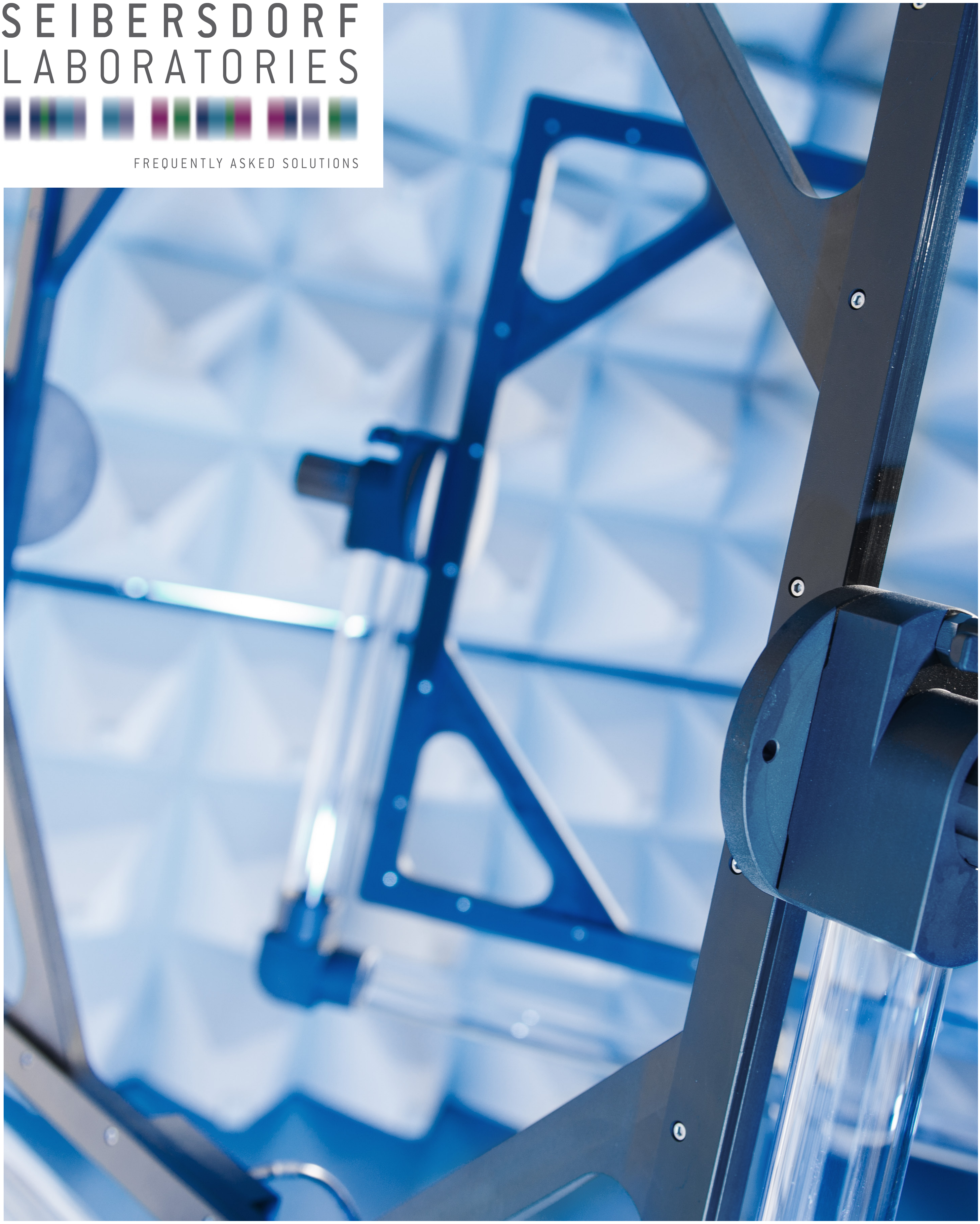

MANUAL

PLA - PRECISION LOOP ANTENNA

SEIBERSDORF LABORATORIES

E M C & O P T I C S

MANUAL
PLA – Precision Loop Antenna

PLA-R	Receive Antenna
PLA-T	Transmit Antenna
PLA-TC	Transmit Antenna Control Unit
PLA-GD	Ground Loop Decoupling Unit

Applications for radiated emission testing and Site Validation

20.06.2018
Version 1.0

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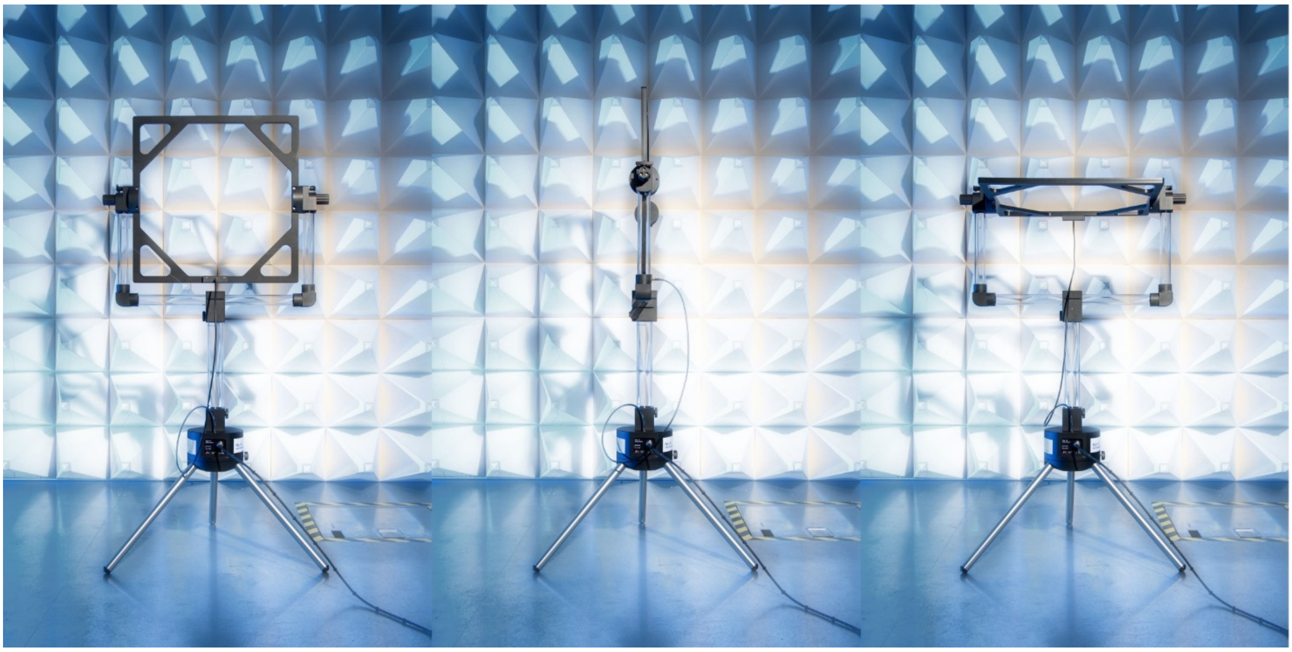
1. Introduction

The **P**recision **L**oop **A**ntennas (PLA) were developed by Seibersdorf Laboratories due to industry demand for an EMC test site validation system below 30 MHz and a radiated emission test antenna for 9 kHz – 30 MHz with automated overload (saturation) indication in the test software.



Active **receive** antennas for this frequency range are available since many decades but they all lack of a convenient overload indication which makes them unsuitable for fully automated tests. Design goal was a battery powered active receive antenna that detects overload of the preamplifier on all wave shapes of the RF signals and indicates this on the RF-output in a way that fully automated tests with state of the art EMI-receivers are possible (patented).

For the site validation in the frequency range 9 kHz – 30 MHz additionally a battery powered active **transmit** antenna was designed. The antenna stand integrates laser pointers for easy positioning and adjustment.

This manual describes in detail the application of the PLA for disturbance testing and site validation.

Technical specifications of the antennas are presented.

2. Description of the Antennas

The PLA is an active antenna system covering the frequency range 9 kHz to 30 MHz which comes in two versions for transmit and receive operation.

PLA-R system for receiving signals

PLA-T system for transmitting signals

Both antennas can be operated in passive mode (without amplifier) as well.

In **Figure 1** the PLA-R and PLA-T is shown. Each antenna consists of the amplifier box which forms a tripod and the loop antenna which can be oriented in three orthogonal directions.

Both antennas are equipped with a laser alignment system for easy and convenient setup of the antennas.

The size and shape of both antennas are identical; they differ only in the amplifier box.

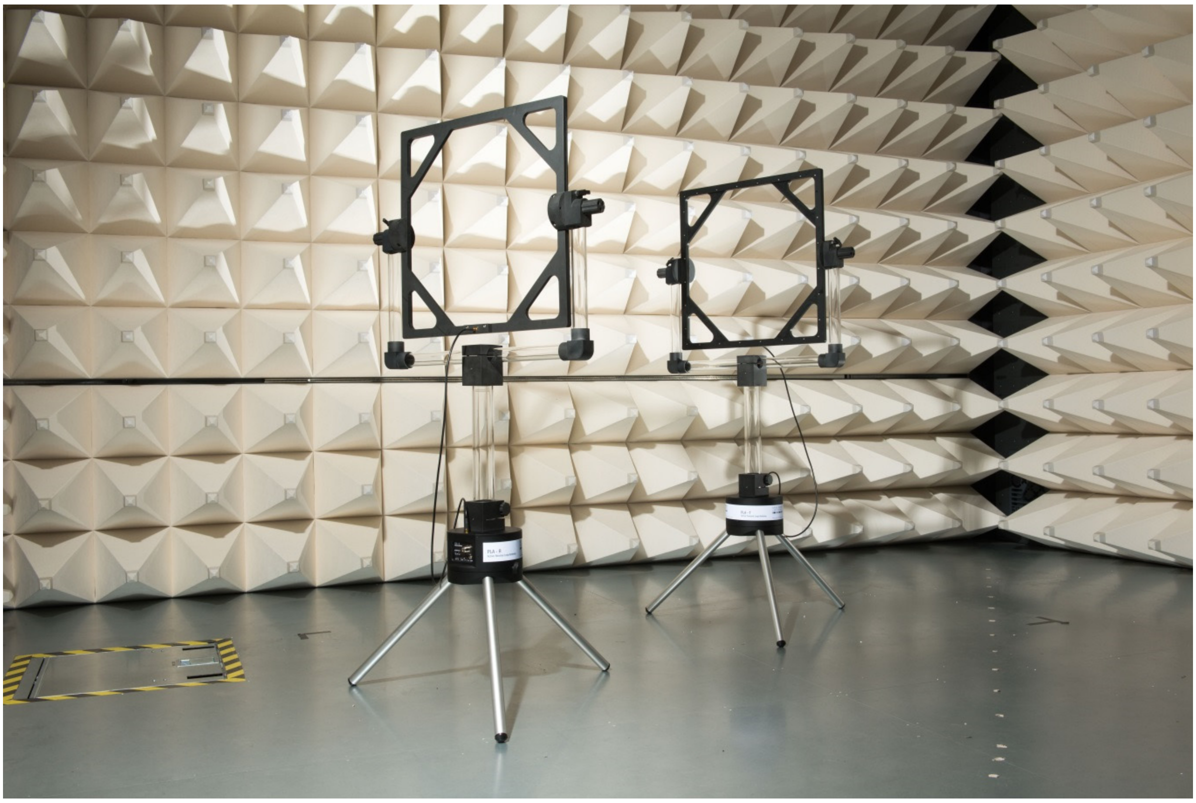


Figure 1: Transmit and Receive PLA at work

2.1. PLA-R Receive Antenna

The receive antenna (PLA-R) operation elements are shown in **Figure 2**. When the power is switched OFF, the middle position of the toggle switch, the system operates in passive mode.

The left position of the toggle switch, ON, sets the antenna into active mode.

In position LAS, the right position of the toggle switch, the laser alignment system is turned on. More information about the laser alignment system can be found in chapter 4.4.

Figure 2: PLA-R amplifier box

A second toggle switch is used to turn ON and OFF the pulse generator. The third position TEST is used to test is the detector works reliable.

There are two LEDs to show the status of the overload detection. ACT indicates that the overload detector is armed. If the detector recognises overload the SAT LED will light up.

Three POWER LEDs indicate the state of the battery. Normal state (charged) is indicated by green colour. In state yellow operation is still possible, but a soon recharge is recommended. If the red LED is light up, further operation is impossible and immediate recharge is required.

The amplifier box of the PLA-R antenna consists of an amplifier (Amp), an overload detector (OL) and a pulse generator (PG), see **Figure 3**. If the antenna is operating in passive mode, **Figure 3**(a), the signal of the antenna is routed directly to the output connector.
In active mode, **Figure 3**(b), the signal magnitude is increased by the amplifier. If the input signal becomes too large the amplifier will be saturated. To prevent this, the overload detector will observe the output signal of the amplifier. If the overload indicator is active, a pulsed signal will be routed to the output, **Figure 4**(a). This strong wideband signal will force the attached EMI-receiver into overload.
To test if the detections works reliable, the test mode is foreseen, see **Figure 4**(b). This is required as the overload detection of the EMI receiver depends on the bandwidth and input attenuator settings. More information to test the reliability of the overload detection if found in chapter 6.3.

a) b)

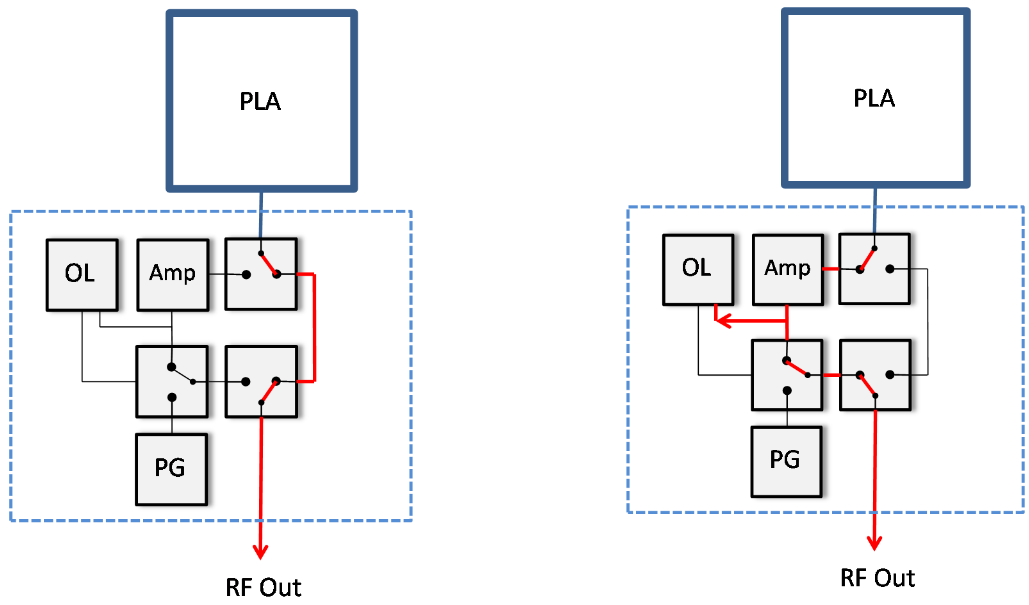


Figure 3: Schematic of PLA-R
a) passive mode
b) active mode, no overload detected

Amp: preamplifier; OL: overload detection; PG: pulse generator

a) b)

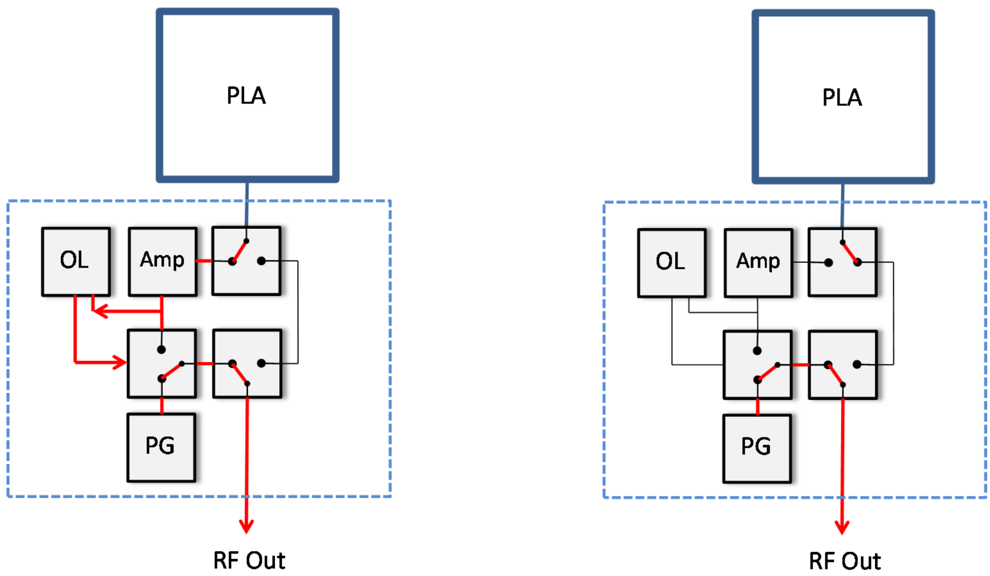


Figure 4: Schematic of PLA-R
a) overload detected
b) test of pulse generator

Amp: preamplifier; OL: overload detection; PG: pulse generator

Depending on the application and the connected device the saturation detection (SATURATION DET) shall be active (ON) or deactivated (OFF).

CAUTION:	Make sure that the connected receiving device is capable to withstand the pulsed signal. Specification of the pulsed signal is found in chapter 4.2

The overload detector is sensitive to single pulses also.

CAUTION:	The overload detector may be activated during setup by switch-on currents of EUTs and ESD discharges in anechoic chambers. This is normal operation and does not indicate a failure of the PLA-R.

2.2. PLA-T Transmit Antenna

The transmit antenna (PLA-T) operation elements are shown in **Figure 5**. When the power is switched OFF (middle position of the toggle switch) the system operates in passive mode.

The left position of the toggle switch, ON, sets the antenna into active mode.

In position LAS (right position of the toggle switch) the laser alignment system is turned on. More information about the laser alignment system can be found a chapter 4.4.

Figure 5: PLA-T amplifier box

There are two LEDs to shown which amplifier is active. In case of the broadband amplifier LED BB is on. For the high current amplifier the LED HC is active.

Three POWER LEDs indicate the state of the battery. Normal state (charged) is indicated by green colour. In state yellow operation is still possible, but a soon recharge is recommended. If the red LED is light up, further operation is impossible and immediate recharge is required.

Similar to the PLA-R the PLA-T has a passive mode where the signal is routed from the input connector directly to the antenna, see **Figure 6** (a).
If the antenna is operating in active mode and no switch signal is present the input signal is increased by the broadband amplifier, see **Figure 6** (b).

The amplifier box of the PLA-T antenna consists of two amplifiers: a broadband amplifier (Amp WB) and high current amplifier (Amp HC). To switch between the two amplifiers a switching signal with a frequency above the antenna frequency band is used. The presence of this signal is checked by the switch detector (SD). To separate the signals a low pass (LP) and a high pass (HP) filter are used. To switch to the high current amplifier it is necessary to feed the switch signal to the antenna, which is done by the PLA-TC transmit antenna control unit. More information about the PLA-TC can be found in chapter 2.3.

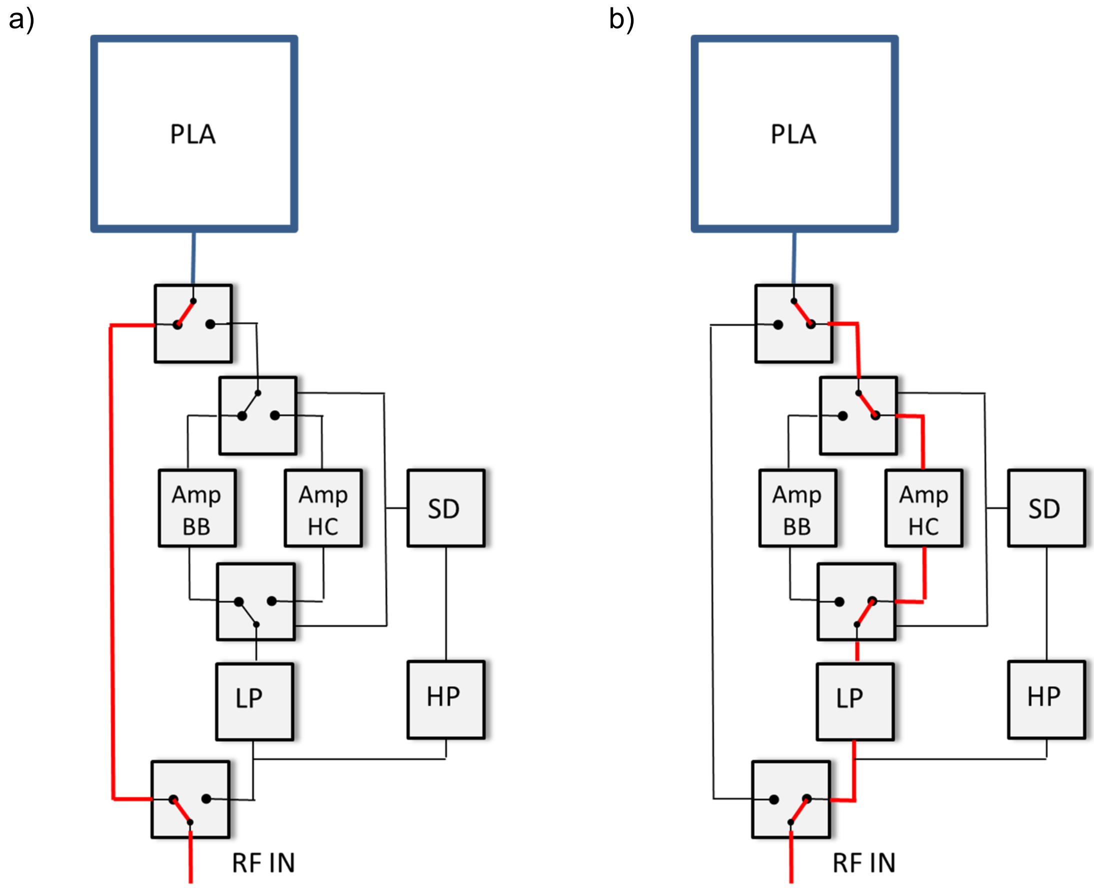


Figure 6: Schematic of PLA-T
a) passive mode
b) broadband amplifier mode

Amp BB: broadband amplifier; Amp HC: high current amplifier; LP: low pass filter; HP: high pass filter; SD: switchdetector

2.3. PLA-TC Transmit Antenna Control Unit

The transmit antenna control unit is required to activate the PLA-T high current amplifier in case high dynamic is required.

Figure 7: PLA-TC Transmit Antenna Control Unit

The unit has two status LEDs. The first one indicates that the unit is powered up. The second one lights up if the high current amplifier mode is switched on.

There are two possibilities to control the transmit antenna control unit:

- USB: The PLA-TC is connected to a PC via the USB cable. The switching between both modes is done via software (PLA-TC App).
- Manual: By pressing the small button next to the LEDs the PLA-TC is switched to the next mode. In the manual mode the PLA-TC can be powered by a PC or the PLA-TC power supply.

PLA-TC consists of a relay, a switch signal generator (SSG), a controller (C), a signal combiner (+) and a 50 Ω termination, see **Figure 8**.

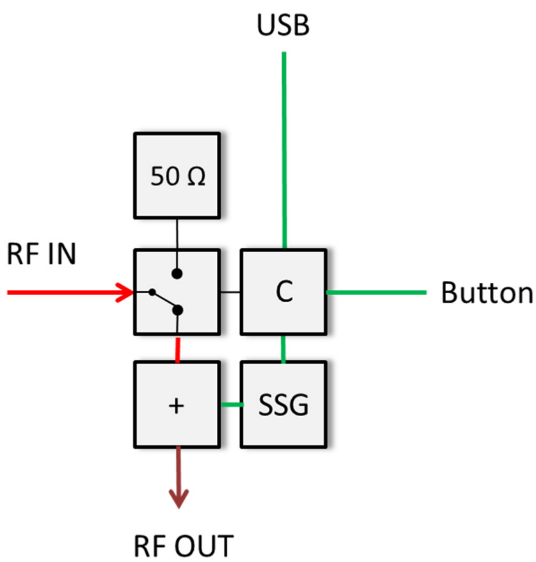


Figure 8: Schematic of PLA-TC

SSG: Switch Signal Generator; +: Signal combiner, C: Controller

The signal combiner adds the switch signal to the antenna cable. Since hot switching will harm the relays of the PLA-T the transmit control will switch with three steps:

- Remove the RF signal from RF OUT by switching to 50 Ω termination using the relay
- Turn on the switch signal
- Switch back the relay to RF IN

The PLA-TC App is included (see USB stick as part of the PLA - set) and requires Windows 7 or Windows 10 and USB 2.0 or higher.

After starting the PLA-TC App a connection to the PLA-TC is established by pressing the “Connect” Button. If this is successful the App will show “Connection established”. Press the switch button to switch to the next mode. The current mode is also shown.

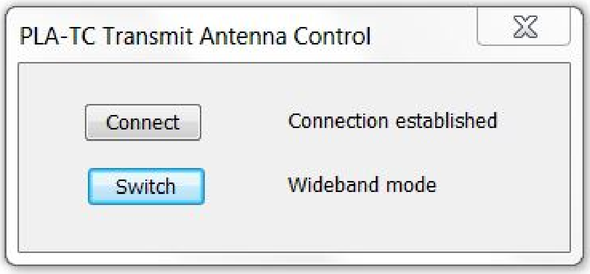


Figure 9: PLA-TC App

2.4. PLA-GD Ground Loop Decoupling Unit

The Ground Loop Decoupling Unit is used to prevent ground loops during site validation. Ground loops are critical in the frequency range from 9 kHz to 100 kHz and can decrease the dynamic range dramatically. More information about ground loops can be found at [15].

Figure 10: PLA-GD Ground Loop Decoupling Unit

The Ground Loop Decoupling Unit consists of a RF wideband transformer and provides galvanic isolation between output and input ground, see **Figure 11**.

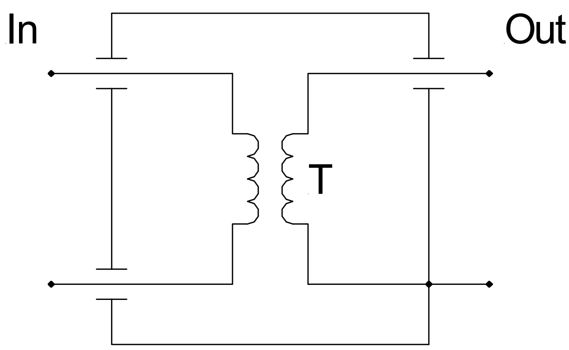


Figure 11: Schematic of PLA-GD

3. Technical Specifications

3.1. PLA-R Receive Antenna

Specification	PLA-R
Frequency range	9 kHz - 30 MHz
Antenna area	Square, 60 cm side length
Antenna height (center)	1.3 m
Nominal gain of preamplifier	40 dB
Typical magnetic field antenna factor	see **Figure 12**
Antenna output VSWR (active)	<1.1
Typical noise floor	see **Figure 13**
Maximum field strength	see **Figure 14**
Saturation indication sensitive to	single pulse
Saturation indication minimum on time	3 s
Output level at maximum field strength (CW) in active mode	112 dBµV
Cross-polarization	> 30 dB
Connector type	Type N female
Output coupling	AC
Pulse generator • Voltage • Pulse repetition frequency • Pulse width Spectrum	 30 V 10 kHz, 1 MHz 200 ns, 12 ns see **Figure 15** and **Figure 16**
Temperature stability of antenna factor • Laboratory use (20° C - 25°C) • Field use (10° C – 35° C)	 ± 0.025 dB ± 0.1 dB
Laser alignment accuracy	± 0.5 cm ± 0.5 °
Battery operation time • continuous use • Time left under condition “yellow”	 > 24 h > 1 h
Batteries	internal, 10 cell NiMH (12V) (factory serviceable only)
Laser class, see Annex II	2
Temperature operating range	10°C - 35°C
Weight of Antenna including tripod	12.5 kg
Dimensions of flight case	89 x 83 x 28 cm, weight 32kg

Table 1: Technical specifications of PLA-R

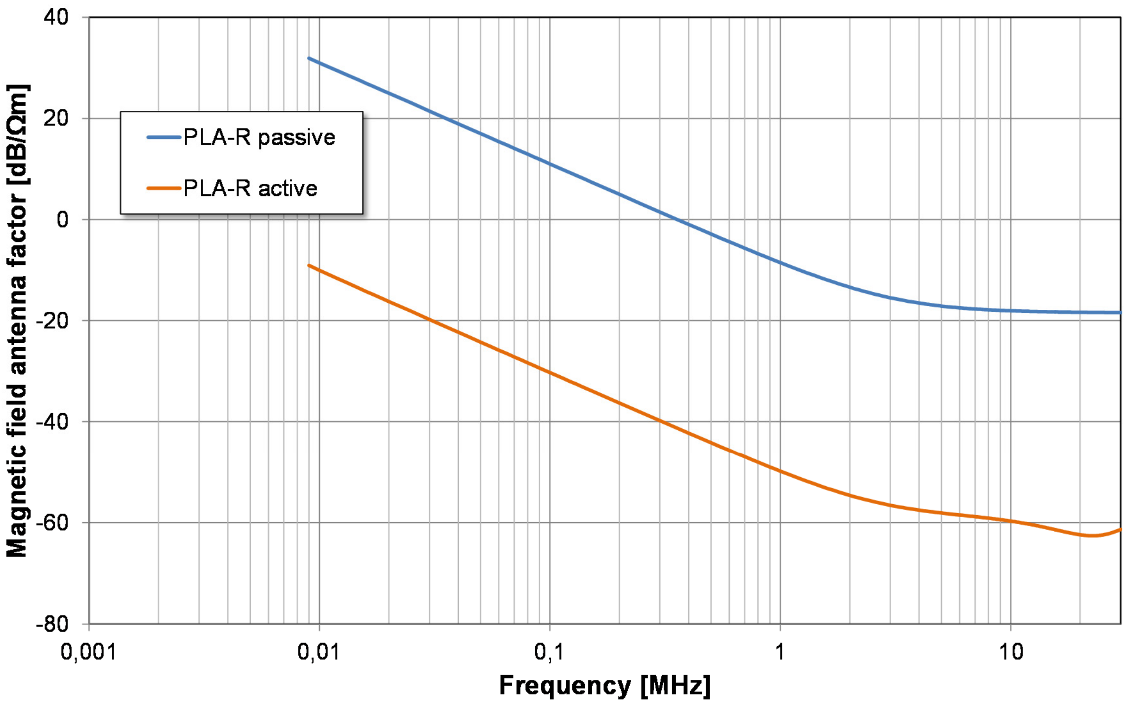


Figure 12: Typical magnetic field antenna factor

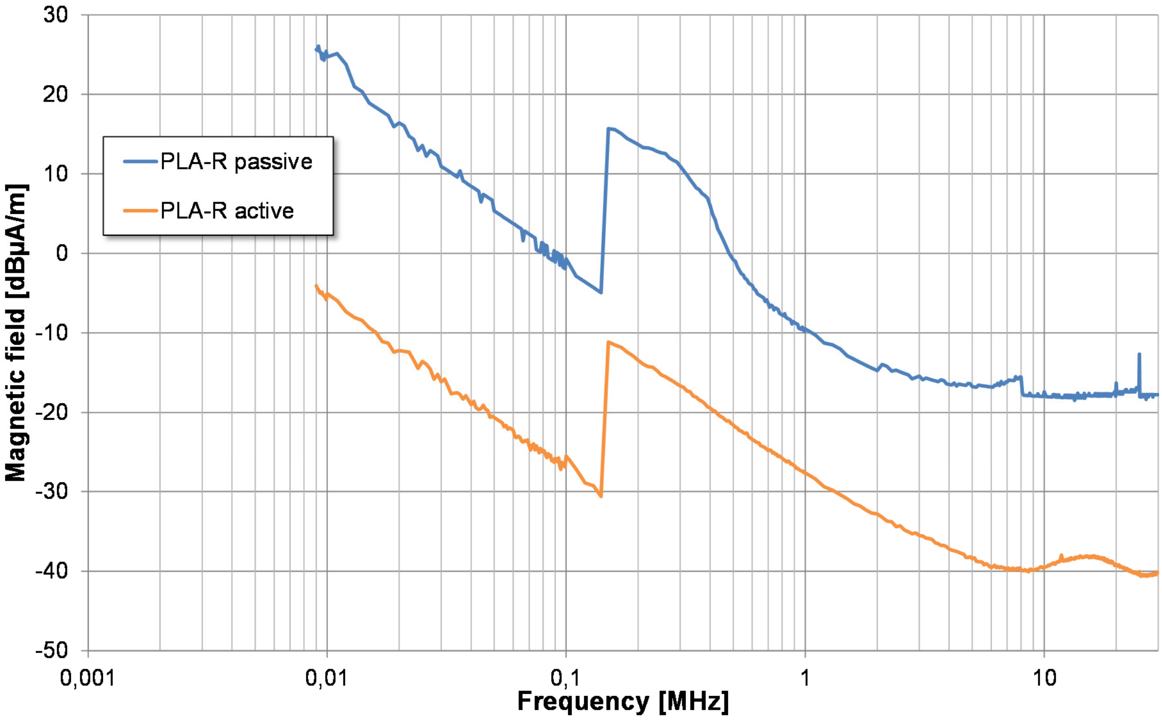


Figure 13: Typical noise floor measured with typical EMI Receiver, CISPR bandwidth, Quasi-Peak detector and 10 dB input attenuation

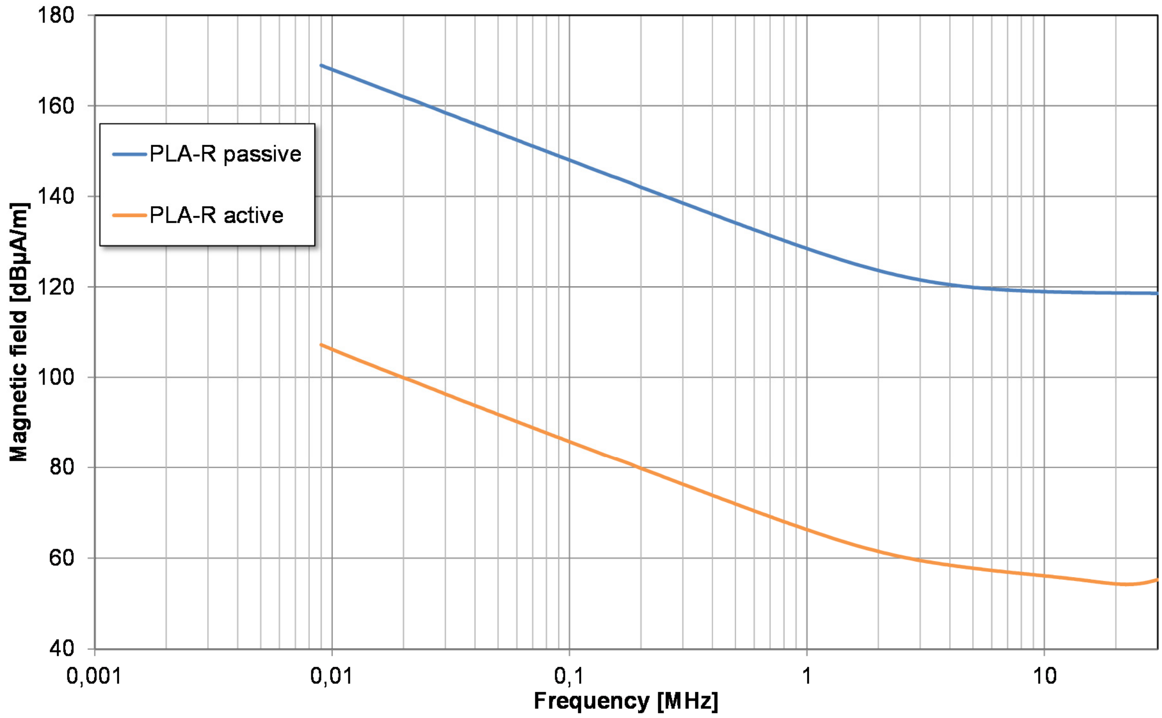


Figure 14: Typical maximum field strength; max. +30 dBm on RF input of EMI receiver

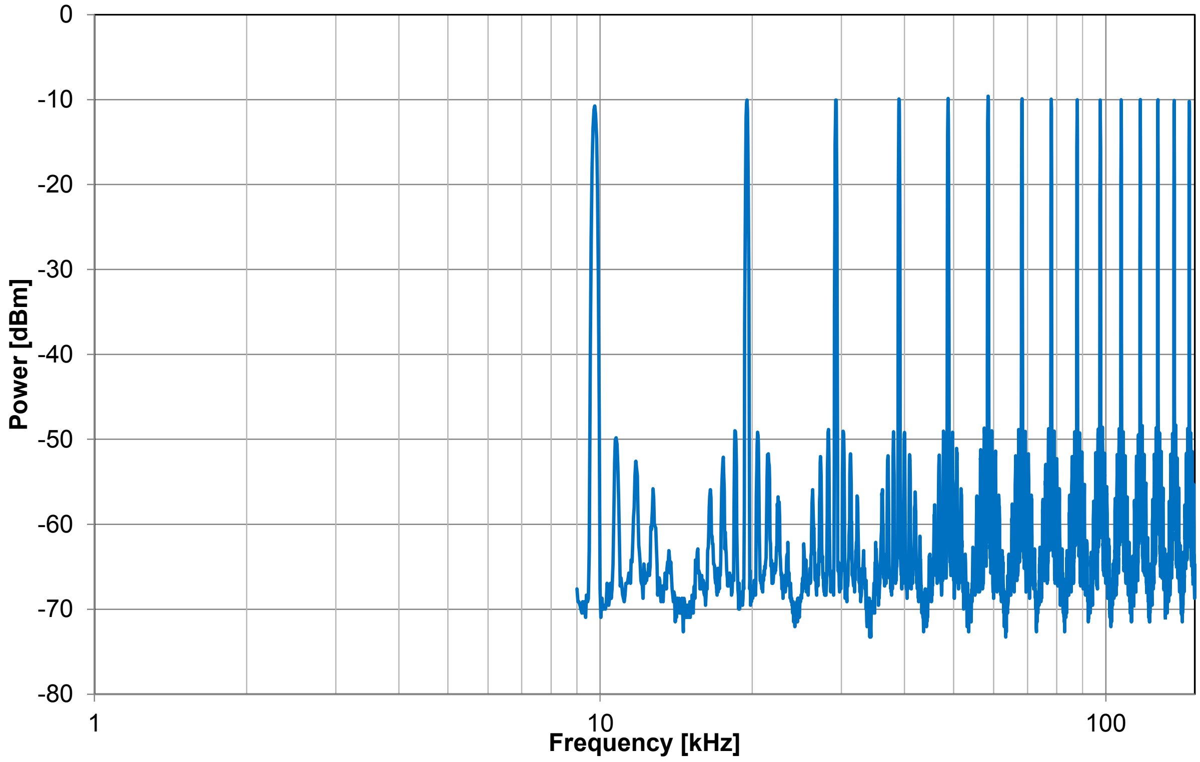


Figure 15: Spectrum of pulse generator, CISPR Band A

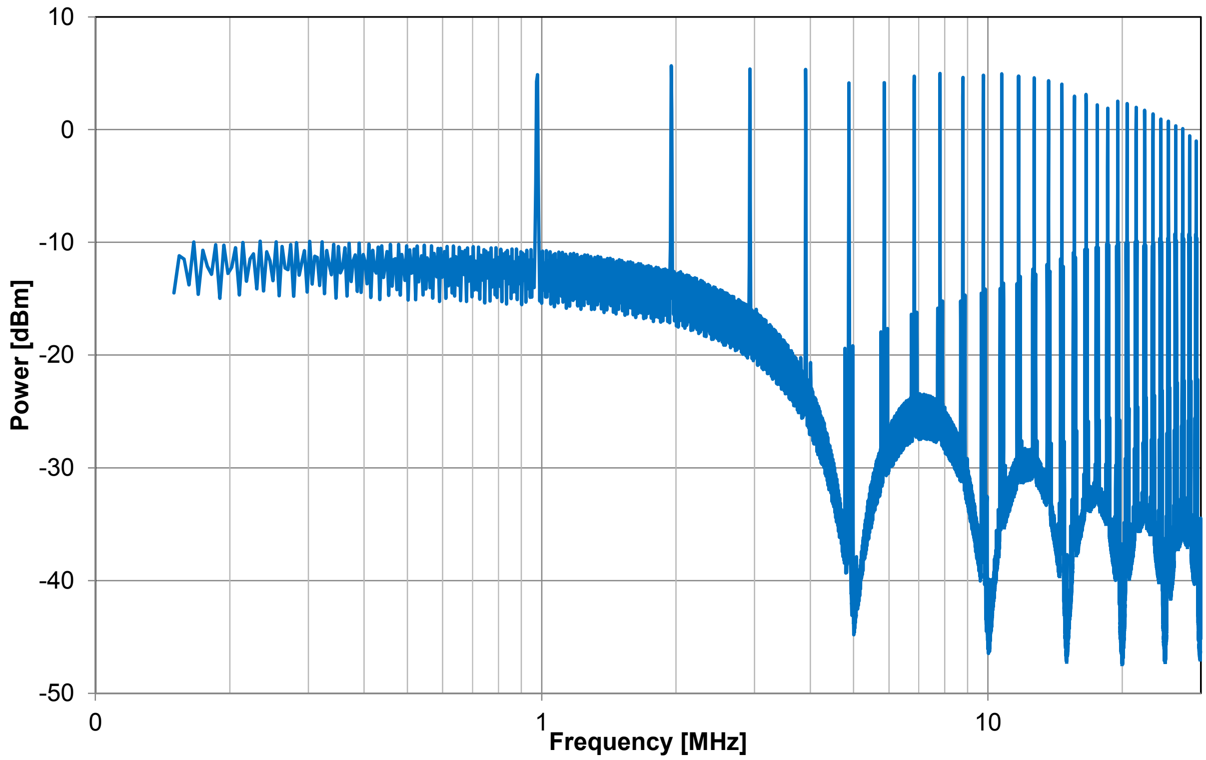


Figure 16: Spectrum of pulse generator, CISPR Band B

3.2. PLA-T Transmit Antenna

Specification	PLA-T High current amplifier	PLA-T Broadband amplifier
Frequency range	9 kHz – 200 kHz	9 kHz – 30 MHz
Equivalent output power in 50 Ω system	see **Figure 17**	
Antenna area	Square, 60 cm side length	
Antenna height	1.3 m	
Input power range	-30 dBm - -6 dBm in active mode < +46 dBm in passive mode	
VSWR (active)	<1.4 not including PLA-TC <1.1 including PLA-TC	
Typical antenna factor	see **Figure 18**	
Connector type	Type N female	
Temperature stability of antenna factor • Laboratory use (20° C – 25°C) • Field use (10° C – 35° C)	± 0.05 dB ± 0.25 dB	± 0.025 dB ± 0.15 dB
Laser alignment accuracy	± 0.5 cm ± 0.5 °	
Battery operation time • MNSA measurement typical use • SE measurement typical use • Time left under condition "yellow"	> 12 h > 6 h > 1 h	
Batteries	internal, 10 cell NiMH (12V) (factory serviceable only)	
Laser class, see Annex II	2	
Temperature operating range	10°C – 35°C	
Weight of PLA-T Antenna including tripod	12.5 kg	
Dimensions of Antenna Set incl.flight case	89 x 83 x 53 cm, weight 62 kg	

Table 2: Technical specifications of PLA-T

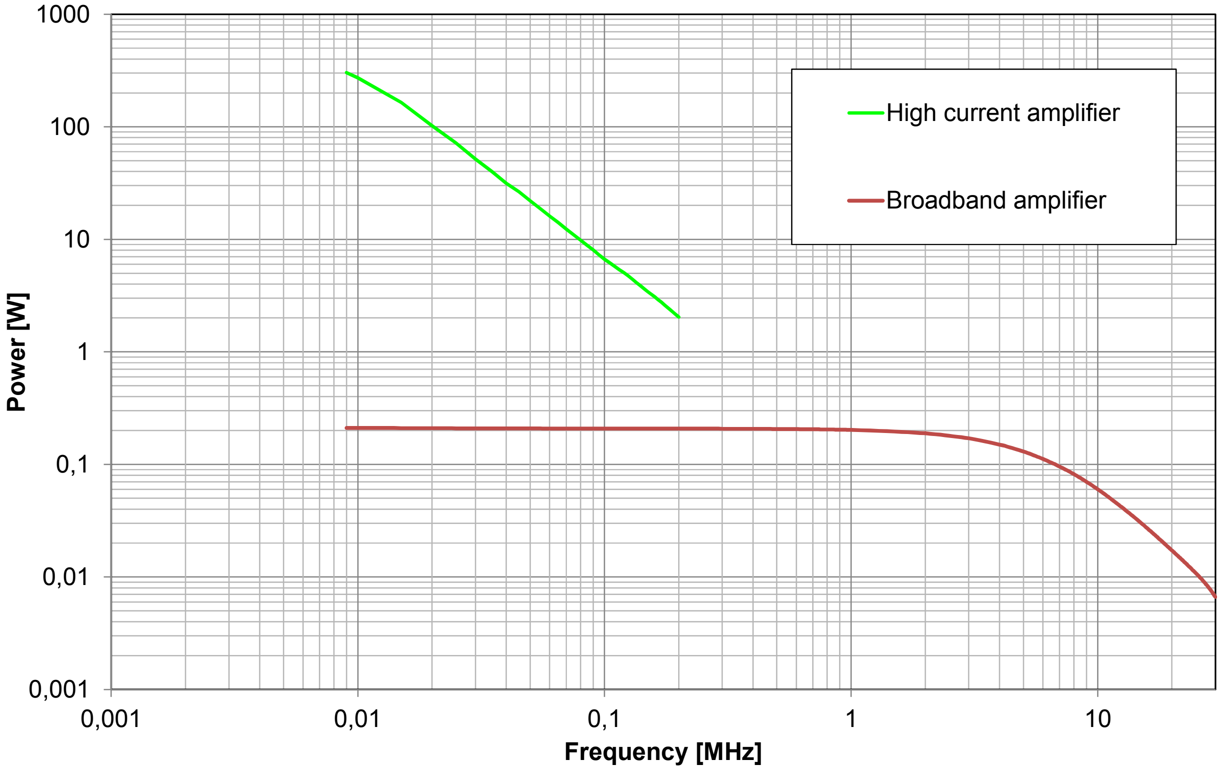


Figure 17: Typical equivalent transmit power in 50 Ω system

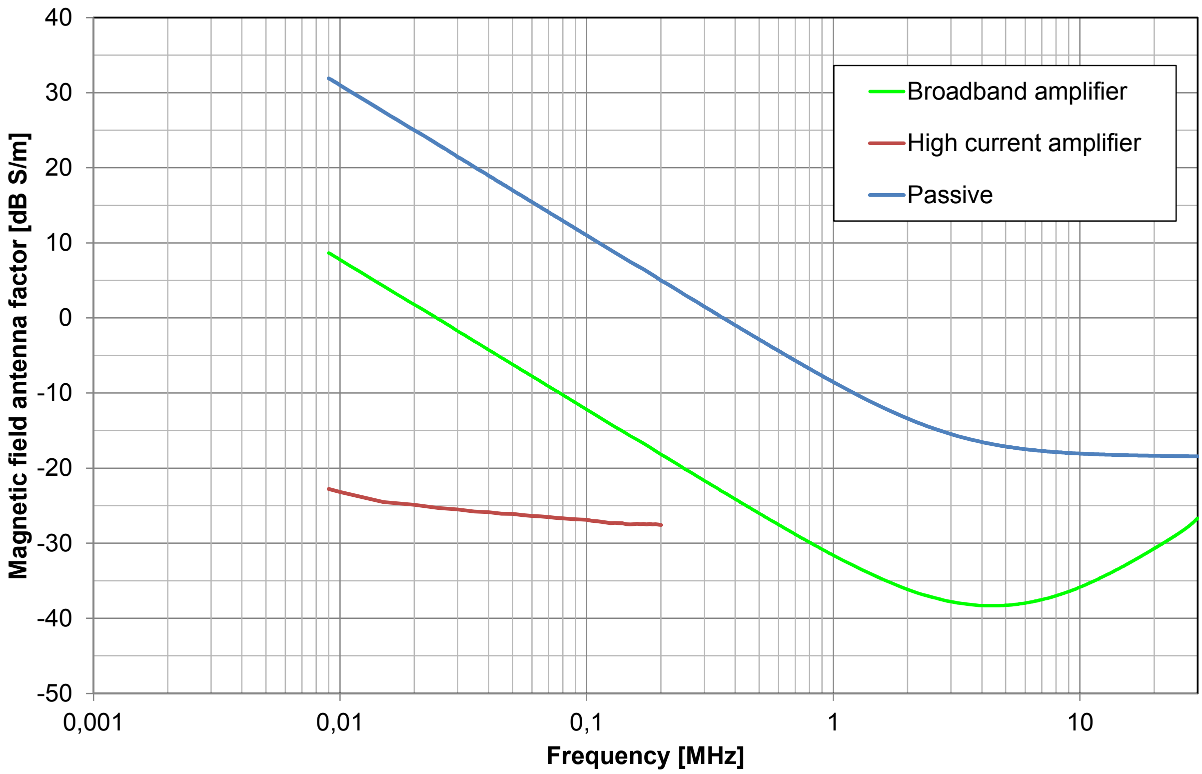


Figure 18: Typical magnetic field antenna factor

3.3. PLA-TC Transmit Antenna Control Unit

Specification	PLA-TC
Frequency range	9 kHz – 30 MHz
Insertion Loss	see **Figure 19**
Maximum input power	+10 dBm
USB Version	2.0
USB connector	Type B
USB power supply mode	Low power mode < 100 mA
Operating system	Windows XP, Vista Windows 7, Windows 8, Windows 10
VSWR	< 1.2
Connector type	Type N female
Temperature operating range	10°C – 35°C
Dimensions	146 x 69 x 32 mm
Weight	0.235 kg

Table 3: Technical specifications of PLA-TC

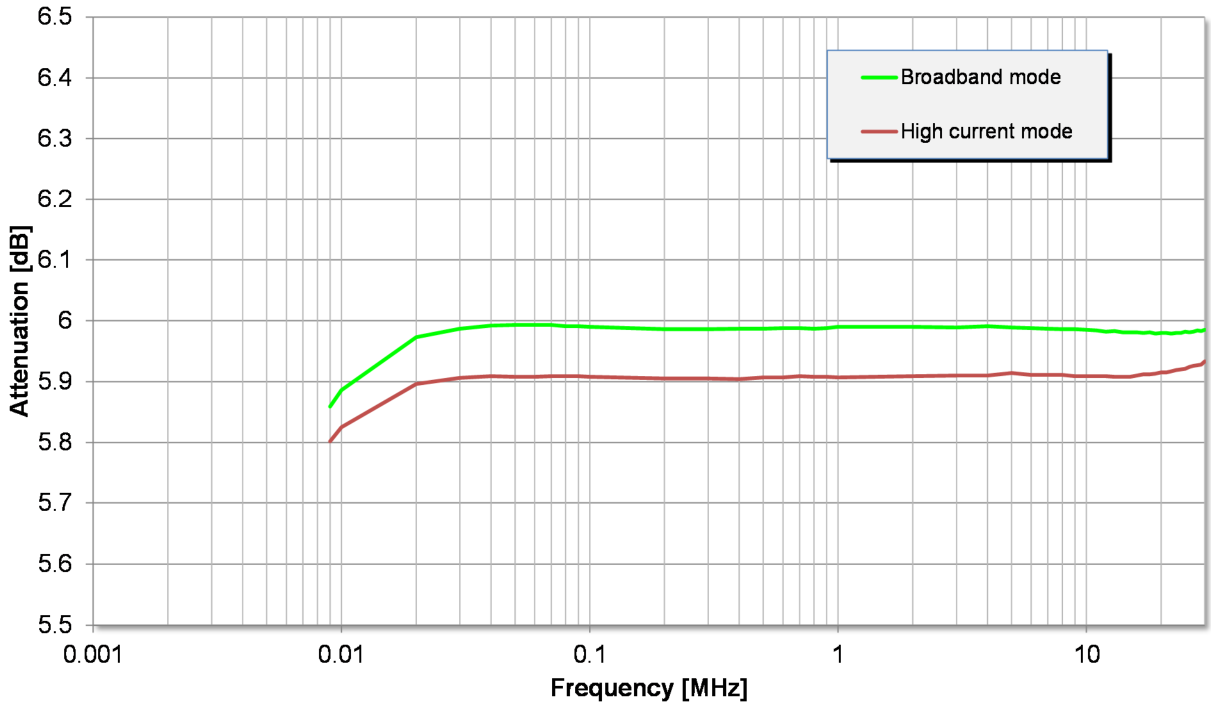


Figure 19: Insertion Loss of PLA-TC

3.4. PLA-GD Ground Loop Decoupling Unit

Specification	PLA-GD
Frequency range	9 kHz – 30 MHz
Insertion loss	see **Figure 20**
Maximum input power	+20 dBm
VSWR	< 3
Temperature operating range	10°C – 35°C
Dimensions	141 x 55 x 32 mm
Weight	0.245 kg

Table 4: Technical specifications of PLA-GD

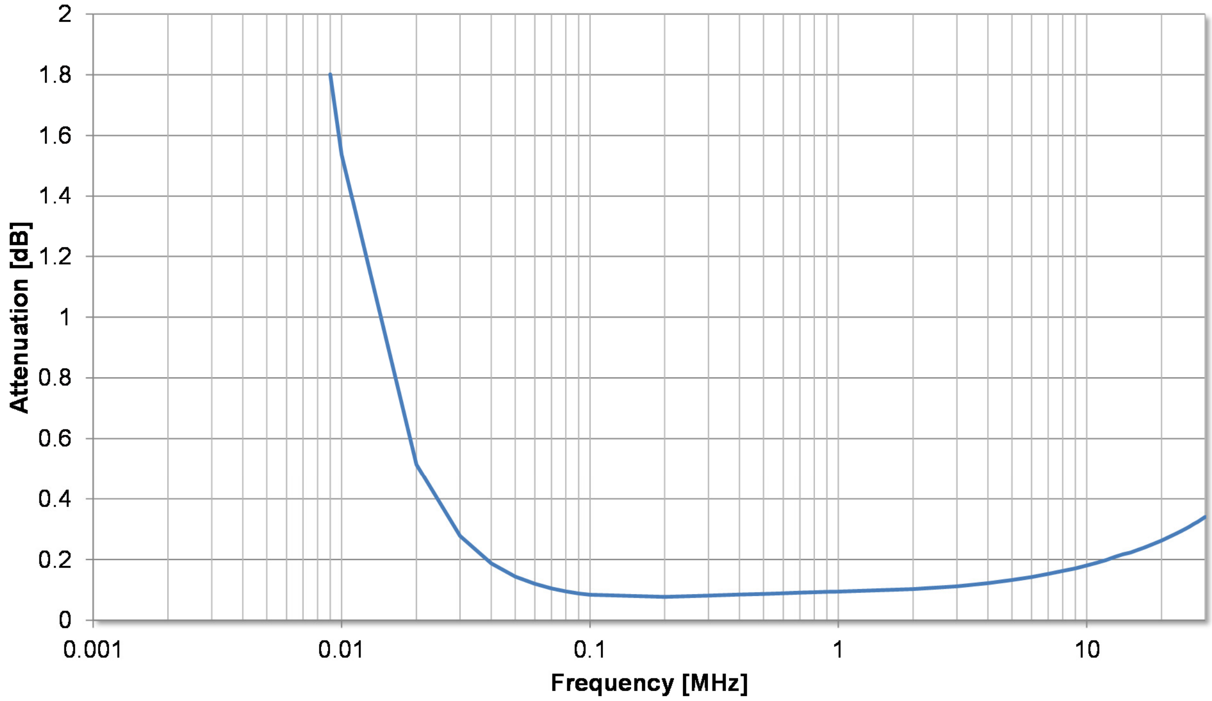


Figure 20: Insertion Loss of PLA-GD

3.5. Charger

The built-in batteries of the PLA-R and the PLA-T antennas are charged with the enclosed Ansmann ACS 110 Traveller charger.

Figure 21: Charger

Due to the switch mode power supply and an exchangeable primary plug set, worldwide use is possible. When charging is completed the charger automatically switches to trickle charge. Please follow the instructions of the enclosed original manual of the charger.

Specification	
Input voltage	110...240 VAC @ 50...60 Hz
Connection on the primary side	Euro, US, J, Australia primary adapters
Connection on the secondary side	coaxial plug, positive inner
Output	1.45 – 14.5 V DC, max 800 mA
Dimensions	118 x 62 x 48 mm
Weight	0.280 kg

Table 5: Technical specifications the charger

4. Installation and Operation

The antenna components are stored in a flight case for protection and easy shipment.

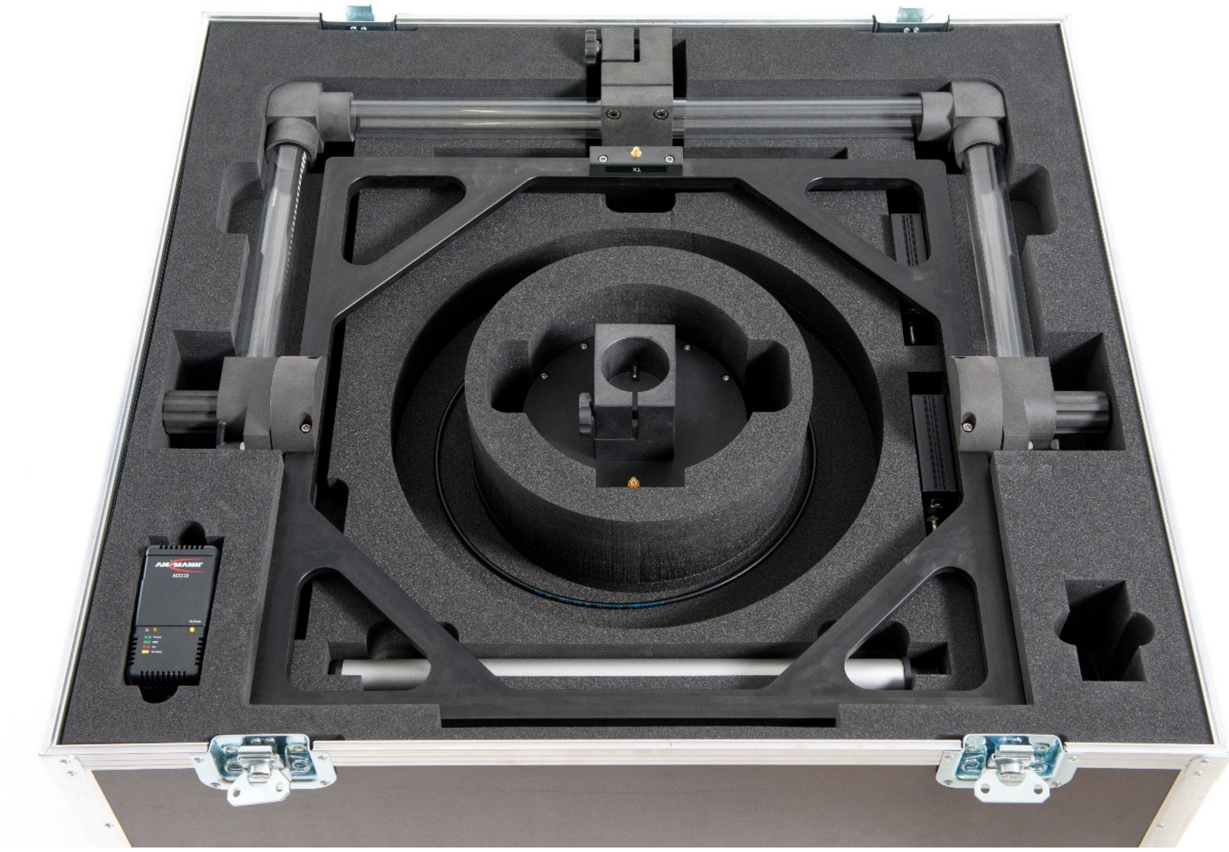


Figure 22: Flight case with PLA elements

4.1. PLA-R receive antenna set components

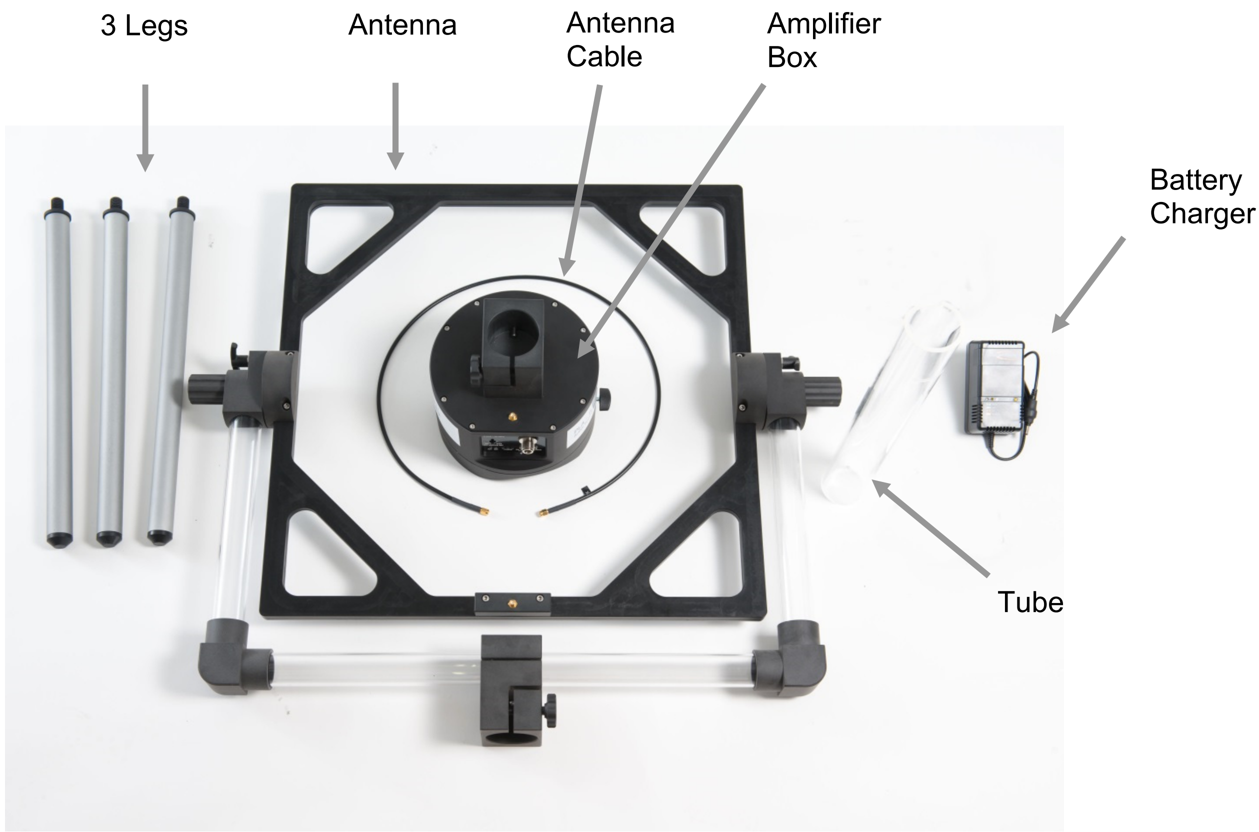


Figure 23: PLA-R components

4.2. PLA-T transmit antenna set components

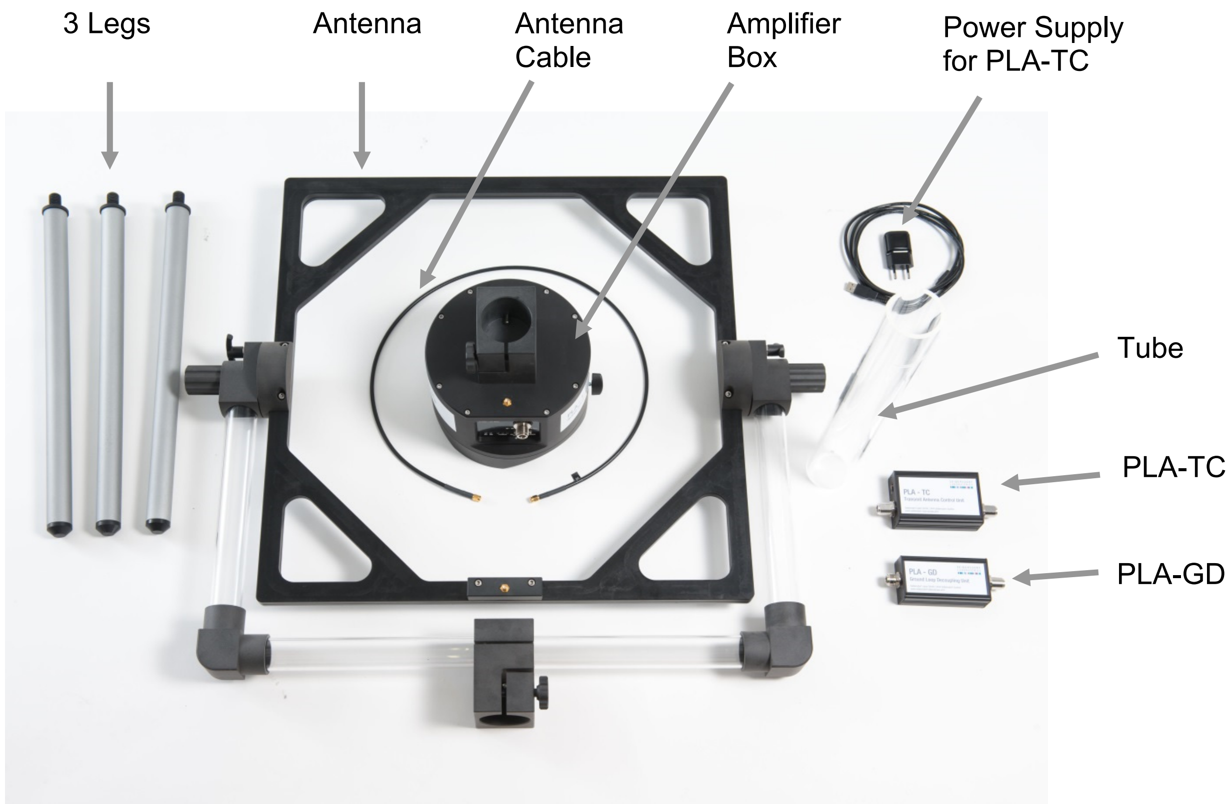


Figure 24: PLA-T components

4.3. Assembly of PLA-T and PLA-R

Mount the 3 Legs by turning the Amplifier Box upside down.

Insert the Tube with the milled slot downwards to the fixation of the Base Block.

Fix the Tube with the black screw by hand.

Put the Antenna on the Tube, with the SMA connector of the antenna oriented to the control elements of the amplifier Box.

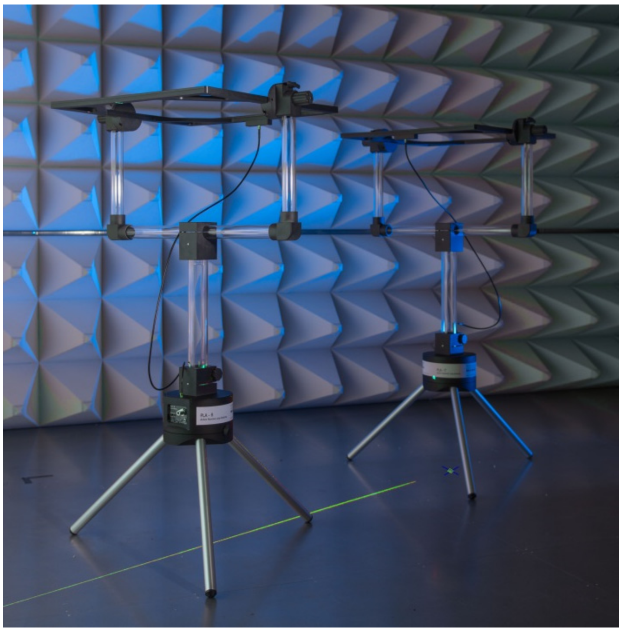
Fix the Antenna with the black screw by hand.

Connect the Antenna cable (SMA connector) to the antenna. Use a torque wrench to tighten the connector-nut.

The other end of the Antenna cable has to be connected to the Amplifier Box.

4.4. Laser alignment system

A precise positioning of the PLA antennas is given by the built in laser apertures.
The dot laser indicates to the measurement position on the ground. For a parallel alignment of the PLA antennas the use of the lign lasers is very helpful.

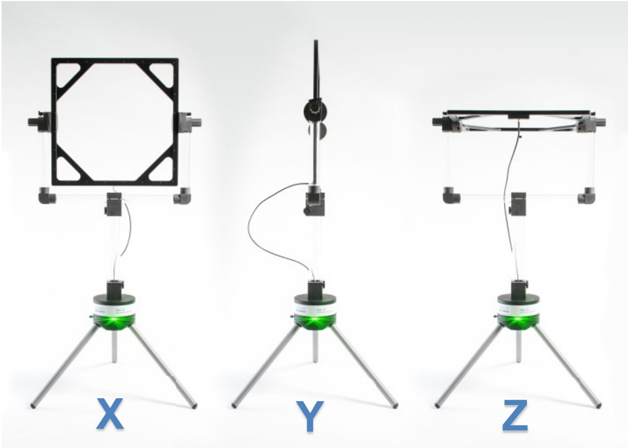


To adjust the line laser release the screw on the Amplifier Box and rotate the case to the target. After the alignment tighten the screw again.

4.5. Polarization Change

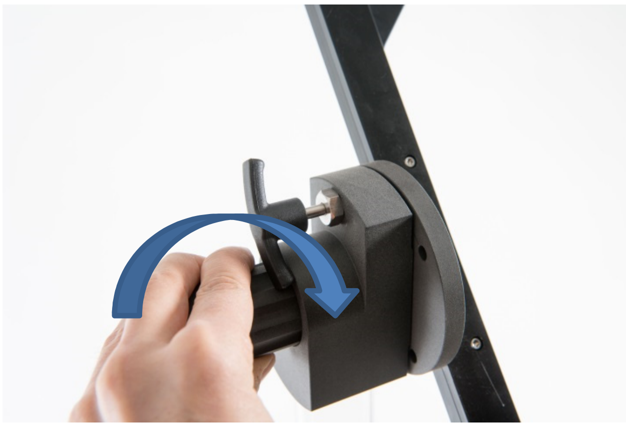
Polarization Changes of the PLA Antennas can be done very easy and without any tools.

PLA Antenna in X, Y and Z Polarization. →



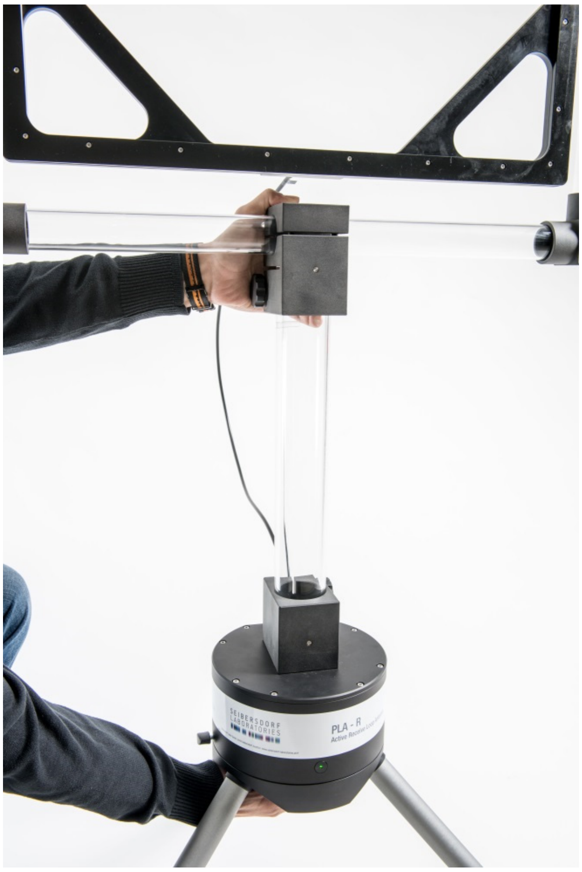
When the antenna is in X-Polarization, turn the Antenna by 90° according to the milling of the Tube to change to Y-Polarisation.

To change to Z- -Polarization, turn the Antenna back to X-Polarisation. Pull out both locking devices and rotate the antenna 90°.



Correct position of Z-axis →

Correct movement of PLA-R/PLA-T →
Support the Amplifier Box by hand.



Incorrect →

PLEASE NOTE:

Damage of the PLA due to incorrect movements is not covered by warranty!

4.6. Maintenance

The PLA-R/PLA-T antennas, including its accessories does not require any user maintenance. Care of the antennas is limited to external components such as cables or connectors.

Clean the exterior of the equipment using a soft cloth and a mild cleaner.

Warranty may be void if the housing is opened.

5. Applications

5.1. Magnetic Field Site Validation

Methods for the validation of test site for magnetic field disturbance measurements are given by CISPR 16-1-4 [1]. This standard defines the Normalized Site Attenuation (NSA) as well as the Reference Site Method (RSM). Test setup and procedure are identical; difference is only the type of antenna calibration and the resulting post processing. Additional information about magnetic field site validation can be found at [22][23][24].

Magnetic field site validation is desired for the test distances 3 m, 5 m and 10 m. Sites to be tested are Open Area Test Sites (OATS) and semi anechoic chambers (SAC). Magnetic field disturbance measurements are not intended for fully anechoic rooms (FAR).

To perform a site validation the pair of loop antennas is set up in three orthogonal orientations, see **Figure 25**. The height of the antenna reference point is 1.3 m above the ground plane. The reference point is defined by the centre of the circular or rectangular loop antenna.

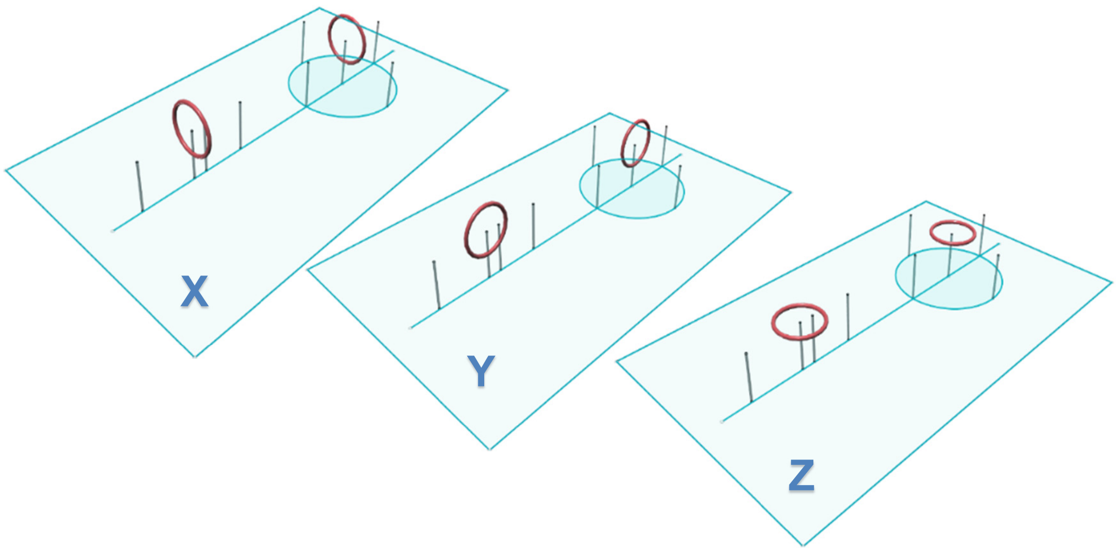


Figure 25: Test set up for site validation

These three orientations are required in 5 points inside the test volume, see **Figure 26**. The distance between transmit and receive antenna is kept constant for all measurement points. The antennas are always aligned to each other.

For each test distance the maximum test volume is defined by CISPR 16-2-3 [7].

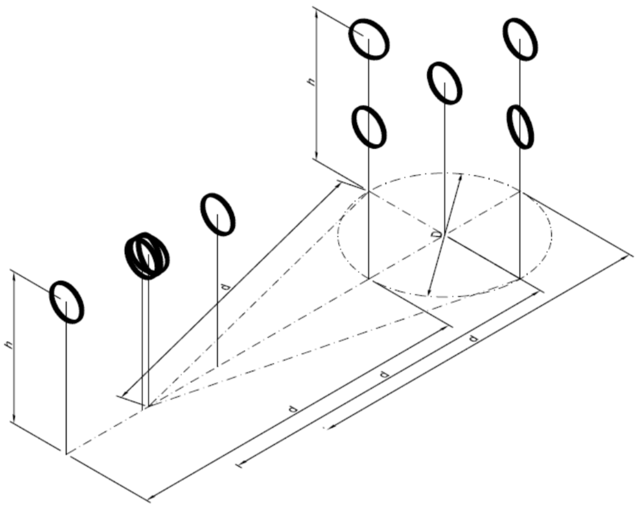


Figure 26: Test points inside test volume; orientation H_x shown

A site attenuation measurement is performed in two steps. In the first one transmit and receive cable are connected together - the receive level is recorded as V_{DIRECT}.

In the second step the receive level V_{SITE} is recorded, when the cables are connected to the antennas.

Depending on test distance and frequency ranges following amplifiers of the PLA-T are recommended.

Test distance	9 kHz – 200 kHz	200 kHz – 30 MHz
3 m	Broadband amplifier	Broadband amplifier
5 m	Broadband amplifier	Broadband amplifier
10 m	High current amplifier	Broadband amplifier

Table 6: Recommended amplifier of PLA-T for site validation

CAUTION: Do not forget to consider the loss of PLA-TC and PLA-GD during measurement of V_{DIRECT}.

CAUTION: It is not required to install the PLA-TC into the transmit path if only the broadband amplifier of the PLA-T is used.

CAUTION: Consider the maximum input power of the PLA-T of -6 dBm.

CAUTION: Measuring with network analyser it's recommended to switch off the saturation detection as it's not required and the strong comb signal might damage your network analyser.

In case of the **NSA method** the site attenuation deviation is calculated as follows:

$$\Delta A_S = V_{Direct} - V_{Site} - \left(F_{a,TX} + F_{a,RX}\right) - A_N$$

where

V_{Direct}	is the level recorded by the receiver if transmit and receive cable are connected via a barrel connector, in dBm or dB(μV);
V_{Site}	is the level recorded by the receiver if transmit and receive cable are connected to the antennas, in dBm or dB(μV);
$F_{a,TX}$	is the transmit magnetic field antenna factor, in dB(S/m);
$F_{a,RX}$	is the receive magnetic field antenna factor in dB(S/m);
A_N	is the theoretical normalized site attenuation, in dB(m^2/S^2), specified in Annex II;
ΔA_S	is the site attenuation deviation, in dB.

According to CISPR 16-1-4 a site attenuation deviation of ±4 dB is allowed.

It is recommended to use the antenna pair method given in CISPR 16-1-4 to calibrate the sum of $F_{a,TX}$ and $F_{a,RX}$. A sample certificate for the PLA-T and PLA-R can be found in Annex IV.

In case of the **RSM method** the site attenuation deviation is calculated as follows:

$$\Delta A_S = V_{Direct} - V_{Site} - A_{APR}$$

where

V_{Direct}	is the level recorded by the receiver if transmit and receive cable are connected via a barrel connector, in dBm or dB(μV);
V_{Site}	is the level recorded by the receiver if transmit and receive cable are connected to the antennas, in dBm or dB(μV);
A_{APR}	is the Antenna Pair Reference, in dB;
ΔA_S	is the site attenuation deviation, in dB.

At a test distance of 10 m a high dynamic range is required. If the typical setup with measurement devices outside the shielded room is used a ground loop is formed, see **Figure 27**. A current will flow between the chassis of the signal generator, the transmit cable shield, the penetration panel, the receive cable shield, the chassis of the receiver, protective earth to the power outlet and protective earth to the chassis of the signal generator.

There are several possibilities to avoid a ground loop. Extensive information about ground loops during site validation can be found at [15].

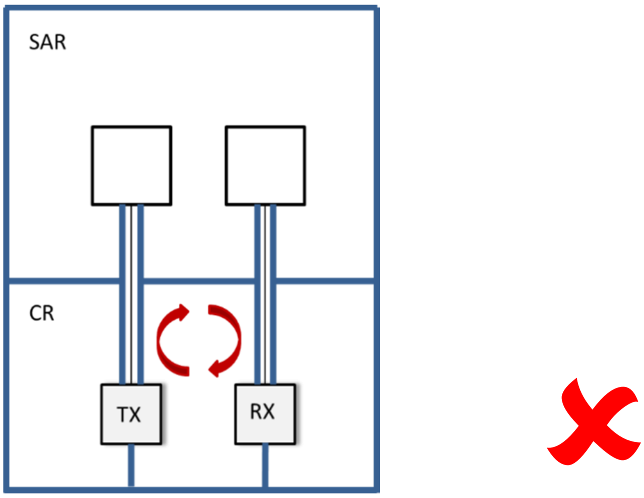


Figure 27: Ground loop formed by measurement devices

One possibility to avoid a ground loop is to place the signal generator inside the shielded room. In this case there is no contact between transmit and receive cable shield, see **Figure 28**.

CAUTION:	Any electric contact between the transmit cable shield and the ground plane will result in a ground loop. Isolate barrel connectors lying on the ground.

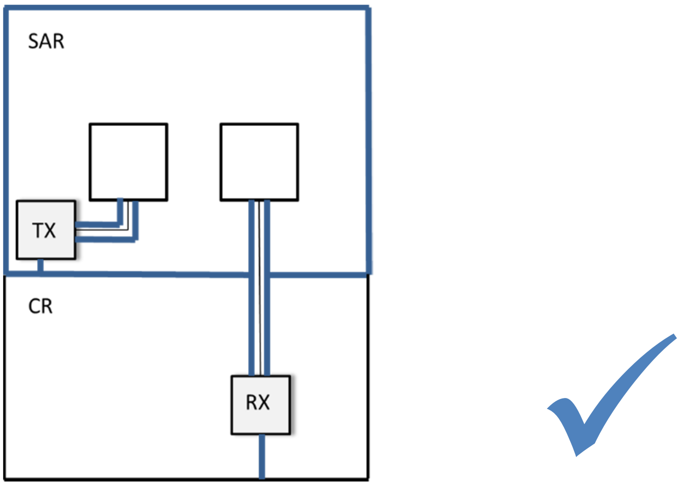


Figure 28: Operation of generator inside the shielded room

Avoiding an electric contact at the penetration panel will avoid a ground plane, see **Figure 29**.

CAUTION: A shielded control room (CR) is required to avoid ambient noise.

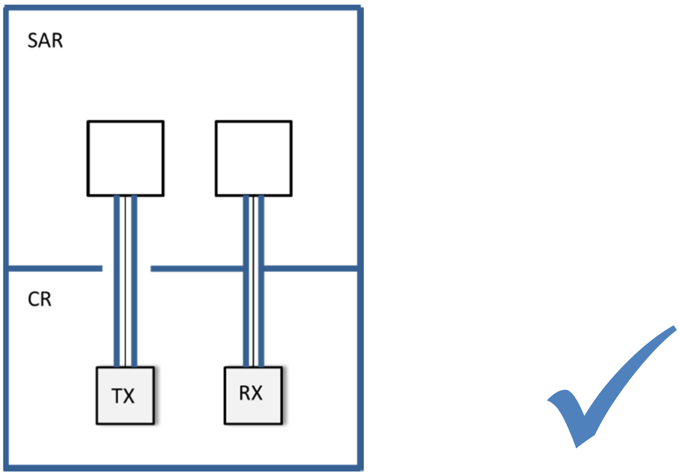


Figure 29: Operation of generator and receiver in CR, TX cable not connected to shielding

Some arbitrary waveform generators have an electric isolation between device chassis and signal ground. In this case no ground loop will occur, see **Figure 30**.

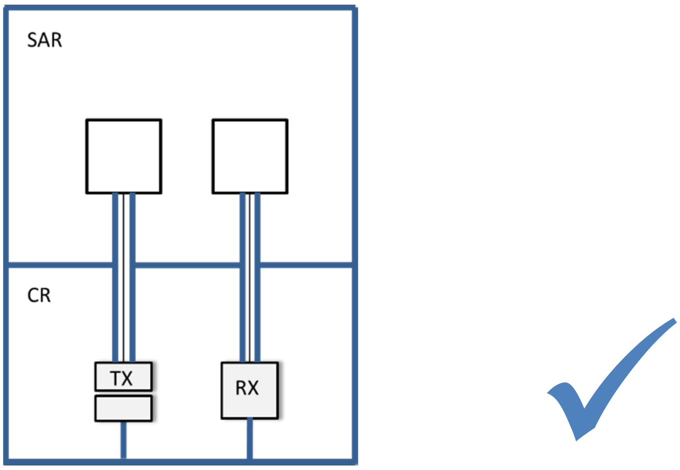


Figure 30: Operation of generator with isolation between ground and earth

The recommended possibility to avoid a ground loop is to use the PLA-GD, see **Figure 31**. Due to the isolation between the two ground connections no current flow is possible. A description of the PLA-GD can be found in chapter 2.4, technical information in chapter 3.4.

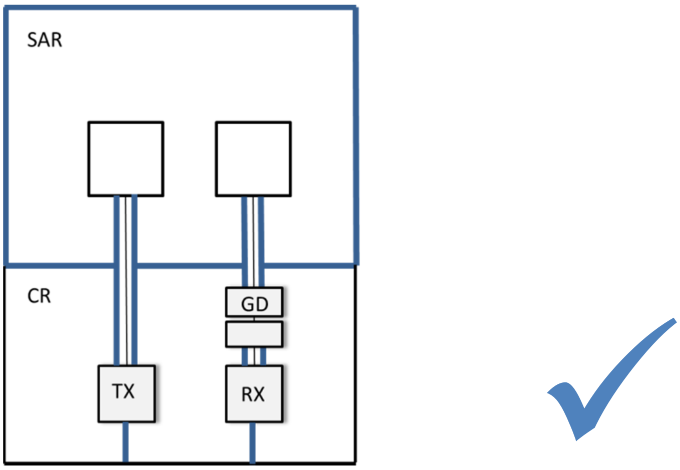


Figure 31: Use of PLA-GD

Typically RF cables are routed between the bottom of the shielding and the raised floor / ground plane, see **Figure 32**. In this case measures against a ground loop outside the shielding will not have an effect. To avoid such secondary ground loops, RF cables should be disconnected from the bulkheads of the floor panel.

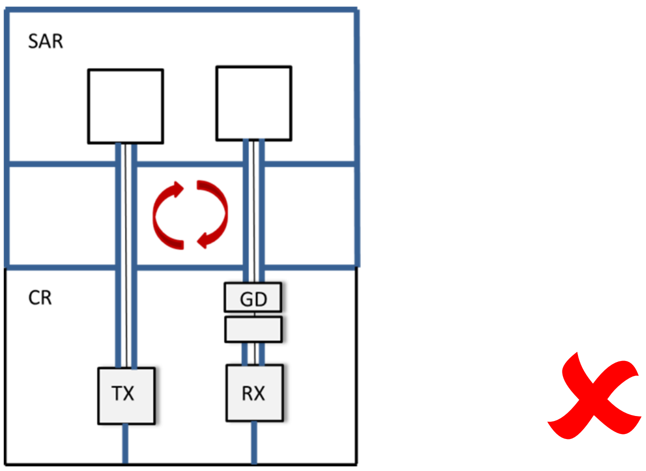


Figure 32: Ground loop with fixed installed cables beneath ground plane

5.2. Shielding Effectiveness

The PLA set can be used for shielding effectiveness measurements according to

- EN 50147-1 [10]
- IEEE Std. 299 [1]
- NSA No. 94-106 [20]

Following standards cannot be used

- MIL-STD 285 [17] - Different requirement for loop size

The shielding effectiveness measurement according EN 50147-1 is measured by two steps. The first step is to measure H_0 in the reference configuration, see **Figure 33**(a). Therefore both antennas a placed parallel to each other at a distance d_0, where

$$d_0 = d_1 + d_2 + d_3$$

Typically d_1 and d_2 are 30 cm, d_3 is the thickness of the shielded wall.
After this normalization, the receive antenna is setup inside the shielded enclosure and the transmit antenna outside.
The magnetic field H_1 is measured and the shielding effectiveness is calculated by

$$A = 20\log\left(\frac{H_0}{H_1}\right)$$

Since the antenna factor of the receive loop is equal for both measurement the formula is simplified to

$$A = 20\log\left(\frac{V_0}{V_1}\right)$$

Shielding effectiveness measurements according to other standards are performed using the same principle. Differences are the required antenna orientations and distances as well as limits.

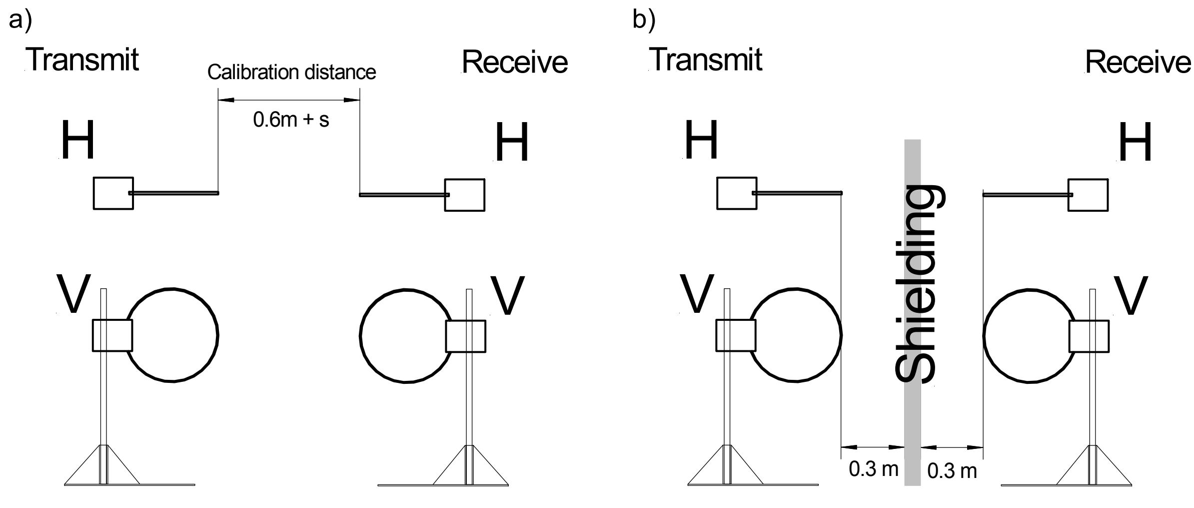


Figure 33: Shielding effectiveness measurement setup
a) calibration; the calibration distance should include the thickness of the shielding
b) measurement

The typical dynamic range for shielding effectiveness measurements using the PLA set is given in **Figure 34**.

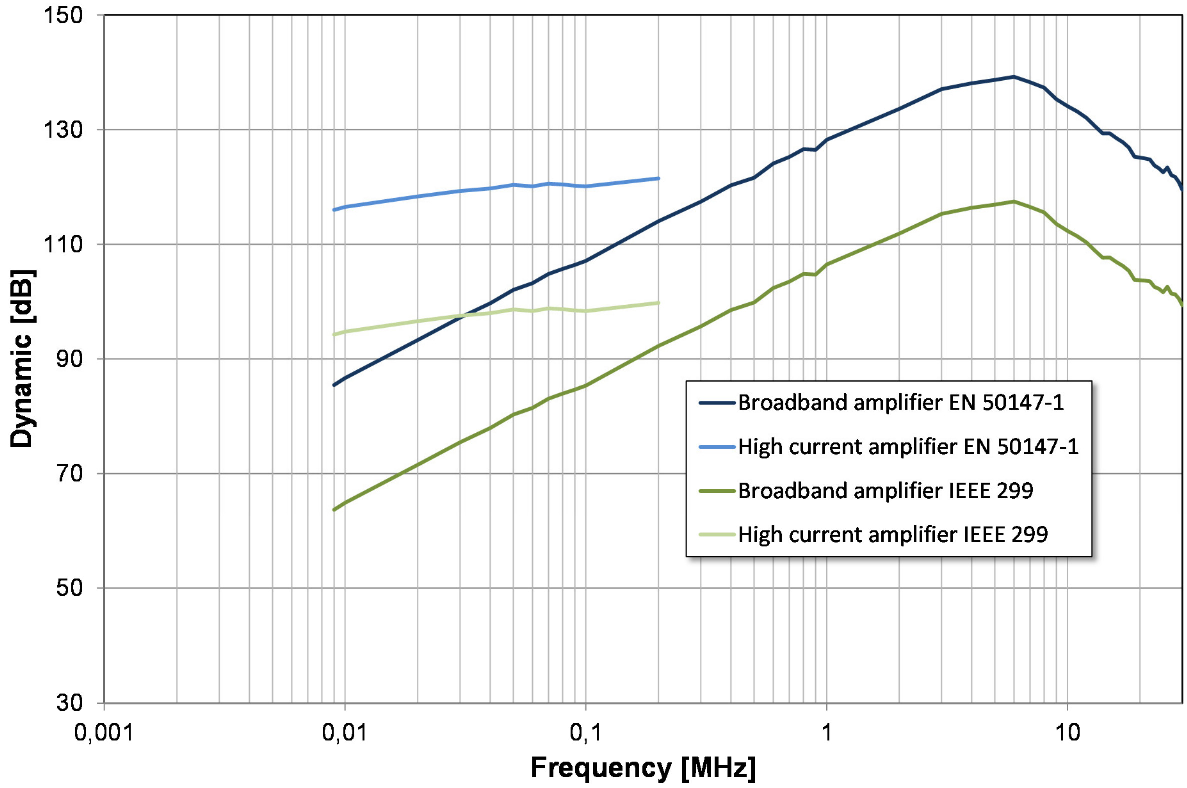


Figure 34: Dynamic range; 10 Hz resolution bandwidth

5.3. Radiated Disturbance

The PLA-R antenna can be used for radiated disturbance measurements according to

- ANSI C63.4 [1]
- CISPR 11 [2] including draft [3]
- CISPR 14 [4]
- CISR 16-2-3 draft [7]
- CISPR 36 [8]
- EN 302 291-1 [9]
- ETSI TR 103 409 [11]
- IEC/PAS 62825 [12]
- ITU-R SM.2303-1 [14]
- SAE J551-5 [21]
- Volkswagen TL 81000 [25]

Following standards cannot be used

- MIL-STD-461G [18] and preceding - Different requirement for loop size and number of turns
- MIL-STD-462D [19] and preceding - Different requirement for loop size and number of turns

Radiated disturbance measurements are performed by using the magnetic field antenna factor. To calculate the magnetic field also the cable loss between antenna and receiver has to be considered

$$H[dB\mu A/m] = U_{receiver}[dB\mu V] + F_A[dBS/m] + A_{cable}[dB]$$

CAUTION:	Do not mix up the magnetic field antenna factor [dBS/m] with the antenna factor [dB/m]. Some standard require magnetic field measurements and define an electric field limit. In this case a wave impedance of 377 Ω is assumed.

Typically an EMI receiver according to CISPR 16-1-1 [5] is used for compliant radiated disturbance measurements. This standard described the function of the quasi-peak detector and the requirements regarding dynamic range which are fulfilled by using a preselector. Using a preamplifier between antenna and EMI receiver may cause some troubles; see Annex K of CISPR 16-1-6. The same is true for active antennas. Saturation and intermodulation can invalidate the test results especial for pulsed signals. More information about measuring pulsed magnetic fields can be found at [16].

To avoid those problems the PLA-R is equipped with a saturation indication feature. The saturation detection is sensitive to single pulses also. After a saturation event the indication remains on for at least 3 seconds.

A human observation of the saturation indication LED is not necessary due to the patented overload handover. In case of saturation of the antenna a strong wideband signal is generated and routed to the antenna output. This signal is strong enough to force the EMI receiver into overload, which is also recognized by the automated EMC control software.

To ensure proper function suitable settings on the EMI receiver must be found. If a high input attenuation is set, the pulsed signal will not affect an overload.

CAUTION:	Before using the saturation indication feature, the operator has to check if the EMI receiver with the current settings will show an overload due to the pulsed signal. Failure to do so will result in erroneous measurement results.

Typical values to the most common EMI receivers are given in **Table 7** to **Table 9**.

	Frequency	Max. Attenuation
CISPR Band A	9 kHz – 150 kHz	30 dB
CISPR Band B	150 kHz – 30 MHz	25 dB

Table 7: Typical settings for Rhode & Schwarz ESIB

	Frequency	Max. Attenuation
CISPR Band A	9 kHz – 150 kHz	25 dB
CISPR Band B	150 kHz – 30 MHz	40 dB

Table 8: Typical settings for Rhode & Schwarz ESW

	Frequency	Max. Attenuation
CISPR Band A	9 kHz – 150 kHz	16 dB
CISPR Band B	150 kHz – 30 MHz	24 dB

Table 9: Typical settings for Keysight MXE N9038A

If the used EMI receiver is not listed following procedure to find maximum attenuation should be used:

1. Tune receiver to frequency of CISPR Band A where no harmonic is inside the resolution bandwidth e.g. 25 kHz
2. Set attenuator to 10 dB
3. Turn on pulse generator with test switch, see **Figure 2**.
4. Increase attenuation until no overload is shown by the receiver.
5. Switch back one attenuator step and note maximum attenuation
6. Repeat step 1 to 5 with frequency of Band B. Due to preselector design testing at several frequencies may be required.

The operator has to decide if the PLA-R antenna is used in active or passive mode. This decision has to be made according the minimum / maximum field strength, see **Figure 13** and **Figure 14**, and the applicable limit.

CAUTION: Do not forget to assign the correct antenna factor to your EMI measurement software when changing the operation mode of the PLA-R.

Typically for measurements at 3 m distance the noise floor when using the PLA-R in passive mode is sufficient. When the equipment under test (EUT) shows strong pulsed signals, the use of the passive mode is also recommended.

6. Literature and information

[1] ANSI C63.4, “American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz”, IEEE, 2014

[2] CISPR 11, “Industrial, scientific and medical equipment – Radio-frequency disturbance characteristics – Limits and methods of measurement”, Edition 6.1, 2016-06

[3] CISPR 11, “Industrial, scientific and medical equipment – Radio-frequency disturbance characteristics – Limits and methods of measurement”, draft standard CIS/B/687/CDV, 2017

[4] CISPR 14, “Electromagnetic compatibility – Requirements for household appliances, electric tools and similar apparatus – Part 1: Emission”, Edition 6.0, 2016-08

[5] CISPR 16-1-1, “Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-1: Radio disturbance and immunity measuring apparatus – Measuring apparatus”, Edition 4.0, 2015-9

[6] CISPR 16-1-4, “Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-4: Radio disturbance and immunity measuring apparatus – Antennas and test sites for radiated disturbance measurements”, CIS/A/1250/CD, IEC, 2018

[7] CISPR 16-2-3, “Specification for radio disturbance and immunity measuring apparatus and methods – Part 2-3: Methods of measurement of disturbances and immunity – Radiated disturbance measurements”, CIS/A/1250/CD, IEC, 2018

[8] CISPR 36, “Electric and hybrid road vehicles - Radio disturbance characteristics - Limits and methods of measurement for the protection of off-board receivers below 30 MHz”, draft Standard CIS/D/439/CDV, 2017

[9] EN 302 291-1, “Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices (SRD); Close Range Inductive Data Communication equipment operating at 13,56 MHz; Part 1: Technical characteristics and test methods”, 2005-07

[10] EN 50147-1, “Anechoic chambers - Part 1: Shield attenuation measurement“, March 1996

[11] ETSI TR 103 409, “System Reference document (SRdoc); Wireless Power Transmission (WPT) systems for Electric Vehicles (EV) operating in the frequency band 79 - 90 kHz”, V1.1.1, 2016-10

[12] IEC/PAS 62825, “Methods of measurement and limits for radiated disturbances from plasma display panel TVs in the frequency range 150 kHz to 30 MHz”, Public available specification, pre-standard, Edition 1.0, 2013-01

[13] IEEE Std. 299-2006, “IEEE Recommended practice for Measurement of Shielding Effectiveness of High-Performance Shielding Enclosures”, 28 February 2007

[14] ITU-R SM.2303-1, “Wireless power transmission using technologies other than radio frequency beam”, Report, SM Series, Spectrum management, 06/2015

[15] A. Kriz, „Ground loops during site validation of anechoic rooms below 30 MHz”, IEEE Symposium on Electromagnetic Compatibility, Signal and Power Integrity, Long Beach, California, USA 2018

[16] A. Kriz, „Saturation of Active Loop Antennas”, IEEE Symposium on Electromagnetic Compatibility, Signal and Power Integrity, Ottawa, Canada 2016

[17] MIL-STD-285, “Military Standard Attenuation Measurements for Enclosures, Electromagnetic Shielding, for Electronic Test Purposes, Method of”, 25.06.1956

[18] MIL-STD-461G, “DEPARTMENT OF DEFENSE INTERFACE STANDARD REQUIREMENTS FOR THE CONTROL OF ELECTROMAGNETIC INTERFERENCE CHARACTERISTICS OF SUBSYSTEMS AND EQUIPMENT”, 11 December 2015

[19] MIL-STD-462D, “MILITARY STANDARD MEASUREMENT OF ELECTROMAGNETIC INTERFERENCE CHARACTERISTICS”, 11 January 1993

[20] NSA No. 94-106, “National Security Agency Specification for Shielded Enclosures”, 24 October 1994

[21] SAE J551-5, “Performance Levels and Methods of Measurement of Magnetic and Electric Field Strength from Electric Vehicles, Broadband, 9 kHz to 30 MHz”, Rev. Jan 2004

[22] F. W. Trautnitz, J. Riedelsheimer, „Erstellung eines Validierungsverfahrens für EMV Messplätze im Frequenzbereich von 9 kHz bis 30 MHz mit Magnetfeldantennen“, EMV Düsseldorf, 2014

[23] F. W. Trautnitz, J. Riedelsheimer, „Validierung von Feldstärke - Messplätzen im Frequenzbereich von 9 kHz – 30 MHz mit Rahmen-Antennen“, EMV Düsseldorf, 2016

[24] F. W. Trautnitz, A. Kriz, A. Morgenstern, J. Riedelsheimer, R. Svadlenka „Eignung von Messplätzen im Frequenzbereich von 9 kHz bis 30 MHz mit Rahmenantennen“, EMV Düsseldorf, 2018

[25] Volkswagen TL 81000, „EMV von Kfz-Elektronikbauteilen“, Konzernnorm, Ausgabe 2016-02

ANNEX I. WARRANTY

Seibersdorf Labor GmbH, hereinafter referred to as the Seller, warrants that standard Seibersdorf Laboratories products are free from defect in materials and workmanship for a period of two (2) years from the date of shipment.

Standard Seibersdorf Laboratories products include the following:

- Antennas
- Cables
- Reference Radiators
- Software
- Antenna stands and positioners

If the Buyer notifies the Seller of a defect within the warranty period, the Seller will, at the Seller's option, either repair and/or replace products which prove to be defective during the warranty period.
There will be no charge for warranty services performed at the location the Seller designates. The Buyer must, however, prepay inbound shipping costs and any duties or taxes. The Seller will pay outbound shipping cost for a carrier of the Seller's choice, exclusive of any duties or taxes.

This warranty does not apply to:

- Normal wear and tear of materials
- Consumable items such as fuses, batteries, etc.
- Products that have been improperly installed, maintained or used
- Products which have been operated outside the specifications
- Products which have been modified without authorization
- Calibration of products, unless necessitated by defects

THIS WARRANTY IS EXCLUSIVE. NO OTHER WARRANTY, WRITTEN OR ORAL, IS EXPRESSED OR IMPLIED, INCLUDING BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. THE REMEDIES PROVIDED BY THIS WARRANTY ARE THE BUYER'S SOLE AND EXCLUSIVE REMEDIES. IN NO EVENT IS THE SELLER LIABLE FOR ANY DAMAGES WHATSOEVER, INCLUDING BUT NOT LIMITED TO, DIRECT, INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, WHETHER BASED ON CONTRACT, TORT, OR ANY OTHER LEGAL THEORY.

ANNEX II. Safety against electromagnetic fields

The PLA-T transmit antenna radiated a strong magnetic field when high current amplifier is used. Therefore information about Electromagnetic Fields (EMF) is given.
This information can be used to state compliance with Directive 2013/35/EU - on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (electromagnetic fields).

EMF data sheet:

Issued by	Seibersdorf Labor GmbH
Valid from	2018-08-01

Equipment information:

Brand name	Seibersdorf Laboratories
Model name	PLA-T
Intended use	occupational

Basic information:

Applied regulation	none
Referenced limits	Directive 2013/35/EU, Recommendation 1999/519/EC
Applied standard	IEC 62226-3-1

Non-Thermal effects need to be considered for workplace assessment	yes
Thermal effects need to be considered for workplace assessment	yes

Data is based on maximum power source capability

EMF data for non-thermal effects:

	Head		Trunk	Limb hand
	Sensory effects	Health effects		
Required minimum distance	1 cm	1 cm	1 cm	0 cm

Table II.1: EMF data for non-thermal effects

EMF data for thermal health effects:

	Head	Trunk	Limb hand
Required minimum distance	1 cm	1 cm	0 cm

Table II.2: EMF data for thermal health effects

Distance where compliance with general public limits is reached: 25 cm

ANNEX III. Laser Safety

As described in chapter 2 the PLA-TX and PLA-RX has a dot-laser and a line laser. The laser apertures are shown in **Figure 35**.

Figure 35: Laser Apertures

The product is classified as Class 2 laser product and complied with IEC 60825-1:2007 and 21 CFR 1040.10 and 1040.11 except for deviations pursuant to Laser Notice no. 50, date June 24, 2007.
The radiation emitted from the product is less than then exposure limits given by directive 2006/25/EC, if an exposure time less than 0.25 s is assumed.
The specifications of the laser are found in **Table 10**.

	dot-laser	line-laser
Wavelength	532 nm	532 nm
Maximum output	1 mW CW	1 mW CW
Divergence	0,5 mrad	0,5 mrad
Fan angle	-	90°

Table 10: Laser Specification

On the bottom of the “antenna box” a warning label is placed near the laser aperture of the dot-laser, see **Figure 36**.

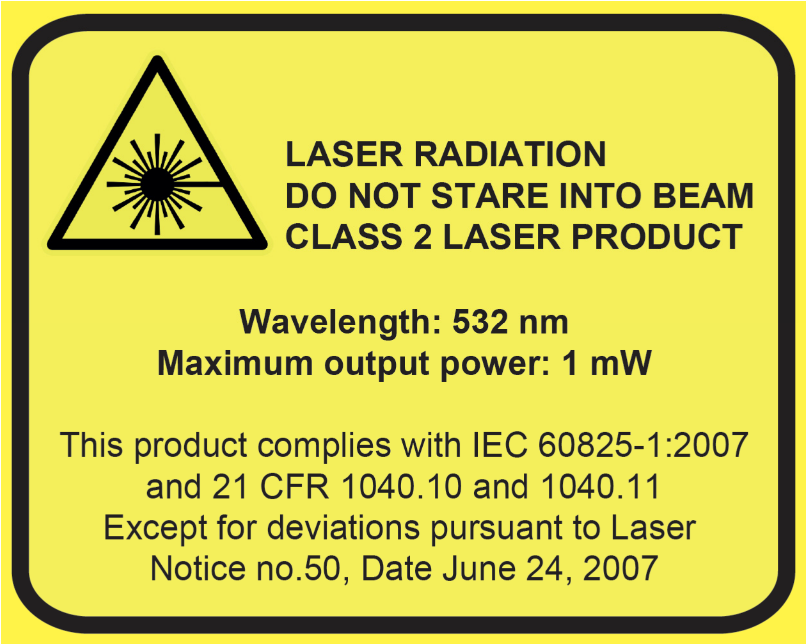


Figure 36: Warning label

ANNEX IV. Battery Information

The amplifier box of PLA-R and PLA-T include a 10-cell Nickel-Metal hydride battery pack each.

A sealed Nickel-Metal hydride cell/battery is not hazardous in normal use; especially the release of hydrogen gas is excluded.

In case of mistreatment (abusive over charge, reverse charge, external short circuit…) and in case of fault some electrolyte can leak from the cell through the safety device. In these cases refer to the risk of potassium hydroxide solution (corrosive, pH > 14). The electrode materials are only hazardous, if the materials are released by mechanical damaging of the cell or if exposed to fire.

Storage is preferred at room temperature 20°C. Avoid large temperature changes. Do not store close to the heating. Avoid direct sunlight.

In the European Union, manufacturing, handling and disposal of batteries is regulated on the basis of the DIRECTIVE 2006/66/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 6 September 2006 on batteries and accumulators and waste batteries and accumulators and repealing Directive 91/157/EEC. Customers find detailed information on disposal in their specific countries using the web site of the European Portable Batteries Association (http://www.epbaeurope.net/legislation_national.html).

Users outside EU should consider the local law and rules.

Nickel-Metal hydride Batteries (also referred as “Dry cells”) are not defined as dangerous goods under IATA Dangerous Goods Regulations (DGR) 57th edition 2015. This kind of batteries are not subject to the IATA-DGR as they are compliant with the special provision requirements.
In addition, the IATA-DGR require the words “not restricted” and Special Provision number A199 on the air waybill, when air waybill is issued.

For maritime transport the Nickel-Metal hydride batteries are regulated by IMDG (Inter-national Maritime Dangerous Goods) under UN3496 BATTERIES, NICKEL METAL HYDRIDE, CLASS 9 with Special Provision 117 and 963. They are not subject to other provisions of this Code if less than 100 Kg total gross weight is loaded in a cargo transport unit.

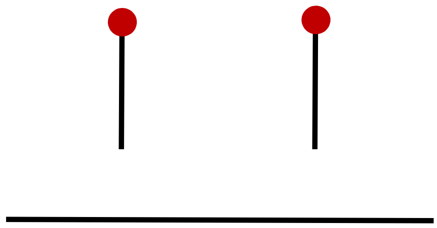
Nickel-Metal hydride Batteries are no subject of the Dangerous Goods Regulations ADR/RID for Transports on Road or Rail.

ANNEX V. NSA values for site validation

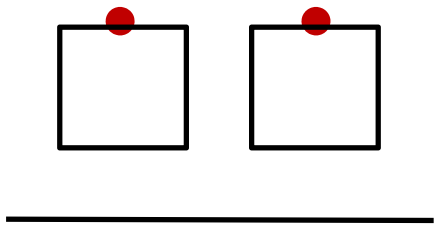
The NSA values are given in **Figure 38** and are available as Excel File for download (https://rf.seibersdorf-laboratories.at/products-services/products/pla-set). **Table 11** to **Table 13** shows a few values of the tables.

According to CISPR 16-1-4 additional information together with the NSA values should be supplied to maintain traceability.
This information should contain:
Description of feed points, see **Figure 37**
NEC source code, see **Table 14**
used NEC core: 4NEC2, Version V5.7.4, Arie Voors, HTTP://WWW.QSL.NET/4NEC2

a) H_X front view



b) H_Y front view



c) H_Z top view

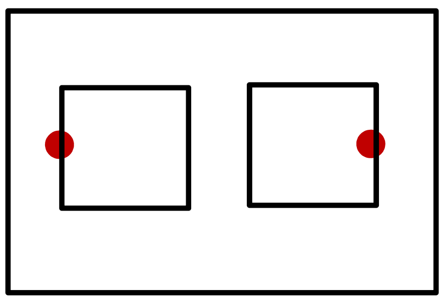
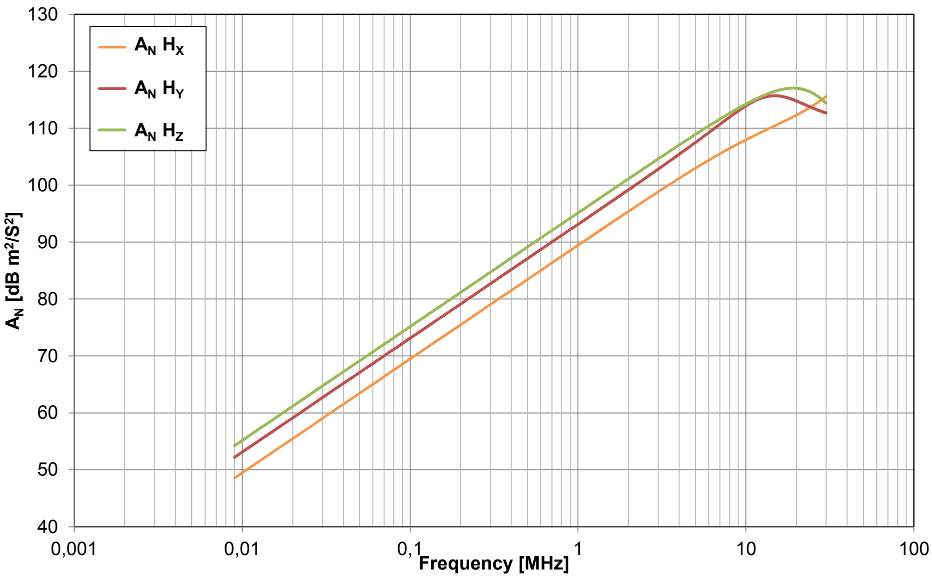
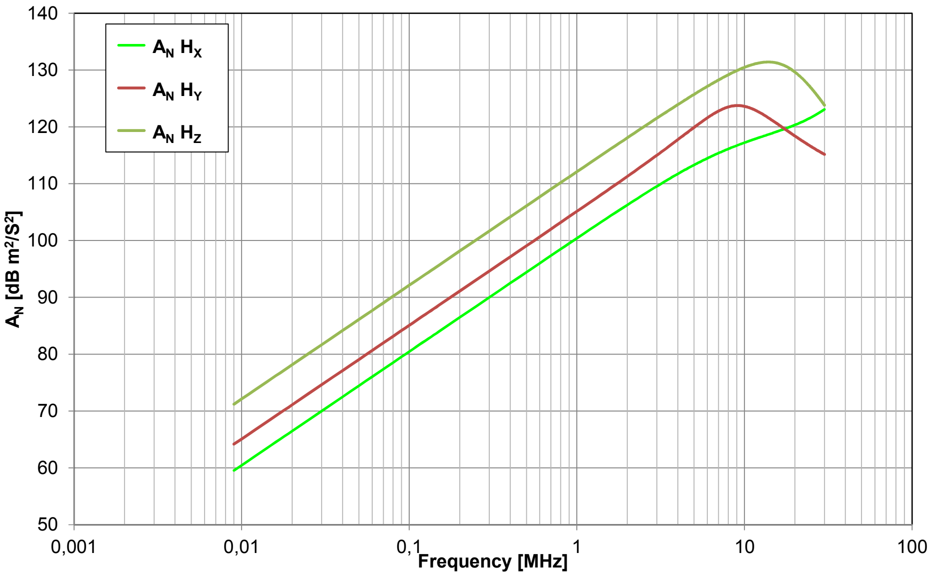


Figure 37: Specification of the feed points

a)



b)



c)

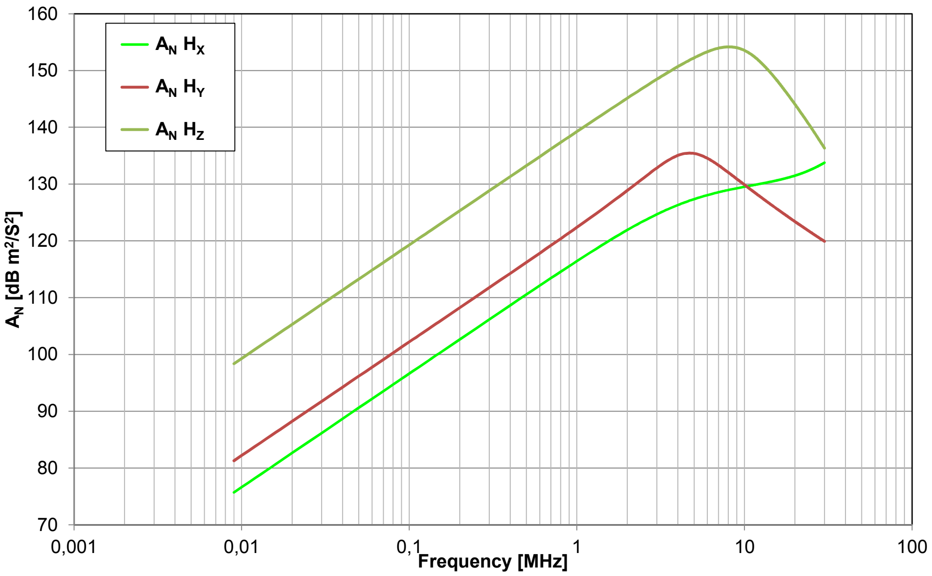


Figure 38: NSA values a) 3 m b) 5 m c) 10 m

Table 11: NSA values, 3 m

Frequency MHz	F_{aH} dB S/m	SIL H_x dB	SIL H_y dB	SIL H_z dB	A_N H_x dB m^2/S^2	A_N H_y dB m^2/S^2	A_N H_z dB m^2/S^2
0,009	31,91	112,36	116,01	118,04	48,54	52,19	54,23
0,01	30,99	111,45	115,09	117,13	49,46	53,11	55,14
….							
29,9	-18,44	78,68	75,83	77,54	115,56	112,71	114,43
30	-18,44	78,71	75,82	77,50	115,60	112,70	114,39

Table 12: NSA values, 5 m

Frequency MHz	F_{aH} dB S/m	SIL H_x dB	SIL H_y dB	SIL H_z dB	A_N H_x dB m^2/S^2	A_N H_y dB m^2/S^2	A_N H_z dB m^2/S^2
0.009	31.91	123.36	127.98	135.03	59.54	64.17	71.21
0.01	30.99	122.44	127.07	134.11	60.46	65.08	72.13
…							
29.9	-18.44	86.17	78.31	87.00	123.05	115.19	123.88
30	-18.44	86.19	78.28	86.94	123.08	115.17	123.83

Table 13: NSA values, 10 m

Frequency MHz	F_{aH} dB S/m	SIL H_x dB	SIL H_y dB	SIL H_z dB	A_N H_x dB m^2/S^2	A_N H_y dB m^2/S^2	A_N H_z dB m^2/S^2
0.009	31.91	139.53	145.10	162.18	75.72	81.29	98.37
0.01	30.99	138.62	144.19	161.27	76.63	82.20	99.28
…							
29.9	-18.44	96.86	83.06	99.53	133.74	119.94	136.42
30	-18.44	96.88	83.03	99.46	133.76	119.92	136.35

Table 14: NEC source code

```
CM SEIBERSDORF LABORATORIES
CM SIMULATION OF SIL
CM PRECISION LOOP ANTENNA PLA
CM 2018
CM
CE
GW 1 9 0.300 -0.300 0 -0.300 -0.300 0 0.001
GW 2 9 0.300 0.300 0 -0.300 0.300 0 0.001
GW 3 9 0.300 -0.300 0 0.300 0.300 0 0.001
GW 4 9 -0.300 0.300 0 -0.300 -0.300 0 0.001
GW 5 9 0.300 -0.300 0 -0.300 -0.300 0 0.001
GW 6 9 0.300 0.300 0 -0.300 0.300 0 0.001
GW 7 9 0.300 -0.300 0 0.300 0.300 0 0.001
GW 8 9 -0.300 0.300 0 -0.300 -0.300 0 0.001
GM 0 0 90 180 0 0 0 1.300 0
GM 0 0 0 0 0 0 3.000 0 5
GE 1
GN 1
EK
EX 0 1 5 0 0 2 0
LD 0 1 5 5 50 0 0
LD 0 5 5 5 50 0 0
FR 0 1 0 0 30.000 1
PT 0 5 5 5
XQ
```

ANNEX VI. Sample Certificate of Antenna Calibration

A sample calibration certificate for the PLA-R is given on the following pages.

Kalibrierstelle für Antennen und Feldsonden
Calibration Body for Antennas and Field Probes

Akkreditiert durch / *accredited by*
AKKREDITIERUNG AUSTRIA

Kalibrierschein nach ISO/IEC 17025
Calibration Certificate according to ISO/IEC 17025

Kalibrierzeichen
Calibration mark

EH-AXXX/XX
ÖKD 13

Gegenstand *Object*	Loop Antenna
Hersteller & Typ *Manufacturer & Type*	Seibersdorf Laboratories PLA-R
Herstellernummer *Serial number*	
Auftraggeber *Customer*	
Auftragsnummer *Order Nr.*	
Anzahl der Seiten des Kalibrierscheines *Number of pages of the certificate*	1 - 4
Datum der Kalibrierung *Date of calibration*	

Akkreditierung Austria ist Vollmitglied bei der International Laboratory Accreditation Cooperation ILAC und Unterzeichner der MRAs für die Bereiche „Testing, Calibration and Inspection“.

Die Kalibrierung erfolgt auf der gesetzlichen Grundlage des Akkreditierungsgesetzes in gültiger Fassung entsprechend den Anforderungen der ÖVE/ÖNORM EN ISO/IEC 17025.

Dieser Kalibrierschein dokumentiert die Rückführbarkeit auf nationale Normale zur Darstellung der physikalischen Einheiten in Übereinstimmung mit dem Internationalen Einheitensystem (SI).

Für die Einhaltung einer angemessenen Frist zur Wiederholung der Kalibrierung ist der Benutzer verantwortlich.

Akkreditierung Austria is a full member of the International Laboratory Accreditation Cooperation ILAC and a signatory of the MRA for "Testing, Calibration and Inspection".

The calibration is performed in accordance with the Akkreditierungsgesetz in the amended version and the requirements of ÖVE/ÖNORM EN ISO/IEC 17025.

This calibration certificate documents the traceability to national standards, which realize the physical units or measurements according to the International System of Units (SI).

The user is obliged to have the object recalibrated at appropriate intervals.

Dieser Kalibrierschein darf nur vollständig und unverändert weiterverarbeitet werden. Auszüge oder Änderungen sind unzulässig. Kalibrierscheine ohne Unterschrift haben keine Gültigkeit.

This calibration certificate may not be reproduced other than in full. Calibration certificates without signature are not valid.

Datum *Date*	Zeichnungsberechtigter *Authorized person*	Bearbeiter *Person responsible*
	______________________	____________________

Measurement Procedure: CISPR 16-1-6

The antenna factor is determined by first measuring the direct line, network analyser (NWA) to input and output of the TEM-cell with the loop antenna positioned at the centre of the 50 Ω TEM-cell (the plane of the loop perpendicular to the magnetic field and parallel to the direction of the propagation) and second by connecting the output of the loop with the input of the NWA while the TEM-cell is terminated with 50 Ω [1].

Measurement Equipment

Type	Identification
Network analyzer Agilent Technologies E5061B	E0192
TEM Cell	E1022
Cable with ferrits	E4919, E4807
50Ω termination	E1352
Attenuator 10dB	E1372, E1285
CalStan 10.0	E0920

Environmental Conditions

Control Room Temperature	21 °C	± 3 °C
Control Room Humidity	50 %	± 10 %

Results

The measured antenna factors are given in the tables and figures attached to this certificate. Any quoted uncertainty refers only to the measured value at the time of calibration and does not carry any implication regarding the long-term stability of the antennas.

Type	Figure/Table
Magnetic Antenna Factor	Figure 1, Table 1

Use of the Antenna Factor

The antenna factor was calculated according to:

H [dBµA/m] = V [dBµV] + AFH [dB/Ωm]

AFH = Magnetic field antenna factor
H = Magnetic field strength at the loop antenna´s terminal
V = Voltage at terminals of loop antenna

Accuracy of Calibration

The reported expanded uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k = 2, which for a normal distribution corresponds to a coverage probability of approximately 95%. The standard uncertainty of measurement has been determined in accordance with EA 4/02 [2].

References

[1] CISPR 16-1-6:2014/AMD1:2017, Specification for radio disturbance and immunity measuring apparatus and methods - Part 1-6: Radio disturbance and immunity measuring apparatus - EMC antenna calibration.

[2] EA 4/02: “Expression of the Uncertainty of Measurement in Calibration”, European co-operation for Accreditation, September 2013, rev01.

Figure 1: Magnetic Antenna Factor

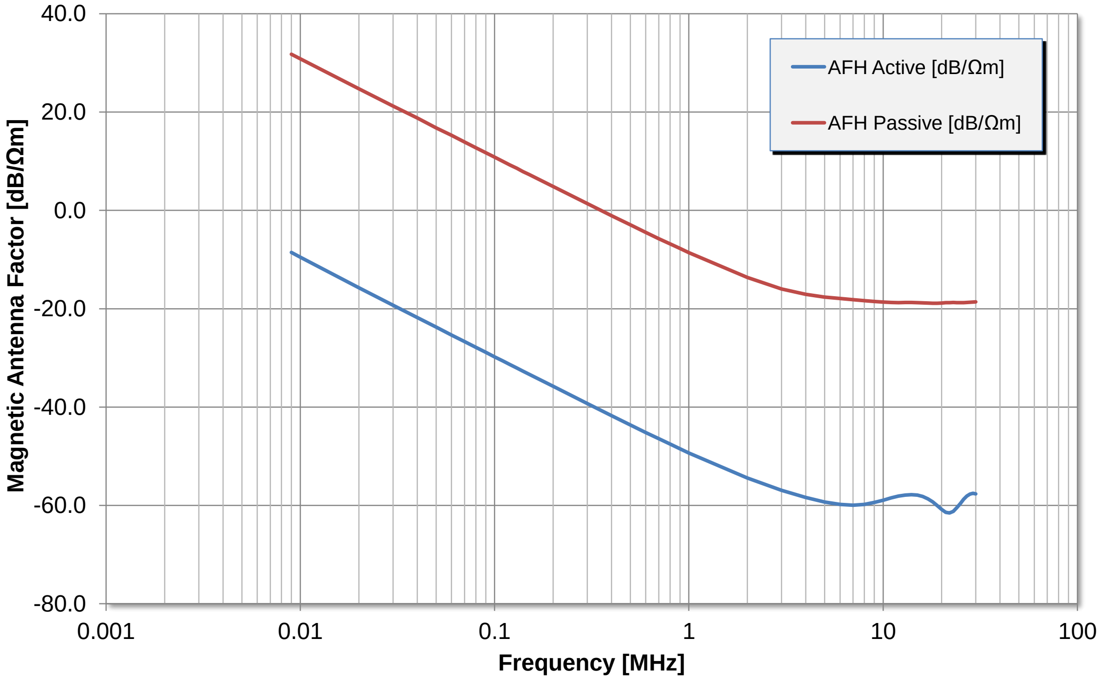


Table 1: Magnetic Antenna Factor

f [MHz]	AFH Active [dB/Ωm]	AFH Passive [dB/Ωm]	U [dB]	f [MHz]	AFH Active [dB/Ωm]	AFH Passive [dB/Ωm]	U [dB]
0.009	-8.5	31.7	±1.2	0.8	-47.5	-6.8	±1.2
0.01	-9.5	30.8	±1.2	0.9	-48.5	-7.8	±1.2
0.02	-15.7	24.7	±1.2	1	-49.3	-8.6	±1.2
0.03	-19.3	21.2	±1.2	2	-54.4	-13.6	±1.2
0.04	-21.8	18.8	±1.2	3	-56.9	-16.0	±1.2
0.05	-23.7	16.8	±1.2	4	-58.4	-17.1	±1.2
0.06	-25.3	15.3	±1.2	5	-59.3	-17.6	±1.2
0.07	-26.7	13.9	±1.2	6	-59.8	-17.9	±1.2
0.08	-27.8	12.7	±1.2	7	-59.9	-18.2	±1.2
0.09	-28.9	11.7	±1.2	8	-59.8	-18.4	±1.2
0.1	-29.8	10.8	±1.2	9	-59.4	-18.5	±1.2
0.11	-30.6	10.0	±1.2	10	-58.9	-18.7	±1.2
0.12	-31.4	9.2	±1.2	11	-58.5	-18.7	±1.2
0.13	-32.1	8.6	±1.2	12	-58.1	-18.7	±1.2
0.14	-32.7	7.9	±1.2	13	-57.9	-18.7	±1.2
0.15	-33.3	7.3	±1.2	14	-57.8	-18.7	±1.2
0.2	-35.8	4.8	±1.2	15	-57.9	-18.7	±1.2
0.3	-39.3	1.4	±1.2	16	-58.2	-18.8	±1.2
0.4	-41.7	-1.1	±1.2	17	-58.6	-18.8	±1.2
0.5	-43.6	-3.0	±1.2	18	-59.3	-18.9	±1.2
0.6	-45.2	-4.5	±1.2	19	-60.0	-18.9	±1.2
0.7	-46.4	-5.7	±1.2	20	-60.8	-18.8	±1.2

f [MHz]	AFH Active [dB/Ωm]	AFH Passive [dB/Ωm]	U [dB]
21	-61.4	-18.8	±1.2
22	-61.5	-18.7	±1.2
23	-61.2	-18.7	±1.2
24	-60.4	-18.8	±1.2
25	-59.6	-18.8	±1.2
26	-58.8	-18.8	±1.2
27	-58.1	-18.7	±1.2
28	-57.7	-18.7	±1.2
29	-57.5	-18.6	±1.2
30	-57.7	-18.6	±1.2

ANNEX VII. Sample Certificate of Sum of Antenna Factors

A sample calibration certificate for the PLA-Set is given on the following pages.

KALIBRIERSCHEIN
CALIBRATION CERTIFICATE

EH-AXXX/XX
ISO 17025

Gegenstand *Object*	Pair of loop antennas
Hersteller & Typ Manufacturer & Type	Seibersdorf Laboratories PLA-T (TX) PLA-R (RX)
Seriennummer *Serial number*	
Auftraggeber *Customer*	
Auftragsnummer *Order Nr*	
Umfang des Kalibrierscheines *Extent of the certificate*	10 Seiten / pages
Datum der Kalibrierung Place and *date of calibration*	

Dieser Kalibrierschein dokumentiert, dass der genannte Gegenstand nach festgelegten Vorgaben geprüft und gemessen wurde. Die Kalibrierung erfolgte mit Messmitteln und Normalen, die direkt oder indirekt durch Ableitung mittels anerkannter Kalibriertechniken rückgeführt sind auf nationale oder internationale Normale zur Darstellung der physikalischen Einheiten in Übereinstimmung mit dem Internationalen Einheitensystem (SI). Wenn keine Normale existieren, erfolgt die Rückführung auf Bezugsnormale der Seibersdorf Laboratories.
Grundsätze und Verfahren der Kalibrierung entsprechen ISO/IEC/EN 17025. Das angewandte Qualitätsmanagement System ist zertifiziert nach ISO/EN 9001.
Für die Einhaltung einer angemessenen Frist zur Wiederholung der Kalibrierung ist der Benutzer verantwortlich.

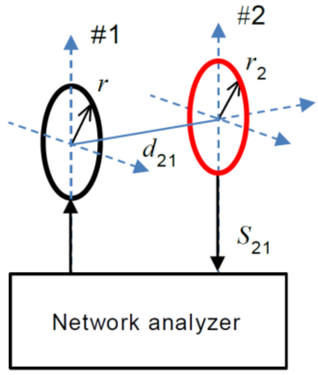
This calibration certificate documents, that the named item is tested and measured against defined specifications. Calibration is performed with test equipment and standards directly or indirectly traceable by means of approved calibration techniques to national or international standards, which realise the physical units of measurements according to the International system of Units (SI). In all cases where no national standards are available, measurements are referenced to standards of Seibersdorf Laboratories.
Principles and methods of calibration correspond with ISO/IEC/EN 17025. The applied quality system is certified to ISO/EN 9001.
The user is obliged to have the object recalibrated at appropriate intervals.

Datum *Date*	Zeichnungsberechtigter *Authorized person*	Bearbeiter *Person responsible*
	______________________	____________________

Seibersdorf Labor GmbH | 2444 Seibersdorf, Austria | Tel.: +43 (0) 50550-2500 | Fax: +43 (0) 50550-2502 | E-Mail: rf-calibration@seibersdorf-laboratories.at
http://rf.seibersdorf-laboratories.at/ | Regional court Wiener Neustadt | Company no: 319187v | DVR no: 4000728 | VAT: ATU64767504 | Tax no: 192/6571 | Certified according to ISO 9001:2008
Bank details: Erste Bank der Österreichischen Sparkassen AG | Sort Code 20111 | Account no 291-140-380/00 | IBAN AT112011129114038000 | BIC GIBAATWW

Calibration Procedure

The sum of transmit antenna and receive antenna factor is calibrated using the two antenna method according to draft CISPR 16-1-6 [2]. This is done at a height of 1.3 m at the open area test site. Depending on dynamic range requirements the test distance is selected accordingly.



The procedures are according to the requirements of ISO/EN 17025, the equipment manuals and our internal work procedures.

Measurement Equipment

Type	S/N	Identification	Cal. Cert.	Cal. due
Test Receiver R&S ESIB 7	1000136	E0118	E51928 D-K-15070-01-01 2017-08	30.08.2019
Open Area Test Site	NA	E1010	NA	NA
CalStan 10.0	NA	E0920	NA	NA

Environmental Conditions

Temperature	19 °C ± 3 °C
Humidity	60% ± 10 %

Measurement Uncertainty

Any quoted uncertainty refers only to the measured value at the time of calibration and does not carry any implication regarding the long-term stability.

Result	Antenna mode	Expanded Uncertainty
$F_{a,TX}+F_{a,RX}$	Active	± 0.6 dB
$F_{a,TX}+F_{a,RX}$	Passive	± 1 dB

The reported expanded uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor $k = 2$, which for a normal distribution corresponds to a coverage probability of approximately 95%. The standard uncertainty of measurement has been determined in EA 4/02 [3].

Results

The measured results are given in the figures and tables attached to this certificate. All numerical values are given in a separate file in Microsoft Excel format.

Result	Test Distance d	Height h	TX Antenna Mode / RX Antenne Mode	Figure / Table
$F_{a,TX}+F_{a,RX}$	0.3 m	1.3 m	Broadband / Active	1
$F_{a,TX}+F_{a,RX}$	1 m	1.3 m	High Current / Active	2
$F_{a,TX}+F_{a,RX}$	0.3 m	1.3 m	Passive / Passive	3

References

[1] Draft CISPR 16-1-4: “ Draft amendment to CISPR 16-1-4 for test site validation from 9 kHz to 30 MHz”, For IEC use only - no public document, CISPR/A/1101/DC, 2014-12-19

[2] Draft CISPR 16-1-6: “Amendment 2 - Specification for radio disturbance and immunity measuring apparatus and methods - Part 1-6: Radio disturbance and immunity measuring appratus - EMC antenna calibration”, For IEC use only - no public document, CISPR/A/1221/CD, 2017-07-14

[3] EA 4/02: “Expression of the Uncertainty of Measurement in Calibration”, European co-operation for Accreditation, September 2013, rev01.

Figure 1: Sum of Antenna Factors $F_{a,TX}+F_{a,RX}$ measured at 0.3 m test distance, TX Broadband mode, RX Active mode

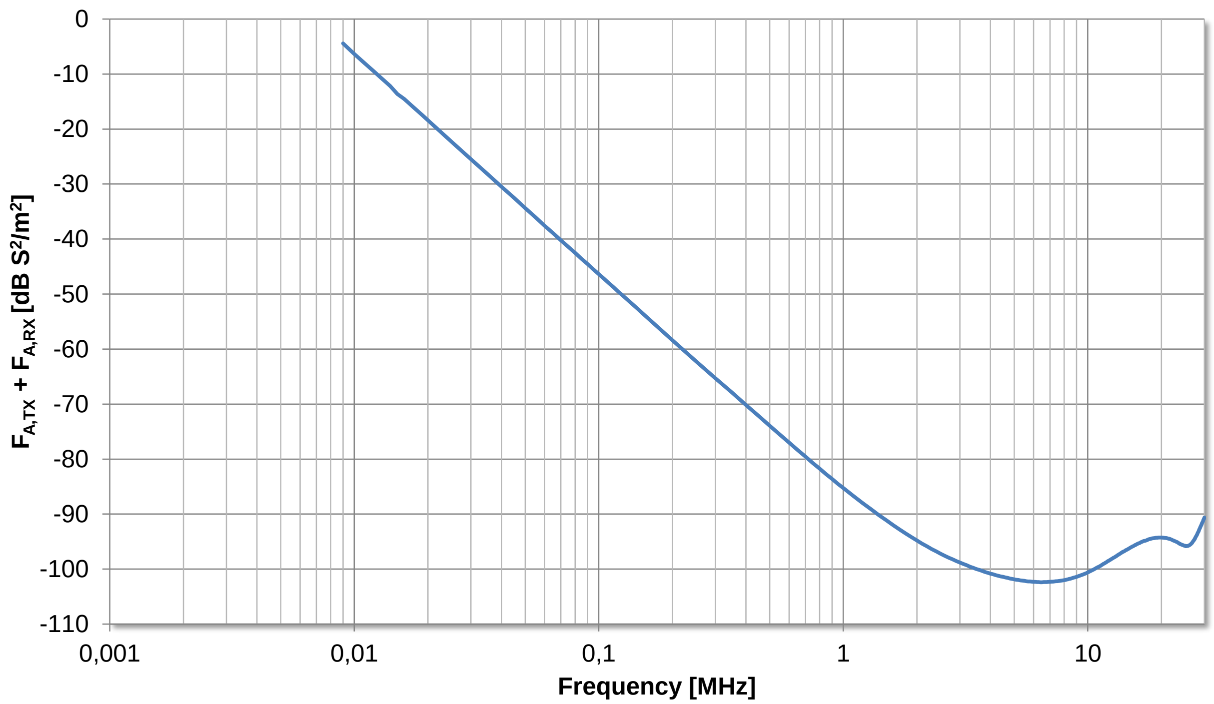


Table 1: Sum of Antenna Factors $F_{a,TX}+F_{a,RX}$ measured at 0.3 m test distance, TX Broadband mode, RX Active mode

f [MHz]	$F_{A.TX}+F_{A.RX}$ [dB S^2/m^2]	f [MHz]	$F_{A.TX}+F_{A.RX}$ [dB S^2/m^2]	f [MHz]	$F_{A.TX}+F_{A.RX}$ [dB S^2/m^2]
0.009	-4.43	0.090	-44.55	0.80	-81.74
0.010	-6.34	0.095	-45.49	0.85	-82.71
0.011	-7.97	0.100	-46.37	0.90	-83.62
0.012	-9.47	0.105	-47.22	0.95	-84.47
0.013	-10.89	0.110	-48.02	1.0	-85.26
0.014	-12.16	0.115	-48.79	1.1	-86.71
0.015	-13.63	0.120	-49.52	1.2	-87.99
0.016	-14.53	0.125	-50.23	1.3	-89.14
0.017	-15.58	0.130	-50.90	1.4	-90.20
0.018	-16.59	0.135	-51.56	1.5	-91.13
0.019	-17.51	0.140	-52.19	1.6	-92.00
0.020	-18.43	0.145	-52.80	1.7	-92.79
0.025	-22.31	0.150	-53.40	1.8	-93.52
0.030	-25.47	0.20	-58.38	1.9	-94.19
0.035	-28.16	0.25	-62.24	2.0	-94.81
0.040	-30.48	0.30	-65.30	2.1	-95.35
0.045	-32.50	0.35	-67.89	2.2	-95.87
0.050	-34.36	0.40	-70.15	2.3	-96.35
0.055	-36.01	0.45	-72.15	2.4	-96.79
0.060	-37.59	0.50	-73.94	2.5	-97.21
0.065	-38.91	0.55	-75.54	2.6	-97.57
0.070	-40.20	0.60	-77.00	2.7	-97.92
0.075	-41.40	0.65	-78.34	2.8	-98.24
0.080	-42.51	0.70	-79.56	2.9	-98.53
0.085	-43.57	0.75	-80.69	3.0	-98.82

f [MHz]	$F_{A.TX}+F_{A.RX}$ [dB S^2/m^2]	f [MHz]	$F_{A.TX}+F_{A.RX}$ [dB S^2/m^2]	f [MHz]	$F_{A.TX}+F_{A.RX}$ [dB S^2/m^2]
3.1	-99.07	9.7	-100.87	16.3	-95.25
3.2	-99.31	9.8	-100.78	16.4	-95.16
3.3	-99.56	9.9	-100.70	16.5	-95.12
3.4	-99.78	10.0	-100.60	16.6	-95.06
3.5	-99.98	10.1	-100.51	16.7	-95.01
3.6	-100.16	10.2	-100.41	16.8	-94.95
3.7	-100.34	10.3	-100.33	16.9	-94.93
3.8	-100.51	10.4	-100.23	17.0	-94.89
3.9	-100.67	10.5	-100.14	17.1	-94.86
4.0	-100.82	10.6	-100.04	17.2	-94.82
4.1	-100.95	10.7	-99.93	17.3	-94.78
4.2	-101.08	10.8	-99.83	17.4	-94.77
4.3	-101.20	10.9	-99.74	17.5	-94.70
4.4	-101.31	11.0	-99.66	17.6	-94.64
4.5	-101.41	11.1	-99.55	17.7	-94.62
4.6	-101.51	11.2	-99.45	17.8	-94.58
4.7	-101.60	11.3	-99.37	17.9	-94.54
4.8	-101.70	11.4	-99.26	18.0	-94.51
4.9	-101.78	11.5	-99.16	18.1	-94.47
5.0	-101.86	11.6	-99.05	18.2	-94.45
5.1	-101.93	11.7	-98.95	18.3	-94.41
5.2	-101.98	11.8	-98.85	18.4	-94.40
5.3	-102.03	11.9	-98.75	18.5	-94.38
5.4	-102.09	12.0	-98.66	18.6	-94.37
5.5	-102.12	12.1	-98.56	18.7	-94.36
5.6	-102.19	12.2	-98.47	18.8	-94.35
5.7	-102.22	12.3	-98.35	18.9	-94.34
5.8	-102.25	12.4	-98.26	19.0	-94.31
5.9	-102.29	12.5	-98.16	19.1	-94.31
6.0	-102.31	12.6	-98.07	19.2	-94.31
6.1	-102.33	12.7	-97.97	19.3	-94.28
6.2	-102.35	12.8	-97.87	19.4	-94.27
6.3	-102.37	12.9	-97.80	19.5	-94.27
6.4	-102.38	13.0	-97.71	19.6	-94.25
6.5	-102.38	13.1	-97.61	19.7	-94.25
6.6	-102.38	13.2	-97.51	19.8	-94.26
6.7	-102.35	13.3	-97.42	19.9	-94.25
6.8	-102.34	13.4	-97.33	20.0	-94.27
6.9	-102.33	13.5	-97.24	20.1	-94.27
7.0	-102.31	13.6	-97.15	20.2	-94.27
7.1	-102.29	13.7	-97.06	20.3	-94.28
7.2	-102.27	13.8	-96.96	20.4	-94.28
7.3	-102.24	13.9	-96.87	20.5	-94.30
7.4	-102.22	14.0	-96.82	20.6	-94.32
7.5	-102.19	14.1	-96.73	20.7	-94.33
7.6	-102.15	14.2	-96.66	20.8	-94.33
7.7	-102.11	14.3	-96.57	20.9	-94.36
7.8	-102.09	14.4	-96.50	21.0	-94.37
7.9	-102.06	14.5	-96.42	21.1	-94.39
8.0	-102.02	14.6	-96.35	21.2	-94.43
8.1	-101.97	14.7	-96.27	21.3	-94.44
8.2	-101.91	14.8	-96.20	21.4	-94.47
8.3	-101.85	14.9	-96.12	21.5	-94.47
8.4	-101.80	15.0	-96.05	21.6	-94.51
8.5	-101.74	15.1	-95.98	21.7	-94.53
8.6	-101.67	15.2	-95.91	21.8	-94.56
8.7	-101.60	15.3	-95.85	21.9	-94.61
8.8	-101.53	15.4	-95.78	22.0	-94.63
8.9	-101.49	15.5	-95.71	22.1	-94.69
9.0	-101.41	15.6	-95.65	22.2	-94.72
9.1	-101.34	15.7	-95.58	22.3	-94.78
9.2	-101.26	15.8	-95.53	22.4	-94.81
9.3	-101.19	15.9	-95.46	22.5	-94.85
9.4	-101.11	16.0	-95.42	22.6	-94.88
9.5	-101.04	16.1	-95.34	22.7	-94.92
9.6	-100.95	16.2	-95.29	22.8	-94.96

f [MHz]	$F_{A.TX}+F_{A.RX}$ [dB S^2/m^2]	f [MHz]	$F_{A.TX}+F_{A.RX}$ [dB S^2/m^2]	f [MHz]	$F_{A.TX}+F_{A.RX}$ [dB S^2/m^2]
22.9	-94.98	25.3	-95.81	27.7	-94.09
23.0	-95.03	25.4	-95.81	27.8	-93.95
23.1	-95.07	25.5	-95.80	27.9	-93.81
23.2	-95.12	25.6	-95.79	28.0	-93.67
23.3	-95.16	25.7	-95.77	28.1	-93.54
23.4	-95.21	25.8	-95.73	28.2	-93.37
23.5	-95.25	25.9	-95.70	28.3	-93.24
23.6	-95.30	26.0	-95.67	28.4	-93.13
23.7	-95.35	26.1	-95.62	28.5	-92.95
23.8	-95.40	26.2	-95.57	28.6	-92.79
23.9	-95.46	26.3	-95.51	28.7	-92.61
24.0	-95.49	26.4	-95.45	28.8	-92.47
24.1	-95.53	26.5	-95.37	28.9	-92.33
24.2	-95.57	26.6	-95.30	29.0	-92.18
24.3	-95.60	26.7	-95.20	29.1	-92.03
24.4	-95.61	26.8	-95.13	29.2	-91.87
24.5	-95.65	26.9	-95.04	29.3	-91.72
24.6	-95.67	27.0	-94.92	29.4	-91.57
24.7	-95.70	27.1	-94.82	29.5	-91.42
24.8	-95.72	27.2	-94.69	29.6	-91.23
24.9	-95.74	27.3	-94.61	29.7	-91.09
25.0	-95.76	27.4	-94.48	29.8	-90.94
25.1	-95.81	27.5	-94.34	29.9	-90.80
25.2	-95.81	27.6	-94.22	30.0	-90.65

Figure 2: Sum of Antenna Factors $F_{a,TX}+F_{a,RX}$ measured at 1 m test distance, TX High current mode mode, RX Active mode

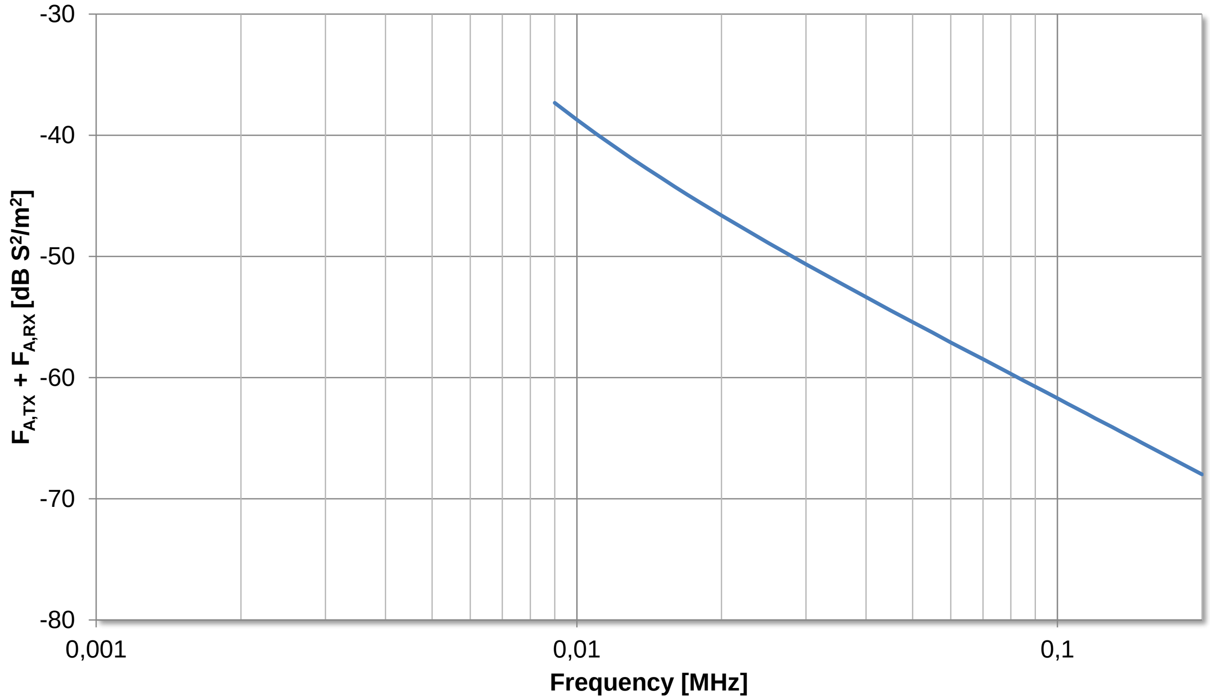


Table 2: Sum of Antenna Factors $F_{a,TX}+F_{a,RX}$ measured at 1 m test distance, TX High current mode, RX Active mode

f [MHz]	$F_{A.TX}+F_{A.RX}$ [dB S^2/m^2]	f [MHz]	$F_{A.TX}+F_{A.RX}$ [dB S^2/m^2]
0.009	-37.33	0.065	-57.80
0.010	-38.72	0.070	-58.48
0.011	-39.91	0.075	-59.10
0.012	-40.96	0.080	-59.68
0.013	-41.91	0.085	-60.24
0.014	-42.76	0.090	-60.75
0.015	-43.52	0.095	-61.24
0.016	-44.26	0.100	-61.71
0.017	-44.91	0.105	-62.15
0.018	-45.53	0.110	-62.57
0.019	-46.08	0.115	-62.97
0.020	-46.62	0.120	-63.36
0.025	-48.87	0.125	-63.73
0.030	-50.65	0.130	-64.08
0.035	-52.11	0.135	-64.42
0.040	-53.36	0.140	-64.75
0.045	-54.46	0.145	-65.07
0.050	-55.42	0.150	-65.38
0.055	-56.28	0.20	-67.98
0.060	-57.10		

Figure 3: Sum of Antenna Factors $F_{a,TX}$+$F_{a,RX}$ measured at 0.3 m test distance, TX Passive mode, RX Passive mode

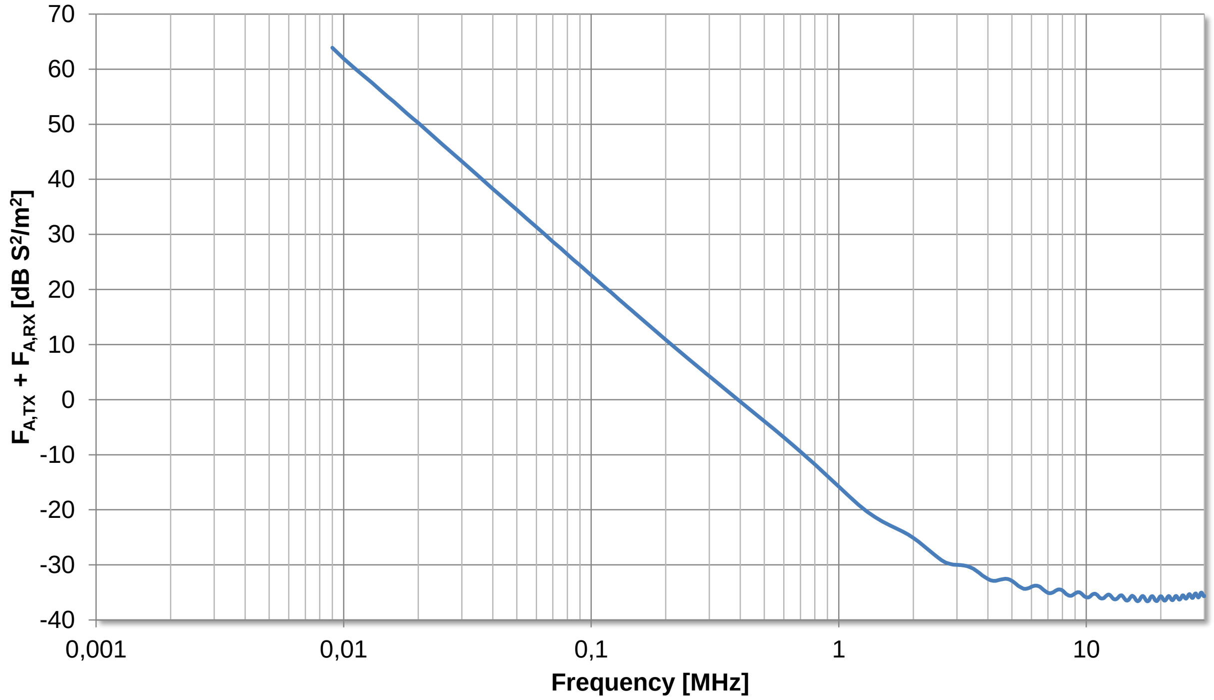


Table 3: Sum of Antenna Factors $F_{a,TX}$+$F_{a,RX}$ measured at 0.3 m test distance, TX Passive mode, RX Passive mode

f [MHz]	$F_{A.TX}$+$F_{A.RX}$ [dB S^2/m^2]	f [MHz]	$F_{A.TX}$+$F_{A.RX}$ [dB S^2/m^2]	f [MHz]	$F_{A.TX}$+$F_{A.RX}$ [dB S^2/m^2]
0.009	63.87	0.090	24.39	0.80	-11.75
0.010	61.89	0.095	23.47	0.85	-12.83
0.011	60.26	0.100	22.59	0.90	-13.86
0.012	58.85	0.105	21.76	0.95	-14.85
0.013	57.55	0.110	20.97	1.0	-15.80
0.014	56.25	0.115	20.21	1.1	-17.53
0.015	55.05	0.120	19.49	1.2	-19.05
0.016	54.03	0.125	18.80	1.3	-20.31
0.017	52.96	0.130	18.14	1.4	-21.33
0.018	51.98	0.135	17.49	1.5	-22.12
0.019	51.06	0.140	16.88	1.6	-22.77
0.020	50.24	0.145	16.28	1.7	-23.34
0.025	46.35	0.150	15.71	1.8	-23.89
0.030	43.27	0.20	10.89	1.9	-24.46
0.035	40.64	0.25	7.23	2.0	-25.09
0.040	38.28	0.30	4.27	2.1	-25.77
0.045	36.29	0.35	1.78	2.2	-26.50
0.050	34.48	0.40	-0.34	2.3	-27.23
0.055	32.83	0.45	-2.21	2.4	-27.94
0.060	31.33	0.50	-3.90	2.5	-28.59
0.065	29.96	0.55	-5.44	2.6	-29.14
0.070	28.68	0.60	-6.85	2.7	-29.56
0.075	27.51	0.65	-8.18	2.8	-29.81
0.080	26.40	0.70	-9.43	2.9	-29.95
0.085	25.37	0.75	-10.62	3.0	-29.99

f [MHz]	$F_{A.TX}+F_{A.RX}$ [dB S^2/m^2]	f [MHz]	$F_{A.TX}+F_{A.RX}$ [dB S^2/m^2]	f [MHz]	$F_{A.TX}+F_{A.RX}$ [dB S^2/m^2]
3.1	-30.03	9.7	-35.49	16.3	-36.49
3.2	-30.09	9.8	-35.67	16.4	-36.35
3.3	-30.22	9.9	-35.80	16.5	-36.16
3.4	-30.43	10.0	-35.89	16.6	-35.95
3.5	-30.72	10.1	-35.93	16.7	-35.79
3.6	-31.10	10.2	-35.90	16.8	-35.68
3.7	-31.49	10.3	-35.81	16.9	-35.64
3.8	-31.89	10.4	-35.66	17.0	-35.69
3.9	-32.24	10.5	-35.49	17.1	-35.80
4.0	-32.55	10.6	-35.35	17.2	-35.97
4.1	-32.78	10.7	-35.25	17.3	-36.17
4.2	-32.89	10.8	-35.23	17.4	-36.36
4.3	-32.88	10.9	-35.27	17.5	-36.51
4.4	-32.79	11.0	-35.38	17.6	-36.58
4.5	-32.68	11.1	-35.54	17.7	-36.59
4.6	-32.58	11.2	-35.73	17.8	-36.55
4.7	-32.53	11.3	-35.90	17.9	-36.44
4.8	-32.55	11.4	-36.02	18.0	-36.26
4.9	-32.68	11.5	-36.08	18.1	-36.07
5.0	-32.89	11.6	-36.10	18.2	-35.88
5.1	-33.17	11.7	-36.08	18.3	-35.73
5.2	-33.48	11.8	-35.98	18.4	-35.68
5.3	-33.77	11.9	-35.82	18.5	-35.67
5.4	-34.01	12.0	-35.65	18.6	-35.76
5.5	-34.21	12.1	-35.51	18.7	-35.90
5.6	-34.33	12.2	-35.41	18.8	-36.10
5.7	-34.36	12.3	-35.38	18.9	-36.28
5.8	-34.27	12.4	-35.41	19.0	-36.44
5.9	-34.14	12.5	-35.52	19.1	-36.54
6.0	-33.98	12.6	-35.68	19.2	-36.57
6.1	-33.85	12.7	-35.86	19.3	-36.55
6.2	-33.76	12.8	-36.05	19.4	-36.46
6.3	-33.76	12.9	-36.18	19.5	-36.32
6.4	-33.84	13.0	-36.25	19.6	-36.13
6.5	-34.01	13.1	-36.27	19.7	-35.95
6.6	-34.23	13.2	-36.23	19.8	-35.80
6.7	-34.50	13.3	-36.15	19.9	-35.70
6.8	-34.73	13.4	-35.99	20.0	-35.68
6.9	-34.92	13.5	-35.82	20.1	-35.73
7.0	-35.06	13.6	-35.66	20.2	-35.84
7.1	-35.13	13.7	-35.56	20.3	-36.00
7.2	-35.12	13.8	-35.52	20.4	-36.18
7.3	-35.02	13.9	-35.55	20.5	-36.34
7.4	-34.86	14.0	-35.64	20.6	-36.44
7.5	-34.70	14.1	-35.80	20.7	-36.49
7.6	-34.56	14.2	-36.00	20.8	-36.48
7.7	-34.47	14.3	-36.19	20.9	-36.42
7.8	-34.46	14.4	-36.35	21.0	-36.30
7.9	-34.51	14.5	-36.45	21.1	-36.14
8.0	-34.65	14.6	-36.48	21.2	-35.96
8.1	-34.85	14.7	-36.44	21.3	-35.82
8.2	-35.07	14.8	-36.36	21.4	-35.70
8.3	-35.29	14.9	-36.20	21.5	-35.66
8.4	-35.43	15.0	-36.02	21.6	-35.69
8.5	-35.55	15.1	-35.83	21.7	-35.76
8.6	-35.60	15.2	-35.69	21.8	-35.92
8.7	-35.59	15.3	-35.62	21.9	-36.08
8.8	-35.50	15.4	-35.62	22.0	-36.23
8.9	-35.34	15.5	-35.71	22.1	-36.34
9.0	-35.19	15.6	-35.84	22.2	-36.40
9.1	-35.05	15.7	-36.04	22.3	-36.40
9.2	-34.97	15.8	-36.25	22.4	-36.35
9.3	-34.94	15.9	-36.42	22.5	-36.26
9.4	-35.00	16.0	-36.53	22.6	-36.12
9.5	-35.12	16.1	-36.58	22.7	-35.94
9.6	-35.29	16.2	-36.57	22.8	-35.80

f [MHz]	$F_{A.TX}+F_{A.RX}$ [dB S^2/m^2]	f [MHz]	$F_{A.TX}+F_{A.RX}$ [dB S^2/m^2]	f [MHz]	$F_{A.TX}+F_{A.RX}$ [dB S^2/m^2]
22.9	-35.68	25.3	-36.12	27.7	-35.20
23.0	-35.63	25.4	-36.07	27.8	-35.28
23.1	-35.64	25.5	-36.00	27.9	-35.41
23.2	-35.70	25.6	-35.87	28.0	-35.57
23.3	-35.82	25.7	-35.72	28.1	-35.73
23.4	-35.97	25.8	-35.55	28.2	-35.84
23.5	-36.11	25.9	-35.41	28.3	-35.91
23.6	-36.22	26.0	-35.32	28.4	-35.90
23.7	-36.28	26.1	-35.30	28.5	-35.84
23.8	-36.29	26.2	-35.33	28.6	-35.72
23.9	-36.25	26.3	-35.44	28.7	-35.56
24.0	-36.17	26.4	-35.58	28.8	-35.40
24.1	-36.02	26.5	-35.73	28.9	-35.23
24.2	-35.85	26.6	-35.88	29.0	-35.09
24.3	-35.70	26.7	-35.97	29.1	-35.02
24.4	-35.58	26.8	-36.00	29.2	-35.02
24.5	-35.52	26.9	-35.98	29.3	-35.08
24.6	-35.52	27.0	-35.91	29.4	-35.18
24.7	-35.56	27.1	-35.78	29.5	-35.32
24.8	-35.66	27.2	-35.64	29.6	-35.46
24.9	-35.80	27.3	-35.45	29.7	-35.58
25.0	-35.93	27.4	-35.31	29.8	-35.66
25.1	-36.05	27.5	-35.23	29.9	-35.67
25.2	-36.11	27.6	-35.18	30.0	-35.64

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