

SEIBERSDORF  
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FREQUENTLY ASKED SOLUTIONS



# MANUAL

## RefRad X - Field Source and Comb Generator



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## RefRad X

RefRad X – Field Source and Comb Generator  
LISN Coupler

# Notice

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# Table of Contents

<b>1.</b>	<b>INTRODUCTION.....</b>	<b>6</b>
<b>2.</b>	<b>CONTENT OF SETS.....</b>	<b>7</b>
2.1.	RefRad X Set (RR 4).....	8
2.2.	Field Source Set (RR 5).....	8
<b>3.</b>	<b>INSTALLATION AND OPERATION.....</b>	<b>9</b>
3.1.	Placing into Operation .....	10
3.2.	Measurements with RefRad X .....	13
3.3.	Frequency calibration .....	15
<b>4.</b>	<b>DESCRIPTION OF THE REFRAD X SYSTEM COMPONENTS AND ACCESSORIES.....</b>	<b>18</b>
4.1.	RefRad X Comb Generator .....	18
4.2.	Conical Antenna Element.....	20
4.3.	H-Holder .....	24
4.4.	Charger .....	26
4.5.	Protective Attenuator.....	27
4.6.	Transport Case.....	28
4.7.	LISN Coupler .....	29
4.8.	Software CalStan 11 .....	31
<b>5.</b>	<b>APPLICATIONS.....</b>	<b>32</b>
5.1.	System Check with Radiated Field .....	33
5.2.	Coaxial System Check .....	35
<b>6.</b>	<b>LITERATURE AND INFORMATION .....</b>	<b>36</b>
<b>ANNEX I.</b>	<b>WARRANTY .....</b>	<b>37</b>
<b>ANNEX II.</b>	<b>BATTERY INFORMATION.....</b>	<b>38</b>

# 1. INTRODUCTION

The Reference Radiator Model X (RefRad X) was developed by Seibersdorf Laboratories for checking the quality of radiated and conducted EMC tests. This battery-operated comb generator will radiate a precisely defined field strength for checking radio frequency measurement systems in a frequency range of 10 kHz to 3 GHz.

The first Reference Radiator developed in 1990 was given the name "RefRad". Main purpose was the validation of EMC test sites with a battery-powered source avoiding any cables on the transmit side.

In 2003, the engineers developed a test device for checking the functionality of field strength measurement systems: the RefRad 3000, an improved comb generator with an increased frequency range. This device served EMC test laboratories for quality assurance in interference field strength measurements on electronic devices: A rapid "System Check" implemented by measuring the field strength of the RefRad and comparing it with the known setpoint. Defective components in the measuring system can therefore be detected before the testing activity commenced.

In 2007, the research team improved the RefRad, developing a comb generator with new functions. The electronics of the innovative RefRad X are integrated in one of the conical antenna elements, thus guaranteeing good symmetry in radiation. The synchronisation of the comb generator clock frequency with that of the measurement receiver enables a very small measuring bandwidth and therefore improves the signal-to-noise ratio by up to 30 dB. LISN couplers were developed for checking the line impedance stabilization network for conducted emission measurements.

**An updated RefRad X version with optimised housing, increased battery capacity, OLED display and new frequency calibration was released in 2023. The built-in oven controlled local oscillator (OCXO) can be tuned to match customers EMI receiver reference frequency to increase dynamic range and reduce measurement time. Due to this new calibration feature, the fibre link is not required anymore.**

This manual describes in detail the application of the RefRad X and its accessories for:

- **System Check with Radiated Field**
- **System Check with LISN Coupler**
- **Field Strength Transfer**
- **Shielding Attenuation Measurement**

Technical specifications of the system and radiation patterns are presented.

## 2. CONTENT OF SETS

Table 1 shows the available measurement sets and their components.

		RefRad X Set <sup>1</sup>	Field Source Set <sup>2</sup>
RefRad X Comb Generator		✓	✓
Battery Charger		✓	✓
Protective Attenuator		✓	✓
CAL Cable		✓	✓
Conical Antenna Element		-	✓
H-Holder		-	✓
Transport Case		✓	✓
LISN Coupler		optional	optional
Software CalStan 11		optional	optional

**Table 1:** Contents of different RefRad X sets and options

<sup>1</sup> Set RR 4 in price list

<sup>2</sup> Set RR 5 in price list

2.1. RefRad X Set (RR 4)



Figure 1: Contents of the RefRad X set

2.2. Field Source Set (RR 5)



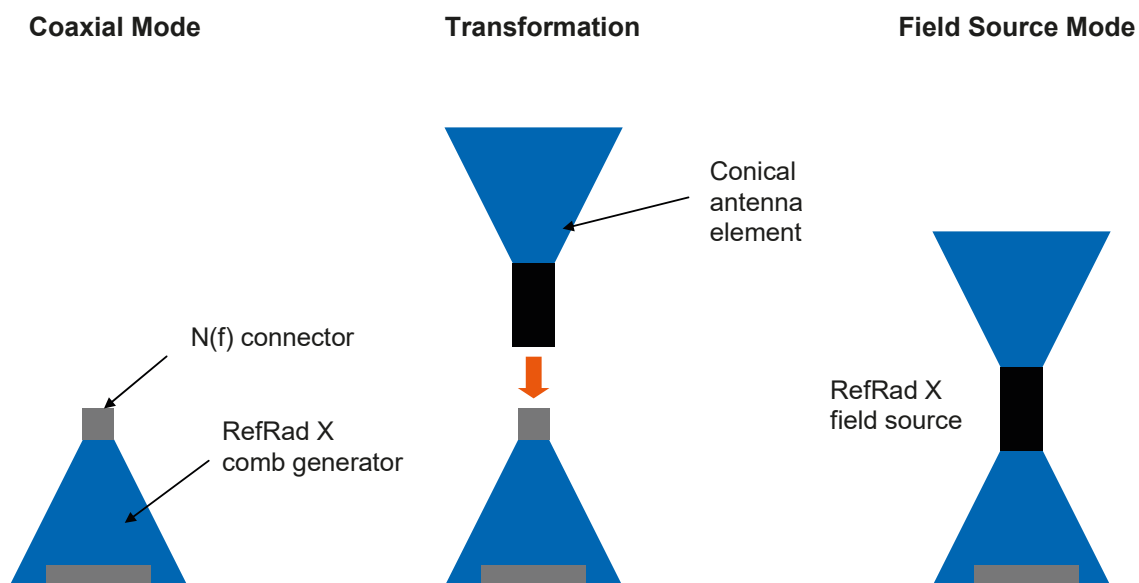
Figure 2: Contents of the Field Source set



### 3. INSTALLATION AND OPERATION

For electromagnetic compatibility (EMC) and electromagnetic field (EMF) testing it is important to validate the radiated and conducted measurements on a regular basis for quality assurance reasons. The modular concept, the selectable line spacing and the ultra-wide frequency range makes the RefRad X to a one box solution for much more flexibility in EMC and EMF testing.

RefRad X can be used as a classical comb generator for all kinds of coaxial measurements and measurements with LISN coupler. With the conical antenna element attached, it transforms into a field source (patented) - an antenna with built-in comb generator (see Figure 3).



**Figure 3:** Schematic of the RefRad X comb generator (left) for coaxial measurements via the N-connector and the transformation (centre) to the RefRad X field source (right) using the Conical antenna element

**ATTENTION !**

**Before using RefRad X please read this operating manual!**

### 3.1. Placing into Operation

#### ON:

Press ON/OFF/MODE button for **1 sec.** until “**starting...**” is indicated.



Figure 4: ON/OFF symbol

The same spectrum that was used last time is activated automatically and displayed e.g. 5 MHz. The symbols in the display are explained in Figure 5.

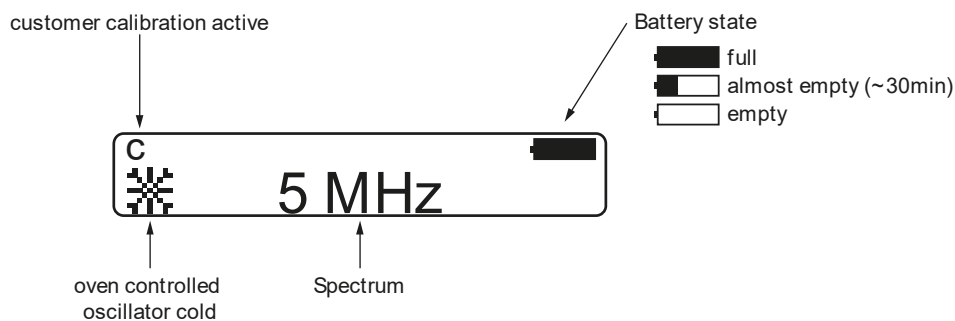


Figure 5: Display symbols

In case of battery state “almost empty” re-charge the comb generator within 30 min.

#### OFF:

RefRad X can be switched OFF from each MODE by pressing ON/OFF/MODE button for **3 sec.** until “**Shutdown?**” is indicated.



1 sec. ON / 3 sec. OFF

Figure 6: ON/OFF switching process

## SPECTRUM selection: (5 MHz, 1 MHz, 10 kHz)

By pressing the ON/OFF/MODE button for a short period the next possible spectrum is shown, indicated by a question mark “?”.

By pressing the button again within 3 seconds the whole sequence can be stepped through: **5MHz?** - **1MHz?** - **10kHz?** - **5MHz?** and so on.

When the desired spectrum (line spacing) is shown it is activated after 3 seconds and the question mark “?” disappears. See Figure 8 for a flow-chart description



Figure 7: Spectrum selection

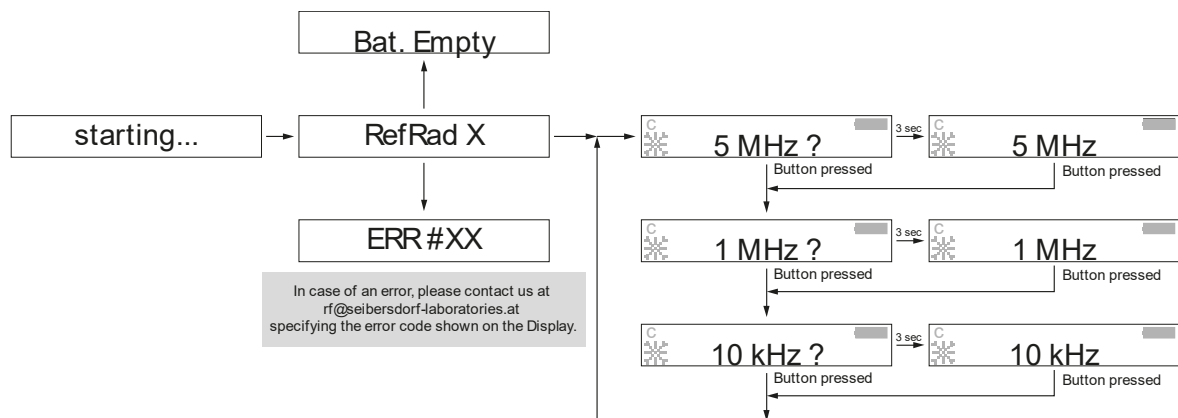


Figure 8: Mode selection

## Frequency calibration:

RefRad X can be switched to Calibration MODE by pressing ON/OFF/MODE button for 6 sec. until “Freq. Cal.” is indicated. See chapter 3.3 on how to perform the frequency calibration



Figure 9: Frequency CAL. selection

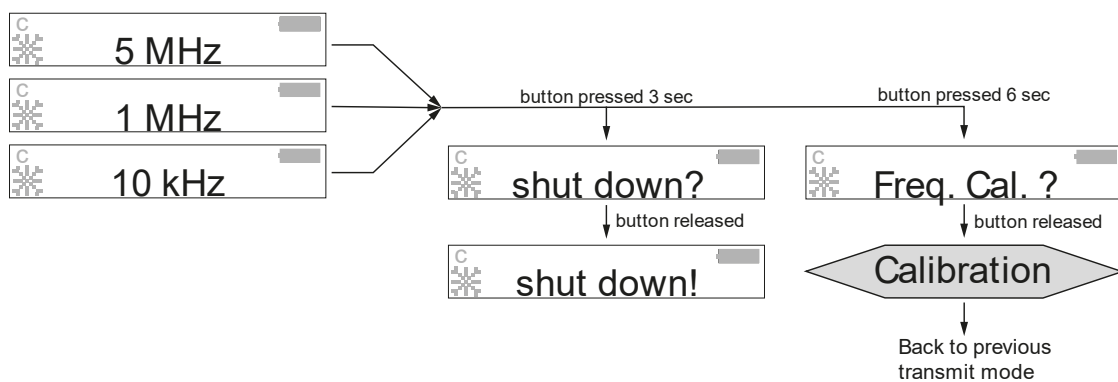


Figure 10: Shut down or start calibration

### Note!

Please make sure RefRad X is fully charged before performing frequency calibration.

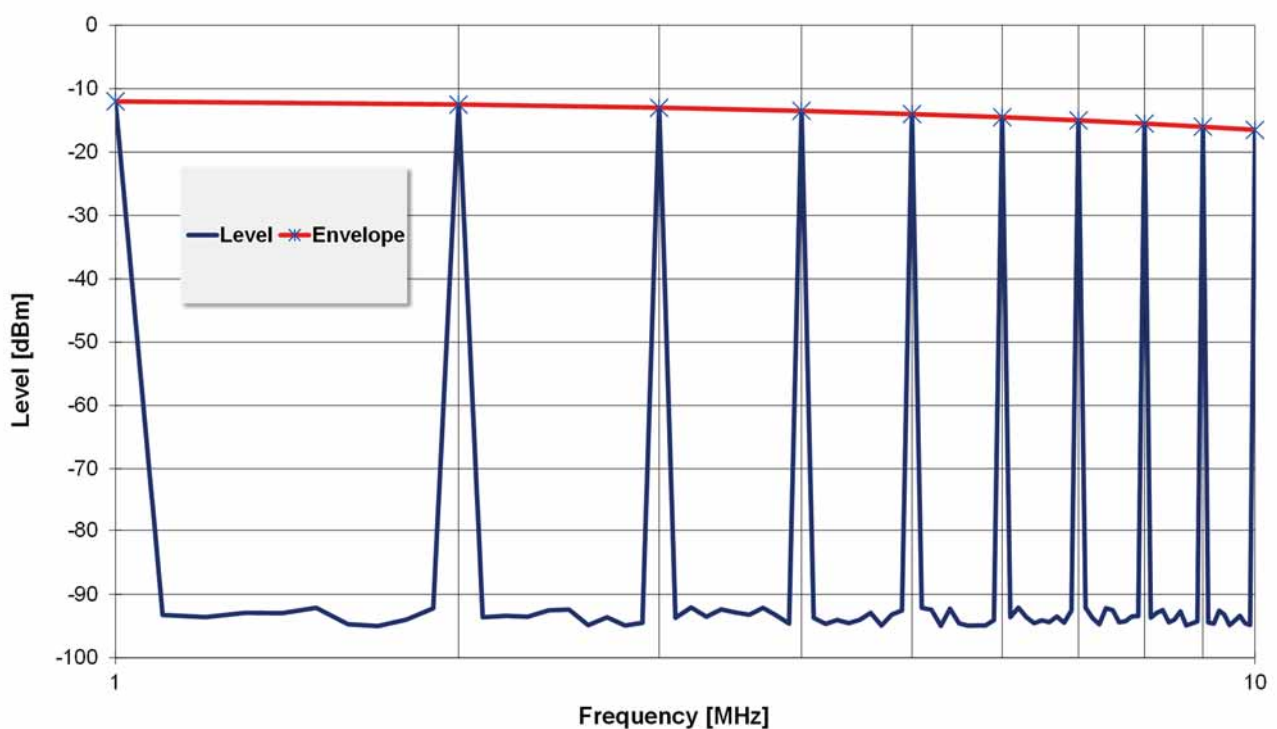
## 3.2. Measurements with RefRad X

The device may only be operated by qualified and trained personnel. Seibersdorf Laboratories will not be liable in case of improper use.

The RefRad X comb generator is not designed to be operated using the battery charger as a power source.

A properly charged RefRad X comb generator is required for all measurements.

It is recommended that the measurement in the frequency domain is done with the same frequency of the selected spectrum (or with multiples of the selected spectrum) so that only the relevant signal information (power level, voltage, field strength) is shown as the upper envelope curve (see Figure 11). Comparing the noise signal in between the frequency lines is irrelevant.



**Figure 11:** Measurement example of the 1 MHz spectrum  
the receiver should take the level reading in 1 MHz (or multiple) steps

Like all comb generators, RefRad X uses a built-in crystal oscillator. The settings on the measurement instrument (e.g. receiver) have to be made with consideration of this effect by using a proper resolution bandwidth which is larger than the frequency error (e.g. 1.5 kHz) and as low as possible for getting a good signal-to-noise ratio.

The bandwidth of the generated spectral lines is very small so that the resolution bandwidth (RBW) of the receiver has no influence on the measured amplitude as long as it covers one and ONLY one line. Due to the frequency difference of the oscillator in the receiver and the RefRad X, a spectral line may be seen with a frequency offset. The amount of difference depends on the oscillator frequency difference and the measured frequency e.g., if the oscillator difference is 500 ppb and a measurement is performed at 3 GHz the spectral line has a frequency offset of 1.5 kHz. If the RBW is set too low, the signal could not be measured correctly. In this case the custom frequency calibration is recommended. So the oscillator difference can be reduced to 5 ppb (under the assumption of a “perfect” stable 10 MHz reference 5ppb is the max. difference after successful custom calibration) and the offset of the spectral line at 3 GHz to 15 Hz. Typically, a frequency calibration is required if a low RBW is necessary due to dynamic range requirements e.g., shielding attenuation measurements. Please keep in mind that the oscillator difference could change with time and temperature after frequency calibration.

#### **ATTENTION !**

For coaxial measurements make sure to use the protective attenuator as the peak output voltage of the comb generator may exceed the allowed receivers input voltage and the broadband comb spectrum may overload the mixer.

When operating the RefRad X in Field Source mode special care must be taken not to disturb the environment (e.g. by operating it in anechoic chambers, GTEM cells and not in the unshielded laboratory).

### 3.3. Frequency calibration

RefRad X local oscillator (OCXO) can be tuned to match customers EMI receiver reference frequency to increase dynamic range and reduce measurement time. No additional device (FibreLINK) is needed any more.

The RefRad X offers two types of frequency calibration:

- Factory calibration
- Custom calibration

#### Factory calibration:

Factory calibration will be performed by manufacturer using a very accurate 10 MHz reference source. Factory calibration is active, except Custom Calibration is set.



Figure 12: Display symbol

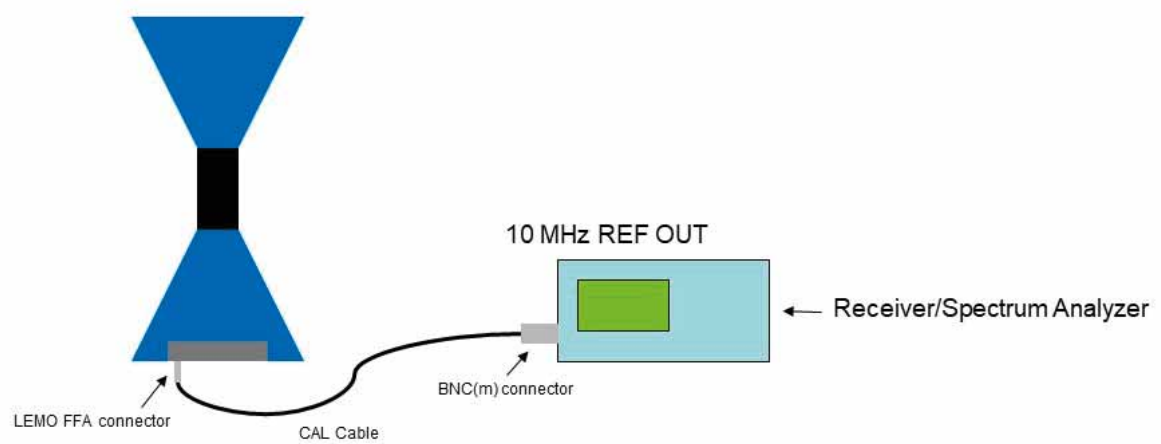
- Switch on the RefRad X
- After 15 min warm up time, the specified frequency accuracy is met.

#### Custom calibration:

If necessary (e.g. shielding attenuation measurements) a Custom calibration can be performed, where RefRad X and Receiver/Spectrum analyzer are matched.

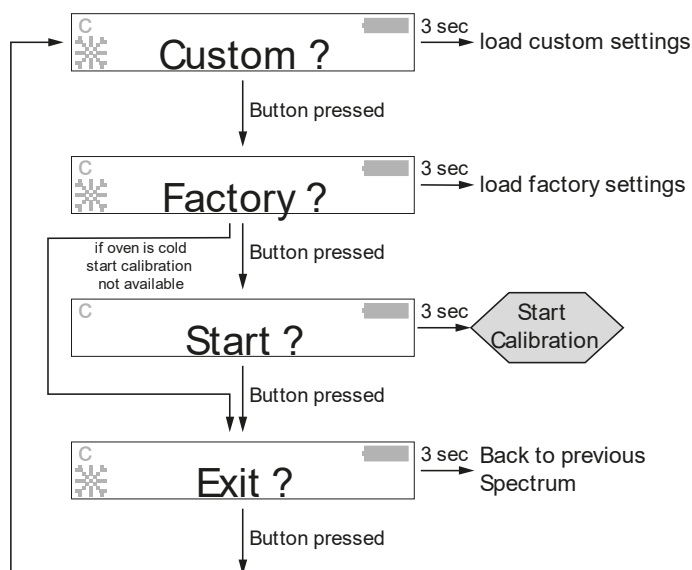
For best calibration accuracy make sure that the instruments are stored and operated within there specified temperature ranges to reduce frequency drift.

- Switch on the RefRad X and Receiver/Spectrum Analyzer and allow for proper warmup
- Connect the included CAL Cable, see Figure 13
- After **15 min** warm up time frequency calibration starts automatically, “**Read value**” is indicated (counting down 100 sec.)
- The calibration is stored automatically and activated
- Active custom calibration will be indicated on the Display “C”, see Figure 12
- In case the custom calibration was not possible/successful “**Inv Ref., Cal Aborted! or Nr Step Fail**” is indicated and the previous performed custom calibration is still active.
- A successfully completed custom calibration replaces the previous saved calibration.



**Figure 13:** Schematic of the RefRad X custom calibration

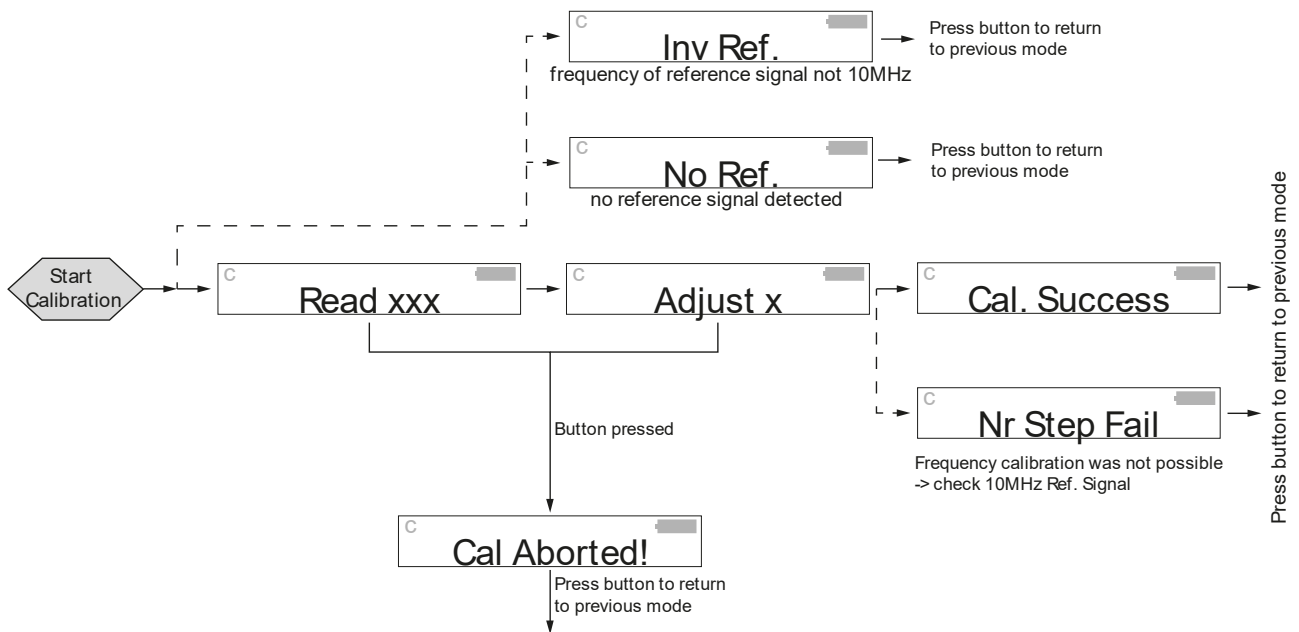
#### Calibration menu:



**Figure 14:** Flow chart calibration menu



## Calibration routine:



**Figure 15:** Flow chart calibration routine

### Attention!

When oscillator cold symbol is indicated, frequency calibration is not possible.

To guarantee a precise Frequency Calibration, a warmed-up Receiver/Spectrum Analyzer is mandatory. Recommended warm up time is 30 minutes.

Prior Condition: Receiver/Spectrum Analyzer and RefRad X has been stored at environmental temperature for min. 2 hours. Please refer to the manufacturer's instructions for further information.

## 4. DESCRIPTION OF THE REFRAD X SYSTEM COMPONENTS AND ACCESSORIES

### 4.1. RefRad X Comb Generator



Figure 16: RefRad X

#### 4.1.1. Description

The comb generator RefRad X (see Figure 16) produces pulses with a repetition rate of 100  $\mu$ s, 1  $\mu$ s or 200 ns in time domain. These pulses represent a comb spectrum with a line spacing of 10 kHz, 1 MHz or 5 MHz in frequency domain. All frequency lines are present at the same time (see Figure 17) therefore no remote control between the comb generator and the receiver is required.

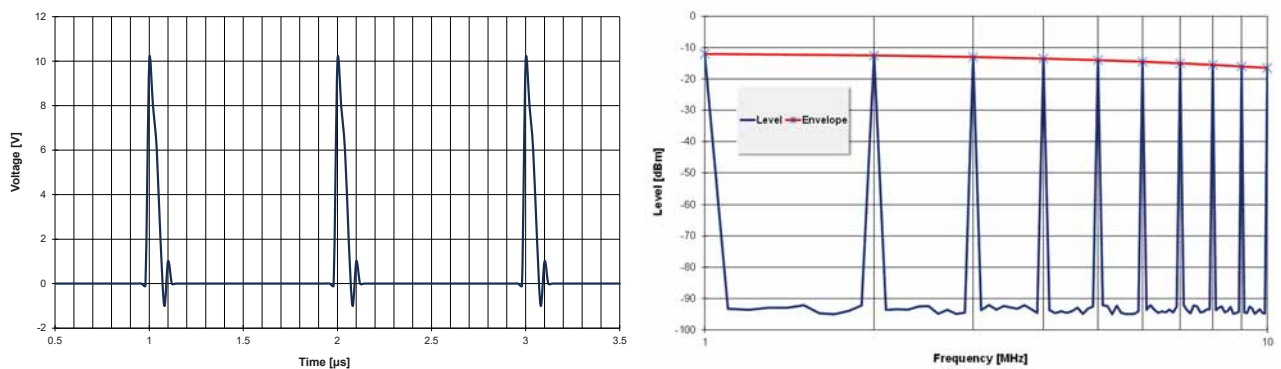
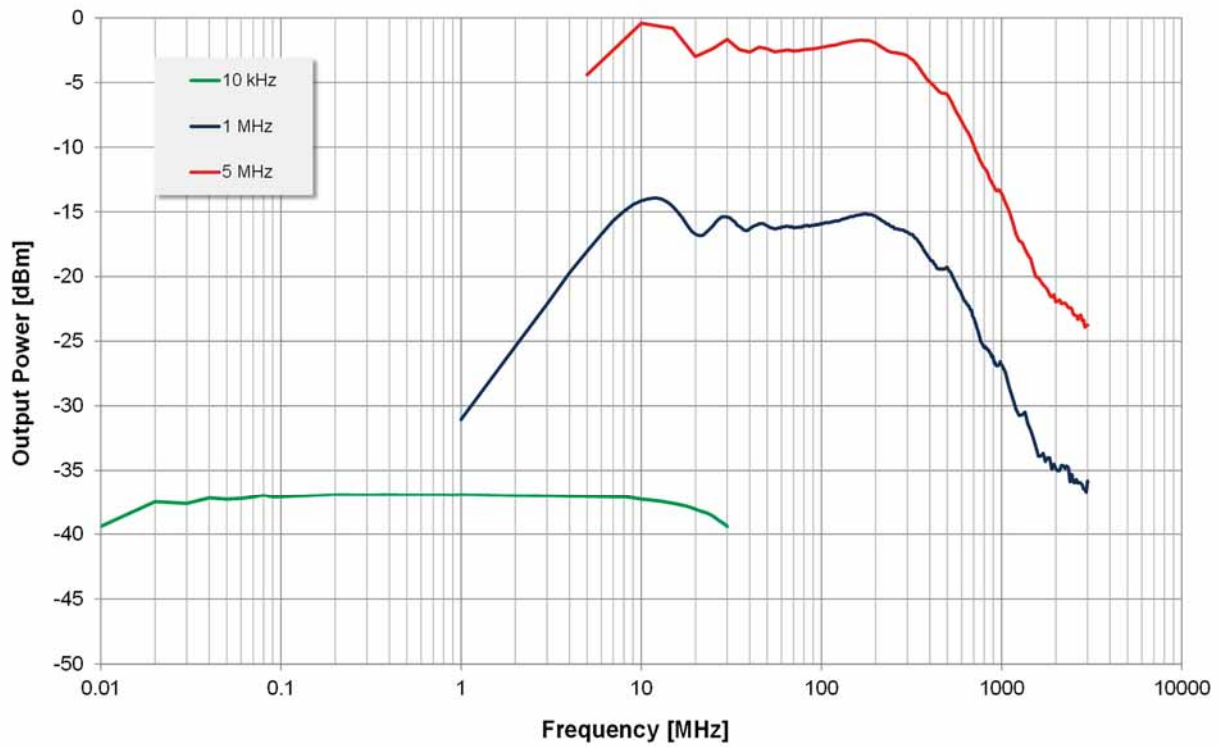


Figure 17: The RefRad X comb generator pulses in time domain (left) and in frequency domain (right), 1 MHz spectrum

#### 4.1.2. Technical Specifications

Technical Specifications	
Frequency range	10 kHz – 3 GHz
Spectrum /Line spacing	10 kHz, 1 MHz, 5 MHz
Frequency stability after 15min. warm up time	± 20 ppb over temp. range ± 500 ppb max./ year
Amplitude per line (coaxial)	Figure 18
Amplitude stability	± 0.4 dB, temperature range 10°C - 35°C
Frequency Calibration Signal (CAL IN)	Level range: +10 dBm / -10 dBm Waveform: Sine or Square Frequency: 10 MHz ± 25 Hz
Batteries	internal, NiMH (factory serviceable only)
Battery operation time	> 13 hours (10 kHz), 13 hours (1 MHz), 7 hours (5 MHz)
Charging time	~ 5 hours
RF-output connector	N-female
Tripod thread	¼" UNC20
Climatic operation conditions	Temperature: 10 – 40 °C Humidity: 30 – 80% avoid humidity and rain
Dimension of RefRad X	144 mm Ø x 126 mm
Weight of RefRad X	1.09 kg

**Table 2:** Technical specifications of RefRad X comb generator



**Figure 18:** Typical coaxial output for all three line spacings

## 4.2. Conical Antenna Element



**Figure 19:** Conical Antenna Element

### 4.2.1. Description

To operate the RefRad X in Field Source mode, the conical antenna element (Figure 19) must be connected to the coaxial RF-output of the comb generator (Figure 20).

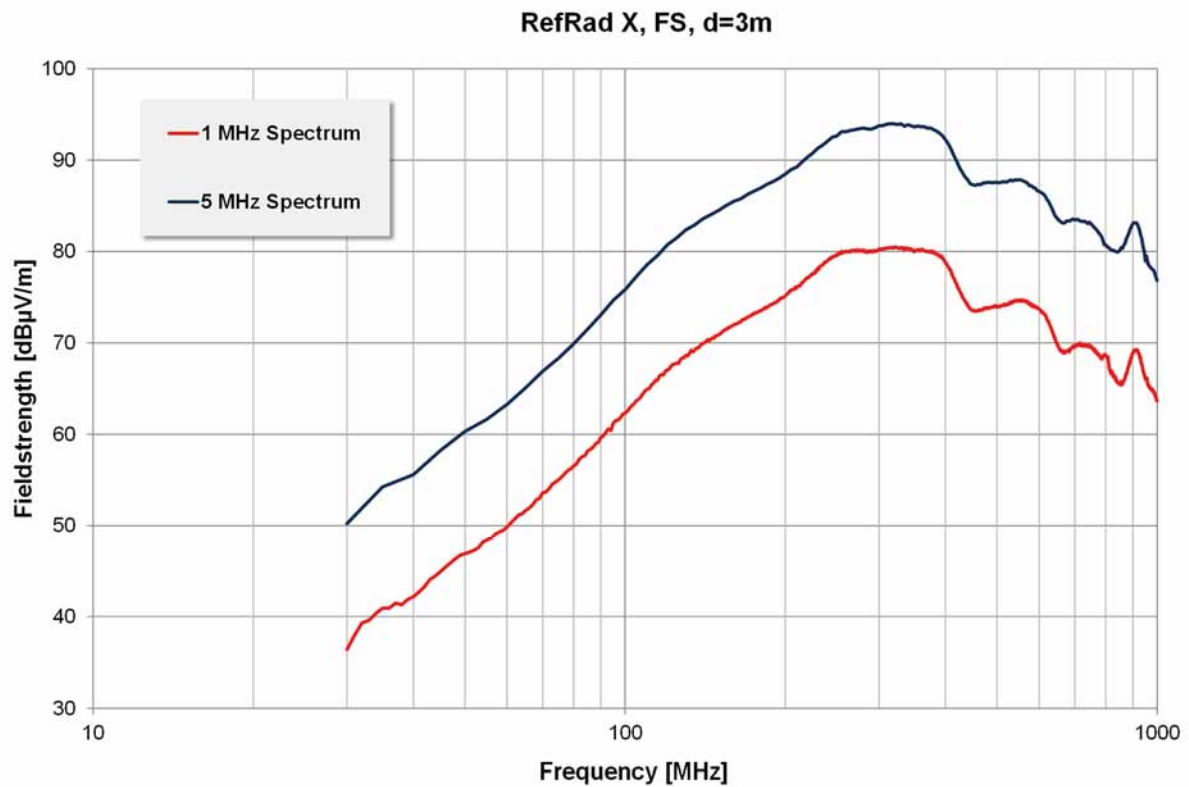


**Figure 20:** RefRad X in field source mode, mounted on the H-Holder in horizontal polarisation

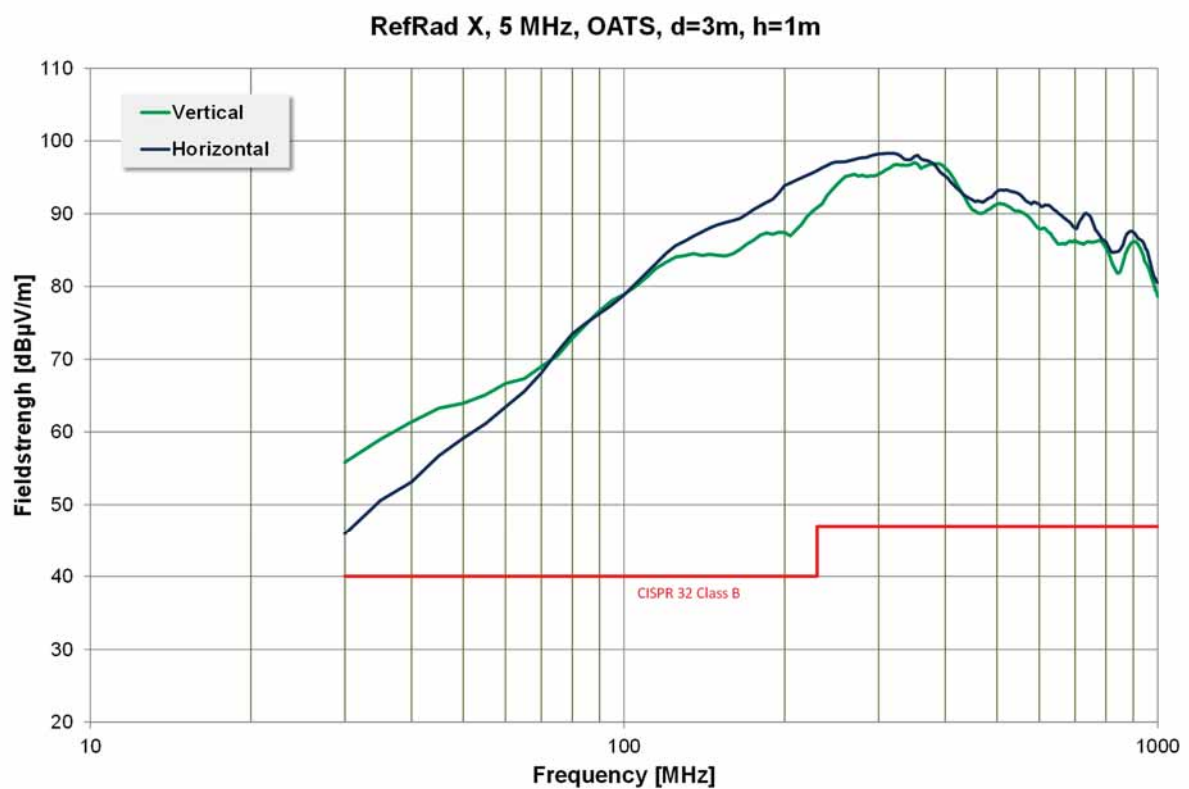
### 4.2.2. Technical Specifications

Technical Specifications	
Frequency range	30 MHz – 3 GHz
Field strength	Figure 21 to Figure 22
Radiation pattern	Figure 23
Dimension of RefRad X with conical antenna element	144 mm Ø x 285 mm
Weight of RefRad X with conical antenna element	1.65 kg

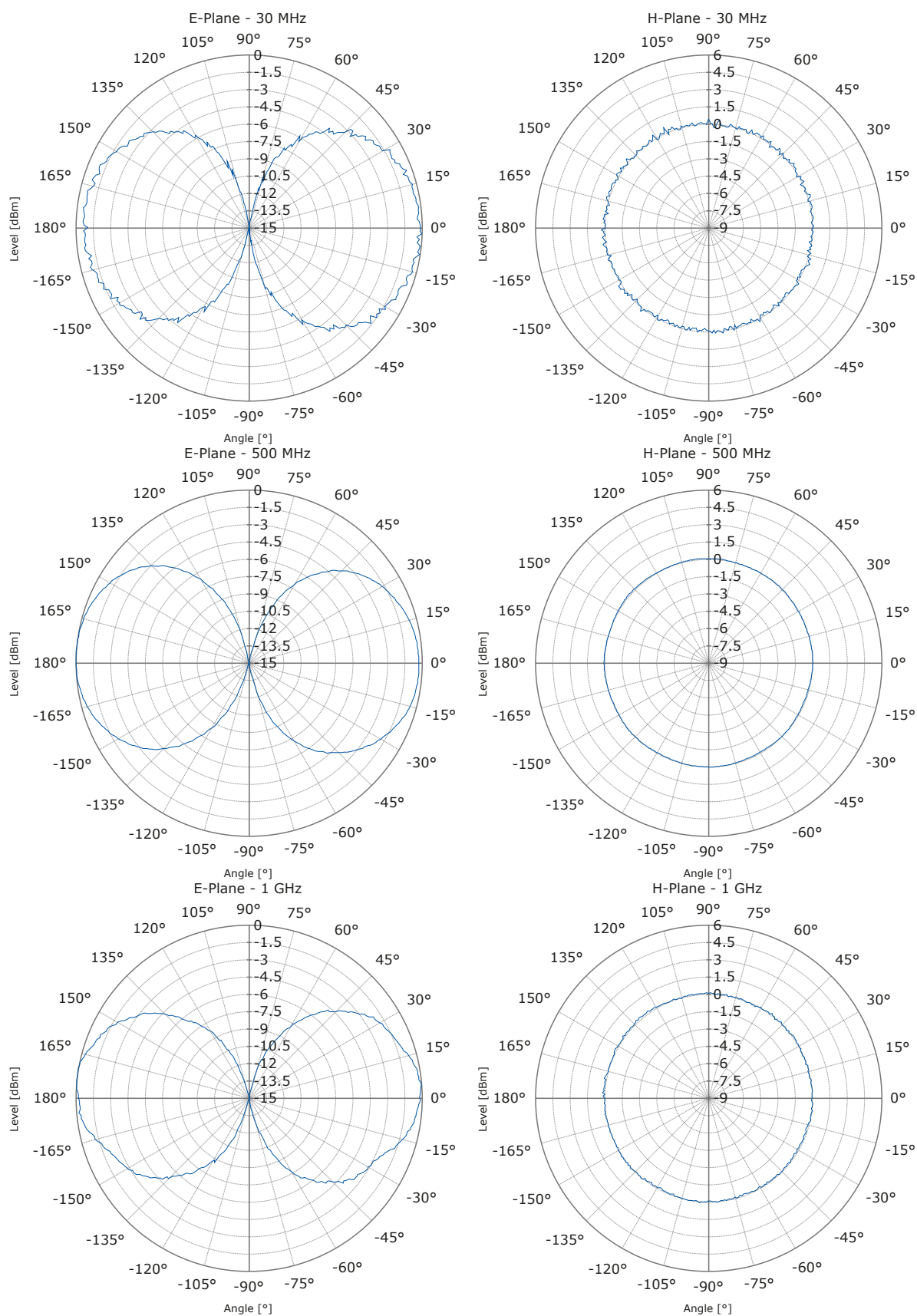
**Table 3:** Technical specifications of the conical antenna element



**Figure 21:** Typical field strength measured in free space  
1 and 5 MHz line spacing in 3 m distance



**Figure 22:** Typical field strength measured above groundplane  
5 MHz line spacing in 3 m distance, horizontal and vertical polarization



**Figure 23:** Typical radiation pattern in E- and H- plane

### 4.3. H-Holder

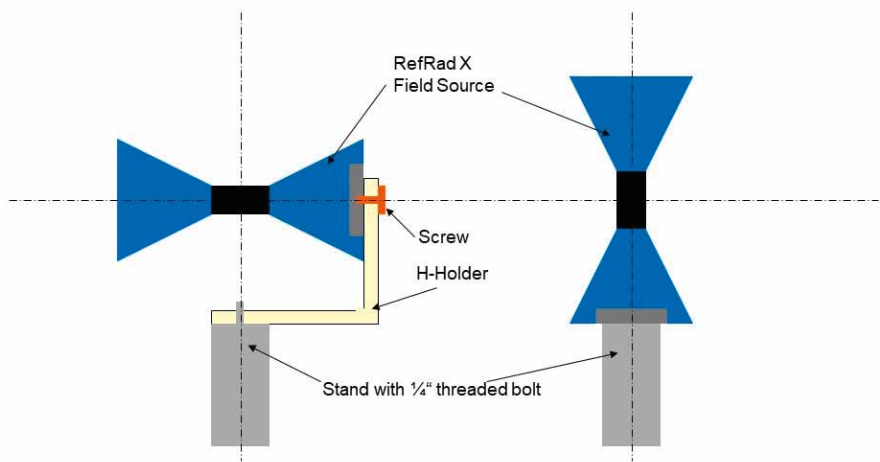


**Figure 24:** H-Holder

The H-Holder (Figure 24) is used for mounting the RefRad X in horizontal orientation onto a tripod or stand. Figure 25 shows the proper mounting.



Note that one hole has a thread (to be mounted on the stand) and the other hole has no thread (use the enclosed screw to fix onto the RefRad X).



**Figure 25:** Mounting the RefRad X in horizontal polarization (left) and vertical polarization (right)

Technical Specifications	
Material	Plexiglass®
Dimensions	170 x 160 x 36 mm
Weight	0.15 kg
Max load	2.5 kg
Screw	1/4" x 15 mm

**Table 4:** Technical specifications of the H-holder

## 4.4. Battery Charger



**Figure 26:** Battery Charger

The built-in batteries of the RefRad X are charged with the enclosed Ansmann ACS 110 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 over to trickle charge. Please follow the instructions of the enclosed original manual of the charger.

Technical Specifications	
Input voltage	110...240 VAC @ 50...60 Hz
Connection on the primary side	Euro, US, J, AU primary adapters
Connection on the secondary side	coaxial plug, positive inner
Output	1.45 – 14.5 V DC, max 800 mA, 9.6 VA
Dimensions	118 x 62 x 48 mm
Weight	280 g

**Table 5:** Technical specifications of the Battery Charger

### Attention!

- ONLY USE THE SUPPLIED CHARGER
- INDOOR USE ONLY
- DO NOT USE CHARGER WITH DAMAGED CORD OR PLUG

### 4.5. Protective Attenuator



**Figure 27:** Protective Attenuator

An attenuator is delivered together with the RefRad X for conducted measurements to protect the measurement instruments (receiver or spectrum analyzer) from overload and damage. The attenuator must be connected between the output of the RefRad X and the input of the measurement instrument.

Technical Specifications	
Nominal attenuation	20 dB
Frequency range	DC – 12 GHz
Max. power	2 W
Connector type	N-Type

**Table 6:** Technical specifications of the Protective Attenuator

### 4.6. Transport Case



**Figure 28:** Transport Case with RefRad X Field Source set

A transport case is available for safe storage and transportation of the RefRad X and all its available accessories.

Technical Specifications	
Dimensions of transport case	65 x 47 x 22 cm
Weight of empty case	4.9 kg
Weight of complete sets	RefRad X Set: 6.6 kg Field Source Set: 7.1 kg

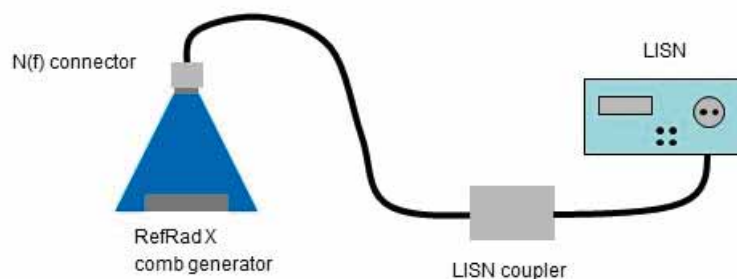
**Table 7:** Technical specifications of the Transport Case

## 4.7. LISN Coupler



**Figure 29:** 3 LISN Coupler: AC230V (CEE 7/3), AC400V (CEE16A, CEE32A) plug, DC BNC

The LISN coupler is used for a check of conducted emission test setup using the RefRad X comb generator (10 kHz spectrum). The LISN coupler feeds the RF-signal from the RefRad X into the LISN in a well-defined way (see Figure 30). Individual couplers for each LISN type are available (DC LISN coupler, 2-phase LISN coupler and 3-phase LISN coupler).



**Figure 30:** Schematic of the RefRad X connected via a LISN coupler to a LISN.

Technical Specifications	
Available types / Max. Voltage	230V, CEE 7/3 plug → 230V 400V, CEE16A, CEE32A plug → 400V DC, BNC plug → 24V
RF connector	BNC-female
Length of cable	10 cm (230V) 20 cm (400V)
Dimensions	100 x 40 x 25 mm (DC) 120 x 105 x 34 mm (230V, 400V)
Weight	~ 0.3 kg

**Table 8:** Technical specifications of the LISN Coupler

#### WARNING !

LISN Coupler works with high electrical voltage, therefore **NEVER** use a damaged Coupler. For your personal protection you have to check the electrical safety in regular intervals in accordance with relevant applicable regulations.

Your Coupler is supplied with power from the LISN, which is used on a residual-current circuit-breaker free electrical circuit, so check protective earth before mains connection.

## 4.8. Software CalStan 11

CalStan 11 is a software tool for automation of radio frequency (RF) calibrations and measurements. The software controls the instruments via GPIB bus or LAN, reads the measurement values and computes the results. The purpose of the software is to perform calibrations of test equipment and validations of test setups, such as antennas, cables, EMC test sites, setup tables, etc.

Check at <https://rf.seibersdorf-laboratories.at/products-services/products/calstan> for the latest version.

Technical Specifications	
CalStan modules	Site VSWR Measurement NSA Measurement in semi anechoic chambers NSA Measurement in fully anechoic rooms NSIL module Cable Loss Experimental Measurement
Operating systems	Windows 7 Windows 8 Windows 8.1 Windows 10
Minimum computer requirements	2 GHz CPU 4 GB RAM
Additional hardware	National Instruments GPIB card or GPIB-USB-HS interface
Installed software	.NET framework version 4.8 (or higher) <sup>3</sup> National Instruments Runtime v18.5 <sup>4</sup> (or higher)

**Table 9:** Technical specifications of the software CalStan11

<sup>3</sup> The .NET framework can be downloaded from <https://dotnet.microsoft.com/download/dotnet-framework/net48>

<sup>4</sup> National Instruments Runtime is usually shipped with the GPIB card.

## 5. APPLICATIONS

Seibersdorf Laboratories offers two measurement sets containing the RefRad X and components tailored for different applications.

- RefRad X Set
- Field Source Set

Application	Description
<b>System Check with Radiated Field</b>	<p><b>Procedure:</b> the well-defined field generated by the <b>RefRad X Field Source</b> is measured with the EMC/EMF measurement system. This measurement is done once with a well-checked setup as reference and it is repeated before each measurement campaign. A comparison between the reference and the actual system check ensures the quality of the results.</p> <p><b>Advantages:</b></p> <ul style="list-style-type: none"><li>• convenient detection of defects in the receiving system</li><li>• suitable for all antennas</li><li>• suitable for GTEM and other micro cells</li></ul> <p><b>Considerations:</b></p> <ul style="list-style-type: none"><li>• influenced by the test environment (EMF)</li><li>• influenced by the EUT (EMC)</li><li>• coupling to the receive cable hinders fault detection</li><li>• positioning can be critical</li></ul>
<b>System Check with LISN Coupler</b>	<p><b>Procedure:</b> check of conducted emission test setup using the <b>RefRad X Comb Generator</b> and the LISN coupler. Same procedure as System Check with Radiated Field.</p> <p><b>Advantages:</b></p> <ul style="list-style-type: none"><li>• reliable detection of defects in the measurement system</li><li>• easy and precise operation</li></ul> <p><b>Considerations:</b></p> <ul style="list-style-type: none"><li>• individual coupler required for each LISN type</li></ul>



Application	Description
Field Strength Transfer	<p><b>Procedure:</b> the <b>RefRad X Field Source</b> is used as signal generator <u>and</u> transmit antenna to compare the site attenuation of different test site types. The field strength generated is measured on the calibration site (e.g. Open Area Test Site) and then in the GTEM cell. The difference is the correction factor of the cell.</p> <p><b>Advantages:</b></p> <ul style="list-style-type: none"> <li>• calibration of TEM and GTEM cells</li> <li>• no metallic feed cable – no field disturbance</li> <li>• high measurement speed with modern EMI receiver</li> <li>• high output power guarantees a good signal-to-noise ratio</li> </ul> <p><b>Considerations:</b></p> <ul style="list-style-type: none"> <li>• overload of receiver possible when no attenuator is used</li> </ul>
Shielding Attenuation Measurement	<p><b>Procedure:</b> the <b>RefRad X Field Source</b> is used as signal generator <u>and</u> transmit antenna to investigate the shielding attenuation of enclosures.</p> <p><b>Advantages:</b></p> <ul style="list-style-type: none"> <li>• high output power guarantees a good signal-to-noise ratio</li> </ul>

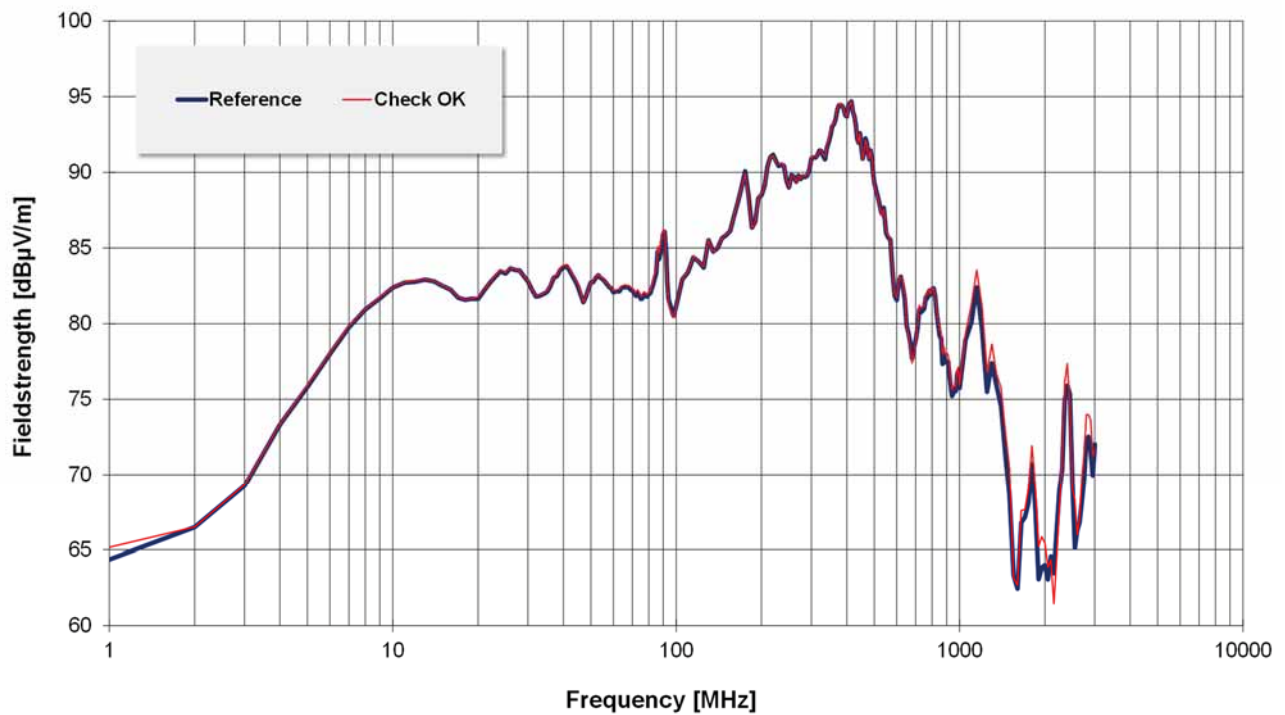
## 5.1. System Check with Radiated Field

The system check with the radiated field is easy and convenient but not always reliable. Due to the distance of several wavelengths between EMF measurement antenna and the field source, reflections from surrounding objects influence the result. The positioning of the source is a critical parameter. For EMC measurements a high-quality functional check is possible if the test site is empty and the positioning is done very precisely. Otherwise just a signal/no signal decision should be made.

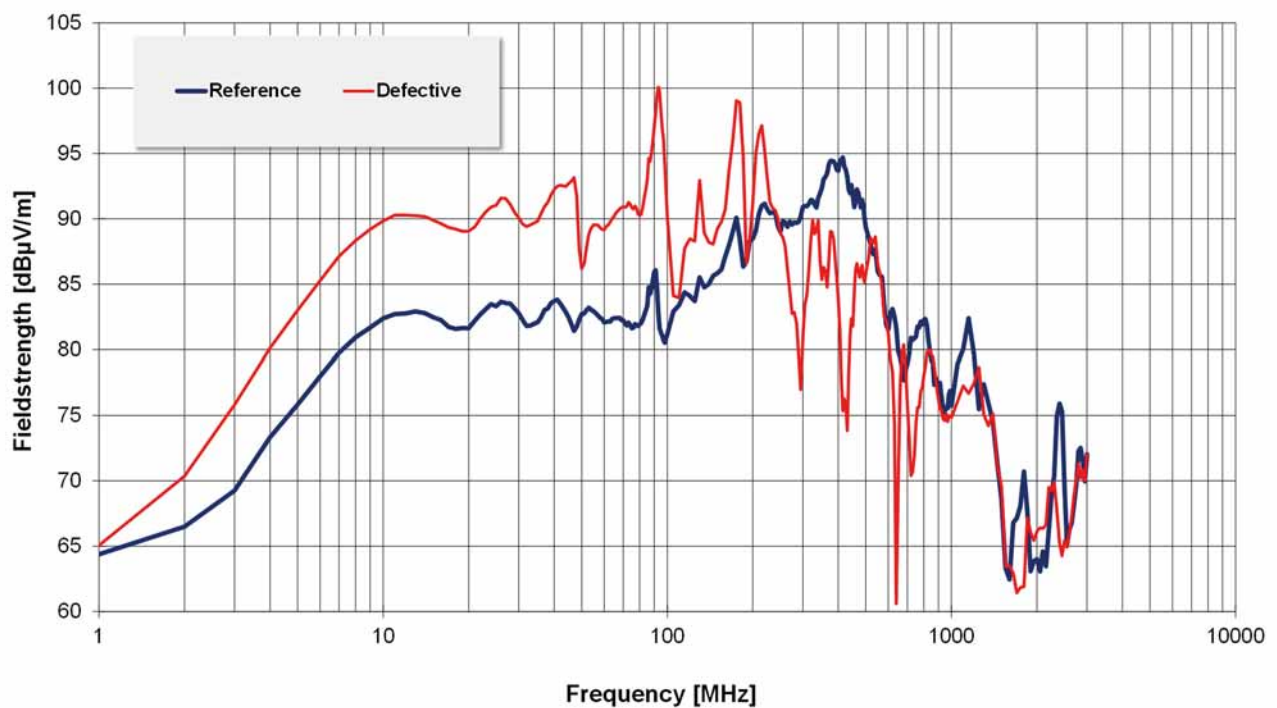
Some defects of the measurement system (e.g. broken connection between antenna element and balun) cause such a strong imbalance in the antenna system that the receive cable acts as part of the antenna. In this case the measured field strength can be higher in some frequency ranges. Therefore, it is not possible to guarantee reliable identification of broken equipment using this method.

In Figure 31 the results of two system checks with the field source in a distance of 15 cm from the receive antenna are shown. The upper graph shows the reference trace and the result of a check where the system worked well. A good match of the traces is only possible when the positioning is done extremely carefully. The lower graph shows the result of a system check when there was a problem. The receiving antenna was damaged by an intentionally broken soldering of an internal connection to the conical element. It is apparent that the received signal is different (sometimes lower, sometimes higher) than the reference signal. Therefore, detection of a failure can be difficult if a limited frequency range is only investigated (e.g. GSM 900).

a)



b)



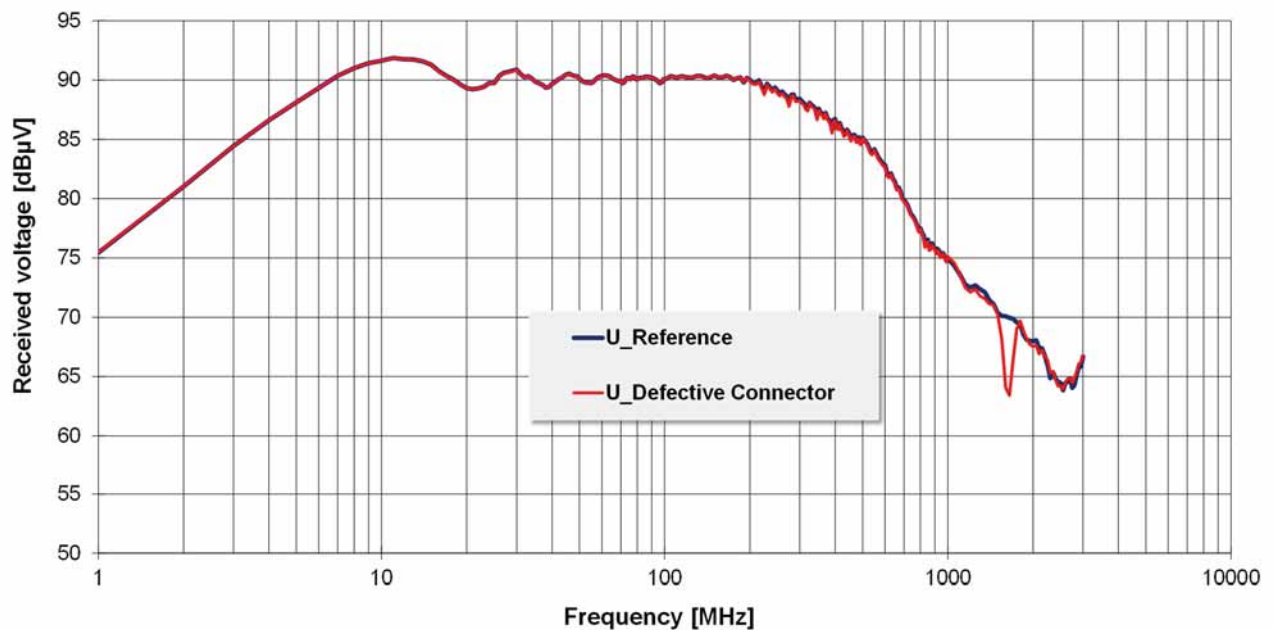
**Figure 31:** Functional check with the field source positioned 150 mm in front of the PCD 8250 antenna, showing (a) a well working and (b) a defective system

## 5.2. Coaxial System Check

The coaxial system check is used to distinguish the source of error. To perform this check a prior reference measurement is required. This should be done by connecting the RefRad X comb generator via the protective attenuator to the receive cable.

If the system check with the antenna coupler shows a deviation above the quality threshold the coaxial system check helps to identify the source of the problem. In case of a similar deviation the antenna is not responsible for the problem. The problem could be caused by the cable, the receiver or the comb generator. If the result of the coaxial check is within the specifications it is very likely that the antenna is the source of the deviations.

In Figure 32 the results of a coaxial system check are shown. For the system check measurement a damaged coaxial adapter was used. The received signal at 1600 MHz is lower, an indication for failure. These kinds of failures can be very narrowband and therefore it is recommended to use a fine frequency resolution (e.g. 1 MHz) for the test.



**Figure 32:** Coaxial System check showing a defective connector

## 6. LITERATURE AND INFORMATION

- [1] CISPR 16-1-4 Ed. 4.0, 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, 08.01.2019
- [2] ANSI/IEEE C 63.4a-2017, 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 Amendment 1: Test Site Validation, 13.10.2017
- [3] CalStan 11 Manual, [www.seibersdorf-rf.com/calstan](http://www.seibersdorf-rf.com/calstan)
- [4] W. Müllner, A. Kriz, H. Haider, G. Kolb: „Conducted and Radiated Comb Generator Measurement Techniques“, 7-th International Symposium on Electromagnetic Compatibility and Electromagnetic Ecology, June 26-29, Saint-Petersburg
- [5] Alexander Kriz, Wolfgang Müllner: „Validierung von EMV Emissionsmessplätzen im Frequenzbereich 1 GHz bis 18 GHz nach dem Site VSWR Verfahren“, e&i, ÖVE Verbandszeitschrift, Heft 1-2.2006

## 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, OR ANY OTHER LEGAL THEORY.

## ANNEX II.

## BATTERY INFORMATION

The RefRad X includes a 6-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](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) 64<sup>th</sup> edition 2023, errors and modifications subject to change. 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



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