HFW59D

High Frequency Analyser
For frequencies from 2.4 GHz to 10 GHz

Instruction Manual

Revision 1.5

This manual is subject to continuous updates, amendments and adjustments. The most current version can always be found for download on your local distributor's homepage or under www.gigahertz-solutions.de

Due to the rapid expansion of the sources of high frequency radiation, we strongly recommend to repeat measurements at regular intervals!

Thank you!

We appreciate the confidence you have shown in purchasing this HF Analyser. It will allow a professional analysis of the exposure with high frequency (HF) radiation corresponding to the building biology recommendations.

If you should encounter any problems, please contact us immediately. We are here to help.

For your local distributor please check:
www.gigahertz-solutions.com

Contents

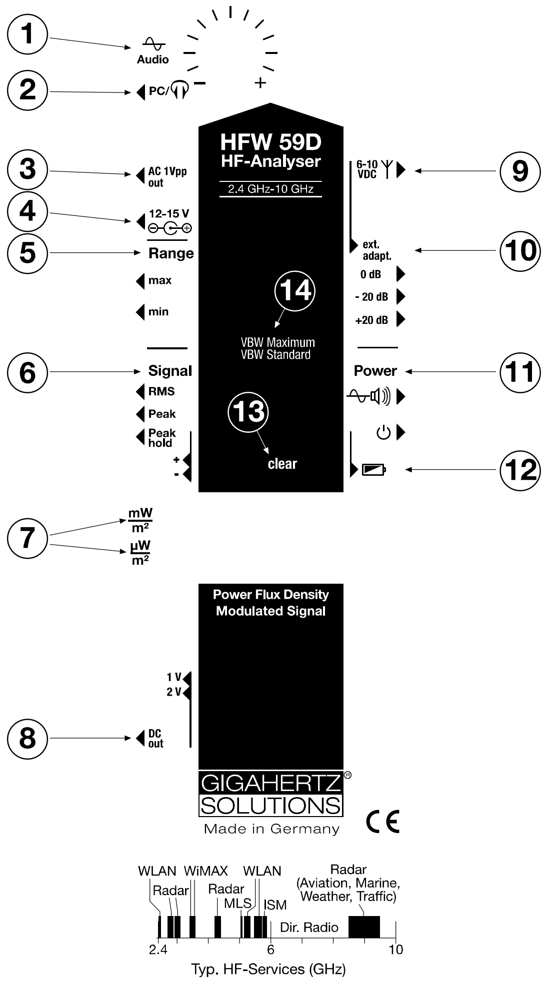
Safety Instructions:

The HF analyser should never come into contact with water or be used outdoors during rain. Clean the case only from the outside, using a slightly moist cloth. Do not use cleaners or sprays.

Due to the high sensitivity level, the electronics of the HF analyser are very sensitive to heat, impact as well as touch. Therefore do not leave the instrument in the hot sun, on a heating element or in any other damaging environment. Do not let it drop or try to manipulate its electronics inside when the case is open.

The antenna entry is protected against overload. No damage can be caused by especially mobile phones, wireless LAN routers or similar devices, no matter how close they are to the antenna.

Functions & Controls



The HF component of the testing instrument is shielded against interference by an internal metal box at the antenna input (shielding factor ca. 35 – 40 dB)

1) Volume control for the audio analysis (on/off switch ∿.🔊).
2) Jack, 3.5 mm: AC output for the modulated part of the signal, for audio analysis via PC or headset.
3) Calibrated AC output 1 Volt peak-peak, proportional to the field strength.
4) Jack, 12-15 Volt DC for charging the battery. AC adapter for 230 Volt/50 Hz and 60 Hz is included. For other Voltages/Frequencies please get an equivalent local AC adaptor with the output parameters 12 – 15 Volt DC / >100mA.
   Caution: If an alkaline battery is used, under no circumstances should the power adapter be connected at the same time, otherwise the battery may explode.
5) Measurement ranges
   max = 19.99 mW/m² (= 19,990 µW/m²)
   min = 1999 µW/m²
   Scaling differs when applying the optionally available amplifier or damper!
6) Selector switch for signal evaluation. In the peak hold mode you can choose a time setting for the droop rate (Standard = "+"). The peak hold value can be manually reset by pressing (13) "clear".
7) A little bar on the very left of the LCD indicates the unit of the numerical reading:
   bar on top = **m**W/m² (Milliwatts/m²)
   bar on bottom = **µ**W/m² (Microwatts/m²)
8) DC output, allows you to connect additional instruments, e.g. data logging devices for longterm recordings. Scalable to 1 V DC full scale.
9) Connecting socket for antenna cable. The antenna is inserted into the cross slot at the front tip of the instrument.
10) Power Level Adapter Switch for external optional amplifier or attenuator only (not part of the standard scope of supply). For regular use of the instrument the switch should be in pos. "0 dB". (Any other position will shift the decimal point to an incorrect position).
11) ON/OFF switch. Using the top switch-position activates the audio analysis mode.
12) Load indicator
13) Push button to reset peak hold. (Push and hold for 2 seconds or until the readings no longer drop)
14) Switch for selecting the Video Bandwidth.

Switches for rarely used functions are recessed in the casing of the instrument.

Contents of the package

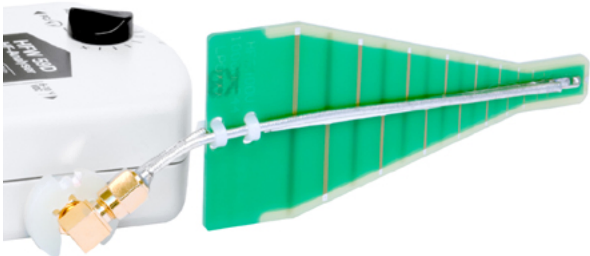
Meter, attachable antenna incl. cable, rechargeable battery pack (in the meter), mains adapter, manual.

Getting Started

Connecting the Antenna

Screw the SMA angle connector of the antenna connection into the uppermost right socket of the HF analyser. It is sufficient to tighten the connection with your fingers. (Do not use a wrench or other tools because over tightening may damage the threads).

Normally, the sources of radiation in the frequency range subject to measurement are vertically polarised. Therefore, the antenna should ideally be aligned as shown in the photo below:



Important: Please do not bend or twist either of the antenna cables.

For a horizontal antenna alignment please do not twist the cable itself, but turn the whole measurement device into the right direction. With the help of the LED at the antenna tip you can control the connection of the antenna cable to the device.

Please do not touch the antenna cable during measurement.

Further notes to the antenna

The SMA connection between the antenna and the meter is the highest quality industrial HF connection of this size. Furthermore, the semi-rigid antenna cable implied has excellent parameters for the frequency range in question. It is designed for several hundred bending cycles without causing losses to the quality of the measurements. The special implementation of a second “dummy” antenna cable is the subject matter of one of our pending patents, and compensates the internal weakness of the “simple-log-per-antenna” which is based on conductor plates. These are also sensitive to frequencies below the specified bandwidth, thus possibly falsifying measurements in the principal direction. The antenna supplied with the meter can suppress these disturbances by approx. 15 to 20 dB (in addition to the 40 dB of the internal high pass filter).

Checking Battery Status

If the “Low Batt” indicator appears in the center of the display, measurement values are no longer reliable. In this case, the battery needs to be charged.

If there is no display at all upon switching the analyser on, check the connections of the rechargeable battery. If that does not help try to insert a regular 9 Volt alkaline, (non-rechargeable) battery.

If a non-rechargeable battery is used, do not connect the analyser to a charger / AC-adaptor!

Note

Each time you make a new selection (e.g. switch to another measurement range), the display will systematically overreact for a moment and show higher values which will, however, droop down within a couple of seconds.

The instrument is now ready for use.
In the next chapter you will find the basics for
true, accurate HF-measurement.

Properties of HF Radiation…

This instruction manual focuses on those properties that are particularly relevant for measurements in residential settings.

Across the specified frequency range (and beyond), HF radiation causes the following effects in materials exposed to it:

1. Partial Permeation
2. Partial Reflection
3. Partial Absorption.

The proportions of the various effects depend, in particular, on the exposed material, its thickness and the frequency of the HF radiation. Wood, drywall, roofs and windows, for example, are usually rather transparent spots in a house.

Minimum Distance

In order to measure the quantity of HF radiation in the common unit “power density” (W/m²), a certain distance has to be kept from the HF source.

For measurements in the lower frequency limits of the HFW59D, the minimum distance between the antenna tip and the object of measurement should be half a meter.

Polarization

When HF radiation is emitted, it is sent off with a "polarization". In short, the electromagnetic waves propagate either vertically or horizontally. Therefore, both planes of polarization ought to be checked in order to identify the one applying to the object in question. Please note that the antenna supplied with this instrument measures the vertically polarized plane if the upper surface of the meter is held horizontically.

… and Consequences for the Execution of Measurements

When testing for HF exposure levels in an apartment, home or property, it is always recommended to **record individual measurements** on a data sheet. Later this will allow you to get a better idea of the complete situation.

It is important to repeat **measurements several times**: First, choose different daytimes and weekdays in order not to miss any of the fluctuations, which sometimes can be quite substantial. Second, once in a while, measurements should also be repeated over longer periods of time, since a situation can literally change "overnight".

Even if you only intend to test indoors, it is recommended first to take measurements **in each direction** outside of the building. This will give you an initial awareness of the "HF tightness" of the building and also potential HF sources inside the building (e.g. WLAN access points, also from neighbours).

Furthermore, you should be aware that taking measurements indoors adds another dimension of testing uncertainties to the specified accuracy of the used HF analyser due to the narrowness of indoor spaces. According to the "theory", quantitatively accurate HF measurements are basically only reproducible under so-called "free field conditions", yet we have to measure HF inside buildings because this is the place where we wish to know exposure levels. In order to keep system-immanent measurement uncertainties as low as possible, it is imperative to carefully follow the measurement instructions.

As mentioned earlier in the introduction, even slight changes in the positioning of the HF analyser can already lead to rather substantial fluctuations in measurement values. (This effect is even more prevalent here than in the ELF range). **It is suggested that exposure assessments are based on the maximum value within a locally defined area** even though this particular value might not exactly coincide with a particular point of interest in, for example, the head area of the bed.

The above suggestion is based on the fact that slightest changes within the environment can cause rather major changes in the power density of a locally defined area. The person who performs the HF testing, for example, affects the exact point of the maximum value. It is quite possible to have two different readings within 24 hours at exactly the same spot. The maximum value across a locally defined area, however, usually only changes if the HF sources are subject to change. This is why the latter value is much more representative for the assessment of HF exposure.

Preliminary Notes Concerning the Antenna

The supplied logarithmic-periodic antenna (or aerial), has exceptional **directionality**. Thus it becomes possible to reliably locate or "target" specific emission sources in order to determine their contribution to the total HF radiation level. To know exactly the direction from where a given HF radiation source originates is a fundamental prerequisite for effective shielding.

The readings from the instrument's display always reflect the integral power density at the measurement location coming from the direction the antenna is pointing at (i.e. based on the spatial integral of the "antenna lobe").

The LogPer antenna supplied is optimised for a frequency range of 2.4 to 10 GHz. It covers the frequencies of both WLAN bands, bluetooth, zigbee, various radar frequencies (especially also the densely used frequency band from 8.5 to 9.5 GHz which includes radar for the control and survey of the air and shipping traffic, as well as further frequency bands used commercially or for military purposes, especially for the directional radio. Critical medicals consider these pulsed or spread spectrum modulated signals as biologically especially harmful.

In order to avoid measurement values to be falsified by the often dominant radiation sources from frequencies below, such as DECT or GSM, the HFW59D is equipped with an internal high pass filter at 2.4 GHz, causing these lower frequencies to be suppressed.

Step-by-Step-Instruction to HF-Measurement

Procedure for the Quick Overview Measurement:

The HF analyser and antenna are to be checked following the instructions under "Getting Started".

First set the measurement range ("Range") switch to "max". Only if the displayed measurement values are persistently below approx. 0.10 mW/m², change to the measurement range "min" (199.9µW/m²).

Set the "Signal" switch to "Peak"

HF radiation exposure can differ at each point and from all directions. Even though the HF field strength of a given space changes far more rapidly than in the lower frequencies, it is neither feasible nor necessary to measure all directions at any given point.

Since there is no need to look at the display during an overview measurement, you only need to listen to the **audio signal**. It is very easy to walk slowly through in-door or out-door spaces in question. In doing so, constantly move the antenna or the HF analyser with attached antenna in each direction. This will provide you with a quick overview of the situation. In in-door spaces, antenna movements towards the ceiling or the floor will reveal astonishing results.

As already mentioned above, the aim of the quick overview measurement is to identify the zones of local peaks, not to supply exact data.

Quantitative Measurement

Once the relevant measurement points have been identified following the instructions in the previous section, the quantitative and precise measurements can be started.

Setting: **"Range"**

Select the appropriate switch settings as described under "Quick Overview Measurements": First switch the Range switch to "max". Only switch to "min" if you're constantly shown very low values. Basic rule for measurement range selection:

Basic rule for measurement range selection:

As coarse as necessary, as fine as possible

Power densities beyond the designed range of the instrument (display shows "1" on its left side with the range set to "max") can still be measured by inserting the attenuator DG20_G10, available as an optional accessory. By setting the "ext. adapt." switch to 20 dB on your instrument, you will ensure a correct display of the measurement value (i.e. indication of unit and correct decimal point).

The optional HF preamplifier HV20_2400G10, to be used as plug-in into the antenna input socket, increases the sensitivity by a factor of 100. With the help of this, the meter reaches a theoretical minimum resolution of 0.01 µW/m². The realistic minimum resolution is slightly lower due to the noise margin.

Measurement ranges of the HFW59D

Range	Bar on LCD	**Instrument as delivered,** i.e. without preamplifier or attenuator ("ext. adapt." to "0 dB") **Displayed** value & unit
max		0.01 - 19.99 **m**W/m²
min		1 - 1999 **µ**W/m²
Simply read out, no correction factor		

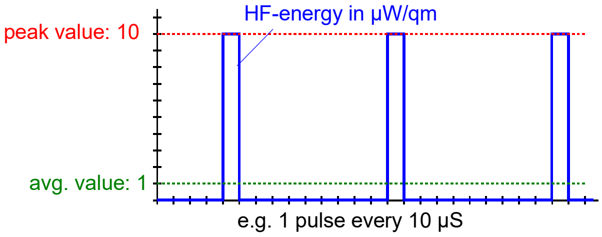
Range	Bar on LCD	**With ext. Attenuator DG20,** ("ext. adapt." to "-20 dB") **Displayed** value & unit
max		1 - 1999 **m**W/m²
min		0.1 - 19.99 **m**W/m²
Simply read out, no correction factor		

Range	Bar on LCD	**With ext. Preamplifier HV20,** ("ext. adapt." to "+20 dB") **Displayed** value & unit
max		0.1 - 199.9 **µ**W/m²
min		0.01 - 19.99 **µ**W/m²
Simply read out, no correction factor		

Setting:
"Signal"

Peak / RMS

The following illustration shows the difference in the evaluation of a pulsed signal if displayed as an average value reading or a peak value reading ("RMS" and "Peak"):



With the switch set to "Peak", the meter will display the full power flux density of the pulse (10 µW/m² in the graph). With the switch set to "RMS", the meter will take the mean of the power flux density over the total period of time, for instance 1 µW/m² in the above graph (=((1x10)+(9x0))/10).

With the switch set to "Peak" or "Peak hold", the display will show the "RMS value during the pulse", which is a common practice in the building biology.

Nevertheless, the "true" mean value is of great interest, too:

- The "official" limit values are always based on mean value examinations. When analysing "official" measurement results, therefore, such as those for instance done for cell phone operators, it may be useful to have a possibility of comparison.

Users of professional spectrum analysers please note:

- The value for pulsed radiation shown on the display of the Gigahertz Solutions HF Analysers with the signal switch set to “Peak” corresponds to the equivalent value in µW/m² resulting from the “Max. Peak” function of a modern spectrum analyser (elder spectrum analysers had a similar function mostly called “positive peak”).
- The switch setting “RMS” corresponds the “true RMS” setting of a modern spectrum analyser (elder spectrum analysers have a similar function mostly called “normal detect”, as well as a setting for the video bandwidth adapted to match the pulse).

Peak Hold

In the interior, local peak values are mostly subject to strong fluctuations (caused by multiple reflections). In order not to overlook any local maxima (so called hot spots), indoor measurements should, therefore, preferably be done with the “Peak hold” setting.

Switching impulses can cause “pseudo peaks” which will appear on your display. These can be deleted by pressing and holding the “clear” button for several seconds (while keeping the “clear” button pressed, the measurement will turn into a regular peak measurement). Releasing the “clear” button will trigger the period during which the maximum value is to be determined.

In the “Peak hold” mode, the sound signal remains proportional to the currently measured power flux density. This helps finding the absolute maximum within the measured area.

The droop rate, at which the held peak value decreases over time can be controlled with the “+” and “-” switch. Even after several minutes, the value displayed is still within the specified tolerance. Nevertheless, the display should be checked frequently in order to obtain the most accurate readings. In the case of very high and short signal peaks, the holding capacity of the “Peak hold” function needs several recurrences (less than a second) to fully load.

Setting:
“VBW”

For the HFW59D, “VBW Maximum” is the standard setting with which the most common sources of radiation within the meter frequency range, i.e.

- Radar (a short beep every few seconds) as well as
- Wireless LAN in standby mode (a very quick “tuc-tuc-tuc-…”)

are displayed directly, without the need of any conversion factors.

In the process of up- and downloading data via wireless LAN or within the upper LTE band, the so called crest factors need to be additionally taken into consideration. In this case, the displayed value needs to be taken by 4 (or doubled twice). With the help of the audio analysis, these signals can easily be distinguished from the radar signals[1].

Information on radar measurements:

For air and sea navigation, a radar antenna slowly rotates around its own axis, thereby emitting a tightly bundled “radar ray”. Even with sufficient signal strength, this ray can only be detected every couple of seconds, for a few milliseconds. This requires special measurement technology.

To be on the safe side, we recommend the following procedure for the acoustic identification of a radar signal (a short “beep” which will recur every few seconds, in extreme cases only every 12 seconds, in the case of reflections maybe also at shorter intervals):

Switch meter settings to “VBW Maximum” and “Peak hold” and take several measurements of the radar signal from varying measurement points in order to be able to identify the main direction of emission and to record the quantitatively correct measurement value.

If the location of the radar base is not known, the quasi isotropic UBB antenna is particularly useful for the determination of the maximum exposure values.

Quantitative Measurement:
Determination of Total Exposure

Hold the HF analyser from its rear side with a **slightly outstretched arm**.

In the area of a **local maximum,** the positioning of the HF analyser should be changed until the highest power density (the most important measurement value) can be located. This can be achieved as follows:

- By **scanning** “all directions” with the LogPer to locate the direction from which the major HF emission(s) originate. In apartment houses also scan from top to bottom.
- By **rotating** the HF analyser around its longitudinal axis up to 90°, thus taking into account the polarization plane of the HF radiation.
- By **changing the measurement position** and avoid measuring exclusively in one spot, in order to avoid measuring exclusively at a point of local or antenna-specific cancellation effects.

Some manufacturers of field meters propagate the idea that the effective power density should be obtained by taking measurements of all three axes and calculating the result. Most manufacturers of professional testing equipment, however, do not share this view.

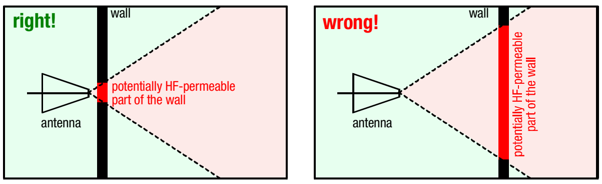
[1] Users of HF59B please note the different recommendations regarding the VBW settings

In general, it is well accepted that exposure limit comparisons should be based on the maximum value emitted from the direction of the strongest radiation source.

To be on the safe side with exposure limit comparisons, it might be useful to multiply the displayed value by a factor of 2, and take the result as a basis for your comparison. This method is often applied by building biologists in order to avoid to be assuming a far lower exposure than realistically existent should the meter be measuring in the lower tolerance field, taking into account, however, that this may lead to far too high values if the meter was to be measuring in the higher tolerance area.

Quantitative Measurement:
Identification of HF inflow

As a first step eliminate sources from within the same room (e.g. wireless LAN). Once this is completed, the remaining radiation will originate from outside. For remedial shielding it is important to identify those areas of all walls (including doors, windows and window frames!), ceiling and floor, which are penetrated by the radiation. To do this one should not stand in the centre of the room, measuring in all directions from there, but monitor the permeable areas with the antenna (LogPer) directed and positioned close to the wall[2]. That is because the antenna lobe widens with increasing frequency. In addition reflections and cancellations inside rooms make it difficult and often impossible to locate the "leaks" accurately. See the illustrating sketch below!



The uncertainty of localization with HF-antennas

The shielding itself should be defined and surveyed by a specialist and in any case the area covered by it should be much larger than the leak.

[2] Please note: In this position the readings on the LCD only indicate relative highs and lows that cannot be interpreted in absolute terms.

Guidelines, Limiting and Precautionary Values

The official regulations in many countries specify limits far beyond the recommendations of environmentally oriented doctors, “building biologists” and many scientific institutions and also those of other countries. They are vehemently criticised, but they are nonetheless “official”, and often the basis for authorization procedures. The limit value is frequency-dependent and in the HF range of interest here lies between 4 and 10 W/m² (1 W/m² = 1,000,000 µW/m²). It is based on an average value evaluation, which building biologists consider far too low. The same point of criticism also applies to the official limit values of other countries, as well as of the ICNIRP (International Commission on Non-Ionizing Radiation Protection) – the so-called non-thermal effects of EMF are neglected. This is also “officially” described in a commentary published by the Swiss Federal Office for Environment, Forest and Landscape dated Dec. 23, 1999. These “official” limits are far beyond the range of this instrument, which is optimized for accurate measurement of power densities targeted by the building biologists.

The building biology guideline SBM 2015 classifies the following steps:

Building biology guideline acc. to SBM-2015 © Baubiologie Maes / IBN				
Anomaly	**none**	**slight**	**strong**	**extreme**
(µW/m²)	< 0,1	0,1-10	10-1000	> 1000

The "Bund fuer Umwelt und Naturschutz Deutschland e. V." (BUND) proposes 100 µW/m² outside buildings. In view of the shielding properties of normal building materials, far lower values exist inside buildings.

In February 2002 the Medical Authority of the Federal State of Salzburg, Austria, recommends to reduce its “Salzburger Precautionary Recommendation” from 1,000 µW/m² to 1 µW/m² inside buildings and 10 µW/m² outside. These limits are based on empirical evidence over the past few years.

In summary it confirms the justification of precautionary limits well below the present legal limits.

Users of mobile phones and Wifi please note: Even at significantly lower power flux densities than the strict values recommended by the SBM for pulsed radiation, i.e. at values of approx. 0.01 µW/m², you will always have excellent cell phone and wireless LAN reception.

Audio Analysis of Modulation

The audio analysis of the modulated portion of the HF signal helps to identify the source of a given HF radiation signal. There is a selection of audio samples on our homepage (high frequency meters).

How to proceed:

For audio analysis, simply turn the volume knob of the speaker at the top of the case all the way to the left (“-”). If you are switching to audio analysis while high field strength levels prevail, high volumes can be generated quite suddenly. This is especially true for measurements which are to be taken without audio analysis. The knob is not fastened with glue to prevent over winding. However, if by accident you should turn the knob too far, simply turn it back again. No damage will be caused.

The volume can be controlled with the “audio” knob. Note: The power consumption of the speaker is directly proportional to the volume.

Use of Signal Outputs

AC output:

The AC output “PC/head-set”, 3.5 mm jack socket, is meant for in-depth analysis of the AM/pulsed content of the signal by headset.

DC output (2.5 mm jack socket)**:**

For a (longterm) recording of the display value. When “Full Scale” is displayed, it has 1 VDC output.

The normal auto power off function is automatically deactivated as soon as external devices are connected, and is only automatically reactivated if a total discharge is imminent.

Further Analysis / Optional Accessories:

Available from Gigahertz Solutions:

- For increasing the measurement range of the HFW59D:
  Preamplifier HV10 for measuring very weak HF signals with a higher resolution.
  Attenuator DG20_G3 for measuring extra strong HF signals.
- **HF-Analysers < 2,4 GHz**
- **Meters for the low frequencies:** Also for this frequency range, Gigahertz Solutions offers a broad range of professional measurement technology. The new NFA series, for instance, which

allows a three-dimensional measurement of alternating electrical and magnetic fields.

- **Data loggers:** All NFA-meters, starting from the NFA30M, can equally be applied as data loggers for long-term recordings with our HF analysers (only those with DC output).

Battery Management

The instrument comes with a rechargeable, high quality internal NiMH-Battery. The quality of these high-capacity NiMH batteries (far better than NiCd batteries, for instance) can be best maintained if they are almost totally discharged (i.e. used) before being fully recharged (for > 13 hours or until the green charging LED turns off). The loading procedure is started by switching the meter on and off once only after connecting it to the power supply unit.

Changing the rechargeable Battery

The battery compartment is at the back of the analyser. To remove the lid, press on the grooved arrow and pull the cap off. **Insert only rechargeable batteries. If you use regular alkaline (non – rechargeable) batteries do not use a charger or AC-adapter!**

Auto-Power-Off

This function conserves energy and extends the total operating time.

1. In case you have forgotten to turn OFF the HF analyser or it has been turned ON accidentally during transport, it will shut off automatically after 40 minutes.
2. If “low batt” appears vertically between the digits in the center of the display, the HF analyser will turn OFF after 3 min in order to avoid unreliable measurements. In that case charge the rechargeable battery.
3. The built-in function, Auto-Power-Off, will automatically be de-activated by plugging in a 2.5 mm DC. The function will also automatically be re-activated to prevent a total discharge of the battery by further operation.

Mains operation

The HF analyser can also be supplied with power by using the mains adapter (for instance for long-term measurements in combination with the NFA). When doing so, please take care to turn the volume button right down to zero (“-”), otherwise you might hear the 50 Hertz noise of the mains voltage.

Interferences may, however, also be caused by high frequency couplings through the power supply unit. This can easily be tested by unplugging the power supply unit from the meter while in use. If the measurement value now shows a significant drop, this is a sign of an unwanted coupling.

For long-term measurements, the more reliable solution is to use a car battery with short cable to the power supply jack, or alternatively to apply ring ferrites onto the power supply cable (please see photo).

Warranty

We provide a two year warranty on factory defects of the HF analyser, the antenna and accessories.

Antenna

The antenna is made of a highly durable FR4 based material that can easily withstand a fall from table height. The luminous diodes at the antenna tip serve as additional proof of functionality, as they signalise a continous contact of all antenna elements while the meter is switched on. Any mechanical damage will cause either one or even both diodes to go out. The warranty will cover any damages caused by falls, should this ever occur.

HF Analyser

The analyser itself is definitely **not** impact proof: Due to the comparatively heavy battery pack and the large number of delicate components, damages caused by shock cannot be ruled out. Any damage as a result of misuse or shock is therefore excluded from this warranty.

Our silicone holsters have proven to be rather helpful for the protection of the meters.

For questions or service contact the vendor of your instrument.

Manufacturer:

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Conversion Table

(µW/m² to mV/m)

µW/m²	mV/m	µW/m²	mV/m	µW/m²	mV/m
0,01	1,94	1,0	19,4	100	194
-	-	1,2	21,3	120	213
-	-	1,4	23,0	140	230
-	-	1,6	24,6	160	246
-	-	1,8	26,0	180	261
0,02	2,75	2,0	27,5	200	275
-	-	2,5	30,7	250	307
0,03	3,36	3,0	33,6	300	336
-	-	3,5	36,3	350	363
0,04	3,88	4,0	38,8	400	388
0,05	4,34	5,0	43,4	500	434
0,06	4,76	6,0	47,6	600	476
0,07	5,14	7,0	51,4	700	514
0,08	5,49	8,0	54,9	800	549
0,09	5,82	9,0	58,2	900	582
0,10	6,14	10,0	61,4	1000	614
0,12	6,73	12,0	67,3	1200	673
0,14	7,26	14,0	72,6	1400	726
0,16	7,77	16,0	77,7	1600	777
0,18	8,24	18,0	82,4	1800	824
0,20	8,68	20,0	86,8	2000	868
0,25	9,71	25,0	97,1	2500	971
0,30	10,6	30,0	106	3000	1063
0,35	11,5	35,0	115	3500	1149
0,40	12,3	40,0	123	4000	1228
0,50	13,7	50,0	137	5000	1373
0,60	15,0	60,0	150	6000	1504
0,70	16,2	70,0	162	7000	1624
0,80	17,4	80,0	174	8000	1737
0,90	18,4	90,0	184	9000	1842

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