ROM-Elektronik GmbH

RF-Analyzer HFR-4

Manual

rom elektronik

Preliminary notes - Notes on safety

You have acquired an electronic measuring device. Handle your HFR-4 carefully! Due to the high level of sensitivity, the electronics of the measuring device are sensitive to shocks and jolting. Please do not let it fall!

The antenna of the device conducts electric current very well. Do not bring the antenna too near plug sockets, current-carrying cables or rigs! The HFR-4 could be destroyed with contact of the antenna with current! Also the electric shocking of the user cannot be entirely excluded!

The HFR-4 does not belong in children's hands! Although the device is quite rugged, nevertheless the antenna can suffer damage in case of inappropriate use.

Never bring to the HFR-4 in contact with water! Do not use in the rain. The sensitive electronics can be damaged.

Avoid high temperatures! The device should not be placed on heating units or left in the car in summer under full sunlight!

Please note that the device uses a relatively large amount of current and thus the battery can be used up fast. The HFR-4 signals a used battery in the display with the message "Change battery". Rechargeable batteries can also be employed.

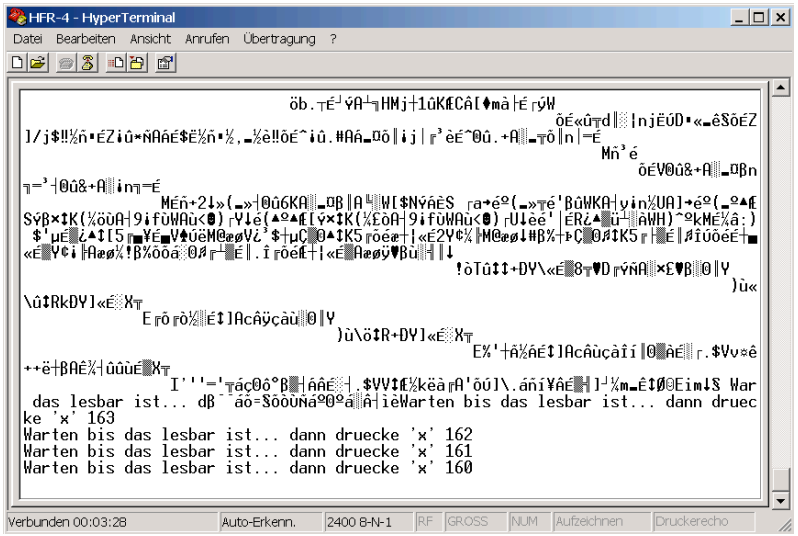
The HFR-4 is maintenance-free. A re-calibration is not necessary! Clean the device only on its exterior with a moist cloth. Do not use any cleaning agents!

Operational startup

If not already carried out, insert a 9 V battery (or rechargeable battery) into the battery compartment on the reverse side.

Screw one of the supplied logper antenna onto the HFR-4 where appropriate, tighten with a tool. We recommend to start with the large one.

Where the number in the second line decreases continuously. The following should be observed on the screen terminal.



Bildschirm für die Baudratenkalibrierung

If the text "Wait until it can be read ... then press x" can be read off without error, then please activate the key "X" on the PC keyboard. The correct baud rate is now set adjusted and stored permanently.

This procedure can be repeated as often as necessary.

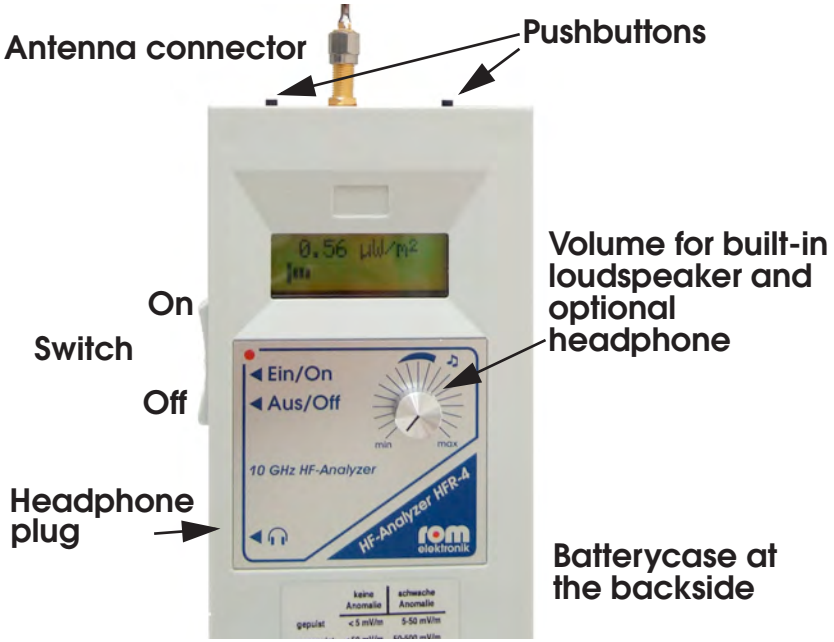
Liability and guarantee

Every liability which arises from application of the device is excluded. The guarantee period is 24 months from delivery date. Within this time, all deficiencies, which are not attributed to inappropriate treatment, are repaired immediately and clear of all charges. In case of repair being necessary, please send the device to us with the proof of purchase.

Assistance and support

Should you require assistance in the application of the device, then you can reach us under Fax No.: 08282-7305 or Tel.: 08282-7385 with operational questions concerning the device.

Switch on the HFR-4 with the slide switch located on the side.



Bedienelemente des HFR-4

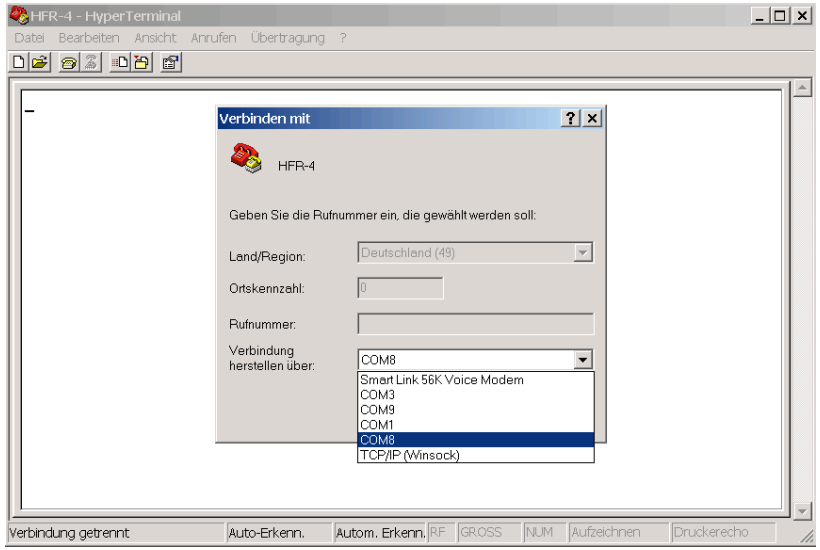
The following message should appear shortly on the display:

```
ROM-Elektr.
HFR-4 V2.0
```

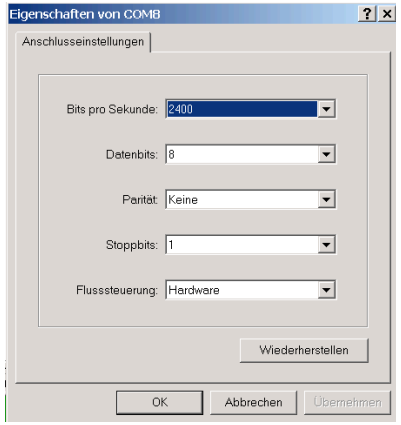
then e.g.

```
 218 µW/m²
```

With this, your HFR-4 is in operation.



Eine freie, serielle Schnittstelle auswählen



Schnittstellenparameter auf 2400 Baud, 8 Datenbits, 1 Stopbit, keine Parität einstellen

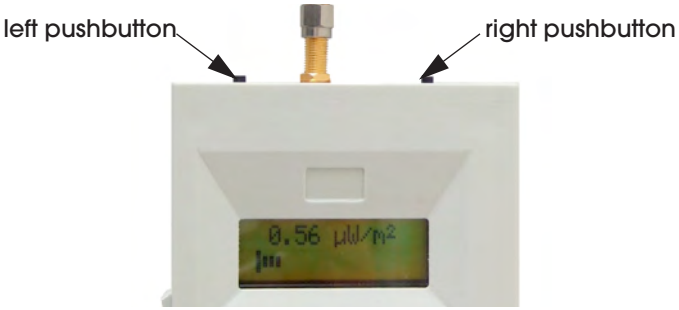
ing. The corresponding base stations, on the other hand, can be identified through a high whistling tone with approx. 1733 Hz (8x217 Hz =1733 Hz).

Radar systems send signals from 600 Hz to 1200 Hz.

There are innumerable other, in-part "exotic" signals, which cannot all be counted here. With time, you will gain your own experience.

Functions

TThe pushbuttons located on the front side are employed to alternate between the different functions of the HFR-4.

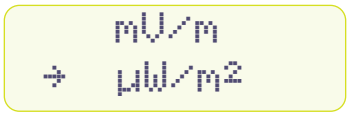


Selection of the measurement unit

The HFR-4 is able to indicate the measured value either in units of electrical field strength (mV/m) or in radiant flux density (µW/m^2). The unit is changed as follows:

Keep the left-hand pushbutton (LT) pressed and then press the right-hand pushbutton (RT) until the following display appears.

With the left-hand pushbutton (LT), the selection is reached:



In the same way, you can skip back and forth between the units with the

ons is possible.

Connection of the plug for headphones or signal analysis with spectrum analyzer

With a little practice and experience, allocation of the demodulated signals to the transmitter can be established through the acoustics.

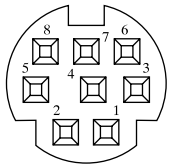
This outlet can also be connected with an AF spectrum analyzer. In the meantime, some few spectrum analyzers have become available; either as a pure software solution (connection over sound card and PC), or as an accessory unit, such as e.g. our ADC appliance series.

Options

Der HFR-4 kann mit einem Schreiberausgang (0-2,5 V) oder/und seriellem RS232 Computerschnittstelle geliefert werden. Auch eine Nachrüstung ist möglich.

Anschlußbelegung Schnittstelle

1 = not connected
2 = not connected
3 = TxD (transmit data)
4 = Ground
5 = RxD (receive data)
6 = DC-output 0 - 2,5 Volt
7 = not connected
8 = Analog-Output from Detector



DC-Output (Analog writer outlet)

The measured value is provided as electric voltage in the range from 0 volt to 2.5 volt (R_{min}=>10 kOhm) at the cinch socket.

Detector-Output

Here the direct detector output voltage is available (ca. 0,4 Volt to 1,7 Volt, R_{min}=>10 kOhm)

deactivated automatically on restart.

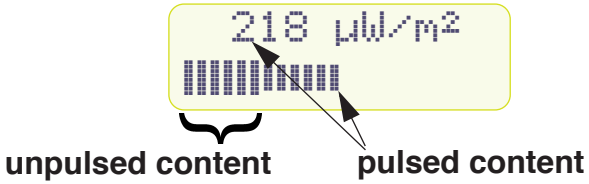
With a press on the right-hand pushbutton (RT), you return to normal operation indication.

Modulation

Radio frequency signals are difficult to measure, not only because of their very different frequencies. A complicating factor is that there are also many different modulation methods. The latest research results indicate that the modulation method (e.g. pulse modulation) has a strong influence on the biological relevancy of a radio frequency signal.

Exactly as biological systems, the radiation detector also does not react similarly to all modulation methods. The modulation of the RF signals can be detected over the built-in loudspeaker.

The HFR-4 has a fixed integrated peak value recording and displays the non-pulsed value and pulsed value simultaneously in the display!



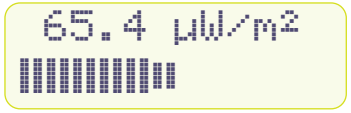
The problem of the peak value recording is the following: The measuring device requires a certain time for the measurement. The measuring device sometimes "checks" whether there is a measured value present. If this by chance always occurs between the "check" pulses, then the measuring device displays a very low measured value. Nevertheless, now and then it catches a pulse and displays this as well. However, this happens much too seldom.

The peak value recording "notices" a certain time for the peak value of the pulse. Thus the opportunities for the measuring device to measure the correct peak value are greater. If the pulse width is very narrow (approx. 100 ns = 100 nanoseconds = 100 billionths of a second with DECT), then, under certain circumstances, the "peak value storage" is not filled completely and the measured value is a little too low. If the pulse lasts longer (>0.3µs, GSM approx. 577 µs), then the opportunities that the "peak value storage" is filled completely increase, which again results in a correct measured value indication.

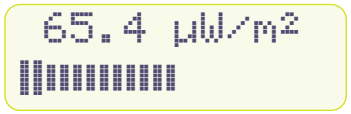
PeakHold

The HFR-4 has a peak-hold funcion. This funcion enables to „freeze" the measured value on the display. Therefore, it is necessary to push the left but-

65.4 µW/m^2



This signal consists almost exclusively of the pulsed content and a peak value of 65.4 µW/m^2



If a too high RF level is applied, then the following appears in the digital display

Please switch off the HFR-4 immediately, in order to avoid damage to the HFR-4.

Notes on the antenna

The delivered logper antenna is part of a measuring system! Please take corresponding care when handling it! It receives electromagnetic radiation in the range from 900 MHz to 2600 MHz. It can bend slightly in the area of the plug. If this occurs, it can be carefully straightened again. This should not happen too often, however, so that permanent damage is excluded.

Evaluation of the results of measurement

Basically, an evaluation of the measured values is to be recommended in accordance with the provision principle. With frequent employment of the device, you will also get a feeling for which measured value is normal and which measured value can be regarded as increased, or maybe even dubious. The following Table 5 gives provisional values for provision and limit values.

Dr. Lebrecht von Klitzing (Luebeck), who carried out investigations concerning the influence of brain currents through pulsed radio frequency radiation, indicates the value 0.1 mW/cm^2 = 1 mW/m^2 for short-term exposures as a lowest influence threshold. For constant loads, such as e.g. in case of DECT base stations, which continuously emit pulsed radio frequency, 5 µW/m^2 = 0.5 nW/cm^2 ≈ 40 mV/m should not be exceeded!
If measured values above 2000 mV/m and/or 10 mW/m^2 are received

$$\frac{E}{H} = 377\Omega \qquad \text{(GL 2)}$$

S:	Radiant flux density	(W/m^2)
E:	Electrical field strength	(V/m)
H:	Magnetic field strength	(A/m)

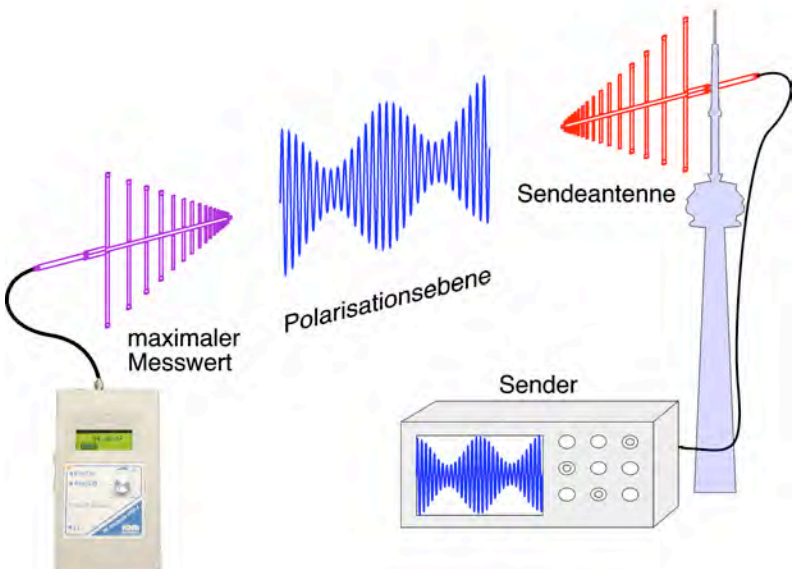
It is therefore sufficient to measure one variable in order to be able to determine all others as well. Very frequently it is the radiant flux density S that is measured. Our HFR-4 measures the component of the electrical field strength!

For the measurement, a suitable antenna is required, which absorbs a certain radiant flux density quantity with its effective surface A_W and converts it into a line-conducted wave. The power of this wave results from the radiant flux density and the effective surface of the antenna:

$$P_E = S \cdot A_W \qquad \text{(GL 3)}$$

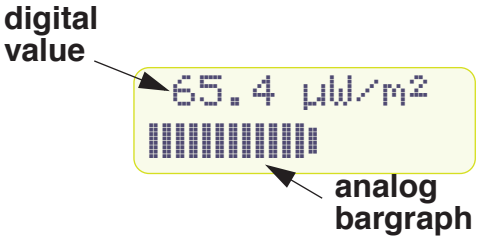
P_E:	Received power
A_W:	Effective surface of the antenna
S:	Radiation flux density

The measuring range of the HFR-4 extends from approx. 6 mV/m to 2000 mV/m or from 0.1 µW/m^2 to 10,000 µW/m^2. If higher levels should be measured, the measuring range can be adapted upwards through external attenuators. There are attenuators available with 6 dB, 10 dB and 20 dB. The attenuators are easily connected between antenna an HFR-4.



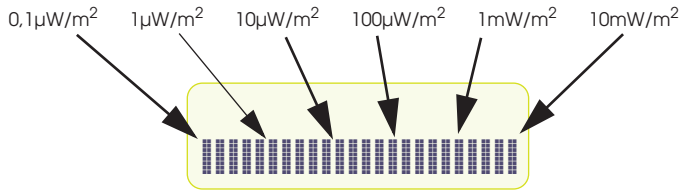
Maximum measured value if transmitting and receiving antenna point in same direction and polarization level.

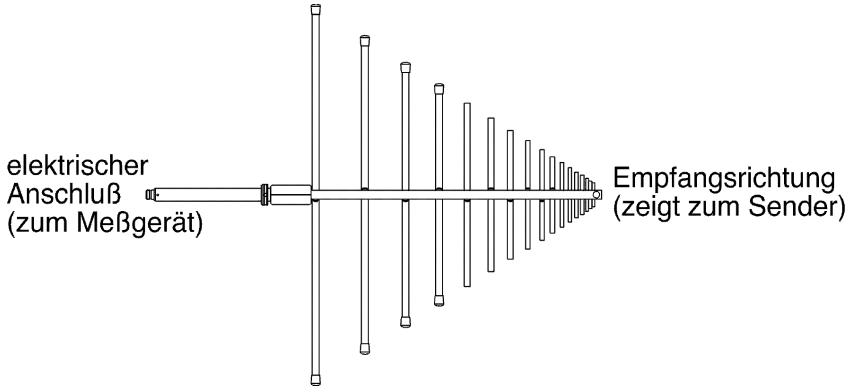
lue and the analog value measured value as a bar.



The analog bar has a logarithmic sub-division. This has two advantages:

1. At low levels, a clear display is visible on the bar.
2. With the measured value indication of the electrical field strength in mV/m, a simple estimate of the radiant flux density in µW/m^2 is possible.





A logper antenna consists of several dipoles of different lengths. Every rod pair receives a different frequency. The long rods are responsible for the low frequencies (larger wavelength) and the short rods for the high frequencies (smaller wavelength). Wavelength and frequency have the following relationship to each other:

$$c_0 = \lambda \cdot f \qquad \text{(GL 4)}$$

- λ: Wavelength
- c_0: Velocity of light (=300,000 km/s)
- f: Frequency

With the HFR-4 the electrical field strength E can be measured in mV/m and the radiant flux density S in µW/m^2 and converted back and forth with the formula (3). Prerequisite, however, is that the effective surface area of the antenna is known.

The effective surface area is not constant, however, but dependent on frequency:

$$A_W = G \cdot \frac{\lambda^2}{4\pi} = G \cdot \frac{c_o^{\,2}}{4\pi f} \qquad \text{(GL 5)}$$

- G: Antenna gain (= amplification; frequency-dependent)
- λ: Wavelength
- c_0: Velocity of light
- f: Frequency

Many thanks for deciding on the purchase of this device.

You are now able to determine the high-frequency situation quickly and simply, and carry out a simple selection of the frequency ranges (as it were, a simplified RF spectral analysis).

The operation of the HFR-4 is simple. We have given this the highest priority value!

Through our long-standing experience in RF measuring device construction, with support from the University of the German Armed Forces, Munich, our "large" HF Measuring Unit PDM-3 and its "little brother" HFR-2, as well as our multifrequency filter MFF-1, have undergone some decisive improvements. Only by means of this (expensive) development effort, could we also realize many of these improvements for the HFR-4.

The HFR-4 is a broadband receiver for the verification and evaluation of high-frequency signals (mobile telephones C-Net, GSM900, GSM1800, cordless telephones (DECT, CT1+ ...), radio and television transmitters, microwave cookers ...).

The built-in peak value recording allows the measurement of pulsed RF signals according to building-biology requirements.

The sensitivity and gauging accuracy has been further increased in comparison with the HFR-2. On the LC display of the conveniently handled device, the electrical field strength can be read off directly in mV/m or the radiant flux density in $\mu W/m^2$.

The indicated values agree in a range ±3 dB in case of approx. 4 GHz and direction of the antenna in the plane of polarization.

Over the switchable internal loudspeaker, the modulation of the radio frequency signals can be made audible (e.g. pulsed RF radiation).

The direction and the polarization of the RF radiation can be determined simply by the attachable, logarithmic-periodic broadband antenna included in the scope of delivery, (logper antenna).

Montage der Antenne mit Aufddrehhilfe

Frequeny range

800 MHz to 2,6 GHz	2 GHz to 10 GHz
large antenna	small antenna
	

Tecnical Data

Frequency range:	ca. 1 MHz bis 8000 MHz teilweise kompensiert (ca. 1 MHz bis 10000 MHz with decreased precision)
Measuring range:	6 mV/m to 2000 mV/m (= ca. 0,1- 10000 $\mu W/m^2$ = 10 pW/cm^2 - 1 $\mu W/cm^2$)
Max. sensitivity:	Better than 0,01 $\mu W/m^2$ (= 1 pW/cm^2)
Filter frequency ranges:	± 3 dB in the range 2 GHz to 6 GHz
Display:	LC-Display, 2 lines
Ambient temperature:	0 to 40°C
Dimensions:	85mm x 117mm x 55mm
Functions:	Adjustable volume
Weight:	Approx. 300 g
Power supply:	9V block battery
Current consumption:	max. 40 mA
Scope of delivery:	HFR-4, Logper-Antenna 900 MHz - 2600 MHz , Logper-Antenna 2000 Mhz - 11000 MHz, Battery charger, 2 batteries

Also optionally available with serial computer interface and recorder outlet

Tips and notes on frequently asked questions

Avoid the operation of a mobile telephone (cell phone) in direct proximity to the HFR-4! Never allow the antennae of the HFR-4 and mobile telephone to come in contact during operation!
DANGER OF DESTRUCTION!

In case of the peak value recording, it takes a certain time until the measured value has adapted; in particular downwards. The reason for this is that the measured values are stored and a certain time passes (approx. 30 sec) until this storage is emptied. Also, the display becomes very unstable if pulsed signals are registered.

Functions of the push buttons

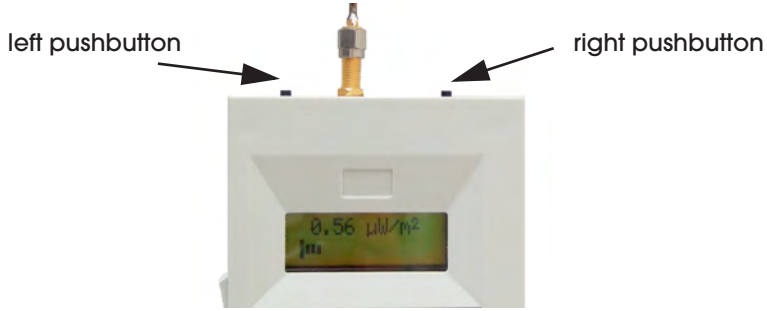


Tabelle of the function on activating the pushbuttons

Table of the function on activating the pushbuttons

left pushbutton	right pushbutton	Function
push		Peak value storage (PeakHold) On/Off switching
push and hold	then push	Branching off in main menu
push in main menu		Selection between display or menu data logger
	push in main menu	Branch between mV/m and µW/m2
push in display menu		Selection between mV/m and µW/m2
	push in display menu	Return to the normal operation indication
push in data logger menu		Set or delete dataLog and/or cyclical flag
	push in data logger menu	Return to the normal operation indication

Built-in loudspeaker

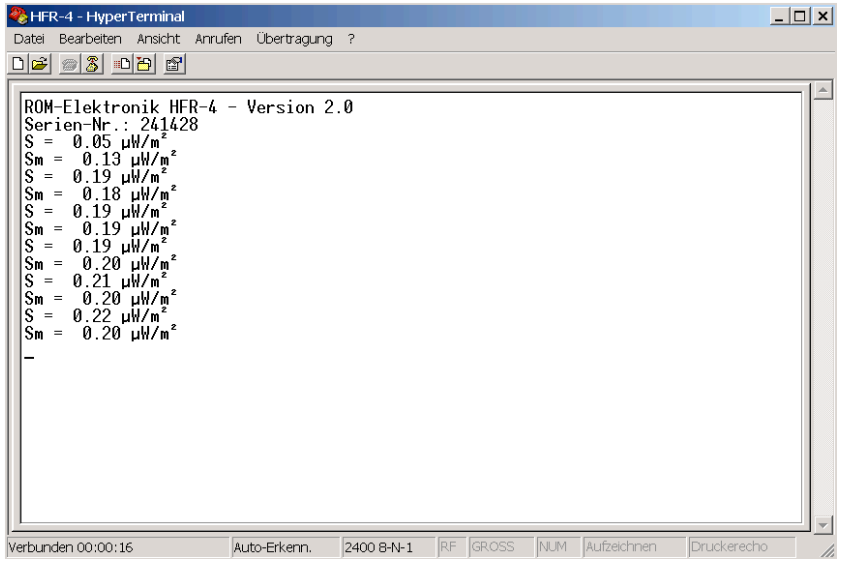
A volume control is located on the front panel of the HFR-4. The volume of the built-in loudspeaker can be adjusted here and/or optionally using plugged-in headphones.

The loudspeaker reproduces the modulation signals which are received over the antenna. Do not be surprised when you hear the signals for the first time. Here you get an impression that signals are in the "ether" that you do not notice because none of your senses is able to register these.

A signal which is simple to identify is that of a DECT cordless telephone. The base station constantly sends a 100 Hz tone whether telephoning or not! As soon as the power plug is pulled on the base station, the hum tone disappears.

Mobile telephones (cells), which communicate according to the GSM standard, send a 217 Hz signal. However, this is sent only during telephon-

After a click on OK, the first data can be sent to the PC.



Datenausgabe des HFR-4

If everything has proceeded successfully, data should now appear continuously on the screen in similar form as represented above. If a filter is selected, this is output behind the measured value.

Setting adjustment of the correct baud rate

If, contrary to expectation, only unreadable "hieroglyphs" should appear on the PC, this can be attributed to a slightly deviating baud rate of PC and HFR-4.
In this case, the HFR-4 can be re-calibrated. For this, the left-hand and right-hand pushbuttons are to be pressed SIMULTANEOUSLY with switching on. A signal appears on the display as follows:

```
OscCal: 7E
EEPROM: 126
```

after a pause followed by

```
Kalibrier-
wert:  63H
```

left-hand pushbutton (LT). The arrow to the left near the unit identifies the selection. The selection is confirmed with the right-hand pushbutton (RT) and the display changes into the display mode:

```
 65.4 µW/m²
```

Configuration of the data logger

The HFR-4 is able to transmit measured values to a data logger connected to the serial interface (e.g.: Uni MMC Data Logger I or our data logger that is just being developed). The configuration of the device for operation with a data logger is as follows:

```
 65.4 mV/m
```

In normal operation indication, hold the left-hand pushbutton (LT) pressed and press the right-hand pushbutton (RT), then the following display appears.

```
→Anzeige
 DatenLogger
```

Then selecting the data logger entry with the left-hand pushbutton (LT).

```
 Anzeige
→DatenLogger
```

With every press on the left-hand pushbutton (LT), the data logger (Data Log.) is activated or deactivated. Whether the data logger is activated or not, this can be identified on the "<" character at the end of the word.

```
→DatenLog.<
```

When "Data Log." is activated, all measured values with 4800 baud are transferred to a connected data logger over the serial interface.

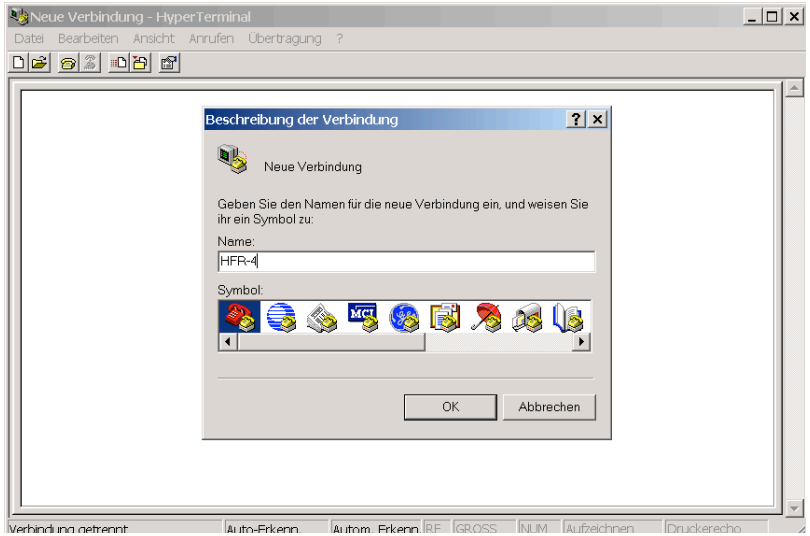
If "cyclical" is activated, the filters are additionally cyclically changed according to 5 measured values in each case.

The selected adjustments remain until the switch-off of the device and are

Serial RS232 data output (PC connection, alternative method)

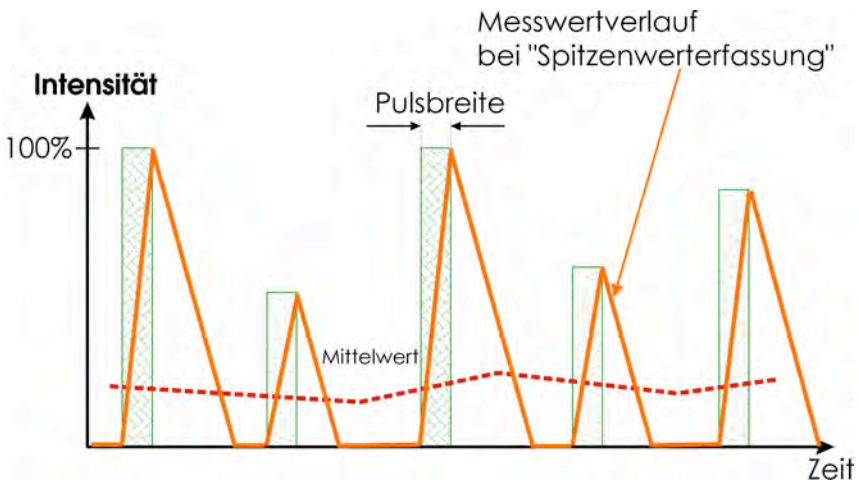
Below is described the procedure in example form for a Windows PC. A similar procedure is possibly necessary for other computers. Where appropriate, inquire with your computer dealer or specialist.

Start the software "Hyper Terminal" on the PC (can be found in /Program/Communication/Hyperterminal). After the start, the configuration is to be carried out.



Anlegen einer neuen Verbindung

The interface must be set adjusted to 2400 baud 8N1!



Difference between average value and peak value recording

ton (LT) until the symbol for peak-hold apears.

With activated peak-hold, the value reading changes wehenever the measured value is greater then stored value. The bargraph shows allways the actual value (follows the actual reading).

RF Basics

In case of high frequencies, electrical fields (E-fields) and magnetic fields (H-fields) no longer exist independently of each other. They are both in a fixed relationship and carry energy together. The radiant flux density S results from the energy that flows through a certain section area (m^2) per unit of time (sec).

S, E and H can be converted at any time[1]:

$$S = E \cdot H = \frac{E^2}{377\Omega} = H^2 \cdot 377\Omega \qquad \text{(GL 1)}$$

and

1.Only valid in free space

("MAX!" display in the HFR-4), screening measures are certainly to be recommended. Possibly a precise measurement through a specialist should also be recommended here, in order to obtain clarity about the actual loading (strength, frequency, modulation, etc.).

We provide different screening materials. If required, inquire with us!

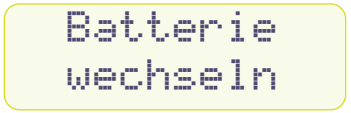
Limit value in W/m²	Limit value in W/cm²	Limit value in mV/m	Recommended in case of
0,1-5 µW/m²	0,001-0,5 nW/cm²	5-50 mV/m	Weak anomaly according to SBM 2003 for pulsed radiation
>10 µW/m²	>1 nW/cm²	>50 mV/m	Weak anomaly according to SBM 2003 for unpulsed radiation
1 mW/m²	0,1 µW/cm²	614 mV/m	EEG changes (pused, v. Klitzing)
>100 mW/m²	>10 µW/cm²	6140 mV/m	ECOLOG
2-10 W/m²	0,2-1 mW/cm²	27500-61000 mV/m	BImSchV (according to frequency)
2-10 W/m²	0,2-1 mW/cm²	27500-61000 mV/m	Population (according to frequency)

Table 5: Provision and limit values (selection)

Maintenance of the device and battery changes

Please use only a slightly moistened cloth for cleaning the device. Never treat the housing and the display with aggressive cleaning agents!

A necessary battery change is signaled through

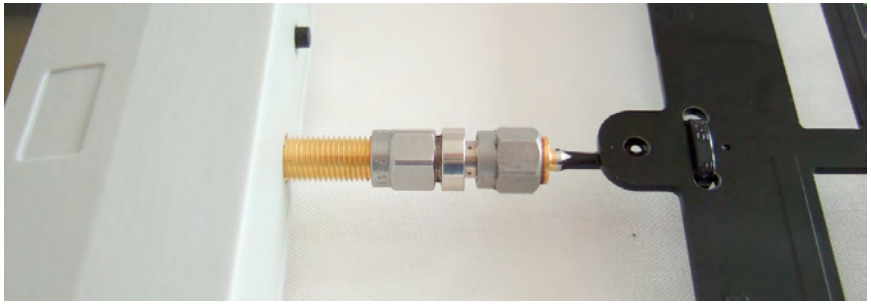


Then switch off the device and take off the battery compartment cover on the reverse side and take out the used battery. Insert a standard 9 volt battery (9 volt block) as a new battery and close the battery compartment cover. The device is now ready for operation again.

Employ the HFR-4 measuring device only for those measurements described in this direction. Contraventions can result in destruction of the measuring device and loss of guarantee.

Technical appendix

Standard headphones (mono or stereo) can be connected to the headphone output. In this way, improved acoustic identification of the modulati-



Assembled attenuator

	Attenuation factor for field strength (mV/m)	Attenuation factor for power (µW/m²)
6 dB	2	4
10 dB	3	10
20 dB	10	100

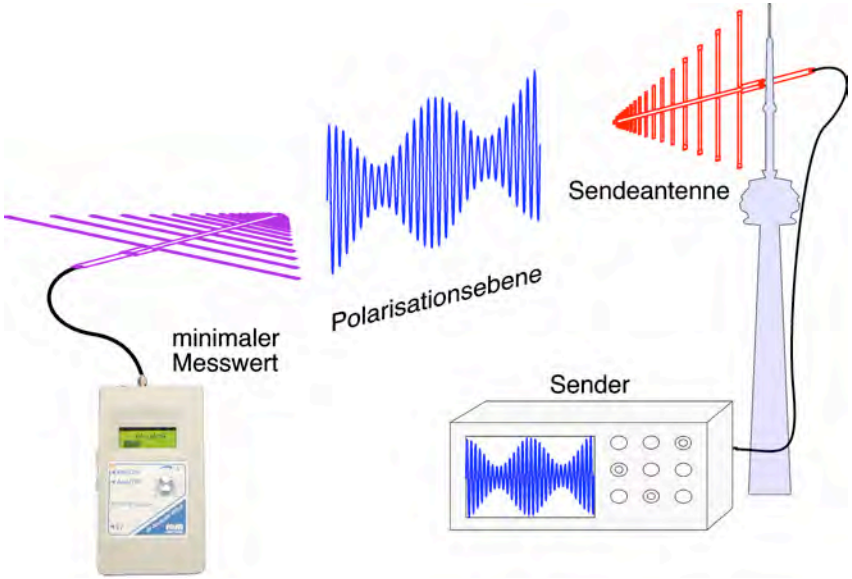
Table 2: Attenuation factors for available attenuators

The most frequently required attenuators are those with 10 dB and 20 dB. If e.g. you wish to extend the measuring range from the present 10 mW/m² to 1000 mW/m² (approx. 20V/m), you require the 20 dB attenuator (Factor 100).

Attenuator

If you wish 10,000 mW/m² (approx. 61V/m), then you must additionally employ the 10 dB attenuator (Factor 100 + Factor 10 = Factor 1000 = 30 dB).

Included in the scope of delivery of the HFR-4 is a logarithmic- periodic antenna (logper antenna) for the frequency range 900 MHz to 2.6 GHz, for financial reasons in the form of a printed circuit board! With this, the direction and polarization of the RF radiation can basically be exactly determined.

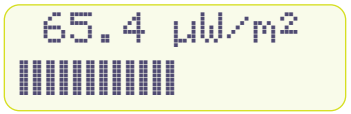


Minimum measured value if transmitting and receiving antenna point in same direction but have different planes of polarization.

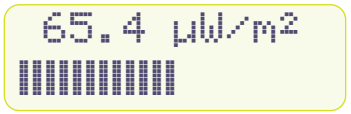
The analog bar additionally displays the average value and peak value simultaneously. Thus a simple appraisal of the pulsed signal content with respect to non-pulsed content is possible.

This is appropriate since, in the building-biology, different recommendations exist for pulsed and non-pulsed signals.

A non-pulsed signal with 65.4 µW/m² is indicated in the following example



A non-pulsed signal with 65.4 µW/m² is indicated in the following example·



Here, a non-pulsed signal with a small pulsed content and a peak value of

In order to be able to determine the radiant flux density exactly with Equations (3) and (5), you must measure not only the received power, but you must also determine the frequency. For this, spectrum analyzers are generally used, which are very expensive because of their complicated structure.

If it is a question of the effect of electromagnetic waves on persons, however, the radiant flux density generally does not have to be determined exactly. Here it is of primary importance to know the order of magnitude of the radiant flux density, in order to make a judgment of the potential danger. The RF analyzer HFR-4 has been developed for this purpose. It consists of a very sensitive RF power measuring device (detector). Since the detector cannot determine the frequency of the radio frequency radiation, no high-precision measurements are possible with it for the above explained reasons.

Uncertainties of measurement

From the above-mentioned facts, it can be identifiable that, with the measurement of the radio frequency, uncertainties of measurement (measuring errors) must be expected.

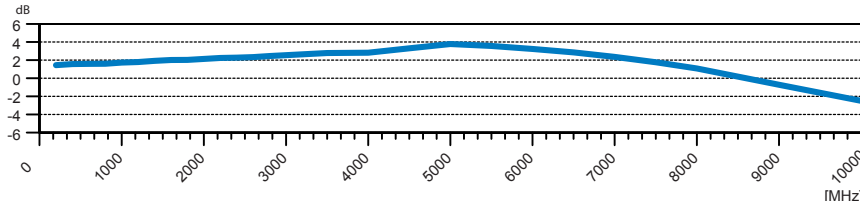
Which order of magnitude of the measuring errors must be dealt with? If we look at the best RF measuring devices which can be bought, they mostly have an uncertainty of measurement of ±3 dB. In the measuring of output, 3 dB means a factor of 2! For the measured value, this means that the true value or can be twice as large or only half the indicated value. Expressed in percent, we therefore have an uncertainty of measurement of ±50% with a very good measuring device!

In case of more economical devices, these measuring errors are often far greater. However, what is the situation with the HFR-4? We must consider the inadequacies of the antenna and the measuring device. This is because the combination of the two of them should supply the "correct" measured value.

A high level of linearity is necessary for the measuring device (in order to keep the measuring error low). High-frequency amplifiers generally have a more or less linear frequency response. Without special measures, this unsuitable characteristic can affect the overall linearity.

Only by means of large-scale development efforts and with close cooperation and support through the University of the German Armed Forces, Munich, could a suitable radio frequency circuit finally be developed, which does not indicate the disadvantages mentioned. The results of these efforts are represented in the following graphics.

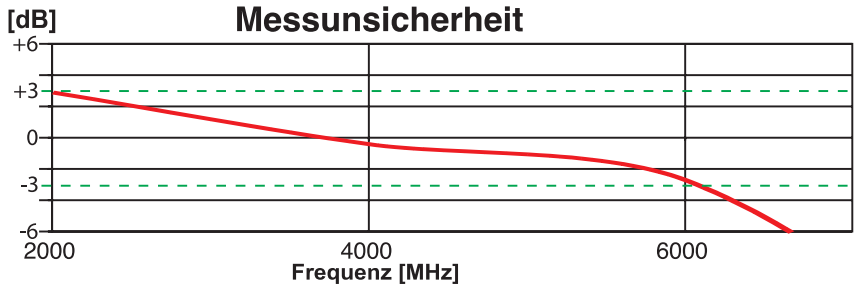
In order to achieve a corresponding sensitivity, antennas are required which supply a sufficient outlet voltage in a large frequency range. Logarithmic-periodic antennas are very well suited for this. Therefore 2 of these



Linearity characteristic of the input amplifier circuit of the HFR-4

antennas are also included in the scope of delivery of the HFR-4.

However, these have the disadvantage that their outlet voltage decreases with the square of the frequency. In case of measurement with a spectrum analyzer, the fault arising from that can be calculated from the result of measurement, since the frequencies of the measured signals are known. In case of a broadband measuring device, such as the HFR-4, on the other hand, the fault must be taken into consideration. The following graphics indicate the error curve.



Uncertanty of „System HFR-4“ (HFR-4 and antenna)

It is good to recognise that in the frequency range from ca. 2000 MHz to ca. 6000 MHz, the uncertanty is between formerly said ±3dB.

Polarisation

If we consider the electrical field component of an electromagnetic wave, it is determined that this is in one plane. This plane is also designated as a plane of polarization. The maximum measured value is provided in the case where the receiving antenna points in the same direction and plane as the transmitting antenna.

Measured value representation

In the display, the digital measured value is represented as a numerical va-