ROM-Elektronik GmbH

RF-Analyzer HFA-3

Manual

rom elektronik

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).

Reference: In case of the mobile communications frequency ranges GSM900, GSM1800 and 3G (UMTS) of our HFA-3, ONLY the so-called Downlink is measured; therefore the frequencies of the base stations! A mobile communications telephone can be measured in the operating mode "All-pass", since the frequency range (GSM900, GSM1800 or 3G (UMTS)) is generally known in this case.

The operation of the HFA-3 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 HFA-3.

The HFA-3 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. 1 GHz (1000 MHz, GSM900 area) 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).

Technische Daten

Frequency range:	**ca. 100 MHz bis 2500 MHz (Approx. 10 MHz to 3000 MHz with decreased precision)**
Measuring range:	**6 mV/m to 2000 mV/m (= ca. 0,1- 10000 µW/m² = 10 pW/cm² - 1 µW/cm²)**
Max. sensitivity:	**Better than 0,01 µW/m² (= 1 pW/cm²)**
Filter frequency ranges:	**All-pass network, broadband (100 MHz to approx. 3 GHz)**
	GSM 900 (935 MHz to 960 MHz)
	GSM 1800 (1805 MHz to 1880 MHz)
	Cordless telephones according to DECT standard (1880 MHz to 1890 MHz)
	3G (UMTS) (2110 MHz to 2170 MHz)
	WLAN, Bluetooth, microwave oven (2400 MHz to 2500 MHz)
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. 20 mA**
Scope of delivery:	**HFA-3, Logper-Antenna 900MHz - 2600 MHz, Battery**

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 HFA-3! Never allow the antennae of the HFA-3 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.

The measurements of the long-term recording are always stored on the hard disk TO AVOID DATA LOSS!

~H0000.TMP: Header file

~A0000.TMP: Measurement file

In the case of a program crash, a valid file HFA-3 can be generated from these files, where the following occur

- The program is newly started,
- The recording is set adjusted
- in the menu: Recording\Save is selected with specification of a name. This file can be again normally loaded with Recording\Open and displayed as color graphics!

Preliminary notes - Notes on safety

You have acquired an electronic measuring device. Handle your HFA-3 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 HFA-3 could be destroyed with contact of the antenna with current! Also the electric shocking of the user cannot be entirely excluded!

The HFA-3 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 HFA-3 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 HFA-3 signals a used battery in the display with the message "Change battery". Rechargeable batteries can also be employed.

The HFA-3 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 the supplied logper antenna onto the HFA-3 where appropriate, tighten with a tool.

Installation of the antenna with tuning assistance

ROM-Elektronik GmbH

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.

Setting adjustment of the correct baud rate

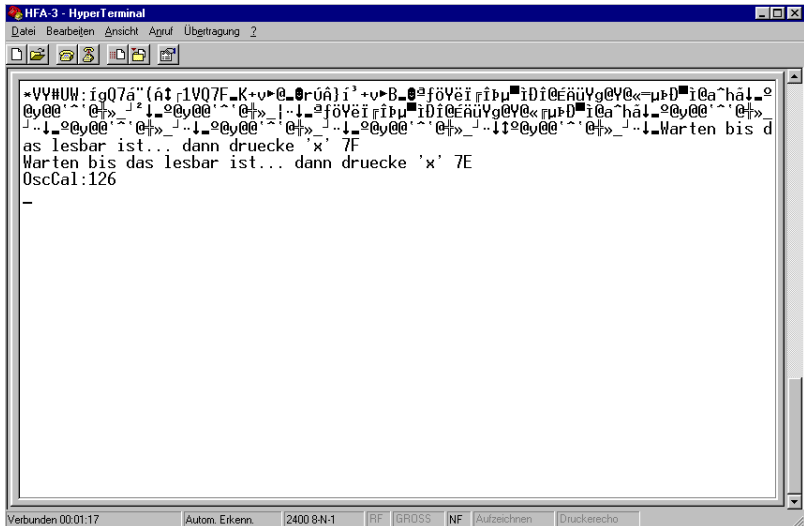
If, contrary to expectation, only unreadable "hieroglyphs" should appear on the PC, this can be attributed to a slightly deviating baud rate of PC and HFA-3.
In this case, the HFA-3 can be re-calibrated. For this, the left-hand and right-hand pushbuttons are to be pressed SIMULTANEOUSLY with switching on. A signal appears on the display as follows:

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

after a pause followed by

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

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

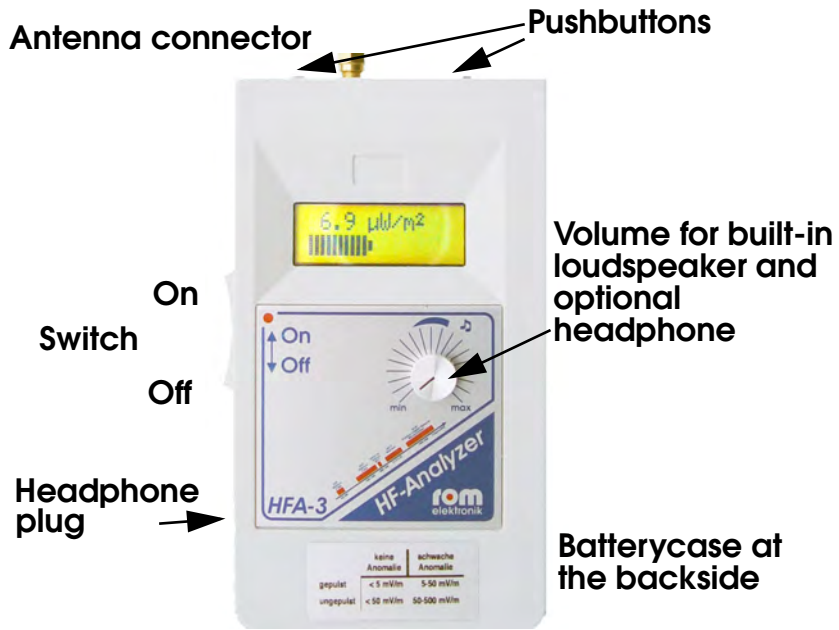


Screen for baud rate calibration

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.

Switch on the HFA-3 with the slide switch located on the side.



Operator elements of the HFA-3

The following message should appear shortly on the display:

```
ROM-Elektr.
HFA-3 V2.0
```

then e.g.

```
65.4 mV/m
```

With this, your HFA-3 is in operation.

Built-in loudspeaker

A volume control is located on the front panel of the HFA-3. 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 telephoning. 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.

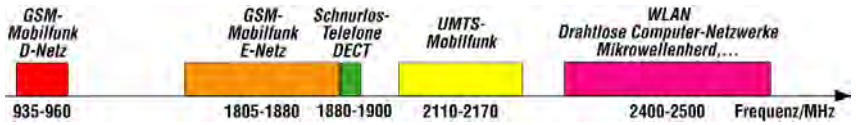
There are innumerable other, in-part "exotic" signals, which cannot all be counted here. With time, you will gain your own experience.

Functions

The HFA-3 has a built-in filter bank in order to carry out the measurement for individual frequency ranges only. The filters are set adjusted to fixed frequencies. In the measurable frequency range, the 3 bands of the mobile communications are offered (GSM900, GSM1800, 3G (UMTS)), cordless telephones (DECT) and the services employed for computer networking, such as WLAN and Bluetooth.

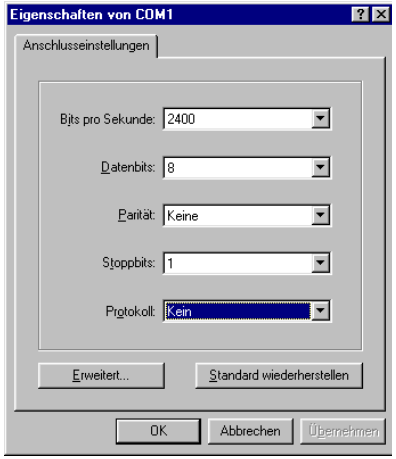
Frequency designation	Frequenzbereich
All-pass network (no filter)	10 MHz to approx. 2500 MHz
GSM900	935 MHz to 960 MHz
GSM1800	1805 MHz to 1880 MHz
DECT (Digital Enhanced Cordless Telephone)	1880 MHz to 1890 MHz
3G (UMTS)	2110 MHz to 2170 MHz
WLAN, Bluetooth, Mikrowellenherde	2400 MHz to 2500 MHz

Designation and frequency range of the frequency filter of the HFA-3



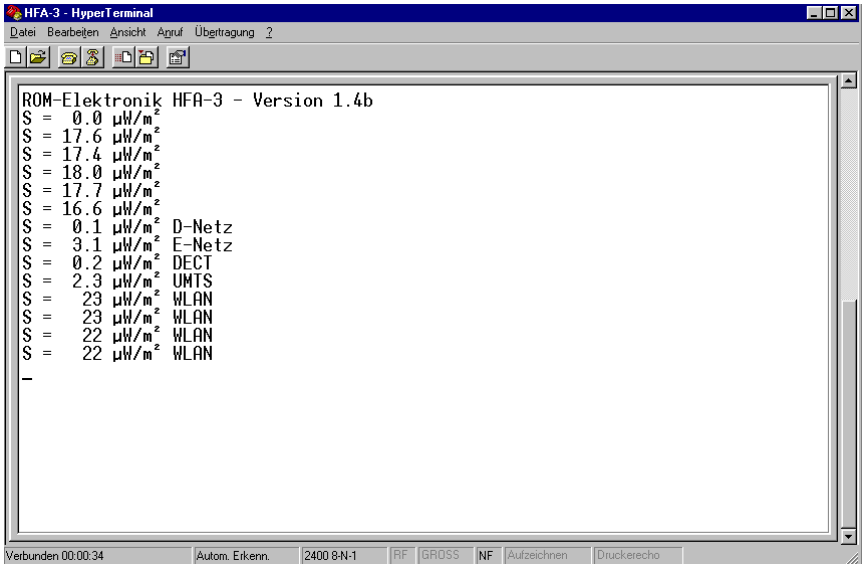
Situation of the frequency filters on the HFA-3

The pushbuttons located on the front side are employed to alternate bet-



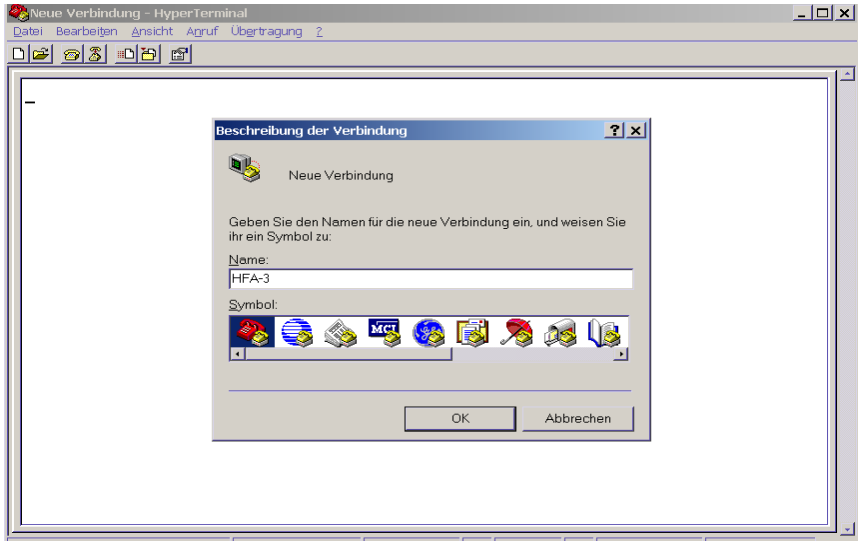
Select 2400 baud, 8 databits, 1 stopbit, no parity

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



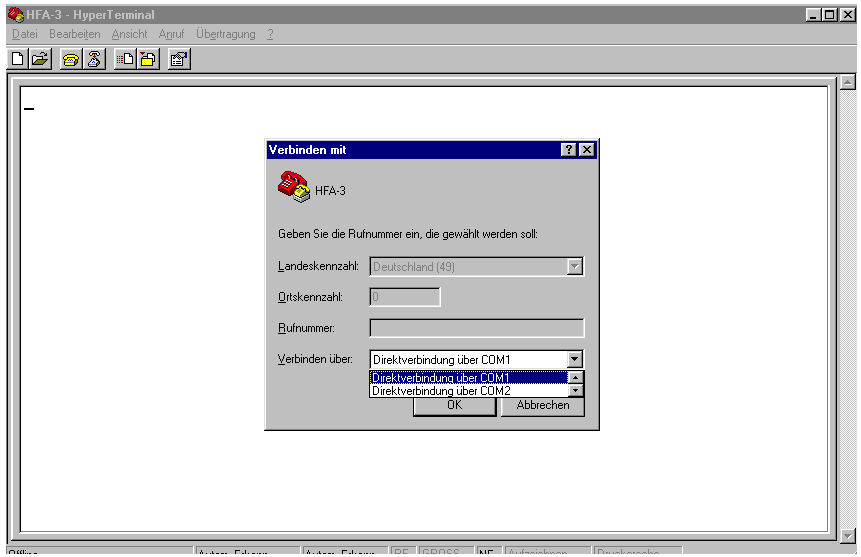
Data output of the HFA-3

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.



Attach a new connection

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



Select a free serial interface

ween the different functions of the HFA-3.

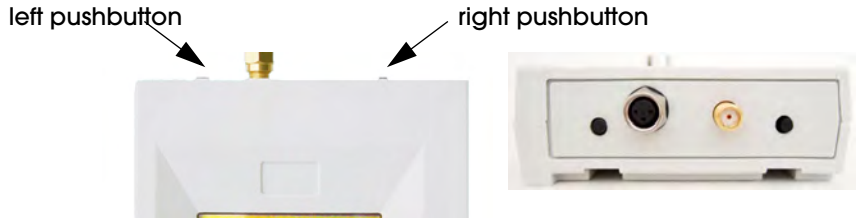
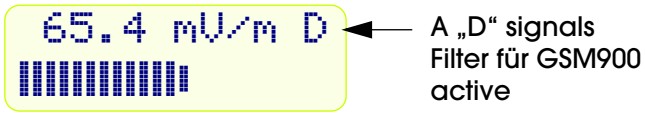


Table of the function on activating the pushbuttons

left pushbutton	right pushbutton	Function
push		**Peak value storage (PeakHold) On/Off switching**
	push	**RF filter stored cyclically at every actuation**
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**

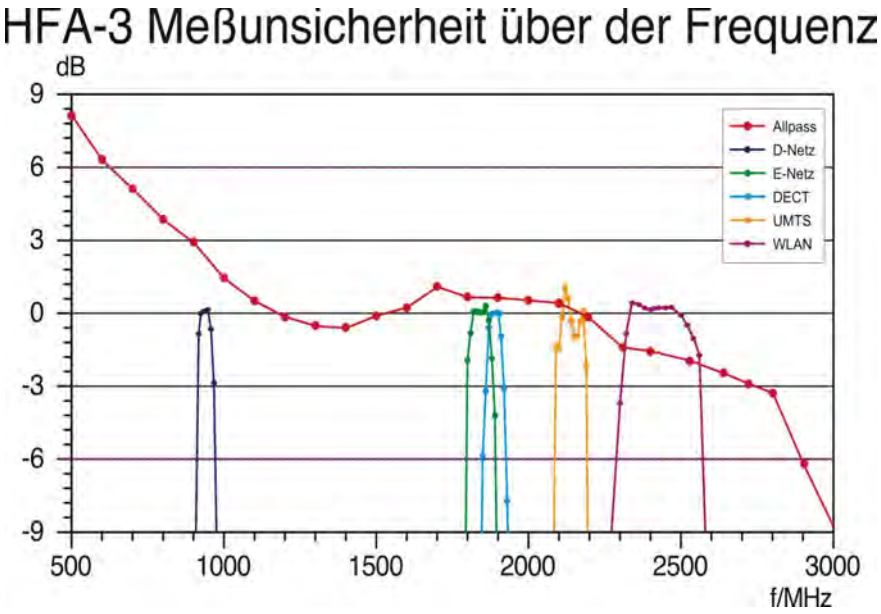
Frequency filters

The individual frequency ranges are selected with the right-hand pushbutton (RT). Simply activate the pushbutton until the required symbol for the frequency range is indicated in the display.



Symbol In the display	Meaning
D	Filter for GSM900 (935 MHz to 960 MHz) active
E	Filter for GSM1800 (1805 MHz to 1880 MHz) active
d	Filter for DECT (1880 MHz to 1890 MHz) active
U	Filter for 3G (UMTS, 2110 MHz to 2170 MHz) active
W	Filter for WLAN (2400 MHz to 2500 MHz) active

Table 1: **Meaning of the symbols in the display**



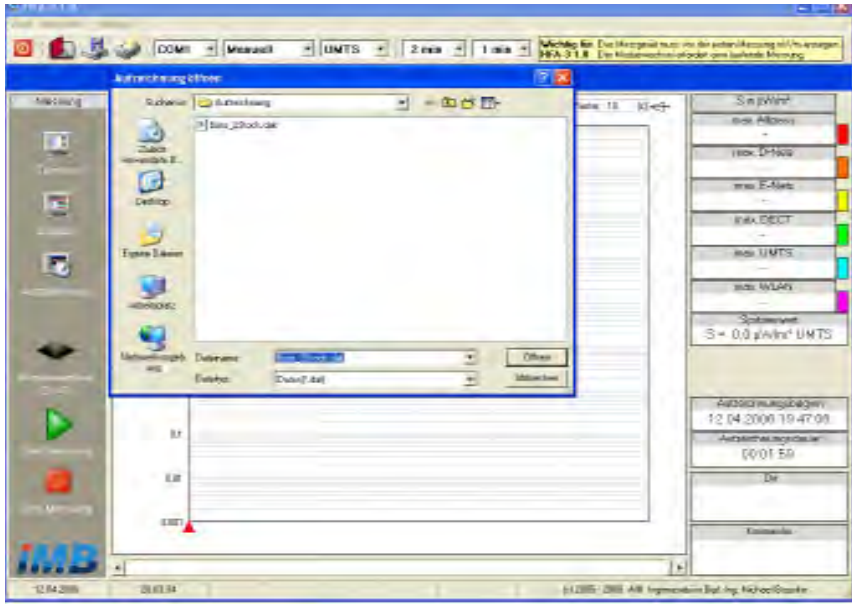
Typical frequency response of the HFA-3

Selection of the measurement unit

The HFA-3 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.

- The program is restarted,
- The recording is set adjusted
- in the menu: Recording\Save is selected with specification of a name. This file can be normally loaded again with Recording\Open and displayed as color graphics!



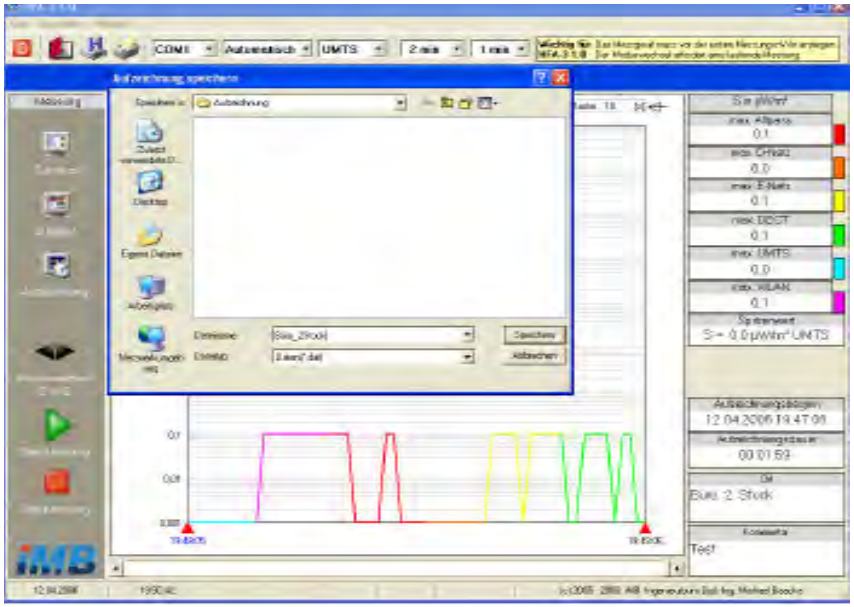
Display of recording, open recording

In order to save the data on a PC (long-term recording), the HFA-3 is to be connected with a free serial interface using the cable supplied (if option has been ordered). If your PC does not have any serial interface, the connection can also be realized with a USB serial converter.

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.



Display of recording, Save recording

All specifications from the recording display are stored in an ASCII file (mode, maximum values, recording beginning, recording duration, location and comment).

The measurement curve is saved with time, measured value, filter and color code.

Thus it is possible to load an already implemented recording into the HFA3 1.0 again at a later time for viewing.

This comes about by clicking the icon Open (or in the menu) and by selection of a file name in the opening dialog window. The file is searched for first in the Directory\Recording as a default.

The measurements are always saved on the hard disk IN ORDER TO AVOID DATA LOSS!

~H0000.TMP: Header file

~A0000.TMP: Measurement file

In the case of a program crash, a valid file HFA-3 can be generated from these files where

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

```
    mV/m
→   µW/m²
```

In the same way, you can skip back and forth between the units with the 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 HFA-3 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
```

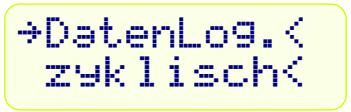
Then selecting the data logger entry with the left-hand pushbutton (LT).

```
 Anzeige
→DatenLogger
```

Through pressing the right-hand pushbutton (RT), change into the data logger menu.

```
→DatenLog.
 zyklisch
```

With every press on the left-hand pushbutton (LT), the arrow changes between both options and the data logger (Data Log.) and the filter rotation (cyclical) is activated or deactivated. Whether the data logger and/or the filter rotation is activated can be identified on the "<" character at the end of the word.



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 deactivated automatically on restart.

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

PeakHold

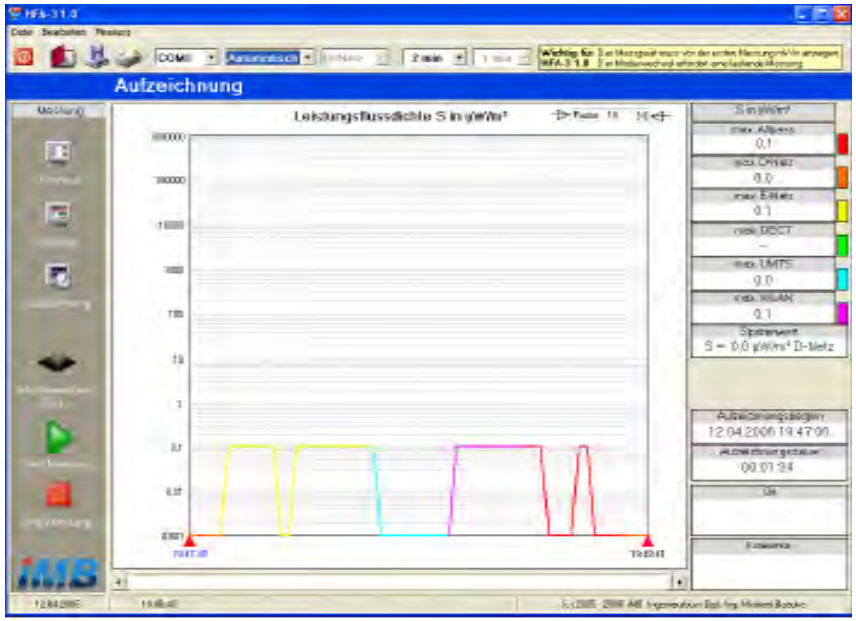
The HFR-4 has a peak-hold funcion. This funcion enables to „freeze" the measured value on the display. Therefore, it is necessary to push the left button (LT) until the symbol for peak-hold appears.

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)

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.



Display indication: Power flux density S, Mode: automatic

With a click on the Save command button (or in the menu) a recording can be saved.

A dialog window is opened in this case, in which the file name for the recording and a memory location (path) for this file are entered. Standard memory location is the Directory\Recording which is attached during the installation.

The filter areas are color coded in the measurement curve (frequencies: e.g. GSM900). The color codes are indicated near the text fields of the maximum values.

The color codes (as in display indication) are as follows:

red	Allpass
orange	GSM900
yellow	GSM1800
green	DECT
blue	3G (3G (UMTS))
magenta	WLAN

Below the text fields for the maximum values of the recording is the text field in which the current measured value is indicated with regard to amount and units.

Further displayed are the recording beginning (date, time) and the recording duration. These text fields are filled automatically on start of the measurement.

Two information text fields are available for the optional storing of the recording:

Location: Specifications of the point of measurement as a text field (text length is limited!)

Comment: Memos for the measurement are entered here

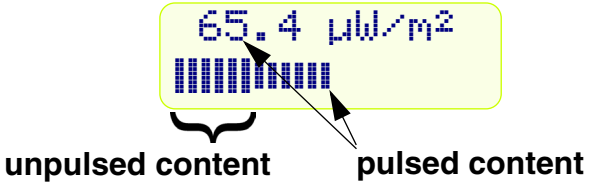
The peak values of the recording for the individual filter adjustment are displayed in the text fields and in the diagram (frequency ranges: e.g. GSM900), either for the field strength or the power flux density.

By clicking on the icon Mode Change, you can alternate between these operating modes. With every change of mode, the displays and the diagram are deleted and a new recording begun.

Especially helpful at this point is the automatic setting adjustment in the mode display list. All filters (frequency bands) are then processed at intervals of 8 seconds, one after each other. The measurement curve is further traced according to the just processed filter (frequency range) in the assigned color.

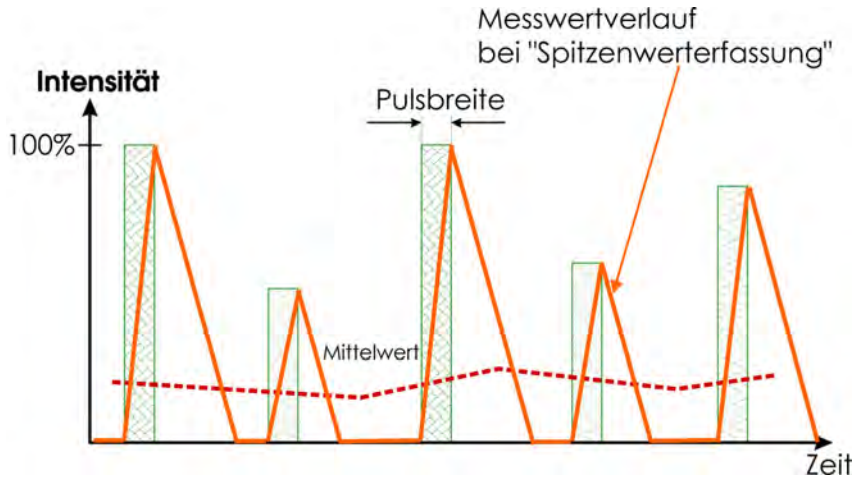
Reference: This adjustment functions only in case of on-going measurement and always begins with the all-pass network filter (independent of what was set adjusted prior to the start of the measurement.

The HFA-3 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.



Difference between average value and peak value recording

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

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

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 HFA-3 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:

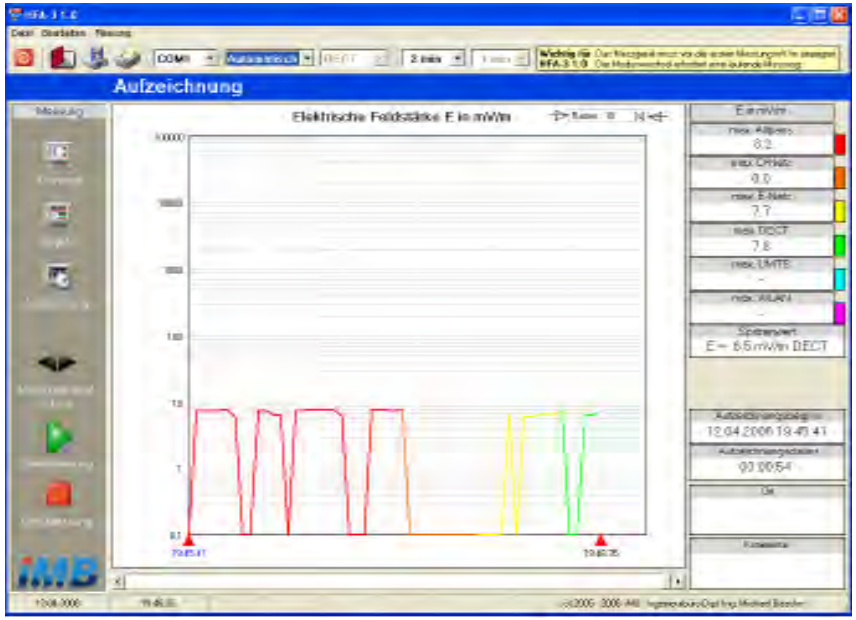
$$P_E = S \cdot A_W \qquad \text{(GL 3)}$$

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

1.Only valid in free space

Recording

This display is used to enable the observation and saving of the time-related progress or the fluctuations of the field strength and/or the power flux density during a measurement.



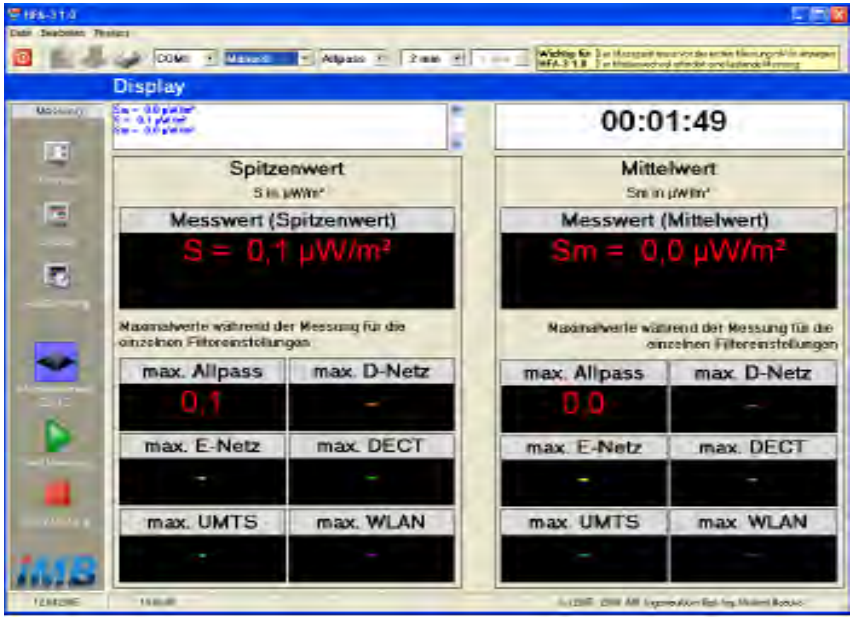
Display indication: Power flux density S, Mode: manual

The peak values of a measurement are recorded exclusively. The representation of the measured values is implemented in a logarithmic diagram over time, after the measurement has been started. When the set-adjusted recording width (see chapter on display list) is reached during the recording, then the measurement curve scrolls automatically further. The corresponding time markers are fixed at the left-hand and right-hand edge of the graphics. The time difference between these time markers then corresponds exactly to the recording width.

The recording ends when the set adjusted value of the recording duration is reached (see chapter on display list).

The maximum values during a recording are indicated in separate text fields, which are located at the right-hand edge of the display window.

and begins always with the all-pass network filter (independent of what was adjusted prior to the start of the measurement).



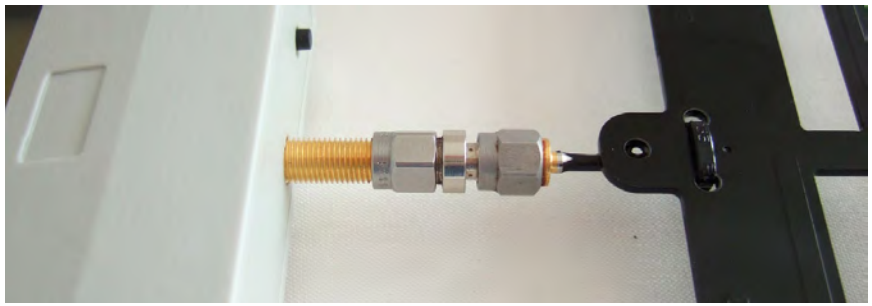
Display indication: Power flux density S, Mode: manual

The measuring range of the HFA-3 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.

	Attenuation factor for field strength (mV/m)	Attenuation factor for power (µW/m^2)
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/m^2 to 1000 mW/m^2 (approx. 20V/m), you require the 20 dB attenuator (Factor 100).



Assembled attenuator

If you wish 10,000 mW/m^2 (approx. 61V/m), then you must additionally employ the 10 dB attenuator (Factor 100 + Factor 10 = Factor 1000 = 30 dB)..

Attenuator

Table 3: Conversion of the radiant flux density V/m and A/m

	S in mW/m²	S in µW/cm²	E in V/m	H in A/m	H in mA/m
	200	20	8,68	0,023	23,03
	100	10	6,14	0,016	16,29
	50	5	4,34	0,012	11,52
	20	2	2,75	0,007	7,28
	S in µW/m²	S in nW/cm²	E in mV/m	H in mA/m	H in mA/m
Measuring range of the HFA-3	10000	1000	1940	0,005	5,15
	5000	500	1370	0,004	3,64
	2000	200	870	0,002	2,30
	1000	100	614	1,629	1628,70
	500	50	434	1,152	1151,60
	200	20	274	0,728	728,36
	100	10	194	0,515	515,03
	50	5	137	0,364	364,18
	20	2	86,8	0,230	230,33
	10	1	61,4	0,163	162,87
	5	0,5	43,4	0,115	115,16
	2	0,2	27,5	0,073	72,84
	1	0,1	19,4	0,052	51,50
	0,5	0,05	13,7	0,036	36,42
	0,2	0,02	8,6	0,023	23,03
	0,1	0,01	6,1	0,016	16,29

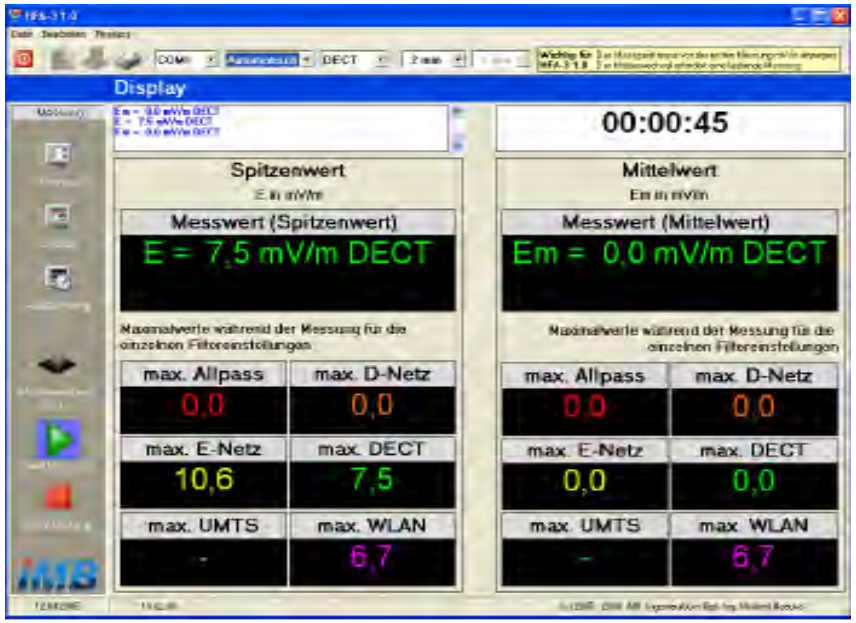
Included in the scope of delivery of the HFA-3 is a logarithmic- periodic antenna (logper antenna) for the frequency range 900 MHz to 2.6 GHz, for financial reasons in the form of a printed circuit board! With this, the direction and polarization of the RF radiation can basically be exactly determi-
ned.

ring the measurement in the individual filter areas (e.g. GSM900) either for the field strength or the power flux density (click the icon Mode Change).

The displays are color coded:

Readings:	green	Fieldstrength E in V/m
	red	Radiant flux density S in µW/m²
Maxima:	red	Allpass
	orange	GSM900
	yellow	GSM1800
	green	DECT
	blue	3G (3G (UMTS))
	magenta	WLAN

.



Anzeige Display, Feldstärke E, Modus: automatisch

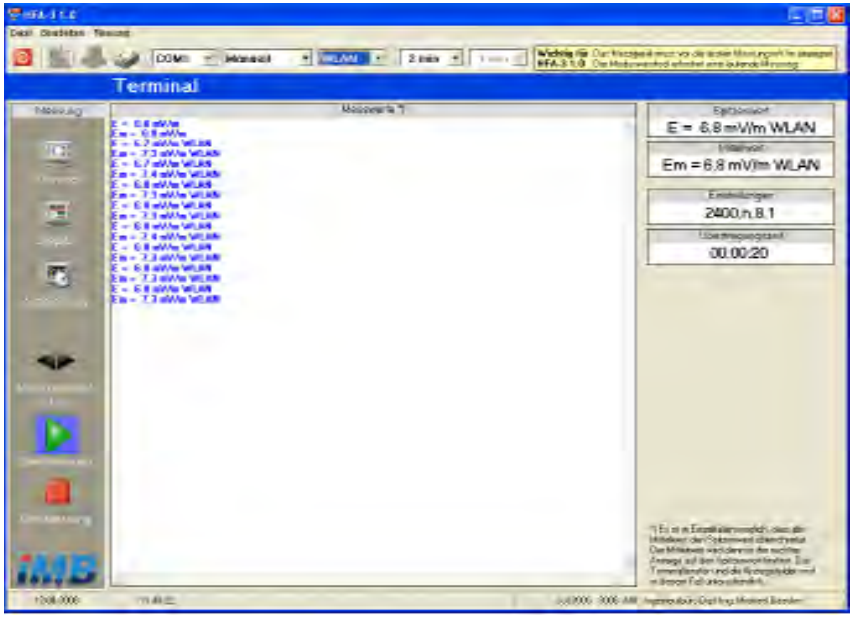
It is particularly helpful at this point to automatically set adjust the mode in the display list. All filters (frequency bands) are then processed at intervals of 8 seconds, one after each other.

Reference: This adjustment functions only in case of on-going measurement

In addition, the transmission rate of the RF sensor on the PC is indicated in the field Settings, as well as the transmission time that is written during the measurement.

Reference 1: The mode change from field strength to power flux density, as well as the setting adjustment of the filter (frequency range; e.g. GSM900), has effect only if the measurement is already running.

Reference 2: It is possible in individual cases that the display of the average value exceeds the display of the peak value. The average value is then limited to the peak value in the text field Average Value. That is not the case In the field Measured Values, because the values are indicated here as they arrive.



Terminal display

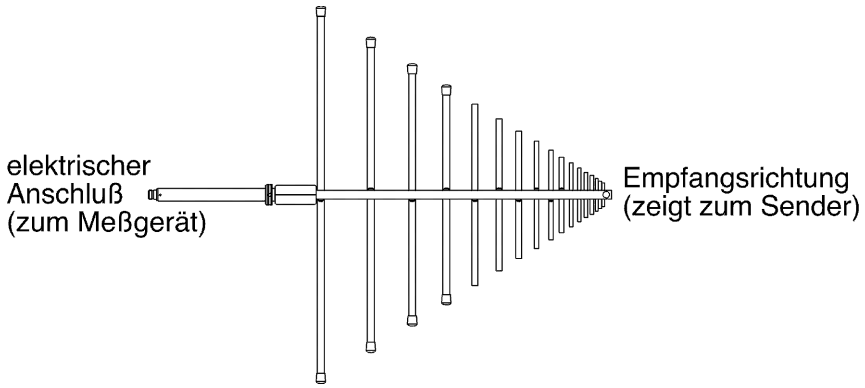
Display

With this display, the measured values from the RF sensor are displayed in large text fields, which can still be read at some distance from the PC.

A small terminal field is available in the left upper edge, which records the successful run of a measurement as a status window.

The transmission time is displayed near this.

In the text fields are displayed all measured values and their maximums du-



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 HFA-3 the electrical field strength E can be measured in mV/m and the radiant flux density S in $\mu W/m^2$ 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

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 HFA-3 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.

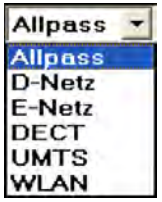
Which order of magnitude of the measuring errors must be dealt with? If we look at the best RF measuring devices which can be bought, they mostly have an uncertainty of measurement of ±3 dB. In the measuring of output, 3 dB means a factor of 2! For the measured value, this means that the true value or 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 HFA-3? 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, antennae are required which supply a sufficient outlet voltage in a large frequency range. Logarithmic-periodic antennae are very well suited for this. Therefore this an-



The filter (frequencies) in the selection list can be adjusted manually or automatically. The maximum values for every filter range are evaluated and can be stored during the stored long-term measurement.

Selection list: Filter

In this selection list are listed the available recording duration for the long-term recording. When the adjusted time has expired, the measurement is ended automatically

Selection list: Recording duration

In this selection list are listed the two possible recording widths. The recording width is the time, which is represented as maximal during the long-term recording. If the recording duration exceeds the recording width, the graphics are scrolled automatically. The recording width is stored with that i.e. if a measurement is loaded again, only so much of the measurement curve is represented that fits into the recording width. The remaining part of the measurement curve is made visible by shift of the horizontal scroll bar ("scrolled").

Selection list: Recording width

Terminal

With this display, the outputs peak value and average value are displayed both with regard to amount and with the respective dimension. The values are displayed as they come over the interface ("endless loop" in the measuring device). A clock cycle is not available.

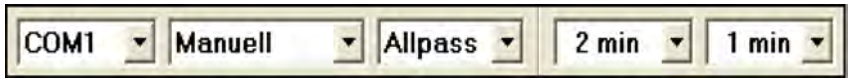
As soon as the measurement is started (click on the icon Start Measurement, or out of the menu) the read-out values are represented in the text field Measured Values under each other, where the peak value and average value alternate.

The last measured values in each case are represented for diagnostic purposes in the separate text fields Peak Value and Average Value in a larger font.

Alternatively, a measurement can be ended by clicking this icon.

The change of mode is possible only by clicking the icon

Selection list.



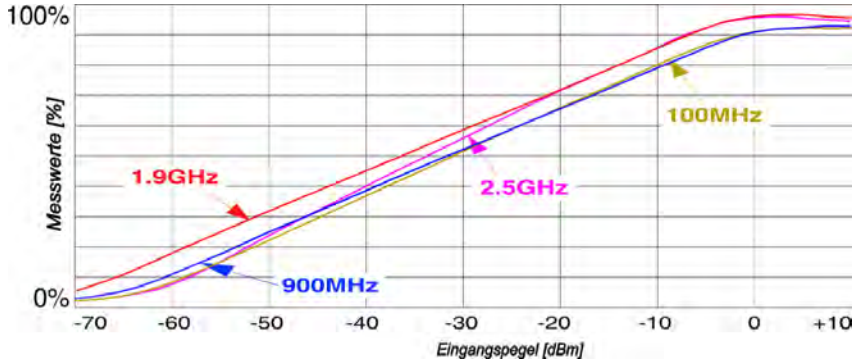
Auswahlliste

In case of most computers, the serial interface is connected with COM1. If the HFA-3 does not function with COM1, another port should be selected from the list of available COM ports. The program determines all connections available on your system. It is also possible to connect the HFA-3 to the computer by means of a USB-serial converter. USB ports are also displayed in the selection list as COM.

Selection list: COM port

The presetting is manual, i.e. during a measurement, the filter must be adjusted manually. With automatic adjustment, the filters are incremented every 8 seconds. In this way, the measurement is evaluated with only one click in all filter areas and the maximum values determined. In case of the long-term recording, the characteristic plot the maximum value is additionally recorded as a function of the filter areas. The filter areas are encoded in color.

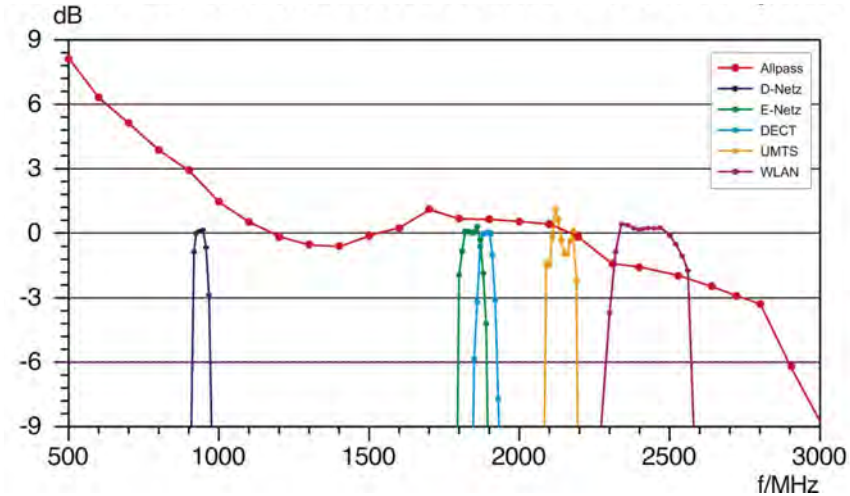
Selection list: Mode



Linearity characteristic of the input amplifier circuit of the HFA-3

tenna is also included in the scope of delivery of the HFA-3.

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 HFA-3, on the other hand, the fault must be taken into consideration. The following graphics indicate the error curve.



Uncertanty of HFA-3

A good feature can be identified, in that the uncertainty of measurement is within the mentioned ±3dB in the frequency range from approx. 900 MHz to approx. 2500 MHz. This means that GSM900 and cordless telephone CT1+

are registered correctly. When we consider the frequency range 600 MHz to 2600 MHz, the uncertainty of measurement is still within ±6dB. In practice this means that, in all-pass operation (= broadband), 3G (UMTS) and WLAN signals can be somewhat undervalued, therefore a measured value is displayed which is too small.

We can counter this situation through the use of the built-in filters! The HFR-3 has frequency-specific calibration factors for every filter. Through this, it is possible to consider an individual calibration factor in operation with selected filter, which influences the entire frequency response.

In other words: As is clear from the above graphics, the sensitivity decreases somewhat in all-pass operation (red curve) in the WLAN frequency range. If the filter is now switched on for WLAN, the actual, true measured value is displayed, which can be significantly above the value that was determined in all-pass operation.

Do not be surprised if, for example, you measure a pure WLAN signal and, in case of activated WLAN filter, a higher measured value is displayed than in all-pass operation. A similar effect can possibly also be observed with DECT and 3G (UMTS) signals.

Reverse attenuation

Reverse attenuation is indicated for every filter, with reference to the transmission loss.

The reverse attenuation thus indicates how frequencies are strongly suppressed, at least outside of the pass band.

For example, the damping of the GSM900 filter is 64 dB in the pass band and 35 dB in the reverse attenuation range. Frequencies in the reverse attenuation range are therefore decreased by 29 dB more than in the pass range. The reverse attenuation is 29 dB.

The reverse attenuation applies for frequencies with sufficient separation from the respective mobile communications frequency range.

Filter	Reverse attenuation	Elec. field strength remaining display	Power flux density remaining display
	At least	At most	At most
GSM900	29dB	3,5%	0,13%
GSM1800	34dB	2,0%	0,04%
DECT	40dB	1,0%	0,01%
3G (UMTS)	16dB	15,8%	2,51%
WLAN	24dB	6,3%	0,40%

Table 4: Reverse attenuation of the filters to 2.5 GHz

Table 4 shows typical reverse attenuations of the filter up to 2.5 GHz. The

Alternatively a measurement can be stored by klicking this symbol. This symbol is only active in long term storage.

Alternatively a measurement can be opened by klicking this symbol. This symbol is only active in long term storage.

Menuleiste

now be saved (see later).

Change of mode: It is possibly to carry out a "change of mode" from field strength to power flux density and vice versa, only during an on-going measurement. The programming of the HFA3 measuring device requires this. For this, it should also be ensured through the user that the measuring device is in Mode E (field strength, display V/m) before the first measurement with the HFA3 1.0 software.

Reference: Some adjustments in the menu bars or selection lists (e.g. filter, automatic system mode) are effective only after the measurement has been started.

Alternatively, the terminal display can be selected by clicking this icon.

Alternatively, the indication display can be selected by clicking this icon.

Alternatively, the recording display can be selected by clicking this icon.

Alternatively, a measurement can be started by clicking this icon.

Copy: the actual content of the displayed window will be copied to the clipboard. With STRG+V it is possible to paste this into your word processor software (i. e. WORD).

Menuleiste: Bearbeiten

Terminal: Direct display of the raw information from the HFA-3. The displayed information is time independent and shows the values as it is received.

Display: display the readings with maximum and medial value as text with big letters. The different frequency bands are color coded.

Display: Terminal, display, recording are possible representations for the measuring data from the RF sensor.

Recording: The values have a clock cycle and are represented in this clock cycle graphically. Long-term measurements are therefore possible. The measured values can be stored and the stored measurements loaded again (more on this later).

Recording only: File options are possible for the long-term recording only.

Open: Open a stored measurement and load into the recording window. All long-term data, as well as the maximum values in the six different filter ranges (e.g. GSM900, GSM1800, WLAN…), are displayed again.

Save: Save the current long-term recording with all maximum values in the filter ranges.

Deletion: Deletion of the current long-term recording and all displays.

Measurement: Change of mode and start/stop measurement are the operating options during the measurement procedure.

Start measurement: The measurement is started and the measurement represented in the display is selected beforehand.

Stop measurement: The measurement is stopped. The measurement can

indicated values are "worst case values" and presuppose a sufficient separation distance to the pass band (normally 10 dB to 20 dB). They do not apply for the mutual suppression of GSM1800 and DECT

Example:

The GSM900 filter has a minimum reverse attenuation of 29 dB. This means that all frequencies outside of the pass band are decreased by at least 29 dB more strongly than GSM900 frequencies.

At an assumed point of measurement, GSM900- and GSM1800 frequencies are present. In the case of the HFA-3, we set the filter to GSM900 (because e.g. only GSM900 interests us)!

The influence of the E-field strength measurement values of the GSM1800 frequencies will then become noticeable with 3.5% of their initial value at most. The correction of the display is already considered here. Assuming the real field strength in the GSM1800 range is 1 V/m (mV/m =1000). Then the remaining display amounts to only maximum 0.03 V/m (= 30 mV/m)!

If the measured value indication is employed for the power flux density, the display of the GSM1800 frequencies is then reduced to 0.13%. With a power flux density of 1 mW/m^2 (=1000 $\mu W/m^2$), the remaining display is only 0.0013 mW/m^2 (=1.3 $\mu W/m^2$).

The indicated values are the worst values up to 2.5 GHz. In most cases, the suppression of the other mobile communications signals is still far better than indicated here. This applies in particular for 3G (UMTS). The selectivity of the filters, which is very high in most cases, also enables a measurement of certain mobile communications frequency ranges, if other mobile communications signals are far stronger.

In practice this means:

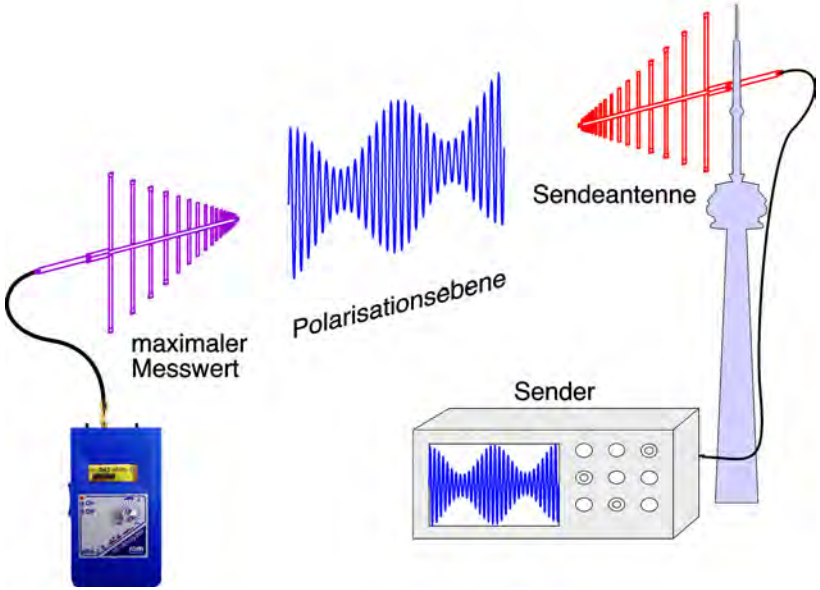
If, for example, the power flux density of the GSM1800 frequencies at a point of measurement is 10 times stronger than the power flux density of the GSM900 frequencies, in spite of this, the strength of the GSM900 frequencies can be determined very exactly with utilization of the GSM900 filter.

DECT, GSM1800

GSM1800 and DECT frequencies are virtually seamlessly close to each other. The selectivity of the filters is certainly good, but there are physical limits. As can also be identified in the above graphics, the responses (green and turquoise) of GSM1800 and DECT overlap a little. In practice e.g. in case of selected GSM1800 filter, signals from a DECT base station located nearby can also be measured and vice versa.

Polarisation

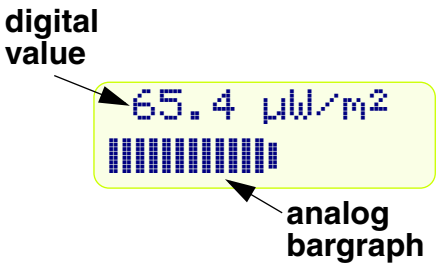
If we consider the electrical field component of an electromagnetic wave, it is determined that this is in one plane. This plane is also designated as a plane of polarization. The maximum measured value is provided in the case where the receiving antenna points in the same direction and plane as the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



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

Measured value representation

In the display, the digital measured value is represented as a numerical value and the analog value measured value as a bar



Operating elements and displays

The operation of the HFA3 1.0 software is possible via the menu bar, command buttons and icons. Below are presented all operating elements

Statusleiste

Bedienelemente

Menu bar, command buttons and icons

Drucken: Das aktuelle Anzeigefenster wird mit seinem gesamten Inhalt an den installierten Drucker gesandt.

Beenden: Alle Messungen werden angehalten und die Software beendet.

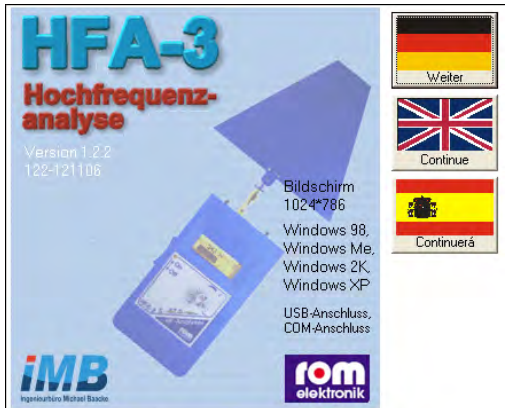
Menuleiste: Datei

Anstelle des Menüeintrags bewirkt ein Klick auf dieses Icon in der Schaltflächenleiste das Auslösen des Druckvorganges.

Anstelle des Menüeintrags bewirkt ein Klick auf dieses Icon in der Schaltflächenleiste das Beenden des Programms.

Menuleiste

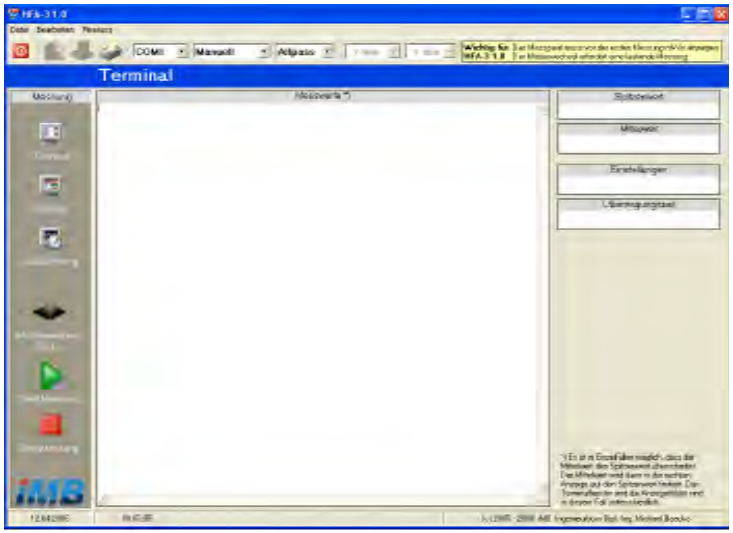
After the start of the program, the start display screen appears (see Illustration). After approx. 5 seconds, the actual program then starts. The actual program is started without further delay by a mouse click on the command button "Continue".



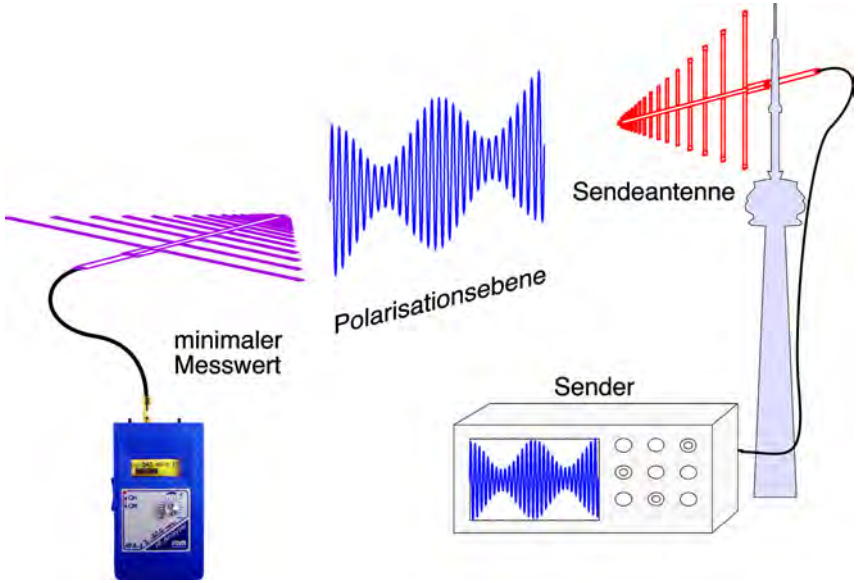
Selection of the representations and start of the measurements

The multiple-language version offers English, French and Spanish, as well as German.

After the start, the display **Terminal** is displayed automatically.



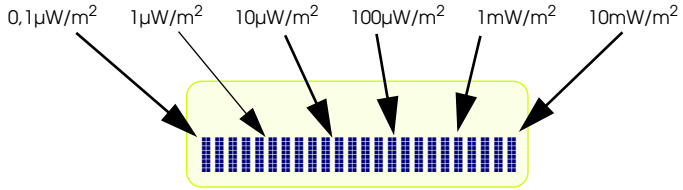
Bedienelemente und Anzeigen



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

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

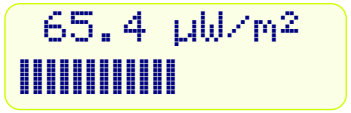
1. At low levels, a clear display is visible on the bar.
2. With the measured value indication of the electrical field strength in mV/m, a simple estimate of the radiant flux density in $\mu W/m^2$ is possible.



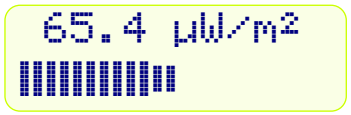
The analog bar additionally displays the average value and peak value simultaneously. Thus a simple appraisal of the pulsed signal content with respect to non-pulsed content is possible.

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

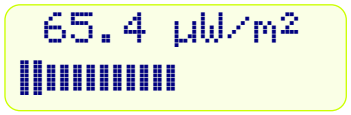
A non-pulsed signal with 65.4 µW/m^2 is indicated in the following example:



Here, a non-pulsed signal with a small pulsed content and a peak value of 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 HFA-3 immediately, in order to avoid damage to the HFA-3.

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

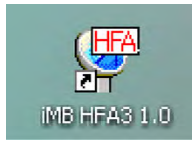
Basically, an evaluation of the measured values is to be recommended in accordance with the provision principle. With frequent employment of the device, you will also get a feeling for which measured value is normal and which measured value can be regarded as increased, or maybe even dubious. The following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

After termination of the installation, you have a HFA3 1.0 icon on your desktop, as well as a program group iMB > HFA3 1.0 in the program strip

The start using the program group is implemented by clicking, as represented below.

Start aus der Programmgruppe

You can also start HFA3 1.0 with a click on the window icon on the desktop.



Start vom Desktop aus

Explorer offers a third possibility. With this, you can start "HFA3_10.exe" directly in the installation directory.

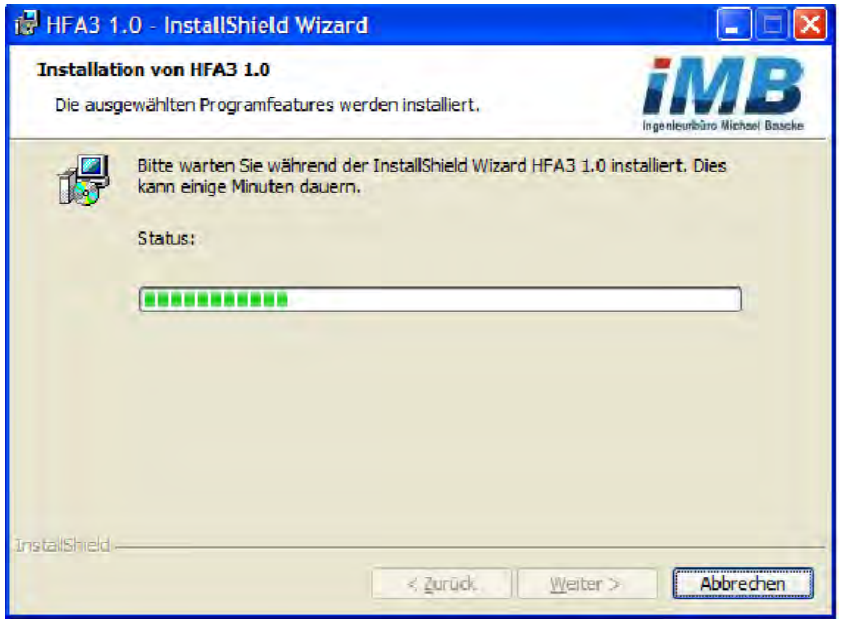
The installation routine generates the following directory structure:

Main directory:	Here is located the program file HFA3_10.exe.
Subdirectory "Recording":	Here are filed the files of the recordings.

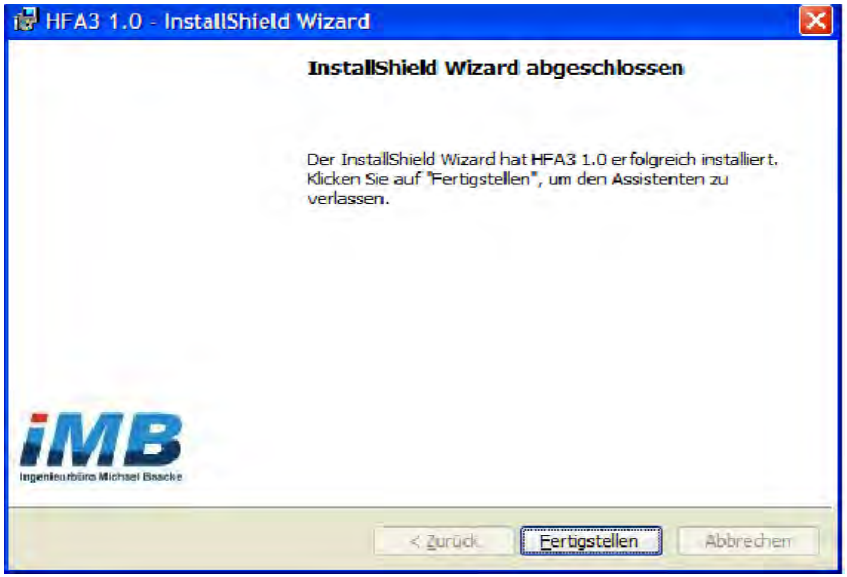
Starting the program

Because of the many different PC configurations, the operational startup is not always completely problem-free. It is recommended to keep to the following precedence during the operational startup:

1. Connection of PC and sensor with the serial cable at the serial connection of the PC.
   Reference:
2. If no serial connection is available on the PC, a so-called USB serial adapter must be employed. You can obtain such an adapter through specialist retailing or from ROM-Elektronik. The operational startup of the adapter is implemented according to the manufacturer's directives.
3. Switching on the measuring device
4. Start the program
5. Selection of the representations and start of the measurements



Step 5 of the installation



Step 6 of the installation (finish

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 ("MAX!" display in the HFA-3), 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!

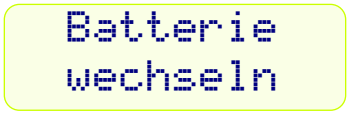
Limit value in W/m^2	Limit value in W/cm^2	Limit value in mV/m	Recommended in case of
0,1-5 µW/m^2	0,001-0,5 nW/cm^2	5-50 mV/m	Weak anomaly according to SBM 2003 for pulsed radiation
>10 µW/m^2	>1 nW/cm^2	>50 mV/m	Weak anomaly according to SBM 2003 for unpulsed radiation
1 mW/m^2	0,1 µW/cm^2	614 mV/m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

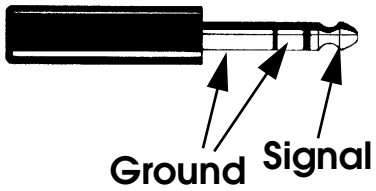


Then switch off the device and take off the battery compartment cover on the reverse side and take out the used battery. Insert a standard 9 volt battery (9 volt block) as a new battery and close the battery compartment cover. The device is now ready for operation again.

Employ the HFA-3 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 modulations 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.

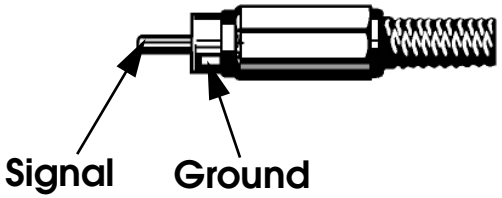
Options

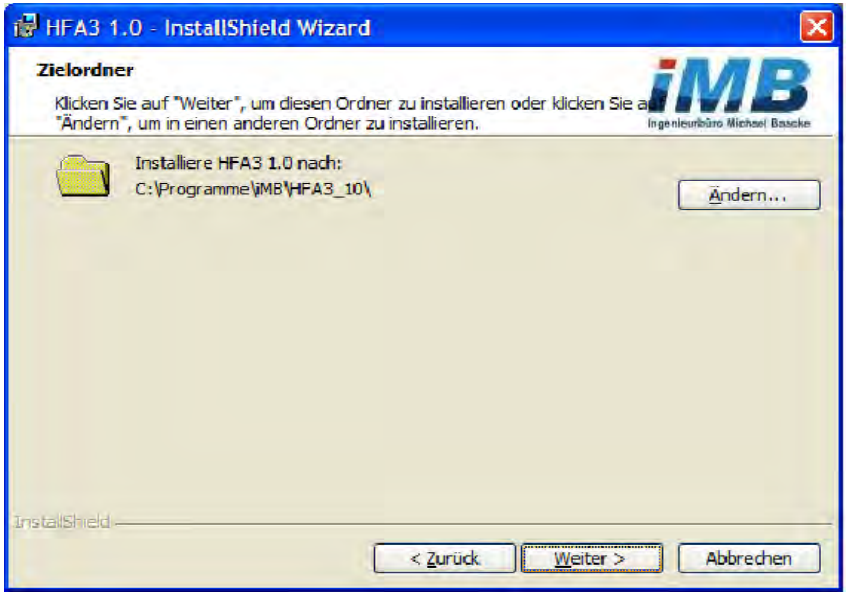
The HFA-3 can be supplied with a recorder outlet (0-2.5V) and/or RS232 serial computer interface. A retrofit is also possible.

serial interface connector

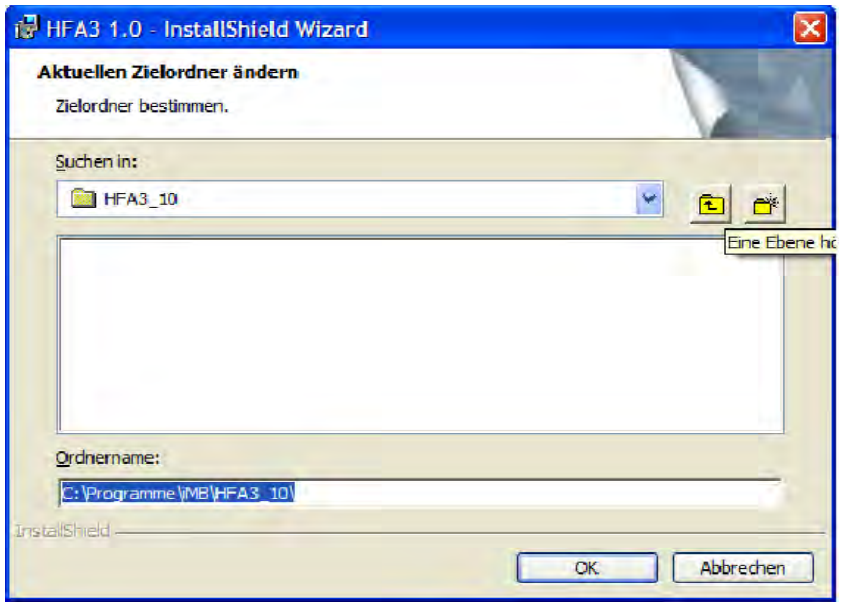
DC-Output (Analog writer outlet)

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.



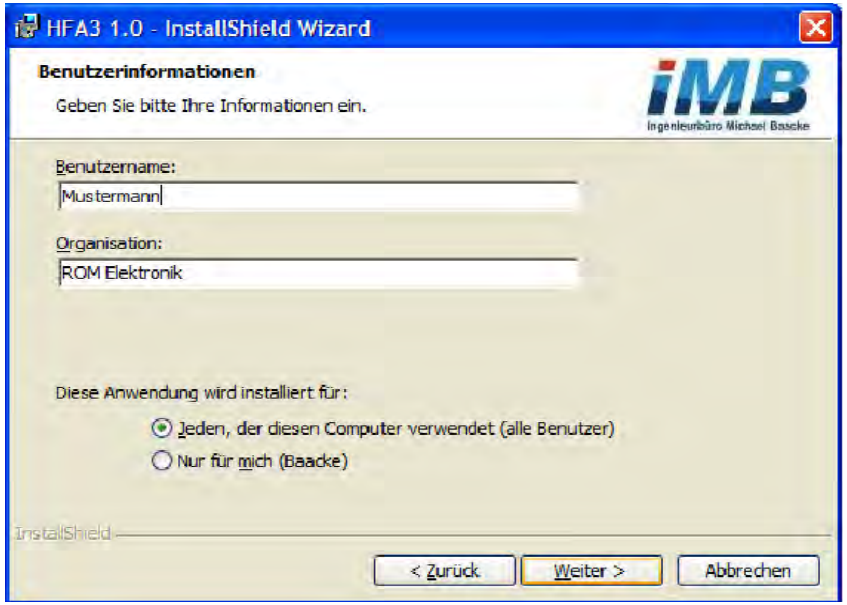


Step 1 of the installation (destination)



Schritt 4b der Installation (Zielordner)

.Continue the installation in Step 3 with "Continue >" and enter your perso-



Step 3 of the installation (personal data)

nal data into the fields mentioned below.

If you are logged on as an administrator, you have to arrange the selection of the software HFA3 1.0 for all users or only for yourself. Continue the installation with "Continue >"

Reference: If the installation should not start successfully, as administrator you must log on and repeat the installation, where appropriate.

In Step 4 of the installation, you can select a directory on your computer in which HFA3 1.0 with its subdirectories should be stored. The directory "C:\Programme\iMB\HFA3_10" is provided as standard. It is recommended to accept this path since, with this, under certain circumstances problems with pre-determined PC configurations are avoided.

Continue the installation of HFA3 1.0 with <OK> in Step 4a and 4b.

Important notes on the HFA-3 software

1. There are many different operating systems and PC configurations. In case of most PC's, the installation of the program and the operational startup functions smoothly. This cannot always be guaranteed however. If there are problems, please contact ROM-Elektronik. All problems in this connection have basically been solved up to now.
2. The sensor is designed for control over the serial interface of the PC. If your PC possesses only USB interfaces, please contact ROM-Elektronik. However, there are corresponding adapters where, under certain circumstances, a special software adaptation is necessary.
3. The program works with a screen resolution of 1024 x 768 pixels. Only if the employed PC also works with this screen resolution, will the display fill the complete screen. If the PC works with a higher resolution e.g. 1268 x 1024 pixels, then the display occupies only a part of the PC screen. The program is usable in this case. If the PC works with a lower resolution e.g. 800 x 600 pixels, then only part of the display is visible. The program can be used with difficulty only. The PC should then be adjusted to a higher resolution.
4. The color representations "Hi-Color" or "True-Color" offer the best color quality.
5. The program is very extensive and has several thousand programming lines. In spite of intensive testing, faults can still occur. If faults occur with you, we would request that you send a maximally precise error description to ROM-Elektronik. At regular intervals, improved program versions are published on the home page of ROM-Elektronik, that you can download free of charge.
6. If you have suggestions for the program or for the cube, we would request that you send them to us.
7. A diagnostic program is included in the program, with which the communication to the cube can be checked if the cube does not react in normal operating modes. The diagnostic program is used for troubleshooting the possible error cause in case of problems, together with the manufacturer (by telephone). For this reason, the use of the diagnostic program is described in abbreviated form only in this direction.

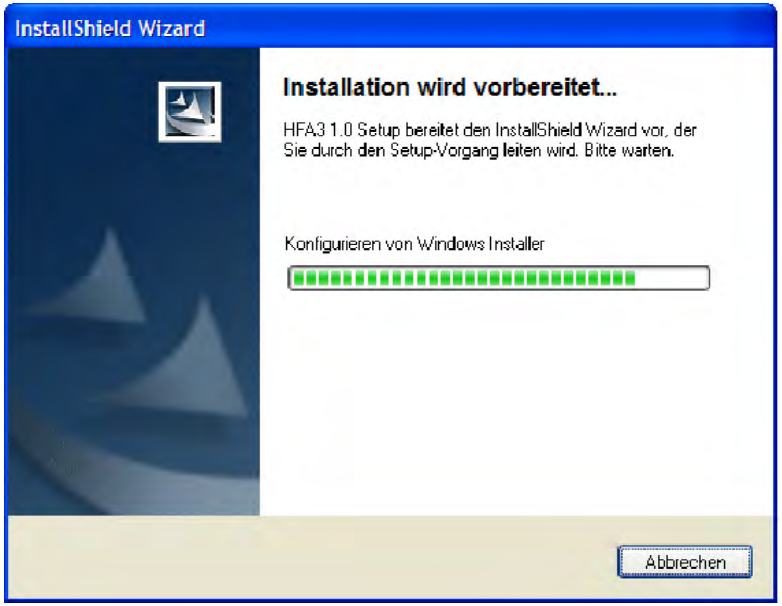
Installation

Please place the program CD into the compact disk drive of your computer and start the installation:

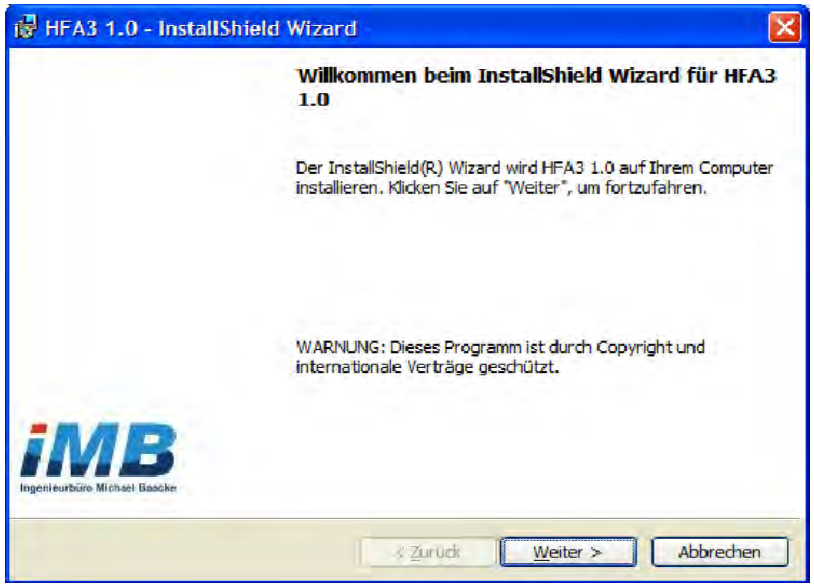
Click on d:\setup.exe (where appropriate, you can have a disk drive alpha-

betic character other than d: for your compact disk drive).

Following this, you are guided by the individual steps of the installation.



Step 1 of the installation (start)



Step 2 of the installation