Manual
SPECTRAN NF

AARONIA AG

WWW.AARONIA.DE

®

Made in Germany

Please read the following manual carefully before starting up your measurement device. The manual gives you useful instructions how to operate the unit correctly.

With your purchase of this SPECTRAN low-frequency measurement device, you have bought professional equipment which allows you measuring low-frequency fields.

Please note: For measuring high-frequency fields (cellphones, mobile communication, RADAR, TV and others), you would need additionally one of our high-frequency HF-SPECTRAN models.

Therefore we recommend purchasing one of our cost-effective measurement BUNDLES, which you can obtain from Aaronia at any time by paying the corresponding price difference.

Upgrading to a higher-grade SPECTRAN model (for example, an NF-5030 instead of the NF-1010E) is possible at any time. Likewise, OPTIONS like memory expansions, frequency expansions or a higher-grade battery can also be purchased and added to your unit whenever you need them.

In case of replacement, our devices are optimally recycled, including all circuitry. In this regard, also check our warranty's terms and conditions in the chapter "The Aaronia warranty".

Contents

Chapter | **Page**

ATTENTION:
Always screw antennas and adapters always in a <u>non-violent</u> way. Please use for loosening or screwing of SMA connections ONLY the enclosed SMA tool, which offers an over-tightening protection.

Don't bring ever the analyzer in contact with water. Don't use it if it is raining. The sensitive electronic system could otherwise be damaged.

Avoid excessively high temperatures. Do not leave the device on heating radiators, in direct sunlight or in your car.

Due to the high sensitivity, the sensors and display of this device are shock-sensitive, therefore it should be handled with care. Don't let the device or antennas, falling down as they could be damaged or destroyed!
Consequently, we strongly recommend to usw our special transport case for storage and transportation. It is also available as a <u>very durable version</u> made of special plastics (available at an extra charge).

Even though all SPECTRAN models are pretty safe due to their counter-sunk screws, they should not be kept in the reach of children, as they might be a potential threat in this case!

Your measurement device is maintenance-free. **Only** clean it outside with a damp cloth. Do **not** use any cleaning supplies.

WARNING:
Avoid overloading the input by applying signals with excessive power as otherwise the highly-sensitive circuitry could be destroyed! The maximum applicable voltage is only 200mV (0.2V). Voltages bigger than 1V can destroy SPECTRAN's highly sensitive amplification circuitry!

Please check before initial operation the completeness of delivery. Reclaim missing parts immediately at Aaronia or at your Aaronia dealer.

The package should include:

(1) CD, containing this manual, MCS PC Software (Windows, MAC, Linux) and more
(2) SPECTRAN NF Spectrum Analyzer incl. 1300mAh Battery (installed)
(3) Small aluminum transport case. When purchasing a measurement Bundle, the bigger version of the transport case is included in delivery

3.0 LC Display
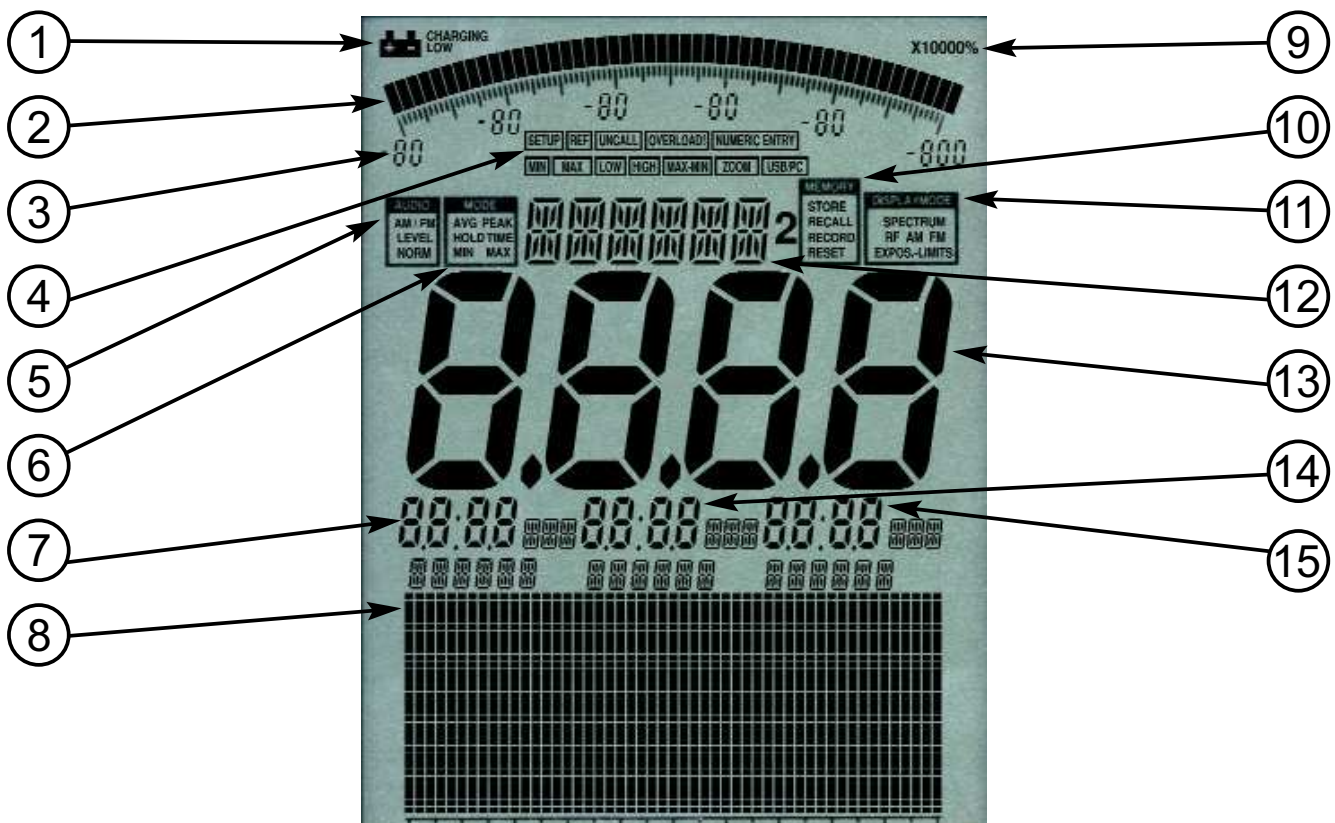
(1)   **BATTERY display**
(2)   **BARGRAPH** (50 segments)
(3)   **Bargraph scaling** (6 number blocks)
(4)   **STATUS field**:
          SETUP, REF, UNCALL, OVERLOAD!, NUMERIC ENTRY, MIN, MAX
          LOW, HIGH, MAX-MIN, ZOOM, USB/PC
(5)   **AUDIO Status field**
          AM/FM, LEVEL, NORM
(6)   **MODE Status field**:
          AVG, PEAK, HOLD, TIME, MIN, MAX
(7)   **MARKER block 1**
(8)   **Graphics display** (Pixel display)
(9)   **MULTIPLICATOR field**
(10)   **MEMORY Status field**:
          STORE, RECALL, RECORD, RESET
(11)   **DISPLAY MODE Status field**:
          SPECTRUM, RF, AM, FM, EXPOS.-LIMITS
(12)   **INFO display**
(13)   **MAIN display**
(14)   **MARKER block 2**
(15)   **MARKER block 3**
Depending on the model, not all display elements may be available!
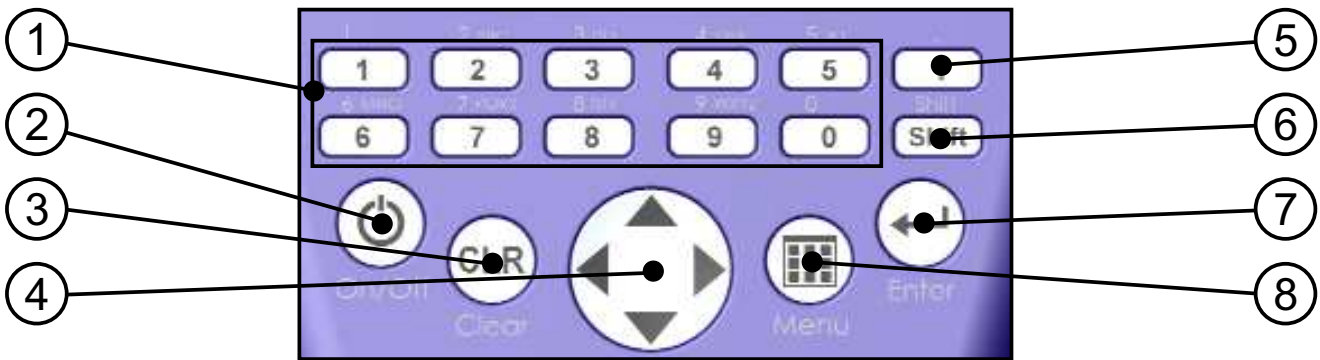
(1) Numeric block (hotkeys)
    1 = **RAIL** (traction power) 15-30Hz
    2 = **POWER** (mains frequency 50Hz or 60Hz) 45-65Hz
    3 = **HARMON** (50Hz/60Hz harmonic) 90-500Hz
    4 = **TCO 1** (shortend TCO frequency range 1) 500Hz-2kHz
    5 = **TCO 2** (TCO frequency range 2) 2kHz-400kHz
    6 = **SENSOR** (sensor type and axis: Mag, Msta, E-Fld, Analog)
    7 = **DIM** (H-field measurement dimension: 1D, 2D or 3D)
    8 = **RBW** (resolution bandwidth)
    9 = **SPTIME** (sample time in mS or S)
    0 = **ATTEN** (attenuator: auto, 0dB, 10dB, 20dB, 30dB, 40dB)
(2) On-/Off key
    Turn the unit on/off
(3) Clear-/Reset key
    1.) **Resets the settings to default incl. 0dB attenuator.**
    2.) When in main menu: clear entry
(4) Arrow keys
    1.) With activated menus: selection of menu entries
    2.) In **Spectrum analysis** mode:
        Right/left key: move frequency range by one SPAN.
        Up/down key: move reference level by 10dB.
    3.) In **Exposure limits** mode:
        Right/left key: select exposure limit.
    4.) In **Audio** mode:
        Right/left key: move center frequency by one RBW.
        Up/down key: decrease/increase RBW (bandwidth).
(5) Dot key
    1.) Modes **Spectrum analysis** / **Exposure limits**: HOLD on/off.
    2.) Mode **Audio**: Switch between AM and FM.
(6) Shift key
    Mode **Spectrum analysis** & **Exposure limits**: Detector RMS/MinMax.
(7) Enter key
    1.) Switch between the three main modes Spectrum analysis, Exposure limits and Audio.
    2.) While navigating menus: confirm selection or entry (usual enter key).
(8) Menu key
    Call up / dismiss **main menu** for changing various settings.

To explain the use of SPECTRAN, we will measure its own <u>power supply</u>. During this procedure, you will get to know the <u>3 different operation modes</u> of SPECTRAN, as well as the important <u>HOLD feature</u> and the <u>panning approach</u>:

It is really very simple, **just follow the following instruction <u>step by step</u>:**

How to prepare SPECTRAN for measurement:
Remove the protective film from the display. Should you not yet have charged the integrated battery, you can also operate SPECTRAN with the included power supply (**further information on page 51**).
Next, press the on/off switch located in the lower left corner.
SPECTRAN is now switched on and will perform a brief calibration procedure.

For easier orientation, we will now briefly show the most important aspects of the SPECTRAN display:

BARGRAPH (trend display when Reflev is <u>not</u> in Auto-mode)
Depending on signal strength, the half-circle will grow or shrink. A very handy function for quickly changing levels!

MODE status field (MinMax and HOLD)
Displays the detector and mode which is used. Possible values are: <u>MIN MAX</u> and <u>HOLD</u> (advanced HOLD mode).

INFO display
Displays the current physical unit and various menu information.

DISPLAY MODE status field
Displays the current operation mode of SPECTRAN. Possible values are: <u>SPECTRUM</u> (spectrum analysis), <u>EXPOS.-LIMITS</u> (exposure limits) and <u>AM</u> / <u>FM</u> (audio output).

MAIN display
Displays signal strength or voltage in T, G, V/m, A/m or V.

MARKER block (1 to 3)
Displays <u>frequency</u> and <u>signal level</u> or <u>voltage</u> of the strongest signals. Up to three markers can be displayed simultaneously.

GRAPHICS display (here: spectrum display)
This highly versatile display field can provide a multitude of textual and graphical information (spectrum or exposure limit display, menus).

Now we're ready for making measurements of SPECTRAN's own power supply. First, plug the power supply into a power socket. Now, you can measure the magnetic field of the power supply as follows:

Switch on the unit and press key 2. That's all you have to do. Now, the most "popular" measurement will be carried out:
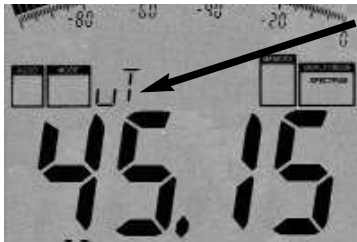
The frequency range between <u>**45 and 65Hz**</u> is measured (sweeped) now. The large main display shows the **strength of the magnetic field** in Tesla (T), the so-called readout. Above the readout on the main display, the physical unit is shown. Depending on field strength, it will automatically switch between (for example) **µ**T and **m**T (autorange feature). If you approach the power supply, the field strength will increase, likewise, it will rapidly decrease when you move further away.

It might be necessary to set the correct mode of operation by using the Enter key. Push it repeatedly until the **display mode status field** reads "*SPECTRUM*".

Of course, SPECTRAN is far more capable than this, so following is a **more detailed** introduction about how to use **further features**:

5.1 Choosing the sensor [Key 6]:

In general, you should know that there are **two different kinds of fields** that are measurable with SPECTRAN in the proximity of electrical appliances 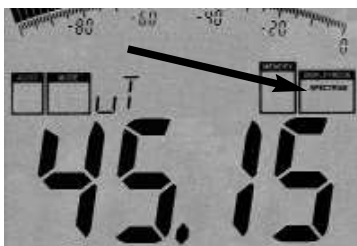and installations: **electric** alternating fields and **magnetic** alternating fields. For each of these field types, you need an appropriate sensor. Both sensors are already integrated into our SPECTRAN devices. The appropriate sensor can be chosen at any time using the **key 6** (use the up/down arrow keys to choose, and apply your selection with the Enter key).

For <u>**magnetic**</u> fields, you need the *Mag* sensor. Press the **key 6** and select the *Mag* sensor (further options are XY-Mag, YZ-Mag and ZX-Mag).

If you want to measure **electric** fields, press the **key 6** and select the *E-Fld* sensor. Please note that measurement of electric fields can be easily interfered. Please have a closer look at the "Measurement of electric fields" section for more information.

Using our **Option 006, which can be retrofitted as an upgrade at any time,** you can also measure **STATIC** magnetic fields, like the **geomagnetic field** (geological dislocation) or the strength of **magnets** (for example in loudspeakers). To do this, just press key **6** and select the *MSta* sensor (possible choices are X-MSta, Y-MSta and Z-MSta).

If you have an NF-3020 or better, you can also select the external input (SMA socket), which allows you to connect arbitrary external sensors like large, highly sensitive coils, testing probes, or other special antennas. You could also simply measure a voltage. This input provides you with a whole range of new possible applications and converts SPECTRAN into a versatile all-rounder. For using the external input, press the **key 6** and choose *Analog*.

5.2 Choosing the mode of operation [Enter key]:

All SPECTRAN models offer **3 different MODES OF OPERATION:**
- **SPECTRUM analysis** (graphical display of signal levels and frequencies)
- **EXPOSURE LIMIT display** (percentage of a particular exposure limit)
- **AUDIO output** (makes modulated signals audible)
You can switch between the different modes of operation at any time by using the Enter key.

5.3 Mode *Spectrum analysis*:
(The DISPLAY MODE status field displays "SPECTRUM")

Press the **Enter key** until the **display mode status field** reads "**SPECTRUM**". SPECTRAN will now provide a readout similar to the one shown in the picture on the left. Should the **large main display** show *"0000"*, then **no** signal is found. In this case, you probably have to measure closer to the signal source. During every measurement, a *small dot* will constantly move from the left to the right edge of the upper part of the **graphics display**. **Only when this point reaches the right edge, the measurement is completed and all readout values are updated, very often it will be so fast that you won't even notice.**

The **main display** shows the current field strength, in our example it is 45,15µT.

Directly below up to 3 so-called "**markers**" are displayed. These show the frequency and corresponding signal strength of the strongest signal sources. In our example, we have two **markers**. **Marker**1 at *30Hz* and *45µT* and **marker**2 at *50Hz* and *75µT* (*75µT* is at the same time the strongest signal overall, that's why it is also displayed on the **main display**).

Marker1
30Hz
45µT

Marker2
50Hz
75µT

**Graphical display
with SPECTRUM graph**
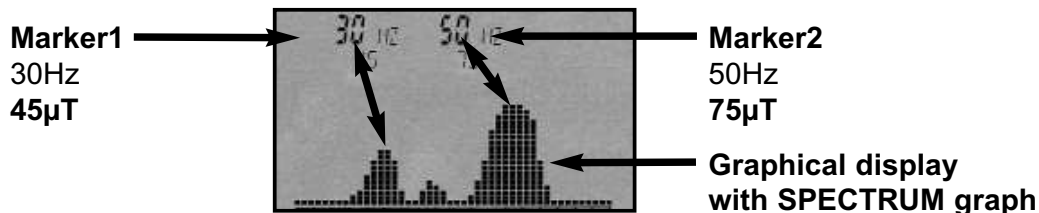
Below the **markers**, the **graphics display** shows a graphic consisting of a number of little "hills". This graphic is called "<u>SPECTRUM DISPLAY</u>". The higher the "hills", the stronger the corresponding signal. The markers mentioned previously show the frequency and level at the peaks of each "hill".

Using frequency charts, it is also possible to make assumptions on the **origin or source** of the corresponding signal. See our **frequency charts on page 56** for more details. Please note that marker-frequencys are always shown with one decimal place.

5.4 HOLD mode
(The MODE status field displays "HOLD")

As you have probably already noticed, the display changes **constantly**. This is completely normal as the field strength also **changes with distance to the signal source**. Simply try it out yourself - move the device around the signal source and keep an eye on the display and the changing readouts.

Often, the user just wants to check the **highest possible readout**. However, as the display always keeps changing, this might cause difficulties. To solve these problems you can use the so-called **HOLD mode**. To activate it, press the dot key. The **mode status field** will display "*HOLD*". From now on, only the strongest measured signal will be displayed. Furthermore, the spectrum display will not be erased - it seems to literally "freeze". By pressing the dot key a second time, "HOLD" will disappear from the MODE status field and HOLD mode is turned off.

5.5 The panning approach

When evaluating exposure limits, usually only the **maximum signal level** is important. This maximum can be determined by using the so-called "panning approach", which is already established as a **legally binding means** of measurement in many countries. Proceed as follows:

Choose the desired frequency range. In our example, we have already done so (key 2). Activate HOLD mode (dot key) as described previously. Afterwards please also activate 3D measurement by pressing the 8 key. This will save you the hassle of having to move the device around constantly in **all** directions near the measurement subject.

Now, keep measuring until the value stops changing completely. You have now determined the signal maximum at a particular position/location.

However, should you wish to determine the signal maximum in an entire room, you additionally need to measure at every possible position. Walk through the entire room, pay special attention to the walls and electrical appliances, where you will often find the strongest signals due to electrical wiring. During measurement, the displayed signal strength will rapidly increase, until at some point it will stop changing and "freeze" at the signal maximum. This can take several minutes when testing an entire room. After completion of this procedure, the maximum signal strength found in the entire room is shown on the display.

As field strength diminishes very rapidly with increasing distance (depending on the source, r, r^2 or even r^3), you can quite easily determine the exact location of a signal source (the higher the signal level, the closer the source). Of course, you will need to turn off HOLD mode in this case. Next, simply try to find the signal maximum in various rooms to get acquainted with the panning approach and the importance of HOLD mode.

Now, of course your measurement result is not that useful if you cannot relate it to any exposure limits. Until today this used to be very complex with the need to browse complex tables and convert between physical units. A highly daunting task for the novice and even for some experts. SPECTRAN offers therefore a special and easy to handle mode for exposure limit calculation:

5.6 *Exposure limits* mode

(The DISPLAY MODE status field displays "EXPOS.-LIMITS")

Press the **Enter key** until the **display mode status field** shows "***EXPOS.-LIMITS***".

As usual, the strongest signals will be shown along with their frequencies and levels as markers, as in the spectrum analysis mode. The large main display will again show the level of the strongest signal found.

However, in the graphics display below, the strongest signal will be shown now **as a percentage in relation to an exposure limit**: As various very different exposure limits and recommendations are existing for the various fields of interest and professional groups, SPECTRAN offers an entire range of different exposure limits. **You can select the desired exposure limit by using the right/left cursor keys.** Find a more detailed introduction to these exposure limits on pages 47 and following in this manual.

Please try it yourself: Select all the different exposure limits and compare the results. The available exposure limits are:

xTESLA = Shows the readout in Tesla
ICNIRP = ICNIRP recommendation also German limit (General population)
BGRB11 = BGFE limit for workplace exposition (exposition class **2**)
BImSch = 26. BimSchV (Indutrial German limit) (**only** 16,66Hz, 50Hz, >10MHz)
TCO99 = International limit for computer screens (**only** from 5Hz-400kHz)

In our fictional example, the exposure limit bargraph shows an approximation to the German ICNIRP limit of 69%. When EXCEEDING the exposure limit, the display will show percentages **above** 100% (for example, 128,00 = limit exceeded by 28%). When exceeding the exposure limit by more than 999.99%, the display will show "***.**", indicating overflow.

HINT: You will always find **current or updated exposure limits** on the Aaronia homepage for downloading, e. g. when legal changes occur and official limits are altered This allows you to keep your SPECTRAN always updated. We also recommend our free PC analysis software, which offers a lots of additional features.

Another approach to precisely locate a signal or determine its origin is demodulation. This feature allows you to hear potential pulsing or modulation of a signal source. As with other features, SPECTRAN has a special mode for this kind of operation:

5.7 *Audio output* mode (demodulator)

(the DISPLAY MODE status field displays "AM" or "FM")

Display is "frozen"
Pixel display is turned off

All SPECTRAN models offer a so-called ***demodulator***. This demodulator turns pulsings and modulation of signal sources into **tones**.

Frequency-accurate and selective acoustic representation of a signal can be helpful with identification and location of a signal source. As demodulation occurs in realtime, it is suited perfectly to find the signal source very quickly. SPECTRAN offers two different demodulation modes:

AM (amplitude modulation "AM")
FM (frequency modulation "FM").

You can switch between the demodulation modes by pressing the dot key (the DISPLAY MODE status field displays " "AM" or "FM").

You can adjust the volume by turning the volume knob on the left side.

ATTENTION: During audio analysis, the entire display will be "frozen" and the pixel field is turned off completely to save computing power for demodulation. Then ONLY <u>acoustic</u> **reproduction of the signal is carried out!**

In contrast to simple broadband detectors, SPECTRAN performs its demodulation only at a specific frequency (center frequency). Thus, you can selectively „listen" small individual frequency ranges. However, please note that filtering in this mode is slightly less stringent. As a result, strong signals on neighbouring frequencies might "bleed" onto the actual selected frequency and be audible as well.

For optimal audio reproduction of signals, you can choose between several filter bandwidths by using the **up/down arrow keys**. The currently selected filter will be shown in the large INFO display.

You will often find that it is difficult to accurately find the right center frequency and demodulation is bad or not successful at all. Hence, by pressing the **right/left arrow keys**, you can fine-adjust the center frequency. The used step width is based on the filter you have previously selected. For example, should you have chosen a 1kHz filter, fine-adjustment will take place in steps of 1kHz, and so on. The new center frequency will be shown on the large INFO display after changes.

ATTENTION: For optimal audio reproduction of signals, their levels should be significantly higher than the noise floor.

So far, our examples were only using the provided frequency presets available at key 2 (45-65Hz). However, you can also make a **manual**, highly precise frequency range (sweep) adjustment:

Recall frequency range presets
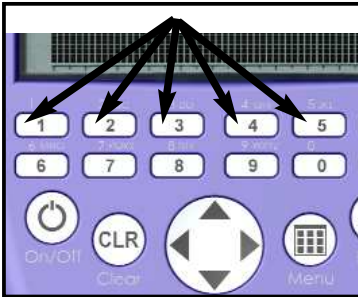
At the keys 1 - 5 are different presets available including the optimal frequency selection for **traction power** (16.7Hz), **mains power** (50Hz/60Hz), harmonics, TFTs, switching power supplies and others.

Usually these are the measurements which almost anybody wants to carry out. The amateur in particular will appreciate these presets, as all frequency parameter are already adjusted.

However, you can also make a **manual**, highly precise frequency range (sweep) adjustment. This way, you can set a frequency range exactly tailored for a specific signal source in order to measure **only this** single source.
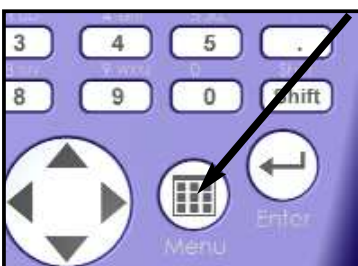
To set the frequency range, you simply need to know the start and stop frequencies of the subject to be measured and provide them to SPECTRAN. **You can find an excerpt from the start and stop frequencies of various signal sources in the frequency table on page 56.**

Manual adjustment

There are two ways for setting up the requested frequency range exactly. You can either go in the menu to the **Start** and **Stop** frequency, or just work with the **Center** frequency.

In the following paragraphs, you will find an explanation of such a manual measurement, using a TV set or computer monitor as an example. **Proceed as follows:**

First of all, have a look at the frequency list on **page 56**. From this list, you can derive that TV sets or computer monitors work in the frequency range from approx. 31kHz to 56kHz. We choose a slightly more liberal frequency range of 20kHz to 70kHz. These are the searched start and stop frequencies which you have to set as follows:

1.) Please choose in the menu **fLOW** to enter the **START frequency**

A suffix-list will be displayed then. Please use the arrows keys to select **kHz**. Confirm your selection by pressing the Enter key.

The large main display will now show **zero**. In addition, the large status field will display **START**. Now by using the number keys, enter the START frequency in kHz, in our example, 20kHz. Hence, enter **20** (you can correct typing errors by using the CLR key and entering the number again). Press then the Enter key once again to confirm your entry.

Leave the the entry by pressing the menu key and you are back in the main menu.

2.) Please choose in the menu **fHigh** to enter the **STOP frequency**

Again, the suffix-list with **Hz**, **kHz**, **MHz** etc. will appear. Choose **kHz** once again. Press the Enter key to confirm your selection.

Again, the display will show **zero**. In addition, the large status field displays **STOP**. Again, enter the STOP frequency in kHz by using the number keys. In our case, we want to measure up to **70**kHz, so enter **70**. Again, press the Enter key to confirm your entry.

Leave the the entry by pressing the menu key and you are back in the main menu.

As the next step we need to select the appropriate filter and sampletime (display speed):

3.) Choose a **filter (RBW)** in the menu at „RBW"

The filter should be at least 10 times smaller than the SPAN (at our example 70-20=50kHz). A list with various filter bandwidths will be displayed. Please choose a bandwidth of **3kHz**. Confirm your selection by pressing Enter.

Leave the the entry by pressing the menu key and you are back in the main menu.

4.) Choose the **SampleTime (SpTime)** in the menu at „SpTime"

A list consisting of **ms** and **s** will be displayed. Use the arrow keys to select **mS** and confirm your selection with Enter.

The large main display will now show **zero**. In addition, the large status field will display **SWEEP**. Enter now the required sampletime in mS by using the number keys - in our case, 300mS.

Enter **300** and press the Enter key to confirm.

Leave the the entry by pressing the menu key and you are back in the main menu.

Please leave then the main menu and all settings are saved. The sweep (measurement) will be carried out with our specified parameters.

All following measurements **only** use the specified frequency (sweep) range from **20kHz to 70kHz**, that means all operating modes (exposure limit display and spectrum display) now **only** refer to this specified frequency range!

Now you can measure **precisely which fields with which frequencies** are being generated by your monitor or TV set.

Next, experiment a bit: For example, change the Sampletime (key 8) to 100mS or 1S, or change the filter (key 9) to 10kHz or 1kHz and observe the displayed changes.

You will notice very soon a simple regularity:

1.) The higher the sampletime the more accurate are the measured values but the longer time takes the sweep

2.) The bigger the RBW the lower is the required sampletime to get accurate measurements

Please note that only **full kHz** will be displayed for all frequency redisplays in the menue because the display is limited to 4 digits (9999). For example an entry of 50Hz will result a 0 (0kHz) display and 6,788kHz will be displayd as 7kHz (rounded).

HINT: You can permanently save this setup as a custom preset as a "hotkey" of your choice. Find more details on the following pages.

HINT2: You can switch between the modes **Spectrum analysis**, **Exposure limits** and **Audio** at any time by pressing the Enter key.

Further hints and other information related to setting a frequency range and to other options available in the main menu are available in the section "The main menu" on the following pages.
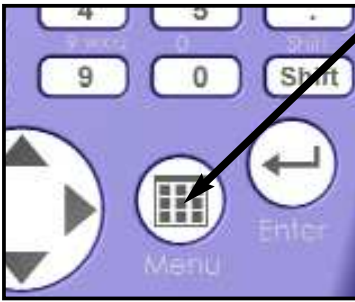
By pressing the **menu key**, you go directly to the heart of SPECTRAN: the menu system.
Here, you can control the entire device, change various settings, but also starting the datalogger or save and recall your own programs. By pressing the menu button again, you can exit the menu at any time.
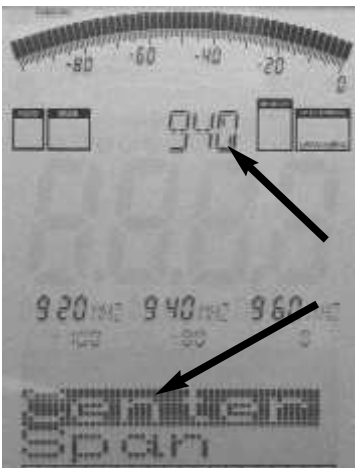
SPECTRAN's easy to operat menu system works as follows:
The currently selected menu entry is shown in inverse (dark background), as can be seen in the example on the left ("Center").
The setting of the currently highlighted menu entry is always shown as "clear text" in the large info field at the top - in this example it is the currently configured center frequency ("940"). This avoids the need for tiresome, one-by-one activation of menu entries to browse values.

The marker blocks 1-3 **continuously** display the following information:
START, **CENTER** and **STOP frequencies** (as integers in Hz, kHz or MHz)
In the next line, the current settings for **Range**, **MrkLvl** and **Reflev** are displayed.
This is very practical: For example, you can query the current frequency range (among other settings) at any time during a measurement by just pressing the menu button. After you have checked the current values, please just press the menu button again and the measurement will continue without any changes in settings.

To step through the menu entries, use the up/down arrow keys or the jog dial.
To activate the currently highlighted menu entry, press the enter key. Now you can change the current setting by using the keypad, or make a selection by using the up/down arrow keys. To confirm your entry or selection, press Enter once again, and you will come back to the menu.
All changes will only take effect after you leave the menu completely.

A complete step-by-step description of each menu entry follows.

7.1 Sensor (choose sensor and axis) [Key 6]

Use **Sensor** to select the sensor or input which you want to use. By choosing this you select at the same time which kind of field you want to measure (magnetic field, static magnetic field, electric field).

Starting with the NF-3020, you can also select an external input (SMA connector). Here you can attach arbitrary external sensors, like large, highly-sensitive coils, E-field and H-field probes or other specialized antennas. This connector opens lots of possibilities and applications and converts SPECTRAN to a multi-talent measurement device.

At the same time, you can select the desired measurement axis/plane (XY, YZ, ZX) in the Sensor menu when doing 2D measurements.

Available choices are:

"Mag" = internal 3D air-core coil (for magnetic alternating fields)
   XY-Mag (**X** axis resp. **X & Y** axes when doing a **2D** measurement)
   YZ-Mag (**Y** axis resp. **Y & Z** axes when doing a **2D** measurement)
   ZX-Mag (**Z** axis resp. **Z & X** axes when doing a **2D** measurement)

"MSta" = internal static magnetic field sensor, **only available with Option 006!**
   Measurement of static magnetic fields (**geomagnetic field, magnets)**
   X-MSta (**X** axis resp. **X & Y** axes when doing a **2D** measurement)
   Y-MSta (**Y** axis resp. **Y & Z** axes when doing a **2D** measurement)
   Z-MSta (**Z** axis resp. **Z & X** axes when doing a **2D** measurement)

E-Feld = Internal 1D E-Sensor (measurement of alternating electric fields)
Analog = SMA input, **only applicable to NF-3020 or higher** (highly sensitive measurement of an external alternating field up to 0,2V max)

Note: At magnetic fields you can change the dimension (1D, 2D, 3D) at any time with hotkey 7.

There are TWO ways to set the frequency range manually:
- **Center** (Center frequency) and **Span** (Frequency range width)
or
- **fLow** & **fHigh** (Start and stop frequency)

7.2 Center (Center frequency)

Chooses the frequency displayed in the middle of the readout. When changing the **Center frequency**, the **SPAN** parameter (see following description) is preserved. That way you can quickly evaluate different frequency ranges with identical **SPAN** and without tedious re-adjustment of **Start/Stop frequencies**.
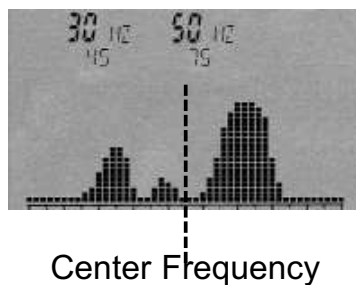
Center Frequency

7.3 Span (Frequency range width)

Span adjusts the **width of the sweep**. Changes are relative to the before mentioned "**Center frequency**" of the display. By changing **Span**, the **Start/Stop frequency** (see following description) is automatically adjusted to be able to conform to the **Span**. Therefore the **Span** function can be compared to a "magnifying glass", though only operating in the X axis.
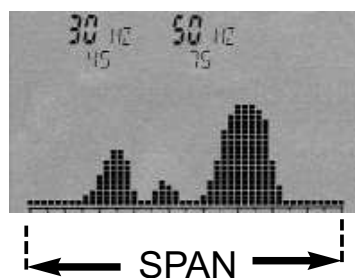
SPAN

EXAMPLE: You have chosen 2**kHz** as the **Center frequency**. Now choose 2**kHz** as **Span**, and it will be sweeped from 1 to 3kHz. Choose 3**kHz** as **Span** and the sweep will be performed from 0,5 to 3,5**kHz** etc. In other words, you always increase or decrease the resolution, centered around the **Center frequency**.

HINT: The right/left arrow keys can be used to move the sweep range directly one **SPAN** unit to the right or left.
For best level-results you should choose the **Span** not bigger then 20 times the RBW size (e.g. 1kHz RBW = maximum 20kHz **Span**).

7.4 fLow & fHigh (Start- & Stop frequency)

fLow (start frequency) sets the frequency where the sweep should begin, whereas **fHigh** (stop frequency) sets its ending frequency. By choosing these two parameter, the complete **frequency range** which will be sweeped is defined.

Please note that a large frequency range will badly squeeze the display horizontally (in the X axis) and thus significantly reduces measurement accuracy. Individual signals, especially when close together, will often not be distinguishable anymore. However, if you narrow the frequency range, you will be able to analyze the sweep range **more precisely**. You will be able to see far more details and **higher accuracy**. A large frequency span is thus mostly useful for a broad overview, **not for exact measurements**.

fLow (Start-Frequency) **fHigh** (Stop-Frequency)

7.5 RBW (Bandwidth) [Key 9]

By adjusting **bandwidth**, you can adjust detail clarity and sensitivity at the same time. When **bandwidth** is setted at a very high value or even FULL, the sweep will be very fast, however, the display becomes comparatively inaccurate and sensitivity is low. Hence, very weak signals will not be picked up anymore. The smaller the **bandwidth**, the longer the sweep will take, but the display will be more precise and weaker signals can still be displayed. Thus, for example, a single signal initially sweeped with high **bandwidth,** can turn out to be a number of several narrow, close together signals. However, this gain in accuracy has its disadvantage in the far longer sweep times.

RBW (300Hz)   **RBW** (3Hz)
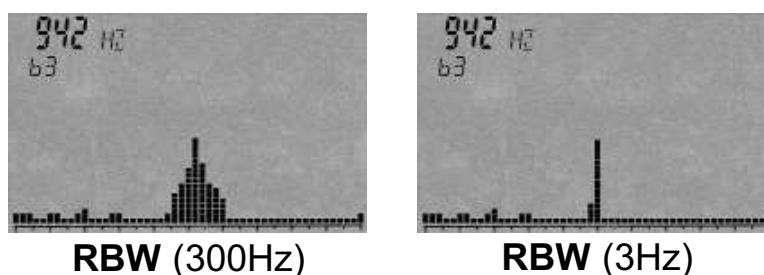
HINT: To accelerate measurement of small frequency ranges with extremely small filters, **DFT**-FFT mode is **automatically** activated when using a SPAN between **10-200Hz** and a **0,3Hz**, **1Hz** or **3Hz** filter. Thanks to this mode, **significantly** faster sweep times can be achieved in spite of extremely narrow filters.

7.6 Dim (1D, 2D or 3D measurement) [Key 7]

The "Dim" setting determines in how many dimensions you want to measure magnetic fields: 1-dimensional, 2-dimensional or 3-dimensional (isotropic) measurements are available. Naturally, measurements will be slower in 2D or 3D as the number of sweeps (and therefore the total sweep time) necessary increases 2- or 3-fold to complete a measurement. However, units equipped with DDC (Option 005) will be as fast in 2D as in 1D mode, as two channels can be used simultaneously. Likewise, in 3D mode, sweep time is only double the normal sweep time instead of triple without DDC.

Further related information can be found in "Measurement in 1D, 2D or 3D".

7.7 VBW (Video filter)

The so-called **Video filter** is intended for **optical** smoothing of the signal. The lower the **Video filter** setting, the broader and "smoother" becomes the display of the signal . Using this filter, you can mostly suppress unwanted noisefloors, harmonics or sporadic peaks. However, with a low **Video filter** setting, the display can become less meaningful. In our example, there might be there **three** separate signals. However, the low video filter straightens these signals out to become **one** single "smooth" signal. The alleged noise band around the signal has also been "smoothed out". Thus, when dealing with weak signals, the **Video filter** should be used only at a higher setting.
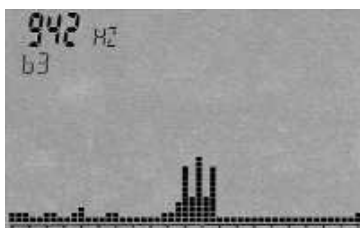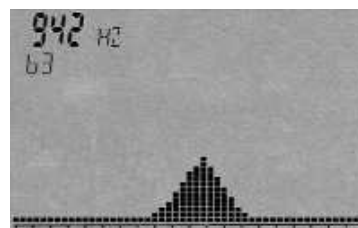
VBW=3Hz   **VBW**=300Hz

7.8 SpTime (Sampletime) [Key 8]

Determines the **time per sample**. As a single sweep consists of several samples, total sweep time is a multiple of the sampletime. The higher the **sampletime** setting, the more accurate the measurement, however, the longer it will take. You can enter values either in **mS** (milliseconds) or **S** (seconds). Possible values range from 0.001 to 999.9. The longer the Sampletime, the more accurate the measurement.
Please note: The maximum usable sampletime in DFT mode is 5s. The maximum sampletime in non DFT-mode is 240s.

7.9 Reflev (reference level) [Up/Down arrow keys]

By setting the so-called **reference level**, you can adjust the position of the displayed signals in relation to the upper screen edge (the so-called reference level). This feature can be uses to eliminate visually distracting background noise or other small signals from the display so that only the "peaks" of the strongest signals remain. Other signals will be "cut off" at the bottom. Available options are:

Auto
Unit
m-Unit
µ-Unit
n-Unit

Reflev (reference level)
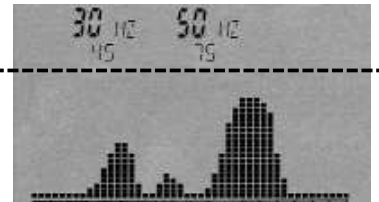
With the **Auto** mode (default), SPECTRAN will **automatically** calculate the optimum reference level AFTER taking the sweep (this might be corrected during the next sweep), by taking into account the highest measured signal level. A very convenient feature especially when the signal level is not known.

However, automatic adjustment cannot always provide "optimal" scaling: By constantly changing the reference level, the display can always keep "jumping", which might be interfere when doing slow sweeps. Another problem is, that background noise would be displayed as a "full signal" when there is no other signal. To alleviate this problem, you can set a **fixed** reference level by using one of the **Unit**, **m-Unit**, **µ-Unit** or **n-Unit** settings and get a "background-noise less" display. With these settings, the reference level will be set according to the physical unit selected in the **UNIT** menu (see also 7.15). For example, if you are measuring in Tesla, using the **m-Unit** setting will set the reference level to **1mT**. In theory, only signals stronger than 1µT and below 1mT will be displayed (in practice, however, due to the low resolution of the LCD, 20µT is a more realistic).

If you would like to display signals smaller than 1µT again, please just change the reference level accordingly:

-------------------------- 1T (Unit)

Reflev (reference level) --------------------------- 1**m**T (m-Unit)

-------------------------- 1**µ**T (µ-Unit)

-------------------------- 1**n**T (n-Unit)
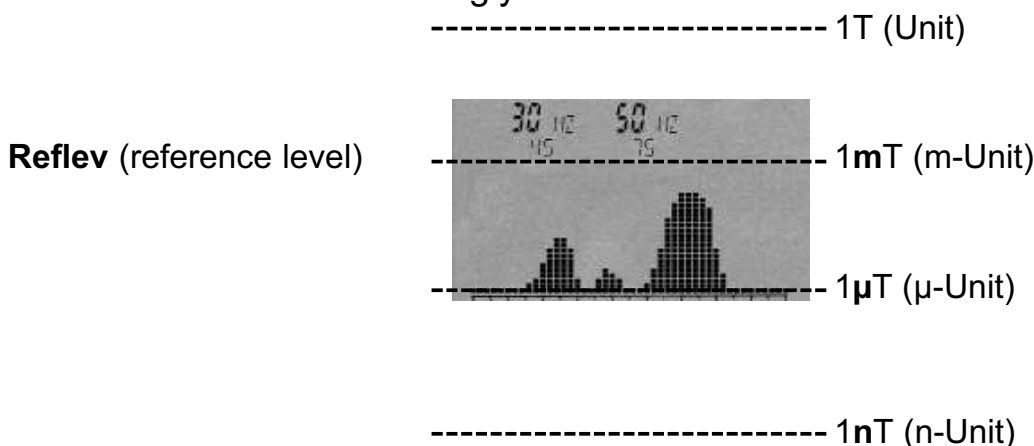
7.10 Range (dynamics)

The **range** setting determines the "scaling" of the visible part of the spectrum. It also provides **linear** and **logarithmic** display modes.

In the linear display mode, level changes of weak and strong signals are visualized equally, without artificial scaling/distortion.

To visualize very weak signals more clearly, you can use the logarithmic display mode, where small level changes will result in large changes in the graphical display. Furthermore, the stronger the signal becomes, the more "compressed" it will become in the display. But please note that changes in very strong signals will not be as clearly visible as with linear mode: the display is distorted to better visualize small level changes in very weak signals.

Linear = linear display

l**og10** = logarithmic display with maximum enlargement

log100 = logarithmic display with medium enlargement

lg1000 = logarithmic display with optimum overview

Setting the range to lg1000 (maximum) provides the clearest possible overview of all signal sources. The lg100 and lg10 settings in turn provide more detail, however, parts of the signal sources above or below could now be "cut off". The **range** setting can be therefore compared with a "magnifying glass" that only affects the Y axis. The vertical bars caused by the individual signals are virtually "squeezed" in order to be able to display them all.

Range (dynamics)
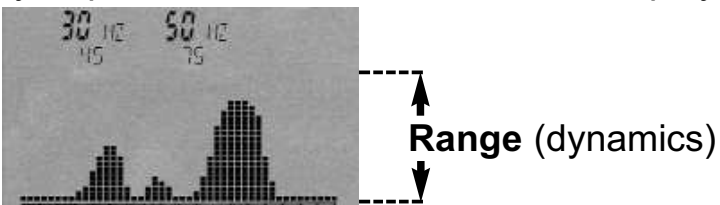
7.11 Atten (attenuator) [Key 0]

An **attenuator**, as the name implies, attenuates the signal by the corresponding amount in dB. This makes sense particularly with very strong signals, for example, to avoid overloading the external SMA input. Possible choices are:

Auto = An appropriate attenuator is chosen automatically (10dB and 20dB)

0dB = No attenutator (highest sensetivity)

10dB = Attenuate input signal by 10dB

20dB = Attenuate input signal by 20dB (only NF-5020/5030!)

30dB = Attenuate input signal by 30dB (only NF-5020/5030!)

40dB = Attenuate input signal by 40dB (only NF-5020/5030!)

NOTE: You **always** have to set the 0dB, 30dB and 40dB attenuator manually. They will **not** be set with the "Auto" function!

7.12 Demod (demodulator/audio output)

The **demodulator** allows you to audibly reproduce pulsings and modulations of up to approx. 3.5kHz. SPECTRAN offers two **modulation modes**:
AM (**A**mplitude **m**odulation) and **FM** (**F**requency **m**odulation). You can switch between "**AM**" **and** "**FM**" at any time by pressing the dot key. By selecting **Off** or pressing the menu key, the **demodulator** can be turned off.

Please note that in oposition to the usual broadband detectors, **demodulation** only occurs around the **center frequency**! The **bandwidth** is adjustable using the **RBW** setting. Hence, you can selectively "monitor" small frequency ranges. However, in this mode, the filter is slightly "softer" compared to other modes, so unwanted strong signals on neighbouring frequencies might audibly "spill" into the currently selected frequency range.

This frequency-exact, selective "acoustic evaluation" can be helpful when identifying signal sources. As **demodulation** occurs in real-time, it is also perfectly suited for locating signal sources very quickly.

7.13 Detec (RMS or MinMax detector) **[Shift key]**

Here you can choose between two different detectors. Possible choices are:
RMS (Default)
MinMax
This mode allows you, for instance, to find out if a certain signal is modulated: When the displayed signal level is larger in MinMax mode than in RMS mode, the signal must be modulated. If both modes show a nearly identical display, the signal is unmodulated.
HINT: You can change the detector at any time by just pressing the Shift key.

7.14 Hold (activate HOLD mode)

By selecting **On** you can activate **HOLD** mode, indicated by the word "HOLD" in the status field. Likewise, **Off** turns it back off.

In **HOLD** mode, the spectrum display does **not** get erased, thus **all** measured signals stay visible **at all times**. **Only** signals **stronger** than those already recorded will be able to overwrite the display.

Likewise, only the highest markers since the last activation of **HOLD** mode will be displayed, including frequency and field strength/voltage. **HOLD** mode turns SPECTRAN into a very sophisticated tool - it is really an "**ADVANCED** HOLD": You can use this mode for creating **full-day diagrams**: Just leave SPECTRAN in HOLD mode for, say, 24 hours, and the next day you will be able to check what exactly happened in the past 24 hours. This way, you can also use

SPECTRAN as an **"EVENT RECORDER"** for recording intermittent signals: just leave SPECTRAN running in **HOLD** mode until the requested event occurs. **HOLD** mode is also indispensible for conducting measurements according to the **panning approach** (see also the section about "correct measurement")
Another application where **HOLD** mode is **extremely helpful** is **exposure limit calculation**: You can use data acquired in **HOLD** mode for quick and easy comparison of exposure limits. You do **not even** need to start a new measurement, as all markers and other relevant information are preserved. Please just switch to **exposure limits** mode after measurement, and the corresponding result is displayed immediately.
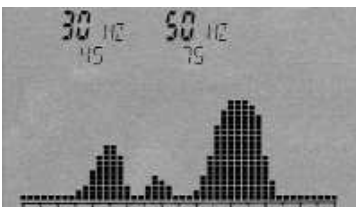
A typical measurement result after evaluating a room for 20 minutes with **HOLD** mode active. You can clearly see that only two main signal sources / frequency bands have been detected during the entire measurement (30Hz and 50Hz).

HINT: You can switch **HOLD** mode on and off at any time by pressing the dot key (switching it off deletes the HOLD memory).

ATTENTION: Please note that when using the Reference Level "Auto" setting in combination with HOLD mode, the spectrum display can quickly get "filled up" because of the automatic scaling. Such a combination of settings is generally of limited use.

7.15 Unit (Select physical unit)
The **Unit** setting allows you to specify the physical unit used to display measurement results. Options are "Tesla", "Gauss" and "A/m". Two further options, "Volt" (external SMA connector) and "V/m" (E-field sensor) are automatically chosen when the corresponding sensor is selected.

Hint: In "EXPOSURE LIMITS" mode, the measurement result additionally gets displayed as a figure and bargraph. In this mode you can display the result with **two units AT ONCE** (for example, Gauss and Tesla SIMULTANEOUSLY).

Hint2: You can even use this feature for **conversion** of units. Simply "freeze" the current reading by using HOLD mode, then choose a different unit. The conversion result will be displayed immediately (as far as physically possible).

7.16 UScale (Set scaling of physical unit)

UScale allows you to choose the prefix of the physical unit.
Selecting "Auto" automatically selects the prefix ("p", "n", "µ", "m", "k"). However, you can also set a fixed prefix, where possible options are: "p" (Pico), "n" (Nano), "µ" (Micro), "m" (Milli), "Unit" (only full units WITHOUT prefix) and "k" (Kilo).

7.17 MrkCnt (Set number of markers)

MrkCnt is used to set the number of markers. Possible values are 1,2 or 3.
If you only need to measure one frequency you should reduce the number of markers to "1". Then you will get a very stable display with no "jumping" markers after every sweep.

7.18 MrkLvl (Set starting level of markers)

MrkLvl is used to set a specific signal strength from which **markers** are generated and **exposure limit calculations** are performed. Available settings range from 20% to 80% and correspond to the relative height of the peaks in the bargraph display.

At the 80% setting, **markers** are only generated with relatively strong signals, compared to the 20% setting, where far weaker signals, but also potential interference, are shown as **markers**. The default (60%) offers the best balance of both extremes in most cases.

7.19 MrkDis (Marker display mode)

The **marker display mode** determines how markers are displayed. As the available display space for showing markers very differs in size and readability, two different modes are available:

Freq. (frequency) displays the frequency of each marker in the large display. Its amplitude (or similar applicable property) is small displayed beneith the frequency.

Ampl. (amplitude) displays the amplitude (or similar property) of each marker in large, and the frequency in the smaller display field. Usually, the **Freq.** mode will be preferred as the frequency usually is the most important piece of information and therefore should be the most readable as well.
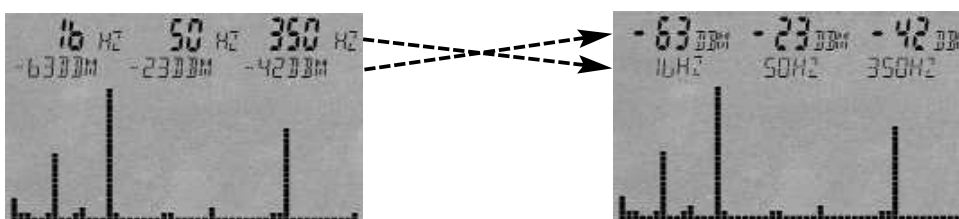
Freq. (larger frequency display)   **Amp.** (larger amplitude display)

7.20 Bright (Set display brightness)

The **Bright** option allows you to change display brightness. Simply turn the Jog Dial until the desired brightness level is reached, and confirm the setting by pressing the Enter key. The new setting will be permanently saved.

7.21 Logger (Invoke recording/data logger) (not active)

With the **logger** option, you can start a long-term recording in the current frequency range (NF-5010 and better). The logger will regularly record the strongest signals together with their frequency and amplitude over a freely adjustable timespan. This feature can be used, for example, to create perfect **full-day diagrams**. After processing this data, for example by using a PC-based spreadsheet software, you could end up with a graphic similar to the one shown on the left.
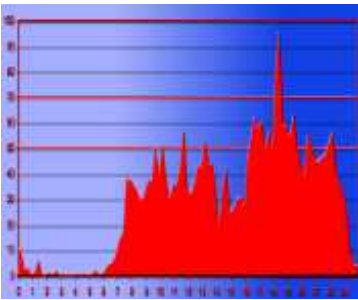
After activating, the device will query the following parameters:

"**Count**" =   Enter the **number** of logs (recorded events)
"**Time**" =   Enter the **duration** of the pauses between the individual logs, in seconds.
"**FILEId**" =   Enter the **program number** used to store the recorded data. This number is later used to download the recorded data using our PC software. **ATTENTION! Currently, our PC software only supports program number "1000"!**

After setting "**FILEId**", the memory status field will show "**RECORD**" and the logger is „armed". Press the menu button again, and the recording will start. After each recorded event, the remaining number of events to record will be displayed briefly in the pixel display (counter) to estimate how long the recording will take. Furthermore, a short beep will be emitted each time when an event is recorded. When recording is finished, "**RECORD**" will disappear from the memory status field. The recorded data can now be downloaded using the PC software "LCS": Launch in the LCS software the "File manager" in the "Extras" menu and click on "logger data" in the "Spezial" directory. Logger data is then immediately displayed as a table (first column amplitude in dBm, second column frequency).
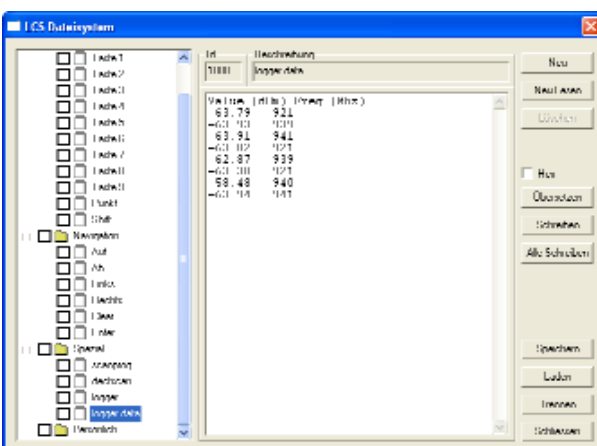
By using the standard "Copy and paste" feature, you can now transfer the data for further processing, for example, into a spreadsheet application.
ATTENTION: Please note that depending on the size of data, downloading and displaying all data can take some time. dBm values are transfered with two decimal places.

ATTENTION: Please note that the internal 64K memory can quickly get filled up. Consequently, we **strongly** recommend our 1MB memory expansion (**Option 001**) for using the logger-function.

7.22 RunPrg (Run program)

SPECTRAN features its own file system which is loaded with various programs. You can even write your own programs and store them right there. Also, saved SETUPs (see the following paragraph) use this program feature. Every program is stored with a specific number. When using this function, any of these programs can be recalled and executed by just typing its number.

7.23 Setup (Configuration)

Use **Setup** to manage individual configurations and programs.

The **Store** option will save the current configuration (fLow, fHigh, RBW, VBW, SpTime, Atten, RefLev, Range, Detec) as its own little program. Please enter a number **above 200** to store configurations. The previously described **RunPrg** function can be used to recall a configuration. **Del** deletes a previously stored configuration: please just enter the corresponding program number.

Factor recalls the factory settings. **This option is especially useful for unexperienced users having "messed up" the device's configuration.**

Attention: Please note that you can only store full kHz frequency values with the **Store** comand but if you use our free LCS PC-software there is not such a limitation. With the PC software you can store much more values like used sensor, unit, scale etc.

HINT: When using program numbers **100** to **109**, you can directly recall the corresponding program using **keys 0 to 9**! However, the previous key assignment will be overwritten.

8.1 Noise floor

The so-called noise floor indicates the lower range limit below measurements become physically impossible. Only interference can be found below this limit. Visually, this will be shown as a collection of little "dots" or bars in SPECTRAN's display which either stay at fixed places or change with every sweep (noise). **Depending on the actual frequency, however, the noise floor can very vary**. Usually the noise floor will increase significantly in lower frequency levels. For example, the noise floor at 50Hz (mains power) is significantly stronger than at 500Hz. This is often called the "0Hz spike":
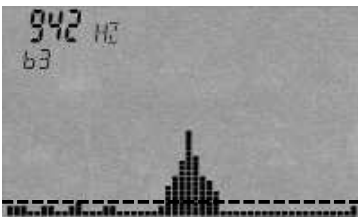
↓ **Noise floor** (below this imaginary line)

8.2 The 0Hz spike and the noise floor

When using a spectrum analyzer, the closer you get to a "frequency" of 0Hz (the so-called 0Hz spike), the stronger the **natural noise floor** becomes and the worse the measurement accuracy will be. Measurements quickly hit physical limits in this range. To achieve still the best possible sensitivity, at least the **residual noise** of the amplifiers, i.e. the measurement electronics themselves, has to be kept to a minimum by using only high-grade, **extremely low-noise amplifiers** like in SPECTRAN, which actually goes quite close to the actual physical limits.

When doing measurements close to 0Hz, pay attention to the following recommendations:

The closer you get to the 0Hz spike, the stronger the "received" noise and the less accurate the measurement:
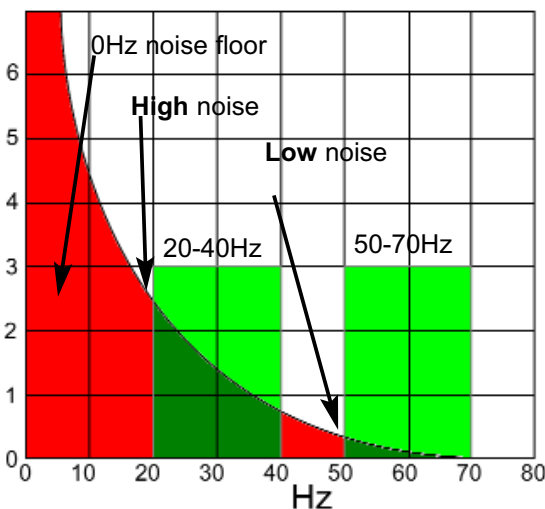
The simulated graph shows the 0Hz spike as a steep curve starting at 0Hz (left side) which quickly flattens towards higher frequencies.

Also visible: the simulated sweep from 20-40Hz results in a much higher value of background noise (about 2,5) than another from 50-70Hz (0,2) even though the SPAN of both sweeps is identical.

Always use the smallest possible SPAN when measuring close to the 0Hz spike in order to reduce the noise floor:
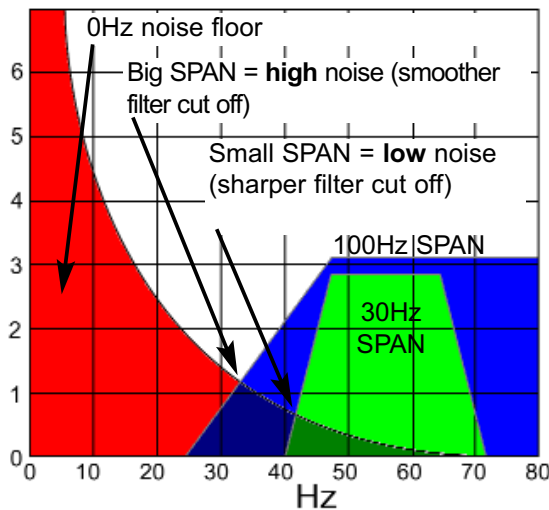
The SPAN itself also influences the strength of the noise floor due to the steepness of the filters. These become smoother with a bigger SPAN and also start capturing "neighbouring" signals.

While this hardly matters with "higher" frequencies, the difference much more significant near the 0Hz spike. In spite of an identical starting frequency setting, the noise floor is much stronger with a bigger SPAN than when using a small SPAN.

Try to avoid measurements near the 0Hz limit whenever possible.

Try not to use 0Hz as starting frequency.
If possible, try to measure from **1kHz** or, even better, **10kHz** to 100kHz instead of **0Hz** to 100kHz. Spectrum analyzers try to dampen the noise floor close to the 0Hz spike when doing large sweeps that start close to 0Hz. This has the side-effect of a very low sensitivity in the "lower frequency range". Thus, do not expect a 50Hz signal to be measured correctly when using a sweep of 0Hz to 100kHz.

However, should you despite of this wish to measure close to the 0Hz spike (for example, 50Hz mains or 16.7Hz traction power), you should use the smallest possible filters (0,3Hz, 1Hz or 3Hz). However, this naturally leads to an extremely slow sweep. As this is not very practical, we have developed a very fast sweep mode for exactly this case: the **DFT** sweep. Basically, it uses FFT, but avoids its typical aliases. DFT mode is **automatically** activated if both of the following apply:

a) The 0,3Hz, 1Hz or 3Hz filter is used
AND
b) a SPAN smaller than 200Hz, but at least 10Hz is chosen
In the current software revision, there are still two further restrictions:
c) only use SPANs which are multiples of 15, like 15Hz, 30Hz, 45Hz etc.
d) always use a SPAN which is SMALLER than the difference between 0Hz and the chosen starting frequency "flow". Otherwise, you will get erroneous results.

Examples:

flow=30Hz and fhigh=60Hz (SPAN=30Hz): OK (ex.: **50Hz mains**).

flow=15Hz and fhigh=30Hz (SPAN=15Hz): OK (ex.: **16.7Hz traction power**).

flow=29Hz and fhigh=59Hz: WRONG. The distance to 0Hz is too small compared to the SPAN. It is 29Hz, but the SPAN is set to 30Hz. The distance to 0Hz should be therefore at least 30Hz.

flow=16Hz and fhigh=30Hz: WRONG. The SPAN is not a multiple of 15 (as it is set to 14Hz), resulting in WRONG measurement results.

Also see the chapter on "DFT mode (rapid measurement with 1-3Hz RBW)"

8.3 Choosing the right filter (RBW)

The correct filter setting depends on various factors, among them the selected SPAN. Usually, the filter should be SMALLER than the selected SPAN, as otherwise, signals outside the (visible) SPAN will be also received and erroneously displayed, which is only tolerable in very rare cases. Most of the time, a filter at least 10 times smaller than the SPAN should be chosen. For example:

SPAN=100Hz; set filter to 10Hz (or smaller)

SPAN=500kHz; set filter to 100kHz or 30kHz (or smaller)

However, note that the selected filter directly influences the sweep speed and display accuracy: the larger the selected filter, the faster the sweep but the less accurate the display.

The following illustrations explain the filter problem, assuming a sweep from 50 to 60 kHz. The grid lines show the visible range:

Graphical approximation of the 10 **1**kHz filter

10µT signal at 46kHz

1µT signal at 58kHz

50-60kHz

Good visible:
The 46kHz signal outside the visible sweep range is not taken into account, as the 1kHz filter only "catches" a small frequency band outside the visible 50-60kHz sweep range. **The display would show the right value of 1µT.**

Graphical approximation of **30**kHz filter

10µT signal at 46kHz

1µT signal at 58kHz

50-60kHz

In contrast, when using a 30kHz filter, the 46kHz signal outside the visible sweep range will be caught as well, as the wide 30kHz filter will also encompass a wide range outside the visible 50-60kHz sweep. **The display would show a wrong value of 10µT.**

Do you like however to perform a very accurate level measurement, you should not set the filter bandwidth too narrow, as very narrow filters can, due to the inherent phase noise, display levels lower than actually present.
For example, consider measurement of a signal at 100kHz, using a 10kHz filter. Changing to a 3kHz or 1kHz filter might not cause any significant change in the displayed level. However, at some point, for example with the 300Hz or 100Hz filter, the displayed signal level will suddenly drop slightly, thereby delivering an incorrect readout due to phase noise.

8.4 Choosing the right Sampletime (SpTime)

If you want to measure levels it is **very important** to choose the right sampletime. If you use a to small sampletime you can get to low level results. Especially if you use low filter (RBWs) you have to set the sampletime quite high (depending on filter even up to a view seconds).
The right sampletime depends on the used Filter (RBW). You should set the following RBWs and sampletime:
10Hz=70s, 30Hz=30s, 100Hz=7s, 300Hz=3s, 1kHz=700ms etc.
If the Span is bigger then 20 times the RBW you must use a higher sampletime!
Please note that the sampletime in DFT mode (1Hz and 3Hz filter) is limited to 5s. A too small sampletime in DFT mode is easy to detect: The levels will frequently change a lot after each sweep. If you use our free PC-Software you will then see a "snake like" graph in the spectrogram window. Simply change the sampletime to a higher value until you get a stable reading after each sweep.

8.5 Measurement of electric fields & all fields above 500kHz

Correct measurement of potential-free electric fields or magnetic fields above 500kHz requires a bit of technical knowledge, as measurement results can quickly become inaccurate due to objects in immediate proximity, such as walls, trees, or the operator her-/himself. Consequently, please take care of the following:

- You should maximize the distance between your body and the measurement instrument. **Consequently, you should measure by using a non-conductive, wooden tripod or similar,** and increase the distance between your body and the device to about 1-2m. Also, please note that these fields quickly diminish in proximity to the floor. Thusly, most measurements of electric fields are carried out at a height of about 1-3m above the floor. Should you wish to measure with the instrument in your hand anyway, you should only measure with your arm extended. Also, only handle the device by its tail end, as the sensors are located close to the front of the case. **However, please note that the measured values will be 3 to 4 times too**

large when doing such a "manual" measurement!

- Be sure that no other persons are near by where you make your measurements, as they could influence the results.
- The device and the used tripod must not be covered by dew. This could lead to extremely inaccurate results.
- Operation with connected USB or audio cables or the included power supply can distort the field and lead to extremely inaccurate results. Always measure with battery supply and without any cables connected.
- Use the "panning approach" to determine the E-field maximum as the E-field sensor can only measure in one dimension. Otherwise, wrong (too low) levels could be measured. This is especially possible, when several wires, signal sources or various other sources of interference are occuring. On the other hand, should you measure a single subject, such as a free-field high voltage line, the measurement inaccuracy without the panning approach is often below 5% and therefore often tolerable.

WARNING! Please note that various so-called "construction biologists" and their "measuring instruments" <u>wrongly</u> measure **potentials** with ground reference. **This approach violates any applicable EMC security standards and is thusly WRONG and legally worthless!**
Consequently, the results obtained from such "measurements" are **not** comparable at all to results obtained with SPECTRAN, as SPECTRAN measures <u>according to standards</u> (**potential-free**, without ground reference).

8.6 Sensitivity

Please be aware that with spectrum analysers, the noise floor and sensitivity **is subject to significant fluctuations** depending on the frequencies measured. In general you can say: the lower the frequencies, the higher the noise floor and the worse the sensitivity. In practice: **Using the same filter settings, for example, "100kHz", you can measure significantly weaker fields than at the "50Hz" setting.**
Also see the section "The 0Hz spike and the noise floor"

8.7 Measurement inaccuracy

Aaronia provides a **typical** accuracy rating for each SPECTRAN model.
However, this also means that higher deviations **could** happen.
Especially when approaching the so-called noise floor or the highest measurable levels, accuracy will **naturally** decrease.

Even though SPECTRAN instruments already are impressively accurate consi-
dering their price, **in practice** an even higher measurement inaccuracy than the
one specified for the instrument has to be assumed. There are various reasons
for this, such as temperature dependance, reproducability and many others.
This has to be taken into account at every measurement.

8.8 The cursor and zoom features

In *spectrum analysis* mode, you can use the **Jog Dial** to
activate a cursor. This cursor allows you to determine the
exact frequency and signal strength at an arbitrary point
in the display. To activate the cursor, simply rotate the Jog
Dial and the cursor will appear as a thin line in the spec-
trum. To deactivate it, simply press the menu key twice.
The part of the display covered by the cursor gets drawn
in reverse colour, thereby preserving its information.
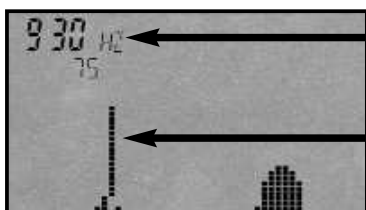
Frequency and **level**
at the current cursor position

Cursor
Parts of the graphic covered by
the cursor are drawn inverted

By rotating the Jog Dial, the cursor can be placed at any desired position on the
display. The readout on the large main display, the exposure limit display and
demodulation now EXCLUSIVELY represent the frequency at the current cursor
position! The current frequency and level display at the cursor position only get
updated **after** each sweep and are displayed in the first (leftmost) marker field.
Naturally, no auto marker functionality is available in this mode.

Once you have positioned the cursor, you can **zoom into** a signal by **pressing**
the Jog Dial. This will set the CENTER frequency to the current cursor positi-
on/frequency, halve the SPAN and initiate a new sweep. In other words, you
zoom into the signal by 50%. This procedure can be repeated as often as you
wish until the desired resolution has been reached. A very useful feature. But
please note that a zoom back out is not possible.
You can turn off the cursor by pressing the menu key twice.

ATTENTION: The cursor should NOT be used in HOLD mode, as it will not be
erased (just like the rest of the display) and thus produce an entirely "black" and
useless display very quickly!

8.9 DFT mode (rapid measurements with small RBWs)

All series 50xx SPECTRAN models feature a "superfast" **DFT** mode (**d**igital **f**ourier **t**ransformation). **DFT mode is <u>automatically</u> activated when the following settings are used:**

a) an RBW of 0,3Hz, 1Hz or 3Hz

AND

b) a SPAN smaller than 200Hz (with 10Hz being the minimum)

The DFT mode allows a significantly faster sweep when using extremely narrow filters and is especially suitable for measurement of mains power (50Hz) or traction power (16.7Hz). In contrast to regular FFT, **DFT** does NOT produce the infamous aliases known from FFT.

ATTENTION: For quick <u>searching</u> of signals, you could even use a **too low setting** for sweep time in DFT mode. This allows very fast sweeps, but inherently may produce **wrong results**. For preventing users from misinterpreting these, the **UNCAL display** is automatically activated as soon as a too short sweeptime is chosen, indicating that measurement results are not reliable. However, it is still possible to locate quickly a signal source or verify its presence.

More information on DFT mode can be found in the section"The 0Hz spike and the noise floor".

8.10 Choosing the right attenuator

SPECTRAN contains a highly accurate internal attenuator, allowing the attenuation of input signals to prevent overdrive of the internal amplifier.

Without using the attenuator, serious measurement errors and even destruction of the internal amplifier could occur. To choose the right attenuator for your measurement, proceed as follows:

Initially, always select the highest attenuator (40dB) and, if there is a usable readout, remember its value. Afterwards change to the next smaller attenuator (30dB). If the new readout value is significantly lower than the previous one, the amplifier is already suffering from overdrive, so you should change back to the higher attenuator. However, should the readout be almost identical, this attenuator is the correct choice.

Further indications of having chosen the wrong attenuator is an unsteady readout and a cluttered graphical display.

When supplying **external signals** via the **SMA connector**, we recommend the following attenuator settings (100kHz signal):

>=1mV: **10dB**, >=5mV: **20dB**, >=10mV: **30dB**, 50mV and above: **40dB**.

When measuring magnetic fields by using the internal sensor, the attenuator should be configured as follows:
>=200nT: **10dB**, >=700nT: **20dB**, >=2µT: **30dB**, 7µT and above: **40dB**.

8.11 The Autorange function

Magnetic fields are measured in Tesla or Gauss, electric fields in V/m. However, as these fields can quickly vary in lots of factors and SPECTRAN additionally provides an extremely wide dynamic range, display of all possible levels would require a huge display with DOZENS of digits. To allow an usable readout with just 4 digits, SPECTRAN provides the "Autorange" function which is popular in professional measurement technology. SPECTRAN simply prepends an internationally standardized prefix to the actual value:

k = 1000 (Kilo=thousandfold)

m = 1/1000 (one thousandth)

µ = 1/1.000.000 (one millionth)

n = 1/1.000.000.000 (one billionth)

p = 1/1.000.000.000.000

Let's use 0.000,000,797 T as an example. This huge row of zeroes can simply be replaced by one of the prefixes above, which simplifies the display enormously. One possible illustration would be 0.797**µ**T (0.7 **millionth** of a Tesla), another 797**n**T (797 **billionth** of a Tesla). As this example clearly shows, the readout would literally drown in a huge pile of "zeroes" without the autorange function. However, using the "**µ**" or "**n**" prefixes, display is still accurately possible even with just 4 digits.

This of course also works with very large values, like 20,000 V/m. Here, the display would just show 20**k**V/m (20 **kilo**Volts/meter).

SPECTRAN automatically changes the prefix used, you do not need to make any manual adjustments.

8.12 Spurious

Because of the very high sensitivity of the SPECTRAN, the internal probes can even measure the very low emissions of its own circuits. Typical are multiply signals of 1,6MHz (3,2MHz, 4,8MHz etc.), which is the frequency of the onboard switching power supply, and multiply signals of about 128kHz (256kHz, 378kHz etc.), which is the LCD clock. With the E-Field sensor you can also measure multiply 65Hz signals which is the refreshrate of the LCD.

Usually all those signals are very small and should not disturb any measurement. Anyway we will add a function in one of the next software revisions to remove them automatically.

Measurement of static magnetic fields (Option 006)

Activating the sensor
To measure static magnetic fields like the earth's magnetic field or that of regular magnets, you will need our internal static magnetic field sensor (option 006). Static mode is automatically activated when you set **fLow=0Hz** and **fHigh=0Hz**. Now, choose the sensor and/or axes in the **SENSOR** menu (or key 6). Available choices are (**X**-MSta, **Y**-MSta, **Z**-MSta). Obviously, as a static magnetic field has a frequency of 0Hz, there is no **spectrum** display. Instead, a **time domain** display is provided (if the selected sampletime is above 77mS), i.e. level changes are displayed on a time axis. The speed of this time domain display can be changed in the SpTime menu (or key 6). If you set the sampletime lower then 77mS you will get a direct level display instead. Setting up the sampletime can be done in the menu SpTime (key 8).

The measurement
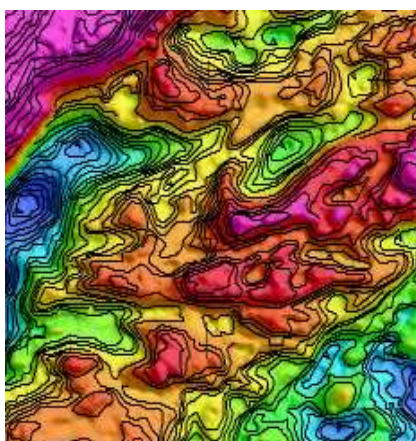
The earth is a huge magnet surrounded by a magnetic field. The magnetic flux density varies between 30 µT and 60µT depending on your location. In Germany, a flux density of approx. 45µT is common.

This so-called geomagnetic field can be drastically influenced by construction materials in buildings. Therefore the results of indoor measurements will differ significantly depending on the location.

Even "in the field", measurement results can differ widely as the earths geophysical characteristics distort the magnetic field. That's why even detailed maps of the geomagnetic field are available (see image example).

Distortion of the geomagnetic field due to a bigger metallic obstacle, such as a spade, can still be detected by SPECTRAN even from some distance.

The 24Bit option (option 009) increases the sensitivity <u>yet further</u> and allows the detection of even very minimal changes. Therefore it is perfect suitable for geomagnetic analysis or for accurate measurements of regular magnets.

Currently, the static magnetic field sensor does not have a zero reference, i.e. it can only display DIFFERENCES in field strength. A zero reference and consequently a calibration is only possible with our zero-gauss-chamber. Then even the direct value of static magnetic field can be displayed.

Measurement in 1D, 2D or 3D

All SPECTRAN models feature an integrated 3D measurement coil which allows isotropic measurement of magnetic fields in all directions (axes) at the same time. You can also choose whether you want to measure in only 1 axis (1D), two axes (2D) or in all 3 axes (3D) simultaneously.
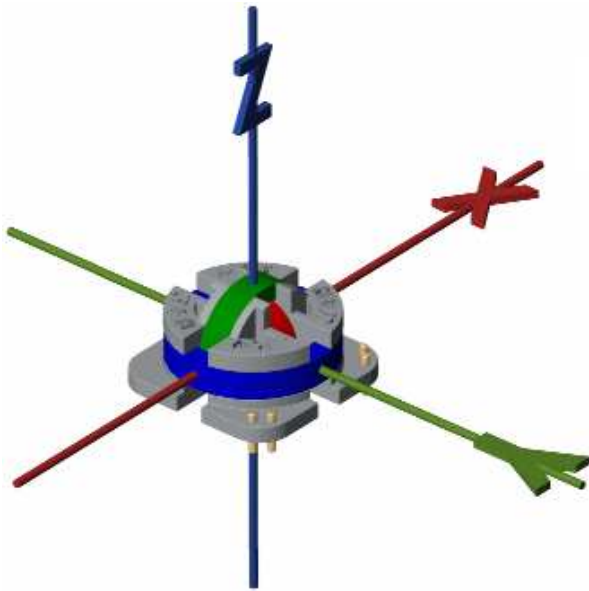
Likewise, you can also adjust the number of axes when measuring with the optional sensor for STATIC magnetic fields (option 006).

When doing measurements in all three axes (a so-called isotropic measurement), the spacial orientation of the measuring instrument has no influence on the measurement results. Therefore, wrong orientation of the measurement instrument and thus wrong measurement results become impossible. The only disadvantage of this technology is the higher sweeptime. A 2D or 3D measurement will generally be slower by nature, as obviously the number of necessary sweeps will increase 2- or 3-fold. However, should your instrument be equipped with the DDC option (option 005), the sweep times in 1D and 2D mode will be the same, as two channels can be measured at the same time. In 3D mode, likewise, sweep time will only be twice as long as in 1D mode, and not three times as long as when not using DDC.

Results of 2D and 3D measurements are calculated as a quadratic mean using the following formula:

$$3D\ (X+Y+Z) = \sqrt{X^2 + Y^2 + Z^2}$$
$$2D\ (X+Y) = \sqrt{X^2 + Y^2}$$
$$2D\ (Y+Z) = \sqrt{Y^2 + Z^2}$$
$$2D\ (Z+X) = \sqrt{Z^2 + X^2}$$

In the "Dim" menu (or key 7), you can select if you wish to measure in 1D, 2D or 3D. The default setting is "1D".

ATTENTION: Please note that during 2D or 3D measurements, both the main display **and** the spectrum display represent the **TRUE quadratic mean of the single axes**. Hence, it would be wrong to interpret the value shown in the main display as the quadratic mean of the displayed markers!

Aligning the internal sensor

E-field sensor

The sensor for **electric fields** only measures in one dimension.

You can achieve optimal results by making sure that the field goes through the sides of the device (Y axis), see picture.

The sensor is located in the upper left corner of the device (right below the AUDIO STATUS display).

H-field sensor (alternating magnetic fields)

The sensor for **alternating magnetic fields** can measure in 3 dimensions (isotropically). Thus, you will always get an accurate measurement independantly on how you align the device.

When measuring the X axis only, the magnetic field needs to be aligned that it goes through the front of the unit. Likewise, it needs to go through the sides for Y axis measurements, or through the top/bottom for Z axis measurements (see picture).

The sensor is located at the center of the device (below the INFO display).

M-field sensor (static magnetic fields e. g. magnets, geomagnetic field)

The sensor for **static magnetic fields** can measure in 3 dimensions (isotropically). Thus, you will always get an accurate measurement no matter how you align the device.

When measuring the X axis, the magnetic field needs to be aligned such that it goes through the front of the unit. Likewise, it needs to go through the sides for Y axis measurements, or through the top/bottom for Z axis measurements (see picture). The sensor is located in the upper left corner next to the SMA input (below the nameplate).

SPECTRAN offers the possibility to choose between several different physical units. You can select between various units for magnetic fields at any time in the "Unit" menu.

Possible choices are: **T**, **G** and **A/m**.

Measuring <u>field strength</u> [V/m; A/m; T; G]

When using **an antenna or sensor** instead of direct signal input to make measurements, yo mostly wish to measure field strength (instead of voltage or output).

SPECTRAN allows measurement of electric fields in V/m.

Magnetic fields can be measured in G (Gauss), T (Tesla) or A/m (Amperes/meter).

As the readout can quickly turn into a gigantic row of digits when measuring field strengths, SPECTRAN offers a very practical **autorange feature**: instead of an endless row of digits, it simply adds a corresponding prefix to the readout, such as **p**, **n**, **μ** or **m** (for example: **m**T).

Measuring <u>voltage</u> [V]

When using direct signal input via the SMA connector, you can directly measure the applied signal in Volts [V]. Input voltage can range from approx. **200nV** to **200mV**. The extremely high sensitivity of only 200nV allows measurement of even the weakest signals.

You can expand the measuerement range with our optional Differential Probe up to 240V! The probe also protects the input from to high voltage (up to 1500V). The probe is a "must have" if you want to measure DSL lines etc.

"Turbo" sweep

The basic factor behind sweep speed is of course the sample time. The smaller the sample time, the faster the sweep. However, the selected filter and SPAN settings also influence sweep speed: the broader the filter, the faster the sweep - the larger the SPAN, the slower the sweep.

Thusly, fast measurement of broad frequency ranges is only possible with large filter settings. Simply choose a different **RBW** setting. Also, don't forget to set **SpTime** to a smaller value. However, due to the higher filter bandwidth, the frequency display can be a bit less accurate than with narrower filters. Also, signals now need to be stronger in order to be still measurable.

Mapping keys with your own parameters and settings

Keys 0 till 9 can be also mapped with custom configurations (including start-/stop frequency, RBW etc.). Program numbers 100 till 109 correspond to keys 0 till 9 and can be used for assignment to these keys. Simply store the current configuration in one of these program numbers, using the menu entry **Setup** & **Store**. You will then be able to recall these settings at any later time using the corresponding number key. If you want even more convenience, you should use our PC analysis software "LCS" or „MCS", where you can additionally add practical notes to your settings.

You can always recall the factory settings using the menu command "Factor" in the "Setup" menu.

Exposure limit calculations and display with "weak" signals

In such a situation, simply set the marker level **Marker** to a higher sensitivity. The "20%" setting corresponds to the highest sensitivity.

"Conversion" of measurement results into other physical units

As you already know, using the HOLD feature, you can "freeze" a measurement result. After doing this, you can simply change to a different unit [T, G, A/m, dBm, dBµV] or [V/m, dBm, dBµV] and the old value will instantly be converted to the newly selected unit after you leave the menu. You can repeat this procedure as often as you wish. Very practical for a quick conversion from e. g. Tesla [T] to Gauss [G].

Correct settings for manual input/measurements

We recommend our PC analysis software "LCS" or „MCS" for such tasks. Here, you can find many optimized "profiles" from mains power to TCO99 or energy-saving lamps. In addition, information such as channel numbers etc. are also displayed. These parameters can then simply be "copied" and transferred to SPECTRAN.

However, we also have a special setting just for 50Hz/60Hz mains power:
Simply use **quick measurement via key 2**. In this mode, 50Hz resp. 60Hz signals from power lines, electrical appliances or high-voltage lines can be measured and displayed quickly and easily.

PC analysis

We offer you our FREE PC analysis software "LCS" and „MCS" for SPECTRAN at our homepage. Only this PRO application shows the full power which is inside SPECTRAN. You should use this software whenever possible to be able to fully and optimally use the power of your instrument.


14.1 Limits for personal safety

There are international recognized limits for power wires and the appliances connected to them, as well as various precautionary limits and recommendations. Depending on the country, professional sector or the various interest groups, however, they all can differ significantly.

The **German** exposure limits are dictated by the Regulierungsbehörde für Telekommunikation und Post (Reg TP, roughly: regulating body for telecommunications and post), which is a subsidiary of the Bundesministerium für Wirtschaft und Arbeit (BMWA, roughly: ministry of commerce and labour). Most national and international bodies recognize these recommendations. They are part of the German "26. BimSchV" (ordinance for electromagnetic fields) and follow the international ICNIRP recommendation.

The German exposure limits are intended for quadratic means of measurements taken during **intervals of 6 minutes** and subdivided by frequency ranges. Furthermore, there are seperate limits depending on the group of persons affected. As an example, we will use the limit for the "generic population":

Frequency	E-field [V/m]	H-field [µT]	M-field [A/m]
Below 1 Hz	-	40.000	32.000
1-8 Hz	10.000	40.000 / f	32.000 / f²
8-25 Hz	10.000	5.000 / f	4.000 / f
0,025-0,8 kHz	250 / f	5 / f	4 / f
0,8-3 kHz	250 / f	6,25	5
3-150 kHz	87	6,25	5
0,15-1 MHz	87	0,92 / f	0,73 / f
1-10 MHz	87 /$\sqrt{f}$	0,92 / f	0,73 / f
10-400 MHz	27,5	0,092	0,073
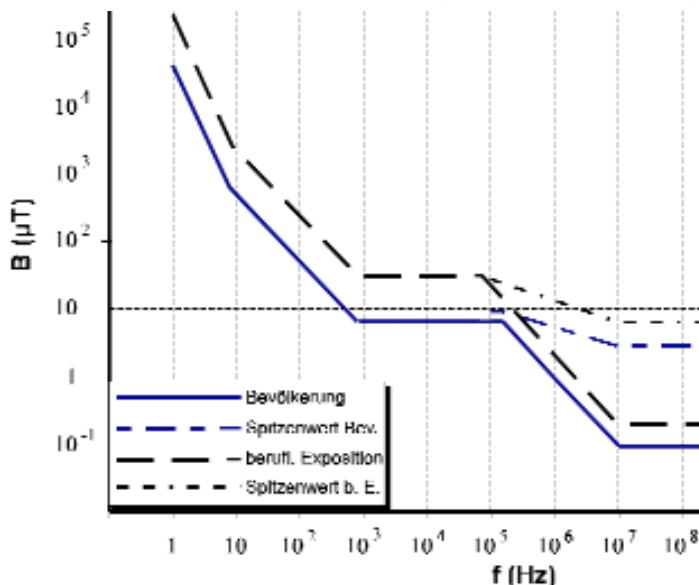
The chart on the left graphically represents, among others, the before mentioned formulas for H fields over a frequency range from 0Hz to 400MHz. **The curve clearly indicates that the widely used, cheap broadband testers CANNOT determine these exposure limits properly as they do <u>not</u> take signal frequency into account.**

Moreover, the significant differences of exposure limits for various groups of persons are clearly visible, as well as the corresponding "maximum values".
For EM fields at the workplace, there is a seperate prescription from the German "Berufsgenossenschaften" (BGV B11) which allows higher exposure for a short time period.

Mathematical examples:
The 50Hz power supply system (mains wiring, high-voltage lines) would have a maximum allowed electric field strength of under 250/0,050 = **5.000 V/m**.

In contrast, an energy-saving lamp with an operating frequency of 5kHz, the electric field strength may only be less than **87 V/m** - a big difference.

Those low-frequency fields with the highest impact in daily life are those caused by regular mains wiring and appliances operated very closely to the human body, such as electrical shavers and hair dryers. Contrary to popular belief, appliances such as TVs, computers and monitors are neglectible as they are mostly shielded very well (TCO99) or operated at "large" distances (TV) and thus, exposure levels are very low.

14.2 Device limits

In contrast to limits for personal safety, the so-called **device limits** are often SIGNIFICANTLY more restrictive and are subject to greater variations depending on frequency. For example, a hair dryers limit is totally different to that of a computer monitor - values may well vary by a factor of 100. **Nevertheless, all device limits must also conform to limits for personal safety and are a subset of those.**
A good example for device limits are the well-known monitor labelling schemes "MPR2" and the more stringent "**TCO99**", the latter of which will be outlined here. TCO99 recommendations are again frequency-dependant:

Frequency	E field [V/m]	H field [µT]
5Hz-2kHz	10	0,200
2kHz-400kHz	1	0,010

There is a vast difference to the personal safety limits outlined previously. However, it is noteworthy that the TCO99 recommendation also prescribes complex details of the measurement setup such as specific distances, antennas, number of measurements taken, monitor settings etc. for correct measurement.

14.3 "Construction-biological limits" & "Precautionary limits"

The **countless** "construction-biological limits" are vastly different from the official limits for personal safety - they are mostly **significantly** lower. To one's great surprise, however, they often do not have **any** "frequency component" (in contrast to the highly complex official ICNIRP limits, which are also legally binding in Germany). In other words, they are completely **identical**, for instance, at 16.7Hz (traction power) as well as 50Hz (mains).

Hence, technicians in professional measurement technology are astounded at this rather "strange" way to evaluate exposure limits, predominantly used by construction biologists. However, there is a simple explanation for this relatively simple way of evaluating exposure limits:

The "measurement equipment" used in this sector is predominantly based on the so-called "broadband/diode detector" technology. However, it is physically **impossible** to conduct **frequency-selective** measurements with these devices. Hence, **frequency-selective** construction-biological limits would simply not be manageable. In any case, this might change very soon thanks to SPECTRAN, as frequency should really not be swept under the carpet.

Even if supporting such trivial "precautionary limits" in a real measurement device, such as SPECTRAN, does bother us intensely, we decided to support at least the ECOLOG-institute and BUND "precautionary limits".

The following limits **can all be called up in "Exposure limits" mode by using the right/left cursor keys - they will be displayed instantly**:

ECOLOG = ECOLOG institute precautionary limit*   **0,1µT or 20V/m**
BUND = BUND precautionary limit for relaxation areas   **0,01µT or 0,5V/m**

Please note that these values could change at any time. Thus, please consult the respective entities when in doubt.

*Only applicable to 50Hz

## 12.0 SMA input (measurement of external signals)

Starting with the NF-3020, an SMA input is available. Here, you can connect arbitrary external sensors, like large, highly sensitive coils, specialized antennas or taps and similar devices. The incoming signal strength is then shown in volts.

This additional input allows a wide range of additional applications and converts SPECTRAN into a true all-round instrument. To activate the SMA input, simply press the **key 6** and select the **analog** sensor (the **Status display** reads "*ANALOG*").

The highly sensitive, ultra low-noise input of SPECTRAN (depending on model down to $0.74nV/\sqrt{Hz}$) has specifically been designed for measurement of extremely weak signals, thus the maximum allowable input voltage is very small. The maximum input voltage is 200nV to 200mV (0.2V) with a frequency of max. 30MHz (if the SPECTRAN is equipped with this option).

> **WARNING:** Be sure not to overload the input! The maximum allowable voltage is just 200mV (0.2V). Voltages more than 10V can destroy SPECTRAN's highly sensitive amplifier circuitry!

You can expand the measurement range with our optional Differential Probe up to 240V! The probe also protects the input from to high voltage (up to 1500V). The probe is a "must have" if you want to measure DSL lines etc.
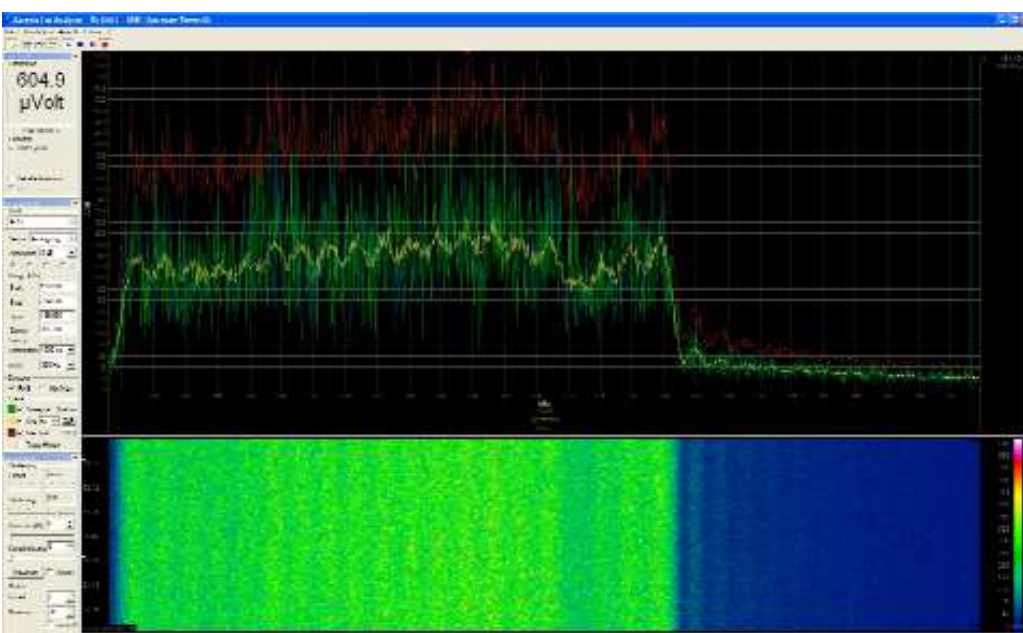
SPECTRAN as **DSL-Tester:** The Upstream of a DSL1000 line. Measured with a SPECTRAN NF-50xx with DDC and our active Differential Probe. Our free PC-Software "LCS" even shows the smallest change with extremly high resolution!

15.2 External DC input (battery charging)

All SPECTRAN RF measurement devices contain a high-performance battery package which is already installed in the unit. **However, this battery is not yet charged due to safety reasons**. Please charge it with the included charger. For this, connect it to your usual mains and plug the small phone jack into the DC input on the SPECTRAN. **Now turn OFF your SPECTRAN** and the battery pack will be automatically charged. Full charge is reached after about 24 hours for the standard 1300mAh battery, and about 36 hours for the 3000mAh version.

Operating with an external power supply:

As described above, the DC input is suitable for charging the internal battery pack. However, it can also be used for operating SPECTRAN independently of the internal battery pack.

You can also connect other **DC power sources** from **8V to 12V max.**, by using a 3,5mm phone jack. Polarization of the jack needs to be as follows:

The **inner conductor** must be "+", the **outer conductor** must be "-".

Using our optional car power adapter (see price list), you can also operate SPECTRAN devices in your car.

Should you wish to operate SPECTRAN via the wall power supply, please note that the power supply will cause additional interference. **This may lead to mismeasurement in extreme cases**.

Please note that the included switching power supply operates between 55kHz and 65kHz (60kHz Center plus 10kHz Spread Spectrum).

All cables/devices used for connection to the external DC input must supply a DC voltage between 8 and 12V via a standard 3,5mm phone jack (inner conductor PLUS, outer conductor MINUS).

15.3 Audio output
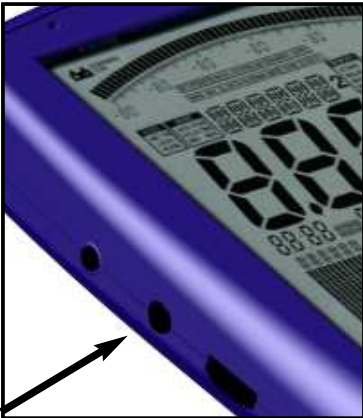
This is a standard 2,5mm STEREO phone jack that can be connected to any device which offers an audio input. Depending on model and manufacturer, these are labeled differently: e.g. PHONO, CD, LINE IN, MIC etc. Depending on the kind of input, you need a fitting adapter cable, which you can purchase from any specialised trade.

The internal speaker will not switched off if you use the audio output.

15.4 Jog Dial / Volume control
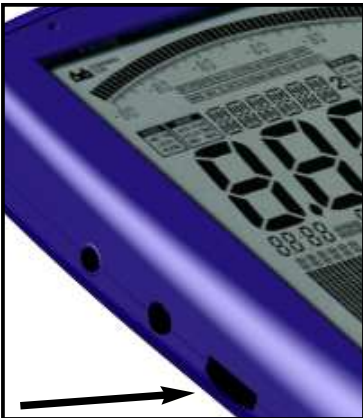
The Jog Dial, like on modern cell phones or PDAs, replaces the up/down arrowkeys ("turn" the jog dial) and the Enter key (briefly "press" the jog dial). You can e.g. control the complete menu system just with this practical little wheel.

However, with the demodulator activated, this jog dial can be used as a volume control. As precaution, before connecting anything to the audio output, you should turn this volume control down to zero to avoid overload.

15.5 USB connector

The 5-pin mini USB B connector on the SPECTRAN allows fast communication with a computer or notebook. With this feature, you can e.g. download data from SPECTRAN's data logger, perform software (firmware) updates or perform advanced signal analysis using your PC with our SPECTRAN PC software.

For this connection, you need a high-grade, shielded USB 2.0 cable with USB A to Mini USB B 5-pin (see Aaronia accessory list).

Measurements <u>directly next to appliances</u>:

- Electric stove	500 V/m	10.000 nT
- TV set	**5.000 V/m**	10.000 nT
- Hi-fi system	500 V/m	5.000 nT
- Hair dryer	1.000 V/m	**100.000nT**
- Electric blanket	**5.000 V/m**	5.000 nT
- Dimmer	1.000 V/m	300 nT
- Wall outlet	200 V/m	
- Fuse box	300 V/m	500 nT
- Computer screen	200 V/m	1.000 nT

Measurements <u>at larger distance</u>:

- Beneith a 10kV high-voltage line	500 V/m	5.000nT
- Beneith a 110kV high-voltage line	3.000 V/m	20.000nT
- Beneith a 380kV high-voltage line	**10.000 V/m**	50.000nT
- In the vicinity of a 380kV substation	**15.000 V/m**	**500.000nT**

Tesla	Oersted	Gamma
1 T	10,000 Oε	—
0.1 T (100 mT)	1,000 Oε	—
0.01 T (10 mT)	100 Oε	—
0.001 T (1 mT)	10 Oε	—
1×10^{-4} T (100 μT)	1 Oε	100,000 γ
1×10^{-5} T (10 μT)	100 mOε	10,000 γ
1×10^{-6} T (1 μT)	10 mOε	1,000 γ
1×10^{-7} T (100 nT)	1 mOε	100 γ
1×10^{-8} T (10 nT)	100 μOε	10 γ
1×10^{-9} T (1 nT)	10 μOε	1 γ
1×10^{-10} T (0.1 nT)	1 μOε	0.1 γ

Conversion table for <u>MAGNETIC FIELDS</u>

1 nT	= 0,001µT	= 0,000.001mT	= 0,01mG	= 0,000.01G
10 nT	= 0,01µT	= 0,000.01mT	= 0,1mG	= 0,000.1G
100nT	= 0,1µT	= 0,000.1mT	= 1mG	= 0,001G
1.000nT	= 1µT	= 0,001mT	= 10mG	= 0,01G
10.000nT	= 10µT	= 0,01mT	= 100mG	= 0,1G
100.000nT	= 100µT	= 0,1mT	= 1.000mG	= 1G
1.000.000nT	= 1.000µT	= 1mT	= 10.000mG	= 10G
10.000.000nT	= 10.000µT	= 10mT	= 100.000mG	= 100G
100.000.000nT	= 100.000µT	= 100mT	= 1.000.000mG	= 1.000G

G = Gauss, T = Tesla, n = nano (one billionth), µ = micro (one millionth)
m = milli (one thousandth)

1 Gauss = 1 Oersted ("Oersted" is used in various countries, mostly in eastern Europe)

Conversion table for <u>ELECTRIC FIELDS</u>

0,01 mV/m	= 0,000.01V/m	= 0,000.000.01 kV/m
0,1 mV/m	= 0,000.1V/m	= 0,000.000.1 kV/m
1 mV/m	= 0,001V/m	= 0,000.001 kV/m
10 mV/m	= 0,01 V/m	= 0,000.01 kV/m
100 mV/m	= 0,1 V/m	= 0,000.1 kV/m
1.000 mV/m	= 1 V/m	= 0,001 kV/m
10.000 mV/m	= 10 V/m	= 0,01 kV/m
100.000 mV/m	= 100 V/m	= 0,1 kV/m
1.000.000 mV/m	= 1.000 V/m	= 1 kV/m
10.000.000 mV/m	= 10.000 V/m	= 10 kV/m
100.000.000 mV/m	= 100.000 V/m	= 100 kV/m
1.000.000.000 mV/m	= 1.000.000 V/m	= 1.000 kV/m

V/m = Volts/meter
k = kilo (thousandfold)
m = milli (one thousandth)

Table 5 Gain and corresponding dB values

1	0 dB
2	3 dB
2,5	4 dB
4	6 dB
5	7 dB
8	9 dB
10	10 dB
100	20 dB
1 000	30 dB
10 000	40 dB
100 000	50 dB
1 000 000	60 dB
10 000 000	70 dB

dB = decibel

Table 3 dBm to dBW and W (and corresponding prefixes):

0 dBm	-30dBW	0,001W	1mW
-10dBm	-40dBW	0,000.1W	100µW
-20dBm	-50dBW	0,000.01W	10µW
-30dBm	-60dBW	0,000.001W	1µW
-40dBm	-70dBW	0,000.000.1W	100nW
-50dBm	-80dBW	0,000.000.01W	10nW
-60dBm	-90dBW	0,000.000.001W	1nW
-70dBm	-100dBW	0,000.000.000.1W	100pW

dBm = decibelmilliwatts, dBW = decibelwatts, W = watts,
mW = milliwatts, µW=microwatts, nW= nanowatts, pW=picowatts

Table 4 Frequency, wavelength and official band abbreviation

3 Hz-30 Hz	100.000 km - 10.000 km	ULF
30 Hz-300 Hz	10.000 km - 1.000 km	ELF
300 Hz-3 kHz	1.000 km - 100 km	VF
3 kHz-30 kHz	100 km - 10 km	VLF
30 kHz-300 kHz	10 km - 1 km	LF
300 kHz-3 MHz	1 km - 100 m	MF
3 MHz-30 MHz	100 m - 10 m	HF
30 MHz-300 MHz	10 m - 1 m	VHF
300 MHz-3 GHz	1 m - 10 cm	UHF
3 GHz - 30 GHz	10 cm - 1 cm	SHF

Table 7 Frequencies of various interference sources (examples)

Frequency range	Description
16,67Hz	Traction power (Germany)
50Hz	Mains power (Europe)
60Hz	Mains power (US and others)
50Hz-200Hz	Welding and high voltage utility network
200Hz-1kHz	Power converters and high voltage utility network
31kHz	CRT TV
40kHz	Energy-saving lamp (21W, Osram)
42kHz	30" TFT monitor (Dell)
45kHz	Energy-saving lamp (8W, Osram)
49kHz	17" TFT monitor (Dell)
52kHz	24" TFT monitor (Dell)
56kHz	20" TFT monitor (Dell)
60kHz	Battery charger (noname)
77,5kHz	DCF77 (German reference time broadcast)
125-135kHz	RFID
13,56MHz	RFID

We provide significantly more exhaustive lists on the Aaronia homepage. If you want true "luxury", you can also find our free PC analysis software right there!

Table 8 Field strengths of magnetic fields and distance

Single conductor	1/r
Two conductors, opposite polarities	1/r²
Electric coils, transformers, motors	1/r³

What is a frequency range?

Imagine a giant motorway, several kilometres wide, with thousands of individual lanes. On this motorway, all imaginable kinds of vehicles can be found: pedestrians, motorcycles, cars, trucks etc.. To not let them go into one others way, every lane is reserved for only a single group of road users: e.g., lane 1 ONLY for cyclists, lane 3 ONLY for pedestrians, lane 40 ONLY for trucks etc.. Depending on the density of the individual kinds of traffic, these lanes also have corresponding widths. For example, the lane reserved for cyclists is much narrower than the one for trucks and so on. Electromagnetic fields work exactly like this, just that the lanes are called *frequency ranges* and the vehicles are called *applications* (for example, a traction power line, mains cable or a TV are all applications - just as **every** appliance that somehow makes use of electricity, including their cables).

Every *application* utilizes its very own, reserved, exclusive *frequency range*. By assigning a seperate *frequency range* for each *application*, conflicts between individual applications can be avoided (just as with the different vehicles on the motorway) - so that for instance, a cellphone cannot disrupted by a high-voltage line.

Big differences between exposure limits

Back to our motorway: Of course, all road users also have their own specific speed limits. For our example, a pedestrian may only walk at up to 5 km/h., cars might go at up to 300km/h.

Exposure limits for *applications* work similarly, just that the word "speed" is replaced with *field strength*: a traction power line operating at 16.7Hz for instance, may only emit a *field strength* of 7,500V/m, while a 50Hz power line's limit is 5,000V/m, an energy saving lamp's maximum is only a few V/m, and so on. As a practical example, following are three official exposure limits:

Frequency [Hz]	Application	Limit [V/m]
16,7	Traction power	8.500
50	Mains power	5.000
40.000	Energy saving lamp	87

It is easily noticable that each *application* may only operate in EXACTLY ONE *frequency range*. The significant differences between the individual limits are also clearly visible.

Why spectrum analysis?

There are two principal reasons:

1.) You would like to know WHICH EXACT applications are operating,

2.) You would like to measure the exposure created by **each individual application**, for example, to evaluate excess of exposure limits.

Regarding 1.):

Let's reconsider our 'giant motorway' example:

Remember that every lane was only intended for the use of a single kind of vehicle. Now imagine that a huge bridge crossed this motorway and you standing on the bridge and looking down on the motorway. Wow, what a mess!

Now, imagine you would like to know what exactly happens on the motorway, seperately per lane. As the motorway is incredibly wide, you will need some quite good binoculars, even if you only want to have a small overview. Let's imagine that you can evaluate a range of 400m with your binoculars. Next, you would like to determine what lanes have traffic right now and how fast it is going. Consequently, you will take a piece of paper and note the corresponding lane number and measured speed. Starting at lane 1, you write down: nothing! OK, next, lane 2: nothing either! OK, lane 3: yes, there's something going at 18km/h. Lane 4: nothing. And so on - until you have reached the last lane. What have you achieved? Well, you have just performed an *analysis* of the entire lane **range** of 0-400m. Or, in other words: you have performed a **RANGE** ANALYSIS. Analysis, as you know, means dividing something into smaller pieces and evaluate those. In our case, the wide motorway was that "something", and the smaller pieces were the individual lanes. Now, the word "range" can be replaced with the word "***SPECTRUM***", and there we are: we have just performed a ***SPECTRUM ANALYSIS***! Well, who would have thought that you are a ***spectrum analyser!***

But joking aside: now the only thing missing is a "lane plan" which would provide detailed information which lanes correspond to which vehicles, and you can determine exactly what vehicles were just been travelling.

That's exactly what happens when doing ***spectrum analysis***:

There are "lanes" here as well, just that these lanes are called ***frequency ranges***. The width of these ***frequency ranges*** is measured in ***Hz*** (Hertz). As very often these ranges fall into very high ***Hz*** ranges, numbers would grow quite large when actually using this unit. Consequently, the unit is often prefixed, resulting in ***kHz*** (1,000***Hz***) or ***MHz*** (1,000,000***Hz***). This way, working with these numbers becomes much more comfortable. Likewise, 1.000.000***Hz*** could also be expressed as 1.000***kHz*** or 1***MHz***, and so on.

Back to our example: the individual vehices are called *applications* and have handy abbreviations: for instance, the *application* "traction power" has its own *frequency range* of 16.7Hz.
We will also replace the formerly used expression "speed" with something else: *field strength*.

So far we are done with all the physical units and wording. Next, spectrum analysis itself; it works exactly like our motorway:
Say our spectrum analyser should measure all *frequency ranges* from 0*Hz* to 400*Hz* (in our metaphor, the 400m range of the giant motorway). It will step by step measure each *frequency range* individually. Starting at 0-1*Hz*, then 1-2*Hz* and so on, until it reaches 400*Hz*. It will also exactly record the signal strength in each *frequency range*, also providing us with the *signal strength* in each of the *frequency ranges*.

Some practical examples:
Let's assume we want to accurately study the *frequency range* from 0Hz to 400Hz, and let's further assume that the following 3 *applications* are currently active in this range, with varying *signal levels* (in practice, you will often find a far bigger number of applications):

| Frequency range [MHz]	Application	Measurement
16.7Hz	Traction power	40
50Hz	Mains power	20
350-360Hz	Unknown	80

How could such a result be displayed optimally on a measurement device? Well, first of all, we apply the frequency range of 0Hz to 400Hz on the X axis, from left to right:

0Hz ━━━━━━━━━━━━━━━━━ 400Hz

OK, now that was simple. Now, we tag each of the 3 applications on the X axis, according to their frequencies, and their positions in the frequency range become visible:
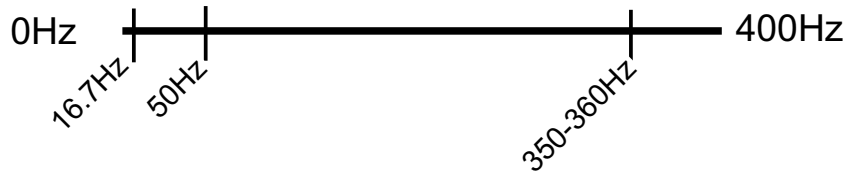
Not that difficult, either. Finally, we represent the strength of each signal in terms of vertical bars with corresponding heights along the Y axis:
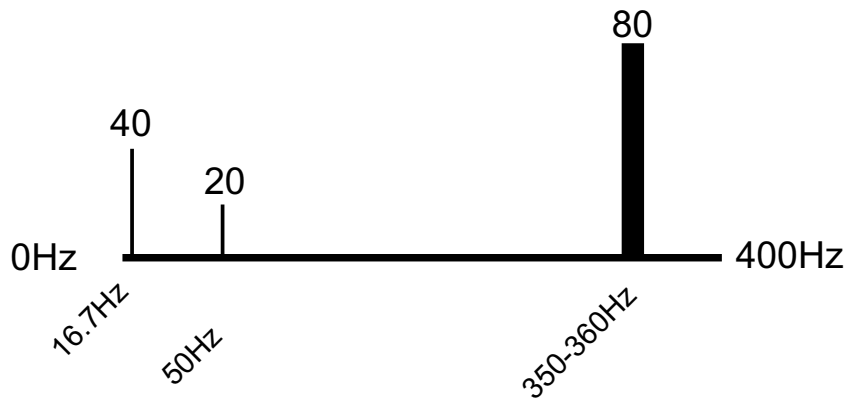
In addition, we have made the markers as wide as the *frequency range* of each application (the so-called *bandwidth*): our unknown signal occupied the frequency range from 350 to 360Hz - accordingly, its *bandwidth* was 10Hz (360-350Hz = 10Hz).

Well, it was all quite simple at the end, wasn't it? We now have a single display consisting of ALL information available about the three signal sources.

In practice, this display could look similar to the following image on an idealized measurement device:
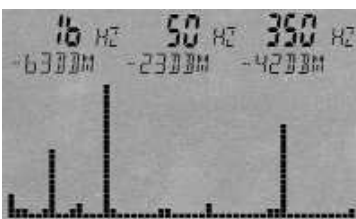
 This example image also shows 3 *main signal sources*, from left to right:
Signal #1=16.7Hz at -63dBm
Signal #2=50Hz at -23dBm
Signal #3=350Hz at -42dBm

These signals are illustrated as vertical bars on the display. Our previously deter-mined rule applies here too: the higher the **signal strength**, the higher the bar. More precise information about the individual bars is shown from left to right as **markers** in the upper part of the display. On the left, **marker 1** (the leftmost bar) indicates a frequency of 16.7Hz at -63dBm. In the centre, **marker 2** (second bar from the left) indicates 50Hz at -23dBm. Finally, **marker 3** (the rightmost bar) dis-plays 350Hz at -42dBm.

Remark: the configured **frequency range** is constantly being analysed. Thus, the display will keep changing all the time. This process is called **sweeping**.

What information did we get from the entire process?

1.) In the entire frequency range from 0 to 400Hz there are 3 main signal sources.
2.) The frequencies and signal strength of all 3 signal sources are exactly known.

As the exact frequencies of the signal sources are now known, it is now easy to determine the actual entity or service emitting the signal by using a so-called frequency table (see also the frequency table on page 56, or the more exhaustive frequency tables on the Aaronia homepage).

Using these frequency tables, we can determine the source of our 16.7Hz signal as follows:
16,7Hz = Traction power
In other words, we are dealing with an overhead line or similar railroad installation.

Aaronia warranty

Guaranteed upgrade service to newer models.
You can simply replace one of our measurement devices with a **better model of the same series** <u>at any time</u> by paying the corresponding difference in price.
For example, should you have purchased a **SPECTRAN NF-1010E** and after some time, you would like more sensitivity, you can simply pay the price difference between the two models and upgrade to a **SPECTRAN NF-5030**.

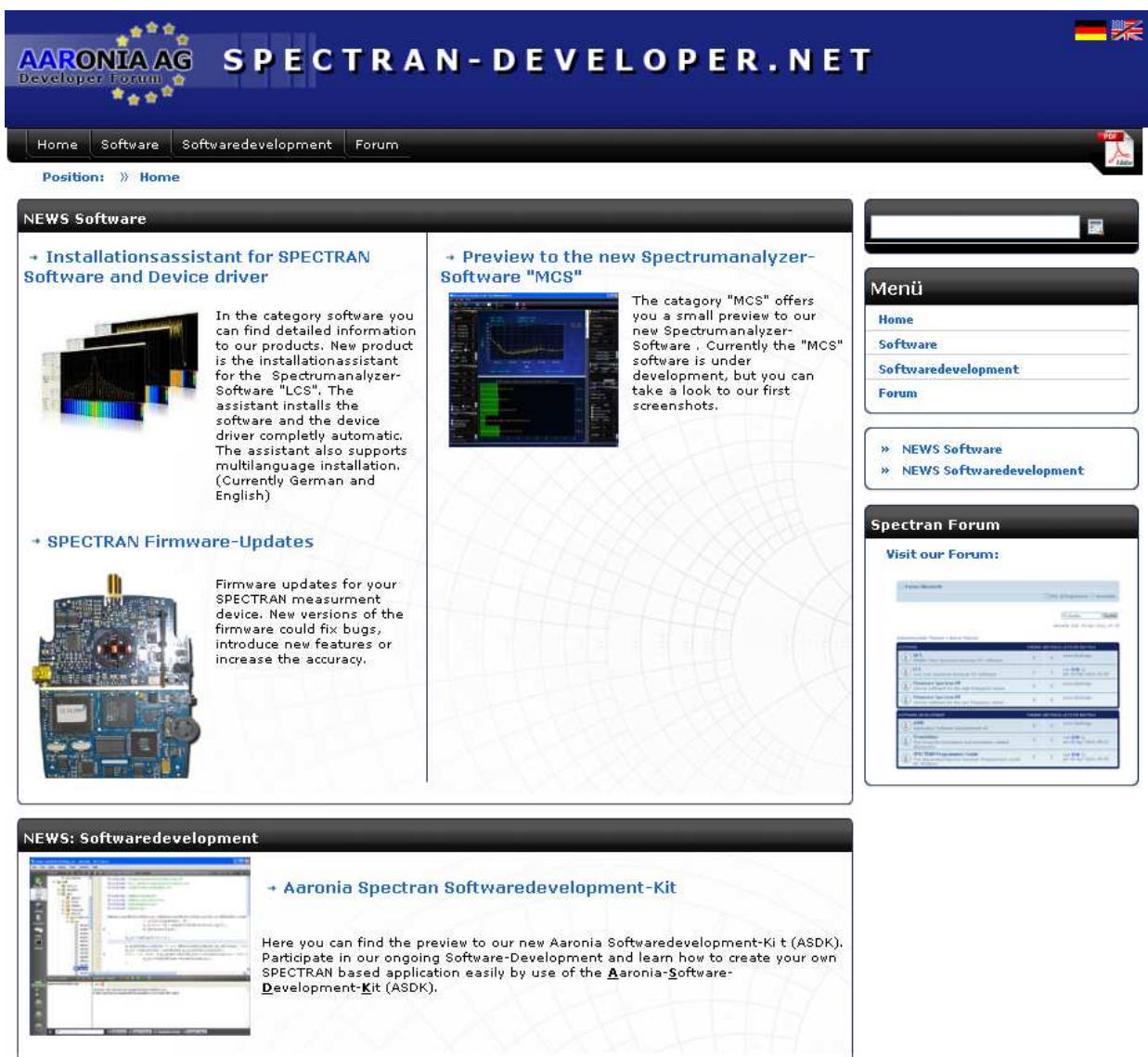**Guaranteed replacement in case of product range additions**.
As soon as new instruments are ready for launch, you can upgrade your product to a more current model <u>at any time</u> by paying the price difference.
Our customers have first taken the opportunity to accept this offer in the year 2000, when upgrading from the older Multidetektor 1 series to the new Multidetektor II models. These customers only needed to pay half the price for the new Multidetektor II, with Aaronia recycling the old instruments in an ecologically compatible manner.

10 years warranty on all models.
We offer 10 years warranty for all our instruments. We promptly exchange defective units in a non-bureaucratic way, promised!
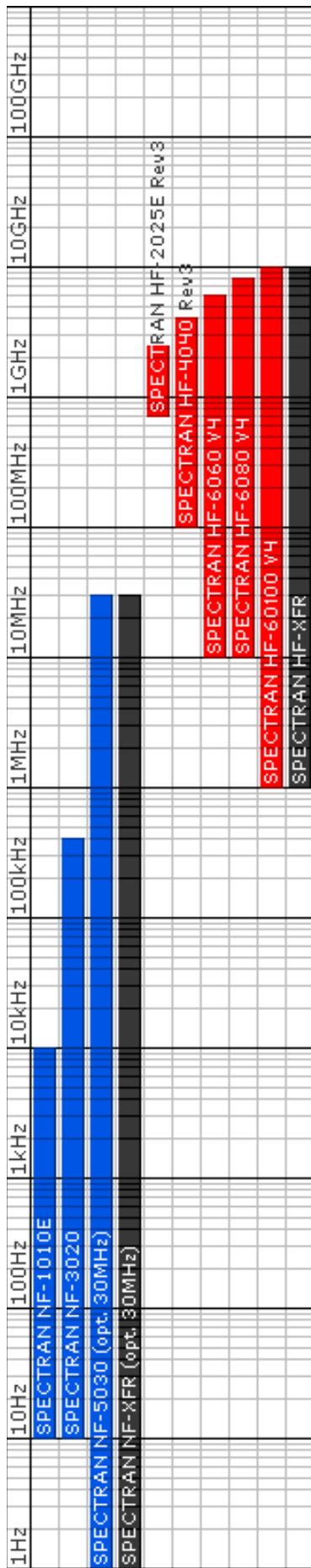
Please visit our **support website:**

http://spectran-developer.net

This site offers:
- Free **Firmware updates**
- Free **PC Analyzer-Software** (MAC OS, Linux and Windows)
- Free **ASDK** (**A**aronia-**S**oftware-**D**eveloper-**K**it)
- **P-CODE programing samples** and **SPECTRAN TUNING**
- **User Forum** incl. **FAQ**
- **News** on latest Aaronia products

AARONIA AG
WWW.AARONIA.DE

SPECTRAN Spectrum Analyzer

SPECTRAN NF-1010E	
SPECTRAN NF-3020	
SPECTRAN NF-5030 (opt. 30MHz)	
SPECTRAN NF-XFR (opt. 30MHz)	
SPECTRAN HF-2025E Rev3	
SPECTRAN HF-4040 Rev3	
SPECTRAN HF-6060 V4	
SPECTRAN HF-6080 V4	
SPECTRAN HF-60100 V4	
SPECTRAN HF-XFR	

HyperLOG and BicoLOG Antennas and Probes

HyperLOG 7025
HyperLOG 7025 X
HyperLOG 7040
HyperLOG 7040 X
HyperLOG 7060
HyperLOG 7060 X
HyperLOG 7080
HyperLOG 7080 X
HyperLOG 60100
HyperLOG 60180
HyperLOG 4025
HyperLOG 4025 X
HyperLOG 4040
HyperLOG 4040 X
HyperLOG 4060
HyperLOG 4060 X
HyperLOG 3080
HyperLOG 3080 X
HyperLOG 30100
HyperLOG 30180
HyperLOG 20300 EMI
HyperLOG 20600 EMI
OmniLOG 90200
BicoLOG 5070
BicoLOG 30100
BicoLOG 30100E
BicoLOG 20100
BicoLOG 20100E
BicoLOG 20300
Aaronia EMV Probe-Set PBS1 & PBS2
Aaronia Active Differential Probe (NF-50xx series)
Geophon (Aaronia GEO Series)