

Manual SPECTRAN V5

Please read the following manual carefully before using your measurement device. This manual contains important information on how to properly operate this unit.

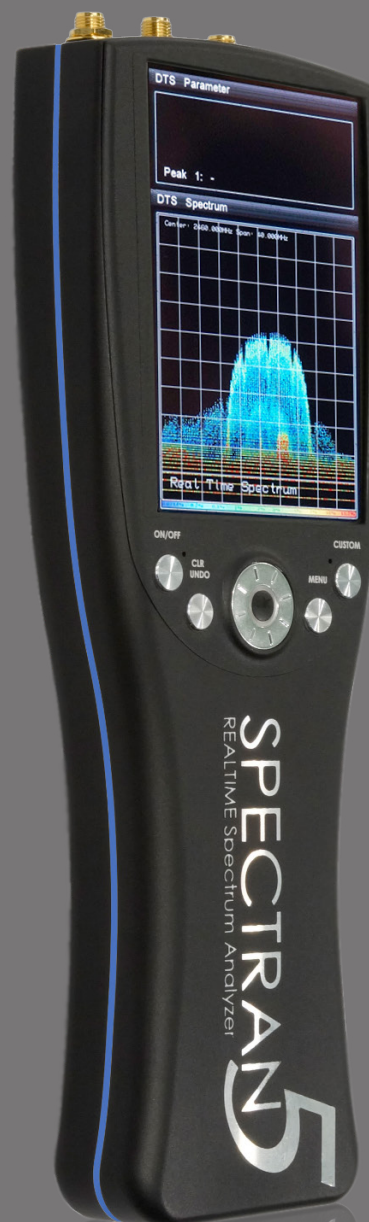


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1. Introduction

Dear customer,

By purchasing this Spectran high-frequency measurement device you acquired a professional piece of equipment which allows measurement of high-frequency fields.

The measuring instrument has been constructed according to state-of-the-art technology and fulfills the requirements of the applicable European and national guidelines.

Please note: For measurement of low frequency fields (high-voltage lines, traction power, various household appliances etc.) you need additional one of the NF series Spectran models.

1.1. Liability

This document was compiled with great care and checked for accuracy.

Nevertheless mistakes cannot be excluded. We do not take over any liability. We cannot guarantee the completeness, the correctness and the accuracy of information.

We reserve ourselves the right to change our products, specifications and documentations without any notice. We have no obligation for revision of documents and manuals we delivered in the past.

1.2. Warranty

Despite the greatest care in development and production of this device and the free software RTSA Suite; Aaronia AG only takes liabilities for certain purposes, if this has been assured in writing. No warranty can be assumed for the performance and flawlessness of the software for all usage conditions and cases and for the results produced when utilized by the user. No additional guarantees or assurances are made regarding marketability, freedom of defect of title, integration or usability for certain purposes unless they are required in accordance with the law and cannot be limited. Justified guarantee claims are limited to the right of require rectification or replacement delivery. Regarding infringements, violations of patents, rights of ownership or the freedom from interference by third parties, Aaronia AG cannot warrant or guarantee that it is free of error.



1.3. Safety Guidelines

In the event of any damages resulting from failure to follow these operating instructions, the claim under guarantee is discharged. We accept no liability for consequential damages.

In the event of property and personal damages resulting from improper handling or failure to follow safety advices, we accept no liability.

For reasons of safety and admissibility (CE) the unauthorized conversion and/or alteration of the product is not permitted.

As voltage source, please only use a property mains socket (100-240Volt, 50/60Hz). Make sure that the cable isn't squeezed or damage by sharp edges.

In order to avoid any damage, please read this user manual carefully before starting to use the device.

The commissioning should only be performed by qualified and instructed personnel.

Never expose the device to water. Never use it outdoors while it is raining. Otherwise the sensitive electronics could be damaged.

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

The device is maintenance-free. Only clean it externally with a damp cloth.

Due to the high sensitivity, the sensors and display of this device are sensitive to shock; hence it should be handled with care. For safekeeping and transport, please use the included case.

Even though the device is well secured through the use of counter-sunk screws, it should still not be reachable by children as it could easily be diverted from its intended use.

This device is connected to a mains socket and the derived voltages, it is **not** meant for the hands of children.

Consider the regulations for prevention of industrial accidents for electrical installations and equipment, by government safety organization in industrial facilities.

In schools, educational establishments, hobby and self-help workshops the operation of this product must be supervised by trained personnel.

1.4. Scope of Delivery

Included in the Delivery:

- a) SPECTRAN V5 Analyzer
- b) OmniLOG 70600 (700MHz-6GHz) antenna
- c) USB stick with USB driver, PC software and manual
- d) Charger (power supply) with four international power adapters
- e) Aaronia 8000mAh NiMh battery (not visible, because built into SPECTRAN)
- f) Outdoor transport case
- g) Docking Station (optional)



Please check immediately after receiving the package for completeness. Report missing parts immediately to Aaronia or your local Aaronia dealer.

WARNING:

Avoid overloading the input by feeding too much power, otherwise the highly sensitive electronics may be destroyed!

The maximum permitted peak power that can be applied at the input of the SPECTRAN V5 is:

- Activated Preamplifier: Max. 0dBm (Peak)
- Deactivated Preamplifier: Max. +20dBm (Peak)

2. Connectors

2.1. Power Cable / Battery Charging



Standardized 3.5mm mono „jack“. The input voltage must be between 5V and 5.9V DC (direct current). The included power supply provides a voltage of 5.5V at up to 6A (33W).

While being operated, the analyzer needs about 23W, without internal battery only 18W. To operate the device connect the charger to a power supply, connect the jack plug of the charger with the power connector of the SPECTRAN. The charging LED of the SPECTRAN should turn red.

Now the internal battery is being charged automatically. A complete charge cycle takes approximately 8-10 hours. When the battery is fully charged, the charging LED turns green (power supply has to be connected).

2.2. USB Ports (Master & Slave)



2 Mini-USB „B“ ports (5-pins)

USB MASTER

For the direct communication with a computer or notebook, for example for reading out the data logger, loading firmware updates or using the SPECTRAN PC software „RTSA Suite“. The „RTSA Suite“ enables a real-time connection to the analyzer and a highly advanced signal analysis at the PC.

USB SLAVE (currently disabled)

For connecting additional hardware, for example our GPS Logger, IsoLOG 3D Mobile antenna etc.

TIP: In order to connect the device to a PC, we recommend the specially shielded Aaronia USB 2.0 cable (USB A to mini USB B 5-pin), which has EMC filtering (see Aaronia accessories).

2.3. Audio Port



Standardized 3,5 mm mono jack-plug

You can connect a headset with a standardized 2.5 mm mono „jack“ to the audio port.

You can also connect the audio port with an adapter cable to the audio input (Phono, CD, Line in, Mic, etc.) of your PC

2.4 μ SD Card (internal removable storage)



With our special μ SD cards, you can record up to 64GBs or 128GBs of measurement data inside the analyzer. The μ SD card works under FAT32 and can thus be directly read on a PC via the included adapter.

64GB is sufficient for approx. 30 min of measurement data (with full data throughput).

The μ SD card is currently not supported, but can be activated by a firmware update.

2.5. Aaronia UHSC



The Aaronia UHSC port allows direct access to the SERDES outputs / inputs of the ECP3 FPGA SPECTRAN V5. These provide extremely fast data transfer of up to 4x3GSPS.

Corresponding adapters for USB 3.0, USB 3.1 and Gigabit Ethernet respectively are being prepared.

2.6. SMA Ports (50 Ohm)

The SPECTRAN V5 has 3 SMA ports, which are assigned as follows:

Vector generator (output) / OPTION. Can be activated via software key

RF (input)

Power meter (input) / OPTION. Can be activated via software key starting from RF 80100

The optional vector generator output allows the playback of IQ signals in the frequency range from 45MHz to 6GHz with up to 15dBm of output power, which were previously recorded via USB or on the internal μ SD card. This option can be enabled through the firmware (currently inactive).

The RF input is the actual connection of the SPECTRAN V5 to the outside world. The included antenna can be connected here.

The optional power meter input allows the measurement of ultra short signals in the frequency range up to 40GHz. This option can be enabled through the firmware (currently inactive).



2.7. Powering the device with an external power supply

In addition to charging the internal battery, the included power supply also allows to operate the analyzer independently of the internal battery pack.

Other DC sources between 5V and up to a maximum of 5.9V can also be connected. A 3.5mm jack plug must be used as the connecting plug. The connection plug has to be poled as the following:

Internal pole „plus“ / external pole „minus“

An optional power adapter for a 12V connection available from Aaronia makes it possible to operate the analyzer in the car.

Please note that by operating the analyzer with the power supply, additional interferences are produced by the power supply, that might distort the measurement result. To avoid these possibly occurring interferences for long-term measurements, we recommend to operate the analyzer via a large, external battery. Those can (on average) provide power up to several weeks. The power or battery packs from specialized electronics retailers are particularly advantageous. These usually have a regular 12 V connection and can therefore be operated with the afore mentioned adapter cable.

CAUTION: All cables / devices that you connect to the external power connector of the SPECTRAN V5 must provide a direct current of 5V up to 5.9V. A standard plug with a 3.5 mm diameter must be used as the plug (Internal polarity PLUS - external polarity MINUS)

Pay attention to the cable cross-section, because without an internal battery the device requires around 18W of power. With an internal battery around 23W of power are needed because of the additional charging circuit

3. OVERVIEW FRONT PANEL

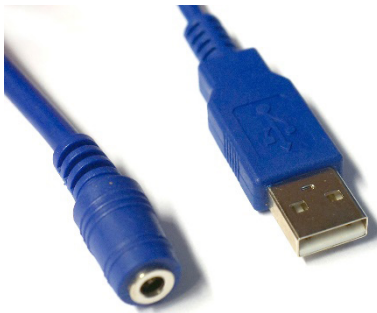
3.1. Control elements



1	On/Off-Button On/Off LED	<p>Turns the device (Booting takes about 10 seconds) on or off.</p> <p>Emergency shutdown (e.g. during a crash): Hold the button for about 10 seconds until the device is turned off. The related LED „flickers“ orange while the device is booting. After the device has been successfully booted, the LED takes over the control function: During normal operation, the LED flashes orange in a one second rhythm. When the device crashes, the LED lights permanently .</p>
2	Clear-/Undo-Button	Currently not assigned
3	Rotary knob	<p>In „Demodulation“ mode: Move the displayed demodulation marker in the spectrum (turn the rotary knob to the right or left)</p> <p>In „Marker“ mode: Move the displayed marker in the spectrum (turn the rotary knob to the right or left)</p>
4	Menu Button	Opens the main menu. The following operation is done by touch screen. Please use the included touch pens which are attached to the back of the SPECTRAN V5. You can also operate the menu with your finger, but the precision will be much lower.
5	Custom-Button Custom LED	<p>In „Waterfall“ mode: Adjust the color table automatically.</p> <p>The LED will light RED when the external power supply is connected (battery charging). It might take up to 30 seconds to detect the external power supply. The LED lights GREEN when the internal battery is charged AND the external power supply is connected.</p> <p>ATTENTION: Please check, particularly in regard to the docking station, that the charge LED lights up - otherwise you have not inserted the device properly into the docking station and the battery cannot be charged. A USB connection to the device might also not be possible.</p>

3.2. Docking Station

The docking station allows a more convenient operation with the SPECTRAN V5, especially if the device is connected via USB to a computer/notebook/tablet. Furthermore it ensures a perfect heat dissipation, because the fan can operate unobstructed - therefore we recommend to use the docking station whenever possible.



Connect the long, blue power cord of the docking station to the included 5.5V adapter of the SPECTRAN V5 and **connect the adapter to your power supply**. Now connect the long, blue MASTER-USB cable of the docking station to your PC (if available /desired) - ready.

Currently the short, blue SLAVE USB cable of the docking station is not activated and therefore does not have to be connected.

Once you have inserted the device into the docking station, the CUSTOM LED of the V5 should light up RED. This means that the battery is charging. It may take up to 60 seconds to detect the external power supply. The CUSTOM LED lights up GREEN when the internal battery is charged AND the external power supply is connected.

CAUTION: For the docking station please make sure that the charging LED of the V5 lights up, otherwise you have not properly inserted the device into the docking station and the battery cannot be charged. In this case a USB connection to the device might also not be possible.

The figure below shows the proper position: More than half of the capital „A“ of „SPECTRAN“ must be covered and only the small „e“ of „Analyzer“ is fully visible.




NEVER force the device into the docking station. A little bit of pressure and some slight back and forth movements might be needed until the device is fully locked into place, as shown above. Please make sure that the device is placed correctly into the docking station!

4. Functions

4.1. Main menu




Tap the touch screen to open the main menu. You can operate the whole analyzer with the menu control:

Press the  „Return“ button to leave the menus or to cancel a selection/input.

Press the  „Delete“ button to delete an input.



Some menus like „CenterFrq have no  „Return“ button. In this case you can only exit the menu by entering a respective number value.

Changes are always adopted directly when leaving the menu and you will return directly to the spectrum display, sub menus are skipped.

Tip: In the spectrum display the following informations are displayed constantly, from the left to the right:

Center frequency and SPAN

This provides a quick overview during ongoing measurements.

4.2. Menu Items

There are two options to set the frequency range manually:

- via **CenterFrq** (center frequency) and **Span** (frequency width) or
- via **StartFrq & StopFrq** (Start- and-Stop frequency)

4.2.1. Center (middle frequency) Default: 940MHz



Displays the frequency in the middle of the screen. In case of changes to the middle frequency, the span parameter will be adopted. Advantage: Quick check of different frequency ranges with identical span and without changes to the start-/stop frequencies.

4.2.2. Span (frequency range) Default: 44MHz



Span determines the frequency range for the measurement. The afore mentioned center frequency is not affected. Instead in case of changes to the span, the „Start/Stop-frequency“ will automatically be adjusted to retain the Span. The Span function is comparable with a „magnifier function“, which, however, only works on the X axis.

In real time mode the Span cannot be chosen freely. Instead the following fixed REAL TIME bandwidths can be chosen due to the internal filter matrix:

175MHz (Optional)
 88MHz (Optional)
 44MHz
 22MHz
 11MHz
 5,5MHz
 2,7MHz
 1,09MHz
 547kHz
 219kHz
 109kHz
 54,7kHz
 21,9kHz
 10,9kHz
 5,47kHz
 2,19kHz

If you enter a „wrong“ Span, the next closest Span will be chosen automatically. For example if you enter 40MHz Span, 44MHz will be chosen automatically.

Example: Enter middle frequency „2450“ MHz, then:

Enter 40MHz Span	→	measuring range = 2.440MHz to 2.460MHz
Enter 200kHz Span	→	measuring range = 2.439,9MHz to 2.440,1MHz

An enlargement / reduction of the resolution is always „centered“ around the middle frequency.

The grid display allows for a rapid frequency allocation of the individual signal sources, since a box always corresponds to 1/10 of the set span.

In SOFT mode the Span can be freely selected and may be very large. Please note however, that currently the RBW is still fixed at 200kHz. Because of the screen size, we recommend that the span in this mode should be no more than 1GHz and no less than 5MHz.

4.2.3. StartFrq & StopFrq (Start- & Stop-frequency)



StartFrq (Start frequency) determines at which frequency the measuring range should start, while StopFrq (Stop frequency), determines at which frequency the measuring range should stop. This results in the entire frequency range (Span), which is measured.

The displayed grid allows for a rapid frequency allocation of the individual signal sources, since a box always corresponds to 1/10 of the set span

Tip: A large frequency range reduces the measurement accuracy and makes the presentation on the X-axis more difficult. Therefore single signals, especially those close to each other, are often indistinguishable. For a better presentation of large-frequency ranges, we strongly recommend to use the supplied RTSA Suite software.

Reduce the frequency range, so you can explore the range in more detail. You get a much higher level of detail and a higher measurement accuracy. Therefore we only recommend a large frequency range to get a quick overview, but not for an accurate measurement.

4.2.4. Bandwidth (Bandwidth) Default: 200kHz (only SOFT mode)



Bandwidth (Bandwidth) simultaneously sets the level of detail and sensitivity. **In real time mode this function cannot be set manually, instead the bandwidth is calculated automatically from the Span. The formula here is $\text{Span}/220 = \text{Bandwidth}$. So for a Span of 44MHz the bandwidth corresponds to 200kHz.**

For a high bandwidth the measurement is fast, but the display is relatively inaccurate and the sensitivity is relatively low. Weak signals can no longer be recorded.

The smaller the bandwidth, the longer the measurement, but the more accurate the display and weaker signals can be displayed. For example, a signal, previously measured with a high bandwidth, might turn out to be multiple, narrow band signals lying closely together when measured with a lower bandwidth.

The bandwidth can still not be selected in SOFT mode.

4.2.5. SweepTime (Sweep time) Default: 10mS (only in SOFT mode)



Determines the measurement period. The higher the sweep time the more accurate the measurement, but the longer the measurement period.

This item is disabled in real time mode, because that mode always measures with the maximum sweep time.

Please note: A faster sweep time, depending on SPAN and RBW, is not always implemented since the hardware may not. Therefore the sweep time should be no less than 5 mS.

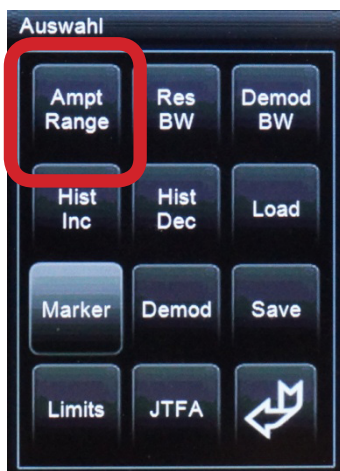
4.2.6. RefLevel (reference level) Default: 0dBm



The reference level sets the position of the displayed signals relative to the top of the screen in dBm. The lower the setting (e.g. -20dBm), the closer to the noise and the more interfering signals will be visible.

The reference level is used as graphic suppression of interfering, weak signals. The higher the reference level, the more weak signals and interference are hidden. Usually 20 to 30dBm are optimal. Here only the „peaks“ of the strongest signals are still being displayed, the rest will be „cut off“. A strong main signal is more visible. On the other hand in order to be able to display weak signals, the reference level should be set as low as possible.

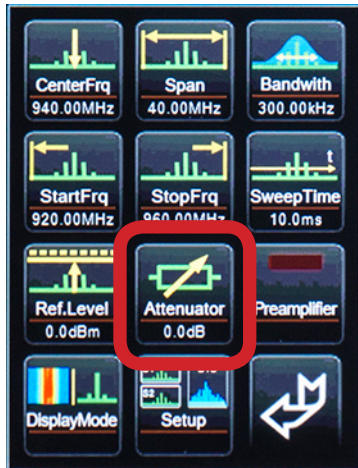
4.2.7. Ampt Range (dynamics) Default: 100dB



Dynamics determines the amplitude scale. A high dynamic range allows for a better overview of the different signal sources, but very weak signals are displayed poorly. A small dynamic value reveals more details, but some of the signal sources might be „cut off“ at the top or bottom (depending on the RefLevel setting). Therefore the dynamics can be compared with a „zoom function“ in the Y-axis.

The displayed grid allows for a quick level overview of the different sources, since a box always corresponds to 1/10 of the set dynamics.

4.2.8. Attenuator (Attenuator) Default: 0dB



The attenuator (built in) attenuates any fed signals by the corresponding dB value to avoid an overload of the RF input.

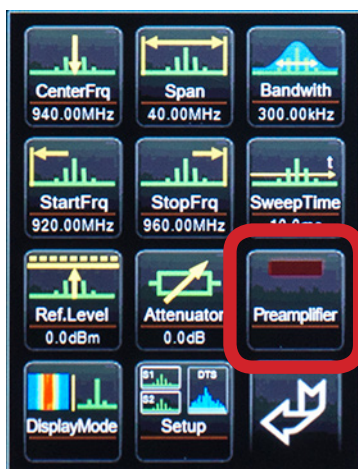
The attenuator can be adjusted in 0.5dB increments up to 31.5dB.

WARNING:

For signals over -20dBm you need to add/adjust the attenuator accordingly to avoid incorrect measurements!

If the signal strengths is above 0 dBm (peak), the input might be damaged or destroyed if you don't add an attenuator!

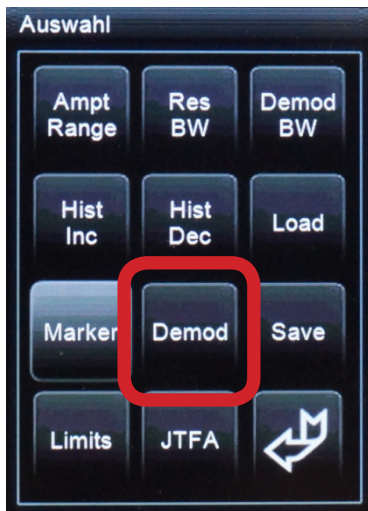
4.2.9. Preamplifier (Preamplifier) Default: AUS



The internal, low-noise preamplifier (preamp) amplifies incoming signals, depending on the frequency by about 15 dB. It increases the measurement sensitivity significantly. By default the preamplifier is disabled (red LED is off). If the preamplifier is enabled the LED is bright red.

Please note that the internal preamplifier does not amplify constantly throughout the frequency range. At very low frequencies the amplification is quite high (about 25dB) and then decreases linearly to approximately 15dB at 6GHz and then remains constant at about 15dB to 20GHz.

4.2.10. Demod (Demodulator/Audio-Analysis) Only in Real Time Mode!



The demodulator makes pulsing & modulations up to 10 kHz audible and allows for „eavesdropping“ of individual signal sources (such as radio stations, two-way radios, etc.).

4 types of modulation are available:

AM (amplitude modulation)
FM (frequency modulation)
PM (phase modulation)
IQ data (only available via the PC software)

CAUTION: When the demodulator is enabled the internal fan is switched off which means that the device will slowly heat up. Therefore, turn off the demodulator to activate the fan again and to cool the unit down.

„OFF“ turns off the demodulator and turns on the fan again.

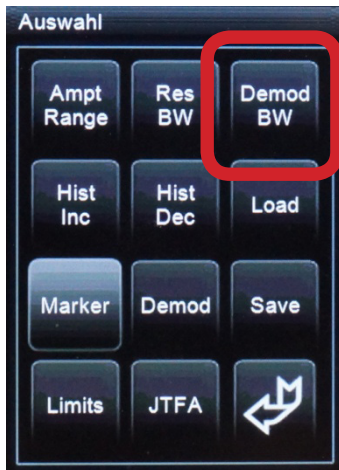
After the activation, you will automatically get to the spectrum display, where a thin red dashed cursor will be displayed. At exactly this point, the signal will be demodulated. You can move the cursor back and forth with the jog dial anywhere in the spectrum. That way you can approach individual signals, for example radio stations, and make them audible.

For large RTBW's starting from 44MHz, you must change the symbol processing to „Time“ in the JTFA menu, otherwise there will not be enough data supplied for a demodulation!

The demodulation bandwidth can be set in the menu item „Demod BW“.

Tip: Since the demodulation is performed in quasi „real time“, it is also suitable for the rapid detection of a signal source.

4.2.10.1. Demod BW (Demodulator Bandwidth)



The demodulator bandwidth allows a clearer demodulation of individual signals. With it, the demodulation bandwidth can be adjusted according to the signal width. For FM for example you should select a rather high bandwidth of about 500kHz, for AM, the bandwidth can be considerably narrower (for example, 20 kHz). Ultimately you will have to experiment to find the perfect bandwidth for each demodulation.

4.2.11. Marker (Cursor) **ONLY available in real time mode**

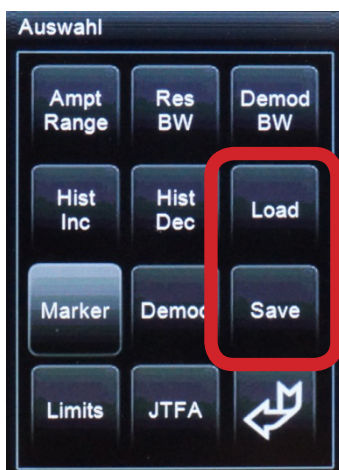


With the cursor you can exactly determine the frequency of single signals in the spectrum.

After the activation, you will automatically get to the spectrum display, where a thin red/black dashed cursor will be displayed. At this point, the frequency will display the signal in the „DTS Parameter“ window. You can move the cursor back and forth with the jog dial to move it anywhere in the spectrum in order to approach specific signals .

To disable the cursor you only have to enable the menu item Marker again.

4.2.12. Load & Save (Load and Save the Setup) **ONLY in soft mode**

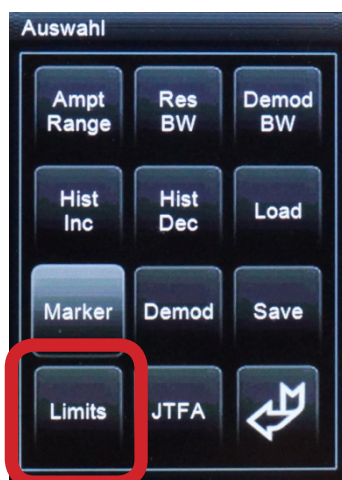


With Load and Save you can save up to 10 individual soft displays in the memory of the SPECTRAN. Here different parameters of the soft displays (also for a two- or four-fold constellation) are saved. This data will be saved for each soft display:

- Center frequency (respectively start and stop frequency)
- Span
- Attenuator
- Preamplifier
- Sweep time
- Dynamics
- Reference Level
- Display Mode
- Limits

This way you can, for example, save a complex four-fold soft display with completely different parameters and retrieve it again at any time. There are 10 storage locations - „Setup 1“ to „Setup 10“ available. Before overwriting single setups you will have to confirm the overwriting with „Yes“ or deny it with „No“. Loading might take some time.

4.2.13. Limits is ONLY available in soft mode



With „Limits“ you can define a maximum („Max“) or a minimum („Min“) level value (in dBm), which will be applied to the complete spectrum. With the „Limit On“ button you can turn the set limits on and off.

If the limit is reached/exceeded, the frequency and the level value will be displayed in red in the peak marker.

If you set the MAX limit to -60dBm the trigger occurs as soon as a level of -60dBm is exceeded.

If you set the MIN limit to -60dBm the trigger occurs as soon as the highest level falls under -60dBm.

4.2.14. JTFA (Optimize the symbol processing)

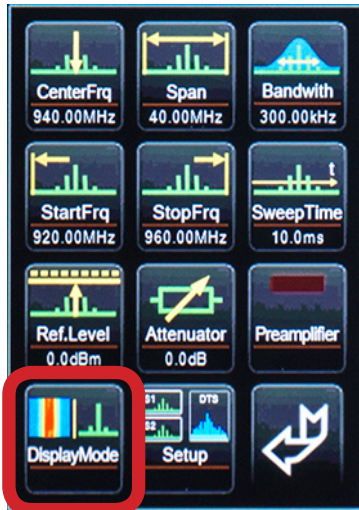


With „JTFA“ you can adjust the real time measurement according to your requirements. Here you have direct access to the symbol processing and can for example suppress unwanted signals already in the run up. The following are available:

- Time Domain optimized. Considers each symbol, optimal for the display of very short signals.
- Freq Frequency Domain optimized. Considers each symbol, optimal for the display of very short signals.
- Std. (Default) Averages the symbols. This way possibly interfering extremely short symbols disappear and the spectrum has optimal aliases suppression, additionally there is less data.

More settings are being prepared!

4.2.15. Display Mode (Display Mode)



In display mode you can choose between the main modes „DTS“ (real time mode) and „Soft“ (sweep mode) respectively. For each of these two modes you can also select a separate display type and the number of windows (only in soft mode).

You configure your complete spectrum view in the Display Mode sub-menus. Please note that there are different options depending on the mode. Specifically available:

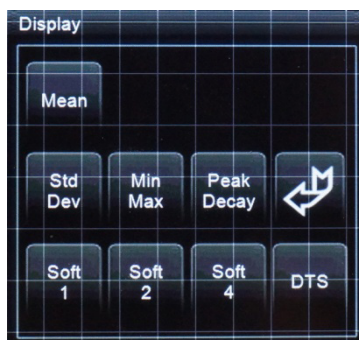
In REAL TIME (DTS) mode (Default):

- Hist (Real time histogram view)
- WF (Real time waterfall view)
- Soft 1 (Displays one soft spectrum window)
- Soft 2 (Displays two soft spectrum windows)
- Soft 4 (Displays four soft spectrum windows)
- DTS (Switches to real time mode)

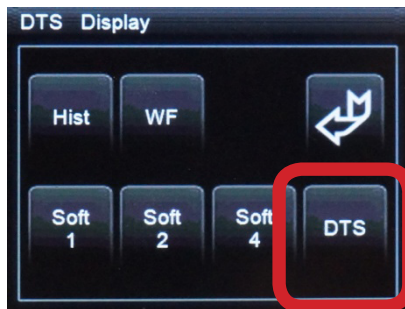


In SOFT mode:

- Mean (Regular spectrum view (Clear/Write))
- Hr. Dev (AVG and Min/Max)
- Min Max (AVG, Min and Max)
- Peak Decay (Max hold limited in time)
- Soft 1 (Displays one soft spectrum window)
- Soft 2 (Displays two soft spectrum windows)
- Soft 4 (Displays four soft spectrum windows)
- DTS (Switches to real time mode)



4.2.16. DTS Display Mode (real time mode)

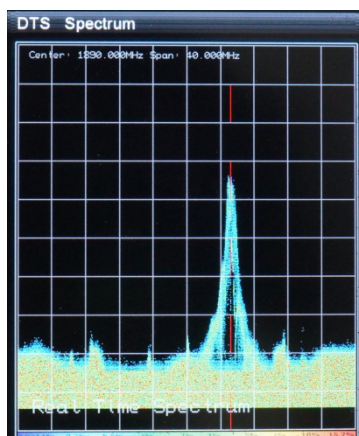


In the real time mode „DTS“ around 50,000 symbols per second are calculated and graphed. Here, there are two display modes available:

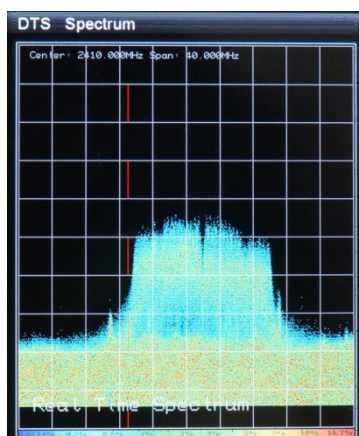
- Hist (Histogram view)
- WF (Waterfall view)

Via „Setup/Demod“ you can demodulate a signal in the spectrum. If clicked, a cursor, which you can position anywhere on the spectrum with the help of the jog dial, appears. Simultaneously, the frequency of the signal is displayed.

4.2.17. DTS Histogram View



DECT Histogram



WIFI Histogram

In the histogram, the frequency (X-axis), level (Y axis) and frequency of occurrence (color) of the signal is displayed at the same time. In this case the signal frequency is represented by blue (very rare) to red (very often). The data is held in an adjustable ring buffer which is displayed in color: A common signal at the same level and frequency will appear in red, while a signal which rarely occurs or only occurred once is in blue. Therefore this display allows you to perfectly track the temporary interferences or hidden signals within a signal.

You can control the color distribution of the histogram display under „Hist Inc“ and „Dec Hist“ in the menu „Setup“.

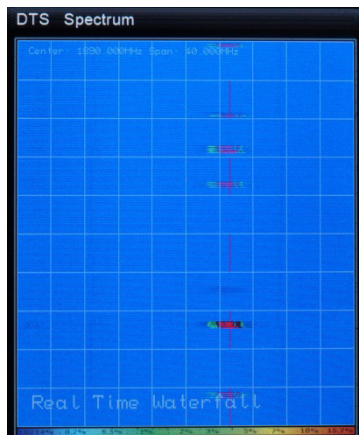
„Hist Inc“ thereby controls the percentage, with which the histogram ring buffer should be filled (from 0.01%). The default value is 0.5%.

„Hist Dec“ controls the percentage, with which the histogram ring buffer should be emptied. The default value is also 0.5%.

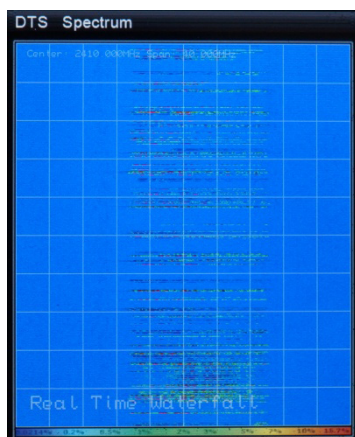
With the „CLR UNDO“ button you can delete the ring buffer of the histograms at any time. This can take about 2-3 seconds.

With the „CUSTOM“ button you can automatically adjust the color scale.

4.2.18. DTS Waterfall-Display



DECT Wasserfall



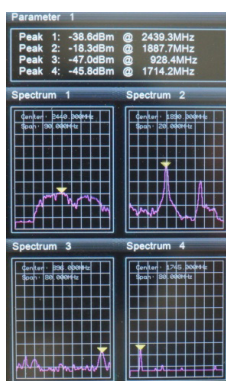
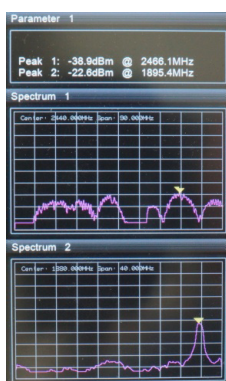
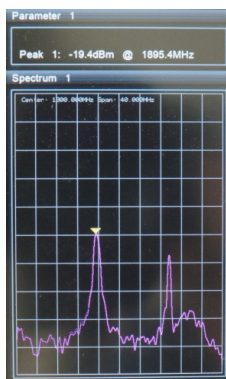
WIFI Wasserfall

The waterfall display shows the frequency (X- axis) and level (color) in the time range (Y-axis).

Here the single symbols are updated constantly from top to bottom. The display works extremely fast and therefore can be used perfectly for the bearing of signals.

With the „CUSTOM“ button you can automatically adjust the color scale.

4.2.19. SOFT Mode



In soft mode the SPECTRAN V5 works like a regular sweep spectrum analyzer.

As a special feature, 1 (Soft 1), 2 (Soft 2) or 4 (Soft 4) independently adjustable frequency bands can be operated and displayed simultaneously.

Thus, e.g. ISM433, GSM900, GSM1800, and Wlan24 can be monitored simultaneously WITHOUT having to display the intermediate frequency range.

Each of the spectra can be provided with their own parameters to ensure the best possible representation.

In each spectrum, the highest value (peak view) is automatically detected and marked with a red marker in the spectrum and the frequency and level are displayed in the parameter window. You can switch the marker on/off in the "Setup" menu, with the "Marker" button.

Furthermore, now there are 4 different display modes available via „Display Mode“:

- Mean = Default display (yellow). Equivalent to a clear/write
 - Std Dev = min (white) and average (blue filled)
 - Min Max = Min (white), max (white dots) and average (blue filled)
 - Peak Decay = Max over time (pink) and Min (white dots).
- The drop rate of „Max on time“ can be adjusted via „Setup/Decay%“. 1% corresponds to a very slow decay rate (1% of the value per sweep). 100% corresponds to an immediate drop after each sweep (therefore corresponds to a clear/write). The default value is 10%.

The entire window- and setting configurations can be saved as its own setup under „Setup / Save“ and recalled again at any time via „Setup / Load“. Here up to 10 setups („Setup 1“ to „Setup 10“) are available.

5. Correct measurement

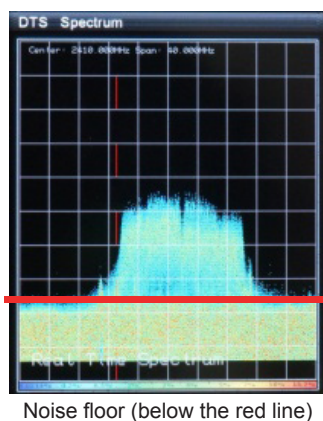
Note that when measuring high frequency radiation, you will encounter some „strange characteristics“ which can be pretty irritating particularly for novices.

In practice, high frequency radiation rarely constantly fades with distance from the source: due to reflections, diffusion and diffraction (by houses, trees, walls, furniture etc.) massive selective concentration (so called “Hot Spots”) is often noticeable, especially inside rooms. Here, the difference in measured signal strength can easily vary by a factor of 10 or 100 in a range of just a few cm. Thus, it is sometimes pretty difficult to find the actual source or the maximum strength of RF radiation.

High-frequency fields are often also measurable on metal objects, as these act as antennas and cause the corresponding „concentration“, reflection or forwarding of high frequency radiation. Thus, electrical cables are another medium for high-frequency radiation and can “catch” it and “release” it again at a totally different location. Hence, even well shielded rooms can become “contaminated” again, just because of a trivial mains cable. To avoid this, shielded rooms must be equipped with so called mains filters.

However, the utilization of normal power cables for data transmission (e. g. Internet, signal, video and audio transmission) also is a serious source of interference and radiation.

5.1. Noise floor



The so-called noise floor indicates the limit below which real measurements become impossible. Here, only interference will be detected. Visually, Spectran would display this as a collection of small “points” or bars which either stay statically at the same place or change with every sweep (noise). However, depending on frequency and selected settings, the noise floor can be vastly different and must be determined before starting a measurement.

In the case of Spectran, the noise floor increases with lower frequencies – for example, the noise floor at 100MHz is significantly higher than it is at 5GHz. However, skilled users can usually still “tease out” useful readings and distinguish between noise and even very weak, real signals. Determining the noise floor is relatively straightforward: Simply conduct a “measurement” without an antenna and/or signal source or by connecting a 50 Ohms terminator. Any signals then possibly shown are the noise floor of your instrument.

5.2. Harmonics

A typical effect when working with spectrum analyzers: When dealing with comparatively strong signals, a number of weaker signals with fixed offsets relative to the actual signal appear, the so-called „harmonics“. These are “phantom” signals with frequencies that are multiples of actual signals.

For example, a 400MHz signal will also be visible around 800MHz, 1200MHz, 1600MHz etc., a 1800MHz signal will also appear at 3600MHz, 5400MHz and so forth. These are commonly called second harmonic, third harmonic etc.

Thus; when in doubt, one should always consider an additional measurement at half the center frequency. If a correspondingly stronger signal is found there, the previously measured one would be a harmonic.

With the current firmware, Spectran already attenuates harmonics by approximately 30-50dB, depending on signal strength.

5.3. Sensitivity

Please note that the noise floor (and therefore sensitivity) in spectrum analyzers can be subject to significant variation depending on frequency.

Even a frequency adjustment of just a few MHz can decisively alter the noise floor characteristics. In general, however, Spectran’s noise floor increases with lower frequencies, while sensitivity decreases.

A practical example: Using the same filter settings, you can measure considerably weaker signals at 5 GHz than at, say 100MHz.

5.4. Measurement inaccuracy

Aaronia states a typical accuracy for each Spectran model. However, this means that higher deviations are entirely possible. Especially when you approach the so-called noise floor or the maximum sensitivity of a spectrum analyzer, accuracy decreases by principle.

Even though Spectran instruments offer an impressive accuracy considering their price, a higher measurement inaccuracy, than the base instrument itself has, is assumed in practice: The reason behind this are further factors which can influence measurement inaccuracy: Some of them are: temperature dependence, repeatability, antenna errors, modulation dependence etc.

According to BUWAL (see also www.BUWAL.ch), one should always expect an extended measurement inaccuracy of at least 35 % even with absolutely professional equipment. So, expressed in dB, you should always expect a rounded ± 3 dB and consider this in every measurement.

Example: You measure a value of -45dBm. So, the actual result could, according to the mentioned measurement inaccuracy, vary between -42dBm ($-45\text{dBm} + 3\text{dB}$) and - 48dBm ($-45\text{dBm} - 3\text{dB}$). Thus, as you want to measure radiation exposure, you should always assume the highest value, namely -42dBm.

5.5. Measurements of satellite TV



DC-blocker provides protection from potentially damaging DC voltages for Spectran's input.

You can directly connect Spectran to your LNB's output (or alternatively, to the attached satellite cable or receiver) in order to perform measurements.

Please note that the receiver supplies a 13/18 V DC voltage to the LNB, which will consequently also be fed into Spectran's input. While Spectrans can accept DC voltages of up to 50V, it is always possible for the DC voltage to vary significantly and intermittently exceed acceptable levels, leading to the destruction of the unit's input.

We thus strongly recommend you use the optional DC blocker which can simply be inserted before Spectran's input and effectively eliminates any DC voltages.

It does not influence measurements in any way.

5.6. Measurement with a direct cable connection



20dB Attenuator

Please be careful not to destroy Spectran's input circuitry when conducting measurements with direct cable connections to other equipment (especially in the case of function or RF generators) as such equipment might generate excessively high voltages or power. Even a very short overload can irreversibly destroy Spectran's extremely sensitive input.

To prevent damage due to excessive input levels, be sure to always utilize our optional 20dB attenuator in such applications.

6. Spectrum analysis basics

6.1. What is a frequency range?

Imagine a giant motorway, several kilometers wide, with thousands of lanes. Every imaginable kind of vehicle can be found here: motorcycles, cars, trucks, etc. In order for them to not get into each other's 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 traffic caused by the individual groups, these lanes also have different widths: For example the lane reserved for cyclists is far narrower than that reserved for trucks, etc. High frequency ranges work the same way, here the "road users" are applications (for example, a cell phone, a microwave oven, a radio-controlled car lock, in effect all appliances that somehow work with radio waves).

Every application has its own frequency range for exclusive use. By assigning a separate frequency range for each application, conflicts between different "road users" can be avoided, so that e. g. a cell phone cannot be disturbed by a microwave oven.

6.2. Big difference 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 on the contrary, may speed up to 250 km/h. Exposure limits for radio applications work similarly: Here, however, the word "speed" is replaced by the transmitting power. E. G., a broadcast station may have an enormous transmitting power of 1 000 000W or more, in contrast, a radio-controlled car lock only a few mW (1mW=0.001W) etc. 3 examples of exposure limits in practice.

Frequency range (MHz)	Application	Power limit (W EIRP)
1 880 – 1 900	DECT phones	0.25
2 320 – 2 450	Amateur radio (11 cm)	750
5 725 – 5 825	WLAN 802.11a	0.025

It is easily visible that each radio application may only use one exactly defined frequency range. Also, the high differences in admissible transmitting power are noticeable.

6.3. Application of spectrum analysis

There are 2 main reasons for application of spectrum analysis:

- You would like to know which radio applications are active.
- You would like to measure the exposure caused by each of the radio applications separately, e. g. for evaluating exceeding of exposure limits.

Regarding a:

Let's reconsider our "giant motorway" example: Remember that every lane was only intended for use by a single kind of vehicle. Now imagine that a huge bridge crossed this motorway, with you standing on the bridge and looking down on the motorway.

Now, for example, you would like to know exactly what is happening on the motorway, on every single lane. However, the motorway is incredibly wide, so you would need rather good binoculars to be able to even look a few km far. Let's just imagine that your binoculars have a range of 6km (6000m). Now you would like to know how much traffic there is on a specific lane and how fast it is traveling. So, you'll take a piece of paper and write down the number of the lane and the data you evaluated. Starting at lane 1, you see: nothing – OK, let's go on with lane 2 – nothing either. Now lane 3 – OK, there is some traffic going at 18 km/h. Continuing with lane 4 – nothing, etc., until you have reached the last lane. What have you accomplished now? You've performed an analysis of the entire range of lanes from 0 – 6 km. Or, in other words: You performed a range analysis. As you know, to analyze something means breaking it down into smaller parts which can be evaluated. In this case, the 6 km wide motorway was that big "something" and the smaller parts were the individual lanes. The word "range" can now be replaced by the word "Spectrum" and there we are. You have performed a spectrum analysis.

If you now in addition have a lanes plan telling you which lane is assigned to which kind of vehicle, you can exactly determine what kinds of vehicles have just been traveling.

Spectrum analysis in high frequency technology works exactly like that: There are „lanes“, here as well. Though, these lanes are called frequency ranges. The width of these frequency ranges is measured in the unit Hz (Hertz). However, as the frequency ranges are mostly found in high Hz ranges, writing them in plain Hz would require huge numbers. Thus, the unit Hz is often extended to MHz (1.000.000Hz) and GHz (1 000 000 000Hz). Like this, the whole thing becomes much clearer. So, 1 000 000 000Hz can also be written as 1 000MHz or 1GHz.

The different kinds of vehicles are called radio applications and have their own abbreviations: e. g. the radio application "UMTS" (the new, digital mobile communications standard) has its own frequency range which spans 1900 to 2200MHz (1.9 – 2.2GHz).

The speed at which the vehicles are traveling can now be replaced by a new expression: the signal strength or level.

So far, we have now explained the used expressions and units. Now, high frequency analysis works just as our motorway example:

For example, our measurement device should evaluate all frequency ranges from 1MHz to 6 000MHz (in pictures, our 6 000 m wide motorway). Step by step, every frequency range is evaluated precisely. First: 0 to 1MHz, then 1MHz to 2MHz etc. until 6 000MHz. Also, the signal strength of every frequency range is exactly stored. Like this, we also learn what signal strength is present on which frequency range.

7. Physical units

7.1. Measuring transmission power (dBm; dB μ V)

Measurements of communications equipment often show extremely big differences between levels. Therefore, it is useful to express signal levels in logarithmic units to avoid “drowning” readings in an endless number of zeros. Thus, our Spectran HF-2025E e. g. already features a measurable level range of -80dBm to 0dBm. As amplification increases tenfold once every 10dB, “readings” of 0 to 100,000,000 would need to be displayed. Though, these “numeric giants” would be nearly unreadable and result in steady, drastic changes of the displayed values. So, we use the much easier to handle logarithmic unit dB:

As logarithms are dimensionless, logarithmic readings are always relative to a certain reference level, i. e., a relationship between two levels is established. A common reference level that has become a standard in radio technology is 1mW or 1 μ V. So, logarithmic level readings are expressed in **dB milliwatts** [dBm] or **dB microvolts** [dB μ V].

7.2. Field strength [V/m; A/m] and power density [W/m²]

If you don't feed signals directly and instead perform measurements using an antenna, you will mostly want to measure the so-called field strength or power density instead of power. In professional measurement technology, mostly only the “manageable” electric field strength is measured, using the unit V/m. As with dBm, V/m produces manageable readings without endless rows of zeroes. In contrast, cheap broadband instruments often only provide readings of power density (mostly in μ W/m²) to confuse the operator with allegedly huge changes in “electrosmog” strength. This is just as if you measured distances on motorways in mm: Frankfurt to Munich = 400,000,00 mm. Certainly impressive, but just pure showiness, as it's just 400km. Manageability and readability is left behind, as the display constantly changes in huge steps. Of course, Spectran can also display power flux density in μ W/m² or other “Giga-units”. However, in contrast to the aforementioned cheap devices, Spectran offers a practical Autorange feature in W/m²-mode, e. g. instead of displaying an endless number of zeroes; it just displays the corresponding abbreviation f, p, n, μ or m before the unit.

7.3. Calculating the wavelength in [m]

To calculate the wavelength from the frequency, use the following formula:

$$\lambda = \frac{c}{f}$$

Here, c corresponds to the speed of light in $\left[\frac{m}{s}\right]$ (rounded to 300,000km/s in our example), „ f “ to the frequency of the radiation in [Hz], and λ to the wavelength in [m]. Examples:

$$\lambda = \frac{300\,000\,000 \frac{m}{s}}{900\,000\,000 \text{ Hz}} = 0,33 \text{ m}$$

(For 900 MHz, the result is 0.33m)

$$\lambda = \frac{300\,000\,000 \frac{m}{s}}{1\,800\,000\,000 \text{ Hz}} = 0,17 \text{ m}$$

(For 1 800 MHz, the result is 0.17 m)

$$\lambda = \frac{300\,000\,000 \frac{m}{s}}{2\,000\,000\,000 \text{ Hz}} = 0,15 \text{ m}$$

(For 2 GHz, the result is 0.15 m)

Further information concerning wavelength is contained in table 4.

7.4. Calculating the „close-up range“ in [m]

If you want to perform a measurement, you need to do this outside of the so called close-up range of the transmitter. The close-up range depends on the transmitter frequency. According to the aforementioned formula, the closeup-range can be determined quickly. Here, you simply need to multiply the resulting wavelength by a factor of 10 (there are some sources which only use a factor of 3). The result is the close-up range, i. e. the minimum distance to the transmitter in which a realistic and sensible measurement can be achieved.

Example: For a „900MHz cell phone“ the wavelength is:

$$\lambda = \frac{300\,000\,000 \frac{m}{s}}{900\,000\,000 \text{ Hz}} = 0,33 \text{ m}$$

Hence, the close-up range is $0.33\text{m} * 10 = 3.3\text{m}$.

It is easy to see, that e. g. measurements taken directly next to the cell phone will definitely result in wrong readings.

Inside the close-up range, E and H fields would need to be measured separately. However, outside the close-up range, both field types are coupled tightly to each other, so knowing the strength of one of them will be enough to derive the other.

7.5. Calculating power density [W/m²] from power [dBm]

Only if you know the transmitter's frequency you can convert from dBm to W/m². You will also need the antenna gain of the antenna used for measurement. The formula you need looks like this:

$$S = \frac{10^{\left[\frac{-40-4,9}{10}\right]}}{1000} * \frac{4 * \pi}{0,31579^2} = \frac{0,00003236}{1000} * \frac{12,566}{0,0997} = 0,00000408 \text{ W/m}^2 = 4,08 \text{ } \mu\text{W/m}^2$$

8. Tables

8.1. Convesion tables

Table 1: Conversion dBm to W/m² with HyperLOG-antenna

Assuming the use of an „idealized“ measurement setup, like our HyperLOG antenna with 5dBi gain and one of our 1m RG316U cables with 1dB damping, the following conversion table can be applied to the signal sources below (figures in W/m²):

dBm	GSM900	UMTS	Lambda X	WLAN	GSM1800
+10	0.45	2.2	1.34	3.3	1.8
+9	0.36	1.8	1.06	2.7	1.4
+8	0.28	1.4	0.84	2.1	1.1
+7	0.23	1.1	0.67	1.7	0.90
+6	0.18	0.89	0.53	1.3	0.72
+5	0.14	0.70	0.42	1.06	0.57
+4	0.11	0.56	0.34	0.84	0.45
+3	0.09	0.44	0.27	0.67	0.36
+2	0.07	0.35	0.21	0.53	0.29
+1	0.06	0.28	0.17	0.42	0.23
0	0.045	0.022	0.13	0.033	0.018
-10	0.004 5	0.002 2	0.013	0.003 3	0.001 8
-20	0.000 45	0.000 22	0.001 3	0.000 33	0.000 18
-30	0.000 045	0.000 022	0.000 13	0.000 033	0.000 018
-40	0.000 004 5	0.000 002 2	0.000 013	0.000 003 3	0.000 001 8
-50	0.000 000 45	0.000 000 22	0.000 001 3	0.000 000 33	0.000 000 18
-60	0.000 000 045	0.000 000 022	0.000 000 13	0.000 000 033	0.000 000 018

We assumed the following center frequencies (f) here:

GSM900 (f = 900MHz),	Lambda X (f = 1550MHz),
GSM1800/DECT (f = 1800MHz),	UMTS (f = 2000MHz)
WLAN/microwave ovens (f = 2450MHz).	

The conversion table demonstrates that per 10dB step, power density decreases by a factor of 10. This applies in a similar manner to the 1dB steps, which also change in a constant manner. Consequently, this table permits easy and fast conversion of indicated dBm values (for example, from the optional PWK detector) into PEAK field strength or, respectively, power density in W/m². This table can just as well be used with different antennas, attenuators or cables:

For example, should you be using our 20dB attenuator (option), you would extract those rows from the table whose dBm values are 20dB higher, for example, -10dBm instead of -30dBm. As a different example, should you be using an antenna with 24dBi gain, you would use those values 19dB lower than the actual reading ((24dBi minus 5dBi [as 5dBi gain is already included in the calculated table values])). For example: -43dBm instead of -24dBm.

If you were using a cable with 5dBi damping, you would need to refer to those values 4dB higher than the measured value (5dB minus 1dB [as 1dB damping is already included in the calculated table values])).

That is -24dBm in place of -28dBm.

TIP: Even in case you do not know the frequency of the signal source, you can still achieve a comparatively exact field strength measurement by simply using the „Lambda X“ column. This column presents a weighted average of all possible frequencies between 900MHz and 2.4GHz, still giving you an accuracy of approximately +/-4dB. That is still significantly better than the inherent inaccuracy of various rudimentary instruments for field strength measurement available from third parties. The frequency range from 900MHz to 2.4GHz spans a large variety of typically interesting signal sources – for example, all cellular phone networks (GSM900, GSM1800, UMTS) and the respective phones, as well as 2.4GHz WLAN and microwave ovens.

Table 2: Conversion from W/m² to µW/cm² and mW/cm²

0.000 001 W/m ²	0.000 1 µW/cm ²	0.000 000 1 mW/cm ²
0.000 01 W/m ²	0.001 µW/cm ²	0.000 001 mW/cm ²
0.000 1 W/m ²	0.01 µW/cm ²	0.000 01 mW/cm ²
0.001 W/m ²	0.1 µW/cm ²	0.000 1 mW/cm ²
0.01 W/m ²	1 µW/cm ²	0.001 mW/cm ²
0.1 W/m ²	10 µW/cm ²	0.01 mW/cm ²
1 W/m ²	100 µW/cm ²	0,1 mW/cm ²

Table 3: Conversion from µW/cm² to V/m and A/m

0.000 1 µW/cm ²	0.019 4 V/m	0.000 051 5 A/m
0.001 µW/cm ²	0.061 4 V/m	0.000 162 A/m
0.01 µW/cm ²	0.194 V/m	0.000 515 A/m
0.1 µW/cm ²	0.614 V/m	0.001 62 A/m
1 µW/cm ²	1.94 V/m	0.005 15 A/m
10 µW/cm ²	6.14 V/m	0.016 2 A/m
100 µW/cm ²	19.4 V/m	0.051 5 A/m

Table 4: dBm to dBW and W

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 5: Frequency, wavelength and frequency band denomination

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 6: Power amplification factor and corresponding value in dB:

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 = Dezibel

8.2. Frequency tables

Table 7: Cell phone frequencies and providers

Start-/	Stop-Frequency	Abbreviation	Provider
864,1	868,1	CT2	Private
885,0	887,0	CT1+ (UL)*	Private
914,0	915,0	CT1 (UL)*	Private
930,0	932,0	CT1+ (DL)*	Private
959,0	960,0	CT1 (DL)*	Private
1.880	1.900	DECT	Private
5.725	5.825	DECT2	Private

All frequency values in MHz.

(UL) = „Uplink“ mostly means „portable device“ (mobile transmitter, which transmits towards the base station, e. g. a cellphone).
 (DL) = „Downlink“ mostly means „base station“ (fixed transmitter which transmits towards the portable device, e. g. a base station).

* License expired
 CT1+: cordless phone (analogue). License expires 1/1/2007 10mW EIRP.
 DECT: Base station always transmits even when not handling calls. 250mW EIRP.
 DECT2: New generation of cordless phones (DECT successor). 25mW EIRP.

More extensive lists on www.aaronia.com

Table 8: German GSM900 frequencies and providers

Start-/	Stop-Frequency	Abbreviation	Provider
876,2	880,0	GSM-R (UL)	Deutsche Bahn
880,1	885,1	GSM900 (UL)	E-Plus
885,1	890,1	GSM900 (UL)	O2-Germany
890,2	892,4	GSM900 (UL)	Vodafone
892,6	899,8	GSM900 (UL)	T-Mobile
900,0	906,0	GSM900 (UL)	Vodafone
906,2	910,4	GSM900 (UL)	T-Mobile
910,6	914,2	GSM900 (UL)	Vodafone
914,4	914,8	GSM900 (UL)	T-Mobile
921,2	925,0	GSM-R (DL)	Deutsche Bahn
925,1	930,1	GSM900 (DL)	E-Plus
930,1	935,1	GSM900 (DL)	O2-Germany
935,2	937,4	GSM900 (DL)	Vodafone
937,6	944,8	GSM900 (DL)	T-Mobile
945,0	951,0	GSM900 (DL)	Vodafone
951,2	955,4	GSM900 (DL)	T-Mobile
955,6	959,2	GSM900 (DL)	Vodafone
959,4	959,8	GSM900 (DL)	T-Mobile

All frequency values in MHz.

(UL) = „Uplink“ mostly means „portable device“ (mobile transmitter which transmits towards the base station, e. g. cellphones) Pulsed at 217Hz. Power variable between 20mW-2W (Peak).

(DL) = „Downlink“ mostly means „Base-station“ (fixed transmitter which transmits towards the portable device, e. g. cell towers). Pulsed at 217Hz. Control channel pulsed at 736Hz. Power variable between 0.5 and 400W ERP. Range of up to 32 km.

More extensive lists on www.aaronia.com

Table 9: German GSM1800 frequencies and providers

Start-/	Stop-Frequency	Abbreviation	Provider
1 710.0	1 725.0	GSM18K (UL)	Militär
1 725.2	1 730.0	GSM18K (UL)	T-Mobile
1 730.2	1 752.4	GSM18K (UL)	O 2
1 752.8	1 758.0	GSM18K (UL)	Vodafone
1 758.2	1 780.4	GSM18K (UL)	E Plus
1 805.0	1 820.0	GSM18K (DL)	Militär
1 820.2	1 825.0	GSM18K (DL)	T-Mobile
1 825.0	1 847.4	GSM18K (DL)	O 2
1 847.8	1 853.0	GSM18K (DL)	Vodafone
1 853.2	1 875.4	GSM18K (DL)	E Plus

All frequencies are stated in MHz.

(UL) = „Uplink“ mostly means „portable device“ (mobile transmitter which transmits towards the base station, e. g. cellphones) Pulsed at 217Hz. Power variable between 25mW-1W (Peak).

(DL) = „Downlink“ mostly means „Base-station“ (fixed transmitter which transmits towards the portable device, e. g. cell towers). Pulsed at 217Hz. Control channel pulsed at 1.736Hz. Power varies between 0.5 to 300W ERP. Range of up to 16km.

More extensive lists are available on the Aaronia website www.aaronia.com.

Table 10: German UMTS frequencies and providers

Start-/	Stop-Frequency	Abbreviation	Provider
1 920.3	1 930.2	UMTS (UL)	Vodafone
1 930.3	1 940.2	UMTS (UL)	Group 3G
1 940.3	1 950.2	UMTS (UL)	e-plus
1 950.0	1 959.9	UMTS (UL)	MobilCom
1 959.9	1 969.8	UMTS (UL)	O2
1 969.8	1 979.7	UMTS (UL)	T-Mobile D
2 110.3	2 120.2	UMTS (DL)	Vodafone
2 120.2	2 130.1	UMTS (DL)	Group 3G
2 130.1	2 140.0	UMTS (DL)	e-plus
2 140.0	2 149.9	UMTS (DL)	MobilCom
2 149.9	2 159.8	UMTS (DL)	O2
2 159.8	2 169.7	UMTS (DL)	T-Mobile D

All frequencies are stated in MHz.

(UL) = „Uplink“ mostly means „portable device“ (mobile transmitter which transmits towards the base station, e. g. cellphones). Power varies between 2.5mW to 250mW.

(DL) = „Downlink“ mostly means „base station“ (fixed transmitter which transmits towards the portable device, e. g. cell tower). Power varies between 0.5 to 500W ERP. Range of up to 8 km.

More extensive lists are available on www.aaronia.com

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