

Rev 2.6  
29.12.2015

# Handheld Spectrum Analyzer *SPECTRAN*® V4

Portable Spectrum Analyser with world record in sensitivity (DANL)

## References / examples of proof:

- ◆ EADS, Munich, Germany
- ◆ Mercedes Benz, Austria
- ◆ Deutsche Bahn, Berlin, Germany
- ◆ EnBW Kernkraft GmbH, Germany
- ◆ RTL Television, Cologne, Germany
- ◆ NDR, Hamburg, Germany



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# Specifications

## SPECTRAN® HF-6060 V4:

- ◆ Up to **100x faster SampleTime** as Rev.3
- ◆ Up to **60dB higher sensitivity** as Rev.3
- ◆ 14Bit Dual-ADC
- ◆ DDC Hardware-Filter
- ◆ 150 MIPS DSP (CPU)
- ◆ Frequency range: 10MHz to **6GHz**
- ◆ Max measurement range: -135dBm (1Hz)
- ◆ Max measurement range PreAmp: **-150dBm** (1Hz)
- ◆ AbsMax Level: +10dBm
- ◆ Lowest possible SampleTime: **1mS**
- ◆ Typ. accuracy: +/- 2dB\*\*
- ◆ Dimensions (L/W/D): (260x86x23) mm
- ◆ Weight: 420gr
- ◆ **Warranty: 10 years**

## SPECTRAN® HF-6080 V4:

- ◆ Up to **100x faster SampleTime** as Rev.3
- ◆ Up to **70dB higher sensitivity** as Rev.3
- ◆ 14Bit Dual-ADC
- ◆ DDC Hardware-Filter
- ◆ 150 MIPS DSP (CPU)
- ◆ Frequency range: 10MHz to **8GHz**
- ◆ Max measurement range: -145dBm (1Hz)
- ◆ Max measurement range w. PreAmps: **-160dBm** (1Hz)
- ◆ AbsMax Level: +10dBm
- ◆ Lowest possible SampleTime: **1mS**
- ◆ Typ. accuracy: +/- 2dB\*\*
- ◆ Dimensions (L/W/D): (260x86x23) mm
- ◆ Weight: 420gr
- ◆ **Warranty: 10 years**

## SPECTRAN® HF-60100 V4 (with World record in sensitivity!):

- ◆ Up to **100x faster SampleTime** as Rev.3
- ◆ Up to **80dB higher sensitivity** as Rev.3
- ◆ 14Bit Dual-ADC
- ◆ DDC Hardware-Filter
- ◆ 150 MIPS DSP (CPU)
- ◆ Frequency range: 1MHz (9kHz with Option 900) to **9,4GHz**
- ◆ Max measurement range: -155dBm (1Hz)
- ◆ Max measurement range w. PreAmps: **-170dBm** (1Hz)
- ◆ AbsMax Level: +20dBm
- ◆ AbsMax Level: **+40dBm** (Option)<sup>3</sup>
- ◆ Lowest possible SampleTime: **1mS**
- ◆ Typ. accuracy: +/- 1dB\*\*
- ◆ Dimensions (L/W/D): (260x86x23) mm
- ◆ Weight: 420gr
- ◆ **Warranty: 10 years**



## Application examples Spectran HF-60xxx Spectrum Analyzer

### Analysis and measurement of:

- ◆ Wlan
- ◆ UMTS
- ◆ WiFi
- ◆ active Radar
- ◆ GSM
- ◆ Mobile phones
- ◆ Bluetooth
- ◆ Microwave ovens
- ◆ DECT phones
- ◆ TETRA
- ◆ radio stations
- ◆ TV stations
- ◆ various EMC limits



## Compact, affordable and sensitive

Based on a patented spectrum analyzer method Aaronia can offer a professional RF measurement at a spectacular price level.

The SPECTRAN V4 Analyzer have an extremely compact design and an incredibly high sensitivity (HF-60100 V4 up to -170dBm (1Hz) with pre-amps).

Detect sources of interference, find out more about their causes, determine the frequency and intensity of the signal sources, measure limits and boost the functionality by using our high-end PC software.

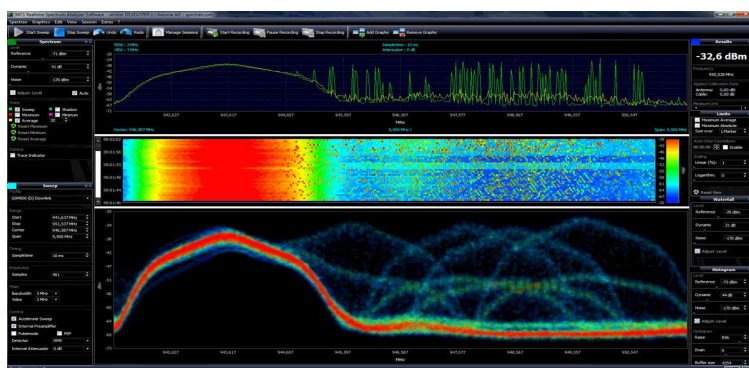
All SPECTRANs are developed, individually produced and calibrated in Germany at the Aaronia factory. This guarantees highest standard so that Aaronia can offer every customer a full 10 year warranty for all SPECTRAN spectrum analyzer and EMC antennas.

## Free Software

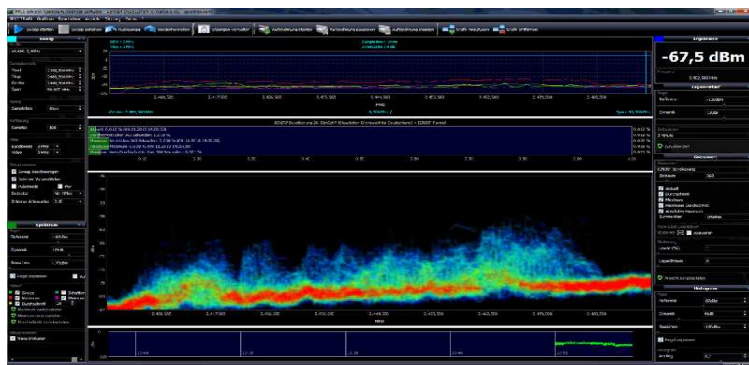
The spectrum analyzer software "MCS" for PC, MAC or Linux shows the real potential of the SPECTRAN. The software can be used in addition to the Spectrum Analyzer. The connection works in real time, i.e. there is no time difference between signal analysis and representation on the screen.

- ◆ Multi-device capability, remote control of several SPECTRAN. These can be controlled on a single PC.
- ◆ Works on all major operating systems like Mac OS, Linux and Windows
- ◆ Real-time remote control function with all SPECTRAN spectrum analyzer via the integrated USB port
- ◆ Unlimited number of limit displays e.g. EN55011, EN55022, etc., including display of ICNIRP limit lines and limit-bar graphs
- ◆ Multi Window Support
- ◆ Powerful undo feature
- ◆ Channel and provider display
- ◆ Custom skins and color settings
- ◆ Reporting and recording function

and much more...



GSM Signal



WLAN Signal



## Scope of delivery

- ◆ RF spectrum analyzer SPECTRAN HF-6060 V4, HF-6080 V4 or HF-60100 V4
- ◆ HyperLOG 7060, 6080 or 60100 EMC/directional antenna
- ◆ 1300mAh power battery with charger
- ◆ Pistol grip with miniature tripod mode
- ◆ SMA toolset
- ◆ SMA adapter
- ◆ 1m SMA cable
- ◆ Sturdy aluminum-design carrycase (with custom padding!)
- ◆ Exhaustive manual with lots of basic information, hints and exposure limit tables

# SPECTRAN® HF (RF) Spectrum Analyser

APPLICATION EXAMPLES: Measurement of (active) radar, mobile communications, mobile phones, UMTS, DECT phones, transmission towers, WLAN, Wifi, Bluetooth, microwaves etc.

	Entrance	Intermediate	Professional			Outdoor
Specifications base unit <sup>(1)</sup>	HF-2025E	HF-4040	HF-6060V4	HF-6080V4	HF-60100V4	HF-XFR
Frequency Range (min)	700MHz	100MHz	10MHz	10MHz	1MHz	1MHz
Frequency Range (max)	2,5GHz	4GHz	6GHz	8GHz	9,4GHz	9,4GHz
Optional PEAK Power-Detector (Maximum usable frequency) <sup>(3)</sup>	2,5GHz	4GHz	6GHz	8GHz	10GHz	10GHz
DANL (Displayed Average Noise Level) <sup>(2)</sup>	-80dBm	-90dBm	-135dBm(1Hz)	-145dBm(1Hz)	-155dBm(1Hz)	-155dBm(1Hz)
DANL (Displayed Average Noise Level) with Preamps (Option 020,321) <sup>(2)</sup>	-	-	-150dBm(1Hz)	-160dBm(1Hz)	-170dBm(1Hz)	-170dBm(1Hz)
Max Power at RF input	0dBm	0dBm	+10dBm	+10dBm	+40dBm <sup>(2)</sup>	+40dBm <sup>(2)</sup>
RBW (resolution bandwidth) (min)	1MHz	100kHz	10kHz	3kHz	200Hz <sup>(2)</sup>	200Hz <sup>(2)</sup>
RBW (resolution bandwidth) (max)	50MHz	50MHz	50MHz	50MHz	50MHz	50MHz
EMC-Filter 200Hz, 9kHz, 120kHz, 200kHz, 1,5MHz, 5MHz	-	-	-	-	✓	✓
Demodulator	AM	AM/FM	AM/FM	AM/FM/PM	AM/FM/FM/GSM	AM/FM/FM/GSM
Detector	RMS	RMS	RMS/MinMax	RMS/MinMax	RMS/MinMax	RMS/MinMax
Units dBm, dBµV, V/m, A/m, W/m² (dBµV/m etc. via PC software)	✓	✓	✓	✓	✓	✓
Internal Datalogger (size). Expandable to 1MB (option 001)	-	64K	64K	64K	64K	harddisk
Lowest SampleTime	100mS	100mS	10mS	10mS	5mS	5mS
Accuracy (typical)	+/-4dB	+/-3dB	+/-2dB	+/-2dB	+/-1dB	+/-1dB
<b>Highlights</b>						
Real-time remote control via USB	✓	✓	✓	✓	✓	internal
Calibration setup (antenna, cable, attenuator etc.)	✓	✓	✓	✓	✓	✓
Exposure limit calculation according to ICNIRP, EN55011, EN55022 etc.	ICNIRP only	ICNIRP only	ICNIRP only	ICNIRP only	✓	✓
Extended full ICNIRP range	-	-	-	-	✓	✓
Suitable for pre-compliance test	-	-	-	-	✓	✓
Realtime limit calculation with simultaneous percentage display	-	✓	✓	✓	✓	Analyzer sw
Time-Domain and fast Zero-Span sweep	-	-	✓	✓	✓	✓
Vector power measurement (I/Q) and True RMS	-	✓	✓	✓	✓	✓
Simultaneously displays frequency and signal strength	✓	✓	✓	✓	✓	Analyzer sw
Up to 3 marker (showing both frequency and field strength)	-	✓	✓	✓	✓	unlimited
Jog Dial controlled manual marker readout	-	✓	✓	✓	✓	key & touchpad
Write, AVG and Hold function	no AVG	no AVG	✓	✓	✓	& Min, Max
DECT and TimeSlot Analyzer	✓	✓	✓	✓	✓	✓
Audio Level Indicator (changes audio frequency vs power level)	-	-	✓	✓	✓	-
Free of charge firmware update (via Internet)	✓	✓	✓	✓	✓	✓
Supports programming of custom P-Code & C++ based custom software	-	✓	✓	✓	✓	✓
14Bit Dual-ADC & DDC Hardware-Filter	-	-	✓	✓	✓	✓
150MIPS high performance DSP (Digital Signal Processor)	-	-	✓	✓	✓	✓
Large high resolution multifunctional LCD (95mm)	✓	✓	✓	✓	✓	14" TFT
Spectrum display (51x25 pixel)	✓	✓	✓	✓	✓	Analyzer sw
High resolution 50 segment bargraph (trend display)	✓	✓	✓	✓	✓	Analyzer sw
Enhanced, much sharper Aaronia LCD display (3d generation)	-	-	✓	✓	✓	14" TFT
Integrated battery charger (supports our optional LiPo battery)	✓	✓	✓	✓	✓	XFR charger
Internal speaker	Piezo	✓	✓	✓	✓	✓

Please continue on next page



HF-2025E



HF-4040



HF-6060 V4



HF-6080 V4



HF-60100 V4



HF-XFR



# SPECTRAN® HF (RF) Spectrum Analyser

APPLICATION EXAMPLES: Measurement of (active) radar, mobile communications, mobile phones, UMTS, DECT phones, transmission towers, WLAN, Wifi, Bluetooth, microwaves etc.

	Entrance	Intermediate	Professional			Outdoor
Connectors / Interface	HF-2025E	HF-4040	HF-6060V4	HF-6080V4	HF-60100V4	HF-XFR
USB 1.1/2.0	✓	✓	✓	✓	✓	2x
Audio output (2,5mm jack)	✓	✓	✓	✓	✓	3,5mm jack
Charger plug (max. 12V)	✓	✓	✓	✓	✓	✓
50Ohm SMA input (f)	✓	✓	✓	✓	✓	✓
Jog Dial (easy usage of menu operation and volume control)	-	✓	✓	✓	✓	key & touchpad
1/4" tripod connector	✓	✓	✓	✓	✓	in-Vehicle docking
<b>Included In Delivery</b>						
OmniLOG 90200 Antenna	-	-	-	-	-	✓
HyperLOG EMC directional LogPer antenna (model)	7025	7040	7060	6080	60100	60100 (black)
SPECTRAN 1300mAh rechargeable battery (integrated)	✓	✓	✓	✓	✓	6 cell battery
Battery charger and power supply incl. international adapter sit	✓	✓	✓	✓	✓	no adapter set
Aluminum carrying case with foam protection	✓	✓	✓	✓	✓	-
Detailed English manual (on CD)	✓	✓	✓	✓	✓	installed
Analyzer Software for MAC-OS, Linux and Windows (on CD)	✓	✓	✓	✓	✓	installed
SMA tool	✓	✓	✓	✓	✓	✓
SMA adapter	✓	✓	✓	✓	✓	-
<b>Available Options (extra charge)</b>						
Option 001 (1MB memory expansion)	-	✓	✓	✓	✓	harddisk
Option 002 (high accurate 0,5ppm TCXO timebase)	-	-	-	-	✓	installed
Option 020 (15dB internal low noise preamplifier, switchable)	-	-	✓	✓	✓	installed
Option 20x (Real-time Broadband Peak Power Meter)	✓	✓	✓	✓	✓	✓
Option UBBV1 (40dB external preamplifier 1MHz-1GHz)	-	-	✓	✓	✓	✓
Option UBBV2 (40dB external preamplifier DC-8GHz)	-	-	✓	✓	✓	✓
<b>Optional Accessories</b>						
USB Cable (special EMC screened version)	✓	✓	✓	✓	✓	installed
3000mAh Lithium Polymer (LiPo) Power-Battery	✓	✓	✓	✓	✓	-
Car Power Adapter (operate or charge via cigarette lighter)	✓	✓	✓	✓	✓	-
Outdoor Rubber Protection (perfect for outdoor usage)	✓	✓	✓	✓	✓	-
Pistol Grip / Miniature Tripod	✓	✓	✓	✓	✓	-
Heavy Multifunctional Pistol Grip	✓	✓	✓	✓	✓	-
Aluminum Tripod (big version)	✓	✓	✓	✓	✓	-
DC-Blocker (protects the input against DC voltage)	✓	✓	✓	✓	✓	✓
20dB Attenuator (expands the measurement range by 20dB)	✓	✓	✓	✓	✓	✓
PBS1 Near Field Probe Set (passive)	-	-	-	-	✓	✓
PBS2 Near Field Probe Set (active, incl. UBBV2 preamplifier)	-	-	-	-	✓	✓
ADP1 Active Differential Probe (conductive measurement)	-	-	-	-	✓	✓
5m or 10m low loss SMA Cable	✓	✓	✓	✓	✓	✓
Calibration Resistor (needed for noise floor calibration, SMA)	-	-	✓	✓	✓	✓
Calibration Certificate	✓	✓	✓	✓	✓	✓
Heavy Plastic Carrying Case	✓	✓	✓	✓	✓	-

<sup>(1)</sup> The new V5 real-time spectrum analyser generation up to 80GHz is already in development. Please contact us for further details!

Preliminary specifications dated 01.03.2013. The V4 and XFR series are available with latest Beta firmware. The Beta firmware is constantly in development. Some functionality may still be limited and not fully to specifications (Beta status). By regularly checking our homepage for updates, you can always keep your measurement device up-to-date. As soon as V1.0 of the firmware is released, all functionality and features will be fully available. Range, sensitivity and accuracy can change depending on frequency, setup, antenna and used parameters. Precision datas are based on Aaronias calibration-reference under specific test conditions. Unless otherwise stated, these specifications are according to the following reference conditions: Ambient temperature 22±3°C, relative air humidity 40% to 60%, continuous wave signal (CW), RMS detection. V4 and XFR DANL @3,6009GHz. Maximum sensitivity of Rev.3 units: -90dBm @2,2GHz.

<sup>(2)</sup> Standard: +20dBm. Only with optional 20dB attenuator +40dBm. Standard: 1kHz. Only with option 002 down to 200Hz.

<sup>(3)</sup> Depending on frequency the option 20x offers a sensitivity down to -50dBm and max. +10dBm, with optional 20dB attenuator +30dBm.



HF-2025E



HF-4040



HF-6060 V4



HF-6080 V4



HF-60100 V4



HF-XFR

# OPTIONS Spectran 60xxx series

## Option 001: 1MB memory expansion

This internal memory expansion is a MUST-HAVE particularly when using the data logger, as the standard capacity can quickly become exhausted in this mode. The memory expansion provides space for more than 10,000 logs, while the standard memory will only accommodate approximately 100 of them.  
Standard memory size is 64K.

Order/Art.-No.: 180

## Option 020: Internal 15dB low-noise preamplifier

This option provides an internal, super low-noise 15dB preamplifier, enabling maximum performance particularly when measuring extremely weak signals. It is switched via a TRUE RF switch. There really is no excuse for not ordering this one, considering its very attractive price!  
The maximum sensitivity of the V4 series without option 020 is lower by 15dB.

Order/Art.-No.: 177

## Option 002: 0.5PPM TCXO timebase

(Only available for Spectran® HF-60100 V4).

This highly precise TCXO timebase, which has been especially developed for the SPECTRAN®, offers significantly reduced phase noise (jitter). This will allow the use of far narrower filters (in development), which will in turn vastly enhance sensitivity. To fully exploit the maximum sensitivity of the HF-60100 V4, this option is indispensable! Furthermore, the TCXO timebase allows far more accurate frequency measurement and display and is therefore a MUST-HAVE for future applications like time-domain measurements or code-selective measurement of UMTS, all already in development.  
The standard accuracy without option 002 is 50ppm.

Order/Art.-No.: 181

## Option 20x: 6GHz / 8GHz / 10GHz peak power meter

A 6 to 10GHz peak power meter (3 versions depending on the SPECTRAN® model, see our price list). This option augments your SPECTRAN® with a power meter with up to 10GHz of bandwidth. Furthermore, it allows exact measurement of signal peaks with high crest factor like those occurring in WLAN technology, or extremely short signals, like RADAR bursts. What's more, measurement is performed in REAL TIME and BROADBAND, while at the same time being temperature-compensated. It is also an ideal solution for measurement of cable attenuation or receiver output. Depending on the actual frequency, the power meter provides a sensitivity of up to approx. -50dBm, while the maximum permissible level is +10dBm. By adding our 20dB attenuator (see price list), the maximum measurable signal level can be enhanced to +30dBm or +50dBm!

Order/Art.-No.: 182-x

## Option 015: Audio Signal Tracker

The Option 015 provides an acoustic representation of the signal intensity, similar to a Geiger counter. This allows a fast and convenient localization of the signal source. Perfectly suitable for signal direction finding, finding hidden transmitters or aligning antennas, especially in combination with the Peak Power Meter (Option 20x). As a highlight, the dynamic can be adapted optimally by moving the reference level.

Order/Art.-No.: 178-1

## Option 900: 9kHz frequency extension

(Only available for Spectran® HF-60100 V4).

Extends the start frequency to 9 kHz. The new, usable frequency range with Option 900 is 9kHz - 9.4 GHz. Perfect for the measurement of conducted emissions according to interference standards such as EN55015, EN61800-3 etc.

Order/Art.-No.: 189-2

## Option 022: 40dB low-noise preamplifier 1MHz-10GHz

(Only available for Spectran® HF-60100 V4).

This option provides an external, super low-noise 40dB preamplifier, enabling maximum performance particularly when measuring extremely weak signals at a EN55011, EN55022 or EN50371 EMC-test. If you use our BicoLOG antenna or our PBS1 Probeset and EMC-Sniffer this amplifier is a MUST HAVE to get the best performance!  
The 40dB preamplifier is already included in the EMC-Bundle1.

Order/Art.-No.: 321

# Recommended accessories

## Heavy Plastic Carrycase PRO

Shock resistant, heavy version with padding. Offers spaces for 2 SPECTRAN units with all accessories and a HyperLOG 70xx or 60xx antenna. A MUST for the professional user or outdoor usage!

Order/Art.-No.: 243



## Calibration Certificate

Available for all SPECTRAN® units. With detailed calibration sheet.

Order/Art.-No.: 784



## 3000mAh LiPo Power-Battery

Offers a MUCH higher runtime of your SPECTRAN (up to 400%). Strongly recommended for autonomic measurement! The 1300mAh standard-battery will be replaced.

Order/Art.-No.: 254



## DC-Blocker (SMA)

It prevents the RF-input of the SPECTRAN to be destroyed by the DC-voltages of f.e. DSL/ISDN lines.

Order/Art.-No.: 778



## Pistol grip / miniature tripod

Detachable handle with super-practical miniature tripod mode: this handle is attachable to the backside of the unit and allows optimal handling (esp. for directional measurement) and even fixed installation of the unit. STRONGLY recommended for PC use!

Order/Art.-No.: 280



## USB Cable (Special Version)

To connect your Spectran to the PC. Special version with high performance EMC-ferrite. STRONGLY recommended for PC use!

Order/Art.-No.: 774



## Car power adapter for mobile use

With power-LED. For charging batteries or operating our units in your car, including special plug.

Order/Art.-No.: 260



## Calibration Resistor (DC-18GHz)

This calibration resistor is necessary for the best possible calibration of the noise-floor of each Spectran V4-Analyzer.

Order/Art.-No.: 779



## Aluminum tripod

Height adjustable, high stability. STRONGLY recommended for PC use! Max. height: 105cm.

Order/Art.-No.: 281



## 1m / 5m / 10m SMA-Cable

High quality special SMA cable for connecting any HyperLOG®-Antenna or BicoLOG®-Antenna with our RF Spectrum-Analyzer. Available as 1m, 5m and 10m Cable. All versions: SMA plug (male) / SMA plug (male).



## Protection rubber

Protect and personalize your SPECTRAN with a sturdy rubber case and keep it scratch-n-dent free. Allows full access to all functions.

Order/Art.-No.: 290



## 20dB SMA high-end Attenuator

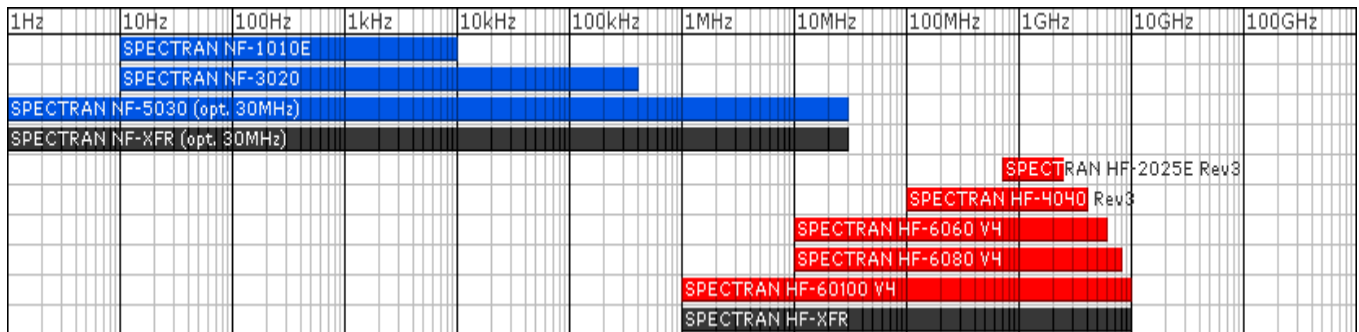
Expands the measurement range to +40dBm. (ONLY SPECTRAN HF-60100 V4 and HF-XFR).

Order/Art.-No.: 775

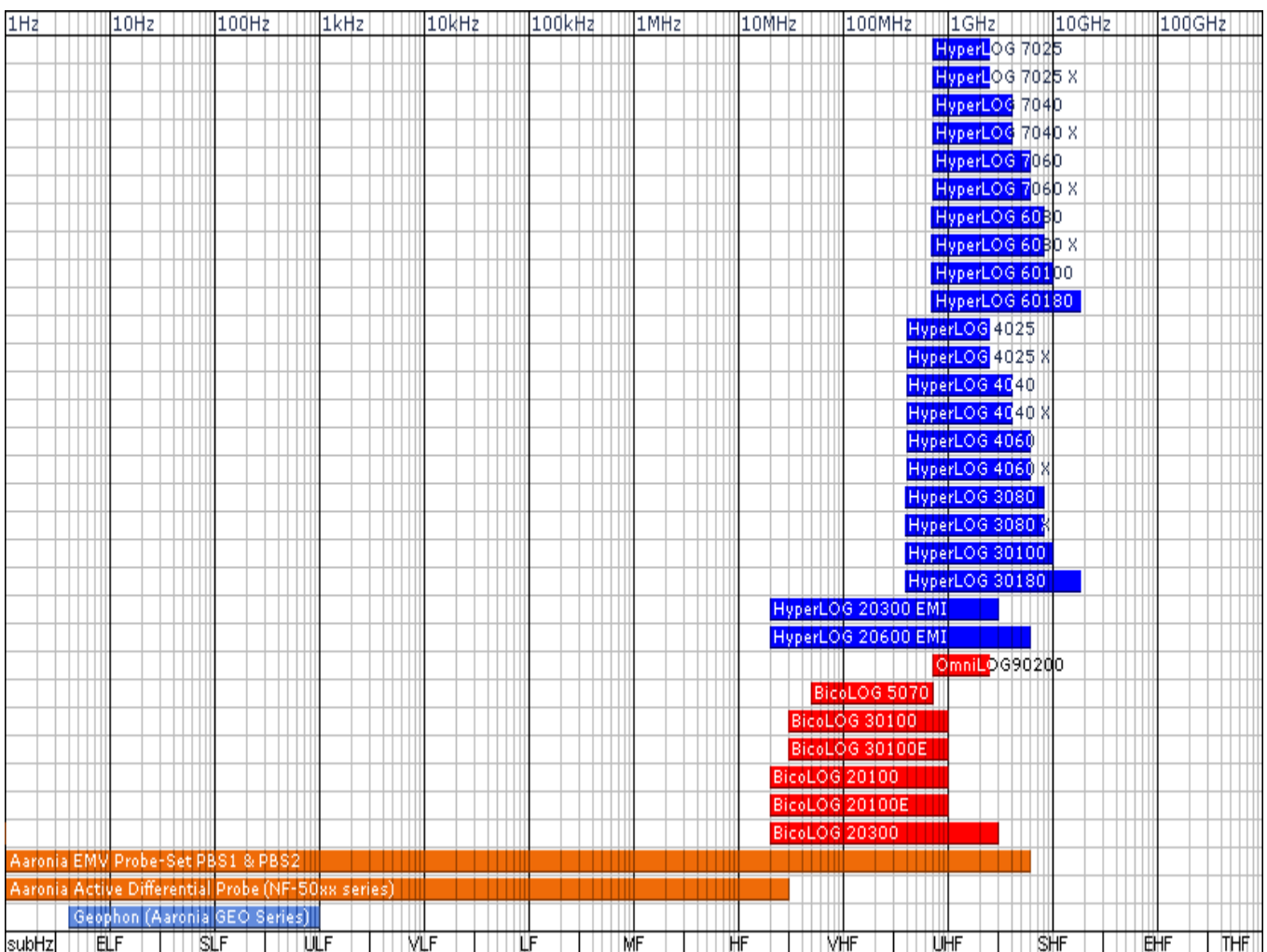


# Frequency overview Analyzers & Antennas

# Frequency Overview SPECTRAN Spectrum Analyzer



## Frequency Overview HyperLOG and BicoLOG Antennas and Probes





# References

## Cross-Section of Aaronia Clients

### Government, Military, Aeronautic, Astronautic

- ♦ NATO, Belgium
- ♦ Department of Defense, USA
- ♦ Department of Defense, Australia
- ♦ Airbus, Germany
- ♦ Boeing, USA
- ♦ Bundeswehr, Germany
- ♦ NASA, USA
- ♦ Lockheed Martin, USA
- ♦ Lufthansa, Germany
- ♦ DLR, Germany
- ♦ Eurocontrol, Belgium
- ♦ EADS, Germany
- ♦ DEA, USA
- ♦ FBI, USA
- ♦ BKA, Germany
- ♦ Federal Police, Germany
- ♦ Ministry of Defense, Netherlands

### Research/Development, Science and Universities

- ♦ MIT - Physics Department, USA
- ♦ California State University, USA
- ♦ Indonesian Institute of Science, Indonesia
- ♦ Los Alamos National Laboratory, USA
- ♦ University of Bahrain, Bahrain
- ♦ University of Florida, USA
- ♦ University of Victoria, Canada
- ♦ University of Newcastle, United Kingdom
- ♦ University of Durham, United Kingdom
- ♦ University of Strasbourg, France
- ♦ University of Sydney, Australia
- ♦ University of Athens, Greece
- ♦ University of Munich, Germany
- ♦ Technical University of Hamburg, Germany
- ♦ Max-Planck Institute for Radio Astronomy, Germany
- ♦ Max-Planck Institute for Quantum Optics, Germany
- ♦ Max-Planck-Institute for Nuclear Physics, Germany
- ♦ Max-Planck-Institute for Iron Research, Germany
- ♦ Research Centre Karlsruhe, Germany

### Industry

- ♦ APPLE, USA
- ♦ IBM, Switzerland
- ♦ Intel, Germany
- ♦ Shell Oil Company, USA
- ♦ ATI, USA
- ♦ Microsoft, USA
- ♦ Motorola, Brazil
- ♦ Audi, Germany
- ♦ BMW, Germany
- ♦ Daimler, Germany
- ♦ Volkswagen, Germany
- ♦ BASF, Germany
- ♦ Siemens AG, Germany
- ♦ Rohde & Schwarz, Germany
- ♦ Infineon, Austria
- ♦ Philips, Germany
- ♦ ThyssenKrupp, Germany
- ♦ EnBW, Germany
- ♦ RTL Television, Germany
- ♦ Pro Sieben – SAT 1, Germany
- ♦ Channel 6, United Kingdom
- ♦ CNN, USA
- ♦ Duracell, USA
- ♦ German Telekom, Germany
- ♦ Bank of Canada, Canada
- ♦ NBC News, USA
- ♦ Sony, Germany
- ♦ Anritsu, Germany
- ♦ Hewlett Packard, Germany
- ♦ Robert Bosch, Germany
- ♦ Mercedes Benz, Austria
- ♦ Osram, Germany
- ♦ DEKRA, Germany
- ♦ AMD, Germany
- ♦ Keysight, China
- ♦ Infineon Technologies, Germany
- ♦ Philips Semiconductors, Germany
- ♦ Hyundai Europe, Germany
- ♦ JDSU, Korea
- ♦ Wilkinson Sword, Germany
- ♦ IBM Deutschland, Germany
- ♦ Nokia-Siemens Networks, Germany