narda Safety Test Solutions®
an L3 Communications Company

A pocket glossary of
interference localization terms

Third edition, revised

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The examples given refer to the
Interference and Direction Analyzer
IDA-3106, firmware version 1.4.0

Contents

Dear reader:

We hope that this handy pocket glossary will be helpful to you as you carry out your daily tasks of localizing unintentional, unwanted, or unauthorized interference and surveying wireless transmitters. The focus is on on-site search work, direction finding and measurement over the "last mile", and in the near-field region. The situation in these areas can be very complex, so automatic direction finders are only of limited usefulness, making hand-held direction finders the instrument of choice. Such hand-held devices have a long history, stretching back to the middle of the last century and characterized by empirical experiments and practical applications. In recent years, direction finding and localization have been investigated and improved using algorithmic methods. Now, both this expert knowledge and the basic theoretical science are combined with the latest instrument technology, so that it is now possible to analyze, search, and then record the results efficiently, easily, quickly, and accurately.

The initial idea was to just explain the terms related to hand-held direction finding in the strictest sense. Signal analysis is very much a part of modern direction finding and localization, however, being in fact indispensable for successfully locating signal sources. Particularly if the signals are unknown, localization is based on precise analysis of the problem (detecting and isolating the signals in the spectrum, establishing the important signal parameters in the time and frequency domains, and determining the way that interference is occurring). Hand-held direction finding (with correction of the bearing results for reflections and co-channel interference) follows this step. The final step is to determine the precise location

of the emission, which is done either by triangulation or by manual refinement of the bearings, depending on the physical circumstances.

A whole range of technical terms is used to describe the physical problems, possible measurement errors and technical challenges for those making the measurements that are tied up with the process of direction finding and localization. This glossary should help you to understand these terms, and it also gives you some useful tips gathered from experienced experts, which should make practical direction finding easier. We hope it will be a helpful companion to you as you progress towards becoming a specialist in signal analysis and interference localization.

Wishing you every success in your career,

Your Narda Test Solutions Team

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Example: A log-periodic antenna generates a base voltage of 60 dBµV at 1 GHz. What is the field strength?

1 GHz = 10 x 100 MHz or (8 + 20) dB(1/m). With a gain of 4 dB, this gives 24 dB(1/m). The field strength is therefore about 84 dBµV/m.

Note: If the measuring equipment with a magnetic frame antenna displays results in dBµV/m instead of dBµA/m, background subtraction of 51.5 dB resulting from the characteristic field impedance of 377 Ω takes place, i.e. 0 dBµA/m = 51.5 dBµV/m. This conversion is only applicable to measurements in the far field.

Tip:

- Commercially available antennas have negligible squint. Deviations occur principally because of reflections, which "bend" the fields.

▶ Direction finding antenna, ▶ Bearing accuracy

ATT, Attenuation

ATT stands for attenuation, i.e. the input attenuation in dB.

▶ Attenuator / Input attenuator

Attenuator, Input attenuator

Generally: A component that reduces the RF energy by a defined amount and which can also effect impedance matching, depending on the design.

Specifically: An attenuator fitted in the input stage of the instrument that can be switched in steps, and which thus shifts the ▶ Dynamic range so that the signals can be captured optimally.

The **attenuation** (ATT) is based on the ratio of output power to input power, and must be corrected by the voltage transmission coefficient where there is also impedance matching.

Tips:

- 10 dB ATT improves the input reflection coefficient in many cases.
- 10 dB ATT improves input stage overload protection.
- Changing the ATT shifts the ▶ Dynamic range and gives the ▶ Measurement range.
- The finer the attenuator steps (e.g. 1 dB), the better the utilization of the dynamic range.
- The attenuator provides important protection for the 1st mixer and preamplifier stages, and should always be set to 10 dB when the instrument is being switched on.

AUTO, Auto-coupling

Automatic coupling of setting parameters that affect each other, e.g.:

- **RBW – VBW**. The ▶ VBW gives additional smoothing when it is less than the ▶ RBW. This helps separate impulses and continuous signals, but can also falsify the results.
- **Span – RBW – Sweep time**. These values are essentially linked by physical factors. ▶ Span, ▶ RBW, ▶ SWT
- **ATT – REF** ▶ Attenuator / Input attenuator, ▶ Reference

Tips:

- Coupling enables rapid, high accuracy measurement. This is advantageous in many cases.
- Measuring instruments indicate when coupling has been disabled (by an asterisk, color or similar indicator).
- Disabling automatic coupling is useful for special applications, such as intermodulation measurements, searching for burst signals, etc.

AV, Avg, Average

In EMC measurements, the average is understood as the average voltage of the envelope curve over a given measurement time.

The IDA determines the true power average.

▶ Detector

Average noise level

▶ Intrinsic noise, ▶ NF, Noise factor, ▶ Noise figure

Averaging

Signals are averaged by recording their values over a defined measurement time, determining the average value and then displaying it. The results thus are not available until the end of the measurement time.

Averaging can make it difficult to take bearings on brief signals, which can often disappear into the noise floor by being averaged.

▶ Detector, ▶ Scope Mode

Azimuth

The azimuth of an antenna refers to the horizontal angle of an antenna to a reference direction (e.g. North or the axis of a vehicle).

Compare ▶ Elevation

Bearing, Direction finding

In radio navigation, the angle is measured at which the radio waves transmitted from a beacon arrive at the point of measurement. This is called radio direction finding. The location of the radio beacon can be determined from two or more such radio bearings (▶ Triangulation).

Direction finding in the real field is complicated by countless reflections and shadowing due to all kinds of buildings, which obscure or mask the actual direction. Ultimately, though, consistent tracking of reflections can also reveal the location. The trick is to recognize the important information, but as the situation often changes within a very short distance, it can be very difficult to maintain a clear view.

These interference effects can be minimized by the use of appropriate correction tables for fixed direction finding equipment, but such tables are not useful for portable equipment.

Since the angle of incidence of the signal being located and its variation with time are unknown, and it is impossible to memorize the many measurement results which may be obtained over the course of several days, the following functions provide useful assistance:

- Meaningful summarization (by quadratic regression) of many measurement values into a displayed value that is updated regularly, e.g. every 0.5 s.
- Polar diagram for recording all-round bearings.
- Maps for plotting the individual bearings.
- GPS and electronic compass.

Examples of all-round bearings:

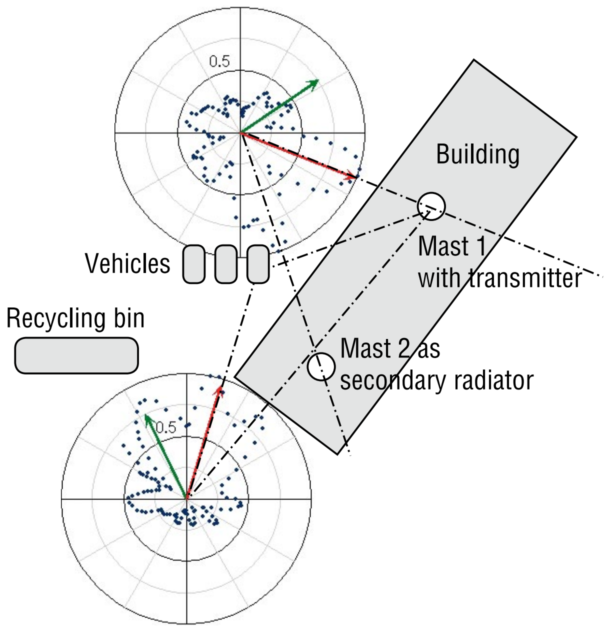


Diagram of a real situation with mobile phone antennas on the roof of a building. From the upper measuring point, the bearing is directly on the trans-mitting antennas. from the lower measuring point, the instrument "sees" the reflections from a vehicle and a recycling bin. (Red arrow = bearing result; green arrow = actual orientation of the DF antenna)

Tips:

- Practice direction finding on a cell phone transmitter on a high building.
- Move around the building at various distances and try to follow the reason for the indicated direction.
- Observe the field strength changes caused by shadowing.

▶ Horizontal scan, ▶ Rules for hand-held and mobile direction finding

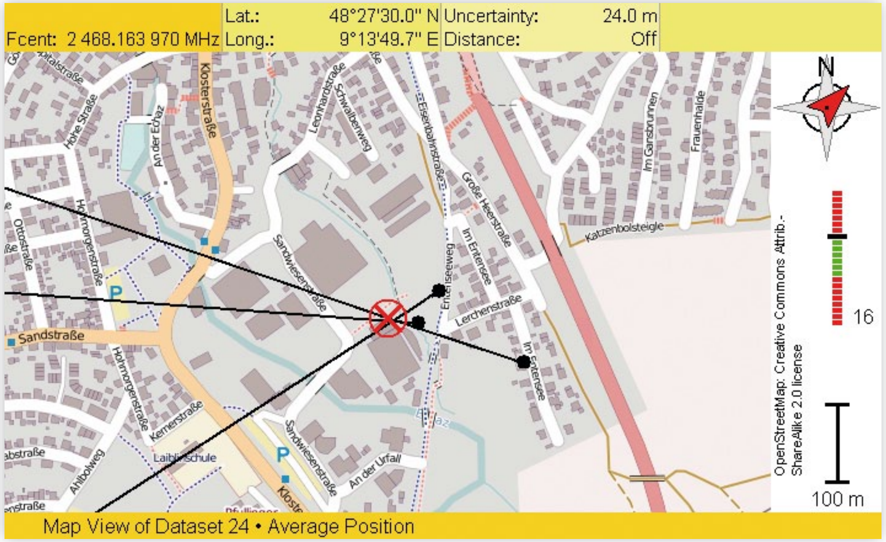
Bearing accuracy

Bearing errors only become really significant over long distances. Bearing accuracy is affected by many factors. Some of these are:

- Every ▶ Antenna has an area in the main lobe where the level only changes marginally.
- The antenna "sees" a total level made up from the direct beam and several reflections. The resultant that is formed by this rarely points exactly to the signal source being looked for.
- External fields and magnetic objects cause compass errors.
- The displayed level is made up from many separate measurements, which can also affect the bearing result depending on how the signal varies with time and in space during the measurement. Intelligent direction finding algorithms help to reduce this error contribution.
- If the signal being looked for over modulates the device during the direction finding sweep, it will not be possible to take a bearing because the measured level will not alter or will change in an undefined manner during over modulation.

All these factors result in a localization error, such that the several bearings taken do not intercept at one point, but define an area instead.

A circle within which the signal source is most likely to be located can be plotted on the triangulation map from this information.



Triangulation
Source: Narda Safety Test Solutions

Tips:

- The highest bearing accuracy is important for fixed measuring stations. It is less important for hand-held direction finders.
- A signal source cannot usually be located by means of just two or three measurements.
- The closer you get to the source, the less important the aforementioned errors become.
- The main thing is that the resulting bearing lines plotted on corresponding maps become very clear.

▶ Compass

BFO, Beat frequency oscillator

Oscillator built in to the receiver that renders audible signals having suppressed, continuous, or keyed carriers, such as SSB, CW, Morse code telegraphy.

Tip:

- Skilful selection of the BFO frequency enables you to acoustically attenuate one of two adjacent signals within the same RBW by varying the BFO or the center frequency.

Bin

Frequency sampling point resulting from a Fourier transformation. A Bin itself has no width, but the Bins are spaced equidistantly within a FFT.

▶ FFT, Fast Fourier transformation

CAL, Calibration

The following should be distinguished from each other, although they are often confused in practice:

- **Verification**: This is carried out by a bureau of standards and is a statutory requirement for certain sectors (e.g. scales in retail premises).
- **Calibration**: Comparison of an instrument with a standard such as a defined voltage or frequency. The standard itself is also calibrated within an unbroken chain of calibration. The instrument user bears the responsibility for setting the instrument calibration intervals.
- **Self test**: Often called CAL, this should be performed (on the warmed-up device) and briefly recorded before and after making every set of measurements that are intended as proof, otherwise the results may be questioned.

Tips:

- Modern devices have sophisticated self test routines. These guarantee narrow tolerances for the lifetime of the device. Thought should be given as to whether this may be enough for many applications.
- This is particularly applicable to hand-held direction finders, since the bearing is always determined from relative measurements.
- If the measurement uncertainty is too high, though, misinterpretation can easily occur, particularly if the measurements have to be made at different times. It is then impossible to tell whether the transmitter being located or the measuring instrument itself is the cause of a change in the measured value.

CBW, Channel bandwidth

Suitably high selectivity for individual signals can be achieved by optimizing the channel bandwidth. This is particularly advantageous for time-domain analysis (IDA Level Meter and Scope modes).

If small interference signals are detected close to strong payload signals, a matched channel bandwidth with low shape factor is essential in order to
a) analyze the signal as completely as possible, and
b) separate the signal from adjacent interference.

Finely tunable filter banks with steep cutoff characteristics (low shape factor) are useful because they can closely simulate the behavior of the disturbed device.

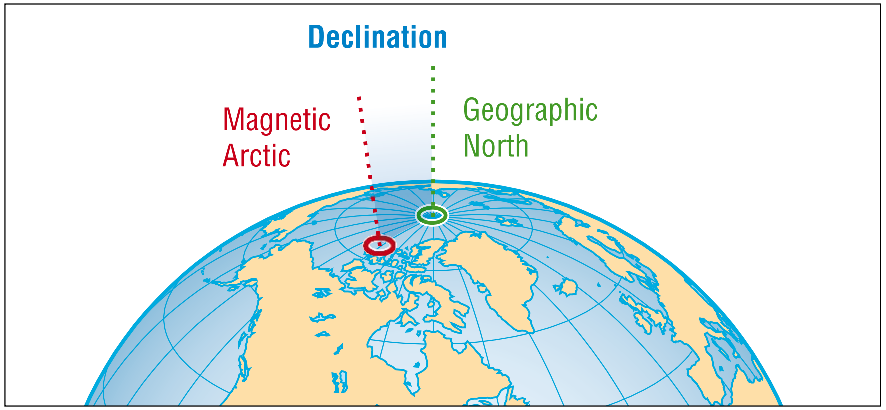
Tip:

- Instruments with Gaussian filters for spectral analysis and additional (steep) channel filters for time domain measurements are often beneficial for direction finding work.

▶ Filter types, -characteristics, ▶ Time domain measurement

Compass

The magnetic declination is the deviation of the arctic magnetic pole from the geographical North pole.



The clearer notation using brackets should be used whenever confusion may occur (e.g. m = milli or meters?)

See: IEC 60027-3:2002 Letter symbols to be used in electrical technology – Part 3: Logarithmic and related quantities, and their units.

Delta spectrum

The actual spectrum is recorded first and saved as a reference trace. The delta spectrum then shows the deviations from this reference trace, making complex frequency distributions easier to see. The delta spectrum is useful for locating changed or new transmitters and for analyzing variable carrier signals.

Tips:

- Saved reference traces are useful for checking and documenting environments that are to be protected, as well as for later, rapid checks for changes.
- Instruments that save the I/Q data enable virtually random analysis at any time, allowing comparison with new situations.

▶ Trace

Demodulation

Demodulation of the signal is a great help to experienced users when searching for an interference signal, since the signal can be quickly classified by its demodulated sound.

The human ear can perceive interference noise as a change in the audio signal before it becomes visible in the spectrum.

Tip:

- Amplitude demodulation modes are used in preference, applying different bandwidths (0.5 to 10 kHz).

Detector

Every measuring instrument is designed to display the correct numerical value of the RMS level applied to the input. This means that the signal at the IF output corresponds to the signal at the RF input (but is not necessarily equal to it).

The quantities to be measured often change rapidly over time. For this reason, it is not feasible to display every single sample value; instead, many values are collected together over the measurement time and a display value is formed from them. This task is performed by the detector.

- **+PEAK** detector displays the value of the highest sample occurring during the measurement period;
  –PEAK detector displays the value of the lowest sample occurring during the measurement period.
- **SAMPLE (SA)** displays a sample taken at the same point in every measurement (e.g. every first sample).
- **RMS (root mean square)** computes and displays the root mean square value (power average) from all the samples taken in a measurement period.
- **AVG (Average)** on the IDA displays the true power average
- **AV (Average)** on many other devices displays the average voltage value (CISPR 16 or the identical DIN EN 55016 use the term averaging for the voltage average).

Tips:

- +PEAK values are not exceeded by the other detectors (using the same RBW and other basic conditions).
- It is often useful to make several measurements using different detectors / measurement times if the situation is unclear.
- It is advantageous to have measuring equipment that can display the results from several detectors at the same time, making them truly comparable.

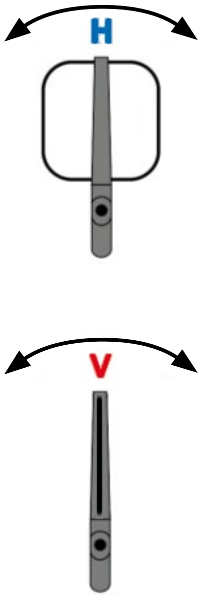
▶ Trace

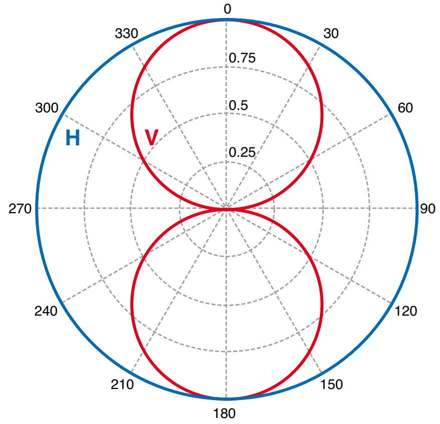
DF, Direction finding

Procedure for determining the direction or bearing.

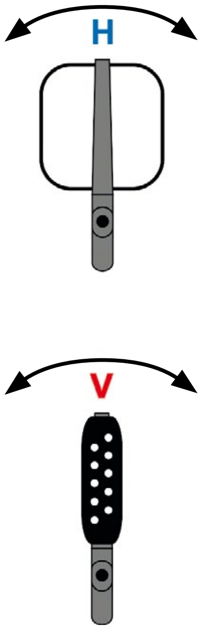
Direction finding is a special IDA operating mode that allows you to generate bearing diagrams automatically or by user-definition and

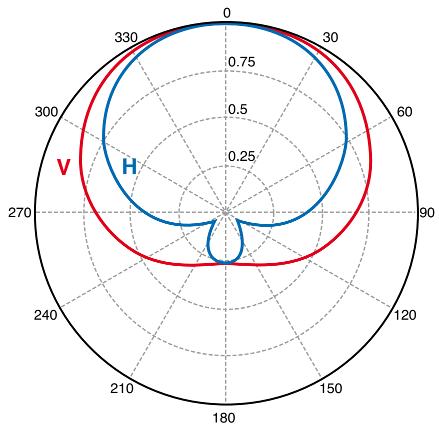
Examples:



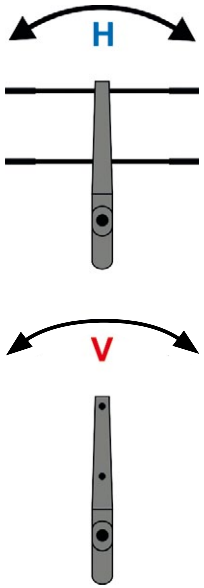


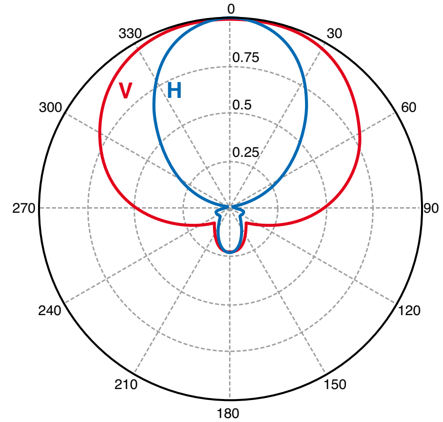
9 kHz – 30 MHz *magnetic loop. The direction of a source can be determined very accurately using the null point (+90°). Unwanted signals can also be suppressed using the null point.*



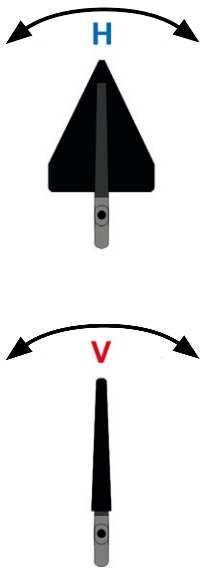


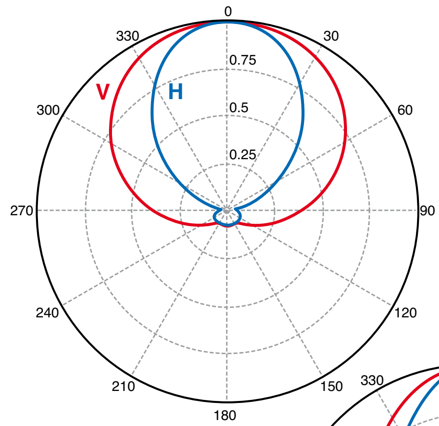
20 MHz – 250 MHz *directional antenna. The combination of a magnetic loop and an electric dipole results in a cardioid. Although the cardioid characteristic looks very flat, it shows clear differences in level with just a few degrees change.*

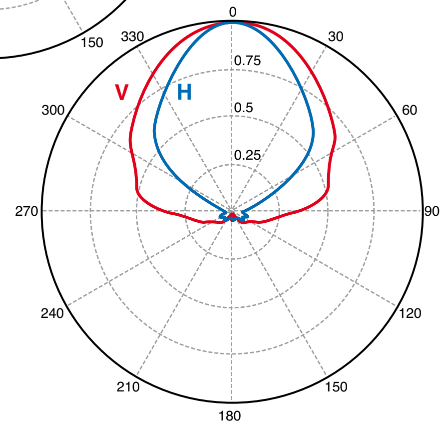




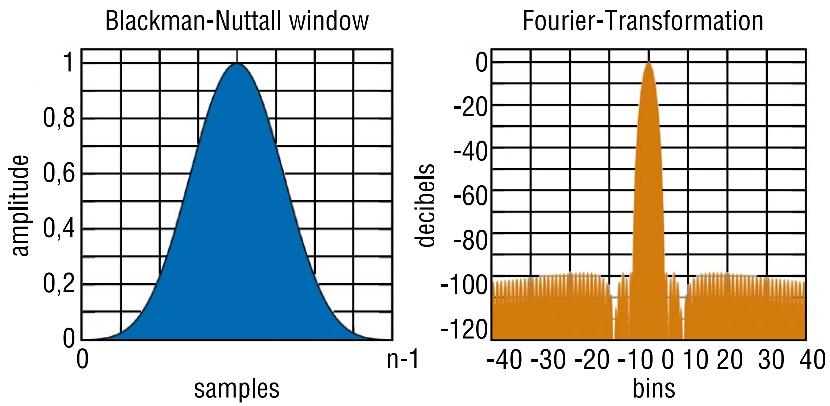
200 MHz – 500 MHz *directional antenna. Electrical dipole.*







400 MHz – 6 GHz *directional antenna. Log-periodic antenna. Top: Response pattern at 750 MHz; right: at 2.25 GHz.*



The Blackman-Nuttall window (left: time domain, right: frequency domain) has better selectivity than the Gaussian filter usually used in spectrum analysis and also possesses very good sideband suppression. Even narrow pulses can be processed well with appropriate time overlapping. Source: http://en.wikipedia.org/wiki/File:Window_function_and_frequency_response_-_Blackman-Nuttall.svg

Tip:

- The window type can considerably distort the results. The default settings recommended by the manufacturer should not be altered and an overlap of at least 50 % should be used to avoid level errors and underestimation of short impulses.

Zero span

In Zero span mode, the spectrum analyzer is tuned to a constant frequency and functions as a conventional receiver. Used in conjunction with steep, wide and fast channel filters, this gives ▶ Scope mode.

The IDA 2 hand held direction finder

- Frequency range 9 kHz to 6 GHz
- Spectrum analysis with resolution bandwidths (RBW) from 10 Hz to 20 MHz, with fine adjustment
- Spectrum analysis with up to 22 MHz span at the same time as a single FFT
- Scope mode (receiver operation) with channel bandwidth (CBW) from 100 Hz to 32 MHz and steep, finely adjustable channel filters. Time resolution down to 32 ns, display range up to 24 h
- Noise figure 7 dB up to 3 GHz, 10 dB up to 6 GHz, preamp in the handle switched on
- Antennas with automatic recognition and application of correction factor by the basic unit
- Direction finding with automatic creation of polar diagrams and plotting of results on geographical maps
- Spectrogram computed line by line or without time and frequency limitation (Stitched mode)
- Fast spectrogram with gapless recording of measured values; span up to 22 MHz, time resolution down to 1 μs at 8 ms time span, max. recording time 2500 s
- IDA saves up to 250,000 I/Q data pairs for subsequent internal alteration of display parameters and for external evaluation and documentation

Technical advances, errors and omissions excepted