INTERFERENCE AND DIRECTION ANALYZER

IDA-3106

smArt DF®

narda® Test Solutions
an L3 Communications Company

NARDA TEST SOLUTIONS

USER-DEFINED TECHNOLOGY

Know-how from a long-established company

Narda Safety Test Solutions GmbH was established in 2000. The company originated from the high frequency measurement division of the once renowned company of Wandel & Goltermann.

Narda Safety Test Solutions is now part of L-3 Communications, New York. L-3 Communications, established in 1997, operates 75 Business Units worldwide, has around 63,000 employees, and generates net sales of more than 15 billion US dollars (2011). The Narda Group within L-3 Communications comprises ten divisions with some 2,800 employees. The oldest companies in the Narda Group can look back on 80 years of business experience and have key competences in microwave components, antennas, and satellite communications.

Market leader in RF Safety

As a member of the Narda Group, Narda Safety Test Solutions is a leading supplier of measuring equipment for RF safety, EMC, and RF testing.

RF Safety

The product range includes wideband and frequency-selective measuring devices, and monitors for wide area coverage or which can be worn on the body for personal safety.

EMC

This unit offers instruments for determining the electromagnetic compatibility (EMC) of devices under the PMM brand name.

RF Testing

Designated Narda Test Solutions, this business unit covers spectrum analyzers and instruments for monitoring radio fields, and for measuring and identifying radio sources.

Three sites

Narda Safety Test Solutions has development and production facilities at its headquarters in Pfullingen / Germany as well as at Hauppauge, Long Island / USA, and Cisano / Italy. It also has its own representative in Beijing / China. A worldwide network of sales partners guarantees customer focus. Calibration and servicing is carried out in the company's own laboratory in Germany or in its own internationally accredited laboratory in Italy. Other services offered include training programs. The company operates a management system compliant with ISO 9001/2008 and ISO/IEC 17025.

Sustainability

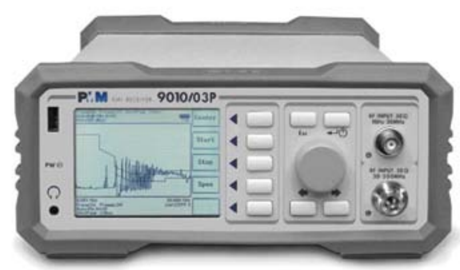
Narda is convinced that sustainable and environmentally sound practices contribute to the success of the company. The aim is therefore to manufacture durable products, make economical use of resources, and avoid damaging the environment. The basis for all new developments is formed by the European Parliament Directives 2002/95/EC (RoHS), 2002/96/EC (waste equipment) and 2003/11/EC (dangerous substances).

Know-how

As one of the leading providers of high-quality, application-oriented measurement technology solutions, Narda does not develop a single product without first consulting a large number of customers. This ensures that the applied know-how of people on the ground is reflected in Narda products, such as the Interference and Direction Analyzer IDA-3106.

Narda Broadband Field Meter NBM-550

Directional couplers from Microwave East, the oldest company in the Narda Group



EMI Receiver and Analyzer PMM 9010/03P for verifying electromagnetic compatibility

IDA-3106

INTERFERENCE AND DIRECTION ANALYZER

A direction finder with receiver qualities

The Interference and Direction Analyzer IDA-3106 was specially developed for identifying and localizing interference, impairments, and unknown sources. It is not simply a receiver with attached antennas; the IDA is a complete measuring system from a single source, tailored perfectly to perform the job of efficiently localizing signal sources. It is a real direction finder in hand-held format with the qualities of a receiver.

The IDA-3106 is designed as a hand-held unit for on-site use. However, the IDA is much more than just a conventional manual direction finder. Features that used to be available only in larger scale systems have been made affordable and portable with the IDA-3106. The IDA translates the technically feasible into a tactical solution. It is a device for the "last mile", the direct path to the target.

Interference search and direction finding are technically complex operations. The IDA as a specialized device makes light of this application, not least because of its intelligent direction finding concept, smart*DF*. The invisible can be visualized.

Exchangeable antennas up to 6 GHz

Handle with built-in electronic compass: featherlight, thanks to power supply from basic unit

IDA-3106 for indoors and outdoors: weighs only three kilos, robust, splash proof, with clear display and a keypad that can also be operated when wearing gloves

smart*DF*

MAKING THE INVISIBLE VISIBLE

An illegal transmitter? Or a legal transmitter not operating within specifications? An industrial controller causing fizzle on an adjacent band? Or just crackle from a poor contact in the building wiring? Searching for interference and impairments in the high frequency range gets more and more complicated as mobile communications become more widespread and modulation methods more sophisticated. These days, localizing interference is often like searching for a needle in a haystack. You can waste an enormous amount of time if the equipment is not up to the job.

Designed from experience, tested in practice

The smart*DF* concept developed by Narda makes possible a consistent procedure for identifying anomalies in the radio spectrum, analyzing the suspect signals, and localizing their sources.

smart*DF* is an integrated concept. It includes the direction finding antennas, which are not only electrically optimized for the application but also ergonomically designed for on-site use over long periods. It also includes compass and GPS functions. The hardware and software of the IDA basic unit, equipped with a whole range of tools for localizing interference and impairments, is likewise included. When all of these are used together purposefully, the result is a considerable saving in time and increased reliability of direction finding. The smart*DF* procedure consistently follows three steps: Detect – Analyze – Localize.

Three steps for a result

Detect
The first step is to find the suspect signals in the radio spectrum at the location where interference is apparent. Several signals are usually involved, resulting in considerable time and effort for measurement and documentation when conventional hand-held direction finders are used.

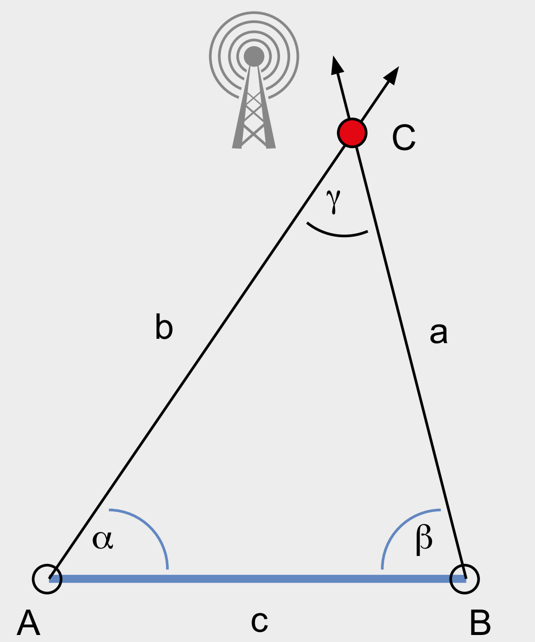
Analyze
The second step is to analyze the suspect signals. It is important to obtain as much information as possible about them, so that an initial decision can be made regarding which signals should be investigated further.

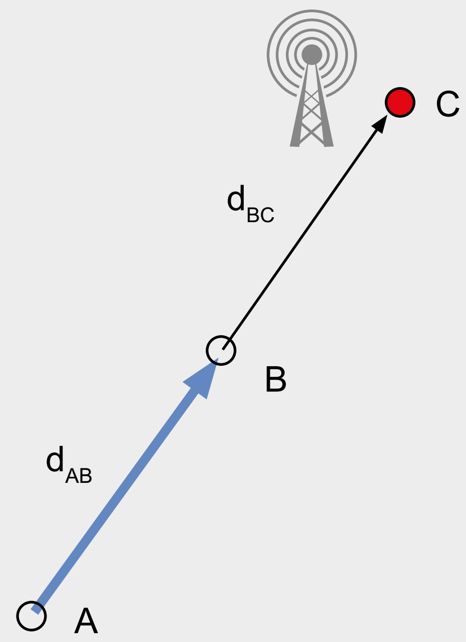
Localize
The third step is to measure the angle of incidence of the remaining suspect signals and to determine the locations of their sources by triangulation. Once you know the possible location of the interferer, you can take appropriate measures to eliminate it.

The IDA provides support for measurement staff in the form of many tools that considerably simplify the job of tracing individual interferers. For example, filters with extremely steep cutoffs ensure high suppression of neighboring channels, time-domain measurement allows qualification of pulsed signals, and demodulation during direction finding enables clear identification of the source being located. This reduces the risk of incorrect bearings and avoids the annoyance of repeating measurements.

The IDA shows its true strength when the direction finding task is complex: several transmitters to be located, strong signals on neighboring frequencies, co-channel interference or reflections. All steps in the process are carried out purposefully, highly effectively, quickly and certainly with the help of the IDA. In terms of technical strategy, detection in the first step results in a list of potentially suspect signals, which is revised by analysis in the second step so that only the signals that are actually suspect remain. This list can then be rapidly processed in the third step of localization.

The IDA smart*DF* feature supports measurement staff during this procedure. The individual tools are described from the technical viewpoint on the following pages. Their consistent application is then demonstrated by means of an example.





Localization using triangulation
Basically, the distance between two measurement points A and B and the angles α and β must be measured. The IDA determines the distance from the difference in GPS data, and the angles are determined by direction finding or by horizontal scanning at the measurement points. The IDA then calculates the location of point C.
Expressed mathematically:
From the trigonometric rules:

$$\frac{a}{\sin\alpha} = \frac{b}{\sin\beta} = \frac{c}{\sin\gamma} \quad \text{and} \quad \alpha + \beta + \gamma = 180°$$

it follows that:

$$a = \frac{c \cdot \sin\alpha}{\sin\gamma} \text{ and } b = \frac{c \cdot \sin\beta}{\sin\gamma} \text{ where } \gamma = 180° - \alpha - \beta$$

For good measurement accuracy, angle γ must not be too acute. For simple triangulation, though, this means that there must be a long distance between A and B if the source is a long way off

smart*DF* provides alternatives. On the one hand, it enables direction finding from as many locations as you like, even ones that are close together, in order to calculate the most likely position of the source. On the other hand, it allows you to use and combine direction finding data obtained using different instruments.

Localization using the Distance function
The person making the measurement moves in a straight line towards the source and measures the field strength at two locations A and B on this line. The IDA calculates the most likely position of the source C from the difference. For the result to be meaningful, the signal must be stable, the measurements must be made in the far field, the source must not have any distinct vertical directivity, and the field must not be distorted by any significant reflection. smart*DF* can include the Distance result as additional information in the Triangulation result.

Triangulation and Distance function

The physical background: In the far field, the field strength decreases proportionally to the inverse of the distance from the source (1/r law). Doubling the distance thus results in halving the field strength. Mathematically, this relationship can be generally expressed e.g. for electric field strength E by the following formula:

$$d_{BC} = \frac{d_{AB}}{\left(\frac{E_B}{E_A} - 1\right)}$$

DETECT ANOMALIES

WHAT IS SUSPECT?

Spectrum at 12 GHz/s sweep rate

Sensitivity -160 dBm/Hz: Nothing is missed

Quick test: Shows up intrinsic impairments

The identification of signals emanating from illegal sources or potential interferers within tightly packed radio spectra is the first task. How this problem is solved determines the subsequent course of action: The more certain the detection, the smaller the effort needed for analysis and localization. The IDA provides all the tools you need. Spectrum analysis forms the basis, with properties such as high dynamic range, low noise, high frequency resolution, and rapid recording being prerequisites. IDA combines all of these with an operating concept that takes new users through to the result in easy steps, but still allows “old hands” to make the most of the technical and physical limits of the procedure.

Reference Level Search

The automatic reference level search function determines the correct drive level for the entire frequency range in just 15 seconds – without clipping or loss of dynamic range. The estimation can be made more or less conservatively (to give greater or lower clipping immunity).

Switchable preamplifier

The antenna handle contains a switchable 20 dB preamplifier, which enables the IDA to measure very weak signals. You can also insert passive external networks between the handle and the basic unit without degrading the dynamic range. For example, bandpass filters can be used to improve far-off selectivity and large signal behavior.

Variable input attenuator

The IDA uses a true reference circuit as its input attenuator, which can be set in 1 dB steps. This allows full use of the dynamic range in all cases.

Identification of intrinsic impairments

A ±5 dB button switches the input attenuator in 5 dB steps. Examining the spectrum when this is done will reveal any lines that are due to possible over-modulation of the instrument, distinguishing them from real signals. This avoids chasing phantom signals during the subsequent search.

Fast, even at small resolution bandwidths

Thanks to analysis using fast Fourier transformation (FFT), the IDA reaches a sweep rate of up to 12 GHz/s. Sweeping a frequency range (Fspan) of 134.2 kHz takes less than 420 milliseconds at a resolution bandwidth (RBW) of 10 Hz. A sweep over the full 6 GHz takes less than 1.5 seconds at a RBW of 500 kHz.

FFT and bandwidths – how they are related

IDA computes the spectrum from one or more FFTs, depending on the selected frequency span and resolution bandwidth. The frequency spacing of the FFT nodes, i.e. measurement points versus frequency, is approximately half the chosen RBW. The IDA manages larger frequency spans by stringing together several overlapping FFTs, successively retuning its analog receiver section to several frequencies if necessary, without you being aware of this or having to make any adjustments. Even the largest frequency spans can thus be measured with the finest resolution.

The advantage of narrow resolution bandwidths

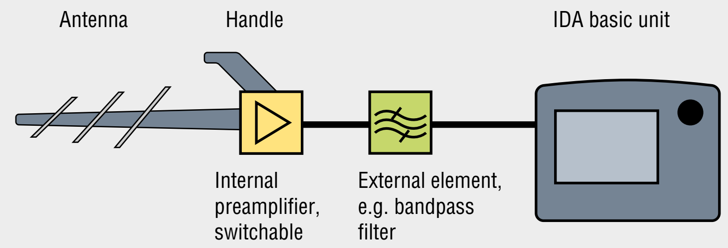
Unknown spectra often contain all sorts of signals, ranging from strong sources with a wide spectral range through to weak transmitters with just one narrow line. A narrow RBW is helpful here for resolving individual carriers within a frequency channel and separating them from interference directly adjacent to the carrier, for example. At the same time, a small RBW reduces the displayed intrinsic noise of the instrument, making even low power interference visible.

27,000 measurement points in memory

A measurement result can contain up to 27,517 measurement points over the frequency range, each of which can contain up to six result types such as maximum value, average value, and so on. That quantity of data cannot be shown on any display. The IDA saves the original set of data in each case and only reduces the data for the display. The IDA uses the original data for subsequent evaluations, e.g. when using the marker. Not even the smallest bit of information goes missing.

Multi-Channel Power

Based on a spectrum analysis, the IDA calculates the channel power of up to 500 freely definable channels – ideal for repeated monitoring tasks. The center frequency, channel bandwidth, and measurement bandwidth (RBW) can be set separately for each channel. In this way, you can capture the entire frequency range of interest with channel assignments in one sweep and compare this with earlier measurements to detect anomalies.



Signal path from antenna to basic unit. The high clipping margin of the preamplifier means that a filter can be inserted between it and the basic unit. All the relevant transmission factors in the signal path, from antenna conversion factor through to preamplifier, filter, external attenuators and RF cables can be saved by the IDA and taken into account in the displayed measurement values along with the transfer function of its own input stage.

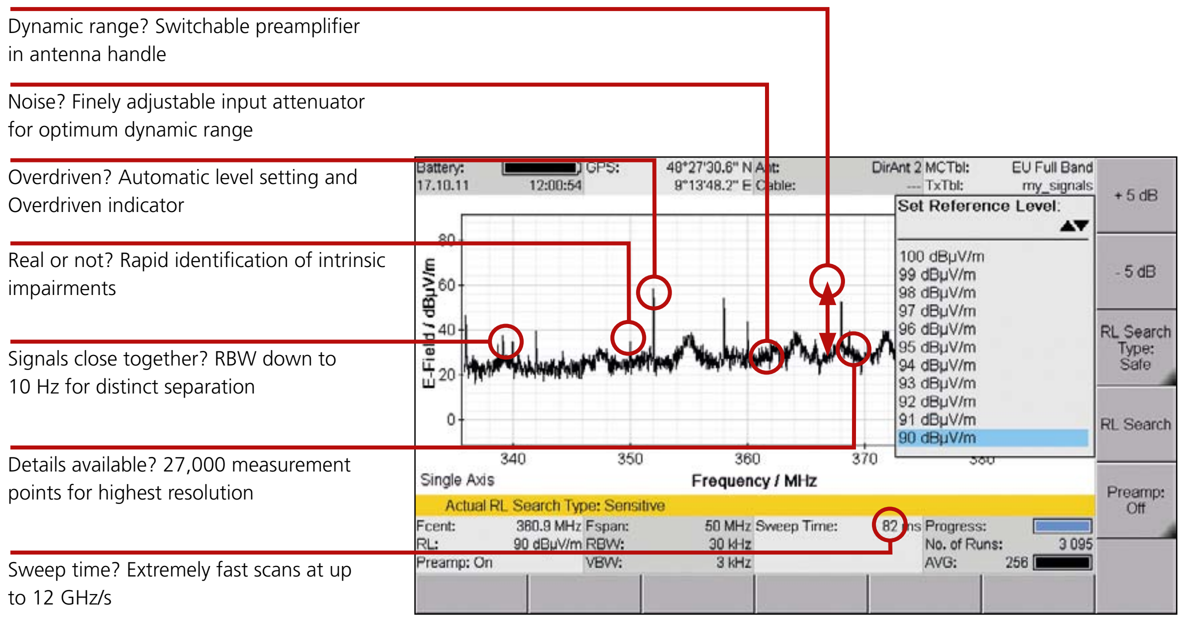
No data compression: All measured values are saved

Transmitter table: Work through a list

Transmitter table

You can mark suspect signals in the spectrum and save them in a transmitter table with relevant parameters such as center frequency, bandwidth, antenna type, and polarization. This table can then be recalled and worked through successively at each measurement location and in every operating mode of the instrument. The instrument makes the necessary settings automatically and saves the measurement and direction finding results along with the correct source assignment, an enormous help if a large number of suspect signals have to be checked out initially.

A typical IDA scan over 50 MHz



ANALYZE SIGNALS

WHO'S TRANSMITTING? WHAT'S INTERFERING?

Up to 32 MHz resolution bandwidth

Once you have identified the potentially suspect signals, they need to be analyzed to find out exactly which one or other source is actually illegal or spurious. There is nothing more time consuming than tracing signals that turn out to be from known sources in the end. It is just as inefficient to track a lot of potentially suspect signals as a precaution only to qualify them later during a program of measurements.

80 dB adjacent channel rejection

The tools provided by the IDA for clear-cut analysis of the signals are capable of much greater precision of analysis than that of previous receivers. These tools include audio demodulation, oscilloscopic display, and the provision of I/Q data. The result is an adjusted transmitter table that only contains the sources that actually need to be traced, for example.

Spectrum

Spectrum analysis is the classic operating mode used for finding irregular signals; the result is used as the basis for the further procedure. Exceptionally, the IDA makes fast measurements with high resolution at the same time.

Level Meter

The level characteristics of an individual signal that has been isolated from the spectrum can be assessed using this operating mode. The IDA makes real-time continuous measurements at bandwidths settable between 100 Hz and 32 MHz; the center frequency can be set directly from the marker position in the spectrum. Excellent channel separation thanks to a steep RC filter (see page 21) prevents you from taking the wrong bearing on neighboring channels.

The IDA computes the peak and RMS values simultaneously. The instantaneous values are shown on the screen as bar graphs, and the maximum values that have occurred since the start of the measurement are marked. The IDA initially calculates the instantaneous power level. A variable video filter with exponentially decaying impulse response can be employed so that the peak display can also be used to reliably measure the average power of short noisy bursts of the type often encountered in modern communications.

The signal crest factor is easily determined by comparing the peak and average values. Measurements on radar installations are no problem, either: Just one full sweep of the radar is enough to measure its peak power density with absolute certainty.

Scope

The time response in particular gives information about the character of a signal. The IDA displays time signals with a resolution of down to 31.25 ns in Scope mode (option). This means that it can make amplitude modulation visible, resolve TDMA signals down to individual timeslots, and even display burst and radar signals. You can thus characterize the signals, providing much of the validation for the subsequent program of measurements.

Trigger

The IDA provides a wide range of trigger functions to ensure that you do not miss the "right time". You can set the trigger level and the rising or falling edge as the trigger conditions. As with a storage oscilloscope, you can shift the time display forwards or backwards using the trigger delay setting. The IDA can be triggered by the first trigger event (Single), by every trigger event (Multiple), manually, by timer control, or simply used in free run mode.

Demodulation

AM, FM and SSB demodulators are provided as standard in Level Meter and Direction Finding modes. These enable you to additionally classify the signals identified according to audio content. Using the transmitter table, you can call up and detect the stored transmitters in sequence without the bother of having to tune the IDA to each one separately.

I/Q data

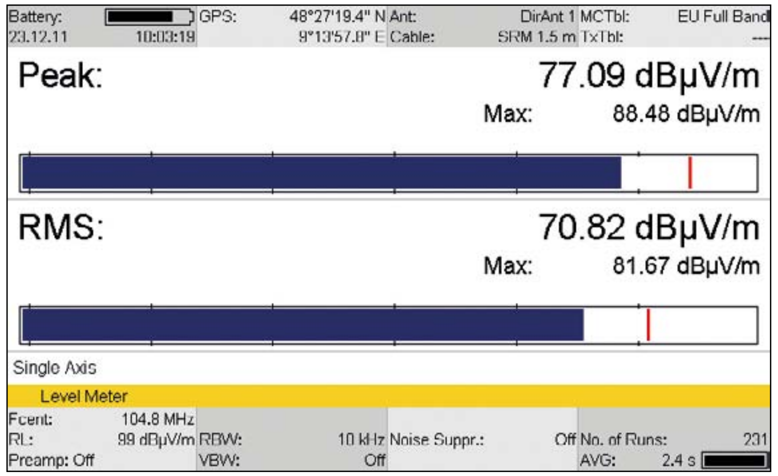
Internally, the IDA processes both the real (in-phase component) and the imaginary (quadrature component) parts of the signal. If the Scope option is fitted, the IDA also makes the saved I/Q data available externally. It can record up to 250,000 I/Q data pairs. With a time resolution of 200 µs, this gives a recording time of 50 seconds. The trigger functions are the same as those in Scope mode.

Using external software, you can extract practically any possible information from the I/Q data of the IDA, even down to the actual message content. The IDA does not use any special export formats. The raw formats are useful for explicit classification and for comparison with databases, for example.

Switching between operating modes

Each operating mode of the IDA is basically independent and can be set with its own set of measurement parameters without affecting any of the other operating modes. The special feature of the smart***DF*** concept is that you can switch directly from one operating mode to another without needing to access the main menu. The IDA then uses the parameter settings already made. In other words, you can carry out different measurement tasks one after the other but independently of each other. Example: Monitor the entire spectrum for unwanted signals, observe FM radio channels for variations in power level / field strength, measure the time characteristics of an individual transmitter, and demodulate another signal. You can revert to the first measurement with its original settings at any time. It is just as easy to subsequently switch to direction finding.

Up to 250,000 I/Q data pairs



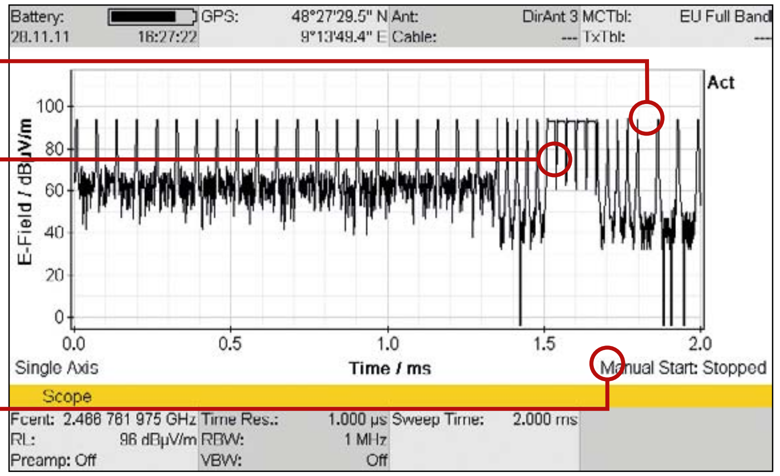
The IDA displays the instantaneous peak and RMS values as bar graphs in Level Meter mode; the red markers indicate the maximum values that occurred during the measurement period. All values can also be read off numerically.

Typical display of signal versus time characteristic in Scope mode

All events captured? Seamless monitoring

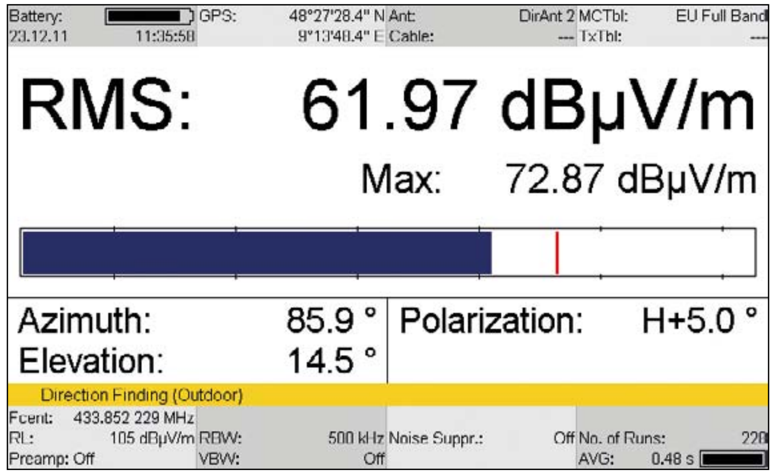
Details available? Resolution down to 31.25 ns

Missed a one-off event? Comprehensive trigger functions

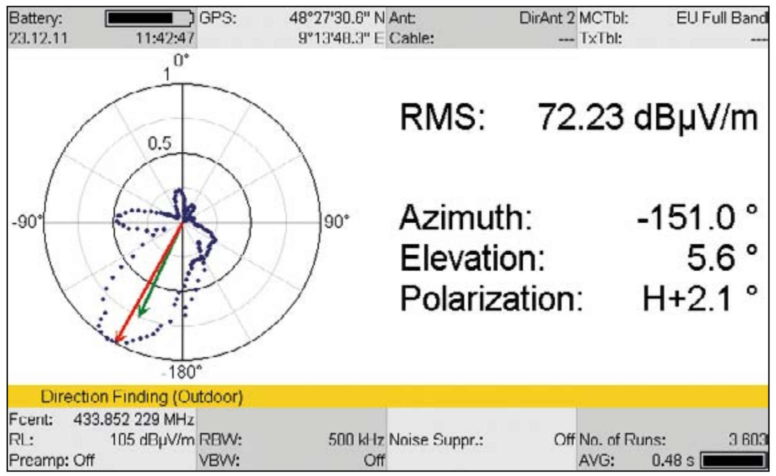


SOURCE LOCALIZATION

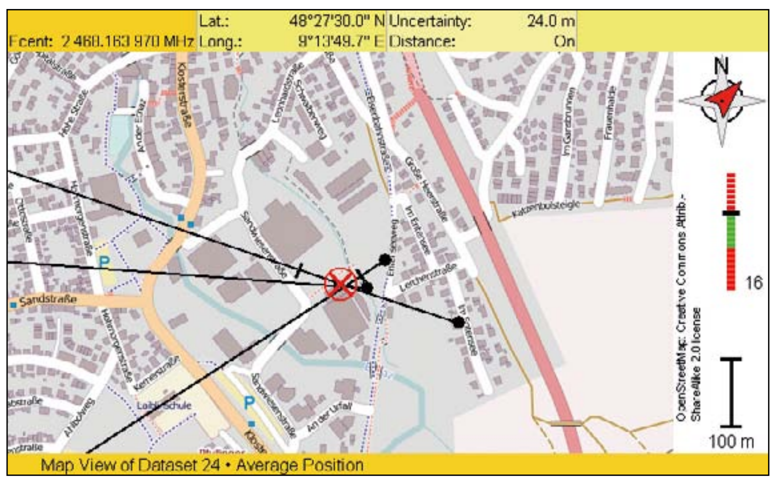
WHERE'S IT COMING FROM?



Direction finding by maximum value search: Visually by observing the bar graph or acoustically from the pitch of the tone.



Results of a Horizontal Scan: Polar diagram with computed direction of incidence (red arrow), current antenna direction (green arrow) and numerical values. You can adjust the red arrow manually in order to take information from reflections into account or to correct the bearing on a strong common channel transmitter, for example.



Bearing result shown on a map automatically. A combination of triangulation and distance measurement. The red circle indicates the most likely position of the source.

The IDA provides excellent tools for the last step towards the end result, unambiguous determination of the location of the source(s) under investigation. Other transmitters often occupy the frequency under observation or the channel that you are looking at. Reflections frequently distort the bearing result. The signal level of the source under investigation varies depending on the measurement location. All of these factors can cast doubt on any purely automatically determined bearing result, both physically and statistically. For this reason, the IDA doesn't simply show the basic bearing results or just evaluate them intelligently, it also makes all the measurement data available so that experienced users can avoid incorrect bearings and improve the results of direction finding. That is what makes smart*DF*: The combination of personal experience with ingenious algorithms.

Manual Bearing

Manual bearing is the traditional method of determining the direction of a source from the maximum level. The IDA allows you to find the direction visually and acoustically. The IDA shows the actual measured level as a bar graph on the display, and also indicates the numerical values of the level, azimuth, elevation, and polarization. You can also track the level acoustically: The stronger the signal, the higher the tone.

Horizontal Scan

For a Horizontal Scan, the person making the measurement turns through 360° once, holding the antenna. The IDA records the measurement results either quasi-continuously at its maximum measurement rate or at discrete intervals controlled by pressing the Start/Stop button on the antenna handle, and displays them as a polar diagram. At the same time, it calculates the main direction of incidence of the source. The result display is unique, since the polar diagram shows the current antenna direction and the automatically calculated value for the main direction of incidence as well as all the measurement results obtained during a scan.

Additional help is provided by an audio "spirit level": A high-pitched tone is output if the antenna position deviates by more than ±5° from the normal direction of polarization (roll angle); if the elevation angle deviates by more than ±5° from the horizontal, a low-pitched tone can be heard. This means that you can concentrate on e.g. the level shown on the display without having to keep an eye on the antenna.

Audio "spirit level" for undistracted reading

Manual correction

In an undistorted field emanating from a single source, the polar diagram represents the directional characteristic of the antenna. Deviations that can adversely affect the bearing result are mostly due to reflections, refractions, or common channel interference. Making a second measurement from an offset location can reveal reflections, and live demodulation identifies common channel interference. The IDA has a unique correction feature: If irregularities are present in the polar diagram when taking bearings, you can repeat parts of the measurement and correct the measurement trace as often as you like and only save the result when it is plausible.

Any number of corrections until the result is valid

Triangulation

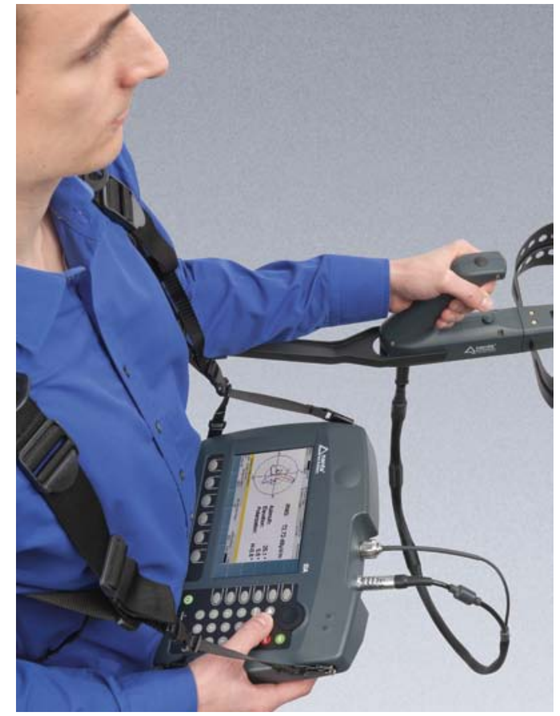
Two or more manual bearing or horizontal scan results form the basis of triangulation. These measurements must be made from different locations. The IDA automatically determines the measurement locations by GPS and calculates the most likely position of the source. This corresponds to the intercept point of the two bearings when two measurements are used. Several bearing intersections arise from multiple measurement locations; these indicate the position of the source to a high degree of certainty.

Bearing results from other measurement locations

The measurement locations must be far enough apart for triangulation to be accurate (see page 5). If you are a long way from the source, you do not necessarily have to travel a long distance though. You can also use the results from other direction finders to save you the journey or to support your results. The IDA uses the external results in the evaluation in the same way as its own. It is thus possible to make simultaneous measurements from several locations and exchange the results between locations by radio link or mobile phone.

Localization by distance measurement

Localizing the source using the Distance function of the IDA is another way to save covering long distances. Once you have determined the bearing of the source, you can move in a straight line towards the source and the IDA will calculate the likely position of the source from the difference in levels (see page 5). The Distance function is normally used together with triangulation. The IDA combines the two results, marks the likely location of the source and indicates the uncertainty with a



circle. You can quickly see in practice whether an additional distance measurement will give a more accurate determination of the position by switching the Distance function on and off: The circle shown round the assumed location of the source will vary accordingly.

Map option: Show results geographically

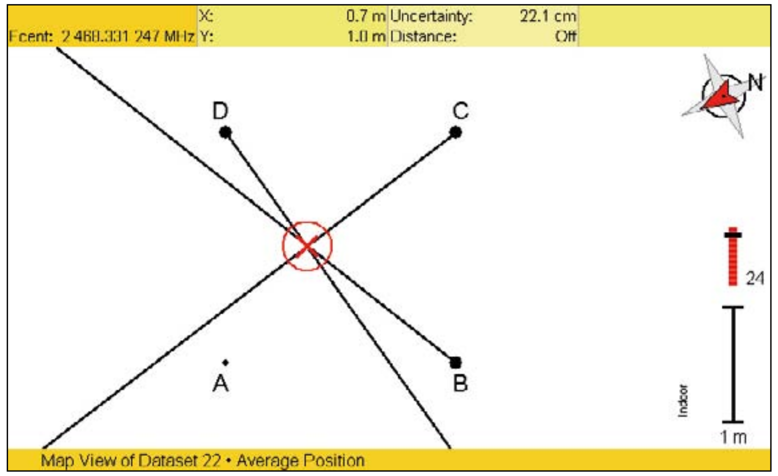
Map display

The measurement locations and the computed source location are uniquely defined by their GPS data. Nevertheless, it can be useful to show them on a map so you can correlate them geographically. The IDA can import maps from OpenStreetMap and superimpose the results on them with the Map option. You can use the NardaMap Tools software to save the maps on a microSD card which slots into the IDA.

Automatically ignore unlikely results

Automatic or manual evaluation

If you have direction finding results from different locations that show excessive deviations, you need to reject the widely differing results and only use the ones that are largely consistent for localization. Your own experience is a possible key to success here: You can manually exclude unlikely results from the calculation. Instead of relying on a hunch, though, you can use the Auto Disable Bearings function of the IDA. As suggested in the ITU Handbook on Spectrum Monitoring, the IDA initially assigns each bearing to a sector that is determined by the bearing line and a bearing uncertainty set according to



Direction finding (indoors): The IDA indicates the source location as an x/y value referred to point A

empirical values. The IDA takes only the bearings with sectors that overlap at a similar location into account and ignores all the others, since they contradict the best bearing results.

Indoor support

Determination of the measurement location by GPS does not work well enough for direction finding within a small area such as inside a building. The IDA has the solution to this problem, too: Direction Finding (Indoor). For this, you define a virtual rectangle in the room by entering the dimensions and the azimuth. The four corners or reference points can selected regardless of the room geometry; they only need to be accessible for the measurement and be far enough away from walls and reflecting objects to ensure that reflections do not falsify the result. You can now localize the source by making measurements from the four reference points. You have all the same options available as for outdoor direction finding: manual bearing, horizontal scan and subsequent triangulation. The IDA shows the result in Cartesian coordinates and displays it on a sketch plan of the room

Indoor: Localization in virtual space

HANDLE

MORE THAN JUST A HOLDER

Although the handle is a technically sophisticated device with several functions, it is shaped ergonomically and comfortable to hold. The antennas can be attached to it vertically or horizontally. It contains a switchable preamplifier (see page 7), a compass, position sensors, and a Start/Stop button for controlling measurements. The antenna handle communicates with the basic unit via a control cable.

Reliable RF connection with frequency response compensation

A resilient precision locking mechanism holds the antenna in place and provides a reliable RF connection to the handle. A ferrite-clad cable that does not distort the directional characteristic of the antenna even at low frequencies is used for the RF connection between the handle and the basic unit. This enhances the level accuracy that can be achieved.

The transfer function of the handle including cable with the preamplifier activated and deactivated is measured during production and the data stored in an EEPROM in the handle. The basic unit reads this data automatically via the control cable when the handle is connected and takes it into account in correcting the frequency response.

Holder designed for a relaxed grip: The arm support makes it possible to hold the handle complete with antenna with just one finger.

Power supply from basic unit and handle

No additional battery is needed to power the active antenna handle. The handle simply draws its power from the basic unit through the control cable. This makes the handle even lighter and there is no danger of losing power in the middle of a long-term measurement. In fact, the Li-Ion battery in the basic unit can be hot swapped even while a measurement is in progress.

Automatic antenna and polarization detection

The IDA basic unit automatically recognizes the antenna type and direction of polarization via the control cable, and disables the frequency ranges not covered by the antenna to prevent unnecessary false bearings.

Compass

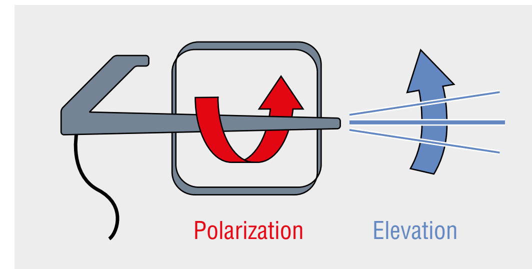
There is a precision position-compensated electronic compass in the handle. Data from the compass is also transferred to the IDA basic unit via the control cable. The compass is adjusted during production after it has been built in to the handle so it shows no deviation due to the handle. If required, you can numerically enter the local declination (angle between geographic and magnetic North) into the IDA basic unit.

There is a second compass in the basic unit itself so that electronic maps can easily be aligned with North on the IDA display. Here too you can record any magnetic declination correction value for the measurement location if needed.

3D position detection with audio “spirit level”

Furthermore, the handle contains position sensors that measure the elevation and roll (polarization) angles of the antenna. The elevation and polarization are important factors in determining the direction of a signal source when taking manual

Hot-swappable batteries



Position sensors in the handle measure the roll (polarization) and elevation angles of the antenna.

bearings. In contrast, the roll and elevation angles should be kept constant while turning the antenna for a Horizontal Scan. The audio “spirit level” is very useful here because it makes any deviations audible, so you don’t have to keep your eyes on the instrument display.

Start/Stop button

Seemingly trivial, but very useful in practice: The ability to start, stop, or correct a measurement with a thumb press on the antenna handle. You only need to press the Save button on the basic unit to store the direction finding result when you are satisfied with the result.

ANTENNAS

OVERLAPPING FREQUENCY RANGES, PRECISE DIRECTIVITY

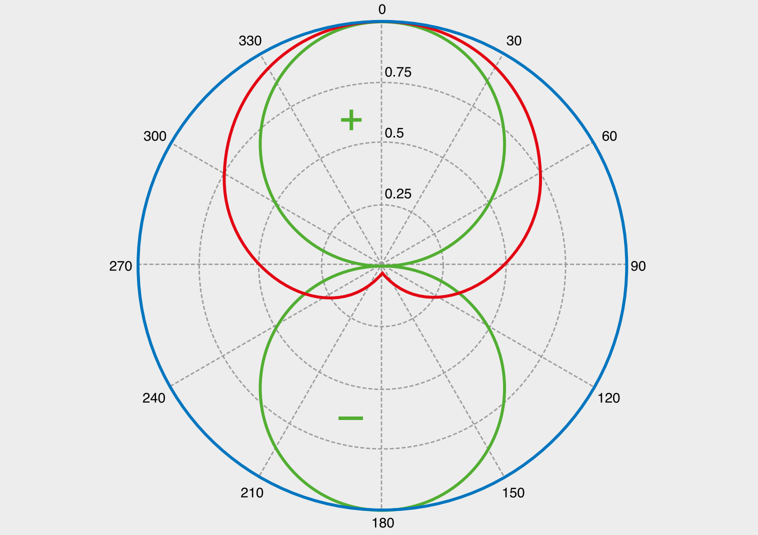


Figure 1: The directional characteristic of the loop antenna (red) results from superimposing those of a magnetic loop (green) and an electric dipole (blue).

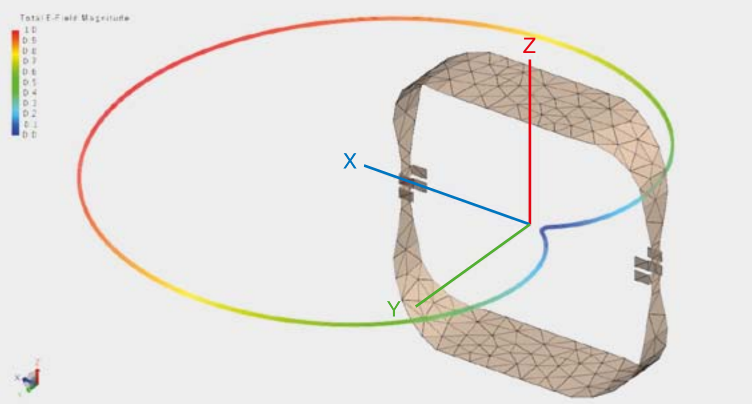


Figure 2: Typical horizontal directional characteristic of the loop antenna, computed for the far field.

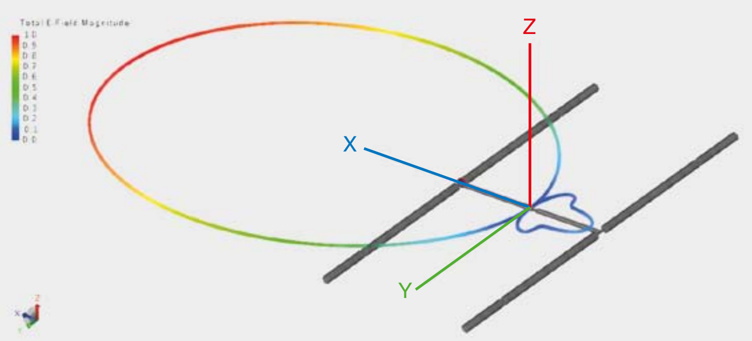


Figure 3: Typical horizontal directional characteristic for the directional dipole antenna, computed for the far field.

The wide frequency range of the IDA basic unit cannot sensibly be covered with a single directional antenna. For this reason, the IDA-3106 Set contains three antennas that are each optimized for their particular frequency range with regard to sensitivity and directivity, resulting in excellent bearing accuracy. The fact that their frequency ranges overlap each other by about 20% is of great tactical value.

Antenna 1 covers the frequency range from 20 MHz to 250 MHz. Starting in the region of the ISM frequency of 27 MHz, it is also particularly suitable for interference and impairment searches in the UHF broadcast radio band and also includes the lower end of the VHF TV band including DAB.

Antenna 2 covers the frequency range from 200 MHz to 500 MHz, making it ideal for interference and impairment searches on all the communications services located in that band. It also covers the ISM frequency at 433 MHz.

Antenna 3 with its frequency range from 400 MHz to 6 GHz covers the entire range of mobile communications services including LTE and WLAN. It also captures L-, S-, and C-band radar.

The IDA basic unit will in principle also work with antennas from other manufacturers. Using Narda antennas has the advantage that the IDA basic unit automatically recognizes the antenna type and polarization direction via the handle and also automatically takes the typical frequency-dependent antenna factors into account. These factors for other antennas can be uploaded to the basic unit using the IDA-Tools software.

All Narda antennas are extremely light in weight yet robust. Their simple exterior belies the fact that they are high-tech products. Here, then, are some details:

Antenna 1: Loop antenna
The principle here is well established; back in 1971 Sony patented a special version for TV reception (US Pat.3573830). Narda has specially optimized the design to generate a relatively narrow major lobe in the response pattern, in fact at frequencies up to 250 MHz. The lightweight metal loop is pleated to give it mechanical stability.

The principle is based on a combined measurement of the electric and magnetic fields. Figures 1 and 2 show the relationship between a horizontally polarized magnetic field component and an electric field component that is perpendicular to it. The magnetic field component induces a voltage in the loop with magnitude and phase dependent on the direction of the incident wave. The characteristic appears in the response pattern as a figure of eight on its side. In itself, this could be used to determine the direction, but there would be two possible results at 180° to each other. For this reason, the voltage derived from the electric component of the field is also used. The loop is used as a dipole for this, which is possible as long as the dimensions are small compared with the wavelength. The receiving characteristic in the horizontal plane is a circle without any predominant direction. Superimposing the two voltages results in a cardioid, which exhibits a broad maximum in the principal direction and a minimum in the opposite direction.

The antenna also works when placed horizontally. In this case, the electric field strength results in a figure of eight and the magnetic field in a circular characteristic, producing a very similar cardioid when superimposed.

Antenna 2: Directional dipole antenna
The dipole antenna can be used from as low as 200 MHz. The directional characteristic of this antenna has also been optimized, so that it shows a much more pronounced directivity compared to the loop antenna. It also has high sensitivity, with an typical antenna factor of 23 dB (1/m) between 300 and 400 MHz.

Antennas of a similar type have been in use since the 1950s and are familiar to radio hams as HB9CV antennas. The principle here is based on the combination of two elementary electric dipoles, i.e. dipoles that are short compared to the wavelength. The desired directivity is obtained by inverse phase connection of the two dipoles and suitable dimensions and spacing. As shown in figure 3, the response pattern in the horizontal plane exhibits a relatively narrow lobe in the principal direction and unimportant side lobes in the opposite direction. The vertical plane shows a cardioid similar to that of the loop antenna. Figure 4 shows the three-dimensional response pattern obtained using a computer simulation.

Antenna 3: Log-periodic antenna
Log-periodic antennas are a standard part of EMC measurement practice. The log-periodic antenna from Narda is optimized for a largely constant directional characteristic over its entire frequency range from 400 MHz to 6 GHz. It avoids the otherwise usual high frequency effects such as broadening of the major lobe and the occurrence of distinct side lobes. It also effectuates strong "FM suppression" below 400 MHz. The antenna elements are encased in a tough foam shell, which is virtually transparent to the magnetic field in contrast with a hard shell.

The antenna comprises an array of individual dipoles arranged in decreasing length and spacing along the principal direction. They are connected in opposite phase. Depending on the frequency, an active zone forms as a phase center where the element length corresponds to about half the wavelength. The longer rear elements thus account for the lower frequency range, with the phase center moving forwards as the frequency increases. In this way, a pseudo frequency-independent antenna is produced.

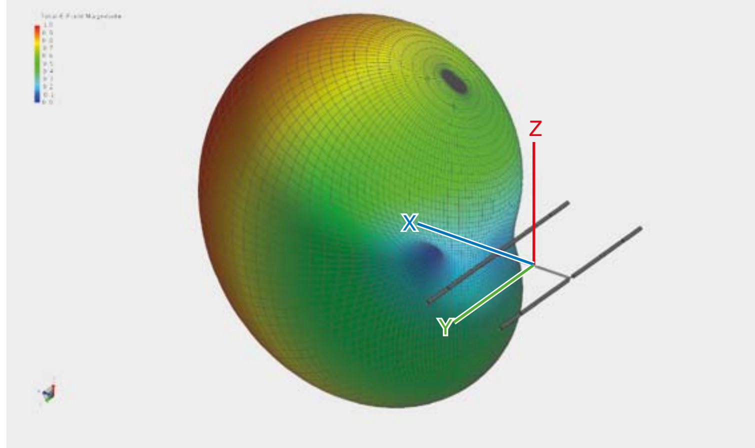


Figure 4: Three-dimensional directional characteristic of the directional dipole antenna, computed for the far field.

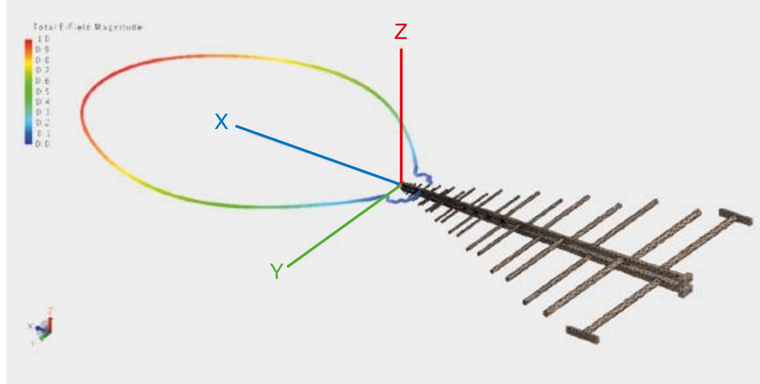


Figure 5: Typical horizontal directional characteristic of the log-periodic antenna: A narrow lobe. The vertical characteristic is a somewhat wider cardioid.

EXAMPLE

smart*DF* IN ACTION

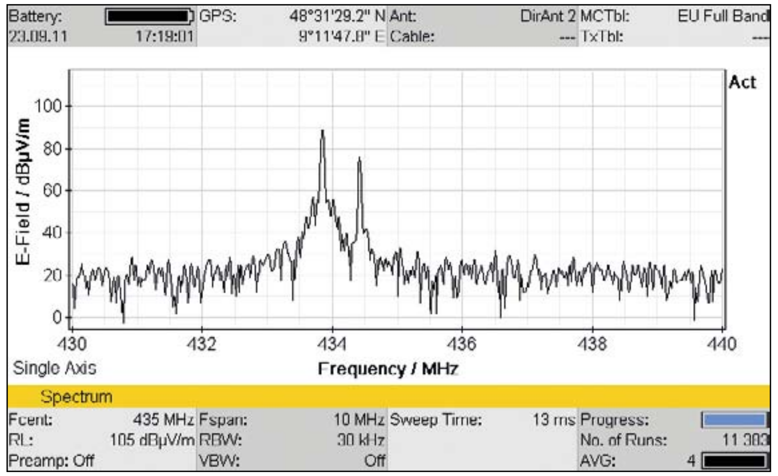


Figure 1: Sweep across the ISM frequency band at 30 kHz resolution. This takes just 13 milliseconds with the IDA.

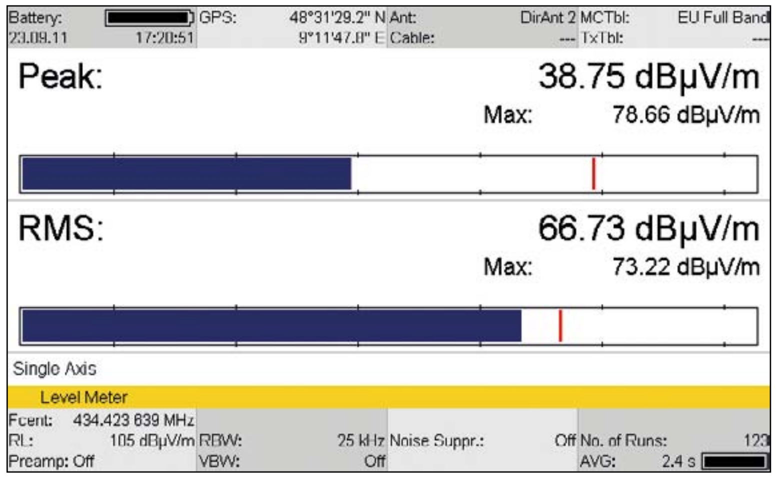


Figure 2: Level of the data signal, typically strongly variable. The peak value maximum is naturally above the RMS value while the instantaneous peak value is below the RMS value averaged over 2.4 seconds. Demodulation yields various whistling sounds.

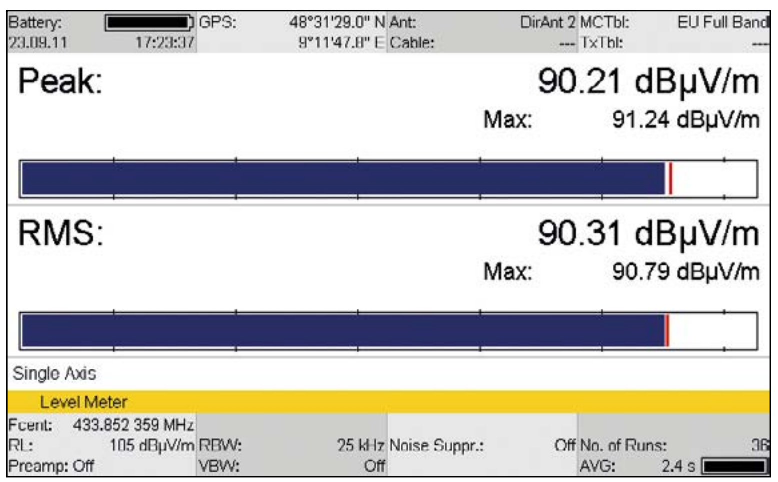


Figure 3: Level of the interfering FM signal, typically fairly constant.

Summer. Friday evening. Time to enjoy some food and drink outside in the beer garden. When things get busy, things need to move fast. Staff can only keep up with orders thanks to an efficient team in the kitchen, quick service, and the EPOS system: When it's working properly, serving staff at the table can enter the guest's orders for food and drink into the mobile terminal which relays the orders direct to the kitchen by radio link, and they can print out the bill and accept card payments when it's time to pay. Sometimes, though, communications between the EPOS terminal and the mobile terminals are disrupted, even though the equipment is working properly according to the manufacturer. External interference is the most likely culprit.

The EPOS system operates in the 433 MHz ISM frequency band, which is used by all and sundry: baby monitors, weather stations, light switches, garage door openers and all kinds of industrial control systems. The difficulty faced when trying to determine the source of interference is that most of these devices only transmit intermittently, just like the EPOS system itself. However, transmissions from the EPOS system are under your control. You have to be on the watch for external interference and react quickly when it appears. A clear case for smart***DF***.

Detect
Time: 17:19. A sweep from 430 to 440 MHz broadly covering the ISM band (433.05 MHz to 434.79 MHz) shows two clearly modulated signals (figure 1). The center frequencies can be determined precisely using the marker: 433.852 and 434.424 MHz.

Analyze
Time: 17:20. Switching to Level Meter mode and activating the Demodulation function reveals that the weaker signal at around 434.4 MHz is a data signal (figure 2). This could be from a car key, but as it can be reliably reproduced by operating a mobile EPOS terminal, the source is obvious.

Time: 17:23. The stronger signal at around 433.9 MHz after FM demodulation turns out to be music (figure 3). This is probably coming from some wireless headphones operating in the ISM band. More precise spectrum analysis at a resolution of 300 Hz shows a typical FM spectrum, but doesn't give any new insights: Simply "eavesdropping" is, as often the case, the best way to find out.

Time: 17:30. The interference has disappeared for a while. Displaying the time characteristic of an EPOS transaction in Scope mode shows an unimpaired data signal (figure 4).

Localize
Time: 17:37. The interference is back again. Time enough to do a Horizontal Scan, which gives a more accurate indication of the direction than a manual bearing.

Time: 17:39. The result is ready (figure 5). The bearing points to a house across the road.

Time: 17:42. A second Horizontal Scan enables triangulation (figure 6). The source is in one corner of the house. A subsequent manual bearing with audio maximum search seems to indicate that the source is on the top floor.

Time: 17:58. The source is located: A check with the residents has located a student who has been trying to block out the noise from the beer garden by listening to hard rock on his wireless headphones.

And the solution is given, too: Replace the headphones (which are an older product) with a new pair operating in the 860 MHz SRD (Short Range Devices) band. This will benefit the student, too, as the SRD band is divided into sub-bands for specific uses to prevent mutual interference between analog and digital signals.

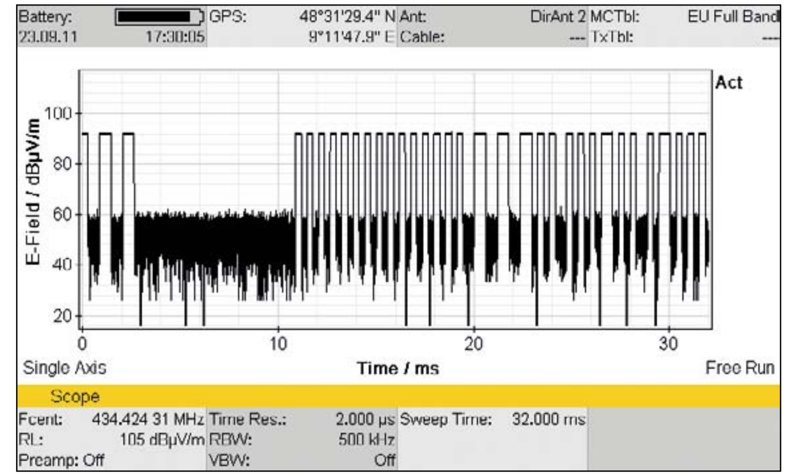


Figure 4: Data signal versus time, here unimpaired. The data and synchronization pulses can be clearly seen.

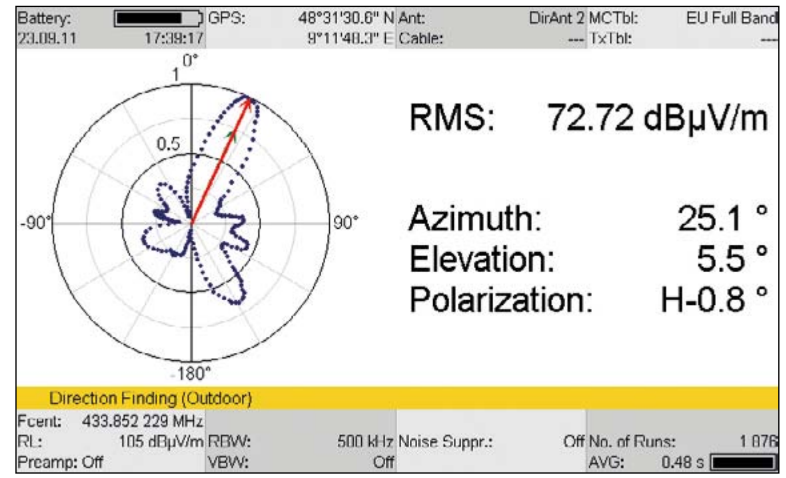


Figure 5: Result of a Horizontal Scan, shown as a polar diagram.

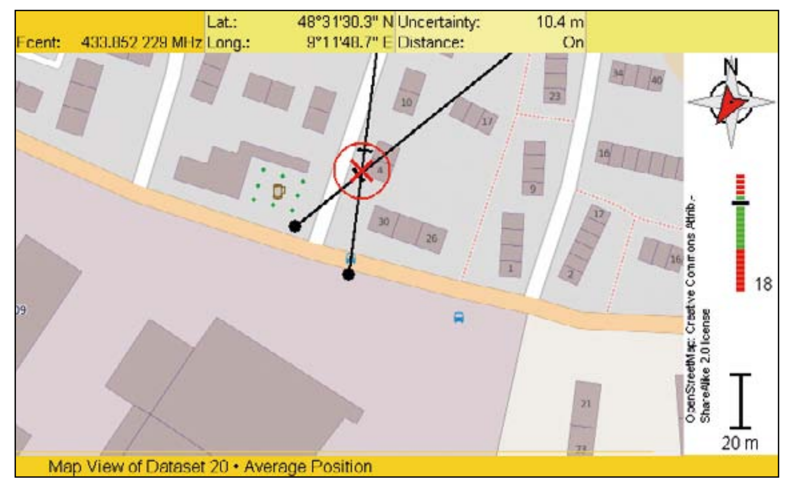


Figure 6: Localization by triangulation superimposed on a street map.

TECHNICAL DETAILS

THE END DEFINES THE MEANS

Purely digital techniques cannot cope with analyzing signal frequencies of up to 6 GHz with high sensitivity and a wide dynamic range. For this reason, the IDA uses a combination of analog preconditioning and digital post processing – both state of the art.

ANALOG SIGNAL PROCESSING

Conventional heterodyne

Basically, the analog section of the IDA is just like a conventional heterodyne receiver. It has some special features though, which are worth a closer look.

Pre-selection
To begin with, the input section is protected against DC voltages of up to 50 V by capacitive isolation. A diplexer splits the input signals into frequencies above and below 42 MHz. This ensures that a strong AM transmitter cannot over-modulate the selection path for higher frequencies, for example. Additional pre-selection is by means of band-pass filters.

Input attenuator: True reference circuit

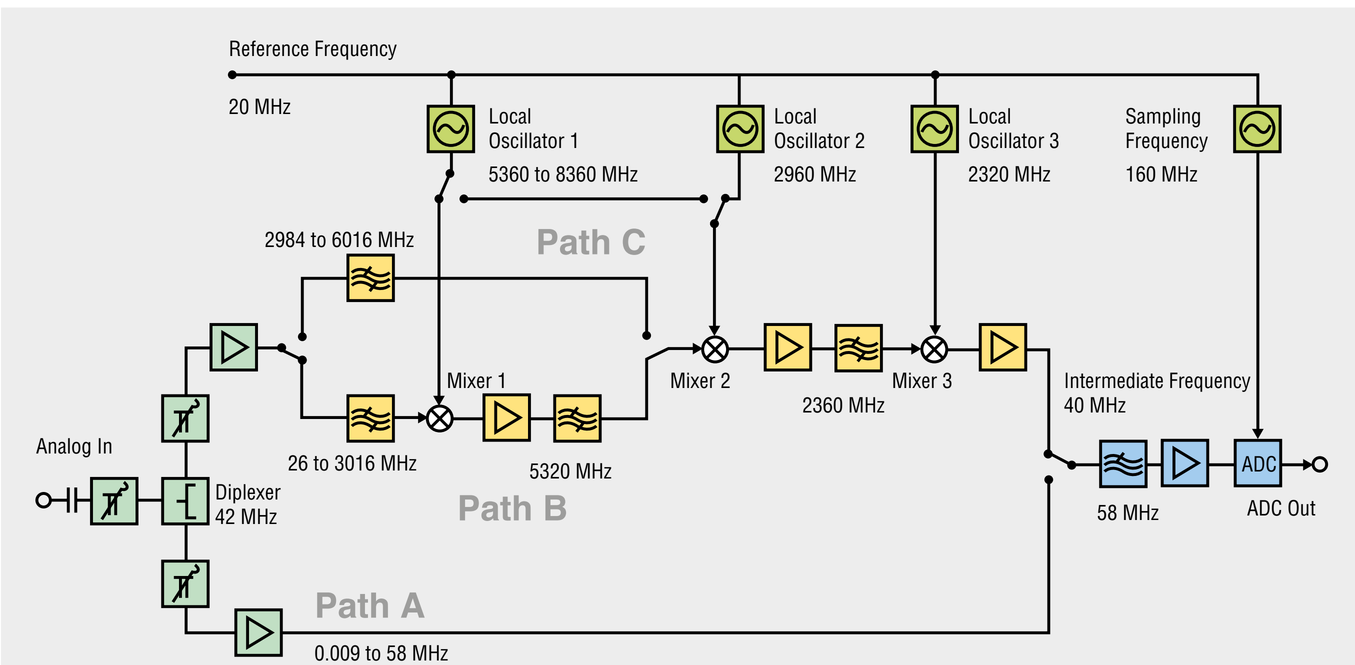
Path A: Lower frequency band
Why convert when the analog to digital converter (ADC) can process the lower frequencies directly? The IDA does without conversion for frequencies up to 42 MHz*, giving it hitherto unrivalled accuracy and dynamic range.

Path B: Mid-range frequency band
Frequencies between 42 MHz and 3 GHz* are subjected to a three-stage conversion. Heterodyning with the variable frequency of Local Oscillator 1 in Mixer 1 results in up-conversion of the input signal to an intermediate frequency of 5320 MHz. This is followed by two down-conversions, first to 2360 MHz and then to 40 MHz, which is a frequency that can be handled by the ADC without problems.

Path C: Upper frequency band
Local Oscillator 1 with its variable frequencies is connected directly to Mixer 2 for center frequencies between 3 and 6 GHz*. The input signal thus undergoes down-conversion directly to 2360 MHz and then to 40 MHz.

Input attenuator
The IDA uses true reference circuits (step attenuators) with 1 dB intervals for setting the input sensitivity. This enables the high dynamic range of the IDA to be fully utilized at all times. More than this: Experts can spot whether weak lines in the spectrum are real signals or the eventual products of intrinsic intermodulation, which are unavoidable above a certain level even in a superlative instrument. All you need to do is change the reference level (and therefore the measurement range) by a few dB. The effect on real signals is linear but is disproportionate on intermodulation. The optimum measurement range can therefore always be set, and you won't end up chasing down virtual signal sources.

* Nominal center frequency. The path must also be open for the maximum resolution bandwidth of 32 MHz, i.e. 42 ±16 MHz, 3000 ±16 MHz, etc.



Simplified block diagram of IDA analog section. The switch settings show the signal path for mid range frequencies (path B).

DIGITAL SIGNAL PROCESSING

The samples, arriving at a rate of 160 MHz, are first of all fed through a digital down converter. This is arranged as an I/Q demodulator: By multiplication with the cosine and sine of the LO oscillation, the real component (in-phase, I) and the imaginary component (quadrature, Q) are available separately at the output. The I/Q data are present in real time; the sampling rate corresponds to the bandwidth, i.e. a maximum of 32 MHz. The IDA can save up to 250,000 pairs of I/Q data for subsequent evaluation.

THE ADVANTAGES

On the one hand: Real time data at a high data rate. On the other hand: Huge memory depth. This combination gives the IDA superior qualities.

State of the art digital signal processing

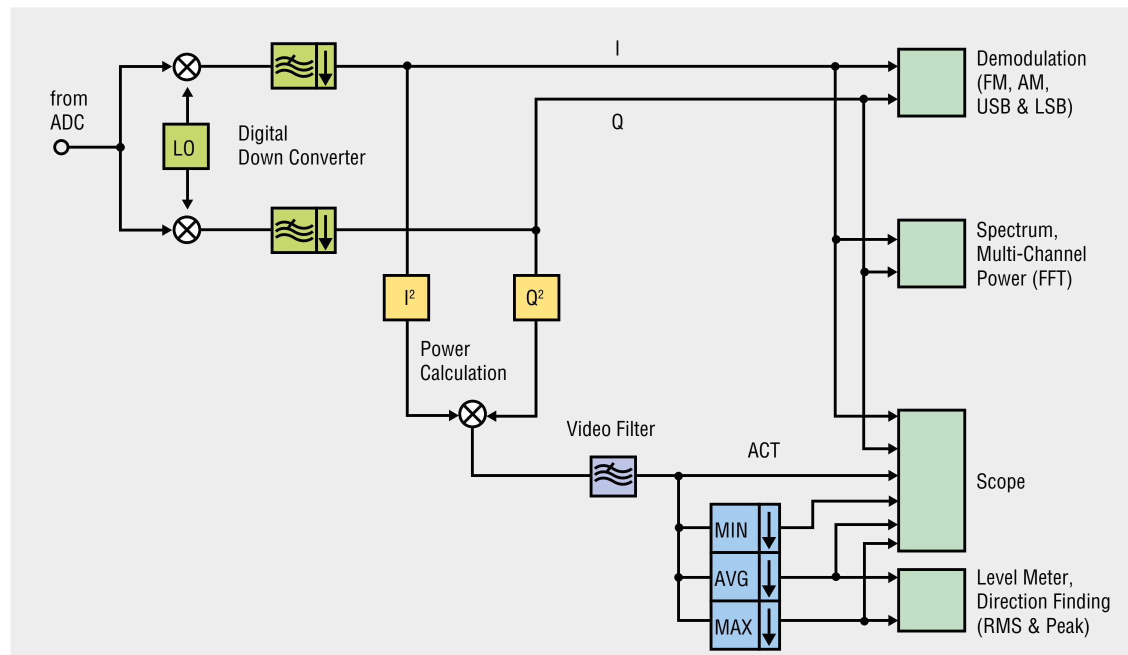
Correct power summation
The IDA computes the square of the magnitude of the real and imaginary parts (I, Q) in real time. The power values are thus available as instantaneous (actual) values (ACT) and can be shown directly in Scope mode.

No data compression
Unlike ordinary spectrum analyzers, the IDA does not routinely reduce the data to match the display resolution. Regardless of the display itself, all the data is retained in the background. In Spectrum mode, this means that up to 27,517 spectral values are available.

No data reduction, no loss of information

Direct demodulation
Demodulation in real time is also possible for frequency modulated signals (FM), amplitude modulated signals (AM), and of the upper (USB) and lower (LSB) sidebands for single sideband modulation.

All in one: A programmable receiver
The combination of analog and digital signal processing makes the IDA into an all-rounder. It is a direction finder, spectrum analyzer, and a receiver for AM, FM and wireless signals right up into the UMTS, LTE and WLAN ranges.



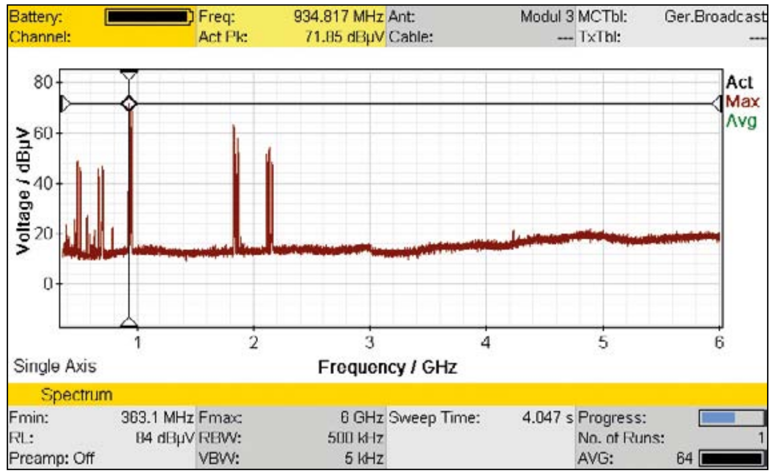
Simplified block diagram of IDA digital section. The blocks represent functional units rather than circuit components.

TECHNICAL DETAILS CONTINUED

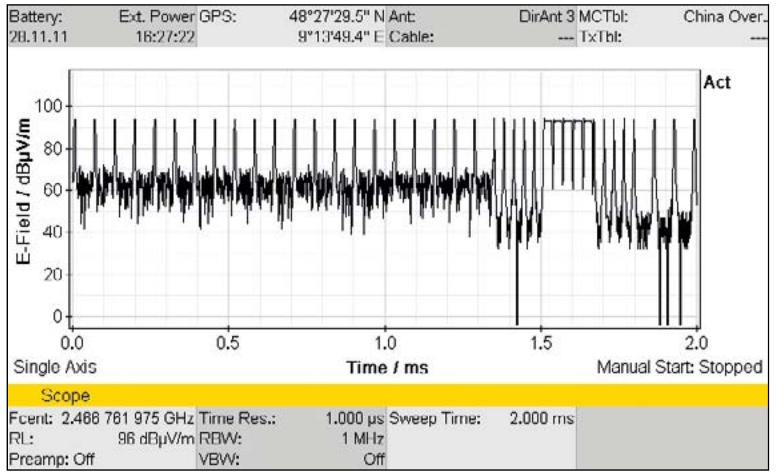
OPERATING MODE IMPLEMENTATION

Spectrum

The IDA computes the spectrum by means of a fast Fourier transformation (FFT) with up to 32,768 sampling points. The IDA strings several FFTs together for frequency spans of more than about 27 MHz. The frequency spacing of the FFT sampling points is around half of the RBW setting. For efficient calculation, the IDA only uses FFT lengths that correspond to a power of two. The IDA provides a peak marker function for accurate measurement of the frequencies and levels of spectral lines that are not exactly on a frequency point of the FFT raster. The algorithm used for this interpolates the actual frequency and level values with high precision.



Spectrum, measured over 6 GHz at a resolution bandwidth (RBW) of 500 kHz and a video bandwidth (VBW) of 5 kHz.



Scope, time response measured at a resolution bandwidth of 1 MHz and a resolution time of 1 μs.

The IDA can implement a video filter in Spectrum mode by continuously recording the I/Q data over several FFT lengths. It then computes successive, chronologically highly overlapping FFTs from this. The IDA then calculates and displays the average value of the several chronologically arranged power values that result in this way for each frequency point in the spectrum.

The example shown left depicts a scan up to 6 GHz with strong radio / TV signals at several hundred MHz, GSM-900 (marker position), GSM-1800 and UMTS at around 2.2 GHz.

Multi-Channel Power

Based on Spectrum mode, the IDA calculates the channel power for up to 500 freely definable channels. You can set the center frequency, channel bandwidth and measurement bandwidth (RBW) for each channel separately.

Scope

This operating mode provides a wide range of facilities for signal analysis, as it makes a large amount of information available. The IDA can continuously display the I/Q data individually or simultaneously versus time at the full sampling rate. The time resolution corresponds to the inverse of the resolution bandwidth. At a bandwidth of 32 MHz, the resolution is thus 31.25 ns, which is fine enough to capture a radar impulse. A 5 kHz bandwidth, suitable for AM signals, gives a resolution of 200 μs. Since up to 250,000 pairs of values can be recorded, this gives a recording time of 50 seconds.

The IDA can reduce the data in the time domain for longer recording times. This is done by forming the average value (AVG) and saving the maximum and minimum values (MAX, MIN). The IDA always saves all three values and shows them at the same time. Although this data reduction results in a loss of time resolution, the level information is entirely retained.

The example shown left depicts the signal from a video camera at 2.4 GHz at high resolution. The synchronization block seen on the right, containing pre-equalizing, image synchronization, and post-equalizing pulses (five of each), is typical of such signals.

Level Meter, Direction Finding

The level display is likewise based on formation of the average and storing of the maximum value. In this case, the IDA uses overlapping time windows to obtain the correct root mean square (RMS) value with settable integration time from the average (AVG) in each case. The peak value is held for 480 ms to make even very short impulses visible.

MORE SPECIAL FEATURES

Channel separation using steep filters

The digital down converter low pass filters have raised-cosine (RC) characteristics with a roll-off factor of 0.16. In Level Meter and Scope modes, where a high degree of channel separation is required, the steep cutoff of these filters enables clean separation of closely adjacent channels. Strong transmissions on neighboring frequencies do not affect the direction finding result even if the signal source is weak.

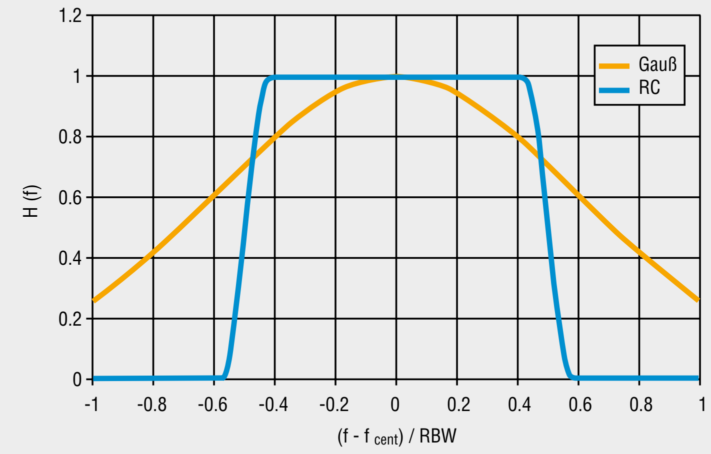
Conventional Gaussian filters are provided in Spectrum mode. They are implemented by means of a suitable window function of the FFT.

Variable video bandwidth

The video filter in Spectrum mode has already been described on the previous page. A video filter is also available in Scope and Level Meter modes. This is implemented by means of a recursive low pass filter computed in real time. By shrewdly selecting the video bandwidth, you can pre-average strongly fluctuating signals and so reduce noise without losing the signal peaks.

Parallel demodulation

The IDA can demodulate signals at the same time as making measurements in Level Meter and Direction Finding modes: FM up to a bandwidth of 200 kHz, AM up to a bandwidth of 20 kHz, and single side-band modulation up to 10 kHz. A beat frequency oscillator (BFO) helps to tune the receiver frequency audibly. A squelch function suppresses audio signals that are too small. Automatic level control (ALC) adjusts the output volume automatically. And another practical detail: The IDA can save audio data as a WAV file.



Comparison of Gaussian filter and raised-cosine (RC) filter frequency responses. Gaussian filters show no overshoot in the step response but have a smooth transition between the pass band and the stop band. In contrast, RC filters are characterized by very steep cutoff edges.

View inside the IDA-3106 during final assembly: A combination of many different types of circuit in a very small space

THE IDA SET

COMPLETE WITH ANTENNAS AND SOFTWARE

IDA-3106 is a complete measuring system. Complete means: All the components are from one source. Complete also means: All the components are matched to each other and recognize each other. They can be combined quickly and without problems on-site. And, of course, everything that belongs together is also packed together, ready to hand.

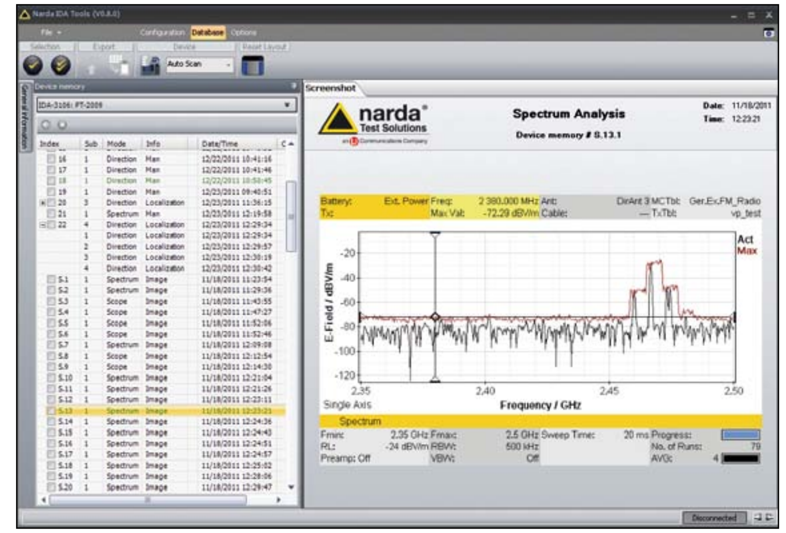
The basic unit, antennas and all accessories can also be purchased separately.
Scope and I/Q Recorder modes and the Map function are options at additional cost.

IDA-3106 Interference Analyzer,
Set with 20 MHz – 6 GHz Antennas
Part number 3106/102

Directional Antenna 1, 20 MHz – 250 MHz

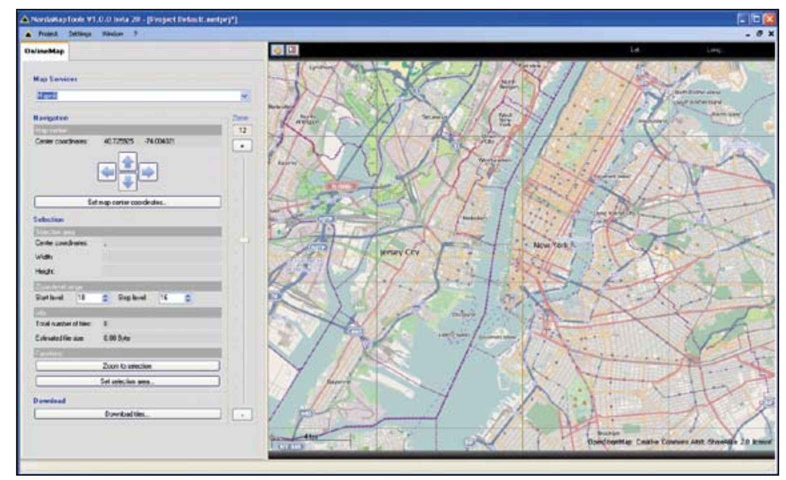
Directional Antenna 2, 200 MHz – 500 MHz

Directional Antenna 3, 400 MHz – 6 GHz



Convenient result evaluation with IDA Tools

IDA Tools
This free PC software is used to configure the IDA basic unit, read out measurement data, and update the firmware. IDA Tools can be used to create transmitter tables and upload them to the instrument, for example, or to read out data such as WAV files from demodulation recording, or screenshots from the instrument.



Preparation of map materials with NardaMapTools

Map Option
With this option, the IDA can superimpose the results of direction finding on a map. Map materials can be conveniently prepared using the NardaMap-Tools software and saved on a microSD card, which slots in to the IDA basic unit.

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