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The signal beneath the signal: IDA 2 makes payload and interference signals clear

The Interference and Direction Analyzer IDA 2 obtains high resolution spectrograms, persistence spectrums and time characteristics based on I/Q data

Detecting RFI, revealing the causes of interference, locating unauthorized transmitters – all these are tasks performed by modern direction finding equipment. Spectrum analysis and time domain displays give much information about the type of signal, but they don't reveal everything. They are limited to recording the amplitude versus frequency and / or versus time, and often lose information due to display compression. The full picture is only seen when the measured values are recorded without compression and separated into their real and imaginary components, usually referred to as the in phase and quadrature components, or I/Q for short.

IDA 2, the new Interference and Direction Analyzer from Narda Safety Test Solutions, does not simply record and save the I/Q data. It can also evaluate the data immediately, on site, where the results are needed for tracing impairments and interference straight away, rather than back in the office long after the event. Of course, results can *also* be checked in the office, in case something was missed in haste on site.

New operating mode *I/Q Analyzer*

I/Q data streaming, 32 MHz wide

The new function can be selected as *I/Q Analyzer* mode, just like *Spectrum* or *Time Domain (Scope)* modes. And, as in *Time Domain (Scope)* mode, the IDA 2 runs in *Zero Span* mode as an *I/Q Analyzer*, being tuned to a fixed frequency, i.e. one channel that is selectively captured. The ability to set unusually high channel bandwidths (CBW) of up to 32 MHz is a special feature of the instrument.

250,000 I/Q data pairs

When you start the measurement, the IDA 2 records the results continuously in real time as I/Q data pairs with a memory depth of 250,000 data pairs. The IDA 2 can even perform some evaluations online, e.g. displaying the pure I/Q data or the *Magnitude* versus time, computing a *High Resolution Spectrogram* or building up a *Persistence Spectrum*. When you stop the measurement, either manually or by automatic trigger, the last 250,000 I/Q data pairs are still stored, uncompressed, in the background. In this way, any evaluation and display can be produced subsequently from one and the same data set, rather like the way that RAW data in digital photography can be used to produce lower resolution and more or less strongly compressed JPG files. The reverse is, of course, impossible.

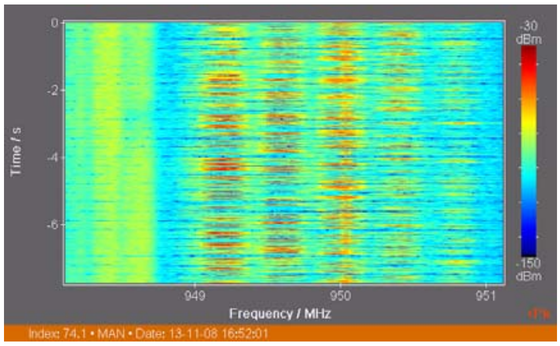
The IDA 2 must necessarily compress the spectrums to correspond with the available number of display pixels in *High Resolution Spectrogram Full* display mode. However, everything is shown in *High Resolution Spectrogram Zoom* display mode: Every line of pixels corresponds to exactly one spectrum, with the color indicating the particular level.

The IDA 2 writes a specified number of spectrums over each other in a *Persistence Spectrum*. The color here indicates how often a particular level value occurred.

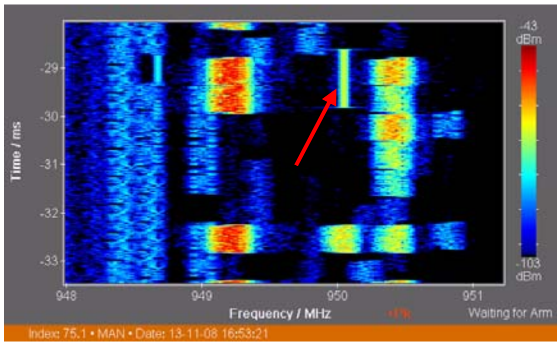
How is the I/Q Analyzer used?

Example: GSM. Is there interference or an illegal transmitter hidden under the “active” spectrum? This can be particularly difficult to determine if the GSM modulation method uses frequency hopping, where the communications channel switches frequency every 4.6 ms or so. If the illegal transmitter also hops, it cannot be detected in the normal spectrogram. It is visible in the *High Resolution Spectrogram*, obtained from the I/Q data, revealed by the different duration and correlation.

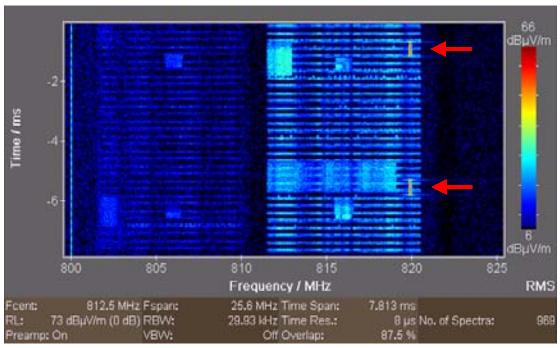
Another example: LTE. Interference due to intermodulation from (and with) GSM signals is not uncommon because the antennas are usually located together on the same roof. Just the rectification effect of a rusty gutter or a couple of rusty rivets on the mast is enough to generate intermodulation, which is superimposed on the RF field. A first for a hand held device: the *High Resolution Spectrogram* of the IDA 2 makes the whole frame structure visible, including everything that does not belong there, too.



A “normal” GSM downlink traffic spectrum, obtained in Spectrum mode with 20 ms resolution.



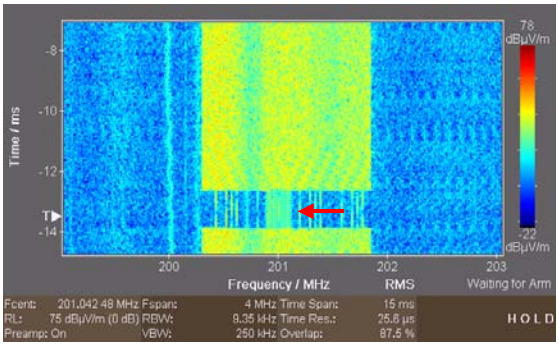
High Resolution Spectrogram Zoom of GSM downlink traffic showing a 4 ms segment from a total time span of 62.5 ms. Time resolution is 16 µs. The illegal transmitter can be seen immediately, as its duration does not correspond to the normal GSM timeslot length of 546 µs.



High Resolution Spectrogram Full of two LTE channels. Resolution 8 µs. The frame structure is clearly seen – practically a textbook image – with its resource grid and synchronization signals.
The repeating interference, naturally, does not fit.

What about an interference signal hidden beneath a DAB channel? This can best be detected in the transmission "gaps": DAB transmits a null character for synchronization at fixed intervals, during which only the carrier frequencies remain. Any interference cannot avoid detection in the *High Resolution Spectrogram* as well as in the *Persistence Spectrum* of the IDA 2.

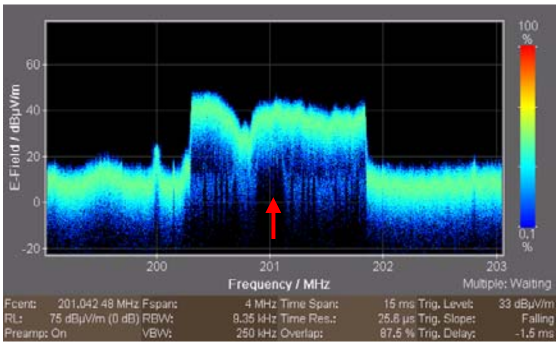
An illegal transmitter, deliberate jamming, an unknown defective device, or intermodulation from authorized communications signals: The signal versus time characteristics often tell much about the type of signal. The *Magnitude* setting of IDA 2 displays the magnitude of the I/Q data versus time, so that the timeslot structure of a GSM intermodulation can be clearly seen, for example.



High Resolution Spectrogram Zoom of a DAB channel, triggered on the null character. The interferer can be clearly seen in the gap.

Trigger

The IDA 2 shifts the I/Q data continuously through its memory on a first in, first out basis during the measurement. Just as with an oscilloscope, you can set triggers that capture the measurement results when specific events occur, e.g. when a specific level is first exceeded or whenever this level is exceeded. The Trigger Delay setting is important here; this lets you capture the measurement values before *and* after the event. After all, you will generally need to visualize both the cause *and* the effect. The SAVE function stores the I/Q data permanently in the IDA 2 memory for later evaluation.



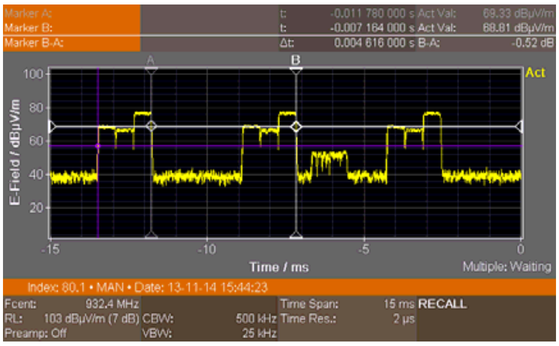
The same signal in a Persistence Spectrum obtained from the same I/Q data set. The interference is visible here, too: At around 201 MHz, the signal level does not drop to around the noise level as expected.

Evaluation of I/Q data

There is a causal relationship between the channel bandwidth, resolution bandwidth, window overlap, time resolution, and possible recording time in any digital analyzer like the IDA 2.

Recording time: Dependent on CBW

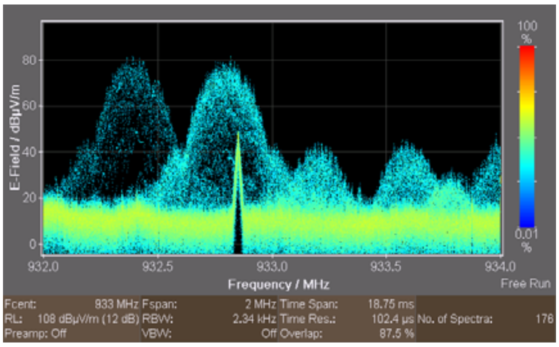
At the maximum channel bandwidth (CBW) of 32 MHz, the IDA 2 captures an I/Q data set every 31.25 ns, corresponding to the inverse of the CBW. This gives a recording time of 250,000 • 31.25 ns = approx. 7.8 ms with a memory capacity of 250,000 data pairs. That may not seem like much, but it is enough to capture cyclical sequences in modulated communications signals completely. The recording duration increases correspondingly for a narrower CBW, so that at the other extreme, a CBW of 100 Hz would give a recording time of 2,500 seconds.



A GSM downlink signal shown in Magnitude display mode, triggered on the rising edge. Time resolution is 2 µs. The 546 µs timeslots can be clearly seen and the frame duration can be measured using markers A and B: Δt = 4.616 ms.

Time resolution for *High Resolution Spectrogram* and *Persistence Spectrum*: Dependent on RBW and window overlap

The *High Resolution Spectrogram* and *Persistence Spectrum* are possible evaluations of the I/Q data that can be made online or subsequently, but also immediately, on site. The IDA 2 uses FFT analysis for this. The signals that have already been captured selectively by means of the selected channel bandwidth (CBW) are further separated into their spectral components by this. Regardless of the setting used for capturing the measured values, you can now determine or change the FFT parameters: the number of FFT samples and hence the resolution (RBW) within the channel bandwidth, as well as the window overlap, i.e. the overlap of the time segments from the data set that are to be used for a FFT.



Persistence Spectrum of a GSM downlink signal. The underlying interference at around 932.8 MHz can be clearly seen.

Resolution 1 µs

The rule is: The fewer the FFT samples and the greater the overlap, the finer the time resolution, i.e. the succession of spectrums. As an example: The FFT yields a usable bandwidth of 25.6 MHz for a channel bandwidth (CBW) of 32 MHz. With 256 FFT samples, the IDA 2 computes a spectrum with a resolution bandwidth (RBW) of about 240 kHz. If you select a window overlap (FFT Overlap) of 87.5 %, you will obtain spectrums with a time resolution of 1 µs, corresponding to one million spectrums per second. For this reason, other analyzers compress the data for resolutions below 20 ms. IDA 2 retains the data without compressing it.

Summary

Based on the I/Q data, the battery operated, hand held IDA 2 weighing just 3 kg offers a depth of analysis that was previously only available using costly and heavy laboratory instruments. Weak or sporadic interference, which may be hidden beneath strong, and possibly variable frequency useful signals can now be revealed directly on site using the IDA 2. In doing so, IDA 2 makes a significant contribution to the security of modern communications.

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