Manual

go2DECODE

Product Version v24.1

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PROCITEC®
HOUSE OF SIGNALS

Imprint

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1. General

1.1. Welcome to go2DECODE

go2DECODE is an extremely efficient software product whose major functions are to recognize modems and to analyze signals in various fields of reconnaissance. Modems (as combinations of demodulator and decoder) are the central items in the automatic recognition process.

The analysts' knowledge and experience are employed to compile modems and modem lists for automatic recognition, i.e. the system is knowledge-based software.

The application provides numerous functions like:

- Modem identification

- Demodulation and decoding of detected modems

- Technical analysis of communication signals

- Receiving and recording of emissions

- Monitoring of specific frequencies

- Monitoring of communication networks

This wide range of functions makes it a powerful tool for a great variety of applications. Since this approach is based on profound knowledge, the application allows automatic identification and production of modems which are added to the system by the user. The close link between demodulator and decoder will minimize the identification error rate.

Comprehensive analysis tools allow the manual extraction of technical parameters of unknown and new modem types in order to include these into the knowledge base for future automatic processing.

The individual software modules communicate via LAN, i.e. every module may run on its individual hardware and transfer the data to the other modules (which is the common procedure in large-scale multi-channel systems), if required by the application. The application thus provides the option to use detached receivers, to process unknown signals and to supervise the routine work in other locations or on independent hardware. In the existing stand-alone system, all functional units are applied on one individual hardware unit.

The software modules are neither platform nor operating system sensitive, i.e. they run on any commercial standard hardware (COTS) under any standard operating system (Windows® and Linux®). Since the modules do not depend on specific hardware, the use of new and more efficient hardware generations will increase the performance of the application by simple means.

Due to the high modularity with TCP/IP-based data interchange via LAN, the application and its individual components can be integrated into existing systems, or adapted to new tasks in a quick and simple way. Some of demodulators and decoders in new modems can be interchanged. This facility ensures that the system can be employed in varying scenarios. The adaptability of the application to future technology trends guarantees a maximum life cycle and a safe investment.

Note: Please find information about the current version in the "readme.txt" file. Some functions depend on the version of your software. Any requests and suggestions will be appreciated. We are happy to receive your information via the support contacts stated in chapter Support.

1.2.　The go2signals product-line

The use of radio communication is constantly rising. The traditional approach of monitoring these more and more connected signal scenarios with a manual approach of channel stepping and manual search is not promising for future challenges.

The product line go2signals covers customer requirements from traditional manual signal handling up to fully automatic intelligence system. This provides processing speed and user comfort of automatic intelligence systems even from single user working positions. It is the perfect solution for mobile, stand-alone and remote controlled applications as well as a start into the world of automatic monitoring.

SUITES	
MONITORING SUITE	Bundles all products around monitoring and signal production
ANALYSIS SUITE	Bundles all products around signal analysis, signal simulation and de-coder development
COMPONENTS SUITE	Bundles all products around integrable system components

Table 1: go2signals Suites

PRODUCTS	
GO2MONITOR	Radio monitoring, signal classification, signal decoding and signal recording software solution for complete signal scenario surveillance (HF, VHF, UHF, SAT bands)
GO2MONITOR LOWSWAP	Radio monitoring, signal classification, signal decoding and signal recording software solution for complete signal scenario surveillance (HF, VHF, UHF, SAT bands) optimized for low-SWaP equipment
GO2MONITOR OPERATOR	Application for setting up additional operator stations for manual sig-nal processing and result viewing for an existing central go2MONITOR system
GO2MONITOR RESULT	Application to set up an additional workplace for go2monitor result pro-cessing
SCL	Software integrable automatic signal modulation and modem classifi-cation C++ library
GO2DECODE	Analysis, demodulation and decoding of known and unknown radio sig-nals. Creating and editing of customer defined modems and decoders
GO2ANALYSE	Analysis, evaluation and manipulation of bit streams for the determina-tion of coding characteristics

Table 2: go2signals Products

2. Installation

2.1. System Requirements

The following operating systems are supported (64bit only):

Windows®

- Windows® 10 (de/en)
- Windows® 11 (de/en)

Linux®

- CentOS 7.x (7.5 or higher, 7.5 is recommended)
- RHEL 8.x (8.4 or higher, 8.4 is recommended)
- Ubuntu 22.04 LTS

PC or notebook with a minimum of

- one hard disk
- one DVD-ROM drive (for installation only)
- one free USB port (dongle version only).

External AudioPlayer under Windows® requires that Media Feature Pack is installed. Only Windows® N editions do not have it installed by default.

There may be additional requirements dependig on the selected receiver (see chapter Supported receivers. For further information please visit our website www.procitec.com or contact our support at service@procitec.com.

2.2. Installation Instructions

An installation wizard guides you through the setup step by step through the entire installation.

go2DECODE is not compatible with an ampersand character ("&") in the username. Please choose a different username.

Make sure no dongle is connected to the USB port of your computer.

If the software was delivered on DVD, insert the go2DECODE DVD into the DVD-ROM drive. If the software was downloaded, unpack the delivered ZIP-archive.

2.3. Copy Protection via CodeMeter®

An application protected by CodeMeter® can only run if the CodeMeter® is connected and its driver is installed. The CodeMeter® may be shipped with the software or can already be at hand. An encrypted license file (.maw) is needed. It contains information about the CodeMeter® and the unlocked features depending on the licensed configuration of the software.

If you desire to use a CodeMeter® already at hand, please contact our support at service@procitec.com.

2.4. Installing the Software on Windows®

Make sure **no** dongle is yet connected to the USB port of your computer.

Insert the go2DECODE DVD into the DVD-ROM drive. The setup will start automatically; otherwise start the file "setup.exe" from the DVD. Follow the instructions on the screen.

2.5. Installing the Software on Linux®

The installation of the application requires superuser rights.

To start the installation, execute the "setup.sh" script, and confirm the installation if asked to do so. The installation routine will set up all components required by the application.
Attention: The pro_postgres system user is removed when the application is uninstalled.

2.6. Connecting the Dongle

2.6.1. Local CodeMeter®-Connecting

Connect the CodeMeter® to an available USB Port of the computer. The CodeMeter® must remain connected to the local USB port while using the software.

Note: If the CodeMeter® was previously connected, diconnect it. Restart and reconnect the CodeMeter®.

The installation is now complete.

2.6.2. CodeMeter®-Connecting via Network

Note: The connection of a CodeMeter® on a network is described below for the Windows® operating system. For support with the connection for the Linux® operating system, please contact our support at service@procitec.com.

Depending on the configuration of the software, copy protection can also be provided by another computer or server on the network. Therefore, a CodeMeter® containing multiple licenses has to be connected to this "copy protection server". These licenses can then be provided via network to the go2DECODE installations on client computers.

To install a copy protection server, follow the steps below.

1. Uninstall all CodeMeter® components

2. Install the CodeMeter® runtime from DVD (applies only to the server)

3. Connect the CodeMeter®

4. Start the server as described below

2.6.2.1. Open Server

The CodeMeter® control center shown in Figure 1 is opened by selecting **<Start Menu><All Programs>** **<CodeMeter><CodeMeter Control Center>**.
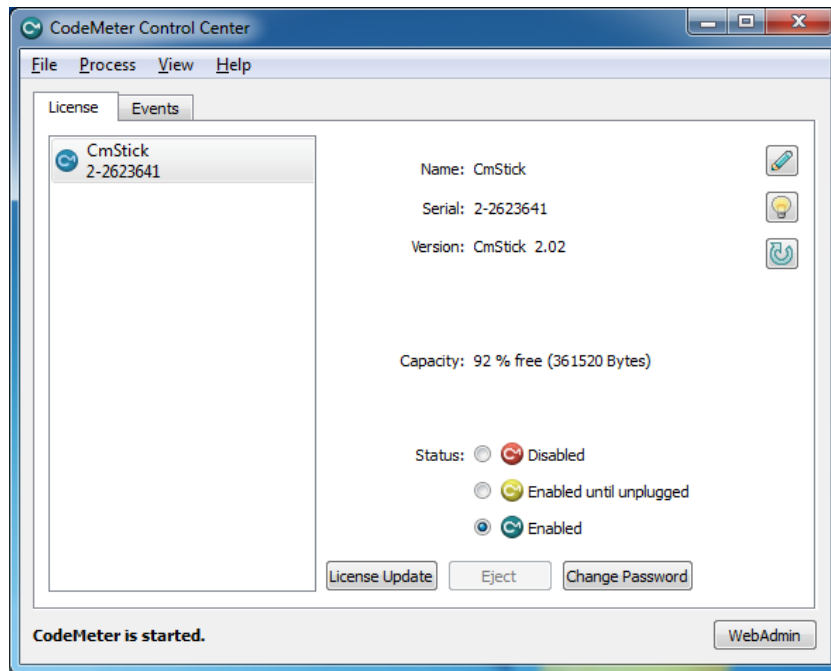
Figure 1: CodeMeter® Control Center

To call the CodeMeter® WebAdmin module, click **<WebAdmin>** in the CodeMeter® Control Center.
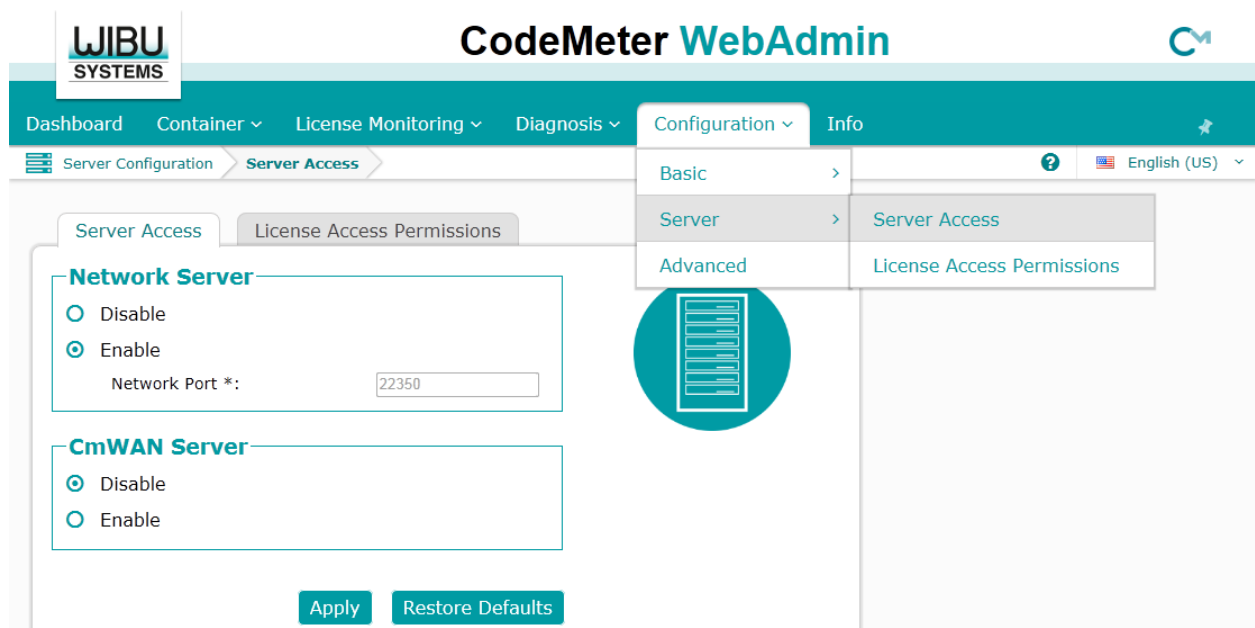
Figure 2: Setup CodeMeter® Server

In the Network Server section, select <**Enable**> and click <**Apply**>.

Note: The server service can also be disabled (stopped) here.

In the CodeMeter® Control Center (see Figure 1), select <**Process**><**Restart CodeMeter Service**>.

The WebAdmin also provides information about connected CodeMeter® such as the quantity of used and available licenses.
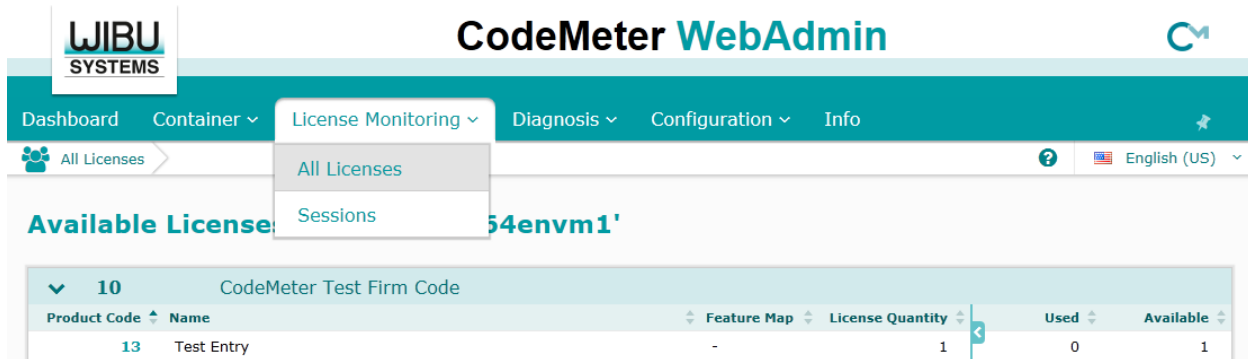
Figure 3: License Information

The CodeMeter® should now also be accessible by the go2DECODE installation on the client computer. If not, you can add the server name or its IP address to the Server Search List on the client via the WebAdmin interface.
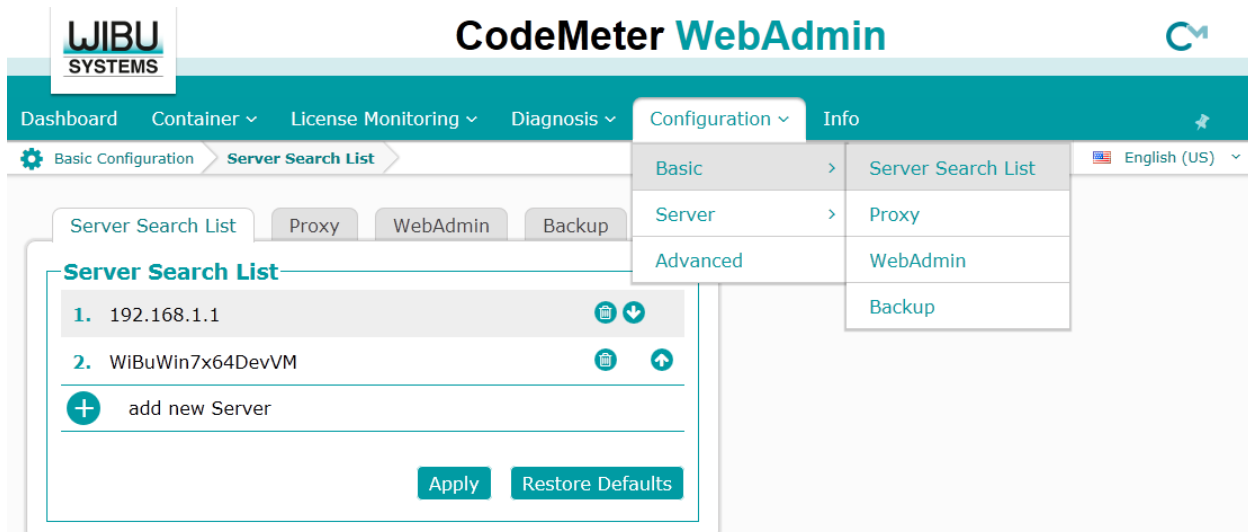
Figure 4: Server Search List

2.6.2.1.1. Stop Network Server

The network server is terminated via the CodeMeter® WebAdmin module (see Figure 2). Under the Server Access tab, select <**Disable**> and confirm by clicking the <**Apply**> button.

2.6.2.2. Troubleshooting

Should the remote client not be able to connect to the server, the firewall should be configured to allow communication on port 22350.

Another possibility to establish a connection is to stop and then restart the server.

2.6.2.3. Connected Clients

As soon as the CodeMeter® runtime software is installed on a connected network client, it will be possible to access its WebAdmin module via:

> http://<ClientNameOrIPAddress>:22350/index.html

2.7. Starting the Software

When you start the software for the first time, you will be asked to point to the location of the provided license file. The file will be automatically copied to the appropriate subfolder in your user folder.

1. Start the application

2. Click <**Yes**>

3. In the file dialog that opens, select the path to the MAW file that is included to activate the software and select the correct file

4. The file will be copied to your user folder and renamed to "default.maw"

Note: When you launch the application for the first time, you may receive a warning from the Windows® Firewall. This is because individual applications communicate with each other on localhost via TCP/IP. This communication can be approved without any security risk.

2.8. License Renewal

If you have a new license file - for a new software version or with extended options - you have to delete the old license file from the appropriate user folder:

- Windows®

  %USERPROFILE%\go2SIGNALS\go2DECODE x.y\default.maw

- Linux®

  $HOME/go2SIGNALS/go2DECODE x.y/default.maw

Note: "x.y" denotes the old version, e.g. v19.1

After you restart the software, you will be asked to point to the location of the provided license file. The file will be automatically copied to the appropriate subfolder in your user folder.

2.9. Update From Older Versions

go2DECODE stores all user modified data in the respective user folder on

- Windows®

```
%USERPROFILE%\go2SIGNALS\go2DECODE x.y
```

- Linux®

```
$HOME/go2SIGNALS/go2DECODE x.y
```

Note: x.y denotes the major (x) and minor (y) version, e.g. v19.1 for go2DECODE v19.1.

These files will remain when you uninstall the software.

2.9.1. Update

If there is only a change in the revision number (last number of the version, e.g. from v19.1.1 to v19.1.2) go2DECODE will immediately use your existing user data.

However, if you prefer a clean installation you can either delete or rename the folder go2DECODE x.y on

- Windows®

```
%USERPROFILE%\go2SIGNALS
```

- Linux®

```
$HOME/\go2SIGNALS
```

before you launch go2DECODE.

2.9.2. Upgrade

In case of the installation of a new version an existing older version will be automatically uninstalled.

2.10. Uninstallation

On Windows®, select in the <**Control Panel**> <**Programs and Features**> go2DECODE and then click <**Uninstall**>.

On Linux®, use the package manager for the uninstallation.

3. Overview

3.1. Software Modules

The software contains the following modules:

- APC (**A**utomatic **P**roduction **C**hannel)

- SDA (**S**ignal **D**isplay & **A**nalysis)

- DANA (**D**igital **AN**alogue **A**udio Interface)

- SOMO (**SO**ftware **MO**dulator)

- PMO (**P**roduction **M**emory **O**bserver)

- RCM (**R**eceiver **C**ontrol **M**odule)

- Decoder Development for Python based decoders (pyDDL)

- Sonagram Viewer

On the one hand, the perfect coordination between the software modules SDA, APC and DANA increases the efficiency of the application. On the other hand, each of these modules will operate perfectly on its own.

Figure 5 provides a functional overview of the software modules SDA, APC, DANA, RCM and SOMO, in combination with a selected range of potential signal sources.
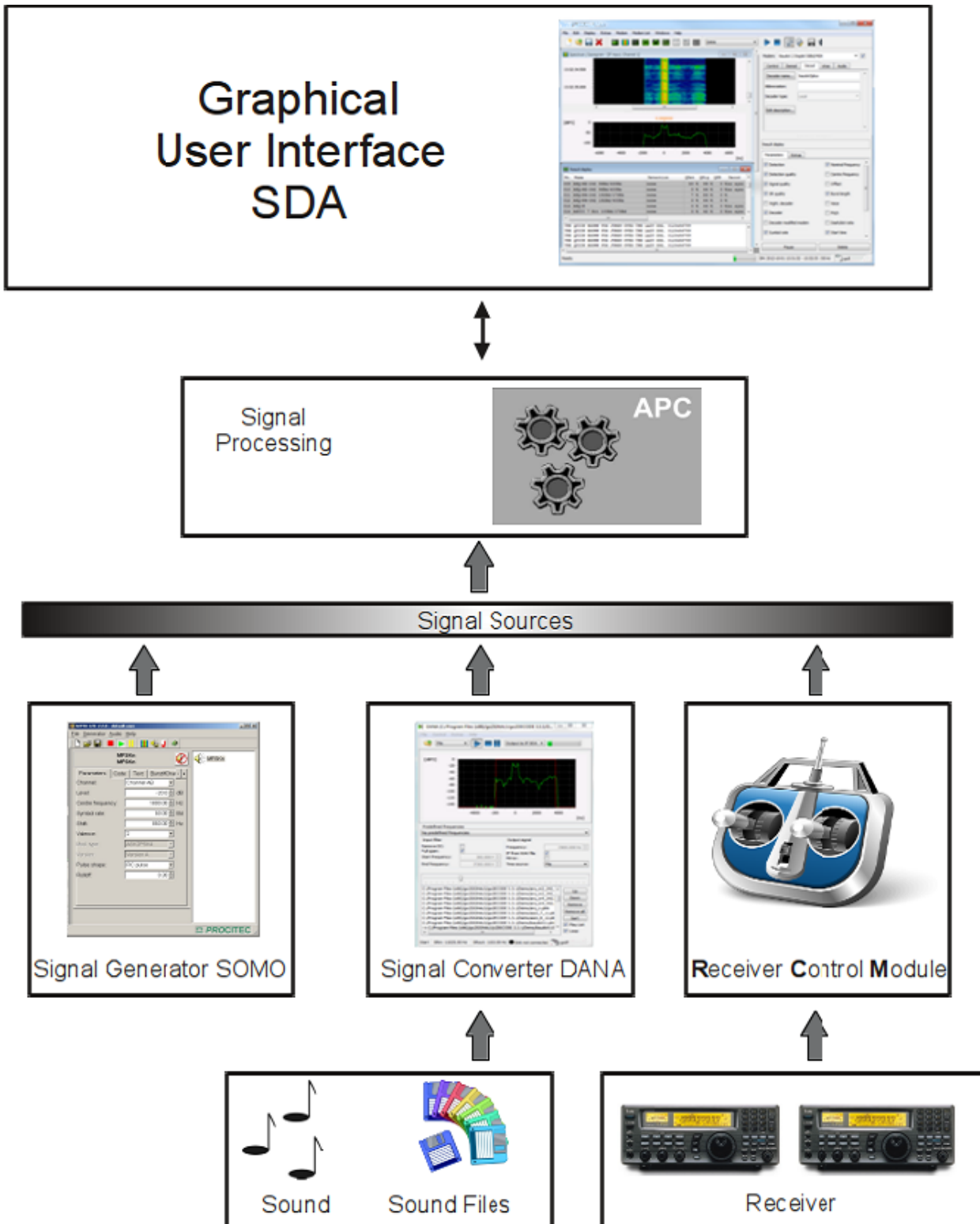
Figure 5: Software Modules Overview

The lower section of the figure shows potential signal sources, which are either linked internally to the sound card of a computer (SOMO, or any type of software player), or delivered to the system via the analog input of the sound card (line-in, base band output of any receiver (see central left section)). In addition, signals can also be fed into the system without a detour via the sound card (no hardware-related loss of quality) (e.g. via TCP/IP).

DANA (Signal-Converter, center of Figure 5) is used as a signal converter and provides the module APC with the signal data in the required form of digital IF.

The module **APC** (central section of Figure 5) handles the processing of signals, from the recognition of modems via the demodulation and decoding up to the permanent production of the message content. APC is a background process without user interface.

The module **SDA** (see top section of Figure 5) carries out the numerous tasks involved in display and user interaction. On the one hand, it provides graphic displays of the results supplied by the module APC; on the other hand, the user can edit parameters to control the operating mode of the APC.

3.1.1. SOMO (Signal Generator)

Availability depends on the software version.

The **So**ftware **Mo**dulator is a signal generator for standard signals. SOMO can be used for training and simulation. In combination with a go2DECODE; it is an excellent training tool for inexperienced analysts. For more information on SOMO please refer to the SOMO Instruction Manual.

3.1.2. DANA

The converter module DANA (**D**igital **An**alog **A**udio Interface) receives the existing input data from sound card or file and converts it into complex signal streams that can be processed by the APC. DANA features a graphical user interface which provides the option to edit various parameters. Among these parameters is the frequency, which is used to add an offset to adapt the center frequency of a signal delivered by an external receiver, or a signal file, to the reference frequency of a demodulator. For more information please refer to chapter Tools Tools.

3.1.3. APC

The APC (**A**utomatic **P**roduction **C**hannel) module is the core of the application. This software module handles the complete signal processing operation in a technical sense. Its tasks are real-time identification, demodulation, and decoding of signals pre-processed by DANA. The results are sent to SDA for display.

The APC controls the following tasks:

- Energetic fine segmentation (signal detection and signal selection)

- Detection (modem identification)

- Demodulation and decoding (modem production)

The application works as a knowledge-based system, i.e. the software is capable of reliable recognition, demodulation and decoding of modems which have been included in the knowledge base (decoder list) of the system, using the experience of the analysts. The delivery contains a selection of demodulators and decoders as well as selected modems built-up from them. The user can edit the parameters of the demodulators, change demodulators, and setup additional modems from the existing demodulators and decoders. The decoder description language based on Python (pyDDL) offers the functionality to develop new decoders, which again can be combined with existing demodulators.

3.1.4. SDA

The module SDA (**S**ignal **D**isplay & **A**nalysis) contains the graphical user interface. The main functions of the SDA are:

- Display and monitoring of the incoming signals

- Audio playback for live listening

- Short time signal memories display

- Results display

- APC control

- Modem parameters configuration

- Display parameters configuration

- Provider of the analysis tools like constellation display, eye pattern display etc.

For further details on the various SDA functions and its operation, please see chapter SDA Operating Modes.

3.1.5. PMO

The module PMO (**P**roduction **M**emory **O**bserver) is a tool to manage the production results of the APC. It displays all decoder production results as well as AF and IF recordings and binary output files generated by the APC. The PMO interface displays the results and recordings in a clear structure and enables the user to select the specific date of the production of interest in order to view the desired recordings.

3.1.6. RCM

The purpose of the module RCM (**R**eceiver **C**ontrol **M**odule) is the communication with external hardware receivers. These can be used directly as a signal source. This module will be started automatically in the background. The configuration will be discussed in more detail in chapter Options and Receiver configuration, respectively.

3.1.7. Decoder Development Python

Availability depends on the software version.

The Decoder Development is build up on the open source tool SPYDER and supports development of decoders based on the Python based Decoder Description Language (pyDDL). It is a complete integrated development environment (IDE) for Python with an extensive editor and a debugger which is specialized for the development of pyDDL decoders. The debugger allows for detailed program analysis including the monitoring of variables, data input/output and the setting of breakpoints.

3.1.8. Sonagram Viewer

Availability depends on the software version.

The Sonagram Viewer is a standalone application of the spectrum/sonagram display. AF and IF WAV files can be loaded and the spectrum and sonagram of the complete file can be viewed offline. All the control and cursor functions of the usual display are available. The Sonagram Viewer can be either launched from the SDA Extras menu or from the PMO context menu.

3.2. Signal Sources

Signals can be provided to the application from different signal sources. Simplified, three categories of sources are available:

- •   Signals from sound cards (via DANA)

- •   Signals from files (via DANA)

- •   Signals from IQ data streams (LAN, data streams from any type of receiver, depends on availability)

In the next sections of this document, we provide an overview of all functions available. By design the modules can run on different computers and exchange the data via TCP/IP. go2DECODE, however, is delivered as a standalone system whose modules are setup to run on one single computer.

3.3. Versions

go2DECODE is available in different configurations:

- •   „Light" is used for production only using a predefined knowledge base. Merely a waterfall display (sonagram) of the input signal and the production results are shown. Any modems developed by the technical center can be imported to extend the knowledge base. It is further possible to record unknown signals. These signals can then be later analyzed in the technical center.

- •   "Standard" contains the functions for recognition (detection), demodulation and the decoding of the signals, using the knowledge base. Online and offline analysis of signals is possible by the means of different displays which help to measure various signal parameters. The system's knowledge base will grow if new modems are added or existing ones modified.

- •   "Professional" is intended for use in the technical center for online and offline analysis of signals, automatic recognition, demodulation and decoding. This version is setup for decoder development using pyDDL, the universal demodulators and the proprietary decoders. This way, the system's knowledge base will grow if new modems are added. Newly developed modems can be deployed to the two other versions or go2MONITOR for further use.

Note: Since version 21.2.0 the "Professional" variant requires the additional installation of "go2signals Analysis Suite". This includes the supplementary applications SOMO, Sonagram Viewer and pyDDL Decoder Development.

The following table shows the available features:

Group	Feature	Light	Standard	Professional
Module	APC	+	+	+
	SDA	+	+	+
	DANA	+	+	+
	SOMO	-	-	+
	PMO	+	+	+
	RCM	+	+	+
	Decoder Development pyDDL	-	-	+
	Sonagram Viewer	-	-	+
Automatic Processing	Start / Stop	+	+	+
	Processing of Modem Lists	+	+	+
	Force Processing of Specific Modem	+	+	+
	Recognition Strategy First	+	+	+
	Recognition Strategy Best	+	+	+
Signal Displays	Spectrum / Sonagram	+	+	+
	Spectrum	-	+	+
	Autocorrelation Display	-	+	+
	Constellation Display	-	+	+
	Time Domain	-	+	+
	Eye Pattern	-	+	+
	Analysis Display	-	+	+
	Hell Display	-	+	+
	Bit Display	-	+	+
	Manual Signal Analysis	-	+	+
Knowledge Base of Modems	New Modem List	-	+	+
	Load Modem List	+	+	+
	New Modem	-	+	+
	Load Modem	+	+	+
	Change Modem Parameters	-	+	+

Group	Feature	Light	Standard	Professional
Result Handling	Text Display	+	+	+
	Display of Measured Parameters	+	+	+
	Result File for Production	+	+	+
	WAV Files for Voice and Morse	+	+	+
Signal Input	TCP/IP	+	+	+
	WAV files	+	+	+
	Sound Card	+	+	+
	Receiver Control	+	+	+
Demodulators	Analysis	-	+	+
	Automatic Processing	+	+	+
Decoder	Analysis	-	+	+
	Automatic Processing	+	+	+
Decoder Development pyDDL	Editor	-	-	+
	Debugger	-	-	+
Recording	IF to WAV Files	+	+	+
	AF to WAV Files	+	+	+
Replay	WAV Files	+	+	

Table 3: Application Features

3.4. Application Demonstration

For demonstration purposes the <**DEMO**> can be started.

The DEMO will start three modules:

- **DANA**
  Filtering and conversion of the input signal into digital IF

- **APC**
  Automatic recognition of modems whose parameters have been entered into the knowledge base

- **SDA**
  Result display for APC and user interface for monitoring and manual analysis of the digital IF

The signal sources are files that are part of the installation.
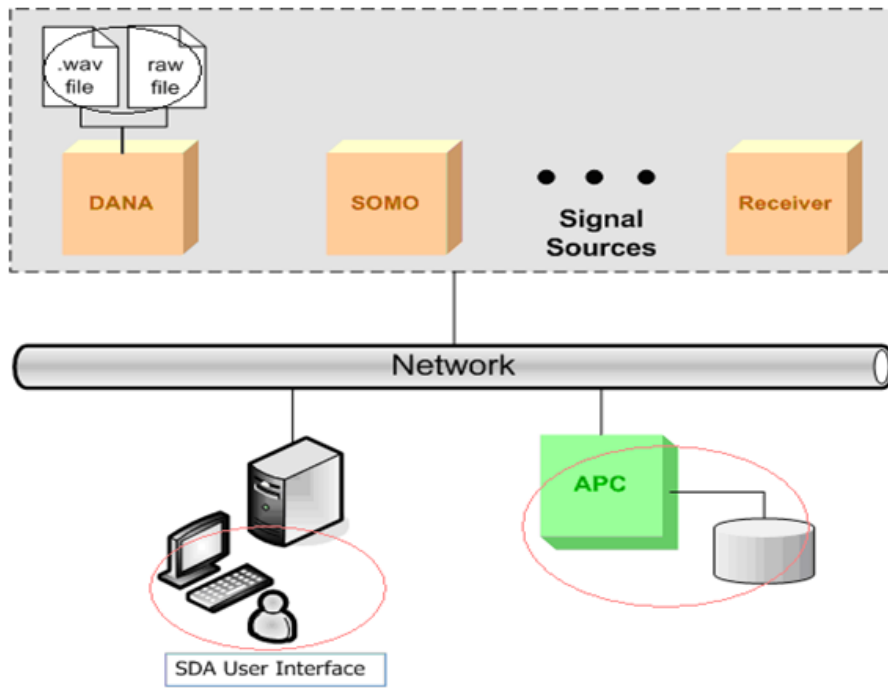
Figure 6: Signal Sources

4. Basics

4.1. Software Start

Start the software or one of the additional tools either using the desktop icons or from the PROCITEC program group on the start menu:

Icon	Name	Description
	go2DECODE	Start the application including SDA, DANA etc.
	DEMO	Starts playing back demo signals. This feature is only available if the signal files have been installed.
	Signal Generator	Start SOMO (Software Modulation Signal Generator) (Availability depends on the software version)
	PMO	Start PMO (Production Memory Observer) for viewing results
	DANA	Start DANA (Digital analog audio interface) for signal input
	Decoder Development (pyDDL)	Start Decoder Development for pyDDL (availability depends on the software version)
	Receiver Configuration	Starts Receiver Configuration Tool

Table 4: Items in start menu

After starting the application, the SDA will appear as in Figure 7. You will see:

- a spectrum/sonagram display

- a result display

- the menu bar

- the toolbar

- two property sheets

- the status bar

Together with the SDA, DANA will start. The APC is started in background without any GUI.
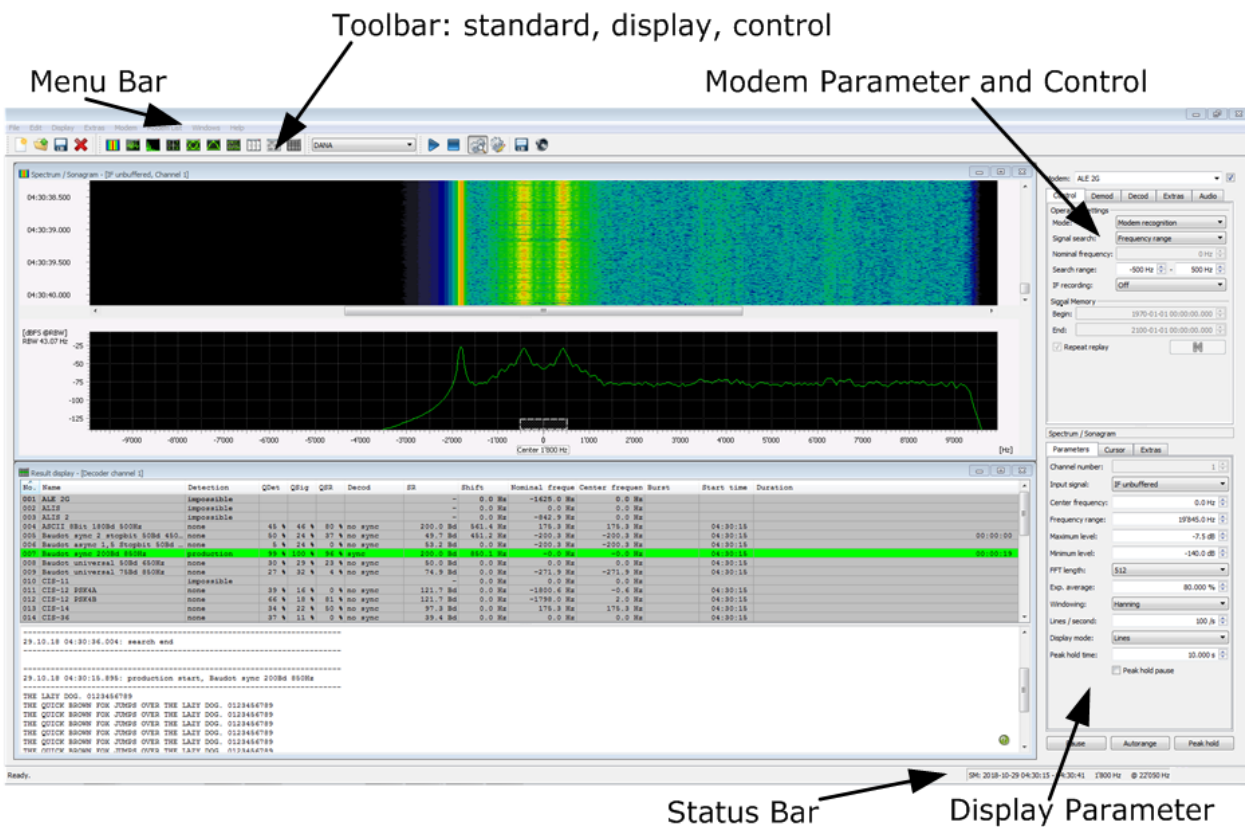
Figure 7: SDA User Interface with DANA

The left part of the window features two displays.

The spectrum / sonagram is a signal display showing the digital IF signal in two different presentations. The sonagram (top) shows the energy distribution of the signal in the frequency-time domain while the spectrum (bottom) indicates the spectral energy distribution of the most recent line at the bottom of the sonagram display.

The result display shows the modems currently stored in the knowledge base of the APC and the results of the automatic modem identification process.

The right-hand side of the window displays the following property sheets:

- In the upper part the parameters for APC control and parameter input for the APC modems are indicated. These parameter tabs include the demodulator parameters and the decoder selection.

- The lower part shows the parameters of the currently active display, like general display parameters, cursor parameters and display parameters.

The status bar of the SDA is located at the bottom of the window. It indicates status messages, the time interval covered by the signal memory of the APC (SM = short-time memory) and the absolute receiver frequency of the input signal which corresponds to the complex frequency 0 (IF = intermediate frequency).

In the result display, you will first see the APC search. The color of the modem in the list varies depending on the state of recognition (e.g. the Morse line first turns yellow then orange when the demo file for Morse is played). This indicates that the Morse signal has been recognized by the APC. A moment later, the modem turns green and the decoded Morse text is displayed showing the final results.

In demo mode, this process repeats with each signal replayed.

4.2. SDA Operating Modes

The SDA provides the option to supply signals from different sources. The following signal sources are available in the default installation:

- DANA

- SOMO

- Signal Memory

These modes can either be set on the menu <**Extras**><**Mode**> or the toolbar.

Further signal sources can be added via <**Extras**><**Options**>, e.g. external hardware receivers.

4.2.1. DANA

This is the application to stream WAV-files or signals which are connected to the input of the sound card. If you are using DANA as the signal source, the APC receives the signal data from DANA. For more information please refer to chapter Tools.

4.2.2. SOMO

Availability depends on the software version.

SOMO is a signal generator for various signal types. It can serve as a signal source for the APC. You must start first SOMO from <**Extras**><**Launch SOMO**>.

4.2.3. Signal Memory

The APC stores the input signal it receives in internal signal memory. The capacity is about 5 min (depending on the input sampling rate).

Signal memory also may be used as signal source for replaying the signal which was stored beforehand in the internal signal memory of the APC. This is helpful if you want to analyze short signal parts.

The Signal Memory settings are used to set the start and end time of the short-time memory. Activate the <**Start**> button to start over. To switch off continuous play, deselect the check box <**Repeat replay**> below the <**End time**> label.

4.2.4. Operation

In case you want to switch between signal-sources, please activate the stop symbol in the toolbar. Select the new signal-source and activate the start symbol in the toolbar.

If the button <**Modem recognition**> is activated, the system automatically evaluates the modem with the best recognition results. Once the modem is found, production will start at the time the search was originally started. Production will then be faster than real time until all former signal data has been processed by the APC. Subsequently, the data is processed in real time again. The production will automatically stop and a new search started if the emission ends.

If <**Production**> is selected, then the APC tries to produce results with the modem currently selected. The current modem is displayed above the control and modem parameters. Additionally, it is displayed in bold letters in the result display. In this mode no automatic recognition is carried out. We recommend this mode for signal analysis.

During automatic production the stored control and modem parameters are used by the APC. If a signal is not recognized by the APC in automatic mode, either modify the parameters of the existing modem or create a new one.

To edit the modem parameters, first select manual mode and the modem to be edited. To do so, either use the modem list or double-click the respective modem in the result display.

Now select the <**Demod**> tab in the modem parameters form. Now you can edit the demodulator parameters e.g. the symbol rate or the shift of an FSK modem.
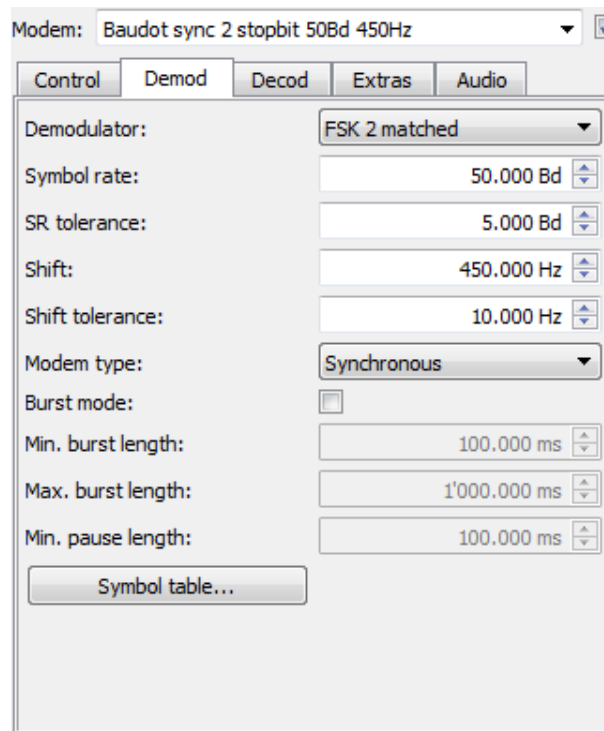
Figure 8: Demod Parameter Setting

To create a new modem, select the menu item <**Modem**><**New modem**>. Now change the demodulator type and enter the correct parameters.

If the demodulated signal has to be decoded, select a decoder on the <**Decod**> tab. Click on <**Decoder Name**>. A list of existing decoders will be displayed. Select the decoder and confirm by <**Ok**>. Now, the selected decoder will be used for decoding.

If there is no appropriate decoder, either modify an existing decoder or create a new one. For details see pyDDL manual.

4.2.5. Displays

The various signal displays can be used to determine the demodulator parameters. Cursor are available to measure e.g. the shift or the symbol rate. The cursor are superimposed in the spectrum/sonagram display via the <**Cursor**> tab.

Figure 9: Signal analysis tools

This way you can e.g. measure the shift by activating the <**X Cursor**> in the spectrum / sonagram and placing the first cursor on the lower frequency and the second cursor on the higher frequency (drag and drop).

Other displays available for signal analysis are eye-pattern or the constellation display. If the APC is able of demodulate the signal, then the output of the demodulator, the symbol stream, can be viewed using the Hell and bit displays. The Hell display uses the time and the bit display the number of bits per line as the reference for the x-axis.

4.3. File Menu
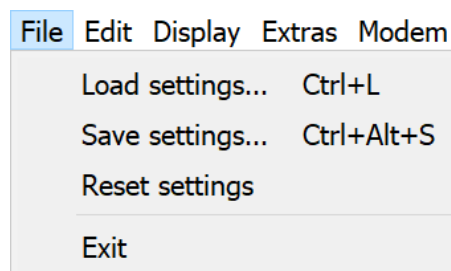
Figure 10: File Menu

Any changes in the GUI are automatically saved when you exit the application. This comprehends the following settings:

- Window position and window size of main window

- Show/hide property sheets

- Window positions and window sizes of the individual displays, if open

- All display parameters

- Window position and window size of the decoder editor as well as the last decoder edited, if open

- Modem list last in use

- Operation mode last in use

- Signal source definitions

- Positions of all tool bars

4.3.1. Load Settings…

Load previously saved settings from a file of your choice.

Before loading the settings, switch to <**Production**>.

4.3.2. Save Settings…

Save current settings to a file of your choice.

4.3.3. Reset Settings

On selection of this option the current settings are replaced with the default settings of the installation.

4.3.4. Exit

Exit go2DECODE.

4.4. Edit Menu
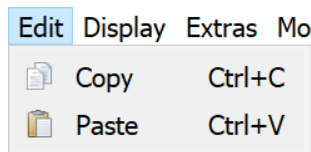
Figure 11: Edit Menu

Highlighted text blocks can be transferred to the clipboard of your computer and pasted in other positions in the text using the functions Copy and Paste.

4.5. Display Menu

This menu presents the various signal displays available in go2DECODE.
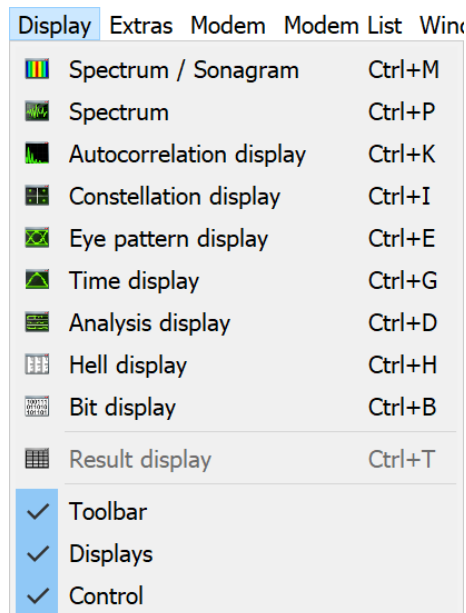
Figure 12: Display Menu

4.5.1. Spectrum/Sonagram

The spectrum/sonagram display shows the spectrum of signals over time. One important application is monitoring of the input signal. It displays both, the actual signal spectrum as well as the sequence of the most recent spectra in a waterfall display called sonagram.

The following figure shows an example of the spectrum/sonagram display.
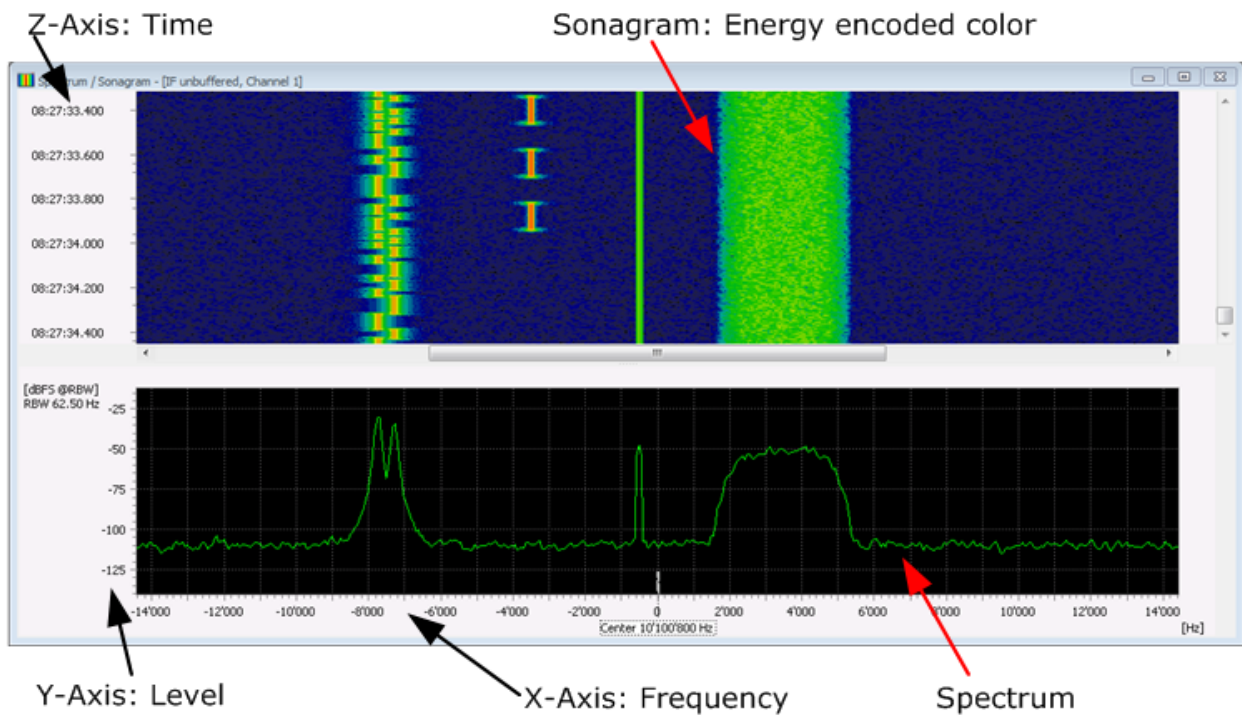
Figure 13: Spectrum/Sonagram

The spectrum/sonagram display is divided into two panels.

The upper panel shows the sonagram (spectrogram). Each horizontal line represents a certain time. The color represents the power on this frequency (from black to blue to green to red). The labels on the time axis (Z-Axis) show the recording period of the signal. Changes in the signal level in the course of time can be identified by changes in color.

In the lower panel of this display the spectrum (FFT) is shown.

X-Axis: Frequency 0 corresponds to the center frequency of the applied signal, e.g. the parameter <**signal frequency**> in DANA or a receiver frequency.

Y-Axis: Shows the logarithmic power, displayed in dBFS. This refers to the level of the signal. 0 dBFS represents full scale and -100 dB is 100 dB below full scale. 0 dBm is for 1 mW, -50 dBm means 50 dB below 1 mW, which equals 10^{-5} mW.

The spectrum/sonagram display provides an overview of the power distribution of the applied signal. The values and ranges of frequency, power level and time can be measured using cursor.

4.5.1.1. Power spectrum

The power spectrum (default) varies the displayed power level depending on the configured FFT length. With the next higher FFT length (factor 2), the spectra resolution is doubled and together with that also

the bandwidth of one FFT bin is halved. Thus, also the measured power is halved. With the next smaller FFT length (factor 0.5) the measured power is doubled.

Measuring the power of a modulated signal requires accumulating the power over the signal's bandwidth. See chapter Power and SNR measurement.

The samplerate of a signal and the FFT length define the frequency resolution (also known as bin width, also known as RBW for **r**esolution **b**and**w**idth):

RBW = samplerate / FFT length

The value below the Y-Axis label ([dBFS @ RBW] or [dBm @ RBW]) shows the current resolution bandwidth.

4.5.1.2. Power spectrum density

The unit commonly used for power density is "dB per Hz"; thus normalized to 1 Hz – independent of FFT length. However, the FFT length still defines the frequency resolution.

In a frequency band containing white noise only, the measured power density does not change with the FFT length. In a power spectrum the power level varies for different FFT lengths, which influences the frequency resolution (RBW).

For signals with a bandwidth smaller than the RBW, normalization makes no sense. Especially for unmodulated carriers, the power density cannot get measured, because the power is erroneously distributed over the RBW. A finer frequency resolution has to be applied by increasing the FFT length. Alternatively a power spectrum can be used in order to measure such signals.

In <**Extras**><**PSD normalization**> Power spectrum or power spectrum density (PSD) can be selected (see Figure 25).

To allow direct comparison of the resulting level with other software or other measurement devices, the parameter *normalization* bandwidth in the spectrum/sonogram display can be used. The measured power in the resolution bandwidth (RBW) is normalized to this normalization bandwidth. The default normalization bandwidth is 500 Hz.

Selection of <**Extras**><**PSD normalization**> is also available with context menu by pressing the right mouse button inside the spectrum/sonagram display. The menu then shows the item <**Power Spectrum Density (PSD)**> (see Figure 14).
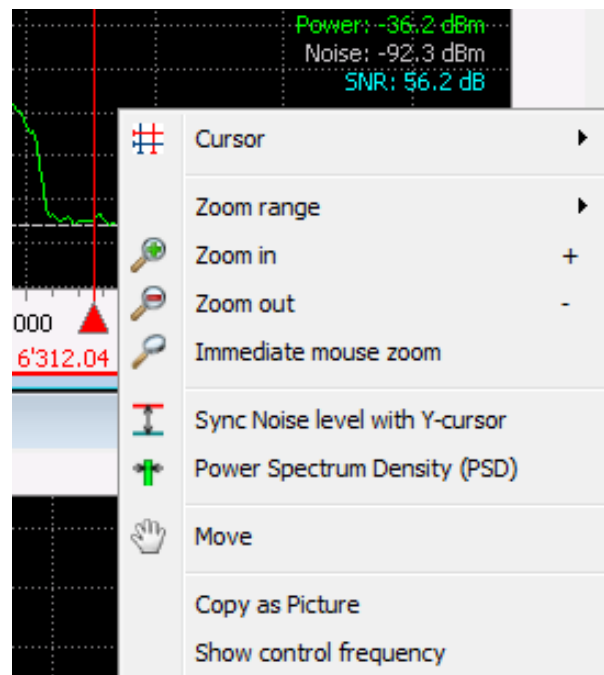
Figure 14: Spectrum/Sonagram - Context menu

The normalization bandwidth is only available in <**Extras**>.

4.5.1.3. Power in dBm

The levels are usually displayed without units in dB / dBFS, when no reference level is available with the signal data.

In case a receiver or in general a signal stream provides go2DECODE with a signal together with its reference power level as meta information, then spectrum/sonagram automatically displays the power level in "dBm". 0 dBm corresponds to 1 milliWatt power.

4.5.1.4. Power and SNR measurement

When spectrum/sonagram display is paused and the X-cursor are active, the upper right corner of the spectrum view shows the total power (total power: signal power S + noise power N), the noise power (N) and the signal to noise ratio SNR (S/N).

These values are calculated for the frequency band spanned by the X- cursor.

The calculation is performed based on the visible spectrum and thus is influenced by various parameters like <**FFT length**>, <**windowing**>, <**exp. Averaging**> and the spectrum display, e.g. <**Average value Cur. 1/2**>. Depending on these parameters, the measured values will vary by some dB. <**Average value Cur. 1/2**> is required for the measurement of short bursts.

The noise level is determined automatically and shown with a horizontal dashed grey line (see Figure 15). The level is calculated from the visible spectrum. It is important to have enough flat noise-only bands in the view. This can be controlled with the parameters <**Center frequency**> and <**Frequency range**>. The dashed grey line is for verification of the estimated noise level.
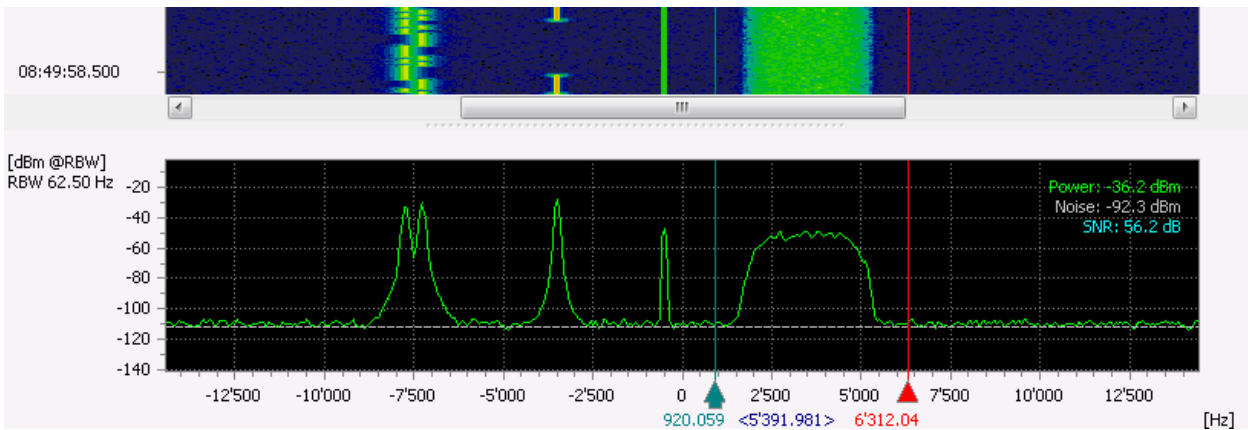
Figure 15: Spectrum/Sonagram with measurement values power, noise and SNR

Selecting the context menu item <**Sync Noise level with Y-cursor**> (see Figure 14), the Y-cursor are displayed at the currently estimated values for power and noise (red: power, green: noise) (see Figure 16). Modification of the X-cursor leads to a recalculation of the measured values and the Y-cursor also get updated. In case the Y-cursor get modified manually, e.g. for adjusting the noise floor, then the labels in the upper right corner are marked with a star to show that these are not the automatically determined values (see Figure 17).

Measurements functions for power and SNR are only available with the input signals "IF unbuffered" and "IF input".
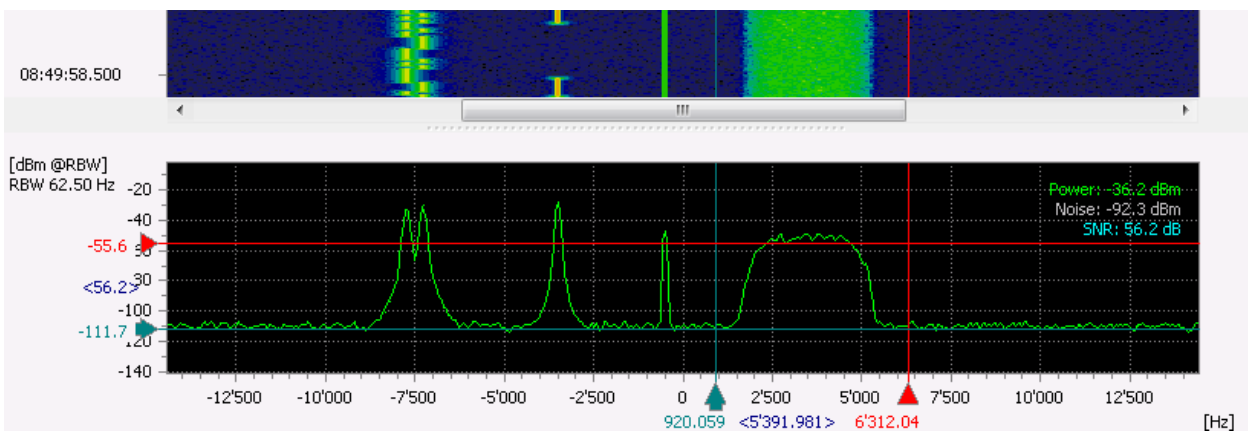
Figure 16: Spectrum/Sonagram with synchronized Y-cursor
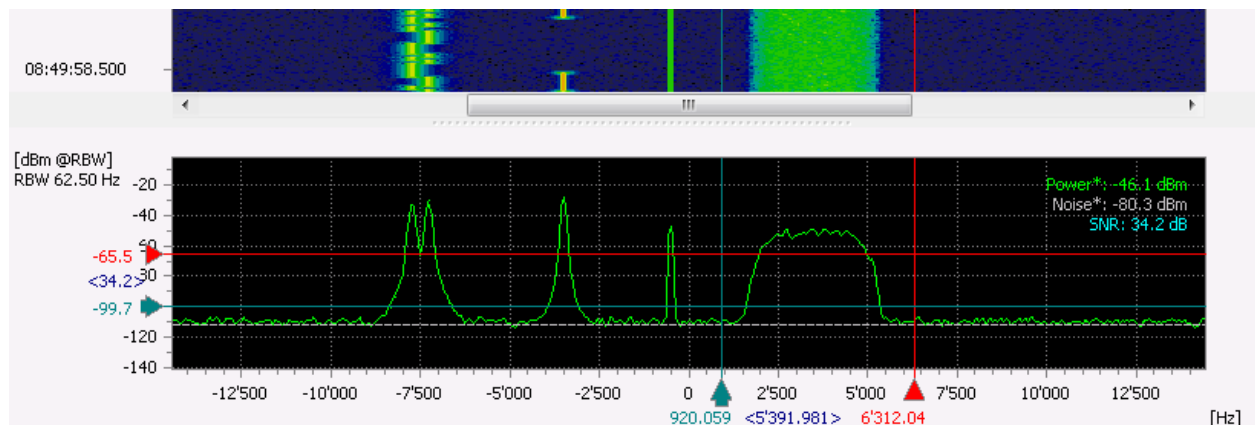
Figure 17: Spectrum/Sonagram with manually positioned Y-cursor

All spectral components between the X-cursor are used for calculation of "power". This also includes regions which obviously contains just noise.

The APC uses knowledge of the modem to be produced and the unused regions' power is not taken into account. Accordingly the SNR measurement in the APC is modem specific and the measured values will differ from the values in the spectrum/sonagram display.

Accurate SNR measurements are not possible for signals with smaller bandwidth than the RBW. Pure (unmodulated) carriers don't use bandwidth, thus the SNR can only be specified for a given bandwidth.

The SNR is calculated using following simple formula:

$$SNR = (Total\ Power - N) / N = S / N$$

The value is then displayed in dB.

4.5.1.5. Spectrum/Sonagram-Specific Display Controls

The spectrum/sonagram display has various special features to simplify the navigation. To use the keyboard shortcuts, make sure the GUI focus is actually on the sonagram display (indicated by the blue title bar).

Scrollbars

The display window features a scrollbar each in frequency direction and in time direction (provided the signal exceeds the display section). In addition to the common drag functions, there are several keyboard shortcuts for scrollbar operations.

Zoom Functions

The sonagram software provides convenient zoom functions for quick navigation and analysis. The default zoom factor is 2, respectively its reciprocal in opposite direction. Custom zoom factors can be set on the display's property sheet on <**Extras**><**Relative Zoom Factor**>.

Popup Menu

The spectrum/sonagram display provides a popup menu (right click) with a number of useful items:
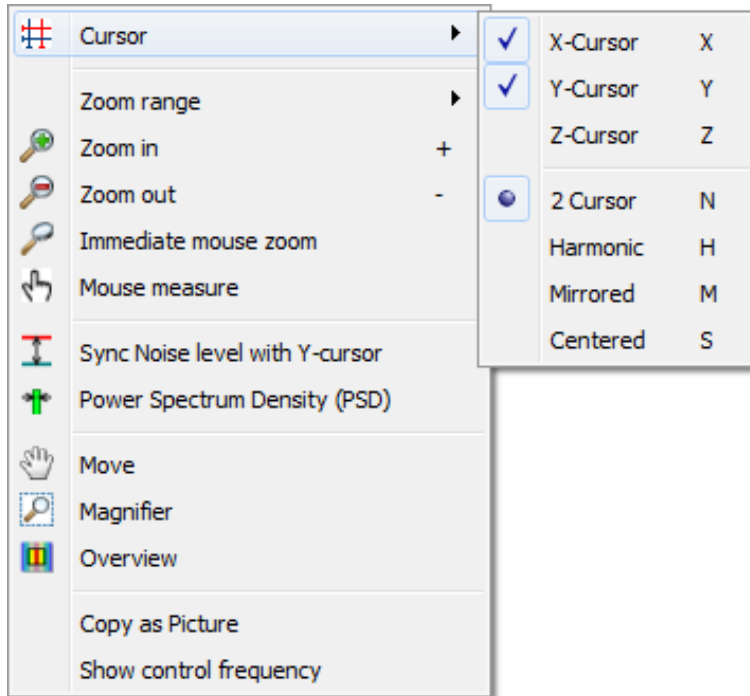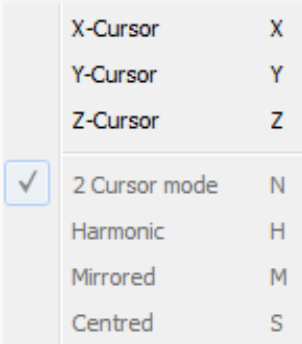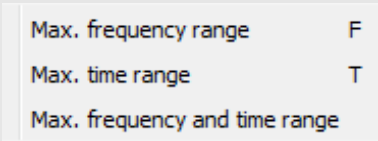
Figure 18: Spectrum/Sonagram - Popup Menu

Parameter	Function
\<Cursor\>	Activate and deactivate X-, Y-, Z- and **\<Harmonic\>** *Figure 19: Cursor selection* • 2 Cursor mode 2 independent, moveable cursor will be displayed in the window. • Harmonic Several cursor are activated at equidistant intervals. In this mode, the first cursor will move all other cursor. The intervals are defined by grabbing and moving the second or any following cursor. The Harmonic function can only be applied in combination with X-cursor, Y-cursor or Z-cursor. It serves to measure repeating intervals. • Mirrored Several cursor are activated at equidistant intervals. Cursor 1 will be on one side and in the middle of the even-numbered equidistant cursor and the odd-numbered equidistant cursor is located on the other side. If you move one cursor (except Cursor 1) all other cursor besides Cursor 1 will move symmetrically. • Centered Several cursor are activated at equidistant intervals. In contrast to **\<Mirrored\>**, all cursor (except Cursor 1) and the cursor which is in the opposite of the first mirrored cursor are moving.
\<Zoom range\>	• Max. frequency range. Zoom to maximum frequency range • Max. time range. Zoom to maximum time range (show entire buffer without scrollbar) • Max. frequency and time range *Figure 20: Maximize zoom range*
\<Zoom in\>	Enlarged view of the section delimited by the cursor. Repeat this process until the spectrum area displayed is satisfactory.

Parameter	Function
\<Zoom out>	Reduced view of the section delimited by the cursor. Repeat this process until the spectrum area displayed is satisfactory.
\<Immediate mouse zoom>	Zoom in by clicking the mouse at the desired position (zoom out using the **\<Ctrl>** key).
\<Mouse measure>	Delivers X-, Y- and Z-values at the current mouse position in the sonagram in the X-, Y- and Z-cursor 1 boxes and displays them. If there is no valid Y-value the Y-cursor 1 is set to the smallest allowed value. This feature is only available if the sonagram is paused.
\<Move>	The mouse pointer changes into a hand. Drag the displayed section in the desired direction by moving the mouse while keeping the left mouse button pressed.
\<Sync Noise level with Y-cursor>	The Y-cursor are displayed at the currently estimated values for power and noise (red: power, green: noise). See chapter Power and SNR measurement.
\<Power Spectrum Density (PSD)>	Switches between power spectrum and power spectrum density (PSD).
\<Magnifier>	The mouse pointer changes into a magnifying glass superimposed on a rectangle. On mouse click, a separate window is opened showing the magnified contents of the sonagram display center. Select the section to magnify, either by drawing a rectangle before activating the magnifier function or simply clicking the position of interest in the sonagram display.
\<Overview>	Opens a sonagram with an overview of the complete signal located in the buffer. In addition you see a rectangular mark around the section in the actual sonagram display.

Table 5: Spectrum/Sonagram Parameters - Popup Menu

4.5.1.6. Spectrogram/Sonagram Keyboard Shortcuts

The following keyboard shortcuts are available in the spectrum/sonagram display:

Parameter	Function
Mouse Wheel focus on sonagram	Move scrollbar in time direction
Mouse Wheel focus on spectrum	Move scrollbar in frequency direction
\<Left Arrow>	Move scrollbar to lower frequencies. Additional **\<Ctrl>** scrolls one page
\<Right Arrow>	Move scrollbar to higher frequencies. Additional **\<Ctrl>** scrolls one page
\<Up Arrow>	Move time scrollbar one step towards the start. Additional **\<Ctrl>** scrolls one page
\<Down Arrow>	Move time scrollbar one step towards the end. Additional **\<Ctrl>** scrolls one page

Parameter	Function
\<Page Up\>	Move time scrollbar one page towards the start. Additional **\<Ctrl\>** jumps directly to the start
\<Page Down\>	Move time scrollbar one page towards the end. Additional **\<Ctrl\>** jumps directly to the end
\<Home\>	Move time scrollbar directly to the start
\<End\>	Move time scrollbar directly to the end

Table 6: Spectrum/Sonagram Display Control, Keyboard Shortcuts: Scroll functions

Parameter	Function
\<Ctrl\> + Mouse Wheel	Zoom in/out in time
\<Ctrl\> + Drag area with Mouse	Zoom into dragged area
\<Shift\> + Mouse Wheel	Zoom in/out in frequency
\<Ctrl\> + **\<Shift\>** + Mouse Wheel	Zoom in/out in time and frequency
\<+\> / **\<P\>**	Zoom in Graphical Zoom enlarges the visible frequency by factor ½ each time it is activated. If there is a drawn rectangle (by mouse) in the display window, it is zoomed into this section. After zooming, the rectangle, shown as a white dotted line, will disappear - as if clicked any position in the display window.
\<-\> / **\<M\>**	Zoom out The displayed frequency area is enlarged by factor 2

Table 7: Spectrum/Sonagram Display Control, Keyboard Shortcuts: Zoom functions

Parameter	Function
	Most Cursor shortcuts are toggle functions
\<X\>	Activate and deactivate the (X) frequency-cursors
\<Y\>	Activate and deactivate the (Y) level-cursors
\<Z\>	Activate and deactivate the (Z) time-cursors
\<N\>	Switch to normal 2 cursor mode (no toggle function)
\<H\>	Activate and deactivate Harmonic cursor mode: • all harmonic cursors placed at one side • dragging cursor 1: moves all cursors - keeping distances • dragging cursor >= 2: Cursor 1 stays in place - all other stretch/move

Parameter	Function
<I>	Activate and deactivate mirrored cursor mode: • harmonic cursors placed on both sides of Cursor 1 • dragging Cursor 1: moves all cursors - keeping distances • dragging Cursor >= 2: Cursor 1 stays in place - all other stretch/move
<S>	Activate and deactivate centered cursor mode: • harmonic cursors placed on both sides of Cursor 1 • dragging Cursor 1: moves all cursors - keeping distances • dragging Cursor >= 2: cursors at opposite side stay in place - all other stretch/move

Table 8: Spectrum/Sonagram Display Control, Keyboard Shortcuts: Cursors

Parameter	Function
<J>	Searches the spectrum for the maximum and displays the corresponding X/Y value as a tooltip. With active X-Cursors the search range can be restricted. The values are automatically inserted into the clipboard. The tooltip disappears as soon as the key is released.
<U>	Same as <J>, but searching for the minimum.
<L>	X-Cursor 1 and Y-Cursor 1 are moved to the next maximum of the spectrum curve towards lower frequencies, if X-Cursors are active. If <**Peak-Hold**> is activated, the maxima on the compressed curve are selected.
<R>	Same as <L>, but towards higher frequencies.

Table 9: Spectrum/Sonagram Display Control, Keyboard Shortcuts: Minimum/Maximum

4.5.1.7. Spectrum/Sonagram Parameters Settings

As with all displays, the spectrum/sonagram's parameters are edited on the property sheet, which features several tabs.
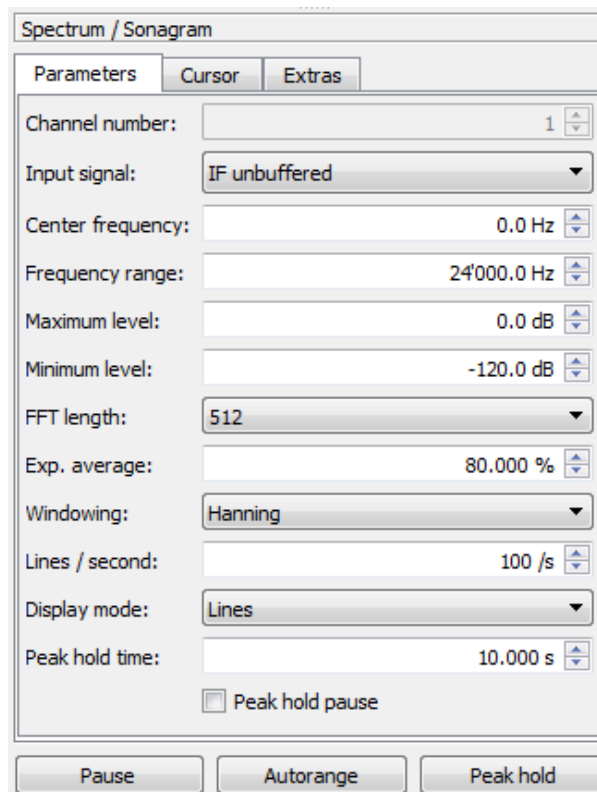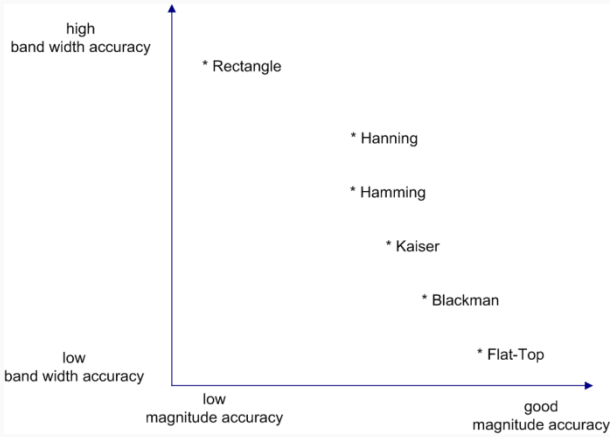
Figure 21: Spectrum/Sonagram - Parameters

To show the parameters of the spectrum/sonagram, select the <**Parameters**> tab. The following parameters are available:

Parameter	Function
<**Channel Number**>	There are signals that consist of several signal parts, e.g. the input signal channel in an MFSK2 modem. The channels of such signals are selected as the input signal by their channel number.
<**Input signal**>	Use this parameter to select the input signal of the display. If the automatic production is active, you can only select the input IF. While setting the parameters of the demodulator, it may occur that a previously selected input signal is no longer available. In this case, the selection *no signal* will be displayed.
<**Center frequency**>	The frequency section to be viewed is set in combination with the frequency range. The center frequency is the center of the section.
<**Frequency range**>	The frequency section to be viewed is set in combination with the center frequency. The frequency range is the range within the section. The zoom can thus be set manually.
<**Maximum level**>	Definition of the level range in the spectrum display. The maximum level is the upper end of the section.
<**Minimum level**>	Definition of the level range in the spectrum display. The minimum level is the lower end of the section.
<**FFT length**>	Number of values of frequency in which the signal is displayed. To obtain a higher resolution of the displayed frequency range, increase the FFT length.

Parameter	Function
<Exp. Average>	The spectrum is displayed in average of several spectrums. The result of a change of the spectrum will be a total view of the spectrum. 　　　0%:　　No average 　　- 80%:　　Low average 　80% - 99%:　　High average 　　100%:　　No updating of the spectrum
<Windowing>	The FFT algorithm is used for the calculation of the spectrum. This algorithm, however, shows inaccuracies in the amplitude (attenuation) as well as in the bandwidth (expansion) of a signal due to the finite signal probe. These inaccuracies can be reduced using windowing: *Figure 22: Accuracies of windowing functions*
<Lines / second>	Number of spectrums that can be calculated and displayed within one second. This parameter serves to set the time resolution for the sonagram, thus also setting the scroll speed.
<Display mode>	Use this parameter to set the type of the display: Line: the spectrum is displayed as a closed curve. Bar: the individual values are displayed as bars.
<Peak hold time>	When the time adjusted has elapsed, the peak hold (the red curve in the spectrum) will be reset to the current values. 0 means no reset.
<Peak hold pause>	This check box is used to freeze the continuous display after a period specified in the spin box <**Peak hold time**> (The button <**Pause**> is activated and locked). It can only be selected if the button <**Peak hold**> has been activated. This function will not stop the signal flow between the signal processing modules. To reactivate the continuous update of the display, press the button <**Pause**> again (toggle switch).
<Pause>	In Pause, the display is stopped (not the signal processing). Modification of the parameters is possible for a more detailed analysis of the current signal range.
<Autorange>	Automatic setting of the displayed range to view the total amplitude and frequency range. The mode autorange analyzes approx. 12 spectral lines. The display is adapted on every change of the range.

Parameter	Function
\<Peak hold\>	By activating **\<Peak hold\>**, the maximum energies in the spectrum are recorded and displayed as a red curve.

Table 10: Spectrum/Sonagram - Parameters Tab
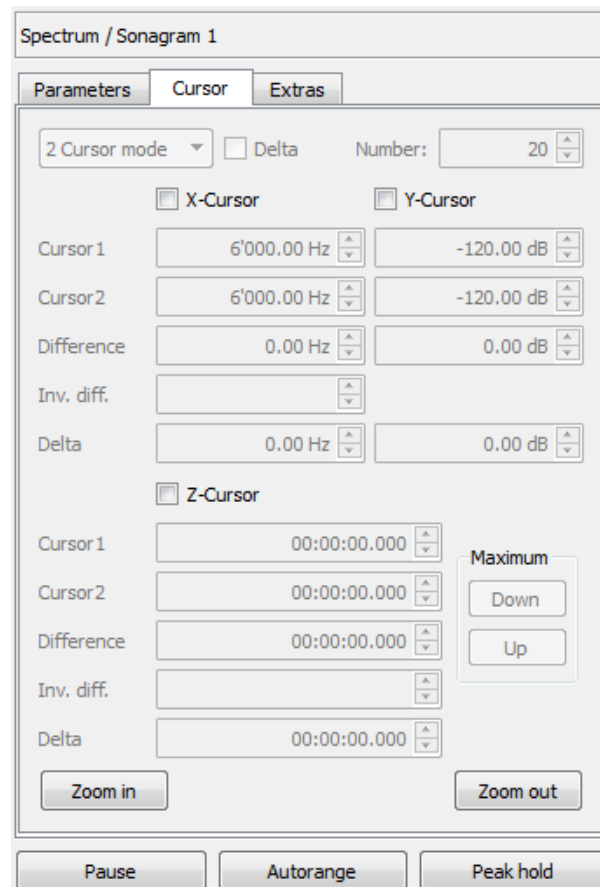
4.5.1.8. Spectrum/Sonagram Cursor Settings

Figure 23: Spectrum/Sonagram - Cursor

The **\<Cursor\>** tab contains all functions related to cursor operations except for the **\<Zoom\>** buttons and the relative zoom factor setting. These are located on the **\<Extras\>** tab of the Spectrum/Sonagram Display.

Additionally, the spectrum/sonagram display features a popup menu and keyboard shortcuts. For details see chapter Spectrogram/Sonagram Keyboard Shortcuts.

Parameter	Function
Dropdown Menu Cursor mode	• **2 Cursor mode** 2 independent, moveable cursor will be displayed in the window. • **Harmonic** Several cursor are activated at equidistant intervals. In this mode, the first cursor will move all other cursor. The intervals are defined by grabbing and moving the second or any following cursor. The Harmonic function can only be applied in combination with X-cursor, Y-cursor or Z-cursor. It serves to measure repeating intervals. • **Mirrored** Several cursor are activated at equidistant intervals. Cursor 1 will be on one side and in the middle of the even-numbered equidistant cursor and the odd-numbered equidistant cursor is located on the other side. If you move one cursor (except Cursor 1) all other cursor besides Cursor 1 will move symmetrically. • **Centered** Several cursor are activated at equidistant intervals. In contrast to <**Mirrored**>, all cursor (except Cursor 1) and the cursor which is in the opposite of the first mirrored cursor are moving.
<**Delta**>	The positions of Cursor 1 and Cursor 2 stay the same during changes of the cursor mode or the number of cursor, if this checkbox is not activated, otherwise the positions of the 2 outermost cursor are tried to keep fixed. This allows aconvenient way to have multiple cursor at equidistant intervals in a specific area without the need to adapt the cursor. To cancel the additional cursor, select "2 Cursor" mode.
<**Number**>	Use this spin box to determine the number of cursor to be displayed in Harmonic mode.
<**X-Cursor**>	The cursor are activated/deactivated in X-direction. They are used to measure values of time.
<**Y-Cursor**>	The cursor are activated/deactivated in Y-direction. They are used to measure the values on the Y-Axis (which varies from display to display, i.e. phase, frequency etc.).
<**Cursor 1**>	Coordinates of the first X-, Y- and Z-cursor each
<**Cursor 2**>	Coordinates of the second X-, Y- and Z-cursor each
<**Difference**>	Difference between Cursor 1 and Cursor 2
<**Inv. diff.**>	Inverted difference is a helpful function for direct readout of symbol rate (determination of which is a major purpose of the Z-cursor) according to the formula 1 / [value in box Difference]
<**Delta**>	Gap between the minimum and maximum cursor. In "2 Cursor" mode it is the same as Difference, in all other cases it is Difference times Number - 1.
<**Z-Cursor**>	The cursor are activated in Z-direction. They are used to measure values of time.
<**Cursor 1**>	Coordinates of the first X and Y Cursor each
<**Cursor 2**>	Coordinates of the second X and Y Cursor each
<**Difference**>	Difference between Cursor 1 and Cursor 2

| Parameter	Function
<Inv. diff.>	Inverted difference is a helpful function for direct readout of symbol rate (determination of which is a major purpose of the Z-cursor) according to the formula 1 / [value in box Difference]
<Delta>	Gap between the minimum and maximum cursor. In "2 Cursor" mode it is the same as Difference, in all other cases it is Difference times Number - 1.
<Down>	Sets X-cursor 1, Y-cursor 1 to the next visible maximum on the spectrum line against X-direction, if cursor are activated.
<Up>	Sets X-cursor 1, Y-cursor 1 to the next visible maximum on the spectrum line in X-direction, if cursor are activated.
<Zoom in>	With enabled cursor, the button <**Zoom in**> serves to graphically zoom into the area delimited by the cursor. With disabled cursor, the zoom enlarges the area by factor ½ each time it is activated (X-direction only). Additionally, the user may draw a rectangle in the display window and zoom into this section graphically by means of the button <**Zoom in**>. If the display window has activated cursor, the zoom via rectangle will take priority. After zooming, the rectangle shown as a white dotted line will disappear. Otherwise, simply click any position in the display window to delete the rectangle.
<Zoom out>	Each time the button <**Zoom out**> is activated, the display area is enlarged by factor 2. With disabled cursor, the zoom is exclusively made in X-direction.
<Pause>	In Pause, the display is stopped (not the signal processing). Modification of the parameters is possible for a more detailed analysis of the current signal range.
<Autorange>	Automatic setting of the displayed range to view the total amplitude, frequency and phase range. The display is adapted on every change of the range. On pressing <**Autorange**> again, this process will be deactivated (toggle).
<Peak hold>	By activating <**Peak hold**>, the maximum energies in the spectrum are recorded and displayed as a red curve.

Table 11: Spectrum/Sonagram - Cursor Tab
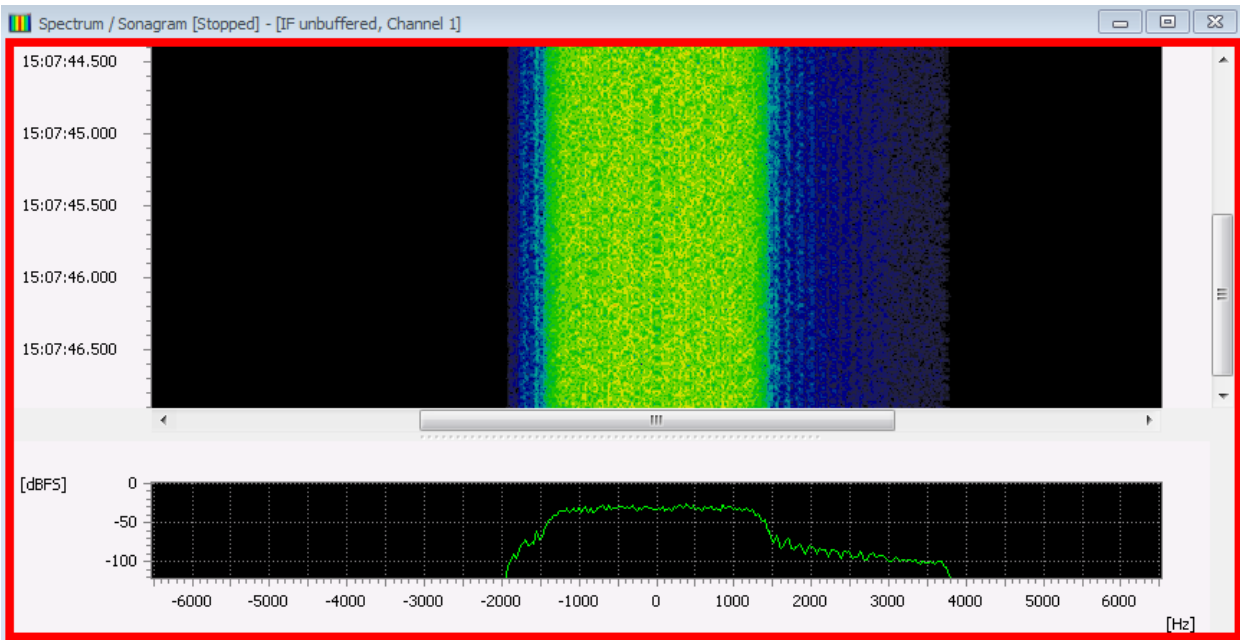
Figure 24: Spectrum/Sonagram - Display Paused

4.5.1.9. Spectrum/Sonagram Extras Settings
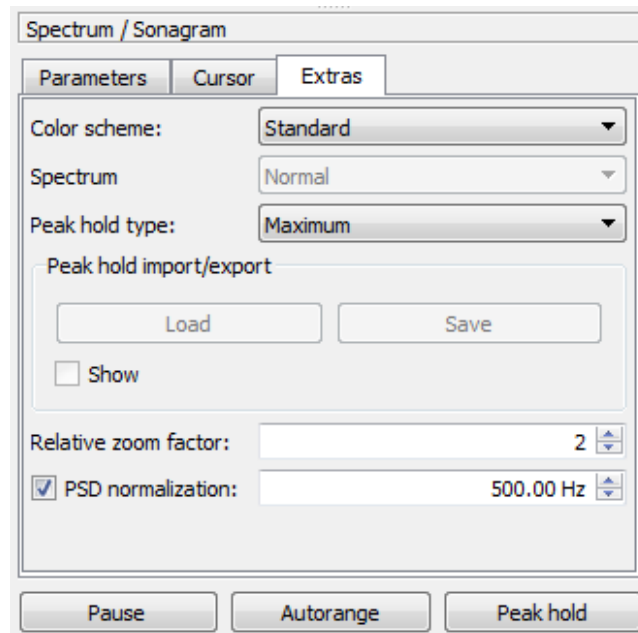

Figure 25: Spectrum/Sonagram - Extras

The <**Extras**> tab features additional options with regard to the display type. The dropdown list box <**Color scheme**> is used to select the color schemes for the displays.

Color Scheme	Foreground Color	Background Color
Standard	light	black
Inverse	dark	white
Monochrome	shades of grey	white

Table 12: Spectrum/Sonagram - Color Schemes

Additionally the <**Extras**> tab has a dropdown list Spectrum, which is inactive unless the Z-cursor are enabled. Specify whether you wish to display

Spectrum	Sector
Normal	exponential averaged spectrum
At Cursor	the spectrum exactly at the position of Cursor 1
Average value Cur.1/2	the averaged spectrum between the two cursor

Table 13: Spectrum/Sonagram - Spectra

The dropdown list <**Peak hold type**> offers the values:

- Maximum

- Minimum

- Average

The group box <**Peak hold import/export**> is used to <**Load**> and <**Save**> peak hold values for accurate comparison. The two functions are inactive unless the buttons <**Pause**> and <**Peak hold**> are selected.

The curves are stored in ".csv" format (Comma Separated Value), which can be processed in Microsoft® Excel or an editor like e.g. Microsoft® WordPad. When loading saved data, then they are inserted in the spectrum display as a yellow line. The check box <**Show**> is not active unless data have been loaded.
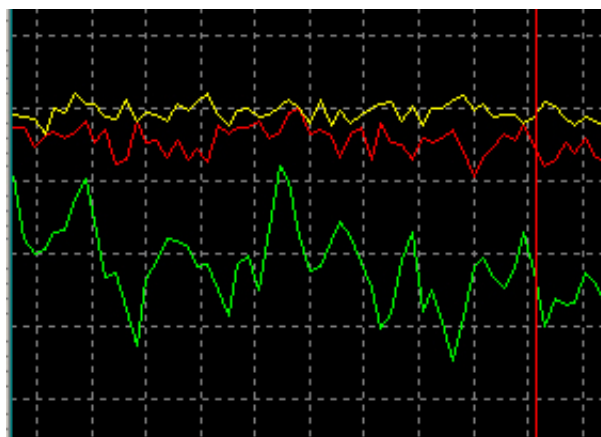
Figure 26: Peak Hold Comparison with a Loaded Curve

Please make sure to display the inserted data using the original or similar FFT length.

With <**Relative zoom factor**> the favored relative zoom factor is set for zooming out and its reciprocal for zooming in. The default value in this spin box is "2".

The <**PSD normalization**> button is described in chapter Power spectrum.

4.5.2. Spectrum

The menu item <**Spectrum**> displays the distribution of the power over a frequency range, just as the spectrum/ sonagram display does.

The frequency and levels can be measured using cursor. In contrast to the spectrum/sonagram display the signal can be squared for additional analysis (PSK modulation order).
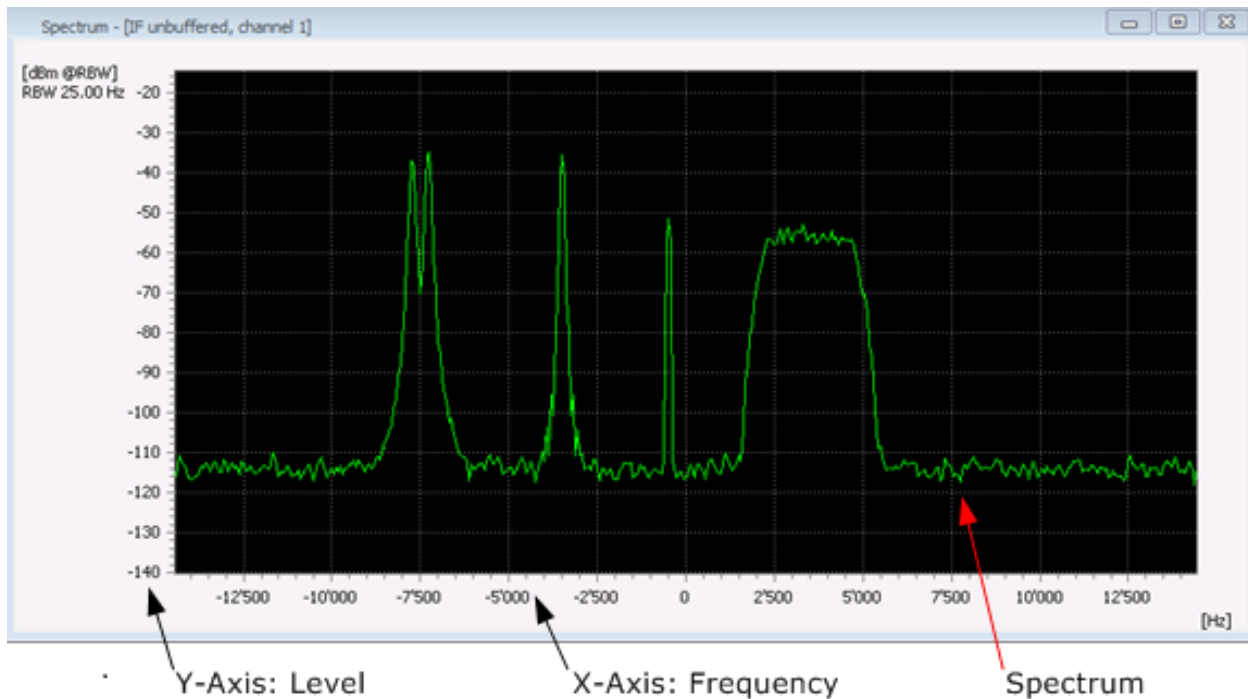

Figure 27: Spectrum

The parameters are edited via the property sheet as with all displays. They are distributed on several tabs.

4.5.2.1. Spectrum Keyboard Shortcuts

The following keyboard shortcuts are available in the Spectrum display:

Group	Parameter	Function
Zoom Functions	<**Ctrl**> + Mouse Wheel	Zoom in/out (no cursor activated)

Group	Parameter	Function
	<+>	Zoom in With enabled cursor, the keyboard shortcut <+> is used to graphically zoom into the area delimited by the cursor. With disabled cursor, the zoom enlarges the area by factor ½ each time it is activated (X-direction only). Additionally, the user may draw a rectangle in the display window and zoom into this section graphically using the shortcut <+>. If cursor are activated, the zoom via rectangle will take priority. After zooming, the rectangle, shown as a white dotted line, will disappear. Otherwise, simply click any position in the display window to remove the rectangle.
	<->	Zoom out Each time the shortcut <-> is activated, the display area is enlarged by factor 2. With disabled cursor the zoom is made in X-direction only.
Cursor	<X>	Activate and deactivate X-cursor (toggle function)
	<Y>	Activate and deactivate Y-cursor (toggle function)
	<H>	Activate and deactivate Harmonic cursor mode (toggle function)
Minimum / Maximum	<J>	Searches the spectrum for the maximum and displays the corresponding X/Y value as a tooltip. With an active X cursor the search range can be restricted. The values are automatically inserted into the clipboard. The tooltip disappears as soon as the key is released.
	<U>	Same as <J>, but searching for the minimum.
	<L>	If the X-Cursor is activated, X-Cursor1 and Y-Cursor1 are set to the next maximum of the spectrum curve against the X-direction. If <**Peak-Hold**> is activated, the maxima on the compressed curve are selected.
	<R>	Same as <L>, but opposite direction.

Table 14: Spectrum Display Control, Keyboard Shortcuts

4.5.2.2. Spectrum Parameter Settings

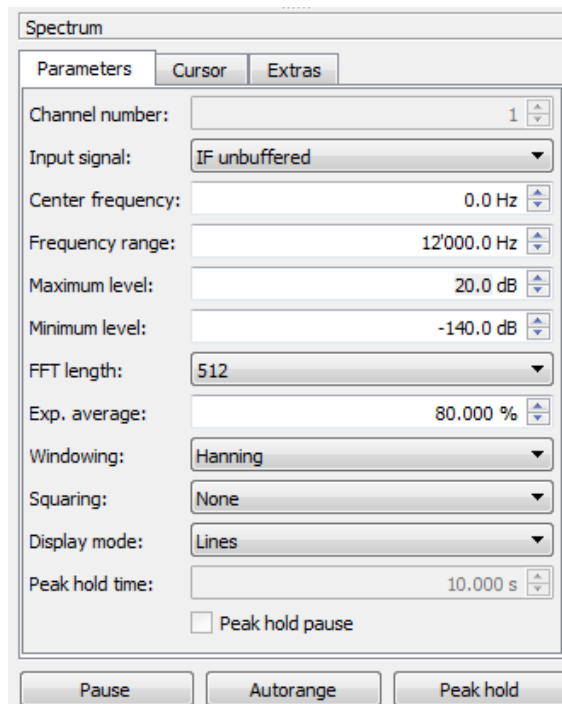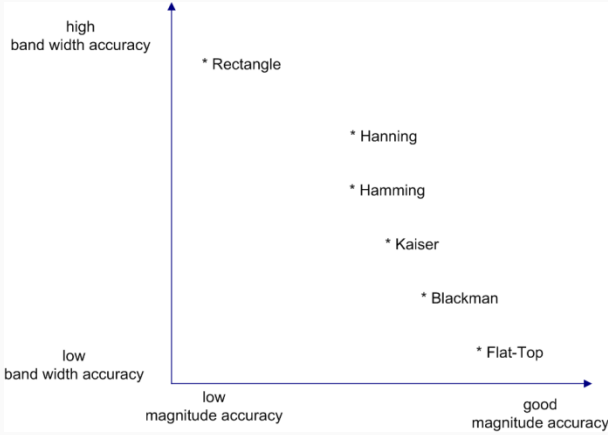The parameters of the spectrum are displayed by activating the <**Parameters**> tab.

Figure 28: Spectrum - Parameters

The following parameters are available:

Parameter	Function
<Channel Number>	There are signals that consist of several signal parts, e.g. the input signal channel in an MFSK2 modem. The channels of such signals are selected as the input signal by their channel number.
<Input signal>	Use this parameter to select the input signal of the display. If the automatic production is active, you can only select the input IF. While setting the parameters of the demodulator, it may occur that a previously selected input signal is no longer available. In this case, the selection *no signal* will be displayed.
<Center frequency>	The frequency section to be viewed is set in combination with the frequency range. The center frequency is the center of the section.
<Frequency range>	The frequency section to be viewed is set in combination with the center frequency. The frequency range is the range within the section. The zoom can thus be set manually.
<Maximum level>	Definition of the level range in the spectrum display. The maximum level is the upper end of the section.
<Minimum level>	Definition of the level range in the spectrum display. The minimum level is the lower end of the section.
<FFT length>	Number of values of frequency in which the signal is displayed. To obtain a higher resolution of the displayed frequency range, increase the FFT length.

Parameter	Function
<Exp. Average>	The spectrum is displayed in average of several spectrums. The result of a change of the spectrum will be a total view of the spectrum.
	0%: No average
	- 80%: Low average
	80% - 99%: High average
	100%: No updating of the spectrum
<Windowing>	The FFT algorithm is used for the calculation of the spectrum. This algorithm, however, shows inaccuracies in the amplitude (attenuation) as well as in the bandwidth (expansion) of a signal due to the finite signal probe. These inaccuracies can be reduced using windowing:
	Figure 29: Accuracies of windowing functions
<Squaring>	Number of squaring operations applied to the time signal. Example: The modulation order (2 /4, 8) of PSK modems can be identified in a single (double, triple) squaring by the formation of a peak in the center of the spectrum. Additionally, the symbol rate of such a modem can be seen by measuring the frequency interval between the main peak and the secondary peak. In this process, the frequency scaling must be taken in consideration, and the measured value must be multiplied by 2 or 4.
<Display mode>	Use this parameter to set the type of the display: Line: the spectrum is displayed as a closed curve. Bar: the individual values are displayed as bars.
<Peak hold time>	When the time adjusted has elapsed, the peak hold (the red curve in the spectrum) will be reset to the current values. 0 means no reset.
<Peak hold pause>	This check box is used to freeze the continuous display after a period specified in the spin box <**Peak hold time**> (The button <**Pause**> is activated and locked). It can only be selected if the button <**Peak hold**> has been activated. This function will not stop the signal flow between the signal processing modules. To reactivate the continuous update of the display, press the button <**Pause**> again (toggle switch).
<Pause>	In Pause, the display is stopped (not the signal processing). Modification of the parameters is possible for a more detailed analysis of the current signal range.

Parameter	Function
\<Autorange\>	Automatic setting of the displayed range to view the total amplitude and frequency range.
\<Peak hold\>	By activating **\<Peak hold\>**, the maximum energies in the spectrum are recorded and displayed as a red curve.

*Table 15: Spectrum - Parameters Tab*

4.5.2.3. Spectrum Cursor Settings

The cursor parameters are displayed by activating the \<**Cursor**\> tab of the respective display. You can thus insert cursor into the display, which serve to select or clarify specific display sections, or measure the signal data. The \<**Cursor**\> tab shows the coordinates of the individual cursor positions in editable spin boxes.
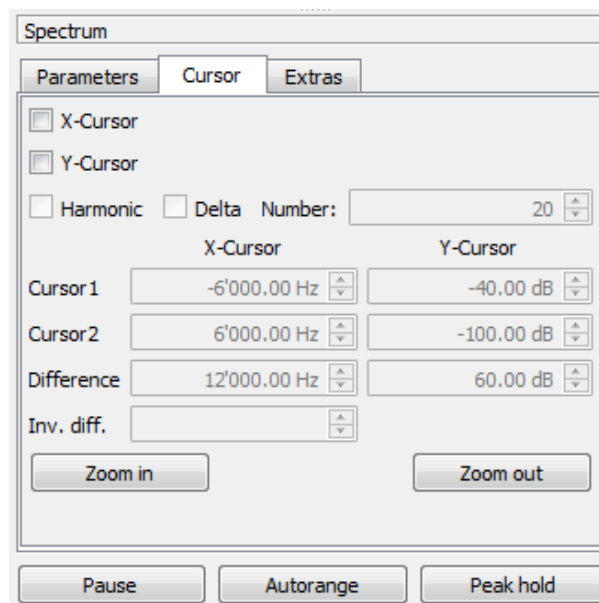
Figure 30: Spectrum - Cursor

The following parameters are available:

Parameter	Function
\<X-Cursor\>	The cursor are activated/deactivated in X-direction. They are used to measure values of time.
\<Y-Cursor\>	The cursor are activated/deactivated in Y-direction. They are used to measure the values on the Y-Axis (which varies from display to display, i.e. phase, frequency etc.).
\<Harmonic\>	Several cursor are activated at equidistant intervals. In this mode, the first cursor will move all other cursor. The intervals are defined by grabbing and moving the second or any following cursor. The Harmonic function can only be applied in combination with X-cursor or Y-cursor. It serves to measure repeating intervals.

Parameter	Function
<Delta>	The positions of Cursor 1 and Cursor 2 stay the same during changes of the cursor mode or the number of cursor, if this checkbox is not activated, otherwise the positions of the 2 outermost cursor are tried to keep fixed. This allows aconvenient way to have multiple cursor at equidistant intervals in a specific area without the need to adapt the cursor. To cancel the additional cursor, deactivate **<Harmonic>**.
<Number>	Use this spin box to determine the number of cursor to be displayed in Harmonic mode.
<Cursor 1>	Coordinates of the first X-, Y- and Z-cursor each
<Cursor 2>	Coordinates of the second X-, Y- and Z-cursor each
<Difference>	Difference between Cursor 1 and Cursor 2
<Inv. diff.>	Inverted difference is a helpful function for direct readout of symbol rate (determination of which is a major purpose of the Z-cursor) according to the formula 1 / [value in box Difference]
<Zoom in>	With enabled cursor, the button **<Zoom in>** serves to graphically zoom into the area delimited by the cursor. With disabled cursor, the zoom enlarges the area by factor ½ each time it is activated (X-direction only). Additionally, the user may draw a rectangle in the display window and zoom into this section graphically by means of the button **<Zoom in>**. If the display window has activated cursor, the zoom via rectangle will take priority. After zooming, the rectangle shown as a white dotted line will disappear. Otherwise, simply click any position in the display window to delete the rectangle.
<Zoom out>	Each time the button **<Zoom out>** is activated, the display area is enlarged by factor 2. With disabled cursor, the zoom is exclusively made in X-direction.
<Pause>	In Pause, the display is stopped (not the signal processing). Modification of the parameters is possible for a more detailed analysis of the current signal range.
<Autorange>	Automatic setting of the displayed range to view the total amplitude, frequency and phase range.
<Peak hold>	By activating **<Peak hold>**, the maximum energies in the spectrum are recorded and displayed as a red curve.

Table 16: Spectrum - Cursor Tab

4.5.2.4. Spectrum Extras Settings
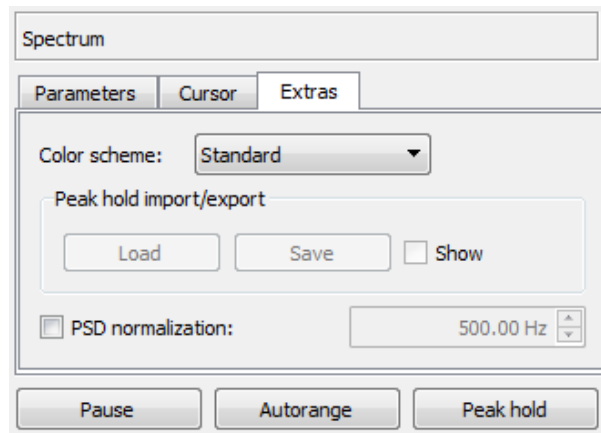
Figure 31: Spectrum - Extras

The <**Extras**> tab features additional options with regard to the display type. The dropdown list box <**Color scheme**> is used to select the color schemes for the displays:

Color Scheme	Foreground Color	Background Color
Standard	light	black
Inverse	dark	white
Monochrome	shades of grey	white

Table 17: Spectrum - Color Schemes

The group box <**Peak hold import/export**> is used to <**Load**> and <**Save**> peak hold values for accurate comparison. The two functions are inactive unless the buttons <**Pause**> and <**Peak hold**> are selected.

The curves are stored in ".csv" format (Comma Separated Value), which can be processed in Microsoft® Excel or an editor like e.g. Microsoft® WordPad. When loading saved data, they are inserted in the spectrum display as a yellow line. The check box <**Show**> is not active unless data have been loaded.

The <**PSD normalization**> button is described in chapter Power spectrum.
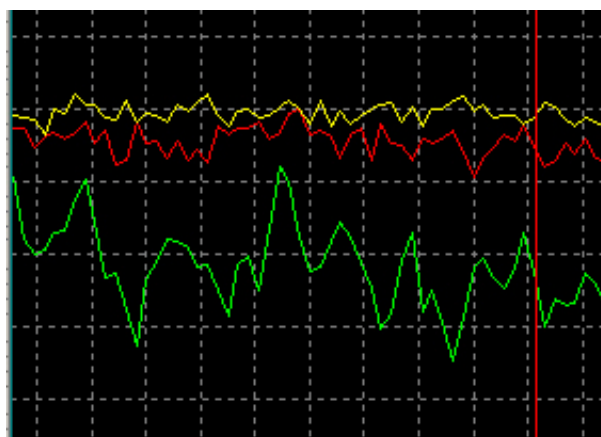
Figure 32: Peak Hold Comparison with a Loaded Curve

Please make sure to display the inserted data using the original or similar FFT length.

Similar to the Spectrum/Sonagram, the unit automatically changes into "dBm" when the preconditions are met.

The power spectrum density with configurable normalization bandwidth is also available.

4.5.3. Autocorrelation Display

The autocorrelation function is an analysis method to find repeating patterns in a signal. With this function, a signal is compared with a time-shifted copy of itself. The result of this function is the rate of similarity between the original and the time-shifted copy.

If a certain pattern is repeated over time, this rate has a peak each time the copy is shifted by the period (or a multiple thereof) of the repetition. The repeated pattern can be a constant sequence of training symbols. Or in case of a multichannel signal (MPSK, OFDM) it is easily possible to determine the channel distance. The autocorrelation is very robust against noise. Thus, it is possible to identify repeating patterns under poor receiving conditions.

The autocorrelation display shows the autocorrelation results of the signal.
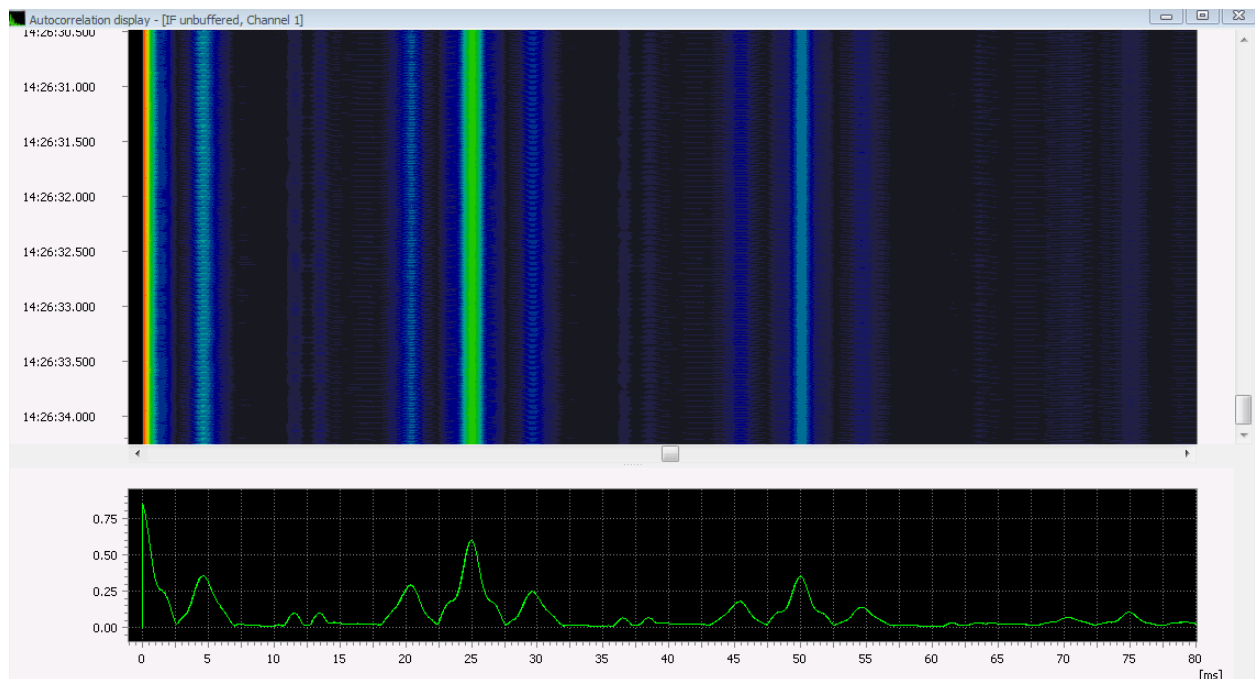
Figure 33: Autocorrelation Display

On the X-Axis the time-shift between the original and its copy is represented, on the Y-Axis the relative rate of similarity.

This rate is 1 if the time-shift is 0, since the original and its copy are the same in this case. In the figure above there are peaks every 25 ms, so there is a periodicity of 40 Hz in this example.

Note: The correlation value of 1 at positon 0 is deliberately hidden since it does not contain any useful information and would disturb the automatic scaling.

4.5.3.1. Autocorrelation Keyboard Shortcuts

The following keyboard shortcuts are available in the autocorrelation display:

Group	Parameter	Function
Scrollbars	Mouse Wheel	Move scrollbar in time direction
	<Shift> + Mouse Wheel	Move scrollbar in X direction
	<Right Arrow>	Move X scrollbar to the right
	<Left Arrow>	Move X scrollbar to the left
	<Up Arrow>	Move time scrollbar up (closer to the start)
	<Down Arrow> >	Move time scrollbar down (closer to the end)
	<Page Up>	Move time scrollbar up one page towards the start
	<Page Down>	Move time scrollbar down one page towards the end
	<Home>	Move time scrollbar up to the start
	<End>	Move time scrollbar down to the end
Zoom Functions	**<Ctrl>** + Mouse Wheel	Zoom in/out (no cursor activated)
	<+>	Zoom in With enabled cursor, the keyboard shortcut <+> is used to graphically zoom into the area delimited by the cursor. With disabled cursor, the zoom enlarges the area by factor ½ each time it is activated (X-direction only). Additionally, the user may draw a rectangle in the display window and zoom into this section graphically using the shortcut <+>. If cursor are activated, the zoom via rectangle will take priority. After zooming, the rectangle, shown as a white dotted line, will disappear. Otherwise, simply click any position in the display window to remove the rectangle.
	<->	Zoom out Each time the shortcut <-> is activated, the display area is enlarged by factor 2. With disabled cursor the zoom is made in X-direction only.
Cursor	<X>	Activate and deactivate X-cursor (toggle function)
	<Y>	Activate and deactivate Y-cursor (toggle function)
	<Z>	Activate and deactivate Z-cursor (toggle function)
	<H>	Activate and deactivate Harmonic cursor mode (toggle function)
	<N>	Activate and deactivate 2 cursor mode (toggle function)
	<M>	Activate and deactivate mirrored cursor mode (toggle function)
	<S>	Activate and deactivate centered cursor mode (toggle function)
Minimum / Maximum	<J>	Searches the autocorrelation for the maximum and displays the corresponding X/Y value as a tooltip. With an active X cursor the search range can be restricted. The values are automatically inserted into the clipboard. The tooltip disappears as soon as the key is released.

Group	Parameter	Function
	<U>	Same as <J>, but searching for the minimum.
	<L>	If the X-Cursor is activated, X-Cursor1 and Y-Cursor1 are set to the next maximum of the autocorrelation curve against the X-direction. If <**Peak-Hold**> is activated, the maxima on the compressed curve are selected.
	<R>	Same as <L>, but opposite direction.

Table 18: Autocorrelation Display Control, Keyboard Shortcuts

4.5.3.2. Autocorrelation Parameter Settings

The parameters of the autocorrelation display can be displayed by activating the <**Parameters**> tab.

Figure 34: Autocorrelation Display - Parameters

The following parameters are available:

Parameter	Function
<**Channel Number**>	There are signals that consist of several signal parts, e.g. the input signal channel in an MFSK2 modem. By using the channel number the channels of such signals can be selected as the input signal.
<**Input signal**>	Use this parameter to select the input signal of the display. If the automatic production is active, you can only select the input IF. While setting the parameters of the demodulator, it may occur that a previously selected input signal is no longer available. In this case, the selection *no signal* will be displayed.
<**Center X**>	Definition of the center of the display in X-direction.
<**Range X**>	Definition of the range of the display in X-direction.
<**Maximum Y**>	Definition of the maximum of the display in Y-direction.
<**Minimum Y**>	Definition of the minimum of the display in Y-direction.
<**Vector length**>	Sets the maximum time-shift for the autocorrelation-function.
<**Exp. Average**>	Sets the autocorrelation averaging factor.

Parameter	Function
\<Windowing\>	Selects the windowing function for the autocorrelation-function. Available window-functions: Hanning Hamming Blackman Blackman Harris Flat Top Kaiser Rectangle
\<Lines / second\>	Sets the number of lines per second in the waterfall part of the autocorrelation display.
\<Display mode\>	Use this parameter to set the type of the display: Line: the autocorrelation is displayed as a closed curve. Bar: the individual values are displayed as bars.
\<Peak hold time\>	Sets the time for which a peak value is displayed.
\<Peak hold pause\>	This check box is used to freeze the continuous display after a period specified in the spin box **\<Peak hold time\>** (The button **\<Pause\>** is activated and locked). It can only be selected if the button **\<Peak hold\>** has been activated. This function will not stop the signal flow between the signal processing modules. To reactivate the continuous update of the display, press the button **\<Pause\>** again (toggle switch).
\<Pause\>	In Pause, the display is stopped (not the signal processing). Modification of the parameters is possible for a more detailed analysis of the current signal range.
\<Autorange\>	Automatic setting of the displayed range to view the total real and imaginary part
\<Peak hold\>	Press this tab to display the peak of the autocorrelation function. The value shown is the maximum over the most recent time-period defined by the peak hold time.

Table 19: Autocorrelation Display - Parameters Tab

4.5.3.3. Autocorrelation Cursor Settings

The cursor parameters are displayed by activating the **\<Cursor\>** tab of the respective display. You can thus insert cursor into the display, which serve to select or clarify specific display sections, or measure the signal data. The **\<Cursor\>** tab shows the coordinates of the individual cursor positions in editable spin boxes.
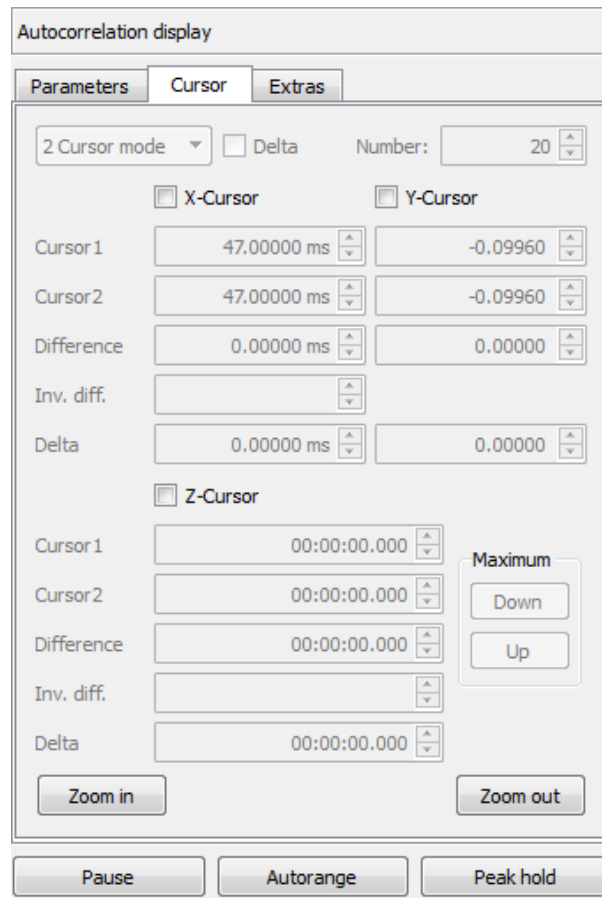
Figure 35: Autocorrelation Display - Cursor
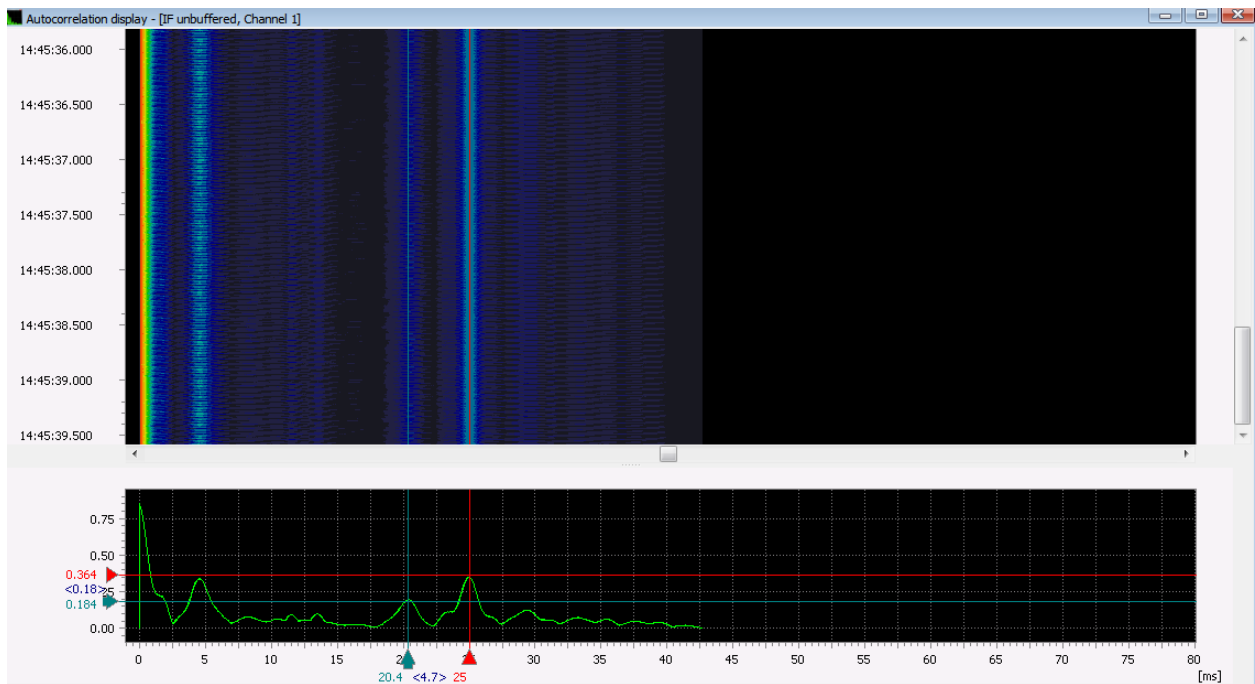
Figure 36: Autocorrelation Display - with 2 Cursor

Parameter	Function
Dropdown Menu Cursor mode	• 2 Cursor mode 2 independent, moveable cursor will be displayed in the window. • Harmonic Several cursor are activated at equidistant intervals. In this mode, the first cursor will move all other cursor. The intervals are defined by grabbing and moving the second or any following cursor. The Harmonic function can only be applied in combination with <**X-Cursor**>, <**Y-Cursor**> or <**Z-Cursor**>. It serves to measure repeating intervals. • Mirrored Several cursor are activated at equidistant intervals. <**Cursor 1**> will be on one side and in the middle of the even-numbered equidistant cursor and the odd-numbered equidistant cursor is located on the other side. If you move one cursor (except Cursor 1) all other cursor besides Cursor 1 will move symmetrically. • Centered Several cursor are activated at equidistant intervals. In contrast to <**Mirrored**>, all cursor (except Cursor 1) and the cursor which is in the opposite of the first mirrored cursor are moving.
<**Delta**>	The positions of <**Cursor 1**> and <**Cursor 2**> stay the same during changes of the cursor mode or the number of cursor, if this checkbox is not activated, otherwise the positions of the 2 outermost cursor are tried to keep fixed. This allows aconvenient way to have multiple cursor at equidistant intervals in a specific area without the need to adapt the cursor. To cancel the additional cursor, select "2 Cursor" mode.
<**Number**>	Use this spin box to set the number of cursor to be displayed in any mode except "2 Cursor" mode.
<**X-Cursor**>	These cursor areactivated/deactivated in X-direction. They are used to measure values of time in the realtime part of the display.
<**Y-Cursor**>	These cursor are activated/deactivated in Y-direction. They are used to measure the values on the Y-Axis (which varies from display to display, i.e. phase, frequency, etc.) in the realtime part of the display.
<**Cursor 1**>	Coordinates of the first X- and Y-Cursor each in the realtime part of the display.
<**Cursor 2**>	Coordinates of the second X- and Y-Cursor each in the realtime part of the display.
<**Difference**>	Difference between <**Cursor 1**> and <**Cursor 2**>
<**Inv. diff.**>	Inverted difference is a helpful function for direct readout of symbol rate (determination of which is a major purpose of the Z-cursor) according to the formula 1 / [value in box Difference]
<**Delta**>	Gap between the minimum and maximum cursor. In "2 Cursor" mode it is the same as Difference, in all other cases it is Difference times Number - 1.
<**Z-Cursor**>	These cursor are activated in Z-direction. They are used to measure values of time in the waterfall part of the display.

Parameter	Function
<Cursor 1>	Signal-timestamp at the first position.
<Cursor 2>	Signal-timestamp at the second position.
<Difference>	Time-difference between **<Cursor 1>** and **<Cursor 2>**
<Inv. diff.>	Inverted difference is a helpful function for direct readout of symbol rate (determination of which is a major purpose of the Z-cursor) according to the formula 1 / [value in box Difference]
<Down>	Sets X-cursor 1, Y-cursor 1 to the next visible maximum on the autocorrelation curve against X-direction, if cursor are activated.
<Up>	Sets X-cursor 1, Y-cursor 1 to the next visible maximum on the autocorrelation curve in X-direction, if cursor are activated.
<Zoom in>	With enabled cursor, the button **<Zoom in>** serves to graphically zoom into the area delimited by the cursor. With disabled cursor, the zoom enlarges the area by factor ½ each time it is activated (X-direction only). Additionally, the user may draw a rectangle in the display window and zoom into this section graphically by means of the button **<Zoom in>**. If the display window has activated cursor, the zoom via rectangle will take priority. After zooming, the rectangle shown as a white dotted line will disappear. Otherwise, simply click any position in the display window to delete the rectangle.
<Zoom out>	Each time the button **<Zoom out>** is activated, the display area is enlarged by factor 2. With disabled cursor, the zoom is exclusively made in X-direction.
<Pause>	In Pause, the display is stopped (but not the signal processing), and the display is framed by a red rectangle. Modification of the parameters is possible for a more detailed analysis of the current signal range.
<Autorange>	Automatic setting of the displayed range to view the total amplitude, frequency and phase range
<Peak hold>	By activating **<Peak hold>**, the maximum energies in the autocorrelation are recorded and displayed as a red curve.

Table 20: Autocorrelation Display - Cursor Tab

4.5.3.4. Autocorrelation Extras Settings
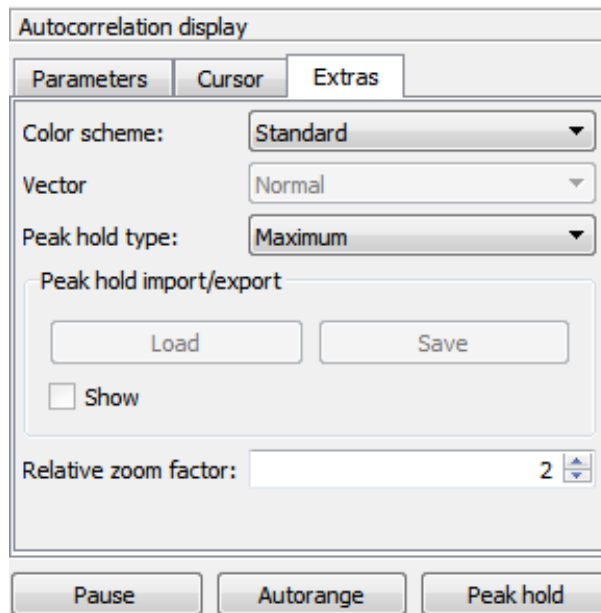
Figure 37: Autocorrelation Display - Extras

The <**Extras**> tab features additional options with regard to the display type. The list box <**Color scheme**> serves to select the color schemes for the displays:

Color Scheme	Foreground Color	Background Color
Standard	light	black
Inverse	dark	white
Monochrome	shades of grey	white

Table 21: Autocorrelation Display - Color Schemes

Additionally the <**Extras**> tab has a dropdown list <**Vector**>, which is inactive unless the Z-cursor are enabled. Specify whether you wish to display:

Vector	Sector
Normal	exponential averaged autocorrelation
At Cursor	the autocorrelation exactly at the position of Cursor 1
Average value Cur.1/2	the averaged autocorrelation between the two cursor

Table 22: Autocorrelation Display - Autocorrelation

The dropdown list <**Peak hold type**> offers the values:

- Maximum

- Minimum

- Average

The group box <**Peak hold import/export**> is used to <**Load**> and <**Save**> peak hold values for accurate comparison. The two functions are inactive unless the buttons <**Pause**> and <**Peak hold**> are selected.

The curves are stored in ".csv" format (Comma Separated Value), which can be processed in Microsoft® Excel or an editor like e.g. Microsoft® WordPad. When loading saved data, then they are inserted in the autocorrelation display as a yellow line. The check box <**Show**> is not active unless data have been loaded.
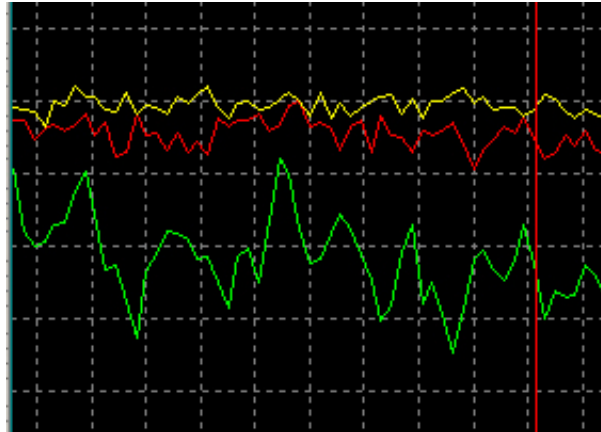
Figure 38: Peak Hold Comparison with a Loaded Curve

Please make sure to display the inserted data using the original or similar FFT length.

With <**Relative zoom factor**> the favored relative zoom factor is set for zooming out and its reciprocal for zooming in. The default value in this spin box is "2".

4.5.4. Constellation Display

The constellation display shows the signal in the complex plane of numbers as a real part (in phase) and an imaginary element (quadrature). Several signal sections can be displayed in a superimposed display.

The display can be operated in the modes absolute or difference phase. These two display types can be displayed in synchronization with the symbol rate which is recovered by the demodulator.
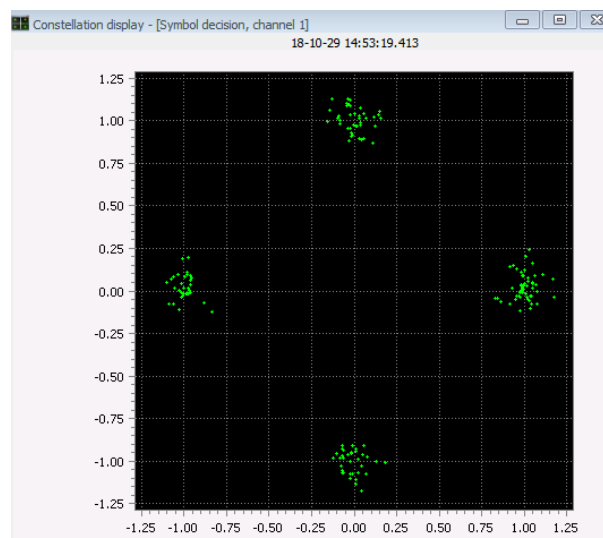
Figure 39: Constellation Display

For the real part, an X-Axis is drawn in the display. The imaginary element is drawn on the Y-Axis.

In mode difference phase, the difference between the phase of the current value and the phase of the previous value is displayed. This eliminates the potential rotation of the signal vector.

In mode absolute SR or difference phase SR, only the values used for symbol decision will be displayed. This way, signal transitions will be deleted. In a correct demodulation (for example PSK4, QAM), the phase star of the current demodulation will be displayed.

4.5.4.1. Constellation Parameter Settings

The parameters of the constellation display can be displayed by activating the <**Parameter**> tab.
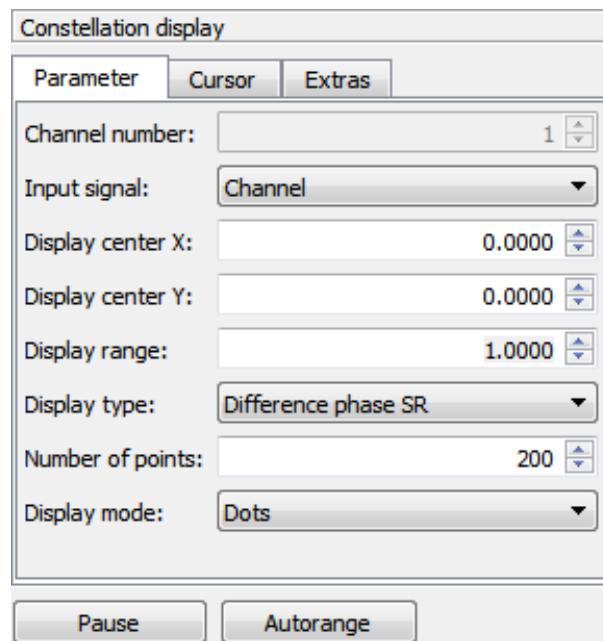
Figure 40: Constellation Display - Parameters

The following parameters are available:

Parameter	Function
<**Channel Number**>	There are signals which consist of several signal parts, e.g. the input signal Channel in an MFSK2 modem. By using the channel number the channels of such sig-nals can be selected as the input signal.
<**Input signal**>	Use this parameter to select the input signal of the display. If the automatic production is active, you can only select the input IF. While setting the parameters of the demodulator, it may occur that a previously selected input signal is no longer available. In this case, the selection *no signal* will be displayed.
<**Display center X**>	Definition of the center of the display in X-direction. The display range of the real part is set in combination with <**Display range**>.
<**Display center Y**>	Definition of the center of the display in Y-direction. The display of the imaginary element is set in combination with <**Display range**>.
<**Display range**>	Definition of the range of the display in X-direction and Y-direction. The display range of the real part is set in combination with <**Display center X**>, and the display range of the imaginary element is set in combination with <**Display center Y**>. The zoom can thus be set manually.

Parameter	Function
<Display type>	Use this parameter to set the type of the display:
	Absolute: Display of the complex signal
	Absolute SR: Display of the complex signal only at the symbol rate time
	Difference phase: As Absolute, but phase as difference
	Difference phase SR: As Absolute but phase as difference and only at the symbol rate time
<Number of points>	Sets the number of signals drawn in superimposed display.
<Display mode>	Use this parameter to set the display mode of the display: Dots: Every value in the complex plane of numbers is displayed as a point. Lines: The individual values are linked and are displayed as a continuous row.
<Pause>	In Pause, the display is stopped (not the signal processing). Modification of the parameters is possible for a more detailed analysis of the current signal range.
<Autorange>	Automatic setting of the displayed range to view the total real and imaginary part

Table 23: Constellation Display - Parameters Tab

4.5.4.2. Constellation Cursor Settings

The cursor parameters are displayed by activating the <**Cursor**> tab of the respective display. You can thus insert cursor into the display, which serve to select or clarify specific display sections, or measure the signal data. The <**Cursor**> tab shows the coordinates of the individual cursor positions in editable spin boxes.
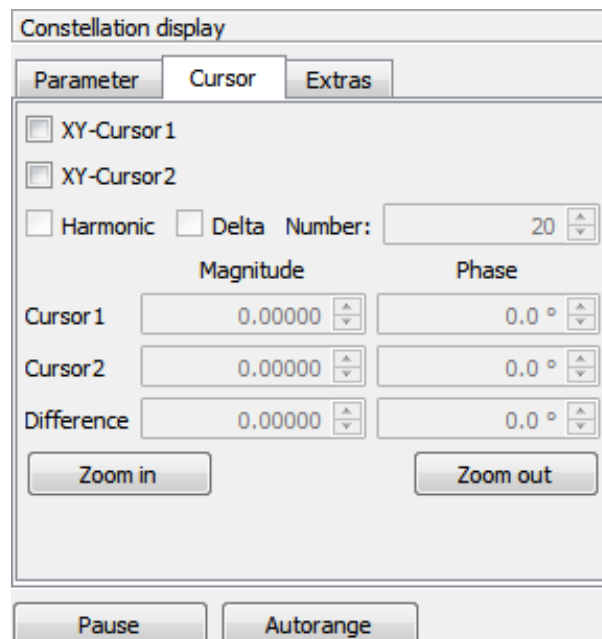

Figure 41: Constellation Display - Cursor

Parameter	Function
<XY-Cursor 1>	The cursor are activated/deactivated in XY-direction. They are used to display the current value in difference of phase.
<XY-Cursor 2>	The cursor are activated/deactivated in XY-direction. They are used to measure the previous value in difference of phase.
<Harmonic>	Several cursor are activated at equidistant intervals. In this mode, the first cursor will move all other cursor. The intervals are defined by grabbing and moving the second or any following cursor. The Harmonic function can only be applied if XY-Cursor 1 and XY-Cursor2 are activated. It serves to measure repeating intervals.
<Delta>	The positions of Cursor 1 and Cursor 2 stay the same during changes of the cursor mode or the number of cursor, if this checkbox is not activated, otherwise the positions of the 2 outermost cursor are tried to keep fixed. This allows a convenient way to have multiple cursor at equidistant intervals in a specific area without the need to adapt the cursor. To cancel the additional cursor, deactivate <**Harmonic**>.
<Number>	Spin box to determine the number of cursor to be displayed in <**Harmonic**> mode.
<Cursor 1>	Coordinates of the first X-, Y- and Z-cursor each
<Cursor 2>	Coordinates of the second X-, Y- and Z-cursor each
<Difference>	Difference between <**Cursor 1**> and <**Cursor 2**>
<Zoom in>	With enabled cursor, the button <**Zoom in**> serves to graphically zoom into the area delimited by the cursor. With disabled cursor, the zoom enlarges the area by factor ½ each time it is activated (X-direction only). Additionally, the user may draw a rectangle in the display window and zoom into this section graphically by means of the button <**Zoom in**>. If the display window has activated cursor, the zoom via rectangle will take priority. After zooming, the rectangle shown as a white dotted line will disappear. Otherwise, simply click any position in the display window to delete the rectangle.
<Zoom out>	Each time the button <**Zoom out**> is activated, the display area is enlarged by factor 2. With disabled cursor, the zoom is exclusively made in X-direction.
<Pause>	In Pause, the display is stopped (but not the signal processing), and the display is framed by a red rectangle. Modification of the parameters is possible for a more detailed analysis of the current signal range.
<Autorange>	Automatic setting of the displayed range to view the total real and imaginary part.

Table 24: Constellation Display - Cursor Tab

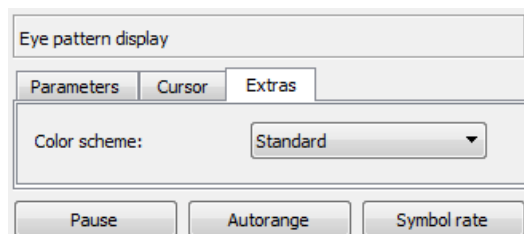### 4.5.4.3. Constellation Extras Settings
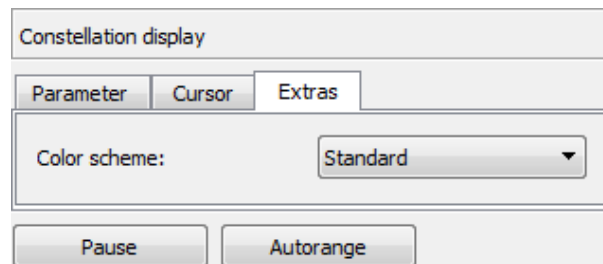
Figure 42: Constellation Display - Extras

The <**Extras**> tab features additional options with regard to the display type. The dropdown list box <**Color scheme**> is used to select the color schemes for the displays:

Color Scheme	Foreground Color	Background Color
Standard	light	black
Inverse	dark	white
Monochrome	shades of grey	white
Persistent	Color intensity depending on data point density	white

Table 25: Constellation Display - Color Schemes

4.5.5. Eye Pattern Display

"In telecommunication, an eye pattern, also known as an eye diagram, is an oscilloscope display in which a digital signal from a receiver is repetitively sampled and applied to the vertical input, while the data rate is used to trigger the horizontal sweep.

It is so called because, for several types of coding, the pattern looks like a series of eyes. It is an experimental tool for the evaluation of the combined effects of channel noise and intersymbol interference on the performance of a baseband pulse-transmission system. It is the synchronized superposition of all possible realizations of the signal of interest viewed within a particular signaling interval.

Several system performance measures can be derived by analyzing the display. If the signals are too long, too short, poorly synchronized with the system clock, too high, too low, too noisy, or too slow to change, or have too much undershoot or overshoot, this can be observed from the eye diagram. An open eye pattern corresponds to minimal signal distortion. Distortion of the signal waveform due to intersymbol interference and noise appears as closure of the eye pattern" [1]

As shown in Figure 43, several signal sections can superimpose in one display.

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[1] "Eye pattern". In: Wikipedia, The Free Encyclopedia. Date of last revision: 23 April 2019. Date retrieved: 15 August 2019. https://de.wikipedia.org/w/index.php?title=Schlumpf&oldid=186910315
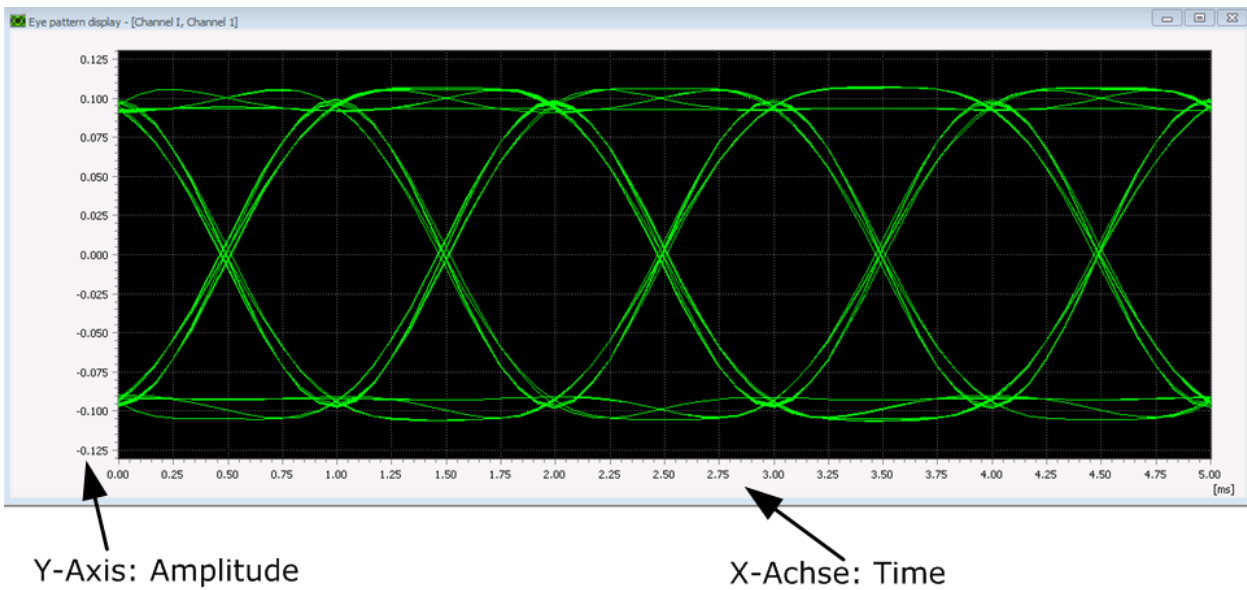
Figure 43: Eye Pattern Display

The display shows the time on the X-Axis. The time 0 is the start of the signal section. Depending on the input signal selected either the amplitude, the phase (°) or the frequency (Hz) will be displayed on the Y-Axis.

The eye pattern display provides an overview of the course of the signal during the time curve, and serves to monitor the signal symbol rate which is reconstructed by the demodulator. The values of time, amplitude, phase and frequency can be measured using cursor.

4.5.5.1. Eye Pattern Parameter Settings

The parameters of the eye pattern display can be displayed by activating the <**Parameters**> tab.
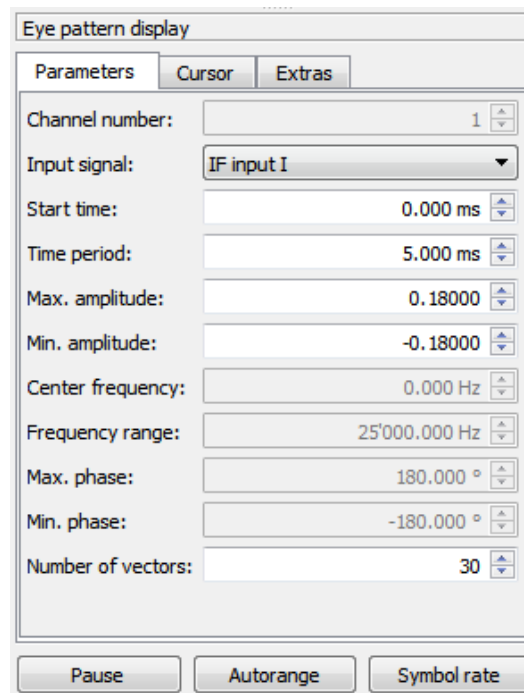
Figure 44: Eye Pattern Display - Parameters

The following parameters are available:

Parameter	Function
<Channel Number>	There are signals that consist of several signal parts, e.g. the input signal channel in an MFSK2 modem. By using the channel number the channels of such signals can be selected as the input signal.
<Input signal>	Use this parameter to select the input signal of the display. If the automatic production is active, you can only select the input IF. While setting the parameters of the demodulator, it may occur that a previously selected input signal is no longer available. In this case, the selection *no signal* will be displayed.
<Start time>	The period of time to be viewed is set in combination with the time period.
<Time period>	The period of time to be viewed is set in combination with the start time. A zoom thus can be set manually. See parameters **<Zoom in>** and **<Zoom out>** in Eye Pattern Cursor Settings.
<Max. amplitude>	Definition of the amplitude range of the eye pattern display. The maximum amplitude is the upper end of the section. This parameter is not available if Freq., Freq. filtered or Phase has been selected as the input signal.
<Min. amplitude>	Definition of the amplitude range of the eye pattern display. The minimum amplitude is the lower end of the section. This parameter is not available if Freq., Filtered Frequency or Phase has been selected as the input signal.
<Center frequency>	The frequency section to be viewed is set in combination with the frequency range. The center frequency is the center of the section. This parameter is not available unless Freq., Filtered Frequency or Phase has been selected as the input signal.

Parameter	Function
<Frequency range>	The frequency section to be viewed is set in combination with the center frequency. The frequency range is the range within the section. The zoom can thus be set manually. This parameter is not available unless Freq., Filtered Frequency or Phase has been selected as the input signal.
<Max. phase>	Definition of the phase range of the eye pattern display. The maximum phase is the upper end of the section. This parameter is not available unless Phase has been selected as the input signal.
<Min. phase>	Definition of the phase range of the eye pattern display. The minimum phase is the lower end of the section. This parameter is not available unless Phase has been selected as the input signal.
<Number of vectors>	Sets the number of signals which are drawn one above the other. With this option, you can adjust the superimposing of the signal vectors.
<Pause>	In Pause, the display is stopped (not the signal processing). Modification of the parameters is possible for a more detailed analysis of the current signal range.
<Autorange>	Automatic setting of the displayed range to view the total amplitude, frequency or phase range.
<Symbol rate>	Switch the display of the symbol rate pins in the eye pattern display on and off (toggle function) by using this parameter.

Table 26: Eye Pattern Display - Parameters Tab

4.5.5.2. Eye Pattern Cursor Settings

The cursor parameters are displayed by activating the <**Cursor**> tab of the respective display. You can thus insert cursor into the display, which serve to select or clarify specific display sections, or measure the signal data. The <**Cursor**> tab shows the coordinates of the individual cursor positions in editable spin boxes.
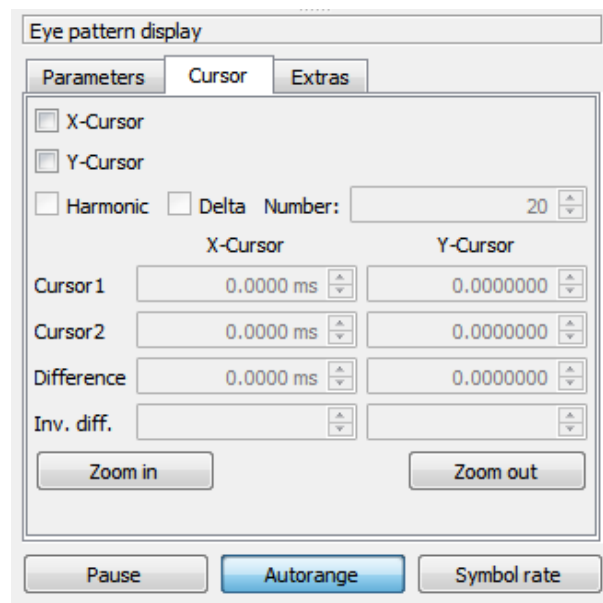
Figure 45: Eye Pattern Display - Cursor

The following parameters are available:

Parameter	Function
<X-Cursor>	The cursor are activated/deactivated in X-direction. They are used to measure values of time.
<Y-Cursor>	The cursor are activated/deactivated in Y-direction. They are used to measure the values on the Y-Axis (which varies from display to display, i.e. phase, frequency, etc.).
<Harmonic>	Several cursor are activated at equidistant intervals. In this mode, the first cursor will move all other cursor. The intervals are defined by grabbing and moving the second or any following cursor. The Harmonic function can only be applied in combination with X-cursor or Y-cursor. It serves to measure repeating intervals.
<Delta>	The positions of Cursor 1 and Cursor 2 stay the same during changes of the cursor mode or the number of cursor, if this checkbox is not activated, otherwise the positions of the 2 outermost cursor are tried to keep fixed. This allows a convenient way to have multiple cursor at equidistant intervals in a specific area without the need to adapt the cursor. To cancel the additional cursor, deactivate **<Harmonic>**.
<Number>	Use this spin box to determine the number of cursor to be displayed in Harmonic mode.
<Cursor 1>	Coordinates of the first X-, Y- and Z-cursor each
<Cursor 2>	Coordinates of the second X-, Y- and Z-cursor each
<Difference>	Difference between **<Cursor 1>** and **<Cursor 2>**
<Inv. diff.>	Inverted difference is a helpful function for direct readout of symbol rate (determination of which is a major purpose of the Z-cursor) according to the formula 1 / [value in box Difference]

Parameter	Function
<Zoom in>	With enabled cursor, the button <Zoom in> serves to graphically zoom into the area delimited by the cursor. With disabled cursor, the zoom enlarges the area by factor ½ each time it is activated (X-direction only). Additionally, the user may draw a rectangle in the display window and zoom into this section graphically by means of the button <Zoom in>. If the display window has activated cursor, the zoom via rectangle will take priority. After zooming, the rectangle shown as a white dotted line will disappear. Otherwise, simply click any position in the display window to delete the rectangle.
<Zoom out>	Each time the button <Zoom out> is activated, the display area is enlarged by factor 2. With disabled cursor, the zoom is exclusively made in X-direction.
<Pause>	In Pause, the display is stopped (not the signal processing). Modification of the parameters is possible for a more detailed analysis of the current signal range.
<Autorange>	Automatic setting of the displayed range to view the total amplitude, frequency and phase range.
<Symbol rate>	Switch the display of the symbol rate pins in the eye pattern display on and off (toggle function) by use of this parameter.

Table 27: Eye Pattern Display - Cursor Tab

4.5.5.3. Eye Pattern Extras Settings

Figure 46: Eye Pattern Display - Extras

The <**Extras**> tab features additional options with regard to the display type. The dropdown list box <**Color scheme**> is used to select the color schemes for the displays:

Color Scheme	Foreground Color	Background Color
Standard	light	black
Inverse	dark	white
Monochrome	shades of grey	white

Table 28: Eye Pattern Display - Color Schemes

4.5.6. Time Display

The time display shows the signal in the time domain, i.e. it serves as an oscilloscope.
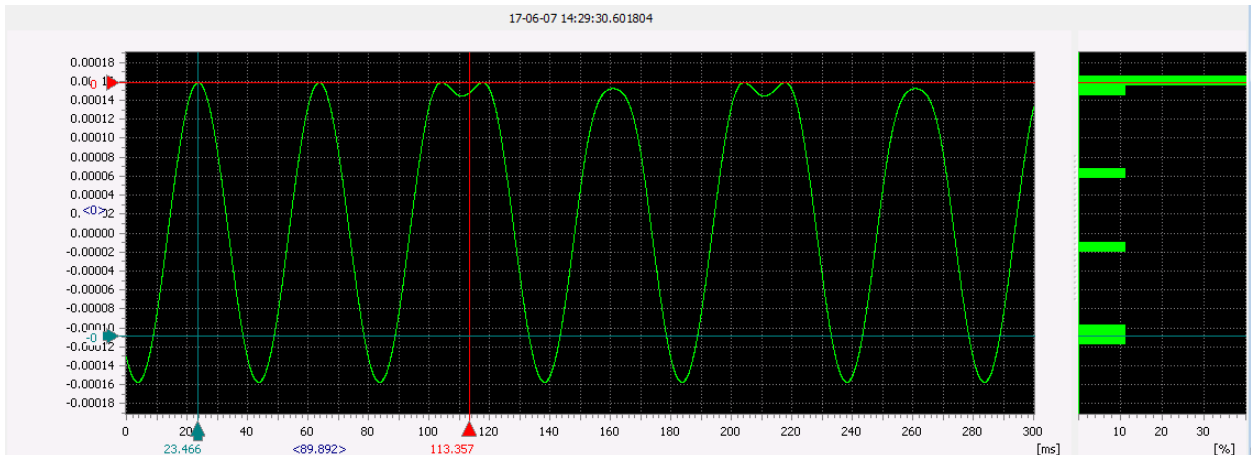
Figure 47: Time Display

This display is divided into two parts. In the left part the time evolution of the signal is displayed. The X-Axis of the display shows the time difference to the absolute time displayed in the top of the view.

In the right part accumulations of signal values are displayed in histograms. The signal values displayed in the left part are sorted into histograms with 40 equidistant bins and normalized to 100%. If harmonic time cursor and pause is active, the signal values are taken at the positions of the time cursor to build the histograms. The histograms can visualize accumulations of signal values better than the time displays.

The area used for time or histogram displays can be adjusted by a splitter in the middle.

4.5.6.1. Time Display Parameter Settings

The parameters of the time display can be displayed by activating the <**Parameters**> tab.
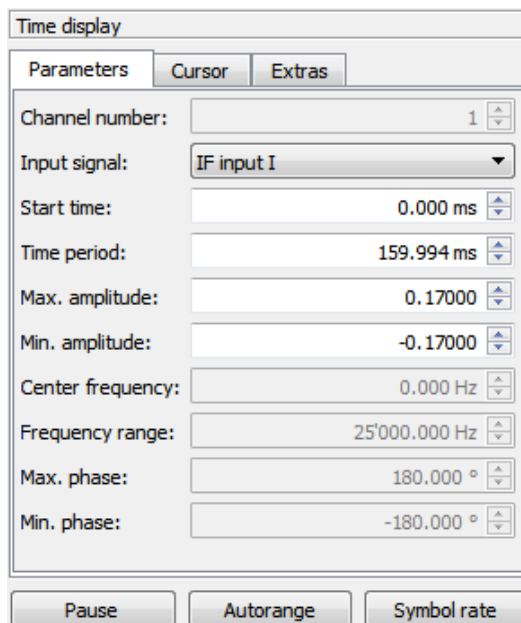
Figure 48: Time Display - Parameters

The following parameters are available:

Parameter	Function
<Channel Number>	There are signals that consist of several signal parts, e.g. the input signal channel in an MFSK2 modem. By using <**Channel number**> the channels of such signals can be selected as the input signal.
<Input signal>	Use this parameter to select the input signal of the display. If the automatic production is active, you can only select IF input. While setting the parameters of the demodulator, it may occur that a previously selected input signal is no longer available. In this case, the item no signal will be displayed.
<Start time>	Definition of the start time.
<Time period>	Definition of the range of the display in the time-domain.
<Max. amplitude>	Definition of the maximum displayed signal amplitude.
<Min. amplitude>	Definition of the minimum displayed signal amplitude.
<Pause>	In Pause, the display is stopped (not signal processing). Modification of the parameters is possible for a more detailed analysis of the current signal range.
<Autorange>	Automatic setting of the displayed range to view the total amplitude, frequency or phase range.
<Symbol rate>	Switch the display of the symbol rate pins in the eye pattern display on and off (toggle function) by using this parameter.

Table 29: Time Display - Parameters Tab

4.5.6.2. Time Display Cursor Settings

The cursor parameters are displayed by activating the <**Cursor**> tab of the respective display. You can thus insert cursor into the display, which serve to select or clarify specific display sections, or measure the signal data. The <**Cursor**> tab shows the coordinates of the individual cursor positions in editable spin boxes.
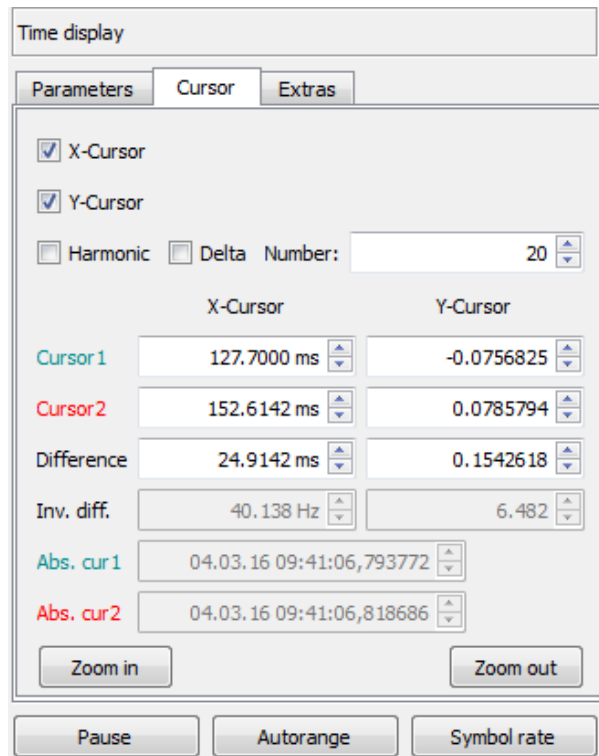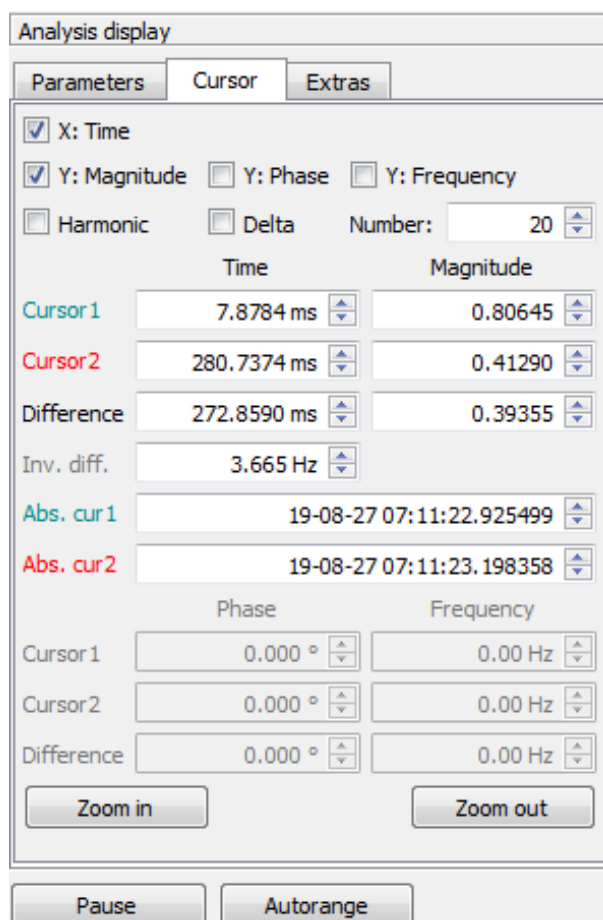
Figure 49: Time Display - Cursor

Parameter	Function
<X-Cursor>	The cursor are activated/deactivated in X-direction. They are used to measure values of time.
<Y-Cursor>	The cursor are activated/deactivated in Y-direction. They are used to measure the values on the Y-Axis (which varies from display to display, i.e. phase, frequency, etc.).
<Harmonic>	Several cursor are activated at equidistant intervals. In this mode, the first cursor will move all other cursor. The intervals are defined by grabbing and moving the second or any following cursor. The Harmonic function can only be applied in combination with X-cursor or Y-cursor. It serves to measure repeating intervals.
<Delta>	The positions of Cursor 1 and Cursor 2 stay the same during changes of the cursor mode or the number of cursor, if this checkbox is not activated, otherwise the positions of the 2 outermost cursor are tried to keep fixed. This allows a convenient way to have multiple cursor at equidistant intervals in a specific area without the need to adapt the cursor. To cancel the additional cursor, deactivate **<Harmonic>**.
<Number>	Use this spin box to set the number of cursor to be displayed if **<Harmonic>** is activated.
<Cursor 1>	Coordinates of the first X- and Y-Cursor each.
<Cursor 2>	Coordinates of the second X- and Y-Cursor each.
<Difference>	Difference between **<Cursor 1>** and **<Cursor 2>**
<Inv. diff.>	Inverted difference is a helpful function for direct readout of symbol rate (determination of which is a major purpose of the Z-cursor) according to the formula: 1 / [value in box Difference]

Parameter	Function
\<Abs. cur1\>	Absolute time of the first **\<X-Cursor\>**.
\<Abs. cur2\>	Absolute time of the second **\<X-Cursor\>**.
\<Zoom in\>	With enabled cursor, the button **\<Zoom in\>** serves to graphically zoom into the area delimited by the cursor. With disabled cursor, the zoom enlarges the area by factor ½ each time it is activated (X-direction only). Additionally, the user may draw a rectangle in the display window and zoom into this section graphically by means of the button **\<Zoom in\>**. If the display window has activated cursor, the zoom via rectangle will take priority. After zooming, the rectangle shown as a white dotted line will disappear. Otherwise, simply click any position in the display window to delete the rectangle.
\<Zoom out\>	Each time the button **\<Zoom out\>** is activated, the display area is enlarged by factor 2. With disabled cursor, the zoom is exclusively made in X-direction.
\<Pause\>	In Pause, the display is stopped (but not the signal processing), and the display is framed by a red rectangle. Modification of the parameters is possible for a more detailed analysis of the current signal range.
\<Autorange\>	Automatic setting of the displayed range to view the total amplitude, frequency and phase range
\<Symbol rate\>	Switch the display of the symbol rate pins in the eye pattern display on and off (toggle function) by use of this parameter.

Table 30: Time Display - Cursor Tab

4.5.6.3. Time Display Extras Settings
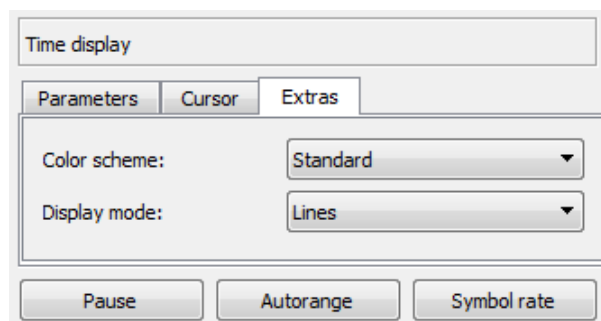
Figure 50: Time Display - Extras

The **\<Extras\>** tab features additional options with regard to the display type. The dropdown list box **\<Color scheme\>** is used to select the color schemes for the displays:

Color Scheme	Foreground Color	Background Color
Standard	light	black
Inverse	dark	white
Monochrome	shades of grey	white

Table 31: Time Display - Color Schemes

Additionally the <**Extras**> tab has the drop-down list <**Display mode**> with offers the values:

Display mode	Display
Lines	The signal values are linked and are displayed as a continuous line
Dots	Every signal value is displayed as a point

Table 32: Time Display - Display modes

4.5.7. Analysis Display

In contrast to the other display types, the analysis display does not depend on the availability of a demodulator. You can apply a filter to select the signal (parameters <**Filter center**> and <**Filter bandwidth**>) and displays the curves of the three most important characteristics over the specified period of time:

- amplitude (magnitude)

- phase

- and frequency

Depending on the modulation type, there are characteristic signal curves.
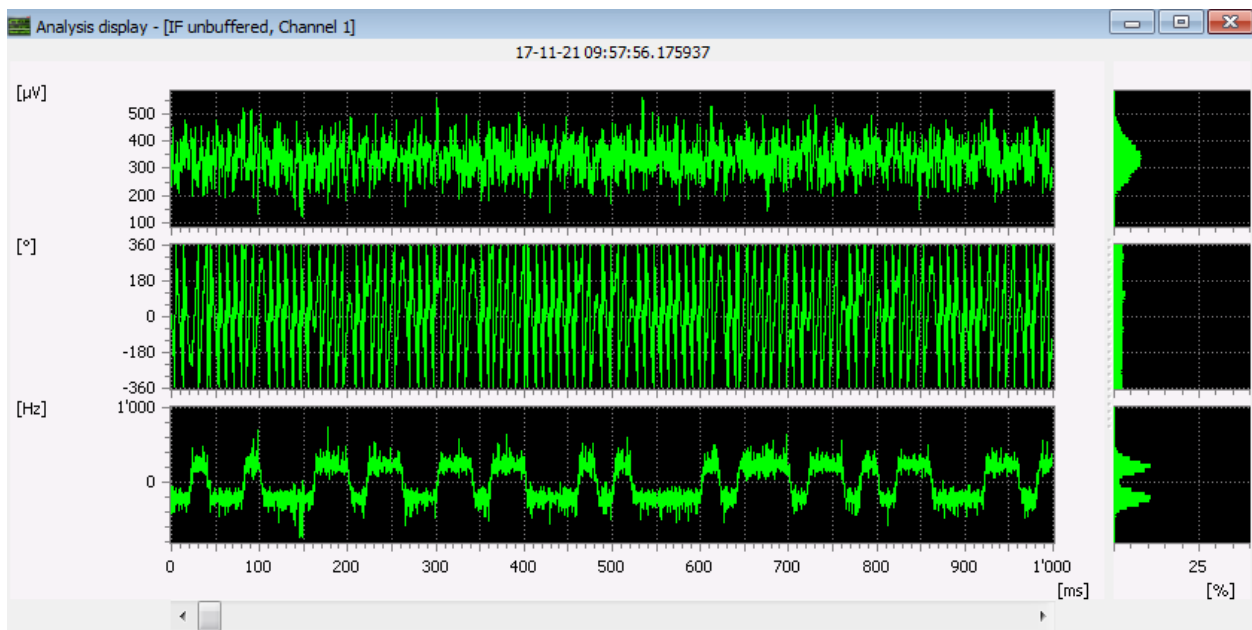
Figure 51: Analysis display of a frequency modulated (FSK) signal
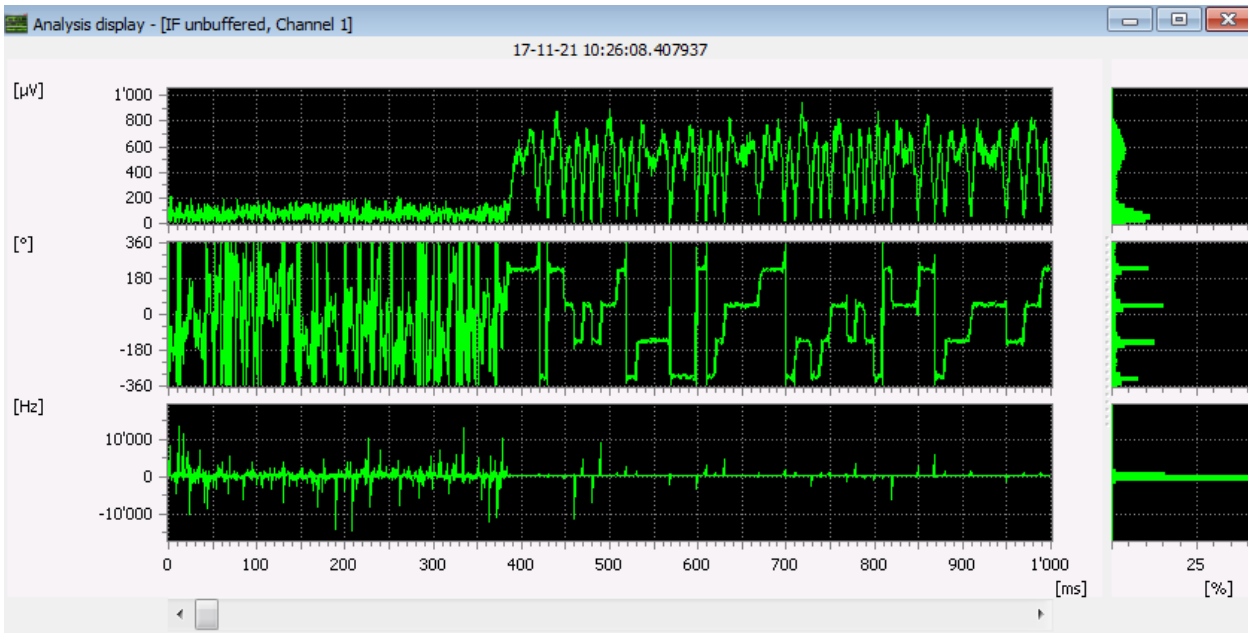
Figure 52: Analysis display of a phase modulated (PSK) signal

This display is divided into six parts.

On the left side the time evolution of the signal is displayed:

- The left upper part displays the curve of the level (amplitude) of the signal.

- The left central part displays the phase of the signal.

- The left lower part displays the frequency of the signal.

The left X-Axis of the display is the time difference to the absolute time displayed at the top.

On the right side accumulations of the signal values (on their left) are displayed in histograms.

The signal values displayed in the left part are sorted into histograms with 40 equidistant bins and normalized to 100%. If harmonic time cursor and pause is active, the signal values are taken at the positions of the time cursor to build the histograms. The histograms can visualize accumulations of signal values better than the time displays and help to discover the used signal modulation i.e. FSK, PSK, ASK.

The area used for time or histogram displays can be adjusted by a splitter in the middle.

4.5.7.1. Analysis Display Keyboard Shortcuts

The following keyboard shortcuts are available in the analysis display:

Group	Parameter	Function
Zoom Functions	\<Ctrl\> + Mouse Wheel	Zoom in/out (no cursor activated) in time domain
	\<Shift\> + Mouse Wheel	Zoom in/out (no cursor activated) in Y domain of specific display (magnitude, phase, frequency)

Group	Parameter	Function
	<+>	**<Zoom in>** With enabled cursor, the keyboard shortcut <+> is used to graphically zoom into the area delimited by the cursor. With disabled cursor, the zoom enlarges the area by factor ½ each time it is activated (X-direction only). Additionally, the user may draw a rectangle in the display window and zoom into this section graphically using the shortcut <+>. If cursor are activated, the zoom via rectangle will take priority. After zooming, the rectangle, shown as a white dotted line, will disappear. Otherwise, simply click any position in the display window to remove the rectangle.
	<->	**<Zoom out>** Each time the shortcut <-> is activated ,the display area is enlarged by factor 2. With disabled cursor the zoom is made in X-direction only.
Cursor	<X>	Activate and deactivate X/ time-cursor (toggle function)
	<Y>	Activate and deactivate Y/ magnitude-cursor (toggle function)
	<P>	Activate and deactivate Y / phase-cursor (toggle function)
	<F>	Activate and deactivate Y / frequency-cursor (toggle function)
	<H>	Activate and deactivate <**Harmonic**> mode (toggle function)

Table 33: Analysis Display Control, Keyboard Shortcuts

4.5.7.2. Analysis Parameter Settings

The parameters of the analysis display are shown on the <**Parameter**> tab.
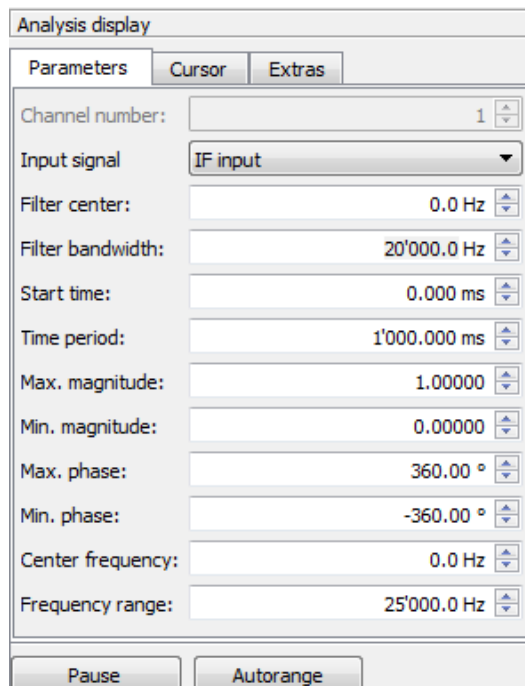
Figure 53: Analysis Display - Parameter

The following parameters are available:

Parameter	Function
<Channel number>	There are signals which consist of several signal parts, e.g. the input signal Channel in an MFSK2 modem. By using the channel number the channels of such signals can be selected as the input signal.
<Input signal>	Use this parameter to select the input signal of the display. If the automatic production is active, you can only select IF input.
<Filter center>	Definition of the center frequency of the filter. The filter range, i.e. the signal section to be analyzed, is set in combination with the filter bandwidth.
<Filter bandwidth>	Definition of the bandwidth of the filter. The filter range, i.e. the signal section to be analyzed, is set in combination with the filter center.
<Start time>	The period of time to be viewed is set in combination with the time period. The start time can also be set via the scroll bar under the time axis.
<Time period >	The period of time to be viewed is set in combination with the start time. A zoom thus can be set manually.
<Max. magnitude>	Definition of the magnitude range of the analysis display. The maximum magnitude is the upper end of the section.
<Min. magnitude>	Definition of the magnitude range of the analysis display. The minimum magnitude is the lower end of the section.
<Max. phase>	Definition of the phase range of the analysis display. The maximum phase is the upper end of the section.
<Min. phase>	Definition of the phase range of the analysis display. The minimum phase is the lower end of the section.
<Center frequency>	The center frequency is the center of the section.
<Frequency range>	The frequency range is the range within the section. The zoom can thus be set manually.
<Pause>	In Pause, the display is stopped (not the signal processing). Modification of the parameters is possible for a more detailed analysis of the current signal range.
<Autorange>	Automatic setting of the displayed range to view the total amplitude, frequency and phase range

Table 34: Analysis Display - Parameters Tab

4.5.7.3. Analysis Cursor Settings

The <**Cursor**> tab of the Analysis Display provides separate check boxes and spin boxes to activate and adjust the Y-cursor in the magnitude, phase, and frequency plots <**Y: Magnitude**>, <**Y: Phase**> and <**Y: Frequency**>) along with a check box for X-cursor through all plots (<**X: Time**>).

The cursor parameters are displayed by activating <**Cursor**> of the respective display. You can thus insert cursor into the display, which serve to select or clarify specific display sections, or measure the signal data. <**Cursor**> shows the coordinates of the individual cursor positions in editable spin boxes.

Figure 54: Analysis Display - Cursor

Parameter	Function
\<X: Time\>	The cursor are activated/deactivated in X-direction. They are used to measure values of time.
\<Y: Magnitude\>	The cursor are activated/deactivated in Y-direction. They are used to measure the values on the Y-Axis (which varies from display to display, i.e. magnitude, phase, frequency etc.).
\<Y: Phase\>	The cursor are activated in Y-direction. They are used to measure the phase
\<Y: Frequency\>	The cursor are activated/deactivated in Y-direction. They are used to measure the values of frequency on the Y-Axis (which varies from display to display, i.e. magnitude, phase, frequency, etc.).
\<Harmonic\>	Several cursor are activated at equidistant intervals. In this mode, the first cursor will move all other cursor. The intervals are defined by grabbing and moving the second or any following cursor. The Harmonic function can only be applied in combination with X-cursor or Y-cursor. It serves to measure repeating intervals.
\<Delta\>	The positions of Cursor 1 and Cursor 2 stay the same during changes of the cursor mode or the number of cursor, if this checkbox is not activated, otherwise the positions of the 2 outermost cursor are tried to keep fixed. This allows a convenient way to have multiple cursor at equidistant intervals in a specific area without the need to adapt the cursor. To cancel the additional cursor, deactivate **\<Harmonic\>**.

Parameter	Function
\<Number\>	Use this spin box to determine the number of cursor to be displayed in Harmonic mode.
\<Cursor 1\>	Value of the first Time, Magnitude, Phase and Frequency cursor, respectively
\<Cursor 2\>	Value of the second Time, Magnitude, Phase and Frequency cursor, respectively
\<Difference\>	Difference between Cursor 1 and Cursor 2
\<Inv. diff.\>	Inverse value of the difference (only for Time axis)
\<Abs. cur1\>	Absolute time of the first Time Cursor.
\<Abs. cur2\>	Absolute time of the second Time Cursor.
\<Zoom in\>	With enabled cursor, the button **\<Zoom in\>** serves to graphically zoom into the area delimited by the cursor. With disabled cursor, the zoom enlarges the area by factor ½ each time it is activated (X-direction only). Additionally, the user may draw a rectangle in the display window and zoom into this section graphically by means of the button **\<Zoom in\>**. If the display window has activated cursor, the zoom via rectangle will take priority. After zooming, the rectangle shown as a white dotted line will disappear. Otherwise, simply click any position in the display window to delete the rectangle.
\<Zoom out\>	Each time the button **\<Zoom out\>** is activated, the display area is enlarged by factor 2. With disabled cursor, the zoom is exclusively made in X-direction.
\<Pause\>	In Pause, the display is stopped (not the signal processing). Modification of the parameters is possible for a more detailed analysis of the current signal range.
\<Autorange\>	Automatic setting of the displayed range to view the total amplitude, frequency and phase range.

Table 35: Analysis Display - Cursor Tab

4.5.7.4. Analysis Extras Settings
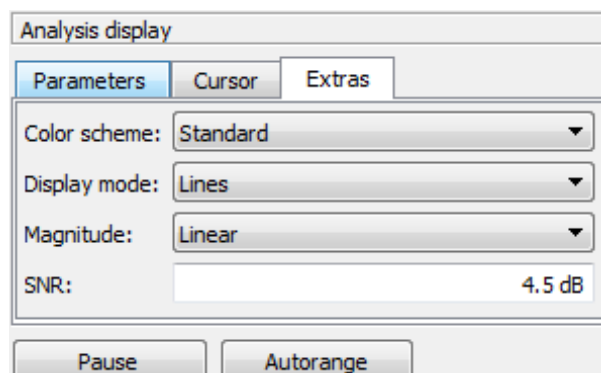
Figure 55: Analysis Display - Extras

The **\<Extras\>** tab features additional options with regard to the display type.

	Parameter	Action
<Color scheme>	Standard	Foreground light, background black
	Inverse	Foreground dark, background white
	Monochrome	Foreground shades of grey, background white
<Display mode>	Lines	The values are linked and are displayed as a continuous line
	Dots	Every value is displayed as a point
<Magnitude>	Linear	Display magnitude with linear scaling
	Logarithmic	Display magnitude with logarithmic scaling • in dB, without reference level • in μV, when reference level available
	Logarithmic power	Display with logarithmic scaling in dBm, when reference level is available
	Logarithmic current	Display with logarithmic scaling in dBμV, when reference level is available
<SNR>		Calculated SNR for the Y / magnitude cursor

Table 36: Analysis Display - Color Schemes

4.5.7.5. Power and SNR measurements

The SNR value is calculated and shown when the Y / magnitude cursor are active.

The larger cursor value is interpreted as the total power level (signal power S + noise power N). The smaller cursor value is interpreted as the noise power level N. There is no automatic determination of the noise floor.

The SNR is calculated with formula S / N.

To ensure valid measurement results when using the cursor, the correct parameterization of filter center and filter bandwidth is required.

There are 2 support functions in the context menu of the magnitude view, when X / time cursor are active (see Figure 56):
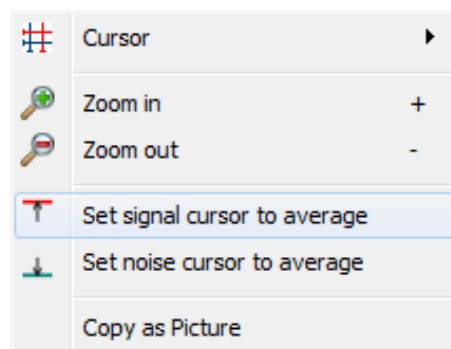
Figure 56: Analysis Display - Context Menu

<Set signal cursor to average> calculates the effective magnitude (using the power) between the X-cursor and sets Y / magnitude Cursor 1.

<Set noise cursor to average> calculates the effective and sets Y / magnitude Cursor 2.

These support functions are important, especially for amplitude-modulated signals - but also for noise, because the effective values can be different than the peaks of the histograms:
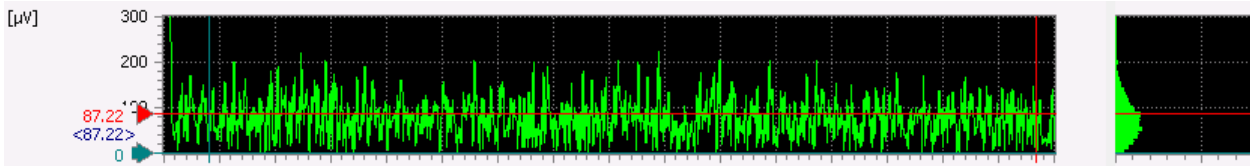
Figure 57: Analysis Display: effective value
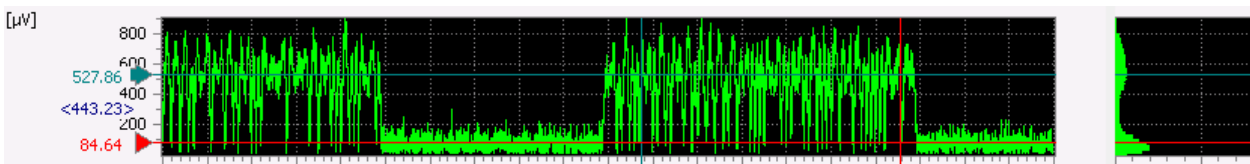
Figure 58: Analysis Display: SNR measurement in linear domain
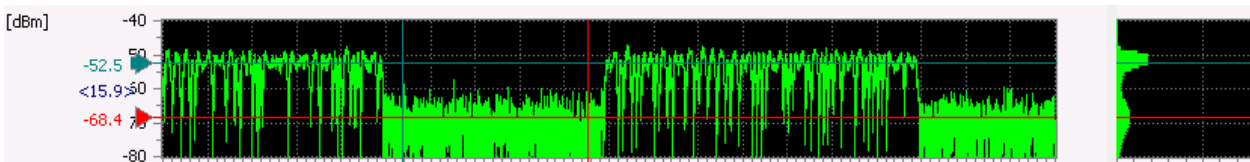
Figure 59: Analysis Display: SNR measurement in logarithmic domain

4.5.8. Hell Display

The Hell display shows the variation of the signal in time in scales of gray. The scales of gray are produced by evaluation of the individual samples of the signal.
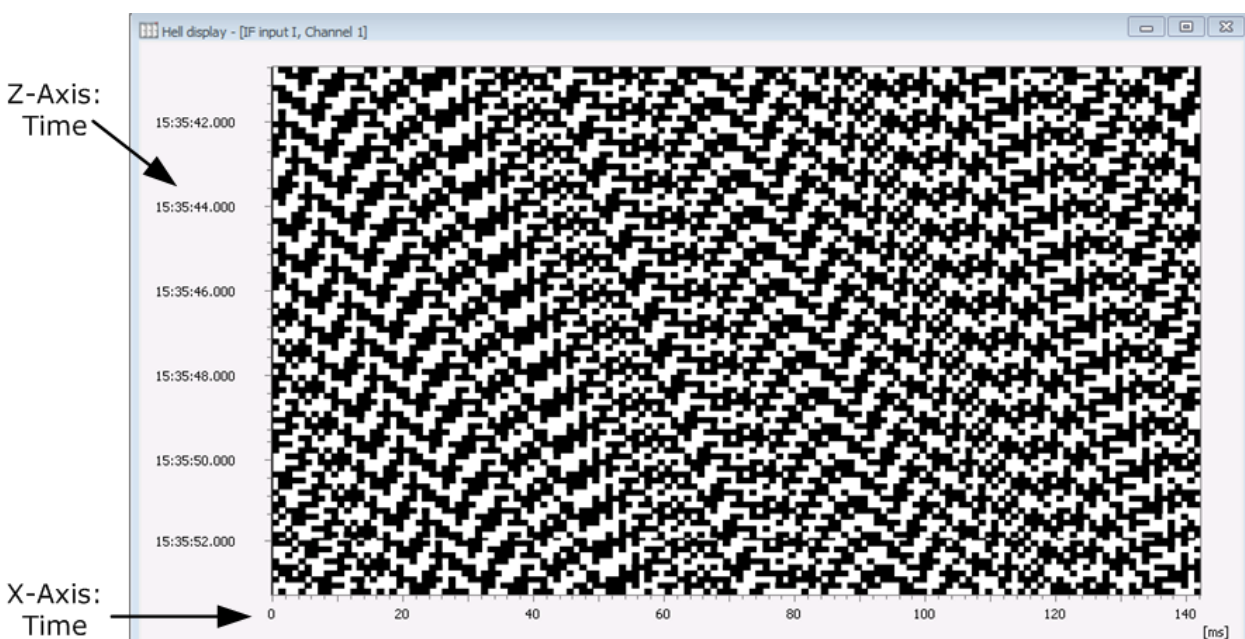
Figure 60: Hell Display

An X-Axis is drawn in the Hell display for the periods of a row. The values of time are drawn on the Z-Axis. The Hell display provides an overview of bit patterns in the signal and allows for the analysis of bit lengths and the definition of the circulation times of specific signals. The values of time of the bits can be measured by using the cursor.

4.5.8.1. Hell Parameter Setting

The parameters of the Hell display can be displayed by activating the <**Parameters**> tab.
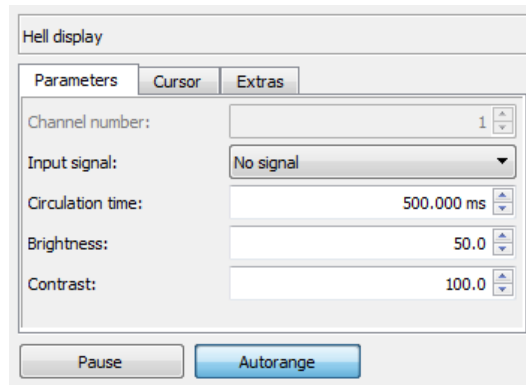
Figure 61: Hell Display - Parameters

The following parameters are available:

Parameter	Function
<**Channel number**>	There are signals which consist of several signal parts, e.g. the input signal Channel in an MFSK2 modem. By using the channel number the channels of such signals can be selected as the input signal.
<**Input signal**>	Use this parameter to select the input signal of the display. If the automatic production is active, you can only select IF input. While setting the parameters of the demodulator, it may occur that a previously selected input signal is no longer available. In this case, the selection no signal will be displayed.
<**Circulation time**>	Defines the time required to draw a row. By using this parameter you can set the skew of a symbol pattern in that way, that the frames are positioned vertically. The display range of the pattern can be doubled or halved by doubling or halving the circulation time. If the skew is positioned vertically, the symbol rate can be defined: 1000 / duration of one column of the frame (to be measured using X-cursor and Harmonic).
<**Brightness**>	Sets the brightness of the display. The lower the brightness, the darker the image. When the display type is inverted, the image becomes darker as the brightness increases.
<**Contrast**>	Sets the contrast of the display. The higher the contrast, the lower the number of shades of gray in the image. With a high contrast, the image has a high definition. With a low contrast, the image is dim.
<**Pause**>	In Pause, the display is stopped (not the signal processing). Modification of the parameters is possible for a more detailed analysis of the current signal range.
<**Autorange**>	Automatic setting of the displayed range to view shades of gray

Table 37: Hell Display - Parameters Tab

4.5.8.2. Hell Cursor Settings

The cursor parameters are displayed by activating the <**Cursor**> tab of the respective display. You can thus insert cursor into the display, which serve to select or clarify specific display sections, or measure the signal data. The <**Cursor**> tab shows the coordinates of the individual cursor positions in editable spin boxes.
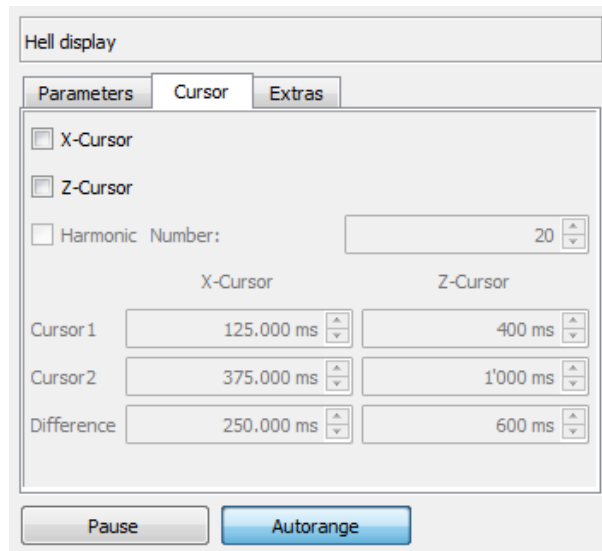
Figure 62: Hell Display - Cursor

Parameter	Function
<**X-Cursor**>	The cursor are activated/deactivated in X-direction. They are used to measure periods of a row.
<**Z-Cursor**>	The cursor are activated in Z-direction. They are used to measure values of time.
<**Harmonic**>	Several cursor are activated at equidistant intervals. In this mode, the first cursor will move all other cursor. The intervals are defined by grabbing and moving the second or any following cursor. The Harmonic function can only be applied in combination with X-cursor or Y-cursor. It serves to measure repeating intervals.
<**Number**>	Useed to determine the number of cursor to be displayed in <**Harmonic**> mode.
<**Cursor 1**>	Coordinates of the first X-, Y- and Z-cursor each
<**Cursor 2**>	Coordinates of the second X-, Y- and Z-cursor each
<**Difference**>	Difference between Cursor 1 and Cursor 2
<**Pause**>	In Pause, the display is stopped (not the signal processing). Modification of the parameters is possible for a more detailed analysis of the current signal range.
<**Autorange**>	Automatic setting of the displayed range to view shades of gray

Table 38: Hell Display - Cursor Tab

4.5.8.3. Hell Extras Settings
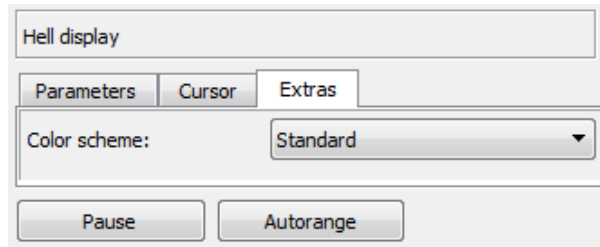
Figure 63: Hell Display - Extras

The <**Extras**> tab features additional options with regard to the display type. The dropdown list box <**Color scheme**> is used to select the color schemes for the displays:

Color Scheme	Foreground Color	Background Color
Standard	light	black
Inverse	dark	white

Table 39: Hell Display - Color Schemes

4.5.9. Bit Display

Symbols are the output of a demodulation process. Every symbol can be viewed as a sequence of bits. The bit display shows symbols or bits.
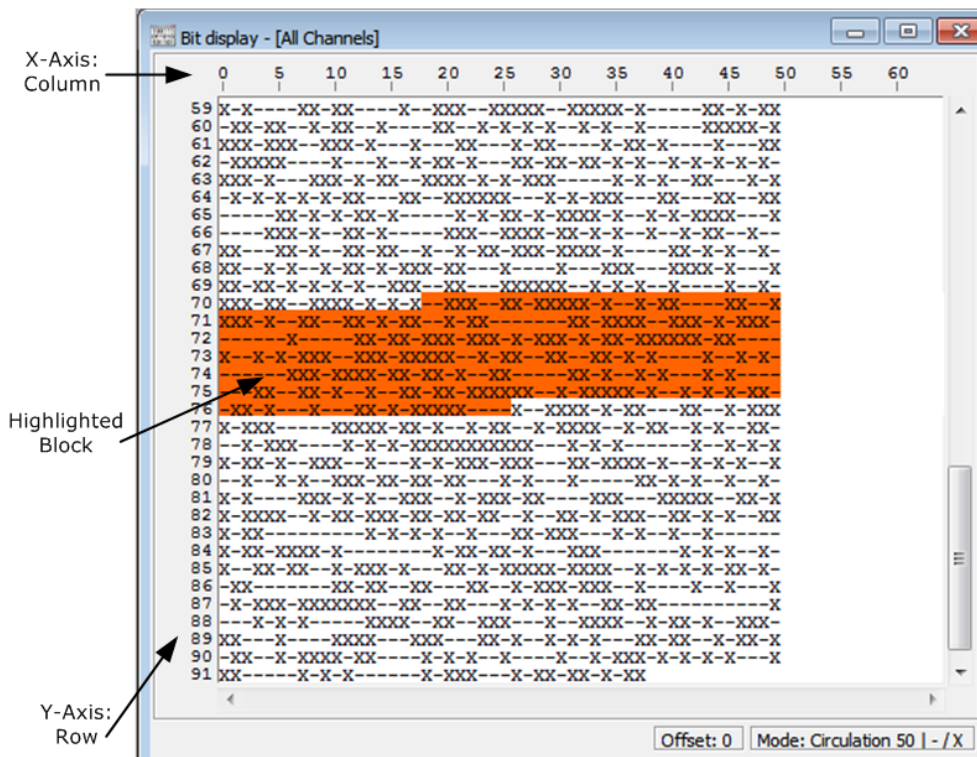
Figure 64: Bit Display

Column numbers for the bits or symbols are drawn on the X-Axis. The row numbers are drawn on the Y-Axis.

The bit display presents an overview of sequences of symbols and serves to analyze repeating bit patterns. Parts of the bit patterns can be highlighted. The highlighted part of the bit pattern or all bits saved in the bit display can be saved in a file.

Zoom in/out is possible by pressing <**Ctrl**> key and using the mouse wheel.

4.5.9.1. Bit Display Parameter Setting
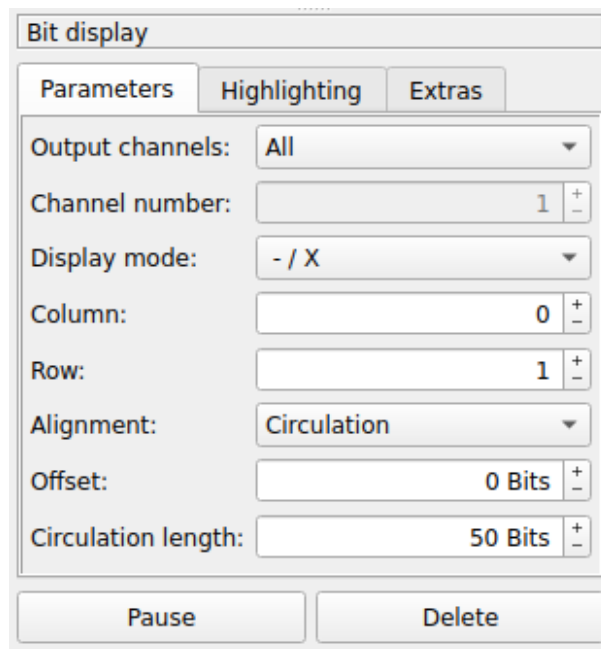
Figure 65: Bit Display - Parameters

Parameter	Function
<**Output channels**>	One symbol may consist of several channels, e.g. in an MFSK2 modem. This parameter serves to set the channels to be displayed: All: All channels of the symbol are displayed. Channel number: Symbols of a specified channel are displayed.
<**Channel number**>	Sets the channel of the symbols displayed. In a modem with one channel, there is only channel number 1.

Parameter	Function
<Display mode>	Use this parameter to set the mode in which the bits are displayed. If bits are displayed, the character left to the slash "/" stands for bit 0, and right to the slash "/" for bit 1. The bit ordering is always LSB first. For example, symbol 3 is serialized into bits 110.
	– / X Display the bits as "–" (value 0) and "X" (value 1)
	. / 1 Display the bits as "." (value 0) and "1" (value 1)
	White / Black Display the bits white (value 0) and black (value 1)
	L / H Display the bits as "L" (value 0) and "H" (value 1)
	Symbols Display a symbol number (integer) instead of bits. The number of bits per symbol depends on the configured modulation.
<Column>	Sets the number of the column in which the bit pattern is displayed. The column is in the left end of the section to be viewed.
<Row>	Sets the number of the row in which the bit pattern is displayed. The row is in the upper end of the section to be viewed. This parameter cannot be modified unless the display type has been suspended using **<Stop>** or **<Pause>** .
<Alignment>	This parameter serves to select the mode which defines the length of a row: Circulation: The parameter Circulation defines the length of a row. Burst: The duration of a burst (in symbols) defines the length of a row. The mode Burst length should not be set unless there is a modem in which the burst mode has been activated.
<Offset>	Defines the number of the first bit from which the bit pattern is displayed.
<Circulation length>	Defines the number of bits required to draw a row. If the length is greater than the visible section, the invisible section can be displayed by means of the parameter Column. Columns which include only one bit number are called frames. Use this parameter to set the skew of the bit sequences to make the repeating bit patterns visible with frame. This parameter cannot be modified unless the row mode has been set to Circulation length.
<Pause>	The display is suspended in Pause and the parameters can be modified for a more detailed analysis of the bit pattern.
<Delete>	Clears the display

Table 40: Bit Display - Parameters Tab

4.5.9.2. Bit Display Highlighting Settings

The parameters of the highlight function can be displayed and modified by activating the **<Highlighting>** tab in enabled mode Pause.

Use the mouse for the highlighting operation:

- Move the mouse pointer to the start position of the block to be highlighted.

- Press the left mouse button.

- If the <**Shift**> key is held down during the selection, a block selection is created. If the block selection is already activated via the parameters, the block selection is deactivated again by pressing and releasing the <**Shift**> key.

- Drag the highlight to the end position of the block without releasing the left mouse button.

- After releasing the mouse button, the desired block has been defined.

Use the right mouse button to open a popup menu in the bit display. The popup menu serves to:

- Copy the highlighted block to the clipboard of the system.

- Save all symbols of the bit display to a file.

- Save the highlighted block to a file.

The individual items of the highlight option can be edited:
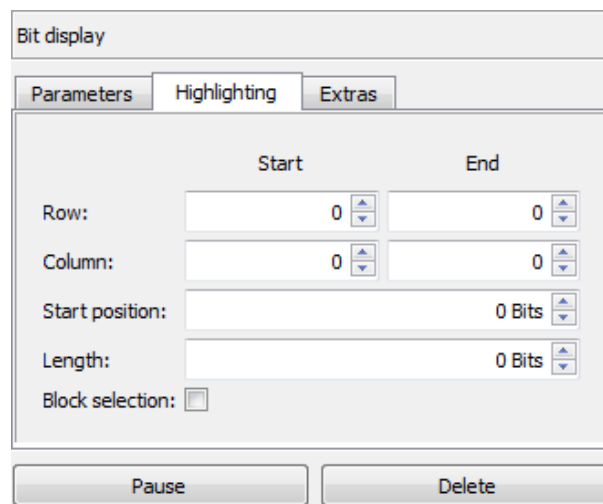
Figure 66: Bit Display - Highlighting

Parameter	Function
<**Row**>	Defines the start and the end of the row of the highlighted block.
<**Column**>	Defines the start and the end of the column of the highlighted block.
<**Start position**>	Defines the start of the selection in bits if block selection disabled.
<**Length**>	Defines the length of the selection in bits if block selection disabled.
<**Block selection**>	When deactivated, all bits are marked continuously from the start position. When the block selection is activated, a rectangular section (matching columns only) will be highlighted, i.e. the bits to the left of the start column and the bits to the right of the end column are not marked. Alternative switching with the <**Shift**> key while marking with the mouse. The switching of the block selection can influence the already marked area.
<**Pause**>	In <**Pause**> the display is stopped (not the signal processing). Changing the parameters is possible to analyze the bit pattern in more detail.
<**Delete**>	Clears the display and all bits stored in the bit representation.

Table 41: Bit Display - Highlight

4.5.9.3. Bit Display Extras Settings

The <**Extras**> tab serves to change the font size of the bit display and to include the bit display quality.
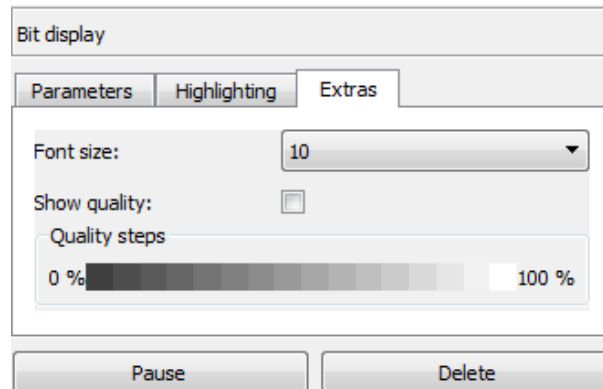
Figure 67: Bit Display - Extras

Parameter	Function
<**Font size**>	Defines the size of a bit in the display. With small font sizes, more bits will be visible than with large font sizes. Identification of details will be harder with small font sizes.
<**Show quality**>	Highlights the quality of the individual bits in shades of gray. The lighter the color, the better the quality of the individual bit.

Table 42: Bit Display - Extras Tab

Copy picture to clipboard

In every display there is an entry "Copy as Picture" in the context menu. This will copy the complete display into the clipboard as an image. This can then be pasted into another application, e.g. MS Word®.

4.6. Extras Menu
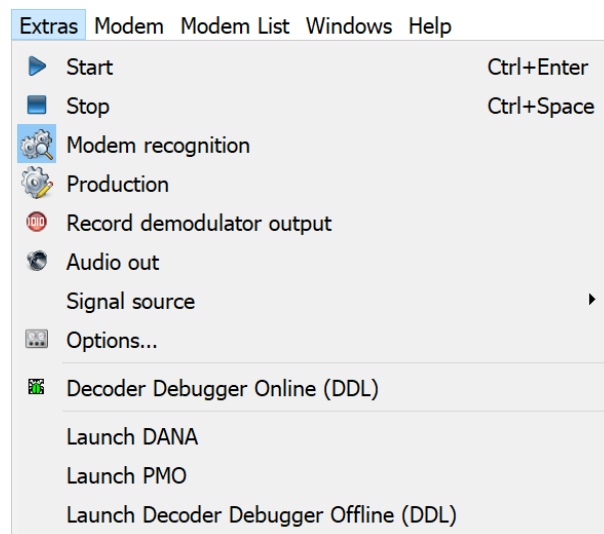
Figure 68: Extras Menu

This menu provides various control functions and settings.

4.6.1. Start

Start the signal processing mode of the APC. At the same time, the APC output is transferred to the SDA.

4.6.2. Stop

Stop the signal processing mode of the APC.

4.6.3. Modem Recognition

Start the automatic signal processing mode of the APC. In addition, <**Start**> must be selected to produce some output. Once the automatic production mode has been started, the control and modem parameters can no longer be modified.

When the Modem recognition and start is enabled, then the search for a modem from the modem lists is started, i.e. the system searches for a modem that matches the signal. If a modem is found, production is started and output is produced from this modem as long as the signal is available.

4.6.4. Production

Start the manual production mode of the APC. The APC starts production with the selected modem.

4.6.5. Record demodulator output

Select this menu item to start recording the demodulator output (bit stream) during production. The created ".rec" file can later on be loaded into the Decoder Development Environment or the go2ANALYSE for further analysis of the bit stream.

4.6.6. Audio out

This item provides a toggle to start and stop the Audio out function.

4.6.7. Signal sources

This item is used to select one of the available signal sources. In the default installation you can choose between DANA, SOMO and Signal Memory. Via <**Extras**><**Optionen…**> further signal sources can be added.

4.6.8. Options

This menu item is only available if the signal processing is stopped.
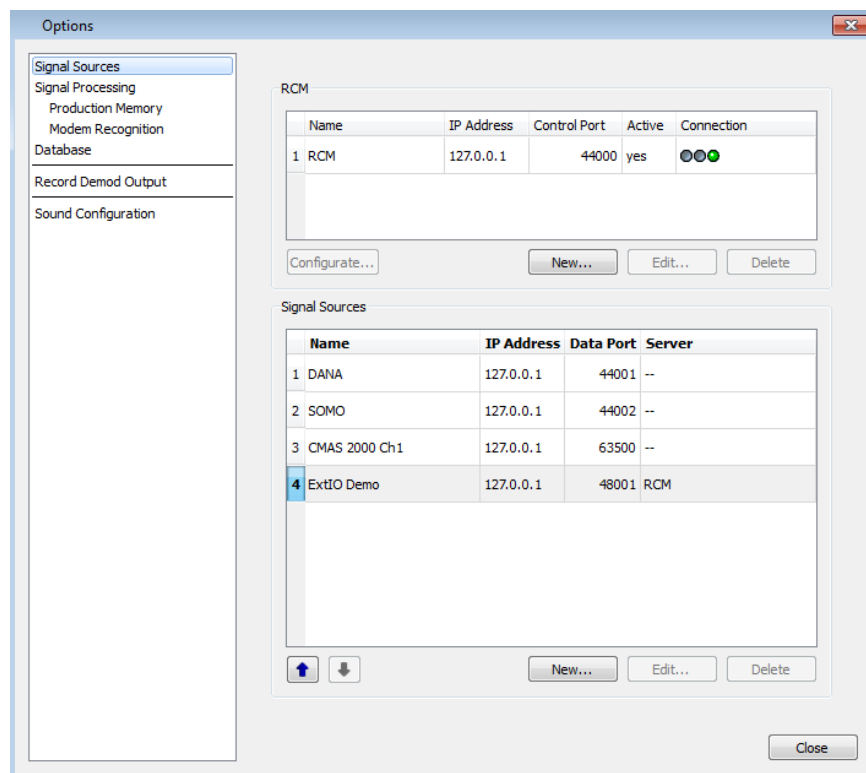
Figure 69: Options Signal Sources Settings

Via the dialog <**Optionen…**> you can

- Setup the signal sources

- Adjust general parameters for the signal processing in the APC

- Set limits for the recording of symbols

- select and configure the soundcard for audio output

Signal Sources

In this dialog you add, modify and delete the available signal sources for the signal server.

The group field "RCM" shows a table of the connected signal servers. Signal servers are applications which are used to provide separate signal sources (RCM provides the possibility to use multiple receivers as signal sources). The item can be active or in-active. It should be noted that besides a local RCM that is always started together with go2DECODE it is possible to connect to a remote RCM on a different computer. The configuration of the receivers the local RCM is connected to is done with the <**Configure...**> button and is described in detail in chapter Receiver configuration.

Each signal server has a name (chosen by the user), an IP-address and a control port for communication. Servers can be active or non-active. No connection will be established to inactive servers. The column connection shows the status on the active servers.

🔴⚪⚪ No connection

⚪⚪🟢 Connection is established

⚪⚪⚪ No connection (Server inactive)

You can create new a signal server by selecting the button <**New...**>. A dialog with the input fields appears. The name of the server must be unique. You accept the modified values by selecting the <**OK**> button. The <**Cancel**> button discards all changes and quits the dialog screen.
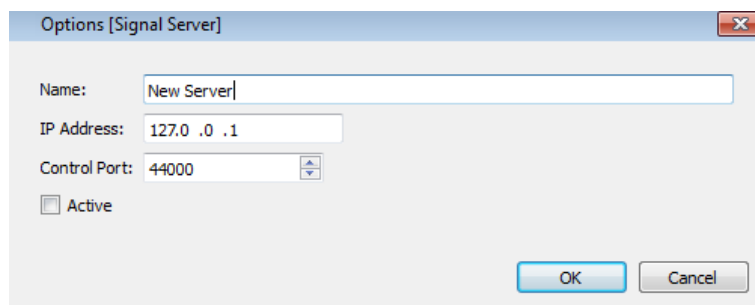
Figure 70: Dialog New Signal Server

The Signal Server sends a list of available Signal Sources to the SDA after the connection is established. These Signal Sources correspond to the configured receivers within the RCM.

Close the options dialog with <**OK**>, You can now select the new Signal Source in the drop-down list of signal sources in the SDA.

If the selected Signal Source is a RCM configured receiver, the toolbar will be extended by activated elements to control various parameters of the receiver easily, i.e. receiver frequency, bandwidth, gain control.

Figure 71: Example of receiver control elements

The visible control elements can vary depending on the selected receiver respectively its configuration.

By selecting the <**Edit...**> button a dialog to modify the signal server settings appears.

Server settings are cleared via the button <**Delete**> A security check will pop up and if you confirm, the settings of the selected server will be cleared.

Note: All related signal sources and the table content will be cleared, too.

The group field *Signal Sources* is used for input and change of the signal sources. Signal sources (DANA, SOMO, streams etc.) deliver streams which are processed by the signal processing component (APC). There are user-defined signal sources and pre-defined signal sources provided by the software.

An overview is shown in Figure 69. Each source has a unique name, an IP-address and a control port and data port and server assignment. In the column Server you can see either "none" for user-defined sources or the name of the signal server. The display order in the table is equivalent to the display of the signal sources in the selected list of the SDA tool bar. Use the arrows up ⬆ and down ⬇ to rearrange the order.

Using the <**New…**> button you can create new (user-defined) definitions of a signal source. A dialog with input fields for designation of IP-Address and a data port appears. The IP-address will define the computer on which the application providing the signal stream is running. The data port defines the related port. You accept the modified values by selecting the <**OK**> button. The <**Cancel**> button discards all changes and quits the dialog screen.
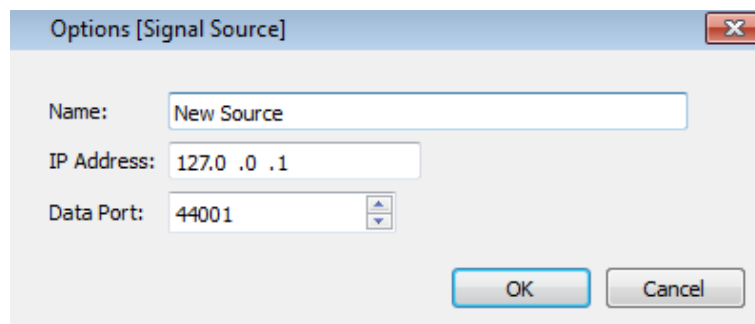
Figure 72: Dialog New Signal Source

By selecting the <**Edit…**> button a dialog to modify the signal sources appears.

Existent sources (user predefined) will be deleted via the <**Delete**> button. A security check will pop up and if you acknowledge, the settings of the selected signal source will be cleared.

Signal Processing

This dialog defines the Automatic Production Channel (APC) to be used.
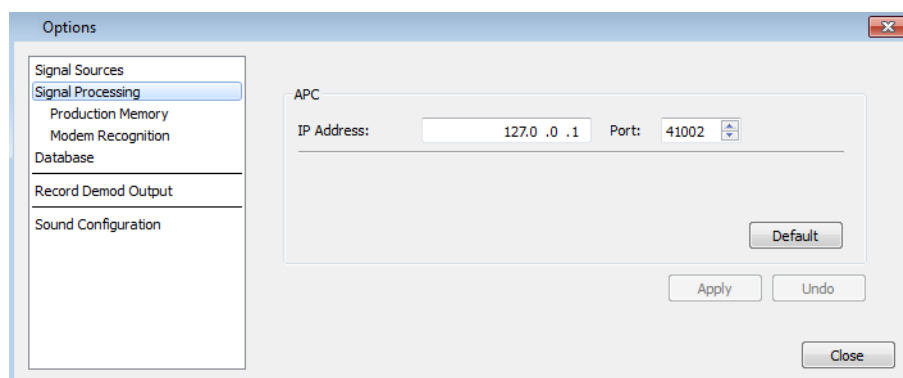
Figure 73: Options Signal Processing Settings

For identification of the component please insert an IP-Address and a port number.

Select <**Default**> to reset to the default settings.

Select <**Apply**> or <**Undo**> if you like to apply or discard your settings.

Production Memory

Various results of the APC are saved in the Production Memory as files (IF recordings, voice/Morse recordings, binary files, XML results) on the harddisk. With the help of the Production Memory Observer (PMO) you can access these files.

There are the following options:
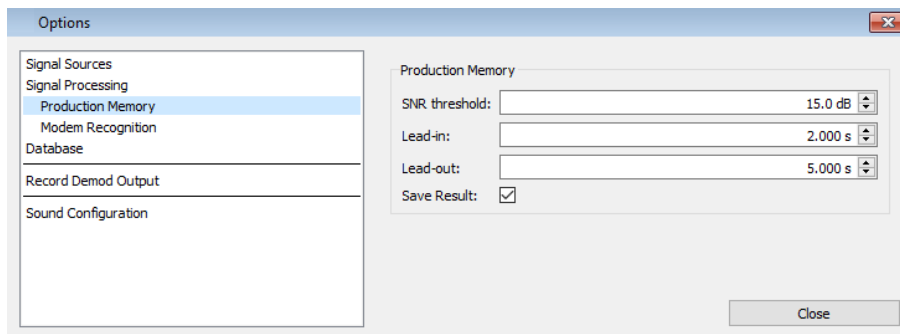
Figure 74: Options Production Memory Settings

SNR Threshold

Here you can define the minimum signal to noise ratio (SNR) that is required to start the recording of the input signal. See IF Recording.

Lead-in/Lead-out

If in the property sheet of the demodulator the option "Audio file" is activated in the procedures for voice or Morse signals recorded the transmitted AF signal.

The parameter Lead-in defines the start of the recording in advance of the detected production start time. In contrast, the parameter Lead-out defines how much longer the recording will last if the voice/Morse detector has lost the signal and stopped production.

Save Result

If enabled, which is the default, the decoder output during production will be saved in an XML-file.

Dialog Modem Recognition
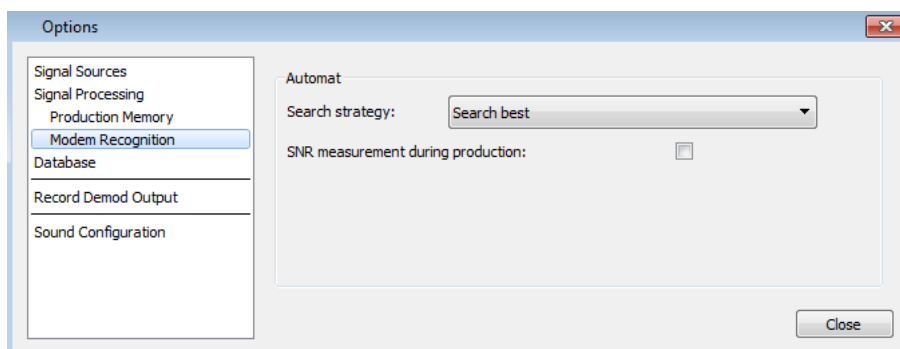
Figure 75: Options Production Memory Settings

Search strategy

- Search first: The modem which first exceeds the result threshold will be processed by the APC.

- Search best: The modem with the best result of all modems above the result threshold will be processed by the APC.

- Automatic: The optimal search strategy is set based on the receiver frequency. For the HF range (< 30 MHz) this means the strategy "Search best" and for the VUHF range the strategy "Search first" and further optimizations with regard to reducing the search time. This is the recommended mode.

SNR measurement during production

If enabled (default: off) then the signal-to-noise-ratio (SNR) will be determined during production and the average value will be output at the end of the production in the XML result text.

Database

Here you can enable/disable the modem database for plain files. For more details see chapter Modem and Decoder Database.
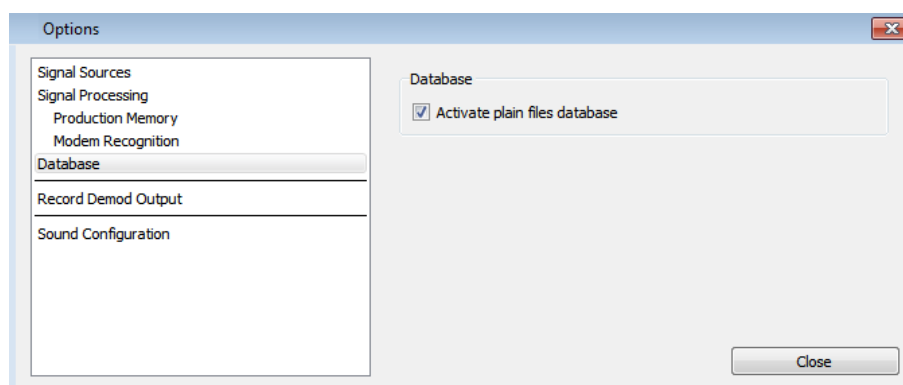
Figure 76: Options Database

Record Demod Output

<**Record Demod Output**> is used to edit the maximum number of recorded symbols.
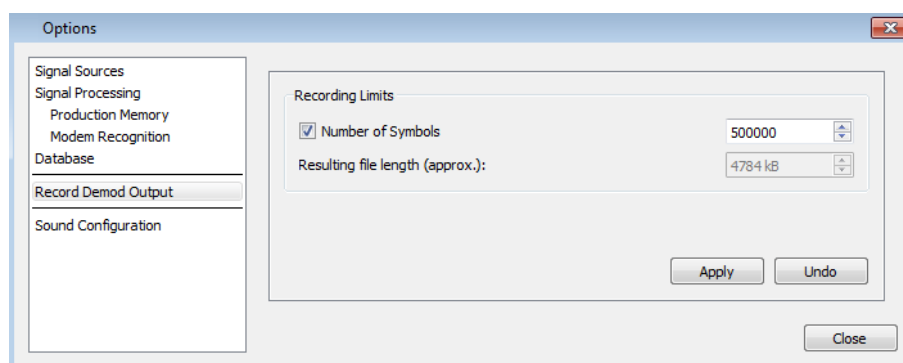
Figure 77: Options Record Demodulated Output Settings

You can enter a value if <**Number of Symbols**> is checked. The textbox <**Resulting file length (approx.)**> shows the expected file size. If no maximum is set then the recording will be stopped automatically at the end of the production.

Sound Card Configuration

If your system features various sound cards (e.g. with different numbers of channels), use the <**Sound configuration**> tab to select and configure the existing sound output devices.
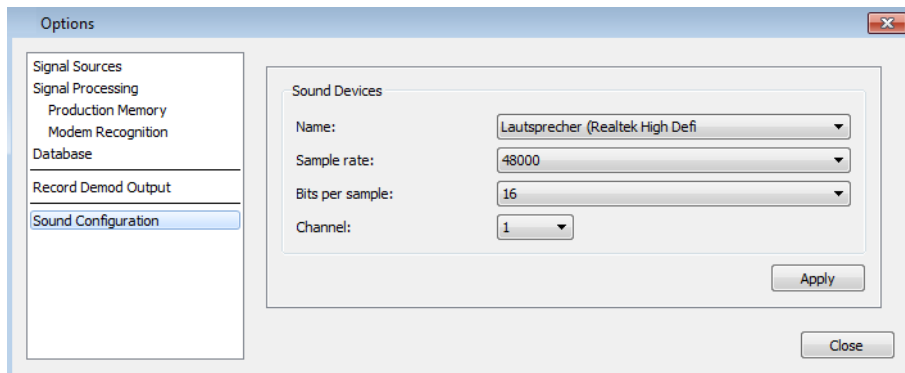
Figure 78: Options Sound card Configuration Settings

When the dialog box is displayed, select the desired sound device, enter the values for sample rate and bits per sample, and edit the number of channels. For details see chapter Sound Configuration.

4.6.9. Launch DANA

Launch DANA

Note: if DANA is running already nothing will happen.

4.6.10. Launch SOMO

Launch SOMO (Availability depends on the software version.)

4.6.11. Launch PMO

Launch PMO

4.6.12. Launch go2ANALYSE

Launch go2ANALYSE (Availability depends on the software version).

4.6.13. Launch Sonagram Viewer

Launch Sonagram Viewer (Availability depends on the software version).

4.6.14. Launch Decoder Development (pyDDL)

Launch external Decoder Development Environment for Python based decoders (Availability depends on the software version).

4.7. Modem Menu

The modem description (hereinafter referred to as "modem") provides the demodulator and decoder parameters of the modem. All demodulator and decoder parameters are saved in the modem file.

Note: the decoder itself is not part of the modem file.

The various rows in the modem list each represent one specific modem.
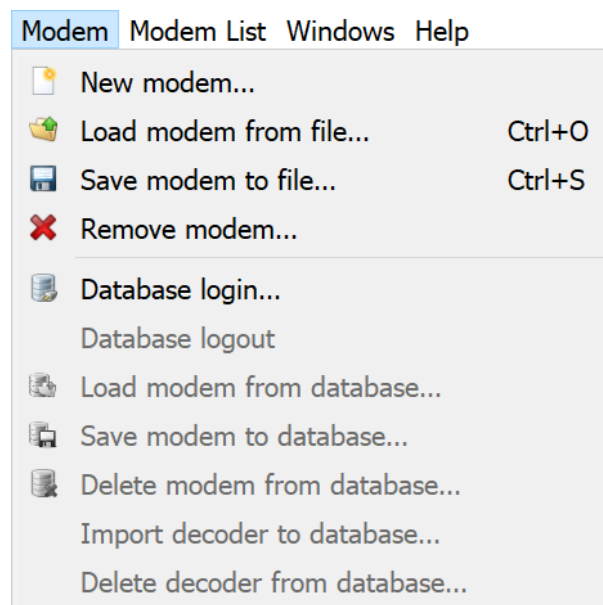
Figure 79: Modem Menu

Each modem can be saved either individually in one file or in combination as a modem list.

4.7.1. New Modem

Add a new modem to the bottom of a modem list. A dialog will appear that shows a list of all the available modems in the installation folder. The modems are grouped (e.g. HF, VHF). You can choose which group is displayed. The group "User folder" shows all modems that were found in your user folder (including subfolders). Some of the listed modems will exhibit a short description. When you start typing in the upper text box the list will filtered. Wildcards are supported. Select one or several modems to load. If you click the button <**New modem**> then no modem file is actually loaded but a template is added to your list.

4.7.2. Load Modem from File

Load modems previously saved. A dialog window is displayed for selection of one or several modem files (.ver). The modems will be added to the bottom of the modem list.

4.7.3. Save Modem to File

Save the modem currently selected in the modem list. A dialog window is displayed to enter a file name for the modem. Although it is possible to save the modem file anywhere on your hard-disk it is recommended - and proposed - to save it in your user folder. Then it will show up in the <**New modem...**> dialog.

4.7.4. Remove Modem

Remove the modem currently selected from the modem list.

4.7.5. Database related menu entries

Activation and usage of database related menu entries shown in Figure 79 are explained elaborately in chapter Modem and Decoder Database.

4.8. Modem List Menu
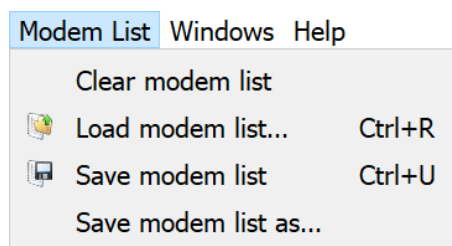
Figure 80: Modem List Menu

The modem list includes all modems currently available as well as various additional parameters. In detail, these are:

- Search strategy

- Signal search mode (frequency range or nominal frequency)

- Result threshold

- IF Saving mode

- Recording SNR

4.8.1. Clear Modem List

Create a new empty list. The current settings for nominal frequency respectively search range remain unchanged.

4.8.2. Load Modem List

Load one of the modem lists previously saved to a data medium. A dialog window is displayed for selection of a modem list. Once the loading process has been completed, the former modem list will be replaced by the new one.

Two types if modem lists are supported

- *.cmf: This type of modem list contains the complete definitions of the individual modems as well as command informations.

- *.mlst: This type of modem list only contains a reference to the individual modems. These are then automatically loaded from the installation folder. If no suitable individual modem is found, then this modem is ignored.

In the installation directory, the folder 'modemlists' contains a number of predefined lists (mlst).

4.8.3. Save modem list

Save the current modem list. The list is always saved as type '.cmf'. The list contains all changes to the parameters of the individual modems.

4.8.4. Save Modem List as

Save the current modem list. A dialog window is displayed where the file name for the modem list can be entered

4.9. Windows Menu
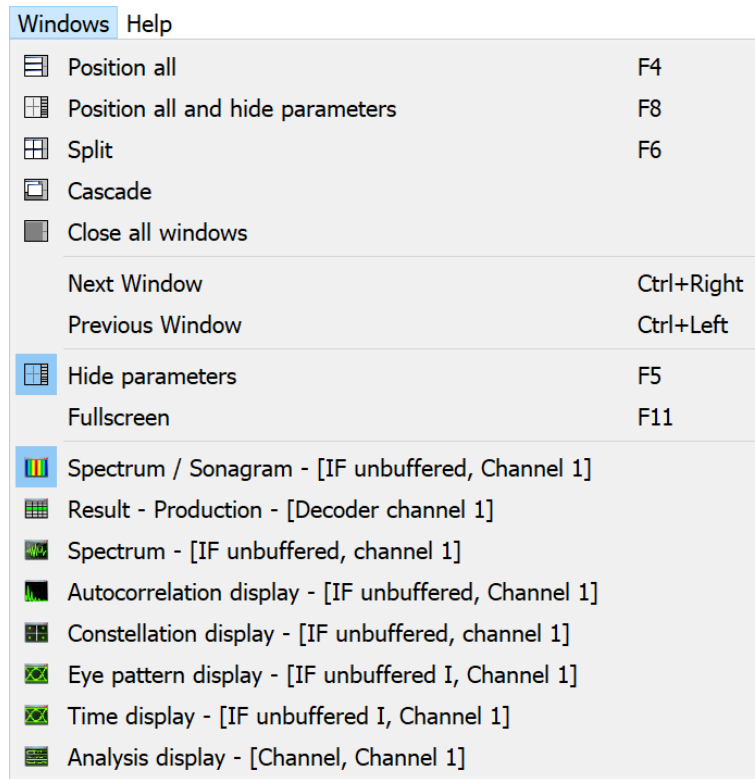
Figure 81: Windows Menu

Menu <**Windows**> serves to arrange the displays of SDA more clearly and shows a list of all SDA windows which are currently open. Selecting one of these windows will bring it to the foreground. Figure 81 shows open spectrum, result, constellation, bit display views. These menu entries are user specific.

Persistent menu entries shown in upper half of menu <**Windows**> are explained below:

4.9.1. Position all

Arrange all signal and result display windows one below the other. Every window is displayed in the same size.

4.9.2. Position all and hide parameters

Arrange all signal/result display windows one below the other in equal size, and show or hide all property sheets (whichever applicable).

Use <**Ctrl**>+<**Tab**> to switch between display windows. Minimized windows will be restored if activated via the menu.

4.9.3. Split

Arrange SDA windows both next to each other and below each other.

4.9.4. Cascade

Arrange the windows of the signal displays on top of each other.

4.9.5. Close all windows

Close all open SDA windows.

4.9.6. Next Window

Places the focus on the next window or switches to it.

4.9.7. Previous Window

Places the focus on the previous window or switches to it.

4.9.8. Hide parameters

The property sheet currently displayed at the right is hidden and, vice versa, hidden property sheets are displayed.

4.9.9. Fullscreen

Switch the display to full screen modus (toggle function).

4.9.10. Remaining menu entries

Remaining menu entries are described in chapter Display Menu.

4.10. Help Menu
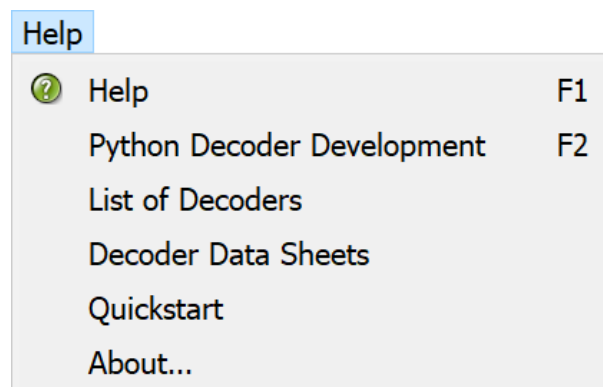
Figure 82: Help Menu

This menu provides detailed information about various subjects.

4.10.1. Help

Activate this item to display the present this Operating Manual.

4.10.2. Python Decoder Development

Displays the instruction manual for the development of Python based decoders (pyDDL).

4.10.3. List of Decoders

Opens a list of available decoders.

4.10.4. Decoder Data Sheets

Displays a detailed description of available decoders.

4.10.5. Quickstart

Opens a quickstart for go2DECODE.

4.10.6. About

Displays a splash screen with version and copyright information.

4.11. Toolbar

The toolbar displays the major functions of the menu bar as icons. To activate the desired function, left click on the respective icon. Individual parts of the toolbar can be hidden or moved around.

Figure 83: SDA Toolbar

The icons are listed in the order of their appearance on the toolbar:

Icon	Function
	New modem
	Load modem from file
	Save modem to file
	Remove modem from modem list
	Open spectrum/sonagram

Icon	Function
	Open spectrum
	Open autocorrelation display
	Open constellation display
	Open eye pattern display
	Open time display
	Open analysis display
	Open Hell display
	Open bit display
	Open result display
DANA ▼	Drop-down list box featuring the available signal sources
	Start the signal processing of the APC. SDA will now receive signal data
	Stop the signal processing of the APC. SDA will not receive any further signal data
	Enable modem recognition mode
	Enable manual production mode
	Record demodulator output
	Switch Audio output on/off

Table 43: SDA Toolbar Icons

4.12. Shortcuts

The following shortcuts are available for quick activation of frequently used functions:

Function	Shortcut
Load settings	<**Ctrl**>+<**L**>
Save settings	<**Ctrl**>+<**Alt**>+<**S**>
Copy	<**Ctrl**>+<**C**>
Paste	<**Ctrl**>+<**V**>
Spectrum / sonagram	<**Ctrl**>+<**M**>
Spectrum	<**Ctrl**>+<**P**>
Autocorrelation display	<**Ctrl**>+<**K**>
Constellation display	<**Ctrl**>+<**I**>
Eye pattern display	<**Ctrl**>+<**E**>
Time display	<**Ctrl**>+<**G**>
Analysis display	<**Ctrl**>+<**D**>
Hell display	<**Ctrl**>+<**H**>
Bit display	<**Ctrl**>+<**B**>
Result Display	<**Ctrl**>+<**T**>
Start	<**Ctrl**>+<**Return**>
Stop	<**Ctrl**>+<**Space Bar**>
Load modem from file	<**Ctrl**>+<**O**>
Save modem to file	<**Ctrl**>+<**S**>
Load modem list	<**Ctrl**>+<**R**>
Save modem list	<**Ctrl**>+<**U**>
Position all	<**F4**>
Position all and show/hide parameters	<**F8**>
Show next window	<**Ctrl**>+<**Right**>
Show previous window	<**Ctrl**>+<**Left**>
Hide/show parameters	<**F5**>
Full screen	<**F11**>
Show instruction manual	<**F1**>
Show manual for development of Python based decoders (pyDDL)	<**F2**>

Table 44: SDA Shortcuts

4.13. SDA Window

To navigate in the main window of SDA and to activate the functions, use one of the following three methods (depending on the current function):

- •   Keyboard shortcuts

- •   Left mouse button

- •   Popup menu via the right mouse button

You will find an overview of this subject in chapter Shortcuts. Use the keyboard to enter, edit or delete text.

When the SDA has been started using modem recognition, a search for the modem with the best result of all modems is carried out. Once the modem has been found, production starts from the time at which the search was started. This process will be faster than real time until the software has processed all existing signal data. Afterwards, the SDA will again receive the data in real time.

When starting the program, the SDA user interface is shown as follows.
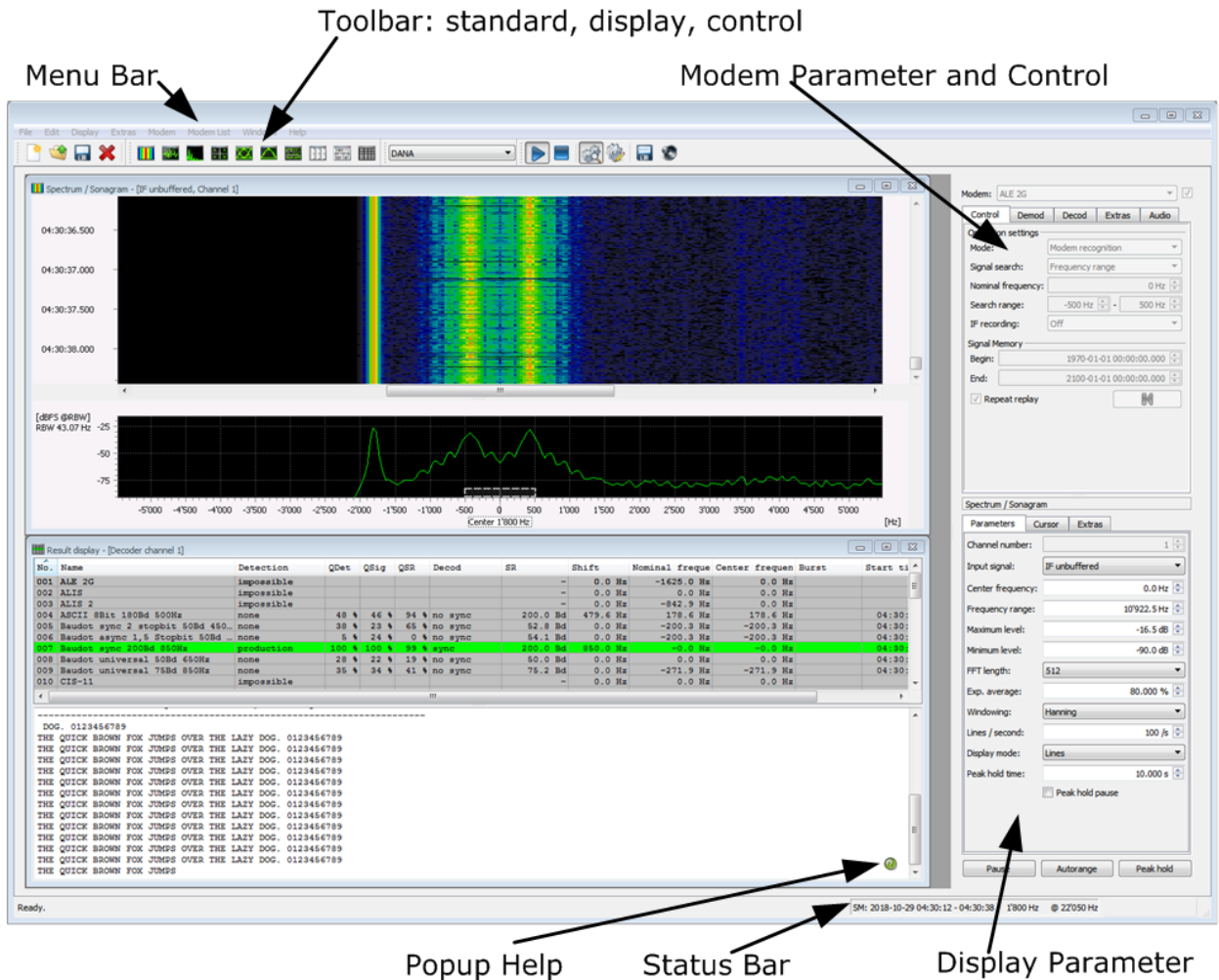
Figure 84: Typical SDA Interface

The SDA interface consists of four sections.

The left section contains all display windows currently open.

The right section features property sheets to view and edit the various parameters. Each sheet consists of several tabs.

- • On the upper right is a sheet which serves to control the APC and to edit the parameters of the modems (demodulator selection and parameters, decoder selection, extras for modem parameter editing, and audio out, i.e. demodulator parameters and gain control). The modem currently active is displayed in a drop-down list box above these tabs.

- • The display parameters on the lower right will vary with the active display window. To activate a display window on the left, left click the desired window and its parameters will be displayed on the lower right.

- • Modems and displays are described in detail in the subsequent chapters.

There is a menu bar below the title bar of the program window, below the menu bar is a toolbar featuring frequently used items from the menu bar. In general, these are icons to open the displays and icons for control of the APC.

At the bottom of the user interface is a status bar. The left part of the status bar shows alert messages, errors or messages about the connection status to the APC.

The right part shows information about the status of the internal signal memory of the APC: the time range of the currently stored signal, its input (receiver) frequency and its samplingrate. A click with the left mouse button will enlarge or reduce the font size of the shown frequency. A click with the right mouse button displays a menu where the displayed frequency unit can be defined (default is Hz).

To the left a label indicates wether modem exclusion based on frequency information is enabled (default) or not. If enabled then modems will be excluded from search if their frequency range does not match the input signal. This applies only for recognition mode. In case of an input signal with unknown or false receiver frequency, e.g. the replay of a signal file without valid frequency information in DANA, this option should be disabled. A click with the left mouse button will toggle this option on or off. This setting is saved and restored when go2DECODE is started.

The section Frequency ranges explains how to edit these frequency ranges of a modem.

4.13.1. APC (Automatic Production Channel)

The task of the APC is the fully automated signal processing. This is achieved by detecting the signal and identifying the modem. The signal is then demodulated and decoded. Each of these steps can be controlled and modified by using the Automat control and the modem parameters (demodulator selection and parameter setting, decoder selection, extras for modem parameter setting, and demodulator parameters and gain control for audio out). The results are controlled and displayed in the result display.

4.13.2. Result Display
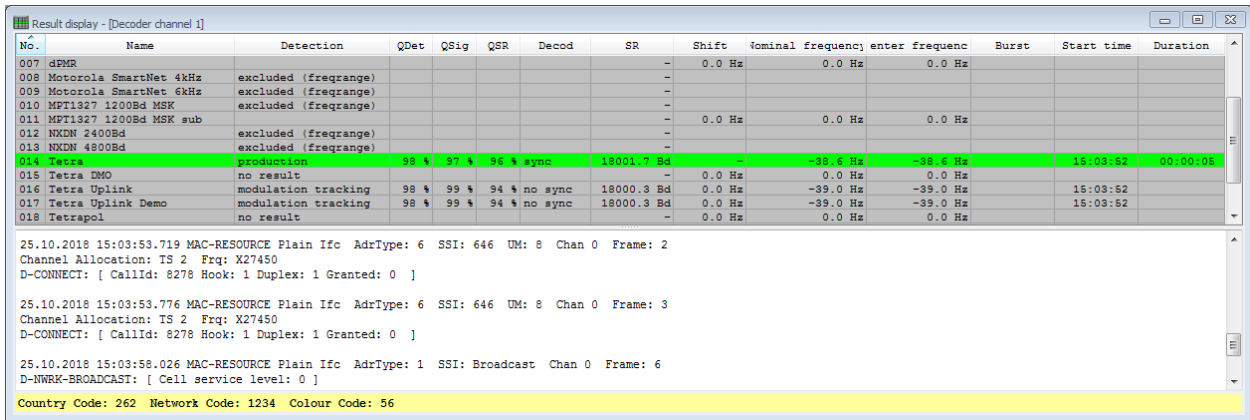
Figure 85: APC Result Display

The result display shows the search and production results of the APC. The display consists of 3 parts:

- **Modem table**: In the upper part of the display, you can see a table with intermediate results of demodulation and detection of all modems or that of a single active procedure (**marked bold**).

- **APC results**: In the lower area, the final results (messages from the APC, decoded text, runtime errors of the decoder) of search and production of the APC are displayed textually

- **Decoder status bar**: The status bar, highlighted in yellow at the bottom, shows important parameters, results and status of the active decoder live. The content depends on the decoder and can therefore be empty. Examples of the content are for example:

    - Network and country codes

    - currently active transmission type (e.g.: idle, data, voice, ...)

    - detected decoding modes (e.g. interleaving, scrambling, code rate, ...)

    The status bar provides a fast overview of important and basic decoder results so that they do not have to be extracted manually from the sometimes quite extensive overall results.

Depending on the modem status, you will see the following APC messages in addition to the decoder result in the lower pane during production (apart from those that are self-explanatory like "search start" or "production start" etc.):

Message	Description
unidentified signal detected	Unknown signal detected - edit parameters
unidentified signal detected, closest [modem name]	Unknown signal detected with indication of closest possible modem - you may want to edit the parameters
unidentified signal detected, modulation similiar [modem name]	Unknown signal detected with modulation similiar to modem indicated - you may want to edit the parameters
modulation detected [modem name]	Modulation detected with indication of modem
modem detected [modem name]	The modem has been detected and production has started.

Table 45: SDA Messages

To change the font size in the lower part of the window, see Result Display Extras Settings.

4.13.2.1. Parameter Setting

To view the parameters of the result display, do a right-cklick on the "Result Display Table Header" to open the context menu. All results except *No.* and *Name* are displayed by activating the various checkboxes.
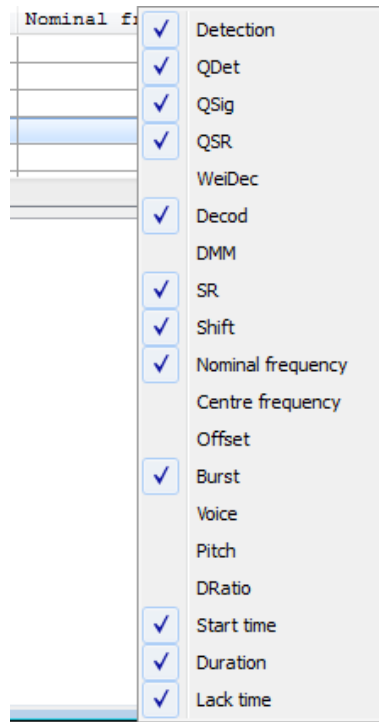
Figure 86: SDA Selection of Result Production

The table lists the results in the upper part of the display together with their tasks:

Result Column	Function
No.	Modem number in the current list
Name	Name of modem

Result Column	Function	
Detection	Detection status of modem:	
	No result:	No statement on modem status possible
	Inactive:	Modem is deactivated (either manually or automatically during search)
	Not detected:	Modem has not been detected
	Waiting for decoder:	Only modulation parameters has been detected, results from decoder are still pending
	Modulation:	Modem has been detected on the basis of the modulation parameters
	Modem:	Modem has been detected
	Signal lost:	Modem was detected but is lost now
	Production:	Modem is in production
	Modulation tracking:	The modulation type has been detected, tracking parameters
	Modem tracking:	The modem has been detected, tracking parameters
	Excluded (freqrange)	Modem has been excluded due to receiver frequency
	Excluded (segmentation)	Method excluded on the basis of segmentation results (e.g. spectrum does not fit)
	Excluded (bandwidth)	Modem has been excluded due to inappropriate bandwidth
	Excluded (noprod)	Modem does not support manual production (multi-modem)
	Excluded (nofreqsearch)	Modem does not support automatic search within a frequency range
	Excluded (decod error)	Modem has been excluded due to a decoder runtime error
	Excluded (demod error)	Modem has been excluded due to a demodulator error (e.g. demodulator not available)
	Excluded (license)	Modem has been excluded due to a missing license
	Excluded:	Modem excluded due to wrong parameters
QDet	Overall detection quality of modem (summation of various quality ratings)	
QSig	Quality of signal based on symbol (hard) decisions	
QSR	Quality of measured symbol rate	
WeiDec	Weighting of decoder	

Result Column	Function
Decod	Status of decoder: No sync: Decoder not detected Identified: Decoder has detected modem characteristics in the data stream Accepted: Decoder has definitely identified the modem Sync: Decoder has found some modem characteristics but not identified it Error: Decoder runtime error
DMM	This column indicates whether the demodulator has been modified by the decoder or not.
SR	Measured symbol rate (speed at which the signal is transmitted) or keying rate (number of characters per minute) for Morse modems
Shift	Measured shift (interval between the lowest and the highest frequency) of an FSK modem
Nominal frequency	Nominal frequency of the signal - relative to the center of the input signal
Center frequency	Center frequency of the signal - relative to the center of the input signal
Offset	Offset between nominal and center frequency
Burst	Length of burst (only if burst mode is enabled for this modem). Burst emissions are not continuous.
Voice	Transmission mode in a speech modem: USB (One Side Band: Upper side band) LSB (One Side Band: Lower side band) DSB (Double Side Band, Amplitude modulation) FM (Frequency modulation)
Pitch	Fundamental frequency of the perceived voice signal
DRatio	Scanning rate (dash-to-dot rate) of a Morse modem
Start Time	Time at which the modem was detected
Duration	Period during which the signal was detected
Lack Time	Time interval in which the signal was not detected

Table 46: SDA Parameter Settings

4.13.2.2. Result Display Parameter Setting

To view the parameters of the result display, select the <**Parameters**> tab. All results except No. and Name are displayed by activating the various check boxes.
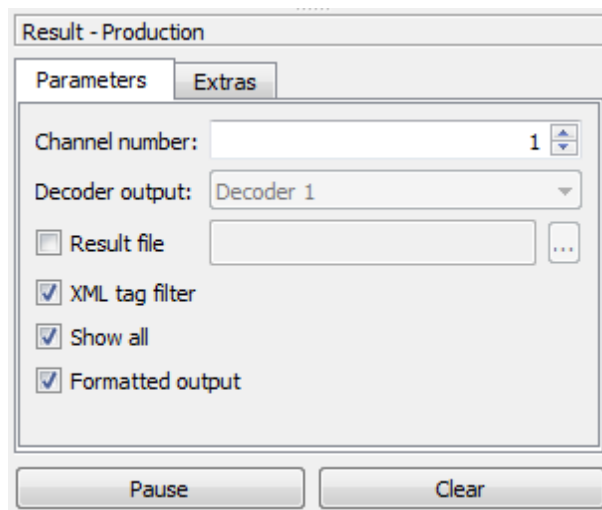
Figure 87: Result Display Parameters Settings

To edit the display parameters of the final results in the lower part of the display, select the <**Parameters**> tab. The following parameters are available:

Parameter	Function
Channel Number	This option serves to display the text of the respective decoder channels. Most modems only show output on channel 1. Some modems display additional results (e.g. LSB decoded results, CRC) on the other channels. A HEX output is sometimes available on channel 16.
Decoder Output	Toggle between Decoder 1 and 2 (default is decoder 1). This option is only effective if the demodulator used is F7B/F7W.
Result file	By activating this check box, the raw results of the output will be saved in a file. If no file has been specified, a file dialog will be displayed to select a base directory in which to save the results. A "results" directory is created in the base directory. The file "apcresult.xsl" (required to view the result file formatted within a web browser) is copied to this directory.
XML tag filter	The plain XML result is displayed if this check box is not checked
Show all	Enable this check box to view additional messages in the lower result pane, like the modem closest to the unknown signal.
Formatted output	Select this check box to activate the formatted outp If not checked a considerable amount of additional information of the search results is displayed.
<**Pause**>	The display is halted in pause. Now edit the parameters for more detailed examination of the results.
<**Clear**>	Clears the buffer and the display of the final results

Table 47: Result Display Parameters Settings

4.13.2.3. Result Display Extras Settings

The font size of the text output (lower window of the result display) can be changed under the <**Extras**> tab. If the display focus is on the text output, the font size can also be changed using the following key combinations:

- • by pressing <**Ctrl**> and using the mouse wheel

- • by using the keyboard shortcut <**Ctrl**>+<**+**> or <**Ctrl**>+<**-**>

- • by using the keyboard shortcut <**Ctrl**>+<**Up**> or <**Ctrl**>+<**Down**>
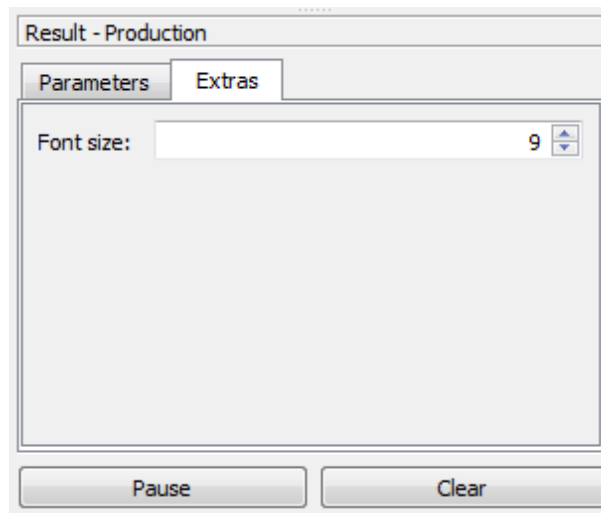
Figure 88: Result Display Extras Settings

4.13.2.4. Popup Menu Results Table

A popup menu is opened by a right-click in the results table. Various functions can be applied to the modem displayed in this table:

Parameter	Function
Use modem	The active modem (bold) is replaced by the selected modem
Save modem	Save the modem previously selected from the modem list to a data medium. Open a dialog window for input of a file name for this modem.
Remove modem	The selected modem is removed from the modem list.
Enable modem	Enable modem if it was disabled
Disable modem	Modem will be ignored during modem recognition
Add to multimodem	This allows to add the selected modem as a submodem to a multimodem. If there are any multimodems in the current modem list they will we listed here. The entry "New MultiModem" will automatically create a new multimodem and add the selected modem as a submodem. Note that the modem will be then removed from the list.

Table 48: Result Display Pop-Up Results Table

You may also use (activate) modems by double clicking the respective modem row in the table.

Another popup menu will open by a right-click in the result text window:

Parameter	Function
<Copy>	Copy highlighted result text to clipboard
<Select All>	Select complete result text

Table 49: Result Display Pop-Up Text Result

The contents of the result windows can also be selected using the mouse.

Note: The result window will stop scrolling if the scroll bar is touched. To re-enable scrolling move the scroll bar to the bottom.

4.14. APC Control Parameters
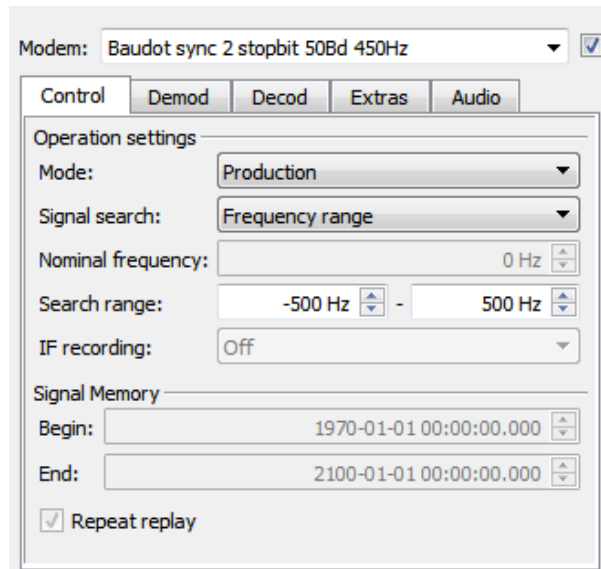
Figure 89: SDA Control Parameter

4.14.1. Modem List

Apart from the result display, the modem list is the other way to display all modems.
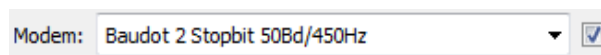
Figure 90: Drop-down List Box Modem

It includes all modems that can be used in automatic production to identify the modem of a new signal. To show the modem list, activate the box Modem in the drop-down list.
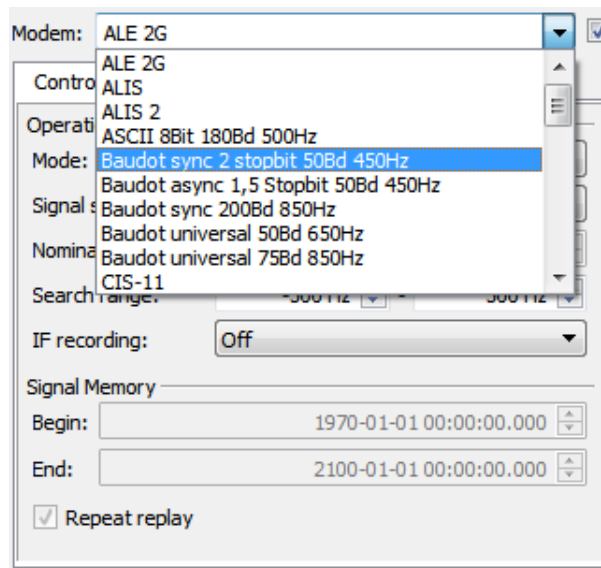
Figure 91: Drop-down List Box Modem with Modem List

Once the drop-down list is activated, a text cursor will appear so that the name of the active modem can be edited. On pressing the down control on the right, the drop-down list will open showing the list of modems. If the list includes a great number of modems, a scrollbar will appear on the right. Grab the slider of this scrollbar with your mouse cursor and slide downward to see the remaining part of the modem list. Click the desired modem to activate it. Use the cursor keys "Up" (↑) and "Down" (↓) to quickly move between modems.

Deactivating the check box to the right of the drop-down list box will deselect the modem from the APC modem list. Use this feature to exclude modems from the modem list in automatic production.

Tab	Task
<Control>	Modify the parameters controlling the automatic production. This will affect the entire modem list.
<Demod>	Select demodulator and edit the parameters of the active modem (not available during automatic search)
<Decod>	Decoder selection of the active modem
<Extras>	Edit additional parameters of the active modem
<Audio>	Parameters to control the audio output

Table 50: SDA Tabs

The functions of these tabs are explained below.

4.14.2. Control Settings

The control parameters serve to set the following areas of the APC.

- Automatic identification
- Duration of the production process
- Supervising of the production process

- Saving of signals

In addition to the direct input, the time parameters and the numerical values can be edited using the cursor keys "Up" (↑) or "Down" (↓) (corresponding to the up/down controls on the right of the spin box). This will change the digit on which the cursor is positioned. Position the cursor by means of the cursor keys "Right" (→) or "Left" (←).

Activate the <**Control**> tab to edit the parameters:
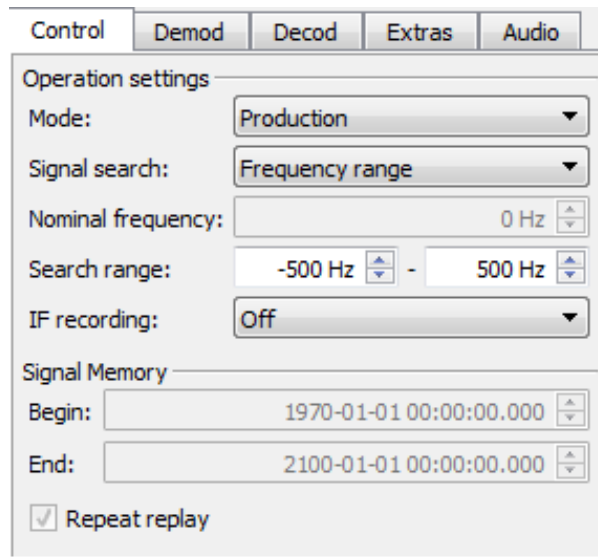
Figure 92: APC Control Parameters

4.14.2.1. Mode

Selection of the operating mode. You can select between:

- Modem Recognition (automatic mode)

- Production (manual mode)

4.14.2.2. Signal Search

- Frequency Range: The APC searches for signals in the defined search range and automatically determines the correct center frequency within the given range based on the results of the segmentation. Modems might be excluded on if their energy spectrum does not fit the current signal.

- Nominal frequency: Manual definition of the frequency offset of the signal. This is controlled on the <**Extras**> tab together with the modem-specific parameter Offset Nominal Frequency. There is only minimal center frequency correction carried out by each demodulator.

4.14.2.3. Nominal Frequency

Nominal frequency for every modem if <**Nominal frequency**> is used. Offset Nominal frequency on the <**Extras**> tab is added to this value for each modem.

4.14.2.4. Search Range

Modem types will be searched in the defined search range around the intermediate frequency (f = 0) if "Frequency Range" is used.

4.14.2.5. IF Recording

You can record the input signal by the APC. The recordings will be saved in the production memory on the hard-disk. The start of the recording can be dependent on different conditions.

- Off: Signal is not recorded.

- Detected modem: Recording is started on successful search when production starts

- Unknown Signal: Recording is started when no matching modem has been found, when a signal has been detected by the energy detector in the segmentation, and when this signal has at least the signal-noise ratio defined in Record SNR (see options menu)

- Signal detected: Recording is started as soon as some signal has been detected, and when the signal has at least the signal-to-noise ratio defined in Record SNR

- On: The complete signal is recorded.

Note: Please note that the recordings also depend on the begin and the end.

4.14.2.6. Signal Memory

These controls are only available when Signal Memory has been selected as signal source.

4.14.2.7. Begin

Time at which the recorded signal is read from the short-time memory.

4.14.2.8. End

Time at which the reading from the short-time memory is stopped.

4.14.2.9. Repeat Replay

You can have the recorded signal played repeatedly. To do so, select this check box.

The start and end times can be set both manually and by using the sonagram. First, activate the Z-cursor in the sonagram. Open the popup menu (right-click) in the sonagram (signal source must be set to Signal Memory), and use this menu to adopt the time position settings of the cursor as parameters for the start and end time of the short-time memory replay. On selecting <**Begin**> or <**End**>, only the start time or the end time will be set; otherwise, the entire time range will be set.
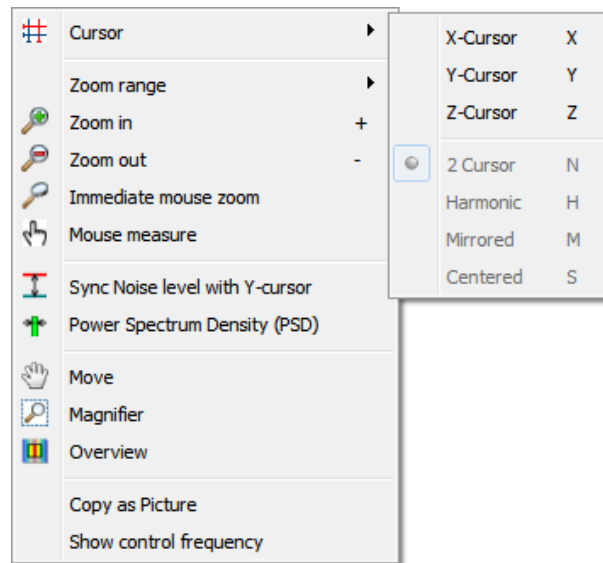
Figure 93: Sonagram Popup Menu

The parameter settings will take effect not only on all modems but also on all signal displays.

4.14.3. Demodulator Settings

The setting of the modem parameters directly affects the signal processing process. This way the characteristics of the modem can be modified. Transmission of a signal using high frequencies requires influencing ("modulating") the signal to encode the transferred information in the signal. The basic high frequency (HF) signal is also called carrier. The APC has to reverse ("demodulate") this influence to recover the information. The results of the demodulating process are symbols (one or several bits). Adjust the demodulation using the demodulation parameters. To do so, open the <**Demod**> tab.
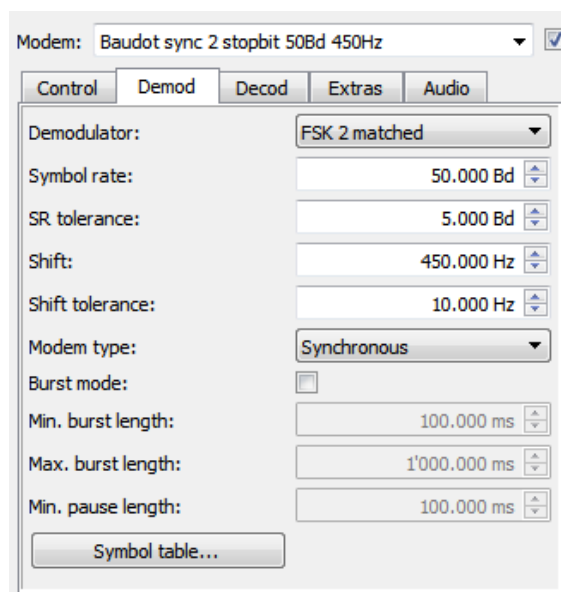
Figure 94: Tab Demod with Demodulator Drop-Down List

The Demodulator drop-down list box provides an extensive range of demodulator types. Select the appropriate demodulator type:

Demodulator Type	Demodulation of...
Voice	Speech signal
Morse	Morse signal
F7B/F7W	Four-channel frequency shift keyed and Morse signal
ASK 2, 4, 8	Amplitude shift keyed signal
FSK discr.	Frequency shift keyed signal
FSK 2 matched	Frequency shift keyed signal (shift is much bigger than symbol rate)
FSK 2 auto shift	Frequency shift keyed signal, automatic measurement of shift
Multitone (MFSK)	Multi-tone frequency shift keyed signal
MFSK 2	Multi-channel frequency shift keyed signal
(G)MSK	(Gauss windowed) minimum shift keyed signal
TFM	Tamed frequency shift keyed signal
DPSK 2, 4, 8,16 A/B	Differential phase shift keyed signal
PSK 2, 4, 8,16 A/B	Absolute phase shift keyed signal
PSK data aided	Phase shift keyed signal, equalizer based on known training sequences/ symbols, which are parameterized by the decoder
MDPSK2, 4, 8, 16 A/B	Multi-channel differential phase shift keyed signal
MPSK2, 4, 8, 16 A/B	Multi-channel absolute phase shift keyed signal
OQPSK	Offset quadrature phase shift keyed signal
QAMn	Quadrature amplitude modulated signal (4x4 up to 16x16 constellation and generic user definded constellations)
s OFDM	Orthogonal frequency division multiplexed signal
CHIRP	with phase shift keying modulated chirp signal
MultiModem	Combination of several modems
Analogue Selcal	Distinct analog selcals (multitone)
Clover II	Clover II signal
Clover 2000	Clover 2000 signal
Clover 2500	Clover 2500 signal
Coquelet	Special filter demodulator for Coquelet signals
MT63	MT63 signal
Pactor II	Pactor II signal
Pactor III	Pactor III signal
Pactor IV	Pactor IV signal
THROB / THROBX	THROB or THROBX signal

Table 51: Demodulator Types

Various parameters are available for every demodulator type. Some demodulators allow for changes in their symbol tables, i.e. modification of the symbol values produced by the demodulator in question.

In a symbol table with entries of 2 or more bits, these are specified LSB-first (least-significant-bits first). For example, the table entry "011" with 3 bits is assigned the symbol 6.
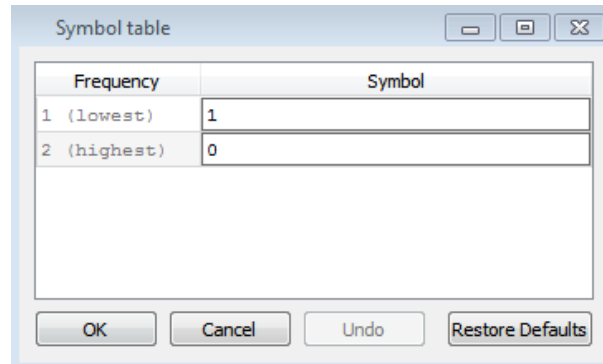
Figure 95: Demodulator Table of Symbols

4.14.4. Decoder Settings

The results of the demodulation process are symbols. These symbols can be decoded using an appropriate decoder. To do so, select the appropriate decoder from the list of decoders in the <**Decod**> tab. Additionally, decoders can be parametrized and edited.
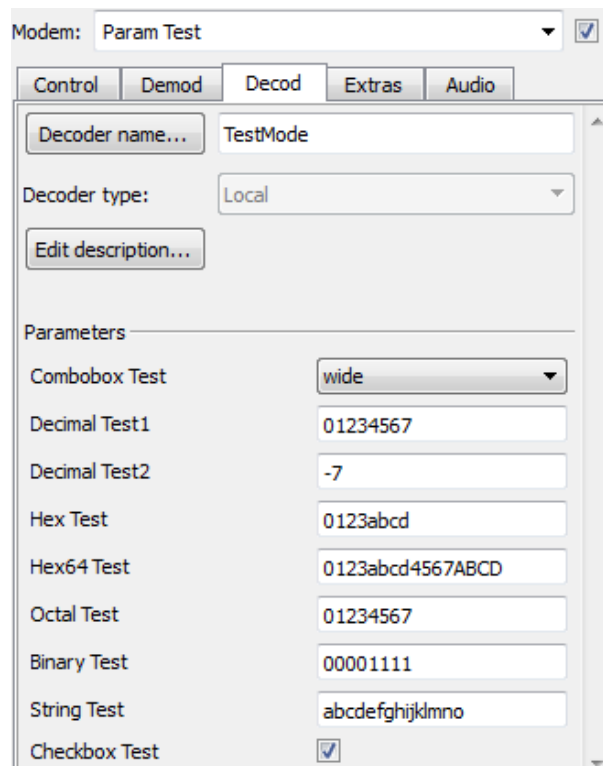
Figure 96: Parameters for Decoder Selection

The following table explains the parameters of the decoder selection.

4.14.4.1. Decoder Name

Specifies the name of the decoder in use. Press the button <**Decoder name...**> to open the dialog for selection of a decoder from the decoder list.

If the demodulator type is set to F7B/F7W then depending on the mode two decoders have to be set.

Note: Manual entries of the decoder name will cause the system to verify the existence of this decoder in the list of decoders. Please notice the decoder type.

4.14.4.2. Decoder Type

If a database is connected, the decoder type can be changed between local or database.

- Local: Decoders are retrieved from the computer running the GUI

- Database: Decoders are retrieved from a connected database

4.14.4.3. Edit Description

If the source code of the selected decoder is available to the system then a click on this button will unpack the decoder and open its source code in the external Python decoder development based on Spyder. If no decoder name is given then it will just start Spyder.

4.14.4.4. Decoder List

If you press the button <**Decoder name...**>, the decoder list will be displayed:
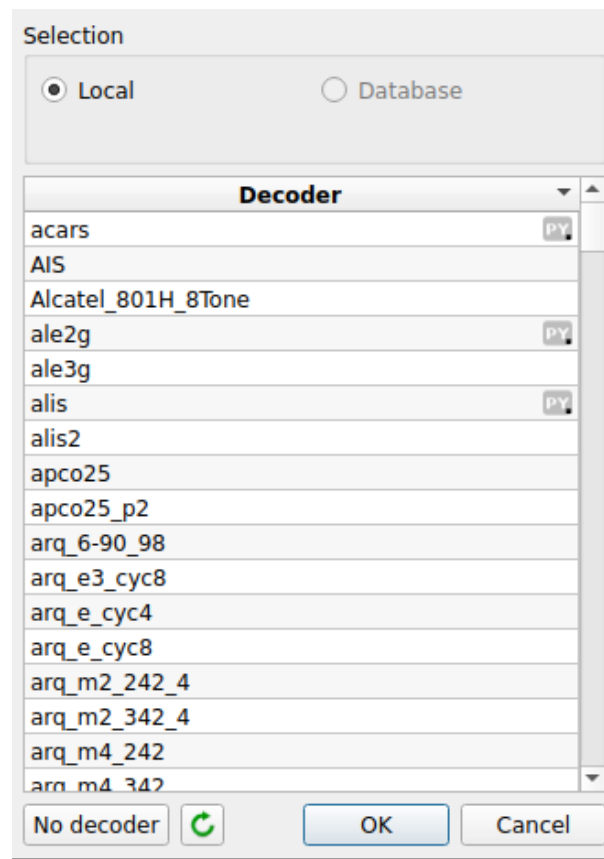
Figure 97: List of Decoders

This list shows the names of all decoders known to the APC. The two radio buttons Local and Database are not relevant unless go2DECODE operates within a system that includes a database. Select the desired decoder via double click, or use the up/down keys on the keyboard to move in the list and press <**OK**> to confirm your selection. Activating the button <**No decoder**> will remove the decoder from the modem. To exit without a new selection, click <**Cancel**>. To update the list of local decoders click 🔄.

4.14.4.5. Parameters

go2DECODE provides the option to initialize a selection of decoder variables to user-defined values. The available parameters are displayed in the Parameters box. Depending on the decoder and modem implementation this makes it possible e.g. to select the alphabet or the desired submode etc.

These variables have to be defined in the decoder source code as well as in the modem ("ver") file. They can hold numerical and textual data. Data can even be selected using a combo box or a checkbox.

In the modem file the variables are stored in the <**DecoderParameters**> section. This section defines the variable name, its format and current value which are needed by the decoder as well as the definition of the graphical representation that is needed by the SDA to display them. There are five classes of GUI elements possible:

- Combobox

- Textbox

- Checkbox

- List

- Matrix

The textboxes have each a format:

- dec

- bin

- oct

- hex

- string

Thus, it is possible to define the graphical representation of each decoder individually.

Parameters elements can be added, changed or removed by clicking <**Edit parameters…**>. In the there-upon upcoming XML editor one can see already defined decoder paramter elements in their XML repre-sentation. Using the toolbar, one can add templates of GUI elements, as shown above, to parameters list. The according XML template will be shown appended to already defined elements. After adjusting the templates and confirming by clicking on <**OK**>, freshly applied elements will appear in "Parameters" field. Clicking on <**Cancel**> will reject all changes.

The parameter elements List and Matrix can be set via XML to a fixed or a dynamic number of rows. With dynamic number of rows, the following key combination is used to add or to remove rows:

- <**Ctrl - Enter**> - add a row

- <**Ctrl - Delete**> - delete a row

To do this, the text cursor must be in the desired row.

In the examples folder of the installation you will find a decoder and a modem file which will exhibit the various possibilities.

In Figure 98 you can see parameter elements and their XML representation.
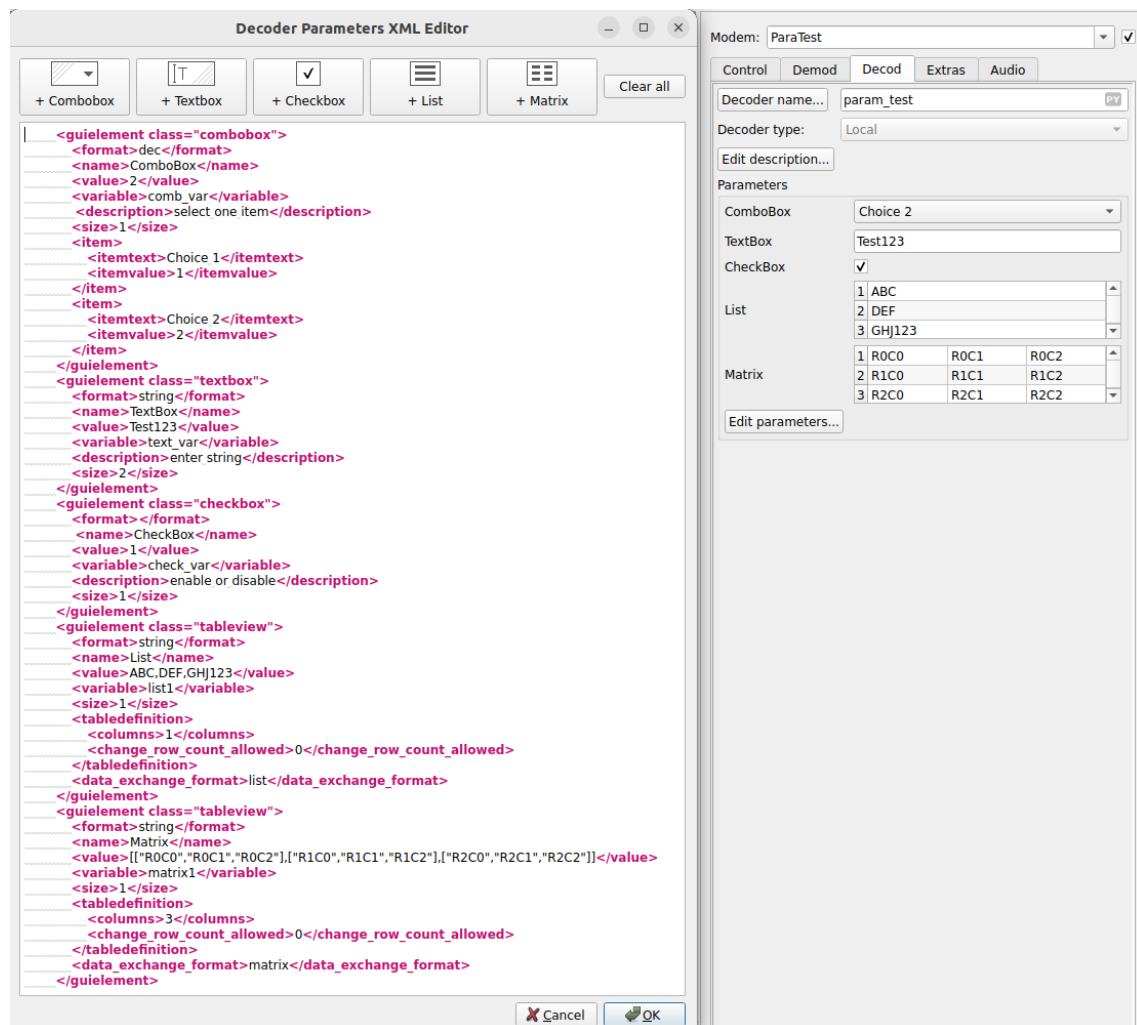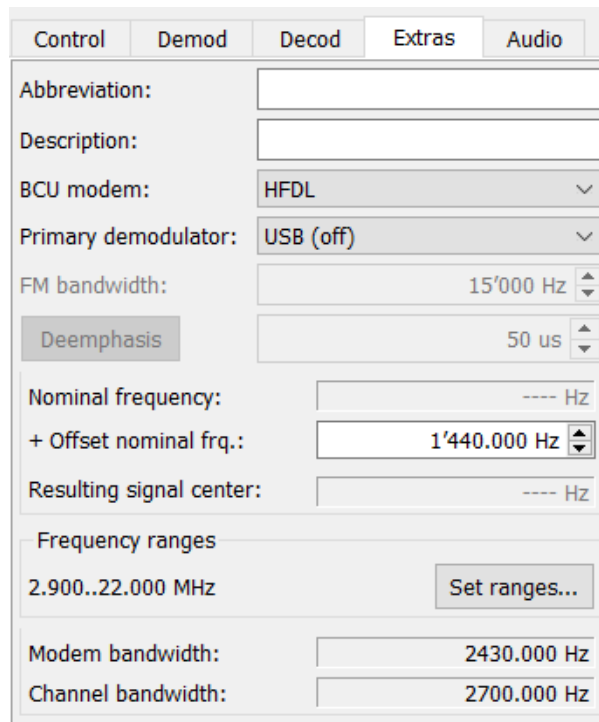
Figure 98: Decoder - Parameters - XML Editor

4.14.4.6. Protected Decoders

Specific decoders may be subject to license restrictions, i.e. they are protected and can only be run if the required license is installed. As no source code is available for these decoders, it is impossible to view or change them by using the decoder editor.

4.14.5. Extras Setting

The <**Extras**> tab features modem parameters that are impossible to assign to any demodulator or decoder parameters. The following table describes these general modem parameters:

Figure 99: Modem Parameter Setting Extras tab

4.14.5.1. Abbreviation

Defines the abbreviation of the modem. The maximum input is 5 characters.

4.14.5.2. Description

A short description of the modem. This description will be shown in the dialog which appears when "New Modem" is selected.

4.14.5.3. BCU modem

Stores the corresponding BCU (Broadband Classification Unit) modem in the APC modem. This information is used by other Procitec products in broadband classification so that the corresponding APC modem can be triggered if the BCU modem is successfully classified.

In the APC modem file, an ID is stored under the XML tag <MatchingBCUModem>, which is assigned to exactly one BCU modem. The assignment of the ID to the BCU modem name can be found in the file "bcumodemlist.xml" in the go2DECODE installation folder. To create your own assignments, it is possible to copy the XML file to the user directory under go2SIGNALS/go2DECODE<version > and adapt it accordingly. After restarting go2DECODE, the modified list is loaded and can be selected in the <**BCU modem**> field.

4.14.5.4. Primary Demodulator

Type of primary demodulation (USB(off), LSB, AM, FM). The primary demodulation will be applied first before the actual demodulation starts.

4.14.5.5. FM Bandwidth

Assumed bandwidth when FM primary demodulation is selected (usually this is in the range of 12..15 kHz)

4.14.5.6. Deemphasis

Most FM systems use a system of emphasis where the higher frequencies are increased in amplitude before the modulation off the carrier. At the receiver, the higher frequencies must be deemphasized in order to recover the original baseband signal. This is done by activating <**Deemphasis**>.

You have to enter a value for the time constant used for de-emphasis. In most countries 50 μs are used. In the US and South-Korea 75 μs are common.

4.14.5.7. Nominal Frequency + Offset nominal frq.

An offset is used to adjust a deviation from the theoretical, nominal frequency for the current modem. The resulting frequency is used in the demodulator. This feature requires that the parameter Signal Search on the <**Control**> tab is set to Nominal frequency.

In case of an AM or a FM primary demodulation this parameter denotes the offset between the AM/FM carrier and the actual signal that contains the secondary modulation.

4.14.5.8. Resulting signal center

This shows the assumed center frequency depending on the Nominal frequency and Offset nominal frequency. The value depends on the demodulator setting. In case of a single channel signal, nominal and center frequency are usually identical. Well-known exceptions can be found in the literature or the decoder datasheets. In case of a multichannel signal, the nominal frequency is most of the times the frequency of the first (lowest frequency) channel.

4.14.5.9. Frequency ranges

This shows the overall frequency range (min..max) where this modem is active. The modem will be excluded from search in recognition mode if its frequency range does not match the input signal. When hovering over the label a tooltip will show all the defined frequency ranges. The button <**Set ranges...**> opens a dialog to define the frequency ranges.
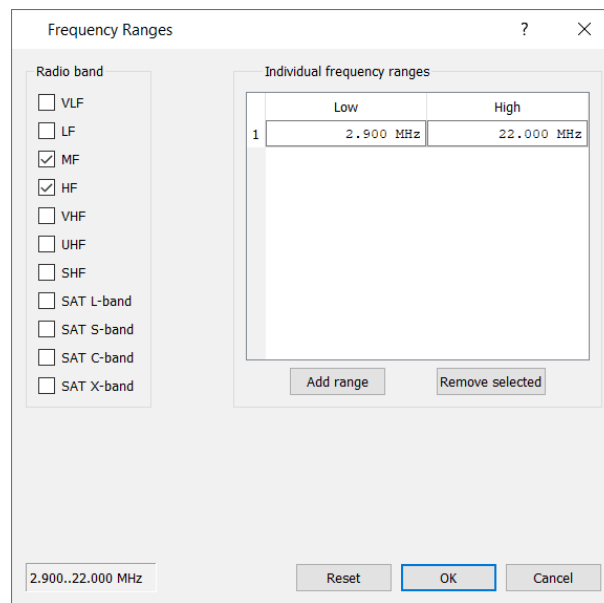
Figure 100: Frequency ranges dialog

On the left side of the dialog window is a list of possible radio bands where the modem is active. A radio band is a frequency range between two defined limits, e.g. 3..30 Mhz for HF. The definitions are according to ITU except the satellite (SAT) bands. A tooltip of every radio band checkbox indicates its frequency limits. More than one radio band can be selected if necessary.

If the limits of the set radio bands are too broad or if it is necessary to exclude some ranges then it is possible to define one or more individual frequency ranges in the table on the right side of the dialog. These individual ranges will overwrite the frequency settings of the defined radio bands.

In the lower left corner is the overall frequency range (min..max) shown where this modem is active and which is a summation of all set radiobands and/or individual frequency ranges. This range depends on the current settings and is updated if any changes are made.

- <**Reset**>: remove all defined frequency ranges and radio bands. Modem has then no frequency range restrictions.
- <**Cancel**>: discard all changes and close dialog.
- <**OK**>: accept all changes and close dialog.

If any of the parameter settings are invalid then the <**OK**> button is disabled and an error message is shown. As soon as the issue is resolved the <**OK**> button is reenabled.

4.14.5.10. Modem bandwidth

This field shows the bandwidth of the selected modem. The value is automatically calculated depending on the demodulator type and its current parameters. Primary modulation is taken into account. It is not possible to change the value but it is saved in the modem file.

4.14.5.11. Channel bandwidth

This field shows the minimum channel bandwidth that is required for proper demodulation and to allow symbol rate and frequency corrections. If the input signal has less bandwidth then this modem is automatically disabled. The value is automatically calculated depending on the demodulator type and its current parameters. It is not possible to change the value but it is saved in the modem file.

4.14.6. Audio Setting

The <**Audio**> tab shows parameters for the audio output of signals (signal type IF unbuffered).
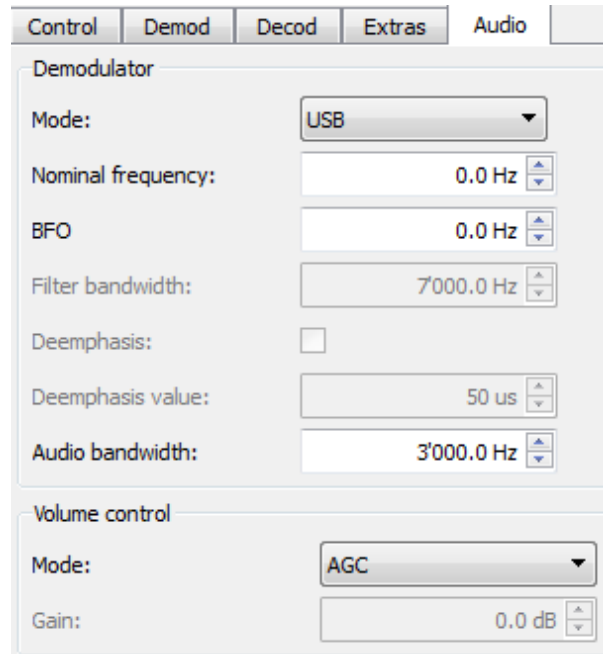
Figure 101: Audio Parameters

To activate Audio Out, click the speaker icon [icon] on the toolbar or use the menu item <**Extras**><**Audio Out**>.

4.14.6.1. Mode

Operating mode of the voice (audio) demodulator

- USB
  Upper one-side band amplitude modulation

- LSB
  Lower one-side band amplitude modulation

- AM
  Two-side band amplitude modulation

- NFM / WFM
  Narrowband and broadband frequency modulation. The bandwidth can be set via the parameter Filter Bandwidth.

- FM-USB
  Frequency modulation, contains several embedded signals (FDM). The single channel to be listened to can be selected with the help of the parameters Offset and Audio Bandwidth. Single channel is in USB mode.

- FM-LSB
  Frequency modulation, contains several embedded signals (FDM). The single channel to be listened to can be selected with the help of the parameters Offset and Audio Bandwidth. Single channel is in LSB mode.

- Digital
Digital voice, depends on modem

4.14.6.2. Nominal Frequency

Defines the frequency of the audio signal to be listened to (Hz). This is the center frequency for AM and FM signals, respectively the upper and lower frequency for one-side-band modulated signals.

4.14.6.3. BFO

Defines the frequency of the oscillator used to create an audible frequency signal for one-side-band modulated signals (mode USB, LSB) (Hz).

4.14.6.4. Offset

Defines the frequency offset of the single channel in case of the operating mode FM-USB/FM-LSB.

4.14.6.5. Filter Bandwidth

Defines the bandwidth of FM signals (NFM / WFM and FM-USB/FM-LSB mode only) (Hz).

4.14.6.6. Deemphasis Check Box

All FM systems adopt a system of emphasis where the higher frequencies are increased in amplitude before being used to modulate the carrier. At the receiver, the higher frequencies must be deemphasized in order to recover the original baseband signal. This is done by activating <**Deemphasis**>.

4.14.6.7. Deemphasis

Defines the time constant used for de-emphasis. For European FM radio, this is usually 50μs and for US radio 75μs.

4.14.6.8. Audio Bandwidth

Defines the bandwidth of the demodulated audio signal to be listened to (Hz)

4.14.6.9. Digital Channel

Only available in mode Digital. Either four channels will be replayed simultaneously or only the selected channel. The availability of the individual channels depends on the modem and the actual input signal.

4.14.6.10. Volume Control Mode

Defines whether to use automatic (AGC) or manual (MGC) signal amplification.

4.14.6.11. Gain

Defines the gain in MGC mode (dB)

Note: <**Nominal frequency**> and bandwidth can either be set in the corresponding spin boxes or they can be adapted in the sonogram display by dragging the lines in the display with the mouse.

4.14.7. Control Frequencies

The various control frequencies for signal search (search range, center frequency, nominal frequency) which are described in chapter Control Settings can be visualized in the Spectrum/Sonagram display. This makes it necessary to check "Show control frequency" in the context menu. Dependent on the operating mode (modem recognition, production) and the strategy for signal search one or several white markers will appear in the display. These markers are coupled with the corresponding input fields, so that a movement of these markers with the mouse induces a change of the values in these fields and vice versa.

Note: The markers are only visible for the input signals "IF unbuffered" and "IF input". The markers in the spectrum display are always visible and cannot be moved with the mouse.

4.14.7.1. Frequency Range

If signal search is set to Frequency Range and the operating mode Modem Recognition (automatic mode) is selected then the frequency range in which the APC looks for signals is displayed as a hatched area in the Spectrum/Sonagram display. In addition, the center of the search range is indicated with another marker that exhibits the actual receiver frequency at the bottom.
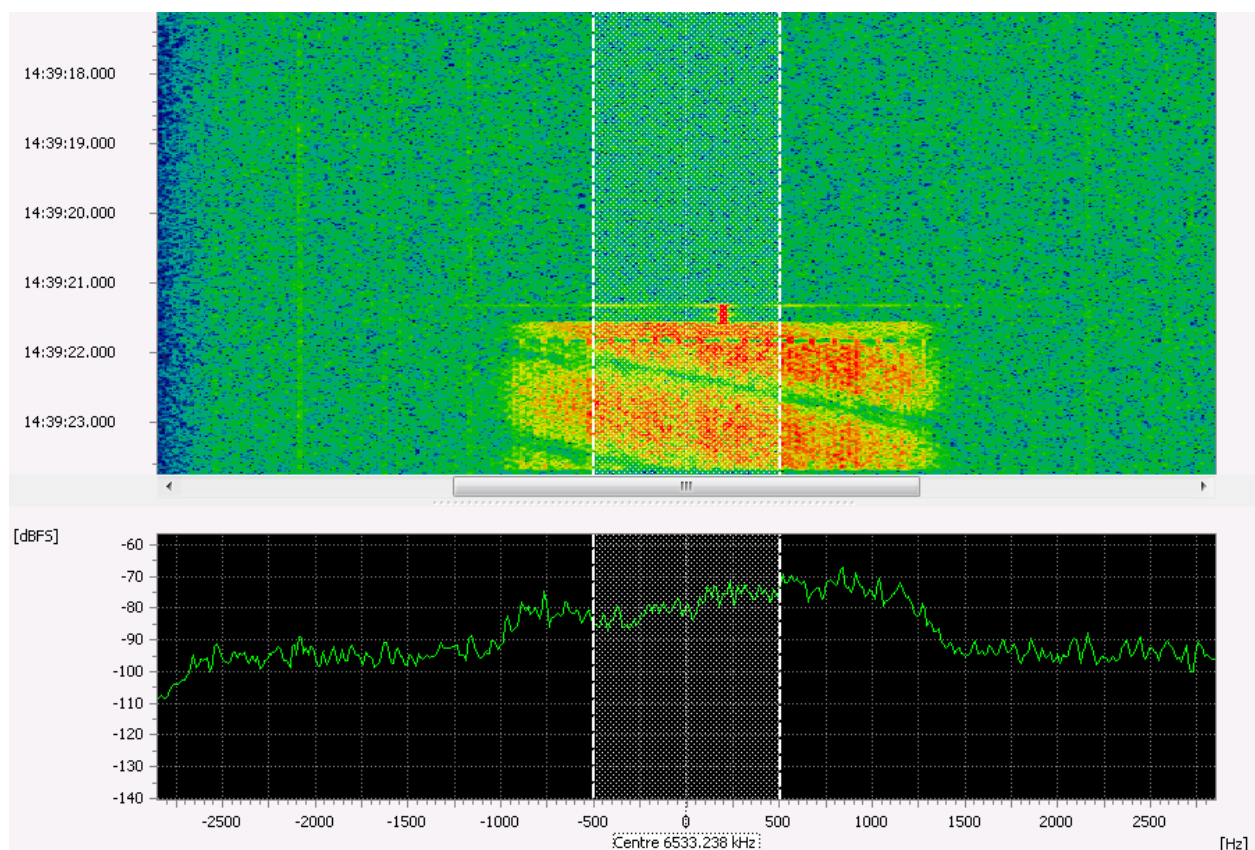
Figure 102: Spectrum/Sonagram with frequency search range and operating mode modem recognition

The search range can be moved with the mouse as a whole if it is "grabbed" in the center. But the upper and lower limit can be moved separately, too.

Furthermore, it is possible to set the search range even if "Show control frequency" is not checked in the context menu. For this purpose, select an area with the mouse in the sonagram display (selection along time axis is irrelevant) and then select "Set frequency search range" from the context menu. It is required that the signal processing is stopped during this action.

If the operating mode is switched to Production then only a marker for the center frequency will be visible. Because in manual mode no segmentation and thus no frequency search is carried out.
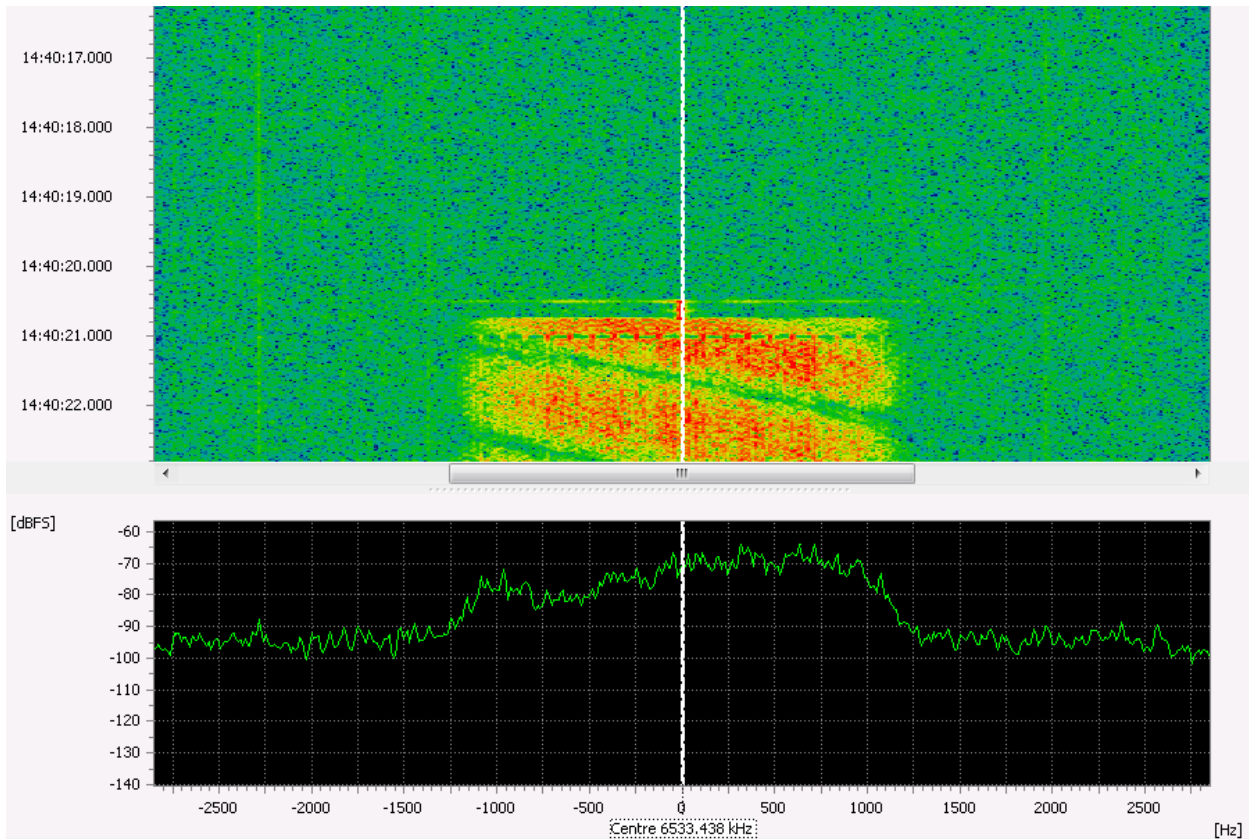
Figure 103: Spectrum/Sonagram with frequency search range and operating mode production

4.14.7.2. Nominal Frequency

If signal search is set to Nominal Frequency then the type of marker that is shown in the Spectrum/ Sonagram display changes wether signal processing is started or stopped.

If signal processing is running then only a single marker that indicates the global nominal frequency is visible. Again, the marker exhibits the actual receiver frequency at the bottom.
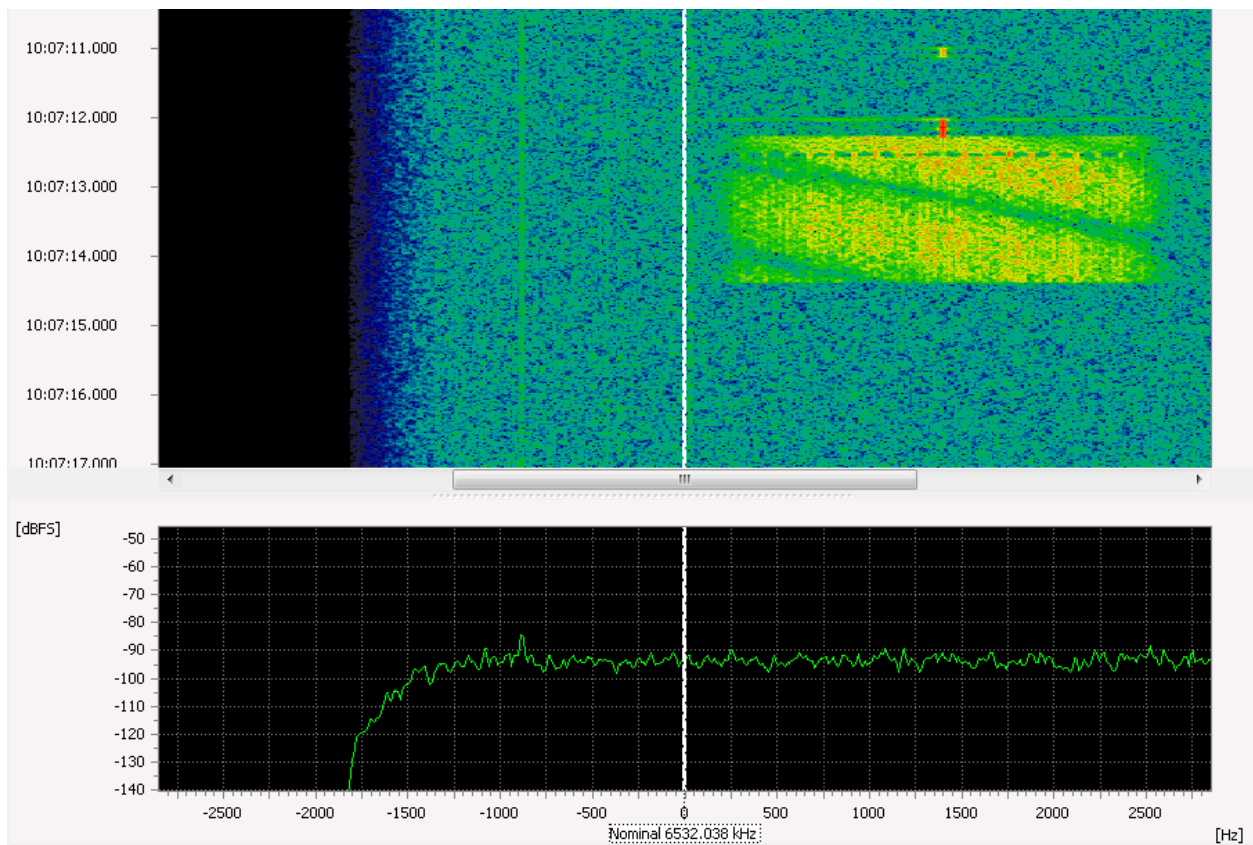
Figure 104: Spectrum/Sonagram with nominal frequency and operating mode modem recognition if signal processing is running

If signal processing is stopped then besides the global nominal frequency that is valid for all modems in the list another marker indicates the center frequency of the currently selected modem. In this case the offset nominal frequency specified in chapter Nominal Frequency + Offset nominal frq will be taken into account. To clarify which modem is actually selected its name will be shown in the sonagram display next to the marker.
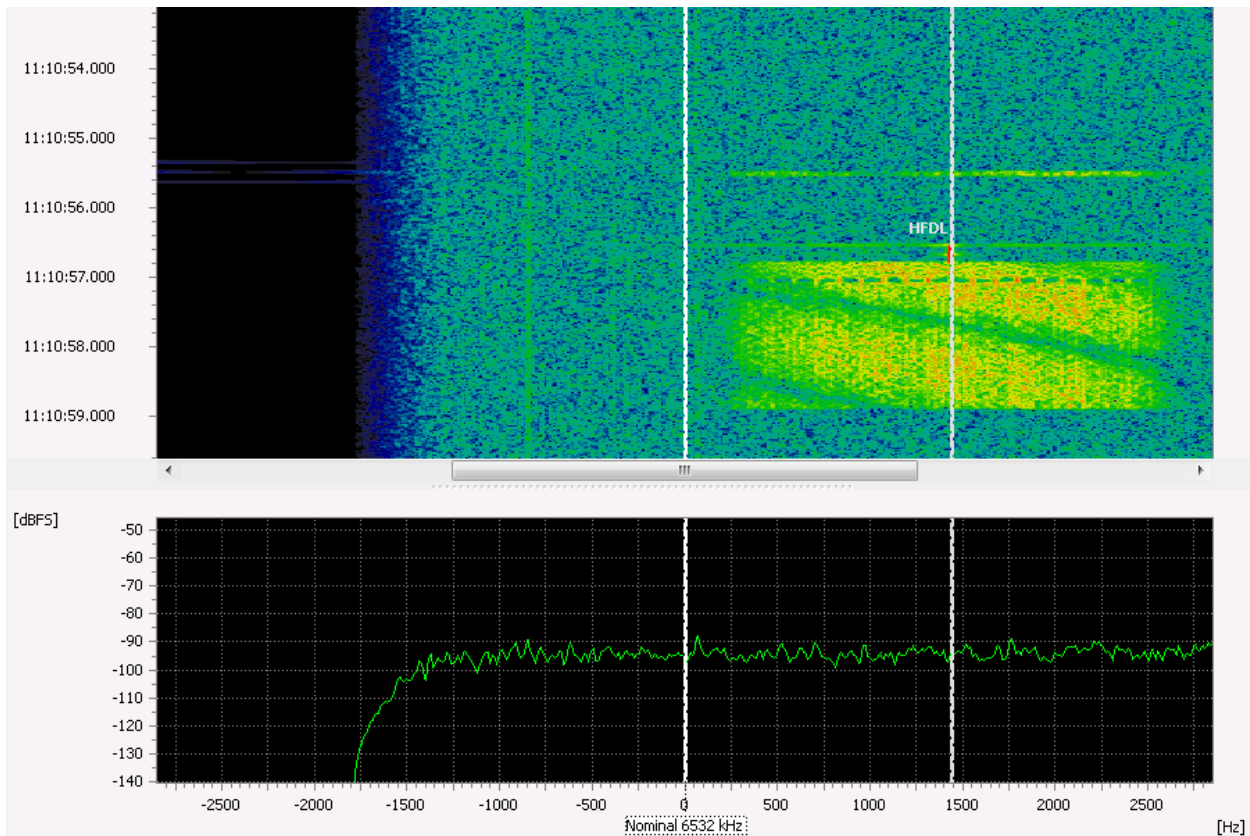
Figure 105: Spectrum/Sonagram with nominal frequency if signal processing is stopped and a single channel modem is selected

If the currently selected modem is a multichannel/multitone modem or one with a FSK demodulator then besides the center frequency all channels/tones will be marked with a single vertical line.
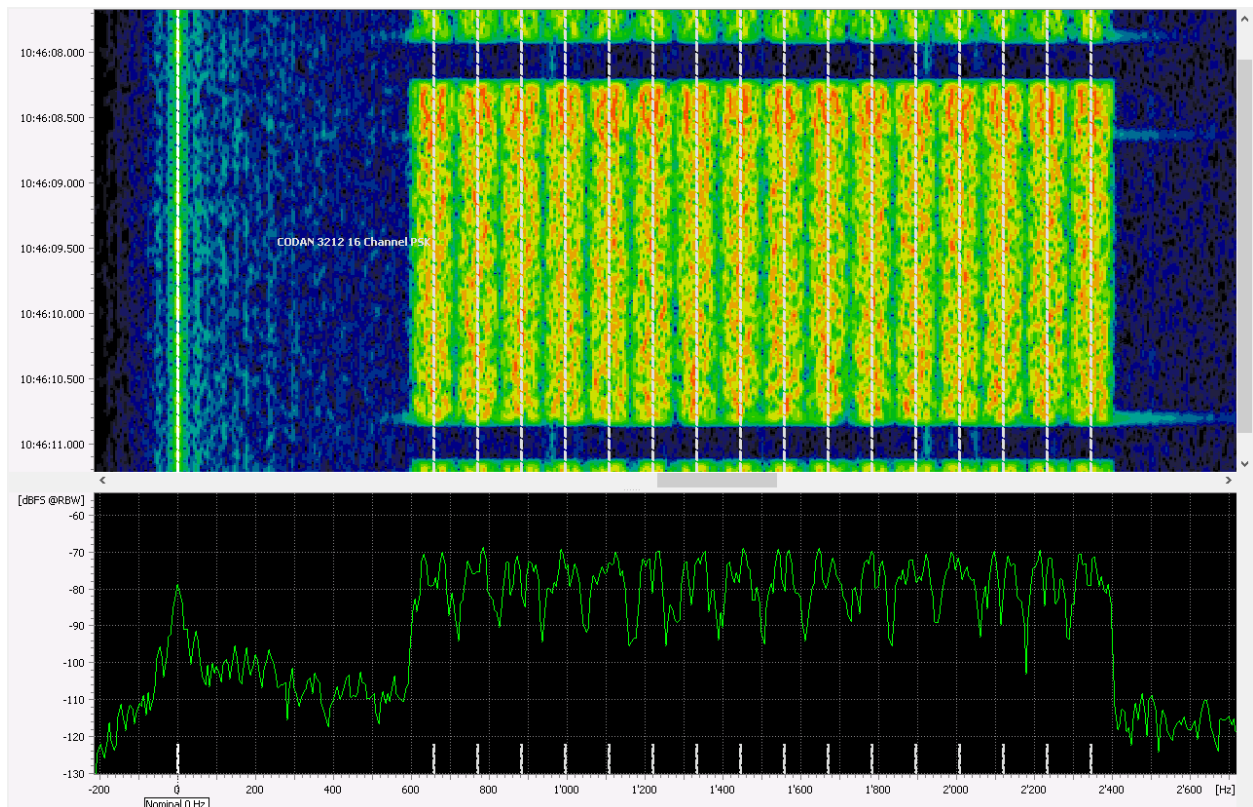
Figure 106: Spectrum/Sonagram with nominal frequency if signal processing is stopped and a multichannel modem is selected

4.15. SDA Signal Displays

The signal displays have numerous different tasks depending on the operating condition of go2DECODE.

When modem recognition is enabled, the displays serve to monitor the input signal and to verify the result. In production (either the APC has recognized a modem and switches from search to production mode or the manual production is enabled) all display functions are enabled, such as:

- Monitoring of the input signal

- Measuring of signal parameters, for example modulation type, symbol rate, modulation order

- Quantification of the signal and demodulation quality

- Identification of the modem parameters in the signal as well as in the demodulated bit stream

4.15.1. Displays and Signal Types Available

The following displays are available:

Display	Application
Spectrum / Sonagram	Monitoring of input signal, measuring of bandwidth, measuring of signal start or signal end, burst length measuring, measuring of the shift in FSK, etc.

Display	Application
Spectrum	Frequency and level measuring (resolution to MHz range), quadrature for identification of PSK signals etc.
Autocorrelation Display	Find repeating patterns in a signal (training sequences) or determine the channel distance of multichannel PSK or OFDM signals.
Constellation Display	Determination of the version in PSK, modulation order in PSK/QAM, etc. The function difference phase produces a vertical display, even if the parameter setting for the signal center is not perfect.
Eye Pattern Display	Verification of the symbol rate.
Time Display	Analyzing the signal (amplitude, phase, current frequency) in the time domain (oscilloscope)
Analysis Display	Simultaneous magnitude, frequency and phase measuring
Hell Display	Identification of frames, patterns, etc. by means of the intermediate results of a demodulator, as well as measuring of the symbol rate.
Bit Display	Identification of frames, patterns, synchronous words, etc. of the demodulated signals

Table 52: Display Types

Figure 107: Examples of Signal Analysis

4.16. Signal processing with the SDA

Signal processing is done in several steps.

- Recording of the signal (A/D conversion, sound card, WAV file, etc.)
- Filtering
- Demodulation
- Decoding

Each step supplies temporary results (for example internal IF signals, demodulated bits, etc.) which can be selected as a signal to be displayed in order to verify the processing or to analyze the signal information. Each display is adjusted separately by means of the Input Signal parameters.

The following table explains the different input signals:

Input Signal	Description
IF unbuffered	Intermediate frequency before being stored into the short term memory as received from the signal source. Used to check the input signal.
IF input	Intermediate frequency at the input of the signal processing unit. Used to check the input signal. Signal times depend on the internal detection of the signal and identification of a modem in the APC.
Primary demod. AM/FM I	After AM/FM primary demodulation (only available if primary demodulation is selected)
IF reduced	Additional internal intermediate frequency. The bandwidth of the signal has been roughly adapted according to the selected symbol rate. Used to check the demodulator setting.
Channel	The signal after the channel filter of the respective demodulator. Only signal relevant signal components are available. Also used to check the demodulator settings.
AGC | AFC	QAM and PSK demodulators have a frequency control (AFC) and a level control (AGC) whose function can be checked by means of this input signal.
Magnitude	Amplitude demodulated input signal (AM). Shows the energy loss of the signal.
Difference magnitude	Especially the FSK2 matched demodulator uses two channels and therefore has two AM signals. The difference between these two signals can be verified using this input signal.
Phase	Phase demodulated input signal (PM).
Frequency	Frequency demodulated input signal (FM).
Filtered magnitude	Filtered amplitude demodulated input signal.
Filtered difference magnitude	Difference between the two filtered AM signals.
Filtered frequency	Filtered frequency demodulated input signal.
Symbol decision	Signal prepared for symbol decision
Symbol rate	Symbol rate pins of the samples as input signal
Equalizer	The equalizer identifies and calculates distortions from the channel signal. Used to check the equalizer.

Input Signal	Description
Symbols	Output of the demodulator

Table 53: Input Signal Parameters

The analysis of the intermediate signals after the individual process steps not only serves to check the demodulator functions but also enhances the range of available analyzing methods. For example, periodical fluctuations in the signal energy (and thus the symbol rate) can be measured using the input signal magnitude with the help of the spectrum. Another example is to use the input filter of the demodulator. The input signal can be used for the separation of the signal to be analyzed from a signal mix (elimination of distortions).

The availability of the input signals depends on the demodulator selected, as some demodulators will not calculate every signal, and some displays cannot display every signal. If a signal is of complex type, e.g. IF Unbuffered, then the real part (I) and imaginary part (Q) are available, too. The following table shows the possible combinations.

Input Signal ↓ / Display →	Spectrum / Sonagram	Spectrum	Autocorrelation	Constellation	Eye Pattern	Time	Analysis	Hell	Bit
IF Unbuffered I resp. Q					+	+		+	
IF Unbuffered	+	+	+	+			+		
IF Input I resp. Q					+	+		+	
IF Input	+	+	+	+			+		
Primary demod AM/FM I	+	+	+		+	+			
IF reduced I resp. Q					+	+		+	
IF reduced	+	+	+	+			+		
Channel I resp. Q					+	+		+	
Channel	+	+	+	+			+		
AGC | AFC I resp. Q					+	+		+	
AGC | AFC	+	+	+	+					
Magnitude	+	+	+		+	+		+	
Diff. Magnitude	+	+	+		+	+		+	
Phase					+	+		+	
Frequency	+	+	+		+	+		+	

Display → Input Signal ↓	Spectrum / Sonagram	Spectrum	Autocorrelation	Constellation	Eye Pattern	Time	Analysis	Hell	Bit
Filtered magnitude					+	+		+	
Filtered diff. magnitude					+	+		+	
Filtered Frequency					+	+		+	
Symbol Decision I resp. Q					+	+		+	
Symbol Decision	+	+	+	+					
Symbol Rate					+	+		+	
Equalizer I resp. Q					+	+		+	
Equalizer	+	+	+	+					
Symbols									

Table 54: Input Signal and Display Combinations

5. Details

5.1. PMO (Production Memory Observer)

PMO (**P**roduction **M**emory **O**bserver) is a tool to view the production results of the APC. It displays all decoder production results as well as AF and IF recordings and binary output files. The PMO interface displays the results and recordings in a clear structure and enables the user to select the specific date of the production of interest in order to view the desired recordings.

Note: The size of the folder where the APC stores its production results (the folder *mem_prod* in your corresponding user folder) grows in size with time. In particular, if you have many IF and AF recordings. If you are running short on hard disk space you should move some of the old folders (they are sorted by date) to another storage location. But you should never move or delete the *mem_prod* folder itself while the software is running.

5.1.1. Start of PMO

Launch it directly from <**Extras**> menu in SDA or from the start menu of your desktop.

5.1.2. Operation of PMO

5.1.2.1. Initial Configuration

After the installation of PMO the configuration file "pmo.conf" is filled.

Here you can specify which external applications are used to display individual results if you do not like the default settings:

- playing audio recording (default is Windows$^®$ Media Player)

- displaying decoder production results (default is MS WordPad$^®$)

- IF-files have to be played via DANA

If you want to use a Hex-Editor of your own choice, you have to modify the configuration file accordingly. At the first start of the PMO the configuration file is copied from the application-directory to the user-directory. Any change can be accomplished there.

```
<?xml version="1.0" encoding="utf-8" ?>

<configuration>

  <appSettings>
    <add key="LogLevel"            value="0" />
    <add key="LogProtocol"         value="0" />
    <add key="LogPerRun"           value="0" />
    <add key="LogMaxFileSize"      value="2" />
    <add key="LogMaxFileNumber"    value="5" />
 </appSettings>

  <common>

    <!-- Path to the APC that is to be observed. Default is PMO directory. -->
    <add key="APC_PATH" value="default" />

    <!-- Alternatively we can specify another production memory for fall back. -->
    <add key="MEM_PROD_PATH" value="undefined" />

    <!-- Alternatively we can specify if user can browse for production memory. -->
    <add key="MEM_PROD_PATH_BROWSE" value="0" />

    <!-- Refresh information about content of production memory every 50ms. -->
    <add key="UPDATE_INTERVAL" value="200" >/

    <!-- Two files with pause intervals < 500ms will be concatenated to one emission. -->
    <add key="INTERVAL_FOR_EMMISIONS" value="500" />

    <!-- WAV media player capable of playing '*.m3u' playlists -->
    <!-- Linux default is to use xdg-open -->
    <!-- Windows default is mplayer2.exe -->
    <add key="WAV_PLAYER" value="default" />

    <!-- RAW file player (DANA): default location is PMO directory -->
    <add key="RAW_PLAYER" value="default" />

    <!-- XML reader: -->
    <!-- Linux default is 'kwrite' if not defined by '\$EDITOR' or '\$VISUAL' -->
    <!-- Windows default is wordpad.exe -->
    <add key="XML_READER" value="default" />

    <!-- HEX reader: -->
    <!-- Linux default is to use okteta -->
    <!-- Windows default is ../3rd_Party/TinyHexer/mpth.exe -->
    <add key="HEX_READER" value="default" />

    <!-- complex WAV export -->
    <wavexport
      <add key="WAV_CONVERTER_1" value="./sovi"/>
      <add key="WAV_CONVERTER_PARAM_1" value=""/>
      <add key="WAV_CONVERTER_TEXT_1" value="Open in Sonagram Viewer"/>
    </wavexport>

  </common>

</configuration>
```

Figure 108: Initial Configuration

5.1.2.2. Features of PMO

The following dialog window is displayed:
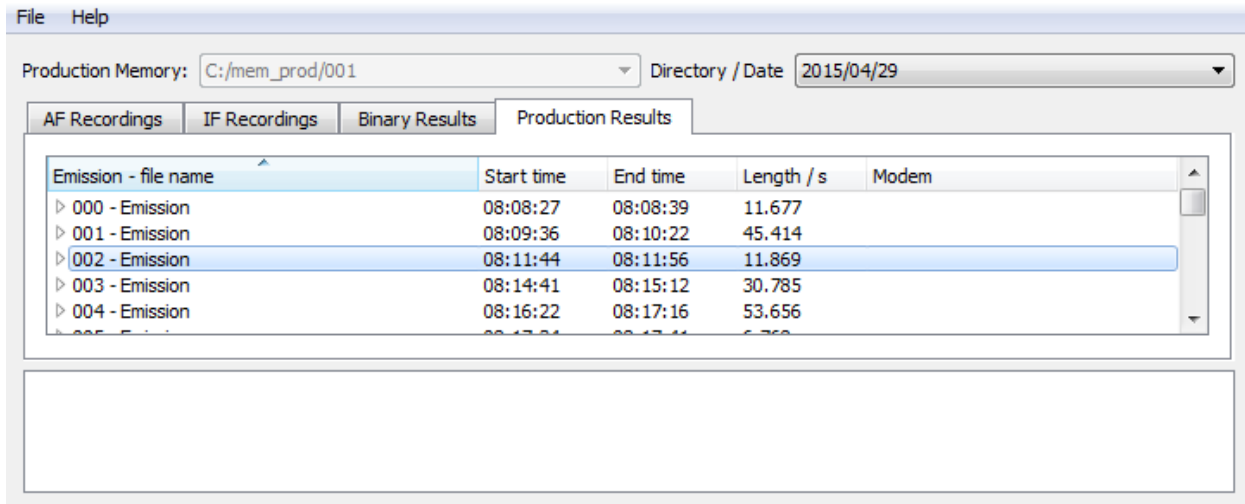
Figure 109: PMO User Interface

Select the desired date in /AuswahlDirectory / Date on the top right. The production results and recordings for this date are then shown in a tree structure on the three tabs <**AF recordings**>, <**IF recordings**>, <**Binary results**> and <**Production results**>. All files belonging to the same emission are stored in one folder. The recording time limit is configurable (APC configuration file "apc.conf") and the folders *XXX - Emission* may therefore contain several files.

The <**AF recordings**> tab shows the audio files (".wav") of the emission. These files are played back using the media player specified in the PMO configuration file.

The <**IF recordings**> tab shows the complex WAV files which can be replayed by DANA for further analysis. There is also the possibility to view the spectrum/sonagram of these files in the Sonagram Viewer application.

The <**Binary results**> tab features the binary output files from certain decoders, e.g. Pactor II. Depending on the individual decoder various file types are produced. In general, files with the extension ".bin" hold binary data and will be displayed in the Hex-Editor specified in the PMO configuration file (a simple Hex-Editor is part of the installation). Files with the extension ".xdat" are in XML format and hold information about the content of the binary files. This file type is displayed in the XML text editor specified in the PMO configuration file.

Finally, the <**Production results**> tab features the results in ".txt" format. These files are displayed in the text editor specified in the PMO configuration file.

The desired files are opened immediately in the dialog window. Double click the respective folder *XXX - Emission* to view the files available. Subsequently, to play the file, simply double click the respective file, or use the popup menu. Note that the media player will play all subsequent audio files, if any, once the first file played is finished.
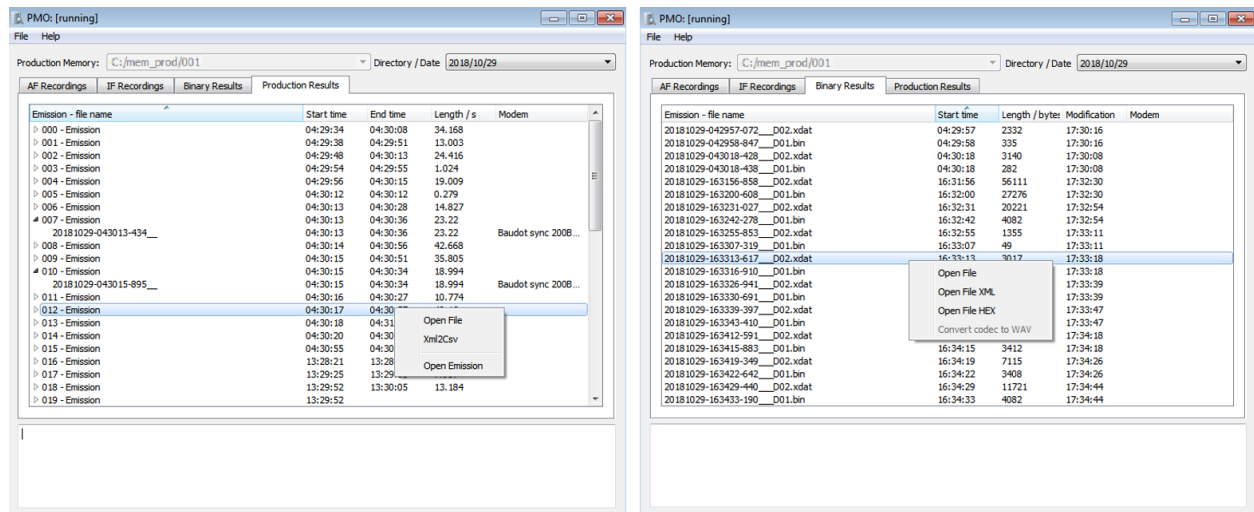
Figure 110: User Interface with Popup Menu

5.1.3. Control of PMO

The popup menu of PMO provides useful tools for playing, exporting, and file or emission handling. The menu items of the context menu depend on the file type and the tab in which the file is listed.
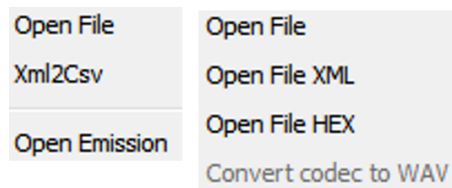
Figure 111: Popup Menu PMO

When you select the command <**Open file**>, the program opens the selected file or folder and offers additional options for further processing, depending on the file type. <**Xml2Csv**> converts Xml files in the CSV format that can be read by Microsoft® Excel. With <**Convert codec to WAV**> the files and emissions are converted from the ".codec" format to the ".wav" format.

5.2. Analysis of Unknown Signals

go2DECODE is an efficient tool for manual analysis and processing of unknown modulated signals. There are three different basic processing steps:

- •   Determine modulation parameters

- •   Demodulate signal

- •   Decode contents

The following table provides typical measuring and processing functions:

Symbol	Function
Spectrum / Sonagram	Input signal monitoring Bandwidth measurement Measurement of signal start or signal end Burst length measurement Measurement of shift with FSK
Spectrum	Frequency and level measurements Squaring to detect PSK signals
Autocorrelation Display	Identify repeating patterns (training symbols) or determine channel distance in multichannel signals. Helpful to distinguish technical signals from noise even under poor conditions.
Analysis Display	Determine modulation type (ASK, PSK, FSK) and modulation order
Constellation Display	Determination of type and modulation order with PSK/QAM. The function Difference Phase creates an upright display even if the parameters of the signal frequency have not been set exactly.
Eye Pattern Display	Measurement and control of symbol rate and signal quality
Time Display	Measurement of the time signal (oscilloscope)
Bit Display Hell Display	Detection of frames, patterns, synchronous words etc. in the demodulated data stream
Signal Memory	With a signal memory of 5 min, which automatically takes records in online mode, i.e. the last 5 min are available for analysis after switching to offline mode
Cursor Functions Harmonic Cursor	Measurements of time, frequency, amplitude, angle, level etc. This cursor allows for precise measurement of signals with equidistant contents (symbol rate, Harmonics etc.)
Universal analysis demodulator with free parameter setting	Processing of the signals down to bit level. The temporary results of the demodulator (AM demodulation, FM demodulation, filtered time signal, and many others) can be used immediately as an input for analysis displays (expanded analysis options, e.g. analysis with symbol rate, in the center of the symbols, via demodulated signal contents etc.)
Spectrum via AM demodulated time signal	Determination of the symbol rate with unknown signals (modulation type also unknown)
Universal, freely programmable decoder	Decoding of the demodulated data stream
Fast visualising (up to 1,000 FFT/s) and direct parameter editing	Assists in the processing of signals and gives the impression of an analogous measuring device

Table 55: Measuring and Processing Functions

5.2.1. Activate Manual Analysis

Apply the unknown signal to the input and start go2DECODE. The displays shown on application may vary depending on the current presetting (Autostart). Select the mode *Modem Recognition* and press the

<**Start**> button to start the signal flow. If not yet active, start the Spectrum/Sonagram Display to obtain an overview of the signal applied to the input.
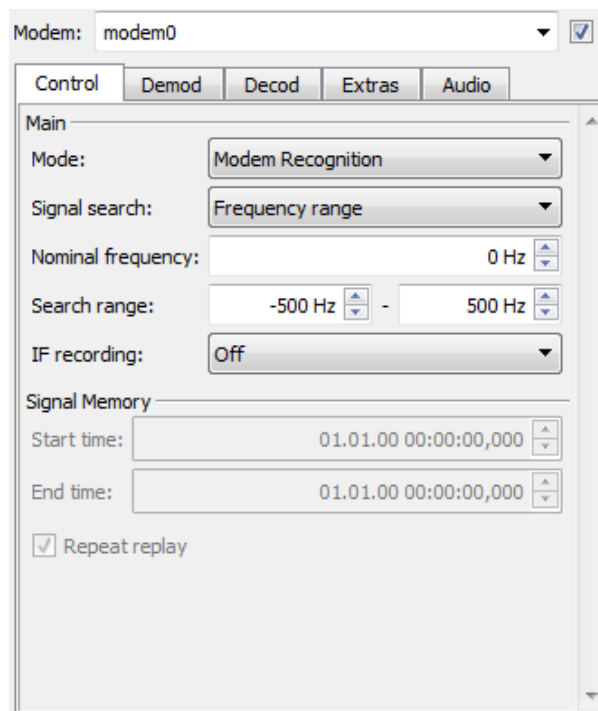
Figure 112: Control Tab on Property Sheet

Normally, a known signal will be demodulated and decoded automatically if the parameters have been entered into the knowledge base. Deactivate the automatic mode (Automat) to switch to manual processing. To do so, click the <**Control**> tab in the property sheet and select the mode *Production*.

We recommend to create a new (blank) modem to avoid unintentional modification of the stored modems. Select the menu item New modem on the Modem menu (the drop-down combo box now shows the default name *modem0*).

5.2.2. Analyze FSK Signals

The transmission of information with a 2-FSK signal takes place by switching between 2 frequencies, while only one frequency is active for a certain period of time. Therefore the needed parameters for demodulations are the distance between the two used frequencies and the symbol rate.

This paragraph describes typical methods for a manual analysis of FSK modulated signals. For this purpose, we shall use the example file "5-2_FSK_example.wav" stored in the directory *examples/analysis* in the go2DECODE directory and load the file in DANA. Click the button <**Start**> in DANA and go2DECODE to play the signal file and activate the check box <**Loop**> in DANA to repeat the signal continually.

The demodulators expect the signal frequency centered at 0 Hz. For analysis, DANA should therefore be set to the center frequency of the signal so that it appears in go2DECODE centered. In the case of the example signal, please set the parameter Frequency to 1800 Hz. This frequency is also stored in the example file and can be accepted by activating the checkbox <**IF from WAV file**>.

The premade modem list "5-2_FSK_example.cmf" and the configuration file "5-2_FSK_example.conf" for go2DECODE (to be found in the *examples/analysis* subdirectory of the go2DECODE install directory) allow a quicker entry into the analysis. First, the modem list should be opened via <**Modem List**><**Load Modem**

List>, then the configuration file via <**File**><**Load settings**>. Now you can see the sonagram with the corresponding spectrum and a separate spectrum display. The following sections mainly use these displays. The <**Windows**><**Split**> button assigns all available screen space to the graphs.

5.2.2.1. Adapt Display Area to Input Signal

There is a chance that the displayed spectrum of the signal is outside the adjusted display zone as shown in the following examples:
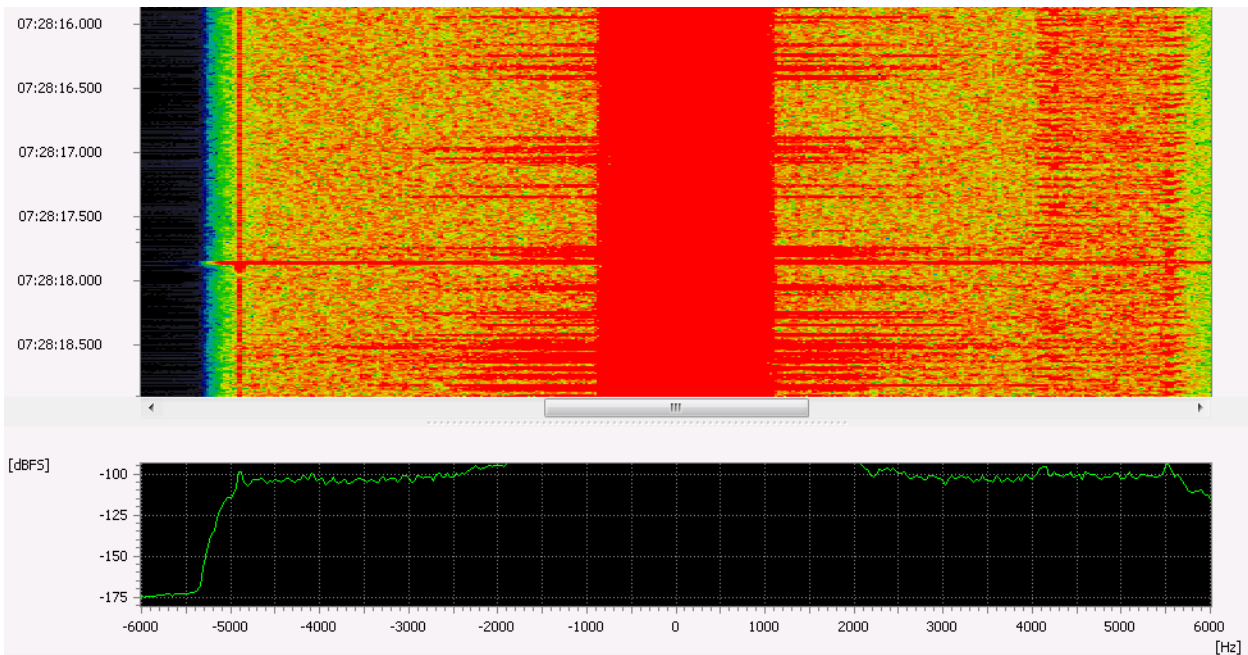
Figure 113: Display of an over modulated Signal

Inadequate scaling will cause the display of an over modulated signal where the signal characteristics will be impossible to view. Due to the inappropriate scaling, the signal can be hardly recognized in Figure 113 above as well as the insufficiently controlled signal in the following Figure 114.
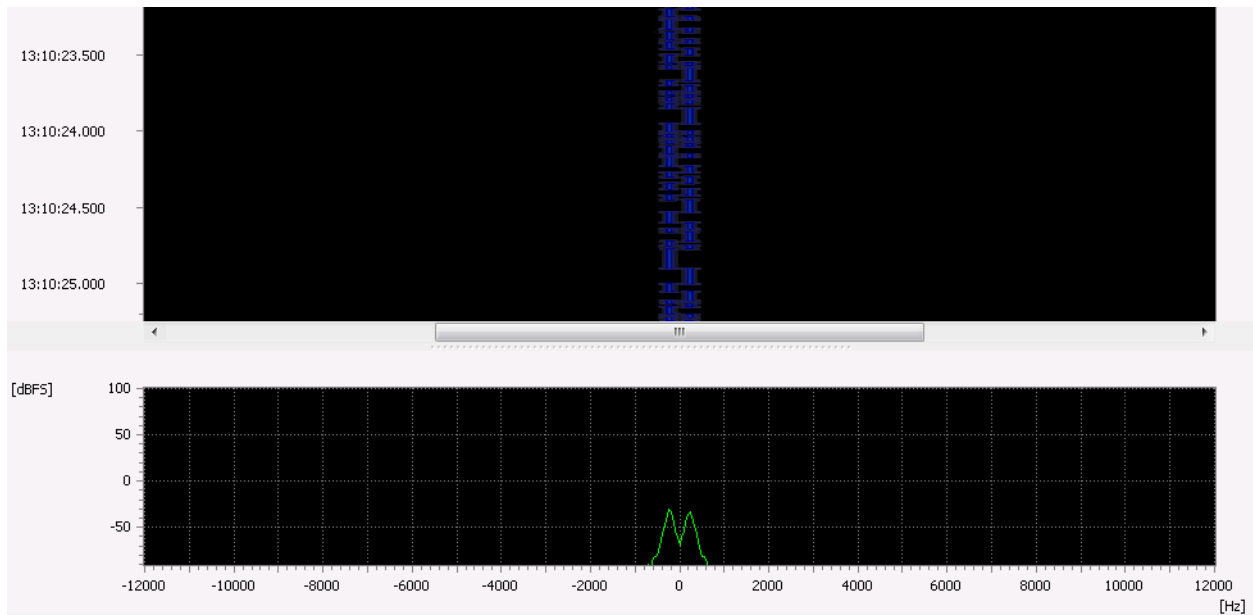
Figure 114: Display of an insufficiently controlled signal

Press the button <**Autorange**> to set the scaling automatically. This button is located at the bottom of the spectrum/sonagram display property sheet in Figure 115.

Figure 115: Spectrum/Sonagram Parameters Tab on Display Property Sheet

Subsequently, the spectrum/sonagram should have the appearance shown in Figure 116.
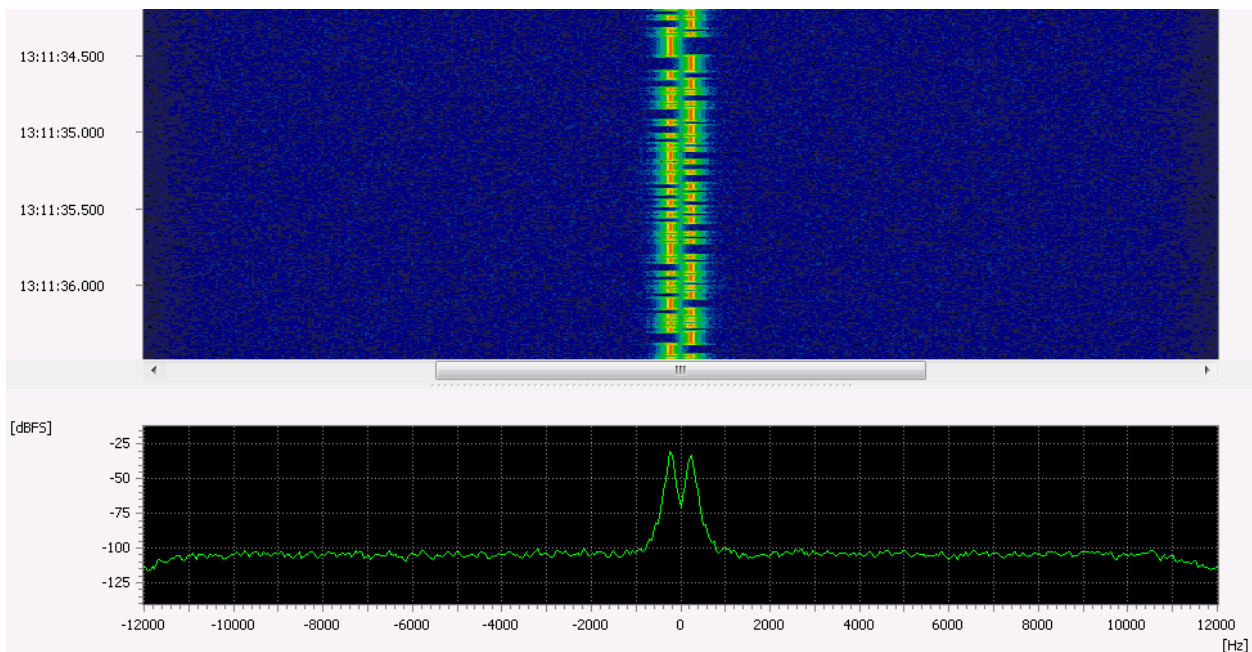
Figure 116: Corrected Scale

The FSK signal is clearly visible in symmetry with the origin. The noise level is -125 dBFS.

The demodulators expect to receive their signal in a symmetrical arrangement around the center (0 Hz). If the input signal is outside the center, adjust the signal by use of DANA (parameter Output Signal - Frequency). A coarse setting is sufficient to carry out the following analyzing steps.

5.2.2.2. Measure Signal Center and Shift

Activate the check box <**X-Cursor**> on the <**Cursor**> tab in the display control to obtain an enlarged view of the relevant areas of the spectrum as shown in Figure 117.
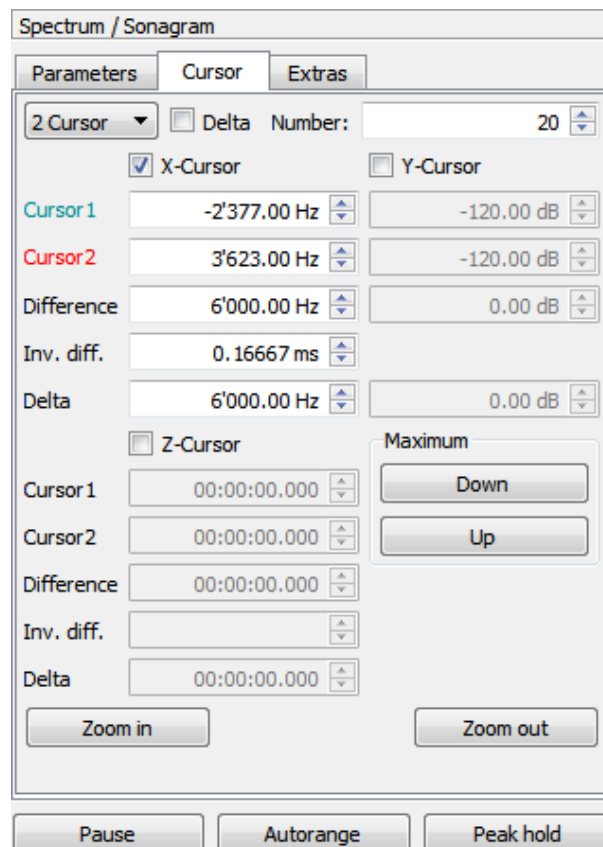
Figure 117: Cursor Tab on Display Property Sheet

Two cursor (red and green) will appear in the sonagram. Both can be freely positioned using the mouse (see Figure 118. Position one cursor each on either side of the signal, next press the button <**Zoom in**> on the <**Extras**> tab to obtain an enlarged view of the section delimited by the cursor. Repeat this process until the spectrum area displayed is satisfactory. Alternatively you can also navigate by marking the area with the mouse and clicking with the right mouse button in the marked area.
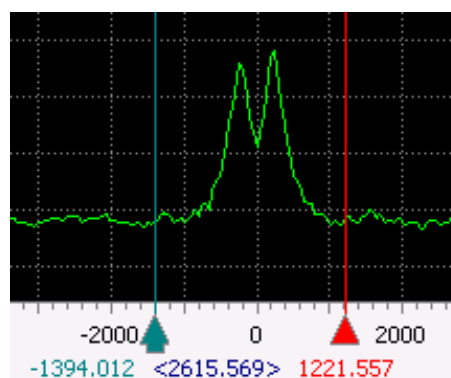
Figure 118: Two Cursor Positioned Around the Relevant Spectrum Area

The spectrum/sonagram now should resemble the display in Figure 119.
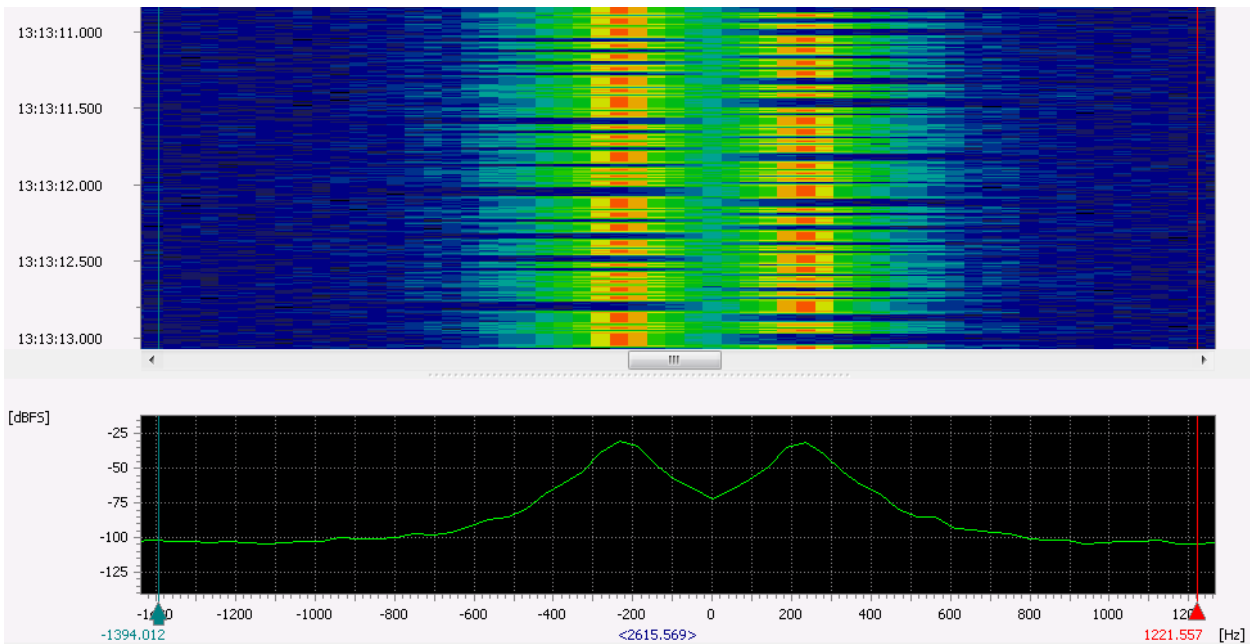
Figure 119: The Enlarged Spectrum has a Low Resolution

FFT Length 512

To improve the frequency resolution, increase the <**FFT length**> on the <**Parameters**> tab (exemplary values: 2048, 4096 or 8192). As expected, this is achieved at the expense of the quality of the time resolution, which will deteriorate (the blanking of the signal is impossible to recognize in the sonagram).
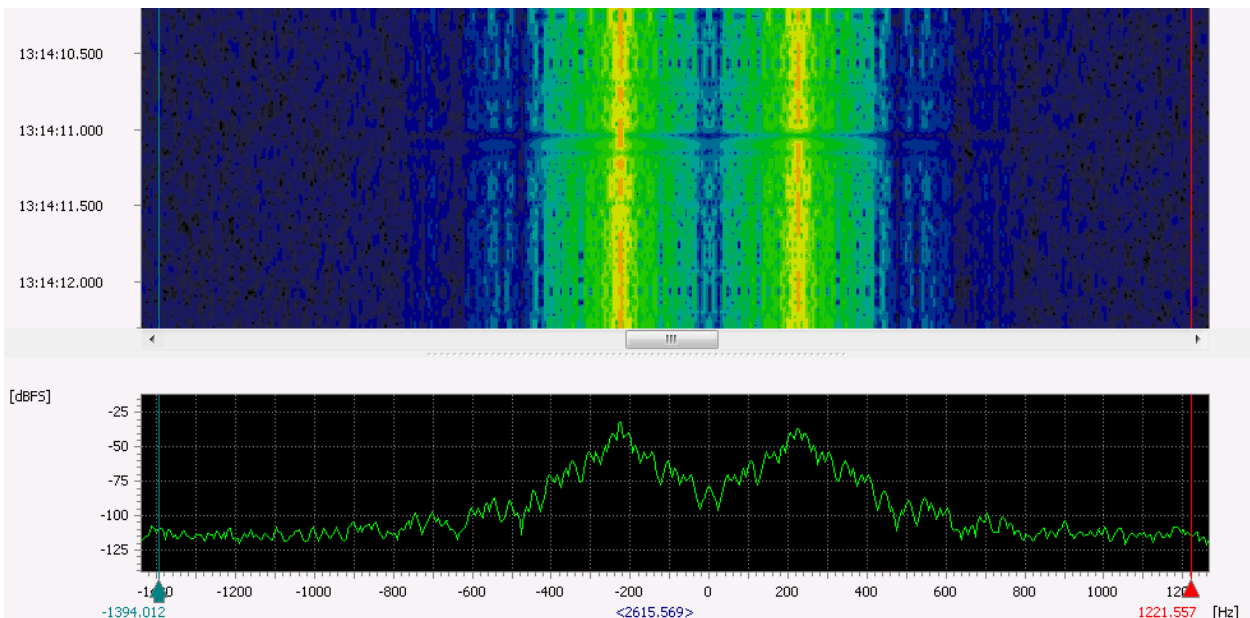
Figure 120: Increased Spectrum Resolution

FFT Length 4096

The so-called 'shift' is the distance between the two exterior shift-keying frequencies (strong signal peaks). Activate the button <**Peak hold**> on the property sheet to localize the exact position of the peaks and to measure the distance between them.

A red line is created every "n" seconds, depicting the maximum amplitudes. The length of this time interval can be adjusted manually in the spin box <**Peak hold time**> on the <**Extras**> tab, if necessary.

Place one cursor each on the maximum positions. Read out their exact positions and distance on the frequency axis:
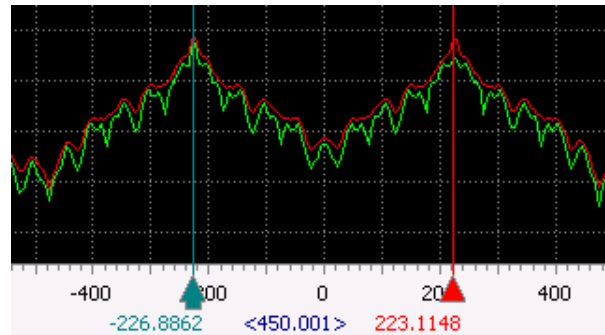
Figure 121: Spectrum with Peak Hold Curve

Consequently, the shift is of 450 Hz approx., which supplies the second demodulation parameter.

5.2.2.3. Determine Symbol Rate in Sonagram

Due to the time resolution, measuring the symbol rate in the sonagram display will only make sense with low symbol rates (<100 Bd).

Expand the window by dragging the lower margin downwards with the mouse for optimum working conditions.

Since the measuring of the symbol rate will not require a precise frequency resolution, set the FFT length to a value at which the symbols are clearly recognized. In Figure 122, said value is 512.

The number of rows created per second must be increased considerably to allow for visual recognition of the time shift between the two frequencies. This is achieved by changing the value in the spin box <**Lines / second**> on the <**Parameters**> tab. Appropriate values would range e.g. from 600/s to 1000/s.

Press <**Pause**> The screen should now resemble Figure 122.
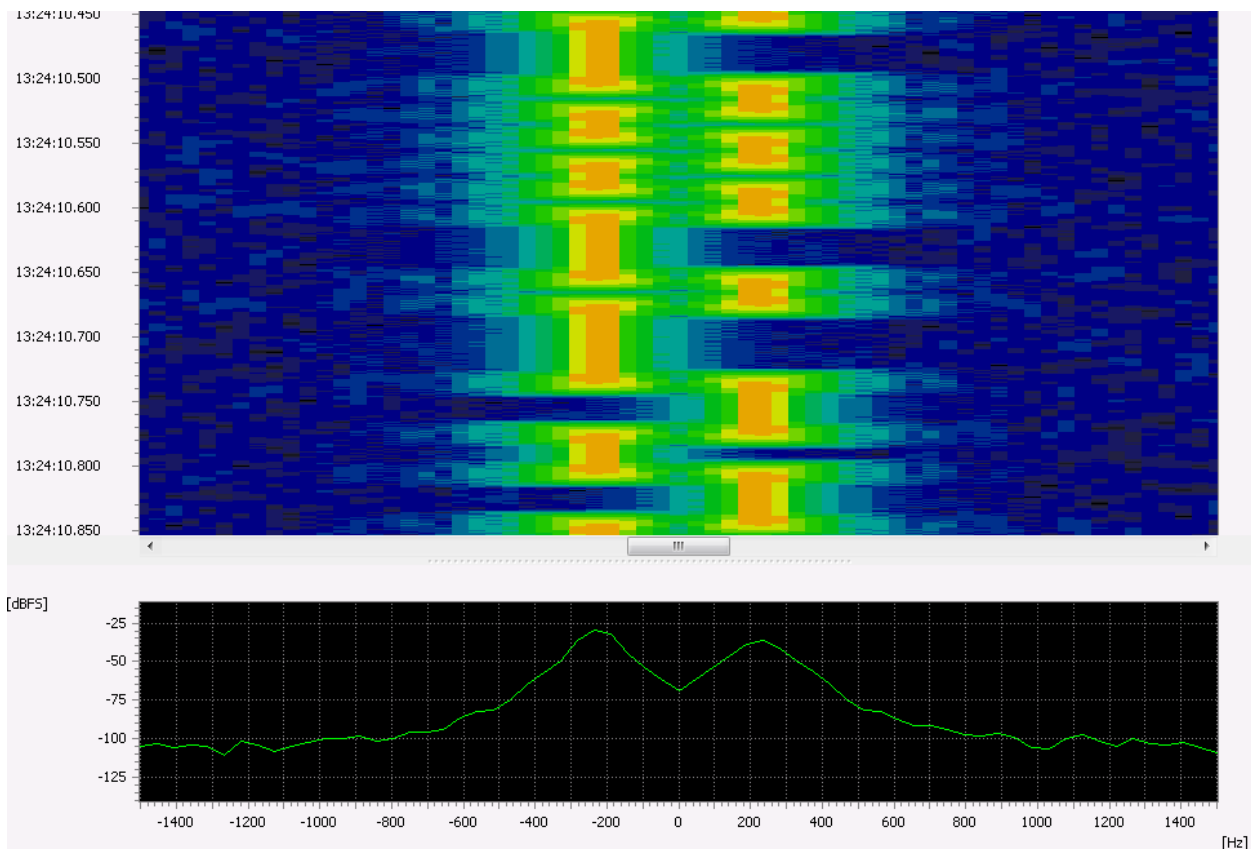
Figure 122: Zoom in of the Spectogram

The sonagram has been expanded. The number of rows created per second has been increased considerably. The exact shift between the frequencies can clearly be seen.

Now activate the check box <**Z-Cursor**> with the extension <**Harmonic**> on the <**Cursor**> tab. Additional red cursor will appear at equidistant distances to the green and the red cursor.
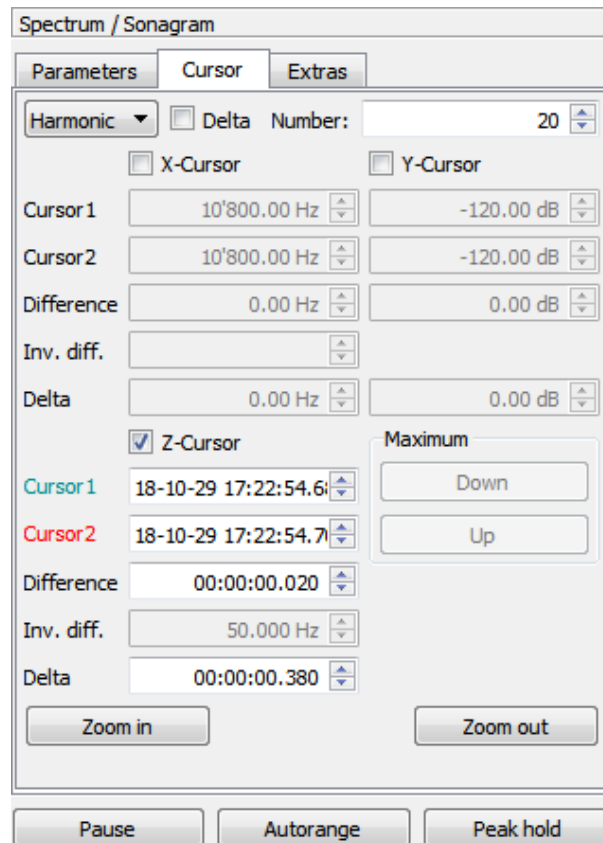
Figure 123: Cursor Tab on the Display Property Sheet

In Figure 123 the distance between two adjacent cursor is 0.020 s.

Drag these cursor to create a grid on the frequency changes. The distance between two cursor must exactly coincide with the shortest recognizable time as shown in Figure 124.
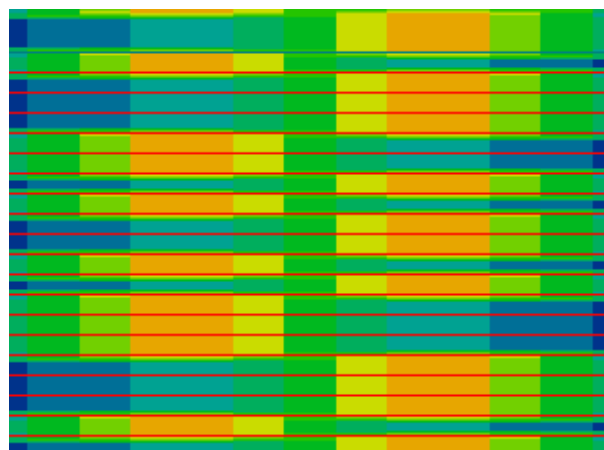
Figure 124: Frequency Response Characteristics with Grid Overlay

The frequency changes are now integrated into a grid. The shortest time is located exactly between the two cursor and corresponds to one bit.

Read out the distance between two adjacent cursor from the cursor positions on the X-axis or on the property sheet.

According to the formula: SR = 1 / T$_{bit}$, the symbol rate then is 50 Bd.

In the next step, return to the standard display without cursor and deactivate the button <**Pause**> on the property sheet.

Note: The display will not be updated while set to <**Pause**>. However, this will not affect the internal processing and the display in other windows. To suspend all processes currently active, click the button <**Stop**> on the <**Control**> tab on the property sheet.

5.2.2.4. Determine Symbol Rate by Spectrum via Envelope

Depending on the modulation type (typically with ASK, FSK, QAM, and many others), changes of symbols frequently coincide with abrupt energy decreases. When calculating a spectrum via the signal envelope, a peak or an abrupt decrease will occur on the location of the symbol rate, depending on the characteristics of the individual signal.

Signals that are suitable for input for the displays are generated in the demodulators. Consequently, the signal selection and the signal characteristics (bandwidth, scanning rate etc.) will be affected by the parameters of the demodulator.

To use the input signal *Diff. Magnitude* as an input as shown below, select the demodulator FSK2 matched. Enter the measured shift parameter and make a rough estimation of the symbol rate, or select a high value (e.g. 400 Bd).

This measuring process also can be carried out using the input signal *Magnitude* in the demodulator ASK2.

Open <**Spectrum**> via the toolbar. The entire frequency spectrum is displayed. As in all windows of this type, the characteristics of this display are shown on the property sheet.

Contrary to the sonagram, this option serves to select additional views via the drop-down list box *Input Signal* on the <**Parameters**> tab (see Figure 116. Select *Diff. Magnitude*. This display in Figure 125 will show a significant and abrupt energy decrease at the position of the Baud rate and multiples of it. Important is the correct setting of the center frequency. This can be checked with the signal *IF unbuffered* in the spectrum. The two signal peaks should be symmetrical around the frequency 0 Hz.
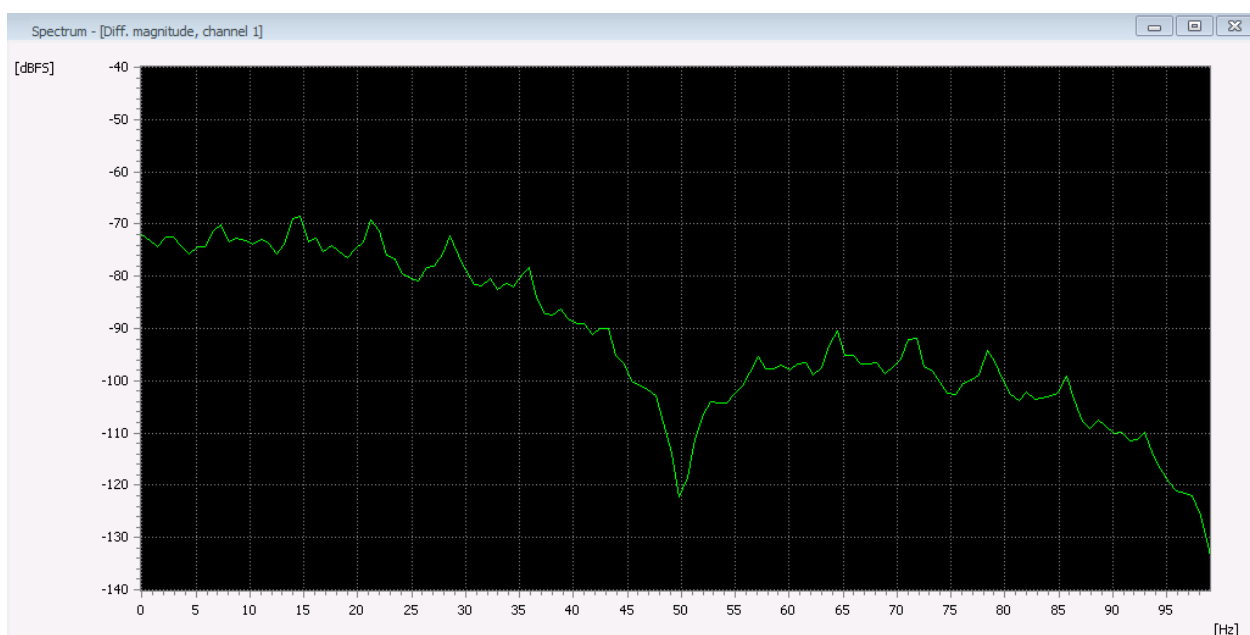
Figure 125: Spectrum over the Envelope Curve (Difference Magnitude) of the FSK Signal

The measuring accuracy can be increased by selecting a greater FFT length and by zooming in the range around 50 Hz (using the X-cursor).

Further, you may select another procedure alternatively: Enter 50 Hz as the <**Center frequency**> and 80 Hz as the <**Frequency range**> on the <**Parameters**> tab (see Figure 115. The spectrum will display the frequency range between 10 Hz and 90 Hz.

5.2.2.5. Determine Symbol Rate by Measurement in Time Signal

Another method is to measure the time interval between the symbols. This requires a demodulation of the signal, i.e. the appropriate modulation type must be known. The symbol rate can be roughly estimated but the parameter value entered must be equal to or greater than the actual value.

Select the demodulator to *FSK 2 matched,* enter the measured shift and a symbol rate of 200 Bd (intentionally a greater value). Select the display type Eye pattern display (on the <**Display**> menu or the toolbar) and the input signal *Diff. Magnitude.*

Difference magnitude is an intermediate step in demodulation, where the signal is demodulated still without knowing the symbol rate. However, the individual data bits are visible as a result. Therefore, a rough pre-selection of the symbol rate is required to prevent the demodulator from selecting too low a bandwidth for filtering and too low a scanning rate for the signal.

With strong noise or external signals, excessive bandwidths (greater symbol rate selected) may cause distortion signals to be visible in the difference magnitude.

Select a time interval for the eye pattern display permitting to recognize several symbols (in this case e.g. 400 ms):
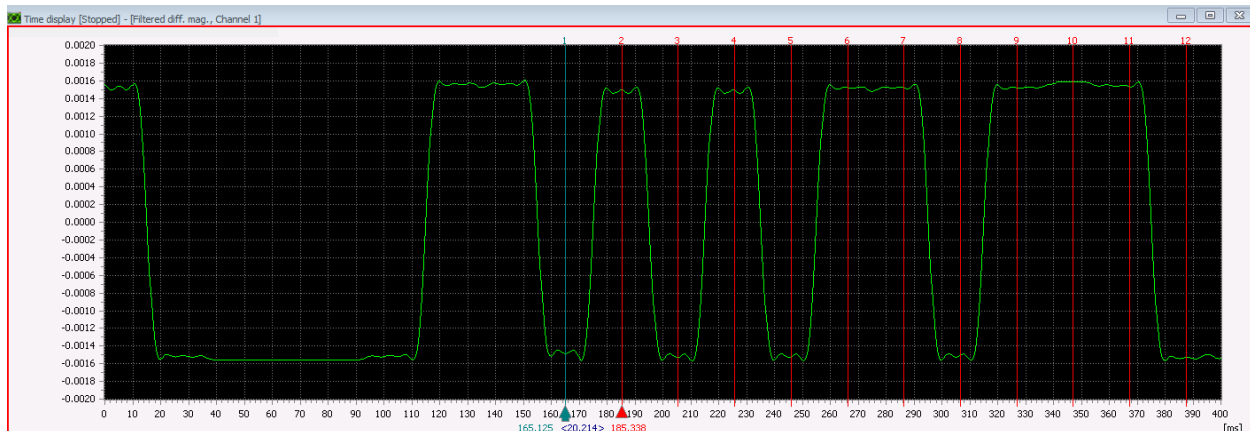
Figure 126: Eye Pattern Display via Difference Magnitude

The demodulated symbols are clearly visible in Figure 126.
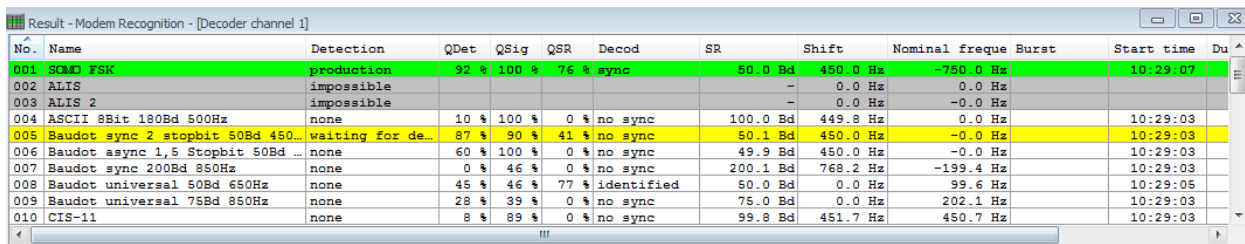
In order to measure, simply switch the display to <**Pause**>. Activate the check boxes <**X-Cursor**>. Use the cursor to measure the distance of the symbols. In this case, the individual cursor have been positioned on the center of the symbols. Another option is to use the symbol edges as reference points.

According to the formula: SR = 1 / T_{bit}, the measured symbol interval of 20.214 ms results in a symbol rate of 49.47 Bd.

5.2.2.6. Measure Shift and Baud Rate via Demodulator

Further, the demodulator itself can be applied for automatic measurement of the shift and the symbol rate. Select the demodulator *FSK2 matched* and enter the roughly measured shift and symbol rate magnitudes.

Note: When using the demodulator *FSK2 matched*, and provided the search is carried out with the *Automat*, nominal frequency or search range, the shift will, in addition to the demodulator measurement, be measured automatically if the tolerance value entered is greater than half the shift value or greater than 1.2 * symbol rate. The measuring result is sent to the demodulator.

No.	Name	Detection	QDet	QSig	QSR	Decod	SR	Shift	Nominal freque	Burst	Start time	Du
001	SCMO FSK	production	92 %	100 %	76 %	sync	50.0 Bd	450.0 Hz	-750.0 Hz		10:29:07	
002	ALIS	impossible					-	0.0 Hz	0.0 Hz			
003	ALIS 2	impossible					-	0.0 Hz	-0.0 Hz			
004	ASCII 8Bit 180Bd 500Hz	none	10 %	100 %	0 %	no sync	100.0 Bd	449.8 Hz	0.0 Hz		10:29:03	
005	Baudot sync 2 stopbit 50Bd 450…	waiting for de…	87 %	90 %	41 %	no sync	50.1 Bd	450.0 Hz	-0.0 Hz		10:29:03	
006	Baudot async 1,5 Stopbit 50Bd …	none	60 %	100 %	0 %	no sync	49.9 Bd	450.0 Hz	-0.0 Hz		10:29:03	
007	Baudot sync 200Bd 850Hz	none	0 %	46 %	0 %	no sync	200.1 Bd	768.2 Hz	-199.4 Hz		10:29:03	
008	Baudot universal 50Bd 650Hz	none	45 %	46 %	77 %	identified	50.0 Bd	0.0 Hz	99.6 Hz		10:29:05	
009	Baudot universal 75Bd 850Hz	none	28 %	39 %	0 %	no sync	75.0 Bd	0.0 Hz	202.1 Hz		10:29:03	
010	CIS-11	none	8 %	89 %	0 %	no sync	99.8 Bd	451.7 Hz	450.7 Hz		10:29:03	

Figure 127: Result Display

In Figure 127 the measuring values of the demodulator are shown in the table. The measuring values of the active demodulator are highlighted in green in the result display (<**Display**> menu or toolbar). The symbol rate and shift values can be read out directly from this table.

To be on the safe side, verify the quality of the signal (QSig) and the symbol rate (QSR). Values of less than 50 % indicate either a severe distortion of the signal, selection of an inappropriate demodulator, or inadequate parameter settings, all of which may cause a bad result.

Another method to verify whether the demodulator has a correct symbol rate can be applied in the eye pattern display. Set the eye pattern display to the signal input *Filtered diff. mag.*. Set the display type to Eye pattern display and increase the <**Number**> of vectors to e.g. 20.

Modify the parameter time period to a value that will make one to three symbols visible. In the mode eye pattern display, the start time of the display is synchronized with the symbol rate from the demodulator. The result will be an "eye", provided an appropriate symbol rate has been selected (see Figure 128).
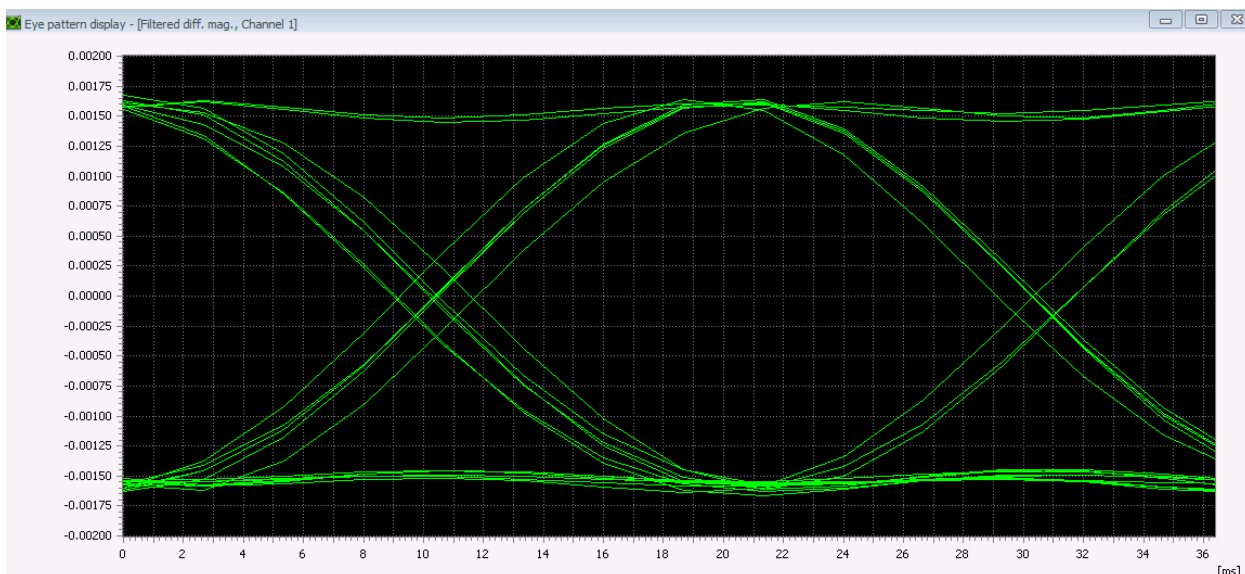
Figure 128: Eye Pattern Display with Filtered Difference Magnitude

If there is no visible "eye", the symbol rate of the demodulator is incorrect.

5.2.2.7. Search for Repeating Frames in Demodulated Bit Stream

Activate the bit display (<**Display**> menu or toolbar) to display the demodulated bits as shown in Figure 129.

Figure 129: Bit Display of Demodulated Bits

A typical search is for repetitions in the data stream. Modify the parameter *Circulation length* and check the display. Once a pattern shows up, the circulation length corresponds to the repetition length or a multiple of its magnitude.

Figure 130: Bit Display

Circulation lengths corresponding to a multiple of the repetition rate will cause "Frames".

5.2.2.8. Decoding

The message in the example used was encoded by means of the Baudot modem (in this case with one start bit and one stop bit). To obtain this message, select the appropriate decoder: Press the button <**Decoder name…**> on the <**Decod**> tab. Select *baudot11* and confirm with <**OK**>. The decoded message is displayed in the result window in Figure 131.

CONGRATULATIONS. YOU ARE SUCCESSFULLY DEMODULATING AND DECODING THE ANALYZED FSK 2 SIGNAL.
HERZLICHEN GLUECKWUNSCH. SIE DEMODULIEREN UND DEKODIEREN DAS ANALYSIERTE FSK 2 SIGNAL ERFLOGREICH.

CONGRATULATIONS. YOU ARE SUCCESSFULLY DEMODULATING AND DECODING THE ANALYZED FSK 2 SIGNAL.
HERZLICHEN GLUECKWUNSCH. SIE DEMODULIEREN UND DEKODIEREN DAS ANALYSIERTE FSK 2 SIGNAL ERFLOGREICH.

CONGRATULATIONS.

Figure 131: The Decoded Text is shown in the Result Display

5.2.2.9. Save Modem

At this point, the essential parameters of your modem have been defined. Edit the name in the drop-down list box *Modem*: on the control property sheet (e.g. "My first modem" or "FSK2 450/50 Baudot11"). Save the modem by selecting the menu item "Save modem to file…" on the Modem menu. Enter the desired file name (e.g. "test" or "my_fsk.ver") and click the button <**Save**>. In the automatic mode the modems analyzed will be recognized automatically.

5.3. Samples

Select <**Programs**> <**PROCITEC**> <**go2DECODE**> <**DEMO**> in the Windows® start menu to start demo mode.

5.3.1. SDA in DEMO Mode

On start of go2DECODE-DEMO, the SDA will appear as in the screenshot below. You will see a spectrum/-sonagram display, a result display, the menu bar, the toolbar, two property sheets, and the status bar. DANA starts at the same time.
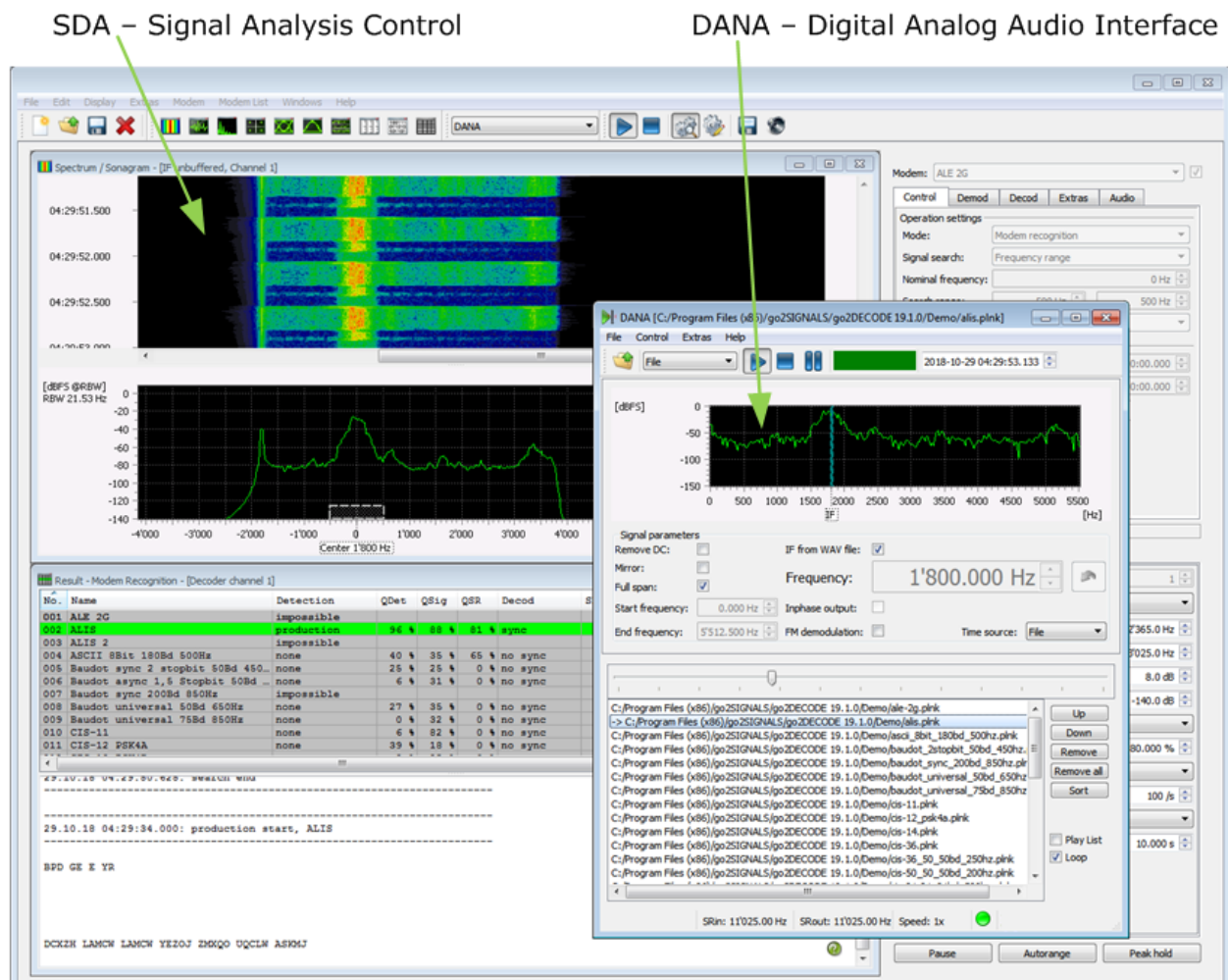
Figure 132: DANA, SDA (and APC) with Signals from .wav Files

Calling go2DECODE-DEMO will start three applications. Use the options specific to your operating system to switch from one application to the other:

- DANA: Filtering and conversion of the input signal into digital IF

- APC: Automatic recognition of modems whose parameters have been previously entered into the knowledge base (no graphic interface)

- SDA: Result display for APC and user interface for monitoring and manual analysis of the digital IF

Below you will find 2 examples.

Example 1: Morse Signal by SOMO

In Figure 133 a morse signal with a center frequency of 4500 Hz is generated and played using the software modulation generator SOMO.
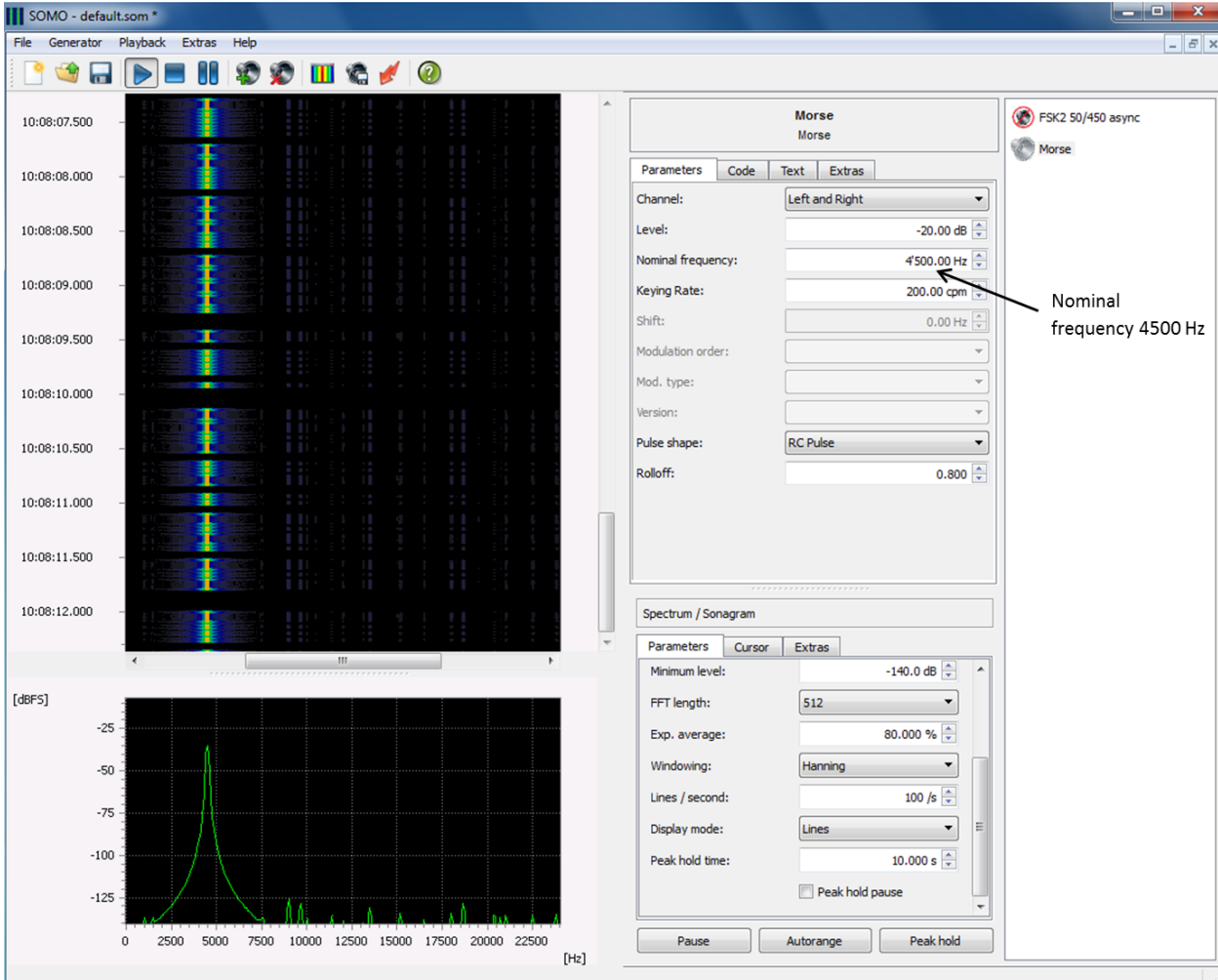
Figure 133: Signal Generation Using SOMO

This input signal is then filtered from 4,000 Hz to 5,000 Hz and shifted by 4,500 Hz using DANA (see Figure 134).
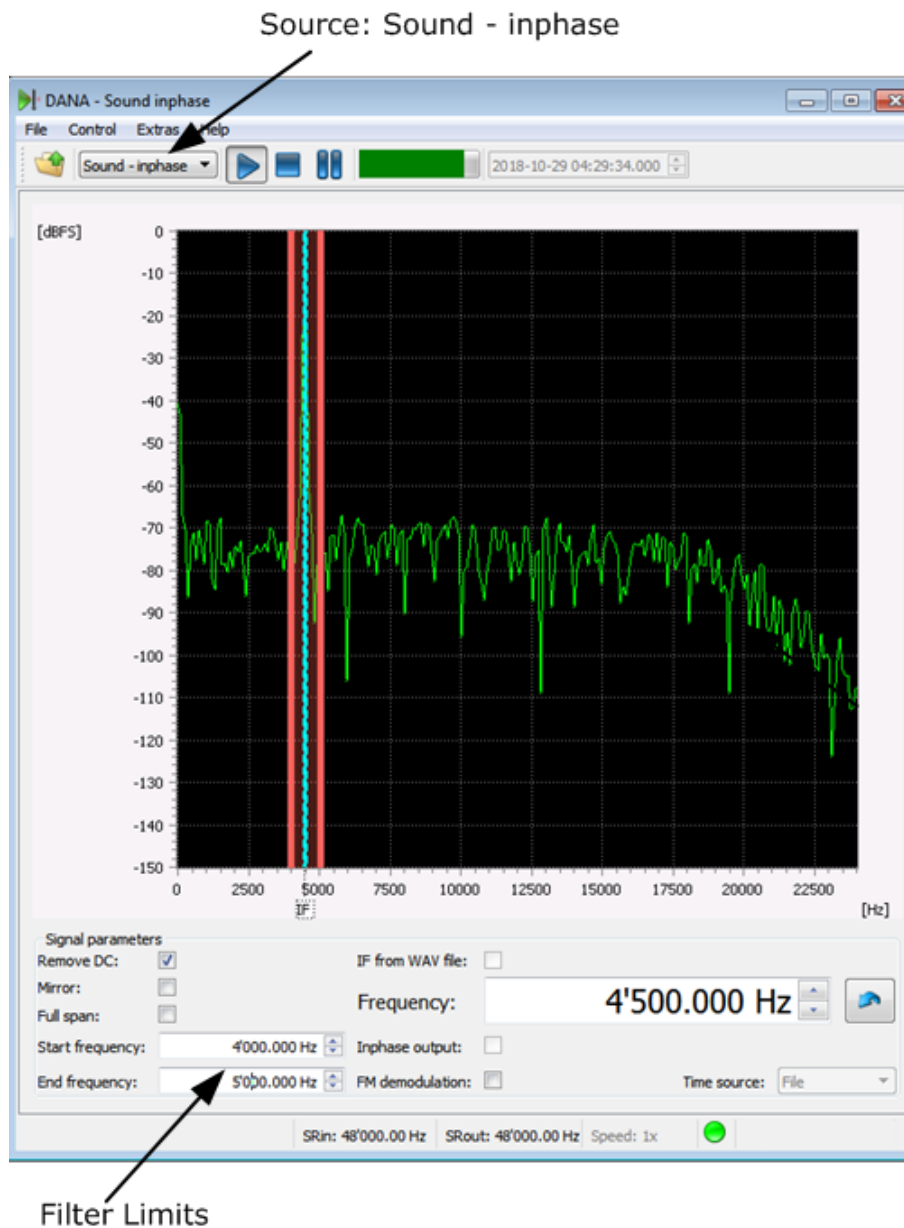
Figure 134: Input Signal in DANA with Filter Range 4-5 kHz
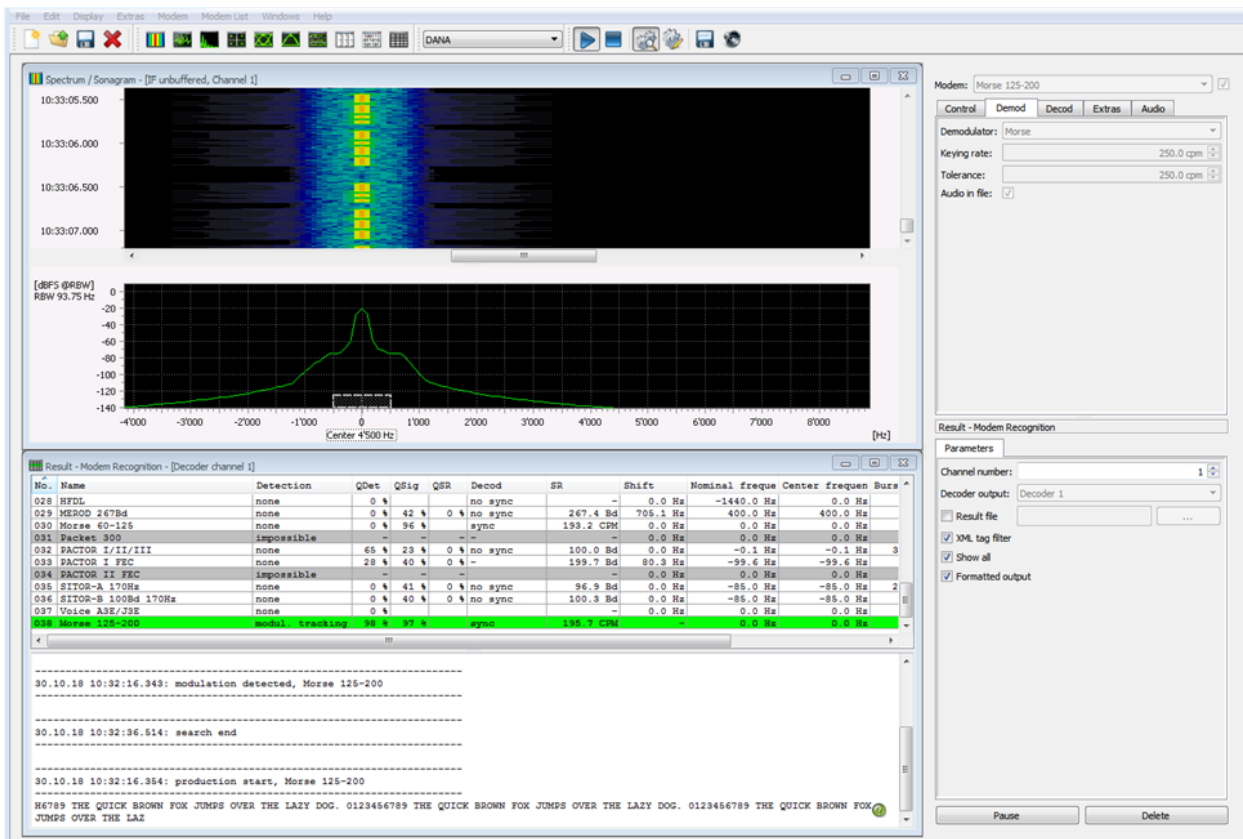
Figure 135: Signal in SDA Processed by APC

Example 2: USB speech signal

A **USB speech signal** is played and processed directly by DANA. In this example in Figure 136, the signal is not filtered, but it is shifted by 4800 Hz:
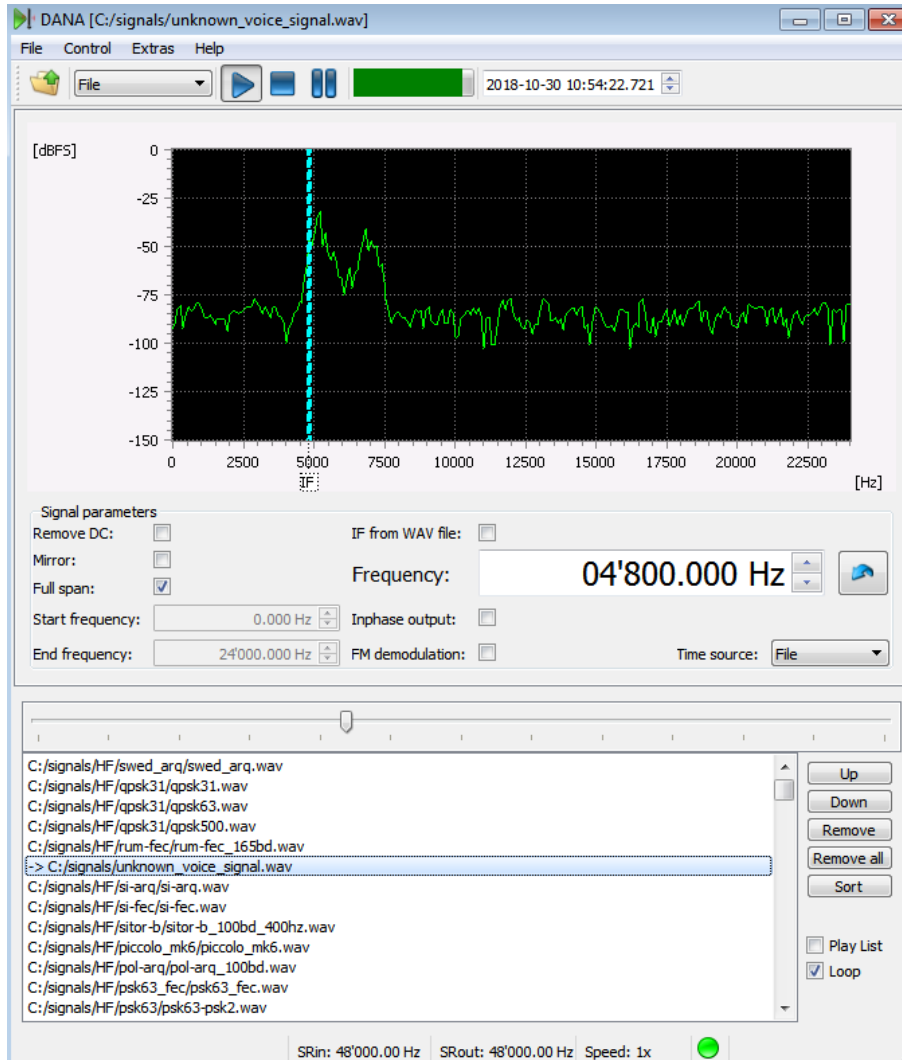
Figure 136: Input Signal in DANA
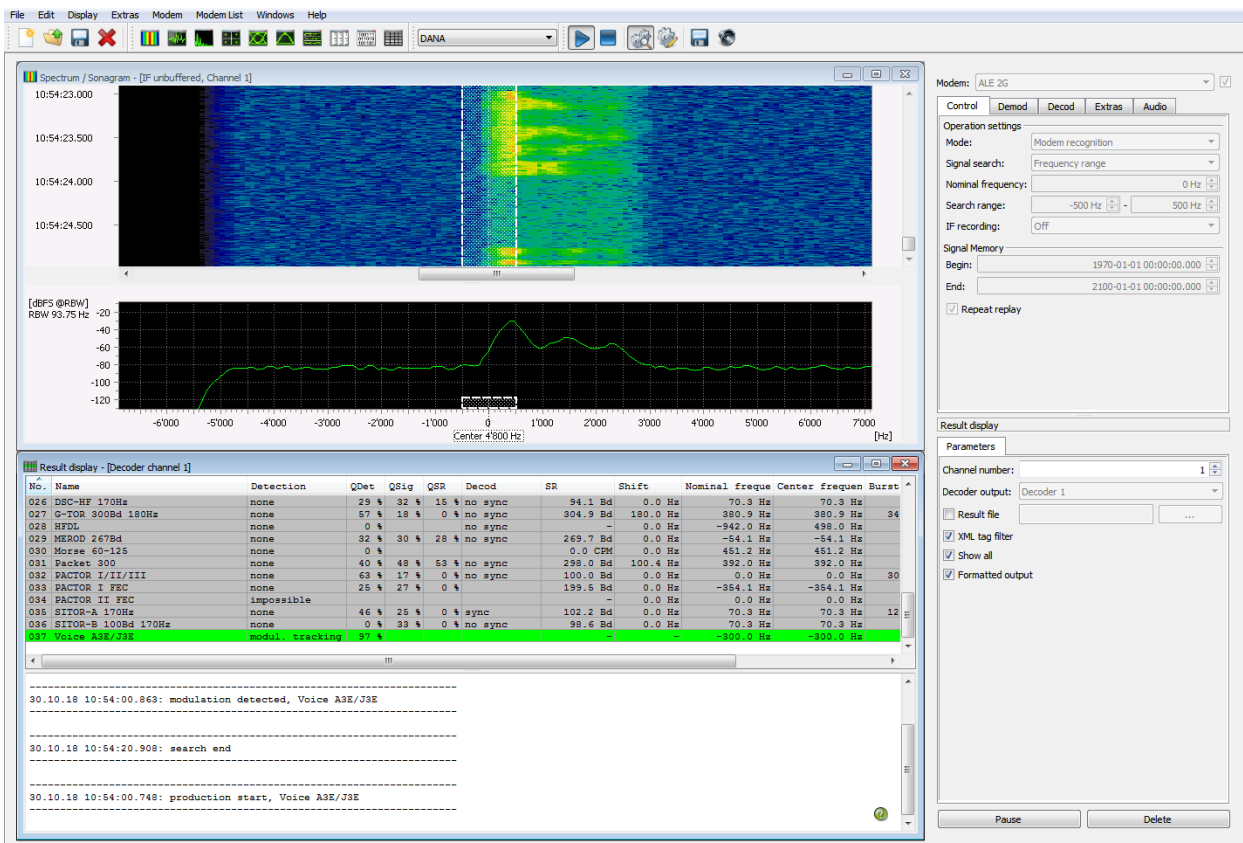
Figure 137: Speech Signals in SDA Processed by APC

5.3.2. Generating Signals Using SOMO

SOMO (*Software Modulation Signal Generator*) can generate a multitude of differently modulated signals. These signals can be used e.g. as input signals for DANA, to establish a comprehensive test scenario for go2DECODE the application in a very short period of time.

Generating Signals

Between one and 100 signals can be generated and played back, individually or in combination. Select the desired signal type on the <**Generator**> menu, e.g. Morse. This signal is then displayed in the *List of Generators*. A generator highlighted, i.e. selected, in this list can be edited via the parameter window. To activate or deactivate the generator, double click the speaker off icon 🚫 or the speaker icon 🔊.

All activated signals are calculated and generated or stopped and paused, using the buttons <**Start**> ▶, <**Stop**> ⬛ and <**Pause**> ▮▮ on the <**Control**> menu or the icons on the toolbar.

Transferring the Signal to APC directly

Set the signal source in SDA to <**SOMO**> (see chapter SDA Operating Modes). Please note, that the nominal frequency of 12,500 Hz in SOMO will be visible at 0 Hz in SDA.

Transferring the Signal to APC using DANA

To ensure a correct signal processing in the APC, be sure to set the source to *Sound* in DANA and observe the nominal frequency adjusted in SOMO.

If the nominal frequency in SOMO has not been changed, either select the default setting for SOMO in DANA or enter the nominal frequency adjusted in SOMO in DANA in the box <**Frequency**> as well.

Example:
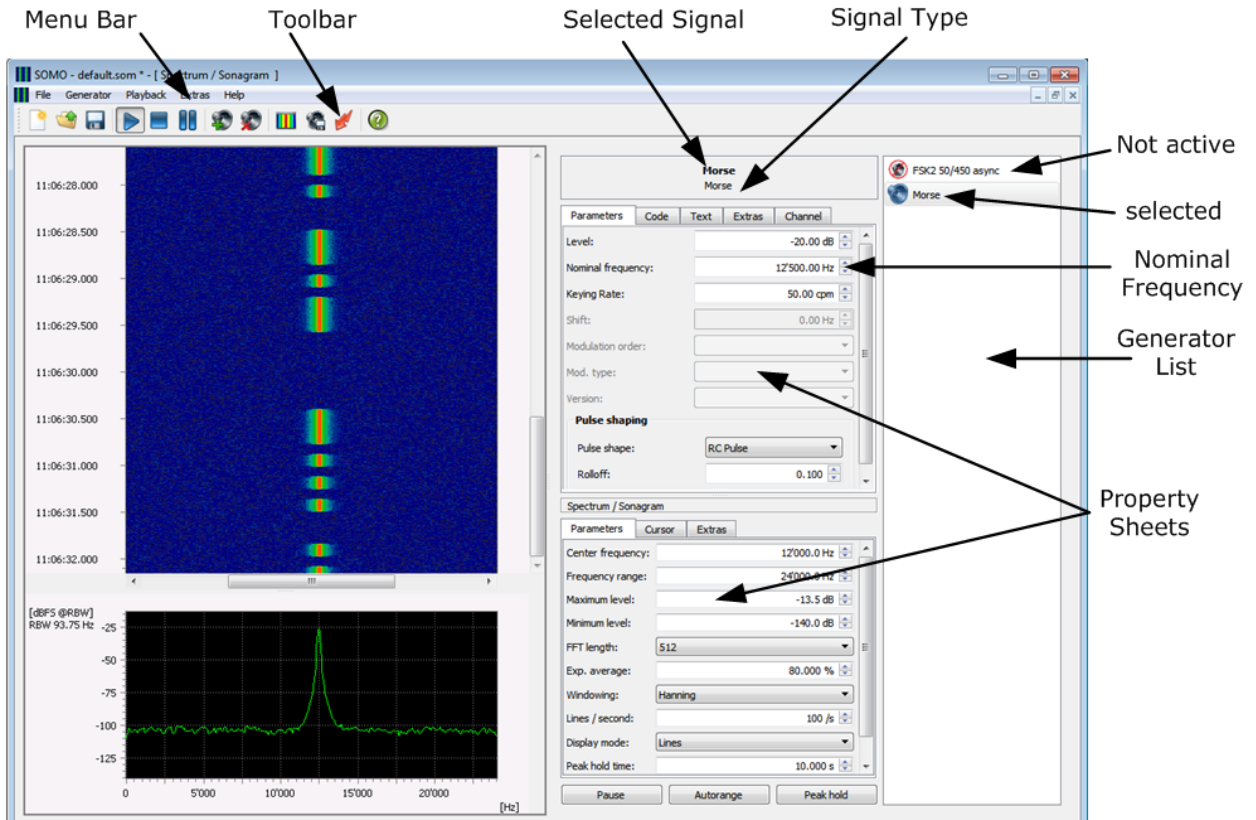
Figure 138: Signal Generation Using SOMO

Figure 139 shows that two signals are generated, one of which is inactive. The selected Morse signal has a nominal frequency of 12,500 Hz. If 12,500 Hz is entered in DANA as frequency, this Morse signal will be processed in the APC.
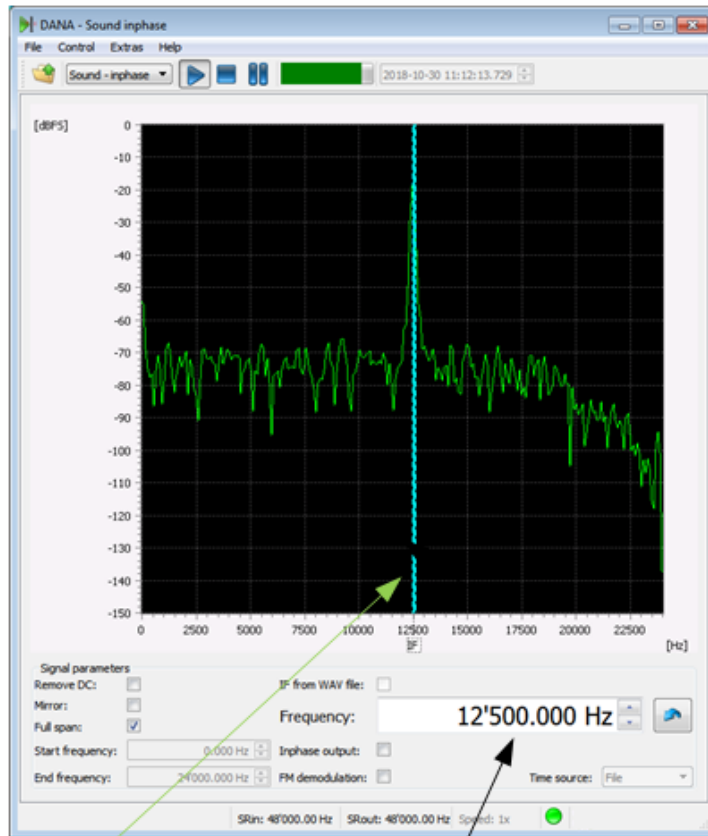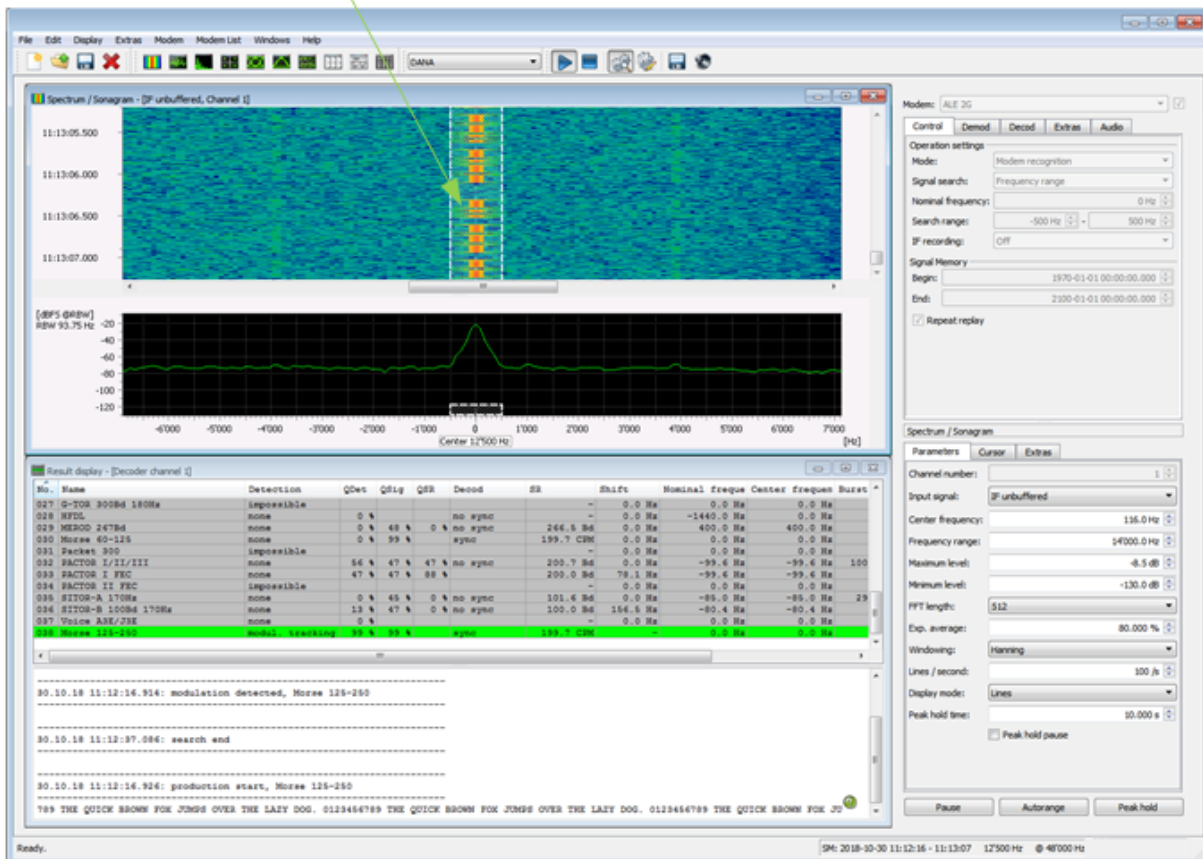
Figure 139: Morse Signal Played Back with DANA and Identified in SDA

6. Options

6.1. Modem and Decoder Database

Besides loading and saving the modem and decoder files on your local computer, it is possible to store and retrieve them from an external database. This makes it easier to share them with your colleagues and ensure that everybody is working on the same basis.

The common scenario is one operator place with a professional license installation where modems and decoders are modified or created and then stored in the database and several monitoring operators that retrieve the modems and decoders from the database.

The following features and operations are independent on the type of database you are using. There is always a common interface. A plugin mechanism will ensure the proper connection to the database.

For very large systems, a full-fledged database server can be applied. However, this is not part of this installation and an additional license is needed. However, the common go2DECODE installation supports a so-called plain files database. Here the files are stored as normal files in an arbitrary folder that can reside on your local computer or on a network share. Read and write access can be restricted by normal means. Although such a plain files database has less features then a true database server (e.g. there is no locking mechanism when several users try to write to the database) its installation and maintenance is much easier.

6.1.1. Activation

To activate the GUI elements to access the database, open <**Extras**><**Options…**>. In section <**Database**>, enable <**Activate plain files database**>. This will enable some additional entries in the <**Modem**> menu (see Figure 79), add some icons to the toolbar and add some more menu options to the <**Decoder Editor**>.

6.1.2. Modems Menu and Database Access
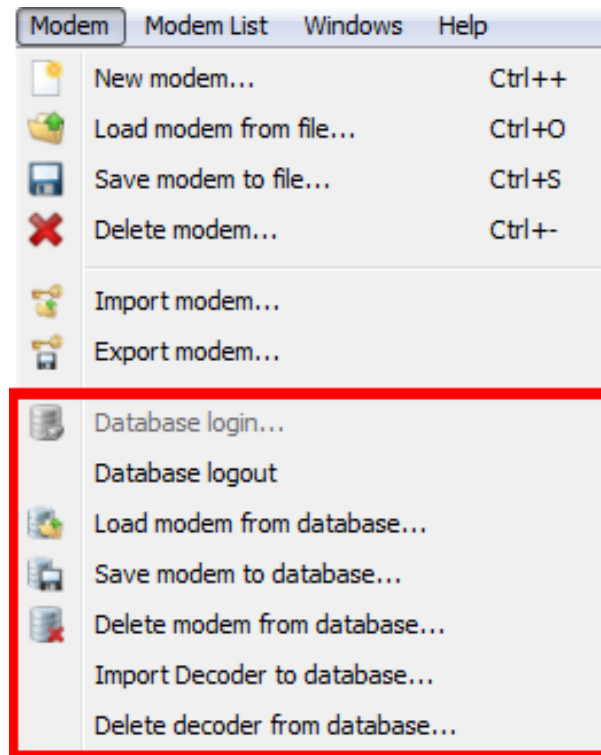
Figure 140: Database releated part of modems menu

Here in Figure 140 you will have the following additional entries which are disabled unless you login into the database (see chapter Database login..).

6.1.2.1. Database login...

In case of an actual database server you will be prompted with a login dialog where you have to enter username and password. For the plain files database you will be prompted for a folder name. You can either accept the suggested folder - your last choice is stored - or you can open a file dialog when you click the <...> button and then navigate to the desired folder. Network shares are supported.

You have now read-only or read and write access to the database. This depends either on your user rights in the database server or on your read/write access rights in the selected folder. If have read-only access then you will not be able to delete or modify modems or decoders in the database.

Note: In case of the plain files database the two folders "modems" and "decoders" will be created automatically in the chosen folder if they do not exist. It is possible to access these folders with the file explorer and add/remove files directly.

6.1.2.2. Database logout

Logout of the database. All database access is now disabled until you login again.

6.1.2.3. Load modem from database...

A dialog will appear that shows a list of the currently available modems in the database.

Modem	Description	Abbreviation	Mod. type	SR	Shift	ID
ALE 2G			Multitone (MFSK)	125.005 Hz	--	-1
CODAN Selcal			FSK 2,3,4 discr.	100.000 Hz	200.000 Hz	-1
Coquelet-13 75ms			Multitone (MFSK)	13.336 Hz	--	2069
Twinplex			F6/F7B	100.000 Hz	--	-1
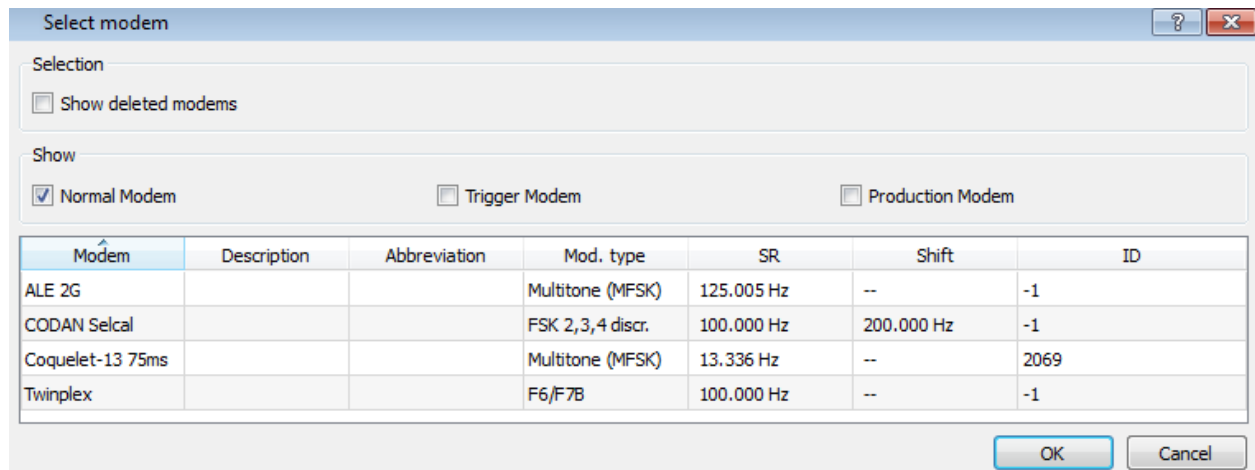
Figure 141: Dialog Load Modem from Database

The table in Figure 141 will show the modem name, a short description, an optional abbreviation, the modulation type, the symbol rate and shift if available. Select one or more modems from the list and then click the <**OK**> button. The modems will be added to your modem list and the dialog will close.

The context menu of each modem allows deleting one or more selected modems from the database. The option to restore deleted modems has no effect in case of the plain files database.

6.1.2.4. Save modem to database...

To save a local modem to the database you have select it in the Result Display modem list. Afterwards select the menu entry <**Save modem to database...**>. If you answered the following request positively the modem file and the associated decoder binary file will be saved in the database. The operation will fail if the decoder binary file is not found. The decoder text file will be saved, too, if found.

An existing modem in the database with the same name will be overwritten. There is a request dialog to confirm overwriting.

6.1.2.5. Delete modem from database...

When you select this menu entry you are asked if you want to delete the currently selected modem from the database. In case of the plain files database the file is irreversibly deleted.

6.1.2.6. Import Decoder to database...

This entry allows saving one or several existing decoders directly into the database without prior compilation. You will be prompted with a file dialog where you can select which decoder binary files should be imported. The decoder text files will be saved, too, if found.

6.1.2.7. Delete decoder from database...

A dialog will appear that shows a list of all decoder in the database. Here you can select one or more decoders and then delete them from the database.

6.1.3. Toolbar

Figure 142: Standard toolbar with data base plugin

Figure 142 shows the standard toolbar. The data base plug-in was activated via <**Extras**><**Options**> <**Database**> and is explained in Table 56.

Icon	Function
	Database login
	Load modem from database
	Save modem to database
	Delete modem from database

Table 56: SDA Toolbar Icons

6.1.4. Decoder Type

From now on when you select a decoder for a modem you can choose between local and database decoder (see chapter Decoder Type).

6.2. SOMO

See separate manual.

7. Technical Reference

7.1. Sound Configuration

7.1.1. Select Audio Output

To call the list of existing devices in order to view and select the desired sound device, open the dialog box Sound Configuration via the menu item <**Extras**><**Sound Configuration…**>.
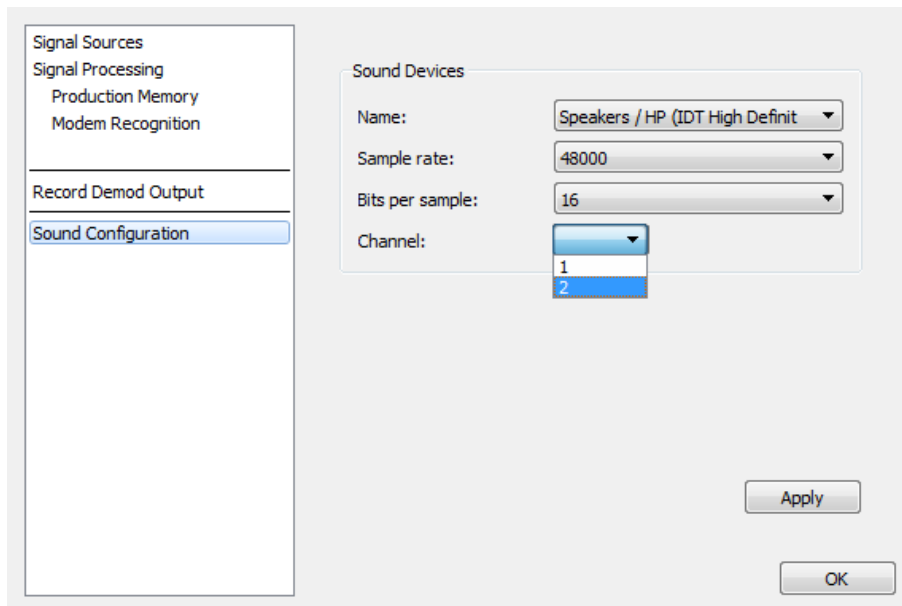
Figure 143: Sound Configuration Dialog Box

Parameter	Description
<Name>	Select the desired sound device from the list of available devices.
<Sample Rate>	Select the sampling rate of the selected sound card (provided the sound device supports the respective sampling rate).
<Bits per Sample>	Set the resolution of the selected sound device.
<Channel>	Specify which sound card output (or input) is to be used for the output or input of data.

Table 57: Sound Configuration Parameters

7.1.2. Configure Multi-Channel Sound Device

The parameters of multi-IO sound devices are preset in an XML configuration file named "cardlist.xml" This file, which is located in your installation directory, holds the configurations and descriptions of various

sound cards, i.e. number of channels, sampling rates, internal names, etc. so that the exact parameters of one's specific sound device can be preset. The configuration is assigned to the respective module by means of the sound card description.

Edit the file using an appropriate editor like e.g. Microsoft® Notepad.

Should "cardlist.xml" not be found, the software will use the default values:

Parameter	Range	Description
Sampling Rate	96 000 Hz (Studio) 48 000 Hz (R-DAT) 44 100 Hz (CD) 32 000 Hz 24 000 Hz 22 050 Hz 16 000 Hz 11 025 Hz 8 000 Hz	Sampling rate setting of sound device (provided the sound device supports the respective sampling rate).
Bits per Sample	8 bits 16 bits (default) 24 bits 32 bits	Resolution of sound device
Number of channels	2	It is assumed the sound card is a stereo sound card.

Table 58: Multi Channel Sound Configuration Parameters

7.1.3. Configuration File "cardlist.xml"

This section describes the contents of the configuration file for sound devices and the respective tags. The values stored for each sound card are:

```
<card>
  <name>ensonic1371</name>
  <description>
    <desc>ENS1371 - Ensoniq AudioPCI</desc>
    <desc>Creative Sound Blaster-PCI</desc>
  </description>
  <channels>2</channels>
  <bitspersample>
    <bps>8</bps>
    <default>16</default>
  </bitspersample>
  <samplerate>
    <sr>12000</sr>
    <sr>24000</sr>
    <default>44800</default>
  </samplerate>
</card>
```

Figure 144: Configuration file sound device

Table 59 shows the admissible tags and their description:

Tag	Description
bitspersample	Defines the list box Bits per Sample of the sound device
bps	Individual item displayed in list box Bits per Sample
card	Configuration of one sound device
channels	Defines the number of channels of the respective sound device
default	Defines the default value for • Sampling rate • Bits per sample • The value is also displayed as clickable parameter item in the list box
descriptions	Several device description entries are admissible enclosed by the tags <description> ... </description>. Note: These descriptions correspond to the descriptions that the system returns as a hardware description (different on Windows® and Linux®).
desc	Individual item displayed in list box Bits per Sample
name	Internal name (the name *must not* include the characters dot, space or underscore)
samplerates	Defines the list box Sample Rate of the sound device
sr	Individual item displayed in list box Sample Rate

Table 59: Sound Device Configuration Tags

Configuration Example

```
<cardlist>
    <card>
        <name>ensonic1371</name>
        <descriptions>
            <desc>Ensonic AudioPCI</desc>
            <desc>ens1371 - AudioPCI</desc>
        </descriptions>
        <channels>2</channels>
        <bitspersample>
            <bps>8</bps>
            <bps>16</bps>
            <default>32</default>
        </bitspersample>
        <samplerates>
            <sr>12000</sr>
            <sr>24000</sr>
            <default>44800</default>
        </samplerates>
    </card>
    <card>
        <name>audigy2nx</name>
        <descriptions>
            <desc>SB Audigy 2 NX</desc>
            <desc>USB Audio - SB Audigy 2 NX
</desc>
        </descriptions>
        <channels>4</channels>
        <bitspersample>
            <bps>8</bps>
            <default>16</default>
            <bps>32</bps>
        </bitspersample>
        <samplerates>
            <sr>12000</sr>
            <sr>24000</sr>
            <default>44100</default>
            <sr>48000</sr>
        </samplerates>
    </card>
</cardlist>
```

Figure 145: Configuration Example

7.2. Demodulator Parameters

Various parameters are available for every demodulator type. Some demodulators allow for changes in their symbol tables, i.e. modification of the symbol values produced by the demodulator in question.

The following table provides a detailed description of the parameters:

Parameter	Function
<Adaptive equalizer>	These parameters serve to switch the LMS transmission-channel equalization on and off. This compensates distortions that occur during transmission. LMS (Least Mean Squares) is the applied equalizing algorithm.
<Audio in file>	Activate the recording of ".wav" files by means of these parameters. This requires saving the active IF. If this function records the signal, a ".wav" file is recorded simultaneously.
<BT>	This is the product of -3dB bandwidth and symbol duration, and is a specific characteristic of GMSK. Typical values are e.g. 0.25 for Tetrapol, 0.3 for GSM, and 0.5 for DECT.
<Burst mode>	This parameter serves to switch the burst mode on or off. The three parameters <**Max. burst lenght**>, <**Min. burst lenght**> and <**Min. pause lenght**> are only available in burst mode. Bursted signals only exist within a period defined by means of the burst length. Between such periods, they have a pause defined by means of the pause length.
<**Channel1 abs. phase**>	Defines the absolute phase of channel 1 in mode OFDM
<**Channel1 diff. phase**>	Defines the differential phase of channel 1 in mode OFDM
<**Channel distance**>	Defines the distance between the individual channels
<**Channel position type**>	Choose between the lists items *Channel distance* and *Channel frequencies*
<**Constellation...**>	For the QAM demodulator it is hereby possible to define arbitrary custom constellations and symbol mappings. There is a separate document about the XML structure.
<**Configure...**>	Activates/deactivates the control of certain OFDM parameters with a XML description. Hereby, it is possible to parameterize the OFDM demodulator in a much more powerful way than the GUI allows. There is a separate document about the XML structure.
<**Constellation**>	Absolute/differential phase constellation for OFDM channels
<**Distance F1 <-> F2**>	Defines the distance between frequency 1 and frequency 2 of an F7B/F7W modem
<**Distance F2 <-> F3**>	Defines the distance between frequency 2 and frequency 3 of an F7B/F7W modem
<**Distance F3 <-> F4**>	Defines the distance between frequency 3 and frequency 4 of an F7B/F7W modem
<**Edit submodems...**>	For Details see chapter MultiModem

Parameter	Function
<Mode>	Mode of F7B/F7W, i.e. content of left and right channel (Data / Data, Data / Morse, Morse / Data, Morse / Morse, Data / -, - / Data, Morse / -, - / Morse, Data (interleaved))
<Filters...>	Invokes dialog to define individual window function and filter parameters
<Frequency table...>	Provided the selected list item in the drop-down list box Channel position type is *Channel frequencies*, activation of this button will display a table for input of the desired frequency for each channel. Using the button <Init> in this table, the frequency can be initialized at equidistant intervals based on the current entries in *Channel distance* and *No. of channels*. Manual editing is possible via double click on the respective cell. Subsequently, the various frequencies from this table will be used. The setting procedure for the parameter *Tone* position type is identical.
<Increment abs. phase>	Defines the increment of the absolute phase in mode OFDM
<Increment diff. phase>	Defines the increment of the differential phase in mode OFDM
<Keying rate>	Defines the keying rate (cpm) in a Morse modem. This is the number of characters produced per minute.
<Keying rate tolerance>	Defines the keying rate tolerance (cpm) in a Morse modem.
<Max. burst length>	Defines the maximum time the signal exists in burst mode (s). If the burst detection module cannot detect the burst end then the burst will be cut at the maximum length. A value of 0 s indicates there is no upper limit for burst length. In this case the measured burst length is omitted for the calculation of the demodulator quality.
<Min. burst length>	Defines the minimum time the signal exists in burst mode (s)
<Min. pause length>	Defines the minimum pause length between two signals in burst mode (s)
<Min. burst SNR>	Defines the minimum SNR at which a burst signal is detected A value of 0 dB will trigger an automatic internal setting of an optimal minimal SNR value in regard to the chosen demodulator type
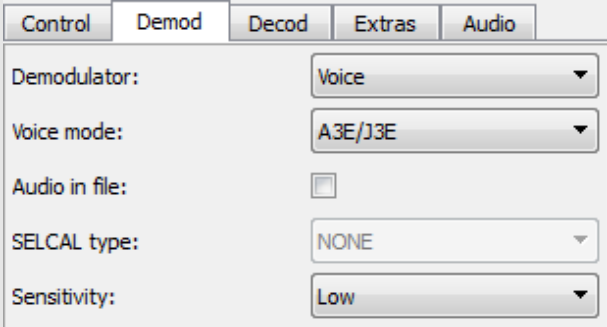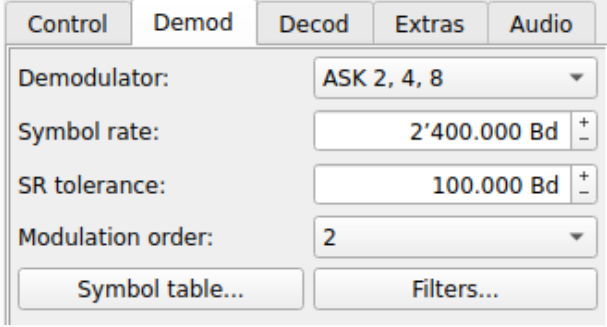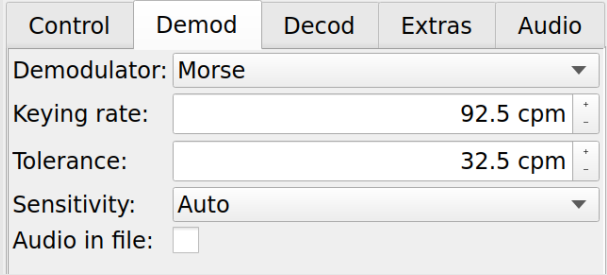
Parameter	Function
\<Modem type\>	Defines the mode of FSK demodulation, namely: • Synchronous: If there are no or hardly no symbols that occur as single symbols but only as double, triple etc. ones, the symbol rate quality will deteriorate to 0 permanently to indicate that there is a demodulation with a multiple of the actual symbol rate • Asynchronous: Support of half start/stop bits • Asynchronous Baudot: Baudot encoding with arbitrary varying stop bit length • Multi SR: Multiple symbol rates. The symbol rate quality will not deteriorate if the demodulation is made with a multiple of the actual symbol rate • Oversampling 2x, 4x, etc.: Multiple sampling during a symbol duration Note: the symbol quality may deteriorate. Heavily interfered signals may require setting the symbol rate tolerance to 0 to prevent the symbol rate from drifting off.
\<Modulation order\>	Defines the number of potential bit counts of a symbol (2-order 1 bit, 4-order 2 bits, etc.). One bit is the lowest transmissible binary unit of information. It can have the values 0 and 1.
\<No. of channels\>	Defines the number of channels
\<SELCAL type\>	Defines the type of the SELCAL data
\<Sensitivity\>	Defines the voice sensitivity: Low (not sensitive) Medium (sensitive) High (very sensitive) For a well-balanced detection and misdetection ratio, we recommend to set this parameter to Medium by default.
\<Shift\>	Defines the interval between lowest and highest frequency (Hz) in an FSK modem
\<Shift tolerance\>	With this parameter the admissible inaccuracies in the shift (Hz) can be modified. Note: the software may reduce the shift tolerance value entered to an appropriate value for the demodulator used. Furthermore please note that a tolerance value of 0 Hz will lead to a setting where shift measurement is not taken into consideration. Exception with *FSK2 matched*: When using the demodulator *FSK2 matched*, and provided the search is carried out with the *Automat*, *nominal frequency* or *search range*, note that the shift will, in addition to the demodulator measurement, be measured automatically if the tolerance value entered is greater than half the shift value or greater than 1.2 * symbol rate. The measuring result is sent to the demodulator.

Parameter	Function
\<Simultaneous tones\>	Displays the adjusted number of simultaneous tones in multitone demodulator
\<Special channels\>	Number of special channels
\<Special channels\>	Provided at least one special channel has been entered, activating this this button will display a table for input of the type and the special characteristics of the respective channel: Channel Number: Channel number in the channel grid (manual editing is possible), values less than 1 and greater than the parameter No. of channels are possible. Type: Type of pilot tone or constellation, respectively Phase [deg]: (only with pilot tones) Reference phase at sampling time Gain [dB]: Gain or attenuation factor Symbol rate
\<Symbol rate (Channel A/B)\>	Displays the symbol rate setting (Bd: symbols/second). The symbol rate is the transmission rate of the signal.
\<Symbol rate tolerance\>	With this parameter, change the admissible inaccuracies in the symbol rate. Note: the software may reduce the symbol rate tolerance value entered to an appropriate value for the demodulator used. If very small tolerance values are set (<1 % of symbol rate) deviations from the nominal value will not cause a downgrading of the measurement.
\<Symbol table...\>	Serves to display and edit the symbol table. This parameter defines the bit number of the symbol. The physical limit condition for the bit number, which can be set in the right part of the symbol table, is specified in the left part of the symbol table. The bits are specified in LSB-first (least-significant-bit first) order.
\<Time delay...\>	Defines the time delay (phase offset) for every channel relative to the first channel
\<Tone distance\>	Defines the intervals between the individual tones (Hz)
\<Tone duration\>	Sets the preset duration of a tone in the multi-tone demodulator
\<Tone duration tolerance\>	Defines the admissible inaccuracies in the tone duration (ms). Note: the software may reduce the shift tolerance value entered to an appropriate value for the demodulator used.
\<Tone position\>	Choose between the list items *Tone distance* and *Tone frequencies*
\<Total no. of tones\>	Displays the adjusted total number of tones in multitone demodulator
\<Type\>	Select type MSK, GMSK (linear) and GMSK (non-linear). GMSK: for BT values less than 0.5 we recommend GMSK (non-linear).
\<Version\>	Displays the adjusted PSK version A or B. In PSK, the bit values are encoded by the shift between phase angles of the signal (the angles depend on the modulation order). In version B, the number of shifts is doubled. Version B allows for an easier recovery of the symbol rate from the signal.

Parameter	Function
\<Voice Mode\>	The voice mode specifies the modulation types to be detected by the speech modem. The software can search for single modulation types or combinations thereof. In the drop-down list box select from the following parameters: A3E/J3E One and two side band A3E Two side band amplitude modulation with carrier J3E One side band modulation without carrier J3E/USB One side band: Upper side band J3E/LSB One side band: Lower side band F3E Frequency modulation Once the software detects the voice modulation type to search, the result is indicated in the Result Display and recording is made provided the check box Audio in file is selected. Should the software detect any voice modulation types that do not correspond to the type to search for, the Result Display treats the respective modem as if nothing had been detected.

Table 60: Demodulator Parameter Functions

The applied parameters of every demodulator are depicted in Demodulator Parameters.

Demodulator	Additional Settings
Voice (Speech)	 *Figure 146: Voice Parameters*
ASK 2, 4, 8 (Amplitude Shift Keying, 2, 4, 8-order amplitude shift keying)	 *Figure 147: ASK Parameters*
Morse	 *Figure 148: Morse Parameters*

Demodulator	Additional Settings
F1A	 *Figure 149: F1A Parameters*
F7B/F7W	 *Figure 150: F7B/F7W Parameters*

Demodulator	Additional Settings
FSK 2 matched (Frequency Shift Keying, 2-order frequency shift keying with matched filter demodulator, modulation index > 1)	 *Figure 151: FSK2 matched Parameters* *Figure 152: Frequency to Symbol Conversion Table Parameters* Note: Similar tables are available with all FSK modems.

Demodulator	Additional Settings
FSK discr. (Frequency Shift Keying, 2-order, 4-order, or 8-order frequency shift keying with discriminator, FM demodulation, modulation index 0.2 ... 10)	*Figure 153: FSK discr. Parameters* Note: the parameter Shift describes the frequency distance between two adjacent tones. With modulation index > 1 the demodulator "Multitone (MFSK)" or "FSK 2 matched" should be used.
FSK 2 autoshift	*Figure 154: FSK 2 autoshift Parameters*

Demodulator	Additional Settings
Multitone (MFSK)
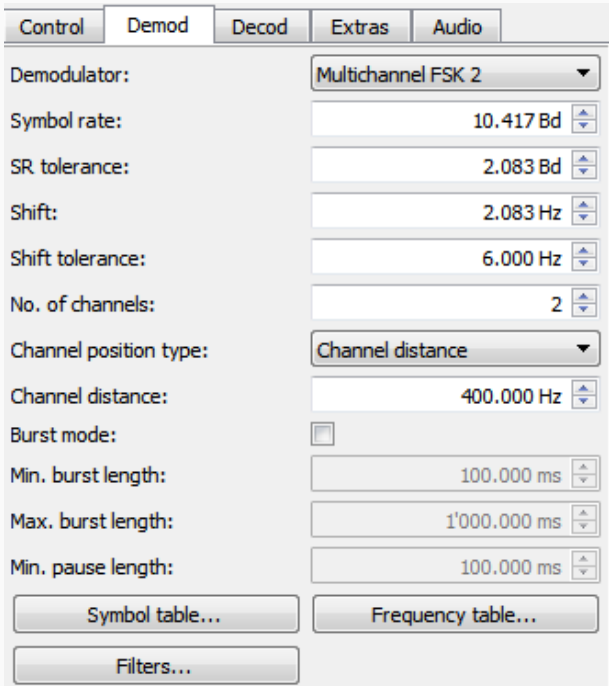
Figure 155: Multitone (MFSK) Parameters
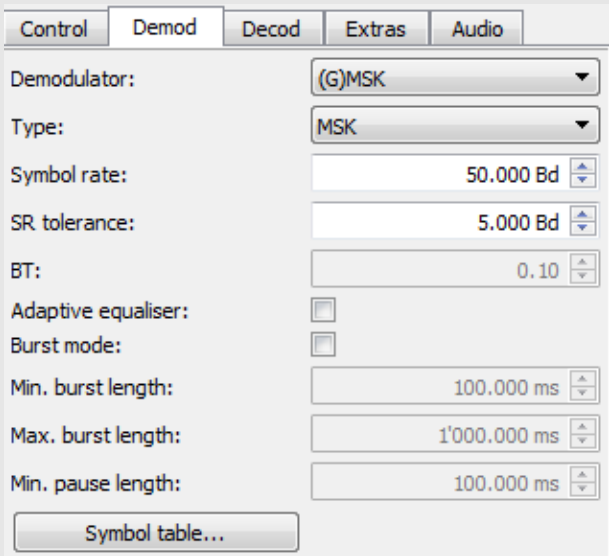
Figure 156: Frequency Table for Multitone Modems
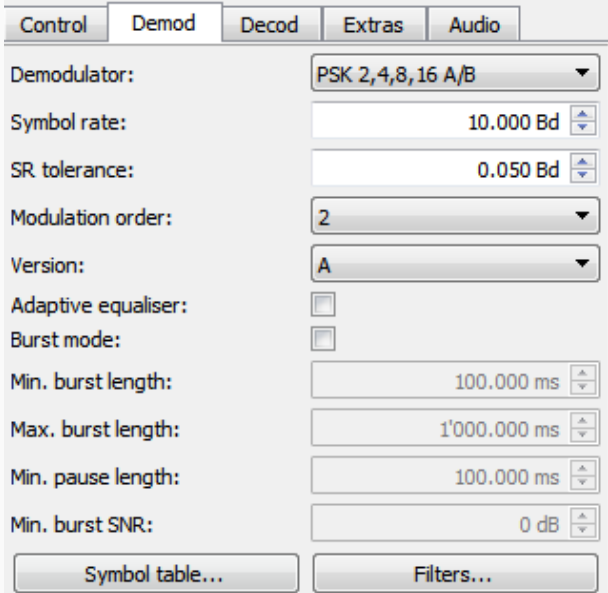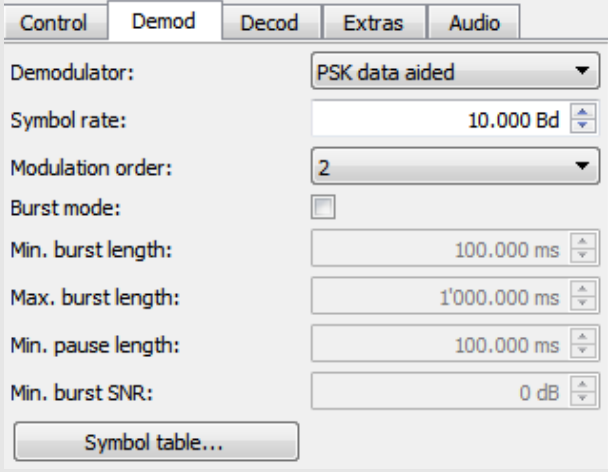
Note: Similar tables are available with all multitone modems. |

Demodulator	Additional Settings
Multichannel FSK 2	 *Figure 157: Multichannel FSK 2 Parameters*
(G)MSK ((Gauss Windowed) Minimum Shift Keying, bivalent frequency shift keying with minimum shift, modulation index = 0.5)	 *Figure 158: (G)MSK Parameters*
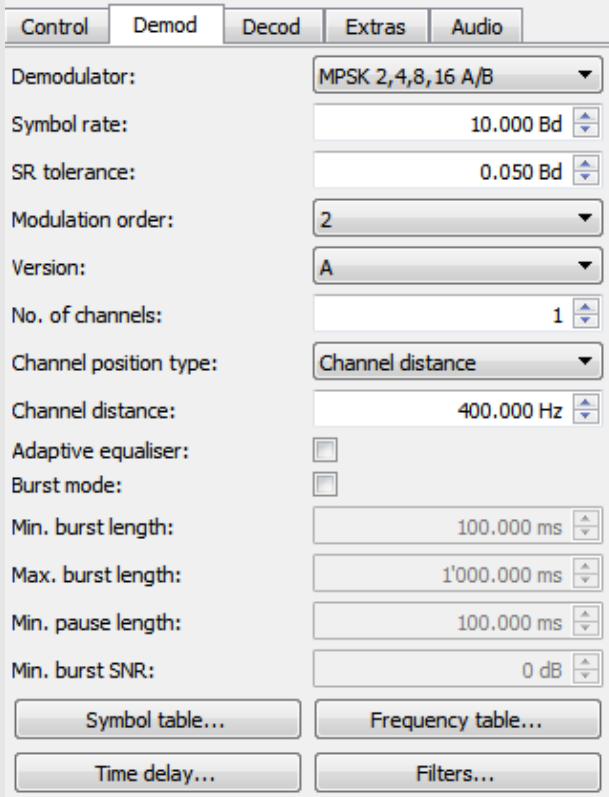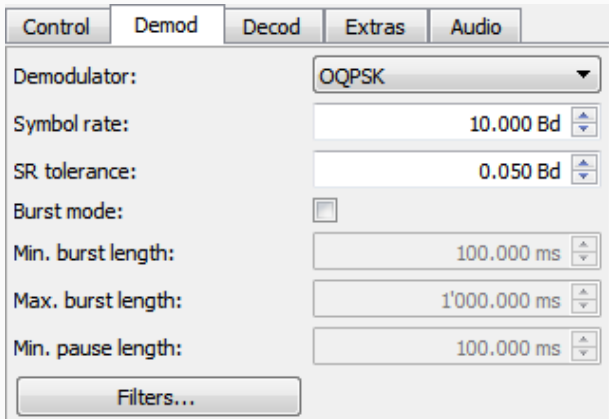
Demodulator	Additional Settings
TFM

Figure 159: TFM Parameters |

Demodulator	Additional Settings
DPSK 2, 4, 8, 16 A/B (Differential Phase Shift Keying)	 *Figure 160: DPSK 2,4,8,16 A/B Parameters* *Figure 161: Phase to Symbol Conversion Table* Note: Similar tables are available with all PSK modems. *Figure 162: PSK Channel Filter Parameters* Note: This dialog is available with all PSK demodulators and with some FSK demodulators. Here you can override the predefined parameters for the channel filters. Only expert users should alter these settings.

Demodulator	Additional Settings
PSK 2, 4, 8, 16 A/B (Phase Shift Keying, absolute phase shift keying)	 *Figure 163: PSK 2,4,8,16 A/B Parameters*
PSK data aided	 *Figure 164: PSK data aided Parameters*

Demodulator	Additional Settings
MDPSK 2, 4, 8, 16 A/B (Multi-DPSK, 2-, 4-, 8- or 16-order multi-channel differential phase shift keying, 2 - 100 channels)
Figure 165: MDSPK 2,4,8,16 A/B Parameters |

Demodulator	Additional Settings
MPSK 2, 4, 8, 16 A/B (Multi-PSK, 2-, 4-, 8- or 16-order multi-channel absolute phase shift keying)	 *Figure 166: MPSK 2,4,8,16 A/B Parameters*
OQPSK (Offset Quadrature Phase Shift Keying)	 *Figure 167: OQPSK Parameters*

Demodulator	Additional Settings
QAM n (Quadrature Amplitude Modulation, square and any user-defined constellations)	 *Figure 168: QAM n Parameters Parameters* Note: Any user-defined constellations can be demodulated via the "Configure..." button and using an XML description. Some sample constellations are available via the XML editor, which opens when pressing the button. The XML format is described in a separate document.
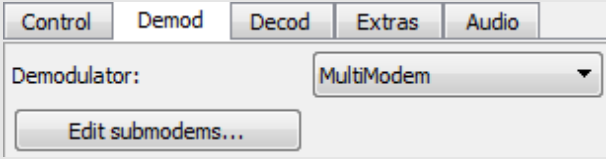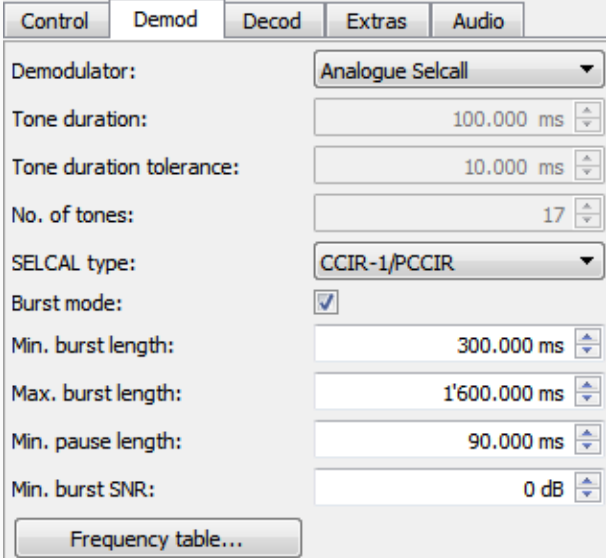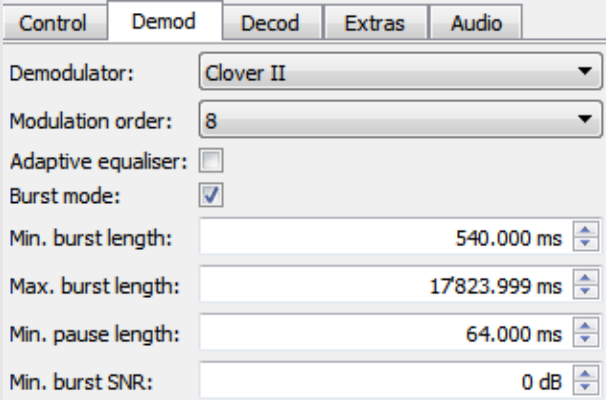
Demodulator	Additional Settings
OFDM (Orthogonal Frequency Division Multiplexed signal)	 *Figure 169: OFDM Parameters* Note: An XML editor has been added so that the parameters of the OFDM demodulator can be edited. XML files created with the PROCITEC Signal Analyzer Tool can be imported. *Figure 170: OFDM Constellations*

Demodulator	Additional Settings
MultiModem Continuous production across multiple (sub)modems	*Figure 171: MultiModem*
Analogue Selcall	*Figure 172: Analogue Selcall Parameters*
Clover II	*Figure 173: Clover II Parameters*
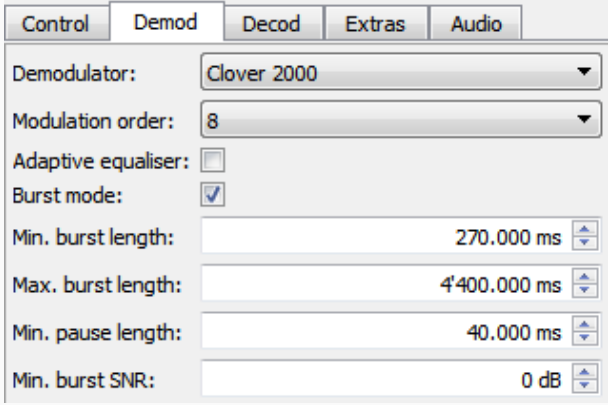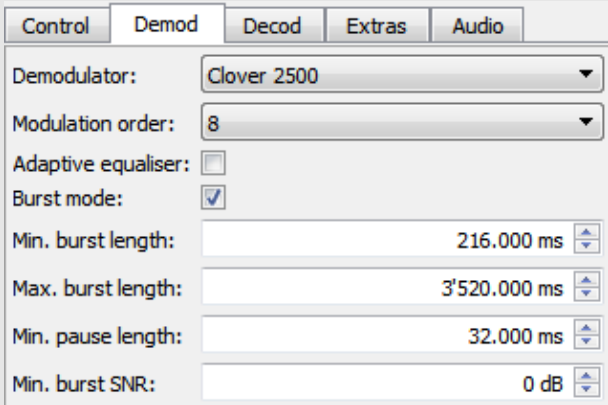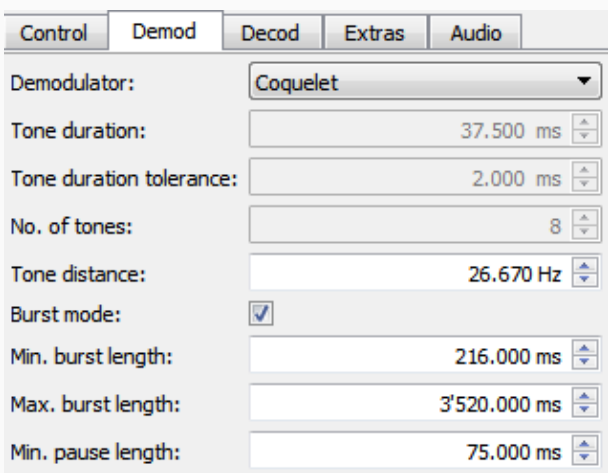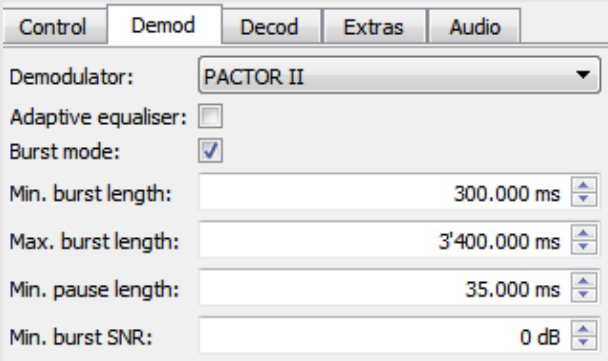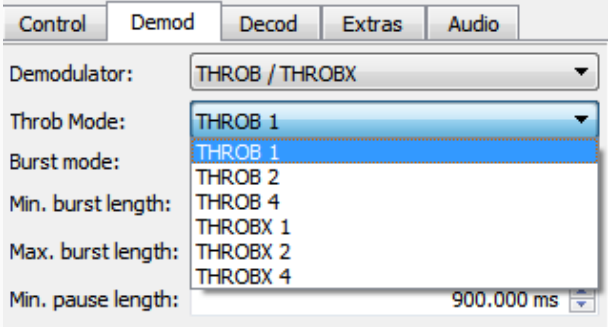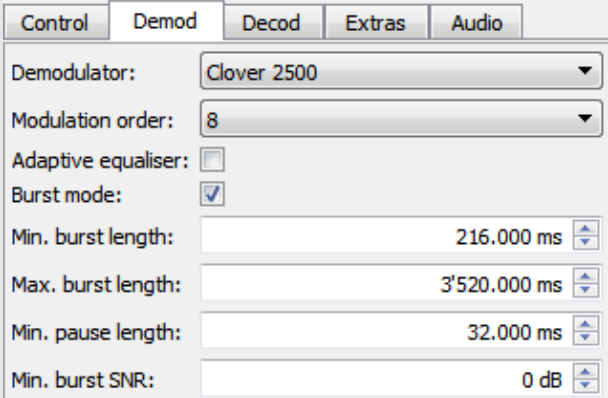
Demodulator	Additional Settings
Clover 2000	Figure 174: Clover 2000 Parameters
Clover 2500	Figure 175: Clover 2500 Parameters
Coquelet (Special filter demodulator for Coquelet signals)	Figure 176: Coquelet Parameters

Demodulator	Additional Settings
Pactor II/III	*Figure 177: Pactor II/III Parameters*
THROB / THROBX	*Figure 178: THROB / THROBX Parameters*
MT63	*Figure 179: MT63 Parameters*
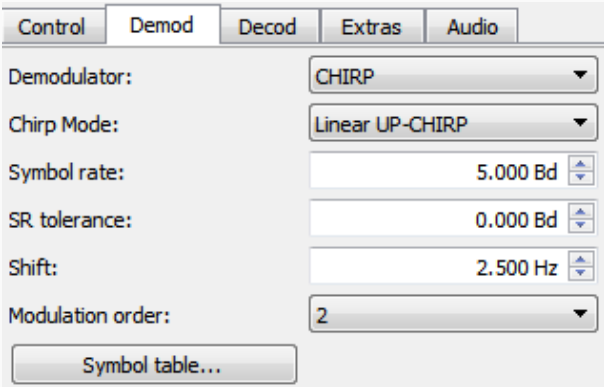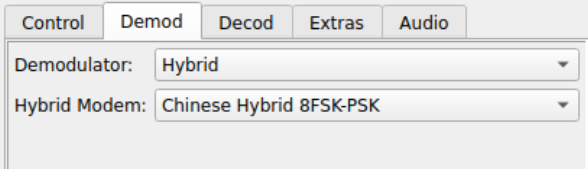
Demodulator	Additional Settings
CHIRP (with phase shift keying modulated chirp signal)	 *Figure 180: CHIRP Parameters*
Hybrid Modems with some submodi	 *Figure 181: Hybrid Parameters*

Table 61: Demodulator Settings

7.2.1. MultiModem

The demodulator type *MultiModem* allows the continuous production across multiple (sub)modems. In general, when the APC notices that the emission of a modem ends then it will stop the production and start a new search. A subsequent emission might then be detected and a new production is started. However, in some cases it is preferable to have a continuous production even if the emission switches to a different mode. E.g. Pactor modems usually start in Pactor I mode (FSK) and then later switch to a multichannel PSK (Pactor II or Pactor III).

A multimodem is a bundle of several submodems. Each submodem is a complete modem with a demodulator and a decoder. Whenever the APC notices the emission end for one of the submodems it will start an internal search for one of the other submodems. If the (internal) search is successful the production will continue with the new submodem. From the outside the production appears to be continuous. Only if the (internal) search fails then the production is ended and a normal search starts.

The only parameters of a multimodem are a list of submodems. When the button <**Edit submodems...**> is clicked a dialog appears.
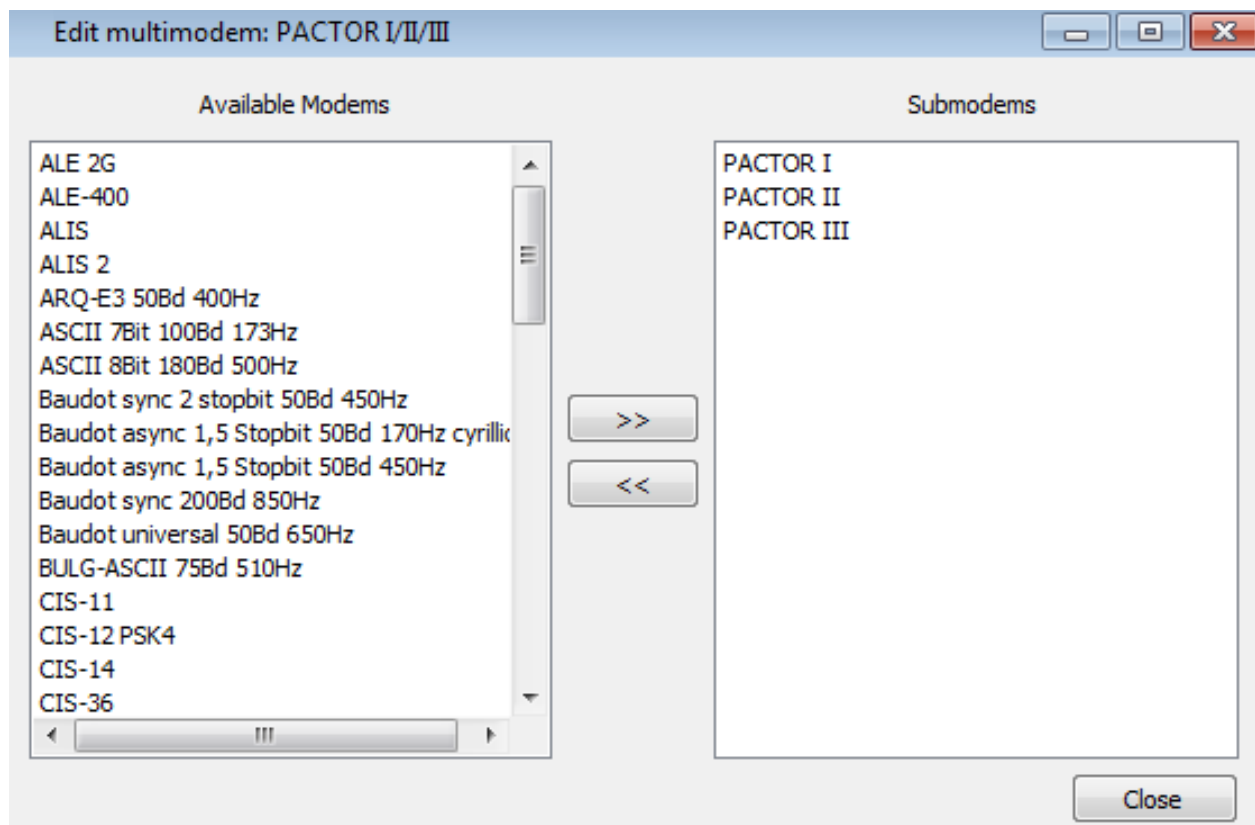
Figure 182: Dialog Edit MultiModem

On the left in Figure 182 is a list of all modems that are currently loaded (multimodems excluded). On the right is a list of the current submodems. A submodem can now be easily added by selecting one of the modems from the left list and clicking the < >> > button in the center. The modem will then be removed from the normal modem list and added as submodem to the multimodem. To remove a submodem just select it on the right side and click the < << > button. The submodem will then be again a part of the normal list and its parameters can be edited.

For the creation of a MultiModem the following workflow is recommended:

1. Analyse the signal manually and determine which modems are actually needed for every part of the emission. Adjust the demodulator settings and decoder accordingly.

2. Create a normal modem list with all of these modems.

3. Start the automatic production. Several production results – one for every modem found in the emission - should be shown. The production results should cover the complete emission.

4. Create a MultiModem and add all of the above modems as submodems.

5. Start again an automatic production. Now only one production result that covers the complete emission should be shown. The content of the production result should be identical to the results when a normal modem list was applied.

Warning: A multimodem is automatically deactivated when in manual production mode.

7.2.2. External modems as plugins

The APC has a plugin mechanism for external modems. This demodulator-interface can be used to integrate demodulators which have been developed by the customer and which he does not want to distribute. It is a C-interface that allows integrating a complete modem - demodulator plus decoder - as an external library (DLL/shared lib) into the APC. It is also possible that the external library only demodulates and then a pyDDL decoder is applied. The comprehensive API allows the integration of the external modem into the automatic recognition process of the APC.

The usage of a C-interface does not impose any restrictions on the programming language that is actually used for the plugin. It can be written in C, C++, Java, Python etc. The plugin can even be just a thin proxy for a hardware modem - local or remote.

The installation contains two plugins as examples. In the subfolder "modems/ExtModemDemo" you will find the modem files. The actual libraries (DLLs) can be found in the subfolder "extmodem" of the installation folder. The example modems only demonstrate the integration of external plugins into the automat of the APC. They do not actually demodulate/decode a signal.

A detailed description of the C-interface and C++ example code is available on request. For more information please contact service@procitec.com.

7.3. Receiver configuration

This chapter describes the necessary configurations to use a receiver in the go2DECODE product line environment. Receivers are controlled by the Receiver Control Module (RCM). With the help of the Receiver Configuration Tool it is possible to define receiver parameters like IP-address, control port etc. and to enable or disable the support for certain receivers. After making changes to the configuration, it might be necessary to restart the software to apply new settings. There are two ways to open the receiver configuration tool:

- either select <**Extras**><**Options...**>, under splice bar *Signal Sources* in field <**RCM**> click on *RCM*, then click <**Configure...**>

- or select <**Receiver Configuration**> from go2DECODE program group on start menu

7.3.1. Receiver configuration dialog
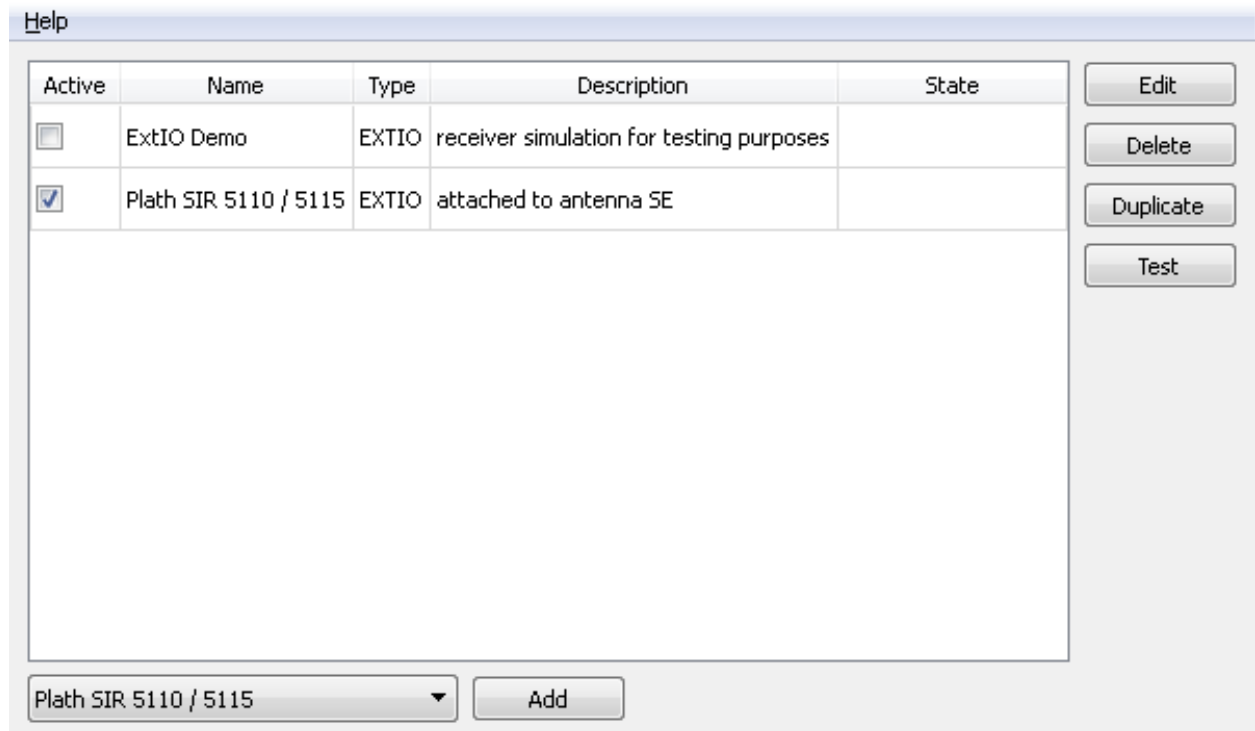
Figure 183: Receiver Configuration Tool

On startup it will show a list of currently configured receivers. The fields have the following meaning:

Active

This indicates if a receiver is enabled or not. Disabling a receiver makes it unavailable but keeps its configuration. It is recommended to disable not-connected receivers. Status can be changed by single mouse click of the checkbox.

Name

Name of the receiver

Type

Type of receiver connection

Description

An individual description of the receiver

State

This field shows the status and result of the test procedure

7.3.2. Supported receivers

The following receivers are supported:

Receiver	Interface	Comment	Linux® (Cent-OS)	Linux® (Ubun-tu)	Windows®
Plath SIR 51xx	LAN	Plath WinDF/Winmon application is needed to perform basic receiver settings (ports, addresses, etc.). Each single sub-band (768 kHz bandwidth for SIR 51xx) can be used as a virtual receiver.	yes	yes	yes
IZT R3000 series	LAN	Default configuration uses one spectrum overview channel and one data channel for up to 2 MHz bandwidth. Other configurations available upon request. Multiple templates are available: • wideband usage with one overview spectrum and one IQ channel up to 2.4 MHz • wideband usage with only one IQ channel, up to 20 MHz bandwidth, using multicast • for use as Narrowband receiver (with NRC license only).	yes	yes	yes
IZT SignalSuite R4000	LAN	Support of R4000/Signal Suite. Control can be carried out directly from our software or via IZT Signal Suite. Block size up to 64 K supported.	yes	yes	yes
R&S®EM100 / PR100	LAN	Other compatible R&S® receivers may also work by using this driver	yes	yes	yes
R&S®EB500	LAN	Bandwidth up to 5 MHz supported	yes	yes	yes
R&S®EB510	LAN		yes	yes	yes
WinRadio G31DDC Excalibur	USB	Receiver driver (from CD or manufacturer's website) has to be installed first. Recommended/tested version is v1.69 (other versions not officially supported).	no	no	yes
WinRadio G33DDC	USB	Receiver driver (from CD or manufacturer's website) has to be installed first. Recommended/tested version is v2.13 (other versions not officially supported).	no	no	yes

Receiver	Interface	Comment	Linux® (Cent-OS)	Linux® (Ubun-tu)	Windows®
WinRadio G35DDC	PCI-e	Receiver driver (from CD or manufacturer's website) has to be installed first. Recommended/tested version is v1.42 (other versions not officially supported).	no	no	yes
WinRadio G39DDC Excelsior	USB	Receiver driver (from CD or manufacturer's website) has to be installed first. Recommended/tested version is v1.58 (other versions not officially supported).	no	no	yes
Grintek GRXLAN	LAN	See below for IP-settings instructions	no	no	yes
narda® NRA-3000 / NRA-6000 / IDA 2	LAN		yes	yes	yes
Microtelecom PERSEUS	USB	Native support only for USB 2.0. Experimental support for USB 3.0 by using ExtIO driver with limited functionality. Receiver driver (from CD or manufacturer's website) has to be installed first. The following files have to be copied manually from the driver installation to the "32bit" subdirectory of the installation directory: • All "perseus*.sbs" files • All "perseususb*.dll" files	no	no	yes
RFSPACE SDR-14	USB	Experimental support	no	no	yes
ThinkRF WSA5000-408	LAN	VITA49 protocol is used. Maximum bandwith is 781 kHz.	yes	yes	yes
ThinkRF WSA5000-427	LAN	VITA49 protocol is used. Maximum bandwith is 781 kHz.	yes	yes	yes
ThinkRF R5500-408	LAN	VITA49 protocol is used. Maximum bandwith is 6.25 MHz.	yes	yes	yes
ThinkRF R5500-427	LAN	VITA49 protocol is used. Maximum bandwith is 6.25 MHz.	yes	yes	yes
RTLSDR / Noxon USB-sticks	USB	Experimental support. Libraries are not included. See chapter Installation of Missing ExtIO Libraries.	no	no	yes
SDRplay RSP	USB	Experimental support. Separate configurations for RSP1 and RSP2 variants. Libraries are not included. See chapter Installation of Missing ExtIO Libraries.	no	no	yes

Receiver	Interface	Comment	Linux® (CentOS)	Linux® (Ubuntu)	Windows®
AirSpy	USB	Experimental support. Libraries are not included. See chapter Installation of Missing ExtIO Libraries	no	no	yes
Test Reciever		Receiver simulation for testing purposes	yes	yes	yes
CommsAudit CA7851	LAN	No receiver control, only VITA 49 wideband signal interface	yes	yes	yes
Signal Hound BB60C and BB60D	USB	Windows®: The driver software for the receiver must be installed on the system. This can be done using the Spike™ software provided by Signal Hound®. The software can be downloaded from the manufacturer's website. Linux®: It must be ensured that the "libusb-1.0" library is installed on the system. In addition, special "Device Permissions" must be set for the receiver. Read the corresponding instructions (README.txt) in the Signal Hound® SDK. The SDK can be downloaded from the manufacturer's website.	yes	yes	yes
Other generic "Winrad ExtIO" supported receivers		Not included, experimental support possible	no	no	yes
Generic VITA 49	LAN	Generic VITA-49 driver which has to be para- metrized for a specific receiver type. It is supposed to be used only by experienced technician familiar with VITA-49 protocol details. Experimental support.	yes	yes	yes
narda® SignalShark® 3310	LAN	No receiver control. Support of Vita-49 streams up to 6 MHz.	yes	yes	yes
RFSPACE NetSDR	LAN	Separate HF/VUHF-configurations	yes	yes	yes

Receiver	Interface	Comment	Linux® (Cent-OS)	Linux® (Ubuntu)	Windows®
USRP X310	LAN	Receiver driver (from CD or manufacturer's website) has to be installed first (32-bit version for Windows®, 64-bit version for Linux®). Recommended/tested version is v4.0 (other versions not officially supported). Please note that the driver version has to be compatible with the USRP Firmware version. The UHD library (uhd.dll / libuhd.so) has to be copied manually from the driver installation to the "32bit" subdirectory of the installation directory (for Linux® directly into the installation directory). If necessary, the environment variable UHD_RFNOC_DIR has to contain a subdirectory of the UHD-installation (usually: <UHD_install_dir>/share/uhd/rfnoc). Installation under Linux® may require building your own UHD driver to support CentOS 7 platform. The Boost library has to be installed additionally version must be compatible with UHD driver). Installation under Windows® requires installation of the "libusb" library. The library (libusb-1.0.dll) has to be located in the "32-bit" subdirectory of the installation directory. See receiver documentation and online resources for further details.	yes	no	yes

Table 62: Supported receivers

Maximal supported bandwidth may be less than actual maximal bandwidth of the actual receiver. This depends on performance and license issues.

7.3.3. Adding a receiver

To add a new receiver select a template from the dropdown list at the bottom of the main window and then select <**Add**>. A new dialog window will appear showing various receiver parameters. The type of parameters and thus the layout of this dialog depends on the selected receiver.
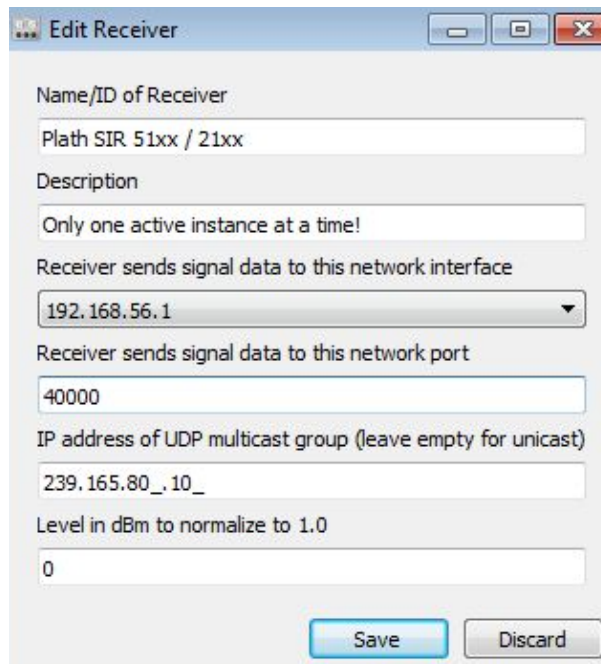
Figure 184: Edit receiver parameters

If the default parameter values are okay then close the window by clicking the button <**Discard**>. If any changes were made e.g. to the IP address in case of a network receiver then select the <**Save**> button to take over the new parameters and close the dialog.

For technical reasons, adding more than one receiver of the same type is not supported for some receivers. In this case, after adding the first receiver configuration, the buttons <**Add**> and <**Duplicate**> will be disabled and the selection of the affected template in the dropdown will be deactivated as well.

If you need support for more than one receiver of certain type and Receiver Configuration does not support it, please contact our support via service@procitec.com for help and further details regarding manual configuration.

7.3.4. Edit receiver parameters

To edit the parameters of a receiver which is already in the list. Either select it and then click the button <**Edit**> on the right side or apply a double-click on the row. The previously described parameter dialog will appear.

7.3.5. Delete receiver

A receiver can be removed from the list when the button <**Delete**> is selected. If a receiver should only be temporarily deactivated it is recommended using the checkbox in the "Active" table column to disable it instead. This will keep its configuration parameters for later use.

7.3.6. Duplicate receiver

The <**Duplicate**> button will create a copy of the selected receiver configuration. The parameters of the newly created receiver configuration must be edited afterwards.

7.3.7. Test receiver

It is possible to test the connection to a configured receiver with the <**Test**> button. It will start a new RCM instance in the background with the currently shown configuration and check the data connection. This might take some time. The result of the test connection will be shown in the table column *State*. It is recommended to disable all but one receiver for testing.

7.3.8. Troubleshooting

LAN receivers:

To connect to a receiver over LAN-interface you have to provide the IP-address and control port of the receiver. Consult the receiver handbook if you would like to know the default IP-address or change the IP-address of the receiver.

Attention: Make sure that the receiver and the PC on which RCM is running are in the same network.

Attention: Activating not-connected network receivers might produce delays and problems during initialization.

Attention: To operate LAN-receivers, any security questions regarding firewall rules after the first start of your product must be acknowledged. This can also be needed after connecting a new receiver and adding it into the product. If the communication between your product and the receiver does not work, you should consider that the firewall you are using interferes with or even prevents the data exchange.

USB receivers:

Make sure that the USB-drivers are installed properly. Also check the connection between receiver and PC.

Attention: Activating not-connected USB receivers might produce delays and problems during initialization.

7.3.9. Remote installation

It is possible to install RCM and the Receiver Configuration Tool on a different computer, too. There is no need for an additional license. However, it is the customer's responsibility to automatically start RCM on this computer.

7.3.10. Installation of Missing ExtIO Libraries

To put some of the supported receivers into operation, external ExtIO libraries are necessary. These libraries are, if possible under the terms of license, delivered with go2DECODE.

For the following receivers, this is not possible:

- • RTL-Stick
- • AirSpy
- • SDRPlay

To put the above receivers into operation, it is necessary to install the ExIO libraries manually. If this is not done yet, the RCM configuration tool shows a warning when one of these receivers is added.

It is recommended to use the libraries that come with the receiver. If these are not available, the latest version from the manufacturer/developer website should be downloaded.

The libraries have to be renamed to a specific filename for each of the receivers as shown in

The library must be available in the form of a specific file name according to Table 63.

Receiver	Name
RTL-Stick	ExtIO_RTL.dll
AirSpy	extio_airspy_cmake_mgw-v1.0.7.dll
SDRPlay RSP1	ExtIO_SDRplay_RSP1.dll
SDRPlay RSP2	ExtIO_SDRplay_RSP2.dll

Table 63: ExIO Libraries

Note: If the library you downloaded has a different name, please rename it accordingly.

To install the library in go2DECODE, copy the library file (after renaming if necessary) to the 32 bit folder in the installation directory of go2DECODE. Typical folders are:

- Windows®

  <installation path> \32 bit,
  e.g. C:\Program Files\ procitec\go2DECODE\32 bit

- Linux®

  /opt/procitec/go2DECODE/

To determine if the installation was successful, start the Receiver Configuration tool (restart if already running) and add the corresponding receiver (see chapter Adding a receiver). If the installation was successful, no warning is shown.

7.4. List of Decoders

See separate document for a list of supported and delivered decoders. In addition, there is a separate document with a short description of every decoder (datasheet).

8. FAQ

8.1. Decoders

8.1.1. Adjusting the Polarity

If decoding is not possible as the decoder cannot automatically detect the polarity of the signal, then we recommend changing the primary demodulator from USB (off) to LSB.

8.2. Interfacing

8.2.1. Connect go2DECODE to go2MONITOR

Define a new signal source in the menu <**Extras**><**Options**> (e.g. go2MONITOR CH1). For a connection to go2MONITOR channel #1, connect to port 36600; for channel #2, connect to port 36601, etc.
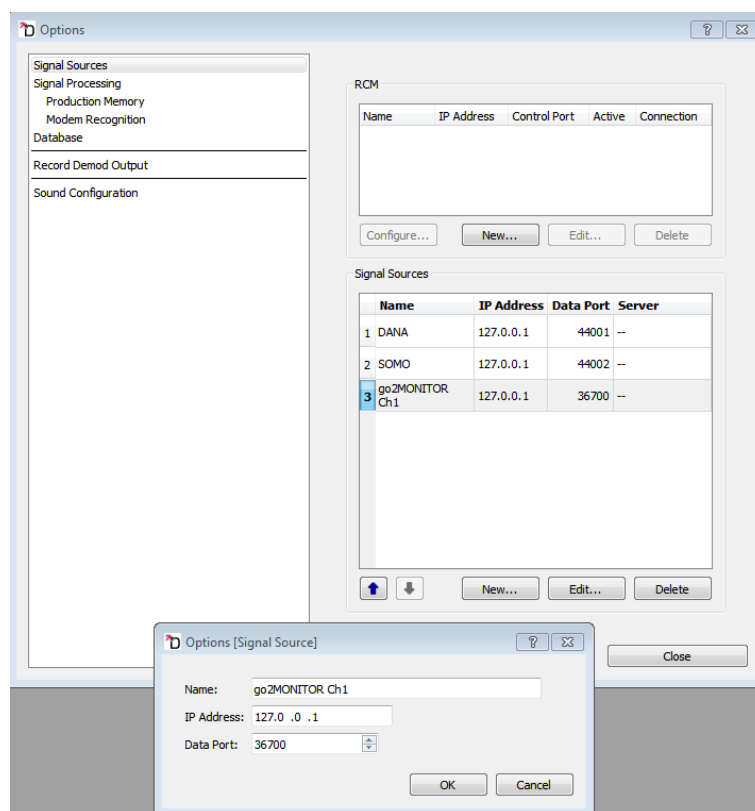
Figure 185: Define go2MONITOR Input in go2DECODE

8.3. Miscellaneous

8.3.1. Disable tool tips

Open the "sda.conf" file in the user folder and set the value of ShowToolTips to 0.

8.3.2. Start the SDA with a different configuration file

Example:

    sda.exe –conf C:\Temp\my_sda.conf

As default, the SDA looks for its configuration file "sda.conf" first in the user folder and then in the installation folder. On the command line you can parameterize the configuration which will be loaded (in the example C:\Temp\my_sda.conf).

8.3.3. Change language of GUI

To do this, it is necessary to create the file "prolang.cfg" in the user folder and then modify it with a text editor. Valid entries are "de" for German and "en" for English. go2DECODE must be restarted after the change.

8.3.4. Location license file

The license file "default.maw" is stored and searched for in the user folder.

    (.../<user>/go2SIGNALS/go2DECODE<version>)

Alternatively, it can be stored in the installation folder.

8.3.5. Drag-and-Drop

Modems and modem lists can be added via drag-and-drop to go2DECODE. This also applies to WAV files in DANA. It is possible to select multiple files at the same time.

8.3.6. go2DECODE runs very slowly or seems to stuck

If go2DECODE is parameterized with a very long modem list and / or fed with a broadband input signal, it takes a long time until the automatic detection is finished. go2DECODE seems to stuck, but it continues to run in the background. It is recommended not to use a broadband input signal, but to use only the necessary narrowband input signal. Furthermore, the modem list should be limited to possible modems.

8.3.7. Modem is not found or decoded

There are several possible reasons:

- Nominal frequency or search range is not set correctly

- Signal quality is too bad

- The modem is not included in the modem list, not selected or not active

- The mode is set to production: only the selected modem is active. Other modems in the list are ignored.

8.3.8. Installed modems

The displayed modems in the result display are not all installed or existing modems and doesn't represent the complete modem database. Modems can be added via <**Modem**><**New Modem**>.

8.3.9. Result location

Results produced are stored by go2DECODE in the user folder under

"…/<user>/go2SIGNALS/ go2DECODE<version>/mem_prod"

in addition to the output in the user interface.

8.3.10. Connection with WebSDR

Through DANA, both complex and real live audio signals can be used, e.g. to integrate a WebSDR. To do this, the audio output must be redirected to an audio input in the operating system. Under Windows®, e.g. "Virtual Audio Cable" can be used. In DANA, the source must be switched to sound, selecting either real or complex (IQ). The audio input is selected under <**Extras**><**Sound Configuration**>.

8.3.11. File extensions

- ".ver" – Single Modem

- ".cmf" – List of modems (complete modem definitions)

  ".mlst" – List of modems (only modem references)

- "_dec.pkg" – pyDDL decoder package

- "_dec.py" – pyDDL Decoder Python source file

- ".wav" – signal file, real or complex

- ".para" – signal parameters for wav files (like receive frequency)

8.3.12. Compressed signal files

If signal files have been lossy compressed (e.g. mp3), important signal information (e.g. phase) which are necessary for demodulation are usually lost. This difference is not acoustically audible but prevents decoding for most modems. Only simple modems, e.g. morse, are rather uncritical in this regard. Signal files, even after reconversion of mp3 or similar, are therefore mostly unusable.

8.3.13. Real and complex signals

A complex signal consists of 2 real channels (I and Q components). The spectrum of a complex signal generally differs at positive and negative frequencies. Real signals are single-channel. Since the spectrum of a real signal is symmetric around 0 Hz, the redundant negative frequencies are usually not displayed in spectrum representations.

In DANA, files with 2 channels are played by default as a real signal and only the first channel is used. In order to play the file in as a complex signal, you have to right-click on the path of the corresponding file in the file list and set the mode to IQ. The signal must be selected and played at the same time.

8.3.14. Spinbox features

The values of all spinboxes can be changed using the mouse wheel. The digit marked by the cursor changes. Furthermore, the unit can be changed by right-clicking on the spinbox and previously entered values are displayed again.
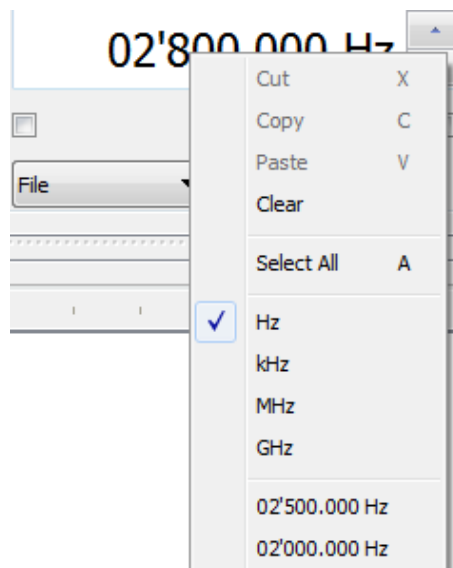
Figure 186: Spinbox menu

8.3.15. Unattended Installation on Windows®

To perform an unattended, also called silent or automatic, installation the following command may be used:

    go2decode-setup.exe /silent

For deployment using MSI packages refer to the file readme.txt on the installation medium.

8.3.16. Changing the font size

The font size can be adjusted for high-resolution monitors as follows:

- By setting the parameter "--font-size <XX>" at startup via the command line. The font size is only changed for the current call.

- In the user directory under "go2SIGNALS/go2DECODE<version>" as a permanent entry in the file "sda.conf". The key **<add key="GlobalFontSize" value="XX"/>** under the entry <appSettings> has to be updated or created.

9. Tools

9.1. DANA

9.1.1. Welcome to DANA

DANA is an abbreviation for *Digital Analog Audio Interface*. DANA converts analog signals into complex IF signals and provides these complex signals as a TCP/IP signal server to the APC. The process is shown in Figure 187.
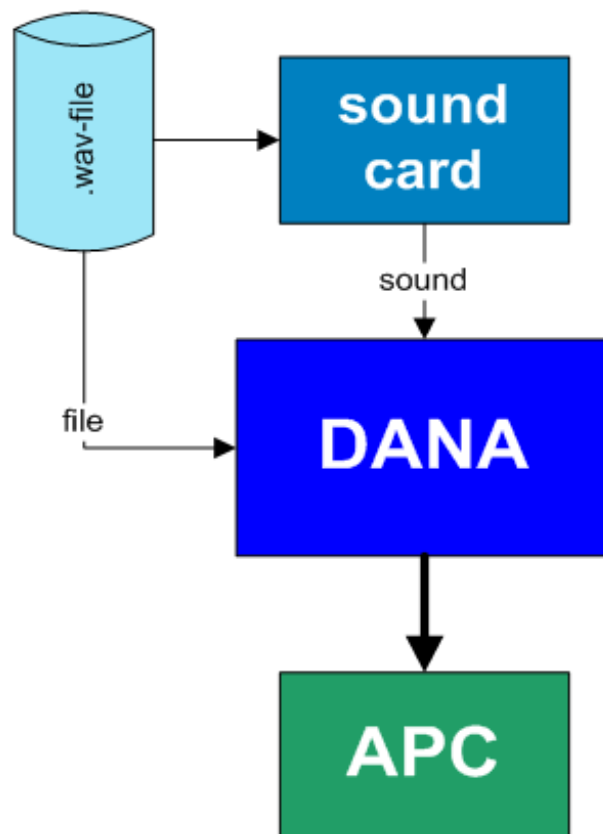
Figure 187: DANA Functions

Two kinds of sources are available:

- **Sound**: Analog signals from the sound card with a sampling rate of 48 kHz or 96 kHz (online), e.g. signals generated and played back using the signal generator SOMO, or WAV files (playing mode *Sound*) played by means of any media player.

- **File**: WAV files can also be played back directly using DANA. The APC has to be ready (indicated by the green dot on the status bar). In contrast to other players, no audible sound output is available.

The input signal is converted into a digital intermediate frequency (IF). The input-signal can be shifted by an offset (mixed) and it can be filtered. To add a filter, the center frequency and the bandwidth (start/end frequency) has to be entered.

To enable the decoder to process the signal correctly, the frequency of this signal must fit, i.e. the processing result mainly depends on the input in the spin box <**Frequency**>. The frequency of most of the signals will fit when the center of the output signal is in zero position.

Spectrum Display

The spectrum of the input signal is displayed with adjusted filter range.

The individual menus and windows of DANA are explained on the following pages. The appearance of the DANA screen depends on the selection of the setting *Sound* or *File*. In the setting *File*, a play list with the corresponding functions and parameters will be displayed in addition.

9.1.2. Control from user interface

DANA user interface

The user interface of DANA can be seen in Figure 188.
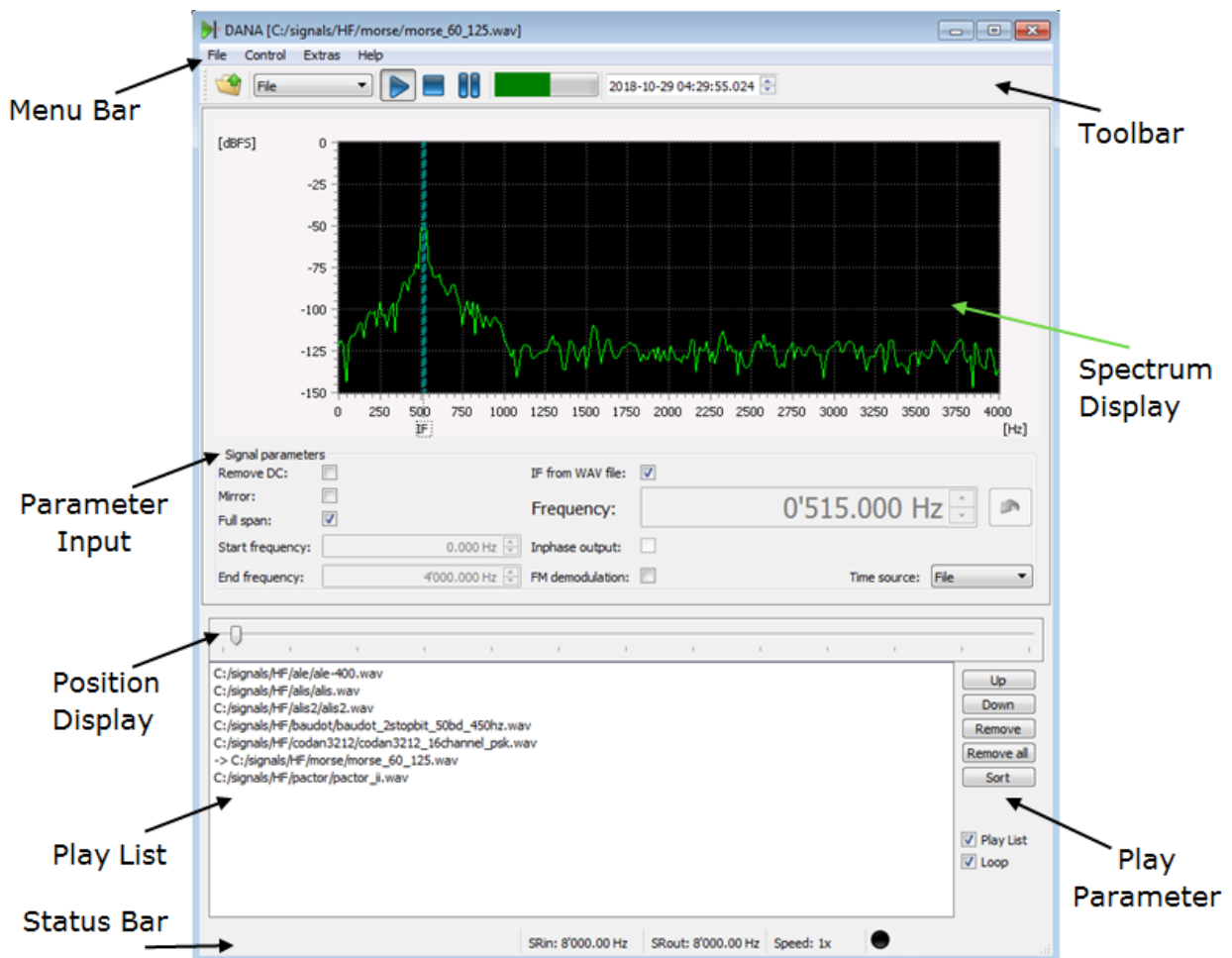
Figure 188: DANA User Interface

Start of DANA

In go2DECODE DANA is started automatically. In addition, it is possible to start it by hand in go2DECODE with the help of the <**Extras**> menu. It is also possible to start DANA from the from the <**Startmenü**> of your desktop.

9.1.2.1. Menu Bar

The menu bar of DANA is displayed in Figure 189.
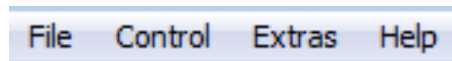
Figure 189: DANA Menu Bar

9.1.2.1.1. Menu File

If <**File**> is selected, the list shown in Figure 190 will be opened.
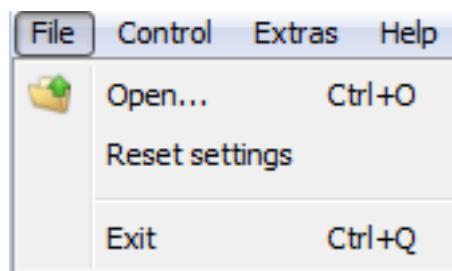
Figure 190: DANA Menu File

Menu Item	Function
Open…	Load selected WAV files into the play list. These are only visible if the source is *File*. Simultaneous selection and loading of several files is possible.
Reset Settings	All settings will be reset to their factory settings. The play list will not be modified.
Exit	The application will close. The settings and the play list will be stored.

Table 64: DANA File Functions

9.1.2.1.2. Menüpunkt Control

The menu <**Control**> is shown in Figure 191.
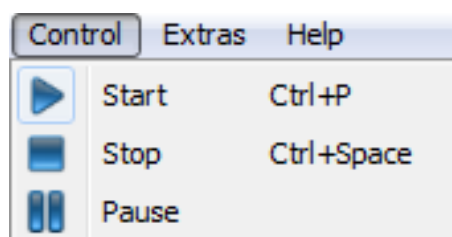
Figure 191: DANA Menu Control

Menu Item		Function
▶	Start	Start playback. APC receives signal data.
■	Stop	Stop playback. APC no longer receives any signal data.
❚❚	Pause	With DANA in mode <**Start**>, playback will be halted; DANA in mode <**Pause**>, playback will be restarted.

Table 65: DANA Control Functions

9.1.2.1.3. Menu Extras

When <**Extras**> is selected, the list in Figure 192 will be opened.
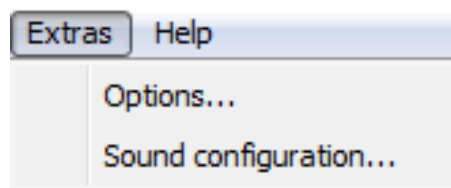
Figure 192: DANA Menu Extras

Options...

<**Options...**> controls the handling of files or signals, respectively. It consists, as shown in Figure 193, of two group boxes.
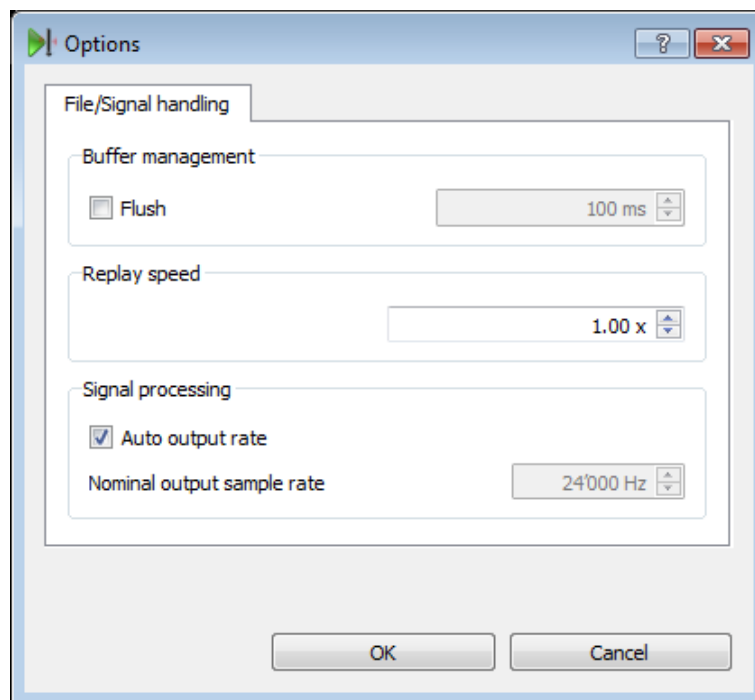
Figure 193: DANA Options Menu

If the checkbox <**Flush**> in group box *Buffer management* is enabled then DANA will send some noise for a specific time after playing back a file with deactivated loop function. This is done in order to flush the

internal APC buffers. This option is helpful if the signal ends jointly with the input file. At signal end if the flush is deactivated or at the end of the flush, the internal APC buffers are additionally emptied via a signal end (EoS) signaled by DANA.

The replay speed while playing from file can be set in the spin box <**Replay speed**> A replay slower than real time (factor < 1) is advisable for input signal with a very high sampling rate or to analyze very short burst signals. Replaying faster than real time is helpful for the fast production of long signal recordings or for modems with a very small symbol rate. It is to be noted that the APC has an internal limit for the production which is regulated by the license.

When the checkbox <**Auto output rate**> in the group box *Signal Processing* is activated, DANA will use the input sampling rate for the output. Otherwise DANA will select a value close to the one specified in the spin box <**Nominal output sample rate**> and resample the input signal.

Sound Configuration...

If the system features various sound cards (e.g. with different numbers of channels), this item can be used to select and configure the existing sound input devices.
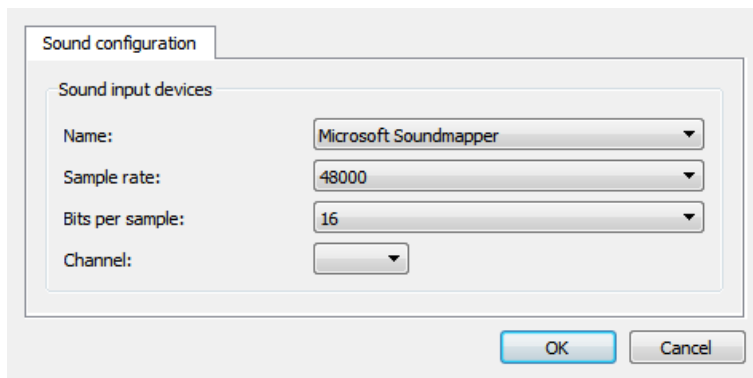
Figure 194: DANA Sound Configuration Menu

In the in Figure 194 displayed dialog box, the desired device can be selected with <**Name**>.To configure the input device, <**Sample rate**>, <**Bits per sample**> und <**Channel**> can be used.

Note: This menu entry might not be accessible if no actual recording device is plugged in (e.g. a microphone).

9.1.2.1.4. Menu Help

The <**Help**> menu can be seen in Figure 195.
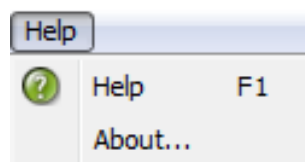
Figure 195: DANA Menu Help

Menu item	Function
Help	Opens the online help.

Menu item	Function
About…	Displays information about DANA.

Table 66: DANA Help Functions

9.1.2.2. Toolbar

The toolbar of DANA is displayed in Figure 196.

Figure 196: DANA Toolbar

9.1.2.2.1. Signal Source

With the combo box in Figure 197 it is possible to define the signal source in DANA.
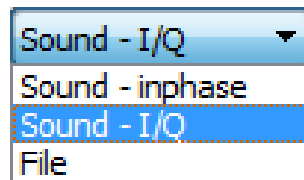
Figure 197: DANA Signal Source

Signal Source	Description
Sound - inphase	The signal is received from the current recording source of the system, e.g. Windows® Media Player or a receiver's audio output. This is an online signal source, i.e. the playback is in real-time and if the APC is not able to process the input signal fast enough then it will drop it.
Sound - I/Q	Similar to *Sound – inphase,* but stereo input signal is interpreted as quadrature I/Q signal. One important application is to connect the I/Q output of another program through a virtual audio cable with DANA.
File	Load WAV files: The file is played directly via DANA. Usually this is an offline signal source, i.e. if the APC is not able to process the input signal fast enough then DANA will have to wait. Playback is in real-time if not specified otherwise on the command line. Note: This entry might not be accessible if no actual recording device is plugged in (e.g. a microphone).

Table 67: DANA Auswahlmöglichkeiten Signalquelle

9.1.2.2.2. Control Icons

The Control Icons ▶ Start, ■ Stop and ❚❚ Pause will be explained in Table 65.

9.1.2.2.3. Gain Display

The bar graph shows the input signal level.
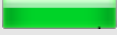
Bar Graph	Description
Green	all right
Red	over modulated.
	If the display is red (over modulated) and *Sound* input is selected, then the volume of the soundcard output has to be reduced, until the gain display turns green (please refer to the documentation of your operating system for details).

Table 68: DANA Gain Display

9.1.2.3. Spectrum Display and Conversion Parameter Setting
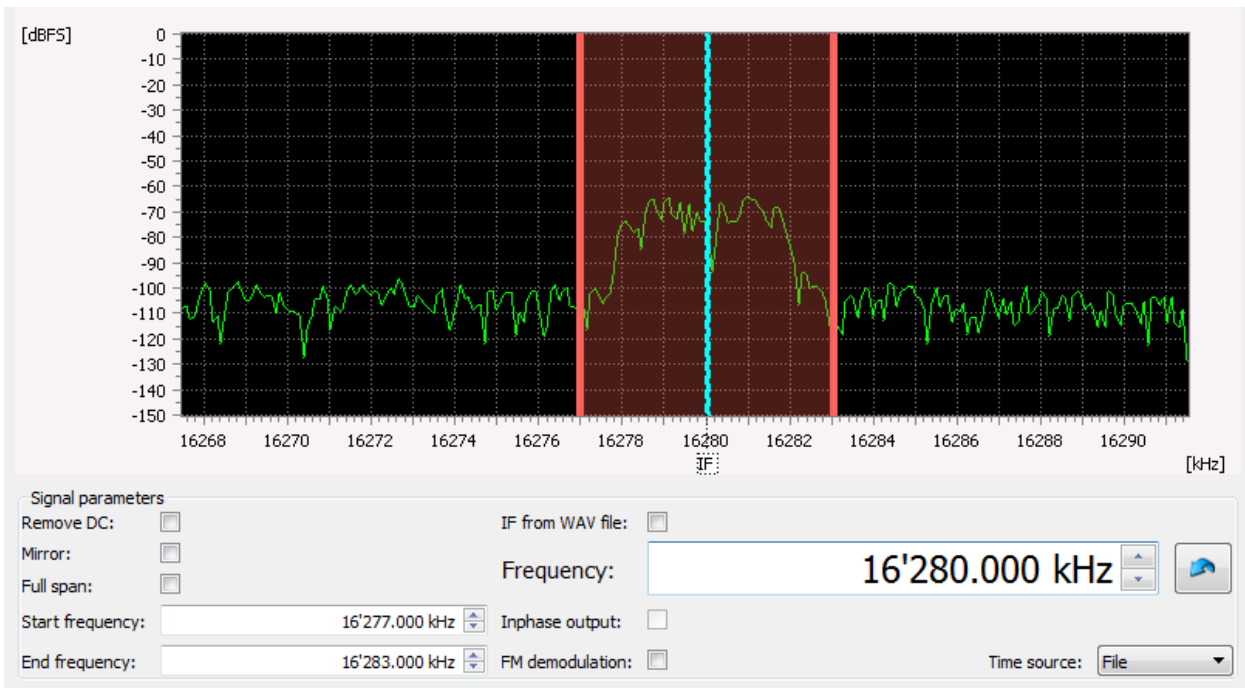
Figure 198: DANA Input signal with band-pass filter enabled

In this window, the spectrum (green) of the input signal is displayed (in dBFS) above the frequency axis (in Hz). Additionally, the band-pass filter (red) for the signal is displayed. The blue line indicates the selected center frequency for the IF of the input signal. If <**IF from WAV File**> is not activated, as is the case in the figure above, the center frequency can be changed in the <**Frequency**> box or directly by moving the blue indication line with the mouse.

Figure 198 shows an example of an input signal with a band-pass filter from 16.277 kHz to 16.283 kHz. Start and end frequency of the band-pass filter can be changed in the corresponding spin boxes or directly by moving one of the red lines in the spectrum with the mouse.

The following shows how the conversion can be parameterized.

Input Filter Settings

In Figure 199, the existing settings for the input filtering are shown.
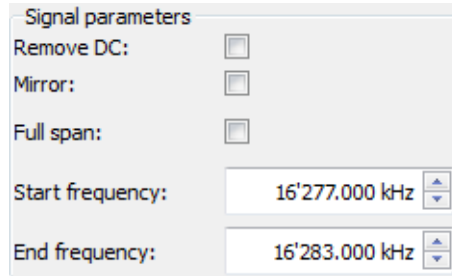
Figure 199: DANA Input Filter

Parameter	Description and Input Options
\<Remove DC\>	Removes the DC bias in the input signal. This option is particularly relevant for signals from the sound card.
\<Mirror\>	If signals are in reverse position (LSB, USB), the mirror mode can be activated to turn these signals to the correct position.
\<Full Span\>	This option deactivates the band-pass filter. The input signal is not filtered.
\<Start frequency\>	Defines the lower frequency for the band-pass filter. The value displayed refers to the input signal.
\<End frequency\>	Defines the upper frequency for the band-pass filter. The value displayed refers to the input signal.

Table 69: DANA Parameter Input Filter

Output Signal

In Figure 200 sind Einstellungen für das Ausgangssignal dargestellt.
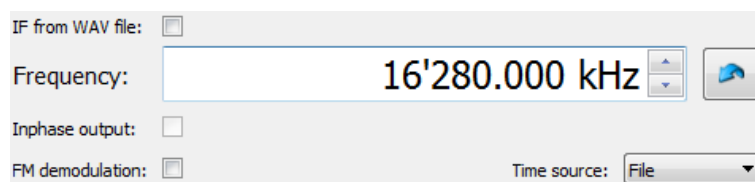
Figure 200: DANA Output Signal

Parameter	Description and Input Options
\<IF from WAV file\>	The relative mixer frequency (IF) by which the input signal will be shifted is retrieved automatically from the audio file if available. WAV files created by PROCITEC applications will store this mixer frequency in the file itself. It is also possible to create a text file with the identical name as the WAV file but with the extension "*.para" and the content "IFFrequency xxx.x". Replace xxx.x with the desired mixer frequency. If the "*.para" file is found, it will have priority over the value stored in the WAV file itself. The "*.para" file can also be created from the context menu. See chapter Play List.

Parameter	Description and Input Options
\<Frequency\>	The frequency entered defines the absolute frequency position in the input signal which is shifted to zero in the output signal. The spin box allows direct input in Hz, kHz, MHz or GHz. For more options, the context menu has to be opened. If the icon is clicked then the relative mixer frequency (IF) is reset to zero.
\<Inphase output\>	Enforce output of an inphase (real) signal (in contrast to a complex signal which is used as default). This will set IF automatically to zero. The checkbox is only enabled if input signal is real and the checkbox **\<Full span\>** is enabled. Should be enabled if input signal is from a receiver's FM discriminator output and demodulator should work only with the inphase part (e.g. 4-ASK).
\<FM demodulation\>	The output signal will be the frequency demodulated (after band-pass filter and frequency mixing). A squelch is automatically applied to suppress noise. It is recommended to apply a band-pass filter. (Can be combined with option **\<Inphase output\>** if necessary.)
\<Time source\> *File*	The original creation time stored in the audio file or if not available the latest modification date is used (available in file mode only). DANA will act as an offline signal source for the APC.
\<Time source\> *System clock*	The current system clock of the computer, which is stored in the audio file, is used. If the checkbox **\<Play List\>** is activated, all files will be processed as files belonging to one emission (available in *File* mode only). DANA will act as an online signal source for the APC.

Table 70: DANA Parameter Output Signal

9.1.2.4. Play List
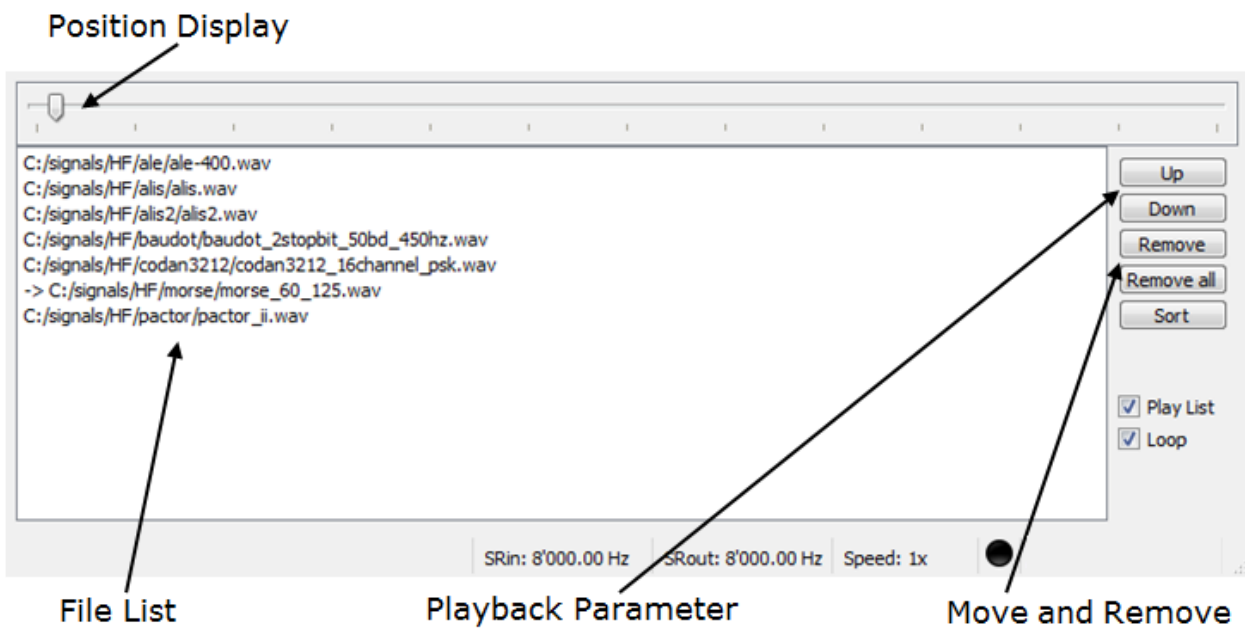
Figure 201: DANA Play List

File List

DANA shows the list of loaded files. The current replay file is marked in the play list with an arrow on the left side in front of the filename.

Note: The play list is available in *File* mode only.

When a file in the list is double clicked, then this file will be made active and replayed. The files can not be played until the APC is ready. There is also a context menu available which entries depend on the file:

Status	Description
● Green dot	Sink connected
● Black dot	Sink not connected

Table 71: DANA APC-Status

Context Menu

There is also a context menu available which entries depend on the file:

Function	Description
Remove	Remove file from list (use <**Ctrl**> or <**Shift**> to select several files).
Save IF	Save the currently parameterized frequency in a text file in the same folder where the WAV file resides. This file will have the identical name as the WAV file but with the extension "*.para". The stored frequency will be automatically loaded if <**IF from WAV file**> is enabled. (Menu entry only available for active WAV file.)
Set receiver frequency (RF)	Opens a dialog for setting the receiver frequency and saves it in a text file with the extension "*.txt" parallel to the WAV file. See also **Set IQ mode**.
Set IQ mode	In case the input file is replayed as audio file but contains indeed IQ (complex) data then select this entry. A text file will be created in the same folder where the WAV file resides. This file will have the identical name as the WAV file but with the extension "*.txt". There will be the info stored that the file has IQ data. DANA will automatically reload the information from this file in the future. WAV files containing IQ data created by go2signals applications are automatically correctly recognized. (Menu entry only available for active WAV file.)
Set audio mode	Undo above action and treat input file as normal audio input. This Menu entry is only available for active WAV file.

Table 72: DANA Context Menu

Add and Remove Files

Files are loaded using <**File**><**Open**> or via the toolbar by clicking the icon 📂. In either case, the dialog box shown in Figure 202 will be opened.
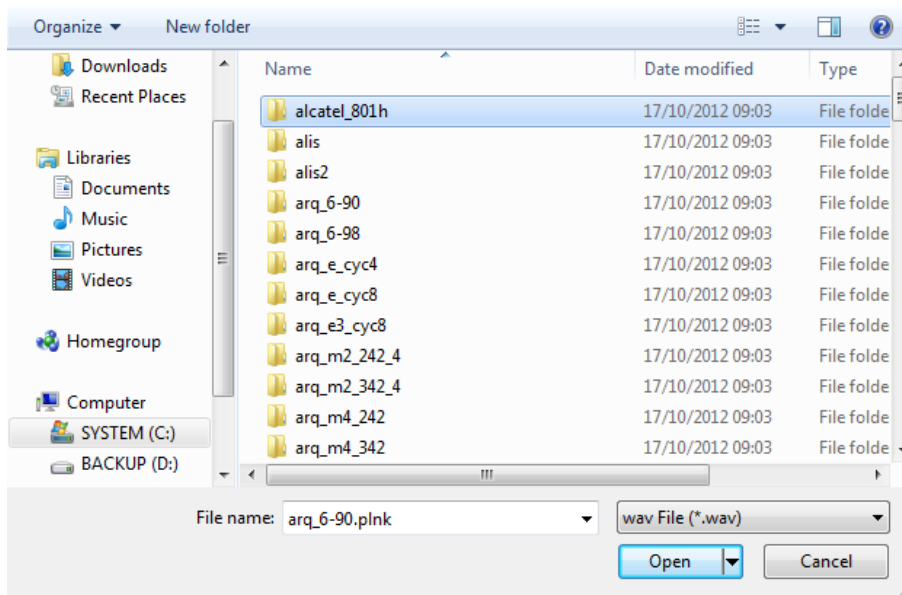
Figure 202: DANA Add or Remove Files

In this dialog window, first the file type and then one or more files have to be selected. New files are added to the existing play list. Drag'n and drop of files from the File Explorer is supported, too.

Files selected with the mouse (use <**Ctrl**> oder <**Shift**> key to select several entries) can be moved or removed using the buttons to the right of the play list (see Figure 201):

Button	Function
<**Up**>	Move selected files upward by one position
<**Down**>	Move selected files downward by one position
<**Remove**>	Remove the selected files from the play list
<**Remove all**>	Remove all files from the play list
<**Sort**>	Alphabetical sorting of the playlist based on the file path

Table 73: DANA Buttons Play List

Play Files

Playback can be started either via double clicking the desired file in the list or by activating <**Start**>. The currently replayed file is indicated by an arrow on the left side.

The different play modes are selected by checking the checkboxes <**Play List**> and/or <**Loop**>.

Button	Function
<**Play List**>	The list is played once from the file marked
<**Loop**>	The file or the files are played repeatedly

Table 74: DANA File Play Modes

Position Display

The progress bar shows how much of the currently active file has been played. By moving the slider, it is possible to directly jump to a location. Alternatively, the current file time can be entered in the input field can be changed at the top right (not available if input signal is from soundcard or time source is set to system).

Note: The input field is inactive if *Sound* is the input source or system time is set as the time source.

Status Bar

| SRin: 8000.00 Hz | SRout: 8000.00 Hz | Speed: 1x | 🟢 |
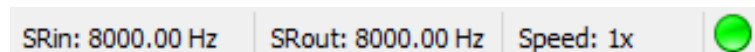
Figure 203: DANA Status Bar

The status bar (see Figure 203) displays following information.

Panel	Content
SRin	Input sampling rate
SRout	Output sampling rate
Speed	Replay speed (if this field is greyed out then replay is in real time, e.g. if replay is from soundcard)
APC Status	🟢 = Sink connected ⚫ = Sink not connected

Table 75: DANA Status Bar Panels

A click with the mouse on the panels *SRout* or *Speed*, respectively, will open the options menu directly.

9.1.3. Control from command line

It is possible to control a running instance of DANA completely from the command line. It is possible to start/stop the replay, add files, change input parameters, etc.

To get a complete list of existing options type "Dana /help" on the command line.

A. Support

Requests and suggestions?

All requests or suggestions regarding our go2signals product-range are very much appreciated; we would be delighted to hear from you.

Any questions? We are happy to assist you!

If you have any further questions, please do not hesitate to contact our Support Team for rapid assistance – just raise a service request at: **http://servicedesk.procitec.com**.
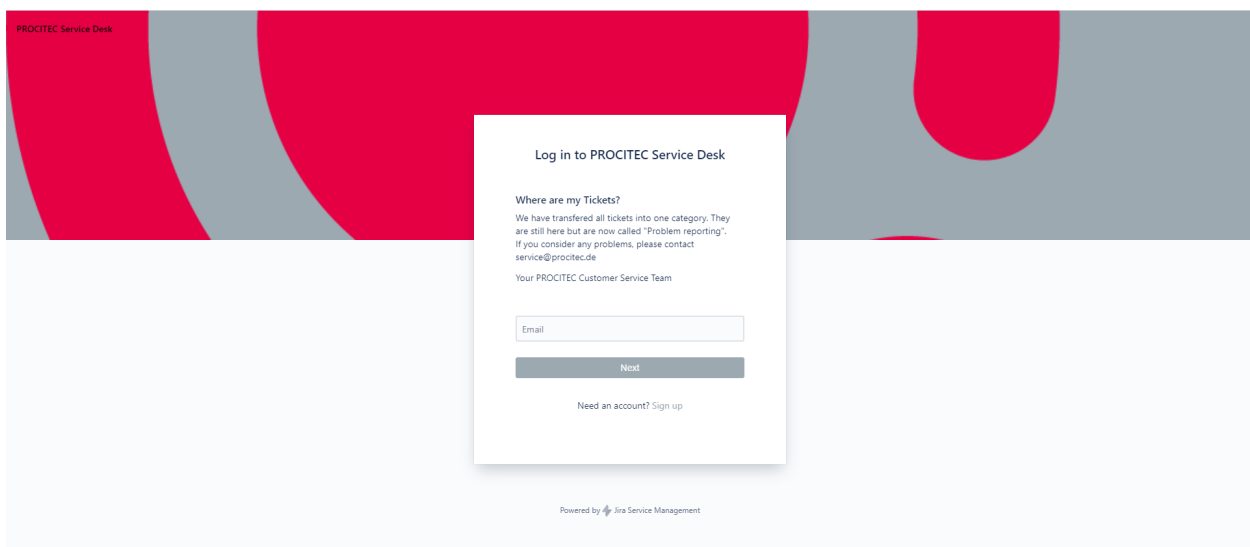
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