WAVECOM Monitoring System

W-SPECTRA, W-SPEED Manual V9.0.0

by WAVECOM ELEKTRONIK AG



PUBLISHED BY
WAVECOM ELEKTRONIK AG
Hammerstrasse 8
CH-8180 Buelach
Switzerland

Phone +41-44-872 70 60
Fax +41-44-872 70 66
Email: info@wavecom.ch
Internet: http://www.wavecom.ch

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General Information

Welcome

Thank you for choosing Wavecom monitoring system and decoder product. The product that you have purchased includes the latest technology in data decoding, together with the latest software release available at the time of shipment.

Please check our website at http://www.wavecom.ch for software updates.

Before you install the product, please also check the latest documentation on the installation DVD or on our website.

WAVECOM ELEKTRONIK AG develops and sells products for wireless (HF/VHF/VHF/SHF) data monitoring in all frequency bands.

Our main decoder and monintoring product series are:

- W-SPECTRA is a complete automatic spectrum monitoring system over all frequency bands (HF/VHF/UHF/SHF).
- W-PCI and W-PCIe are hardware decoders with two physically independent channels. W74PC is hardware decoder with four physically independent channels.

  W-CODE is a stand-alone software decoder working with native host hardware, like a built-in soundcard or other audio devices.

  All hardware decoders (W-PCI, W-PCIe and W74PC) and the software decoder W-CODE have the same decoding functionalities.
- W-PCI-LAN and W-PCIe-LAN are hardware decoders running in a ruggedized mobile computer. They are a complete data decoding system.

Revisions

Version	Date	Changes
1.0.0	05-Jan-2015	Launch of W-SPECTRA and W-SPEED.
1.1.0	06-Jun-2015	New features and functionalities in W-SPECTRA and W-SPEED.
2.0.0	11-Jan-2017	Incorporate Wavecom native device W-PCIe as an HF receiver for W-SPECTRA. Significant improvement. New decoders: PACTOR-4 and TETRAPOL.
3.0.0	20-March-2018	New mode can be classified and detected: CODAN-3212, CODAN-CHIRP. TETRAPOL voice decoding with live output to the speaker.
4.0.0	26-June-2018	Spectrum Analysis tool integrated into W-SPECTRA. It runs as a search strategy. W-SPEED display bandwidth extended to 30 MHz.
5.0.0	12-Feb-2020	New mode: FT8. Improve Spectrum Analysis (W-SA) module. Improve decoders TETRAPOL and DMR. Display time stamp in 1 millisecond (ms) resolution for each frame. To put inline with W-CODE V10.1.0.
6.0.0	26-Aug-2021	Inline with W-CODE V10.2.0.
7.0.0	09-May-2023	Inline with W-CODE V11.1.0.

Version	Date	Changes
		- TETRAPOL: each frame is displayed with a time-stamp at the time of decoding. With this method we can verify that 50 frames are decoded each second. DMR also has this real time-stamp display. - Decryption capability in NXDN. - Decryption capability in DMR with Basic, ARC-4 and AES-256, licensed by Motorola Inc. - Improving DMR decoding and extend its protocol implementation. - Revise Wavecom Classifier. - Extend wideband classifier (W-CL-WB): classify DMR, dPMR and NXDN signals as 4-Level FSK. These signals can also be detected in Classifier Codecheck (CCC). - TETRA and TETRAPOL signals can be detected by the wideband classifier (W-CL-WB) and Classifier Codecheck (CCC). - Review on TETRAPOL. Improve voice decoding. - Add two new entries in "Tools" menu: "Edit DMR Cipher Key" and "Edit NXDN Cipher Key".
8.0.0	17-Sept-2024	Inline with W-CODE V14.0.0 - General review on the wideband classifier (W-CL-WB) - Improve AM, FM, USB and LSB voice classification. Output the demodulated voice live to the speaker when the signal is detected. - New mode LINK-11-SLEW (Serial Tone Link Eleven Waveform). - Review HFDL (HF-ACARS): Add Confidence, Center. Display frame with CRC error – dump all bytes. - Display details (airline name, airport name and country code, name etc.) on Airline Code, Airport and Aircraft Registration in the mode HFDL (HF-ACARS), VDL-M2 and ACARS. - Add Confidence and Carrier Frequency in VDL-M2 mode.
9.0.0	18-Oct-2025	- Review and extend WiNRADiO XRS plug-in to controll G69DDCe. - Redesign the SDR Connection GUI: Select RxInput only available for Wavecom W-PCIe receiver. For WiNRADiO receiver, it is not necessary to select an antenna input, it is set by the receiving frequency.

Recommended WAVECOM Products and Services

W-BV BitView Tool

The highly sophisticated BitView Tool is an external off-line, stand-alone .NET application for analysis of unknown signals.

BitView has a number of features:

- Bit manipulation tools
- Bit display tools (text, graphics)
- Simultaneous processing of multiple analysis sessions
- Auto-update functionality
- Report generator (parameters, data, ASCII, XML)
- Drag and drop of functions
- Re-arrangement of functions in a tree view
- Nested docking

- Auto hide
- Drag and drop of windows
- Application and modification of alphabets
- Persistent-to-XML file (screen layout is restored at start-up time)
- .NET technology
- No installation required, just run the executable
- Data stream and data file import from W61PC/LAN, W-PCI, W-PCIe and W-CODE
- MatLab and C# user defined functions

W-Sat-email-Decoder

The W-Sat-email-Decoder takes as its input a session file and the corresponding text files, as produced by a WAVECOM decoder, or any text file from an external source containing emails. It does protocol decoding and decompression, the email(s) and possible attachment(s) are output as files. The following email systems will be recognized and decoded respectively.

Email system	Recognize	Decode
AMOS	Y	Y
Blast	Y	N
Dualog	Y	Y
GlobeWireless	Y	Y
GTMail	Y	Y
MS-RAS PPP	Y	Y
MS-RAS TCP/IP	Y	N
Rydex	Y	Y
se@comm	Y	Partially
SkyFile	Y	Y
UUCP	Y	Y
UUPlus	Y	Y
Xdatos	Y	Partially
ZModem	Y	Y

Introduction

W-SPECTRA

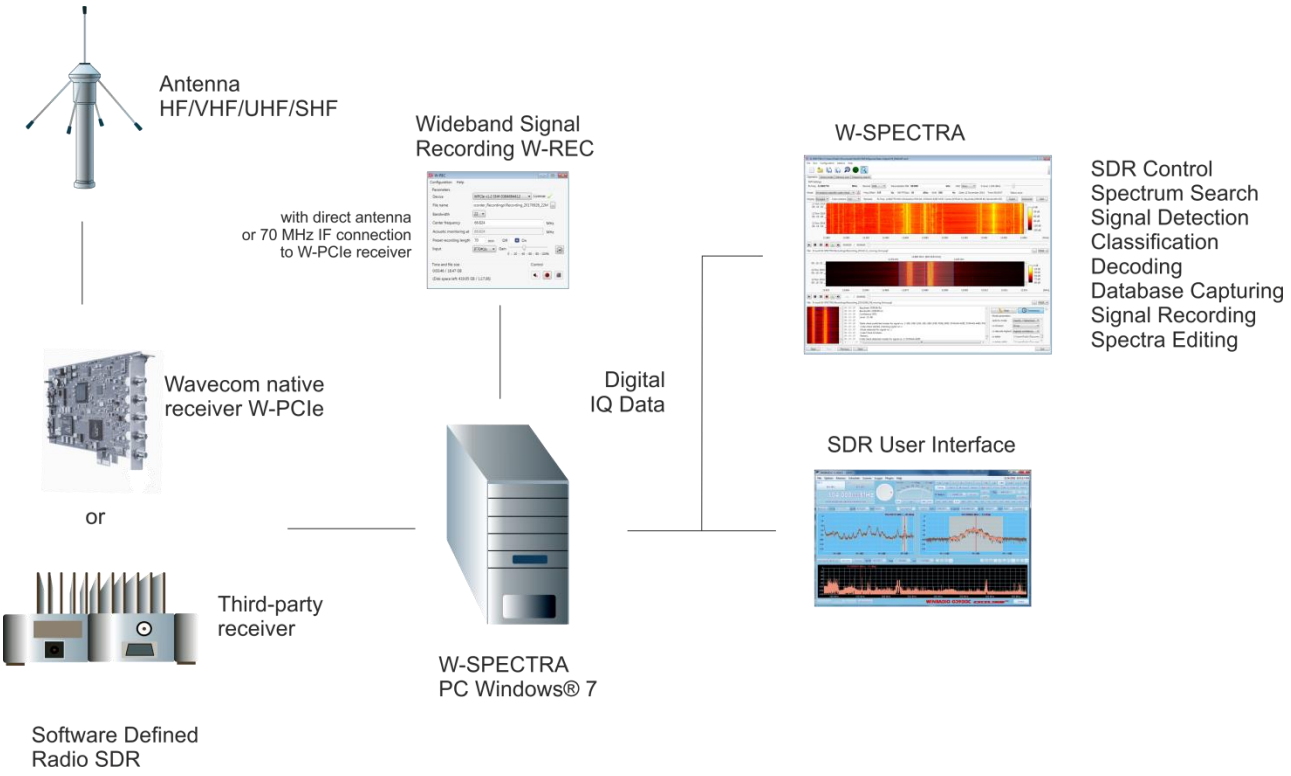
In the modern data communication and signal intelligence the user requires more and more a complete automatic system which can monitor certain frequency bands and fulfil the following main tasks:

- It controls the receiver directly, set the receiver frequency, demodulator and demodulator bandwidth, etc.
- It detects, classifies and decodes signals automatically.
- It records the results of detection, classification and decoding into a database.
- It records the spectrum in a wide bandwidth, so that the user can analyse the whole spectrum afterwards.

W-SPECTRA is exactly such a system to meet these major demands. W-SPECTRA provides:

- Comprehensive online (real-time) monitoring functions, running through the entire radio spectrum from ELF to SHF
- Intuitive graphical user interface: its main operation tab covers all online monitoring activities
- Built-in bi-directional control of receivers (native Wavecom W-PCIe receiver or WiNRADiO G3xDDC)
- Three monitoring modes: Direct Mode, Memory Scan and Frequency Search
- More than 220 mode decoders and protocols over HF/VHF/UHF/SHF
- Wideband (2 MHz) and narrowband (96 kHz) FFT and sonagram displays
- Wideband (2 MHz) and narrowband (96 kHz) signal recording in baseband (IQ) and signal playback
- Signal recording is made with various important side information (meta-data) on-the-fly, such as the receiver frequency, bandwidth and timestamp for complete investigation of the whole spectrum after the online monitoring
- Automatic demodulation and decoding of known signals to the content level
- Automatic search, classification and code check of signals over a user-defined frequency band and certain search strategy
- Automatic or manual capturing of results into a database
- Display of detection, classification and decoding results in a separate window
- Detection, classification and decoding results can be saved into files as well
- User configurable database template
- Database in XML format, providing easy processing by third-party applications
- Integrity check of the database
- Wideband spectrum editing: display a wideband IQ recording in a 2-dimensional sonagram, zoom-in view of the sonagram and cut out a signal anywhere (in time and frequency domains) from a wideband IQ recording for classification and decoding afterwards.

A typical configuration of an automatic spectrum monitoring system with W-SPECTRA can look like the following:

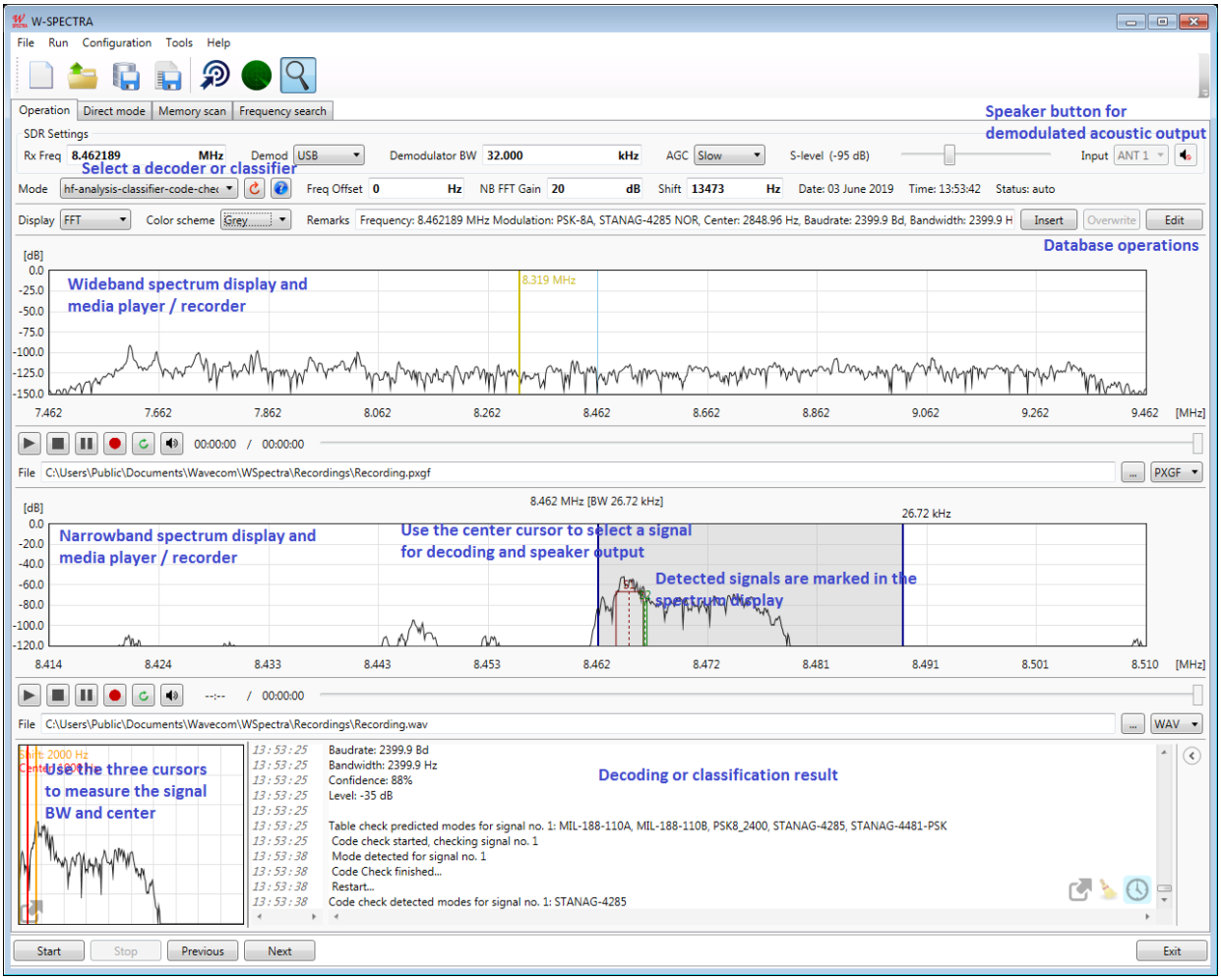


Example setup of a monitoring system with W-SPECTRA.

W-SPECTRA connects to a Software Defined Radio (SDR) and takes over its full control. A built-in mass storage device (e.g., an SSD) can be used by W-SPECTRA for wideband IQ signal recording.

All important operation activities are covered in the W-SPECTRA GUI "Operation" tab:

- Full receiver control: set the receiver frequency, demodulator, demodulator bandwidth, AGC, squelch level and antenna input etc. directly
- Spectrum analysis detects signals and marks them in the narrowband spectrum display (96 kHz)
- Choose a classifier or a decoder manually or automatically
- Display the classification result into a database entry
- Database operations: insert, overwrite and manually edit an entry
- Wideband spectrum display (2 MHz) with IQ signal recording and playback
- Narrowband spectrum display (96 kHz) with IQ signal recording and playback
- Display detailed classification and decoding result
- Switch among the three operation modes: Direct Mode, Memory Scan and Frequency Search
- Four buttons (Start, Stop, Previous and Next) control the work flow of the three operation modes.



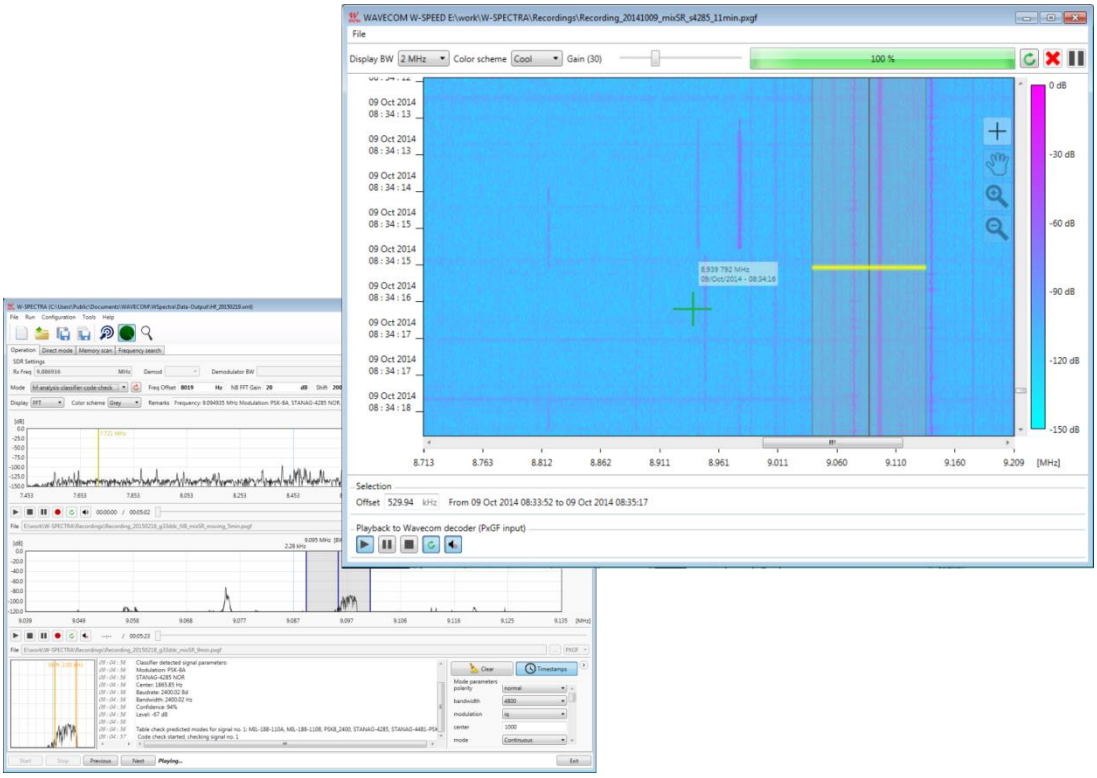
W-SPECTRA GUI Operation tab contains five parts: direct receiver control, classifier and decoder setting, wideband spectrum display and media player/recorder, narrowband spectrum display and media player/recorder and classification and decoding result display.

W-SPEED

While running online (real-time) spectrum monitoring, a system (e.g., W-SPECTRA) can usually classify and decode signals in a limited bandwidth (e.g., 96 kHz) in real-time (online). The reasons are usually limited processing bandwidth of certain components and limited computation power. Signals outside the processing bandwidth can not be processed online. To solve this problem W-SPECTRA makes a recording of signals in a much wider bandwidth (2 MHz) than it is processing online. The recording is done in a lossless way, usually in baseband IQ and the recorded signal is processed afterwards by the Spectrum Editing tool W-SPEED.

W-SPEED loads a recorded signal and displays it in a two-dimensional sonagram with the frequency as the x-axis and time as the y-axis. The sonagram display bandwidth is selectable among 250 kHz, 500 kHz, 1 MHz, 1.5 MHz, 2 MHz, 4 MHz, 8 MHz, 10 MHz, 12 MHz, 16 MHz, 24 MHz and 30 MHz, with 2 MHz as default. The user can examine the sonagram by zooming-in to and navigating over the spectrum, mark an interesting signal and send this signal to W-SPECTRA or other Wavecom decoders (e.g., W-CODE) for classification and decoding.

A typical setup of this spectrum investigation is as in the following



Example setup of the Wavecom spectrum editing tool W-SPEED working together with the monitoring system W-SPECTRA. The user can select a 96 kHz wide signal stripe and send it to W-SPECTRA for detail investigation.

Setup

W-SPECTRA, W-SPEED

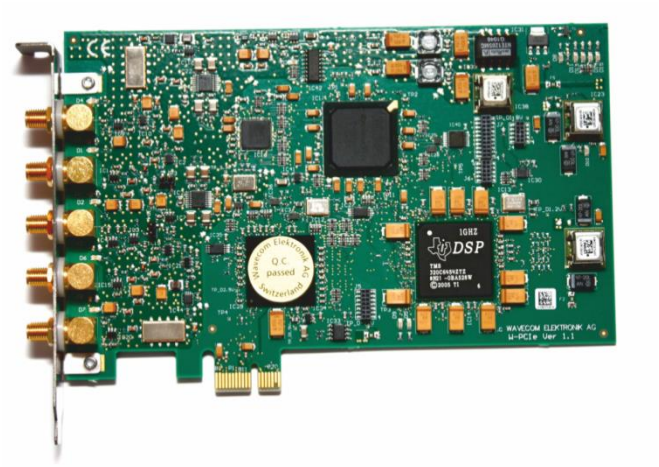
The automatic monitoring system W-SPECTRA and the spectrum editing tool W-SPEED provide all functions required to analyse, classify, decode and process radio data communications over the entire frequency spectrum. Both are licensed software, running on existing equipments of the customer. This feature allows seamless integration with SDR (Software Defined Radio) receivers with IQ data and TCP/IP data outputs. The license for the software is programmed on a CmStick USB key. One client license is provided with each software package (multiple licenses on request).

W-PCIe Receiver Installation

Before unpacking the W-PCIe card and installing it into your PC please make sure that you are attached to the electric ground to avoid damaging static sensitive components on the card or in the computer.

Power off your computer, unplug it from its power source and disconnect or turn off all peripherals. Carefully remove the cover of the computer and locate a free PCI express slot. Firmly insert the card into the slot. Close the computer cover and switch on the power.

WARNING: THE A/D CONVERTER ON THE W-PCIe CARD MAY DEVELOPE ENOUGH HEAT TO PRODUCE BURNS OR START A FIRE IF PLACED NEAR FLAMMABLE OBJECTS. WAVECOM WILL NOT BE RESPONSIBLE FOR ANY DAMAGES RESULTING FROM NON-COMPLIANCE WITH THIS WARNING.



W-PCIe receiver.

W-PCIe card have five SMA signal inputs. The following table is a technical hardware specification.

Specification		
Card type	Half-size PCIe x1 card (W-PCI Express)	
Inputs	AFIF#1 and AFIF#2 for direct HF antenna connection	IF70#1a, IF70#1b and IF70#2

Specification		
Frequency range	50 Hz – 25 MHz	52.5 MHz – 87.5 MHz (SAW filter)
Input impedance	50 Ohm	50 Ohm
Bandwidth	5 kHz – 500 kHz	
Frequency raster DDC	1.0 Hz	
Input max sampling rate	92.16 MHz	
Sampling rate jitter	1 ps	
Connector	SMA female	
Two simultaneously active inputs	AFIF#1 or IF70#1a or IF70#1b – with – AFIF#2 or IF70#2	
Dimensions (LxWxH)	168x106x22 mm	
Weight	150 g	
Power requirement (typical values)	1.0 A @ +3.3 V, 0.4 A @ +12 V	
Bus interface	PCIe x 1, 250 MB/s	
Operating temperature range	0 °C to 50 °C	
Case temperature range	0 °C to 55 °C	
Storage temperature range	0 °C to 70 °C	
Relatively humidity (non-condensing)	10 to 90%	
A/D converter	16-bit	
Digital down converter (DDC)	FPGA	
License key	In-card license, no external license key necessary	
Conformity	CE ISO 9001 ISO 14001 RoHS	

W-SPECTRA and W-SPEED Hardware Installation

The license to run W-SPECTRA and W-SPEED is delivered on a USB dongle. Just insert the USB license key(s) in any USB socket.

Software Installation

W-SPECTRA supports the native Wavecom receiving device W-PCIe and the WiNRADiO Software Defined Radio (SDR) receivers G3xDDC.

- To use W-PCIe as a receiver, make sure that the Wavecom Virtual Audio Cable (VAC) is first properly installed. Then install W-SPECTRA. It contains the controlling of the W-PCIe receiver.
- To use WiNRADiO G3xDDC receivers with W-SPECTRA, make sure that the G3xDDC software and the WiNRADiO Virtual Sound Card (VSC) are already installed.

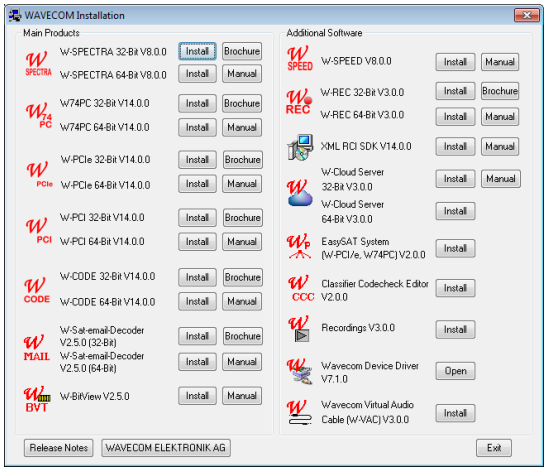
Insert the WAVECOM installation DVD in the drive. When requested, point the auto start wizard to the disc drive and start installation.

Note: To run installation you need to have the **Administrator** right. After installation, you can run the applications W-SPECTRA and W-SPEED if you are a member of the **Administrators**, **Power Users** or **Users** group.

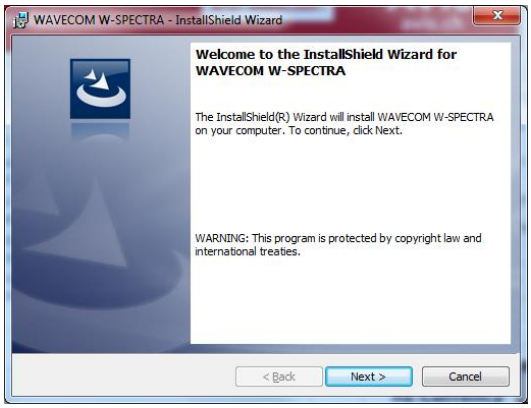
Before the installation of a software update, the old version must be uninstalled (see "Software Uninstall" on page 14). After uninstallation has completed, insert the WAVECOM installation disc in the drive; the installer will start automatically. Otherwise, it can be started with **Windows Explorer** by double-clicking **Installation.exe**.

Without loosing generality we show the installation steps on the example W-SPECTRA.

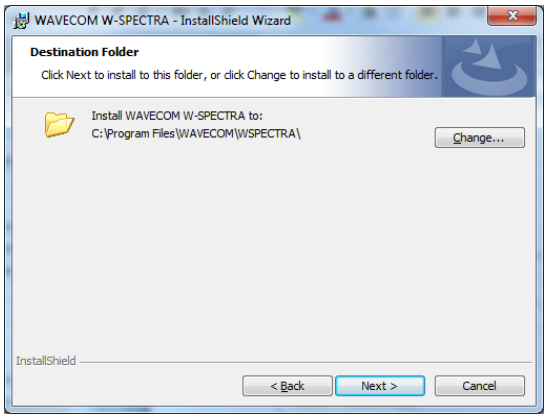
The selection dialogue of the installation program is displayed:



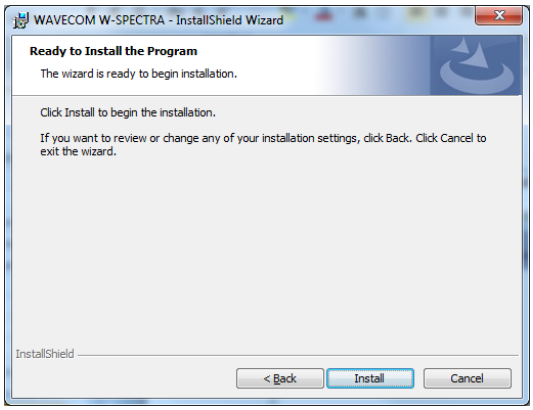
Click the "W-SPECTRA" button to install the W-SPECTRA application.



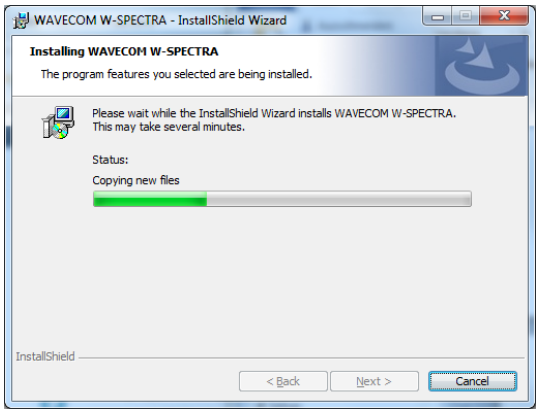
First, you will see the welcome screen. Click "Next" to continue the installation.



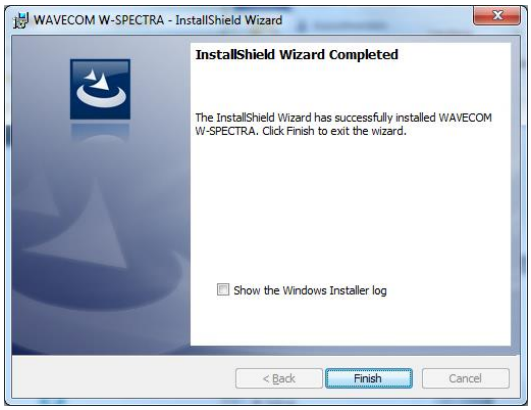
Change the destination folder and click "Next" to continue the installation.



Click "Next" to continue the installation.



Wait until the installation is finished.



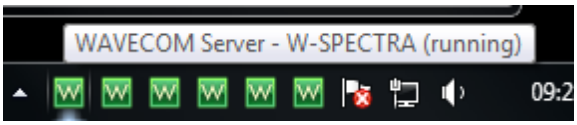
If the installation was successful, click **Finish** to complete the process.

Note: If a firewall is enabled on your system, depending on its security level settings, various components of W-SPECTRA may ask to access the Internet or the trusted zone of the firewall. You will have to manually grant access to these components.

Check for hidden windows if the installation process seems to "hang" (this can be done by pressing the Alt+Tab keys). Sometimes windows in the background are waiting for a button to be pressed to allow the installation to proceed.

W-SPECTRA Server

W-SPECTRA runs in a client/server architecture. The W-SPECTRA server is running as a Windows service, which will start automatically at the PC startup. The corresponding tray icon indicates the server status as below.



Status of the W-SPECTRA server.

Make sure that the server is in "running" status. The user can also start the server manually by right clicking the mouse or just double clicking the desktop icon "W-SPECTRA".

W-SPECTRA Licensing

The license of W-SPECTRA is programmed on a USB key (Wibu CmStick). The software is delivered with one year free update, i.e., the customer will get new software versions free of charge during one year after the date of purchase. The update period can be extended for max. 5 years. The purchased software version itself runs without time limit.

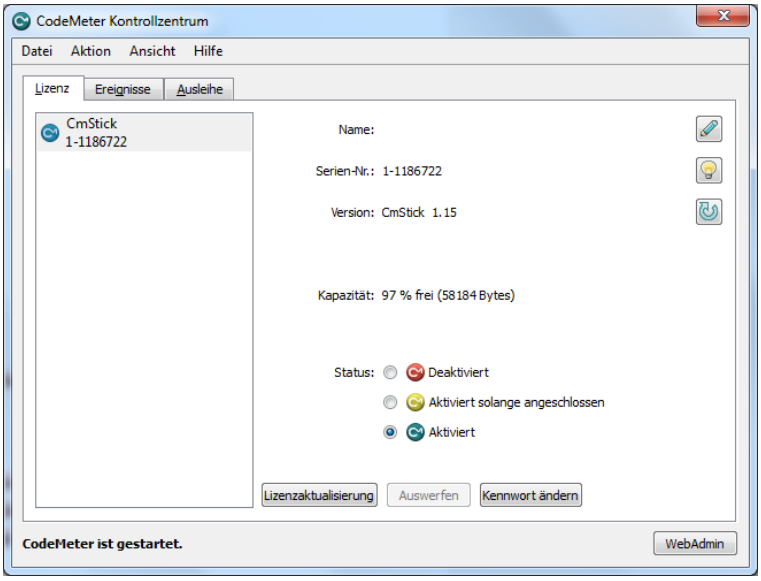
On request, different licensing models are available:

- Single-user licenses
- Network licenses with floating licenses (sharing of W-SPECTRA and options between different computers)
- Licenses for other WAVECOM software products and third party products may also be stored on the CmStick

Software Updates

Software released during the update period can be installed at any time.

New licenses can be loaded to the CmStick without sending the physical USB key to WAVECOM. Just click **License Update** on the **CodeMeter Control Center** and follow the information provided by the assistant.



How to update a license.

Software Options

W-SPECTRA runs with two options: Spectrum Analysis (W-SA) and narrowband classifier (W-Classifier-NB, with 8 kHz bandwidth) or wideband classifier (W-Classifier-WB, with 96 kHz bandwidth) (see "License System, Software and Options" on page 257).

Both Spectrum Analysis (W-SA) and Classifiers (W-CL-NB or W-CL-WB) are delivered with separate licenses. They can be shared by other Wavecom decoders, e.g., W-CODE. If the customer already has a license (W-SA, W-CL-NB or W-CL-WB), he can just order the W-SPECTRA. In this case W-SPECTRA will run with the existing licensed option.

To order the W-SPECTRA software, please follow this procedure:

- Place an order W-SPECTRA with the proper option. If you already have a CmStick, you may give us the serial number of your CmStick.
- WAVECOM will process your order and forward you an invoice.
- After the payment has been received, a new key or license file for your existing CmStick will be delivered.

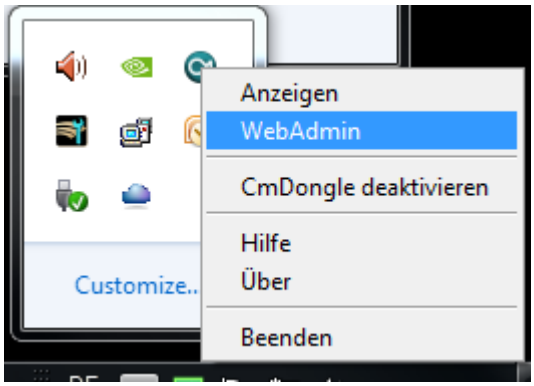
To process an order for options, the following information is required:

- Complete address
- Ordered items
- Email or mail delivery
- Serial number and remote context file of CmStick to be updated, if applicable

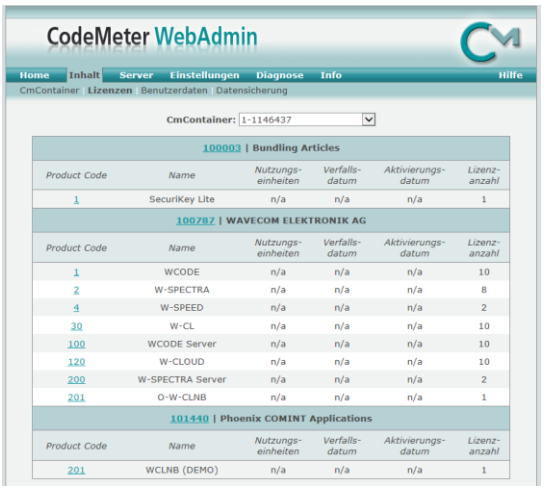
W-SPECTRA License Checking

To check the license(s) on the CmStick follow these steps:

Open the CodeMeter WebAdmin interface from the CodeMeter tray icon.



Press the **"WebAdmin"**.



Licenses available on the CmStick are listed in this screen.

Item	Remarks
Product Code	Displays the product code
Name	Displays the name of the product item, normally the name of the product
Feature Map	Displays the feature map
Licenses	Displays the total number of network licenses
Maintenance Period	Display the maintenance period of the license. Wavecom uses this to check whether the license is valid to run a new software version
User Limit	Displays the number of licenses, which are currently used in the user limit mode
No User Limit	Displays the number of licences that are currently used in the no user limit mode
Exclusive	Displays the number of licences that are currently used in the exclusive mode
Shared	Displays the number of licences that are currently used in the shared mode
Free	Displays the number of licences that are currently free
Details	Displays detailed information about the respective network licences in use

Important: If you have multiple CmSticks plugged into computers in the same local network, refer to

"License System, Software and Options" on page 257.

Software Uninstall

In certain situations, e.g., when updating the application, it is necessary to uninstall the software. Use the following commands:

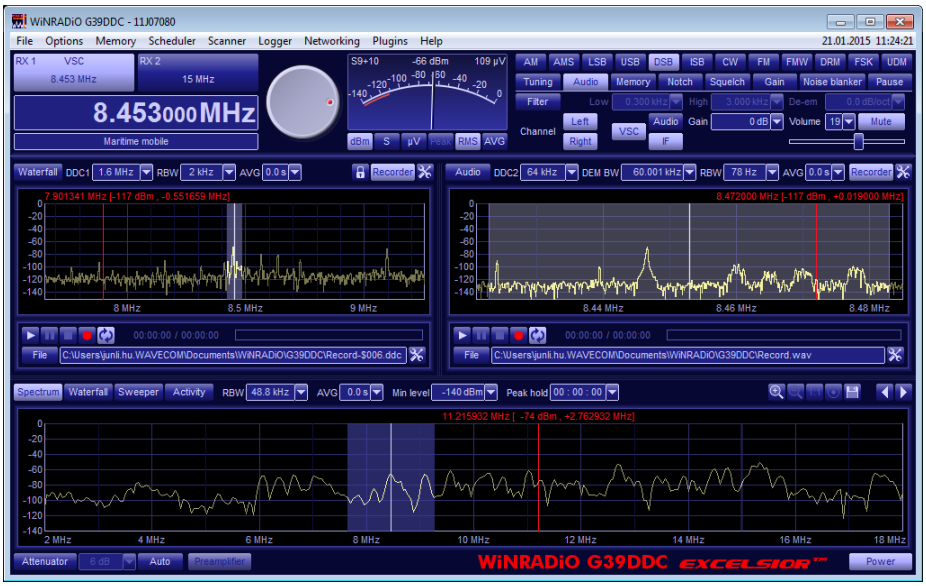
VISTA	XP	Windows 7
➢ Click on **Start,** go to the **Computers** menu and click the **Uninstall or change a program** button ➢ Select **WAVECOM W-[XX]** from the list ➢ Click **Uninstall**	➢ Click on **Start,** go to the **Settings** menu and open **Control Panel** ➢ Select the **Add/Remove Programs** icon ➢ Select **Install/Uninstall** ➢ Choose **WAVECOM W-[XX]** from the list ➢ Click **Add/Remove**	➢ Click on **Start** and open the **Control Panel** ➢ Select the **Programs** icon ➢ Select **Programs and Features** ➢ Choose **WAVECOM W-[xx]** from the list ➢ Click **Uninstall** in the menu

The application has now been removed from the PC - it is possible, however, that the shortcut icons may have to be removed manually.

Complete Automatic Monitoring System W-SPECTRA

First Start

- ✓ After the software and the CmStick have been successfully installed, W-SPECTRA can be started either from the Windows Start menu or by double-clicking the program icon on your desktop.
- ✓ The user can either choose a W-PCIe receiver or a WiNRADiO G3xDDC.
- ✓ In the case of W-PCIe as a receiver, the user can select a device in the "SDR settings" GUI (see **Direct Receiver Control**). In the "SDR Settings" in the Operation GUI the user can set the receiver frequency, the demodulator, the demodulator bandwidth and the antenna input. He can also turn on the speaker for acoustic monitoring purpose.
- ✓ In the case of WiNRADiO G3xDDC, the user needs to start the WiNRADiO G3xDDC native GUI and select the device in the "SDR settings" GUI (see **Direct Receiver Control**). For example,



WiNRADiO G39DDC native GUI.

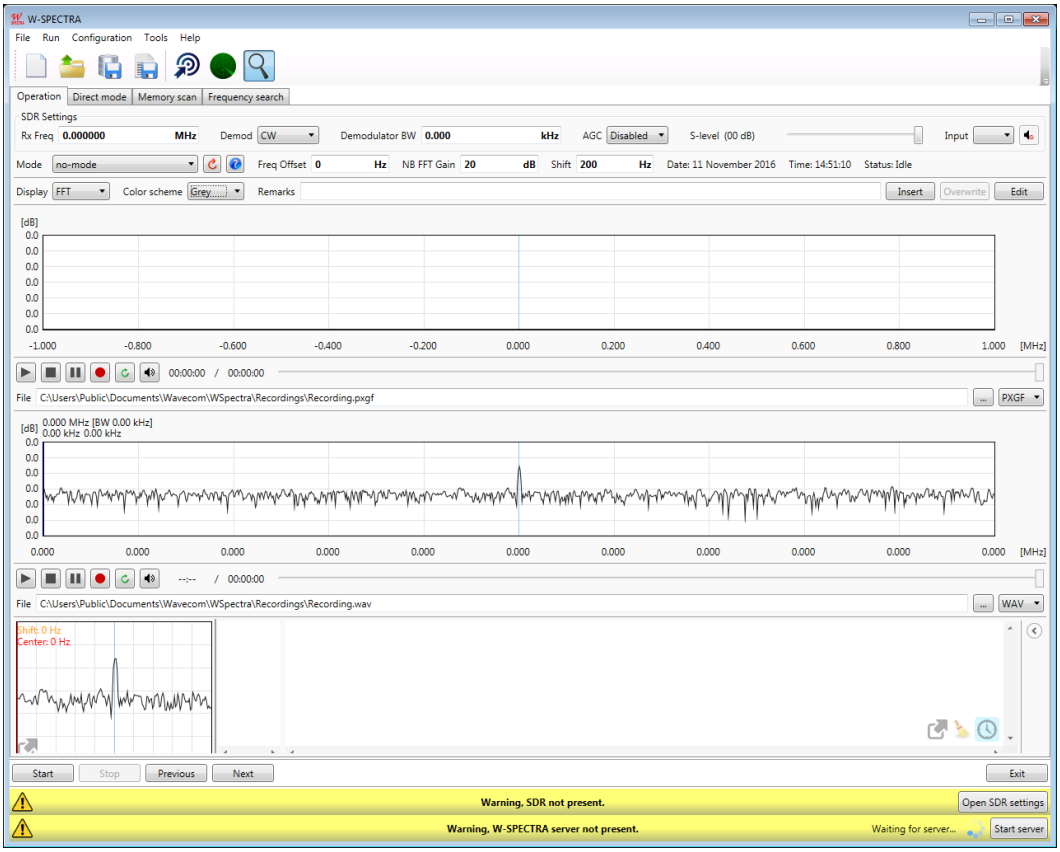
- ✓ Proper operation of W-SPECTRA is indicated by the WAVECOM Server Control icon in the Windows system tray in the taskbar. If the the icon is green, the server is operating normally. You may also move the mouse over the icon and check that you get this status message: **WAVECOM Server – W-SPECTRA (running)**.

  The following GUI shows that W-SPECTRA is running properly. It is connected to an SDR (e.g., W-PCIe receiver) and is classifying signals coming from the receiver.



W-SPECTRA works properly.

- There are five major parts in the W-SPECTRA main GUI:
  - Direct receiver (SDR) control
  - Run a decoder or a classifier, database operations
  - Wideband (2 MHz) spectrum display and media player/recorder
  - Narrowband (96 kHz) spectrum display and media player/recorder
  - Decoder or classifier setting and display of results.
- The user can set the receiver frequency, demodulator and demodulator bandwidth using the W-SPECTRA GUI or the native SDR GUI, e.g., WiNRADiO G39DDC GUI. Settings will be synchronised in both GUIs.
- The user can further move the tuning cursor inside the narrowband spectrum display to select the signal at a certain frequency for classification and decoding and output this signal to the speaker applying a proper demodulator. The acoustic output to the speaker works only for W-PCIe receiver. For G3xDDC receiver this functionality is implemented in its native WiNRADiO GUI.
- The user can view the spectrum up to 2 MHz in the wideband display.
- The signals in the middle 96 kHz wide stripe of the wideband display will be shown in the narrowband spectrum display. The user may move the middle cursor in the narrowband display to locate the signal.
- The user may choose a classifier or decoder in the pull-down list "Mode" and the selected signal (by the tuning cursor in the narrowband spectrum display) will be classified or decoded. The result will be displayed in the lower part of the GUI.
- If no receiver (SDR) is running or the W-SPECTRA server stops, warning messages will appear in the W-SPECTRA GUI. The user may take actions according to the message.

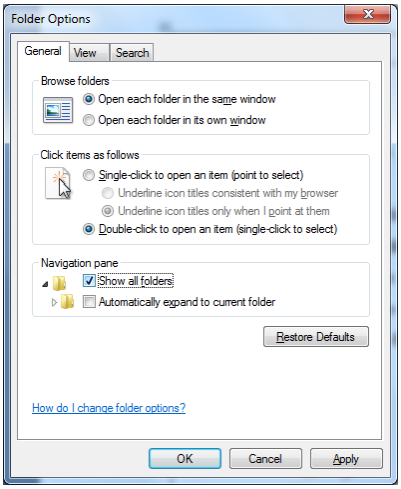


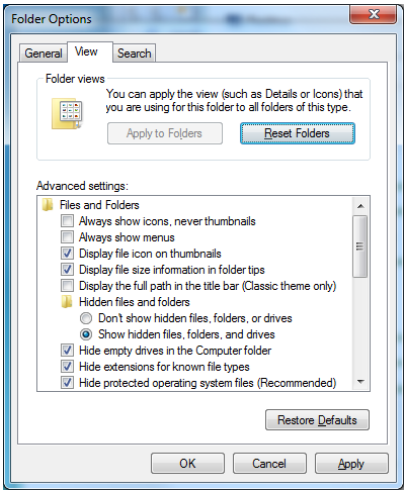
If the receiver is not running or the W-SPECTRA server stops, warning messages will appear. The user may take corresponding actions.

Default Data and Program Folders (Paths)

To see all folders, select **Folder Options** in the **Control Panel**

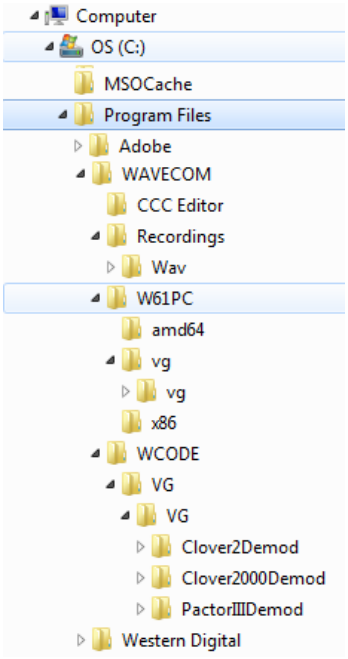
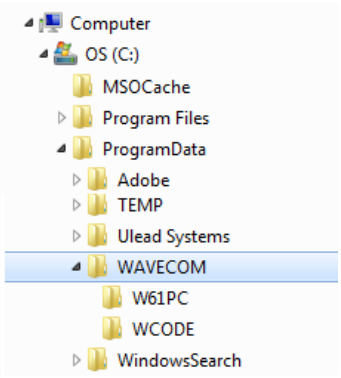
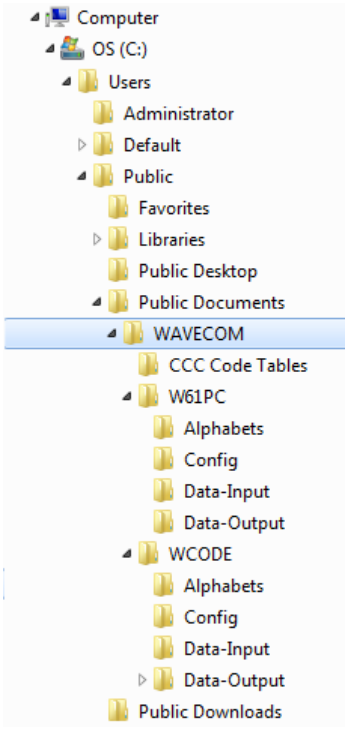
- Enable **Show all folders**.
- Enable **Show hidden files, folders and drives**





Path names can vary if you use a non-English language operating system or if you are not using the Microsoft "Windows Explorer".

Folder	XP	Vista
Program Folder (Read only, RO)	C:\Program Files\WAVECOM\<*Product*>\	C:\Program Files\WAVECOM\<*Product*>\
Global Data (Read only, RO)	C:\Documents and Settings\All Users\Application Data\WAVECOM\<*Product*>\	C:\ProgramData\WAVECOM\<*Product*>\
Global Data (Read & write, RW)	C:\Documents and Settings\All Users\Documents\WAVECOM\<*Product*>\	C:\Users\Public\Public Documents\WAVECOM\<*Product*>\
User Specific Roaming Data	C:\Documents and Settings\\<*Username*>\\Application Data\WAVECOM\<*Product*>\	C:\Users\<*Username*>\AppData\Roaming\WAVECOM\<*Product*>\
User Specific Non-Roaming Data	C:\Documents and Settings\<*Username*>\Local Settings\Application Data\WAVECOM\<*Product*>\	C:\Users\<*Username*>\AppData\Local\WAVECOM\<*Product*>\

Program Folder	Global Data (RO)	Global Data (RW)
		

Main Menu

The main menu includes all submenus relating to operating modes, as well as setup, analysis, classification, decoding and database functions.

The WINDOWS operating system is based on a multitasking kernel and can handle several tasks simultaneously, and therefore interaction with the menu system will not interrupt the execution of an active function. This allows, for example, the integrity check of a database running without interrupting other activities.

W-SPECTRA Main GUI Screen Display

When working properly (connected to a receiver and the W-SPECTRA server is running), the main GUI should look as the following.



W-SPECTRA is running properly (e.g., with WiNRADiO G3xDDC as a receiver). It is classifying a signal and doing code check.

As a standard WINDOWS procedure a left-click on a menu item will display the corresponding drop-down menu.



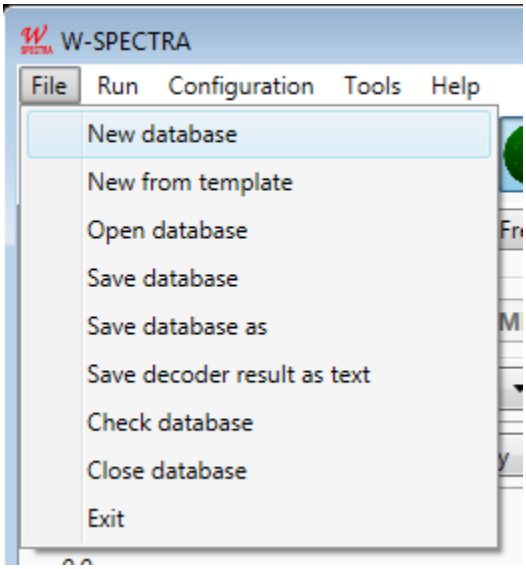
W-SPECTRA menu items: File, Run, Configuration, Tools and Help.

The W-SPECTRA menu includes **File**, **Run**, **Configuration**, **Tools** and **Help**.

- File menu includes various database operations.
- Run menu sets the three W-SPECTRA operation modes: Direct Mode, Memory Scan and Frequency Search.
- Configuration menu includes the receiver (SDR) setup, the startup behavior and customization of the database.
- Tools menu includes additional functionalities of W-SPECTRA.
- Help menu includes the software version and build information.

The button line under the menu line includes "**New database**", "**Open database**", "**Save database**", "**Save decoder result as text (bitmap)**", "**Run Direct mode**", "**Run Memory scan**" and "**Run Frequency search**". When moving the mouse to the buttons the corresponding hint will appear.

File Menu

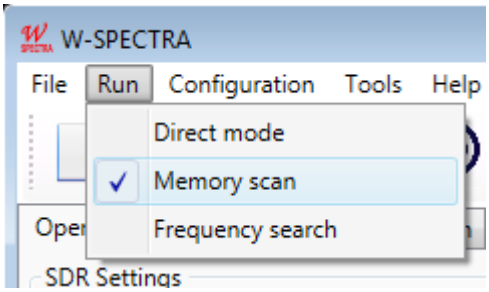


W-SPECTRA File menu.

Using the **File** menu, the user can access

New database	Open an empty database using the template which is already active in W-SPECTRA. The user can view the active database template by clicking the tab "Direct mode", "Memory scan" or "Frequency search".
New from template	Open an empty database with a user configured template.
Open database	Open an existing database.
Save database	Save the changes (new entries etc.) into the database.
Save database as	Save the changes in the database under another name.
Save decoder result as text (or as bitmap)	Save the classification and decoding result into a TXT file or as bitmap when the result is a picture.
Check database	Check the integrity of a database: remove null entries and remove duplicate entries. (See "Database Operations and Integrity Check" on page 40.)
Close database	Close the database.
Exit	Exit the W-SPECTRA application.

Run Menu

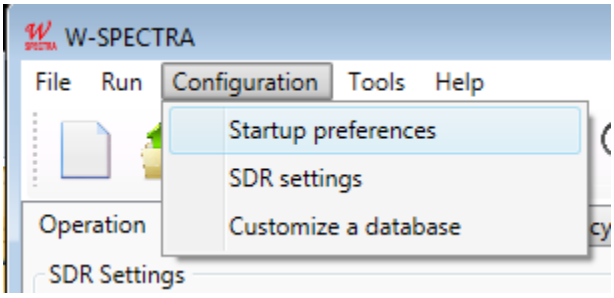


W-SPECTRA Run menu.

With the menu "Run" the user can switch W-SPECTRA among the three operation modes: "Direct mode", "Memory scan" and "Frequency search". The user can also switch to a mode by clicking the corresponding button.

Each operation mode defines a different automatic work flow and running behavior of W-SPECTRA.

Configuration Menu



W-SPECTRA Configuration menu.

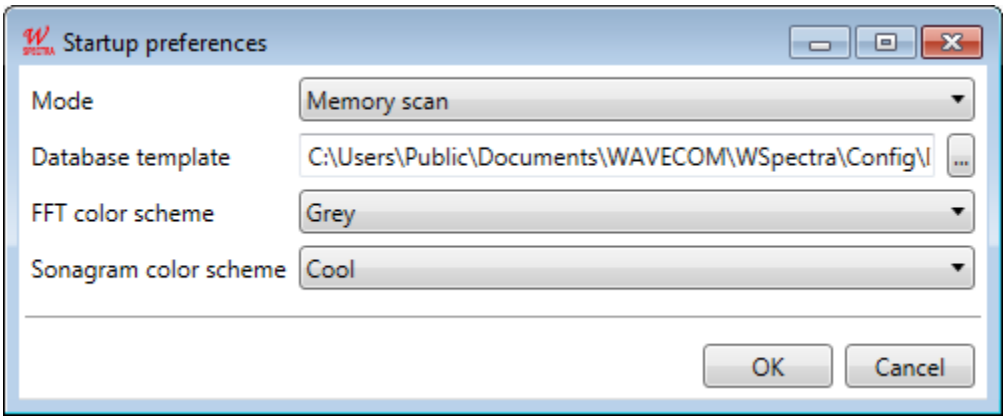
Configuration menu includes

Startup preferences	This menu opens a dialog window, in which the user can set the default behavior of W-SPECTRA at startup. The user can define which operation mode (Direct mode, Memory scan or Frequency search) should W-SPECTRA run when it starts. The user can define which database template should be loaded when W-SPECTRA starts. The user can define which color scheme should apply to the FFT display and sonagram display.
SDR settings	This menu will open a configuration window where the user can scan all receivers (W-PCIe receiver or WiNRADiO G3xDDC) which are running on the local computer, choose a receiver, connect or disconnect it. The user can set the default values of "Receiver frequency", "Demodulator", "Demodulator bandwidth", "AGC", "Squelch level" and "Input". When closing the window the default values are saved. (see "Direct Receiver Control" on page 29.)
Customize a database	Open a configuration window where the user can define a database template. (see "User Configurable Database" on page 34.)

Startup Preferences

The "Startup preferences" under the Configuration menu starts a window where the user can define the following default values when W-SPECTRA starts up.

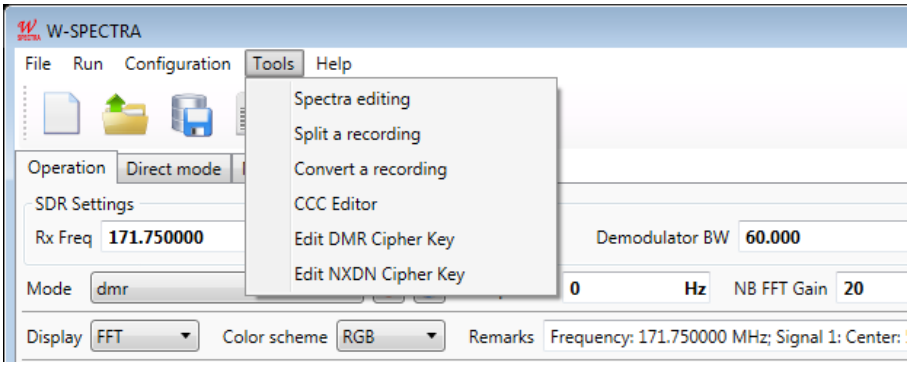
- Mode: means which of the three operation modes (Direct mode, Memory scan or Frequency search) should W-SPECTRA run.
- Database template: which database template should W-SPECTRA load. When no template is specified, only the 6 mandatory database fields are displayed.
- FFT color scheme and
- Sonagram color scheme define the color schemes of the spectrum display in the Operation tab.



W-SPECTRA "Startup preferences" under Configuration menu.

Tools Menu

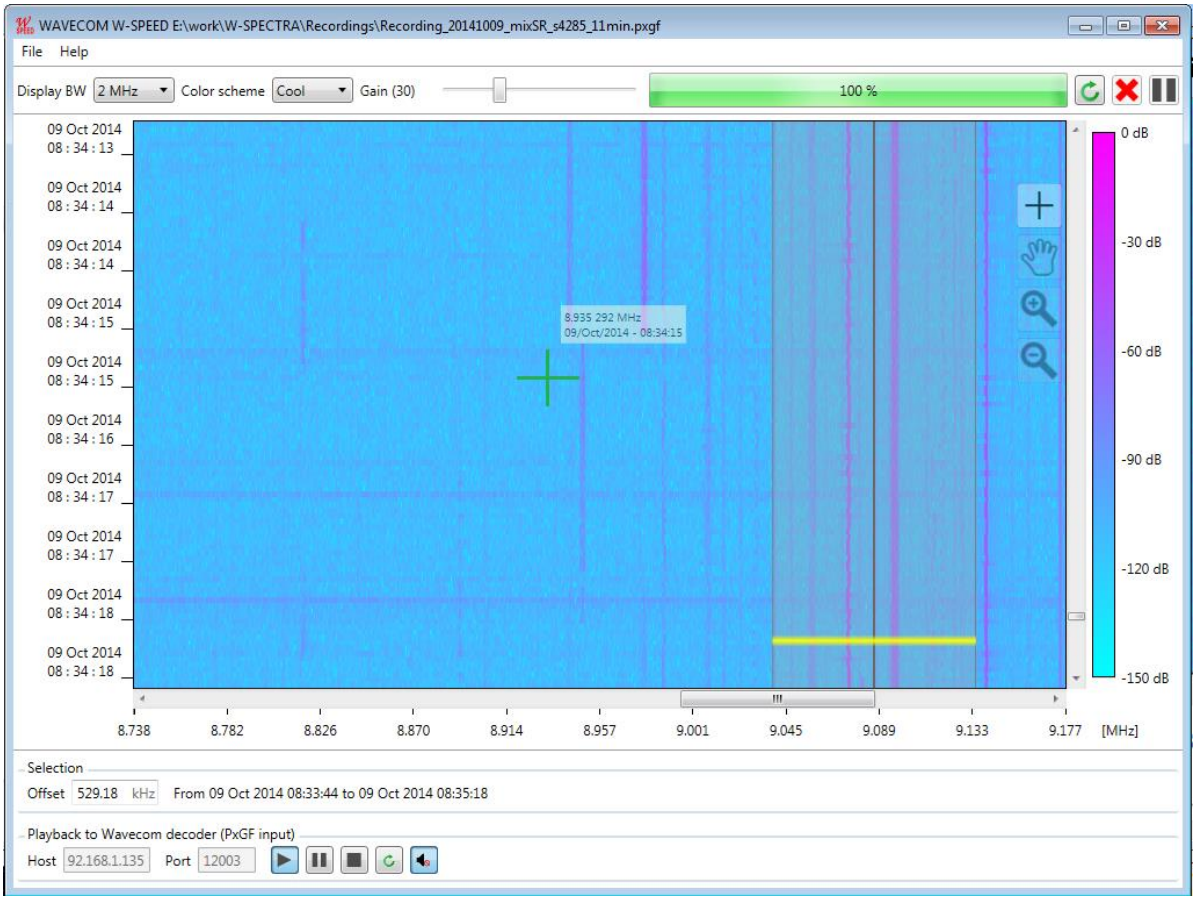
In the **Tools** menu the user can open additional functionalities or tools of W-SPECTRA.



W-SPECTRA Tools menu.

The user can open six tools: "Spectra editing" (W-SPEED), "Split a recording", "Convert a recording", "CCC Editor" (CCC table editor), "Edit DMR Cipher Key" and "Edit NXDN Cipher Key".

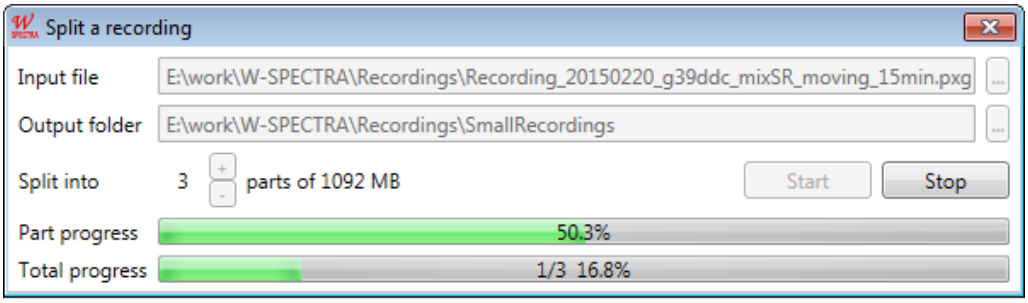
By choosing "Spectra editing" the user can run the spectrum editing tool W-SPEED.



Spectra Editing tool (W-SPEED).

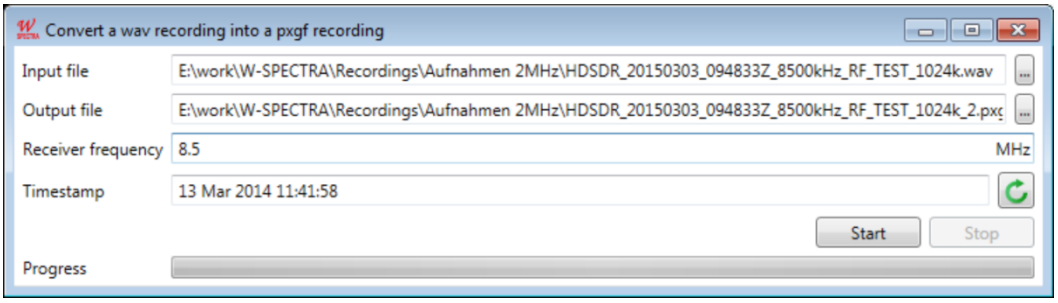
With W-SPEED user can display a recorded signal in a two-dimensional sonagram in different display bandwidths. The user can zoom-in to the sonagram, find an interesting signal, mark (select) it and send it to W-SPECTRA or other Wavecom decoders for detailed investigation.

By choosing "Split a recording" user can call a function to split a big PXGF recording into several equal-size consecutive small recording files. (Details in "Split a Recording".)



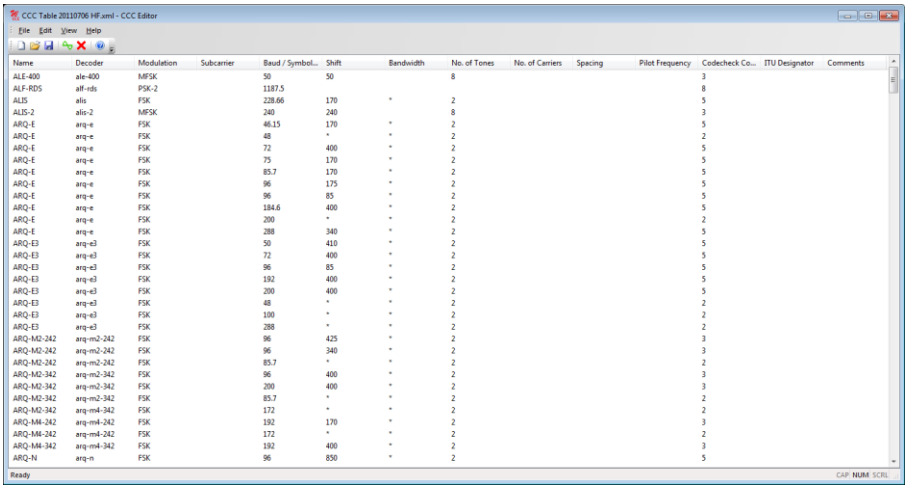
Split a big PXGF recording to several consecutive small recordings.

By choosing "Convert a recording" user can convert a WAV recording to the PXGF format. (Details in "Convert a Recording".)



Convert a WAV recording to the PXGF format.

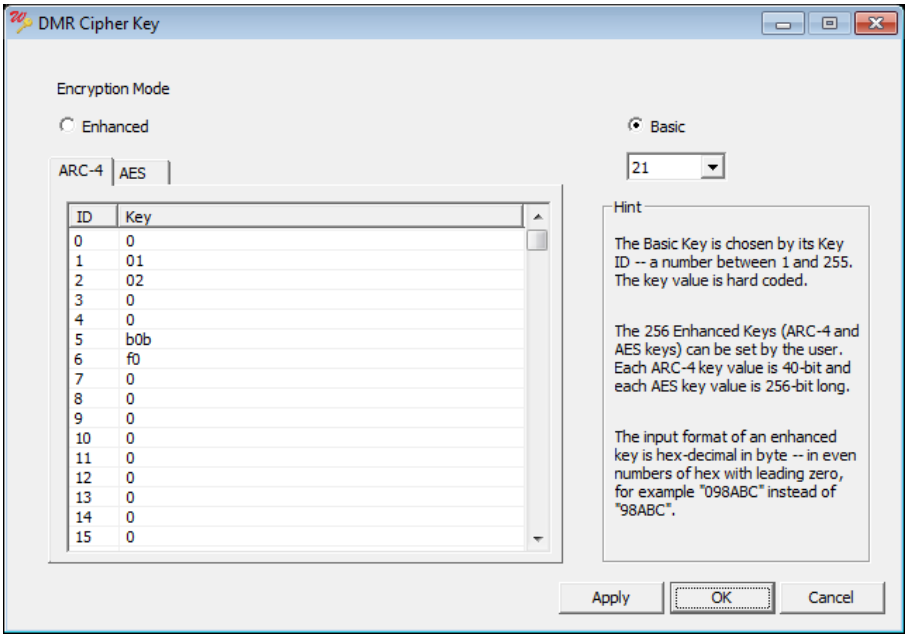
By choosing "CCC Editor" user can open a tool to edit the Classifier Code Check lookup table.



Classifier Code Check table editor (CCC Editor).

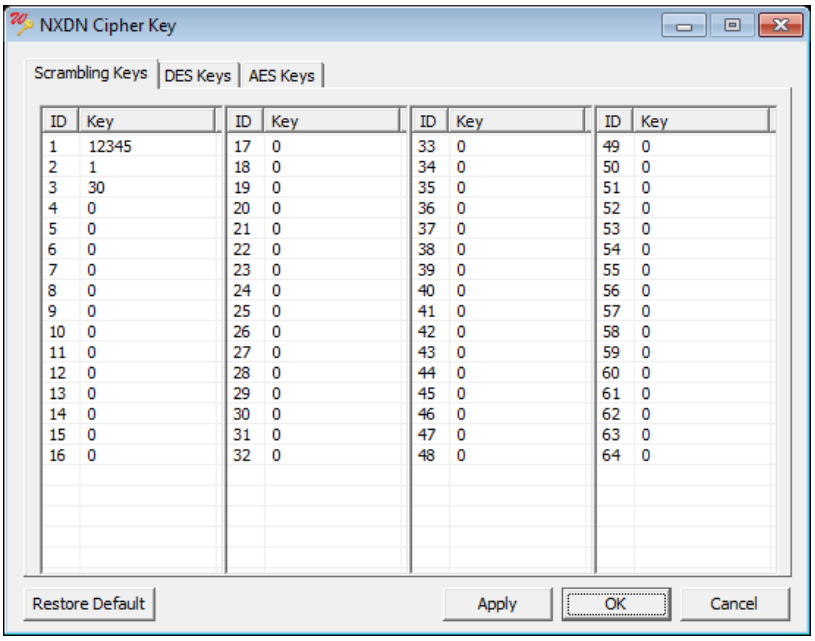
This lookup table is used by the Classifier Code Check in W-SPECTRA to get correct code check result. This editor is the same as used in the Wavecom decoders, e.g., W-CODE.

By choosing "Edit DMR Cipher Key" user can edit the cipher keys used in the DMR decoder.



GUI to edit DMR cipher key.

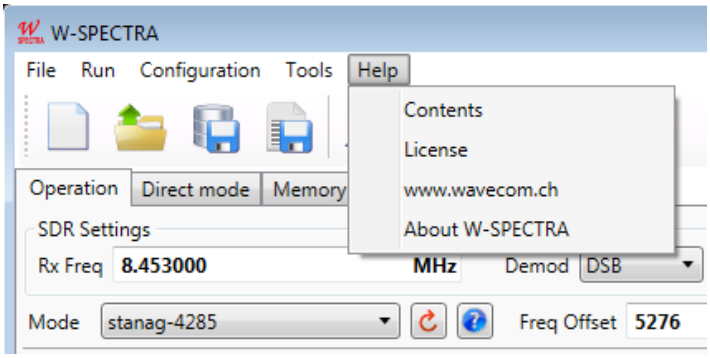
By choosing "Edit NXDN Cipher Key" user can edit the cipher keys used in the NXDN decoder.



GUI to edit NXDN cipher key.

Help Menu

In the **Help** menu there are the user manual and other additional information.



W-SPECTRA Help menu.

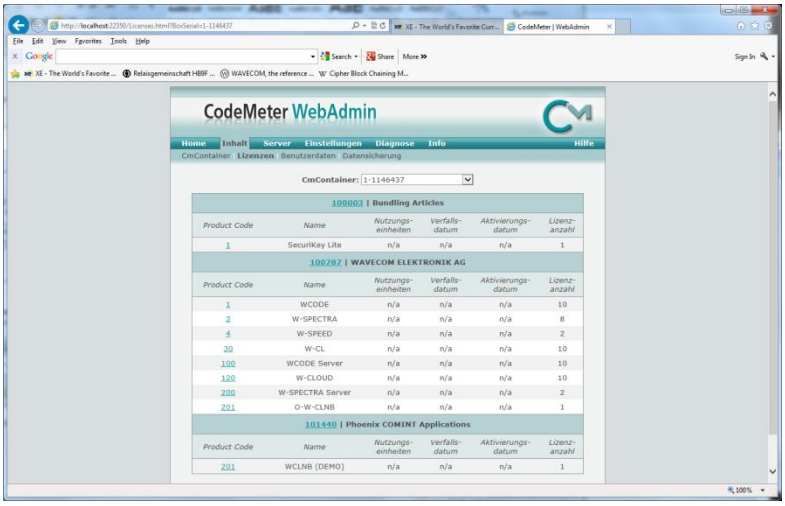
Contents

Selecting **Contents** opens the online help system.

Help on clicked buttons, menus and windows are then available.

License

Under the "Help" menu "**License**", the user can check the licenses on a USB key.



W-SPECTRA licenses on a USB key.

One complete set of W-SPECTRA licenses consists of

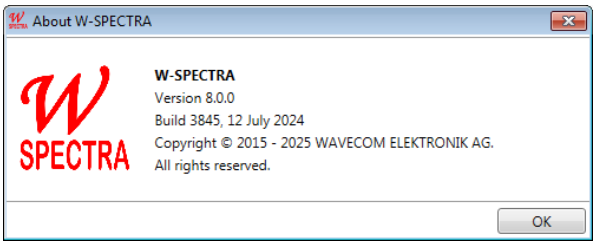
- 1 pcs W-SPECTRA Server (Code 200)
- 4 pcs W-SPECTRA (Code 2)
- 1 pcs Spectrum Analysis or Classifier license (Code 201 for narrowband or Code 101 for wideband)
- 1 pcs W-SPEED (Code 4).

WAVECOM on the Web

Selecting the link **www.wavecom.ch** the user can visit the website of the company WAVECOM ELEKTRONIK AG.

About W-SPECTRA

In the **Help** menu the user can check the version and build information of W-SPECTRA.

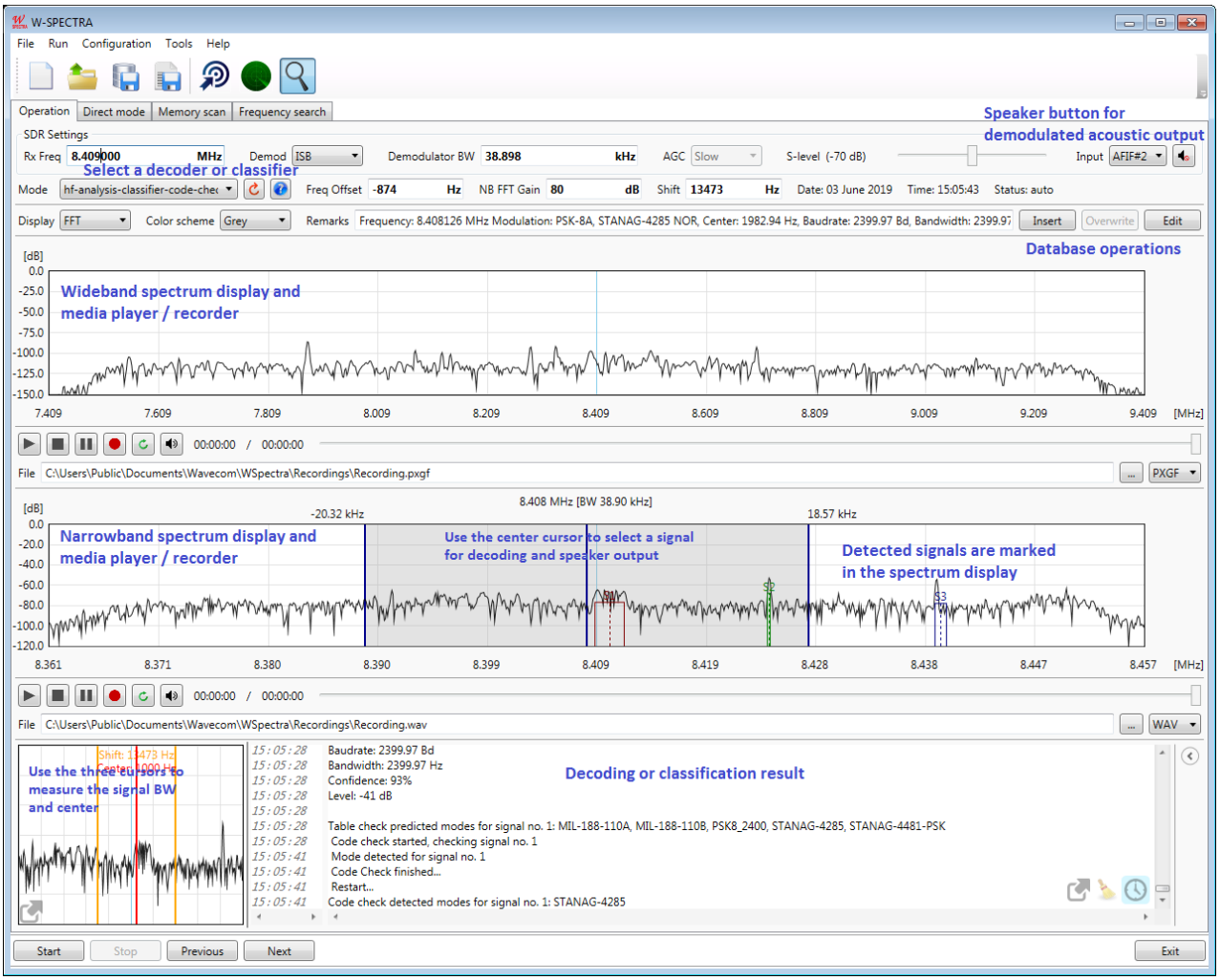


W-SPECTRA version, build no. and build date.

The Operation Tab

There are four tabs in the W-SPECTRA main GUI: Operation, Direct mode, Memory scan and Frequency search.

When the user starts W-SPECTRA, the main GUI displays the "Operation" tab. All major activities (receiver control, spectrum display, database operations, classification and decoding etc.) for automatic spectrum monitoring are accessable in this tab.



W-SPECTRA main GUI in Operation tab (with comments).

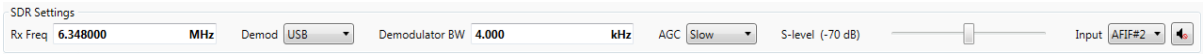
There are five major parts in the Operation tab: direct receiver control, classifier, decoder and database control, wideband spectrum display and media player/recorder, narrowband spectrum display and media player/recorder and the display of classification and decoding results.

Direct Receiver Control

W-SPECTRA scans all SDR receivers (native Wavecom W-PCIe receivers and WiNRADiO G3xDDC series) running on the local computer when it starts up, puts them in a list sorted by the serial number in the ascending order. W-SPECTRA automatically connects to the first receiver in the list and take over full control of it. The user can set the receiver frequency, demodulator, demodulator BW, AGC, squelch level, antenna input and turn on/off the speaker in the W-SPECTRA GUI.

For W-PCIe receiver, the available demodulators are USB, LSB, ISB, AM and FM with a demodulator bandwidth in the range between 4 kHz and 96 kHz. The AGC and squelch level have no influence on the W-PCIe receiver, they are set to default values. There are two inputs (AFIF#1 and AFIF#2) for direct HF antenna connection. The speaker can be turn on/off for demodulated acoustic signal output.

For WiNRADiO G3xDDC receiver, the available demodulators are USB, LSB, ISB, DSB, AM, AMS, FM, FMW, CW, DRM, FSK and UDM with a demodulator bandwidth in the range between 1 Hz and 320 kHz. There is only one antenna input (ANT 1). The speaker button in the Operation GUI is disabled, since it is implemented in the native WiNRADiO GUI.



Direct receiver control in the W-SPECTRA Operation tab.

For WiNRADiO, the receiver setting is bi-directional, i.e., the user can also set values in the native SDR GUI and they will be synchronised in both directions. For W-PCIe receiver the values are only set in the SDR Settings in the Operation GUI.

W-SPECTRA uses default values to set the SDR when it starts. The default values can be changed in the "SDR settings" window in the **Configuration** menu. This window lists ("Recan") all SDRs which are running on the local computer. The user can choose one SDR, change the default value of

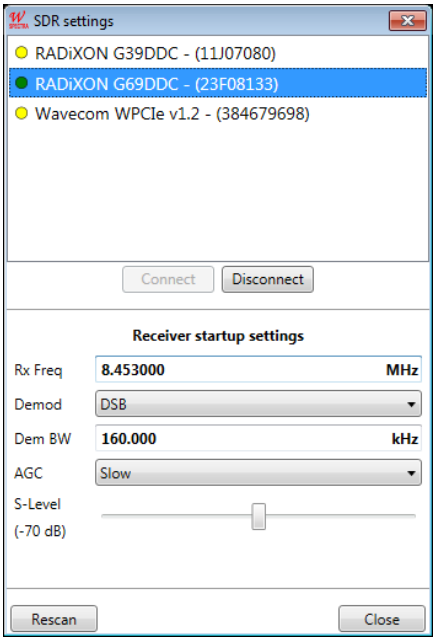
- Rx frequency
- Demodulator (Demod)
- Demodulator bandwith (Demod BW)
- Automatic gain control (AGC) and
- Squelch level and
- Antenna Input

and connect to that receiver.

The default values will be saved by closing the window.

There are three color indicators:

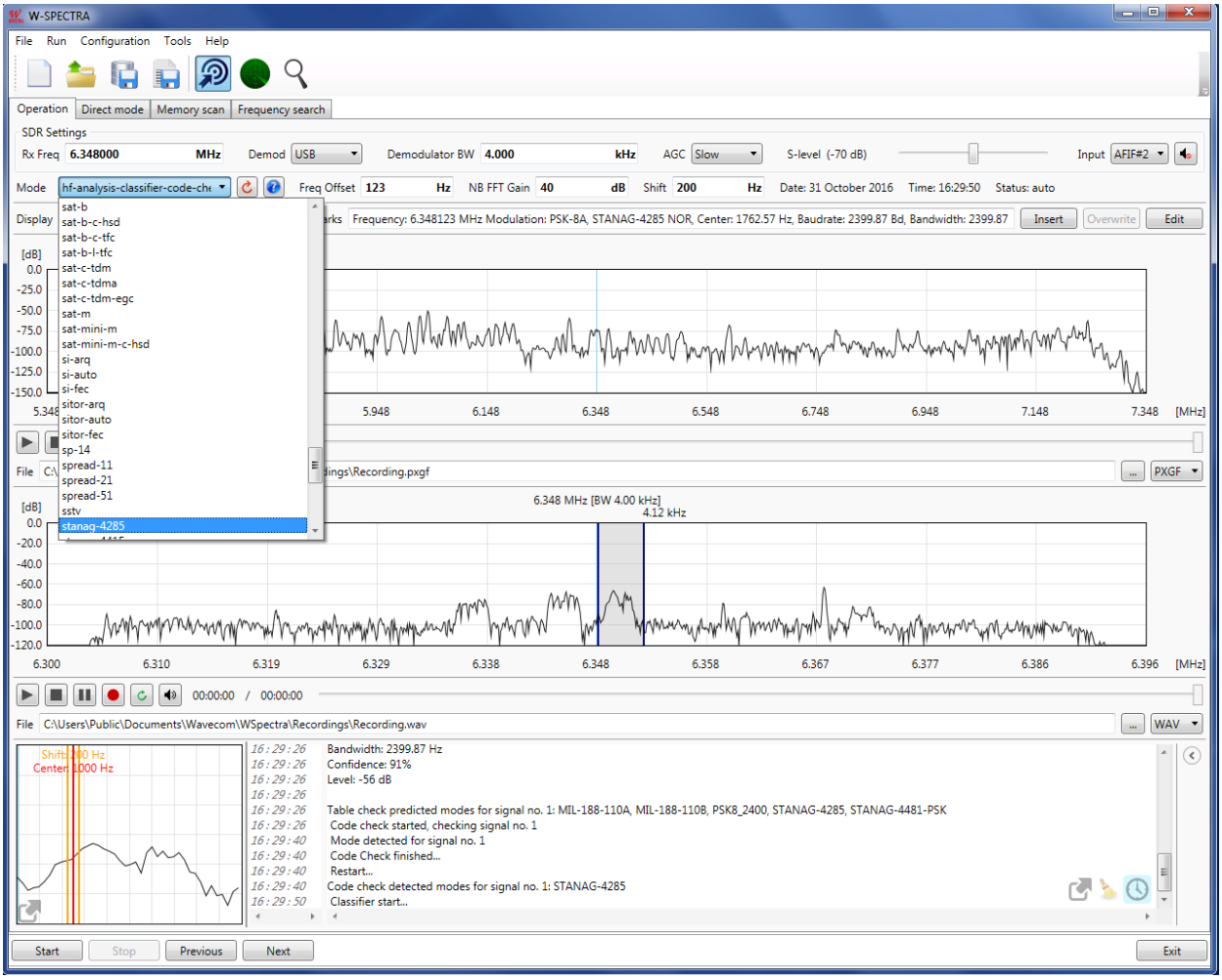
- Yellow: the receiver is running properly and ready for connection to W-SPECTRA
- Green: the receiver is now connected to W-SPECTRA and works properly and
- Black: the receiver is not running now (offline).



SDR settings window in the Configuration menu.

Classifier, Decoder and Database Operations

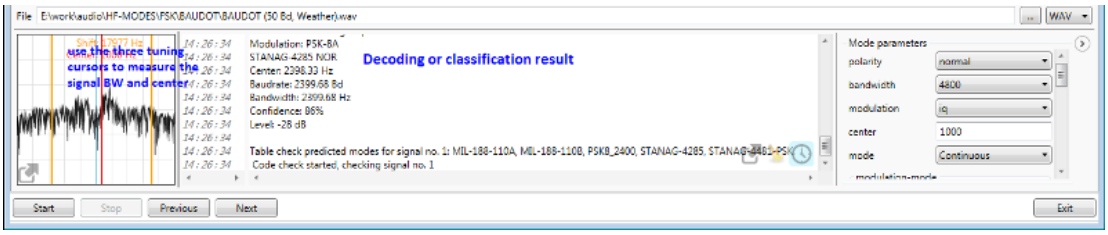
In this area the user can choose from a pull-down list "Mode" to run a signal processing component (classifier, classifier code check or a decoder) to analyse the selected signal from the receiver. The mode (decoder or classifier) can also be set by W-SPECTRA when it is running in automatically.



Select a decoder or a classifier from the Mode list.

To process a signal properly the user needs to

- Set the "Freq Offset" or move the frequency cursor in the narrowband spectrum display to select the signal,
- Change the "NB FFT Gain", so that the signal has a proper level in the narrowband spectrum display,
- Set the "Shift" value, if necessary, and
- Set other decoder parameters in the lower right panel of the GUI.



The lower part of the W-SPECTRA Operation tab displays classification or decoding results.

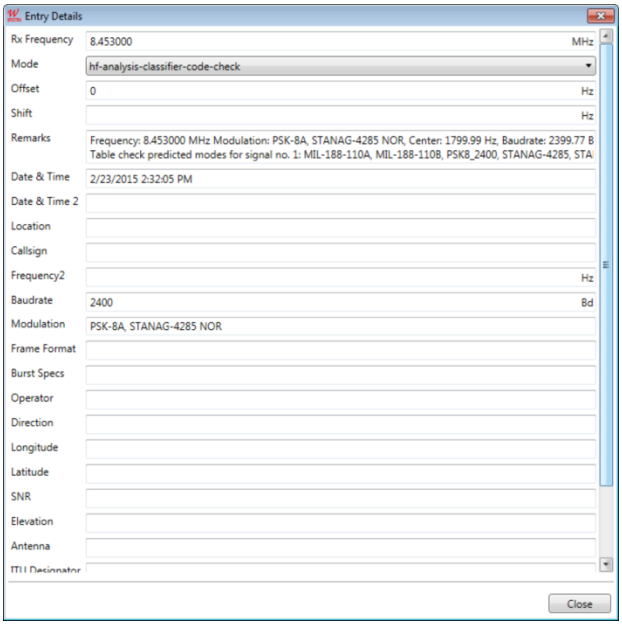
In the small spectrum display in the lower left corner of the GUI the user can measure the bandwidth (shift) of the signal by moving the two yellow cursors.

To set the "Freq Offset" or locate a signal by moving the three frequency tuning cursors in the narrowband spectrum display, the user should make sure that

- For HF decoders the signal should appear at the right-hand side of the middle tuning cursor,
- For VHF/UHF-DIR decoders the middle tuning cursor should be placed at the middle of the signal,
- For VHF/UHF-SUB decoders the signal should appear at the right-hand side of the middle tuning cursor, and
- For SAT (satellite) decoders the middle tuning cursor should be placed at the middle of the signal.

The values in the "Mode", "Freq Offset" and "Shift" appear also in the corresponding database fields, together with "Remarks" and "Date & time". When a classifier or a classifier code check is running, the result will be displayed in the "Remarks" field.

The user can **Insert** or **Overwrite** the entry into the database by clicking the corresponding button. Using the **Edit** button the user can manually change values of a database entry.

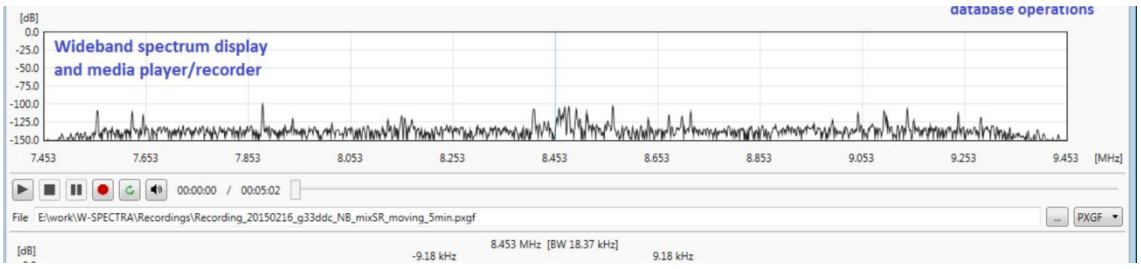


Edit a database entry by clicking the "Edit" button.

Wideband Spectrum Display and Media Player/Recorder

In the Operation tab there are two spectrum displays where the user can view signals in a wide spectrum range and in more detail, respectively.

The wideband spectrum display has a bandwidth of 2 MHz. This display usually corresponds to the wideband spectrum of an SDR, like the DDC1 in WiNRADiO G3xDDC. The spectrum middle is the receiver frequency (Rx Freq). The user can change the Rx Freq by clicking the mouse at another position in the spectrum.



Wideband spectrum display and media player/recorder.

Below the spectrum display there is a media player/recorder, where the user can make an IQ recording of the 2 MHz wide spectrum. The recording format is PXGF, it allows a simultaneous recording of important side information such as

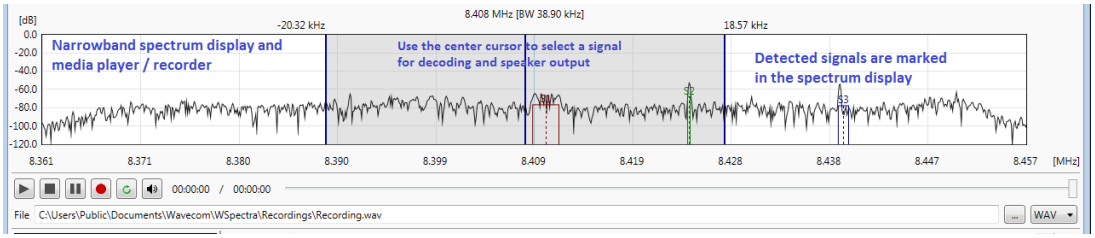
- receiver frequency (Rx Freq)
- recording bandwidth and
- timestamp.

The recording of the side information is *on-the-fly*, i.e., the value can change during the recording. This allows a full recovery of information when a recording is played back and investigated in detail afterwards. During playback the receiver frequency and timestamp in the recording is displayed in "Rx Freq" and "Date & Time" fields, respectively. The user can select a 96 kHz stripe to pick an interesting signal, display this stripe in the narrowband spectrum display. In the narrowband spectrum display the user can move the tuning cursor to select a signal at certain frequency to a classifier or a decoder for detail analysis. At the same time the selected signal will be acoustic demodulated (by the demodulator and its bandwidth) and output to the speaker. During playback the user can drag the progress button to any position of the recording.

Note: Only make (wideband) recordings on a built-in storage medium (e.g., built-in harddisk or SSD). Don't use external USB harddisk, nor over the network, because the max. speed of external devices may be insufficient for the wideband recording and this may cause loss of data.

Narrowband Spectrum Display and Media Player/Recorder

The narrowband spectrum display is of 96 kHz wide. This display usually corresponds to the narrowband spectrum of an SDR, like the DDC2 of WiNRADiO G3xDDC. The narrowband spectrum corresponds to the middle of the wideband spectrum display.



Narrowband spectrum display and media player/recorder Spectrum Analysis displays and marks detected signals.

Spectrum Analysis will detect and mark the signals in this display pane. The user can view the target signal in more detail and select the signal for classification or decoding by moving the middle frequency tuning cursor to the right position. The distance of the middle tuning cursor to the spectrum middle is displayed in the "Offset" field.

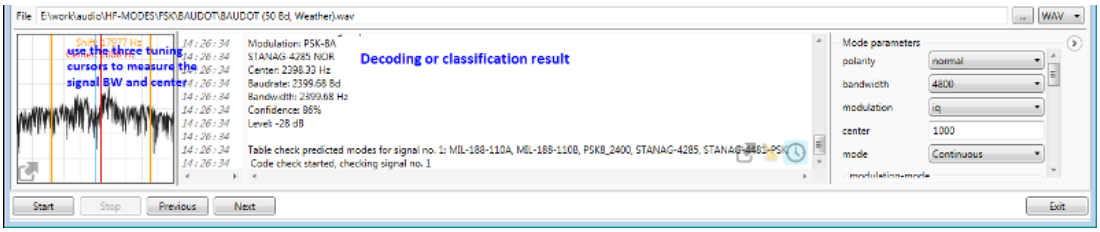
Below the spectrum display, there is a narrowband media player/recorder, where the user can make an IQ recording of the 96 kHz wide spectrum. Unlike in the wideband media player/recorder, the recording format can be PXGF or WAV. Whereas the PXGF format allows the recording of the side information, the conventional WAV format does not have this capability: the bandwidth (sampling rate) is fixed at the beginning of the recording and no side information can be periodically saved (implanted) during the recording.

The playback works in the same way as in the wideband media player/recorder. The frequency offset, the demodulator and the demodulator bandwidth apply to the acoustic signal output when the speaker button is on.

A recording can be played back in both media players and the playback runs in real-time.

Display of Classification and Decoding Results

The lower part of the Operation tab is the display window for classification and decoding results.



The lower part of the Operation tab displays the classification and decoding results and the parameter settings.

In the right lower part of the result display there are three transparent buttons. The user can:

- Display the result in a separate and bigger window by clicking the "Window" button.
- Clear the display window by clicking the "Clear" button.
- Turn on and off the timestamp display by clicking the "Timestamp" button.

The right panel consists of the set of parameters of the classifier or decoder which is just running. The small spectrum display at the left side is a duplicate of the spectrum in the three tuning frequency cursors of the narrowband spectrum display. Two yellow cursors in this small display can be used to measure the bandwidth of a signal.

There are four operation buttons (**Start**, **Stop**, **Previous** and **Next**) at the bottom of the GUI. Their functionality depends on the three W-SPECTRA operation modes (Direct mode, Memory scan and Frequency search).

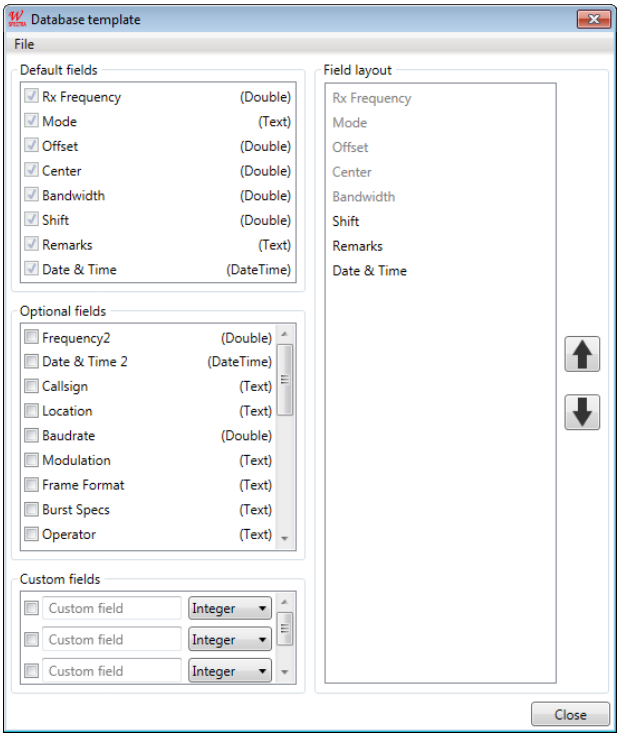
User Configurable Database

As an automatic spectrum monitoring system W-SPECTRA consists of a user configurable database. The database is in XML format, which make it easy for third-party access and processing. The database contains 8 mandatory fields, 23 optional fields and three custom free editable fields.

Database field definition		
Eight (8) mandatory fields	Callsign	Elevation
Rx Frequency (receiver frequency)	Location	ITU Designator
Mode (decoder or classifier running)	Baudrate	Remote Name
Offset (middle cursor of the NB spectrum display)	Modulation	Polarisation
Center	Frame Format	Satellite Name
Bandwidth	Burst Specs	Satellite Position
Shift	Operator	Links to Templates
Remarks	Direction	Links to Files
Date & Time	Longitude	Links to Internet

23 optional fields	Latitude	**Three custom free editable fields**
Frequency 2	SNR	
Date & Time 2	Antenna	

The first 8 database fields are mandatory. The use can define his own database template in the Configuration menu "Customize a database" by choosing from the 23 optional fields and defining his own database fields (up to three).



Define a database template.

In all three W-SPECTRA operation modes the user can open his customized database template to capture monitoring results manually or automatically.

Three Operation Modes

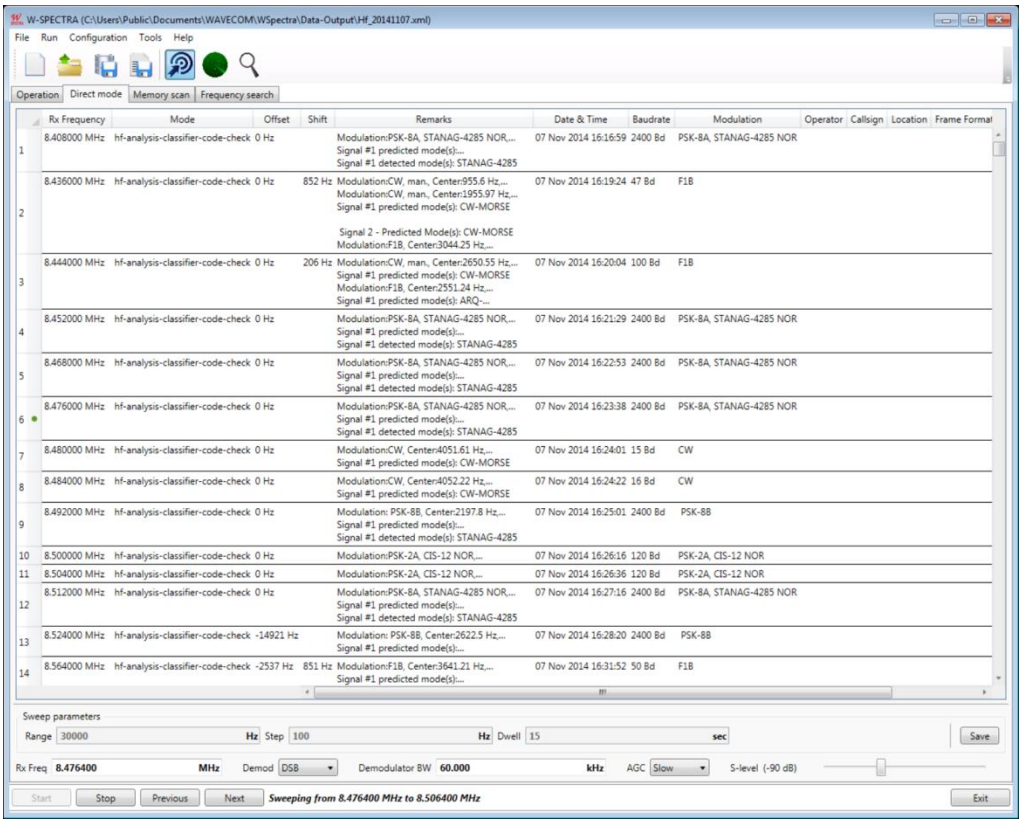
W-SPECTRA works in three operation modes: Direct mode, Memory scan and Frequency search. All three modes can work in an automatic or a manual way. The user can select a signal by placing the middle frequency tuning cursor in the narrowband spectrum display and turn on a classifier or a decoder. Results are displayed in the lower part of the Operation tab. In each mode, W-SPECTRA opens a database with a user defined template to capture the monitoring results.

Direct Mode – Begin the Spectrum Monitoring

W-SPECTRA "Direct mode" is designed for a user to begin the spectrum monitoring mainly in a manual way.

- The user can set the receiver frequency manually and turn on a classifier or a decoder to monitor and decode a signal.

- To select a signal the user can move the middle frequency tuning cursor in the narrowband spectrum display. Please note that for HF, VHF/UHF-SUB decoders or classifier the signal should appear at the right-hand side of the middle cursor; for VHF/UHF-DIR and SAT decoders or classifier the middle tuning cursor should be placed in the middle of the signal.
- The user can manually insert results into a database by clicking "Insert" or "Overwrite" button in the Operation tab. The user can also edit a database entry by clicking the "Edit" button in the Operation tab.
- All database entries are displayed in the "Direct mode" tab.
- The Direct mode can also run automatically to "sweep" the spectrum in a small range so that a signal can be fine tuned to the spectrum middle. The user can also do this tuning manually by clicking the "Previous" or the "Next" button.



"Direct mode" tab with database and sweep parameters setting.

In the "Direct mode" tab the user can view and edit database entries. In the lower part the user can set parameters of the automatic sweep:

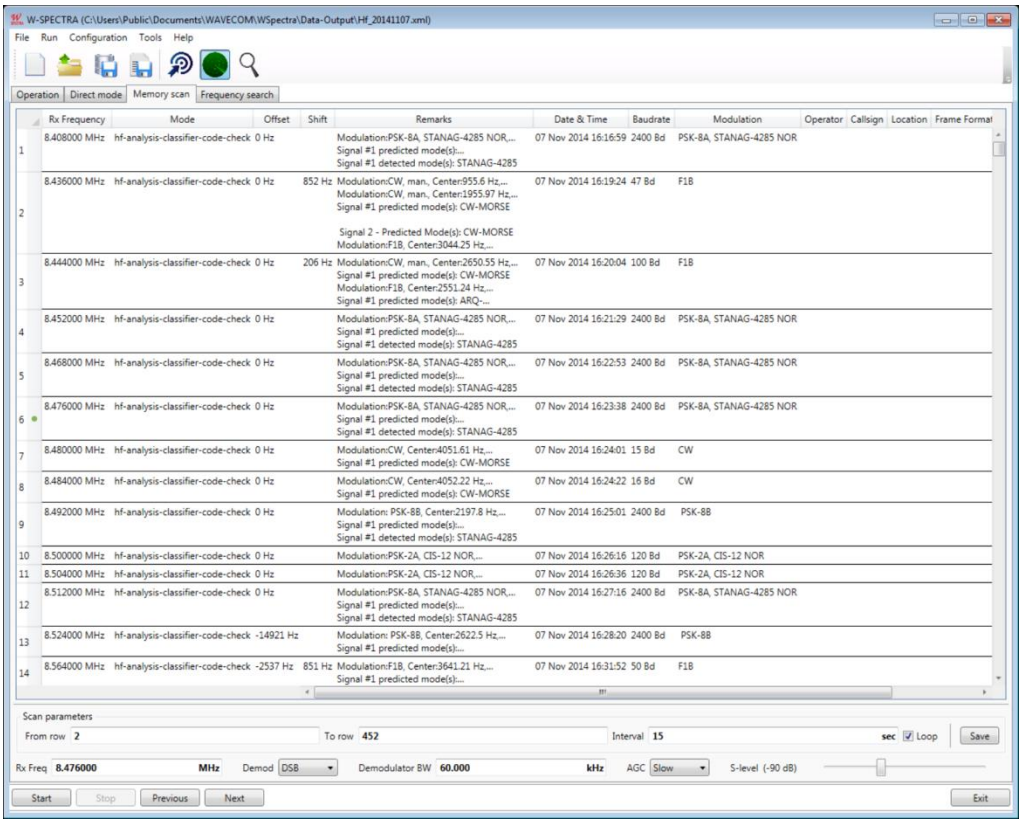
- Range: how far the spectrum sweep can run.
- Step: frequency step of each jump.
- Dwell: how long should the spectrum stay at one frequency until it moves to the next frequency (+/- step size). It defines how fast the sweep is running.

The four buttons at the last line have the following definition:

- Start button: starts the sweep function. The receiver will jump to the next frequency according to the "Step" size and "Dwell" interval.
- Stop button: stops the automatic sweep function.
- Previous and Next buttons: the user can tune the receiver frequency manually to the previous and next frequency according to the "Step" size, respectively.

Memory Scan – Revisit and Verify the Spectrum

W-SPECTRA runs in Memory scan mode over an existing database. Each database entry sets the receiver (SDR) and the decoder or classifier accordingly. In this way the user can revisit the spectrum and verify the database entries. The user may insert a new entry into the database or just overwrite the old one.



"Memory scan" tab with a database and scan parameters setting.

In the "Memory scan" tab the user can open an existing database and edit database entries manually.

In the lower part of the tab there are three parameters, defining the behavior of the Memory scan mode:

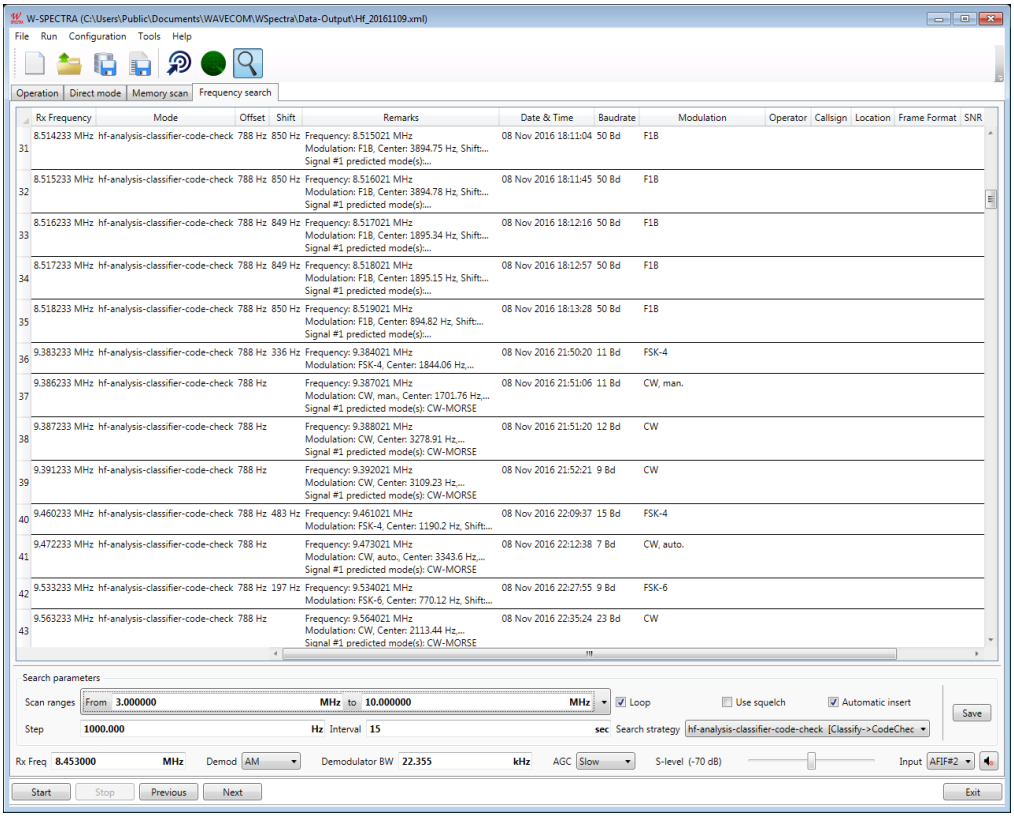
- "From row" and "To row": define which range of a database should be used when revisiting the spectrum automatically (pressing the Start button).
- Interval: how long (in time) does W-SPECTRA stay at one database entry until it switch to the next entry when it is running in the automatic mode.
- Loop: is a checkbox. It defines whether the memory scan should begin from the first database entry (From row) when it reaches the last database entry (To row).

The four buttons in the last line of the GUI have the following functions:

- Start button: starts the automatic memory scan from the database entry defined in the "From row" and jump to the next entry after the "Interval" period.
- Stop button: stops the memory scan function.
- Previous and Next buttons: manually jump to the previous and next database entry, respectively. When the "Loop" is checked, these two buttons work in the corresponding way.

Frequency Search – Automatic Spectrum Monitoring and Database Capturing

With the "Frequency search" mode W-SPECTRA can scan over an entire frequency band, e.g., the HF band (3 – 30 MHz), run a classifier and code check (with different search strategies), search for signals and capture the classification results into a database automatically. This mode is the *most powerful* part of W-SPECTRA as an automatic spectrum monitoring system – signals in a certain frequency band will be automatically detected, classified, checked and captured into a database.



"Frequency search" tab with a database and search parameters setting.

To run the automatic frequency search the following parameters should be set:

- "From" and "to": define the search range of a certain frequency band. The whole frequency band is divided into three sub-ranges.
- Step: defines the unit size each time when the system jumps to the next frequency.
- Interval: defines how long should the frequency search mode stay at one frequency before it jumps to the next frequency. Note that the Interval should not be too short, so that the classifier has enough time to catch the signal and deliver result. A reasonable value can be 15 seconds.
- Search strategy: defines how does spectrum analysis, classifier or classifier code check work when it catches a signal. The possible strategies are Spectrum Analysis, Classify, Classify – Tablecheck, Classify – Tablecheck – Codecheck, Classify – Tablecheck – Decoding and Classify – Tablecheck – Codecheck – Decoding.

  When the spectrum analysis, classifier or classifier code check delivers results, parameters will appear in their corresponding database fields and the whole result will appear in the "Remarks" field.
- Loop: is a checkbox. It defines whether the frequency search should begin from the first frequency (From) when it reaches the last frequency (to).
- Use squelch: is a checkbox. When it is selected (checked), the system will deliver a result when the signal is above the squelch level.

- Automatic insert: is a checkbox. It defines when the frequency search delivers a result (signal above the squelch level or some classifier code check results) whether it will be inserted into the database. The new database entry appears in the "Frequency search" tab.

At the bottom of the GUI there are four buttons with the following functions:

- Start button: starts the frequency search from the first frequency defined in "From" field and jump to the next frequency (+ Step) after an Interval period.
- Stop button: stops the frequency search function.
- Previous and Next buttons: manually jump to the previous and next frequency respectively according to the Step size. When the "Loop" is checked, these two buttons work in the corresponding way.

There are 6 search strategies in which the spectrum analysis and the classifier code check can work:

Process Steps	Meaning
P0	Spectrum analysis is performed. Signals in a bandwidth are detected, the most important signal parameters are measured.
P1	Classification is performed. Signals in a bandwidth are detected and classified. More detail signal parameters are measured.
P2	Classification and table check are performed, but no decoding.
P3	Classification, table check and code check are performed, but no decoding.
P4	Classification and table check are performed and finally the signal is decoded if a mode with an associated, valid detector was found.
P5	Classification, table check and code check are performed and finally the signal is decoded if a mode with an associated, valid detector was found.

Scan Delay in Automatic Modes

In all three operation modes (Direct mode, Memory scan and Frequency search) the classifier code check adopts a "scan delay" method: When the classifier and code check find a signal at a frequency, the automatic jump to the next frequency / database entry is deferred until the complete classifier code check result is delivered. In this way W-SPECTRA delivers more precise, stable and reliable monitoring results.

Summary of the Three Operation Modes

The following table summarizes the three operation modes and their parameters.

	Direct mode	Memory scan	Frequency search
Description	Detect, classify and decode a signal by setting a receiver frequency manually. Use "Sweep" mode to catch a signal in a small range	Rescan and verify the spectrum according to database entries. New result can be inserted into the database	Automatic search signals (detect, classify and code check) over a predefined frequency band according to a search strategy. Results are automatically inserted into a database
Start button	Start to sweep over a defined frequency range	Start to rescan the spectrum according to the database entries	Start to search signals in a wide range of frequency

	Direct mode	Memory scan	Frequency search
Stop button	Stop sweeping	Stop rescan	Stop searching signals
Previous button	Jump to the previous frequency according to the step size	Jump to the previous database entry	Jump to the previous frequency according to the step size
Next button	Jump to the next frequency according to the step size	Jump to the next database entry	Jump to the next frequency according to the step size
Default (recommended) values	Sweep range: 3000 Hz Step size: 100 Hz Dwell period: 1 sec	Time interval: 15 sec	Step size: 1000 Hz Time interval: 15 sec

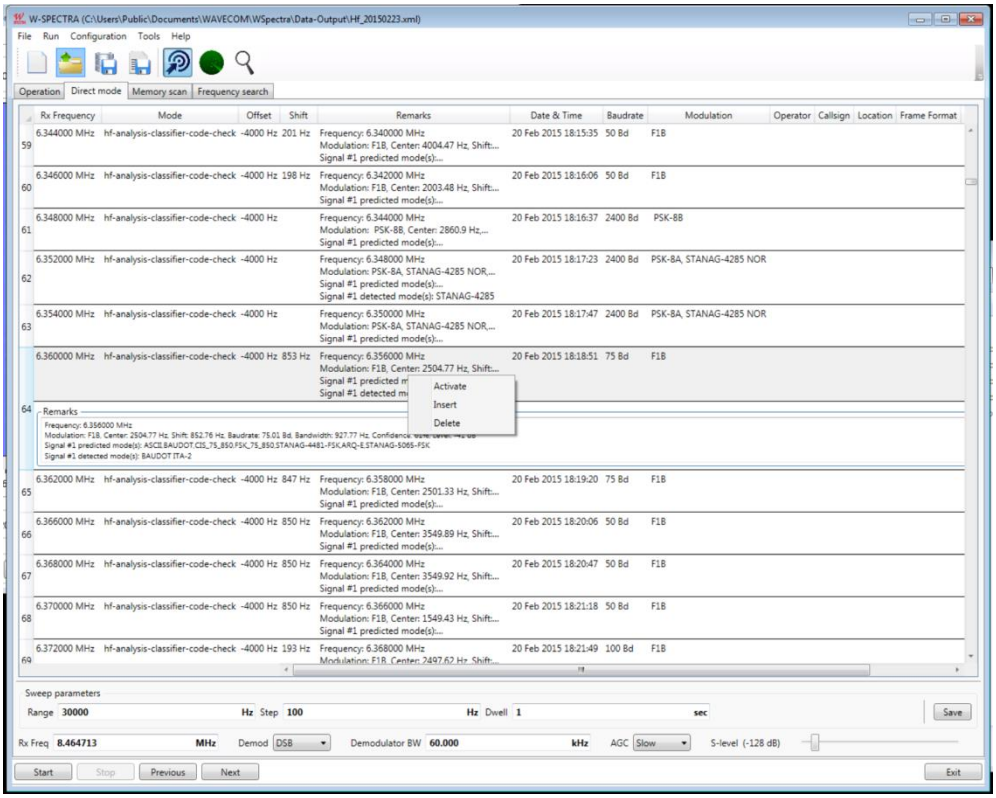
Automatic operations (by clicking Start button) will stop when the "Previous" or "Next" button is clicked.

During the automatic operation, a recording can not be played back by the media player/recorder (wideband or narrowband) or W-SPEED and vice versa.

Database Operations and Integrity Check

When a database is open in an operation tab, the user can right click the mouse and open a context menu with the entries: "Activate", "Insert" and "Delete".

- Activate: this will set the receiver and W-SPECTRA according to the database entry – set the Rx Freq. and run the mode in W-SPECTRA with various parameters.
- Insert: insert a new database entry above the selected entry. The user can edit the blank entry freely.
- Delete: this will delete a database entry. After an active "Save database" this entry is deleted effectively.

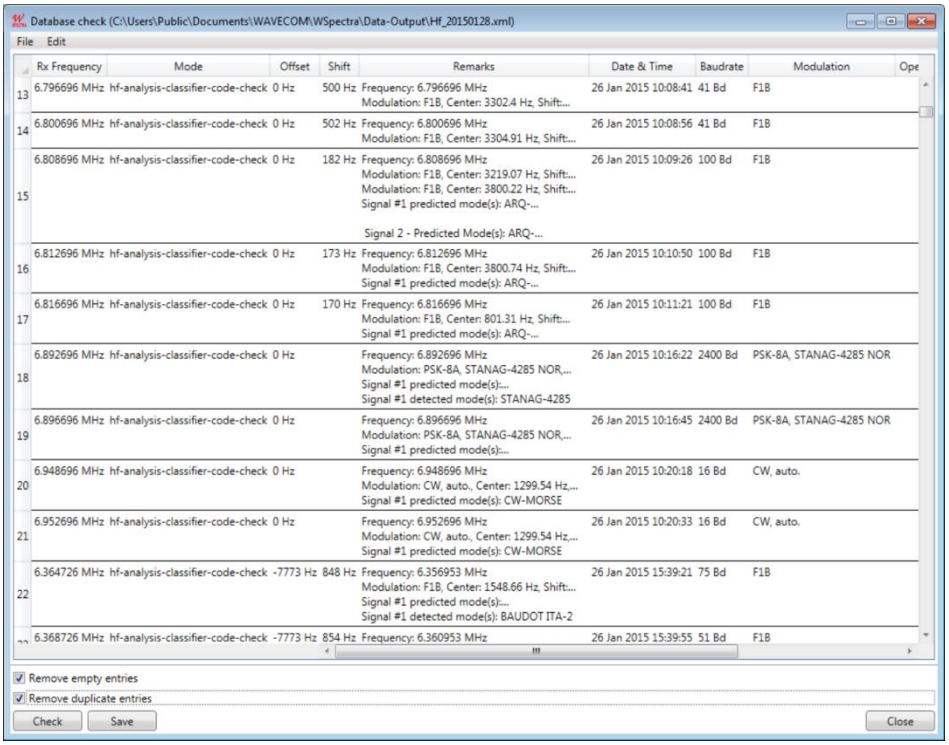


Database operation using a context menu "Activate", "Insert" and "Delete".

Under the File menu there is a "Check database" function which can check the integrity of the database.

It can

- Remove empty entries: entirely blank entries will be removed.
- Remove duplicates entries: redundant entries with identical content, including identical timestamp, will be removed.



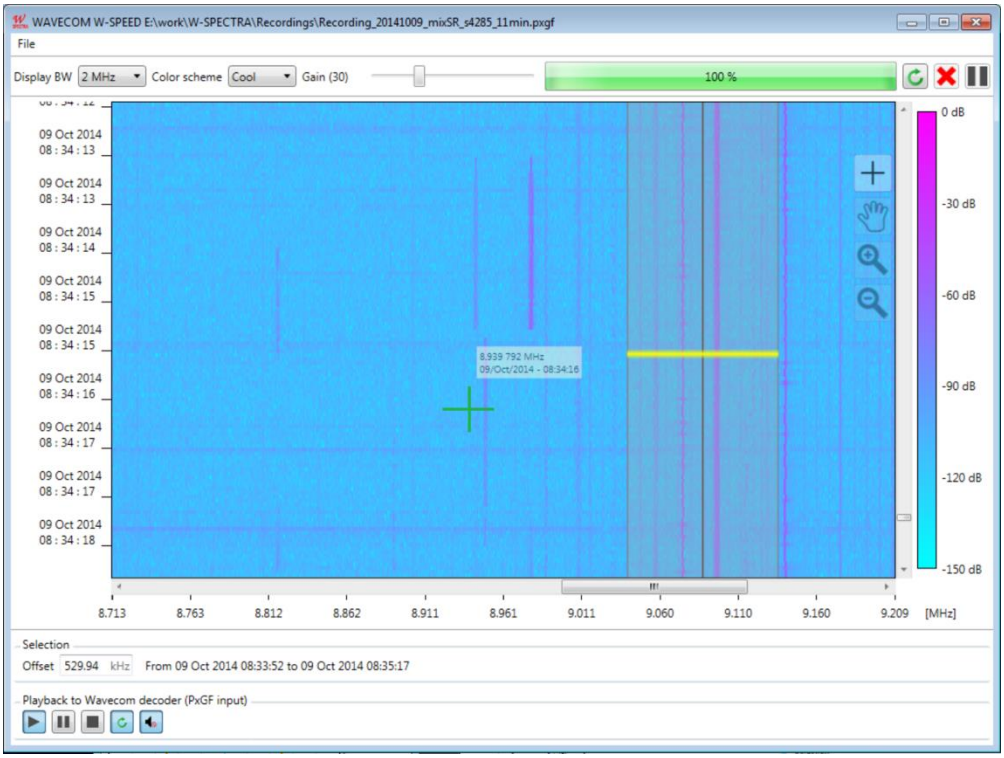
"Check database" under the File menu.

Spectrum Editing Tool (W-SPEED)

Main Functionalities

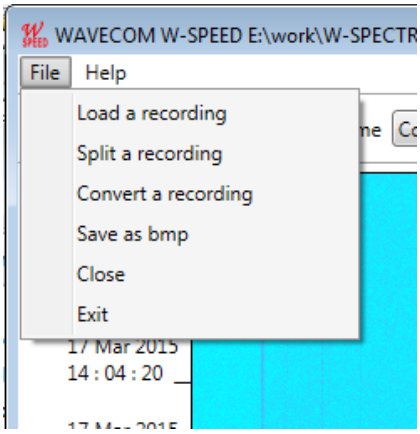
With W-SPECTRA the user can monitor the spectrum *online*, i.e., the signals in the 96 kHz bandwidth around the receiver frequency will be analysed, classified and decoded online (in real-time). Signals outside this 96 kHz monitoring bandwidth can not be processed online. However, they are not lost: the user can make a wideband (2 MHz) IQ recording with various side information in PXGF format using the wideband media player/recorder.

With the Spectrum Editing tool (W-SPEED) a wideband IQ recording can be displayed in a two-dimensional sonagram (frequency as the X-axis and time as the Y-axis) with zoom-in and free navigation functions. Interesting signals can be selected (marked) and sent to W-SPECTRA or other Wavecom decoders for afterwards processing.



Spectrum Editing Tool (W-SPEED) displays a recording in a 2 MHz wide sonagram. The user can select an interesting signal anywhere in the sonagram and send to W-SPECTRA for detail analysis.

File Menu



W-SPEED File menu.

The File menu consists of following functions:

- Load: opens a (wideband) PXGF recording and displays it in a two-dimensional sonagram.
- Split a recording: splits a big PXGF recording into several equal-size consecutive small recordings.
- Convert a recording: converts a WAV recording into PXGF format with on-the-fly side information (receiver frequency and timestamp).
- Save as bmp: saves the two-dimensional songagram as an image.
- Close: closes the recording and sonagram.
- Exit: closes the application.

Sonagram in Different Bandwidths

W-SPEED loads an IQ recording in PXGF format. This format carries the actual timestamp, receiver frequency and bandwidth (sampling rate) throughout the whole recording. W-SPEED displays a PXGF recording in a sonagram with selectable bandwidths. W-SPEED displays the actual timestamp as the Y-axis. It labels the X-axis with the absolute receiver frequency (Rx Freq) when it hasn't changed during the whole recording, otherwise the X-axis is labeled with the relative frequency with +/- half of the selected display bandwidth and 0 in the middle.

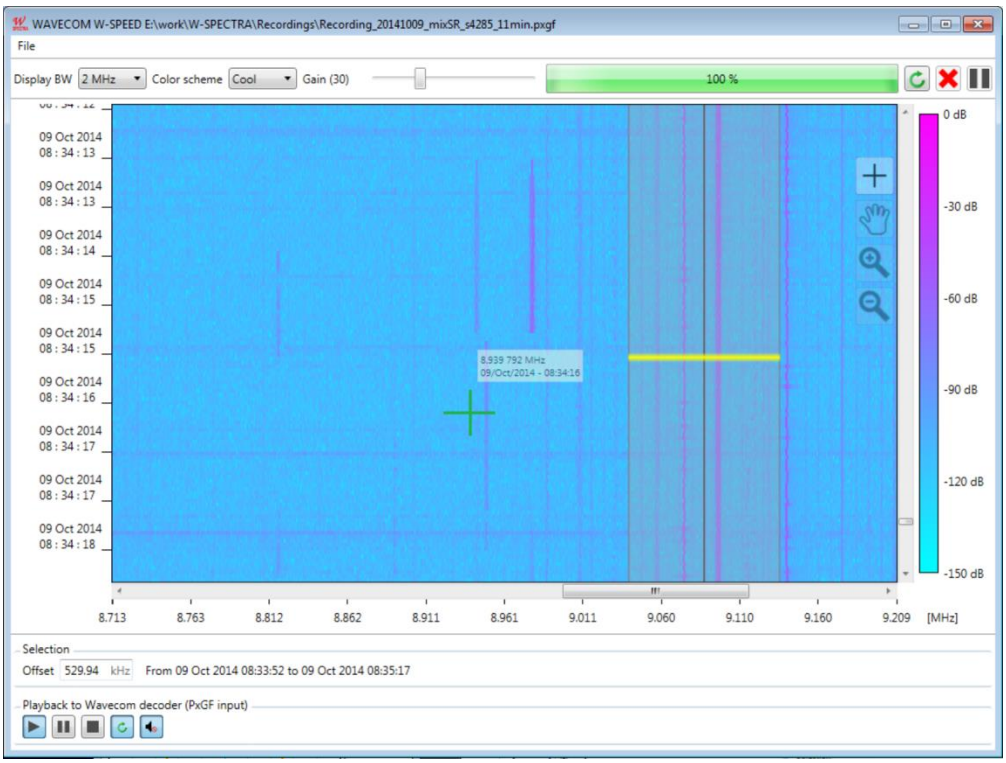
The user can:

- Select a "Display bandwidth" among 250 kHz, 500 kHz, 1 MHz, 1.5 MHz, 2 MHz, 4 MHz, 8 MHz, 10 MHz, 12 MHz, 16 MHz, 24 MHz and 30 MHz. Default bandwidth is 2 MHz.
- Change the "Color scheme" of the sonagram display.
- Change the "Gain". This will change the signal amplitude during the calculation of sonagram.
- Click the button "Reload", "Stop" or "Pause" to make the corresponding action to the sonagram calculation and display.
- View the progress of the sonagram display.
- Move a cross cursor over the entire sonagram and spot display the "Rx Freq" and timestamp of any point in the sonagram.
- Zoom-in view (max. 32 times) displays a sonagram in a max. resolution of 60 Hz per pixel at the display bandwidth of 250 kHz.
- Two-dimensional navigation over the entire sonagram.

Note: The computation load of W-SPEED can be quite high when it is displaying an IQ recording into a two-dimensional sonagram. When possible please turn off the online classification or decoding in W-SPECTRA: set the Mode to "no-mode".

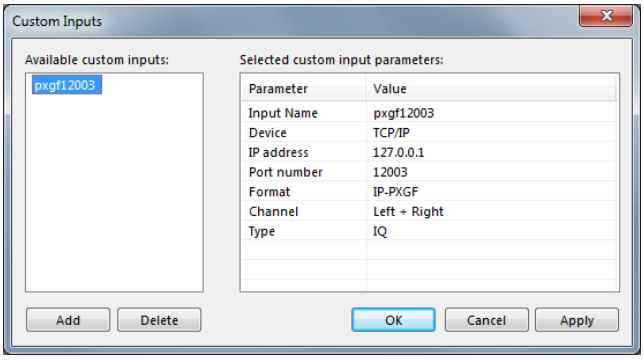
Select a Signal and Playback

After W-SPEED finished displaying an IQ recording into a 2-dimensional sonagram the user may navigate to anywhere of the sonagram, select a signal of his interest by pressing down the left mouse button and making a stripe with a fix width of 96 kHz. The user can send (stream) the selected signal to W-SPECTRA for detailed investigation by pressing the "Play" button. At the same time the 96 kHz-wide signal is output to the speaker for acoustic monitoring. The user may fine tune the frequency position of the selected stripe by adjusting (editing) the value in "Offset" during the streaming of the signal.



Press down the left mouse button, select a 96 kHz signal stripe and send it (playback) to W-SPECTRA or other Wavecom decoders for detailed investigation.

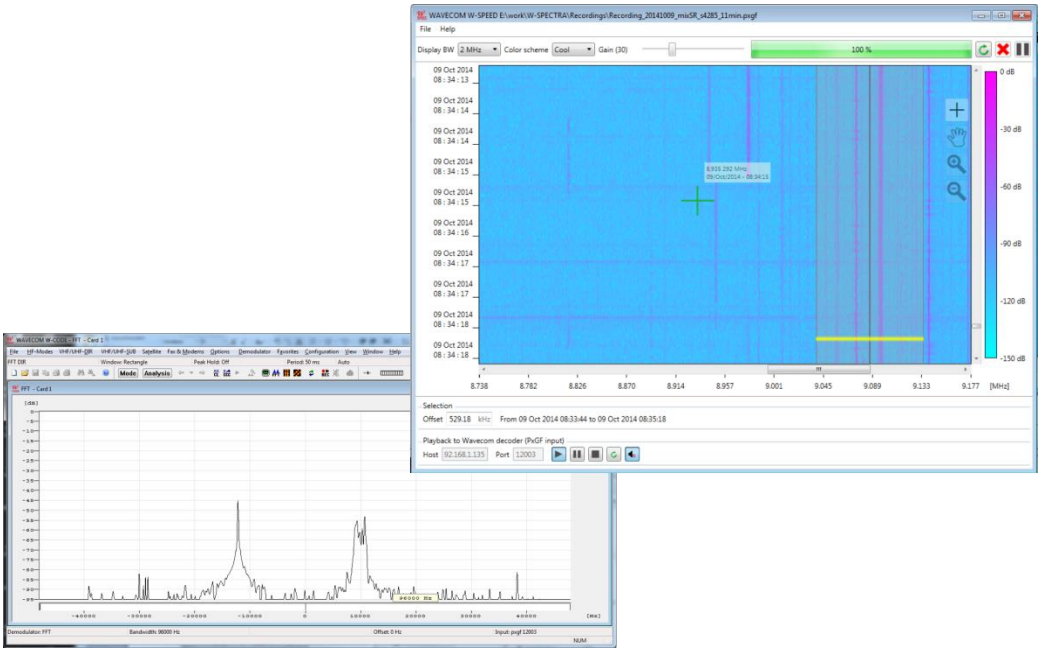
The selected signal stripe can also be sent to other Wavecom decoders, e.g., W-CODE. The user needs to define a "Custom Input" with the PXGF format as the following example:



Define a PXGF input (in W-CODE) using the "Configuration" menu -> "Custom Input".

The PXGF input should have the "format" set to "ip-pxgf" and "channel-config" set to "iq".

After the user opened the corresponding PXGF input in W-CODE, he may send the selected 96 kHz signal stripe from W-SPEED to W-CODE for further processing.



Stream a 96 kHz signal stripe from W-SPEED to W-CODE at the PXGF input with port number 12003.

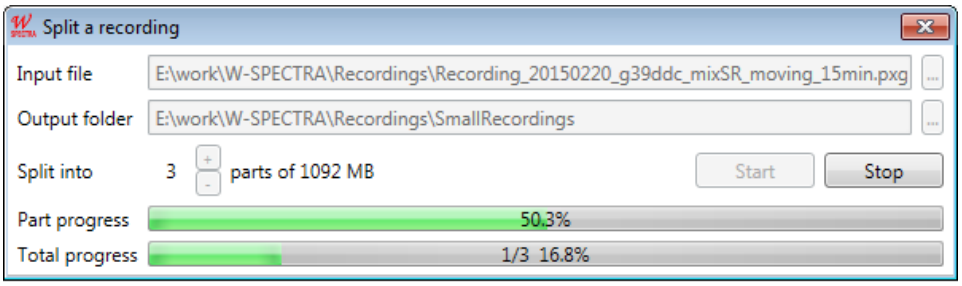
Note: W-SPECTRA uses the TCP/IP ports 12007, 12009, 12011, 27001 and 33264 for its own operation. Please don't use these ports when defining a PXGF input or other TCP/IP connections.

Split a Recording

Usually a wideband recording can get huge. The wideband recording made by W-SPECTRA is 2 MHz wide, in I/Q, each I and Q parts are 16 bits. This make a one-minute recording 0.5 GB; one hour 30 GB and for one day (24 hours) the recording will be 720 GB. Although the capacity of modern storage media can easily accommodate these huge files, it may be inconvenient to view and analyze a huge recording at one time.

The function "Split a recording" under the File menu divide a big PXGF recording into several consecutive recording files in reasonable size.

Because the recording format PXGF allows intrinsic side-information (recorded periodically throughout the whole file), recordings after split can be processed by W-SPEED and W-SPECTRA as the original file.



Split a PXGF recording into several small part recordings.

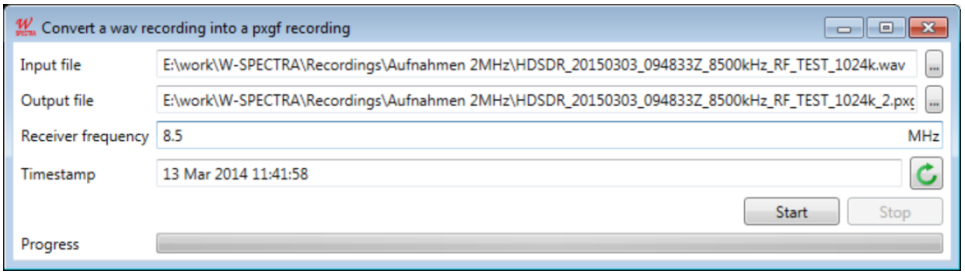
The file splitting scheme is:

- A recording bigger than 10 GB can be split into max. 10 equal size files;
- A recording between 9 GB and 10 GB can be split into max. 9 equal size files;
- The minimum size of a recording which can be split is 2 GB. It can be split into max. 2 files.

Convert a Recording

In most cases the user makes a recording in WAV format. In this format there is no elegant way to save some important side-information e.g., receiver (Rx) frequency and timestamp. User may write these information in the file name. With the "Convert a recording" program the user can convert a WAV file into a PXGF recording. The user may input the "Receiver frequency" and the beginning "Timestamp", so that these information will be implanted into the PXGF recording during the conversion.

The advantage of this "on-the-fly" side-information is, the user can later split a PXGF recording when it is too big without losing any information.



Convert a WAV recording to the PXGF format.

Note: The conversion supports a WAV recording with sampling rate between 48 kHz and 30 MHz and bit per sample should be 8, 16, 24 or 32.

Parameters and Options

W-SPECTRA runs a classifier, a decoder or other analyse tools with its default parameters. The user may change / set new values to the parameter in the lower right corner of the W-SPECTRA GUI "Operation" tab.



Set parameter value of a mode in the lower right corner of the W-SPECTRA GUI Operation tab.

Alphabet...

The **Alphabet** menu has options for transparent and normal output. The normal output includes fonts for e.g., **Latin**, **Greek**, **Cyrillic**, **Hebrew**, **Arabic** alphabets.

The ASCII character sets for output in **German**, **Bulgarian, US**, **Swedish, Danish-Norwegian, Chinese** or other alphabets may also be selected.

Skyper, an alphabet which is used in POCSAG mode in Germany, is also available.

The transparent alphabet includes output of non-printable characters of a data transmission, e.g., ITA-2 control characters like Letter Shift and Figure Shift, or undefined upper case characters. In normal alphabets these characters are not output.

Auto Decrypt

Decryption can be switched on/off with **Auto Decrypt**. If enabled, the key is displayed in the status bar.

Bit Inversion Mask

One or several data bits may be inverted by using the **Bit Inversion** item.

The **Bit Inversion Mask** can be entered in three different ways:

- In the top input box a decimal number between 0 and 31 may be entered
- In the center input box the same number may be entered in binary format with the least significant bit to the right
- In the bottom check boxes a logical "1" is entered with the mouse by clicking in the check box

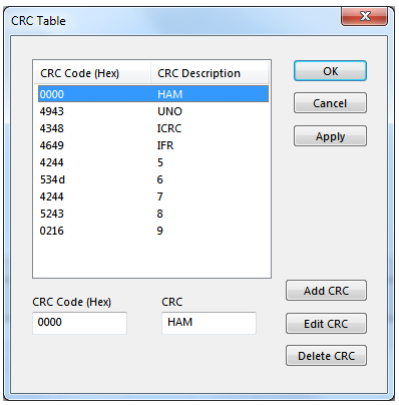
Bit Inversion is only implemented for ITA-2 (Baudot) based bit streams.

CRC Recognition

An automatic detection of the CRC can be switched on/off with **CRC**.

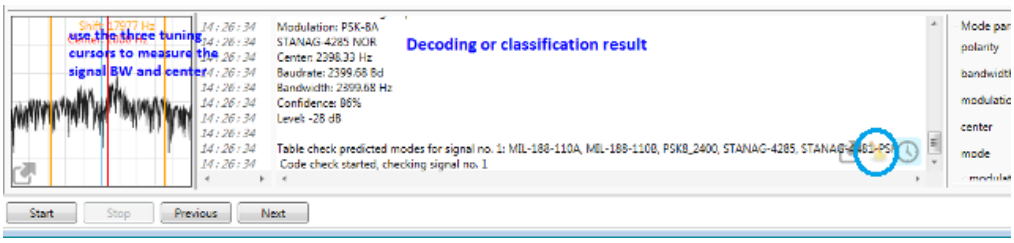
CRC Table

A table of CRC's is stored as \Config\CRCTable.xml. The user may open and edit this xml file by clicking the "Edit" button beside the "CRC" parameter.



Clear Screen

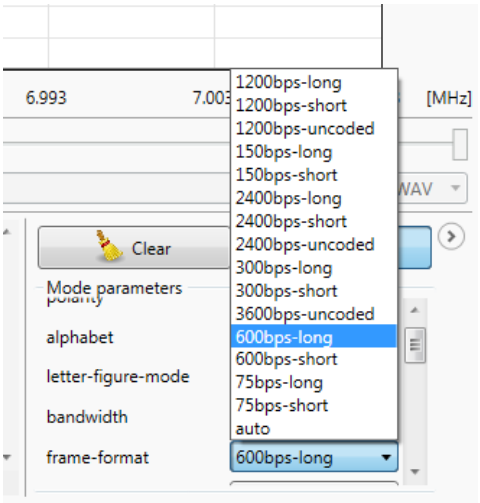
There is a "Clear" button at the lower right corner of the result display window. Click this button to clear the screen, all the output in the display window will be deleted.



A "Clear" screen button in the result window.

Frame Format...

This parameter is available in most MIL/STANAG modes. The user may choose a valid frame format from the list.



IAS

IAS is the abbreviation for ISO-ASYNCHRONOUS and SYNCHRONOUS modes. Iso-asynchronous modes have start and stop elements like Baudot, but the code words have an integer number of elements. The IAS function is used for the extremely accurate baud rate estimation of a synchronous or iso-asynchronous bit stream.

The automatic phase correction for the ideal bit center sampling (bit synchronism) is completely independent of the IAS function and is always active. The extremely accurate baud rate determination uses the number of necessary phase correction steps for the baud rate determination.

In modes working with an interrupted data stream such as PACKET-300, it may be advantageous to be able to switch off the baud rate correction to prevent drifting of the pre-selected baud rate. When the IAS function is disabled, any pre-selected variable baud rate will be treated in the same way as a fixed baud rate.

In most of the VHF/UHF modes the IAS is permanently disabled. This is due to the lack of phase coherence between successive data blocks. An exact measurement of the phase shift is not possible for an extended period of time.

In the event of adverse HF reception conditions (fading), enabling IAS may offer substantial advantages. The software will decrease the size of the phase correction steps in accordance with the verified, reduced phase errors, and thus prevent bit glitches and the resulting loss of synchronism. It is therefore recommended to enable IAS as a default.

Choose “on” and “off” to enable and disable the **ias** parameter, respectively.

Letters/Figures...

This option is only available for ITA-2 based modes.

The **Letters/Figures** dialog box contains the options **Normal**, **Letters Only**, **Figures Only** and **Unshift on Space (UOS**). **Letters** and **Figures** designates the ITA-2 lower (letters) and upper (figures) cases.

For reception under normal conditions the selection of one case or the other is controlled by the reception of the shift characters.

Special alphabets, e.g., Chinese, comprise only letters so forcing a shift into lower case mode may be an advantage (**Letters Only**). Selecting this function may also be advantageous when searching for a bit inversion pattern, as the pattern may be more easily recognized.

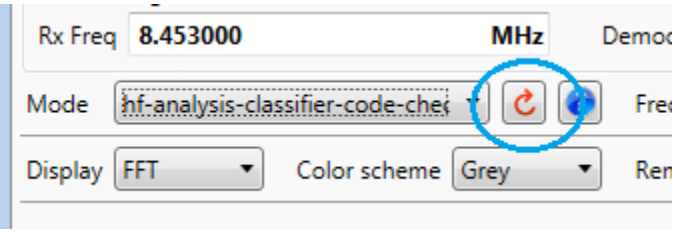
In weather code transmissions five figure groups are used - in this case one may force a shift into upper case (**Figures Only**).

The **Unshift on Space (UOS)** function forces a shift into lower case after a space character has been received. In this manner the readability of the transmission may be enhanced under poor conditions (weak signals or interference).

Compared to the **Letters Only** mode, UOS has the advantage that single, upper case characters like periods/full-stops and commas are correctly printed. The drawback is that the software will incorrectly shift to lower case when receiving figure groups separated by space characters.

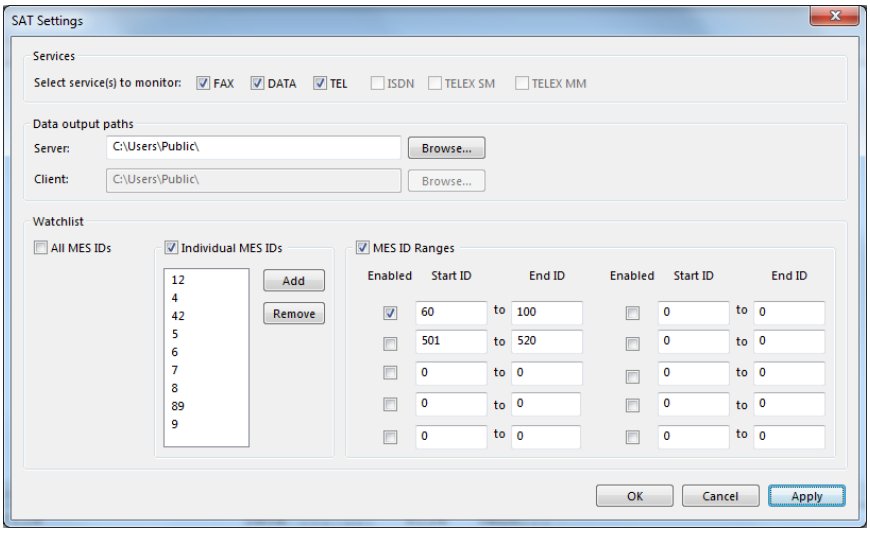
Resync Mode

There is a "Resync" button beside the "Mode" field in the W-SPECTRA GUI Operation tab. This function forces a re-synchronization of the current mode.



Press the "Resync" button to restart a decoder or a classifier.

SAT Settings…



For the SAT Modes, additional parameters can be set in the **SAT Settings** dialog box.

These settings are:

- **Service**: Select the service to monitor. Choose between:

  FAX/DATA/TEL/HSD/TELX_SM/TELX_MM. There are two different possibilities for monitoring telex:

  - TELX_SM: Single message monitoring: only the telex of the MES found in the Control Channel will be recorded.

- TELX_MM: Multi message monitoring, the mode stays on the TDM channel until there are no more Telex transmissions on this channel.

➢ **Server**: Set the Windows directory for the output files on the server.

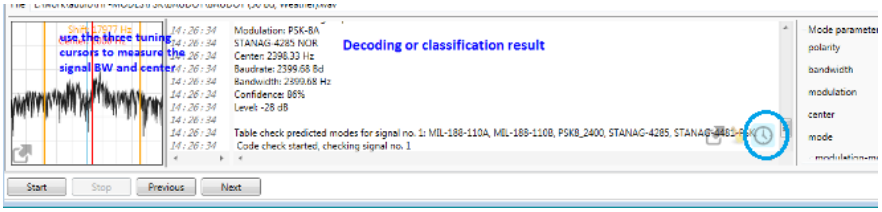
➢ **Client**: Set the Windows directory for the output files on the client computer. This setting is only enabled on a remotely-connected GUI.

➢ **Watchlist**: Click the **All MES IDs** box, if all MESs must be monitored; leave this box empty if only specific MESs should be monitored. Enter these MES IDs into the combo box. If ranges of MES IDs should be monitored, enter and enable each range.

See "SAT System" on page 238.

Timestamp

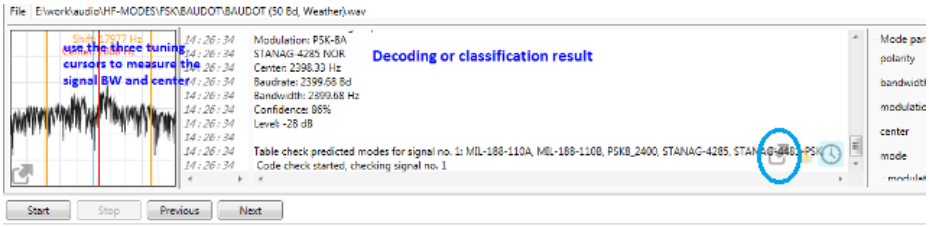
By clicking **Timestamps** in the lower right corner of the result display window, the local time will be displayed beside each output line.



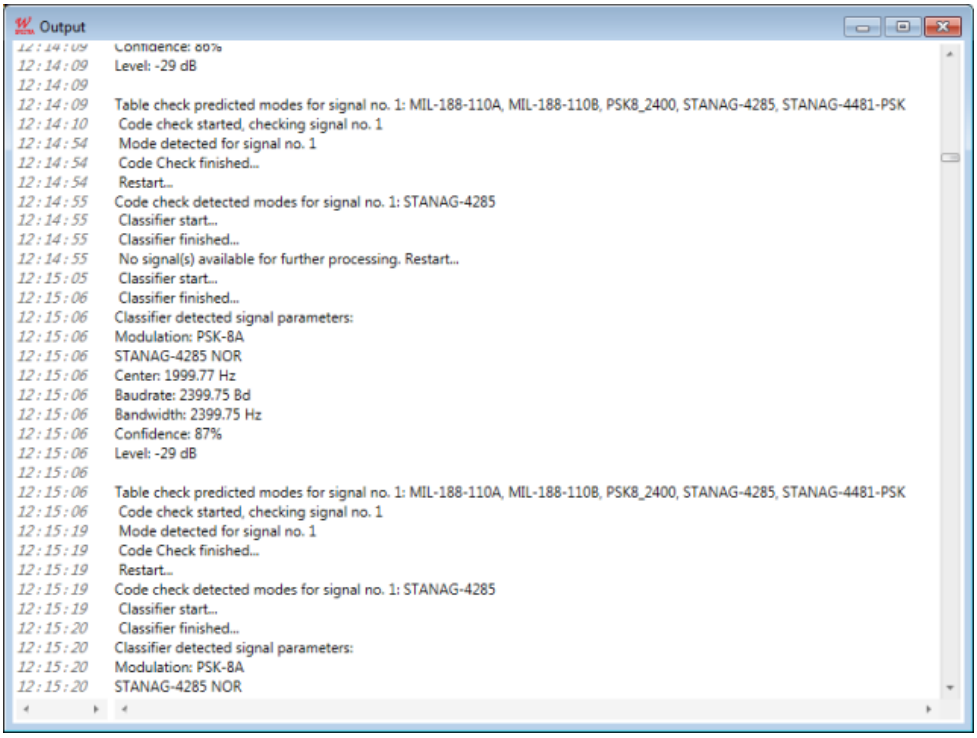
Click the "Timestamp" button to turn on and off the timestamp in the result display.

Display Results in a Separate Window

By clicking **Window** button in the lower right corner of the result display window, a separate window will open to display the decoding result. This is helpful, because the result display window in W-SPECTRA may be quite small.



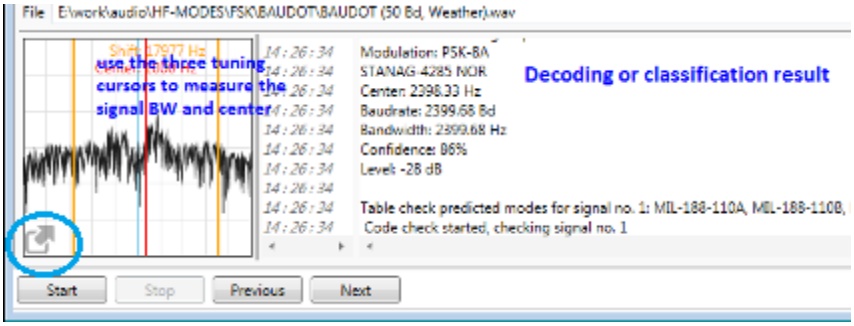
Click the "Window" button will open a separate window to display the result.



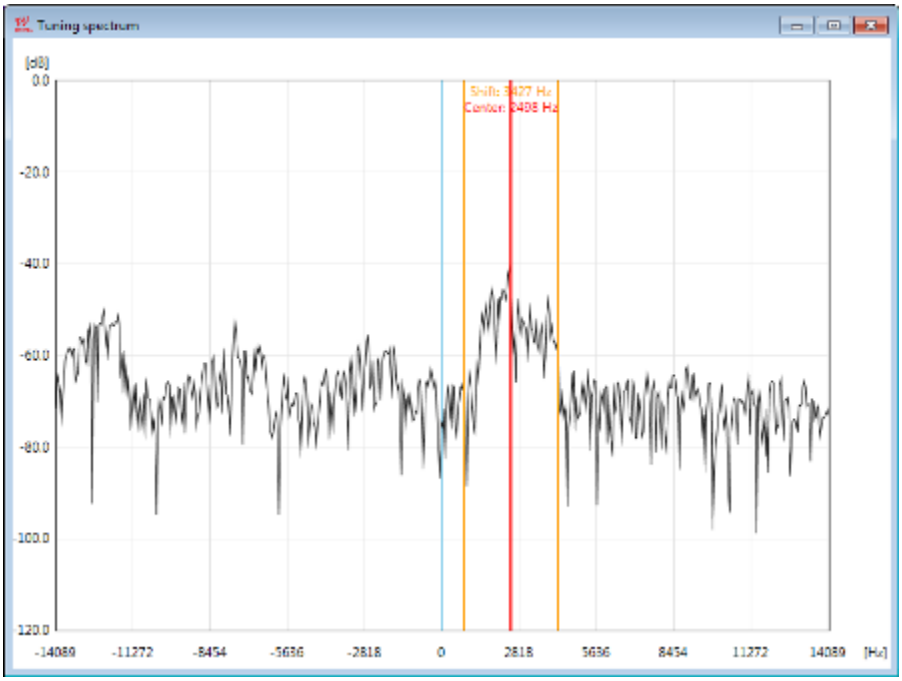
A separate window to display the result.

Display Tuning Spectrum in a Separate Window

By clicking **Window** button in the lower right corner of the result display window, a separate window will open to display the decoding result. This is helpful, because the result display window in W-SPECTRA may be quite small.



Click the "Window" button will open a separate tuning spectrum window.



A separate tuning spectrum window.

Using the three cursors in the separate tuning spectrum window, the user can measure the signal center and bandwidth in a more convenient way.

Auto

By setting the "auto-mode" to "on" the mode parameters "shift", "center" and "baudrate" are automatically calculated and adjusted. After the recalculation the "auto-mode" goes to "off".

Modulation

In the **Modulation** pull-down list the user may set the demodulator of a mode decoder.

Most HF, VHF or UHF modes use a pre-selected demodulator mode for optimum performance, but sometimes different demodulators may be chosen.

AM

Satellite weather charts are transmitted using AM. This demodulator uses the quadrature I/Q demodulation method.

The level displayed by the level indicator corresponds to the AM modulation depth of the signal.

BPSK

BPSK shifts the carrier phase ±180 degrees. For carrier recovery a Costas loop is used - this is a PLL with a special phase comparator, which removes the payload data from the PLL loop. The input signal is then down-converted to base band by mixing the carrier in a complex mixer, and the resulting signal is the data signal.

BPSK is almost exclusively used for satellite data links.

CW

The CW demodulator utilizes a steep, adaptive band pass filter and automatic amplitude control. The AGC attack time may be adjusted according to the propagation conditions. The filter response may be set to **Slow**, **Normal** or **Fast**. This demodulator produces high quality CW decoding. It is important to select the appropriate receiver AGC response (normal or slow).

DSP

The DSP mode utilizes an I/Q demodulator (Hilbert transformation). The received signal is split into an in-phase component and a quadrature component. Next, amplitude normalization takes place and the resultant signal is used for the frequency conversion. This method is characterized by a linear relationship between the received frequency and the output voltage of the demodulator.

The DSP demodulator has a good signal-to-noise ratio and yields very good results under most conditions.

DPSK

In differential PSK the absolute carrier phase cannot be used for data recovery as is the case with BPSK and QPSK. To decode multiphase DPSK (up to 16DPSK) the input signal is mixed with a complex, phase regulated reference signal. The resulting data reduced signal is then filtered in a low pass filter. The following phase comparator calculates the phase difference between the signal from the integrator and the delayed signal.

A variant of DPSK is used almost exclusively when phase modulation is employed on short wave data links.

DBPSK

Similar to DPSK, but has two phase shifts at ± 180 degrees.

DQPSK

Similar to DPSK, but has four phase shifts at ± 90 and ± 180 degrees.

DTMF

This demodulator handles multi-frequency signals. Filters are switched in on the various frequencies of the signal and the amplitude is then calculated for each frequency. Next the amplitudes are evaluated. Two simultaneous tones are demodulated. The SNR is the same as for the mark-space demodulator.

DXPSK

Adaptive DPSK demodulator for PACTOR-II. This demodulator will automatically adapt itself to DBPSK, DQPSK, D8PSK or D16PSK.

D8PSK

Similar to DPSK, but has eight phase shifts at ±45, ±90, ±135 and ± 180 degrees.

D16PSK

Similar to DPSK, but has sixteen phase shifts at ±22.5, ±45, ±67.5, ±90, ±112.5, ±135, ±157.5 and ±180 degrees.

FFSK and GFSK

Depending on the mode, the FFSK (Fast Frequency Shift Keying) and GFSK (Gaussian Frequency Shift Keying) demodulator is automatically selected. Basically this demodulator utilizes the I/Q principle (Hilbert). However, filters are adjusted to accommodate the special demands of these modes.

MFSK

This demodulator handles multi-frequency signals. Filters are switched in on the various frequencies of the signal and the amplitude is then calculated for each frequency. Next the amplitudes are evaluated. Depending on the number of tones used, the filters are configured as phase linear FIR filters or as IIR filters. The SNR is the same as for the mark-space demodulator. Simultaneous multi-tone decoding (e.g., DTMF) is not possible with this demodulator.

MS (Mark-Space)

The mark-space demodulator processes the two keying frequencies of a FSK signal. These are fed to two phase linear FIR filters and the amplitude is then calculated. The mark-space demodulator exhibits an extremely good noise distance and should be used for all FSK modes utilizing a speed of less than 300 Baud.

OQPSK

Carrier recovery is mandatory to demodulate OQPSK. As OQPSK has phase shifts at ±90 degrees, the signal must be squared two times to produce a carrier at four times the original frequency. A PLL recovers the carrier in frequency and phase with ambiguities at ±90 and ±180 degrees. A complex mixer down converts the signal to base band and the resulting signal is the data signal. In contrast to QPSK, OQPSK has only phase steps of ±90 degrees in one step. First the in-phase part is switched, then after half a

symbol duration the quadrature part is switched. The advantage of this process is a smaller amplitude variation.

OQPSK is used almost exclusively for satellite data links.

QPSK

Carrier recovery is mandatory to demodulate QPSK. As QPSK has phase shifts at ±90 and ±180 degrees, the signal must be squared two times to produce a carrier at four times the original frequency. A PLL recovers the carrier in frequency and phase with ambiguities at ±90 and ±180 degrees. A complex mixer down converts the signal to base band, and the resulting signal is the data signal.

QPSK is almost exclusively used for satellite data links.

SUBTONE

The same as DSP, but the parameters are optimized for low frequencies.

Passband Center

Set a value in the **passband-center** to adjust the center frequency of the passband filter.

For more details see "Passband Filter Support" on page 59.

Passband Bandwidth

Set a value in the **passband-bandwidth** to adjust the bandwidth of the passband filter.

For more details see "Passband Filter Support" on page 59.

Center

Set a value in the **center** to adjust the demodulator center frequency within 1 Hz accuracy. For modes utilizing direct FSK this button is not available: in this case the offset frequency is equal to the effective center frequency.

Shift

Set a value in the **shift** to adjust the frequency shift in 1Hz steps. In HF modes the range is 50 Hz – 3500 Hz, and in VHF-UHF modes using direct FSK the range is 50 Hz – 16000 Hz.

Baudrate

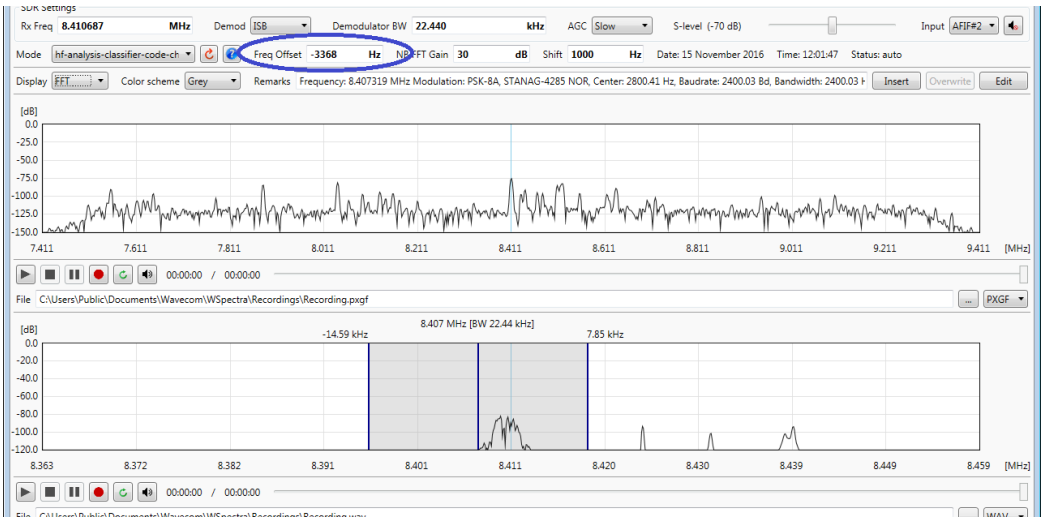
Set a value in the **baudrate**.

Polarity

Set the **polarity** to toggle "normal" or "inverse". Usually when the signal is from the USB (upper side band) the polarity should be set to "normal" and vice versa.

Frequency Offset

By adjusting the middle frequency tuning cursor in the narrowband spectrum display the user can place a signal for correct decoding. The relative distance of the middle cursor to the spectrum middle appears in the "Freq Offset" of the W-SPECTRA GUI.



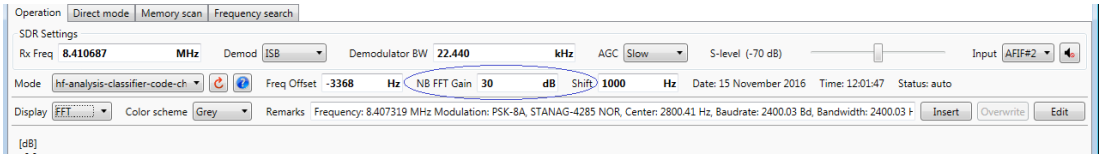
Moving the middle frequency tuning cursor in the narrowband spectrum display will set the "Frequency Offset".

The "Freq Offset" should be set, so that

- For HF and VHF/UHF-SUB modes, the signal appears at the right-hand side of the middle frequency tuning cursor.
- For VHF/UHF-DIR and SAT (satellite) mode, the middle frequency tuning cursor is placed at the middle of a signal.

NB FFT Gain

The user may adjust the "NB FFT Gain" to amplify or weaken the signal level: when no signal is appearing in the narrowband spectrum display, the user may increase the gain to view and decode the signal.

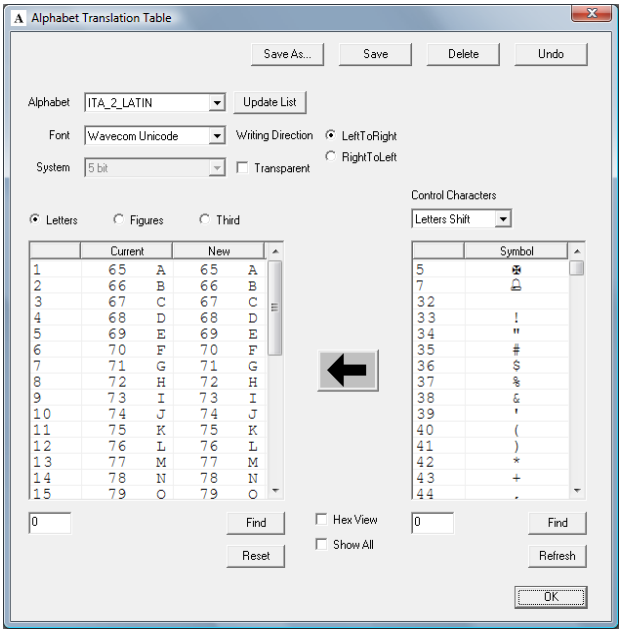


Adjust the "NB FFT Gain" to reach a good FFT display and decoding quality.

Note: To reach a good decoding quality the user should usually use a small gain value. The gain should be set to a value, so that the signal appears just a little bit in the narrowband spectrum display.

Custom Alphabets

The user can define his own "Custom Alphabets" under the menu "Configuration" -> "Custom Alphabets". Only 5-bit alphabets are accommodated, and the number of custom alphabets is limited to 16.



The **Custom Alphabets...** dialog box displays a number of input fields:

- Clicking **Save As...** opens a dialog box, in which to enter a name for the newly created translation table. Press **OK** to close the dialog box and save the new translation table. The translation table contains the actual values set in the **Alphabet Translation Table** dialog. The name of the new table appears in the **Alphabet** combo box and a new .xml file with the name of the table is created containing the table data.
- Pressing **Save** stores the current dialog settings to the translation table that is active as shown in the **Alphabet** combo box. The data is stored in an .xml file under Wspectra\Alphabets folder.
- Clicking **Delete** deletes the active translation table.
- Pressing **Undo** will replace the new, user selected values in the dialog box with the values stored for the current alphabet.
- The **Update List** is used to add the user created alphabets to the list of alphabets. By pressing the **Update List** button, the **Alphabet** directory is searched for .xml files related to new alphabet. If a new one is found the list and the **Alphabet** combo box are updated.
- The **Alphabet** combo box shows the names of all translation tables. By selecting an entry the stored data for the specific translation table are displayed. Note that the most recent changes to the current alphabet are not saved until **Save** is pressed.
- Select the font that is used to display the translation tables by pressing **Font**.
- The **Alphabet** list control (left list) displays the characters defined for the current alphabet. The first column shows the position index in the alphabet for the characters. The second column (**Current**) shows the currently defined value of the character at the selected position. The third column (**New**) shows the user defined character value. By pressing the **Save** button, the **Current** value becomes the **New** value.
- The **Font** list control (right list) displays all the characters defined in the selected font. The first column shows the decimal or hex character value. The second column (**Symbol**) shows the character. Selected characters are copied to the selected rows in the **Alphabet** list by pressing the **Arrow (←)** button.
- Using the **Writing Direction** radio buttons**,** a **LeftToRight** or **RightToLeft** output direction of the decoded text may be selected
- The **System** combo list is used to set the length of the codeword for a user defined alphabet. The present version allows only 5-bit alphabets.
- Click **Transparent** to select if control characters are to be displayed in the decoded text.

- Depending on which radio button, i.e., **Letters, Figures** or **Third,** is selected, the letters, figures or third shift control characters of the current 5-bit custom alphabet are displayed in the list control.
- The **Control Characters** combo box contains the control characters that can be added to an alphabet, i.e., the **Letters Shift**, **Figures Shift**, **Third Shift**, **Unperforated Tape**, **Space**, **Linefeed** and **Carriage Return** characters. Select a character, then press the **Arrow (←)** button to copy the selected character to the selected row in the custom **Alphabet** list.
- The **Arrow (←)** button is used to move characters to the translation table. Press this button to copy the selected character in the **Font** table, or the selected entry in the **Control Characters** combo box to the selected position in the **Alphabet** table.
- The **Find** button and the edit box to the left of the button are used to find a character (decimal or hex value) in the **Alphabet** or **Font** table.
- Press **Reset** to replace all character values in the custom **Alphabet** list with '0' .
- Press **Refresh** to reload all characters of the current font and update the display. This feature is useful when the font has been changed.
- Pressing **Hex View** to display the hex value for all characters; otherwise, decimal values are used.
- When **Show All** is enabled, the positions of undefined characters are displayed in the **Font** character table.
- Press the **OK** button to close the window. Recent changes are not saved - if the latest changes have to be saved, press the **Save** button before pressing OK.

Passband Filter Support

Perfect signal processing (filtering) is essential for the best decoding results which are achieved by using the correct filters in the receiver. Doing so prevents blocking effects from strong nearby signals. However correctly processed signals may be unavailable, e.g., when a receiver does not offer optimum filters or when using recorded signals. To overcome these obstacles additional passband filters are included in the WAVECOM decoders to assist the operator in separating signals within the analyzed frequency spectrum.

Depending on the demodulator (Modulation) used by a mode the user may set the passband filter parameters: Passband Center, Passband Bandwidth and Center. (See the table below).

Item	PB Conf.	Remarks
DSP	+	Freely configurable
AM	+	Freely configurable
CW	+	Freely configurable
GFSK	+	PB center frequency controlled from offset frequency setting
FFSK	+	PB center frequency controlled from offset frequency setting
MARK-SPACE	-	PB automatically adjusted depending on center, shift and speed
MFSK	-	Individual tones are filtered and PB automatically adjusted depending on tone spacing, center and speed
DTMF	-	Individual tones are filtered and PB automatically adjusted depending on tone spacing, center and speed
BR6028	-	Preconfigured filters that cannot be changed. The location of the pilot tone can be manually set
BPSK	+	Freely configurable
QPSK	+	Freely configurable
OQPSK	+	Freely configurable
DPSK	-	PB bandwidth automatically adjusted depending on center, shift and speed. The center frequency can be manually set
DXPSK	-	PB bandwidth automatically adjusted depending on center, shift and speed. The center frequency can be manually set
DBPSK	-	PB bandwidth automatically adjusted depending on center, shift and speed. The center frequency can be manually set
DQPSK	-	PB bandwidth automatically adjusted depending on center, shift and speed. The center frequency can be manually set
D8PSK	-	PB bandwidth automatically adjusted depending on center, shift and speed. The center frequency can be manually set
D16PSK	-	PB bandwidth automatically adjusted depending on center, shift and speed. The center frequency can be manually set
IQ	+	Freely configurable
ANALYSE	+	Freely configurable
FFT	-	No filtering implemented
TIME	-	No filtering implemented
OFDM	-	No filtering implemented
SUBTONE	-	No filtering implemented
DISCRIMINATOR	-	No filtering implemented
EXT-DEM	-	No filtering implemented
BYPASS	-	No filtering implemented

Transmission Modes

ACARS

Aircraft **C**ommunications **A**ddressing and **R**eporting **S**ystem (ACARS) is a carrier sensing, multiple access packet radio system for aircraft communications. ACARS operates in the VHF band, mainly around 130 MHz, using 2400 bps NRZI coded coherent audio frequency MSK (Minimum Shift Keying - a particular form of FSK) on AM to make use of standard aircraft AM communications equipment.

Parameter	Value
Frequency range	VHF
Operation modes	CSMA/CD packet ARQ system
Modulation	AM, SUB FSK
Symbol rate	2400 Bd
Center frequency	1800 Hz
Shift	1200 Hz
Receiver settings	AM, BW = 3 kHz
Input format(s)	AF, IF
Additional Info	ITA-5 with parity and block coding Frequencies Europe: 131.725, 131.525, 131.825 MHz Frequencies USA: 131.550, 130.025, 129.125, 131.475, 130.450, 131.125, 136.700, 136.750, 136.800 MHz Frequency Japan: 131.450 MHz

To receive ACARS an omni-directional 108-136 MHz antenna, a VHF AM receiver (scanner) with 13 kHz channel bandwidth and a corresponding AF output is necessary. As the ACARS packets are very short, turn the squelch of the receiver OFF.

Speed selection is not available for ACARS as only one speed is in use (2400 Baud).

Processing of ACARS Messages

It is possible to do some interpretation of ACARS messages. The following options are available:

Reassemble multipart messages

This setting enables the reassembling of bigger messages which are sent in several parts. Instead of showing each part separately, the message is shown as one single message when the last part has been received. The message header is still shown separately for each part.

Parse ADS-C messages

This setting enables the parsing of ADS-C messages (Automatic Dependent Surveillance - Contract). When an ADS-C message is received, it is decoded and the additional information is shown in the output window.

ACARS Frame

Parameter	Value
Pre-key	16 characters All binary “ones”
Bit Sync	2 characters “+” , “*”
Character Sync	2 characters SYN, SYN (0x16)
Start of Heading	1 character SOH (0x01)
Mode	1 character
Address	7 characters
Technical Acknowledgement	1 character
Label	2 characters
Block Identifier	1 character
Start of Text	1 character
	STX (0x02) - if no text ETX (0x03)
Text	220 characters maximum, printable characters only
Suffix	1 character, if single or terminal block ETX, else ETB (0x17)
Block Check Sequence 16 bits	
BCS Suffix 1 character DEL (0x7F)	

Messages may be single or multi-block. The pre-key sequence and the BCS have no parity bits.

ACARS communications are divided in Category A and Category B.

Using Category A, an aircraft may broadcast its messages to all ground stations. This is denoted by an ASCII "2" in the Mode field of the downlink message. The WAVECOM software translates this character to "A".

Using Category B an aircraft transmits its message to a single ground station. This is denoted by an ASCII character in the range "@" to "]" in the Mode field of the downlink message.

The ground station may use either "2" or the range "`" to "}" in the Mode field. All ground stations support Category A, but may uplink "`" to "}" in the Mode field.

The WAVECOM software translates the ground station address (also called the Logical Channel Number) into a number in the range 0...29.

A station will transmit after having monitored the HF channel for traffic, otherwise it waits until the channel is clear. If a collision occurs between the packets of two stations transmitting at the same time, they will back-off and new transmission intervals will be set by random interval timers in the radio equipment.

At the receiving end, a block check calculation is made and compared to the calculation appended to the packet by the transmitting station. If the downlink messages contain errors, no response will be given and the transmitting station will retransmit the packet a number of times, until a positive acknowledgement is received and the message can be deleted from storage, or the aircrew be alerted to its non-transmission.

If an uplink message is found in error, the airborne equipment will generate a negative acknowledgement (NAK), which triggers an uplink retransmission. Retransmission is also triggered by timeout.

Positive acknowledgement from the aircraft consists of the transmission of the Uplink Block Identifier of the correctly received block. Positive acknowledgement from the ground station consists of a similar transmission of the Downlink Block Identifier.

Acknowledgements are placed in the Technical Acknowledgement field.

The general response message label is "_DEL" (0x5F or 0x7F). Messages with this label contain no information except acknowledgements and are used for link maintenance.

The traffic exchanged can be requests for voice communication, weather reports, access to airline computer systems, reading of aircraft automatic sensors, flight plans, messages to be routed to destinations in

the international airline data network - in fact much traffic previously carried by voice, has been transferred to ACARS.

The text field of the ACARS packet is used for messages with a fixed format, free text, or a mixture of formatted and free text. Standard 7-bit ASCII is used; bit 8 is an odd parity bit and LSB (bit 1) is transmitted first.

ACARS Downlink Message Example

(#8) 06-11-1996 18:43:32 M=06 ADDR= HB-INR TA=Q ML=Q0 B=6 MSN=0635 FID=SR6767

(Bold typeface indicates decoder generated characters)

Decoded	Interpretation
(#8)	Decoder generated message number
06-11-1996 18:43:32	Decoder generated timestamp (optional)
M=	Mode Category A = A,
	Category B = 0..29
ADDR=	Aircraft address
	(aircraft registration or flight identifier)
TA=	Technical acknowledgement
	(downlink 0...9, uplink A...Z, a...z, NUL (00h))
ML=	Message Label (message type)
B=	Uplink/Downlink Block Identifier
	(downlink 0...9, uplink A...Z, a...z, NUL (00h))
MSN=	Message Sequence Number
FID=	Flight Identifier

In this case record **#8** decoded at **18:43:32** contains a message from a Swiss aircraft with registration **HB-INR** using logical channel **06** to transmit and acknowledgement of uplink block **Q** and a link test (**Q0**) with block identifier **6** and message sequence number **0635** (here the time in minutes and seconds after the hour is used - other formats are also in use). The flight is Swissair **SR6767**.

A few examples of the more important or frequently seen ACARS messages:

M=06 **ADDR=** HB-IND **TA**=NAK **ML=**_☐ **B=**3 **MSN=**2810 **FID=**OS005

Using logical channel **06** an unsolicited (TA=**NAK**) general response _☐ without information is transmitted as block **3** from aircraft **HB-IND** on flight **OS005** with sequence number **2810**. General responses are mainly used for block acknowledgement purposes.

M=06 **ADDR=** ☐☐☐☐☐☐☐ **TA**=NAK **ML=**SQ **B=** 00XSZRH

This is a "squitter" - an ID and uplink test message transmitted at regular intervals from ground stations. This one is a squitter **(SQ)** version 0 **(00)** from a SITA **(XS)** ground station in Zurich, Switzerland **(ZRH)**. The ☐ denotes the ASCII NUL character (00h) used for broadcast. A block identifier is not used.

M=06 **ADDR=** OY-MDS **TA**=5 **ML=**:; **B=**131125

This is a data transceiver auto tune message **(:;)** from ground station **06** commanding the ACARS transceiver of aircraft **OY-MDS** to change its frequency to 131.125 MHz. At the same time acknowledgement is given for the aircraft's downlink block **5**.

AIS

AIS also known as (Universal) Automatic Identification System (UAIS) is a worldwide radio system for ship collision avoidance and navigational advice. AIS-equipped ships continuously transmit short messages containing information like position, course over ground, speed over ground, and so on. All information may be sent from ship to ship, as well as well as from ship to shore. This is very useful for Vessel Traffic

Systems (VTS) in congested areas such as harbors, rivers and archipelagos. Tranmissions may be in broadcast mode or individually addressed. The messages may contain a fixed content in binary format, free text or binary information defined by international, regional or national authorities (see table below).

Parameter	Value
Frequency range	VHF
Operation modes	SOTDMA FEC
Modulation	GMSK
Symbol rate	9600 Bd
Receiver settings	BW = 15 kHz
Signal source(s)	IF

Transmission is 9600 Baud GMSK modulation over 25 or 12.5 kHz channels using the HDLC packet protocol. Each station transmits and receives over two radio channels to avoid interference problems. Self-Organizing Time Division Multiple Access (SOTDMA) is used. One Time Division Multiple Access (TDMA) frame corresponds to one minute and contains 2250 slots.

Each frame contains an 8-bit ramp up and a 24-bit synchronization sequence. At the beginning and end of each frame, a HDLC flag (01111110) is sent. After the 8-bit preamble, 168 bits of data and a 16-bit CRC checksum are sent in a default packet (one slot). Long transmission packets may occupy two to five continuous slots. Bit stuffing and NRZI encoding is used.

Traffic can be monitored on the AIS1 Channel 87B 161.975 MHz and AIS2 Channel 88B 162.025 MHz

From **Options | Display Mode**, All frames or Error free frames may be selected.

AIS Binary Messages

Area	Designation	Function	Message
Global	International	0, 2, 3, 4, 5, 11, 12, 13, 14, 15, 16, 17	
St.Lawrence Seaway	SLS	1 (Metro/Hydro)	1, 2, 3, 6
		2 (Vessel/Lock)	1,2
		32 (Special)	11
USA/Canada	PAWSS	1 (Metro/Hydro)	4,5
		2 (Vessel/Lock)	3
Rhine/Danube	Inland	10, 21, 22, 23, 24, 40, 55	

ALE-400

Amateur version of MIL-188-141A.

For more details see "MIL-188-141A" on page 139.

Parameter	Value
Frequency range	HF
Operation modes	ALE, Broadcast/Simplex FEC
Modulation	MFSK-8
Symbol rate	50 Bd
Center frequency	1625 Hz
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF

ALF-RDS

ALF-RDS (**A**ccurate positioning by **L**ow **F**requencies) is a German system for the transmission of DGPS information on low frequencies (in this case 123, 7 kHz). Data is transmitted in RDS format. RDS (Radio Data System) is a one-way data transmission system used by FM broadcasters worldwide to broadcast program, time and traffic information on a 57 kHz BPSK DSB sub carrier with suppressed carrier and a bit rate of 1187.5 bps. In the case of ALF-RDS, the transmission is made in SSB with a decreased level pilot carrier to reduce bandwidth.

Parameter	Value
Frequency range	HF
Operation modes	Broadcast FEC
Modulation	BPSK
Symbol rate	1187.5 Bd
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF

The basic RDS data unit is a group which consists of four blocks, each having 16 data bits and 10 error detection and correction bits. Groups are divided into type A and B, each containing 16 different groups.

In the upper window, a **Display Mode** can be selected. The default display mode is **All Blocks**, which displays the information of each block. **Binary** will display the contents of a group in binary format.

In the lower window, other information like flags, time, program information and transmitted text is displayed.

ALIS

ALIS (**A**utomatic **Li**nk **S**et-up) is a simplex ARQ system and operates at a Symbol rate of 228.66 Baud on the radio link.

ALIS is described in report 551-2 of the ITU "Reports of the CCIR 1990 - Fixed Services at Frequencies below about 30 MHz".

Parameter	Value
Frequency range	HF
Operation modes	FSK, Simplex ARQ
Modulation	FSK
Symbol rate	228.66 Bd, variable 30-650 Bd
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF
Additional Info	ITA-2 with block coding

The transmission block of the standard ARQ system consists of 2 identification bits, 30 data bits and 16 CRC bits. Data transmission is transparent for ALIS. Known systems are however structured around six ITA-2 characters.

The two identification bits indicate one of four possible system states. The CRC checksum enables detection and correction of transmission errors.

The acknowledgement block is 16 bits in length. The total transmit-receive cycle for ALIS is 111 bits, which corresponds to a duration of 485.4 ms. An error free transmission is equivalent to a terminal baud rate of 100 Baud.

The ALIS system automatically determines the optimal operating frequency after having received a CALL command. The station then sends a synchronization word, address, block counter and a status word. The receiving station correlates this bit sequence and synchronizes itself. If the data transmission link fails, ALIS will search for a new frequency to re-establish the link.

ALIS-2

ALIS-2 (**A**utomatic **Li**nk **S**et-up) is a simplex system operating with a baud rate of 240.82 baud. ALIS-2 is described in the "Report of the CCIR 1990, Fixed Service at Frequencies below about 30 MHz" of the ITU.

Parameter	Value
Frequency range	HF
Operation modes	Simplex ARQ
Modulation	MFSK-8
Symbol rate	240.82 Bdd
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF
Additional Info	ITA-5

ALIS-2 is 8-FSK modulated. The tone spacing is 240 Hz, and the tone duration is 4.15254 ms. The transmission block consists of 55 tri-bits, resulting in 165 bits per frame. In addition to the preamble of 21 bits, each block contains 126 data bits. The preamble includes an identification code, allowing different systems to be identified.

Two identification bits signal four operational states: traffic, idle, RQ and binary data transfer. The 16-bit CRC-checksum serves the detection of transmission errors and error correction purposes.

The overall transmission and receive cycle of ALIS-2 is 354 bits, which is equivalent to 490 ms. In case of an error-free data transmission, the terminal bit rate is 720 bit/s.

ALIS-2 almost always uses the ITA-5 ASCII alphabet.

The ALIS-2 system automatically determines the optimum operating frequency after having received a CALL command. The station then sends a synchronization word, address, block counter and a status word. The receiving station correlates this bit sequence and synchronizes itself. If the transmission link is interrupted, ALIS-2 will search for a new frequency to re-establish the link.

If an ALIS-2 system is identified the status line will display **System: "XXXXXXXXh"**, where "XXXXXXXXh" denotes an eight digit hex id string.

AMSAT-P3D

AMSAT (Radio Amateur Satellite Corporation) OSCAR-40 (AMSAT Phase 3D) is the latest satellite in the Phase 3 series of high altitude radio amateur satellites.

The satellite telemetry system may be monitored.

Parameter	Value
Frequency range	VHF/UHF
Operation modes	FEC telemetry
Modulation	BPSK
Symbol rate	800 Bd (with Manchester coding)
Receiver settings	FM, BW = 5 kHz
Input format(s)	AF, IF
Additional Info	ITA-5

A complete telemetry frame consists of a 4 byte preamble, a 512 byte data set and a 2 byte CRC check-sum. The 400 bps information is differentially encoded then EXORed with a 400 bps clock signal to create a Manchester coded PSK signal.

The P3 flight computer of AMSAT OSCAR-40 uses a radiation hardened Cosmac CDP-1802 microprocessor running at 100K instructions/sec. The operating system is called IPS, an acronym that translates as "Interpreter for Process Structures".

A small part of the computer's 64 kBit memory is used by IPS as workspace. 256 bytes of data collected via a 128 channel ADC, and 128 bytes of digital data is stored in this area called the IPS "SysPage".

The "SysPage" covers a lot of measurement functions: Status, navigation, power and temperature.

The decoder is able to demodulate, decode, verify (CRC) and display the data content in binary or as text. The so called "A" or "E" packets are processed further and the information is displayed in four sections: Main status, temperatures, power and sensors.

From **Options | Display Mode**, All frames or Error free frames may be selected.

Selecting **Options | Display** offers the option of an **ASCII** or **RAW** bits display.

APCO-25

Project 25 (P25) or APCO-25 is a set of standards for digital radio communications for public safety, security, public service and commercial applications. It is standardized by Telecommunications Industry Association (TIA) and supports both voice and data transmissions. APCO-25 compliant technology is being deployed in several phases. Wavecom decoder currently supports only Phase 1 systems.

Parameter	Value
Frequency range	VHF, UHF
Operation modes	Digital voice and data (Phase 1)
Symbol rate	4800 Bd
Modulation	Continuous 4 Level FM (C4FM) - CQPSK
Receiver settings	BW = 12.5 kHz
Input format(s)	IF
Access method	FDMA

Parameter	Value
Voice codec	IMBE (Rate 7.2 kbps)

The common air interface of the APCO-25 Phase 1 system is described in TIA-102.BAAA-A. The devices may use both the C4FM and CQPSK modulation techniques which can be demodulated with a single demodulator. The system uses frequency channels of 12.5 kHz bandwidth to transmit 9600 bits per second. Analog audio is digitized by using the full rate IMBE vocoder (7.2 kbps) before transmission (TIA-102.BABA).

The system allows group and individual calls, where each device has its own ID as well as one or more talk-group IDs. Each call is marked as a group or individual call with its source and destination addresses. The decoded voice calls can be monitored live using the default sound card of the system and they are also automatically saved under the default Data-Output directory as .wav files. Live sound streaming can be disabled using the mute button on the upper pane.

The contents of the decoded data packets are printed out as raw data and are not further analyzed.

The Offset should be set to the center frequency of the channel to be decoded. The Polarity of the signal is detected automatically.

ARQ6-90 and ARQ6-98

ARQ6-90 and ARQ6-98 systems transmit 6 characters of 7 bits each in every data block resulting in a total of 42 bits. The SITOR alphabet with a mark-space ratio of 3:4 is used.

Parameter	Value
Frequency range	HF
Operating modes	Simplex ARQ
Modulation	FSK
Symbol rate	200 Bd, variable 30-650 Bd
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF

Both systems operate on the ARQ principle. Using the ARQ method, a data block of 42 bits is transmitted. The SITOR alphabet is used to protect the transmitted data. After each transmission the direction of transmission is reversed and the remote station acknowledges error-free data or requests a repetition of data received in error.

The two systems only differ in the duration of the request cycle interval.

A complete cycle for ARQ6-90 has duration of 450 ms of which the data block is 210 ms an interval is 230 ms.

A complete cycle for ARQ6-98 has duration of 490 ms of which the data block is 210 ms an interval is 280 ms.

ARQ-E

The ARQ-E duplex systems operate at Symbol rates of 46.2, 48, 50, 64, 72, 86, 96, 144, 184.6, 192, and 288 Baud on the radio link.

Parameter	Value
Frequency range	HF
Operation modes	Duplex ARQ
Modulation	FSK
Symbol rate	46.2, 48, 50, 64, 72, 86, 96, 144, 184.6, 192, and 288 Bd, variable 30-

Parameter	Value
	650 Bd
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF
Additional Info	ITA-2 with parity and identification bit

ARQ-E synchronization may be started by the selection of a baud rate. An AUTO program start causes the automatic determination of the frequency shift and baud rate to be executed first. The signal polarity (USB or LSB sidebands) is automatically detected.

After synchronization to an ARQ-E system has been achieved, the detected repetition rate is displayed (4, 5 or 8 cycles). This parameter may give clues to the identity of the transmission.

If a continuously repeated character (often FFFF) is decoded whilst working in the ARQ-E mode, it is most likely an ARQ-E3 system being monitored. ARQ-E employs the ARQ-1A alphabet with parity checking which allows the detection of transmission errors.

Full-duplex systems transmit a RQ character after having detected an erroneous character or in the presence of excessive signal distortions. The remote station subsequently repeats the last three, four or seven characters preceded by the RQ character.

To maintain synchronization between the two stations both transmitters operate continuously and send the idle bit pattern if no traffic is transmitted.

ARQ-E3

ARQ-E3 systems often operate at Symbol rates of 48, 50, 96, 192 and 288 Baud on the radio link.

Parameter	Value
Frequency range	HF
Operation modes	Full-duplex ARQ
Modulation	FSK
Symbol rate	48, 50, 96, 192 and 288 Bd, variable 30-650 Bd
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF
Additional Info	ITA-3

ARQ-E3 synchronization may be started with the selection of a baud rate. An AUTO program start causes the automatic determination of the frequency shift and baud rate to be executed first. The signal polarity (USB or LSB sidebands) is automatically detected.

After synchronization to an ARQ-E3 system has been achieved the detected repetition rate is displayed (4 or 8 cycles). This parameter may give clues to the identity of the transmission.

If the same continuously repeated character (often 0xFFFF) is decoded whilst working in the ARQ-E3 mode, it is most likely an ARQ-E system which is being monitored. ARQ-E3 employs the ITA-3 alphabet (balanced 3:4 mark-space ratio) for data transmission and error detection.

Full-Duplex systems transmit a RQ character after having detected an erroneous character or in the presence of excessive signal distortions. The remote station subsequently repeats the last three or seven characters preceded by the RQ character.

To maintain synchronization between the two stations both transmitters operate continuously and send the idle bit pattern if no traffic is transmitted.

ARQ-M2-342 and ARQ-M2-242

These operating modes also known as TDM or ARQ-28, conforming to CCIR recommendations 342-2 and 242. Two 50 Bd Baudot channels are interleaved to form a time multiplexed aggregate bit stream. Multiplex frames of 28 and 56 bits are used.

Parameter	Value
Frequency range	HF
Operation modes	Duplex ARQ TDM
Modulation	FSK
Symbol rate	96, 87 and 200 Bd, variable 30-650 Bd
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF
Additional Info	ITA-3

ARQ-M2-342 and ARQ-M2-242 systems operate at Symbol rates of 85.7, 96 or 200 Baud on the radio link.

The ITA-3 7-bit alphabet is used allowing error detection. The ITA-3 alphabet is a balanced code in which each character has a mark-space bit ratio of 3:4. ARQ-M2-342 and ARQ-M2-242 systems are full-duplex systems.

Full-duplex systems send a repeat request (RQ) character to the remote station if a character error has been detected or the distortion or fading becomes excessive. This results in the re-transmission of the last 3 or 7 characters preceded by the RQ request control character.

According to the CCITT recommendation, the repetition cycle may span 4 or 8 characters, as is the case with ARQ-E. The longer RQ-cycle of 8 characters has never been monitored.

In addition to the time multiplexing of several channels (division channels); each division channel may be further subdivided into sub-channels resulting in a multitude of possible modes of operation. At present however no transmissions with sub-channel division are known. Systems employing sub-channel division may be recognized by a rhythmic blinking of the Error indication (system state) in the decoder status bar.

ARQ-M4-342 and ARQ-M4-242

These operating modes also known as TDM or ARQ-56, conforming to the CCIR recommendations 342-2 and 242. Four 50 Bd Baudot channels are interleaved to form a time multiplexed aggregate bit stream. Multiplex frames of 56 bits are used.

Parameter	Value
Frequency range	HF
Operation modes	Duplex ARQ TDM
Modulation	FSK
Symbol rate	172 and 192 Bd, variable 30-650 Bd
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF
Additional Info	ITA-3

ARQ-M4-342 and ARQ-M4-242 systems operate at a Symbol rate of 172 or 192 Baud on the radio link.

The ITA-3 7-bit alphabet is used allowing error detection. The ITA-3 alphabet is a balanced code in which each character has a 3 to 4 ratio between mark and space bits (balanced code). ARQ-M4-342 and ARQ-M4-242 are full-duplex systems.

Full-duplex systems send a repeat request (RQ) character to the remote station if a character error has been detected or the distortion or fading becomes excessive. This results in the re-transmission of the last 3 or 7 characters preceded by the RQ request control character.

According to the CCITT recommendation, the repetition cycle may span 4 or 8 characters, as is the case with ARQ-E. The longer RQ-cycle of 8 characters has never been monitored.

In addition to the time multiplexing of several channels (division channels); each division channel may be further subdivided into sub-channels resulting in a multitude of possible modes of operation. At present however no transmissions with sub-channel division are known. Systems employing sub-channel division may be recognized by the rhythmic blinking of the Error indication (system state) in the decoder status bar.

ARQ-N

ARQ-N uses the ARQ-1A alphabet (as does ARQ-E). Character inversion (as in the case of ARQ-E or ARQ-E3) is not defined for ARQ-N. The lack of inversion makes it impossible to automatically determine the length of the RQ cycle. However, known systems operate exclusively with a single RQ character and three repeated characters.

Parameter	Value
Frequency range	HF
Operation modes	Duplex ARQ
Modulation	FSK
Symbol rate	48, 64, 72 86, 96 and 192 Bd, variable 30-650 Bd
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF
Additional Info	ITA-2 with parity and identification bit

Known ARQ-N systems operate exclusively at a symbol rate of 96 Bd on the radio link.

The synchronization phase for the ARQ-N mode of operation may be initiated via the AUTO function or by manual selection of the baud rate.

Signal polarity (USB or LSB sidebands) is automatically detected.

Full-duplex systems transmit the RQ character after having detected an erroneous character or in the presence of excessive signal distortions. The remote station subsequently repeats the last three characters preceded by the RQ character.

To maintain synchronization between the two stations both transmitters operate continuously and send the idle bit pattern if no traffic data is transmitted.

ASCII

The ASCII code, which is internationally adapted as the CCITT ITA-5 alphabet, is used in all kinds of data transfer of information between computers or computer based equipment. Only the 7-bit values 0 – 127 are internationally defined and standardized. For asynchronous transmissions, the code consists of a start bit, 7 or 8 data bits, one parity bit (optional) and 1 or 2 stop bits.

Parameter	Value
Frequency range	HF
Operation modes	Asynchronous
Modulation	FSK
Symbol rate	50, 75, 100, 110, 150, 180, 200, 300 and 600 Bd, variable 50-1200 Bd
Receiver settings	DATA, CW, LSB or USB

Parameter	Value
Input format(s)	AF, IF
Additional Info	ITA-5

For ASCII mode standard baud rates from 110 to 300 Baud are available. Non-standard baud rates may be selected using the **Baudrate** menu item.

The parity bit allows error detection. The number of "1"s is counted. If an odd number is found and parity has been defined as ODD, then the parity bit should be "1", otherwise an error has occurred. If parity has been defined as EVEN and an even number of "1"s is found, then the parity bit should also be "1".

The ASCII code does not distinguish between a "Letters" or "Figures" case as does Baudot because 7 or 8 data bit ASCII has 128 or 256 possible bit combinations. This covers most symbol requirements.

ASCII based transmissions are finding their way into radio data communications because of the compatibility with computer communications thus avoiding time and resource consuming code conversions.

From **Options/Frame length** and **Parity** the various code word lengths and parity options may be selected.

Mark parity means that the parity bit is always set to the mark signal condition, and likewise, space parity always sends the parity bit in the space signal condition. Since these two parity options serve no useful purpose whatsoever, they are almost never used.

ATIS

ATIS is an abbreviation of "Automatic Transmitter Identification System". ATIS is used in the VHF-UHF radio systems on the river Rhine and automatically generates the identification signal at the end of each period of speech transmission. In case of lengthy transmissions, the ATIS signal is required to be transmitted at least once every five minutes.

Parameter	Value
Frequency range	VHF/UHF
Operation modes	FEC
Modulation	FM, SUB FSK
Symbol rate	1200 Bd
Center frequency	1700 Hz
Shift	800 Hz
Receiver settings	FM, BW = 12 kHz
Input format(s)	AF, IF
Additional Info	7 Bit decimal code with redundancy

ATIS conforms in certain aspects to the CCITT Recommendation 493-3. The specifications are directed at all river Rhine nautical radio installations, fixed as well as mobile stations and has been in use there since 1994 and from 1995 also internationally.

The ATIS signal sequence is transmitted using the FSK with space and mark frequencies of 1300 Hz and 2100 Hz and a modulation rate of 1200 Baud. The higher frequency corresponds to the B-state of the signal and the lower to the Y-state.

The ATIS sequence consists of a country identifier and a four digit call-sign, e.g., PE 1234 for a Dutch vessel or HB 6235 for a Swiss vessel.

All sequences are transmitted twice (DX and RX positions). A 10-bit code is used in this synchronous system. Bits 8, 9 and 10 are a binary representation of the number of bits in the B-state. The error check character corresponds to a modulo-2 sum of the corresponding information bits.

ATIS Country Identification Code

Code	Country	Code	Country	Code	Country
Z	Albania	O	Austria	O	Belgium
L	Bulgaria	D	Germany	F	France
9	Croatia	H	Hungary	P	Netherlands
H	Liechtenstein	L	Luxemburg	S	Poland
Y	Romania	O	Slovak Rep.	H	Switzerland
O	Czech Rep.	T	Turkey	U	Ukraine
U	Russia Federation	Z	Macedonia	Y	Latvia
E	Estonia	L	Lithuania	S	Slovenia
Y	Yugoslavia				

AUM-13

AUM-13 is a sequential 13 tone mode, which is optimized for the transmission of numeric codes. AUM-13 is similar to SP-14.

Parameter	Value
Frequency range	HF
Operation modes	Broadcast, unprotected
Modulation	MFSK-13
Symbol rate	8 Bd
Shift/Bandwidth	480 Hz
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF

Each tone has been assigned a character:

- 10 tones are assigned to the numerals 0-9
- One tone is used as an idle character
- One tone is used as a space character
- One tone is used as a repetition indicator

A transmission is initiated with a start sequence, which identifies this mode and may be used for accurate tuning. This sequence is transmitted at 1 Baud, which makes it readable even during very unfavorable conditions.

The data proper is transmitted at a rate of 8 Baud. As the transmission rate is very low this mode is insensitive to fading and multipath propagation.

A MFSK IAS will retrieve symbol clock. In order to process both baud rates used by AUM-13, the IAS has to be configured to a baud rate of 16 Baud. Thus at a rate of 1 baud 16 symbols per transmitted symbol, and at 8 Baud two symbols per transmitted symbol, must be received with a certain tolerance. Even if for instance the same character is received 16 times in succession, error correction is impossible due to the fact that in case of repetition of numerals the numeral itself is followed by the repetition indicator.

AUTOSPEC

The standard baud rate for AUTOSPEC is 68.5 Bd.

The parity dependent repeat transmission of the 5 data bits is easily recognized by ear for certain character combinations. The IDLE signal also has a distinctive sound.

Parameter	Value
Frequency range	HF
Operation modes	FEC
Modulation	FSK
Symbol rate	62.3, 68.5, 102.63 and 137 Bd, variable 30-650 Bd
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF
Additional Info	10-Bit Bauer Code

The Bauer code is used for error detection and correction purposes. Each code word consists of 10 bits. The five leading bits are a character of the ITA-2 alphabet and the trailing 5 bits are a direct repetition of the first five bits. If even parity is present, the last five bits are inverted before transmission.

The Bauer code can correct single bit errors and corrected characters are displayed in red on the screen display. Characters which have been found to contain more than a single bit error are represented by the underline symbol. Error correction may be enabled or disabled by selecting **ECC** (Error Correction Control).

BAUDOT

The Baudot code has been the most common telegraph code used as a result of the widespread use of teleprinter, its place now being gradually taken over by ASCII.

Baudot is internationally approved as CCITT alphabet ITA-2, but several national modifications to ITA-2 exist as do completely different character assignments, e.g., Arabic alphabets Bagdad-70 and ATU-80, Russian M2, and alphabets using a third shift to accommodate the shift between Latin and another character set.

Baudot is the basis for many codes in use on radio circuits due to the need for easy compatibility with teleprinter networks and equipment.

Parameter	Value
Frequency range	HF
Operation modes	Asynchronous
Modulation	FSK
Symbol rate	45.45, 50, 70, 75, 100, 150 and 180 Bd, variable 30-650 Bd
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF
Additional Info	ITA-2

For the BAUDOT the **Auto** option starts the process of automatically setting up the demodulator and determining the baud rate and signal polarity.

The **Baudrate** item in the **Demodulator** menu allows a manual start of signal decoding with polarity determination remaining automatic. The user may also enter a baud rate of his choice. Setting the demodulator up for correct shift and center frequency must also be done manually via the **Demodulator** menu.

In the case of a manual start, the polarity is also determined and the signal is tested for a valid asynchronous data format. If valid parameters are detected, the output of text is started. Even in the case of a break in the received signal, the software does not attempt automatic synchronization. This prevents the premature termination of data capturing in the presence of transient interference to the signal.

The **Auto** mode will automatically cause a return to synchronization if lengthy periods of signal loss are experienced or a pre-defined error rate exceeded.

A Baudot code word consists of a start bit, 5 data bits and 1, 1.5 or 2 stop bits giving each character a length of 7, 7.5 or 8 bits. Baudot is an asynchronous code in which synchronization is performed for each character by the start and stop bits.

Baudot transmissions may be rendered unreadable by inverting one or several data bits. Using the **Bit Inversion** item in the **Options** menu any of the 32-bit inversion patterns may be pre-selected.

Isochronous or synchronous Baudot uses 7 bits and is especially used for on-line crypto systems.

BIIS

Binary Interchange of Information and Signaling is an ETSI-standard (ETS 300 230) used for transmission of signaling information for selective calls, status messages, short text messages and data.

Parameter	Value
Frequency range	VHF/UHF
Operation modes	CRC and parity
Modulation	FM, SUB FFSK
Symbol rate	1200 Baud
Center frequency	1500 Hz
Shift	600 Hz
Receiver settings	FM, BW = 15 kHz
Input format(s)	AF, IF
Additional Info	Signaling data, Short Data transfer, HDLC possible, ETSI-standard (ETS 300 230)

The system operates at 1200 Bit/s using indirect FSK modulation in the VHF or UHF band. To accommodate the different types of data, a number of code words have been defined. Every transmission consists of at least one address word. Additional data such as telephone numbers or short text messages may be appended to the address word as one or more data blocks.

For the transmission of longer data packets the High-Level Data Link Control (HDLC) protocol may be implemented in the BIIS devices.

Status messages are transmitted within the address word. The address word contains the Operational Mode Characteristic (OMC), a regional code indicating the country of the device, a common address part, the transmitter address and the receiver address. The address data is displayed in hexadecimal format. OMC code and regional code are displayed as short strings. There are 64 OMC codes consisting of a category part (CAT) and a function part (FNC). Some codes are custom, status or reserved codes. The following table shows all valid codes in string and binary representation.

OMC Strings

C	A	T	F	N	C	String
0	0	0	0	0	0	EmRes
1	0	0	0	0	0	Status1
0	1	0	0	0	0	EmAck
1	1	0	0	0	0	Reser1
0	0	1	0	0	0	EmCall
1	0	1	0	0	0	Status9
0	1	1	0	0	0	SysCon
1	1	1	0	0	0	Cust1
0	0	0	1	0	0	TXKeyON
1	0	0	1	0	0	Status5
0	1	0	1	0	0	BusyAck
1	1	0	1	0	0	Reser5
0	0	1	1	0	0	BroCal
1	0	1	1	0	0	Status13
0	1	1	1	0	0	VotNow
1	1	1	1	0	0	Cust5
0	0	0	0	1	0	CleaDow
1	0	0	0	1	0	Status3
0	1	0	0	1	0	GenAck
1	1	0	0	1	0	Reser3
0	0	1	0	1	0	NorCall
1	0	1	0	1	0	Status11
0	1	1	0	1	0	DiaDat
1	1	1	0	1	0	Cust3
0	0	0	1	1	0	RepON
1	0	0	1	1	0	Status7
0	1	0	1	1	0	IntermAck
1	1	0	1	1	0	Reser7

C	A	T	F	N	C	String
0	0	1	1	1	0	ManRes
1	0	1	1	1	0	Status15
0	1	1	1	1	0	MobEn
1	1	1	1	1	0	Cust7
0	0	0	0	0	1	Cancel
1	0	0	0	0	1	Status2
0	1	0	0	0	1	RepAck
1	1	0	0	0	1	Reser2
0	0	1	0	0	1	PriCal
1	0	1	0	0	1	Status10
0	1	1	0	0	1	ShorDat
1	1	1	0	0	1	Cust2
0	0	0	1	0	1	TXKeyOFF
1	0	0	1	0	1	Status6
0	1	0	1	0	1	CalBaAck
1	1	0	1	0	1	Reser6
0	0	1	1	0	1	ReqCalBa
1	0	1	1	0	1	Status14
0	1	1	1	0	1	SatusReq
1	1	1	1	0	1	Cust6
0	0	0	0	1	1	MaintID
1	0	0	0	1	1	Status4
0	1	0	0	1	1	AbsentUna
1	1	0	0	1	1	Reser4
0	0	1	0	1	1	TelCall
1	0	1	0	1	1	Status12
0	1	1	0	1	1	ChanCha
1	1	1	0	1	1	Cust4

C	A	T	F	N	C	String
0	0	0	1	1	1	RepOFF
1	0	0	1	1	1	Status8
0	1	0	1	1	1	RejAck
1	1	0	1	1	1	Reser8
0	0	1	1	1	1	ExtAdr
1	0	1	1	1	1	Status16
0	1	1	1	1	1	MobDis
1	1	1	1	1	1	Cust8

Depending on the OMC code, the address word can be followed by one or more data words. Four such cases exist:

Telephone Call

One or more data words containing a telephone number are appended to the address word. The telephone number is displayed in the decoder output.

External Addressing

A datagram for external addressing consists of two address words. The first address word carries the transmitter address including the transmitter regional code and the second address word carries the receiver address including the receiver regional code.

Short Data Transfer

A short data transfer is very similar to the transmission of a telephone number. The address word is followed by some data words. The display format of the decoded information can be switched between binary, hexadecimal, and text data. Text data is displayed in ASCII format.

Dialog Data Transfer

In case of dialog data transfer the BIIS address word is followed by a HDLC control block. This control block is analyzed by the decoder module and the contents are displayed as plain text.

The control block consists of an address, a command-response bit, a control field indicating the frame type and a 32-bit parameter field in hexadecimal format.

I-frames and S-frames contain a receive sequence number N(R) or send sequence number N(S). The usual HDLC commands and responses are displayed in abbreviated form.

Data words following the HDLC control block can be displayed in binary or hexadecimal format.

In the case of system control data (OMC = 011000), a 6-bit custom code is transmitted instead of transmit and receive addresses.

Further information about the OMC coding, regional codes and the HDLC protocol may be found in the ETSI-standard ETS 300 230.

For validation of the code words, CRC and parity checks are used. If the CRC or the parity is incorrect the decoder output is displayed in red.

BR-6028

BR-6028 is a VFT (Voice Frequency Telegraph) frequency and time diversity modem using 7 data channels. It is sometimes also known as "BARRIE" or "USA-7" channel modem.

Parameter	Value
Frequency range	HF
Operation modes	Baudot, ASCII
Modulation	VFT FSK
Symbol rate	45.45, 50, 75, 100, 103.7 Bd, variable 30-110 Bd
Pilot Tone	560 Hz
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF

Theoretically the system may handle channel dropouts of up to 3 seconds before errors occur. An un-modulated pilot tone is transmitted at 560 Hz.

Tune to the "**Pilot Tone**".

	Center (Hz)	Space (Hz)	Mark (Hz)
Pilot Tone	560		
CH1	850	765	935
CH2	1190	1105	1275
CH3	1530	1445	1615
CH4	1870	1785	1955
CH5	2210	2125	2295
CH6	2550	2465	2635
CH7	2890	2805	2975

- Channel spacing: 340 Hz
- Shift: 170 Hz
- Channels are delayed by a multiple of 1.024 seconds
- Symbol rate: 45-100 Baud
- Modes: Baudot, ASCII, and some FEC modes

Use the alphabet option to select the correct protocol and alphabet.

BULG-ASCII

For BULG-ASCII the standard baud rates 110 to 600 Bd may be directly selected. Other baud rates up to 1200 Baud may be selected using the variable baud rate option.

Parameter	Value
Frequency range	HF
Operation modes	Asynchronous duplex ARQ
Modulation	FSK
Symbol rate	110, 120, 150, 180, 200, 300 and 600 Bd, variable 50–1200 Bd
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF

BULG-ASCII is a full-duplex mode using go-back-7-frames ARQ and a variable data frame length. Frames are transmitted with a preceding frame counter for transmitted and received frames and an appended CRC check sum.

ASCII modes using iso-asynchronous start-stop bit patterns are frequently encountered in the HF bands. BULG-ASCII employs the standard ITA-5 alphabet, a national alphabet and transfers compressed and encrypted messages and files.

CCIR

The entire call number is transmitted by consecutive tones in decade sequence. When two identical digits are to be transmitted consecutively, then an eleventh frequency is used as a repetition identifier. If more than two identical digits are to be transmitted, the repetition tone is appended to the digit tone (e.g., 22222 is transmitted as f2 fw f2 fw f2, where f2 is the tone for "2" and fw is the repetition tone).

Parameter	Value
Frequency range	VHF/UHF
Operation modes	Analogue Selcal
Modulation	FM, SUB Tones
Receiver settings	FM, BW = 12 kHz
Input format(s)	AF, IF

In most systems the accuracy of the single frequencies has to be within +1/-1.5% of the nominal value.

Decoding the selective calls is started by clicking on a system. If transmission and system selection conform, the call sign is displayed on the monitor. In the **Options** menu a **Time stamp** function can be enabled to add date and time to each call.

Tone Allocation

Digit	Hz	Digit	Hz
0	1981	8	1747
1	1124	9	1860
2	1197	A	2400
3	1275	B	930
4	1358	C	2247
5	1446	D	991
6	1540	E	2110
7	1640	9	1860

Tone Duration

Protocol	Time
CCIR-1	100 ms
CCIR-2	70 ms
CCIR-7	70 ms

CCITT

The entire call number is transmitted by consecutive tones in decade sequence. When two identical digits are to be transmitted consecutively, then an eleventh frequency is used as a repetition identifier. If more than two identical digits are to be transmitted, the repetition tone is appended to the digit tone (e.g., 22222 is transmitted as f2 fw f2 fw f2, where f2 is the tone for "2" and fw is the repetition tone).

Parameter	Value
Frequency range	VHF/UHF
Operation modes	Analogue Selcal
Modulation	FM, SUB Tones
Receiver settings	FM 12 kHz, narrow
Signal source	AF, IF

In most systems the accuracy of the single frequencies has to be within +1/-1.5% of the nominal value.

Decoding the selective calls is started by clicking on a system. If transmission and system selection conform, the call sign is displayed on the monitor. In the **Options** menu a **Time stamp** function can be enabled to add date and time to each call.

Tone Allocation

DIGIT	Hz		
0	400	7	1477
1	697	8	1633
2	770	9	1800
3	852	A	1900
4	941	B	2000
5	1209	C	2100
6	1335	D	2200
7	1477	E	2300

Tone duration: 100ms.

CHINESE 4+4

Chinese 4+4 is a multi-carrier transmission mode. It consists of 8 carriers. They are 300 Hz apart, execpt the 4th and 5th carriers, which are 450 Hz apart from each other.

Parameter	Value
Frequency Range	HF
Operation modes	Multi-carrier PSK
Modulation	DQPSK
Symbol rate	75 Bd
Shift	300 Hz between each carrier, 450 Hz between the two carriers in the middle
Receiver settings	LSB or USB
Input format(s)	AF, IF

Every carrier is DQPSK modulated with a symbol rate of 75 baud.

Wavecom Chinese 4+4 decoder uses Hadamard soft-decision decoding. During decoding the paramater Confidence shows the error correction quality. A values above 95% means almost all errors are corrected. However, this is just a qualitative measure.

The decoder can correct a center frequency error of up to +/- 30 Hz automatically. The user needs to place the frequency cursor in this range. The user has to specify the polarity of the signal, i.e., **NOR**(mal) or **INV**(erse).

CHU

CHU is a radio station operated by the National Research Council of Canada.

It continuously broadcasts time information on 3330 kHz, 7850 kHz and 14670 kHz.

The information provided is the Gregorian year, Julian date, UTC hour, minute and second. Further information is a leap second warning, DUT1, the difference between the International Atomic Time TAI and UTC and the code for the Canadian daylight time indication.

Parameter	Value
Frequency Range	HF
Operation modes	Time information
Modulation	FSK
Symbol rate	300 Bd
Center frequency	2125 Hz
Shift	200 Hz
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF
Additional info	Reference tone on 1000 Hz

The coded message is transmitted using Frequency Shift Keying, the baud rate is 300 baud, the mark-frequency is 2225 Hz, and the space-frequency 2025 Hz.

The display shows the information of each packet on a single line.

The first packet, sent at the 31st second of each minute, provides the year, the delta-information and the daylight saving pattern code.

The following packets, sent between seconds 32 and 39, provide day, hour, minute and actual second.

The user can specify the polarity of the received signal, i.e., **NOR**(mal) or **INV**(erse).

CIS-11

CIS-11 transmissions are mainly in the Russian M2 (3-SHIFT-CYR) adaptation of the ITA-2 alphabet. It is a full-duplex system with two transmission frequencies.

Parameter	Value
Frequency range	HF
Operation modes	Full-duplex
Modulation	FSK
Symbol rate	100 Bd, variable 30-650 Baud
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF
Additional Info	ITA-2 with 4-bit parity

CIS-11 operates at a Symbol rate of 100 Bd on the radio link.

Synchronization for the CIS-11 mode is started with the selection of a baud rate. An **AUTO** start causes the automatic determination of the frequency shift and baud rate to be executed first. The signal polarity (USB or LSB sidebands) is automatically detected.

The CIS-11 data format is 11 bits wide. Data bits 1 - 5 contain the M2 character. The data bits are arranged in reverse order if compared to normal M2 systems. Bits 6 and 7 specify the system state as well as the alphabet.

Bits 8 - 11 handle error detection. The four test bits allow the position of a bit in error to be computed and then to be corrected. The value of the parity bits is obtained by calculating the modulo-2 sum of the binary weights of the respective information bits.

To maintain synchronization between the two duplex stations, both transmitters operate continuously and transmit idle characters if no traffic is transferred.

CIS-12

CIS-12 is a multi-channel system using 12 channels each modulated with 120 Bd DBPSK or DQPSK. Each channel has a separation of 200 Hz to neighbor channels. An unmodulated pilot carrier is placed at +3300 Hz from the suppressed carrier.

Parameter	Value
Frequency range	HF
Operation modes	12-Channel-PSK
Modulation	DBPSK or DQPSK
Symbol rate	120 Bd
Center frequency	1800
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF
Additional Info	HEX and ASCII output are provided

Output may be selected as **Hex** or **ASCII**.

CIS-14

CIS-14 is a full-duplex system using two frequencies.

As in the case for other time multiplex modes (TDM), e.g., ARQ-M2-242 and ARQ-M2-342, CIS-14 bit interleaves two channels into a frame of 14 bits.

Parameter	Value
Frequency range	HF
Operation modes	Duplex ARQ TDM
Modulation	FSK
Symbol rate	96.0 Bd
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF
Additional Info	Cyrillic third shift with parity

CIS-14 employs a radio channel Symbol rate of 96 Baud.

Synchronizing to a CIS-14 signal may be initiated by selecting a baud rate or **Auto**. Starting **Auto** will automatically determine shift, center frequency and baud rate.

The two first bits of the multiplex frame identify the channel state as IDLE or TRAFFIC. Then two bit interleaved M2 data code words follow. The last two bits are parity bits used for error detection. Parity is calculated depending on the position of '1' bits.

In **Code Check** the simple data format of CIS-14 with only two parity bits may unfortunately lead to unavoidable detection errors.

CIS-36

CIS-36 in error-correcting traffic mode is using a horizontal line- and vertical block-error-detection. Each block has ten data frames and a parity frame. Each data frame has five data characters and one parity character. In case an error is detected the receiving station starts ask for a frame repetition (NAK instead of ACK) from the last complete and correctly received frame.

Parameter	Value
Frequency range	HF
Operation modes	Duplex ARQ
Modulation	MFSK-36
Speed	25, 50 or 100 ms
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF

CIS-36 is operating with Symbol rates of 10, 20 or 40 Bd which is equivalent to tone duration of 100, 50 or 25 ms.

Transmissions in CIS-36 are mostly in Russian using an ITA-2 alphabet. CIS-36 is a full-duplex mode with two transmission frequencies, but can also be used in simplex mode.

CIS-36 is based on the older PICCOLO-MK1 system. However, the signal is not symmetric and uses three frequency groups with 10, 11 and 11 frequencies. The tone spacing is 40 Hz. The theoretical bandwidth is 1400Hz.

In on-line crypto traffic mode the control tones #1, #12, # 24 and #36 are rarely sent so between the three frequency groups a spacing of 80 Hz seems to appear.

The decoder shows the shift cursors at the tone position #2 and #35 (resulting in a 1320 Hz shift).

The 10 Bd variant is used for manually transmitted operator messages and is mostly unencrypted. The automatic switching of the tone length is initialized by control sequences.

When message traffic has to be sent, the system switches to 20 or 40 Bd. This part is either coded or online encrypted in almost every transmission. Special control sequences are used for transmission control, call set up and clearance.

CIS-36 also has SELCAL and link establishment features.

CIS-36-50

CIS-36-50, also known as BEE-36 or T600, is a synchronous system. Usually a 36 Bd idle sequence is transmitted, followed by 50 baud traffic.

Parameter	Value
Frequency range	VLF, HF
Operation modes	Simplex
Modulation	FSK
Symbol rate	36, 50, 75, 100, 150 Bd
Shift	85, 125, 250 and 500 Hz, variable 50-3500 Bd
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF

All traffic is encrypted.

A message begins with a bit synch sequence and a start-of-message preamble. Message data is sent with a 7-bit, 3:4 ratio alphabet, and ends with an end of transmission sequence containing at least 4 end-of-transmission characters.

The length of a message is variable. If a transmission contains more than one message, the start of message sequence is left out between messages.

Occasionally traffic with call signs in FSK CW is transmitted.

CIS-50-50

CIS-50-50 is very similar to CIS 36-50, but uses different baud rates and shifts.

Parameter	Value
Frequency range	VLF, HF
Operation modes	Simplex
Modulation	FSK
Symbol rate	50 and 100 Bd
Shift	85, 125, 250 and 500 Hz, variable 50-3500 Bd
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF

Idle dot reversals are transmitted at 50 Bd, followed by traffic in 50 baud (more rarely in 100 Baud).

All traffic is encrypted.

A message begins with a bit synch sequence and a start-of-message preamble. Message data is sent with a 7-bit, 3:4 ratio alphabet, and ends with an end of transmission sequence containing at least 4 end-of-transmission characters.

The length of a message is variable. If a transmission contains more than one message, the start of message sequence is left out between messages.

Occasionally traffic with call signs in FSK CW is transmitted.

CLOVER-2

CLOVER-2 is an adaptive modulation system with ARQ and FEC (broadcast) modus. It uses Reed-Solomon (RS) coding to achieve a remarkable performance even under poor HF propagation conditions.

Parameter	Value
Frequency range	HF
Operation modes	Half-duplex ARQ
Modulation	PSK2A, PSK4A, PSK8A, PSK16A, ASK2PSK8, ASK4PSK16, 2DPSK2A 4 tones
Symbol rate	4 x 31.25 Bd
AFC	±200 Hz, with max. single step ±10 Hz.
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF
Additional Info	ITA-5, Optional Mode

Data is modulated onto four tones spaced 125 Hz. The modulation rate of each tone is 31.25 Baud. The supported modulation techniques include binary phase-shift keying (PSK2A), quaternary PSK (PSK4A), 8-PSK (PSK8A), 16-PSK (PSK16A), binary amplitude-shift keying combined with 8-PSK (ASK2PSK8), quaternary ASK combined with 16-PSK (ASK4PSK16), and two-channel diversity binary PSK (2DPSK2A).

CLOVER-2 frame includes CCB (Clover Control Block) and data block with variable lengths and modulations. Each data block is displayed immediately after receiving. The decoder status indicates “TRAFFIC”. When a CCB is received, the decoder status switches to “IDLE”. The content in a CCB is displayed only when call sign or text is available. The call sign is displayed in the status line and the short text is displayed in the main window.

RS coding is utilized to correct transmission errors. Four coding levels (called RS Efficiency) are specified, which allow for more or less error correction within a block. The percentages in the following list of coding

levels, relate the number of information symbols (user data) to the block length, a block comprises user data and parity check symbols:

- ROBUST: 60%
- NORMAL: 75%
- FAST: 90%
- OFF: 100% (i.e., no error correction)

The level of RS Efficiency is automatically detected by the demodulator.

Important parameters of a data block or a CCB are displayed in the decoder status bar. The modulation is displayed in **Format**, the block length and RS code efficiency are displayed in **RS Code**. The display **Carrier** shows the center frequency of the current block after tracking.

Using **Options | CRC Table** a certain CRC mask can be defined, see "CRC Table" on page 49.

The **Options | Display Mode** provides the options to display **All Frames** or **Error free Frames**, which means frames with the correct CRC check.

CLOVER-2000

CLOVER-2000 is an adaptive modulation system with ARQ that uses Reed-Solomon (RS) coding to achieve a remarkable performance even under worst HF propagation conditions. Data are modulated onto eight tones spaced 250 Hz. The modulation rate of each tone is 62.5 Bd. The supported modulation techniques include binary phase-shift keying (PSK2A), quaternary PSK (PSK4A), 8-PSK (PSK8A), 16-PSK (PSK16A), binary amplitude-shift keying combined with 8-PSK (ASK2PSK8), quaternary ASK combined with 16-PSK (ASK4PSK16), and two-channel diversity binary PSK (2DPSK2A).

Parameter	Value
Frequency range	HF
Operation modes	Half-duplex ARQ
Modulation	PSK2A, PSK4A, PSK8A, PSK16A, ASK2PSK8, ASK4PSK16, 2DPSK2A 8 tones
Symbol rate	8 x 62.5 Bd
AFC	±400 Hz, with max. single step ±15 Hz
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF
Additional Info	ITA-5, Optional Mode

RS coding is utilized to correct transmission errors. Four coding levels (called RS Efficiency) are specified, which allow for more or less error correction within a block. The percentages in the following list of coding levels, relate the number of information symbols (user data) to the block length, a block comprises user data and parity check symbols:

- ROBUST: 60%
- NORMAL: 75%
- FAST: 90%
- OFF: 100% (i.e., no error correction)

The level of RS Efficiency is automatically detected by the demodulator.

After successful synchronization, it may take up to a minute before any text is output in the GUI.

Using **Options | CRC Table** a certain CRC mask can be defined, see "CRC Table" on page 49.

The **Options | Display Mode** provides the options to display **All Frames** or **Error free Frames**, which means frames with the correct CRC check.

CLOVER-2500

CLOVER-2500 is almost identical to CLOVER-2000. The only differencies are as follows:

- Baudrate: 78.125 Bd (CLOVER-2000: 62.5 Bd)
- Spacing: 312.5 Hz (CLOVER-2000: 250 Hz)
- Center: 1562.5 Hz (CLOVER-2000: 1500 Hz)

Otherwise the mode has the same features as CLOVER-2000.

CODAN-CHIRP

Parameter	Value
Frequency range	HF
Operation modes	Peer-to-peer / Broadcast
Modulation	Differential BPSK, 32 carriers
Center	1500 Hz
Symbol rate	80 Bd each carrier
AFC	ca. ±25 Hz automatic frequency error correction
Receiver settings	USB or LSB
Input format(s)	AF, IF

Prior to sending data between the CODAN modems, a proprietary ALE (Automatic Link Establishment) is used for link establishment consisting with an 80 Baud (symbols/sec) Chirp signal. CODAN-CHIRP uses DBPSK modulation across 32 channels with 80 Hz of spacing and a bandwidth of 2560 Hz.

CODAN-CHIRP is based on the US federal standard (FED-STD-1045). The data station originating a data call transmits a Chirp sequence with signalling information. This information causes a RING signal at the receiving node. If the receiving node accepts the call, an exchange of more signalling information follows. The signalling information contains the source and destination address, as well as the parameters of each modem, such as the serial number, the tuning and the transmission mode: secure, secure interactive and unsecure (compressed or uncompressed). In a peer-to-peer communication, the sender and the receiver exchange information about their parameters, whereas in a broadcast communication only the sender sends information about his parameters. Once all the signalling information has been sent, the link is established and the data transfer between the modems begins.

The transmission format of CODAN-CHIRP is as follows: First the Chirp signal starts with a 23 bit preamble sequence, which is followed by a 32 bit frame-indicator. The frame-indicator is followed by 96 bits of data. In some transmissions there are several pairs of frame-indicator and data. The last 48 bits among the 96 data bits are the inverse of the first 48 bits. Additionally, the data is interleaved and encoded using the Golay (24, 12) block code, which means that 12 data bits are encoded to produce 24 bit code words. So the first 48 data bits are divided into 24 bits of actual data and 24 Golay encoded bits, and the last 48 bits are the inverse of the first 48 bits.

The mode CODAN-CHIRP is implemented in **HF Modes → PSK & OFDM**. The decoder demodulates and decodes the Chirp signal using frequency correction. The CODAN-CHIRP decoder automatically corrects small frequency deviations from the exact center frequency of the signal. The polarity (NOR or INV) of the signal is automatically identified by the decoder. For CODAN-CHIRP, the decoder identifies the source and destination address, as well as information about the serial number, the tuning and the transmission mode (secure, secure interactive or unsecure, compressed or uncompressed). The decoded output is displayed in ASCII and HEX.

CODAN-SELCAL

The mode was developed by the Australian CODAN PTY. and is very similar to GMDSS/DSC.

Parameter	Value
Frequency range	HF
Operation modes	Digital Selcal
Modulation	FSK
Symbol rate	100.0 Bd
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF
Additional Info	ITU R M.493 alphabet

CODAN SELCAL operates with 100.0 Bd and can be started by selecting the mode.

A preamble of at least 100 dot reversals, which are 50 changes between "0" and "1" (low and high bit), precedes the data block. This lead-in has duration of 2.0 seconds. Digital MARK "1" is represented by a frequency of 1870 Hz and SPACE by 1700 Hz.

The dot pattern is followed by a word synchronization sequence called the "phasing preamble". The characters no. 125 and no. 108 are alternately transmitted for 1.2 seconds.

This sequence is followed by the data block with different control characters and the message. Each data byte consists of 7 data bits and 3 parity bits. Thus the duration of each character is 100 ms.

Selecting **Options | Display** offers the option of an **ASCII** or **RAW** bits display.

CODAN-3212

Parameter	Value
Frequency range	HF
Operation modes	Peer-to-peer / Broadcast
Modulation	8-PSK, 16-QAM, 32-QAM and 64-QAM
Center	1500 Hz
Symbol rate	1800 Bd
AFC	ca. ±20 Hz automatic frequency error correction
Receiver settings	USB or LSB
Input format(s)	AF, IF

CODAN-3212 is an HF transmission mode defined and developed by the same named Australian company.

CODAN-3212 HF Data Station: The CODAN-3212 HF data modem provides a robust method of data communication over an HF path. A standard CODAN-3212 HF data station comprises a CODAN-3212 HF transceiver, which is capable of high-speed data transfer, an antenna system, a 12 V DC power supply, a CODAN-3212 HF data modem and a PC with terminal software. The connection between the PC and the CODAN-3212 modem can be established via an Ethernet connection or by connecting a cable between a serial COM port on the PC and the DATA connector on the modem. The data is passed from the terminal software of a PC to the CODAN-3212 HF data modem. It is processed by the modem and then sent to the CODAN-3212 HF transceiver for transfer via HF to the other CODAN-3212 transceivers. At the receiving node, the data is passed from the transceiver to the modem, where it is decoded and displayed at the terminal software of the remote PC. All modems need to be set such that they use the same high-speed

waveform. There are two possibilities to send data between CODAN-3212 modems. Either by a broadcast connection or by a peer-to-peer connection. The difference between these two connections is that in a peer-to-peer connection only two modems can be addressed, whereas in a broadcast connection all modems within a certain address range can be addressed. In a peer-to-peer connection the receiving node needs an explicit confirmation from the sending node that the data has arrived, whereas in a broadcast connection the receiving node does not need an explicit confirmation. The transceivers of the addressed CODAN-3212 modems need to be set to the same channel, in order to process the data from the sending modem. Additionally, in a peer-to-peer connection the data can be sent with a compression, which is not possible in a broadcast connection. A lossless compression format is used for compressing Codan-3212 data stream with arbitrarily length.

CODAN-3212 Waveform: The modem uses a high-speed waveform to address other CODAN-3212 modems. The CODAN-3212 waveform is based on the STANAG-4539 waveform, which has been modified for commercial use. This waveform transports data in conjunction with a STANAG-5066 protocol. The waveform is centered at 1500 Hz with a baudrate of 1800 symbols per second. The supported waveforms of the modem are:

User data rate	Waveform
80 baud CHIRP	Proprietary link establishment
2400 bps	CODAN-9001/9002/3012
16 Channel QPSK	CODAN-3012
75 bps	CODAN-3212: Modified STANAG-4539 serial tone waveform (in conjunction with STANAG-5066 Protocol)
150 bps	
300 bps	
600 bps	
1200 bps	
2400 bps	
3600 bps	
4800 bps	
6000 bps	
7200 bps	

The characteristics of the CODAN-3212 waveform are shown below:

User data rate	FEC coding rate	Interleaver	Modulation
75 bps	1/2	Short or Long	8-PSK (Walsh)
150 bps	1/8	Short or Long	8-PSK
300 bps	1/4	Short or Long	8-PSK
600 bps	1/2	Short or Long	8-PSK
1200 bps	1/2	Short, Medium or Long	8-PSK
2400 bps	3/4	Short, Medium or Long	8-PSK
3600 bps	3/4	Short, Medium or Long	8-PSK
4800 bps	3/4	Short, Medium or Long	16-QAM
6000 bps	3/4	Short, Medium or Long	32-QAM
7200 bps	3/4	Short, Medium or Long	64-QAM

CODAN-32122 Decoder: Each transmission of a CODAN-3212 message begins with a synchronization phase (preamble). In the preamble, the data rate and the interleaver setting are encoded.
For user data rates up to and including 1200 bps, the preamble includes 480 8-phase symbols. The preamble lasts for 0.8 seconds in case of messages with a SHORT interleaver and 6.4 seconds for messages with a LONG interleaver setting. The preamble is followed by the data phase, which is of unlimited length. The data phase consists of an undefined number of interleaver blocks. Each interleaver block is divided into user data and channel probe. The user data is of unknown phase, whereas the channel probe has a predefined phase pattern. The probe pattern, which corresponds to the known 8-phase symbols, is regularly inserted to make sure the decoder will synchronize at any time of the transmission, without having to repeat the preamble at regular intervals.

Preamble (0.8 or 6.4 s)	Interleaver 1	Interleaver 2	Interleaver 3	...	Interleaver N

For user data rates above 1200 bps, the preamble includes 287 8-PSK symbols. The preamble is followed by the data block of unlimited length. The data block consists of 256 symbols paired with a 31 mini-probe

pattern. After 72 user data - mini-probe pairs, a 103-symbol mini-preamble is inserted. The mini-probe pattern and the mini-preamble are regularly inserted to make sure the decoder does not loose synchronization. The FEC and interleaver are used to reduce the effects of fading, frequency drift, multi-path effects and burst noise in the HF transmission. At the end of the transmission, a certain bit pattern is transmitted (in HEX: 0x4B 0x65 0xA5 0xB2) to mark the end of the message.

Tuning the decoder: The decoder processes the signal in both SSB settings: USB and LSB. This can be selected with **Polarity** in the menu, where NOR means USB and INV means LSB. The correct polarity for the CODAN-3212 decoder is NOR. The **Center** frequency of the decoder should be set to 1500 Hz when decoding a CODAN-3212 signal. Small frequency deviations are automatically compensated in the decoder. By using the bar-graph, any remaining frequency difference can be compensated by fine tuning of the receiver frequency or by adjusting the center frequency of the decoder.

Decoder Output Display: The decoded CODAN-3212 data stream can be displayed in **HEX**, **BINARY**, **ASCII ASYNC**, **ASCII SYNC**, or in conjunction with the **STANAG-5066** protocol, selected from **Options, Message type**. The decoder stops displaying data when the EOM message is received. In **HEX** and in **BINARY** the decoded binary data is simply displayed as it is. In **ASCII ASYNC** the data is displayed with the following structure: 1 start bit (= 0), 7 data bits and 1 stop bit (= 1). The display is stopped when more than 3 NULL characters are received or when the asynchronous data structure is violated more than 8 times. In **ASCII SYNC** the data is displayed with 8 data bits and no start and stop bits. In the **STANAG-5066** protocol the number of data bits should be set to 8-bits, the synchronization mode should be SYNC, the order of synchronization should be LSB and the polarity should be NORMAL. The STANAG-5066 protocol interpreter processes the data until the SYNC sequence (0x09 0xD7) has been found. This sequence can appear more than once in a row. This sequence is followed by the protocol header, which is followed by the actual data. A 32-bit data CRC indicates if the data is corrupted or not. If the CRC is wrong and the data has been transmitted with a compression, the resulting output of the decoder is not reliable anymore until the next transmission. Without compression the resulting output is still readable, except for the bytes which are corrupt.

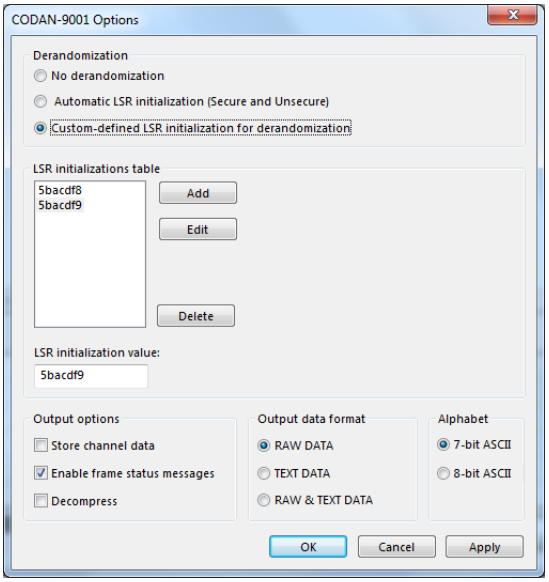
CODAN-9001

CODAN-9001 is an asynchronous adaptive ARQ system. Data is modulated onto 16 tones, spaced at 112.5Hz intervals. The modulation rate of each tone is 75 Baud; the modulation type is differential quaternary phase-shift keying (differential PSK4A).

Parameter	Value
Frequency range	HF
Operation modes	Half-duplex asynchronous adaptive ARQ
Modulation	Differential PSK4A; 16 tones
Symbol rate	16 x 75 Bd
AFC	In the range ±3100. automatic frequency control (AFC): +/-35 Hz
Bandwidth	1800 Hz
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF

Parameter	Value
Supported functions	Output of demodulated multichannel symbols Derandomization of secure-mode Derandomization of unsecure-mode Arbitrary start values for derandomization of secure-modes Output of recognized start value in secure-mode Output of status information Output of recognized frame type Decoding of chat-messages into text Decoding of text-file transmissions into readable output Decoding of data- transmissions into hexadecimal output Decompress data Store Channel Data for analysis purposes Automatic recognition of secure and unsecure modes 7-bit-ASCII Alphabet used by CODAN-9102-Software Secure Interactive Packets
Please enquire	Chirp decoding

The picture below shows the **CODAN-9001 Options** dialog. The settings from the dialog are stored into the Codan9001Options.xml file.



The CODAN-9001 data transmission system uses a variable randomization in secure- and secure-interactive mode. The randomization vector can change between successive transmissions. The randomization value is shown in the status pane. In the two status-lines at the top of the decoding window the frame type (DATA, ACK, IDLE) and some information about the decompressor (if used) are presented.

Possible derandomization options:

- **No derandomization** - no manipulation of the demodulated symbols; in this case it is not possible to recognize frame characteristics and decode into TEXT DATA. Because the decoder does not recognize the frame length, with every synchronization the maximum frame length is used for decoding.
- **Automatic LSR initialization (Secure and Unsecure)** - handles both the secure and unsecure transmission cases; an unsecure transmission is automatically recognized. In the secure case the decoder calculates the start value.

- **Custom-defined LSR initialization for derandomization** - expects a seven-digit hexadecimal value for initialization (note that it is important to enter leading zeros). This option should be used if the initialization value is known, or if it is not possible to calculate the value automatically due to poor signal conditions.

The CODAN-9001 decoder has the following output options:

- **Store channel data**. The channel data output is very useful for analysis purposes. In the channel data output every channel packet is stored in a file.

  (C:\Users\Public\Documents\WAVECOM\W61PC\Data-Output\CODAN9001[SN])

- **Enable frame status messages**. It is possible to activate frame status messages, with the relevant checkbox. The frame status messages are printed in the decoder output. They show [PREAMBLE FOUND] and [EXTENDED PREAMBLE FOUND].

- **Decompress**. The user can control the decompressor and the channel data output. Please refer the section Compressed Mode specifics for further information on Compressed Mode. The user can set the decoder/decompressor into the initial state with the **Mode-Resync** button in the **WAVECOM Toolbar**.

- **RAW DATA** - the output consists of synchronized and demodulated multichannel symbols in hexadecimal representation. Every symbol consists of 32 bits (16 channels * 2 bits/channel).

- **TEXT DATA** - the demodulator output is processed into readable text.

- **TEXT & RAW DATA** - if possible the decoder decodes into readable text, otherwise it outputs the demodulated multichannel symbols as RAW DATA.

- **7 or 8-bit-ASCII**. CODAN-9001 can use a 7-bit or an 8-bit alphabet, the choice being made by selecting the appropriate radio button. The 7-bit alphabet is often used in transmissions handled by the CODAN-9102 software.

The data is presented in two ways: hexadecimal-form, and ASCII-form.

At the beginning of every line the user can find the following information about the channel data packet:

- CRC OK or CRC NOK (not O.K.)
- SEQ [Nr] (Sequence number, a counter from zero up to the length of the packet)
- ARQ [Nr] (ARQ number used from the modems to request packets not received correctly)

At the end of a packet some statistical data is stored.

In secure mode the channel data packet output is adapted, as the secure interactive packets have a slightly different structure.

The extended preamble gives an indication as to whether the transmission is a group or broadcast call. The frame type, shown in the decoder status bar, indicates if the current package is ACK, IDLE or DATA. If a data package with a known length is recognized, the decoder shows its length.

DECODING OF CODAN DATA MODEM SIGNALS

Introduction

This section intends to offer an overview of the issues related to the practical decoding of the CODAN data modem protocol using WAVECOM decoders. It is important for the user to be aware of any constraints and limitations inherent in the decoding process during non-cooperative interception of this mode, and so possible issues are explained below.

Protocol overview

The CODAN-9001 modem uses 16 DQPSK carriers for the transport of payload data. Each carrier is independently modulated with data.

Each individual channel carries a channel packet. All 16 concurrent channel packets constitute a frame and a number of frames constitute a multi-frame.

CODAN-9001 modem frame structure

CH	Frame 1	Frame 2	Frame 2	...	Frame n
1	Chnl packet 01	Chnl packet 17	Chnl packet 33	....	...

CH	Frame 1	Frame 2	Frame 2	...	Frame n
2	Chnl packet 02	Chnl packet 18	Chnl packet 34	...	...
3	Chnl packet 03	Chnl packet 19	Chnl packet 35	...	...
...	...	...	...	...	...
16	Chnl packet 16	Chnl packet 32	Chnl packet 48	...	Chnl packet m
Multi-frame 1					

Each payload data packet has a constant length and a sequence number. However, the numbering in the figure above only serves as an example, and due to the use of ARQ-based retransmissions the numbering may not be sequential.

For the purpose of this explanation payload data is considered to be unprocessed user data and channel encoded user data.

Independent of the payload data field, the sequence number field has its own error detecting and correcting code. Payload data in each channel packet is protected by a cyclic redundancy code (CRC). This feature is included in order to allow the ARQ protocol to request retransmission of packets received in error.

A session consists of one or more multi-frames. Depending on the amount of data queued for transfer the length of a multi-frame may vary. The receiving modem will extract the frames from the multi-frame determining the number of channel packets and checking whether payload data was received without errors. If a channel packet was received in error a re-transmission is requested. It should be clear from this that a multi-frame may consist of a mixture of new data and re-transmitted data. Re-transmitted data may appear on any channel and in any position within a multi-frame. Additionally the transmitting modem may opt to send ALE-like parity bit packets in a separate frame and even on another channel within the same multi-frame as the payload data packet to which it belongs. This is indicated by the two packets belonging together carrying the same sequence number. This mechanism is predominantly seen when the link quality deteriorates and consequently the number of re-transmissions increases.

In the "Broadcast" and "Group" modes multi-frames with new data appear for every fourth multi-frame – in between data and coding information is repeated in the remaining three multi-frames.

Compressed mode specifics

For point-to-point channels CODAN modems utilize a dictionary based compression method, which allows compression to be independent of the statistical characteristics of the source data. The dictionaries are dynamically built depending on the data previously transmitted. Each modem uses one dictionary for reception and another one for transmission in such a way that a transmission dictionary at one end of the link corresponds to a reception dictionary at the opposite end of the link. The ARQ protocol ensures that the dictionaries are updated and synchronized. If the dictionaries deviate decompression becomes impossible as the buffer contents cannot be reconstructed. It is thus clear that for non-cooperative interception deviating dictionaries pose a major problem.

CODAN decoding at the practical level

When engaging in non-cooperative monitoring a number of issues arise:

- All frames and the sequence counters contained in therein must be received without errors. Re-transmitted packets must be discarded.
- Missing packets or packets with a failed CRC must not be accepted; otherwise data output will be incomplete.

In case of uncompressed transmissions packets with a failed CRC may be marked as such. In case of compressed transmissions decompression consequently becomes impossible due to the deviating dictionaries built during the non-cooperative interception session. Only when a new link is set up, it is possible to start over with empty dictionaries. It is important to understand that in case of compressed transmissions exclusively the data from one party may be forwarded to the de-compressor. This understanding is especially important if during non-cooperative interception both parties in a "Chat Session" are received as forwarding the data from both parties will immediately poison the dictionary.

HF transmission issues

The CODAN ARQ protocol is adapted to the propagation conditions in the HF range, but obviously relies on an active link between the two communicating parties. This link does not exist in the case of non-

cooperative monitoring and thus complete and correct data output is fully dependent on error-free reception – there is no way to ask for re-transmission.

As transmissions do not contain source or destination addresses the monitor in case of single-frequency half-duplex traffic must manually select the party to monitor. This may be achieved by adjusting the receiver squelch, adjusting the receiver HF gain or the use of directional antennas to suppress the unwanted signal.

Real-time monitoring issues

To capture the contents of a CODAN modem data transmission the monitoring equipment should be placed as close as possible to the transmitter site of the interesting party. This is the only way to ensure that the quality of the signal is sufficient to secure that all transmitted packets are correctly captured.

To facilitate the decoding of data the WAVECOM decoder in addition to outputting the decoded data in the decoder window also saves raw channel data with sequence numbers and including bad packets to a text file. The text file may be processed manually or by a user provided application.

COQUELET-13

COQUELET-13 is an asynchronous system and uses a start and idle tone of 1052 Hz. As with COQUELET-8, the first group contains 8 tones for keying, and the second group 4 tones.

Parameter	Value
Frequency range	HF
Operation modes	Asynchronous simplex
Modulation	MFSK-13
Speed	50.0 or 75.0 ms
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF
Additional Info	ITA-2

COQUELET-13 has a tone duration of 75 ms which is equivalent to a 50 Bd Baudot transmission, with 1.5 stop bits. Two code tables are defined for this mode, **Code Table 0** and **Code Table 1**.

Tone Assignment of COQUELET-13

Tone Number	Frequency Hz	Bit 1	Bit 2	Bit 3	Bit 4	Bit 5
First tone Group						
1	812			1	1	1
2	842				1	1
3	872					1
4	902			1		
5	932			1		1
6	962			1	1	
7	992				1	
8	1022					
9	1052	Idle or start tone				
Second Tone Group						
10	1082	1	1			
11	1112	1				
12	1142		1			
13	1172					

COQUELET-8

COQUELET-8 is an MFSK (Multiple Frequency Shift Keying) system, and like the PICCOLO system translates an ITA-2 character into a sequence of two tones.

Parameter	Value
Frequency range	HF
Operation modes	Simplex
Modulation	MFSK-8
Speed	37.5, 50.0 or 75.0 ms
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF
Additional Info	ITA-2

The first group of tones contains 8 tones (1 - 8) and the second group the tones 5 - 8. Tones 1 - 4 of the second group are not defined.

Coquelet-8 is a synchronous system with a tone duration of 75.0 ms, 50.0 ms or 37.5 ms. One ITA-2 character is transmitted in 75 or 150 ms, which is equivalent to 50 or 100 Bd Baudot with 1.5 stop bits (codeword length 7.5 Bit).

An IDLE sequence is sent when no traffic is at hand. Transmissions start with a synchronization preamble, and end with several EOT characters.

Tone Assignment of COQUELET-8

Tone Number	Frequency Hz	Bit 1	Bit 2	Bit 3	Bit 4	Bit 5
First tone Group						
1	773			1	1	1
2	800				1	1
3	826					1
4	853			1		
5	880			1		1
6	907			1	1	
7	933				1	
8	960					
Second Tone Group						
5	880	1	1			
6	907	1				
7	933		1			
8	960					

COQUELET-80

COQUELET-80 is a synchronous MFSK system with error correction (FEC). Various references note two different systems: COQUELET-80S and COQUELET-82S. COQUELET-82S can be used in both side bands and uses extended handshaking and synchronizing sequences (extended protocol).

Parameter	Value
Frequency range	HF
Operation modes	Simplex FEC
Modulation	MFSK-8
Speed	37.5, 50.0 or 75.0 ms
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF
Additional Info	ITA-2

COQUELET-80 is used with the ATU-80 (Arabic) or the ITA-2 (Latin) alphabet. As for COQUELET-8 a character is coded with two tone assignments from group 1 and group 2.

Error correction is done by transmitting every character twice with a specified time offset. The second transmitted character is mathematically reformatted (MOD 8). The leading (DX) and trailing characters (RX) always have the same ODD or EVEN parity.

At the beginning of a message the RX character positions are filled with IDLE sequences. This mode does error recognition, but no error correction.

Tone Assignment of COQUELET-80

Tone Number	Frequency Hz	Bit 1	Bit 2	Bit 3	Bit 4	Bit 5
First Tone Group						
1	773			1	1	1
2	800				1	1
3	826					1
4	853			1		
5	880			1		1
6	907			1	1	
7	933				1	
8	960					
Second Tone Group						
5	880	1	1			
6	907	1				
7	933		1			
8	960					

CTCSS

The CTCSS selective calling system is defined according to EIA standard RS-220 and operates in the sub-audio range. Applying this **C**ontinuous **T**one **C**ontrolled **S**quelch **S**ystem stations may be selectively called either as a single user or as a group.

Parameter	Value
Frequency range	VHF/UHF
Operation modes	Analogue Selcal
Modulation	FM, SUB Tone
Receiver settings	FM, BW = 12 kHz
Input format(s)	AF, IF

Tone Allocation

Tone no.	Freq. Hz	Tone no.	Freq. Hz	Tone no.	Freq. Hz
1	60.0	19	118.8	37	183.5
2	67.0	20	120.0	38	186.2
3	69.3	21	123.0	39	189.9
4	71.9	22	127.3	40	192.8
5	74.4	23	131.8	41	196.6
6	77.0	24	136.5	42	199.5
7	79.7	25	141.3	43	203.5
8	82.5	26	146.2	44	206.5
9	85.4	27	151.4	45	210.7

10	88.5	28	156.7	46	218.1
11	91.5	29	159.8	47	225.7
12	94.8	30	162.2	48	229.1
13	97.4	31	165.5	49	233.6
14	100.0	32	167.9	50	241.8
15	103.5	33	171.3	51	250.3
16	107.2	34	173.8	52	254.1
17	110.9	35	177.3		
18	114.8	36	179.9		

A CTCSS controlled receiver only switches on, in case a carrier modulated with the pre-programmed CTCSS tone is received. For this system 52 tones are defined:

CV-786

CV-786 is an asynchronous FSK system and is based on ASCII. No error detection or error correction is implemented.

Parameter	Value
Frequency range	HF
Operation modes	Asynchronous
Modulation	FSK
Symbol rate	50,75, 100 or 150 Bd, variable 30-650 Bd
Center frequency	2000 Hz
Shift/Bandwidth	850 Hz
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF
Additional Info	Async FSK only

For CV-786 mode standard baud rates from 50 to 150 Baud are available. Non-standard baud rates may be selected using the **Baudrate** menu item.

From **Options | Alphabet**… you can select from different ITA-2 and ITA5 aphabets.

CW-MORSE

The **Auto** function will automatically detect Morse keying speeds within the range 0 - 90 WPM (words per minute). The keying speed is continuously updated and displayed.

Parameter	Value
Frequency range	HF
Operation modes	Simplex/Duplex ARQ, Broadcast
Modulation	CARRIER KEYING
Speed	0 - 90 WPM
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF

The center frequency can be set to any value between 200 and 3400 Hz via the **Center** item in the **Demodulator** menu. The center frequency is nominally 800 Hz which is dictated by the quartz filters of professional receivers while other receivers work with 1000 Hz.

The shift can be set between 100-300 Hz and controls the lock-in-range of the center frequency (bandwidth = 1.2 x shift).

Using **Options | Alphabet** the output can be set to Latin, Cyrillic, Greek, Arabic or Hebrew.

Using **Options | AFC** the continuous automatic tuning to the center frequency of the CW-Morse signal can be enabled or disabled.

The software reports an error condition (ERROR) if the controlled parameters as the dot-dash ratio, the inter-word or inter-character breaks deviate too much from the standard, and error-free decoding cannot be maintained.

DCS SELCAL

DCS stands for **D**igital **C**oded **S**quelch (also known as DCSS, **D**igitally **C**oded **S**quelch **S**ignaling), and is used for selective calls and remote control applications.

Parameter	Value
Frequency range	VHF
Operation modes	Digital Selcal
Modulation	FSK
Symbol rate	133.7,134.4, 137 Bd
Receiver settings	FM, BW = 15kHz
Input format(s)	IF

The data is transmitted on sub audible tones within the frequency range 2 Hz to 300 Hz. In practice, DCS is similar to CTCSS, but uses 104 octal 3-digit code words instead of continuous analogue tones.

The data is sent as a series of 23-bit GOLAY encoded frames without any sync bits. Polarity can be normal or inverse, and must be selected by the user.

DCS Code Table

Normal	Inverse	Normal	Inverse	Normal	Inverse	Normal	Inverse
023	047	155	731	325	526	516	432
025	244	156	265	331	465	523	246
026	464	162	503	332	455	526	325
031	627	165	251	343	532	532	343
032	051	172	036	346	612	546	132
036	172	174	074	351	243	565	703
043	445	205	263	356	212	606	631
047	023	212	356	364	131	612	346
051	032	223	134	365	125	624	632
053	452	225	122	371	734	627	031
054	413	226	411	411	226	631	606
065	271	243	351	412	143	632	624
071	306	244	025	413	054	654	743
072	245	245	072	423	315	662	466

Normal	Inverse	Normal	Inverse	Normal	Inverse	Normal	Inverse
073	506	246	523	431	723	664	311
074	174	251	165	432	516	703	565
114	712	252	462	445	043	712	114
115	152	255	446	446	255	723	431
116	754	261	732	452	053	731	155
122	225	263	205	454	266	732	261
125	365	265	156	455	332	734	371
131	364	266	454	462	252	743	654
132	546	271	065	464	026	754	116
134	223	274	145	465	331		
143	412	306	071	466	662		
145	274	311	664	503	162		
152	115	315	423	506	073		

DGPS

DGPS (Differential Global Positioning System) data is mainly transmitted in the low frequency band e.g., 285 - 315 kHz. It is a correction signal for GPS receivers, and is used to increase the accuracy of the satellite-based GPS signal. DGPS is based on the transmission of correction data by a reference station, the position of which has been determined with high accuracy by traditional position-finding measurements. With the correction data, an absolute accuracy to within 4 meters can be achieved.

Parameter	Value
Frequency range	HF
Operation modes	Broadcast FEC
Modulation	Minimum-Shift-FSK
Symbol rate	100.0 and 200.0 Bd
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF
Additional Info	ITA-5

Transmissions use MSK (Minimum Shift Keying) with speeds of 100 or 200 baud.

DGPS has been implemented according to RTCM SC-104 "Recommended Standards for Differential Navstar DGPS Service" v.2.0, Jan. 1990.

- These messages are decoded: 1, 3, 7, 9, 13, 16.
- These messages are NOT decoded, but their type is indicated: 2, 4, 5, 6, 8, 10, 11, 12, 14, 15, 17, 60-64.
- Compared to M.823-2 messages 4 and 5 are not decoded by my implementation neither are the equivalent GLONASS.

DGPS data, which is formatted according to RTCM v.2.0 or 2.1, is continuously transmitted in frames consisting of a varying number of data words. The two first words of each frame contain the reference station id, the message type, a sequence number, the frame length and the health of data. A data word has a length of 30 bits: 24 data bits and 6 parity bits. The last two bits of a word are used as an EXOR function for selected bits of the succeeding data word. The value of the last bit indicates whether the next data word is sent with inverse or normal polarity.

If **Normal 3, 5, 7, 16** is chosen in the **Message Type** options field, messages containing ASCII text are decoded, in case of numbers their meaning is displayed as well. The message types 1, 6 and 9 containing the real DGPS information are not displayed in this mode of operation. Selecting **Raw excl. 1, 6, 9** offers a raw bit display except of the message types 1, 6 and 9 and **Diff. corrections** displays the corrections messages. By selecting the **All frame headers** option, all frame headers are displayed regardless of the message type. In case of a parity-error the data transferred in the related data word are displayed in red characters to indicate a potential error.

RTCM v.2.0 and 2.1 are not completely compatible, but both systems are used. This may lead to erroneous interpretation of certain frame types.

More detailed information may be found in "RTCM Recommended Standards for Differential NAVSTAR GPS Service 2.0" (RTCM paper 134-89/SC104-68).

DMR

DMR (Digital Mobile Radio) is a two-channel digital TDMA system for the transmission of voice and short text messages.

For voice the AMBE++ (or AMBE+2) codec by DVSI is used. Data transmission accommodates 7-bit ASCII only.

Parameter	Value
Frequency range	VHF/UHF (136 – 147 / 403 – 470 MHz)
Operation modes	Digital 2-channel TDMA two-way data and voice system
Modulation	4FSK with pulse shaping
Symbol rate	4800 Bd
Receiver settings	BW = 30 kHz
Input format(s)	IF
Additional Info	Data or voice

To use the mode, set **Offset** to the frequency of the IF output of the receiver and select the correct **Polarity**. From **Options** use the **Message Type** menu to select an output method. If **All Frames** is selected, data and voice frames as well as all control frames will be displayed. Voice is output in real-time to the speaker. At the same time the latest voice session will be saved in a .wav-file in the default data output directory (see **Default Data and Program Folders** section). The input bits to the vocoder are saved in Hex in a separate file alongside the .wav file. This feature is useful when the voice session is encrypted. The user can analyze and try to decrypt the bits.

A "Bit Transparent" format is also available in "Message Type", with this output format the decoded bits will be output before they are processed by the protocol interpreter. In this case no text or voice output is available. This format can be mainly used to analyse the bit stream when it deviates from the user data protocol.

A time stamp is displayed to each frame at the time of decoding. Since the decoder works in real-time, the time of decoding is also the time of signal receiving (with a neglectale delay). The time stamp has a resolution of 1 millisecond (ms). The time stamp display delivers a method to verify whether each received frame is decoded in real-time. In a continous state we can count 16 frames each second in each slot. This matches to the 30 ms frame length in both slot 1 and 2. Both slots are interleaved.

The display parameter "**Confidence**" indicates the quality of decoding - a value above 95% indicates a very high quality, whereas a value below 85% indicates that decoding is unreliable. Minor center frequency deviations are automatically compensated. The value of the **Carrier** parameter is the center frequency after error correction - this value should remain close to the IF of the receiver.

Motorola markets DMR radio systems as MOTOTRBO, known sometimes in Asia as XiR.

Wavecom DMR decoder works with all equipments compatible to the ETSI standards, e.g., MOTOTRBO series from Motorola and Hytera DMR devices.

The current implementation complies with the ETSI DMR standard series:

- ETSI TS 102 361-1 V2.3.1 (2013-7)

- ETSI TS 102 361-2 V2.2.1 (2013-7)
- ETSI TS 102 361-3 V1.2.1 (2013-7) and
- ETSI TS 102 361-4 V1.6.1 (2014-6)

It covers all three layers of the DMR protocol stack:

- Layer 1: Air interface physical layer
- Layer 2: Air interface data link layer and
- Layer 3: Air interface call control layer.

Wavecom DMR decoder covers all three tier services:

- Tier 1: Direct mode
- Tier 2: Direct mode and base station communication
- Tier 3: Trunking protocol.

Decoding outputs (text, voice and service messages) from the two TDMA slots are sorted in two separate windows. The following two screen shots show a DMR data and voice transmission and real communication on a base station, respectively.

Wavecom DMR decoder can decrypt secured text and voice transmission of Motorola MOTOTRBO series.

There are two kinds of encryption mode: Basic and Enhanced. For Basic mode the encryption is done by a scrambler. This is a simple but weak encryption and can easily be hacked, because the same text message (plain text) will always deliver the same encrypted bit pattern (cipher text). This delivers some clue on the scrambler. The decoder needs to use the same Key ID (between 1 and 255) as the sender. The scrambler value to each key ID is hardcoded by Motorola and is not sent over the air (OTA) for security reason.

The Enhanced mode is based on two encryption algorithms: Motorola propriatory ARC-4 encryption algorithm with a 40-bit key and the Advanced Encryption Standard (AES) with a 256-bit key. Unlike the Basic mode, it is almost impossible to hack the Enhanced encryption, especially AES-256 – each time a plain text will be encrypted to different a cipher text.

The decoder must use the same key list the sending device. The user can edit up to 256 enhanced keys. Each key is 40-bit (5 bytes) and 256-bit (32 bytes) long, respectively. The input format of the key value is hex-decimal. Use leading zero to make sure that there are even number of hex-decimal digits, e.g., "0123AB" instead of "123AB". The decoder reads the key ID sent by the encrypting device over the air and uses the corresponding key value for decryption. The key value itself is not sent over the air for security reason.

When the key ID for the basic mode or the key list for the enhanced mode matches to the one used by the sender, a secured text or voice transmission can automatically be decrypted to clear text or voice, respectively. Otherwise the text is unreadable and the voice is unaudible.

Wavecom decryption function has a "late-entry" feature: the user can enter the correct key ID or key value during the decoding session and the output text or voice will get clear immediately.

dPMR

dPMR (digital Private Mobile Radio) is an open ETSI standard published under the references TS 102 490 (License-free) and TS 102 658 (Licensed). It uses FDMA technology with a channel spacing of 6.25 kHz and supports voice and data applications. The modulation scheme is 4FSK with a bit rate of 4800 bps.

Parameter	Value
Frequency range	Unlicensed: ETSI TS 102 490 446.100 - 446.200 MHz (CEPT ECC/DEC/(05)12) 149.01875 - 149.11875 MHz Licensed: ETSI TS 102 658 Licensed PMR frequency bands
Operation modes	FDMA, digital voice and data system

Modulation	4FSK (constant envelope FSK)
Symbol rate	2400 Bd
Receiver settings	BW ≥ 6.25 kHz
Input format(s)	IF
Additional Info	Voice codec: AMBE+2 (3600 bps) Bit rate: 4800 bps Supported Modes ➢ dPMR446 ➢ dPMR Mode 1 ➢ dPMR Mode 2

TS 102 490 covers only license-free hand portable equipment operating in peer-to-peer mode. The radios should have an integral antenna and are limited in their output power. The standard is also called as dPMR446.

TS 102 658 uses the same air interface technology as in dPMR446 without the limitations of the license-free counterpart. It supports different levels of functionality as listed below.

- Mode 1: Peer-to-peer direct network
- Mode 2: Conventional repeater network
- Mode 3: Managed centralized network

The current version of the dPMR decoder supports the Modes 1 and 2 as well as the license-free dPMR446 operation.

To use the mode set **Offset** to the IF output of the receiver. Decoded voice will be saved in a ".wav" file in the default **Data-Output** directory. Use the **Mute** button to mute or un-mute live voice output to the speaker. In the menu "Option -> Message Type" user can set decoder output to "Data & Voice Frames" or "Bit Transparent". With "Bit Transparent" option the frames are just output in bits and no protocol decoding is made. This may be useful when the frames are coded in another way than according to the ETSI standard.

DTMF

The entire call number is transmitted by consecutive tones in decade sequence.

Parameter	Value
Frequency range	VHF/UHF
Operation modes	Analogue Selcal
Modulation	FM, SUB Tones
Receiver settings	FM, BW = 12 kHz
Input format(s)	AF, IF

The entire call number is transmitted by consecutive tones in decade sequence.

In most systems the accuracy of the single frequencies has to be within +1/-1.5% of the nominal value.

If a DTMF call is received, the call sign is displayed on the monitor. In the **Options** menu a **Time stamp** function can be enabled to add date and time to each call.

Tone Allocation

Digit	Hz	Digit	Hz
0	941/1336	8	852/1336
1	697/1209	9	852/1477

Digit	Hz	Digit	Hz
2	697/1336	A	697/1633
3	697/1477	B	770/1633
4	770/1209	C	852/1633
5	770/1336	D	941/1633
6	770/1477	*	941/1209
7	852/1209	#	941/1477

Tone duration: 70 ms.

DUP-ARQ

DUP-ARQ is a semi-duplex system. The radio channel is used by a DUP-ARQ system in the same way as a simplex system, both stations alternating in transmitting blocks of five characters and a Hamming check-sum. If a transmission error occurs a repeat request is initiated and the last data block is re-transmitted.

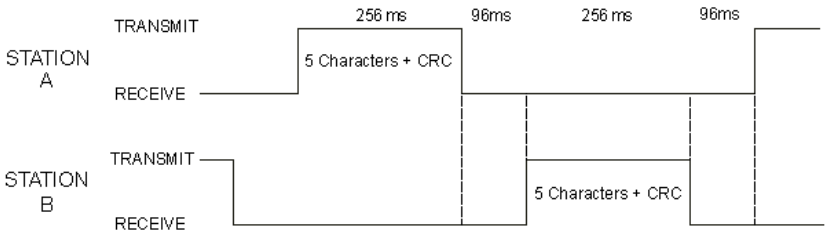
Parameter	Value
Frequency range	HF
Operation modes	Semi-duplex ARQ
Modulation	FSK
Symbol rate	125 Bd, variable 30-650 Bd
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF
Additional Info	ITA-2 with block coding

DUP-ARQ operates at a Symbol rate of 125 Bd on the radio link.

If only one station is sending data, the other station transmits an IDLE pattern and initiates RQ cycles in case of transmission errors.

DUP-ARQ has automatic channel selection facilities. Before transmission starts, the best available short-wave transmission channel is selected and its quality is continuously checked for the duration of the transmission. Within a given frequency range the system may select one of 5 possible channels which are spaced at 400 Hz intervals. Because of this channel selection mechanism, the two linked stations may transmit at different frequencies.

The polarity of the bit stream (upper sideband (USB) or lower sideband (LSB)) cannot automatically be derived from the signal. Polarity may be manually selected by using the **Polarity** menu field. Polarity inversion does not cause a loss of signal synchronization.



DUP-ARQ-2

DUP-ARQ-2 is a further development of the DUP-ARQ system and the system characteristics are very similar. DUP-ARQ-2 allows transmission of ITA-2 (Baudot) or ITA-5 (ASCII) characters depending on the application.

Parameter	Value
Frequency range	HF
Operation modes	FSK, Duplex ARQ
Modulation	FSK
Symbol rate	250.0 Bd
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF
Additional Info	ITA-5 with block coding

DUP-ARQ-2 operates at a Symbol rate of 250 Baud on the radio link. A complete transmission cycle is 176 bits (704 ms). Both stations alternate in transmitting data blocks of 64 bits each.

The data format is 2 data blocks of 32 bits each. The blocks correspond to the DUP-ARQ (ARTRAC) system. Each of the two blocks contains a 5 bit checksum (inverted Hamming) for error detection and a single bit for the global parity (odd parity). Three 8 bit characters are transmitted in the data block. Two bits remain unused and are set to zero.

Special blocks defining IDLE, INTERRUPT and other special functions are transmitted. For these blocks the two normally unused bits specify the particular special functions with the combinations "10" or "11".

DUP-ARQ-2 has automatic channel selection facilities. Before transmission starts, the best available shortwave transmission channel is selected and its quality is continuously checked for the duration of the transmission. Within a given frequency range the system may select one of 5 possible channels which are spaced at 400 Hz intervals. Because of this channel selection mechanism the linked stations may transmit at different frequencies.

DUP-FEC-2

DUP-FEC-2 is a further development of the DUP-ARQ-2 system and the system characteristics are very similar. DUP-FEC-2 allows transmission of ITA-2 (Baudot) or ITA-5 (ASCII) characters.

Parameter	Value
Frequency range	HF
Operation modes	Broadcast/Duplex FEC
Modulation	FSK
Symbol rate	125.0 and 250.0 Bd, variable 30-650 Bd
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF
Additional Info	ITA-5 with block coding

DUP-FEC-2 has a radio channel rate of 125 or 250 Baud. A data frame is 32 bits long. For error protection a five bit CRC-sum (inverted Hamming) and a single bit for global parity (odd parity) is used.

DUP-FEC-2 is often used as a full-duplex system. As is the case with other full-duplex systems transmission simultaneously takes place on two different frequencies. If an error occurs special sequences are transmitted to signal this condition and a block repetition is requested (RQ).

If errors are received the two last 32 bit blocks are retransmitted when the radio channel rate is 125 Baud and three blocks when working at 250 Baud.

Like DUP-ARQ-2, DUP-FEC-2 has many special blocks for IDLE and RQ.

DZVEI

The entire call number is transmitted by consecutive tones in decade sequence. When two identical digits are to be transmitted consecutively, then an eleventh frequency is used as a repetition identifier.

Parameter	Value
Frequency range	VHF/UHF
Operation modes	Analogue Selcal
Modulation	FM, SUB Tones
Receiver settings	FM, BW = 12 kHz
Input format(s)	AF, IF

If more than two identical digits are to be transmitted, the repetition tone is appended to the digit tone (e.g., 22222 is transmitted as f2 fw f2 fw f2, where f2 is the tone for "2" and fw is the repetition tone).

In most systems the accuracy of the single frequencies has to be within +1/-1.5% of the nominal value.

For ZVEI modes having nominal tone durations of 70 ms, the duration of a single tone may vary ± 15 ms.

Decoding the selective calls is started by clicking on a system. If transmission and system selection conform, the call sign is displayed on the monitor. In the Options menu a Time stamp function can be enabled to add date and time to each call.

Tone Allocation

Digit	Hz	Digit	Hz
0	2200	8	1830
1	970	9	2000
2	1060	A	825
3	1160	B	740
4	1270	C	2600
5	1400	D	885
6	1530	E	2400
7	1670	F	680

Tone duration: 70 ms.

EEA

The entire call number is transmitted by consecutive tones in decade sequence. When two identical digits are to be transmitted consecutively, then an eleventh frequency is used as a repetition identifier.

Parameter	Value
Frequency range	VHF/UHF
Operation modes	Analogue Selcal
Modulation	FM, SUB Tones
Receiver settings	FM, BW = 12 kHz
Input format(s)	AF, IF

If there more than two identical digits are to be transmitted the repetition tone is appended to the digit tone (e.g. 22222 is transmitted as f2 fw f2 fw f2, where f2 is the tone for "2" and fw is the repetition tone).

In most systems the accuracy of the single frequencies has to be within +1/-1.5% of the nominal value.

Decoding the selective calls is started by clicking on a system. If transmission and system selection conform, the call sign is displayed on the monitor. In the **Options** menu a **Time stamp** function can be enabled to add date and time to each call.

Tone Allocation

Digit	Hz	Digit	Hz
0	1981	8	1747
1	1124	9	1860
2	1197	A	1055
3	1275	B	930
4	1358	C	2400
5	1446	D	991
6	1540	E (REPETITION)	2110
7	1640		

Tone duration: 40 ms.

EFR

A German company operates a radio broadcast load balancing and ripple control system for electrical power distribution networks. Short telegrams are used to control street lights, heaters, tariff switching etc.

Parameter	Value
Frequency range	HF
Operation modes	Broadcast asynchronous ASCII
Modulation	FSK
Shift/Bandwidth	340 Hz
Symbol rate	200.0 Bd
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF

The subscribers control their equipment by sending messages to the central computer of service provider. The central computer forwards the messages to transmitters in Frankfurt am Main (DCF49, 129.1 kHz) and Burg (DCF39, 139.0 kHz).

Transmissions are 200 Bd ASCII FSK with a shift of 340 Hz.

The transmission format is based on DIN-19244, i.e., start bit, 8 data bits, parity bit and stop bit. The length of the data frame is variable; therefore a length field is required. The frames consist of a start character, followed by the length information, which is sent twice. The fourth byte is the start character again. Bytes five to seven are message number, address field A1 and address field A2. After a maximum of 16 data bytes, a checksum is transmitted and finally the stop character. The checksum is an addition of the message number, address and data fields without considering carry bits. Messages are sent twice to increase transmission security.

Two user data protocols are in use, Semagyr-TOP and Versacom. As messages do not contain a protocol identifier both formats are displayed together with the raw data string in hexadecimal format. Using **Options/Display Mode...** the display may be toggled between **All frames** and **Error free frames**.

If messages are not at hand, EFR periodically transmits time signals which allow the receivers to synchronize their internal clock. From time to time, a test signal is transmitted containing the name of the transmitter, e.g., DCF49.

EIA

The entire call number is transmitted by consecutive tones in decade sequence. When two identical digits are to be transmitted consecutively, then an eleventh frequency is used as a repetition identifier.

Parameter	Value
Frequency range	VHF/UHF
Operation modes	Analogue Selcal
Modulation	FM, SUB Tones
Receiver settings	FM, BW = 12 kHz
Input format(s)	AF, IF

If more than two identical digits are to be transmitted, the repetition tone is appended to the digit tone (e.g., 22222 is transmitted as f2 fw f2 fw f2, where f2 is the tone for "2" and fw is the repetition tone).

In most systems the accuracy of the single frequencies has to be within +1/-1.5% of the nominal value.

Decoding the selective calls is started by clicking on a system. If transmission and system selection conform, the call sign is displayed on the monitor. In the **Options** menu a **Time stamp** function can be enabled to add date and time to each call.

Tone Allocation

Digit	Hz	Digit	Hz
0	600	8	1728
1	741	9	1869
2	882	A	2151
3	1023	B	2433
4	1164	C	2010
5	1305	D	2292
6	1446	E (REPETITION)	459
7	1587		

Tone duration: 33 ms.

ERMES

ERMES is a Europe-wide high speed paging system with a user data rate of 6250 bps, in comparison to POCSAG, which has a maximum rate of 2400 bps. ERMES radio data may be transmitted using frequency or time multiplexing, or both. All transfer modes do however utilize the same modulation format on the same frequency. ERMES is used in several European countries, whereas Asian countries tend use FLEX as standard, which is a technically comparable Motorola system.

Parameter	Value
Frequency range	VHF/UHF
Operation modes	Broadcast pager
Modulation	4-PAM/FM
Symbol rate	3125 Bd
Receiver settings	FM, BW = 15-30 kHz
Input format(s)	IF

Parameter	Value
Additional Info	Bit rate = 6250 bps

Radio Link

ERMES employs a radio link transfer protocol conforming to the ETSI pr ETS 300 133-4 standard (ETS 300 133-1 to ETS 300 133-7). Transmissions are within the range from 169.4125 MHz to 169.8125 MHz all over Europe. Channel spacing is 25 kHz. The nominal frequencies and the channel numbering are defined as:

fn = 169.425 + n * 0.025 MHz

n = Channel number (0...15)

ERMES transmitter allocations follow the CEPT T/R 25-07, Annex 1 recommendation.

Modulation

ERMES modulation is 4-PAM/FM. The four frequency pulse-amplitude modulation carries two bits (dibit) per frequency step. In addition to coherent phase keying ERMES also utilizes pre-modulation pulse shaping. To decrease bit error rate, data is encoded using the Gray code.

The nominal frequencies are:

Carrier	Dibit symbol
+ 4687.5 Hz	10
+ 1562.5 Hz	11
- 1562.5 Hz	01
- 4687.5 Hz	00

The ERMES Protocol

A sequence of 60 seconds is partitioned into 60 cycles. The sequences are synchronized to UTC. The cycles have duration of exactly one minute, and synchronize the various ERMES networks (transmitters). In this way the receivers will only receive one or more cycles and thus power consumption is substantially reduced.

Each cycle is subdivided into five subsequences of 12 seconds each. In order to maintain synchronism between networks the subsequence number (command SSN = 0) is transmitted preceding every UTC minute marker.

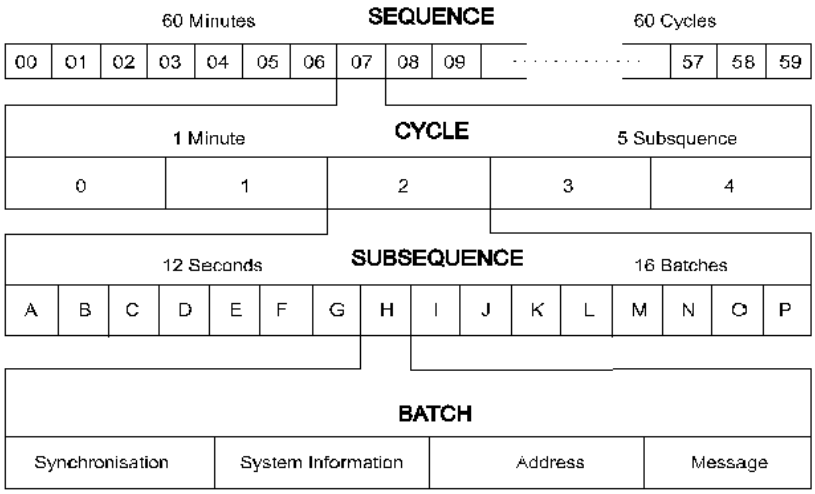
A subsequence may also have duration of less than 12 seconds. The remaining time is used for transmitter switching.

Each subsequences is further divided into 16 batches designated A to P. Thus the pagers are divided into 16 groups. The transfer mode (tone call only, numerical call, alphanumerical call) is controlled by the position of the batch number.

The receiver addressing only takes place within the appropriate batch. After decoding its address the receiver will wait on the same frequency for data. Data may be transmitted within the same batch, within another subsequence batch or within subsequent subsequences.

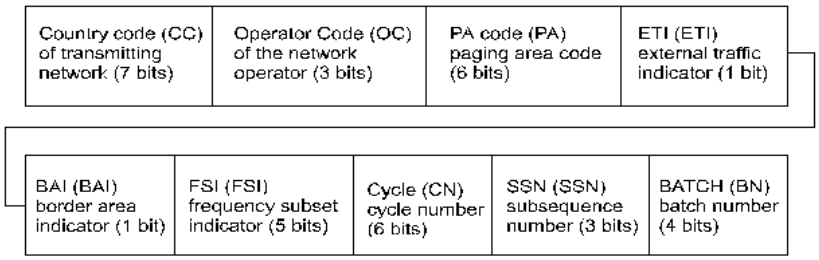
Each batch is subdivided into four parts: synchronization, system information, address and text.

Protocol Structure



System Information

Network and system information is transmitted within the system subdivision of a batch. The system information is divided into two parts, System Information (SI) and Supplementary System Information (SSI).



Depending on the value of the SSI flag the Supplementary System Information (SSI) carries information on zone, local time and date. Another option displays day of week, month of year and year.

Data

ERMES transmits data in fixed-length frames of 36 bits. A frame may carry an additional data field and the text data.

Message Frame (MHEAD)

Local Address (LADDR) full local address of the receiver (22 bits)	Message Number (MNUM) individual / group calls (5 bits)	External bit (EB) local or external receiver (1 bit)	All (ALL) additional info (1 bit)	VIF variable Info field (7 bits)

The Variable Information Field (VIF) has two main options depending of the status bit ALL = 0 or ALL = 1.

Variable Information Field Without Supplementary Information

RSVD for future definition (1 bit)	Paging Category (PCAT) 00 tone 01 numeric 02 alphanumeric 03 transparent (2 bits)	UMI (UMI) Urgent indicator 0 normal message 1 urgent message (1 bit)	ALERT (ALERT) alert (alarm) signal indicator type 0 - 7 (3 bits)

Variable Information Field With Supplementary Information

The ETS 300 133-4 standard has a very fine grained subdivision of the VIF and this enables ERMES to be used for a wide range of applications.

AIT (AIT) Additional information type long message, remote programming, miscellaneous, additional character set, temporary address pointers and more	AIN (AIN) Additional information number urgent alert 0-7, non-urgent alert 0-7, paging area, identity code, add or replace data in pager, country code and more

ERMES and other pager systems are losing importance in Europe due to the surge in GSM usage, and several networks have been closed down.

EURO

The entire call number is transmitted by consecutive tones in decade sequence. When two identical digits are to be transmitted consecutively, then an eleventh frequency is used as a repetition identifier.

Parameter	Value
Frequency range	VHF/UHF
Operation modes	Analogue Selcal
Modulation	FM, SUB Tones
Receiver settings	FM, BW = 12 kHz
Input format(s)	AF, IF

If more than two identical digits are to be transmitted, the repetition tone is appended to the digit tone (e.g., 22222 is transmitted as f2 fw f2 fw f2, where f2 is the tone for "2" and fw is the repetition tone).

In most systems the accuracy of the single frequencies has to be within +1/-1.5% of the nominal value.

Decoding the selective calls is started by clicking on a system. If transmission and system selection conform, the call sign is displayed on the monitor. In the **Options** menu a **Time stamp** function can be enabled to add date and time to each call.

Tone Allocation

DIGIT	EURO	DIGIT	EUR
0	979.8	8	510.7
1	903.1	9	470.8
2	832.5	A	433.9
3	764.4	B	400.0
4	707.4	C	368.7
5	652.0	D	1153.1
6	601.0	E	1062.9 (Repeat)
7	554.0	F	339.9

Tone duration: 100 ms.

FEC-A

FEC-A uses a convolutional error correction scheme based on data bits being read into a shift register, the length of which may be changed. Values of 72 and 128 bits are common.

Parameter	Value
Frequency range	HF
Operation modes	Broadcast/Simplex FEC
Modulation	FSK

Parameter	Value
Symbol rate	96, 144 and 192 Bd, variable 30-650 Bd
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF
Additional Info	ARQ1A with convolutional coding

The FEC-A mode is started by selecting a standard baudrate from the **Baudrate** item in the **Demodulator** menu. Frequency shift and baud rate are determined using **FSK Analysis**. For automatic tuning **Auto** may be selected.

The synchronization or idle state is easily recognized by its sound. It is an alternating mark-space keying sequence (mark-space ratio approx. 40% - 60%).

Shift register length is set using the **S-Reg** item in the **Options** menu. Incorrect selection of the S-Reg parameter causes incorrect error correction,and the data output rapidly becomes corrupted. If error correction is disabled (**ECC** off), the length of the shift register will not affect decoding (**S-Reg** not visible). This feature allows any FEC-A signal to be decoded.

FEC-A will detect and correct transmission errors up to a certain limit; in the case of extreme interference, error correction may worsen the situation, so reception without error correction may improve performance.

FEC-A uses the ARQ-1A alphabet. Every second bit of the bit stream is used for the convolutional error correction and thus each codeword consists of 14 bits.

FELDHELL

Feld-Hell is a synchronous picture telegraph system invented in the 1930s. It uses a virtual matrix laid down on the character to be transmitted. The pixels of the matrix are then sent, scanning the matrix from the bottom of the first column (left) to the top of the last column (right), covering a matrix of 7 columns x 14 lines. The first and last columns are blank, as are the top and bottom lines, giving an effective matrix of 5 x 10 pixels. Pixels are always sent in pairs.

Parameter	Value
Frequency range	HF
Operation modes	Graphic mode, Broadcast/Simplex
Modulation	CARRIER KEYING AM
Symbol rate	122.5 Bd
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF
Additional Info	Synchronous matrix picture telegraphy

The original Hell system was a very simple mechanical one with an indented wheel for each character used to generate the transmit pulse trains via a contact.

In the receiver, the pulses activated a printing magnet with a writing edge, which pushed a paper tape towards a helix inked by an ink roller.

No means of synchronization besides nominal helix speed was used - speed differences showed up as rising or falling lines of letters - but as the pitch of the helix was designed to print a double row of characters, one complete character would always be displayed on the tape.

Hell utilizes AM in the form of CW or A2. When receiving Feld-Hell the decoder will emulate the original Hell tape printer and print each character twice making exact phasing unnecessary as at least one character will be complete and unbroken.

By selecting **122.5 Bd** or **Variable rate** reception is started. Selecting the **Polarity** will determine normal or inverse screen color.

In the **Demodulator** submenu the special function fields **AM-Gain** and **AM-Offset** are placed. Centering of the signal deviations on the bar graph is controlled by adjusting **AM-Offset**. In addition maximum deviation is required on the bar graph. This is done by adjusting **AM-Gain**. It should be noted that these two adjustments are influenced by each other.

Right-click on the image to open the **Zoom** menu, which allows the user to zoom in and out on the image.

FLEX

FLEX is another mode used for pager transmissions. It is often combined with POCSAG and GOLAY/GSC.

Parameter	Value
Frequency range	VHF
Operation modes	Broadcast pager
Modulation	FFSK
Symbol rate	1600, 3200 and 6400 Bd
Receiver settings	FM, BW = 15 kHz
Input format(s)	IF
Additional Info	ASCII

FLEX specifies 4 different transmission modes:

Modulation	Baud rate	Bit rate	Transmitted phases
FFSK	1600 Bd	1600 bits / sec	A
4FFSK	1600 Bd	3200 bits / sec	A, B
FFSK	3200 Bd	3200 bits / sec	A, C
4FFSK	3200 Bd	6400 bits / sec	A, B, C, D

First, a preamble is sent, which identifies the modulation type. Next, a Frame Information Word (FIW) is transmitted to identify the cycle and frame number. The preamble and FIW are always transmitted as FFSK 1600 Baud. After the preamble and FIW, the message is sent with the modulation according to the preamble.

The message block contains the information and consists of 11 blocks. Each block carries 8 words with 32 bits each. The length of a message block is always constant.

The basic modulation type FFSK, 1600 Baud can transmit one message block. With a higher modulation type, it is possible to transmit four complete and independent message blocks. To distinguish between the different message blocks, they are called phase A to D.

A message block contains a lot of smaller messages. 8 different message types are used with FLEX:

- Alphanumeric / Secure messages for text based messages
- Three types of numeric messages
- Binary messages
- Tone Only messages
- Instruction messages for configuring the pager devices

FM-HELL

FM-HELL is a synchronous picture telegraph system like FELDHELL. It is using a virtual matrix laid down on the character to be transmitted. The pixels of the matrix are then sent, scanning the matrix from the bottom of the first column (left) to the top of the last column (right) covering a matrix of 7 columns x 14 lines. Pixels are always sent in pairs.

Parameter	Value
Frequency range	HF
Operation modes	Graphic Mode, Broadcast/simplex
Modulation	FSK
Symbol rate	122.5 Bd
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF

By selecting the mode with a baud rate of 122.5 Bd, reception is started. Selecting **Polarity** will determine normal or inverse screen color.

FMS-BOS

FMS-BOS is a radio signaling system for security authorities and organizations. The system allows for a major reduction in message interchange between mobile units and a control center by digital transmission of abbreviated telegrams.

Parameter	Value
Frequency range	VHF
Operation modes	Simplex
Modulation	FM, SUB FSK
Symbol rate	1200 Bd
Receiver settings	FM, BW = 12 kHz
Input format(s)	AF, IF
Additional Info	BCD-Code with block coding

FMS-BOS operates at 1200 bit/s using FSK modulation of 1200 Hz and 1800 Hz tones.

FMS-BOS Transmission Example

```
FZ-->LS : BOS-K 1, LK d, OK 10, FZ 7611, ST d, ZBV 1
```

The FMS-BOS data telegrams always have the same structure and a length of 48 bits regardless of the transmission direction or message contents. The actual information is contained in 40 bits. The BCD code is used to transmit the digits in the telegram.

A FMS-BOS message is preceded by 12 bits of carrier and a sync character (0x1a).

The message itself consists of 10 BCD blocks.

Block 1 is the **BOS service identifier** (0...f) identifying the service issuing the message.

Block 2 is the s**tate identifier** (0...f) identifying the German state. Due to the fact that the number of states exceeds the number of available identifier digits, digits E and F are additionally identified by the location identifier to be used by two states each.

Blocks 3 - 4 are the **location identifier** (e.g., OK 10) and can assume one of 99 different possibilities. The actual value is determined by each individual state.

Blocks 5 – 8 are the **vehicle identifier** (e.g., 4213) and can contain one of 9999 combinations. The individual identifiers are assigned by each specific service.

Block 9 is the **status** field contains the actual information. 16 different messages may be transmitted. Depending on the R direction bit status messages attain different meanings. Furthermore the actual meaning of a status message is determined by the service and the individual states.

The last block 10 is mapped to 4 bits in the telegram and serves to communicate the equipment capability (B, bit 1), direction (R, bit 2) and abbreviated tactical information (X, Y, bits 4 – 5).

B

0 – Vehicle – dispatcher communications only

1 – Duplex communications possible

R

0 – Vehicle – Dispatcher

1 – Dispatcher – Vehicle

XY

Locally defined

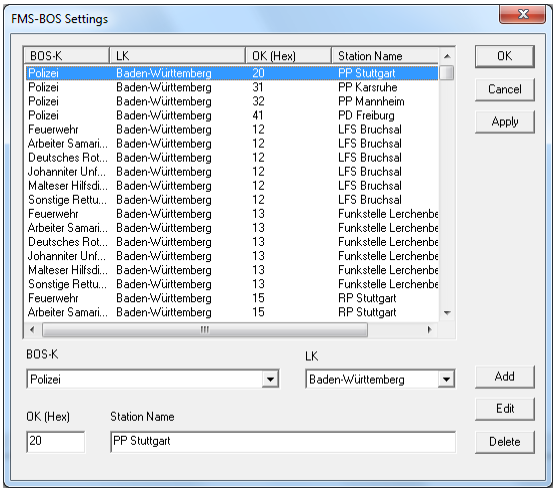
For data protection, a 7-bit Abramson code redundancy block is appended to the data block. This is followed by a single stop bit which is however not tested.

As FMS data messages does not carry a date-timestamp, this information is generated by the real-time clock of the decoder and output to screen as the first data field.

BOS-Identifier	Character	BOS-Identifier	Character
Police	1	German Red Cross	9
Federal Border Protection	2	"Johanniter" First Aid Service	A
Federal Criminal Bureau	3	"Malteser" Support Service	B
Catastrophe Protection Service	4	Life saving organization	C
Customs	5	Miscellaneous rescue services	D
Fire Brigade	6	Civil protection services	E
Technical Support Service	7	Remote command	F
"Arbeiter-Samariter" Federation	8		

State identifier	Character	State identifier	Character
Sachsen	0	Rheinland-Pfalz	A
Federal	1	Schleswig-Holstein	B
Baden-Wuerttemberg	2	Saarland	C
Bayern I	3	Bayern II	D
Berlin	4	Mecklenburg-Vorpommern	e (00 – 49)
Bremen	5	Sachsen-Anhalt	e (50 – 99)
Hamburg	6	Brandenburg	f (00 - 49)
Hessen	7	Thueringen	f (50 – 99)
Niedersachsen	8	Rheinland-Pfalz	A
Nordrhein-Westfalen	9		

FMS-BOS Settings



To apply or manipulate the various FMS-BOS stations select **Options/FM-BOS Settings...**

A table of FMS-BOS users is stored in \config\FmsbosSettings.xml.

FT8

FT8 (**F**ranke **T**aylor 8) is an 8 tone MFSK mode, which is optimized for the transmission of numeric codes. It is one of the digital modes in the program package WSJT (**W**eak **S**ignal communication by K1**JT**), named after the Nobel Prize laureate Joseph H. Taylor Jr (1993 Nobel Prize in Physics). As the name suggests, the digital modes are designed for making reliable QSOs under extreme weak signal conditions.

Parameter	Value
Frequency range	HF
Operation modes	Simplex
Modulation	8-FSK
Symbol rate	6.25 Bd
Receiver settings	USB or LSB
Input format(s)	AF, IF
Additional Info	with FEC

An FT8 cycle starts every 15 seconds, at the 0-th, 15-th, 30-th and 45-th second of a minute. An FT8 signal starts 0.5 seconds into a cycle and lasts 12.64 seconds. It consists of 79 symbols, each 0.16 seconds long. Each symbol is a single steady tone. For any given signal there are eight possible tones. The tone spacing is 6.25 Hz.

FT8 Frame Structure



	no transmission	
Sync	Costas Sync Array (2, 5, 6, 4, 1, 3)	3 * 7 symbols
Data		2 * 29 symbols
Total		79 symbols

Following message types can be decoded:

- CQ {call} {grid}, e.g. CQ CA0LL GG77
- CQ {xy} {call} {grid}, e.g. CQ JA CA0LL GG77
- {call} {call} {report}, e.g. CA0LL OT7ER R-07
- {call} {call} 73/RRR/RR73, e.g. OT7ER CA0LL 73
- Free-text messages (up to 13 characters from a limited alphabet)
- Telemetry data (71 bits as 18 hex symbols)

GMDSS/DSC-HF

GMDSS (**G**lobal **M**aritime **D**istress and **S**afety **S**ystem) is a worldwide system for handling maritime emergency and safety transmissions. Part of the system is DSC (Digital Selective Calling). Each user of the GMDSS is assigned a nine-digit number (MMSI – Maritime Mobile Service Identity) from the mobile maritime service. 3 digits of this number are used as a country code.

Parameter	Value
Frequency range	HF
Operation modes	Broadcast/Simplex
Modulation	FSK
Symbol rate	100.0 Bd
Shift	170 Hz
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF
Additional Info	ITA-5

DSC is used on HF and VHF. On HF the system is working with 100 baud and a shift of 170 Hz.

Selecting **Options/Display** offers the option of an **ASCII** or **RAW** bits display.

The complex structures of the DSC are described in detail in the ITU-Rec. M.493-11.

GMDSS/DSC-VHF

GMDSS (**G**lobal **M**aritime **D**istress and **S**afety **S**ystem) is a worldwide system for handling maritime emergency and safety transmissions. Part of the system is the DSC (Digital Selective Calling).

Each user of the GMDSS is assigned a nine-digit number (MMSI – Maritime Mobile Service Identity) from the mobile maritime service. 3 digits of this number are used as a country code.

Parameter	Value
Frequency range	VHF/UHF
Operation modes	Broadcast/Simplex
Modulation	FM, SUB FSK
Symbol rate	1200 Bd
Center frequency	1700 Hz
Shift/Bandwidth	800 Hz
Receiver settings	FM, BW = 12 kHz
Input format(s)	AF, IF
Additional Info	ITA-5

DSC is used on HF and VHF. On VHF the symbol rate is 1200 baud and the center frequency is 1700 Hz and the shift is 800 Hz.

Selecting **Options/Display** offers the option of an **ASCII** or **RAW** bits display.

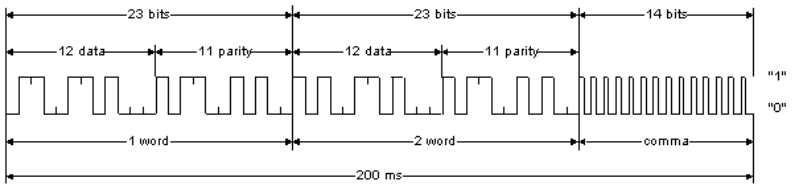
The complex structures of the DSC are described in detail in the ITU-Rec. M.493-11.

GOLAY/GSC

The GOLAY/GSC pager system originates in the USA and is based on the binary code found by Marcel GOLAY/GSC. GOLAY has been in use since 1973. The first standard defined only tone calling and could handle a maximum of 400,000 addresses. After 1982 the system also allows for alphanumeric transmission and up to 4 million addresses may be selected via a coded preamble.

Parameter	Value
Frequency range	VHF
Operation modes	Broadcast FEC
Modulation	FSK
Symbol rate	300/600 Bd adaptive
Receiver settings	FM, BW = 15 kHz
Input format(s)	IF

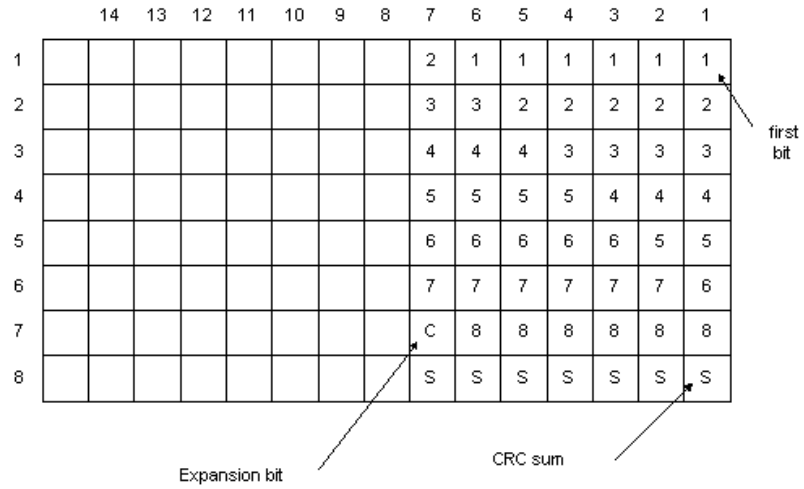
GOLAY Addressing Format



This illustration shows the basic address format of the Golay Sequential Code (GSC). It is constructed from two code words which are derived using the Golay (23,12) algorithm. The bit rate for each code word is 300 bit/s. Each received Golay word can contain up to three errors before integrity is compromised. The GSC is asynchronously decoded. To separate adjacent addresses, a separator word (comma) is transmitted at a rate of 600 bit/s.

The message format is based on eight BCH (15,7) code words that are grouped together to have exactly the same length as an address. Messages and addresses are thus easily interleaved. Each message block may contain up to 12 numeric or 8 alphanumeric characters. Messages which are longer than a single block may be transmitted using any desired sequence of blocks. By implementing block coding, two errors may be corrected in the BCH (15,7) codeword. The bits within a block are interleaved during transmission which allows the correction of burst errors affecting up to 16 bits, which is equivalent to a fading protection of 27 ms.

GOLAY Data Block with Eight Alphanumeric Characters



This illustration shows a block of eight alphanumeric characters of 6 bits each. The high fading protection is achieved by transmitting columns rather than rows (interleaving). In this way a burst error affecting 16 bits does not cause a character error. In addition each block contains a checksum computed by binary addition of the information bits of the other 7 words adding to the error detection capability of the system.

In high capacity systems the GSC makes use of grouping. For this purpose 16 calls are stacked together. Each stack is preceded by one of 10 copy information blocks that consists of 18 repetitions of a single Golay codeword. In this way all receivers in a system are grouped in 10 header block groups and each receiver only has to decode the stack that is preceded by its particular header block.

GOLAY also has a facility for optimizing voice calls. A special audio control code is used to separate voice messages.

GOLAY uses direct frequency modulation. Proper decoding is only possible from the receiver IF output (455 kHz, 10 MHz or 21 MHz).

G-TOR

G-TOR operates at a radio channel rate of 100, 200 or 300 Bd. The quality of the radio channel determines the actual adjusted baud rate.

Parameter	Value
Frequency range	HF
Operation modes	Simplex ARQ
Modulation	FSK
Symbol rate	100, 200 and 300 Bd adaptive
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF
Additional Info	ITA-5 with block coding

By clicking the **Auto** button, the demodulator will automatically adjust to the actual shift and center frequency followed by phasing with automatic baud rate and signal polarity detection.

With some skill the actual baud rate of G-TOR may be easily recognized. Baud rates of 100, 200 and 300 Baud may be manually selected. If so phasing will be accelerated.

After synchronism with a G-TOR signal has been achieved, the software will ensure the baud rate adaptation as is the case in **Auto** mode. After the end of transmission the software will re-synchronize.

The cycle duration of G-TOR is always 2.4 s. The data frame has a length of 1.92 s, which leaves 0.16 s for acknowledgement from the remote station. At 300 Baud 69 data bytes are transferred, at 200 Baud 45 bytes and at 100 Baud 21 bytes. After the end of the data block a control byte and a 16 bit CRC sum are appended.

On the receiving side up to 3 incorrect bits may be corrected using a (24, 12) Golay code. In addition the data bits are interleaved (bit interleaving).

The complex G-TOR system is described in detail by the manufacturer KANTRONICS in a booklet ("G-TOR, The New Mode, Articles, Charts, Protocol", edited by Shelley Marcotte).

Two code tables are defined for this mode, **Code Table 0** and **Code Table 1**, which may be selected from **Options/Code Table**.

GW-FSK

GW-FSK is used by Globe Wireless on the Maritime Data Network of the company.

Parameter	Value
Frequency range	HF
Operation modes	Simplex ARQ
Modulation	FSK
Symbol rate	100 or 200 Bd
Shift	200 Hz
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF
Additional Info	ASCII

The GW-FSK frame consists of three sections: header, data and control. At 100 baud the size of the data field is 48 bits and at 200 baud the size is increased to 112 bits. Each frame contains 6/14 characters or data bytes. For smaller packets a filler '<' is used. For 100 baud the error detection is unknown while the 200 baud sub mode uses a 16 bit CRC for error detection.

GW-FSK operates adaptively so the baud rate can be either 100 or 200 baud. The baud rate depends on propagation as well as the type of transmission. Station idle and start of communication is done with 100 baud. Traffic and GPS position messages are transmitted at 200 baud.

Station idle and ID signals are transmitted at short intervals whenever the shore station is idle. The format is synchronous ASCII.

Most of the traffic is compressed. From time to time uncompressed GPS position data in NMEA format is transmitted on ship frequencies.

GW-FSK can be found on all short wave maritime bands.

GW-OFDM

GW-OFDM is an HF data-transmission system wholly owned and operated by GlobeWireless. Twenty-four HF coastal radio stations provide connection to the land network. Additionally, GlobeWireless offers an email service for vessels around the world. The equipment required by the user consists of a proprietary GlobeWireless data modem (e.g., GL 5100) and shortwave radio equipment, and is installed and maintained by the company.

Parameter	Value
Frequency Range	HF
System	OFDM, ARQ
Modulation	OFDM with DQPSK
Center Frequency	1500Hz
Shift/Bandwidth	750–2000 Hz
Symbol rate	62.5 Bd per carrier (max. 32 carriers)

Parameter	Value
Receiver Settings	LSB/USB (automatic polarity recognition)
Input format(s)	AF, IF
Additional Info	AFC, Adaptive number of carriers, compression

GW-OFDM-Modulation and Protocol

GlobeWireless-OFDM employs a dynamic increase and decrease in the number of OFDM carriers; the number of carriers can vary between 12 and 32. Each carrier is modulated with DQPSK.
The main specifications of GW-OFDM are:

- 12 to 32 subcarriers
- DQPSK modulation
- 62.5 Hz subcarrier spacing (symbol duration 16ms)
- Cyclic prefix / guard interval duration 2ms
- 700-2700 Hz occupied bandwidth
- Pilot tone for synchronization and frequency tracking

The system ensures error free data exchange with an ARQ protocol – if a reception error occurs, the information receiving station (IRS) can request the retransmission of the corrupted packet from the information sending station (ISS). To reduce the peak-to-average power ratio, a scrambler is used. Different compression algorithms are used to achieve efficient data throughput.

Decoder

There are long packets containing data and short packets containing control or request information for the ARQ process.
The decoder can recognize and decode the following packet types:

Packet type	Function	Source
IDLE	Idle frame	ISS
DATA	Data frame	ISS
RQ	Frame with Acknowledge(ACK) or Not Acknowledge(NAK)	IRS
OVER	ISS requests to become IRS	ISS
FORCED OVER	IRS accepts the OVER	IRS
END	ISS indicates end of Transmission	ISS
END ACK	IRS acknowledges end of transmission	IRS
MYCALL	Contains selcall of the calling station	Not specified

RQ, FORCED OVER and END ACK are short packets. The others are long packets.

The decoded packet types are shown in the upper status bar.

In the next lower status bar the following information is shown:

- Number of carriers/channels
- For long packets: Number of channels with CRC OK and CRC FAILED
- For RQ packets: Number of channels with ACK, NAK, and wrongly decoded channels (UNKN)

Due to the compression employed by GW-OFDM, decoded data is not available until the end of a transmission. The end of a transmission is indicated by an END or END ACK packet, or after a timeout of several seconds. After a transmission ends, the decoded data packets are put together and further processed to a text file which contains information about the transmitting station and which can further contain compressed emails and/or several commands. If the processed data packets yield evaluable data, the following information is shown:

- Transmitting station information

- If emails are found and extraction is successful (possibly with a CRC-Error): Data transmission information and the extracted emails are printed
- If emails are found but extraction fails, the cause for the failure is printed
- Otherwise if only commands are found, they are printed

In addition to the decoded output, several files are generated in the Global Data (RW) directory. In the subdirectory "GWOFDM[SN]", all decoded emails are stored, either as text file (OutFileTXT) or in a folder as .SSP-file (OutDir). The .SSP files can be opened with any standard text editor. The subdirectory RAW_DATA saves for every transmission a log file with all detected packets and – if a transmission contains data packets – a data file with the decoded data packets put together is created. These files can be used for advanced examination of the transmission. In the subdirectory TRANSMISSION_DATA data packets of aborted transmissions are saved, which are used in case of a continuation of the transmission. Files in the RAW_DATA and TRANSMISSION_DATA directory are deleted after two hours, or when the mode is closed.

As the GW-OFDM-signal contains no redundancy, sufficient reception quality is important: every DATA packet must be received at least one time without corruption. In the case of packet repetition, the decoder can handle multiple received packets. It should be noted that the decompressor has no error correction - even one wrong bit can produce a completely false decoded output.

GW-PSK

GW-PSK is used by Globe Wireless on the Maritime Data Network of the company. The network works with several digital modes in an adaptive system. GW-FSK is always used for opening a connection. Depending on propagation conditions, it may switch to GW-PSK or other digital modes.

Parameter	Value
Frequency range	HF
Operation modes	Simplex ARQ
Modulation	DQPSK, D8PSK
Symbol rate	200 Bd
Bandwidth	400 Hz
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF
Additional Info	ASCII

GW-PSK is DQPSK and D8PSK modulated with a bandwidth of 400 Hz. The bit rate is 400 bits/s or 600 bits/s with a fixed symbol rate of 200 Baud.

A GW-PSK frame consists of 288 or 432 bits. Each frame contains 25 characters or data bytes. For error detection a 16 bit CRC-checksum is required. For smaller packets, a filler 'U' for traffic or '<' for last packets is used.

A GW-PSK signal is tuned in the same way as a PACTOR-II signal. The precision of the center frequency is very important and influences directly the performance of the decoding.

Most of the traffic is compressed. From time to time uncompressed GPS position data in NMEA format is transmitted on ship frequencies. GW-PSK stations can be found on all maritime bands and also in the fixed service bands. More Information is available on http://www.globewireless.com.

HC-ARQ

HC-ARQ is a simplex system operating at a symbol rate of 240 Bd on the radio link.

Parameter	Value

Parameter	Value
Frequency range	HF
Operation modes	Simplex ARQ
Modulation	FSK
Symbol rate	240.0 Bd, variable 30-650 Bd
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF
Additional Info	ITA-2 with block coding

HC-ARQ does not use a fixed timing cycle so data blocks of the information sending station (ISS) and the acknowledgement blocks of the information receiving station (IRS) have no fixed timing frame.

Synchronization is achieved by a long bit sequence at the start of each block. The start sequence consists of the bit pattern 1000 1011 10101 0010 and 16 subsequent control bits. After the start sequence sixty ITA-2 characters and 32 check bits for each block follow.

HC-ARQ may be set to one of three data block lengths with 30, 60 or 180 characters (150, 300 or 900 data bits). However, the system is not adaptive and the block length must be set to the same value by both stations before transmissions start.

HC-ARQ was originally intended for use in telephone line based data transmission, but it is also found on short-wave.

HF-ACARS

HF Data Link (HFDL) protocols are defined in the ARINC (Aeronautical Radio, Inc.) Specification 635-3, published on December 29, 2000. The development of HF Data Link service builds on the experiences of ACARS (Aircraft Communications Addressing and Reporting System), therefore HFDL is also known as HF-ACARS.

Parameter	Value
Frequency range	HF
Operation modes	Simplex ARQ TDM
Modulation	M-ary PSK
Symbol rate	1800 Bd
User data rate	300, 600, 1200 or 1800 bps
Receiver settings	USB
Signal source(s)	AF, IF

The protocols are compatible with the OSI model and enable the ground stations and avionics systems on aircraft to communicate with each other in a bit-oriented message format.

HF Data Link employs M-ary Phase Shift Keying (M-PSK) to modulate a carrier centered at RF+1440 Hz, where RF is the nominal HF carrier frequency. The carrier is modulated with 1800 symbols per second (Baud). However, the rate at which user data is transmitted can be selected to be 300, 600, 1200 or 1800 bps.

HFDL air-ground protocols employ a slotted Time Division Multiple Access (TDMA) protocol.

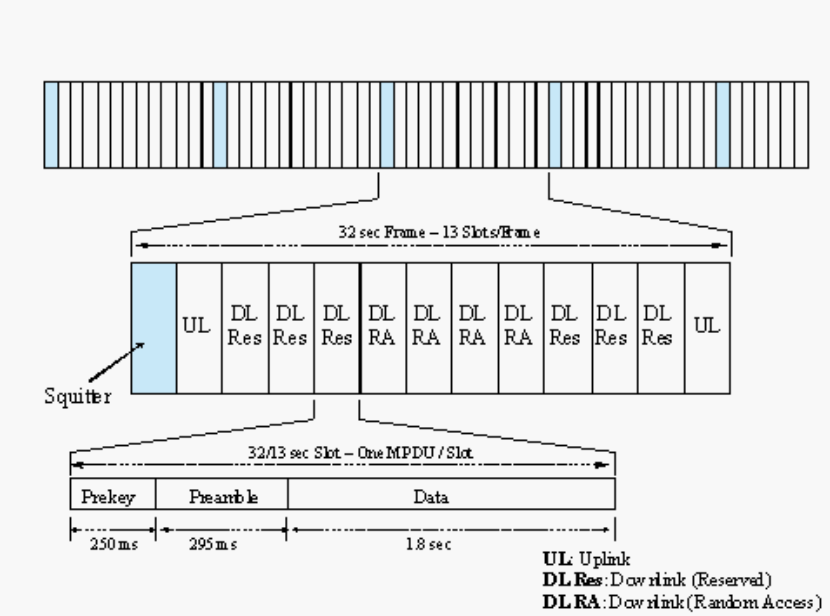
Every frame has duration of 32 seconds and is divided into 13 slots. The first slot is called a Squitter, which carries various types of information, including slot acknowledgement and assignment codes.

The next 12 slots of a frame are called Medium access Protocol Data Units (MPDU). They are used by aircrafts and ground stations to exchange different kinds of data, e.g., aircraft logon/logoff requests, aircraft position, frequency assignment etc. Each MPDU contains several Link Protocol Data Units (LPDU), which may consist of Basic Data Units (BDU).

Each slot (Squitter or MPDU) has the same structure:

Parameter	Value	Remarks
Pre-key	249 ms	1440 Hz single tone
Preamble	295 ms	Known BPSK symbols for synchronization purposes
Data	1.8 sec (single slot) or 4.2 sec (double slot)	Data section structured in data-probe pairs (45 M-PSK symbols each: 30 user data symbols and 15 known BPSK symbols for synchronization purpose)

The following diagram shows the TDMA slotted frame structure.



The HF-ACARS decoder detects each slot with the characteristic pre-key (1440 Hz single tone), uses the preamble to synchronize the slot, eliminates various distortions in the HF communication channel, configures several components of the decoder, demodulates the user data section and decodes it according to the HFDL protocol interpreter.

Each message is finally output on the screen in Squitter (SPDU) format, Uplink MPDU format (from ground station to aircraft) or Downlink MPDU format (from aircraft to ground station).

Only when a HFDL slot is successfully detected, the decoder enters the **Traffic** state, otherwise it remains in the **Sync** state.

Usually an HFDL station sends the signal with USB setting. However the decoder has the possibility to process signals in both USB and LSB settings. This can be done by setting the polarity in the menu neither to NOR for USB and INV for LSB signals.

The center frequency of the decoder should be set to 1440 Hz when the receiver is set to the nominal frequency of the ground station. A small frequency difference will be automatically compensated by the decoder. However, the center frequency can be tuned by ±400 Hz from its nominal setting.

There are two internal system configuration files for the display of HFDL messages, hfacars.txt and hfacars.dat. These files should not be modified by the user.

HNG-FEC

HNG-FEC uses a 15 bit code, the first 5 bits corresponding to the ITA-2 alphabet. The first and last bits of this code word are inverted (Inv, Nor, Nor, Nor, Nor, Inv). The remaining 10 bits are used for error detection and correction. Error correction is done by table look up of the character which closest matches the one that was received in error.

Parameter	Value
Frequency range	HF

Parameter	Value
Operation modes	Broadcast /Simplex FEC
Modulation	FSK
Symbol rate	100.05 Bd, variable 30-650 Bd
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF
Additional Info	ITA-2 with 10 Bit redundancy

HNG-FEC operates at a symbol rate of 100.05 Baud on the radio link.

HNG-FEC employs bit spreading (interleaving) with a distance of 64 bits, each new character starting at intervals of 15 bits. The software synchronizes to traffic as well as idle bit patterns. The idle binary bit pattern is given by 110 100 110 010 011.

Transmission reliability for HNG-FEC is good with the code spread offering additional immunity against burst errors.

HNG-FEC is started by clicking the **Auto** button or by selecting a **Baudrate** in the **Demodulator** menu. By toggling the **ECC** item in the **Options** menu error correction may be enabled or disabled.

ICAO SELCAL

ICAO selective calling was initially defined in 1985 using twelve tones (Tones "A" to "M", but without tone "I"). In 1994 the ICAO calling system, also known as ANNEX10, was extended with the additional tones "P", "Q", "R" and "S" and now operates with 16 tones.

Parameter	Value
Frequency range	HF
Operation modes	Analogue Selcal
Symbol rate	1000 ms
Modulation	USB
Receiver settings	USB
Input format(s)	AF, IF

The allocation of selective call addresses is exclusively managed by Aeronautical Radio, Inc. ARINC (ICAO Designator Selcal Registry).

Each address consists of two pairs of tones, e.g., "AB-CD". Both pairs have a duration of 1,000 ms. Between each pair an interval of 200 ms is inserted. ICAO Selcal is used on all frequency bands (HF and VHF/UHF).

ICAO Selcal Tone Allocation

Designation	Frequency (Hz)	Designation	Frequency (Hz)
RED "A"	312.6	RED "J"	716.1
RED "B"	346.7	RED "K"	794.3
RED "C"	384.6	RED "L"	881.0
RED "D"	426.6	RED "M"	977.2
RED "E"	473.2	RED "P"	1083.9
RED "F"	524.8	RED "Q"	1202.3
RED "G"	582.1	RED "R"	1333.5
RED "H"	645.7	RED "S"	1479.1

LINK-11 (CLEW and SLEW)

Link-11 is specified under STANAG-5511 (Standardization Agreement) by NATO Standardization Agency (NSA), titled Tactical Data Exchange Link-11 / 11B.

Link-11 is an automatic high-speed HF / UHF data link exchanging picture compilation, command status and control information. Link-11B is an automatic high-speed multimedia point-to-point data link exchanging picture compilation, command status and control information. Both are also known as Tactical Digital Information Link (TADIL).

There are two types of transmission waveform: Link-11-CLEW – Conventional Link Eleven Waveform and Link-11-SLEW – Serial-tone Link Eleven Waveform.

Link-11-CLEW (Conventional Link Eleven Waveform), also known as TADIL-A, is a transmission mode used mostly in the HF band to run a tactical digital information network. This mode is specified by the US Department of Defense (DoD) in MIL-STD-188-203-1A (on 8th January 1988) and later promulgated in STANAG-5511 (on 28th February 2006).

Parameter	Value
Frequency range	HF
Operation modes	Multi-carrier, DQPSK
Symbol rate	75 Bd or 45.45 Bd
Modulation	16-tone, DQPSK
Receiver settings	USB
Shift/Bandwidth	2310 Hz
Center	1650 Hz
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF

Link-11-CLEW has 16 carriers: one Doppler tone at 605 Hz; 14 data carriers starting at 935 Hz with tone distance of 110 Hz and the 16th carrier at 2915 Hz is used for data and synchronization, see table below. Except the Doppler tone, other carriers are DQPSK modulated at the symbol rate of 75 or 45.45 Baud.

Data is transmitted in two 30-bit frames, each consisting of 24 information bits and 6 error detection and correction bits (Hamming code). The information message is essentially a 48-bit word. A frame is transmitted in parallel on 15 multiplexed tones. Diversity is available as required by identical transmissions of independent side bands.

Number	Frequency (Hz)	Description	Bit location
1	605	Doppler	-
2	935	Data	0 and 1
3	1045	Data	2 and 3
4	1155	Data	4 and 5
5	1265	Data	6 and 7
6	1375	Data	8 and 9
7	1485	Data	10 and 11
8	1595	Data	12 and 13
9	1705	Data	14 and 15
10	1815	Data	16 and 17
11	1925	Data	18 and 19

Number	Frequency (Hz)	Description	Bit location
12	2035	Data	20 and 21
13	2145	Data	22 and 23
14	2255	Data	24 and 25
15	2365	Data	26 and 27
16	2915	Data / Sync	28 and 29

There are 5 frame formats:

- DNCS IM: Data Net Control Station Interrogation Message
- DNCS IWM: Interrogation with Message.
- PRM: Picket Reply Message. Picket is the switch setting of the Link-11 terminal equipment in a TDS (Tactical Data System)
- SB: Short Broadcast
- Net Test

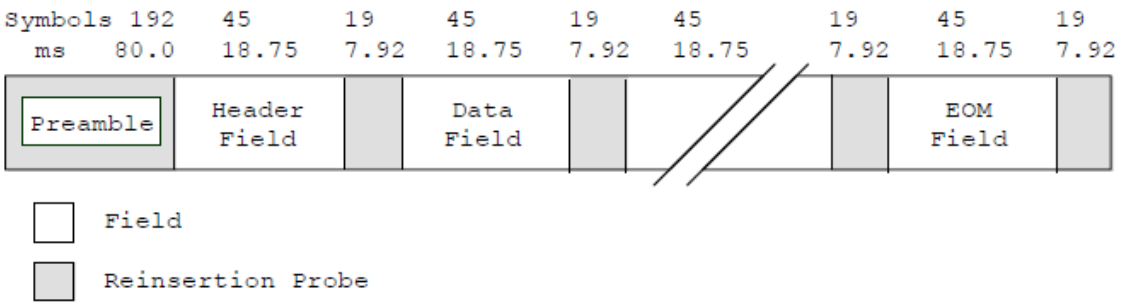
To decode LINK-11-CLEW, choose the correct **Polarity**, put the Doppler Tone cursor in the FFT tuning window to the Doppler tone. Small frequency error (+/- 30 Hz) and Doppler shift will be corrected automatically and displayed in the **Freq Err/Doppler Shift** field. The data is displayed in the main text window. Because the mode transmits link information, the data is displayed in a 30-bit group hex.

The frame format is displayed together with the baudrate in the **Format** field. **Confidence** shows the decoding quality: a value over 95 means the FEC has probably corrected all bit errors, the data decoded is mostly reliable.

Link-11-SLEW is a transmission mode with a single carrier (at 1800 Hz) modulated by QPSK data symbol at a rate of 2400 baud.

Parameter	Value
Frequency range	HF
Operation modes	Single-carrier, QPSK
Symbol rate	2400 Bd
Modulation	QPSK
Receiver settings	USB
Shift/Bandwidth	2600 Hz
Center	1800 Hz (carrier frequency)
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF

The SLEW waveform transmission format consists of an acquisition preamble followed by two or more fields. Each field is followed by a reinsertion probe. The first field follows immediately after the preamble. The first field is the header field and contains information that is used by the Combat Data System (CDS) and the encryption device. If a PU (Participating Unit) has data to transmit, successive data fields follow the reinsertion probe of the preceding fields. These data fields consist of track data and other user data. The last field to be transmitted is the end-of-message (EOM) field. The transmission ends with a reinsertion probe.



The preamble is 80 ms long, it consists of a 192 tri-bit known sequence generated from a pseudo random code.

The reinsertion probe (7.92 ms) contains a known sequence of 19 tri-bits (all zero) symbols and shifted by a scrambler. The probe is inserted between fields and used by a receiving PU to track the channel conditions, thus permitting adjustments to coefficients within the adaptive equalizer.

A field contains a data sequence conveying information originating from either CDS or the Data Terminal (DT). The data from these sources are accommodated using three different types of fields. These are the header field, the CDS data field and the EOM field. Each field is 18.75 ms long and consists of 45 QPSK symbols (90 bits). The 90-bit sequence consists of 78 data bits and 12 CRC bits for error detection. The 78 data bits are the output of a Full Tail Biting Convolutional Block Encoder (FTBCB) at the rate of 1/2 (for header field) or 2/3 (for data field).

There are two SLEW transmission types.

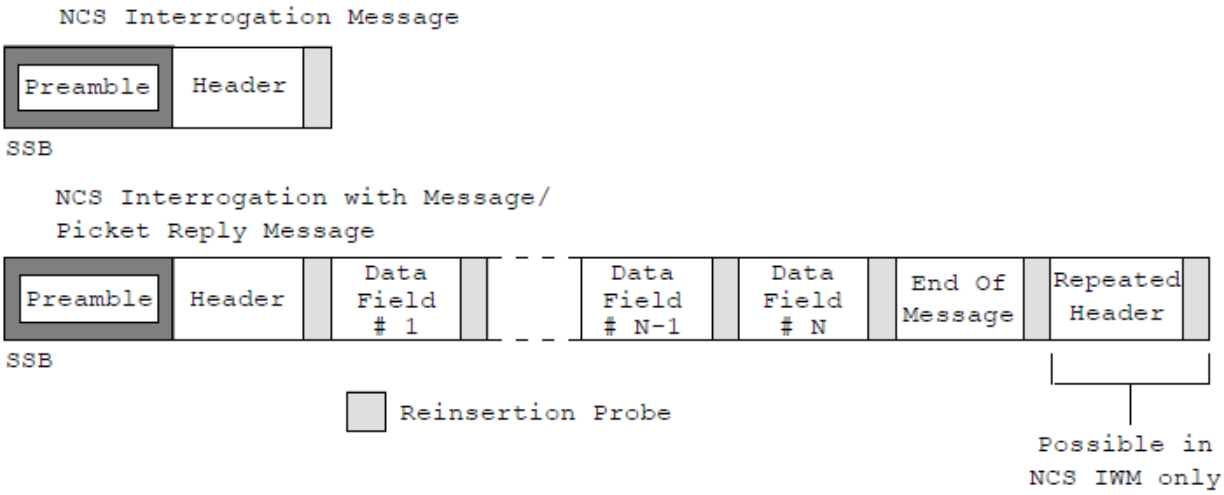
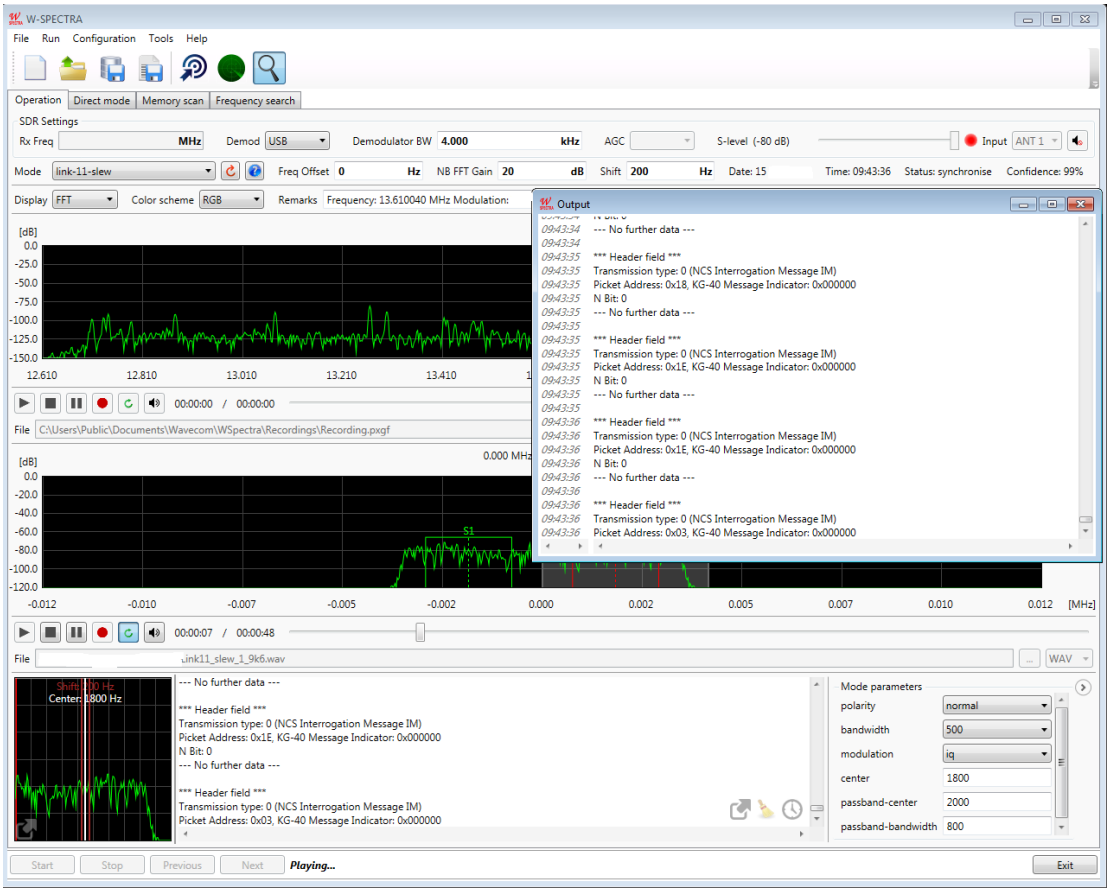


FIGURE B-12 SLEW Transmission Types

The first type of transmission is the NCS (Net Control Station) Interrogation Message (IM). This transmission is only initiated by the NCS. It comprises a preamble and a header fields. The transmission does not include any CDS data fields or an EOM field. The second type of transmission is the NCS IWM (NCS Interrogation with Message) or picket reply message. This type of transmission can be initiated by either the NCS or a picket. It comprises a preamble, one header field, several CDS data fields and an EOM field. In NCS IWM the tripplet – header, data and EOM – can appear directly after a reinsertion probe, without a new preamble.

To decode LINK-11-SLEW, choose the correct **Polarity**, set the correct **Center** using the FFT tuning window. Frequency error (+/- 80 Hz) will be corrected automatically and the true signal center will be displayed in the **Carrier** field. The data will be displayed in the main text window. Frames with CRC error will be displayed in red.

Confidence shows the decoding quality: a value over 95 means the FEC has probably corrected all bit errors, the data decoded is mostly reliable.



MD-674 ASYNC

MD-674 is an asynchronous FSK system and is based on ASCII. No error detection or error correction is implemented.

Parameter	Value
Frequency range	HF
Operation modes	Broadcast
Modulation	FSK
Center frequency	1275 Hz
Shift	85 Hz
Symbol rate	50, 75, 100 and 150 Bd
Modulation	FSK
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF
Additional Info	Async FSK only

For MD-674 mode standard baud rates from 50 to 150 Bd are available. Non-standard baud rates may be selected using the **Baudrate** menu item.

From "**Options | Alphabet...**" ITA5 and ITA2 are available as output formats.

MD-674 is also known as Wireline FSK.

METEOSAT

The METEOSAT software has been specifically tailored to the transmissions of meteorological satellites parked in geo-stationary orbit at 0.2 degrees East and transmitting on 1691.0 MHz. Transmissions are always at 240 rpm using an IOC of 288. In contrast to short-wave stations which use frequency modulation, satellite weather images are transmitted using amplitude modulation. For this purpose the decoder is fitted with a DSP AM demodulator with an integrated software FIR low-pass filter.

Parameter	Value
Frequency range	VHF/UHF
Operation modes	Broadcast
Modulation	FM, SUB AM
Speed	240 RPM
Receiver settings	FM BW = 40 kHz
Input format(s)	AF
Additional Info	IOC 288

The software is started in automatic mode by clicking on the **Auto** button or on **Drum speed** for manual mode. In manual mode the correct display of the image is controlled using the **Phase** function in the **Options** menu.

The special items **AM-Gain** and **AM-Offset** are placed in the **Demodulator** menu. Centering of the signal deviation on the bar graph is controlled by adjusting **AM-Offset**. In addition maximum deviation is required on the bar graph. This is done by adjusting **AM-Gain**. It should be noted that these two adjustments are influenced by each other.

Meteosat reception requires a parabolic reflector and receiver. The AF output of the receiver may be fed directly into the decoder, which converts it into a weather image viewing station providing excellent image quality.

The decoder allows a continuous and smooth alignment of the image as it is being received from **Options/Fine Speed**. By using the **Phase** item in the **Options** menu the image can be shifted into the correct position. **Flip Left-Right** and **Flip Top-Down** will reverse the image or turn it upside down.

MFSK-20

MFSK-20 is a sequential 20 tone mode, which is optimized for the transmission of numeric codes. MFSK-20 is similar to SP-14 and AUM-13.

Parameter	Value
Frequency range	HF
Operation modes	FSK, Broadcast/Simplex
Modulation	MFSK-20
Speed	100 ms, 50 ms
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF

Most of the tones have been assigned a character:

- 10 tones are assigned to the numerals 0..9
- One tone is used as an idle character
- One tone is used as a space character
- One tone is used as a repetition indicator
- Six tones are assigned to characters

All other tones are undefined.

A transmission is initiated with a start sequence, which identifies this mode and may be used for accurate tuning. This sequence is transmitted at 1 Baud, which makes it readable even during very unfavorable conditions.

The data is transmitted at a rate of 10 or 20 Baud. A block synchronization sequence is initially transmitted followed by the five digit code words. If more than one block is transmitted, a block synchronization sequence is inserted between the different blocks. As the transmission rate is very low this mode is insensitive to fading and multipath propagation.

MFSK-8 and MFSK-16

MFSK-8 and MFSK-16 are multi-frequency shift keying digital transmission modes. MFSK-8 uses a set of 8 tones with the equal distance of 7.81 Hz, MFSK-16 a set of 16 tones with the equal distance of 15.625 Hz. The baud rate of MFSK-8 is 7.81 Bd and that of MFSK-16 is 15.625 Bd.

Parameter	Value
Frequency range	HF
Operation modes	FEC
Modulation	MFSK-32 / MFSK-16
Symbol rate	7.81 Bd for MFSK-8, 15.625 Bd for MFSK-16
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF
Additional Info	MFSK Varicode

Both modes are used to transmit text file (ASCII file). The ASCII character is first converted to Varicode, which encodes frequently used characters to short length bit combinations and less frequently used characters to longer length bit combinations. For example, 'e' is mapped to '1000' and 'Z' is mapped to '110111000'.

The Varicode bit stream is then coded with a FEC (Forward Error Correction) algorithm. To combat frequency fading problems during the transmission, the FEC bit stream is interleaved before it is assigned to tones (source coding).

In both decoders only the center frequency needs to be tuned.

After the center frequency is set, the decoder first synchronizes, most importantly, to the polarity of signal. This takes for MFSK-8 between 5 and 40 seconds, for MFSK-16 between 2 and 7 seconds – this mainly depends on the baud rate of the mode. During the sync phase no text will be output on the screen.

After the decoder is synchronized, it enters the **Traffic** state, and a text file will be output on the screen. The synchronization is maintained as long as the MFSK signal is stable. When the noise is too strong or the signal disappears, the decoder begins to resynchronize – the status changes from **Traffic** to **Sync**.

Tuning a MFSK-8 and MFSK-16 Signal

The only tuning parameter in MFSK-8 and MFSK-16 signal is the center frequency. Set **Peak Hold** to **Max Hold** using the Options menu. After all tones are displayed, determine the minimum and maximum frequency of the tone set using the cursors. With the center cursor the center frequency may be set more accurately. Especially for MFSK-8 the center frequency needs to be set precisely, because the tone distance is only 7.81 Hz.

After the decoder has been synchronized, it enters the **Traffic** phase. The polarity status field on top indicating "N" (for Normal) or "I" (for Inverse) shows whether the MFSK signal is USB (Upper Side Band) or LSB (Lower Side Band). The transmitted text file is output in the window.

MIL-188-110-16Tone (MIL-188-110A/B Appendix B)

MIL-188-110-16Tone is a non-mandatory part of the MIL-STD-188-110 military standard for use by all departments and agencies of the Department of Defense.

Parameter	Value
Frequency range	HF
Operation modes	Simplex
Modulation	16 tone DPSK Doppler Tone: 605 Hz, Freq1: 935 Hz, ... Freq16: 2585 Hz. Shift 110 Hz
Symbol rate	75 Bd
Center frequency	1760 Hz
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF

BINARY, HEX and ASCII output are provided.

MIL-188-110-39Tone (MIL-188-110A/B Appendix C)

MIL-STD-188-110 39 Tone is a non-mandatory part of the MIL-STD-188-110 military standard for use by all departments and agencies of the Department of Defense.

Parameter	Value
Frequency range	HF
Operation modes	PSK, Simplex
Modulation	39 tone Q-DPSK
Symbol rate	44.44 Bd
Center frequency	1800 Hz
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF

Definition

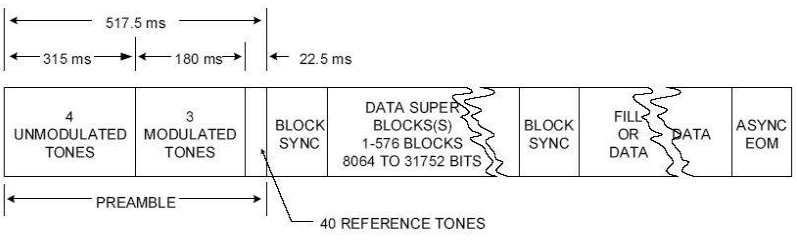
The modulation technique used in this mode consists of differential quadrature phase shift keying (QDPSK) of 39 orthogonal sub carriers in the range from 675Hz to 2812.5 Hz, and an additional unmodulated Doppler reference tone at 393.75Hz.

The modulation speed (symbol rate) is always 44.44 Bd. Through the transmission of redundant information on certain tones, different user data rates can be achieved within a range of 75 to 2400 bps.

This mode uses FEC and interleaving to combat the effects of fading, frequency shift, multipath, and burst noise.

The user data is transmitted using a continuous frame structure with a variable block length (number of symbols), depending on user data rate and message type.

Each transmission starts with a preamble, consisting of three phases, followed by block synchronization and data segments. The data block immediately follows the next block synchronization segment defining again the start of the next data block. This repeated frame structure enables synchronization of the demodulator at any time of transmission.



The end of transmission is determined by an EOM sequence (at least ten ones "1").

Data Display

There are two different types of data transmissions - synchronous and asynchronous.

In the synchronous data mode, the data is bit synchronously displayed as 7 bit characters, while in the asynchronous mode, different character lengths are possible using start, stop and parity bits. The parity, start and stop bits, as well as the special "null" characters, inserted by the modem and not being part of the data stream, are ignored by the display.

The decoder stops displaying data after the EOM sequence is received and goes to **Sync** state and resynchronizes.

In **Options/Frame Format** the user data rate and interleaver length can be set.

In **Options/Diversity** a value between **Time / Frequency** and **Frequency Only** diversity can be selected. The value must be set correctly for all user data rates except 2400 and 1200 bps.

In **Options/Message Type** all the different character lengths and number of extracted data bits can be set.

Tuning the decoder

The **Polarity** of the decoder should be set according to the signal. When the received signal is in **NOR** polarity (USB), the Doppler frequency should be tuned to 393.75 Hz using the **Offset**, all the 39 tones are at the right side of the Doppler tone; when the signal is in **INV** polarity (LSB), the Doppler frequency should be tuned to 3206.25 Hz using the **Offset**, with all the 39 tones at the left side of it.

The correct decoding process is indicated by a **Confidence** value, with 100 for a 100% correctly decoded message. However, finally getting a useful data output can only be achieved by selecting the proper message type, frame format (user data rate / interleaver), diversity and signal center.

MIL-188-110A

MIL-188-110A Serial (single tone) is one of the most popularly used modes in long-haul HF data modems. The mode is specified by the US Department of Defense (DoD) in the "Military Standard Interoperability and Performance Standards for Data Modems" (30. Sept. 1991).

Parameter	Value
Frequency range	HF
Operation modes	Unprotected/FEC
Modulation	8-PSK
Symbol rate	2400.0 Bd
Center frequency	1800 Hz
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF

This mode employs 8-ary phase shift keying (PSK) on a single carrier frequency (1800 Hz) as the modulation technique for data transmission. Serial binary information (raw data) accepted at the line side input is converted into a single 8-ary PSK-modulated output carrier. The modulation of this output carrier is a constant 2400 Baud waveform regardless of the actual user data rate.

MIL-188-110A single tone waveform has the following characteristics:

Baud-rate	User data rate (bps)	FEC coding rate	Interleaver	No. of unknown 8-phase symbols, (User Data)	No. of known 8-phase symbols, (Channel Probe)
2400	4800	No coding	ZERO (No interleaver)	32	16
2400	2400 (Data)	1 / 2	SHORT or LONG	32	16
2400	2400 (Voice)	1 / 2	SHORT	32	16

Baud-rate	User data rate (bps)	FEC coding rate	Interleaver	No. of unknown 8-phase symbols, (User Data)	No. of known 8-phase symbols, (Channel Probe)
2400	1200	1 / 2	SHORT or LONG	20	20
2400	600	1 / 2	SHORT or LONG	20	20
2400	300	1 / 4	SHORT or LONG	20	20
2400	150	1 / 8	SHORT or LONG	20	20
2400	75	1 / 2	SHORT or LONG	All	0

Each transmission of a MIL-188-110A message begins with a synchronization phase (preamble) – 0.6 seconds for message with ZERO or SHORT interleaver setting and 4.8 seconds for a message with LONG interleaver setting – followed by the data phase, which is of unlimited length. The data phase is structured in User Data – Channel Probe pairs. The phase value of a User Data symbol is unknown, whereas the Channel Probe has a predefined phase pattern.

Preamble (0.6 s or 4.8 s)	Interleaver 1	Interleaver 2	Interleaver 3	...	Interleaver N

The FEC and interleaver are used to combat the effects of fading, frequency drift, multi-path effects, and burst noise affecting the HF transmission. The known 8-phase symbols – the Channel Probe – are transmitted to keep the receiver, mainly the equalizer, on track. Thus the receiver can be resynchronized without the preamble being regularly repeated.

The MIL-188-110A decoder processes all the above settings except 2400 bps voice. Generally MIL-188-110A user data is transmitted in binary mode, i.e., in a transparent mode. Thus upper protocols layers are required to further process this data stream. For this reason the decoder displays the user data **BINARY, HEX**, **ASCII ASYNC** or **ASCII SYNC** format selected from **Options/Message Type...**.

In the **HEX** display mode, the decoded binary data is just displayed as it is.

In **ASCII ASYNC** mode, the bit stream is searched with an ASCII ASYNC structure, i.e., one start-bit (0), 8 data-bits and at least one stop-bit (1). The 8 data bits are transmitted with the LSB first. The display is stopped when more than 3 NULL characters are received or when the asynchronous data structure is violated more than 8 times.

In **ASCII SYNC** mode, each 8 bits (LSB first) represent one ASCII character.

Tuning the Decoder

The decoder processes signal in both SSB settings: USB and LSB. This can be selected with **Polarity** in the menu: NOR means USB and INV means LSB signal.

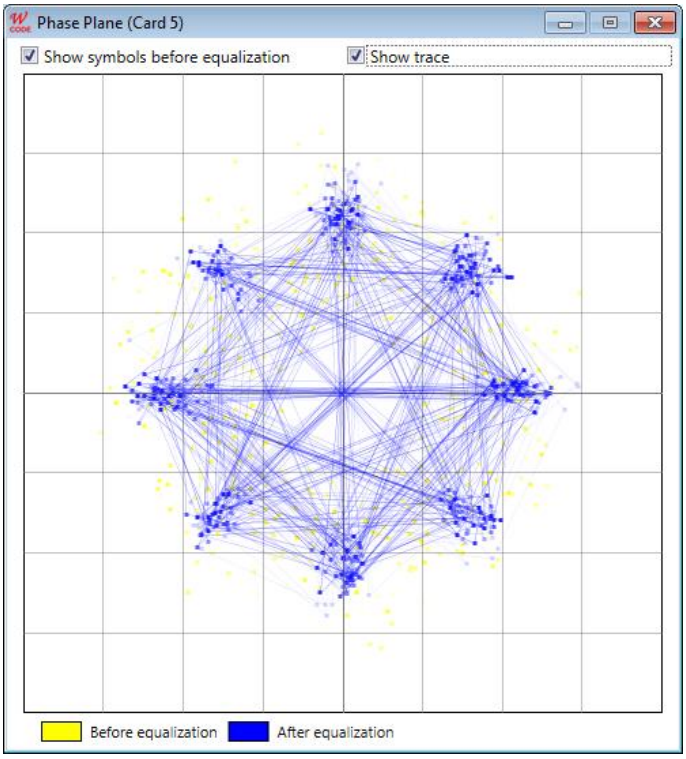
The center frequency of the decoder should be set to 1800 Hz when the receiver is correctly tuned to the transmitting station. Small frequency variations are automatically compensated in the decoder. The center frequency of the decoder can be adjusted to ±400 Hz from its normal setting. By using the bar-graph, any remaining frequency difference can be compensated by fine tuning of the receiver frequency or by adjusting the center frequency of the decoder.

On-going Synchronization

The decoder synchronises both on the preamble and on the probe sequence. This on-going feature makes sure that the decoder will synchronise at any time of the transmission.

Dedicated Phase Plane

The decoder uses an equalizer to demodulate the high-speed PSK signal. To visualize the power of equalizer, user can turn on the dedicated phase plane in **Options** –> **Show Phase Plane**. The points in yellow is after synchronization befor the equalizer and points in blue is after the equalizer.



MIL-188-110A-MOD

MIL-188-110A-MOD is a modified version of the popular MIL-188-110A mode.

Parameter	Value
Frequency range	HF
Operation modes	Unprotected
Modulation	8-PSK
Symbol rate	2400 Bd
Center frequency	1800 Hz
Receiver settings	LSB or USB
Input format(s)	AF, IF

Like MIL-188-110A, this mode employs 8-ary phase shift keying (PSK) on a single carrier frequency (1800 Hz) as the modulation technique for data transmission. The carrier modulation is a constant 2400 Baud waveform.

Each transmission of a MIL-188-110A-MOD message begins with a 267 ms long synchronization phase (preamble) followed by the data phase, which is of unlimited length. The data phase is structured in User Data (20 unknown 8-PSK symbols) – Channel Probe (20 known 8-PSK symbols) pairs.

The MIL-188-110A-MOD decoder demodulates the waveform and displays the raw demodulated output in **HEX** format.

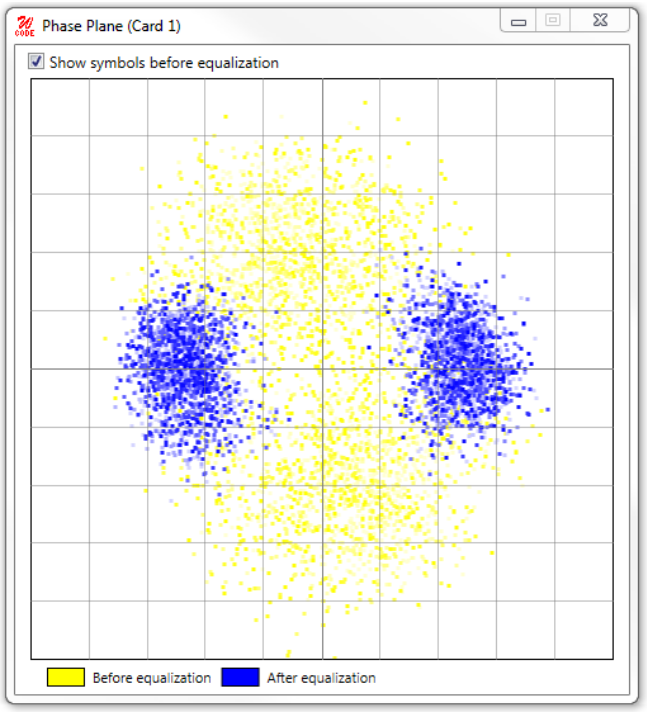
Tuning the Decoder

The decoder processes signals in both SSB settings: USB and LSB. This can be selected with **Polarity** in the menu: NOR means USB and INV means SSB.

The center frequency of the decoder should be set to 1800 Hz when the receiver is correctly tuned to the transmitting station. Small frequency variations are automatically compensated in the decoder. The frequency of the decoder can be adjusted to ±400 Hz from its normal settings. By using the bar-graph, any remaining frequency difference can be compensated by fine tuning of the receiver frequency or by adjusting the center frequency of the decoder.

Dedicated Phase Plane

The decoder uses an equalizer to demodulate the high-speed PSK signal. To visualize the power of the equalizer, the user can turn on the dedicated phase plane in **Options** -> **Show Phase Plane**. The points in yellow refer to data symbols before equalization, whereas the blue points refer to data symbols after equalization.



MIL-188-110B (Appendix C), STANAG 4539

The MIL-STD-188-110B "Interoperability and Performance Standards for Data Modems", published on 27th April 2000 by the US Department of Defense (DoD) includes in its appendices different kinds of modem waveforms. The Appendix C defines the HF data modem waveforms and coding specifications for data rates above 2400 bps, i.e., for data rates of 3200, 4800, 6400, 8000 and 9600 bps. Uncoded operation at 12800 bps is a DO (Design Objective). The single-tone waveforms specified use 8-PSK, 16-, 32- and 64-QAM on a single carrier frequency (1800 Hz) as the modulation techniques. The waveform has a unique symbol rate of 2400 Bd. Together with a constraint length 7, rate 1/2 convolutional code (FEC), punctured to rate 3/4, the various effective user data rates (except 12800 bps) are realized. A linear interleaver is used to redistribute the FEC coded user data bits of a certain block length ranging from 0.12 sec to 8.64 sec, thus producing a delay in the data transmission.

Parameter	Value
Frequency range	HF
Operation modes	PSK, Broadcast/Simplex FEC
Modulation	8-PSK, 16-QAM, 32-QAM and 64-QAM
Symbol rate	2400.0 Bd
Center frequency	1800 Hz
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF

This mode is equivalent to NATO STANAG 4539.

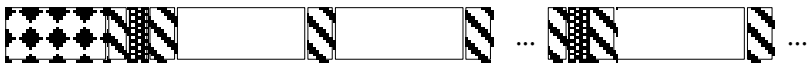
MIL-188-110B Appendix C single-tone waveform has the following characteristics:

Baud rate	User data rate (bps)	Inter leaver	Modulation (bit per symbol)	FEC coding rate	No. of un-known sym-bols (User Data)	No. of known 8-PSK sym-bols (Channel Probe)
2400	3200	variable	QPSK (2)	1/2, punctured to 3/4	256	31
2400	4800	variable	8-PSK (3)	1/2, punctured to 3/4	256	31
2400	6400	variable	16-QAM (4)	1/2, punctured to 3/4	256	31
2400	8000	variable	32-QAM (5)	1/2, punctured to 3/4	256	31
2400	9600	variable	64-QAM (6)	1/2, punctured to ¾	256	31
2400	12800	N/A	64-QAM (6)	N/A	256	31

Variable Interleaver

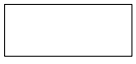
- Ultra short
- Very short
- Short
- Medium
- Long
- Very long

Each transmission of a MIL-188-110B message begins with a synchronization phase (preamble) which includes 287 8-PSK symbols. In the preamble the modem setting, i.e., user data rate and interleaver size, is coded. This auto baud feature should be used to configure the modem to decode the data bits. After the preamble the user data bits are transmitted in blocks of 256 symbols paired with 31-symbol mini-probe blocks. After 72 user data – mini-probe pairs a 103-symbol mini-preamble is inserted. The number of data blocks in a transmission is in principle unlimited. A unique bit pattern (in hexadecimal number, 4B65A5B2, MSB first) is sent to mark the end of message (EOM). The EOM sequence is followed by flush bits, for flushing the FEC coder and for the complete transmission of the remainder of the interleaver data block





Initial Synchronization Preamble – 287 symbols



Data Block – 256 symbols



Mini-probe – 31 symbols



Regularly Re-inserted Mini-Preamble – 103 symbols

The FEC and the interleaver are used to combat the effects of fading, frequency drift, multi-path effects, and burst noise etc. in the HF transmission. The mini-probe and regularly re-inserted mini-preamble are transmitted to help keep the receiver synchronized.

The MIL-188-110B decoder processes all the above settings except 12800 bps. This setting is usually not to be used for reliable data transmission, because it has neither FEC nor interleaving. Generally MIL-188-

110B transmits the user data in binary mode, i.e., it does not care which type of data is transmitted. This should be defined by the protocol layer using the MIL-188-110B mode. For this reason the decoder just displays the user data in **BINARY, HEX**, **ASCII ASYNC**, **ASCII ASYNC (7 Data bits and 0 Stop bit)** or **ASCII SYNC** format which may be selected from **Options/Message Type...**. The decoder stops displaying data after the EOM bit pattern is received.

In the **HEX** display mode, the decoded binary data is just displayed as is, MSB first. Display is terminated when more than 25 NULL hexadecimal characters have been received.

In **ASCII ASYNC** mode, the bit stream is searched with an ASCII ASYNC structure, i.e., one start bit (0), 8 data bits and at least one stop bit (1). The 8 data bits are transmitted LSB first. In addition to the EOM pattern, the display will stop if more than 300 NULL characters are received or if the async data structure is violated more than 80 times.

In **ASCII ASYNC (7 Data bits and 0 Stop bit)** mode, the bit stream is searched with another ASYNC structure, i.e., one start bit (0), 7 data bits. The 7 data bits are transmitted LSB first. In addition to the EOM pattern, the display will stop if more than 300 NULL characters are received.

In **ASCII SYNC** mode, each 8 bits (LSB first) represent one ASCII character. The display will stop if the EOM pattern is received or if more than 20 NULL characters are received.

Tuning the decoder

The decoder processes the signal in both SSB settings: USB and LSB. The sideband can be selected with the **Polarity** option in the menu: **NOR** means USB and **INV** means LSB signal.

The center frequency of the decoder should be set to 1800 Hz when the receiver is correctly tuned to the sending station. Small frequency variations are automatically compensated for in the decoder. The center frequency of the decoder can be adjusted to ± 400 Hz from its normal setting. By using the bar graph, any remaining frequency difference can be compensated for by fine-tuning of the receiver frequency or by adjusting the center frequency of the decoder.

Dedicated Phase Plane

See "MIL-188-110A" on page 134.

MIL-188-141A

MIL-188-141A Standard, also known as Automatic Link Establishment (ALE), specified by the US Department of Defense in September 1988 and with two Change Notices in June 1992 and September 1993, is a procedure whereby radio stations are able to automatically set up their link thus eliminating the need for skilled operators - in fact the growing lack of trained and experienced staff was a driving force behind the idea of ALE.

In March 1999 MIL-188-141A was integrated into the new specification MIL-188-141B, Appendix A. The message protocol was thereby extended slightly.

Parameter	Value
Frequency range	HF
Operation modes	Broadcast/Simplex FEC
Modulation	MFSK-8
Symbol rate	125.0 Bd
Center frequency	1800 Hz
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF

A station will transmit a link quality burst which may or may not contain the address of another station on a series of pre-assigned frequencies. The listening station(s) will continuously scan through these frequencies. During scanning the receiving station will perform a link quality analysis and measure signal to noise ratio and bit error ratio. These measurements are used to set up a table in memory of link quality assessments for each station and frequency.

Based on the values of the table, the best frequency available is selected when the station wishes to transmit. When the ALE controller of a receiving station hears its own address (or the address of the group

to which it belongs) it will stop the scanning and respond to the call. The stations will then either switch to a low speed data exchange mode or to a high speed data (FSK or PSK) modem or to voice mode.

The MIL-188-141A signal is an 8-tone MFSK signal in the range 750 - 2500 Hz spaced 250 Hz apart. Each tone (symbol) is 8 ms long corresponding to 125 Baud and represents three bits giving a bit rate of 375 bps.

The MIL-188-141A bit-stream is structured in 24-bit frame, which includes three bits preamble for the frame type and three 7-bit ASCII characters or just 21 bits unformatted binary data.

To increase robustness the 24-bit frame is Golay (24, 12) encoded, and then interleaved giving a total frame length of 48 bits + 1 stuff bit. Each 49-bit code word is transmitted three times one after another to combat burst interference.

In both specifications, especially according to MIL-188-141B Appendix B, the 21-bit ALE frame data can be encrypted before transmission. This feature is named Link Protection. The data may be encrypted according to different classified application levels: AL-1 to AL-4. Unencrypted data is transmitted with AL-0.

The MIL-188-141A mode decoder processes the signal automatically after the center frequency is set. It synchronizes the signal in both USB and LSB polarities. There are two display modes selected the in **Display Mode** menu: **All Frames** and **Valid Frames Only**. The first option just displays the frames without checking if the ALE protocol is strictly observed; the second option displays the frames according to the ALE protocol defined according to MIL-188-141B (Appendix A), which is backwards compatible to MIL-188-141A. In both options the frame data can be displayed in **ASCII**, **HEX** or both **ASCII and HEX** formats. This can be set by using the **Display** menu.

Only unencrypted data can be displayed correctly with the mode decoder. For protected application data – according to MIL-188-141B Appendix B (Link Protection) – the display may be meaningless, because a user specific key is necessary for data decryption.

MIL-188-141B (Appendix C)

MIL-188-141B Appendix C defines the third generation (3G) high frequency (HF) radio technology including advanced automatic link establishment (ALE), automatic link maintenance, and high performance data link protocols. This advanced technology improves on the performance of previous similar techniques (e.g., 2G-ALE). The specification is issued by the US Department of Defense (DoD) in the "Interface Standard Interoperability and Performance Standards for Medium and High Frequency Radio Systems" (1st March 1999).

Parameter	Value
Frequency range	HF
Operation modes	Broadcast/Simplex FEC
Modulation	8-PSK
Symbol rate	2400 Bd
Center frequency	1800 Hz
Receiver settings	DATA, CW, USB, LSB
Input format(s)	AF, IF

This mode employs 5 constituent burst waveforms BW0 to BW4 for the various kinds of signaling required in the system, so as to meet their distinctive requirements as to payload, duration, time synchronization, and acquisition and demodulation performance in the presence of noise, fading, and multi-path. All of the burst waveforms use the basic 8-ary PSK serial tone modulation of an 1800 hertz (Hz) carrier at 2400 symbols per second (Baud). The same modulation is used in MIL-188-110A serial mode.

The burst waveforms have the following preamble and data structure.

Waveform	Burst duration	Preamble	Payload
BW0	613.33 ms, 1472 PSK symbols	160.0 ms, 384 PSK symbols	26 bits
BW1	1.30667 s, 3136 PSK symbols	240.0 ms, 576 PSK symbols	48 bits

Waveform	Burst duration	Preamble	Payload
BW2	640 + (400 * n) ms, 1536 + (960 * n) PSK symbols, n = 3, 6, 12, or 24	26.67 ms, 64 PSK symbols	1881 * n bits
BW3	373.33 + (13.33 * n) ms, 896 + (32 * n) PSK symbols, n = 64, 128, 256, or 512	266.67 ms, 640 PSK symbols	8 * n + 25 bits
BW4	640.0 ms, 1536 PSK symbols	None	2 bits

The data in the different burst waveforms is used for different purposes:

- BW0 is used for 3G-ALE PDUs (Protocol Data Unit)
- BW1 for traffic management PDUs and HDL (High-rate Data Link Protocol) acknowledgement PDUs
- BW2 for HDL traffic data PDUs
- BW3 for LDL (Low-rate Data Link Protocol) traffic data PDUs
- BW4 for LDL acknowledgement PDUs

The MIL-188-141B decoder processes the waveforms BW0, BW1 and BW4 only, because the configuration (number of data packet, FEC encoding and interleaver) of BW2 and BW3 is negotiated during the peer-to-peer communication, e.g., between two modems.

The decoder displays the payload data of BW0 and BW1 in **BINARY, HEX**, **ASCII ASYNC**, **ASCII ASYNC (7 data bits, 0 stop bit)** and **ASCII SYNC** formats selected from **Options/Message Type**.

In the **HEX** mode the payload data is displayed as it is, MSB first.

In the **ASCII ASYNC** mode the payload data is displayed as ASCII character, i.e., one start-bit (0), 8 data-bits (one ASCII character) and at least one stop-bit (1). The 8 data-bits are LSB first. The display is stopped when 300 NULL (all zero in 8 data-bits) characters are received or if the async data structure is violated more than 80 times.

In the **ASCII ASYNC (7 data bits, 0 stop bit)** the data is displayed in a similar way – one start bit (0), 7 data bits (LSB first) and no stop bit. Also the display terminates when more than 300 NULL characters occur or the async data structure is violated more than 80 times.

In the **ASCII SYNC** mode the payload data is segmented into 8-bit (LSB first) ASCII characters and displayed.

The waveform BW4 has only 2 bits payload data, they are displayed in HEX format (MSB first).

Tuning the decoder

The decoder processes the signal in both SSB settings: USB and LSB. This can be selected with **Polarity** in the menu: NOR means USB and INV means LSB signal.

MIL-M-55529A NB/WB

MIL-M-55529A is an asynchronous FSK system and is based on ASCII. No error detection or error correction is implemented.

Parameter	Value
Frequency range	HF
Operation modes	Broadcast
Modulation	FSK
Symbol rate	50,75, 100 or 110 Bd
Center frequency	2000 Hz
Shift	85 Hz (NB), 850Hz (WB)

Parameter	Value
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF
Additional Info	Async FSK only

For MIL-M-55529A mode standard baud rates from 50 to 110 Bd are available. Non-standard baud rates may be selected using the **Baudrate** menu item.

From **Options | Alphabet**… you can select from different ITA-2 and ITA5 alphabets.

MIL-M-55529A is also known as MD-522 / GRC.

The center frequency of the decoder should be set to 1800 Hz when the receiver is correctly tuned to the sending station. Small frequency variations are automatically compensated in the decoder.

The center frequency of the decoder can be adjusted by ± 400 Hz from its normal setting. By reading the bar graph, any remaining frequency difference can be compensated by fine-tuning of the receiver frequency or by adjusting the center frequency of the decoder.

MOBITEX-1200

Mobitex 1200 is a multiple access packet radio system for wireless communications. Mobitex 1200 operates in the VHF band 76 – 82 MHz in Sweden and around 160 MHz in Finland, using 1200 bps FFSK indirect FM. In Sweden a nationwide system channel is operating on 76.7375 MHz for base-to-mobile communications and on 81.7375 MHz in the opposite direction.

Parameter	Value
Frequency range	VHF
Operation modes	Slotted Aloha TDMA system, full-duplex
Modulation	FM, SUB FFSK
Symbol rate	1200 Bd
Center frequency	1500 Hz
Shift	600 Hz
Receiver settings	Narrow FM, BW = 15 kHz
Input	AF, IF

When traffic is low it is transmitted on the system channel, but if it is heavy the base stations may automatically set up additional traffic channels or local system channels.

The Mobitex 1200 frames consist of a frame header with a unique synchronization word, base station identification, traffic area identification and control flags followed by zero or more blocks of data, max 32 blocks. Each block consists of 6 bytes followed by an error correcting code.

Each system is identified by the unique 4 hexadecimal digit sync word. The sync word is inverted for mobile-base communication.

The first data block – the link header - contains addressing information, frame type id, sequence number, number of blocks in the frame and other control information. Frames can either be data link frames used for the management of traffic or payload data frames called MRM frames. The payload frames contain so called MPAKs, i.e., Mobitex packets which can have a total length of 512 bits. If the message is longer it is split into a number of sequences.

The first payload data block contains MPAK header information: source and destination addresses, subscription flags, packet class and packet type information and a timestamp if they are transmitted in the base-to-mobile direction. The remote terminals do not insert a time stamp, this is done by the network.

The system has four payload packet classes, PSUBCOM for subscriber packet switched communication, PSOSCOM for alert messaging, CSUBCOM for circuit-switched subscriber communication, and DTESERV for service messages.

PSUBCOM will accommodate text (7-bit ASCII text), data (transparent data), status messages (transparent data) and data of higher level protocols like OVLS, identified by a protocol identification byte after the time stamp.

Mobitex 1200 also has voice call ability.

MOBITEX-8000

Mobitex 8000 is a multiple access packet radio system for wireless communications developed from the older Mobitex 1200 bps system. Mobitex 8000 operates in the UHF bands and is found around 420 and 900 MHz in a number of countries using direct 8 kbps GMSK modulation.

Parameter	Value
Frequency range	UHF
Operation modes	Slotted Aloha TDMA system, full-duplex
Modulation	GMSK
Symbol rate	8000 Bd
Shift	± 2 kHz
Receiver settings	Narrow FM, BW = 15 kHz
Input	AF, IF
Additional Info	Mobitex Network Settings, Message Type

The Mobitex 8000 frames consist of a frame header with a unique synchronization word, base station identification, traffic area identification and control flags followed by zero or more blocks of data, max 32 blocks. Each block consists of 18 bytes followed by two CRC bytes.

The data block bytes are protected by a 4-bit (12, 8) Hamming code so each data word is 12 bits long. For further protection the data bits are interleaved. However, the frame header is not interleaved and does not have a CRC sum appended.

Each system is identified by the unique 4 hexadecimal digit sync word. The sync word is inverted for mobile-base communication.

Important: The sync word must be chosen for proper decoding in the **Mobitex network settings** and depends on the Mobitex network provider.

The first data block contains addressing information, frame type id, number of blocks and other control information. Frames can either be data link frames used for the management of traffic or payload data frames called MRM frames. The payload frames contain so called MPAKs, i.e., Mobitex Packets which can have a total length of 512 bits. If the message is longer it is split into a number of sequences.

The first payload data block contains MPAK header information: source and destination addresses, subscription flags, packet class and packet type information and a timestamp if they are transmitted in the base-to-mobile direction. The remote terminals do not insert a time stamp, this is done by the network.

The system has two payload packet classes, PSUBCOM for subscriber packet switched communication and DTESERV for service messages.

PSUBCOM will accommodate text (7-bit ASCII text), data (transparent data), status messages (transparent data) and higher protocol data identified by a protocol identification byte after the time stamp.

MODAT

The entire call number is transmitted by consecutive tones in decade sequence. When two identical digits are to be transmitted consecutively, then an eleventh frequency is used as a repetition identifier.

Parameter	Value
Frequency range	VHF/UHF

Parameter	Value
Operation modes	Analogue Selcal
Modulation	FM, SUB Tones
Receiver settings	FM, BW = 12 kHz
Input format(s)	AF, IF

If there more than two identical digits are to be transmitted the repetition tone is appended to the digit tone (e.g., 22222 is transmitted as f2 fw f2 fw f2, where f2 is the tone for "2" and fw is the repetition tone).

For MODAT mode having nominal tone durations of 40 ms, the duration of a single tone may vary ± 5 ms.

Decoding the selective calls is started by clicking on a system. If transmission and system selection conform, the call sign is displayed on the monitor. In the **Options** menu a **Time stamp** function can be enabled to add date and time to each call.

Tone Allocation

Digit	Hz	Digit	Hz
0	637.5	6	1537.5
1	787.5	7	1687.5
2	937.5	8	1837.5
3	1087.5	9	1937.5
4	1237.5	E (REPETITION)	487.5
5	1387.5	TONE DURATION	40 ms

Fax & MODEMS Half-Duplex

FAX-G3-V.17

Parameter	Value
Frequency range	2-Wire
Operation modes	FAX Modem
Modulation	128QAM, HDX
Speed	14400/12000/ 9600/7200 bps
Input format(s)	AF

Additional information see "Modem and FAX Modes" on page 238.

FAX-G3-V.27ter

Parameter	Value
Frequency range	2-Wire
Operation modes	FAX Modem
Modulation	D8PSK,HDX
Speed	4800 bps
Input format(s)	AF

Additional information see "Modem and FAX Modes" on page 238.

FAX-G3-V.29

Parameter	Value
Frequency range	4-Wire
Operation modes	FAX Modem
Modulation	16QAM, HDX
Speed	9600 bps
Input format(s)	AF

Additional information see "Modem and FAX Modes" on page 238.

FAX-G3-V34hdx

Parameter	Value
Frequency range	
Operation modes	FAX Modem
Speed	Up to 33600 bps
Modulation	Trellis coded QAM, HDX
Input format(s)	AF

Additional information see "Modem and FAX Modes" on page 238.

V.21, BELL103

Parameter	Value
Frequency range	2-Wire
Operation modes	DATA Modem
Modulation	FSK
Speed	300 bps
Input format(s)	AF

Additional information see "Modem and FAX Modes" on page 238.

V.22 / V.22bis, BELL212A

Parameter	Value
Frequency range	2-Wire
Operation modes	DATA Modem
Modulation	DPSK/16QAM
Speed	1200/2400 bps
Input format(s)	AF

Additional information see "Modem and FAX Modes" on page 238.

V.23

Parameter	Value
Frequency range	2-Wire
Operation modes	DATA Modem
Modulation	FSK
Speed	1200 bps
Input format(s)	AF

Additional information see "Modem and FAX Modes" on page 238.

FAX & MODEMS Full-Duplex

V.26 / V.26bis

Parameter	Value
Frequency range	2-Wire
Operation modes	DATA Modem (Full-Duplex)
Modulation	DPSK
Speed	2400 bps
Input format(s)	File (2 channels)

Additional information "Modem and FAX Modes" on page 238.

V.32 / V.32bis

Parameter	Value
Frequency range	2-Wire
Operation modes	DATA Modem (Full-Duplex)
Modulation	4QAM/16QAM/32QAM/64QAM/128QAM (Trellis coded Modulation)
Speed	14400/120009300/7200/4800 bps
Input format(s)	File (2 channels)

Additional information see "Modem and FAX Modes" on page 238.

V.34

Parameter	Value
Frequency range	2-Wire
Operation modes	DATA Modem (Full-Duplex)
Modulation	MD-TCM (Multi-Dimension Trellis Coded Modulation)
Speed	33600/31200/28800/26400/24000/21600/19200/16800 bps
Input format(s)	File (2 channels)

Additional information see "Modem and FAX Modes" on page 238.

V.90

Parameter	Value

Parameter	Value
Frequency range	2-Wire
Operation modes	DATA Modem (Full-Duplex)
Modulation	PCM/TCM
Speed	56000/33600 bps
Input format(s)	File (2 channels)

Additional information see "Modem and FAX Modes" on page 238.

V.92

Parameter	Value
Frequency range	2-Wire
Operation modes	DATA Modem (Full-Duplex)
Modulation	PCM
Speed	56000/48000 bps
Input format(s)	File (2 channels)

Additional information see "Modem and FAX Modes" on page 238.

MPT-1327

Trunked mobile radio makes a limited number of radio channels available for a relatively large number of mobile subscribers by channel sharing and appropriate access and signaling procedures on a control channel. The software monitors control and traffic channels.

Parameter	Value
Frequency range	VHF/UHF
Operation modes	Duplex ARQ TDMA, Dynamic Frame Length Slotted ALOHA
Modulation	FM, SUB FSK
Symbol rate	1200 Bd
Center frequency	1500 Hz
Shift/Bandwidth	600 Hz
Receiver settings	FM BW = 15 kHz
Input format(s)	AF, IF
Additional Info	Channel spacing = 12.5 kHz NZRI

A trunked network is controlled by a fixed base station (TSC - Trunked System Controller). Wide areas requiring radio coverage are divided into cells each of which is controlled by a TSC. The TSCs are connected to a hub and are controlled by a Management Controller. The TSCs register roaming of the mobile units and route traffic to the TSC which is nearest to the subscriber. TSCs may be connected to the public telephone network.

Trunked systems may carry voice or data signals. The mobile unit uses two-channel simplex and the base station full-duplex.

The British MPT-1327 specifications for trunked private land mobile radio systems have won general and de facto acceptance in Europe. MPT-1327 specifies the general signaling features to be used on the trunked system. The system is used in the UK, France, Germany (Chekker, License A), Switzerland (Speedcom) and the Scandinavian countries with national adaptations.

The control channel is divided into the Forward Control Channel from base station to units, and the Return Control Channel from units to base.

The forward control channel may be dedicated (fixed), non-dedicated (any free channel) or the same for all TSC's, which then access the channel in TDMA (time division multiple access).

The return control channel is randomly accessed by the mobiles in timeslots of 106.7 ms (128 bits).

The forward control channel is divided into time slots each carrying two 64-bit code words:

- A Control Channel System Codeword (CCSC), which identifies the system to radio units and provides synchronization to the following address codeword.
- An address codeword, which is the first codeword of any message and defines the nature of the message.

A message consists of a codeword sync sequence, an address codeword and one or more data code words. A codeword contains 48 information bits and 16 check bits. If bit 1 is logical one the codeword is an address codeword, otherwise it is a data codeword.

The more important address code words are:

ALOHA (ALH)

TSC to mobile. Carries information on the number of time slots in the succeeding frame and the channel number of the control channel.

REQUEST (RQS)

Mobile to TSC. Requests for action by the TSC.

AHOY (AHY)

TSC to mobile. General availability check.

ACKNOWLEDGEMENT (ACK)

TSC to mobile, mobile to TSC. Response to RQS or AHY. ACK from TSC also carries ALOHA time slot information.

GO-TO-CHANNEL (GTC)

TSC to mobile. Carries information on traffic channel number allocated for requested call.

The return control channel for the mobile units is accessed randomly using a particular form of the slotted ALOHA protocol. The TSC continuously sends sync messages on the forward control channel to the mobiles inviting random access messages. These TSC messages contain a parameter indicating the number of following timeslots - a frame - available. The mobile unit finds a random slot in the frame for its message. If the messages of two or more units collide, the collision is detected by the TSC which now increases the number of timeslots for the next frame and the mobile units retransmit.

If you select **Fixed stations** AHL messages will be filtered out except for the two following a non-AHL message. This is to prevent the display being flooded by these messages which are the most numerous in the system.

If you select **Mobile stations** all messages in the control channel will be displayed, and the messages which are identical, but have different labels depending on their origin from TSC or mobile, will be labeled with their mobile label.

Error correction may be enabled or disabled by toggling the **ECC** menu item.

A PC generated timestamp may be inserted ahead of the decoded message. Go to the **Options** menu and enable the **Time stamp** function.

Here are a few examples of the most frequent MPT messages monitored on the Forward Control Channel transmitted by the TSC. The most common message is ALH, a general invitation to transmit any single codeword message:

ALH(P:42,I1:5461,CH:3,WT:6,M:0,N:4).

Invitation to all mobile units belonging to group **42-5461 (P:42,I1:5461)** to transmit. The message is sent on control channel **3 (CH:3)**, the TSC responses may be delayed by **6** slots **(WT:6)**, **no** subdivision of the radio population is enabled **(M:0)** and the next frame contains **4** random access timeslots **(N:4)**.

A radio unit calls another unit with the same prefix:

AHY(P:79,I1:760,I2:770,D:0,P:0,CHK:1,E:0,AD:0).

General availability check on the called **(D:0)** unit **760 (I1:760)** sent before allocating a traffic channel. The TSC is checking if the called unit is ready for a data call **(CHK:1).** The calling party **770 (I2:770)** is requesting a non-emergency transaction. No data codeword **(AD:0)** is appended to this AHY message.

GTC(P:79,I1:760,CH:427,I2:770,N:0).

Calling unit **770** and called unit **760** are directed to proceed with traffic on channel **427 (CH:427)**. The next frame contains **no** timeslots **(N:0)**.

A broadcast message:

BCAST(SYSDEF:5,SYS:20265,CH:520,SPARE:0,RSVD:00,ADJ:2).

Option for non-active radio units to determine the signal strength **(SYSDEF:5)** at the following time slice on control channel **520 (CH:520)** of system **20265 (SYS:20265)** having local serial number **2 (ADJ:2)**.

To select monitoring either the base station (**Fixed**) or the **Mobile**s, use **Options/Station.** To change the display format of Data Code Words use **Options/Format**.

NATEL

The entire call number is transmitted by consecutive tones in decade sequence. When two identical digits are to be transmitted consecutively, then an eleventh frequency is used as a repetition identifier.

Parameter	Value
Frequency range	VHF/UHF
Operation modes	Analogue Selcal
Modulation	FM, SUB Tone
Receiver settings	FM BW = 12 kHz
Input format(s)	AF, IF

If there more than two identical digits are to be transmitted the repetition tone is appended to the digit tone (e.g., 22222 is transmitted as f2 fw f2 fw f2, where f2 is the tone for "2" and fw is the repetition tone).

In most systems the accuracy of the single frequencies has to be within +1/-1.5% of the nominal value.

Decoding the selective calls is started by clicking on a system. If transmission and system selection conform, the call sign is displayed on the monitor. In the **Options** menu a **Time stamp** function can be enabled to add date and time to each call.

Tone Allocation

Digit	Hz	Digit	Hz
0	1633	8	1336
1	631	9	1477
2	697	A	1633
3	770	B	600
4	852	C	1995
5	941	D	2205
6	1040	E	1805
7	1209	Tone Duration	70 ms

NMT-450

NMT-450 is an analogue mobile telephone system, developed by the Telecommunication Administrations of Denmark, Finland, Norway and Sweden. The idea was to establish a compatible, automatic, public mobile telephone system in the Nordic countries.

Parameter	Value
Frequency range	VHF/UHF (450 MHz)
Operation modes	Duplex FEC TDMA
Modulation	FM, SUB FFSK
Symbol rate	1200.0 Bd
Center frequency	1500 Hz
Receiver settings	FM BW = 12 kHz
Input format(s)	AF, IF

NMT-450 mobile station signals can be found from 453 MHz to 457.5 MHz, base station signals from 463 MHz to 467.5 MHz. The frequency range is divided into 180 channels of 25 kHz each (channel 1 -180).

In areas with a lot of mobile subscribers, an extended band from 452.5 MHz - 452.975 MHz (mobile) and 462.5 MHz - 462.975 MHz (base) may be used as an option. The offset between mobile and base frequency is always 10 MHz.

Control messages (signals) containing system wide information, assignment, status and dialed number are exchanged between the mobile station and the base station.

All signals are transmitted at 1200 Bd FFSK with a center frequency of 1.5 kHz and a shift of 600 Hz.

An encoded NMT-450 frame has a length of 166 bits. Every frame contains 15 bits bit sync sequence followed by an 11 bits frame sync sequence. The last 140 bits contains the encoded message. In order to combat errors on the radio path, due fading and interference, an error-correcting code is used.

Today, NMT-450 is used in Sweden and a modified NMT-450 in Poland and Eastern Europe. More information can be found in the NMT DOC 450-1 / 450-3 specifications.

NOAA-GEOSAT

The NOAA-GEOSAT software has been specifically tailored to the transmissions of meteorological satellites. Transmissions are always at 120 rpm using an IOC of 576. In contrast to short-wave stations which use frequency modulation, satellite weather images are transmitted using amplitude modulation.

Parameter	Value
Frequency range	VHF/UHF
Operation modes	Broadcast
Modulation	FM, SUB AM
Center frequency	1800 Hz
Speed	120 RPM, IOC=576
Receiver settings	FM, BW = 40 kHz
Input format(s)	AF, IF

The software is started in free-run mode by enabling the mode. Because this mode has no synchronization sequence the correct display of the image is controlled by using the **Phase** function in the **Options** menu.

The special items **AM-Gain** and **AM-Offset** are placed in the **Demodulator** menu. Centering of the signal deviations on the bar graph is controlled by adjusting **AM-Offset**. In addition maximum deviation is required on the bar graph. This is done by adjusting **AM-Gain**. It should be noted that these two adjustments are influenced by each other.

The orbiting satellites may be received with an active antenna and a high quality VHF-UHF receiver. An optimal receiving station allows reception for approximately 20 minutes before the satellite has moved below the horizon. The AF output of the receiver may be fed directly into the decoder, which converts it into a weather image viewing station providing excellent image quality.

Polarization problems occur with orbiting satellites resulting in reception gaps of up to 2 minutes. A special antenna may alleviate this problem.

Due to the Doppler effect the frequency of the received signal may change as much as 1000 Hz during the reception period. The receiver should therefore have a built-in automatic frequency control (AFC) capability.

NWR-SAME

NWR is the abbreviation for NOAA (National Oceanic and Atmospheric Administration [USA]) Weather Radio All Hazards, which is operated by the NWS (National Weather System). A similar system using the same message format is operated as weather radio Canada by the Meteorological Service of Canada.

Parameter	Value
Frequency range	VHF/UHF
Operation modes	Broadcast
Modulation	FM, SUB FSK
Center frequency	1822.9 Hz
Shift	800 Hz
Symbol rate	520.83 Bd
Receiver settings	FM
Input format(s)	AF, IF

SAME is the abbreviation for Specific Area Message Encoding.

This feature is incorporated in information regarding severe weather conditions, which is distributed by the NWS. The area to which such a message applies is restricted by the area code, thus avoiding false alarm in areas which are not affected by the weather condition which causes the alarm.

The coded message is transmitted, using Audio Frequency Shift Keying, on the audio channel of the NWR transmitter system. Seven channels on 162.400, 162.425, 162.450, 162.475, 162.500, 161.525 and 162.550 MHz are assigned to this task.

The baud rate is 520.83 Bd the mark frequency is 2083.3 Hz and the space frequency 1562.5 Hz, all values fixed.

The user cannot change the audio frequency by tuning the receiver.

For this reason the center frequency is preset, as well as the baud rate.

The display shows the information of the messages split into its meaningful parts.

A message contains a preamble (sync word), a data header part, an alert tone signal (if applicable), a voice message part and an end-of-message part. The data part format is as follows:

ZCZC-ORG-EEE-PSSCCC-PSSCCC+TTTT-JJJHHMM-LLLLLLLL

ZCZC Start-of-message header block code

ORG Originator header block code

EEE Event header block code

PSSCCC Geographical area header block code

TTTT Purge time header code block

JJJHHMM Original dissemination time header block (Julian date, UTC)

LLLLLLLL Message originator header block

The area-code (PSSCCC) is divided into state, county and subpart-code, the dissemination date is divided into day, hour and minute.

If the message originator (LLLLLLLL) is a NWS office, the ICAO location identifiers are used, e.g., KDTX/NWS. If the message is a re-broadcast, the call sign of the broadcast station is used, e.g., KFAB/AM or WDAF/FM.

ORG – Originator Codes

Event	Code
Broadcast station or cable system	EAS
Civil authorities	CIV
National Weather System or Meteorological Service of Canada	WXR
Primary Entry Point System	PEP

EEE - EAS Event Codes

Event	Code	Event	Code
Emergency Action Notification*	EAN	Tropical Storm Warning	TRW
Emergency Action Termination*	EAT	Tsunami Watch	TSA
National Information Center*	NIC	Tsunami Warning	TSW
National Periodic Test*	NPT	Winter Storm Watch	WSA
National Audible Test**	NAT	Winter Storm Warning	WSW
Network Notification Message**	NMN	National Information Center	NIC
National Silent Test**	NST	Avalanche Watch	AVA
Blizzard Warning	BZW	Avalanche Warning	AVW
Coastal Flood Watch	CFA	Child Abduction Emergency	CAE
Coastal Flood Warning	CFW	Civil Danger Warning	CDW
Dust Storm Warning	DSW	Civil Emergency Message	CEM
Flash Flood Watch	FFA	Earthquake Warning	EQW
Flash Flood Warning	FFW	Evacuation Immediate	EVI
Flash Flood Statement	FFS	Fire Warning	FRW
Flood Watch	FLA	Hazardous Materials Warning	HMW
Flood Warning	FLW	Law Enforcement Warning	LEW
Flood Statement	FLS	Local Area Emergency	LAE
High Wind Watch	HWA	911 Telephone Outage Emergency	TOE
High Wind Warning	HWW	Nuclear Power Plant Warning	NUW
Hurricane Watch	HUA	Radiological Hazard Warning	RHW
Hurricane Warning	HUW	Shelter in Place Warning	SPW

Hurricane Statement	HLS	Volcano Warning	VOW
Severe Thunderstorm Watch	SVA	Administrative Message	ADR
Severe Thunderstorm Warning	SVR	Practice/Demo Warning	DMO
Severe Weather Statement	SVS	Required Monthly Test	RMT
Special Marine Warning	SMW	Required Weekly Test	RWT
Special Weather Statement	SPS	Transmitter Backup	TXB
Tornado Watch	TOA	Transmitter Off	TXF
Tornado Warning	TOR	Transmitter On	TXO
Tropical Storm Watch	TRA	Transmitter Primary On	TXP

* Federal Communication Commission and Federal Emergency Management Agency codes

** Canadian codes

PSSCCC - FIPS Area Codes (USA)

Code	Area		
01	Alabama	50	Vermont
02	Alaska	51	Virginia
04	Arizona	53	Washington
05	Arkansas	54	West Virginia
06	California	55	Wisconsin
08	Colorado	56	Wyoming
09	Connecticut	57	Eastern North Pacific Ocean, and along U.S. West Coast from Canadian border to Mexican border
10	Delaware	58	North Pacific Ocean near Alaska, and along Alaska coastline, including Bering Sea and Gulf of Alaska
11	District of Columbia	59	Central Pacific Ocean, including Hawaiian waters
12	Florida	60	American Samoa
13	Georgia	61	South Central Pacific Ocean, including American Samoa waters
15	Hawaii	64	Federated States of Micronesia
16	Idaho	65	Western Pacific Ocean, including Mariana Island waters
17	Illinois	66	Guam
18	Indiana	67	Johnston Atoll
19	Iowa	68	Marshall Islands
20	Kansas	69	Northern Mariana Islands
21	Kentucky	70	Palau
22	Louisiana	71	Midway Islands
23	Maine	72	Puerto Rico

Code	Area		
24	Maryland	73	Western North Atlantic Ocean, and along U.S. East Coast, from Canadian border south to Currituck Beach Light, N.C.
25	Massachusetts	74	U.S. Minor Outlying Islands
26	Michigan	75	Western North Atlantic Ocean, and along U.S. East Coast, south of Currituck Beach Light, N.C., following the coastline into Gulf of Mexico to Bonita Beach, FL., including the Caribbean
27	Minnesota	76	Navassa Island
28	Mississippi	77	Gulf of Mexico, and along the U.S. Gulf Coast from the Mexican border to Bonita Beach, FL.
29	Missouri	78	Virgin Islands of the U.S.
30	Montana	79	Wake Island
31	Nebraska	81	Baker Island
32	Nevada	84	Howland Island
33	New Hampshire	86	Jarvis Island
34	New Jersey	89	Kingman Reef
35	New Mexico	91	Lake Superior
36	New York	92	Lake Michigan
37	North Carolina	93	Lake Huron
38	North Dakota	94	Lake St. Clair
39	Ohio	95	Palmyra Atoll
40	Oklahoma	96	Lake Erie
41	Oregon	97	Lake Ontario
42	Pennsylvania	98	St. Lawrence River above St. Regis
44	Rhode Island	50	Vermont
45	South Carolina	51	Virginia
46	South Dakota	53	Washington
47	Tennessee	54	West Virginia
48	Texas	55	Wisconsin
49	Utah	56	Wyoming

PSSCCC - FIPS Area Codes (Canada)

Code	Area		
01	Nova Scotia, New Brunswick, Prince Edward Island	06	Saskatchewan
02	Newfoundland and Labrador	07	Alberta
03	Quebec	08	British Columbia
04	Ontario	09	Nunavut, Yukon Territory, North West Territories
05	Manitoba		

NXDN

NXDN™ is a proprietary narrowband digital protocol developed by ICOM Inc. and JVC KENVOOD Co. to provide a low complexity digital radio protocol solution which satisfies the FCC narrowbanding mandate.

Parameter	Value
Frequency range	VHF/UHF
Operation modes	Digital voice and data system
Modulation	4-level FSK
Vocoder	AMBE+2™
Transmission Rate	4800 bps/9600 bps
Channel Spacing	6.25 kHz/12.5 kHz
Input format(s)	IF
Optional Features	Digital Scrambling, Encryption, Trunking Mode

The modulation type enables manufacturers to use existing analog FM designs with the addition of extra components for digital capability. This provides backwards compatibility with the analog systems and reduces the complexity of development.

To use the mode set **Offset** to the IF output of the receiver. The current version implements the decoding of voice and data. When a call occurs, some status messages are displayed in the text output. Data transmissions are displayed as a hex dump of the decoded data. The parameter **Confidence** shows the demodulation quality.

Decoded voice will be saved in a ".wav" file in the default **Data-Output** directory. Use the **Mute** button to mute or un-mute live voice output to the speaker. The input bits to the vocoder are saved in Hex in a separate file alongside the .wav file. This feature is useful when the voice session is encrypted. The user can analyze and try to decrypt the bits.

For encrypted NXDN transmission (voice call or data call), the decoder can decrypt the voice or data when it has the correct cipher key. A clear voice will be output to the speaker and be saved in a ".wav" file. And clear text will be output to the screen. Without a proper cipher key, the voice will be unaudible and the text output will be unreadable.

Three cipher key types (Scrambling, DES and AES) are used in the NXDN secure communication. Each type has a 64-key list, which is stored in "Users\Public\Documents\WAVECOM\WSPECTRA\config*.xml". The user can edit the key directly in the list.

A Scrambling key must be positiv and not bigger than 32767 (0x7fff).

A DES key must be 64-bit in HEX (16 Hex numbers) and an AES key must be 256-bit in HEX (64 Hex numbers). The key lists must match those in the sending device. An encrypted signal carries information on the encryption method (Scrambling, DES or AES) and the key ID, so that the decoder can do decryption over the air (OTA).

OLIVIA

Olivia is a mode developed by Pavel Jalocha, who, among other modes, developed the basics of PSK31. He named this mode after his daughter.

Parameter	Value
Frequency range	HF
Operation modes	Boroadcast
Modulation	MFSK
Submodes	250 Hz / 8 Tones / 31.25 Bd 500 Hz / 8 Tones / 62.5 Bd 500 Hz / 16 Tones / 31.25 Bd 1000 Hz / 32 Tones / 31.25 Bd
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF
Additional Info	7038.5 MHz, 10133.65 MHz, 14075.65 MHz, 14107.5 MHz, 18102.65 MHz, 21086.5 MHz, 28076.0 MHz

Olivia focuses on robustness against signal-path disturbances, especially fading and multipath propagation. This requirement results in a low data-throughput and in a standard configuration five characters are merged into one block and transferred in two seconds, i.e., 2.5 characters per second.

The signals are MFSK-modulated, mostly with a baud rate of 31.25. In this way all transmitted energy is concentrated in a single tone of relatively long duration.

The standard center frequency depends on the chosen bandwidth, i.e., it is 500 Hz plus half of the selected bandwidth. The user can tune the receiver so that the signal has a center frequency according to the standard, or change the center frequency manually. The bandwidth can be changed manually as well.

The polarity of the signal is being detected and the demodulator set accordingly.

For each character a confidence value is calculated and evaluated. Data with a confidence value of at least 90% are displayed in black, with a confidence-value of at least 50% they are shown in red - otherwise a red underline character is displayed. A block with a confidence value of less than 75% is not shown at all.

ORBCOMM

The ORBCOMM System is a wide area, packet switched, two-way data communication system. Communications to and from Subscriber Communicators (SC) to ORBCOMM Gateways are accomplished through a constellation of Low-Earth Orbit (LEO) Microstar satellites. ORBCOMM Gateways are connected to dial-up circuits, private dedicated lines or the Internet.

Parameter	Value
Frequency range	VHF, 137 – 138 MHz
Operation modes	Downlink to Subscriber Communicator
Modulation	SDPSK
Symbol rate	4800 Bd
Bandwidth	10 kHz
Receiver settings	FM BW = 15 kHz
Input format(s)	IF

The ORBCOMM System consists of a Network Control Center (NCC) that manages the overall system worldwide and three operational segments:

- a space segment consisting of 36 LEO Satellites.
- a ground segment consisting of Gateway Earth Stations (GES) and control centers located throughout the world.
- a subscriber segment consisting of communicators used by ORBCOMM System subscribers to transmit and receive information to and from the LEO Satellites.

RF communication within the ORBCOMM System operates in the very high frequency (VHF) portion of the frequency spectrum between 137 and 150 (MHz). The ORBCOMM Satellites have a subscriber transmitter that provides a continuous 4800 bps stream of packet data. Each Satellite also has multiple subscriber receivers that receive short bursts from the SCs at 2400 bps. The ORBCOMM System will be capable of providing near real-time wireless data communications service around the world.

All communications within the ORBCOMM System must pass through an ORBCOMM Gateway. An ORBCOMM Gateway consists of one Gateway Control Center (GCC)—the facility that houses the computer hardware and software that manages and monitors message traffic—and a GES. The GES provides the link between the Satellite constellation and an ORBCOMM GCC.

Using the ORBCOMM System, a typical messaging scenario will proceed, as shown in the following sequence:

- An ORBCOMM System subscriber creates a message, which is intended for receipt by another subscriber's home computer. Using an e-mail program on a laptop PC, the subscriber downloads the message to a SC.
- The SC transmits the message to the Satellite that receives, reformats and relays the message to a GES.
- The GES transmits the message over a dedicated line to the GCC that places the message on the public switched network for delivery to the receiver subscriber's PC Internet provider.
- The receiver subscriber downloads the message once the computer makes a connection via modem to its Internet service provider.
- A message from the home base to the subscriber follows the reverse route: PC to the Internet over a public switched network to the GCC, GCC to GES, GES to Satellite, and finally Satellite to SC and SC to the user display. Even "direct" subscriber-to-subscriber transmissions must pass through an ORBCOMM Gateway.

The software is able to decode the continuous 4800 bps stream of packet data coming from a satellite. Not all messages could be shown as text, but all messages are available in hexadecimal notation.

PACKET-1200

PACKET-1200 can be monitored in the amateur VHF and UHF bands. This mode uses indirect FM (sub carrier) modulation.

Parameter	Value
Frequency range	VHF/UHF
Operation modes	Duplex FEC TDMA
Modulation	FM, SUB FSK
Symbol rate	600 and 1200 Bd
Center frequency	1700 Hz
Shift	1000 Hz
Receiver settings	FM BW = 12 kHz
Input format(s)	AF, IF
Additional Info	ITA-5 with block coding, amateur AX.25 System

To start PACKET-1200, select 1200 Bd or 600 Bd. The correct shift or center may be set in the Demodulator menu. Standard values for the center frequency and the shift are 1700 Hz and 1000 Hz.

The packet radio protocol is a derivative of the X.25 and HDLC computer network protocols. Packet radio is a synchronous system in which data is transmitted in ASCII character packets.

At the start and end of each block a control character or flag (01111110) is sent. The address can consist of up to 80 characters, but 16 or 24 character addressing is common when using direct connections or a single repeater.

The packet protocol distinguishes between three frame types: I (Information), S (Supervisory) and U (Unnumbered). Payload data transfer uses I frames or very rarely U frames. S and U frames are used for transmission control.

The data field can contain up to 256 characters. All characters and character combinations are permitted since transmission is transparent. A checksum is sent in the FCS field.

The status field contains three fields with connection status information in addition to the call-signs:

Frame types are indicated by I, S or U.

S-frame status messages, e.g., Receiver Ready (RR), Receiver Not Ready (RNR) or Reject (REJ) are displayed.

In the third field the transmit and receive sequence numbers are displayed. This number ranges from r0 to r7 or s0 to s7. The sequence number indicates to the opposite station which packets have been received free of errors.

The large volume of available radio amateur literature is recommended for further study of the packet radio system.

PACKET-300

PACKET-300 is mainly used by radio amateurs. Very seldom 600 Baud test transmissions may be heard. On HF SSB modulation (LSB or USB) is standard.

Parameter	Value
Frequency range	HF
Operation modes	Duplex FEC TDMA
Modulation	FSK
Symbol rate	300 and 600 Bd, variable 30-650 Bd
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF
Additional Info	ITA-5 with block coding, amateur AX.25 System

The packet radio protocol is a derivative of the X.25 and HDLC computer network protocols. Packet radio is a synchronous system in which data is transmitted in ASCII character packets.

At the start and end of each block a control character or flag (01111110) is sent. The address can consist of up to 80 characters, but 16 or 24 character addressing is common when using direct connections or a single repeater.

The packet protocol distinguishes between three frame types: I (Information), S (Supervisory) and U (Unnumbered). Payload data transfer uses I frames or very rarely U frames. S and U frames are used for transmission control.

The data field can contain up to 256 characters. All characters and character combinations are permitted since transmission is transparent. A checksum is sent in the FCS field.

The status field contains three fields with connection status information in addition to the call-signs:

- Frame types are indicated by I, S or U.
- S-frame status messages, e.g., Receiver Ready (RR), Receiver Not Ready (RNR) or Reject (REJ) are displayed.

- In the third field, the transmit and receive sequence numbers are displayed. This number ranges from r0 to r7 or s0 to s7. The sequence number indicates to the opposite station which packets have been received free of errors.

The large volume of available radio amateur literature is recommended for further study of the packet radio system.

PACKET-9600

PACKET-9600 may be monitored in the amateur UHF and SHF bands. 2400 Baud transmissions are rare. Some digipeaters support two modes, PACKET-1200 and PACKET-9600.

Parameter	Value
Frequency range	VHF/UHF
Operation modes	Duplex FEC TDMA
Modulation	GFSK
Shift/Bandwidth	4800 Hz
Symbol rate	2400, 4800 and 9600 Bd
Receiver settings	FM BW = 15 kHz
Input format(s)	IF
Additional Info	ITA-5 with block coding Amateur AX.25 System

To start PACKET-9600 select a baud rate. The correct shift may be set in the **Demodulator** menu. The default value for the shift is 4800 Hz.

As PACKET-9600 uses direct FSK modulation, the offset frequency pre-selection is equal to the center frequency of the IF input. Some digipeaters offset their transmit frequency up to 1.000 Hz from their normal frequency and this introduces many reception errors. The frequency offset is compensated by changing the offset frequency.

The packet radio protocol is a derivative of the X.25 and HDLC computer network protocols. Packet radio is a synchronous system in which data is transmitted in ASCII character packets.

At the start and end of each block a control character or flag (01111110) is sent. The address can consist of up to 80 characters, but 16 or 24 character addressing is common when using direct connections or a single repeater.

The packet protocol distinguishes between three frame types: I (Information), S (Supervisory) and U (Unnumbered). Payload data transfer uses I frames or very rarely U frames. S and U frames are used for transmission control.

The data field can contain up to 256 characters. All characters and character combinations are permitted since transmission is transparent. A checksum is sent in the FCS field.

The status field contains three fields with connection status information in addition to the call-signs:

- Frame types are indicated by I, S or U.
- S-frame status messages, e.g., Receiver Ready (RR), Receiver Not Ready (RNR) or Reject (REJ) are displayed.
- In the third field, the transmit and receive sequence numbers are displayed. This number ranges from r0 to r7 or s0 to s7. The sequence number indicates to the opposite station which packets have been received free of errors.

The large volume of available radio amateur literature is recommended for further study of the packet radio system.

PACTOR

PACTOR is a frequent visitor in the amateur radio bands. In addition, commercial users also use this system. The data protocol was modified into several variants for this purpose. The WAVECOM software automatically detects and decodes versions 1 to 8.

Parameter	Value
Frequency range	HF
Operation modes	Simplex ARQ
Modulation	FSK
Symbol rate	100.0 and 200.0 Bd adaptive
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF
Additional Info	ITA-5 with block coding

PACTOR operates as a bit synchronous simplex system in a fixed timing cycle. The entire cycle length is 1.25 seconds and the packet length 0.96 seconds. Consequently the correlation amounts to 250 bits at 200 Baud. The change-over time and signal propagation delay limits the system's range to approximately 20.000 km. For longer distances, a special longpath mode exits, which has longer breaks between frames and thus allows for distances up to 40,000 km.

The PACTOR data block consists of three sections: Header, data and control (status and 16 bit CRC). At 100 Baud the data field is 64 bits and at 200 Baud it increases to 160 bits. Block coding is performed according to the CCITT standard starting with the data section.

PACTOR operates adaptively so the baud rate can be either 100 or 200 Baud. During day time 200 Baud may be successfully used. In the evening, however, strong propagation distortion occurs which necessitates a reduction of the baud rate to 100 Bd.

PACTOR includes HUFFMAN data compression by design. This scheme relies on the fact that frequently occurring characters e.g., space, e, n or i, can be represented with shorter bit combinations than characters which are rarely used. A compression factor of approximately 1.7 is achieved in comparison to uncompressed ASCII.

Looking purely at monitoring, the Huffman code has the disadvantage that compression synchronization may be lost during propagation disturbances and so the remaining text in the data block is also lost.

Detailed descriptions of the PACTOR protocols can be obtained in the radio amateur literature. It must however be pointed out that real-world PACTOR implementations differs considerably from these descriptions.

This mode can also be used to decode connect frames for higher PACTOR levels, as well as frames of the free signal protocol.

Options | CRC Recognition. The detected CRC is displayed in the decoder status bar, see "CRC Recognition" on page 49.

Using **Options | CRC Table** a certain CRC mask can be defined, see "CRC Table" on page 49.

PACTOR-FEC

PACTOR-FEC is a bit synchronous simplex system and is based on PACTOR.

Parameter	Value
Frequency range	HF
Operation modes	Broacast, FEC
Modulation	FSK
Symbol rate	100 and 200 Bd

Parameter	Value
Shift	200 Hz
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF
Additional Info	ITA-5 with block coding

The PACTOR-FEC data block consists of three sections: Header, data and control (status and 16 bit CRC). At 100 Bd the data field is 64 bits and at 200 Bd it increases to 160 bits. Block coding is performed according to the CCITT standard starting with the data section.

In contrast to PACTOR, all data blocks are in consecutive order with no or little space between them. They are several variants on the market. The baud rate is fixed to 100 or 200 Bd. PACTOR-FEC is used for broadcast transmission and is recognized by the FSK Code Check or Classifier Code Check.

PACTOR-II

With PACTOR-II, a modern, narrow-band and reliable two-channel PSK mode is available, which covers the needs of both amateur and professional users for a secure and fast data transmission system. The good performance during disturbances and a small bandwidth of 500Hz are achieved by the use of a two channel DPSK modulation. As propagation conditions change, PACTOR-II is able to select the most suitable modulation (DBPSK, DQPSK, D8PSK, D16PSK and 16PSK) and the length of the frame (SHORT or LONG). Under very poor conditions PACTOR-II changes to DBPSK short block, which has a frame duration of 1.25 seconds and carries only a small amount of data. For very good conditions, D16PSK with a long frame is used, which transfers a large amount of data and needs 3.75 seconds.

Parameter	Value
Frequency range	HF
Operation modes	Simplex ARQ
Modulation	Two channel DBPSK, DQPSK, D8PSK, D16PSK adaptive, 16PSK
Symbol rate	100.0 Bd
Automatic frequency control (AFC):	± 50 Hz
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF
Additional Info	ITA-5 with block coding HEX (Binary Output) 7.035 MHz, 14.070 MHz

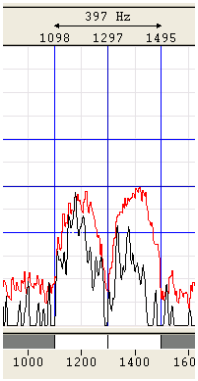
To achieve a data transmission which is robust against all kind of disturbances, a decision must be made, whether a short or a long frame-length should be used. The resulting input bit stream is then terminated with a convolutional encoded and interleaved CRC-sum. After that, the symbol mapping for the two channels is done, and then this signal is applied to the DPSK or PSK demodulator.

To extract the data from a PACTOR-II signal, the signal is received and demodulated with a two channel demodulator. The center frequency must be adjusted to the center between the two channels. To achieve the best performance, the AFC (automatic frequency control) should be enabled. After the demodulation and the bit synchronization, the symbols of the two channels are combined to one bit stream. After the modulation type has been determined, the resulting bit stream is de-interleaved, passed through a Viterbi-decoder. In a next step the CRC is checked.

PACTOR-II is suited to the transfer of large files rather than hand-typed text. The data may be transmitted as ASCII without compression or can be compressed with HUFFMAN or PSEUDO-MARKOV compression. In addition, run length encoding (RLE) is included.

Tuning a PACTOR-II Signal

After launching the mode, the first step is to look for a valid PACTOR-II signal in the spectrum:



The bandwidth of the spectrum can be switched between 500 Hz, 1000 Hz, 4000 Hz and 24000 Hz. The upper and lower frequency boundaries of the signal are the selected with the right and left cursors. With the center cursor, the center frequency may be set more precisely. **The precision of the center frequency is very important and directly influences the performance of the decoding**.

To ensure, that the system can handle drifting signals or a coarsely adjusted center frequency, **AFC** may be enabled in the **Demodulator** menu. The carrier tracking function is now activated. If the deviation between the tracked and the adjusted center frequency is too large, the center frequency should be corrected. The carrier tracking only works over a range of the center frequency ± 10 Hz.

The deviation of the adjusted center frequency and the tracked frequency is shown in the tuning display. If a PACTOR-II signal was not found, the bar of the tuning display moves randomly. If a valid PACTOR-II signal was detected, the bar is frozen during the entire frame and shows the deviation. Now the center frequency may be manually adjusted to fit the correct frequency if necessary.

If a valid PACTOR-II signal was found the detected modulation type, frame length and the polarity is displayed. If it was an error free frame, the detected compression type, the status and the decoded text is displayed.

Options | CRC Recognition. The detected CRC is displayed in the decoder status bar, see "CRC Recognition" on page 49.

Using **Options | CRC Table** a certain CRC mask can be defined, see "CRC Table" on page 49.

Options | Auto Decrypt. If enabled, the mode tries to calculate the key of encrypted connections. It may take a few seconds until the key has been determined correctly. This function can not be used together with CRC Recognition.

PACTOR-II-AUTO

Fully automatic switching between PACTOR-II (ARQ) and PACTOR-II-FEC may be achieved by selecting **PACTOR-II-AUTO** mode.

PACTOR-II-FEC

With PACTOR-II-FEC, a modern, narrow-band and reliable two-channel PSK mode is available, which covers the needs of professional users for a secure and fast data transmission system. The good performance during disturbances and a small bandwidth of 500Hz are achieved by the use of a two channel DPSK modulation.

Parameter	Value
Frequency range	HF
Operation modes	PSK, Simplex FEC
Modulation	Two channel DQPSK
Symbol rate	100.0 Bd
Automatic frequency control (AFC):	± 50 Hz
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF
Additional Info	ITA-5 with block coding HEX (Binary Output)

In contrast to PACTOR-II, modulation and block length in PACTOR-II-FEC is fixed to "DQPSK LONG BLOCK". Where PACTOR-II uses ARQ, i.e., after each block sent, an acknowledge message from the receiving station is required, PACTOR-II-FEC has no acknowledge return channel. Thus, the receiving station must be able to do all the error correction. This is achieved by using a Viterbi decoder with k = 9 and code rate = ½. Interleaving protects the transmission against fading. Using a DQPSK modulation is a good compromise when looking at the amount of bits transmitted and the necessary signal-to-noise-ratio.

To extract the data from a PACTOR-II-FEC signal, the signal is received and demodulated with a two channel DPSK-demodulator. The center frequency must be adjusted to the midpoint between the two channels. To achieve the best performance, the AFC (automatic frequency control) should be enabled. After the demodulation and the bit synchronization, the symbols of the two channels are combined to one bit stream. After the modulation type has been determined, the resulting bit stream is de-interleaved, passed through a Viterbi decoder and the CRC is checked.

PACTOR-II-FEC uses the same compression algorithms and CRC masks as PACTOR-II.

Options | CRC Recognition. The detected CRC is displayed in the decoder status bar, see "CRC Recognition" on page 49.

Using **Options | CRC Table** a certain CRC mask can be defined, see "CRC Table" on page 49.

Tuning a PACTOR-II-FEC signal

See "PACTOR-II" on page 161.

PACTOR-III

PACTOR-III is an adaptive transmission mode that provides higher throughput and improved robustness compared to PACTOR-I and –II, both designed for operation within a bandwidth of 500 Hz. To achieve the improved features, PACTOR-III uses up to a maximum of 18 tones spaced 120 Hz, thus occupying a maximum bandwidth of 2160 Hz. Six so-called **Speed Levels (SL)** are specified, which are predefined combinations of modulation type (DBPSK or DQPSK), channel coding and number of tones (2, 6, 14, 16, or 18) as well as positions of tones. For all Speed Levels, the modulation rate of each tone is 100 Bd.

Parameter	Value
Frequency range	HF
Operation modes	Half-duplex synchronous ARQ
Modulation	DBPSK, DQPSK; 2, 6, 14, 16, or 18 tones
Symbol rate	100.0 Bd
AFC	±50 Hz
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF

Parameter	Value
Additional Info	ITA-5 with block coding 14.106 MHz, 21.112 MHz Optional Mode

TONE	SL=1	SL=2	SL=3	SL=4	SL=5	SL=6	TF
0						Q	480
1					Q	Q	600
2			B	Q	Q	Q	720
3		B	B	Q	Q	Q	840
4			B	Q	Q	Q	960
5	B	B	B	Q	Q	Q	1080
6			B	Q	Q	Q	1200
7		B	B	Q	Q	Q	1320
8			B	Q	Q	Q	1440
9			B	Q	Q	Q	1560
10		B	B	Q	Q	Q	1680
11			B	Q	Q	Q	1800
12	B	B	B	Q	Q	Q	1920
13			B	Q	Q	Q	2040
14		B	B	Q	Q	Q	2160
15			B	Q	Q	Q	2280
16					Q	Q	2400
17						Q	2520

Tone numbers (TN) and respective frequencies (TF) in Hz as well as modulation types (B = DBPSK, Q = DQPSK) for the 6 Speed Levels (SL).

As propagation conditions change, PACTOR-III is able to select the most suitable speed level. Under very poor conditions PACTOR-III changes to speed level 1, whereas, under optimum conditions, speed level 6 is used. As in the previous PACTOR standards, the frame durations are still 1.25 seconds (short cycle) and 3.75 seconds (long cycle for data mode). Again, a long path option is available to enable contacts up to 40.000 km. In such a case, the duration of the short and long cycle is extended to 1.4 and 4.2 seconds, respectively.

Initial link establishment is achieved using the frequency shift-keying (FSK) protocol of PACTOR-I, corresponding to the lowest protocol level. If both calling and called stations are capable of PACTOR-III, automatic switching to this protocol is done.

For data transmission, which is robust against all kinds of disturbances, a decision must be made, whether a short or a long frame-length should be used. Each frame consists of the user data, a status byte, and

two CRC bytes. This input bit stream is then bit-interleaved and convolutional encoded. After that, the symbol mapping for the different channels is done, and the resulting signals are applied to the DxPSK modulators.

To extract the data from a PACTOR-III signal, the signal is demodulated with the appropriate number of DxPSK-demodulators, according to the speed level. The center frequency must be adjusted to the center between the lowest and highest tone in use. AFC (automatic frequency control) can be switched on or off. After demodulation and bit synchronization, the symbols of the channels are combined to one bit stream, which is de-interleaved and passed through a Viterbi-decoder. The CRC is used to check whether transmission errors occurred. After successful synchronization, it may take several tens of seconds before any text is output in the GUI.

In PACTOR-III, the data may be transmitted as ASCII without compression or can be compressed with HUFFMAN or PSEUDO-MARKOV compression (PMC). In addition, run length encoding (RLE) is included.

PACTOR-4

PACTOR-4 is an adaptive transmission mode that provides higher throughput and improved robustness compared to PACTOR-I, –II and -III. Ten so-called **Speed Levels (SL)** are specified, which are predefined combinations of modulation type (DBPSK, DSSS-DBPSK, DSSS-DQPSK, BPSK, QPSK, PSK-8, QAM-16, QAM-32) and channel coding (1/3, 1/2, 5/6).

Speed Level 1 uses two DBPSK-modulated carriers, similar to PACTOR-II and PACTOR-III, but the carriers change frequencies within a frame. This is done in order to eliminate single-carrier distortions.

For levels 2 to 10, PACTOR-III uses a single PSK-modulated carrier at 1500 Hz with a bandwidth of about 2400 Hz and a modulation rate of 1800 baud. Levels 2 - 4 use spread-spectrum modulation in order to increase the robustness. Levels 5 - 10 use BPSK to QAM-32, and an equalizer to eliminate the effects of the transmission channel.

Parameter	Value
Frequency range	HF
Operation modes	Half-duplex synchronous ARQ
Modulation	2-Channel DBPSK (Level 1) DSSS-DBPSK, DSSS-DQPSK (Level 2 - 4) BPSK, QPSK, PSK-8, QAM-16, QAM-32 (Level 5 - 10)
Symbol rate	1800.0 Bd
Receiver settings	USB
Input format(s)	AF, IF
Additional Info	ITA-5 with block coding HEX (Binary Output)

Initial link establishment is achieved using the frequency shift-keying (FSK) protocol of PACTOR-I, corresponding to the lowest protocol level. If both calling and called stations are capable of PACTOR-4, automatic switching to this protocol is done.

For decoding, the center frequency should be set to a value within +/- 50 Hz of the received signal. Polarity (NOR or INV) has to be selected manually.

The decoder supports several output modes. Decoded Data shows the application-level data. Raw Frames can be used to display the raw data, either with decompression or as received. In this mode, control signals are displayed as well.

If the "HEX" alphabet is selected, the data is displayed in binary (hex) and text, otherwise as normal text.

PCCIR

The entire call number is transmitted by consecutive tones in decade sequence. When two identical digits are to be transmitted consecutively, then an eleventh frequency is used as a repetition identifier.

Parameter	Value
Frequency range	VHF/UHF
Operation modes	Analogue Selcal
Modulation	FM, SUB tone
Receiver settings	FM, BW = 12 kHz
Input format(s)	AF, IF

If more than two identical digits are to be transmitted, the repetition tone is appended to the digit tone (e.g., 22222 is transmitted as f2 fw f2 fw f2, where f2 is the tone for "2" and fw is the repetition tone).

In most systems the accuracy of the single frequencies has to be within +1/-1% of the nominal value.

Decoding the selective calls is started by clicking on a system. If transmission and system selection conform, the call sign is displayed on the monitor. In the **Options** menu a **Time stamp** function can be enabled to add date and time to each call.

Tone Allocation

Digit	Hz	Digit	Hz
0	1981	8	1747
1	1124	9	1860
2	1197	A	1050
3	1275	B	930
4	1358	C	2400
5	1446	D	991
6	1540	E	2110
7	1640		

Tone duration: 100 ms.

PDZVEI

The entire call number is transmitted by consecutive tones in decade sequence. When two identical digits are to be transmitted consecutively, then an eleventh frequency is used as a repetition identifier.

Parameter	Value
Frequency range	VHF/UHF
Operation modes	Analogue Selcal
Modulation	FM, SUB tone
Receiver settings	FM, BW = 12 kHz
Input format(s)	AF, IF

If more than two identical digits are to be transmitted, the repetition tone is appended to the digit tone (e.g., 22222 is transmitted as f2 fw f2 fw f2, where f2 is the tone for "2" and fw is the repetition tone).

In most systems the accuracy of the single frequencies has to be within +1/-1.5% of the nominal value.

Decoding the selective calls is started by clicking on a system. If transmission and system selection conform, the call sign is displayed on the monitor. In the **Options** menu a **Time stamp** function can be enabled to add date and time to each call.

Tone Allocation

Digit	Hz	Digit	Hz
0	2200	8	1830
1	970	9	2000
2	1060	A	825
3	1160	B	886
4	1270	C	2600
5	1400	D	856
6	1530	E	2400
7	1670	F	680

Tone duration: 70 ms.

PICCOLO-MK6 and PICCOLO-MK12

PICCOLO-MK6 and PICCOLO-MK12 are MFSK (multi frequency shift keying) systems. The earlier PICCOLO versions MK1, MK2 and MK3 used 34 or 40 tones, each tone representing one character of the ITA-2 or ITA-5 alphabet respectively.

Parameter	Value
Frequency range	HF
Operation modes	Simplex
Modulation	MFSK-6, MFSK-12
Speed	50 ms, 25 ms
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF
Additional Info	ITA-2 for MK6, ITA-5 for MK12

The tone duration was 100 ms and the tone spacing 10 Hz.

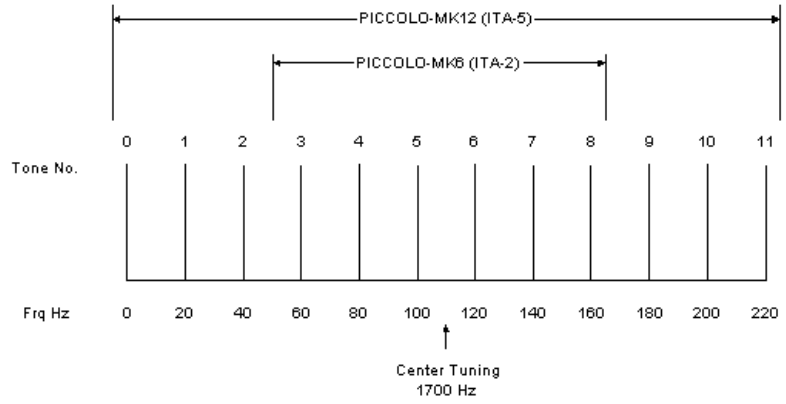
Recent systems operate with two sequential tones. The combination of the two tones defines the transmitted character. An increase in the signal-to-noise ratio is achieved by this method.

PICCOLO-MK6 is based on the ITA-2 Baudot alphabet. 6 tones are used which results in a total of 36 combinations. The tone duration is 2 x 50 ms for one character which corresponds to 75 Baud Baudot with 7.5 bit code words.

PICCOLO-MK12 transmits ITA-5 characters. To transfer 7 bit ASCII characters, twelve tones are required. This produces 144 bit combinations of which 128 are used. The transmission speed is equivalent to an asynchronous data rate of 110 Baud.

The WAVECOM software displays four windows on the screen: **Normal T1/T2**, **Inverse T1/T2**, **Normal T2/T1** and **Inverse T2/T1**. This way of organizing the display is due to the fact that it is not possible for the operator to decide from the monitored tone sequence, whether the first received tone constitutes tone 1 or tone 2 of a character. In addition, reception may occur using either the upper or the lower sideband giving a total of four decoding possibilities. Decoding of data is done simultaneously in all four windows.

Tone Assignment of PICCOLO-MK6 and PICCOLO-MK12



The decoder or receiver must be tuned to obtain the midpoint between tones 5 and 6 as the center frequency. In the case of IDLE (standby) transmissions these two tones are keyed at a rate of 100 ms and tuning becomes quite simple.

Decoding of PICCOLO and COQUELET systems requires receivers with high frequency stability. Thus state-of-the-art receivers using PLL or DDS frequency synthesis are well suited for the reception of these systems.

The software also provides an AFC (Automatic Frequency Control) function. Frequency deviations are continuously monitored by the software and automatic correction is introduced. The control range is ±5 Hz. The AFC function may be enabled/disabled using the **Demodulator** menu.

The MFSK demodulator is intended for use with MFSK systems. This mode may be selected in the **Demodulator** menu via the **Mode** item. The center frequency should be set to approximately 1700 Hz.

One manufacturer has doubled the data transfer rate and shortened the tone duration to 2 x 25 ms. this is equivalent to a transfer rate of approximately 150 Baud Baudot with 7.5 bit codeword. The standby tones were also changed, but otherwise the systems are identical.

Almost all transmissions in PICCOLO-MK6 and PICCOLO-MK12 are encrypted. However, some stations transmit meteorological data and operator communication in clear.

POCSAG

The pager services introduced by a number of PTT administrations use the POCSAG (Post Office Code Standard Advisory Group) standard. Pagers are one-way devices. A base station controls a large number of receivers and a return channel for transmission of reception acknowledgements or text is not available.

Parameter	Value
Frequency range	VHF/UHF
Operation modes	Simplex pager
Modulation	FSK
Symobol rate	512, 1200 or 2400 Bd
Receiver settings	FM BW = 15 kHz
Input format(s)	IF
Additional Info	ITA-5 with block coding, PAGER

POCSAG specifies four different call modes:

Tone only pagers (Mode 0 and 1)

The receiver can receive four different messages. The meaning of the four tones must be determined beforehand. The acoustic signal is supported by the display of the A, B, C or D messages on a small LCD display. All pagers must in principle have tone-only capability as a minimum.

Numeric pagers (Mode 2)

Individual parties receive their messages in the form of transmitted digits and some special characters. In this way for example, the telephone number which the POCSAG subscriber is to call, can be relayed. Messages are displayed on the pager display and may be partially stored.

Alphanumeric pagers (Mode 3)

The pager type which is easiest to use, is the alphanumeric pager where the transmitted message is displayed on the pager display. Such messages may be up to 80 characters long.

A country-wide pager network is, like a mobile telephone service, subdivided into individual cells that are each serviced by a base station.

Cells are fed with information in a time multiplex fashion i.e., messages are transmitted in cycles. This prevents that areas falling in the overlap zone of adjacent cells, receive the same message simultaneously. To prevent the condition that a base station only transmits for one third of the available time, stations are usually equipped to handle four frequencies.

Selecting **Options/Message Type** enables the user to select the various pager modes for display:

1...3: ASCII Mode 1 – 3 in ASCII format

0: BIN Mode 0 in binary format

0...3: ASCII Mode 0 – 3 in ASCII format

0...3: AUTO Mode 0 – 3 automatic format detection

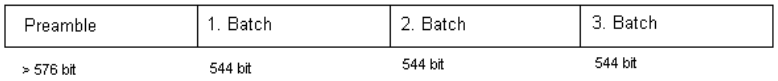
3: ASCII Mode 3 in ASCII format

Data modulation is achieved by direct 2FSK carrier keying with a transmission speed of 512 bit/s. Newer nets operate at 1200 or 2400 bit/s using FFSK modulation.

For reasons of compatibility with older pagers two different bit rates (512 Bit/s and 1200 Bit/s or 1200 Bit/s and 2400 Bit/s) are often used on the same frequency. In some countries POCSAG and GOLAY systems are on the same frequency. By selecting the **Auto speed** function all baud rates are automatically detected and switch-over between 512, 1200 and 2400 bps is performed.

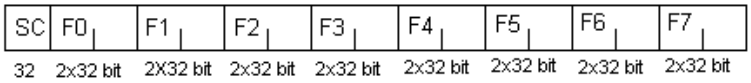
POCSAG Signaling

Generally activation of the HF carrier is followed by the transmission of a preamble or bit synchronization pattern which slaves the receiver to the clock frequency. The preamble contains at least 576 bits and represents a continuously alternating sequence of 010101...0101. Following the preamble, data batches containing the actual information are transmitted, each batch being 17 x 32 bit or 544 bits long.



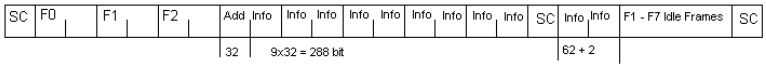
The structure of a batch is fixed: Each batch starts with a 32 bit synchronization codeword with a fixed content.

The synchronization word is followed by eight frames (frame 0 - 7) containing 2 x 32 bits in total. Only the first 32 bits are however used for transmitting a pager address. It would therefore be possible to double the maximum number of subscribers in the group by utilizing the frame contents to its full extent.



The message contents of the code words may include pager addresses or messages destined for specific pager addresses. The frames contained in a batch are numbered from 0 to 7. All pagers are similarly divided into 8 groups with each pager only receiving frames for the group to which it has been assigned. A pager synchronizes itself to the batch synch codeword (SC) and ignores the seven frames which are not applicable.

Following the address at the beginning of a frame, a message of any desired length may be sent. In the case of numeric pagers, digits are sent in BCD code while for alphanumeric pagers the message is transmitted using 7 bit ASCII codes.



The example shows the transfer of a message of 350 bits in frame 3. The first 32 bits of frame 3 are the address codeword (Add). Then follow 4 1/2 frames equivalent to 9 x 32 bits which extend up to the next synch word (SC). The remaining 62 bits fit into frame 0. If the frame containing the end of a message is not required to send a new address, it is filled with IDLE codes until a new address or a new synch word must be sent.

POCSAG mode uses direct frequency modulation. Proper decoding is only possible from the receiver IF output.

POL-ARQ

POL-ARQ is a full-duplex system with two transmitting frequencies. The system is based on the SITOR-ARQ alphabet. This alphabet having a 4:3 mark-space ratio allows error detection. Like all duplex systems, POL-ARQ initiates a request for repetition cycle (RQ) when transmission errors occur.

Parameter	Value
Frequency range	HF
Operation modes	Duplex ARQ
Modulation	FSK
Symbol rate	100, 150 and 200 Bd, variable 30-650 Bd
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF

POL-ARQ operates at a symbol rate of 100 and 200 Bd on the radio link.

To synchronize to this mode select a baud rate. By selecting the **Auto** button, the automatic determination of center frequency, shift frequency and baud rate is performed. Signal polarity (LSB or USB sidebands) is automatically detected.

To maintain synchronization between the two duplex stations, both transmitters operate continuously. If no data is transmitted an idle bit pattern is sent.

At 100 Bd the last three characters are repeated after the RQ character. At 200 Bd the last four characters are repeated (5 character repetition cycle). Due to mode characteristics the character repetition cycle must be controlled manually.

PRESS-FAX

The transmission of press fax images on short-wave is based on gray levels and specific IOC values. A number of IOC assignments were modified for press image transmissions. These special characteristics are taken into account in the PRESS-FAX software.

Parameter	Value
Frequency range	HF
Operation modes	Graphic mode, Broadcast
Center frequency	1900 Hz
Speed	60, 90, 120, 180 and 240 RPM, IOC 288, 352 and 576
Receiver settings	FAX, DATA, CW, LSB or USB
Input format(s)	AF, IF

If the **Auto** function is selected the software waits for the IOC identifier and synchronization sequence. Both parameters are only transmitted at the start of an image and hence capture will only start when the next image occurs. By selecting **PRESS-FAX**, the decoding starts immediately and the drum speed and IOC can be programmed manually via the **Drum speed** and **IOC** items in the **Demodulator** menu. The selected parameters are displayed in the decoder status bar.

The decoder allows a continuous and smooth alignment of the image as it is being received from **Options/Fine Speed**. By using the **Phase** item in the **Options** menu the image can be shifted into the correct position. **Flip Left-Right** and **Flip Top-Down** will reverse the image or turn it upside down.

To enhance the interpretation of gray-scale images, a false **color** option is available. Right-click on the image to opens the **Zoom** menu, and select a color scheme from the bottom part. A checkmark is placed to the left of the selection.

PSK-10

PSK-10 is a very narrow-band and reliable mode developed by F6CTE. The aim of this experimental slow mode is to allow a chat-type communication between hams.

Parameter	Value
Frequency range	HF
Operation modes	Simplex
Modulation	DBPSK
Shift/Bandwidth	40 Hz
Symbol rate	10 Bd
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF
Additional Info	10.148 MHz, 14.075 MHz

The baud rate is fixed at 10 Bd and is optimized to transfer the data rate, which an operator can input on a keyboard by hand.

To separate the transferred characters, the sequence "011" is inserted between every character. Thus the characters can be clearly separated, as long as no "011" sequence appears in the character itself. This was taken into consideration when designing the alphabet.

To optimize the data throughput rate of the system, an alphabet with a variable character length is used. For frequently used characters a symbol is used, which has a short word length (as is done with the Huffman compression). This alphabet is called Varicode and differs from the alphabet used in PSK-31.

PSK-31, PSK-63, PSK-125, PSK-250

PSK-31 is a very narrow-band and reliable mode. The good performance against disturbances is achieved by the use of DPSK modulation. Two demodulators are available:

Parameter	Value
Frequency range	HF
Operation modes	Simplex
Modulation	DBPSK, DQPSK
Symbol rate	31.25, 62.5, 125 or 250 Bd
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF
Additional Info	3.580 MHz, 7.035 MHz, 14.070 MHz

- For normal use, DBPSK can be selected to demodulate a bi-phase modulated signal. The baud rate is fixed at 31.25, 62.5, 125 or 250 Bd and is optimized to transfer data at the keyboard input-rate of an average operator.
- Alternatively DQPSK can be selected to demodulate a four-phase modulated signal. In this mode additional redundancy is generated by a convolutional encoder with a code rate = 1/2 and a constraint length of K=5, i.e., 2 bits were produced per bit by 2 polynomials. After the demodulation of the signal, the encoded bits are converted to a normal bit stream by a Viterbi decoder with K=5 and a code rate =1/2.

To separate the transferred characters, two zeros are inserted between every character. Thus the characters can be clearly separated, as long as no two consecutive zeros appear in the character itself. This was taken into consideration when designing the alphabet.

To optimize the data throughput rate of the system, an alphabet with a variable character length is used. For frequently used characters a symbol is used, which has a short word length (as is done with the Huffman compression). This alphabet is called Varicode.

PSK-63 and higher speeds are used in amateur-radio emergency-networks for information-transfer with the FLARQ-protocol. The decoders for these modes can interpret FLARQ messages.

Tuning a PSK-31, PSK-63, PSK-125, PSK-250 Signal

After launching the mode, the first step is to look for a valid PSK-31 signal in the spectrum. Usually a number of stations are working within the PSK segment which covers a few kHz.

The bandwidth of the spectrum can be switched between 500 Hz, 1000 Hz, 4000 Hz and 24000 Hz. After that the lower limit of the signal may be selected with the left cursor and the upper boundary with the right cursor. Using the center cursor, the center frequency may be more precisely set. The accurate adjustment of the center frequency is very important and directly influences the performance of the decoding.

To ensure, that the system can handle drifting signals or a coarsely adjusted center frequency, **AFC** may be enabled in the **Demodulator** menu. The carrier tracking function is now activated. If the deviation between the tracked and the adjusted center frequency is too large, the center frequency should be corrected. Carrier tracking only works over a range of:

- DBPSK center frequency ± 8 Hz
- DQPSK center frequency ± 4 Hz

Hence adjustment of the center frequency must be accurate.

The tuning display indicates if a DBPSK or a DQPSK signal is being received. Two bars mean DBPSK, four bars DQPSK. The demodulator must be adjusted accordingly.

Polarity of PSK-31, PSK-63, PSK-125, PSK-250

If a LSB signal is received using the receivers USB position or vice versa, the phase-plane is mirrored on the horizontal axis. For a DBPSK signal this has no effect, because all the phase states are on the horizontal axis itself. For DQPSK however this must be considered by switching the polarity. This can be done in the **Demodulator** menu by toggling **Polarity** or with a double-click on the field on the left side of the status field.

PSK-31-FEC

PSK-31-FEC is a narrow-band amateur mode developed by F6CTE. The aim of this experimental slow mode is to allow "chat" communication between hams with much less errors than with PSK-31.

Parameter	Value
Frequency range	HF
Operation modes	Simplex FEC
Modulation	DBPSK
Symbol rate	31.25 Hz
Receiver settings	DATA, CW, LSB or USB

Parameter	Value
Input format(s)	AF, IF
Additional Info	3.580 MHz, 7.035 MHz, 14.070 MHz

The baud rate is fixed at 31.25 Bd. The speed of transmission is about 30 words per minute compared to CW.

Each bit is repeated 13 bits later for forward error correction using the same principle as used in AMTOR FEC or PSK-AM, except that this type of FEC is bit related instead of character related.

To separate the transferred characters, a "011" sequence is inserted between each character guaranteeing separation as long as this sequence does not appear in the character itself.

PSK-31-FEC uses the same varicode alphabet as PSK-10 having a maximum length of seven bits per character.

PSK-63F, PSK-125F, PSK-220F

PSK-63F and PSK-125F, are very narrow-band and reliable modes. The performance against disturbances is achieved by the use of DPSK modulation.

Parameter	Value
Frequency range	HF
Operation modes	Simplex FEC
Modulation	DBPSK
Symbol rate	62.5, 125 and 220 Bd
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF
Additional Info	Varicode, 3.580 MHz, 7.035 MHz, 14.070 MHz

Compared to PSK-31 an improvement was made, concerning the error rate and ionosphere effects such as doppler, fading and multi-path. The result was a mode, which uses forward error correction (FEC) and also has a higher baud rate.

In contrast to PSK-31, only DBPSK modulation is used. The baud rate is optimized to the data rate, which an operator can input on a keyboard by hand.

To recover bit stream after demodulation, a Viterbi decoder with K = 7 and code rate ½ is used. Because of the use of DBPSK only, the mode is insensitive against a confusion of LSB and USB.

To optimize the data throughput rate of the system, the alphabet uses a variable character length. For frequently used characters a symbol is used, which has a short word length (as is done with the Huffman compression).

Note: In contrast to PSK-31 these modes do not use DQPSK modulation.

Tuning a PSK-63F and PSK-125F Signal

After launching the mode, the first step is to look for a valid PSK-63F or PSK-125F signal in the spectrum. It is possible that within a bandwidth of 4 kHz more than on station is working.

The bandwidth of the spectrum can be switched between 500 Hz, 1000 Hz, 4000 Hz and 24000 Hz. After that with the left cursor the lower limit and with the right cursor the upper boundary of the signal may be selected. Using the center cursor, the center frequency may be more precisely set. **The adjustment precision of the center frequency is very important and directly influences the performance of the decoding.**

To ensure, that the system can handle drifting signals or a coarsely adjusted center frequency, **AFC** may be enabled in the **Demodulator** menu. The carrier tracking function is now activated. If the deviation between the tracked and the adjusted center frequency is too large, the center frequency should be corrected. Carrier tracking only works over a range of DBPSK center frequency ± 8 Hz.

Hence adjustment of the center frequency must be accurate.

In contrast to PSK-31, this mode does not use DQPSK modulation.

PSK-AM

PSK-AM is a very narrow-band and reliable amateur mode developed by F6CTE. The aim of this experimental slow mode is to allow chat communication between hams.

Parameter	Value
Frequency range	HF
Operation modes	Simplex
Modulation	DBPSK
Symbol rate	10, 31.25 and 50 Bd
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF
Additional Info	14.075 MHz

PSK-AM is similar to PSK-31, but uses its own fixed length 8 bit alphabet with a 5:3 ratio. Each character is repeated 5 positions later. This diversity in time allows the correction of an invalid character.

Bitstream:

D(x)	R(x-2)	D(x+1)	R(x-1)	D(x+2)	R(x)	D(x+3)

D(x): character

R(x): repeated character

PZVEI

The entire call number is transmitted by consecutive tones in decade sequence. When two identical digits are to be transmitted consecutively, then an eleventh frequency is used as a repetition identifier.

Parameter	Value
Frequency range	VHF/UHF
Operation modes	Analogue Selcal
Modulation	FM, SUB tone
Receiver settings	FM, BW = 12 kHz
Input format(s)	AF, IF

If more than two identical digits are to be transmitted, the repetition tone is appended to the digit tone (e.g., 22222 is transmitted as f2 fw f2 fw f2, where f2 is the tone for "2" and fw is the repetition tone).

In most systems the accuracy of the single frequencies has to be within +1/-1.5% of the nominal value.

For ZVEI modes having nominal tone durations of 70 ms, the duration of a single tone may vary ± 15 ms.

Decoding the selective calls is started by clicking on a system. If transmission and system selection conform, the call sign is displayed on the monitor. In the **Options** menu a **Time stamp** function can be enabled to add date and time to each call.

Tone Allocation

Digit	Hz	Digit	Hz
0	2400	8	2000
1	1060	9	2200

Digit	Hz	Digit	Hz
2	1160	A	970
3	1270	B	810
4	1400	C	2800
5	1530	D	885
6	1670	E	2600
7	1830	F	680

Tone duration: 70 ms.

ROBUST-PACKET

Robust-Packet (RPR, Robust Packet Radio) is a data transmission mode devised from Special Communications Systems GmbH & Co. KG. It is optimized for the deployment in the short wave band. To accommodate the characteristics of this frequency range, for example fading and multipath propagation, a eight carrier OFDM was used.

Parameter	Value
Frequency range	HF
System	OFDM, FEC, CRC
Modulation	OFDM with DQPSK and DBPSK
Center frequency	1500 Hz
Shift	420 Hz
Symbol rate	200 Bd and 600 Bd adaptive
Receiver settings	Data, CW, LSB or USB
Input format(s)	AF
Additional Info	AX.25 data, APRS

Dependent on the speed level (r200 or r600) every carrier is DBPSK or DQPSK at a rate of 50 Bd modulated. Just like in PACKET-RADIO the AX.25-protocol comes into operation. The decoder module detects the speed level and the size of the transmitted packet automatically and shows the result. The payload of one packet can be up to 256 Byte. The real length of one data packed depends on the amount of data to be send. There are 25 different packages. One for connect/disconnect and respectively 12 for the two speed levels with their variable packet length.

To make the transmission as robust as possible, there are several modifications applied onto the AX.25-data stream before the transmission. The call signs are compressed with a special algorithm, the data stream is scrambled, redundancy is added and it is interleaved over the full frame length.

The decoder output is divided in signaling information (call signs with SSIDs, package-identifier and AX.25 control word) and data. It is possible to represent the data as ITA5-US and HEX.

Further description to the signaling information can be found in the AX.25 Link Access Protocol for Amateur Packet Radio.

The package-identifier specifies the used layer 3 protocol.

In the following table, all possible package identifiers are given:

Package-Identifier PID

Hexadecimal value PID	binary value	Layer 3 Protocol
**	xx01xxxx	AX.25 layer 3 implemented

Hexadecimal value PID	binary value	Layer 3 Protocol
**	xx10xxxx	AX.25 layer 3 implemented
0x10	00010000	ISO 8208/CCITT X.25 PLP
0x06	00000110	Compressed TCP/IP packet. Van Jacobson (RFC 1144)
0x07	00000111	Uncompressed TCP/IP packet. Van Jacobson (RFC 1144)
0x08	00001000	Segmentation fragment
0xc3	11000011	TEXNET datagram protocol
0xc4	11000100	Link Quality Protocol
0xca	11001010	Appletalk
0xcb	11001011	Appletalk ARP
0xcc	11001100	ARPA Internet Protocol
0xcd	11001101	ARPA Address resolution
0xce	11001110	FlexNet
0xcf	11001111	NET/ROM
0xf0	11110000	No layer 3 protocol implemented
0xff	11111111	Escape character. Next octet contains more Level 3 protocol information
0x08	00001000	Escape character. Next octet contains more Level 3 protocol information.

RUM-FEC

Parameter	Value
Frequency range	HF
Operation modes	Broadcast/Simplex FEC
Modulation	FSK
Symbol rate	164.5 and 218.3 Bd, variable 30-650 Bd
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF
Additional Info	16 Bit redundancy

RUM-FEC operates at symbol rates of 164.5 and 218.3 Bd on the radio link.

The HNG-FEC and RUM-FEC modes are technically very similar. RUM-FEC alphabet has a codeword length of 16 bits where each of the 32 used bit combinations corresponds to an ITA-2 character.

The RUM-FEC alphabet is designed to obtain a maximum Hamming distance for error detection and has deep interleaving. The actual ITA-2 alphabet is not contained in the code table. As in HNG-FEC error correction is performed by table look-up of the bit pattern (character) closest resembling the character in error.

RUM-FEC has a bit interleaving of 128 bits, each new character starting at intervals of 16 bits. The software synchronizes to traffic as well as idle bit patterns.

Error correction may be enabled or disabled using the **ECC** item in the **Options** menu.

In RUM-FEC mode the signal polarity (sideband) can be manually selected by toggling the **Polarity** item in the **Demodulator** menu. If polarity changes during a transmission, synchronization will not be lost.

SAT-AERO

The SAT-AERO system carries digital voice, fax and low speed data. The channels between aeronautical Ground Earth Stations (GES) and Aircraft Earth Stations (AES) are A-BPSK or A-QPSK modulated with 600, 1200, 4800, 8400,10,500 and 21,500 bps.

Parameter	Value
Frequency range	L-band/C-band
Operation modes, symbol rate, modulation	Inm-Aero (Forward Pd and Psmc logical channels) Forward: - P-channel packet switched data TDM: 600 bps, 1200 bps A-BPSK (SDPSK), 10.5 kbps A-QPSK (OQPSK), convolutional FEC R = ½, k = 7 - C-channel circuit mode SCPC: 8.4 kbps A-QPSK (OQPSK), convolutional FEC R = 2/3, k = 7, 10.5 kbps A-QPSK (OQPSK), convolutional FEC R = ½, k = 7 Return: - R-channel slotted Aloha: 600 bps, 1200 bps A-BPSK (SDPSK), 4.8 kbps, 10.5 kbps A-QPSK (OQPSK), convolutional FEC R = ½, k = 7 - T-channel TDMA: 600 bps, 1200 bps A-BPSK (SDPSK), 10.5 kbps A-QPSK (OQPSK), convolutional FEC R = ½, k = 7 - C-channel circuit mode SCPC: 8.4 kbps A-QPSK (OQPSK), convolutional FEC R = 2/3, k = 7, 10.5 kbps A-QPSK (OQPSK), convolutional FEC R = ½, k = 7
Modulation	A-BPSK (Aviation-BPSK), symmetrical, differential PSK (SDPSK) A-QPSK (Aviation-QPSK), a variant of offset QPSK
Required SNR	>15 dB (20 dB recommended)
Input	IF

Four channel types are used: P(acket switched), R(andom), T(DMA) and C(ircuit switched). Currently only the P channel can be decoded.

Two output formats may be selected, **All Signaling Units** or **Messages Only**. If **All Signaling Units** is selected, all signaling units are shown in hexadecimal except empty signaling units, which are skipped. If **Messages Only** is selected, packet-mode user data is converted to readable text – control and management packets are not decoded.

The satellite covering the Atlantic-East region transmits a 5250 Bd A-QPSK P-channel on 1546.0705 MHz.

SAT-B

The SAT-B system carries digital voice, low and high speed data and telex. The forward direction channels from land earth stations (LES or CES) to mobile earth stations (SES or MES) are 6 kBaud, 12 kBaud and 65.1 kBaud TDM or SCPC depending on service.

Parameter	Value
Frequency range	L-Band/C-Band

Parameter	Value
Operation modes, symbol rate, modulation	Inm-B (Forward NCS and LES Msg Chnl) Forward: 6 kbps DPSK, NCS TDM, LES TDM 24 kbps OQPSK, CES Voice, CES Low Speed Data 132 kbps OQPSK, CES High Speed Data Return: 24 kbps OQPSK, Aloha, TDMA, SCPC
Required SNR	>15 dB (20 dB recommended)
Input format(s)	IF

In idle mode all mobile stations listen to the NCS (Network Control Station) common TDM channel, which carries signaling information. When a mobile station identifies its id in a signaling frame it will act on the commands received from the NCS and in case of a channel assignment message being received tune to the assigned transmit-receive frequency pair. The forward telex traffic channel (from the LES) is also a TDM with the same frame structure as the NCS TDM.

The return channels are all 12 kBaud Aloha for SES requests, call acknowledgements and registration traffic, TDMA for SES response and telex traffic, and SCPC for SES voice, low and high speed data.

64 kbs is only decoded with W-CODE.

WAVECOM software decodes SAT-B fax with 9.6 kbps and low speed synchronous data with 9.6 kbs. The decoder will automatically adjust to the modulation type in use (BPSK or OQPSK).

All SAT Modes store the monitor information in a result file. The list of all result files is displayed in the lower part of the User Interface. The file names are constructed with the Date/Time and possibly additional information.

Additional information:

See "SAT Settings..." on page 51.

See "SAT System" on page 238.

SAT-B-C-TFC

SAT-B-C-TFC mode is used to monitor the C-band return signal of SAT-B, down converted to an IF of 70 MHz.

Parameter	Value
Frequency range	C-Band
Operation modes	Inm-B (Return Msg Chnl)
Symbol rate	12000 Bd
Modulation	OQPSK
Required SNR	>15 dB (20 dB recommended)
Input format(s)	IF

Unlike the other SAT Modes, this mode does not automatically select a frequency. The user has to manually set the frequency and offset to the desired signal, which will then not be interfered with or changed by the mode. The signal level should be at least 16dB over noise - a 20dB level will produce good results.

Session start and end are automatically recognized, but if the signal is too weak meaningful sessions cannot be decoded, and consequently a session file will not be generated, even if some intermittent decoding has occurred. The mode has a filtering function, which deletes short session fragments having been terminated by loss of synchronization.

The following services are decoded:

- Voice
- Low speed data
- Fax

Operation

With the help of the FFT-Analysis-Tool look for a SAT-B signal (bandwidth 20 kHz, OQPSK 12 kSymbol/sec) with a lot of traffic.

In the **Satellite** mode menu choose **Inmarsat, SAT-B-C-TFC**.

The Session Window displays the start and end of a session; only if the service of a session is recognized it will be started, even if the "Progress" field increases its number. The "MES_ID" displayed is the return MESId of the MES; the "Frequency" is a dummy value.

The Session List Window displays the results of the successfully decoded sessions. The decoded data is saved as "_Dat.txt" or "_.WAV" files.

The data extracted from the SCPC frames is examined for duplicate or missing packets. In case of duplicate packets the duplicate packet is discarded..

Especially the case of missing packets may be critical for subsequent upper protocol layer decoding therefore an error mark will be inserted into the file name as "_DatError.txt". However, for some upper layer protocols it is possible to reconstruct the missing data.

Additional information:

See "SAT Settings..." on page 51.

See "SAT System" on page 238.

SAT-B-C-HSD

SAT-B-C-HSD is used to monitor the return channel of SAT-B-HSD transmissions.

Parameter	Value
Frequency range	C-Band
Operation modes	Inm-B (Return Msg Chnl)
Symbol rate	66000 Bd
Modulation	OQPSK
Required SNR	>15 dB (20 dB recommended)
Input format(s)	IF

Unlike the other SAT modes, this mode does not automatically select a frequency. The user has to manually set the frequency and offset to the desired signal, which will then not be interfered with or changed by the decoder (mode). The signal level should be at least 16 dB over the noise, a 20 dB level will deliver good results.

Session start and end are automatically recognized, but if the signal is too weak, meaningful sessions will not be decoded and consequently a session file will not be generated, even if some intermediate decoding has occurred.

The following services are decoded:

- ISDN

Operation

With the help of the FFT-Analysis-Tool look for a SAT-B-C-HSD signal (bandwidth 100 kHz, OQPSK 66 kSymbol/sec) with a lot of traffic.

In the **Satellite** mode menu choose **Inmarsat**, **SAT-B-C-HSD**.

The Session Window displays the start and end of a session. The "MES_ID" displayed is the return MESId of the MES (Mobile Earth Station); the "Frequency" is a dummy value.

The Session List Window displays the results of the successfully decoded sessions. The decoded data is saved as "Hsd.txt".

Additional information:

See "SAT Settings..." on page 51.

See "SAT System" on page 238.

SAT-C-TDM, SAT-C-TDMA, SAT-C-EGC

SAT-C is a satellite based store-and-forward low speed message transmission system operating in the L-band to (forward direction) and from (return direction) the mobile earth stations (MES) and in the C-band to and from the land earth stations (LES) and network control stations (NCS).

Parameter	Value
Frequency range	L-Band (TDM) C-Band (TDMA)
Operation modes	Broadcast/Duplex FEC/ARQ TDM/TDMA
Symbol rate	1200 Bd
Modulation	BPSK
Required SNR	>15 dB (20 dB recommended)
Receiver settings	BW = 5-10 kHz
Input format(s)	IF

Mobile stations may be maritime, land based or aeronautical. The channel rate in both directions is 1200 symbols/sec. Error protection is achieved by convolutional encoding with R = 1/2 and k = 7 giving a user bit rate of 600 bps.

A block or frame of data in the forward direction (TDM) comprises 10368 symbols (8.64 s). Data is highly interleaved to combat slow fades. It is also scrambled to ensure an even distribution of logical 1s and 0s for proper bit synchronization. Frame synch is achieved by using an unscrambled unique word at the beginning of the frame.

The coding will correct some errors otherwise ARQ is used.

The forward channels from the LES and NCS are continuous time division multiplex (TDM) channels and are used for message transmission and signaling.

In the return direction messages are transmitted by the MES on time division multiple access (TDMA) channels assigned by the NCS. The frame length varies between 2176 symbols and 10368 symbols in steps of 2048 symbols.

SAT-C TDM

As for the other Inmarsat satellite modes, the Inmarsat C system uses a NCSC (Network Control Station Channel) for the announcement of new messages for the terminals. At the time of writing these announcements were transmitted on the following frequencies:

Ocean Region	NCSC Frequency	Ocean Region	NCSC Frequency
AOR-W	1537.70 MHz	IOR	1537.10 MHz
AOR-E	1541.45 MHz	POR	1541.45 MHz

The NCSC frequency is fixed for each ocean region. This ocean region is user selectable through the 'Satellite Settings' panel.

In the frequency offset bar the Inmarsat C mode has a **NCSC-Auto** check box.



With this checkbox the user is able to select between two operation modes:

- Fixed Frequency Mode (checkbox not ticked)
- NCSC Auto-Mode (checkbox ticked)

In **Fixed Frequency Mode** the decoder decodes all messages, both signaling and traffic messages on the channel tuned to. The traffic messages are transmitted on frequencies announced on the NCSC. This mode makes it possible to decode for example only the NCSC and display all control information transmitted there. The user may also leave the decoder on a traffic channel frequency.

In the **NCSC Auto-Mode,** the decoder is able to recognize announcements for all MES IDs, for a specific MES ID or a range of MES IDs depending on the watch list settings. The decoder then automatically tunes to the corresponding traffic channel and decodes relevant data traffic corresponding to the settings. In the decoder output window only the data content of the messages for the "MES of Interest" is visible. Messages for any other MES are indicated by the message sequence number and the logical channel assigned to the MES. However, data files are generated for all messages received, except if a watch list was defined. If a watch list was defined only messages for the MES IDs in the watch list are decoded and stored.

Inmarsat C data content is interpreted according to the codes shown in the table below:

"Announcement" message presentation field	WAVECOM decoder output presentation
Pres: 0	ASCII
Pres: 6	Baudot
Pres: [any other]	HEX

In **NCSC Auto-Mode** the decoder interprets the data for the "MES of Interest" according to the value of the presentation field ("Pres:") of the Announcement message. For decoded data not for the "MES of Interest" the configuration selected in the display dialogue is used.

The NCSC Auto Mode is recommended if the user would like to intercept the traffic for a particular target MES.

In case the watch list does not contain any MES ID, the decoder will process the first incoming announcement.

After recognizing a CLEAR signaling packet, the file is stored and may be selected and viewed in the session window. A CLEAR or the selection of NCSC-Auto-Mode will also trigger a retuning of the decoder to the NCSC and subsequent decoding of the control channel.

If more than 42 frames not for the "MES of Interest" were received a timeout occurs and leads also to a retuning to the control channel.

The output window is split in two as in other SAT Modes. The top window ('Session Window') displays the message packages, in the order they are received. The bottom window ('Session List Window') shows the generated files of all successfully received messages.

The **Transmitter ID** field is always empty.

In SAT-C TDM mode the MES ID may assume the value 0. This value is interpreted depending on the type of channel being decoded:

- On a LES TDM channel, MES ID = 0 is interpreted to mean that the MES ID is not known because the message was not correctly terminated
- On a NCS TDM channel, MES ID is always = 0, since these messages are all EGC messages

SAT-C-TDMA

The SAT-C-TDMA mode includes a frequency memory bar, but no capability to find a traffic-frequency from a control channel.

For SAT-C-TDMA files are suffixed with '_r' (for "return").

The MES ID is **always** = 0, because the ID is not transmitted together with the message as the message is identified by the Logical Channel Number (LCN).

SAT-C-TDM-EGC

In addition to TDM channel assignments, the NCSC also broadcasts so-called Group Call Messages (Enhanced Group Calls, EGC), which are not sent to a specific MES, but to groups of MES or to all MES. The name of the file generated for such a broadcast is suffixed with '_e' (for "EGC").

Introduction

The Inmarsat C maritime mobile satellite system has an inherent capability, known as Enhanced Group Call (EGC), which allows broadcast messages to be made to selected groups of ship stations located anywhere within a satellite's coverage. Four geostationary satellites provide worldwide coverage for these types of broadcasts. Two types of EGC services are available: Safety NET and Fleet NET. Fleet NET is a commercial messaging services offered by Inmarsat, and is not recognized by the Global Maritime Distress & Safety System, or GMDSS. Safety NET, along with NAVTEX, is recognized by the GMDSS as the primary means for disseminating maritime safety information. Ships regulated by the Safety of Life at Sea Convention travelling outside areas covered by NAVTEX must carry an Inmarsat C Safety NET receiver by 1 February 1999.

Safety NET Services

Virtually all navigatable waters of the world are covered by Inmarsat satellites. Each satellite transmits EGC traffic on a designated channel at 1.5 GHz. Any ship sailing within the coverage area of an Inmarsat satellite will be able to receive all Safety NET messages broadcast over this channel by that satellite. All Inmarsat C maritime ship stations can monitor the EGC channel. The EGC channel can also be monitored by dedicated receive-only equipment installed separately or as part of an Inmarsat A station.

The International Maritime Organization has announced that by June 1998, broadcasts of navigational and meteorological information will be made for every NAV/MET Area of the globe. Search and Rescue information is also broadcast in most areas.

Inmarsat C Safety NET services currently include:

- Urgency messages and navigational warnings to rectangular or circular areas
- Coastal warnings (in place of NAVTEX; used only in Australia)
- Shore-to-ship distress alerts to circular areas
- Search-and-rescue coordination messages to rectangular or circular areas
- Meteorological and navigational warnings and meteorological forecasts to a NAVAREA
- United States Safety NET broadcasts include:
  - NAVAREA IV and XII navigational warning broadcasts from the U.S. National Imagery and Mapping Agency
  - NAVAREA IV, XII and XVI meteorological forecasts and warnings from the U.S. National Weather Service
  - Distress alerts and search and rescue warnings from the U.S. Coast Guard
  - Atlantic ice reports from the International Ice Patrol, U.S. Coast Guard

Ships located outside a circular or rectangular area will not receive a message addressed to these areas, provided the Inmarsat C satellite terminal is connected to a GPS or similar navigational receiver, or the ship's position has been recently updated manually. If the terminal is not connected to a navigational receiver, then it will receive all such messages. Ships will receive all messages addressed to a NAVAREA if the user has entered the NAVAREA number into the terminal.

The printing of messages already received correctly is automatically suppressed.

Safety NET messages include a special header consisting of five "C" codes:

- C1 - priority code - 1 digit - distress, urgency, safety, routine
- C2 - service code - 2 digits - type of message broadcast
- C3 - address code - 12 characters - area broadcast instructions
- C4 - repetition rate - 2 digits - number and frequency of broadcasts
- C5 - presentation code - 2 digits - type of alphabet used

The National Geospatial-Intelligence Agency (NGA) maintains the Safety NET Users Handbook on the Inmarsat Homepage, and is available at no charge (http://www.inmarsat.com/Maritimesafety/snet.pdf).

Receiving Broadcasts

Most Inmarsat C terminals will not receive a safety broadcast if it is transmitting a message, or if it is tuned to an Inmarsat ocean region not used for safety broadcasts in the area travelled. Most Safety NET messages are rebroadcast after 6 minutes, to give a transmitting terminal time to receive missed messages. Lists of Safety NET broadcast schedules and areas have been published by the JOINT WMO/IOC COMMISSION FOR OCEANOGRAPHY AND MARINE METEOROLOGY to assist ship operators tune Inmarsat C terminals to the proper Inmarsat ocean region.

Although reception of Safety NET traffic is automatic, the shipboard operator must set up the receiver properly at the start of the voyage:

- Select the appropriate broadcast channel. This can often be accomplished by logging on to a land earth station in the ocean region for which needed broadcasts are made.
- Select the NAVAREA identification code.
- If travelling near Australia, select the proper coastal area codes.
- Ensure the Inmarsat C station is connected to a working navigational receiver. If a connection cannot be made, the ship's position must be manually updated every four hours during the ship's voyage. Without these updates, reams of unnecessary broadcast messages will be received.

Broadcast Channel Information

The modulation rate of the broadcast channel is 1200 Baud. Forward error correction is applied to this, creating an effective information transfer of 600 bits per second (rate 1/2 convolutional coding with interleaving is used to disperse error bursts which arise when deep fades are present). This ensures that there is a high probability of receiving a message correctly at the first transmission, irrespective of the atmospheric conditions or the ship's position within the satellite coverage.

Inmarsat Utilities

A copy of the latest version of the "Safety NET Users Manual" is available from the Inmarsat web site, www.inmarsat.com/Maritimesafety/snet.pdf. . The "Inmarsat Maritime Communications Handbook" is no longer available from Inmarsat, but maz be donloaded from other Internet sites.

STATUS OF MARITIME SAFETY INFORMATION BROADCASTS

NAVAREA	NAV	MET	SAR	OCEAN REGION
METAREA	WARNINGS	FORECASTS & WARNINGS	ALERTS	FOR SCHEDULED BROADCASTS
I (UK)	X	X	X	AOR-E
II (France)	X	X	X	AOR-E
III (Spain/Greece)	X	X	X	AOR-E
IV (USA)	X	X	X	AOR-W
V (Brazil)	X	X	X	AOR-E
VI (Argentina)	X	X	X	AOR-W
VII (South Africa)	X	X	X	AOR-E + IOR
VIII (India/Mauritius/La Reunion)	X	X (Note 3)	X	IOR
IX (Pakistan)	X	X	X	IOR
X (Australia)	X	X	X	IOR + POR
XI (Japan/China)	X	X	X	IOR + POR
XII (USA)	X	X	X	POR + AOR-W
XIII (Russian Federation)	X	X (Note 4)		POR

NAVAREA	NAV	MET	SAR	OCEAN REGION
XIV (New Zealand)	X	X	X	POR
XV (Chile)	X	X	X	AOR-W
XVI (Peru/USA)	X	X	X	AOR-W

1. X = Full Service now available.

2. IMO has decided that routine broadcasts of navigational warnings and meteorological forecasts will be made at scheduled times over a single nominated satellite for each NAVAREA/METAREA unscheduled.

Additional information:

See "SAT Settings..." on page 51.

See "SAT System" on page 238.

SAT-M

The SAT-M system carries digital voice and low speed data. The forward direction channels from land earth stations (LES or CES) to mobile earth stations (SES or MES) are 6 kBaud for NCS and LES TDM and 4 kBaud for LES voice and low speed data.

Parameter	Value
Frequency range	L-Band/C-Band
Operation modes	Inm-M (Forward NCS and LES Msg Chnl) Forward: 6 kbps DPSK, NCS TDM (LES TDM optional) 8 kbps OQPSK, LES Voice , LES Low Speed Data Return: 3 kbps DPSK, Slotted Aloha, TDMA, 8 kbps OQPSK SCPC
Required SNR	>15 dB (20 dB recommended)
Input format(s)	IF

In idle mode all mobile stations listen to the NCS (Network Control Station) common TDM channel, which carries signaling information. When a mobile station identifies its id in a signaling frame it will act on the commands received from the NCS and in case of a channel assignment message being received tune to the assigned transmit-receive frequency pair. The forward telex traffic channel (from the LES) is also a TDM with the same frame structure as the NCS TDM.

The return channels are 3 kBaud Slotted Aloha for MES requests, call acknowledgements and registration traffic, TDMA for MES response and 4 kBaud OQPSK for MES voice and low speed data.

WAVECOM decodes SAT-M 2.4 kbps fax and data. The decoder will automatically adjust to the modulation type in use (BPSK or OQPSK).

Additional information:

See "SAT Settings..." on page 51.

See "SAT System" on page 238.

SAT-MINI-M

The SAT-miniM system carries digital voice and low speed data and fax. The forward direction channels from land earth stations (LES or CES) to mobile earth stations (SES or MES) are 6 kBaud for NCS TDM, 2.8 kBaud for LES voice, low speed data and fax.

Parameter	Value

Parameter	Value
Frequency range	L-Band/C-Band
Operation modes	Inm-mM (Forward NCS and LES Msg Chnl) Forward: 6 kbps DPSK, NCS TDM 8 kbps OQPSK, LES Voice SCPC, LES Low Speed Data 64 kbps QAM16, High Speed Data SCPC (ISDN) Return: 3 kbps DPSK, Slotted Aloha, TDMA, 8 kbps OQPSK SCPC 64 kbps QAM16 SCPC (ISDN)
Required SNR	>15 dB (20 dB recommended)
Input format(s)	IF

In idle mode all mobile stations listen to the NCS (Network Control Station) common TDM channel, which carries signaling information. When a mobile station identifies its id in a signaling frame it will act on the commands received from the NCS and in case of a channel assignment message being received tune to the assigned transmit-receive frequency pair.

The return channel is a 2.8 kBaud TDMA 3 kBaud for all service types.

WAVECOM decodes SAT-M 2.4 kbps fax, data as well as 64 kbps ISDN. The decoder will automatically adjust to the modulation type in use (BPSK, OQPSK or QAM16).

Additional information:

See "SAT Settings..." on page 51.

See "SAT System" on page 238.

SAT-MINI-M-C-HSD

This mode is used to monitor the return channel of SAT-MINI-M-HSD transmissions.

Parameter	Value
Frequency range	C-Band
Operation modes	Inm-mM (Return Msg Chnl)
Modulation	QAM16
Symbol rate	33600 Bd
Required SNR	> 20 dB (25 dB recommended)
Input format(s)	IF

Unlike the other SAT modes, this mode does not automatically select a frequency. The user has to manually set the frequency and offset to the desired signal, which will then not be interfered with or changed by the decoder (mode). The signal level should be at least 20 dB over the noise, a 25 dB level will deliver good results.

Session start and end are automatically recognized, but if the signal is too weak, meaningful sessions will not be decoded and consequently a session file will not be generated, even if some intermediate decoding has occurred.

The following services are decoded:

- ISDN

Operation

With the help of the FFT-Analysis-Tool look for a SAT-MINI-M-HSD signal (bandwidth 40 kHz, QAM16 33.6 kSymbol/sec) with a lot of traffic.

In the **Satellite** mode menu choose **Inmarsat**, **SAT-MINI-M-C-HSD**.

The Session Window displays the start and end of a session. The "MES_ID" displayed is the return MESId of the MES (Mobile Earth Station); the "Frequency" is a dummy value.

The Session List Window displays the results of the successfully decoded sessions. The decoded data is saved as "Hsd.txt".

Additional information:

See "SAT Settings..." on page 51.

See "SAT System" on page 238.

SI-ARQ

SI-ARQ is a simplex system similar to for example SITOR. SI-ARQ therefore also sounds similar to the well-known SITOR system. Because data and pause blocks are longer in duration, the perception of a lower baud rate is created.

Parameter	Value
Frequency range	HF
Operation modes	Simplex ARQ
Modulation	FSK
Symbol rate	96.0, 192.0 and 200.0 Bd
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF
Additional Info	ITA-3

SI-ARQ operates at symbol rates of 96, 192 or 200 Bd on the radio link.

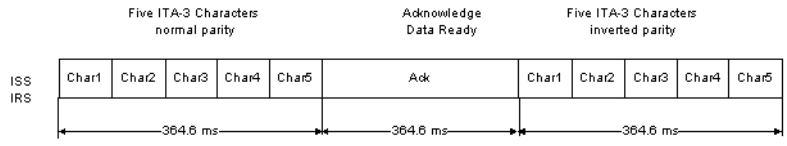
SI-ARQ uses the ITA-3 alphabet for data transmission and error detection. Data blocks usually consist of 5 or 6 characters.

One transmission cycle is made up of twice the length of a character block. If the information sending station (ISS) receives an acknowledgement character, the next data block is sent with inverted phase or polarity. However, if the receiving station (IRS) requests a retransmission, the repeated block is sent with unchanged polarity.

If the ISS does not receive the acknowledgement packet, it transmits a RQ block as is the case with SITOR.

The software automatically detects SI-ARQ block lengths of four, five or six characters and displays this information after phasing has been achieved. The polarity of the signal is automatically detected.

Transmission Sequence of SI-ARQ at 96 Baud with Five Characters



SI-AUTO

Fully automatic tuning to signal center, shift and transmission modes SI-ARQ (Mode A) and SI-FEC (Mode B) may be achieved by selecting **SI-AUTO** mode.

SI-FEC

The SI-FEC sound is similar to the sound of SITOR-FEC. However, SI-FEC is used very seldom and stations mostly switch to this mode only under extremely poor propagation conditions.

Parameter	Value
Frequency range	HF
Operation modes	Broadcast/Simplex FEC
Modulation	FSK
Symbol rate	96.0 and 192.0 Bd
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF
Additional Info	ITA-3

SI-FEC operates at symbol rates of 96 and 192 Bd on the radio link.

SI-ARQ stations can switch to FEC broadcasting operation in similarity to SITOR-ARQ (Mode A) and SI-TOR-FEC (Mode B).

The SI-FEC mode uses the ITA-3 alphabet for data protection. Each character is sent twice, but with a time delay. The repeated character is transmitted with inverted polarity.

For a pair of characters which have been decoded and recognized as error-free one character is displayed. If both characters are received in error the underscore (_) character is displayed.

SITOR-ARQ

SITOR-ARQ is a simplex system where both stations transmit alternately on the same frequency.

The CCIR recommendation 476-3 defines a cycle of 450 ms and the two stations are designated as follows:

- ISS - information sending station
- IRS - information receiving station

The WAVECOM software always decodes the information of the ISS station.

Parameter	Value
Frequency range	HF
Operation modes	Simplex ARQ
Modulation	FSK
Symbol rate	100.0 Bd
Shift/Bandwidth	170 Hz
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF

SITOR systems almost exclusively operate at a symbol rate of 100 Baud and with a shift of 170 Hz.

After the receiver has been correctly tuned, the SITOR mode may be started by selecting a baud rate.

Fully automatic tuning to the signal center and shift may be achieved by selecting the **Auto** button.

The SITOR 7 bit alphabet employs a 3:4 mark-space ratio. The ISS transmits blocks of 210 ms duration each containing 21 bits. In turn the IRS transmits acknowledgement bursts with a duration of 70 ms.

If the ISS does not receive an acknowledgement, a block containing the RQ character is sent. In the case of blocks being received in error by the IRS, the last data block sent is repeated.

SITOR-AUTO

Fully automatic tuning to signal center, shift and transmission modes SITOR-ARQ (Mode A) and SITOR-FEC (Mode B) may be achieved by selecting **SITOR-AUTO** mode.

SITOR-FEC

The SITOR-FEC mode is used in broadcast applications where a return channel is not required or unavailable. Two sub-modes are in use: General broadcasting to a number of stations and selective addressing of only one station.

Parameter	Value
Frequency range	HF
Operation modes	FSK, Broadcast/Simplex FEC
Modulation	FSK
Symbol rate	100.0 Bd
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF

SITOR-FEC transmissions are used in maritime radio communication to distribute traffic lists, news, safety and weather information. Amateurs also use the FEC mode for calls to all (CQ calls).

The selective FEC is used when the receiving station must operate under "radio silence" conditions and hence cannot transmit.

In most cases SITOR-FEC transmissions uses a rate of 100 Baud using the standard shift of 170 Hz.

Each character is transmitted twice with an interval of 35 bits. In the case of error-free reception of both characters, the character is displayed on the screen. The underscore (_) character is displayed if both characters are received in error.

SP-14

SP-14 is an AM modulated sequential 14 tone mode, which is optimized for the transmission of numeric codes.

Parameter	Value
Frequency range	HF
Operation modes	Broadcast/Simplex
Modulation	AM, SUB MFSK-14
Speed	133.3 ms
Receiver settings	AM
Input format(s)	AF, IF
Additional Info	14.891 MHz, 14.888 MHz, 15.791 MHz, 16.291 MHz.

The tone separation is 16 Hz. The center frequency is 409 Hz and the bandwidth is approximately 210 Hz. Each tone has been assigned a character:

- 10 tones are assigned to the numerals 0...9
- One tone is used as a start character
- One tone is used as a stop character
- One tone is used as a space character
- One tone is used as a repetition indicator

A transmission is initiated with a start sequence, which identifies this mode and may be used for accurate tuning. This sequence is transmitted at 1 Baud, which makes it readable even during very unfavorable conditions.

The data proper is transmitted at a rate of 7.5 Baud. A sequence of 19 'P' characters is initially transmitted followed by the five digit code words. The transmission is terminated by transmitting 20 'K' characters. As the transmission rate is very low this mode is insensitive to fading and multipath propagation.

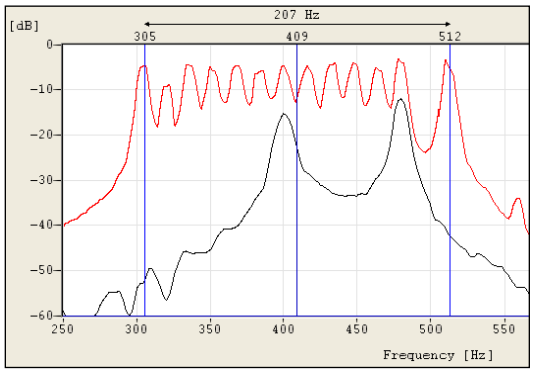
To decode a SP-14 signal it must first be demodulated using an AM demodulator in order to retrieve the MFSK signal. The simplest way is to use the AF output of the receiver and select receiver AM demodulation. If a receiver IF output is used, AM demodulation is not available and decoding becomes difficult. However, using the MFSK demodulator the transmitted symbols may be retrieved. A MFSK IAS using 16 bit over sampling will retrieve symbol clock. In order to process both baud rates used by SP-14, the IAS has to be configured to a baud rate of 15 Bd. Thus at a rate of 1 Bd 15 symbols per transmitted symbol, and at 7.5 Bd two symbols per transmitted symbol must be received with a certain tolerance. Even if for instance the same character is received 15 times in succession, error correction is impossible due to the fact that in case of repetition of numerals the numeral itself is followed by the repetition indicator 'R'.

Tuning a SP-14 Signal

Using the WAVECOM decoder as an example the following shows how decoding SP-14 is performed:

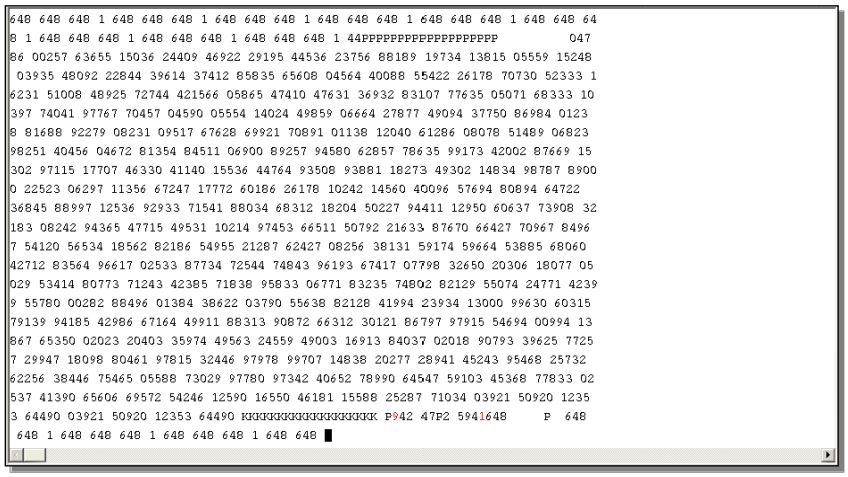
After tuning the receiver to the selected frequency and turning AM demodulation on, the receiver AF output (Line Out) is connected to the AF input.

If the receiver has been correctly tuned the following FFT display is shown:



For the FFT, bandwidths of 500 Hz, 1000 Hz, and 4000 Hz may be selected. A bandwidth of 500 Hz will ensure a good quality of signal display, and will also enable a fine tuning of the signal. Then using the display cursors the center frequency of the signal may be determined. All 14 tones, except tone 2 and tone 13 are clearly displayed. The missing tones are the start and stop indicators which are of course only transmitted at the start and the stop of the transmission. It is important to tune to the signal center frequency as accurately as possible, because accuracy of this tuning directly influences the quality of demodulation and the synchronization. In case the receiver AF output is used, the center frequency should be as close to 409 Hz as possible. The value of the center frequency is directly transferred to the decoding software module.

The screen shot below shows a decoded SP-14 signal.



SPREAD-11, SPREAD-21 and SPREAD-51

Like AUTOSPEC the SPREAD-11, SPREAD-21 and SPREAD-51 modes use the 10 bit Bauer code. For improved reliability in terms of burst errors each character is spread in time (interleaving). After each bit of the 10 bit Bauer code, 50 data bits (alternately 10 or 20) from other characters are sent. New characters start at intervals of 10 bits.

Parameter	Value
Frequency range	HF
Operation modes	Simplex FEC
Modulation	FSK
Symbol rate	68.5-137 Bd, variable 30-650 Bd
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF
Additional Info	10 Bit Bauer Code

The operating menus for the SPREAD-11 and SPREAD-12 are identical to the SPREAD-51 menu and are therefore not treated separately.

SPREAD-51 systems mostly use 102.6 Bd on the radio link - 218 Bd is used more seldom.

The spreading used in the transmission with 11, 21 or 51 bits significantly improves the data transfer reliability. The probability that two or more bits of the same character will be in error is reduced considerably using such bit spreading.

The software synchronizes with traffic or idle characters and the polarity is automatically recognized. Since the SPREAD modes are designed in such a way that they use the same IDLE character as AUTOSPEC, no clear distinction between SPREAD and AUTOSPEC is possible during idle transmissions. Classification is only possible during actual data transmission.

SSTV

SSTV is used to transmit still images over a voice channel. Using a SSB transceiver images may be transmitted world-wide. SSTV is a television standard as the images are scanned row by row and then transmitted at a very low rate hence the designation Slow Scan Television. SSTV is normally used by radio amateurs.

Parameter	Value
Frequency range	HF
Operation modes	Graphic Mode, FSK, Broadcast/Simplex
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF

SSTV transmissions come in a variety of modes. The picture resolution varies from 120 x 120 and a transmission time of 8 seconds to 640 x 480 with a transmission time of over seven minutes. Some transmissions are black-and-white only, and others are in color using either R-G-B or Y-U-V color coding.

On the air, the most common modes are the Scottie and Martin modes.

The WAVECOM SSTV decoder can decode a variety of modes: Martin 1-4, Scottie 1-4, SC-1 modes, SC-2 modes and B/W Robot modes. These modes can be detected automatically. Modes that use Y-U-V color coding are not supported.

Use the **Auto** button to select automatic mode or alternatively select a specific **SSTV Mode** in the **Options** menu. If a specific mode is selected, the system will not change mode if a SSTV signal of a different mode is detected.

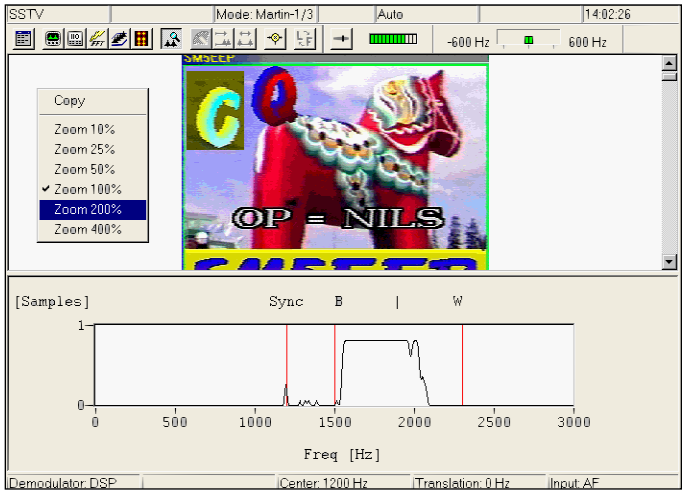
If **Free Run** in the **Options** menu is selected, an image line will be displayed even if no valid Horizontal Sync (i.e., start of a new line) is detected. When **Free Run** is selected, the decoder does not adjust the

picture timings to match the received signal. To manually correct the horizontal timing one uses the **Alignment** option. When the alignment is correct, the picture will be received vertically. One would normally only use **Free Run** mode if the signal is very noisy and the system cannot detect the sync pulses itself or if the picture is very wavy.

Click and drag on the image with the left mouse button to select a portion of the image. The selected portion is displayed in reverse colors. Right-clicking on the picture will bring up a popup menu. To copy the highlighted portion of the image, use the **Copy** item in the popup menu. This copy can be pasted into any graphics application (e.g., WINDOWS Paint), and then stored as an image file using the application.

The popup menu also includes **zoom** options. Different zoom settings from 10% to 400% are available.

For the proper functioning of SSTV, the receiver must be correctly tuned. To assist in tuning, the SSTV display includes a frequency spectrum in the lower window. When correctly tuned, one should see a frequency spike around the sync frequency, and a wide band of frequencies between the black and white frequencies. To visually aid tuning, markers are displayed at the **Sync**, **B**lack and **W**hite frequencies.



SSTV Standards for Synchronization

Parameter	Value
Synch Tone	1200 Hz
Black Tone	1500 Hz
White Tone	2300 Hz
Picture Synch	30 ms
Line Synch	5 ms

SSTV Modes

Mode		Type	Time [s]	Resolution [Pixel x Line]	Notes
Martin	M1	RGB	114	320 x 256	a
	M2	RGB	58	160 x 256	a
	M3	RGB	57	320 x 128	b
	M4	RGB	29	160 x 128	b
Scottie	S1	RGB	110	320 x 256	
	S2	RGB	71	320 x 128	
	S3	RGB	55	320 x 128	
	S4	RGB	36	160 x 128	
Robot	8	B/W	8	160 x 120	c
	12	B/W	12	320 x 120	

Mode		Type	Time [s]	Resolution [Pixel x Line]	Notes
	24	B/W	24	320 x 240	
	36	B/W	36	320 x 240	
B/W Mode	SC-1 8	B/W	8	128 x 128	
	SC-1 16	B/W	16	256 x 128	
	SC-1 32	B/W	32	256 x 256	
Wraase	SC-1 24	RGB	24	128 x 128	b
	SC-1 48	RGB	48	256 x 128	a
	SC-1 96	RGB	96	256 x 256	a
	SC-2 30	RGB	30	256 x 128	
	SC-2 60	RGB	60	256 x 256	
	SC-2 120	RGB	120	512 x 256	
	SC-2 180	RGB	180	512 x 256	

Notes:

* Not implemented

a Top 16 lines gray scale

b Top 8 lines gray scale

c Similar to original SSTV

d No horizontal sync (start of a new line)

STANAG-4285

STANAG-4285 is specified by the NATO (North Atlantic Treaty Organization) Military Agency for Standardization in "Characteristics of 1200 / 2400 / 3600 Bits per Second Single Tone Modulators / Demodulators for HF Radio Links" (16. February 1989).

Parameter	Value
Frequency range	HF
Operation modes	Broadcast/Simplex FEC
Modulation	8-PSK
Center frequency	1800 Hz
Symbol rate	2400 Bd
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF

The modulation technique used in this mode consists of phase shift keying (8-PSK) of a single tone subcarrier of 1800 Hz. The modulation speed (symbol rate) is always 2400 Bd.

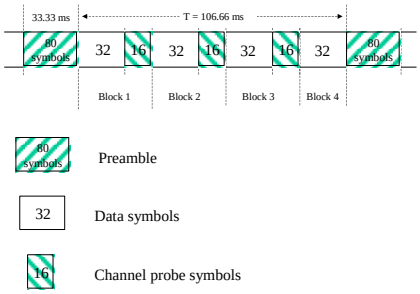
Using different M-PSK modulations and FEC (Forward Error Correction) coding rates, serial binary user information (raw data) accepted at the line side input can be transmitted at different user data rates.

STANAG 4285 single tone waveform has the following characteristics which may be selected from **Options |Frame Format...**:

Baud Rate	User data rate (bps)	User data rate (bps)	FEC coding rate	Interleaver	No. of unknown 8-phase symbols (User Data)	No. of known 8-phase symbols (Channel Probe)

Baud Rate	User data rate (bps)	User data rate (bps)	FEC coding rate	Interleaver	No. of unknown 8-phase symbols (User Data)	No. of known 8-phase symbols (Channel Probe)
2400	2400	3 (8-PSK)	2 / 3	SHORT or LONG	32	16
2400	1200	2 (QPSK)	1 / 2	SHORT or LONG	32	16
2400	600	1 (BPSK)	1 / 2	SHORT or LONG	32	16
2400	300	1 (BPSK)	1 / 4	SHORT or LONG	32	16
2400	150	1 (BPSK)	1 / 8	SHORT or LONG	32	16
2400	75	1 (BPSK)	1 / 16	SHORT or LONG	32	16
2400	3600	3 (8-PSK)	No coding	ZERO	32	16
2400	2400	2 (QPSK)	No coding	ZERO	32	16
2400	1200	1 (BPSK)	No coding	ZERO	32	16

The user data is transmitted using a continuous frame structure. Each frame begins with a 33.33 ms preamble containing 80 symbols, the next 176 symbols are divided into four 32-symbol data segments and three 16-symbol channel probe segments.



At the end of transmission, a certain bit-pattern (in hexadecimal notation, 4B65A5B2, MSB first) is sent to mark the end of message (EOM). The EOM sequence is followed by flush bits, which are for FEC coder flushing and for the complete transmission of the remainder of the interleaver data block.

In most cases FEC and interleaver are used to combat the effects of fading, frequency shift, multipath effects and burst noise. User data is in this case first FEC encoded, interleaved, then mapped into PSK symbol and transmitted in 32 symbol data segment. The 16 symbol channel segment transmitted between every data segment has a known PSK pattern. Its purpose is to keep the demodulator, mainly the equalizer, on track in spite of adverse propagation conditions during the HF transmission.

After the 176 symbol data-probe segment another frame beginning with the same 80-symbol preamble follows immediately. This frame structure makes the synchronization of the demodulator in the mid of the transmission very easy.

The STANAG-4285 decoder processes all the above configurations. This should be set manually in the **Frame Format** menu.

Generally STANAG-4285 transmits the user data in binary mode, i.e., it does not care what type of binary data is transmitted. This should be defined by the higher layer using the STANAG 4285 mode. For this reason the decoder displays the user data in **BINARY**, **HEX**, **ASCII ASYNC**, **ASCII ASYNC** (7 Data bits and No Stop bit) or **ASCII SYNC** format selected from **Options | Message Type...**. The decoder stops displaying data after the EOM bit pattern is received.

In the HEX display mode, the decoded binary data is just display as it is, MSB first.

In ASCII ASYNC mode, the bit stream is searched with ASCII ASYNC structure, i.e., one start-bit (0), 8 data-bits and at least one stop-bit (1). The 8 data-bits are LSB first. In addition to the EOM pattern, the display will stop if more than 300 NULL characters are received or if the asynchronous data structure is violated more than 80 times.

In ASCII ASYNC (7 Data bits and No Stop bit) mode, the bit stream is searched with another ASYNC structure, i.e., one start-bit (0), 7 data-bits. The 7 data-bits are LSB first. In addition to the EOM pattern, the display will stop if more than 300 NULL characters are received.

In ASCII SYNC mode, each 8 bits (LSB first) represent one ASCII character. The display will stop if the EOM pattern is received or if more than 20 NULL characters are received.

A switch Options | Output Demodulated Symbol enables symbol output directly after the demodulator and before channel decoding (FEC). This feature enables the user to analyse the demodulated symbol when the above coding scheme deviates from the standard.

Tuning the decoder

The mode decoder can process signal in both SSB settings: USB and LSB. This can be set by toggling the **Polarity** field: NOR means USB and INV means LSB signal.

The center frequency of the decoder should be set to 1800 Hz when the receiver is correctly tuned to the sending station. Small frequency deviations are automatically tracked and compensated during the decoding. The center frequency of the decoder can be adjusted to ± 400 Hz from its normal setting. By using the bar-graph, any remaining frequency difference can be compensated for by fine-tuning of the receiver frequency or by adjusting the center frequency of the decoder.

Using the Frame Format field the decoder can be set to one of the signal configurations. When the Confidence value is greater than 95 (i.e., 95% correct) in a stable state, the Frame Format is correct.

Dedicated Phase Plane

See "MIL-188-110A" on page 134.

STANAG-4415

The NATO robust, non-hopping, serial (single-tone) mode with tone excision – also known as STANAG-4415 – transmits user data at 75 bps over severely degraded HF channels with large Doppler and multipath spreads.

Parameter	Value
Frequency range	HF
Operation modes	Broadcast/Simplex FEC
Modulation	8-PSK
Center frequency	1800 Hz
Symbol rate	2400.0 Bd
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF
Additional Info	16 Bit redundancy

The on-air waveform specified in this mode is identical to the 75 bps waveform of the MIL-188-110A serial mode. The modulation uses 8-ary phase shift keying (PSK) on a single carrier frequency (1800 Hz). Serial, binary information (raw data), accepted at the line-side input, is converted into a single 8-ary PSK-modulated output carrier at a symbol rate of 2400 Bd.

Each data transmission consists of four distinct phases: The synchronization preamble phase, the data phase, the End-Of-Message (EOM) phase and the coder-interleaver flush phase.

The preamble phase lasts for 0.6 seconds for zero or short interleaver settings and 4.8 seconds when the interleaver size is set to long. This is followed by the data phase, which consists of an unlimited number of interleaver blocks. The raw user data, accepted at 75 bps, is first FEC (Forward Error Correction) encoded. Then the bit-stream is passed through an interleaver with a size of 10*9 = 90 bits size for the short interleaver or 20*36 = 720 bits for the long interleaver. A zero interleaver setting is usually not selected, because through interleaving the effect of short term fading and burst noise can be mitigated.

The coding rate of FEC is 1/2, i.e., after encoding the data rate is 150 bps. Each two bits are then mapped to a 32-bit Walsh sequence, thus yielding the 75*32 = 2400 Bd symbol rate.

At the end of transmission, a certain bit pattern (in hexadecimal notation, 4B65A5B2, MSB first) is sent to mark the end of message (EOM). The EOM sequence is followed by the flush bits, which are for the FEC coder flushing and for the complete transmission of the remainder of the interleaver matrix data block. Therefore both the EOM sequence and the flush bits are treated as normal user data bits and passed to the last interleaver block.

- Preamble (0.6 s or 4.8 s)
- Interleaver 1
- Interleaver 2
- ... ...
- Interleaver N (including EOM & flush bits)

Besides the FEC and interleaver used in this mode, a special component – the tone excision module – is used to pre-process the waveform, so that a more stringent decoding performance can be reached than is the case for the MIL-188-110A mode, even for a severely degraded HF radio link. The tone excision module mainly adaptively eliminates interfering tones, which may occur during the transmission.

As in the MIL-199-110A mode, the raw user data transmitted by the NATO Robust mode is just binary. Therefore the NATO Robust decoder displays the user data in **BINARY**, **HEX**, **ASCII SYNC** and two **ASCII ASYNC** formats selected from **Options | Message Type....** The decoder stops the display after the EOM bit pattern is received and goes to the SYNC status for preamble hunting.

In the HEX display mode, the decoded binary data is just displayed as it is (MSB first).

In the ASCII SYNC mode, each 8 bits (LSB first) represent one ASCII character. The display will stop if the EOM pattern is received or if more than 20 NULL characters are received.

There are two ASCII ASYNC display modes. In the first format (just named ASCII ASYNC) the 8 data bits are preceded by one start bit (0) and followed by at least one stop bit (1). The 8 data bits (LSB first) form an ASCII character. The second format (ASCII ASYNC, 7 Data bit, 0 Stop Bit) displays a 7-bit ASCII character (LSB first) which is preceded by one start bit (0). There is no stop bit in this format. In both modes the decoder will stop displaying, in addition to upon receiving the EOM pattern, when more than 300 NULL characters are received, when the async data structure is violated more than 80 times or the EOM bit pattern is received.

Tuning the decoder

The decoder processes signals in both SSB settings, USB and LSB. This can be selected with the **Polarity** setting in the menu: **NOR** will select USB and **INV** will select LSB.

The center frequency of the decoder should be set to 1800 Hz when the receiver is correctly tuned to the transmitting station. Small frequency variations are automatically tracked and compensated for in the decoder. The center frequency of the decoder can be adjusted to ± 400 Hz from its normal setting. By using the bar graph, any remaining frequency difference can be compensated for by fine-tuning of the receiver frequency or by adjusting the center frequency of the decoder.

Related mode

MIL-188-110A

STANAG-4481-FSK

STANAG-4481 is a synchronous FSK mode, which uses KG-84 encryption for communication. It is commonly found in the HF band. A number of communication parameter settings are possible, but 75 Bd and a shift of 850 Hz are widely used.

Parameter	Value
Frequency range	HF
Operation modes	Broadcast/Simplex FEC
Modulation	FSK
Baud rate	75, 100, 150, 300, 600 Bd
Receiver settings	Data, CW, USB, LSB

Parameter	Value
Signal source(s)	AF, IF

The KG-84 bit stream contains a 64 bits long header followed by two 256 bit message blocks in turn followed by encrypted data terminated by an End-Of-Message. Hence synchronization can only be achieved at the start of transmission using the KG-84 header.

The length of a message is variable. Messages are usually sent consecutively with a short idle sequence between each message.

STANAG-4481-PSK

This STANAG mode is specified by the NATO (North Atlantic Treaty Organization) Military Agency for Standardization as a "Minimum technical equipment standards for naval HF shore-to-ship broadcast system".

Parameter	Value
Frequency range	HF
Operation modes	Broadcast/Simplex FEC
Modulation	BPSK
Symbol rate	2400 Bd
Receiver settings	Data, CW, USB, LSB
Signal source(s)	AF, IF

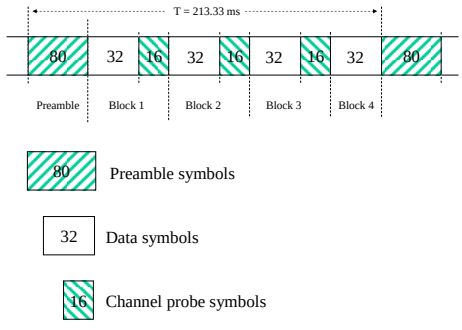
The modulation technique used in this mode is based on the operating conditions encountered by naval broadcasts.

The technology utilizes binary phase shift keying (BPSK) of a single tone 1800 Hz sub-carrier with a constant modulation speed of 2400 Bd. Through the use of BPSK modulation and a FEC coding rate of 1/4, the effective user data rate is 300 bps.

Baud Rate	User data rate (bps)	Bits per symbol (M-PSK)	FEC coding rate	Interleaver
2400	300	1 (BPSK)	1 / 4	long

The user data is transmitted using a continuous frame structure with 213.33 ms per frame. Each frame starts with a preamble containing 80 symbols. The following 176 symbols are divided into four 32-symbol data segments and three 16-symbol channel probe segments.

The 176-symbol data-probe segment immediately follows the next frame, beginning with the same 80-symbol preamble. This repeated frame structure enables synchronization of the demodulator at any time of transmission.



At the end of transmission, an EOM bit pattern (0x4B65A5B2, MSB first) is sent to mark the end of message. The EOM sequence is followed by flush bits, to flush the FEC coder and to complete the transmission of the remainder of the interleaver data block.

FEC and interleaving is used to combat the effects of fading, Doppler spread, multipath and burst noise. User data is first FEC encoded, interleaved, then mapped into BPSK symbols and transmitted in 32 symbol data segments. The 16 symbol channel probe segment transmitted between each succeeding data segment has a known PSK pattern. Its purpose is to keep the demodulator, mainly the equalizer, on track in spite of adverse propagation conditions during the HF transmission.

This STANAG mode is either used to transmit data in transparent binary mode or as ASCII text. For this reason the decoder displays the user data in **HEX**, **ASCII ASYNC**, **ASCII ASYNC (7 Data bits and No Stop bit)** or **ASCII SYNC** format selected from **Options | Message Type...**. The decoder stops displaying traffic after the EOM bit pattern is received.

In the HEX display mode, the decoded binary data is displayed as hex values, MSB first.

In ASCII ASYNC mode, the bit stream is correlated with an ASCII ASYNC structure, i.e., one start-bit (0), 8 data bits and at least one stop bit (1). The 8 data bits are displayed LSB first. In addition to the EOM pattern, the display will stop if more than 300 NULL characters are received or if the asynchronous data structure is violated more than 80 times.

In ASCII ASYNC (7 data bits and no stop bit) mode, the bit stream is correlated with another ASYNC structure, i.e., one start bit (0) and 7 data bits. The 7 data bits are displayed LSB first. In addition to the EOM pattern, the display will stop if more than 300 NULL characters are received.

In ASCII SYNC mode, each 8 bits (LSB first) represent one ASCII character. The display will stop when either the EOM pattern was recognized or more than 20 NULL characters have been received.

Tuning the decoder

The decoder can process signals in both SSB settings: USB and LSB. The sideband is selected by toggling the **Polarity** field of the display: **NOR** will select USB and **INV** will select LSB.

The center frequency of the decoder is set to the default value of 1800 Hz, but can be adjusted within a range from 800Hz to 2400Hz. Small frequency deviations are automatically tracked and compensated during the decoding. By using the bar graph, any remaining frequency difference can be compensated by fine-tuning of the receiver frequency or by adjusting the center frequency of the decoder.

In the **Confidence** field, the quality of decoding can be observed. A well recognized stream is determined by a confidence value being stable and greater than 95 (i.e., 95% of the message is correct).

STANAG-4529

STANAG-4529 is specified by the NATO (North Atlantic Treaty Organization) Military Agency for Standardization in "Characteristics of Single Tone Modulators / Demodulators for Maritime HF Radio Links with 1240Hz Bandwidth" (14. December 1995).

Parameter	Value
Frequency range	HF
Operation modes	PSK, Broadcast/Simplex FEC
Modulation	8-PSK
Symbol rate	1200.0 Bd
Center frequency	1700 Hz
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF
Additional Info	16 Bit redundancy

The modulation technique used in this mode consists of phase shift keying (8-PSK) of a single tone subcarrier that is selectable in 100Hz steps from 800Hz to 2400 Hz, with a default value of 1700 Hz.

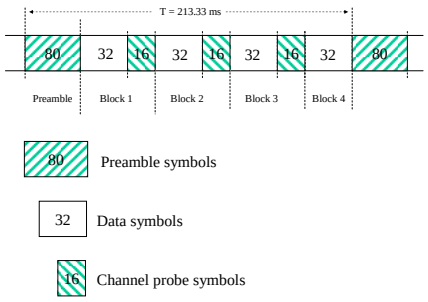
The modulation speed (symbol rate) is always 1200 Bd. Through the use of different M-PSK modulation formats and FEC (Forward Error Correction) coding rates, serial binary user information (raw data) accepted at the line side input can be transmitted at different user data rates.

STANAG 4529 single tone waveform has the following format characteristics which may be selected from **Options | Frame Format...**

Baud Rate	User data rate (bps)	Bits per symbol (M-PSK)	FEC coding rate	Interleaver
1200	1200	3 (8-PSK)	2 / 3	SHORT or LONG
1200	600	2 (QPSK)	1 / 2	SHORT or LONG
1200	300	1 (BPSK)	1 / 2	SHORT or LONG
1200	150	1 (BPSK)	1 / 4	SHORT or LONG
1200	75	1 (BPSK)	1 / 8	SHORT or LONG
1200	1800	3 (8-PSK)	uncoded	ZERO
1200	1200	2 (QPSK)	uncoded	ZERO
1200	600	1 (BPSK)	uncoded	ZERO

The user data is transmitted using a continuous frame structure with 213.33 ms per frame. Each frame starts with a preamble containing 80 symbols. The following 176 symbols are divided into four 32 symbol data segments and three 16 symbol channel probe segments.

The 176 symbol data probe segment immediately follows a next frame beginning with the same 80 symbol preamble. This repeated frame structure allows synchronization of the demodulator at any time of transmission.



At the end of transmission, an EOM bit pattern (4B65A5B2, in hexadecimal notation, MSB first) is sent to mark the end of message. The EOM sequence is followed by flush bits, to flush the FEC coder and to complete the transmission of the remainder of the interleaver data block.

In most cases FEC and interleaving is used to combat the effects of fading, frequency shift, multipath, and burst noise. User data is in this case first FEC encoded, interleaved, then mapped into PSK symbols and transmitted in 32 symbol data segments. The 16 symbol channel probe segment transmitted between each succeeding data segment has a known PSK pattern. Its purpose is to keep the demodulator, mainly the equalizer, on track in spite of adverse propagation conditions during the HF transmission.

Generally STANAG-4529 transmits the user data in transparent binary mode. This should be defined by the higher layer using the STANAG 4529 mode. For this reason the decoder displays the user data in BINARY, HEX, ASCII ASYNC, ASCII ASYNC (7 Data bits and No Stop bit) or ASCII SYNC format selected from **Options | Message Type...**. The decoder stops displaying data after the EOM bit pattern is received.

In the HEX display mode, the decoded binary data is just displayed as it is, MSB first.

In ASCII ASYNC mode, the bit stream is correlated with an ASCII ASYNC structure, i.e., one start-bit (0), 8 data bits and at least one stop bit (1). The 8 data bits are displayed LSB first. In addition to the EOM pattern, the display will stop if more than 300 NULL characters are received or if the asynchronous data structure is violated more than 80 times.

In ASCII ASYNC (7 data bits and no stop bit) mode, the bit stream is correlated with another ASYNC structure, i.e., one start bit (0) and 7 data bits. The 7 data bits are displayed LSB first. In addition to the EOM pattern, the display will stop if more than 300 NULL characters are received.

In ASCII SYNC mode, each 8 bits (LSB first) represent one ASCII character. The display will stop if the EOM pattern is received or if more than 20 NULL characters are received.

Tuning the decoder

The decoder can process signals in both SSB settings: USB and LSB. The sideband is selected by toggling the polarity field of the display: NOR means USB and INV means LSB.

The center frequency of the decoder is set to the default value of 1700 Hz, but can be adjusted within a range from 800Hz to 2400Hz. Small frequency deviations are automatically tracked and compensated during the decoding. By using the bar graph, any remaining frequency difference can be compensated by fine-tuning of the receiver frequency or by adjusting the center frequency of the decoder.

Using the **Frame Format** field, the decoder can be set to one of the above listed user data configurations. A correct coded frame format is determined by a confidence value being stable and greater than 95 (i.e., 95% correct), while for uncoded formats the value has no meaning and remains stable at 75.

STANAG-4539

See "MIL-188-110B (Appendix C), STANAG 4539" on page 137.

STANAG-5065-FSK

STANAG-5065 is a asynchronous FSK system and was developed to provide NATO countries with interoperable shore-to-ship broadcast communications using the low frequency (LF) band (specifically 60 kHz-160 kHz).

Parameter	Value
Frequency range	VLF
Operation modes	Broadcast
Modulation	MSK
Symbol rate	50, 75, 100 or 150 Bd
Center frequency	975 Hz
Shift	85, 850 Hz
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF
Additional Info	Async FSK only

For STANAG-5065 FSK mode standard baud rates from 50 to 150 Bd are available. Non-standard baud rates may be selected using the **Baudrate** menu item.

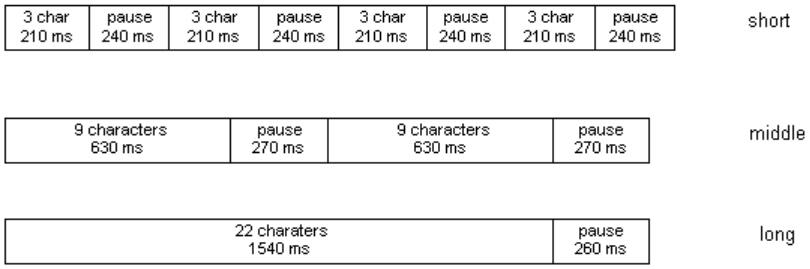
From **Options | Display...** ASCII and BAUDOT ar available as an output formats.

SWED-ARQ

SWED-ARQ is an adaptive telegraphy system which operates at a rate of 100 Bd.

Parameter	Value
Frequency range	HF
Operation modes	Simplex ARQ
Symbol rate	100 Bd, variable 30-650 Bd
Modulation	FSK
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF
Additional Info	SITOR Alphabet

Three different block lengths are used in SWED-ARQ. The short block containing three characters is essentially the same as the SITOR-ARQ mode. If favorable propagation conditions prevail the system will switch to medium block length (9 characters) or to long blocks (22 characters). In case of interference the block length is automatically reduced. The block length is displayed on the status line as either short, middle or long. Longer block lengths effectively increase the data transfer rate. The equivalent Baudot rates are 75 and 100 Bd for medium and long block lengths respectively.



The illustration depicts the protocol of data transmission for the SHORT, MEDIUM and LONG block types.

Given this timing scheme, the two stations can maintain the data link even after losing block length synchronization by re-transmitting the change-over commands. These consist of the IDLE A, IDLE B and other characters but are always three characters long.

In some RQ-cycles, SWED-ARQ makes use of bit center keying and maintains a request counter of cycles deviating from the 3:4 mark-space ratio.

The SWED-ARQ mode may be started by selecting a baud rate. If the transmission channel is subject to very strong interference, the block length change-over might be lost. By reselecting the baud rate, re-synchronization may be reestablished.

When phasing the software automatically recognizes block length and polarity.

TETRA

TETRA (TErrestrial Trunked Radio) is a digital voice and data system for mobile services standardized by ETSI and used for public safety and civilian PMR (Public Mobile Radio). It is closely related to GSM, but has its own unique features, e.g., a direct mode allowing mobile stations to communicate with each other without a base station and air interface encryption.

Parameter	Value
Frequency range	CEPT common EU allocation UHF (Public safety: 385 – 390/395 – 399.9 MHz, civil applications: 410 – 420/420 – 430 MHz)
Operation modes	Digital voice and data system
Symbol rate	18 kBd
Modulation	π/4-DQPSK
Receiver settings	BW = 25 kHz
Input format(s)	IF
Additional info	Data or voice
Operation modes	Trunked (TMO V+D (Voice + Data)), direct (DMO)
Access method	TDMA (Slotted Aloha)
Voice codec	ACELP (4567 bps)

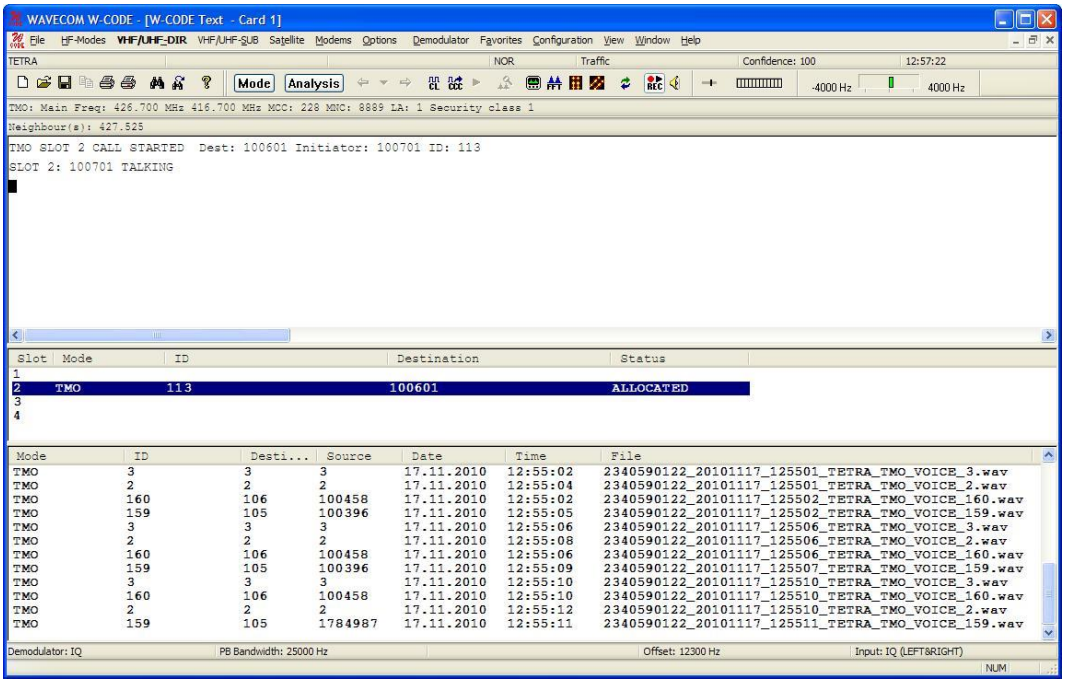
A Short Data Service similar to the SMS of GSM is available. SDS includes a number of protocols, and the WAVECOM decoder supports Text Messaging. For this type of messaging the text itself and delivery status reports are displayed and the messages saved to disk. The other data protocols are displayed as bits due to the lack of detailed protocol descriptions.

TMO and DMO voice calls in all time slots are decoded and can be monitored in real-time as well as saved to disk for later playback and analysis.

User Interface

The user interface for TETRA consists of a three pane window similar to the GUI for the satellite modes and an options dialogue.

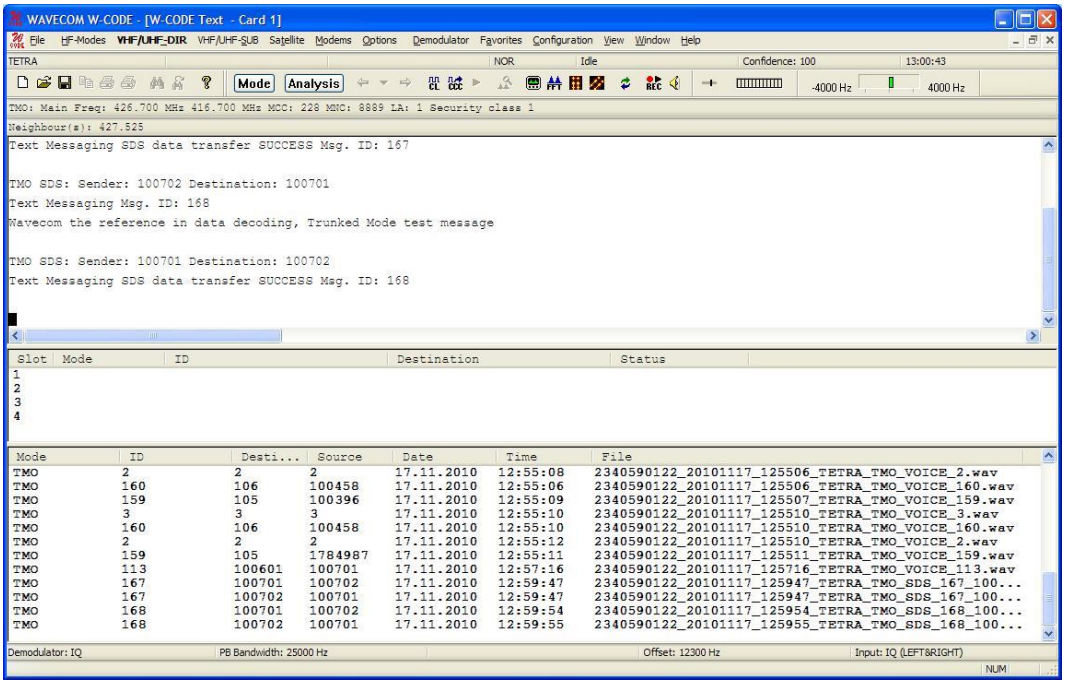
GUI for voice communication



In uppermost part of the GUI two status lines are continuously updated with system information: Mode (TMO or DMO), base station main frequencies, country code (MCC), network code (MNC), local area identification (LA), security class and the frequencies of neighbor base stations.

The upper pane will display signaling information for the signal being monitored. For voice the default display will show slot number, destination and source addresses, call ID and status. Other options are available from **Options | Tetra Settings** (see below).

GUI for SDS



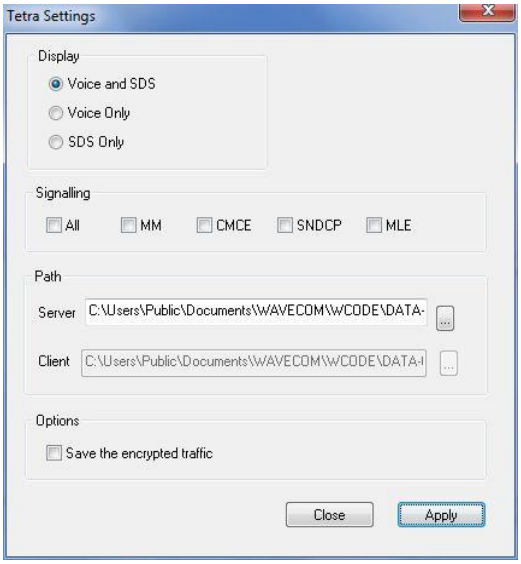
The middle pane contains a list of active TMO and DMO voice sessions. Left-clicking an entry will highlight the row ant send the selected conversation to the audio output. Audio output may be enabled or disabled using the mute button



The lower pane contains a list of saved calls and SDS messages. By double-clicking a file a call or a message is retrieved and displayed or played back.

Tetra Settings...

Various options are available through **Options | Tetra Settings...**



Display The user may select what is to be displayed by clicking one of the radio buttons.

Signaling The checkboxes allows the user to display all layer 3 PDUs (Protocol Data Units) corresponding to the levels of the TETRA protocol stack (for protocol overview, see the WAVECOM white paper WP-TETRA or consult the appropriate ETSI documentation).

PDUs from the following protocol entities are available:

Mobile Link Entity (MLE) – Information on neighboring cells and control of cell reselection.

Mobility Management (MM) - Controls various services, e.g., registration and de-registration, authentication, OTAR (Over-The-Air-Rekeying), mobile station stunning and group attachment.

Sub-Network Dependent Convergence Protocol (SNDCP) – TETRA specific adaptation protocol for IP data.

Circuit Mode Control Entity (CMCE) – Controls all voice and data (SDS).

Call setup, maintenance and tear-down functions.

```
CMCE protocol  D-TX CEASED Destination: 105
0100100100000010011111001001000011110000
MLE protocol  D-NWRK-BROADCAST
1010101001110000110011001011100000101011001111100110100
1001011001111000110100010000000000001001010000000001101
0000000111110101000000001010100001000000111010001000000
```

An excerpt of the display of PDUs, here CMCE and MLE PDUs.

The PDUs in their entirety are not verbally interpreted – only the protocol name and the name of the PDU in question are displayed, whereas payload data is output as bits. The exception here are the SNDCP PDUs which are displayed in formatted as well as binary form. This allows for a better view on the context activation/deactivation as well as packet flow.

```
SNDCP protocol  SN-DATA TRANSMIT REQUEST Destination: 0
SN PDU type: 0x06
NSAPI: 0x0D
Logical link status: 0x01 (Advanced link connected)
Enhanced pi/4-DQPSK service: 0x01 (Enhanced pi/4-DQPSK service requested)
Resource request:
    Connection symmetry: 0x01 (Asymmetric pi/4-DQPSK connection)
    Data transfer throughput(mean value): 0x06 (Reserved)
    Number of pi/4-DQPSK timeslots: 0x03 (4 timeslots)
    Number of pi/4-DQPSK timeslots on downlink: 0x03 (4 timeslots)
    Full pi/4-DQPSK capability on uplink: 0x03 (4 timeslots)
    Full pi/4-DQPSK capability on downlink: 0x03 (4 timeslots)
```

An excerpt of a formatted SNDCP PDU.

If no PDUs are selected – this is the default setting - only the status messages generated by the CMCE protocol will be displayed.

Path The paths for saving output data may be selected here. Use **Server** to set the Windows folder for the output files on the server. Use **Client** to set the Windows folder for the output files on the client. This option is only enabled on a remote GUI.

Options Check this box if you want to save encrypted traffic for further analysis.

Encryption Encrypted data and voice poses specific problems for decoding as decryption of the payload is not attempted. TETRA offers air interface encryption which may cover data, signaling, identities etc.

In the current decoder version encrypted traffic similar to other traffic will trigger the indication "TRAFFIC" in the status box, and an option (see preceding paragraph) is available for saving traffic to a text file containing cell information, destination address and payload data (if an allocation is received). In case of encrypted traffic packets, the payload data is saved together with the number of the slot, frame, multi-frame and hyper-frame being decoded which constitute the Initial Value (IV) for the encryption algorithm. Saved data and meta-information may be fed to an external decryption process. A sample of the text file containing encrypted voice and meta-data is shown below:

```
TMO: Main Freq: 393.912 MHz 383.912 MHz MCC: 000 MNC: 0000 LA: 15972 Security
class 3 and class 1


CN: 3756 CC: 2


Encrypted Channel Allocation Dest: 568463 Slot: 1 Frame: 11 Enc. Mode: 2


1101110100010101000000000010110011001110111001000010000011111110111110010110000000
0001000000100001000000000000000000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000000000000000000000000000000000


2 8 40 5337 (slot - frame - multi-frame - hyper-frame)

1000010101111100110011101000010110001111101101001011000001100001111100110001000000
0001100101001000001101000011100101010101110101101101001010110010000101111110101101
1000011111001100011101110000000100001110110001101000011100001111111000000010101000
001101010100
```

Constraints

WAVECOM's implementation of TETRA is based on TETRA Release 1 and will decode all TMO and DMO voice and data traffic in real-time, albeit with certain constraints (referring to the TETRA reference protocol stack and the appropriate ETSI standards):

Layer	Constraints
Layer 1	➢ Multiple Slot Transmission mode (MST) is not supported ➢ Only downlink bursts are supported in the current decoder version

Layer	Constraints
Layer 2	Logical channels: User plane, traffic channels: ➢ Circuit mode not supported Control plane, control channels: ➢ All channels except Access Assignment Channel (AACH) Protocol Data Units (PDU): ➢ Only downlink PDUs supported
Layer 3	At layer 3, control plane PDUs are user selectable

TETRAPOL

TETRAPOL is a digital voice and data system for mobile services and used for public safety and civilian PMR (Public Mobile Radio). It is defined by the TETRAPOL Forum in a Publicly Available Standard (PAS). It features end-to-end encryption.

Parameter	Value
Frequency range	VHF and UHF: 70 – 520 MHz
Operation modes	Digital voice and data system
Symbol rate	8 kBd
Modulation	GMSK (BT=0.25)
Receiver settings	BW = 12.5 kHz
Input format(s)	IF
Additional info	Data or voice
Operation modes	Trunked or Direct-Mode
Access method	FDMA
Voice codec	RP-CELP (6000 bps)

The WAVECOM decoder can detect Data, Voice, Random Access (RACH), Training, High Rate Data, Direct Mode Emergency Frame and SCH/TI frames with binary outputs. Each frame can be displayed in binary format with associated confidence(s) as well as a verification of the CRC for the given frame. Both VHF and UHF version of the PAS is supported. Currently, it supports the protocol interpretation for Data and RACH frames. The voice frames are finally processed by the TETRAPOL vocoder and output to the speaker for live monitoring purpose. Each voice session is saved in a wav file and the voice frame bits are saved in a txt file.

To use the mode set **Offset** to the center of the received signal. Select the correct polarity with respect to received signal. The TETRAPOL PAS defines two signal types: Downlink and Uplink. Downlink is transmitted as **INV** whilst uplink is transmitted as **NOR**. However some receivers invert the signal at the IF output.

This decoder uses soft-decision for demodulation and decoding to combat various disturbance in the received signal.

The "**Confidence**" (max. value 100) shows the overall decoding quality. The user can use the "**Message Type**" in the "Options" menu to display "Data & Voice Frames", "Data Frames Only" or "Voice Frames Only".

A TETRAPOL terminals can operate in three different modes: Network Mode, Repeat Mode and Direct Mode. In the Network Mode, a Base Station (BS) transmits one Control Channel (CCH) and several Traffic Channels (TCH), which can be in total up to 24 radio channels. Frames are organised in Superframes, with a 4 second period (or 200 frames), which is synchronized by special frames in CCH, e.g., Paging Channel (PCH) and Broadcast Channel (BCH) frames. Repeat Mode is a special form of Network Mode, with only TCH frames and Direct Mode is operated between two terminals in half duplex mode.

The Control Channel (CCH) as shown in Fig. 1 contains BCH (Broadcast CHannel), SDCH (Signalling and Data CHannel), DACH (Dynamic random Access CHannel), PCH (Paging CHannel), RCH (Random access answer CHannel) and RACH (Random Access CHannel). The other type is Traffic Channel (TCH), which can be specific as Voice Channel (Fig. 2) and Data Channel. It contains SCH (Signalling CHannel), SCH/TI (Signalling CHannel/Transmitter Interruption), and Voice/Data Channel.

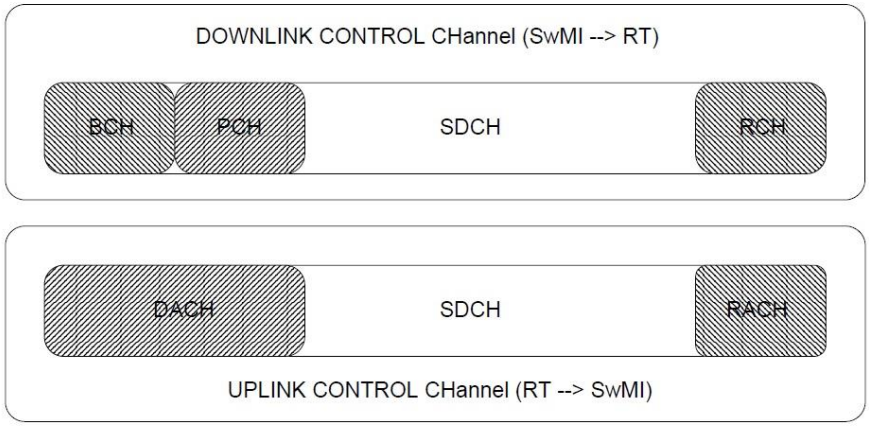


Fig. 1 Control Channel Mode

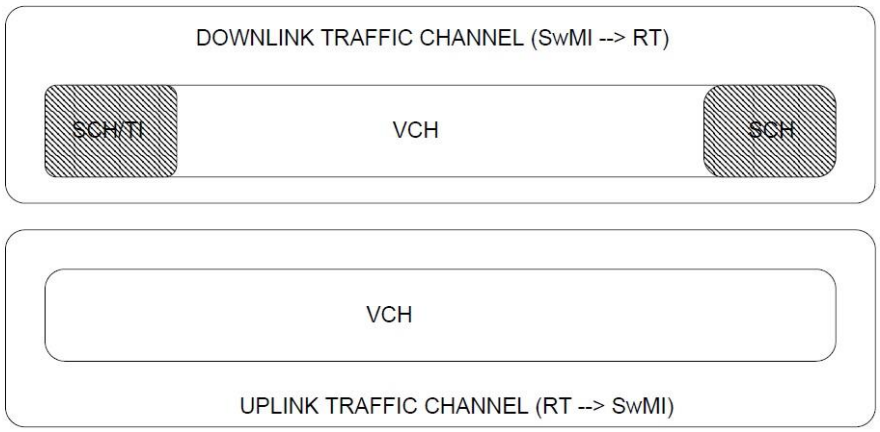


Fig. 2 Traffic Channel Mode: Voice Channel

All these channel frames can be coded in 5 different types in Network Mode: Voice, Data, Random Access Frames, Training Frame, SCH/TI Frames. Additionally, Direct Mode Emergency Frame can also appear in Direct Mode.

Each frame is 120 bits, which is obtained by several steps: discriminator with CRC, channel encoding, interleaving, scrambling with formatting, differential with encoding, and modulation. The precise structures of these are described in the TETRAPOL Specifications Radio Air Interface.

The frames can be interpreted according to the protocol. Examples of decoded frames are shown below.

Data Frame

Each data frame is 74 bits. They can be combined according to the FN bits to form HDLC frame displayed in Hex, with the FCS check in the last two bytes. The first 2 bytes in the HDLC frames contain the address information as shown in the first line. The second line is the 'command field', which indicates the types of the frame. The 'command field' can be: Information (I), Supervision (S), DACH (A) and Unnumbered (U) format (as shown in this example). The following bytes are the information field. The lines beginning with '--' are the header information of the user data, including: type, presence or not of user data to be carried, segmentation or not. The following lines beginning with '----' are contents in each bytes for the application layer.

```
-- DATA FRAME (74 Bits) --
11011111110111111111100000000000000100010000000100100001000010000100000111
FN(Flag Number): 0x01 ASB: 0x00 Frame Count: Unknown
-- DATA FRAME (74 Bits) --
10110010000011010100000000000001000000000011001000100001100000001001101 00
FN(Flag Number): 0x02 ASB: 0x02 Frame Count: Unknown
-- DATA FRAME (74 Bits) --
10100000000110000010110000100000000010000000000011110011011000101010011001
FN(Flag Number): 0x02 ASB: 0x00 Frame Count: Unknown
-- DATA FRAME (74 Bits) --
11001101110010101001010000100000100110010001100011000010101010101010001111
FN(Flag Number): 0x01 ASB: 0x00 Frame Count: Unknown
 ====== HDLC Frame: FCS (Frame Check Sequence) check OK ======
 0x7F 0xFF 0x03 0x00 0x11 0x90 0x10 0x42 0x09 0x56 0x00 0x20 0x00 0x13 0x61 0x40
 0x00 0x83 0x86 0x00 0x02 0xE0 0xD9 0xA8 0x76 0x2A 0x85 0x20 0x13 0x63 0xA8 0xAA
 Z: 0x00 / Y: 0x07 TTI (Temporary terminal identifier): ALL STs 0xFFF
 U Format, M M M: 0 P/E: 0 M M: 0 -> UI (Unnumbered information)
 -- EXT: 0 SEG: 0 ID_TSAP: 0x00
 -- DU_CODOP:  0x90
 ------------------------ D_SYSTEM_INFO-------------------------
 ---- CELL_STATE -> MODE: normal / BCH: 1 / ROAM: 0 All RT accepted / EXP: 0 nor
mal cell
 ---- CELL_CONFIG -> ECCH: no ECCH in service / Attach/detach function: supporte
d / Type of multiplexing: default type / SIM:  Several synchronised base station
s simulcast cell / DC:  Double coverage cell
 ---- COUNTRY_CODE: 9
 ---- SUPERFRAME_CPT: 736
 ---- U_CH_SCRAMBLING: 64
 ------------ Second BCH: restart the frame counter to 104 ---------------
```

RACH Frame

The RACH Frame contains 23 bits, where the last 9 bits are the CRC. The first 3 bits indicates Y address, while the 11 bits are the most significant bits of X address (X12 to X1). The SwMI shall find the missing bit (X0).

```
-- RACH FRAME (23 Bits) --
00000001100110101100101
 Y: 0x00 RTI (Random terminal identifier): 0x0CC or 0x0CD
```

Voice Frame

Each voice frame contains 126 bits. They are processed by the TETRAPOL vocoder, unencrypted clear voice is finally output to the speaker for live monitoring. At the same time each voice session is saved in a wav file and the plain bits are saved in a txt file. In case of the encryption, the voice to the speaker is not audiable, but the plain bits saved in the txt file can be used for further decryption analysis.

```
-- VOICE Frames --
................................................................................
................................................................................
.........................................
-- DATA (74 Bits) --
10011111110111111111100001101000000111111111000000000001110111111110100111101
FN (Flag Number): 0x00 ASB: 0x00 Frame Count: Unknown
 ====== HDLC Frame: FCS (Frame Check Sequence) check OK ======
 0x7F 0xFF 0xC3 0x02 0xFF 0x01 0xB8 0xBF
 Z: 0x00 / Y: 0x07 TTI (Temporary terminal identifier): ALL STs 0xFFF
 U Format, M M M: 6 P/E: 0 M M: 0 -> UI_VCH (VCH information frame)
------------------------ D_VOICE_STUFFING -------------------------


-- DATA (74 Bits) --
10011111110111111111100001101000000111111111000000000001110111111110100111101
FN (Flag Number): 0x00 ASB: 0x00 Frame Count: Unknown
 ====== HDLC Frame: FCS (Frame Check Sequence) check OK ======
 0x7F 0xFF 0xC3 0x02 0xFF 0x01 0xB8 0xBF
 Z: 0x00 / Y: 0x07 TTI (Temporary terminal identifier): ALL STs 0xFFF
 U Format, M M M: 6 P/E: 0 M M: 0 -> UI_VCH (VCH information frame)
------------------------ D_VOICE_STUFFING -------------------------
```

A time stamp is displayed to each frame at the time of decoding. Since the decoder works in real-time, the time of decoding is also the time of signal receiving (with a neglectale delay). The time stamp has a resolution of 1 millisecond (ms). The time stamp display delivers a method to verify whether each received frame is decoded in real-time. In a continous state we can count 50 frames each second. This matches to the 20 ms frame length.

THROB and THROBX

THROB and THROBX are two MFSK modes, created by Lionel Sear, G3PPT. THROBX is an evolution of THROB.

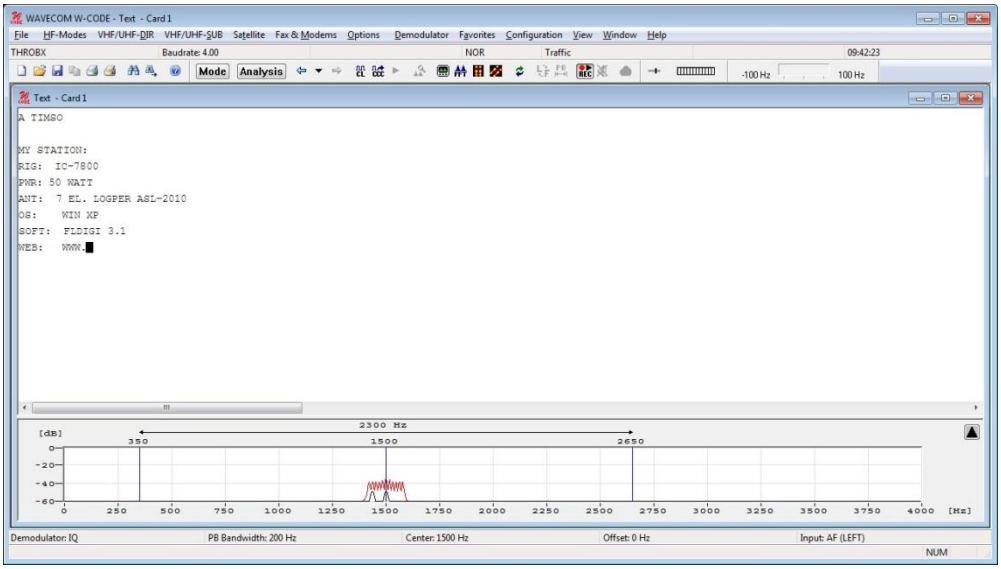
Parameter	Value
Frequency range	HF
Operation modes	Simplex
Modulation	MFSK
Symbol rate	1, 2 or 4 Bd
Receiver settings	USB or LSB
Input format(s)	AF, IF
Additional Info	9 or 11 tones are used

THROB uses 9 frequencies. 1 or 2 tones are sent at the same time. The frequencies are spaced 8 Hz at 1 and 2 baud, and 16 Hz at 4 baud. This allows for 45 characters. The THROB alphabet is slightly larger, so some characters are encoded using a shift character first.

THROBX uses 11 frequencies, spaced 7.8125 Hz apart. 2 tones are sent at the same time, which allows for 55 characters. W-CODE also supports THROBX with 4 baud, which is a non-standard mode, but is supported in the FLDIGI software.

Tuning

Since the spacing between two tones is only about 8 Hz, the tuning of the mode must be very exact. Put the middle tuning cursor to the center of the signal. The center of the MFSK signal can be measured by turning on the "Peak Hold" setting in the FFT tuning window.



TWINPLEX

TWINPLEX (F7B) is a FSK modulation technique with four modulation frequencies. Two transmission channels V1 and V2 are obtained through a combination of the modulation frequencies.

SITOR-TWINPLEX systems employ the second channel to double the data transmission rate from the equivalent of 50 Bd to 100 Bd. The V1 and V2 channels each contain 3 telegraph characters from the SITOR alphabet.

Parameter	Value
Frequency range	HF
Operation modes	Simplex ARQ
Modulation	4FSK
Symbol rate	100 Bd, variable 30-650 Bd
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF
Additional Info	SITOR Alphabet

Twinplex transmissions can have widely varying shifts. Seven standard combinations are available from the Shift item of the Demodulator menu:

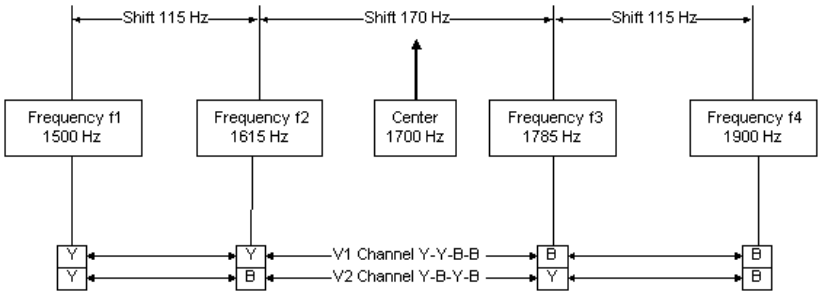
- 100-100-100 Hz
- 200-400-200 Hz
- 170-170-170 Hz
- 115-170-115 Hz
- 200-200-200 Hz
- 115-170-515 Hz
- 65-170-65 Hz

In addition, any desired combination may be programmed.

In addition to shift variations, Twinplex systems may utilize very different keying assignments. On the V1 and V2 channel the software allows the selection of Y-Y-B-B, Y-B-Y-B, B-Y-Y-B, B-Y-B-Y, Y-B-B-Y settings via the Y-B V1 Channel item in the Options menu. In the Y-B V2 Channel menu one of four combinations is selectable.

Most Twinplex stations work with the V1 combination of Y-Y-B-B and Y-B-Y-B (or B-Y-B-Y) in the V2 channel. Transmissions with a B-Y-B-Y combination in V1 and Y-B-B-Y in V2 are however also possible.

TWINPLEX (F7B) Principle of Operation



Measurement and Determination of TWINPLEX Frequency Shifts

Proper tuning is done using the **FSK Analysis**. The frequency shifts may be measured using the cursors.

The effective center frequency is the mid-frequency between the two inner tones f2 and f3. This is also valid in case of asymmetrical shifts, e.g., 115-170-515 Hz.

After the measurements and the determination of the V1 and V2 frequencies, the values found must be set up via the Shift item in the Options menu.

If no standard combination is used, the shift dialog box will allow the entry of any combination.

After the previously described set-up has been completed, the TWINPLEX mode can now be started by selecting 100.0 Bd or a variable baud rate.

The preferred demodulator type is the MFSK mode: Otherwise the DSP mode may be enabled in the Demodulator menu using the Mode item.

The proper assignment of the V1 and V2 keying combinations must now be set-up using the Y-B V1 Channel and Y-B V2 Channel items in the Options menu.

Most stations use the Y-Y-B-B setting for the V1 channel. The second channel frequently uses either the Y-B-Y-B or B-Y-B-Y combination.

If synchronization is not achieved after configuration has been completed, change the V1 and V2 settings until the right combination has been found. For example, transmissions are possible with V1 set to B-Y-B-Y and V2 set to Y-B-B-Y. This combination results in the first three telegraph characters to be transmitted on the V2 channel.

TWINPLEX stations only key the two inner frequencies f2 and f3 during the IDLE state (no traffic) or during the RQ state (incorrect acknowledgement from the remote station). In these states SITOR and TWINPLEX systems cannot be distinguished from each other.

VDEW

The entire call number is transmitted by consecutive tones in decade sequence. When two identical digits are to be transmitted consecutively, then an eleventh frequency is used as a repetition identifier.

Parameter	Value
Frequency range	VHF/UHF
Operation modes	Analogue Selcal
Modulation	FM, SUB tone
Receiver settings	FM, BW = 12 kHz
Input format(s)	AF, IF

If more than two identical digits are to be transmitted, the repetition tone is appended to the digit tone (e.g., 22222 is transmitted as f2 fw f2 fw f2, where f2 is the tone for "2" and fw is the repetition tone).

In most systems the accuracy of the single frequencies has to be within +1/-1.5% of the nominal value.

Decoding the selective calls is started by clicking on a system. If transmission and system selection conform, the call sign is displayed on the monitor. In the **Options** menu a **Time stamp** function can be enabled to add date and time to each call.

Tone Allocation

Digit	Hz	Digit	Hz
0	2280	8	1520
1	370	9	1860
2	450	A	2000
3	550	B	2100
4	675	C	2200
5	825	D	2300
6	1010	E	2400
7	1240		

Tone duration: 100 ms.

VDL-M2

VHF digital link (VDL) Mode 2 is an air-ground data link specified in the ICAO documents "Annex 10 Volume III - Communication Systems" and" Manual on VHF Digital Link (VDL) Mode 2".

Frequency range	VHF
Frquency range	VHF, 136.975 MHz (std. transmission frequency)
Operation modes	CSMA
Modulation	D8PSK
Symbol rate	31.5 kBd
Receiver settings	BW = 15-30 kHz
Input(s)	IF

VDL-M2 uses D8PSK (Differentially encoded 8-Phase Shift Keying) modulation scheme operating at a bit rate of 31.5 kbps in a 25 kHz frequency band. The data is transmitted in the form of short bursts. The maximum number of data bits at a single packet is 217 -1 bits, which corresponds to a packet length of approximately 4 seconds.

Each packet carries a header field, which contains a 48 bits synchronization sequence and a packet length field. The packet length field is protected with a (25, 20) block code, and the remaining data bits are protected with a systematic fixed-length Reed Solomon (255, 249) 28-ary code.

Channel access is achieved using the carrier sense multiple access (CSMA) algorithm and the data link service sublayer uses the aviation VHF link control (AVLC) protocol. AVLC is an extension of the HDLC standard which is specified by the following ISO documents: ISO 3309, ISO 4335, ISO 7809, and ISO 8885.

The AVLC packets start and end with a special flag byte (0x7E) and include a 9 bytes long AVLC header after the start flag and 2 bytes long CRC field before the end flag. The header contains the 24-bit ICAO aircraft/ground station addresses of the sending and receiving terminals and one byte link control field indicating the type of the packet, e.g., INFO, Receive Ready (RR), Exchange Identity (XID), TEST, and Selective Reject (SREJ).

In HEX output mode, the whole AVLC packet is printed bytewise as hex.

In ITA5-US mode the AVLC frame types and 24-bit ICAO aircraft / ground station addresses are decoded and printed. For INFO frames, the data field is decoded correspondingly if it is an ACARS packet, and is printed in hex format (0xXX) if it is an ATN packet. For XID frames, the parameters IDs are mapped to

their names, and corresponding values are printed as hex. For other frame types, the whole data field is printed as hex.

It is recommended to decrease the "Gain" manually until locating the bursts first visually in FFT Direct view with a 48 kHz bandwidth. The polarity should be set also correctly according to the output polarity of the receiver.

From the parameter "display-mode", the user can choose "valid-frames-only", "all-frames" or "indicate-errorneous-frames" may be selected.

VISEL

VISEL, also known as FEC-12 or YUG-MIL, is a synchronous system. This mode is used by defense forces in Eastern Europe.

Parameter	Value
Frequency range	HF
Operation modes	Simplex
Modulation	FSK
Shift/Bandwidth	300 Hz
Symbol rate	81.3, 120.9, 123.5, 125 Bd
Receiver settings	DATA, CW, LSB or USB
Input format(s)	AF, IF
Additional Info	ITA-2

The unusual baud rate of 120.9 Bd is very typical for this mode. Synchronization is done at the beginning of every burst transmission. The unencrypted calling sequence with tactical call signs has an autocorrelation of 12 bits and all bits are interleaved. All traffic is encrypted. Occasionally operator chat in plain text is transmitted.

WEATHER-FAX

A number of stations world-wide transmit weather charts on a regular schedule. During the transmission of an image a characteristic and easily recognizable audio signal is heard. A specific frequency deviation may also be seen on a tuning indicator.

Parameter	Value
Frequency range	HF
Operation modes	Graphic Mode, Broadcast
Center frequency	1900 Hz
Speed	60, 90, 120, 180 and 240 RPM, IOC 288 or 576
Receiver settings	FAX, DATA, CW, LSB or USB
Input format(s)	AF, IF

Most transmitters work with a wide shift (±400 Hz) and a few with narrow shift (±150 Hz).

By selecting the **Auto** function, the software waits for the IOC identifier and synchronization sequence. These signals are only transmitted once at the beginning of an image implying that capturing of the signal will only take place at the start of the next image.

By selecting WEATHER-FAX the application starts immediately. The drum speed and the IOC may be entered manually using the **Drum speed** and **IOC** items available from the **Demodulator** menu. The selected values are displayed in the decoder status bar. In the short-wave band, weather charts are transmitted almost exclusively with speeds of 60, 90 or 120 rpm. In the case of 60 rpm the drum rotates once per second, for 90 rpm at one and a half time and for 120 rpm at a speed of twice a second. The index of

co-operation (IOC) is readily recognizable from the screen display when images are spread out too wide. An IOC of 576 is mostly used on short-wave.

The decoder allows a continuous and smooth alignment of the image as it is being received from Options/Fine Speed. By using the Phase item in the Options menu the image can be shifted into the correct position. Flip Left-Right and Flip Top-Down will reverse the image or turn it upside down.

To enhance the interpretation of gray-scale images, a false color option is available. Right-click on the image to open the zoom menu and from the bottom part selects a color scheme. A checkmark is placed to the left of the selection.

X.25

X.25 can be monitored in the VHF and UHF bands. This mode uses indirect FM (sub carrier) modulation.

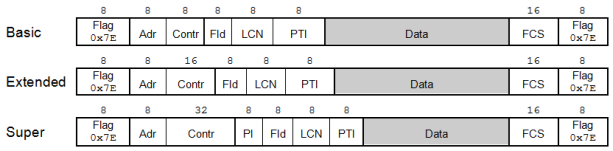
Parameter	Value
Frequency range	VHF/UHF
Operation modes	Duplex FEC TDMA
Modulation	FM, SUB FSK
Symbol rate	300, 600 and 1200 Bd
Center frequency	1700 Hz
Shift	1000 Hz
Receiver settings	FM BW = 12 kHz
Input format(s)	AF, IF
Additional Info	ITA-5 with block coding

To start X.25, select 1200 Bd, 600 Bd or 300 Bd. The correct shift or center may be set in the Demodulator menu. Standard values for the center frequency and the shift are 1700 Hz and 1000 Hz.

X.25 uses a HDLC computer network protocol. X.25 is a synchronous system in which data is transmitted in packets of 8 bit (octets).

Frame Format

X.25 provides three frame formats, the difference being the size of the sequence number.

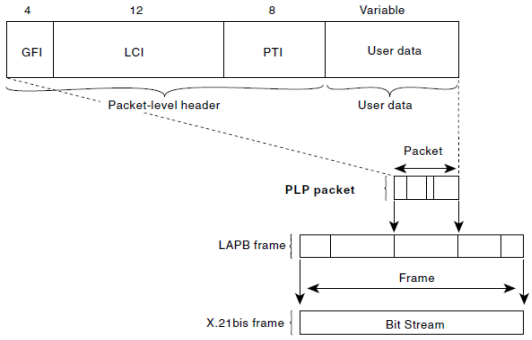


The Basic frame has a frame sequence number size of 3 bits, so that the increment of the sequence number is a modulo 8 operation. In case of the Extended frame, the increment is a modulo 128 operation and in case of the Super frame a modulo 32768 operation.

Packet structure

A X.25 packet constitutes the data field of a LAPB (HDLC) frame with a size of 64 to 4096 bytes.

X.25 PLP encapsulation in a LAPB frame (Cisco “Internetworking Handbook”).



The GFI (General Format Identifier) field contains general information of the packet format, the LCI (Logical Channel Identifier) field contains information on the logical channel and the PTI (Packet Type Identifier) field contains information on the PLP packet type.

The WAVECOM implementation of the X.25 decoder features some options that can be selected:

Options | Frame Format... offers the decoding of **Basic**, **Extended** or **Super** frames.

Options | Display Mode... offers the display of **All Frames** or **Error free Frames**.

Options | Display... selects the kind (**RAW**, **FULLFRAME**, **DATA ONLY**) of data which ar to be displayed

- RAW: The content of the frame is not decoded, only the byte values, starting with the address-field, are displayed (hex being the best choice). In this way signals can be displayed which only to some degree conform to the standard.
- FULL FRAME: This is the general case in which header data as well as user data are displayed. User data ar displayed in the text window and frame and packet headers are displayed in the status lines as well as in the text window.
- DATA ONLY: Frame and packet headers are displayed in the status lines. In the text window only user data are displayed.

ZVEI-1

The entire call number is transmitted by consecutive tones in decade sequence. When two identical digits are to be transmitted consecutively, then an eleventh frequency is used as a repetition identifier.

Parameter	Value
Frequency range	VHF/UHF
Operation modes	Analogue Selcal
Modulation	FM, SUB Tone
Receiver settings	FM, BW = 12 kHz
Input format(s)	AF, IF

If more than two identical digits are to be transmitted, the repetition tone is appended to the digit tone (e.g., 22222 is transmitted as f2 fw f2 fw f2, where f2 is the tone for "2" and fw is the repetition tone).

In most systems the accuracy of the single frequencies has to be within +1/-1.5% of the nominal value.

For ZVEI modes having nominal tone durations of 70 ms, the duration of a single tone may vary ±15 ms.

Decoding the selective calls is started by clicking on a system. If transmission and system selection conform, the call sign is displayed on the monitor. In the **Options** menu a **Time Stamp** function can be enabled to add date and time to each call.

Tone Allocation

Digit	Hz	Digit	Hz
0	2400	8	2000

Digit	Hz	Digit	Hz
1	1060	9	2200
2	1160	A	2800
3	1270	B	810
4	1400	C	970
5	1530	D	886
6	1670	E (REPETITION)	2600
7	1830		

Tone duration: 70 ms.

ZVEI-2

The entire call number is transmitted by consecutive tones in decade sequence. When two identical digits are to be transmitted consecutively, then an eleventh frequency is used as a repetition identifier.

Parameter	Value
Frequency range	VHF/UHF
Operation modes	Analogue Selcal
Modulation	FM, SUB Tone
Receiver settings	FM, BW = 12 kHz
Input format(s)	AF, IF

If more than two identical digits are to be transmitted, the repetition tone is appended to the digit tone (e.g., 22222 is transmitted as f2 fw f2 fw f2, where f2 is the tone for "2" and fw is the repetition tone).

In most systems the accuracy of the single frequencies has to be within +1/-1.5% of the nominal value.

For ZVEI modes having nominal tone durations of 70 ms, the duration of a single tone may vary ±15 ms.

Decoding the selective calls is started by clicking on a system. If transmission and system selection conform, the call sign is displayed on the monitor. In the **Options** menu a **Time Stamp** function can be enabled to add date and time to each call.

Tone Allocation

Digit	Hz	Digit	Hz
0	2200	8	1830
1	970	9	2000
2	1060	A	2600
3	1160	B	2800
4	1270	C	810
5	1400	D	886
6	1530	E	2400
7	1670		

Tone duration: 70 ms.

ZVEI-3

The entire call number is transmitted by consecutive tones in decade sequence. When two identical digits are to be transmitted consecutively, then an eleventh frequency is used as a repetition identifier.

Parameter	Value
Frequency range	VHF/UHF
Operation modes	Analogue selcal
Receiver settings	FM, BW = 12 kHz
Modulation	FM, SUB Tone
Input format(s)	AF, IF

If more than two identical digits are to be transmitted, the repetition tone is appended to the digit tone (e.g., 22222 is transmitted as f2 fw f2 fw f2, where f2 is the tone for "2" and fw is the repetition tone).

In most systems the accuracy of the single frequencies has to be within +1/-1.5% of the nominal value.

For ZVEI modes having nominal tone durations of 70 ms, the duration of a single tone may vary ±15 ms.

Decoding the selective calls is started by clicking on a system. If transmission and system selection conform, the call sign is displayed on the monitor. In the **Options** menu a **Time Stamp** function can be enabled to add date and time to each call.

Tone Allocation

Digit	Hz	Digit	Hz
0	2200	8	1830
1	970	9	2000
2	1060	A	886
3	1160	B	810
4	1270	C	740
5	1400	D	680
6	1530	E	2400
7	1670		

Tone duration: 70 ms.

ZVEI-VDEW

The digital selective calling systems ZVEI and VDEW were defined for selective call and data transmission in the non-public mobile land radio service. The ZVEI system adheres to the recommendation AK SRDS 87-3D, while the VDEW system was known as DIN45013 until 1992. The systems are identical on the physical layer. Due to the special requirements of the VDEW some additional features where added to the ZVEI system.

Parameter	Value
Frequency range	VHF/UHF
Operation modes	Digital Selcal
Modulation	FFSK
Symbol rate	1200 Bd
Center frequency	1500 Hz
Shift/Bandwidth	600 Hz

Parameter	Value
Receiver settings	FM, BW = 12 kHz
Input format(s)	AF, IF
Additional Info	BCD-Code, ZVEI and VDEW digital selective calls differ in codeword interpretation and BAK

In the VDEW system it is possible to concatenate up to four telegrams. The basic telegram (Grundtelegramm) is followed by one or more follow-up telegrams (Folgetelegramme).

The difference between both systems is the BAK (Betriebsartenkennung). VDEW uses the BAK to indicate follow-up telegrams, ZVEI does not. The BAK for the whole message is transferred in the last follow-up telegram. By means of the BAK the decoder detects if it is a VDEW message with follow-up telegrams.

The transmission speed is 1200 bps and the FFSK nominal frequencies are 1200 Hz for logical '1' and 1800 Hz for logical '0'. Indirect modulation (sub carrier) is used. A data packet consists of 64 bits. After a carrier pre-keying, an 8 bit telegram preamble and a 15 bit Barker sequence follow. Data is protected by using 8 bit redundancy.

Mode labeling for ZVEI and VDEW (BAK:)

There are 16 different values for the various call types:

Parameter hex	Value ZVEI (first data word)	Value VDEW (following data words)
0	User defined	Not used
1	Call to mobile	Call to mobile
2	Call to base station	Direct Access
3	Identification	Identification
4	Acknowledgement	Acknowledgement
5	Spare (indicate VDEW)	Sequence telegram
6	Separation call	Separation call
7	Spare	Recall
8	Priority call	Emergency call
9	Status request	Status request/response
A	Spare	Position request
B	Acknowledgement	Acknowledgement
C	Spare	Quick dialing
D	User defined	Data
E	User defined	Spare
F	Emergency call	Not used

Status for ZVEI and VDEW (STAT:)

Four bits are available. In the VDEW system these four bits indicate the number of follow-up telegrams. The last follow-up telegram and a basic telegram without follow-up telegrams are indicated by 0xA. In ZVEI the status bits can be used by the carrier.

Rhombic labeling (RAUTE:)

Four bits are used as additional distinction for a producer designation. The use is not determined.

Manufacturer identification (Herst:)

Two digits are used. The classification is determined by ZVEI.

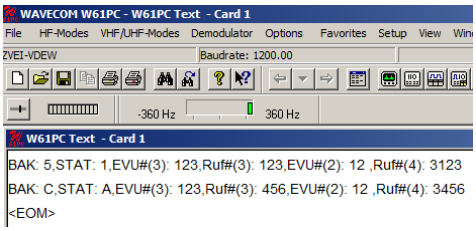
In the newer VDEW system the rhombic labeling and the manufacturer identification are combined into one field of three digits, called EVU number (EVU#:).

Call number ZVEI and VDEW (Ruf#:)

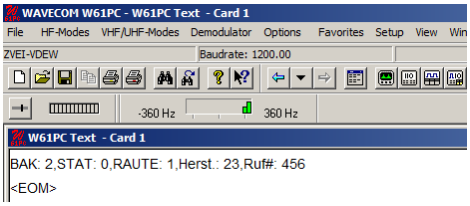
Three digits are used. The hundred-position digit is transmitted first, the one-position digit last. Group calls are transmitted as pseudo-tetrads of '1111' (16). For a group call in the 10s range the digit representing 1s is filled with logical '1'. For a group call in the 100s range, the 1s and 10s digit are filled with logical '1', and for a 1000s range call all 12 bits are filled with logical '1'.

EVU and call number are transferred in a block of six digits. The partitioning is either 3 digits for either items or 2 EVU digits plus 4 call number digits. The chosen variant cannot be derived from the data, so both versions are displayed.

The following picture shows a trace of a VDEW transmission with basic telegram and a single follow-up telegram, displaying both versions of partitioning, i.e., 3 + 3 as well as 2 + 4.



The next picture shows a transmission which can be either a ZVEI message or a VDEW message without follow-up telegram.



The user has to decide from the context which transmission standard was used. In case of a VDEW transmission without follow-up telegram, the rhombic labeling and the manufacturer identification have to be interpreted as EVU#.

Spectrum Analysis and Classifier – the Brain of W-SPECTRA

Overview

To work in its full automatic functionalities W-SPECTRA has an integrated spectrum analysis tool and a signal classifier. There are two different variants of classifier:

- A wideband (up to 96 kHz) version (Classifier-WB) is available with the license code 101. The wideband classifier is suitable to automatically process all signals in HF, VHF/UHF and SAT bands.
- A narrowband (up to 8 kHz) version (Classifier-NB) is available with the license code 201. The narrowband classifier is suitable to automatically process HF signals only.

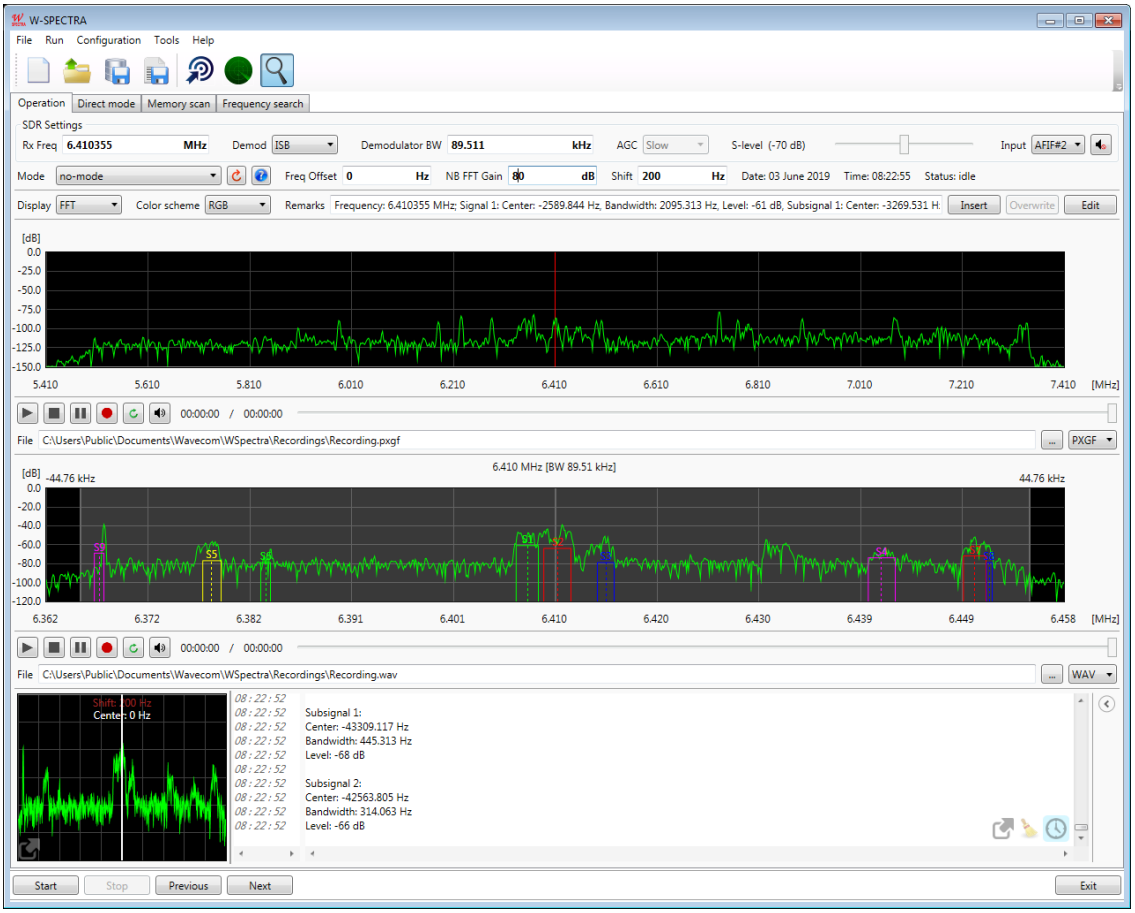
The wideband classifier covers all functions of the narrowband classifier. When there are both wideband and narrowband classifier licenses programmed on the CMStick, the wideband classifier is used by a W-SPECTRA. The narrowband classifier license can be used by another W-SPECTRA in the same local area network (LAN), when it does not carry a classifier license itself.

The Spectrum Analysis and the Classifier, together with the code check, form the brain of W-SPECTRA and deliver the intelligence of the whole monitoring system.

Spectrum Analysis

Spectrum Analysis (W-SA) is a licensed option for W-SPECTRA. It analyses the narrowband spectrum (96 kHz), detects all signals there, measures the center, width, strength of the signals and their detection confidence. Each detected signal will be analysed to their sub-signals, this feature is very help for further analyse of a multi-carrier or multi-tone signal.

The signal detection result will be marked in the narrowband spectrum and displayed in the "Remarks" field as well as in the text output field.



Spectrum analysis results are marked in the (middle) narrowband spectrum and displayed with their details, including sub-signals in the "Remarks" field and at the lower part of the W-SPECTRA GUI.

The user can spontaneously click the "Edit" or "Insert" button to edit or save, respectively, the result into the database.

Further, W-SA can be used as a Search Strategy in "Frequency Search" mode, so that the whole frequency band (e.g., HF band from 3 to 30 MHz) can be searched automatically and all signals (emissions) will be detected and saved in a database.

Classifier

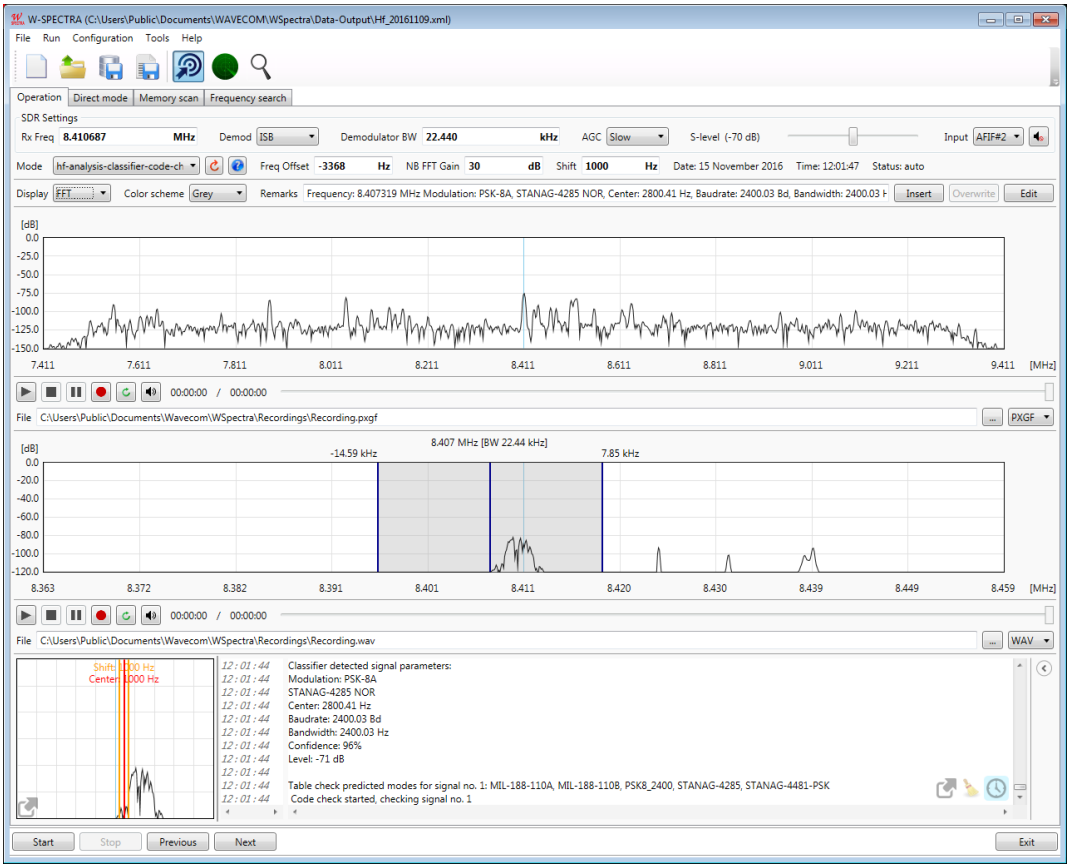
The classifier is another important analysis tool for the classification of unknown signals. W-Classifier (W-CL-NB or W-CL-WB) is more powerful than W-Spectrum Analysis (W-SA). It detects and analyses signals in more details: it can determine the modulation type, baud rate, frequency shift and bandwidth of one or more signals within the classification bandwidth. The wideband classifier will analyse and classify all signals within a bandwidth of up to 96 kHz depending on settings.

How the Classifier Works

Signal classification is done by providing the classifier with a complex sample (IQ) stream of the input signal across the chosen signal bandwidth, for a chosen period of sampling time and at a certain sampling rate. These sample series are examined for the properties of the signals contained within it. The results of the classification are output as a list of classified signal parameters.

Two classification modes are provided: A manual mode and a continuous mode. In manual mode the classifier will make one attempt at classification. In continuous mode, the classifier cyclically classifies signals with a user selectable interval. By default W-SPECTRA runs a classifier in continuous mode.

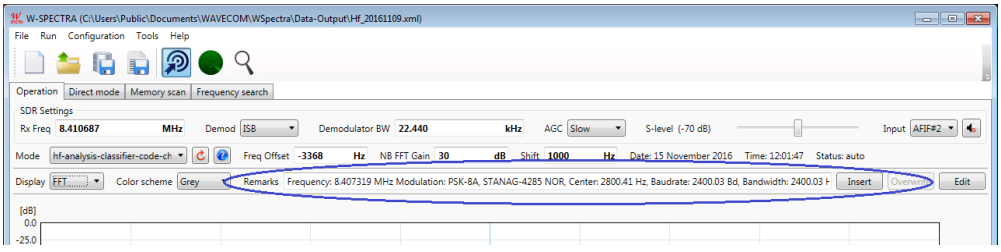
Depending on the complexity of the signals and the selected classification bandwidth, after a few seconds the classification results are listed in the results window.



Classifier results are displayed one after another in the result window at the lower part of the W-SPECTRA GUI.

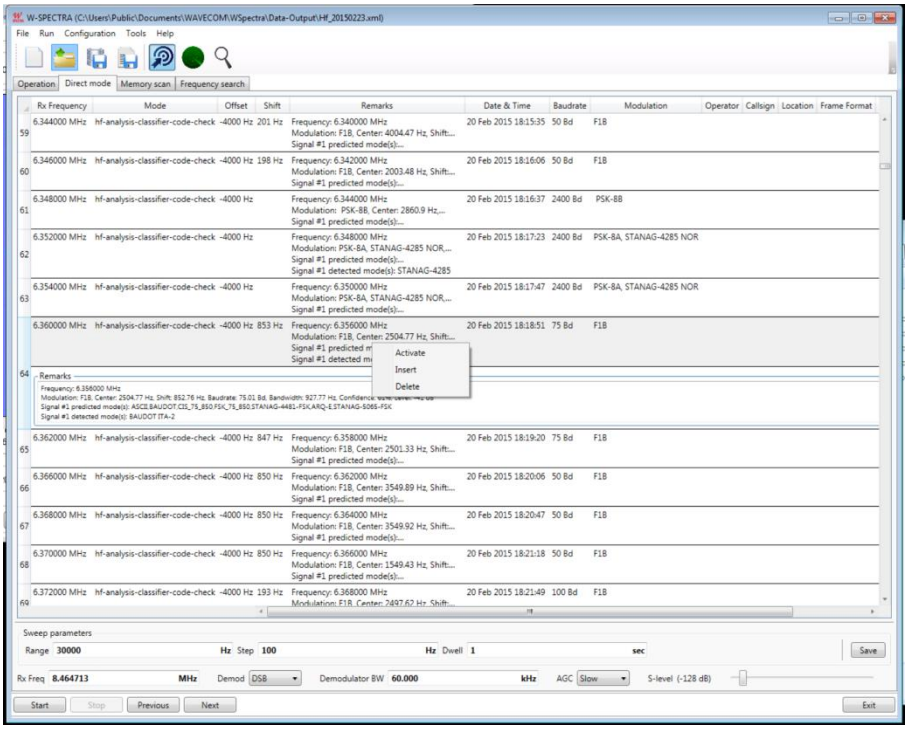
Classification Results List

All signals detected in one classification cycle are displayed in the result window. At the same time they are written to the "Remarks" field, leading with the actual receiver frequency. When the user click the "Insert" or "Overwrite" button, an entry is inserted or overwritten into the database, respectively, together with the actual timestamp.



Classification results are displayed in the "Remarks" field and can be inserted or overwritten into the database.

The "Shift", "Baudrate" and "Modulation" fields are filled with the data of the first classification result and the "Date & Time" with the actual timestamp of the data entry insertion or overwriting.



Insert or overwrite a database entry with classification results.

The actual range of classification depends on the frequency settings. Thus it is important that the mode corresponds to the actual input signal frequency range.

The success of classification attempts depends mainly on the selection of the proper sampling time. To recognize low speed signals, the higher sampling rate, i.e., 3.2 s should be selected.

It is worth keeping in mind that the classifier is based on statistically based estimates of the properties of the input signals, and that many factors determine the reliability of these results – among these are signal quality and application settings. However, together with common sense and good monitoring experience and skills the classifier provides a powerful aid in analyzing unknown signals.

Classifier Parameters

There are following parameters in a classifier:

Modulation Check any number of modulation types or voice using the appropriate check boxes to narrow down the range of recognized signals.

Continuous Mode If continuous classification is desired check this box. Continuous mode can be halted and restarted pressing the **Start/Stop Classifier** button.

If the Continuous Mode check box is left unchecked, each classification must be started manually by pressing the **Start/Stop Classifier** button. The classifier allows only one classification attempt at a time. During classification attempts the **Start/Stop Classifier** button is grayed out.

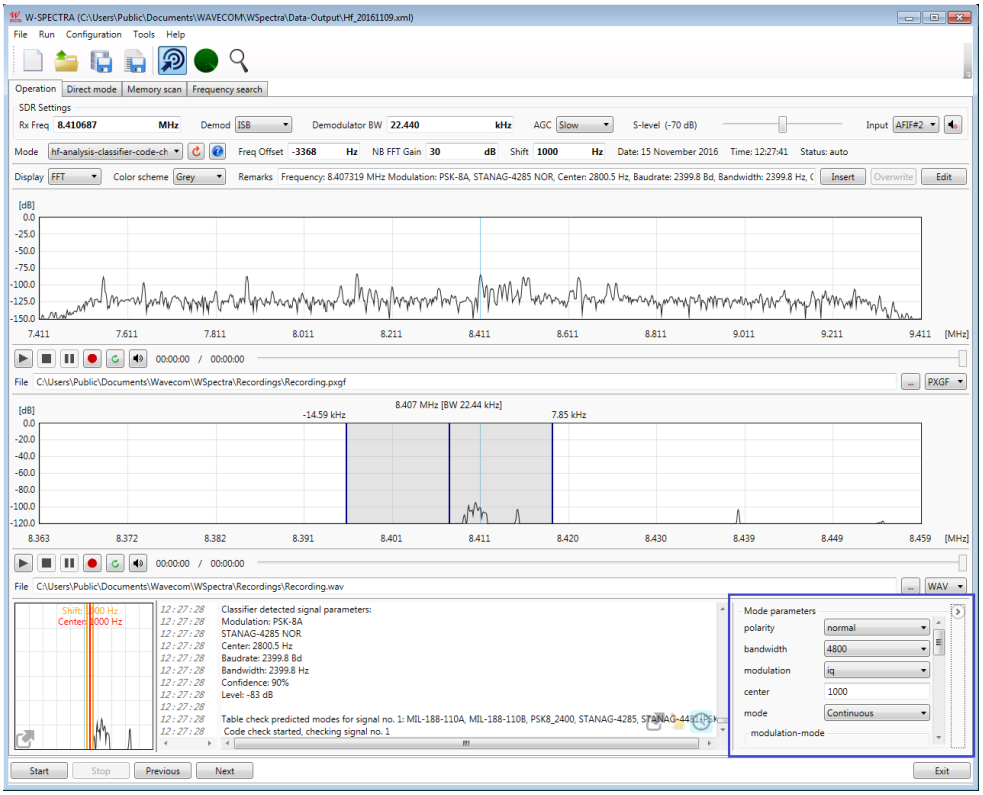
Refresh List If the Refresh List check box is checked, the list of results will be cleared after each classification attempt. This feature is only available when continuous mode is selected.

Cycle Mode This parameter sets the interval between classification attempts if no signals were classified. Enter a restart cycle length ranging from 4 s to 3600 s. Samples are available from two sources:

Samples taken before the classifier was started (select **Previous Samples**).

	Samples taken after the classifier was started (select **New Samples**).
Sample Time	Choose a sample time of **1.6 or 3.2 s**. The probability of correct classification of low symbol rate signals increases when the higher sample time is selected.
OFDM Mode	If **Full Analysis** is selected the modulation format of the OFDM subcarriers is also analyzed. If **Partial Analysis** is selected, the modulation format of the subcarriers is not analyzed.
30 Bd CW-Morse Protection	Checking this box will introduce a feature to prevent the classifier from confusing CW and FSK signals at the edges of the sampled input bandwidth.

The parameters can be set in the lower right corner of the W-SPECTRA GUI.



Set proper value for the classifier parameters.

Caveats

Even though the classifier has been carefully designed, the extreme complexity of classification requires the user to be aware of a few caveats. Common sense and visual inspection, as well as prior monitoring experience, are helpful when dealing with these issues.

Half-Duplex Signals

The classifier will only classify half-duplex or burst signals with difficulty. This is due to the nature of the signal, which is only present for a relatively small fraction of the total sampling time.

Multi-channel Systems

The current version of the classifier will only classify a 12-channel PSK CIS-12 signal as a single, aggregate signal – for all other multi-channel systems the classifier will classify each sub-channel as an individual signal.

MFSK

The current version of the classifier may indicate an incorrect number of tones for MFSK signals.

PSK A and B Signal Confusion

Under certain conditions the classifier cannot distinguish between the A and B variants of PSK modulation. A PSK signal of one variant may be mistaken for the other variant if the signal is offset from the real center frequency with a certain fraction of its baud rate; i.e., for PSK-2 ¼, for PSK-4 1/8 and PSK-16 1/16 of the baud rate. This behavior also includes multiples of the fractions.

OQPSK

The current version of the classifier has difficulties in correctly evaluating the baud rate of OQPSK signals, e.g., Inmarsat-Aero. Additionally, the phase constellation diagram may be incorrect.

Handling of Synchronous and Asynchronous Speeds

The handling of asynchronous Baudot signals with 1.5 stop bits is a challenge. If the classifier does not succeed in recognizing the stop bits, it will classify the signal as a synchronous signal having the double speed of the actual signal.

CW Recognition

The classifier may confuse a low rate FSK signal with a fast CW signal, particularly at the edges of the classification bandwidth. To lower the probability of such behavior, a classification model may be selected which only allows CW signals below 30 Bd to be classified at the edges of the classification bandwidth.

Technical Data of the Narrowband and Wideband Classifier

The technical data of the narrowband and wideband classifier are summarized in the following tables.

Bandwidth HF	4 kHz or 8 kHz (IQ signal: 9.6 kHz)
Sampling interval (Ts)	1.6 sec or 3.2 sec
FSK	30 to 3000 Bd, Shift <= 3500 Hz, Modulation index: 0.5 – 20 Signal must be continuously present during the sampling interval
FSK-4 (F7B)	30 to 300 Bd, Shift <= 3500 Hz
MFSK	4-36 tones
PSK 2/4 Variant A/B	30 to 3000 Bd
PSK 8/16 Variant A/B	30 to 3000 Bd
MIL/STANAG	Classified to protocol
CIS-12	120 Bd, classified as one signal
OFDM	25-512 carriers Tg/Tu = 1/1 to 1/8 >= 25 Bd
OQPSK	25 Bd to 30 kBd
CW-Morse	Ts = 1.6 s: 6 to 60 Bd Ts = 3.2 s: 3 to 60 Bd
Voice	No

Operation	FFT display of classified signals Continuous and single-pass mode Classifier Code Check with look-up table

Narrowband classifier (W-Classifier-NB) technical data.

FSK	m = 0.8: 100 – 2400 Bd m = 0.8: 50 Bd m >= 2: 100 – 2400 Bd m >= 2: 50 Bd	12 dB (Eb/N0) 15 dB (Eb/N0) 14 dB (Eb/N0) 16 dB (Eb/N0)
PSK 2/4 Variant A/B	100 – 2400 Bd	14 dB (Eb/N0)
PSK 8/16 Variant A/B	100 – 2400 Bd	16 dB (Eb/N0)
CW-Morse	8 – 50 Bd	18 dB (Eb/N0)

W-Classifier-NB quality of modulation classification.

FSK	baudrate center frequency	0.3% 2% of baudrate
PSK	baudrate center frequency	0.2% 0.15% of baudrate
CW-Morse	baudrate	5%

W-Classifier-NB accuracy of measured parameters.

Bandwidth HF/VHF/UHF/SHF	500 Hz to 96 kHz (IQ signal: 160 kHz)
Sampling interval (Ts)	1.6 sec or 3.2 sec
FSK	30 Bd to 60 kBd, Shift <= 30 kHz, Modulation index: 0.5 – 20 Signal must be continuously present during the sampling interval
FSK-4 (F7B)	30 to 300 Bd, Shift <= 3500 Hz
MFSK	4-36 tones
PSK 2/4 Variant A/B	30 Bd to 60 kBd
PSK 8/16 Variant A/B	30 Bd to 60 kBd
MIL/STANAG	Classified to protocol
CIS-12	120 Bd, classified as one signal
OFDM	25-512 carriers Tg/Tu = 1/1 to 1/8

	>= 25 Bd
OQPSK	25 Bd to 30 kBd
CW-Morse	Ts = 1.6 s: 6 to 60 Bd Ts = 3.2 s: 3 to 60 Bd
Voice	AM, FM, USB, LSB
Operation	FFT display of classified signals Continuous and single-pass mode Classifier Code Check with look-up table

Wideband classifier (W-Classifier-WB) technical data.

FSK	m = 0.8: 100 – 2400 Bd m = 0.8: 50 Bd m >= 2: 100 – 2400 Bd m >= 2: 50 Bd	12 dB (Eb/N0) 15 dB (Eb/N0) 14 dB (Eb/N0) 16 dB (Eb/N0)
PSK 2/4 Variant A/B	100 – 2400 Bd	14 dB (Eb/N0)
PSK 8/16 Variant A/B	100 – 2400 Bd	16 dB (Eb/N0)
CW-Morse	8 – 50 Bd	18 dB (Eb/N0)

W-Classifier-WB quality of modulation classification.

FSK 100 Bd – 60 kBd	baudrate center frequency	0.3% 2% of baudrate
PSK 100 Bd – 60 kBd	baudrate center frequency	0.2% 0.15% of baudrate
CW-Morse 6 – 50 Bd	baudrate	5%

W-Classifier-WB accuracy of measured parameters.

Classifier Code Check HF/VHF/UHF (CCC)

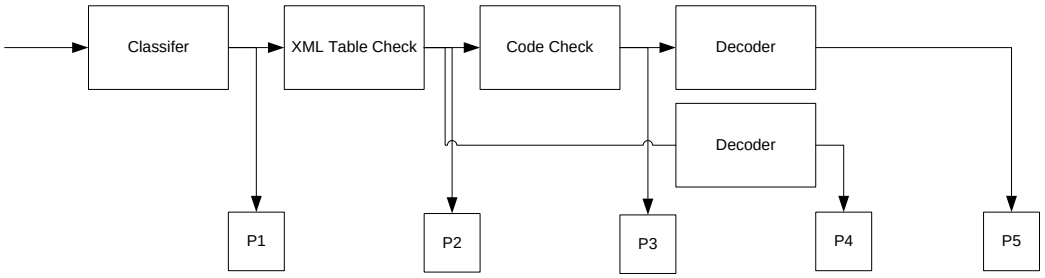
The Classifier Code Check is a versatile analysis tool for the classification of unknown signals and the determination of the protocol (mode) in use. The CCC combines a classifier with a table-based mode check and an advanced code check.

There are two kinds of CCCs in W-SPECTRA. The HF CCC will attempt to process all signals within a bandwidth of up to 4.8 kHz depending on settings and will primarily address the requirements for the analysis of signals below 30 MHz. The VHF/UHF CCC will attempt to process all signals within a bandwidth of up to 96 kHz depending on settings and will primarily address the requirements for the analysis of signals from 30 MHz to 3 GHz. Both CCC will of course work with signals in other frequency ranges if they fall within the bandwidth, and fulfil the other criteria, used by the CCC processes.

How the Classifier Code Check Works

The CCC processes input signals in up to four successive steps as shown in the block diagram below, which also shows the possible signal paths. The user can select how many steps should be involved in the analysis of the signal(s) under investigation.

The possible signal paths of the CCC are shown below.



- The **classifier** attempts to classify the input signals according to their modulation formats.
- The **table check** will check the signal against the entries of an XML-formatted table.
- The **code check** will check by attempting synchronization.
- Finally the signal may be forwarded to a **decoder** for output.

The operation of the CCC is explained in detail below.

Classifier

Signal classification is done by providing the classifier with a sample of the complex values of the input signal across the chosen sampling bandwidth for a chosen sampling time and a chosen sampling rate. This sample is examined for the properties of the signals it contains. The results of the classification are output as a list of classified signal parameters.

Two classification modes are provided: a manual mode and a continuous mode. In manual mode, the classifier will make one attempt at classification. In continuous mode, the classifier cyclically classifies signals with a user selectable interval.

For more details on the operation of the classifier, refer to the section "Classifier" on page 219.

XML Table Check

The objective of the table check is to accelerate the determination of the mode or protocol used by the signal(s) under investigation. The signal parameters are checked against entries in a table in XML format. The file containing the table may be created and edited by the user using **CCC Editor** (see the section "Classifier Code Check Editor" on page 230). Below is a browser excerpt from the XML file with the beginning of the file and entries for two modes, VISEL and VFT-8 200 Bd displayed.

```
<?xml version="1.0" encoding="UTF-8" standalone="yes" ?>
-<SignalDatabase>
-<SignalList>
-<Signal Name="VISEL" Mode="visel" Modulation="FSK" Disabled="0">
  <Baudrate>123.5</Baudrate>
  <Shift>300</Shift>
  <NumTones>2</NumTones>
  <CodecheckCounter>2</CodecheckCounter>
  </Signal>
-<Signal Name="VFT-8 200 Bd" Mode="no-mode" Modulation="FSK" Disabled="0">
  <Baudrate>200</Baudrate>
  <Shift>300</Shift>
  <NumTones>2</NumTones>
  <Spacing>300</Spacing>
```

```
  <NumChannels>8</NumChannels>
  <NumChannelsMin>2</NumChannelsMin>
</Signal>
```

Code Check

Code check tests whether a candidate mode can successfully synchronize to the input signal for a required number of times as specified in the corresponding entry in the XML file (<CodecheckCounter>).

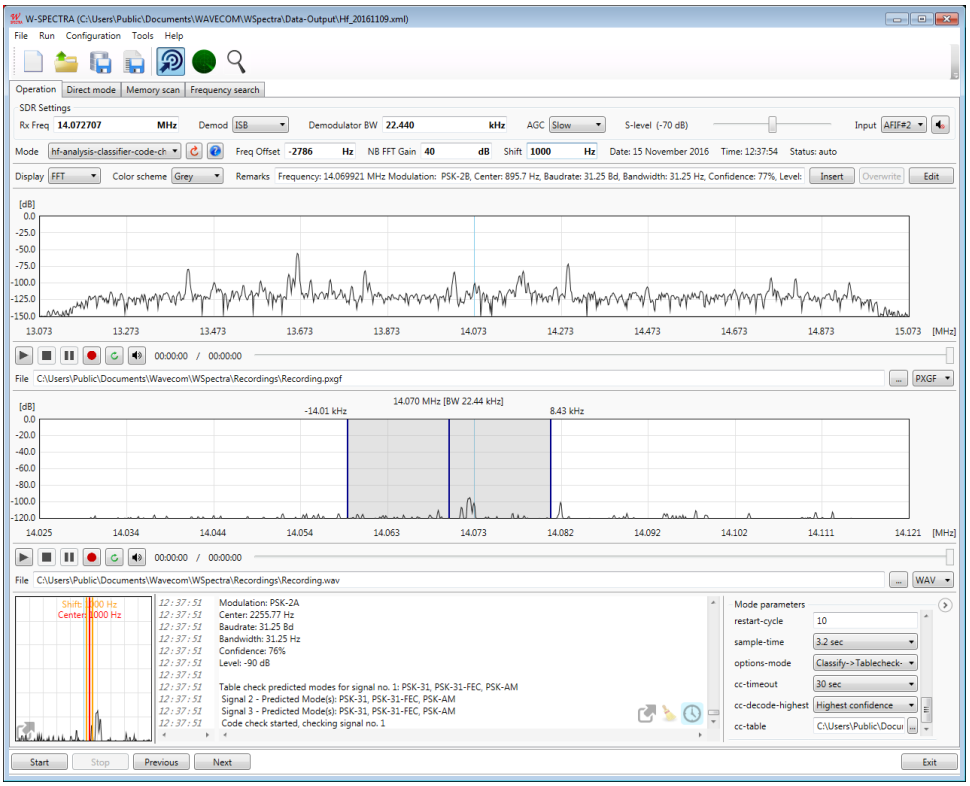
Decode

In the CCC workflow P4 and P5 the corresponding decoder will be called. The signal will be decoded with all detected parameters.

User Interface

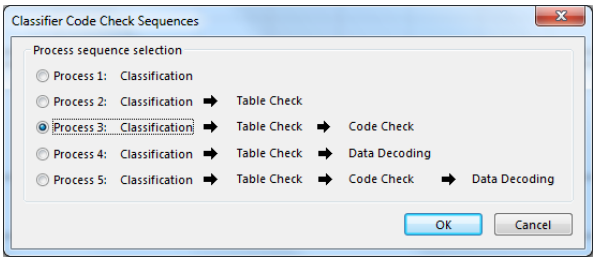
The CCC results are mainly displayed in the result window of the W-SPECTRA Operation tab:

- Classified signal with its parameter values
- Tablecheck results of each signal
- Codecheck results of each signal
- Jump to the corresponding decoder, if applicable
- Status messages of each code check step
- All classified signals with their parameters, tablecheck results and codecheck results are displayed together with the actual receiver frequency (Rx Frequency) in the "Remarks" field
- The parameters of the first detected signal will be displayed in the corresponding database field as well
- The entry will be inserted into the database automatically or by the user. The "Date & Time" is the actual timestamp of the insertion.



Classifier Code Check (CCC) results are displayed in the result window of the Operation tab.

Classifier Code Check Sequences

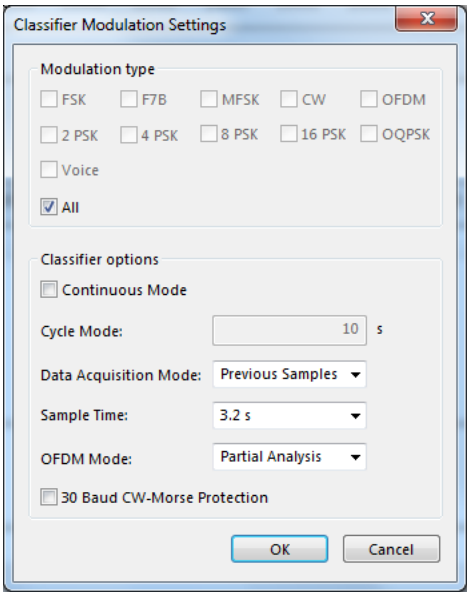


From this list, the desired mode of operation of the CCC is selected. Each process performs one or more steps to narrow down the possible candidates for eventual successful signal determination or decoding. The availability of more or less complex processes allows the user to select the process which is best suited to his purposes.

The process selected is shown in the status line.

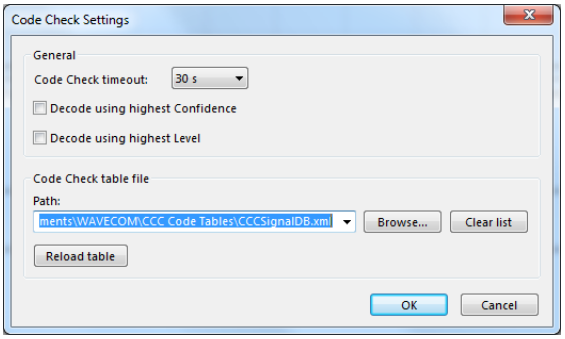
Process	Steps
P1	Only classification is performed, but no decoding.
P2	Classification and table check are performed, but no decoding.
P3	Classification, table check and code check are performed, but no decoding.
P4	Classification and table check are performed and finally the signal is decoded if a mode with an associated, valid detector was found.
P5	Classification, table check and code check are performed and finally the signal is decoded if a mode with an associated, valid detector was found.

Classifier Modulation Settings



These settings control the behavior of the classifier. See the section on "Classifier Code Check HF/VHF/UHF (CCC)" on page 225 for details. Note that the **Refresh List** option is not available when the classifier is used with the CCC.

Code Check Settings



Code Check Timeout

This option specifies the maximum allowable time interval between two successful synchronization attempts performed by a code check process. If the specified time interval is exceeded, the code check process will be interrupted. Available intervals are 15, 30, 45, and 60 seconds.

Decode Using the Highest Confidence

If checked and if decoding is part of the selected CCC process (P4 and P5), decoding is performed for the signal with the highest confidence as determined by the classifier.

Decode Using the Highest Level

If checked and if decoding is part of the selected CCC process (P4 and P5), decoding is performed for the signal with the highest signal level determined by the classifier.

Code Check Table File

Select the XML table to use for the table check or to replace the current file.

A history of previously used XML files is displayed in a drop-down list when clicking on the arrow. Pressing the **Clear List** button, the history list will be reset. A file browser appears when clicking on the folder button.

If the CCC is started without an XML table, a dialog which prompts the user to select an XML table file appears.

Reload Table

Press this button to reload the current XML table.

The reload feature should be used to ensure that modifications of the currently selected file are applied – for instance if CCC Editor has made changes.

Note: The FSK and PSK code checks have built-in automatic polarity detection. For MFSK and MIL or STANAG signals it is necessary to select the appropriate polarity before the Classifier Code Check starts.

Classification Results List

The Classification Results List is identical to the Classifier Classification Results List (see the section on "Classifier" on page 219).

This information is available for all processes.

A list of code checked signals is displayed below the list of classified signals.



Classifie CodeCheck (CCC) will process the detected signals one after the other.

- For each signal the table check result will be displayed: "Table check predicted modes for signal no. n: ….".
- For each signal from the table check a code check will start: "Code check started, checking signal no. n"
- Each code check will deliver a result when a mode is detected: "Mode detected for signal no. n" or it will end with a timeout: "Code check finished"
- After the complete cycle the CCC will restart: "Restart…" and "Classifier start…"

Decoding

Process 4 and 5 complete the classification and code checking steps by automatically switching to decoding of the detected mode.

In the case that a sampling spectrum contains multiple signals, and without any preference set in **Code Check Settings**, Signal #1 is automatically selected for decoding; otherwise the preference checked will determine the selection for decoding.

Scan Delay in Automatic Modes

When W-SPECTRA is running in an automatic mode using a classifier code check and the classifier delivers the first results, the automatic jump to the next frequency or to the next database entry will be defered until the complete results by the code check are delivered.

Classifier Code Check Editor

The **Classifier Code Check (CCC)** option, which allows automatic classification and subsequent decoding of monitored signals, is based on automatic parameter measurements. These code-base measurements may however be replaced by, or be expanded with, table-based parameters. The table records are contained in a XML database file which can be edited by the user using the **CCC Editor**.

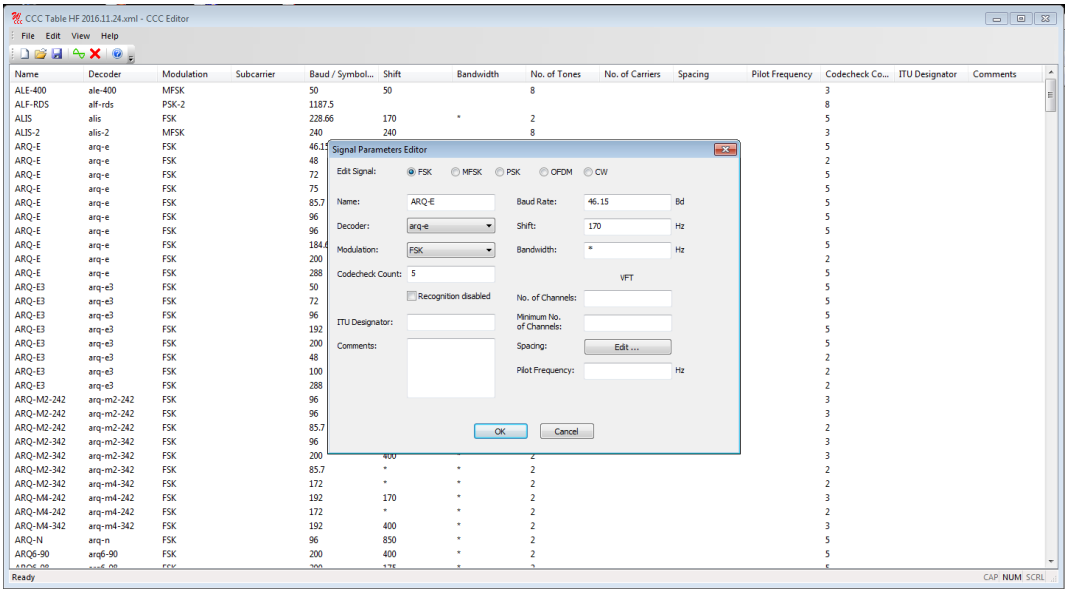
Installation

The CCC Editor is a stand-alone application (**CCC Editor.exe**). It will be installed by the W-SPECTRA installation. After the installation the programm appears in *C:\Program Files\WAVECOM\WSPECTRA.*

At installation time the default data file is installed as *CCC<DateCreated>DB.xml* in *C:\Users\Public\PublicDocuments\WAVECOM\CCC Code Tables*. The user may add any number of database files using any file name – the extension must however always be .XML - as long as the files are correctly-formatted XML files consistent with the code table schema. Using this editor, correct formatting is ensured.

CCC Editor GUI

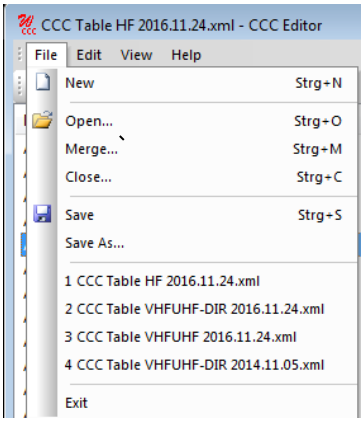
The main window of the CCC Editor is shown below, with an open data table and a table record for ARQ-E opened in the Signal Parameters Editor window.



The table contains a number of columns containing information required for the operation of the CCC in table-driven mode. The information in the columns is entered using the Signal Parameters Editor window.

Clicking the menu items will display the corresponding drop-down menu. Below the menu line a toolbar is placed.

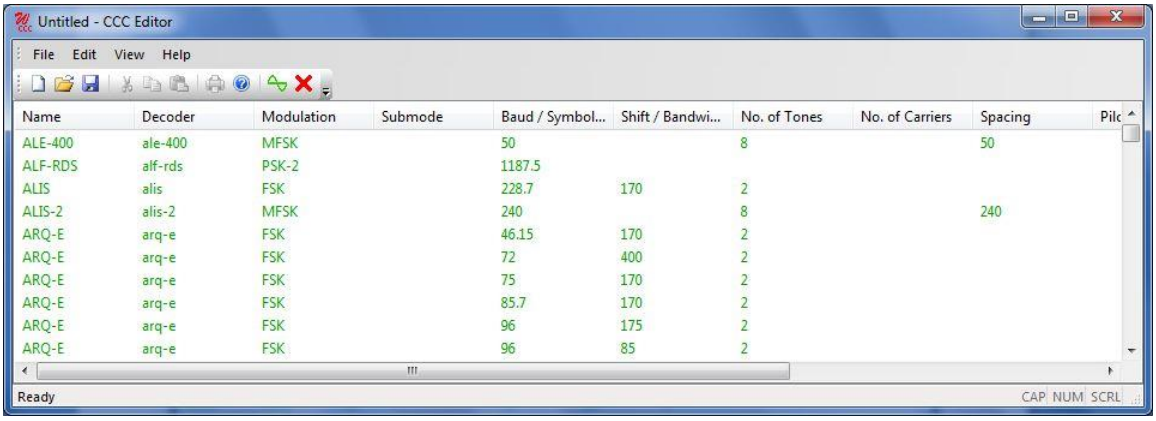
File Menu



In addition to the entries of the standard Windows file menu, the **File Menu** also contains a **Merge** entry, which allows the user to merge two tables. To merge files, click **Merge** to open the **Merge Signal Database** window.

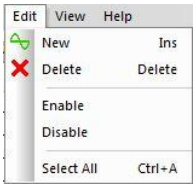


The file contents of the first of the two files to merge now appear in green in the main CCC Editor window



Now, repeat the procedure described above for the second of the two files to merge, i.e., from the **File Menu** select **Merge**, select the file to merge and press **Open**. Now the two files have been merged. To merge additional files, just repeat the steps outlined above.

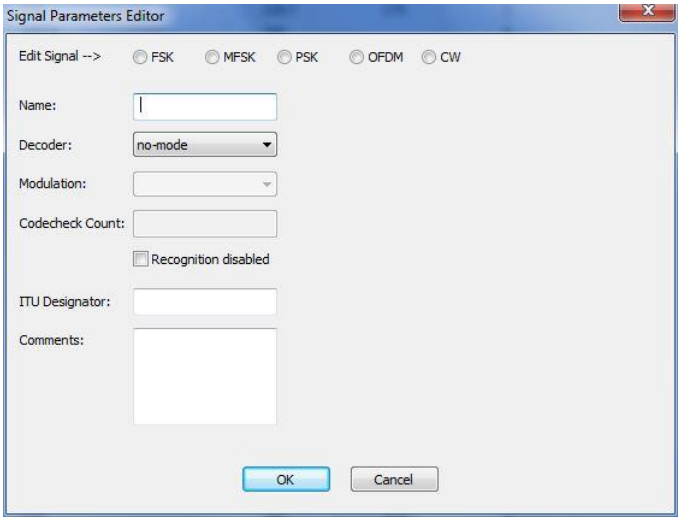
Edit Menu



The edit menu accesses these functions:

New

Pressing this menu item, or selecting an existing record from the CCC Editor main window by left-clicking an entry, will open a **Signal Parameters Editor** window.

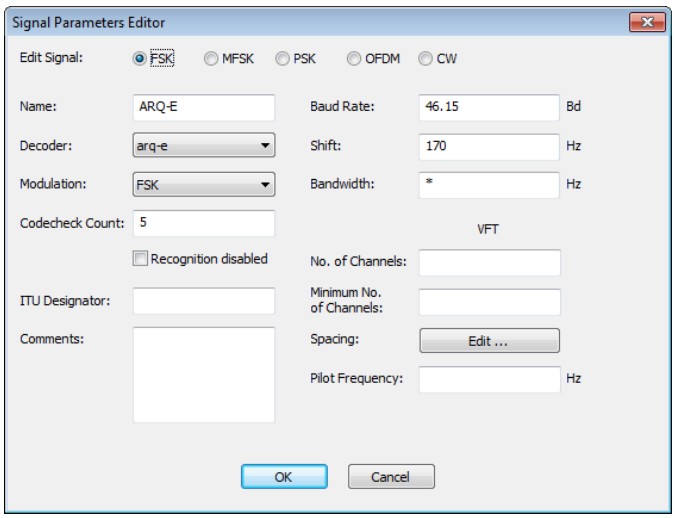


Depending on the selection of modulation method using the **Edit Signal** radio buttons, the editor entry window will appear with different sets of entry fields, see the sections below. The definition of the data-base fields are given at the end of this section.

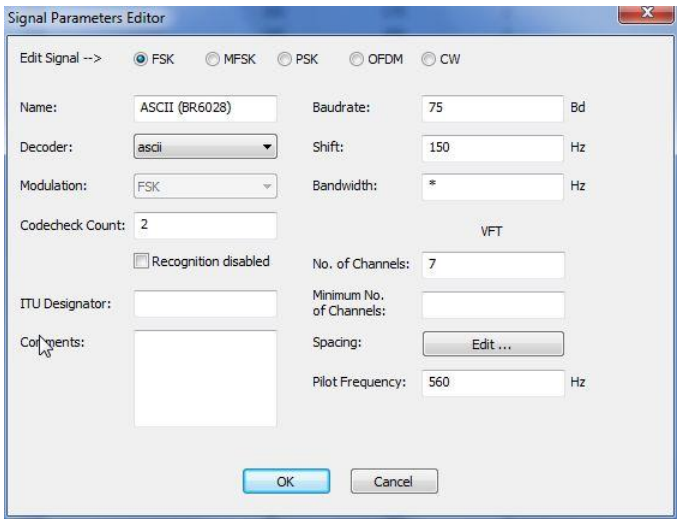
Enter the required parameter values for the desired signal in appropriate fields. Press **OK** to save the record or **Cancel** to cancel the operation.

In numerical fields only the number 0-9 are valid, however, the asterisk (*) can be used as a wild card to indicate that any value is valid.

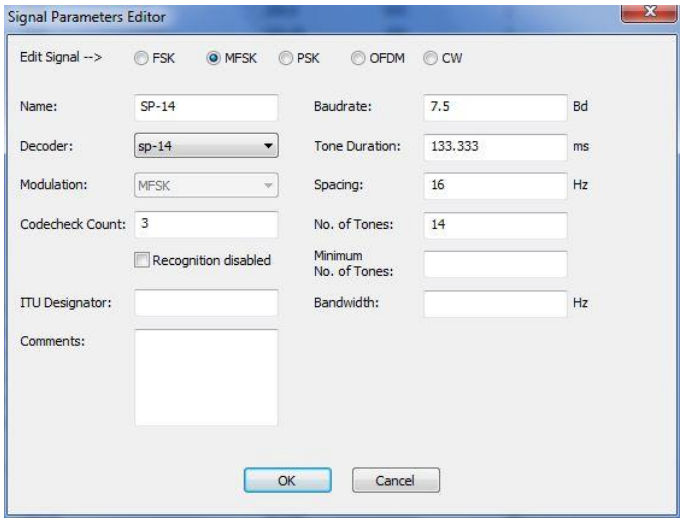
FSK The example above shows the editor window for a FSK signal, e.g., ARQ-E.



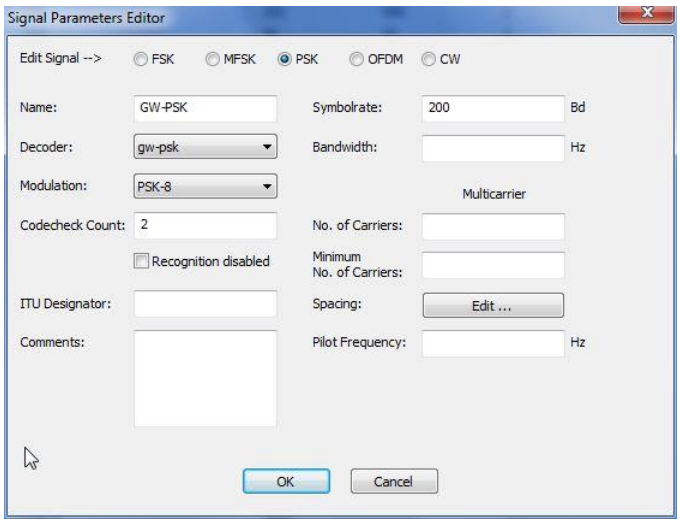
FSK (VFT) For aggregate frequency multiplexed signals, the field under the VFT (Voice Frequency Telegraphy) must also be filled, as shown below for a BR6028 seven sub-carrier signal.



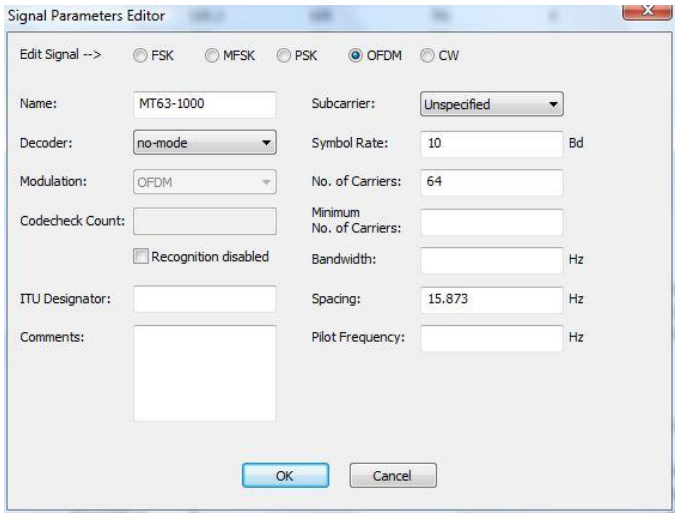
MFSK For multi-frequency shift signals the entry window looks like the example below for a SP-14 signal.



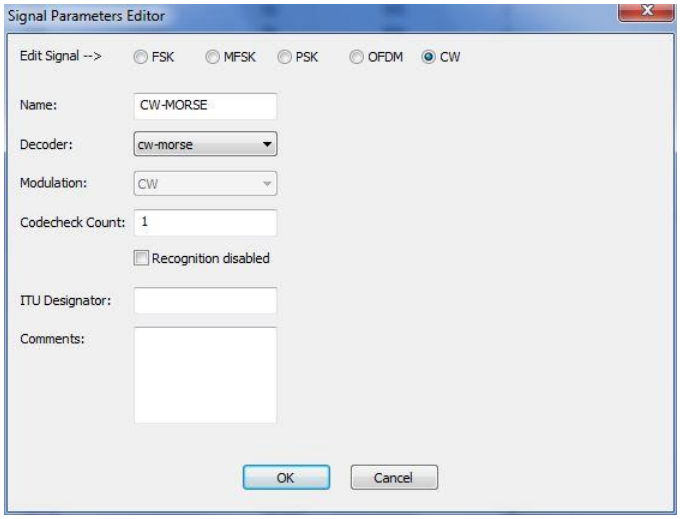
PSK For phase shift keyed signals the entry window looks like the example below for GW-PSK.



OFDM For orthogonal frequency division multiple signals the entry window looks like the example below for MT63-1000.



CW For continuous wave signals the entry window looks like the example below.



Delete

Delete the selected signal record(s) from the table(s).

Enable

Select the desired signal record in the list of records and press this menu item to re-enable a previously disabled signal record.

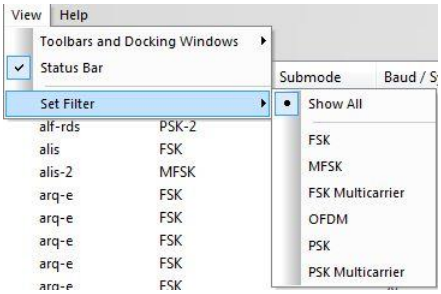
Disable

Use this function to disable a selected signal record, i.e., remove it from the CCC recognition process. The disabled record is greyed out in the list of records.

Select All

Use this funtion to select all signal records in the overview list.

View Menu



The view menu contains these menu items:

Toolbars and Docking Windows

Select this menu item to remove or display the CCC Editor Toolbar. This allows you to configure the toolbar according to your requirements.

Status Bar

Enable or disable the **Status Bar**.

Set Filter

Use this menu item to set up a filtered or non-filtered view of the data base. Filtering takes place according to modulation type as selected from the menu list. **Show All** will display all records.

Help menu

Pressing the Help menu will allow the user to display basic application information.

Database Fields

The individual fields of the data base are described below. Please be aware that certain fields are mandatory and must be filled – an error message is displayed if such a field has not been filled.

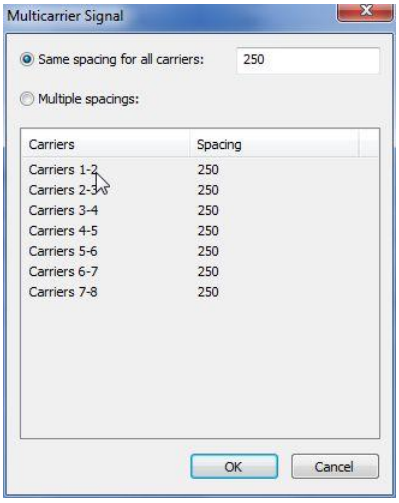


Bandwidth [Hz] Enter the required receiver bandwidth for this signal.

Baud Rate [Bd] **or Symbol Rate [Bd]**	Enter the channel rate in Bd. For two-condition signals, e.g., FSK, PSK-2 or CW, the baud rate equals the bit rate including channel coding overhead if any. For two-condition signals without any overhead, the baud rate equals the user or source bit rate.
Codecheck Count	The number of times the code check must be executed to obtain the desired confidence level.
Comments	A user free text field.
Decoder	Enter the WAVECOM decoder mode used by the CCC. Selected from a drop-down list of available modes.
Name	The name given to the table entry by the user. This field is a free text field.
Modulation	The modulation method used by the decoder. Set by default or selected from a drop-down list of modulation methods available for the selected decoder.
ITU Designator	A user free text field for the ITU emission designator applicable to this signal.
Minimum No. of Carriers	The minimum number of carriers in a multi-carrier system.
Minimum No. of Channels	The minimum number of channels in a VFT system.
Minimum No. of Tones	The minimum number of tones in a multi-frequency system.
No. of Carriers	The number of carriers in a multi-carrier system.
No. of Channels	Number of channels in a VFT system.
No. of Tones	The number of tones in a multi-frequency system.
Pilot Frequency [Hz]	If applicable, the frequency of the system pilot frequency, pilot tone or Doppler correction tone.
Recognition disabled	If checked the signal is not included in the CCC recognition process and the record is greyed out in the list of records.
Shift [Hz]	The frequency shift for two-frequency FSK.

Spacing [Hz]

The frequency spacing between adjacent tones in a multi-frequency system (do not confuse up "Spacing" and "Shift"). For multicarrier systems **Spacing** is user editable by clicking **Edit**, which will open the **Multicarrier Signal** window, see below. If equal spacing is desired press **Same spacing for all carriers** and enter the spacing in the entry field and press **OK** to save.



If **Multiple spacings** are desired press the **Multiple spacings** radio button and select a **Carrier-Spacing** pair from the list:



Enter the desired spacing and press **OK** to save the value.

Submode

The modulation format of the subcarriers of this OFDM system.

Tone Duration [ms]

In MFSK systems the duration of a tone, i.e., the inverse of the system baud rate.

SAT System

Overview

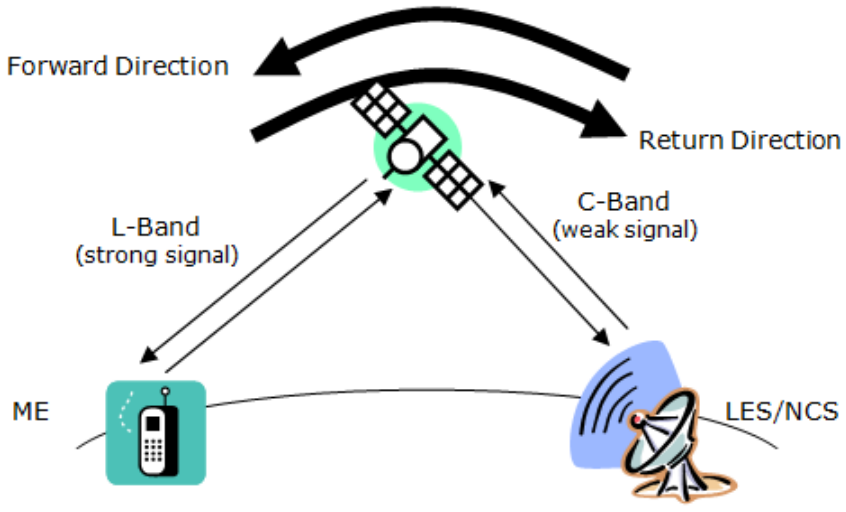
INMARSAT Ltd. is a private satellite provider based in London, UK (http://www.inmarsat.com). It evolved from an inter-governmental organization to its current private status in the late 1990s. It operates a number of geostationary satellites covering the entire surface of the earth (except the polar regions) using global beams, and spot beams for the more traffic intensive regions.

The positions (orbital slots) of the two latest generations of INMARSAT satellites are listed in the table below.

Coverage Area	Satellite Designation	Orbital Position	Former Country Code
Atlantic Ocean Region West (AOR-W)	3F4	54° W	+874
Atlantic Ocean Region East (AOR-E)	3F2	15° W	+871
Indian Ocean Region (IOR)	3F1	64° E	+873
Pacific Ocean Region (POR)	3F3	178° E	+872
Asia, Pacific	I-4 Asia-Pacific (4F1)	143° E	
Europe, Middle East, Africa	I-4 EMEA (4F2)	25° E	
Americas	I-4 Americas (4F3)	98° W	

INMARSAT now uses +870 as a single country code for all regions (SNAC).

Each region has a system architecture as depicted below.



A region is controlled by a Network Control Station, NCS. Its functions are operation of the control channels and allocation of traffic channels and channel resources. Each region may encompass a number of Land Earth Stations, LES. Their functions are interfacing to terrestrial networks (PSTN, data networks, Internet), session control. The user terminals called a Mobile Earth Stations, MES, communicate with the NCS and LES. The NCS communicate with all LES within its control area. The LES and NCS continuously broadcast system information.

Note: The information in the following paragraphs applies to the land mobile and maritime systems offered by Inmarsat. The aeronautical services differ in channel naming, usage and system setup.

Systems

Over time new generations of satellites were launched into orbit, while new services were added. Currently the third and fourth generation of satellites is in operation (3F, 4F). Inmarsat will also be the operator of Alphasat planned for launch in 2012 which will provide L band services in Europe, Middle East and Africa utilizing the expanded L band frequency ranges made available at WARC-03 (World Administrative Radio Conference). The fifth generation is expected to start deployment in 2013 and will operate Ka band transponders for the new INMRASAT GlobalXpress VSAT service offering user bandwidths up to 50 Mbps.

Inmarsat started operations in 1982 with leased satellite capacity for the INMARSAT A system. The table below shows the evolution of the various Inmarsat systems.

System	Services Offered	Introduction	Max User Data Rate (fax, data)
A	Analogue voice, G3 fax, telex, data. Discontinued	1982	3 kHz, 9.6 kbps, 50 Bd, 56 kbps
Aero-H	Digital voice, fax , data	1990	10.5 kbps
B	Digital voice, G3 Fax, data, telex. To be discontinued 2015	1994	9.6 kbps
C	Store-and-forward messaging	1992	600 bps
M	Digital voice, G3/4 fax, data	1993	2.4 kbps
mini-M	Digital voice, G3 fax, data. To be discontinued 2012	1996	2.4 kbps
D	Forward paging	1996	20 bps
D+	Paging with return channel	1997	20 bps
E	Emergency position indicating radio beacon (EPIRB). Discontinued	1997	600 bps
mini-M	Digital voice, G3/4 fax, data	1997	2.4 kbps
Aero-I	Digital voice, fax , data	1998	10.5 kbps
M4 (GAN)	Digital voice, G3/4 fax, data, packet data	2000	64 kbps
R-BGAN	Digital voice, G3/4 fax, data, packet data	2003	144 kbps
BGAN	Digital voice, G3/4 fax, data, packet data	2006	464 kbps
Aero-C	For the aeronautical mobile services , adapted from C		
Swift64	For the aeronautical mobile services, adapted from M4		
mini-M Aero	For the aeronautical mobile services, based on mini-M		
F77	For the maritime mobile service, based on M4, approved for GMDSS, operates in global beams (-4 dB/k antenna), options: 2.4 kbps G3 fax, 9.6 kbps G3 fax, 9.6 kbps async data		
F55	For the maritime mobile service, same as F77, but not approved for GMDSS, operates in spot beams (-7 dB/k antenna), except global 4.8 kbps voice codec, ISDN bearer services are optional and has no optional 2.4 kbps G3 fax		
F33	For the maritime mobile service, (-12.5 db/k antenna), global 4.8 kbps voice codec, optional spot beam 9.6 kbps G3 fax, async data, MPDS		

System	Services Offered	Introduction	Max User Data Rate (fax, data)
mini-C	For the land mobile service, as C, not approved for GMDSS, compact all-in-one unit housed in the antenna		
FleetBroadband	Maritime version of BGAN		
SwiftBroadBand	Aeronautical version of BGAN		
FleetPhone	Maritime, regional satellite phone		
LandPhone	Regional satellite phone, same as FleetPhone		
ISatPhone	Global satellite phone service based on GMR-2	2008	Data: 9.6 kbps

RF Channels

Band	Direction	Frequency
L-Band Frequency Range	Receive (Satellite – MES)	1525.0 – 1559.0 MHz
	Transmit (MES – Satellite)	1626.5 – 1660.5 MHz
C-Band Frequency Range	Receive (Satellite – NCS/LES)	3600.0 – 3629.0 MHz
	Transmit (NCS/LES – Satellite)	6425.0 – 6454.0 MHz

Logical Channels

The logical channels are described in the table below.

Name	Type	Function	Direction
NCS Common	Control	Network Bulletin Board status information	Forward (to MES)
NCS Assignment	Control	Channel assignment	Forward (to MES)
NCS Spot-beam Identification	Control	Spot beam identification for MES	Forward (to MES)
NCS Inter-station	Control	NCS-LES signaling and assignment	Forward (to LES)
NCS Registration Acknowledgement	Control	Registration acknowledgement	Forward (to MES
LES Assignment	Control	Stand-alone or NCS backup assignment	Forward (to MES)
LES Inter-station	Control	LES-NCS signaling	Return (to NCS)
MES Request	Control	Access request channel	Return (to LES, NCS)
MES Response	Control	Signaling response channel	Return (to NCS)
MES Registration	Control	Initial registration	Return (to LES, NCS)
MES Call Acknowledgement	Control	Call acknowledgement	Return (to LES)
SCPC channel	User traffic	Circuit switched	Forward and return
Shared channels	User traffic	Packet switched	Return

The only frequencies the MES initially knows are the frequencies of the NCSC in all regions - all other frequency information is dynamically extracted from the NCS Bulletin Board or in session oriented signaling messages. After being switched on, the MES must be told (or remembers) in which region it is currently located, and will automatically tune to the corresponding frequency of the NCS. The terminal will then search through the NCSS spot beam ID frequencies to identify the best spot beam.

MES Identification

A MES is called from the terrestrial network by its Inmarsat Number (IMN) which is identical to its public telephone number with a country code prefix according to Table 2. Internally the system uses two different (24 bits) IDs:

The Forward MESID, used on the forward path, i.e., in the direction from the Land Earth Station (LES) to the Mobile Earth Station (MES).

The Return MESID, used on the return path, i.e., from the MES to the LES.

These IDs are unrelated to the publicly published IMN and are only known to the Inmarsat system, which maintains a database describing the relationship between the IMN and the MESID pairs. These IDs are hard coded into the satellite terminals at manufacturing time.

Session Signaling

In its idle state, the MES continuously listens to the NCSC, updating its internal network status database (control channels, frequencies, etc) through the Bulletin Board messages.

There are two possibilities for starting a session:

- Fixed station initiates the session;
- MES initiates the session.

Fixed Station Initiated Session

Through the terrestrial network, the fixed station connects to a LES. The LES sends a signaling message to the NCS, which in turn pages the MES via the NCSC. The MES receives the session oriented signaling message with its Forward MESID, and sends a response back to the NCS with its Return MESID. The NCS in turn sends a channel assignment signaling message to both the MES and LES, and both stations will tune to the assigned traffic channel, where the session will take place. The traffic channel carries all user data (voice, fax, data) plus signaling messages as required. At the end of the session, the traffic channel is released and the LES informs the NCS, that the channel is free again. The NCS returns the assigned channel and channel equipment to its pool of available resources.

MES Initiated Session

On a MES Request Channel, the MES sends a request signaling message to the NCS containing its Return MESID. The NCS then sends the traffic channel assignment using the Forward MESID to both the LES and the MES. The remaining part of the protocol is as in the case above.

SAT Operation

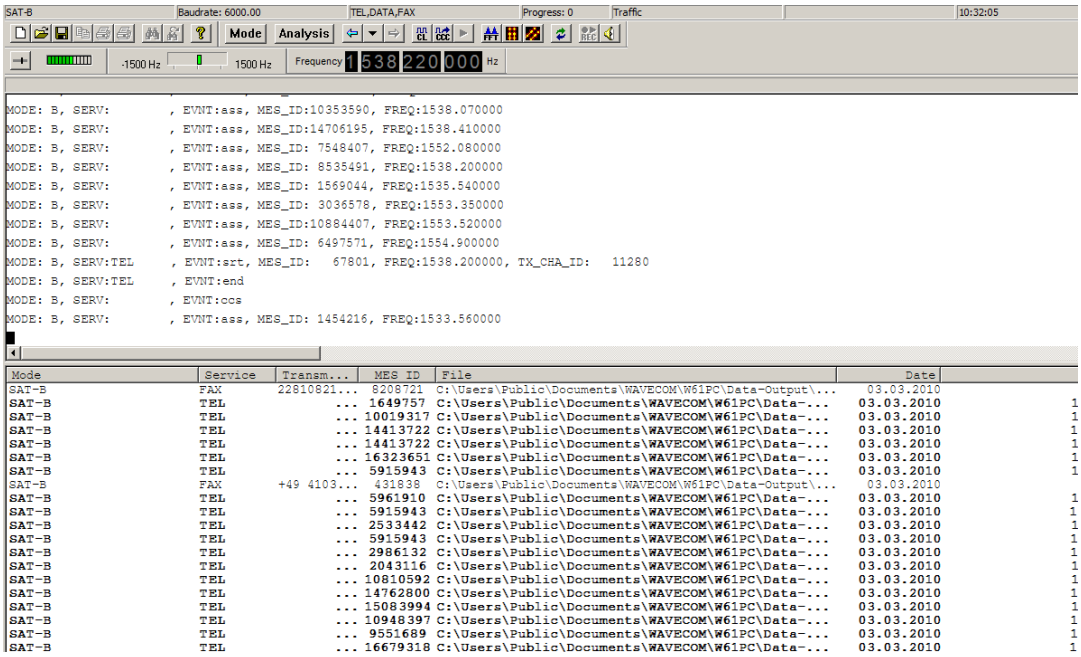
The decoder displays the session output in two windows, a Session Window and a Session List Window.

The Session Window continuously displays control channel information:

Field	
MODE:	B, M, mM
SERVice	DATA (data), FAX (fax), TEL (voice), TELX (telex)
EVeNT	srt Traffic channel start ass Assignment ccs Control channel start end End
MES_ID	Mobile earth station ID
FREQ	Traffic channel frequency
TX_CHA_ID	Channel ID of the uplink channel from the MES

The result (a file) of a monitoring session is listed in the **Session List Window**. Bold font indicates that a file is unread by the user, while normal font indicates that the file has been read (Display Status). In order

to display a file, double click on the corresponding **File** field. This enables the correct viewer. It is also possible to directly view a file through Windows Explorer; however, this does not change the Display Status.



The fields of the **Session List Window** are listed below:

- **Mode:** The mode of the recorded session
- **Service:** The service of the recorded session
- **MES ID:** The Forward MES ID of the user terminal of the recorded session
- **Transmitter ID:** Fax ID (usually a name or fax number)
- **File:** Path and file name of the monitored data. The file name contains the date and time of the session
- **Date, Time:** Start date and time of the recorded session
- **Duration:** Duration of recorded session
- **Size:** For **Fax** service - The number of pages of the fax. For **Data** service - The number of user bytes transmitted

Termination:

- **EOD -** End-of-data
- **ChannelRelease** – Normal channel release
- **StopMode** - Bit stream interrupted
- **SyncLost** – Excessive number of resync attempts
- **TONoSync** – Sync or resync time-out
- **TONoScrVect** – Bad scrambling vector
- **TooManyBadCRCs** – Excessive number of failed checksum calculations
- **UserCanc** – User cancellation

A file in the Session List Window can be deleted by right-clicking on it and following the delete dialog.

For the modes SAT-B, SAT-M and SAT-B-C-TFC it is possible to listen to live voice output during TEL sessions.



With the speaker-button in the tool bar the user can mute the output.

Traffic-Channel Decoder

If monitoring the forward direction in SAT-B, SAT-M or SAT-mM, it is necessary to extract information from the control channel (NCSC) in order to achieve for proper decoding.

The following stand-alone traffic channel decoders are available:

- SAT-B-C-TFC
- SAT-B-L-TFC

The SAT-B-C-TFC-mode can be started via the GUI, whereas the SAT-B-L-TFC can only be started via the XML-RCI.

For proper decoding the SAT-B-L-TFC decoder requires the MES ID and service type (TEL, FAX, DATA) from the control channel. The user may start traffic channel decoding by setting these two parameters in addition to the offset frequency.

The following picture shows the XML parameter set for the SAT-B-L-TFC mode.

```
<Message version="1.0">
 <Information>
  <ParameterList>
   <Parameter name="code" value="sat-b-l-tfc"/>
   <Parameter name="forward-mes-id" value="123456"/>
   <Parameter name="service-type" value="tel"/>
   <Parameter name="modulation" value="oqpsk"/>
   <Parameter name="speed" value="12000.000000"/>
   <Parameter name="passband-center" value="2000"/>
   <Parameter name="passband-bandwidth" value="3600"/>
   <Parameter name="input" value="inp4"/>
   <Parameter name="inputgain" value="70"/>
   <Parameter name="translation" value="66000567"/>
   <Parameter name="als" value="stop"/>
  </ParameterList>
 </Information>
</Message>
```

The Sat Aero System

The Aero services differ in a number of ways from the maritime and land mobile Inmarsat services. Among other characteristics, the Aero system uses specially adapted modulation formats as Aviation-BPSK (A-BPSK) which is differential BPSK and Aviation QPSK (A-QPSK), which is a variant of Offset QPSK (OQPSK).

Services

A number of services are available, as listed below. Voice uses the circuit switched C-channel, whereas data uses the P-channel in the forward direction and the T- or R-channels in the return direction, depending on the size of data to be transmitted (R-channels are used for single signal unit messages). Two data services are available:

- Data-2: Used for ACARS over satellite messages on OSI layer 2 (data link layer)
- Data-3: Used for Aeronautical Telecommunication Network (ATN) OSI-protocol traffic on OSI layer 3 (network layer)

Service	Antenna	Global Beam Operation	Spot Beam Operation	Data Channel Rates	Circuit Switched Channel Rate
Aero-L	Low gain	Yes	No	600, 1200	
Aero-I	Intermediate Gain	Yes	Yes	600, 1200	8400
Aero-H	High Gain	Yes	Yes	600, 1200, 10500	21000
Aero-H+	High Gain	Yes	Yes	600, 1200, 10500	8400, 21000

Channel types

The channel types for Aero are:

P-channel

A packet switched continuous channel in the forward direction ground-to-air from each GES carrying user data and signaling, e.g., system tables broadcast.

R-channel

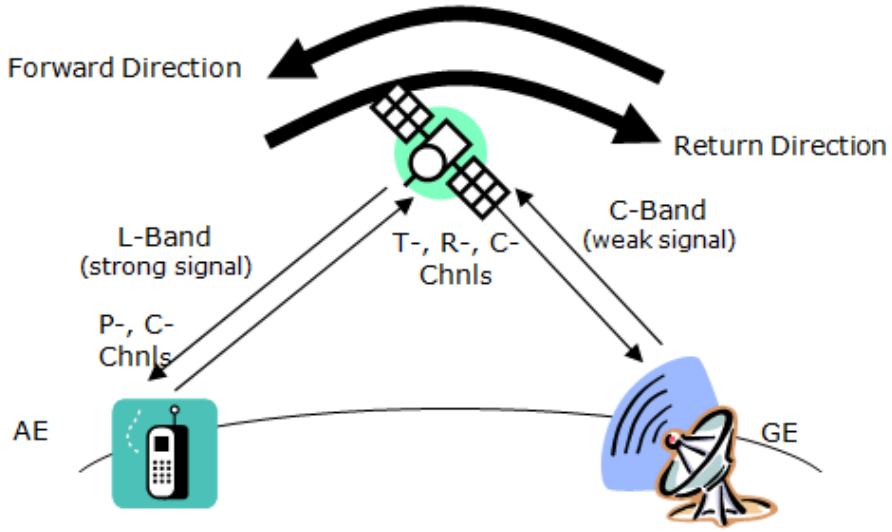
A random access (slotted Aloha) channel in the return direction carrying user data and signaling if the signaling unit is 33 bytes or less.

T-channel

A TDMA channel in the return direction carrying user data and signaling. The GES allocates time slots according to requests from the AES.

C-channel

Circuit-switched SCPC voice channel in both directions.



A satellite region contains one or more Ground Earth Stations (GES). The GES manages the control channels, allocation of traffic channels, channel resources, interfacing to terrestrial networks (PSTN, data networks, Internet) and session control. The user terminals called an Aeronautical Earth Stations, AES, communicate with the GES. The GES communicate with other GES within and outside its region and broadcasts system information.

The only frequencies the AES initially knows are the frequencies of the GES in all regions - all other frequency information is dynamically extracted from the system broadcasts or in session oriented signaling messages. After being switched on, the AES must be told (or remembers) in which region it is currently located, and will automatically tune to the corresponding frequency of the GES and will identify the spot beam ID where it is located.

AES Identification

Each AES is identified by an ICAO assigned 24 bit identification code. For voice an IMN (Inmarsat Mobile Number) is available.

Session Signaling

In its idle state, the MES continuously listens to the GES P-channel updating its internal network status database (control channels, frequencies, etc) through the system table broadcasts.

There are two possibilities for starting a session:

- GES initiates the session;

- AES initiates the session.

GES Initiated Session

Through the terrestrial network, the fixed station connects to a GES. The GES sends a signaling message to the AES on a P-channel. The MES receives signaling message and sends a response back to the GES on a R-channel. The GES in turn sends a channel assignment signaling message for a C-channel SCPC for circuit connections and a T-channel time slot assignment for longer packet switched data connectivity to both the MES and LES, and both stations will tune to the assigned traffic channel, where the session will take place. After the sessions have ended channel resources are returned to the channel resource pool.

AES Initiated Session

On an R-channel the MES sends a signaling message to the GES requesting appropriate C- or T-channel resources. The GES forwards resource allocation signaling messages on the P-channel as described above. Some classes of AES support simultaneous data and voice traffic or more than one voice channel.

Trouble Shooting

Receiver Frequency Error Compensation

The receiver must be tuned exactly to the frequency setting received from the decoder. Any offset must be corrected and entered into the system via the Freq **Offset** field in the **Configuration | Receiver and Satellite Settings...** dialog.

The following procedure can be used to find out and correct this offset:

- After start of the SAT Mode, wait until the receiver displays the frequency of the control channel (see the NCSC table below and take into account down converter use).
- Select spectrum analysis (**VHF/UHF Modes/Analysis DIRECT/Real-time FFT**) on the user interface of the decoder. Make sure all the settings are still correct (**Input, Offset**). Select a bandwidth of 24 kHz, set **Averaging** to about 4 or 5.
- The spectrum of the control channel is about 8 kHz wide, and it should be adjusted so it is in the centre of the 24 kHz FFT display. If this is not the case, determine the frequency offset - if the spectrum is too far to the right of the display, the sign of the offset is negative, otherwise it is positive.
- Now, close the FFT window, select **Configurationet | Receiver and Satellite Settings...**.Enter the amount and sign of the frequency offset into the **Freq Offset** field.
- Start the SAT Mode again, after the receiver has been retuned taking the frequency offset into consideration. Select the FFT again and check if the control channel is now exactly in the middle of the FFT display. Repeat the adjustment if necessary. It is very important that the control channel spectrum should not be offset more than 100 Hz, i.e., it should be symmetrically centered.

Ocean Region	NCSC Inmarsat B/M	NCSC Inmarsat miniM
AOR-W	1538.120000 MHz	1537.3100000 MHz
AOR-E	1538.220000	1537.3200000
IOR	1538.180000	1537.3400000
POR	1538.230000	1537.3300000

Signal Strength

The Signal-Noise Ratio for the control and traffic channels should be at least -18 dB as measured with the FFT of the decoder. Depending on the location of the monitoring system, a dish size of 2 – 3 m will be needed.

Spot Beam Reception

Traffic channels may be in spot beams allocated for power saving and frequency reuse. These spot beams cover only a part of the ocean region for the satellite being monitored. Therefore it is possible that the monitoring systems tunes to a frequency without signal. Nothing can be done in this case (except moving

your antenna at least 500 km!). By observing the Bulletin Board form the NCS the user may deduce which spot beams are visible in his location.

Session Success (Fax)

Patience is required when monitoring satellite transmissions as the monitoring of sessions may fail, in particular fax sessions. The reasons for the failure may be:

- The W61PC monitoring system cannot synchronize to the traffic channel because the traffic channel is not in a spot beam seen by the antenna, or it is too weak. Check the FFT display.
- The W61PC monitoring system cannot synchronize, or it may synchronize, but after some time it loses synch, because the traffic channel is in a spot beam which is disturbed by a neighbor channel. This neighbor channel can be inactive at the beginning of the session, but is activated after a while. Check the FFT display.
- The session is terminated after less than 100 seconds and no fax is received. Many fax sessions never start transmitting fax data, because the handshaking process at the beginning of the session fails. The handshake may take as long as 120 seconds.
- The fax transmission is successful, but the fax viewer does not display anything or displays only a partial fax. This could be due to bit errors preventing the fax decoding process or because the fax devices during the handshake agreed on a coding version not yet implemented in the WAVECOM fax viewer.
- The fax transmission is successful, but output is not the default .TIF file, but a .JBG file, because fax encoding is according to recommendation T.82/85. Call WAVECOM for support on this issue.

SAT-C-TDM, SAT-C-TDMA

The SAT-C system is a simple store-and-forward messaging system.

SAT-C has four operational channels:

NCS Common Channel (SAT-C-TDM)

- Continuous TDM
- 8.64 s frame
- 1200 symbols/s
- Scrambled, encoded and interleaved
- One bulletin board per frame
- Signaling, Enhanced Group Calls (EGC), polls (see below)

LES TDM (SAT-C-TDM)

- Continuous TDM or demand assigned by NCS
- 8.64 s frame
- 1200 symbols/s
- Scrambled, encoded, interleaved
- One bulletin board per frame
- Signaling and LES-mobile messages

MES Signaling Channel

- Slotted Aloha random access, 28 slots/frame, 120 bits/slot
- 1200 symbols/s
- Scrambled, encoded
- Distress and normal calls, data reporting, NCS log-in, log-out (registration)

MES Message Channel (SAT-C-TDMA)

- TDMA
- 1200 symbols/s
- Scrambled, encoded, interleaved

- Mobile-LES messages

Services

SAT-C supports several services:

Store-and-forward messaging

Allows messages to be exchanged between a mobile station and a user connected to the fixed network (telex, modem connection, X.25 or Internet email). Only messages that are received completely error-free are forwarded to the destination.

Distress calls

Distress calls are sent from a mobile (only maritime) to a LES. Distress priority messages may be sent in both directions. Maritime SAT-C forms part of the Global Maritime Distress and Safety System (GMDSS).

Enhanced Group Calls (EGC)

A broadcast service which may be addressed to individual units as well as groups, either geographical or logical. Two EGC services are available:

Fleet NET for commercial traffic and Safety NET for maritime safety traffic, e.g., navigational warnings, weather forecasts or distress call relays.

EGC traffic is transmitted on the NCS Common Channel.

Data reporting

Lets MES send short data reports such as position information, sensor data etc. which are transmitted via the MES Signaling Channel. Two types of data reporting are supported: reserved and unreserved.

Reserved access is controlled from the LES by poll messages which contain instructions on starting time and duration of the reporting and also the type of data report required. A poll message may be interpreted as a programming macro by the MES.

Unreserved access is initiated by the MES itself.

Polling

Used by base stations to initiate transmissions from a MES of text messages or data reports. Polls may be directed to individual stations, to groups or to geographical areas.

VMS (Vessel Monitoring Systems) and SSAS (Ship Security and Alarm Systems)

The C system is also used for the VMS operated by many states for fisheries control and the mandatory SSAS used for pirate and terror alerts.

Operation

A NCS controls each active satellite and the network within the satellite coverage area. Whenever a mobile enters or leaves an ocean region it has to register with the NCS using the MES Signaling Channel. The NCS updates its tables accordingly and informs the other NCSs and LESs within its region. These stations also keep updated tables of MES status.

A NCS Common Channel TDM is transmitted by each NCS - when idle, a MES is always tuned to this channel. A Common Channel frame always has a bulletin board as the first information. This board contains network information for all LES capabilities, channel information and other system information.

Each LES has at least one TDM assigned to it. The assignment may be permanent or on a demand basis.

A LES having a message for a mobile unit advises the NCS, which transmits a call announcement packet on the Common Channel containing the ids of the MES and LES, which LES TDM will be used, call direction and priority. The MES retunes to the assigned LES TDM. The LES TDM also carries a bulletin board with information on which MES Signaling Channel slots are free. The MES finds a free slot and transmits a call announcement response on a MES Signaling Channel. It then returns to the LES TDM. The LES then transmits a channel assignment packet containing message length information, time slot number (Logical Channel Number, LCN) and local routing information. The succeeding message packets are all labeled with the LCN and have also a sequence number and a check sum. The MES must send an assignment acknowledgement packet before message transfer is initiated. The last LES packet is a request for acknowledgement. The MES acknowledge packet will contain a list of packets received in error and the LES will retransmit these packets until all packets have been received by the MES. Then the LES releases the LCN and the MES reverts to idle state.

Message transfer from a mobile station to a LES is initiated by the MES finding the LES TDM frequency information in the NCS bulletin board. It then retunes to this TDM and synchronizes to the TDM frame. The MES finds a free signaling channel slot by reading the LES TDM bulletin board information and transmits an assignment request to the LES. The LES informs the NCS that the MES is busy. It then sends an assignment packet to the MES containing, message channel frequency, slot number and LCN. The MES retunes and starts transmitting its message.

SAT-C is mainly used in maritime communications, but is also widely used for long distance truck fleet management where the trucks are polled and then return position information from a GPS receiver. The system also finds its use in the remote control of pumping stations or remote data acquisition.

Modem and FAX Modes

Overview

The modem and FAX modes available in the decoder are mainly used on land lines, but may in as well be used on for instance satellite links. The modes are mainly analogue in nature.

Parameter	Value
Frequency range	200-3800 Hz (wire)
Symbol rate	2400 - 14400 Bd
Modulation	TCM, DPSK, QAM
Receiver settings	Line coupler required to record WAV files.

The modem and FAX mode is able to decode fax messages that are transmitted over the telephone wire.

There is a "Half-duplex Auto Mode" and a "Full-duplex Auto Mode" that will detect all transmission parameters automatically by analyzing the T.30 signaling.

WARNING: To interface with the line, a line coupler is required. This adapter has two functions: it connects the audio from telephone line to the decoder input at the correct level, and it isolates the recorder electrically from the telephone line. Do not connect the line directly to the decoder input; the decoder will interfere the fax signal and may be destroyed.

Line transmission

The analogue loop

The terrestrial network supporting fax and modem modes – the Public Switched Telephone Network (PSTN) – is still predominantly analogue in nature as far as the local loop (subscriber connection) is concerned. The local loop connects the end user (subscriber) with the global PSTN via a hierarchy of exchanges (central offices). The exchange provides -48 VDC line voltage used for signaling and dialing and a 90-120 VAC ringing voltage. The subscriber loop uses a balanced two-wire pair for both transmission and reception. In the telephone set and in the exchange line card a special device called a hybrid separates the two signal directions. Leased subscriber lines can be ordered as four wire lines having a dedicated pair for each signal direction.

WARNING: DO NOT CONNECT ANY OF THE DECODER OR PC SOUND CARD INPUTS DIRECTLY TO A TELEPHONE LINE! Doing so is illegal and will seriously damage your PC. Use a suitable line adapter or a recorded signal.

E1 and T1 digital trunks

Early telephone networks were entirely analogue networks end-to-end and carrying only one call per line. However, by mid-20th century the backbone trunks had gradually been converted to Frequency Division Multiplexed and later to Pulse Coded Modulated (PCM) digital Time Division Multiplexed coaxial cable carrier frequency lines, or microwave radio links, and more recently to optical Wavelength Division Multiplexed lines. A simultaneous development naturally took place for the exchanges, which developed from electromechanical devices to analogue electronic switches and then on to fully digital operation.

In spite of the progress of IP based telephony, the overwhelming majority of telephone trunks are still today PCM based digital channels organized into hierarchies. These hierarchies fall into two major groups; the European or CEPT hierarchy and the North American hierarchy. The standard CEPT E1 link consists of 30 voice and 2 signaling channels, each 64 kbps, giving a total bandwidth of 2.048 Mbps whereas the North American T1 requires a bandwidth of 1.544 Mbps for a frame consisting of 24 channels, each 64 kbps, plus one framing bit. The basic PCM channel samples the analogue voice signal 8000 times per second, producing 8000 8-bit words per second. Whereas the CEPT basic channel utilizes all 8 sample bits for

voice, the North American channel utilizes one bit for signaling ("robbed bit" signaling). Two different algorithms are used for sampling, A law and mu law.

Large organizations use E1 or T1 subscriber loops to connect their PBX (Private Branch Exchanges) to a PSTN central office.

The line interface is either two coaxial lines or two balanced pairs, one for each direction.

ISDN digital loop

The Integrated Services Digital Network (ISDN) is the oldest attempt of extending the digital infrastructure to the subscriber. ISDN comes in two flavors, the Basic Rate Interface (BRI) delivering 2 x 64 kbps channels + 16 kbps channeling totaling 144 kbps and Primary Rate Interface delivering 30 voice channels + 2 signaling channels equaling an E1 of 2.048 Mbps.

At the subscriber premises a BRI is terminated in a Network Termination box which converts the line signal from the line T interface to a local synchronous interface, the S four-wire interface supporting up to eight devices of which two may be active at the same time. The S bus carries 40 V. Analogue equipment connects to the S bus via a Terminal Adapter (TA).

The local loop (not the S bus) is a normal balanced two-wire pair carrying the T interface line signals, at a voltage at between 25 and 96 VDC.

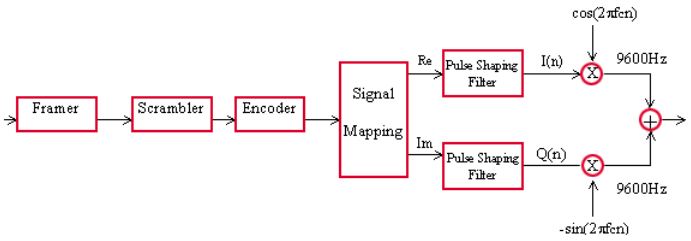
Fax and Data Transmission

In order to transmit the fax and modem data, the signals must be processed in such a way that they are adapted and ruggedized for the transmission over noisy and disturbed telephone lines. Transmit and reception processing takes place in devices called modems – a combination of "modulator" and "demodulator". The properties of various modems are standardized through ITU (International Telecommunications Union) V-series recommendations. Fax standards are laid down in a number of T-series recommendations.

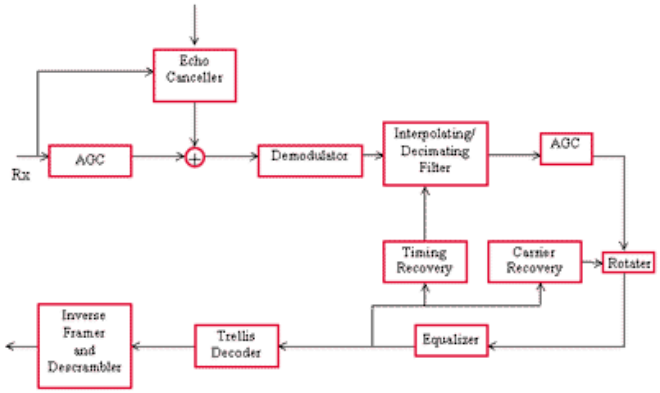
Modem Functionality

The techniques used to make the data more robust include framing, scrambling, error detection and correction and compression,and line conditioning using probing and training signals, which are used to adjust equalizers and echo cancellers at the far end to the actual phase, frequency and amplitude characteristics of the line.

A schematic of the transmission section of a typical modem using phase modulation is shown below. Incoming data is framed as HDLC frames, scrambled to facilitate bit synchronization, and then encoded. The encoded signal is then mapped to the phase changes (and for QAM also to amplitude changes) and used to modulate a quadrature carrier.



The receiving section will attempt to cancel out any echo, then demodulate the incoming signal, recover carrier and bit synchronism then finally de-frame and de-scramble the bit stream. The equalizer will attempt to invert line characteristics, and if Trellis coding has been used a Trellis decoder is inserted.



Handshaking

Before user data can be transmitted, handshaking must take place between the originating and answering modems or fax equipment. Using fax communication as an example, five distinct phases can be identified:

Phase A – Call establishment

Receiver number is dialed and a calling tone (CNG) is sent, and when the receiver goes off-hook it answers with an answer tone.

Phase B – Pre-message procedure

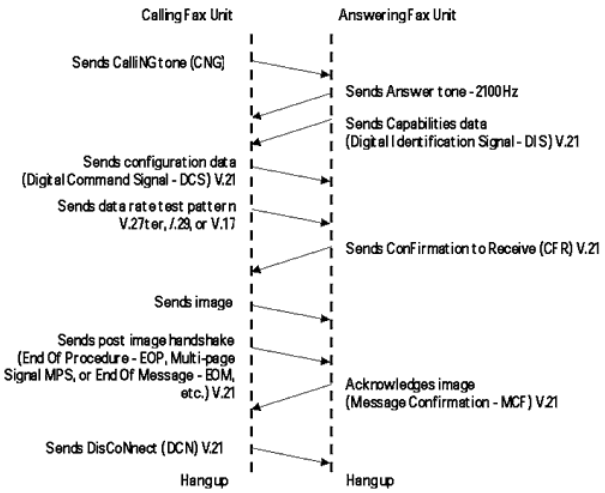
Using V.21, 300 bps FSK, capabilities, configuration and finally rate test signals are exchanged in HDLC frames.

Phase C – Message transmission

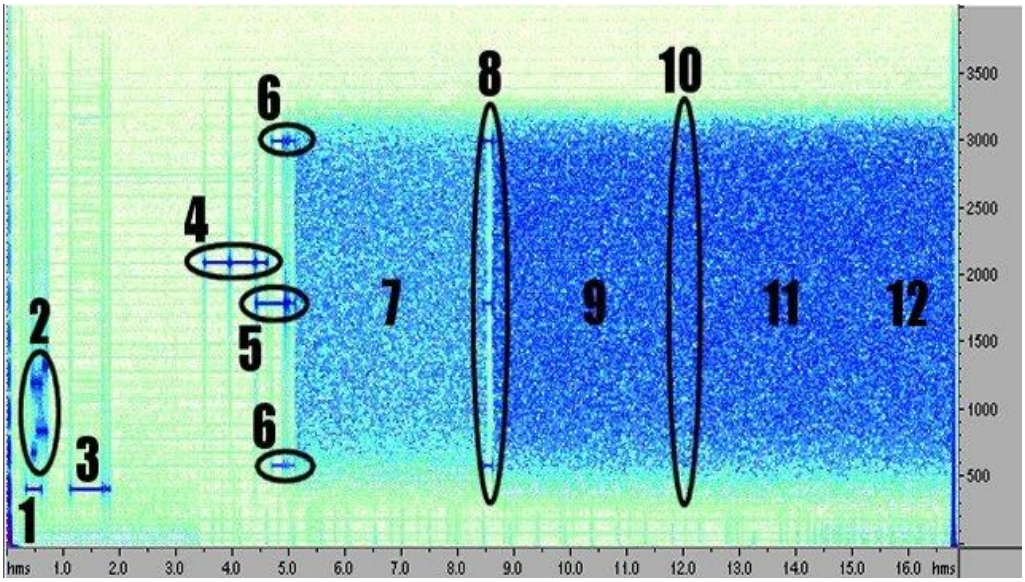
After the Confirmation-to-Receive signal has been received, the originator starts sending images.

Phase D – Post-message procedure

Originator sends a Return-To-Control signal switching both devices back to V.21, and the originator sends end-of-message signals. The answering equipment sends a Message Confirmation signal indicating that the message has been successfully received.



The illustration below is a time vs. frequency spectrum of a V.32 call.



1. PSTN dial tone
2. Calling modem DTMF
3. PSTN rings back tone
4. 2100 Hz phase reversal answer tone
5. 1800 Hz phase reversals tone (calling)
6. 600 + 3000 Hz phase reversals tone (answer)
7. Training sequence, half-duplex (answer)
8. Sync sequence (calling, answer)
9. Training sequence (calling)
10. Sync sequence full-duplex (calling, answer)
11. Second training sequence (answer)
12. User data

Modulation Types

The table below lists the various ITU fax and modem modulation modes.

ITU-T Rec.	User Data Rate [bps]	User Input Transmission Format	Full or Half-duplex	2 or 4 Wire	Modulation
V.17	14400/12000/9600/7200	Fax	HDX	2W	128QAM
V.21 (Bell 103)	0-300	Async	FDX	2W	FSK
V.21 Ch.2	300	Fax	HDX	2W	FSK
V.22	1200	Sync/Async	FDX	2W	DQPSK
V.22bis	2400	Sync/Async	FDX	2W	16QAM
V.23	1200/600 - 75	Async	HDX	2W	FSK
V.26	2400	Sync	FDX	4W	DQPSK
V.26bis	2400/200	Sync	HDX	2W	DQPSK
V.26ter	2400	Sync	FDX	2W	DQPSK
V.27	4800	Sync	FDX	4W	D8PSK

ITU-T Rec.	User Data Rate [bps]	User Input Transmission Format	Full or Half-duplex	2 or 4 Wire	Modulation
V.27bis	4800/2400	Sync	FDX	4W	D8PSK
V.27ter	4800/2400	Fax	HDX	2W	D8PSK
V.29	9600	Fax	FDX	4W	16QAM
V.32	9600/7600/4800	Sync/Async	FDX	2W	Trellis coded 32/16/4QAM
V.32bis	14400/12000/9600/ 7200	Sync/Async	FDX	2W	Trellis coded 128/64/32/ 16QAM
V.34	Up to 33600	Fax/Sync/Async	FDX	2W	Trellis coded QAM
V.90	Down: 56000 Up: 33600	Async	FDX	2W	Down: PCM, digital Up: V.32 analogue
V.92	Down: 56000 Up: 33600	Async	FDX	2W	Down: PCM, digital Up: V.32, analogue. "Internet call waiting"

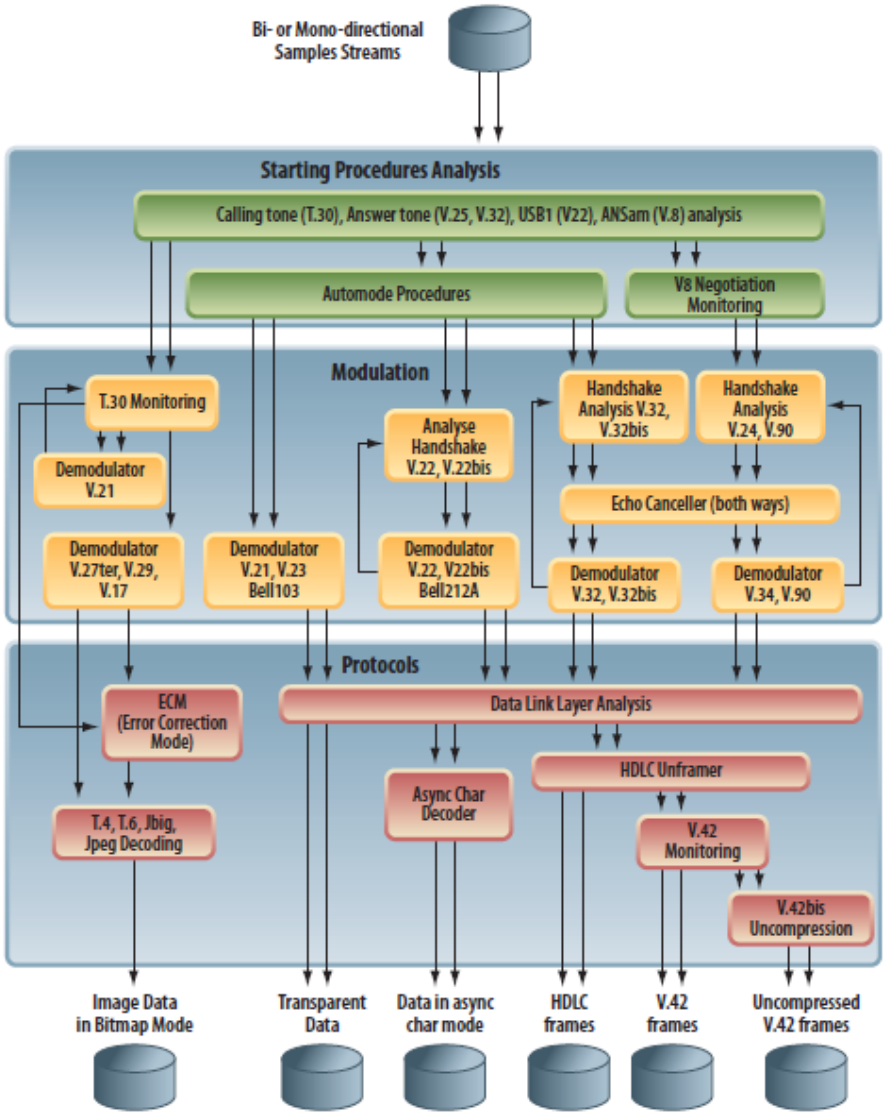
Decoding

The fax and modem decoding features depends on three software modules which analyze one or two incoming bit streams (calling and answering modems) in G.711 format (8 kHz sampling rate, A- or mu-law) or a 16 bit linear format.

The first module analyzes the initial handshakes to route the bit stream(s) to the appropriate demodulation modules – fax or full-duplex data - of the next stage.

The next module demodulates the signal, and echo cancellation is applied if in use.

The last module processes fax ECM (Error Correction Mode) as well as performing data link layer analysis on data signals. The various fax and data modes are then decoded and output in a number of formats.



Capabilities

The decoder capabilities encompass the modulation types and protocols listed below:

Modulation types

FAX	Data	Data
V.17	V.21	V.32
V.21 channel 2	V.22	V.32bis
V.27ter	V.22bis	V.90
V.29	V.23	V.92
V.34hdx	Bell 103	
	V.26	
	V.27	

Protocols

FAX	Data
T.30	Asynchronous
T.4 mono-dimensional, bi-dimensional	Unframed HDLC
T.6	V.42
T.6 ECM	V.42bis
JPEG	MNP 4
JBIG	MNP 5

Input and interfacing

The fax and modem decoder accepts input sampled at 8 kHz with a precision of ± 0.01% and stored into a signed 16 bit linear format. The dynamic range of the input shall not exceed 12 bits + 1 sign bit.

One or two sampled streams are accepted, depending on the capture method being mono-directional or bi-directional.

The input may be a samples file in the format listed below:

- 16-bit signed linear
- 8-bit signed linear
- 8-bit unsigned linear
- A-law
- A-law inverted
- Mu-law
- Mu-law inverted

The decoder will accept fax and modem signals using the AF input. Full-duplex requires two channels (stereo).

In order to interface to a telephone line an adapter blocking the line and ringing voltages to the decoder, but passing through these voltages to the devices must be employed. To capture signals the decoder must be inserted between the calling and the called device.

The actual configuration of the interface adapter will depend on the type of telephone line, the value of line and ringing voltages, local laws and regulations and physical connectors used - line adapters should be acquired locally.

Constraints

If only mono-directional capture is available, the following demodulation constraints apply:

Fax T.30 (V.21 modulated) – Signals from recorded direction demodulated; opposite direction demodulated if echo level is sufficient.

Data V.22/V.22bis – Signals from recorded direction demodulated; opposite direction demodulated if echo level is sufficient.

V.32/V.32bis – Signals from recorded direction demodulated if echo from opposite direction is sufficiently low.

V.34/V.90 – Demodulation impossible.

The recording must include all signaling from the very beginning of a transmission otherwise demodulation and decoding may not be possible. Carrier lost or reception of fax DCN signal is considered as the end of communication.

If a fax sample stream is missing the initial handshake and thus the fax parameters are absent, the signal may still be decoded by manually entering the value of the missing parameters.

For data signals without the initial handshake, the user may force the modulation type in the case of V.22, V.26, V.27, V.29 and V.32 signals with a bit rate lower than 4800 bps.

Output

Fax images and data are output to the display and may also be saved to disk. The following formats are supported:

Fax Images are saved in bitmap or compressed JPEG formats

Handshake information is saved as a text file

Data Transparent data

Data in asynchronous character format (no LAP protocol or data compression)

Decoded HDLC frames (no LAP protocol recognized)

Decoded V.42, V.42bis, MNP 4 and MNP 5 data

License System, Software and Options

License System

W-SPECTRA is available with a Narrowband or a Wideband Classifier. The licenses are provided on a CMStick. A complete set of W-SPECTRA licenses consists of

W-SPECTRA License System	CMStick
	
W-SPECTRA	W-SPECTRA-Server (Code 200, 1 pcs) + W-SPECTRA (Code 2, 4 pcs)
W-CLASSIFIER-NB	O-WC-NCL: Code 201
W-CLASSIFIER-WB	O-WC-WCL: Code 101
W-SPEED (Spectra Editing Tool)	W-SPEED: Code 4

CmStick

In order to activate the application, a software protection device must be connected to the computer. The device is called a CmStick and is available as:

- A small USB device: CmStick, CmStick/C
- A small SD card CmCard/SD, suitable for use in a laptop.
- A PC Card (CmCard/M, Cardbus, 32 Bit)
- An Express Card|34 (CmCard/E)

Without the appropriate valid licenses installed on the CmStick, W-SPECTRA will not work.



CmStick



CmStick/C



CmCard/SD



CmCard/M



CmCard/E

After the installation of the software on the computer, the icon will be presented in the tray icon area.

Note: When a CmStick is plugged into an USB socket of a LCD monitor, the CmStick will not be detected by the software protection server if the monitor is switched off.

Warining: Never try to debug the Wavecom software (e.g., W-SPECTRA). This will disable all the licenses on the CMStick.



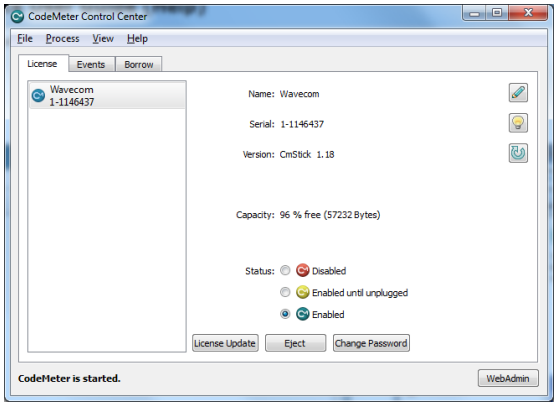
You can find more information regarding the CodeMeter and CmStick in the related help file.

CodeMeter and CmStick User Guide (Help)

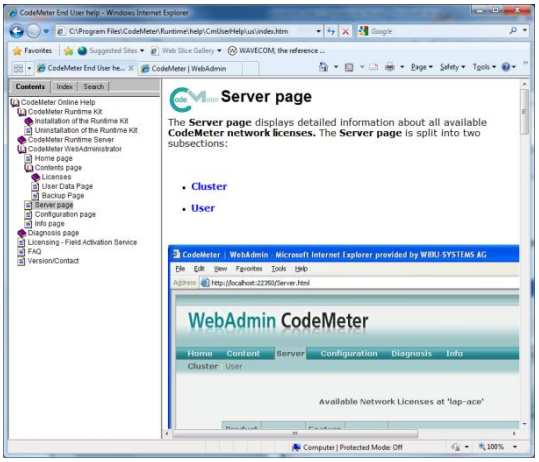
Important: For current and detailed information consult the CodeMeter help files.



For help, click the **CodeMeter Icon**.



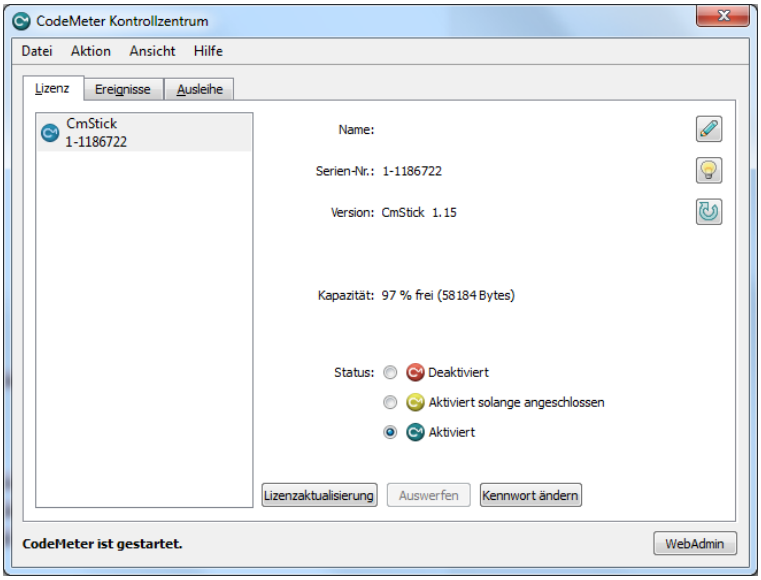
Select "Help" from the menu.



Now you see the CodeMeter help screen.

License Update for CodeMeter and CmStick

New licenses can be loaded to the CmStick without sending the key to WAVECOM. Just click "License Update" on the "CodeMeter Control Center" and follow the information provided by the assistant.


CodeMeter Kontrollzentrum
Datei Aktion Ansicht Hilfe
Lizenz Ereignisse Ausleihe
CmStick
1-1186722
Name:
Serien-Nr.: 1-1186722
Version: CmStick 1.15
Kapazität: 97 % frei (58184 Bytes)
Status: Deaktiviert
Aktiviert solange angeschlossen
Aktiviert
Lizenzaktualisierung
Auswerfen
Kennwort ändern
CodeMeter ist gestartet.
WebAdmin

WAVECOM Data Formats

IP-CONF TCP/IP Data Format

The decoder is able to receive signal data over a TCP/IP stream.

The data format is as follows:

- Sampling rates from 8 kHz to 192 kHz
- IQ data (I) respective "Left Channel"
- IQ data (Q) respective "Right Channel"

...	Left 16 Bits	Right 16 Bits	Left 16 Bits	Right 16 Bits	...

It is not allowed to change the sampling rate during decoding.

IP-PXGF TCP/IP Data Format

OVERVIEW

The PXGF streaming and file format provides a framework for the streaming and storage of sampled data along with the meta data required to process the sampled data. It is a streaming format in that synchronization can be regained if lost.

A file using the PXGF format contains a PXGF stream with a prepended header. The header was designed to allow an application to identify a file without processing the file. The capability to identify files becomes more important as file sizes get bigger. The PXGF file format supports large file sizes.

PXGF DESCRIPTION

The PXGF format was designed to represent sampled data with additional information pertaining to the way in which the data was sampled.

BACKGROUND

The PXGF format is loosely based on the Microsoft RIFF file format. The RIFF format is based on the concept of a chunk. Chunks are blocks that contain specific application defined data. In the RIFF format the complete file is a single RIFF chunk. RIFF chunks and LIST chunks are currently the only two types of chunks that may contain sub-chunks. All the remaining chunks in the file are children of the global RIFF chunk.

The RIFF format is unsuitable for our purposes for two primary reasons:

- The global RIFF chunk is limited in size to 4GB, thereby effectively restricting the file size to 4GB.
- The RIFF format is unsuitable for streaming applications as one need to read the whole file sequentially to be able to parse it. There is no synchronization mechanism available.

For these reasons a new file and streaming format was proposed and developed, namely the PXGF format.

THE PXGF CHUNK STRUCTURE

The PXGF format puts data into chunks. Different types of chunks are defined to store different information. The type of a chunk is specified by an int32 field in the chunk as shown in table 3.1. An application that requires data from a particular chunk will register to receive data from that type of chunk. Chunks that are not recognized are simply skipped over. The size field in the chunk allows unrecognized chunks to be skipped over. Each chunk starts with the sync number 0xa1b2c3d4.

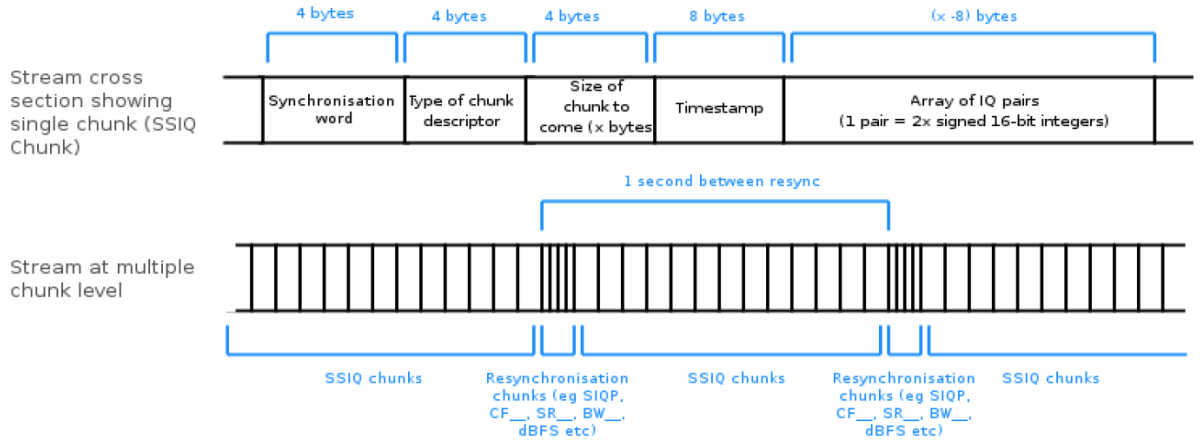
Element	Type	Description
Sync	int32	Synchronization number 0xa1b2c3d4.
Type	int32	Derived from the chunk name, e.g., "SOFH", " EOFH", "SSIQ".
Size	int32	The number of data bytes in the remainder of the chunk The value of size must be a multiple of 4.
Data	byte[size]	The chunk data in a format specific to the type.

- The maximum amount of data in a chunk is limited to 65536 bytes. This limits the separation between sync patterns.
- The length of each chunk must contain an integral number of 32 bit words even though the size element in the chunk header is specified as a number of bytes.
- The PXGF format supports both little and big endian byte ordering, although it may be necessary to provide the stream reader with the endian used depending on its implementation. The endian format for a file or stream may be determined by reading the sync pattern. It is not permissible to mix chunks of different endian format within a stream or file.
- When the PXGF format is used to store information in a file, there must be a global header at the beginning of the file to aid identification of the file format and the data stored in the file. This is necessary due to the potentially large size of files.
- Nested sub-chunks are not supported as this would unnecessarily complicate synchronization.
- The implication of the previous point is that all chunks are at root level and are interpreted entirely sequentially. The parser must know which chunks need to be identified before it can use other chunks. The only constraint here is that files must start with a "SOFH chunk". Due to the sequential nature of parsing and the inability to nest chunks, a separate global chunk is needed to identify the end of the file header, namely the "EOFH" chunk.

APPLICATION NOTES

Above is a graphical illustration showing how PXGF chunks of different type are ordered in a stream/file. Below are some notes to the developer to keep in mind when using the PXGF format in an application.

PXGF Chunk format. Cross section of typical stream.



- The PXGF framework for streaming and storage is designed to be extensible. Different applications require different information and if this information is not available in a stream, then that application will not be able to process that stream successfully. Just because an application uses the PXGF format doesn't mean that it will be able to process all PXGF streams or files. For a particular project care should be taken to ensure that all necessary chunks are included.
- It is recommended that meta data like the sample rate and packing description be sent every second. This allows state information to be recovered if synchronization is lost and makes it possible to process large files from the middle of the file.
- Only data from one data source and of one format must be included in each stream or file. Current formats include "SSIQ" for single channel data and "GSIQ" for multi-channel data. The format

used in files should be indicated using the SOFH chunk. The format name may also be used for the file extension to allow visual discrimination of different files.

- State information is accumulated by an application by reading different chunks sequentially. If synchronization is lost, state information needs to be reset. This is why it is essential to resend meta data every second.
- It is necessary to be able to distinguish between continuous data and block data where only part of the time data is available. Data chunks contain timestamps to enable detection of discontinuities. A chunk has also been defined to indicate discontinuities in the time data, namely the "IQDC" chunk.
- Playback control is essential for the off-line analysis of files, however due to the stream based design of the PXGF format, playback control is not easily supported. The PXGF format uses data chunks supported by a number of meta chunks that describe the state of the data stream. Before processing data chunks it is necessary to obtain sufficient state information, like the sample rate, by processing the necessary chunks in the data stream. The use of an index file has been proposed as a possible solution to the problem of playback control. By reading an index file an application could determine over what period the recording was made and determine where to start processing the stream to play back a particular section.
- C++ and Java libraries have been developed for the writing and reading of PXGF streams. The libraries take care of synchronization and formatting issues; they do not provide or dictate the communication medium.
- The PXGF streaming format does not provide any mechanism for communication between the source of the data stream and the application receiving the data stream. The PXGF stream therefore represents a unidirectional flow of information from the source to the sink of the stream.
- Applications that process PXGF input streams should not make assumptions about the data. For example, if the sample data were being sent using the SSIQ chunk the application should wait for a SIQP chunk to determine the packing of the data rather than assuming a particular packing.

DEFINITION OF CHUNKS

Single channel Short IQ time data – SSIQ chunk

Data is assumed to be continuous when using this data format, if the data is blocky, an IQDC chunk must be sent after every block of continuous data.

Element	Type	Description
lTimestamp	int64	The timestamp is stored as a 64 bit signed number, representative of the time of capture of the first sample in the chunk block, in microsecond resolution. It is stored as the number of microseconds since beginning of the epoch (i.e., 1st January 1970 midnight).
awIQData	int16 [length of IQ data array]	IQ pairs of signed int16 short numbers. Note that regardless of the number of valid bits, the most significant bits in each short should be used. This allows us to specify the full-scale level without needing to specify the number of bits.

Single channel Float IQ time data – SFIQ chunk

Data is assumed to be continuous when using this data format, if the data is blocky, an IQDC chunk must be sent after every block of continuous data.

Element	Type	Description
lTimestamp	int64	The timestamp is stored as a 64 bit signed number, representative of the time of capture of the first sample in the chunk block, in microsecond resolution. It is stored as the number of microseconds since beginning of the epoch (i.e., 1st January 1970 midnight).
awIQData	Float32 [length of IQ data array]	IQ pairs of float32 numbers.

Single channel IQ Packing – SIQP chunk

The information in this chunk is required to parse the data in the SSIQ chunk.

Element	Type	Description
iIsIQPacked	int32	Value 1 for IQ ordering and value 0 for QI ordering. For example: a value of 1 will indicate that the first sample in the element awIQData of a SSIQ chunk is an "I" sample.

Sample Rate – SR__ chunk

Element	Type	Description
lSampleRate_uHz	int64	The number of samples per second that are being recorded by this channel.

BandWidth – BW__ chunk

The bandwidth centred about the centre frequency. If the bandwidth is not centred about the centre frequency use the BWOF chunk instead.

Element	Type	Description
lBandwidth_uHz	int64	The bandwidth of the signal in micro Hertz.

Centre Frequency – CF__ chunk

Element	Type	Description
lCentrFrequency_uHz	int64	The centre frequency of the signal in micro Hertz.

dB Full Scale – dBFS chunk

Element	Type	Description
fFullScaleLevel_dBm	float32	The analogue input level to the ADC in dBm, which will produce maximum full scale digital samples for the current IQ time data chunk integer type. eg. If we are using SSIQ chunks, then a dBFS chunk will indicate the analogue input level that will yield a maximum digital sample swing of +-(2^15-1). Note that this value may be different from the full scale value of the ADC.

Single channel Short Real data - SSR_ chunk

Data is assumed to be continuous when using this data format, if the data is blocky, an IQDC chunk should be sent after every block of continuous data. This chunk can be used to send audio data.

Element	Type	Description
lTimestamp	int64	The timestamp is stored as a 64 bit signed number, representative of the time of capture of the first sample in the chunk block, in microsecond resolution. It is stored as the number of microseconds since beginning of the epoch (i.e., 1st January 1970 midnight).
awRealData	int16[length of real data array]. The length of the array must be a multiple of 2.	Real signed int16 short numbers. Note that regardless of the number of valid bits, the most significant bits in each short should be used. This allows us to specify the full-scale level without needing to specify the number of bits. The number of real int16 shorts in the array must be a multiple of 2.

Single channel Float Real data - SFR_ chunk

Data is assumed to be continuous when using this data format, if the data is blocky, an IQDC chunk should be sent after every block of continuous data. This chunk can be used to send audio data.

Element	Type	Description
lTimestamp	int64	The timestamp is stored as a 64 bit signed number, representative of the time of capture of the first sample in the chunk block, in microsecond resolution. It is stored as the number of microseconds since beginning of the epoch (i.e., 1st January 1970 midnight).
awRealData	Float32[length of real data array].	Real float 32 numbers.

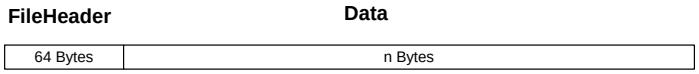
WAVECOM Data File Format

The decoder is able to save data and decoder settings in a special binary file format called **WDA**, which is described in this section. WDA files may used to provide input for the BitView Tool.

WDA files are capable of storing various kinds of information:

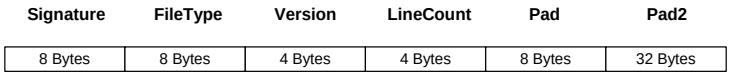
- Text data
- Graphics data
- FELDHELL data
- Signal analysis data
- SAT mode data
- Classifier data
- Classifier CodeCheck data
- Sonagram data

All types of WDA files contain a header that identifies the type of data stored in the file and other information related to the stored data and the data proper (see below).



File Header

Identical information is stored in the first 64 Bytes of the header, but depending on the data stored in the data part of the file, the header may contain additional information, which increases its size.



The default size of the file header is 64 bytes.

The **Signature** is always "WDA".

Note: Older versions may carry the signatures "W51PC", "W41PC" or "W40PC".

The **File Type** is dependent on the stored data and can have the following values:

- Text
- Graphics
- FELDHELL
- SigAnal
- SAT
- Classifr
- CCC
- Sonagram

The **Version** is always "0x00020000" (Version A) or "0x00030000" (Version B).

LineCount contains the number of data lines stored (the data stored is line based, that is a data package represents the data of a line).

Pad contains additional information to be stored.

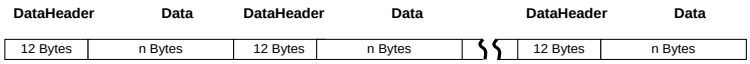
Pad2 contains additional information to be stored.

The 64 Byte struct type below can be used to extract the file header.

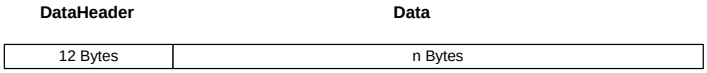
```
struct FileHeader
{
                        char Signature[8];
                        char FileType[8];
                        LONG Version;
                        LONG LineCount;
                        char Pad[8];
                        char Pad2[32];
};
```

Data Structures

Following the header the data is stored as one or more data packages. The file header contains the number of data packages stored.

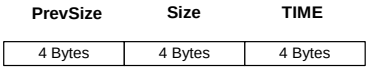


A data package contains a data header and the data itself.



The size of the data header is 12 Bytes.

The data header at the start of each data package contains the following information:



In **PrevSize** the size of the preceding data is stored, **Size** stores the size of the data contained in the succeeding data package and in **TIME** the timestamp of the data is stored.

The 12 Byte LineData struct type below can be used to extract the data header.

```
struct LineData
{
                        LONG PrevSize; // size of the data line before.
                        LONG Size;     // size of the data line.
                        LONG TIME;     // time of the data received.
}
```

File Headers and Data Structures for Individual File Types

The following sections describe the file headers and data packages of the various .WDA file types.

Text data

FileType is "Text".

Header data

This file type uses the file header described in "File Header" on page 264.

The following additional data is stored in the header:

- In Pad[0] the font type

- In Pad[1] the left to right font direction: 1 = RightToLeft, 0 = LeftToRight text direction
- In Pad[2] if Unicode chars are stored: 1 = Unicode, 0 = Ascii characters are stored

Data

This file type uses the data structure described in chapter "Data Structures" on page 265 to store the data.

Every single line of a text document is stored in a separate data package. The length of the line is stored in the data header of the package. The text data is stored as wchar character values occupying two bytes per character.

SAT data

FileType is "SAT".

Header data

This file type uses the file header described in "File Header" on page 264.

The following additional data is stored in the header:

- Pad[0] indicates whether the file contains normal or extended data

Data

This file type uses the data structure described in chapter "Data Structures" on page 265 to store the data.

A data package contains the data of one SAT session saved as a string containing these values:

- Mode: name of the Inmarsat System e.g., SAT-B
- Service: the SAT service e.g., FAX
- MES ID: the identification number
- File: the path of the received file of the SAT session
- DateTime: the date and time of the received session, number of seconds elapsed since midnight (00:00:00), January 1, 1970, coordinated universal time
- Duration: elapsed time for transmitting the session
- Size: size can contain the number of pages or the size of a received field (unit=byte)
- Termination: indicates if transmission successful
- WAVECOM Card ID: the ID of the card which received the session
- Computer Address: address of the computer which received the session
- Already displayed flag: indicates if the received file of the session has already been displayed via the ImagerViewer app (0=no, 1=yes)
- Transmitter ID: Transmitting subscriber identification

Note: The values are written to the string in the same order as listed above.

If not stored with _UNICODE enabled, then the string contains normal 8 bit char characters, from type char, otherwise the string contains 16-bit characters, from type wchar_t.

A char value occupies 1 Byte and a wchar_t value occupies 2 Bytes in the binary .WDA file.

Classifier data

The 'FileType' stored in the file header is "Classifier".

Header data

This file type uses the 'File Header' described in chapter "File Header" on page 264.

The following additional data is stored in the Header:

- In Pad[0]: Timestamp format, how to show timestamp in classifier textview: 0=Timestamp off, 1= show Timestamp in 'Local time', 2= show Timestamp in 'Universal Time Coordinated (UTC)'

Data

This 'FileType' uses the data structure described in chapter "Data Structures" on page 265 to store the data.

A data package in the .WDA file contains the data of one classified signal.

The signal data of a signal detected by the classifier is written to a single string. The following values are written to the string:

- Signal: the signal name displayed in the GUI e.g., 'Signal 1'.
- Mode: the mode name, e.g., 'CW-MORSE'.
- Modulation: the modulation e.g., F1B.
- Center frequency: the center frequency value including the unit, e.g., '1846.5Hz'.
- Shift: the shift value including the unit, e.g., '926.4Hz'.
- Baudrate: the baud rate value including the label if available, e.g., '158.7Bd', otherwise 'unclassified'.
- Bandwidth: the bandwidth value including the unit, e.g., '922.7Hz'.
- Confidence: the confidence value including the unit, e.g., '51%'.
- Mode: the mode value.
- Center: the center frequency value.
- Shift: the shift value.
- BaudrateA: the baudrateA value.
- BaudrateB: the baudrateB value.
- Bandwidth: the bandwidth value.
- Time stamp: the time when the signal was classified, number of seconds elapsed since midnight (00:00:00), January 1, 1970, coordinated universal time.

NOTE: the values are written to the string in the same order as listed above!

If not stored with _UNICODE enabled, then the string contains normal 8-bit characters values, from type char, otherwise the string contains 16-bit characters, from type wchar_t.

A char value occupies 1 Byte and a wchar_t value occupies 2 Bytes in the binary .WDA file.

ClassifierCodeCheck data

The 'FileType' is "CCC".

Header data

This file type uses the 'File Header' described in chapter "File Header" on page 264.

The following additional data is stored in the Header:

- Pad[0]: Timestamp format, how to show timestamp in classifier textview: 0=Timestamp off, 1 = show Timestamp in 'Local time', 2 = show Timestamp in 'Universal Time Coordinated (UTC)'.

Data

This 'FileType' uses the data structure described in chapter "Data Structures" on page 265 to store the data.

A data package in the .WDA file contains the data of one classified signal or the CodeCheck data of a classified signal.

The data stored for the classier CodeCheck is divided into two parts, the Classifier part and the CodeCheck part.

A .WDA file contains at first the classifier data and then the CodeCheck data.

The Classifier data is stored in the way described in chapter "File Header" on page 264.

The data package which contains the text "CodeCheck Data Section" marks the beginning of the CodeCheck data section.

The CodeCheck data of a classified signal is written to a single string. The following values are written to the string:

- The index value of the classified signal.
- The string value with all predicted modes.
- All detected modes (can be more than one), for a detected mode the following values are written to the string:
  - Mode: the name of the detected mode, e.g., 'FEC-A', 'ASCII'.
  - SubMode: the name of the submode e.g., 'SREG - 72 Bits' by FEC-A, '9 Bits' by ASCII-mode.
  - additional description, information: e.g., 'Shift Reg: 72 Bits'.
  - the hits value. Shows how often during checking, a mode was successfully determined.

NOTE: the values are written to the string in the same order as listed above.

If not stored with _UNICODE enabled, then the string contains normal 8-bit characters values, from type char, otherwise the string contains 16-bit characters, from type wchar_t.

A char value occupies 1 Byte and a wchar_t value occupies 2 Bytes in the binary .WDA file.

Graphics data

The **FileType** stored in the file header is "Graphics".

Header data

This file type uses the 'File Header' described in chapter "File Header" on page 264.

The Phase value, the AspectRatio (could be stored in old WAVECOM Data Files, for the actual Software it is not stored anymore) and the Flip Left/Right/Top/Bottom value are stored additionally to the default header.

The following additional data is stored in the Header, following the default header:

FileHeader	Phase	Pad	AspectRatio	FlipHV	Pad
64 Bytes	4 Bytes	4 Bytes	8 Bytes	4 Bytes	4 Bytes

- Phase: Value for moving the image horizontal
- Pad: padding bits for alignment (not used)
- AspectRatio: obsolete, no longer used in the actual software
- FlipHV: 0 = FlipLeftRight & FlipTopBottom disabled, 1 = FlipLeftRight, 2 = FlipTopBottom, 3 = FlipLeftRight & FlipTopBottom
- Pad: padding bytes for alignment (not used)

To the default file header with 64 bytes additional a block of 24 bytes is added that contains the Phase, the AspectRatio, the FlipHV and some padding bytes for alignment.

The Phase value occupies 4 Bytes followed by 4 padding bytes. The Aspect Ration occupies 8 bytes. The FlipHV (Flip horizontal vertical) value occupies 4 bytes followed by 4 padding bytes.

NOTE: the following struct type could be used to extract the data header.

```
struct GraphicsData
{
Long  Phase;
      double AspectRatio;
      int FlipHV;
};
```

Data

This **FileType** uses the data structure described in chapter "Data Structures" on page 265 to store the data.

A data package in the .WDA file contains the data of all pixels of one line in the graphic. The pixel data is stored in BYTES (8-bit type) values, that is one Byte in the .WDA file contains the value of an Pixel in the graphic.

FELDHELL data

The **FileType** is "FELDHELL".

Header data

This file type uses the **File Header** described in chapter "File Header" on page 264.

No additional data is stored in the Header.

Data

This **FileType** uses the data structure described in chapter "Data Structures" on page 265 to store the data.

A data package in the .WDA file contains the data of all pixels of one line in the graphic. The pixel data is stored in unsigned char values(8-bit type), that is one Byte in the .WDA file contains the value of an Pixel in the graphic.

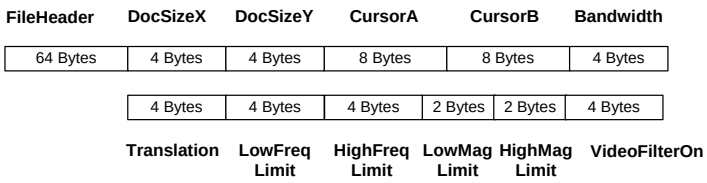
Sonagram data

The 'FileType' stored in the file header is "Sonagram".

Header data

This file type uses the 'File Header' described in chapter "File Header" on page 264.

The following additional data is stored in the Header, following the default header:



- DocSizeX: the document width.
- DocSizeY: the document height.
- CursorA: the value of the cusorA.
- CursorB: the value of the cusorB.
- Bandwidth: the Bandwidth value.
- Offset (Translation): the Offset value.
- LowFreqLimit: the lower frequency limit value.
- HighFreqLimit: the higher frequency limit value.
- LowMagLimit: the lower magnitude limit value.
- HighMagLimit: the higher magnitude limit value.
- VideoFilterOn: the VideoFilter On/Off flag.

To the default file header with 64 bytes additional a block of 48 bytes is added.

The additional block contains display parameter used by the WAVECOM GUI for displaying the stored data correctly.

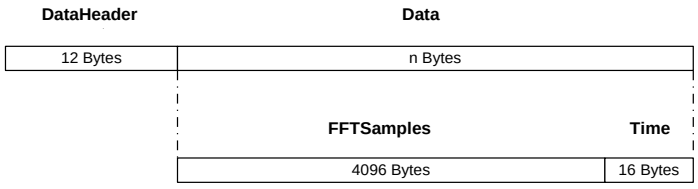
NOTE: the following struct type could be used to extract the data header.

```
struct SonagramData
{
                        long lDocSizeX;
                        long lDocSizeY;
                        double dCursorA;
                        double dCursorB;
                        long lBandwidth;
                        long lTranslation;
                        long lLowFrequencyLimit;
                        long lHighFrequencyLimit;
                        short sLowMagnitudeLimit;
                        short sHighMagnitudeLimit;
                        BOOL boVideoFilterOn;
};
```

Data

This 'FileType' uses the data structure described in chapter "Data Structures" on page 265 to store the data.

The stored sonagram data has the following structure:



- FFT Samples: the first 4096 bytes of the stored data contain the 2048 sample values for the FFT.
- Time: the last 16 bite of the stored data contains the system time timestamp value of the received data(the additional timestamp is necessary because the default timestamp in the data header does not support milliseconds). The TIME value is the the number of seconds elapsed since midnight (00:00:00), January 1, 1970, coordinated universal time, according to the system clock.

The data for the 'Sonagram' file types occupies 4112 bytes inside a data package after the data header.

A data package in the .WDA file contains the data points of one FFT sample and its timestamp value. The FFT sample data points are stored in short values(2-bit type), that is 2 Bytes in the .WDA file contains the value of one FFT sample data point.

NOTE: the following struct type could be used to extract the data.

```
typedef struct ST_SONAGRAM_DATA
{
                            short asFFTSamp[2048];
                            SYSTEMTIME Time;
} ST_SONAGRAM_DATA;
```

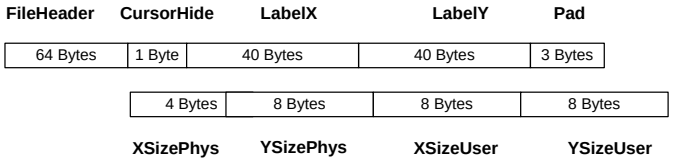
SigAnal data

The **FileType** stored in the file header is "SigAnal".

Header data

This file type uses the 'File Header' described in chapter "File Header" on page 264.

The following additional data is stored in the Header, following the default header:



- CursorHide: flag that indicates if the cursor are hidden.
- LabelX: the x-axis unit label string.
- LabelY: the y-axis unit label string.
- Pad: padding bytes for alignment (not used).
- XSizePhys: the physical width of the data range.
- YSizePhys: the physical height of the data range.
- XSizeUser: the width of the data range in the user interface.
- YSizeUser: the height of the data range in the user interface.

To the default file header with 64 bytes additional a block of 112 bytes is added.

The additional block contains display parameter used by the WAVECOM GUI for displaying the stored data correctly.

NOTE: the following struct type could be used to extract the data header.

```
struct SigAnalData
{
                            char     m_nCursorHide;
                            char     m_strLabelX[40];
                            char     m_strLabelY[40];
                            long     m_Phis_xSize;
                            double m_Phis_ySize;
                            double m_User_xSize;
                            double m_User_ySize;
};
```

Data

This **FileType** uses the data structure described in chapter "Data Structures" on page 265 to store the data.

A data package in the .WDA file contains the data of all data points of one line in the graphic. The data points are stored in long values(4-bit type), that is 4 Bytes in the .WDA file contains the value of one data point in the graphic.

Appendix

Alphabets Details

Unicode

WAVECOM uses a Unicode font to display data, which may be replaced by a user installed font within the ranges indicated below.

Alphabet	Range Hex	Range Dec
Basic Latin	U+0000 - U+007F	0 –127
Latin-1 Supplement	U+0080 - U+00FF	128 –255
Latin Extended-A	U+0100 - U+017F	256 –383
Basic Greek	U+0370 - U+03FF	880 –1023
Cyrillic	U+0400 - U+04FF	1024 –1279
Basic Hebrew	U+0590 - U+05FF	1424 –1535
Basic Arabic	U+0600 - U+06FF	1536 –1791
Letter-like Symbols	U+2100 - U+214F	8448 – 8527
Control Pictures	U+2400 - U+243F	9216 – 9279
Dingbats	U+2700 - U+27BF	9984 –10175
Arabic Presentation Form B	U+FE70 - U+FEFF	65136 –65279

Font-Art

A true type, fixed system font produces a better display of table information.

Transparent

No.	Transparent	LETTER	FIGURE
1	1 1 0 0 0	A	-
2	1 0 0 1 1	B	?
3	0 1 1 1 0	C	:
4	1 0 0 1 0	D	Hex 05
5	1 0 0 0 0	E	3
6	1 0 1 1 0	F	Hex 5D
7	0 1 0 1 1	G	Hex 5B
8	0 0 1 0 1	H	Hex 5C
9	0 1 1 0 0	I	8
10	1 1 0 1 0	J	Hex 07
11	1 1 1 1 0	K	(
12	0 1 0 0 1	L	)
13	0 0 1 1 1	M	.

No.	Transparent	LETTER	FIGURE
14	0 0 1 1 0	N	,
15	0 0 0 1 1	O	9
16	0 1 1 0 1	P	0
17	1 1 1 0 1	Q	1
18	0 1 0 1 0	R	4
19	1 0 1 0 0	S	‘
20	0 0 0 0 1	T	5
21	1 1 1 0 0	U	7
22	0 1 1 1 1	V	=
23	1 1 0 0 1	W	2
24	1 0 1 1 1	X	/
25	1 0 1 0 1	Y	6
26	1 0 0 0 1	Z	+
27	0 0 0 1 0	Carriage Return	
28	0 1 0 0 0	Line Feed	
29	1 1 1 1 1	Hex 25 (%)	
30	1 1 0 1 1	Hex 24 ($)	
31	0 0 1 0 0	Space	
32	0 0 0 0 0	Hex 08	

ITA-2 Alphabet

No.	ITA-2 Alphabet	LETTER	FIGURE
1	1 1 0 0 0	A	-
2	1 0 0 1 1	B	?
3	0 1 1 1 0	C	:
4	1 0 0 1 0	D	
5	1 0 0 0 0	E	3
6	1 0 1 1 0	F	
7	0 1 0 1 1	G	
8	0 0 1 0 1	H	
9	0 1 1 0 0	I	8
10	1 1 0 1 0	J	Bell
11	1 1 1 1 0	K	(
12	0 1 0 0 1	L	)
13	0 0 1 1 1	M	.
14	0 0 1 1 0	N	,
15	0 0 0 1 1	O	9

No.	ITA-2 Alphabet	LETTER	FIGURE
16	0 1 1 0 1	P	0
17	1 1 1 0 1	Q	1
18	0 1 0 1 0	R	4
19	1 0 1 0 0	S	‘
20	0 0 0 0 1	T	5
21	1 1 1 0 0	U	7
22	0 1 1 1 1	V	=
23	1 1 0 0 1	W	2
24	1 0 1 1 1	X	/
25	1 0 1 0 1	Y	6
26	1 0 0 0 1	Z	+
27	0 0 0 1 0	Carriage Return	
28	0 1 0 0 0	Line Feed	
29	1 1 1 1 1	Letter Shift	
30	1 1 0 1 1	Figure Shift	
31	0 0 1 0 0	Space	
32	0 0 0 0 0	Unperforated tape	

ITA-3-Alphabet

No.	ITA-3 Alphabet	LETTER	FIGURE
1	0 0 1 1 0 1 0	A	-
2	0 0 1 1 0 0 1	B	?
3	1 0 0 1 1 0 0	C	:
4	0 0 1 1 1 0 0	D	
5	0 1 1 1 0 0 0	E	3
6	0 0 1 0 0 1 1	F	
7	1 1 0 0 0 0 1	G	
8	1 0 1 0 0 1 0	H	
9	1 1 1 0 0 0 0	I	8
10	0 1 0 0 0 1 1	J	Bell
11	0 0 0 1 0 1 1	K	(
12	1 1 0 0 0 1 0	L	)
13	1 1 0 0 0 0 1	M	.
14	1 0 1 0 1 0 0	N	,
15	1 0 0 0 1 1 0	O	9
16	1 0 0 1 0 1 0	P	0
17	0 0 0 1 1 0 1	Q	1

No.	ITA-3 Alphabet	LETTER	FIGURE
18	1 1 0 0 1 0 0	R	4
19	0 1 0 1 0 1 0	S	‘
20	1 0 0 0 1 0 1	T	5
21	0 1 1 0 0 1 0	U	7
22	1 0 0 1 0 0 1	V	=
23	0 1 0 0 1 0 1	W	2
24	0 0 1 0 1 1 0	X	/
25	0 0 1 0 1 0 1	Y	6
26	0 1 1 0 0 0 1	Z	+
27	1 0 0 0 0 1 1	Carriage Return	
28	1 0 1 1 0 0 0	Line Feed	
29	0 0 0 1 1 1 0	Letter Shift	
30	0 1 0 0 1 1 0	Figure Shift	
31	1 1 0 1 0 0 0	Space	
32	0 0 0 0 1 1 1	Unperforated tape	
	0 1 1 0 1 0 0	Request	
	0 1 0 1 0 0 1	Idle a	
	0 1 0 1 1 0 0	Idle b	

ITA-4 Alphabet

No.	ITA-4 Alphabet	LETTER	FIGURE
1	0 1 1 0 0 0	A	-
2	0 1 0 0 1 1	B	?
3	0 0 1 1 1 0	C	:
4	0 1 0 0 1 0	D	
5	0 1 0 0 0 0	E	3
6	0 1 0 1 1 0	F	
7	0 0 1 0 1 1	G	
8	0 0 0 1 0 1	H	
9	0 0 1 1 0 0	I	8
10	0 1 1 0 1 0	J	Bell
11	0 1 1 1 1 0	K	(
12	0 0 1 0 0 1	L	)
13	0 0 0 1 1 1	M	.
14	0 0 0 1 1 0	N	,
15	0 0 0 0 1 1	O	9
16	0 0 1 1 0 1	P	0
17	0 1 1 1 0 1	Q	1

No.	ITA-4 Alphabet	LETTER	FIGURE
18	0 0 1 0 1 0	R	4
19	0 1 0 1 0 0	S	‘
20	0 0 0 0 0 1	T	5
21	0 1 1 1 0 0	U	7
22	0 0 1 1 1 1	V	=
23	0 1 1 0 0 1	W	2
24	0 1 0 1 1 1	X	/
25	0 1 0 1 0 1	Y	6
26	0 1 0 0 0 1	Z	+
27	0 0 0 0 1 0	Carriage Return	
28	0 0 1 0 0 0	Line Feed	
29	0 1 1 1 1 1	Letter Shift	
30	0 1 1 0 1 1	Figure Shift	
31	0 0 0 1 0 0	Space	
32	1 0 0 0 0 0	Unperforated tape	
	0 0 0 0 0 0	Idle a	
	1 1 1 1 1 1	Idle b	
	1 1 0 0 1 1	Phasing signal	

ITA-5 Alphabet

An alphabet in which 128 unique 7-bit strings are used to encode upper- and lower-case letters, 10 decimal numerals, special signs and symbols, diacritical marks, data delimiters, and transmission control characters, 12 of the 7-bit strings are not assigned to any letter, numeral, or control character, and the unassigned bit strings are open for use in a given country that may have unique requirements, such as monetary symbols; diacritical marks, such as the tilde, umlaut, circumflex, and dieresis, and a two-condition 8-bit pattern may be used that consists of seven information bits and a parity check bit.

DEC	OCT	HEX	BIN	Symbol	HTML Number	Description
0	000	00	00000000	NUL	&#000;	Null char
1	001	01	00000001	SOH	&#001;	Start of Heading
2	002	02	00000010	STX	&#002;	Start of Text
3	003	03	00000011	ETX	&#003;	End of Text
4	004	04	00000100	EOT	&#004;	End of Transmission
5	005	05	00000101	ENQ	&#005;	Enquiry
6	006	06	00000110	ACK	&#006;	Acknowledgment
7	007	07	00000111	BEL	&#007;	Bell
8	010	08	00001000	BS	&#008;	Back Space
9	011	09	00001001	HT		Horizontal Tab
10	012	0A	00001010	LF
Line Feed
11	013	0B	00001011	VT	&#011;	Vertical Tab
12	014	0C	00001100	FF		Form Feed

DEC	OCT	HEX	BIN	Symbol	HTML Number	Description
13	015	0D	00001101	CR
Carriage Return
14	016	0E	00001110	SO	&#014;	Shift Out / X-On
15	017	0F	00001111	SI	&#015;	Shift In / X-Off
16	020	10	00010000	DLE	&#016;	Data Line Escape
17	021	11	00010001	DC1	&#017;	Device Control 1 (oft. XON)
18	022	12	00010010	DC2	&#018;	Device Control 2
19	023	13	00010011	DC3	&#019;	Device Control 3 (oft. XOFF)
20	024	14	00010100	DC4	&#020;	Device Control 4
21	025	15	00010101	NAK	&#021;	Negative Acknowledgement
22	026	16	00010110	SYN	&#022;	Synchronous Idle
23	027	17	00010111	ETB	&#023;	End of Transmit Block
24	030	18	00011000	CAN	&#024;	Cancel
25	031	19	00011001	EM	&#025;	End of Medium
26	032	1A	00011010	SUB	&#026;	Substitute
27	033	1B	00011011	ESC	&#027;	Escape
28	034	1C	00011100	FS	&#028;	File Separator
29	035	1D	00011101	GS	&#029;	Group Separator
30	036	1E	00011110	RS	&#030;	Record Separator
31	037	1F	00011111	US	&#031;	Unit Separator
32	040	20	00100000			Space
33	041	21	00100001	!	!	Exclamation mark
34	042	22	00100010	"	"	Double quotes (or speech marks)
35	043	23	00100011	#	#	Number
36	044	24	00100100	$	$	Dollar
37	045	25	00100101	%	%	Percent
38	046	26	00100110	&	&	Ampersand
39	047	27	00100111	'	'	Single quote
40	050	28	00101000	(	(	Open parenthesis (or open bracket)
41	051	29	00101001	)	)	Close parenthesis (or close bracket)
42	052	2A	00101010	*	*	Asterisk
43	053	2B	00101011	+	+	Plus
44	054	2C	00101100	,	,	Comma
45	055	2D	00101101	-	-	Hyphen
46	056	2E	00101110	.	.	Period, dot or full stop
47	057	2F	00101111	/	/	Slash or divide
48	060	30	00110000	0	0	Zero

DEC	OCT	HEX	BIN	Symbol	HTML Number	Description
49	061	31	00110001	1	1	One
50	062	32	00110010	2	2	Two
51	063	33	00110011	3	3	Three
52	064	34	00110100	4	4	Four
53	065	35	00110101	5	5	Five
54	066	36	00110110	6	6	Six
55	067	37	00110111	7	7	Seven
56	070	38	00111000	8	8	Eight
57	071	39	00111001	9	9	Nine
58	072	3A	00111010	:	:	Colon
59	073	3B	00111011	;	;	Semicolon
60	074	3C	00111100	<	<	Less than (or open angled bracket)
61	075	3D	00111101	=	=	Equals
62	076	3E	00111110	>	>	Greater than (or close angled bracket)
63	077	3F	00111111	?	?	Question mark
64	100	40	01000000	@	@	At symbol
65	101	41	01000001	A	A	Uppercase A
66	102	42	01000010	B	B	Uppercase B
67	103	43	01000011	C	C	Uppercase C
68	104	44	01000100	D	D	Uppercase D
69	105	45	01000101	E	E	Uppercase E
70	106	46	01000110	F	F	Uppercase F
71	107	47	01000111	G	G	Uppercase G
72	110	48	01001000	H	H	Uppercase H
73	111	49	01001001	I	I	Uppercase I
74	112	4A	01001010	J	J	Uppercase J
75	113	4B	01001011	K	K	Uppercase K
76	114	4C	01001100	L	L	Uppercase L
77	115	4D	01001101	M	M	Uppercase M
78	116	4E	01001110	N	N	Uppercase N
79	117	4F	01001111	O	O	Uppercase O
80	120	50	01010000	P	P	Uppercase P
81	121	51	01010001	Q	Q	Uppercase Q
82	122	52	01010010	R	R	Uppercase R
83	123	53	01010011	S	S	Uppercase S
84	124	54	01010100	T	T	Uppercase T

DEC	OCT	HEX	BIN	Symbol	HTML Number	Description
85	125	55	01010101	U	U	Uppercase U
86	126	56	01010110	V	V	Uppercase V
87	127	57	01010111	W	W	Uppercase W
88	130	58	01011000	X	X	Uppercase X
89	131	59	01011001	Y	Y	Uppercase Y
90	132	5A	01011010	Z	Z	Uppercase Z
91	133	5B	01011011	[	[	Opening bracket
92	134	5C	01011100	\	\	Backslash
93	135	5D	01011101	]	]	Closing bracket
94	136	5E	01011110	^	^	Caret - circumflex
95	137	5F	01011111	_	_	Underscore
96	140	60	01100000	`	`	Grave accent
97	141	61	01100001	a	a	Lowercase a
98	142	62	01100010	b	b	Lowercase b
99	143	63	01100011	c	c	Lowercase c
100	144	64	01100100	d	d	Lowercase d
101	145	65	01100101	e	e	Lowercase e
102	146	66	01100110	f	f	Lowercase f
103	147	67	01100111	g	g	Lowercase g
104	150	68	01101000	h	h	Lowercase h
105	151	69	01101001	i	i	Lowercase i
106	152	6A	01101010	j	j	Lowercase j
107	153	6B	01101011	k	k	Lowercase k
108	154	6C	01101100	l	l	Lowercase l
109	155	6D	01101101	m	m	Lowercase m
110	156	6E	01101110	n	n	Lowercase n
111	157	6F	01101111	o	o	Lowercase o
112	160	70	01110000	p	p	Lowercase p
113	161	71	01110001	q	q	Lowercase q
114	162	72	01110010	r	r	Lowercase r
115	163	73	01110011	s	s	Lowercase s
116	164	74	01110100	t	t	Lowercase t
117	165	75	01110101	u	u	Lowercase u
118	166	76	01110110	v	v	Lowercase v
119	167	77	01110111	w	w	Lowercase w
120	170	78	01111000	x	x	Lowercase x

DEC	OCT	HEX	BIN	Symbol	HTML Number	Description
121	171	79	01111001	y	y	Lowercase y
122	172	7A	01111010	z	z	Lowercase z
123	173	7B	01111011	{	{	Opening brace
124	174	7C	01111100	|			Vertical bar
125	175	7D	01111101	}	}	Closing brace
126	176	7E	01111110	~	~	Equivalency sign - tilde
127	177	7F	01111111		&#127;	Delete

SITOR Alphabet

No.	SITOR Alphabet	LETTER	FIGURE
1	1 1 1 0 0 0 1	A	-
2	0 1 0 0 1 1 1	B	?
3	1 0 1 1 1 0 0	C	:
4	1 1 0 0 1 0 1	D	
5	0 1 1 0 1 0 1	E	3
6	1 1 0 1 1 0 0	F	
7	1 0 1 0 1 1 0	G	
8	1 0 0 1 0 1 1	H	
9	1 0 1 1 0 0 1	I	8
10	1 1 1 0 1 0 0	J	Bell
11	0 1 1 1 1 0 0	K	(
12	1 0 1 0 0 1 1	L	)
13	1 0 0 1 1 1 0	M	.
14	1 0 0 1 1 0 1	N	,
15	1 0 0 0 1 1 1	O	9
16	1 0 1 1 0 1 0	P	0
17	0 1 1 1 0 1 0	Q	1
18	1 0 1 0 1 0 1	R	4
19	1 1 0 1 0 0 1	S	‘
20	0 0 1 0 1 1 1	T	5
21	0 1 1 1 0 0 1	U	7
22	0 0 1 1 1 1 0	V	=
23	1 1 1 0 0 1 0	W	2
24	0 1 0 1 1 1 0	X	/
25	1 1 0 1 0 1 0	Y	6
26	1 1 0 0 0 1 1	Z	+
27	0 0 0 1 1 1 1	Carriage Return	

No.	SITOR Alphabet	LETTER	FIGURE
28	0 0 1 1 0 1 1	Line Feed	
29	0 1 0 1 1 0 1	Letter Shift	
30	0 1 1 0 1 1 0	Figure Shift	
31	0 0 1 1 1 0 1	Space	
32	0 1 0 1 0 1 1	Unperforated tape	
	0 1 1 0 0 1 1	Request	
	1 1 1 1 0 0 0	Idle a	
	1 1 0 0 1 1 0	Idle b	

ITA-1 Alphabet

No.	ITA-1 Alphabet	LETTER	FIGURE
1	1 1 0 0 0	R	_
2	1 0 0 1 1	I	
3	0 1 1 1 0	Line feed	
4	1 0 0 1 0	W	?
5	1 0 0 0 0	N	
6	1 0 1 1 0	X	,
7	0 1 0 1 1	U	4
8	0 0 1 0 1	H	-
9	0 1 1 0 0	K	(
10	1 1 0 1 0	S	.
11	1 1 1 1 0	Letter shift	
12	0 1 0 0 1	C	9
13	0 0 1 1 1	Carraige return	
14	0 0 1 1 0	Z	:
15	0 0 0 1 1	O	5
16	0 1 1 0 1	J	6
17	1 1 1 0 1	Figure shift	
18	0 1 0 1 0	T	
19	1 0 1 0 0	M	)
20	0 0 0 0 1	D	0
21	1 1 1 0 0	Space	
22	0 1 1 1 1	A	1
23	1 1 0 0 1	B	8
24	1 0 1 1 1	E	2
25	1 0 1 0 1	G	7
26	1 0 0 0 1	F	

No.	ITA-1 Alphabet	LETTER	FIGURE
27	0 0 0 1 0	V	‘
28	0 1 0 0 0	Q	/
29	1 1 1 1 1	Unperforated tape	
30	1 1 0 1 1	Y	3
31	0 0 1 0 0	L	=
32	0 0 0 0 0	P	%

Questions & Answers

I got the following error message "An unnamed file contains an invalid path". Why?

When installing any WINDOWS operating system, a “Temp” folder is automatically created in your root directory. The decoder software uses this folder to create the required temporary files. Please, check if a ‘Temp” folder is present. If not, just create a new one in your root directory, e.g., "**C:\Temp**".

Why is my CPU at nearly 50 percent utilization, even if no sophisticated mode is enabled?

If data compression encryption is switched on, switch off these features.

Why is my fast CPU at 100 percent utilization when I run the FFT mode?

For graphics intensive tasks (e.g., FFT), the PC CPU uses as much processing power as is available to maximize the display refresh rate. If there is more than one FFT display (i.e., from two or more decoder cards), these will share the available processing power. This will not adversely affect the operation of any other decoder cards in the system.

The IF output of my receiver seems not to be suitable with 10.7 MHz IF input of the decoder card. Is there any solution?

The 10.7 MHz IF s of some receivers typically have a bandwidth of up to 500 kHz, and is intended for a spectrum analyzer. This bandwidth is too wide for the decoder IF input.

A solution is a slight modification of the receiver, i.e., to install a 455 kHz output in the receiver (see WAVECOM’s web site).

What is the maximum number of decoder cards that could be remotely controlled?

In theory, when accessing remote client cards, any number of cards may be controlled remotely from a single computer. There are, of course WINDOWS resource constraints, and network bandwidth constraints that would limit the number of clients that can be simultaneously connected. For the average PC hardware, eight simultaneous clients is the recommended maximum.

Why does connecting to a remote decoder card sometimes take a long time?

Connecting to any decoder card on the network may take up to two minutes. The connection is made by Microsoft DCOM, and the connection delay is the normal DCOM connection time. The wait cursor will appear while the connection is being made.

What should I do if a decoder card needs repair?

Contact your local distributor to arrange the return of your card. If necessary, it will be forwarded to WAVECOM for repairs.

Signal Interference

General

All microprocessors and personal computers emit strong broadband noise signals which propagate along the control and data lines. Strong noise signals are also often produced by printers without noise reduction features. Common noise sources include the unshielded cables for printer, monitor and mouse.

Antenna installation

The antenna is the main factor when it comes to fighting noise. A well-designed long-wire antenna, with a proper impedance matching feeder, installed well clear of any obstructions, seldom exhibits interference problems. In very simple installations where for instance an active antenna is deployed in very close proximity to the decoder or monitor, interference is bound to be present, especially in the 3 - 10 MHz range. Active antennas must always be mounted at least two meters away from any building part to be clear of the noise field which surrounds a building. It is equally important to provide a high quality grounding of the antenna mast (cold water mains).

Receiver

Receivers are often not sufficiently shielded or de-coupled, resulting in noise signals directly entering the receiver. Since many receiver types require an antenna impedance of 50 Ohm for correct matching, any deviation from this impedance results in a large increase in interference levels due to mismatching. This situation may be remedied by inserting an antenna tuner (matching device) between antenna and receiver.

HF cabling

All HF cable plant inside the building must use shielded HF cables.

Grounding

The best grounding is provided by the cold water mains. Hot water or heating pipes are not necessarily grounded. Good quality, effective grounding of the receiving equipment is highly recommended - also for your personal safety.

Location of decoder

Despite multi-layer metallic shielding of the receiver, the PC may still radiate into the receiver if placed in close proximity. This problem may be solved by moving the PC or the receiver or both.

PCs and peripherals

PCs, printers, keyboards etc. can all be sources of heavy interference and noise if placed close to a receiver or an antenna. If possible ground the equipment and place ferrite loads on the cabling connecting the equipment.

Video monitor

If at all possible, use a monitor which conforms to the latest Swedish MPR-II radiation standards or even better to the TCO-92 standards. The improvement in noise reduction offered by such equipment is significant and interference originating from these monitors can be expected to be negligible.

LAN

Computer networks using coaxial cabling with BNC plugs produce very high noise radiation. To combat this noise, install your antenna at least 5 m away from the building.

Conditions of Sale

General

These general conditions of sales are binding if no other conditions have been declared as applicable in the quotation or the order confirmation of Wavecom Elektronik AG.

Customer orders are binding only if Wavecom Elektronik AG has confirmed them in writing.

Prices

The list prices are net, exclude VAT, shipping and packing costs, unless otherwise agreed. Wavecom Elektronik AG reserves the right to adapt its prices to offset cost increases (e.g., production costs and exchange rate fluctuations etc).

Delivery

The delivery time is specified in the confirmation of order/contract. The delivery time may be extended due to unforeseen circumstances such as acts of God (epidemics, earthquake, etc), war, as well as delivery delays from our material suppliers. The delivered goods remain the property of WAVECOM ELEKTRONIK AG until the invoice in total is fully paid.

Dispatch

The customer can choose the method of dispatch. Without specific shipping instructions from the customer, we reserve us the right to arrange the dispatch by any forwarder/courier of our choice. Any complaints regarding damage, delays or loss must be forwarded to Wavecom Elektronik AG in written form within 48h from the receipt of the goods. Complaints of suspected bad packing must be forwarded to Wavecom Elektronik AG on the date of receipt.

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The return of defect goods requires written approval of Wavecom Elektronik AG before the dispatch. For a return during the warranty period, the costs of the shipping the items back to the customer will be paid by Wavecom Elektronik AG. The charges for the shipping the items to Wavecom Elektronik AG must be paid by the customer. For goods returned after the warranty period, the shipping costs for both ways must be fully paid by the customer. Please take great care when returning your goods to us. The customer is responsible for returning the goods to the supplier without damage. We recommend that you use the package material that was used for the delivery.

Our decoding cards require "HIGHSHIELD ELECTROSTATIC SHIELDING". Observe precautions for handling electrostatic discharge sensitive devices! Protect the card against mechanical stress. Insure your returned goods.

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Customer orders can only be accepted against advance payment by bank transfer, Letter of Credit, check or credit card (only up to CHF6,500.-/EUR 4,300.-/USD 5,450.-). For Letter of Credit payments, we charge an additional administration fee.

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Before using our equipment please also take note of the laws and regulations of telecommunications authorities in your country. It is the responsibility of the users to determine whether the reception and decoding of transmissions is permitted or not. The manufacturer or vendor is not liable for violations of laws or regulations.

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Manufacturer Address

WAVECOM ELEKTRONIK AG

Hammerstrasse 8

CH-8180 Buelach

Switzerland

E-mail: info@wavecom.ch

Web: www.wavecom.ch

Glossary of Terms

Active window

The window on the screen where the next action will take place. The active window is indicated by a colored title bar and border.

AF-IN

The AF input has a range of 0 – 16.000 Hz. This input should be used when the source is an AF output (line or speaker) or a 12.0 or 12.5 kHz IF output used in professional digital recorders.

Alert

A warning or notice of an error in the form of a message, a sound from the computer's speaker, or both.

AMBE

Advanced Multi-Band Excitation speech coding.

ANSI

An acronym for the American National Standards Institute, an organization that sets standards for a variety of programming languages and systems.

AOR

Atlantic Ocean Region.

APC

Adaptive Predictive Coding.

ARQ

Automatic repeat request (ARQ) (or automatic repeat-query) is an error-control method for data transmission which uses acknowledgements and requests to achieve reliable data transmission over an unreliable service. An acknowledgement is a message sent by the receiver to the transmitter to indicate that it has correctly received a data frame or packet. A request is a message sent by the receiver to the transmitter to indicate that the sender has to re-transmit the frame/packet; if the sender does not receive an acknowledgement before a timeout, it usually re-transmits the frame/packet until it receives an acknowledgement or exceeds a predefined number of re-transmissions.

ASCII

An acronym for American Standard Code for Information Interchange, pronounced "ASK-ee." It is a code in which the numbers from 0 to 127 stand for letters, numbers, punctuation marks and other characters. ASCII code is standardized to facilitate transmitting text between computers or between a computer and a peripheral device.

Baud rate

The speed in a 2FSK transmission. The duration of a bit is 1/Baud. At 50 Baud a bit is 20ms long.

The speed is given as the channel speed in Bauds. For two level modulation types this equals the raw user bit rate, for four level s the bit rate is doubled, for eight levels it is tripled etc.

Broadcast

Public or private radio station transmitting music, news, etc.

Buffer

A temporary holding area in the computer's memory where information can be stored. In editing, it is an area in memory where cut or copied data is held, sometimes called the clipboard. See also: clipboard and type-ahead buffer.

Clipboard

The holding place for what you last cut or copied; a buffer area in memory. Information contained on the clipboard can be inserted (pasted) into other documents and other WINDOWS applications.

Context sensitive

Able to perceive the situation in which an event occurs. For example, context sensitive help presents information specific to the particular task you are performing, rather than presenting just a general list of commands.

Control key

A specific key, usually abbreviated as "Ctrl", that produces control characters when used in combination with character keys.

CRC

A cyclic redundancy check (CRC) is an error-detecting code designed to detect accidental changes to raw data, and is commonly used in digital data transfer and storage. A CRC-enabled protocol calculates a short, fixed-length binary sequence, known as the check value or improperly the CRC, for each block of data to be sent or stored and appends it to the data, forming a codeword. When a codeword is received or read, the device either compares its check value with one freshly calculated from the data block, or equivalently, performs a CRC on the whole codeword and compares the resulting check value with an expected residue constant. If the check values do not match, then the block contains a data error and the device may take corrective action such as requesting the block be sent again, otherwise the data is assumed to be error-free (though, with some small probability, it may contain undetected errors; this is the fundamental nature of error-checking).

CRCs are so called because the check (data verification) code is a redundancy (it adds zero information to the message) and the algorithm is based on cyclic codes. CRCs are popular because they are simple to implement in binary hardware, are easy to analyze mathematically, and are particularly good at detecting common errors caused by noise in transmission channels. As the check value has a fixed length, the function that generates it is occasionally used as a hash function.

Database management system

(DBMS) - A software system for organizing, storing, retrieving, analyzing and modifying information.

Default button

The push button with a bold border in dialogues. The default button often has a dotted-line border around the button name. The default button is chosen when you press "Enter" (or Ctrl+Enter depending on your configuration).

Default font

Used font if no other font is defined.

DIS

The DIS input (Discriminator) has a range of 0 – 20 kHz. This input is supported by a few VHF-UHF receivers and facilitates the reception of ”Direct FSK” signals like POCSAG or PACKET-9600. The advantage of this input is the easy handling. Only the gain has to be adjusted. There is no need for an adjustment of the center or the translation frequency. DIS is only released for ”Direct FSK” modes.

Disable

To make an item unavailable for use. Disabled items reflect the WINDOWS color settings for disabled commands, and generally appear dimmed and cannot be chosen.

EOD

End-Of-Data.

Error message

A message displayed to tell the user about an error or problem in the execution of a program or in the user's communication with the system. An error message is often accompanied by a beep.

EXT-DEM-IN

The EXT-DEM-IN input must be used if an external demodulator is to be connected. The minimum input level is TTL level (LO = 0 V, HI = +5 V) and the maximum is RS-232C level (LO = -12 V, HI = +12 V). Note that utilizing this facility will disable certain W51PC functions. Thus this input should be employed for special purposes only.

FDX

Full duplex.

FEC

Forward error correction (FEC) is error control methode for data transmission, whereby the sender adds redundant data to its messages, also known as an error-correction code. This allows the receiver to detect and correct errors (within some bound) without the need to ask the sender for additional data. The advantages of forward error correction are that a back-channel is not required and retransmission of data can often be avoided (at the cost of higher bandwidth requirements, on average). FEC is therefore applied in situations where retransmissions are impossible (traffic lists, broadcasts).

FFSK

Fast Frequency Shift Keying.

FFT

Fast Fourier Transform.

File type

The categories of files specified by file extensions: APP, DBF, PRG, CDX, FRX, and so on.

GFSK

Gaussian Frequency Shift Keying.

GUI

Graphical User Interface.

HDX

Half duplex.

Hot key

An underlined letter in a menu or dialogue that you can type to immediately choose an item.

IF-IN-10.7

The IF-IN-10.7 input has a range of 10.685–10.715 MHz (or 21.385 – 21.415 MHz). This IF is common for VHF-UHF receivers.

IF-IN-21.4

The IF-IN-21.4 input has a range of 21.385–21.415 MHz. This IF is common for VHF-UHF receivers.

IF-IN-VAR

The IF-IN-VAR has a range of 14 kHz–1.5 MHz. Most receiver's IF is in this range.

IMBE

Improved Multi-Band Excitation speech coding

Insert mode

The default text-editing mode in which any character you type is inserted at the cursor position and the text to the right of the cursor is shifted to the right.

IOR

Indian Ocean Region.

IQ

In-phase/Quadrature. Used to denote the complex format on which the RF data is processed and stored. The IQ demodulation is also sometimes named Base-band demodulation, quadrature demodulation, or complex demodulation etc.

Keyboard shortcuts

The keystroke combinations that you can use to choose menu options instead of using the mouse.

LAN

Local Area Network.

LES

Land Earth Station.

LNA

Low Noise Amplifier.

Loop

A section of a program that runs repeatedly until a limit or condition is met, such as a variable reaching a specified ending value.

Mark

Application	Condition	Condition
Voltage to signal ground	Negative (-)	Positive (+)
Conventional term	MARK	SPACE
Binary digit value	1	0
Timing signal state	Off	On
FSK signal state	Lower frequency	Higher frequency

MATLAB

MATLAB® is a well-established high-performance language for technical computing. It integrates computation, visualization, and programming in an easy-to-use environment where problems and solutions are expressed in familiar mathematical notation.

Menu bar

A horizontal strip that appears at the top of the screen and contains menu pads.

Menu name

A word, phrase or icon on the menu bar that designates one menu. Selecting the menu pad highlights the name and causes the menu options to appear.

Menu options

Commands, found on menus, that perform specific actions. When you choose a menu option, you are telling the program what action to take.

Menu pads

The menu names found on the menu bar.

Menu system

The combination of the menu bar, menu pads, menus and menu options.

MES

Mobile Earth Station.

MFSK

Multi Frequency Shift Keying.

Minimize

The act of causing a window to become an icon that includes the title of the window.

Modal

Describes the state of a window or dialogue when it does not allow another window or dialogue to be brought in front of it until that window or dialogue is dismissed, for example, the Expression Builder dialogue.

MPDS

Mobile Packet Data System.

NA

Not Available.

NCSC

Network Control Station Channel.

Network

A collection of interconnected, individually controlled computers, together with the hardware and software used to connect them. A network allows users to share data and peripheral devices (such as printers and storage media), to exchange electronic mail, etc.

Non-modal

A window or dialogue that allows another window or dialogue in front of it while it is open, for example, the Command window.

On-line help

A reference guide, accessible while using the software, that provides additional information about commands, functions, and the interface.

Option

Different additional options are available from WAVECOM.

In the manual, options are marked with (Option).

OSI-Layer

OSI (Open Systems Interconnection) is a standard description or "reference model" for how messages should be transmitted between any two points in a telecommunication network.

Paste

To place the contents of the clipboard at the insertion point.

Path name

The full name by which an operating system identifies a file. A path name is a sequence of directory and file names, each preceded by a backslash, that specifies the path from device to directory to file that the operating system takes to locate that file.

PB

Passband.

PC

Personal Computer.

Phase Shift Keying

Phase Shift Keying (PSK) is a digital modulation scheme that conveys data by changing, or modulating, the phase of a reference signal.

Pointer

A small solid box or arrow on the screen that follows the movement of the mouse and shows where your next action will take place.

POR

Pacific Ocean Region.

Professional

Items only available in the professional software version are marked with (Professional).

PSTN

Public Switched Telephone Network.

RHCP

Right Hand Circular Polarization.

Right-clicking

Clicking with the pointing devices right button.

Scroll

To move through the contents of a window or so that a different part becomes visible.

Scroll bars

The controls that are used to view text that extends beyond the edge of a window. A window can have vertical and/or horizontal scroll bars.

SELCAL

Selective call systems are an efficient supplement to voice traffic. One method was the so-called single-tone-mode using five different tone frequencies, another one the two-tone-modes, where the call number is transmitted as frequency combinations.

Developments led to the five-tone-sequence systems. The five digits are often divided into two groups. The first digits work as radio net flags, the last three digits are user call numbers.

The entire call number is transmitted by consecutive tones in decade sequence. When two identical digits are to be transmitted consecutively, then an eleventh frequency is used as a repetition identifier. If there more than two identical digits are to be transmitted the repetition tone is appended to the digit tone (e.g. 22222 is transmitted as f2 fw f2 fw f2, where f2 is the tone for "2" and fw is the repetition tone).

In most systems the accuracy of the single frequencies has to be within +1/-1.5% of the nominal value.

Modifications of the tone allocation and tone duration has led to numerous systems despite many standards.

Only the EURO (EuroSignal) system uses six consecutive tones. The worldwide telephone signaling standard DTMF mode transmits two simultaneous tones.

Server

See file server.

Shift

The difference between two tones in an FSK transmission.

Size control

A screen element found on WINDOWS that allows you to change the window size.

SNAC

Single Network Access Code.

SNR

Signal-to-Noise Ratio.

Space

Application	Condition	Condition
Voltage to signal ground	Negative (-)	Positive (+)
Conventional term	MARK	SPACE
Binary digit value	1	0
Timing signal state	Off	On
FSK signal state	Lower frequency	Higher frequency

Spinner

A control that allows you to increment or decrement numbers either by typing the numbers or clicking the UP and DOWN arrow keys.

String

An item of information consisting of a sequence of text characters.

SW

Software.

TDM

Time Division Multiplex.

TDMA

Time Division Multiple Access.

Text editing window

A window in which text is displayed and can be scrolled.

Text editor

The part of the software that allows you to modify text files.

Text file

A file which contains information expressed in text form and whose contents are interpreted as characters encoded using the ASCII format.

Thumb

A gray box in the scroll bar that indicates the relative position in the text. If you want to move through the text rapidly you can drag the thumb up and down.

Unicode Font

The Unicode standard is intended to provide a 'unique, universal, and uniform' encoding for each character in all living languages (plus a few dead ones). One font (WAVECOM Unicode) is automatically installed on your computer. Other Unicode fonts with are available on the market.

Unlock

To remove the restriction on the use of a disk or a file so that it can be changed, deleted or renamed.

Utility

Transmission in RTTY or FAX.

W-[XX]

Stands for a WAVECOM product code like W-PCI, W-PCIe, W-CODE, W61PC, W-51PC, W41PC or W40PC.

Wildcard

A character that may be used to represent a sequence of characters in a path name. A common wildcard character is the asterisk (*). As an example, if you request a listing of *.TXT files in a particular application, you would see a list of all files ending with the extension TXT.

WINDOWS

Microsoft WINDOWS™ Operating System.

Word-wrap

The automatic continuation of text from the end of one line to the beginning of the next, so that you don't have to press the Enter key at the end of each line you type. If word-wrap is set off, the text you type may extend beyond the edge of the window.

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