4T2 SW Manual RF-Analyser

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1 4T2 Content-Analyser Application

This is the application to perform MPEG Transport Stream Content related measurements.

Please refer to the 4T2 Content-Analyser Software Manual for information on this application.

2 4T2 RF-Analyser Application

This is the application to perform RF COFDM related measurements.

In monitoring applications, the analyser is operating in unattended mode. In this mode, the user is not required to (and must not) change input parameters, such as receiving udp address and port, or to alter the measurement setup, like ignore priority-n errors, for instance.

3 StartUp 4T2 application

A click on the Startup 4T2 symbol in the system tray of the task bar allows the measurement applications to be started directly.

You can also determine here (under ***Startup***...) which application to start automatically with the start of the instrument.

Depending on the installed options, the display may differ from the picture below:

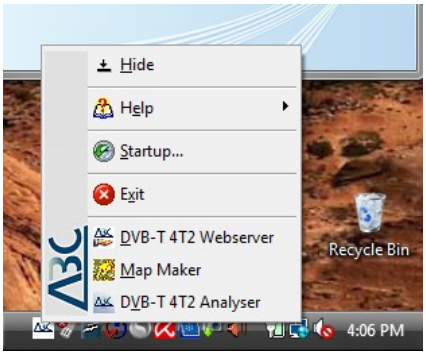


Illustration 1: StartUp 4T2

4 Screen Features

All measurement results, as well as the main device settings are displayed on the application screen.

The 4T2 strictly follows this 'at a glance' philosophy.

Settings, the ***Analysis Menu***, ***Utilities***, and general measurement parameters can always be found at the same location on the screen, at the top, the bottom, and the right hand part of the application area.
The central part of the screen only changes depending on the type of analysis chosen.

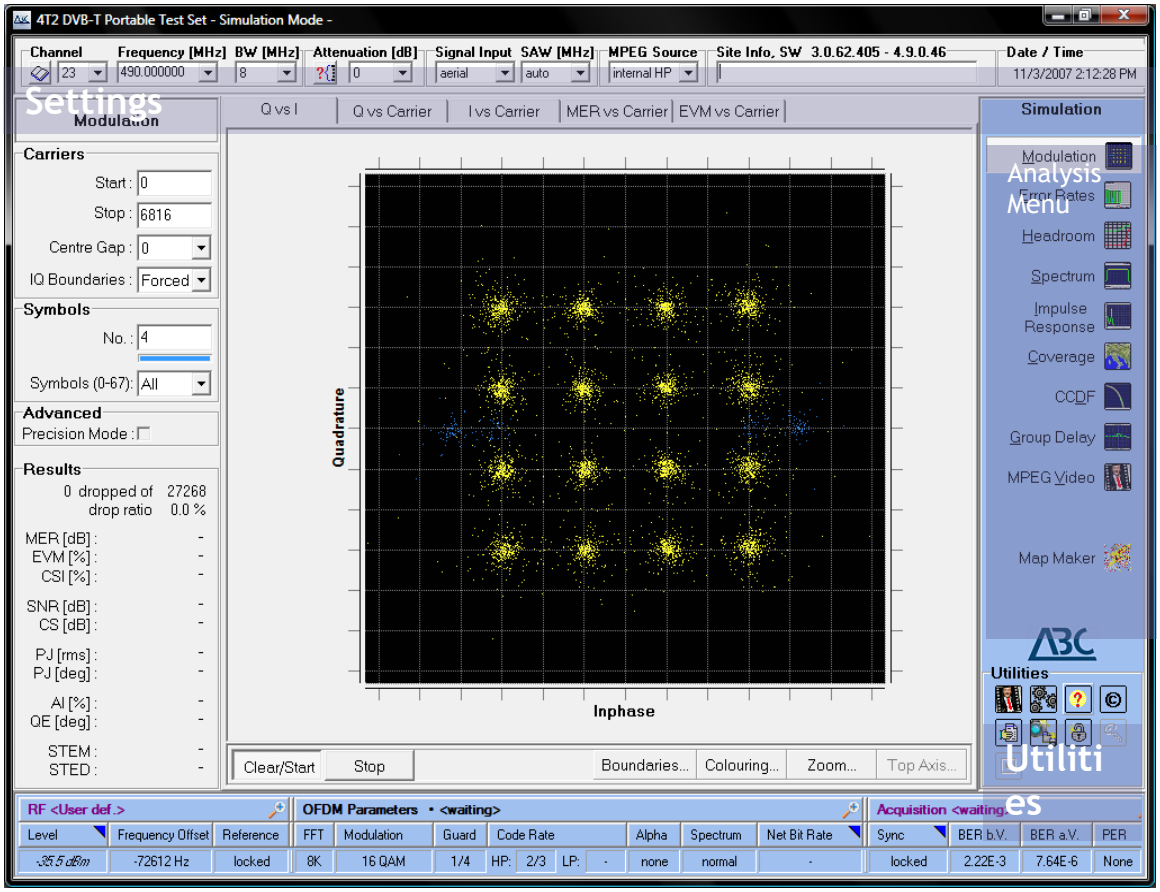


Illustration 2: 4T2 RF-Analyser Application Screen

4.1 Common Screen Features

Illustration 3: Preset section at the upper part of the RF-analyser application-screen

The ***Preset Bar*** section at the upper part of the application-screen holds general-purpose pre-settings and controls valid for all 4T2 analysis menues. It contains selections for channel/frequency, RF-input source, MPEG input source, etc.

The ***Status Bar*** at the bottom part of the application screen is divided into three groups of parameters:

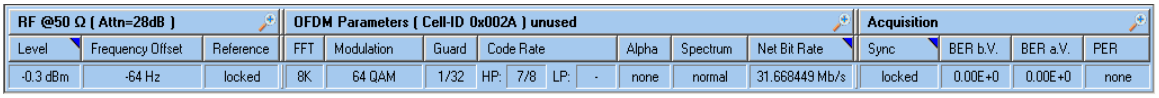


Illustration 4: Status bar of the RF-analyser application-screen with zoom function

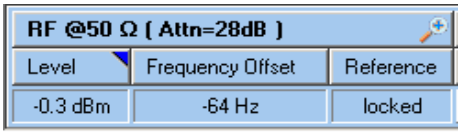
- The ***'RF'*** group on the bottom-left part of the application-screen displays general RF signal information, such as received Signal Level, Frequency Offset and Reference Status.

- The ***'OFDM Parameters'*** group (Orthogonal Frequency Division Multiplex) in the bottom-center part of the application screen provides information on the modulation parameters, such as Cell-ID, FFT length (2k, 4k, or 8k), Modulation type (QPSK, 16QAM or 64QAM), Guard Interval factor, Code Rates (HP, or LP), Spectrum orientation (normal or reverse) and the net data transmission rate in Mbit/s

- The ***'Acquisition'*** group in the bottom-right part of the application-screen informs about the locking status of the receiver, as well as current bit error rates before and after Viterbi plus the resulting MPEG packet errors. Clicking on the ***Sync***-bar opens a popup-menu to allow for re-synchronisation of the receiver front-end.
  In severe reception conditions, the ***re-synchronisation*** can be set to ***Auto***. Please note that the continous re-synchronisation may result in a periodic interruption of the measurement, as well as the video, or streaming displays.
  In normal operation, the re-synchronisation shall **not** be selected.

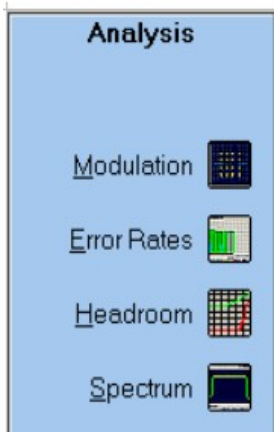
Clicking on the headlines causes the corresponding groups to be zoomed to full status-bar-width for better visibility of the measurement results. Clicking again toggles back to the standard display. The magnifying glass symbol indicates this available zoom function.

A blue triangle in the upper right corner of a parameter field indicates further parameter options. Clicking there results in corresponding popup-menues to open.



4.2 Analysis Menu

Depending on which options have been ordered for your 4T2, some of the menu buttons described below may not be active.

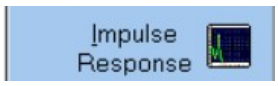


The ***Modulation*** screen allows Q versus I (constellation), Q versus Carrier, I versus Carrier, MER versus Carrier, and EVM versus Carrier measurements. — Basic

The ***Error Rates*** screen displays bar graph presentations of Bit Error Rates over various time intervals. — Basic

The ***Headroom*** screen allows analysing the Carrier to Noise (C/N) performance of the received OFDM signal by simulating a gradually decreasing signal-to-noise (S/N) performance. — Basic

The ***Spectrum*** screen provides measurement possibilities of a spectrum Analyser tailored to DVB applications. — Basic in portable from 2007 onwards



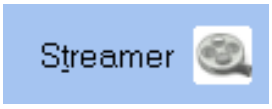
The ***Impulse Response*** screen checks the presence and shape of echoes in the received DVB signal. This is most useful to measure the properties of Single Frequency Networks. — Basic in portable from 2007 onwards

The ***Coverage*** option holds both table-based and map-based tools for performing and analysing GPS-based mobile coverage measurements of up to three RF-channels. — Optional

The ***CCDF*** measurement function gives information about the linearity of the received signal by evaluating the complementary cumulative distribution function. The CREST factor as a single figure of merit is displayed. — Basic

The ***Group Delay*** option allows carrying out measurements of the transit time of a signal through a DUT versus frequency. — Basic

The ***MPEG Video*** screen allows for monitoring of video and audio of the selected channel. — Basic in systems until 2007



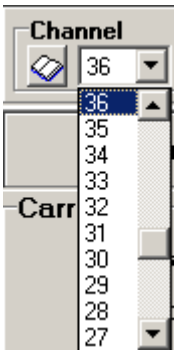
The ***Streamer*** screen allows for forwarding of the entire transport stream content to external decoders, or analysers. — Basic in systems from 2007 onwards

Utilities provides single-click features for file and screen control operations.

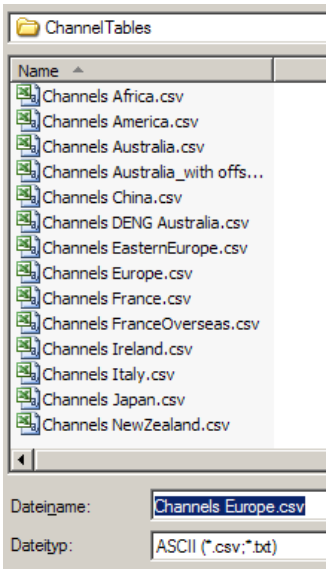
5 Settings and Controls

The 4T2 has been designed with a special focus on easy operability. You will find that not only is the menu structure easy to understand, but also are all the basic pre-settings and control elements displayed at the same position on the application-screen (i.e. on the top and on the bottom of the screen, the ***Settings-Bar***, and the ***Status-Bar***) no matter which type of analysis you decide to perform.
All settings are saved automatically when leaving the 4T2 RF-analyser application, to be restored when launching the next session (”last state“).

5.1 Settings-Bar



The ***Channel*** drop-down list works as a channel selector and is based in terms of channel data on the underlying channel table.

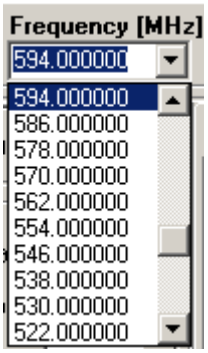


The ***ChannelTables*** button to the left (with the ***book-symbol***) opens the channel table selection dialogue.

The channel table determines which set of channels, including channel number, centre frequency, and channel bandwidth is used by the RF-analyser application.
On selecting a channel, the corresponding frequency and bandwidth are set according to the selected region.

The channel tables are of comma separated values file-type. They are located at c:\program files\ABC\4T2\ChannelTables, and are freely editable and can therefore be adapted to any local requirements.

For example, it is easy and recommended to produce a table containing only the channels used at your destination, making frequency selection simpler.

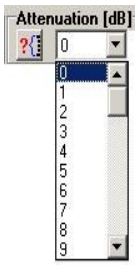


The ***Frequency*** drop-down list displays the centre frequency for the channel selection made from the ***Channel*** drop-down list.

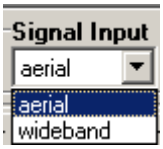
The Frequency drop-down list also allows typing the required input frequency directly.

Please note that setting the frequency to a value different from the one stored in the channel table file, causes the Channel display to go blank in order to indicate that a non-standard setting has been selected.
The 4T2 supports frequency entry in 1 Hz resolution.

The ***BW [MHz]*** drop-down list displays the standard bandwidth for the selected channel, as specified in the underlying frequency table.
Please note that setting the bandwidth of the receiver's input filter to a value different from the one stored in the channel table file, causes the Channel display to go blank in order indicate that a non-standard setting has been selected.



The ***Attenuation [dB]*** drop-down list enables you to set the input attenuator of the receiver in order to attenuate strong input signal levzels or temporarily simulate lower field strengths.
The ***Auto Attn*** button to the left (with the ***Question-Mark*** and ***Scale*** symbols) activates the receiver's input AGC and optimises the input attenuation for best performance. It should be pressed once after tuning the receiver or changing the analysis menue.



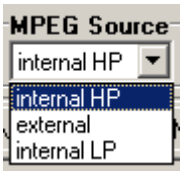
The ***Signal Input*** drop-down list selects between:

- ***aerial*** for antenna and field measurements,
- ***wideband*** for non-selective high performance transmitter measurements (demodulator input).

The 4T2 is equipped with a 2-channel diversity receiver. For ***diversity operation***,the two receiving antennas are connected to the aerial and the wideband input simultaneously. If only one antenna is in use, it has to be connected to the aerial input.

The ***SAW*** drop-down list selects the surface acoustic wave filter setting in the aerial input:

- automatically following the the selected bandwidth or
- 8 MHz, or
- 7 MHz

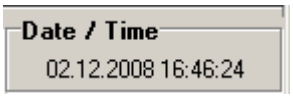


The ***MPEG Source*** drop-down list selects the source of the built-in MPEG hardware decoder, or Streamer Server:

- ***internal HP*** selects the source to the OFDM demodulator's internal high priority transport stream output in case of hierarchical modulation. If hierarchical modulation is not in used, this output always carries the transport stream data.
- ***external*** for external MPEG transport streams fed to the 4T2 ASI, or SPI input.
- ***internal LP*** selects the source of to the OFDM demodulator's internal low priority transport stream output in case of hierarchical modulation.

The ***Site Info*** text box can be used to enter a brief textual description of the measurement site. Please note that text entered in this field will be added to the file names in case of bit error and receiver headroom recordings.

The header also contains the firmware release number. Clicking on ***Site Info*** toggles between software release, device serial number, and IP-address.



The ***Date/Time*** info field displays standard date and time information.

The values are based on the internal PC clock

5.2 Status-Bar

The ***Status-Bar*** at the bottom of the application-screen displays RF-signal measurement results, OFDM parameters, and acquisition parameters, as described below.
A zoom function is included for better visibility of the results. To activate the zoom function, click the headlines.

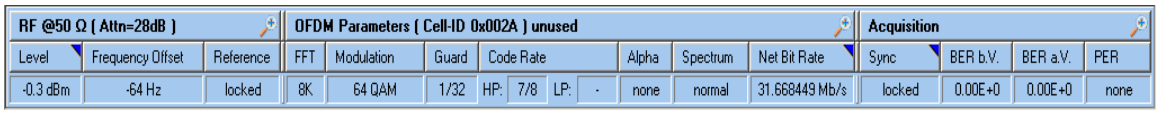
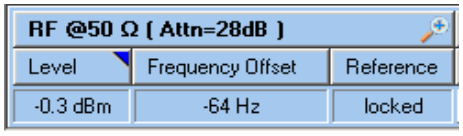


Illustration 5: Status Bar

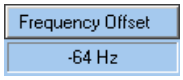
5.2.1 RF-Signal



The ***RF-Signal*** group displays general RF-signal information.

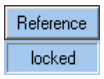
The ***Level*** field displays the instrument input level.

Clicking on the ***Level*** bar opens a dialogue for level conversion functions (please see below).



The ***Frequency Offset*** field provides a readout of the difference between the incoming DVB signal frequency and the internally generated reference according to the currently selected channel. The accuracy of the readout can be improved by applying an external 10 MHz reference.

Please take into account that the 4T2 needs a warm-up phase of about 10 min before reliable offset readouts are possible.

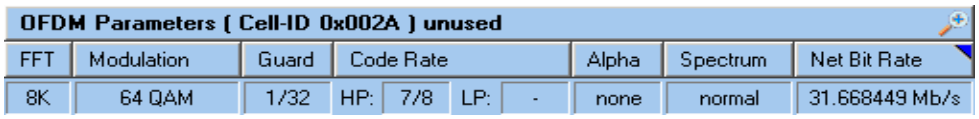


The ***Reference*** field shows the lock status of the 4T2 receiver's input stages related to the internal reference source. For increased accuracy, a 10 MHz source can be fed to the 10 MHz reference input (via BNC connector).

The 4T2 automatically aligns its internal clock to a connected external

reference source.
The status of external reference applied is displayed

5.2.2 OFDM Parameters



The ***OFDM Parameters*** group provides readouts for the **O**rthogonal **F**requency **D**ivision **M**ultiplex modulation properties of the signal. In Germany, common DVB-T COFDM parameter settings are:

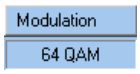
- 16 QAM, Code Rate 2/3, Guard Interval 1/4 in 8 MHz UHF channels
- 16 QAM, Code Rate 3/4, Guard Interval 1/4 in 7 MHz VHF channels

In case of valid Cell ID reception the cell identification is displayed in the header:

The Cell-ID is used for identifying single frequency network cells. In DVB-T, the transmission of the Cell-ID is optional, whereas its use is mandatory in DVB-H.

The ***FFT*** (Fast Fourier Transformation) field indicates the FFT length used for the currently selected channel in OFDM multi-carrier operation.
The FFT length can be either 2k, 4k, or 8k.

- The 2k mode employs 1705 separate carriers (of which 1512 carriers contain MPEG data); the 2k mode is optimised for fast mobile reception.
- The 4k mode is used exclusively in DVB-H networks.
- The 8k mode uses 6817 carriers (6048 carriers containing MPEG data); the 8k mode is optimised for Single Frequency Networks with the possibility of higher transmitter distances.



The ***Modulation*** field displays the type of modulation used in the currently selected channel. In general, every carrier is modulated by a modulation symbol. Two different types of modulation can be used for the OFDM signal: Quadrature Phase Shift Keying (QPSK), or Quadrature Amplitude Modulation (QAM).
The following three modulation types can appear in this field:

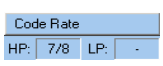
- QPSK, 4 positions, conveying 2 data bits per carrier or
- 16QAM, 16 positions, conveying 4 data bits per carrier or
- 64QAM, 64 positions, conveying 6 data bits per carrier

The ***Guard*** interval factor describes the ratio of the guard interval length to the duration of the symbol part length. The duration of the symbol part in 8 MHz channels is

- 896 µs for 8K mode,
- 448 µs for 4k mode,
- 224 µs for 2K mode.

The following guard interval factors are being used in the DVB-T transmission system: 1/4, 1/8, 1/16, or 1/32.
Example: A guard interval factor of 1/16 results in

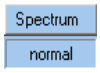
- Tg = 1/16 * 896 µs = 56 µs (for 8K mode), respectively
- Tg = 1/16 * 224 µs = 14 µs (for 2K mode).



The ***Code Rate*** field displays the code rate of inner error correction used in the currently selected channel. The code rate is defined as the ratio of the number of usable symbols to the total number of symbols. The following code rates are specified in the DVB-T system:
1/2, 2/3, 3/4, 5/6, or 7/8.
Lower code rates (e.g. 1/2) offer higher transmission robustness, while

resulting in lower usable data rates.

The ***Alpha*** field displays the alpha factor for hierarchical modulation, which is used as a measure for the ratio of the distance between two neighbouring constellation points of two quadrants to the distance between two neighbouring constellation points within one quadrant.
The alpha factor can either be:
none (1) = non-hierarchical, 2, or 4 = hierarchical.



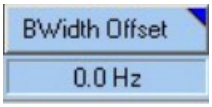
The ***Spectrum*** field indicates the orientation of the analysed spectrum. The spectrum orientation can be either normal or reverse.

The ***Net Bit Rate*** displays the calculated MPEG-TS data payload rate according to the received OFDM Parameters. The Net Bit Rate depends on the modulation scheme, the guard interval ratio, the code rate ratio and the channel bandwidth. The results are displayed in Megabits per second.

Clicking the ***Net Bit Rate*** field opens a pop-up menu to change the display to ***Net Bit Offset***, ***Bandwidth*** or ***Bandwidth Offset***.

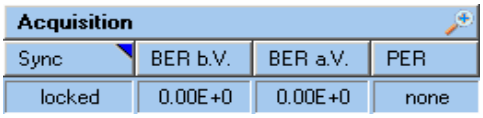
The ***Net Bit Offset*** display shows the rate difference between calculated Net Bit Rate as above and the actual bit rate measured by the 4T2 DVB-T Test Set. Positive values indicate that the incoming MPEG-TS data rate is higher (too high) than the one specified in the standard for the selected modulation scheme. Negative values indicate a lower (too low) data rate.
The results are displayed in bits per second.

The ***Bandwidth*** display shows the calculated bandwidth according to the received OFDM parameters. The bandwidth depends on the channel bandwidth and the FFT length. The results are displayed in Hertz.

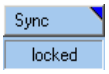


The ***Bandwidth Offset*** display shows the difference between calculated bandwidth as above and the actual bandwidth measured by the 4T2 DVB-T Test Set. Positive values indicate that the incoming OFDM bandwidth is higher (too high) than the one specified in the standard for the selected FFT length and channel bandwidth. Negative values indicate a lower (too low) bandwidth. The results are displayed in Hertz.
Please take into account that the 4T2 needs a warm-up phase of at least 10 min before reliable offset readouts are possible, see remark at Frequency Offset above.

5.2.3 Acquisition



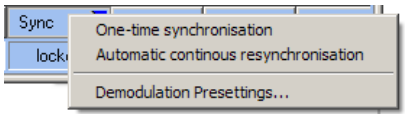
The ***Acquisition*** group at the right bottom of the screen displays the most important properties of the received OFDM signal.



The ***Sync*** field indicates the current status of synchronisation of the OFDM receiver. The following status can be displayed in this field:

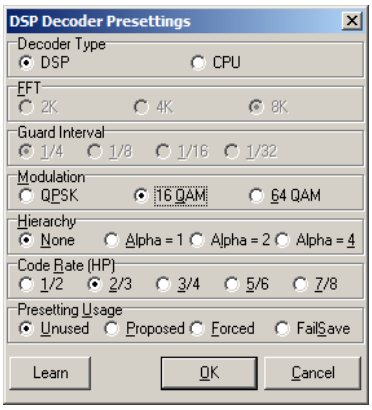
Display	OFDM	FEC (Forward Error Correction)
locked	locked	locked
bad lock	locked	unlocked
unlocked	unlocked	unlocked

Display	source	Situation
serlocked	Single ended receiver	Single-ended Receiver Reception
mrclocked	Maximum ratio combined	Diversity Reception



Clicking the ***Sync*** bar opens the Sync pop-up window:

- One-time synchronisation forces the 4T2 to re-sync.
- Clicking on Automatic continuous resynchronisation activates the 4T2 Auto-Sync mode. In this mode the 4T2 resets automatically every second. It can be used to avoid receiver lock-ups in difficult reception conditions. ***Warning***: Since the 4T2 permanently re-syncs, Error Rate recordings and MPEG stream displays are periodically interrupted. The Auto-Sync status is displayed in red, therefore.
- Demodulation Presettings opens the following window:



Is used to select between decoding by Chipset-DSP (hardware decoding) or by the internal computer CPU (software decoding).

For 4k-mode (DVB-H) CPU decoding has to be used to display a constellation, since the built-in DSP works only in 2k- or 8k-mode. All OFDM parameters may be put in manually but there is also the possibility to use the "Learn" button in order to apply the values directly from the signal.

Only 4T2 with diversity receiver installed, or 4T2-Rack from 2009 model onwards will be able to decode content in case of 4k-mode input.

The ***BER b.V.*** field shows the Bit Error Ratio before Viterbi decoder in the 4T2 receiver.

The ***BER a.V.*** field shows the Bit Error Ratio after Viterbi decoder in the 4T2 receiver.

The ***PER*** field shows the presence of MPEG Packet Errors. MPEG errors have direct impact on the quality of the received program. The following parameters can be displayed in this field: ***None***, or ***Error***.

5.2.4 Input level conversion

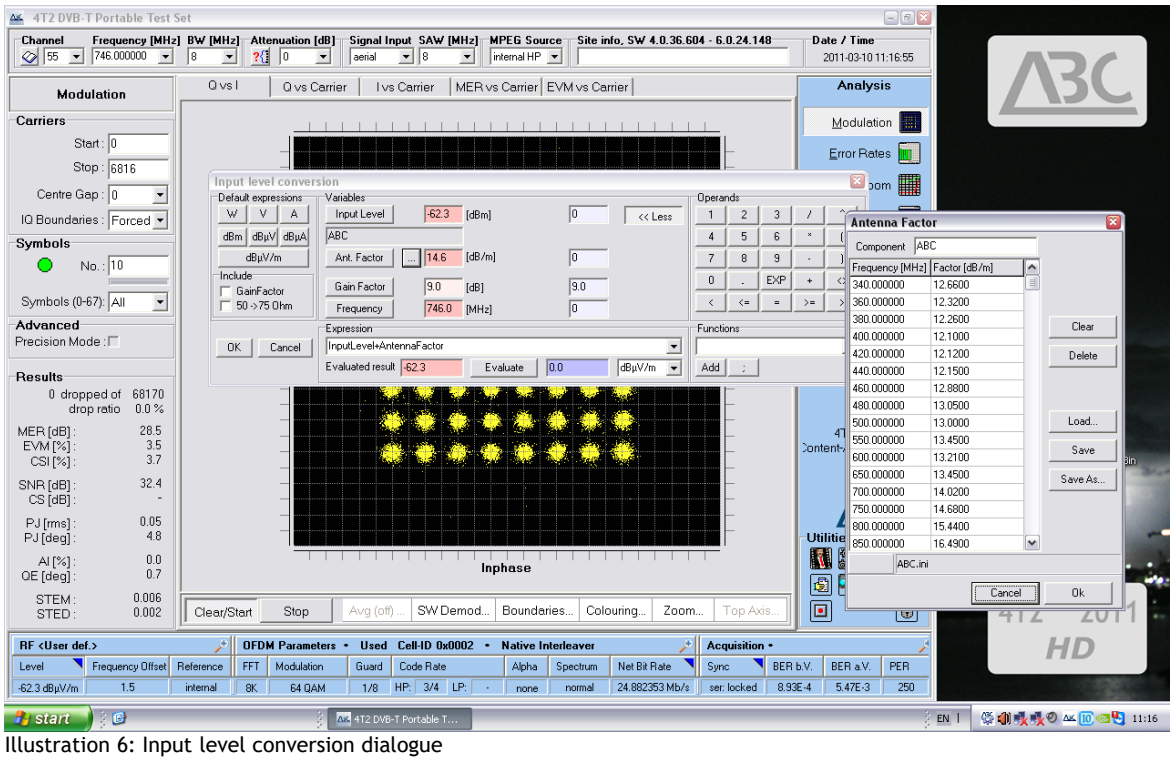


Illustration 6: Input level conversion dialogue

The 4T2 RF-analyser application includes a comprehensive input level conversion formula editor to perform automatic level unit, or level to field-strength conversions.
The conversion can include gain factors, antenna factors, and any other expressible formula.

The results apply to all level displays throughout the 4T2, such as the spectrum, or impulse response analysers.

Tl mpere respectively dBm, dBµV, dBµA or
dl check-box for 75 Ohm inputs is included.

Al ation (positive values), or cable losses
(n

Tl field. Please note that internally the 4T2
w
Fi s of actually measured values. Fields with
lig ntered formula

Tl entered expressions.

Tl ottom-right of the application screen, is
al t connector and an expression (formula) for
in

Ol ge according to the settings in level
cc n the level field.

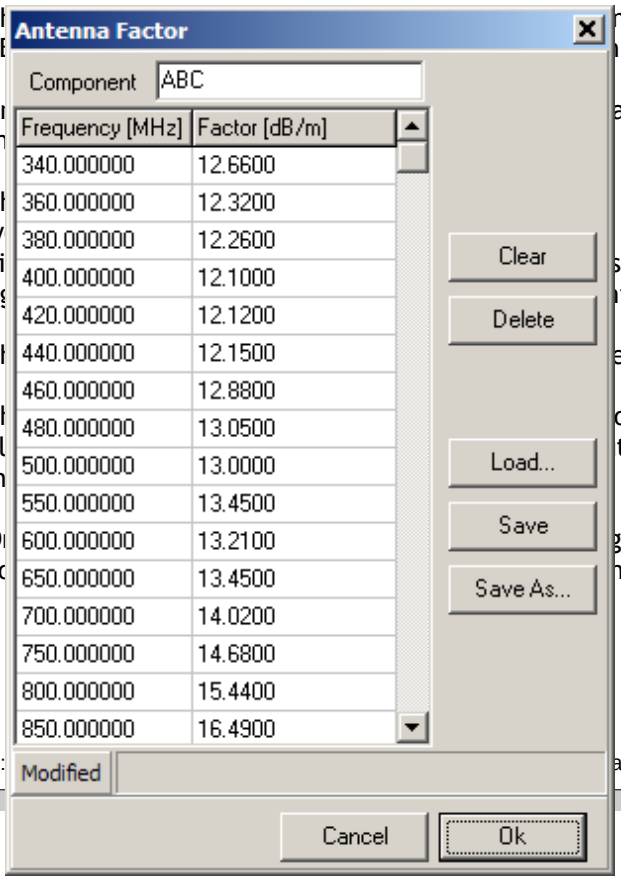


Illustration 7: Antenna Factor entry dialogue

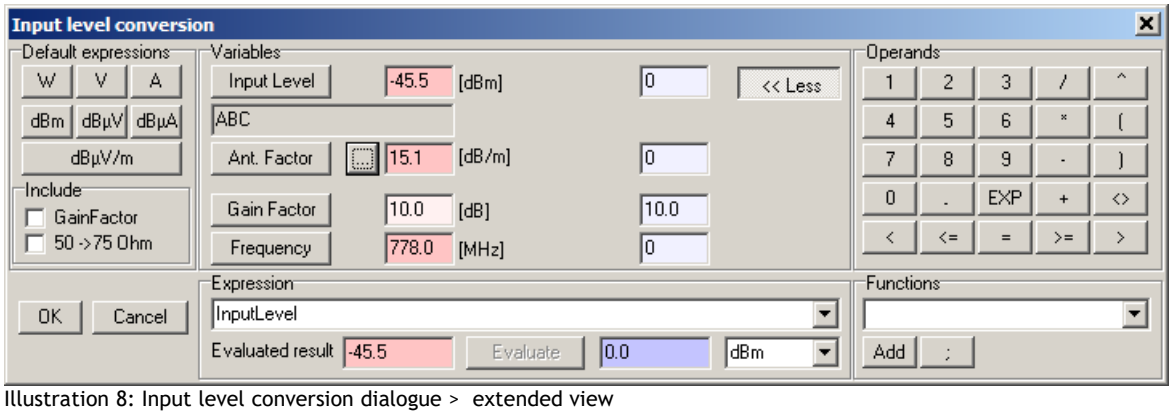


Illustration 8: Input level conversion dialogue > extended view

For user defined level conversions, a comprehensive calculator is provided, giving a variety of mathematical-functions. The evaluated result will be used for all further measurements.

5.3 Utilities

The Utilities buttons are located in the bottom right corner of the screen. They are used for file and screen control operations.

- The ***Video*** key opens an MPEG video window.
- The **Application Setup Files** opens or saves user-specified 'last state' files.
- The ***Help*** key starts the 4T2 online help.
- The ***About*** key informs about the current software version, contains copyright information and informs about ABC and the 4T2 development team.
- The ***System Report*** button creates a report file containing both system and receiver properties. Furthermore, the ***System Report*** contains a snapshot of the current TPS information (TPS = Transmission Parameter Signalling).
  The files are stored in the 4T2\ Reports\ folder by default.
- The ***Save Picture*** button creates a screen shot of the current screen. You can cut the border of a screen shot, turn the screen shot black and white as well as print and save the picture. File formats are "JPEG" or "Bitmap". Default directory is the 4T2\Reports folder.
- The ***Lock*** button disables the user interface to avoid accidental operation. When pressing the ***Lock*** button the overall 4T2 status is written to the last state file.
  Attention: The ***Lock*** button is also used to unlock the 4T2 after finalisation of error rate recordings.
- The ***Key*** button opens up a dialogue window which allows you to activate any of the 4T2 options that may not have been included in the initial 4T2 package when purchased.
  You will be asked by the 4T2 to enter a key to complete the activation of a new 4T2 option.

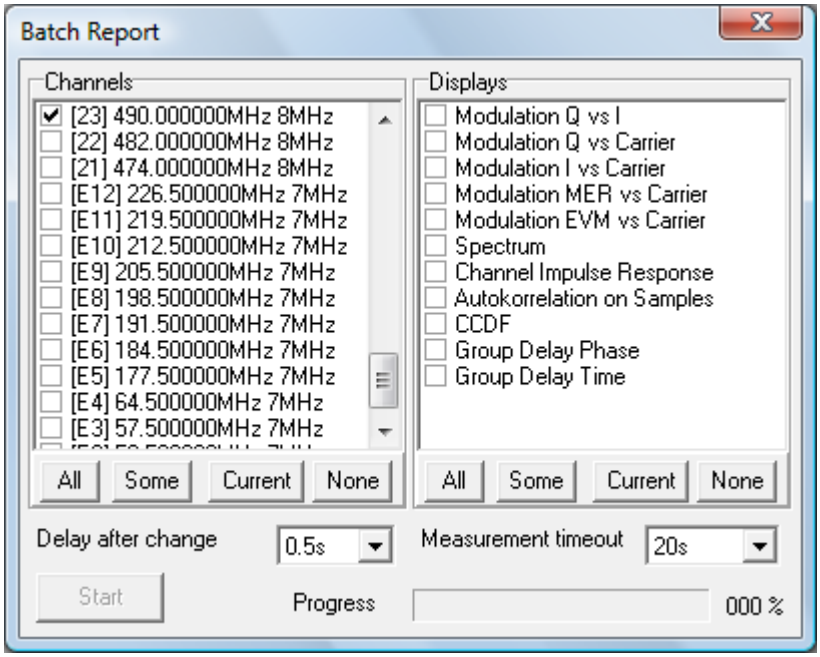


Illustration 9: /Utilities/Batch Report

Batch Report allows for automatic generation of screen-shots to fully evaluate the applied DVB signal. The screen-shots are stored in sub-folders according the channel names.

6 Measurement Functions

The 4T2 DVB-T Test Set works as an off-air receiver with a low-noise tuner input and a high-performance wideband down converter input.
Following the EN 300744 standard, the 4T2 provides evaluation and monitoring of all stages of the digital TV signal, from transmitter to reception in the field.

The system performs real-time measurements of the OFDM modulation parameters as well as input level and frequency offset evaluation. All measurements are performed without the need for any external devices.

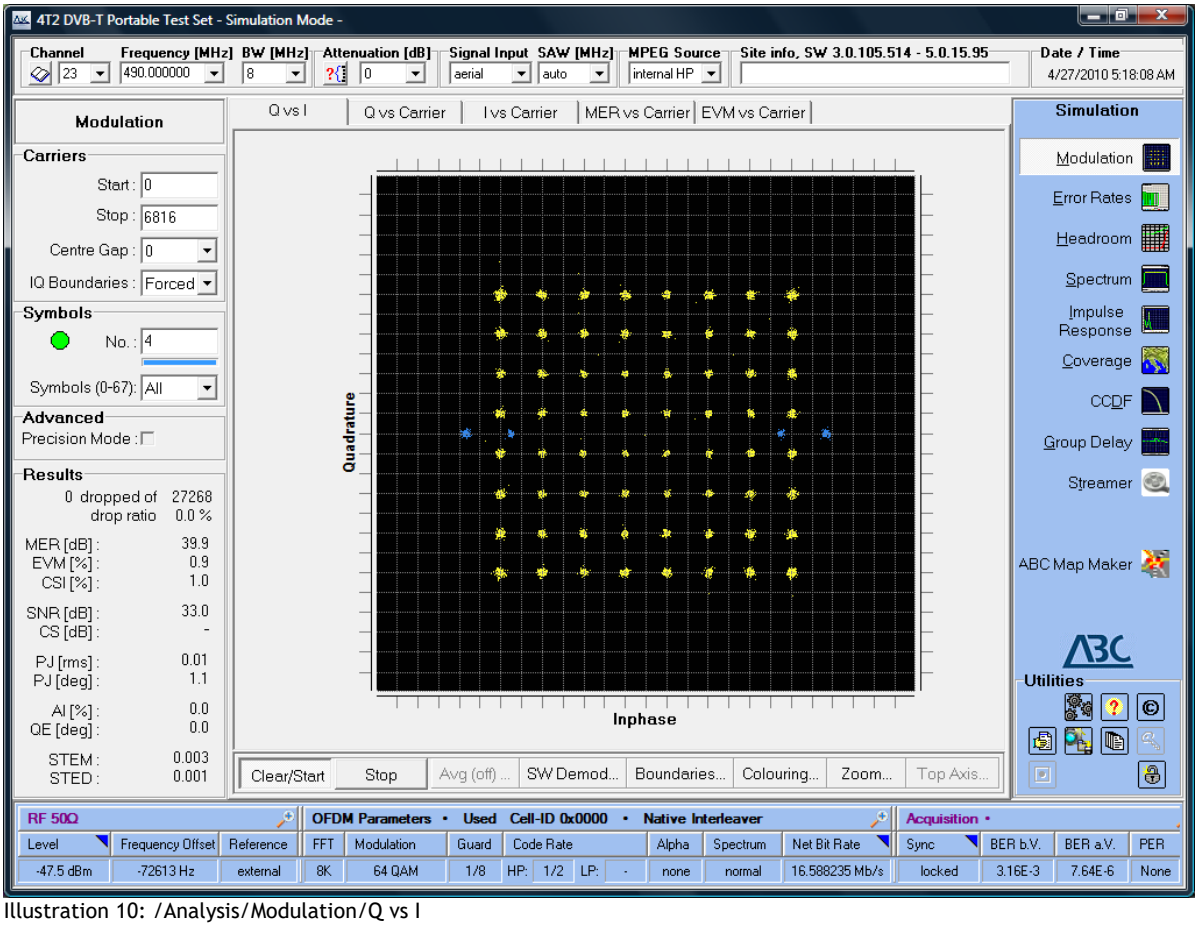


Illustration 10: /Analysis/Modulation/Q vs I

All available analysis features of the 4T2 are displayed as buttons on the right-hand side of the screen, headlined ***Analysis***.

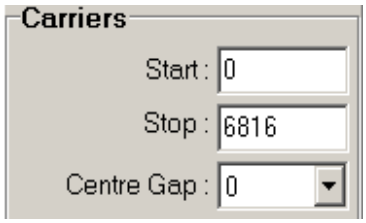
6.1 Modulation

The Analysis Modulation menu provides five different display modes which enable to thoroughly analyse the modulation characteristics of the received signal:

- Q vs I (constellation)
- Q vs Carrier
- I vs Carrier
- MER vs Carrier and
- EVM vs Carrier

6.1.1 Modulation Controls

The following section explains the various control elements which are available to perform a modulation analysis.



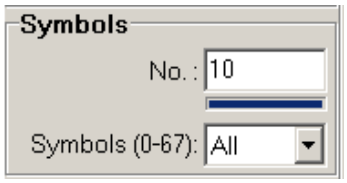
The ***Carrier Start*** field indicates the first carrier of the range of analysed OFDM-carriers.

The ***Carrier Stop*** field indicates the last carrier in the range of analysed OFDM-carriers.

By choosing the number of carriers in the ***Centre Gap*** field, the range for the Carrier Suppression measurement can be selected.

IQ Boundaries determines symbol decision properties and may be beneficial e.g. in low MER environments. Possible values are "Forced", "Squares", "Circles".

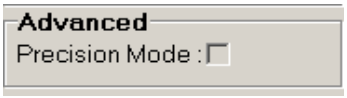
IQ Boundaries can remove constellation points from the calculations if the lay outside the decision area. The number and ratio of dropped constellation points related to number of carriers and symbols is displayed under results. Visibility of boundaries can be toggled with the ***Boundaries*** button below the diagram.



The number of ***Symbols*** being taken into account for the display of measurement results is entered here. The progress bar is helpful especially in case of a high number of symbols.

Symbols (0-67) relates to the pilot scheme displayed. Either all 68 pilots are displayed or only a modulo 4 subset, consisting of

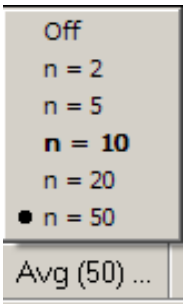
- pilots #0,#4,#8, ... (mod 0),
- pilots #1,#5,#9, ... (mod 1),
- pilots #2,#6,#10, ... (mod 2),
- pilots #3,#7,#11, ... (mod 3).



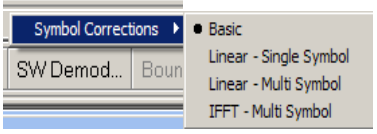
The Precision Mode improves accuracy of the displayed results in 6 MHz channels (4T2 with DSP chip-demodulator).

The ***Clear/Start*** button allows starting a new constellation display.

The ***Stop*** button freezes (holds) the graphic display.



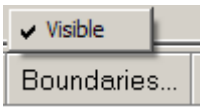
Avg(.n.) is active at MER vs Carrier and EVM vs Carrier measurements. The value in brackets on the button shows the actual setting.



SW Demodulation allows to select 4 different symbol correction methods (channel estimation profiles):

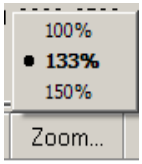
- Basic - according to the symbol gravity point
- Linear - Single Symbol: using pilot carriers on ideal position
- Linear - Multi Symbol: linear interpolation
- IFFT – Multi Symbol: Inverse FFT over all symbols, otimal suited for situations with strong pre – and after-echoes.

Settings are applied when CPU demodulation is activated, see also description of ***Sync*** button.



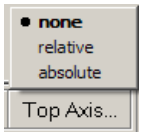
Toggles visibility of IQ Boundaries according to the IQ boundary value selection on the left hand side.

The ***Colouring…*** button selects between fixed or measurement result depending draw colour of the data points. You may select between Yellow, Result and Rainbow.



The ***Zoom…*** button allows for scaling the display of constellation points to 100%, 133% and 150%. 100% display concentrates the constellation in the middle of the screen but shows also pixels which appear far away from the centre points. The other modes give a more detailed display of the data carriers.

In the display modes that show data versus carriers, you are able to zoom in on any range of carriers using your left mouse button. Please refer to (***Q vs Carrier / I vs Carrier Display Mode***) for more details.



The ***Top Axis…*** button is used to adopt the diagram header annotation to the user's requirements. It allows for toggling between the following header scaling:

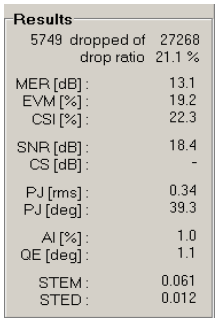
- none: no top axis scale is displayed
- relative: frequency display is zero at the centre position
- absolute: frequency display according to the chosen DVB-T/H channel

Top Axis… it is not available in Q vs I Modulation display mode.

6.1.2 Modulation Results

The 4T2 measures the following parameters of the OFDM Signal in real-time. The results are displayed for the carrier range from ***Start*** to ***Stop*** carrier in the ***Carrier*** group. The number of symbols taken into account is entered in the ***Symbols*** box.

Activating IQ Boundaries may lead to dropping of constellation points outside the decision area. The number of dropped symbols as well as the drop ratio is displayed under ***Results***.



The ***Results*** field summarises the modulation analysis.

The ***Modulation Error Ratio*** (MER) provides a single figure, indicating the quality of the received DVB-T signal. MER is defined as the ratio of I/Q signal power to I/Q noise power; the result is indicated in dB.

MER for digital modulation signals is a substitute to signal to noise ratio (SNR) for analogue signals.

Higher MER values indicate better signal performance.

EVM

The ***Error Vector Magnitude*** (EVM) is closely related to the MER and can be computed from that figure since both EVM and MER essentially measure the same error characteristic.

EVM is defined as the ratio of the average measured error magnitude to the peak symbol magnitude in percent.

CSI

The ***Channel-State Information*** (CSI) is defined as the MER in percent.

SNR

SNR or ***Signal to Noise Ratio*** gives additional information about the quality of the received signal. Since proper SNR measurements require a sound data base, SNR values are displayed only if the number of symbols is >= 20.

CS

The ***Carrier Suppression*** (CS) is a measure for the rejection of unwanted sinusoidal signals affecting the centre of the analysed OFDM signal. CS is measured in dB; high values indicate high suppression or high signal quality. CS is measured only if the Centre Gap is different from 0.

PJ

The ***Phase Jitter*** (PJ) of an oscillator occurs due to fluctuations of its phase or frequency. Using such an oscillator to modulate a digital signal results in a sampling uncertainty in the receiver because the carrier regeneration cannot follow the phase fluctuations.

The Phase Jitter is displayed in degrees.

PJ[rms]

The ***RMS*** (Root Mean Square) ***Phase Jitter*** parameter is a different representation of the Phase Jitter, indicated as an absolute figure with two decimal places.

AI

The purpose of the ***Amplitude Imbalance*** (AI) measurement is to separate the QAM distortions resulting from amplitude imbalance of the I and Q signal from all other kinds of distortions.

The AI parameter is expressed as a percentage.

QE

The ***Quadrature Error*** (QE) parameter describes the distortion of a constellation diagram in case the phases of the two carriers feeding the I and Q modulators are not orthogonal (their phase difference is different from 90°). The QE parameter is indicated in degrees.

STEM

The ***System Target Error Mean*** (STEM) gives a global indication about the overall distortion present on raw data received by the 4T2, including components like Carrier Suppression, Amplitude Imbalance, Quadrature Error and non-linear distortion. For each point in the constellation graph, the 4T2 computes the distance between their ideal symbol point location and the point corresponding to the mean of the cloud of that particular point.

The result is the Target Error Vector (TEV), whose Root Mean Square (average) value is then determined for all points in the constellation diagram and used to compute the numerical readout given in the System Target Error Mean (STEM) field. It is visualised by the displacement of the centres of the clouds in a constellation diagram from their ideal point.

STED

The ***System Target Error Deviation*** (STED) is calculated from the STEM value and defines the STE standard deviation.

6.1.3 Modulation Displays

Q vs I Display Mode (Constellation Diagram)

The constellation diagram is ideally suited for assessing the modulation quality of the DVB-T signal at the first glance. It displays the amplitudes of Q(uadrature) and I(nphase) modulated signals in the complex domain. On demand, the symbol decision thresholds can be displayed. Various degrading effects such as noise, interference, I/Q imbalance, and phase jitter may be viewed on the constellation diagram. Each of these effects results in a distinctive cloud shape or other degradation from the sharp constellation point pattern that can be expected for an ideal signal with no or only little modulation errors.
An example constellation diagram (live screenshot) for a received 64 QAM modulated DVB-T signal appears in the following illustration. Carriers are displayed according to the selected Colour Mode; pilot carriers are always displayed in blue colour.

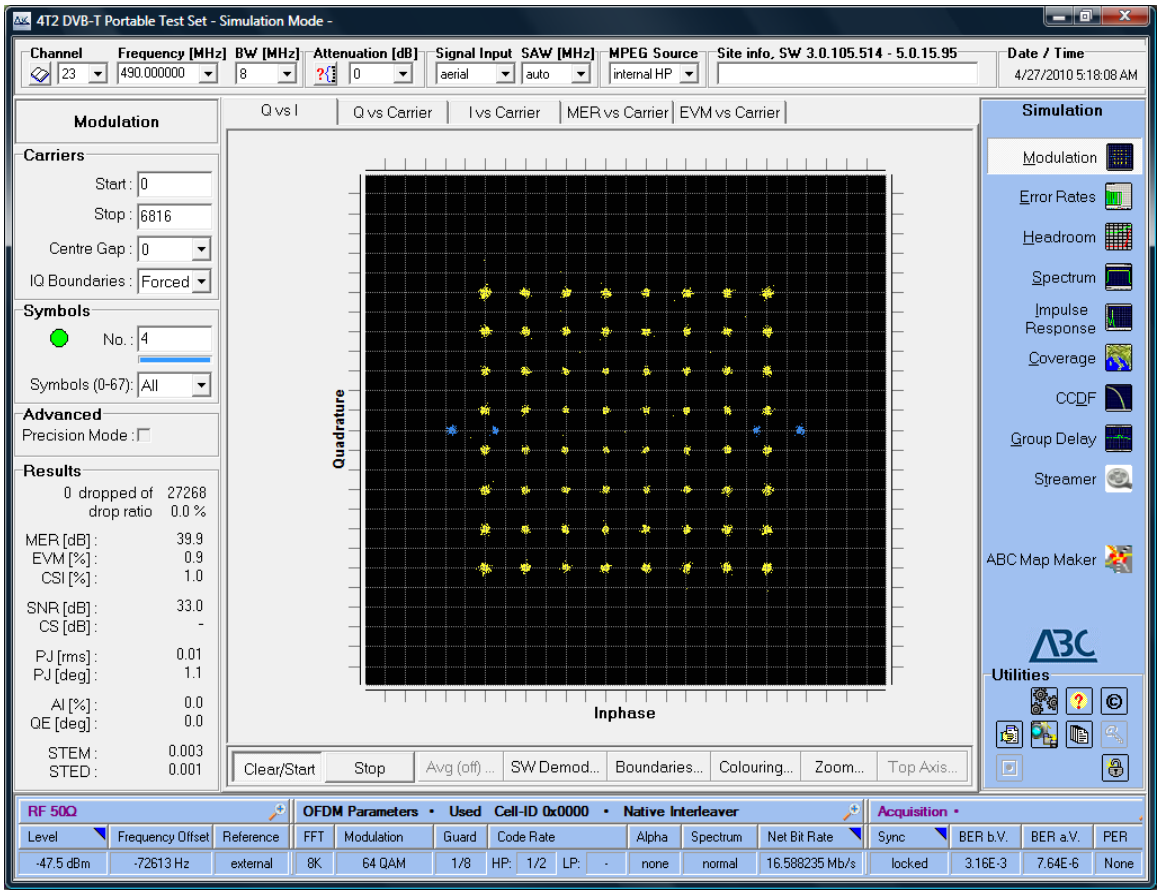


Illustration 11: /Analysis/Modulation/Q vs I display (constellation diagram)

Q vs Carrier / I vs Carrier Display Mode - Zoom Function

In all displays where the number of carriers is indicated on the horizontal axis (Q vs Carrier, I vs Carrier, MER vs Carrier, and EVM vs Carrier), you are able to zoom in on any range of carriers, down to one carrier, by dragging the mouse pointer from left to right over the area of interest while holding the left mouse button down. The exact range of carriers currently being analysed is indicated in the *Carrier Start* and *Carrier Stop* fields. After you have finished analysing a particular section, press the left mouse button and drag the mouse pointer from right to left in order to zoom out again to full span.

A magnifying glass icon at the lower left corner indicates a zoomed display. Clicking on this symbol always zooms back to full span display.

In the Q vs Carrier display the pilots appear on the centre line. Carriers selected in the Centre Gap field appear in red colour.

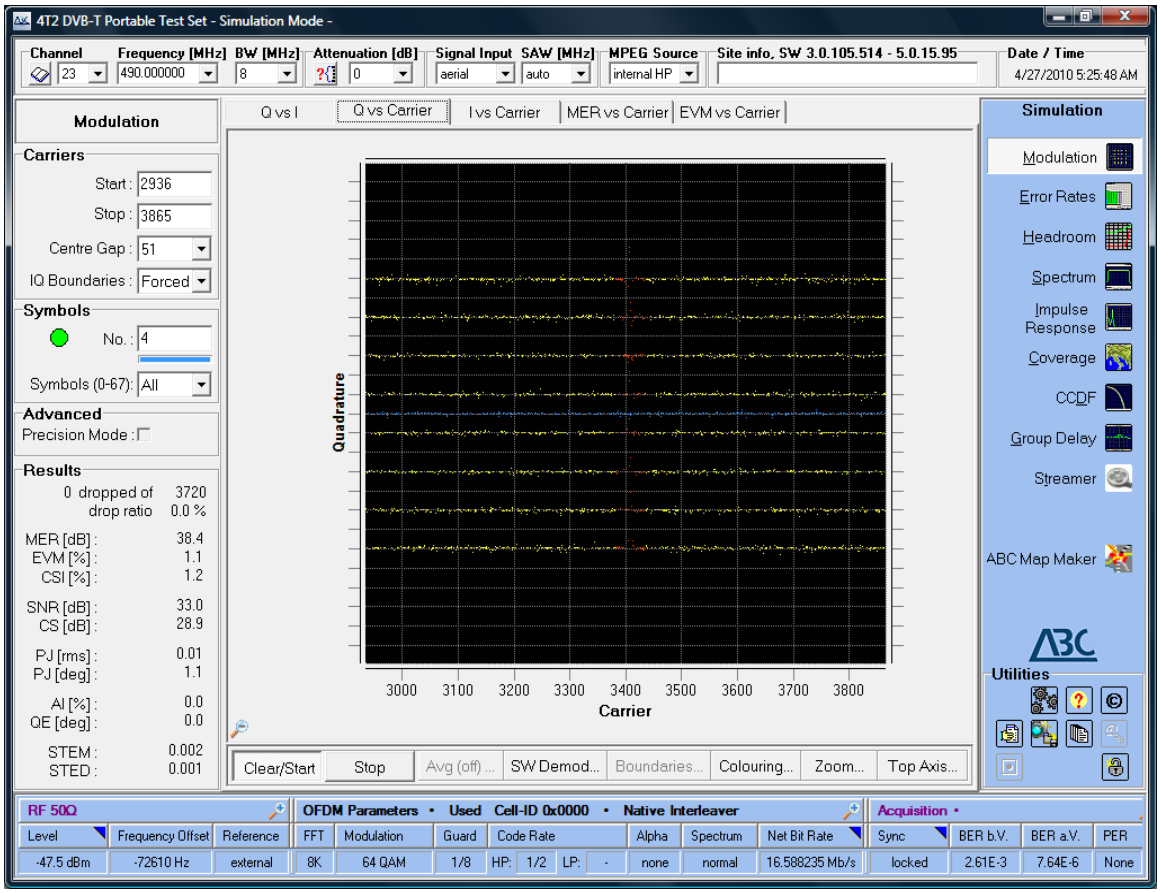


Illustration 12: /Analysis/Modulation/Q vs Carriers

MER vs Carrier / EVM vs Carrier in Zoom Mode

The diagram below shows the MER vs Carrier analysis display (zoomed).

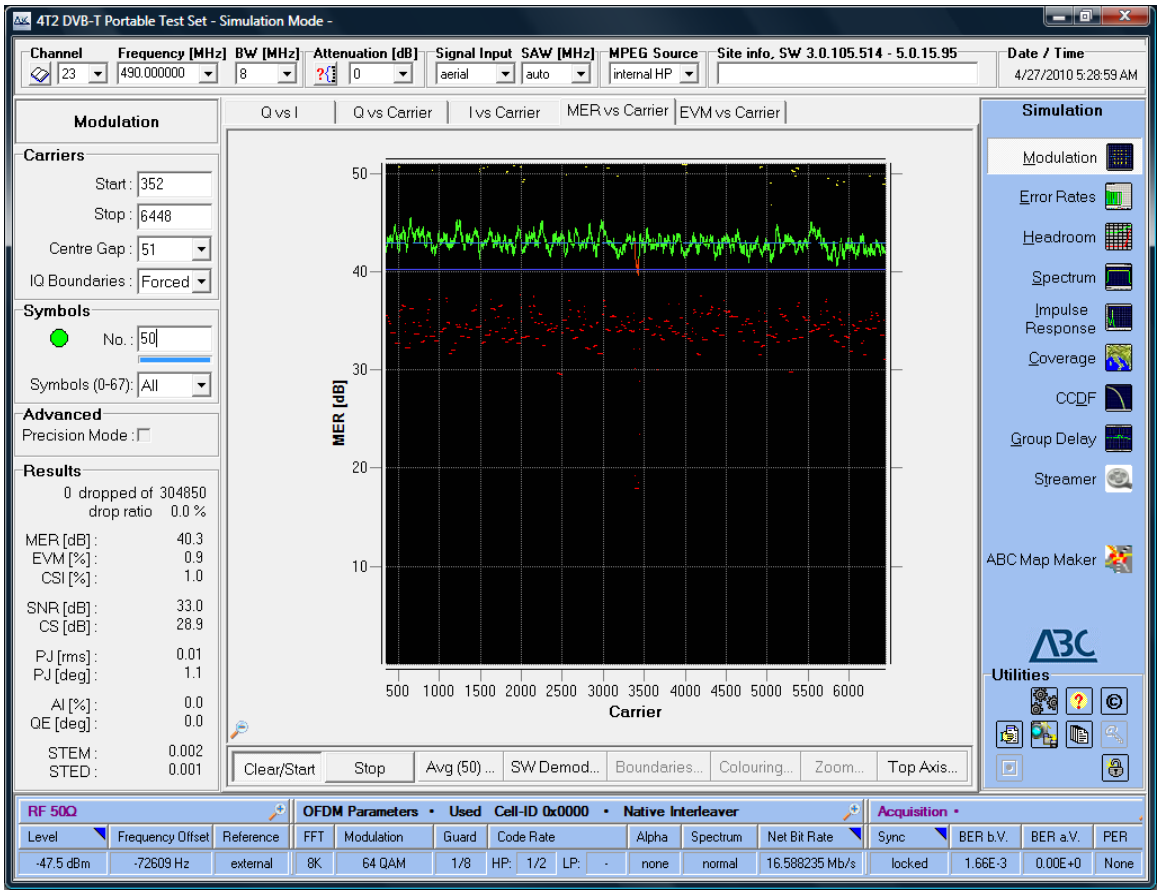


Illustration 13: /Analysis/Modulation/MER vs Carrier

MER vs Carrier gives a variety of information about the MER behaviour of the received signal. The full information is shown when the averaging function is activated by setting a value different from zero at the ***Avg(...)*** bar.

A coloured display is shown, the lines having the following meaning:

- steady blue line: true MER value, according to the measured and displayed MER value
- intermittent blue line: “optical” mean value of the MER curve
- green line: MER curve, averaged over the number of symbols, set by ***Avg(...)***
- red dots: minimum MER value during one average period
- yellow dots: maximum MER value during one average period

Some hints:

- In the case of software demodulation activated (in the ***Sync*** pop-up menu) use an adequate low number of symbols in order to have reasonable response times.
- The same applies to the order of average symbols.

The averaging feature is available at the ***EVM vs Carrier*** measurement function as well (not described here in detail).

6.2 Error Rates

The Error Rates analysis menu provides stacked-bar displays of bit error rates (BER), incoming level and MER performance over time in the central part of the screen, with a minimum of ten measurements per second being averaged to one stacked bar.
In addition, there is a real-time display of current bit error rates in the left part of the screen, headlined ***Error Rates***.

This chapter gives an overview of the controls and the relevant analysis features provided by the 4T2 in the ***Error Rates*** menu.

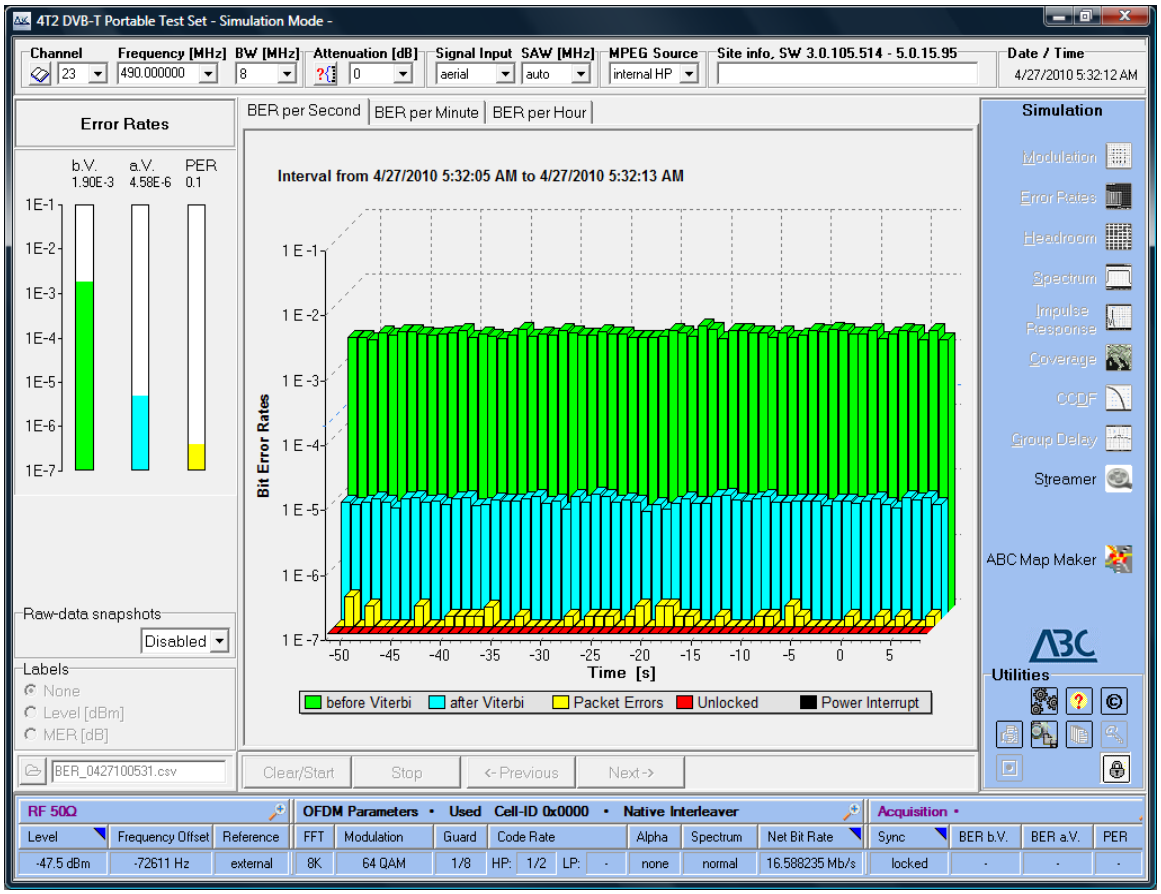


Illustration 14: /Analysis/Error Rates

6.2.1 Background Information

The Bit Error Rate (BER) is the primary parameter which describes the quality of a digital transmission link. The BER is defined as the ratio between erroneous bits and the total number of transmitted bits, i.e. a BER of 1*E-4 means that there is one erroneous bit in a total of 10,000 bits.

6.2.2 Error Rates Controls

The following section explains the various control elements which are available to the user in order to perform an error rate analysis.

Clicking the ***Clear/Start*** button starts a new, real-time BER measurement session. Before actually starting the measurement, a window will pop up, asking you to determine the file name under

which the new measurement results will be saved on hard disk. The default name suggested by the system consists of the letters „BER_“ plus the measurement start time, indicated in „ddmmyyhhmm“ format. To save under this name, click ***Save*****,** or enter any other file name of your choice.

The ***Stop*** button stops the current measurement and freezes the stacked-bar displays of BER over time in the central part of the screen, while the bar display of BER before / after Viterbi including the PER display (Packet Errors) in the current measurement interval (in the left part of the screen) continues to display real-time measurement results.

After having scrolled through a number of measurement result pages, you can click ***Previous*** to display the previous minute/hour of the measurement results.

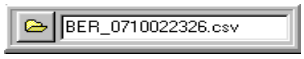
If a recorded measurement includes more samples than can be displayed on one screen, you can click ***Next*** to display the next minute/hour of the measurement results.

Raw Data Snapshots stores raw sample data to the external harddisk for further evaluation by the software demodulator.

This feature provides in-depth information on the incoming signal, even when all other attempts of demodulation fail.

Advanced Broadcast Components is able to provide tools for this in-depth analysis on request.

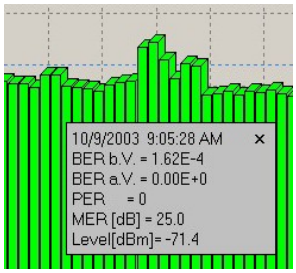
Please note that activating this feature results in a huge amount of data stored, and make sure that your system is able to cope with it.



The ***Open File*** symbol button opens a dialogue box listing the files recorded in previous measurements (each one named according to the measurement start date).

Error Rates measurement results are logged to the 4T2\Error Rates\ directory of the 4T2 hard disk. Any of these files can be loaded and the results analysed using the ***Next*** and ***Previous*** buttons.

The ***Open File*** button is available only when there are no active measurements running, i.e. after clicking ***Stop***.



A right-click on a bar displays recording date and values.

6.2.3 Error Rates Results

Displayed results include BER before Viterbi decoder (**green**), BER after Viterbi decoder (**light blue**), as well as Packet Errors (**yellow**) impairing the decoded video and audio signals, and unlocked status (**red**).

Clicking with the right mouse button on a bar in the graph displays the bar's own measurement results for each parameter.

The display interval for the stacked-bar graph is selectable, thus allowing the user to visualise the impact of bit errors over various time periods: **BER per Second**, **BER per Minute**, and **BER per Hour**.

Since more data is processed in BER per Minute and BER per Hour mode the resultant resolution is higher in these modes: BER per Minute allows displayed BER values down to 1*E-9, BER per Hour allows for BER down to 1*E-10. Please note that in all settings the BER of 2*E-4 is marked as the

commonly accepted limit for BER after Viterbi in order to get a quasi error free (QEF) MPEG decoding output.
In the **BER per Second** mode, the user is able to select **Labels** to be affixed to the measurement bars. Available labels are **Level** (in dBm or dBµV) or **MER** (in dB) values indicated above the graphical display. If activated, this function will display the average level or MER value every five seconds. Measured values are, however, recorded and saved in the measurement result table every second (see table below).

Error Rate recording is automatically continued after a power breakdown. In order to work properly, the keys are locked when starting error logging. If you want to make changes during the logging period (not recommended) you have to remove key lock status manually (see Utilities).

After a power down and power up, the 4T2 boots and starts the Analyser application automatically. If the power break occurred during a recording session the previous recording session will be continued. The same files will be used for data logging.

Error Rate Recording is limited only by the 4T2 hard disk space. As a rule of thumb 10 years of continuous recording would require about 5 GByte of disk space.

Error measurement results of the 4T2 are always stored to file and are thus available for later processing (see 5.2.4). For ease of operation, a new file with measurement results will automatically be created by the 4T2 software if a measurement lasts for more than 24 hours.
In addition to the BER results, for every recorded measurement the 4T2 also creates a file indicating statistical information about the 4T2´s current status, OFDM parameters, etc. This information is stored in a file named „STA_BER_ddmmyyhhmm.csv“ (depending on the measurement start date) and can easily be analysed using MS Excel (see example below).

ABC DVB-T Portable Test Set 4T2 Serial No.: 1000046							
EXE:	Version 2.5	DLL:	DLL Version 2.5 / 15.11.2004				
Site Info							
Receiver Setup							
Date	Time	Channel	Frequency	Bandwidth	Attenuation	Signal Input	MPEG Source
15.11.2004	11:28:15	25	506	8 MHz	0 dB	aerial	internal HP
Receiver Status							
Level[dBm]	Frequency Offset	Reference	Sync State	BER b.V.	BER a.V.	PER	
-81.6	-1 Hz	locked	badlock	9.08E-02	0.00E+00	error	
Decoded TPS Information							
FFT	Modulation	Guard	Code Rate HP	Code Rate LP	Alpha	Spectrum	Net Bit Rate
8K	16 QAM	1/4	2/3	-	none	normal	13,270,588 Mb/s
System Information							
RAM Free	Virtual RAM Free						
132 MBytes	1,945 MBytes						
Options:	Impulse Response	Coverage	MPEG TS	Spectrum			
Installed:	yes	yes	yes	yes			
Last Calibration Date:	no calibration						

6.2.4 Error Rates File Structure

Error rates results are recorded in ASCII format (*.csv) that allows for easy processing with any standard office software package. If you would like to use these data for statistical evaluation,

open your Windows Explorer and select the required file and simply double-click to open with MS Excel.
These files have the following structure:

M-Count	M-BERbV	M-BERaV	M-PER	E-Lock	E-Timing	MM/dd/yyyy	hh:mm:ss	M-Level [dBm]	M-MER	DateTime
6	2.40E-01	0.00E+00	6	Y	N	06.07.2004	11:28:16	-81.6	14.9	6.7.04 11:28
25	8.77E-02	0.00E+00	25	Y	N	06.07.2004	11:28:17	-81.6	14.9	6.7.04 11:28
26	9.07E-02	3.07E-04	26	Y	N	06.07.2004	11:28:18	-81.4	15.1	6.7.04 11:28
26	8.67E-02	1.89E-04	26	N	N	06.07.2004	11:28:19	-81.3	15.5	6.7.04 11:28

Description of the parameters mentioned above:

Column Header description M- == Measured, E- == Error	Value	units
M-Count	number of measurement samples per second	[1]
M-BERbV	bit error rate per second before Viterbi decoding	[1/s]
M-BERaV	bit error rate per second after Viterbi decoding, before Reed-Solomon decoding	[1/s]
M-PER	number of packet errors per second after Reed-Solomon decoding	[1/s]
E-Lock	receiver locked status in negative logic: No (receiver front-end locked) or Yes (receiver front-end unlocked)	[Y|N]
E-Timing	timing status in negative logic: No (more than 10 measurements per second) or Yes (less than 10 measurements per second)	[Y|N]
MM.dd.yy	recording date of measurement sample	[date]
hh:mm:ss	recording time of measurement sample	[time]
M-Level	measured level of the incoming signal	[dBm|dBuv]
M-MER	measured modulation error rate (MER on all OFDM data carriers)	[dB]

6.2.5 Bit Error Rate Current

The fourth tab-sheet *BER current* is a combined two dimensional display of BER before Viterbi, BER after Viterbi, MER and RF Signal.

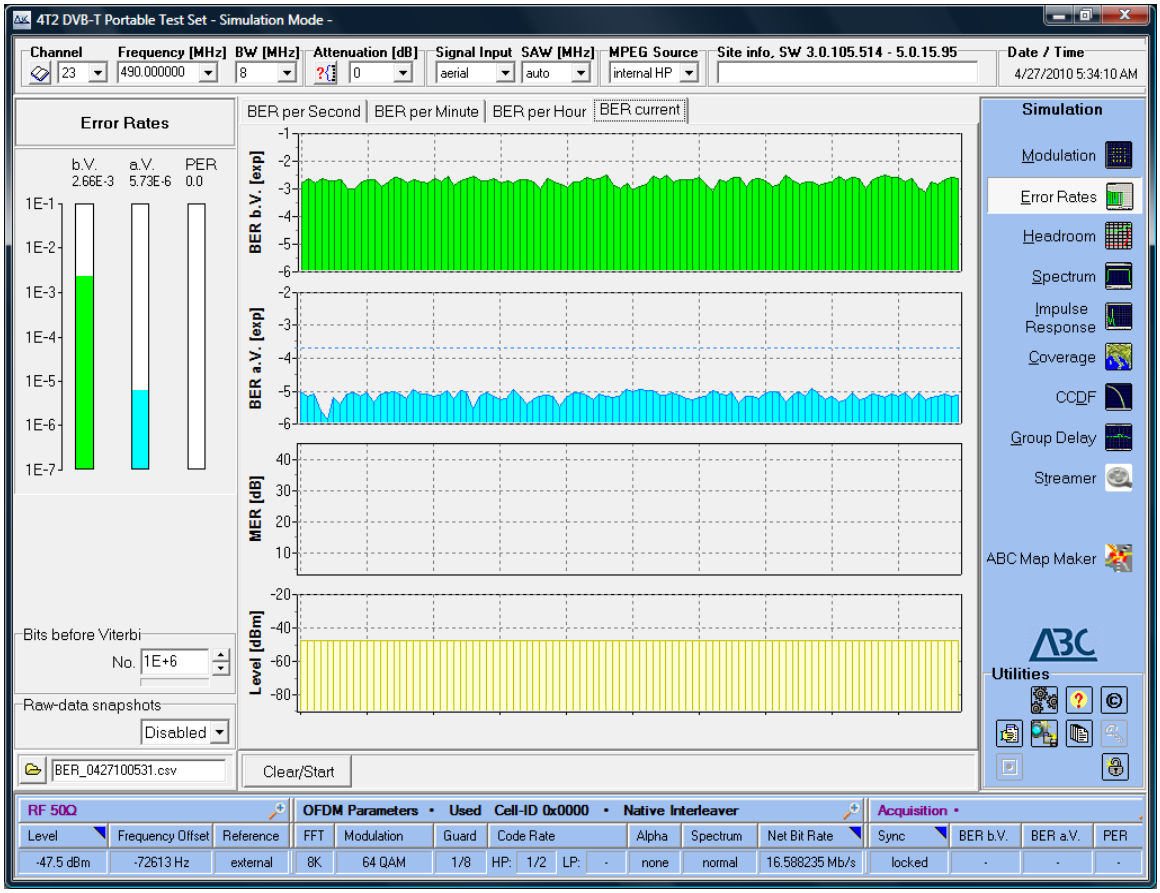
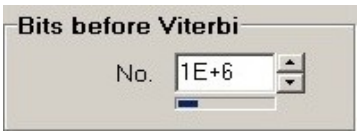
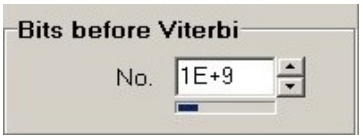


Illustration 15: /Analysis/Error Rates/BER Current (BER, MER, and Level)

By selecting the number of bits before Viterbi different BER accuracy may be reached.



Fastest results; BER values down to 1*E-6 can be measured.



Slowest response but highest accuracy: BER values down to 1*E-9 can be measured.

6.3 Headroom

The Headroom analysis menu allows for assessing the quality of the received OFDM signal by inserting of high input attenuation which is gradually decreased. These measurements are an ideal tool to determine the input signal quality headroom at the site of measurement.
In this analysis mode, the 4T2 gradually attenuates the incoming signal, starting at 30 dB down to 0 dB in 1 dB steps, resulting in an increasing C/N performance and therefore in decreasing bit error rates. Three different display modes are available for this analysis:
BER versus Attenuation, MER versus Attenuation, and BER versus MER.

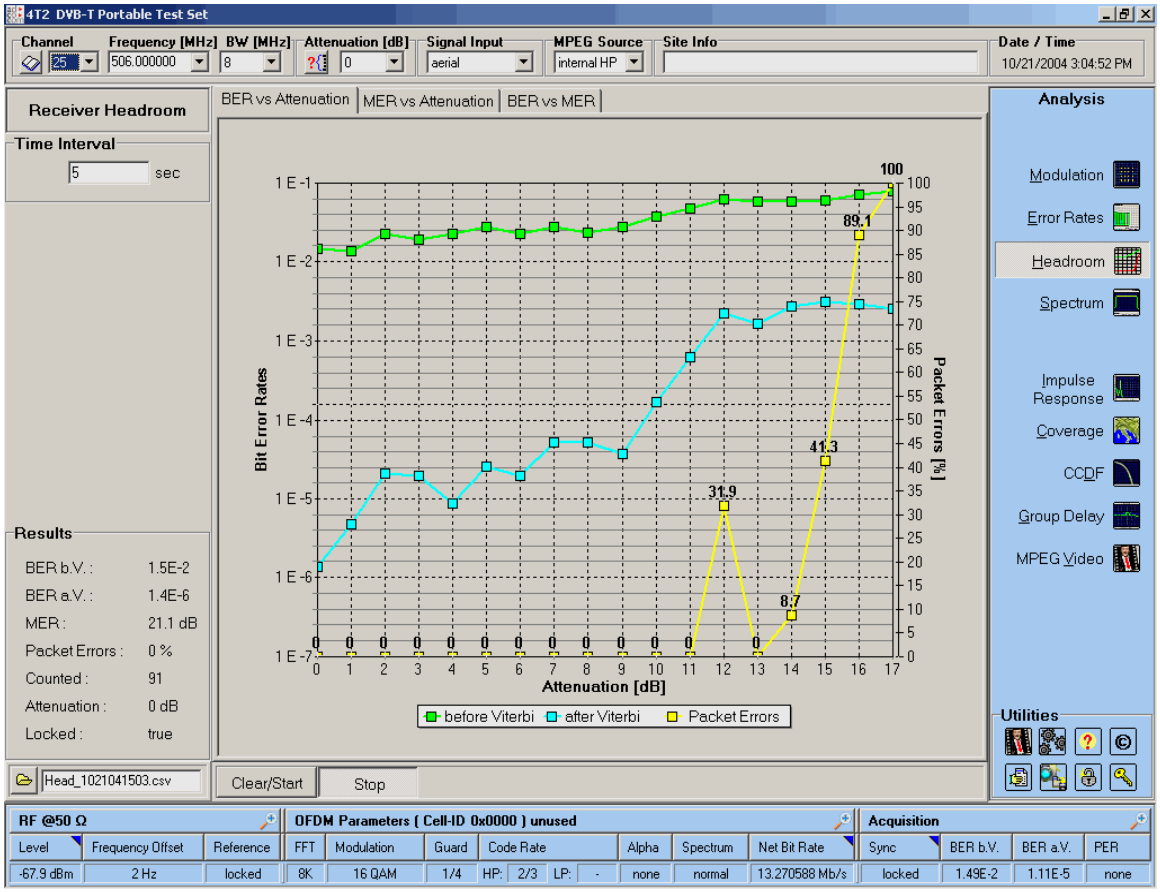


Illustration 16: /Analysis/Headroom (BER vs Attenuation Mode)

In BER vs Attenuation mode, it is easy to determine the “quasi error free” status (QEF = 2*E-4 BER a.V.). In Figure 5-7 it is reached with an attenuation of 11 dB.

6.3.1 Background Information

In order to fully understand the receiving conditions for DVB-T signals at any particular site, it is important not only to exactly measure signal parameters on site (e.g. C/N performance, BER etc.), but also to simulate the effect that various levels of signal attenuation have on the quality of the received signal and on the locked status of the receiver.

6.3.2 Headroom Controls

The following section explains the various control elements which are available to the user in order to perform an on-site receiver headroom analysis.

The ***Time Interval*** entry field lets you determine the time interval (in seconds) for each attenuator step. The minimum value is 1 second. However in order to get stable results, it is recommended to use a longer time interval, e.g. 5 seconds.

Clicking the ***Clear/Start*** button starts a new receiver headroom measurement.

The ***Stop*** button stops the current measurement. If not pressed by the user, any measurement will automatically terminate after having stepped the attenuation of the received signal between 30 dB and 0 dB.

The ***Open File*** symbol button opens a dialog box listing the files recorded in previous measurements for later evaluation.

6.3.3 Headroom Results

Below you will find a list of parameters displayed by the 4T2 ***Results*** group on the left hand side of the screen while a receiver headroom analysis is performed:

BER b.V.	The ***BER before Viterbi*** field indicates the Bit Error rate before processing through the Viterbi decoder.
BER a.V.	The ***BER after Viterbi*** field indicates the Bit Error rate after processing through the Viterbi decoder.
MER:	The ***Modulation Error Ratio*** (MER) is supposed to provide a single "figure of merit" analysis of the received ODFM signal. The MER is defined as the ratio of I/Q signal power to I/Q noise power; the result is indicated in dB.
Packet Errors %:	***Packet Errors*** are defined as erroneous packets in the MPEG transport stream which the decoder has been unable to correct. This field indicates the percentage of MPEG packet errors for a particular attenuation step.
Counted:	The ***Counted*** field gives you the total sum of packet errors that have occurred in the course of a measurement series from 30 dB to 0 dB.
Attenuation:	The ***Attenuation*** field always shows the current level of attenuation in the course of a measurement series from 30 dB to 0 dB.
Locked:	The ***Locked*** field confirms the receiver locking status during a measurement series. Either True or False can be displayed in this field.

The Headroom function may also be used to show the relation between MER and attenuation. See the following figure:

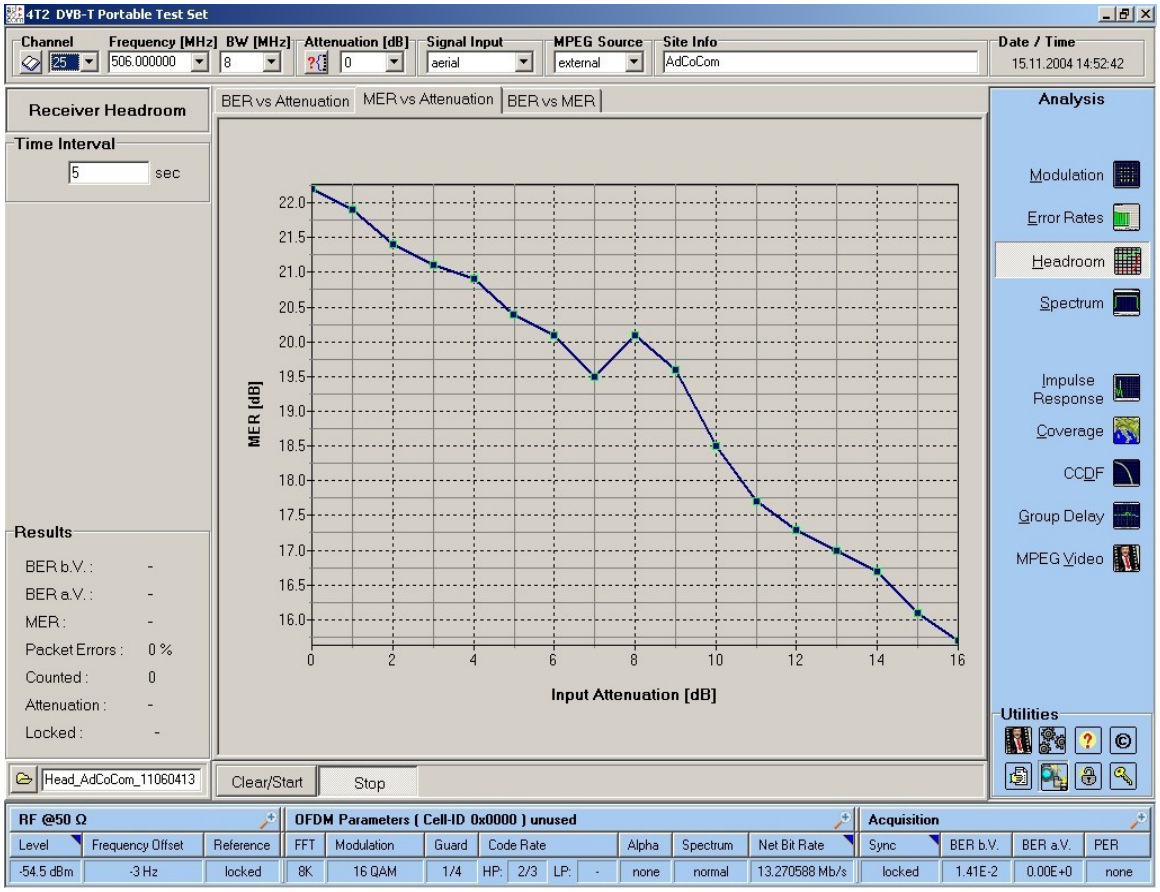


Illustration 17: /Analysis/Headroom (typical MER vs Attenuation)

6.4 CCDF

CCDF (Complementary Cumulative Distribution Function) is a tool to specify the linearity characteristics of the OFDM signal.

6.4.1 Background Information

The CCDF gives information about the amplitude distribution of the signal under test. CCDF curves show the probability (P) of the appearance of any the peak-to-average ratio (PAR) of the measured signal.

Ideal COFDM signals have a noise-like amplitude distribution identical to the so-called Gaussian response. Any non-linear distortion during the processing chain of the COFDM signal, e.g. compression or clipping effects will result in a deviation from the Gaussian response. The 4T2 is able to display the Gaussian curve together with the measured CCDF. This makes detection of deviation from the ideal behaviour easy.

The Crest Factor, as the maximum peak to average ratio in dB is displayed.

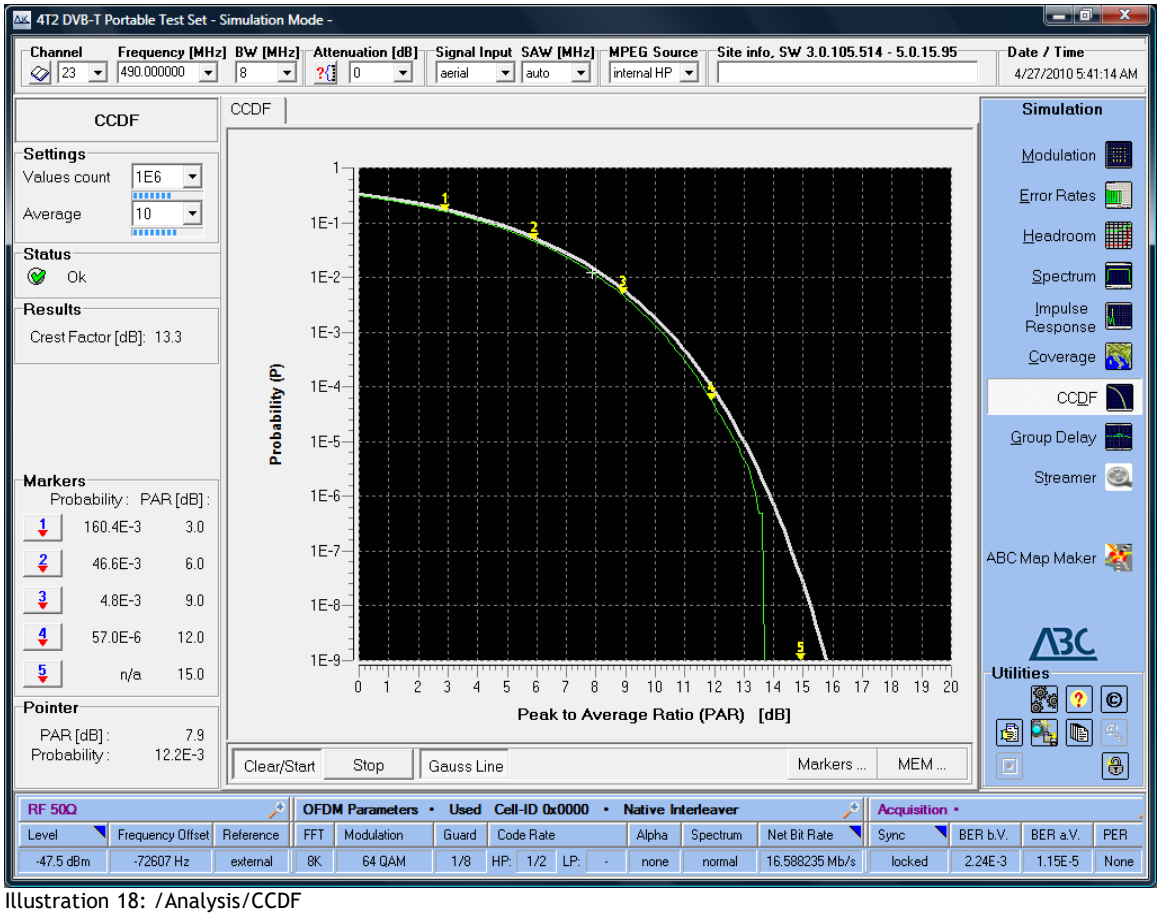


Illustration 18: /Analysis/CCDF

6.4.2 CCDF Controls

The following section explains the various control elements which are available to the user in order to perform CCDF measurements.

The ***Clear/Start*** button starts the CCDF analysis and resets the average counter.

The ***Stop*** button freezes the display.

This item toggles the display of Gauss tolerance field.

The ***Markers ...*** button opens a pop up window with the possibilities of ***Show***, ***Hide*** or ***Edit*** markers. The 4T2 provides 5 markers within the CCDF plane. If the Markers are hidden no measurement results will be available at the bottom left part of the screen. ***Edit*** opens the marker positioning dialogue box.

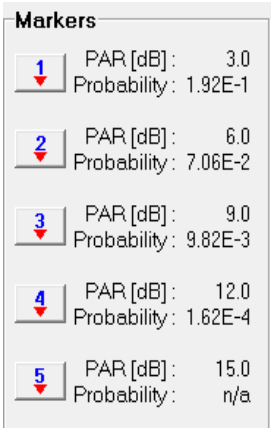
The ***MEM ...*** button opens a pop up window with the possibilities:
Add or ***Clear***.

Add allows for storing of the current trace to the background. Stored traces are coloured in blue. Multiple storing is possible. ***Clear*** removes all stored curves.
MEM ... provides an easy way to compare results of different measurement situations e.g. for adjustment improvements.
The ***MEM ...*** function is also available in the ***Spectrum***, ***Impulse Response***, and ***Group Delay*** mode of operation.

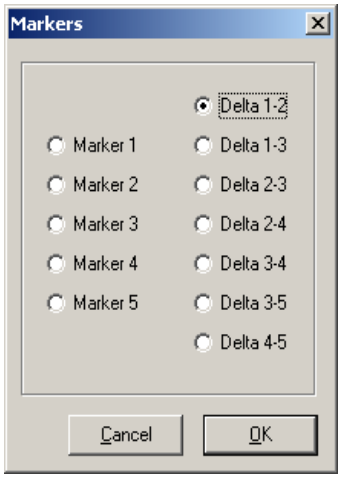
6.4.3 CCDF Results

Below you will find a list of parameters displayed by the 4T2 ***Results*** group on the left hand side of the screen while a CCDF analysis is performed:

The CREST factor is defined as the ratio of the peak voltage to its root-mean-square value. Since the CREST factor doesn't say how often the peak occurs, the CCDF curves give more complete information about the high signal levels than the CREST factor does.

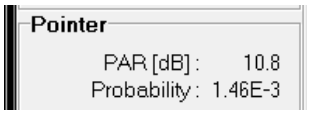


The ***Markers*** area at the bottom left part of the screen contains five result lines for the five markers on the CCDF display.
The peak to average ratio value (in dB) plus the corresponding probability for each marker point are displayed in this section.



Instead of displaying the PAR and probability of a certain marker, you can click the arrow underneath e.g. the figure 1 marker to open the Markers selection dialog.

If you prefer to display e.g. the difference between marker 1 and marker 2, click ***Delta 1-2***.



The ***Pointer*** area displays PAR and probability of the current mouse pointer position in the CCDF diagram.

Some remarks on CCDF:

- CCDF readout, together with the Crest Factor (CF) is used to assess the quality of DVB-T/H power amplifier stages.
- A clean sine-wave signal has a Crest Factor of 3 dB.
- An ideal COFDM signal displays a CF of approximately 14.5 dB.
- Very noisy antenna input signals appear like a noise-only signal, similar to the Gaussian reference curve. Make sure that you actually have a receiver lock when measuring those signals.

6.5 Group Delay

Group delay measures the frequency dependant phase response and transition time of the incoming signal through a device under test (DUT).

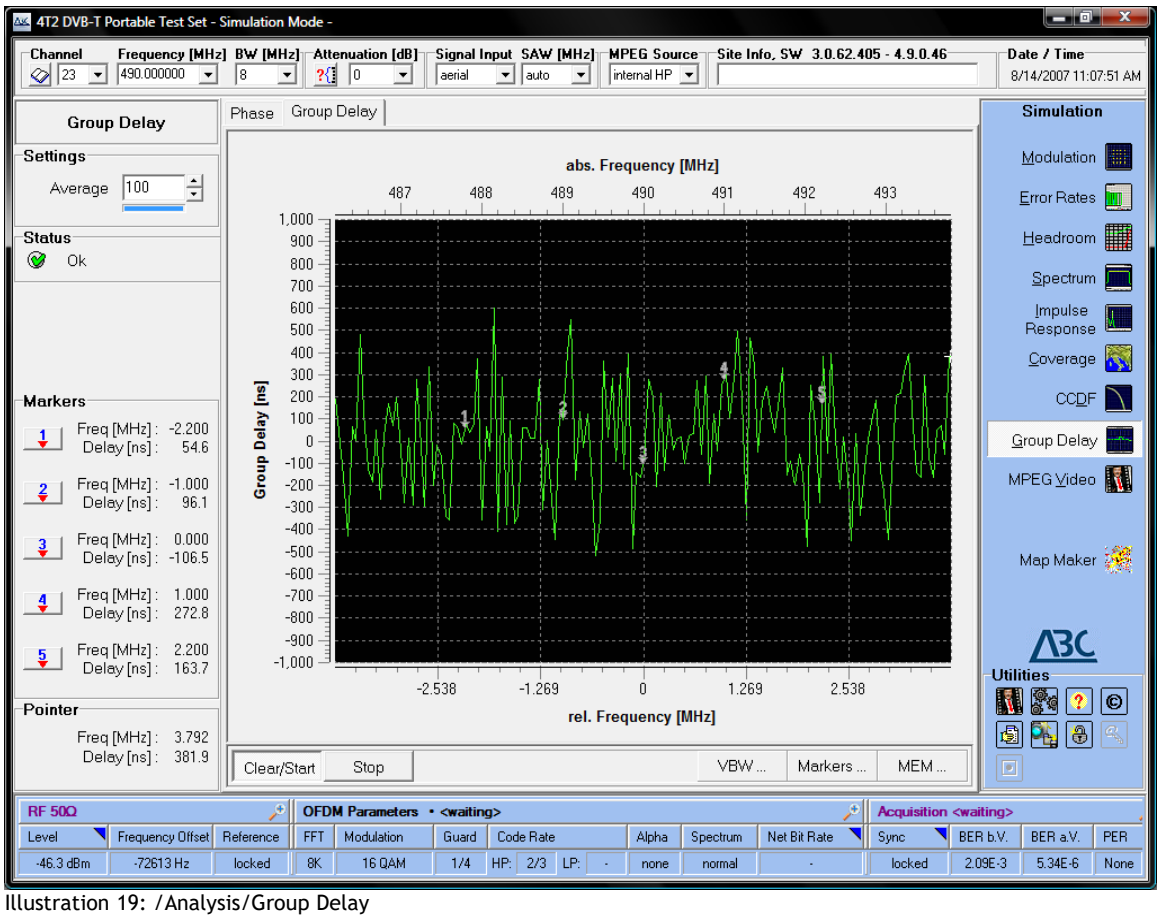


Illustration 19: /Analysis/Group Delay

6.5.1 Background Information

Group delay can be calculated by differentiating the phase response versus frequency.
It reduces the linear portion of the phase response to a constant value, and transforms the deviations from linear phase into deviations from constant group delay (which causes phase distortion in communication systems).
The average delay represents the average signal transit time through a DUT.

6.5.2 Group Delay Controls

The following section explains the various control elements which are available to the user in order to perform Group Delay measurements.

These two buttons are used to toggle the display between Phase and Group Delay results.

The ***Clear/Start*** button starts the group delay analysis and resets the average counter.

The ***Stop*** button freezes the display.

The ***Markers ...*** button opens the following pop-up window:

You may:
Show
Hide or
Edit
markers.

The 4T2 provides 5 markers within the display. If the Markers are hidden, no measurement results will be available at the bottom left part of the screen.

Edit opens the marker positioning dialog.

VBW ... allows for setting the video bandwidth. When clicking on ***VBW ...*** the following pop-up window appears:

The video bandwidth may be selected easily; the default value is displayed in ***bold*** letters. Please note that not every combination of RBW and VBW is possible.

The ***MEM ...*** button opens a pop up window with the possibilities:

Add or
Clear.

Add allows for storing of the current trace to the background. Stored traces are coloured in blue.

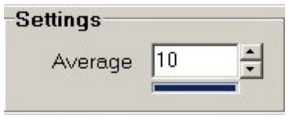
Multiple storing is possible. ***Clear*** removes all stored curves.

MEM ... provides an easy way to compare results of different measurement situations e.g. for adjustment improvements.

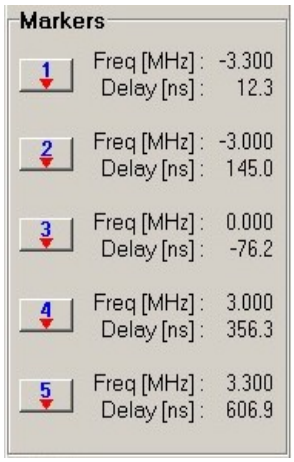
The ***MEM ...*** function is also available in the ***Spectrum***, ***Impulse Response***, and ***CCDF*** mode of operation.

6.5.3 Group Delay Results

Below you will find a list of parameters displayed by the 4T2 ***Results*** group on the left hand side of the screen while a Group Delay analysis is performed:

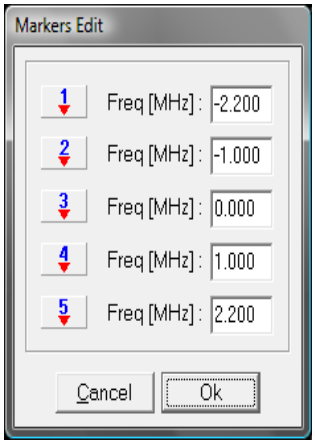


The ***Average*** selector field allows determining the average number of display points per measurement. If required, please click at either the "increase" or "decrease" arrow to change the setting. You may also type the average number directly. The blue bar indicates the progress of the averaging process. This may be helpful especially if averaging takes place over a higher number of symbols.



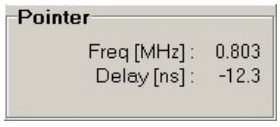
The ***Markers*** area at the bottom left part of the screen contains five result lines for the markers on the Group Delay display.

Depending on the selected results display type (Group Delay or Phase, see 5.5.2), the 4T2 displays either the group delay (in ns) or the phase (in degrees) for each of the defined marker points displayed in this section.



Instead of displaying the delay of a certain marker, you can click the arrow underneath e.g. the figure 1 marker to open the Markers selection dialog.

If you prefer to display e.g. the delay difference (or phase difference) between marker 1 and marker 2, click ***Delta 1-2***.



The ***Pointer*** area displays the group delay (or phase) of the signal at the current mouse pointer position in the diagram.

6.6 MPEG Video (HW decoder option)

Some of the 4T2 portable units are equipped with an internal MPEG hardware decoder.
The MPEG decoder processes MP@ML (main profile at main level).

The MPEG Video function allows you to select a DVB-T channel and perform real-time monitoring of video, either on the 4T2 screen or via an external monitor. Audio is transmitted through the built-in speaker.

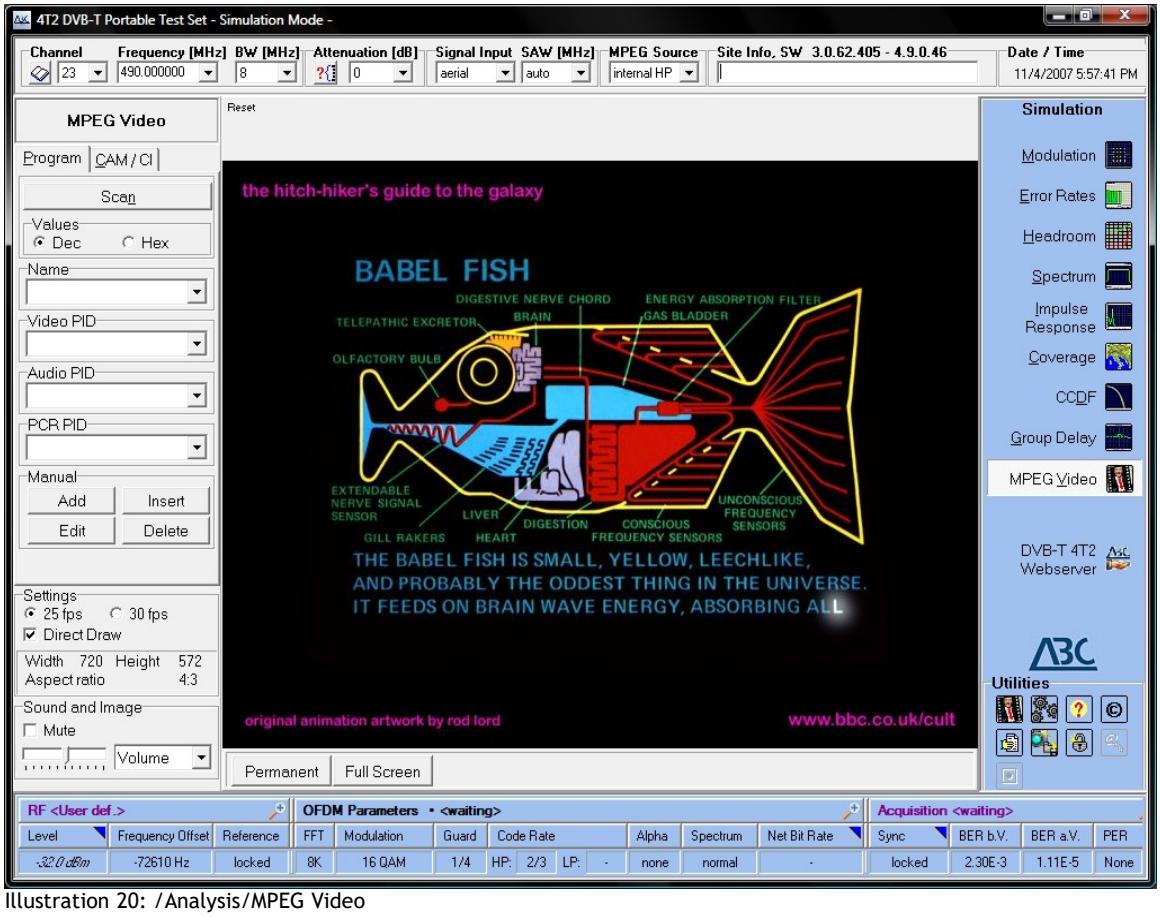


Illustration 20: /Analysis/MPEG Video

The MPEG Video monitoring function can also be superimposed on other measurement windows of the 4T2 by clicking the **Permanent** button, thus allowing for an additional visual check of the monitored channel while performing other measurements.

Full Screen shows the video in the original resolution without other measurement results on the display. Right clicking on the video screen allows for toggling the sound on/off or changing the programs within the multiplex.

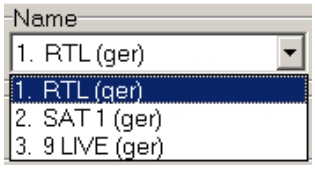
6.6.1 MPEG Video Controls

The following section explains the various control elements which are available to the user in order to monitor the received MPEG video information.

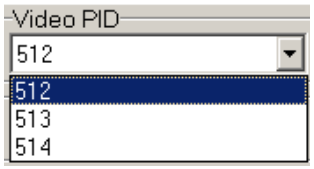
When selecting a certain DVB-T channel, the 4T2 automatically scans for video and audio Packet IDs of this channel. The result of the search is indicated in the list of PID fields: ***Name***, ***Video PID***, ***Audio PID*** and ***PCR PID***.

The scan can also be done manually by using the ***Scan*** button.

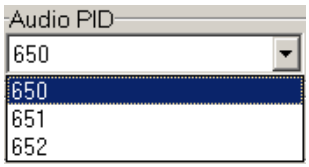
The four drop-down lists in the MPEG Video section enable you to make individual PID selections from the data available within the received DVB-T ensemble.



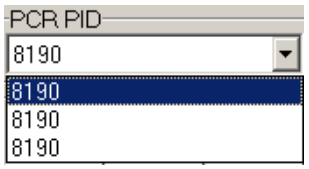
The ***Name*** drop-down list allows you to make your selection from a list of program names, sorted by the criteria "TV" and "radio". Just click any of the available program names, and the relevant program will immediately be displayed on your screen (for video), respectively the audio program will be played using the built-in speaker. After having made a selection in the Name drop-down list, the relevant PID number of the selected program will automatically be displayed in the other combo boxes below.



If you know the exact PID (Packet Identifier) of any program you wish to display, it may be more convenient to select this program by simply entering this PID directly in the ***Video PID*** or in the ***Audio PID*** combo box.



See Video PID.



The PCR (Program Clock Reference) PID is required to synchronise audio information with the relevant video information of a TV program. Unless you change the PCR PID selected by default, the audio signal corresponding to a certain video signal will automatically be synchronised.

Four buttons are used to manually edit PID lists.

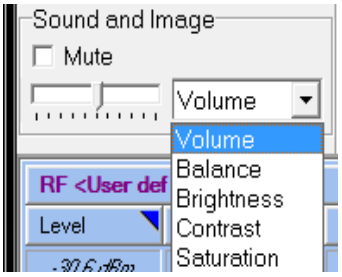
Click the ***Add*** button to enter a new program.

Click the ***Edit*** button in order to edit the current program. Figures can be entered either in decimal or hexadecimal format (prefix "$"), depending on the selection made below.

Click the ***Insert*** button to insert a program name in the PID list.

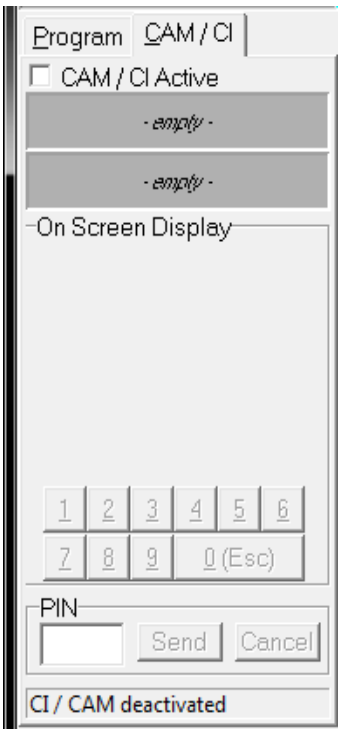
Click the ***Delete*** button to delete an entry from the PID list.

Lists are automatically stored per program.



The ***Sound and Image*** section allows to fine tune the brightness, contrast ,and colour saturation of the monitor.

The ***Volume*** and ***Balance*** controls allow for quick audio channel verification.



The ***Conditional Access Module*** allows to decode encrypted content.

The 4T2 supports standard definition hardware decoding.

There are two CI slots available (optional).

6.7 Streamer

Non hardware decoder versions of the 4T2 implement an MPEG-TS to IP encapsulator and server.

The Server “converts” the demodulated RF-channel content into an IP-based data stream. Clients applications can receive the stream by listening to the IP address and process the signal.

It is not mandatory for the client application to run locally on the 4T2. The processing software can also run remotely on a different computer in the network.

Possible clients are the 4T2 Content Analyser, VideoLan for content decoding, or the StreamXPert for analysis.

Transport streams can be stored on hard disk using the built-in recorder scheduler. An ASI output is provided for stream forwarding.

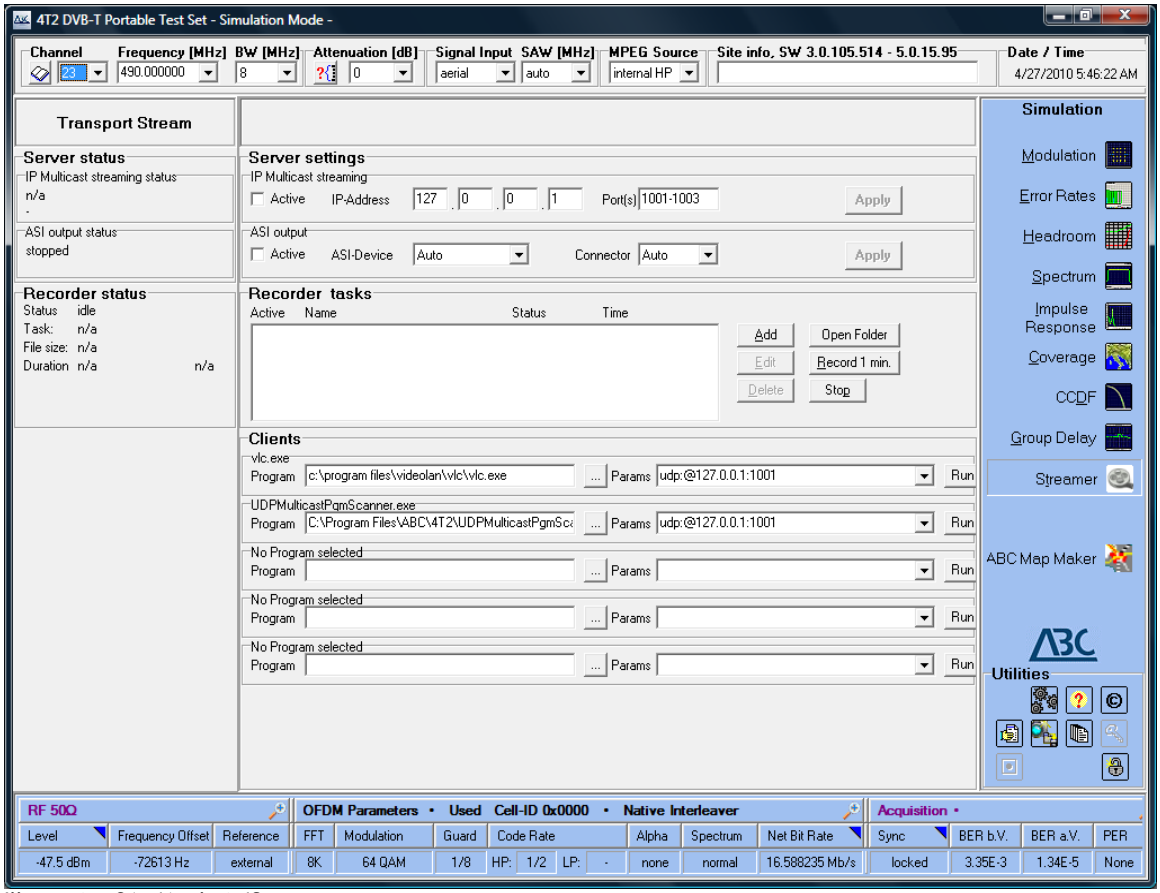


Illustration 21: /Analysis/Streamer

Recommended server settings :

- Protocol: UDP
- IP address: 127.0.0.1 (4T2, not plugged into a network)
- IP address: 225.9.9.1 (in all other cases)
- Ports: 1001 – 1004

Multiple clients must not have the same port setting because they would interlock each other.

Operation recommendations:

- In the client area, any application program with command line parameters can be entered to be launched with a single button click.
- On recording MPEG-TS large files are created. If you expect to use the recorder extensively the use of a NAS HDD device is recommended.
- A second computer, IP connected to the 4T2 can effectively work as an external video decoder / analyser, if required.

6.8 Spectrum Analysis

The ***Spectrum*** analysis menu allows for monitoring the DVB-T signal spectrum. The following figures show typical spectrum displays for modulator measurements and DVB-T live reception.

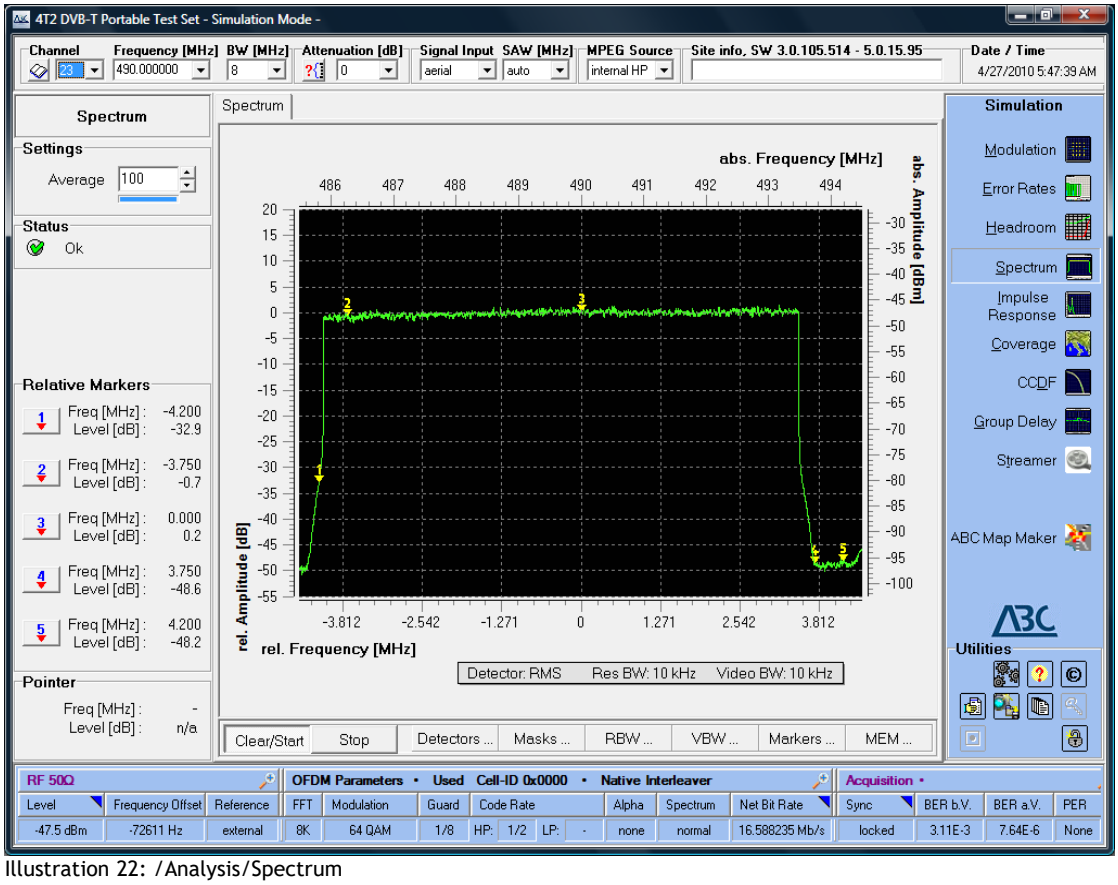


Illustration 22: /Analysis/Spectrum

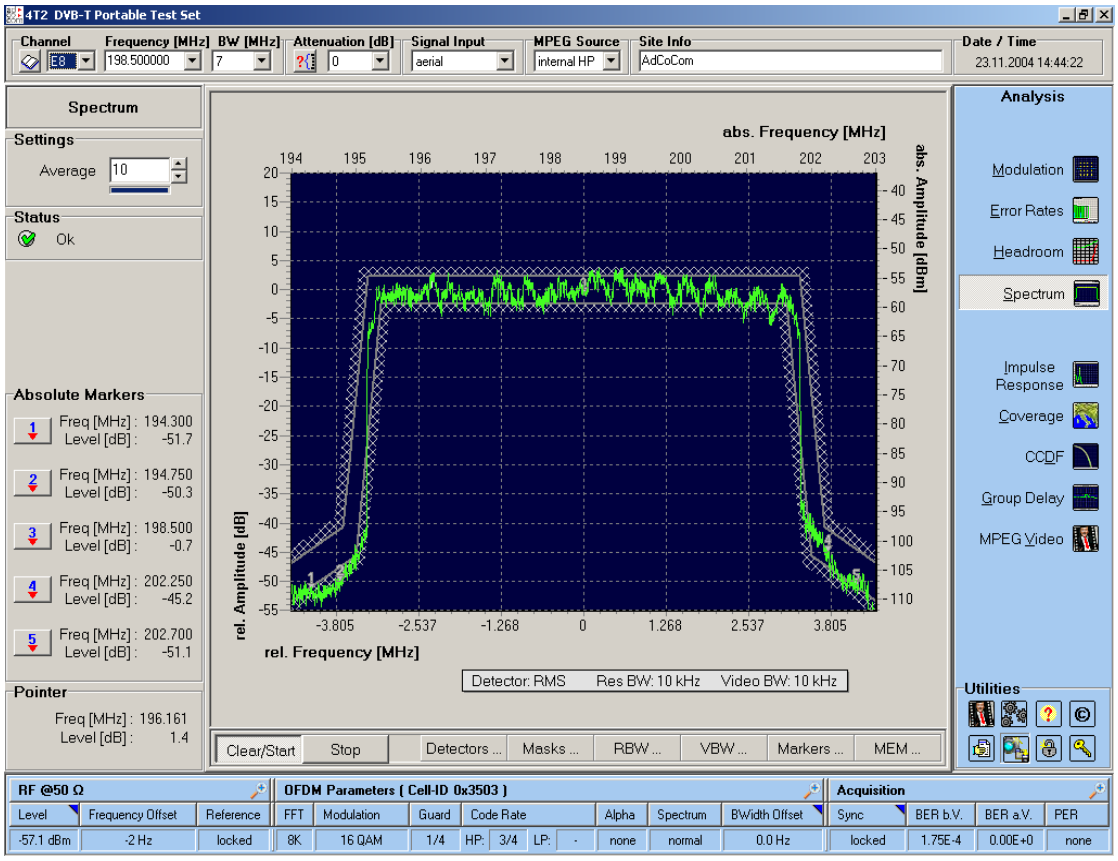


Illustration 23: /Analysis/Spectrum (with masks)

6.8.1 Background Information

The spectral density of a terrestrial DVB signal is defined as the long-term average of the time-varying signal power per unity bandwidth.
In order to avoid the DVB-T signal interfering with signals in other channels, the transmitted spectrum shall comply with defined spectrum masks.
TR 101 290 defines spectrum masks for critical and non-critical cases.

6.8.2 Controls and Displays

The absolute frequency (in MHz) is shown in the upper part of the display and determined by the selected input channel/frequency (e.g. 498.000 MHz if channel 24 has been selected from the European frequency table).
The absolute amplitude (in dBm or dBµV, depending on the selected level unit) is displayed on the right hand side of the screen.
Relative values for amplitude and frequency are displayed on the lower and left axis respectively.
The 4T2 shifts the top of the DVB-T block automatically to match the line relative to 0 dB.

The ***Clear/Start*** button starts the spectrum analysis and resets the average counter.

The ***Stop*** button freezes the display.

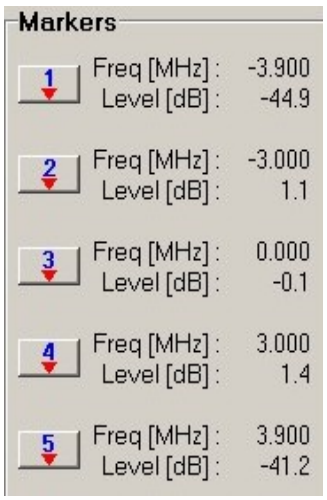
Detectors ... opens the following pop-up window:

Detector modes: Max for maximum /
Avg for average or RMS for root mean square
may be selected.

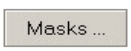
Markers ... opens the following pop-up window:

You may: Show / Hide or Edit markers;
they may be located on:
Relative or Absolute positions.

Five markers are available within the frequency spectrum. If the markers are hidden, no level measurement results will be available at the bottom left part of the screen. ***Edit*** opens the marker positioning dialog.



The ***Markers*** area at the bottom left part of the screen contains 5 result lines for the 5 markers on the spectrum display
.
Absolute or relative frequency (see marker description above) plus the corresponding level or level delta (in dB) is displayed in this section.



Masks ... opens the following pop-up window:

Show / Hide or Edit masks.

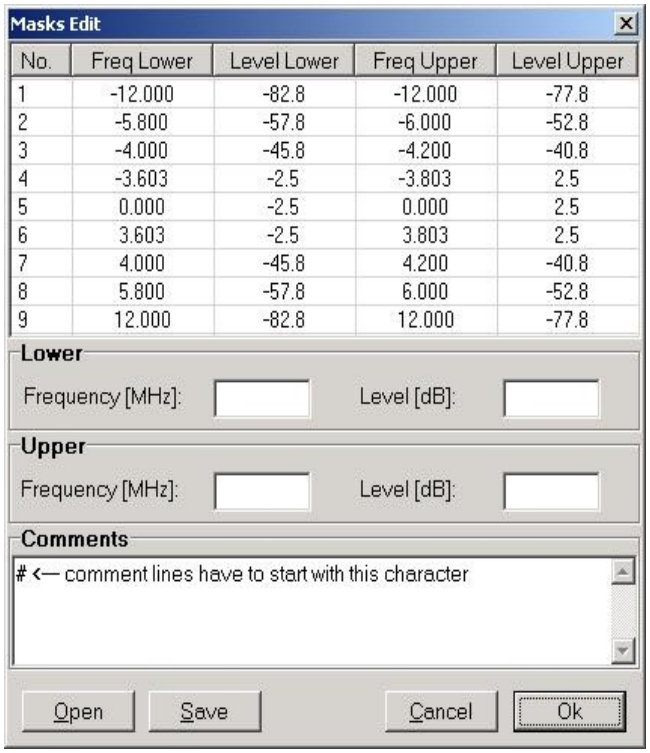
When moving the mouse pointer over ***Masks ...*** field in the ***Show*** status, the name of the currently used mask (as determined by the user) is displayed for about three seconds.

Edit may be used to customise spectrum masks according to individual requirements. It opens up the Edit Mask dialogue, allowing defining 8 segments for the lower and upper limits defining the spectrum mask. For this purpose two times 9 points may be set manually. Points 3, 4 and 5 usually define the pass band of the spectrum. Frequency and level offset for low and high mask limit values can be allocated for each of these points.

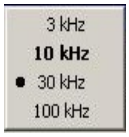
In order to store a defined mask, please click the ***Save*** button.

To retrieve any previously defined and saved spectrum masks, simply click the ***Load*** button within the Masks Edit dialogue.

Per default, masks are stored in the \4T2\spectrum\ subfolder.



RBW ... allows for setting the resolution bandwidth. When clicking on ***RBW ...*** the following pop-up window appears:



The resolution bandwidth may be selected easily; the default value is displayed in ***bold*** letters.

VBW ... allows for setting the video bandwidth. When clicking on ***VBW ...*** the following pop-up window appears:

The video bandwidth may be selected easily; the default value is displayed in ***bold*** letters. Please note that not every combination of RBW and VBW is possible.

The ***MEM ...*** button opens a pop up window with the possibilities:

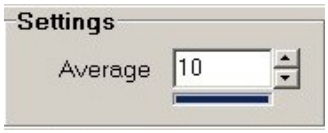
Add or ***Clear***

Add allows for storing of the current trace to the background. Stored traces are coloured in blue.

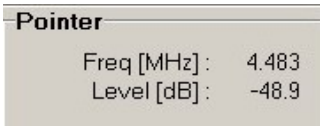
Multiple storing is possible. ***Clear*** removes all stored curves.

MEM ... provides an easy way to compare results of different measurement situations e.g. for adjustment improvements.

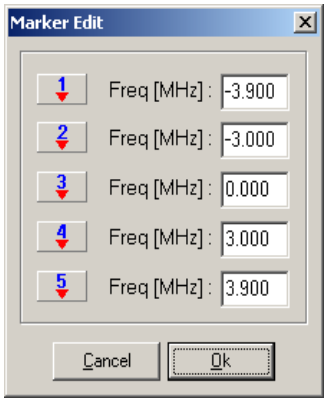
The ***MEM ...*** function is also available in the ***Impulse Response***, ***CCDF*** and ***Group Delay*** mode of operation.



The ***Average*** selector field allows determining the average number of display points per measurement. If required, please click at either the "increase" or "decrease" arrow to change the setting. You may also type the average number directly. The blue bar indicates the progress of the averaging process. This may be helpful especially if averaging takes place over a higher number of symbols.



The ***Pointer*** area displays Frequency and Level of the current mouse pointer position in the spectrum diagram.



If you click at any button containing the red arrows in the ***Markers*** group, the ***Set Marker Display*** opens up allowing setting the results lines values.

Thus you are able to determine, which frequency and amplitude delta or absolute values you want the 4T2 to display.

Markers may also be shifted manually by setting the mouse pointer close to the marker (selection) and moving the mouse right or left with depressed right mouse key.

6.8.3 Shoulder Distance Measurements

Shoulder distances can be measured using the 4T2 with the built-in markers and mask features. Sample files for 7 MHz and 8 MHz non-critical masks are stored on the hard disk in the sub-folder \ 4T2\Spectrum\.

Using zoom and markers, the shoulder distance measurements can be easily performed.

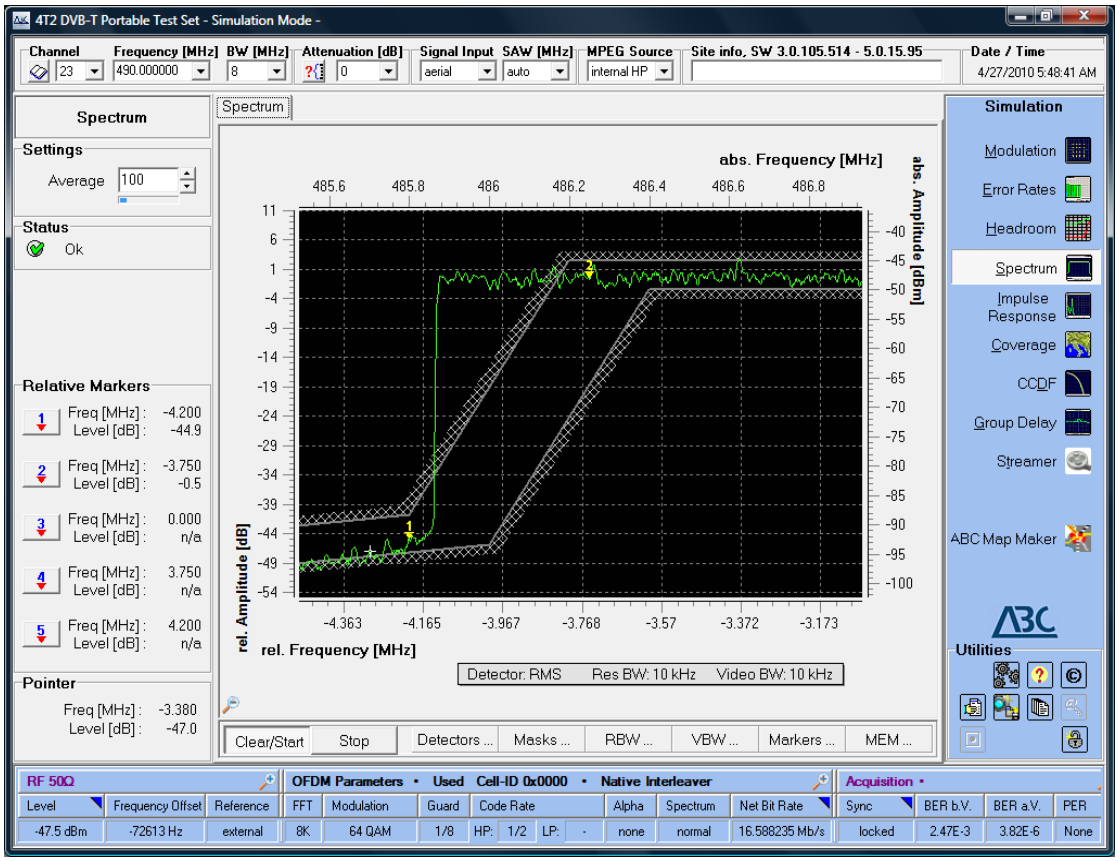


Illustration 24: /Analysis/Spectrum (zoomed to lower shoulder)

Using markers and a zoomed spectrum display, the shoulder distance is available at a glance. As the top area of the DVB-T signal is centred at 0 dB relative, even absolute marker results show already the accurate shoulder distance.

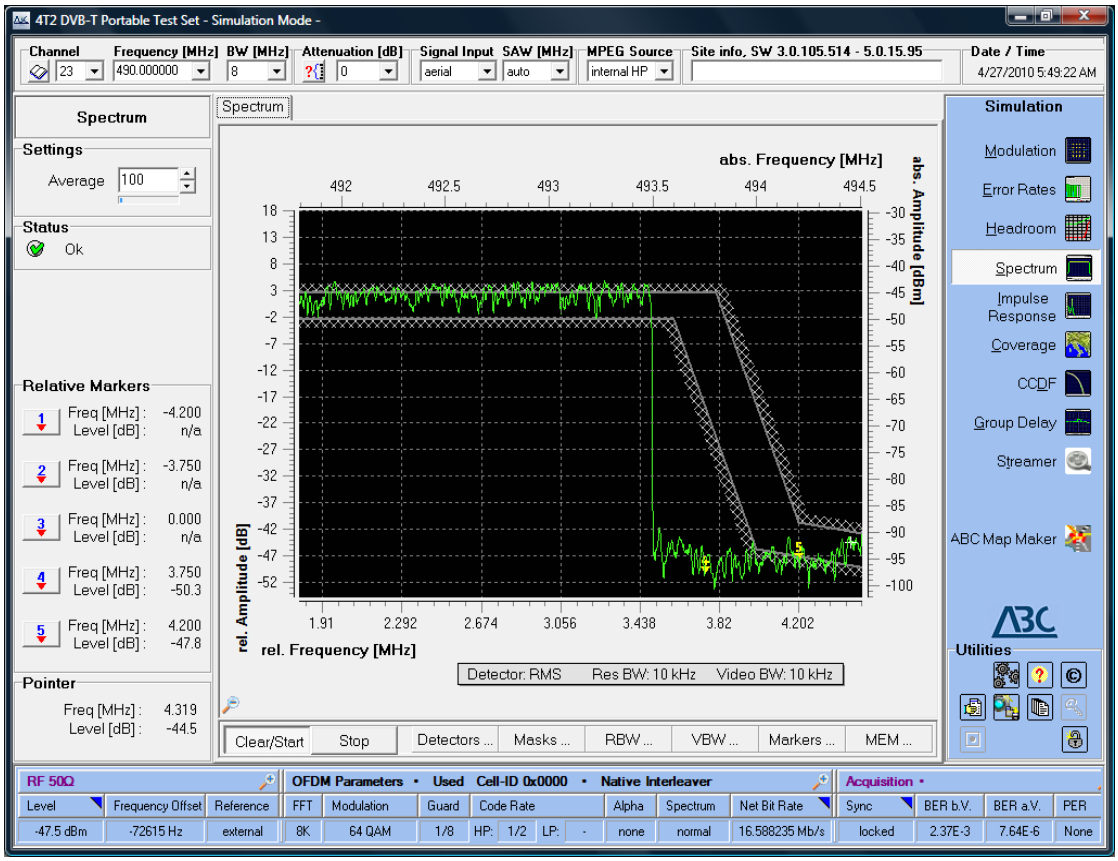


Illustration 25: /Analysis/Spectrum (zoomed to upper shoulder)

The upper shoulder distance is measured the same way as the lower shoulder.

6.9 Impulse Response

The Impulse Response menu enables time domain analysis of the incoming OFDM signal.

It also provides additional information by displaying the corresponding distance (in km) of the received signal on the upper horizontal axis.

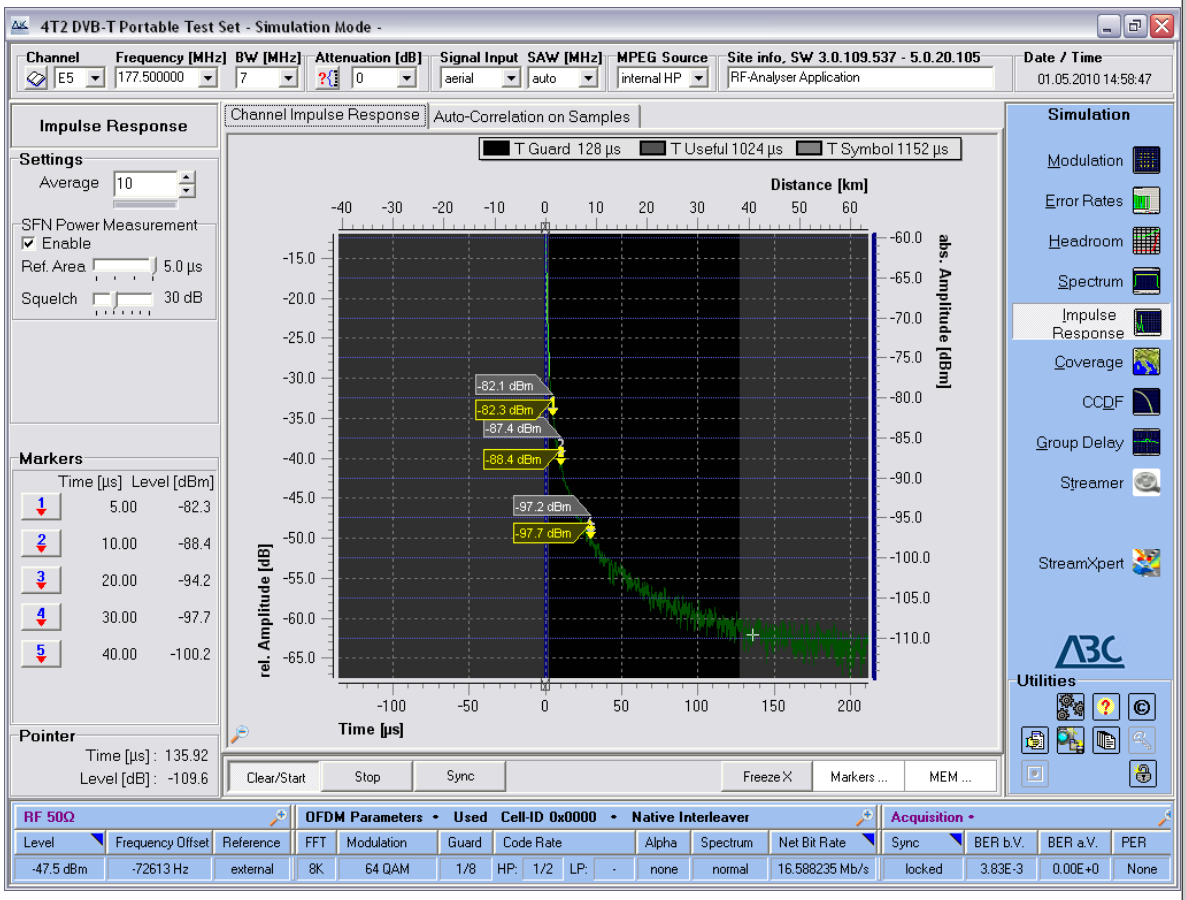


Illustration 26: /Analysis/Impulse Response

6.9.1 Background Information

This measurement may be used in order to analyse the time conditions of several DVB-T signals arriving at the same reception point (resulting in symbol interference), which is particularly useful when monitoring Single Frequency Networks (SFN).
In the Impulse Response screen, the time delay between transmissions in a multi-path environment is displayed.

Two different algorithms are implemented:
Channel Impulse Response, transformation of energy density spectrum into the time domain:

- requires receiver locked state on the incoming DVB-T signal
- delivers precise time and amplitude information
- is restricted to echoes / reflections within the Guard Interval

Auto-Correlation on Samples, IR ~ ACF(F(t)) = IFFT [| FFT (F(t))|^2]:

- works on the digitised input signal
- gives precise time information
- is independent from the signal properties i.e. no DVB-T signal has to be present
- delivers any periodic share of the signal as peak in the display, which in case of a DVB-T signal includes: Guard Interval, FFT length, symbol length and combinations thereof
- Peaks due to echoes / reflections are clearly higher in amplitude than peaks due to internal signal periodicity.

Both algorithms have their advantages and disadvantages. The application shall be chosen according to the input conditions.

6.9.2 Controls and Displays

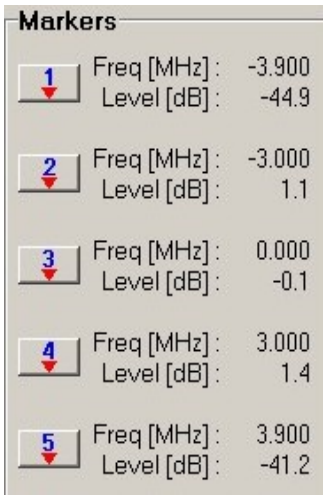
The ***Clear/Start*** button starts the impulse response analysis and resets the average counter.

The ***Stop*** button freezes the display.

Markers ... opens the following pop-up window:

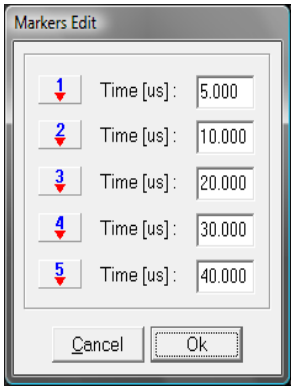
You may: Show / Hide or Edit markers

Five markers are available within the frequency spectrum. If the markers are hidden, no level measurement results will be available at the bottom left part of the screen. ***Edit*** opens the marker positioning dialog.



The ***Markers*** area at the bottom left part of the screen contains 5 result lines for the 5 Markers on the spectrum display.

The exact relative frequency (see Marker description above) plus the corresponding level or level delta (in dB) is displayed in this section.



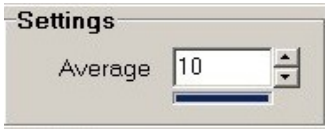
By clicking any button containing the red arrows in the ***Markers*** group, the ***Markers Edit*** dialog opens up allowing to set the results lines values.

Thus you are able to determine which time and amplitude delta or absolute values you want the 4T2 to display.

Zoom Function

Zoom-in on any time range is performed by dragging the mouse pointer over the area of interest from left to right while holding the left mouse button.

To ***Zoom-out*** to full span, hold the left mouse button and drag the mouse pointer from right to left.



The ***Average*** selector field allows determining the average number of display points per measurement. If required, please click at either the “increase” or “decrease” arrow to change the setting.

The ***MEM ...*** button opens a pop up window with the possibilities:

Add or
Clear.

Add allows for storing of the current trace to the background. Stored traces are coloured in blue.

Multiple storing is possible. ***Clear*** removes all stored curves.

MEM ... provides an easy way to compare results of different measurement situations e.g. for adjustment improvements.

The ***MEM ...*** function is also available in the ***Spectrum***, ***Group Delay***, and ***CCDF*** mode of operation.

6.10 Coverage

The Coverage function enables the 4T2 to relate OFDM measurement to position data derived from a GPS receiver. The combined data is logged on the 4T2 disk.
The coverage database is in ASCII comma separated values (csv) and may thus be converted to any file format for post-processing, like using coverage prediction software.

There are up to 4 receivers supported, allowing for a maximum of 4 channels to be measured at the same time.

Currently, the application supports Garmin, and Navilock GPS receivers following the NMEA standard.

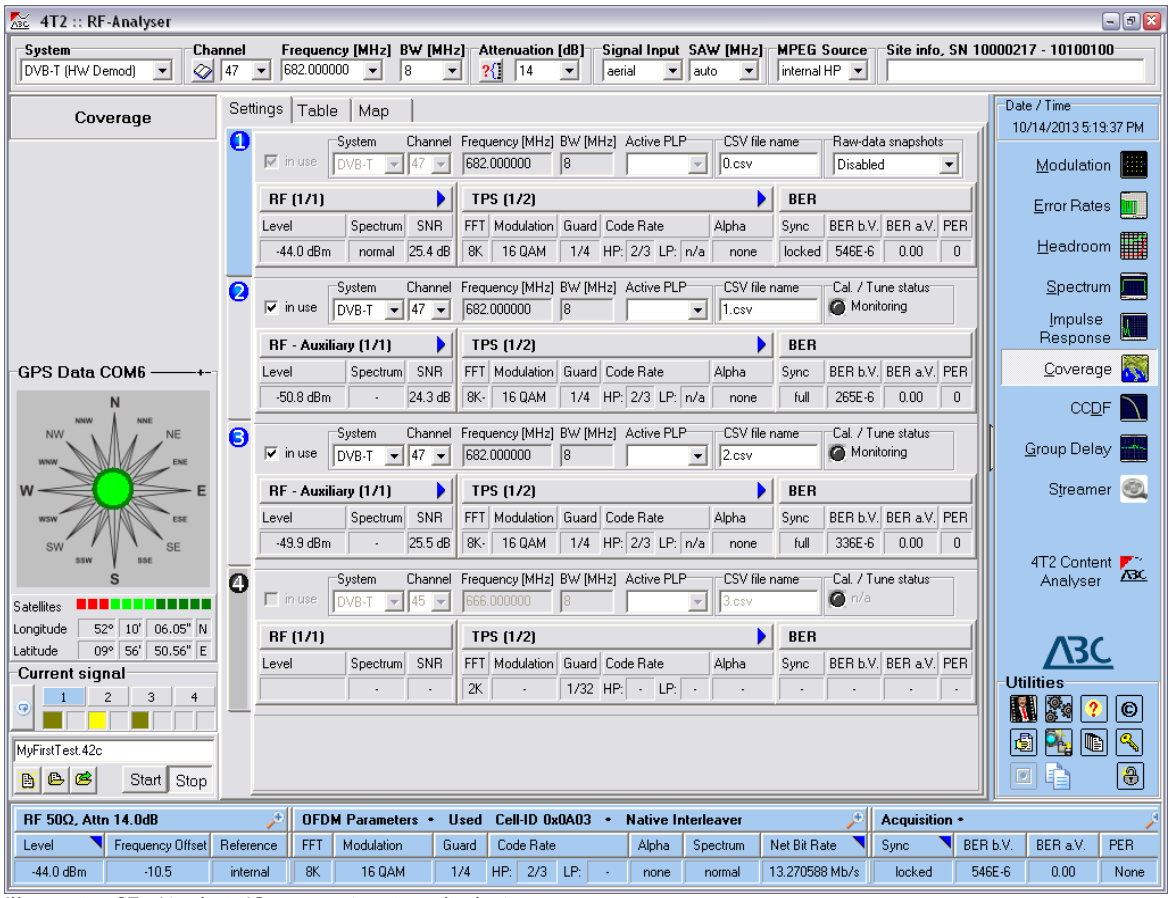


Illustration 27: /Analysis/Coverage (settings display)

6.10.1 Obtaining map information

The process to perform coverage analysis is very simple and can be done in a number of ways, all leading to accurate and reliable results.
The 4T2 can be used to superimpose measurement results on a map of the coverage area, but it is not mandatory to do so. This means that one can perform coverage measurements without loading a map file.
We do, however, encourage to use the map display feature as this is some kind of an online verification during the measurement session.
To use a map for the coverage analysis you will need to have a map-file of sufficient size and resolution in a bitmap format (PNG, JPEG, and BMP supported).

After setting two reference pins, the map is scaled automatically. It is not mandatory to set the reference pins before starting the measurement session. They can be altered during a running measurement session, if necessary.

ABC is providing a **MapMaker** application that enables to obtain up-to-date map data from the internet (Open Street Map Project http://www.openstreetmap.org). The map data is automatically referenced and a loaded map file will immediately display correctly in the RF-Analyser.

6.10.2 Center application screen area

The ***Settings*** tab holds all settings of the measurement receivers in the 4T2.

Up to 4 receivers are supported under positions 1..4.
The position 1 receiver on the top is always the 4T2 main receiver and thus controlled by the main application settings accessible on the very top of the application-screen.

Raw-data snapshots is a debug tool that allows the storage of IF sample data during the measurement run. This is for ABC internal use, should there be very difficult receiving conditions where more expert opinion is required. ABC has specific proprietary debug tools to work on this data. Please note, that this function stores a lot of data. It is therefore recommended to disable during normal use.

Position 2 to 4 are auxiliary receivers and can be tuned in the corresponding dialogues.

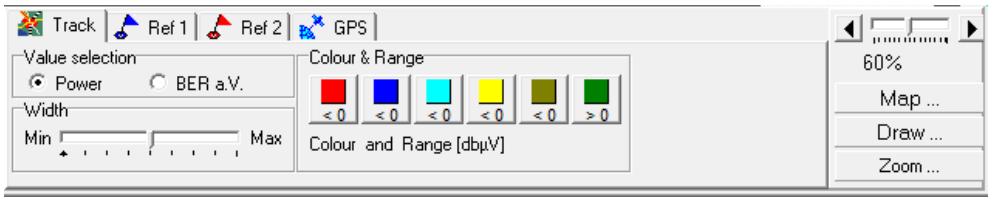
The ***Table*** tab provides a detailed list of all measurement samples that have been gathered during a measurement session.

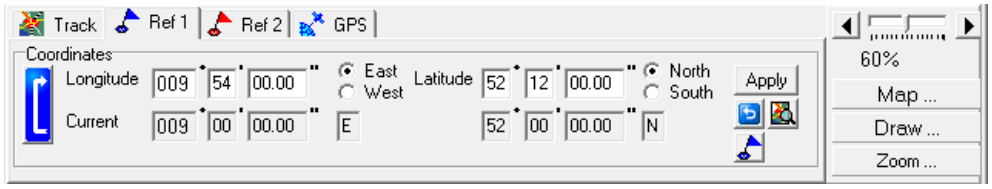
Depending on the position 1..4 selected, the table display changes to the data measured by the corresponding receiver.

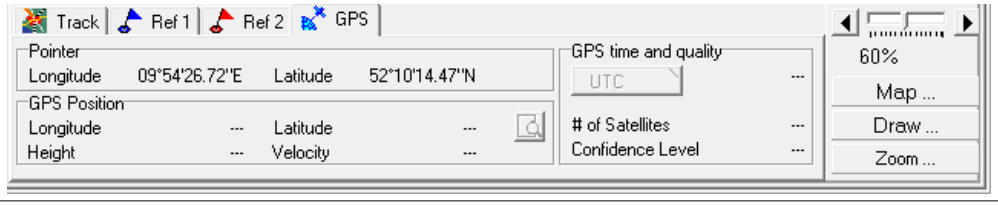
The ***Map*** tab shows the map and the superimposed track herein.

Depending on the position 1..4 selected, the map display changes to the data measured by the corresponding receiver.

The Map tab offers additional tabs for display and documentation:

Track Tab-sheet		
		
Properties of the superimposed track can be selected here: • Value Selection: Colours of the track derived from input level, or bit errors • Width: Width of the displayed track • Colour & Range: Selection of colours related to input properties		

Ref 1/2 Tab-sheet		
		
For manual scaling of displayed map: • Coordinates: Allows the positioning of reference pins on map, and supports the data acquisition from an attached GPS receiver.		

GPS Tab-sheet		
		
Main data display of an attached GPS receiver.		

The button ***Map*** allows the replacement, or selection of a map file.
The button ***Draw*** allows the selection of values to be drawn on the map.
The button ***Zoom*** allows the zoom of the map and measurement data according to user requirements.

6.10.3 Left application screen area

GPS Data COMnn displays the GPS communication and indicates traffic on the interface. While driving, an arrow will point into the direction on the compass dial.

Current position information and the number of satellites received is displayed for data confidence evaluation.

The ***Current signal*** section allows for a quick evaluation of the reception quality. It can be also used to switch between the receivers. A button to the left of the receiver indicators allows for a complete retune of the receiver front-ends.

Waypoints allows for connection to wheel sensors, should GPS not be available (like in tunnels). As there is additional hardware required, please contact ABC for a further explanation of the usage.

Click the ***Start*** button to start a measurement.
Click the ***Stop*** button to terminate the current measurement.

The ***File New*** dialogue allows creating a new coverage measurement project. You will be asked to save the current settings. Entering a new filename opens a project based on the current settings.

The ***File Open*** dialogue allows opening an existing coverage measurement project.

The ***File Import*** dialogue allows opening a legacy single channel coverage project file in the ini format used by **RF-Analyser** up to 2007.

7 Miscellaneous

7.1 Hotkeys

Hotkeys allow quick operation without the need for using a pointing device. They allow for faster navigation by the experienced user as well as for control in automated scripts.

Setup Features

Ctrl-0	Opens the **Select Channel Table** file open box.
Ctrl-1	Highlights the **Channel Selector** .
Ctrl-2	Highlights the **Frequency Selector** .
Ctrl-3	Highlights the **Bandwidth Selector** .
Ctrl-4	Activates the **Automatic Attennuation** process.
Ctrl-5	Highlights the **Manual Attenuation Selector** .
Ctrl-6	Highlights the **Signal Input Selector** .
Ctrl-7	Highlights the **MPEG Source Selector** .
Ctrl-8	Highlights the **Site Info** edit box.

Analysis Selection

Alt-M	Activates **Analysis/Modulation**.
Alt-E	Activates **Analysis/Error Rates**.
Alt-H	Activates **Analysis/Receiver Headroom** .
Alt-S	Activates **Analysis/Spectrum**.
Alt-I	Activates **Analysis/Impulse Response** .
Alt-C	Activates **Analysis/Coverage**.
Alt-D	Activates **Analysis/CCDF**.
Alt-G	Activates **Analysis/Group Delay**.
Alt-V	Activates **Analysis/MPEG Video**.

7.2 Glossary

Abbr.	Meaning	Description
AI	Amplitude Imbalance	The purpose of the AI measurement is to assess the QAM distortions resulting from amplitude imbalance of I and Q signals.
BAT	Bouquet Association Table	A DVB table that describes a set of services grouped together by a broadcaster and sold as a single entity.
BER	Bit Error Rate	The ratio of erroneous bits to the total number of bits transmitted within a certain time interval.
C/N	Carrier-to-Noise	Ratio of RF or IF signal power to noise power
CCDF	Complementary Cumulative Distribution Function	Statistical information about the signal amplitude distribution
CREST		CREST factor is defined as the ratio of the peak voltage to its root-mean-square value
CS	Carrier Suppression	Carrier Suppression is a measure for the rejection of unwanted sinusoidal signals affecting the centre of the analysed OFDM signal. CS is measured in dB; high values indicate high suppression or high signal quality.
CSI	Channel-State Information	The Channel-State Information is calculated as a properly defined distance between the received data symbols and the constellation points. The higher the CSI, the less reliable is the carrier. The average CSI corresponds to a quantised average of the CSI taken over the number of carriers.
DVB-T	Digital Video Broadcasting - Terrestrial	Baseline system for digital terrestrial television
EIT	Event Information Table	The DVB SI table that supplies the decoder with a list of events corresponding to each service and identifies the characteristics of these events.
ETR	ETSI Technical Report	
ETSI	European Telecommunication Standard Institute	
EVM	Error Vector Magnitude	EVM is defined as the ratio of the average measured error magnitude to the peak symbol magnitude and is averaged over a statistically valid number of symbols.
FEC	Forward Error Correction	A method for protecting the transport stream against error by adding error control bits before RF modulation. With these bits, errors in the transport stream may be detected and corrected prior to decoding.
FFT	Fast Fourier Transform	Mathematical calculation for analysing the frequency spectrum of non-periodic functions.
GPS	Global Positioning System	Satellite-based system for exact determination of current location by analysing signals received from the GPS satellites.
HDTV	High Definition Television	Digital TV with a resolution approx. Twice as high as that of Standard Definition TV for both horizontal and vertical dimensions. HDTV has an aspect ratio of 16:9, as compared to 4:3 for SDTV.
IQ	In-phase/Quadrature components	Base-band modulating signals whose amplitudes can be monitored for signal distortions.
IRD	Integrated Receiver Decoder	A receiver with an **MPEG-2** decoder, also known as set-top box.
MER	Modulation Error Ratio	The MER is defined as the ratio of I/Q signal power to I/Q noise power; the result is indicated in dB.
MFN	Multi Frequency Network	DVB-T network configuration with DVT-T transmitters sending different content on different frequencies
MIP	Megaframe Initialization Packet	A transport stream packet used by DVB-T to synchronise the transmitters in a multi-frequency network (MFN).
MP@HL	Main Profile at High Level	**MPEG-2** specifies different degrees of compression vs Quality. Of these, MP@HL is the most commonly used for HDTV.
MPEG	Motion Picture Experts Group	The standards body responsible for the development of MPEG-2, the standard for digital television broadcasting.
NIT	Network Information Table PID 0x0010	The **DVB** table that contains information about a network including its orbit, transponder, etc.
OFDM	Orthogonal Frequency Division Multiplex	Multi-carrier type of modulation used for DVB-T transmission.

Abbr.	Meaning	Description
PAT	Program Association Table PID 0x0000	The MPEG-2 table that identifies all programs in the transport stream and provides the **PID** value for the **PMT** associated with each program.
PCR	Program Clock Reference	A time stamp in the transport stream used to synchronise the decoder's clock with the original system time clock of the encoder. The PCR is transmitted at least every 0.1 seconds.
PES	Packetised Elementary Stream	A stream containing variable-length packets of video, audio, or data.
PID	Packet Identifier	A unique integer value that identifies elements in the transport stream such as tables, data, or the audio for a program.
PJ	Phase Jitter	Rapid fluctuations of phase.
PLL	Phase Lock Loop	The process by which the decoder uses the **PCR** to lock its system time clock to the original system time clock of the encoder.
PMT	Program Map Table	The **MPEG-2** table that indicates the **PID** values for packets containing the audio and video components of a program. It also provides the PID.
PPTR	power peak to RMS	
PTS	Presentation Time Stamp	A time stamp that indicates the moment at which a frame of audio or video must be presented to the viewer. Found in the **PES** header, the PTS is transmitted at least once every 0.7 seconds.
QAM	Quadrature Amplitude Modulation	A modulation scheme for digital signals mainly used in CATV transmission. Amplitude and phase of a carrier are modulated in order to carry information. 64-QAM, 16-QAM, and 4-QAM (QPSK) are commonly used, according to bit rate/ruggedness requirements.
QE	Quadrature Error	The Quadrature Error (QE) parameter describes the distortion of a constellation diagram in case the phases of the two carriers feeding I and Q modulators are not orthogonal (i.e. their phase difference is not 90°).
QPSK	Quaternary Phase Shift Keying	A type of modulation for digital signals mainly used in satellite transmission (DVB-S).
RS	Reed Solomon	Protection code; refers to (usually) 16 bytes of error control code that can be added to every transport packet during modulation.
SDT	Service Description Table	The DVB SI table that describes the characteristics of available services.
SFN	Single Frequency Network	In an SFN, all transmitters within a region are sending the same signal (bit-synchronous), as opposed to multi-frequency networks which are not bit-synchronised.
SI	Service Information	The DVB protocol that specifies transmission of the data required by a decoder to de-multiplex the programs and services in the transport stream. Mandatory DVB SI tables include TDT, NIT, SDT, and EIT.
SNR	Signal to Noise Ratio	Ratio of RF or IF signal power to noise power, indicated in dB
STE	System Target Error	The STE gives a global indication about the overall distortion present on raw received data.
TDT	Time and Date Table	A mandatory DVB SI table that supplies the UTC time and date. This table enables joint management of events corresponding to services accessible from a single reception point.
TEV	Target Error Vector	In a constellation diagram, the distance between the ideal symbol point location and the point corresponding to the mean of the cloud of that particular point, is referred to as TEV.
TS	Transport Stream	A stream of 188-byte packets that contain audio, video or data belonging to one or several programs.

7.3 DVB-T/H Modulation Parameters

Key properties of ***2k***, ***4k***, and ***8k*** modulation modes:

channel BW [MHz]	mode [1]	No of carriers [1]	carrier spacing [Hz]	OFDM width [Hz]	FFT length [1]	OFDM [1]	elementary period [1]	symbol length [us]	frame length sym*68 [us]	super frame length fr*4 [us]	guard [1]	guard [us]	Tsymbol [us]	Cmin [1]	Cmax [1]	scattered pilots [1]
8	2k	1705	4464,29	7,61	2.048	7/8	7/64	224	15232	60928	1/ 4	56	280	0	1704	131
											1/ 8	28	252			
											1/16	14	238			
											1/32	7	231			
	4k	3409	2232,14	7,61	4.096	7/8	7/64	448	30464	121856	1/ 4	112	560	0	3408	262
											1/ 8	56	504			
											1/16	28	476			
											1/32	14	462			
	8k	6817	1116,07	7,61	8.192	7/8	7/64	896	60928	243712	1/ 4	224	1120	0	6816	524
											1/ 8	112	1008			
											1/16	56	952			
											1/32	28	924			

channel BW [MHz]	mode [1]	No of carriers [1]	carrier spacing [Hz]	OFDM width [Hz]	FFT length [1]	OFDM [1]	elementary period [1]	symbol length [us]	frame length sym*68 [us]	super frame length fr*4 [us]	guard [1]	guard [us]	Tsymbol [us]	Cmin [1]	Cmax [1]	scattered pilots [1]
7	2k	1705	3906,25	6,66	2.048	7/8	1/ 8	256	17408	69632	1/ 4	64	320	0	1704	131
											1/ 8	32	288			
											1/16	16	272			
											1/32	8	264			
	4k	3409	1953,13	6,66	4.096	7/8	1/ 8	512	34816	139264	1/ 4	128	640	0	3408	262
											1/ 8	64	576			
											1/16	32	544			
											1/32	16	528			
	8k	6817	976,56	6,66	8.192	7/8	1/ 8	1024	69632	278528	1/ 4	256	1280	0	6816	524
											1/ 8	128	1152			
											1/16	64	1088			
											1/32	32	1056			

channel BW [MHz]	mode [1]	No of carriers [1]	carrier spacing [Hz]	OFDM width [Hz]	FFT length [1]	OFDM [1]	elementary period [1]	symbol length [us]	frame length sym*68 [us]	super frame length fr*4 [us]	guard [1]	guard [us]	Tsymbol [us]	Cmin [1]	Cmax [1]	scattered pilots [1]
6	2k	1705	3348,21	5,71	2.048	7/8	7/48	298,67	20309,33	81237,33	1/ 4	75	373	0	1704	131
											1/ 8	37	336			
											1/16	19	317			
											1/32	9	308			
	4k	3409	1674,11	5,71	4.096	7/8	7/48	597,33	40618,67	162474,67	1/ 4	149	747	0	3408	262
											1/ 8	75	672			
											1/16	37	635			
											1/32	19	616			
	8k	6817	837,05	5,71	8.192	7/8	7/48	1194,67	81237,33	324949,33	1/ 4	299	1493	0	6816	524
											1/ 8	149	1344			
											1/16	75	1269			
											1/32	37	1232			

channel BW [MHz]	mode [1]	No of carriers [1]	carrier spacing [Hz]	OFDM width [Hz]	FFT length [1]	OFDM [1]	elementary period [1]	symbol length [us]	frame length sym*68 [us]	super frame length fr*4 [us]	guard [1]	guard [us]	Tsymbol [us]	Cmin [1]	Cmax [1]	scattered pilots [1]
5	2k	1705	2790,18	4,75	2.048	7/8	7/40	358,4	24371,2	97484,8	1/ 4	90	448	0	1704	131
											1/ 8	45	403			
											1/16	22	381			
											1/32	11	370			
	4k	3409	1395,09	4,75	4.096	7/8	7/40	716,8	48742,4	194969,6	1/ 4	179	896	0	3408	262
											1/ 8	90	806			
											1/16	45	762			
											1/32	22	739			
	8k	6817	697,54	4,75	8.192	7/8	7/40	1433,6	97484,8	389939,2	1/ 4	358	1792	0	6816	524
											1/ 8	179	1613			
											1/16	90	1523			
											1/32	45	1478			

Continuous Pilot Carriers (CP) (Carrier indices) Transmitter Parameter Signalling Carriers (TPS)	
2k mode (45 CP, ***17 TPS***)	8k mode (177 CP, ***68 TPS***)
0 ***34*** 48 ***50*** 54 87 141 156 192 201 ***209*** 255 279 282 333 ***346*** ***413*** 432 450 483 525 531 ***569*** ***595*** 618 636 ***688*** 714 759 765 780 ***790*** 804 873 888 ***901*** 918 939 942 969 984 1050 1101 1107 1110 1137 ***1073*** 1140 1146 1206 ***1219*** ***1262*** 1269 ***1286*** 1323 1377 ***1469*** 1491 ***1594*** 1683 ***1687*** 1704	0 ***34*** 48 ***50*** 54 87 141 156 192 201 ***209*** 255 279 282 333 ***346*** ***413*** 432 450 483 525 531 ***569*** ***595*** 618 636 ***688*** 714 759 765 780 ***790*** 804 873 888 ***901*** 918 939 942 969 984 1050 1101 1107 1110 1137 ***1073*** 1140 1146 1206 ***1219*** ***1262*** 1269 ***1286*** 1323 1377 ***1469*** 1491 ***1594*** 1683 ***1687*** 1704 ***1738*** 1752 ***1754*** 1758 1791 1845 1860 1896 1905 ***1913*** 1959 1983 1986 2037 ***2050*** ***2117*** 2136 2154 2187 2229 2235 ***2273*** ***2299*** 2322 2340 ***2392*** 2418 2463 2469 2484 ***2494*** 2508 2577 2592 ***2605*** 2622 2643 2646 2673 2688 2754 ***2777*** 2805 2811 2814 2841 2844 2850 2910 ***2923*** ***2966*** 2973 ***2990*** 3027 3081 ***3173*** 3195 3387 ***3298*** ***3391*** 3408 ***3442*** 3456 ***3458*** 3462 3495 3564 3600 3609 ***3617*** 3663 3687 3690 3741 ***3754*** ***3821*** 3840 3858 3891 3933 3939 ***3977*** ***4003*** 4026 4044 ***4096*** 4122 4167 4173 4188 ***4198*** 4212 4281 4296 ***4309*** 4326 4347 4350 4377 4392 4458 ***4481*** 4509 4515 4518 4545 4548 4554 4614 ***4627*** ***4670*** 4677 ***4694*** 4731 4785 ***4877*** 4899 ***5002*** 5091 ***5095*** 5112 ***5146*** 5160 ***5162*** 5166 5199 5253 5268 5304 5313 ***5321*** 5367 5391 5394 5445 ***5458*** ***5525*** 5544 5562 5595 5637 5643 ***5681*** ***5707*** 5730 5748 ***5800*** 5826 5871 5877 5892 ***5902*** 5916 5985 6000 ***6013*** 6030 6051 6054 6081 6096 6162 ***6185*** 6213 6219 6222 6249 6252 6258 6318 ***6331*** ***6374*** 6381 ***6398*** 6435 6489 ***6581*** 6603 ***6706*** 6795 ***6799*** 6816

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