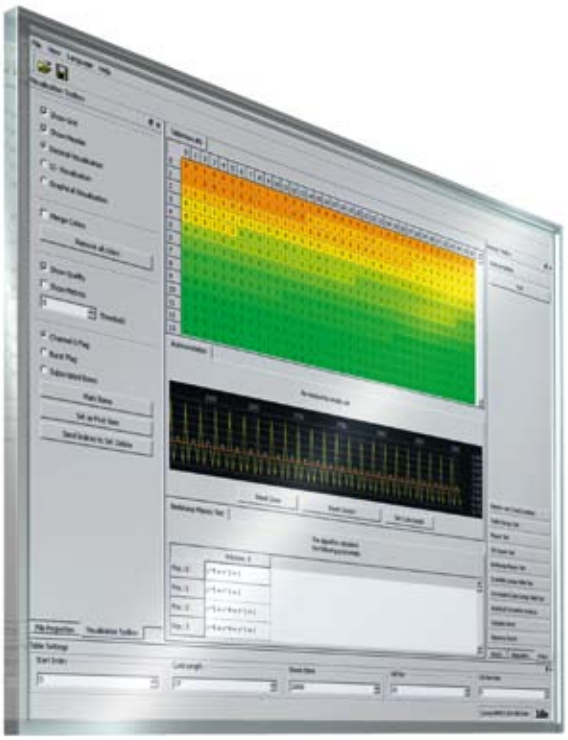
R&S®CA250
Bit Stream Analysis
Analysis and manipulation of signals at bit stream/ symbol stream level



Radiomonitoring & Radiolocation

Data Sheet | 02.02

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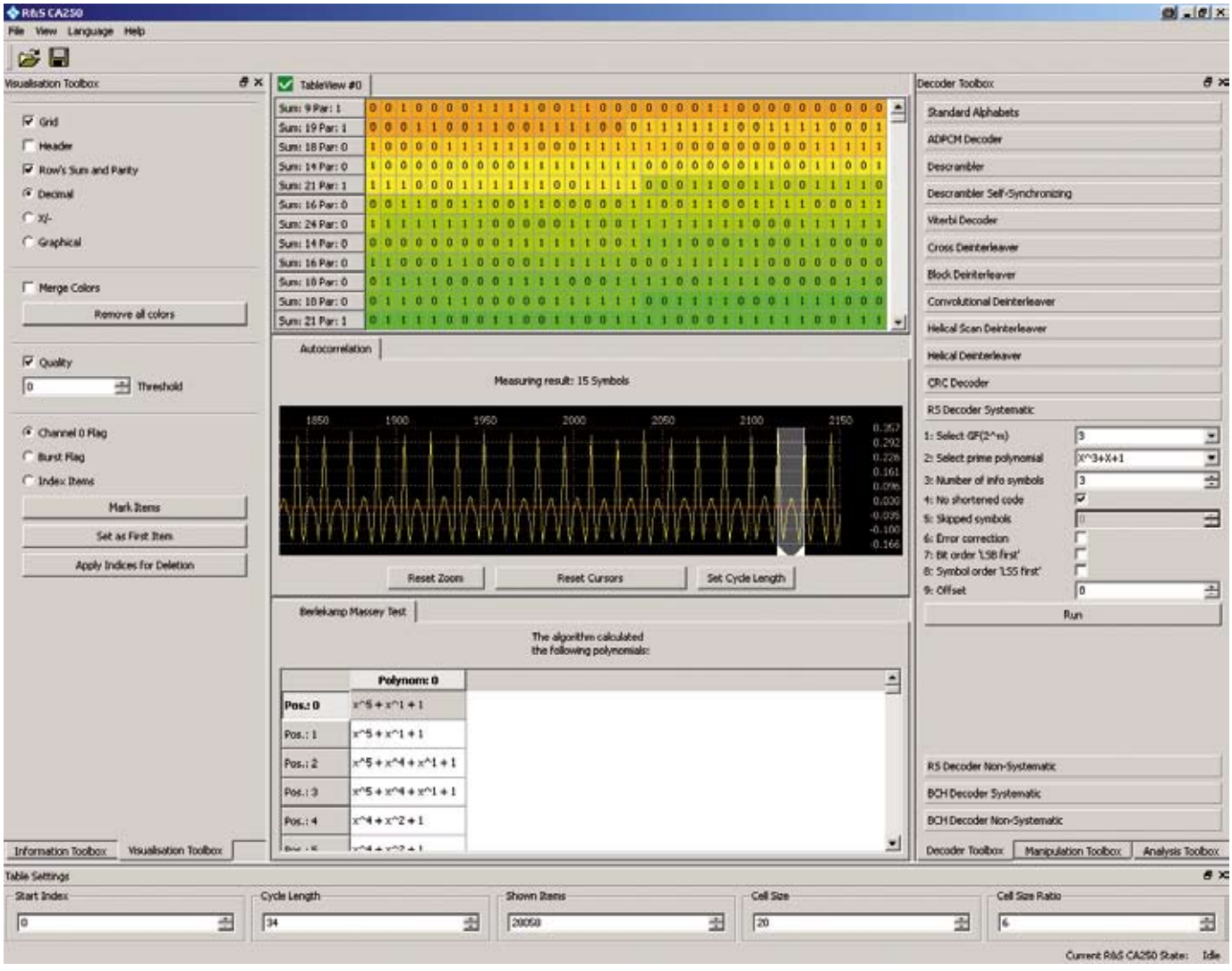
R&S®CA250
Bit Stream Analysis
At a glance

In the field of technical analysis of modern communications signals, the capability to analyze the characteristics of demodulated signals with unknown codings is of major importance. In addition to various symbol stream/bit stream representations, R&S®CA250 provides a large number of powerful analysis algorithms and bit stream manipulation functions.

By selectively using these tools, the user can obtain technical data from the unknown bit stream. This data provides information about the type and content of the analyzed signal. Ideally, it is possible to resolve all aspects of the unknown code, thus allowing the user to program a specific decoder for the unknown signal (e.g. by using the R&S®GX400ID decoder development environment).

R&S®CA250 operating window.



R&S®CA250 Bit Stream Analysis

Benefits and key features

Versatile data import and symbol stream/bit stream representation

- Import of various symbol stream/bit stream formats
- Symbol-to-bit mapping and bit stream representation as 0/1 and -/X representation as well as graphical visualization

▷ page 4

Versatile bit stream analysis functions

- Structure analysis, entropy analysis (block codes), scrambler analysis, convolutional code analysis

▷ page 6

Wide variety of bit manipulation functions

- Deletion, inversion, multiplexing, demultiplexing, descrambling, deinterleaving, decoding of convolutional codes, decoding of standard alphabets and decoding of voice codecs

▷ page 8

Code analysis and automation

- Integration of user-specific algorithms into the R&S®CA250 operation sequences
- Programmable script control for performing automatic analysis sequences

▷ page 9

Payload analysis

▷ page 10

Versatile data import and symbol stream/bit stream representation

Data import and symbol stream/bit stream representation

R&S®CA250 supports the import of files in different symbol stream and bit stream formats. In symbol stream representation, the symbols generated by the demodulator are displayed according to their valency (line-by-line representation from left to right).

The symbol stream is transferred to a bit stream by means of predefined and user-definable symbol-to-bit mapping specifications.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
0	3	2	0	0	0	1	1	2	0	3	2	2	1	1	1	3	2	2	0	2	2	0	0	0	0	3	2	1	1	1	3	2
1	3	3	1	1	3	1	3	2	1	1	1	3	2	2	0	3	1	3	2	0	2	2	1	3	3	2	2	2	0	2	3	3
2	3	2	1	3	2	0	2	2	1	3	3	3	0	3	2	2	1	0	3	3	3	0	2	0	3	2	2	0	2	2	0	0
3	0	0	3	2	1	0	3	2	0	2	2	1	3	3	3	0	3	2	2	1	1	1	3	2	2	0	3	1	3	2	0	2
4	2	1	3	3	2	2	2	1	1	0	0	1	0	0	0	3	2	0	3	1	3	3	3	0	2	0	3	2	3	3	1	1
5	2	2	1	3	2	1	0	3	3	3	1	1	3	1	3	2	1	1	1	2	1	1	2	2	1	3	3	2	2	3	3	1
6	1	2	2	0	1	3	2	3	3	1	1	3	1	3	3	3	0	3	2	3	2	2	2	0	2	3	2	0	1	3	2	3
7	3	0	2	0	3	2	2	0	3	0	0	0	0	3	2	0	3	1	3	2	1	1	0	1	3	1	3	3	3	0	2	0
8	3	2	2	1	0	3	3	3	1	0	1	1	3	2	3	2	2	3	3	1	0	1	1	2	0	3	2	2	1	1	1	3
9	2	2	0	2	2	0	0	0	0	3	2	1	1	1	3	2	3	3	1	1	3	1	3	2	1	1	1	3	2	2	0	3
10	1	3	2	0	2	2	1	3	3	2	2	2	0	2	3	2	1	3	2	0	3	0	1	3	2	3	3	0	2	0	2	0
11	2	0	3	2	2	0	3	0	0	1	3	0	1	3	2	3	2	2	3	3	0	2	1	0	1	1	3	2	2	0	3	1
12	3	2	0	3	0	0	0	0	3	2	0	2	3	3	2	1	3	3	3	1	0	0	3	2	0	2	2	1	3	3	3	1

Symbol stream with four valued symbols (symbol values: 0, 1, 2, 3).

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
0	1	1	1	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	1	1	1	0	1	0	0	1	0	1	0	1	1	1
1	1	0	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	1	1	1	0	0	1	0	1	0	1	1	1	1	0
2	1	1	1	1	0	1	0	1	1	1	0	1	1	1	1	0	0	1	0	1	0	1	1	1	1	0	1	0	0	0	1	1
3	0	1	1	1	1	0	0	0	1	0	1	0	0	1	1	1	1	1	1	0	1	0	1	0	0	0	1	0	1	1	1	1
4	1	1	1	0	0	1	1	1	1	0	0	0	1	0	1	0	0	1	1	1	1	1	1	1	0	0	1	1	1	0	1	0
5	0	1	0	0	1	1	1	1	1	1	0	0	1	0	0	0	1	1	1	0	1	0	0	0	1	0	1	0	0	0	0	0
6	0	0	0	0	1	1	1	0	0	1	0	0	1	1	1	0	0	0	1	0	1	0	0	1	1	1	1	1	1	1	0	0
7	1	1	1	0	1	0	0	1	0	1	0	1	1	1	1	0	1	0	0	0	1	1	0	1	1	1	1	0	0	0	1	0
8	1	0	0	1	1	1	1	1	1	0	1	0	1	0	0	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	1	1
9	1	0	0	0	1	1	0	1	1	1	1	1	1	1	0	0	1	0	0	0	1	1	1	0	1	1	1	1	0	1	0	1
10	1	0	1	0	0	1	1	1	1	0	0	1	0	0	1	1	1	1	1	1	0	1	0	1	1	1	0	1	1	1	1	0
11	0	1	0	1	0	1	1	0	0	1	0	1	1	0	1	0	0	1	1	1	1	1	1	0	1	0	1	1	1	1	0	1
12	0	1	1	0	1	0	0	0	0	1	1	1	1	0	1	1	1	1	0	1	0	1	1	1	0	1	1	1	1	1	1	1

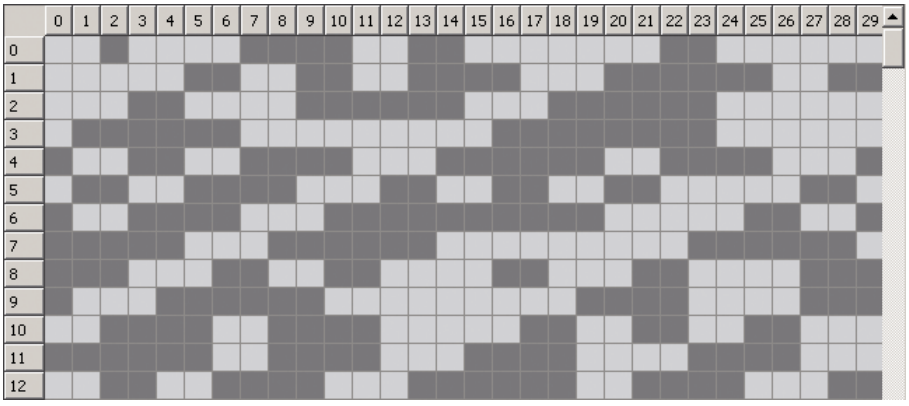
Bit stream in 0/1 representation obtained from a symbol stream after using the natural symbol-to-bit mapping.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
0	-	-	X	-	-	-	-	X	X	X	X	-	-	X	X	-	-	-	-	-	-	-	X	X	-	-	-	-	-	-
1	-	-	-	-	-	X	X	-	-	X	X	-	-	X	X	X	X	-	-	-	X	X	X	X	X	X	-	-	X	X
2	-	-	-	X	X	-	-	-	-	X	X	X	X	X	X	-	-	-	X	X	X	X	X	X	-	-	-	-	-	-
3	-	X	X	X	X	X	X	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	X	-	-	-	-	-	-
4	X	-	-	X	X	-	-	X	X	X	X	-	-	-	X	X	X	X	X	X	-	-	X	X	X	X	-	-	-	X
5	-	X	X	-	-	X	X	X	X	-	-	-	X	X	-	-	X	X	-	-	X	X	-	-	-	-	-	X	X	-
6	X	-	-	X	X	X	X	-	-	-	X	X	X	X	X	X	X	X	X	X	-	-	-	-	-	X	X	-	-	X
7	X	X	X	X	X	-	-	-	X	X	X	X	X	X	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	-
8	X	X	X	-	-	-	X	X	-	-	X	X	-	-	-	-	X	X	-	-	-	X	X	-	-	-	-	X	X	X
9	X	-	-	-	X	X	X	X	X	X	-	-	-	-	-	-	-	-	X	X	X	X	-	-	-	-	X	X	X	
10	-	-	X	X	X	X	-	-	X	X	X	X	-	-	-	-	-	X	X	-	-	X	X	-	-	X	X	-	-	-
11	X	X	X	X	X	X	-	-	X	X	X	X	-	-	-	X	X	X	X	-	-	-	-	X	X	X	X	-	-	-
12	-	-	X	X	-	-	X	X	X	X	-	-	-	X	X	X	X	X	X	-	-	X	X	X	X	-	-	-	X	X

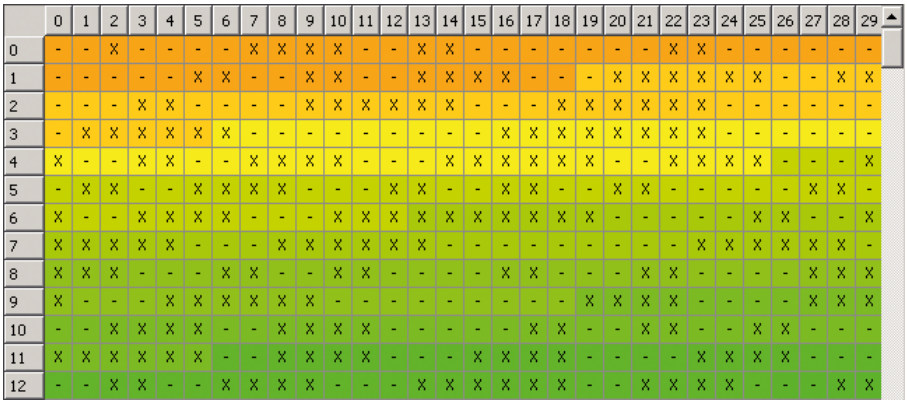
Bit stream in -/X representation.

The bit stream representation can be switched between 0/1 and -/X representation and graphical visualization. In addition, it is scalable with respect to size and form (number of lines x number of columns).

If the original symbol streams were obtained by using R&S®GX400, R&S®GX410 or R&S®GX430, each symbol contains quality information that is added during demodulation. This information is transferred to the bit stream generated from the symbol stream and can be visualized in color. The user can thus easily distinguish between segments with good quality and those with bad quality, where analysis might be less promising.



Bit stream in graphical visualization.



-/X representation of a bit stream with highlighted quality information on every bit (red = low quality, green = high quality).

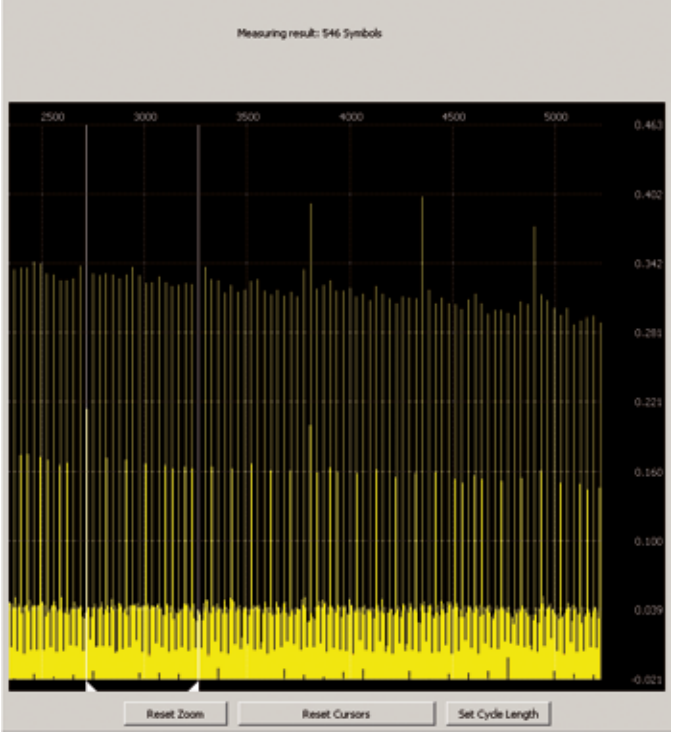
Versatile bit stream analysis functions

Bit structure analysis

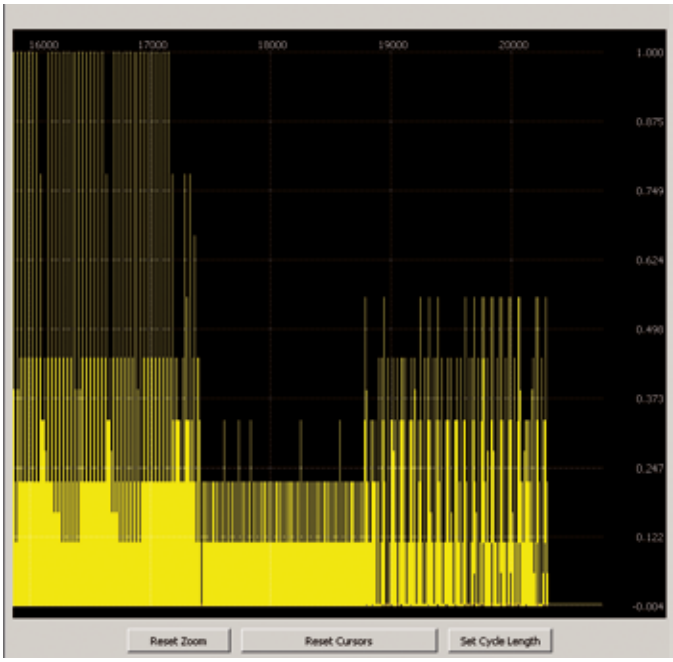
For the analysis of bit structures, R&S®CA250 features versatile functions such as autocorrelation and cross-correlation, configurable pattern search, entropy test (Tsallis, Maurer, Chi-square), calculations of column sum/parity and line sum/parity.

By using the pattern search, the user can detect and display all possible variations of a bit pattern in the bit stream. The parameterization of tolerance ranges with respect to bit errors for the search allows the algorithm to run successfully even in bit streams containing bit errors.

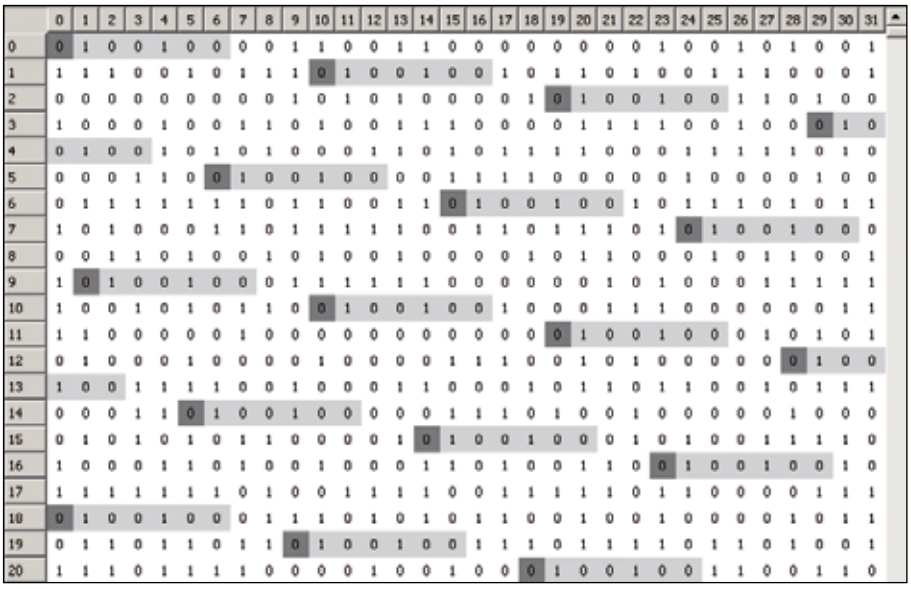
An entropy test is available for analyzing block codes. It involves testing the bit stream with respect to its randomness. Decreases in entropy provide information on the use of a block code with a specific code length. R&S®CA250 offers various statistical analysis methods.



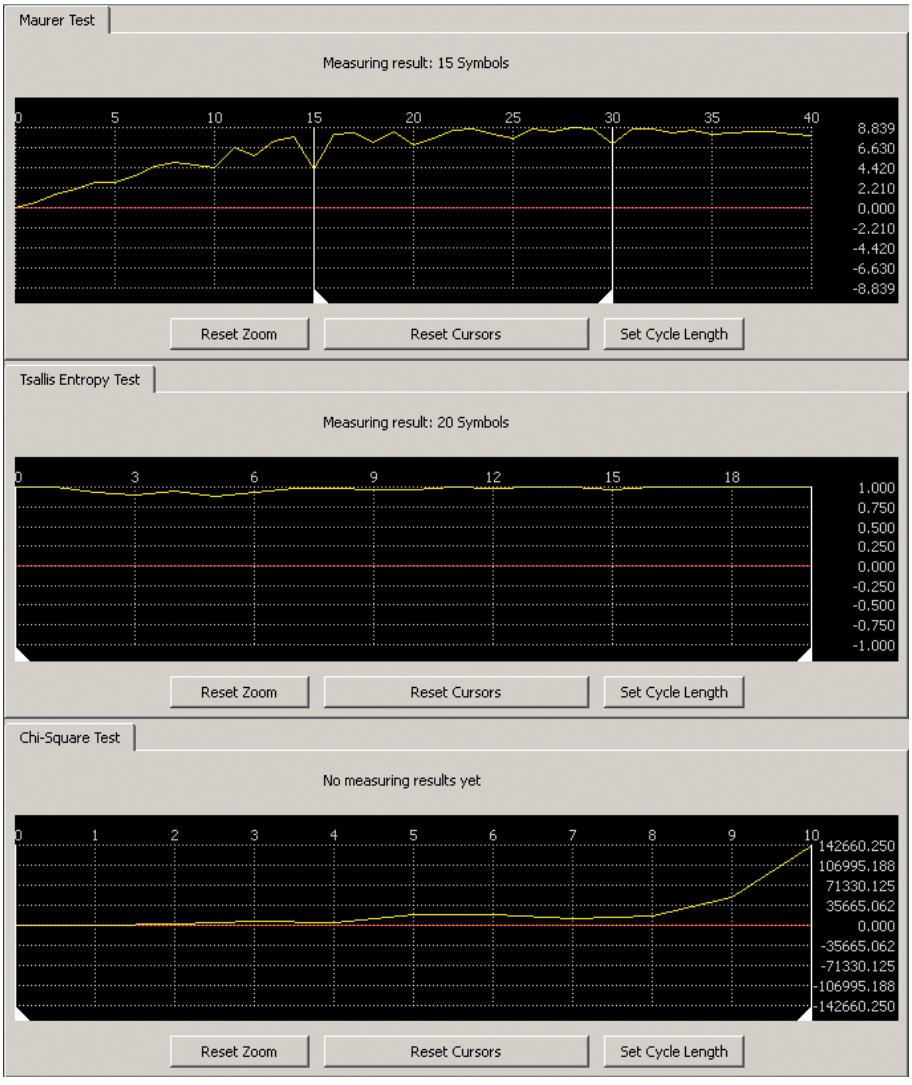
Maxima in autocorrelation representation indicate regular, repeating structures (e.g. frame structures) in the bit stream.



The cross-correlation indicates how often a user-defined bit pattern (e.g. a preamble) occurs in a bit stream.



Search result of the preamble bit pattern 0100100.



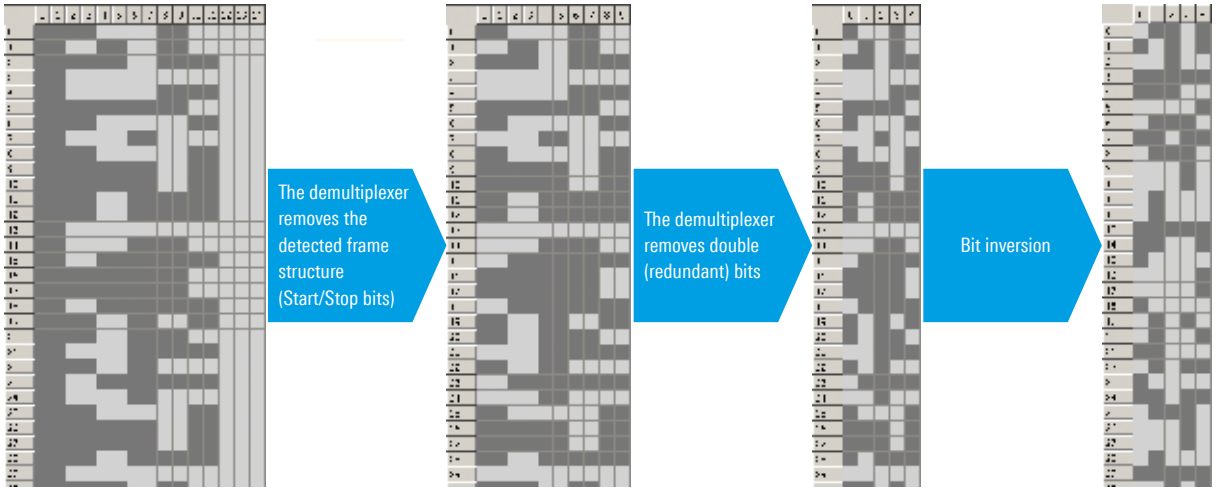
The decreases in entropy in Maurer test (see top representation; search for statistical defects of a random sequence) at the values 15 and 30 substantiate the following: When the bit stream is divided into 15-bit code words, any regular occurrence is revealed (specific code words occur more often than others).

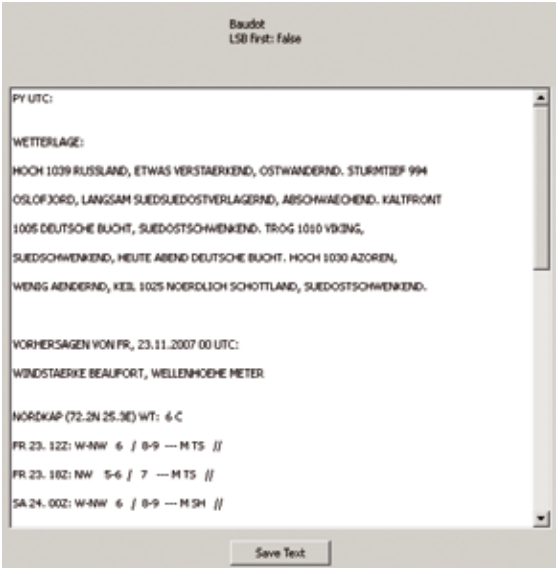
Wide variety of bit manipulation functions

Bit manipulation

R&S®CA250 offers various alternatives for manipulating the bit stream. If an analysis result is available, a function is provided for applying the analysis result to the bit stream and for beginning the next analysis step. In addition to easier manipulation functions such as selective deletion or bit inversion, the following complex functions are available: conversion from differential coding to absolute coding, decoding of line codes (NRZ-L, NRZ-M, NRZ-S), Boolean operations, multiplexing, demultiplexing, descrambling and deinterleaving.

Several bit manipulation steps are applied sequentially to extract the content of the signal





The application of the Baudot alphabet to the bit stream from the section “Bit Manipulation” generates readable text and thus confirms that all analysis and bit manipulation steps (demultiplexing, inversion) have been performed successfully.

Code analysis and automation

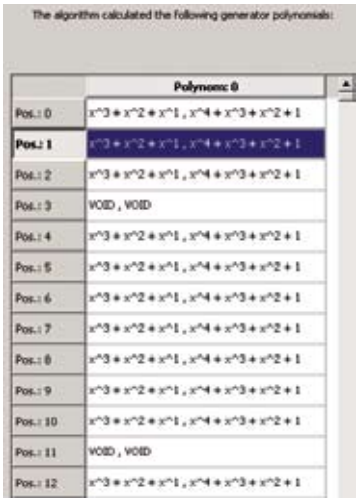
Convolutional code analysis and decoder

Complex convolutional codes are analyzed by using convolutional code analysis, where the generator polynomials, which form the basis of the convolutional code (or of its shift registers), are calculated. The polynomials obtained from this analysis can be transferred to a Viterbi decoder to decode the convolutional code.

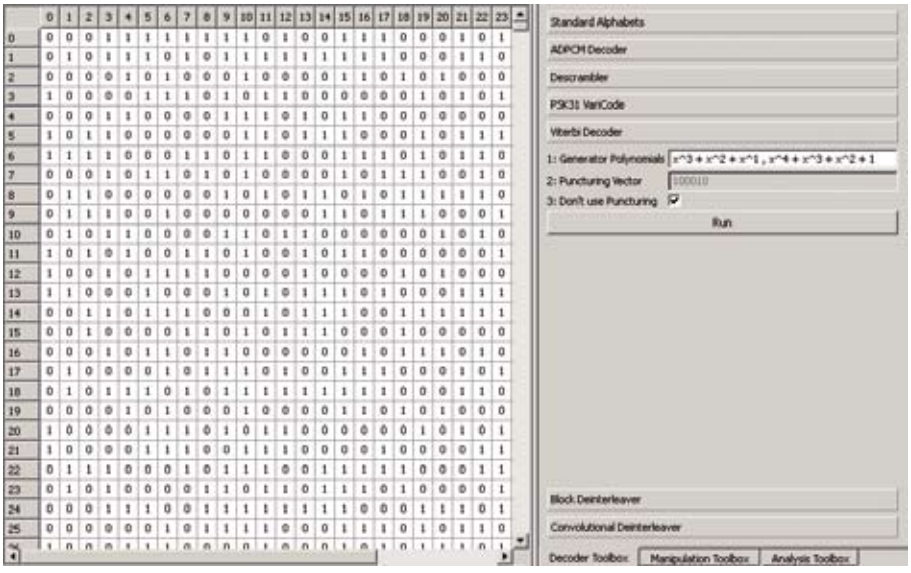
Extension and automation

R&S®CA250 allows the user to integrate bit stream analysis or manipulation algorithms that have been developed by the user. By using the Python script language, the user can program automatic operating sequences to simplify recurrent sequences or to run complicated calculation sequences automatically.

Convolutional code analysis calculates the most likely generator polynomial set for each position in the bit stream.



After removing the convolutional code, further bit inversion and the use of an alphabet (Varicode) are sufficient for obtaining the readable text.

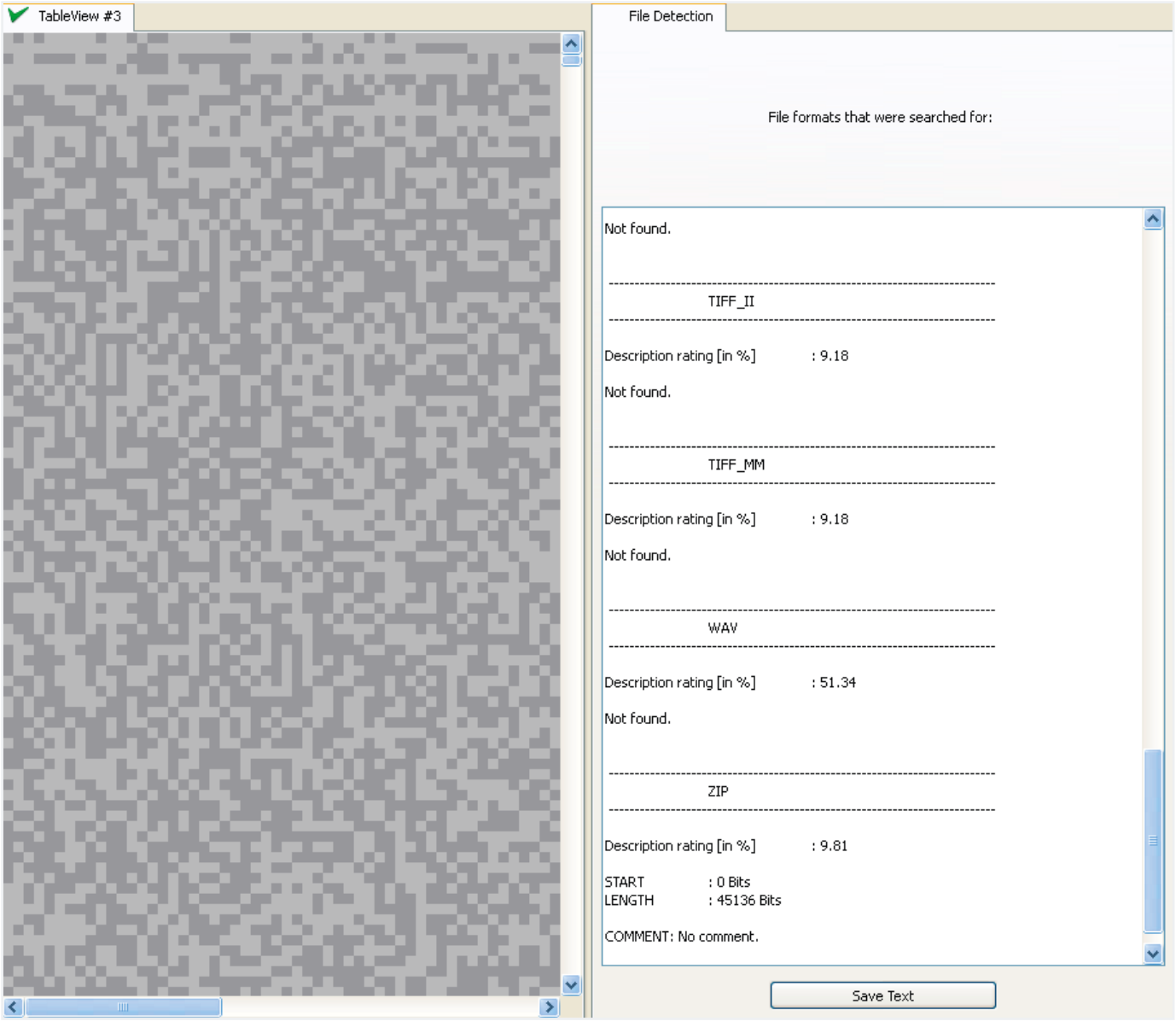


By including and using the generator polynomials in the Viterbi decoder, the convolutional coding on the bit stream is reversed.

Payload analysis

After successful analysis and decoding of a bit stream, its content may be available in plain text. Very often, however, the content is a binary file that requires further processing. By applying file type identification to characteristic bit patterns, the user can determine the type of file that has been extracted (e.g. WAV, ZIP, BMP, PDF, MP3). The user can expand the list of identifiable file types. After the file type has been identified, an appropriate program can be used outside of R&S®CA250 to further process the content.

The decoded bit stream was identified to be a compressed ZIP archive with a length of 45136 bits. The compressed file can be unpacked using the DEFLATE algorithm integrated in R&S®CA250, or it can be decompressed by means of an external UNZIP program after the bit stream has been saved.



Specifications

R&S®CA250 bit stream analysis	
Analysis algorithms	Autocorrelation
	Cross-correlation
	Configurable pattern search
	Tsallis entropy
	Maurer test
	Chi-square test
	Histogram
	Calculation of column sum/parity
	Calculation of line sum/parity
Decoder and manipulation functions	Symbol-to-bit conversion
	Conversion of differential coding to absolute coding
	Line codes
	NRZ-L
	NRZ-M
	NRZ-S
	Boolean operations
	Multiplexing
	Demultiplexing
	Extract items
	Symbol-to-symbol mapper
	Symbol adder
	Channel serialization
	ASCII alphabet
	Baudot (ITA2) alphabet
	ITA3 alphabet
	ITA476-5 alphabet
	ITA2-P alphabet
	RUM-FEC alphabet
	HNG-FEC alphabet
	Varicode alphabet
	Huffmann alphabet
Representation	Symbol stream/bit stream in tabular form
	Decimal representation (0/1)
	Hexadecimal representation
	–/X representation
	Graphical visualization
	Display of demodulation quality as color-coded background
	Tags for start-of-burst
	Tags for the first channel (in multichannel methods)
	Zoom functions
	Line charts
	Window for displaying decoded text
System functions	Generation of reports in XML format (compatible with R&S®ReportEdit)

Recommended computer equipment	
Operating system	Windows
CPU (minimum)	Intel Pentium IV, 3 GHz
Memory (minimum)	1 Gbyte
Graphics card	OpenGL 1.4 capable
Hard disk memory (minimum)	150 Mbyte (for installing R&S®CA250)
Minimum screen resolution	1024 pixel × 768 pixel
Sound playback	Sound card

R&S®CA250-E extended bit stream analysis	
Analysis algorithms	Search for CRC codes
	Search for BCH codes
	Search for Reed-Solomon codes
	Analysis of rate 1/N convolutional codes
	Analysis of 1/N to rate K/N punctured convolutional codes
	Analysis of rate K/N convolutional codes
	Search for the most common polynomials
Decoder and manipulation functions	Block interleaving
	Block interleaver with skip bits
	Cross interleaving
	Convolutional interleaving
	Helical interleaving
	CRC decoder
	BCH decoder
	Reed-Solomon decoder
	Viterbi decoder with/without puncturing

R&S®CA250-P professional bit stream analysis	
Analysis algorithms	Analysis of additive scrambling
	Analysis of multiplicative scrambling
	Analysis of spread spectrum code (DSSS)
Decoder and manipulation functions	Additive descrambling
	Multiplicative descrambling
	Despreader
	A-law/μ-law voice codec (in line with ITU G.711)
	ADPCM voice codec (in line with ITU G.726)
	LD-CELP voice codec (in line with ITU G.728)
	CVSD voice codec (in line with STANAG 4209)
	LPC-10 voice codec (in line with STANAG 4198)
	MELP voice codec (in line with STANAG 4591)
Representation	Audio player for playing back decoded voice codecs
System functions	Application automation via script control (Python)
	Linking of customer-specific algorithms via MS Windows DLL interface

R&S®CA250-PA payload analysis	
Analysis algorithms	File detection
Decoder and manipulation functions	LZRW1-3
	Deflate
	UUDecode
	Sequence generator

Ordering information

Designation	Type	Order No.
Bit Stream Analysis, including bit stream representation and bit stream manipulation	R&S®CA250	4076.5009.02
Options		
Extended Bit Stream Analysis and Decoding; requires R&S®CA250	R&S®CA250-E	4076.5180.02
Professional Bit Stream Analysis and Decoding, including algorithm, expandability and automation (script language); requires R&S®CA250-E	R&S®CA250-P	4076.5196.02
Payload Analysis	R&S®CA250-PA	4076.5215.02

Service you can rely on

- Worldwide
- Local and personalized
- Customized and flexible
- Uncompromising quality
- Long-term dependability

About Rohde&Schwarz

Rohde&Schwarz is an independent group of companies specializing in electronics. It is a leading supplier of solutions in the fields of test and measurement, broadcasting, radiomonitoring and radiolocation, as well as secure communications. Established more than 75 years ago, Rohde&Schwarz has a global presence and a dedicated service network in over 70 countries. Company headquarters are in Munich, Germany.

Environmental commitment

- Energy-efficient products
- Continuous improvement in environmental sustainability
- ISO 14001-certified environmental management system

Certified Quality System
ISO 9001

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