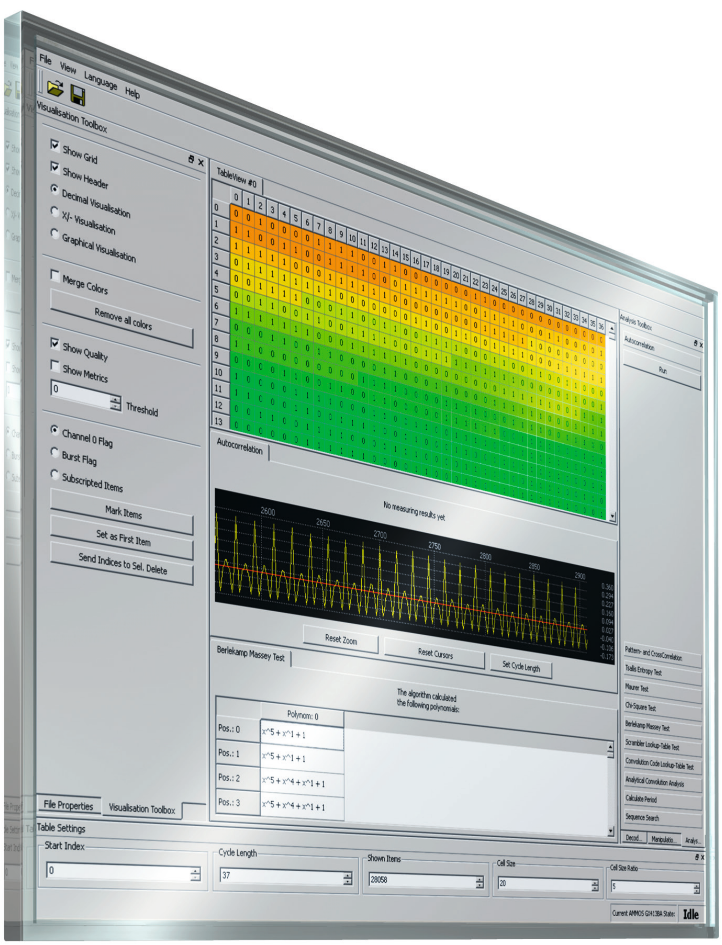
R&S®CA250
Bitstream Analysis
Analysis and manipulation of signals at bitstream/ symbol stream level



ROHDE&SCHWARZ

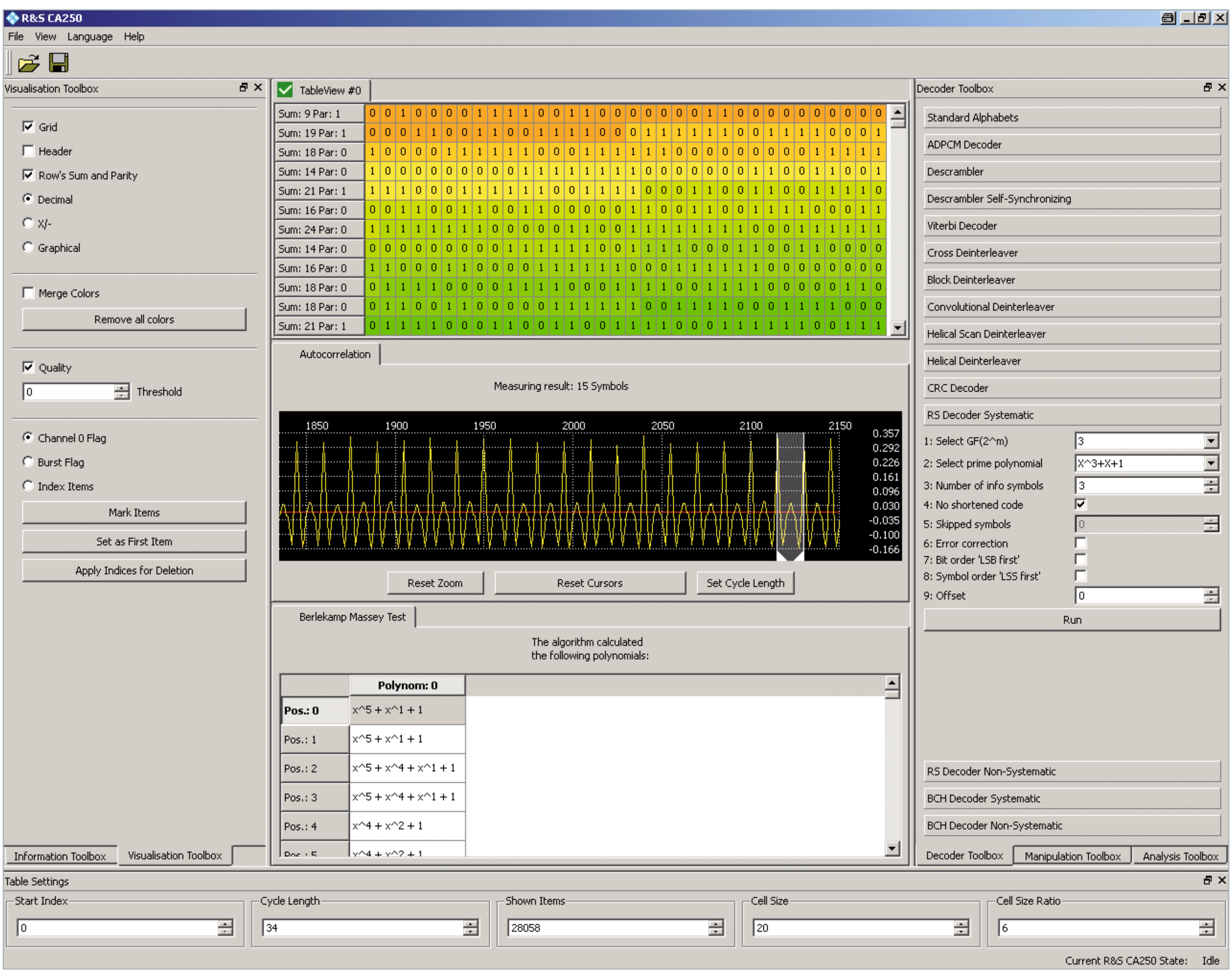
Product Brochure | Version 06.00

R&S®CA250 Bitstream Analysis
At a glance

By selectively using these tools, the user can obtain technical data from the unknown bitstream. 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, thereby allowing the user to program a specific decoder for the unknown signal (e.g. by using the R&S®GX400ID decoder development environment).

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

Operating window



R&S®CA250 Bitstream Analysis Benefits and key features

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

▷ page 4

Versatile bitstream analysis functions
- Structure analysis
- Statistical methods

▷ page 6

Advanced code analysis functions
- Automatic recognition of channel codings (convolutional, Reed-Solomon codes, etc.)
- Manual expert analysis tools

▷ page 7

Wide variety of processing functions for channel-coded bitstreams
- Standard manipulation such as deletion, inversion, multiplexing and demultiplexing
- Complex bitstream processing methods such as descrambling and deinterleaving
- Processing of channel coding (convolutional, Reed-Solomon and other codes)

▷ page 8

Payload analysis and processing
- Automatic detection of typical payload structures
- Various alphabets
- Digital voice codecs
- Processing of compressed data

▷ page 9

Automation, extensibility and versatility
- Integration of user-specific algorithms into the R&S®CA250 operation sequences
- Programmable script control for performing automatic analysis sequences
- Various user-configurable and extensible functions

▷ page 10

Versatile data import and symbol stream/bitstream representation

Data import and symbol stream/bitstream representation

R&S®CA250 supports the import of files in different symbol stream and bitstream 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 bitstream 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 (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

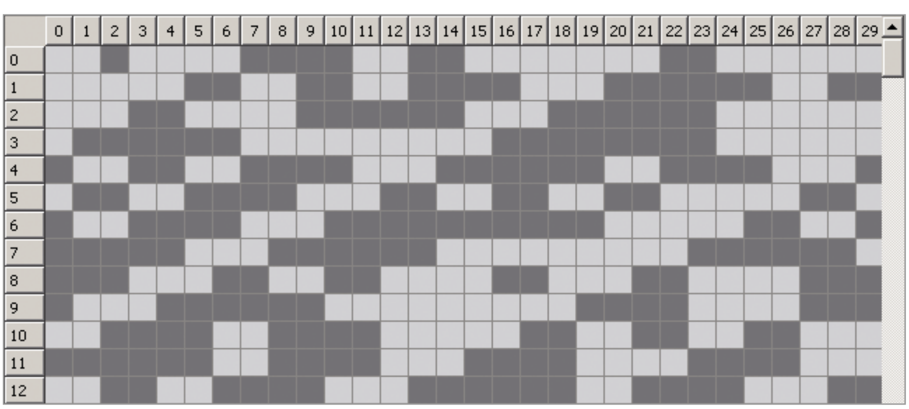
Bitstream in 0/1 representation obtained from a symbol stream after using the natural symbol-to-bit mapping

	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

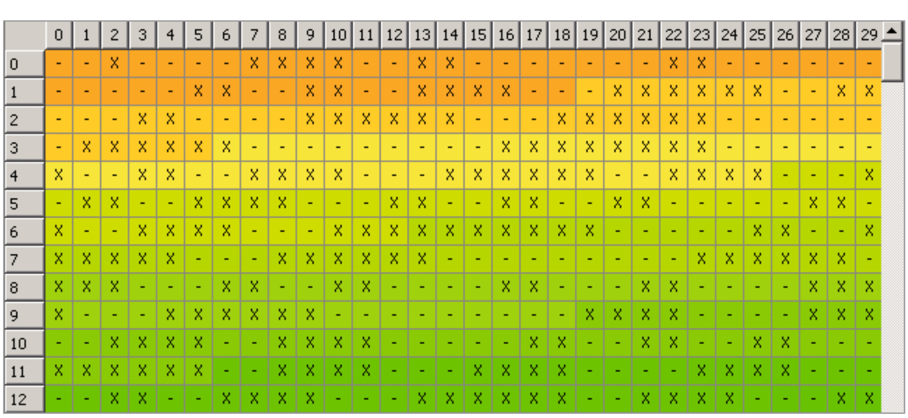
Bitstream in –/X representation

The bitstream 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 × number of columns).

If the original symbol streams were obtained by using R&S®GX400, R&S®GX410 or R&S®CA100, each symbol contains quality information that is added during demodulation. This information is transferred to the bitstream generated from the symbol stream and can be visualized in color. The user can easily distinguish between segments with good quality and those with bad quality, where analysis might be less promising.



Bitstream in graphical visualization



–/X representation of a bitstream with highlighted quality information on every bit (red: low quality; green: high quality)

Versatile bitstream analysis functions

Structure analysis

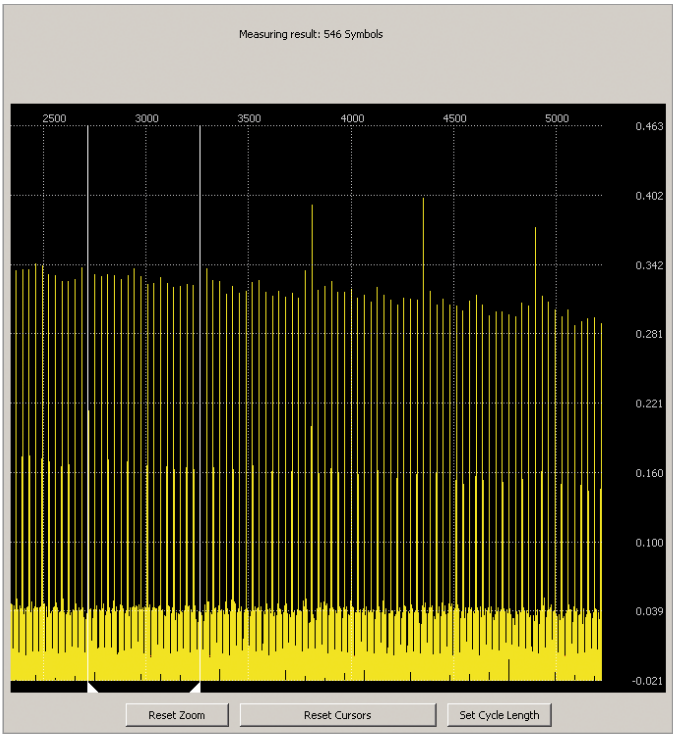
For the analysis of bit structures, R&S®CA250 features versatile functions such as autocorrelation and cross-correlation, configurable pattern search, entropy test (Tsallis, Maurer, chi-square), calculations of column sum/parity and line sum/parity.

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

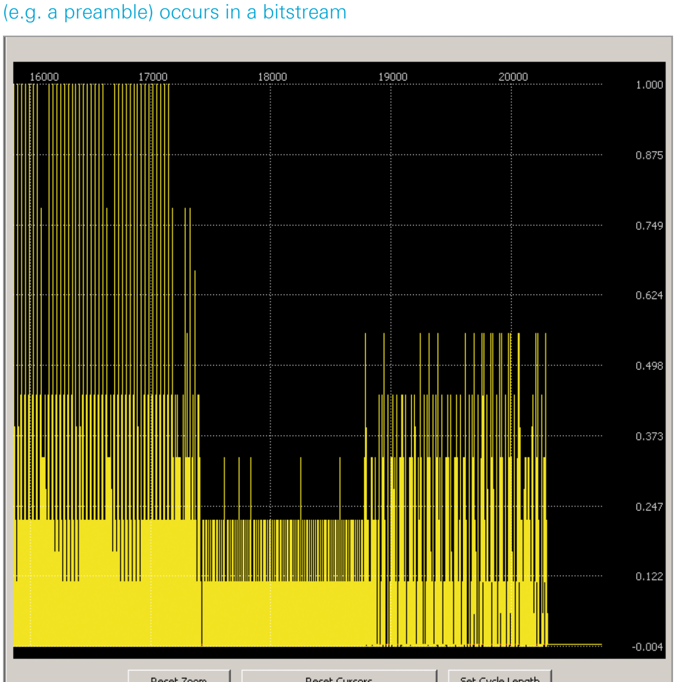
Statistical methods

An entropy test is available for analyzing block codes. It involves testing the bitstream 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.

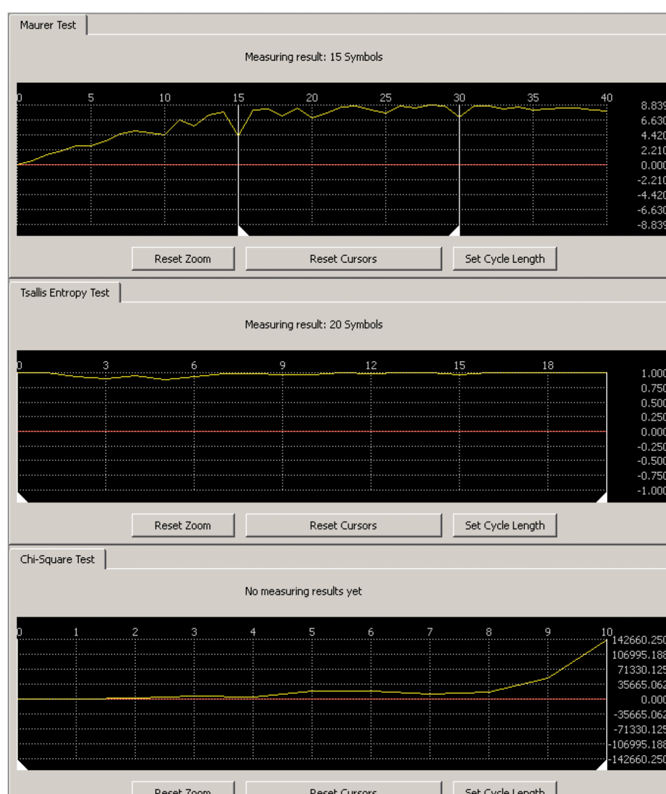
Maxima in autocorrelation representation indicate regular, repeating structures (e.g. frame structures) in the bitstream



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



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 bitstream is divided into 15-bit code words, any regular occurrence is revealed (specific code words occur more often than others).



Advanced code analysis functions

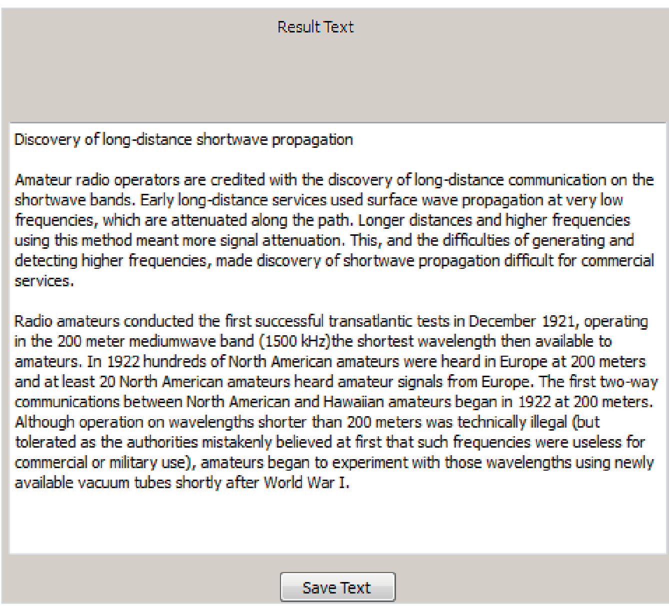
Automatic recognition of channel codings (convolutional, Reed-Solomon codes, etc.)

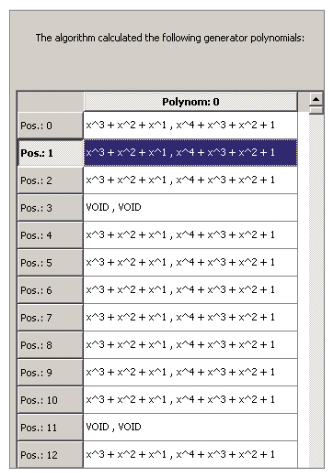
No matter which channel coding, no matter if there are bit errors in the bitstream – R&S®CA250 provides the right tools for recognition of the channel code used. R&S®CA250 features full automatic detection of convolutional, Reed-Solomon and BCH codes.

Manual expert analysis tools

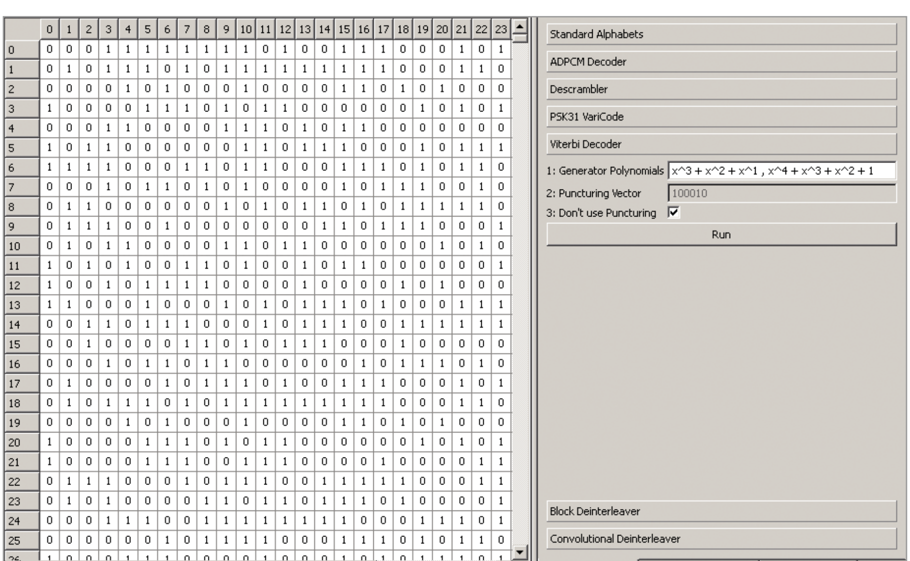
For all of these channel codes, R&S®CA250 provides sophisticated expert analysis tools that give expert analysts the higher level of control and in-depth information they need. Other specific analysis functions for channel codings, such as scrambling and CRC codes, are included. The pictures on this page show a typical analysis flow for a convolutional code.

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





Convolutional code analysis calculates the most likely generator polynomial set for each position in the bitstream

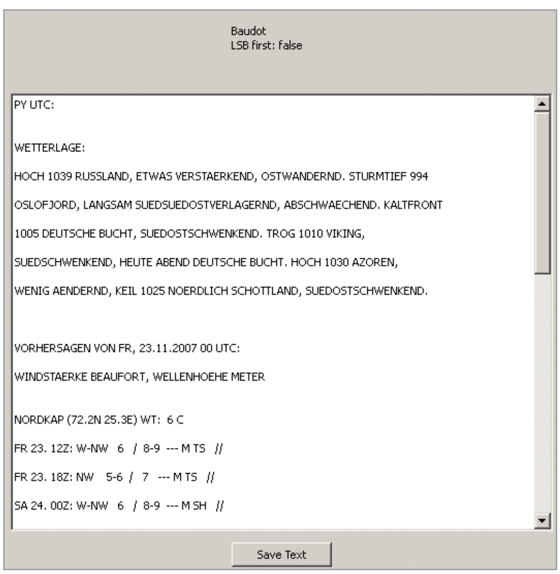


	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
0	0	0	0	1	1	1	1	1	1	1	1	0	1	0	0	1	1	1	0	0	0	1	0	1
1	0	1	0	1	1	1	0	1	0	1	1	1	1	1	1	1	1	1	0	0	0	1	1	0
2	0	0	0	0	1	0	1	0	0	0	1	0	0	0	0	1	1	0	1	0	1	0	0	0
3	1	0	0	0	0	1	1	1	0	1	0	1	1	0	0	0	0	0	0	1	0	1	0	1
4	0	0	0	1	1	0	0	0	0	1	1	1	0	1	0	1	1	0	0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

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

Wide variety of processing functions for channel-coded bitstreams

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



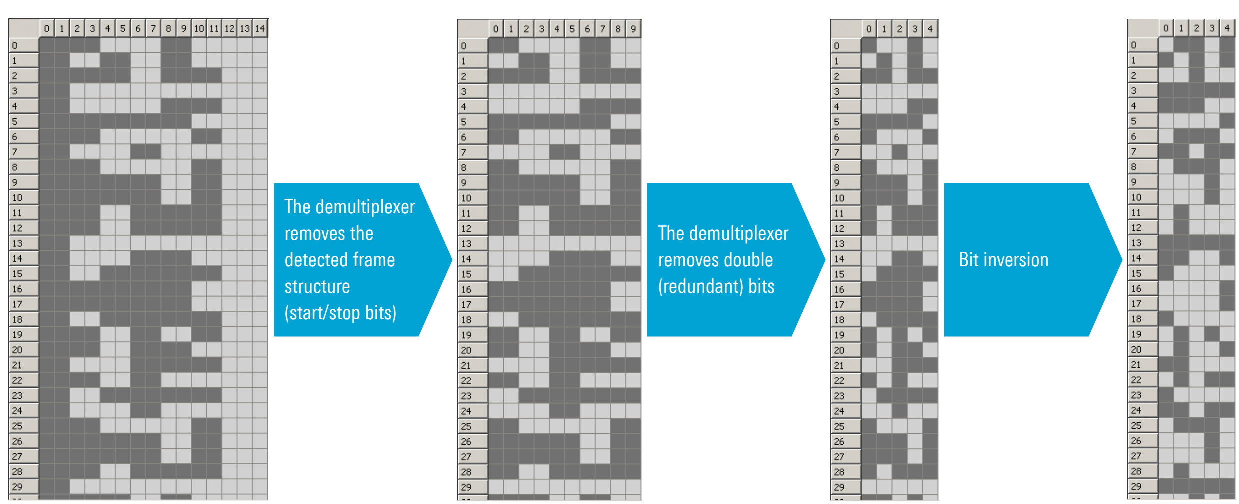
Bit manipulation

R&S®CA250 offers various alternatives for manipulating the bitstream. If an analysis result is available, a function is provided for applying the analysis result to the bitstream 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.

Advanced decoding functions

In modern data transmission systems, typically several channel coding methods are applied subsequently. Therefore, it is important to have the right decoding functions in order to proceed to the transmitted data. Also in this field R&S®CA250 features a wide range of decoding methods. It includes standard decoders such as Viterbi (for convolutional codes), Reed-Solomon, BCH and CRC decoders and also supports many of the most modern decoding methods such as LDPC and various wideband standards.

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



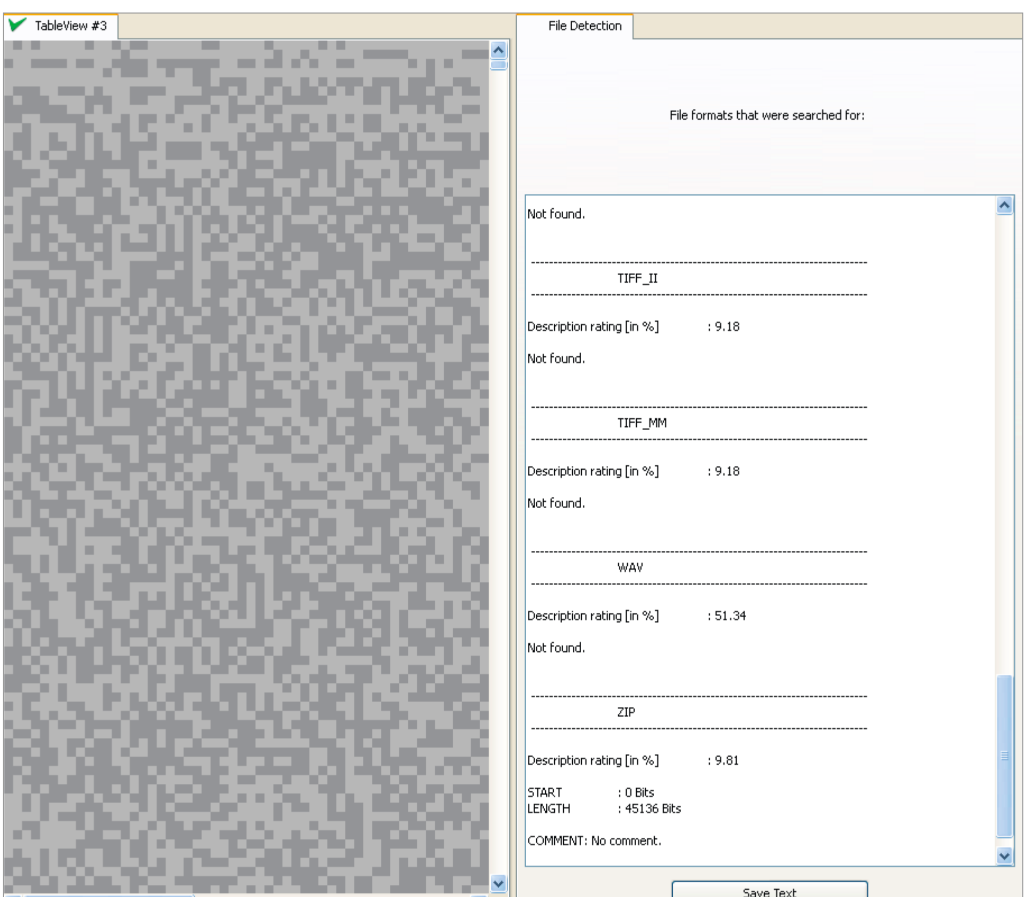
Payload analysis and processing

After successful analysis and decoding of a bitstream, 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.

After successful analysis and decoding of the channel coding layers, the binary content has to be processed according to its type. R&S®CA250 provides a wide variety of tools for this task. The type of the content can be determined using file type identification. This algorithm detects characteristic bit patterns of files, protocols and other payload data structures. R&S®CA250 comes with a library of descriptions for typical payload data (e.g. WAV, ZIP, BMP, PDF, MP3). This library can be easily extended by adding descriptions in .xml format.

Various content types can be processed directly by R&S®CA250. Digital voice is supported with various codecs. Text messages can be easily decoded with numerous alphabet decoders, and even compressed data decoding is supported.

The decoded bitstream was identified to be a compressed ZIP archive with a length of 45 136 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 bitstream has been saved.



Automation, extensibility and versatility

R&S®CA250 offers a broad range of possibilities for custom modifications and extensions. One of those possibilities is the easy integration of user-defined algorithms for bitstream analysis and manipulation. Another valuable feature is the Python script interface. Using the Python script language, the user can program automatic operating sequences to simplify recurrent sequences or to run complicated calculation sequences automatically.

Furthermore, many of the algorithms can be customized by adding or modifying .xml configuration files. This method can be applied to new alphabet decoders for any language, alphabet or character set. The payload analysis can also be extended by this method. It is easy to add the detection of new file formats, protocols or any other content type.

Training courses

The R&S®CA250 training courses offer a combination of classroom based theory lessons and practical exercises. Covering the most important topics, they help analysts to effectively use the R&S®CA250 for bitstream analysis.

The courses provide participants with the necessary knowledge to understand the workflow concept of R&S®CA250 for analysis of recorded symbol streams and bitstreams. All courses are instructor-led with an interactive approach. The instructor uses a mixture of question and answer sessions, continuous assessment and a final exam to ensure effective knowledge transfer.

Course overview

Course title	Target audience	Aim	Duration
R&S®CA250-TI, R&S®CA250 introduction	Decision-makers for signal analysis solutions	Attain basic familiarity with R&S®CA250	1 day (5 hours)
R&S®CA250-TO, R&S®CA250 operator training	Information coding analysts, transmission coding analysts	Attain operational familiarity with R&S®CA250 base version	4 days
R&S®CA250E-TO, R&S®CA250-E option operator training	Information coding analysts, transmission coding analysts	Attain operational familiarity with R&S®CA250-E option	1.5 days
R&S®CA250P-TO, R&S®CA250-P option operator training	Information coding analysts, transmission coding analysts	Attain operational familiarity with R&S®CA250-P option	1.5 days
R&S®CA250PA-TO, R&S®CA250-PA option operator training	Information coding analysts, transmission coding analysts	Attain operational familiarity with R&S®CA250-PA option	0.5 days
R&S®CA250CA-TO, R&S®CA250-CA option operator training	Information coding analysts, transmission coding analysts	Attain operational familiarity with R&S®CA250-CA option	1.5 days
R&S®CA250D-TO, R&S®CA250-D option operator training	Information coding analysts, transmission coding analysts, third-party algorithm developers, system integrators	Attain operational familiarity with R&S®CA250-D option	2 days

Ordering information

Designation	Type	Order No.
Bitstream analysis, including bitstream representation and bitstream manipulation	R&S®CA250	4076.5009.03
Licensing option		
Licensing of R&S®CA250 with USB dongle	R&S®CA250-U	4101.3039.02
Licensing of R&S®CA250 with SD card dongle	R&S®CA250-S	4101.3045.02
Licensing of R&S®CA250 with mini-USB dongle	R&S®CA250-M	4101.3051.02
Options		
Extended bitstream analysis and decoding	R&S®CA250-E	4076.5180.02
Professional bitstream analysis and decoding (requires R&S®CA250-E)	R&S®CA250-P	4076.5196.02
Code analysis (requires R&S®CA250-P)	R&S®CA250-CA	4076.5221.02
Payload analysis	R&S®CA250-PA	4076.5215.02
Development edition	R&S®CA250-D	4076.5238.02
Additional options		
Upgrade package to version ≥ 04.00 (contact Rohde & Schwarz for more information) [1]	R&S®CA250UP	4076.5244.02

[1] Older R&S®CA250 releases with version < 04.00 have to be upgraded before all features described in this brochure can be used. To upgrade, the old USB licensing dongle has to be returned to Rohde & Schwarz and will be replaced with R&S®CA250-U, R&S®CA250-S or R&S®CA250-M.

Note:
Rohde & Schwarz licenses for R&S®CA250 are stored on a USB dongle, mini-USB dongle or SD card. If the dongle or SD card is lost, stolen or misplaced, Rohde & Schwarz will not provide a replacement. All licenses stored on the missing device will have to be purchased again at full price. In the unlikely event that a USB dongle, mini-USB dongle or SD card is corrupt or broken, it will be replaced by Rohde & Schwarz only if the defective device is returned to Rohde & Schwarz. A moderate fee will be charged for producing and sending the replacement.

All options require the R&S®CA250 base version.

Operator training courses		
Designation	**Type**	**Order No.**
R&S®CA250 introduction	R&S®CA250-TI	3637.2530.02
R&S®CA250 operator training	R&S®CA250-TO	3637.3937.02
R&S®CA250-E option operator training	R&S®CA250E-TO	3637.3943.02
R&S®CA250-P option operator training	R&S®CA250P-TO	3637.3950.02
R&S®CA250-PA option operator training	R&S®CA250PA-TO	3637.4140.02
R&S®CA250-CA option operator training	R&S®CA250CA-TO	3637.4156.02
R&S®CA250-D option operator training	R&S®CA250D-TO	3637.4162.02

Your local Rohde & Schwarz expert will help you determine the optimum solution for your requirements.
To find your nearest Rohde & Schwarz representative, visit
www.sales.rohde-schwarz.com

Service that adds value

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

Rohde & Schwarz

The Rohde & Schwarz electronics group offers innovative solutions in the following business fields: test and measurement, broadcast and media, secure communications, cybersecurity, monitoring and network testing. Founded more than 80 years ago, the independent company which is headquartered in Munich, Germany, has an extensive sales and service network with locations in more than 70 countries.

www.rohde-schwarz.com

Sustainable product design

- Environmental compatibility and eco-footprint
- Energy efficiency and low emissions
- Longevity and optimized total cost of ownership

Certified Quality Management ISO 9001

Certified Environmental Management ISO 14001

Rohde & Schwarz training

www.training.rohde-schwarz.com

Regional contact

- Europe, Africa, Middle East | +49 89 4129 12345
  customersupport@rohde-schwarz.com
- North America | 1 888 TEST RSA (1 888 837 87 72)
  customer.support@rsa.rohde-schwarz.com
- Latin America | +1 410 910 79 88
  customersupport.la@rohde-schwarz.com
- Asia Pacific | +65 65 13 04 88
  customersupport.asia@rohde-schwarz.com
- China | +86 800 810 82 28 | +86 400 650 58 96
  customersupport.china@rohde-schwarz.com

PD 5214.0618.12 | Version 06.00 | April 2019 (jr)
R&S®CA250 Bitstream Analysis

5214061812

5214.0618.12 06.00 PDP 1 en