R&S®AMMOS®
R&S®GX401CL
Classification HF

Years of
Driving
Innovation

ROHDE & SCHWARZ
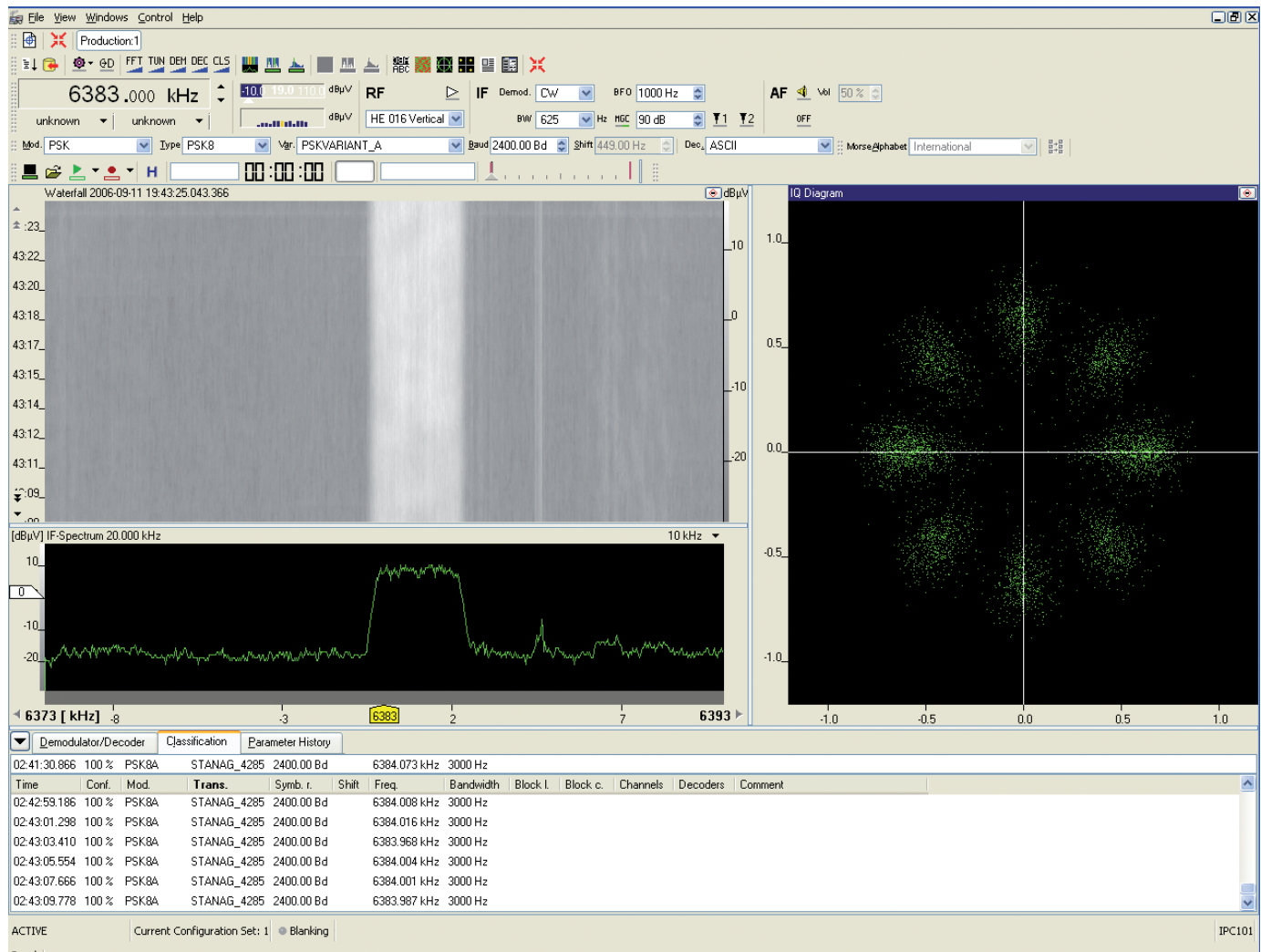
R&S®GX401CL
Classification HF
At a glance

The R&S®AMMOS® system family is designed to detect, automatically intercept, classify, demodulate, decode and analyze radiocommunications signals in the HF and VHF/UHF range.

The R&S®GX401CL classification HF module is used to segment and classify HF transmissions. The classification process contains a modulation recognition module and a bit stream classification module.

R&S®GX401CL offers the following:
▋ Classification of HF signals by modulation type
▋ Recognition of HF signal transmission system
▋ Classification of HF signal bit stream (code)

Screenshot from
R&S®AMMOS®IT software

R&S®GX401CL Classification HF Benefits and key features

Device control

R&S®GX401CL controls the following:
- Segmentation
- Modulation recognition
- Bit stream classification
- Demodulation/decoding (via R&S®GX401DC)
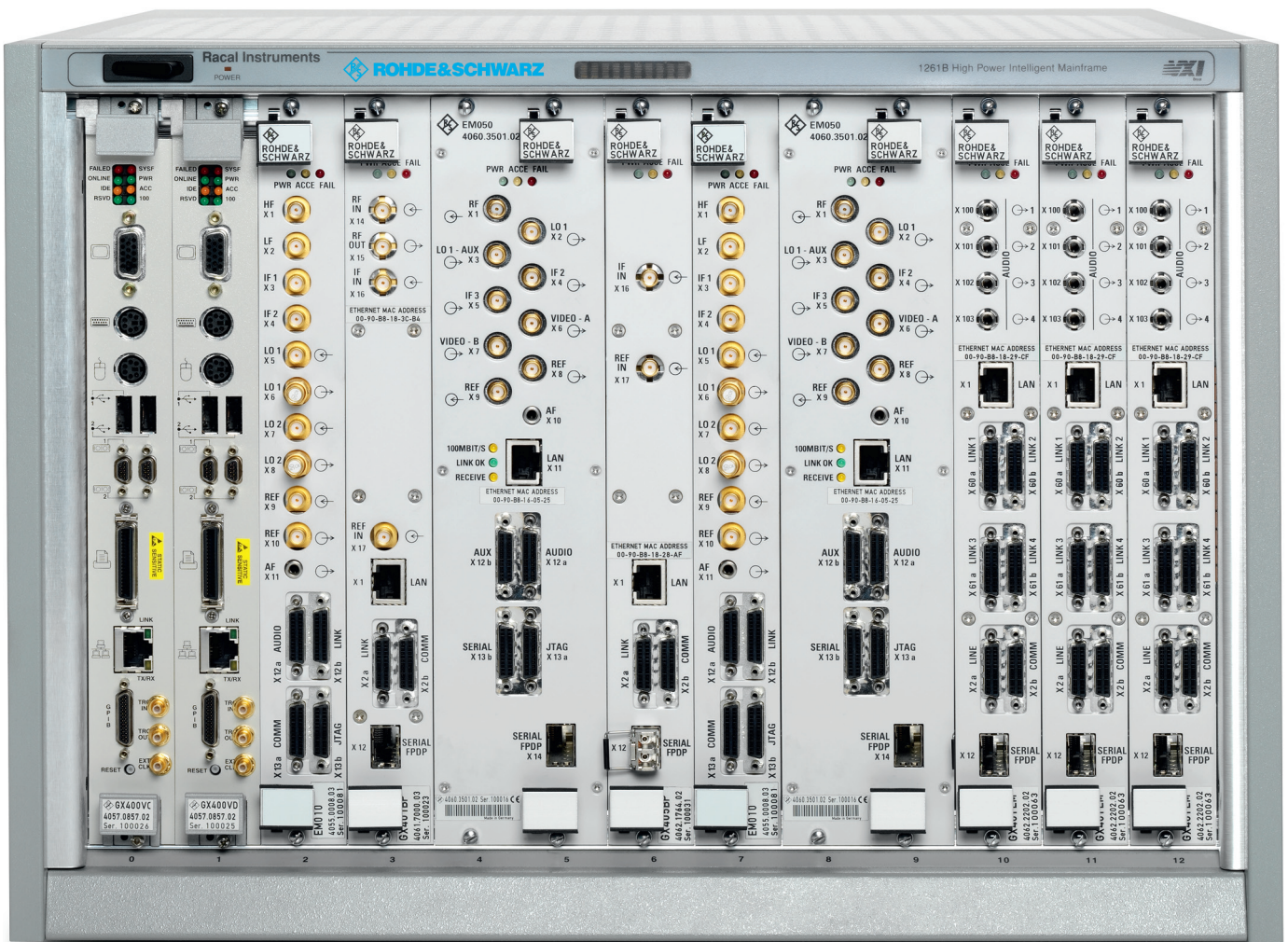- Transmission system recognition

Classification

- Uses modulation recognition to classify the intercepted signal
- Performs decoder based bit stream classification
- User-configurable decision matrix speeds up the bit stream classification process
- Classification bandwidth up to 16 kHz

R&S®GX400 VXI-based monitoring

R&S®GX401CL allows full control to the HF modulation type classification and bit stream classification in the R&S®AMMOS®GX400 sensor groups.
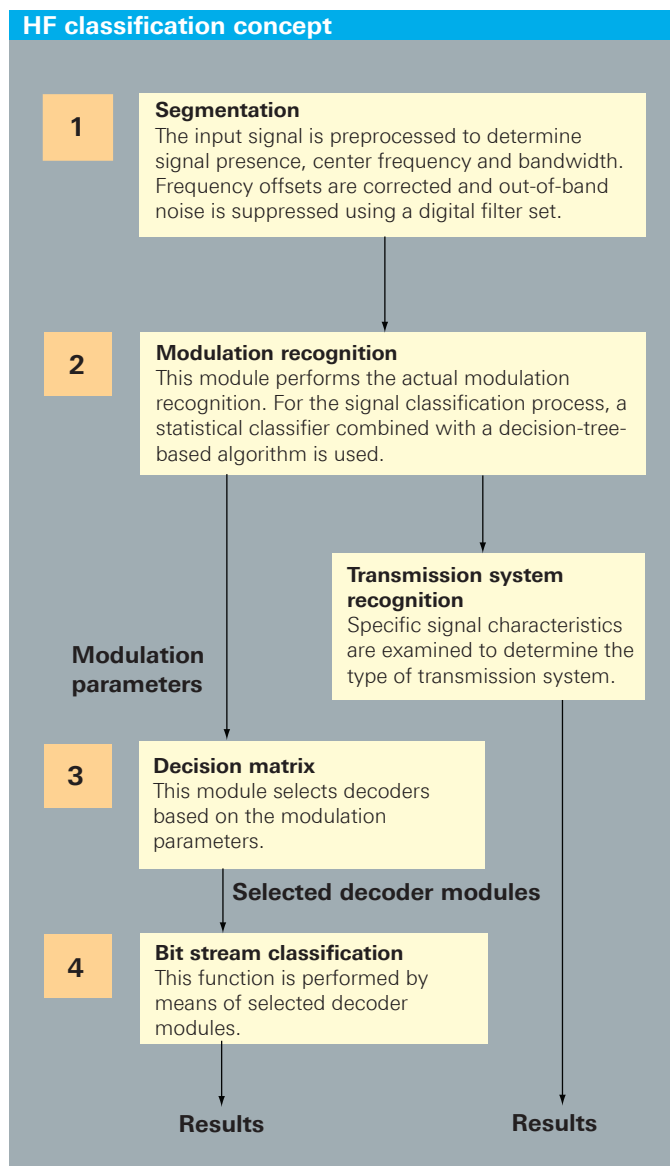
R&S®AMMOS®GX400
sensor group

R&S®GX401CL
Classification

R&S®GX401CL uses modulation recognition to classify the intercepted signal and also performs decoder-based bit stream classification. In the manual mode, the modulation recognition module outputs the results for the operator. The operator can manually set the parameters for demodulation/decoding.

In the automatic mode, the modulation recognition module directly parameterizes the demodulator (R&S®GX401DC), which is parameterized via the sensor control system. The modulation recognition result is also used – together with a matrix reduction filter – by the sensor control to reduce the number of decoding methods for the subsequent bit stream classification process.

The candidate decoders are parameterized and started. By evaluating the decoder status messages, the classification HF module determines a bit stream classification result.

After successful classification, the signal can be demodulated/decoded. In parallel, the modulation recognizer continuously classifies the signal and reports the technical parameters. Information about the classification capabilities of the R&S®GX401CL module is provided in the "Specifications" section at the end of this document.

The decision matrix for bit stream classification evaluates the calculated modulation parameters in order to determine which decoder modules need to be active in the subsequent bit stream classification. This mechanism optimizes and speeds up the classification process.

An entry in the matrix for a decoder module defines the range (e.g. modulation types, variants, baud rate, shift, block length, channel number, etc.) of modulation parameters. If the modulation recognition results fall within the defined range, the decoder module will be active during bit stream classification.

If the results occur outside the defined range, the decoder module will be deactivated during bit stream classification. The decision matrix can be configured by the R&S®AMMOS® operator (in order to modify the current entries or to extend the matrix, e.g. after developing new decoders with the R&S®GX400ID decoder development equipment).

The modulation recognition module included in R&S®GX401CL continuously classifies the signal. A result may be selected manually or automatically in order to set up the demodulator/decoder or to perform bit stream classification.

The classification HF module will process the signal that is nearest to the center frequency of the analysis range. Signals with a bandwidth of up to 16 kHz can be processed.

Classification
R&S®GX401CL provides the following settings:
- Analysis bandwidth
- Starting time
- Restrictive search parameters
  (e.g. analog, digital signal type)

HF classification concept

1 Segmentation
The input signal is preprocessed to determine signal presence, center frequency and bandwidth. Frequency offsets are corrected and out-of-band noise is suppressed using a digital filter set.

2 Modulation recognition
This module performs the actual modulation recognition. For the signal classification process, a statistical classifier combined with a decision-tree-based algorithm is used.

Transmission system recognition
Specific signal characteristics are examined to determine the type of transmission system.

Modulation parameters

3 Decision matrix
This module selects decoders based on the modulation parameters.

Selected decoder modules

4 Bit stream classification
This function is performed by means of selected decoder modules.

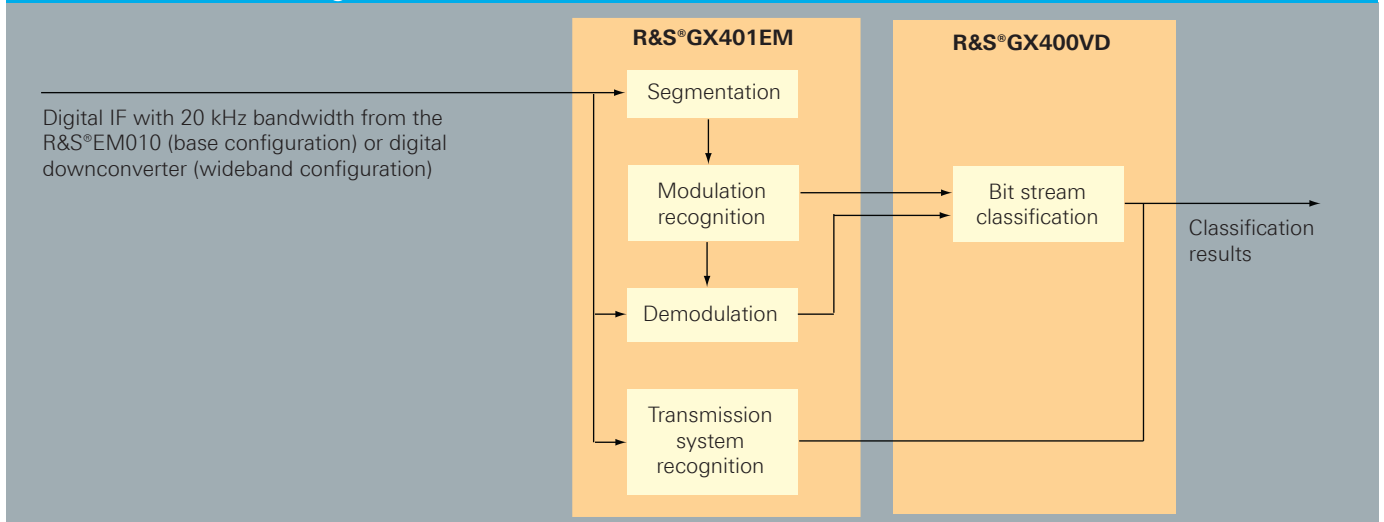Results   Results

R&S®GX400 VXI-based monitoring

The R&S®GX400 VXI-based sensor equipment – which is a sensor group consisting of state-of-the-art VXI receivers and signal processing boards installed in a VXI mainframe – provides high modularity, configurability and multichannel software radio capabilities.

❚ Customer-specific decoders (developed with the R&S®GX400ID decoder development equipment) can be run on the R&S®GX400VD decoder PC for bit stream classification
❚ The number of simultaneously active decoding modules is limited to 16 per running R&S®GX401CL module
❚ The digital IF from the receiver or from the sensor group's external R&S®GX420 replay source (AMREC) is automatically routed to R&S®GX401CL
❚ Transmissions can be recorded/replayed (digital IF) by using the R&S®GX420 recording system
❚ Operators can listen to analog emissions (digital audio)

The control commands, as well as the status data are communicated via the CORBA (common object request broker architecture) interface. The data for visualisation are transferred via TCP/IP or UDP.

R&S®GX401CL block diagram

R&S®GX401EM

Digital IF with 20 kHz bandwidth from the R&S®EM010 (base configuration) or digital downconverter (wideband configuration)

Segmentation

Modulation recognition

Demodulation

Transmission system recognition

R&S®GX400VD

Bit stream classification

Classification results

Specifications

Classification HF

The classification HF module is able to classify the following modulation types (analysis bandwidth up to 16 kHz):

The classification HF module is able to classify the following methods

Analog modulation

CW	
AM DSB-TC	
AM DSB-SC	
AM SSB-LSB	
AM SSB-USB	
FM	

Digital modulation

ASK2	6 Bd to 100 Bd
FSK2	20 Bd to 4800 Bd
FSK4	20 Bd to 3000 Bd
MSK / GMSK	20 Bd to 4800 Bd
PSK2 A/B	30 Bd to 4800 Bd
PSK4 A/B	30 Bd to 4800 Bd
PSK8 A/B	30 Bd to 4800 Bd
OQPSK	30 Bd to 4800 Bd
QAM16	100 Bd to 4800 Bd
multi tone	6 to 32 tones, 5 Bd to 330 Bd
multi channel FSK2 and PSK2	2 to 16 channels, 30 Bd to 4800 Bd, up to 240 Bd per channel

- ARQ-E3
- ARQ-E
  - ARQ1000D
- ARQ-M2 242
  - ARQ TDM 242
- ARQ-M2 342
  - ARQ TDM 342
- ARQ-M4 242
- ARQ-M4 342
- ARQ-N
  - ARQ1000
- ARQ 6-70
- ARQ 6-90
- ARQ 6-98
- ASCII
  - RTTY7
  - IRA-ARQ
- AUTOSPEC
- BAUDOT
  - RTTY5
- BULG-ASCII

- CH4+4 modem
- CIS-11
  - TORG 10/11
- CIS-12
  - FIRE
- CIS-14
  - PARITY 14
  - CIS 96
  - AMOR
  - AMOR 96
  - TORG 14
- CIS-36
  - CROWD 36
  - Russian Piccolo
  - URS multitone
  - CIS 10-11-11 MFSK
- CODAN
- COQUELET 8
  - Mk 2
- COQUELET 13
  - Mk 1
- COQUELET 80
  - Coquelet 8 FEC
- DUP-ARQ
  - ARQ Duplex
- DUP-ARQ-2
- DUP-FEC-2

- FARCOS
- FEC-A
  - FEC100A
- FEC-S
  - FEC1000S
  - SI-FEC
- G-TOR
- HF-FAX (FM)
- HNG-FEC
- MIL-STD 188-110A Serial
- MORSE
- PACTOR I
- PACTOR II
- PACTOR III
- PACKET RADIO
- PICCOLO MK6
- PICCOLO MK12
- POL-ARQ
- PSK-31
  - BPSK31
  - QPSK31
- PSK-63
  - BPSK63
  - QPSK63

- RUM-FEC
  - ROU FEC
- SI-ARQ
  - ARQ-S
  - ARQ1000S
- SITOR-A
  - SITOR-ARQ
- SITOR-B
  - SITOR-FEC
- SKYFAX
- SPREAD11
- SPREAD21
- SPREAD51
- STANAG 4285
- STANAG 4529
- SWED-ARQ
  - ARQ-SWE
- TWINPLEX ARQ (F7B)

Data output interface

The classification HF module measures the following technical parameters (where applicable):

- Center frequency
- Bandwidth
- Signal power
- Start time
- Analog modulation type
- Digital modulation type
- PSK-variant A/B
- Modulation level
- Shift
- Symbol rate
- Channel spacing
- Number of channels
- Burst length
- Confidence level
- Coding method

Accuracy of measured parameters

Within limits shown in the table below

FSK	Baud rate	3‰
	Center frequency	20‰ of baud rate
PSK	Baud rate	2‰
	Center frequency	1.5‰ of baud rate

Results were measured for an additive white gaussian noise (AWGN) channel.

Quality of modulation classification

For the specified S/N ratios, the error rate for false negative reports (classified as unknown) is ≤10%.

For the specified S/N ratios, the probability for false positive reports (classified as incorrect signal type) is ≤1%.

FSK2	m = 0.8 to 1.0	100 Bd to 3000 Bd	12 dB E_b/N_0
		50 Bd	14 dB E_b/N_0
FSK2	m = 5	100 Bd to 600 Bd	14 dB E_b/N_0
FSK4	m = 1	100 Bd to 1200 Bd	11 dB E_b/N_0
MSK	m = 0.5	100 Bd to 4800 Bd	12 dB E_b/N_0
PSK2 A		100 Bd to 4800 Bd	9 dB E_b/N_0
PSK2 B		100 Bd to 4800 Bd	13 dB E_b/N_0
PSK4 A		100 Bd to 4800 Bd	9 dB E_b/N_0
PSK4 B		100 Bd to 4800 Bd	13 dB E_b/N_0
PSK8 A		100 Bd to 4800 Bd	12 dB E_b/N_0
PSK8 B		100 Bd to 2400 Bd	18 dB E_b/N_0
PSK8 B		2400 Bd to 4800 Bd	16 dB E_b/N_0

Results were measured for an additive white gaussian noise (AWGN) channel (m = modulation index).

Ordering information

Type	Designation
Base component	
R&S®GX401CL	Classification HF (requires R&S®GX401DC)
For further information, please refer to the R&S®EM010, R&S®GX401EM, R&S®GX401DC, R&S®GX403TW, R&S®GX400ID and R&S®AMMOS® system family data sheets.	

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 75 years ago, Rohde&Schwarz has a global presence and a dedicated service network in over 70 countries. Company headquarters are in Munich, Germany.

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DQS REG. NO 1954 UM

More information at
www.rohde-schwarz.com
(search term: GX401CL)