Automatic radiomonitoring with the R&S®GX435 signal analysis system

R&S®GX435 is a powerful, flexible, fully automatic solution for detecting, classifying and processing radiocommunications signals. It is used in multichannel monitoring systems in combination with Rohde & Schwarz monitoring receivers to process signals from the HF to the SHF range.

R&S®GX435 at a glance

The R&S®GX435* multichannel signal analysis system supports a wide spectrum of applications ranging from manual signal processing and analysis of an individual signal to automatic recognition of all the signals in a wideband signal scenario. The software runs on modular, easy-to-maintain hardware components (Fig. 1), connected to Rohde & Schwarz monitoring receivers. R&S®GX435 is scalable, from a few channels up to systems with 126 channels per receiver. It also provides open interfaces for integrating customized signal processing modules.

R&S®GX435 combines powerful signal classifiers and an extensive library of demodulators/decoders with automatic signal processing workflows. Users can adapt these extensive resources flexibly to suit their own specifications and requirements. To achieve the most effective signal search and detection workflow, the system supports three different operating modes.

Detection of fixed frequency and burst signals

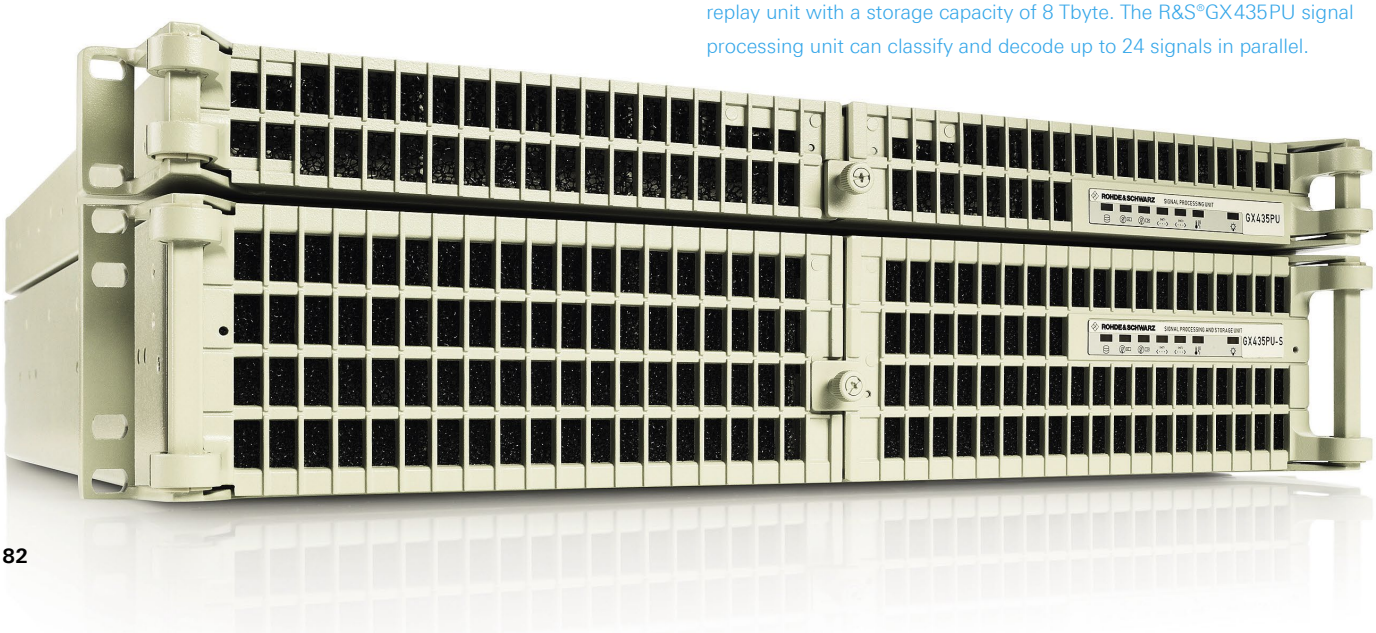
Basics

R&S®GX435 has been specially tailored for fully automatic signal searching, monitoring and processing. The system supports a combination of automatic signal detection and classification with automated signal processing (demodulation, decoding and recording).

In automatic signal detection, the system monitors user-selected frequency ranges for fixed frequency and burst signals. The detector detects signal events in the receiver's FFT spectrum based on spectral energy levels above a defined threshold. This threshold is adapted to reflect the current noise floor. The software generates a detection result for every detected signal that matches the predefined criteria (bandwidth, level, etc.) and compares the results cyclically with the results from prior processing cycles. The detected signals can be classified and measured automatically. The system reports the following emission events:

* The system was presented in NEWS (2011) No. 204, pp. 58–61. It is now marketed as the R&S®GX435 multichannel signal analysis system, with enhanced features and new hardware modules.

Fig. 1 R&S®GX435 comprises two main hardware components based on multicore PC server technology. The R&S®GX435PU-S signal processing and storage unit (lower component) controls the system, detects the signals, computes the digital downconverters and serves as a recording / replay unit with a storage capacity of 8 Tbyte. The R&S®GX435PU signal processing unit can classify and decode up to 24 signals in parallel.



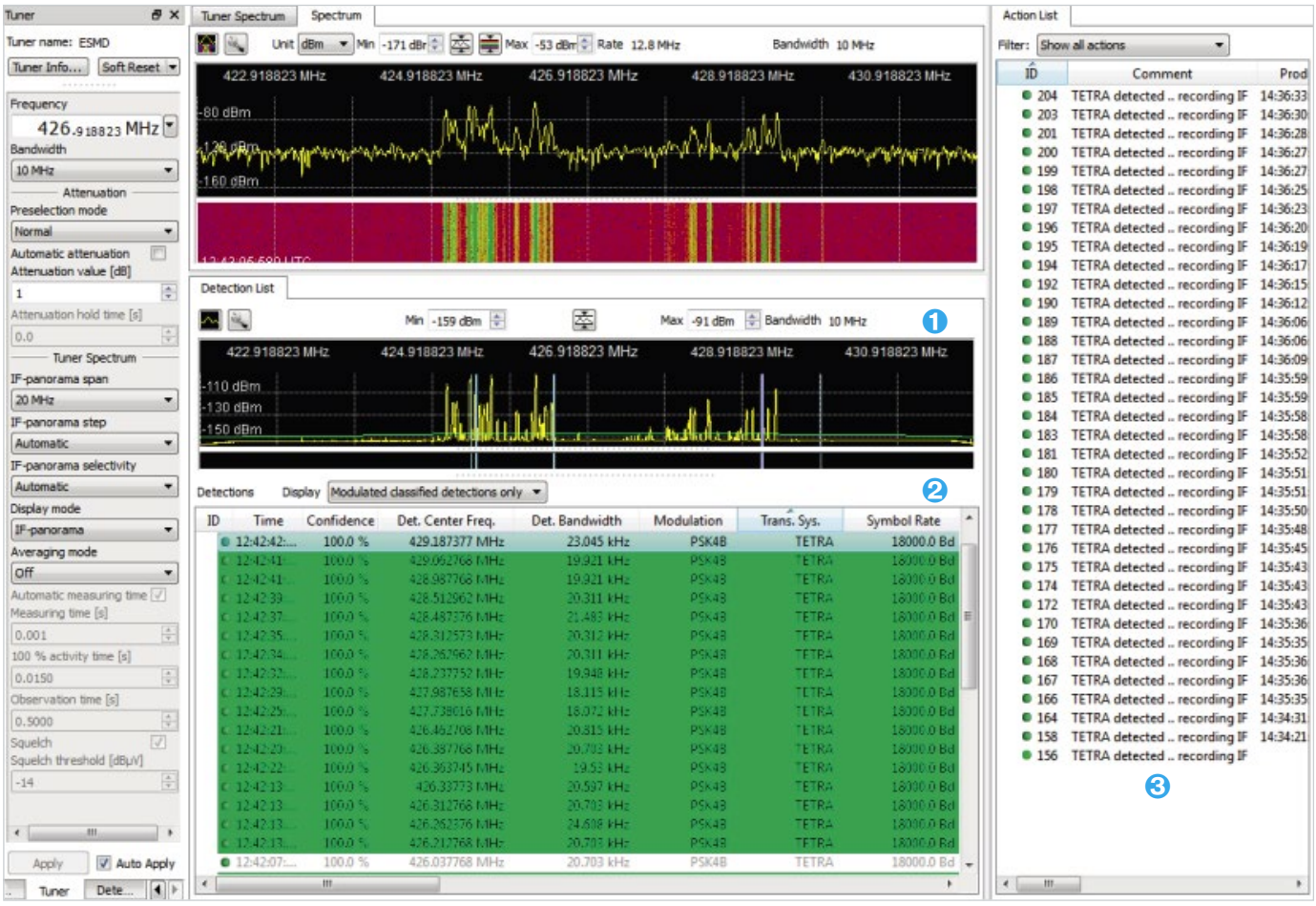


Fig. 2 The fixed frequency mode (FFM) automatically searches for and detects all signals based on their spectral energy (❶) in a defined frequency range within the receiver's realtime bandwidth. The classifiers are then automatically assigned in sequence to the detected signals and the results are compiled in a list (❷). A user-defined rule is applied to each detected signal. The automatic actions that are triggered are logged in a result list (❸).

- New signals (signals exceeding the set threshold for the first time)
- Changes in the characteristics of known signals (changes in the level, bandwidth or center frequency)
- Inactive signals (signals whose level falls below the set detection threshold)
- End of signal

The detector monitors the emission event, determines the emission parameters and tracks the signals based on their assigned emission IDs.

For automatic searching and classification, users can configure the number of classifiers to be used, the desired classification depth and the rules for automatic processing of the detected signals. The classifiers automatically determine the modulation parameters and codes of the emissions found. When more classifiers are allocated, signal scenario reconnaissance is faster and the number of emissions that can be classified in parallel increases. For fully automatic signal processing, users can configure a rule-based automated workflow.

R&S®GX435 has three signal detection modes:

1. Fixed frequency mode (FFM)
2. Scanning mode (with several handoff receivers)
3. Stepping mode (with a single wideband monitoring receiver)

1. Fixed frequency mode (FFM)

Application: automatic signal scenario monitoring and signal detection up to 80 MHz realtime bandwidth, with subsequent automatic signal processing and content recovery.

The monitoring receivers are connected to R&S®GX435 via an Ethernet LAN interface. In the basic version, each receiver delivers an I/Q data stream with a realtime bandwidth of up to 10 MHz. Signal content is extracted with the aid of digital downconverters (DDC) and then processed in parallel, i.e.

classified, demodulated, decoded and the I/Q data recorded (Fig. 2). Each DDC can set its center frequency and bandwidth within the limits of the monitoring receiver's realtime bandwidth. R&S®GX435 works best with Rohde & Schwarz monitoring receivers such as the R&S®ESMD, R&S®EB500 and R&S®EB510. With user-developed drivers, third-party receivers can also be integrated.

The R&S®DDF225 digital direction finder and wideband monitoring receivers such as the R&S®ESMD can be optionally equipped with a board for hardware-accelerated signal processing. The board has four field-programmable gate arrays (FPGA) that support powerful signal processing functions. The most important of these functions are for increasing the detection bandwidth up to 80 MHz and extract a large number of signals via DDCs, enabling the R&S®GX435 multichannel signal analysis system to access wideband signal scenarios up to 80 MHz (HF: 20 MHz) per receiver in realtime for concurrent processing of up to 32 channels (HF: 126).

2. Scanning mode
(with several handoff receivers)

Application: continuous searching for new emissions in a wide frequency range while processing detected signals in parallel.

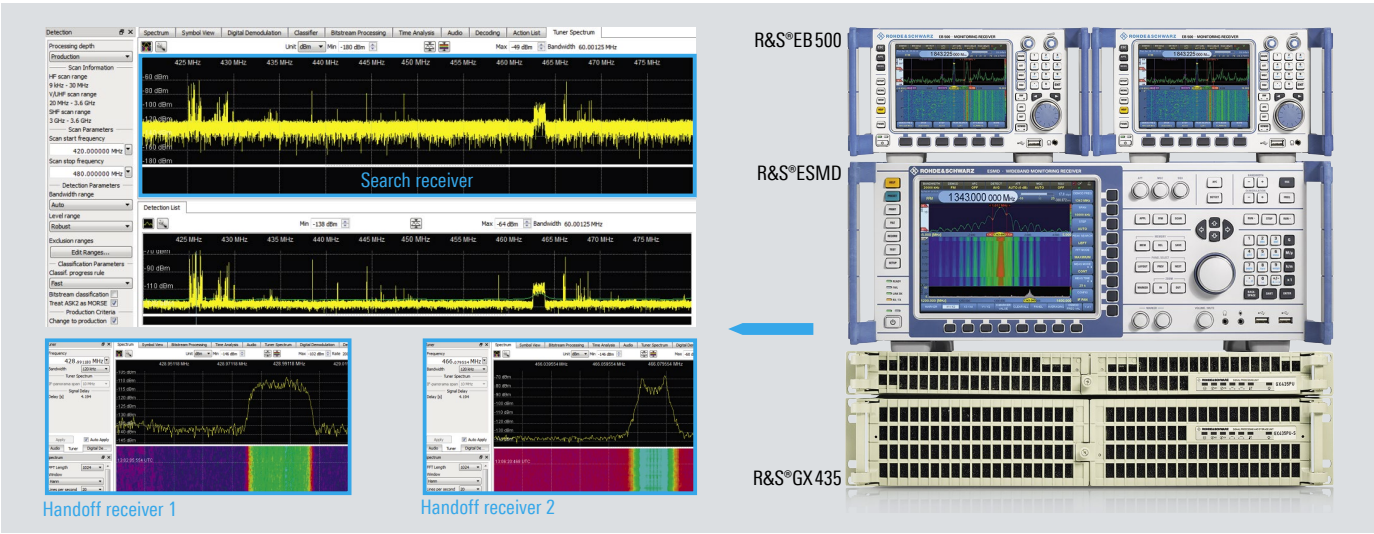
A search receiver is essential when it comes to detecting signals across a wide frequency range. The receiver operates in scanning mode and works with several handoff receivers. The search receiver continuously monitors the spectrum within the set frequency range using panorama scan, and the automatic detector in R&S®GX435 detects all the signals in the range. The handoff receivers act as parallel processing channels to classify, demodulate and decode the detected signals (Fig. 3).

3. Stepping mode
(with a single wideband monitoring receiver)

Application: automatic detection and monitoring of a wide frequency range using a single wideband monitoring receiver; this mode is intended for systems with limited resources.

Compared with the scanning mode described above, the stepping mode only requires a single wideband monitoring receiver with scanning capabilities. First, the receiver operates in scanning mode and searches for emissions in the set frequency range. Next, the scanning mode is halted and the automatic detector searches the spectrum for emissions in the same way as in the fixed frequency mode (see above). The entire scan range is then processed in steps of 10 MHz using DDCs to extract the signals. Steps of 80 MHz are possible using an R&S®ESMD receiver or an R&S®DDF255 direction finder fitted with the hardware-accelerated signal processing board.

Fig. 3 In the scanning mode, the R&S®ESMD wideband monitoring receiver operates as a search receiver, continuously monitoring the spectrum for emissions. Two R&S®EB500 handoff receivers act as processing channels to classify, demodulate and decode signals.



Detecting frequency-agile short-time signals

Application: monitoring frequency-agile radiocommunications.

Besides detecting fixed frequency or burst signals, R&S®GX435 can also automatically detect frequency-agile short-time signals (hoppers). These are intercepted by a detector optimized specifically for this signal type. The detector analyzes each individual hop to determine the relevant technical parameters. This makes it possible to classify each hop and assign it to the relevant transmission system. The software evaluates the parameters statistically and displays the results as a histogram (Fig. 4). It also presents the detection results as a list of short-time emissions along with various parameters, such as frequency, bandwidth, power, start/stop intervals, duration as well as modulation type and modulation parameters. This information enables users to determine the active hopper transmitters and the types of hopper radios.

Summary

R&S®GX435 is a modular, automatic radiomonitoring system for multichannel analysis and processing of analog and digital signals. Thanks to its various signal detection modes and sophisticated signal detectors, it offers fast, reliable and precise signal detection as well as subsequent classification, demodulation, decoding and recording of the signals.

An additional detector, referred to as spectral shape detector, is due to be available in the second half of 2013. It is capable of matching signals based on their spectral shape. Users can then define the spectral shapes of signals of interest, based on either live or recorded signals.

YingSin Phuan

Fig. 4 The spectrum and the waterfall diagram show a frequency hopping signal in the defined frequency range (❶). The histograms (❷) display various emission characteristics (hop duration and bandwidth, modulation type, symbol rate, etc.).