



UltraHD – the future of TV

4K TVs and cameras are already available for affordable prices at any electronics store. There is, however, a great shortage of original 4K content, not least due to broadcast infrastructure insufficiencies. Rohde & Schwarz supplies content providers and network operators with all of the technical means to change this situation.

Ultra high definition television (UHDTV) is one of the hottest topics in the TV industry. Motivated by major sporting events such as the upcoming Olympic Games in Rio, broadcasters, consumer electronics manufacturers and their suppliers are working hard to make UHD solutions ready for use, perfect them and ultimately establish them on the market.

The consumer electronics industry has clearly gained the upper hand in the usual chicken-and-egg dispute this time by offering UHD cameras and TVs. Infrastructure suppliers and broadcasters are faced with the challenge of closing the producer / consumer supply gap and creating a marketable UHD ecosystem. This is no easy task, considering that

data volumes have exploded due to drastically increased picture resolutions (UHD-1: 3840 × 2160 pixels; UHD-2: 7680 × 4320 pixels) and other improvements such as frame rates up to 120 fps, extended color ranges and more powerful audio formats (Fig. 1). The goal, however, is – by using the HEVC (H.265) next-generation coding standard – to achieve twice the compression efficiency of MPEG-4 (H.264) currently used in today's HDTV. As a result, UHDTV programs can then be broadcast via terrestrial networks. In the spring of 2013, the Korean Broadcasting System proved that this entirely feasible when it began using a transmitter from Rohde&Schwarz to regularly broadcast a UHD program in the Seoul metropolitan area (see NEWS 211, page 45).

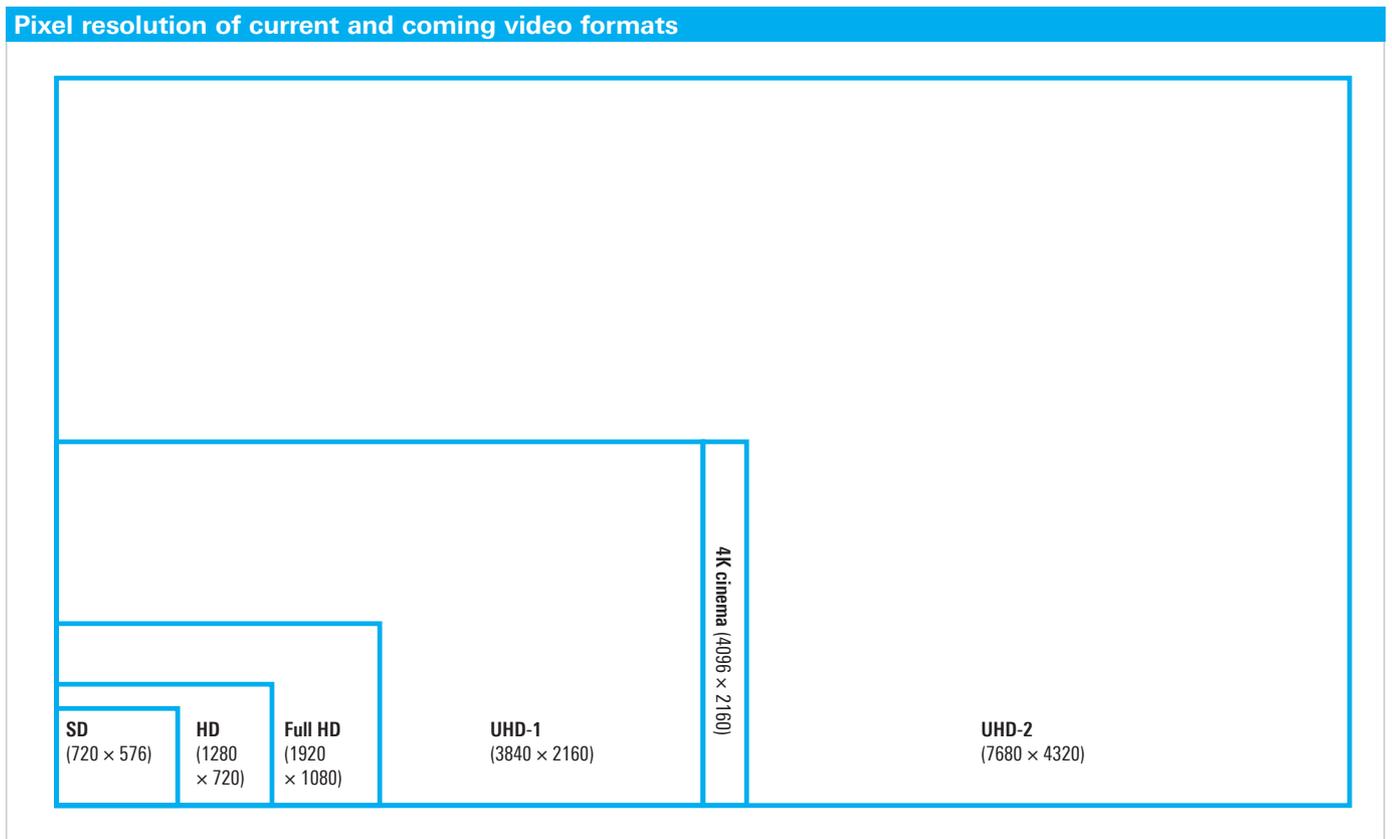


Fig. 1: Comparing pixel counts and their associated data volumes for an uncompressed full-screen picture visualizes the challenge confronting development engineers in coping with UHD.

UHD signal chain from camera to viewer

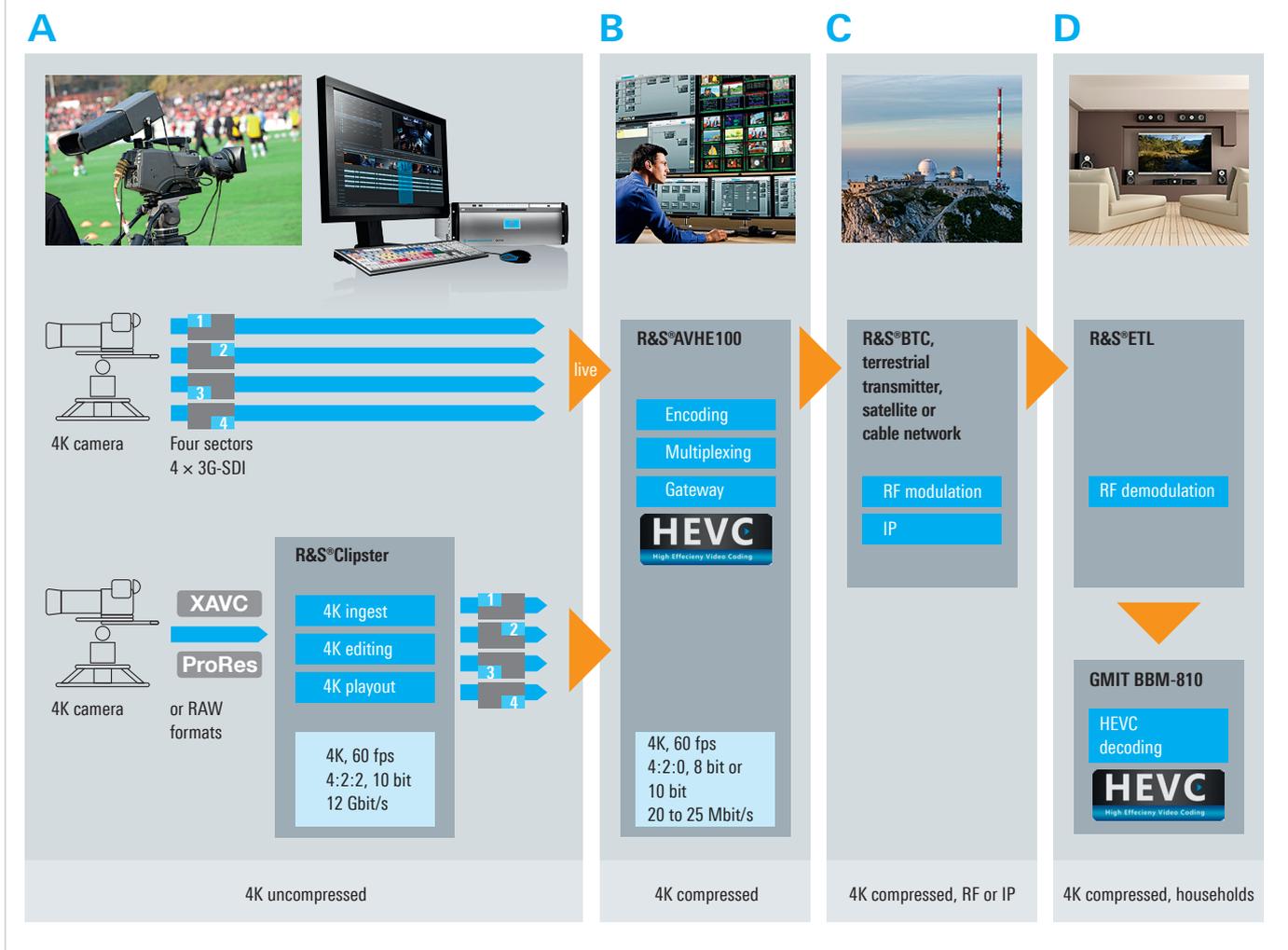


Fig. 2: Components from Rohde&Schwarz enable users to set up an entire UHDTV distribution chain.

Fig. 2 shows a simplified overall UHD signal chain from camera to viewer. Rohde&Schwarz equipment enables users to build the entire chain starting from the camera output.

The original UHD program is recorded with a 4K camera (A). If the broadcast is not live, the uncompressed material is then transferred to a 4K video server (ingest) and edited (e.g. changes to color subsampling and frame rates, special effects, etc.).

When the time to broadcast arrives, the signal is fed via four 3G-SDI cables to a realtime coder, which performs HEVC compression and outputs the result as a transport stream (B).

The transport stream is then broadcast via terrestrial transmitters (DVB-T2), sent to satellite uplinks (DVB-S2) or fed into cable (DVB-C2) or IP networks (IPTV) (C).

The viewer's 4K TV demodulates and decodes the signal on its own or receives it via an HDMI 2.0 connection from a set-top box (D).

The individual steps along this chain are described in greater detail on the following pages.

A Ingest, editing and playback

As a rule, nonlive programs go through an editing, preprocessing and buffering process in the studio prior to preparation for transmission in the headend at broadcast time (Fig. 3). The current generation of R&S®CLIPSTER also accepts camera data in XAVC, ProRes and RAW formats (file-based ingest). All desired operations can then be carried out with utmost ease.

- ▀ Arranging the 4K clips in a timeline
- ▀ Color and other corrections directly on the RAW data

- ▀ Realtime reformatting of the RAW data into any commonly used file format, compressed or uncompressed
- ▀ Interoperable master format (IMF) support: ingest, processing and output (packaging). IMF is used as the standard UHD TV workflow format, as it bridges the gap between digital cinema and the world of broadcasting
- ▀ External R&S®SpycerBox Cell units (see page 9) make it possible to expand the internal R&S®CLIPSTER memory to virtually any capacity. Even Super Hi-Vision (8K) workflows are simple to implement in this way

Ingest, editing and playback



Fig. 3: R&S®CLIPSTER is a high performance universal solution for file-based ingest, digital imaging, format conversion and realtime playback of 4K signals.

B HEVC realtime coder, multiplexer and gateway

The compact R&S®AVHE100 headend processes the 4K program data into a transport stream that can be transmitted. The headend features the latest in high-performance data technology to perform CPU-intensive HEVC encoding in realtime. All of the headend signal flows are IP-based. This is a prerequisite for ensuring high integration density for all functions as well as extensive flexibility in functional structuring to meet individual requirements.

The UHDTV signal is fed from a 4K camera, a downstream control unit or a 4K playout server to the headend via four 3G-SDI cables (data rate: 12 Gbit/s). Unlike other solutions on the market that process the four HD image quadrants separately and only stitch them together into a full 4K picture at the end, the R&S®AVHE100 combines the quadrants prior to editing and works with complete 4K images after that. One advantage is potentially better picture quality, since the higher quality of the playout material ensures that the seams between quadrants remain invisible. In contrast, separate processing can lead to unclear interfaces depending on the quality of encoding. System scalability is

another benefit of complete image processing; customers only purchase the computing power that they need. A typical configuration, for example, is designed for a 4K signal with 60 frames per second and very good picture quality. The hardware (processor performance) is tailored accordingly. Hardware can simply be added if requirements such as higher frame rates appear.

In conclusion, the R&S®AVHE100 performs the following functions:

- Synchronizes the four 3G-SDI signals into a single 4K image (stitching)
- Carries out color subsampling of incoming UHD signals from 4:2:2 to 4:2:0 in line with ITU UHD-1
- Performs HEVC realtime encoding with 8-bit or 10-bit color depth
- Generates UHDTV multiplex and PSI/SI or PSIP information
- Tags T2-MI packets with a timestamp pulled from the GPS signal as required for terrestrial single-frequency network (SFN) broadcasting
- Generates a transport stream via IP or ASI that is fed into the transmission network

HEVC realtime coder, multiplexer and gateway

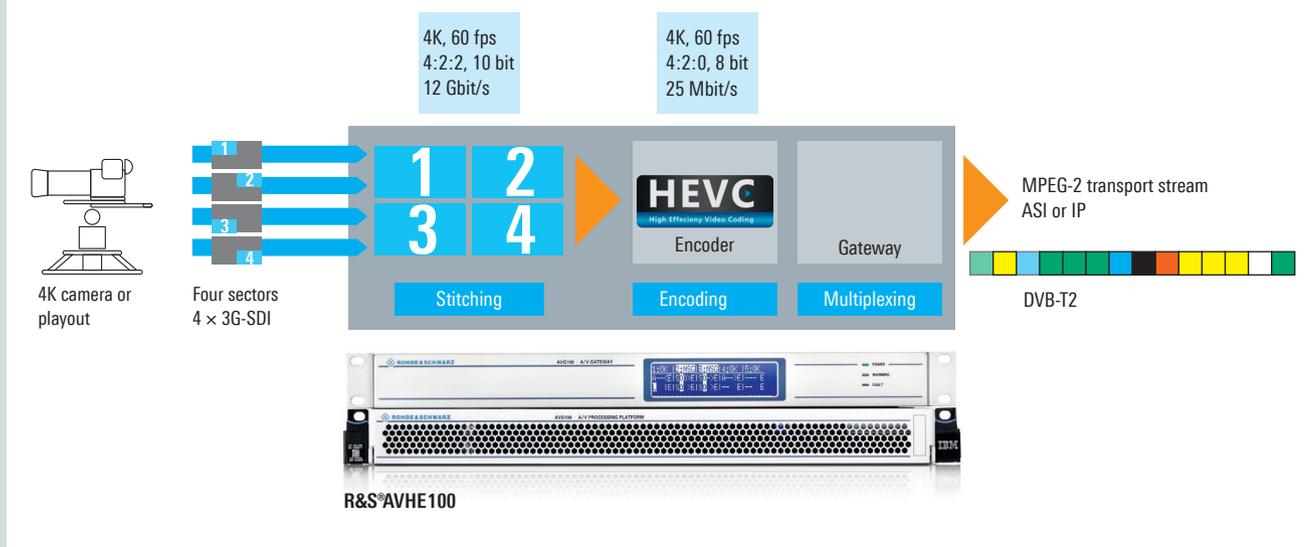


Fig. 4: The R&S®AVHE100 produces full-screen pictures by stitching the four quadrants delivered via 3G-SDI cables and compresses them in realtime using the HEVC codec (H.265). The compressed signal is then packaged into an MPEG 2 transport stream and fed to a distribution network.

C Multistandard RF modulator and transmitter

A wide range of DVB-T2 transmitters of all power classes (e. g. from the R&S[®]THU9 and R&S[®]TMU9 families) is available for terrestrial broadcasting of UHD TV programs. They are capable of receiving transport streams directly, and the first installations are in operation.

The R&S[®]BTC broadcast test center provides a complete test environment for UHD TV consumer electronics. It is an

all-in-one solution, since it can simulate any broadcasting standard and perform both video and audio analysis at the same time. Among many other things, the R&S[®]BTC is a multistandard modulator equipped for the most advanced terrestrial, cable and satellite transmission technologies (Fig. 5). It features a two-path architecture from the base-band to the RF section, enabling simulation of complex scenarios such as MIMO DVB-T2. The R&S[®]BTC can also be equipped with an HDMI analysis module and configured as a complete solution for set-top box testing.

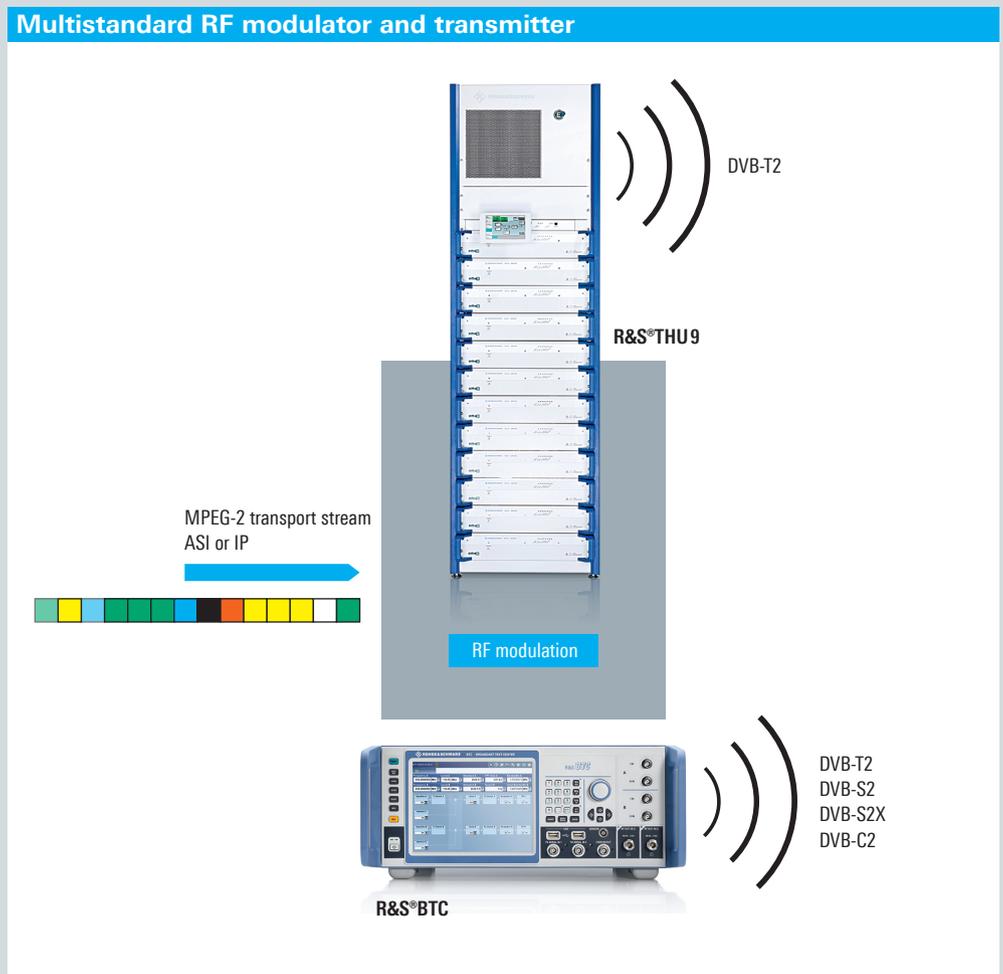


Fig. 5: The compressed UHD transport stream is sent, for example, to a DVB-T2 transmitter or (in the case of a test setup) an R&S[®]BTC broadcast test center, putting its multistandard modulator capabilities to especially good use.

D1 Coverage measurements with in-depth RF and baseband analysis

Reception problems annoy viewers and undermine the image of network operators. This is why network operators carry out T&M monitoring in their coverage areas and take optimization measures when necessary. Verified information on coverage quality is especially indispensable in metropolitan areas where fading and echoes are to be

expected. The R&S®ETL TV analyzer delivers this information. In combination with the R&S®BCDrive drive test software and a GPS antenna, the R&S®ETL provides comprehensive location-specific analysis based on RF and baseband parameters. If desired, Rohde&Schwarz can integrate the instrument and other system components into a turnkey test vehicle (Fig. 6).



Fig. 6: The R&S®ETL TV analyzer provides detailed information on the RF and baseband (transport stream) parameters of terrestrial transmissions. The centerpiece of a coverage measurement system, it analyzes the quality of broadcast networks of all standards.

D2 HEVC realtime decoder and UHDTV quality monitoring

The UHDTV signal chain ends at the viewer's TV, which either carries out demodulation and HEVC decoding itself or uses the A/V signal supplied by a set-top box. However, another solution is required for professional monitoring. The R&S®ETL TV analyzer can handle on-site reception and demodulation. It transfers the transport stream via ASI interface to the BBM-810 broadcast multistream monitor from Rohde&Schwarz subsidiary GMIT. The BBM-810 is a server-based solution that simultaneously monitors

and displays a large number of video and audio programs. It is the only solution on the market capable of simultaneously decoding up to four UHD programs, which it can receive in either uncompressed (via 3G-SDI or 10GigE) or compressed (HEVC / H.265 or H.264) format. In addition to detecting "hard" errors such as picture freeze and picture or sound loss, the BBM-810 can also carry out picture quality analysis based on PSNR and SSIM measurements (relative picture quality compared with a reference) in real-time and use it at the headend output to monitor HEVC encoding quality (Fig. 7).

HEVC realtime decoder and UHDTV quality monitoring

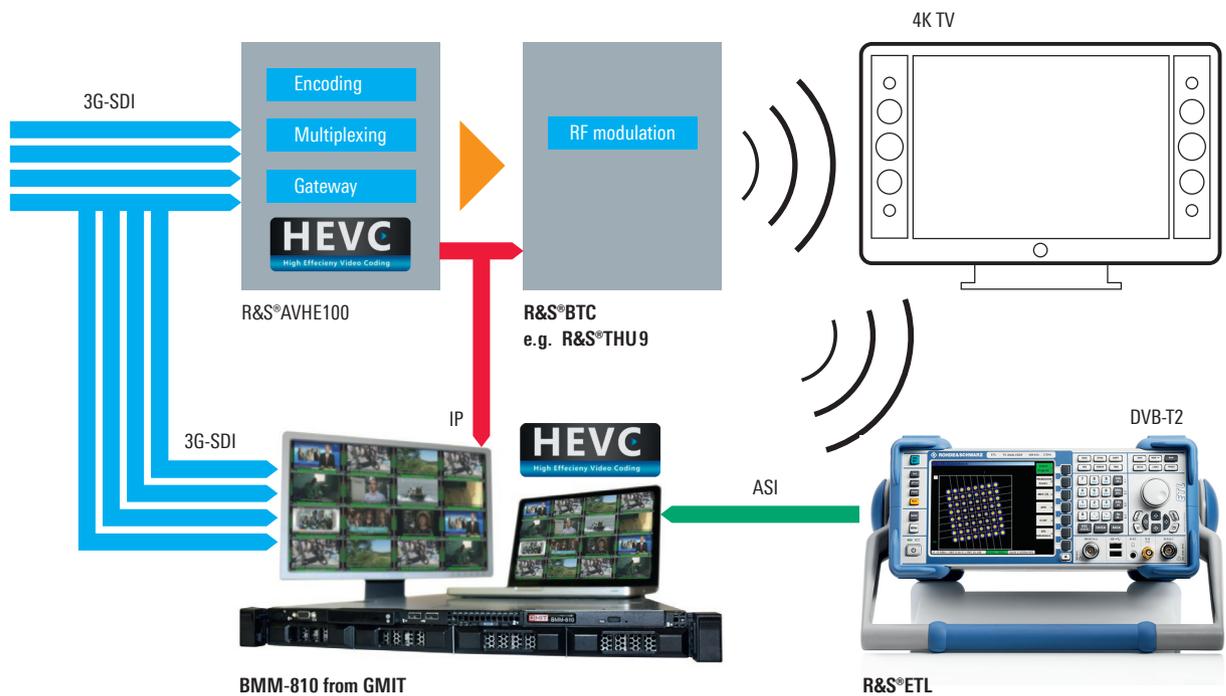


Fig. 7: The BBM-810 from GMIT can simultaneously decode multiple UHDTV programs in realtime and display them on a control monitor along with quality information. Its ability to process both compressed and uncompressed signals and carry out reference-image-based picture quality analysis makes it ideal for continuous headend output monitoring as well as temporary field measurements in tandem with an R&S®ETL.

Summary

Major globally marketable sporting events, the trend toward ever larger picture formats and the availability of 4K consumer electronics are stimulating the broadcasting industry to provide 4K program material and develop suitable broadcast infrastructures. The high UHDTV data rates, however, present broadcasters and their suppliers with considerable challenges

when it comes to realtime processing and program transmission via terrestrial networks with limited channel capacity. Rohde&Schwarz products enable broadcasters to implement entire UHD signal chains, from camera output and distribution network to coverage measurements and quality monitoring.

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