

R&S®UPP audio analyzer: testing HDMI devices

High-resolution digital television signals and top-quality surround sound are the standard in consumer audio and video systems today. Devices communicate and transmit data over a high-definition multimedia interface (HDMI). The interface's numerous features are quite a challenge for test and measurement equipment. Fitted with the R&S®UPP-B4 option, the R&S®UPP audio analyzer meets all the requirements for conducting comprehensive audio measurements on HDMI components.

HDMI – the standard in consumer electronics

With the arrival of advanced CD and DVD players, digital audio connections gradually displaced previous analog solutions. Among professional users, AES/EBU emerged as the dominant interface, whereas in the consumer sector, devices were fitted with the Sony/Philips digital interface (S/PDIF).

The arrival of surround sound (5.1 audio, for instance) created a need for a new, more sophisticated type of interface – ideally one that could combine video and multichannel audio signal transmission over a single cable. This led to the creation of the HDMI standard (see box at right), which enables digital transmission of high-resolution television and top-quality surround sound signals over the same cable. Today's advanced TVs, DVD players, AV receivers and even game consoles all connect with one another via HDMI cables.

This technological advance has created a need for equally capable T&M equipment – a need that the R&S®UPP audio analyzer and the new R&S®UPP-B4 HDMI option fulfill.

HDMI option for the R&S®UPP audio analyzer

Equipped with the R&S®UPP-B4 HDMI option, the R&S®UPP audio analyzer enables product development, quality assurance and production to conduct a comprehensive range of audio measurements on HDMI chips, Blu-ray™ players*, AV receivers, TV monitors and other equipment. The R&S®UPP can conduct measurements on any combination of interfaces: For instance, it can feed I²S signals to a chip and analyze the results at its HDMI port, or it can apply HDMI test signals to the input of an AV receiver and test the audio quality on the receiver's analog loudspeaker outputs. It can even be used to test TV monitors. The R&S®UPP audio analyzer generates test signals in HDMI format and sends them to the DUT. In the simplest scenario, audio functions, such as correct channel assignment, are analyzed by means of listening tests, and video quality is visually analyzed on the TV monitor.

The option can be integrated into each of the three R&S®UPP200, R&S®UPP400 and R&S®UPP800 base units (Fig. 1). This means that all interfaces necessary for audio measurements are included in a single instrument:

Fig. 1 The R&S®UPP800 audio analyzer with the R&S®UPP-B4 option installed. The R&S®UPP family of instruments was covered in detail in NEWS (2010) No. 201, p. 24–27.

* Blu-ray™ is a trademark of the Blu-ray Disc Association.



HDMI at a glance

HDMI is an interface developed especially for the consumer electronics sector. From the very outset, it fulfilled the consumers' wish for simplified equipment cabling and easier operation of system components as well as the movie industry's need for a means of transmission that afforded protection against illegal copying. The standard has gradually been refined in a number of stages. Higher screen resolutions and the demand for greater color range to allow skin tones and higher-contrast scenes to be rendered better called for higher transmission bandwidths. Users also wanted to be able to operate multiple system components with a single remote control. Currently, HDMI version 1.4 is used. It supports bidirectional data transmission (on the audio return channel), new lossless compressed audio coding methods and Ethernet connection. The data transmission rate has now risen to 10.2 Gbit/s – sufficient to meet tomorrow's needs and requirements. With the definition of the Micro HDMI connector, the interface is gradually finding its way into mobile phones and portable audio devices, and a new locking connector means it can now be used in vehicles too. All these features make HDMI the most successful and versatile connector system ever in the field of audio and video.

Data transmission between HDMI source and HDMI sink

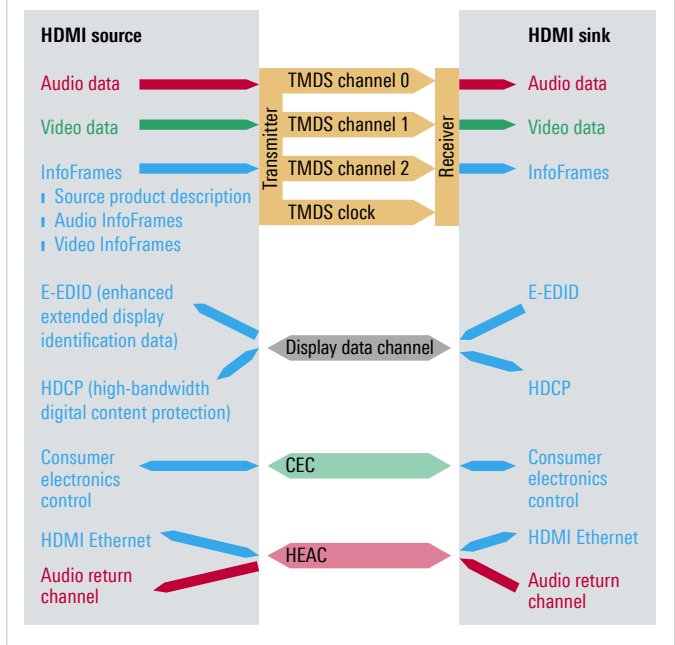


Fig. 2 HDMI transmits data on four separate physical channels.

- Four HDMI ports on the front of the R&S®UPP
- Two-, four- or eight-channel analyzer for parallel and concurrent measurements on analog channels. The inputs are balanced XLR female connectors; a BNC adapter set is available as accessory
- Digital audio interfaces in S/PDIF format with BNC and TOSLINK connectors for two-channel linear PCM audio signals in line with IEC 60958. Compressed audio data streams with up to eight channels in line with IEC 61937 are available for playback and – after Dolby® decoding* (optional) – also analysis
- Digital I²S interfaces for testing audio ICs. There are four data lines each in the transmit and receive directions, allowing signals for up to eight audio channels to be generated and measured in parallel

The data structure in detail – and testing capabilities with the R&S®UPP

Physical data channels

In the HDMI world, there are sources and sinks. An HDMI device can have one or more HDMI inputs and outputs. Every input or output must comply with all requirements for an HDMI sink or HDMI source. There are four separate physical data channels for transmitting the data (Fig. 2):

- Four transition minimized differential signaling (TMDS) line pairs transmit audio and video data as well as InfoFrames
- The display data channel (DDC) is used to exchange information that facilitates the interconnection of various HDMI devices and enables data encryption
- The bidirectional consumer electronics control (CEC) line transmits data that allows all connected HDMI devices to be operated with a remote control
- The HEAC line transmits HDMI Ethernet data and contains the audio return channel

Audio data

HDMI differentiates between a two-channel data structure (stereo) and an eight-channel data structure (surround sound). The digital audio signals are transmitted as linear PCM data with up to 24 bit word length and up to 192 kHz sampling rate. The interface can also transmit encoded data streams, including streams compressed using conventional methods standardized by Dolby.

The R&S®UPP800 audio analyzer can generate up to eight different test signals in HDMI or I²S format at the same time and measure up to eight signals concurrently – in HDMI format, in I²S format and at its analog inputs. Unlike other HDMI T&M equipment, the R&S®UPP offers full, professional audio analyzer functionality:

* Dolby® is a registered trademark of Dolby Laboratories.

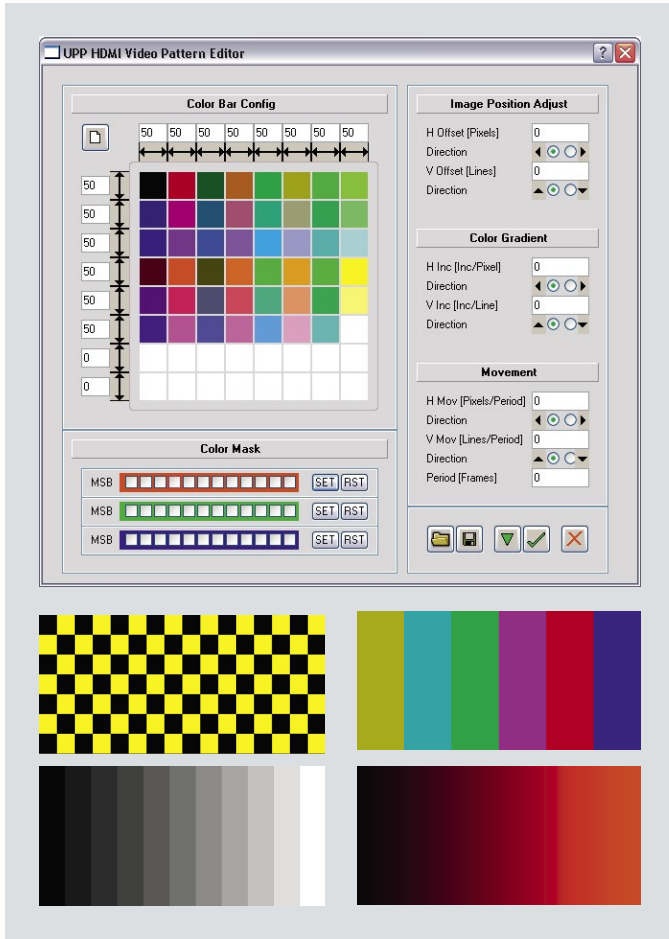


Fig. 3 Multicolor and moving test patterns can be generated with the optional pattern generator.

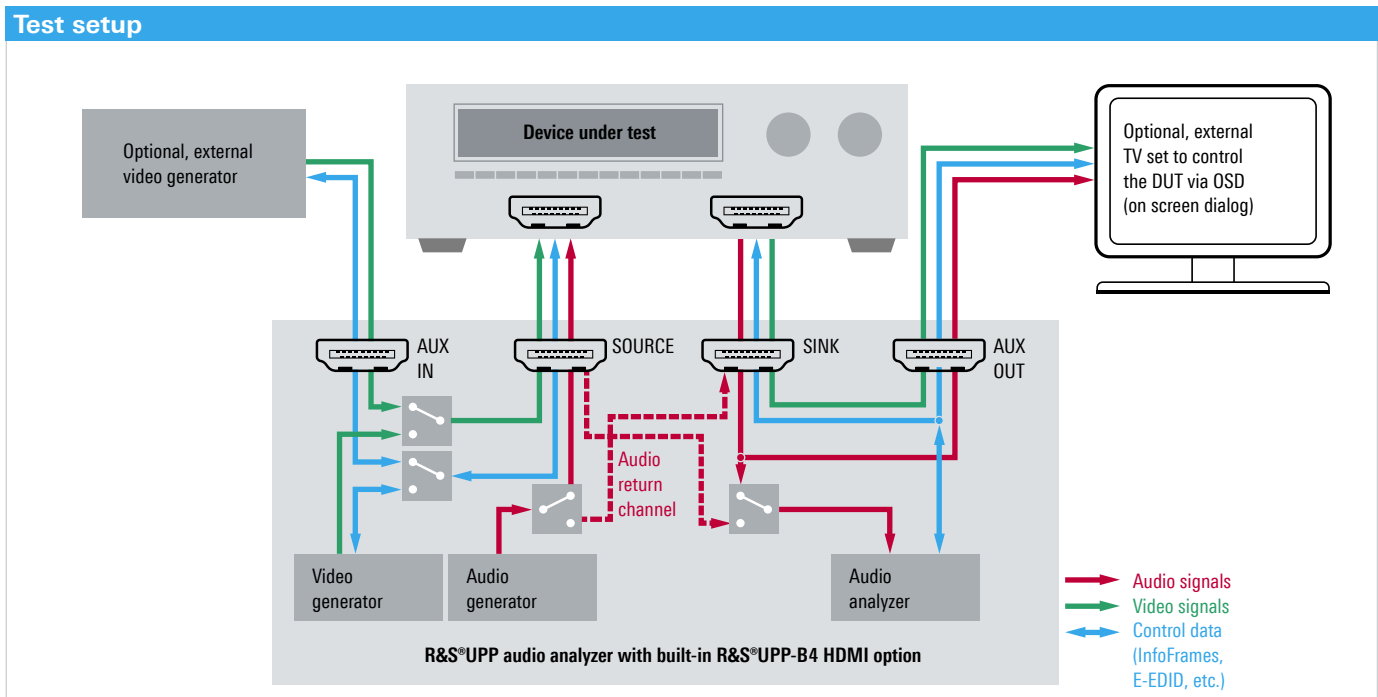
- Its signal generation capabilities range from generating sine and multitone signals for intermodulation measurements and burst and noise signals to playback of voice and music signals
- It can also play Dolby Digital® and Dolby Digital Plus®* encoded signals and decode them to conduct realtime measurements
- In addition to the basic measurements of level, frequency response, crosstalk, SNR, THD+N and phase, the R&S®UPP provides a number of other measurement functions, including modulation factor, DFD, DC voltage and group delay
- It also offers powerful FFT analysis and can display the trace in the time domain. A 1/n-octave analysis option is available as well

Video data

Audio and video data is combined in a common frame structure. HDMI can transmit all of today's common video formats in the highest quality. With the R&S®UPP-B4 HDMI option, the R&S®UPP audio analyzer can generate both audio and video data. In addition to monochrome test patterns, it can optionally output multicolor and moving test patterns (Fig. 3).

* Dolby®, Dolby Digital® and Dolby Digital Plus® are registered trademarks of Dolby Laboratories.

Fig. 4 The R&S®UPP-B4 option has four HDMI ports for connecting DUTs.



Users can choose any colors they wish and set a color depth of 8 bit, 10 bit or 12 bit. The video formats are CEA-861-E standard compliant and are available with resolutions up to 1920 × 1080 pixel.

If users require more complex video signals for test purposes, test patterns and video sequences can be fed in from an external source over another HDMI port on the R&S®UPP (Fig. 4). The audio analyzer combines the picture data with the audio test signals it generates internally and transfers them to the DUT in a single HDMI data stream.

The analyzer section of the R&S®UPP receives all HDMI data and analyzes the audio content. The video content can be passed over a separate HDMI connection to an external monitor for visual analysis. Besides pure audio measurements, the R&S®UPP can optionally conduct a number of basic video measurements:

- Pixel clock, HSync and VSync frequencies, display of timing parameters
- Bit error rate over an HDMI transmission path
- Time offset between video and audio signals using the lip sync function

InfoFrames

A variety of InfoFrames are transmitted over HDMI. The source product description InfoFrame, for instance, contains general information on an HDMI source. The auxiliary video InfoFrame provides an HDMI sink with a range of information, including the video format being transmitted, the color depth, color range, etc. (Fig. 5).

The R&S®UPP audio analyzer generates all this data to match the HDMI signals to be output. Optionally, users can edit the InfoFrame data and deliberately send incorrect data to the DUT in order to test how it will respond and to verify whether it will correct errors as required by the HDMI specification.

Enhanced extended display identification data (E-EDID)

The E-EDID packet is stored in the HDMI sink, for example a TV monitor. It contains all the information that the HDMI source (such as an AV receiver) needs to transmit the video and audio data in the formats that the HDMI sink can process. The data packet is transmitted via the display data channel (DDC). The generator in the R&S®UPP reads the DUT's E-EDID information so that the test signals can be set in the suitable format. Conversely, the analyzer provides the DUT with its E-EDID information. If required, users can alter the R&S®UPP audio analyzer's E-EDID information in order to test how the DUT will respond. In many applications, the comprehensive functionality provided by the R&S®UPP eliminates the need for specialized HDMI protocol testers.

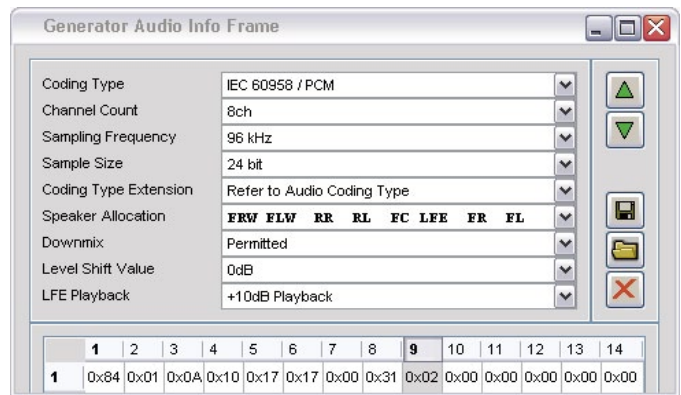


Fig. 5 Interconnected HDMI devices use audio InfoFrames to exchange functionality information.

High-bandwidth digital content protection (HDCP)

This encryption is used to prevent unauthorized copying of films, etc. When the R&S®UPP audio analyzer receives an encrypted signal, it automatically decrypts the signal for measurement.

Consumer electronics control (CEC)

This is an independent, bidirectional data line which transmits signals from a remote control to all connected HDMI devices, allowing users to use the same remote control for all components in a system. In the R&S®UPP audio analyzer, the CEC data is passed on unchanged.

Audio return channel (ARC)

The ARC allows audio signals to be transmitted from a TV to an AV receiver (in order to output audio through the loudspeakers in a multimedia system, for instance). With the HDMI option, the R&S®UPP analyzer can generate and measure audio data on the ARC.

HDMI Ethernet channel (HEC)

The HEC enables HDMI devices to access content on the Internet. For this to function, a device needs to be connected to a LAN (generally, via an RJ-45 port); it can then distribute Internet data over HDMI to other connected devices. The ARC and HEC are transmitted on a separate line in the HDMI line known as the HEAC line. The R&S®UPP audio analyzer has two RJ-45 ports for connecting the Ethernet line and testing Ethernet functionality.



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