HDMI measurements with the R&S®UPP audio analyzer

ROHDE&SCHWARZ

Contents

When testing HDMI devices, it is necessary to measure their audio and video content and analyze the transmitted status and control data.

A Rohde&Schwarz product
R&S®UPP audio analyzer with R&S®UPP-B4 option

Your task

The high-definition multimedia interface (HDMI) has fully captured the consumer market. The interface transmits audio and video data and status and control data on a single cable. The HDMI ports of all consumer electronics equipment – be it Blu-ray™ players [1], AV receivers, set-top boxes, TV monitors, video game consoles, PCs or state-of-the-art smartphones – must be tested. Measurements are performed during development, quality assurance and end-of-line production testing. However, measurements are also needed during the development and testing of HDMI integrated circuits.

The R&S®UPP audio analyzer with integrated HDMI option ideally covers all these requirements. In this configuration, the instrument offers the HDMI, S/P DIF and I²S digital interfaces, as well as analog interfaces. This makes it possible to perform measurements on all HDMI devices with any combination of interfaces.

Key facts

- Fully-fledged audio analyzer with HDMI function
- Generation of audio, video and data signals over HDMI
- Comprehensive audio parameter measurements and basic video parameter measurements
- Display of audio and video InfoFrames
- Supports HDMI standard 1.4b, including audio return channel and HDMI Ethernet
- Digital audio interfaces in line with S/P DIF and I²S as well as analog inputs and outputs
- Up to eight-channel, variable audio test signals at all digital interfaces
- Parallel measurement of audio parameters on up to eight channels simultaneously (analog or digital)

[1] Blu-ray™ is a trademark of the Blu-ray Disc Association.

R&S®UPP800 with R&S®UPP-B4 option.

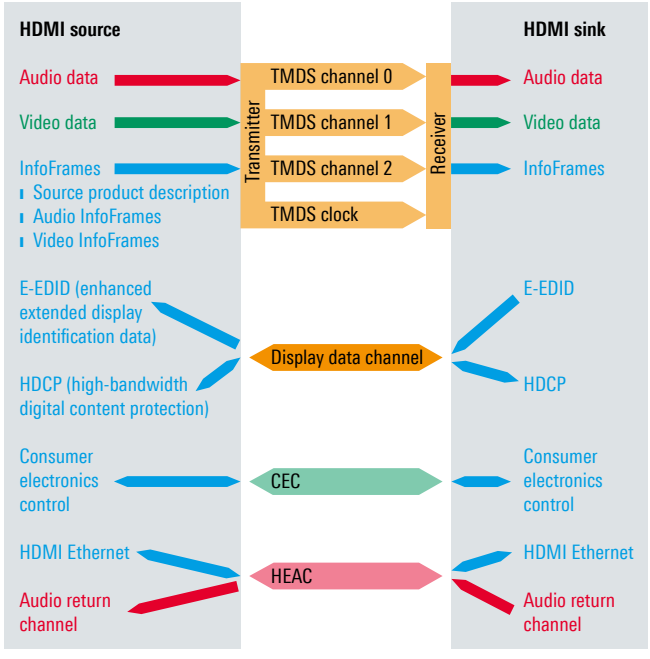
T&M solution

The HDMI standard differentiates between source and sink. An HDMI instrument can have one or more HDMI inputs and/or one or more HDMI outputs. Every input must comply with all HDMI sink rules and every output with the HDMI source rules.

HDMI features four physical data channels over which a series of different signals are transmitted – in part bidirectionally:

- Four transition minimized differential signaling (TMDS) wire pairs for transmitting audio and video data as well as InfoFrames
- Display data channel (DDC) for exchanging information to facilitate the interconnection of various HDMI devices, as well as for data encryption
- Consumer electronics control (CEC) line for bidirectional data transmission to permit remote operation of all connected HDMI devices
- HEAC line for the audio return channel and for transmitting HDMI Ethernet data

Data transmission between HDMI source and HDMI sink



Audio data

The entire range of test signals is used for various types of measurements. HDMI differentiates between layer 0 and 1, i.e. between a two-channel and an eight-channel data structure. It transmits linear pulse code modulated (PCM) data with up to 24 bit word length and up to 192 kHz sampling rate. Precoded data streams compressed in line with the conventional methods standardized by Dolby® [2] can also be used as test signals.

Video data

Audio and video data is transmitted in a common frame structure. The R&S®UPP-B4 option generates both audio and video data. Monochrome (optionally also multicolor and moving) test patterns are available with adjustable colors and color depths in the video formats defined in the CEA-861-E standard with resolutions up to 1920 × 1080 pixel.

Test patterns or other video signals from an external source can additionally be fed in over another HDMI port. This picture data is passed on to the DUT, together with the R&S®UPP's audio test signals. At the analyzer end, all HDMI data is received and the audio content is measured; the video content can be output to an external monitor.

InfoFrames

A series of InfoFrames are transmitted together with the audio/video data. This data is also generated in the R&S®UPP and is output to match the test signals.

Enhanced extended display identification data (E-EDID)

This data packet is stored in the HDMI sink, for example a TV monitor. It contains all of 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.

When generating test signals, 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 R&S®UPP analyzer provides the DUT with its E-EDID information.

Consumer electronics control (CEC)

Via this bidirectional data cable, different HDMI devices can be controlled using only one remote control device. In the R&S®UPP, this data is passed on unchanged.

[2] Dolby® is a registered trademark of Dolby Laboratories.

Audio return channel (ARC)

Audio signals can be transported in the opposite direction via the audio return channel, e.g. in order to transmit the sound of a film received in the TV set to the AV receiver and output it there. The R&S®UPP-B4 option makes it possible to also generate and measure audio data on the ARC.

HDMI Ethernet channel (HEC)

This connection allows Internet information to be accessed from an HDMI device. The R&S®UPP is equipped with RJ-45 ports for connecting the Ethernet cable and testing Ethernet functionality.

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.

HDMI connectors

The R&S®UPP-B4 option features two RJ-45 female connectors for connecting the HEC signals as well as the following four HDMI plug-in connectors:

SOURCE

All audio test signals available in the R&S®UPP audio analyzer can be transmitted to the DUT over HDMI; video data and InfoFrames are also generated; E-EDID is read.

AUX IN

This port allows connection of an external video source, such as a video test generator. The source's unchanged video signal plus the audio data generated in the R&S®UPP are transferred to the DUT via SOURCE.

SINK

This port allows connection of an HDMI DUT to the analyzer section of the R&S®UPP.

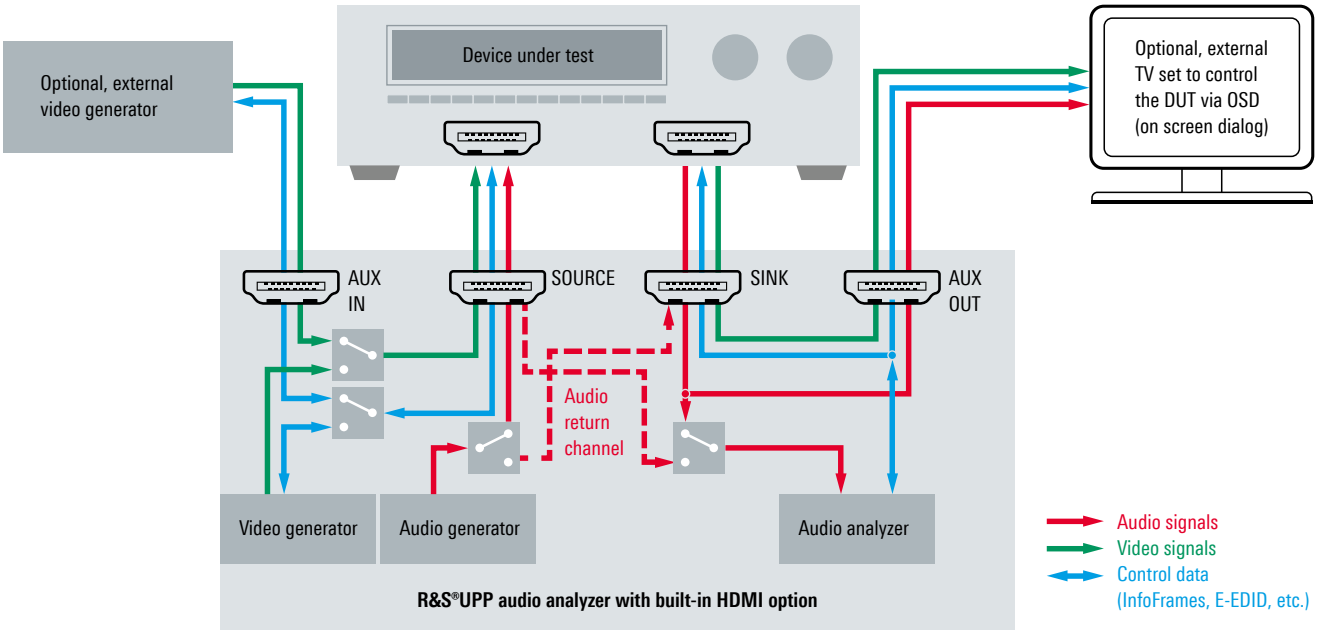
AUX OUT

This port allows connection of a TV monitor; for example, for audiovisual assessment of test signals at the SINK, or to operate the DUT via on screen dialog (OSD).

S/P DIF and eight-channel I²S interfaces on the R&S®UPP-B4 option

In addition to HDMI, the R&S®UPP-B4 option includes digital audio interfaces in S/P DIF format (BNC and TOSLINK) to allow measurements on the standard audio interfaces of consumer electronics equipment. This option also includes I²S interfaces for testing audio ICs. With four I²S data lines each in the transmit and receive directions, up to eight audio channels simultaneously can be generated and measured.

R&S®UPP-B4 option: four HDMI connectors for DUTs



Benefits and key features

Flexible configuration

The R&S®UPP-B4 HDMI option can be integrated into each of the three R&S®UPP200, R&S®UPP400 and R&S®UPP800 base units. This allows users to select a configuration to suit their budget – from an analog, two-channel analyzer up to eight analog analyzer channels operating in parallel. The R&S®UPP-B4 option can handle the eight-channel HDMI structure in all configurations.

All necessary audio interfaces in one instrument

The R&S®UPP provides the required audio interfaces for all HDMI applications:

- Two-, four- or eight-channel analog analyzer for parallel measurements on all channels; balanced inputs using XLR female connectors; BNC adapter set available as accessory
- Digital audio interfaces in S/P DIF format with BNC and TOSLINK connectors for transmitting 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 available for playback and – after Dolby® decoding (R&S®UPP-K41 option) – also analysis
- Digital I²S interfaces for testing audio ICs; with four data lines each in the transmit and receive directions; up to eight audio channels can be generated and measured in parallel
- HDMI support of both audio formats defined in the standard: layer 0 for two-channel transmission and layer 1 for generation and measurement of up to eight audio channels

Comprehensive range of audio signals and measurements

In contrast to other HDMI test instruments, the R&S®UPP makes the full spectrum of audio analyzer functionality available: Up to eight different test signals can be output on the data channels in parallel. The range of signals includes sine signals, multitone signals for intermodulation measurements, burst and noise signals, and playback of voice or music signals. Even Dolby® coded data streams can be played.

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 measurement, DC voltage and group delay. It also offers a powerful FFT analysis and can display the trace in the time domain. The R&S®UPP-K601 option is available for 1/n-octave analysis.

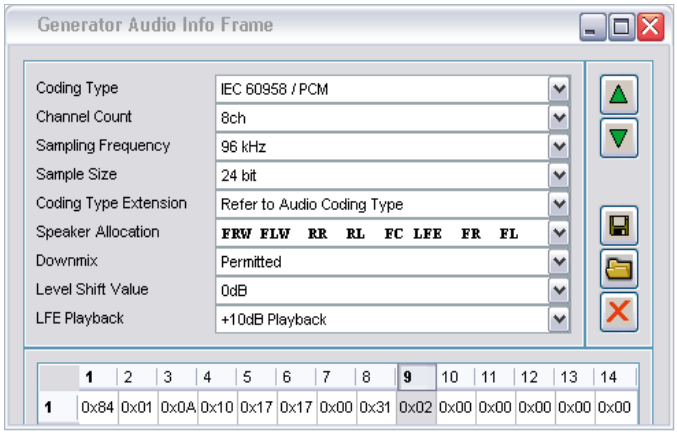
HDMI protocol generation and analysis

HDMI is used to transmit a large amount of status and control data. The R&S®UPP generates the appropriate InfoFrames and stream headers, and can optionally display and edit them. This makes it possible to check how DUTs respond to transmitted, even supposedly incorrect, data. It also generates E-EDID data. The R&S®UPP-K45 option can be used to analyze and edit this data in order to test the behavior of connected DUTs. In many cases, the functionality provided by the R&S®UPP eliminates the need for specialized HDMI protocol testers.

Comprehensive HDMI function testing

In addition to audio data, video signals and InfoFrames, the R&S®UPP audio analyzer also supports the audio return channel. It passes HDMI Ethernet channel (HEC) and consumer electronics control (CEC) through, allowing their functionality to be tested. HDCP-encoded signals are automatically decoded for measurement.

Interconnected HDMI devices exchange information about available functionality via audio InfoFrames.

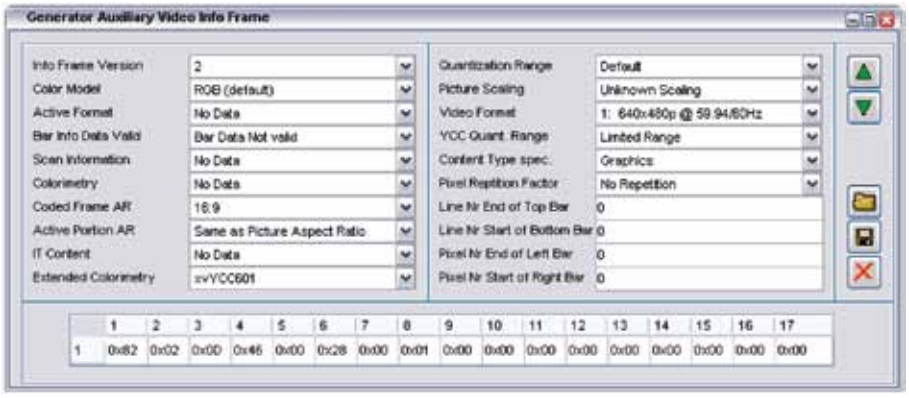


Wide range of video functions

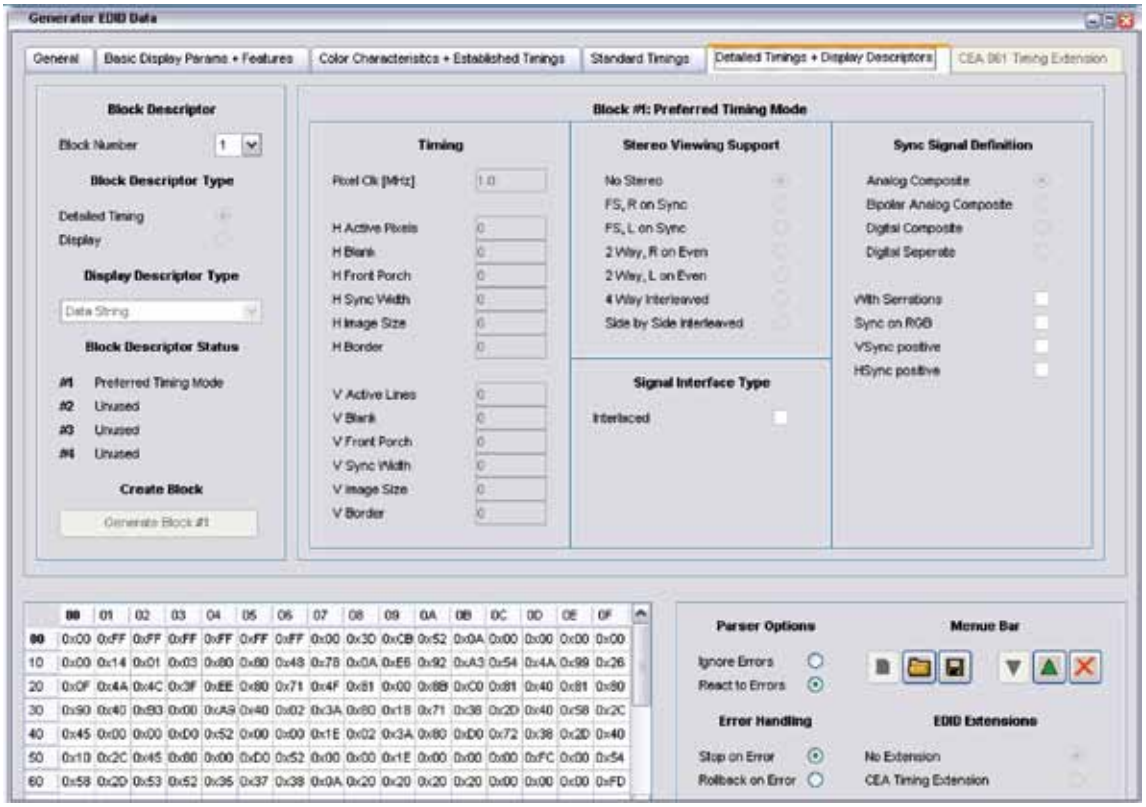
HDMI always includes both audio signals and video data. The R&S®UPP provides a variety of functions for HDMI. The generated video test patterns are frequently sufficient for a visual assessment of the video signal on the DUT. Beyond the monochrome test patterns with adjustable formats and color depths, the R&S®UPP-K45 option offers multicolor and moving test patterns. External video data streams can be supplemented with audio test signals and transmitted to the DUT. Received video images can be output to an external TV monitor.

The R&S®UPP-K45 option offers additional functions, including basic video measurements, such as pixel clock, HSync and VSync frequencies, and display of timing parameters. The bit error rate testing BERT function measures the bit error rate over an HDMI video transmission path. The lip sync function measures the time offset between the video and the audio signal.

Example of a video InfoFrame: The information is displayed in hex format based on the transmitted data structure, as well as in plain text.



E-EDID is the most powerful data block; the large amount of data is organized into several sub-blocks that can be analyzed by the R&S®UPP audio analyzer.



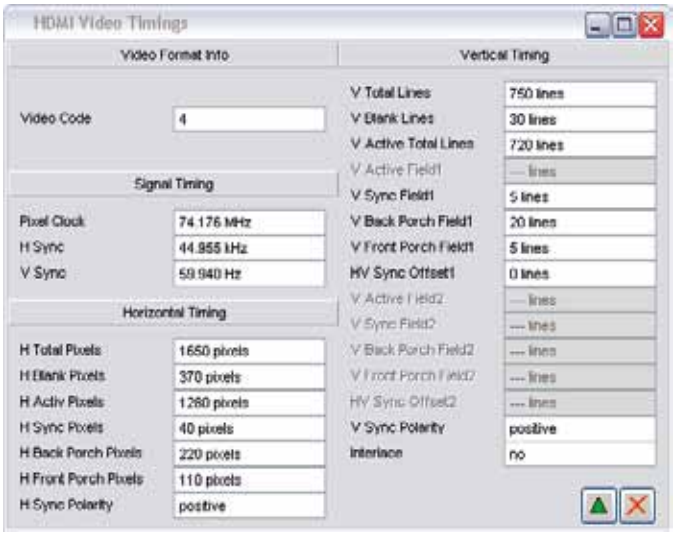
Software enhancements

Decoding of Dolby® coded data streams (R&S®UPP-K41 option)

The HDMI standard also provides for the transmission of coded audio signals. The R&S®UPP-K41 option allows realtime decoding of compressed audio data streams in line with the Dolby Digital® [3] and Dolby Digital Plus® [3] methods on the S/P DIF and HDMI inputs of the R&S®UPP-B4 option. After decoding, the up to eight audio channels can be analyzed using the R&S®UPP audio analyzer's standard test methods.

[3] Dolby Digital® and Dolby Digital Plus® are registered trademarks of Dolby Laboratories.

The R&S®UPP audio analyzer can also be used to analyze video timing.



Extended audio and video measurements (R&S®UPP-K45 option)

The R&S®UPP-K45 option extends the functionality of the R&S®UPP-B4 option to include generator signals and measurements that go beyond purely audio operation.

When generating HDMI test signals, the R&S®UPP automatically generates suitable InfoFrames; the R&S®UPP-K45 option allows these InfoFrames to be displayed and edited. This makes it possible to test how DUTs respond to supposedly incorrect data and to determine to what extent the corrections required in the conformance tests work. Received InfoFrames and stream headers can be displayed and analyzed.

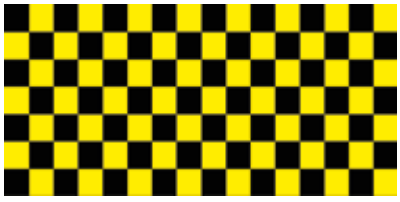
The bit error rate testing (BERT) function measures the bit error rate over an HDMI video transmission path by transmitting defined bit patterns.

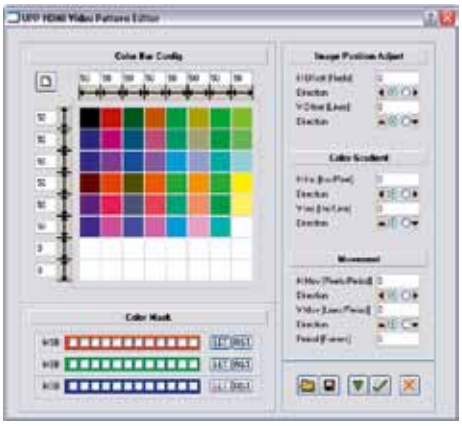
The lip sync function measures the time offset between the video and audio signal, because time differences between voice and mouth movement are disturbing. The generator provides a test signal that can be set within wide ranges.

The pattern generator function generates a large number of multicolor and moving video test patterns.

The pixel clock, HSync and VSync frequencies and the timing parameters of the measured video signal can be displayed.

Video pattern generator and four test patterns





Typical applications

Measurements on HDMI devices generally fall into one of the following basic categories:

- HDMI source tests
- HDMI sink tests
- HDMI end-to-end tests

Blu-ray™ player testing

A typical application for an HDMI source test is testing a Blu-ray player. The required test signals are played back from a Blu-ray test disc, and the DUT transmits them to the analyzer over HDMI (alternatively S/P DIF). The R&S®UPP audio analyzer measures the audio parameters using the audio measurement functions on up to eight channels in parallel, depending on the audio format being used.

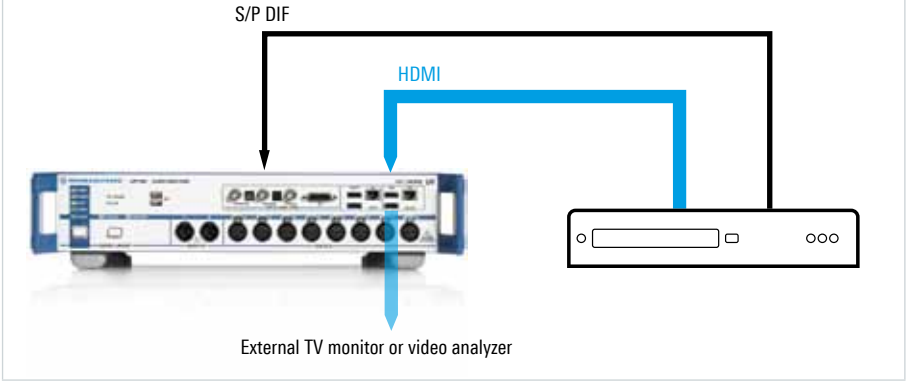
The audio and video InfoFrames can also be analyzed. The response of the DUT to varying E-EDID data from the HDMI sink can be tested by changing the settings accordingly on the R&S®UPP. If necessary, the video content can be output from the HDMI AuxOut jack to a TV monitor for visual assessment or to a video analyzer for further analysis.

TV monitor testing

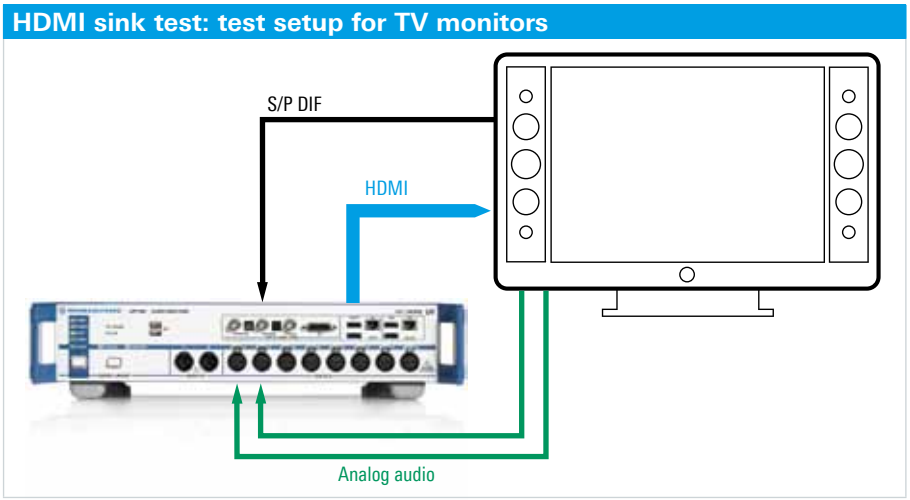
The assessment of a TV monitor is an example of an HDMI sink test. The R&S®UPP audio analyzer generates the test signals in HDMI format and sends them to the DUT. Up to eight different audio signals can be transmitted in parallel over HDMI. In the simplest scenario, audio functions, such as the correct channel assignment, are analyzed by means of listening tests. The audio signals can also be measured in analog format via either the speaker or headphone outputs, or in digital format via the S/P DIF cable. A measurement using the ARC is also possible.

The DUT response to the transmitted data contents of the audio and video InfoFrames can also be tested. The E-EDID data content can be evaluated in the R&S®UPP. The R&S®UPP offers a variety of multicolor and moving test patterns to allow visual assessment of the video quality on the TV monitor.

HDMI source test: test setup for Blu-ray players



HDMI sink test: test setup for TV monitors



AV receiver testing

AV receiver testing presents a wide range of applications. Because AV receivers have both HDMI inputs and outputs, measurements are performed in both directions. Here, too, the R&S®UPP audio analyzer generates complete HDMI test signals, with audio, video and data content.

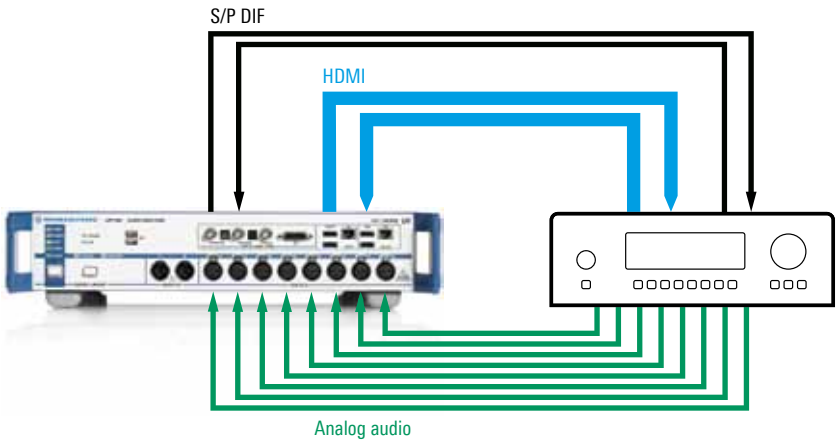
When the test signals are fed in over HDMI, the audio signals are processed in the AV receiver and then sent to the various outputs. They can then be measured in analog format at the speaker, headphone or preamplifier outputs – on up to eight channels in parallel. State-of-the-art AV receivers offer a variety of digital outputs in S/P DIF format, such as RCA jacks for coaxial cables and TOSLINK connectors for fiber optic cables.

In other test applications, the signals are typically applied to the DUT over S/P DIF and can then be analyzed in analog format or over HDMI. Tests using compressed test signals (e.g. using the Dolby® method) are also possible using the R&S®UPP audio analyzer.

The R&S®UPP can analyze audio and video InfoFrames as well as the E-EDID functionality. The data packets are analyzed in this case. However, it is also possible to test the DUT response to the transmission of supposedly incorrect data.

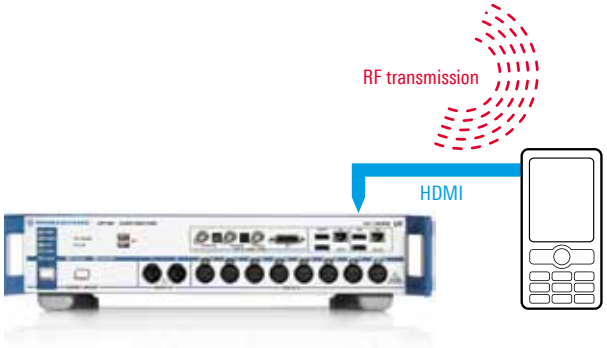
The wide variety of video test patterns allows an assessment of how the video data is processed in the DUT. A visual assessment on a connected TV monitor is usually sufficient. The R&S®UPP offers basic video measurements, such as pixel clock, HSync and VSync frequencies as well as bit error rate and lip sync measurements.

HDMI end-to-end test: test setup for AV receivers



A number of parameters can be measured on an AV receiver.

Smartphone testing

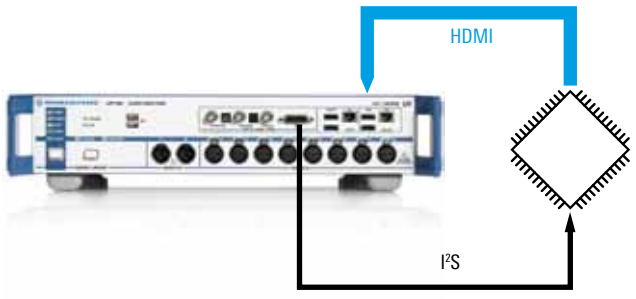


The phone converts the data received over the radio network into HDMI format so that the data can be analyzed.

Mobile phone testing

The latest smartphones receive audio and video data over LTE or WLAN. Smartphones assess the received audio and video signals and then output them over HDMI. Smartphones can alternatively output internally stored AV data. The R&S®UPP analyzes the audio signals and outputs the video signals to an external TV monitor or a video analyzer.

Integrated component testing



When testing integrated components, it is often necessary to generate and analyze both HDMI and I²S audio signals.

Integrated component testing

A number of measurements are needed to test integrated components during development as well as when they are used in consumer electronics equipment. In this case, the HDMI format is often supplemented with digital audio signals in I²S or S/P DIF format – no problem for the R&S®UPP audio analyzer. To allow testing of the eight-channel HDMI data formats, the R&S®UPP with an integrated R&S®UPP-B4 option also provides eight-channel I²S interfaces. This is done by using four parallel data lines, each with two channels, for generating and analyzing the audio test signals. The playback of precoded test data streams and the decoding of test signals in Dolby Digital® or Dolby Digital Plus® format is possible over the HDMI and S/P DIF interfaces offered by the R&S®UPP-B4.

Ordering information

Designation	Type	Order No.
Base unit		
Audio Analyzer, two channels	R&S®UPP200	1411.1003.02
Audio Analyzer, four channels	R&S®UPP400	1411.1003.04
Audio Analyzer, eight channels	R&S®UPP800	1411.1003.08
Included accessories		
Power cable		
Quick start guide		
CD with operating and service manual		
Hardware options		
HDMI and Digital Audio Interfaces	R&S®UPP-B4	1411.2500.02
Software options		
Dolby® Data Stream Decoding for R&S®UPP-B4	R&S®UPP-K41	1411.0813.02
Extended Audio/Video Measurements for R&S®UPP-B4	R&S®UPP-K45	1411.0859.02
1/n Octave Analysis for R&S®UPP	R&S®UPP-K601	1411.0765.02
System components		
XLR/BNC Adapter Set, male	R&S®UP-Z1M	1411.3358.02
XLR/BNC Adapter Set, male/female	R&S®UP-Z1MF	1411.3306.02
8-Channel I²S Cable for R&S®UPP-B4	R&S®UP-Z4	1411.3258.02

R&S®UPP: For product brochure, see PD 5214.3846.11; for data sheet, see PD 5214.3846.22 and www.rohde-schwarz.com

Service you can rely on

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

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

Environmental commitment

- Energy-efficient products
- Continuous improvement in environmental sustainability
- ISO 14001-certified environmental management system

Certified Quality System
ISO 9001

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