MHL2.0 Compliance Testing
Application Note

Products:

- R&S®VTC
- R&S®VTE
- R&S®VTS

The MHL* standard specifies the transmission of high-definition audio and video data on five individual lines, as well as the exchange of bidirectional control information and the supply of power from the sink to the source.

Over 200 million portable CE devices - such as mobile phones, tablet PCs and cameras - already use this interface to present content onto larger screens.

To ensure functionality and interoperability, every new MHL-capable device must, before entering the market, undergo thorough tests at an authorized test center (ATC) in line with the compliance test specification (CTS) issued by the MHL Consortium.

This application note provides an overview of the MHL technology and also describes the Rohde & Schwarz compliance test solution for the system part of the current MHL2.0 standard version.

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MHL2.0 Compliance Testing

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ROHDE&SCHWARZ

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1 Overview

1.1 Mobile High-Definition Link (MHL)

1.1.1 Introduction

MHL development extends back to the 2008 Consumer Electronics Show in Las Vegas, where Silicon Image presented a precursor to the current implementation under the same name. In September 2009, Nokia, Samsung, Silicon Image, Sony and Toshiba formed a working group in order to specify the standard. Since April 2010, they have been known as "MHL Consortium" [1] and "MHL Promoters". MHL, LLC oversees marketing and licensing.

MHL connections allow portable CE devices such as smartphones, tablet PCs or photo/video cameras to transmit uncompressed, encrypted, high-definition content to larger screens. The goal is to achieve video formats of up to 1080p60 and 192 kHz, 7.1 multichannel sound. In a typical scenario, the source is powered and remotely controlled from the screen.

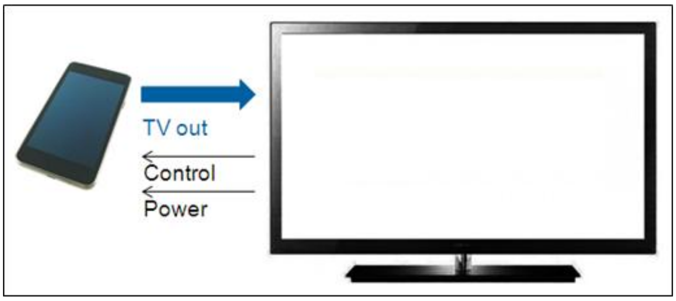


Fig. 1: Purpose of the MHL connection

After its initial publication in 2010, a refined Version 1.2 of the standard was published in December 2011 and in addition, Version 2.0 was introduced at the beginning of 2012. Version 2.0 allows 3D video formats, 900 mA supply current and additional MSC commands (see 1.1.2.2). The latest Version 2.1, which revises Version 2.0, was published in March 2013.

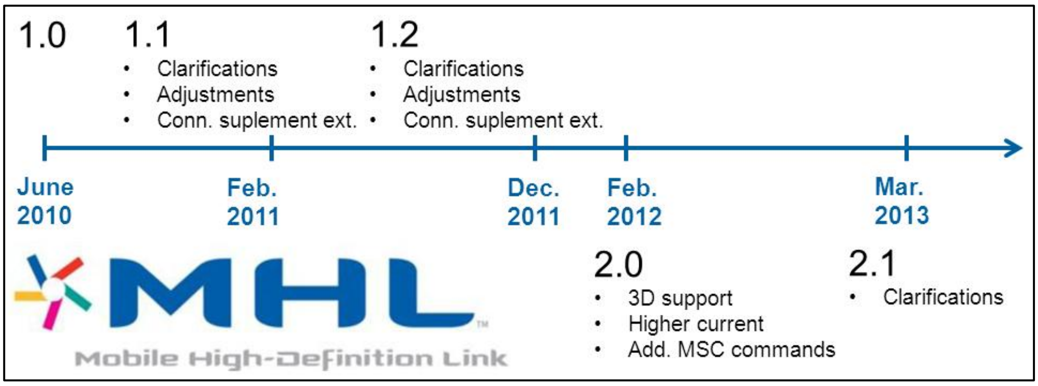


Fig. 2: Development of the MHL standard since its initial publication in 2010

1.1.2 Physical Channels

The MHL standard defines five individual lines for transmission. A differential TMDS pair (see 1.1.2.1) transmits the high-definition audio and video content unidirectionally. While additional control information is exchanged bidirectionally via the CBUS (see 1.1.2.2), the VBUS (see 1.1.2.3) supplies power to the source. A ground wire is also required.

No special connector is specified. The reduced number of lines makes it possible to use connectors (such as micro USB) already available on portable CE devices. This saves the space that would have been needed for an additional interface. The MHL transceiver chip activates when an MHL-capable receiving end is detected, still allowing the USB port to be used for data connections with the PC, as usual.

The reliance on existing interfaces continues with the widely used HDMI type A connection to the screen. However, because its pin assignment and signal waveform differ from MHL, a special MHL transceiver chip is needed. Older devices require an external MHL dongle that sends a standard HDMI signal to the output.

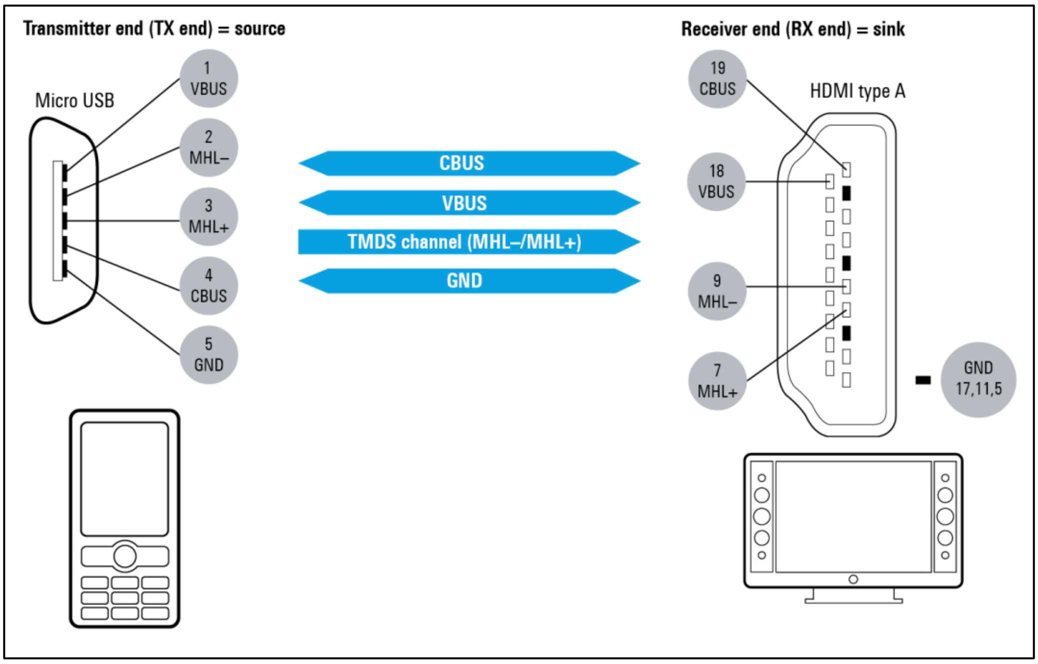


Fig. 3: Typical pin assignments for the five independent MHL lines

1.1.2.1 Transition-Minimized Differential Signaling (TMDS)

Two of the five pins (MHL– and MHL+) form the TMDS channel. This channel holds the digital, encrypted audiovisual (A/V) data as well as an overlaid clock signal. For video transmission, every individual frame is divided into lines, similar to an analog TV signal. The pixels within a line are transmitted successively. The vertical (VSYNC) and horizontal (HSYNC) synchronization signals are again used to tag the start of the frame and the line. Its blanking intervals remain free of A/V data so that they can be used for control periods and data islands.

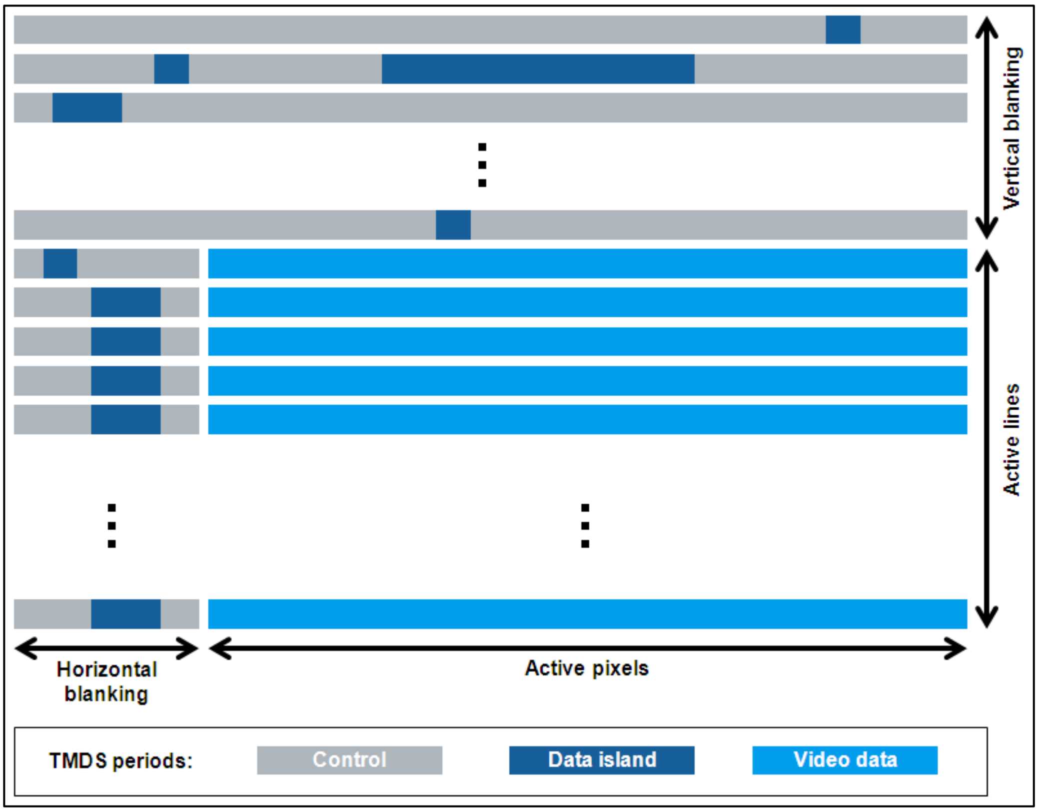


Fig. 4: Transmission structure of the TMDS channel

Data islands can contain various types of content, with the types being reported in the packet header. This makes it possible to transmit the samples from up to eight individual sound tracks in line with CEA-861E. However, the receiver does not initially know the sampling clock. Therefore, to permit recovery, a fractional reference N/CTS (cycle timestamp) to the known TMDS clock is sent at regular intervals in separate packets.

Stuffing packets are sent when no specific content is being transmitted. Content mute packets indicate that the TMDS connection needs to remain in place even though A/V content is not being transmitted at the moment.

Finally, data islands can also be used to transmit EIA/CEA-861E InfoFrames. On the one hand, these InfoFrames can contain the source product description (SPD), which contains the manufacturer and device type of the A/V source. This information can then be displayed to the user in the input selection list of options for the sink. On the other hand, audio InfoFrames and auxiliary video InfoFrames (AVI InfoFrame) are transmitted for signaling the A/V data format. This includes information about resolution, color range, aspect ratio, refresh rates and sound channel allocation.

The color information for a pixel is coded either directly as red/green/blue components (RGB 4:4:4) or — like for an analog TV signal — as luminance Y plus blue or red color difference signals (YCbCr 4:2:2 / 4:4:4). Unlike 4:4:4 mode, in 4:2:2 mode only every second color information is transmitted in the horizontal direction, with the result that the bit depth of every component is increased from the normal 8 bits to 12 bits. The color range definition can follow ITU-R Rec. BT.601 for SD content and ITU-R Rec. BT 709-5 for HD content as well as xvYCC, sYCC601, AdobeYCC601 or Adobe RGB.

The primary factor affecting the data rate in the TMDS channel is the spatial resolution and the refresh rate for video data. The standard lists all conventional formats, although other combinations are possible:

Index	Mode	Refresh rate
1	640x480	59.64/60
2,3	720x480p	59.94/60
17,18	720x576p	50
4	1280x720p	59.94/60
19	1280x720p	50
5	1920x1080i	59.94/60
20	1920x1080i	50
16	1920x1080p	59.94/60
31	1920x1080p	50
34	1920x1080p	30
6,7	720(1440)x480i	59.94/60
21,22	720(1440)x576i	50

Table 1: Possible TMDS video formats

Settings that require fewer than 25 Mpixel/s (e.g. index 1) will use pixel repetition mode. Because it repeats every pixel and thereby doubles the data rate, this mode provides for a more stable overlaid clock signal in the TMDS channel. Conversely, the combinations with the highest expected data rates (e.g. index 16) are moved from the standard 24 bit mode to PackedPixel mode in order to increase the clock rate and at the same time achieve a 4:2:2 reduction. This ensures that the large data volume can be transmitted both reliably and at sufficient speeds.

The audio contents are transmitted in up to eight separate channels at sampling rates of 32 kHz, 44.1 kHz, 48 kHz, 88.2 kHz, 96 kHz, 176.4 kHz or 192 kHz.

1.1.2.2 MHL Link Control Bus (CBUS)

An additional pin transmits bidirectional control signals in the MHL link control bus (CBUS). These handle several tasks. First, they are used to detect that an MHL-capable transceiver is connected. This comprises the hot plug detect (HPD) information, for example. Second, these signals are also used to exchange display data channel (DDC) commands. They allow the MHL A/V source to query the enhanced extended display identification data (E-EDID) for the connected screen. This data contains a listing of all supported A/V formats so that the source can select a compatible format and perform the necessary conversion for transmission.
The DDC also initializes the high-bandwidth digital content protection (HDCP) encryption and ensures that it remains in place by exchanging additional control information before every single transmitted video frame.

Finally, the CBUS can also manage MHL sideband channel (MSC) commands, which allow automatic synchronization of the operating modes for the two connected devices. For example, they can be used to switch both devices on or off at the same time. The user can also use the screen's remote control to configure the A/V source directly. The underlying remote control protocol (RCP) is used to transmit all of these commands. In addition, the UTF-8 character protocol (UCP) transports plain text and the request action protocol (RAP) requests A/V content.

1.1.2.3 MHL Voltage Bus (VBUS)

The screen uses the MHL voltage bus (VBUS) along with the common ground wire to continuously power the normally battery-operated A/V source with 5 Volts and max. 500 mA. In the MHL2.0 specification, the maximum current was increased to 900 mA.

1.2 Rohde & Schwarz Video Tester Family

By taking advantage of the three levels of flexibility offered by the Rohde & Schwarz family of video testers, it is possible to design customized solutions for performing many T&M tasks on A/V interfaces.

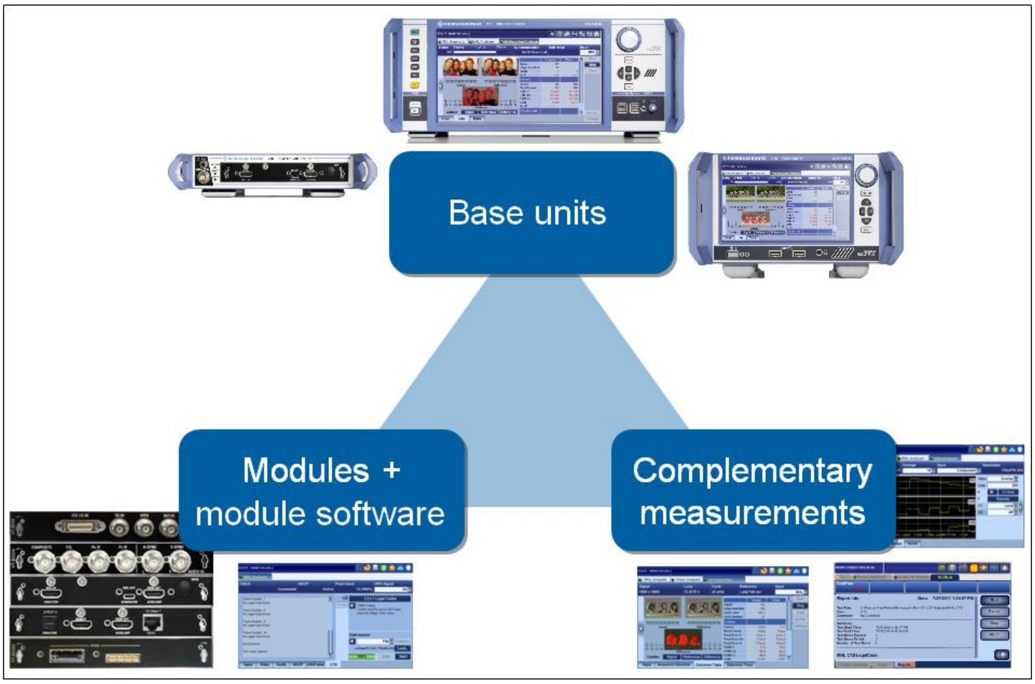


Fig. 5: The Rohde & Schwarz family of video testers offers three levels of flexibility

The three base unit types are designed to meet the different requirements for manufacturing, quality assurance and R&D.

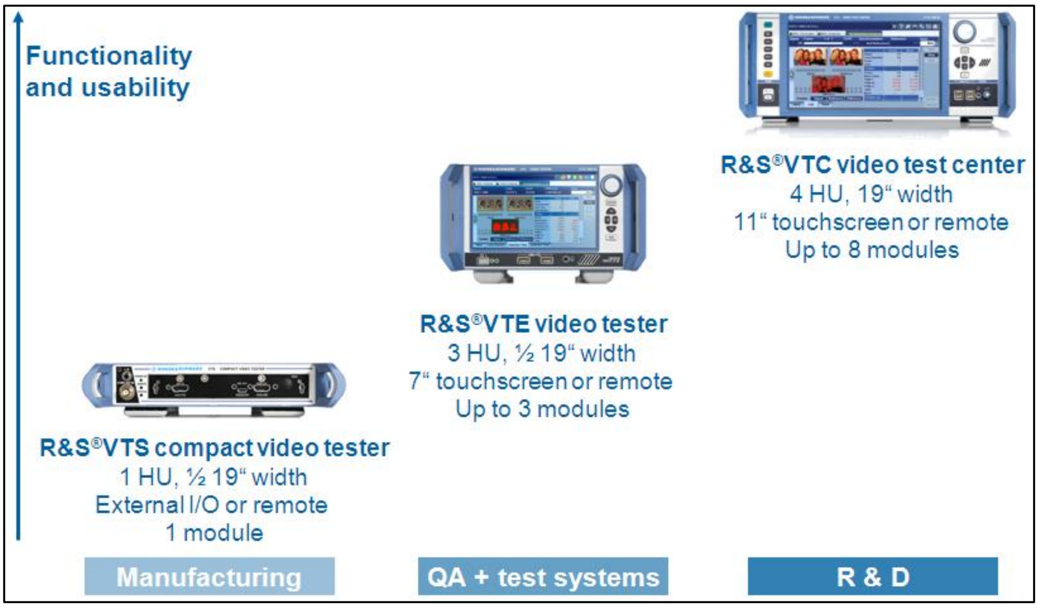


Fig. 6: Features differentiating the R&S®VTS, R&S®VTE and R&S®VTC

The user interface on each of the base units supports multiple languages and allows automated testing with a result log.

The required A/V interfaces and associated measurements are provided by adding separate modules to the base units, making the instruments ready for future developments. The following options are currently available:

- R&S®VT-B2350, MHL generator and analyzer
- R&S®VT-B2351, MHL PackedPixel analyzer

- R&S®VT-B2360, HDMI 225 MHz analyzer
- R&S®VT-B2361, HDMI 300 MHz analyzer

- R&S®VT-B2370, Analog AV analyzer

Finally, the scope of functions can be expanded by adding special software options depending on the application. Besides detailed video or audio analysis or compliance testing, this also comprises objective A/V quality assessment for performance evaluation of transmission paths or CE equipment with respect to the end-user experience.

2 Compliance Testing

2.1 Introduction

To ensure functionality and interoperability, every new MHL-capable device must, before entering the market, undergo thorough tests at an authorized test center (ATC) in line with the compliance test specification (CTS) issued by the MHL Consortium.

The first step for the manufacturer is to register with the MHL Consortium as an adopter. This obligates the manufacturer to adhere to the MHL standard and also to have its device certified at an ATC. Before this final certification step by the ATC, it is recommended that precompliance tests covering as much of the compliance test as possible be performed in the development lab. This is because manufacturers can eliminate uncovered problems more quickly before certification, and making it less likely that they will have to pay to repeat the ATC certification.

Every MHL Consortium adopter gains access to the contents of the standard and to the compliance test specification (CTS), which describes the required procedure and test equipment for every single test criterion.

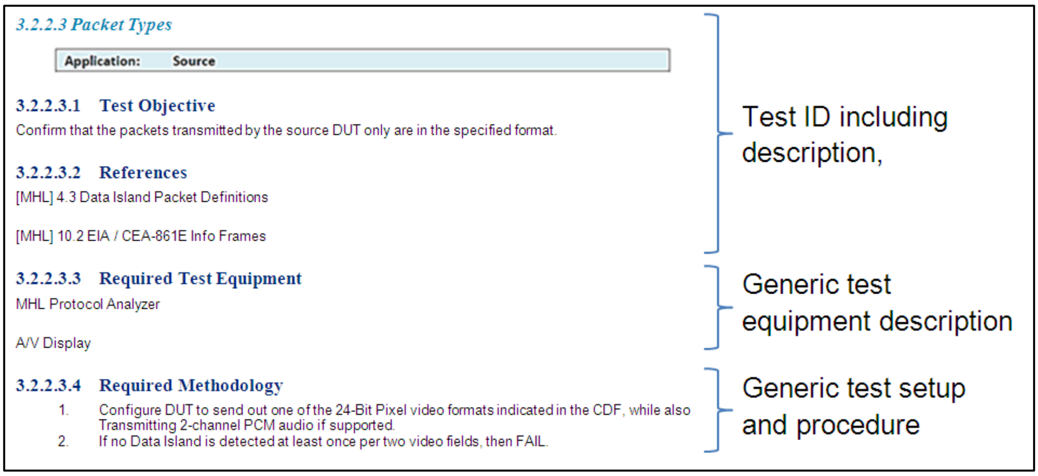
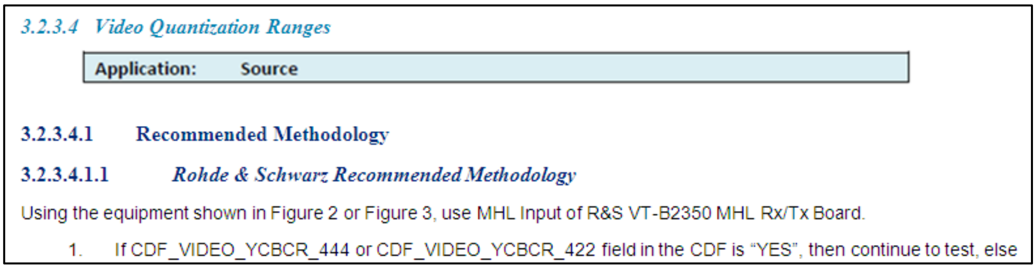


Fig. 7: General structure of the MHL compliance test specification

Every T&M equipment provider provides a detailed description of the configuration and operation of the T&M equipment in a method of implementation (MOI) document. These documents are also available to every MHL adopter.

2.2 Rohde & Schwarz Method of Implementation

The Rohde & Schwarz method of implementation (MOI) document is available to every MHL adopter [1]. It describes in detail how the R&S®VTS, R&S®VTE or R&S®VTC can be used to implement the MHL CTS.


3.2.3.4 Video Quantization Ranges

Application:	Source

3.2.3.4.1 Recommended Methodology

3.2.3.4.1.1 Rohde & Schwarz Recommended Methodology

Using the equipment shown in Figure 2 or Figure 3, use MHL Input of R&S VT-B2350 MHL Rx/Tx Board.

1. If CDF_VIDEO_YCBCR_444 or CDF_VIDEO_YCBCR_422 field in the CDF is "YES", then continue to test, else

Fig. 8: Excerpt from the Rohde & Schwarz method of implementation (MOI) document

The majority of tests for all three MHL device types are supported: sink (e.g. screen), source (e.g. mobile phone) and dongle. This generally includes the checks to ensure that all possible packet types are being processed correctly and that no illegal data is being transmitted. Also included is a check of the implementation of video and audio formats. An analysis of meta and control information exchange completes the offer:

Test item	CTS chapter		
	Source	Sink	Dongle
Supported by Rohde&Schwarz			
System tests	3.2	4.2	5.2
TMDS coding[1]	3.2.2	4.2.1	5.2.1
Video modes[1]	3.2.3	4.2.2	5.2.2
Audio test[1]	3.2.4	4.2.3	5.2.3
EDID test and device capability register test	3.2.6	4.2.5	5.2.5
RCP sub-commands tests	3.2.7	4.2.6	5.2.6
RAP tests	3.2.8	4.2.7	5.2.7
3D video test[1]	3.2.9	4.2.8	5.2.8
UCP tests	3.2.10	4.2.9	5.2.9
Not supported by Rohde&Schwarz			
Electrical tests	3.1	4.1	5.1
HDCP test	3.2.5	4.2.4	5.2.4
CBUS tests	3.3	4.3	5.3

Table 2: Overview of the MHL CTS components supported by Rohde & Schwarz

[1] Requires a DUT with deactivated HDCP.

Configure the R&S®VTS, R&S®VTE or R&S®VTC base unit with the following options to perform the tests:

Option	Purpose
R&S®VT-B2350 MHL RX/TX	Always required
R&S®VT-B2351 MHL RX PackedPixel	Add this module to check PackedPixel video formats from an MHL source[2]
R&S®VT-K355 MHL CTS System Sink Test	Includes the CTS tests for checking MHL sources
R&S®VT-K2355 MHL CTS System Source Test	Includes the CTS tests for checking MHL sinks and dongles

Table 3: Overview of the Rohde & Schwarz video tester device options for MHL CTS testing

Fig. 9: The R&S®VT-B2350 MHL generator and analyzer

See Section 6 for complete ordering information.

The user interface provides a special selection screen for launching the individual tests.

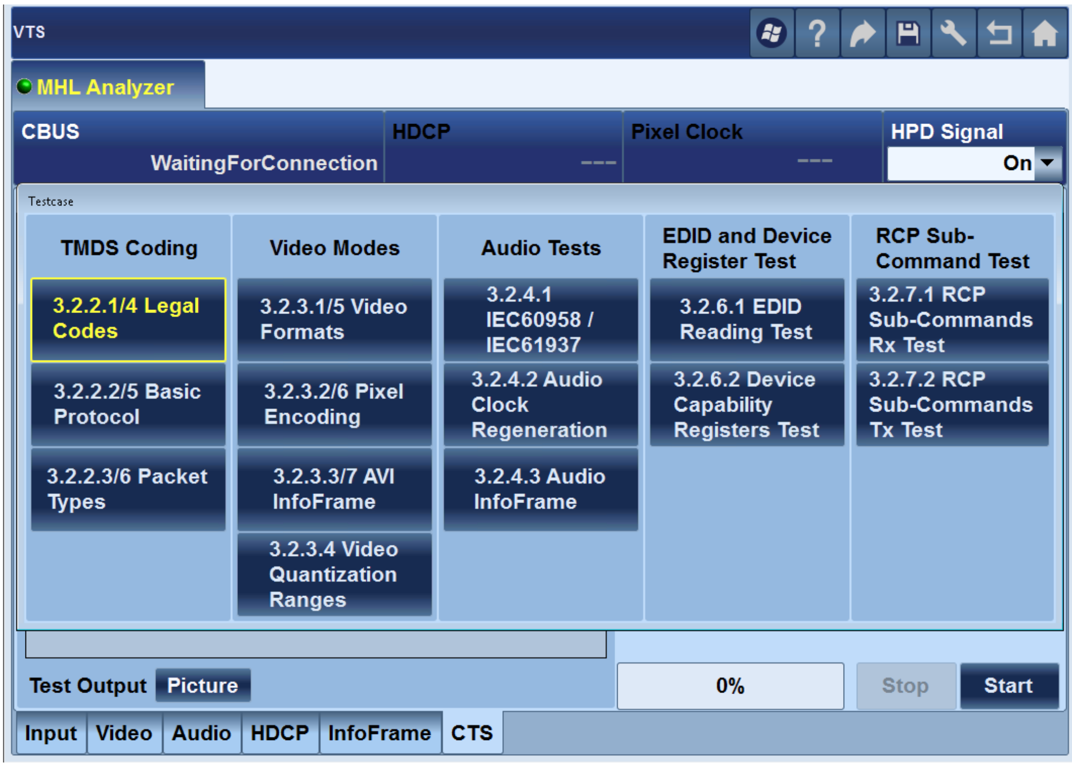


Fig. 10: CTS tests are easy to launch from the user interface

[2] The R&S®VTS cannot support this option due to a single module slot.

3 Abbreviations

ATC	Authorized Test Center
A/V	Audio/Video
AVI	Auxiliary Video Information
CBUS	MHL Link Control Bus
CEA	Consumer Electronics Association
CTS	Compliance Test Specification Cycle Time Stamp
DDC	Display Data Channel
DUT	Device Under Test
E-EDID	Enhanced-Extended Display Identification Data
EIA	Electronic Industries Alliance
HD	High Definition
HDCP	High-bandwidth Digital Content Protection
HDMI	High-Definition Multimedia Interface
HPD	Hot Plug Detect
ITU	International Telecommunication Union
MHL	Mobile High-Definition Link
MOI	Method of Implementation
MSC	MHL Sideband Channel
RAP	Request Action Protocol
RCP	Remote Control Protocol
SD	Standard Definition
SPD	Source Product Description
TMDS	Transition-minimized Differential Signaling
UCP	UTF-8 Character Protocol
USB	Universal Serial Bus
VBUS	MHL Voltage Bus

4 References

[1] MHL Consortium
mhlconsortium.org

[2] Rohde & Schwarz technical overview poster on MHL
http://www2.rohde-schwarz.com/file/MHL_po_en.pdf

5 Additional Information

Our Application Notes are regularly revised and updated. Check for any changes at http://www.rohde-schwarz.com.

Please send any comments and suggestions about this application note to Broadcasting-TM-Applications@rohde-schwarz.com.

6 Ordering Information

Designation	Type	Order No.
Base unit		
Video Test Center	R&S®VTC	2115.7400.02
Video Tester	R&S®VTE	2115.7300.02
Compact Video Tester	R&S®VTS	2115.7100.02
MHL CTS testing		
MHL RX/TX	R&S®VT-B2350	2115.7622.06
MHL RX PackedPixel	R&S®VT-B2351	2115.7645.06
MHL CTS System Sink Test	R&S®VT-K355	2115.8006.02
MHL CTS System Source Test	R&S®VT-K2355	2115.8012.02
Optional: Content analysis		
Video Analysis	R&S®VT-K2100	2115.8029.02
AV Inspection	R&S®VT-K2110	2115.8035.02
AV Distortion Analysis[3]	R&S®VT-K2111	2115.8041.02
Audio Analysis	R&S®VT-K2150	2115.8235.02

[3] Not available for R&S®VTS, requires R&S®VT-K2110.

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.

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