HDMI Sink and Source Compliance Test and Characterization

Application Note
Version 1.0

Introduction

The High-Definition Multimedia Interface (HDMI) is an industry-supported, uncompressed, all-digital audio/video interface. HDMI provides a connection between any compatible digital audio/video sources, such as a set-top box, DVD player, and A/V receiver and a compatible digital audio and/or video monitor, such as a digital television (DTV) [1].

HDMI is the dominant worldwide standard for Digital Connectivity. It is currently supported by over 400 vendors for consumer electronics and products.
HDMI enables standard, enhanced, or high-definition video, plus multi-channel digital audio on a single cable. It is independent of the various DTV standards such as ATSC, DVB (-T,-S,-C). These are encapsulations of the MPEG data streams, which are passed off to a decoder, and sent to the output as uncompressed video data, which can be high-definition. The video data is then encoded with a 'TMDS' (Transition Minimized Differential Signaling) scheme for digital transmission over HDMI. For compliance tests and characterization, a TMDS Signal Generator (see figure 1) is required.

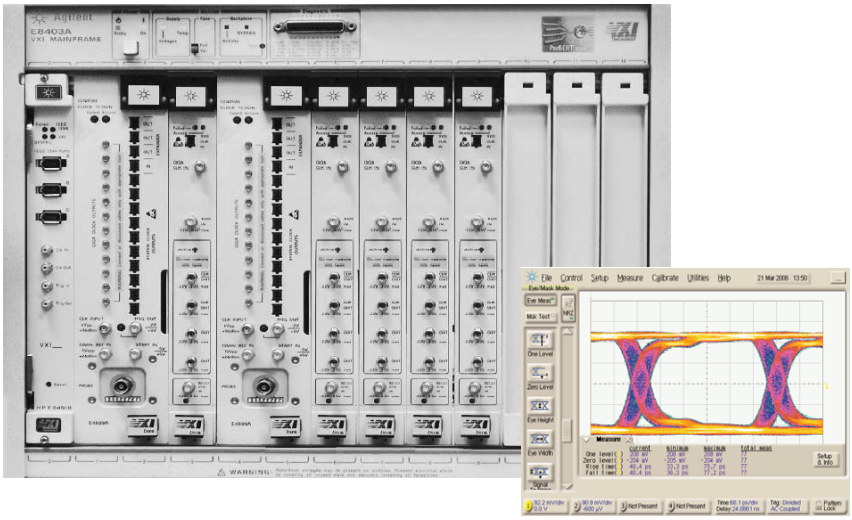

Figure 1: ParBERT 81250-based TMDS Signal Generator

HDMI version 1.2 supports up to 8 channels of one-bit audio. One-bit audio is used on Super Audio CDs.
The standard HDMI Type A connector has 19 pins. The higher resolution Type B with 29 pins has been defined to support resolutions higher than 1080p, although it is not yet in common use. HDMI Type A is backward-compatible with the single-link Digital Visual Interface (DVI) used in modern computer monitors and graphic cards. This means that a DVI source can drive an HDMI monitor, or vice versa, by means of a suitable adapter or cable, but the audio and remote control features of HDMI are not supported by DVI.

HDMI 1.3 achieves deep color, higher speed and greater PC convergence

In January 2006 HDMI licensing LLC, which represents the seven HDMI founder companies announced capabilities under development for the next version of the HDMI. These capabilities include support for deep color, higher speed and easier integration into personal computers. Using one cable to deliver crystal-clear, all-digital audio and video, HDMI will simplify cabling to give customers the best home theater experience [2]. The specification 1.3 was released in June 2006.

Electrical Cable and Sink testing

As HDMI moved with version 1.3 to the area of gigabit speeds, the physical layer parameters like jitter became more and more important. Not only the jitter budget of the data transmitter outputs has to be measured, but the jitter tolerance of the receiver inputs too. Jitter tolerance stimulates the receiver input with adjustable jitter and checks for compliance or performance margins. The HDMI Compliance Test Specification requires the use of a TMDS Signal Generator for electrical cable and sink tests.

Agilent TMDS Signal Generator

The Agilent TMDS Signal Generator provides the data channels D0, D1 and D2 to cover the three colors green, red, blue. The fourth channel D- is used as intra-pair skew channel to provide additional skew testing between normal and complementary data as defined in the HDMI standard. A clock signal is also provided.

Key features of the TMDS Signal Generator for compliance test and characterization are:

- TMDS signal leveling
- Best in class signal performance up to 7 Gb/s with low intrinsic jitter
- Jitter modulation with unique independent clock and data jitter insertion
- Data sequence generator software for HDMI video frames

Full Jitter Tolerance Curve

Only the Agilent TMDS Signal Generator allows measuring the full HDMI jitter tolerance curve. The jitter tolerance test checks the input sensitivity of the sink with regard to stress generated by jitter modulation. Jitter modulation is supported up to 1.5 UI at a max. frequency up to 30 MHz.

Independent Jitter Modulation for Clock and Data

Leading semiconductor suppliers confirm that thorough, in-depth HDMI characterization and margin test requires test modes to modulate jitter for clock and data in synchronous and asynchronous test modes. The Agilent TMDS Signal Generator uniquely provides two individual clock groups. The non-synchronous clock versus data jitter modulation can be freely adjusted with either the integrated HDMI Frame Generator software application or the complementary N5990A Test Automation Software.

Video Framed Data

Video framed data is generated with the powerful sequencer of the ParBERT-based TMDS Signal Generator. Convenient access for manual operation, e.g. for R&D-tye applications, is provided by the HDMI Frame Generator software E4887A-207. In the example shown in figure 2, a 740 x 480 p video frame is generated and repeated infinitely. The software structures the video data in blocks for efficient use of the ParBERT memory and creates the proper bit flow.

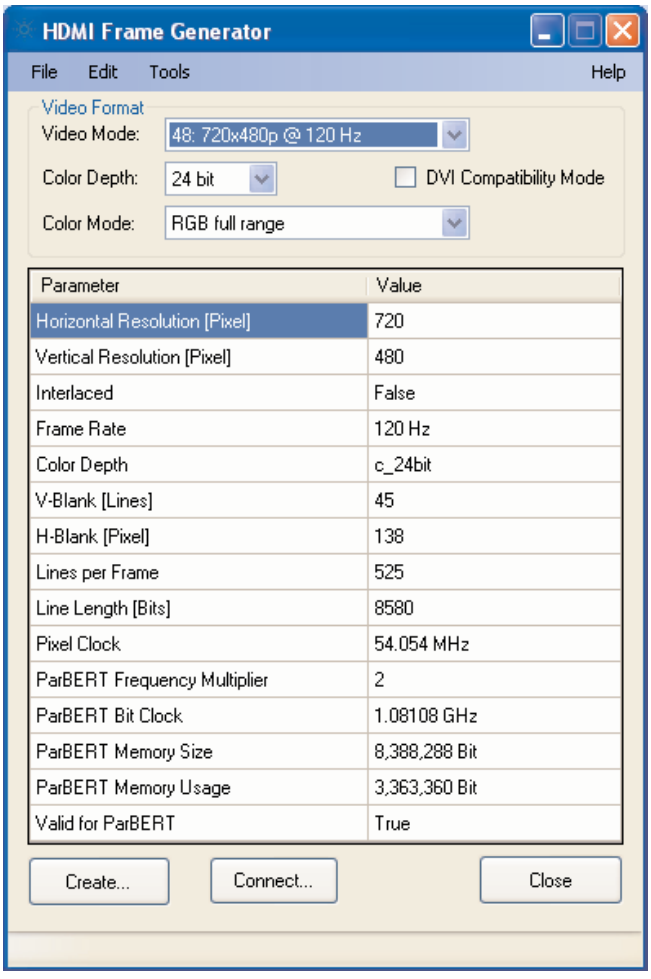

Figure 2: HDMI frame generator software

Test Automation

Automated HDMI compliance and in-depth characterization measurements are enabled by the N5990A Test Automation Software Platform. It runs on the TMDS Generator's PC controller. This software fully configures and controls the required instruments, such as the TMDS Signal Generator for the sink tests or the oscilloscope for the source tests, the selected video format and color depth (see figure 3). System calibration is also provided. System calibration is especially important for the HDMI sink tests to ensure calibrated amounts of jitter are applied to stress the device under test (DUT).

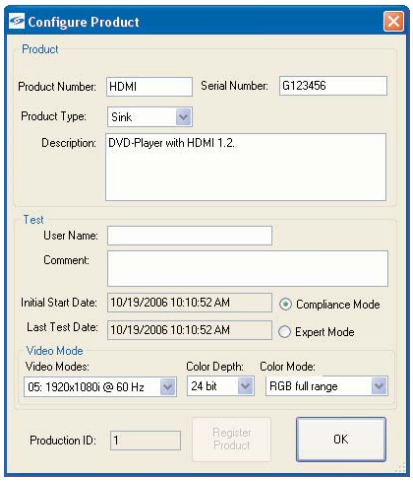

Figure 3: HDMI test configuration

Within each group of tests (calibration, sink, source), individual tests are user-selectable within a test tree-structure (see figure 4, left frame). For most tests, parameters are also selectable in expert mode, within a property tree-structure (right frame). In compliance mode, the tests are conducted as defined in the HDMI Compliance Test Specification (CTS).

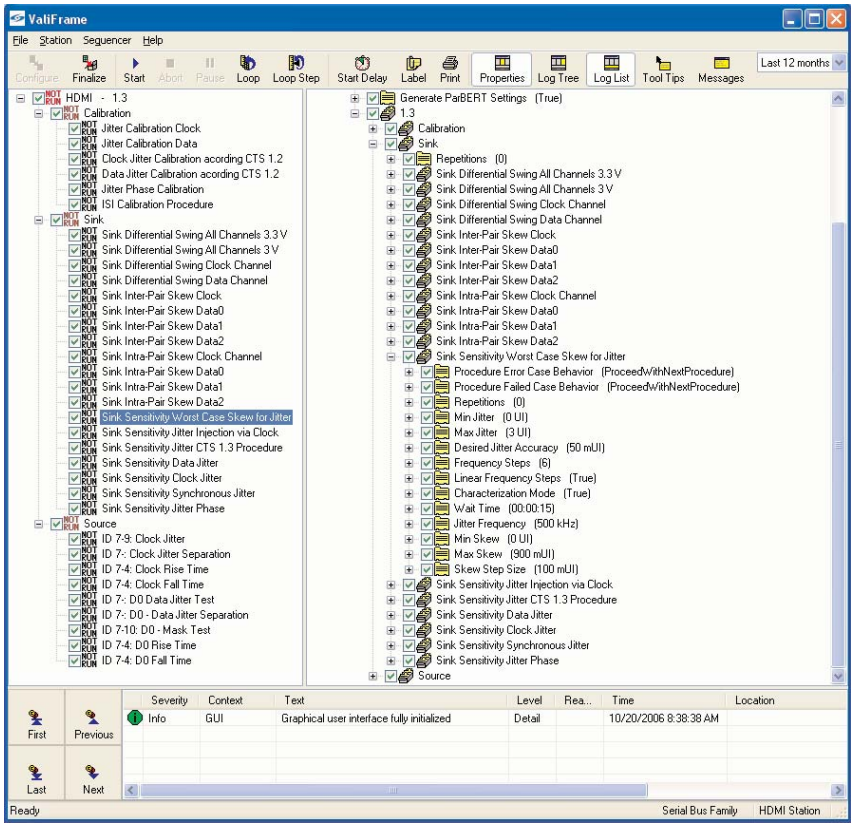

Figure 4: N5990A main screen

Calibration

Calibration results can be depicted as shown on figure 5. For ultimate performance, the N5990A uses the latest software tools within and the Microsoft.NET environment. The C# language avoids overhead which e.g. graphical development environments usually impose. This results in the shortest calibration times on the market. The calibration time which competitive solutions require are often reduced by half. The same applies to test execution.

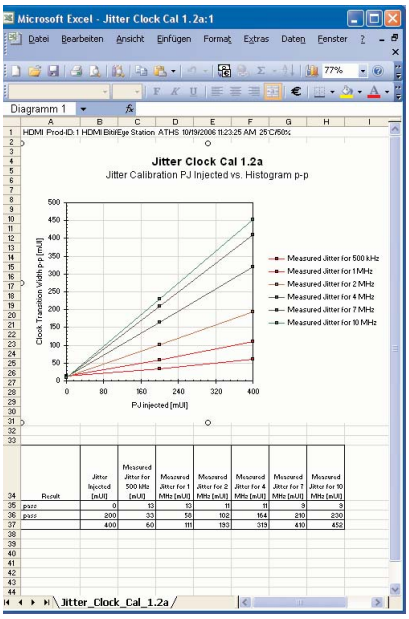

Figure 5: Clock jitter calibration results

Sink Tests

The N5990A Test Automation Platform guides the user through the tests. As an example, figure 6 shows the instructions given for the TMDS min/max differential swing sink test setup (CTS test ID 8-5). In this particular setup, the full TMDS Signal Generator, including clock and data jitter sources and power supplies, is connected to the DUT via a TPA-P. The test will only be started when the user has confirmed the setup.

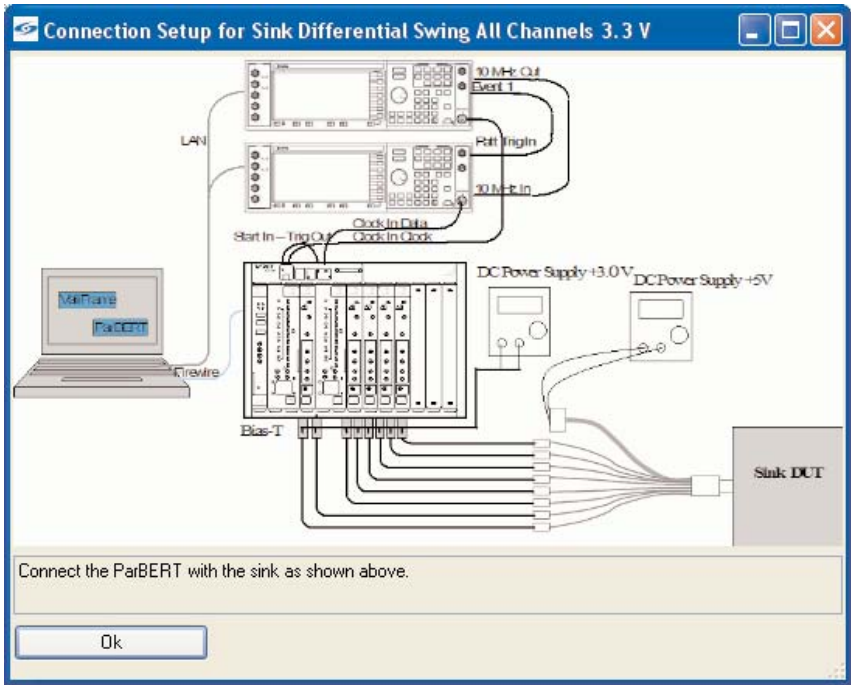

Figure 6: Sink test connection setup example

Results of the crucial jitter tolerance test (test ID 8-7) are given in figure 7. The E4887A TMDS Signal Generator's unique independent clock and data jitter insertion capability provides the most complete test coverage available.

As shown in figure 7, N5990A uses MS Excel to display data graphs and data tables. All test results are copied to the same workbook (see figure 8), hence all data is available in a single place for convenient analysis, storage and post-processing. The productivity gains due to this approach are tremendous.

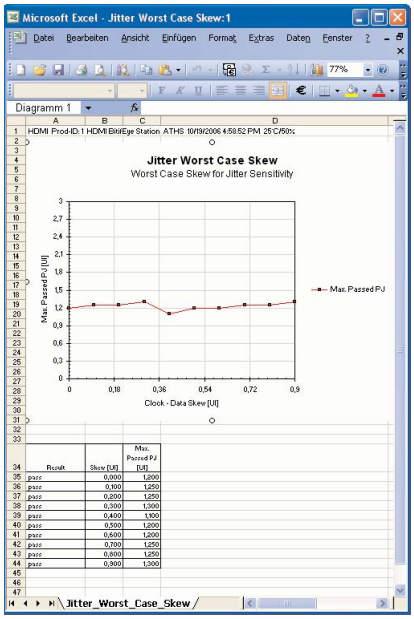

Figure 7: Jitter tolerance results

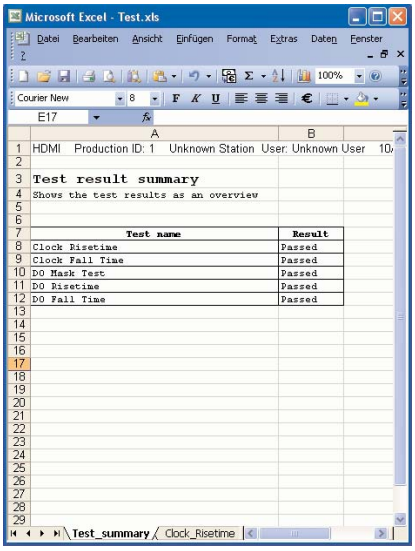

Figure 8: Test result workbook

Source Tests

The Test Automation Platform N5990A interfaces with the HDMI source test application N5399A, which runs on a suitable oscilloscope of the Agilent DSO80000 Series. N5990A configures and starts the source tests. Once the tests are completed, data graphs and tables are uploaded from the oscilloscope to the Automation Platform on the TMDS Generator's PC controller which doubles as overall test controller.

Figure 9 shows the results of the TMDS source rise time test (test ID 7-4). The TMDS data eye diaram (test ID 7-10) results are given in figure 10. The source test data is available in Excel for further processing too.

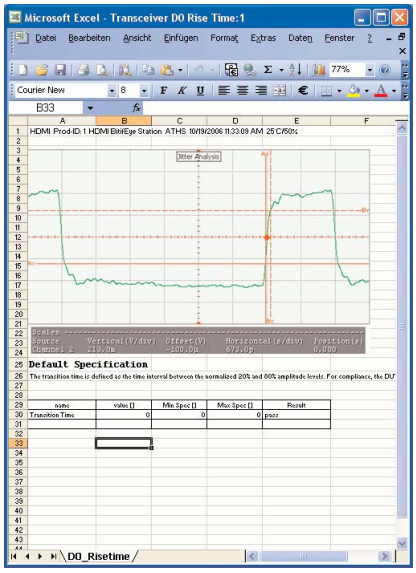

Figure 9: Source rise time test

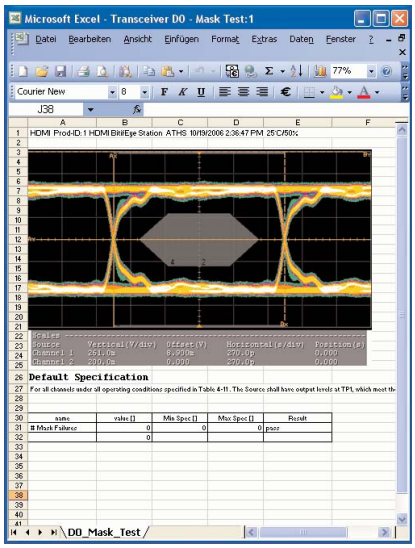

Figure 10: Data eye diagram

Summary

HDMI compliance tests and characterization used to be challenging in the past due to the limitations of existing test solutions in terms of signal quality, system performance and ease-of-use. With the proper test solution, comprising hardware, software and accessories, HDMI tests can now be run reliably and conveniently.

In this application note, high-speed electrical sink and source tests were used as an exemple. The recommended solution for theses tests consists of a TMDS Signal Generator, a high-bandwidth realtime oscilloscope and a test automation software. By using this solution, the tests are facilitated due to substantially, reduced calibration and test times and full, central control over the HDMI test setup as well as central storage of all test data. The Test Automation Software Platform is provided by the Agilent partner BitifEye Digital Test Solutions.

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References

[1] High-Definition Multimedia Interface, Wikipedia, the free encyclopedia
[2] Press release: HDMI To achieve deep color, higher speed and greater PC convergence, Las Vegas, January 3, 2006 http://www.hdmi.org/press/pr/pr_20060103.asp

Related Literature	Pub. Number
Jitter Fundamentals Jitter Tolerance Testing with 81250 ParBERT Application Note	**5989-0223EN**
Jitter Fundamentals ParBERT 81250 Jitter Injection and Analysis Capabilities Application Note	**5988-9756EN**
Next Generation I/O Bus PCI-Express BER Test Solution Application Note	**5989-2690EN**
Second Generation PCI EXPRESS with the J-BERT N4903A Application Note	**5989-4087EN**
Physical Layer Testing of Passive Optical Network (PON) Modules Application Note	**5989-3298EN**

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(fax) (65) 6755 0042
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tm_ap@agilent.com

Contacts revised: 09/14/06

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