Testing your High Definition embedded devices using the HDMI Version 1.3 specification

By Evan Sun
Embedded.com
(11/08/07, 12:46:00 $┘ EST)

HDMI.Org published ver 1.3 of the HDMI specification in June 2006. This version adds higher display resolution formats, including 1,080p, Deep Color formats with serial data rates of up to 3.4Gbps.

HDMI 1.3 is the most significant upgrade yet in the specification that has become the de facto standard interface for high-definition (HD) devices that include DVD players, HDTV and the newest gaming devices. HDMI 1.3 defines the latest HD A/V technology that began hitting the consumer market late 2006, and continues to roll out this year.

To ensure reliable information transmission and interoperability, industry standards specify requirements for the network's PHY. HDMI Compliance Test Specifications (CTS) define an array of compliance tests for the HDMI PHY. Last March, HDMI.Org published an updated CTS (CTS 1.3b) document that incorporates new tests for the capabilities defined in HDMI 1.3.

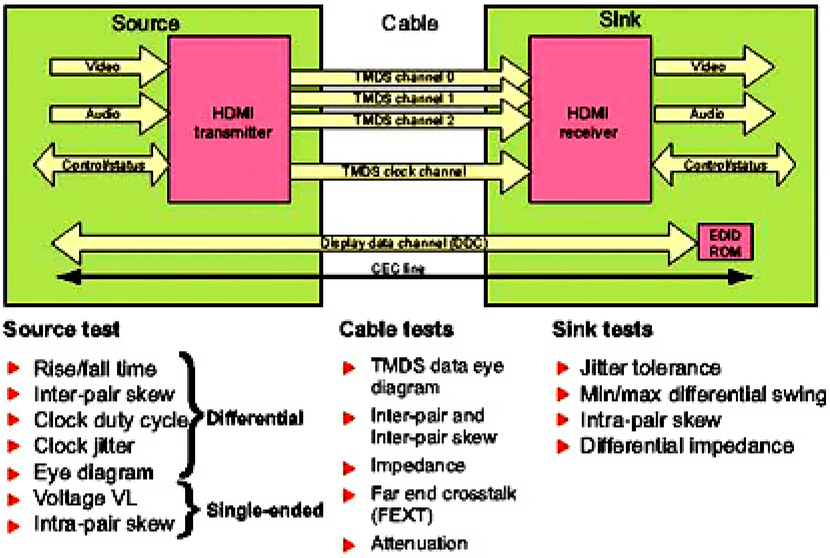

Figure 1: These are the logical links of HDMI TMDS signaling and core tests required by CTS specifications

.

Test challenges
High-quality test and measurement instruments, and solutions for high-speed serial data are fundamental to ensure compliance with the HDMI CTS 1.3b and the development of successful products that implement the HDMI 1.3 specification.

Figure 1 above shows the major elements of the HDMI transmission system - source, cable and sink. While it is recommended to perform as many tests as possible, the core electrical tests are critical for compliance.

Per HDMI CTS 1.3b specifications, the complete compliance test solution includes real-time oscilloscopes, sampling oscilloscopes, signal generators, differential probes and test fixtures. However, the key is how to choose the right test platform to simplify the latest HDMI designs and to ensure compliance with the latest test requirements. Engineers need to integrate several instruments into a complete, flexible and cost-effective solution.

A capable, integrated solution enables fast eye-diagram rendering and jitter verification, required to accumulate huge waveforms within as short a time period as possible.

Also, signal generators need to operate in a closed loop to automatically perform the needed complex cable and sink tests using "one-button" compliance test software resident on an oscilloscope.

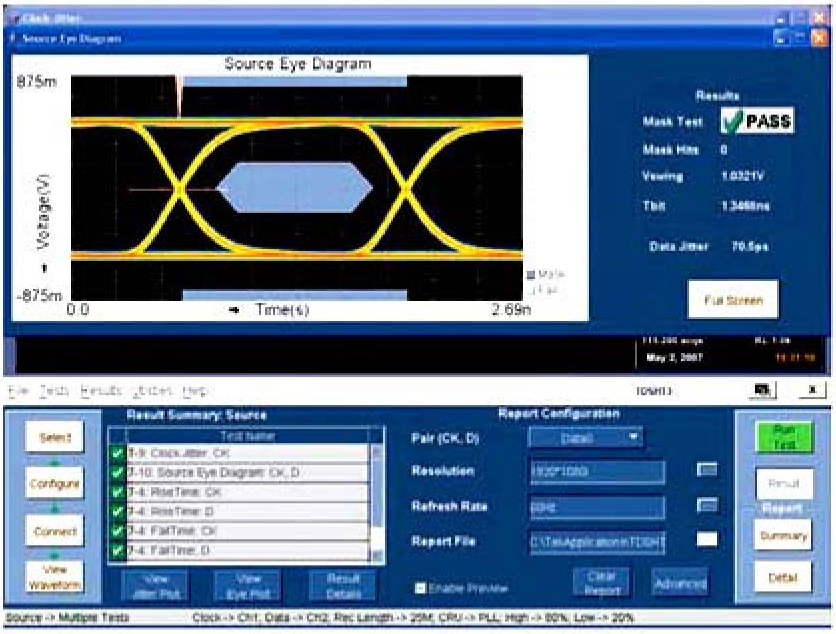

Figure 2: Shown are HDMI source compliance test results.

Real-time oscilloscopes
A complete test solution for HDMI CTS 1.3b includes high-performance hardware and comprehensive software for design and test engineers in consumer electronics, semiconductor and cable manufacturers.

In terms of the key instrument, to test HDMI 1.3 signals need a minimum 8GHz real-time oscilloscope in which HDMI compliance test software is running. **Figure 2 above** is an example of HDMI 1.3 source test results using HDMI compliance test software.

Meanwhile, to ensure adequate representation of signal characteristics, the CTS 1.3b specifies a minimum oscilloscope record length to acquire the data signal.

This ensures that at least 400,000 unit intervals (or Tbit) are accumulated for building the eye diagram. With 16M/20M record length, at least 400,000 unit intervals (UI) can be captured for lower-resolution signals, and over 2.6M UI for higher resolution devices. Considering the bit rate up to 3.4Gbps, the minimum oscilloscope record length is above 16M with high-speed sampling rate (above 10GSps).

At the nerve center of any transmission system is the clock jitter. The jitter test checks to ensure that the clock signal is not carrying excessive jitter - e.g. duty cycle jitter is an excellent method of assessing deterministic jitter.

The CTS also defines the margin to be +10 percent from the nominal 50 percent duty cycle. It's important that the variance in duty cycle is measured over a large number of acquired signals.

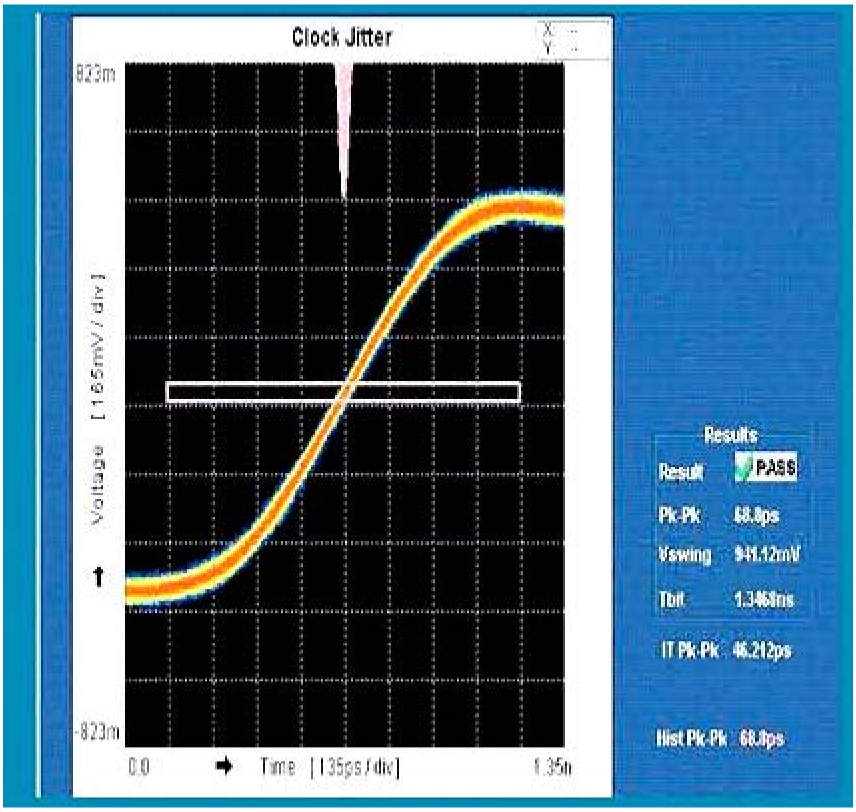

Figure 3: This clock jitter test used DPO technology.

As per the CTS, a minimum of 10,000 triggered waveforms are required for test purposes. Trigger re-arm rates of the oscilloscope then take center stage. Nominally, oscilloscope trigger re-arm rates are of the order of about 100wfms/s.

This can mean unacceptably long acquisition and test times. Fortunately, there are sophisticated techniques such as FastAcq on Digital Phosphor Oscilloscopes (DPO) that enhance the trigger re-arm rates and deliver over 300,000wfms/s.

Figure 3 above demonstrates the clock duty cycle test using the FastAcq technology. Notice the richness of information that ensures clear and compelling measurements.

Signal generators

One of the most critical characteristics of a sink device is its tolerance to specified levels of jitter in the signals. The standard defines the limit as 0.3*Tbit. Specified amounts of jitter are injected in steps (from low to high jitter) into the transmitted **Transition Minimized Differential Signaling (TMDS)** signal until the sink device fails to recover the signal. The amount of jitter that the sink device is able to tolerate is compared against the limits for compliance.

Several measurements are carried out by injecting a specified amount of jitter. Three measurements are performed over two test cases: (a) data jitter frequency at 500kHz and clock jitter frequency at 10MHz, and (b) data jitter frequency at 1MHz and clock jitter frequency at 7MHz.

When selecting the right equipment for the HDMI CTS test setup, it is important to understand the necessary aspects that must be addressed. TMDS signal generation plays a pivotal role in the Sink tests.

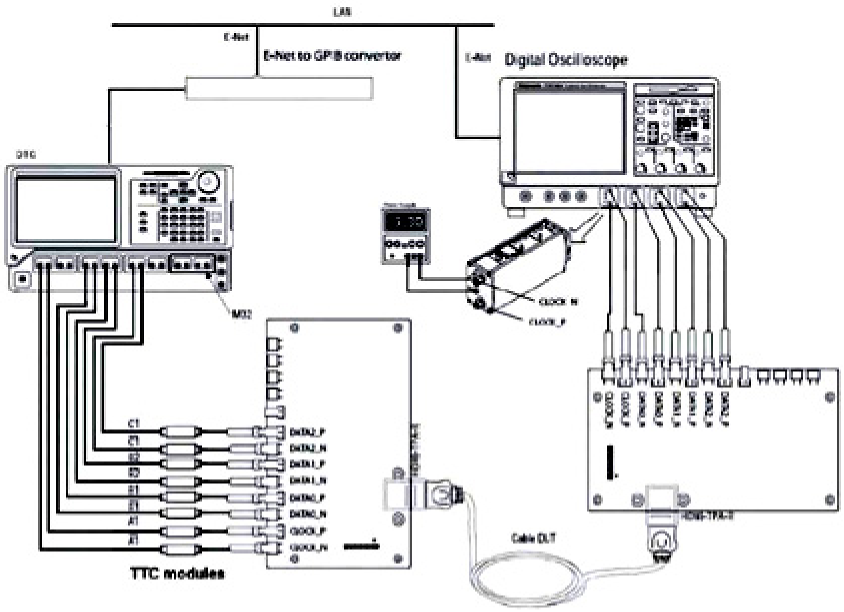

Figure 4: Shown is an integrated sink testing system based on a closed-loop mechanism

.

The key challenge for a signal generator is to provide a full complement of highly accurate signals and the ability to precisely control their parameters.

For performing minimum differential sensitivity tests, a resolution of 20mV is required. The intrapair skew test requires precise delay settings down to sub-picosecond resolution.

The jitter tolerance test assumes larger challenges, since both clock and data jitter need to be varied. Generating jitter frequencies on the order of 10MHz requires a combination of signal generators.

<>Since margins are tight, precise control is required on jitter amplitude. With various parameters to be adjusted and tight margins, this test tends to be extremely complex and can take a very long time to complete. **Figure 4 above** shows an example of an automated sink test system.

The DPO connects to the DTG5334 (TMDS signal generator) using a GPIB cable and to the AWG/AFG (jitter insertion signal generator if required) using a GPIB USB-B cable.

HDMI design and test engineers can control signal generators in a closed-loop mechanism to automatically perform the needed complex cable and sink tests using "one-button" compliance test software resident on the oscilloscope. The closed loop mechanism shrinks test time greatly and eliminates nonlinearities of test setup.

Differential probing system
It's also critical to have a flexible, versatile probing system with high performance. Meanwhile, many of today's high-speed serial data standards use differential signaling on multiple lanes that are challenging to measure simultaneously on a single oscilloscope.

What is needed is an oscilloscope that can simultaneously acquire up to four high-speed differential signals with the use of four differential probes. As an added benefit, the inputs on the probes connect to high quality 50 ohm terminations that offer industry-leading return loss, a critical specification in compliance testing as frequencies increase.

This differential probe provides a common-mode DC voltage input to the termination network. The termination voltage can be supplied either externally by the user or internally by the oscilloscope. In addition, there is also an automatic mode that senses the common mode voltage of the input signal and automatically sets the termination voltage to match.

Sampling scope
Differential transmission lines used in achieving fast data rates are very sensitive to impedance matching.

Consequently, impedance characterization is a very crucial test in HDMI compliance testing. The through-connection impedance has a limit of 15 percent variance to its 100 ohm specification. The impedance at termination needs to be tighter as the margins are only 10 percent of its characteristic value of 100 ohm.

Meanwhile, engineers need to verify cable key characteristics, like intra- and interpair skew and crosstalk. Time Domain Reflectometry (TDR) is a powerful and accurate tool for measuring impedance and length in interconnects.

While fundamental concepts of TDR are relatively simple, a number of issues must be considered to make accurate measurements, the foremost being the ability to perform true-differential TDR.

Evan Sun is Market Development Manager, Asia Pacific Region, Tektronix Inc.