Analysis of common failures of HDMI CT

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The HDMI standard has been broadly adopted since its release several years ago. In order to bear the HDMI logo, all HDMI products must pass the HDMI Compliance Test (HDMI CT). To save time and money, customers should pre-test their HDMI products before sending them to Authorized Test Centers (ATC) for certification. Based on the experiences of numerous pre-tests performed at Analog Devices' HDMI CT lab, this article discusses the most common system design issues that cause products to fail the HDMI CT. It also analyzes specific case failures and offers solutions.

ANALYSIS OF COMMON FAILURES OF HDMI CT:
Almost all devices, including TVs and DVD players, failed the test the first time. Most of the failures were system design and PCB layout related. Special features are sometimes required in order to pass the HDMI CT. For instance, HDCP (High Definition Content Protection) may need to be enabled or disabled in source devices. Both IC and system design and manufacturing companies must completely understand the HDMI specification and Compliance Test Specification (HDMI CTS) in order to design compliant HDMI products. Following are the most common failure items and recommendations for resolving the problems.

1. EDID Test
The source devices are required to support "Enhanced DDC" specification. This means that the source needs to be able to read the EDID information after 256 bytes by using "segment pointer 0x60". Most of the time only 256 bytes are used for EDID, but HDMI CT requires checking that the system is able to read 4 blocks (128 bytes/block), for a total of 512 bytes. It is very important to meet this requirement for the segment pointer in order to pass the HDMI CT.

2. 5V Power of HDMI Transmitter (Tx)
Some customers connected a resistor or diode in series to limit the current of the 5V output. In the HDMI CT, testing 5V power of HDMI Tx requires a 55mA current draw from the +5V power pin during the measurement. This may cause the test to fail, as the power output needs to be between 4.8V and 5.3V to pass. Figure 1 shows that the output drops to 4.45V when a 10-ohm resistor is connected, resulting in the failure of this test.
Output drops when a 10-ohm resistor is connected, resulting in test failure.

It is important to correctly connect the Consumer Electronics Control (CEC) line (Pin 13 of the HDMI connector). If the system is not designed to support the CEC function, designers can leave the line floating. People sometimes want to connect the CEC line to a general-purpose I/O of the video signal processing (VSP) chip to allow for possible extension later. Designers must then make sure the connection meets the HDMI CT criteria, including keeping the maximum DDC line capacitance under 100pF.

**format support of HDMI source devices**

HDMI Specification requires that all HDMI sources must support one of the following formats: 640480p@59.94/60Hz, 720480p@59.94/60Hz or 720576p@50Hz. Another requirement when designing HDMI sources that is sometimes overlooked: if any YPbPr or other non-compressed digital ports on the source device can support the following formats, then the HDMI ports on the same source device must also support them.

- 1280 720p @59.94/60Hz
- 1920 1080i @59.94/60Hz
- 720 480p @59.94/60Hz
- 1280 720p @50Hz
- 1920 1080i @50Hz
- 720 576p @50Hz

**DVI sink (DVI Rx)**

The HDMI Specification requires that all HDMI sources be compatible with the sink devices, which are compatible with DVI 1.0. When an HDMI source is connected to a DVI sink it must meet the following requirements:

- The video formats transmitted are RGB
- No Video Guard Bands are transmitted
- No Data Islands are transmitted

When a source device detects the plug-in of a sink, it shall assume the sink is a DVI device. In the mean time, the source will check if the EDID of the sink contains CEA extension and if the CEA extension contains VSDB (Vendor-Specific Data Block) with valid length. If both are true, then the source will determine that the sink plugged in is an HDMI device.
The failure rate for this test was quite high. As such, designers should familiarize themselves with the EDID requirement of the most updated HDMI specifications. Listed below are some common mistakes that cause failure:

I. In the first 128 bytes of EDID, the "Monitor Range Limit Header" and "Monitor Name Header" must be provided. Both are 18 bytes. If the content of either one of these is shorter than 18 bytes, then it must be filled by 0x20 and finished by 0xA0.

II. Inconsistency of supported video formats between "Short Video Descriptor" (SVD) in EDID and "Capabilities Declaration Form" (CDF). Any formats declared in the CDF must also be listed in the SVD of EDID.

To simplify the system design, some designers connected the +5V voltage of the HDMI input directly to the HPD pin of HDMI Rx through a 1K resistor. In such designs, the EDID EEPROM can not be read and the HPD pin voltage could remain high when the system is put into standby mode or when the ac power is removed. This causes the failure of HDMI CT, because the HDMI Compliance Test Specification requires that the EDID must be accessible and can be read when the HPD pin voltage is high, even when the ac power is removed or the system is put into standby mode. A sample reference design circuit, included in a later section, addresses this issue.

**HDMI Rx TMDS Differential Impedance**

A large number of devices failed this test, even though most system designers were aware of the requirements for input differential impedance. Most of the time, systems failed this test because of high parasitic capacitances from input ESD protection devices or EMI chokes. Most manufacturers of high-speed signal ESD protection devices provide reference designs for system PCB layout with impedance characteristics for their customers. This is one of the tests where system PCB layout affects the test result. Customers need to redesign the PCB if it fails. This affects the production schedule and time to market.

Please notice that in HDMI CTS V.1.3, the criterion for passing this test is different from HDMI CTS V.1.2. The compliant value of through-connection impedance is still 100Ω plus/minus 15% as in the previous CTS, but a single excursion is permitted out to a max/min of 100 ohms plus/minus 25% and of a duration less than 250psecs.

This is one of the most frequently failed tests due to the high capacitance of the MOSFET used for voltage level shift. Use of MOSFET with $C_{iss}$ and $C_{oss}$ under 10pF is recommended on the DDC line to avoid the failure.

When HDMI systems have multiple HDMI inputs, the HDMI specification requires that, for non independent CEC lines, CEC lines from all HDMI inputs (if present) and a single HDMI output (if present) be interconnected. The CTS requirement for this test is less than 5 ohms. Even systems that do not support CEC are still required to interconnect the input CEC lines.

Some customers used the circuit shown in **Fig-2** to use the 5V coming from the HDMI connector and use VCC to supply the 5V voltage needed for HPD. This violates the requirement that, when the HDMI 5V input is at 0V, the HPD voltage should be higher than 0V and lower than 0.4V. The
simplest way to solve this problem is to connect a 1K resistor in series with the HPD pin. The simple switch circuit shown in **Fig-3** works well. Its function is to control the HPD pin and inform the source when the downstream Rx is ready or if the source should re-start certain actions such as High Definition Content Protection (HDCP) authentication. This greatly improves system compatibility.

![Fig-2 HPD Output Voltage](image)

Use of 5V coming from the HDMI connector and VCC to supply the 5V voltage needed for HPD violates HDMI CT.

![Fig-3 HPD Output Voltage](image)

Switch connecting 1K resistor in series with the HPD pin solves this problem.

**HDMI Rx video format support**

One common failure of this test item is that some systems did not meet the requirement that all HDMI sinks must be able to receive 640 480p @59.94/60Hz format. Systems designed for 60 Hz video must be able to support 720 480p @59.94/60Hz input format and systems designed for 50 Hz video must also be able to support 720 576p @50Hz input format. For the sources tested in the ADI lab, many customers overlooked the requirement of supporting the 640480p video format.

Less tolerance for video format timing variation is another common failure of this test. This test shall cover all the supported video formats. Systems supporting 50 Hz are required to tolerate timing variation between 49.75 Hz to 50.25 Hz (50 Hz 0.5%). Systems supporting 59.94 Hz or 60 Hz are required to tolerate the timing variation between 59.64 Hz to 60.3 Hz (59.94 Hz “0.5% to 60 Hz +0.5%).

**wireless repeater devices**

Wireless repeater devices are growing rapidly during the last six to nine months. HDMI Licensing LLC released the test guidance of this type of wireless devices. If the wireless repeaters support High-bandwidth Digital Content Protection (HDCP), then the devices must be tested as HDMI repeaters. If the devices do not support HDCP then they can be tested as repeaters or as independent sources and sinks. If the wireless devices are CEC root devices then the "Physical address" test can be waived.
CONCLUSION:
As discussed above, passing HDMI CT is a fundamental and important step to ensuring product compliance to the HDMI Specification. It also greatly helps improve interoperability between products from different manufacturers. Providing solutions for the most common failures of the HDMI CT not only offers high quality HDMI interface products to CE customers, but also helps them design highly compatible systems.

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