THX Certified 4K Interconnect Program™

For three decades now THX Ltd has been defining benchmark AV quality and certification standards for motion picture content and delivery, from commercial cinemas through to the home. The essence of THX® philosophy is to deliver to the audience a cinematic experience, in both picture and sound, which serves justice to the grand visions of the filmmakers. THX was created by Lucasfilm, and debuted with the third Star Wars installment, 'The Return of the Jedi' back in 1983.

When considering system integrity in its entirety from source through to display, the role of the interconnect is not to be underestimated. After all, it typically accounts for more than 90% of the signal path. THX have recognized this, and combined with today's ubiquity of HDMI®, have developed a remarkably thorough test regime to certify HDMI cables that meet the performance standards of THX. This is called the THX Certified 4K Interconnect Program, supported by the THX Interconnect Specification.

Through this process THX have identified all of the key elements needed for the successful and scalable long term reliable deployment of an HDMI interconnect. The rigorous THX test regime includes a total of approximately 75 individual proprietary tests in eight key areas; high speed data categorization for passive and active cables, S21 network analyzer tests, pixel error analysis, DDC tests, auxiliary functional tests, system interoperability, connector retention force, and overall build quality.

Fig 1: The THX Certified logo as seen on approved products

Background

The performance of an audio visual system is, as it has always been, dependent on the sum of all its parts. HDMI is all too often a cause for concern and unwanted troubleshooting for the custom installation and integration community.

The HDMI cable has long been recognized as the number two cause of HDMI system interoperability problems globally (EDID conflict is #1, in itself also often caused by the cable!). Now with the growth of UHD (4K/2160p), the high speed signaling will likely rise up the 'charts' as a fresh contender for a rising number of application failures in the field. This leads to wasted hours and real calculable costs to integration professionals. Quality cables are proven to save time, and therefore money, maximize audio-visual performance, and minimize the risks of site callbacks.

It is assumed by many that all HDMI cables are compliant and certified. If that were so, and that was adequate, then it should follow that all cables should always work. But in fact they don't. And even if they do work upon deployment, it does not always follow that they will continue to work flawlessly when realities like poor connections, loose connectors, dry solder joints and interferences later come into the fold. It is an undisputable fact that the HDMI cable is a 'lossy transmission line'. It is the degree of loss, and more importantly the additive loss profile across a system, that can distinguish good from bad.

High level third party certification such as that which THX now offers adds to the standard subset of HDMI compliance certification tests . THX in turn validates qualified cables as fit for purpose in higher end, oftentimes more complex AV systems of typically higher bandwidth, as is the case in many premium modern systems.

Past Program Differentiation

Several years ago THX introduced an interconnect certification program which included mostly analogue formats, but did include some select HDMI cables. The focus of that original program (as applied to HDMI) was for assured delivery of 1080p/60 and up to 7.1 channels of audio, as was the maximum expectation at the time. At an aggregate 4.455Gbps, this was a broadly used data rate which sat in between the official 'Standard' and 'High Speed' HDMI cable labels. This program was discontinued in 2012.

The all-new program includes rigorous tests for up to four times the previous data rate, needed for high frame rate UHD video and up to 30.2 channels of HD audio. Other significant upgrades in the new program include comprehensive protocol and functional testing for both low and high speed lanes, as well as stringent measures for mechanical performance and build quality.

HDMI Compliance

THX Ltd is not the first company to offer third party testing and certification services for HDMI cables. It is however unique in mandating fundamental adherence to the HDMI Compliance Test Specification (CTS). This includes acknowledgement of licensees' HDMI Adopter status, where relevant. To this end THX tests have been specifically developed to augment and complement the official standard tests of HDMI Authorized Test Centers (ATC), but value-adding for heightened levels of performance, mechanical integrity and build quality.

The Kordz Group, as the global pilot brand for the THX Interconnect Certification Program for 4K, has been an HDMI Adopter since 2005, and is an HDMI 2.0 Adopter. All Kordz HDMI cables of which have attained THX Certification (amongst others) are also listed on the official HDMI Product Finder portal at hdmi.org, in recognition of their certified compliant status.

Program Overview

The HDMI cable testing regime for THX Interconnect Certification is extremely thorough and rigorous. It can be summarized into eight key areas;

1. Data rate categorization for passive and active cables

The HDMI specification has two defined 'speed' test levels for HDMI cables; 'Standard' at 742.5Mbps/channel (2.22Gbps aggregate) and 'High Speed' at 3.4Gbps/channel (10.2Gbps aggregate). The HDMI 2.0 specification additionally defines a 6Gbps/channel (18Gbps aggregate) level, but does not contain new cable definitions to

support this. Rather it suggests the use of a proprietary new equalizer profile in the sink receiver, which peaks at 3GHz bandwidth (to align with the 6Gbps/ch data rate). This new EQ in proposed to then be used in conjunction with existing 'High Speed' HDMI cables to achieve higher systemic bandwidth capacity. Such enhanced equalization may indeed counter the inevitably higher attenuation at these unprecedented frequencies, but I attest cannot also simultaneously counter the exacerbated effects with increasing cable length.

The THX Interconnect Specification defines tests at two distinct levels; 3.4Gbps/ch and 6Gbps/ch, in both passive and active cable profiles. The 6Gbps/ch level is to ascertain a cable's ability to inherently support this flagship bandwidth level without reliance on unquantifiable external factors such as sink EQ.

The primary differentiator with active cables is in qualifying the power profile employed. After all, active means powered. To ensure compliance THX tests the 5VDC line at the sink connector to ensure it does not present a net current draw in excess of 50mA (see point 5: Functional Tests). Additionally, active cables contain chipsets which may inherently restrict bandwidth capacity, meaning that even with the new HDMI 2.0 EQ in the sink device, an existing active 'High Speed' HDMI cable may not support the new higher bandwidths. THX Certification will make this clear.

2. S21 Network Analyzer tests

HDMI Authorized Test Centers (ATC) conduct exhaustive lab tests to ascertain whether an HDMI cable qualifies as 'Standard' or 'High Speed'. The key test used for this is an eye diagram, or eye pattern. This is a graphical representation of the bit stream of a single channel (in turn) of TMDS. In summary, it depicts rise and fall times, jitter and voltage levels, all of which can restrict the readable duration of a bit. To pass the eye diagram test, the digital bit representation must show a readable length of at least 0.5UI (Unit Interval), or 50% of the total bit length. To make it easy there's a pre-defined hexagon mask in the center of the eye (seen in light grey in Fig 2) which cannot be breached, even momentarily.

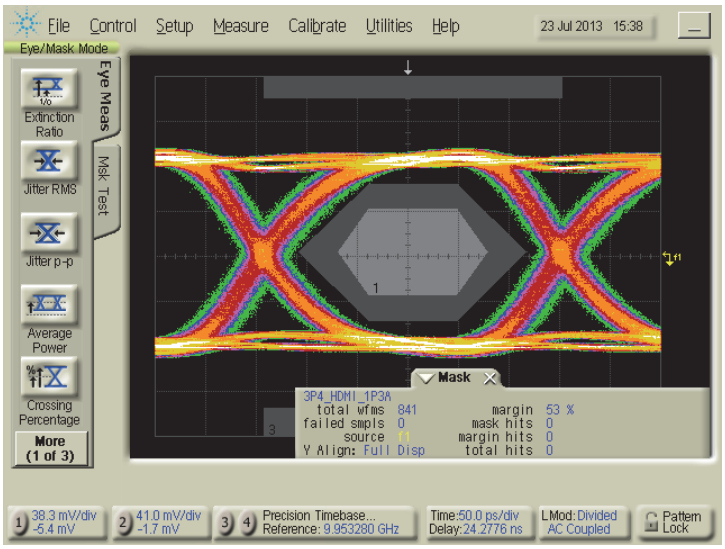

Fig 2: Example of an eye diagram showing the center mask

The THX Interconnect Specification augments the HDMI ATC test suite with a comprehensive 'S-parameter' test, more specifically S21. This provides a catch-all overview of the transmission line system, depicting the aggregate

attenuation characteristic at any given bandwidth. In brief it measures the inherent analogue carrier, rather than what's inside (being the digital element). This test is applied for both passive and active cables alike.

How does it work? There are a whole lot of characteristics in a cable which combine into a singular profile to limit how much bandwidth it can inherently support. Most notable is characteristic impedance and return loss (essentially being the sum of all things), including more technical elements like voltage standing wave ratio and reflection coefficient. The S21 test transmits a frequency sweep into the DUT (Device Under Test, in this case a cable), and captures the signal at the other side. It then compares this to the source (see Fig 3) and plots the resulting attenuation on a frequency/loss curve, where loss is measured in decibels (dB).

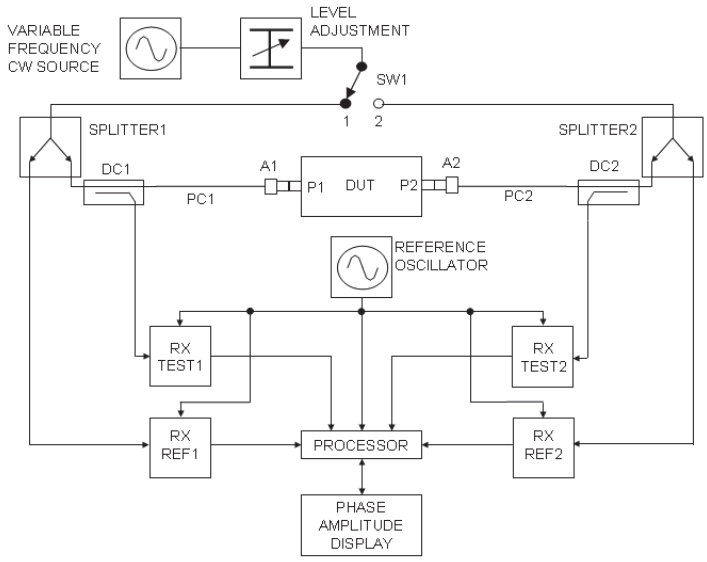

Fig 3: The basic architecture of a two-port vector network analyser.
Graphic by Chris Angove, CC BY-SA 3.0 (original)

The THX Interconnect Specification applies an S21 sweep up to a significant 6GHz bandwidth, plotting the attenuation characteristic to determine the following two levels for the test cable;

- 1.485GHz (4.455Gbps aggregate) for up to 2160p/30 8-bit 4:4:4, 2160p/30 12-bit 4:2:2 or 2160p/60 8-bit 4:2:0
- 3GHz (18Gbps aggregate) for 2160p/60 up to 8-bit 4:4:4 or 12-bit 4:2:2 or 16-bit 4:2:0

A suitable analogy would be to say that the S21 test is akin to showing the overall performance profile of a railway network (the analogue carrier), whereas the eye diagram as used by HDMI ATC shows the resulting number and comfort level of the passengers on the train itself (aka the digital bits).

One test does not supersede the other, but both in tandem provide an even more comprehensive picture of a cable's inherent performance capacity. This is one of many examples of the THX Specification complementing that of the HDMI CTS.

3. Pixel Error Analysis

The pixel error analysis involves subjecting the cable under test to a sustained application at UHD video resolution for a long duration. Lab equipment is used which captures video data through the cable, and compares to the

original source file, reporting any pixel errors (differences). The THX Interconnect Specification allows for ZERO pixel errors over the entire period, being absolute in its quest for flawless delivery.

4. DDC tests

The Display Data Channel (DDC) is a slow speed data bus which employs I²C (or IIC) communications. DDC comprises two wires; one for data (SDA), the other being clock (SCL). This is a critical feature of an HDMI cable, yet often taken for granted. It is responsible for transmitting EDID from sink/display upstream to the source, and HDCP keys downstream from source to sink. This bi-directionality of communications means the signals have to literally take turns, and the protocol uses anti-collision and arbitration techniques to ensure seamless operation, providing the physical wires themselves do not intervene.

In practice the DDC wires cause more interoperability issues than any other in the HDMI ecosystem. High cable capacitance can cause latency which may compromise the anti-collision timings. The DDC wires are typically unshielded in HDMI cables, and crosstalk is a common deficiency caused by poor physical cable construction. Even transition (wire-pin) termination methodologies also negatively impact the loss profile of DDC.

The THX Interconnect Certification tests for DDC include subjecting the cable to sustained HDCP events over a long period. Only ZERO errors over the defined period constitutes a PASS, to validate proper key exchange, and by proxy accurate EDID exchange. Notably the THX test also includes a physical wire construction analysis through dissection (a subset of characteristics in point 8: Build Quality), to ensure best practice to mitigate inherent interference and crosstalk. These tests are over and above the HDMI CTS requirements for cable capacitance to not exceed 700pF in order to safeguard I²C arbitration.

5. Functional Tests for 5V, ARC, HEC and CEC

The THX Interconnect Specification contains four primary functional tests to determine that a cable being tested can flawlessly pass the following four functions in both lab condition and real world application;

+5V Power - Pin 18 in the HDMI connector is for +5V DC power. Defined under section 4.2.7 of the HDMI 1.4b Specification, this is a primary protocol which is in effect the on/off switch for HDMI. It exists to ensure a sink device is notified when a source is present and powered on, with the sink expecting a DC signal in the range of +4.7-5.3V (voltage on TP2), and a net total current draw not exceeding 50mA. There are other relevancies with DC voltage throughout HDMI protocols other than the +5V pin, particularly voltage swing and high/low levels (ie; 1's and 0's) for digital signaling in DDC and TMDS.

Poor connections, thin wire gauge, long lengths, and/or use of poorly conducting materials for the 5V wire can all lead to excessive attenuation which may compromise the ability of an HDMI cable deliver DC within the specified range, compromising compliance and destabilizing fundamental operation. Secondly, any use of the +5V line to power ancillary circuits such as active equalizers within the interconnect may lead to current draw in excess of the maximum 50mA, thereby also risking non-compliance and possibly damage.

The THX Interconnect Specification includes tests to emulate a compliant HDMI source and sink system, and measure the impact of the HDMI cable under test to ensure it will comply with proper connectivity standards .

Audio Return Channel (ARC) - The HDMI specification contains two different modes for ARC; Single Mode and Common Mode. Single Mode shares the Hot Plug Detect (HPD) wire on pin 19 to convey the audio data upstream from display to source side (AVR). As it's always been there for HPD, connection of this pin is omnipresent in all

HDMI cables, irrespective of generation or speed, and as such ARC should (in theory) work through all HDMI cables. By comparison Common Mode employs the twisted pair of HEC (thereby referred to HEAC, the 'A' being for ARC) for superior ARC capability. However as HEC is virtually unused, Common Mode ARC is also typically not used except in some intra-brand applications.

HDMI ATC does not test the functionality of ARC, only the connection of said wire. The THX defined ARC functional test employs an HDMI protocol analyzer connected to an ARC supporting display to validate proper operation of Single Mode ARC.

HDMI Ethernet Channel (HEC) - This feature was added to the HDMI specification in 2010 as part of version 1.4. As an add-on feature it had to make use of limited availability in a high traffic connector. It employs the previously 'reserved' (code for unused) pin 14, and shares pin 19 with HPD. The result is a 100Mbps Ethernet channel for IP based applications (eg; internet sharing between devices), also doubling as an optional platform for Common Mode ARC (see above).

HDMI ATC does not test the functionality of HEC. However the HDMI CTS does specify capacitance limitations, similar to DDC and CEC. Furthermore as pins 14 and 19 are decoupled in the HDMI connector, performance may be limited particularly in substandard cables. The THX defined HEC functional test employs an HDMI protocol analyzer with discrete TX and RX stages, with Ethernet connectivity to both. IP based content is connected to the TX from an external router, through the HDMI cable under test to the RX stage, and out via the Ethernet port to validate proper operation of HEC with real content.

Consumer Electronics Control (CEC) - This is universally employed protocol in HDMI. HDMI 2.0 builds upon this by introducing a new CEC 2.0 standard to offer further advancement for future use, without changing the physical arrangement in the cable. HDMI ATC does not test the functionality of CEC, only the presence of the physical wire on pin 13. The THX defined CEC functional test employs an HDMI protocol analyzer to validate proper operation of CEC in a live transmit-receive operation.

6. Interoperability

This test suite involves a variety of HDMI source and sink devices being systematically interconnected with the test cable to ensure proper operation in real world application, managed in lab conditions.

7. Connector Retention

Section 4.1.9.2 of the HDMI specification clearly defines the dimensional limits of the HDMI type-A male connector. Tolerances in the specification are as tight as +0.04/-0.05mm, notably the limits of the connector shell height and width. It also (ironically) includes details for a "spring property for locking". These specifications are unchanged from the original release HDMI 1.0 which dates back to 2002.

Something that the HDMI specification does NOT define is connector manufacturing methods, materials, or good old fashioned quality. A sensational majority of HDMI connectors in the market are shown to be poorly made, do not fit well or stay securely seated, and therefore evolved as a key point of criticism for the format over the years. HDMI itself took the blame, where it was in fact the implementation by manufacturers which created the problems. This deficiency gave rise to the locking connector phenomenon, which in itself continues to challenge compliance standards.

Kordz has long been a strong advocate for quality HDMI connectors, employing designs and premium materials which deliver a golden example of what the HDMI connector was always intended to be. One that fits well, stays seated, doesn't fatigue, and does not contain a locking mechanism which is outside of the HDMI specification.

THX has now developed the world's first certification standard for compliant HDMI connectors to achieve a defined level of mated receptacle retention force. The test suite involves comprehensive force gauge tests, but also mating with ten leading approved broad market HDMI receptacle samples, to assure both controlled lab condition and real world application suitability.

8. Physical Analysis (Build quality)

This is the final test suite in the comprehensive THX Interconnect Specification. The construction methodology of an HDMI cable has implications on its electrical performance and physical connection integrity, but also on post-deployment reliability and longevity. THX sets very high standards, and has expectations that a THX Certified HDMI cable be accurate in its representation (of specifications), and be constructed to offer the highest performance consistently for the long term.

For the physical analysis tests, a cable sample is dissected and verified for conformity to a range of construction and termination expectations as defined by THX. The above points have already touched on some of these, namely the DDC wire analysis to ensure proper physical geometry of the SDA/SCL pair, and also quality tests of the HDMI connector for sufficient retention force in the mating HDMI receptacle. Another element is to ascertain that the wires inside the cable are consistent with the claims of the manufacturer, in both material and wire gauge.

Conclusion

The THX Interconnect Certification program has been developed to independently test and validate HDMI cables to meet or exceed the stringent standards of THX. It builds upon fundamental HDMI compliance, adding tests for 8.91Gbps and 18Gbps aggregate data rates for next generation high frame rate UHD video, functional tests to emulate real world operation, and physical construction quality and connector retention capacity. The result is a new clearly defined benchmark for quality, to elevate AV performance throughout the industry, and to save integrators' time and alleviate troubleshooting efforts.

Kordz, an HDMI Adopter since 2005, boasting two CEDIA Certified Instructors and Subject Matter Experts on HDMI & UHD, and repeat participant on the HDMI Techzone at CES, have long heralded these same qualities, having built a solid reputation for quality and compliance. We are now proud to be partnered with THX, and to be the pilot brand globally for the new THX Certified 4K Interconnect Program. This provides independent endorsement for the importance of quality connectivity to truly empower next generation UHD video.