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UL 4000

Outline of Investigation for High Speed Cables

Issue Number: 3

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Summary of Topics

This third issue of the Outline of Investigation for High Speed Cables, UL 4000, covers the transmission performance evaluation of high speed cables and clarifies the requirements for the Ethernet and Audio Channel.

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CONTENTS

INTRODUCTION

1 Scope	5
2 References	5
3 Units of Measurement	5
4 Definitions	5
5 Construction	6

PERFORMANCE

6 High Speed Cable Assembly Physical Layer Electrical Characteristics	6
6.1 High-speed audio/video cable assemblies	6
7 Skew	7
7.1 General	7
7.2 Maximum cable assembly inter-pair skew	7
8 Differential Output Eye Mask	8
8.1 General	8
8.2 Apparatus	9
8.3 Preparation of DUT	10
8.4 Procedure	10
9 Insertion loss	11
9.1 General	11
9.2 Inter-pair differential insertion loss deviations	11
10 Differential Input Return Loss	13
10.1 General	13
10.2 Apparatus	13
10.3 Preparation of DUT	13
10.4 Procedure	14
10.5 Results	14
11 HEAC – HDMI Ethernet and Audio Return Channel (If Supported)	14
11.1 General	14
11.2 Apparatus	16
11.3 Preparation of DUT	16
11.4 Procedure	16
11.5 Results	17

MANUFACTURING AND PRODUCTION TESTS

12 Continuity Test	17
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MARKINGS

13 General	17
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APPENDIX A

The following tests are conducted for reference purposes only

A1	Maximum Cable Assembly Intra-pair Skew	.A1
A1.1	Apparatus	.A1
A2	Preparation of DUT	.A1
A3	General	.A1
A3.1	General	.A1
A3.2	Procedure	.A1
A4	Insertion Loss	.A2
A4.1	General	.A2
A4.2	Differential insertion loss	.A2
A4.3	Differential insertion loss deviations	.A4
A5	Far-end Crosstalk	.A6
A6	Differential Impedance	.A7
A7	HEAC – HDMI Ethernet and Audio Return Channel (If Supported)	.A7
A7.1	Intra-pair skew	.A7
A7.2	Differential impedance	.A7

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INTRODUCTION

1 Scope

1.1 This Outline of Investigation describes the requirements used to evaluate the transmission performance of high speed cable assemblies.

1.2 Four types of cable assemblies are covered by these requirements:

- a) Wire-only cables that contain no circuit component.
- b) Passive cables that contain only passive circuit components.
- c) Active cables that contain active equalization circuit components with equalizer functions but do not have converting, transmitting or receiving functions.
- d) Active cables that contain active circuit components that convert or amplify the signals and also contain transmit and receive functions.

2 References

2.1 Any undated reference to a code or standard appearing in the requirements of this outline shall be interpreted as referring to the latest edition of that code or standard.

3 Units of Measurement

3.1 The unit of measure shall be SI. If a value for measurement is followed by a value in other units in parentheses, the second value represents a direct conversion or an alternative value.

4 Definitions

4.1 For the purpose of this Outline, the following definitions apply.

4.2 CABLE ASSEMBLY – A cable and its accompanying connectors intended to be used for a specific purpose.

4.3 CROSSTALK – A measure of the unwanted signal coupling from one pair into another pair.

4.4 DUT – Device Under Test.

4.5 INSERTION LOSS – The signal loss resulting from the insertion of a component, or link, or channel, between a transmitter and receiver (often referred to as attenuation).

4.6 TMDS – Transmission Minimized Differential Signaling.

5 Construction

5.1 The length of a cable assembly shall be within ± 10 percent of the marked length when measured from the face of one connector to the face of the connector at the far end of the cable.

5.2 High-speed cable assemblies may be required to comply with specifications applicable to their particular configuration and use. Other national, international or private performance specifications, applicable to high-speed cables may also be used to evaluate high speed cables as described in particular certification programs.

PERFORMANCE

6 High Speed Cable Assembly Physical Layer Electrical Characteristics

6.1 High-speed audio/video cable assemblies

6.1.1 This section describes the physical layer electrical characteristics for high-speed audio/video cable assemblies. Cables are performance rated according to their ability to transmit two different data rates; 10.2 Gbps cables (3.4 Gbps per channel) and 18 Gbps cables (6 Gbps per channel).

6.1.2 The measurements shown in Table 6.1 are to be made on high-speed audio/video cable assemblies.

Table 6.1
High-speed audio/video cable assembly electrical characteristics

Test	Section reference	Wire & passive cables	Active cables
Maximum Cable Assembly Inter-Pair Skew	7	Y	N
Differential Output Eye Mask	8	Y	Y
Inter-Pair Differential Insertion Loss Deviation (ILD)	9	Y	N
Differential Input Return Loss	10	Y	Y
HDMI Ethernet And Audio Return Channel (HEAC)	11	Y (If supported)	N

6.1.3 Unless specified otherwise within the parameters respective subsection, all tests defined in Table 6.1 are to be measured over a frequency range of N uniformly-spaced frequencies from start frequency f_{min} to stop frequency f_{max} with step size no larger than Δf . Where f_{min} , f_{max} and Δf are defined in Table 6.2.

Table 6.2
Frequency values

Parameter	Bit Rate	
	3.4 Gbps	6 Gbps
f_{min}	1 MHz	
f_{max}	3400 MHz	6000 MHz
Δf	10 MHz	
Note: The bit rates or data rates of high-speed audio/video cables are often referred to by the total rate for three channels. For example, 10.2 Gbps (3 X 3.4 Gbps) and 18 Gbps (3 X 6 Gbps).		

6.1.4 The tests shall be conducted on the longest and shortest lengths of cables when multiple lengths of the same cable type and construction are submitted for evaluation.

6.1.5 Passive and active cables whose performance is dependent on the proper connection of the source and sink ends of the cable assembly to their respective source and sink devices shall only be tested in the correct orientation. Such cables shall be marked to indicate the appropriate connection of the cable.

7 Skew

7.1 General

7.1.1 This section defines skew parameters for a high speed cable assembly. The skew is to be measured on the CLOCK, DATA0, DATA1, and DATA2 differential channels of the cable assembly.

7.2 Maximum cable assembly inter-pair skew

7.2.1 General

7.2.1.1 The inter-pair skew is defined as the absolute difference between the propagation delay of any two differential lanes within a cable assembly. Table 7.1 defines the maximum skew values for assemblies that support a TMDS bit rate up to 3.4 Gbps and 6 Gbps.

7.2.2 Apparatus

7.2.2.1 The apparatus shall consist of a Time Domain Reflectometer (TDR) and two Module/Cable Compliance Boards.

7.2.3 Preparation of DUT

7.2.3.1 The DUT shall be stored in an area that is under lab conditions prior to the test.

7.2.4 Procedure

7.2.4.1 The TDR is calibrated from minus 2 ns to 10 ns using electronic calibration.

7.2.4.2 The DUT is connected to the TDR via two module compliance boards and all unused lanes are terminated to a 50 ohm load.

7.2.4.3 A differential impedance versus time measurement of the CLK channel is made.

7.2.4.4 This process is then repeated for each of the other signaling channels.

Table 7.1
Maximum cable assembly skew

Parameter	TMDS Bit Rate	
	3.4 Gbps	6 Gbps
Maximum Inter-Pair Skew	2.4 nsec	1.75 nsec

8 Differential Output Eye Mask

8.1 General

8.1.1 This test establishes the method to verify that a worst case source signal meets the worst case sync eye diagram after passing through a cable channel. The differential output eye mask measured at each differential channel shall not exceed a maximum hit ratio of 5×10^{-5} while operating at a TMDS bit rate of 3.4 Gbps or 6 Gbps for data channels and 340 Mbps or 600 Mbps respectively for the clock channel, as appropriate for the performance rating of the cable. The clock channel is permitted to be operated at bit rates up to the bit rate of the data channel. See Figure 8.1 and Table 8.1 for the eye mask values.