Evaluation of Transmission Quality by Time-Domain Analysis for High-Speed Interconnectors

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***Abstract* – In this work, based on the measured eye diagram, an approach for the evaluation of transmission quality of the high speed interconnects is demonstrated. The resultant parameters associated the measured eye diagram, for example, Extinction Ratio (ER) and Time Jitter as the transmission quality index, are analyzed with a theoretic prediction comparison.**

***Index Terms* —Time-Domain Reflectometry, high-speed interconnects, eye diagram, Jitter**

1. Introduction

Since the recent development of multimedia, the speed of digital data has been dramatically increased, consequently, the physical characteristics and specifications of electrical connection devices, for example, cable and connectors, have been required and defined with higher and higher standards. Especially what happening in the entertainment industry, the video films with 4K or even 8K format [1] need high speed data transmission between the video source and terminal display.

On the other hand, for evaluating the interconnect devices with high performance, the associated measurement technologies also have progressed profoundly [2][3]. As for the evaluation techniques for those high speed interconnects, engineering approaches may be of either time domain or frequency domain. The Time-Domain Reflectometry - TDR [4], high-speed pulse-train generator and wide-band Oscilloscope are for the former and the Network Analyzer is for the latter. And only Time-Domain technique is discussed in this report. The purpose of all these analyses is to figure out the transmission quality of DUT (Device Under Test).

Eye diagram [3] is an important test for time domain analysis of high speed interconnects. High speed transmission is involved in extreme wide-band operation in spectrum. By eye diagram measurement, the dispersion effect [5] usually associated with wide-band operation is to be analyzed. In this report, time-domain techniques based on the eye diagram are demonstrated to analyze the high-speed interconnects.

2. Measurement Set-up and Theories

The evaluation for high speed interconnects is based on the eye diagram measurement. For generating an eye diagram, referring to Fig. 1,

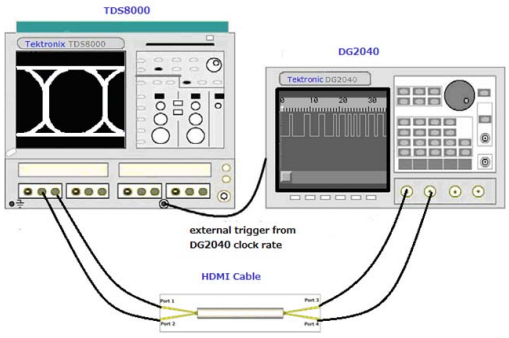

Fig. 1. Set-up for the time domain evaluation

a pulse train generator (Textronix DG2040) is used as the source, through the DUT, and the high-speed oscilloscope of a TDR (Textronix TDS8000) is used to display the eye diagram. Between the generator and the TDR, a triggering cable is used.

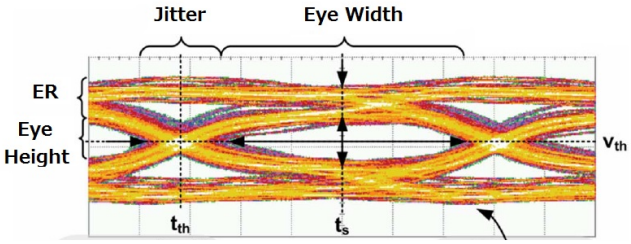

Fig. 2. Characteristic parameters associated with an eye diagram [6]

Within an eye diagram, because of the dispersion effect, there are characteristic parameters [6], by that the performance of high speed interconnects in terms of time-domain operation can be indexed. For example, referring to Fig. 2, the parameters of Eye Width and Eye Height are fundamental ones to describe the feature of an eye diagram. Usually in industry, several fundamental and derived parameters associated with an eye diagram may be defined by companies, forums or institutes, even with deviated definitions.

In the present work, in addition to the Eye Width and Eye Height terms, the Time Jitter and ER (Extinction Ratio) [6]

are taken into account for the evaluation work. As shown in Fig. 2, the Time Jitter stands for the position deviation of rising edge and falling edge in terms of time, and the ER stands for the deviation of logic level. Both of them are caused by the dispersion effect which is further due to the characteristics of materials and structure dimensions of interconnects.

3. Analysis Demonstration

For demonstrating the analysis approach, a pair of HDMI connectors [7] (male + female) is chosen as a DUT as shown in Fig. 3. For being possibly accessed by the measurement equipment, a pair of test fixtures [8] is also realized and assembled with the HDMI connector. The measurement of this demonstration is of single-ended signal only, even the normal signal transmission for the HDMI connector is of differential format (odd mode). Fig. 4 shows the measured eye diagram of the HDMI connector with a single-ended signal at a speed 0.8 Gbps.

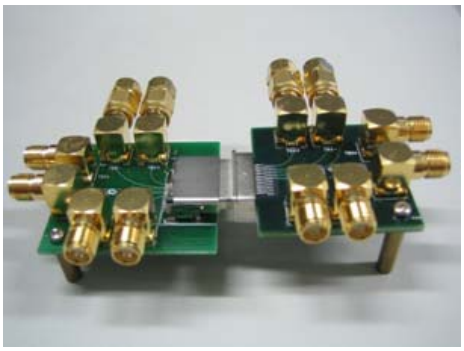

Fig. 3. A pair of HDMI connectors with a pair of test fixtures

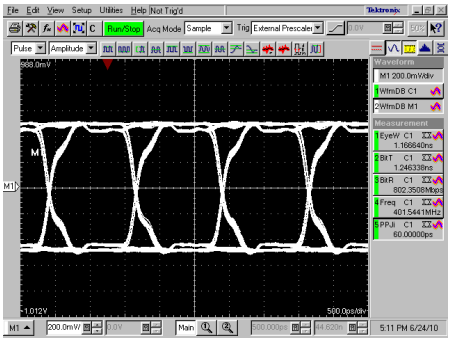

Fig. 4. The HDMI connector's Eye Diagram at 0.8Gbps

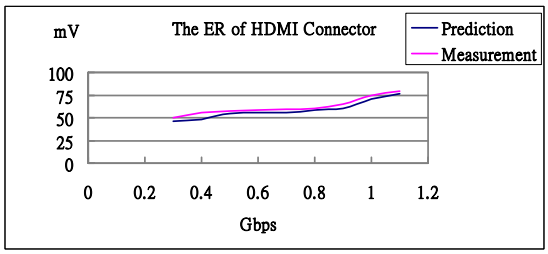

Fig. 5. ER evaluation for HDMI connector

Fig. 5 and Fig. 6 shows the resultant measured ER and Time Jitter for the test bed in Fig. 3 by increasing the data speed (Gbps). The prediction is made by the calculation based on the theoretic approach provided in [6]. Measured step response of DUT when employing a TDR is used in that approach. The ER both of calculation and measurement is quite following the expectation, namely, its value is proportional to the data speed. However, the characteristics of time Jitter is not so linear, and this is a very significant phenomenon which is confirmed by both of theory [6] and the present measurement.

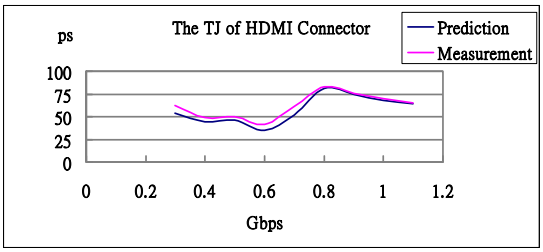

Fig. 6. Time Jitter evaluation for HDMI connector

4. Conclusion

Measurement is carried out for demonstrating the analysis for the high-speed interconnects based on the resultant eye diagram. The associated parameters of the eye diagram are measured and predicted to have an evaluation of the transmission quality. The prediction approach in literature is adopted to have a comparison of such an analysis.

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