EVALUATION AND ANALYSIS OF CONNECTOR PERFORMANCE FOR THE SPACEWIRE BACK PLANE

Session: SpaceWire Components

Short Paper

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ABSTRACT

SpaceWire interconnection using a backplane which makes a system compact has been investigated. In the backplane interconnection system, high-speed signals are connected between daughter boards via connectors and a backplane. The connectors used to interface the daughter boards and the backplane are key components because the impedance mismatching and the transmission loss in the connector might cause serious waveform distortions of high-speeds signal. In this paper, connectors for the backplane, which have been selected by the space qualified design and compactness, are modelled for various cases of signal and ground pin assignment by the measurement of S-parameters. And, then, the evaluation and the analysis are carried out by the SPICE simulation of the signal transmission between daughter boards via the connectors on the backplane. It was found that the crosstalk is generated at the connector and the characteristic impedance of the connector changes according to the pin assignment. Further, it was confirmed that the investigated connector can be used in backplane systems up to 3Gbps when the pin assignment is designed suitable.

1 CONNECTOR EVALUATION BOARD

For on-board equipment, higher-speed signal interconnections are required due to increasing data rates between the boards in the equipment. High-speed SpaceWire interconnection using a backplane which makes a system compact and high-performance has been investigated. The connectors on the backplane are key components because the impedance mismatching and the transmission loss of the connector might cause serious waveform distortions of high-speed signals.

Because no high speed backplane connector with space qualified design was found, a backplane connector without guarantee of high frequency performance was selected from the point of view of space use and compactness for SpaceWire backplane interconnection. In order to evaluate the connector, a pair of printed circuit boards (PCBs) has been developed, one PCB corresponds to a backplane and another PCB corresponds to a daughter board. The backplane connector has four row of conducting pins, and consists of a right angle plug and a receptacle. The plug is mounted on the daughter board and the receptacle is mounted on the backboard, respectively. The signal pins of backplane connector are connected to the SMA connectors on the PCB edges through micro-strip lines on PCBs. Fig.1 shows a photograph of the PCBs for evaluation of the backplane connector.

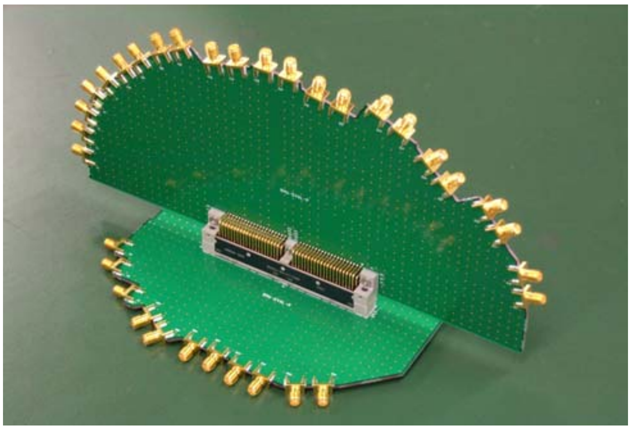


Fig.1: PCBs for Evaluation of a backplane connector

The pin assignment of the connector can cause the changes of the transmission characteristics and the crosstalk. Eight differential mode signal paths with different pin assignment of signal and ground are arranged within the backplane connector. Fig.2 shows the variations of the pin assignment. Fig.3 shows another differential mode signal path within the same connector surrounded by five single pin signal paths. The arrangement of Fig.3 is used for the evaluation of crosstalk (the differential path is a victim and single pin of a, b, c, d, and e are aggressive).

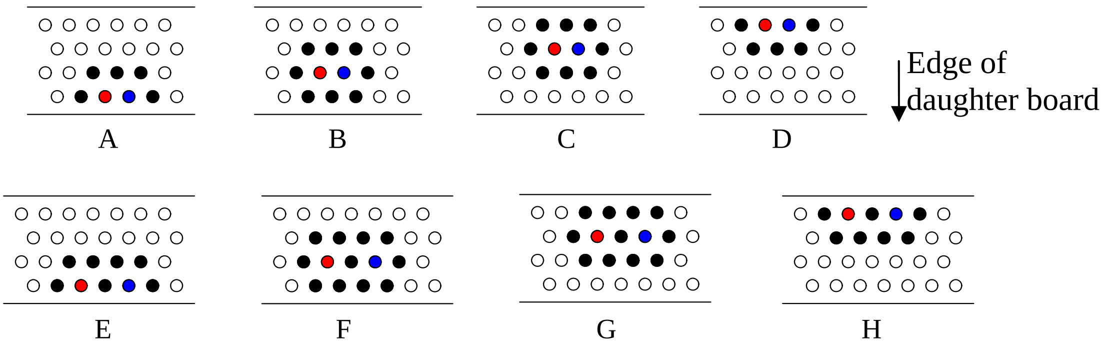


Fig.2: Pin assignment for the transmission characteristics evaluation.
(Red and blue circles are differential pairs. Black and white circles are GND pins.)

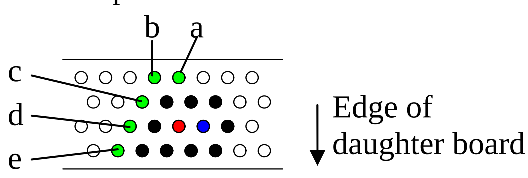
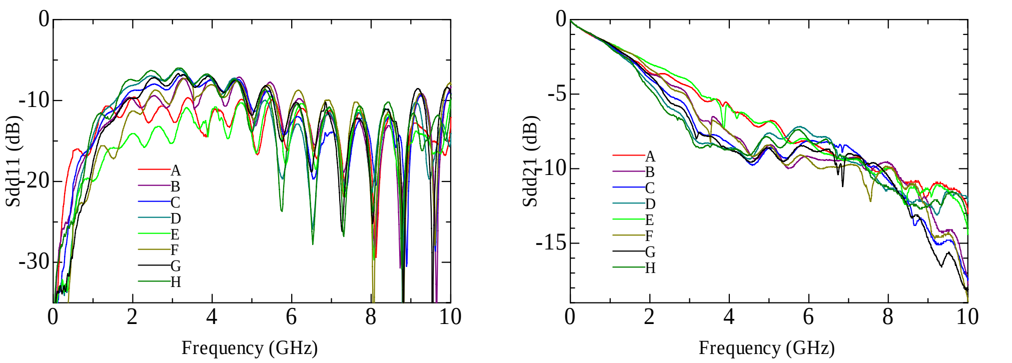


Fig.3: Pin assignment for the crosstalk evaluation.
(Red and blue circles are differential pairs. Black and white circles are GND pins.
And, Green circles are the aggressive signal pins.)

2 MEASUREMENT RESULT OF FREQUENCY CHARACTERISTIC

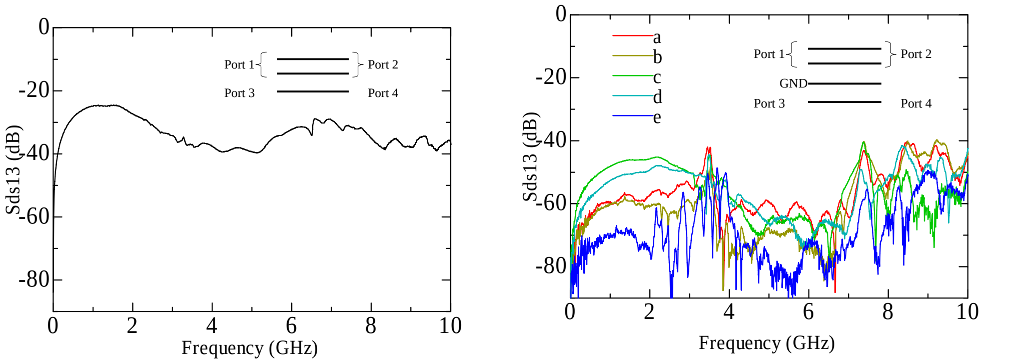
The evaluation PCBs with the mated backplane connector are measured with a four port network analyzer, and mixed-mode S parameters of differential mode are obtained by converting the standard S-parameters [1][2]. Fig.4 shows the measurement results of the differential mode return loss (Sdd11) and insertion loss (Sdd21) including the characteristics of micro-strip lines on PCBs and SMA connector. From Fig.4, it is found that the differences of S-parameters between different pin assignments become remarkable in frequency range higher than 1GHz. Moreover, the pin assignments using the higher row pins (far from edge of daughter board) for signals cause characteristic degradation. Also, the pin assignment with ground pin between two differential signal pins leads to better characteristic than that without ground pin between two signal pins.

Fig.5 shows the measurement results of the near-end crosstalk (Sds13). Fig.5(a) shows the crosstalk using a pin assignment without ground pins around victim (differential signal pins are a and b, and aggressive is c in Fig.3), and Fig.5(b) shows the crosstalk with ground pins around the victim. Crosstalk can be dramatically reduced by ground pins around victim.



(a) Differential return loss (Sdd11) (b) Differential Insertion loss (Sdd21)

Fig.4: Measurement results of the S-parameters of the connector



(a) No GND pins around the victim (b) GND pins existing around the victim

Fig.5: Measurement results of near-end crosstalk.

3 EYE-PATTERN WAVEFORM ANALYSIS

In order to evaluate performance of high speed signal transmission system, an eye-pattern waveform analysis is used because the results can directly compared with eye-mask specifications of SerDes receivers. The eye-pattern waveform can be obtained by the analysis of SPICE simulation using the analytical model such as the signal source, connectors, the transmission line of the PCB traces and through-hole vias. Fig.6 shows the simulated eye patterns of the SpaceWire backplane system with 50 cm total trace and 3.125Gbps data rate using the model of the evaluated backplane connector. In Fig.6, all eye-pattern waveforms are good for transmission because they clear the eye-mask specification. In detail, the waveform is a little different according to the selection of pin assignment of the backplane connector.

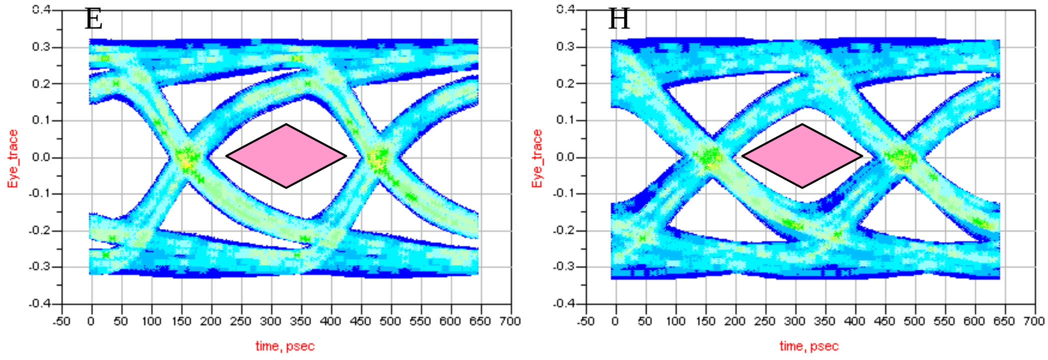


Fig.6: Eye patterns of the analytical result.

4 CONCLUSION

A SpaceWire interconnection system via the backplane using the connector selected by the space qualified design and the compactness was evaluated by the crosstalk measurement and the eye-pattern waveform obtained by the SPICE simulation using the analytical model of the system.

The results of the evaluation are in the followings:

(1) The backplane connector was modelled for various cases of the signal and ground pin assignment by the measurement of the S-parameters.

(2) It was found by the measurement that the pin assignment of the ground pin around the differential pair is effective to reduce the crosstalk from the other signals.

(3) The eye-pattern waveforms were shown by the simulation for the backplane system. It was found that the 3Gbps backplane transmission is possible using the connector selected by the space qualified design.

(4) Totally, it was confirmed by the crosstalk measurement and the waveform simulation that the connector selected by the space qualified design can use for the system of over 1Gbps high speed signal transmission via the backplane by suitable pin assignment design.

5 REFERENCES

1. K. Kurokawa, “Power waves and the scattering matrix”, IEEE Trans. Microwave Theory Tech, vol.13, 1965.

2. David E. Bockelman, William R. Eisenstadt, “Combined Differential and Common-Mode Scattering Parameters”, IEEE Trans. Microwave Theory Tech, vol.43, 1995.