High Frequency Performance Comparison among Three Kinds of Board to Wire Connectors

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Abstract— In this paper, we analyze and compare the properties of three kinds of high frequency board to wire connectors which are horizontal K-type connector vertical K-type connector, and subminiature modular plug-in mini (SMPM) connector. The S-parameters of these connectors were simulated through the High Frequency Structure Simulator (HFSS) software. Using these connectors, three kinds of evaluation boards (EVB) were designed for measuring the high frequency performance of the connectors. The S-parameters of these EVBs were measured and verified through the network analyzer, and the impedances were also measured through the time domain reflector (TDR) The bandwidth of the SMPM connector is about 19 GHz, the bandwidth of the vertical K-type connector is about 23 GHz, and the bandwidth of the horizontal K-type connector is above 25 GHz. The board to wire horizontal K-type connector is more suitable than the other two connectors for 25 Gb/s transmission applications.

1. INTRODUCTION

In recent years, due to the vigorous develop of information and communication technology, it makes the popularization of the internet broadband applications, such as bandwidth internet games, online teaching platform, network conference, and cloud applications. The 100 Gigabit Ethernet can use four parallel 25 Gb/s channels to achieve the transmission rate [1]. The 400GBase SR4 is currently defined 16 parallel 25 Gb/s channels in IEEE P802.3bs [2]. Therefore, the bandwidth of the related device, module, equipment, and network must increase to near 25 GHz. For the high-speed modules, the signal integrity and impedance match between the printed circuit board (PCB) and connector have to be investigated [3–5].

For the 25 Gb/s transmissions on PCB, it has to analyze and verify that the high-speed performances of board to wire connectors can be suitable. We select three kinds of high frequency connectors, which are horizontal K-type connector, vertical K-type connector, and subminiature modular plug-in mini (SMPM) connector, as shown in Figure 1, to analyze and compare. The vertical and horizontal K-type connectors can be easily assembled and reused, and they can be screwed on PCB. However, the size of vertical K-type connector is bigger and it must be fixed on the edge of PCB. For the vertical K-type connector, the length of signal trace is difficultly reduced on PCB, and the area of PCB becomes larger. The horizontal K-type connector can be fixed on the surface of PCB, so the length of signal trace and the area of PCB can be reduced. The SMPM connector can be also fixed on the surface of PCB, but it must be welded on PCB. The size of SMPM connector is smaller than horizontal K-type connector, so the length of signal trace and the area of PCB can be reduced substantially. The high frequency of three kinds of connectors will be simulated through Ansoft HFSS software, and be measured through network analyzer and time-domain reflectometer (TDR).

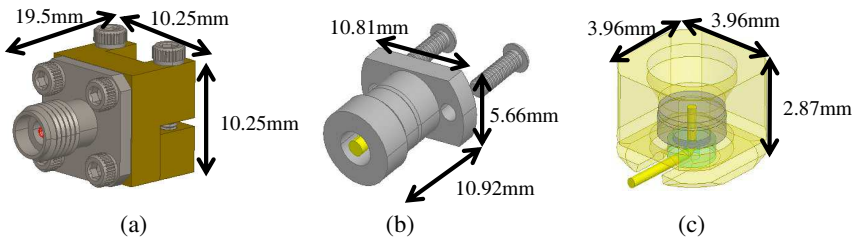

Figure 1: Schematics of three kinds of connectors. (a) Horizontal K-type connector, (b) vertical K-type connector, and (c) SMPM connector.

2. HIGH FREQUENCY SIMULATION OF CONNECTOR

Because the high performance of only connector is measured difficultly, the high performance of only connector is analyzed through simulation software. The reflection and insertion losses of three kinds of connectors were simulated through HFSS software, as shown in Figure 2, and the PCB was not considered in the simulations of connectors. According to the simulations, the reflection losses of three kinds of connectors are below −10 dB within 25 GHz bandwidth, but the reflection losses of K-type connectors are lower than SMPM connector. According to the insertion losses, the bandwidths of three kinds of connectors can be over 25 GHz, but the frequency responses of K-type connectors are flatter than SMPM connector.

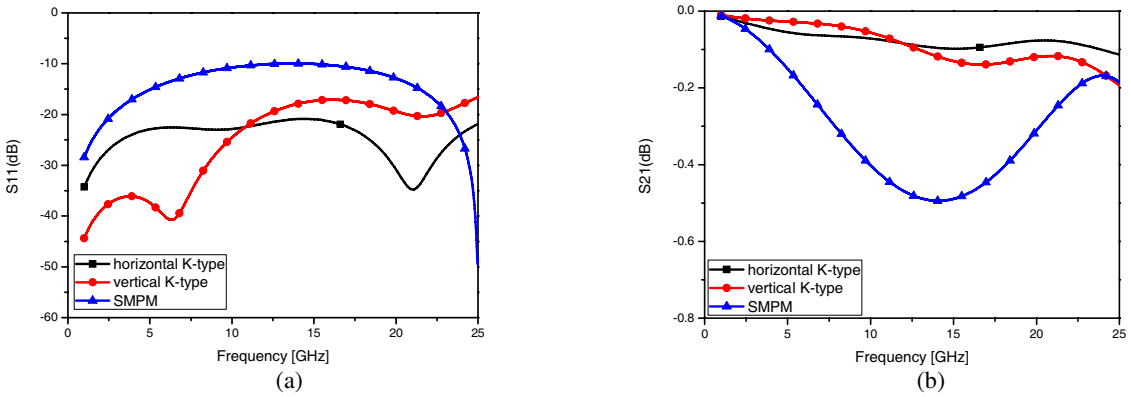

Figure 2: Simulated (a) reflection and (b) insertion losses for three kinds of connectors.

3. SIMULATION AND MEASUREMENT OF HIGH-SPEED PCB WITH CONNECTOR

For verifying the high frequency performance of connector through measurement, a test PCB was designed including three connectors. In our high-frequency test PCB, the insulation material uses Rogers 4350B with dielectric constant 3.66 and the length of the microstrip line is 2.5 cm. For three kinds of connectors, the reflection and insertion losses of PCB were also simulated through HFSS software, as shown in Figure 3. The reflection loss of our test PCB is higher than only connector. The insertion loss of our test PCB is lower than only connector, but the bandwidths of three kinds of connectors can be still over 25 GHz.

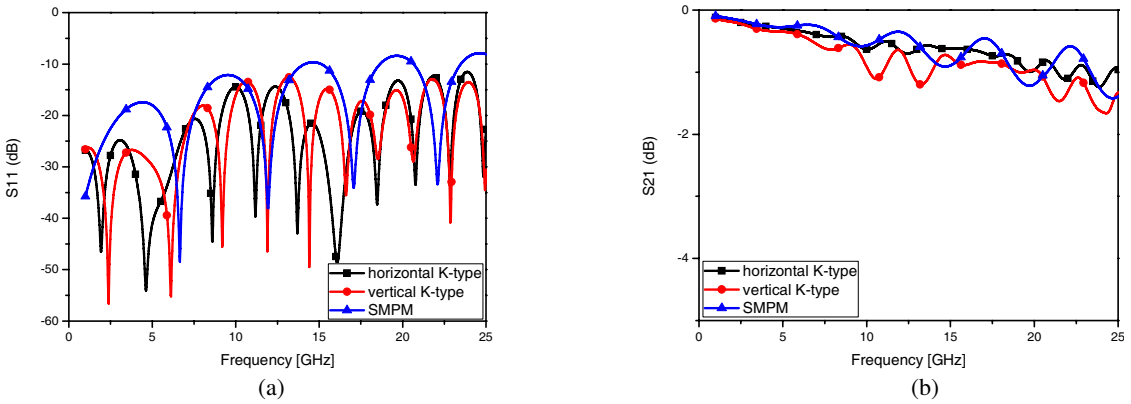

Figure 3: Simulated (a) reflection and (b) insertion losses of PCB for three kinds of connectors.

The reflection and insertion losses of PCB were measured using Agilent 8722ES vector network analyzer, as shown in Figure 4. The performance of PCB with horizontal K-type connectors is better than with other two kinds of connectors. However, the measured insertion losses are higher than the simulations, so the measured −3 dB bandwidth is also lower than the simulations. The bandwidth of vertical K-type connector can be still over 25 GHz, the bandwidth of horizontal K-type connector is about 23 GHz, and the bandwidth of SMPM connector is just about 19 GHz. The simulations of the reflection and insertion losses still show agreement with the measured results.

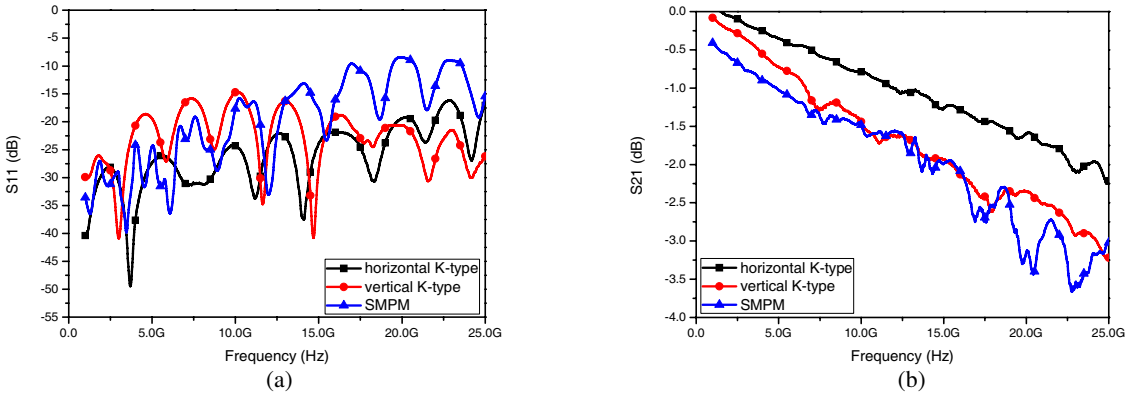

Figure 4: Simulated (a) reflection and (b) insertion losses of PCB for three kinds of connectors.

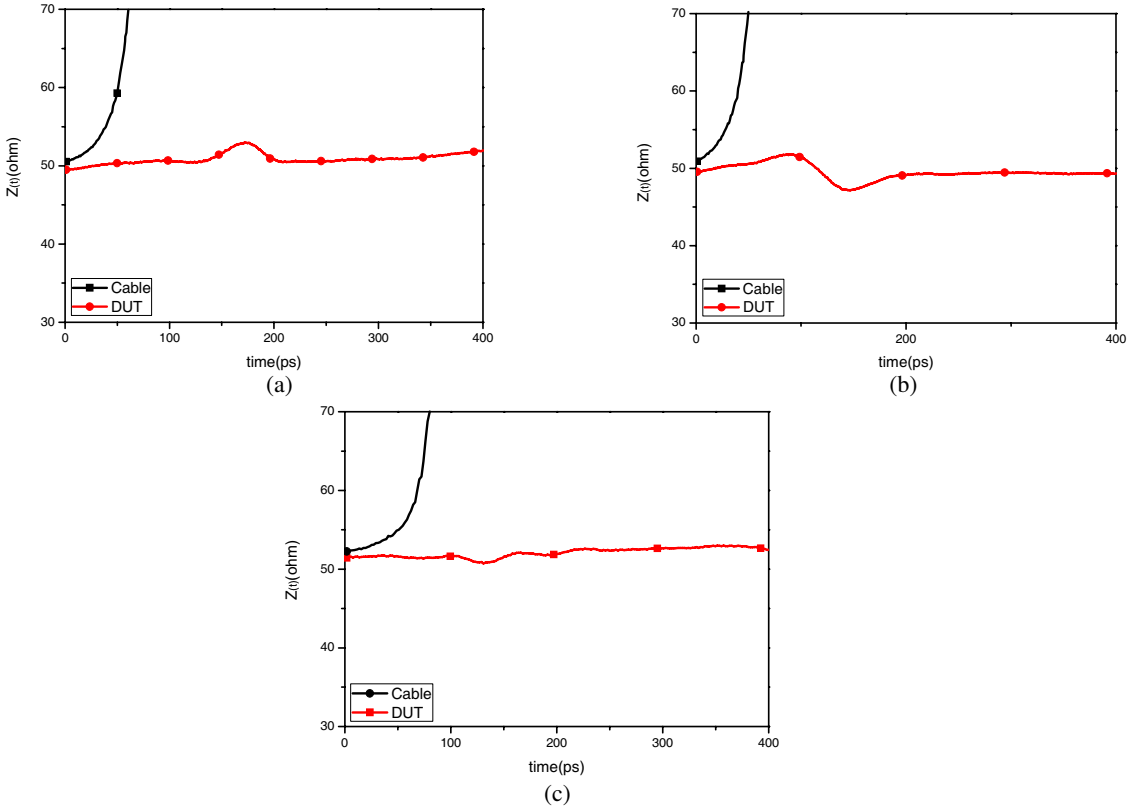

Figure 5: Measured impedance variation using TDR for three kinds of connectors. (a) Horizontal K-type connector, (b) vertical K-type connector, and (c) SMPM connector.

The higher measured insertion losses could be influenced by the fabrication of PCB, the contact between connector and PCB, or the testing cable.

For three kinds of connectors, the impedance variations of transmission were also measured by Agilent 86100A and 54754A TDR module, as shown in Figure 5. The transmission impedances can be kept around 50 Ohm for three kinds of connectors, but the little mismatch of impedance appears at the contact between connector and PCB.

4. CONCLUSION

The high frequency performances of three kinds of board to wire connectors which are horizontal K-type connector, vertical K-type connector, and subminiature modular plug-in mini (SMPM) connector, have been simulated and measure. The performance of the horizontal K-type connector is the best and its bandwidth can be over 25 GHz, but its size is the biggest. The performance of the

SMPM connector is the worst and its bandwidth just is about 19 GHz, but its size is the smallest. The three kinds of connector could be able to be used in 25 G/bs transmission applications. The size of connector is bigger, then the length of trace is longer and the area of PCB is larger. According to the size or cost requirements of PCB, the most suitable 25 G/bs connector can be selected from the three kinds of connectors.

ACKNOWLEDGMENT

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