The Optimized Electrode between a SMPM Connector and a Microstrip for High Frequency Applications

Cheng-Ying Wu, **Hong-Lu Lin**, **Jau-Ji Jou**, **Yaw-Dong Wu**, **and Tien-Tsorng Shih**
Department of Electronic Engineering, National Kaohsiung University of Applied Sciences
Kaohsiung, No. 415 Chien Kung Road, Kaohsiung City, Taiwan

Abstract— In this paper, a smaller and cheaper novel Subminiature Modular Plug-in Mini (SMPM) connector has been used to replace a K-type connector. The SMPM connector is installed on the top of printed circuit board (PCB) and soldering with an electrode to reduce the trace of a microstrip and to maintain the high frequency performance. Three designs of the PCB electrode have been simulated and verified experimentally. The optimized impedance mismatch of the soldering point between a SMPM connector and the PCB electrode is controlled within a range of ±2-Ohm. The 3-dB bandwidth of the whole setup including two SMPM connectors and a 2.5-cm long microstrip is above 25-GHz. This optimization can be used in designing high-speed PCB for the application of 100GBASE Ethernet.

1. INTRODUCTION

Due to the advent of the cloud computing, a high data rate transmission is greatly demand. The data traffic between servers inside a data center becomes busy. The data rate of the servers will be mainly 100 Gb/s for the Ethernet in the future. In IEEE 802.3bm Ethernet standard the 100GBaseSR4 (4 × 25 Gb/s) technology has been proposed. According to the requirement of a 100GBASE Ethernet, the transmitted data rate of a single channel is 25-Gb/s and the aggregated data rate is 100-Gb/s by adopting 4-channel transmission simultaneously [1–3]. The testing setup and connection for a 100-Gb/s environment is very essential. Signal integrity and impedance match are key points in designing either the transmission line on a printed circuit board (PCB) and the connector [4–6].

For high-frequency PCB design, the issue of connection with the connector is investigated worthily. Usually, a K-type connector is generally adopting and soldering with PCB. However, the size of a K-type connector 1.3-cm × 1.7-cm × 1.5-cm (diameter × width × height) is large The K-type connectors are arranged on PCB and the pitch between two connectors is also larger. It makes a difficulty in minimizing the length of a microstrip of a PCB. Therefore, the PCB needs larger area, the trace of microstripe line becomes also longer, and the transmission bandwidth will be limited.

In this paper, the Subminiature Modular Plug-in Mini (SMPM) connector is considered to use on PCB. The size of a SMPM connector, 0.4-cm × 0.4-cm × 0.3-cm (diameter × width × height) is smaller than a K-type connector. Figure 1 shows the schematic of a SMPM connector. Because the smaller connectors are used, the pitch between two connectors can be reduced, the area of PCB is also reduced, and the trace of transmission line can becomes shorter on PCB. Therefore, the high-frequency performance of high-speed PCB becomes better, and the cost can be lower. It will be analyzed that the SMPM connector contacts with high-speed PCB. Using the SMPM connector, the 25-Gb/s operation on PCB will be also verified.

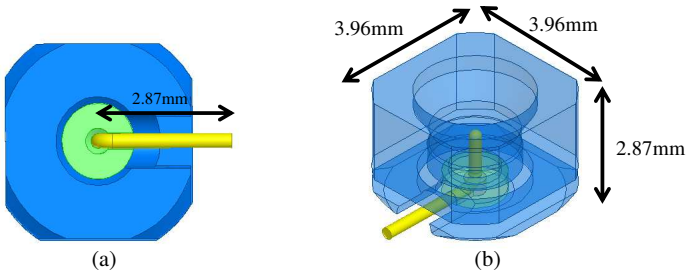

Figure 1: Schematic of a SMPM connector (a) bottom of connector (b) 3D perspective drawing.

2. DESIGN OF ELECTRODE BETWEEN SMPM CONNECTOR AND MICROSTRIP LINE ON PCB

Figure 2 shows the simulated reflection loss and insertion loss of a SMPM connector. The simulated bandwidth of the SMPM connector can be over 30-GHz, so the SMPM connector should be able to use in 25-Gb/s applications. However, the contact between SMPM connector and PCB could induce the transmission bandwidth reducing, so it must be analyzed that the SMPM connector contacts with high-speed PCB.

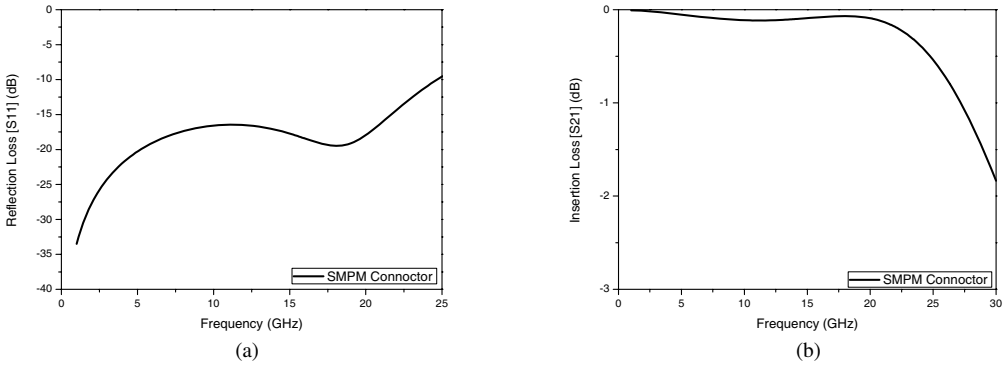

Figure 2: Simulated (a) reflection loss and (b) insertion loss of a SMPM connector.

In our high-frequency PCB, the insulation material uses Rogers 4350B with dielectric constant 366 and the length of the microstrip line is 2.5-cm. We design and analyze three kinds of connects between SMPM connector and microstrip line, as shown in Figure 3. The first kind connect is that the signal pin of SMPM connector contacts with the original microstrip line. The second kind connect is like the first kind but an anti-pad is set on the ground plane under the SMPM connector. The third kind contact has no the anti-pad, but the length of microstrip line is reduced and the contact area of SMPM pin and microstrip line becomes small.

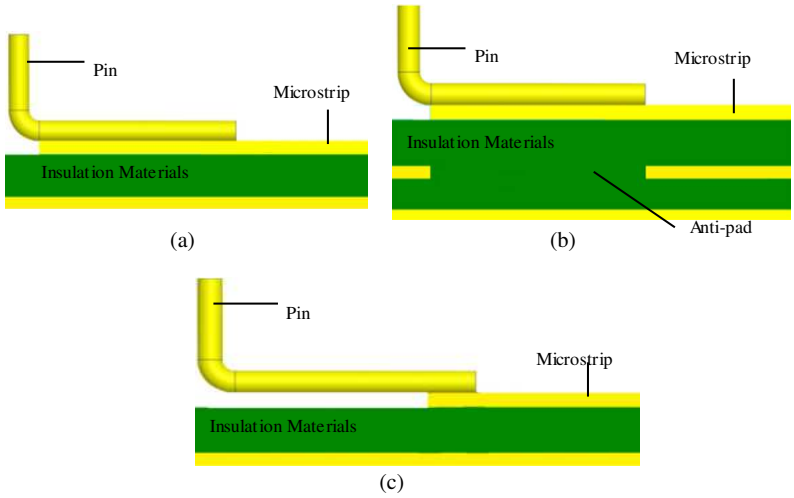

Figure 3: Three kinds of contacts between SMPM connector and microstrip line (a) for original, (b) with anti-pad, and (c) with small contact area.

3. SIMULATION AND MEASUREMENT RESULTS

The S-parameters of transmission with three kinds of contacts are simulated through the 3D electromagnetic simulation software Ansoft HFSS. The S-parameters are also measured using the vector network analyzer Agilent 8522ES, and the experiment setup is shown in Figure 4. In this measurement architecture a SMPM to K-type cable must be used between input/output port of the network analyzer and a device under test (DUT). The loss of the cable must also be considered. Therefore, the circuit model of SMPM to K-type cable is also established. The HFSS simulation

results of three kinds of contacts combine the circuit model of SMPM to K-type cable to simulate the insertion loss of complete transmission through the Agilent ADS simulator, as shown in Figure 5. The insertion loss is also measured using the vector network analyzer, as shown in Figure 6. The simulations with SMPM to K-type cable show good agreement with the measured results. The simulations of the testing without SMPM to K-type cable are also simulated, as shown in Figure 7, and the insertion loss is lower than with SMPM to K-type cable. The loss of our K to SMPM-type cable is large. If the lower loss cable can be used in our experiment, the better performance of SMPM connector testing can be obtained. According to the results, using anti-pad or small contact area, the electrode between SMPM connector and microstrip line can have about 20-GHz transmission bandwidth.

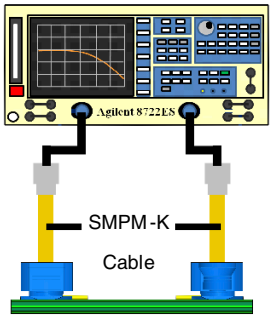

Figure 4: Experiment setup for the SMPM connector testing.

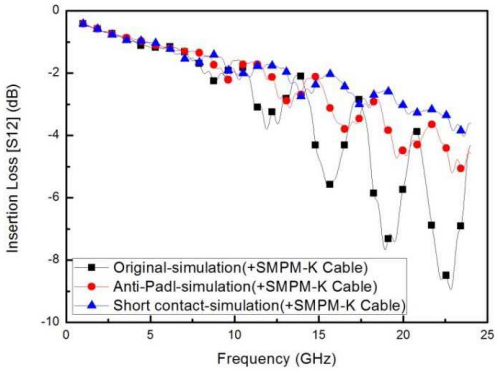

Figure 5: Simulated insertion loss with SMPM-K cable for the SMPM connector testing.

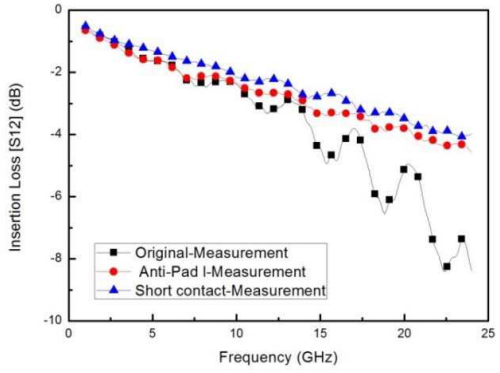

Figure 6: Measured insertion loss with SMPM-K cable for the SMPM connector testing.

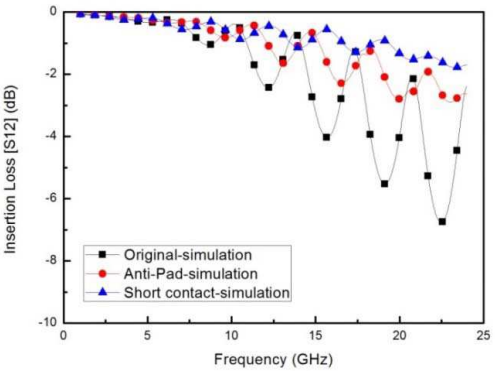

Figure 7: Simulated insertion loss without SMPM-K cable for the SMPM connector testing.

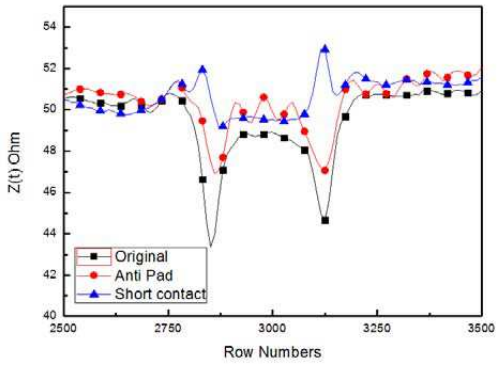

Figure 8: Measured impedance variation using TDR for the SMPM connector testing.

The impedance variations of transmission are also measured by time-domain reflectometer (TDR) for three kinds of contacts, as shown in Figure 8. The transmission impedance has a larger variation in the original testing. However, the transmission impedances can keep around 50 Ω in the cases with anti-pad and small contact area.

4. CONCLUSIONS

The contact electrode between SMPM connector and transmission line had been analyze for high-frequency transmission. Which an anti-pad is set on the ground plane under the contact and the contact area of SMPM pin and microstrip line is reduced, the two kinds of contacts can improve the transmission performance. The high-speed PCB with SMPM connector is verified to be able to operate within 20-GHz, so the SMPM connector can be suitable to apply for 100GBase-SR4 Ethernet technology

ACKNOWLEDGMENT

This paper is supported by the Taiwan Ministry of Science and Technology (NSC 102-2221-E-151-045-MY2).

REFERENCES

1. Ishida, O, "40/100GbE technologies and related activities of IEEE standardization," *Proc. of OFC'2009*, OWR5, 2009.
2. Duelk M. and S. Member, "4 × 25-Gb/s 40-km PHY at 1310 nm for 100 GbE using SOA-based preamplifier," *Journal of Lightwave Technology*, Vol. 26, No. 12, 1681–1689, June, 2008.
3. Sinsky, J. and P. Winzer, "100-Gb/s optical communications" *IEEE Microwave Mag.*, Vol. 10, No. 2, 44, April 2009.
4. Magerl, M., T. Mandic, and A. Baric, "Broadband characterization of SMA connectors by measurements," *MIPRO 2014*, Opatija, Croatia, May 2014
5. McMorrow S. and A. Neves, "A hybrid measurement and electromagnetic field solver approach for the design of high-performance interconnects: An investigation of traces and SMA transitions," *DesignCon 2004 Conference Proceedings*, January 2004.
6. Uesugi, T., N. Okada, T. Saito, T. Yamatoya, Y. Morita, and A. Sugitatsu, "1.3 µm EML TOSA for serial 40 Gbps ethernet solution," *OFC/NFOEC 2010*, OThC2, March 2010.