Antenna Measurement by Simple Optical Link system Using Radio on Fiber Technologies

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***Abstract*— We propose a simple optical fiber link microwave measurement system that consist of a vector network analyzer, two modules of Electric signal to optical signal converter and a module of optical signal to electric signal converter. The system can measure S-parameters of two-port devices using a vector network analyzer (VNA) in full 2-port calibration. In this paper, we show frequency characteristics, the time stability and the ambient temperature stability of the simple optical fiber link system for the antenna properties measurement. In the case of ambient temperature within 3 degrees, $S_{21}(\omega)$ time stability of the simple optical fiber link system is less than 0.1 dB in the frequency range from 30 MHz to 1000 MHz.**

Keywords*— Broadband antenna, Antenna gain, Antenna factor, Radio on fiber, Time stability

I. Introduction

The conventional antenna measurement system usually uses metal coaxial cables. The system has some problems, such as the attenuation of signals in the cables, the reflection on the outside surface and the difficulty of its handling. The optical fiber link antenna measurement system was already proposed [1][2] which can measure the S-parameters of two-port devices using a vector network analyzer (VNA) in full 2-port calibration. Our previous proposed optical fiber link system consists of an Electro-absorptive (EA) modulator, a zero biased UTC-PD [3], two small type bi-directional couplers, an optical field measurement controller made by the NEC Tokin Inc and eight optical fiber cables.In this paper, we propose a simple optical fiber link microwave measurement system that consists of a vector network analyzer, two optical fibers and four module of an electric signal to optical signal converter (EO) and a module of optical signal to electric signal converter (OE). The system can measure S-parameters of two-port devices using a vector network analyzer (VNA) in full 2-port calibration. At first we explained the outline of our simple optical fiber link microwave measurement system. Secondly, we explained the frequency characteristics of the system. Then, we explain the experimental measurement of S21 between the two log-periodic antennas. To validate the performance of the optical antenna measurement system, we compare the measurement results by the optical fiber link system with those by a conventional coaxial cable system. It is shown that the optical system can be used to measure the S-parameters of AUTs without any metal coaxial cable.

II. Outline of our Simple Optical Fiber Link System

Our proposed optical fiber link module consists of a photodiode, a direct modulation type laser diode and optical fiber coupler. For this reason, our proposed module can use for transmitting and receiving the microwave signal. In the case of using two modules, a directional couple and the VNA, we can measure $S_{11}(\omega)$ of an antenna under measurement. In the case of using four modules, two directional couples and the VNA, we can measure S-parameters of two antennas characteristics measurement.
In this section, we explain our optical fiber link system.

A. Frequency response

Fig. 1 shows the setup for the frequency characteristics measurement of our optical fiber link system. Fig. 2 shows $S_{21}(\omega)$ and $S_{31}(\omega)$ measurement results. $S_{21}(\omega)$ and $S_{31}(\omega)$ show a frequency response of a transmitting wave from port 1 to port 2 and leaky wave from port 1 to port 3, respectively. Fig. 3 shows $S_{34}(\omega)$ and $S_{24}(\omega)$ measurement results. $S_{34}(\omega)$ and $S_{24}(\omega)$ show a frequency response of a transmitting wave from port 4 to port 3 and a leaky wave from port 4 to port 2, respectively. These results show the fact that our optical fiber link system can measure S-parameters with more than 20 dB isolation characteristics between port 1 and port 3 in the frequency range from 10MHz to 1 GHz, and can measure more than – 10 dBm transmission loss between port 1 and port 2 in the frequency range from 150 MHz to 2500 MHz.

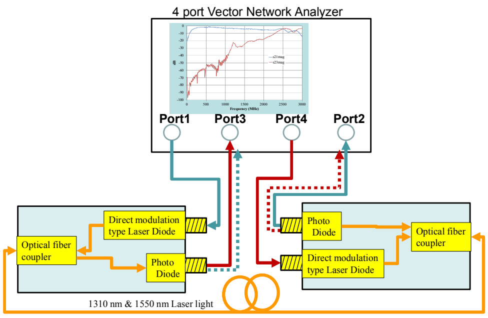

Fig. 1 Outline of the setup for the frequency characteristics measurement of the optical fiber link system.

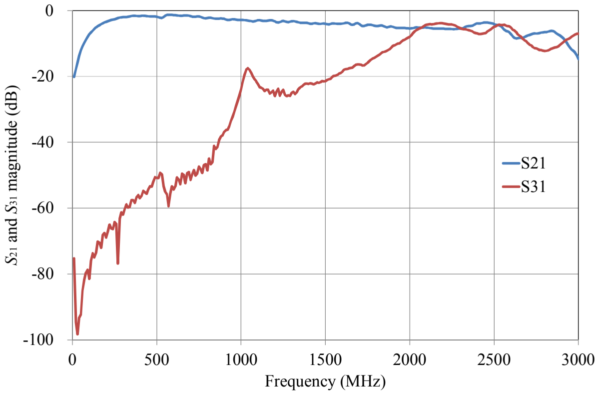

Fig. 2 $S_{21}(\omega)$ and $S_{31}(\omega)$ measurement results of the optical fiber link system.

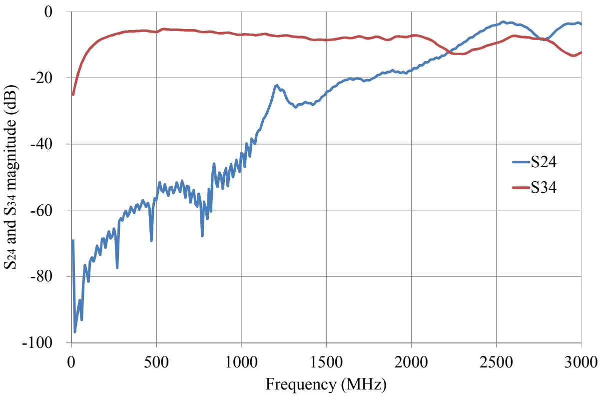

Fig. 3 $S_{24}(\omega)$ and $S_{34}(\omega)$ measurement results of the optical fiber link system.

B. *Lineality*

We explain the linearity of our system as a receiving system. Fig. 4 shows the linearity of our receiving system with the VNA using a step attenuator. These results show the fact that the receiving system can be received more than -60 dBm within the linearity is less than 0.2 dB in the frequency range from 150 MHz to 2 GHz.

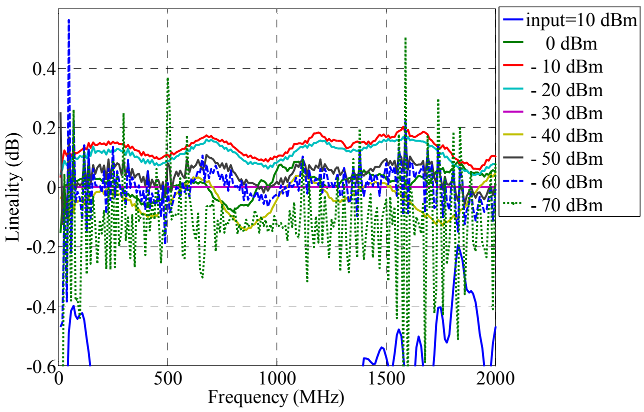

Fig. 4 Linearity of the simple optical fiber link module.

C. *Timestability and temperature dependence*

We explain the time stability of our system. We measure the time stability of the $|S_{21}(\omega)|$ in the interval of 700 minutes after starting the system up. Fig. 5 shows the time stability of the system with the VNA. Fig. 6 shows the ambient temperature of our semi-anechoic chamber during the measurement. In the case of ambient temperature stability is less than 3 degrees, the time stability of our system with the VNA is less than 0.2 dB during 700 minutes in the frequency range from 300 MHz to 1 GHz.

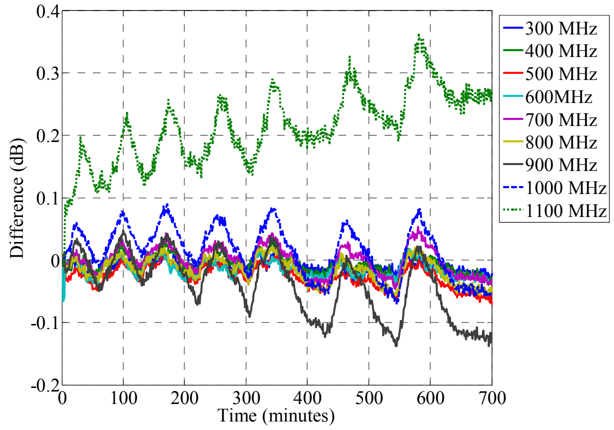

Fig. 5 Time stability of the simple optical fiber link module.

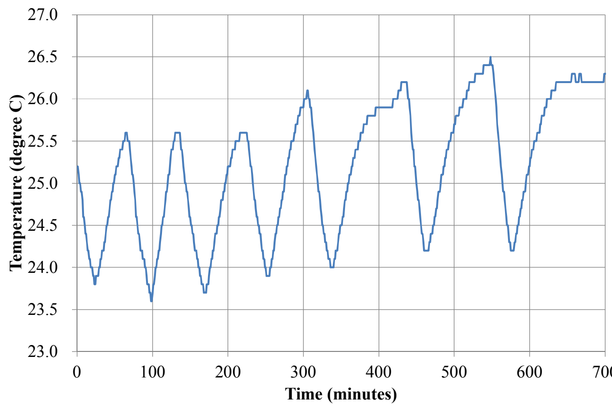

Fig. 6 Time stability of ambient temperature.

III. Antenna Measurement

A. *Antenna measurement using optical fiber link system*

We carry out the $S_{21}(\omega)$ measurement between two log-periodic antennas of UHALP9108A1 (LPDA) as AUTs by the proposed system without coaxial cables after a response calibration to normalize frequency response. These LPDAs is usually uses a radiated EMI (Electromagnetic Interference) measurement. These two LPDAs set 2m high from the absorbing material on the floor with 4 m antenna distance. The $S_{21}(\omega)$ measurement setup and a photo of the setups are shown in Fig. 7, 8 and 9, respectively. Fig. 9 and 10 show measured $S_{21}(\omega)$s and calculated $S_{21}(t)$ envelopes, respectively. [Horizontal Pol.] and [Vertical Pol.] show the measurement results of the horizontal and vertical polarization setting of two LPDAs. The calculated $S_{21}(t)$ envelopes using our proposed system has some difference after 30 ns because the reflection wave arrived from the absorbing materials on the floor.

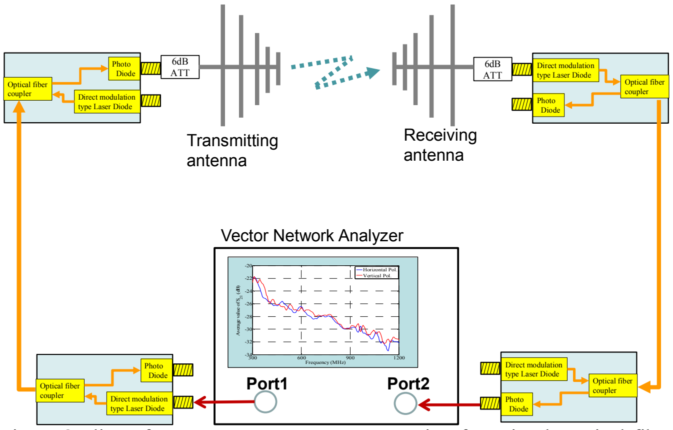

Fig. 7 Outline of antenna measurement setup using four simple optical fiber link modules.

Fig. 8 Photo of antenna measurement setup using four simple optical fiber link modules.

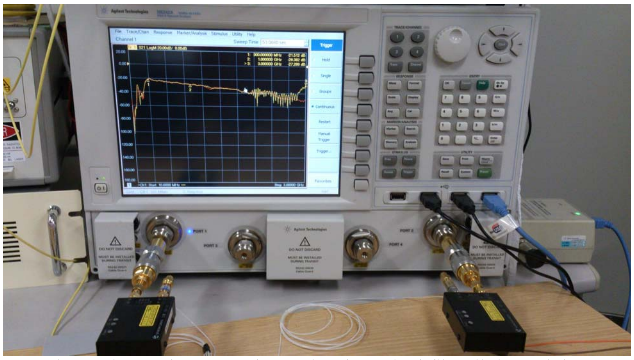

Fig. 9 Photo of VNA and two simple optical fiber link modules.

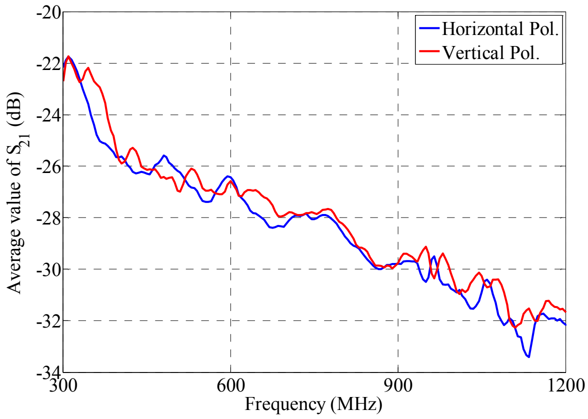

Fig. 10 $S_{21}(\omega)$ of LPDAs using simple optical fiber modules

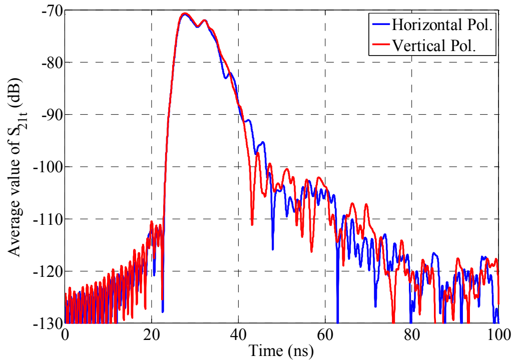

Fig. 11 $S_{21}(t)$ of LPDAs using the simple optical fiber modules.

B. Antenna measurement using coaxial cable system

We explain the time stability of coaxial cable system. We measure the time stability of the $|S_{21}(\omega)|$ in the interval of 700 minutes after starting the system up. Fig. 12 shows the time stability of the coaxial system with the VNA. Fig. 13 shows the ambient temperature of our semi-anechoic chamber during the measurement. In the case of ambient temperature stability is less than 3 degrees, the time stability of the coaxial cable system with the VNA is less than 0.2 dB during 700 minutes in the frequency range from 10 MHz to 1 GHz.

In order to compare the S21 measurement results between the optical system and coaxial cable system, we carry out the $S_{21}(\omega)$ measurement between two log-periodic antennas of UHALP9108A1 (LPDA) as AUTs by using two coaxial cables with 6dB attenuator after a response calibration to normalize frequency response. The $S_{21}(\omega)$ measurement setup is shown in Fig. 14. Fig. 15 and 16 show measured $S_{21}(\omega)$s and calculated $S_{21}(t)$s, respectively. [Horizontal Pol.] and [Vertical Pol.] show the measurement results of the horizontal and vertical polarization setting of two LPDAs. The calculated $S_{21}(t)$ envelopes using our proposed system has some difference after 30 ns because the reflection wave arrived from the absorbing materials on the floor. Then, we compare the measurement results between using the optical system and using the conventional coaxial cable system. The small difference shows good agreement of them within 1 dB from 300 MHz to 1 GHz (Fig. 17). The small deviation shows good agreement of the optical system and the conventional coaxial cable system in time domain from 26 ns to 35 ns (Fig. 18). The disagreement can be explained by the fact that undesired reflection waves received after 35 ns.

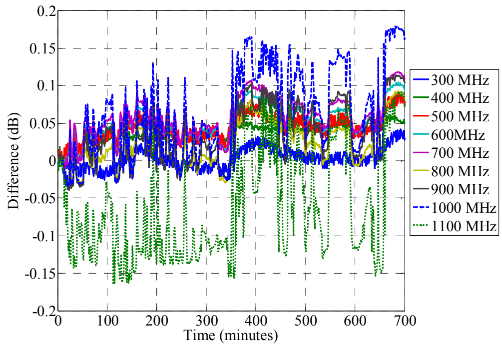

Fig12. Time stability of the coaxial cable system.

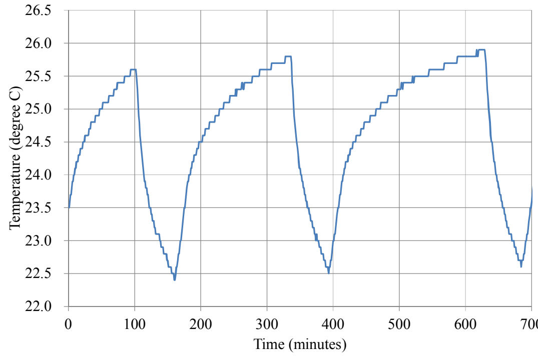

Fig. 13 Time stability of ambient temperature.

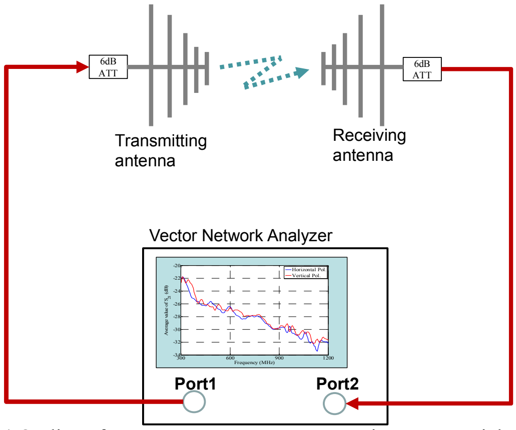

Fig. 14 Outline of antenna measurement setup using two coaxial cables.

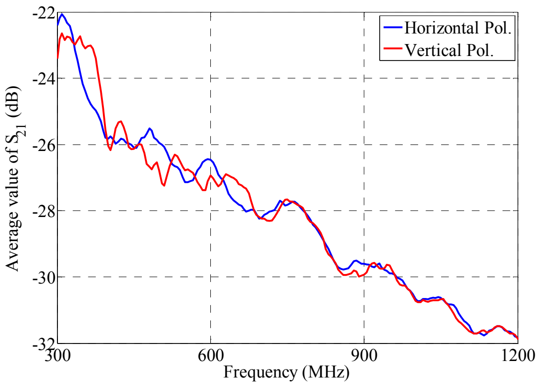

Fig. 15 $S_{21}(\omega)$ of LPDAs using the coaxial cable system.

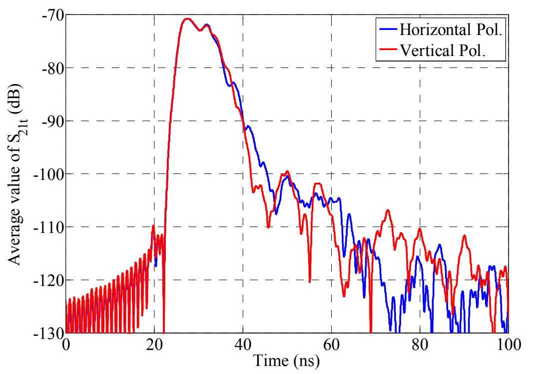

Fig. 16 $S_{21}(t)$ of LPDAs using the coaxial cable system.

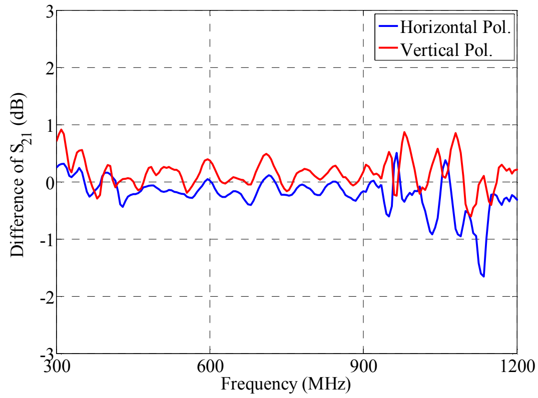

Fig. 17 Difference of $S_{21}(\omega)$s between optical system and coaxial system.

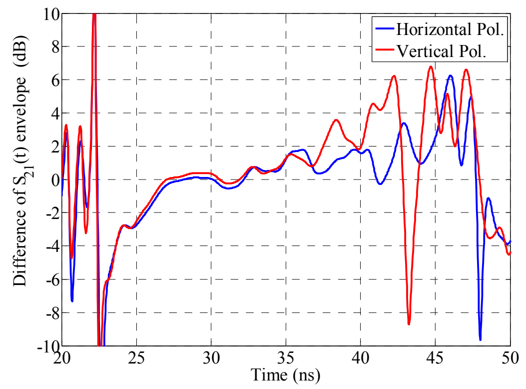

Fig. 18 Difference of $S_{21}(t)$s between optical system and coaxial system.

IV. Conclusion

We propose a new type of simple optical fiber link module for measuring the antenna characteristics. In order to demonstrate the performance of the optical module, we carry out the S21 measurements of two log-periodic antennas. The system can measure the S11 and S21of the AUTs. The results of the S21 of the LPDAs by the optical link module agree well with those of the conventional coaxial system. It is shown by the comparison that the optical system has a good performance to the measurement for S21 even in broad frequency range. Nevertheless, there still remains a small disagreement between the results by the different systems of the optical fiber and metal cable. It is caused by some undesired reflection waves from absorbing materials and the metal coaxial cables. Further improvements on the dynamic range of the system are required for better performance to the degree of the conventional metal cable system.

References

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