Measurement of Reflection Characteristics of Electronically Controlled Reflectarray Antennas

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1. Introduction The free-space method is widely used to measure the reflection characteristics of reflectarray (RA) antennas [1]. With the emergence of large-size electronically controlled RA antennas in recent years, free-space method becomes more complicated (to build a large-aperture plane wave) and costly (a large number of active devices). Therefore, a low-cost measurement method is required to quickly verify the reflection characteristics of designed RA antennas.

2. Principle and Experimental Validation According to the guided wave theory, the parallel plate waveguide (PPW) can simultaneously excite TEM mode, TE mode and TM mode. By adjusting the spacing of the parallel plates, only the TEM wave with the normal incidence can be excited on the test antenna [2]. In addition, according to the image theory, the upper and lower walls of the PPW is equivalent to the one-dimensional (1D) array placed in it into an infinite two-dimensional array. Therefore, using the PPW method, the reflection characteristics of large-size array can be measured with only one row of the original array. Compared with the traditional free-space wave method, this method not only reduces the complexity of the test system, but also greatly reduces the cost of the test array, which has great engineering value. Fig.1 (a) shows that the electric field (E-field) of a typical PPW. It can be seen that the TEM wave is excited in the far region from the source. For decreasing the distance of TEM wave region from the source as well as increasing the E-field magnitude, a horn-shape transition structure is used as the source, as shown in Fig.1 (b). It can be seen that the TEM wave is excited from the end of the transition structure. Therefore, the test antenna can be placed near from the source to increase the received E-field magnitude and to get accurate measured results. Fig. 2 shows the experimental setting of using PPW method to measure the reflection characteristics of the 1-bit RA antenna designed in our previous work. A coaxial-waveguide transition is used to connect VNA and the proposed PPW measurement system. The 1D 1-bit RA antenna is placed in the middle of the PPW and connected with the DC supply by the bias line. The absorber material is used to decrease the undesired reflected wave from boundaries of the PPW. The detailed parameters are also given in the figure. Fig. 3 shows the measured results of designed 1-bit RA antenna. It can be found that the reflection characteristics are well measured. At 11.685 GHz, the phase difference of OFF and ON states is 180 degrees while the amplitudes are almost unchanged, which validates the effectiveness of designed 1-bit RA antenna.

3. Conclusion A fast and low-cost method for measuring the reflection characteristics of electronic controlled RA antennas by using the PPW was demonstrated. The measurement method can be used to accurately measure both the amplitude and phase of reflected wave with only one row instead of the whole antenna, which offers a fast and low-cost way to validate the performance of the RA antennas, especially for large size and electronically controlled RA antennas.

ACKNOWLEDGMENT

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Reference

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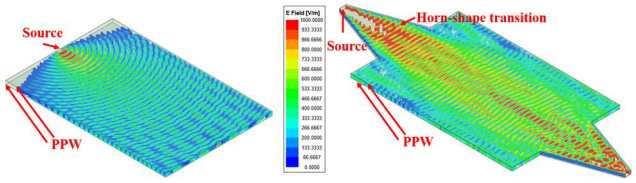

(a) Typical model (b) Proposed model

Fig. 1. Simulated electric field distribution of PPW.

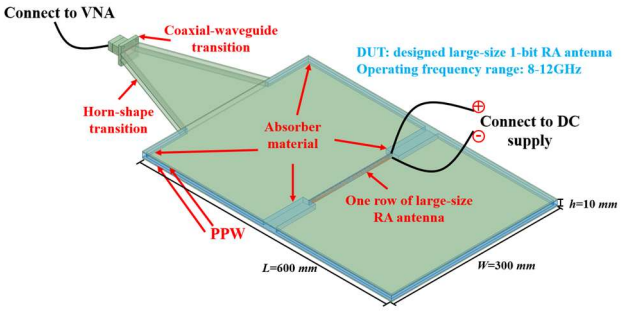

Fig. 2. Exprimental setting of proposed PPW measurement system.

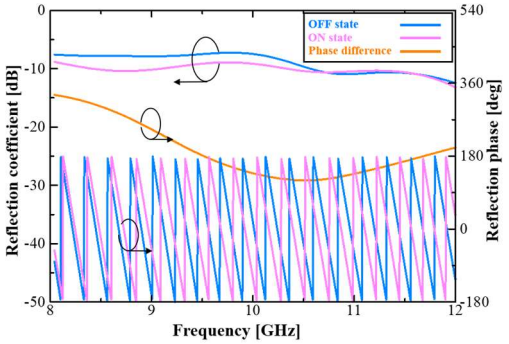

Fig. 3. Measured results of reflection characteristics of designed 1-bit RA antenna.