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Measurement of Reflection Coefficient Distribution near Surface of Reflectarray

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Abstract IEICE A far field measurement system is often used to evaluate the scattering performance of the reflectarray (RA), but the size of this system is quite large. In order to realize a relatively compact system and to get an accurate reflection coefficient distribution, a near-field measurement is required. In this report, a near field measurement system with lens and small size dipole antenna is presented to evaluate the complex reflection coefficient distributions at the surface of a RA by measuring the standing wave. As a result, the distributions of phase and amplitude measured by this method are consistent with the structural characteristics of RA which confirmed that this near field measurement system can be used to evaluate the reflection coefficient at the surface of a RA.

Keywords Reflectarray, Near field measurement, reflection coefficient distribution

1. Introduction

To evaluate the reflection coefficient at the surface of a reflectarray (RA) , the far field measurement has been used which required a large-size measurement system [1],[2]. In this report, a near field measurement [3] is presented to evaluate the complex reflection coefficient distributions by measuring standing wave.

2. Measurement system

A measurement system is shown in Fig. 1. A horn antenna is located on the axis of a lens. Reflectarray with periodical structure in y-direction and with same structures in x-direction, is fixed on XY-actuator. A small dipole antenna is scanned along z-direction by Z-actuator. A horn antenna is located at focal plane of lens and the uniform field distributions in a region of RA are realized.

3. Method and results

3.1. Standing wave method

Incident wave and reflected wave forms a standing wave in a region between lens and reflectarray and were measured by a small dipole antenna [4]. The standing wave ratio is obtained by the maximum and the minimum values of the magnitude of the near-field distributions and then absolute values of the reflection coefficient can be obtained [5]. Standing waves in cases of a conductor plate and a reflectarray are shown in Fig. 2. The absolute values of reflection coefficient are calculated using the values of peaks and nulls, respectively. Then the amplitude of the reflection coefficient can be calculated as:

$$\mathrm{VSRW} = \frac{E_{\max}}{E_{\min}} \qquad |\Gamma| = \frac{\mathrm{VSRW}-1}{\mathrm{VSRW}+1}$$

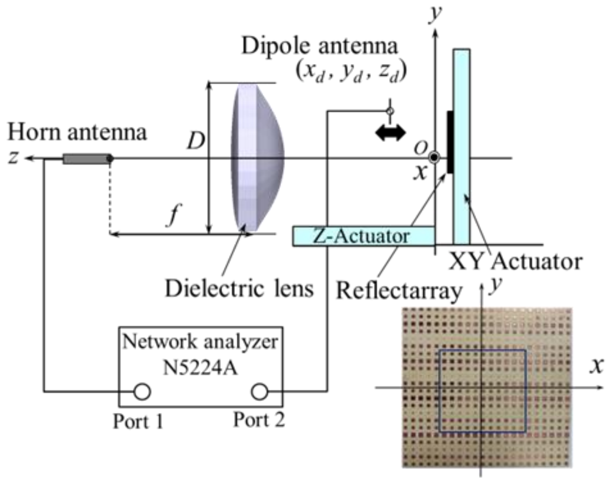

Fig. 1 Measurement system with small dipole antenna and lens.

The phase of reflection coefficient can be calculated from the difference in distance between two nulls of each standing wave as:

$$\phi = \pi \mp 2k(p_2 - p_1) \qquad \Gamma = |\Gamma| e^{j\phi}$$

-: $(p_2 - p_1)$ toward source +: $(p_2 - p_1)$ toward load

3.2. Case of reflectarray

The amplitude and phase distributions of reflection coefficient along y-axis (x=0) and x-axis (y=0) are shown in Fig. 3 and Fig. 4. Large phase and amplitude changes were observed in case of x=0 and few phase and amplitude changes were observed in case of y=0 which will be corresponding to the structure of RA in y-direction and x-direction.

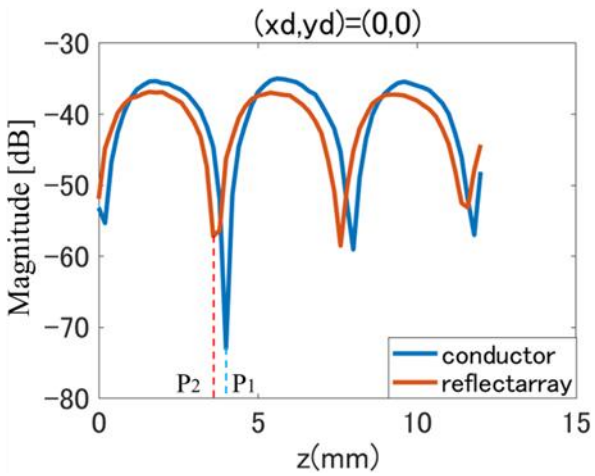

Fig. 2 Standing waves formed by conductor plate and reflectarray.

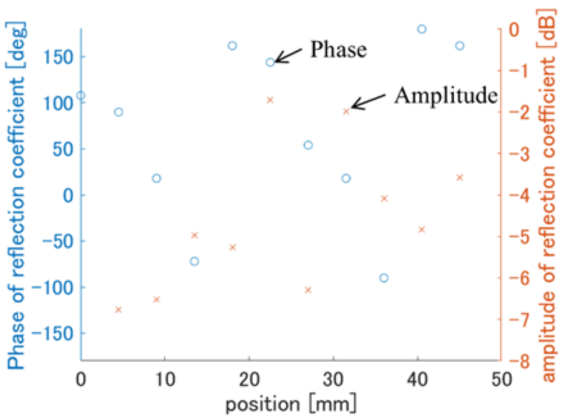

Fig. 3 Phase and amplitude distributions of reflection coefficient along y-axis (x=0). 37.5 GHz.

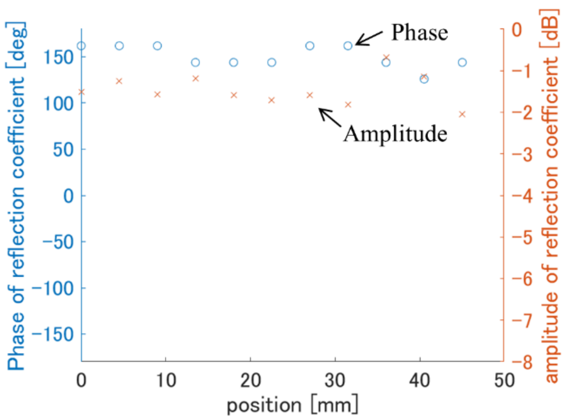

Fig. 4 Phase and amplitude distributions of reflection coefficient along x-axis (y=0). 37.5 GHz.

With this method the phase and amplitude distributions of reflection coefficient of RA can be measured. The amplitude and phase distributions of reflection coefficient of RA are shown in Fig. 5 and Fig. 6. Large phase and amplitude changes were also observed in y direction and few phase and amplitude changes were observed in x direction which will be corresponding to the structure of RA. Although the overall periodicity is not particularly obvious due to the influence of factors in the experimental system such as the receiving antenna, lens and so on, the reflection coefficient of each unit on the RA can be measured by this method, which can make the measurement results more accurate and specific. Especially when measuring liquid crystal reflect arrays under different bias voltages, a relatively specific and accurate reflection coefficient distribution can play a good role in the performance analysis of liquid crystal reflect arrays.

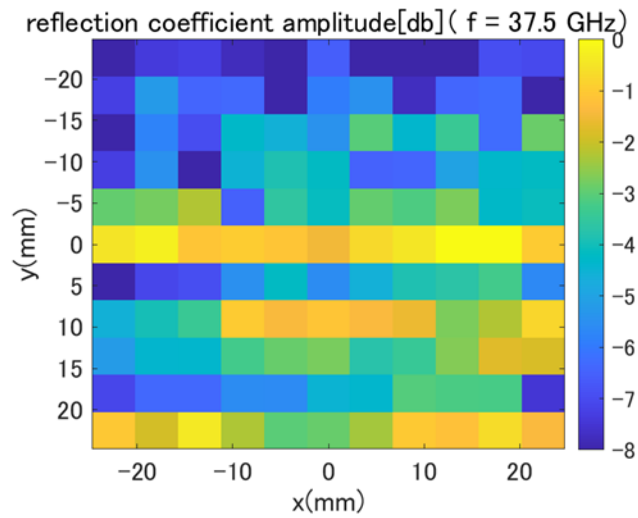

Fig. 5 Amplitude distribution of reflection coefficient. (37.5 GHz).

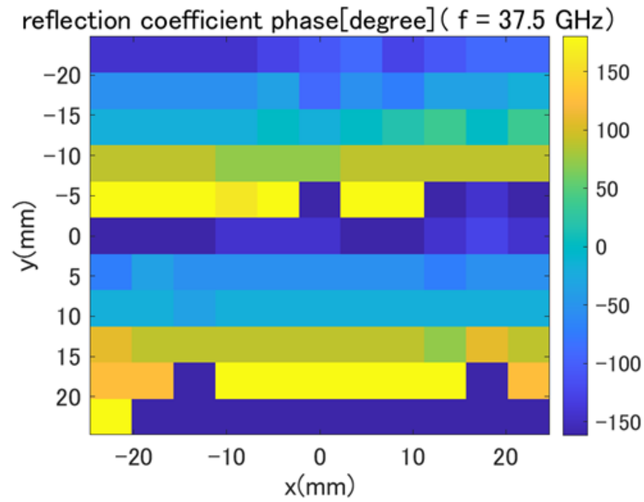

Fig. 6 Phase distribution of reflection coefficient. (37.5 GHz).

4. Conclusion

This report provided a method to measure the distribution of amplitude and phase of the reflection coefficient at the surface of reflectarray using the standing waves. The amplitude and phase distributions of the reflection coefficient of the reflectarray are obtained through experiment. This method can be used to analyze the RA reflection coefficient and loss since it can provide a specific near-field distribution. It can also be used to analyze the far-field distribution of RA by means of near-far-field conversion. In order to reduce the influence of various factors on the experimental results and increase the accuracy of the experimental measurement results, the improvement of measurement systems will be performed in a recent future.

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