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CONSIDERATION OF A RADIAL LINE MICROSTRIP ARRAY ANTENNA

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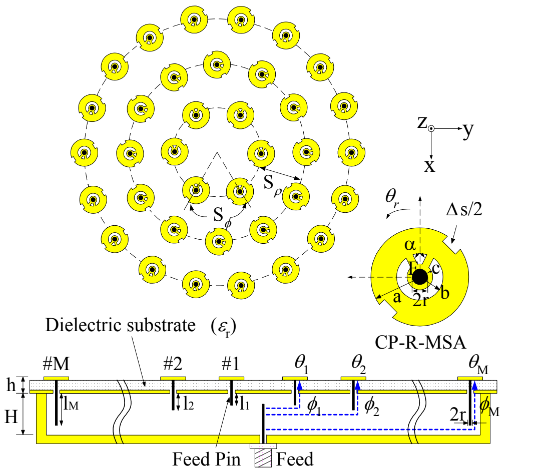
1. INTRODUCTION

In construction of a large-scale multi-element planar array, reduction of the feeding loss is important for realization of high-efficiency performance. There have been many studies recently on the performance of an array antenna fed by a low-loss radial line (RL-MSAA) [1]-[3] because it has high performance. In this paper, a basic design technique for an RL-MSAA that takes into account the effect of the feeding pin of an element antenna is presented and then the radiation properties of a new type of RL-MSAA using a sequential arrangement are described. In order to verify the performances of these antennas, some RL-MSAAs were constructed and tested at the SHF band. Satisfactory performances were achieved in the radiation patterns, axial ratios and input impedance for the RL-MSAA tested here.

2. RADIATION PROPSTIES OF AN RL-MSAA DESIGNED BY CONSIDERING THE EFFECT OF THE FEEDING PIN

The feeding system of the RL-MSAA was constructed with one-layered radial line as shown in Figure 1. A center-fed circularly polarized ring microstrip antenna (CP-R-MSA) [4] is used as an element antenna in the RL-MSAA, and the CP-R-MSA element is arranged radially on a Teflon fiber dielectric substrate (ε_r = 2.55, $tan\delta$= 1.8×10^{-3} , h = 1.2[mm]). Each CP-R-MSA element in the array is coupled electromagnetically via a feeding pin to a radial line. The edge terminal of the radial line is short-circuited, and input power fed by a center coaxial connector is radiated into the



$$\begin{pmatrix} a=3.75, b=1.85, c=1.0, r=0.6, h=1.2, H=7.5, \text{unit:}[mm] \\ \varepsilon_r=2.6, \Delta s/s=4.4[\%], \alpha=55[deg.] \end{pmatrix}$$

Fig.1. Basic configuration of the RL-MSAA.

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free space through the CP-R-MSA elements. The amplitude and phase distributions of the array are set so as to be uniform by controlling the inserted length of the feeding pin (l_p) and the rotational angle (θ_r) of the CP-R-MSA element.

In the design of this type of RL-MSAA, it is important to estimate the phase deviation caused by the feeding pin effect of an element antenna. The relation between phase deviation and length of the feeding pin (l_p), which was obtained by using an electromagnetic (EM) simulator (FIDELITY), is shown in Figure 2.

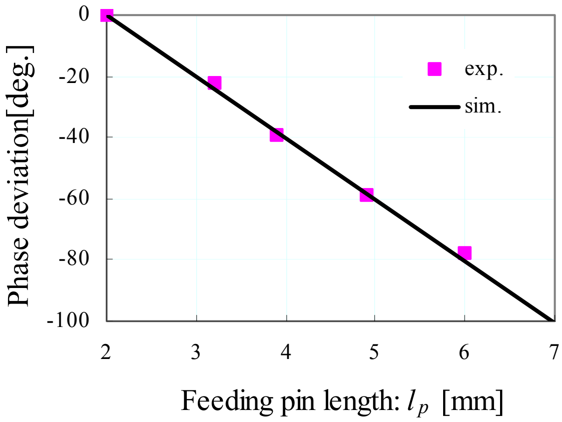
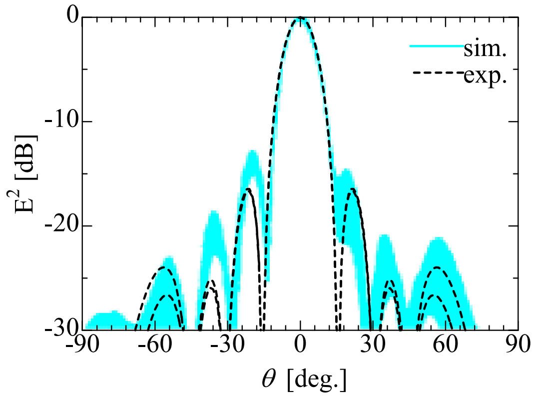


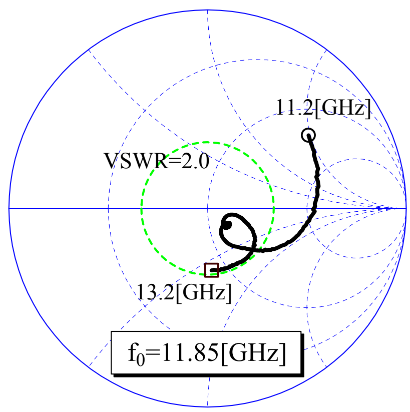
Fig.2. Phase deviation as a function of pin length.

As can be seen in the figure, the experimental results of phase deviation agreed well with the computed results obtained from the EM simulator. The phase distribution of the test array is set so that it will be uniform by considering the phase deviation because of the feeding pin effect of each CP-R-MSA element. A test RL-MSAA in which the phase deviation of an element antenna was compensated was fabricated and tested at the SHF band. An example of the radiation pattern for the test antenna is shown in Figure 3. The main beam of the pattern agreed with the calculated value. Figure 4 shows the input impedance characteristics of the test antenna. As shown in the figure, a broadband bandwidth of 12.3% (USWR $\leq$ 2.0) was achieved in the test antenna. The axial ratio property of the antenna is also shown in Figure 5 as a function of frequency. As shown in the figure, the axial ratio in the boresight direction was less than 1.0 dB over a broadband frequency region.



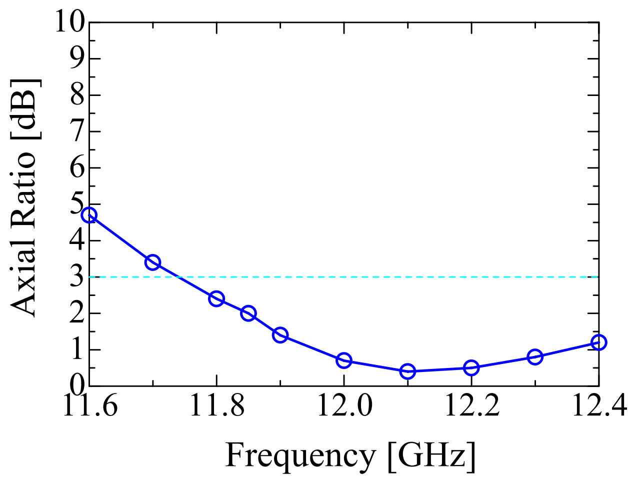
$$\begin{pmatrix} l_1 = 3.7, l_2 = 4.6, l_3 = 5.6, \text{unit}:[\text{mm}], \\ S_\rho = 0.64\lambda_0, S_\phi = 0.67\lambda_0 \\ \theta_1 = 0.0, \theta_2 = -104.4, \theta_3 = 151.0, \alpha = 55[\text{deg.}] \end{pmatrix}$$

Fig.3. Radiation patterns of an RL-MSAA in which the phase deviation of the feeding pin was compensated.



$$\begin{pmatrix} l_1 = 3.7, l_2 = 4.6, l_3 = 5.6, \text{unit}:[\text{mm}], \\ S_\rho = 0.64\lambda_0, S_\phi = 0.67\lambda_0 \\ \theta_1 = 0.0, \theta_2 = -104.4, \theta_3 = 151.0, \alpha = 55[\text{deg.}] \end{pmatrix}$$

Fig.4. Frequency characteristics of input impedance for the test RL-MSAA.

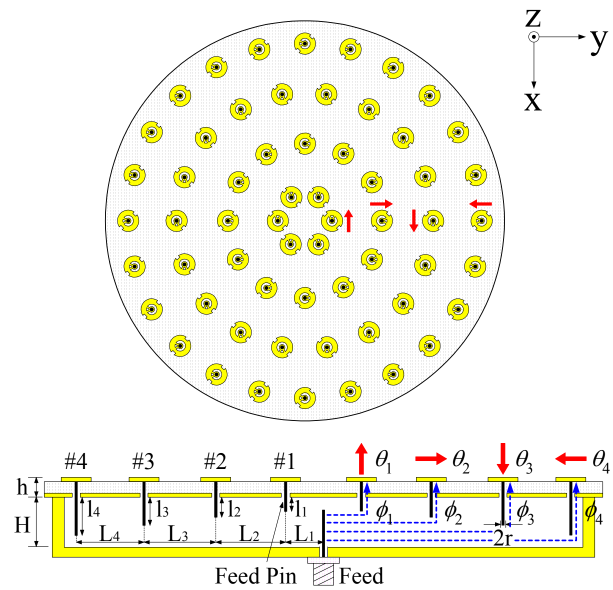


$$\begin{pmatrix} l_1 = 3.7, l_2 = 4.6, l_3 = 5.6, \text{unit}:[\text{mm}], S_\rho = 0.64\lambda_0, S_\phi = 0.67\lambda_0 \\ \theta_1 = 0.0, \theta_2 = -104.4, \theta_3 = 151.0, \alpha = 55[\text{deg.}] \end{pmatrix}$$

Fig.5. Frequency characteristics of boresight axial ratio for the test RL-MSAA.

3. A NEW TYPE OF RL-MSAA USING A SEQUENTIAL ARRANGEMENT

Figure 6 shows the basic configuration of a new type of RL-MSAA using a sequential arrangement. The amplitude and phase distribution of the array are set so as to be uniform by controlling the length of the feeding pin (l_p) and the rotational angle (θ_r) of each CP-R-MSA element. In order to achieve the phase and amplitude distributions required for a sequential arrangement [5], each ringed array of the antenna is fed in uniform amplitude but 90° out of phase, as shown in the Figure 6. Figure 7 shows the axial ratio characteristics of the new type of RL-MSAA shown in Figure 6. As shown in the figure, the axial ratio of the new type of array was suppressed to below 1.5 dB over a broadband frequency region (11.80~12.80 GHz). The return-loss property of the that array was also suppressed to below −10.0 dB over a broadband frequency region (11.25~13.00 GHz). The results of experiments showed that this new type of RL-MSAA performed well in both axial ratio and return-loss characteristics.



$$\begin{pmatrix} a=3.75, b=1.85, c=1.0, r=0.6, l_{p1}=2.9, l_{p2}=4.0, l_{p3}=4.5, \\ l_{p4}=5.5, L_1=0.38\lambda_0, L_2=0.68\lambda_0, L_3=0.71\lambda_0, L_4=0.675\lambda_0, \\ h=1.2, H=7.5, \text{unit}:[\text{mm}], \varepsilon_r=2.6, \Delta s/s=4.4[\%], \\ \alpha=55, \theta_1=0, \theta_2=-90, \theta_3=-180, \theta_4=-270, \phi_1=0, \phi_2=90, \\ \phi_3=180, \phi_4=270, \text{unit}:[\text{deg.}] \end{pmatrix}$$

Fig.6. Configuration of a new type of RL-MSAA using a sequential arrangement.

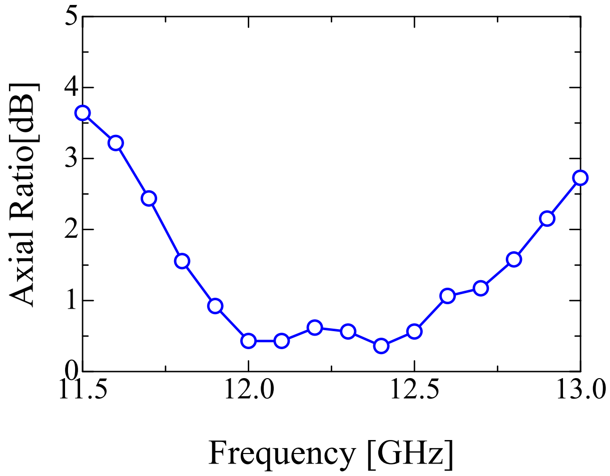


Fig.7. Frequency characteristics of boasight axial ratio for the test RL-MSAA.

4. CONCLUSIONS

An RL-MSAA in which the phase deviation of feeding pin was compensated was fabricated and tested at the SHF band. The results of experiments showed that satisfactory performances were achieved in both radiation patterns and axial ratio characteristics. A new type of circularly polarized RL-MSAA using a sequential arrangement was then designed and tested at the SHF band. The experimental results demonstrated that the test RL-MSAA performed well in terms of both radiation pattern and axial ratio characteristics. The new types of RL-MSAA are considered to be useful models for a circularly polarized planar array.

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