Experimental Study on a Partially Driven Array with Simplified Dipole Elements

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Abstract

As the scale of an array antenna becomes larger, higher costs are demanded. This paper describes the experimental verification of the model method to simplify array antennas and to reduce the cost eventually. By replacing a part of fed elements to parasitic ones and adjusting the element arrangement, we can obtain almost the same characteristic as the fully-fed array antenna. We also describe the comparison between experiments and calculations.

1. INTRODUCTION

Recently, global environment and energy problems have grown into serious problems. As a result, various solutions are considered. SSPS (Space Solar Power Station) is one of the best solutions. In this system, the generated electric power is transmitted by a microwave to the ground [1]. In order to transmit this microwave at high gain, a large-scale array antenna is proposed [2]. This antenna requires a wide effective area.

In an array antenna, as the number of antenna elements increases, more feeder circuits are required and the whole system becomes more complex. Such a complex antenna system requires higher costs. Therefore, by replacing antenna elements to parasitic ones, we expect to optimize the antenna system and to reduce costs.

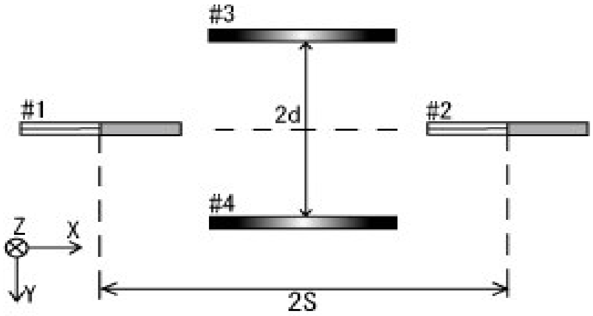
The coupling effect of an array antenna by parasitic elements has been analyzed [3] [4]. We have analytically confirmed that parasitic elements are fed by spatial electromagnetic coupling and investigated the layout of elements considering the coupling between parasitic elements [5]. In this paper, we consider the array antenna with two fed elements and two parasitic ones, and compare the characteristic of this antenna to the result of the calculation. In case the position of fed elements and parasitic ones is ideal, the antenna gain is 8.73 dBi. By changing the length of parasitic elements, the antenna gain can be improved up to 9.0 dBi.

2. EXPERIMENTAL SYSTEM

A. Antenna configuration

Figure 1 is the configuration of the array antenna with two fed elements and two parasitic ones. When we define this system as a unit, it is possible to extend the large scale array easily without breaking the electromagnetic coupling between fed and parasitic elements.

(a) x-z plane



(b) x-y plane

Fig.1: Antenna configuration.

In Fig.1 (b), two fed elements (#1 and #2) are located on a line in the same direction. The distance between them is 2*S*. They are fed at the same phase. The parasitic elements (#3 and #4) are made by brass which are 2.0 mm in the diameter, and 75 mm, which is a half-wavelength at 2.0 GHz. The distance between them is 2*d*. 2*S* is changed with 0.55ë (82.5 mm), 0.75ë (112.5 mm), and 1.0ë (150.0 mm), and *d* is changed by the 0.2ë from 0.2ë (30.0 mm) to 1.6ë (240.0 mm).

B. Fed elements

Figure 2 shows a fed element used in Figure 1. This is a half-wavelength dipole antenna and Table 1 shows the parameters of this fed element.

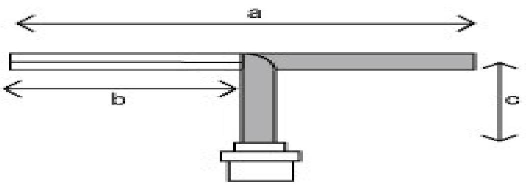


Fig. 2: The fed element.

TABLE1: PARAMETER OF THE FED ELEMENT.

	#1 [mm]	#2 [mm]
a	65.38	66.05
b	32.93	32.61
c	28.71	28.1

The fed elements are made by semi-rigid coaxial cable and a copper wire which are quarter wavelength in waveguide respectively. The outer conductor of the semi-rigid coaxial cable is stripped off at quarter wavelength in waveguide. The diameters of the outer and inner conductor of the coaxial cable are 2.2mm and 0.51mm. The dielectric constant of the internal insulator is 2.1. The diameter of the copper wire is 2.0mm.

In Figure 2, *a* is the total length, *b* is the length of the inner conductor and *c* is the height from the connector.

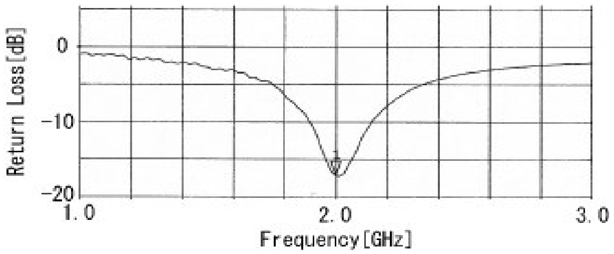


Fig.3: Return loss of the fed element.

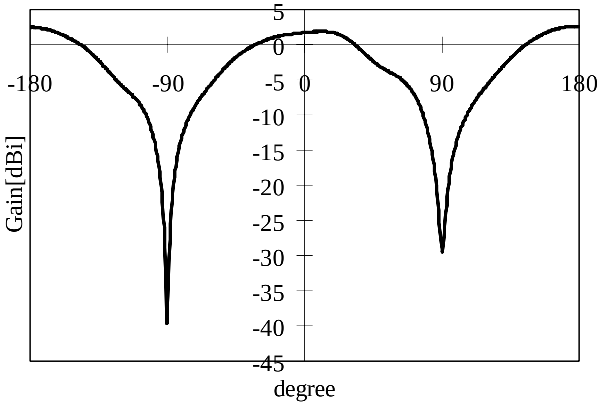


Fig.4: Radiation pattern of the fed element.

Figure 3 shows the return loss of this fed element and Figure 4 shows the radiation pattern of this fed element. The return loss of each element is -18 dB in 2.0 GHz. The maximum gain of this fed element is 2.51 dBi and the half-power beam width is 70 deg. Generally, the maximum gain of the half wavelength dipole is 2.15 dBi and the half-power beam width is 78 deg. Consequently, the directivity of this fed element is higher than that of the general half wavelength dipole.

3. EXPERIMENTAL RESULT

A. Antenna array with two fed elements

Figure 5 shows the layout of the two fed elements. Figure 6 shows the fluctuation of the gain for the distance between two fed elements in the experiment and the calculation.

According to the calculation, the maximum gain is obtained 5.44 dBi at $2S$ = 1.0ë (149.9 mm). In the experiment, it is 5.31 dBi at the same parameter. The difference of the gain between the experimental result and the calculation is 0.07 dBi.

In the experiment, the maximum gain is obtained 5.64 dBi at $2S$ = 0.75ë (112.4 mm). According to the calculation, it is 5.05 dBi. The difference of the gain between the experimental result and the calculation is 0.5 dBi. All elements are supported by formed polystyrene.

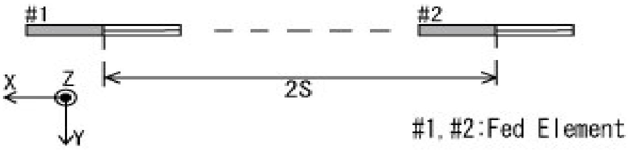


Fig.5: Antenna array with two fed elements.

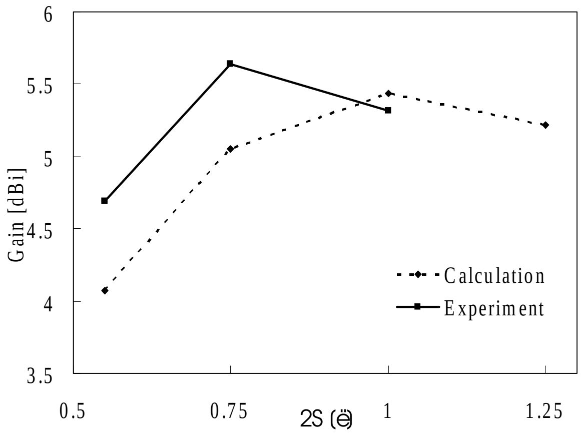


Fig.6: The change of the gain the distance between two fed elements.

B. Antenna array with two fed elements and two parasitic ones

Figure 7 shows the fluctuation of the gain for the distance between two fed elements ($2S$) and the distance between parasitic ones (d) in the experiment and calculation. The gain periodically changes at d = 1.0ë both in the experiment and the calculation. The maximum gain is obtained at d = 0.6ë in any $2S$ and at $2S$ = 0.75ë in any d.

Consequently, at $2S$ = 0.75ë and d = 0.6ë, the maximum gain can be obtained, and it is 8.73 dBi in the experiment and 8.6 dBi in the calculation. In $2S$ = 0.75ë, the minimum gain is obtained at d = 1.0ë and it is 2.2 dBi in the calculation and 3.3 dBi in the experiment.

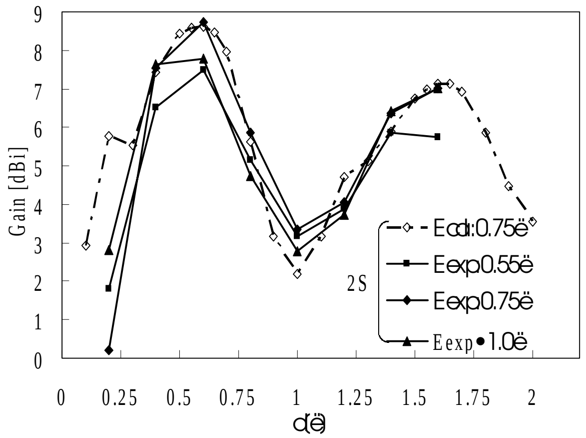
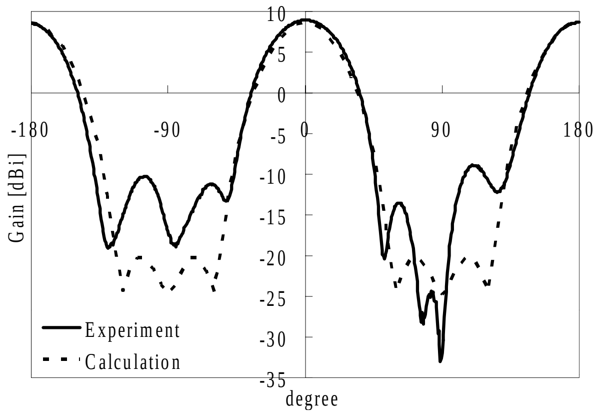


Fig.7: The change of the gain with the arrangement of the elements.

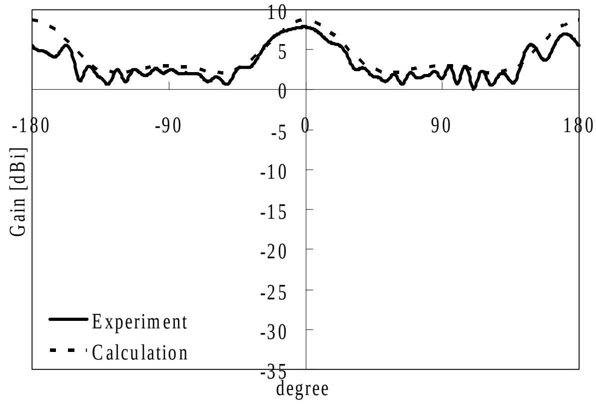
C. Radiation pattern at the maximum gain

Figure 8 shows the radiation patterns at $2S$ = 0.75ë and d = 0.6ë at which the maximum gain can be obtained. The maximum gain is obtained at ±180 deg and 0 deg. Figure 8 show the radiation patterns in E plane and H plane, respectively.

When we compare the experimental result to the calculation, they are almost the same pattern in Fig.8 (a). The half power beam width is ±22 deg in the experiment. It is indicated that the side lobe is suppressed to -10 dBi. According to Figure8 (b), also in H plane, the experimental pattern and the calculation one are the similar patterns. However, ripple has occurred about 110 deg and -130 deg. It is assumed that the influence of cable and feeding circuit is negligible in the experiment.



(a) E plane



(b) H plane

Fig.8: Radiation pattern at the maximum gain condition.

D. Effect of the lengths of parasitic elements

Figure 9 shows the fluctuation of the gain for the lengths of parasitic elements at the maximum gain layout in the experiment. In the experiments we describe at the section 3A, the lengths of the parasitic elements are 750 mm. In this experiment, we change the lengths of parasitic elements by the 0.025ë from 0.4ë to 0.6ë. As a result, the maximum gain is 9.0 dBi when the lengths of the parasitic elements are 0.475ë (712.5 mm).

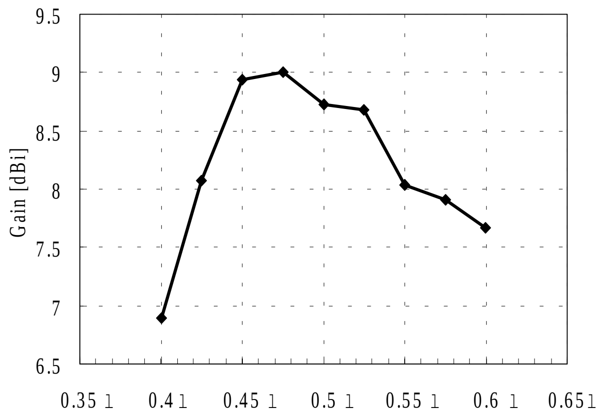


Fig.9: The change of the gain with the lengths.

4. CONCLUSIONS

(1) In an antenna array with two fed elements, the maximum gain is 5.64 dBi at 2S = 0.75ë 112.4mm) in the experiment.

(2) In an antenna array with two fed elements and two parasitic ones, we investigate the arrangement of the elements. The maximum gain is 8.73 dBi at 2*S* = 0.75ë and *d* = 0.6ë.

(3) In the experiment, similar radiation patterns are obtained as well as in the calculation. The half power beam width is ±22 degree.

(4) As the lengths of parasitic elements are changed, the gain is also changed. The maximum gain is improved up to 9.0 dBi by setting the lengths of parasitic elements to 0.475ë.

ACKNOWLEDGMENT

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