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Rigorous Analysis of A Multi-Sector Monopole Yagi-Uda Antenna with metallic Fins

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1. Introduction

We have developed the Multi-Sector Monopole Yagi-Uda Antenna array with Finite Ground Plane and Metallic Fin(MS-MPYA) and presented its fundamental radiation characteristics in the case of 12 sectors [1],[2]. The design goals of MS-MPYA are to cover all directions on the horizontal plane and to achieve a low profile. We clarify that this antenna needs metallic fins to suppress unwanted reflections from adjacent exciters. By using the moment method [3] we determine the fin length that just covers exciters is also most suitable to achieve maximum gain. We have also shown that when we use this fin, the adjacent arrays yield higher gain and sharpen the beam width in the horizontal plane of radiation pattern. Consequently, our interest is in how adjacent array elements and metallic fins behave for antenna characteristic. In this paper we clarify this problem by using poynting vector. The poynting vector has been used to analyze ordinary Yagi-Uda antenna[4] or traveling wave antenna[5].

2. Antenna structure and Analysis model

We show the MS-MPYA antenna structure in Figure 1. The MS-MPYA consists of twelve Yagi-Uda monople arrays each with ten antenna elements, one exciter and other parasitics. The ground plane diameter is 10.0 wavelengths and metallic fin length is 0.5 wavelengths; the cylindrical reflector's diameter, $2S$, is 2 wavelengths. We assume the 19GHz band. Our numerical analyses adopt the moment method. The analysis model and coordinate systems shown in Figure 2 consider three arrays to reduce matrix size. When the array #1 is excited, the other array's exciter become open state.

3. Antenna characteristic

We define three antenna types. Type-A is a three monopole Yagi-Uda arrays with metallic fin as in shown Figure 2. Type-B is one array monopole Yagi-Uda array just remove adjacent arrays from type-A. Type-C is the three array model with no metallic fin. We show the radiation patterns of these antennas in Figure 3. We have already reported that these radiation patterns well match experiment results. Of the three types of antennas, type-A antenna has the highest gain. The half power beam width of the type-B antenna is broader about 10 degrees than type-A. The characteristics of Type-C are not those of a Yagi-Uda antenna. Next, we consider the poynting vector flow of three types of antennas. We adopt the complex poynting vector definition as follows;

$$P = \mathrm{Re}\frac{1}{2}\, E \times \bar{H} \quad [W/m^2]$$

[1].

The MS-MPYA has three dimensional response. We show this by projecting the three dimensional vector on the X-Y plane. In Figure 4, we show the poynting vector flow of these three antenna types. The level which indicates contour level determined from the poynting vector amount as follows.

$$\left|P_{xy}\right|_{dB} = 10\log_{10}\sqrt{p_x^2 + p_y^2} \qquad [2]$$

The vector length corresponds to the $|P_{xy}|_{dB}$ value and the vector arrowhead indicates the ϕ direction. In figure 4 we fix the z coordinate to 3.5 mm. We assumed the elements' height ranging from 2.7 mm to 3.3 mm. Figure 4 (a) shows Type-A, Figure 4 (b) shows Type-B and Figure 4 (c) shows Type-C. In Figure 4 (c) the poynting vector flow divides three directions. We consider that this matches the pattern shapes. The vector flows of type-A and type-B are resemble each other well. The region that $|P_{xy}|_{dB}$ is around -60 dB spreads wider at the neighborhood of the adjacent arrays in Type-A than Type-B. We consider that it is due to pattern shape difference between Type-A and Type-B.

4. Conclusion

We have shown the poynting vector flow of the Multi-Sector Monopole Yagi-Uda Antenna. Comparing three types of antennas, we clarify that using the metallic fin is useful in suppressing the electric power division which occurs on the X-Y plane. Adjacent arrays let power density slightly higher at the neighborhood of the adjacent arrays.

Reference

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[3] G. J. Burke, and A. J. Poggio, "Numerical Electromagnetics Code (NEC) - Method of Moments, Part I-III," Lawrence Livermore National Laboratory, 1981.

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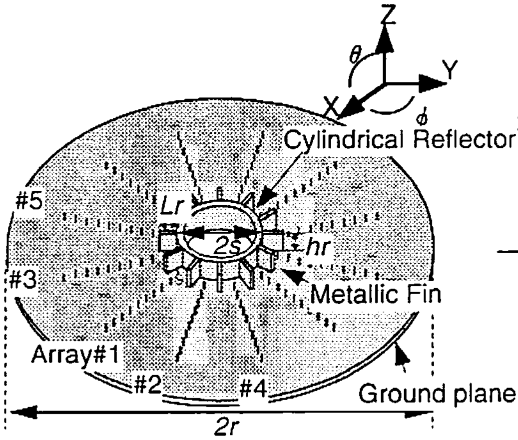


2s: Diameter of a Cylindrical Reflectors 30mm
hr: Height of Cylindrical Reflectors 10mm
2r: Diameter of a Ground Plane. 154mm
Lr: Metallic Fin length. 21mm

Fig.1 Structure of Twelve sector MS-MPYA

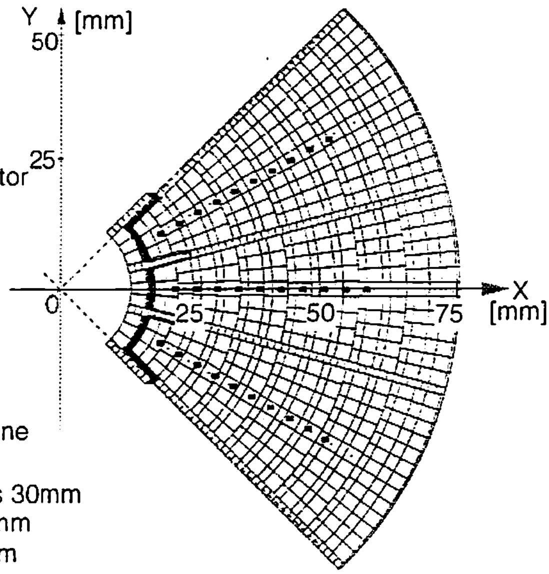
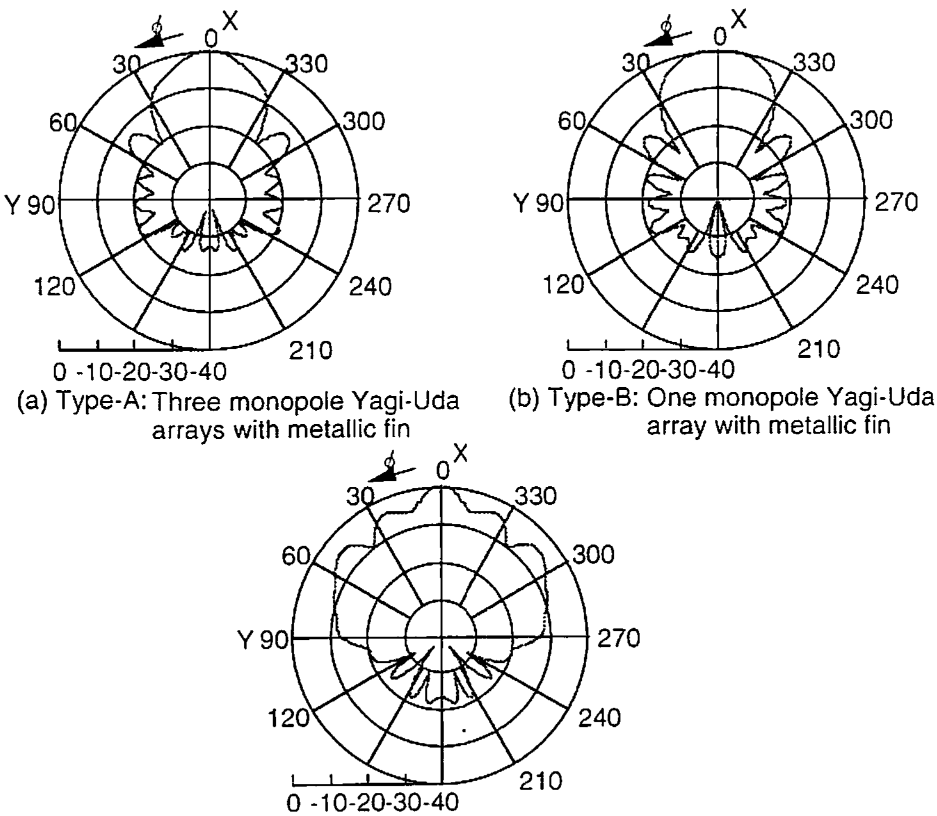


Figure 2 Quarter size analysis model and Coordinates systems

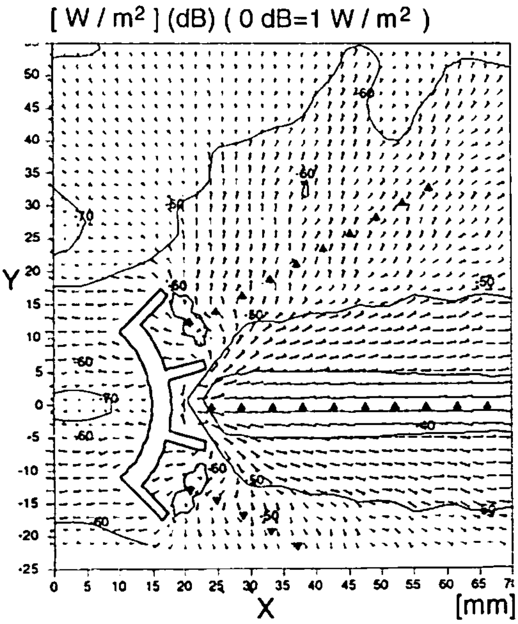


(a) Type-A: Three monopole Yagi-Uda arrays with metallic fin

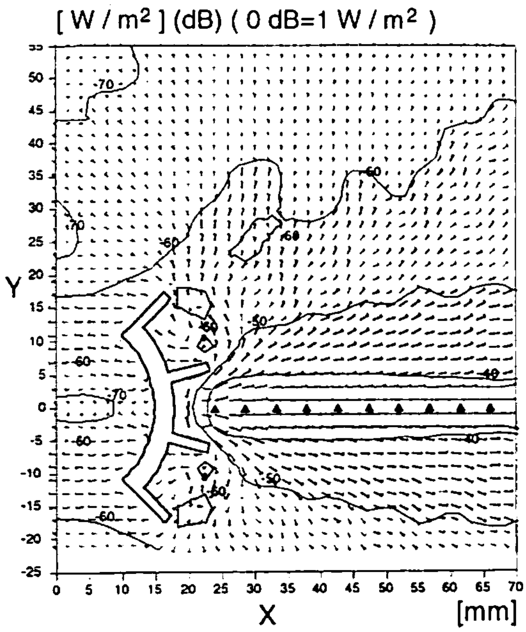
(b) Type-B: One monopole Yagi-Uda array with metallic fin

(c) Type-C: Three array model with no metallic fin

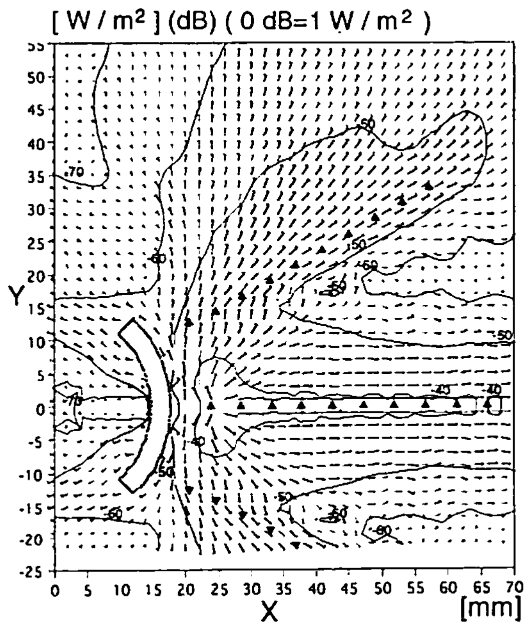
Figure 3 The radiation patterns of MS-MPYA in the horizontal plane



(a) Type-A: Three monopole Yagi-Uda arrays with metallic fin



(b) Type-B: One monopole Yagi-Uda array with metallic fin



(c) Type-C: Three array model with no metallic fin

Figure 4 The poynting vector flow and contour map of MS-MPYA at X-Y plane (z=3.5mm)