CIRCULAR POLARIZED WAVE GENERATED BY DIELECTRIC LOADED PRIMARY RADIATOR

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INTRODUCTION

As well-known, circular polarized wave is adopted for broadcasting satellite of 12GHz band. Usually circular polarized wave transmitted from a satellite is received by parabola antenna or off-set parabola antenna and then the circular polarized wave is changed to linearly polarized wave through several methods. Here, we proposed a dielectric loaded primary radiator which can change circular wave to linear wave directly.

STRUCTURE OF ANTENNA

Fig.1 illustrates structure of this antenna, that is, a dielectric rod is inserted in a rectangular waveguide. When take a side view of this waveguide, the left side of dielectric is inclined to upward 35 degrees and at the front of dielectric a metal plate is attached.
A cross section of this waveguide loaded with dielectric rod is shown in Fig.2. This structure looks like trapped image guide. In case of trapped image guide, dimension of dielectric in the horizontal direction is designed larger than dimension of dielectric in the vertical direction. But, in this case, the size of dielectric in vertical direction has larger dimension compared with that of horizontal direction. Therefore, the electric field must be distributed horizontal direction and the magnetic field must be entirely tangential.
Then, we investigate waves radiated from this antenna. The electro magnetic wave of TE_{01} mode travels in the dielectric rod and this electric wave incident to the metal sheet attached to the front of the dielectric rod and after that, the electric wave shall be radiated from the surface of dielectric with some angle.
Here, we describe more precisely about structure on this antenna. On the metal plate, another thin metals are mounted perpendicular to the plate. When look at the plate from the dielectric side, these thin metals are inclined at an angle of 45 degrees and distance between thin metals is expressed by b as shown in Fig.1. It is necessary to decide above mentioned distance by considering dielectric constant of used material. Polyethylene ($\epsilon_r \simeq 2.25$) is used for this antenna. When the electric field of horizontal direction incident to thin metals, this electric field shall be separate two components, that is, tangential and vertical components to the thin metal plate. At the surface of metal plate, these electric waves will mutually have phase difference of 45 degrees.

In case, the electric waves returned to the input port of the thin metals, phase difference between these waves becomes 90 degrees. Necessary depth of this thin metal to originate circular polarization is obtained as follows.
We express both of the parallel and vertical electric fields in the thin metal by E_1, E_2 respectively. Phase constants corresponding to the electric fields E_1, E_2 can be expressed as

$$\beta_1 = 2\pi f\sqrt{\mu_0\epsilon_0\epsilon_r}\sqrt{1-\left(\frac{\lambda_d}{2b}\right)^2}$$

$$\beta_2 = 2\pi f\sqrt{\mu_0\epsilon_0\epsilon_r}$$

Where f is frequency, $\lambda_d = 1/(f\sqrt{\mu_0\epsilon_0\epsilon_r})$, b is an interval between thin metals as mentioned above.

When the electric fields at the input port of thin metals arrived to the front metal plate, phase difference between two electric fields becomes $\pi/4$. This relation is expressed as

$$(\beta_2 - \beta_1)\ell = \pi/4$$

Where ℓ is length from the input port of thin metal till the front metal. Therefore

$$\ell = \frac{1}{8f\sqrt{\mu_0\epsilon_0\epsilon_r}\left\{1-\sqrt{1-\left(\frac{\lambda_d}{2b}\right)^2}\right\}}$$

Actually, in this antenna, the incident angle of electric wave which enter the thin metals from the right side is 35 degrees. Consequently the necessary length ℓ may be determined considering this angle. For this antenna, the distance between two thin metals and the depth of thin metal are designed to be 11mm, 6mm respectivly.

MEASURED RESULTS

Fig.3 express characteristic of circular polarization. From this results, it is known that the difference between axes is about 2.2dB.

Fig.4 (a), (b) shows E-plane and H-plane pattern.

Fig.5 shows the input inpedance of this antenna and this measurement carried out for the frequency range 11.7 ~ 12.2GHz.

REFERENS

1. J.D. Kraus: "Antennas", McGraw-Hill, 1950, Chap.14, Chap.15.
2. T.Itoh: "Trapped Image Guide for Millimeter-Wave Circuts", IEEE Trans. Microwave Theory and Techniques., MTT-28, No.12, Dec. 1980.

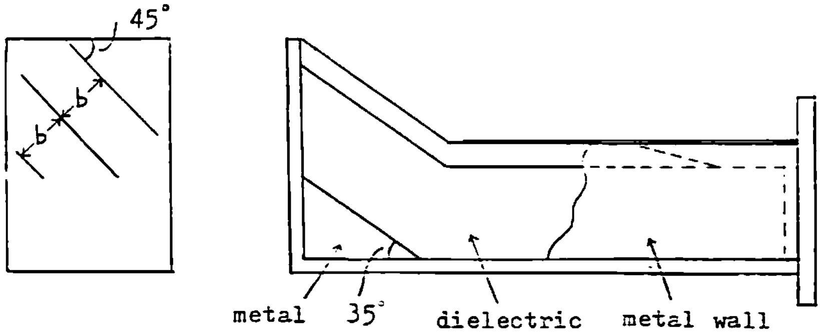


Fig.1 Structure of radiator.

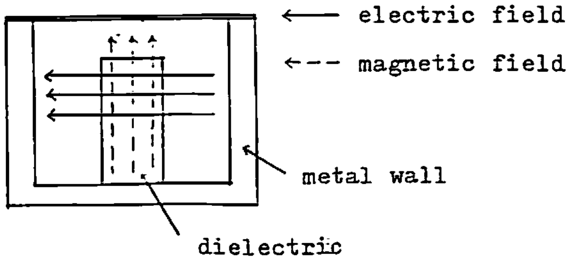


Fig.2 Cross section of waveguide loaded with dielectric and electromagnetic field distribution in it.

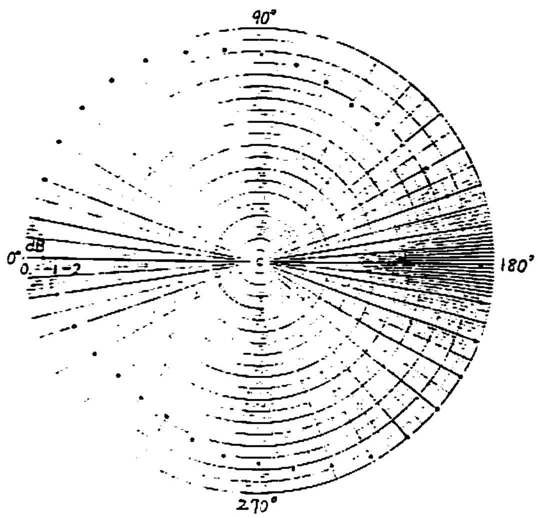
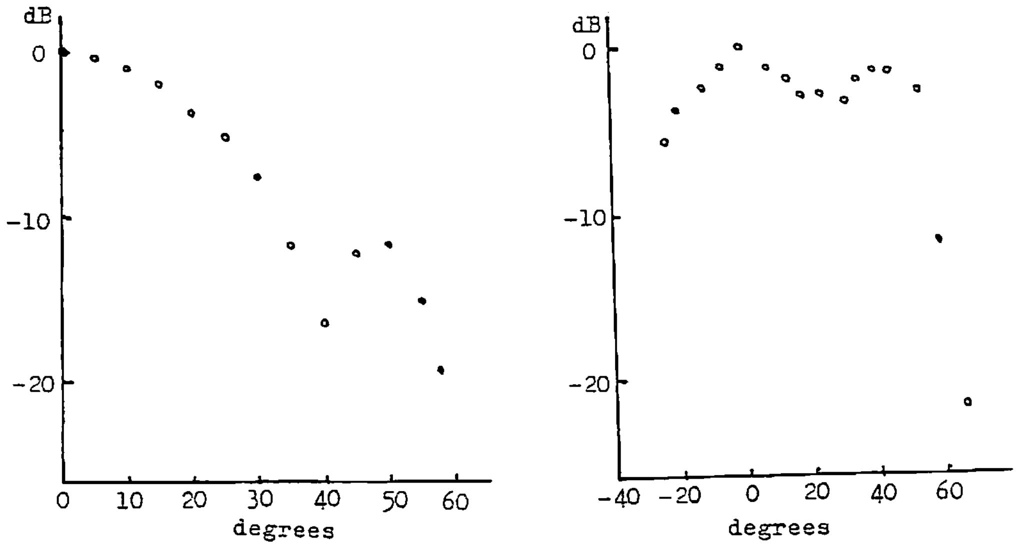


Fig.3 Characteristic of circular polarized wave.



(a) E-plane (b) H-plane

Fig.4 Radiation pattern.

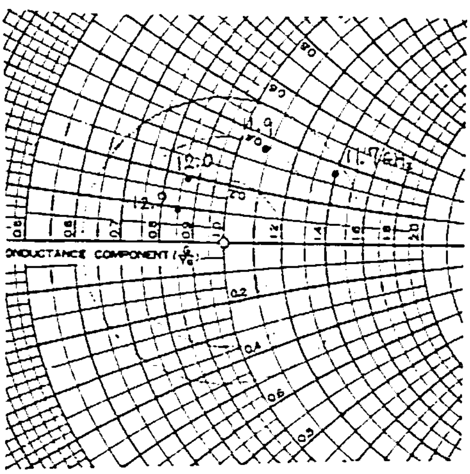


Fig.5 Input impedance.