Design of Waveguide Dielectric Rod Antenna for Shaping FTEP (Flat-topped Element Pattern) for HAPS

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Abstract: This paper presents the design and simulation results of 7 waveguide dielectric rod array antennas for 7 channel DBF(Digital beamformer) receivers for stratospheric system. A waveguide dielectric antenna type, which has FTEP(Flat-toped element pattern) to manufacture easily. Also, the calculated element patterns according to the permittivity are compared. The designed antenna will be used for generating multibeam radiation pattern by means DBF.

1. INTRODUCTION

The needs for broadband communication have been derived to study the new infrastructure defined as HAPS (High Altitude Platform Station), which is being developed in many countries to provide high quality, high data rate, and multimedia services.

ITU-R designated the bands of 27.5~28.35GHz and 31.0~31.3 GHz for HAPS, and requested to study the technical frequency sharing and criteria through Resolution 122[1].

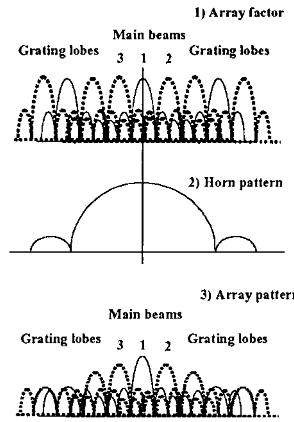
HAPS can provide the wide coverage, high data rate transmission, and broadband services. Therefore, the payload of HAPS should be compact, light, and large capacity because of the limit of weight for HAPS platform. To satisfy this requirement, multibeam phased array antenna can be applied. Also, to reduce the interference between adjacent cells using same frequency, antenna beam pattern is required to strict specification with very low sidelobe level.

To satisfy the antenna radiation pattern with very low sidelobe level, it is necessary to realize with adequate accuracy a certain amplitude distribution in the antenna aperture.

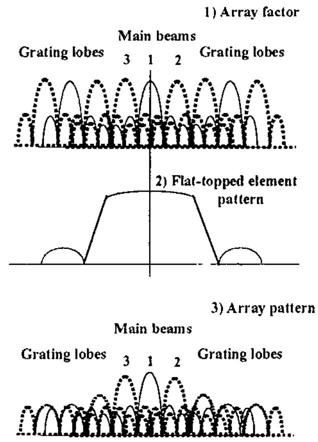
An effective way of the grating lobes suppressing consists in forming a flat-topped element pattern. In particularly, phased array antennas with the flat-topped element pattern for limited field of view can be created on the basis of multiport networks, protruding-dielectric elements, quasi-optical networks of overlapped subarrays and etc.

Fig. 1 shows the horn array radiation pattern and the radiator the flat-topped element pattern (FTEP) using mutual coupling. In this case, the grating lobes are suppressed more effective if the scan sector is wide. The gain degradation is less than in the case of the array with the horn elements.

This paper presents the design of the waveguide dielectric rod array antennas for 7 channel receivers for HAPS. Also, the calculated element radiation pattern will be described and compared. The designed antenna will be used for generating multibeam radiation pattern by means of digital beamformer. Analog beamformer cannot provide the accuracy of digital beamformer because of imperfection of mentioned microwave devices (due to reflections and insertion loss).



(a) The radiation pattern of the horn array



(b) The radiation pattern of the array with FTEP

Fig. 1 Radiation pattern

2. DESIGN OF DIELECTRIC ROD WAVEGUIDE ANTENNA

ITU-R designated the receiving bands of 31.0~31.3 GHz for HAPS system. This antenna is radiator for shaping FTEP using DBF for HAPS receiver.

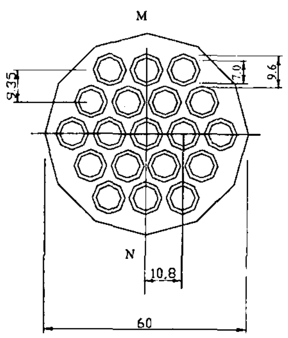
The requirement for 7 channel antenna is shown in (Table 1)

(Table 1) Specification for antenna

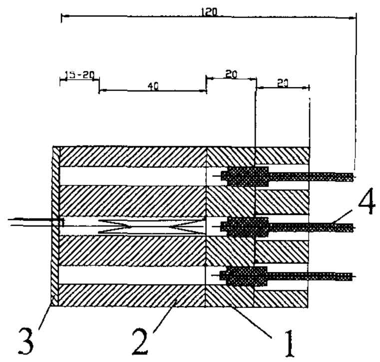
Frequency	31.0 ~31.3 GHz
Sidelob level	Under 10 dB

The scheme drawing of Ka-band radiator structure is shown in (Fig. 2). Dielectric rods are aligned the hexagonal structure. This structure contains:

- waveguide matrix : 1,
- radiators in form of dielectric rods : 19,
- polarizers: 7
- plate with 7 microstrip exciters and coaxial cables.



(a) Upper view



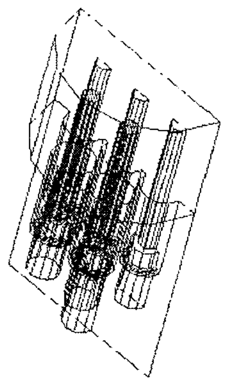
(b) Side view

Fig 2. Scheme drawing of Ka-band radiator structure

The total number of dielectric rods is equal to 19. Only, 7 radiators are active and connected ultimately with the seven channels of the RF Ka-band subsystem. Other 12 dielectric rods are passive and should be connected to matching loads. The passive elements are necessary to shape a flat-topped element radiation pattern of 6 active elements that combine into the first ring surrounding the central radiator. In itself, the central element is surrounded by 6 active radiators. Due to mutual coupling between the radiators, the flat-topped element pattern is formed for the central element.

3. SIMULATION RESULTS

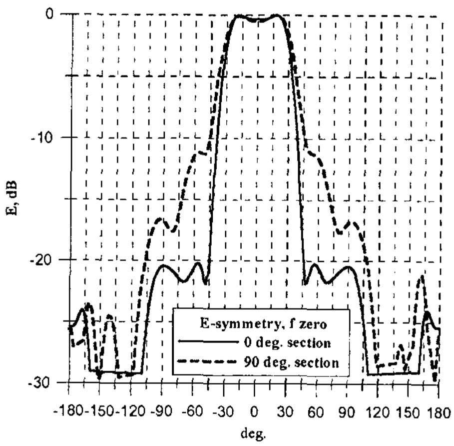
The dimensions of a full antenna model are great in comparison with the wavelength. For efficient simulation, we consider a half of the fragment obtained under insertion of the symmetry plane. (Fig. 3) shows simulation model with symmetric plane. For simulation, it is possible to consider two cases of symmetry plane (E- and H-symmetry) under operating on the circular polarization.



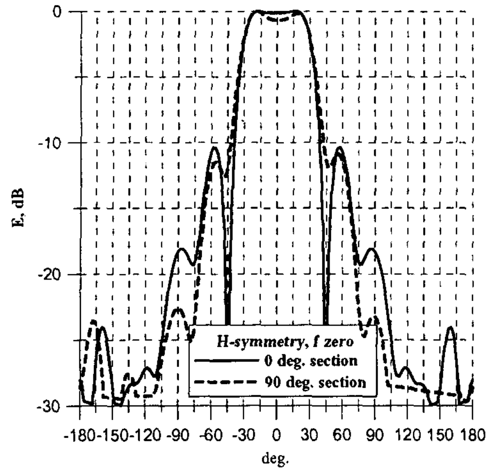
(Fig. 3) Model with the symmetry plane

We calculate the characteristics of the structure for two versions of the rod materials: teflon_based (ε = 2.8, the rod length is L = 17 mm) and ftoroplast-4 (ε = 2.05).

According to the simulation results, the radiation beam patterns of dielectric rod with the high permittivity are better than those of dielectric rod with low permittivity.

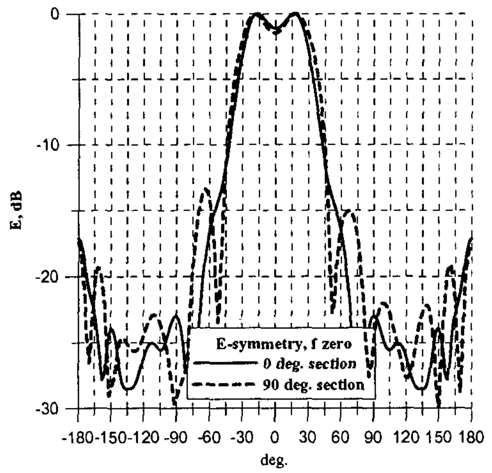


a) E-symmetry plane

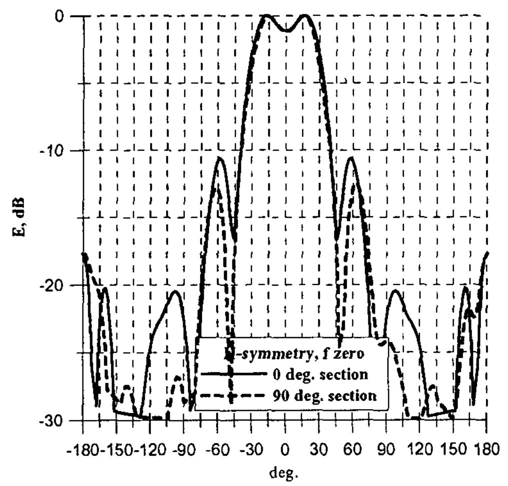


b) H-symmetry plane

Fig 4. Radiation pattern of Ka-band radiator structure (teflon_based ε = 2.8, L=17 mm)



a) E-symmetry plane



b) H-symmetry plane

Fig 5. Radiation pattern of Ka-band radiator structure (ε = 2.05, L=17 mm)

4. CONCLUSION

In this paper, we described the design of the waveguide dielectric rod array antennas for shaping the flat-toped element radiation pattern for 7 channel receivers for HAPS. The calculated element radiation patterns of dielectric rods with the different permittivity are compared. The designed antenna will be used for generating multibeam radiation pattern by means of digital beamformer and is a simplified prototype of more complicated multielement APAA for the stratospheric communication system

References

[1] ITU-R, Resolution 122 (WRC-2000), Use of the bands 47.2-47.5 GHz and 47.9-48.2 GHz by high altitude platform stations (HAPS) in the fixed service and by other services and the potential use of bands in the range 18-32 GHz by HAPS in the fixed service, The World Radiocommunication Conference 2000.

[2] S. P. Skobelev, "Methods and Results of Design Synthesis of Antenna arrays with Flat-topped Sector with Partial Patterns," *IEEE International symposium of Phased Array Systems and Technology, pp.* 438-443, Oct 1996.