COMPACT MULTIBEAM REFLECTOR ANTENNA FOR SATELLITE TV SIGNAL RECEIVING

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Abstract

A design concept of a compact multibeam reflector antenna for satellite TV signal receiving is proposed. Different reflector shapes are discussed. Results of trial calculation are presented.

Keywords: Multibeam antennas, reflector antennas, horn feeds, satellite antennas, satellite communications, satellite links.

1. INTRODUCTION

There are many different concepts of reflector antennas for satellite TV receiving. Mainly, a single parabolic reflector antenna is used for this purpose. Its main advantages are simplicity and cheapness. However, such construction does not allow getting good results when addi-tional customer requirements are imposed, such as multibeam property and compactness.

2. MULTIBEAM ANTENNAS

Recently, a new TV signal standard with large information capacity has got wide spread occur-rence, namely: HD (high definition) standard. In this connection, the number of channels being translated from a satellite in the same frequency band has decreased. The assumption that the number of received channels stays the same brings to the necessity of simultaneous receiving signals from several satellites at the same TV set. If there is enough resources (cash means and free space) it can be done by increasing of an-tennas number correspondingly to number of satellites (or main lobes in given directions). This leads to increasing of antenna system size and decreasing of total antenna efficiency re-counting to a single beam. Thus, there arises a design technical problem for a multibeam an-tenna, i.e. antenna for simultaneous and inde-pendent receiving on the same aperture of sig-nals coming from different directions.

Multibeam property of reflector antennas my be achieved by different means. For instance, it is possible to place several feeds near the focal point of a single reflector parabolic antenna. However, antenna characteristics of such system leave much to be desired. Much more promising for this purpose is the choice of a dual reflector design. Placing in the main reflector aperture several feeds [1, 2] or several pairs “feed - subreflector” [3] it is possible to get a multibeam reception antenna system with improved charac-teristics by adjusting geometric parameters of main reflector and subreflectors.

The choice of single reflector or dual reflector system depends on antenna specification. If it is required to provide multibeam property in continuous sector of angles then subreflector for this sector should be made as a single whole. However, in this case side part of main reflector is being used inefficiently and thus pattern problems may arise. If it is needed to provide multibeam property at several given angles then it is possible to use several subreflectors.

3. COMPACT ANTENNAS

Another line of reflector antennas development is compactness. Big hopes about stripline antennas application did not pay its way due to the several reasons: narrow frequency band, complicated design in case of two polarizations, etc. There exist compact dual reflector antenna systems [3, 4] making it possible to get ratio H/D~0.25 [5], where H is antenna size in axial direction, D is maximal size of antenna aperture. Shape of antenna main reflector and subreflector generatrices can be taken either parabolic and elliptic correspondingly or made corresponding to special equations described in [6, 7].

Main lobe tilting for antenna system [3] in case of feed movement relative to fixed main reflector and subreflector were investigated in [8]. They turned to be insignificant. However, it can be shown that in case of joint movement of feed and subreflector relatively fixed main reflector scanning properties improve.

4. COMPACT MULTIBEAM ANTENNA

From the above said it follows that the design with main reflector and several pairs “feed - subreflector” is a perspective design for a compact multibeam reflector antenna with fixed beam angles. Each subreflector can have the same shape as the subreflector of a single beam compact dual reflector antenna. In particular, field central part of each feed goes to the side part of main reflector and field side part of each feed goes to the central part of main reflector (so called “beam trace inversion” occurs). Thus, in antenna system a line of auxiliary focus occurs. This line can be closed or opened, circular or of other shape, corresponding to analytical or non-analytical function.

5. ANTENNA SYNTHESIS

Synthesis of an antenna system (or its separate parts) represents a numerical procedure. Reflector surface is defined by generatrix shape and generatrix space trajectory. Generatrix space trajectory represents either a close or an open curve. Commonly known combination of generatrices is parabola and hyperbola or ellipse but there can be curves of different shape as well. For instance, in [9] an algorithm presented that can be used for calculation of generatrices shape in accordance with preset field distribution in antenna aperture. Taking into account given antenna specification one can use optimization procedure in order to find geometrical configuration providing maximal antenna aperture efficiency.

6. PRELIMINARY RESULTS

Preliminary calculations have shown possibility of compact multibeam reflector antenna design. Firstly, antenna specification is formulated. Main parameters are number of beams, their directions and gains for every partial pattern. Additional parameter is compactness (i.e H/D ratio where H is axial antenna dimension, D is lateral antenna dimension). Then a class of mathematical surfaces for antenna design should be chosen. Parameters describing the surfaces enter into the function for antenna efficiency calculation. Using optimization algorithm one can find optimal geometrical parameters combination.

In order to fulfill given antenna specification on beam directions one can firstly make lateral displacement of the pair “feed - subreflector” (Fig. 1) and then make additional axial tilts (Fig. 2) of feed and subreflector in order to improve antenna efficiency and feeds arrangement.

7. SUBREFLECTORS CUTTING

As it was mentioned above, the design with main reflector and several pairs “feed - subreflector” has good

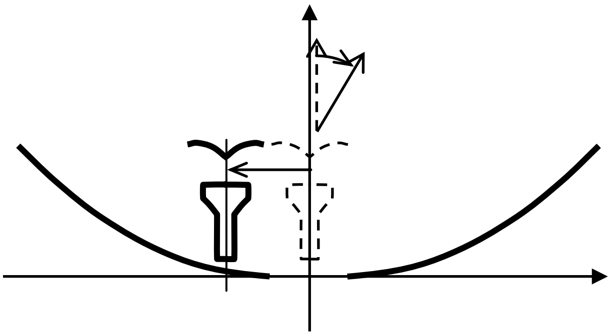

Fig. 1. Illustration of beam tilt dependence on the pair “feed - subreflector” position.

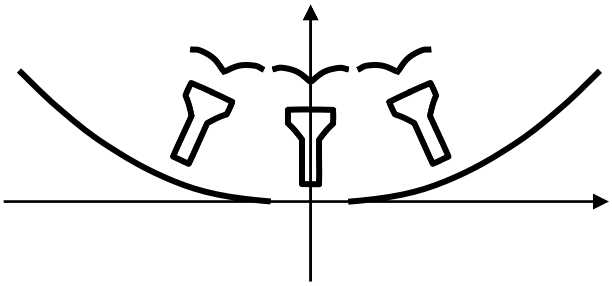

Fig. 2. Design with three pairs “feed - subreflector” disposed in antenna aperture.

perspectives for multibeam antenna design. Preliminary design of this version has shown that for a range of antenna specifications some parts of subreflector surfaces may occupy the same space, i.e. overlap. To solve this problem one can cut side parts of subreflectors (Fig. 3,4). In this case central part of subreflector will stay untouched and will still give its contribution to illumination of the main reflector side part. This is one more advantage of said antenna design.

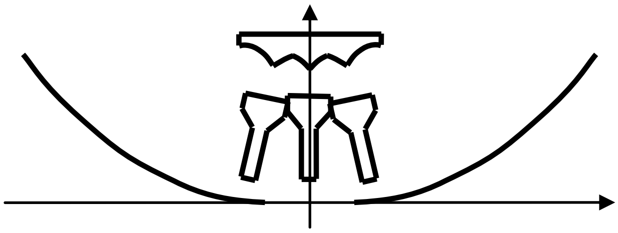

Fig. 3. Design with cut subreflectors, side view.

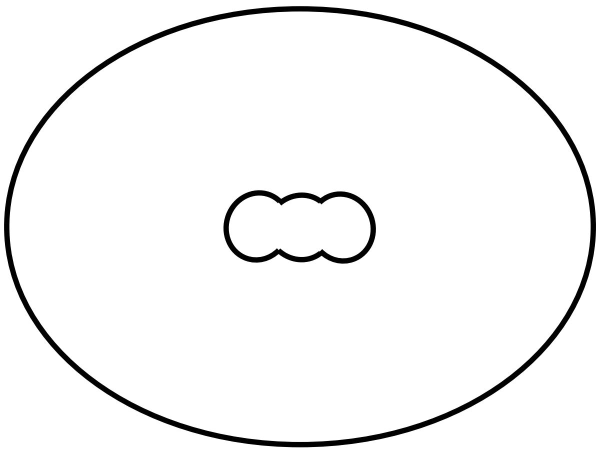

Fig. 4. Design with cut subreflectors, front view.

Preliminary design has been made for a standard corrugated horn of 5.4 cm diameter and beam tilting for three angles -9, 0, 9 grad relative to boresight direction. The results of pattern calculation are shown on the Fig. 5. Antenna aperture efficiency for central and side beams turned out to be about 0.5.

8. Conclusions

This paper presents design concept for a compact multibeam reflector antenna for satellite TV signal receiving. Antenna specification comprises feed type, number and directions of main lobes, gains for each main lobe. Shape and size of main reflector and subreflectors together with their mutual positioning are taken in order to reach maximal values for antenna efficiency together with satisfaction of given antenna specification and additional requirements for compactness (minimal H/D ratio).

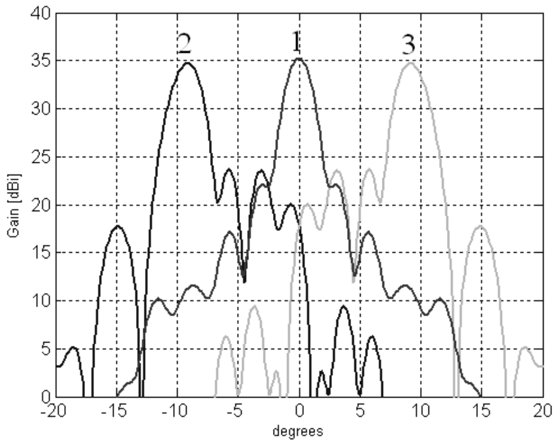

Fig. 5. Sample antenna design calculation results.

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