FINE POINTING SYSTEM FOR MULTIBEAM ANTENNAS

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Introduction

Sometimes a fine pointing or tracking system must be designed for multibeam antennas; if the cluster configuration is previously fixed and a beacon signal must be used, the design of a static split for tracking purposes has some difficulties. This paper presents the design of such a system with an application to a communication problem.

The Multibeam Antenna of the ATLANTIS Project (this study is a part of it) consists of a reflector fed by a set of horns and it must be able to cover separately Spain and Portugal and their corresponding islands (Canary islands and Azores and Madeira islands) for Satellite TV broadcasting purposes, working at 11.7-12.5 GHz. Due to the need to have a better antenna pointing performance that the one provided by a passive system mounted on the usual spacecrafts a RF Sensing Subsystem is required. The objective of this subsystem is to improve the antenna pointing in order to take advantage of the multifeed design that allows to contour beams and/or to have separated beams from the same antenna.

The pointing system

Taking into account that the cluster cannot be modified, some solutions to get a fine pointing were considered, all of them being monopulse systems because it is the only one allowing the best accuracy in the pointing [1]. The main difficulties arise from the geometrical configuration, because the cluster of the Mainland of Spain lobe has an hexagonal symmetry. Fig. 1 shows an overall view of the feed cluster, and fig. 2 the central part of it. The only solution to get a monopulse system in this geometry is to use four horns in a rhombic configuration [2].

Two ways to get the two difference signals were studied (fig. 3): The first one (3a) uses the four horns to get the two difference signals δ_θ and δ_ϕ, and also the four horns to get the sum, Σ , signal. Unluckily in the possible band, (10-11.7 GHz or 12.5-15 GHz), δ_θ and δ_ϕ are null simultaneously not only in a point but over a line; so, this way is not useful to get a pointing system. The second one (3b) uses only two horns in order to obtain each one of the δ_θ and δ_ϕ signals. Since the distance between the horns is different from one to another pair (65.99mm and 38.1mm), the tracking functions will be also different. A study of these functions versus the frequency shows that the difference can be acceptable.

From these considerations the way selected is the last one, but an optimization of the difference between the tracking functions must be carried out in order to determine the optimum frequency. Finally the selected frequency for the RF Sensing function was 11.5 GHz. In figures 4a and 4b both tracking functions are shown, and it can be seen that the tracking slope are different for azimuth (2.50 $V/V/^{\circ}$) and elevation (3.46 $V/V/^{\circ}$). The pointing range is better than $\pm 0.5^{\circ}$ for both axes.

The comparator

The RF Sensing Comparator is not the usual one consisting of four hybrid junctions, but it is formed by only three Magic Tees, one of them having a very particular configuration. The two MT that provide the difference signals are used in an unusual way, the sum signal is obtained in the "E" port and the difference one in the "H" port; the phase balance in all the devices presents some difficulties due to the difference of lengths of the paths at the input of each MT. The difference of phase has been solved using a piece of waveguide different than the one used in the system (WG-17); the width and length of this piece have been calculated by a mode matching method [3]. A very little load (7.5mm length) has been also designed.

An overall view of the comparator can be seen in figure 5. The dimensions of the whole comparator are: length 101.4mm, width 82.2mm and height 72.6mm, what is a very compact device.

Conclusions

A study of the possibilities of a fine pointing system for a multibeam antennas has been made, which has led to a monopulse system using a rhombic array of horns.

The corresponding comparator has been designed and realized in a very compact device, whose main characteristics are summarized next:

Pointing accuracy	$<0.05^{\circ}$	in azimuth
	$<0.05^{\circ}$	in elevation
Tracking slope	2.50 V/V/$^{\circ}$	in azimuth
	3.46 V/V/$^{\circ}$	in elevation

VSWR $\leqslant 1.2$ (for all the 7 ports)
Amplitude balance $\leqslant 0.2$ dB
Phase " $\leqslant 2.9^{\circ}$

Acknowledgements

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References

[1] M.I. Skolnik, "Radar Handbook", McGraw Hill, 1970.

[2] "RF Sensing and Beam Pointing for High Gain Reflector Antennas". Final Report. ESTEC Contract No. 3985/79/NL(DG).

[3] J.L. Fontecha, "Contribución al estudio de transiciones abruptas en guias de ondas y su extensión a problemas de radiación", Doctoral Disertation, Madrid 1986.

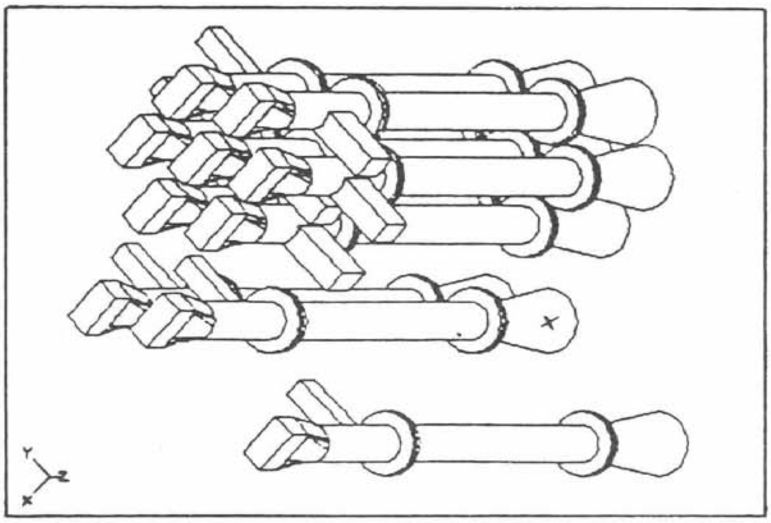


Fig. 1

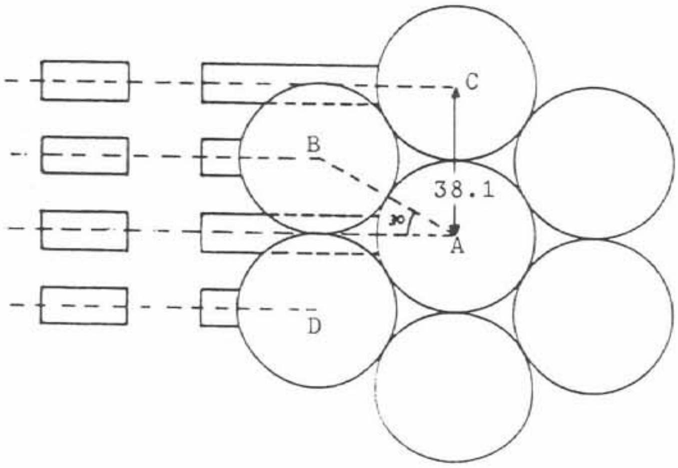


Fig. 2

Fig. 3a

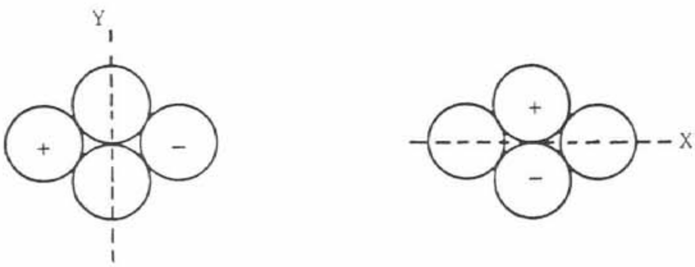
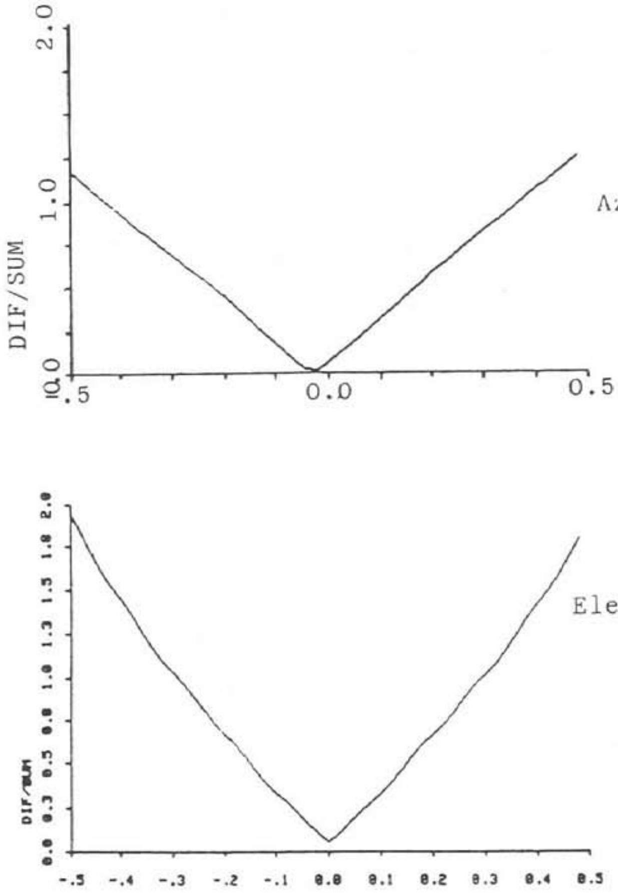


Fig. 3b



Azimuth Monopulse Function
(a)

Elevation Monopulse Function
(b)

Fig. 4

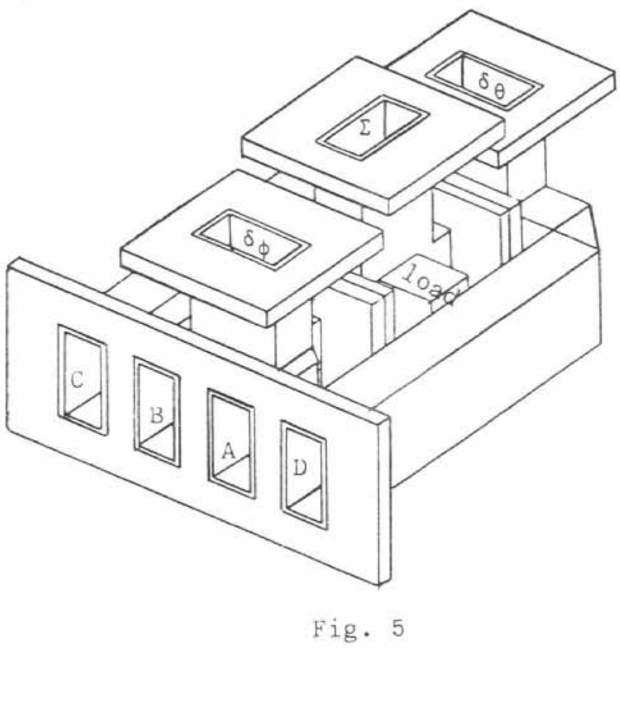


Fig. 5