"VERY SHORT AND EFFICIENT FEEDER DESIGN FROM MONOMODE WAVEGUIDE"

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ABSTRACT

In this paper, we present an original and short corrugated horn antenna profile to obtain the HE_{11} corrugated circular waveguide mode exciting with a pure TE_{11} monomode smooth circular waveguide mode. We will obtain a far field pattern with a very low crosspolarization, high symmetry and very low sidelobes in a wide frequency band.

The proposed corrugated antenna has a longitudinal section composed of two hyperbolic profiles in series, one concave and the other convex united at a point, such that the derivative is continuous. Superimposed there is an additional tapering of the corrugation depth that goes from $\lambda/2$ at taper input to $\lambda/4$ within the first hyperbola.

This original synthesis procedure has been successfully tested by computational simulation. The calculation method has been validated with experimental results of other authors.

INTRODUCTION

High-performance microwave satellite communications, radar and remote-sensing systems often use a reflector antenna as end component of the transmitter and receiver front ends. A reflector antenna consists of two parts: the first one is the reflector itself and the second one is the horn at the focus. The horn antenna is a crucial component because it must match the microwave signal from the source to the reflector antenna with the minimum losses and the maximum efficiency. There are a variety of possible designs for this horn, but the preferred choice at the present for high-performance systems is the corrugated horn[1].

At first, the relative high mass and volume deterred users but in the middle 1980s their electrical advantages strongly outweighed the disadvantages, besides, recently new making technics (electroforming) have appeared.

The HE_{11} mode is the fundamental mode of circular corrugated waveguide. This mode is called quasi-gaussian mode due to its similarity with a fundamental gaussian beam. Consequently, the horn antenna far field pattern will have low sidelobes, high symmetry and low crosspolarization.

PROPOSED PROFILE

As we have already commented, at the output of the horn antenna we want a pure HE_{11} mode. There are differents ways to generate it: coupling engineering technique using waveguide steps or appropriate linear tapers to obtain aprox. 85% of TE_{11} mode and 15% of TM_{11} mode, surface impedance adapters (from λ/2 depth corrugation to λ/4), etc.

In our case, we combine two of these techniques. We start with a monomode smooth circular waveguide (TE_{11} mode), and use a surface impedance adapter at the beginning, superimposed to two hyperbolas defined with the formula[2],

$$r(z) = R_{in}\sqrt{1+\left(\frac{z}{\alpha\cdot k\cdot R_{in}^2}\right)^2}$$

$$f(z) = \begin{cases} r(z) & z < L/2 \\ -r(L-z) + 2\cdot r(L/2) & z \geq L/2 \end{cases}$$

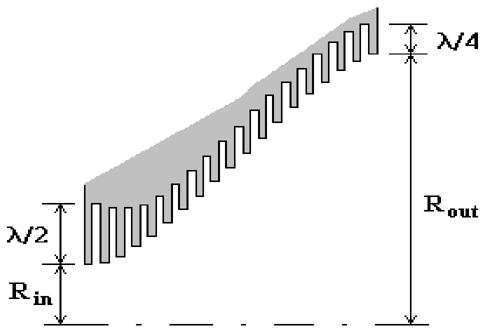

Figure 1: The proposed horn antenna profile.

α being a value approximately between 1.2 and 1.4 which controls the horn antenna slope, *L* the total length which is calculated to achieve the correct output radius (between 0.7λ and 0.8λ) to obtain approximately the HE_{11} mode. The α and the output radius values can be changed slightly from their original values, depending on our particular application.

Another important value is the length of the surface impedance adapter, which must be chosen adequately to obtain a high purity HE_{11} mode.

NUMERICAL METHOD

The used numerical method to obtain the component features is the well-known "Mode Matching and Scattering Matrix" method. Also, to get the far field radiation pattern we have used the equations defined in [3] and the "Moment Methods".

RESULTS

Here, we show a horn antenna working at 8GHz, although we can use it for any frequency. The input mode is the TE_{11} in a monomode smooth circular waveguide.

To start with, the input radius is equal to 22.032mm and the output radius 30.528mm (0.8λ) in a total length of 137.5mm. The corrugation period is λ/3 with a duty cycle of 50%. It is important to remember, the electrical property of the corrugated antenna changes with the parameters of the corrugation: period, depth and duty cycle.

In this design we have worked with a length of the surface impedance adapter equal to 28 mm and an α value of 1.31.

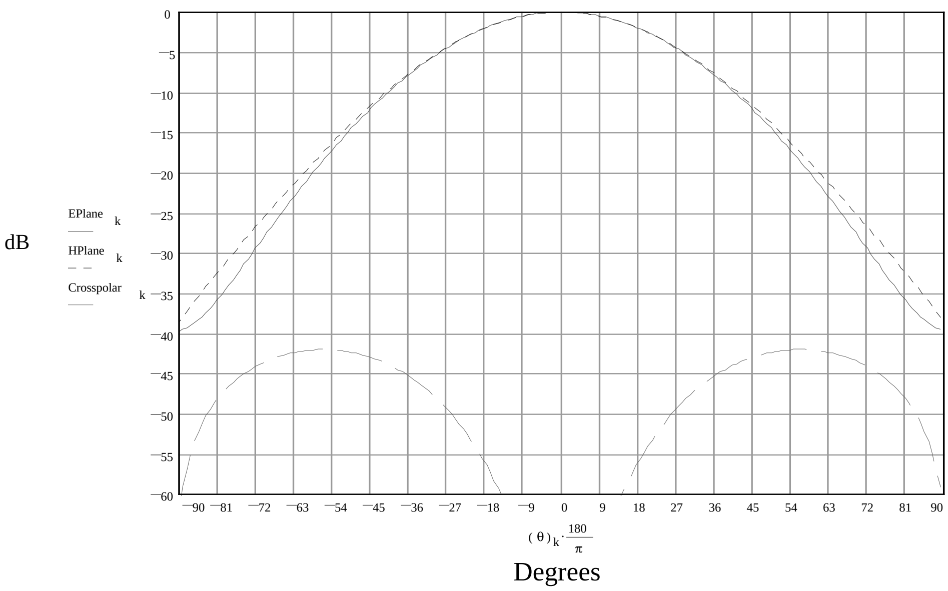

Figure 2.- Far field radiation pattern.

In the figure 2, the far field radiation pattern is shown. It is easy to see the good radiation features, high symmetry, without sidelobes and with very low crosspolarization(<40dB at 58 degrees).

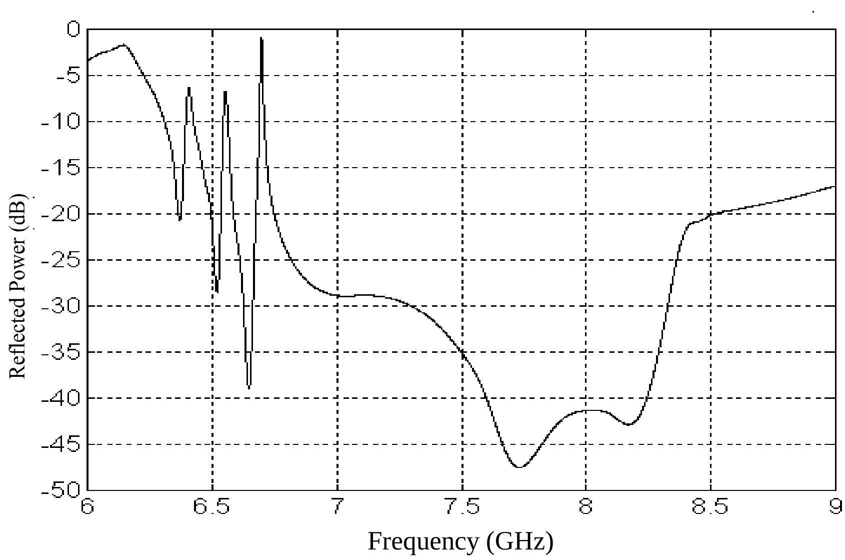

Figure 3.- Reflected power frequency response.

The corrugated structures are characterized for being broadband; we can see, in the figure 3, the proposed horn antenna has a good bandwidth.

If we want to use this horn antenna as feeder in a parabolic reflector configuration, we must define another important characteristics like the gain and efficiency.

In this case the feed gain is 12.7 dB and the total efficiency η[4] is,

$$\eta = \eta_I \; \eta_S \; \eta_P \; \eta_x = 0.79.$$

where η_I, η_S, η_P, η_x, are the illumination, spillover, phase error and crosspolarization efficiency respectively. This efficiency has been obtained using a feed angle of 41 degrees.

CONCLUSIONS

We have presented an original and short corrugated horn antenna which has very good far field radiation characteristics with low sidelobes, high symmetry and low crosspolarization. Besides the profile is valid for any working frequency, and can be used in many applications like satellite communications, testing in low power, radar,....

There are two important parameters in the profile definition, the output radius and the α value, which can be chosen according to the necessities of our particular application.

Besides, we have seen that this horn antenna is broadband and has a good gain and efficiency features.

Finally, in this work, we have presented a brief summary. Nevertheless, many designs have been analyzed, changing parameters like the frequencies, the α values, lengths, corrugation period, the duty cycle,... [5],[6].

REFERENCES

[1] Olver, A. D., Clarricoats, P.J.B., Kishk, A.A. and Shafai, L. “Microwave Horns and Feeds” Chap. 8 and 9, IEE electromagnetics waves series 39. 1994.

[2] Spanish Patent nºP96-01636, “Mode Converter: From smooth circular waveguide TE_{11} mode to corrugated waveguide HE_{11} mode”.

[3] Garin, P., Rebuffi, L. et al., “Circular Waveguide: Reference Formulas for Propagation and Radiation”. XIV International Conference on Infrared and Millimeter Waves. Würzburg 1989.

[4] Rudge, A.W., Milne, K., Olver, A.D. and Knight, P. “The handbook of Antenna Design”, IEE Electromagnetic Waves Series, Volumes 1 and 2, 1986: Peter Peregrinus Ltd.

[5] Gonzalo, R., Del Río, C., Teniente, J. and Sorolla, M. “Optimal horn antenna design to excite high purity gaussian beam using overmoded waveguides”. Digest Int. Conf. On Infrared and Millimeter Waves, Berlin, Germany, July 1996.

[6] Del Río, C., Gonzalo, R. and Sorolla, M., “High Purity Gaussian Beam Excitation by Optimal Horn Antenna”. Proceedings of ISAP’96, pp. 1133-1136, CHIBA, JAPAN.