“OPTIMAL HORN ANTENNA DESIGN TO EXCITE HIGH PURITY GAUSSIAN BEAM USING OVERMODED WAVEGUIDES”

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Abstract
In this paper, we present an original and optimal multimode horn antenna design to excite the fundamental Gaussian beam from an overmoded waveguide. In particular, we focus the study in overmoded circular corrugated waveguide.The horn antenna design considered here, improves the gaussian conversion efficiency, the cross-polarisation and the sidelobes level of some good mixture (aprox. 85% of TE_{11} and 15% of TM_{11}).

1.- Introduccion

High-performance microwave communication, radar, remote-sensing and plasma heating systems often use an antenna horn as transmitter. This horn is a key component. It must match the microwave power from the source to the free space with minimum loss of energy and maximum efficiency. There are several designs for this horn, but for high performance-systems the best one is the corrugated horn[1]. Here, we present an original profile for a corrugated horn which improves gaussian beam behaviour, simetry, sidelobes, crosspolarization,...

2.- Gaussian Modes and Waveguide Modes

As it was shown in [2], there are solutions of the paraxial Helmholtz equation where the field distribution has high correlation with some waveguide modes. The clearest example is the fundamental gaussian beam ψ_0^0, which matches closely the circular corrugated waveguide HE_{11} mode.
The HE_{11} or quasi-gaussian beam is formed approximately by a 85 % of TE_{11} and a 15% of TM_{11} with the proper phases but there are other mode mixtures which produce a ψ_0^0 mode, obtained by correlation of the waveguide modes (R) with the gaussian structure (ω_o) (see figure 1).

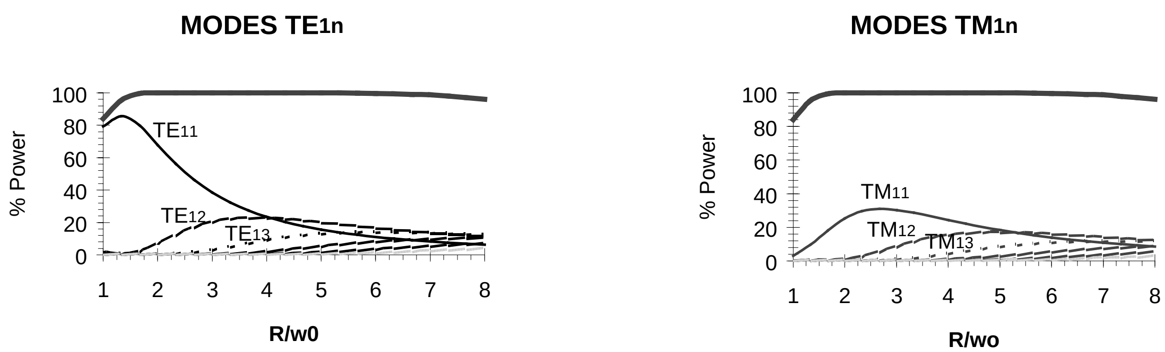


Figure 1 : Mode mixture of TE_{1n} (a) and TM_{1n} (b) necesary to get a fundamental gaussian beam.

These plots are independent of the frequency, so for a given value for R and ω_o (beam waist) the same mode mixtures to get a fundamental gaussian beam are always defined. Besides, this mixture is totally independent of the beam waist position, only a variation in the mode phases to obtain the gaussian expansion can be expected.

3.- Corrugated Horn Antennas for the Gaussian Beam.

The theoretical mode mixtures to obtain the fundamental gaussian beam are known, so we are going to design a device which produce them.
Keeping up with the gaussian beam expansion it seems natural the following profile:

$$r(z) = r_0 \cdot \sqrt{1 + \left| \frac{\lambda z}{\pi \omega_0^2} \right|^2} \qquad (1)$$

where r_o is the input radius, λ is the wavelenght and ω_o is the beam waist for the desired fundamental gaussian beam.
In the picture 2,the profile and the corrugation depth of this horn are presented, where $p \le \lambda / 3$, $d = \lambda / 4$ and $w = p / 2$.

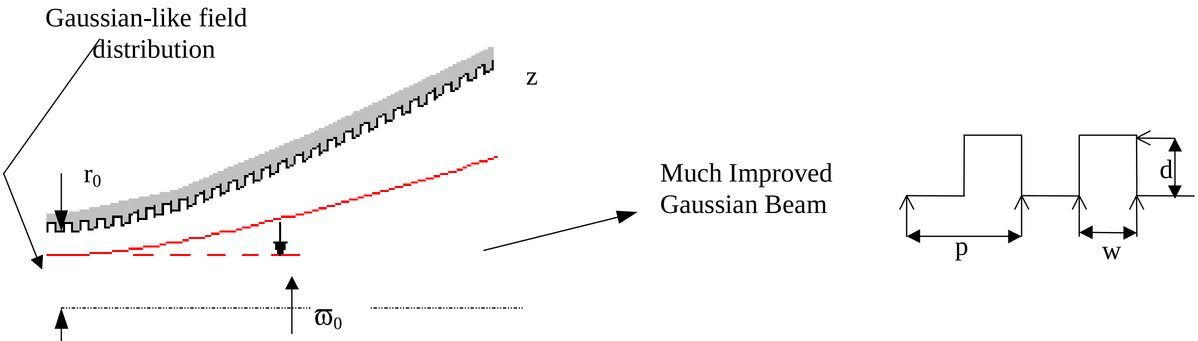
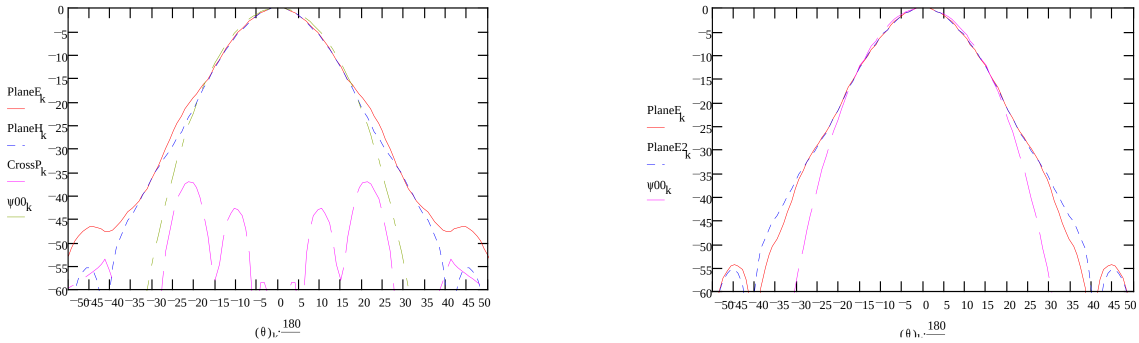


Figure 2 : Optimal horn antenna and corrugation

The antenna input must be a relatively good mode mixture (between 80-20 and 90-10 of TE_{11} and $TM_{11}$with a phase difference of 0º to 15º) to get a very good fundamental gaussian beam with this horn. In the picture 3 it is possible to see the obtained results.



(a) (b)

Figure 3 : (a) Far field pattern E and H planes of the mode mixture that is obtained at the output horn of L=100 mm, crosspolarization and desired gaussian beam ψ_0^0.(b) Far field pattern of the mode mixture for different horn lenghts (L_1=80mm and L_2=100mm) with r_o=19.75mm and ω_o=14.22mm, together with the real gaussian beam.

We can see, in figure 3(a), the improvements: high pattern symmetry of E and H planes, high efficience with a gaussian beam ψ_0^0 (>99%), low sidelobes, low crosspolarization, ...These calculations have been done for different frequencies obtaining the same mode mixture as was shown in figure 1.
On the other hand, in figure 3(b) the gaussian behaviour of these mode mixtures is demostrated because we have two different mode mixtures with output radius of 36.878mm and 43.645mm, that correspond to the mode mixture at the points 2.6 and 3.07 of the figure 1, and we get the same good far field pattern.

4.- References

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

[2] Del Río, C., Gonzalo, R., Sorolla, M., Möbius, A. y Thumm, M. “ High Order Mode Beam Waveguide for Technological Medium Power Millimeter Wave Aplications”. 20th International Conference on Infrared and Millimeter Waves. Conference Digest.1995, pp. 519-520.