

“GENERATION OF THE HE₁₁ MODE FROM MONOMODE SMOOTH CIRCULAR WAVEGUIDE”

Ramón Gonzalo, Carlos del Río and Mario Sorolla
Microwave and Millimeter Group. Public University of Navarra
Campus Arrosadía s/n. E-31006 Pamplona, Spain
Phone: 948 169326 Fax.: 948 169169 e.m.: carlos@upna.es

ABSTRACT

In this paper, we present an original taper design to obtain the HE₁₁ corrugated circular waveguide mode exciting with a pure TE₁₁ monomode smooth circular waveguide mode.

The proposed corrugated taper 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 by experimental results of other authors.

INTRODUCTION

In order to measure or characterise a lot of high power millimetre components or systems, a Gunn diode excitation from a monomode waveguide for low power test is required. Normally, the diode Gunn is built in a rectangular waveguide exciting the TE₁₀ rectangular waveguide mode, and with a conventional converter, this mode can be easily converted to the TE₁₁ circular waveguide mode.

The low power tests must reproduce as well as possible the real working conditions in full power operation. Usually, the components under test needs some special mode as input, then we will need additional mode converters, which are previously characterised, to get this mode.

To test quasi-optical transmission lines, a converter from TE₁₁ monomode waveguide mode to HE₁₁ corrugated waveguide mode, can be very useful. In this paper, an optimum profile to design this taper-converter is presented. The calculation method has been tested with experimental results of others authors [1].

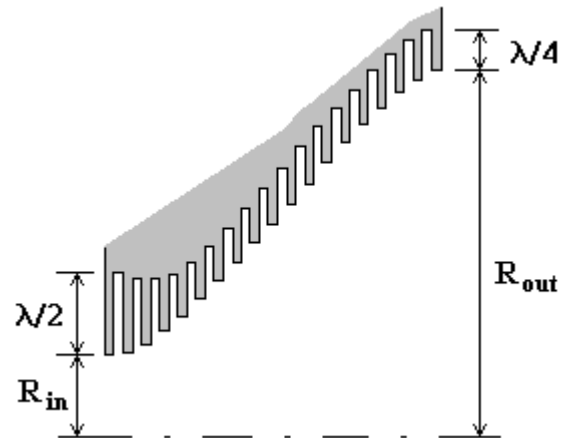
TAPER-CONVERTER PROFILE

There are different ways to generate a HE₁₁ corrugated waveguide mode: coupling engineering using waveguide steps or appropriate linear tapers to obtain aprox. 85% of TE₁₁ mode and 15% of TM₁₁ mode, surface impedance adapters (from $\lambda/2$ depth corrugation to $\lambda/4$), etc.

In our case, we combine two of these techniques, we start with the TE₁₁ in monomode smooth waveguide, and use a surface impedance adapter at the beginning, superimposed to two hyperbolas defined with the formula,

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

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



α being a value approximately of 1.3 which controls the taper slope, L the total length which is calculated to achieve the correct output radius (between 0.7λ and 0.8λ) to obtain approximately the mixture of 85% of TE_{11} and 15% of TM_{11} , the phase will be automatically adjusted. This means, there are a lot of possibilities, and we have to choose the best one for our particular application.

The length for the surface impedance adapter is determined such that the final radius just allows the propagation of the TM_{11} mode.

It is important to remind, that the HE_{11} mode composition changes with the parameters of the corrugation: period, depth and duty cycle. Then, it is very difficult to know, simply looking the output mixture if we are exciting or not an eigenmode of the corrugation waveguide. To show that we are exciting a pure eigen corrugated waveguide mode, one can add a straight corrugated waveguide, in order to see if the field structure keeps constant or not along the waveguide. Another possibility is to compare the far field pattern of the output mixture and the theoretical HE_{11} mode.

Nevertheless, this component can be used also as first step to get a fundamental gaussian beam, only adding an additional taper [2] to get the gaussian behaviour. In this case, the output of the first taper converter can not be necessarily a pure HE_{11} mode, because it is not the final output of the system[3].

RESULTS

Here, as application example, we present a taper-converter working at 8GHz, with an input radius of the monomode circular waveguide of 22.032 mm. and a output radius of 26.738 mm. in a total length converter of 100 mm., the corrugation period of $\lambda/3$ with a duty cycle of 50%; the length of the surface impedance adapter is of 28 mm.

The output mode mixture is:

MODE	% Power	Phase (°)
TE_{11}	86.7268	-86.2587
TM_{11}	13.0885	-77.6980

And, working at 53.2GHz., with an input radius of 2.096 mm., output radius of 4.651 mm., with a total length converter of 20 mm., an adapter length of 8.5 mm., and the same kind of corrugation, the output mixture is:

MODE	% Power	Phase (°)
TE_{11}	84.0915	-60.8162
TM_{11}	15.6544	-62.8080

In both cases the phase difference between TE_{11} and TM_{11} is close to zero, because of the chosen basis for the TE and TM modes. And also in both cases, the mixture along a straight corrugated waveguide keeps constant.

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] Gonzalo, R., Del Río, C. 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.
- [3] Sorolla, M., Del Río, C. and Gonzalo, R. "Optimized antenna system for low power testing of the quasioptical transmission line at TJ-II experiment". Digest Int. Conf. on Infrared and Millimeter Waves, Berlin, Germany, July 1996.