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CORRUGATED HORN ANTENNAS: A REVIEW

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Abstract

In this paper, basic review and design of the corrugated horn is presented. The dependence of radiation pattern of corrugated horn depends on many parameters, so design parameter are discussed and based on discussion the mode converter with variable depth slot is designed which shows good characteristics like return loss and pattern symmetry on given frequency range.

Introduction

One of the simplest and probably the most widely used microwave antenna is the horn antenna. The horn antenna is nothing more than a hollow pipe of different cross sections, which has been tapered (flared) to a larger opening. Horn antennas consist of a flaring metal waveguide shaped like a horn to direct radio waves in a beam. They are used as feeders (feed horns) for larger antenna structures such as parabolic antennas and as directive antennas for such devices. They are used as a feed element for large radio astronomy, satellite tracking and communication dishes. Its widespread applicability stems from its simplicity in construction, ease of excitation, versatility, large gain, and preferred overall performance. Horn antennas are popular in the microwave band (above 1 GHz). They provide high gain, low VSWR (with waveguide feeds), relatively wide bandwidth and they are not difficult to be made [9].

In the 1960s, the idea of corrugated horns was first considered by Kay [1], Simons and Kay [2] and Minnett and Thomas [3], [4]. This was due to the specific interest in achieving symmetric radiation patterns so that low-side lobe and high efficiency reflector antennas could be produced. It was also realised in the 1970s by Parini, Clarricoats, and Olver [5] that corrugated horns radiate very low levels of cross polarisation, which is essential for dual-polarisation operation or frequency re-use. This is the situation where two signal channels are transmitted on orthogonal polarisations at the same frequency, and no interaction takes place between the two channels. Therefore the channel capacity is doubled for a single antenna.
Corrugated horns supporting so-called hybrid modes have become well established as feeds for reflector antennas, and even as direct radiators. It is not difficult to trace the popularity of the corrugated horn, given the ability of certain hybrid modes to produce radiation patterns having extremely good beam symmetry with low cross-polarization levels,
a high beam efficiency with very low side lobes, and the potential for wide-bandwidth performance [7,8]**.** Why they are called "corrugated" is clear from the typical example of a horn shown in Figure1, where the inside wall is manufactured in a succession of slots and "teeth." The purpose of the corrugated surface is to provide the means to support the propagation of hybrid modes within the horn [6].

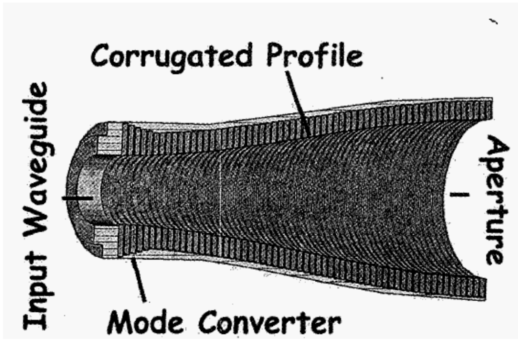

Figure l. A cut-away view of a typical corrugated horn [6].

Hybrid modes are basically a combination of TE and TM modes. For this combination to propagate as a single entity with a common propagating velocity, the horn or waveguide must have anisotropic surface-reactance properties: properties that are satisfied by the corrugated surface. It is worth pointing out that hybrid modes can also be supported by other means, such as waveguides or horns partially filled with dielectric. However, these alternative possibilities are outside the scope of this design note [6].
We begin with some practical considerations. The bandwidth of a horn is usually defined by the frequency range over which the horn is required to have a suitable beam width and beam symmetry for a return loss usually better than 15 to 18 dB, and with a cross polarization maximum better than -20to -25 dB. These values are typical, but many high-performance applications have much tighter specifications [6].
As illustrated in Figure 1, it is usual for the corrugated horn to be connected to a circular, smooth-walled, input waveguide. The fundamental mode of this guide is the TE11 mode, and there is the need for a so-called "mode converter" at the transition between the smooth-walled input waveguide and the body of the corrugated horn. This mode converter is designed ***to*** provide a smooth transition from the TE11 to the HE11 mode supported by the corrugated horn [6].

A. DESIGN PARAMETERS

First, we have the following four frequencies to aid in the design:
fmin: lowest operating frequency
fmax: highest operating frequency
f c:the center frequency
f o: the output frequency[6].

The other main parameters to consider are:

- Choice of the input radius
- Choice of the output radius
- Choice of the depths of the slots
- Choice of corrugation pitch and pitch-to-width ratio
- Choice of the mode converter
- Choice of horn length
- Choice of the corrugated-surface profile
- Phase-center position.[6]

Table 1: Corrugated-horn parameters [6]

Quantity	Symbol
Input Radius	ai
Output Radius	ao
Length	L
Total Number of Slots	N
Total Number of Slots in Mode Converter	NMC
Slot Pitch	P= L/N
Slot Width	W
Slot Pitch to Width Ratio	δ= w/p
Width of the slot teeth	(p-w) = (1- δ)p
Depth of jth slot	dj , where 1≤ j≤ N

Nominal Slot-Depth Calculation

The design of corrugations in a corrugated hom is very important as it provides good performance. One of the most important parameters is the depth of the slot along the length of the horn [6].

Mode Converter

Usually, the input waveguide is excited by a pure TE11 mode and a mode converter is required to do the TE11-to-He11, mode conversion over a specified number of slots. There are basically three types of mode converters. They are as follows:

i) variable-depth-slot mode converter for fmax<1.8 fmin (the most commonly used mode converter);
ii) ring-loaded-slot mode converter for fmax ≤ 2.4 fmin;
iii) variable-pitch-to-width-slot mode converter for fmax ≤ 2.05 fmin, (used occasionally by some horn designers)[6].

B. DESIGN OF CORRUGATED HORN

The geometry of the conical corrugated horn can be classified into four different sections for design purposes
The four regions of a corrugated horn are:

(1) The corrugated profile geometry of the horn that controls pattern symmetry and cross polar characteristics.
(2) The input waveguide region that controls the impedance match and mode conversion level at the throat.
(3) The aperture diameter and flare angle that controls the length of the horn.
(4) The flare section between the throat and aperture generated the higher order modes along the horn.

C. RESULT AND DISCUSSION

The geometry of the horn is shown in the figure 2 where the corrugated horn is designed at 12.46GHz with variable depth mode converter.

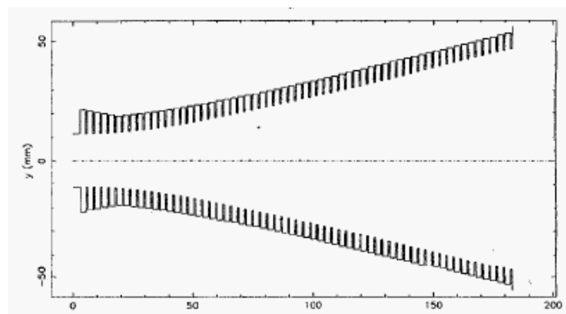

Figure 2: A corrugated horn with a variable-depth-slot mode converter [6].

The radiation pattern obtained is shown in figure 3. Here ,we get return loss at 29.13dB and cross polarisation level is below 45degrees.

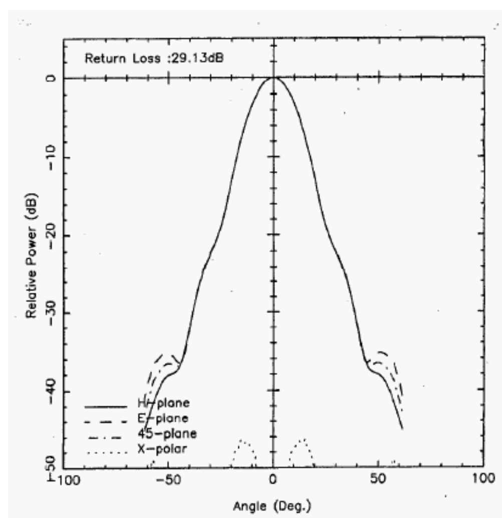

Figure 3: The radiation pattern of a corrugated horn at 12.46 GHz [6]

Design of corrugated horn with variable depth slot mode converter

The corrugated horn with variable depth slot mode converter is been designed at 12.46 GHz with 5 slots as shown in figure 4.

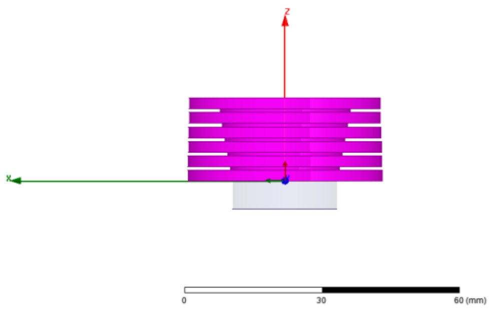

Figure 4: variable depth slot converter with 5 slots.

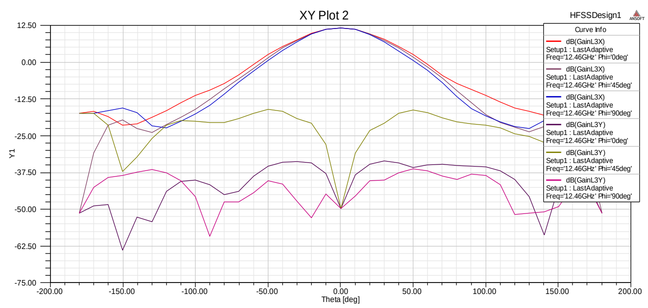

Figure 5: Rectangular plot of variable depth slot converter with 5 slots.

In the figure 5, the radiation pattern of the variable depth mode converter is shown. Here, we get cross polarisation at 45 degrees.

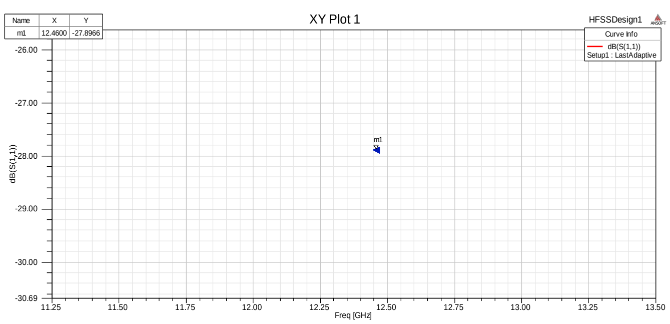

Figure 6: S Parameter plot of variable depth slot converter with 5 slots.

In the Figure 6, the S Parameter of the corrugated horn with variable depth slot mode converter is shown. Here, we get 27.89 dB return loss.

D.CONCLUSION

Review and design parameter of corrugated horn is presented in this paper. Based on the parameter a mode converter is design which shows good pattern symmetry with copolar gain of around 12 dB and cross polarization of around 27dB down to the main beam with the return loss of -27 dB at the design frequency.

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