Design of Planar Arrays with Groove Gap Waveguide Technology Implemented with Glide-Symmetric Holey Structures

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***Abstract*—The design of planar slot arrays in groove gap waveguide technology implemented by glide-symmetric holes is here discussed. Despite the advantages of using holes instead of pins in terms of manufacturing simplicity and cost, the larger size of the holes compared to pins needs to be considered when designing slot arrays without grating lobes. A solution of a slot array excited with the TE_{20} mode is presented, as well as an example with elements separated approximately one wavelength in free space (λ_0) but including corrugations to reduce the grating lobes.**

***Index Terms*—gap waveguide technology, glide symmetry, EBG structures.**

I. INTRODUCTION

The groove gap waveguide is a version of gap waveguide technology that replaces conventional rectangular waveguides [1]. The main advantage of this waveguide is the possibility of being manufactured in two pieces that do not need to be in contact afterwards. This allows the design of complex circuits by texturing one layer and using a simple metal lid on top. At the same time, all the advantages of rectangular waveguides in terms of low losses and power handling capability are preserved.

Recently the convenience of replacing pins by simpler structures like holes in groove gap waveguide has been proposed [2], [3]. To be rigorous, the holes need a glide-symmetric disposition in two planes to exhibit a wide bandgap in all directions in a plane. Once this is made, the width of the stopband is comparable with pins whilst the manufacturing is simplified . To drill holes is easier that milling pins and even more, the holes are much larger in size and periodicity when compared to the equivalent pins.

Designing planar arrays has been one of the envisioned applications of gap waveguide technology from its conception. In this work, we analyze the alternatives and limitations for designing single layer planar arrays based on a classical linear slot array theory. The chosen technology is a groove gap waveguide with glide-symmetric holes.

II. CONSIDERATIONS DESIGNING WAVEGUIDES AND HOLEY EBG STRUCTURES

A good design of a planar slot array based on using a slotted waveguide as a row of the array, starts by selecting a standard waveguide with dimensions as narrow as possible at the design frequency, to allow some space for the holes that are used as EBG structure, and separate the slotted waveguides.

We assume 25 GHz (λ_0=12 mm) as operation frequency. Consequently, we select a standard waveguide WR34 with dimensions 8.636 mm x 4.318 mm. In this case, there is less than 4 mm space to add the holey EBG keeping the inter-row distance below λ_0. One option is to design the array in a narrower waveguide as far as it is not in cutoff at 25 GHz and keeping the same height as WR34 to simplify transitions. If, for instance, we select a width dimension of 7.5 mm which gives a guided wavelength $\lambda_g = 20mm$ at 25 GHz and a cutoff frequency of 20 GHz, there will be 1 mm more space to allocate the EBG structure.

A glide-symmetric periodic structure is designed taking into account these constraints i.e., we select an inter-row distance of λ_0. As a consequence, there is a space of 4.5 mm to allocate the periodic holey EBG. We assume this value as periodicity for the EBG and we set the other dimensions as diameter of the holes d= 3 mm, depth of the holes h= 2 mm and a gap of 0.1 mm. The dispersion diagram of this periodic structure is presented in Fig. 1, which has a stopband covering 25 GHz.

A 9 element linear array is designed to create one row of the planar array. The design of the individual row is made including the lateral walls implemented with the holey structure. These rows will be separated from the contiguous ones by the EBG structure and a number of power dividers can be designed afterwards to feed the arrays. In Fig. 2a, the array made with two rows of slots is presented. As the inter-row distance was set as λ_0, the use of corrugations in between the rows is proposed to get a further improvement in the antenna gain as a consequence of the reduction of the grating lobes. This is illustrated in Fig. 2b. The difference in gain for both cases is 1.2 dB and the grating lobe level is reduced by 3 dB.

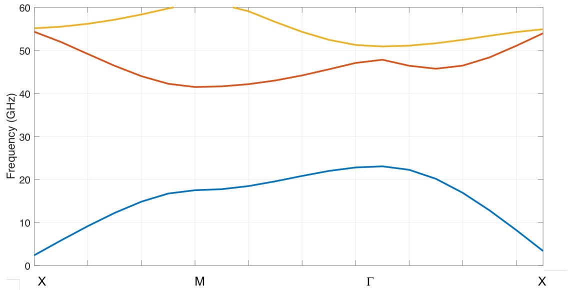

Fig. 1. Dispersion diagram of a holey glide-symmetric EBG structure with dimensions: period a = 4.5 mm, hole diameter d= 3 mm, depth of the holes h= 2 mm and an air gap of 0.1 mm.

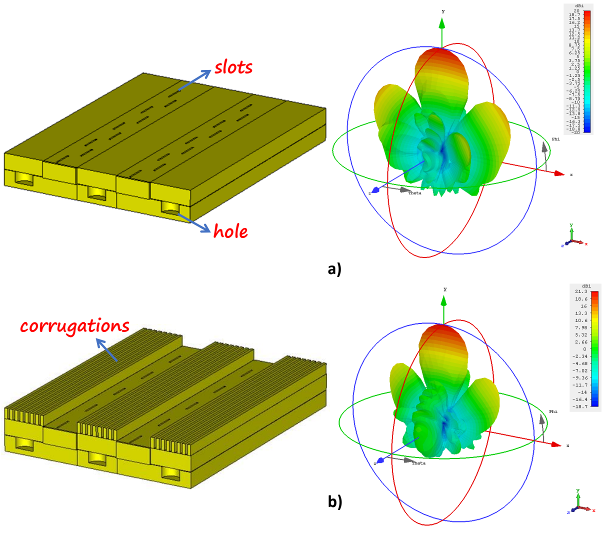

Fig. 2. a) Planar slotted array, b) Planar slotted array with corrugations.

III. SLOT ARRAY USING THE TE_{20} MODE AND A MODE CONVERTER

The design of a mode converter in groove gap waveguide technology with glide-symmetric holes was made following the methodology described in [4] as presented in [2].

The TE_{20} mode can be used to excite a planar slot array of 2 by N radiating elements. An example of such design is described in Fig. 3 for N=4, where the mode conversion can be clearly seen as a representation of the E-field. Simulation results show good matching with the TE_{10} input mode. The radiation pattern of the corresponding structure in Fig. 3 is presented in Fig. 4.

IV. CONCLUSION

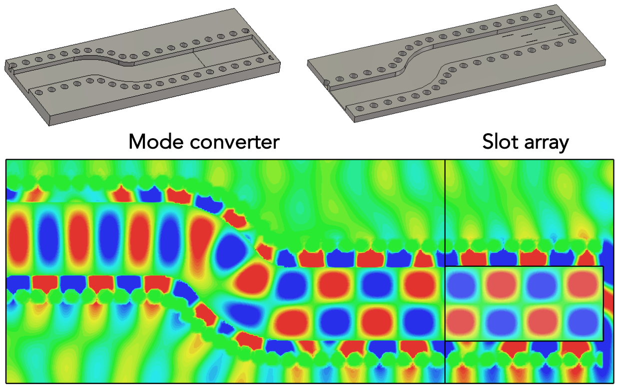

Fig. 3. E-field at 28 GHz and description of the geometry of the mode converter and the 2x4 slot array.

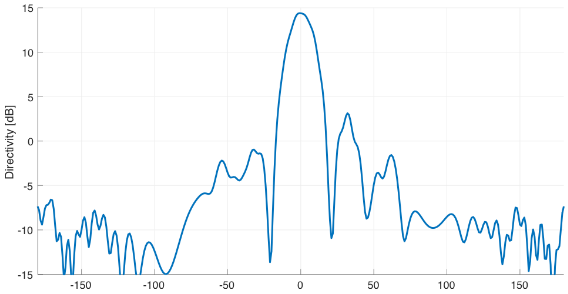

Fig. 4. H-plane radiation pattern of the structure in Fig. 3

The use of glide-symmetric EBG holes to design groove gap waveguide slot arrays is discussed in this paper. The holey unit cell size can compromise the inter-element distance of the rows of slots used in the planar slot arrays. We have explored two possible solutions to overcome this issue. One of them consists of limiting the size of the holes reducing the size of the stopband, as well as the use of corrugations in between the elements. Both techniques can be combined to improve the final result. Another proposed solution uses a mode converter from TE_{10} to TE_{20} to feed an array with two rows of slots.

ACKNOWLEDGMENT

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