A Stopband Filter Design using a 1-D Non-Periodic Defected Ground Structure

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***Abstract*-The one-dimensional (1-D) defected ground structure is used to control the cutoff frequency characteristic. In this paper three non-periodic filters are built, in order to show the versatility of the DGS. Five unit cells different in shape with the same attenuation pole frequency were combined in each filter. The frequency response is essentially the same as for the case of periodic filters with equal square unit cells.**

Keywords: **microstrip filters, defected ground structures**

I. INTRODUCTION

The novel microstrip Defected Ground Structure has been used by several authors to design filters [1], [2]. These filters have a number of attractive features, like a simple and small structure and deep stop-band. Until now, the unit cell of the defected ground structure were very often of square shape, which means that the only dimension to control is the side-length. Thus, the task of the designer was to find the dimension of the unit cell which provides an attenuation pole at the desired frequency. To build a higher order filter, only the connection of several equal lattices was required.

Nevertheless, the versatility of the DGS structures is really high. They provide us a great number of geometric configurations, allowing us to design our circuits according to possible space requirements. It will be proved that the frequency response remains practically unchanged although we combine different unit cell shapes in one particular filter design. This could be summarized in that the only important parameter, from the designer point of view, is the resonance frequency of each unit cell.

Another important conclusion of this paper is that the resonant frequency of a unit cell is not defined by its area but by its perimeter.

In order to show these two conclusions several prototypes of a five-order rejecting band filter have been designed, fabricated and measured, using five lattices different in shape: one square lattice, two rectangular and two circular.

As the behaviour of these DGS at the resonant frequency is just a short-circuit of the transmission line, the distance between cells is not so important as one could expect when designing filters based on a PBG philosophy.

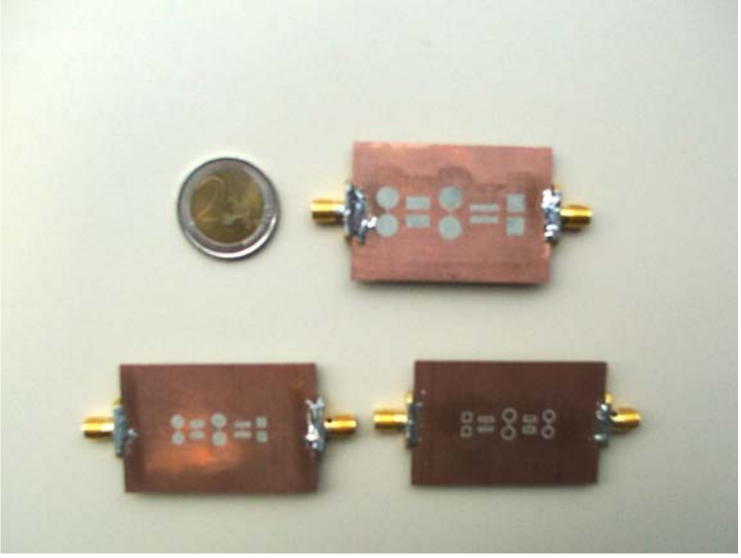

Fig. 1.- Picture of the three stop-band filter prototypes.

II. DGS FILTER CELLS CONFIGURATION

Two filters have been built at 5 GHz and 7.5 GHz, according to the attenuation pole location of [2]. In addition, a third filter at 7.5 GHz was fabricated with the same external dimensions as the previous one, but leaving some conductor inside the substrate holes. It will be proved that the frequency response remains despite the etched area is greatly decreased. Although the design method is different, for comparison purposes, the goals are the same as in [2], and the results will also be the same ones.

Fig. 1 shows a picture of the three built prototypes where the different element shapes etched on the ground metallic plane can be seen. Basically they consist on two etched holes of different geometrical shapes connected with a thin slot perpendicular to the transmission line. The line width is chosen to be 1.2 mm with a dielectric constant of 10.2 substrate which corresponds approximately with a characteristic impedance of 50 Ω.

The idea is to find five different cells which are tuned at the same frequency to be connected in series to generate a five order stop-band filter. Three of them are rectangular and two are circular. In the rectangular cases, we choose a square shape ($a=b$) with a connecting slot width or a gap distance $g=0.2$ *mm* and design two more varying a (side-length in the parallel direction of the transmission line) and b (side-length in the perpendicular direction of the transmission line) keeping the perimeter constant. For these filters $a>b$ is kept because thereby the resonance frequency is more stable. As in the circular lattices the perimeter can not be changed without changing the circle diameter (a), we must also change the gap distance; $g=0.4$ and *0.6 mm* respectively.

We restrict ourselves a maxim precision of 0.2 mm to show the toughness of these filters with respect to the manufacture process. This implies that the pole location of each filter is not exactly the same, but this is not a great problem when they are all connected. To achieve this is indeed only a matter of optimisation, and it brings not much benefit. All the design parameters are collected in table 1.

Cell position	Lattice shape	DGS lattice dimensions			Attenuation pole location, f_0 (GHz)
		g (mm)	a (mm)	b (mm)	
1	square	0.2	4.6	4.6	5.010
			2.6	2.6	7.552
2	rectangular	0.2	7.4	1.8	5.063
			4.2	1.4*	7.458
3	circular	0.6	6.0	-	5.031
			3.6	-	7.375
4	rectangular	0.2	6.0	3.2	5.042
			3.4	2.0*	7.510
5	circular	0.4	5.6	-	5.031
			3.2	-	7.594

Table 1.- List of the dimensions of all the unit cells used in the filter prototypes. NOTE: In the marked cases (*) the perimeter is bigger to let b also be bigger. This corrections are needed at high frequencies.

A third filter is analysed in which the etched elements are not full, i. e., they are filled with conductor again, and what is purely etched is the perimeter of the previous cells. This is done to make clear that what really rules the operation of the filter is the perimeter of the elements. The distances between them are chosen to be about 2 mm between neighbour elements to avoid mutual coupling effects.

III. MEASUREMENTS AND RESULTS

The circuits were fabricated using ROGERS RO3010, with 1.27 mm thick and dielectric constant ε_r of 10.2. Fig. 2,3 and 4 show the measurements of the three filters. As it can be seen, there a reasonable agreement between simulation and measurement and the results are very similar to those obtained in [2] despite using an absolute non-periodic configuration. The cells are different in shape and in area as well. The distances between them also vary from 7.5 to 8.5 mm in the first filter and from 5 to 6 mm in the others.

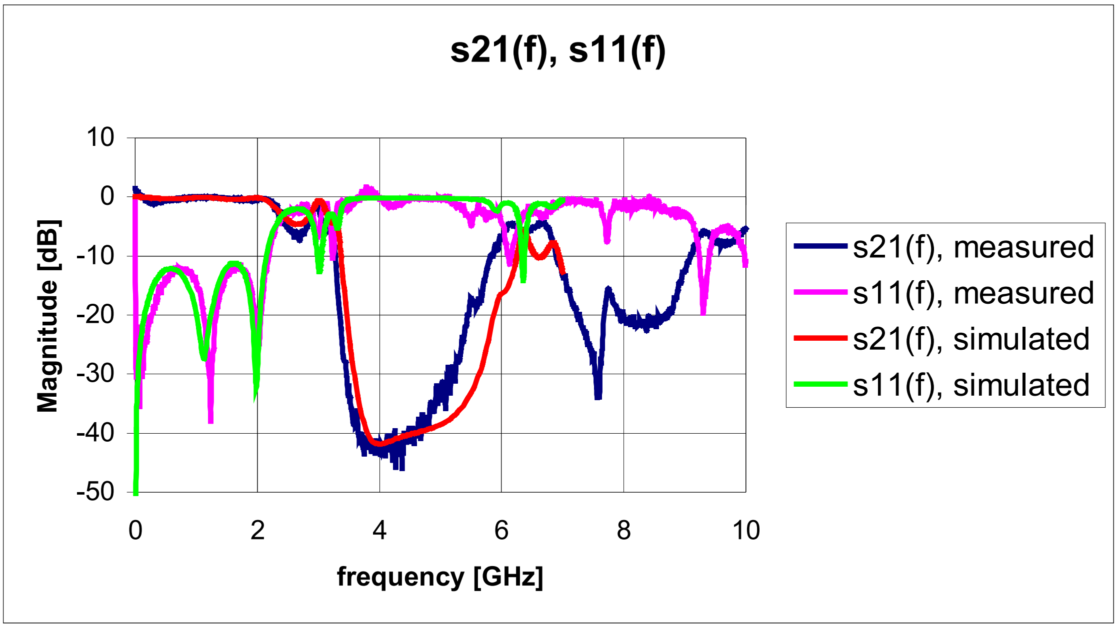

Fig. 2.-Comparison between the measured and simulated S-parameters for the fabricated DGS filter tuned at 5 GHz.

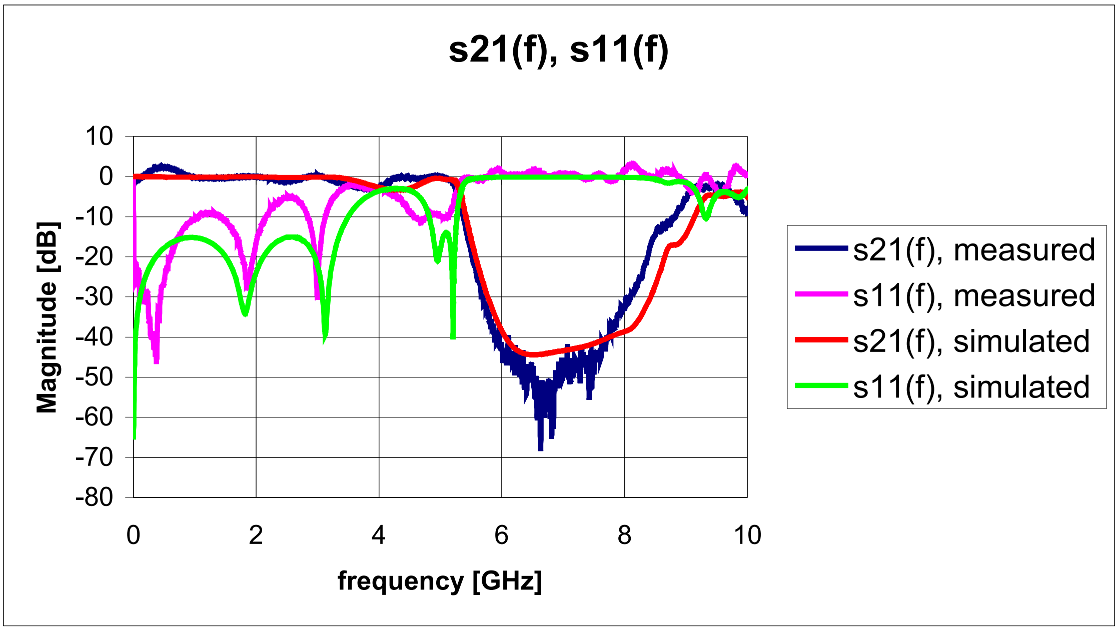

Fig. 3.- Comparison between the measured and simulated S-parameters for the fabricated DGS filter tuned at 7.5 GHz.

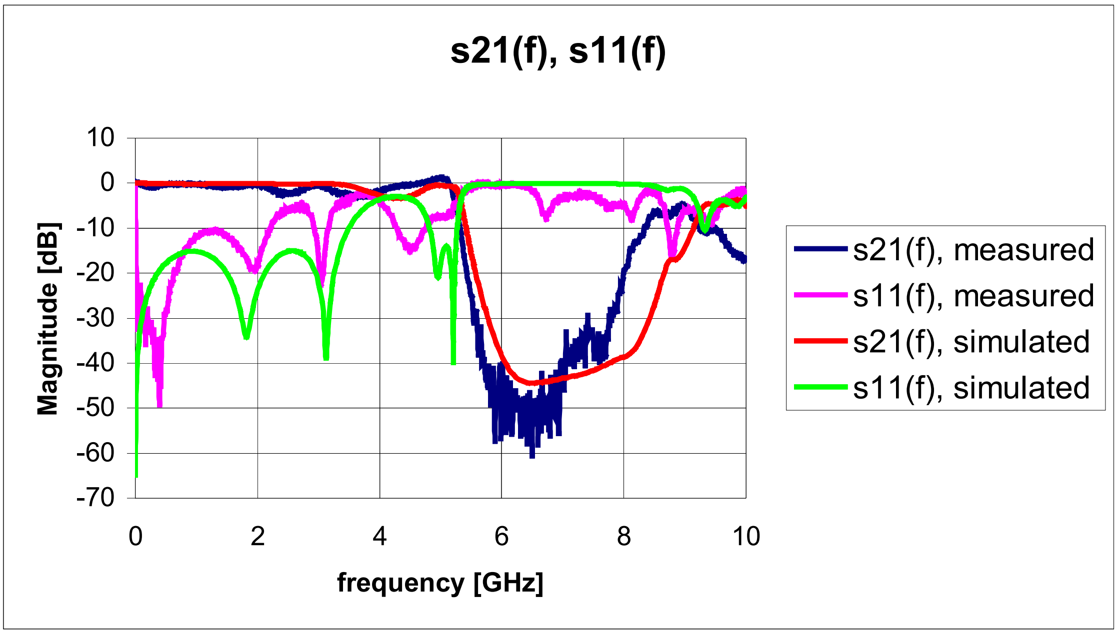

Fig. 4.- Comparison between the measured and simulated S-parameters for the fabricated DGS filter tuned at 7.5 GHz. with only the perimeter etched.

IV. CONCLUSIONS

In this paper we have proved the versatility of the DGS, showing that one can achieve any desired frequency response by placing correctly the attenuation poles. The most important parameter is the perimeter, and reshaping the cells in order to make good use of the space is possible. Moreover, it was proved that the periodicity is not necessary at all for these kind of DGS.

V. REFERENCES

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[2] C.S. Kim, J.S. Park, D. Ahn, and J.B. Lim, "A Novel 1-D Periodic Defected Ground Structure for Planar Circuits", *IEEE Microwave and Guided Wave Letters*, vol. 10, no. 4, April 2000.