A BANDPASS FILTER EXCITED BY PERIODIC CROSS SHAPED CELLS

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Abstract

A uniplanar bandpass Filter is proposed and implemented by coupling the two open ended 50-• microstrip line with the periodic cross shaped cells (PCSCs). The passband characteristics are excited by using PCSCs, and the filter frequency response related to coupling gap and rows of the PCSCs are discussed. The bandpass filter demonstrates the frequency characteristics with a center frequency f_o = 2.16 GHz, a 3-dB bandwidth (FBW) of 23 %, and insertion loss S_{21} of –1.8 dB. There is a good agreement between the experimental and simulation results.

1. INTRODUCTION

Periodic structures are the new class of model in which the band structure concepts of solid-state physics are applied to electromagnetics for radio, microwave, satellite and millimeter wave systems. The periodic structure can not only take on the bandgap properties of the semiconductors in the optical technology, but also be used in microwave circuits, including the antennas, filters, and other active circuits [1-4].

There are several periodic structures using the periodic patterns etched in the ground plane for microstrip circuits have been proposed [1-4]. Propagating electromagnetic waves can have energies or frequencies only at certain wave vector, and their existence at the other wave vector are forbidden. However the mentioned microstrip periodic structures having holes in the substrate or etched patterns in the ground plane, the disadvantages of the structures are the package problem and realization of MMICs. T. Itoh et al. have presented a microstrip bandpass filter fabricated on the uniplanar compact photonic bandgap (UC–PBG) ground plane to suppress the spurious responses of the microwave circuits [5].

Although the advantages of low loss, moderate impedance, and uniplanar feature make the periodic structure to be a very promising candidate as a slow-wave transmission line, there are fewer papers reporting about the bandpass filter excited by the periodic structure. A split mode resonator bandpass filter excited by the modified periodic square patch etched on the ground plane [6]. In this paper, we present another concept of filter structure that a uniplanar bandpass filter using periodic cross shaped cells (PCSCs) to excite passband performance. It is interesting that the PCSCs can be easily fabricated in the top plane without any additional masks or via holes, avoiding the package problem and suitable for MMICs.

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The passband characteristics are excited for this novel structure. The relationships between filter characteristics and coupling gap and rows of the PCSCs are investigated in this paper. There are good agreement between the experimental results of the fabricated filter measured by network analyzer and the simulation results.

2. DESIGN OF UNIPLANAR STRUCTURE

Figure 1 illustrates the configuration of the uniplanar bandpass filter by coupling the two open ended 50-• microstrip line with the PCSCs. The basic structure is two open ended 50 microstrip line in the top layer, as shown in Figure 1(a), and the gap s between the two microstrip lines is 1 mm. Without any coupling elements, the mentioned structure has no passband since the gap between the two conductor lines of 50-• microstrip line have high impedance capacitance effect and the electromagnetic wave can not pass through from port 1 to port 2. By adding the coupling elements of the PCSCs as shown in Figure 1 (b), the filter performance can be expected to be excited. The PCSCs is the simplified structure of the periodic structure in UC-PBG. The bandpass filter coupled to PCSCs can be characterized by parameters: the dimension of the cross shaped cells, the coupling gap g between the two microstrip line and the cross shaped cells and the rows of PCSCs. To simplify the design parameters, each cross shaped cell has the same physical dimension of $L_1 = 0.7$ mm and $W = 0.5$ mm, and the filter characteristics are tuned by the rows and coupling gap g of the PCSCs.

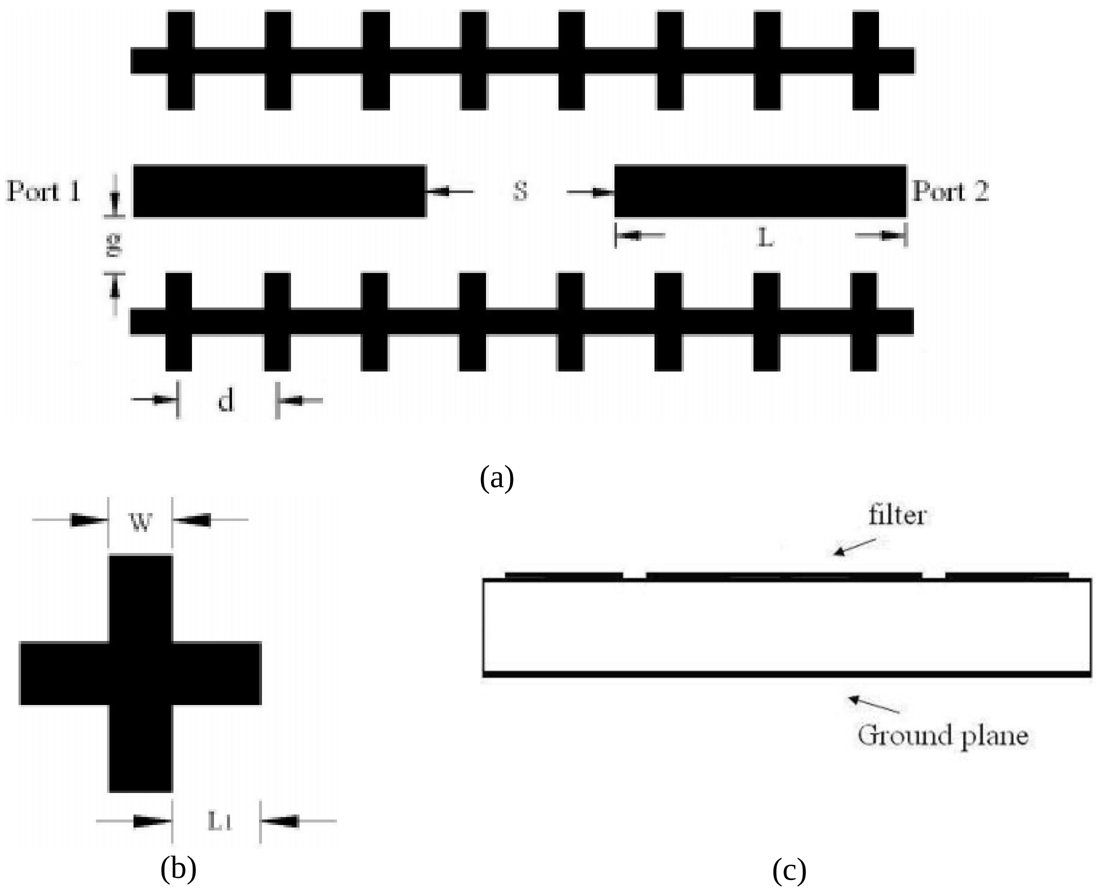

Fig. 1. The bandpass filter excited by PCSCs. (a) Configuration, (b) details of unit cell and (c) cross-sectional view. The parameters are shown as follows: g = 0.1 mm, d = 1.9 mm, L = 17 mm, S = 1 mm, L_1 = 0.7 mm and W = 0.5 mm.

Figure 2 illustrates the filter performance as function of the cell numbers having the same structure in Figure 1(b), and the cell distance d and the coupling gap g are fixed as 1.9 mm

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and 0.1mm. As the cell numbers are increased from four to thirty-six, namely, there are two and eighteen cells located symmetry in each side of the open ended microstrip line, the passband characteristics are excited more obviously and the passband frequency are decreased.

Figure 3 illustrates the filter performance as function of the coupling gap g, where the size of unit cross shaped cells is fixed. As the coupling gap is increased, the center frequency and 3-dB fractional bandwidth (FBW) are almost unchanged while the insertion loss is slightly decreased, respectively. The results may be from the decreased coupling energy. Figure 4 illustrates filter performance of different rows, where each row has 36 PCSCs of the same parameters of Figure 1(a) and the coupling gap g is 0.1mm. As the row number is increased, namely, the numbers of periodic cross shaped cell is increased; the center frequencies are almost unchanged and FBW are slightly decreased. However, the insertion losses decrease rapidly due to more conductor loss in the more periodic metal cells.

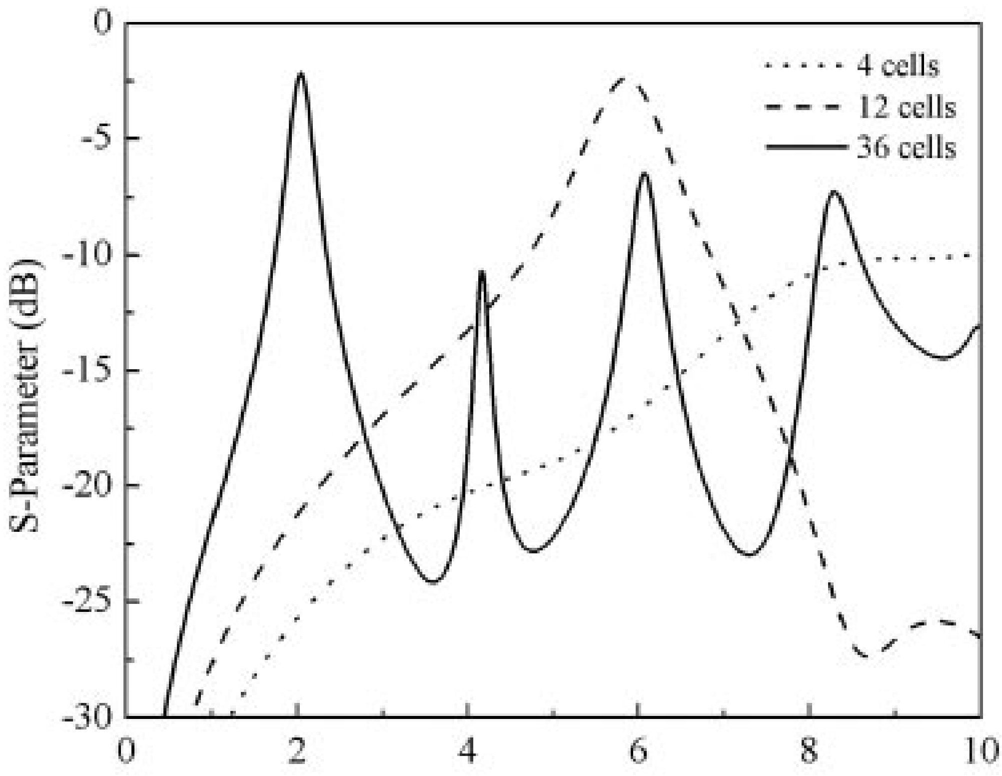

Fig. 2. Filter performance of different cell numbers. The parameters are shown as follows: g = 0.1 mm, d = 1.9 mm, L = 17 mm, S = 1 mm, L_1 = 0.7 mm and W = 0.5 mm.

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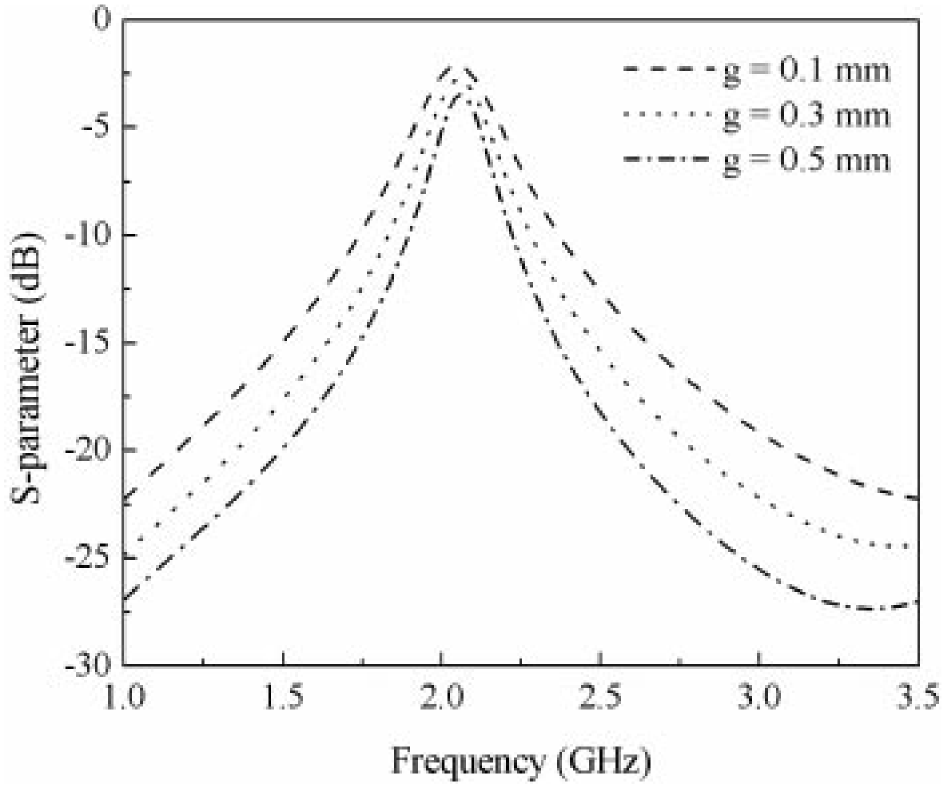

Fig. 3. Filter performance of different coupling gap g. The parameters are shown as follows: g = 0.1 mm, d = 1.9 mm, L = 17 mm, S = 1 mm, L_1 = 0.7 mm and W = 0.5 mm. (Cell distance = 1.9 mm)

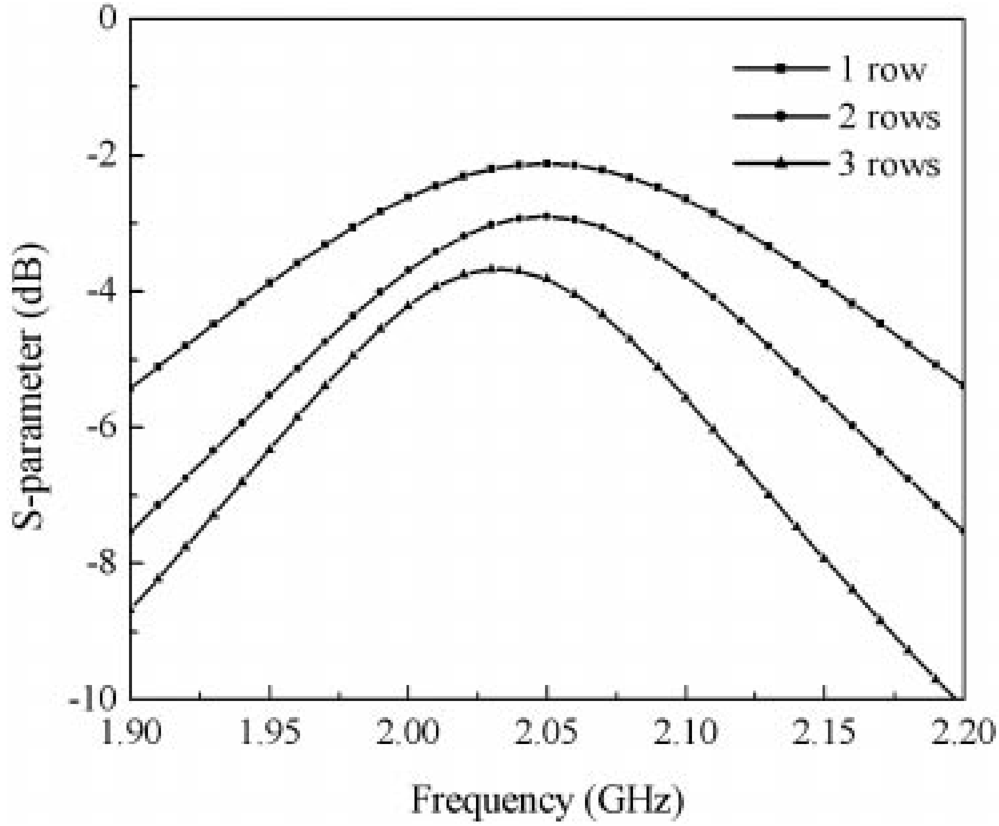

Fig. 4. Filter performance of different rows. The parameters are shown as follows: g = 0.1 mm, d = 1.9 mm, L = 17 mm, S = 1 mm, L_1 = 0.7 mm and W = 0.5 mm. (Cell distance = 1.9 mm)

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3. SIMULATED AND MEASURED RESULTS

From the above discussion, the novel uniplanar bandpass filter by coupling the two open ended 50-• microstrip line with the PCSCs with a center frequency of 2 GHz has been demonstrated using a full-wave electromagnetic (EM) IE3D simulator [7]. There is one row having eighteen cell numbers in each side of the open ended microstrip line. The parameters of the uniplanar bandpass filter are shown as follows: g = 0.1 mm, d = 1.9 mm, L = 17 mm, S = 1 mm, L_1 = 0.7 mm and W = 0.5 mm, which is optimized by the calculation equations for more rejection. Especially, the cell distance to the guide wavelength ratio ($d/\bullet_g$) is 0.02. So, it's natural to expect that the cell distance of the PCSCs must be the order of the guided wavelength to produce the periodic effect of electromagnetic wave.

Figure 5 illustrates the simulated and measured frequency response for the uniplanar bandpass filter by coupling the two open ended 50-• microstrip line with the PCSCs. The uniplanar bandpass filter is fabricated on FR-4 substrate and measured by an Agilent 8753E Network Analyzer. The designed novel uniplanar bandpass filter has performances of the center frequency f_o = 2.16 GHz, FBW is 23 %, and insertion loss of –1.8 dB.

The other differences between the simulated and measured results might be due to material and fabrication error. In addition, we found some interesting things in investigate into the PCSCs according to the center frequency f_0, FBW, S-parameter, and attenuation rate of novel uniplanar bandpass filter.

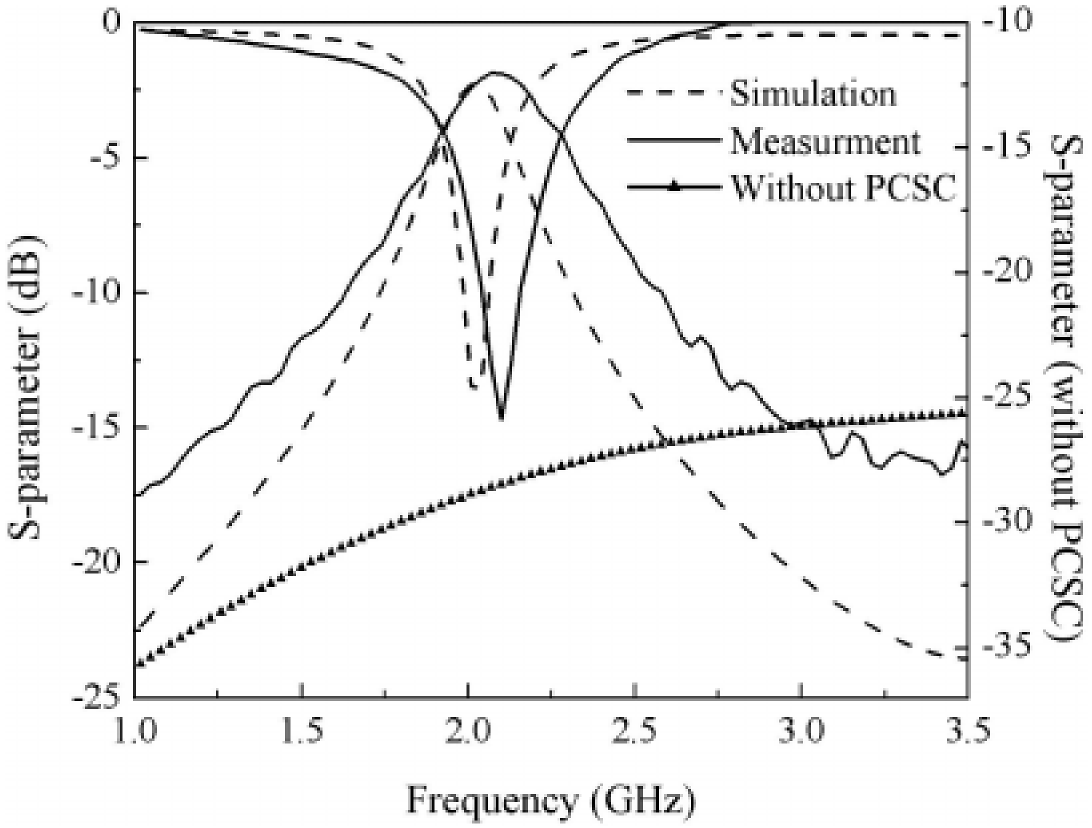

Fig. 5. Simulated and measured filter characteristics of uniplanar PCSCs bandpass filter. The parameters are shown as follows: g = 0.1 mm, d = 1.9 mm, L = 17 mm, S = 1 mm, L_1 = 0.7 mm and W = 0.5 mm.

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4. CONCLUSION

A novel uniplanar bandpass filter by coupling the two open ended 50-• microstrip line with the PCSCs is proposed. The novel uniplanar bandpass filter demonstrates the frequency characteristics with a center frequency f_o = 2.16 GHz, FBW of 23%. The filter performance are effected by the coupling gap and rows of the cross shaped cells. This proposed bandpass filter has great potential actual applications in modern wireless system.

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