Multilayered Parallel Coupled Line Planar Band Pass Filter with Hexagon Resonator

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Abstract— Reduced size, least cost and improved performance have the significant interest in the field of microwave in recent years. This paper proposes a multilayered band pass filter design for wider stop-band and improved return loss using double negative material. The proposed filter is designed with cutoff frequency of 1.5GHz and also proposed design with dielectric constant of 4.3, and substrate height of 1.6mm is simulated using computer simulation technique (CST). The filter is designed in middle layer and hexagon rings structures are on the top layer of the metamaterial structure. The undesired spurious signals are reduced while maintaining the filter pass-band performance by using the repeatedly hexagon ring resonator. The metamaterial has the advantage of compact size with ability to provide improved performance. The performance and bandwidth of the filter has been improved significantly.

Keywords: Coupled line band pass filter (BPF), double negative material, spiral hexagon resonator, Richard's transformation and Kuroda's identities

I. INTRODUCTION

A microwave filter is a two port network used to control the frequency response at a certain point in a microwave system. More especially a band pass filter is a filter which passes all those frequencies lying within a band between a lower cutoff frequency and a higher cutoff frequency and rejects all other frequencies outside this specified band [1]-[3]. A perfect filter is one which has zero insertion loss in the pass band, infinite attenuation in the stop band. Unluckily, the realization of such an ideal filter is not possible. Most filters are approximations and all have their own drawback. Along with excellent performance, size miniaturization of microwave filters is one of the most challenging works in today rapid changing communication world. Conventional End- coupled and parallel –coupled band pass filters are much large in size. Metamaterial is one of the modern areas for size miniaturization and quality results.

Metamaterial is an artificial or man-made material which gains its properties such as negative permeability and negative permittivity both from its structure rather than directly from its composition. The concept of metamaterial was first proposed by Russian physicist Victor Vassalage pondered in 1968 [4].

In 2000, Prof. Pendry's team proposed a structure for negative permeability [5]. Left handed material or metamaterial possesses many new unique feature such as negative refraction, backward wave propagation, reverse Doppler shift [6].

This paper describes about the design of multilayered parallel coupled line band pass filter which works at 1.5GHz.

II. METHODOLOGY

When two exposed transmission lines are neighboring together, power can be coupled between the lines. The cause behind the power coupling is interaction of the electromagnetic fields of each line. Such types of lines are known as coupled transmission lines. Usually minimum three conductors are close proximity but more conductors can be used. Coupled lines band pass filters are popular for their easy fabrication and integration but they suffer from poor performance at higher frequencies. To overwhelm these problems multilayered coupled line band pass filter is designed with spiral hexagon resonator [7], [8].

III. FILTER DESIGNING

The proposed band-pass filter is designed and simulated using CST software with dielectric constant of 4.3 with cut off frequency of 1.5GHz. In the proposed filter design, in the middle layer a parallel coupled line microstrip band-pass filter is designed with spiral hexagon resonator rings on the top layer of the filter structure [9].

A. Design specifications for the filter under consideration are

Relative Dielectric Constant, $\epsilon_r = 4.3$
Cut-off frequency, fc = 1.5GHz
Height of substrate, h = 1.6 mm
Zo = 50 Ω

Each section of the coupled stripline contains three parameters: S, W, d. These parameters can be determined from the values of the odd and even mode impedance (Zoo & Zoe) of each coupled line. Where S, W and d are the separation between the line, width of the line and thickness of the substrate used respectively.

The even and odd impedances of coupled lines are calculated by the formula proposed [1]:

$$Z_{0e} = Z_0[1 + jZ_0 + (jZ_0)^2]$$
$$Z_{00} = Z_0[1 - jZ_0 + (jZ_0)^2]$$

The values of length, width and spacing of proposed filter is tabulated in table 1.

N	Length(mm)	Width((mm)	Spacing(mm)
1	25	7	2
2	30	9	2
3	29	9	2
4	30	6	2

Table 1: Length, Width and Spacing of Parallel stubs.

The proposed coupled line band pass filter is designed by using CST software in middle layer as shown in figure 1.

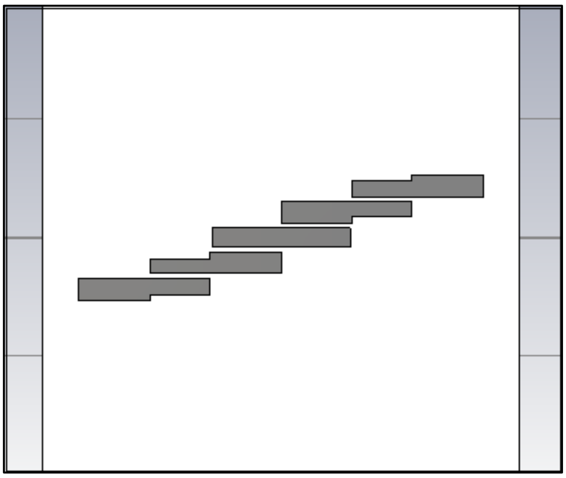

Fig. 1: coupled line band pass filter (middle layer).

Now the top layer of the multi-layered is designed with series of spiral hexagon ring resonators. The dimensional view of the spiral hexagon resonator is shown in fig.2.

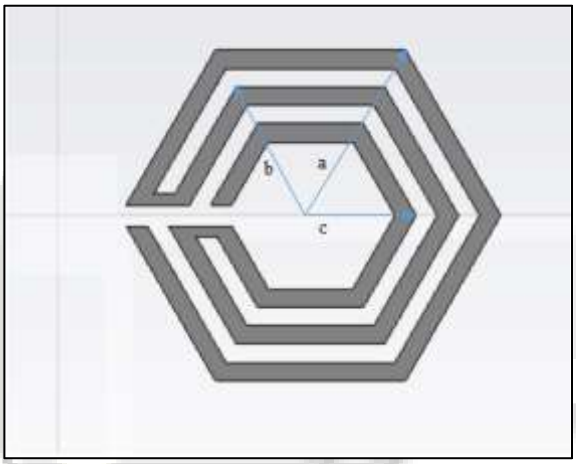

Fig. 2: Spiral hexagon resonator (a=4.5mm, b=3.5mm, c=2.5mm)

The designed top layer of the metamaterial structure is depicted in fig.3.

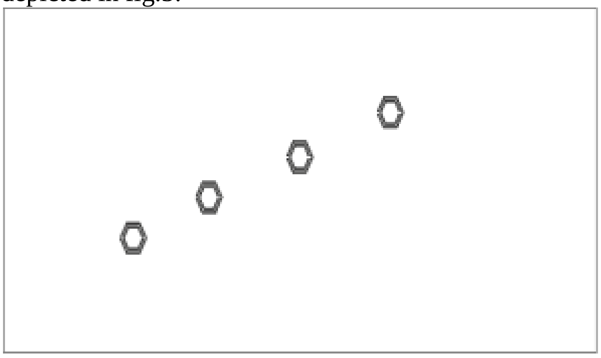

Fig. 3: Top layer of Spiral Hexagon resonator

Finally by proper integrating the designed coupled line band pass filter and metamaterial structure, not only the return loss of the filter can be improved, but also the filter size can be reduced.

IV. Result and Discussion

A multi-layered coupled line band pass filter with spiral hexagon resonator is designed with a cut-off frequency of 1.5GHz. The simulated S11 and S21 results for proposed band pass filter is illustrated in fig.4 to fig.6

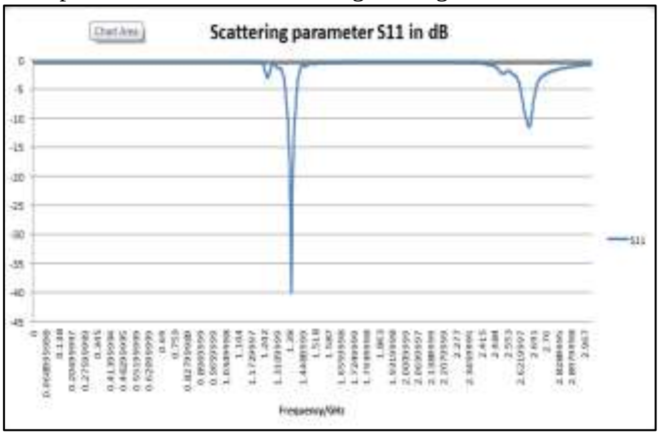

Fig. 4: S11 response of the filter

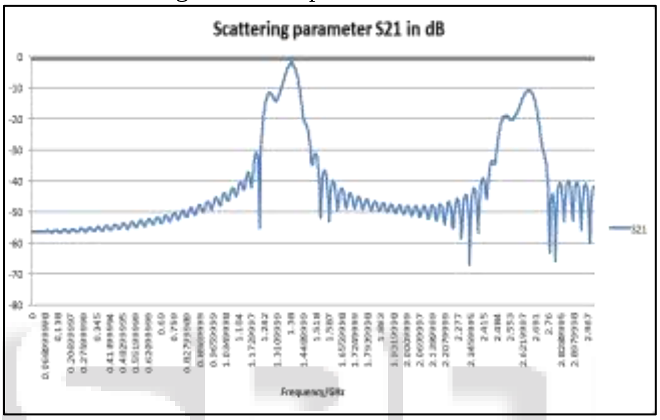

Fig. 5: S21 response of the filter

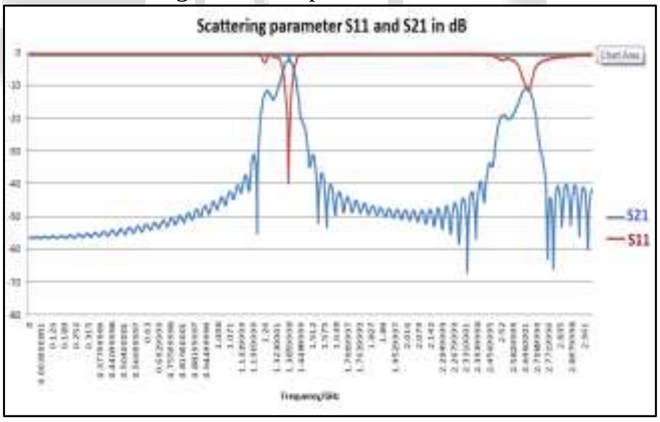

Fig. 6: Combined S11 and S21 responses

From the figures, it is clear that the proposed band pass filter has a cutoff frequency of 1.5 GHz and band width of the filter is 60MHz.

V. Conclusion

This work has presented a study of microstrip band pass filter using metamaterial. The proposed filter shows the improved performance both in pass band and stop band. Filter has a bandwidth of 60MHz and cutoff frequency 1.5 GHz; hence filter is applicable in all modern communication systems.

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