Symmetric Microstrip Meanderspurline Bandstop Filter

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***Abstract*—In this paper, a symmetric microstrip meander spurline bandstop filter (SMMBF) is designed and simulated for X-band applications. The designed bandstop filter has a bandstop characteristic with higher insertion loss. The operating resonance frequencies of the bandstop filter is 9.2 GHz with insertion loss of less than 28 dB and return losses are below 1 dB. The miniaturized resonator filters consist of symmetric meander spurline with inductive and capacitive characteristics. The capacitive loaded spurline resonator filter provides a band rejection frequency response. The quality factor (Q) of the resonators filter is good for implementing in microwave oscillators too. Implementation of such resonator filter in MMIC technology is also possible due to their inherent capability to integrate into small sizes.**

Keywords—Bandstop filter; spurline BSF; resonator filter; microstrip bandstop filter.

I. INTRODUCTION

A bandstop filter (BSF) is very important component in communication systems in which all the desired frequencies are rejected since these filters exhibit bandstop characteristics. The BSFs are required to have higher insertion loss and return loss for good impedance matching with interconnecting components, and high frequency rejection to prevent interference. The higher frequency selectively can determine the guard band between each channel to specify the higher rate of frequency efficiency. In the view of mechanical performance, these BSFs are required to have small volume and good temperature stability. The BSFs which are used in wireless communication system have been demanding tighter requirement in terms of electrical specifications as well as drastic reduction of manufacturing cost and development times [1-2]. Therefore, the area of microwave filters, especially for X-band applications, has experienced significant improvements in theoretical, technological, and performance subjects. One of the significant improvements in resonator filter design process was utilizing spurline configurations. The spurline configuration can overcome the problem of miniaturization, Q-factor, easy fabrication, and low cost material as compared to another various types of resonators like hairpin resonator, dielectric resonator and so on.

A spurline is a simple embedded internal defected line structure; it can be fabricated by a simple etching process and the defected meander spurline also exhibits inductive characteristics. These defected microstrip resonator is also easy to integrate into circuits due to their inherent compact size. The resonator filter is widely used in various communication systems due to their bandstop characteristics, inherently compact size, and bandgap characteristics. The spurline and meander spurline resonators were used to build bandstop filters and circuit modeling due to their significant results [3-4].

II. DESIGN AND SIMULATION

The symmetric microstrip meanderspurline bandstop filter (SMMBF) is simulated using the SONNET Lite 3D planar EM simulator. The SMMBF is simulated using a Teflon substrate with the thickness and the dielectric constant of 0.54 mm and 2.54, respectively [4-6]. The schematic of the SMMBF is depicted in Fig. 1. The final optimized dimension of the symmetric meander spurline structure has a slot width w of 0.15 mm, a slot length l of 5.1 mm and a slot height h of 1.35 mm. In the design process, the spurline slot width is made the same to compare their capacitive and inductive effect on the frequency responses. The equivalent circuit of the designed bandstop filter is depicted in Fig. 2 where Cp_1 and Cp_2 are the parasitic capacitance effects in port 1 and 2 respectively and this also shows a simple RLC network.

When simulating the SMMBF, the overall inductive and capacitive values came to 7.08 nH and 0.048 pF. The simulation result is plotted in Fig. 3. In the simulation result, as a S-parameter responses, the return loss and insertion lossess are 0.12 and 45 dB respectively which are very good results. The 3dB bandwidth is very wide which is over 5 GHz. So, it can be used in the ultrawideband (UWB) applications.

Thus, the effective permittivity of the dielectric substrate increases as the effective inductance and capacitance of the microstrip line increases by spurlines [6]. As mentioned above, the effective inductance and capacitive effect of the spurline is greatly improved in the Q value; therefore, it has potential to achieve a low phase noise when implemented in a microwave oscillator [7-8] which is another advantage of spurline resonator with high Q.

The spurline resonator filter can be etched on a 50 Ω microstrip line 1.49 mm wide (w). There is an obvious bandgap at the resonant frequency of 9.2 GHz. In addition, the spurline resonator provides a higher insertion loss and a narrow bandwidth. Basically, in order to obtain a deeper rejection and a wider bandstop, more open stubs should be employed. However, it would also increase the circuit size and the insertion loss. On the other hand, spurline filter is suitable only for moderate rejection bandwidth applications [9]. The symmetric meander spurline type of resonator filter is designed with the operating frequency of 9.2 GHz and high insertion loss and wideband width.

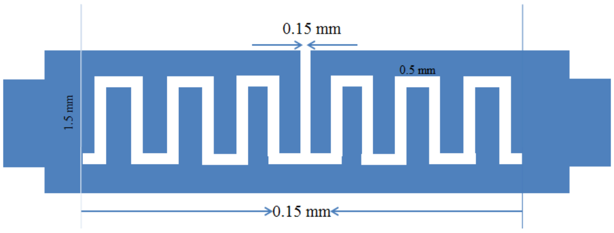

Fig. 1. The schematic of the symmetric meander spurline bandstop filter.

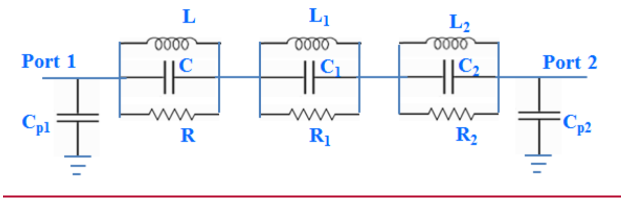

Fig. 2. Equivalent circuit of the designed bandstop filter.

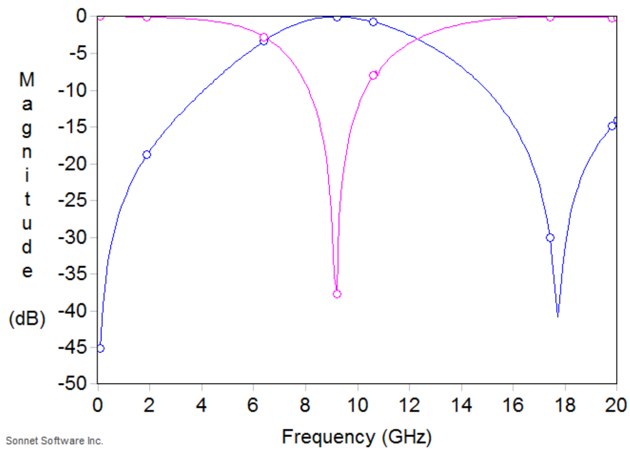

Fig. 3. The schematic of the symmetric meander spurline bandstop filter.

The wave length, L=(λg /4) in microstrip spurline is given by

$$\lambda_g = \frac{\lambda}{\sqrt{\varepsilon_{eff}}} = \frac{c}{f_{bs}\sqrt{\varepsilon_{eff}}} \qquad (1)$$

where L is the length of the spurline; *C* is the light speed (3×108 m/s), f_{bs} the bandstop and (i. e. the desired rejected frequency) frequency and ε_{eff}, the substrate effective permittivity [5]. The electrical length can be calculated from the equation (2).

$$\phi = \beta . l = \frac{2\pi}{\lambda_g} . l \qquad (2)$$

where ϕ is the phase, β, the phase constant, and l, the equivalent electrical length of the spurline.

The electromagnetic simulation is performed to analyze the behavior of the bandstop filter. Therefore, the current distribution simulation results of the symmetric meander spurline resonator are observed at the resonance frequency of 9.2 GHz in the stopband which is illustrated in Fig. 2. The bar in the left side represents the surface current density in (A/m) which is the magnitude of coupling between spurlines and feed lines. As a result of random current density simulations, the current distribution is the lowest at 9.2 GHz frequency in Figure which means the frequencies are rejected at 9.2 GHz in the filter, since the bandstop filter has bandstop characteristics. As can be seen the Fig. 4, the electric field is highly concentrated in the gap that gives capacitive effect. In the same way, the electric field nearly vanishes in the outside of the gap that shows magnetic field and gives inductive effect. The overall performance is summarized in the Table I.

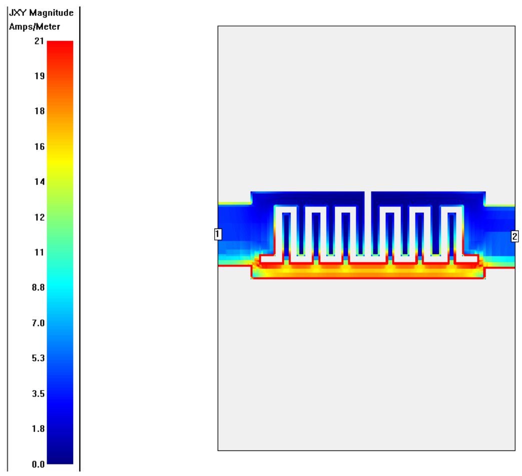

Fig. 4. The current distribution graphs at 9 GHz in the symmetric meander spurline resonator.

TABLE I THE SUMMARY OF THE DESIGNED BSF.

Parameters	Units	Simulation Results
Operating Frequency	GHz	9.2
Insertion Loss (S21)	dB	37
Return Loss (S11)	dB	0.12
Bandwidth	GHz	5.8
Size	5.8 x 2.8	

III. CONCLUSION

The compact microstrip resonator filter is designed and simulated at 9.2 GHz using its bandstop characteristics of spurlines. The simulation result showed good frequency response S-parameters in terms of insertion loss and return loss. Because of the defected nature of the spurline, the filter has further integration potential. The designed bandstop filter has wide bandgap up to 5.8 GHz which can also be used in ultra-wideband application to reject those frequencies.

ACKNOWLEDGMENT

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