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Reduction of Passband Insertion Loss for a Dual Band Bandstop Filter

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ABSTRACT

Two ways are proposed to reduce the passband insertion loss of a compact dual band bandstop filter (BSF). The dual-band BSF has two open stubs, two embedded stubs inside the two open stubs, and one spurline in the connecting line between the two open stubs. The first stopband is around 2.0 GHz, and the second stopband is around 3.0 GHz. The first way to reduce the insertion loss of the passband between these two stopbands is to tune the spurline length. The second way is to replace the spurline with an embedded open stub. Both ways are simulated on Sonnet Suit Software. Simulations show both ways can reduce the passband insertion loss, and the second way is more effective.

Key words: Bandstop filter, spurline, embedded open stub, insertion loss.

1. INTRODUCTION

Microstrip bandstop filters are widely used in microwave subsystems, such as mixers, switches, diplexers, and local oscillators. Hong summarized some techniques to synthesize and design microstrip BSFs [1]. In general, three ways are usually used to design microstrip BSFs [2]. In the first way, resonators are placed close to the main transmission line [1]. At resonant frequencies, the resonators take energy from the main transmission line. In the second way, resonators are connected to the main transmission line [3]. In the third way, defected ground structures (DGS) [4-6] are used.

Dual band microstrip BSFs are attractive for their two separate stopbands. Conventionally, cascading two BSFs having the desired stopbands will generate a dual band microstrip BSF. In this way, the insertion loss in the passband is high and the circuit size increases. Many ideas have been proposed to reduce the size of dual-band microstrip BSFs [4, 7-10]. Recently, a compact dual band bandstop microstrip filter having two open stubs, one spurline and two embedded open stubs was proposed [11]. This compact dual-band BSF has simple structure and is easy to fabricate. However, the insertion loss between the two stopbands is high. To overcome this shortcoming, two ways are proposed in this paper.

First, the length of the spurline is carefully tuned to move the corresponding attenuation pole to a little bit higher frequency. Secondly, an embedded open stub is used to replace the spurline. Both ways are simulated on Sonnet Suite software. Simulations show that the insertion loss between the two stopbands can be reduced in both ways, and the second way is more effective. The simulation software Sonnet Suite is planar 3D EM simulation software based on Method of Moments. It has been widely used by many researchers [12].

2. THE HIGH INSERTION LOSS

Figure1 is the layout of the original compact dual band BSF in [11]. The length of the two stubs and the separation between the two stubs are a quarter of the wavelength at the midband frequency 2.0 GHz. The spurline and the two embedded open stubs generate attenuation poles around 3.0 GHz. Filter structure and dimension details are well described in [11]. This dual band BSF is simulated on Sonnet Suite14.52, and the simulation results are shown in Figure 2. The two open stubs generate the first stopband around 2.0 GHz. The two embedded open stubs and the spurline generate the second stopband around 3.0 GHz. Apparently the insertion loss between these two stopbands is not low.

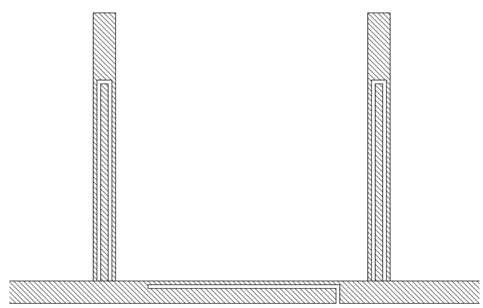

Figure 1: Layout of a compact dual band BSF.

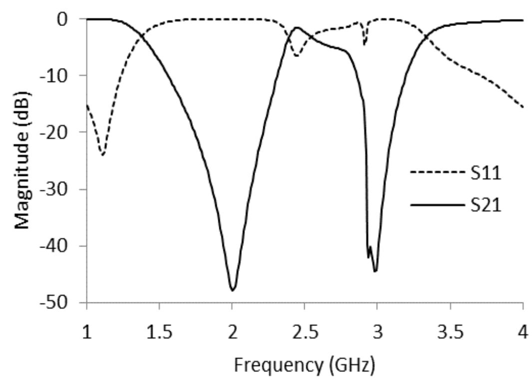

Figure 2: Simulation results of the compact dual band BSF.

3. SPURLINE TUNING

Bates proposed spurline and used it to generate BSFs [13]. To etch a very narrow L-shaped slot on a microstrip forms a spurline. A stopband is generated if the length of the spurline equals to a quarter of the wavelength. In the compact dual band BSF (Figure 1), a spurline is embedded into the connecting line between the two open stubs. Based on simulations in [11], the insertion loss between the two stopbands comes mainly from this spurline. To reduce this insertion loss, the attenuation pole from the spurline need to be moved to a frequency a little bit higher than 3.0 GHz. The width of the new spurline is also reduced to 0.40 mm to decrease the insertion loss between the two stopbands. The length of this spurline is carefully tuned to 10.08 mm. The layout of this new filter is shown in Figure 3.

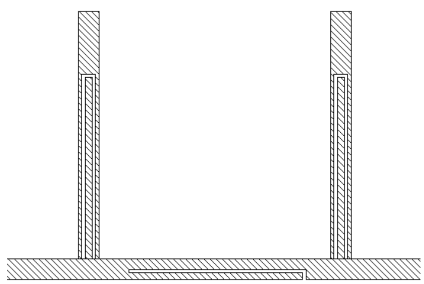

Figure 3: Layout of the BSF with the new spurline

This filter is simulated on Sonnet Suite 14.52, and the simulation results are shown in Figure 4. The two stopbands are still around 2.0 GHz and 3.0 GHz. The attenuation pole from the two embedded open stubs is at 2.99 GHz, and the attenuation pole from the new spurline is at 3.03 GHz. The insertion loss between the two stopbands gets improved. For comparison, the insertion losses of the original BSF in [11] (before spurline tuning) and the new filter after the spurline tuning are shown together in Fig. 5.

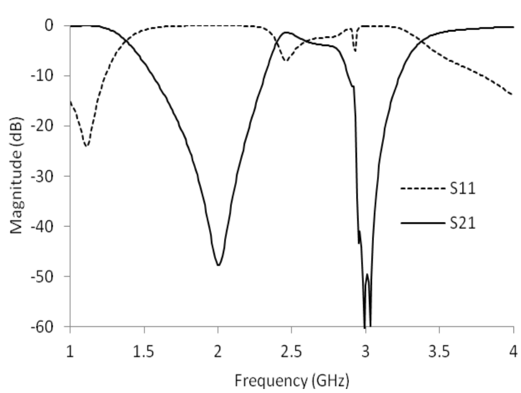

Figure 4: Simulation results of the BSF with the new spurline

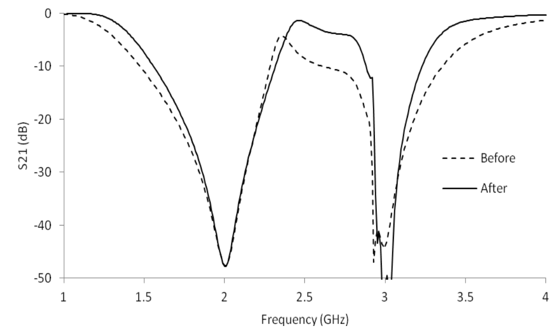

Figure 5: The insertion losses before and after spurline tuning

4. THE THIRD EMBEDDED OPEN STUB

To further reduce the passband insertion loss mentioned earlier, an embedded open stub is used to replace the spurline. Embedded open stub was proposed by Shaman and Hong to form a notch band on an ultra wide band bandpass filter [14]. The attenuation pole occurs when the length of the embedded open stub equals a quarter of the wavelength. The current on a microstrip is mainly distributed at the two edges of the microstrip. The embedded open stub here has less perturbation to the original connecting line than the spurline does. Hence, the filter will have lower insertion loss between the two stopbands.

The third embedded open stub will also generate an attenuation pole around 3.0 GHz. It is also 0.40 mm wide, and the gap is 0.20 mm. Its length is carefully tuned to 10.30 mm and the responding attenuation pole is a little bit higher than 3.0 GHz. The layout of the proposed filter with three embedded open stubs is shown in Figure 6. This BSF is also simulated on Sonnet Suite 14.52, and simulation results are shown in Figure 7. The two stopbands are still around 2.0 GHz and 3.0 GHz. The insertion loss between these two stopbands gets much better. The attenuation pole from the first two embedded open stubs inside the two open stubs is at 2.98 GHz, and the attenuation pole from the third embedded open stubs inside the connecting line is at 3.03 GHz. For better comparison, the insertion losses of the original BSF in Figure 1, the BSF after spurline tuning in Figure 3, and the final BSF with three embedded open stubs are shown together in Figure 8.

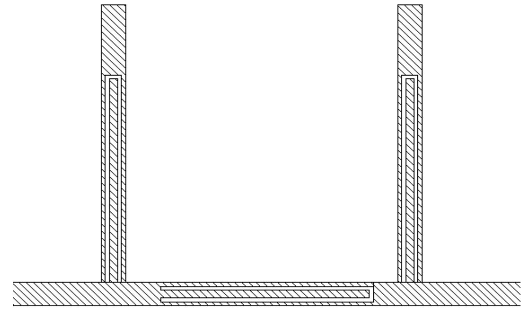

Figure 6: Layout of the BSF with three embedded open stubs

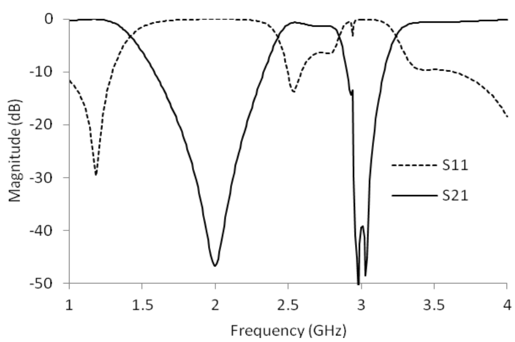

Figure 7: Simulation results of the BSF with three embedded open stubs

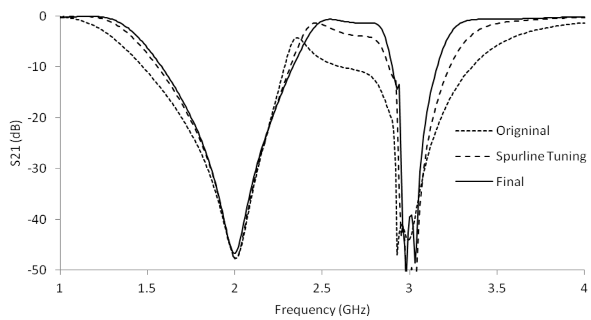

Figure 8: Insertion losses of the original BSF, after spurline tuning, and of the final BSF

5. SUMMARY

The insertion loss between the two stopbands of a compact dual band BSF is high. The two stopbands are around 2.0 GHz and 3.0 GHz respectively. Two ways to reduce the passband insertion loss are proposed, and then simulated on Sonnet Suite. The first way is to use a narrower spurline, and to tune its length carefully. The attenuation pole from the spurline is moved to 3.03 GHz while the attenuation pole from the two embedded open stubs is at 2.99 GHz. The second way to reduce the passband insertion loss is to replace the spurline with an embedded open stub. The length of this embedded open stub is also tuned to move the responding attenuation pole to 3.03 GHz. Simulation results show both two ways can reduce the passband insertion loss, and the second way is more effective than the first way.

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