Bandpass hairpin filters harmonics suppression by using the combination of open circuit stub and spur-line

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Introduction

With the development of various design technologies, the filter is developing towards miniaturization, lower insertion loss, and at the same time, it also need to suppress the influence of parasitic passband between the resonators. Microstrip hairpin filter is widely used in wireless communication system such as WLAN, Bluetooth, radar and mobile communication system because of its small size and narrow passband response. However, due to the quality factor of microstrip line hairpin filter, the parasitic passband has great influence on the performance of the whole filter. To solve this problem, periodic square groove and spur line are introduced into the coupling section of traditional hairpin filter. The aim is to suppress the generation of parasitic passbands by phase compensation. And the open circuited stubs connect to the resonator is equivalent to short-circuit grounding at this frequency which can introduce transmission zero, so it can also suppress the influence of harmonics on the premise of ensuring the good transmission performance of the passband.

The paper proposes a microstrip bandpass filter which uses a variety of structures to suppress harmonics. By connecting two open-circuit stub lines in parallel in the resonator and introducing spur line into the coupling section, it can further suppress harmonics while ensuring good performance of passband. The center frequency of the hairpin filter designed in this paper is 2.5GHz and bandwidth is 200 MHz, which covers the blue-tooth communication band. And extend stopband with a rejection level of 37.5 dB up to $2f_0$, the harmonic suppression effect of the combination of the two structures is much better than that of the single one which can further ensure the performance of the passband.

Conclusion

Using a single spur line structure, the harmonic suppression can be over 20dB by $2.5f_0$, it can effectively suppress harmonics compared with the traditional hairpin filter. On the basis of spur line structure, adding open circuit stub can further suppress harmonics without damaging passband performance, the results show that the harmonic suppression effect is greatly improved within $2f_0$, and the out-of-band attenuation can reach 33dB, the insertion loss is about 1dB. Compared with a single structure, the combination of the two structures can effectively improve the performance of the filter, and the filter proposed in this paper can be used in blue-tooth band.

Method and models

As long as the coupling efficiency K and the quality factor Q of the filter are known, a series of desired filters such as cavity, medium, microstrip and so on can be designed. All parameters can be obtained through the calculation. Due to the parasitic effect between components, the theoretical values calculated need to be further optimized. The simulation starts from a single traditional hairpin filter structure, analyzes the obtained results, and then adds spur line and open stub one by one and compares them with the previous results.

The model of the conventional microstrip hairpin filter shown in Fig.1.However, due to the structural characteristics of the hairpin filter, second harmonics will be generated in the stopband , which will deteriorates the passband performance of the whole filter. Therefore, in order to solve this problem, the introduction of spur line in the coupling section of the resonator to suppress the harmonic is shown in Fig.2. The spur line used in this paper is a simple defect structure achieved by etching a linear groove on the top microstrip line. The phase velocity compensation of the coupled line filter can be achieved by inserting spur line into the coupling edge of the parallel resonator, and the center of the spur line forms a capacitance towards the opening of the coupling direction. However, the introduction of spur line does not suppress the attenuation level of the second harmonic to a large extent within 2f0. Therefore, in order to achieve better inhibition effect within 2f0, an open-circuit stub is introduced on the basis of adding spur wire structure, as shown in Fig.3.

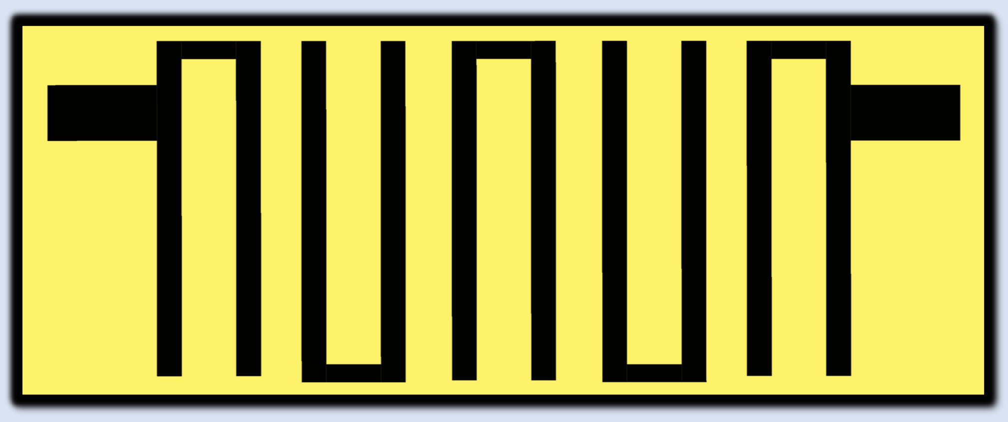

Fig.1. The model of the conventional microstrip hairpin filter

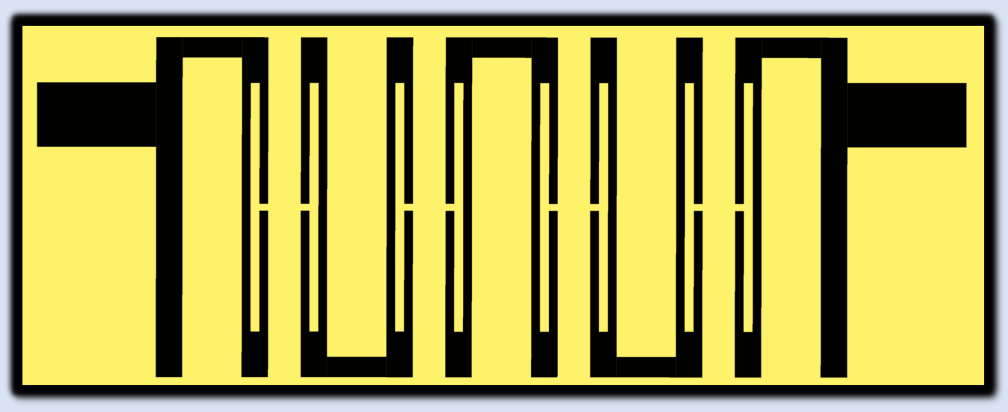

Fig.2. The structure of filter with spur line

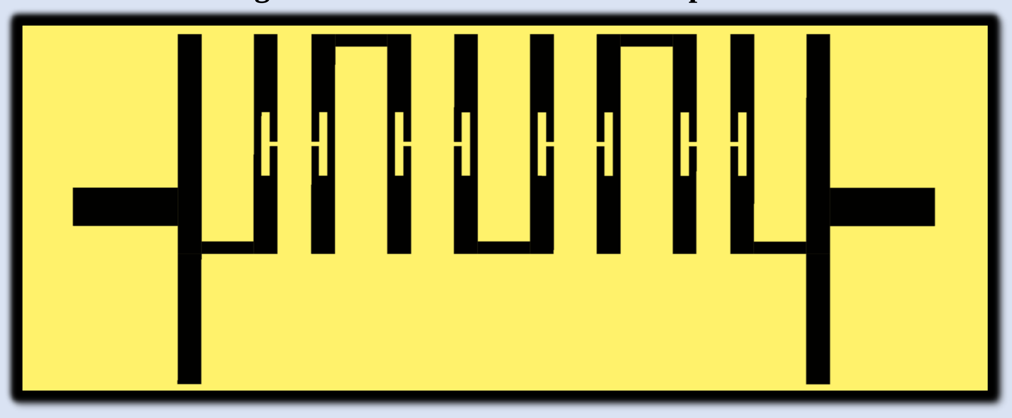

Fig.3. The model of hairpin filter with spur line and open circuit stub

Results

As can be seen from Fig.4, hairpin filter with spur line can suppress harmonic enhancement as much as possible under the condition of ensuring passband performance. The passband insertion loss is about 3dB, and the harmonic suppression can be over 20dB by $2.5f_0$,which greatly improves the performance of the filter by suppressing harmonics. However, the introduction of spur line does not suppress the attenuation level of the second harmonic to a large extent within $2f_0$, and has a slight effect on the passband performance. Therefore, on the premise of ensuring the transmission performance of the passband, the addition of open circuit stub in the first and fifth resonators and its effect on harmonic suppression have been shown in Fig.5.

The result in Fig.5 shows that the harmonic suppression effect is greatly improved within $2f_0$, and the out-of-band attenuation can reach 33dB. The transmission zero appears at 4.3GHz and the maximum attenuation reaches 72dB. The passband performance is good, and the insertion loss at the central frequency is 1.4dB at 2.5GHz. Compared with the addition of a single spur line structure the stop band suppression is significantly enhanced on the premise of ensuring the passband transmission performance, and suitable for use in frequency band below 7GHz.

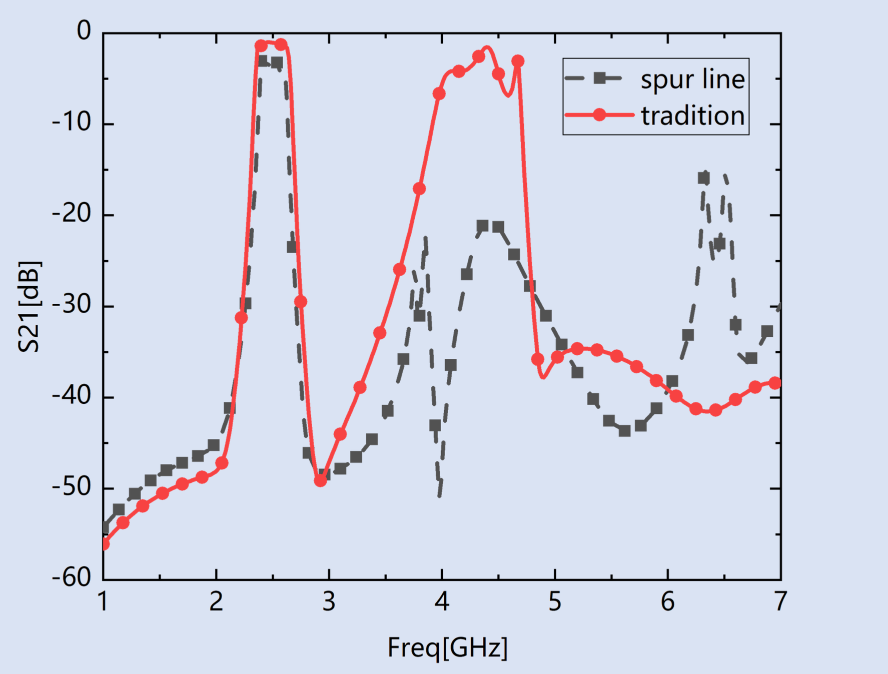

Fig.4. Comparison of influence of Spur line and tradition on S21

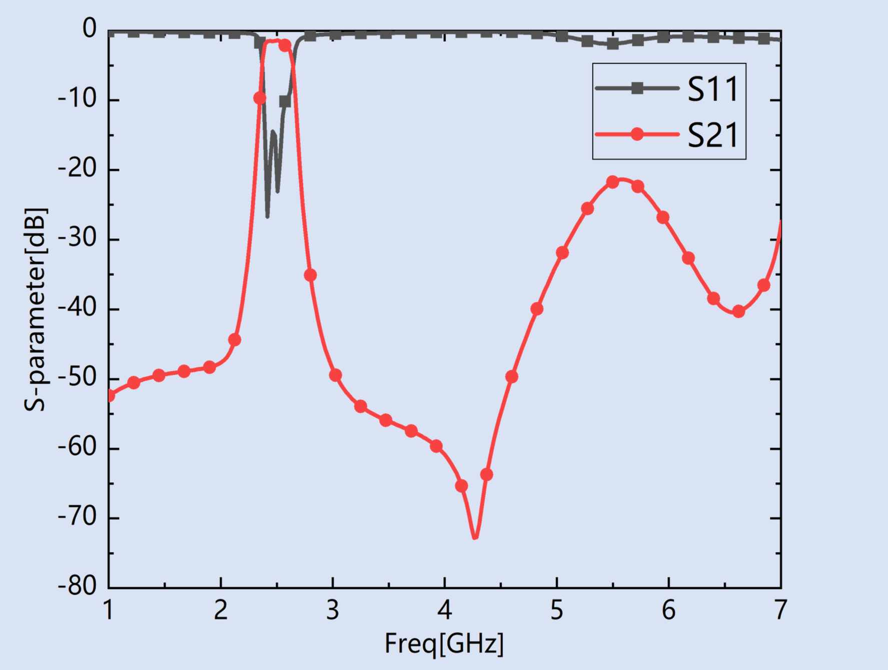

Fig.5. S-parameters of hairpin filter with spur line and open circuit stub

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