Design of Dual Band Microstrip Filter Based on SIR

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Abstract

As the core device in the field of communication, filter is developing towards miniaturization and high frequency. In this paper, a new dual frequency filter based on step impedance resonator is proposed. The resonant frequencies of the proposed stepped impedance resonator (SIR) dual frequency filter are 2.4GHz and 5.2GHz, and the isolation is greater than 20dB.

Introduction

Microstrip filter is widely used in electronic processing, mobile information, radar system, satellite information and so on. The design of microstrip filter is developing towards broadband and miniaturization. Many scholars have proposed a variety of microstrip filter design schemes.

In reference [1], a multi wideband bandpass filter with step impedance resonators is proposed. In reference [2], a three notch bandstop microstrip filter based on Archimedes spiral electromagnetic bandgap structure is proposed. In reference [3], a microstrip BPF with high selectivity and asymmetric frequency response is proposed. In reference [4], a double-layer microstrip filter with etched periodic annular electromagnetic bandgap structure is realized, A narrow band notch UWB filter based on grounded circular patch resonator is implemented in reference [5], a dual notch UWB filter based on T-shaped resonator and L-shaped defected microstrip structure is proposed in reference [6], and a compact dual band pass filter based on Defected split ring resonator (SRR) and irregular Stepped impedance resonator (SIR) is proposed in reference [7]. It can be seen that the realization of small SIR is the key factor to reduce the size of microstrip filter, so this paper mainly designs and realizes the SIR of dual frequency filter.

Design of Microstrip Filter

SIR is a resonant structure of transverse electromagnetic field or quasi transverse electromagnetic field mode formed by two or more transmission lines with different impedances. For the SIR filter, it is very popular to design the filter by adjusting the coupling between microstrip lines. Another similar design method is to increase the frequency band by loading branch resonators on the microstrip line. The basic structure of directly loaded resonator is to load branch in the center of uniform impedance resonator. The purpose of this design is to generate the second frequency band through the coupling between microstrip lines. Microstrip line feeding mode, also known as side feeding, can change the position of feeding point to achieve impedance matching. The first filter is a microstrip line fed Sir dual band filter.

The design method of this filter is based on step impedance resonator (SIR). The resonant frequencies of the designed microstrip filter are 2.4GHz and 5.2GHz, and meeting the requirements of S_{11}≤- 20dB and S_{21}≥- 2dB.

In this design, a half wavelength SIR structure is adopted, and Rogers RO3010 is selected as the dielectric base. Its dielectric constant is 10.2, the dielectric thickness H= 0.635mm, and the patch material is copper, the thickness H_1=0.018mm. Take the impedance ratio k = 0.8, Z_2 = 50 Ω. When the half wavelength Sir resonator is in resonant state, the following formula can be used:

$$K = Z_2 / Z_1 = \tan\theta_1 \tan\theta_2 \tag{1}$$

The total electrical length of SIR can be expressed as:

$$\theta_T = 2(\theta_1 + \theta_2) = 2[\theta_1 + \arctan(K/\tan\theta_1)] \tag{2}$$

In this design, the non equal length is adopted :

$$u = \theta_2 / (\theta_1 + \theta_2) \tag{3}$$

In the above formula, K is impedance ratio, Z_1 and Z_2 are characteristic impedance, When the half wavelength SIR resonator is in resonance state, the relationship between impedance ratio K, characteristic impedanceZ_1,Z_2 and electrical length is θ_T as follows formula (2)

Through the joint calculation of formulas (1), (2) and (3), The following parameters can be obtained:

$$u = 0.57 \qquad Z_1 = 56\Omega \qquad \theta_1 = 47.88° \qquad \theta_2 = 36.12° \qquad \theta_T = 168°$$

The size of microstrip line is calculated by the linear Calc tool of ADS software. The feed mode of the filter is the side feed mode of the microstrip line feed, and the microstrip transmission line and the microstrip radiation patch are integrated to feed. For the microstrip filter, the tap feed mode is easy to realize strong coupling, and can generate transmission zeros on both sides of the passband.After bending the microstrip line and adjusting the parameters, Table 1 is the design size， and the side and top views of the filter are shown in Figure 1.

Table.1. Size of dual band microstrip filter

parameter	Value(mm)
L_1	6.11
L_2	3.51
L_6	2.63
W_1	0.48
W_2	0.46
S_1	0.27
S_2	1.97
S_3	0.05
H	0.635
H_1	0.018
t	0

Table.2. Optimized size of dual band microstrip filter

parameter	Value(mm)
L_1	5.9338
L_2	4.1471
L_6	2.4308
W_1	0.4768
W_2	0.401
S_1	0.2664
S_2	3.4504
S_3	0.0493
H	0.635
H_1	0.018
t	0

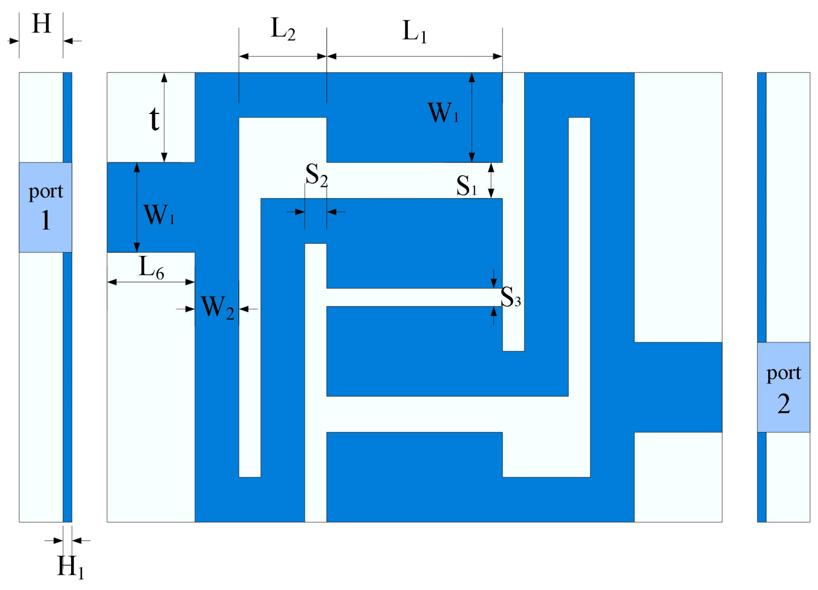

Fig.1. Side and top views of the filter

Analysis of Microstrip Filter

In this paper, a symmetrical L-shaped microstrip filter is proposed. Before modeling, design variables are defined and added in HFSS according to the previous design parameters. After the variables are added, a dielectric substrate made of Rogers ro3010 is created by using the cuboid modeling tool, and then the left L-shaped filter is modeled by the cuboid modeling tool. The modeling part includes the microstrip radiation patch and the microstrip feeding patch, all of which are 0.018mm thick, and the material of the microstrip patch is copper. The second L-shaped microstrip line on the right can be obtained by rotating the L-shaped filter on the left side through a rotation copy operation, first rotating the Z-axis by 180 ° and then translating the second microstrip line obtained by rotation, translating the w-length in the X direction and the L-length in the Y direction. After the microstrip line is established, a new plane with width of W_1 and height of H + H_1 is created at the edge of the feeding patch of the left microstrip line, and the plane is rotated and copied. The specific steps are consistent with the above steps, so the second plane is obtained. The first plane and the second plane are respectively added with the Lumped port excitation. At this time, the excitation source of the filter has been set. After adding air cavity to the filter, setting the dielectric ground and radiation boundary, the model of microstrip filter is basically established. After modeling, the filter is simulated and the waveform is shown in Figure 2. It can be seen from the figure that the first valley bottom is not on the designed frequency point and its S_{11} > - 20dB does not meet the design conditions. Although S_{11} is less than - 20dB, the frequency point is not in the center of passband, and the waveform is not perfect, so the corresponding parameters are scanned first.

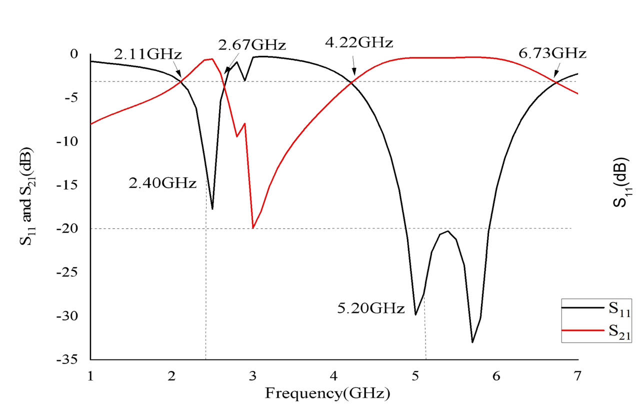

Fig.2. Simulation of filter design size

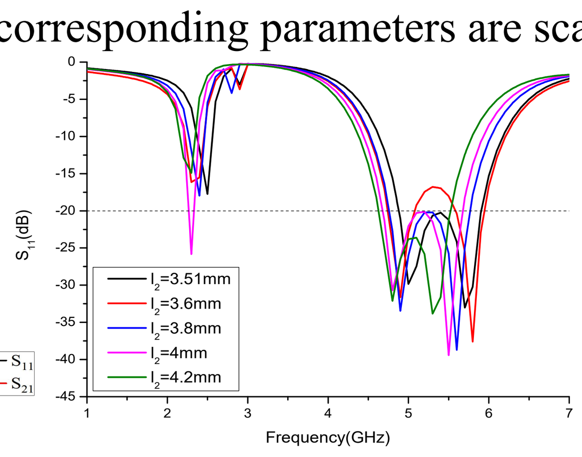

Fig.3. The effect of changes in L_2

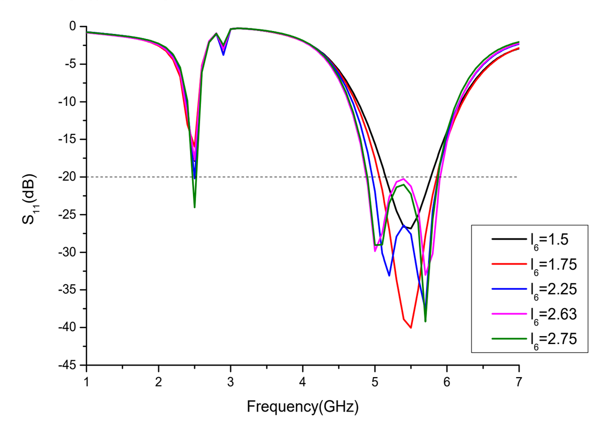

Fig.4. The effect of changes in L_6

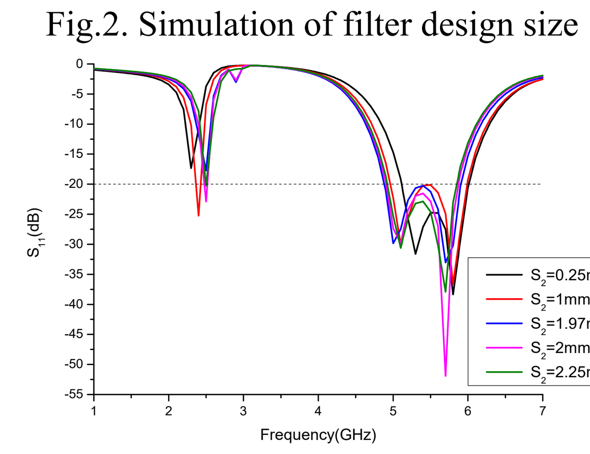

Fig.5. The effect of changes in S_2

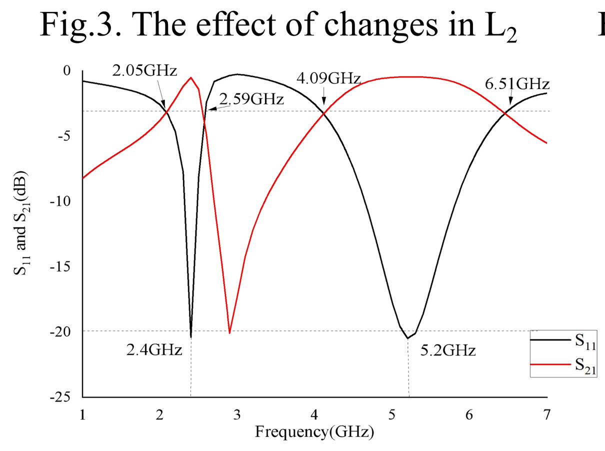

Fig.6. Optimization Results

It can be concluded that L_2, L_6, S_2 and other parameters have a great influence on the waveform of the filter, and other parameters are designed accurately.

Figure 3 shows S_{11} results after L_2 scanning. From Figure 3, it can be seen that the size of L_2 has a great influence on the frequency point. The larger L_2 is, the more left the frequency point moves, and the closer the two frequency points are. Because the relationship between L_1 and L_2 is also electrical length, choosing appropriate L_2 value and L_1 for scanning parameter can get better results. It can be seen from Fig. 4 that the influence of L_6 is mainly the S_{11} value of two frequency points, and the S_{11} value of 2.4GHz increases, the S_{11} value of 5.2GHz decreases, or the S_{11} value of 5.2GHz increases and the S_{11} value of 2.4GHz decreases. Therefore, it is necessary to master the balance and select the most appropriate value for the required standard. From Figure 5, we can see the influence of S_2 size on the waveform. S_2 is the distance parameter between microstrip radiation patches. The larger S_2 is, the farther away from the coupling part can reduce the interference. The optimized objective function is set at the frequency points of 2.4GHz and 5.2GHz, S_{11}≤-20dB and S_{21}≥-2dB, with the weight of 0.5 respectively. The optimized cost value is set to 0.01. The final optimized waveform is shown in Figure 6. The optimized dual frequency filter has a working frequency of 2.2GHz-2.5GHz and 4.6GHz-5.9GHz, and meets the requirements of S_{11}<-20dB and S_{21}>-2dB and frequency points when operating at 2.4GHz and 5.2GHz frequency points. Round the optimized data to four decimal places, and Table 3 is the final optimized size.

Conclusion

In this paper, we design and implement a Sir dual frequency filter. By adjusting the coupling length and coupling distance of microstrip line, the optimal parameters of dual frequency filter are obtained. The resonant frequencies of the dual frequency filter are 2.4GHz and 5.2GHz, and meet the design requirements of S_{11} < - 20dB and S_{21} > - 2dB.

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