A High-Selectivity Microstrip Band-Pass Filter

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***Abstract*—In this paper a high-selectivity microstrip band-pass filter with parallel coupling microstrip line is proposed. This microstrip filter adopts Chebyshev's prototype structure, by adding microstrip line at one end of the parallel coupling line to implement circuit matching and adding a high-pass filter circuit at the other end to improve the transmission characteristics. The filter is designed and simulated by RF software. Compared with the traditional parallel coupled microstrip band-pass filter, the bandwidth of this filter is much narrower, transmission characteristics and reflection characteristics are much better from the simulation results.**

Keywords- microstrip band-pass filter; implement matching; matching circuit

I. INTRODUCTION

Microwave filter is an indispensable part of in the microwave and millimeter wave communication system, and it is the indispensable device in the microwave and millimeter wave systems, its performance is good or bad will often determine the signal quality of the entire communication system. Therefore, high-performance filter design is considered to be crucial for the development of radio frequency communication system. Numerous work has done to alter the structure of the microstrip filter to improve its performance. Jinjun Mo[1] present a high-selectivity microstrip band-pass filter and which is composed of a half-wavelength transmission line with two open-ended stubs at the center of the line. Hussein Shaman[2] use two asymmetric loading stubs designing a novel microstrip parallel-coupled line filter. Sandra Marín[3] by using lumped-element bisected-pi sections at the filter input/output based on the introduction of transmission zeros to improve the stopband response of planar band-pass filters. Parallel coupled microstrip band-pass filter is composed of cascade coupling unit, now has a more mature broadband design method[4], and it widely used in the form of planar microstrip circuit, because of its simple design procedure and insensitivity to manufacturing tolerance[5]. However, the bandwidth of the parallel coupled microstrip band-pass filter is usually wide and the reflection characteristic of the filter is not very good. In this paper the bandwidth of the filter designed is narrower, and the transmission characteristics and reflection characteristics are much better.

II. DESIGN OF THE MICROSTRIP BAND-PASS FILTER

The technical indicators and the basic parameters of the filter: the center frequency of the microstrip filter is 2.5GHz; the bandwidth of the filter is 50MHz; attenuation in the pass band is less than 3dB; attenuation is more than -20dB at 2.45GHz and 2.55GHz; port reflection coefficient is less than -20dB. The main design steps are as follows[6]:

The relative bandwidth and normalized frequency of the filter:

$$W = \frac{\omega_2 - \omega_1}{\omega_0} \tag{1}$$

$$\Omega = \frac{\omega_0}{\omega_2 - \omega_1}\left(\frac{\omega}{\omega_0} - \frac{\omega_0}{\omega}\right) \tag{2}$$

It can be calculated that the filter is four order by the 0.01dB ripple Chebyshev low-pass filter stop-band attenuation characteristic curves and the normalized frequency. Normalized parameters of four degrees Chebyshev filter circuit are g0=1; g1=0.7168; g2=1.2003; g3=1.3212; g4=0.6476; g5=1.1007. Then the odd-even module feature impedance of the coupling transmission line is obtained:

TABLE I. THE ODD-EVEN MODULE FEATURE IMPEDANCE OF THE COUPLING TRANSMISSION LINE. (j REPRESENTS THE COUPLING SECTION UNIT)

j	$(Z_{0e})_{j,j+1}(\Omega)$	$(Z_{0o})_{j,j+1}(\Omega)$
0	60.243	39.754
1	49.526	46.277
2	49.098	46.706
3	49.529	46.276
4	60.243	39.755

TABLE II. THE SUBSTRATE PARAMETERS OF THE MICROSTRIP FILTER

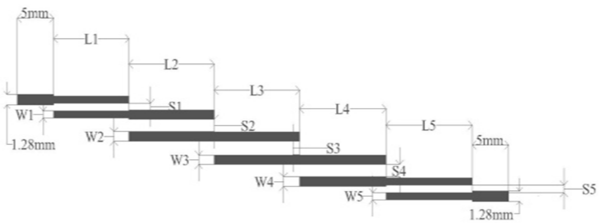
Parameter	Value
Dielectric constant (Er)	9.8
Microstrip relative permeability (Mur)	1
Substrate thickness (H)	1.27 mm
Microstrip package height (Hu)	3.9e+034 mm
Copper foil thickness (T)	0.018 mm
Copper conductivity (Coud)	5.78e6
Loss tangent (Tan d)	0.0001

Set the parameters in the Table I and Table II to the RF software, and then calculate the microstrip line structure parameters (namely W, S, L).

TABLE III. THE STRUCTURE PARAMETERS OF THE MICROSTRIP LINE

j	W(mm)	S(mm)	L(mm)
0,4	1.1663	0.8262	11.7874
1,3	1.3001	3.9797	11.5914
2	1.2991	4.9855	11.5857

Then optimize the schematic and layout of the filter, the schematic and the layout simulation of the optimized filter as shown in Figure I, and the specific dimensions of the parallel coupling line are shown in Table IV.



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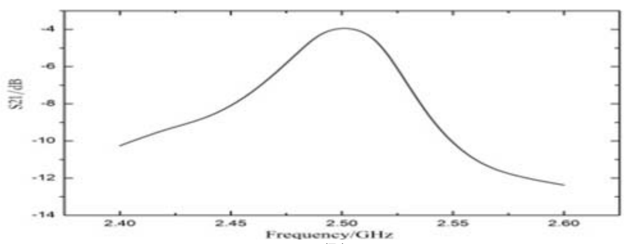

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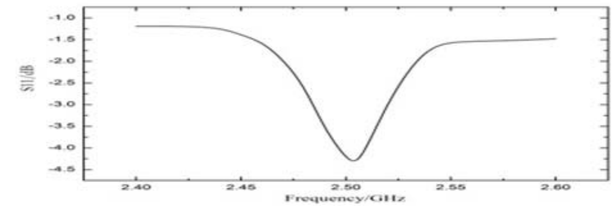


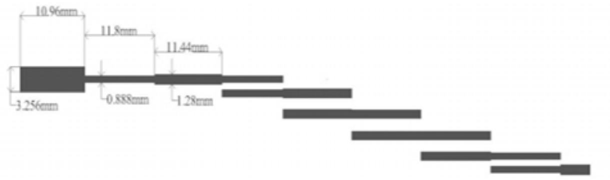
(C)

FIGURE I. (A)THE OPTIMIZED FILTER SCHEMATIC. (B)THE FREQUENCY RESPONSE CURVE OF THE TRANSMISSION COEFFICIENT S_{21}. (C) THE FREQUENCY RESPONSE CURVE OF THE REFLECTION COEFFICIENT S_{11}

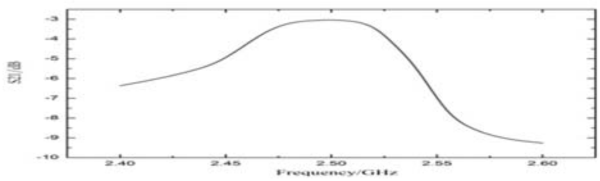
TABLE IV. THE SPECIFIC DIMENSIONS OF THE PARALLEL COUPLING LINE

coupling area code	1	2	3	4	5
W(mm)	0.86822	1.14515	1.12747	1.14512	0.86821
S(mm)	0.91740	1.52027	1.70146	1.52024	0.91745
L(mm)	10.32207	11.66093	11.72336	11.81943	11.81943

From the plots of frequency response curve in Figure I (A) and (B), we can see that the passband attenuation is not ideal and S11 parameter is too large, therefore need to add the matching circuit. Here change the microstrip line which most left side the parallel coupling microstrip line into three sections of microstrip line[7], the schematic and simulation results after the match are shown in Figure II.



(A)



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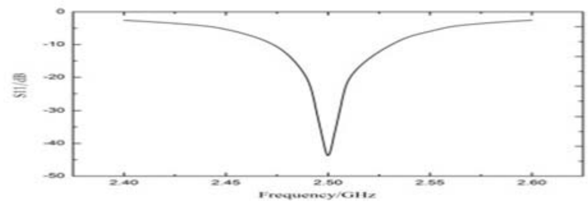

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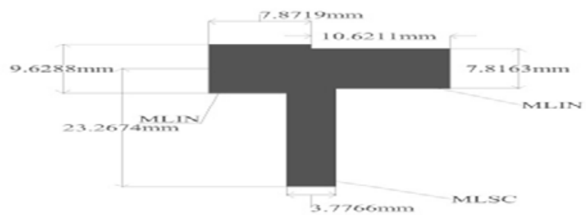
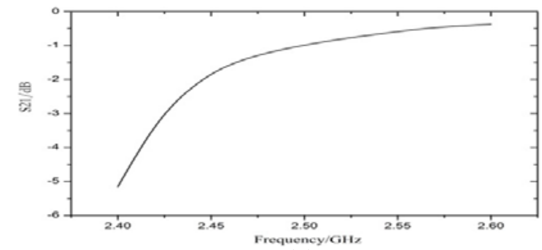
FIGURE II. (A)THE FILTER SCHEMATIC AFTER THE MATCH. (B)THE FREQUENCY RESPONSE CURVE OF THE TRANSMISSION COEFFICIENT S21. (C) THE FREQUENCY RESPONSE CURVE OF THE REFLECTION COEFFICIENT S11

From the Figure II (C) we can clearly see that the filter circuit has been matched, but from Figure II (B) it is obvious that the transmission characteristic of the filter is not very good. Here add a matching circuit at the right of the parallel coupled microstrip line to improve the transmission characteristics, the schematic and simulation results of the matching circuit are shown as Figure III.



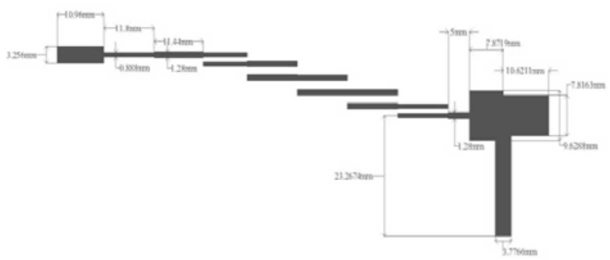
(A)

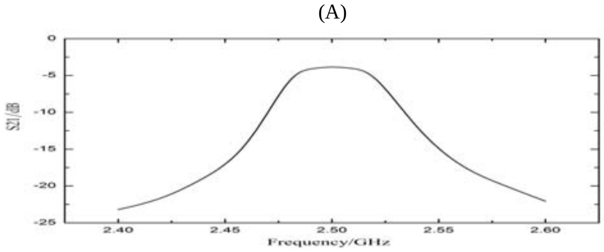


(B)

FIGURE III. (A)THE SCHEMATIC OF THE MATCHING CIRCUIT. (B)THE FREQUENCY RESPONSE CURVE OF THE MATCHING CIRCUIT

As can be seen from the simulation that the entire filter circuit transmission characteristics is not very good after the matching circuit to join. Once again using RF software to optimize, the schematic and simulation results of the final microstrip filter are shown as Figure IV, and the specific dimensions of the final parallel coupling line is shown as Table V. It can be seen from Figure. IV (B) and (C) that the layout simulation results of the final filter basically meet the design requirements.


(A)



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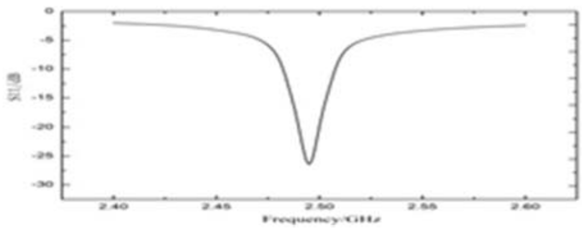

(C)

FIGURE IV. (A)THE SCHEMATIC OF FINAL MICROSTRIP FILTER. (B)THE FREQUENCY RESPONSE CURVE OF THE TRANSMISSION COEFFICIENT S21. (C) THE FREQUENCY RESPONSE CURVE OF THE REFLECTION COEFFICIENT S11

TABLE V. THE SPECIFIC DIMENSIONS OF THE FINAL PARALLEL COUPLING LINE

coupling area code	**1**	**2**	**3**	**4**	**5**
W(mm)	1.07660	1.13595	1.40183	1.22527	1.05751
S(mm)	1.08435	1.3289	1.27816	1.33172	1.08434
L(mm)	10.28077	11.4511	12.02772	11.84306	11.65395

III. RESULTS AND DISCUSSION

The transmission characteristics of the parallel coupled microstrip band-pass filter designed by the traditional design method are usually not ideal, and the reflection is large. Figure I shows that the transmission characteristic of the microstrip filter does not meet the design goals and the S11 parameter is too large. Therefore need to add the matching circuit which left side the parallel coupling microstrip line. From the Figure. II (C) can obviously observe that the filter circuit has been matched, but the transmission characteristic of the filter is not very good. Therefore, it is necessary to further adjust the filter circuit, and then improving the transmission characteristics of the filter. We know that it is possible to improve the transmission characteristics of the band-pass filter by cascading the band-pass filter and the low-pass filter, joint simulation optimization[8]. From the Figure II(B) the transmission characteristic curve of the filter is asymmetrical on both sides of the center frequency. Therefore, it is necessary to change the element value so that the center attenuation keeps stable, and the frequency transmission characteristic curve is symmetrical on both sides of the center frequency. So think of adding a high-pass filter circuit at the right of the parallel coupled microstrip line to improve the transmission characteristics. Next design the high-pass filter circuit and adjust its 3dB attenuation position so that the final output can achieve a better bandpass. However after joining the high-pass filter circuit at the right of the parallel coupled microstrip line, the entire circuit is not very match, the center frequency attenuation is biger and biger, and the signal to noise ratio reduces because of the multi-level filtering. Once again using RF software to optimize till meeting the design requirements. At this point, it is a relatively satisfactory design that obtain ideal passband attenuation in a smaller reflection coefficient.

IV. CONCLUSIONS

In this work we design a high-selectivity microstrip band-pass filter based on the traditional parallel coupling microstrip bandpass filter. By adding microstrip lines and filtering circuit to improve the frequency transmission characteristics and reflection characteristics. From the layout simulation results of the final filter can be seen that the bandwidth of the filter designed is narrower, and the transmission characteristics and reflection characteristics are much better. We can see from the filter design process that the insertion loss of the filter is somewhat large due to design errors and the influence of environmental factors.

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