Compact Bandpass Filter Structure Using an Open Stub Quarter-Wavelength Microstrip Line Corrections

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Abstract — **In this paper, bandpass filter development with the assistance of the Richards- Kuroda Transformation method, on the basis of the known Chebyschev-Lowpass Filter, is presented [1]. A new compact microstrip bandpass filter using a quarter-wavelength λ/4-Transmission Line resonator is proposed[2].The suggested filter consists of four coupled microstrip lines, two are shorted to the ground by an inductive microstrip line, and the other two are coupled together by means of a J-Immitance inverter [3]-[5].**

changing the long open stub, the center frequency shifts to the left or to right within the frequency range. Two-pole–Chebyschev bandpass filter is fabricated, and tested at 4.55GHz.

I. Introduction

Modern personal communication systems require miniaturized high performance bandpass filters having high selectivity in the passband and low insertion loss in the stop band.

This type of filter design is of key importance for the radio frequency engineer, since they are currently used in communication application to reject spurious signal, and to separate different channels in multichannel communication system. Microstrip line bandpass filters with these characteristics must be designed with direct coupling, in order to minimize the dispersion and radiation losses. In order to realise the selectivity, other filters with λ/2 resonators may be used, but the disadvantage here is that they are long and therefore can not be used in all application. To eliminate this disadvantage and thus to manufacture a bandpass filter which is compact and useful in personal communication systems, we suggest a class of bandpass filters, which filters consist of four coupled microstrip lines. Two microstrip lines are shorted to ground by means of inductive microstrip line. The two remaining ones are coupled together by means of a J-Immitance inverter. This structure is improved and simplified through transformation of the short-circuit at the equivalent open-end microstrip line, therefore short-circuits are avoided. In this paper, we describe, how the desired bandpass filters can be designed, using lowpass filters with well-known characteristics. We compare both the measured and simulated performances of the new compact bandpass filters.

II. The transformation from LPF to the BPF

The proposed lowpass filter is a Chebyschev filter of 3rd order, with a cut-off frequency f_c = 2.5GHz, and the element values for this filter are g_2 = 0.712 and $g_1 = g_3$ = 3.345. The filter is transformed into a bandpass one following the three steps listed below: First step: Transformation of lowpass filter to the high pass filter. Second step: The circuit is supplemented mutually with a unit-element. Third step: Kuroda-Transformation and the Method of coupled line Procedures are employed successively as shown in Fig.1. The resulted bandpass filter [6]-[8], that employs the first proposed configuration is shown in Fig.3.

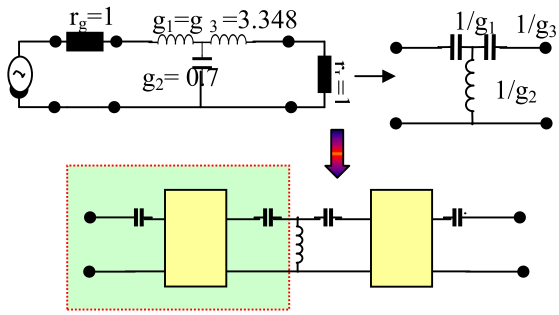

Fig.1 First .Step & Second .Step

III. Structure Description

This bandpass filter (Structure1) is composed of two microstrip quarter-wavelengths resonators and a tapped shorted stub with metallic ground. In order to avoid via holes short-circuits. We proposed another structure, in which the λ/4- the microstrip line will be corrected by means of the following length correcting :

$$\Delta l = \frac{k_1 k_2 k_5}{k_4} h \text{ with } k_1 \approx 0.435 \frac{\varepsilon_{r,eff}^{0.81} + 0.26\eta^{0.854} + 0.236}{\varepsilon_{r,eff}^{0.81} - 0.19\eta^{0.854} + 0.87}$$

$$k_2 \approx 1 + \frac{\eta^{0.371}}{2.358\varepsilon_r + 1} \text{ and } k_4, k_5, \eta = \frac{w}{h}$$

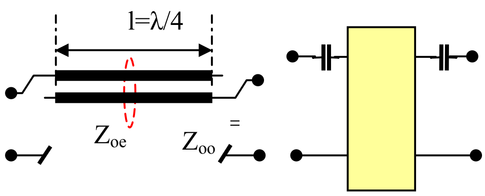

Fig.2 Third.Step & Microstrip coupled line

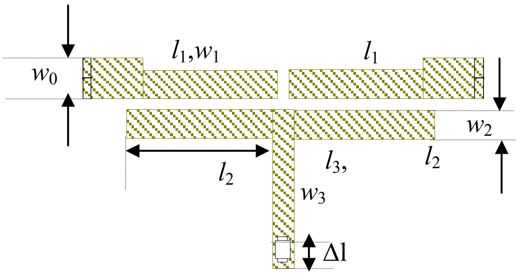

Fig.3 BPF with short- circuit (Structure1), $l_1=l_2=9.37mm,, l_3=5.37mm, w_1=1.45mm, w_2=1.25mm, w_3=1.85mm$

These corrections are applied simultaneously to the three microstrip line l_1, l_3, l_2. In the bandpass filter design (Structure2), the open stub has several important characteristics. By changing the length of the open stub, one can control the center frequency in the passband.

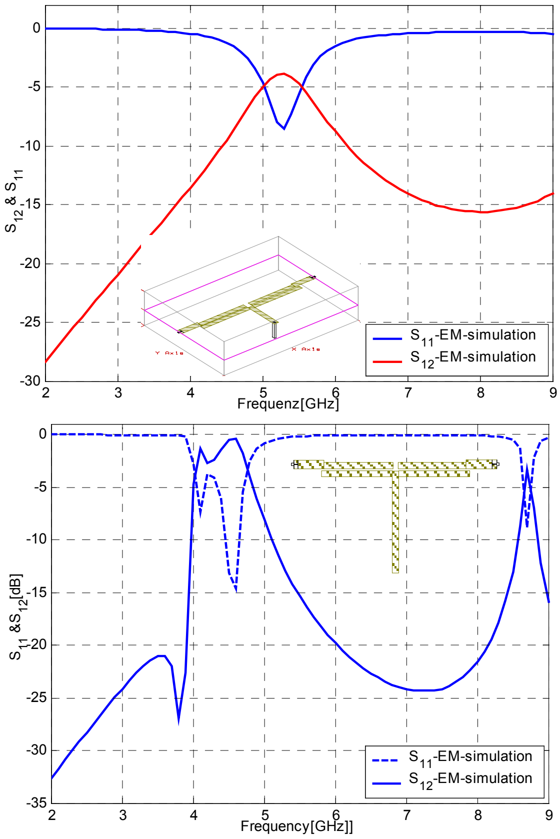

Fig. 4., 5. S_{11} & S_{12} of Structure 1. & Structure 2

IV. Experimental Performance

Bandpass filters based on the proposed method were designed, fabricated and tested. They were fabricated on GaAs substrate with a relative dielectric constant of ε_r = 3.38 and a thickness of h = 0.813mm. The characteristic impedance of the microstrip lines used as resonators is Z_{oe}=74 Ω , Z_{oo}=70 Ω and that of the open stub is 64Ω.

The proposed bandpass filter was designed to have a center frequency of 4.5GHz and a bandwidth of 0.75 GHZ. The circuit-simulation shows good agreement with experimental results. The comparison is shown in Fig. 6.

Turning the filter arms around л/2 reduces the dimension of the filter by approximately 49%, moreover the space of coupling becomes smaller, that causes good results and a high compactness. This is done in Structur(4), which offers with small losses in the passband. as shown in Fig. 7 & Table I.

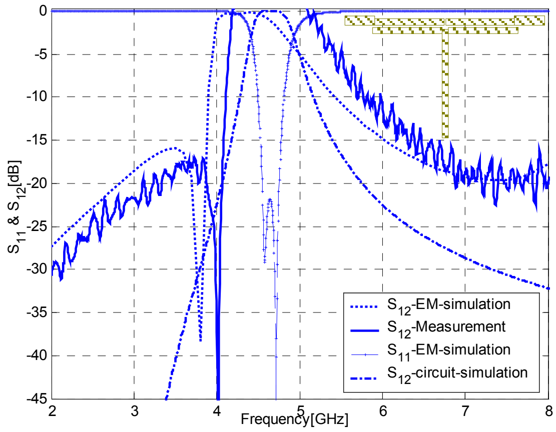

Fig. 6 The comparison of S_{12}-Parameters

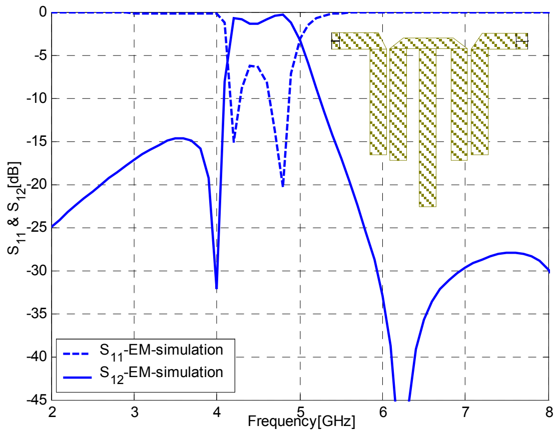

Fig. 7 The response S_{12} of Structure 3

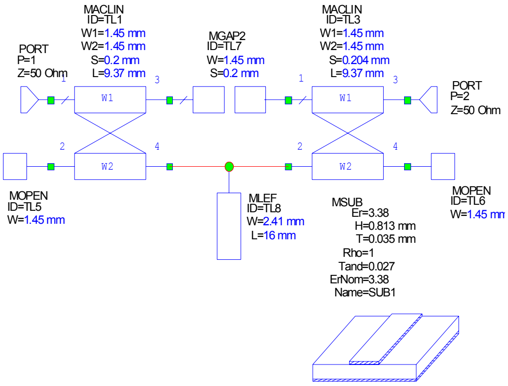

Fig. 8 Equivalent circuit network of the proposed BPF

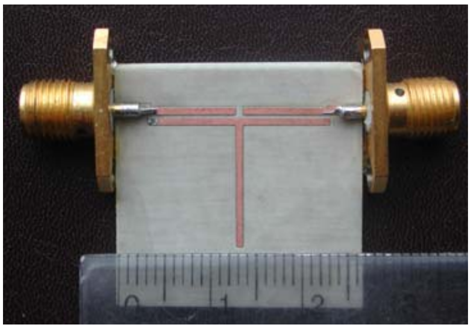

Fig. 9 Photograph of fabricated BPF (Structure3)

Table I
Comparative Study of The BPF-Filter with different geometric structures:

	Structure1	Structure2	Structure3	Structure4
S_{11max}(dB)	9	15	45	20
Bandpass-Band Losses(dB)	4.2	2.3	0.3	1.2
Center Frequency(GHz)	5.2	4.6	4.5	4.52

V. Conclusion

In this paper, the proposed λ/4–microstrip BPF and its equivalent circuit have been proposed.

In order to show the validity of the proposed BPF structure (3) and the derived equivalent circuit, the λ/4 – open-stub-BPF have been designed, fabricated, and then measured. Numerical simulations using Microwave Office show good agreement with experimental results.

Both simulation and measurement on the proposed "corrected"-BPF have demonstrated the optimum performances in passband and stopband.

The last compact BPF was simulated and compareted with proposed (structure3).

Complete agreement between the simulation results for these two filters have been found.

Although to the structure(4) is 49% compact as compared to the structure(3), the losses in the passband is slightly higher for this structure.

This newly proposed filters Structure (3)and (4) could also find various applications such as a multipole switch.

References

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