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Design of Microstrip Bandpass Filter with stub loaded resonators for WLAN Applications

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Abstract: *This paper presents the design of a compact planar Dual band bandpass filter for WLAN application. This filter is developed with two stepped impedance resonators. Two ends of both resonators are mutually coupled. In addition, thedesign equations are also provided. In SIR's the fundamental frequency and higher order harmonics can be easily tuned. The full wave electromagnetic simulation indicate that the filter shows a very good performance with insertion loss and return loss*
Index Terms: *Bandpass filter (BPF), dual-band BPF, Stepped impedance resonator(SIR).*

I. Introduction

The filter is one of the most important components for Wireless Local area Network . Microstrip filters are widely Used in RF/Microwave communications due to its compact Size, light weight, wide bandwidth. The communications standards have divergent specifications such as operating and frequency, modulation bandwidth and power level. Developing a single frequency should operate concurrently at different discrete frequencies. Hence there is a need for dual band or multiband filters.Dual-band bandpass filters (BPFs) especially have attracted many re-searchers. To design the filter with dual passbands, passband functions and two passbands' bandwidths Need to be taken into consideration. There are several studies on dual-band BPFs.

There are several studies on dual-band BPFs. Due to easy adjustment of one passband's frequency, the stacked dual-mode resonator is a good candidate for filters with dual passbands [1]. In [2], a dual-band BPF is obtained with the assistance of frequency transformation and circuit conversion. It is too complex. In[3] the filter design involves conventional network synthesis approach and a number of extra successive frequency transformations and circuit conversions.To obtain dual passbands, two individual circuits are employed for the laminated dual-band BPFs [4]. Furthermore, the frequency-selective resonators [4]–[6] and stepped impedance resonators (SIRs) [7] are often utilized for dual-band BPFs, too.

Two coupled lines , two transmission lines and two stubs are proposed for the planer dual-passband BPF in this letter; this structure is slightly different from [8], where the SIR's are adopted for a single-passband BPF. With the structure shown in

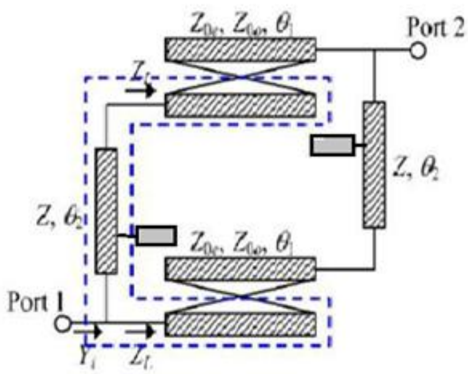

Fig. 1: Layout of proposed dual band BPF

Fig 1. a transmission zero appears in the middle of two equally separated passbands. Moreover, when the coupled line is fabricated with the unequal microstrip circuit, the even and odd-mode phase velocities will decrease the filter's rejection level. Fortunately, the coupling between two shifted coupled lines can better filter's performance in the rejection band.

Consequently, the rejection level obtained by electromagnetic (EM) simulation matches with the theoretical model. Besides, with the proposed filter, there would be a relatively large pass band central frequency ratio, there would be fairly flexible bandwidth ratio too. Furthermore the development of band pass filter including calculation, simulation and measurement of filter parameters has been presented.

II. Design Equations

Fig. 1 shows the architecture of the proposed dual-band BPF, consisting of two coupled lines and two transmission lines. When the absolute bandwidths of two pass bands are different ,the electrical length and are unequal. As a result, the design equations will be very complex. Therefore, equations for the filter with equal pass band bandwidth are introduced in this paper. With the electrical length and equal to , two pass bands with equal bandwidth are obtained. The input admittance ,the area surrounded by dashed lines in Fig. 1, can be then expressed as

$Yi = j \tan\theta[(Z+Z_L/Z(Z_L - Z\tan^2\theta) + 1/ Z_L)]$ (1)

Where $Z_L = \sqrt{Zoe.Zoo}$. (2)

$K= Z_L /Z$ (3)

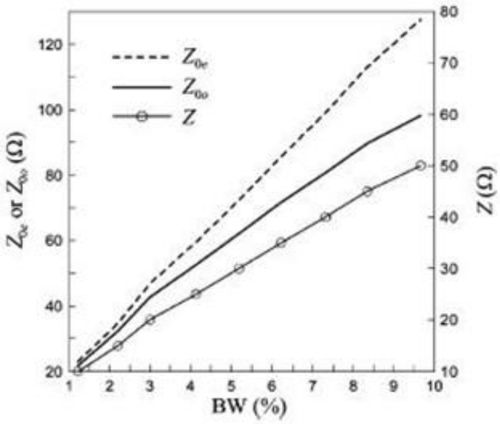

Fig. 2. Relationship between impedances Zoe, Zoo, Z_L and the first passband's absolute bandwidth *BW* with the return loss as 20dB.

The relationship between f1 and f2, each pass band's central frequency, is given by

$f1/f2 = \tan^{-1}\sqrt{(K^2+2K)}/(\pi - \tan^{-1}\sqrt{(K^2+2K)})$ (4)

Therefore, the electrical length θ can be obtained as

$\theta = \tan^{-1}\sqrt{(K^2+2K)}$ (5)

In addition, the electrical length can be also derived from the equation.

180°x f1/(f1+f2) (6)

Fig.2 illustrates the relationship between impedances , and the first pass band's absolute bandwidth *BW* with the return loss as 20dB. Particularly, with fixed , larger and will result in wider bandwidths because two pass bands can be determined by the -parameter. On the other hand, there will be lower rejection levels in the stop band. In addition, with the resonant condition, which is equal to zero, the transmission zeros in the out band can be obtained as

$f_{ZN} = f1.[(N-3). \pi/2] / \tan^{-)1}\sqrt{(K^2+2K)}$ (7)

where N=3,4,5

III. Filter Design

For the exemplary filter, 1 and 1.5 GHz are selected for and , the central frequency of dual passbands, respectively. The electrical length can be then obtained from (3) as 72 . When 3% is chosen for two passbands' absolute bandwidth *BW*, according to Fig. 2, the impedances , , and are 46.91 , 42.63 , and 20 , respectively. As a result, five transmission zeros fz1,fz2,fz3,fz4 and fz5 are derived from (7) as 0.78 GHz, 1.72 GHz, 0, 1.25 GHz, and 2.5 GHz, respectively for the proposed dual-band BPF.

IV. Experimental Results

The exemplary filter in this paper is fabricated on FR4 substrate.This substrate's dielectric constant, loss tangent, dielectric thickness, and metal thickness are 4.4, 0.018, 0.8 mm, and 0.02mm, respectively. These theoretical values are then converted to dimensions of the dual-band BPF .

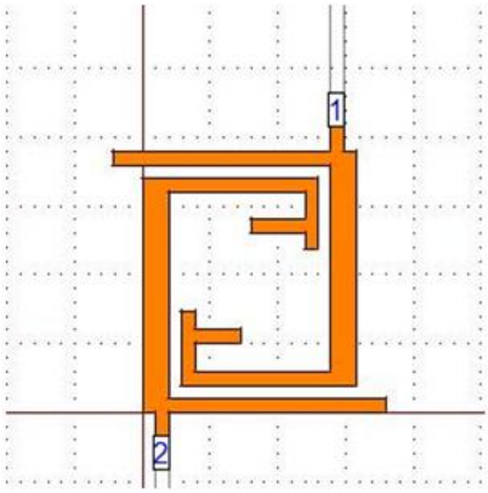

Fig 4. Structure of the dual band band pass filter.

Fig 4 depicts the structure of the dual band BPF and Fig. 5 gives EM simulation and theoretical rediction of the dual-band microstrip BPF. In particular, a spurious peak with a large bandwidth can be observed at 2.5 GHz. Because the coupled lines fabricated with micro strip circuits make unequal even- and odd mode phase velocities.

In order to compensate the unequal the capacitive [9] or inductive [10] compensation, corrugate lines [11], or wiggly lines [12] have been proposed. However, these design procedures are relatively complicated. In [13] a novel structure for dual band band pass filter was proposed. In this paper the structure given in [13] is modified in order to get improved results for insertion and return losses.

With the shifted couple lines, an additional coupling will be resulted being coupled to in Fig. 4. Thus, the spurious caused by the microstrip circuits can be suppressed. Moreover, the spurious peak can be eliminated so that the response represented by the dashed lines in Furthermore, with the coupled line's insertion loss as zero, the coupled length for the shifted coupled line can be obtained from where and are the even- and odd-mode characteristic impedance, respectively. In addition, Table II shows dimensions of the abricated dual-band BPF with shifted coupled lines.

EM simulation and measurement of the dual-band BPF with shifted coupled lines. In terms of measurement, within the first passband, 0.98–1.02 GHz, the insertion loss is smaller than -32 dB while the return loss is greater than -3 dB. Likewise, within the second passband, 1.47–1.52 GHz, the insertion loss is smaller than -42 dB while the return loss is greater than -2 dB. In addition, transmission zeros are located at 0, 0.78, 1.23, 1.79, and 2.53 GHz. The outcome matches well with the EM simulation.

V. Conclusion

A novel structure is developed for the dual-passband BPF in this letter. In particular, dual passbands are achieved by cascading two coupled lines and two transmission lines. Moreover,with the assistance of shifted coupled lines, the spurious peakresulted from microstrip circuits can be eliminated. Finally, a good match between EM simulation and masurement validates our proposed circuits.

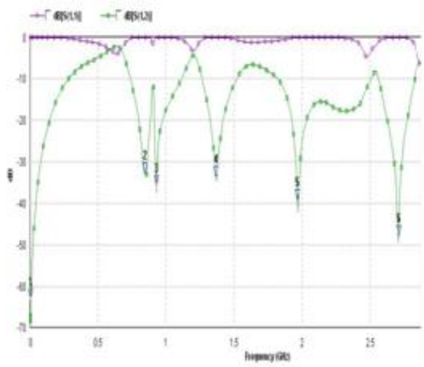

Fig 5. EM simulated result of the proposed dual band BPF.

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