Dual-Band Ring Resonator for Narrowband Application

Nor Fazira Binti Abd Kadir
Faculty of Electrical Engineering
Universiti Teknologi MARA Malaysia
40450 Shah Alam, Selangor, Malaysia
norfaziraabdkadir@yahoo.com

Abstract — **In this paper, a combination of rectangular-shaped ring resonator with three quarter wavelength coupled lines and a stub is proposed to produce a very narrow dual band filter response. The resonator, which in pairs to a high impedance microstrip line, will generate two operating modes in the desired band. The consequences in varying the length of tuning stubs and gap size between tuning stubs and ring resonator have been studied. Realized on FR4 microstrip substrate, the filter is centered at 2.6GHz and 3.4GHz. The measurement results are found to be equivalent with the simulation.**

Index Terms* — *Ring resonator, dual mode, transmission zeros, coupled lines, microstrip line, stub.

I. INTRODUCTION

As wireless communication technology develops rapidly, the microstrip filters with high frequency selectivity, compact size, and wide stopband are highly demanded nowadays [1]. In details dual band resonators have also been widely used in microwave and millimeter wave systems with quite a few types of dual mode microstrip resonators with perturbation element had been investigated, including EBG-based resonator, ring resonator, square ring resonator, multi-arc resonators [2-3]. Moreover, dual-band bandpass filter is one of the key components in the frequency transceiver circuits that must be designed according to the stringent specifications such as selectivity, size and cost [4].

The bones of dual band are two degenerates mode, which excited by asymmetrical feed lines, added notches, or stubs on the ring resonator. Hence, the coupling between the two degenerate modes can be used to produce a bandpass filter [5-6]. Bandpass filters are very important components used to eliminate unwanted harmonics and spurious signals in microwave system. Other than that, these resonators also consist of five transmissions zeros which in create in order to sharpen the rejection skirt, suppress two high harmonic resonant modes and deepen upper-stopband [7].

As the matter of fact, high return loss, low insertion loss and high rejection band are well known to be the desired characteristics of a good filter. Nevertheless, a conventional end to side coupling ring resonator suffers from high insertion loss, which is due to the circuit's conductor, dielectric, radiation losses and an insufficient coupling between feeders and the ring resonator [8].

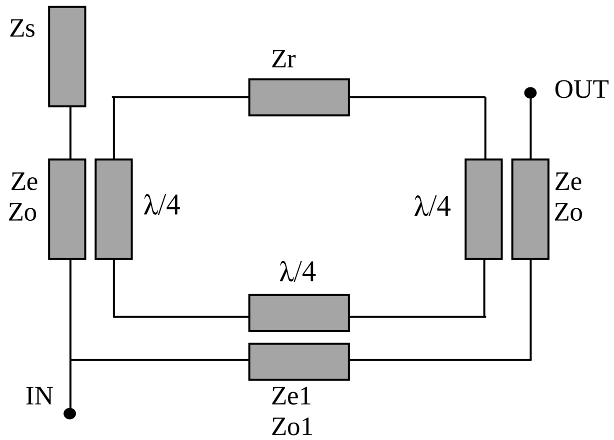

Fig.1 Topology of the proposed dual band ring resonator.

The strength of coupling and resonator frequency is strongly effect by the size of the coupling gap between ring resonator and feed lines. For example, the ring resonator has a tight coupling and can produce a low insertion loss, but the resonant frequency will be affected greatly when the coupling gap size is narrow, however, the ring resonator will has a high insertion loss and the resonant frequency is slightly affected for a wide gap size [9].

The work presented in this paper proposes an original dual-band filter topology derived from three quarter-wavelength square shape ring resonator with one stud attached to it.

In this paper, dual band resonator for narrowband with five transmission zeros using microstrip with low insertion loss had been developed, hence to enhance the coupling and to generate the perturbation for dual mode excitation, coupling arm had been introduced. The effect of the coupling gap and stub length had been studied [10].

II. DUAL-BAND RING RESONATOR DESIGN

In general, the basic structure of the proposed dual band resonator is shown in Fig. 1. The tuning stub is attached to the end of the quarter-wavelength coupling line as seen from the circuit layout.

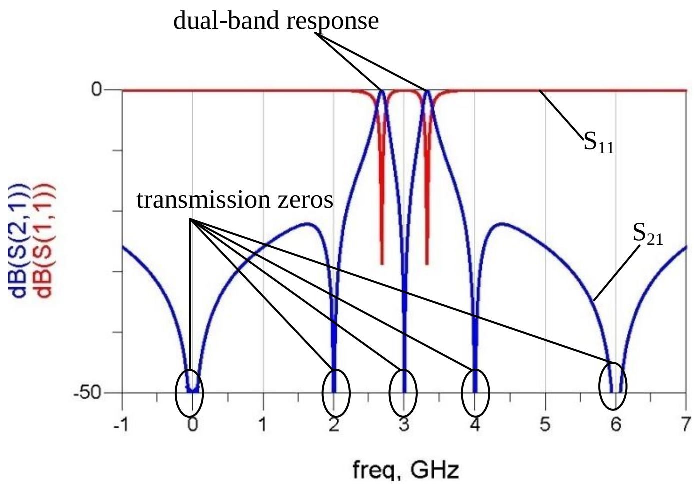

Fig.2 Frequency response of the proposed dual-band ring resonator.

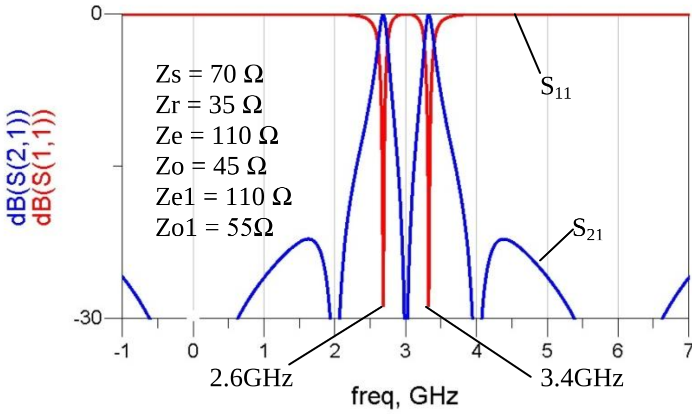

Fig.3 Ideal frequency response of the proposed dual-band ring resonator with a set of impedances.

A working configuration of these parameters values will exhibit a dual-band bandpass response as shown in Fig.2 where the reference frequency of the transmission line length is at 3GHz. The quarter-wavelength couple line creates a bandstop effect exactly at 3GHz which explains the dual-band response produced by the proposed topology.

As shown in Fig.3, 2.6GHz and 3.4GHz are the center frequencies of the first and second passbands. 3GHz frequency is found to be exactly at the center between the passbands. Each passband response is a first order, as one pole exists in the response. A total of five transmission zeros are found in the frequency response of the filter and this will ensure a good level of selectivity.

Furthermore, the other characteristic of the filter response is the amount of frequency separation between the passbands, the bandwidth and the ripple level of the passbands can be varied by varying the impedance of the filter elements (Zr, Zs, Ze, Zo, Ze1, Zo1).

In this experiment, a set of impedances values had been determine in order to get the response as in Fig.3 where Zs = 70 Ω, Zr = 35 Ω, Ze = 110 Ω ,Zo = 45 Ω, Ze1 = 110 Ω, Zo1 = 55Ω.

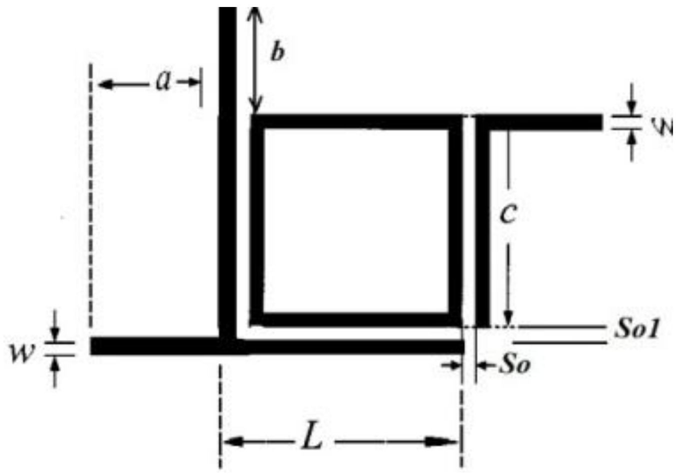

Fig.4 Circuit layout of the microstrip dual-band ring resonator.

III. DUAL-BAND RING RESONATOR REALIZATION

This new topology filter was designed for the center frequency of 2.6GHz and 3.4GHz and fabricated on 1.6mm thick FR4 substrate with dielectric constant ε_r = 4. The circuit layout of microstrip filter is presented in Fig.4. The length of the feed lines is a=15mm the width of the microstrip line is w=2 mm for a 50Ω line, the length of the stubs is b=13mm the gap size between the ring resonator and coupling stubs is So1=0.8mm and So=0.3mm, and the length of one side of the square ring resonator is c=1.4mm.

The response of this resonator had been gain by simulation which had been completed using simulation software. A circuit of this ring resonator is proposed by using all transmission lines with ideal values. Usually, lumped elements is used in order to designed a filter as an ideal lumped elements is not realizable even at lower microwave frequencies, each component has associated electric and magnetic fields and finite dissipative loss.

The simulation had been run in order to obtain the response as in Fig. 2. From the response it can be observed that the center frequency is definitely obtained at 2.6GHz and 3.4GHz. The response below showed that narrow band with return loss of -29dB.

As mentioned above, transmission lines used ideal values of elements. Microstrip line consist of a conductive strip of width W and thickness t and a wider ground plane, separated by dielectric layer of thickness H. A microstrip is also characterized by its attenuation. The attenuation constant is a function of the microstrip geometry, the electrical properties of the dielectric substrate and the conductors, and the frequency.

There are two types of losses in a microstrip line which is a dielectric substrate loss and the ohmic skin loss in the conductors. The losses can be expressed as a loss per unit length along the microstrip line in terms of the attenuation factor. In dielectric substrates, the dielectric losses are normally smaller than conductor losses. However, dielectric losses in silicon substrates can be of the same order or larger than conductor losses. Microstrips also have radiation losses.

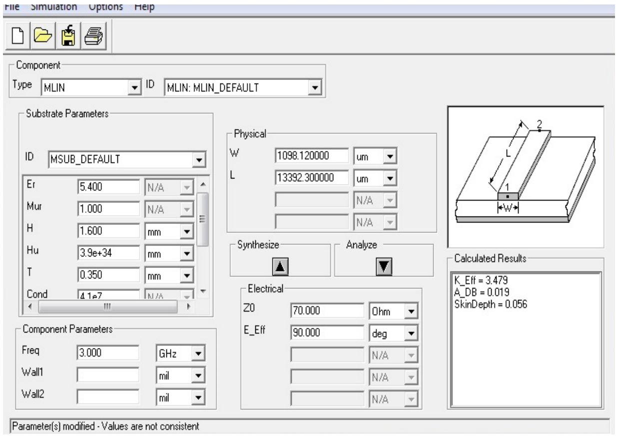

Fig. 6 The Line Calculate in Advanced Design System.

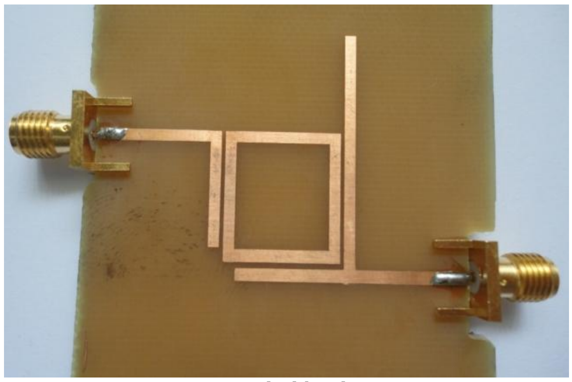

Fig. 7 Microstrip dual-band ring resonator.

Before converting the ideal transmission lines elements to microstrip transmission line, some adjustment must be done. The elements from ideal transmission lines is calcuted together with the actual values such as by adding the dielectric constant, thickness of the microstrip, the center frequency required and etc. using Line Calculate as in Fig. 6. From the Line Calculate the length and the width for microstrip elements is obtanied.

By using the actual values in microstrip transmission lines, the elements in the circuit are calculated together with the parasitic losses. The more elements used in the circuit the harder to get the response as previous. This is because the number of elements is directly proportional to the losses in other way the more elements used; it will produce more parasitic losses. Parasitic losses will affect the response of the resonator and make the response differ from previous as using the transmission lines.

After inserting the values synthesis from Line Calculate it can be observed that the response is totally not the same as the ideal. Thus, several adjustments and tuning need be done to get back the desired response. The response is shift in frequency to the right and as well as the return loss of dB (S (1, 1)) is less than -20dB. Low return loss shows that the system is good because only small amount of signal is reflected back.

Then, after satisfied with the response, the next step is to create the layout of the circuit. In order to create the layout there are several precautions that must be taken care of such as every element in the layout must connected to one another to avoid losses.

In order to obtain a good the momentum response, the microstrip line's value is adjusted one by one and the effects by varying the values is noted. From this step, it can be said that by varying the length of the microstrip lines, it will affect the shifting of the frequencies as the length is shorten, the frequencies will shift to the right and vice versa. Moreover, by decreasing the gap between the coupling lines, it will increase the affected the height of the response.

From the momentum response, it can be observed that the response is changing from bad to worse. This is

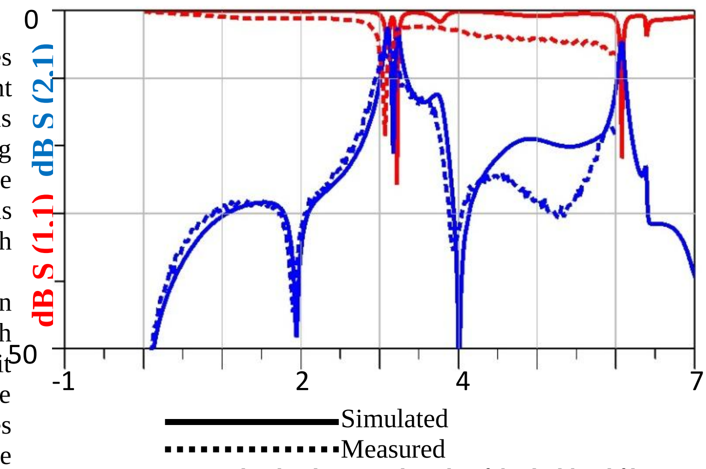

Fig.8 Simulated and measured results of the dual-band filter

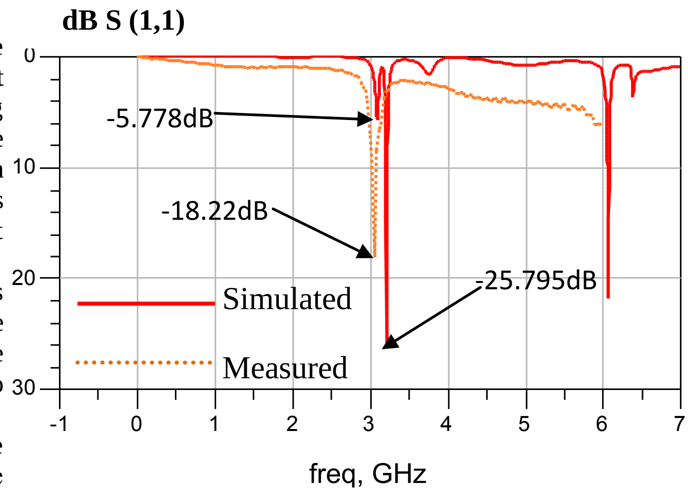

Fig. 9 Simulated and measured results of the dual-band filter for dB S(1,1)

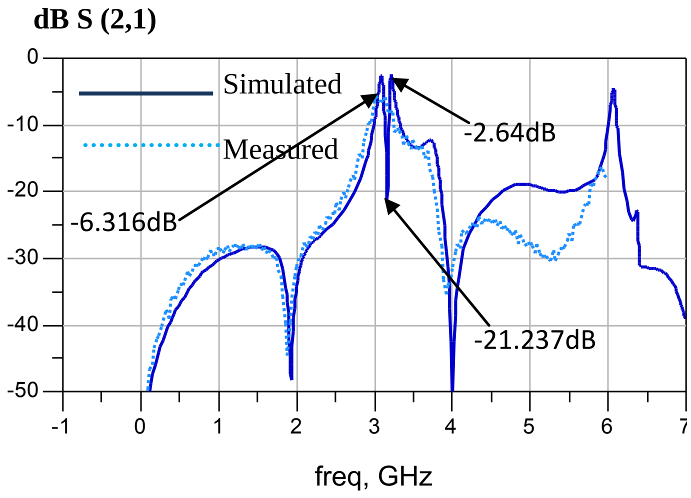

Fig. 10 Simulated and measured results of the dual-band filter for dB S(2,1)

because, in momentum response the layer of the microstrip, thickness and dielectric constant as well as all the actual losses in concerned.

After studying the characteristic of the filter, a compact dual-mode resonator is fabricated on FR4 substrate with dielectric constant ε_r = 4 through the standard PCB fabrication process and its photograph are shown in Fig. 7. The comparison of measured and simulated frequency response of the S-magnitude is shown in Fig. 8 and illustrated is not good agreement with simulated results.

Fig. 9 and Fig. 10 show the compared result of simulated and measured response for dB S(1,1) and dB S(2,1) respectively. The passband centered at 3.06GHz and the insertion loss of -6.316dB is mainly due to the high loss tangent of the substrate and radiation loss of the microstrip. The dispersion of the material toward the frequency had caused the center transmission zeros that separates the passband is not exactly at 3GHz.

The performance of the fabricated response and simulated response had been compared. The dual mode of dB (S (1, 1)) magnitude from fabricated response is only appearing at one frequency with -18.222dB. And the dB (S (2, 1)) is -7.234dB which it supposed to be in dual band with both at -0.845dB. Moreover, there are only three transmissions zeros and no dual band exist in the fabricated response.

IV. CONCLUSION

In this paper, a dual band resonator for narrowband application with five transmission zeros has been proposed. By changing the length of tuning stubs and gaps size between the tuning stub and ring resonator, the insertion loss and frequency response of the filter can be optimized. To acquire a low insertion loss and band pass characteristic, the ring resonator should have stronger coupling between the feeders and ring resonator.

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