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DESIGN OF MICROSTRIP BANDPASS FILTER WITH SQUARE LOOP RESONATORS

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ABSTRACT : This letter proposes a dual band microstrip bandpass filter for dual band applications at 1 to 3 GHz for communication systems. the pass band of the filter covers 1.6 GHz in first band and 2.1 GHz in second band The design consists of four square loop resonators also known as loading elements present internally helps in designing compact filter. The advantage of the microstrip bandpass filters are that it is easy to integrate in the RF device, convenient to design, small in size and low insertion loss. This design is simulated using FR_4 substrate with dielectric constant of 4.6 and copper as the conductor.

I. INTRODUCTION

A Dual_band bandpass filter is a key component of wireless communication system. As dual_band bandpass filters are can operate in different frequencies these are widely used in communication systems [1]. Design of the microstrip bandpass filter with high performance and its compact size has great interest.

There are many different design procedures for designing dual_band bandpass filter using dual mode resonators [2][6]. Intuitively, a dual-band filter can be designed with the combination of two single-band bandpass filters with additional external combining networks [3-4]. In [5] a dual_mode dual_band bandpass filter is achieved using square loop resonator in open circuited stub, which reduces the total size but also creates a second bandpass filter. The center frequency controlling is achieved by changing the connection of loading elements. In [5] the design is fabricated in RT/Duroid as the substrate with thickness of 1.2mm and In and Out connected to the design by means of couplers with dimension of 25×25 mm^2.The proposed bandpass filter is designed and simulated with Advanced Design System(ADS).

II. DESIGN

The filter presented here is basically the same filter equivalent circuit of [7] the major difference is the substrate used and the source is applied directly to the design without the couplers

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A. Iteration 1

In [3][4] the designing of the single band filter is designed by the combination of the two single bandpass filter. Fig.1 single_pass bandpass filter consists of the two square loop resonators in the open circuited stub. The square loop resonators are placed internally for the reduction in the dimensional size. The pair of square loops resonators in the circuit improves the gain and return loss based on the dimension of the resonator. When the dimension of the stub determines the passband frequency. The simulated result is shown in the Fig.2

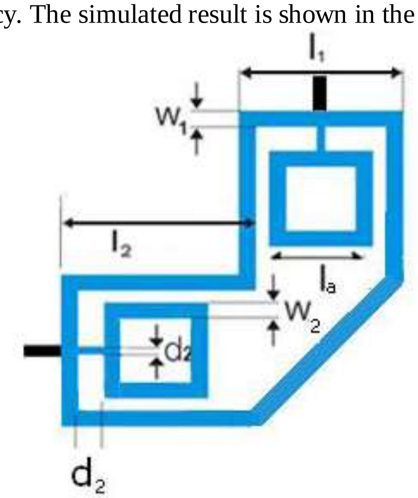

Fig.1: single_pass band pass filter

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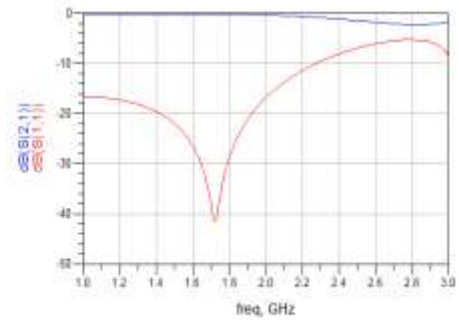

Fig.2: simulated result of single_band band pass filter

This structure results in covering a band of 1-1.8GHz which is considered as the first passband when it is in the dual-band and another set of single band filter with the pass band is said to be second passband.Thus by combination of the two bandpass filters will lead to the design of the dual_band band pass filter.

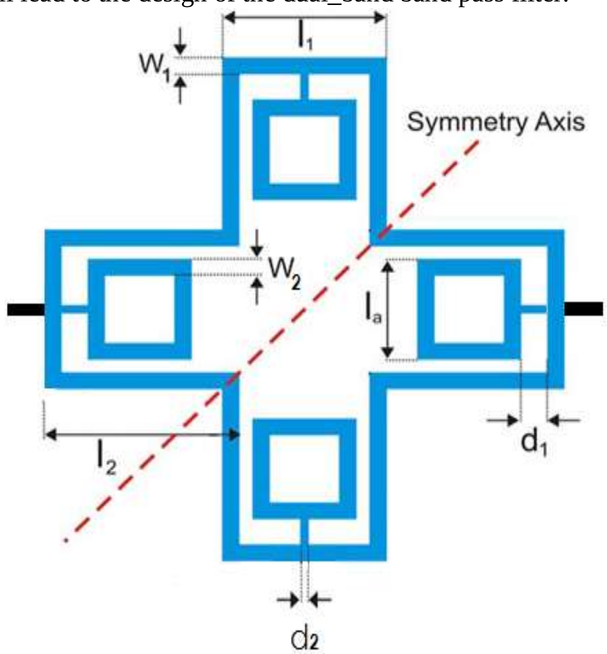

Fig.3: Filter configuration of Dual_band Square loop resonator bandpass filter

This design Fig.3 is based on a meandered square loop resonators in open circuited stub which is located internally helps to reduce the size of the filter. The filter configurations are shown in the TABLE I in mm.

W1	0.8
W2	0.8
D1	1.2
D2	0.4
LA	4.8
L1	7.6
L2	9.0
L2	9.0

Z	50Ω
ε_r	4.6

TABLE I : The configuration for the filter

Square loop loading elements located inside is not only to satisfy compactness, but also to achieve the second passband which is done by shifting the first harmonic to lower frequencies. The charge distribution for the each passband is illustrated in Fig.5, where the charges are distributed in resonator at the second passband is higher Fig.5b than the charges distributed in the first passband of the filter Fig.5a. The design is simulated in FR_4 substrate with thickness of 1.67mm and copper as the conductor. The simulated result of the proposed filter is shown in the Fig.4

B. GENERAL EQUATIONS

To design the filter are using the parameters $frequency(f_0)$, dielectric constant(ε_r), height (h), patchwidth (w)
For calculating the patch width (w)

$$w = \frac{c}{2f_0}\sqrt{\frac{2}{\varepsilon_r + 1}}$$

Calculating the effective dielectric constant (ε_{reff})

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{w}\right]^{\frac{-1}{2}}$$

Length(ΔL) can be calculated using the equation

$$\Delta L = 0.412h\left[\frac{\varepsilon_{reff+0.3\frac{w}{h}+0.264}}{\varepsilon_{reff} - 0.258\frac{w}{h} + 0.8}\right]$$

There are parameters that effects the insertion loss of the filter There are three major contributors to the insertion loss of the filter. They are the conductive, dielectric, and inter stage coupling losses. As the coupling is not the major factor in the design the other losses like conductive and dielectric loss has great role in the design. The conductive loss is due to the finite conductivity of the conducting material, the dielectric loss is due to the nonzero loss tangent of the dielectric substrate, both conductive and dielectric losses are affected by the material properties, which are fixed in the design.

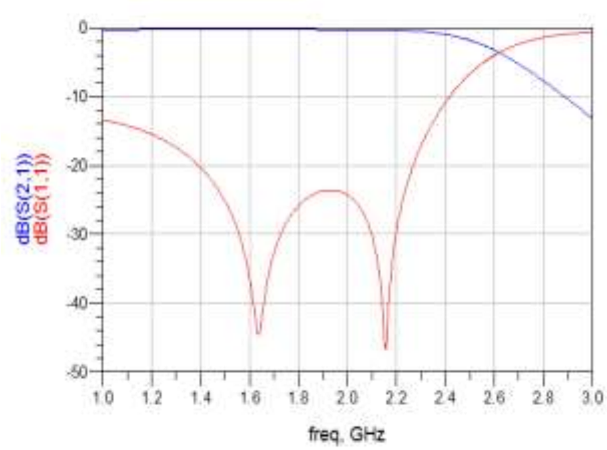

Fig 04: simulated result of the dual mode square loop resonator bandpass filter

The parameter values that are obtained are
center frequencies(f_0)
f_{01} 1.6 GHz

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f_{02} 2.1 GHz
dielectric constant(ε_r) 4.6,
height (h) 1.6mm.
Calculated result for the frequency f_{01}1.6 GHz
the patch width(w) is 0.0542 mm
ε_{reff} 2.846
$\Delta L = 1.048 \times 10^{-3}$

Calculated result for the frequency f_{02} 2.1GHz
the patch width(w) 0.041mm ,
ε_{reff} 2.840
ΔL 1.048×10^{-3}

III. Experiment results

The proposed dual-band microstrip bandpass filters characteristics have been simulated on FR_4 substrate with 4.6 relative dielectric constant and 1.67 mm thickness. TABLE II compares the insertion and return loss of the existing system and the proposed system. Compared to the work in [5] [7], the insertion loss is improved as well as the return loss in the proposed system. At the operating frequencies 1.6 and 2.1 GHz the insertion losses are -0.19, -0.34dB and the return losses >-40dB.The summary of the results are given in the TABLE II

	f_0 (GHz)	**IL (dB)**	**RL (dB)**
first passband	**1.63**	**0.19**	**44.5**
second passband	**2.15**	**0.34**	**46.8**

TABLE II: Summary of Proposed system

IV.CONCLUSION

In this study, dual-mode dual-band microstrip bandpass filters with square loop loading elements, which are located inside the meandered loop resonator designed with FR_4 substrate and copper as conductor. Dual-band filter are designed at 1.6 and 2.15 GHz. Designed filters is simulated using the ads software to measure its results.

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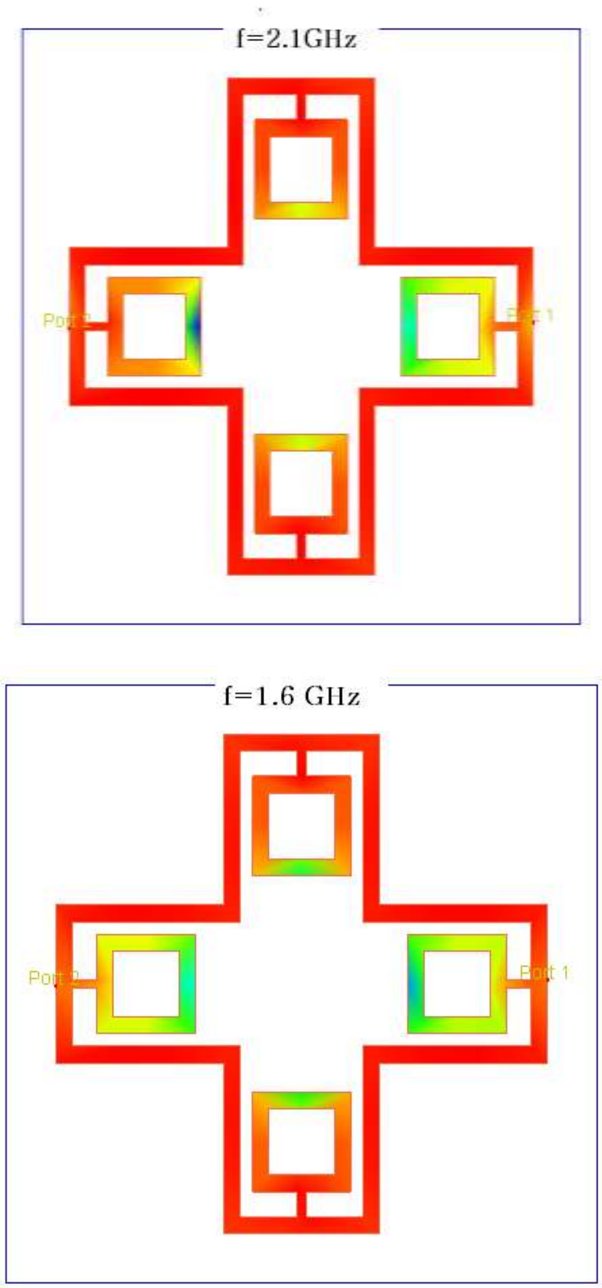

a. charge distribution in first passband b. charge distribution in second passband

Fig.5: the charge distribution of the first and second passband of the proposed filter design

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