Design and Performance Analysis of wideband Filter for 4 to 8 GHz Application

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Abstract- The presented paper is a stepped impedance resonators SIR with suspended strip line microstrip filter for wide-band applications in C band. We designed Three microstrip filter each of them having step index resonator with different thickness of feed line. We have also used suspended strip line in final proposed design in order to improve the bandwidth. On the basis of simulation result we get dual-band of operation with Bandwidth of 320 MHz, and 1880 MHz at center frequency 4.4 GHz and 6.5 GHz respectively.

Keywords— Wideband Filters, Return Loss, VSWR Stepped Impedance Resonators (SIR).

I. INTRODUCTION

Wideband filter is one of the most important communication devices in modern wireless communication system. As the wideband filter has great importance hence it is one of the hot choices for researchers. With the development of modern PCB fabrication techniques, Microstrip structure gain pace in the development of RF components. C-band frequency range has great application in modern wireless communication. The content of this paper is organized as follows. Section II, illustrate the fundamental concepts and different design equations associated with the microstrip lines. Section III describe all three proposed designs of microstrip bandpass filter for wideband applications. Section IV represents different simulation results such as $S_{11,}$ VSWR bandwidth etc.for the proposed design, and finally in section V, a conclusion is drawn.

II. CHARACTERISTIC OF MICROSTRIP LINES

The designing of microstrip filter is based on the designing of microstrip structure and resonating parameters of the filter. Based on transmission line equivalent, lumped parameter part for a filter and its characteristics are compared by the impedances of the transmission lines. The preference of the type of response will depend upon the required points of interest. The various parameters which impact the design of microstrip filters are discussed in this section.

Transmission characteristics of microstrips structures are designed by two basic parameters, first one is effective dielectric constant ε of material used as substrate and second one is the characteristic impedance of microstrip structure ie Z_c, which is given by the following equations,

$$\varepsilon_{re} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left(1 + \frac{10}{u}\right)^{-ab} \quad (1)$$

where $u = W/h$, and

$$a = 1 + \frac{1}{49}\ln\left(\frac{u^4 + \left(\frac{u}{52}\right)^2}{u^4 + 0.432}\right) + \frac{1}{18.7}\ln\left[1 + \left(\frac{u}{18.1}\right)^3\right] \quad (2)$$

$$b = 0.564\left(\frac{\varepsilon_r - 0.9}{\varepsilon_r + 3}\right)^{0.053} \quad (3)$$

The accuracy of this model is better than 0.2%
for $\varepsilon_r \leq 128$ and $0.01 \leq u \leq 100$.
The value of the the characteristic impedance isgiven by

$$Z_c = \frac{\eta}{2\pi\sqrt{\varepsilon_{re}}}\ln\left[\frac{F}{u} + \sqrt{1 + \left(\frac{2}{u}\right)^2}\right] \quad (4)$$

where $u = W/h$, $\eta = 120\pi$ohms, and

$$F = 6 + (2\pi - 6)\exp\left[-\left(\frac{30.666}{u}\right)^{0.7528}\right] \quad (5)$$

III. PROPOSED WIDEBAND FILTER

In this part of the manuscript we have presented three novel designs of microstrip filter structures. The presented designs are step index resonator (SIR) in first design on the other hand the thickness of feed line is changed and a step index feed line is presented which shift the resonating frequency towards lower end, and finally the third design is combination of SIR, Step Feeding and suspended impedance line to get arostrip filter. Detail of all the proposed designs are explained in the following sections

A. First Proposed Filter with SIR

First design is the basic model for Microstrip filter using SIR, consist of a four metallic patch line two of them has a dimension of 28 mm × 2 mm, one has dimension of 20 mm × 2 mm and last one of dimension 14 mm × 2 mm, the feed line of 26 mm × 6 mm. The patch is grown on a substrate of FR4 material of thickness 1.6 mm with dimension of 32 mm × 26 mm. On the other hand Ground plain is a Perfect Electric Conductor (PEC) of area 32 mm × 26 mm as shown in the Figure 1.

The proposed design of SIR based microstrip filters are simulated using ansys-HFSS software. We use two feeding port as input and output port; both of them are symmetrical to each other with the dimensions of 6 mm × 6 mm.

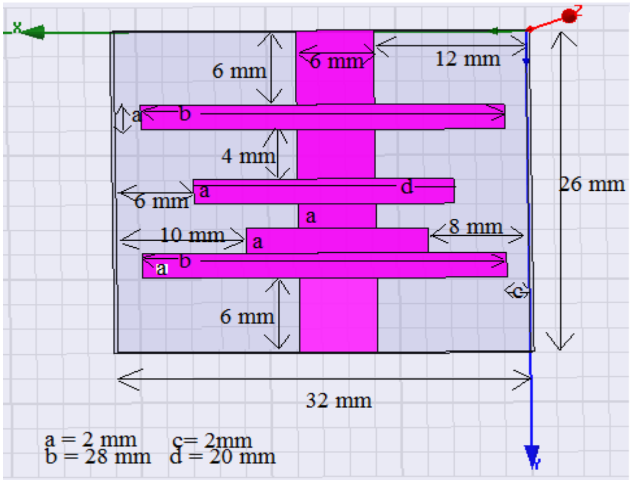

Figure.1 Top view of First SIR Design model.

B. Second Proposed Filter with SIR

In the second design we again use the concept of SIR on patch structure as that of first design but in this design we use the SIR concept on feed line as well to change the resonate frequency. Patch is made-up of four metallic patch line two of them has a dimension of 28 mm ⨯ 2 mm, one has dimension of 20 mm ⨯ 2 mm and last one of dimension 14 mm ⨯ 2 mm, and the feed line using SIR has four section two of them has a dimension of 6 mm ⨯ 6 mm, one has dimension of 4 mm ⨯ 4 mm and last one of dimension 2 mm ⨯ 2 mm.

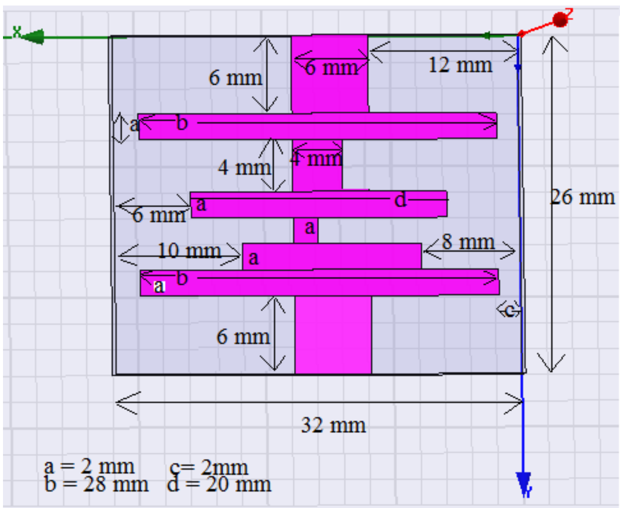

Figure.2 Top view of Second SIR Design model.

The patch is grown on a substrate of FR4 material of thickness 1.6 mm with dimension of 32 mm × 26 mm. On the other hand Ground plain is a Perfect Electric Conductor (PEC) of area 32 mm × 26 mm as shown in the Figure 2.

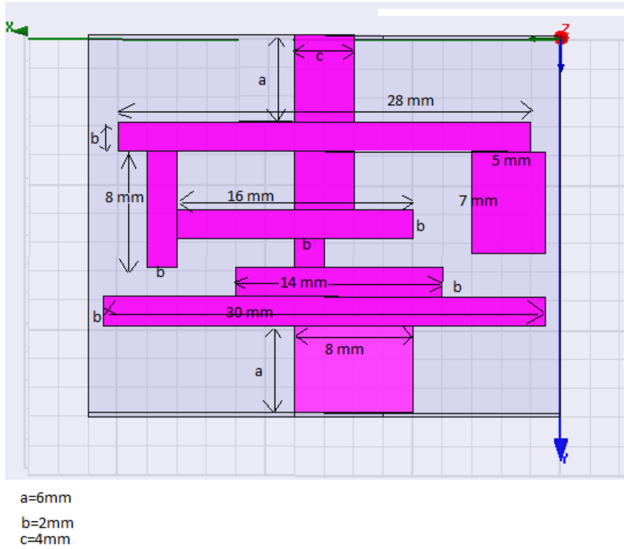

Figure.3 Top view of Third SIR Design model with suspended Impedance Line.

C. Third Proposed SIR Filter with Suspended Impedance Line

The final design is again a SIR patch and feed line structure. Patch is made-up of four metallic patch line of dimension of 28 mm ⨯ 2 mm, 16 mm ⨯ 2 mm, 14 mm ⨯ 2 mm, and 30 mm ⨯ 2 mm, and the feed line using SIR has four section two of them has a dimension of 4 mm ⨯ 6 mm, one has dimension of 2 mm ⨯ 2 mm and last one of dimension 8 mm ⨯ 6 mm. shown in figure 3. We have also used two suspended impedance line on both side of first patch line with dimension of 2 mm ⨯ 8 mm, and 5 mm ⨯ 7 mm. The substrate and ground plane are having same dimension as used in previous design with substrate thickness of 1.6 mm.

IV. RESULTS

The setup frequency for all the proposed design is analyzed on a frequency range of 2 to 8 GHz. The major performance parameters [13,14] such as Return Loss, Bandwidth, Q Factor, VSWR, and Insertion Loss, with Number of radiating frequency are presented for the proposed microstrip filter design. In 1st design we achieve a bandwidth of 315 MHz and 602 MHz at center frequency of 2.1 GHz and 7.3 GHz respectively. On the other hand for second design we achieve a bandwidth of 310 MHz and 660 MHz at center frequency of 1.8 GHz and 7.1 GHz respectively. Likewise for third design we get much increased bandwidth of 1880 MHz at center frequency of 6.5 GHz and bandwidth of 320 at center frequency of 4.4 GHz, the overall results observed by the three proposed designs are shown in table 1, 2 and table 3.

Table 1: Result analysis of First Design Model.

Centre Frequency (GHz)	Insertion Loss (dB)	Bandwidth -10dB (MHz)	VSWR (dB) minimum	Return loss (dB) minimum	Q-Factor
2.1	-1.62	315	1.26	-18.82	6.69
7.3	-4.24	602	1.65	-12.14	12.05

Figure 3, 4 and 5 shows return loss S_{11}, VSWR, Insertion loss S_{21}, and Bandwidth of first proposed design.

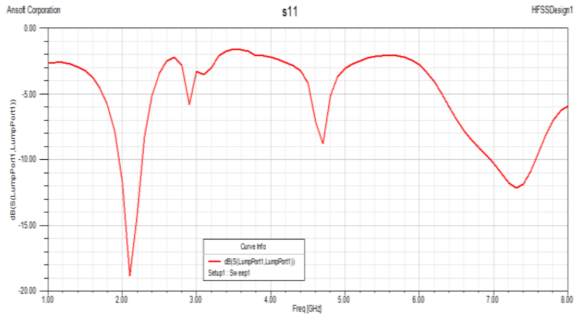

Figure.3 : Return loss for simulation result for Design 1

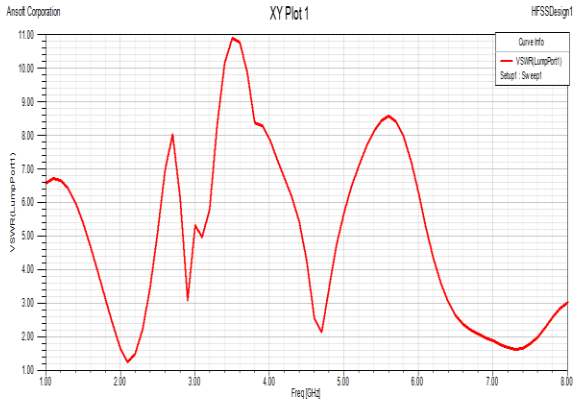

Figure.4 : VSWR for simulation result for Design 1

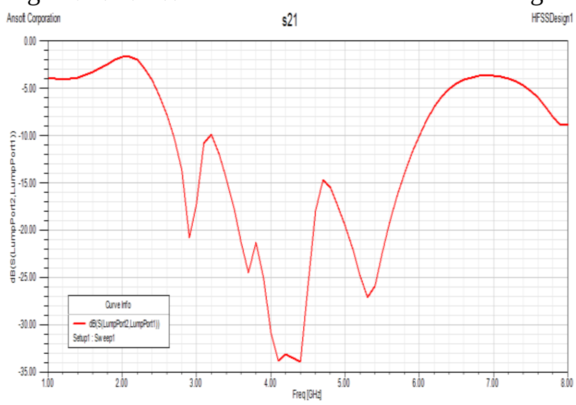

Figure.5 : Insertion Loss for simulation result for Design 1

Table 2: Result analysis of Second Design substrate.

Centre Frequency (GHz)	Insertion Loss (dB)	Bandwidth -10dB (MHz)	VSWR (dB) minimum	Return loss (dB) minimum	Q-Factor
1.8	-1.40	310	1.33	-16.99	5.63
7.1	-4.82	660	1.44	-14.83	4.82

Figure 6, 7 and 8 shows return loss S11, VSWR, Insertion loss S21, and -10 dB Bandwidth for second design.

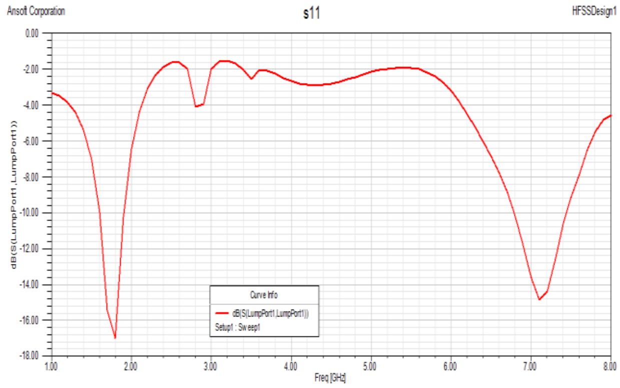

Figure.6 : Return loss of simulation result for Design 2.

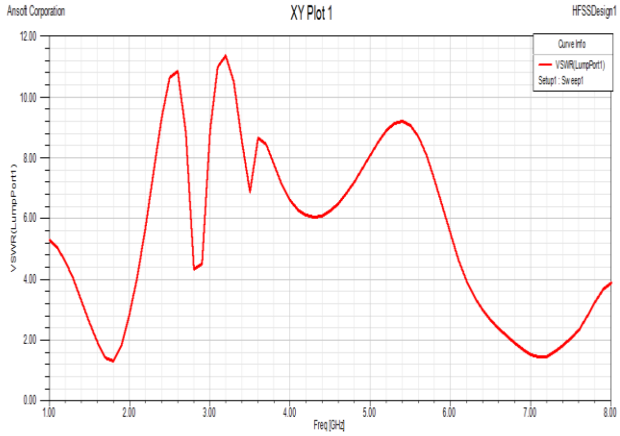

Figure.7 : VSWR of simulation result for Design 2 .

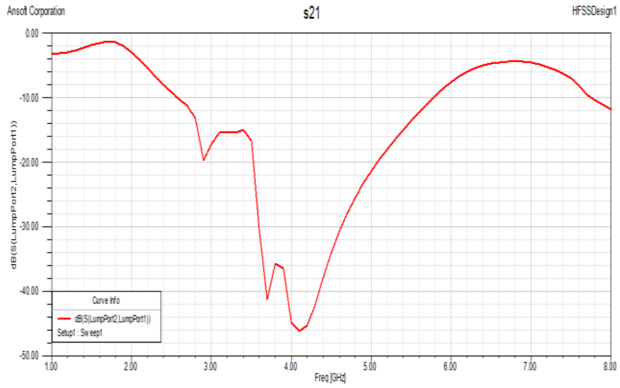

Figure.8 : Insertion Loss of simulation result for Design 2.

Table 3: Result analysis of Third Design

Centre Frequency (GHz)	Insertion Loss (dB)	Bandwidth -10dB (MHz)	VSWR (dB) minimum	Return loss (dB) minimum	Q-Factor
4.4	-5.63	320	1.70	-11.76	13.92
6.5	-19.45	1880	1.08	-28.10	3.43

Figure 9, 10 and 11 shows return loss S_{11}, VSWR, Insertion loss S_{21}, and Bandwidth for third design.

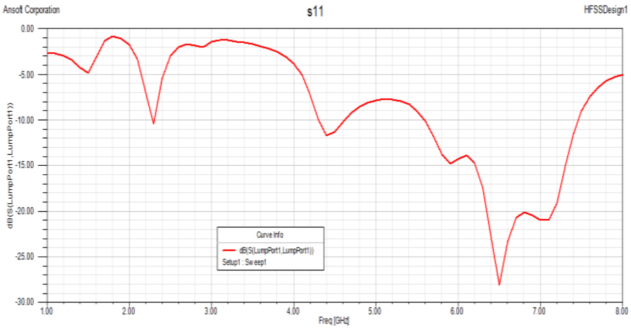

Figure.9 : Return loss of simulation result for Design 3.

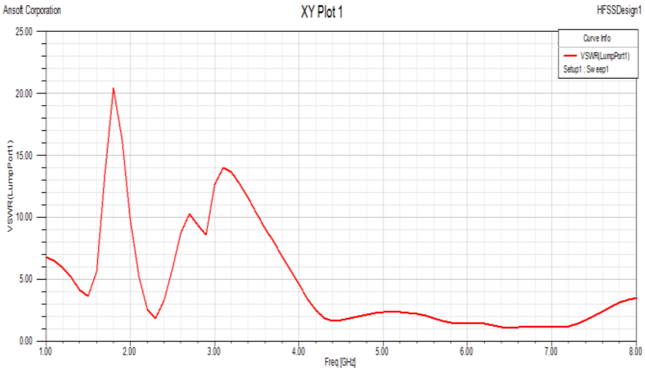

Figure.10 : VSWR of simulation result for Design 3 .

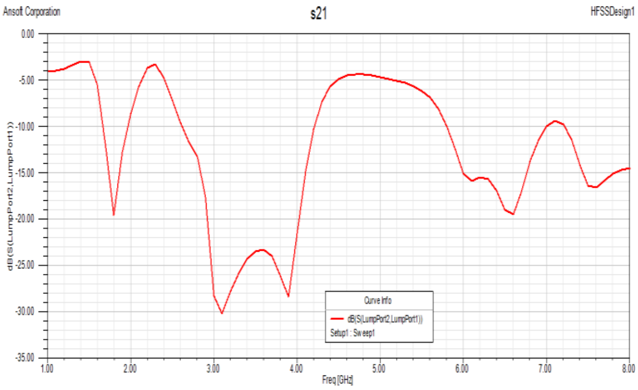

Figure.11 : Insertion Loss of simulation result for Design 3.

V. CONCLUSION

In the presented work, the best results is obtained in terms of wider operating bands is design 3rd. In this case we have Dual-band of operation with Bandwidth of 320 MHz, and 1880 MHz at center frequency 4.4 GHz and 6.5 GHz respectively. For 2nd design we again have Dual-band of operation with Bandwidth of 310 MHz, and 660 MHz at center frequency 1.8 GHz and 7.1 GHz. For Q-Factor best value is obtained in 3rd design i.e 13.92 at 4.4 GHz centre frequency. Return loss is best for 3rd design with -28.10 dB at 6.5 GHz.

Thus for all proposed design we can see that the by changing the thickness of feed line in step Indexed way the center frequency shift towards lower frequency range. The suspended Strip lines are used for bandwidth enhancement by around 2.85 times of the design without suspended strip lines.

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