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Design of Low Pass and Notch Filter Using Microstrip Lines

Birajdar Rushikant, Mulla Sajeed and Shete Jagdish

***Abstract*—In this paper, the designing and simulation of the filter is carried out. The notch and low pass filters are designed using microstrip structure with FR4 material having dielectric constant of 4.4 and order 2. The effect of the length and width on the range of the filter is verified. The Notch filter structure designed using single stub between source and load of microstrip line. The band of the Notch filter depends on the length and width of the stub. It can be varied by varying the parameters.**

***Index Terms*—low pass filter, notch filter, microstrip.**

I. INTRODUCTION

FILTERS are the circuits which are used for passing the specific range of frequencies through it. The specific frequency range is called as the bandwidth of that filter or the frequency response of that filter[1]. There are types of the filters like Active Filters, Passive Filters, and Distributed Element Filters. Beyond some few Mhz, it is impossible to make active, passive filters, hence it is suitable to use the distributed filters made up of the microstrip or stripline[2]. Engineering applications like wireless communication needs the RF filtering. By using microstrip filters instead of the regular filter made up of inductor and capacitor, it gives the same result but in the less area and with the same accuracy. Their main advantages are low-cost equivalent and compact design in comparison with waveguide and coaxial filters[3]. Most of the systems have radio frequency components. But it costs high. By making use of the microstrip filters it reduces the compactness as well as the price of the system. There different types of the filters such as lo pass, high pass, band pass, band reject (notch). In this paper the two types of the filters such as Low pass filter, Notch filter are designed. The low pass filters are the filters which are used for the passing low frequency components through it. Low pass filter passes the frequencies below the certain frequency, which is known as the cut off frequency of the low pass filter. The frequency response curve of the low pass filter gives us the range of the filter i.e. which frequency components will get passed through it and which will get rejected through it[4]. The ideal frequency response curve of the low pass filter is shown in Fig.1 a)

The Notch filters are also known as the band reject filter with narrow bandwidth. Notch Filters can also be implemented by using the DGS[5]. These types of filter are used for the rejecting the specific but very narrow frequency range [6]. The frequency response curve for the notch filter is shown in Fig.1 b). High pass filters are that filter which passes the high frequency component and rejects the low frequency components. High frequency filters are used whenever there is need of the removal of the high frequency noise signals. The frequency response curve for the high pass filter is as shown in Fig. 2 a). The band pass filter are the filters which passes only the certain amount of frequencies which are lying between the two cut off frequencies. The frequency response curve of the band pass filter is as shown in Fig.2 b)

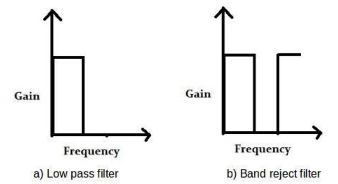

Fig. 1. Frequency response curve of filters

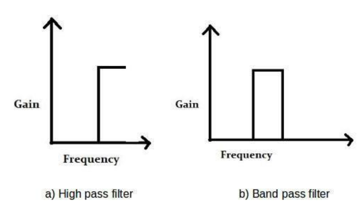

Fig. 2. Frequency response curve of filters

The rest of the paper is mentioned as below. The methodologies, implementation, result and conclusion are described in section II, III, IV and V respectively.

II. METHODOLOGIES

The steps for filter design are as follows:

1) First calculate the order of the filter by using the cut-off frequency and the attenuation vs. normalized frequency curve.
2) Use the filter prototype and find the element values.
3) Calculate the impedance of each microstrip line.
4) Use the kurodas identity to convert the short circuited stub into the open circuited stub
5) Denormalize the impedance of the microstrip lines.
6) Calculate length and width of the microstrip lines, stubs.
7) Design the filter in the QUCS and HFSS Software

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III. Implementation

First With the help of given cut off frequency , first find the order of frequency with help of the Attenuation versus normalized frequency for maximally flat filter prototypes curve as shown in Fig.3. The order of the filter as"2" is obtained.

After finding order then by using the Element Values for Maximally Flat Low-Pass Filter Prototypes and filter prototypes, it gives values of the elements in the filter(shown in Table 1). The prototype of the low pass filter are shown in

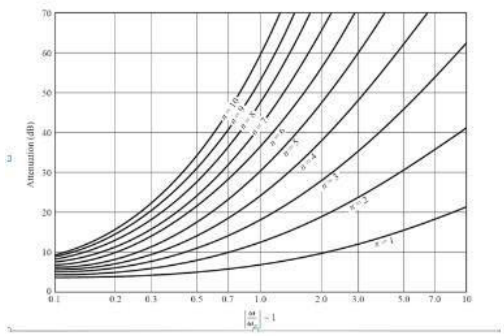


Fig. 3. Attenuation versus normalized frequency for maximally flat filter prototypes curve[7],[8].

Fig.4 [7],[8],[9]: The circuit diagram of low pass filter is as

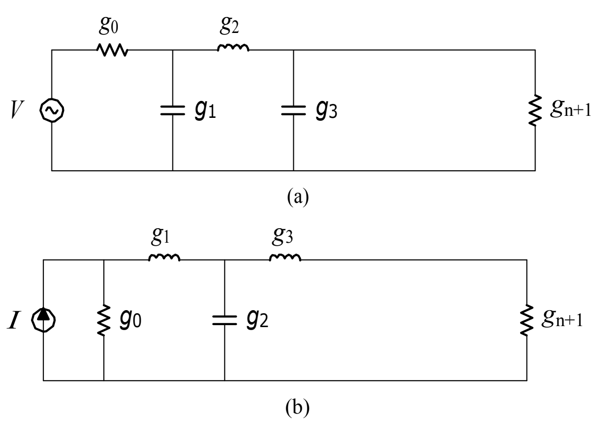


Fig. 4. Low Pass Filter prototype

TABLE I: Element values for maximally Flat Low Pass Filter Prototype ($g_0 = 1$, $\omega c = 1$, $N = 1$ to 10) [7],[8],[10]

N	g_1	g_2	g_3	g_4
1	2.0000	1.0000		
2	1.4142	1.4142	2.0000	
3	1.0000	2.0000	1.0000	1.0000

shown in Fig.5 Now calculate the impedance of the Inductor. For inductor $X_L = Z_0 \times tan(\beta l)$, $\beta = 2\pi/\lambda$ and $l = \lambda/8$, hence $\beta l = 45^0$, $tan(\beta l) = 1$. $X_L = Z_0 = 2\pi f L = 0.5692\Omega$, For capacitor, $Z_0 = X_C = 1/(2\pi f C) = 1.7546$ [8].
Now, by using the kuroda identity (shown in Fig. 6), convert the short circuited stub to the open circuited stub. And the resultant circuit is as shown on next slide and the modify value of the Z_0 of each microstrip line. $N^2 = 1 + \frac{Z_2}{Z_1}$ Circuit

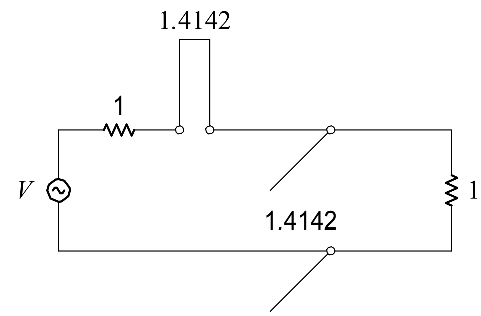


Fig. 5. Circuit Diagram With The Help Of Microstrip Lines

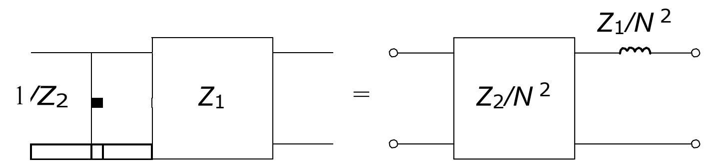


Fig. 6: Kuroda's Identity [7]

Diagram after applying the kuroda's identity it transforms to the circuit, as shown in Fig.7 Now after denormalizing, it

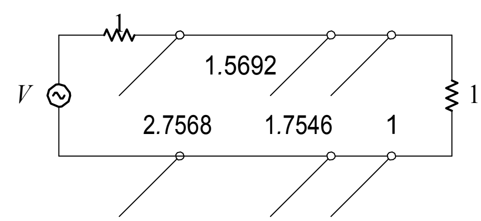


Fig. 7. Circuit diagram after transforming short circuited stub to the open circuited stub using Kuroda's Identity

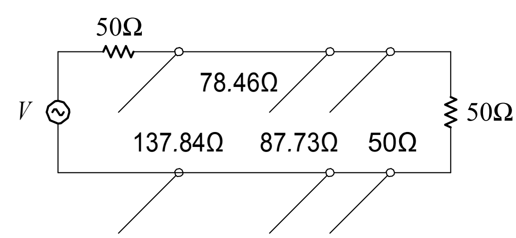


Fig. 8. Circuit diagram after transforming short circuited stub to the open circuited stub using Kuroda's Identity

gives the required circuit diagram as shown in Fig.8. Now using QUCS Software, calculate the length and width of the stub. And it provides the required circuit diagram as shown in Fig.9 The output response curve of the above circuit is as shown in Fig.10 Design it in the HFSS Software, as shown in Fig.11 And finally it gives the expected output, as the frequency response curve. The frequency response curve of the above is shown in Fig.12 From the output it is clear that the cut off frequency of the above schematic is between 800 MHz to 810MHz.And our given cut off is 806MHz.It gives the accurate output. Similarly design the notch filter in QUCS (QUITE UNIVERSAL CIRCUIT SIMULATOR) &

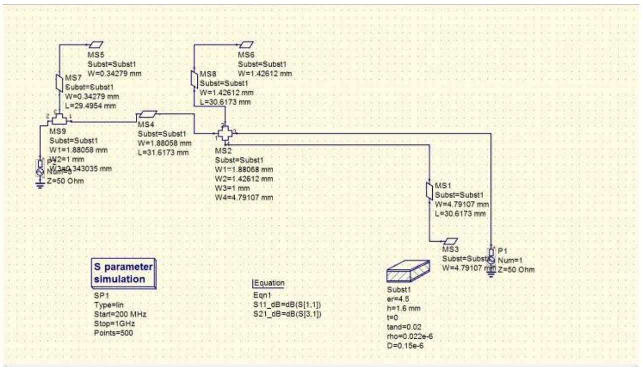


Fig. 9. Low Pass Filter Using Qucs

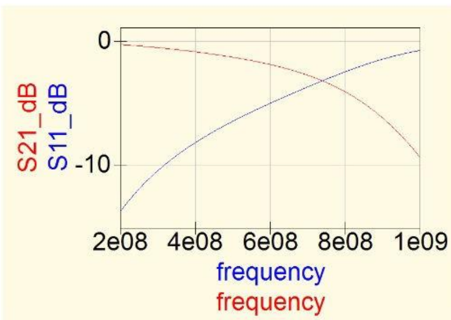


Fig. 10. Low Pass Filter Response Using Qucs

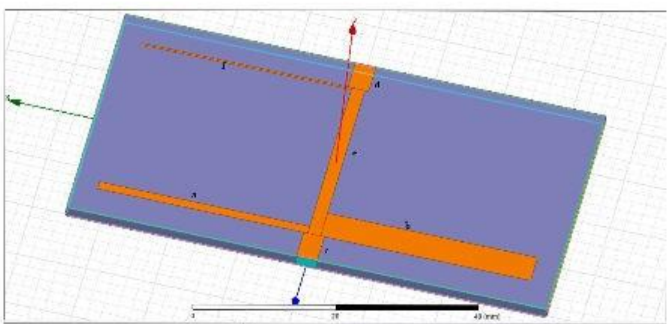


Fig. 11. Low Pass Filter Using HFSS Software (a:(length=1.42612mm,width= 30.6173 mm), b:(length=4.79107 mm ,width= 30.6173 mm), c,d:(length= 5 mm,width= 3 mm), e:(length=31.6173 mm ,width= 1.88058 mm))

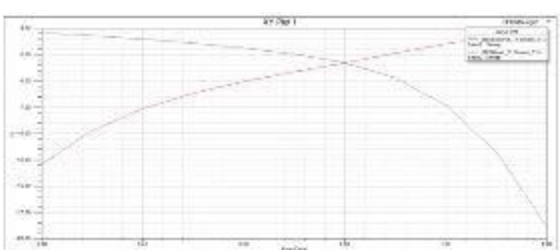


Fig. 12. Low Pass Filter Response In HFSS Software

HFSS (HIGH FREQUENCY STRUCTURAL SIMULATOR) Software, as shown in Fig.13 The frequency response curve in

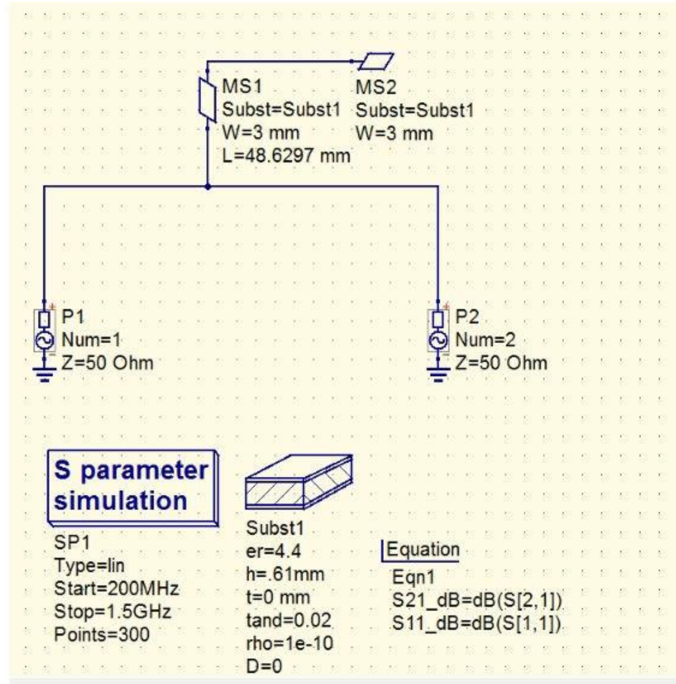


Fig. 13. Notch Filter Using Qucs

QUCS is as shown in Fig. 14 After changing the starting and

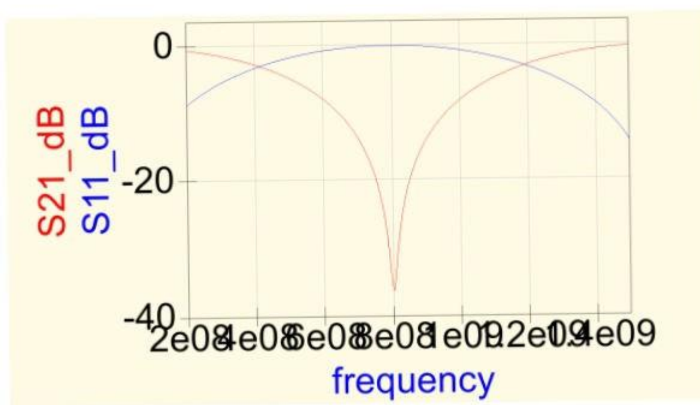


Fig. 14. Notch Filter Response Curve in Qucs.

end limits ,it gives the results as shown in Fig.15 And from images it is clear that output in QUCS is an accurate output as which is required. Now do it in HFSS as shown in Fig.16 And the frequency response of the above schematic is as shown in Fig.17 The filter prototypes are fabricated in laboratory with help of conventional method. The photograph of fabricated low pass filter and notch filter prototype are shown in Fig 18 and Fig. 19 respectively. Here it gives the correct output, hence our design is accurate.

IV. Result

It is observed that by changing the length and width of the microstrip line the frequency range of the filter can be changed. When there is increase the length of the stub of the notch filter the cut off frequency get shifted towards left side

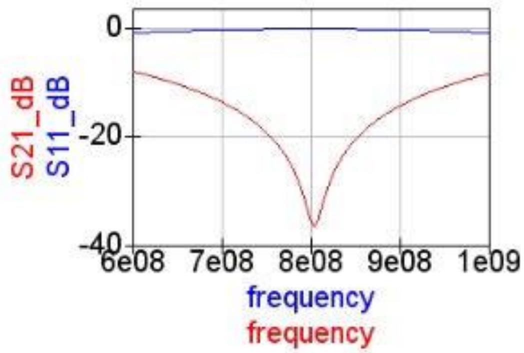


Fig. 15. Notch Filter Response Curve in Qucs.

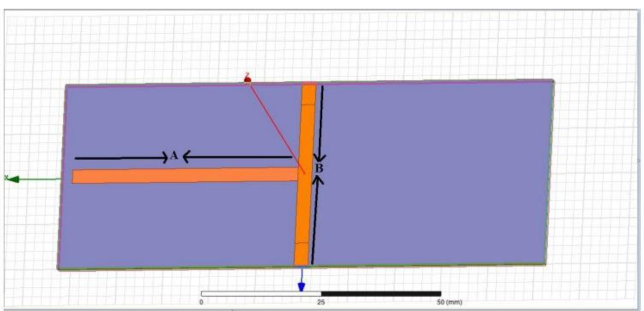


Fig. 16. Notch Filter Design in HFSS. (A:(length=48.6297 mm, width= 3mm), B: (length= 40.6173 mm ,width= 3 mm))

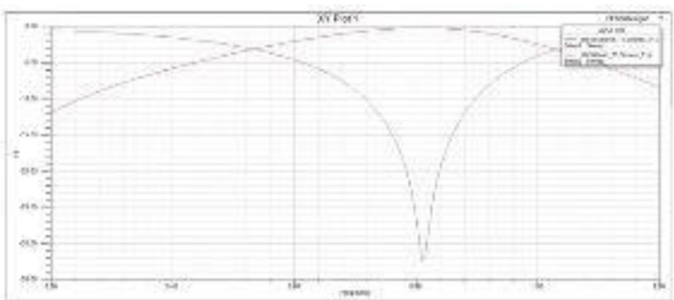
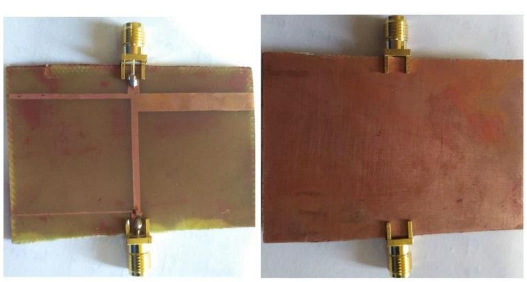
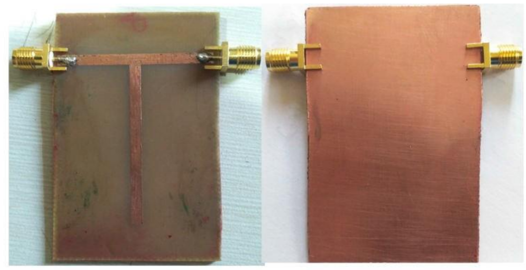


Fig. 17. Notch Filter Response Curve In HFSS.



a) Top Side b) Back Side

Fig. 18. Low pass filter prototype



a) Top Side b) Back Side

Fig. 19. Notch filter prototype

(decreases).The cut off frequency of the low pass filter at -3.5dB is 806 MHz. For -9dB level, the pass band of the notch filter is from 720MHz to 920MHz.

V. Conclusion

In this paper the low pass filter and the notch filter, with cut off of 806MHz has been analyzed. The result obtained using simulation software. It is observed that if the length increases the cutoff frequency decreases and length decreases cutoff frequency increases. The design has been performed using the HFSS Software, and the results of the parameters have been shown. The notch and low pass filter accurately performed as per simulation result. The contributory work of filter design is the implementation of low profile directly couple notch filter for about 20% bandwidth. The notch filter is designed with help of simple transmission line model, the rigorous filter design procedure is not followed for the same.

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