Designing Microstrip Band Reject Filter with Wide Bandwidth Covering S Band to C Band Using IE3D

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Abstract: This paper describes the design of a newly proposed 2 pole wide band micro strip band stop filter with open circuited stubs covering S band to C band. This paper represents the design and simulation of wide band bandstop filter using microstrip which is designed to have a central frequency of 3.7GHz.The filter is fabricated on a FR-4 substrate having dielectric constant ε_r=4.4 and thickness h=1.6mm.Microstrip technology is used for simplicity and ease of fabrication. The design and simulation are performed using method of moments based electromagnetic simulator IE3D.

Keywords: *Microstrip Line, Wideband, Band reject filter, IE3D.*

I. INTRODUCTION

With the rapid development of modern wireless systems, compact size, low losses, high selectivity, low cost and high performance components are the design goals. Filter is an essential component in modern communication system. In response to this need, recently many planar filters with band pass, low pass or band stop performances have received wide attention and many techniques and methodologies have been investigated. With the enhancement in filter technology various structures have been developed in order to enhance the frequency response Stepped impedance [1,7], inter-digital [2] and spiral [3] structure have already shown the capability in improving response of a resonator. Narrow band Band stop filter (BSF) [4] and wideband Band stop filter [5, 6] is one key component in modern communication system. It plays a major role of filtering out undesired frequencies and passing the desired signal. We have designed the band stop filter with open-circuited stubs, where the shunt quarter-wavelength, open-circuited stubs are separated by unit elements(connecting lines) that are a quarter wavelength long at the mid band frequency.

II. DESIGN METHODOLOGY

Design problem: A micro strip band stop filter is designed based on a two-pole (n=2) Maximally-flat low pass prototype. The band stop filter is designed to have a fractional FBW=0.58 at a midband frequency =3.5 GHz.
The filter impedance $\mathbf{Z_0}$=50Ω.

The filter design steps are described as follows:

1. We have started the design procedure with a two- pole (n=2) ladder-type low pass prototype (i.e., with Maximally flat response) with element values of the low pass prototype are taken from normalized values g_i i.e., g_1, g_2, g_3.From [8] the element values of the low pass prototype are $g_0 = g_3 = 1.0, g_1 = g_2 = 1.4142$.
2. The normalized element values of the low pass prototype filters are then transformed to the L-C elements for the desired mid band frequency f_0 and desired source impedance, which is normally 50 ohms for micro strip filters.
3. Then we implement a frequency mapping using the following equation

$$\Omega=\Omega_c \alpha \tan\left(\frac{\pi}{2}\frac{f}{f_0}\right) \quad (1)$$

Where $\alpha = \cot\left[\frac{\pi}{2}\left(1-\frac{FBW}{2}\right)\right]$

In equation (1) Ω and Ω_c are the normalized frequency variable and the cut off frequency of a low pass prototype filter, f and f_0 are the frequency variable and the midband frequency of the corresponding band stop filter. The fractional bandwidth of the band stop filter defined by:

$$FBW=\frac{f_2-f_1}{f_0} \quad \text{with } f_0=\frac{f_1+f_2}{2} \quad (2)$$

4. The frequency mapping involves the Richard's transformation. Using Richard's transformation [9] the shunt (capacitive) elements of low pass prototype become shunt (open-circuited) stubs of the mapped band stop filter and the series (inductive) elements becomes series (short-circuited) stubs. Kuroda's identity [9] is used to remove the series short circuited stubs to obtain the desired transmission line band stop filter.

5. The design equations for band stop filters of this type available in [8] are given as follows for Ω_c=1, Z_A=$Z_0 g_0$ and the bandwidth parameter α defined in equation (1).

$$Z_1 = Z_A\left(1 + \frac{1}{\alpha g_0 g_1}\right);\ Z_{1,2} = Z_A(1 + \alpha g_0 g_1)$$

$$Z_2 = \frac{Z_A g_0}{\alpha g_2};\quad Z_B = Z_A g_0 g_3;$$

Here Z_A and Z_B are the input and output port impedance 50Ω microstrip transmission line and the width is taken as 3.059mm for the input and output of the transmission line.

6. The next main step in the design of micro strip band stop filter is to find an appropriate micro strip realization that approximates the lumped element filter. The filter is fabricated on a FR-4 substrate having dielectric constant $\varepsilon_r = 4.4$ and of thickness h=1.6mm.

7. Using the design equation given in procedure (8), the different line impedance values of open stubs are calculated. The micro strip widths and guided quarter wavelength at 3.5 GHz associated with the required characteristic impedances can be found using the following micro strip design equation [9].

For $\frac{W}{h} < 2$,

$$\frac{W}{h} = \frac{8\exp(A)}{(\exp(2A) - 2)} \qquad (3)$$

Where $A = \frac{Z_c}{60}\sqrt{\frac{\varepsilon_r + 1}{2}} + \frac{\varepsilon_r - 1}{\varepsilon_r + 1}\left(0.23 + \frac{0.11}{\varepsilon_r}\right)$

For $\frac{W}{h} > 2$, $\frac{W}{h} = \frac{2}{\pi}\left[B - 1 - \ln(2B - 1) + \frac{\varepsilon_r - 1}{2\varepsilon_r}\left\{\ln(B - 1) + 0.39 - \frac{0.61}{\varepsilon_r}\right\}\right]$ (4)

Where, $B = \frac{377\pi}{2Z_0\sqrt{\varepsilon_r}}$

The effective dielectric constant is given by:

$$\varepsilon_{re} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{w}\right]^{-0.5} \qquad (5)$$

The guided wavelength can be found as follows:

$$\lambda_{ge} = \frac{\lambda}{\sqrt{\varepsilon_{re}}} \qquad (6)$$

The physical length of the stub can be found as follows:

$$l = \frac{\lambda_{ge}}{4} \qquad (7)$$

TABLE-I: DIMENSIONS FOR BAND STOP FILTER WITH OPEN CIRCUITED STUBS (FOR N=3)

Z(Ω)	W(mm)	λ_g (mm)	ε_{re}	L(mm)
Z_A=Z_B=50	3.0590	47	3.3302	5.875
Z_1=138.38	0.2465	50.40	2.891	12.60
Z_2=72.154	1.5544	48.17	3.1652	12.044
$Z_{1,2}$=84.6	1.08864	48.731	3.0937	12.182

III. SIMULATION AND FABRICATION

A simulation study was performed to verify the validity of the above dimensions in millimeter wave regime. For the simulation purpose we have used Method of Moment based Full-wave EM solver IE3D [11]. Simulated structure of the desired band stop filter with all the dimensions is shown in fig.1. The fabricated structure of the proposed wide band bandstop filter with open circuited stub is shown in figure2.

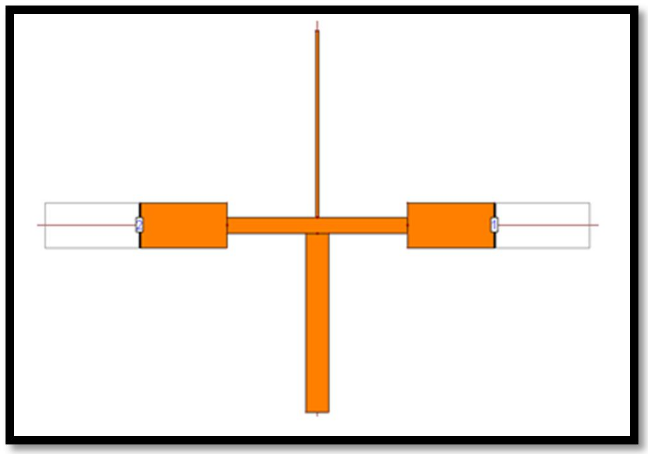

Figure 1: Layout of the Proposed Microstrip band stop filter

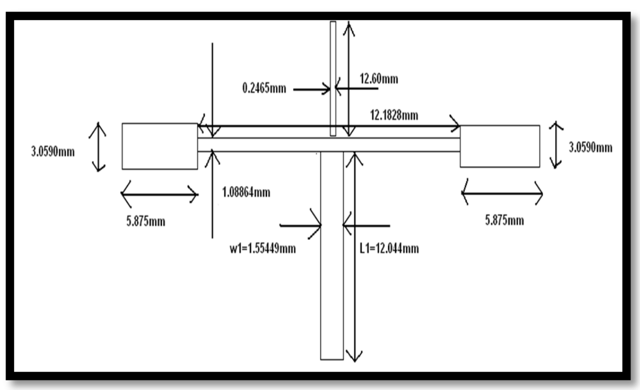

Figure 2: Layout of the Proposed Microstrip band stop filter with dimensions

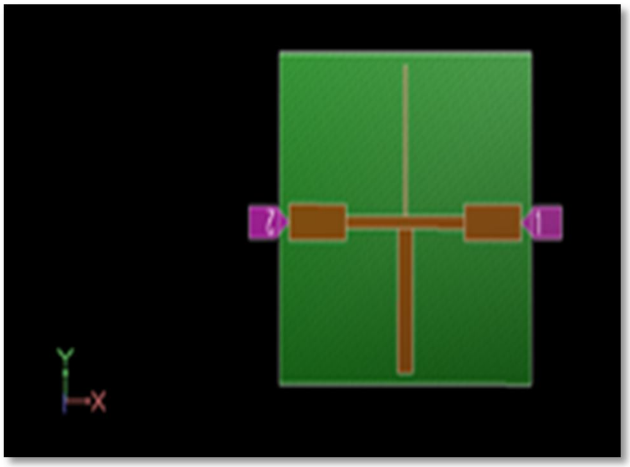

Figure 3: 3D view of the Proposed Microstrip band stop filter with dimensions

IV. RESULTS & DISCUSSION

Fig.4 indicates the simulated response of the proposed bandstop filter structure shown in fig.1 using EM solver IE3D. From the graph shown in fig.4, the centre frequency is found to be 3.73 GHz with insertion loss (S21) -54dB. The band edge frequencies are 2.55GHz and5.77GHz respectively. The calculated -3db bandwidth is nearly 86.32% which is higher than the desired value (58%).

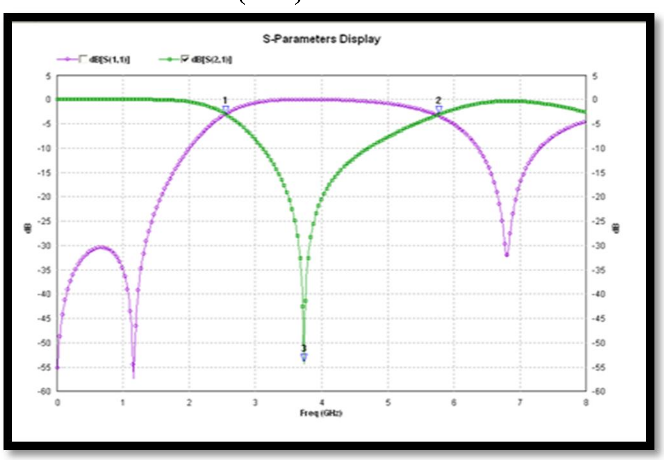

Figure 4: Response of the proposed filter

V.CONCLUSION

In this paper a new design structure of micro strip band stop filter has been discussed that improves upon the performance of structure discussed in[8].The band stop filter proposed in this paper covers the band width extending from S-band to C-band applications. Wideband band stop filters are important components in microwave and millimeter wave wireless communications. It rejects higher harmonics and spurious pass bands. Compared to different structures of band stop filters [12-14], the structure of the new proposed band stop filter described in this paper is very simple and compact, but it provides good performance.

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REFERENCES

[1] Y.Z.Wang and M.L.Her,"Compact microstrip bandstop filters using stepped impedance resonator and spur-line sections,".IEE Proceedings microwaves,antennas and propagation, vol.153,issue 5,oct,pp 435-440,2006.

[2] R.Y.Yang, M.H.Weng,C.Y.Hung,H.J.Chess and M.P. Houng," Novel compact microstrip interdigital bandstop filters,"IEEE Trans on Ultrasonics,Ferroelectrics and Frequency control,vol.51,issue 8,Aug.,pp.1022- 1025,2004.

[3] Joubert.J,"Spiral microstrip resonators for narrow stopband filters,"IEE Proceedings Microwaves,Antennas and Propagation,vol.150,issue6,Dec.,pp493-496,2003.

[4] Design of Narrow Band Reject Filter Niteshkumar,namarta sahayam, International Journal of Scientific & Engineering Research, Volume 2, Issue 12, December-2011

[5] J. Shi, J. X. Chen, and Q. Xue, "Compact microstrip lowpass filter with wide stop-band integrating a bandstop structure in an open-loop resonator," Microwave and Optical Technology Letters, vol. 47, no. 6, pp. 582–584, 2005.

[6] M. Y. Hsieh and S. M. Wang, "Compact and wideband microstrip bandstop filter," IEEE Microwave and Wireless Components Letters, vol. 15, no. 7, pp. 472–474, 2005

[7] Y. Z. Wang and M. L. Her, "Compact microstrip bandstop filters using stepped-impedance resonator (SIR) and spur-line sections," IEE Proceedings: Microwaves, Antennas and Propagation, vol. 153, no. 5, pp. 435–440, 2006.

[8] J.S. Hong, and M.J. Lancaster, Micro strip Filters for RF/Microwave Applications, Wiley, New York, 2001.

[9] Microwave Engineering, D M Pozar, 3rd Edition.

[10] G. L. Matthaei, L. Young, and E. M. T. Johns, Microwave Filters, Impedance Matching Networks, and Coupling Structures. Norwood, MA: Artech House, 1980.

[11] IE3D Software Release – 14, Developed by M/S Zeland Software Inc.

[12] R.Wu,S.Amari,and U.Rosenberg"New cross coupled microstrip bandreject filters,"2004 IEEE MTT-S Digest,pp1597-1600.

[13] R.V.Synder ,"Realization of dual mode band rejection filters,"1979 IEEE MTT-S,Digest,pp.264-268.

[14] J.R.Qian and W.C.Zhuang,"New narrowband dual mode bandstop waveguide filters."IEEE Trans.MTT-31, no12,Dec1983,PP.1045-1050

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