ISSN: 2278 – 909X
International Journal of Advanced Research in Electronics and Communication Engineering (IJARECE)
Volume 4, Issue 10, October 2015

Compact Microstrip Coupled line Bandpass Filter for C Band Applications

Anishamol Asokan, Bindu C J, Anju Pradeep, Binu Paul, S Mridula

Abstract—**The paper presents a novel and compact microstrip band pass filter for C-band applications. The filter consists of three parallel-coupled lines quarter wavelength long at the center frequency (6 GHz) of the required operating band (4-8GHz). Quarter wavelength short-circuited stubs in the form of stepped impedance resonators at the end of the central line introduce the required transmission zeros at the upper band edge thus controlling the upper cut off frequency. The width of the coupled lines control the lower cut off frequency.**

***Index Terms*— Bandpass filters, Coupled line filters, Microstrip filters, Stepped Impedence Resonator.**

I. INTRODUCTION

The IEEE C-band (4 to 8GHz) and its variations contain frequency ranges that are used for many satellite communications, transmissions, Wi-Fi devices, cordless telephones, and weather radar systems. The rapid growth of mobile and wireless communication system technology in today's world has increased the need for bandpass filters. Due to the advantages of low cost, light weight, small size and easy fabrication, microstrip planar filters have many RF/microwave applications [1, 2]. Parallel-coupled line bandpass filters [4] have been extensively adopted in the RF front end of microwave and wireless communication systems. In this paper a microstrip parallel coupled line filter with shunt short stubs is proposed for C band applications.

Procedure for Paper Submission

II. FILTER GEOMETRY

The filter consists of three parallel-coupled lines quarter wavelength long (L=5.91mm) at the center frequency (6 GHz) in the required operating band (4-8GHz). The required transmission zeros at the upper end of the pass band are introduced using quarter wavelength short-circuited stubs in the form of stepped impedance resonators (SIR) formed by a high impedance inductive stub and a low impedance capacitive stub (L_1, L_2& L_C). The width of the coupled lines (W) control the lower cut off frequency. Fig.1 shows the layout of the filter structure designed using a substrate with ε_r=4.4, h=1.6mm and loss tangent 0.02.

The simulated S parameters are shown in Fig.2. The simulated bandwidth obtained is from 3.51 GHz to 8 GHz. The result shows an insertion loss less than 1 dB and an attenuation of 38.16 dB in the lower stopband and 17.86 dB in the upper stopband. The simulated roll off rate in the lower edge is 32.19dB/GHz and in the upper edge is 49.41 dB/GHz.

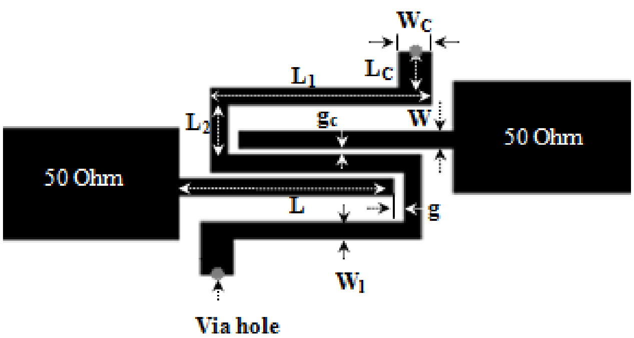


Fig.1. Layout of the Filter Structure
(W_c=0.95, W_l=W=0.5, L_1=6.2, L_2=1.36, L_{ind}=L_1+L_2, L=5.91, g_c=0.15, g=0.28, L_c= 1) All dimensions in mm

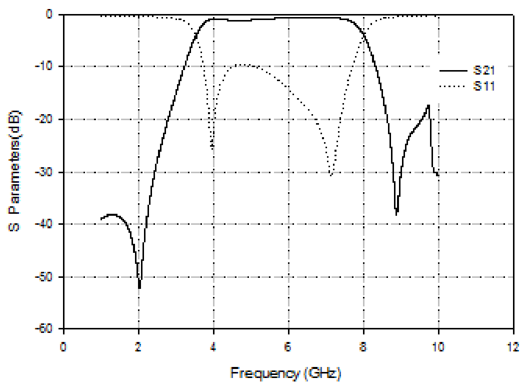


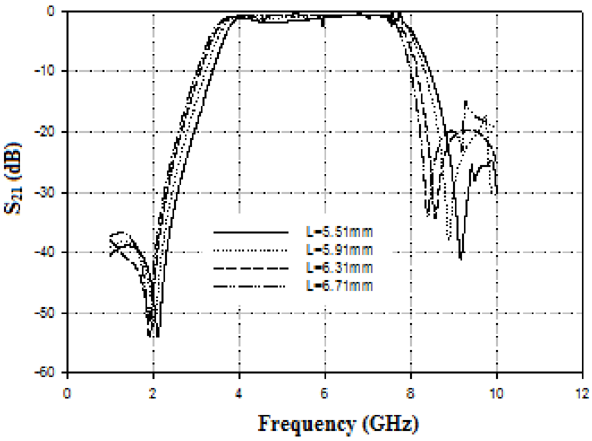
Fig.2. Simulated S Parameters

Fig.3 (a) shows the optimetrics study on length of the coupled lines (L). The entire band is shifted to right by reducing the length of coupled lines.The optimetrics study on

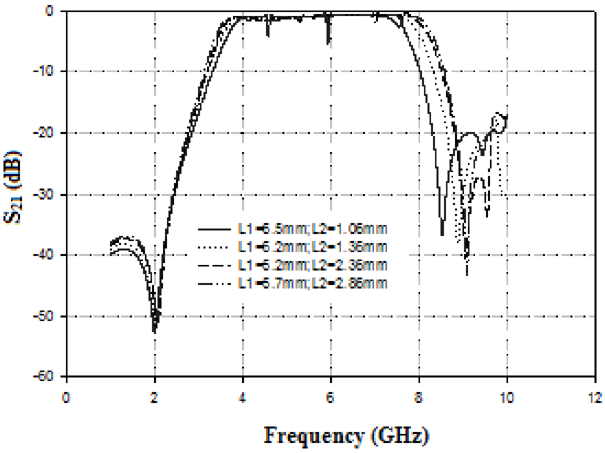
Manuscript received Oct 19, 2015.

***Anishamol Asokan**, Division of Electronics Engineering, School of Engineering, CUSAT, Cochin, India.*
***Bindu C J,** Division of Electronics Engineering, School of Engineering, CUSAT, Cochin, India.*
***Anju Pradeep,** Division of Electronics Engineering, School of Engineering, CUSAT, Cochin, India,.*
***Binu Paul,** Division of Electronics Engineering, School of Engineering, CUSAT, Cochin, India.*
***S Mridula,** Division of Electronics Engineering, School of Engineering, CUSAT, Cochin, India.*

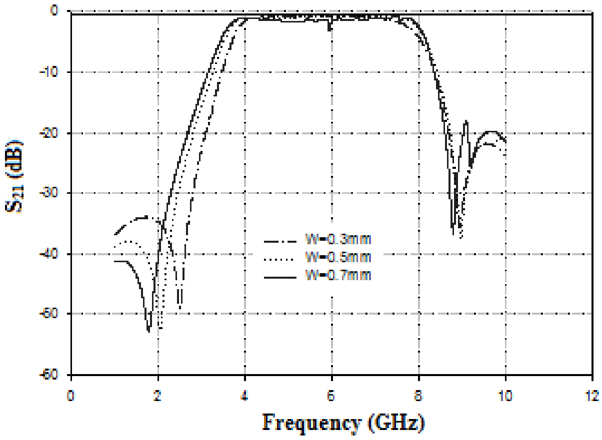
the length of the stub sections without changing the total length is shown in Fig.3 (b).It can be seen from the figure that the upper cut off frequency is increased by reducing the ratio L_1:L_2. The lower cut off frequency can be varied by varying the width of coupled lines (W) as shown in Fig.3(c).



(a) Entire band is shifted to right by reducing the length of coupled lines



(b) Variation of upper cut –off frequency by changing the length ratio L_1:L_2 by keeping total length of the stub constant



(c) Variation of lower cut-off frequency by changing the width of coupled line

Fig.3. Parametric Analysis

III. EQUIVALENT CIRCUIT

Fig.4 shows the LC equivalent circuit of the filter modeled using CST Microwave Studio. The values L_{SIR} andC_{SIR} represent the parallel LC resonators introduced by the SIR. L_3, C_3, L_4, C_4, and L_5, C_5, L_6, C_6 represent coupled line sections which give the bandpass nature to the filter. C_p is the distributed shunt capacitance between transmission line and ground.

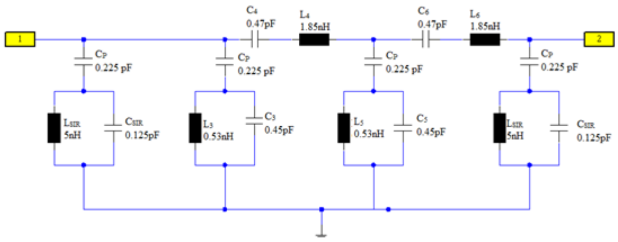


Fig.4. Equivalent circuit of the Filter

The inductance value L_{SIR} is calculated using the following expression [5].

$$L_i = f_c \lambda_{gl} L / Z_{0l} \quad (1)$$

Where, $L_i = L_1 + L_2 = 7.56$ mm, f_c = 6 GHz, λ_{gl} = guide wavelength for inductive stub = 28.532mm, Z_{0l}=113.41 Ohms is the characteristic impedance of the inductive transmission line section. The computed inductance value is 5nH.

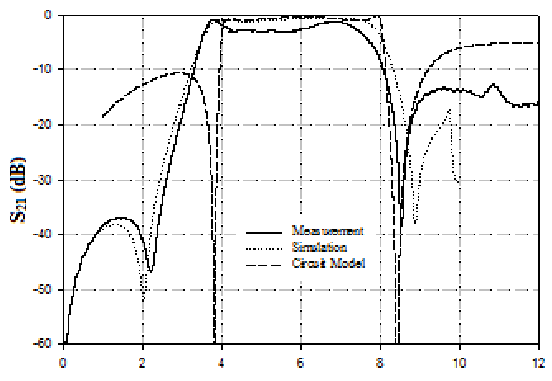
The value of capacitance for the length L_c=1mm is computed using the expression [5].

$$L_c = f_c \lambda_{gc} Z_{0c} C_s. \quad (2)$$

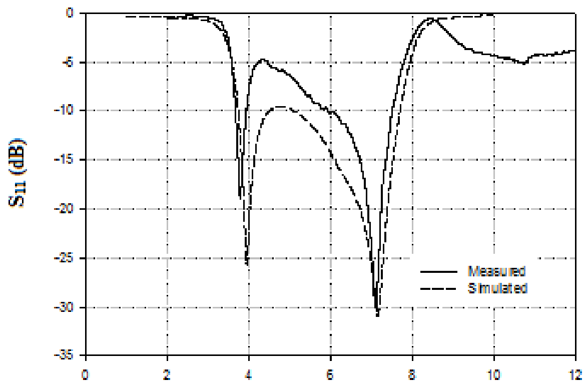
Where, f_c = 6 GHz, λ_{gc} = guide wavelength in the capacitive stub = 28.075 mm, Z_{0c}=90.34 Ohms is the characteristic impedance of the capacitive transmission line section. The computed capacitance value is 0.625 pF. Taking into consideration the coupling of SIR with other parts of the filter structure, the values are optimised and equivalent circuit with optimised values is shown in Fig.4.The lumped elements values corresponding to the coupled line sections (L3-L6 and C3-C6) are computed according to [3].

IV. EXPERIMENTAL RESULTS

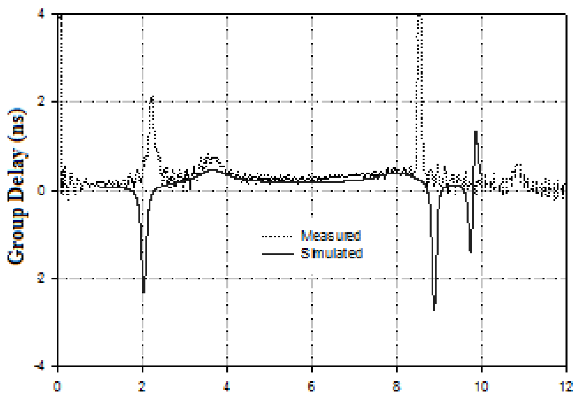
The filter structure is implemented on FR4-epoxy substrate with a dielectric constant of 4.4; thickness 1.6 mm and loss tangent 0.02. Measurements are taken using Agilent E8362B PNA. Experimental results closely agree with simulated results. The simulated and measurement results are shown in Fig.5 (a-c). Measured stop band attenuation is better than 37dB in the lower side and 13dB in the upper side. The photograph of the fabricated prototype filter is shown in Fig.5 (d). Roll off rate is 33.35 dB/GHz in the lower side and 44.58dB/GHz in the upper side.Group delay is 0.25ns and variations are less than 0.15ns. Slight discrepancies in measured results can be attributed to fabrication inaccuracies.



(a) S_{21} of circuit simulation, EM simulation and measurement for the Proposed filter.



(b) Simulated and Measured S_{11}



.(c)Simulated and Measured Group Delay of the proposed filter

Fig.5. Results

Table I. shows the comparative study of parameters of the proposed filter with similar reported works. As can be seen from Table.1 the proposed filter is compact and has better lower stopband attenuation and good roll off rate. The insertion loss can be improved by using a low loss substrate.

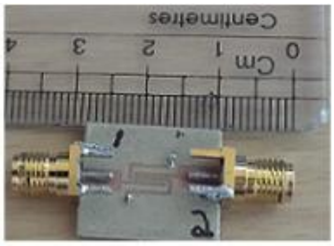


Fig.5. (d) Photograph of the Fabricated Prototype filter

Table I. Comparison of Parameters of Proposed filter with similar works.

Parameter	**Proposed filter**	**[4]**	**[5]**	**[6]**	**[7]**	**[8]**
Insertion Loss(dB)	**3.2**	1	2.4	1.8	0.53	2.1
Passband(GHz)	**3.53-8**	3.7-8.3	3.17-10.6	3.1-10.6	3.85-10.44	1.85-3.05
Rolloff Rate – Lower,Upper(dB/GHz)	**33.35, 44.58**	Not Specified	147, 30	Not Specified	Not Specified	Not Specified
Stopband attenuation-Lower,Upper(dB)	**37,13**	25,24	28,20	Not Specified	Not Specified	28,18
Group delay variations(nS)	**0.25**	**0.25**	0.2	0.2	0.25	Not specified
Size	**17.85×6.24 mm²**	16×3.15 mm²	20×6.6 mm²	35×8mm²	5×7.6mm²	22×18 mm²
Substrate [ε_r/h]	**4.4/1.6mm**	10.8/1.27 mm	4.4/1.6 mm	2.2/0.254 mm	2.2/0.508 mm	Not specified

V. Conclusion

A novel and compact microstrip band pass filter is presented for C-band applications. Good roll off rate and better stopband attenuation are the main features of the proposed filter. The filter exhibits good group delay performance making it suitable for communication applications. Use of a low loss substrate can lead to lesser insertion loss.

.

Acknowledgment

The authors gratefully acknowledge the experimental facilities extended by the Centre for Research in Electromagnetics and Antennas (CREMA), Cochin University of Science and Technology. The research is financially supported vide KSCSTE-ETP Project (ETP/03/2013/KSCSTE date 26.09.2013).

References

[1] Shuh-Tai. LU, Ping-Chun tDeng, Ji-Chyun Liu, Tai-I-WU, “On the relationship among dual-mode double-ring and double slot-ring resonators for wide band-pass filter design”, Microwave and Optical Technology Letters, Vol. 50, No.1, 2008.

[2] W.J.Lui, Z. Deng, C.H. Cheng, H.B. Zhu, “Novel multilayer microstrip bandpass filter with multislots on ground plane”, Microwave and Optical Technology Letters, Vol. 47, No.4, 2005.

[3] D. M. Pozar, Microwave Engineering, 2nd. New York: Wiley, 1998.

[4] Hussein Nasser Shaman, “Design of a Compact C-band Microstrip Bandpass Filter for Satellite Communications Applications,” 978-1-4673-1989-8/12/$31.00 ©2012 IEEE.

[5] Chettiparampil J. Bindu, ShantaMridula, and PezholilMohanan, “High Selectivity Filter Employing Stepped Impedance Resonators, Series Capacitors and Defected Ground Structuresfor Ultra Wide Band Applications”. Progress in Electromagnetics Research C, Vol. 49, 123-131, 2014.

[6] J.-W. Baik, T.-H. Lee and Y.-S. Kim, “UWB bandpass filter using microstrip-to-CPW transition with broadband balun,” IEEE Microw. Wireless Compon. Lett. vol. 17, no. 12, pp. 846–848, 2007.

[7] M. S. Razalli, A. Ismail, and M. Adzir Mahdi, "Novel Compact "Via-Less" Ultra-Wide Band Filter Utilizing Capacitive Microstrip Patch," Progress In Electromagnetics Research C, PIER 91, 213–227, 2009.

[8] Chongcheawchamnan. M, Phromloungsri. R, Krairiksh. M, Robertson I.D,"Microstrip ring resonator filter with inductively-compensated parallel-coupled feed and stepped-impedance design", Electronics Letters, Volume: 43, Issue: 23, 2007

Anishamol Asokan was born in India. She received the BTech degree in Electronics and Communication from Mahatma Gandhi University in 2012.

Bindu C J was born in India. She received B Tech Degree in Electrical Engineering from Calicut University in 1988. She received Post Graduate Diploma in Computer Applications and Client Server Computing during 1994-'98 and M Tech degree in Embedded Systems in 2008 from Calicut University. She has over 12 years of teaching experience in various professional institutions in Kerala. Her areas of interest include embedded systems, planar transmission lines and filters. She is a member of IEEE and a life member of the Indian Society for Technical Education.

Anj u Pradeep was born in India. She received the BTech degree in Electronics and Communication from Kerala University in 1 993, and the MTech degree in Microwave and Radar Engineering in 2008 from Cochin University of Science and Technology (CUSAT). She is currently pursuing a PhD degree at CUSAT. She has been involved in teaching undergraduate students in engineering colleges since 1995. She was awarded the Young Scientist Award i n the field of physical sciences for the best paper presentation at the first Kerala Women's' Science Congress 2010. Her areas of interest include metamaterials and optimization techniques. She is a life member of the Indian Society for Technical Education.

Binu Paul was born in India. She received her M.Tech and Ph.D. degree in Electronics from Cochin University of Science and Technology in 1996 and 2006 respectively. During 1995–1999, she served the Institute of Human Resources Development (IHRD), Government of Kerala, and India, as Lecturer in Electronics. She joined the Division of Electronics and Communication Engineering, School of Engineering, Cochin University of Science and Technology, as Lecturer in January 1999. Her research interests include Microstrip Antennas, FDTD Analysis of Antennas and Wireless Communication. Binu Paul is a member of the Indian Society for Technical Education and Institute of Electrical and Electronics Engineers.

S. Mridula was born in India. She received the Btech degree in Electronics and Communication from the Kerala University in 1 988, and the MTech degree in Electronics from the Cochin University of Science and Technology (CUSAT) in 1 999. She was awarded the K. G. Nair Endowment Gold Medal for securing the first rank in the university. She received her PhD in Microwave Electronics from CUSAT in May, 2006. She has over 1 9 years of teaching experience in various professional institutions in Kerala, and is presently serving as Reader, Division of Electronics Engineering, School of Engineering, and CUSAT. Her areas of interest include planar antennas, dielectric-resonator antennas, radiation hazards of mobile handset antennas, and computational electromagnetics. She is a member of the IEEE, a life member of the Institute of Electronics and Telecommunication Engineers (India), and a life member of the Indian Society for Technical Education.