International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 2 Issue 10, October - 2013

# Dual-band and tri-band filter design for multi-band communication systems

Ms. Shruti Awasthi, Mr. Praveen srivastava)
*Electronics & communication Engineering*
*Kanpur Institute of Technology, Kanpur*
*GBTU, India*

## Abstract

*This paper presents dual and tri band pass filter. These filters are designed by using folded stub loaded resonator technique. The second and third bands are affected by the inner stubs inserted in a random position to make it feasible to self control on the electrical features. The central frequencies are obtained in two and three bands are in equal intervals. Insertion loss and attenuation are very less and high out of band rejection capability is observed. The center frequencies are located to design are 2.1 GHz, 3.77 GHz for dual band pass filter designing and tri band central frequencies are expected as 2 GHz, 4.5 GHz and 7.6 GHz . Good pass band is obtained. Results are compared using simulation process and theoretical analysis. We will simulate the results by considering all the theoretical parameters and then synthesizing will be done to give the performance by comparison. High selectivity will result better performance.*

## 1. Introduction:-

**Dual band pass filter:** As important building blocks of wireless communication systems, band-pass filters (BPFs) have gained a lot of attention. Much research has been conducted, such as UWB filters miniaturized filters and multi-band filters. With the deployment of multi-band wireless system, the capabilities of accessing multi-band frequencies are needed to reduce the number of components in RF systems [6]. Modern dual-band operation electronic devices require the development of efficient and compact dual-band filters. Indeed, the development of dual-band and multi-band filters is a very active research field now a day [8]. To meet the increasing communication requirements, many wireless communication systems have been developed and widely used in people's daily life, such as GSM (800/900 MHz), WCDMA (2.1 GHz), WLAN (2.4/5.2 GHz) and Wimax (3.5 GHz). To incorporate two or more desired communication bands in a single unit and filter unwanted frequencies, filters with a multi-band response have attracted more and more interest in modern microwave filter design [9]. Due to the rapid development of intelligent zed wireless communication systems, compact, high performance and low-cost filters are needed. Researches show great interest on band pass filters (BPFs) with dual- and tri-pass band that can work in multiple communication bands [10]. There is an increasing demand of dual-band microwave devices. To meet the demand, much research has been carried out. A dual-band band-pass filter (BPF) was achieved by a cascade connection of a BPF and a band-stop filter, with the drawback of a large circuit size and also a resonator is embedded in another one to obtain two pass-bands. Dual-band filters can also be realized by combining two sets of resonators with common input and output. Besides utilizing two or more resonators, a dual-band filter can be designed by using a stepped-impedance resonator (SIR). The main disadvantage of some of the cited design methods is that they yield large size filters compared with implementations based on the use of small, intrinsically dual-band, and resonators [8].

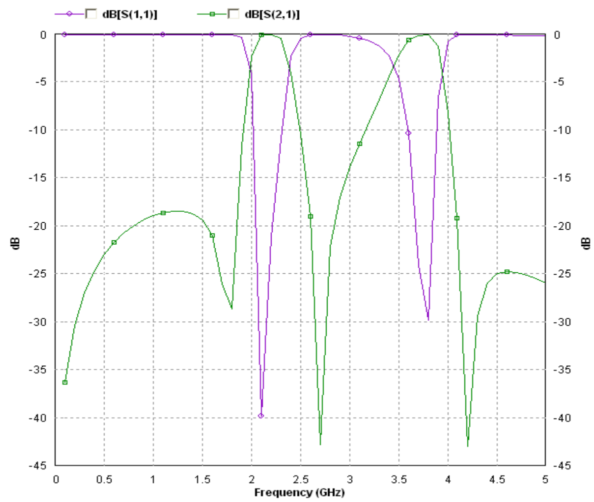
**Tri-band pass filter:**

For tri-band BPF designs, a typical method is to use tri-section stepped- impedance resonators (SIRs). By controlling the electronic length ratios and impedance ratio, tri-band responses can be obtained.However, the resonant frequencies are dependent and the degrees of freedom are limited. Another typical way to design tri-band BPFs is to combine several sets of resonators. Three sets of resonators are utilized and each set of resonator forms a pass band. Thus, a tri-band response can be achieved. One resonator is used to realize one pass band and the other set of resonator is employed to obtain two pass bands. Using this method, the pass band frequencies and bandwidths can be easily controlled. However, it is difficult to reduce the filter size. Recently, stub-loaded resonators are combined with other resonators to obtain tri-band responses [2].

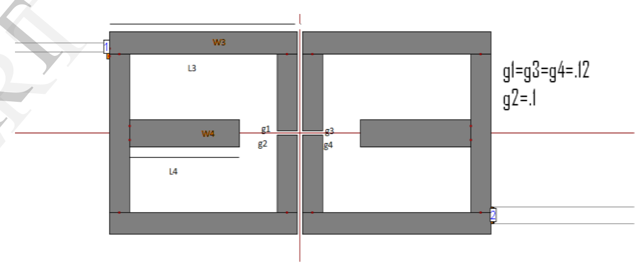
Multi-band multi-standard wireless communication Systems have been gaining much attention in recent Years. These systems prefer multi-band transceivers to several Single-band ones. In tri-band transceivers, tri-band band-pass Filters (BPFs) are important building blocks and thus heavily demanded [11].

*Design of dual band pass filter:*

For designing a dual band pass filter, resonators specifications and dimensions like stub lengths, and positions are determined. Gap between the resonators are determined. Three coupled techniques electric, magnetic and mixed are used. Once the resonators dimensions are determined then position of the tapping is used to evaluate the frequency bands of both. The proposed dual band pass filter consist folded stub loaded resonators coupled together with the open stubs inserted inside. By open loop SLR technique, a dual-band filter is designed. The configuration is shown in Fig**.** 1(b). It has two open SLRs. By Comparing with the normal open-loop resonator, this resonator has an additional open stub inside the loop, which shows that dual-band process is obtained while size is maintained. The pass band frequencies can be calculated by the whole length of the open loop resonator and the length of the open stub. The pass band bandwidths of filter are dependent on the quality factors and the coupling coefficients between the resonators. Therefore, the difference between resonators and distance determine the frequencies for bands. The substrate used in this design has a relative dielectric constant of 4.5 and a thickness of 1.5mm. The dimensions are selected as follows: $W_1$=0.9 mm$W_2$= 1.2 mm, $W_3$= 1.5 mm, $L_3$=11.2 mm, $L_4$=6.7 mm, d=0.6 mm, $g_1$=0.3 mm, $g_2$=0.3 mm. Length of open loop is 47.66 mm. Stub length $w_3$ is changed i.e. 3.59 mm and port 1, 2 lengths are changed while changing the resonators gaps $g_1$,$g_2$,$g_3$ and $g_4$ above and lower axis and at the end of each resonator respectively. Now gaps between resonators and from the axis are changed as $g_1$=$g_3$=$g_4$=0.12 mm and $g_2$=0.1mm. The expected pass band frequencies are 2.1GHz and 3.77 GHz.




1. (a) Simulated dual band results with 2.1 GHz and 3.77 GHz central frequencies. (b) Dual band pass filter circuit






*Design of tri-band pass filter:*

Two open stub-loaded resonators which are coupled are employed to design the tri-band pass filter. For completing the filter values for the bandwidths of generated three pass bands, the coupling coefficients and quality factor for external M and $Q_{ext}$ are calculated and defined as:

$$M = \frac{\text{Fractional bandwidth}}{(m_1 m_2)^{(1/2)}} \quad (1)$$

$$Q_{ext} = \frac{m_0 m_1}{\text{Fractional bandwidth}} \quad (2)$$

where $m_0$ and $m_1$ are the single values of the function for the filter. The coupling coefficients and external quality factors can be evaluated from simulated coefficient of transmission, expressed as:

$$K = \frac{f_{High}^2 - f_{Low}^2}{f_{High}^2 - f_{Low}^2} \quad (3)$$

$$Q_{exa} = \frac{2Wo}{W_3 \text{in decibels}} \quad (4)$$

where $f_{High}$ and $f_{Low}$ are defined to be the higher and lower of the two resonant modes, $W_0$is the resonant frequency and $W_3$ is the 3dB bandwidth. From the simulated result, First, second and third band centre frequencies are 2, 4.5 and 7.6 GHz having attenuations 38.6 dB, 24 dB and 21.7 dB respectively.

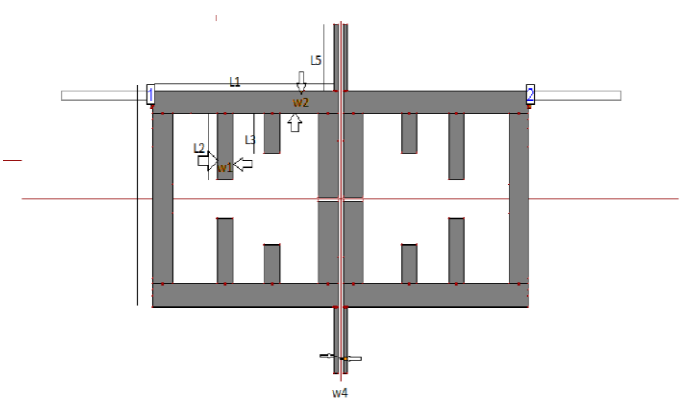
In the Stub loaded resonator, the admittance $Y_1$ and $Y_2$ of the stub $l_1$ and $l_2$ are determined by the stub widths $w_1$ and $w_2$. In this paper, the even and odd mode situations for resonance can be expressed as:

$$Y_{iod} = \frac{Y_1}{j\tan(\beta'_1.l_1)} = 0 \quad (5)$$

$$Y_{ieve} = jY_1 \frac{2Y_1(\tan\beta'_2.l_1) + Y_1\, 2Y_1(\tan\beta'_2.l_2)}{2Y_1 - Y_2\tan(\beta'_2.l_1/2)\tan(\beta'_2.l_2)} = 0 \quad (6)$$

The inverted impedances are determined by the width of the stub, the length of stub and can be evaluated from (5) and (6). The coupling coefficient of the odd mode is found to be very less. In order to enhance the coupling intensity of the odd mode, this design has been adopted.

**Simulation results:**

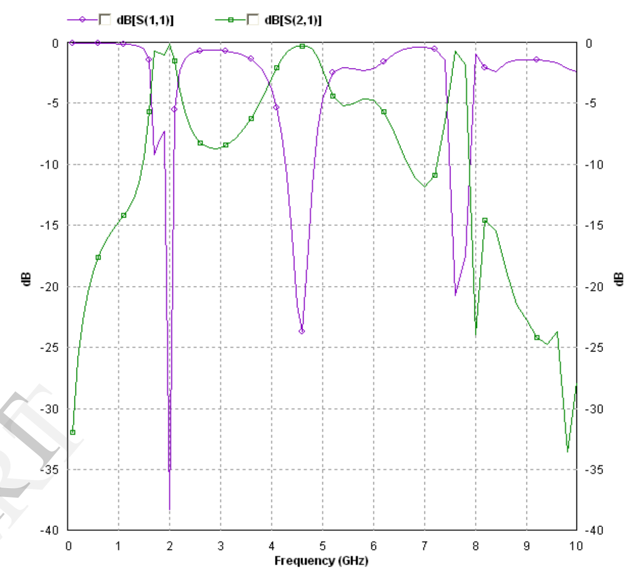



2. (a)Tri-band pass filter circuit

Following are the dimensions selected for tri band pass filter designing:

w1=0.925mm,w2=0.9mm,w4=0.25mm,L1=11.2mm, L2=3.4mm, L3=2.025mm , L5=3.4mm.

Material used having dielectric constant 4.5 and thickness for substrate is 1.5mm.




(b) Simulated tri-band pass filter result with material 4.5 and material thickness is 1.5mm with identical dimensions used in dual band pass filter design.



Tri-band simulated results→

- In tri band filter, we obtained the sharp results. First band has very less attenuation around 38.6 dB at 2GHz centre frequency.
- Second band has attenuation 24.0 dB at 4.5 GHz centre frequency.
- Third band is operating at 7.6 GHz centre frequency which has 21.7 dB attenuation.
- All three bands are operating at approx equal intervals in frequencies, which will give excellent results compare to previous results.

**Conclusion:** This letter present a Stub loaded resonator using open stubs. The qualities of SLR can be attained by theoretical analysis and proved by simulation Fig. 1(a), 2(b). The newly proposed SLR introduces the gain that its resonant frequencies of even-mode can be varied, whereas those of odd-mode are constant. The measured results agree well with simulated ones. The behavior of resonance and quality factor of the proposed stub-loaded SIR is analyzed, providing a design guideline to realize the tri-band filter. In addition, good pass band selectivity and isolation of each pass band can be attained due to the displaying of the transmission zeros near each pass band edge.

**Future Scope:** Several techniques to enhance the selectivity based on the open stubs and feeding tapped line. Better coupling methods can be used to decrease the insertion loss.

**References:**

1. *A. Namsang and P. Akkaraekthalin, "microstrip bandpass filters using end-coupled asymmetrical step-impedance resonators for wide-spurious response" Progress In Electromagnetics Research C, Vol. 14, 53-65, 2010.*
2. *Wei-Yu Chen, Min-Hang Weng, Member, IEEE, and Shoou-Jinn Chang, Senior Member, IEEE, "A New Tri-Band Bandpass Filter Based on Stub-Loaded Step-Impedance Resonator" IEEE MICROWAVE AND WIRELESS COMPONENTS LETTERS, VOL. 22, NO. 4, APRIL 2012.*
3. *Chang Chen, Weidong Chen, and Zhongxiang Zhang," A Novel Dual-mode Dual-band Bandpass Filter with DGS" Progress In Electromagnetics Research Symposium Proceedings, Marrakesh, Morocco, Mar. 20-23, 2011.*
4. *G. Chaudhary, Y. Jeong, K. Kim, and D. Ahn," design of dual-band bandpass filters with controllable bandwidths using new mapping function" Progress In Electromagnetics Research, Vol. 124, 17-34, 2012.*
5. *Priyanka Mondal, Student Member, IEEE, and Mrinal Kanti Mandal, Student Member, IEEE, "Design of Dual-Band Bandpass Filters Using Stub-Loaded Open-Loop Resonators" IEEE TRANSACTIONS ON MICROWAVE THEORY AND TECHNIQUES, VOL. 56, NO. 1, JANUARY 2008.*
6. *Xiu Yin Zhang*, Li Gao, Ze Yu Cai, and Xiao-Lan Zhao, "novel tri-band bandpass filter using stub-loaded short-ended resonator" Progress In Electromagnetics Research Letters, Vol. 40, 81-92, 2013.*
7. *Xiu Yin Zhang, Student Member, IEEE, Jian-Xin Chen, Student Member, IEEE, Quan Xue, Senior Member, IEEE,and Si-Min Li, "Dual-Band Bandpass Filters Using Stub-Loaded Resonators" IEEE MICROWAVE AND WIRELESS COMPONENTS LETTERS, VOL. 17, NO. 8, AUGUST 2007.*
8. *M. D. C. Vel¶azquez-Ahumada, "Application of stub loaded folded stepped impedance resonators to dual band filter design" Progress In Electromagnetics Research, PIER 102, 107-124, 2010.*
9. *Xin Lai, Chang-Hong Liang, Senior Member, IEEE, Hao Di, and Bian Wu, "Design of Tri-Band Filter Based on Stub Loaded Resonator and DGS Resonator" IEEE MICROWAVE AND WIRELESS COMPONENTS LETTERS, VOL. 20, NO. 5, MAY 2010.*
10. *Xuehui Guan1; 2, Fang Wen1, Wei Fu1, Haiwen Liu1, Guohui Li2, and Lu Zhu1, "A Tri-band Bandpass Filter Using Short-stub Loaded SIR" PIERS Proceedings, Suzhou, China, September 12-16, 2011.*
11. *Xiu Yin Zhang, Member, IEEE, Quan Xue, Senior Member, IEEE, and Bin Jie Hu, Member, IEEE, "Planar Tri-Band Bandpass Filter With Compact Size" IEEE MICROWAVE AND WIRELESS COMPONENTS LETTERS, VOL. 20, NO. 5, MAY 2010.*