Design of a High Selectivity Quadband Bandpass Filter Based on Open Loop Stub Loaded Resonator for UMTS, WLAN, Wimax and ITU Applications

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Abstract: ***This paper presents high selectivity micro strip Quad band band pass filter Based on OLSLR (Open loop stub loaded resonator) for various wireless communication applications such as UMTS (Universal Mobile Telecommunication Systems) at 2.1GHz, WLAN (Wireless Local Area Networks) at 4GHz, Wimax (Worldwide Interoperability For Microwave Access) at 6.2GHz And ITU (International Telecommunication Unions) at 7.2GHz.Where pair of resonator is capacitiely coupled to each other and the feed lines. First and the third pass bands are generated by resonator A. The second and the fourth pass bands are excited by resonator B. The proposed technique provides sufficient degree of freedom to control the center frequency and bandwidth of the four pass bands by varying the dimensions of stub. In addition, six transmission zeros created around the pass bands results in a quad-band filter with high selectivity***

Keywords: OLSLR (Open loop stub loaded resonator) Band pass filter (BPF), TransmissionZeros, Coupling coefficient, Bandwidth.

1. Introduction

Wireless communication is rapidly gaining an importance in our modern society. In addition there is a high demand for multiband band pass filters in wireless communication devices such as RF transceivers to operate in multiple but separated frequency bands so that users can access various services with a single multimode handset or terminal. Higher order band pass filters are routinely modeled by cascading multiple single/dual-mode resonators. This straightforward approach results in an significant increase in the overall filter size and raises the fabrication cost. However, although many different methods [1-5] have been reported in generating multiband in a single configuration, the main problems still exist and it is due to difficulties in achieving good performance for all pass bands, especially with more than three pass bands. The proposed filter uses capacitive coupled two open loop resonators with a stub loaded on the center of the resonator. The resonant frequencies were controlled by tuning the length and width of the stub loaded in open loop resonator. The bandwidth of the four pass bands are different with high insertion loss. This filter cascaded a set of stub loaded open loop resonator along feeding lines. Despite being a simple design, the insertion losses are around 3dB and occupied a wide area. we proposed Quad band band-pass filters using stub-loaded resonators UMTS, WLAN, WiMAX and ITU applications. First, microstrip coupled filter is designed based on coupling matrix syntheses to achieve a band pass behavior at 2.1GHzand 6.2GHZ. Second, microstrip coupled filter is designed based on coupling matrix syntheses to achieve a band pass behavior at 4GHzand 7.2GHZ. The proposed Quad-band filter generates six transmission zeros located around the passbands to realize high selectivity, sharp 3dB roll-off and high out-of-band rejection The planar structure facilitates the design and reduces fabrication cost. With a size of 15mm×27mm the filter is miniature compared to the aforementioned filters and this eases integration in wireless systems. The filter structure provides sufficient degree of freedom to control the center frequency and bandwidth of the four passband responses. The filter was designed and simulated at 2.1/4/6.2/7.2/ GHz for different applications such as UMTS, WLAN, WiMAX and ITU. Two transmission lines with the characteristic impedance of 50 Ω are directly connected to the outer resonators, acting as input and output ports.

2. Filter Configuration and Analysis

a) *Resonators Configuration*

Figure 1 shows the configuration of open loop resonator for the proposed filter. It consists of two resonators. Stub-loaded resonators 1 and 2 are λ/2 open-circuited at the coupling ends, and their other ends are parallel coupled to the 50 Ω input/output feedlines .

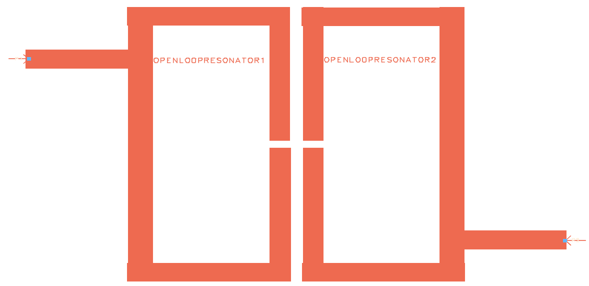

Figure 1: Layout of capacitive coupled open loop resonator

Open-loop resonator also known in the literature as split ring resonator. This resonator resonates when the length of the resonator corresponds to λ/2[6]. The open end of resonator provides a capacitive coupling in parallel to the main path that provides a transmission zero at the higher stop band.

Due to the fact that the electric field at the open sides of the open loop resonator is maximum at the resonance frequency of the resonator, and the magnetic field is maximum at the center of the resonator the coupling nature between two open loop depends on the neighboring side. Thus by having the resonators coupled from the open ends, capacitive coupling is generated, while having the resonators coupled from the opposite sides, an inductive coupling is generated [3].

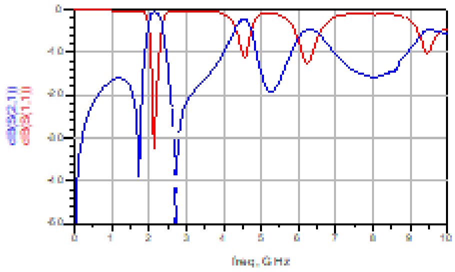

Figure 1 (a): Simulated response of open loop resonator

From the simulated response it is observed that four pass bands generated. The design of proposed filter is accomplished by extracting the coupling coefficient and the external quality factor.Figure1adepicts the simulated insertion loss and return loss of the proposed BPF based on the optimization technique for extracting the coupling matrix with the aforementioned specifications for tuning the center frequencies. of first and third pass bands an open stub is loaded at the center of the resonator1.

b) Open loop stub loaded resonator Configuration

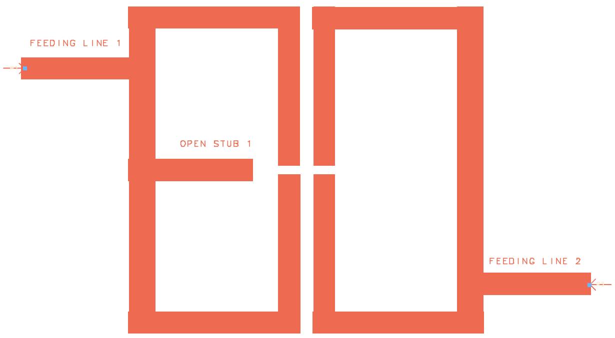

Figure 2: Layout of open loop stub loaded resonator

It consists of a transmission line of length L and a open stub loaded at the center can be utilized to tune the even-mode resonant frequencies of the resonator whereas, it has no impact on the odd-mode resonant frequencies [4]. As a result, it is easy to adjust the pass band frequencies. Hence a stub is loaded at the center of the resonator1to tune the centre frequencies of first and third pass bands by varying the length and width of the stub. The resonating frequency of a resonator is given by $Fc=1/\ (2\pi\ LC)$ Where, Fc – resonating frequency in GHz L –inductance in nH, C – Capacitance in Pf L & C are assumed and the resonator is designed.

The two parameters that control the resonance frequencies are:

1. The width of the narrow strip line *w*, which affects only the quasi-lumped resonance without main change of the open-loop resonance, so by increasing *w*, the inductive value of the strip line is decreased, that will shift the quasi-lumped resonance to a higher frequency band, and vice versa[2].

2. The other parameters that mainly affect the open-loop resonance are the spacing between the open ends of the resonator *s*, and width of the open ends *x*, Decreasing *s* decreases the capacitive coupling between the open-ends of the resonator, which shifts the open-loop mode to a higher frequency and vice versa. On the other hand, increasing *x* increases the capacitive value between the open ends which shifts the open-loop mode to lower frequency band [2].

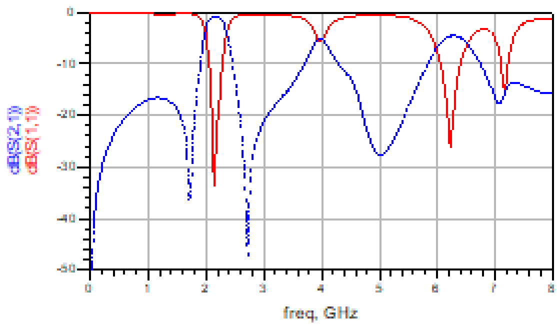

Figure 2 (a): Simulated response of open loop resonator

Figure 2 a depicts the simulated improved insertion loss and return loss of the first and third pass bands. Filter is designed such that the first pass band whose center frequency is 2.1GHz for UMTS(Universal Mobile Telecommunication Systems) applications with and third pass band whose center frequency is 6.2GHz for WiMAX (Worldwide interoperability microwave access)applications.

3. Proposed Filter Implementation

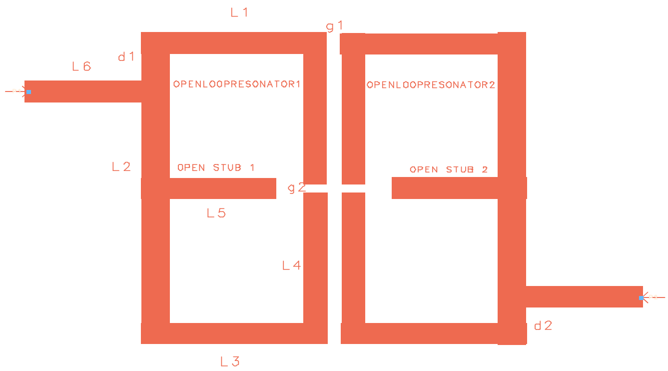

Figure 3: Layout of Proposed Filter

The layout of second order SLR band pass coupled filter is illustrated in figure3. The main block of the proposed filter is two half-wavelength resonators with two open stubs. The open stub is connected at the midpoint of the microstrip line. The dimensions of the band pass filter are added in table1. The filter is designed by calculating the coupling matrix and external quality factor. By adjusting the gap (g) between resonators and the distance (d) of the microstrip line, the band pass filter with the desired output can be achieved. The software ADS is used for simulation. The proposed band pass filter is mounted on FR4substrate with relative dielectric constant (εr) = 4.6, thickness (h) = 1.6mm and loss tangent (tan δ) = 0.01.

For satisfying filter specification for the bandwidths of the pass bands, the desired coupling coefficients $M_{i,\ j}$ and external quality factor Q_e methodology are performed. The theoretical $M_{i,j}$ and Q_e are calculated and defined as

$$M_{i,j} = \frac{FBW}{\sqrt{g_1 g_2}} \quad (1)$$

and

$$Q_e = \frac{g_0 g_1}{FBW} \quad (2)$$

Where FBW is fractional bandwidth, and gn and g_{n+1} are element values of the filter response function.The simulated S-parameters of the proposed BPF are shown in figure3a and it can be noticed that the first pass-band frequency f1 is held constant at 2.1 GHz by fixing the conventional micro strip half-wavelength resonator1. The third pass-band frequency f3 is tuned to 6.2GHz by changing the length and width of stub1.Similarly Second pass band frequency f2 is 4GHz and by changing the length and width of stub2 fourth pass band frequency f4 is 7.2GHz. It is known that the coupling coefficients related with the desired fractional bandwidths are controlled by the coupling spacing (g) [11].The external quality Qe at the corresponded frequencies f0, f1, f2 andf3 with respect to the length d defined by the tapped location to the symmetric plane is analyzed. The coupling coefficients Ki, j and external quality Qe can be calculated by the equation (10) and(11)

$$K_{i,j} = \frac{f_H^2 - f_L^2}{f_H^2 + f_L^2} \quad (3)$$

And

$$Q_e = \frac{2\omega_0}{\Delta\omega_{3\ dB}} \quad (4)$$

The filter was simulated on a substrate FR4with a thickness of 1.6mm and relative dielectric constant of 4.6mm.Following the design methodology in the preceding section, the filter's dimensions were calculated to be (in millimeters): L1 = 8, L2 = 15, L3 = 8, L4 = 7.1, L5 = 4.6, L6=5, W1 = 1, W2=1.2, d1 =2.3, d2=1.7, g1= 0.7and g2= 0.4 which corresponds to a characteristic impedance of 50Ω. Simulations were performed using ADS software tool

Table 1: Dimensions of the proposed Quad band filter (all in mm)

L1	L2	L3	L4	L5	L6	W1	W2	g 1	g 2	d1	d 2
8	15	8	7.1	4.6	5	1	1.2	0.7	0.4	2.3	1.7

4. Simulation Results

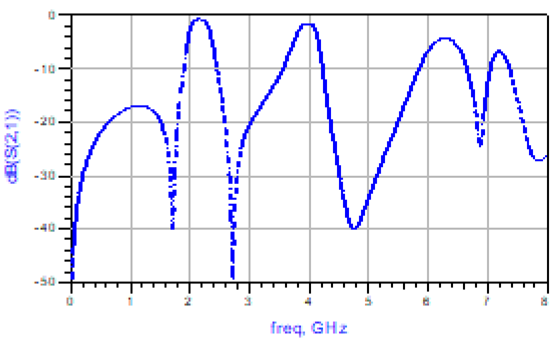

Figure 3 (a): Simulated Insertion loss response of proposed filter

The proposed filter introduces insertion loss 0.7dBfor f1, 1.6dB for f2, 4.3dB for f3 and 6.6dB for f4. The proposed filter introduces return loss 32dBfor f1, 45.6dB for f2, 35.8dB for f3 and 19.1dB for f4

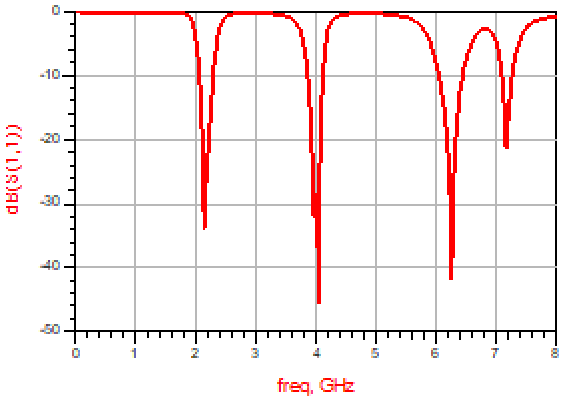

Figure 3 (b): Simulated Return loss response of proposed filter

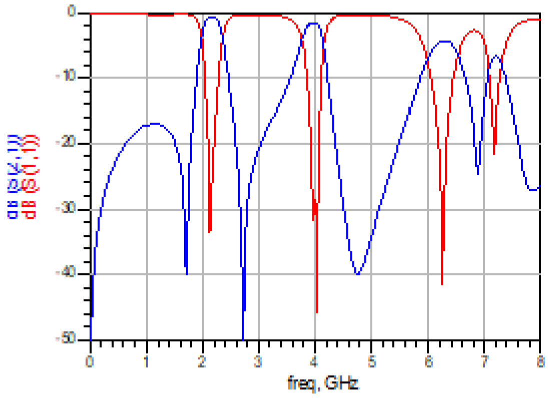

Figure 3 (c): Simulated Insertion loss and Return loss response of proposed filter

The filter has four pass band responses centered at 2.1/4.0/6.2/7.2GHz with high selectivity of50/50/40/28 dB respectively. The insertion losses at the four pass bands are less than 0.7/1.6/4.3/6 dB respectively. The corresponding return losses are greater than 32dB, 45dB, 35dBand19dB respectively. The band width of first band is 2100MHz, second band is 1900MHz, third band has2200MHz and the fourth band has2000MHz.

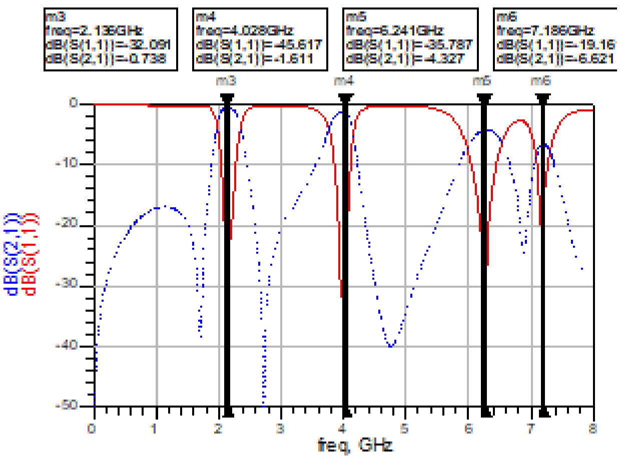

Figure 3(d): Simulated Return loss response of proposed filter

Table 2: Quad band filter response

	I Band	II Band	III Band	IV Band
Resonance frequency (GHz)	2.1	4.0	6.2	7.2
Maximum Insertion loss (dB)	0.7	1.6	4.3	6.6
Maximum Return loss (dB)	32.1	45.6	35.8	19.1

5. Conclusion

A high selective quad-band bandpass filter based on open loop stub-loaded resonator is presented. A pairs of resonators are used to excite quad-mode resonances. The proposed technique provides a sufficient degree of freedom to alter the filter's specifications in terms of centre frequency and bandwidth the insertion loss and return loss were greatly reduced. Each pass band has good selectivity with high interference suppression and stop band attenuation with the following bandwidths and center frequencies.First band- Bandwidth of 2100MHz with center frequency 2.1GHz and selectivity -50dB.Second band- Bandwidth of 1900MHz with center frequency 4GHz and selectivity -50dB.Third band- Bandwidth of2200MHz with center frequency 6.2GHz and selectivity -40dB.Fourth band- Bandwidth of 2000MHz with center frequency 7.2GHz and selectivity -25dB.

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