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Dual-Mode X-Band Bandpass Filter Using Stepped Impedance Resonator and Vias

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ABSTRACT: In this paper, the Dual-mode high performance filter using stepped impedance resonator (SIR) and vias for satellite application is presented. The high frequency bandpass filter is used in the filter design of X-Band (8 to 12 GHz) frequency. The dual-mode stub loaded resonators, which consists of microstrip resonators with vias of distinct radius on each stub. This dual-mode resonator filter design involves FR4 substrate with ε_r of 4.6 and a thickness of 2.2mm. The simulated results are obtained with better return loss and good insertion loss with wide stopband.

KEYWORDS: Microstrip filter, Dual-mode resonators, Stepped Impedance Resonator, X-band or SHF Bandpass Filters.

I. INTRODUCTION

X band or SHF (Super High Frequency) satellite communication is most widely used by the military forces for beyond line of sight communication. X band is used because it provides a compromise between the characteristics of different frequency bands which is particularly suited to the needs of Military users. The characteristic includes Interference Resilience, Rain Resilience, Data rate. The filter can have either wideband or narrow band bandwidth. The main function of a filter is to either separate or combine different frequencies and discriminate between wanted and unwanted frequencies. This makes them useful in order to confine the RF/Microwave signals within the assigned spectral limits. They can be realized in a variety of ways which include resonators, waveguide, coaxial line or microstrip for instance, either as a lumped element or distributed circuits. More stringent requirements are being placed on filters as the emerging applications require more functionality. These requirements may include: Higher Performance Smaller Size, Lighter weight, Lower cost. As these multifunctional capability requirements increase, further development of new technologies is required, namely reconfigurable/tunable filters. Novel Microstrip open loop resonator bandpass filter based on a basic stepped-impedance resonator is proposed in [10]. The optimal design for a miniaturized stepped-impedance resonator is employed by this layout, which can be reduce size and improve the spurious suppression. A modified λ/4 stepped impedance resonator (SIR) is proposed, in which a shunt open stub is loaded between the low impedance line and high impedance line of a conventional λ/4 SIR. Based on this modified λ/4 SIR, a compact dual-band bandpass filter (BPF) with high selectivity is presented in [12].A new approach of designing a bandpass filter by applying a combination of microstrip and cylindrical shape of dielectric resonators for have a compact size, good sharpness on the sides, and small loss. Numerous technique in practice to suppress harmonic resonance spurious radiation [13].

II. DESIGN METHODOLOGY

The dual-mode filter structure of BPF is given in Fig.1 resembling a pair of stepped impedance resonator with a center stub connecting each filter with two symmetrical arms is designed. The idea of using this filter structure is to provide increased transmitted power with a better insertion loss and return loss. The size, shape of the filter will influence the perfect matching of the filter. Most of the planar bandpass filters built on microstrip structures are large in size and their first spurious resonance frequencies at $2f0$ and $3f0$ is the center frequency, which may be closed to the desired frequencies. Therefore SIR, is presented not only to reduce the size but also to control the spurious mode frequencies.

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III. DUAL MODE RESONATOR

The Stepped Impedance Resonators (SIRs) with dual-mode response have been found advantageous in designing microstrip bandpass filters with good passband and stop band performance. To begin the design, it is very important to determine the coupling property between two cascaded dual-mode stepped impedance resonators [9]. One of the key features of an SIR is that its resonant frequencies can be tuned by adjusting its structural parameters, such as the high Z and low Z segments. In this design, two resonators are used as input and output resonators with the central stub having three small via. In [10], [11] the via-holes are used to make immittance inverters which are used to make dual mode resonators. Because the immittance inverter values are basically determined by the inductances of the via-holes, [10] and [11] make an effort to design, model, and characterize the via-holes. By contrast, the via-holes is used

A. *Design of stepped impedance resonator:*

Fig. 1 depicts the layout of the stepped impedance resonator microstrip bandpass filter. A pair of symmetrical cross shaped open-ended stubs are tapped at each side of the central point of the λ/2 SIR. Such paired stubs with total length of about λ/2 construct an equivalent line resonator, which is much more compact in comparison with its counterpart with linear open stubs.

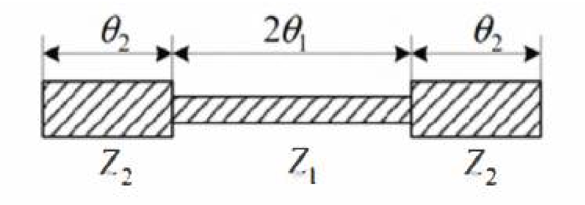

Fig.1 Structure of stepped impedance resonator

Two coupling lines which are connected to port embrace the low-impedance segments of the SIR to get much stronger coupling than their counterparts with parallel coupling. In these cases, the out-of-band performance is good because of effect of SIR used in the filter design.

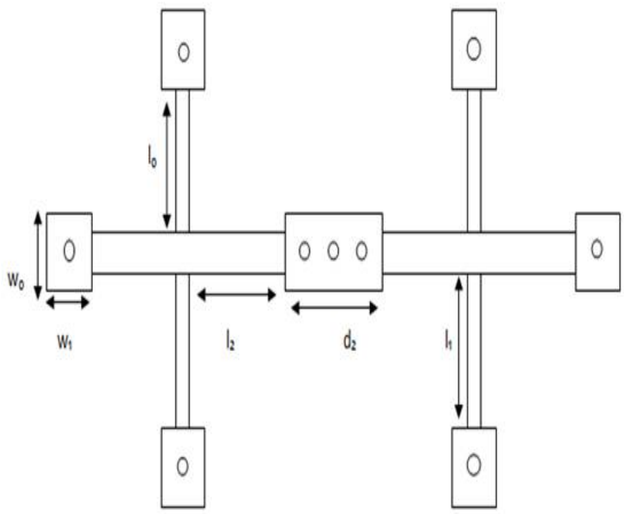

Fig.2 Top view of the structure of dual-mode resonator

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The coupled structures shown in the fig 2 follows a pattern that can be described as stepped impedance resonators. By using the coupling mechanism between the microstrip lines, the higher order mode resonances of the filter can be omitted or shifted to another resonance point.

Two identical microstrip structures are coupled with each other at the middle of the BPF filter. The arms of the coupling structures are folded to decrease the total size of the filter which makes the filter design more compact. At the edge of each microstrip coupling structure, a cascaded structure is introduced to cope with the different impedance characteristic. It can be observed from the layout that two different thickness microstrip lines are coupling with each other. It is valid for both identical microstrip coupled structures.

Parameters	Value
w_o	1.4 mm
w_1	1.4 mm
w_3	1 mm
l_o	3.2 mm
l_1	3.4 mm
d_1	2.8 mm
d_2	1.6 mm

Table.1

The via or hole in the filter and a minute changes in the width of the via has greater effect in its insertion loss characteristics in both the proposed filter designs of X-band. Here the via with the varied radius of r = 0.2 to r = 0.4 has been used for the optimization of the filter characteristics.

IV. Filter Design Technique

The design consists of two vertical and two horizontal stubs with one small via in each stub and three small via in the center stub which is connecting the structure. Both the resonator structure resembles each other in its dimension. The filter has a total length of 17.6 mm with a height of 9.8 mm. Various dimensional parameters of the structure includes w_o=1.4 mm, w_1= 1.4 mm ,w_2= 1 mm ,l_o= 3.2 mm ,l_2=3.4 mm, d_1= 2.8 mm, d_2=1.6 mm with the Via has a diameter of 0.04 mm and it is designed using the schematic simulation of ADS and optimization features.

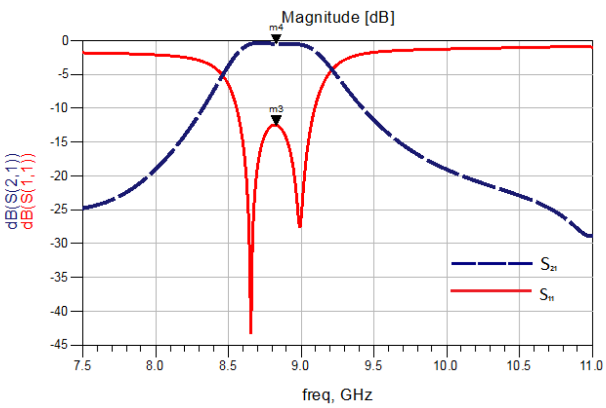

Fig 3. Simulated performance of the filter

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V. SIMULATION RESULTS

The network showed in Fig. 1 is able to transmit 22 packets if total transmission energy metric is used and 17 packets if used maximum number of hops metric. And the network lifetime is also more for total transmission energy. It clearly shows in Fig. 2 that the metric total transmission energy consumes less energy than maximum number of hops. As the network is MANET means nodes are mobile and they change their locations. After nodes have changed their location the new topology is shown in Fig .3 and energy consumption of each node is shown in Fig. 4. Our results shows that the metric total transmission energy performs better than the maximum number of hops in terms of network lifetime, energy consumption and total number of packets transmitted through the network. A X-Band microstrip bandpass filter is designed to make the frequency between 8-9GHz .The filter material is FR4, whose dielectric constant is 4.6, thickness is 2.2 mm. The simulated filter as shown in Fig. 2 occupies an area of about 17.6 mm which predicts the return loss of -12.490 dB in the passband and insertion loss of -0.478 dB throughout the operation frequency of X-band communication as shown in Fig 2. and as the simulated result shows it has good Out Of Band Rejection characteristics.

Parameters	Values
Insertion Loss	-0.478 dB
Return Loss	-12.490 dB

Table 2

VI. CONCLUSION AND FUTURE WORK

This paper has proposed a simple design procedure of dual-mode microstrip bandpass filter based on the stepped impedance resonator. The calculated design values were used in the simulation tool (Advanced Design System) to calculate the performance of the filter. The results shown in Fig.3 indicated that the passband agrees well with the target.

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