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Design of Dual C-shaped Ring Resonator

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ABSTRACT

This paper proposes the design of dual C-shaped square ring resonators which are placed opposite to each other. These filtering square resonators are bounded by three sides with an open end on the fourth side. These ring filters have an oppositely faced ring within itself to augment the filtering capability. This filter operates in the UWB band and has a wide bandwidth. This dual ring resonator is operated at about 5.8GHz band on FR4 Epoxy glass substrate which has a dielectric constant of 4.4. The basic structure of the filter is etched on a ground plane. This design possesses the ease of fabrication, providing high out of band rejection. The return loss of this dual square ring filter is about -60 dB which is highly efficient and depicts the excellent return loss property of the proposed bandpass filter.

KEYWORDS

Band Pass Filter (BPF);
FR-4 Epoxy; Resonator;
Ultra-Wide Band (UWB)

1. INTRODUCTION

Band Pass Filter is an integral part of communication system that passes a set of frequencies while attenuating the others. Earlier, Ultra-Wide Band (UWB), having a range of 3.1-10.6 GHz, was used only for military purposes but after its acquisition by FCC [1], this band became extensively useful due to its advantages like wider bandwidth and low power consumption and suitability in short range communications. Hence, this paper proposes the design of a symmetrical UWB Bandpass filter, and it is simulated using IE3D software.

The compact and miniaturized structure of the filter provides robust performance in terms of band rejection and losses. The dual square ring resonators have drawn much attention because of their ability to exhibit high selectivity. This filter design highly rejects the undesired frequency without any interference. The effectiveness of this filter can be determined by the immense increase in the return loss. As far as the reflection loss is concerned, it is also quite a low value about -0.28dB. This paper provides a modification to the existing dual ring resonator structures as this topology includes a C-shaped ring within the dual rings. This configuration improves the capacitive coupling. Multiple number of substrates have been used for this topology, but FR-4 Epoxy provides an enhanced result. Innovative research on dual-ring resonator was given first by Wolff and Knoppik [2]. Further research has been made in this field to improve its performance and make the filter more compact. The proposed square ring resonator also created a good passband.

The proposed paper focuses on the design and implementation of Novel Dual C-shaped Ring Resonator. The paper consists of the following sections: Section II deals with the Design of the Ring Resonator, Section III presents the Parametric Study, Section IV gives the Simulation results, Section V deals with the Analysis and Section VI puts forward the Conclusion.

2. DESIGN OF SQUARE RING RESONATOR

There is an ever-increasing demand of the bandpass filter. The fundamental function of the bandpass filter is to filter out the undesired frequency signals. The design of bandpass filters with high accuracy provides a promising advantage. This leads to the design of bandpass filter with precisely high accuracy, improved bandwidth and adjustable centre frequency. Another most important parameter is the reduced size of the filter. Some filters are designed with such miniaturization [3] that they can be embedded into the feed of the antenna.

In this paper, a filter is referred, the schematic diagram of which is given in figure1. It comprises of dual C-shaped square ring resonators. These are placed opposite to each other beside the feed of the filter. The two ports are connected to the feed which is placed over the etched ground. The structure resembles two C-shaped designs which are mirror images of each other. Additional smaller C-shaped [4-5] rings which are inverted with respect to the outer rings are placed, which improve the coupling capacity of the filter. It successfully suppresses the spurious out of band signals. The frequency response has high gain and low transmission loss.

The proposed filter has a symmetrical structure, and the design of this filter is based on microstrip technology. The rings present within the ring depict a compact [6-7] structure which

can be easily manufactured at a low cost. This bandpass filter can also be integrated with other microwave devices. The shift from conventional ring resonator structure to a nested ring like filter has helped to achieve best S parameters in the given UWB frequency range. Moreover, this filter structure is very easy to realize [8]. For designing this filter IE3D has been used. The parameters [9] for designing dual square ring resonator are listed in Table 1.

Table 1: Design Specifications

SERIAL NO.	DESIGN PARAMETERS	VALUES USED
1	Substrate Height	1.5 mm
2	Dielectric Constant of FR4 Epoxy	4.4
3	Loss Tangent	0.02
4	Length of Feed	8.23mm
5	Width of Feed	2.86mm
6	Ring Width of Outer Ring	1 mm
7	Ring Width of Inner Ring	0.5 mm

3. PARAMETRIC STUDY

Keeping the outer dimension of the outer ring and the ring-width of outer as well as inner ring constant, S Parameters and center frequency (f_c) for varying dimensions of inner ring are observed and tabulated in Table 2. The design for the proposed filter is shown in Figure 1.

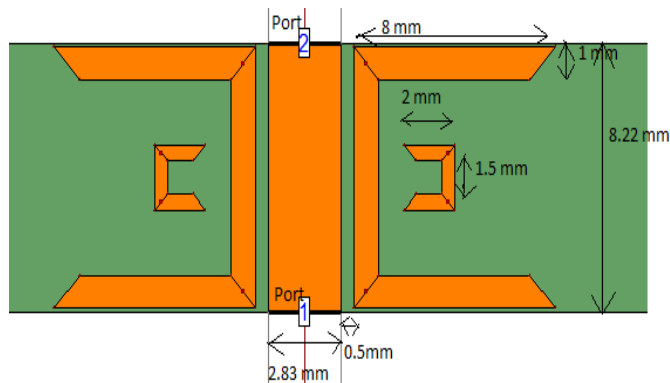


Fig. 1 Dual C-shaped Ring Resonating Filter

4. SIMULATION RESULTS

The design is simulated using IE3D software. Epoxy FR4 substrate has been used for the design. The best result has been obtained in the filter which has outer ring with outer dimension 8mm and ring width of 1mm. The inner ring has outer dimension of 2mm and ring width of 0.5mm. The spacing between the feed and edge of the filter is taken to be 0.5mm. The S11 is observed to be -60.5dB and S21 is found to be -0.36dB at centre frequency 5.09GHz. The passband and stopband are analyzed, and the bandwidth is calculated as 4.393 GHz. The simulated graph is shown in figure 2.

Table 2: Tabulation of Observations

Outer Ring	Inner Ring	S-Parameters		Centre Frequency f_c (in GHz)
		S11 (in dB)	S21 (in dB)	
6	2	-27	-0.75	7.147
	3	-35	-0.76	6.78
	4	-16.48	-2.14	6.29
7	2	-41.24	-0.48	5.93
	3	-59.07	-0.54	5.83
	4	-36	-2.5	7.67
8	2	-60.5	-0.36	5.09
	3	-47.19	-0.374	5.04
	4	-40.45	-0.50	5.35

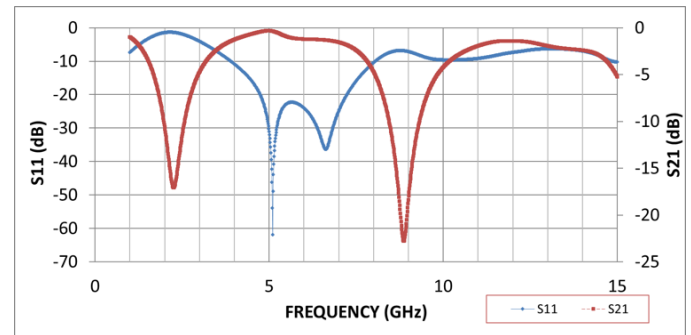


Fig. 2 S-parameters for the proposed design

5. ANALYSIS

The proposed dual C-shaped ring resonator is simulated between 1 to 15 GHz. In the proposed design, a smooth gain curve is achieved. The transmission loss is observed to be very flat over the entire band. The return loss is much below -10 dB which implies more than 90% of the input energy is delivered with negligible loss of power. This performance is due to the excellent coupling of the ring filter. Moreover, the steepness of transition bands exhibits the outstanding performance of the filter which helps to select the useful frequency and simultaneously suppress the undesired frequency. The simulation and measured results matched well.

6. CONCLUSION

The salient feature of ring resonator is that it attenuates the range of frequencies beyond the given range. It is observed that when a small piece of ring is inserted within two outer ring resonators, it creates a good passband. The extended bandwidth that is obtained is very apt for ultra-wide band applications. One of the prominent advantages of dual C-shaped ring resonating filter is that there is almost no reflection of signal at the input port and the transmission loss

is minimum as compared to the other bandpass filters. Hence these filters can be used for wide range of applications at the lower microwave frequency range with the same antennas, couplers, oscillators. The reduced complexity of the filter makes it light in weight. The filter has a compact and miniaturized size which makes it portable for WLAN applications at 5.8GHz band.

It is more efficient as compared to the other ring bandpass filter designs as it has better return loss characteristics and a miniaturized size. The filter can be used along with a UWB antenna, which will be useful for several indoor applications [3]. A prototype filter is planned to be fabricated by the authors using Epoxy FR4 substrate for further work relating to this paper.

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