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A Novel Compact Microstrip Band Pass Filter using Non Uniform Line Resonator for GPS Application

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Abstract—*In this paper, a novel compact microstrip band pass filter using non uniform line resonator with defected ground structure(DGS) unit for GPS application (central frequency 1.5 GHz) is proposed. This filter is operating at downlink central frequency 1.5 GHz with 6.66% bandwidth. The proposed filter consists of a novel non uniform line resonator with defected ground structure, which provides compact structure in comparison to the conventional structures. This non uniform line resonator is constructed by attaching pair of capacitive open-ended stubs at its central location. The proposed circuit is realized using Arlon AR 600 substrate with dielectric constant of 6 and substrate height of 1.27 mm in CST simulator. The simulated result gives 0 dB insertion loss (IL) and return loss (RL) better than 30dB in the specified band. Proposed filter can be used for applications where size of GPS is critical, such as animal behaviour studies, botanical specimen location, biomedical sensors etc.*

Keywords*: Bandpass filter, defected ground structure, Uniform impedance resonator, stepped impedance resonator (SIR).*

1. INTRODUCTION

Due to the rapid development of intelligent wireless communication systems, compact, high performance and low-cost filters are needed. Filter is an essential part of telecommunication and radar systems, therefore affecting the performance and cost of these systems [1-5].

Bandpass filters using coupled lines increases the bandwidth of the pass band. Microstrip bandpass filters using coupled lines has been presented in [5], [6], [12-14]. But in microstrip parallel-coupled lines bandpass filter , due to the inequality between the even and odd-modes phase velocities of the coupled line spurious responses are generated at the multiple of operating frequency and due to this spurious responses which generate at twice the center frequency $2f_0$ of the filter passband , microstrip parallel-coupled line filter has asymmetrical passband response [7]. The unequal phase velocities in parallel-coupled microstrip filters significantly deteriorate the performance of the filter [16-21]. For suppressing these harmonics stepped impedance resonators are used to realize MBPF. This SIR approach gives good harmonic suppression by making the central frequency of second band far apart from the fundamental frequency [15]. BPF using SIRs has been presented in [6], [7], [9-13]. A SIR resonator, which is working as multi mode resonator (MMR), with two sections of coupled lines, is used for developing the ultra wide band (UWB) BPF [14]. This Wide band is achieved by combining the step resonator with coupled lines. BPF with DGS makes the filter compact and overall size gets reduced. An open-loop dumbbell-shaped DGS bandpass unit for 1.5 GHz band is proposed in [4]. In this the two transmission zeros bounding the passband have been controlled by the open-loop edge length and open-end location. While in [8] extra 1.57 GHz band is achieved using DGS.

In order to suppress higher order spurious frequencies in this work the effect of DGS in SIR is investigated and a novel structure of bandpass filter using SIR with DGS without coupled lines is presented. In this paper non uniform line resonator using Arlon AR 600 substrate, with DGS is used to develop BPF for GPS application. Proposed BPF is having smaller size and reduced higher order frequencies to provide uniform response due to SIR with DGS.

Basic objective of this paper is to design more compact, smaller size BPF using SIR and investigate the effect of DGS in SIR for achieving smaller size BPF for GPS application.

2. NON UNIFORM LINE RESONATOR

Non uniform transmission lines are mainly used as impedance-matching devices, pulse transformers, resonators, couplers and filters.

A Non uniform Transmission Line (NTL) which is open or short circuited can be considered as Non uniform Impedance Resonator (NIR). The characteristic impedance function of the microstrip NIRs or strip width of the NIR, is expanded in a truncated Fourier series, for synthesizing NIRs. Then, through an optimization approach the optimum values of the coefficients of the series are obtained [14]. For designing the filters, oscillators and mixers resonators are one of the important elements. Normally in RF and Microwave circuits microstrip resonators are used. The length of conventional resonators is a half of the wavelength (open-circuited resonators) or a quarter of the wavelength (short-circuited resonators). However, it is a significant interest to design resonators with smaller length than of the conventional resonators. Two or more transmission lines of different characteristic impedance are connected together to make SIR and these microstrip SIRs have discontinuities at the connecting points between two transmission lines. Microstrip Non uniform Impedance Resonator (NIR), is an open- or short-circuited Non uniform Transmission Line (NTL).In fact, NIRs is a general case of SIRs[14].

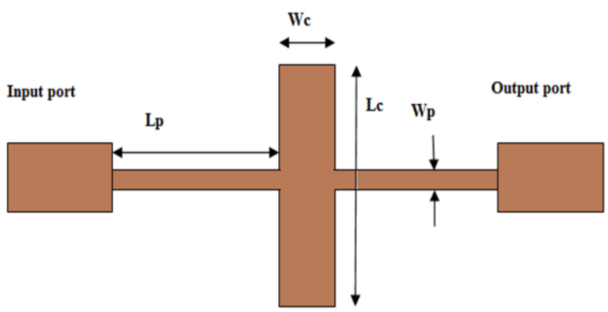

Fig. 1: Configuration of proposed bandpass filter

3. ANALYSIS AND DESIGN OF PROPOSED BANDPASS FILTER

The proposed BPF consists of a non uniform line resonator. This non uniform line resonator is constructed by attaching pair of capacitive open-ended stubs at its central location as shown in Fig. 1. The width and the length of the horizontal line of the non-uniform line resonator are denoted by Wp and Lp while the width and the length of the vertical line are denoted by Wc and Lc, respectively. EM simulation of non uniform line resonator is shown in Fig. 5 . This gives return loss of 0dB at 1.5 GHz. To improve the insertion loss at upper transmission zero DGS structure is introduced. In order to achieve this, the parameters of the proposed BPF are chosen as follows: Arlon AR 600 substrate with dielectric constant of 6 and substrate height of 1.27 mm.Wp=0.1mm, Lp=11.2mm ,Wc=1.3mm , Lc= 5.3mm

For the measurement, a 5-mm long microstrip feed line is added at both input and output. The simulated insertion loss is found to be less than 1.0 dB at the center frequency of the passband. The measured return loss is better than 30dB at 1.5 GHz. The filter shows two new transmission zeros at the lower and upper edges of the desired passband and one attenuation poles inside the passband.

4. EXPERIMENTS

The performance of the filter for different shaped DGS structure is tabulated in table. Fig. 2 shows the bottom view of the proposed filter for circular DGS units. In table 1 and 2 analysis of the filter for circular shaped DGS structure with radius of 3 mm and 4 mm respectively are shown. Comparison among them in terms of S_{11}, S_{21} are shown in Fig. 6 and 7. As the distance between, circular DGS units of 3mm, is increased S_{11} gets decreased while S_{21} at 2.81 GHz is increased. For circular DGS units of 4mm radius, as the distance between them is increased S_{11} at 1.5 GHz remains approximately constant while S_{21} at 2.81 GHz gets decreased. Fig. 3 shows the bottom view of the filter for rectangular shaped DGS units. In table 3 analysis of the filter for rectangular shaped DGS structure with varying center to center distance is shown. Comparison among them in terms of S_{11}, S_{21} is shown in Fig. 9. As the distance between them is increased S_{11} at 1.5 GHz gets decreased while the S_{21} at 2.3058 GHz gets increased so the isolation at the edge of the upper pass band can be controlled by the DGS units. Fig. 4 shows the bottom view of the BPF with rectangular dumbbell shaped DGS unit and its EM simulated response is shown in Fig. 8.This rectangular dumbbell shaped DGS unit improves the isolation at the upper edge of the passband.

Table 1: Comparison table for circular DGS units of 3mm radius with varying center to center distance

For Radius-3 center to center distance between circular DGS unit (mm)	S11 at 1.5Ghz (R.L.)	S21 at 1Ghz (I.L.)	S21 at 2.81Ghz (I.L.)
12	34.177	14.51	6.0435
16	33.265	14.119	7.3459
20	32.093	14.379	8.1274

Table 2: Comparison table for circular DGS units of 4mm radius with varying center to center distance

For Radius-4 center to center distance between circular dgs unit(mm)	S11 at 1.5Ghz (R.L.)	S21 at 1Ghz (I.L.)	S21 at 2.81Ghz (I.L.)
14	31.963	15	9.8206
18	31.442	15.421	7.6064

Table 3: Comparison table for rectangular DGS units with varying center to center distance

Center to center distance between dgs unit(mm)	S11 at 1.5Ghz (R.L.)	S21 at 1Ghz (I.L.)	S21 at 2.3058Ghz (I.L.)
25	32.353	12.947	7.2157
29	31.602	15	9.2922

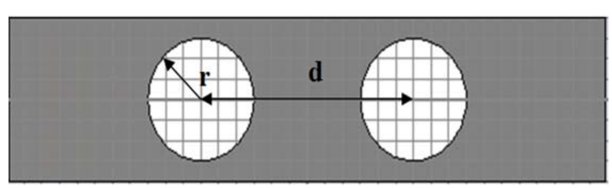

Fig. 2: Bottom view of bandpass filter for circular DGS unit

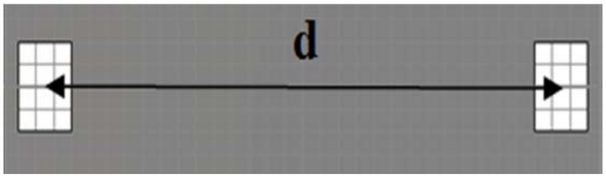

Fig. 3. Bottom view of bandpass filter for rectangular DGS Unit

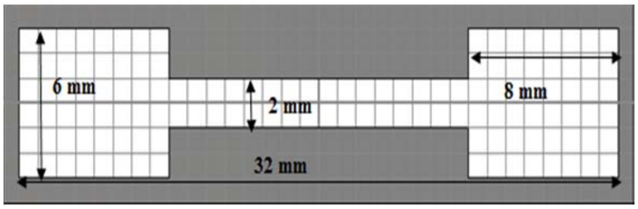

Fig. 4. Bottom view of bandpass filter for rectangular dumbbell Shaped DGS unit

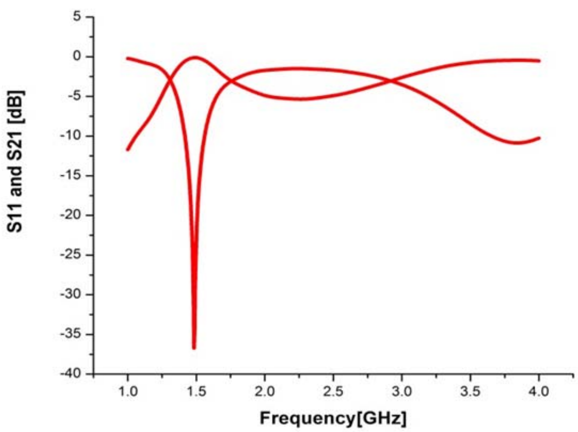

Fig. 5 EM-simulated response of the filter without DGS unit.

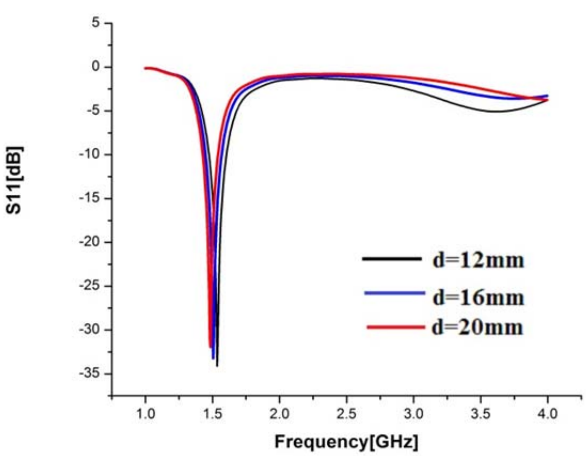

Fig. 6 EM-simulated response of the filter for circular shaped DGS units of 3 mm radius

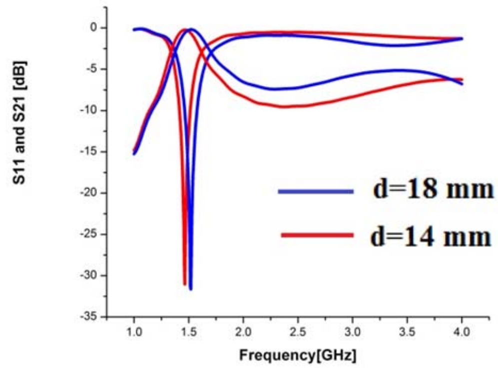

Fig. 7 EM-simulated response of the filter for circular DGS Units of 4 mm radius

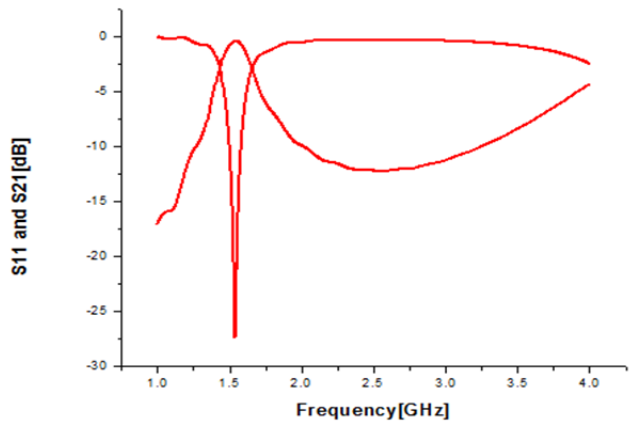

Fig. 8 EM-simulated response of the filter for rectangular dumbbell Shaped DGS unit.

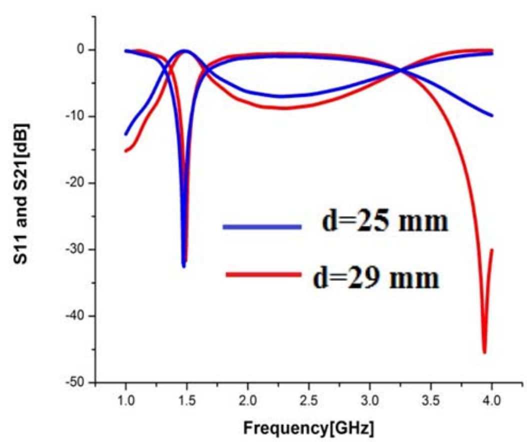

Fig. 9 EM-simulated response of the filter for rectangular shaped DGS units.

5. CONCLUSION

In this paper, a novel compact microstrip BPF using non uniform line resonator with DGS unit for GPS application is proposed. The filter structure consists of a non uniform line resonator with DGS. This DGS gives transmission zero around the upper passband. The rectangular dumbbell shaped DGS structure gives the transmission zero at 2.3058 GHz. As a result, this new transmission zero around the upper passband enhances the selectivity of the desired passband significantly. The design was successfully realized and verified by CST simulator.

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