

Design of Ultra Wideband Bandpass Dual Band Filter Using Defected Ground Structures

Maryam Jaldi and Majid Tayarni

Abstract—This paper presents a novel approach for designing compact and ultra wideband filter with independently controlled central frequencies. The structure consists of a microstrip line and two defected ground structure cells that are imbedded together. Each of the cells results in respective passband, outer cell for the first passband and inner one for the second passband. By changing dimensions of the resonators the central frequency of two passbands can be independently regulated in a wide range. Several attenuation polls in the stopband are realized that improve the isolation between two passbands. A 1.8GHz, 3.3GHz dual band filter is designed and simulated with fractional bandwidth of 43% and 15%.

Index Terms—Dual band, defected ground structure, bandpass filter, microstrip, wideband

I. INTRODUCTION

Recent development in wireless communication systems has presented new radio frequency devices operating in multiple separated frequency bands. For example, global systems for mobile communication (GSM) and wireless code division multiple access (WCDMA) must receive and transmit signals at 900MHz and 1800MHz. IEEE 802.11a and IEEE 802.11.b wireless local area network (LAN) should operate in ISM 2.4 & 5GHz and GPS should operate at 1.57GHz. So many components such as antennas, couplers or filters have been proposed that operate in two or more frequencies. Among them dualband bandpass filter is a key component in RF systems. We should notice that, it is important to design the structure such that has minimum size, low insertion loss and high selectivity.

The concept of dualband filters was first mentioned in [1] by the cascade connection of two individual filters. But the structure demands extra impedance matching networks at the input and output of the filter and it occupies large size. Another method is to use stepped impedance resonators. Two resonant frequencies of these structure can be controlled by the impedance ratio and electrical length of two sections[2]. Because there is only one parameter to control the second band, it is difficult to design two adjacent passbands also they have high insertion loss. In [3] a dualband filter using LTCC techniques is proposed, where two single band bandpass filters are combine together, each filter has its own input and output ports so that an additional circuit network is needed to combine them. [4] proposed a dual mode dualband filter

using double square loop structure. Each transmission band is realized using a dual mode square loop resonator. In [5] two sets of resonators are employed in parallel leading to a large size. Capacitor loaded pseudo-interdigital filter is presented in [6]. Open stub resonators are used to design dualband filter in [7]. However, these filters can hardly regulate the bandwidth of two bands and because of the narrow bandstop nature of open stubs, the stopband rejection is limited.

Although a lot of research have been done on the design of dual band filter but there is some design limitations have not been fully overcome. For most of these structures it is difficult to realize ultra wideband (UWB) dual passband filters. On the other hand, only a small number of high selectivity dual band bandpass filters, with responses exhibiting transmission zeroes at both sides of each passbands, have been proposed [8].

Recently, defected ground structures (DGS) are one of the most interesting areas of research. DGS is realized by etching off a defected pattern from the backside metallic ground plane and has periodic or non periodic structure. Since DGS cells have resonant properties, they are useful in the improvement of response of microwave structures such as antenna, coupler, oscillator. Also they can be useful in spurious suppression [9] and development bandwidth properties in the wideband filter [10].

However, few attempts have been assigned to use DGS cells as a building block of microwave circuits. Because there are too many design parameters such as shape, spacing, number of cells and etc so design procedure is difficult.

In this paper a novel dual band bandpass filter is proposed in which DGS resonators are building block of the filter. The structure consists of two embedded resonators in which the inner resonator, control the second band and the outer one, control the first band. To design a dual band filter, first two individual bandpass filters is designed. By changing the dimension of cells, the properties of filters can be controlled.

The article is organized as followed: In II, base on [11], the bandstop properties of a DGS cell is demonstrated. By changing line properties, a bandpass filter is obtained. According to that, a novel DGS single band bandpass filter is proposed. In section III, a dual band filter is designed. The response of the filter is improved in section IV. Finally a conclusion is drawn in section VI.

II. CHARACTERISTICS OF THE DGS CELLS

Fig. 1 shows the schematic diagram of DGS cell with its microstrip line, with face to face coupling which was used in [11] to design a dual band filter. The line width should be chosen for the characteristic impedance of 50Ω , but it can be

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shown that by etching defected ground, effective dielectric constant ϵ_{re} of the microstrip is increased thus the characteristic impedance will be greater than 50Ω . So for matching the microstrip line to the ports, we suggest that the width of the line above the DGS section should be increased, also we should connect two line with characteristic impedance of 50Ω at the two ports of the structure. The substrate with a dielectric constant of 6.15, loss tangent of 0.0019 and thickness of 0.72 mm is considered. In order to investigate the frequency response of the DGS cell, it is simulated by CST EM-simulator. The dimension of the structure is tabulated in table I. Dimensions are based on mm.

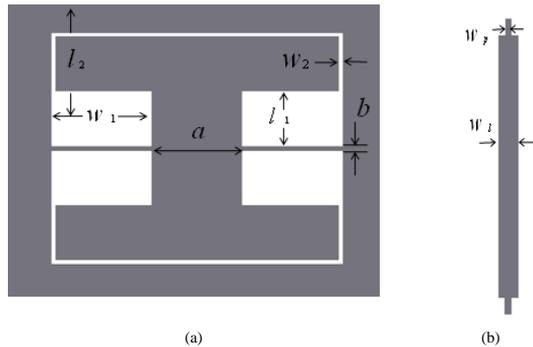


Fig. 1. Layout of a band stop filter (a) ground plane using DGS resonators with face to face coupling, (b) microstrip line.

TABLE I: PHYSICAL DIMENSION OF THE STRUCTURE OF DGS BANDSTOP FILTER WITH FACE TO FACE COUPLING.

l_1	l_2	W_1	W_2
2.5	2.5	4	0.15
a	b	W_p	W_l
3	0.3	1	2.4

Fig. 2 illustrates the simulated response of this structure which is of order two and the two equal resonators are coupled together via the line. The band stop response of this structure shows two poles in the bandstop due to the two resonators that are coupled together.

Because of its tight coupling, this structure shows sharper transition compared to the back to back filter investigated in [11]. Also this DGS cell has the ability that we can embed another resonator to it, to design a dual band filter with compactness.

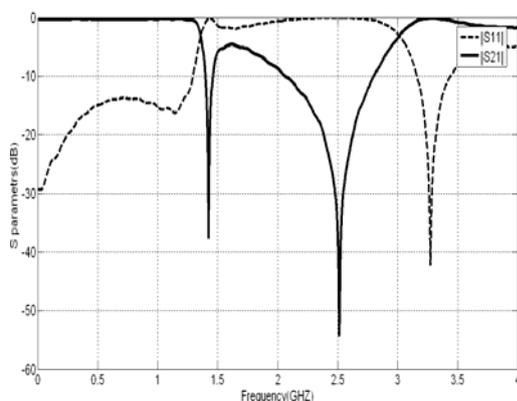


Fig. 2. Simulated S-parameters characteristic of the bandstop DGS filter with face to face coupling.

By etching a gap in the line, the bandstop response of this

filter is converted to a bandpass one with the same central frequency. The schematic view of the line with interdigital gap is illustrated in Fig. 3 where $e=1.8\text{mm}$, $d=0.25\text{mm}$ and $g=0.4\text{mm}$.

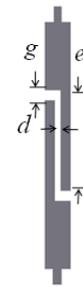


Fig. 3. Schematic view of the line with interdigital gap.

The simulated response of the filter is shown in Fig. 4 where the central frequency of the filter is 1.8GHz.

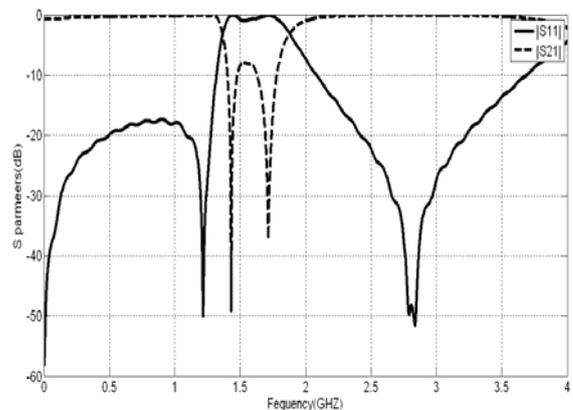


Fig. 4. Simulated S parameters characteristic of DGS bandpass filter using line with interdigital gap.

By changing the dimension of DGS cells, central frequency of the bandpass filter can be changed easily.

Now, we can use this DGS structure to design a dualband filter. But the structure mentioned above, interfaces a great problem due to the need to shorten the dimensions of the cell for the second band design and the spacing (W_2) is bounded to a lower limit due to technology restriction.

So, we propose a new DGS cell, with meander section. The meander lines, lead to an increase in the current path, compensating the effects caused by the increase in spacing.

The proposed cell and its response are illustrated in Fig. 5 and Fig. 6, respectively. Central frequency of this bandpass filter is 3.2 GHz. The dimension of the structure is tabulated in table II.

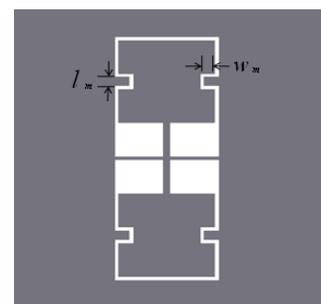


Fig. 5. Schematic view of the ground plane of the proposed DGS bandpass filter.

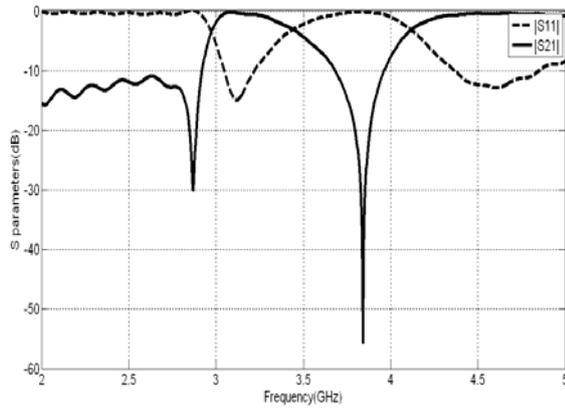


Fig. 6. Simulated S parameter characteristic of the proposed DGS band pass filter.

TABLE II: PHYSICAL DIMENSIONS OF THE PROPOSED DGS BANDPASS FILTER.

l_1'	l_2'	w_1'	w_2'
1	2.8	1.3	0.1
a'	b'	w_m	l_m
0.1	0.05	0.3	0.3

III. DESIGN OF THE DUALBAND FILTER

To design a dual band filter, we should first design two single bandpass filter at the desired frequencies base on the abovementioned structures. It means we should use the structure of Fig. 1 for the first band and the structure of Fig. 2 for the second band. So we have designed two filters with central frequencies of 1.8 GHz and 3.2 GHz. The dimension of filters are base on table I and table II. Now, two filters are embedded together. The simulation results of the proposed dual band filter is illustrated in Fig. 7.

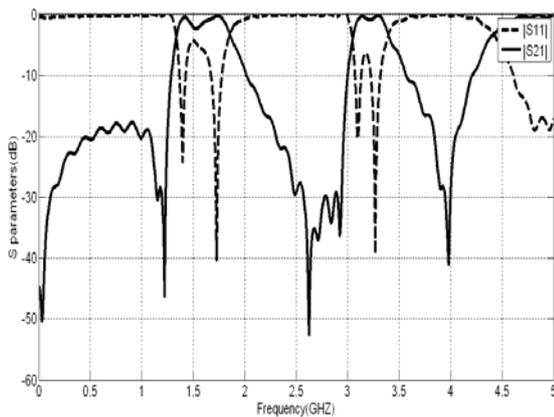


Fig. 7. Simulated S parameter characteristic of the proposed dual band DGS bandpass filter.

IV. IMPROVEMENT OF THE RESPONSE

In the simulated response of Fig. 7, it can be seen that the stopband rejection between two bands is less than 30 dB also sharpness of the two bands should be better. So we improve the results of the filter, in the final step. For that, we propose a new structure with separation of 9.8 mm, which is composed of cascade connection of three cells. The schematic diagram of the structure is illustrated in Fig. 8 and the simulation results are shown in Fig. 9. The stopband rejection between

two passbands is now more than 40 dB and the sharpness of two bands have been improved. The bandwidth of the first band is 43.3%, and of the second band is 14.8%

The optimized length parameters are tabulated in table III.

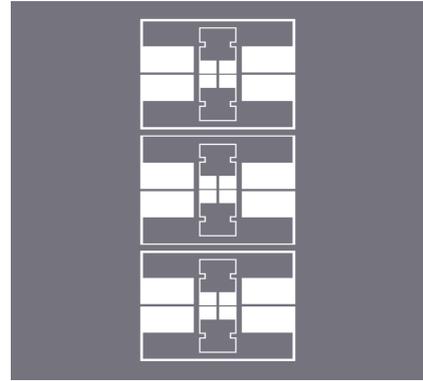


Fig. 8. Schematic view of ground plane of the proposed ultra wide band DGS dual band filter with cascaded resonators.

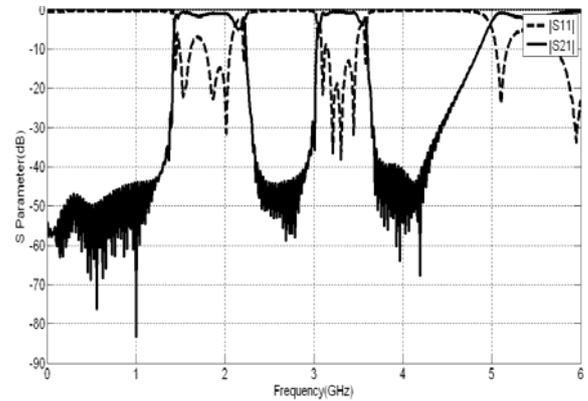


Fig. 9. Simulated S parameter characteristic of proposed dual band bandpass filter with cascaded resonators.

TABLE I: OPTIMIZED DIMENSION OF THE PROPOSED THREE SECTIONS DGS DUAL BAND BANDPASS FILTER

l_1	l_2	w_1	w_2
2.1	2.3	4	0.15
l_1'	l_2'	w_1'	w_2'
1.1	2.7	1.3	0.1
a	b	a'	b'
1.8	0.1	0.1	0.05
w_m	l_m	w_p	w_l
0.3	0.3	1	2.3
d	e	g	
0.25	1.8	0.4	

It can be seen that in this dual band response, each band is the same as the response of the corresponding single band filter, so each band is independent from another. Also this structure is wideband at two passbands. As shown in fig. 10, we can shift the second passband of the filter while the first passband is not changed. In the structure II, w_1' , w_2' and l_1' are changed to 1.1, 0.1 and 1.1 mm respectively. And in

the structure III, w_2 is changed to 0.09mm.

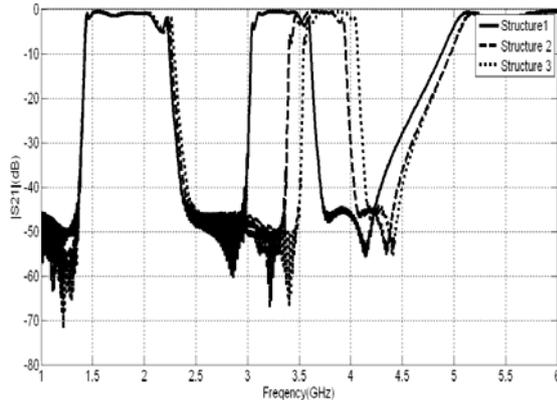


Fig. 10. Comparison of frequency responses of the dualband filter with variation of some dimension of the inner resonator.

V. CONCLUSION

In this paper, a novel approach to design dual band bandpass was proposed. The approach is based on designing two kind of defected ground structure cells. Each of them can realize one of the desired transmission bands. By embedding these two cells, a compact dual band filter is achieved. By changing the dimension of each cell, two passband frequencies can be regulated independently. It has been shown, by cascading three sections of these DGS cells, an ultra wideband, dual band is realized that provide good rejection between two transmission bands and has high selectivity and low insertion loss.

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