SPURIOUS RESPONSE SUPPRESSION IN THREE POLES HAIRPIN BANDPASS FILTER USING DEFECTED GROUND STRUCTURES

N. Amar Touhami
Abdel Malek Essaadi University/ Faculty of Sciences, Tetuan, Morocco
A. Zakriti
Abdel Malek Essaadi University/ National School of Applied Sciences, Tetuan, Morocco
M. Lamsalli
M. Boussouis
Abdel Malek Essaadi University/ Faculty of Sciences, Tetuan, Morocco
A. Tribak
National Institute of Posts and Telecommunications, Rabat, Morocco

Abstract:
The demand of high data rate in wireless communications requires higher system bandwidth. In this work, the design of wideband BPF with suppression of higher harmonics has brought about by considering the UWB BPF as a hairpin filter structure with DGS BSF. As a result, the structure is simple and compact. The expected result of a simple BPF together with DGS is to have a compact UWB bandpass filter with significantly higher harmonics suppression. The filter performances are exhibits |S21| more than -0.2 dB, |S11| less than -10dB, center frequency of proposed filter is around 4GHz with operating bandwidth 38% and can suppress unwanted passband to below -25 dB

Key Words: Defected Ground Structures, Bandpass filter, Stopband filter, Spurious response supression

Introduction

In modern wireless and mobile communication systems, filters are always playing important and essential roles. Planar filters are particularly popular structures because they can be fabricated using printed circuit technology and are suitable for commercial applications due to their compact size and low-cost integration [1]. For a planar filter design, it is necessary to select proper resonator types since resonators are the basic components of a filter. To reduce the resonator size, several types of resonators such as the U-shaped hairpin resonators [2], [3], the open-loop resonators [4] and the folded open-line resonators [5], [6] have been proposed to design different kinds of bandpass filters.

The stringent requirements of modern microwave communication systems demand high performance and compact filtering structures. Recently, there has been an increasing interest in electromagnetic band gap (EBG) materials for applications in microwave and millimetre wave filters and other devices. Several compact and high performance filters have been reported using generic structures called the defected ground structures (DGS). Since DGS cells have inherently resonant properties, many of them have been used in filtering circuits to improve the stop and pass band characteristics. The DGS have been proposed for improving the spurious response of microstrip low pass filters [7-8] and coupled microstrip line bandpass filters [9-10]. In all these reports, DGS are not viewed as the central building blocks, they are rather used to enhance the response of already designed devices such as filters and couplers.

In this paper, a design of wideband BPF with suppression of higher harmonics has brought about by considering the UWB BPF as a three poles Hairpin BPF with DGS BSF. The expected result of a simple BPF together with DGS microstrip is to have a compact UWB bandpass filter with significantly higher harmonics suppression.

Three Poles HAIRPIN BPF Structure Design

In this paper, a design of wideband bandpass filter is based on a conventional Hairpin bandpass structure. Based on the dimensions listed in figure 1, simulation of three poles hairpin line BPF with CST software was performed as shown in figure 2. We consider only |S11| and |S21| because the filters designed are symmetrical so |S11| is very nearly |S22| and |S21| is very nearly |S12|.

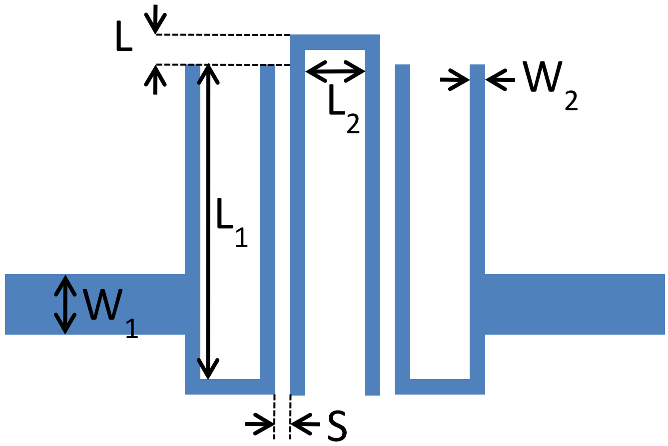


Figure 1: Layout of three poles hairpin line BPF on a 1.27mm thickness substrate with a relative dielectric constant of 6.15 (W1 = 1.85mm, W2=0.5mm, S=0.3mm, L1=10mm, L2=L3= 1mm)

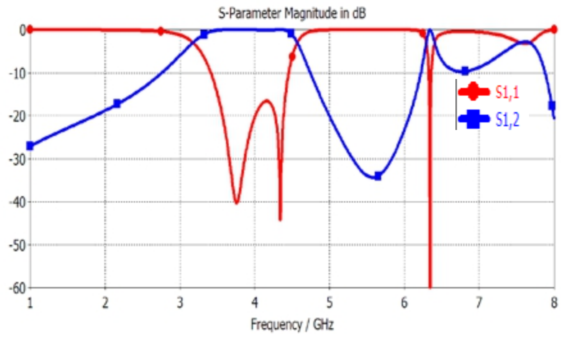


Figure 2: Simulation response of three poles hairpin line BPF

From the simulation response of three poles hairpin line BPF the simulated performance has 3 dB bandwidth from 3.2-4.7 GHz and shows second passband around 6.4 GHz. The response of hairpin line filter exhibits sufficient bandwidth that covers an ultra-wideband application but its undesired second passband must be minimized. The deployment of a bandstop filter as cascading section with the bandpass filter is a classical technique to reduce unwanted passband. By taking the advantages of an attenuation pole of the designed DGS having resonant frequency at the second passband, the unneeded passband is drastically reduced.

DGS BSF Design

Several Compact and high performance components have been reported by using the generic structure called the defected ground structure (DGS) for the microstrip line. DGS BSF has been attractive to obtain the function of unwanted frequency rejection and circuit size reduction.

The structure of DGS BSF can provide cutoff frequency and attenuation pole in some frequencies without any periodic array of DGS [11]. The defected areas can be realized by dumbbell slot, rectangular, circular slot, arrow slot shape and slot variation as shown in Figure 3.

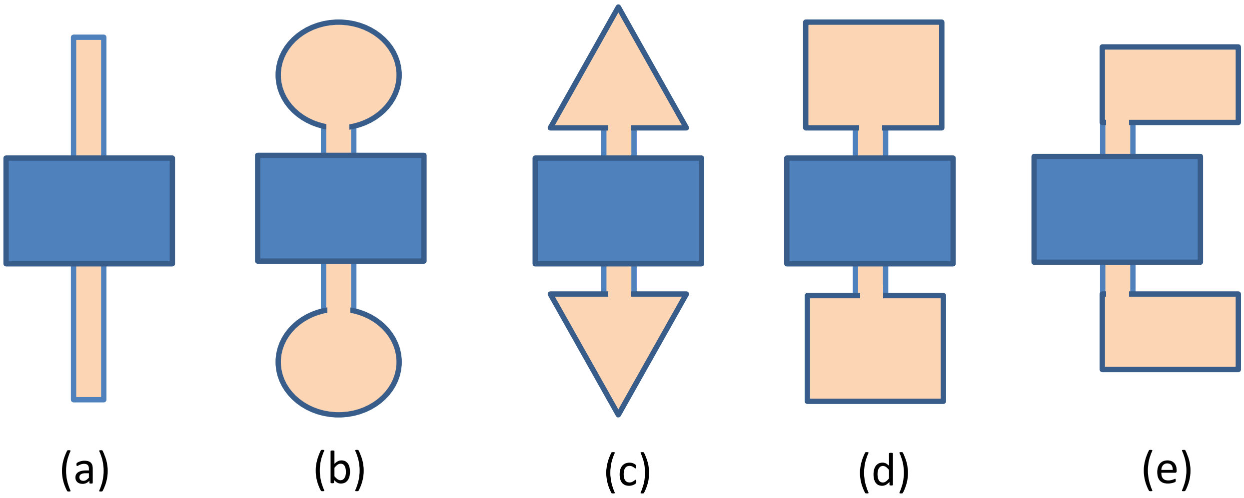
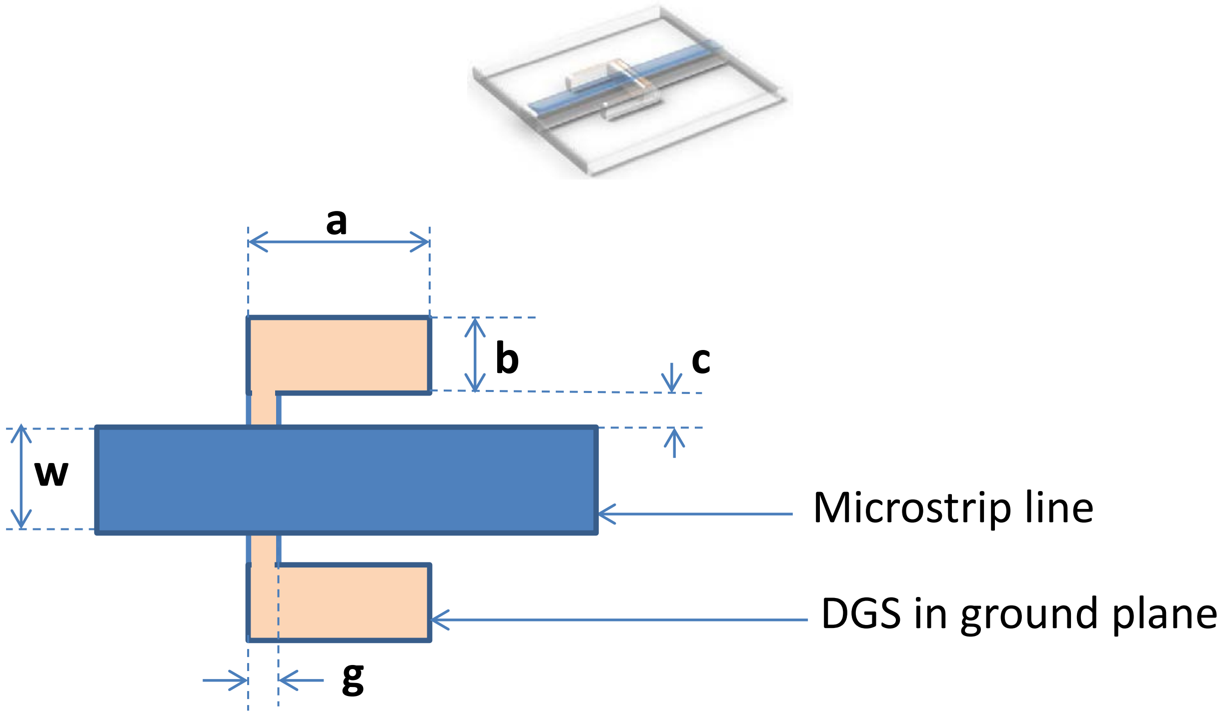


Figure 3: Example of DGS BSF shapes (a) rectangular (b) circular (c) arrow and (d) dumbbell (e) slot variation

The three dimensional view of microstrip line with DGS shape shown in Figure 4(a), the etched lattice shape of the proposed DGS section is located on the backside metallic ground plane.



(a) (b)

Figure 4: (a) Three dimensional view of microstrip line with DGS slot variation shape **(b)** Layout of DGS

A DGS BSF has four design parameters (*a*, *b*, *c* and *g*) (see figure 4b). Figure 2 shows the second passband of the three poles hairpin line BPF occurring around 6.4 GHz. Therefore, the DGS BSF must be designed to have attenuation pole at unwanted that frequency. In this paper, we use simulation oriented to design and optimize for DGS BSF layout. In order to investigate the frequency characteristics of the DGS section, we simulated the DGS unit section and considered the effect of parameter that affect to |S21|. The simulation results show that they are bandstop filter characteristics, as expected. The cutoff frequency mainly depends on the square area in a ground plane. There is also attenuation pole location, which is due to the gap width.

Figure 5 shows the response of |S21|, when increase *a* by 0.5 mm per one step the result is attenuation pole decreased.

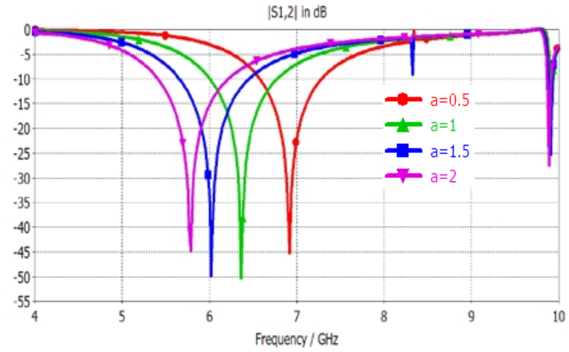


Figure 5: Investigate parameter *a* (varies *a*, *b* =4 mm, *c* = 1 mm and *g* = 0.2 mm)

Figure 6 shows the response of |S21|, when increase *b* by 1 mm per one step the result is attenuation pole decreased as same as *a*.

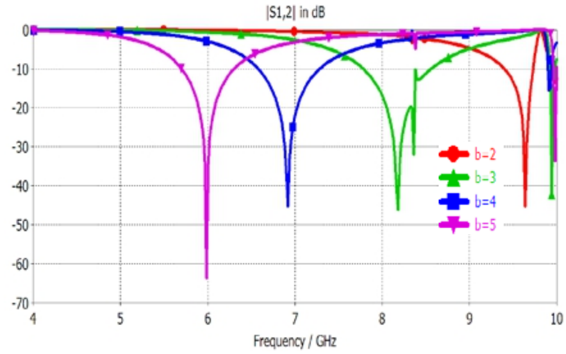


Figure 6: Investigate parameter *b* (*a* = 0.5mm, varies *b*, *c* = 1 mm and *g* = 0.2 mm)

Figure 7 shows the response of |S21|, when increase *c* by 1 mm per one step the result is attenuation pole decreased as same as *a* and *b*.

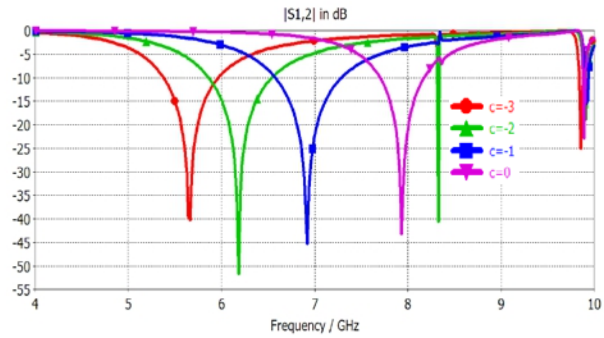


Figure 7: Investigate parameter *c* (*a* = 0.5 mm, *b* = 4 mm, varies *c* and *g* = 0.2 mm)

Figure 8 shows the response of |S21|, when increase *g* by 0.2 mm per one step the result is attenuation pole increased.

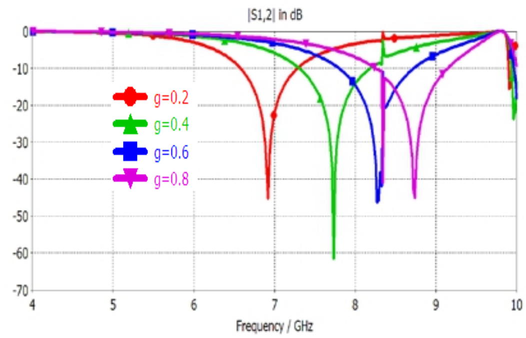


Figure 8: Investigate parameter *g* (*a* = 0.5 mm, *b* = 4 mm, *c* = 1 mm and varies *g*)

From investigating all parameters of the DGS BSF, we can summarize the effect as in Table1.

TABLE I. SUMMARIZED OF INVESTIGATION PARAMETERS

Increase	Effect to attenuation pole
a	decrease
b	decrease
c	decrease
g	Increase

So the greatest response used for suppression second passband which occurs from three poles hairpin line BPF and is able to cover the passband has dimension of the DGS BSF at *a* = 0.5 mm, *b* = 4 mm, *c* = 1 mm and *g* = 0.2 mm (see figure 9)

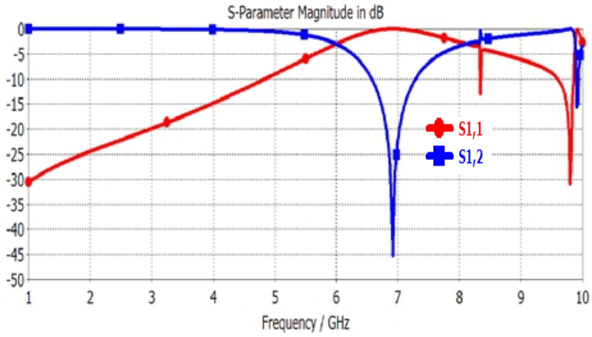


Figure 9: Simulation response of DGS BSF

HAIRPIN Filter with DGS BPF Design

From the structure of the three poles hairpin line BPF and DGS BSF, the structure of wideband BPF which significantly suppresses unwanted passband is shown in Figure 10.

In figure 11 we can see the simulation results of the hairpin BPF incorporating DGS structures. The Simulated |S21| achieve below -20 dB in the stopband and less than -0.2 dB in the pass band. Comparing with |S11| of the conventional BPF, |S11| of the DGS BPF is poorer, but the operating bandwidth increased.

Figure 10: Layout of three poles hairpin line BPF with defected ground structure

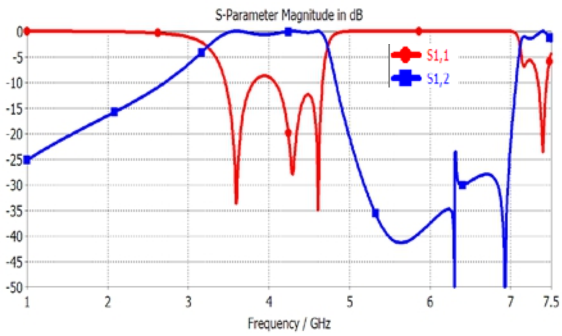


Figure 11: Simulation response of three poles hairpin line BPF with DGS BPF

Conclusion

A three poles hairpin line bandpass filter with defected ground structure of microstrip line is introduced and demonstrated in this paper. The conventional bandpass filter is firstly designed and its response proposed unwanted passband. Cascading DGS with that three poles hairpin line BPF introduces attenuation pole contributing the suppression of unwanted second passband. The filter performances are exhibits |S21| more than -0.2dB, |S11| less than -10 dB, center frequency of proposed filter is around 4GHz with operating bandwidth 38% and can suppress unwanted passband to below -20 dB.

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