A novel UWB Filter with H- shaped defected ground structure

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In this letter a novel ultra-wide band (UWB) band pass filter with compact size and improved upper stop band performance has been studied and implemented using the defected ground structure (DGS) loaded with the multimode resonator. By varying the iterations in the defected ground structure the resonant modes can be roughly allocated in 9.95-11.56 GHz In order to enhance the coupling degrees the gap between the resonators are varied to improve the insertion loss at -1.5 dB in the pass band. Meanwhile, the insertion loss is higher than 25dB in the lower stop band and the phase is ± 180º in the pass band.

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1. Introduction

Ultra-wideband (UWB) filters are passive microwave structures with frequency spectrum extending from 3.1 to 10.6 GHz [1]. However, this wide frequency domain is home to other wireless services like wireless local area network (WLAN), C band, X band etc. These multiple narrow pockets of RF energies are significant sources of interference to the UWB system. Therefore, the need of an UWB filter with embedded interference elimination property and simultaneously improved isolation. Few structures in this regard were proposed recently [2-5].

UWB filter with dual notch bands using asymmetric coupling strip is reported in [2] and a simplified composite right/left- handed (SCRLH) resonator based UWB filter generates dual notches in [3]. The structure in [2] provides multiple paths for signal flow which enables it to generate multiple transmission zeroes, whereas the SCRLH is equivalent to two shunt-connected series LC resonance circuit which generates the dual notch. A dual notched band UWB filter with two electromagnetic band gap (EBG) structure is reported in [4]. An UWB filter with triple notched band using triple mode stepped impedance resonator is reported in [5]. Here the triple mode resonator is equivalent to three shunt connected series LC resonance circuit which generates the triple notch. However, none of the above [2-5] shows significant stop band extension. In this research paper we have proposed an UWB with multiple notched band and simultaneously extended stopband.

The structure selected is broadside coupled micro strip -to coplanar waveguide (CPW) based UWB filter [6] because of its flat pass band and strong inherent coupling. In this structure defected ground structures (DGS) of different kinds are implemented in the CPW to generate the pass band notches. Meander shaped non equi-dimensional DGS and CSRR implemented in the CPW under the patches generates the triple pass band notch whereas spur lines embedded in the output and input feeding lines bring about stop band extension by suppressing the spurious stop band harmonics.

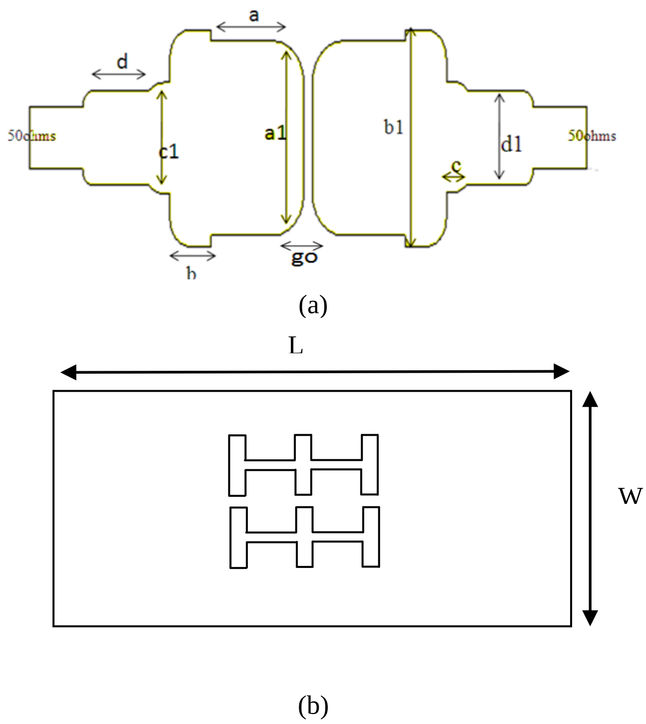


Fig. 1. (a) Top view and (b) Bottom view of the proposed filter design.

For all the defects (meander DGS, CSRR and spur lines), notch frequency positions are function of defected geometry. By varying the DGS in H- shaped to obtain the proposed UWB filter for X-band is designed using the commercial full wave CST Microwave studio.

2. Bandpass filter with a slot dgs

The structure of the resonance unit on the top layer is shown in Figure.1 (a) and (b), which is similar to the conventional ones, except for the cut patch on ground as shown in case 3. The other dimensions of the unit are as follows: a = 4.5 mm, a1 = 7 mm, b = 2 mm, b1 = 7.8 mm c=1.3mm, c1=1.3mm, d=2.9mm, d1=3.4mm, and width of the50 Ω feed lines is 2.2mm. The simulation results shown in Figure. (3a) indicate it is a bandpass filter with elliptic function. The center frequency of the pass band is fc1 = 10.75 GHz with two attenuation poles at 9.6 GHz and 11.2GHz is shown in Fig.3a.

3. UWB bandpass filter using h -shaped DGS

Fig. 2. Exhibit the detailed structure of the single bandpass filter on defected ground structure. The corresponding dimensions are respectively: lw1 = 2 mm, lw2 = 0.*5* mm, lw3 = 0.*75* mm Figure.5.shows the simulation results and the center frequency f_c= 11 GHz with two attenuation poles at 10.006 GHz and 11.65 GHz. It is obvious that there is coupling between the resonator and ground. The coupling strength is determined by gap width *go*. In conventional design of filter, the used method to tune the resonance frequency f is to change the size of the filter

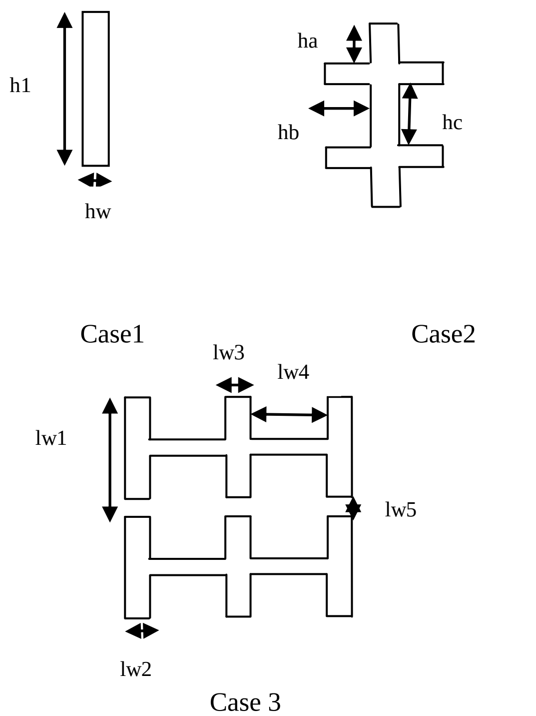


Fig. 2. Defected structure on the ground plane of the proposed filter design

$$f = \frac{c}{l\sqrt{\varepsilon eff}} \tag{1}$$

$$\lambda = \frac{c}{f\sqrt{\varepsilon eff}} \tag{2}$$

f decreases when *L* increases. While in the present design, besides changing L, the resonance frequency *f* can be shifted by altering the gap width *g0*. It should be noticed that the resonance frequency *f* decreases with coupling strength and *L* increases caused by the decrease of *g0* while insertion loss keeps almost the same. Fig. 5 demonstrates the passband shifts from 11.05 GHz to 10.006 GHz by altering *g0* from 0.4 mm to 1.0 mm.

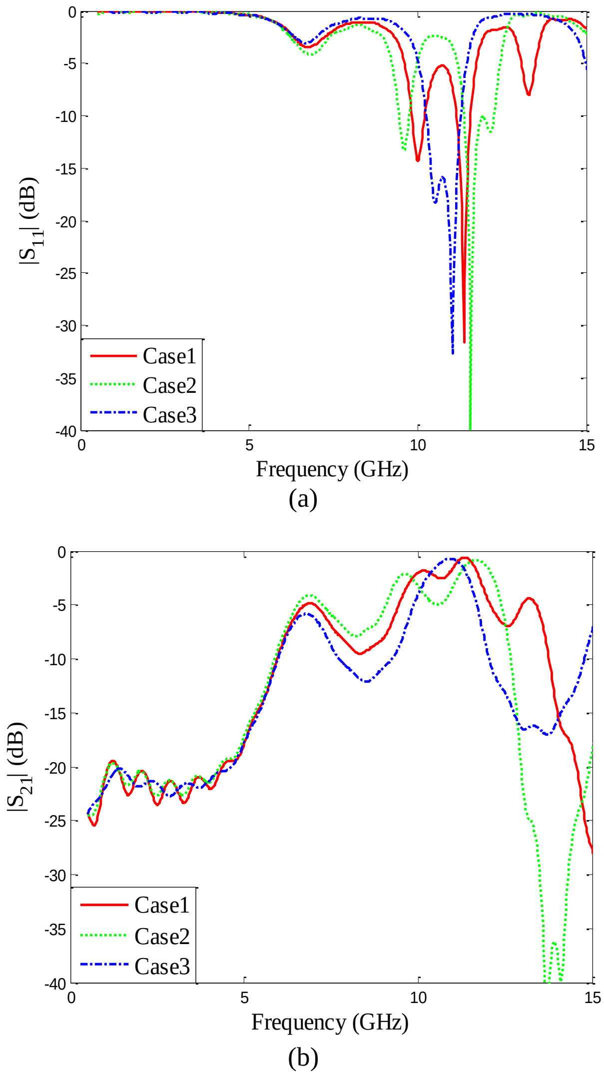


Fig .3. Simulated (a) S_{11} magnitude (b) $S_{21}$of the filter under various DGS structure.

4. UWB bandpass filter design

The proposed filter, shown in Fig.1, is designed using the methodology of broadside coupling of micro strip-to-CPW structure [7], where in micro strip lines on the top are coupled to the open ended CPW on the ground via a common dielectric layer. The substrate used has dielectric constant of the 4.6 with thickness 1.2 mm.

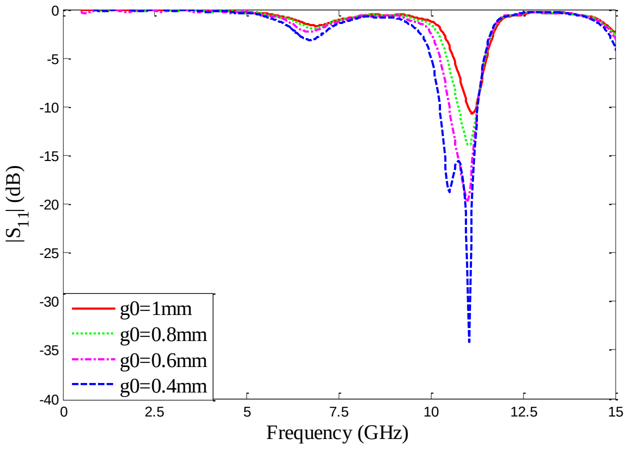
Table 1. Dimensions of the Proposed Filter

Parameters	Dimensions (mm)
a1,a	7,4.5
b1,b	7.8,2
c1,c	4,1.3
d1,d	3.4,2.9
L,W	27,15.8
lw1,lw2,lw3	2,0.5,0.5
lw4,lw5	1,0.75
go	0.4
h1,hw	6,0.8
ha,hb,hc	1,1.2,2

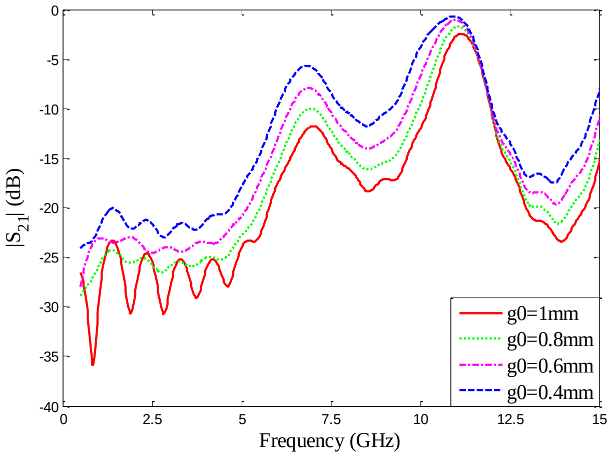
Table 2. performance of the proposed filter.

S_{11} at -3 db for case 3	Pass band (GHz)			Insertion loss	Band width
	f_L	f_U	f_C		
	9.95	11.56	10.75	-1.5dB	1.6098

The basic UWB band pass filter (BPF) structure can be assumed to be made up of two single micro strip-to-CPW coupled sections, which has wideband band pass property. The bandwidth of this structure is a function of coupled length L, whereas the coupling strength and the resonant frequency depend upon the gap (g_0= 0.4mm)between the two single sections. The gap shifts the transmission zero hence improves the selectivity at the high frequency end, but provides no significant effect to the pass band bandwidth. The dimensional parameters of the filter structure are optimized to generate the requisite UWB pass band is shown in Fig. 4.



(a)



(b)

Fig. 4. Simulated (a) S_{11} (b) S_{21} magnitude of the proposed filter with various coupling factor.

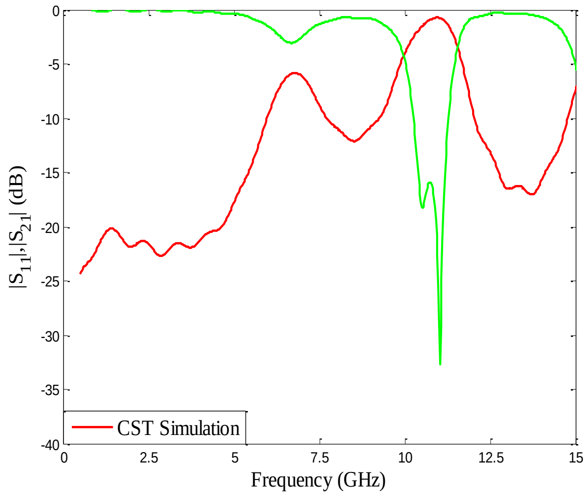


Fig. 5. Simulated $S_{11}$and S_{21} magnitudes of the proposed filter.

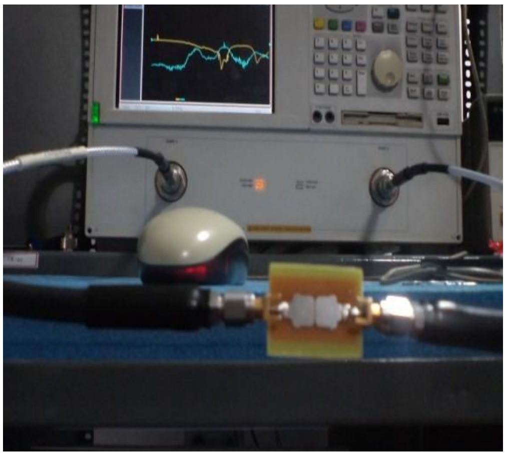


Fig. 6. Measured magnitude of the filter using Agilent network analyzer N520a

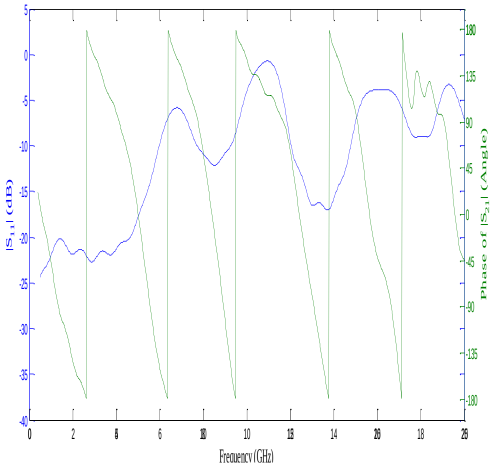
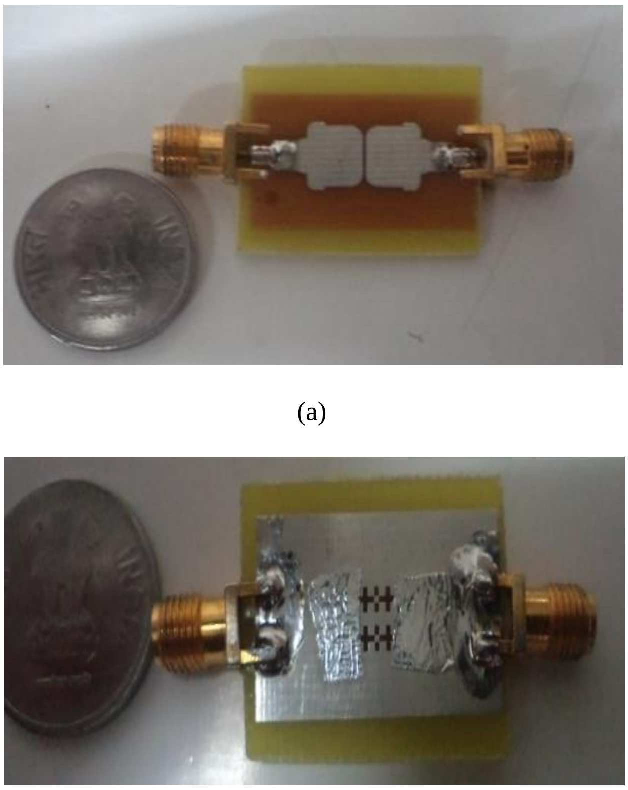


Fig7: simulated magnitudeS_{21} and phase of the filter using CST



(a)

(b)

Fig8: Photography of the fabricated proposed UWB filter (a) top view (b) bottom view.

Table 3. Comparison of the filter parameters

Performance	Case1	Case2	Case3
S_{11}	-31dB at 11.376 GHz	-38 dB at 11.577 GHz	-33dB at11.25GHz
S_{21}	-2.55dB	-2.03dB	<1.5dB
Phase at pass band	nonlinear	linear	Linear-180º
Size	20X28X1.2mm	19X27X1.2mm	15.8X27X1.2mm

5. Conclusion

A compact bandpass filter has been proposed and investigated through the EM simulation and experiment. Measured results reveal that the filter achieves a compact size, good bandpass performance, low insertion loss, good selectivity at passbands edges and wide stopband. The filter has strong design feasibility, since the pass band can be easily determined by tuning the dimensions of the asymmetric SIRs. This study provides a simple and effective method to design a bandpass filter without complex fabrication process. The superior features indicate that the proposed filter has a potential to be utilized in UWB systems.

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