Multiband Bandpass Filter Using a Modified Right Triangular Patch Resonator at UWB

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Abstract: **A novel and compact BPF with multiple passband notching at frequency 1)2.5 GHz to 3.5 GHz 2) 5.5 GHz to 6.5 GHz 3)9.5 GHz to 9.8 GHz is designed and simulated in HFSS software. This filter consist of modified right triangular patch resonator with Two orthogonal L-shaped stub created on patch and three rectangle slots created at ground plane and with using Defected Microstrip Structure(DMS). The designed resonator and DMS show multiband and multiple mode characteristics. The equivalent circuit model and their R, L, C parameters and their values are also extracted by HFSS. This BPF is designed in such a way that the filter gives BANDSTOP response at Wi-Max and Wireless LAN frequencies to reduce interference. The measured result exhibits wide passband and low insertation loss characteristics for the proposed filter.**

Index Terms : Bandstop Filter ,Band pass Filter ,Ultrawide Band (UWB) ,High Frequency Structure Simulator(HFSS),Modified right triangular patch resonator (MRTPR), Defected Microstrip Structure (DMS).

I.INTRODUCTION

Bandstop Filters (BSFs) are used to suppress the noise and frequency signal which are not used for particular application. Bandpass filter are used to pass the necessary bands for communication purpose. The performance of the filter directly influences the quality of the modern communication system. The UWB frequency band of 3.1 GHz to 10.6 GHz are interfering with the wireless local network signals such as WiMAX frequency at 3.5 GHz [9], and the WLAN systems operate in the 5.0 GHz frequency bands, e.g., 5.15 to 5.35 (IEEE 802.11a lower bands) and 5.725 to 5.825 GHz (IEEE 802.11a upper bands). Hence, a compact microwave bandpass filter working in the UWB system requires a design of reconfigurable bandstop filter in order to avoid being interfered by the undesired signals such as the WLAN radio.
This structure is designed using ROGER RT /DUROID 5880 substrate with dielectric constant 2.2,dielectric thickness 0.508mm and loss tangent=0.0009. There are techniques available for bandwidth improvement, harmonic rejection, compact size, and sharp cut-off. However, there is trade-offs most of the time that, if one parameter is improved, another parameter would be degraded. Improving multiple parameters given above is a challenging task, especially, for microstrip filter technology which is a low cost and desirable one. Many available compact resonator structures can be found in literatures. Some of them, such as a strip line resonator with one grounded end [1], hairpin resonator [2], and Defected microstrip structure (DMS) etc.; have the size constraint of a quarter wavelengths. Additionally, folded quarter-wavelength resonator [3], ring resonator, spiral resonator [4], etc., have a smaller size than a quarter-wavelength. But, they are usually not applicable for broadband filter designs due to the difficulty in realizing the strong couplings. For that dual mode resonator filter is widely used. The triangular patch resonator with 10% fractional bandwidth have been investigated[5].A circular patch resonator with single slot created on the patch has been used to design dual mode band pass filter which has -3db fractional bandwidth less than 10%[6]The E-shaped patch resonator BPF has been designed and implemented. It has fractional bandwidth less than 2%[7].all the above mention filters the indentation losses are greater than 1 dobbin recently various new filters on Defected Microstrip Structure(DMS) have been broadly studied. An integrated comb-line BPF with T-shaped DMS at the external input and output coupling transformers has been studied [8], which has a FBW of 2%.a low pass filter (LPF) using G-shaped DMS has also been described and discussed.
The proposed filter has good selectivity small insertion loss and sharp cutoff. To obtain good selectivity various types of slots are created on the patch. They are shown in below figure.

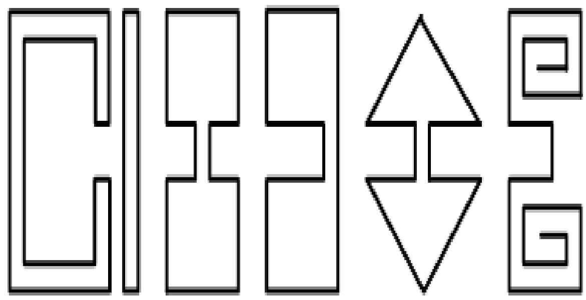


Figure 1.Various shape of slots on patch to achieve rejection at Wi-Max and Wireless-Lan.

II INTRODUCTION OF PATCH

The basic microstrip patch is shown in figure 2.There are basically 3 layers in microstrip patch 1) ground plane 2) dielectric substrate and 3) patch. A patch antenna is a narrowband, wide-beam antenna fabricated by etching the antenna element pattern in metal trace bonded to an insulating dielectric substrate, such as a printed circuit board, with a continuous metal layer bonded to the opposite side of the substrate which forms a ground plane. Common microstrip antenna shapes are square, rectangular, circular and elliptical, but any continuous shape is possible. Some patch antennas do not use a dielectric substrate and instead made of a metal patch mounted above a ground plane using dielectric spacers; the resulting structure is less rugged but has a wider bandwidth. Because such antennas have a very low profile, low cost, easily fabricated are mechanically rugged and can be shaped to conform to the curving skin of a vehicle, they are often mounted on the exterior of aircraft and spacecraft, or are incorporated into mobile radio communications devices. Such an array of patch antennas is an easy way to make a phased array of antennas with dynamic beam forming ability.

An advantage inherent to patch antennas is the ability to have polarization diversity. Patch antennas can easily be designed to have vertical, horizontal, right hand circular (RHCP) or left hand circular (LHCP) polarizations, using multiple feed points, or a single feed point with asymmetric patch structures. This unique property allows patch antennas to be used in many types of communications links that may have varied requirements.

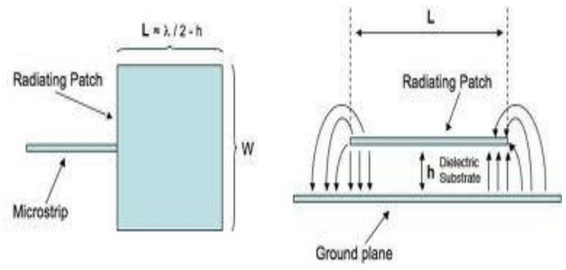


Figure 2 Patch antenna

The frequency of operation of patch antenna of figure 2 is determined by length L. The centre frequency of patch is given by following equation. The equation says that the microstrip antenna should have length equal to one half of a wavelength within the dielectric substrate medium.

$$f_c \approx \frac{c}{2L\sqrt{\varepsilon_r}} = \frac{1}{2L\sqrt{\varepsilon_0 \varepsilon_r \mu_0}} \quad (1)$$

If the capacitor and inductance of patch resonator are varied by creating slots on patch we get the multiband characteristics is achieved. In this proposed filter the same passband and stopband characteristic of patch is used.For multiband rejection the various types of slots are created on the patch of the basic structure. Rectangular waveguide does not use for filtering purpose at particular band frequency and so the researchers uses patch technology. But the disadvantage of patch is it cannot handle high power and multi band tuning is difficult.

III.FILTER DESIGN AND SIMULATION RESULT

This filter is designed using Anasoft High Frequency Structure Simulator Software. This proposed filter structure is designed using ROGER RT /DUROID 5880 substrate with dielectric constant 2.2,dielectric thickness 0.508mm and loss tangent=0.0009.The basic design of bandpass filter is given below in fig.3.The length and width of all the patch element is shown in the figure.

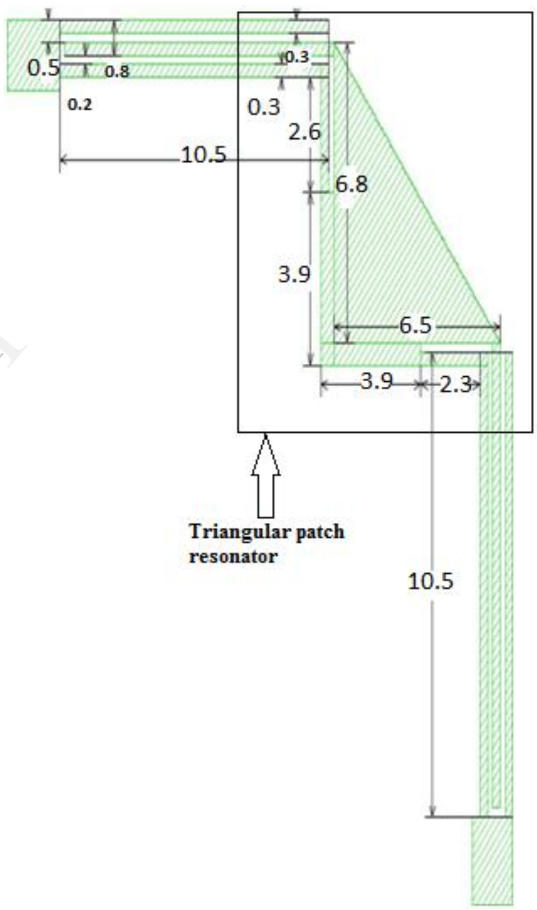


Figure 3 Basic structure

The scattering parameter and VSWR graph for above structure is given below in fig.4 and 5.

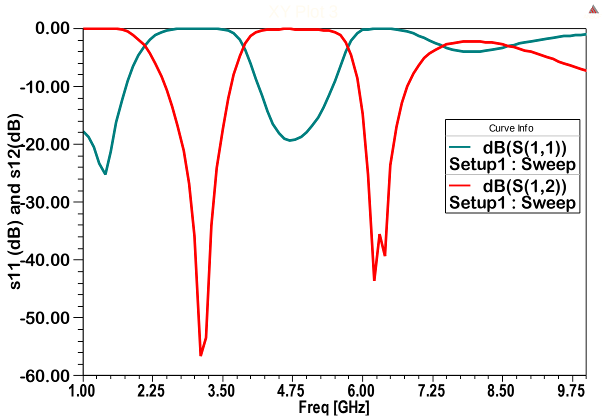


Figure 4 s parameter of basic structure

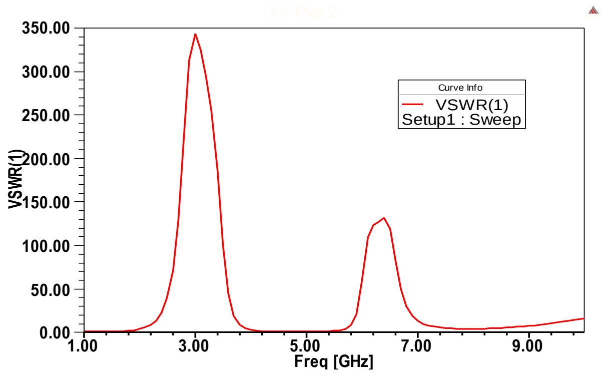


Figure 5 VSWR of basic structure

In above structure, the two orthogonal stubs of resonator are cascaded with the input and output DMSs, respectively. Also, the middle triangular patch of DMSs are overlapped with the stubs of resonator each other. If the slots of various shapes are creating in right triangular patch resonator and the length of stub and patch resonator are varied we get notching at 2.4 GHz Bluetooth freq, 3.2 GHz WI-max freq. and 5.4 GHz Wireless-LAN frequency. The defected microstrip structure is used for the same types of s11, s12 and VSWR characteristics with high sharpness and high quality. The triangular dumble shape and rectangular slots give batter response than the basic structure. The rectangular slots have length 0.5 mm and width 4.5 mm and triangular slots with center point distance 0.5mm and height 1mm.

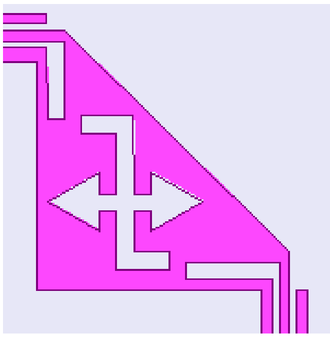


Figure 6 structure (1) rectangular and triangular slots

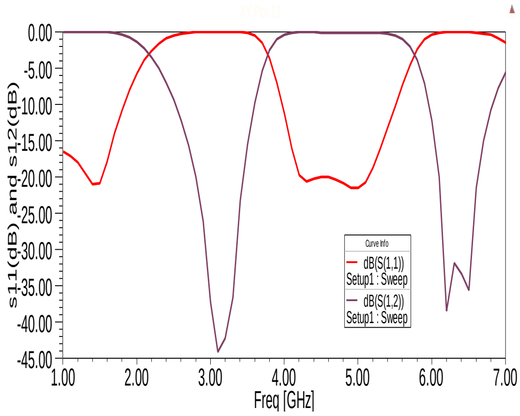


Figure 7 s parameter of structure (1)

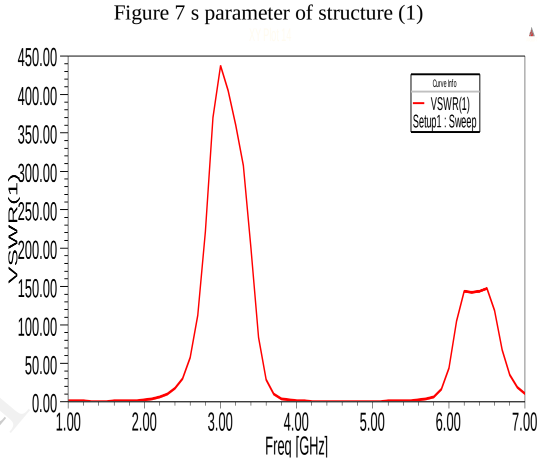


Figure 8 VSWR of structure (1)

The simple 2 slots as shown in figure 9 created on right triangular patch resonator is gives the batter result at Wimax and wireless-Lan frequency. The two bands are separated by each other if we increase the length of stub by 0.5mm.Because by changing the stub and patch resonator‘s lengths we can change capacitor and inductor value, so its directly affects the mutual coupling between the two orthogonal stubs and triangular patch resonator.

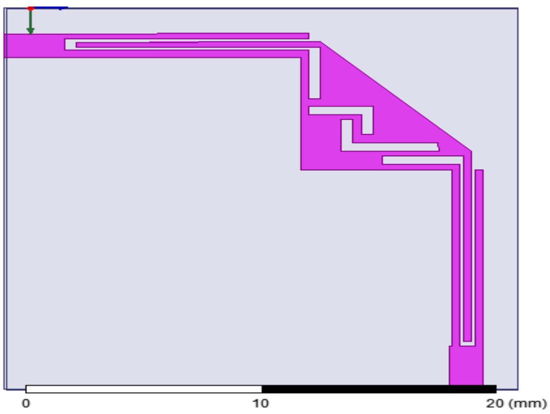
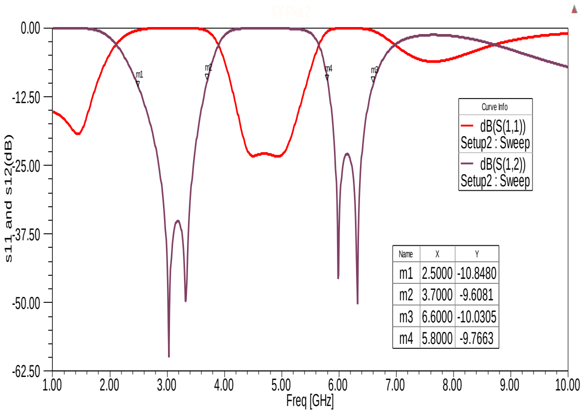


Figure 9 structures (2) of two rectangular slots



Name	X	Y
m1	2.5000	-10.8480
m2	3.7000	-9.6081
m3	6.6000	-10.0305
m4	5.8000	-9.7663

Figure 10 s parameter of structure (2)

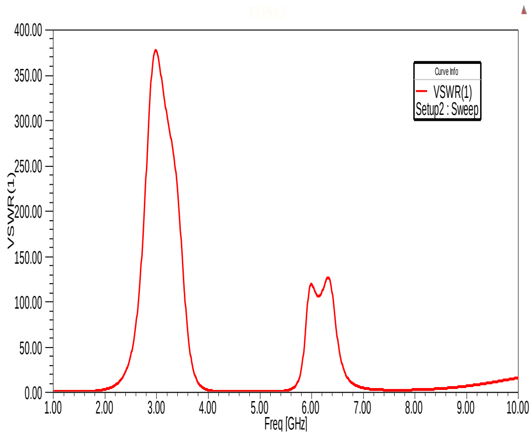


Figure 11 VSWR of structure (2)

Coupling circuit of the basic structure

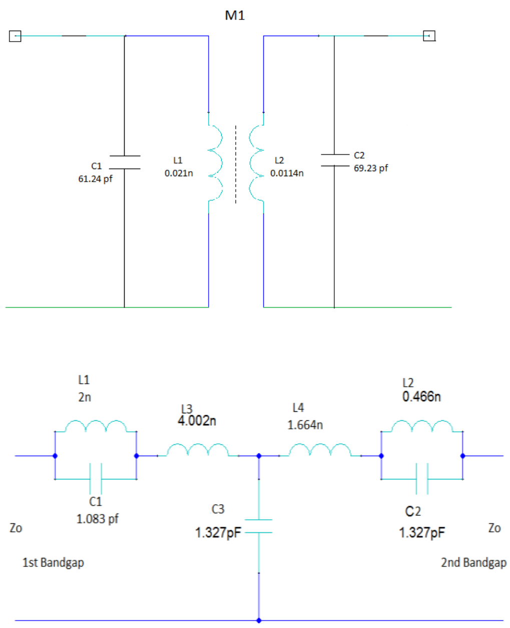


Figure 12 coupling circuit of filter

The coupling circuit of two stubs and the triangular patch resonator is given above in figure 12. The basic attention in above circuit is the central T network consists of L3, L4 and C3.These three element's value changes the cutoff frequency of filter. In the circuit the values of inductor and capacitors are changed by following equation,

$C_3 = 1/\omega_t X_{21}$ (2)

$L_{i+2} = \frac{Xii - X21}{\omega t} + \frac{Li}{\left(\frac{\omega t}{\omega i}\right)2-1}$ (3) for i=1,2

$Qe,i = \frac{f0,i}{\Delta f - 3dB,i}$ (4) for i= 1,2.

Where ω_t is transit frequency Xii, X21 are imaginary part of the three Z-parameters at ωt .In addition Zo is the characteristic impedance of transmission line.The characteristic impedance Z0 of the input/output microstrip transmission. f0, i is the central frequency of the resonant mode, Δf_3dB, i is the -3 dB bandwidth of the resonant mode.

Lines is 50Ω. Finally, the effective dimensions of the fabricated filter are approximately 17.7mm_18.0mm (0.39 λg_0.40 λg), where λg is the guided wavelength at the midband frequency of designed BPF in the substrate. The values of capacitor c_3 and inductors L_3 and L_4 are changed by above equation.

By creating the second structure on the basis of the figure the two bands are separated whose center frequencies 3 GHz and 6.1 GHz. Two rectangular slots are created on the triangular patch so the resonant frequency changed by equation (1) .The two bands are separated with changing the length and width of this two slots .The scattering parameters s11 and s12 and VSWR graphs are shown in figure 2(b) and 2(c).From this graphs the VSWR is high from frequency 2.5 GHz – 3Ghz and 5.9 GHz -6.6Ghz.So the these two bands are rejected and the other frequency bands are passed by the filter.

In structure in figure 13 the two slots created on patch. one is rectangular which has length 2.5 mm and width 0.9 mm and the other is triangular which has centre width 0.5mm and height 1mm.The other rectangular slots which is connected to triangular slots which has length 0.3 mm and width 4 mm.Two frequency variation is achieved by this two slots one is the VSWR is high at 2.4 GHz Bluetooth frequency ,Wireless Lan frequency and Wi-Max frequency. The impedance is drastically changed by the triangular slot so the resonant frequency is varied.

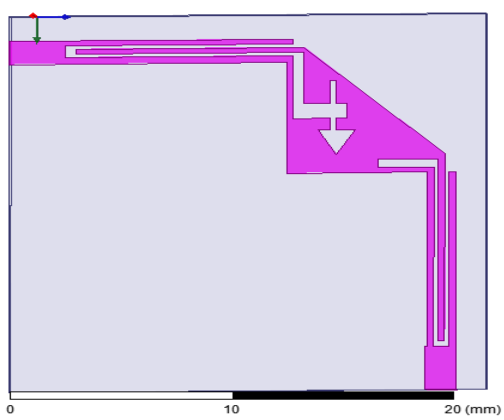


Figure 13structure(3) triangular and rectangular slots

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The band separation is created by defected microstrip patch structure.

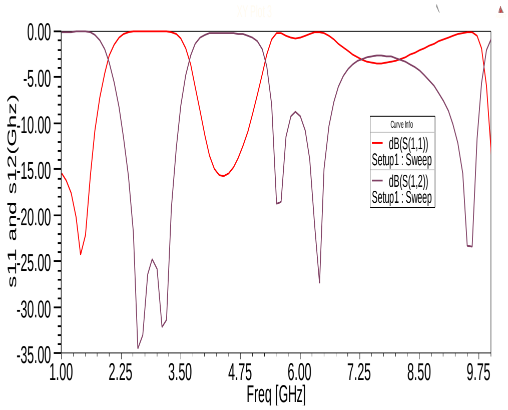

Figure 14 s parameter of structure (3)

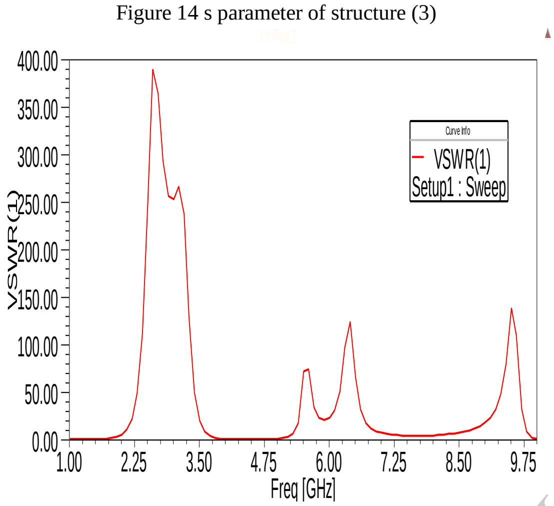

Figure 15 VSWR of structure (3)

The rectangular patch has length 7mm and width 12 mm add with triangular patch the high pass filter characteristic is achieved. The cutoff frequency for this filter is 7.25 GHz. The frequency band from 1.4 GHz to 7.25 GHz is rejected and the frequency above 7.25 GHz is passed by this highpass filter.

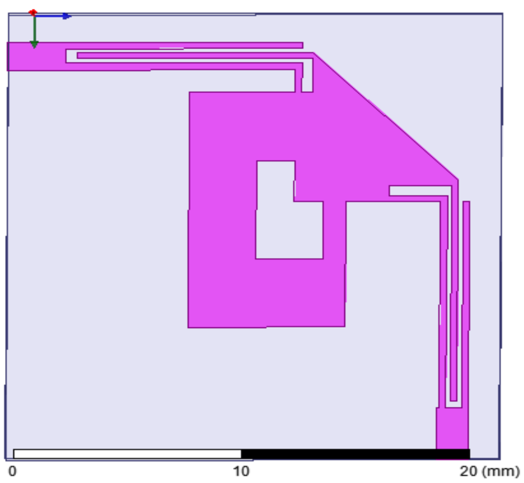

Figure 16 High pass filter structure (4)

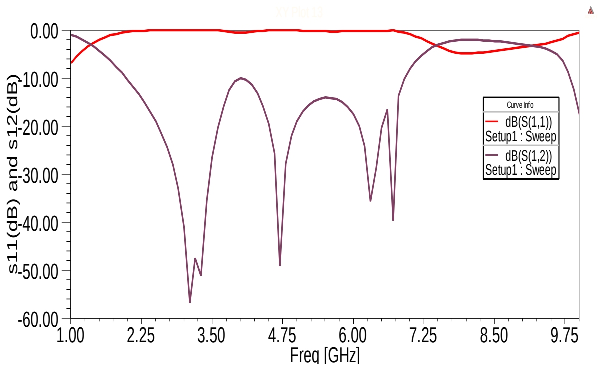

Figure 17 s parameter of structure (4)

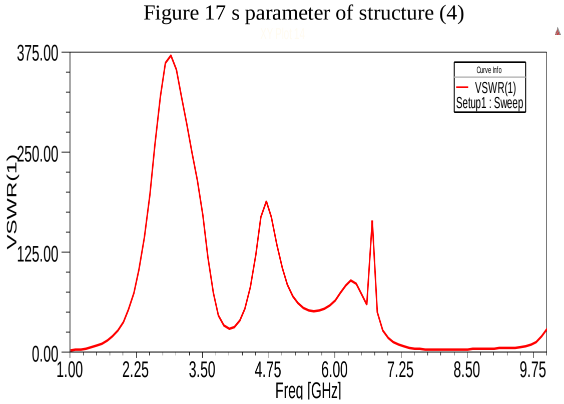

Figure 18 VSWR parameter of structure (5)

CONCLUSION

In this Paper, a low insertion loss and wideband dual-mode BPF has been proposed. The high selectivity and compact filter is implemented by a modified right-triangle dual-mode patch resonator cascaded and overlapped with a pair of input/output DMSs, which exhibit a dual-bandgap characteristic. As a result, the novel dual-mode BPF using a simple combined geometric structure has a simple design procedure and an attractive outlook for modern wireless applications. By using this structure we can get high pass and low pass responses. The Cost of Rogger/ RT 5880 substrate is high. The cost of the structure may be reduced we use low cost FR4 substrate and implement the same types of BPF.

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