

Design of UWB Filter with Notch Band for WLAN (5.3-5.8 GHz) Signal Interference Rejection

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ABSTRACT : In this letter, a design of Compact Ultra-Wideband (UWB) bandpass filter with a switchable notch band for WLAN (5.3-5.9GHz) interference rejection is proposed. As 5.3-5.9GHz wireless local area network (WLAN) is existed in UWB spectrum range (3.1 -10.6GHz) and may interfere with UWB system operation. The UWB bandpass filter is implemented using a basic multiple mode resonator (MMR) structure feed by interdigital coupled lines for achieving higher degree of coupling. The notch band is obtained using a etched slot on main microstrip line. The centre frequency and bandwidth of notch band is optimized. The filter is compact in size with dimension 37.4 X 25 mm². The electromagnetic simulation software, Computer Simulation Technology Microwave Studio (CST MWS) is used for the simulation and analysis of the designed structure. For fabrication of this structure Rogers RT5880 substrate of thickness 0.4 mm and dielectric constant 2.2 is used. Measured and simulated results show good agreement.

Keywords - WLAN, Microstrip, MMR, UWB

I. INTRODUCTION

The tremendous progress in Ultra wideband (3.1–10.6 GHz) radio technology is reported now days. The researchers' interest rose dramatically in developing UWB devices due to its potential application in modern short distance defense and commercial communication systems. Ultra wideband (UWB) band pass filter (BPF) is an important part of and UWB communication system[1-2]. There are various types of UWB bandpass filters are reported In recent years[3-13]. To achieve low cost and easy integration, these filters are usually implemented in a microstrip or coplanar waveguide technology.

The 5.2-5.8 GHz wireless local area network (WLAN) signal is interfered with UWB system operations in the UWB in-door specification (3.1 - 10.6 GHz) standardized by U.S. (FCC). There are many designs are reported for rejecting these WLAN signals. Most of these designs used stepped impedance resonators [14], defective ground structure (DGS) [15]. The DGS structure has a serious drawback of packaging, because there is an absence of ground plane and EM field is leaked so we cannot use it for commercial fabrication purpose. Whereas stepped impedance resonators create structure too bulky and required additional space.

In this letter, A compact UWB bandpass filter is proposed using a multiple mode resonator (MMR) structure. The stop band selectivity is improved by achieving higher degree of coupling using interdigital coupled lines. The notch band for WLAN interference rejection is realized by etching a slot in the main microstrip line in MMR structure. In this design notch band is realized on the main structure itself so the design space is reduced. The switching feature is added here by using diode D1, so we can switch the notch band ON/OFF in our UWB passband according to our need. Fig. 1 shows the proposed filter structure. All dimensions of this filter are presented in TABLE I.

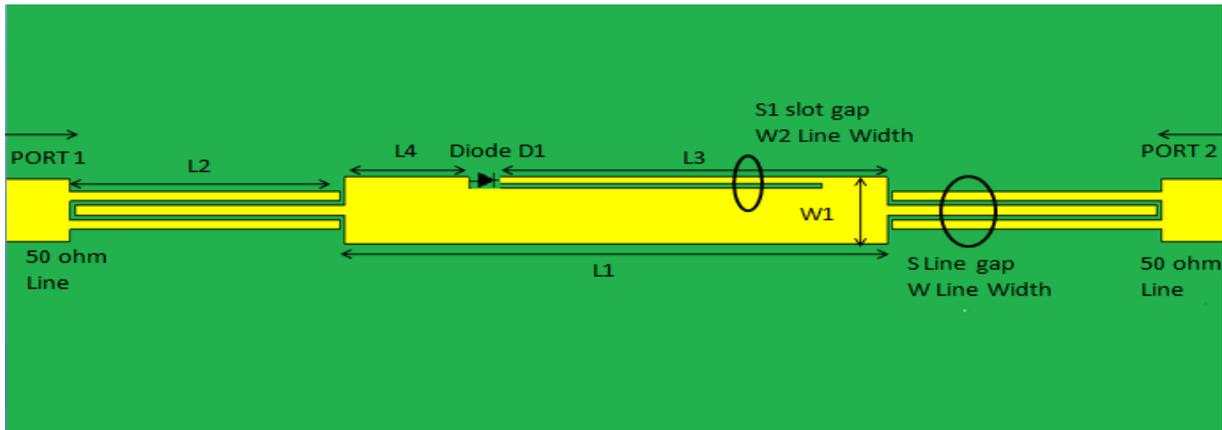


Fig. 1 Layout of the proposed UWB bandpass filter with notch band

TABLE I. Dimension of proposed filter

| Filter parameter | Value | Filter parameter | Value |
|------------------|--------|------------------|--------|
| L_1 | 16.6mm | S_1 | 0.15mm |
| L_2 | 8.25mm | W | 0.3mm |
| L_3 | 12.2mm | W_1 | 2.1mm |
| L_4 | 3.8mm | W_2 | 0.2mm |
| S | 0.15mm | | |

II. FILTER DESIGN

The basic UWB band pass filter is designed using a MMR structure based on stepped impedance resonator discussed in chapter three. At the central frequency of the UWB passband, i.e., 6.85 GHz, the MMR structure composed of one half wavelength $\lambda/2$ low-impedance line section in the center and two identical $\lambda/4$ high-impedance line sections at the two sides. The low impedance section is 59.42Ω and high impedance section of the MMR is 138Ω resulting in an impedance ratio of 2.32. Impedance ratio greater than 1 is utilised to design UWB filters. In this design we use Interdigital coupled lines as a I/O feed lines. The width of feed lines W is 0.3 mm and spacing S which is optimized at 0.15 mm for proper response. When giving energy to the MMR coupling energy of interdigital coupling is high compared with the single line parallel coupling.

Many designs are reported based on defective ground structure for creating notch band in a UWB passband. But due to the various drawbacks of DGS structure including the commercial packaging and fabrication problem, here we proposed a etched slot in the main microstripline in MMR structure to create a notch band. It does not require any additional structure as reduced the overall dimension.

Fig. 2 shows the etched slot structure in the main microstrip line. The stub length L_3 and slot gap S_1 and line width W_2 is optimized at 12.2 mm, 0.15 mm and 0.2 mm respectively for notch band of center frequency 5.6 GHz and bandwidth 5.3-5.8 GHz (0.5GHz). The center frequency and bandwidth of notch band varies with the parameters L_3 , S_1 and W_2 .

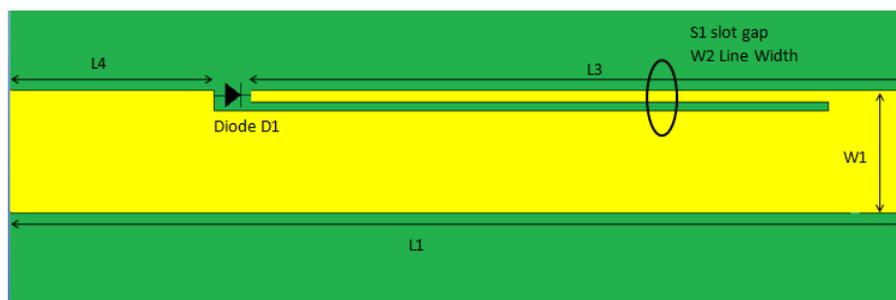


Fig. 2 Etched slot structure for notch band realization

The centre frequency of notch band varies with the length L3. The length of open stub transmission line is such that quarter-wave-length at the desired notched frequencies. The variation of centre frequency with length L3 is presented in TABLE II. Fig. 3 shows the variation of centre frequency of notch band with stub length L3 keeping S1 and W2 constant.

TABLE II. Variation of centre frequency with stub length L3

| Stub Length L3 | Centre frequency of notch band |
|----------------|--------------------------------|
| 7.2 mm | 7.7 GHz |
| 8.2 mm | 6.85 GHz |
| 9.2 mm | 6.2 GHz |
| 10.2 mm | 5.5 GHz |
| 11.2 mm | 5 GHz |
| 11.8 mm | 4.8 GHz |

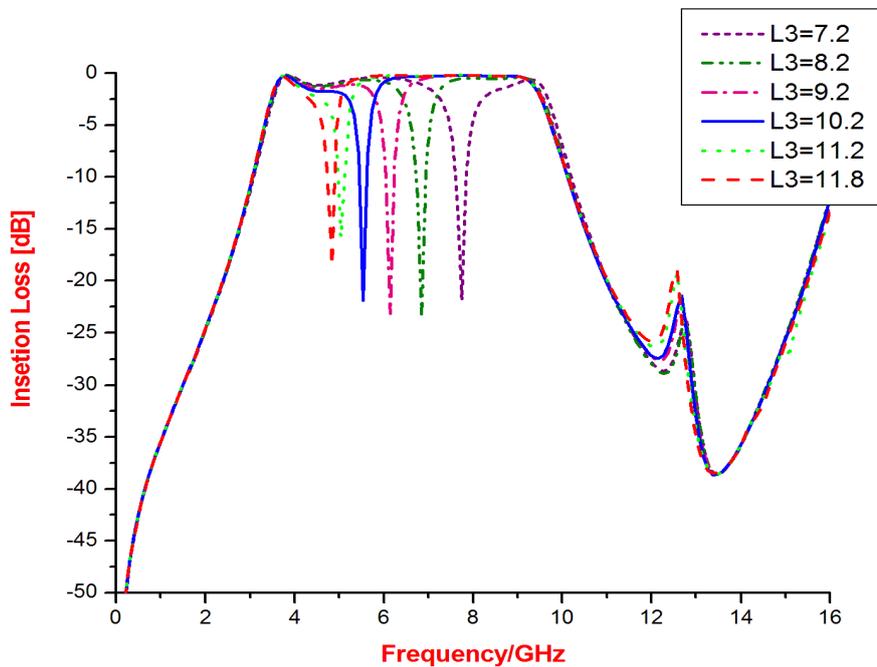


Fig. 3 Variation of centre frequency with stub length L3

The bandwidth of notch band varies with the slot gap S1. The variation of bandwidth of notch band with slot gap S1 is presented in TABLE III and shown in Fig. 4 keeping L3 and W2 constant.

TABLE III. Variation of bandwidth of notch band with slot gap S1

| Line Width W2 | Bandwidth of notch band |
|---------------|-------------------------|
| 0.1 mm | 0.3 GHz (5.4-5.73 GHz) |
| 0.15 mm | 0.5 GHz (5.3-5.8 GHz) |
| 0.2 mm | 0.7 GHz (5.1-5.8 GHz) |
| 0.25 mm | 0.8 GHz (5.0-5.8 GHz) |
| 0.3 mm | 1.0 GHz (4.8-5.8 GHz) |
| 0.35 mm | 1.2 GHz (4.6-5.8 GHz) |

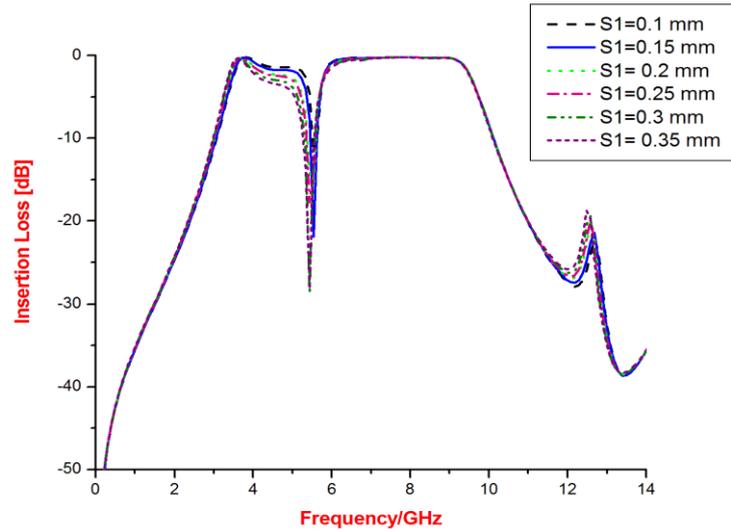


Fig. 4 Variation of bandwidth of notch band with slot gap S1

The bandwidth of notch band also varies with the line width W2. The variation of bandwidth of notch band with line width S1 is presented in TABLE IV and shown in Fig. 4 keeping S1 and L3 constant.

TABLE IV. Variation of bandwidth of notch band with line width W2

| Line Width W2 | Bandwidth of notch band |
|---------------|-------------------------|
| 0.1 mm | 0.4 GHz (5.3-5.7 GHz) |
| 0.15 mm | 0.5 GHz (5.25-5.75 GHz) |
| 0.2 mm | 0.7 GHz (5.1-5.8 GHz) |
| 0.25 mm | 0.8 GHz (5.05-5.85 GHz) |
| 0.3 mm | 1 GHz (4.9-5.9 GHz) |
| 0.35 mm | 1.1 GHz (4.85-5.95 GHz) |

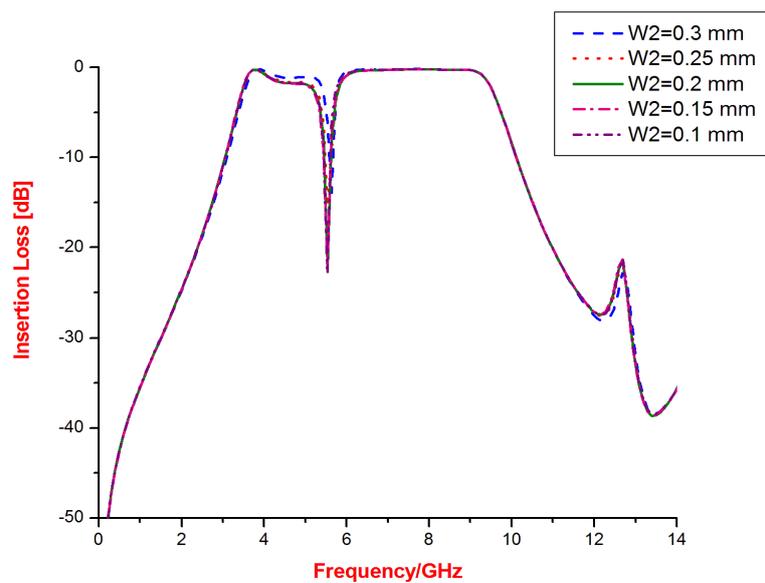


Fig. 5 Variation of bandwidth of notch band with line width W2

The switching scheme is achieved by introduction of Diode D1 in the etched slot. When diode is in forward bias (ON) state we get the UWB passband from 3.3 to 11 GHz without notch band. When diode is in reverse bias (OFF) state we get a notch band from 5.3 to 5.9 GHz for WLAN interference rejection. So by this scheme we provide additional swichable notch band feature in this design.

III. SIMULATED AND MEASURED RESULTS OF PROPOSED FILTER

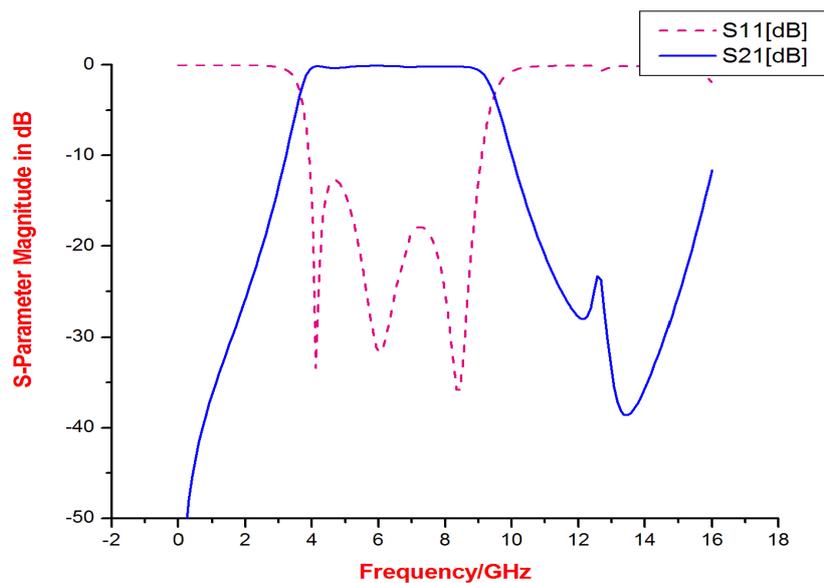
The EM simulated frequency response and fabricated measured result of propose UWB bandpass filter with a switchable notch band for WLAN signal interference rejection is discussed here. The electromagnetic simulation software, Computer Simulation Technology Microwave Studio (CST MWS) is used for the simulation and analysis of the designed structure. The return loss S11, insertion loss S21 and group delay is discussed in this section.

Based on the design analysis presented above, the UWB BPF is realized by MMR feed by interdigital coupled lines. Notch band for WLAN interference rejection is implemented using etched slot structure. Switchable notch band characteristics is achieved using Diode D1. The substrate used is Rogers RT5880 with a relative dielectric constant of 2.2 and a thickness of 0.4 mm. Fig. 6 shows the photograph of the fabricated UWB BPF.

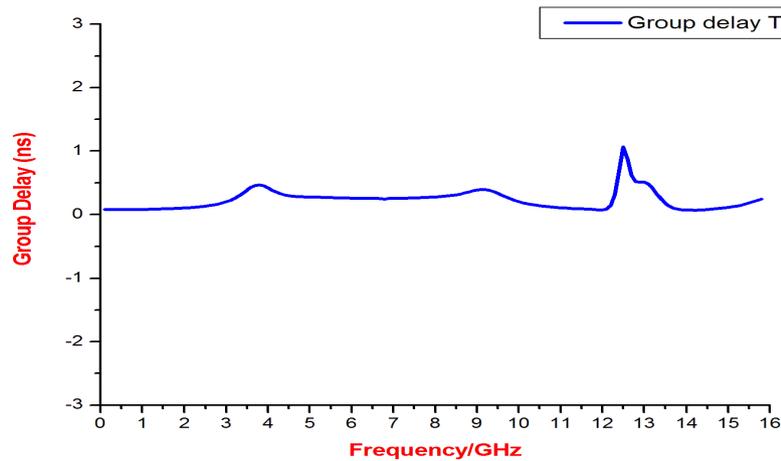


Fig. 6 Photograph of the fabricated UWB filter with WLAN notch

There are only simulated result of switching is presented here because switch based on lumped element could not be implemented easily in this design. When the Diode D1 is in forward bias (ON) state the EM simulated frequency response of proposed filter is shown in Fig. 7(a). The filter has the passband from 3.3 to 10.6 GHz. The passband is almost flat with attenuation around 0.3 dB in the whole passband. The return loss S11 is almost less than -10 dB in the whole passband. Group delay of proposed filter when diode D1 is ON is around 0.2 ns and overall linear in the whole pass band.



(a)

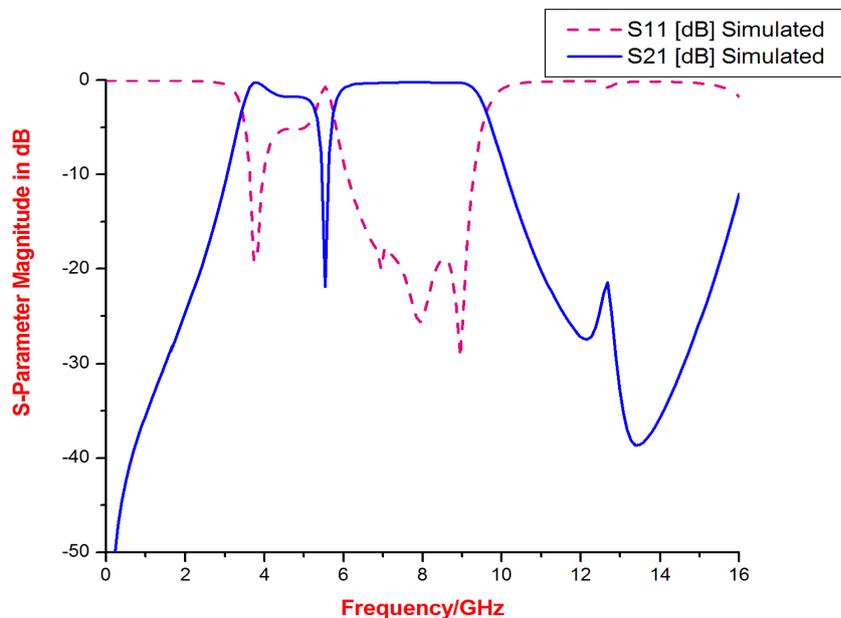


(b)

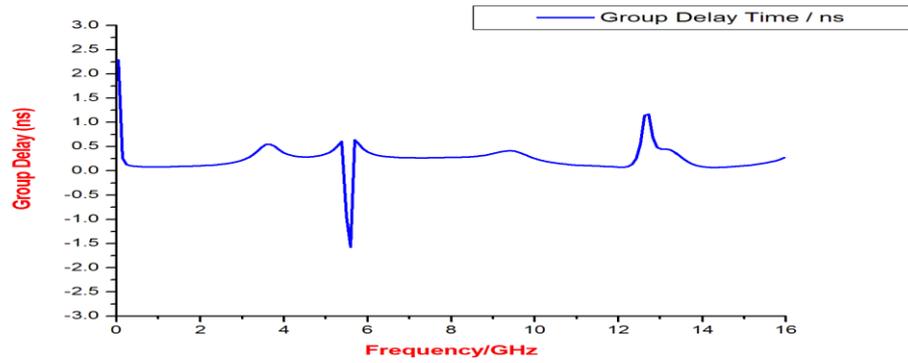
Fig. 7 Simulated result of proposed UWB BPF when diode D1 is ON state (a) Frequency response (b) group delay result

Fig. 8 (a) shows the EM simulated frequency response of proposed filter when Diode D1 is in reverse bias (OFF) state. In the OFF state we get the high selective notch band to suppress the undesired WLAN signal interference starts from 5.3 GHz to 5.8 GHz with attenuation around 25 dB. Group delay of proposed filter with notch band is around 0.2 ns and overall linear in the whole pass band as shown in Fig. 8 (b).

The fabricated measured results of the proposed UWB BPF with WLAN notch is presented in Fig. 5.9. The comparison of simulated and measured result is presented in Fig. 5.10, good agreement between simulated and measured results is observed. There are slight discrepancy may be due to the unexpected tolerance of fabrication and implement. In addition, the group delay within the UWB passband is between 0.56–0.85 ns, showing a good linearity.

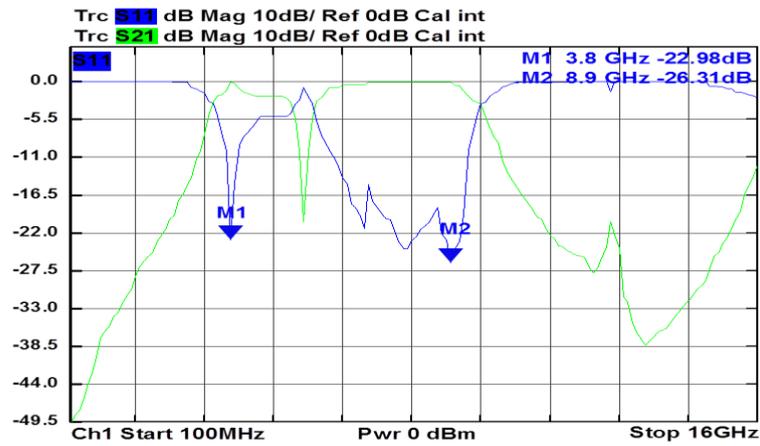


(a)

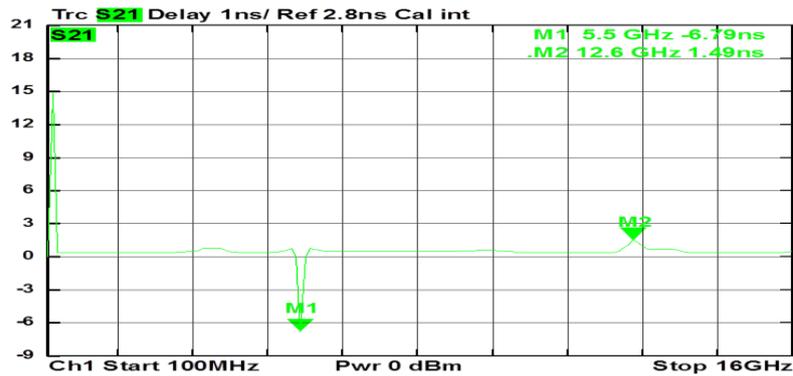


(b)

Fig. 8 Simulated result of proposed UWB BPF when diode D1 is OFF state (a) Frequency response (b) group delay result

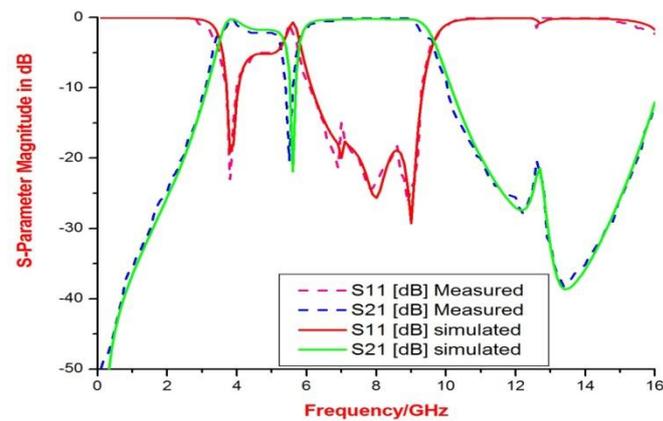


(a)



(b)

Fig. 9 Fabricated measured result of proposed UWB BPF with WLAN notch (a) Frequency response (b) group delay result



(a)

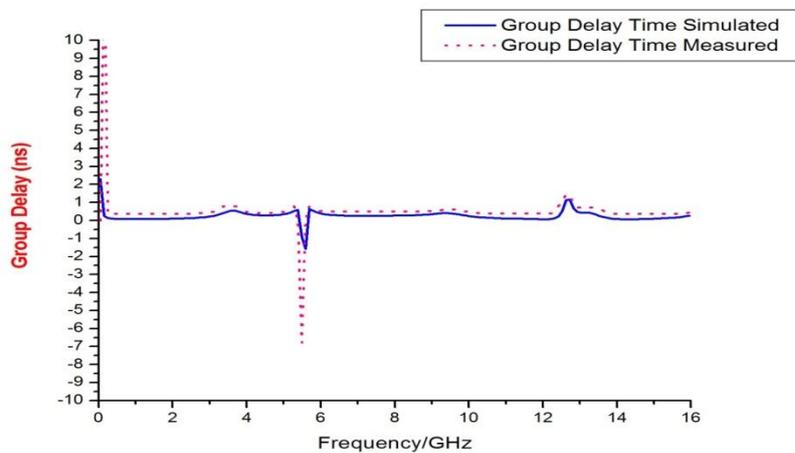


Fig. 10 Comparison of simulated and fabricated measured result of proposed UWB BPF with WLAN notch (a) Frequency response (b) group delay result

IV. CONCLUSION

In this letter, a design of UWB bandpass filter with notch band for WLAN interference rejection is proposed. Here we implement a notch band in the same structure by etching out the slot in the main structure, which reduce the size because no extra circuitry is required for band stop filter. There is also switchable feature introduced using a diode. So due to its compact size $37.4 \times 25 \text{ mm}^2$ and satisfactory passband and stopband performance, the filter can be useful for commercial UWB wireless communication systems.

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