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Design of UWB Filter with Tunable Notchband

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Abstract**——** In this paper, design of compact ultra- wideband (UWB) band pass filter with a tunable notch band at WLAN (5.2-5.8 GHz), X-band applications like satellite communications (8.4 GHz) and radar systems (10 GHz) signal interference rejection is proposed. As these signals coexist with UWB spectrum range (3.1-10.6 GHz) and may interfere with UWB system operation. The UWB band pass 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 an etched slot on main microstrip line. There is switching feature also provided for notch band by using a diode. The filter is compact in size with dimension 18 X 14 mm^2 with the ground plane. For designing of this structure Taconic substrate of thickness 0.787 mm and dielectric constant 2.2 is used. The electromagnetic simulation software, Computer Simulation Technology Microwave Studio (CST MWS) is used for the simulation and analysis of the designed structure.

Keywords**—** *Ultra Wide Band, Interdigital, Multiple Mode Resonator*

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I. INTRODUCTION

Due to ever increasing data rate and system compactness, there is great demand for broadband and high data rate systems. Due to its inherent properties, UWB is considered as a potential candidate for high-speed data transmission, low cost and short range indoor wireless 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.

But UWB bandwidth faces interference due to many sub communication bands such as WLAN (5.3-5.8 GHz) and X band applications like satellite communications (8.4 GHz) and radar systems (10 GHz), etc. In order to avoid sub band interference, it is important that the UWB system should possess a multi-band reject filter characteristic for interfering microwave bands.

In this paper, a compact UWB band pass filter with multiple tunable notch bands is proposed using a multiple mode resonator (MMR) structure. The notch band for interfering microwave bands 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 tunable feature is added here by using diode D1, D2 and D3 so we can switch the notch band ON/OFF in our UWB passband according to our need. Figure 1 shows the proposed filter structure. All dimensions of this filter are presented in Table I.

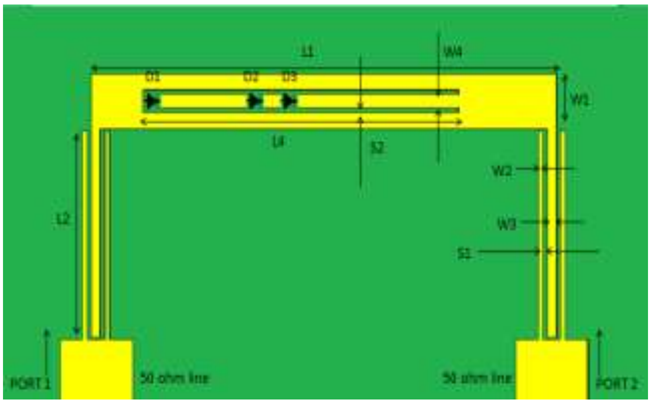


Figure 1. Layout of the proposed UWB band pass filter with notch band

Table I DIMENSION OF PROPOSED FILTER

Filter parameter	Value	Filter parameter	Value
L1	15.45mm	W1	2mm
L2	7.65mm	W2	0.15mm
L4	10.5mm	W3	0.3mm
S1	0.15mm	W4	0.3mm
S2	0.35mm		

II. Filter Design Process

The basic UWB band pass filter is designed using a MMR structure based on stepped impedance resonator. At the central frequency of the UWB passband, i.e., 6.85 GHz, the MMR structure composed of one half wavelength λ/2 low-impedance line section in the center and two identical λ/4 high-impedance line sections at the two sides. The low impedance section is 59.42 Ω and high impedance section of the MMR is 138 Ω resulting in an impedance ratio of 2.32. Impedance ratio greater than 1 is utilized to design UWB filters. In this design we use interdigital coupled lines as an 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.

In this design an etched slot in the main micro stripline in MMR structure is used to create notch band. It does not require any additional structure as reduced the overall dimension. The centre frequency of notch band varies with the open stub length in the etched slot structure. The length of open stub transmission line is such that quarter-wave-length at the desired notched frequencies. When we change the length of open stub in the etched slot the centre frequency of notch band gets changed. Using this concept we implement here three tunable notch bands. Diodes D1, D2 and D3 are used for tuning purpose of notch band. The diode working is described below in three cases.

Case I: When diode D1 is in OFF and D2 and D3 is ON state

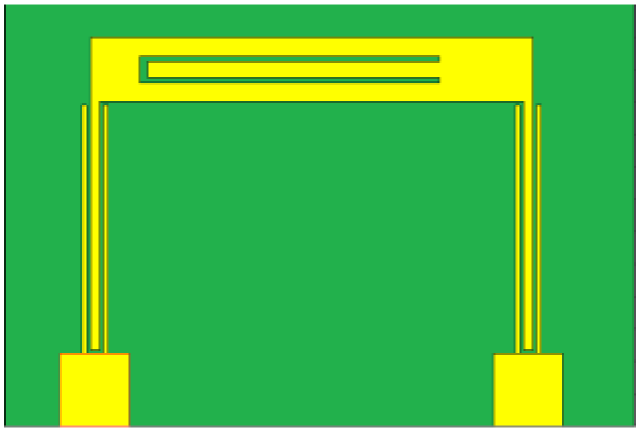
When diode D1 is in OFF state, It will provide a high resistance path to the line and diode D2 and D3 is in ON state provide low resistance like a conductor, the equivalent structure in this case is shown in Figure 2(a). This structure provides a WLAN notch at 5.6 GHz in the UWB passband.

Case II: When diode D2 is in OFF and D1 and D3 is ON state

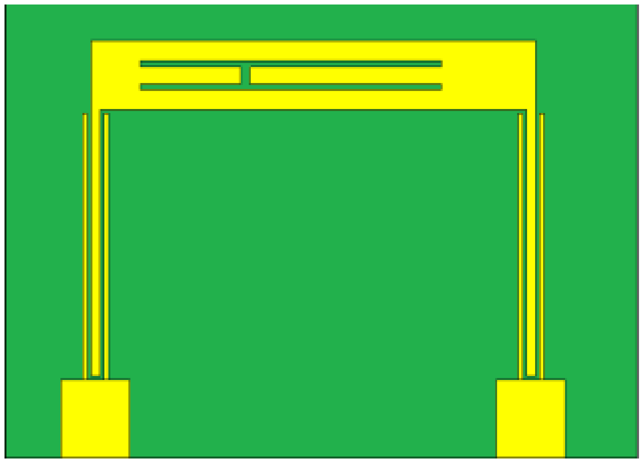
When diode D2 is in OFF state, It will provide a high resistance path to the line and diode D1 and D3 is in ON state provide low resistance like a conductor, the equivalent structure in this case is shown in Figure 2(b). This structure provides a notch band for interfering satellite communications (8.4 GHz) signal in UWB passband.

Case III: When diode D3 is in OFF and D1 and D2 is ON state

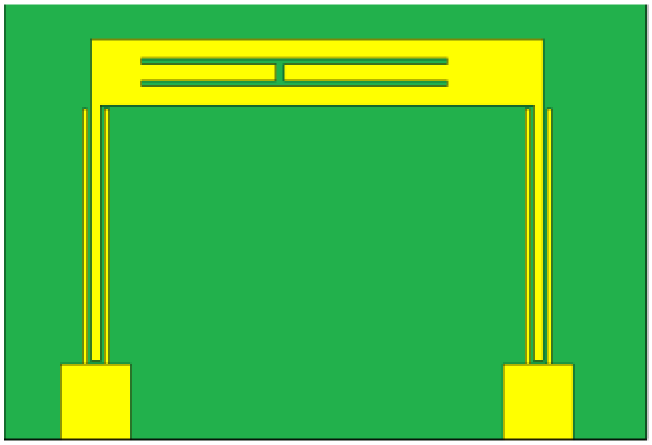
When diode D3 is in OFF state, It will provide a high resistance path to the line and diode D1 and D2 is in ON state provide low resistance like a conductor, the equivalent structure in this case is shown in Figure 2(c). This structure provides a notch band for radar systems (10 GHz) signal in UWB passband.



(a)



(b)



(c)

Figure 2. Equivalent UWB filter structure (a) When diode D1 is in OFF state (b) When diode D2 is in OFF state (c) When diode D3 is in OFF state

III. Simulation Results and Discussion

The EM simulated frequency response of propose UWB bandpass filter with a switchable notch band for WLAN (5.2-5.8 GHz), X-band applications like satellite communications (8.4 GHz) and radar systems (10 GHz) 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 S21and group delay is discussed in this section.

Case I: When all the diodes D1, D2 and D3 are in forward bias (ON) state

The EM simulated frequency response of proposed filter in this case is shown in Figure 3 (a). The filter has the passband from 3.3 to 11 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 ON is around 0.2 ns and linear in the whole pass band as shown in Figure 3(b).

Case II: When diode D1 is in OFF and D2 and D3 are in ON state

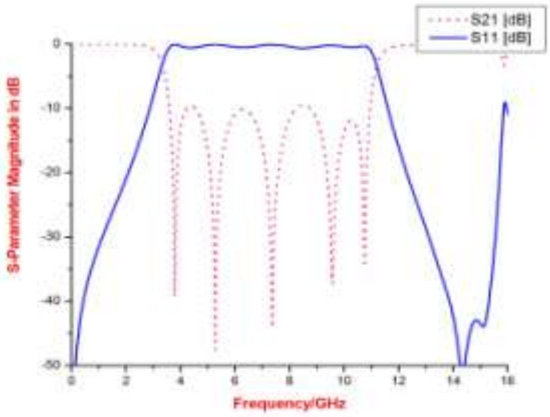
The EM simulated frequency response of proposed filter when Diode D1 is in reverse bias (OFF) state is shown in Figure 4 (a). In the OFF state we get the high selective notch band to suppress the undesired WLAN signal interference starts from 5.3 GHz to 5.8 GHz with attenuation around 20 dB. Group delay of proposed filter with notch band is around 0.2 ns and overall linear in the whole pass band as shown in Figure 4(b).

Case III: When diode D2 is in OFF and D1 and D3 are in ON state

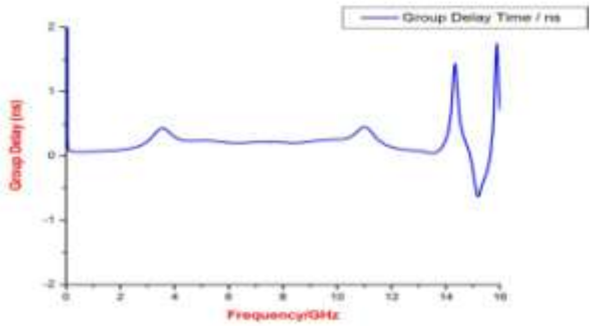
The EM simulated frequency response of proposed filter when Diode D2 is in reverse bias (OFF) state is shown in Figure 5 (a). In the OFF state we get the high selective notch band to suppress the interfering satellite communications (8.4 GHz) signal starts from 8.1 GHz to 8.6 GHz with attenuation around 20 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 Figure 5(b).

Case IV: When diode D3 is in OFF and D1 and D2 are in ON state

The EM simulated frequency response of proposed filter when Diode D3 is in reverse bias (OFF) state is shown in Figure 6 (a). In the OFF state we get the high selective notch band to suppress the interfering radar systems (10 GHz) signal starts from 9.8 GHz to 10.3 GHz with attenuation around 20 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 Figure 6(b).

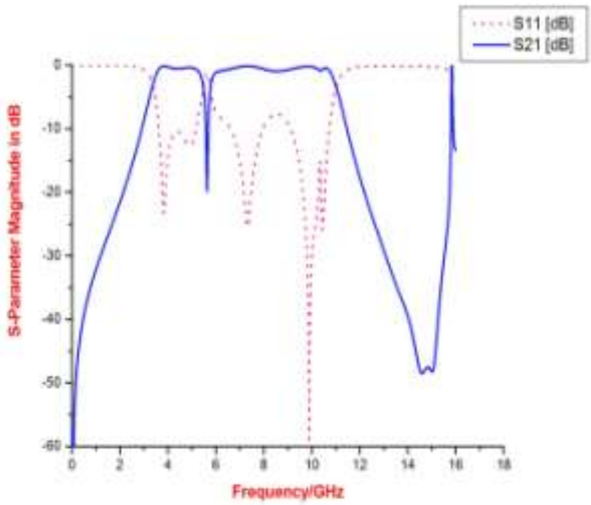


(a)



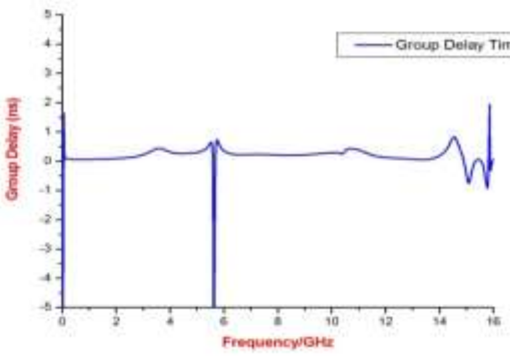
(b)

Figure 3. Simulated result of proposed UWB BPF when all diode D1, D2 and D3 is ON state (a) Frequency response (b) Group delay result



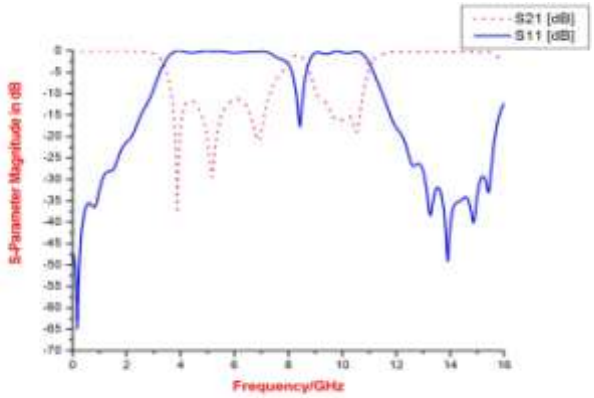
(a)

 ISSN: 2454-4248
45 – 49

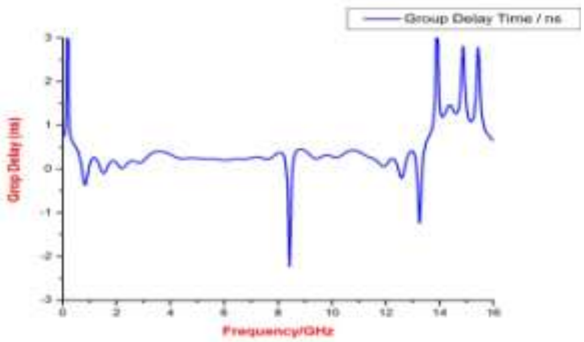


(b)

Figure 4. Simulated result of proposed UWB BPF when diode D1 is OFF state (a) Frequency response (b) Group delay result

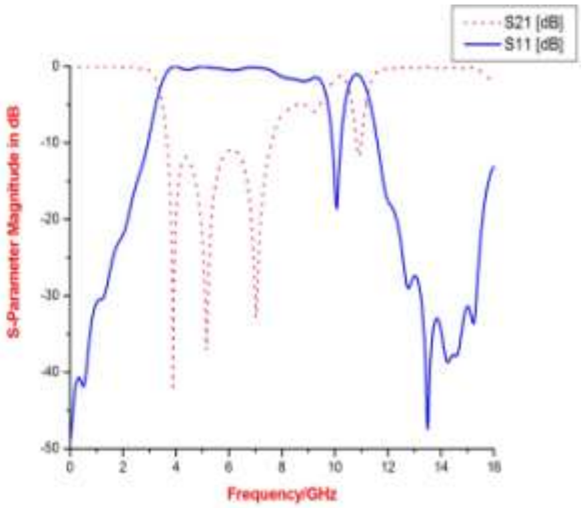


(a)

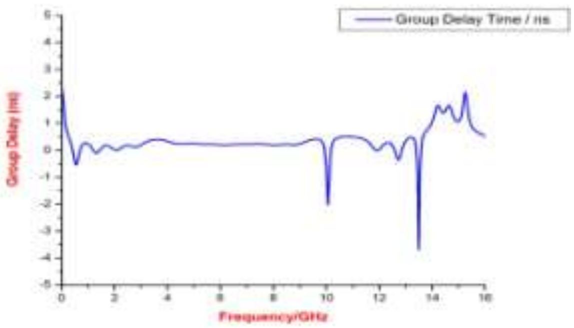


(b)

Figure 5. Simulated result of proposed UWB BPF when diode D2 is in OFF state (a) Frequency response (b) Group delay result



(a)



(b)

Figure 6. Simulated result of proposed UWB BPF when diode D3 is in OFF state (a) Frequency response (b) Group delay result

IV. CONCLUSION

In this paper, a design of UWB band pass filter with notch band for WLAN (5.2-5.8 GHz), X-band applications like satellite communications (8.4 GHz) and radar systems (10 GHz) signal interference rejection is proposed. Here implementation of notch band in the same structure is done 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 tunable feature introduced using diodes. So due to its compact size 22 X 18 mm^2 and satisfactory passband and stopband performance, the filter can be useful for commercial UWB wireless communication systems.

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