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CPW Fed Miniaturized Tri-Notched Ultra-Wideband Antenna

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Abstract: A Coplanar Waveguide (CPW) fed miniaturized ultra wide band (UWB) antenna with Triple band rejection capabilities is presented. The Antenna is prototyped for ultrawideband (UWB) communication applications. By implementing asymmetric structure, the miniaturization in the antenna has been achieved and has a very compact size of $22 \times 13 \times 1.5 mm^3$ which is the most suitable antenna to be used for USB dongle applications. Measured and Simulated results show that the proposed UWB Antenna operate from 3.1 to 10.6 GHz for VSWR < 2 with stable and advantageous radiation patterns. The proposed Band-notch antenna can reject worldwide interoperability for microwave access (WiMAX) band (3.3-3.6 GHz) and wireless local area network (WLAN) frequency bands (Lower WLAN (5.15-5.325) and (Upper WLAN (5.725-5.825) GHz). Triple Band rejection capabilities has been achieved by etching three Complementary split rings resonators (CSRR) in the radiating patch.

Keywords: CPW, UWB, UWB Tri-Notch, WLAN, WiMAX, Miniaturization.

1 Introduction

Coplanar Waveguide (CPW) fed Monopole antennas have been extensively used for the design of wireless ultrawide band (UWB) communication systems due to their specific advantages of low cost, simple structure and omnidirectional radiation pattern. As the FCC allocated the frequency spectrum of 3.110.6 GHz for UWB Communication applications, 3.1 to 10.6 the design of UWB antennas has been major research topic among the researchers [1].

There are several important challenges that need to overcome while designing an UWB antenna, such as miniature size, acceptable gain, wide impedance bandwidth, stable and advantageous radiation pattern and interferences due to other existing technologies. As 3.3 to 3.6 GHz frequency band has been allocated for worldwide interoperability for microwave access (WiMAX) and 56 GHz frequency band has been reserved for wireless local area network (WLAN). So frequency band rejection capabilities in UWB system are required in order to eliminate this electromagnetic interference.

To obtain band rejection capabilities filters may also be used, but it increases the complexity as well as size of the system. Therefore, UWB antenna with band rejection capabilities is the most suitable and economic solution of this problem. Various antennas with band rejection capabilities have been proposed in the literature [2,3,4,5,6] The common practice to achieve band rejection capabilities is to etch different types of slots such as H-shaped, C-shaped, U-shaped in the radiating patch of UWB antenna [2,3,4,5] Several antenna having dual band rejection capabilities have been proposed in the literature [5,6].

In this paper, we firstly present a miniaturized reference UWB antenna. This antenna is fabricated on FR4 substrate with $\varepsilon_r = 5.4$. The total size of the antenna is $22 \times 13 \times 1.5 mm^3$, which makes it a good candidate for portable UWB communication applications. Measured and Simulated results show that the proposed antenna could cover the whole UWB frequency band from 3.1 to 10.6 GHz. Then a miniaturized UWB antenna with triple band rejection capabilities is successfully designed by etching three Complementary split rings resonators (CSRR) in the radiating patch. The simulated VSWR shows that this antenna could operate from 3.1 to 10.5 GHz with VSWR less than 2, except the rejected band at 3.3 to 3.6 GHz, 5.1-5.35 GHz and 5.7 to 5.95 GHz for filtering the WiMAX, Lower WLAN and Upper WLAN frequency bands respectively. Simulated radiation

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patterns and surface current distributions are also given, and stable radiation patterns could be observed. The table below shows the superiority of miniaturized UWB antenna over the proposed UWB antennas.

Table 1: Comparison between presented and recently reported UWB antennas.

Literature	Pass Band	Dimensions
[7]	3.5 to 12 GHz	28 mm × 24 mm × 1.6 mm
[8]	3 to 10.6 GHz	26 mm × 24 mm × 1.6 mm
[9]	1.08 to 27.4 GHz	124 mm × 120 mm × 1.5 mm
[10]	3.5 to 31.9 GHz	35 mm × 30 mm × 0.8 mm
[11]	3 to 11 GHz	30 mm × 36 mm × 1.5 mm
[12]	3.1 to 11.45 GHz	28 mm × 14.5 mm × 0.8 mm
[13]	3 to 11.2 GHz	44 mm × 49.5 mm × 1.5 mm
[14]	2.82 to 13.95 GHz	30 mm × 36 mm × 0.4 mm
[15]	3.1 to 11 GHz	32 mm × 28 mm × 1.5 mm
This Paper	3.1 to 20 GHz	22 mm × 13 mm × 1.5 mm

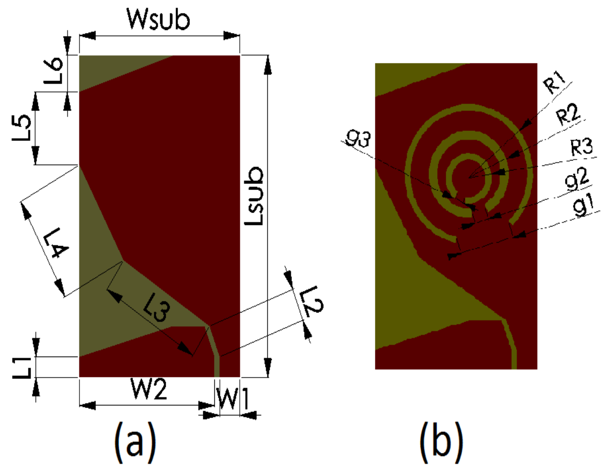

Fig 1. Geometry of the proposed antennas
(a) Miniaturized Reference UWB Antenna (3.1-10.6 GHz) (b) Miniaturized proposed triple notch UWB Antenna

2 DISCUSSION ON GEOMETRICAL STRUCTURE AND SIMULATION RESULTS

The geometry of the miniaturized UWB band-notch antenna is given in Fig.1, and the parameters are optimized using CST and HFSS. The antenna is fabricated on FR4 substrate with $\varepsilon_r = 5.4$ and the length and width of substrate is Lsub=22mm and Wsub=13mm respectively. Detailed dimensions of the antenna are W1=1.6mm, W2=10.2mm, L1=1.4mm, L2=2.1mm, L3=4.5mm, L4=6.5mm, L5=5mm, L6=2mm, g1=4.2mm, g2=1.2 mm, g3=0.7mm, R1=5.3mm, R2=3.3mm and R3=2mm. This antenna consists of a polygon radiation patch and a polygon ground. The Microstrip feed line is modified to have a tapered structure at the feeding point in order to improve impedance matching condition.

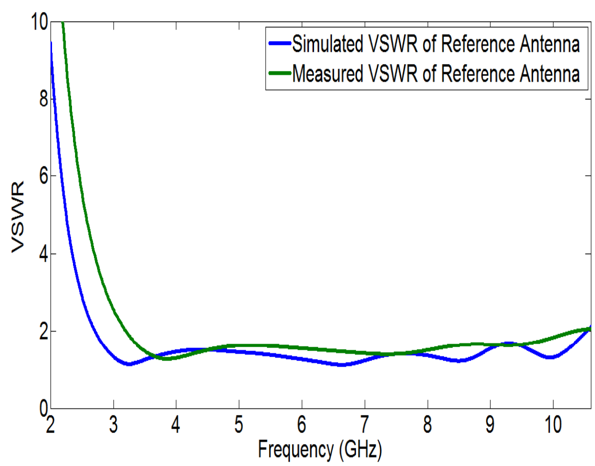

Fig 2. Simulated and Measured VSWR of Reference UWB Antenna

3 Reference Miniaturized UWB Antenna

First a Reference Miniaturized UWB antenna has been designed and fabricated. Simulation is done using CST Microwave studio suite. The antenna simulated shows that it covers the entire UWB band from 3.1-10.6 GHz. Agilent E8364B network analyser is used to obtain measured results. The Simulated and Measured results agree well as shown in Fig.2. The simulated and measured bandwidth is from 3.1 to 10.6 GHz. The discrepancy is mainly due to Connector Losses and hand-welding inaccuracy.

4 Miniaturized UWB Antenna with Triple Band Rejection

The Triple band-notch UWB antenna is presented in this section. The WLAN frequency band 5/6 GHz, which further comprises of Lower WLAN (5.15-5.35 GHz) and upper WLAN (5.725-5.825 GHz) is notched using the two inner split ring resonator while the WiMAX frequency band 3.3/3.6 GHz is notched using the outer split ring resonator. The results are acceptable and shows an improved Triple notch behavior as shown in Fig.3.

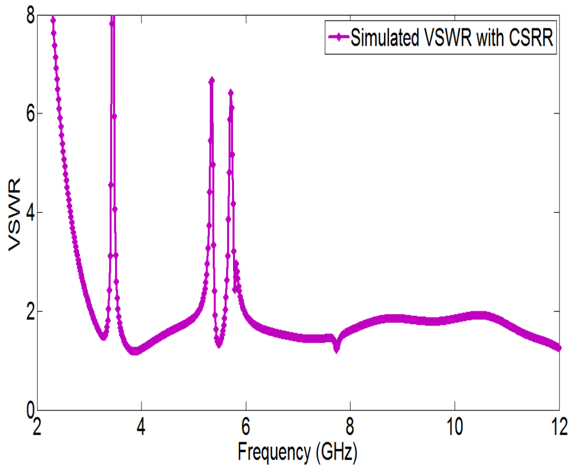

Fig 3. Simulated VSWR of Triple Band-Notch UWB Antenna

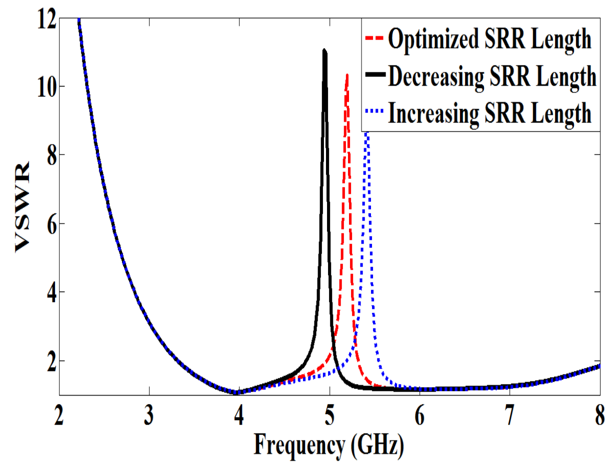

Fig 5. controlling mechanism for Lower WLAN band-notching

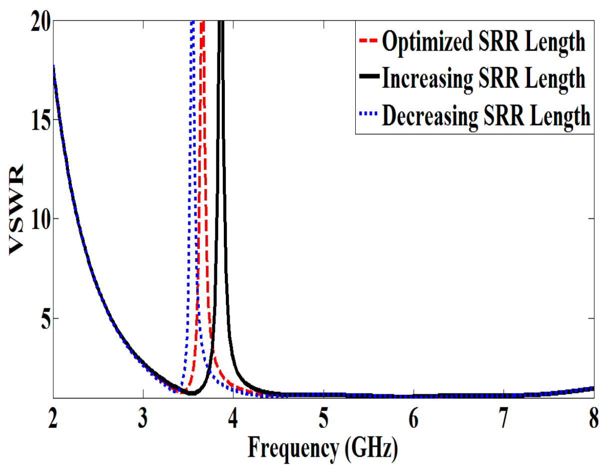

Fig 4. Controlling mechanism for WiMAX band-notching

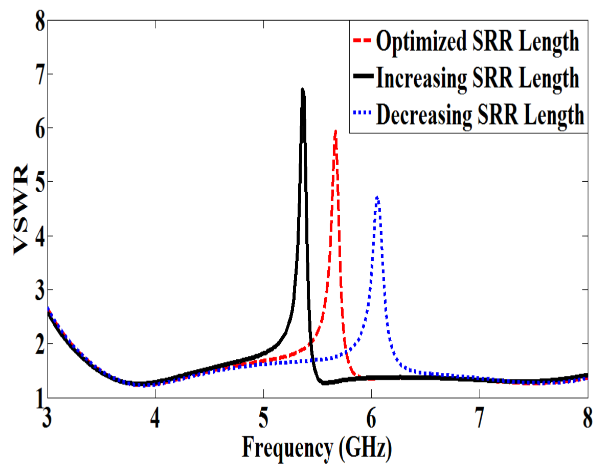

Fig 6. Controlling mechanism for Upper WLAN band-notching

5 Controlling Mechanism for Band-Notching

The optimization of triple notching is done by simulating the antenna at different slot radius of the rings. By increasing radius of the rings actually increases the length of the slot which in turn shift the notch towards the lower frequencies. Similarly by decreasing radius decreases length of the rings which in turn shift the notch towards the high frequencies. The controlling of notch bands for WiMAX, Lower WLAN and Upper WLAN frequency bands is shown in Fig. 4, 5 and 6 respectively.

6 Surface Current distributions

Fig.7. shows the simulated current distributions on the surface of the proposed antenna at 3.5, 5.25, 5.75, and 8.5GHz. At 8.5 GHz the current flows along the Microstrip feed line, while low current densities around the slot. On the other hand, the surface current distribution on the antenna at 3.5, 5.25 and 5.75 GHz is concentrated around the complementary split ring resonators (CSRR) which shows that complete electromagnetic energy is concentrated around the slots.

7 Radiation Pattern

The simulated Far field radiation pattern of the proposed antenna at different frequencies is shown in Fig.8. Also the gain plot of the proposed antenna is shown in Fig.9. The gain plot further reveals that gain is supressed well in the WiMAX and WLAN bands.

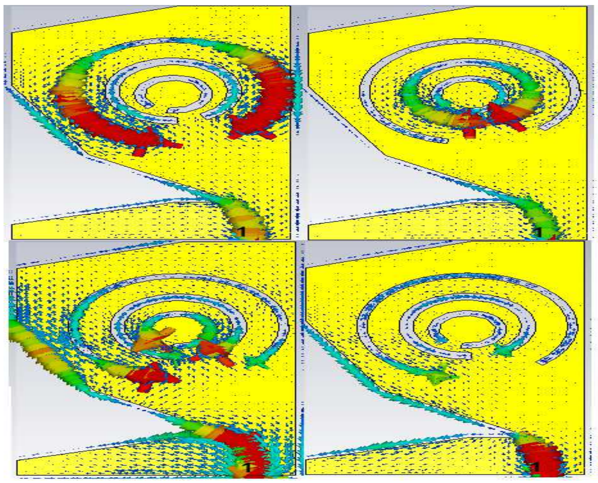

Fig 7. Surface Current Distributions at: (a) 3.5 GHz (b) 5.25 GHz (c) 5.75 GHz (d) 8.5 GHz

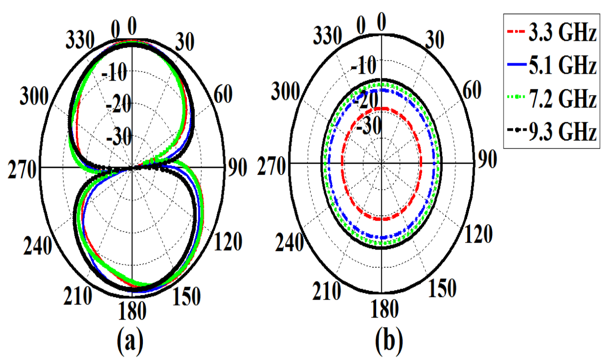

Fig 8. Simulated Radiation patterns: 3.3 GHz; 4.5 GHz; 6.5 GHz; 9.5 GHz

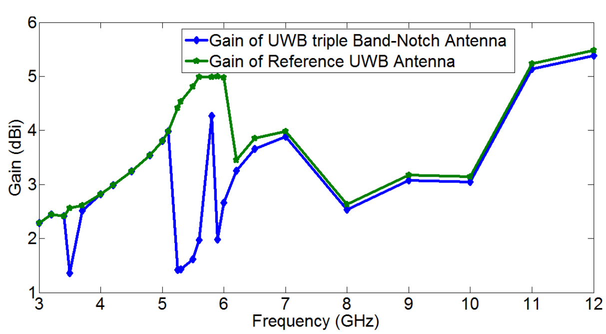

Fig 9. Gain of UWB antenna with and with out notch

8 Conclusion

In this paper, a miniaturized CPW fed ultra-wideband antenna has been presented. The potential interference between the UWB system WiMAX and WLAN bands has been mitigated by introducing CSRR in the radiating patch. The antenna results has been analysed showing good stable gain except at the notch frequencies. The antenna provides best matching and low VSWR in the frequency band from 3 to 10.6 GHz with a band-rejection capabilities at 3.3-3.6 GHz, 5.15-5.35 GHz and 5.7-5.95 GHz. The antenna has a very compact size of $22 \times 13 \times 1.5mm^3$ which makes them to use it in the portable UWB devices without causing electromagnetic interference.

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