Compact Triple band Notch Ultra Wide band (UWB) Antenna

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Abstract : This paper consists of a compact triple -notch band antenna system for ultra-wideband (UWB) applications so as to suppress undesired signals of conventional narrow band communication technologies. The notch bands are WiMAX (3.3–3.8 GHz), WLAN (5.1–5.825 GHz), and X -band downlink satellite communication systems (7.25–7.75 GHz). Two complentary split ring resonators slots are introduced to achieve the notches at WLAN and X-band downlink. The third notch is obtained by introducing a stub on the radiating patch to obtain a notch at WiMAX band. The size of the overall antenna is 20 × 30 mm^2 .The results obtained show that the proposed antenna is a good candidate for UWB applications. The proposed antenna operates over the entire UWB frequency band of (*3.1-10.6 GHz*).

IndexTerms – **Stubs, Notch bands, UWB antenna**

I. INTRODUCTION

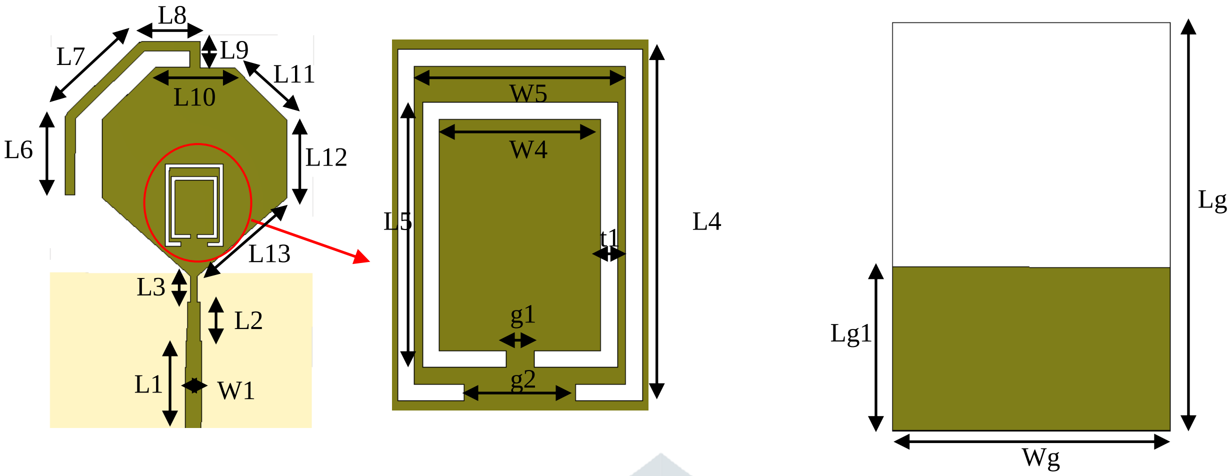
In recent years, UWB systems are gaining huge interest because of various applications in the fields of medical, health monitoring, entertainment, and remote sensing systems. UWB technology provides high data rates, low power spectral density, large bandwidth, and robustness to multipath fading. Various broadband antennas for UWB applications using wide variety of antenna configurations are used [1]–[6]. UWB is an unlicensed frequency band, as declared by the Federal Communication Commission (FCC), in frequency range from 3.1–10.6 GHz [7]. Ultra-wideband (UWB) technology became the potential candidate in the race of the wireless world. By utilizing this band of frequency, personal networks can be setup to control different devices within the home or office. The power levels needed for UWB are lower than those for mobile phones, which is a great advantage so far as mobility and battery life is concerned. It can also carry a huge amount of data potential bandwidth is quoted in hundreds of mega bits per second, making it a lot faster than Bluetooth at 2 Mbit/s, and the latest 54 Mbit/s Wi-Fi standards. Security is less of a problem with UWB as the short pulses are difficult to intercept, but range remains an issue. Signals can travel only small distances of the order of 10 to 20 meters. With the rapid development of wireless communications, the requirement of compact and planar UWB antennas is gaining huge interest due to various features such as low cost, simple structure, ease of fabrication, wide bandwidth, and omnidirectional radiation pattern [8].

In previous years, various techniques have been presented to introduce the notch bands in UWB antennas. The easiest method to introduce by etching suitable structures on the radiating patch or ground plane [9]–[20]. In [21], a cpw fed UWB antenna integrated with stub loaded meander line resonator is proposed to achieve the triple notch bands. In [22] stubs and slots in the radiating patch and parasitic stubs in the ground palne to achieve three notch bands. Another method is the insertion of resonator structures (such as split ring resonators) to create notch bands[23]–[24]. In addition, notch bands can be obtained by embedding slots and stubs in feed line [25]. In [26], a triple notch band UWB antenna (22mm×18mm) is designed with good performance characteristics and occupies area of 396mm2 which is larger in size and not recommended for most of the portable wireless communication systems.

In this paper a microstrip fed printed antenna is proposed. It is printed on dielectric substrate (GML 1000 lossy) with dielectric constant 3.2. The impedance of the microstrip line is 50 Ω. The main parameters affecting the antenna operation are analyzed in CST Microwave Studio software. The proposed antenna has a size of 20×30 =600 mm^2.

II. ANTENNA DESIGN

The proposed antenna is designed using CST Microwave Studio Software. The antenna is designed on substrate GML 1000 with thickness of 0.508mm and dielectric permittivity, ε_r of *3.2*, loss tangent tanδ =0 .004 and thickness h =0.508 mm. The design of band notched ultra-wideband is starts with the heptagonal monopole structure shown in Fig. 1. The optimized length of the feed line is L1 + L2 + L3 = 12mm, and the width (W1 =1.2 mm) of the 50-Ω feed line for the material is calculated using [10]. In order to get a wide impedance bandwidth for the entire UWB band, a stepped feed line is introduced. The optimized dimensions of the step feeds are L1×W1, L2×W2 and L3×W3. In order to suppress the interference, complementary split ring resonators (CSRR) are inserted on the surface of the heptagonal radiator along with a stub as shown in Fig. 1(a) so as to achieve notches at the desired frequency bands [11]. The dimensions of the two rectangular CSRR are indicated in Fig. 1.The inserted CSRRs and the stub does not affect the impedance bandwidth performance other than creating notch bands. The widths of metallic contact for the inner and outer rings are g1=0.7mm, g2 =2mm. The magnitude of S_{11} plot for the proposed antenna element is shown in Fig. 2. The surface current distributions with CSRR are demonstrated at various frequencies(3.1 GHz, 3.5 GHz, 5.5 GHz, 7.5 GHz) are shown in Figs.3-5. It is observed that with CSRR and stub, the surface current is strongly concentrated around the rings and stub for the respective notch bands. Therefore, at the notch bands frequencies the effect of radiation is very weak, resulting in creation of notches around desired frequency bands. The dimensions of the proposed single antenna element, which is shown in Fig. 2(a), are as follows: Lg = 30mm, Wg = 20mm, Lg1 = 12.2mm , L1 = 7mm, L2 = 3mm, L3 = 2mm, W1=1.2mm, W2 =1mm, W3 = 0.52mm, L4=6.3mm, L5=4.75mm L6 = 6mm, L7 =7 .53mm, L8 =4.375mm, L9 = 2mm, L10 =6mm, L11 =5.65mm, L12 = 6mm, L13 = 9.02mm,W4=3.5mmW5=3.8mm,t1=0.3mm g1 =0 .5mm and g2 =2 mm.



(a) (b)

Figure 1. Antenna Configuration (a) Front Side (b) Back Side of MIMO antenna

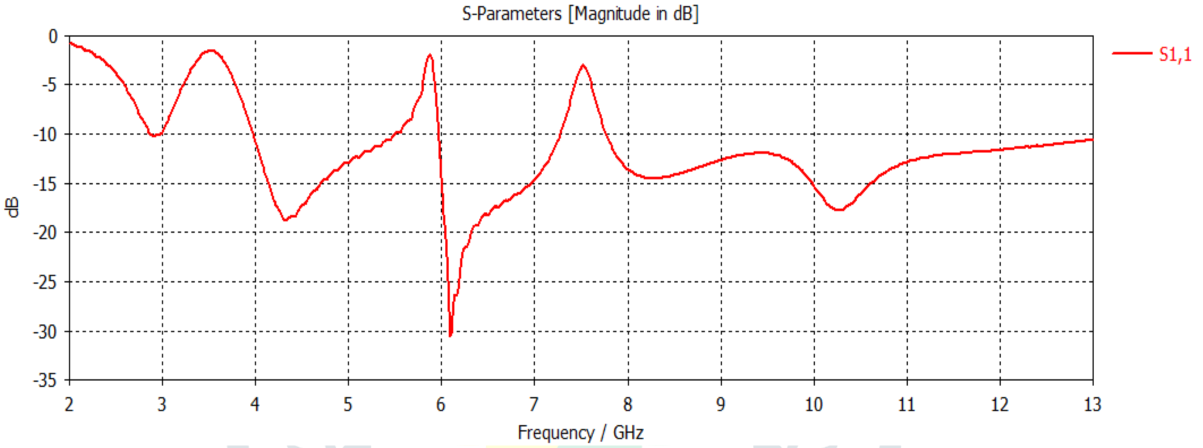


Figure 2. Reflection coefficient plot for the proposed antenna.

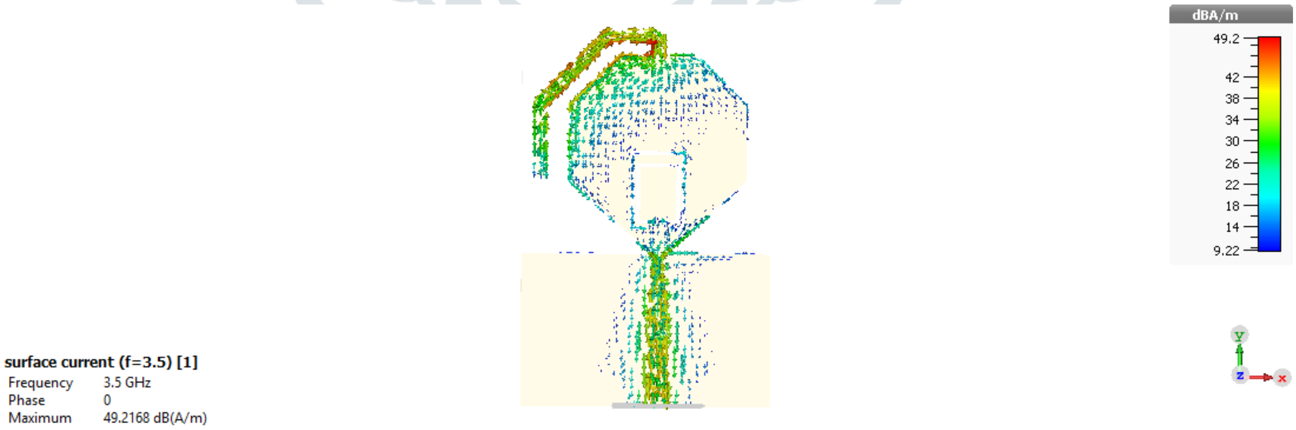


Figure 3. Current distributions on proposed antenna at 3.5 GHz.

Figure 4. Current distributions on proposed antenna at 5.8 GHz.

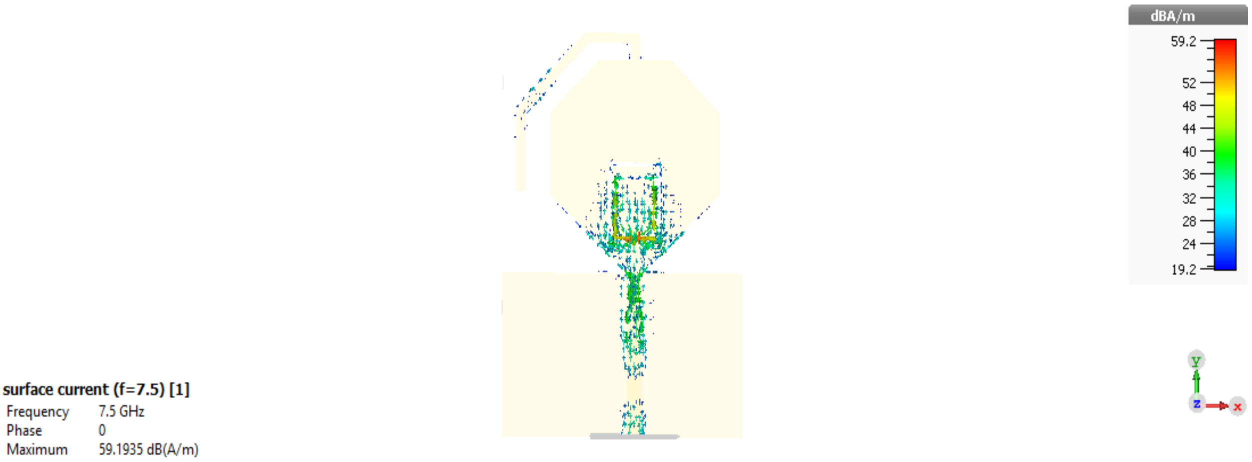


Figure 5. Current distributions on proposed antenna at 7.5 GHz.

III. RESULTS AND DISCUSSION

A. REFLECTION COEFFICIENT

The simulated refection coefficient (obtained using CST software) is shown in Fig. 2. The plot shows a wide impedance bandwidth from 2.85 GHz to 13GHz with rejection in the WiMAX band from 3.3–3.8 GHz, WLAN band from 5.2–6.1 GHz and X band satellite communications from 7.3–8.2 GHz.

B. GAIN AND RADIATION EFFICIENCY

This antenna exhibits stable radiation patterns throughout UWB range as demonstrated in Fig. 6-8. Fig. 9 and Fig.10 show gain and efficiency values as a function of frequency respectively. However, the proposed antenna maintains stable gain at pass band frequencies. This antenna exhibits a maximum gain of 5 dB. A significant gain reduction is observed at notch band frequencies. Efficiency values are mainly depending on impedance matching between the antenna element and feed line. Impedance mismatch leads to lower efficiency values. The proposed antenna structure exhibits adequate radiation efficiency in pass band frequencies and very low radiation efficiency in notch band frequencies. The pass band efficiency values are sufficient for satisfactory transmission and reception of signals

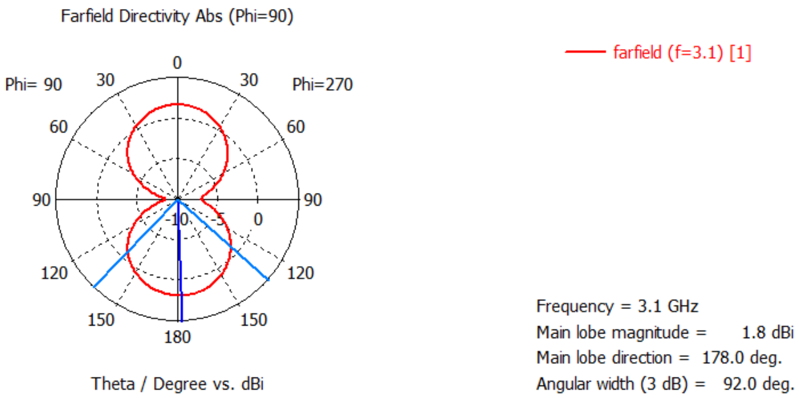


Figure 6. Radiation pattern of proposed antenna at 3.1 GHz.

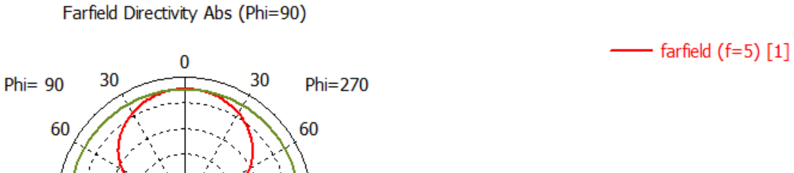


Figure 7. Radiation pattern of proposed antenna at 5 GHz.

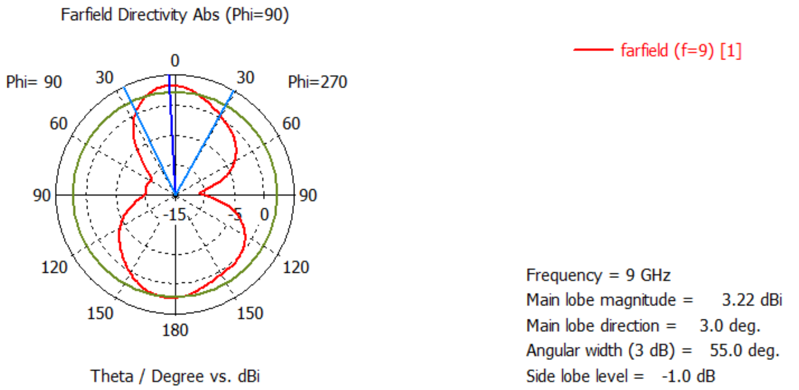


Figure 8. Radiation pattern of proposed antenna at 9 GHz.

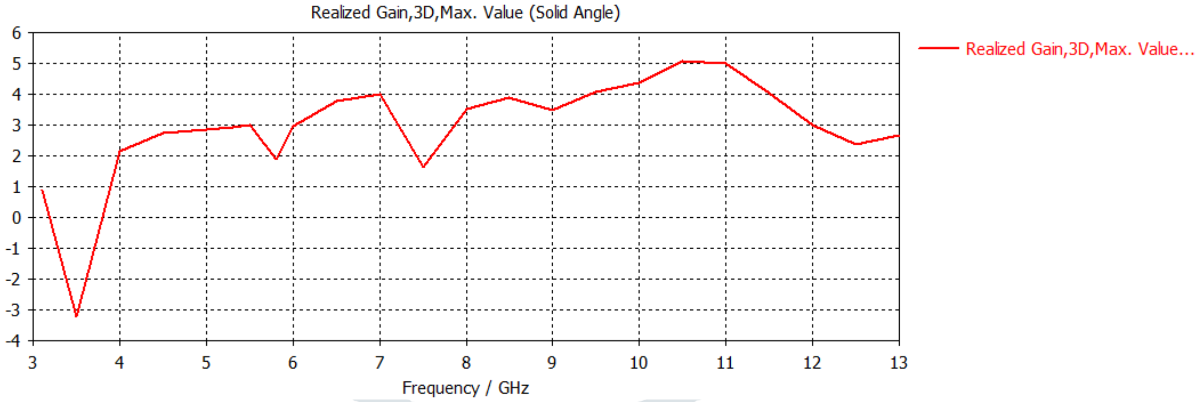


Figure 9. Gain of the proposed antenna.

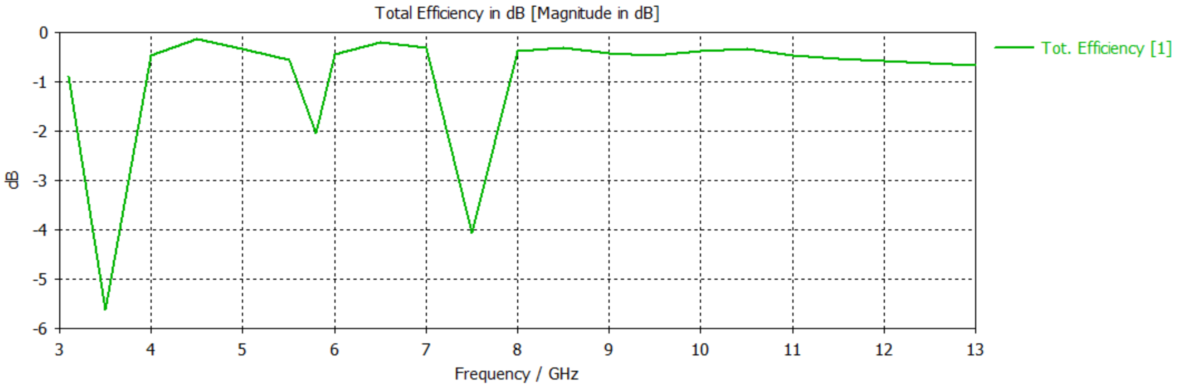


Figure 10. Radiation efficiency of the proposed antenna.

IV. CONCLUSION

A compact UWB antenna with triple band-notched characteristics to avoid the interference from existing WiMAX, WLAN and X band satellite communication channels. The simulated and measured −10 dB impedance bandwidths exhibit UWB frequency operation from 2.85–13 GHz with notch bands at WiMAX (3.3–3.8 GHz), WLAN (5.2–6.1 GHz), and X band satellite communications (7.3–8.2 GHz). Two notch bands are created with complementary split ring resonators and the third notch is created using a stub without deteriorating the impedance bandwidth. The proposed antenna can be a good candidate for UWB wireless applications due to its compact size and stable radiation patterns.

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