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Compact concentric ring shaped antenna for ultra wide band applications

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Abstract. A novel antenna for compact size, simple structure suitable for low cost fabrication is proposed for UWB application. A compact ring shaped monopole antenna is designed to cover the entire ultra wide bandwidth which has straight forward printed circuit board integration. The dimensions of the antenna are 16mm × 12mm × 0.787mm. More specifically, the impedance matching of the antenna is improved by employment of the tapered microstrip feed line. The measurement and simulation results show that the proposed antenna achieves good impedance bandwidth from 6.5 GHz to 25 GHz which covers the entire UWB. The antenna also has a gain approximately 2.5dBi from 6 GHz to 22 GHz. Compared to the existing UWB antennas, the presented modified structure has the smallest size, the widest bandwidth and better return loss characteristics.

1. Introduction

Ultra-wideband (also known as UWB, ultra-wide band and ultra band) is a radio technology pioneered by robert a. scholtz. The federal communications commission (FCC) and the international telecommunication union radio communication sector (ITU-R) currently define UWB when signal bandwidth exceeds 20% of the centre frequency.UWB technology has been widely used in radar and portable devices (like cell phone and laptop etc.), wireless body area network (WBAN) as well as a wireless personal area network (WPAN) applications. The major challenges in design of UWB antenna are low profile, compact size, good impedance matching and stable omni-directional radiation pattern.

In recent years several UWB antennas have been reported, such as a compact size rectangular patch with centre slot and three via holes which gives a constant gain and stable radiation patterns over the frequency range 2.0 to 12.0 GHz [1]. Lin, S. explained a semi-circle monopole antenna to have a omni-directional characteristic in H-plane [2]. A novel planar triangular monopole antenna (PTMA) is presented by Lin, C.C. which has impedance bandwidth up to about 4:1 [3]. And finally a compact ultra-wideband annular ring antenna is designed with band notch characteristics for wireless local area network (WLAN) and dedicated short-range communication (DSRC) [4]. But few UWB antennas have a structural complexity i.e. the radiators is etched on a substrate and placed vertically 0.5mm above the ground plane [5], which is difficult to integrate in UWB electronics. In the above mentioned

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antennas the feeding techniques employed are coplanar waveguide, simple microstrip line and slotted structures.

Day by day, demands of UWB antenna have been increasing gradually; due to improved performances, higher bit rate transmission speeds and there may be need for new and future UWB wireless scheme. In this paper, another promising bandwidth enhancement technique of using a concentric ring shaped monopole antenna is presented. The proposed antenna has improved performance when compared with some recently reported UWB monopole antennas from open literatures [3, 4][6–10].

2. Antenna Design

The printed planar monopole antennas have been widely used in wireless communication devices. They are very popular for volume limited and wideband applications. The topology of the presented antenna composed of a tapered microstrip feed line and a concentric ring shape monopole. The annular ring resonates more than one mode by which the bandwidth of antenna is increase. It is implemented using rogers RT/duroid 5880 board material, which has relative permittivity $\varepsilon_r = 2.2$, height 0.787mm. The top and side views of the presented antenna are shown in figure 1. The antenna overall size is 16mm × 12mm × 0.787mm and to improve impedance matching, it is necessary to transform the impedance of the input feeding microstrip line (50Ω) to the input impedance (100Ω) of the transition.

The original UWB antenna operating at higher frequencies for the simple microstrip feed line is generally limited to around 10 GHz. Here, using tapered microstrip feed line with proper parameters instead of simple feed line, there is an improvement in impedance matching and the impedance bandwidth of the presented antenna can be extended up to 25 GHz. Different kind of feeding techniques are available, but the presented tapered microstrip line configuration offered a simple and very low cost solution for the UWB antenna designs, while also offering good performance values in terms of 50 Ω impedance matching. Using parametric study, the dimension of the tapered microstrip line are optimized, while maintaining the width of the input feed line, the concentric ring monopole, and the characteristics of the utilized substrate.

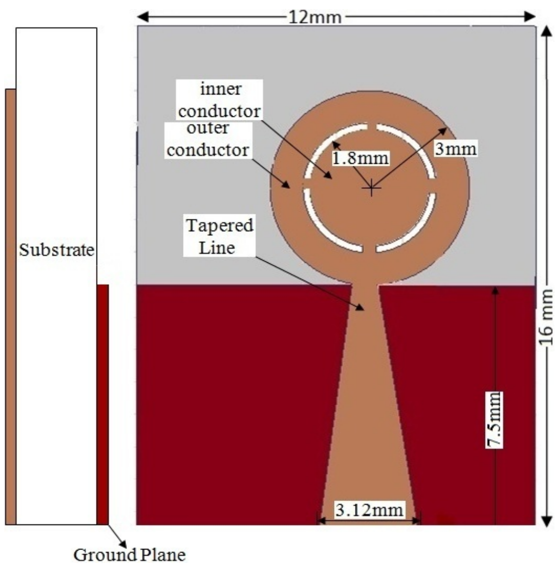


Figure 1. Geometry of the monopole antenna.

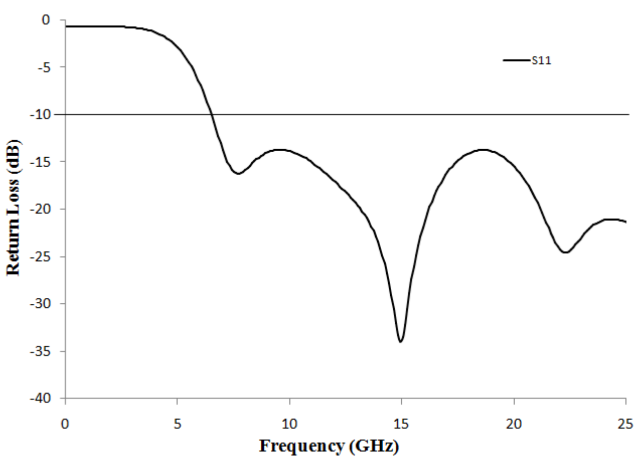


Figure 2. Simulated return loss of the antenna.

3. Result and Discussion

The simulation of the proposed antenna and optimization was done by using the high frequency structure simulator (HFSS) version 15. The simulated return loss of the presented antenna exhibits a wideband performance from 6.5 GHz to beyond 25 GHz for $S_{11} < -10$ dB is shown in figure 2. The photograph of the fabricated original antenna for front and back side is shown in Figure 4 and figure 5 respectively. The return loss of the antenna is measured from 1 to 13.5 GHz as shown in figure 6. The measured result shows good agreement with simulation results. The simulated radiation pattern for the monopole antenna is shown in figure 3 at 15 GHz, 20 GHz. Nearly good omni-directional patterns have been observed in H-plane, and the patterns in the E-plane are close to bidirectional for both 15GHz and 20GHz. The antenna has a gain of 2 to 2.9 dBi from 6 to 22 GHz as shown in figure 7. Better antenna performances for practical applications can be attained as a RT/duroid 5880 substrate is used for fabricating the antenna. Because of its low dissipation factor of RT/duroid 5880 performance is extended to Ku-band and above.

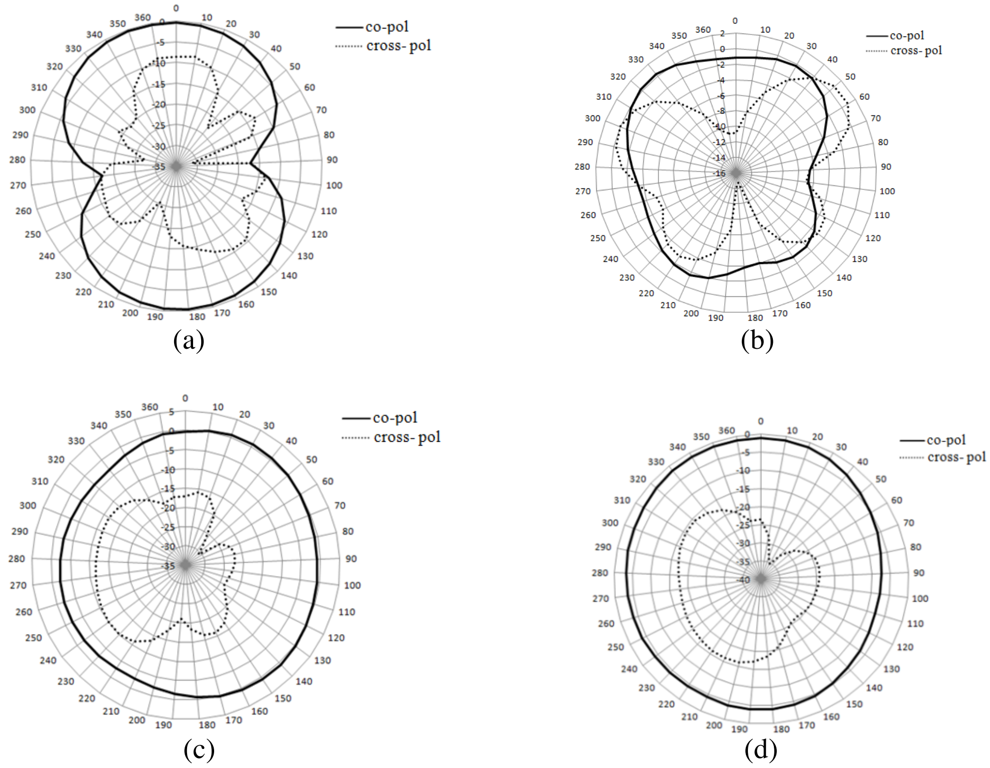


Figure 3. Simulated E-plane radiation patterns of the UWB antenna at (a) 15GHz, (b) 20GHz. And H-plane radiation pattern at (a) 15GHz, (b) 20GHz.

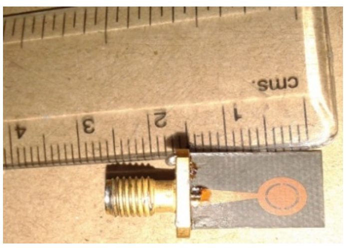


Figure 4. Fabricated front side of the antenna

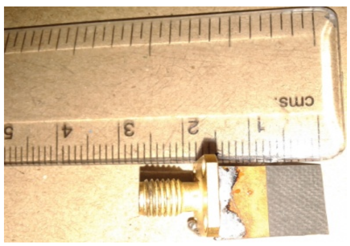
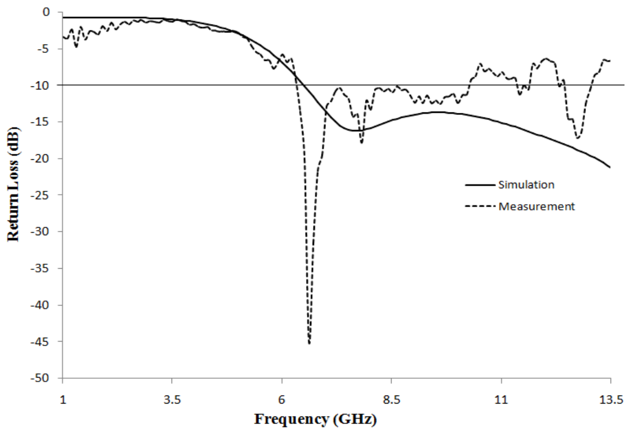


Figure 5. Fabricated back side of the antenna



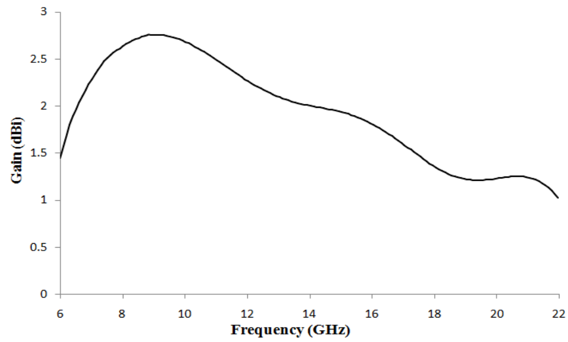


Figure 6. Measured and simulated return loss of the antenna. **Figure 7.** Simulated gain in E-plane.

4. Conclusion

A UWB monopole antenna with very compact size and extremely wide band from 6.5 GHz to beyond 50 GHz is presented in this paper. Concentric ring shape and tapered microstrip feed line are employed for size reduction and band enhancement, respectively. Therefore, the presented antenna has smaller size and wider band compared with existing antennas. Furthermore, the simulated and measure results indicate that the presented antennas also have simple structure, acceptable radiation patterns and these advantages make the antenna a suitable candidate for practical UWB applications.

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