Design and Analysis of Ring Shaped UWB Microstrip Patch Antenna with Coplanar Waveguide Fed

Radwan Abdulhadi Elbasir[1], Anil Kumar[2]

[1]Sam Higginbottom University of Agriculture, Technology and Sciences, Communication Dept., Allahabad, India

[2]Sam Higginbottom University of Agriculture, Technology and Sciences., Allahabad, India

Abstract: ***A compact ultawideband antenna (UWB) is presented here with ring shaped structure consisting of triangular shaped patch in centre of ring. The antenna is fabricated onto Rogers R03003 substrate with an overall dimension of 47X47 mm. The substrate has dielectric constant of 3 and thickness of 1.6mm. The antenna is fed by a coplanar waveguide in order to have low radiation loss and impedance match. The simulated experiment shows that the proposed antenna achieves good impedance matching over an operating bandwidth of 2.2–2.7 GHz (20%) and 3.2-15 GHz (129.67%) that covers the entire UWB band. Its gain varies between 1.5 to 3 dBi for most of the frequency band. This makes the proposed antenna suitable for being used in UWB communication applications.***

Keywords: Ultra-wide band antenna, Waveguide fed, Microstrip patch antenna, Microwave

1. Introduction

Over the years there has been a huge demand of high data rate application, thus it given boost to design of ultra-wideband (UWB) antenna. This has few good characteristics like low cost, low complexity, low spectral power density, high data resolution, very low interference, and extremely high data transmission rates [1]. For different wireless communication applications, a UWB antenna must be small in dimension and inexpensive without degrading the performance. Stable omni directional radiation patterns, gain flatness, and linear phase variation are few requirements for UWB applications [2]. Designing of an efficient and low-profile UWB antenna to match these applications is still a major challenge. Apart from this one serious limitation of the microstrip antenna was its narrow bandwidth characteristics, being 15 to 50% that of commonly used antenna elements such as dipoles, slots, and waveguides horns [3]. This limitation was successfully removed by achieving a required matching impedance bandwidth ratio, for that it was necessary to increase the size, height, volume or feeding and matching techniques [4]. Recently many authors have published many paper which cover wideband and given many technique to achieve ultra-wideband. [5-10]

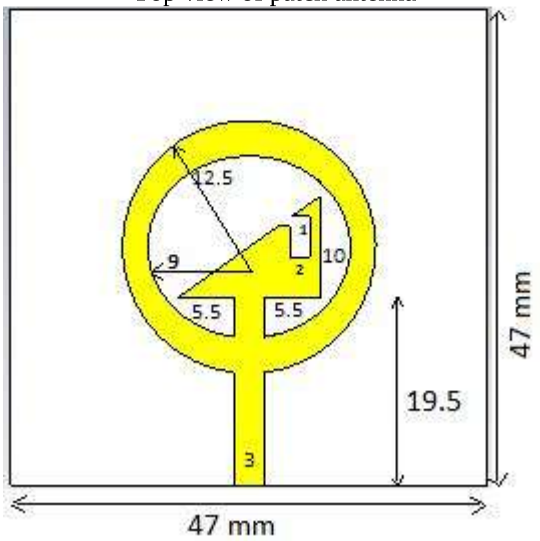
UWB have wide applications in short range and high speed wireless systems, such as ground penetrating radars, medical imaging system, high data rate wireless local area networks (WLAN), communication systems for military and short pulse radars for automotive even or robotics. The antenna is one of the crucial components, which determines the performance of UWB system.

Generally, UWB communication antennas require low voltage standing wave ratio (VSWR<2), constant phase center, constant group delay, and constant gain over entire operating frequency band. In this paper, an UWB patch antenna has been proposed with optimized dimensions which give good return loss, VSWR, gain, and desired bandwidth. The antenna consists of a circular ring patch and circular wide slot cut in the Centre. In the Centre another patch with the triangular patch has been to provide larger bandwidth. The antenna is fed with 50Ω microstrip line through coplanar waveguide structure. This antenna is design in such way that it can be fit in most of wireless device therefore it is easy to integrate with microwave circuitry for low manufacturing cost. In recent years coplanar waveguide fed antennas are being extensively investigated. The coplanar waveguide, compared with the microstrip line, has advantages such as low radiation loss, less dispersion, uniplanar configuration and easy mounting of shunt lumped elements or active devices. Optimum dimensions of the antenna are obtained by simulating the design in CST. The Section II of this paper describes the antenna design. The computer simulation results are presented in section III. Finally, the paper is concluded in Section IV.

2. Antenna Design

The proposed design of UWB antenna is simple and compact that introduces low distortions with impedance bandwidth of 20% for first band (2.2-2.7 GHz) and impedance bandwidth of 129.67% for second frequency band (3.2-15 GHz). The geometry and configuration of the proposed antenna is shown in Fig.1. The antenna consists of a Circular ring with wide slot in centre. In the centre of wide slot a triangular patch is there which provide wideband. In triangular patch inverted shaped slot has been cut, this has been in order to increase electrical path. on the back side antenna consists of rectangular patch which serve as ground plane. The entire antenna structure was designed on Rogers RO3003 (tm) substrate with dielectric constant of 3 and thickness of 1.6 mm. Roger RO3003 is chosen for dielectric material as it is performance sensitive and it offer superior high frequency performance with low cost fabrication. Front design of antenna consists of circular ring with outer ring having radius of 12.5 mm. whereas the inner ring is ellipse with vertical axis on 20mm and horizontal axis of 18mm. The outer ring radius dimension is chosen in order to get resonance around 3.5 GHz. Whereas inner ellipse dimension is chosen in such way to give resonance around 5.2 GHz. Apart from this a triangular patch is made in centre of ring which has a perimeter of around 48mm with inverted L Shaped slot cut. This particular design is made in order to multiple electrical patch and give better impedance match over wide frequency. Back design consist of the ground plane with 47x10.5 mm of rectangular patch, this ground plane dimension have seen selected after number of trials in simulation software to get better impedance match in desired frequency band. It is to be noted that all the dimension shown in figure 1.

Top view of patch antenna



Bottom view of patch antenna

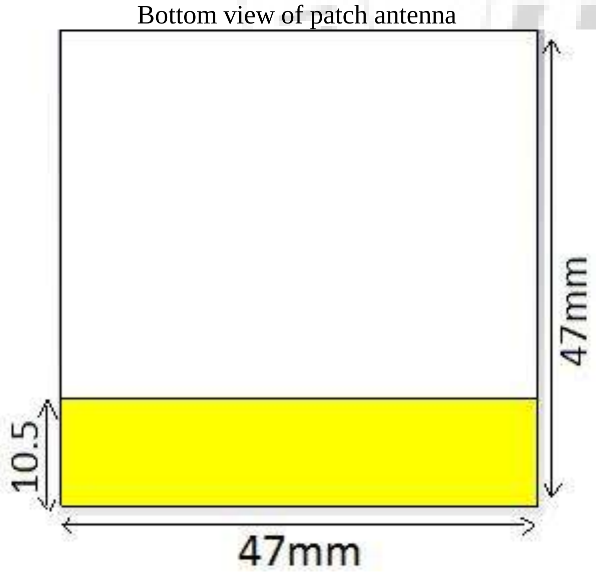


Figure 1: Geometry of antenna

3. Result and Discussion

All the result used in this paper are simulated results of CST microwave Studio. To check the accuracy of the result of the simulation the same antenna structure was simulated in HFSS simulation software also, and its results were almost same to the CST result. Antenna geometry is shown is shown in Fig 1.While its results are shown in Fig.2-5.

The overall goal of the proposed antenna design is to achieve good return loss below -10 dB. Suitable antenna geometry is needed for this purpose. The proposed UWB antenna shows the simulated operating frequency band of 2.2-2.7 GHz, and 3.2-15 GHz by implementing the optimum dimensions of the CPW feed and the circular shaped slot in center of circular patch. Also a triangular shape patch has been made in centre of slot to get furtherer improvement in bandwidth. Fig. 2 shows the simulated return loss of the patch antenna, which is showing good matching at large bandwidth. The first band is of 0.5 GHz with maximum return loss of -27dB at 2.4 GHz and second band is of 11.8 GHz with maximum return loss of -22 dB at 8.5 GHz. Fig. 3 shows the VSWR magnitude of the antenna which is below 2 for the entire UWB band

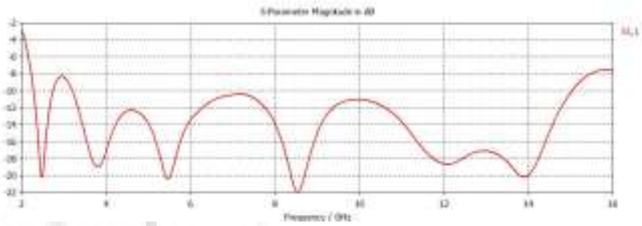


Figure.2. Simulated S11 proposed antenna.

Fig. 3 shows the simulated result of VSWR against frequency (GHz). The VSWR of the antenna is closely related to the return loss. VSWR varies from 1 to 2 throughout the frequency region i.e. 2.2-2.7 GHz, and 3.2-15 GHz. From the Fig.3 it is clear the proposed antenna have indeed good return loss and VSWR for entire UWB band is below 2. Based on the simulated results, the proposed antenna exhibits good UWB characteristics and operates from 2.2 GHz-2.7GHz, and 3.2.-15 GHz, having impedance bandwidth of 20% and 129.67% respectively. It complies with the VSWR range from 1 to 2 throughout the impedance bandwidth.

Fig.4 shows the radiation pattern of antenna at 3.5 GHz, 5.7 GHz, 9 GHz and 12 GHz. From the figure it clear that radiation pattern of antenna is almost Omni directional for the most the frequency in the desired frequency band. At some frequency the radiation is not Omni directional this is because impedance match is function of frequency and it is very difficult maintain impedance match and desired radiation pattern. At specific frequency if radiation pattern is Omni directional then same

Antenna at higher frequency will not have the Omni-directional radiation pattern this because the wavelength for higher frequency have changed. Well in this proposed design we try to maintain Omni directional pattern for the most of frequency. Since UWB antenna are used in home and industry where prime requirement is Omni directional pattern. In this design triangular patch were introduced within circular ring patch to provide better bandwidth. Apart from this inverted L shaped slot was cut in triangular patch to different electrical path within antenna. So that it can resonate at different frequency with desired radiation pattern

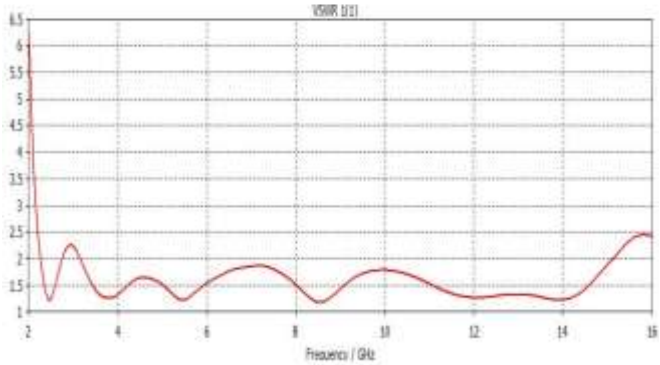
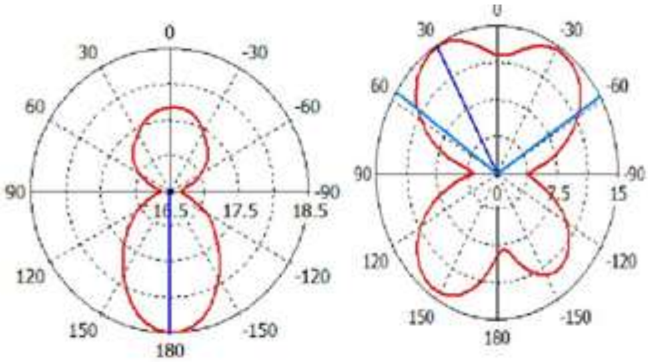


Figure 3: Simulated VSWR of proposed antenna



9 GHz **12GHz**

Figure 4: Simulated radiation pattern of antenna at 3.5 GHz, 5.7 GHZ, 9 GHz and 12 GHz.

Fig 5. Shows gain of proposed antenna. From the figure it is clear that gain of antenna varies between 1.5 to 3dBi for the most of frequency. With maximum gain is of 4 Dbi at 9 GHz.

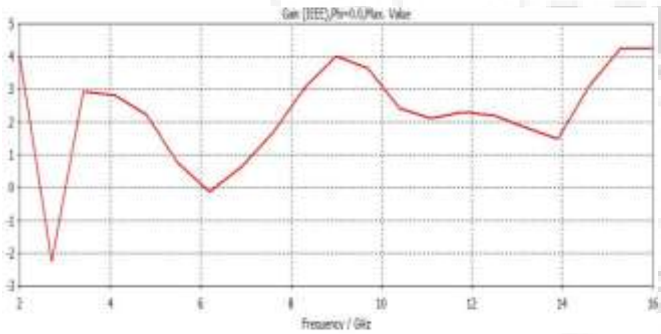


Figure 5: Simulated gain of proposed antenna

4. Conclusion

A coplanar waveguide fed micro strip UWB patch antenna is presented in this paper. Simulation of the antenna structure was done in CST. All the simulation results show that antenna structure is good for UWB application. It has good return loss of -20 dB at 2.4 GHz and -22dB at 8.5 GHz .The dimension of antenna is 47×47×1.6 mm3.The stimulated results of the proposed antenna satisfy the 10-dB return-loss requirements for UWB as defined by the FCC. The proposed antenna structure is flat, small, and its design is simple and can be easily mounted and packaged with other microwave devices and circuits. The proposed UWB antenna structure can be used for futuristic UWB systems. Good coverage, stable transmission characteristics of this proposed antenna indicate that the proposed compact antenna is well suitable for integration into UWB portable devices. The proposed antenna fulfills the requirement of WiFi (2.4/5.2/5.8 GHz) and WiMax (2.5/3.5/5.5 GHz) The antenna can also be used in smart grid technology (11-18 GHz) and it can be used efficiently as Backhaul and Backbone transport for various applications such as SCADA. Further the antenna can also be used in European fixed satellite systems which have appreciable gain in 12-14 GHz band of frequencies. It is therefore possible to conclude that the presented antenna will prove advantageous in modern multi layered microwave circuits and cover entire UWB band application.

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