Ultra-wideband Antenna for WLAN, WiMAX and LTE Applications

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ABSTRACT
A compact ultra-wideband antenna (UWB) is presented in this paper for WLAN, WiMAX, LTE and Smart grid applications. The proposed antenna comprises a circular patch and rectangular slot in center of circular patch and apart from this it also consists of four small rectangular slots around circular patch to provide wideband. The antenna is fabricated onto Rogers R03003 substrate with an overall dimension of 47X47 mm^2. The substrate has dielectric constant of 3 and thickness of 1.6 mm. The simulated experiment shows that the proposed antenna achieves good impedance matching an operating bandwidth of 2.5–8.2 GHz (106.5%) and 10-15 GHz (40%) that covers the lower UWB and higher UWB band. Thus it covers WLAN 5.2/5.8 GHz band, WiMAX 2.5/3.5/5.5 GHz band and LTE 2.5-2.69 GHz band. The gain of this antenna varies between 2-3 dBi for most of the frequency band and therefore the proposed antenna is suitable for being used in UWB communication applications.

Keywords
Ultra-wideband antenna, WLAN, WiMAX, LTE and CST Microwave Studio.

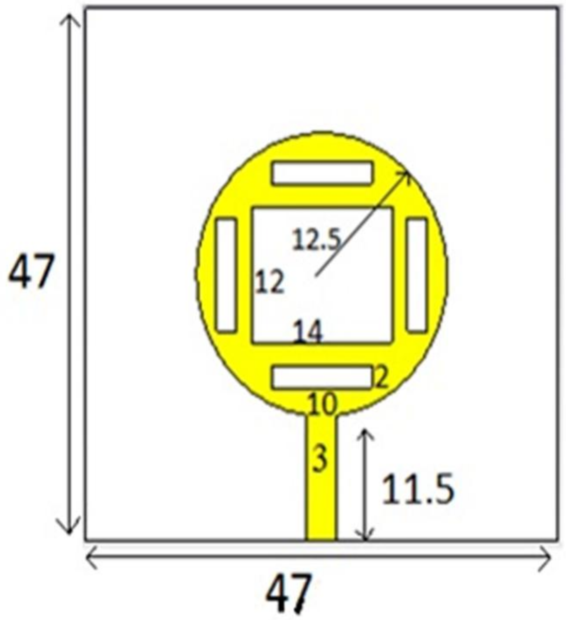
1. INTRODUCTION
Ultra-wideband (UWB) technology have attractive characteristics like low cost, low complexity, low spectral power density, high data resolution, very low interference, and extremely high data transmission rates which made it suitable for various wireless communications [1]. For different wireless communication applications, a UWB antenna must be electronically small and inexpensive without degrading the performance. Designing of an efficient and low-profile UWB antenna to match the applications such as stable Omni directional radiation patterns, gain flatness, and linear phase variation which are required to fulfill the demands of UWB 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 [2]. This limitation was successfully removed by achieving a required matching impedance bandwidth ratio and for that it was necessary to increase the size, height, volume or feeding and matching techniques [3]. Recently many research papers have been published which cover wideband and given many techniques to achieve ultra-wideband [4-9].

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 or robotics. The antenna is one of the crucial components, which determines the performance of UWB system [10].

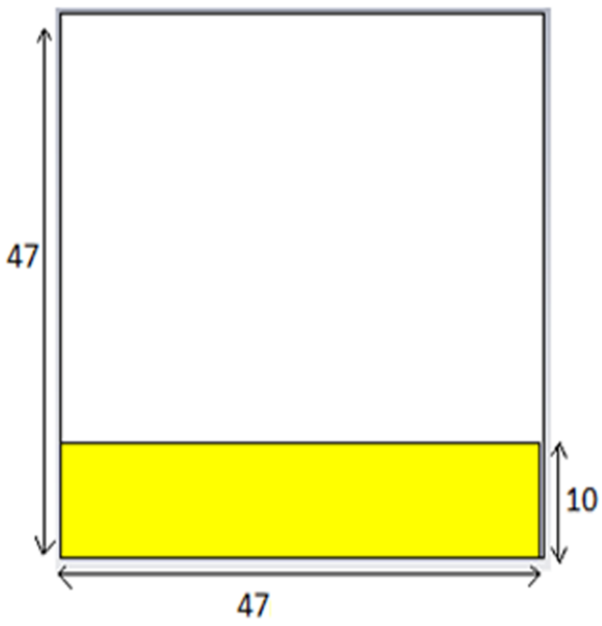
Generally, UWB communication antennas require low Voltage Standing Wave Ratio (VSWR<2), constant phase center, constant group delay, and constant gain over entire operating frequency band [11]. In this paper, an UWB patch antenna has been proposed with optimized dimensions which give good return loss, VSWR, gain, and desired bandwidth. The antenna consists of a circular patch and wide slot cut in the center of circular patch. The antenna is fed with 50 Ω microstrip line through coplanar waveguide structure. This antenna is easy to integrate with microwave circuitry for low manufacturing cost [12]. In recent years coplanar waveguide fed antennas are being extensively investigated [13-14]. 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 [15]. The design of antenna is simulated in CST Microwave Studio for obtaining the optimum dimensions of the antenna. The rest of the paper is organized as follows: Section 2 describes the antenna design, Computer Simulation Technology results are presented in section 3 and finally Section 4 concludes the paper.

2. ANTENNA DESIGN
The proposed design of UWB antenna is simple and compact that introduces low distortions with impedance bandwidth of 106.6% for first band (2.5-8.2 GHz) and impedance bandwidth of 40% for second frequency band (10-15 GHz). The geometric configuration of the proposed antenna is shown in figure 1. The antenna consists of a circular patch with wide slot in centre of the patch on one side of antenna substrate where it consists of rectangular patch in ground plane on other side of substrate. The entire antenna structure was designed on Rogers RO3003 substrate with dielectric constant of 3 and thickness of 1.6 mm. Rogers RO3003 is chosen for dielectric material as it is performance sensitive and it offer superior high frequency performance with low

cost fabrication. The front design of the proposed antenna consists of circular patch with radius 12.5 mm. This dimension is chosen in order to get resonance around 3.5 GHz. Apart from this two type of slot is cut into circular patch first slot rectangular slot in the centre of patch with 52 mm of perimeter this provide resonance of antenna around 5.7 GHz.



Top view



Bottom view

Fig 1: Geometry of antenna

Other slot is around the bigger slot with perimeter of 24 mm this is to provide additional electrical path so that antenna can resonate at higher frequency. Back design consist of the ground plane with 47x10 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 dimensions shown in figure 1 is in mm.

Table 1. Dimensions of the Proposed Antenna

Substrate Length	47 mm
Substrate Width	47 mm
Substrate Thickness	1.6 mm
Circular Patch Radius	12.5 mm
Wide Rectangular Slot Length	12 mm
Wide Rectangular Slot Width	14 mm
Small Rectangular Slots Length	2 mm
Small Rectangular Slots Width	10 mm
Coplanar Waveguide Feed line Length	11.5 mm
Coplanar Waveguide Feed line Width	3 mm

3. RESULTS AND DISCUSSION

In this paper CST Microwave Studio is used for the design, simulation and analysis of the proposed antenna. Figure 2 shows the S_{11} parameter of the proposed antenna and it has good impedance match over two bands (2.5-8.2 GHz) and (10-15 GHz) with reflection coefficient less than -10 dB. The first band has bandwidth of 5.7 GHz with maximum return loss of -37 dB at 5.2 GHz and second band is of 5 GHz with maximum return loss of -47 dB at 13.7 GHz by implementing the optimum dimensions of the CPW feed and the rectangular shaped slot in center of circular patch.

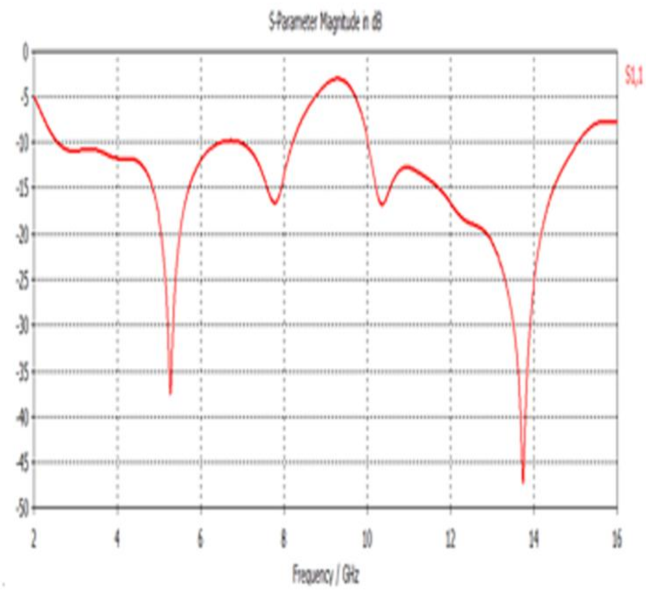


Fig 2: Simulated S_{11} parameter of proposed UWB antenna

Figure 3 shows the VSWR magnitude of the antenna which is fairly below 2 for the frequencies in which antenna is resonating. The VSWR of the antenna is closely related to the return loss. VSWR varies from 1 to 2 throughout the frequency region i.e. 2.5-8.2 GHz and 10-15 GHz, except from 8.3 GHz to 9.9 GHz. Since UWB characteristic requires the VSWR to be in the range of 1 to 2, the frequency region from 8.3 GHz to 9.9 GHz for the measured result does not agree with the UWB characteristic. Based on the simulated results, the proposed antenna exhibits good UWB characteristics and operates from 2.5 GHz-8.2GHz, and 10-15

GHz, having impedance bandwidth of 106.5% and 40.0% respectively. It complies with the VSWR range from 1 to 2 throughout the impedance bandwidth.

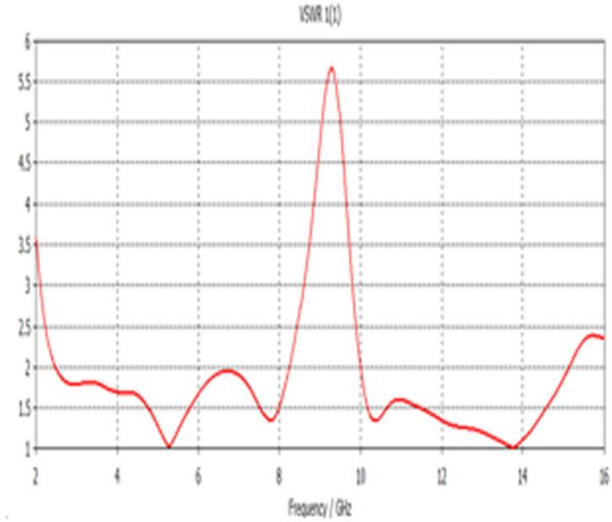


Fig 3: Simulated VSWR of proposed antenna

Figure 4 shows the radiation pattern of antenna at 5 GHz, 8 GHz, 9 GHz and 14 GHz.

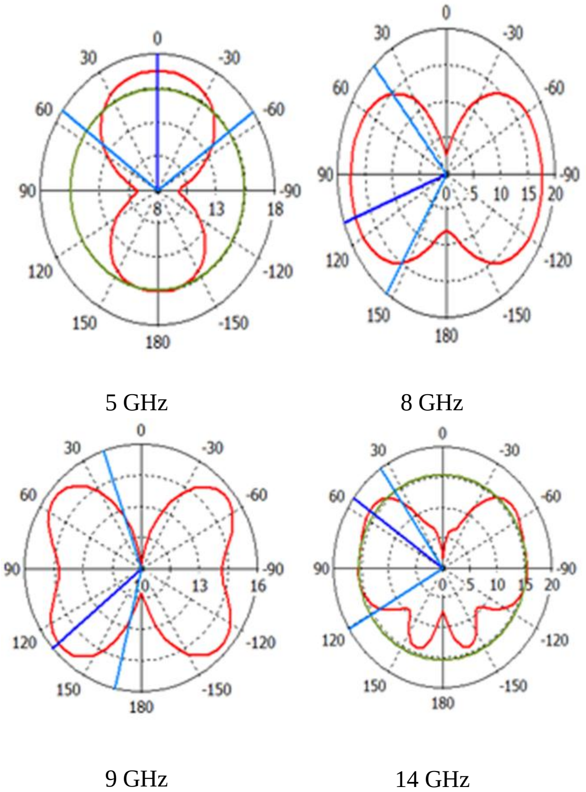


Fig 4: Simulated radiation pattern of the proposed antenna at 5 GHz, 8 GHZ, 9 GHz and 14 GHz

From the figure it clear that radiation pattern of antenna is almost Omni directional for most of 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 slot were introduced within circular patch to provide different electrical path within antenna. So that it can resonate at different frequency and with desired radiation pattern.

Figure 5 shows the gain of the proposed antenna. From the figure it is noticed that the gain of antenna varies between 2 to 3 dBi for the most of frequency and with the maximum gain of 3.4 dBi at 8.2 GHz.

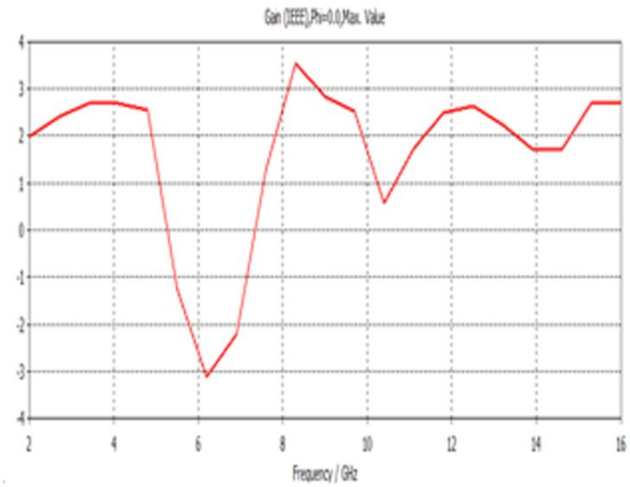


Fig 5: Simulated gain of proposed antenna

3.1 Results Comparison

The simulated results of the proposed antenna shows that it has quite good large bandwidth which is better than UWB antenna paper published earlier, paper [16] shows that it covers impedance bandwidth of 46.6% for the first band (5.82-8.8 GHz) and 41.32% for the second band (10.8-15.8 GHz) only.

Table 2. Comparison of Results

Parameters	Proposed Antenna	Paper [16]
Bandwidth	2.5-8.2 GHz (first band) 10-15 GHz (second band)	5.82-8.8 GHz (first band) 10.8-15.8 GHz (second band)
Impedance Bandwidth	106.6% (first band) 40% (second band)	46.6% (first band) 41.32% (second band)
VSWR	2.5-8.2 GHz and 10-15 GHz	3.9 GHz, 5.82-8.8 GHz and 10.8-15.8 GHz

4. CONCLUSION

A coplanar waveguide fed microstrip patch antenna design and simulation in CST Microwave Studio has been presented in this paper with gain of 3.4 dBi and appreciable value of return loss of -37 dB at 5.2 GHz and -47dB at 13.7 GHz. The dimension of antenna is 47×47×1.6 mm^3.The simulated results of the proposed antenna satisfy the -10 dB return loss requirements for UWB as defined by the FCC. The characteristics of the proposed antenna such as good coverage and stable transmission indicate that the proposed compact antenna is well suitable for integration into UWB portable devices. The proposed antenna fulfills the requirement of WLAN (5.2/5.8 GHz), WiMAX (2.5/3.5/5.5 GHz) and LTE (2.5-2.69 GHz). The antenna can also be used in smart grid technology (11-18 GHz) and in European fixed satellite systems which have appreciable gain in 12-14 GHz band of frequencies.

5. REFERENCES

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