PERFORMANCE COMPARISON OF TWO PLANAR MONOPOLE ANTENNA FOR ULTRA-WIDEBAND APPLICATIONS

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ABSTRACT

In this communication, two distinct compact planar monopoles are designed and constructed. Two composition (circular and rectangular shaped radiating elements) are presented. The slots and step-shaped are integrated in the radiating elements to improve the impedance matching characteristics of the antennas. Two feeding techniques (microstrip and coplanar waveguide feeds) are performed to couple the electromagnetic waves. Both the two antennas shows promising performance for UWB applications. Numerical and exploratory strategies are performed to exhibit and discuss about the proposed designs. The results of CPW-fed receiving wire uncover preferable execution over the transmission line fed reception apparatus.

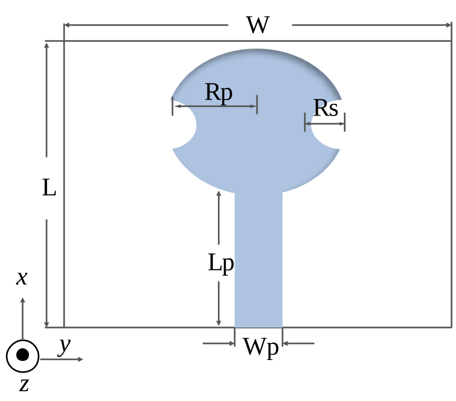
1. INTRODUCTION

The ever-growing demand for high data rate and more user capacity increases the need to use the available spectrum effectively. Compact ultra-wideband antennas have become one of the key components due to its capability of covering wide frequency bands. Designing such ultra-wideband antenna system with compact size and without vitiating on receiving wire performance is a significant errand. Federal communication commission has set a frequency scope of 3.1 – 10.6 GHz for UWB systems [1] - [3]. Microstrip radiators inherently have limited size and narrow impedance bandwidth characteristic, there have been many approaches developed for bandwidth enhancement so as to achieve UWB characteristics. Recently, several UWB antennas by using microstrip feeding techniques have been reported in the literature [4] – [8]. The use of coplanar waveguide feeding concept have been researched in [9] in which, a step-shaped patch and defective ground structure is used. The work in [10] used microstrip to coplanar-waveguide transition in order to accomplish a broadband circularly polarized receiving wire. Coplanar-waveguide fed circularly patch antenna inspired by reduced ground plane and CSRR slot for ultra-wideband was analyzed in [11]. Researchers in [12] – [14] use asymmetric coplanar strips (ACS) feeding techniques in order to realize UWB frequencies. Apart from using the aforementioned feeding techniques for UWB achievements there are some other important techniques developed by researchers for bandwidth enhancement, for example, the use of metamaterial structures [15] – [16], electromagnetic band gap (EBG) structures [17], partial ground plane [18] and introducing slots [19] – [29].

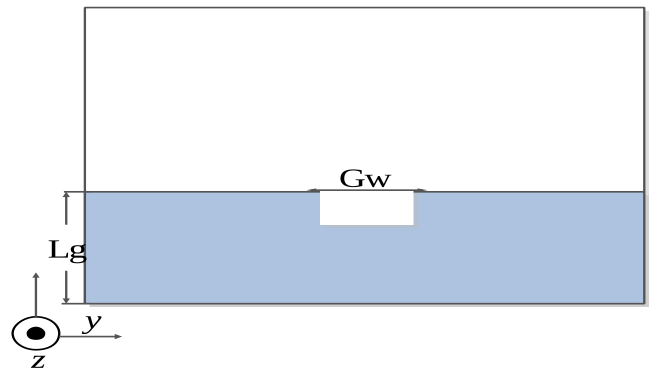
In this communication, the design and performance comparison of two compact miniaturized microstrip patch antenna is presented. The first antenna is a circular-shaped with two circular slots around the radiating element fed by a microstrip feeding techniques while the second antenna is a coplanar-waveguide-fed step shaped patch antenna. Both the two antennas can find application in UWB wireless communication operating in (2.8 – 12GHz) and (2.7 – 12GHz) respectively. The configuration of the first antenna is presented in section II, while section III is the design and configuration of the second antenna, results and discussion is presented in section IV where the performance comparison and validation of the proposed analysis will be discussed. Finally, section V is the concluding remarks.

2. DESIGN PROCEDURE FOR CIRCULAR SHAPED ANTENNA

The geometry of UWB circular reception apparatus is pictured in figure 1 a. The antenna is simulated using time domain analysis in CST version 2017. The system is deployed on a dielectric substrate: FR4 epoxy with an overall permittivity of 4.3, 0.025 loss tangent and stature of 1.6mm. The absolute structure zone was to improve the impedance width of the proposed receiving wire from 2.8 GHz to 12 GHz, two slots are set at each side of the transmitting component with a defected ground plane. The two openings play an important role in improving the impedance width of the proposed antenna. Incredible depiction to the extent wideband and radiation properties are the advantages of circular shaped reception apparatus. The optimized parameters of the circular shaped antenna are presented in table 1 below. Another structure which we can call it a partial ground structure has additionally assumes a significant role for improving the performance of the monopole radio wire, as clearly shown in figure 1 b. The area of the hole controls the data transfer capacity of the monopole radio wire, for the fact that current distribution in the ground plane will make impact and the conduct of the monopole antenna [30].



(a)



(b)

Fig. 1. Antenna geometry; top view (a), bottom view (b)

Table 1. Circular UWB antenna parameters

Optimized Antenna parameters			
Parameter	***Size (mm)***	***Parameter***	***Size (mm)***
L	30	R_S	23
L_g	10	W	17
L_P	11.05	W_P	12
R_P	9.35	G_W	9

3. DESIGN CONFIGURATION OF UWB STEP-SHAPED ANTENNA

The proposed step-shaped UWB antenna as shown in figure 2 consist of two rectangular ground plane and stepped-gradient structure as the main radiating element. The substrate thickness is 1.6mm with a dielectric constant of 4.3. The coplanar-waveguide feed line is designed by using a rectangular patch connected with the main radiator. The two structures (patch and the ground) are placed on top of the substrate. the CPW-feed line is fed by 50Ω impedance. The width of the feeding line is 2.8mm while the ground gap that is, a space between the feeding line and the two ground plane is 0.3mm. The rectangular coplanar waveguide serves as the ground plane of the antenna. The optimal dimensions for the antenna are listed in table 2. A parametric analysis is presented using different values of R_S that is, the radius of the slot in order to have an optimum value of that can give us a better performance of the antenna. Figure 3 shows the S_{11} for the various radius of the slot in which 2.6mm is chosen as the radius of the slot.

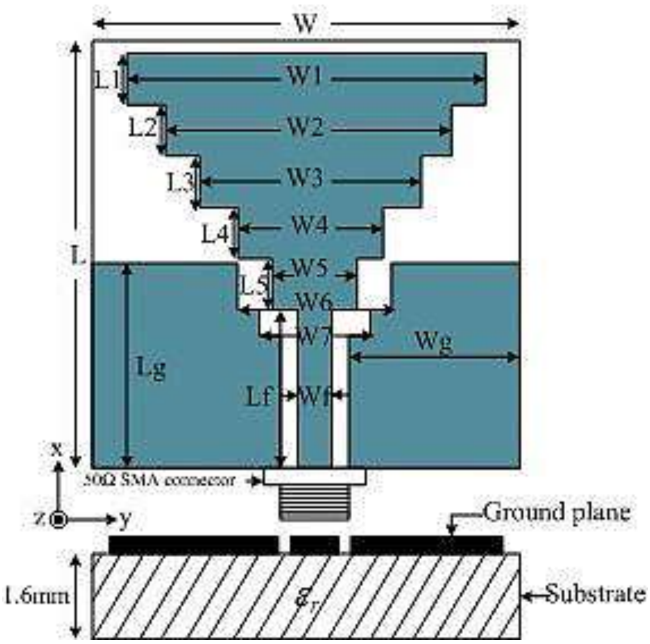


Fig. 2. Configuration of the step-shaped UWB antenna

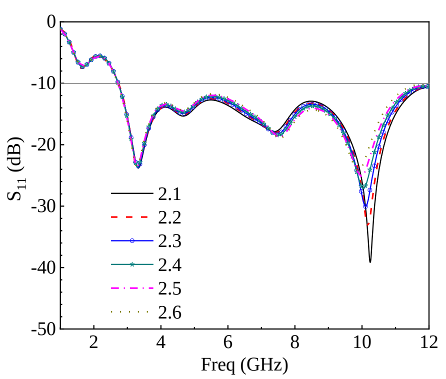


Figure 3. S_{11} plot for various radius Rs (mm) for circular shaped antenna

Table 2. Basic parameters of step-shaped antenna

Optimized Antenna parameters			
Parameter	***Size (mm)***	***Parameter***	***Size (mm)***
L	32	W1	23
L1	8	W2	17
L2	4	W3	12
L3	2.5	W4	9
L4	2.5	W5	6
L5	2	W6	10
Lf	11	W7	8
Lg	12.5	Wf	2.8
W	26	Wg	11.3

4. RESULTS AND DISCUSSION

Based upon the design parameters shown in figure 1 and figure 2, the proposed UWB antennas was constructed, measured and analyzed as follows

A. Impedance bandwidth

The construction of the proposed UWB antennas were carried out at the institute of micro-nano photo electronic and electromagnetic technology innovation, school of electronics and information engineering Hebei university of technology china. Figure 4 shows the measured and simulated |S11| against frequency of the proposed UWB circular antenna, figure 5 is the voltage standing wave ratio (VSWR) of less than 2.0, but greater than 1.0 for the UWB circular-shaped antenna. It can be observed from figure 4 that the |S11| is <-10dB with an impedance percentage bandwidth of 200% from 2.8 GHz to 12 GHz. The prototype of circular shaped antenna is presented in figure 6. The results for the measurement and simulation of step-shaped UWB antenna is shown in figure 7 with close agreement between the set of data. A little different between simulated and measured results are likely caused by measurement effects, construction imperfection, SMA join effects and quality of the substrate, not all of which were included in the simulations. The results show an impedance percentage bandwidth of 201% from 2.7 GHz to 12G Hz and a voltage standing wave ratio (VSWR) of less than 2.0:1.0 as pictured in figure 8. The constructed photograph of step-shaped UWB antenna is depicted in figure 9.

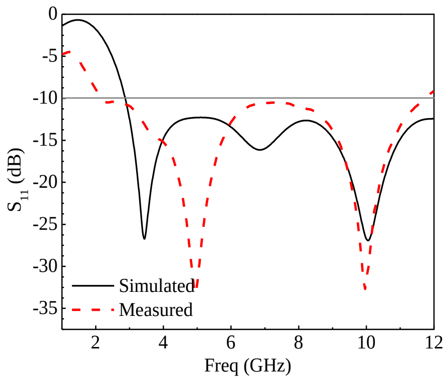


Fig. 4. Measured and simulated S11 of circular shaped antenna

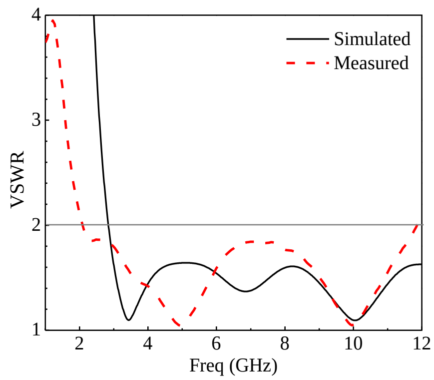
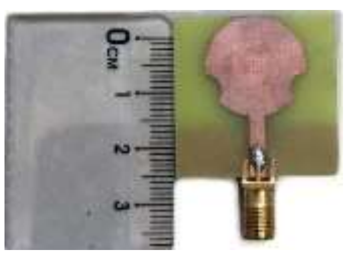


Fig. 5. Measured and simulated VSWR of circular shaped antenna



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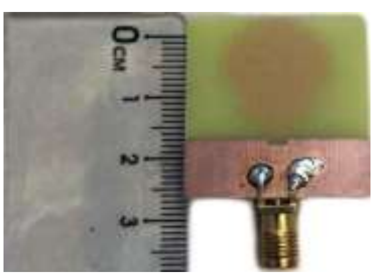


(b)

Fig. 6. Photograph for circular shaped; top view (a), bottom view (b

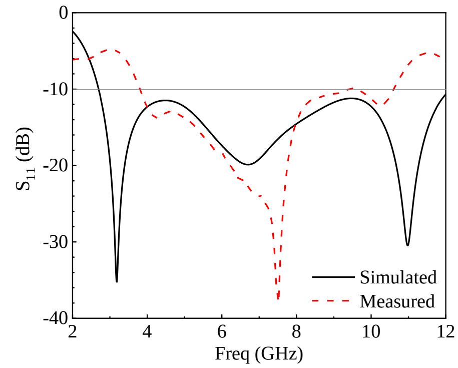


Fig. 7. Measured and simulated S11 for step- shaped antenna

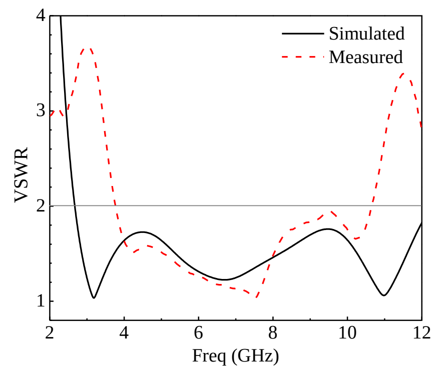


Fig. 8. Measured and simulated VSWR for step- shaped antenna

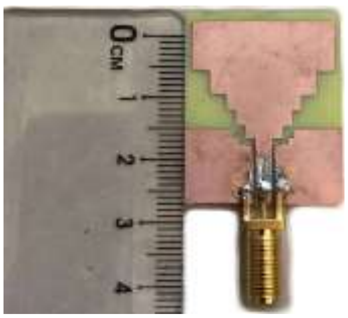
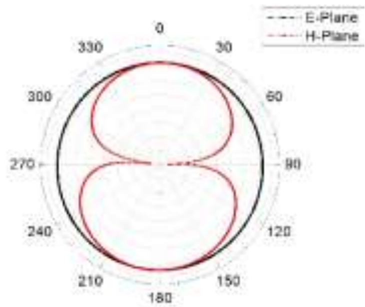


Fig. 9. Fabricated photograph of step-shaped antenna

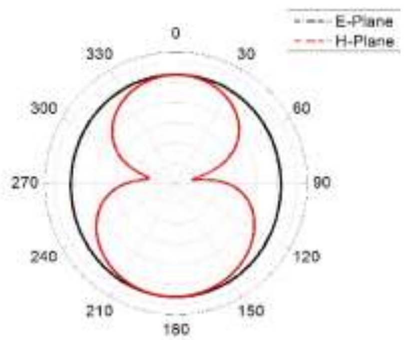
B. Radiation pattern

The far field radiation properties of the proposed UWB circular shaped antenna is taken at 2.8 GHz, 4.5 GHz, 5.8 GHz and 9.5 GHz as presented in figure 10. From the figure it was clearly shows that the antenna radiation pattern is nearly Omni-directional. The 3D radiation pattern together with their respective gains at

2.8 GHz, 4.5 GHz, 5.8 GHz and 9.5 GHz is also shown in figure 11. The peak gain over the UWB frequency is shown in figure 12.



(a)



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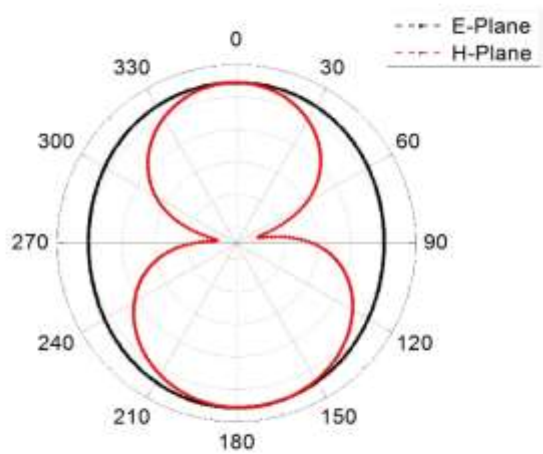

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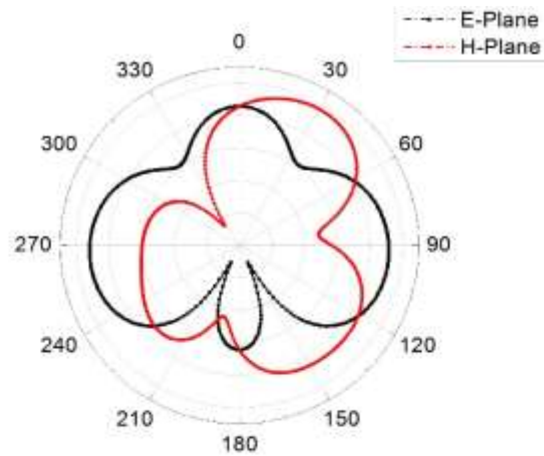
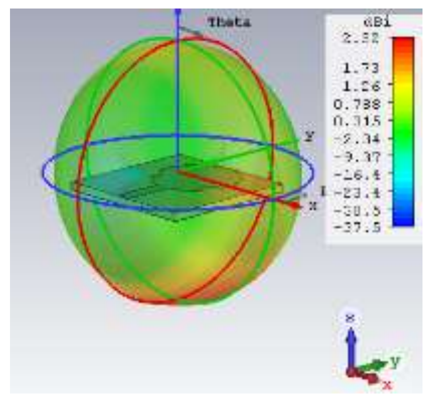


(d)

Fig. 10. Radiation pattern; 2.8GHz (a), 4.5GHz (b), 5.8GHz (c), 9.5GHz (d) for circular shaped UWB antenna.



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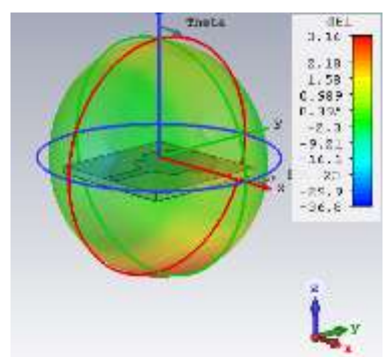

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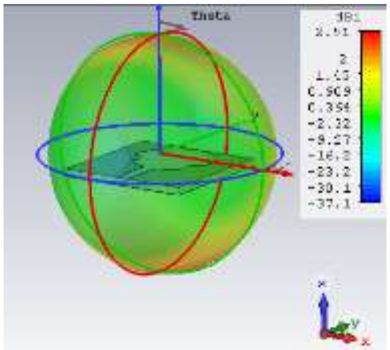

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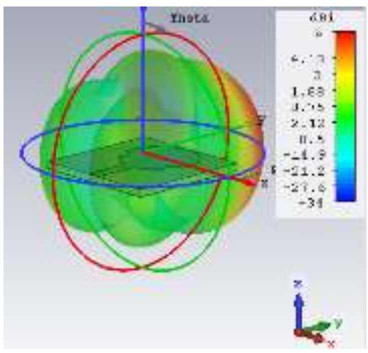

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Fig. 11. 3D radiation pattern; 2.8GHz (a), 4.5GHz (b), 5.8GHz (c), 9.5GHz (d) for circular shaped UWB antenna.

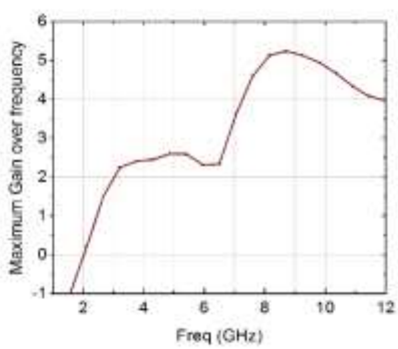
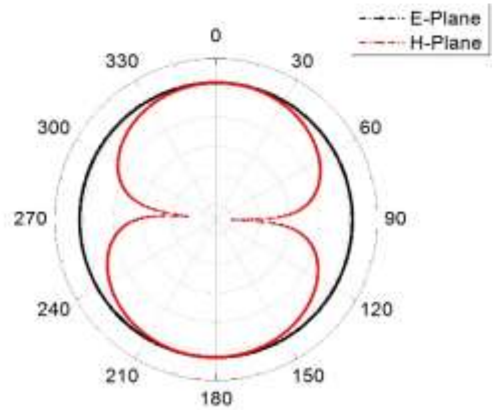
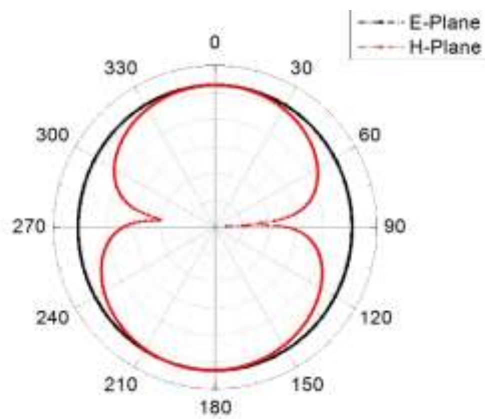


Fig. 12. Peak gain of a circular shaped antenna.

Figure 13(a) through (d) shows the normalized far field radiation properties in the H- and E-fields for the step-shaped UWB antenna at 2.7 GHz, 4.5 GHz, 5.8 GHz and 9.5GHz respectively. The result shows that the antenna radiation pattern is quasi omni-directional suitable for receiving signals from all directions. The antennas cross polarization performance deteriorates with increasing frequency, for the fact that at higher band the working wavelength becomes teeny close to the size of the antenna. Fig. 14(a) through (d) is the 3D radiation pattern together with their respective gains at 2.7GHz, 4.5 GHz, 5.8 GHz and 9.5 GHz. Fig. 15 tract the antennas peak gain as a function of operating frequency from 2 to 14 GHz, across the full impedance bandwidth of 2.7 to 12 GHz, indicating that the antenna design is suitable for use in UWB systems.



(a)



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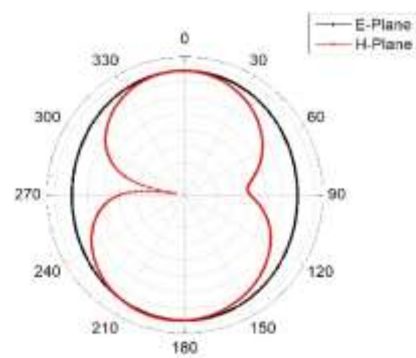

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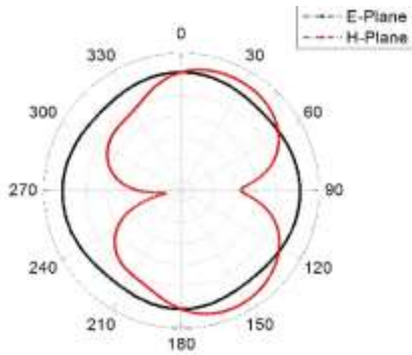

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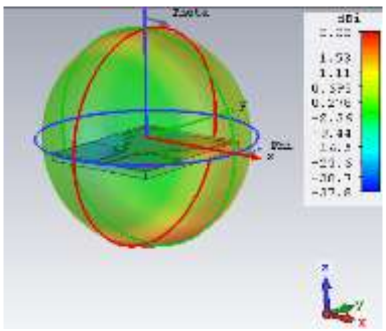
Fig. 13. Radiation pattern; 2.8GHz (a), 4.5GHz (b), 5.8GHz (c), 9.5GHz (d) for step-shaped UWB antenna.



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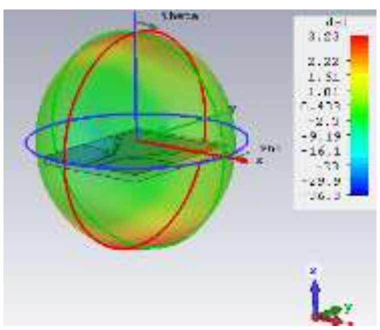

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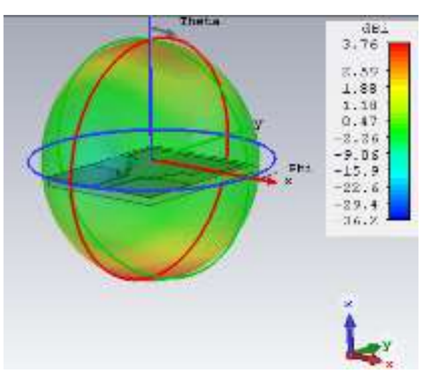

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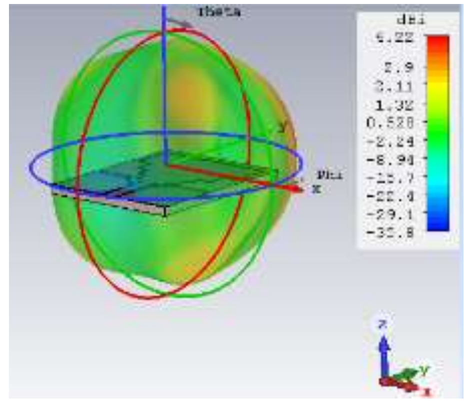


(d)

Fig. 14. 3D radiation pattern; 2.8GHz (a), 4.5GHz (b), 5.8GHz (c), 9.5GHz (d) for step-shaped UWB antenna.

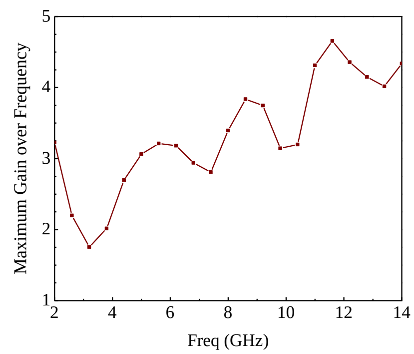
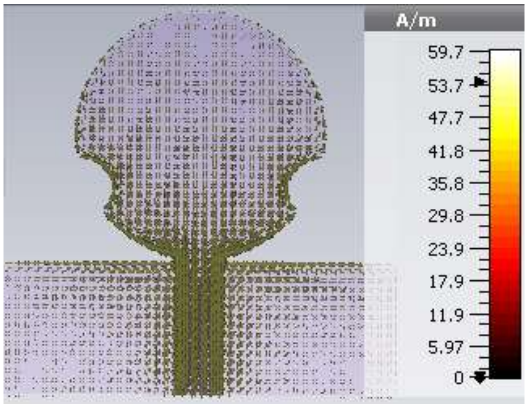


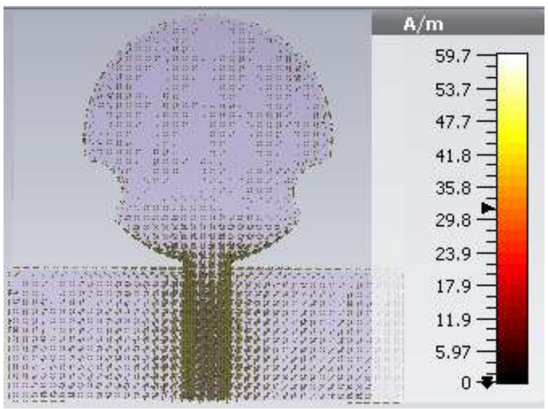
Fig. 15. Maximum gain over frequency for step-shaped antenna.

C. Current distribution

The circular shaped UWB antenna current sequence at 2.8 GHz and 2.5 GHz is illustrated in figure 16(a) through (d). The current sequence maintains a balanced order in terms of flow for both the ground and the patch. Wide impedance width is attained. Figure 17(a) through (d) is also the current sequence of step-shaped UWB antenna at 2.7 GHz, 4.5 GHz, 5.8 GHz and 9.5 GHz. The current distribution is obtained at 90-degree phase.



(a)



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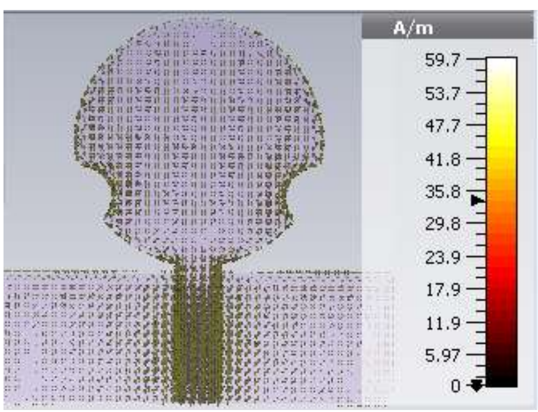

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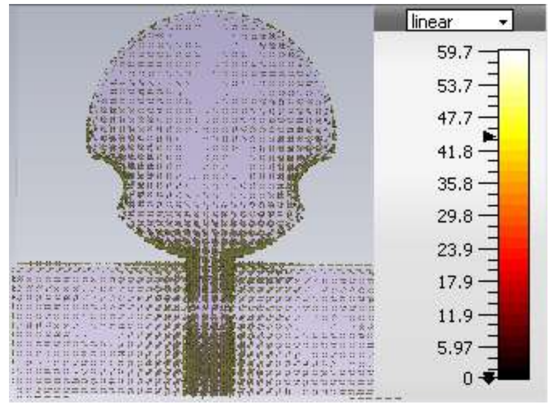
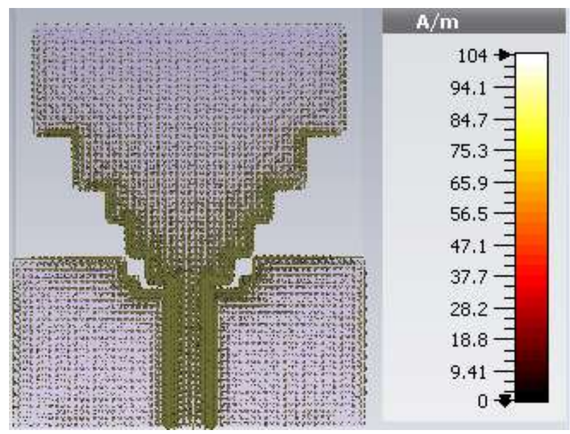
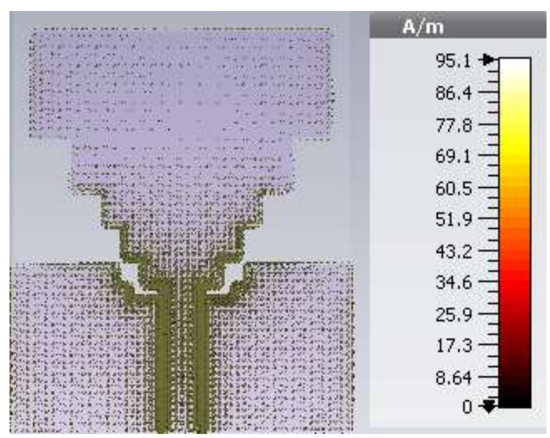


(d)

Fig. 16. Current distribution; 2.8GHz (a), 4.5GHz (b), 5.8GHz (c), 9.5GHz (d) for circular-shaped UWB antenna.



(a)



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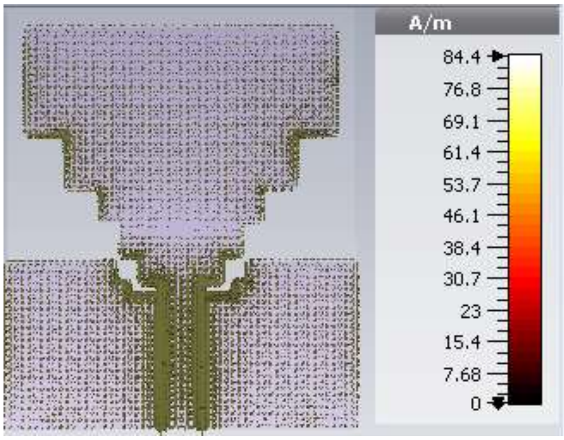

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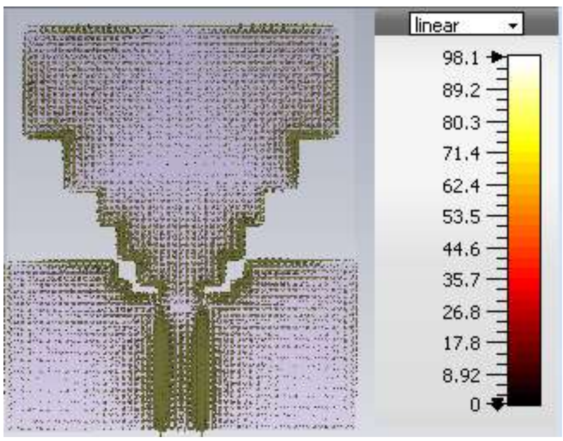

(d)

Fig. 17. Current distribution; 2.7GHz (a), 4.5GHz (b), 5.8GHz (c), 9.5GHz (d) for step-shaped UWB antenna.

The performance summary between UWB circular-shaped antenna and step-shaped UWB antenna in terms of type of feed, shape, dimension of the antenna, and percentage bandwidth is given in table 3. As can be seen from the table, the step-shaped antenna has higher performance than the circular shaped antenna.

Table 3. Summary comparison between the two antennas

Summary Comparison			
Technique	***Bw (%)***	***Size (mm)***	***Feed***
Circular shape	200	30x30x1.6	microstrip
Step-shaped	202	26x32x1.6	CPW

5. CONCLUSION

A circular printed monopole and stepped gradient planar antennas fed by microstrip line and CPW are presented in this letter. The proposed designs were simulated using computer simulation technology version 2017. Both the designs have shown acceptable results. The parameters like size, bandwidth, compactness and feeding technique were compared with each other to analyze the pros and cons of the designs. The circular shaped antenna has shown limitations in impedance bandwidth and size compactness, while CPW-fed step-shaped have higher impedance bandwidth and compactness. After this analytical and experimental study, CPW-fed antenna can be recommended as one with high performance for UWB applications.

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