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A Novel Ultra-Wide Band CPW Fed Printed Antenna for IoT Wireless Applications

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Abstract: Ultra-Wide Band (UWB) is a wireless technology used for developing high rates of data transfer over a short distance. Due to its less power density, and minimal size, it has become currently an exciting area having various applications. The novel coplanar waveguide (CPW) fed printed antenna presented in this paper exhibits the UWB characteristics. The dimensions of the designed antenna are 25 x 35 x 1.6 mm^3 and developed on an FR4 substrate which was a low-cost laminate and by varying feed widths and radii of resonator UWB operating frequencies obtained. The UWB antenna proposed has a frequency ranging from 3.54 GHz to 12 GHz, thus covering the WiMAX/WLAN, 3G, 4G, and UWB bands.

Index Terms: UWB, CPW, WLAN, Wi-Max.

I. INTRODUCTION

Internet of Things (IoT) applications brought significant advancements in many fields such as networking, microelectronics, wireless communication systems, etc. This technology provides vital features such as real-time analytics, environmental sensing, restrained analytics over the network. To attain reliable communication, the devices linked to IoT are compact, energy efficient and should operate on multiple bands. So, using a single wideband antenna is more appropriate than using multiple narrowband antennas. Hence, UWB antennas have high data rates, low power requirement, high bandwidths, small size, and low cost are a promising solution to IoT applications. This kind of antennas provides a more significant number of advantages when compared with the microstrip antennas were commonly used as these common antennas gives a suitable impedance matching and omnidirectional radiation pattern.

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These CPW fed antennas have a higher number of attractive features like low dispersion and ease integration with both the passive and active devices. These antennas also provide a good impedance matching and a broadside radiation pattern. The CPW structure is designed by placing a conductor as a central strip and is separated by a small gap from the ground planes on both sides of it. A U-shaped slot obtains an inscribed square, a circular fractal antenna for an Ultra-Wideband frequency range proposed in [1-3]. By altering the feed area, adding a fractal geometry to a wire square circle antenna is introduced [4]. In [5-7] a monopole antenna with a staircase and an inverted staircase structures for UWB applications are proposed. A CPW fed MIMO antenna introduced is [8] for WLAN application. In [9] demonstrates that a tapered step ground and EBG structure are used to enhance the bandwidth and gain for a CPW fed monopole antennas used for Wideband applications. A monopole antenna of the polygon-shaped patch with fractal elements attached to it is used to enhance bandwidth in [10-13]. A compact UWB antenna with CPW-fed with a gain variation less than 4 dBi covering from 3.08 GHz to 10.6 GHz is recommended [14-16]. In [17] a staircase shaped monopole UWB antenna with dual-band characteristics is proposed. The Slot antenna with wideband characteristics using CPW fed line with a rectangular slot [18-19] and with hexagonal patch [20] are discussed and by varying the geometry to get proper impedance matching for getting ultra-wide bandwidth. Different tuning techniques are implemented for the circular slot [21-23] and the bow-tie slot also [24-26].

The microstrip patch antennas give less bandwidth, complex structures and several antennas can cover multiple bands. Coplanar Waveguide feeding technique enables bandwidth enhancement, uniplanar design, and ease of installation with MMIC and active components making it useful for IoT applications. A circular patch with a resonator and CPW feeding technique is used. The microstrip patch is fed using a 50-ohm feed line with the rectangular design printed on the FR4 substrate.

II. ANNTENNA DESIGN SPECIFICATONS

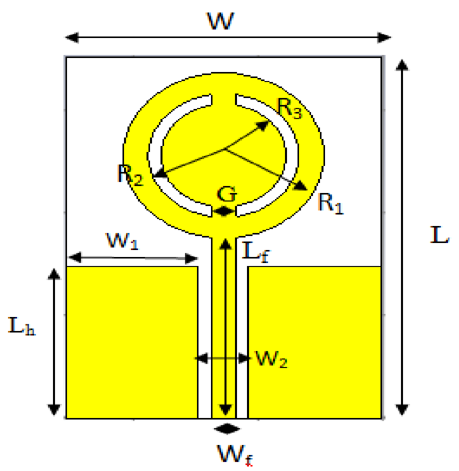


Fig. 1: Proposed antenna.

Table 1: Proposed CPW Antenna Design Parameters Value.

S. No	Parameters	Value (mm)
1	Length of a substrate (L)	35
2	Width of a substrate (W)	25
3	Length of ground (L_h)	14.8
4	Width of the feed (W_f)	2
5	Length of the feed (L_f)	18.5
6	Width of the ground (W_1)	10.5
7	Spacing between the ground planes (W_2)	3
8	Radius of the circular patch (R_1)	8
9	Outer radius of the Resonator (R_2)	6
10	Outer radius of the Resonator (R_3)	5
11	Height of substrate (H)	1.60
12	Thickness of substrate (T)	0.0256
13	Gap between two split rings (G)	2

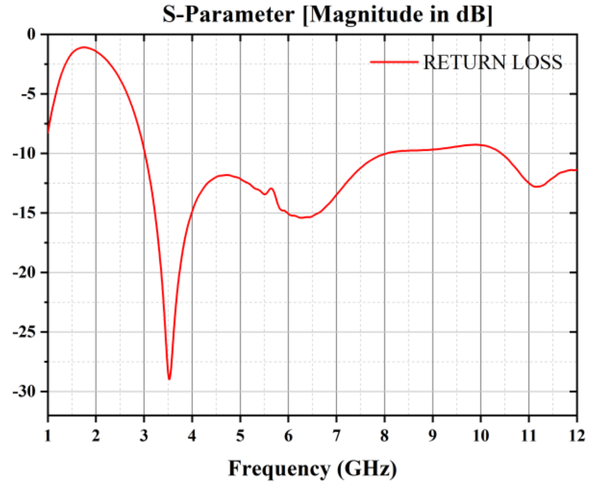
Fig. 1, exhibits the proposed antenna of CPW circular patch. To achieve UWB, CPW antenna consists of radius R_1, R_2, and R_3 fed by a microstrip line feed. This antenna has two semi-circular slots over the circular patch which is a vital element to decide the operating frequency of the antenna since they can adjust the electromagnetic coupling impacts so that the patch improves its bandwidth. The presented antenna printed on an FR4 substrate with a coplanar waveguide feed line. It has a thickness of 1.6 mm and with a permittivity of 4.4. By differing L_f, W_1, W_2 and L_h value the impedance matching and gain can be altered. The proposed antenna optimized parameters are in arranged in Table 1.

The circular patch coplanar waveguide antenna with wideband characteristics and enhanced performance in WiMAX/WLAN band introduced in this paper. The dimensions of the circular shaped patch have been optimized to accomplish the UWB characteristics. The ground plane dimensions are 14.8 × 10.5 mm^2. The ground plane helped in achieving the target port impedance at the resonant frequency band. A designed parametric examination for the antenna proposed and the simulation carried by CST microwave studio. The optimized values of all geometric variables are in Table 1. The presented antenna is intended for change in the electromagnetic coupling impact by varying length and width of the rectangular feed line and radius of a circular patch.

III. RESULTS AND DISCUSSIONS

The parameters of the design proposed of CPW circular antenna are operating from 3.54 GHz to 12 GHz thereby all the applications utilizing these frequency ranges. The proposed antenna used for Wi-fi operations. The length, width, and thickness of the proposed antenna are 35 mm, 25 mm and 1.6 mm respectively. From dimensions, it has a small size and is compact because of its implementation using PCB technology enabling easy integration on small devices.

In Fig. 2, the proposed antenna with the return loss and VSWR parameters are shown. This antenna operates in the range of UWB with a return loss of -28.5 dB at the frequency 3.54 GHz with a corresponding VSWR which is having less than 2.



(a)

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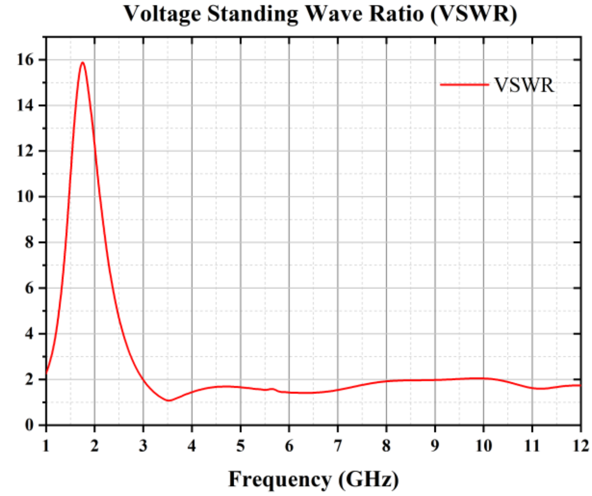
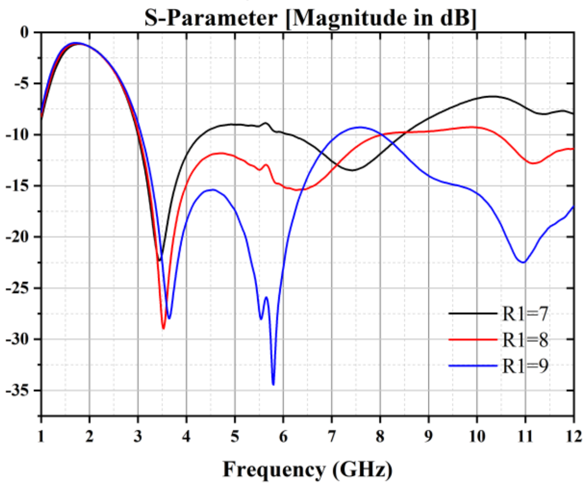


(b)

Fig. 2: (a) Return loss, (b) VSWR parameters of the proposed antenna.

Fig. 3(a) plots the varying radius R_1 and keeping all other parameters as constant. It is observed that by varying R_1 from 7 mm to 9 mm. The optimum return loss is -34.5 dB at 5.85 GHz for the radius R_1 is 9 mm. The corresponding VSWR is less than two shown in Fig. 3(b).



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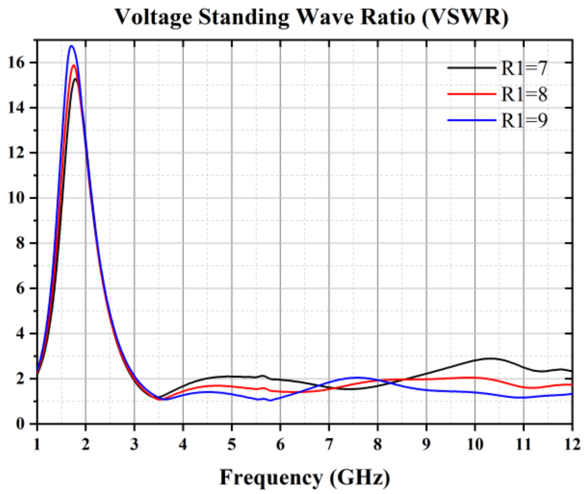
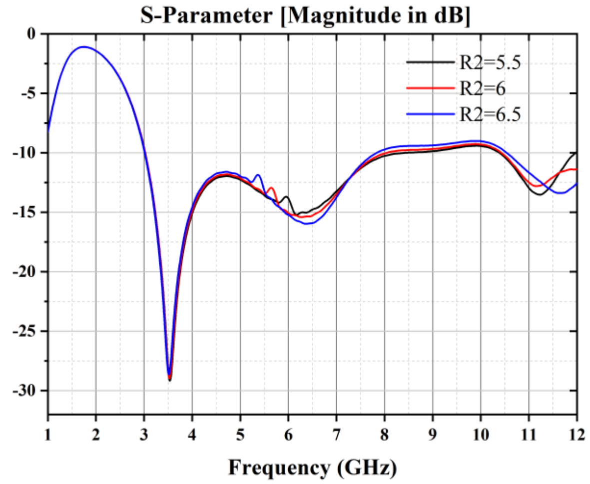


(b)

Fig. 3: (a) Return loss, (b) VSWR parameters by varying radius R_1.

Fig. 4(a) shows the return loss of the antenna by modifying the outer radius R_2 parameter is changing from 5.5 mm to 6.5 mm and maintained the remaining parameters fixed. The optimized value for R_2 is 6 mm and observed return loss is -28.5 dB at 3.54 GHz. The corresponding VSWR is less than 2 as shown in Fig. 4(b).



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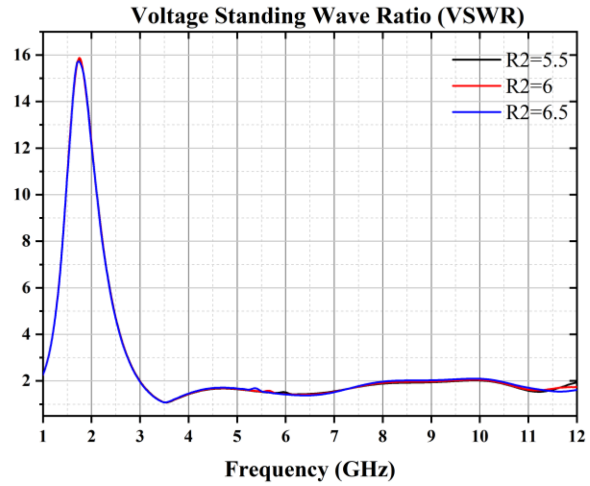

(b)

Fig. 4: (a) Return loss, (b) VSWR parameters by varying outer radius R_2.

Fig. 5(a) represents the return loss of the proposed antenna by varying outer radius R_3 and keeping all other parameters as constant. It can be observed that by varied R_3 from 4 mm to 6 mm with an optimal return loss is observed as constant -28.5 dB at 3.54 GHz for all R_3 varied values. The corresponding VSWR is less than 2 is shown in Fig. 5(b).

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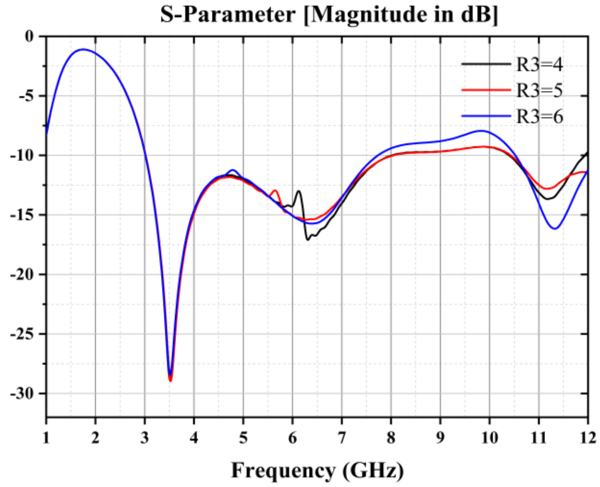

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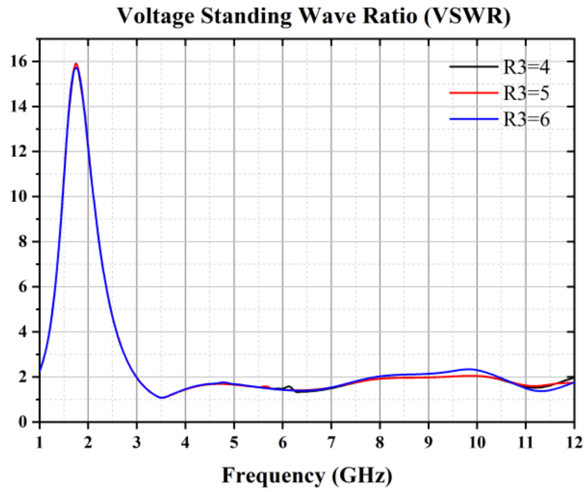
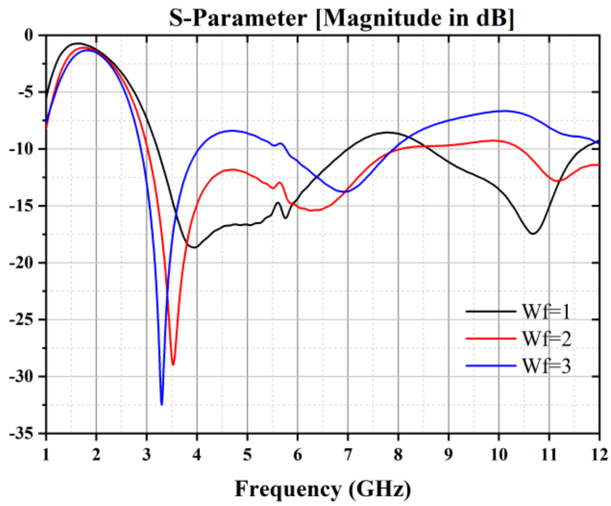


Fig. 5: (a) Return loss, (b) VSWR parameters by varying outer radius R_3.

The resonant frequency is modified by varying the width of the feed strip. When W_f is 1 mm, the resonant frequency is 3.9 GHz with the return loss at -18.5 dB.



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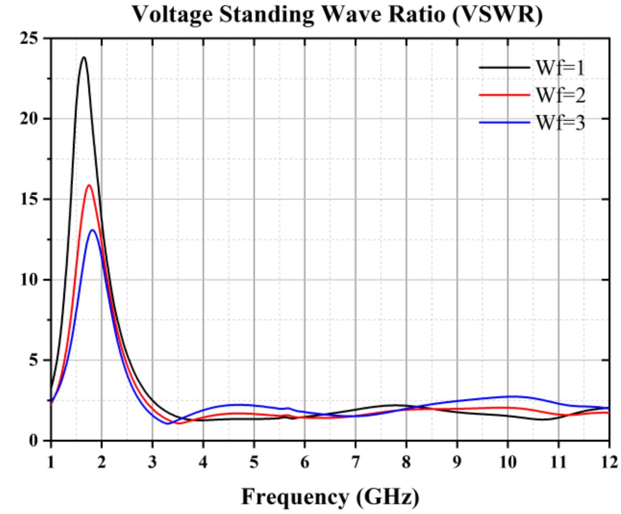
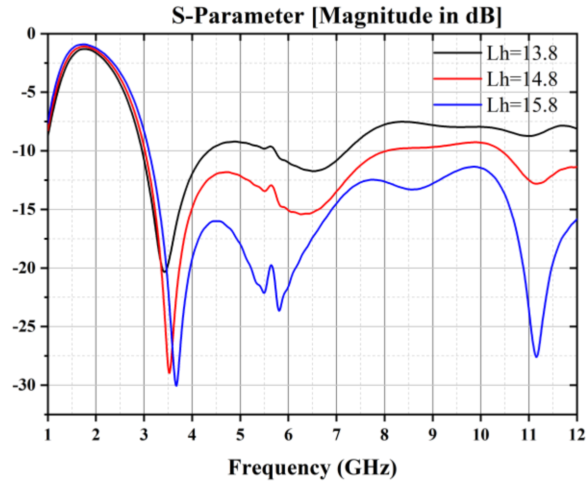


(b)

Fig. 6: (a) Return loss, (b) VSWR parameters by varying W_f.

When W_f is increased to 2 mm, the resonating frequency shifted to 3.54 GHz the return loss is -28.5 dB but when W_f is 2 mm observing the UWB characteristics. Further increasing W_f to 3 mm increase the return loss to -33.5 dB. Therefore, W_f is 3 mm taken as the optimal feed width for the proposed antenna according to simulation results shown in Fig. 6(a). The W_f is 3 mm considered as the optimized result. Fig. 6(b) represents the corresponding VSWR plots of varying W_f.

Fig. 7(a) shows the return loss by modifying L_h parameter is changing from 13.8 mm to 15.8 mm and remaining parameters are not varying. The optimized value for L_h is 15.8 mm and observed return loss is -30 dB at 3.6 GHz. The corresponding VSWR is less than 2 is as shown in Fig. 7(b).



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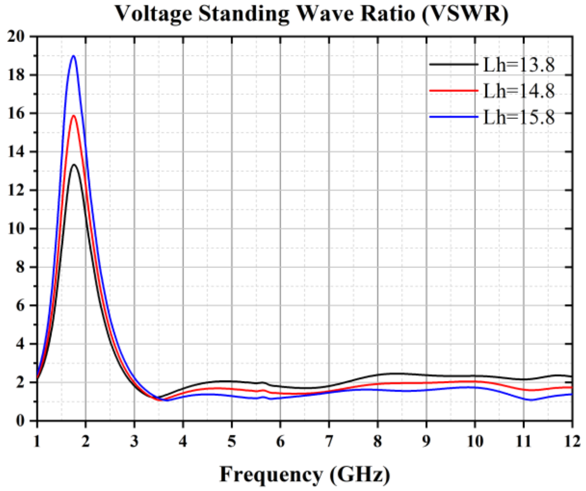
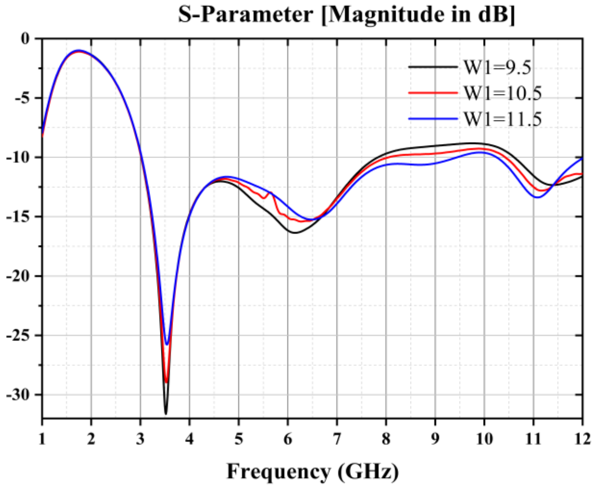


(b)

Fig. 7: (a) Return loss, (b) VSWR parameters by varying L_h.

Fig. 8(a) represents return loss of the proposed antenna by varying W_1 and keeping all other parameters as constant. The W_1 parameter is ranging from 9.5 mm to 11.5 mm with an incremental step of 1 mm. The optimized value for the W_1 is 10.5 mm with the return loss of -28.5 dB at 3.54 GHz. The corresponding VSWR is less than 2 is as shown in Fig. 8(b).



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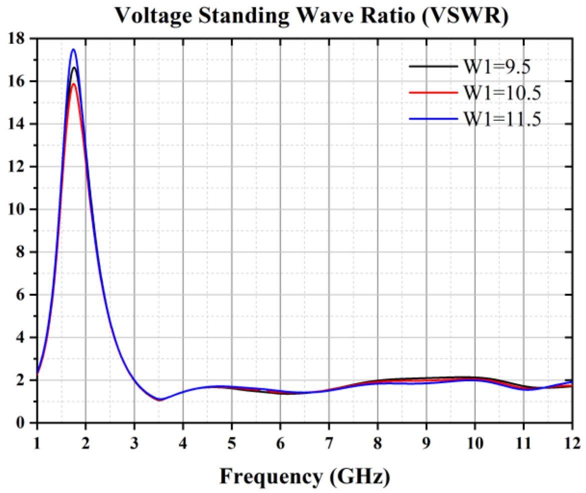
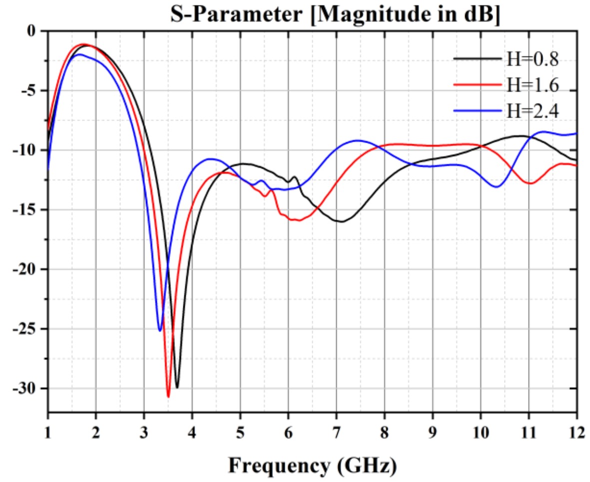


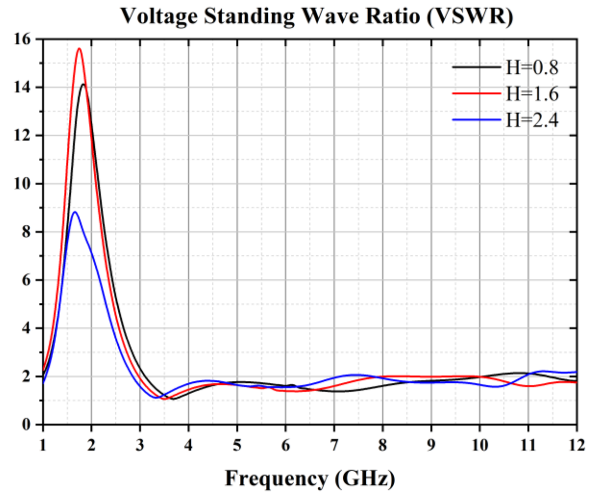
(b)

Fig. 8: (a) Return loss, (b) VSWR parameters by varying W_1.

Fig. 9(a) represents the return loss of the proposed antenna by varying Hand keeping all other parameters as constant. The H parameter is varied from 0.8 mm to 2.4 mm with an optimal return loss obtained is -30.5 dB at 3.54 GHz with a height of the substrate 1.6 mm. The corresponding VSWR is less than 2 is as shown in Fig. 9(b).



(a)



(b)

Fig. 9: (a) Return loss, (b) VSWR parameters by varying H.

Fig. 10(a) shows the return loss by varying G ranging from 1 mm to 3 mm and without changing other parameters. The optimal return loss observed is -28.5 dB at 3.54 GHz with a gap between split rings 2 mm. The corresponding VSWR is less than 2 is as shown in Fig. 10(b).

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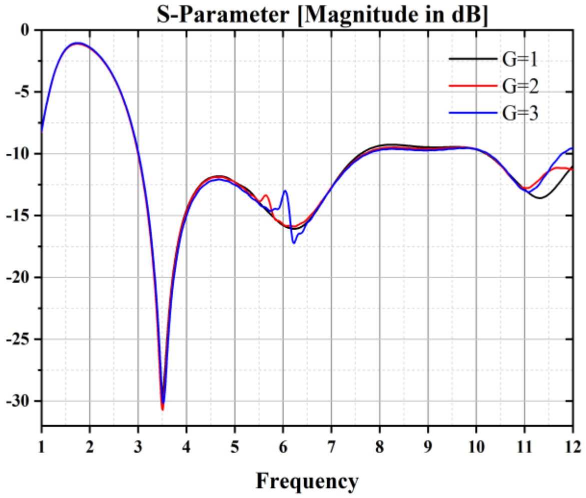
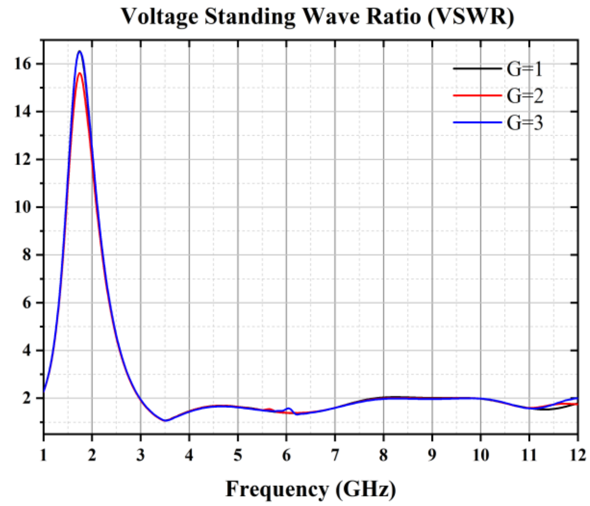


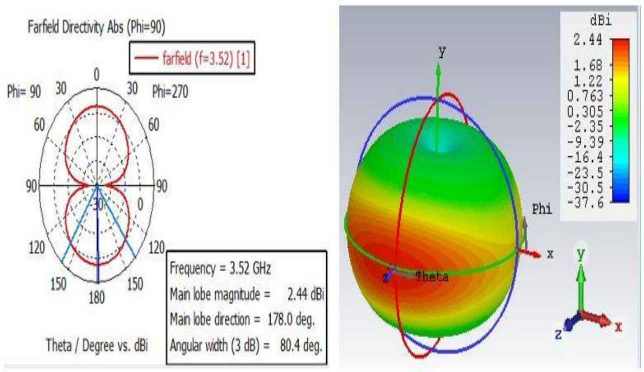
(a)



(b)

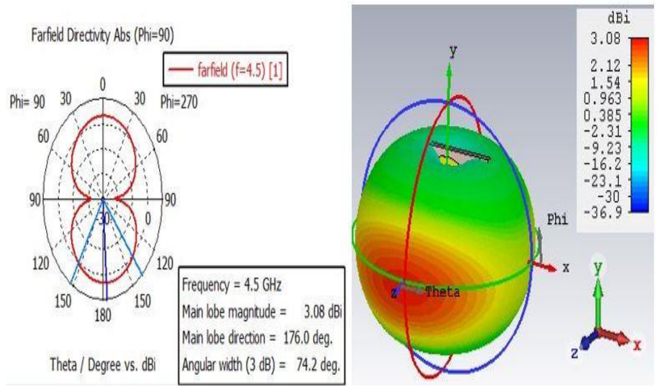
Fig.10: (a) Return loss, (b) VSWR parameters by varying G.

The antenna has a gain of 2.44 dB with main lobe magnitude and directions as 2.44 dBi, 178.00 at the resonating frequency of 3.52 GHz. For the frequency of 4.5 GHz and 6 GHz, the simulated gain of 3.08 dB and 3.96 dB is respectively, and main lobe directions as the proposed antenna are shown in Fig. 11, 12 and 13. Although the higher gain at 6 GHz, it has improper UWB characteristics making our proposed antenna suitable for UWB applications. WLAN (IEEE 802.11g) and WiMAX (IEEE 802.16d) applications use frequencies which lie in the operating range of the proposed antenna; hence this antenna can be used for the applications as mentioned earlier.



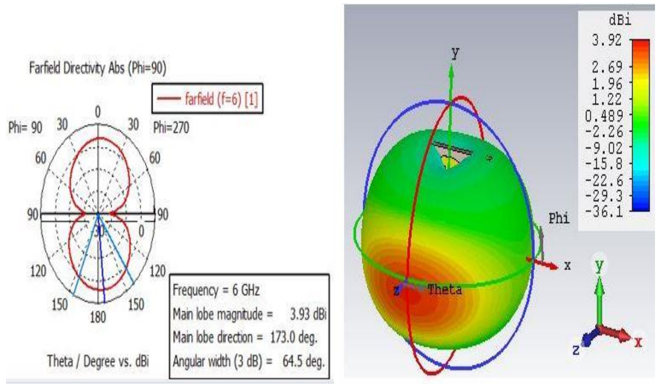
(a) (b)

Fig. 11: (a) 2-D (b) 3-D Radiation Pattern for CPW and Polar Plot at 3.52 GHz



(a) (b)

Fig 12: (a) 2-D (b) 3-D Radiation Pattern for CPW and Polar Plot at 4.5 GHz



(a) (b)

Fig. 13: (a) 2-D (b) 3-D Radiation Pattern for CPW and Polar Plot at 6 GHz

IV. CONCLUSION

In this paper, a novel compact CPW-UWB antenna is proposed. The CPW antenna system consisted of two semi-circular split rings with rectangular ground planes. The presented CPW antenna system has a very compact size; the overall volume is 35 x 25 x 1.6 mm^3. The small antenna was operating in the UWB frequency range. The antenna designed and optimized for a frequency range from 3.54 GHz to 12 GHz.

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The simulated results show as proposed antennas could be a good feature in Ultra-WideBand for IoT applications.

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