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A COMPACT DEFECTED GROUND OCTAGONAL SHAPED PATCH ANTENNA FOR UWB APPLICATIONS

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ABSTRACT

A compact defected ground octagonal shaped patch antenna is presented. The antenna uses duroid (ε_r= 2.2) as a substrate. The ultra-wideband (UWB) range is covered using octagonal stub and rectangular slot. Octagonal stub is used for impedance matching. The stub and rectangular slot shows a good coupling in the entire UWB range. The designed antenna provides a wide bandwidth which ranges from 3.5 to 13.2 GHz (9.7 GHz) with VSWR less than 2. A thorough study of radiation characteristics of the antenna is presented. The proposed antenna has a small size of 22×24×1.6 mm^3 while sustaining the UWB performance.

KEYWORDS: Compact antenna, defected ground, patch antenna, ultra wideband (UWB).

INTRODUCTION

In recent wireless communication systems, antennas are required which are compact in size, simple in structure and stable in gain and radiation characteristics while holding an enormously wide operating frequency range. In 2002, the Federal Communication Commission (FCC) allocated the spectrum from 3.1 to 10.6 GHz for unlicensed UWB measurements and communication applications with EIRP less than -41.3 dBm/MHz.[1] Since then ultra wide band (UWB) antennas have fascinated the research scholars both in academics and industries. Ultra wide band technology overtakes existing wireless standards such as Bluetooth PANs and 802.11 LANs with the competency to handle multiple high data rate streams at lower consumed power in simple, compact transceiver architecture.[2]

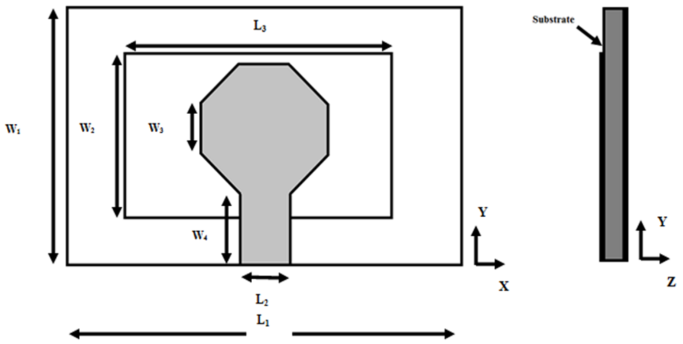
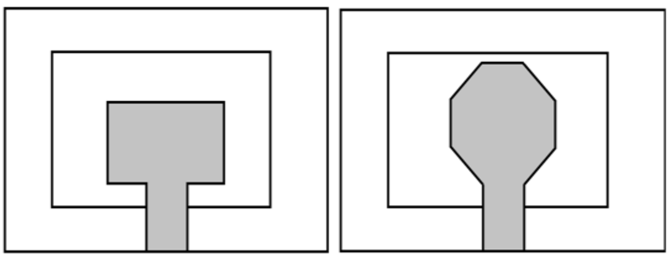


Fig.1. Geometry of the proposed antenna.

The microstrip ultra wideband (UWB) antennas have enticed much attention owing to their advantages such as simple structure, high data rate, low profile, easy integration with monolithic microwave integrated circuits (MMICs) and ease of fabrication. However the design of a wideband antenna is not an easy task particularly for a portable device because a trade-off between the size, cost and bandwidth has to be accomplished simultaneously. Various shapes of printed slot antennas have been presented in open literature.[3]-[7] including tapered shape slot antenna, semi elliptical monopole, open slot antenna with bandwidth enhancing and a printed wide slot antenna with a rotated slot.

In this communication a compact defected ground octagonal shaped patch antenna is proposed. The measured impedance bandwidth of the proposed antenna is 9.7 GHz from 3.5 to 12 GHz (defined by -10 dB return loss). In addition, the proposed antenna has a simple structure and a small size i.e. 22×24×1.6 mm^3. The designed antenna has been simulated using High Frequency Structure Simulator (HFSS) 14.0.

ANTENNA CONFIGURATION AND DESIGN



Antenna 1 **Proposed Antenna**

(a) **(b)**

Fig. 2. Different tuning stubs a) Rectangular b) Octagonal.

The geometry of the proposed octagonal shaped slot antenna is shown in the Fig.1. The proposed antenna is composed of four parts: 1) octagonal patch, 2) substrate i.e. duroid (ε_r = 2.2, tanδ =0.01), 3) rectangular slotted ground, 4) microstrip feed. The dimensions of the substrate are 22×24×1.6 mm^3 ($L_1 \times W_1 \times h$). The proposed antenna has a rectangular stub on the top side of the substrate which is fed by a 50-Ω microstrip line of width 3 mm and length 6 mm. This is optimised size of the feed to achieve a miniaturized design.

The rectangular slot in the ground plane shows strong coupling to the feeding structure. Therefore, by properly selecting the slot shape and tuning stub, good impedance bandwidth and radiation characteristics can be achieved. All parameters of the antenna are simulated using the Ansoft HFSS 14.0 commercial software. The optimized parameters of the proposed antenna are mentioned in the Table 1.

It initiates with the design of antenna 1, which consists of a straight microstrip feed line, a rectangular patch and a rectangular slotted ground as shown in Fig. 2. The antenna 1 gets two impedance bandwidths with -10 dB return loss (3.9-7.8 GHz) and (10-14 GHz). However it can't satisfy the requirement of UWB applications. It is worth stating that when the rectangular patch of the antenna is fed by a 50 Ω microstrip line multiple resonances can be generated, however, impedance matching of the antenna is poor.

Table 1: Design parameters of the proposed compact microstrip fed defected ground octagonal shaped patch antenna shown in Fig.1.

Parameters	**L_1**	**L_2**	**L_3**	**W_1**	**W_2**	**W_3**	**W_4**
Unit (mm)	22	18	3	24	9.75	2.5	6

To enhance the impedance matching of the proposed antenna an octagonal patch is connected to the straight microstrip line. The proposed antenna could get an ultra-wide impedance bandwidth with good impedance matching after cutting rectangular slot on the ground and octagonal shaped patch with side 2.5 mm. Using octagonal patch a wide band impedance characteristics (3.5-13.2 GHz) is obtained.

VARIATION OF SLOT SIZE WIDTH

Fig.3 shows the results of the proposed antenna with width of slot (W_2) ranges from 9 to 10 mm (step size of 0.25 mm). Usually a large slot is used in a UWB antenna to achieve a high level of electromagnetic coupling to the tuning stub. It can be realized that the $S_{11} < -10$ dB bandwidth of the antenna increases as W_2 increases from 9 to 9.75 mm. However, further increase in W_2 decreases the bandwidth. Hence, $W_2 = 9.75$ is chosen as optimum slot width covering 3.5 to 13.2 GHz.

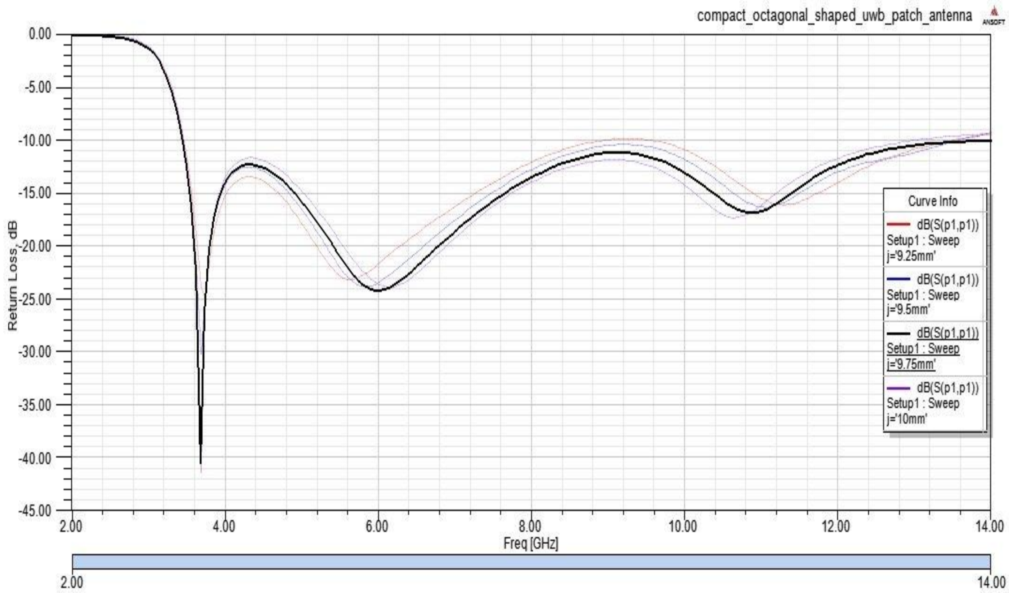


Fig. 3. Effects of varying slot width W_2

EFFECT OF PATCH SHAPE

Variation of the tuning stub shape and slot shape will change the coupling and hence, control the impedance matching. In order to optimize coupling between microstrip line and slotted ground, rectangular patch is replaced by octagonal patch. Fig.4 shows the return loss (S_{11}) parameter for both patch shapes.

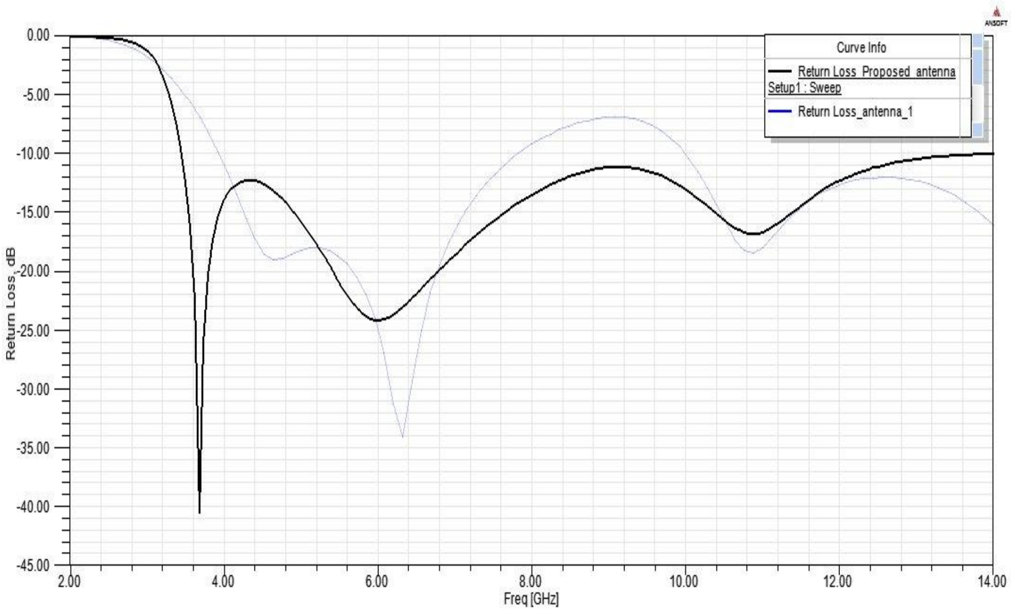


Fig. 4. Simulated return losses of antenna 1 and proposed antenna.

RESULTS AND DISCUSSION

The proposed antenna is simulated using the Ansoft HFSS 14.0. Fig.5 shows the simulated return losses of the proposed antenna. From the simulated result, a wide operating bandwidth from 3.5 to 13.2 GHz with -10 dB return loss has been obtained. It can be perceived that the proposed antenna could produce three resonant frequencies (3.68, 6.02 and 10.88 GHz) covering the UWB band. The VSWR curve for the proposed antenna is shown in the Fig.6.

The width of the slot W_2 affects impedance bandwidth of the proposed antenna. Fig.3 shows the simulated return loss curves for different values of W_2 keeping all other parameters same as in proposed design. W_2 = 9.75 mm gives the optimum results. The gap (h) between patch and ground plays a significant role in impedance matching. It is observed that h=1.6 mm is optimum value which provides best results.

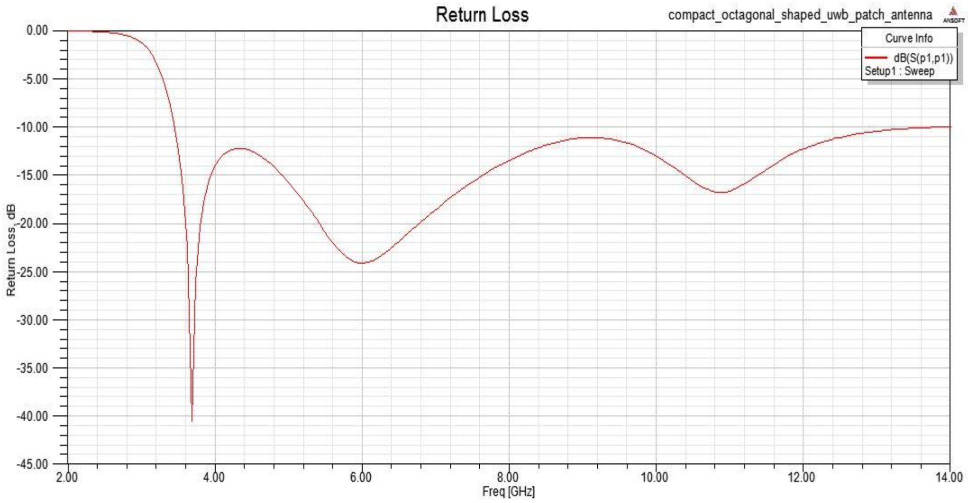


Fig. 5. Simulated return loss of the proposed antenna.

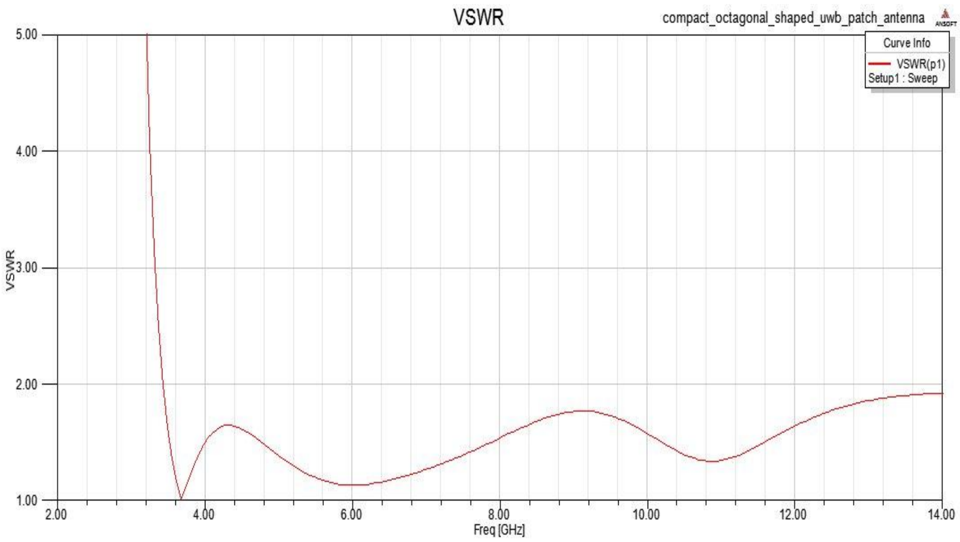
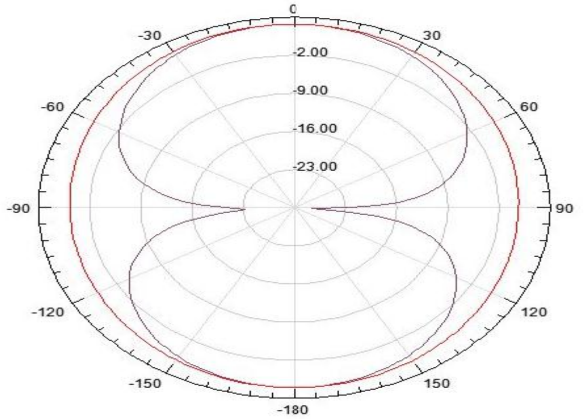
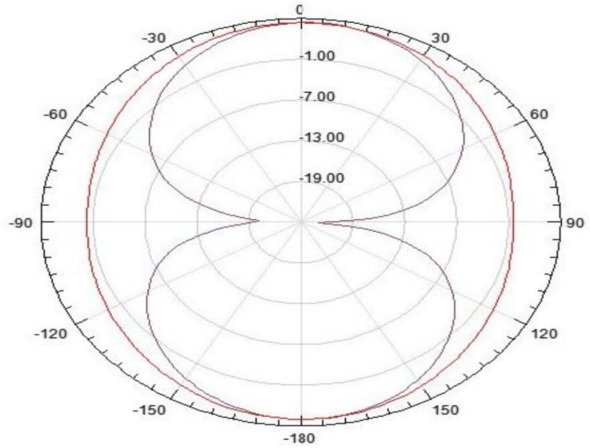


Fig. 6. Simulated VSWR of the proposed antenna.

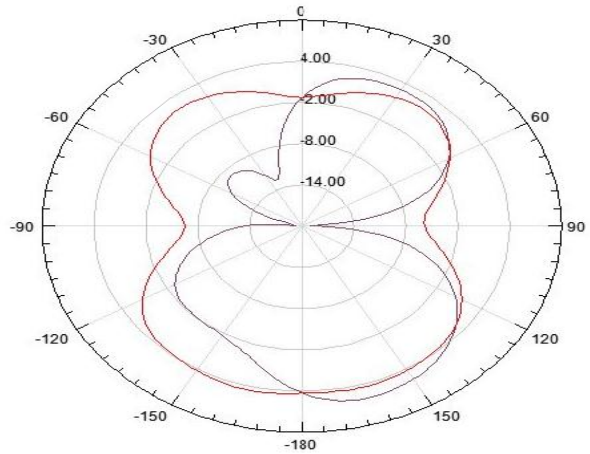
The simulated radiation patterns at 3.68, 6.02 and 10.88 GHz are plotted in the Fig.7. From the point of view of the results, the proposed antenna displays nearly omnidirectional radiation patterns. It is worth mentioning that the antenna has an overall size of 22×24×1.6 mm^3 which is one of the smallest UWB microstrip antennas.



(a)



(b)



(c)

Fig. 7. Radiation pattern for various resonance frequencies for the proposed antenna (a) 3.68 GHz (b) 6.02 GHz (c) 10.88 GHz.

CONCLUSION

A compact defected ground octagonal shaped patch antenna for UWB applications is proposed. The simulated results of the antenna show stable radiation patterns over UWB band as well as extra bands. The good impedance matching characteristic and omnidirectional radiation patterns over the entire operating bandwidth of 3.5 to 13.2 GHz (9.7 GHz) make this antenna a suitable candidate for UWB applications and systems.

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