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UWB Elliptical Patch Antenna with Partially Hexagonal Ground Plane

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Research Article

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ABSTRACT: Innovative methods for creating a partly hexagonal ground plane with an elliptical patch antenna for pulse transmission are presented in this research. The suggested ultra-wideband (UWB) antenna introduces a rectangular gap in the hexagonal ground plane and is fed by a microstrip line. When the voltage standing wave ratio (VSWR) is less than 2:1, the suggested antenna's simulated impedance bandwidth ranges from 3.2 GHz to 12.9 GHz. The simulation program CST Microwave Studio is used to analyze the antenna utilizing FR-4 substrate with a dielectric constant of 4.4 and a substrate thickness of 0.8 mm. In relation to -10 dB, the simulated findings have shown a fair return loss. The antenna's emission patterns at various frequencies are shown.

KEYWORDS: Ultra-wide band (UWB), elliptical patch antenna, hexagonal ground, microstrip, and pulse communication.

INTRODUCTION

The industry has recently seen a growth in the production of ultra-wideband (UWB) antennas. The Federal Communication Commission (FCC) has allocated 7.5 GHz of bandwidth (3.1 to 10.6 GHz) for Ultra-wideband (UWB) applications [1]. One important aspect of choosing a UWB antenna design is to ensure that the design will not cause the pulse to spread and low-power pulses when it is transmitted and another is that the antenna will be highly efficient in radiating electromagnetic energy. Impulse-Ultra wideband (I-UWB) is a carrier less short range communications technology in which its transmission occupies a bandwidth of more than 20% of its center frequency (>500 MHz) [5-6].

The impedance bandwidth in UWB antenna design is often expressed in terms of voltage standing wave ratio (VSWR) or return loss. The return loss should typically be less than –l0 dB or VSWR<2.1. From a systems perspective, the antenna's response should span the whole working bandwidth. The UWB antenna should ideally be small, planar, inexpensive, and dependable [1-4]. Rectangular, circular, square, elliptical, and pentagonal forms are among the designs that have recently been suggested for UWB systems and exhibit large bandwidth [7–10].In this paper, a novel UWB patch antenna is presented. The proposed UWB patch antenna is designed with partially hexagonal ground plane having rectangular slot of desired operating frequency range. The antenna consists of an elliptical patch, a partial hexagonal ground plane and 50 ohm microstrip feeding line. This antenna is easy to integrate with microwave circuitry for low manufacturing cost. Optimum dimension of the antenna is obtained by simulation software CST Microwave Studio. The antenna design and computer simulation of UWB antenna results are presented.

ANTENNA DESIGN

A traditional elliptical patch antenna, measuring L = 30 mm in length and W = 31.5 mm in width, is made on FR4 substrate with a substrate thickness of 8 mm, a substrate dielectric constant of 4.4, and a substrate loss tangent of 0.0025. It resonates at certain frequencies with less bandwidth, making it unsuitable for UWB systems. In order to overcome this restriction and attain ultra-wideband, this patch antenna was modified by using the hexagonal ground plane. We get the ultra-wideband from 3.2GHz to 12.9GHz by adding a rectangular slot to the top edge of the hexagonal ground.

Elliptical patch antenna

This section presents the design of an elliptical patch antenna with dimensions L x W and elliptical patch lengths of semi major and semi minor axes R1 = 10 mm and R2 = 9 mm, respectively. The antenna is designed on FR4 substrate with a substrate thickness of 0.8 mm, a substrate dielectric constant of 4.4, and a substrate loss tangent of 0.0025. Figure 2.1 depicts this whole arrangement in perspective. The antenna's ground plane is 30 mm by 31.5 mm. A microstrip line feed (50 ohm feed line) is used to feed the antenna.
The results are shown in Fig. 2, when antenna is microstrip line fed, it resonates at frequency
11.2 GHz and 16.99 GHz in the frequency range 0-20 GHz as shown in Fig.1. So the impedance bandwidth is very low.

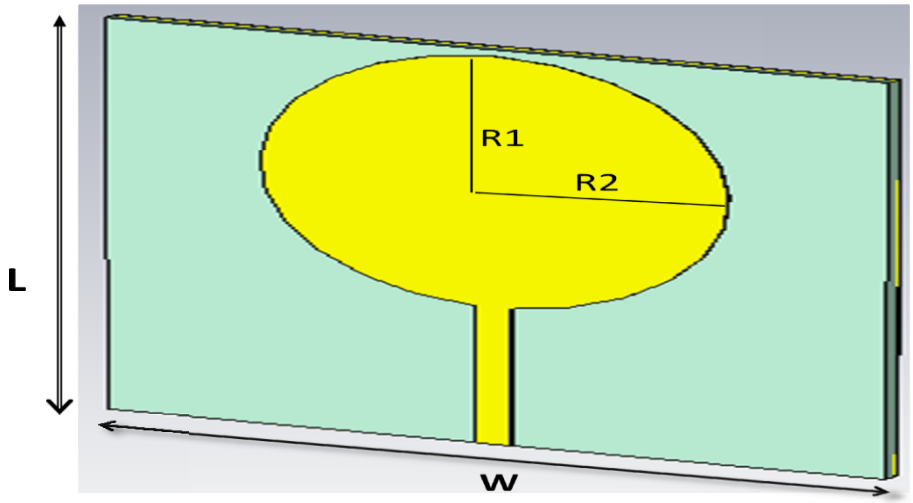


Fig. 1: An illustration of a traditional elliptical patch antenna

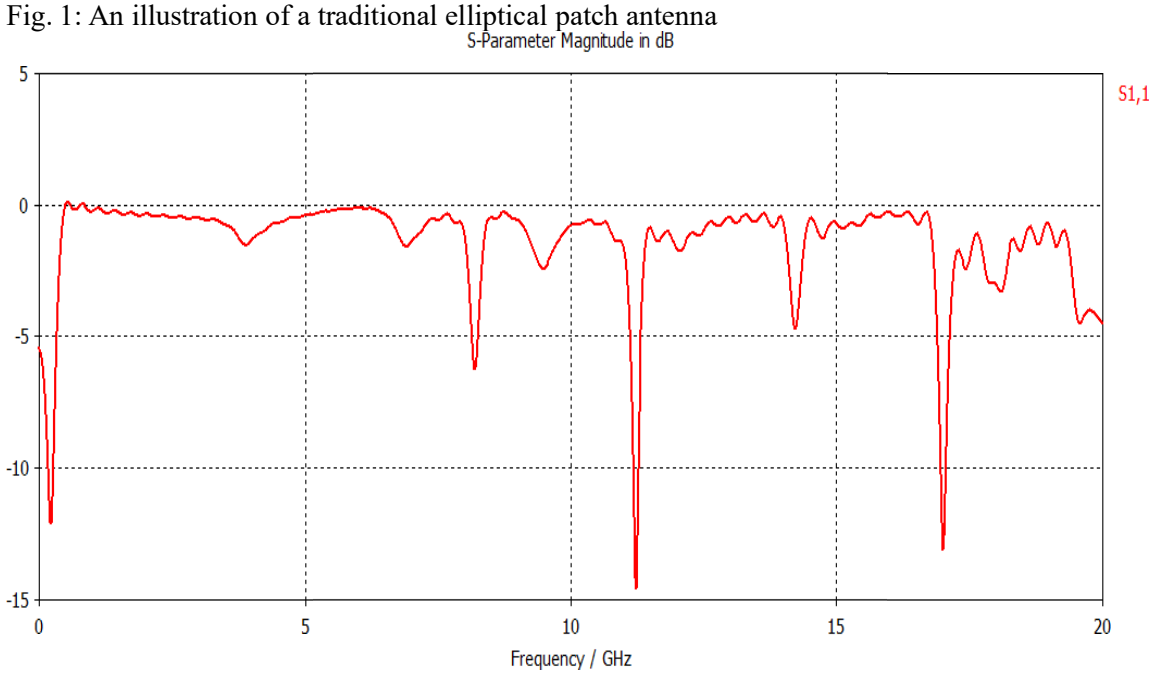


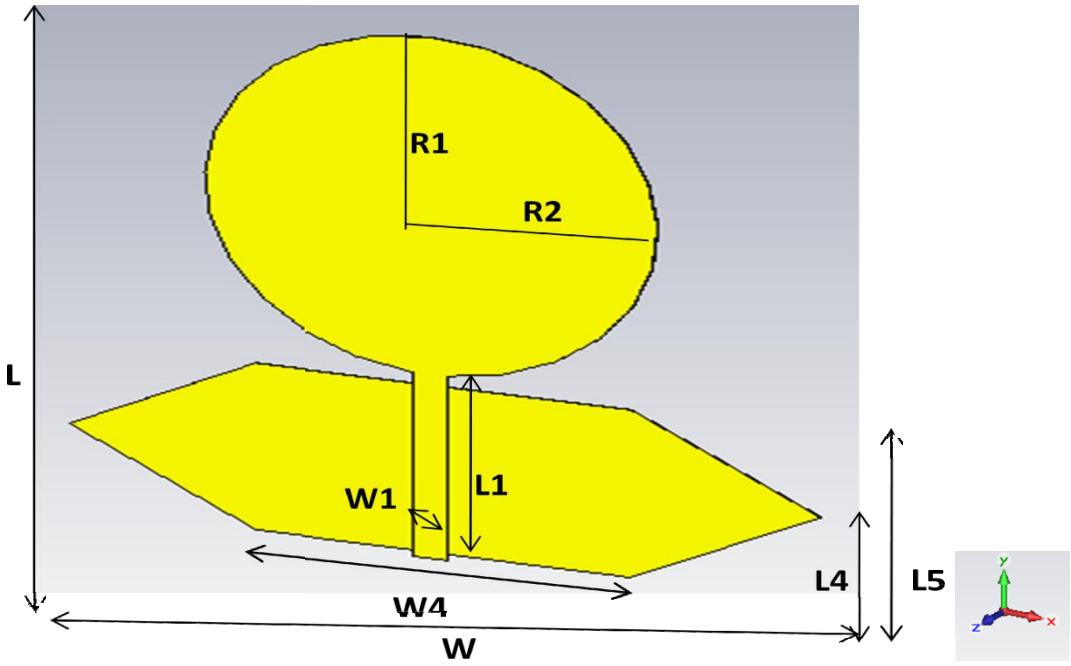
Fig. 2: Return loss simulation with elliptical patch antenna frequency

Hexagonal Ground Elliptical Patch Antenna

Low bandwidth was offered by the elliptical patch antenna in the preceding section. Without affecting the patch, we further altered the ground's hexagonal form in this region. Fig. 3 displays the antenna's top perspective. The 0.8 mm FR4 substrate is still being used to create the antenna.
As shown in Fig. 4, a microstrip line-fed antenna produces a virtually ultra-wideband yet touches the -10dB line

at two frequencies, resulting in excellent matching in the frequency range of 0-20 GHz. As shown in Fig. 5, the VSWR displayed by the antenna at resonant frequency is less than 2:1.

Fig. 3: An elliptical patch antenna with a hexagonal ground in top viewFig. 4: Return loss and frequency



simulation for an elliptical patch antenna with a hexagonal ground

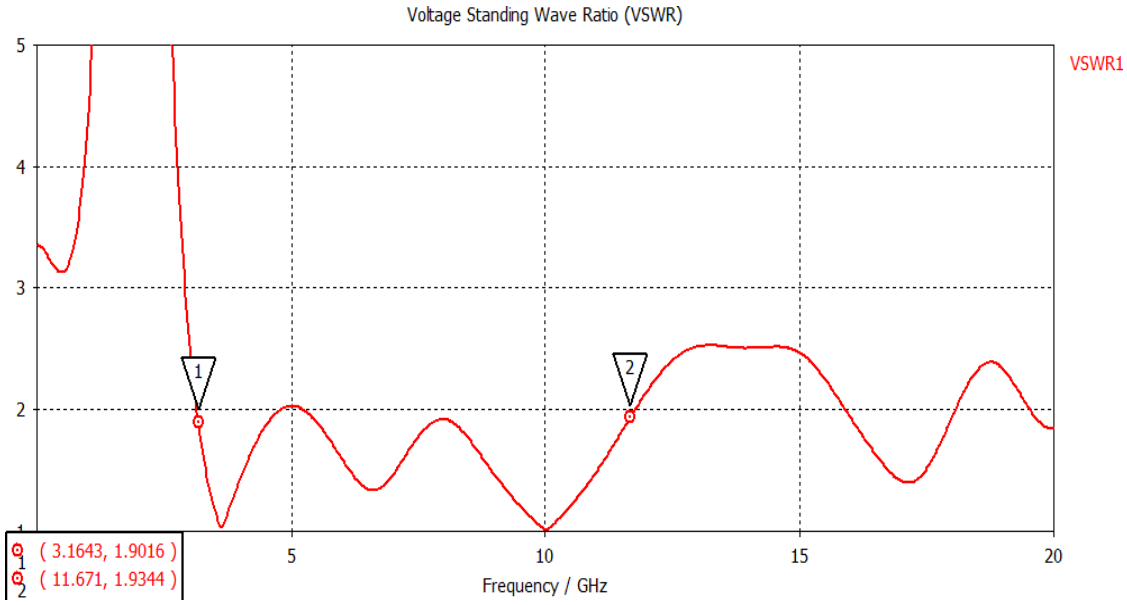


Fig. 5: VSWR simulation using an elliptical patch antenna with a hexagon-shaped ground

ELLIPTICAL PATCH ANTENNA WITH A CHANGED HEXAGONAL GROUND

The elliptical patch antenna in the preceding section had a fair bandwidth, but it touched the -10dB line at two frequencies. In this step, we added a rectangular slot to the ground plane without affecting the patch, further altering the hexagonal ground. Fig. 6 displays the antenna's top and rear views. This antenna is fed by a microstrip strip line with a length of L1=11.2mm and a width of W1=1mm. As shown in Fig. 7, the ground plane behind the patch is entirely deleted, and a hexagonal ground plane with a height of H3=0.5mm is positioned directly below the microstrip line.

Fig. 7 displays the antenna's top and side views along with its measurements. Just below the strip line, a rectangular slot measuring L6=4.5mm and W5=1.6mm is cut at the designated location in the ground plane. The

glass epoxy FR4 substrate (εr = 4) is used in the design of the patch.tanδ = 0.025, substrate thickness 'h' = 0.8 mm) with dimensions 30mm x 31.5mm above the ground plane.

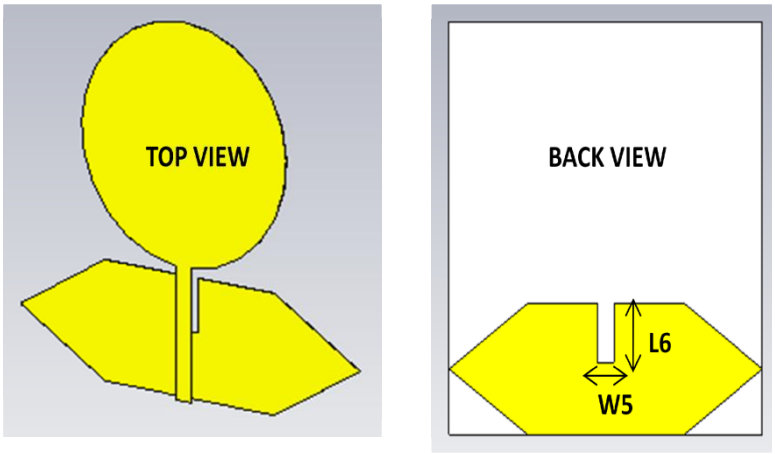


Fig. 6: Top and rear views of an elliptical patch antenna with a modified hexagonal ground

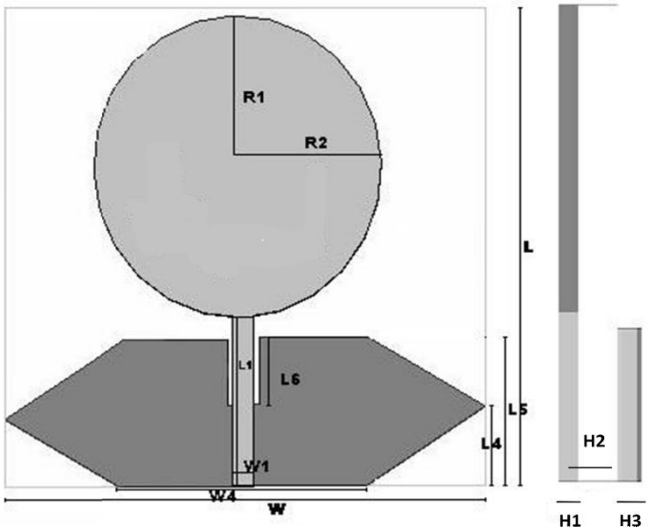


Fig. 7: Top and side views of the redesigned hexagonal ground and elliptical patch antenna with all measurements

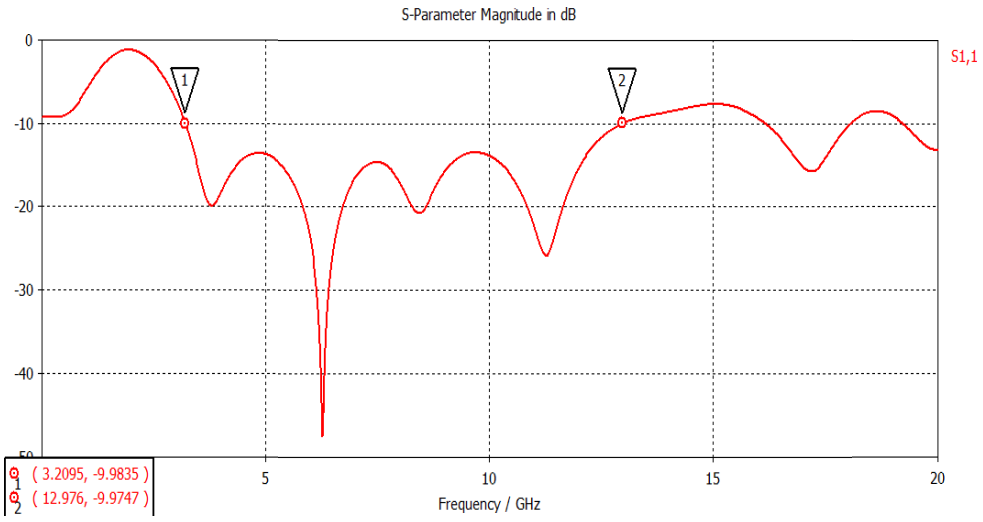


Fig. 8: Return loss and frequency simulation for an elliptical patch antenna with a modified hexagonal ground

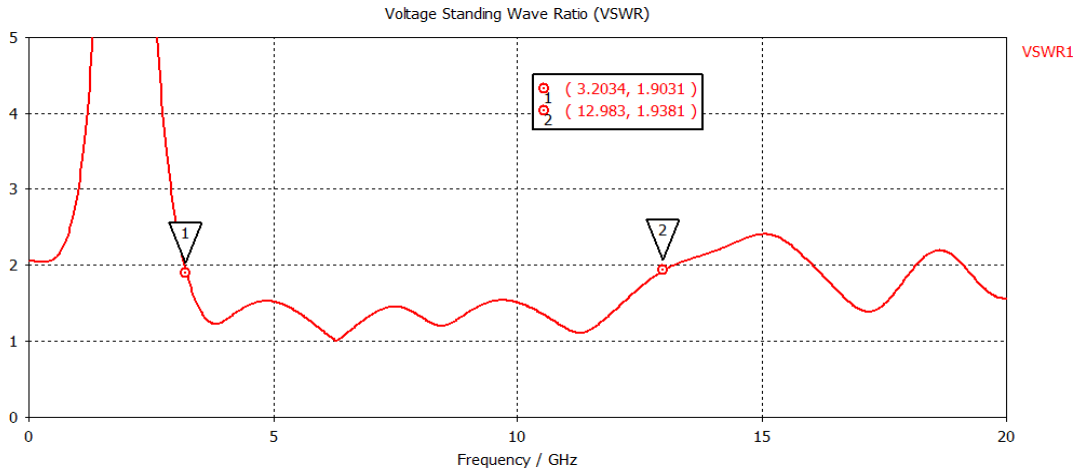


Fig. 9: VSWR simulation using an elliptical patch antenna's frequency and a modified hexagonal ground

As seen in Fig. 8, we get ultra-wideband from frequency 3.20 GHz to 12.97 GHz when a rectangular slot is placed in the hexagonal ground plane of the antenna. As shown in Fig. 9, the VSWR displayed by the antenna at resonant frequency is less than a 2:1 value.

SIMULATION RESULTS

The elliptical patch with a variable ground plane shape maximizes the antenna's performance. For various ground plane shapes with elliptical patches, the antenna's bandwidth and return loss vary as a function of frequency. According to the FCC for UWB systems, a rectangular slot put into a hexagonal ground plane antenna offers ultra-wide bandwidth in the whole range of 3.1–10.6 GHz. The performance of the antenna is significantly impacted by the hexagonal ground plane that is suggested in this communication. Figure 2.8 displays the return loss (S11) variant of an elliptical patch antenna with a modified hexagonal ground plane. As shown in Fig. 10, the greatest gain attained with the suggested design is close to 4.8dB, and the proposed antenna's gain varies as a function of frequency. Figures 11–12 show the simulated radiation patterns of the suggested antenna at various frequencies.

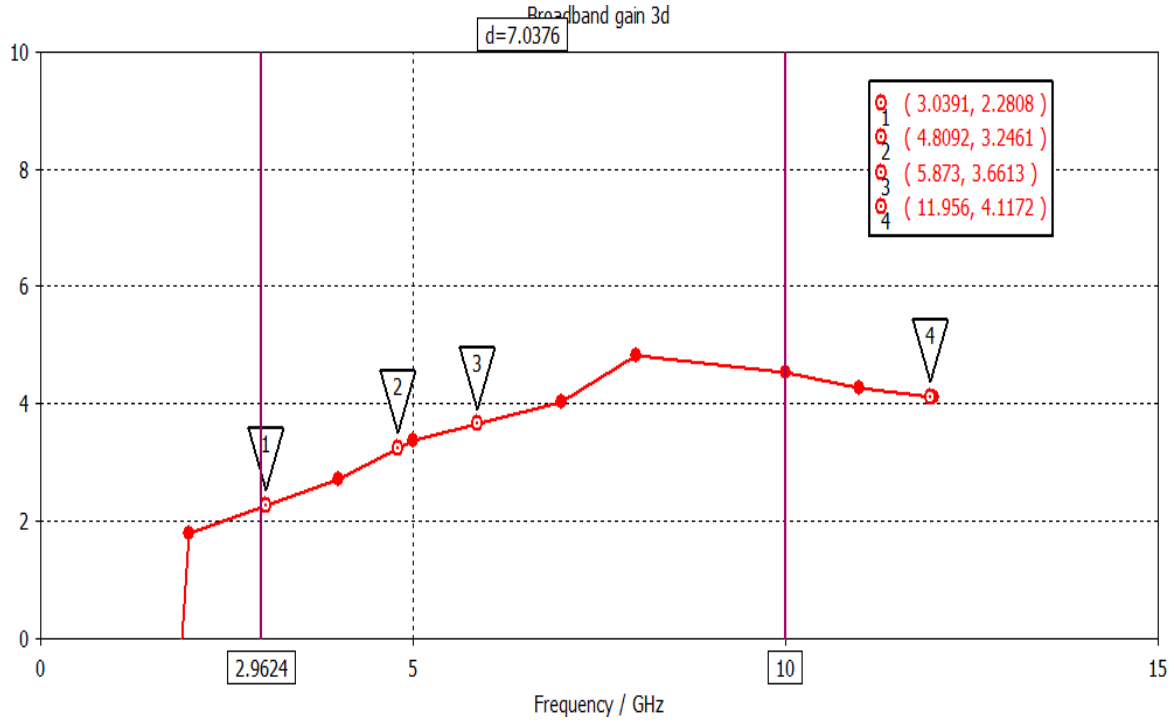


Fig. 10: Changes in Simulated Gain with Elliptical Patch Antenna Frequency with Modified Hexagonal Ground

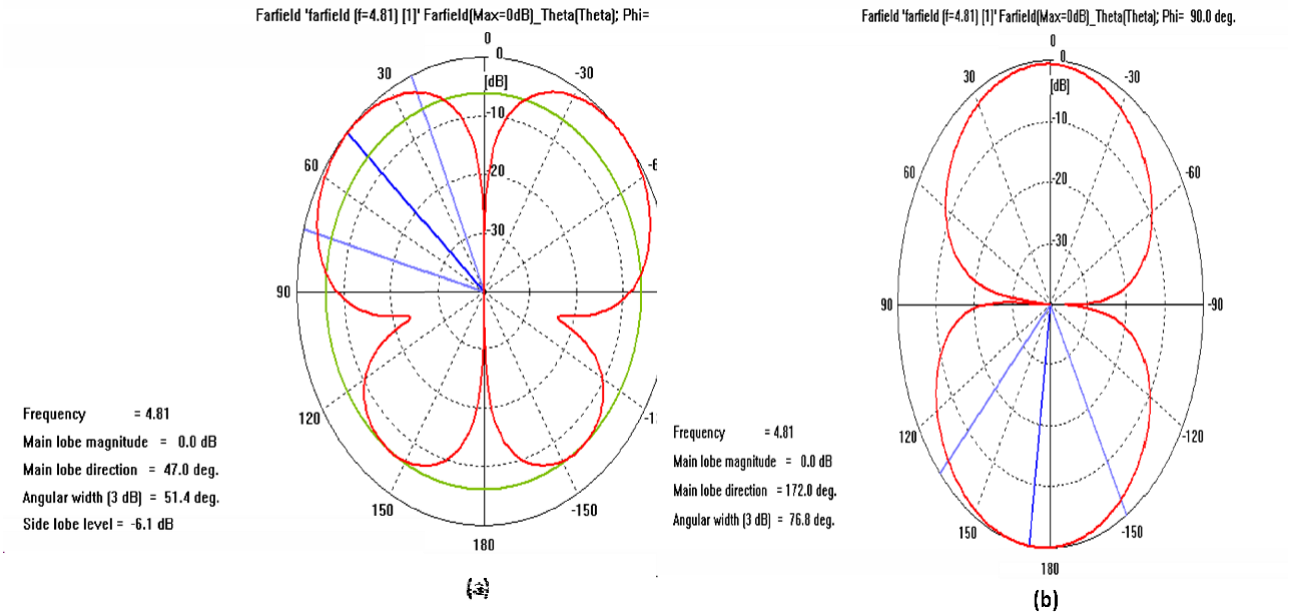


Fig. 11: Elliptical patch antenna radiation patterns with a modified hexagonal ground were simulated at 4.81 GHz (a) at α = 00 and (b) at α = 900.

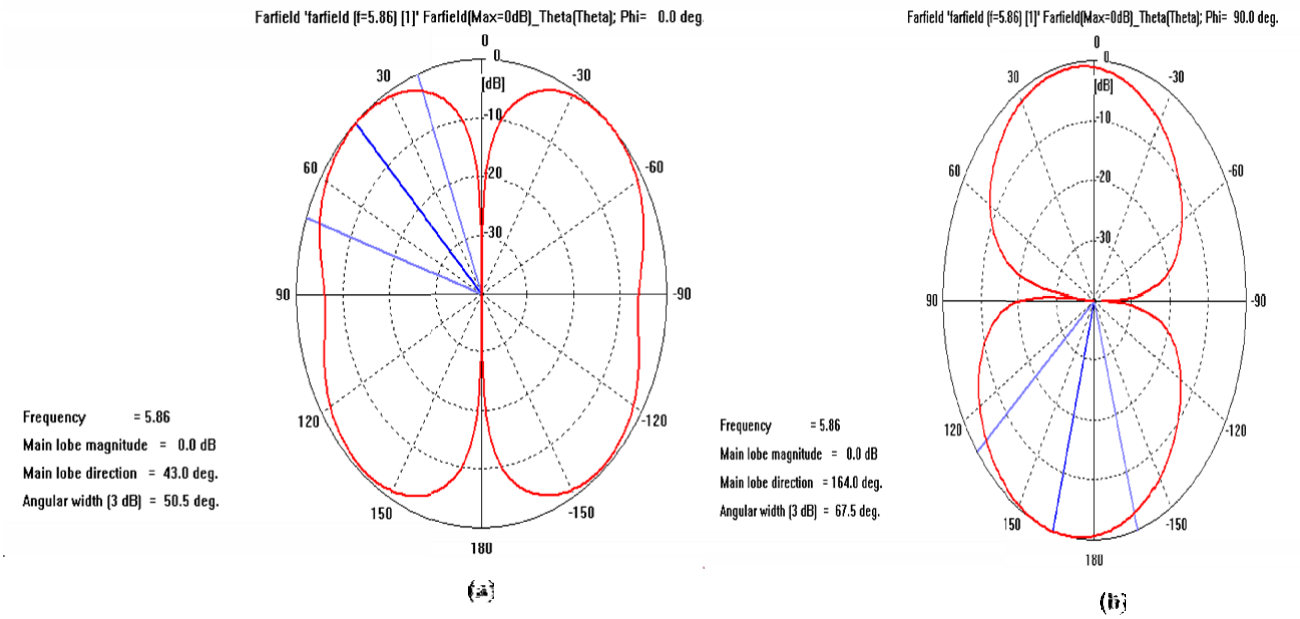


Fig. 12: Elliptical patch antenna radiation patterns with a modified hexagonal ground were simulated at 5.86 GHz (a) at α = 00 and (b) at α = 900.

CONCLUSION

The design of an ultra-wideband antenna for UWB communication systems is presented in this study. By gradually altering the ground plane with an elliptical patch, we were able to establish a broad operating bandwidth and consistently acquire the radiation performance of the patch antenna. The suggested antenna design is straightforward, inexpensive, and simple to include into microwave circuits. The antenna's performance was further improved in the next stage by adding various profile slots to the patch, which allowed us to get the band rejection characteristic. The suggested antenna is being tested to confirm the obtained outcomes.

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