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Design and Fabrication of Ultra Wide Band Hexagonal Shaped Microstrip Antenna for WPAN Applications

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Abstract

The paper introduces ultra-wideband (UWB) antenna for WPAN application with reduced ground plane size. This paper proposes a hexagonal antenna with microstrip feed line. The proposed antenna with small size and different ground structure is considered to reduce the surface wave and to achieves high impedance bandwidth and good gain performance for ultra wide band (UWB) range i.e. 3.1–10.6 GHz. Three variations of the antenna design by using different ground size, shape such as rectangular, semicircle, circular and two different substrates are considered. Return losses are considered satisfactory below -10 dB and VSWR considered being well if it is below 2. In last section the return loss performance of fabricated antenna is measured and it shows agreement with the simulated data with little variation.

Keywords: Antenna; ultra wide band; WPAN; wireless and mobile communication; electromagnetic; multi-physics.

1 Introduction

In the recent years, interesting characteristics of ultra wideband (UWB) technology such as high data rate, high data resolution, robustness to multi-path fading and very low interference which is requirement of next generation wireless systems, has made it a good candidate for wireless communication systems [1]. Rather more emphasis has been given to WPAN technology in recent

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technologies. The extensive research is going in development of WPAN technology to provide reliable wireless connections between computers, portable devices and consumer electronics within a short range [2]. With the help of UWB technology, users can share photos, videos and even networked printer attached with different computers in home network [3]. UWB has an ultra-wide frequency bandwidth which enables support to high data rate multimedia applications [4]. Recently, various types of UWB antennas have been proposed to achieve the requirement for different applications. The federal communications commission (FCC) has allocated the frequency spectrum from 3.1 GHz to 10.6 GHz as the ultra wide band (UWB) in the year 2002. Since then technology has witnessed immense growth and applicability in real time applications [5].

In 2005, Wu and chen [6] explained the comparison of various planar antennas. This type of antennas is used due to its characteristics as broad impedance bandwidths and compact size. In literature, planar antennas with ultra wideband support have been proposed. For example, the planar square monopole, disc/half-disc antenna, bottom fed elliptical antenna, stepped-fat dipole antenna, and diamond dipole antenna were studied for UWB systems In [7], the butterfly-shaped monopole antenna is proposed for UWB band of 3.1-10.6 GHz. Authors proposed antenna which consists of a novel butterfly shaped monopole for ultra wide band operation. The reduced ground plane structure is also proposed as ultra wide band antenna in literature [8]. The antenna is fabricated on PCB structure and the overall dimensions of proposed antenna in [8] are 25 mm × 25 mm × 1.5 mm. The patch consists of a notch while strip feeds the patch of the proposed antenna. The ultra wide band antennas are printed on PCBs for advantages such as low profile, lightweight, ease of fabrication and wide frequency bandwidth. The same structure can be obtained with coplanar waveguide type of feed and given in [9], these antennas have recently been introduced for obtaining considerably larger Impedance bandwidth by using different patch shapes such as rectangular, circular, and elliptical [10]. In all the above mentioned antennas the size of the required ground plane used is very high and only lower UWB band is obtained rather than the whole UWB antenna band i.e. 3.1-11.0 GHz.

This paper describes a Hexagon shaped UWB antenna which achieves high impedance bandwidth and gain performance across an ultra wide band (UWB) operating bandwidth of 3.1–11.0 GHz with reduced ground size. In this paper a UWB Antenna with Hexagonal shape radiator on one side and ground on bottom side has been taken. The ground-plane effect on impedance performance of the antenna has been significantly investigated on different frequency by taking the different size and shape of ground. Also the effect of antenna with notch and without notch is simulated. The notch extends the effective current path and concentrates majority of the current on the radiator instead of the system ground plane.

2 Antenna Design

The design is based on a small hexagonal UWB shaped patch with overall dimensions of antenna 17 mm × 17 mm × 1.6 mm. Fig. 1 illustrates the evolution of the proposed microstrip antenna on FR4 substrate with dielectric constant, ε_r=4.4 and a finite-size system ground plane. The optimized antenna dimensions are as follows: the feed length is 3 mm, feed width is 4 mm, Side of hexagonal patch is 6 mm, and ground length is 5 mm. The parameters are selected according to the -10 dB return loss bandwidth in range 3.0 to 11 GHz.

The antenna is excited at a 50Ω impedance matching using microstrip feed line. Three techniques are proposed in the paper for ultra wide band support (i) two notches, (ii) different ground size and shape (iii) different substrate material, which can lead to good impedance match and satisfy UWB requirement. The antenna is fabricated using standard PCB fabrication techniques and shown in Fig. 2.

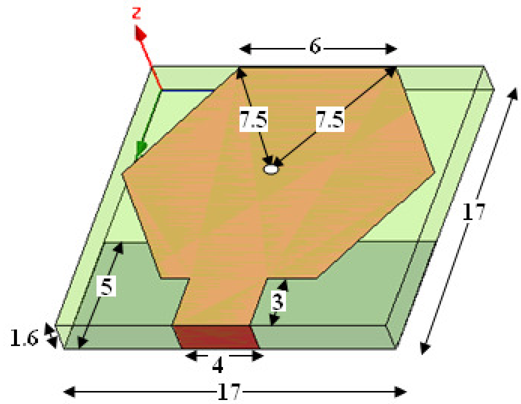

Fig. 1. Proposed structure of hexagonal antenna

Fig. 2. Fabricated antenna

3 Results and Discussion

The antenna is simulated using HFSS software and analyzed for various electromagnetic parameters. The parametric sweeps are used to optimize the different parameters of antenna. In Fig. 4, the return loss for ground size of 5 mm and 10 mm are shown. It can be observed that the ground size should be chosen 10 mm for its virtue of better return loss. The fabricated antenna is tested for its return loss performance with vector network analyzer and the comparison of simulated and measured results are shown in Fig. 3 and found very proximate to each other. The antenna is also analyzed for different ground structures (rectangular, circular, semi circle) as shown in Fig. 5. It is found that rectangular shape has maximum resonant frequency and minimum return loss. Different notches cut from patch show the significant impact on the antenna performance in the form of enhanced bandwidth and improved current flow. As shown in Fig. 6 it can be observed that the antenna with notch is suitable for two specific frequencies in lower band as well as in higher band.

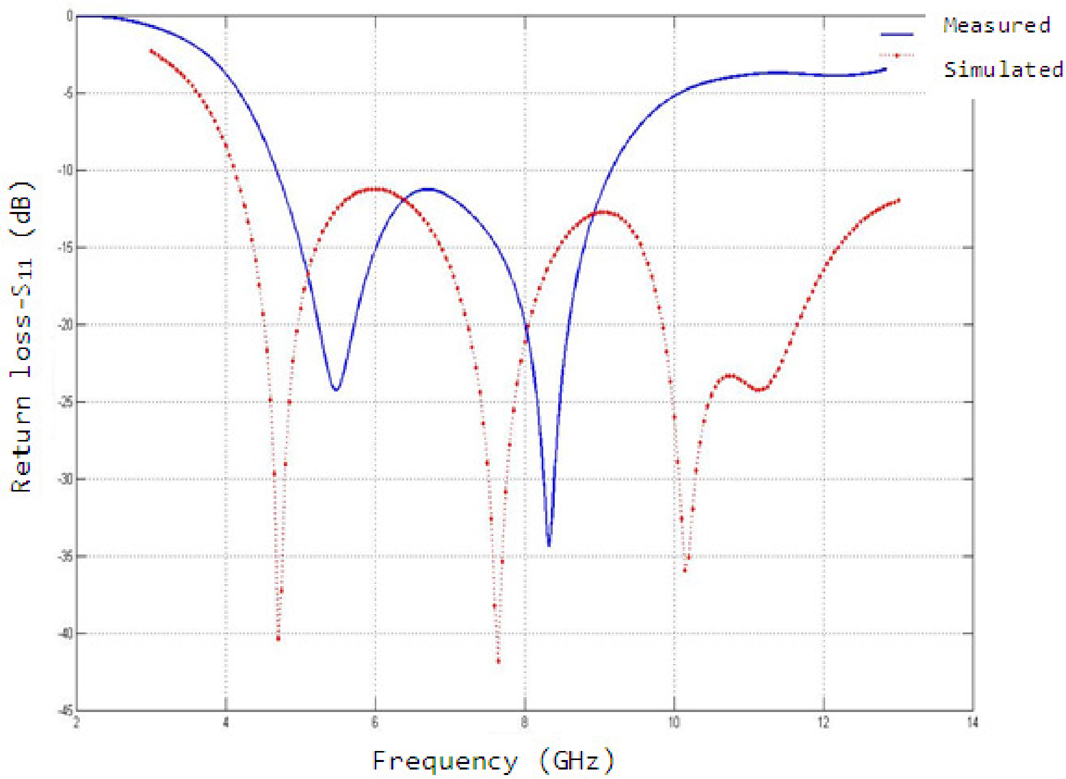

Fig. 3. Comparison of the simulated and measured return loss (RL)

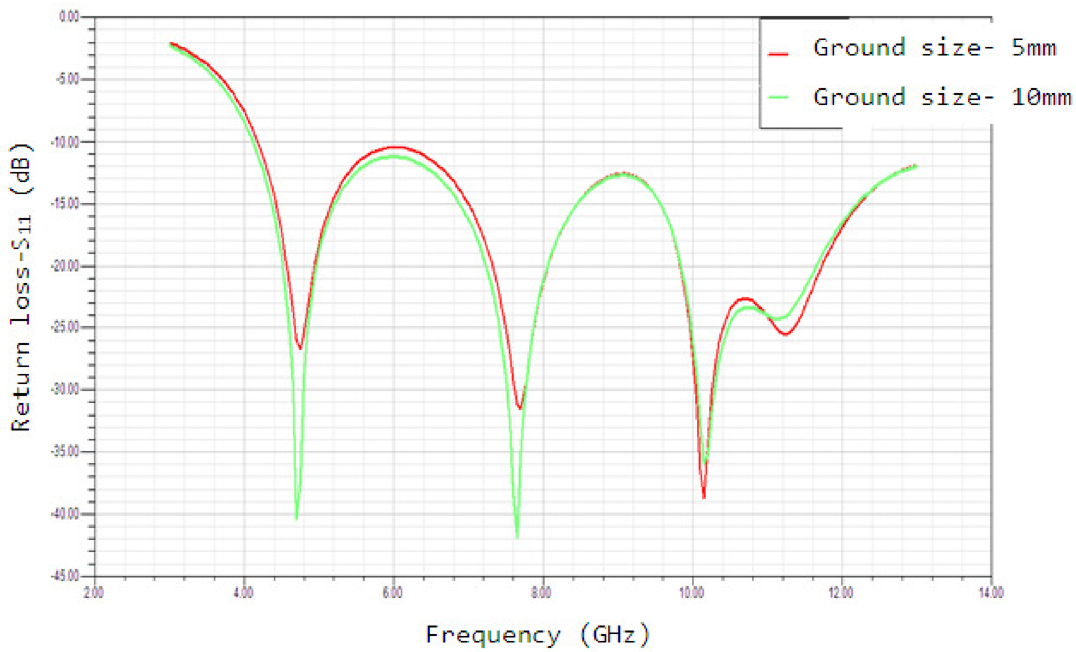

Fig. 4. Comparison of return loss at different ground size

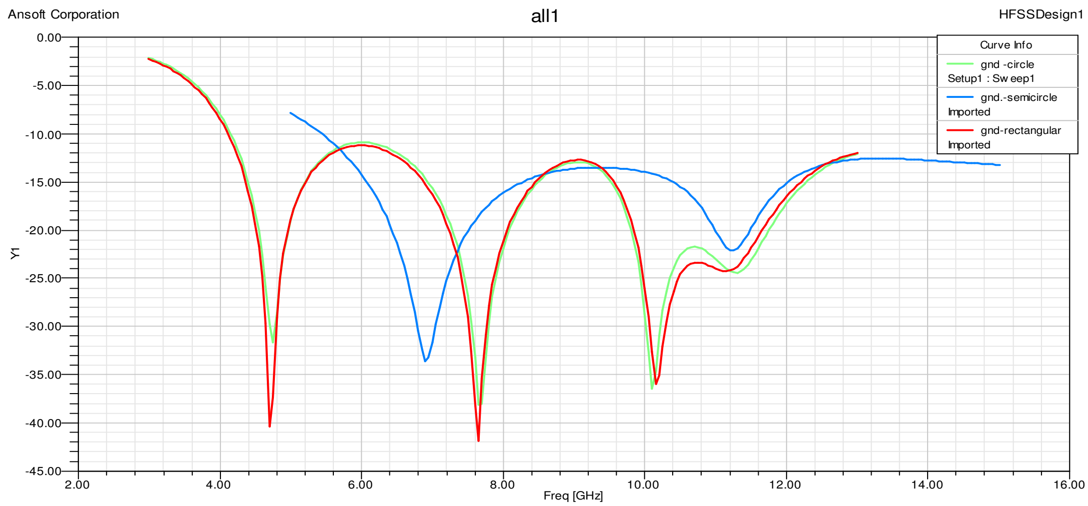

Fig. 5. Comparison of return loss at different ground structure

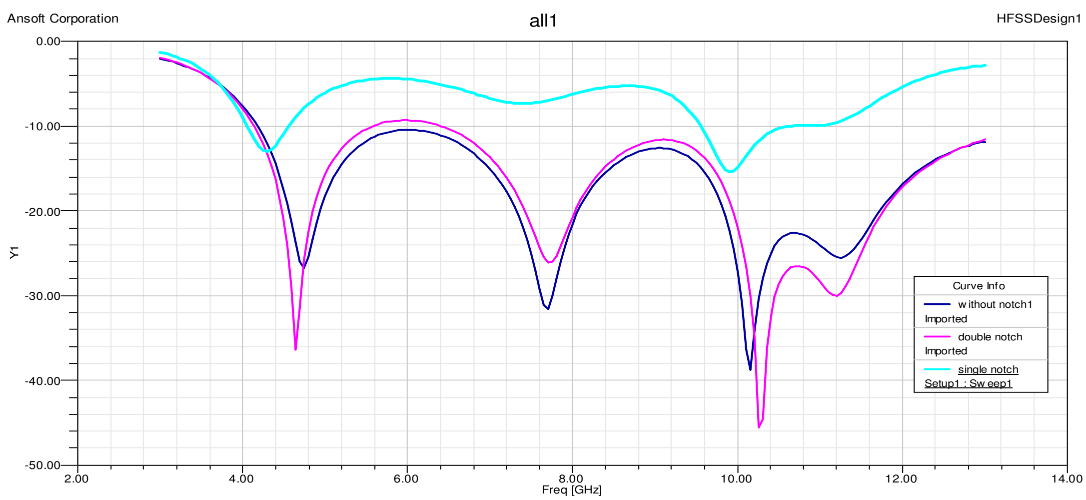

Fig. 6. Comparison graph for the different notches cut from the radiating patch

3.1 Radiation Pattern and Electric Field

The radiation pattern and electric field of the final shape of antenna is given at three different frequencies i.e at 5 GHz, 7 GHz. and 10 GHz as shown in Figs. 7 to 13. The radiation pattern in E-plane is shown in the figures. It is clear from the figures that the antenna radiation pattern is quite similar to pattern obtained from dipole. As the requirement of specified application for Ultra wide band antenna, the proposed antenna exhibits the return loss property with good gain. The electric field distribution is shown in Figs. 10 and 11 which defines the excitement of fundamental modes for the frequencies 5 GHz and 7 GHz. The radiation pattern so proposed in the paper is well suited for WPAN application due to its attributed moderately good gain for short range communication.

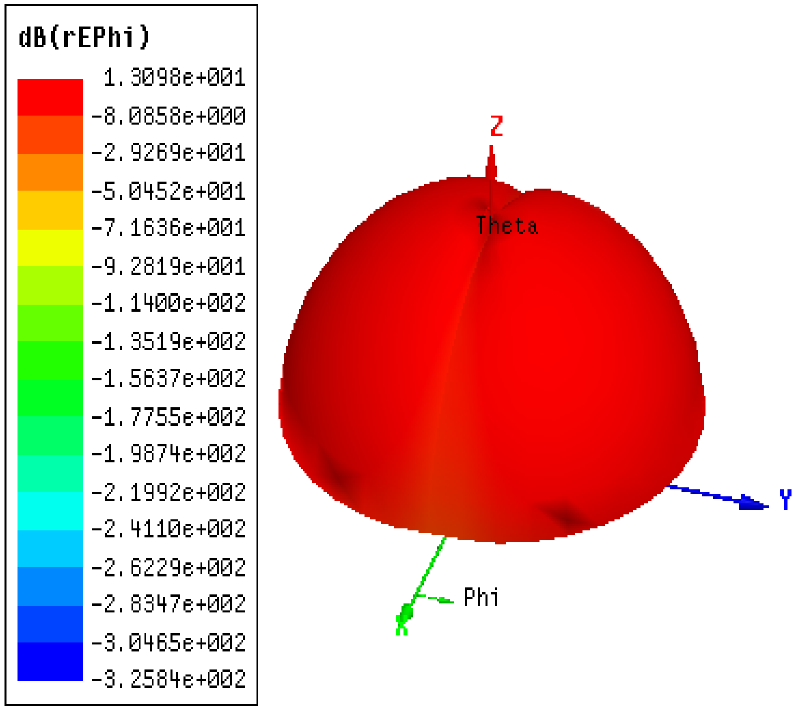

Fig. 7. Electric field pattern in dB at 5 GHz

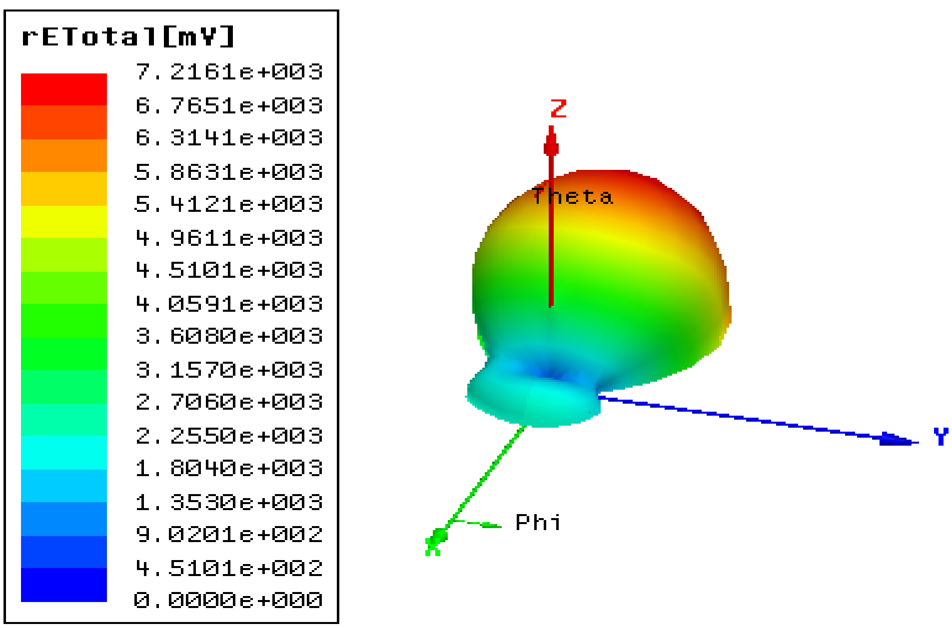

Fig. 8. Electric field distribution in mV at 7 GHz

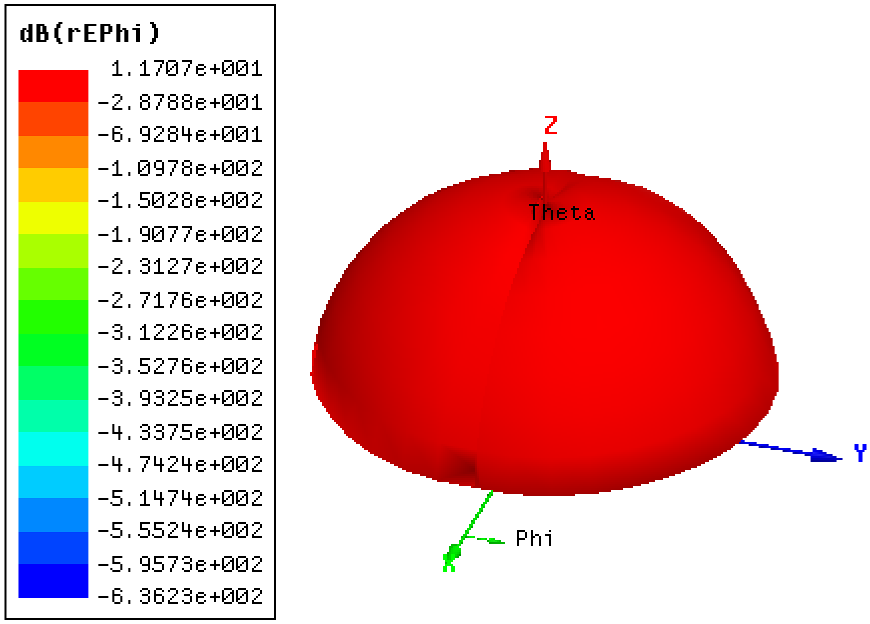

Fig. 9. Electric field pattern in dB at 7 GHz

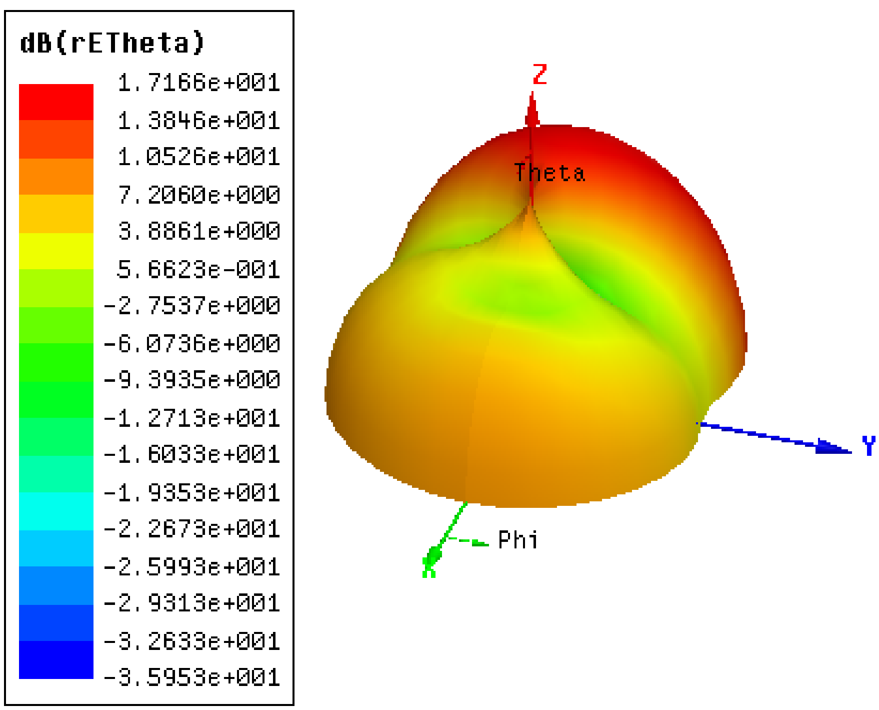

Fig. 10. Electric field distribution in db at 10 GHz

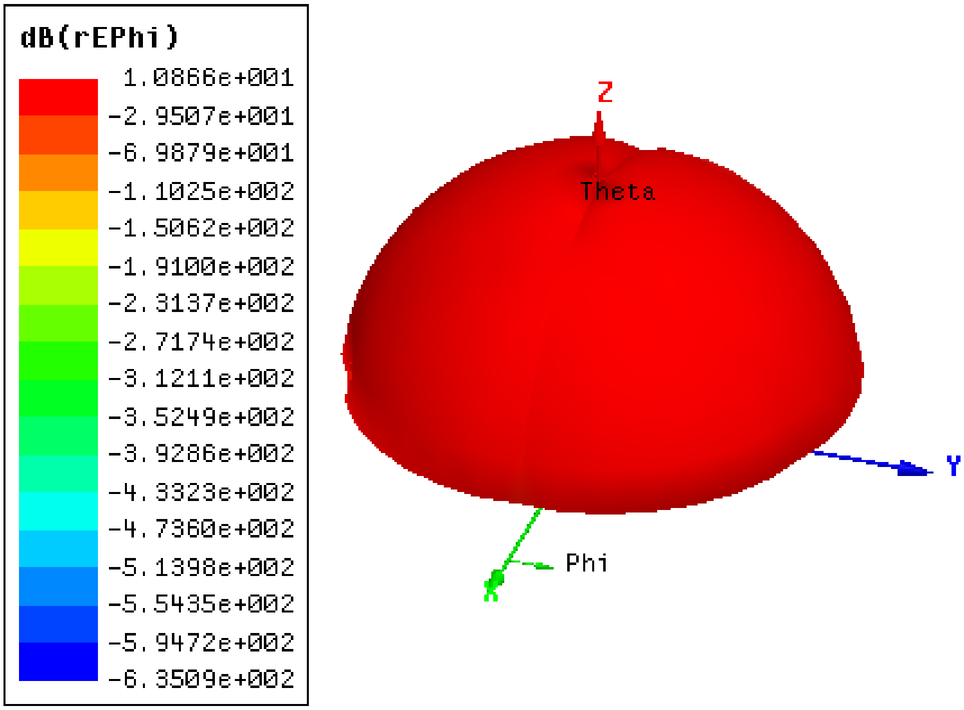

Fig. 11. Electric field pattern in dB at 10 GHz

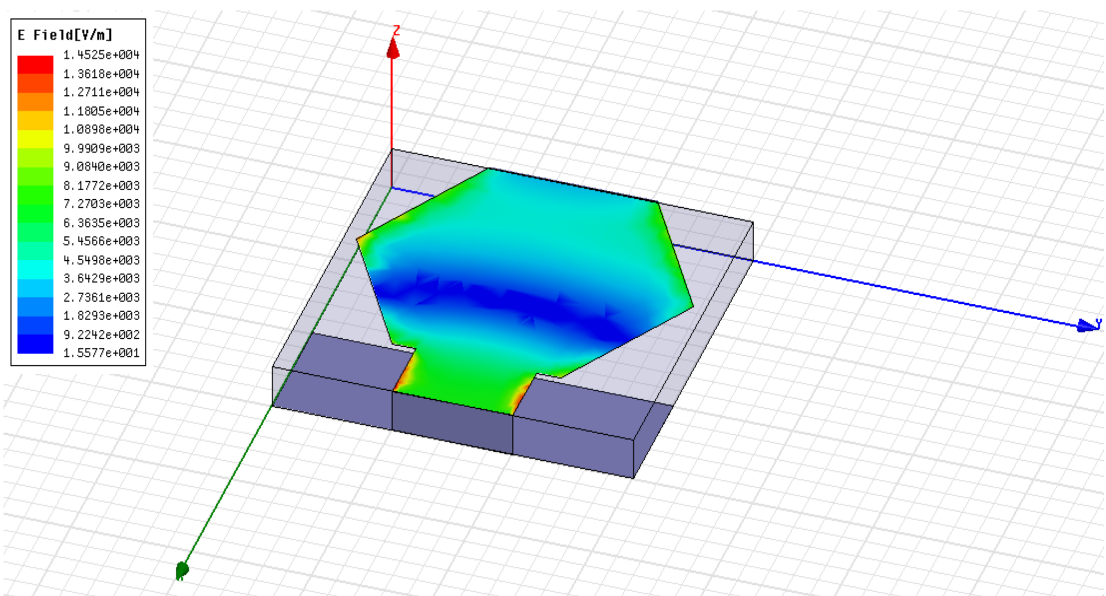

Fig. 12. Electric field distribution in patch at 5 GHz

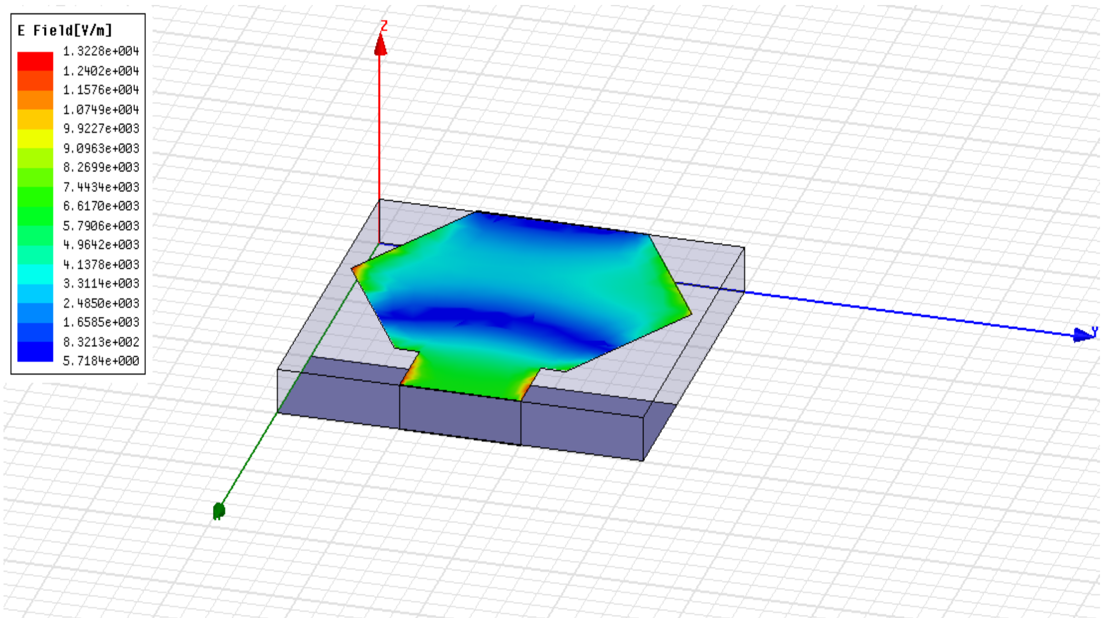

Fig. 13. Electric field distribution in patch at 7 GHz

4 Conclusion

The paper introduces the hexagonal shaped ultra wide band antenna for WPAN application. The reduction in ground size is utilized for enhancing bandwidth of the antenna. The antenna parameters are optimized with parametric sweeps for ground dimension of 5 mm and 10 mm. The antenna with optimized parameter is fabricated and tested for the performance. The antenna is simulated in HFSS, ver. 11, and measurements are performed with a vector network analyzer (VNA) in ideal anechoic chamber. It has been observed that simulated and measured results are having very close agreement and return losses are less than -10 dB for frequency range 3.1 GHz to10.6 GHz. The proposed antenna exhibits VSWR<2 and efficiency is (ή) of89%. The gain of proposed antenna is around 5dBi with little variation at different frequencies.

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Competing Interests

Authors have declared that no competing interests exist.

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