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DESIGN OF A WIDEBAND TWO-LAYER PATCH ANTENNA FOR IOT APPLICATIONS

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Abstract
In this paper, a new design of a Wideband two-layer patch antenna with bandwidth characteristics is proposed. The antenna consists two patches one is driving element and another one is radiating element. The radiating patch is further improved to enhance the bandwidth of the proposed antenna. The fractal concept is followed to enhance the bandwidth of the antenna. Sierpinski Carpet concept is followed to improve surface current density on the radiating element. With this design the return loss response is found to be below -10dB with the frequency range of 5.2 GHz to 5.87 GHz with this the antenna radiates electromagnetic waves uniformly over the frequency band. As this antenna operating from 5.2 GHz to 5.87GHz, it is a suitable candidate for IoT applications**.**

Keywords: Bandwidth; Ground plane; electromagnetic waves; Slotted rectangular patch

1. Introduction
In today's world antenna plays a major role in wireless communication, due to its vast use in devices like-mobile phones, GPS systems, mp3 players etc. The antenna is a device i.e. used for efficient transmission and reception of electromagnetic waves. Depending upon the use, the antenna can operate in different frequency bands. In this paper, a wideband two layer patch antenna is designed with improved bandwidth in C- band i.e. ranging from 5.2GHz to 5.8GHz. C-band is mainly used where clarity and quick response is very much essential like in satellite communication, Wi-Fi, vehicular and IoT applications etc.

Among the different types of antenna present nowadays, a lot of research is going on microstrip antenna because of its advantages like- low cost, lightweight, compatibility for an embedded antenna in handheld wireless devices [1-3] and high performance. The main problem in this antenna is narrow bandwidth. Y. Sung and co. suggested an idea to enhance the bandwidth of the antenna by introducing parasitic centre patch [4]. Moreover some planar antenna has been introduced Sierpinski carpet fractal concept to improve the performance of the antenna [5-6].

The bandwidth of an antenna is inversely related to patch area; hence by loading different slots the area can be minimized as a result, bandwidth can be improved [7-8]. The objective of this paper is to improve the bandwidth of microstrip antenna by multi layering the patches and by introducing fractal concept on the radiating element.

Section 2 gives information about the design of microstrip antenna .section 3 gives a brief explanation to the simulation and result. Section 4 concludes the work with future works.

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2. Antenna Design and Specification

The basic steps for the development of antenna are given below. The thickness of dielectric material, width and length of the patch, extension length of radiating patch is first calculated before designing the antenna using the following mathematical expressions.

Thickness of the dielectric medium is given as:

$$h \leq 0.3 \times \frac{c}{2 \times \pi \times f_r} \times \sqrt{\varepsilon_r} \tag{1}$$

Width of the radiating patch is as follows:

$$w = \left(\frac{c}{2 \times f_r}\right)\left(\sqrt{\frac{\varepsilon_r + 1}{2}}\right) \tag{2}$$

Length of metallic patch is calculated as:

$$L = \frac{c}{2 \times f_r \times \varepsilon_{reff}} - 2\Delta l \tag{3}$$

Where

c : Velocity of light $= 3 * 10^8$ m/s

ε_r : Dielectric constant of the substrate

f_r : Resonant frequency of antenna

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2} \times \sqrt{\left(1 + \left(\frac{12h}{w}\right)\right)} \tag{4}$$

Extension length of the radiating patch is as:

$$\Delta l = 0.412 \times h \times \left[\left(\frac{\varepsilon_{reff} + 0.03}{\varepsilon_{reff} - 0.258}\right) \times \left(\frac{w + 0.264h}{w + 0.8h}\right)\right] \tag{5}$$

The structure of suggested microstrip antenna is shown in Figure 1. The antenna consists of a radiating patch over the dielectric substrate and the ground plane is etched on the bottom side of the substrate. The designed antenna is excited by the help of microstrip feed line. The driving patch is etched on the Duroid substrate of dimension 2.0cm*2.4cm*0.1cm. At high frequency, the performance of the antenna can be further improved by introducing Sierpinski carpet concept on radiating patch. A 50ohm coaxial feed is connected to the driving element. The Duroid substrate is metalized on top and the bottom side and it has a low permittivity of 2.2, low loss and it enhances the performance of the antenna. The dimension of the driving element is 1.8cm*1.6cm*0.03cm, and the reflection loss shows the suggested microstrip patch antenna is able to achieve wide bandwidth varies from 5.2GHz to 5.8GHz. Here the radiating patch is placed just above the driving element at a height of 0.4cm and material having low permittivity is used to provide mechanical stability to the radiating patch. The performance of the antenna can be further improved by inserting slots on the radiating patch. The optimised parametric values of the suggested antenna are noted in Table 1.

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Table 1: Design parameters

Parameters	W_{ls}	L_{ls}	W_p	L_p	H	h1	g	t
Unit(cm)	2.0	2.4	1.6	1.6	0.4	0.1	0.2	0.03

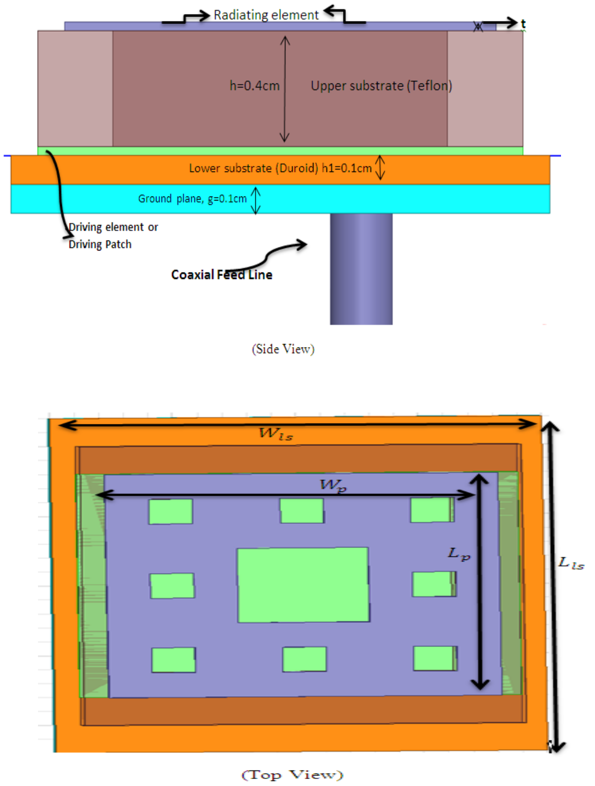

Figure 1, Geometry of proposed antenna

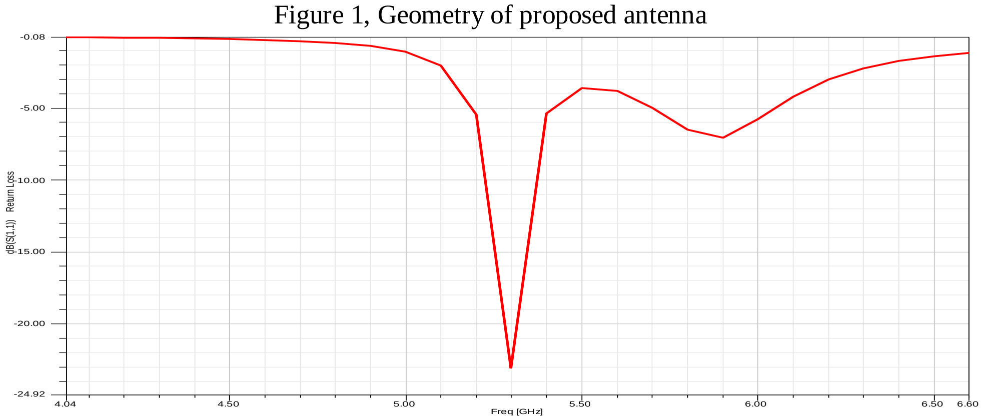

Figure 2, Return loss response of single layer patch antenna

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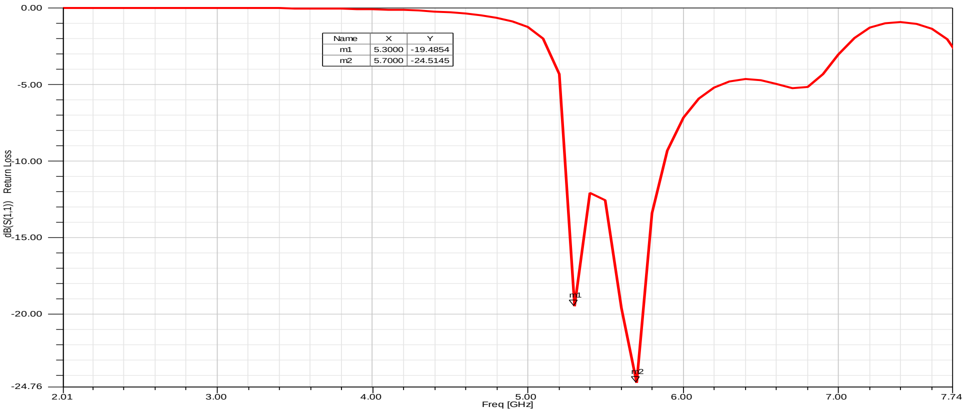
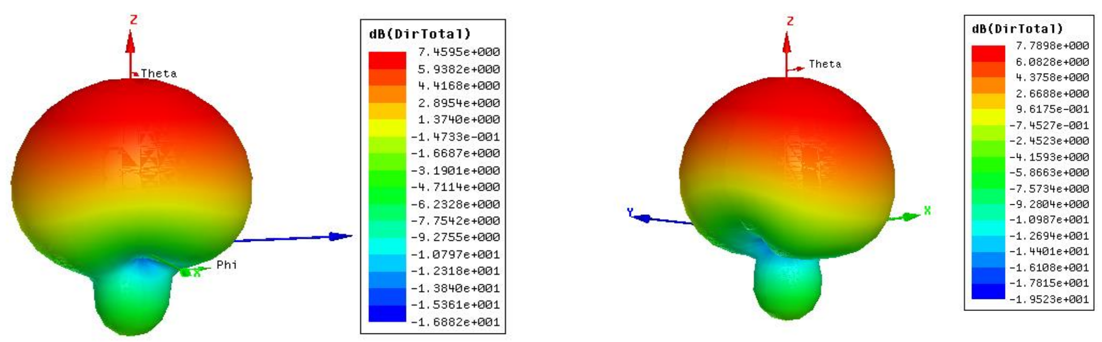


Figure 3, Return loss vs. frequency response of modified antenna

3. Result and Discourse

The proposed two-layer patch antenna is simulated using HFSS software. The return loss of microstrip antenna before modification is shown in fig 2 and from figure 3 it is observed that the return loss response of the two-layer proposed antenna with a modified radiating element. The return loss is below -15 dB which is much better than the unmodified antenna. As the return loss is very low, it shows proper impedance matching in between patch and feed. The bandwidth of the designed antenna is 0.67GHz ranging from 5.2GHz-5.87GHz and getting two notches at 5.3GHz and 5.68 GHz within the frequency band.

The 3D radiation patterns of the designed antenna at different frequencies are shown in fig 4 and it is observed that it radiates electromagnetic waves are propagating maximally in the upper hemisphere of the patch. The antenna is more directive in the forward direction with a minimum back loop. Fig.5 depicts its 2D radiation pattern in H-plane. From figure 6, it is observed that the antenna offers directional radiation pattern in the operating range. The voltage standing wave ratio of the proposed antenna is depicted by fig.7.The VSWR is found to be less than 2.15 in the frequency range ranging from 5.2GHz to5.87GHz and it indicates that antenna is properly matched over the operating range. The designed antenna shows a flat gain variation over the operating range as shown in fig.8. The surface current distribution over the radiating patch is shown in fig.9.The current density of the patch is increased by inserting Sierpinski carpet structure on the radiating element.



(a) (b)

Figure 4, 3D radiation pattern of proposed antenna at (a) 5.3GHz and (b) 5.8GHz

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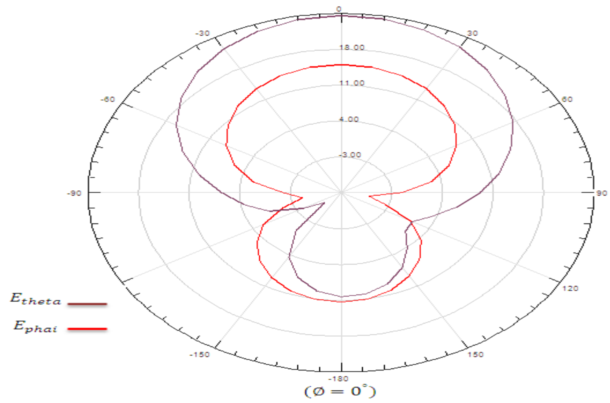

Figure 5, 2D Radiation Pattern of designed antenna in H-plane ($\emptyset = 0^{\circ}$)

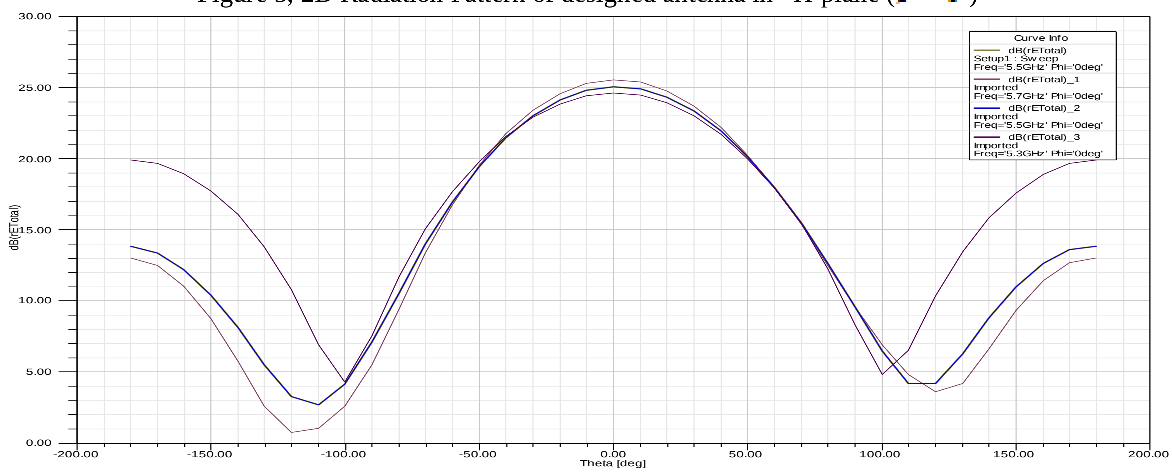

Figure 6, Radiation pattern for different frequency vs. theta

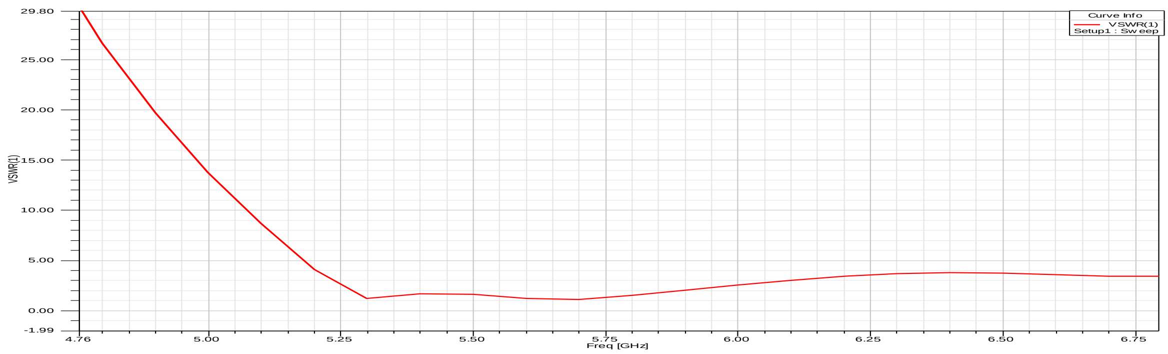

Figure 7, VSWR response of the proposed antenna

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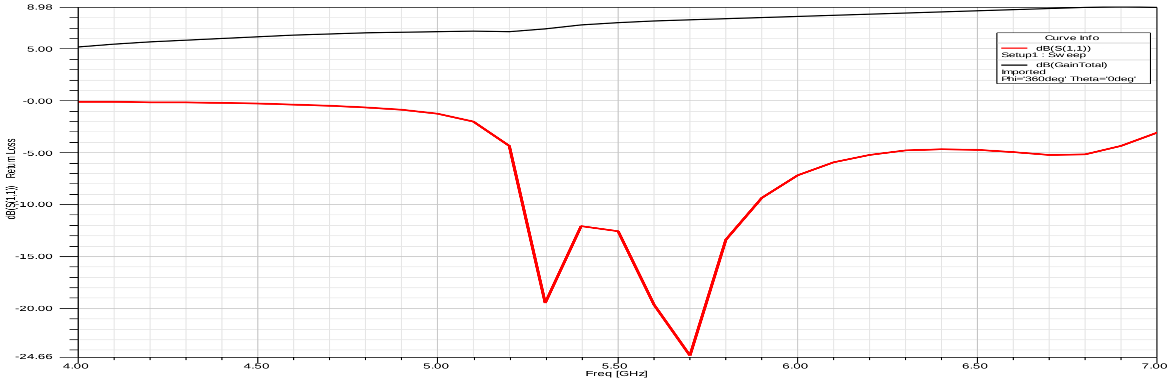

Figure 8, Gain vs. Return loss response of the proposed antenna

4. Conclusion

The proposed two-layer patch antenna is simulated successfully using HFSS software and the parameters of the antenna have been examined for an ideal design. The overall dimension of the antenna is 2cm*2.4cm*1cm. Moreover, by adding the Sierpinski carpet structure on the radiating patch improves the frequency bandwidth as well as the performance of the antenna. After simulation, it is observed that the proposed antenna has directional radiation pattern and smooth gain variation over the frequency range. As the antenna is operating from 5.2GHz to 5.87 GHz, the two-layer patch antenna is preferred for Wi-Fi, IoT sensor employment, and other C-band applications.

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A Brief Author Biography

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