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Design and Fabrication of Microstrip Patch Antenna for Cognitive Radio Application

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***Abstract*: This paper presents a rectangular microstrip patch antenna the antenna designed over the operating frequency is 2.4GHz using the substrate material as FR-4 epoxy which has the dielectric constant of 4.3 the designed antenna has low profile, low cost, easy fabrication and good isolation. The antenna is designed by using HFSS software.**

***Keywords*: Rectangular patch antenna, Micro strip patch, Coaxial feed.**

1. Introduction

Micro strip patch antennas are increasing in popularity for use in wireless applications due to their low profile and light weight properties. Some of their principle advantages a light weight, low volume, low fabricated cost, low profile the coaxial probe feed can be advantages due to ease of fabrication

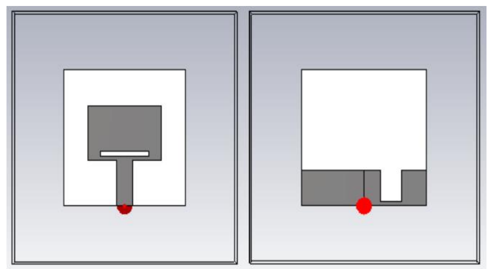
An antenna is device that converts electronic signal to electromagnetic wave effectively with minimum loss of signal. A microstrip patch antenna consist of a radiating patch on one side of dielectric substrate which has ground plane in other side. The patch is generally made of conducting material such as copper or gold and can be take any possible shape.

A microstrip patch antenna in its simplest configuration consist of a metallic radiating patch. On one side of the copper ground plane on the other side. Microstrip antenna are attractive due to their light weight, and low cost. These antennas can be integrated with printed board and active devices.

2. Antenna Design

The antenna geometry is shown in Fig. 1. First design consist of simple rectangular patch, size characterized by (L,W,h) which is inset fed type. For this designed we have used FR4 epoxy substrate having dielectric constant of 4.4 with loss tangent of 0.018. Next design has a rectangular - shaped patch, it was design to enhance the rectangular patch antenna results. The slot length of (L_s), width (W_s), and position (P_s) are important parameters in controlling the achievable bandwidth. Fig. 2 shows the HFSS design of rectangular-shaped patch antenna.

The rectangular-shaped antenna is design on substrate with dimension of length 28mm width 1.6mm and height of 29mm The following parameters for antenna structure can be calculated based on selected resonant frequency and dielectric of substrate [1].



Front Back
Fig. 1. Design of rectangular-shaped patch antenna

Rectangular Micro strip patch antenna is composed of a patch of length L and width W placed above the dielectric substrate having a dielectric constant εr and with the substrate thickness h. The design formulae for the rectangular microstrip is given below [3].

The micro strip patch antenna width can be calculated using given equation:

$$Wp = Vo/2fr*\sqrt{(2/(\varepsilon r+1))} \quad (1)$$

Where εr is the value of dielectric constant of substrate Vo is the speed of light and fr is the resonant frequency. As the substrate dielectric used is other than air hence, some of the radiation field lines radiate from the conducting patch through air to ground plane and some of fringing field radiates through the substrate this is known as fringing effect. This effect changes the dielectric of substrate and the size of antenna is increased electrically by an amount of △L [1].

The change in dielectric constant is represented by effective dielectric given by:

$$\varepsilon eff=(\varepsilon r+1)/2 + (\varepsilon r-1)/2\ (-1/2\ \sqrt{(1+12\ h/Wp)}\ ) \quad (2)$$

The length of patch can be calculated using following equations:

$$Lp = 1/(2fr\sqrt{\varepsilon eff}) * 1/\sqrt{\mu 0\varepsilon 0} - 2\triangle L \quad (3)$$

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The dimensions of patch along its length have been extended on each end by a distance △L, and its formula is given below [1]:

$$\triangle L = h*(0.412((\varepsilon eff+0.3)/(\varepsilon eff-0.258))*((Wp/h+0.264)/(Wp/h+0.8)))$$

The ground plane is kept constant all the shapes considered here. having a length Lg and width Wg. The length and width of the ground plane can be calculated by [3]:

$$Lg = 6h+L \quad (5)$$

$$Wg = 6h+W \quad (6)$$

Feeding technique used: Feeding techniques are used to excite the antenna and act as input source.

Various types of feeding techniques like inset feed, coaxial probe feed, aperture coupling and proximity coupling are popular.

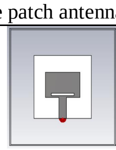
In this paper, we have first used inset feed technique in rectangular patch antenna. With inset feed good matching condition can be obtained Inset Feed method does not require any additional matching arrangement. It is achieved by properly controlling the inset position and width [5].

The feed length is 16.6mm and feed width is 2.8mm.

In rectangular-shaped design, coaxial probe feeding technique is used. Coaxial feed is anon planar feeding technique in which a coaxial cable is used to feed the patch. The outer conductor of the cable is connected to the ground plane and the inner conductor penetrates through the dielectric making a metal compact with the patch. The advantage with coaxial feed is that coaxial probe can be placed at any desired location inside the patch metal in order to match the input impedance, which is not easy with inset feed [4].

The location of probe in our design is defined by X,Y,Z co-ordinates,(12.25,0,1.6).

Table 1
Comparison for both the patch antenna design

MODELS	
FEED	3.5mm *- 1.6mm
GND	28mm*11mm S(4.5mm*10mm)
PATCH	14mm* 10.5S(1mm*1.6mm)
SUBSTRATE	28mm* 29mm
FRQUENCY	2.6GHz
VSWR	1.4238dB
RETURN LOSS	-21.9386dB

3. Measured Results

A rectangular patch and a few E-shaped micro strip patch antennas are designed and simulated. Measured results are obtained to compare with simulation results.

A. Return Loss (S11)

It is an amount of power absorbed by a load when power from a source is sent to it. The return loss being the difference the incident power and the reflected. The return loss plot of rectangular patch is shown below in Fig. 2.

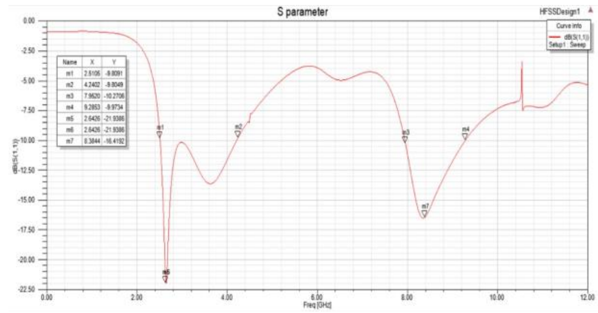


Fig. 2. S-parameter for rectangular-shaped patch antenna

The above Fig. 2 depicts the return loss plot for rectangular -shaped patch antenna. In rectangular-shaped patch antenna Return Loss is obtained at -21.938dB

B. VSWR

It is a function of the reflection coefficient which describes the power reflected from the antenna. The smaller the VSWR, the better the antenna is matched to the transmission line and more power is delivered to the antenna. The VSWR plot of rectangular patch is shown below in Fig. 3.

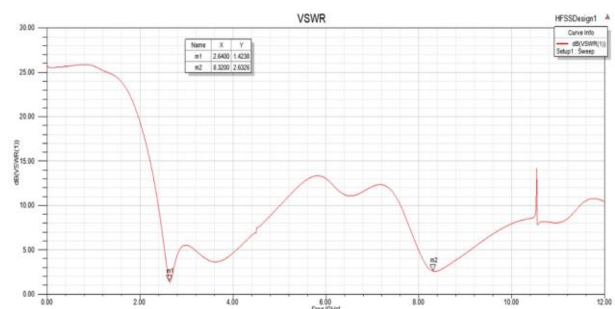


Fig. 3. VSWR for rectangular-shaped patch antenna

The above Fig.3 depicts the VSWR plot for rectangular -shaped patch antenna. In rectangular-shaped patch antenna VSWR is obtained at 1.42

C. Impedance

Antenna impedance is related to the voltage to the current at the input the antenna. The Impedance plot of rectangular patch is shown below in Fig. 4.

The above Fig. 4 depicts the Impedance plot for rectangular -shaped patch antenna. In rectangular-shaped patch antenna Impedance is obtained at 50.02ohm

D. Radiation pattern

It is radiation property of the antenna as a function of space co-ordinates. It is determined in a far field region and is show as a function of directional characteristics. The *Radiation pattern* plot of rectangular patch is shown below in Fig. 5.

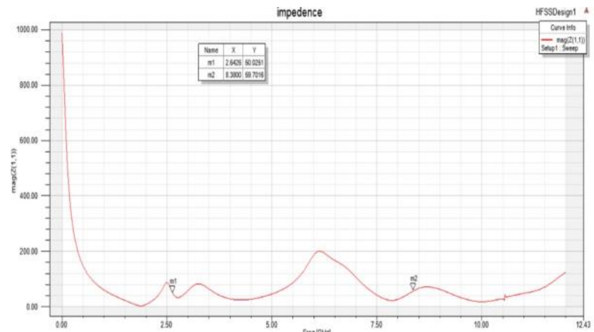


Fig. 4. Impedance for rectangular-shaped patch antenna

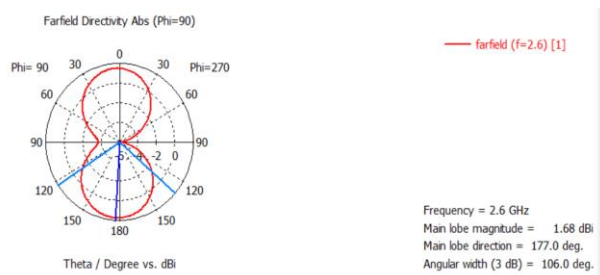


Fig. 5. *Radiation pattern* for rectangular patch antenna

The above Fig. 5 depicts the *Radiation pattern* plot for rectangular -shaped patch antenna. In rectangular-shaped patch antenna *Radiation pattern* is obtained at 1.68dB

E. Gain

It considers the efficiency of the antenna as well as its directional capabilities. Fig.6 shows the gain plot of rectangular patch antenna which is obtained 2.6dB. Rectangular-shaped patch antenna gain was analyze which is found to be 2.6dB. Fig.6 depicts the gain of Rectangular-shaped patch antenna, comparatively more than rectangular patch antenna.

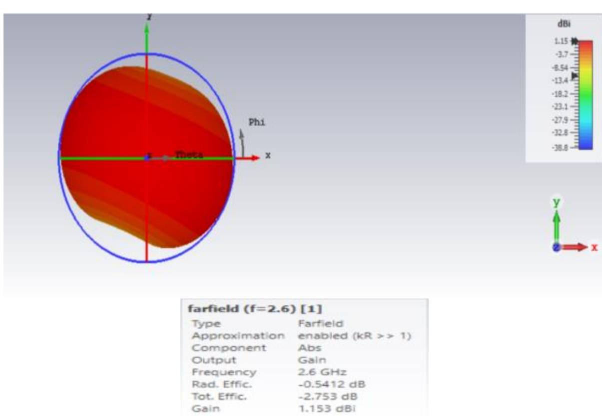


Fig. 6. Gain rectangular-shaped patch antenna

F. Efficiency

Efficiency is measured by the electrical losses which occurs in the antenna. It is the ratio of total power radiated by an antenna to the net power accepted by the antenna from the connected transmitter.

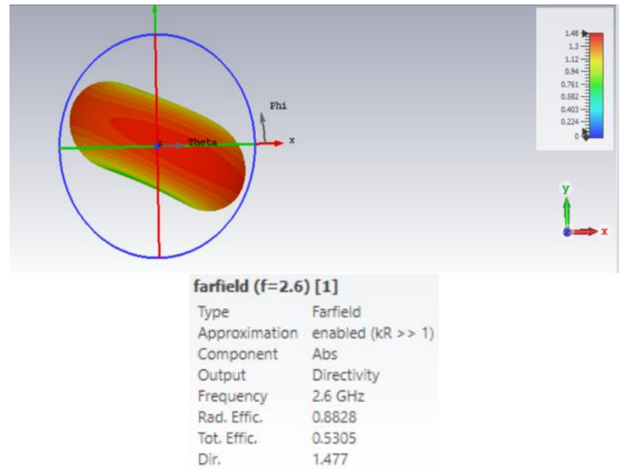


Fig.7. Efficiency of rectangular-shaped patch antenna

G. Directivity

It means how directional an antenna's radiation pattern is. Antenna that radiates equally in all directions has directionality equal to 0, and directivity equal to 1(0 dB).

Table 2
Comparison between simulated Antenna's Characteristics

Sr. No.	Parameters	Shaped Design
1.	Return loss(S11)	-21.93dB
2.	Radiation Efficiency	83.2%
3.	Directivity	1.48
4.	Gain	2.6dB

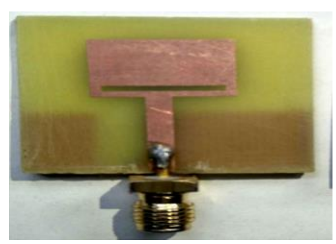


Fig. 8. Fabricated front rectangular patch antenna

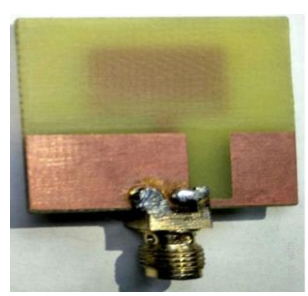


Fig. 9. Fabricated back rectangular-shaped patch antenna

4. Result and Discussion

Rectangular shaped micro strip patch antenna has been designed and simulated using Ansoft HFSS Software at 2.6 GHz and antenna characteristics have been observed and compared with results of Rectangular [1]. Micro strip patch antenna design at different frequency. For Rectangular Micro strip patch antenna Return loss is obtained -19.95 dB and gain obtained is 5.52 dB for rectangular shaped micro strip patch antenna return loss is obtained -21.93dB and gain is 2.6 dB Thus, results are improved in E shaped patch antenna also efficiency is enhanced in rectangular shaped.

5. Conclusion

From the above we conclude that the Rectangular-shaped patch antenna has an optimal Result in all the parameters compared to that of the Rectangular Micro strip patch antenna, and it provides narrow bandwidth with low gain and directivity. Antenna design for mobile network and Wi-Fi network at 2.6GHz has application for industrial, medical, scientific and WLAN applications. Hence the Rectangular-shaped patch antenna is well suited for mobile network and Wi-Fi network application. By using other substrate material and different feeding techniques the antenna characteristics can be improved further and enhancement can be achieved for frequency band which will have more transmission and receiving power for increasing the distance of communication [1].

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