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Design of Micro-Strip Antenna at Frequency (fr) = 6.5 GHz

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Abstract – Micro-strip patch antenna has penetrated deep in the market due to its advantages. After studying micro patch antennas, there are some draw backs of it. One of the drawbacks includes the narrowband performance. The primary reason for this is its resonant nature. An E-shaped micro strip patch antenna is used for the broadband applications. This E-shaped antenna is used for the purpose of improving antenna shrinking and information measurement to name a few. This paper shows the detail study of Cowl's research by using 2 different aspects of micro strip patch antenna.The antenna operated at a frequency of 5GHz. Antennas used were single part narrow band rectangular micro strip patch antenna and slot cut E-shaped micro strip patch antenna. Simulation method included high frequency structure machine (HFSS). Different properties such as Cable loss, information measurement and VSWR were studied using both types of antennas. These properties were then compared between each other.

Keywords –Micro-Strip, Antenna, Frequency, 6.5GHz, Rectangular patch

I. Introduction

The concept of micro strip patch antennas was developed in the 1970's when the electronic circuits became smaller with the advancements in science. Micro-strip patch antenna has a patch of conduct material. This patch is attached on the top of a grounded plane dielectric substrate. Some of the authors have explained the ground plane and its radiations for many configurations by using a dielectric substrate. Micro strip patch antenna was developed by in 1972 by Bob Munson. His early work on it was used only for low profile applications such as its use in rockets and missiles having flush mounted antennas. This application showed that the concept is not valid for papers but it was meant for the practical life. With the passage of time many mathematical models were designed and developed for the antennas having patches to be called as patch antennas later. This type of patch antennas was then used for many different types of applications and it spread out into various fields. The importance of patch antennas can be checked by reading many papers, articles published in the last decade. Today designers prefer the use of micro-strip patch antennas for their various purposes. They are preferred due to its maximum radiations and low dielectric constant substrates. The most common shape of this micro strip patch can be rectangular and circular configurations. The conducting patch can take any shape to emit radiations. Configurations other than rectangular and circular are complex due to their heavy numerical computations. A patch antenna can be identified through its Length, width, radiations, gain and input impedances etc. Figure show the structure of a micro strip patch antenna.

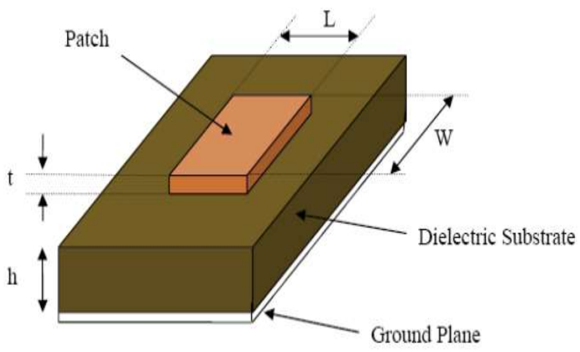

Figure 1: Structure of Micro-strip patch antenna

A plane surface is on the other side. The most common of all micro strip patch antennas is the one with rectangular configuration. The patch of antenna is made up of copper which is a conducting metal. Another metal can also be used such as Gold for the purpose of conduction. The patch antennas can be in different shapes like circular, rectangular, elliptical, triangular etc. the basic antenna component includes Length (L) and Width (W) of the strip conductor. The length of the patch depends upon the height, width of dielectric substrate.

II. PARAMETERS

There are three main specifications of the micro-strip patch antennas, which depends upon the whole system. The parameters are resonant frequency, the stature of the substrate and the dielectric steady. This paper shows the three parameters in which the resonant frequency is taken to be 6.5 GHz. A dielectric constant of 4.3 has been used. The height of the substrate is taken to be 1.50 mm. CST microwave studio software has been used for the purpose of designing this type of patch antenna. Micro strip patch antenna contains three layers namely the Patch, Substrate and the earth level surface. The design is show in the fig 2.

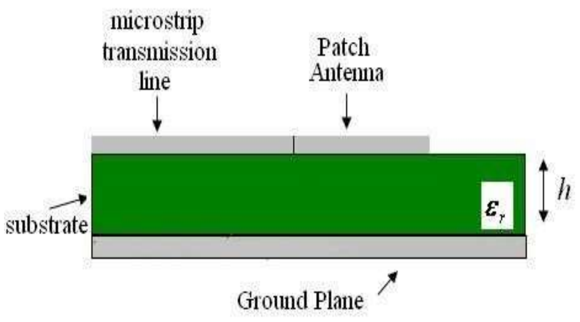

Figure 2. Micro strip patch antenna

A. Patch

It is the top mainly layer of the micro-strip patch antenna. It is usually made up of Copper or Gold. Electromagnetic radiations actually emit from here. To determine the operating frequency we use the length and the width of the antenna. The magnitude of the antenna decreases with the increase in the frequency. Similarly, the decrease in the frequency results in the increase in the size of the antenna.

B. Substrate

The selection of a suitable substrate for micro strip patch antenna is critical. The substrate depends on the thickness and appropriate loss tangent. For a thicker substrate the radiation increases, decreased conductor loss and enhanced impedance bandwidth. This thicker substrate must be mechanically strong. There are things that needed to be note down during these characteristics. They are di-electric loss, surface wave loss, the weight and unrelated radiation emission. When the substrate gets thicker from 0.11λo, the rectangular patch antenna stops resonating. The primary reason for this is the inductive reactance of the feed.

C. Di-electric Constant

Dielectric constant plays an important role in fringing field. Its role is somehow similar to that of the width in the substrate. A substrate with low di-electric steady results in the increased fringing fields. This results in the increase of power radiation.

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III. BASIC PARAMETERS

The three basic parameters of the patch antenna include the operating frequency, di-electric constant used and the height of the substrate.

A. Operating Frequency

The frequency range in accordance with the ISM guidance ranges from 2400 to 2483MHz. This range of frequencies are used normally for the wireless networks, Bluetooth and other such applications. The resonant frequency selected in this paper is to be 6.5 GHz.

B. Di-electric substrate

The constant of substrate used in the current design is selected to be 4.3. A high valued dielectric substrate is selected in this current design. This is done because of the fact that the antenna dimensions will get smaller by doing so.

C. Height of Substrate

The antenna should not be sizeable while using it in the small devices such as cellular phones etc. This leads us to the fact that the height of the dielectric substrate used should be small in size. This paper discusses with its current design shows the use of the dielectric substrate with a height of 1.6mm.

IV. ANTENNA DESIGN

Before designing a micro strip patch antenna, we need to choose the specific dielectric constant and the height of the substrate. The parameters depend upon the designed frequency. The current design chosen here has frequency of 6.5 GHz. FR4 is the dielectric material selected for this purpose. The dielectric constant has value of 4.5 in the current design. The height of the substrate is chosen to be 1.5 mm. To reduce the dimension of the antenna, we need to choose a substrate with a high di-electric constant.

The important parameters for the design are following.

- f_r= 6.5GHz
- ε_r= 4.5
- h=1.5mm

The parameters to be calculated are as given below.

Step1: Calculation of the width(W):
***Width (W)*:**
The width of the patch can be calculated by the following equation

$$W = \frac{C_0}{2fr}\sqrt{\frac{2}{\varepsilon r + 1}}$$

Where,
W it is the Width of the patch
C_0 it is the Speed of light
ε_r it is the value of the dielectric substrate

Where c is the speed of light, fr is the Resonant Frequency and εr is the Relative Dielectric Constant, obviously, different widths might be picked yet for widths littler than those chosen by width condition, radiator effectiveness is lower while for bigger widths, the impacts are more noteworthy however for higher modes may result, causing field contortion.

$$W = \frac{c}{2fr}\sqrt{\frac{2}{\varepsilon r + 1}}$$

$$W = \frac{3 \times 10^8 \times 10^3}{2 \times 6.5 \times 10^9}\sqrt{\frac{2}{4.3 + 1}}$$

$$W = \frac{3 \times 10^{11} \times 10^{-9}}{13}\sqrt{\frac{2}{5.3}}$$

$$W = \frac{3 \times 10^{11} \times 10^{-9}}{13}\sqrt{0.3773}$$

$$W \quad \frac{3\times10^2}{13}.0.614$$

$$W = 14.17$$

Substituting c=3.0×10^(11)mm/s,
$\varepsilon_r = 4.3$
and
$f_r = 6.5$ GHz,
we get:

W = 14.17mm

Step2: Calculation of effective dielectric constant (ε_{reff}):
Effective refractive index:

The successful refractive record estimation of a fix is an essential parameter in the structuring methodology of a microstrip fix receiving the wire. The radiations going from the fix towards the ground go through the air and some through the substrate (called as bordering). Both the air and the substrates have diverse dielectric esteems, along these lines so as to account this, we discover the estimation of successful dielectric steady. The estimation of the viable dielectric (εreff) steady is determined to utilize the accompanying condition.

$$\boldsymbol{\varepsilon reff} = \left(\frac{(\varepsilon r + 1)}{(2)}\right) + \left(\frac{(\varepsilon r - 1)}{(2)}\right)\left[1 + 12\left(\frac{h}{W}\right)\right]^{-1/2}$$

$$\boldsymbol{\varepsilon reff} = \left(\frac{(4.5 + 1)}{(2)}\right) + \left(\frac{(4.5 - 1)}{(2)}\right)\left[1 + 12\left(\frac{1.5}{38.3}\right)\right]^{-1/2}$$

$$\boldsymbol{\varepsilon ref} = 2.75 + 1.75\left[1 + 12(0.039164)\right]^{-1/2}$$

$$\boldsymbol{\varepsilon reff} = 2.75 + 1.75\left[1 + 0.46997\right]^{-\frac{1}{2}}$$

$$\boldsymbol{\varepsilon reff} = 2.75 + 1.75\left[1.46997\right]^{-\frac{1}{2}}$$

$$\boldsymbol{\varepsilon reff} = 2.75 + 1.75(0.82479)$$

$$\boldsymbol{\varepsilon reff} = 2.75 + 1.4433$$

$$\boldsymbol{\varepsilon reff} = 3.744$$

Substituting ε_r=4.3,
W=38.3mm
and
h=1.5mm,
we get:
ε_{reff}=3.744

In which "h" could be the breadth in the substrate along with εr could be the dielectric frequent in the substrate. Due to fringing discipline about the periphery in the area, electrically the antenna appears bigger than its actual size. Δl requires this influence throughout consideration which enable it to possibly be indicated since:

wherever L is usually the length of this area, N would be the size in the area, f_o is usually concentrate on resonance regularity, c would be the rate regarding gentle inside a cleaner plus the powerful dielectric regular can end up being computed by the equation:

Step3: Calculation of the resonant length of patch (L):

The length (L) of the patch can be calculated by using the follow equation.

$$L = \frac{C_0}{2fr\sqrt{\boldsymbol{\varepsilon reff}}} - 2\boldsymbol{\Delta}L$$

L =L_{eff} - 2ΔL
L= 9.47927- 2(0.7439)
L= 9.772mm
Substituting Leff=9.47927mm
and
ΔL=0.7439mm,
we get,
L=9.772mm

Step4: Calculation of ground plane dimensions (Lg and Wg):

Earth plane is equal to the distance end to end and width of the substrate. The following equations are using to calculate the distance end to end of a ground plane (Lg) and the width of an earth plane (Wg).

Lg= 6h + L
Lg = 6(1.5) + 7.9914
Lg = 9 + 7.9914
Lg = 16.0014
W_g = 6h + W
Wg = 6(1.5) + 13.9159
Wg = 9 + 13.9159
Wg = (22.9159)mm

Substituting h=1.5mm,

L=9.772mm and W=13.9159, we get Lg=16.0014mm

and Wg=22.9159mm

V. Results

The Micro-Strip Rectangular patch antennas simulation is perform by CST software. The parameters evaluated were VSWR, Radiation pattern, Return loss, Directivity, Gain, 3D polar plot.

Figure 3 demonstrates the recreated return loss of the rectangular opened fix receiving wire (Fig.1-b). It is discovered that the proposed radio wire gives a bandwidth6.0 GHz. (CST) and 4.8 to 6.5 GHz (CST), which covers the whole band. The great assertion is acquired among HFSS and CST results.

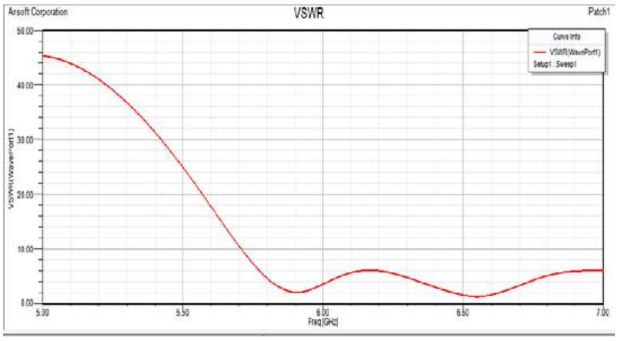

Figure 3: Radiation Pattern for Rectangular patch antenna

Figures 4 plot the simulated radiation pattern 6.5 GHz. Also to the regular monopole receiving wire, the radiation examples of the proposed reception apparatus are almost unidirectional over the working transfer speed.

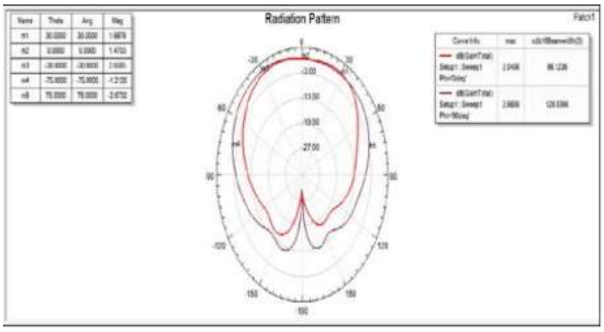

Figure 4: Radiation Pattern for Rectangular patch antenna

In fig 5 the 3d polar plot for rectangular patch it gain the different Values of return loss and gain of frequencies

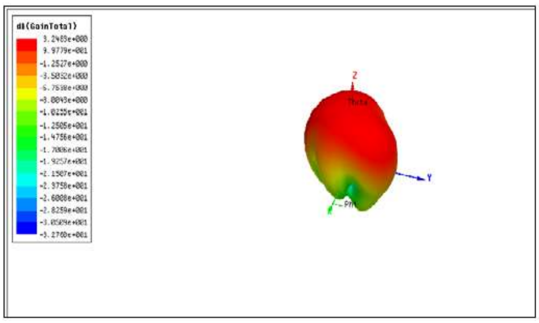

Figure 5: 3d polar plot for Rectangular patch antenna

In this fig 6 for rectangular pitch it show directivity of 6.5it antenna Radiation of intensity average overall direction.

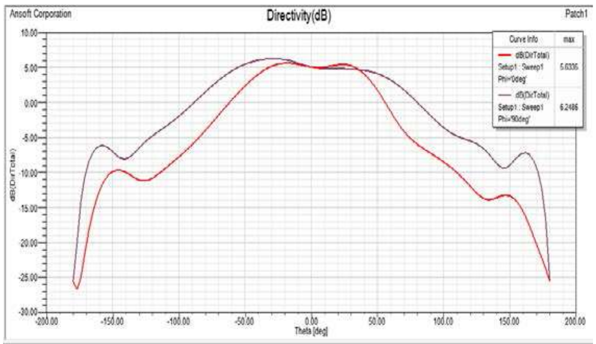

Figure 6: Directivity for Rectangular patch antenna

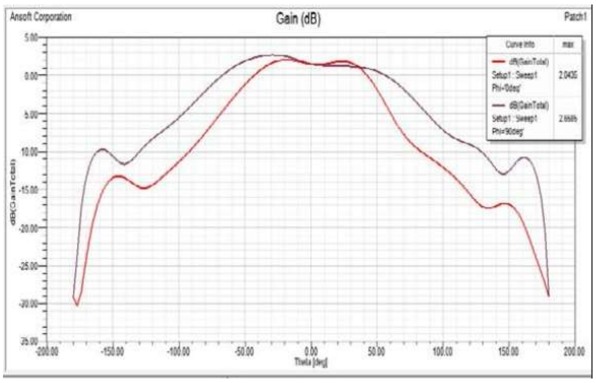

Figure 7: Gain for Rectangular patch antenna

VI. Parameters

The directivity was defined from the radiation intensity in the beam direction of total beam power it expect total radiated power In this figure show the gain of rectangular of patch antenna 6.5 Ghzdbof bandwidth increase.

Table 1. Parameters

Parameters	**Rectangular patch**
Resonant frequency	6.5GHZ
Bandwidth	140MHZ
Return loss(dB)	-16.70
VSWR	1.34
Gain(dB)	5.90
Directivity(dB)	6.87

VII. CONCLUSION

The design and simulation of Micro strip rectangular patch antenna 6.5GHZ was successfully designed and analyzed using CST. The performance parameters were achieved with Return loss -16.70dB, gain 5.90 dB, directivity 6.87dB and bandwidth 140 MHz for rectangular patch antenna. The use of slotted patch reduces the size of antenna (pitch) then we get higher bandwidth, and minimum loss which is the area that can be improved with the proposed design.

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