

Design and Analysis of Rectangular Microstrip Patch Antenna Using Inset Feed Technique for Wireless Application

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ABSTRACT: Recently, the field of wireless communication is the most widely researched area and the study of communication system is incomplete without knowing the operation and the use of different types of antenna. Although there are many types of antenna, antennas that are having light weight, compact, inexpensive and are capable of maintaining high performance over a wide range of frequencies are preferred. One of the antenna that fulfill the above mentioned criteria is the Microstrip patch antenna. Hence in this paper the design of the rectangular microstrip patch antenna with inset feed technique is designed for 5.2 GHz WLAN application. The Rectangular microstrip patch antenna is designed using Computer Simulation Technology (CST) Microwave Studio which is a commercially available electromagnetic simulator.

KEYWORDS: CST, Microstrip patch antenna, Radiation pattern, Return loss, WLAN.

I. INTRODUCTION

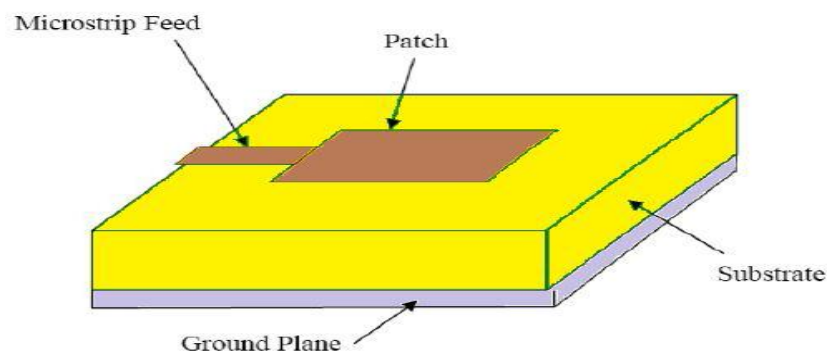
An Antenna is a transducer that transmits or receives electromagnetic waves. Since it converts voltage and current on a transmission line into an electromagnetic field it is called a transducer. Antennas are a key component of all types of wireless communication – be it a television set in our homes, the FM Radios in our automobile or the mobile phones which have become almost an integral part of most people's lives. All these devices require an antenna to function. The study of antennas and their field pattern is an important aspect of understanding many applications of wireless transmission technology. Microstrip patch antenna is crucial in many of the modern day practical applications, like that of Wireless local area networks (WLAN's), mobile cellular handsets, global positions system (GPS) and other upcoming wireless terminals. Because the size of the antenna is directly tied to wavelength the resonant frequencies they are mostly used at microwave frequencies [1,2].

Wireless Local Area Network also known as WLAN is a type of local area network that uses high frequency radio waves rather than wire to communicate between nodes. Norman Abramson, a professor at University of Hawaii developed the first wireless computer communication network ALOHA.net. In 2009 802.11n was added to 802.11. It operates in both 2.4GHz and 5GHz bands at maximum data transfer rate of 600 Mbits/s. Most newer routers are able to utilize both wireless bands known as dual band, This allows data communication to avoid crowded 2.4GHz band which is also shared with Bluetooth Devices and microwave ovens. The 5.2 GHz band is also wider than that of 2.4 GHz band with more channels which permits a greater number of devices to share the space [3].

II. MICROSTRIP PATCH ANTENNA

A microstrip patch antenna consists of a thin metallic patch above a large metallic ground plane. The patch is supported by a Dielectric sheet known as a substrate. The patch is usually etched on the dielectric substrate using printed circuit board technology. Therefore a microstrip patch is also referred to as PRINTED ANTENNAS. The performance of patch depends on its size and shape. A microstrip patch can be fed either by a microstrip transmission line or co-axial transmission line. The microstrip line can be etched along with the patch in a single process. In order to access the

appropriate Impedance point on the patch, a recess is created in the patch .The depth of the recess is adjusted to achieve the impedance matching .A patch antenna fed with a co-axial transmission line has about 2 to 4% Input bandwidth. A single patch antenna provides a maximum directive gain 6-9 db. An advantage inherent to patch antenna is the ability to have polarization diversity. Patch antennas can be easily designed to have vertical ,horizontal ,right hand circular polarization RHCP or left hand circular (LHCP) polarization using multiple feed points or a single feed point with asymmetric patch structures .The patch usually fed along the centre line to symmetry and thus minimize the excitation of undesirable modes .The patch is generally square, rectangular, circular ,triangle and elliptical the most commonly employed microstrip patch antenna is a rectangular microstrip patch antenna[1].



ANTENNA PARAMETERS

Radiation pattern

A radiation pattern defines the variation of the power radiated by the antenna as a function of the direction away from the antenna. It is a plot of relative field strength of radio waves emitted by the different angles..

Return Loss:

It is the loss of signal power resulting from the reflection caused at a discontinuity in a transmission line. This discontinuity can be a mismatch with the terminating load or the device which is inserted in the line. It is expressed in ratio in dB :

$$RL(dB) = -10 \log_{10} (P_i/P_r)$$

A match is good if the return loss is high. Taking the ratio of reflected to incident power. The return loss will be negative. The return loss with negative sign is called reflection coefficient. It is expressed in ratio in dB:

$$RL'(dB) = 10 \log_{10} (P_r/P_i)$$

Standing Wave Ratio:

The SWR is the voltage ratio called VSWR and current ratio called ISWR. Power SWR is the square of the VSWR. Normally problem with a transmission line is impedance mismatch in the cable tend to reflect radio waves back to source and preventing all the power from reaching the destination point. The infinite SWR represent complete reflection. The SWR meter measures the value of SWR. Ideal transmission line would have SWR of 1:1 and there is no reflection and there is no reflection. VSWR value should be greater than or equal to +1 and not more than 3. The VSWR can be represented by

$$VSWR = V_{max}/V_{min}$$

S-parameter:

S-parameters describe the input output relationship between ports in an electrical system. For instance S12 represents the power transferred from port 1 to port 2.S21 represents the power transferred from port 1 to port 2.If S11=-10dB shows that 3dB of power is delivered and -7dB is reflected power and the rest was accepted by the antenna. This accepted power is either radiated or absorbed, most of them radiated. Return loss is the difference between forward and reflected power in dB.

Smith chart:

The smith chart is a tool for visualizing the impedance of a transmission line and antenna system as a function of frequency. The smith chart is plotted on the complex reflection coefficient plane in two dimensions and is scaled in normalized impedance, admittance or both using different colors. It is a useful tool for making the equations involved in transmission lines easier to manipulate.

Polarization:

An antenna is a transducer that converts radiofrequency electric current to electromagnetic waves that are then radiated into space. The electric field or “E” plane determines the polarization or orientation of the radio wave. In general, most antennas radiate either linear or circular polarization. A linearly polarized antenna radiates fully in one plane containing the direction of propagation in a circular polarized antenna, the plane of polarization rotates in a circle making one complete revolution during one period of the wave. An antenna is said to be vertically polarized when its electric field is perpendicular to the earth’s surface. Horizontally polarized antennas have their electric field parallel to the earth’s surface.

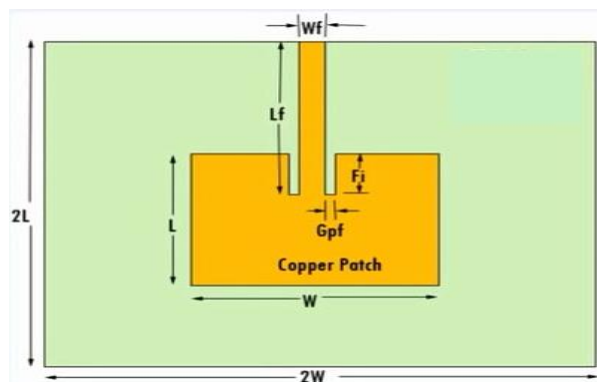
ANTENNA DESIGN

In this session antenna has been designed using a CST microwave studio software and display the parameters by the figures. First of all there is a need to choose the dielectric constant and substrate height and these are the basics to design an antenna. These are chosen according to the design frequency and our designed frequency is 5.2GHz. The WLAN application uses the frequency range from 5.150GHz to 5.310GHz. The dielectric material selected for our design is FR4 which has a dielectric constant of 4.9. The height of the dielectric substrate is 1.6mm.

Hence the essential parameters for the design are

- fo= 5.2GHz
- εr = 4.9
- h=1.6mm

Design Specification:



Step1: Calculation of the width(W):

The width of the Microstrip patch Antenna is given as

$$W = \frac{c}{2f_0 \sqrt{\frac{\epsilon_r + 1}{2}}}$$

Substituting c=3.00e+008m/s, εr=4.9 and fo=5.2GHZ, we get **W=0.01679=16.79mm**

Step2: Calculation of effective dielectric constant(εreff):

$$\epsilon_{reff} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2} \left[1 + 12 \frac{h}{W} \right]^{-\frac{1}{2}}$$

Substituting $\epsilon_r=4.9$, $W=16.79\text{mm}$ and $h=1.6\text{mm}$, We get $\epsilon_{\text{reff}}=4.2818$

Step3: Calculation of extension length(ΔL):

$$\Delta L = 0.412 \frac{\left(\frac{W}{h} + 0.264\right) (\epsilon_{\text{reff}} + 0.3)}{(\epsilon_{\text{reff}} - 0.258) \left(\frac{W}{h} + 0.8\right)}$$

Substituting $W=21.27\text{mm}$, $h=1.6\text{mm}$ and $\epsilon_{\text{reff}}=4.2818$, We get $\Delta L=0.45\text{mm}$

Step4: Calculation of effective length (L_{eff}):

$$L_{\text{eff}} = \frac{c}{2f_o \sqrt{\epsilon_{\text{reff}}}}$$

Substituting $\epsilon_{\text{reff}}=4.3636$, $c=3.00\text{e}+008\text{m/s}$ and $f_o=5.2\text{GHZ}$, We get $L_{\text{eff}}= 14 \text{ mm}$

Step5: Calculation of actual length of patch (L):

$$L = L_{\text{eff}} - 2\Delta L$$

Substituting $L_{\text{eff}}=14\text{mm}$ and $\Delta L=0.45\text{mm}$, We get, $L=13\text{mm}$

Step6: Calculation of ground plane dimensions (L_g and W_g):

$$L_g=6h+L \quad W_g=6h+W$$

Substituting $h=1.6\text{mm}$, $L=13\text{mm}$ and $W=16.79\text{mm}$, We get

$$L_g=22.6\text{mm} \quad W_g=26.3\text{mm}$$

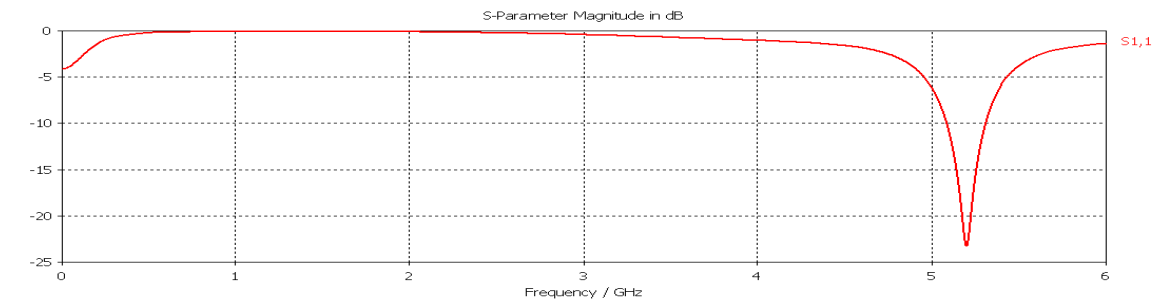
The wing structure of an aircraft is connected to the fuselage through keel beam. So the wing structure is act as a cantilever beam connected with fuselage. One end of the wing structure can be fixed and taken as the boundary conditions of the model. This was satisfied by fixing all six degrees of freedom on the nodes corresponding to the fixing point.

TABLE1:Design specification of the proposed antenna

DESIGN PARAMETER	VALUE
Dielectric constant(ϵ_r)	4.9
Length(L)	13mm
Width(W)	16.79mm
Feed length(Lf)	9.5mm
Feed width(Wf)	8mm
Feed insertion(Fi)	4mm
Feed gap(Gpf)	1
Thickness(h)	1.6mm
Operating frequency	5.2GHz

STIMULATED RESULTS USING CST

S- PARAMETER



From **Figure:1** it is concluded that the resonant frequency is 5.2 GHz, with the db and magnitude displayed Vs frequency .This parameter describes the input –output relationship of an electrical system

SMITH CHART:

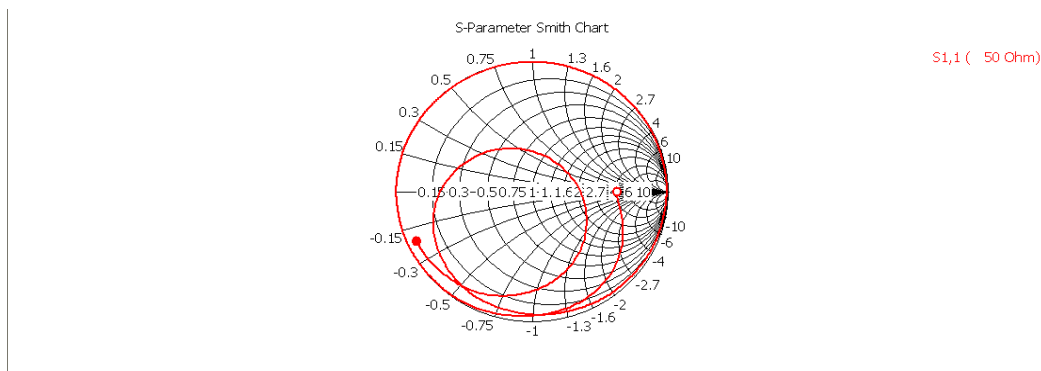


Figure:2 depicts the smith chart of the proposed antenna. The goal of the smith chart is to identify all possible impedances on the domain of existence of the reflection coefficient .

RADIATION PATTERN:

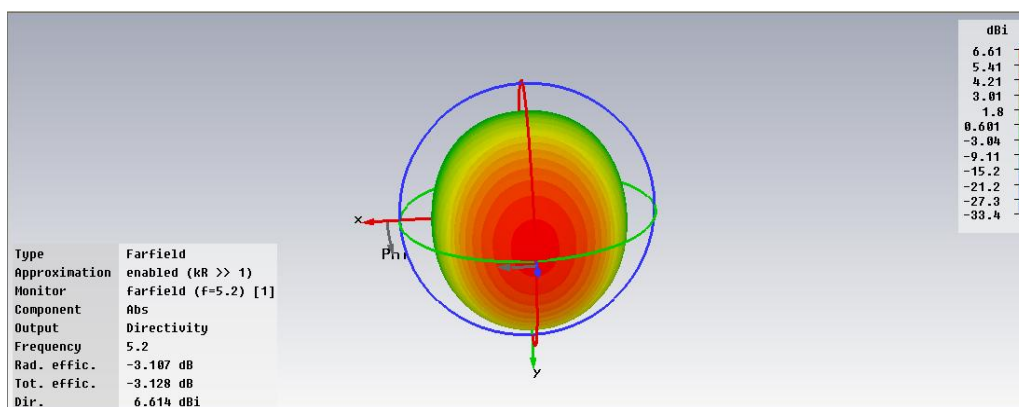


Figure:3 shows the radiation pattern of the proposed antenna. It shows the 3-D radiation pattern with directivity of 6.614 db for proposed antenna configuration at the resonating frequency of 5.2 GHz.

SURFACE CURRENT:

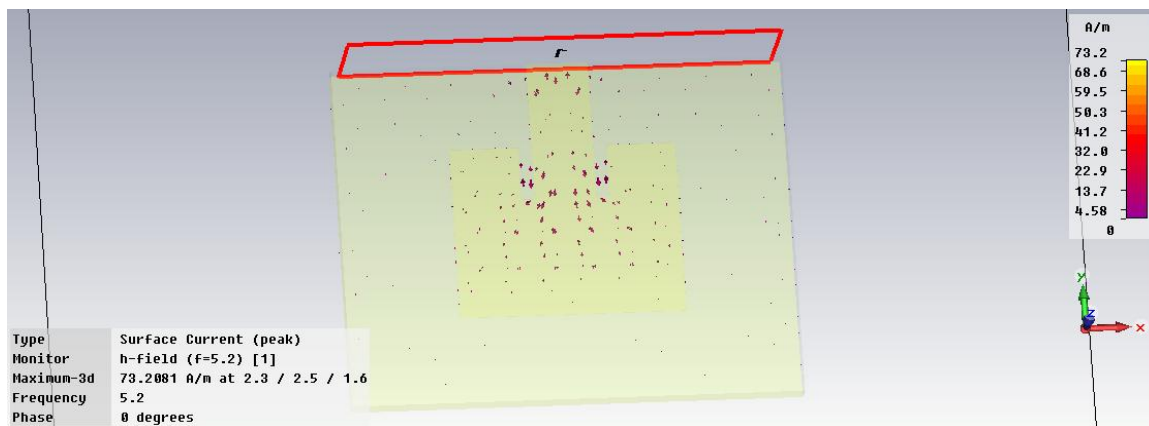


Figure:4 shows the surface current distribution of the proposed antenna

H-FIELD

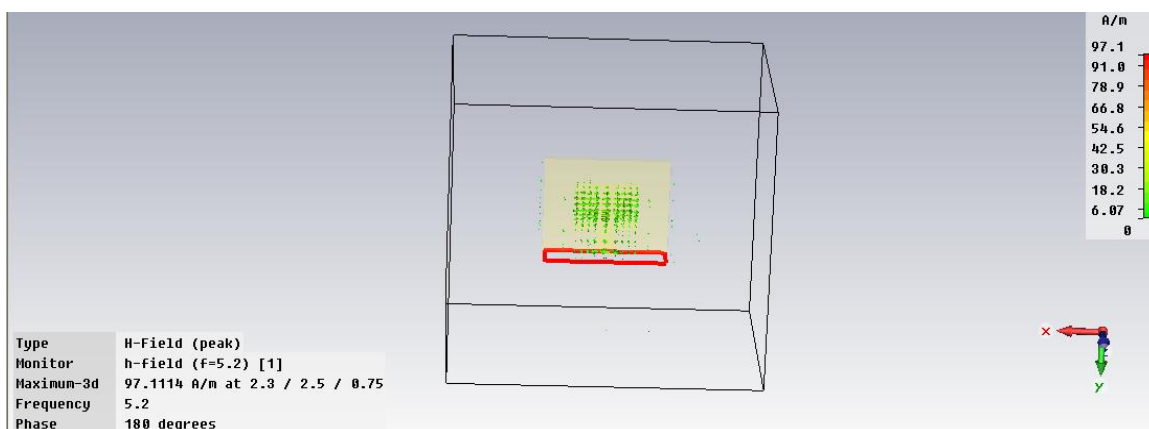


Figure: 5 shows the H-Field of the proposed antenna

VI. CONCLUSION

In this paper, a simple rectangular microstrip patch antenna for application in 5.2 GHz WLAN Frequency band is demonstrated and designed using CST Microwave Studio software. The radiation pattern and other important parameters such as gain, efficiency and return loss has been studied. This is operating in the frequency band of 4.8GHz–5.4 GHz. The return loss at 5.2 GHz frequency is below -10 db which shows that there is good matching at frequency points. Also the main advantage of this feeding technique is that feed can be given anywhere inside the patch which makes easier fabrication compared to other feed technique. In future Micro strip patch antenna array will be designed for the same operating frequency range in order to achieve the maximum gain which is highly suitable for S-band applications following conclusions are drawn from the studies conducted.

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