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A Report on

Work from Home Internship (Challenging Problems)

CALCULATION OF RADIATION PROPERTIES OF RECTANGULAR MICROSTRIP PATCH ANTENNA

By

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Under the Guidance of

Mrs. V.Vijayalakshmi

Assistant Professor

CERTIFICATE

This is to certify that the Work from Home Internship Project Titled Calculation of radiation properties of rectangular microstrip antenna array has been carried out by N.Preethi -2451-17-735-025,B.Prashansa Evangeline -2451-17-735-055 under the guidance of Mrs. V Vijayalakshmi by means of Work from Home and using On-Line & available Resources / Tools.

Mrs. V.Vijalakshmi

Asst.Professor

Dr.S.P.Venu Madhava Rao

Professor and HOD

DECLARATION

We hereby declare that the Work from Home Internship Project titled Calculation of radiation properties of rectangular microstrip antenna array has been executed by us and has not been submitted for any other Project.

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ACKNOWLEDGEMENT

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ABSTRACT

We observe a rapid growth in development of wireless communication. Antennas are preferred in most of their applications. There are different types of antennas available. A microstrip patch antenna array is one of the simplest forms. Compared with conventional antennas, microstrip patch antennas have more advantages and better prospects such as light weight ,low volume and ease of fabrication. They can be manufactured inexpensively and are versatile in nature.

In this project we have designed microstrip patch antenna using MATLAB software. It is a tool that enables computation, programming and graphically visualizing the results. Using this software we observed radiation properties of microstrip patch antenna and h shaped microstrip patch antenna. Both the results have been compared. Using this software we can observe radiation pattern for different antennas. Here, we discuss the design of microstrip patch antenna and radiation properties.

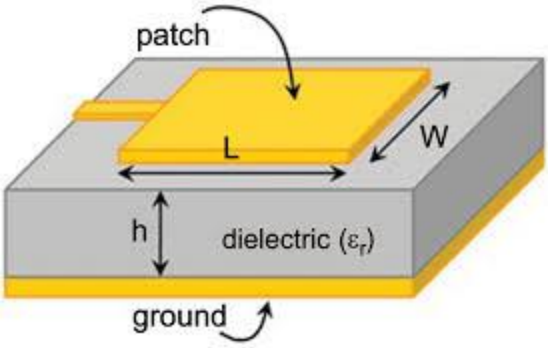
CHAPTER 1

INTRODUCTION

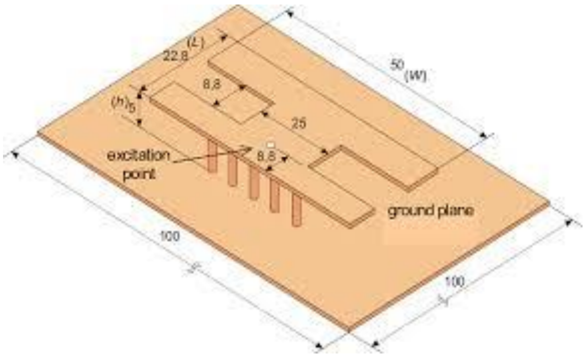
Antenna is a transducer designed to transmit or receive electromagnetic waves. Microstrip antenna was introduced by Deschamps in 1950s. Microstrip antennas have several advantages over conventional microwave antenna and therefore are widely used in many practical applications. Microstrip patch antennas consist of a patch of metallization over ground plane separated by a dielectric substrate. They are commonly referred to as patch antennas also. The thickness of substrate, h is usually very small compared to λ0, the free space wavelength.

A microstrip patch antenna (MPA) consists of a conducting patch of any planar or nonplanar geometry on one side of a dielectric substrate with a ground plane on other side. It is a popular printed resonant antenna for narrow-band microwave wireless links that require semi hemispherical coverage. Due to its planar configuration and ease of integration with microstrip technology, the microstrip patch antenna has been heavily studied and is often used as elements for an array. A large number of microstrip patch antennas have been studied to date. An exhaustive list of the geometries along with their salient features is available . The rectangular and circular patches are the basic and most commonly used microstrip antennas. These patches are used for the simplest and the most demanding applications. Rectangular geometries are separable in nature and their analysis is also simple. Both linear and circular polarizations can be achieved with microstrip patch antennas. Array of patch antennas can be used in order to increase the directivity or to have scanning capabilities.

The basic mechanism of radiation of patch antenna is the fringing of fields beyond the edges of patch element. The feeding of patch antenna produces the current density and electric and magnetic fields in the region between patch element and ground plane, the fields fringe beyond the physical dimensions of patch, and these 4 fringe fields produce the radiation. The amount of fringing of fields depends upon the dimensions of patch, and the height and dielectric constant of substrate. The increase in height of substrate causes increase in fringe fields. The higher dielectric constant of the substrate binds the fields more tightly inside the substrate region between patch and ground plane and reduces the fringe fields. More the amount of fringing, better would be the radiation efficiency of patch antenna.



The main disadvantage associated with microstrip antennas (MSAs) is their narrow bandwidth. Many efforts and techniques have been developed for enhancing the bandwidth of these antennas [2][3]. One popular technique is the utilization of parasitic patches. But the addition of parasitic patches causes enlarge geometry with increased complexity in array fabrication. This is particularly inconvenient for a co-planar case. Alternatively, bandwidth can also be enhanced by employing a substrate of sufficient thickness which allows the penetration of field lines in it. Such a technique requires a coaxially fed method that usually causes increased cross-polarization in H-plane. This also limits the useful bandwidth of an antenna which is usually less than 10% of the central frequency. This limited bandwidth is associated with increased inductance caused by the longer probe.



Signal processing is essential for a wide range of applications, from data science to real-time embedded systems. MATLAB and Simulink products make it easy to use signal processing techniques to explore and analyse time-series data, and they provide a unified workflow for the development of embedded systems and streaming applications.

With MATLAB and Simulink signal processing products, you can:

● Acquire, measure, and analyse signals from many sources.

● Design streaming algorithms for audio, smart sensor, instrumentation, and IoT devices.

● Prototype, test, and implement DSP algorithms on PCs, embedded processors, SoCs, and FPGAs MATLAB and signal processing products help us analyse signals from a range of data sources.

● Pre-process and filter signals prior to analysis.

● Explore and extract features for data analytics and machine learning applications.

● Analyse trends and discover patterns in signals.

● Visualize and measure time and frequency characteristics of signals.

CHAPTER 2

PROBLEM DESCRIPTION

ANALYSIS METHOD FOR MICROSTRIP ANTENNA

The preferred models for the analysis of microstrip patch antennas are the transmission line model, cavity model, and full wave model (which include primarily integral equations/Moment Method). The transmission line model is the simplest of all and it gives good physical insight.

TRANSMISSION LINE MODEL

This model represents the microstrip antenna by two slots of width W and height h, separated by a transmission line of length L. The microstrip is essentially a nonhomogeneous line of two dielectrics, typically the substrate and air.

most of the electric field lines reside in the substrate and parts of some lines in air. As a result, this transmission line cannot support pure transverse electric-magnetic (TEM) mode of transmission, since the phase velocities would be different in the air and the substrate. Instead, the dominant mode of propagation would be the quasi-TEM mode. Hence, an effective dielectric constant (ε_{re}) must be obtained in order to account for the fringing and the wave propagation in the line. The value of ε_{re} is slightly less than ε_r because the fringing fields around the periphery of the patch are not confined in the dielectric substrate but are also spread in the air as shown in Figure above. The expression for ε_{re} is

$$\varepsilon_{re}= ((\varepsilon_r+1)/2)+((\varepsilon_r-1)/2)(1+12H/W)^{-0.5} \quad \ldots\ldots\ldots\ldots\ldots (1)$$

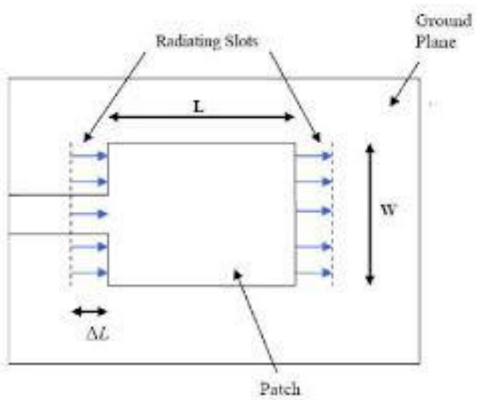
Where ε_{re} = Effective dielectric constant

εr = Dielectric constant of substrate

h = Height of dielectric substrate

W =Width of the patch

In order to operate in the fundamental TM10 mode, the length of the patch must be slightly less than $\lambda/2$ where λ is the wavelength in the dielectric medium and is equal to $\lambda o/\sqrt{\varepsilon reff}$ where λo is the free space wavelength. The TM10 mode implies that the field varies one $\lambda/2$ cycle along the length, and there is no variation along the width of the patch. the microstrip patch antenna is represented by two slots, separated by a transmission line of length L and open circuited at both the ends. Along the width of the patch, the voltage is maximum and current is minimum due to the open ends. The fields at the edges can be resolved into normal and tangential components with respect to the ground plane.



The normal components of the electric field at the two edges along the width long and hence they cancel each other in the broadside direction. The tangential components which are in phase, means that the resulting fields combine to give maximum radiated field normal to the surface of the structure. Hence the edges along the width can be represented as two radiating slots, which are $\lambda/2$ apart and excited in phase and radiating in the half space above the ground plane. The fringing fields along the width can be modelled as radiating slots and electrically the patch of the microstrip antenna looks greater than its physical dimensions.

With the advent of communication engineering the necessity of size reduction and wide bandwidth with the patch radiator are essential to meet the requirement for practical applications. Consequently the design of compact microstrip antennas with broadband/dual band characteristics is significant especially in satellite links, wireless local networks, cellular telephones, synthetic aperture radars, and radio frequency identification systems. A number of approaches have been reported to obtain compact dual band microstrip antenna such as loading of rectangular, circular, and triangular patches by shorting pins, loading by crossed slot and the use of a rectangular ring. These dual band operations can be at fixed frequencies or tunable at both or one of the frequency.

CHAPTER 3

IMPLEMENTATION

1.Matlab code for single microstrip patch antenna

```
%Size of PCB
pcbThickness = 1.6e-3; %1.6mm
pcbLength = 152.4e-3; %152.4mm or 6inch
pcbWidth = 101.6e-3; %101.6mm 0r 4inch

%Specifying Material of PCB
pcbMaterial = 'FR4';
pcbEpsilonR = 4.4;

%Creating dielectic Material
d = dielectric(pcbMaterial);
d.EpsilonR = pcbEpsilonR;
d.Thickness = pcbThickness;

 GndPlane = antenna.Rectangle('Length',pcbLength,'Width',pcbWidth);

 AntennaPlane=antenna.Rectangle('Length',5e-2,'Width',5e-2,'Center',[0,0]);

 p=pcbStack;
 p.Name = 'Strip-fed slot';
p.BoardShape = GndPlane;
p.BoardThickness = pcbThickness;
p.Layers = {AntennaPlane,d,GndPlane}; %[x Cordinate,y Cordinate,startLayer
stopLayer]
p.FeedLocations = [0,0,1,3];

p.Layers={AntennaPlane,d,GndPlane};

%Plotting Different patterns and graphs
figure(1);
show(p); %Display Antenna

figure(2);
pattern(p,1.82e9); %Display Radiation Pattern at 1.82GHZ

figure(3);
impedance(p,1.6e9:2e7:2.2e9); %Display Impedance Graph from 1.6GHz to
2.2GHz

freq = linspace(1.6e9, 2.2e9, 50);  % Creating Frequency Vector
s = sparameters(p,freq,50);     % Calculate S11 for all frequencies

figure(4);
rfplot(s);%Display S11 Plot
```

2.Matlab code for h shaped antenna

```
%Size of PCB
pcbThickness = 1.6e-3; %1.6mm
pcbLength = 152.4e-3; %152.4mm or 6inch
pcbWidth = 101.6e-3; %101.6mm 0r 4inch

%Specifying Material of PCB
pcbMaterial = 'FR4';
pcbEpsilonR = 4.4;

%Creating dielectic Material
d = dielectric(pcbMaterial);
d.EpsilonR = pcbEpsilonR;
d.Thickness = pcbThickness;

AntennaPlane=antenna.Rectangle('Length',0.5e-2,'Width',5e-2,'Center',[0, 0]);
%Creating Feed Plane of Antenna
GndPlane = antenna.Rectangle('Length',pcbLength,'Width',pcbWidth);
%Creating Ground Plane of Antenna

%Creating Different Shapes of antenna
Rec = antenna.Rectangle('Length',10e-2,'Width',2e-2,'Center',[0,-20e-3]);
Rec1 = antenna.Rectangle('Length',6e-2,'Width',2e-2,'Center',[0,20e-3]);

%%Creating PCB Stack
p = pcbStack;
p.Name = 'Strip-fed slot';
p.BoardShape = GndPlane;
p.BoardThickness = pcbThickness;
p.Layers = {AntennaPlane,d,GndPlane}; %[x Cordinate,y Cordinate,startLayer
stopLayer]
p.FeedLocations = [0,(-pcbWidth/2)+6e-2,1,3];

%Adding all different shapes of antenna
AntennaPlane = AntennaPlane + Rec + Rec1;
p.Layers = {AntennaPlane,d,GndPlane};

%Plotting Different patterns and graphs
figure(1);
show(p); %Display Antenna

figure(2);
pattern(p,1.82e9); %Display Radiation Pattern at 1.82GHZ

figure(3);
impedance(p,1.6e9:2e7:2.2e9); %Display Impedance Graph from 1.6GHz to
2.2GHz
```

```
freq = linspace(1.6e9, 2.2e9, 50);  % Creating Frequency Vector
s = sparameters(p,freq,50);     % Calculate S11 for all frequencies

figure(4);
rfplot(s);%Display S11 Plot


%Generating Gerber Files for Fabrication
C = PCBConnectors.SMA_Cinch;
W = PCBServices.PCBWayWriter;
W.Filename = 'antenna_design_file';

gerberWrite(p,W,C);
```

Matlab functions used in designing above antennas

antenna.Rectangle()-creates a rectangle centered at origin and on the X-Y plane

length, width and centre can be specified for any antenna.

antenna.Rectangle('length', value, 'width', value, centre[value])

dielectric()-returns dielectric materials for use as a substrate in antenna elements

linspace(a,b,n)-generates a row vector y of n points linearly spaced between and including a and b

pattern(object, frequency, azimuthal elevation)- plots the radiation pattern of antenna or antenna array object using the specified azimuth elevation angles

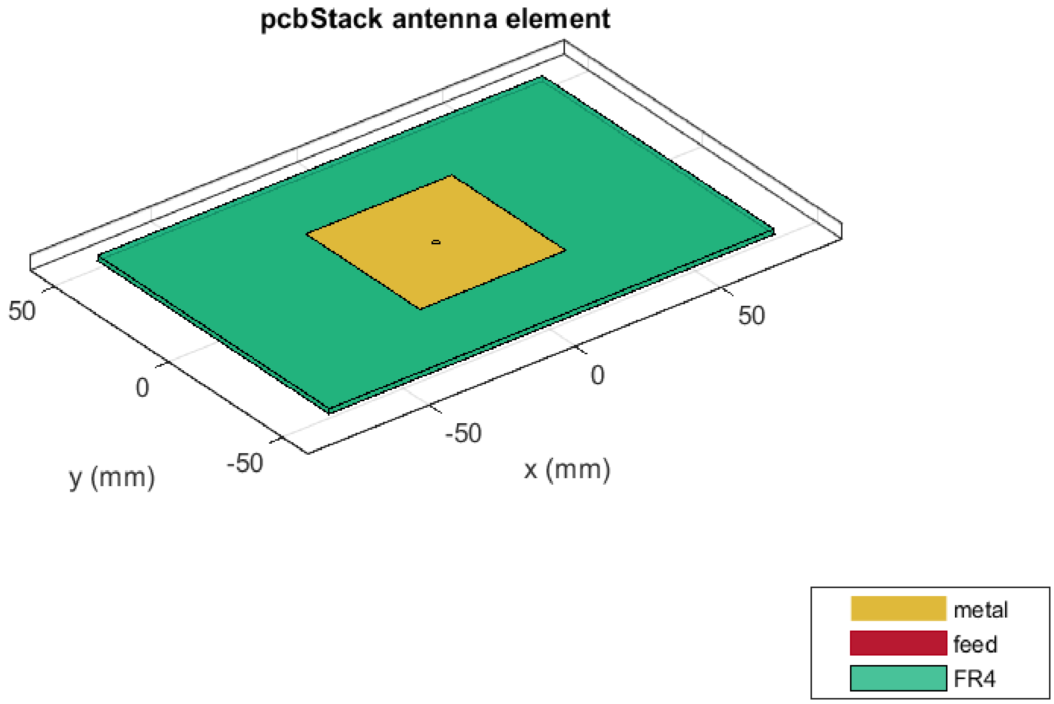
sparameters(circuitobj,freq,Z0)- calculates S-parameters of a circuit object with given reference impedance Z0

rfplot(s)- plots the magnitude in dB versus frequency of all S-parameters on the current object

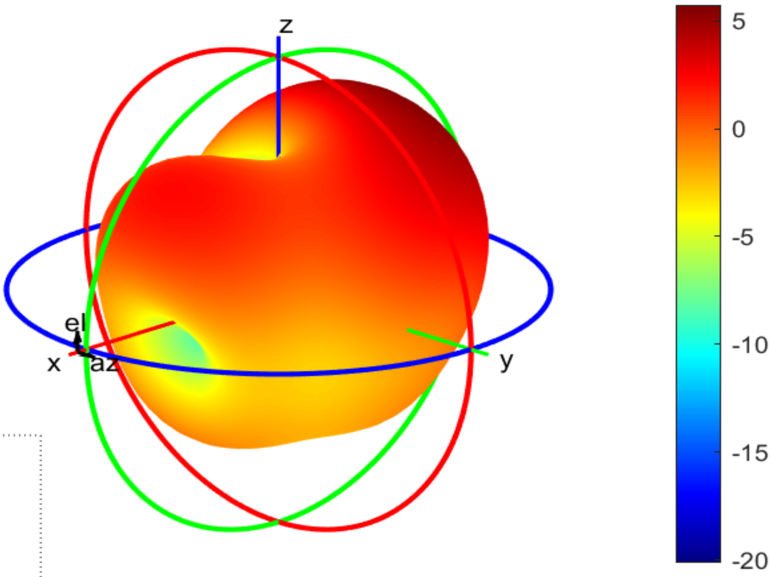
gerberWrite(design object,writer,rfconnector)- creates a Gerber file using specified PCB writer and connector services.

CHAPTER 3
RESULTS

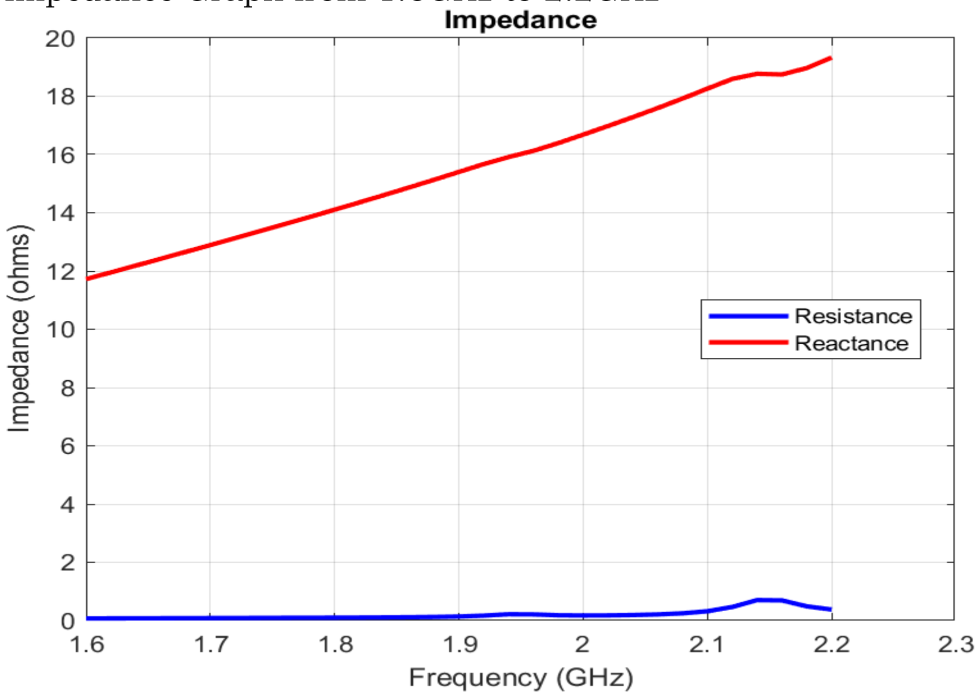
Output for single microstrip patch antenna



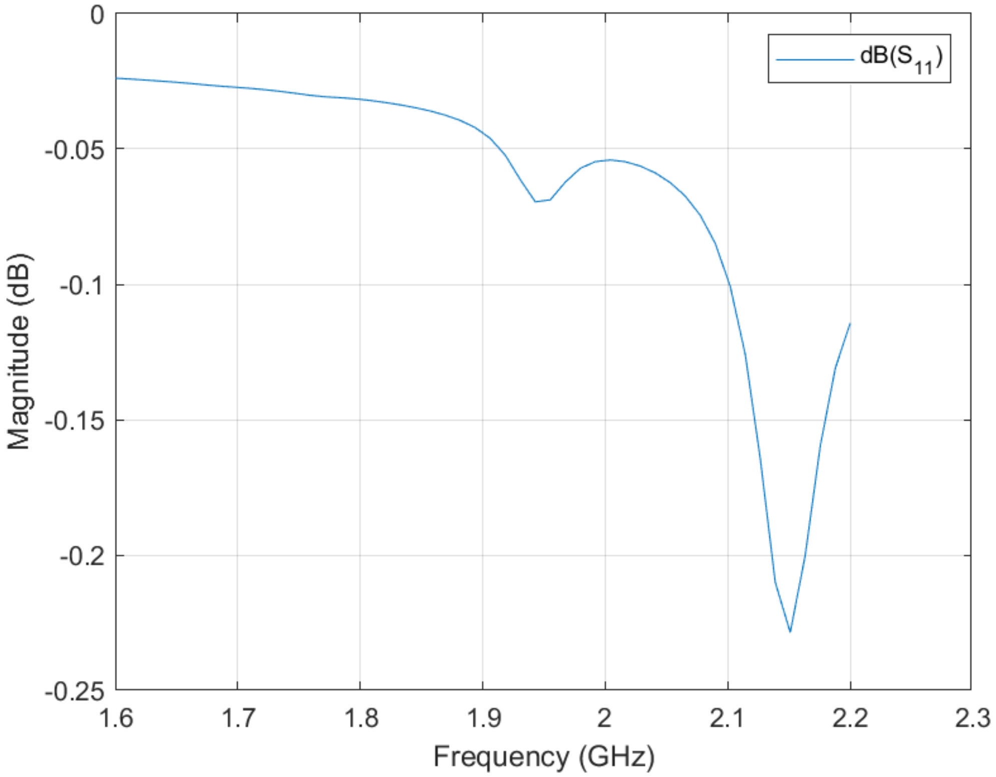
Radiation Pattern at 1.82GHZ



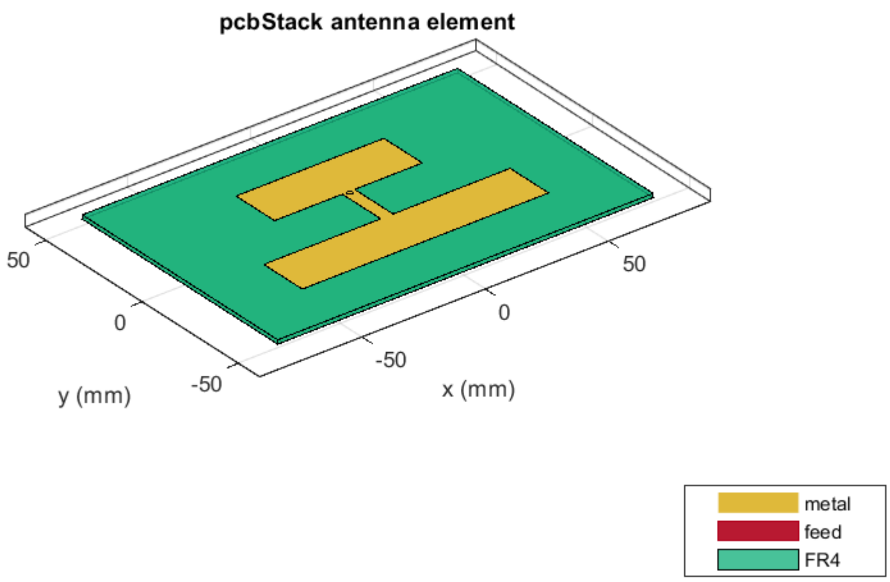
Impedance Graph from 1.6GHz to 2.2GHz



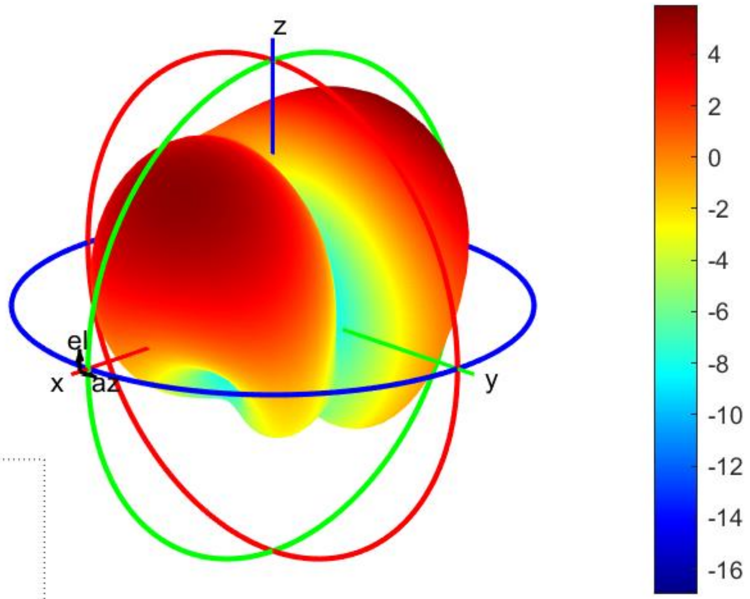
Rf plot of s parameters



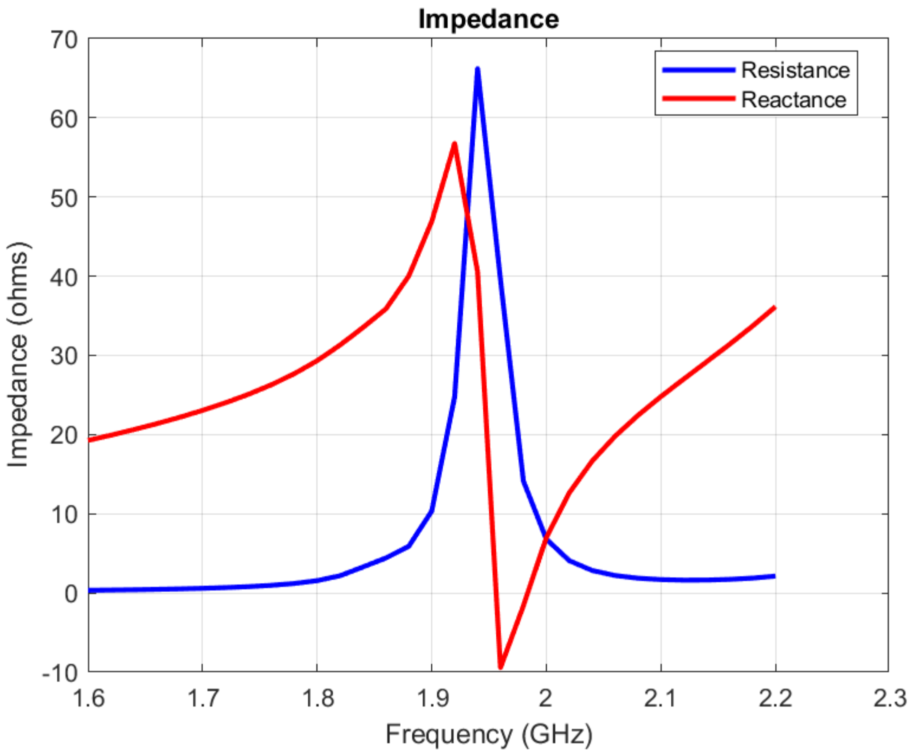
Output for h shaped microstrip patch antenna



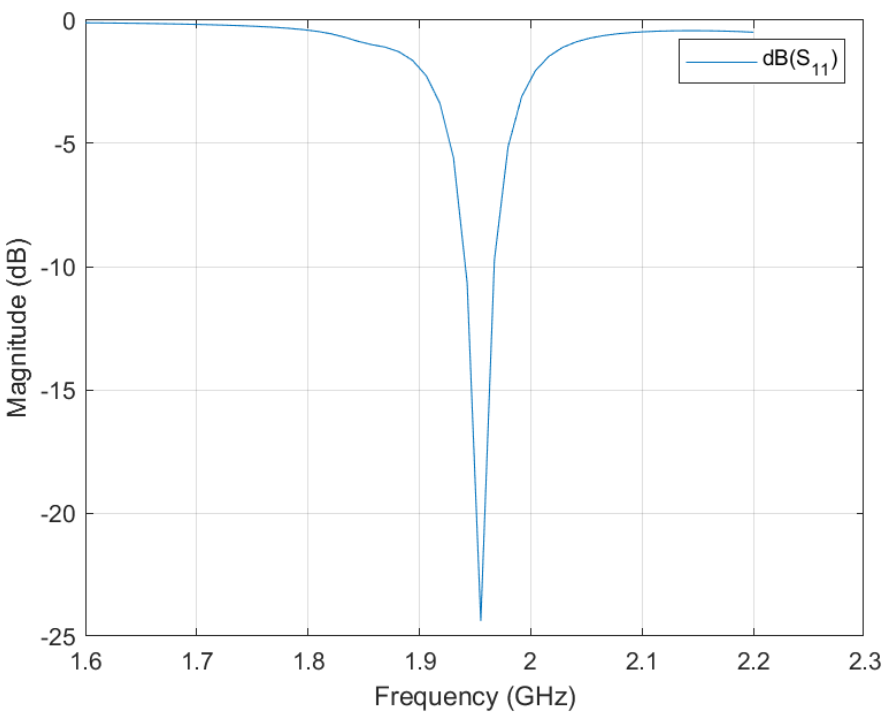
Radiation pattern at 1.82GHz



Impedance Graph from 1.6GHz to 2.2GHz



Rf plot of s parameters



COMPARISON OF THE ABOVE ANTENNAS

SINGLE MICROSTRIP PATCH ANTENNA	H- SHAPED MICROSTRIP PATCH ANTENNA
Design frequency: 1.82GHz	Design frequency: 1.82GHz
Gain max value: 5.69dBi	Gain max value: 5.86dBi
Gain min value: -20.1dBi	Gain min value: -17dBi

From the above comparisons and graphs, we observe increase in gain of H-shaped microstrip patch antenna. With low bandwidth, broadband applications using conventional patch designs are limited. For the antenna miniaturization and bandwidth improvement H-shaped microstrip patch antenna are used. Due to its smaller size, the h-shaped microstrip patch antenna replaces rectangular patch antenna at UHF frequencies .

APPLICATIONS

The micro strip patch antennas are famous for their performance and robust design. Micro strip patch antennas engaged for civilian and military applications such as radio-frequency identification (RFID), broadcast radio, mobile systems, global positioning system (GPS), television, multiple-input multiple-output (MIMO) systems, vehicle collision avoidance system, satellite communications, surveillance systems, direction founding, radar systems, remote sensing, missile guidance.

ADVANTAGES AND DISADVANTAGES

Micro strip patch antenna has several advantages like they are lighter in weight, low volume, low cost, low profile, smaller in dimension and ease of fabrication and conformity. The various advantage and disadvantage are

S. No.	ADVANTAGES	DISADVANTAGES
1	Low weight	Low efficiency
2	Low profile	Low gain

3	Thin profile	Large ohmic losses
4	Required no cavity backing	Low power handling capacity
5	Linear and circular polarization.	Excitation of surface waves
6	Capable of dual and triple frequency operation	Polarization purity is difficult to achieve
7	Feed lines and matching network can be fabricated.	Complex feed structure require high performance arrays

CONCLUSION AND FUTURE SCOPE

This project is on the Rectangular micro strip patch antenna .The technology used and research work increases the use of Micro strip antenna and their performance day by day and also make better utilization in future. Many techniques improve gain and bandwidth of the Micro strip Antenna. Due to this survey effect of disadvantages can be minimized. The feeding techniques also improve their performances. There are many simulation software are developed for micro strip antenna which make easy of designing in proper ,accurately and in automatic way with eliminating all complexity.