# DESIGN AND DEVELPOMENT OF EFFICIENT MICROSTRIP PATCH ANTENNA

Project report submitted in partial fulfillment of the requirement for the degree of Bachelor of Technology

In

**Electronics & Communication Engineering**

By

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to

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# DECLARATION

We hereby declare that the work presented in this report entitled **"Design and Development of Efficient Microstrip Patch Antenna "** in partial fulfillment of the requirements for the award of the degree of **Bachelor of Technology** in **Electronics & Communication** submitted in the department of Electronics & Communication Engineering**,** Jaypee University of Information Technology Waknaghat is an authentic record of our own work carried out over a period from August 2017 to May 2018 under the supervision of **Dr. Naveen Jaglan** (Assistant Professor (Senior Grade) in Department of Electronics & Communication Engineering). The matter embodied in the report has not been submitted for the award of any other degree or diploma.

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This is to certify that the above statement made by the candidate is true to the best of my knowledge.

Dr. Naveen Jaglan

Assistant Professor (Senior Grade)

Electronics & Communication Engineering

Dated:

# ACKNOWLEDGEMENT

It is great pleasure to present this report on the project named "**Design and Development of Efficient Microstrip Patch Antenna**" undertaken by us as part of our B. Tech (ECE) curriculum.

We are thankful to our university i.e Jaypee University of Information Technology for offering us such a wonderful challenging opportunity and we have taken efforts in this project and it is a pleasure that we find our self-penning down these lines to express our sincere thanks to the people who helped us along the way in completing our project.

First and foremost, we would like to express our gratitude towards our project guide - Dr. Naveen Jaglan for placing complete faith and confidence in our ability to carry out this project and for providing us his time, inspiration, encouragement, help, valuable guidance, constructive criticism and constant interest. They took personal interest in spite of numerous commitments and busy schedule to help us complete this project. Without the sincere and honest guidance of our respected project guide we would have not been to reach the present stage.

Date:

Aditya Sheoran

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## ABBREVIATIONS

MPA Microstrip Patch Antenna

CPA Circular Patch Antenna

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## Abstract

This project report covers a brief information of Antennas and apply them to design Microstrip Patch Antennas. Any communication model broadly comprises of receiver end and transmitter end. Antenna is a transducer (device that converts one form of energy into other) which converts electrical current and electrical voltages in radio waves at transmitter end and radio waves back to electrical current and voltages at receiver side. Talking about physical appearance Antenna is a metallic device which is used for radiating and receiving radio waves. We have also covered different feeding techniques of Microstrip Patch Antenna and various parameters of Antenna. Microstrip Patch Antenna consists of dielectric substrate, on one side of the dielectric substrate we have a radiating patch and on the other side we have a ground plane. We can use different value of substrate for the design purpose of Microstrip Antennas and the value of dielectric constant usually lie in the range of $2.2 \leq €_r \leq 12$. Substrate with lower dielectric constant provides better efficiency and larger bandwidth. In addition we have used HFSS(High Frequency Structure Simulator) to design Microstrip Patch Antenna at 2.4GHz and 10GHz using different feeding techniques. Also we have designed 2*1 Array.

# 1. CHAPTER - INTRODUCTION

The IEEE Standard Definitions of terms for Antennas defines the Antenna as “a means for radiating or receiving radio waves.”

At transmitter end, the radio transmitter gives electric current and voltage to the antenna terminal and the antenna emits energy from the applied current or voltage in the form of radio waves and at the receiver side, the antenna cut-off some of the power and produces electric current and voltage back from radio waves. The cut-off power is the power loss during transmission.

## 1.1 Types of Antennas

We will now discuss different types of Antenna.

### 1.1.1) Wire Antennas [2]

Wire antennas can be virtually found everywhere- on buildings, aircrafts, ships and so on.Wire antenna comes with various shapes such as straight wire, helix or loop. Because of the simplicity in its construction, circular loop is the most common used wired antenna.

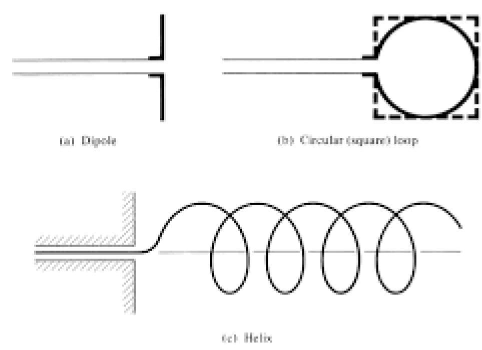


**FIGURE 1.1** Types of wire antennas

### 1.1.2) Aperture Antennas[2]

Aperture antennas can be very easily implemented on aircraft or spacecraft. These antennas have an aperture at the end(transmission line terminates with an open end which radiates energy).

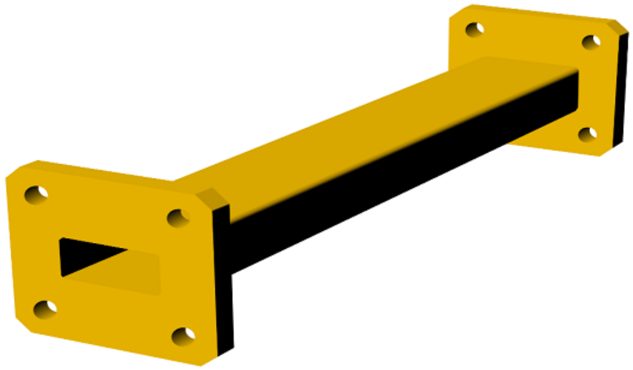

**FIGURE 1.2** Aperture antenna configuration

### 1.1.3) Microstrip Antennas [2]

Microstrip Patch Antenna consists of dielectric substrate with radiating patch on one side and ground plane on the other side. They can easily be implemented using because Printed Circuit technology, therefore also known as Printed Antennas. MPA patches comes in variety of shapes such as rectangular, triangular, circular. Due to ease of installation rectangular patch is preferred. They are antennas with low height and width also known as Low profile antennas. They can easily be mounted on planar and non-planar surfaces. MPA are simple inexpensive and simple to manufacture.

MPA gives large directivity but also leads to increase in size of individual element. MPA also gives poor efficiency, if we increase the height of substrate efficiency also gets increased but that also leads to increase in Bandwidth. With increase in height of substrate surface waves gets introduced which eventually extract some power from the  receiver side and leads to power loss during the transmission. We can eliminate these surface waves by building cavities i.e by separating patch and ground by dielectric sheet. For better efficiency we use dielectric substarte with lower values. To overcome these disadvantages we use Array antennas.

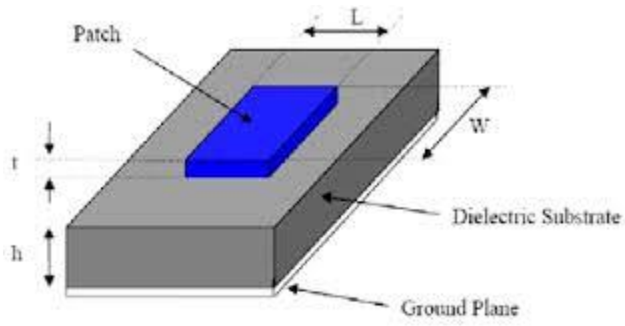


**FIGURE 1.3** Microstrip Patch Antenna

### 1.1.4) Array Antennas [2]

In Array antenna we connect several antennas in a regular structure and arrange them to form a single antenna. The elements of array are taken as identical in most cases just for the ease of installation. The antennas in array are organised in such a way that radiation from every element is added to get overall maximum radiation in a particular direction.

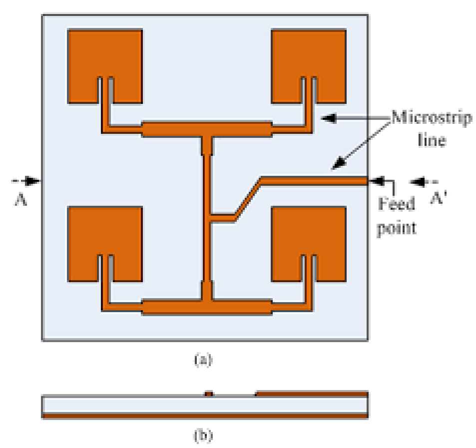


**FIGURE 1.4** Array antennas

## 1.3 Antenna Parameters

Performance of an antenna is defined by various measurable factors or parameters. Some of the parameter definitions will be discussed in this chapter.

### 1.3.1) Radiation Pattern

Radiation pattern shows relative field strength transmitted from or received by the antenna graphically. Graphical representation shows sidelobes and backlobes.

Radiation pattern for an antenna includes:

a. *Field pattern* (in linear scale) shows plot of magnitude of electric or magnetic field as a function of angular space.
b. *Power pattern* (in linear scale) shows a plot of square of magnitude of magnetic or electric field as a function of angular space.
c. *Power pattern* (in dB) shows the magnitude of electric or magnetic field, in decibels, as a:function of angular space.

HPBW(Half Power Beamwidth) is the angular separation in which the magnitude of radiation drecreases by 50%. All three patterns shows the same angular separation.

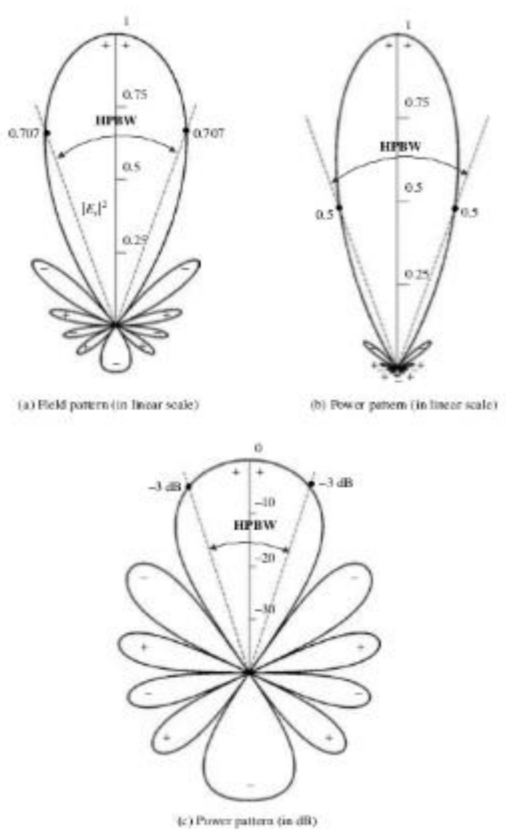


**FIGURE 1.5 (a)**Field pattern (in linear scale), (b)Power pattern (in linear scale), (c)Power pattern (in dB)

### 1.3.2) Directivity

Directivity is all about direction in any communication process. It is a measure of how directional an antenna's radiation pattern is. Antenna's radiation goes over all direction after transmission which leads to loss in power received at the receiver end. Therefore, Directivity gives the "ratio of radiation intensity in a given direction to that of radiation intensity spread over all directions". Since it is the ratio of radiation intensities, it is a dimensionless quantity and is expressed in dBi(decibel isotropic), *i* in the unit stands for isotropic.

### 1.3.3) Antenna Gain

Another important parameter that defines the performance of an antenna is Gain of antenna. Gain of an antenna descirbes how well the antenna converts input power into radio waves transmitted in a specified direction. Combination of antenna's directivity and electrical efficiency.Gain is usually measured in dB.

$$G = \eta D$$

**G =** Antenna Gain

**η** = Antenna efficiency

**D =** Directivity

### 1.3.4) Antenna Efficiency

Efficiency of any system is measured by its useful outcome to that of total energy supplied to it. Antenna efficiency is the ratio of power successfully received by an antenna to that of power given to the antenna before transmission. A part of power gets lost during transmission due to various losses.

a) *Impedance mismatch loss* : Impedance mismatching between transmission line and antenna.
b) *Dielectric loss* : Due to conductivity of dielectric material present near an atenna.

c) *Conduction loss* : Antenna is formed by a conducting metal, conduction loss arises due to finite conductivity of that metal.
d) *Power loss* : Result of conduction and dielectric loss.
e) *Insertion loss* : Power loss due to insertion of any unknown or unwanted device during transmission.

All these losses degrade the efficiency of antenna.

$$\eta = P_{rad} / P_{inp}$$

$\eta$ = Antenna efficiency

$P_{rad}$ = Power Radiated

$P_{inp}$ = Input power

## 1.2 Application of Antennas

In any communication model we need Antennas are communicating in a wireless channel. Antennas are used in small areas to satellite communications. Here are some of the widely used applications of Antennas:

### 1.2.1) Remote sensing

### 1.2.2) Defense Radar

### 1.2.3) Biomedical Engineering

# CHAPTER 2. LITERATURE SURVEY

Long-range communication as we all know, is practically impossible to implement with the use of wires. Now-a-days Wireless system has become the foremost part of a human life. Talking about mobile networks, to the laptop users to use it at any location, wireless communication has proved its importance in today's world. Most of the electronics equipments we notice around us uses wireless mode of transmission. We can use wireless technology in following situations:

- To cover a large distance which is beyond the reach of typical cabling,
- To enable a back up communication link in case of any network failure,
- To connect mobile users and network without any physical contact.

Talking about the components of any wireless system, antenna plays an important role in communication in any wireless system. Any communication model broadly comprises of receiver end and transmitter end. Antenna is a transducer (device that converts one form of energy into other) which converts electrical current and electrical voltages in radio waves at transmitter end and radio waves back to electrical current and voltages at receiver side. Talking about physical appearance Antenna is a metallic device which is used for radiating and receiving radio waves.

With increase in satellite communication, use of antennas in aircraft and spacecraft has also increased with this demand of low-profile antenna also increases for reliable communication.

Microstrip patch antenna are known for their ease in designing, fabrication and their widespread usage. MPA are used in wireless and radio communication. These antennas have small height and width i.e they are known as low-profile antennas. Being low profile antennas they often shows high input impedance. They can be mounted on planar and non-planar surfaces. They can easily be manufactured using printed-circuit technology, and are very simple and inexpensive to manufacture. MPA are also becoming popular due to their low cost of substrate material and fabrication.

Advantages of MPA :

- Low weight,
- Low cost,
- Ease of installation,
- Low profile,
- Easy to implement on planar and non-planar surfaces.

Antenna design is a advance and original task where we can study new types of antenna everytime we design an antenna.

2.1) **The study presented in IEEE Research paper published in Microwave & Optoelectronic Confrence** shows that Microstrip is probably the best and progressive reception technology ever. Its usage has increased because of many advantages it offers, for example, light weight, low profile, simple and ease creation, planar yet in addition conformal to non-planar surfaces, simple reconciliation of parts (counting dynamic gadgets), simple relationship in exhibits, and flexibility as far as electromagnetic attributes (input impedance, radiation design, polarization). It can be utilized as a part of an extremely wide scope of frequencies generally from 1 GHz to 100 GHz. Obviously it likewise has a few disadvantages, the most surely understood being the inability to transfer large amount of data and low productivity. However even these disadvantages have been overcome. A few strategies have been produced to expand the transfer speed and extremely wideband microstrip reception technologies have been displayed [1] [2]. The advancement of new advances and forms and the utilization of certain materials have given low loss microwave and millimeter wave substrates.

2.2) **A review paper on Technique and Design for Microstrip Patch** Antenna showed that MPA being small in size, is used in modern communication devices over conventional antennas. For designing efficient, low profile, small antenna MPA is preferred over any other antennas. A narrowband, widebeam antenna which is fabricated by joining the antenna element pattern joined to an dielectric substrate with ground plane on the opposite side of the substrate is known as array. Microstrip radio wires are best decision for remote gadgets i.e for wireless communication in view of attributes like low profile, low weight, simplicity of creation and minimal effort. Since usually practice to consolidate a few radios into one remote and utilize single reception apparatus. Microstrip radio wire experiences disadvantages like they have less transfer speed and gain.

2.3) **Analysis and Design of Rectangular Microstrip Patch Antenna at 2.4 GHz by Ismael Saad Eltoum** designed a Rectangular MPA at 2.4 GHz which is used for wireless communication. The patch could be of different shapes available but being easy to fabricate Rectangular patch antenna was designed. High Frequency Structure Simulator(HFSS) software was used for the design purpose. The parameters used was :

- Dielectric constant(Duroid) = 4.4
- Height of substrate = 1.60 mm
- Input Impedance = 50 ohms

The return loss graph is :

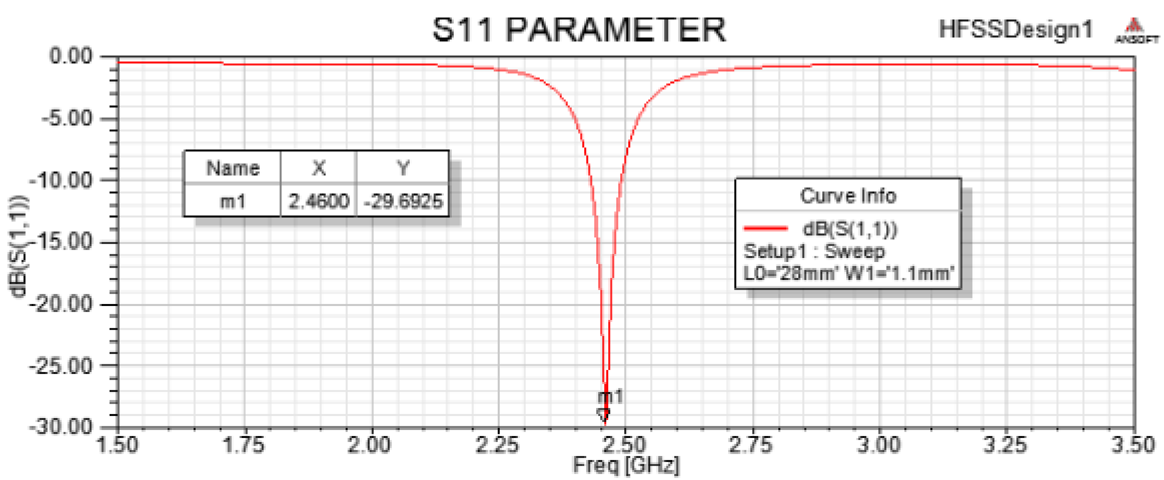


**FIGURE 2.1** Return loss graph at 2.4 GHz

2.4) **Design and Development of Microstrip Rectangular Patch Antenna with different feed techniques by A.M Prasana Kumar, ACS College of Engineering, Karnatka, India** : Any communication model comprises of a transmitter, receiver and a communication channel. Antenna plays a major role in communication process. An antenna is used to radiate in a particular frequency or range of frequencies. MPA consists of radiating patch on one side and ground plane on the other side of dielectric substrate. It talks about contacting and non contacting feeding methods.

Coaxial feed and Microstrip feed comes under contacting feed method whereas aperture coupled feed and proximity coupled feed comes under non contacting feed method because ground separates the two substrate in non contacting feed methods. For design of Rectangular MPA parameters used were:

- Dielectric constant(Duroid) = 2.4
- Height of substrate = 1.575 mm
- Width of patch( W) = 0.035 mm
- Width of ground = 0.035 mm
- Resonant frequency = 4 GHz

Formulae used for calculation of various parameters:

Microstrip patch antenna width (W):

$$W = \frac{c}{2f_0\sqrt{\frac{(\varepsilon_r + 1)}{2}}}$$

Effective Dielectric constant:

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

Effective Length:

$$L_{eff} = \frac{c}{2f_0\sqrt{\varepsilon_{reff}}}$$

Length Extension:

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

Actual length of Patch:

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

Simulation and Results:

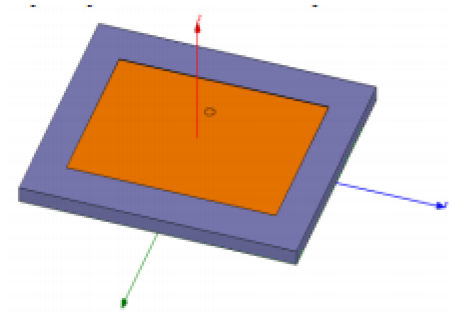

**FIGURE 2.2** Rectangular patch antenna with inset feed

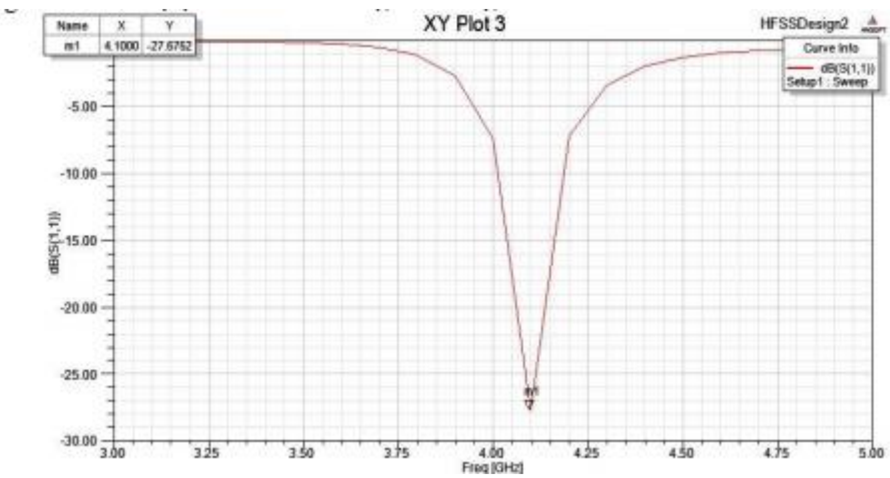


**FIGURE 2.3** Return loss at 4 GHz with inset feed

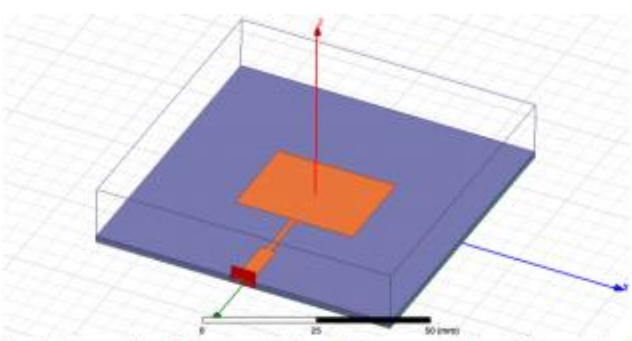

**FIGURE 2.4** Rectangular patch antenna with coaxial feed

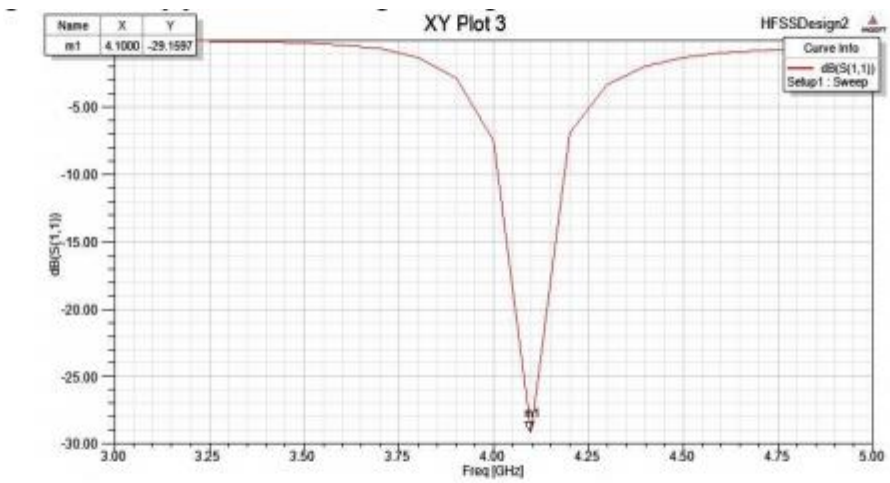


**FIGURE 2.5** Return loss at 4 GHz with coaxial feed

2.5) **A 1*2 Circular patch Antenna Array for next generation 802.11ac WLAN applications, Kinza Shafique, Muhammad Mustaqim :** Some radiation characteristics are not achievable by single element. Therefore, many applications requires combination of more than one radiating elements, which are arranged in such a way radiation from every element after adding up gives maximum radiation in a particular direction or desired direction.

In array antenna we connect multiple antennas together, which works as a single antenna for transmitting and receiving radio waves. It gives improved performance to that of single antennas also increases the overall gain of the antenna.

Antenna array design is an alternate way to achieve large directivity without increase in size of individual element. In Array antenna we connect several antennas in a regular structure and arrange them to form a single antenna. The elements of array are taken as identical in most cases just for the ease of installation. The antennas in array are organised in such a way that radiation from every element is added to get maximum radiation in a particular direction.

2.6) **Our work includes:**

1. design of Rectangular MPA at 2.4 GHz with coaxial feed
2. Design of Rectangular MPA at 10 GHz with coaxial feed
3. Design of Rectangular MPA at 10 GHz with inset feed
4. Design of 1*2 Circular patch array with coaxial feed

In our research we followed given steps to design antennas.

Step 1 : Determination of width(W) of MPA

Step 2 : Calculation of effective dielectric constant

Step 3 : Calculation of length extension $\Delta L$

Step 4 : Calculation of length of patch

Step 5 : Calculation of effective length of patch

Step 6 : Calculation of ground dimensions

$Lg=6h+L$

$Wg=6h+W$

# 3. CHAPTER – MICROSTRIP PATCH ANTENNA

MPA are used in wireless and radio communication. These antennas have small height and width i.e they are known as low-profile antennas. Being low profile antennas they often shows high input impedance. They can be mounted on planar and non-planar surfaces. They can easily be manufactured using printed-circuit technology, and are very simple and inexpensive to manufacture.

As shown in Fig MPA consists of dielectric substrate($€_r$≤10) with radiating patch on one side and ground plane on the other side. Substrates with different values can be used for the deisgn purpose, with dielectric constant usually in the range of 2.2≤ $€_r$ ≤12. Subsrate with lower value of dielectric constant provide better efficiency and larger bandwidth.

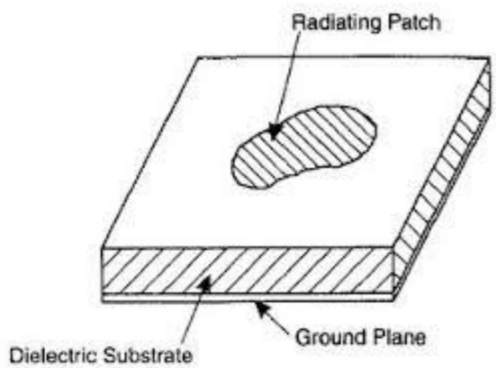


**FIGURE 3.1** Microstrip Patch Antenna

The radiating patch may be square, strip, rectangular, circular, elliptical or any other configuration show in Fig 3.2

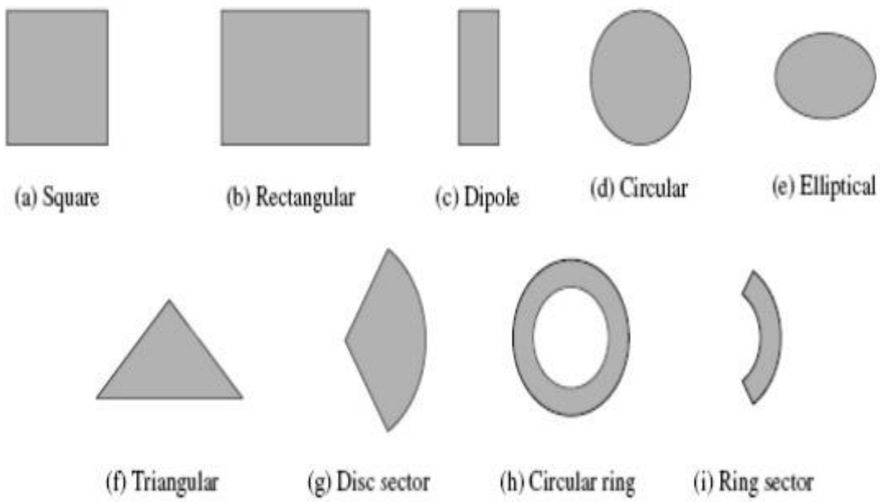


**FIGURE 3.2** Different Shapes of Radiating Patch

## 3.1 Feeding techniques

Microstrip Antennas can be fed using different feeding techniques. The four most common used feeding techniques are discussed below.

### 3.1.1) Microstrip Line Feed

It is one of the easiest method to fabricate, simple to match by controlling the inset position , a conducting strip is attached to the patch which can also be considered as an extension to the patch. But if we increase the thickness of the patch surface waves gets introduced which leads to fake radiation and a generous amount of power loss and practical design limits the bandwidth(2-5%).

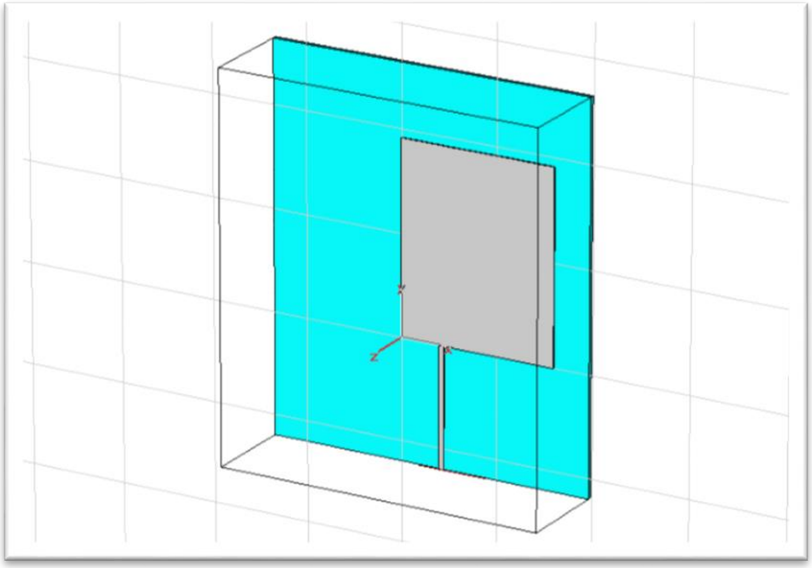

**FIGURE 3.3** Microstrip Line Feed

### 3.1.2) Coaxial Line Feed

Coaxial cable consists of inner and outer conductor. The inner conductor of the coaxial cable is attached to the radiation patch of the antenna and the outer conductor is attached to the ground plane. This feeding is also easy to fabricate and has low radiation.

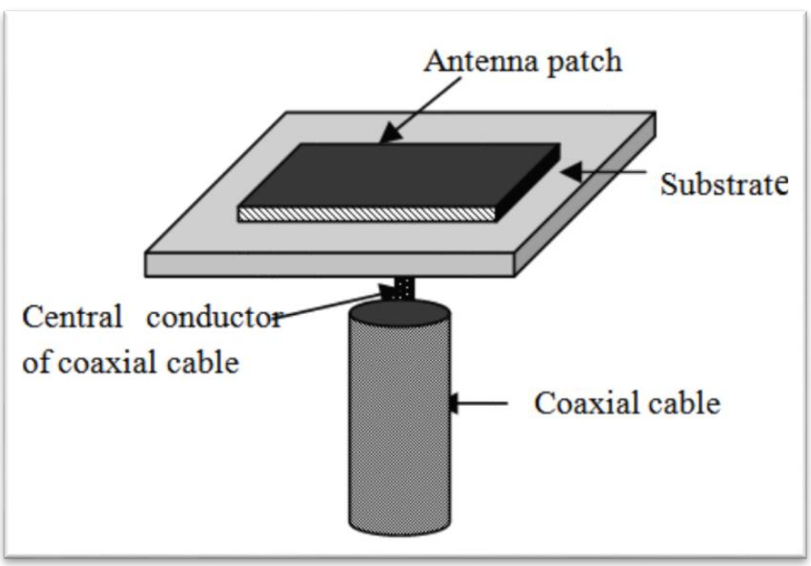


**FIGURE 3.4** Coaxial Line Feed

### 3.1.3) Aperture Coupling

Aperture coupling as shown in fig. consists of two different substrates separated by a ground plane. It has narrow Bandwidth and most difficult of all the feeding techniques to implement. Below the lower substrate there is a Microstrip line feed whose energy is coupled through a slot on the ground plane to the patch which separates the two substrate. Because of the separation we get a lower substrate and a top substrate. Thick low dielectric constant material is used for top substrate and high dielectric material is used for lower substrate. The ground plane separating the two substrate minimize the fake radiation also isolates the feed from radiating element.

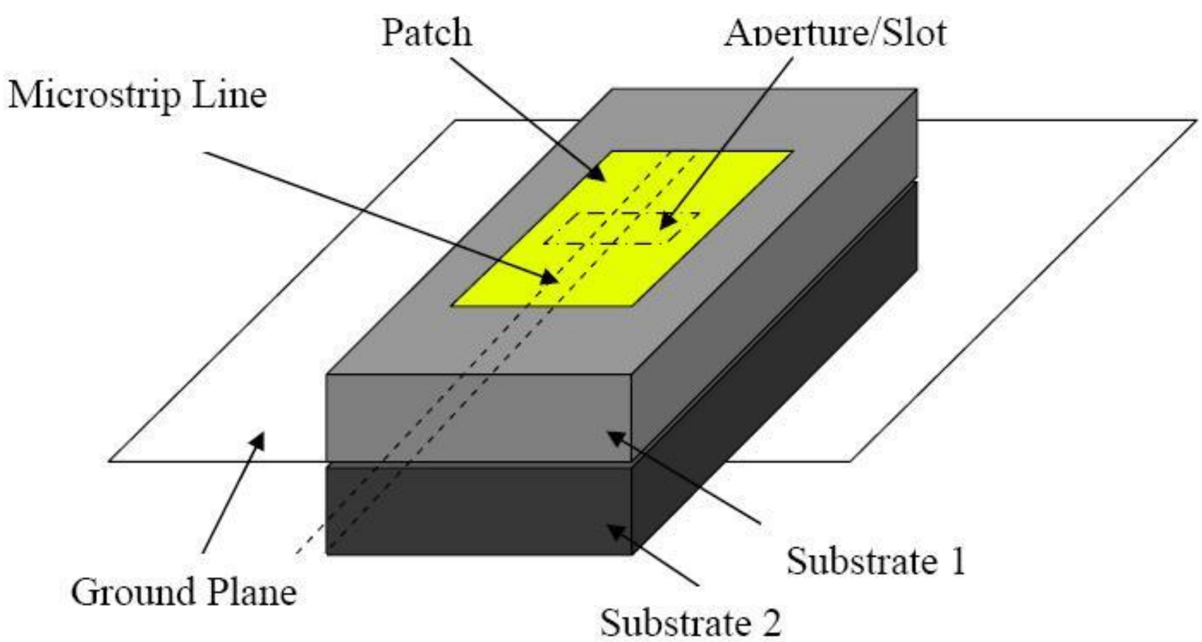


**FIGURE 3.5** Aperture Coupling

### 3.1.4) Proximity Coupling

Of the four feeds, discussed above Proximity coupling has the largest Bandwidth and low fake radiation. Two dielectric substrates are used in such a way that the feed line is between the two substrate and radiating patch is on the top of upper substrate. Its fabrication is more difficult.

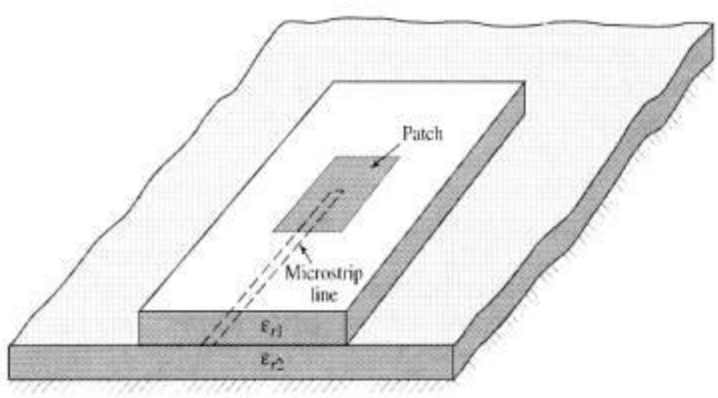


**FIGURE 3.6** Proximity Coupling

## 3.2 Design of Rectangular Patch Antenna

**SOFTWARE USED : HFSS**

High Frequency Structure Simulator allows us to solve any arbitrary 3D geometry. It's a tool used for Antenna design.

### 3.1.3) Design of Rectangular patch antenna at 2.4 GHz

PARAMETERS USED:

- Dielectric constant(Duroid) = 2.4
- Height of substrate = 3.2 mm
- Length of patch (L) = 40 mm
- Width of patch( W) = 30 mm
- Length of ground = 100 mm
- Width of ground = 90 mm

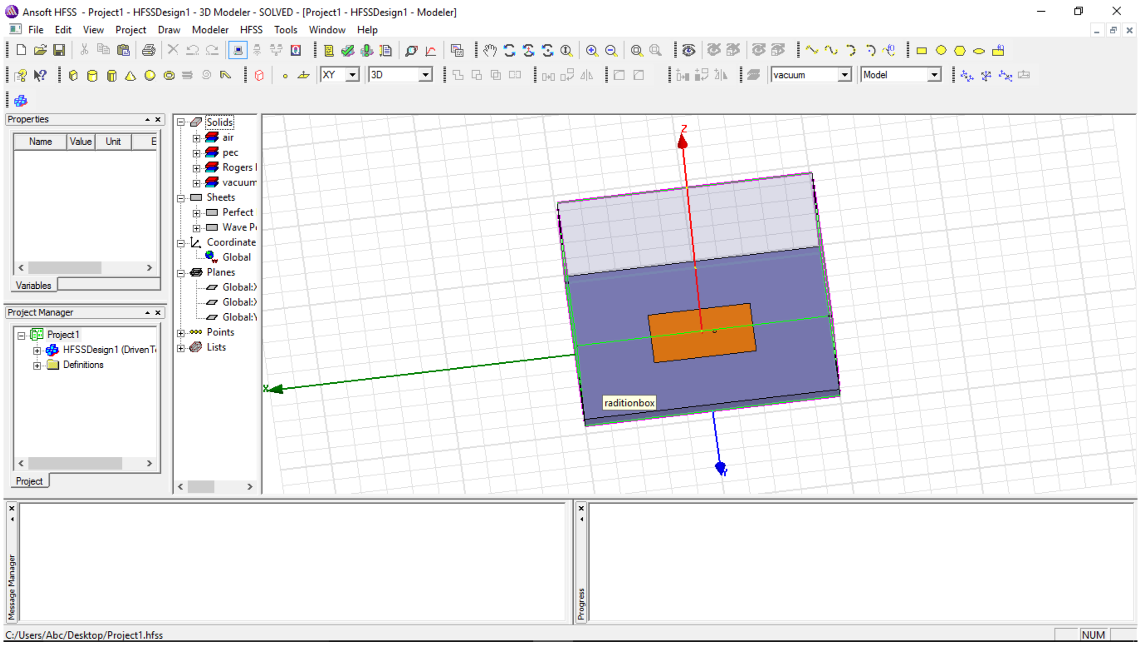


**FIGURE 3.7** Design of Microstrip patch antenna at 2.4 GHz

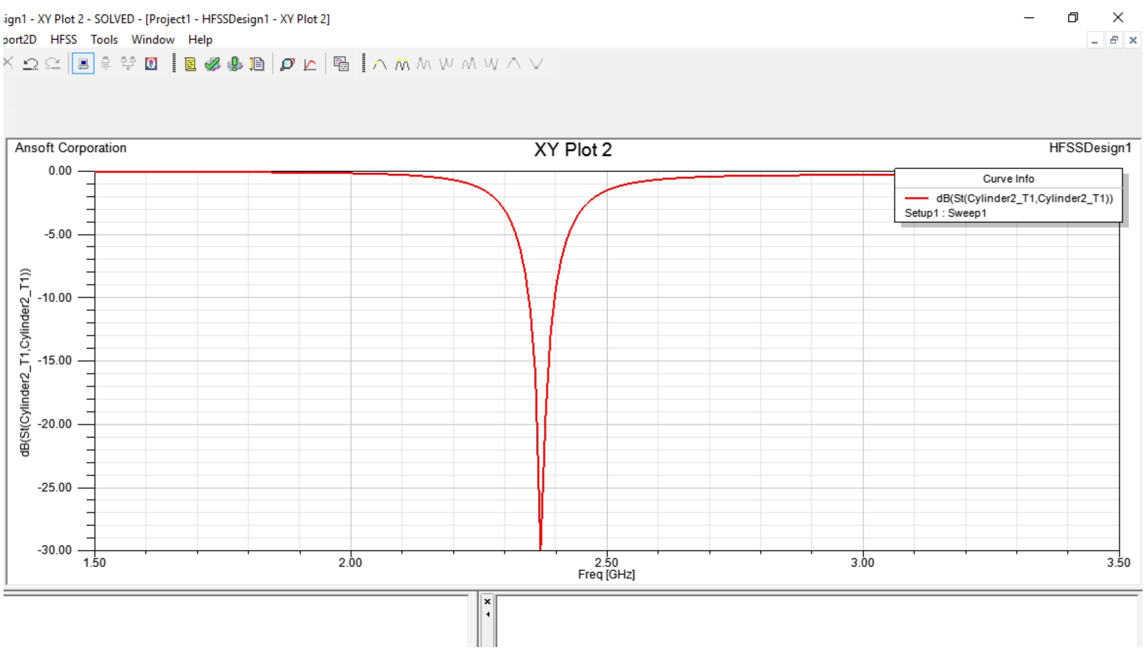


**FIGURE 3.8** Gain plot of Microstrip patch antenna at 2.4 GHz

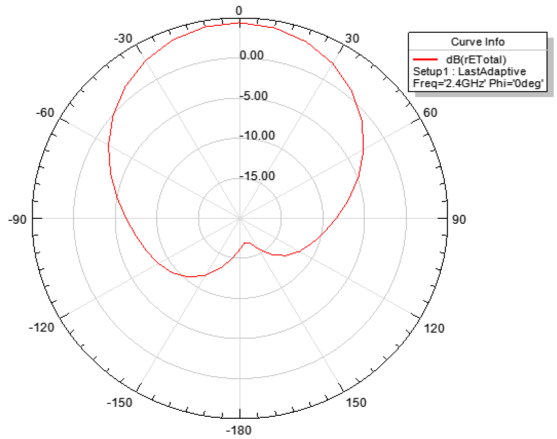


**FIGURE 3.9** Radiation pattern of Microstrip patch antenna at 0 degree

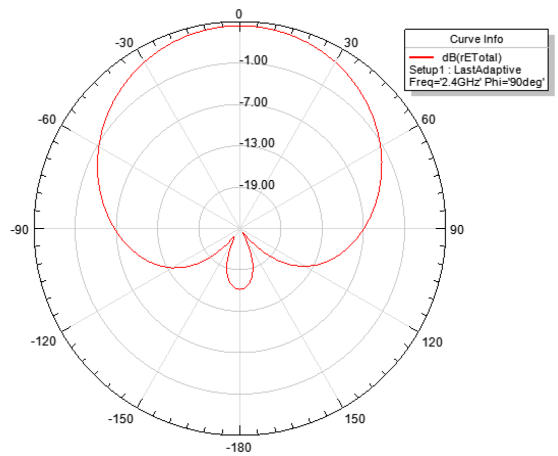


**FIGURE 3.10** Radiation pattern of Microstrip patch antenna at 90 degree

| **Stimulated Parameters** | **Values** |
|---|---|
| Directivity | 5.447 dBi |
| Gain | 5.3611 Db |
| Radiation Efficiency | 98.4 % |
| Radiated Power | 20.1 Mw |

**TABLE 3.1**

### 3.1.3) Design of Rectangular patch antenna at 10 GHz with Coaxial Feed

PARAMETERS USED:

- Dielectric constant(Duroid) = 4.4
- Height of substrate = 1.6 mm
- Length of patch (L) = 7.0861 mm
- Width of patch( W) = 9.14 mm
- Length of ground = 16.68 mm
- Width of ground = 18.74 mm

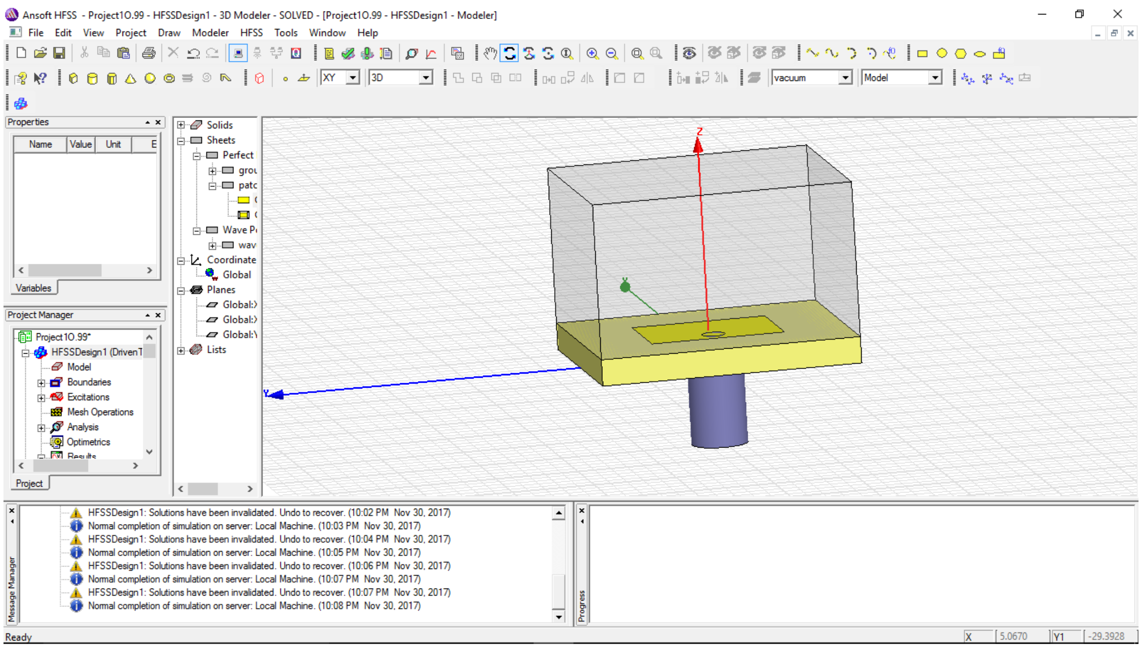


**FIGURE 3.11** Design of Microstrip patch antenna at 10 GHz

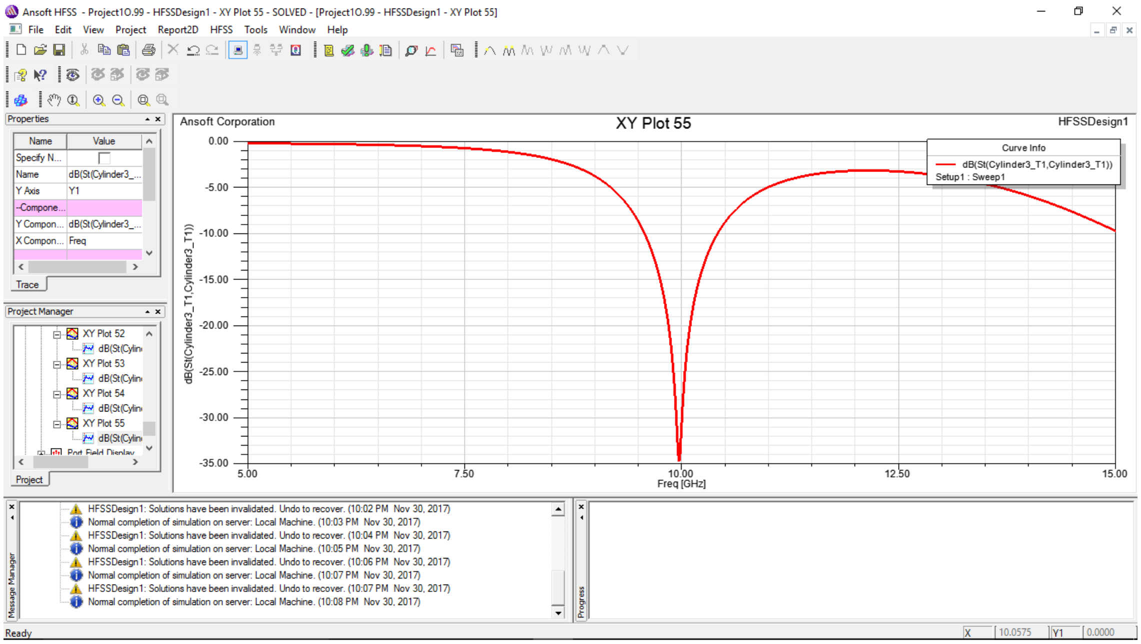


**FIGURE 3.12** Return loss of Microstrip patch antenna at 10 GHz

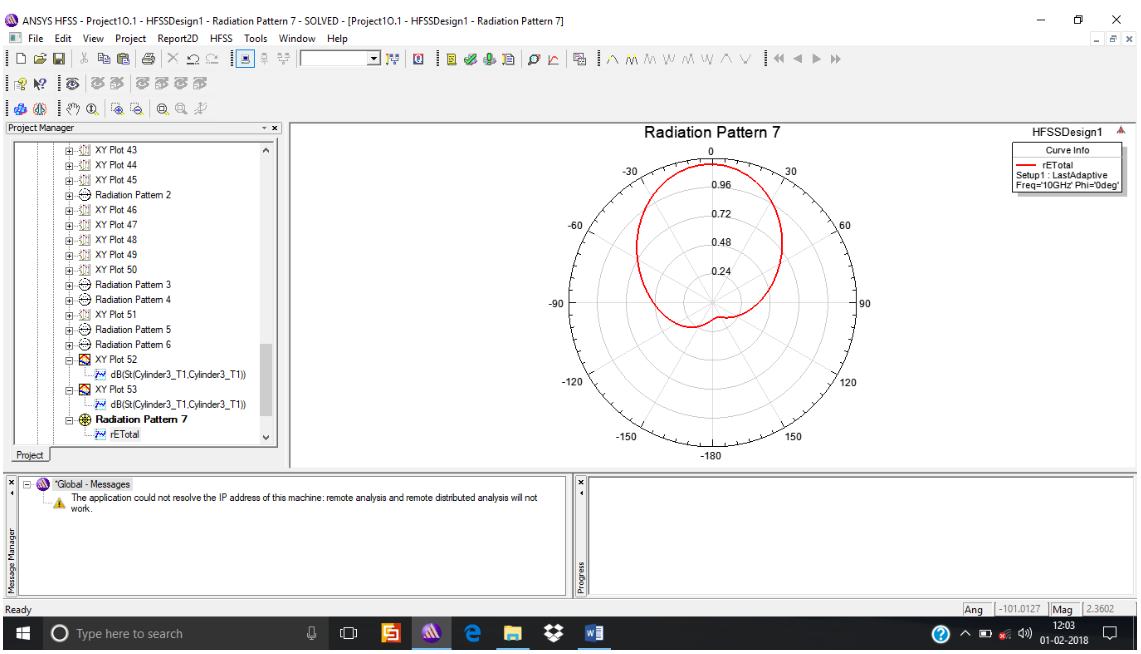


**FIGURE 3.13** Radiation plot at 0 degree (E plot)

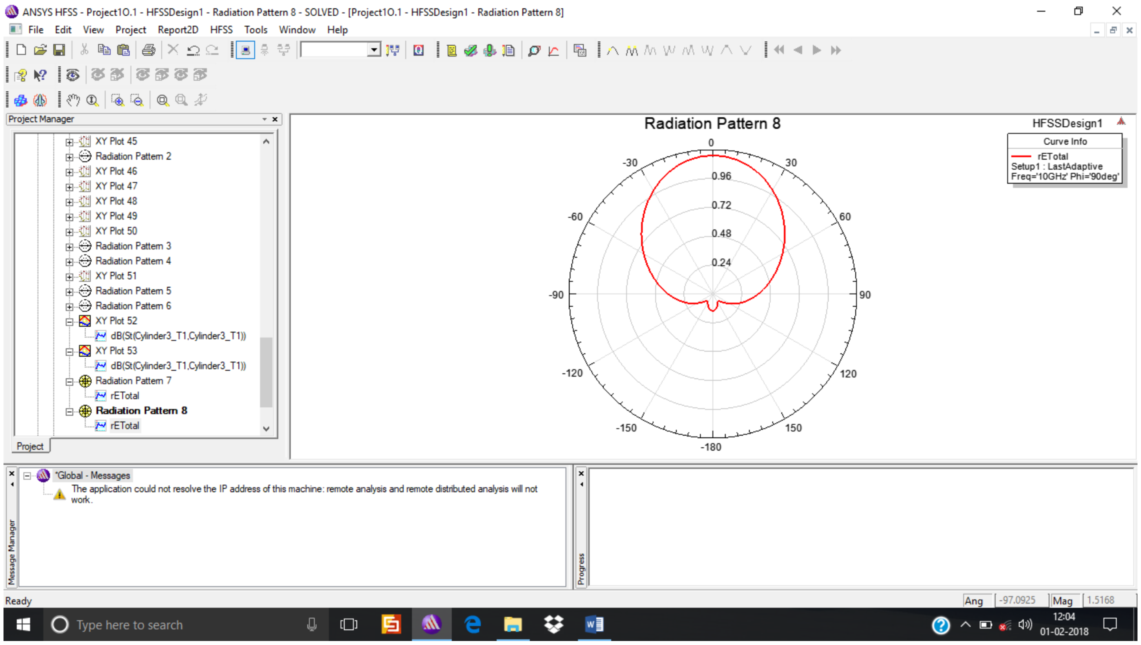


**FIGURE 3.14** Radiation plot at 90 degree (H plot)

| Stimulated Parameters | Values |
|---|---|
| Directivity | 2.7345 dBi |
| Gain | 2.2886 Db |
| Radiation Efficiency | 83.5 % |
| Radiated Power | 8.025 mW |

**TABLE 3.2**

### 3.1.3) Design of Rectangular patch antenna at 10 GHz with Inset Feed

PARAMETERS USED:

- Dielectric constant(Duroid) = 4.4
- Height of substrate = 1.6 mm
- Length of patch (L) = 7.0861 mm
- Width of patch( W) = 9.14 mm

- Length of ground = 16.68 mm
- Width of ground = 18.74 mm

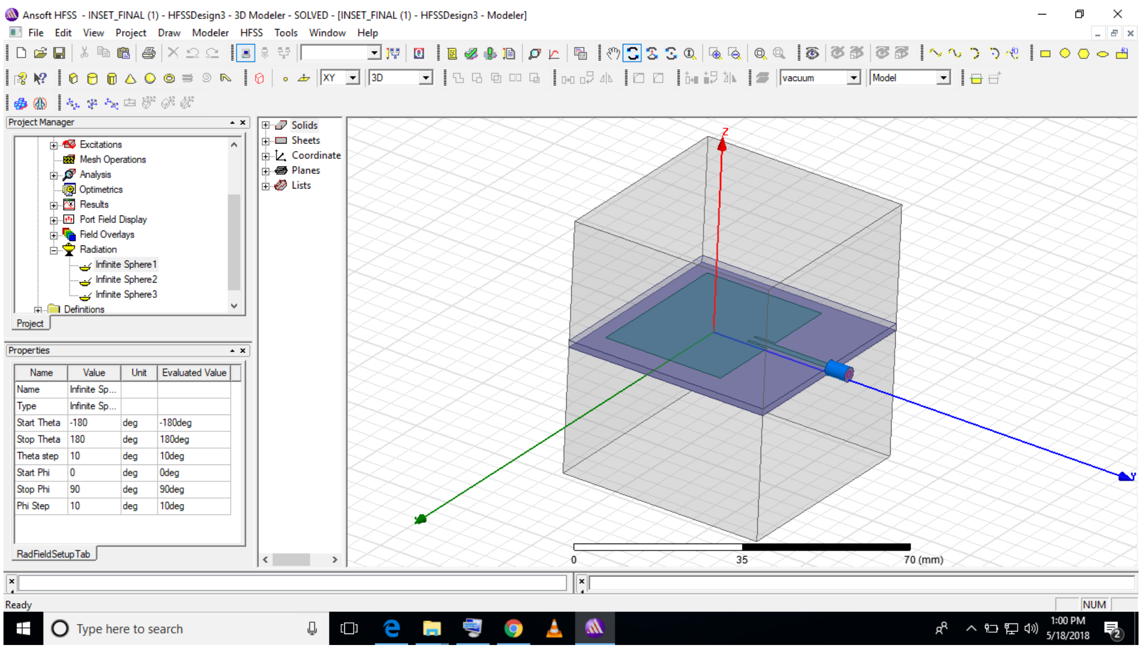


**FIGURE 3.15** Design of Microstrip patch antenna at 10 GHz with inset feed

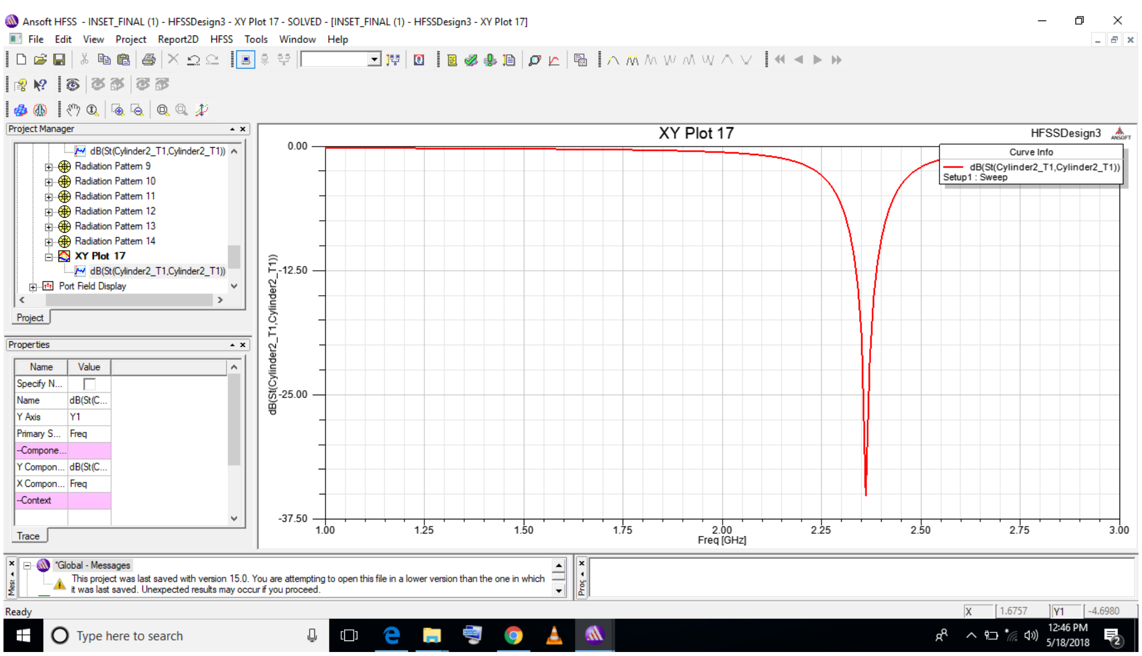


**FIGURE 3.16** Return loss of Microstrip patch antenna at 10 GHz

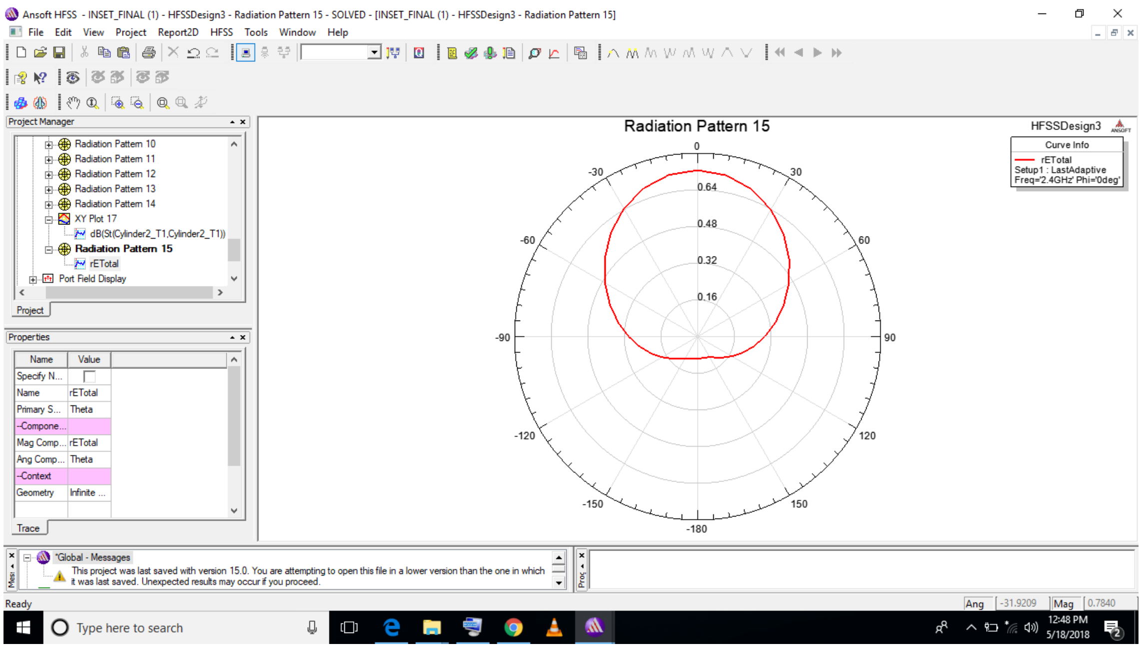

**FIGURE 3.17** Radiation pattern of Microstrip patch antenna at 0 degree

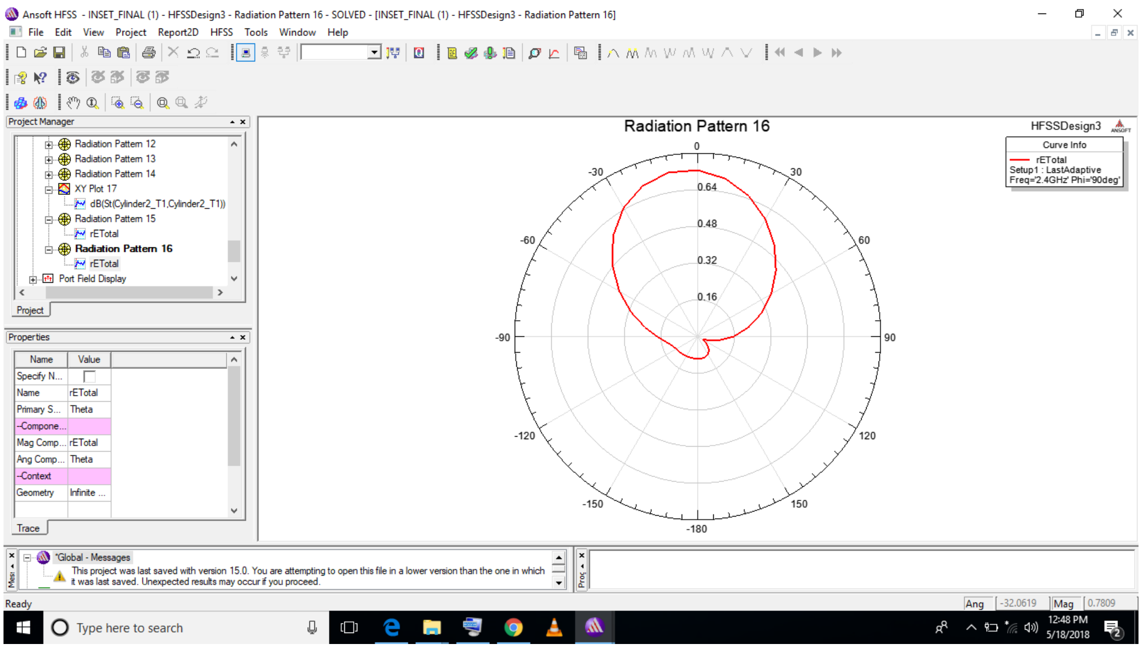

**FIGURE 3.18** Radiation pattern of Microstrip patch antenna at 90 degree

| Stimulated Parameters | Values |
|---|---|
| Directivity | 2.7345 dBi |
| Gain | 2.2886 dB |
| Radiation Efficiency | 83.5% |
| Radiated Power | 8.025 Mw |

**TABLE 3.3**

# 4. CHAPTER – ANTENNA ARRAY

Some radiation characteristics are not achievable by single element. Therefore, many applications requires combination of more than one radiating elements, which are arranged in such a way radiation from every element after adding up gives maximum radiation in a particular direction or desired direction.

In array antenna we connect multiple antennas together, which works as a single antenna for transmitting and receiving radio waves. It gives improved performance to that of single antennas also increases the overall gain of the antenna.

Antenna array design is an alternate way to achieve large directivity without increase in size of individual element. In Array antenna we connect several antennas in a regular structure and arrange them to form a single antenna. The elements of array are taken as identical in most cases just for the ease of installation. The antennas in array are organised in such a way that radiation from every element is added to get maximum radiation in a particular direction.

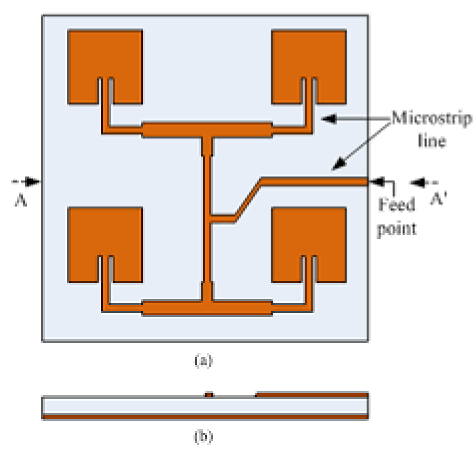


**FIGURE 4.1** Antenna Array

## 3.1.3) Design of 1*2 Circular Patch Array at 2.4 GHz

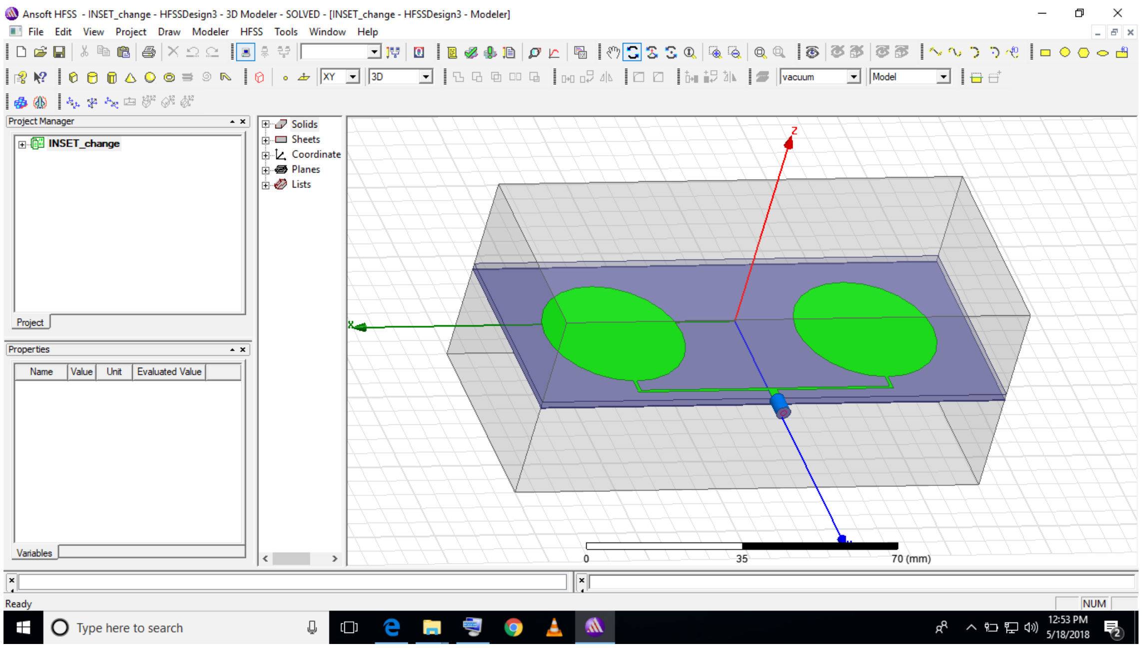


**FIGURE 4.2** Design of 1X2 circular patch antenna

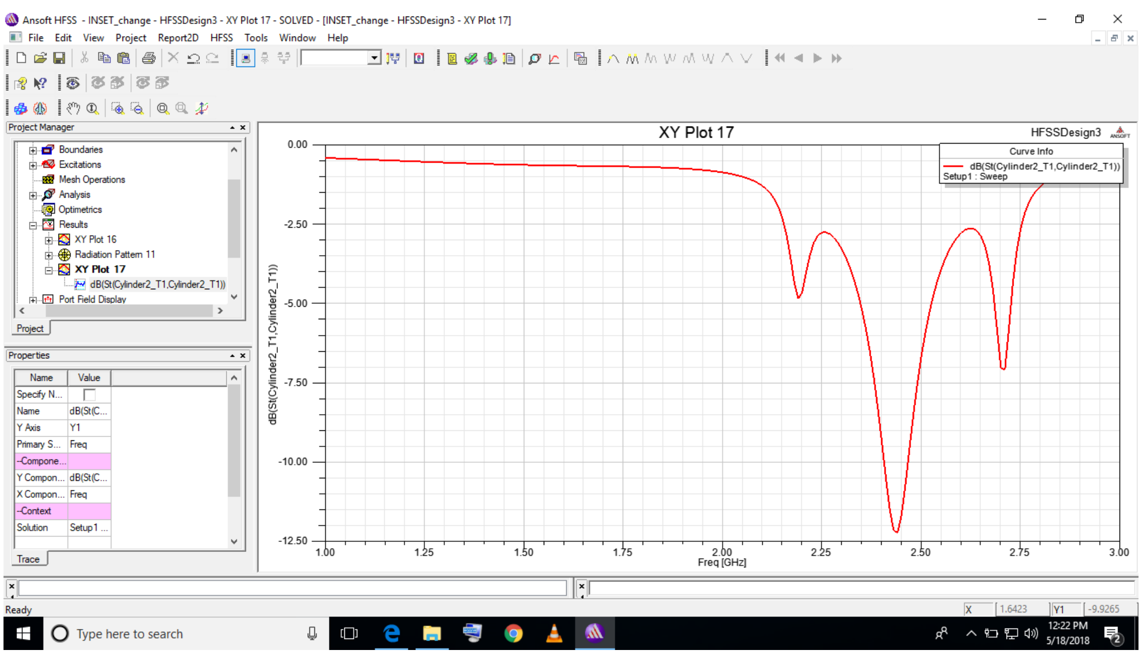


**FIGURE 4.3** Return loss of CPA 1X2

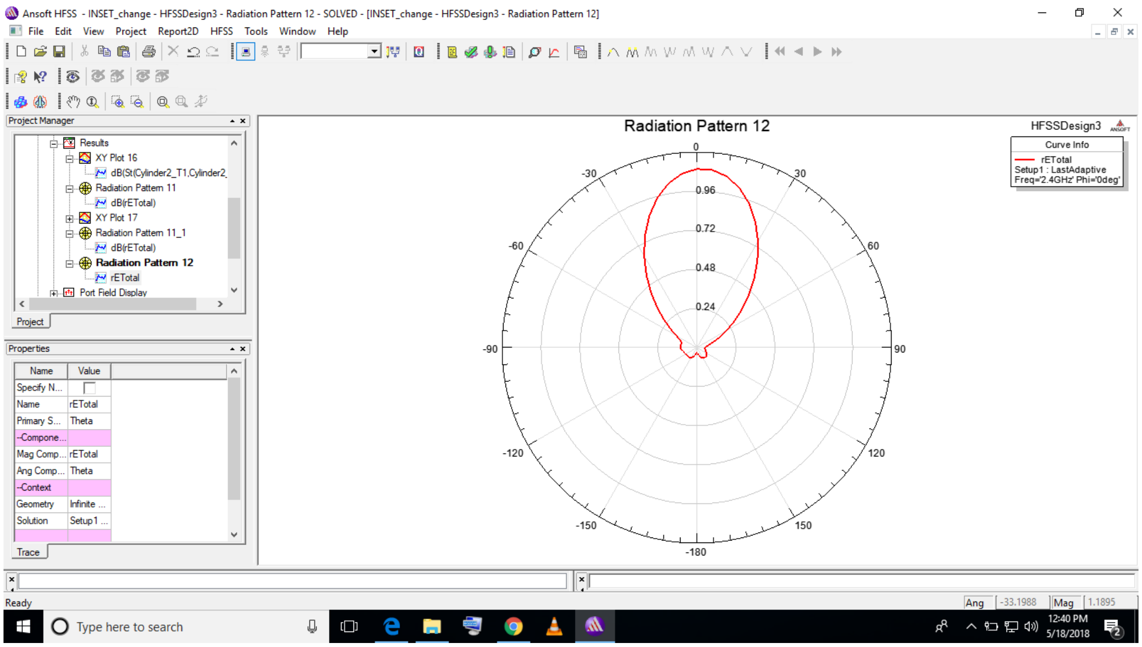


**FIGURE 4.4** Radiation pattern of CPA at 0 degree

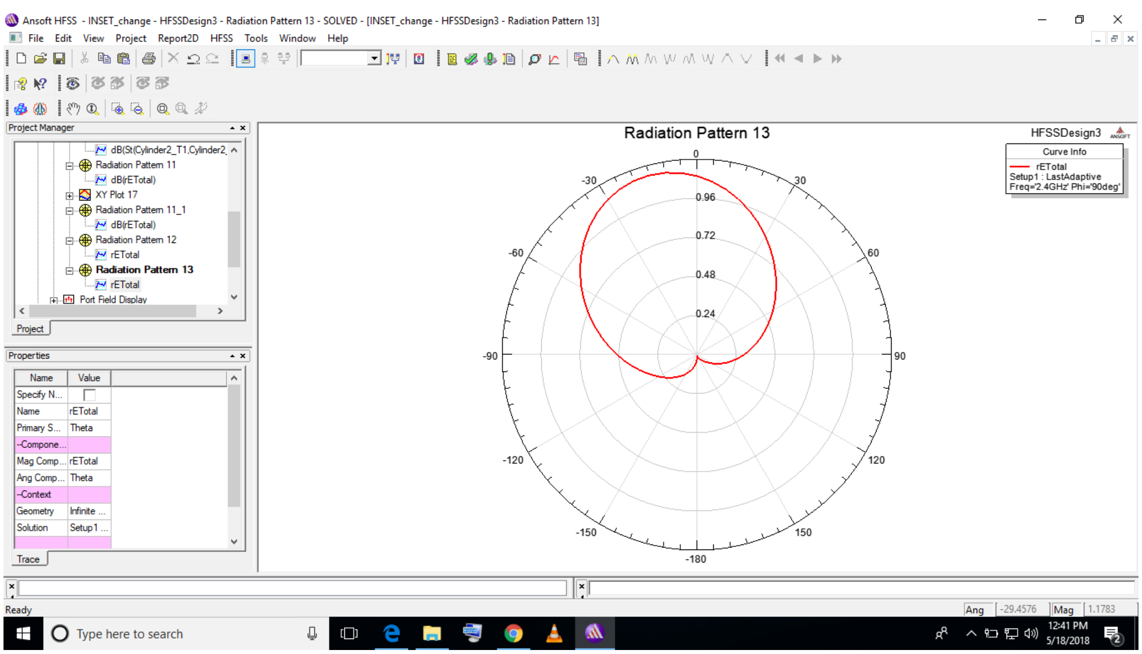


**FIGURE 4.5** Radiation pattern of CPA at 90 degree

| Stimulated Parameters | Values |
| --- | --- |
| Directivity | 4.8375 dBi |
| Gain | 2.7679 dB |
| Radiation Efficiency | 57% |
| Radiation Power | 4.8 mW |

**TABLE 4.1**

# 5. CHAPTER - CONCLUSIONS AND FUTURE WORK

In this research, we successfully designed MPA on different frequencies with different feeding techniques. We observed that coaxial feeding techniques is easy to implement. In order to improve directivity we used arrays in place of single element and also designed 1X2 circular patch array with coaxial feeding. From these results, we can see that in case of array with increases in number of patches, directivity and radiation pattern show a noticeable amount of improvement.

We know that with increase in number of patches directivity of antenna increases. So we will design 1X4 and 8X1 in order to increase the directivity of the antenna.

## REFERENCES

[1] Custodio Peixerio “Microstrip Patch Antennas : An historical perspective of Develpoment” IEEE Research paper.

[2] Rachmansyah, Antonius Irianto, and A. Benny Mutiara, “Designing and Manufacturing Microstrip Antenna for Wireless Communication at 2.4 GHz,” International Journal of Computer and Electrical Engineering, Vol. 3, No. 5

[3] Ismael Saad Eltoum “Analysis and Design of Rectangular Microstrip Patch Antenna at 2.4GHz”

[4] Bancroft, R. “Microstrip and Printed Antenna Design,” Noble Publishing 2004.

[5] Deschamps, G.A., “Microstrip Microwave Antennas”, Third symposium on the USAF Antenna Research and development program, University of IIIinois, Moticello, IIIinois, October 18-22, 1953.

[6] Barret, R. M., “Microwave printed Circuits-a historical survey,” IEEE Transactions on microwave Theory and techniques, vol.3, No.2, pp. 1-9.

[7] Bernhard, J.T., Mayes, P.E., Schaubert, D., and Mailoux, R.J.,”A commemoration of Deschamps’ and Sichak’s ‘Microstrip Microwave Antennas’: 50 years of Development, divergence,and new directions,” Proceedings of the 2003 Antenna Applications Symposium , Moticello, IIIinois, september 2003, pp. 189-230.

[8] Lo, Y.T., Solomon, D.,and Richards , W.F.,”Theory and Experiment on microstrip Antenna,” IEEE Transactions on antenna and propagation, March1979, vol. AP-27, pp. 137-149.

[9] Licul, S., Petros, A., and Zafar, l., “Reviewing SDARS antenna requirements,” Microwave & RF September 2003, Vol. 43, pp. 51-62.

[10] Denlinger, E.J., “Radiation from Microstrip Radiators” IEEE Transactions on microwave Theory and techniques, April1969, vol.17, No. 4, pp. 235-236.

[11] Hashibul Alam "Design Rectangular Microstrip Patch Antenna" for IEEE 802.15.3a (WPAN) with MB-OFDM Ultra Wide Band Communication System

[12] Constantine A.Balanis, "Antenna Theory Analysis and Design", Third Edition.

[13] Richards, W.F., LO, Y.T., and Harrison, D.D., "An improved theory for microstrip antennas 72 and application" IEEE Transactions on antenna and propagation January 1981,vol. AP-29,pp. 38-46.

[14] R.J. Mailloux, J.F. Mcllvenna and N.P. Kemweis-Microstrip Array Technology IEEE Transactions on Antennas and Propagation,Vol.29,No.1,January 1981.

[15] A.M Prasanna Kumar "Design and Development of Microstrip Rectangular Patch Antenna with Different Feed Techniques" Volume 6, Issue 4, April 2016 ISSN: 2277 128X International Journal of Advanced Research in Computer Science and Software Engineering.

[16] Kinza Shafique, Muhammad Mustaqim "A 1*2 Circular Patch Antenna Array for next generation 802.11ac WLAN Applications"

[17] Alak Majumder, "Rectangular Microstrip Patch Antenna Using Coaxial Probe Feeding technique to Operate in S=Band", IJETT, Volume 4, Issue 4, April 2013.

[18] Lalit Kaushal, „Design Analysis and Performance Assessment of Rectangular Microstrip Patch Antenna for WLAN", IJERT, ISSN: 2278 – 0181, Vol. 4 Issue, July – 2015.

[19] Sandip Gajera, Hasani Mahesh, Naresh Patel, "Comparative Analysis of Microstrip Line and Coaxial Feeding Technique for Rectangular Microstrip Patch Antenna", IJECSE, ISSN – 2277 – 1956, Vol. 2N2 – 719 – 725.

[20] Tanish Narang; Shubhangi jain; "Microstrip Patch Antenna- A Historical Perpective of the Development",Conference on Advances in Communication and Control Systems 2013 (CAC2S 2013).

[21] Ogunlade Michael Adegoke; Ismael Saad Eltoum; "Analysis and Design of Rectangular Microstrip Patch Antenna AT 2.4GhzWLAN Applications", International Journal of Engineering Research &Technology (IJERT) ISSN: 2278-0181Vol. 3 Issue 8, August – 2014.

[22] Nandini Ammanagi, Rahul Khadilkar, Akash Harwani, Disha Budhlani, Disha Dembla; "Comparison of the performance of Microstrip Antenna at 2.4GHz Using Different Substrate Materials", International Journal of Engineering and Advanced Technology (IJEAT) ISSN: 2249 – 8958, Volume-3, Issue-4, April 2014.

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