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SEMISTER PROJECT

Title:Model and Simulate Planar Array Antenna for Radar Application

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Approval page

This is to certify that Project Report entitled “**Model and Simulate Planar Array Antenna for Radar Application”**that is submitted by this group members in partial fulfillment of the requirement for the award of the Semester project in ELECTRICAL AND COMPUTER ENGINEERING(Communication Stream) of Debre Tabor University, is a record of the candidate own work carried out by him under my own supervision. The matter embodies in Semester project is original.

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DECLARATION

WE, the undersigned, declare that the work which is being presented in the project entitle,“ Model and simulate Planar Array Antenna for Radar Application”

The requirements of the bachelor degree of engineering in communication submitted to electronics and communication stream chair school of electrical and computer Engineering, Debre Tabor University, is an authentic record of our own work carried out under supervisor of Mrs.Muhabaw A.

Acknowledgment

Nothing can be done without the help of God. Behind every activity's success there is his strong hand. First of all we would like to express our gratitude to the almighty God who helped us to do this semester project, although we don't deserve to thank him with our little hand. We would like to say thank you to our adivesor.Mr. Muhabaw A., who advised and tells us how to correct it and also the way to finish semester project and thank you our group memberand also 5th year communication Students.

Abstract

Micro strip patch antenna has gained much attention of research community because of its low profile, light weight and conformal to non-planar surfaces. But is the limitation of low gain, small bandwidth and poor efficiency. This limitations can be overcome by using antenna arrays.

The main objective of this project is analysis a planar array antenna for radar application. To radiates and receive this electromagnetic wave, the parameters of antenna must be designed properly. To design planar array antenna, the main parameters are beam width, radiation pattern, efficiency, directivity, gain etc. The control parameters for antenna array are: the number of antenna elements, spacing between antenna elements, magnitude and phase of excitation amplitudes, and the geometrical shapes of the patch. The main objective of this project is to improve the performance of planar array antenna for radar system by using the following control parameters: in case on single element varying the number of antenna elements, the space between the adjacent element and the geometrical shape of each element.

The performance of the proposed array will be evaluated using several metrics. This is evaluated using HFSS software.

In this project, a planar array antenna with a 10.5 GHz working frequency is constructed. The substrate utilized is FR4 epoxy, ground and patch utilized are copper, which has a thin substrate with a 1.6 mm thickness and a low dielectric constant of 4.4. Transmission line model using HFSS are used to compute the sizes of the patch, the substrate ground plane, the gap, and the feed line.

Using εr=4.4 this design is utilized to get the best configuration in terms of desired values for RL, VSWR, and bandwidth. We can obtain the RL of -28.899 dB, VSWR of 1.0736, which indicates that there are no losses, the gain of 1.8427dB, the directivity of 2.1639dB,the efficiency of 85.2% and the BW of 810 MHZ.

Keywords: *Micro Strip antenna, planar array antenna; model and simulate using HFSS software.*

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List of Abbreviation

VLF	very law frequency
LF	low frequency
HF	high frequency
VHF	very high frequency
SIW	substrate integrated wave guide
IEEE	institute of electrical and electronic engineers
RF	radio frequency
HPBW	half power beam width
FNBW	first null beam width
VSWR	voltage standing wave ratio
BW	band width
RL	return loss

Chapter One

1. Introduction

1.1 Background

Antenna is a device that radiates and receives electromagnetic wave or that transmit information from one media to another media[3]. There are different types of antenna depend on different criteria. Based on physical property those can be classified as Wire Antennas, Aperture Antennas, Micro strip Antennas, Array Antennas [3]. Amongst those type of antenna , micro strip patch antenna also known as printed antenna which is fabricated using printed circuit board technology and is used to convey microwave-frequency signals .It consists the radiated patch on one side of dielectric substrate which have a ground plane in the other side. Micro strip patch antenna have low profile, conformable to planar and non-planar surfaces, simple and inexpensive to manufacture using modern printed-circuit technology, mechanically robust when mounted on rigid surfaces, compatible with MMIC designs. But it has low efficiency, low power, high poor polarization purity, poor scan performance, spurious feed radiation and very narrow frequency bandwidth, which is typically only a fraction of a percent or at most a few percent.

One of the major advantages of micro strip antenna is the simplicity of array construction .The radiating elements may be etched jointly with the feed network as an integrated structure leading to a very compact and low cost design. Planar array antenna is an antenna in which all of the elements of micro strip are in one plane. Planar arrays provide directional beams, higher bandwidth, symmetrical patterns with low side lobes, much higher directivity (narrow main beam) than that of their individual element [5]. As the increase of array antenna to the extent it will be unmanageable i.e. increase in size and the cost will be very high and it will be complex. It also expiate when the array increases, there will be a loss of feeding network such as conductor loss, radiation loss and dielectric loss [7].By considering this one and the above problem. Array number will not be very large.

Array antenna may linear, circular or planar. Antennas have so many applications. Among those for radar, aircraft, spacecraft, missile etc.

Radar is electromagnetic sensor used for detecting, locating, tracking, and recognizing objects of various kinds at considerable distances [4]. It operates by transmitting electromagnetic energy that radiated by antenna toward objects and observing the echoes returned from them. Planar array antenna is an antenna in which all of the elements are in one plane. Planar arrays provide directional beams, symmetrical patterns with low side lobes, much higher directivity (narrow main beam) than that of their individual element [5]. Applications of planar array antenna are tracking radars, remote sensing, communications, etc.Planar array antenna in radar application, the planar array antenna emits electromagnetic radiation, a portion of which is reflected back by the target. The planar array antenna receives this reflected energy and delivers it to the receiver.

1.2 Antenna for radar application

1.2.1 Radar System

The word radar is an abbreviation for Radio Detection and Ranging[11].Radar refers to electronic equipment that detects the presence of objects by using reelected electromagnetic energy. Under some conditions a radar system can measure the direction height, distance and speed of the objects. The frequency of electromagnetic energy used for radar is unaffected by darkness and also penetrates fog and clouds. This permits radar systems to determine the position of airplanes, ships or other obstacles that are invisible to the naked eye because of distance,darkens or weather.

Radar is an addition to man's sensory equipment which affords genuinely new facilities. It enables a certain class of objects to be "seen" that is, detected and located at distances far beyond those at which they could be distinguished by the unaided eye. This "seeing" is unimpaired by night, fog, cloud, smoke, and most other obstacles to ordinary vision. Radar further permits the measurement of the range of the objects it "sees" with a convenience and precision entirely unknown in the past. It can also measure the instantaneous speed of such an object toward or away from the observing station in a simple and natural way. Radar works by sending out radio waves from a transmitter powerful enough so that measurable amounts of radio energy will be reflected from the objects to be seen by the radar to a radio receiver usually located, for convenience, at the same site as the transmitter.

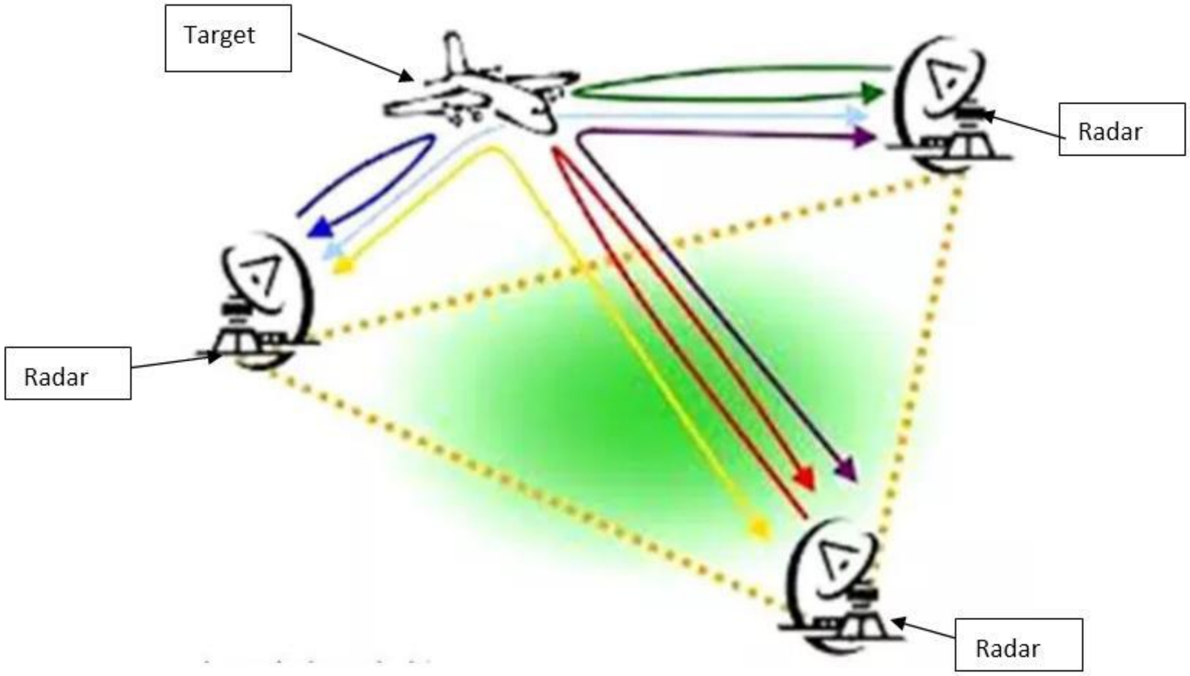

Figure 1. radar detecting the target

The properties of the received echoes are used to form a picture or to determine certain properties of the objects that cause the echoes. In pulse radar, the transmitter is modulated in such a way that it sends out very intense, very brief pulses of radio energy at intervals that are spaced rather far apart in terms of the duration of each pulse. During the waiting time of the transmitter between pulses, the receiver is active. Echoes are received from the nearest objects soon after the transmission of the pulse, from objects farther away at a slightly later time, and so on. When sufficient time has elapsed to allow for the reception of echoes from the most distant objects of interest, the transmitter is keyed again to send another very short pulse, and the cycle repeats. Since the radio waves used in radar are propagated with the speed of light, c, the delay between the transmission of a pulse and the reception of the echo from an object at range R will be the factor 2 entering because the distance to the target has to be traversed twice, once out and once back

$T=2R/C$…………………………..2.1

The ability of a Radar to discriminate between targets close together in space, improves as the beam width of the antenna is narrowed. Targets at the same range can be distinguished by radar as being separate if they are separated in azimuth by an angle larger than one beam width; thus the quality of the picture afforded by radar improves as the beam width is reduced. For an antenna of given size, the beam width can be decreased only by lowering the wavelength. The operation of a radar set depends on the detection of a weak signal returned from a distant reflecting object Free-space propagation of radar. if radar set and target were isolated in unbounded empty space and to be realized if the following conditions are fulfilled.

1. No large obstacles intervene between antenna and target, along an optical line of sight.

2. No alternate transmission path, via a reflecting surface, can be followed by a substantial fraction of the radiated energy.

3. The intervening atmosphere is homogeneous with respect to index of refraction, at the frequency used.

4. The intervening atmosphere is transparent, i.e., does not absorb energy from the wave, at the frequency used.

Basic parts of Radar are:

- ✓ A Transmitter: It can be a power amplifier like travelling Wave Tube or a power Oscillator like a Magnetron. The signal is first generated using a waveform generator and then amplified in the power amplifier.
- ✓ Waveguides: The waveguides are transmission lines for transmission of the RADAR signals.
- ✓ Antenna: The antenna used can be a parabolic reflector, planar arrays or electronically steered phased arrays.
- ✓ Duplexer: A duplexer allows the antenna to be used as a transmitter or a receiver. It can be a gaseous device that would produce a short circuit at the input to the receiver when transmitter is working.
- ✓ Receiver: It can be super heterodyne receiver or any other receiver which consists of a processor to process the signal and detect it.
- ✓ Threshold Decision: The output of the receiver is compared with a threshold to detect the presence of any object. If the output is below any threshold, the presence of noise is assumed. Application area of radar; radar is applicable for

- ➢ Military purpose: In air defense it is used for target detection, target recognition and weapon control (directing the weapon to the tracked targets)
- In missile system to guide the weapon
- Identifying enemy locations in map
- ➢ Air Traffic Control purpose: To control air traffic near airports. The Air Surveillance RADAR is used to detect and display the aircraft's position in the airport terminals.
- To guide the aircraft to land in bad weather using Precision Approach RADAR
- To scan the airport surface for aircraft and ground vehicle positions
- ➢ Remote Sensing purpose: RADAR can be used for observing weather or observing planetary positions and monitoring sea ice to ensure smooth route for ships.
- ➢ Ground Traffic Control purpose: RADAR can also be used by traffic police to determine speed of the vehicle, controlling the movement of vehicles by giving warnings about presence of other vehicles or any other obstacles behind them
- ➢ Space application: To guide the space vehicle for safe landing on moon.
- To observe the planetary systems
- To detect and track satellites
- To monitor the meteors

Antenna is one of the most critical parts of a radar system. It performs the following essential functions:

- ➢ Impedance transformation (free space intrinsic impedance to transition line characteristics impedance)
- ➢ Propagation mode adaptor (free space fields to guided waves)
- ➢ Spatial filter (radiation pattern direction dependent sensitivity)
- ➢ Polarization filter (polarization dependent sensitivity)

1.3 Antenna and antenna type

The IEEE Standard Definitions of Terms for Antennas (IEEE Std 145–1983) defines the antenna or aerial as "a means for radiating or receiving radio waves."[3] It is a transducer ,an electromagnetic radiator, sensor and an impedance machining device that convert radio frequency(RF) fields or electromagnetic wave in to current and voltage and vice versa[7]. It have an arrangement of metallic conductor with an electrical connection to receiver or transmitter. To radiate the electromagnetic wave for long distance i.e. for radar system the antenna is design in high efficient, directivity and good resolution.

Based on different criteria i.e. depend on physical structure, frequency range, application area, size and shape antenna is classified as follow.

Based on a physical structure, the antennas can be:

- ✓ Wire antennas
- ✓ Aperture antennas
- ✓ Reflector antennas
- ✓ Micro strip antennas
- ✓ Array antennas
- ✓ Lens antennas

And based on frequency range, the antenna can be classified:

- ✓ Very low frequency(VL)
- ✓ Low frequency (LF)
- ✓ High frequency(HF)
- ✓ Very high frequency (VHF)

1.4 Antenna parameter

Design of an antenna entails creating a physical structure that has satisfies some pre-established performance criteria. The result is the antenna behaving in a desired way. To be able to accurately describe how an antenna performs, we need to first define relevant antenna parameters. The following are some important parameters that are useful in evaluating the performance of an antenna:

1. Radiation Pattern
2. Beam-width
3. Directivity

4. Gain

5. Feed-point impedance

6. Polarization

1.4.1 Radiation Pattern

The radiation pattern is a depiction of the angular variation of radiated energy around an antenna. The radiation fields from a transmitting antenna vary inversely with distance i.e. $1/r$. The variation with observation angles (θ & ϕ), however, depends on the physical configuration of the antenna. In most cases, the radiation pattern is determined in the far-field region and is represented as a unction of the directional coordinates.Relevant radiation properties of an antenna include radiation intensity, electromagnetic field strength, directivity, power flux density, phase and polarization. The property of most concern is the spatial distribution of radiated energy as a function of the observer's position on a surface of constant radius enclosing the antenna The various distinct segments of a radiation pattern are referred to as lobes, which may be classified into main (or major), minor, side, and back lobes. A radiation lobe is a "portion of the Radiation pattern bounded by regions of relatively weak radiation intensity

- A major lobe is defined as "the radiation lobe containing the direction of maximum radiation
- A minor lobe is any lobe that isn't the major lobe.
- A side lobe is a radiation lobe oriented in a direction other than the intended
- The back lobe is a radiation lobe whose axis is directly opposite that of the main lobe of an antenna.
- Minor lobes usually represent radiation in undesired directions and antenna designers often strive to minimize them All these are illustrated in Figure below

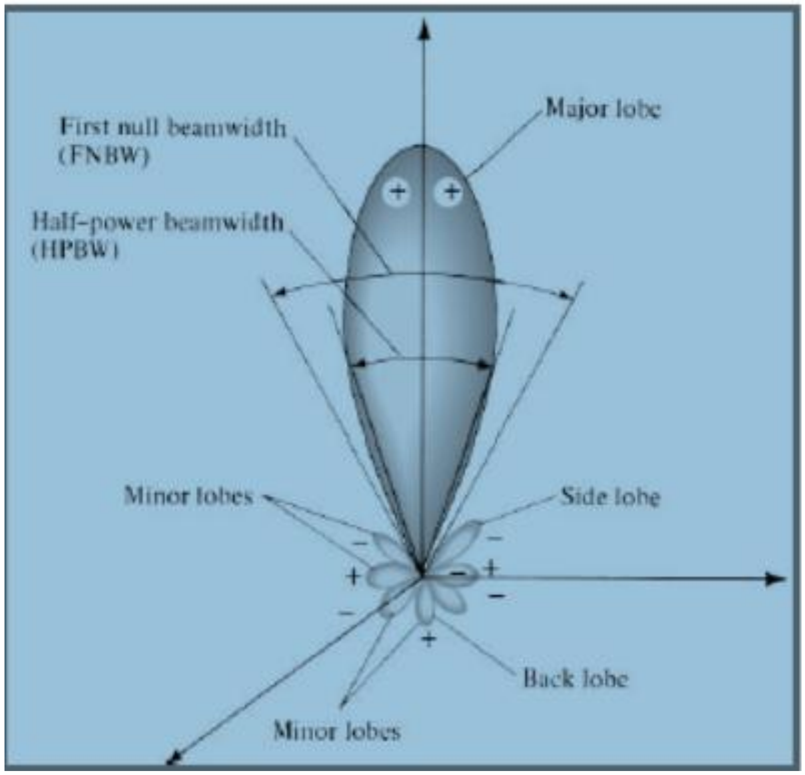

Figure 2.Radiation Lobes and Beam widths of an antenna pattern

1.4.2 Beam width

The beam width of an antenna is a parameter that is associated with the radiation pattern. The beam width is defined as the angular separation between two points of identical radiation power on opposite sides of the main lobe. In an antenna pattern several beam widths can be specified One of the most commonly used is the Half-Power Beam width (HPBW). The HPBW is the angle between the two directions in which the radiation intensity is one-half value of the maximum in a plane containing the maximum Another important beam width is the angular separation between the first nulls encountered on either side of the maximum. It is referred to as the First-Null Beam width (FNBW). The beam width of an antenna is a very important figure of merit for directional antennas and is there is often a trade-off between it and the number and magnitude of side-lobes. In addition, the beam width of the antenna is also used to describe the resolution capabilities of the antenna to distinguish between two adjacent radiating sources or radar targets. A common resolution criterion states that the capability of an antenna to distinguish between two sources is equal to half the first-null beam width (FNBW/2), which is usually used to approximate the half-power beam width (HPBW).

1.4.3 Directivity

An important characteristic of an antenna is how much it concentrates energy in one direction in preference to other directions .This property is called directivity and is defined as "the ratio of the radiation intensity in a given direction from the antenna to the radiation intensity averaged over all directions .Directivity is the ability of an antenna to focus energy in a particular direction. The definition of the directivity according to IEEE Standard145-1983: "Directivity (of an antenna) (in a given direction) is the ratio of the radiation intensity in a given direction from the antenna to the radiation intensity averaged over all directions". Note that the radiation intensity is equal to the total power radiated by the antenna divided by 4π. Directivity is always greater than one [13].

$$D=4\pi U/Prad \qquad (2.2)$$

Where

U = radiation intensity (W/unit solid angle)

$Prbd$ = total radiated power (W)

The average radiation intensity is equal to the total power radiated by the antenna divided by 4π.If the direction is not specified, the direction of maximum radiation intensity is implied.

The directivity of a non-isotropic source is thus equal to the ratio of its radiation intensity in a given direction over that of an isotropic source mathematically.

1.4.4 Gain

The Gain of an antenna in a given direction is defined as the ratio of the radiation intensity in that direction to that which would be obtained from an isotropic radiator fed by the same source .

The radiation intensity corresponding to the isotropic ally radiated power is equal to the power accepted by the antenna from the source divided by 4π.

The directive gain (according to IEEE Std 145-1983) is "the ratio of the radiation intensity, in a given direction to the radiation intensity that would be obtained if the power accepted by the antenna were radiated isotropically". We can obtain gain from directivity of the antenna:

$$G=eD \qquad (2.3)$$

Where

e is the efficiency of the antenna.

Gain is always less than directivity because efficiency is between 0 and 1. The directivity increases with increase in substrate thickness h and patch width W [13].

Or can be express mathematically

$Gain$=4π $\frac{\text{radiation intensity}}{\text{total input power}}$

$$G= 4\pi \frac{\mathbf{U(\theta,\varphi)}}{\boldsymbol{pin}} \quad \ldots\ldots 2.4$$

Where

U = radiation intensity

Pin = total power accepted by the antenna

1.4.5 Polarization

The polarization of an antenna is the polarization of the wave that the antenna radiates in a given direction. This is the direction of the electric field of the wave with respect to the horizontal axis. The polarization of an antenna is determined both by its structure and its orientation.

1.4.6 Voltage Standing Wave Ratio (VSWR)

Maximum power transfer can take place only when the impedance of the antenna (Zin) is matched to that of the transmitter (Zs). According to the maximum power transfer theorem, maximum power can be transferred only if the impedance of the transmitter is a complex conjugate of the impedance of the antenna under consideration and vice-versa.

Thus, the condition for matching is:

$$Z_L = Z_s$$

If the condition for matching is not satisfied, then some of the power maybe reflected back and this leads to the creation of standing waves, which can be characterized by a parameter called as the Voltage Standing Wave Ratio (VSWR).

VSWR= $\frac{1+|\tau|}{1-|\tau|}$

Reflection coefficient =$\frac{\mathrm{ZL-Z0}}{\mathrm{ZL+Z0}}$

1.4.7 Return Loss

Return loss is an important parameter when testing an antenna. It is related to impedance matching and the maximum transfer of power theory. It is also a measure of the effectiveness of an antenna to deliver of power from source to antenna. The return loss (RL) is defined by the ratio of the incident power of the antenna $pin$to the power reflected back from the antenna of the source $pref$the mathematical expression is:

$$Rl={}^{10}log^{10}\frac{pin}{pref} \quad \text{(dB)} \qquad \ldots\ldots 2.5$$

For good power transfer, the ratio $\frac{pin}{pref}$ is high.

Or

$$\text{RL}=10\log10\left[\frac{Z1+Z2}{Z1+Z2}\right] \ldots\ldots 2.6$$

Z_1 And Z_2 is the impedance of the source and the antenna.

1.4.8 Efficiency

For a micro strip patch antenna, efficiency can be defined as the power radiated from the Micro strip element divided by the power received by the input to the element. Factors that Affect the efficiency of the antenna and make it high or low are the dielectric loss, the conductor loss, the reflected power (Voltage Standing Wave Ratio VSWR), the cross polarized loss, and power dissipated in any loads in the element.

$$e=\frac{Prad}{Prec} \ldots\ldots 2.7$$

Where :

P_{rad} =Power radiated by the antenna.

P_{rec} =Power accepted by the antenna.

Because of an attractive further of micro strip antenna there is different application in wireless, satellite, radar, military, aircraft and misallies. in those application the micro strip antenna to be good in bandwidth, efficiency and gain. This will improve by increase of the array number.

1.5 Micro strip Antenna

Micro strip is a type of electrical transmission line which can be fabricated using printed circuit board technology, and is used to convey microwave-frequency signals. It consist of a radiating patch on one side of a dielectric substrate and a ground plane on the other side [9]. This types of antenna have an attractive feature of its low profile, conformable to planar and non-planar surfaces, simple and inexpensive to manufacture using modern printed-circuit technology, mechanically robust when mounted on rigid surfaces, compatible with MMIC designs,. But it has the limitation of low gain, small bandwidth and poor efficiency [10].There are different microstrip geometrical shapes such as the square, circular, triangular, semicircular, sectorial, and annular ring shapes. The Cross-section of microstrip geometry: Conductor is separated from ground plane by dielectric substrate Upper dielectric is typically air as shown figure below

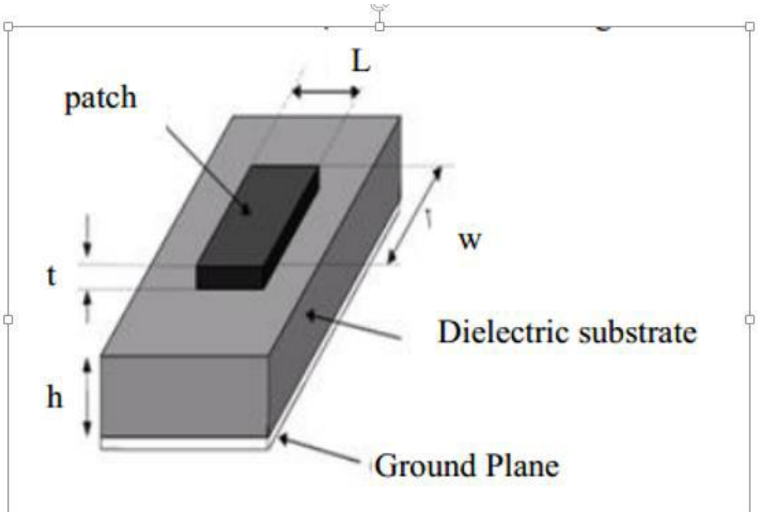

Figure 3.micro strip patch antenna

1.5.1 Micros trip Feeding Methods

There are many configurations that can be used to feed micro strip antennas. The four most popular are the micro strip line, coaxial probe, aperture coupling, and proximity coupling.

The micros trip feed line is also a conducting strip, usually of much smaller width compared to the patch. The micros trip-line feed is easy to fabricate, simple to match by controlling the inset position and rather simple to model. However as the substrate thickness increases, surface waves and spurious feed radiation increase.

Coaxial-line feeds, where the inner conductor of the coax is attached to the radiation patch while the outer conductor is connected to the ground plane, are also widely used. The coaxial probe feed is also easy to fabricate and match, and it has low spurious radiation. However, it also has narrow bandwidth and it is more difficult to model, especially for thick substrates.

The aperture coupling of is the most difficult of all four to fabricate and it also has narrow bandwidth. However, it is somewhat easier to model and has moderate spurious radiation. The aperture coupling consists of two substrates separated by a ground plane. On the bottom side of the lower substrate there is a[15].

micros trip feed line whose energy is coupled to the patch through a slot on the ground plane separating the two substrates.

There for our amine is to increase the bandwidth of the antenna so we select the microstrip line feeding techniques.

1.5.2 Micros trip Models of system

There are many methods of analysis for micro strip antennas. The most popular models are the transmission-line, and full wave.

The transmission-line model is the easiest of all, it gives good physical insight, but is less accurate and it is more difficult to model coupling .Compared to the transmission-line model, the cavity model is more accurate but at the same time more complex. However, it also gives good physical insight and is rather difficult to model coupling, although it has been used successfully .In general when applied properly, the full-wave models are very accurate, very versatile, and can treat single elements, finite and infinite arrays, stacked elements, arbitrary shaped elements, and coupling. However they are the most complex models and usually give less physical in sight.

1.5.3 Micro strip Array Antenna

Array antenna is an antenna in which all of the elements are in one plane. As an element increase the performance also increase i.e. bandwidth, gain, efficiency and directivity. The efficiency of micro strip antenna arrays may be improved significantly by reducing losses in the feed network. Losses in the micro strip feed network are due to conductor loss, radiation loss and dielectric loss. [12]

- In an array of identical elements, there are at least five controls that can be used to shape the overall pattern of the antenna. These are:

- [3]the geometrical configuration of the overall array (linear, circular, rectangular, Spherical,etc.)
- the relative displacement between the elements
- the excitation amplitude of the individual elements
- the excitation phase of the individual elements
- the relative pattern of the individual elements

1.5.4 Planar array Micro strip Patch Antenna:

Planar Array mean: It is an aggregate of elementary antenna on the planar surface. It provide directional beams, symmetrical patterns with low side lobes, much higher directivity (narrow main beam) than that of their individual element. In principle, they can point the main beam toward any direction. Planar arrays [16].Have elements in two dimensions and used to scan the main beam toward any point in space, making them useful in many applications.

Antenna array composed of several similar radiating elements. Element spacing and the relative amplitudes and phases of the element excitation determine the array's radiating properties. It is often impossible to generate a desired antenna pattern with just one antenna. Antenna Arrays 'collaborating' to synthesize radiation characteristics not available with a single antenna. They are able

- To match the radiation pattern to the desired coverage area
- To change the radiation pattern electronically (electronic scanning) through the control of the phase and the amplitude of the signal fed to each element
- To adapt to changing signal conditions .
- To increase transmission capacity by better use of the radio resources and reducing interference Some of design variables using two or more antenna number elements are, Physical arrangement of elements, Amplitude and Phase of input signals.

Planar micros trip patch antennas are the preferred choice of antennas for printed circuit boards due to their :

- low profile,
- Capable of dual and triple frequency operations,

- Can be easily integrated with microwave integrated circuits (MICs),
- Mechanically robust when mounted on rigid surfaces.
- have a very high antenna quality factor (Q)
- Low cost and ease of integration with other microwave devices in micros trip technology

1.6 Problem statement

Long range Radar system requires high gain, high directivity and low side lobe levels. Different antenna types are used, but they are limited in performance of low directivity, low beam width, and limited operation frequency bands. These limitations can be overcome by using the planar array antenna.

1.7 Objective

1.7.1 General objective

➢ The main objective is to model and simulate the planar array antenna for radar application.

1.7.2 Specific Objective

✓ To analysis the parameter of planar array antenna.

✓ To measure the performance of planar array antenna.

1.8 Scope of the project

➢ This projects is start at gather(collect or prefers) of the parameters of planar array antennas up to model and simulate of planar array antenna for the use of customers.

1.9 Significant of the project:

The significance of this project is: Our project significant is used to model the best planar array antenna for radar application that use in militaries.

1.10 Methodology

During the topic was raised ,we immediately select the topic and have submitted it to the department then collecting the data by preparing questioners to have knowledge for the topic and search to a Google and download the paper related to this topic.

- After this we have started our work by collecting all the necessary data that are related to the title.
- Then we analysis all the data mathematically to design
- We learn programing software and simulation

Chapter Two

2.1 Literature Review

In [1] antenna bandwidth enhancement is done for three different geometry shapes, the U, E and H. The results obtained clearly show that, bandwidth of conventional rectangular micro strip antenna can be enhanced from 4.81% (100MHz) to 28.71% (610 MHz), 28.89% (630MHz) and 9.13% (110MHz) respectively using U, E and H-patch over the substrate. The limitation of this paper is it consider only the shape of the substrate. We will improve the above limitation by increasing the substrate thickness, lowering the dielectric constantIn [2] a method of amplitude-phase synthesis of planar antenna arrays based on the principle of partial beam is done. In this paper it was done only consider the amplitude effect. This is the limitation of this project. Upon these review we have to do in addition to these of phase and amplitude concepts the antenna parameters such as directivity ,antenna efficiency, beam width, gain can also improve by varied the space of adjacent antenna element, the number of element in planer array antenna and the size of planer array antenna.In [6] Design and Measurement of Array Antennas for 77GHz Automotive Radar Application, these persons work based on the linear one and substrate integrated waveguide (SIW) feeding network is proposed for transmitter of long range radar. This paper of limitation is only based on the effect of waveguide consideration in only for automotive at a particular frequency. We will improve the limitation by increasing the substrate thickness, lowering the dielectric constant and increase the number of array element.In[8] low gain, low efficiency and high return loss improved is done by varying Substrate Material at Different Frequencies and it was improved. But the limitation is only considered the geometry shape 3 and frequency. We will improve the above limitation by increasing the substrate thickness, lowering the dielectric constant and increase the number of array element From the above literature it is noticed that different researchers have tried to improve bandwidth using antenna of different geometrical shapes excited by amplitudes having same magnitude and phase. In the proposed work, three different control parameters, number of elements, spacing between elements, and geometrical shape of elements will be used.

Chapter Three

3. System Model and Simulation

3.1 system modeling

In this chapter, the procedure for designing a rectangular micro strip patch antenna is explained. Next, it we design the micro strip array in radar application. Finally we simulate the single and array micro strip patch antenna in HFSS. Figure 3.1 shows the overall works projects.

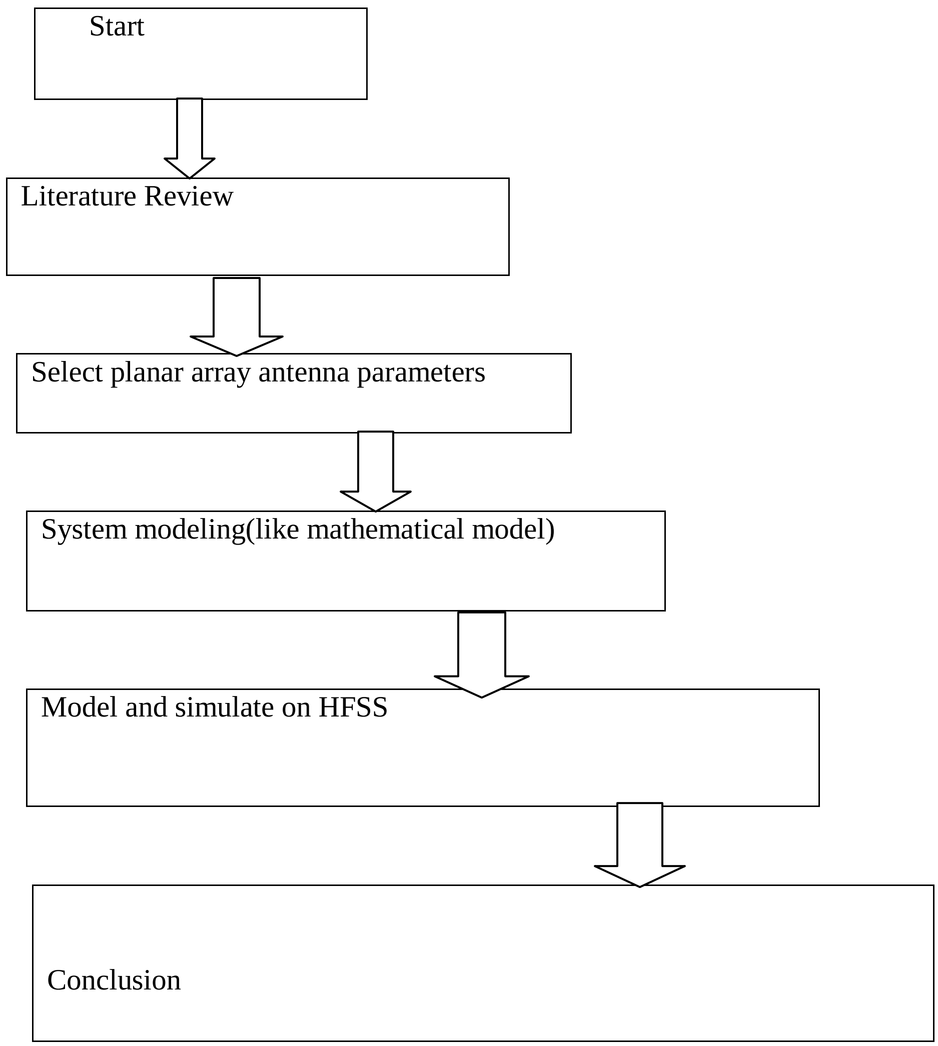

Figure 4. flow chart of procedure

3.2 design of planar array micro strip patch antenna

The essential parameters for the design of a rectangular Micro strip Patch Antenna are:

- The resonance frequency (fo): is a frequency that operate in a given system. The radar operating frequency is varying with depend on their application most radar work in microwave frequency ranging from 1 GHz to 40 GHz. We select 10.5 GHz as resonance frequency, x band radar operates from range 8GHz to 12 GHz and it applicable with police [14].
- Substrate selection: Substrate in patch antenna is principally needed for the mechanical support of antenna metallization. For providing this support a substrate with dielectric material is needed, which effects the electrical performance of the antenna. The characteristics of substrates i.e., dielectric constant, loss tangent and their variation with temperature and frequency are to be considered for the selection of substrate. Similarly, other physical properties like resistance to chemicals, tensile and structural strengths, flexibility are important for fabrication process. ART-Duriod was picked as the substrate material because of the low cost and easy to fabricate. The dimensions of the inset feed patch antenna are determined using equations in following steps by considering the ART-Duriod. substrate material with thickness of, h=1.6 mm.

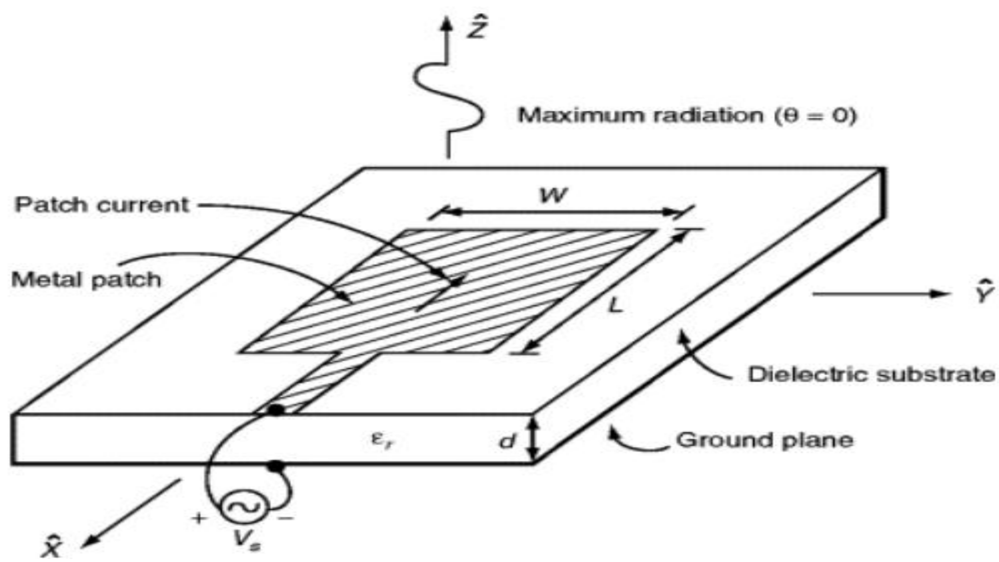

Figure 5.micro strip patch antenna

3.2.1 Feed Techniques

There are four kinds feeding techniques such as: micro strip line, coaxial probe, aperture coupling, and proximity coupling. Because of micro strip-line feed is easy to fabricate, simple to match by controlling the inset position and rather simple to model we select the micro strip-line feeding.

3.2.1.1 Micro strip Line Feed

In this type of feed technique, a conducting strip is connected directly to the edge of the micro strip patch. The conducting strip is smaller in width as compared to the patch and this kind of feed arrangement has the advantage that the feed can be etched on the same substrate to provide a planar structure.

The purpose of the inset cut in the patch is to match the impedance of the feed line to the patch without the need for any additional matching element. This is achieved by properly controlling the inset position. Hence this is an easy feeding scheme, since it provides ease of fabrication and simplicity in modeling as well as impedance matching. However as the thickness of the dielectric substrate being used, increases, surface waves and spurious feed radiation also increases, which hampers the bandwidth of the antenna. The feed radiation also leads to undesired cross polarized radiation.

3.2.1.2 Coaxial Feed

The Coaxial feed or probe feed is a very common technique used for feeding Micro strip patch antennas. The inner conductor of the coaxial connector extends through the dielectric and is soldered to the radiating patch, while the outer conductor is connected to the ground plane.

The main advantage of this type of feeding scheme is that the feed can be placed at any desired location inside the patch in order to match with its input impedance. This feed method is easy to fabricate and has low spurious radiation. However, its major disadvantage is that it provides narrow bandwidth and is difficult to model since a hole has to be drilled in the substrate and the connector protrudes outside the ground plane, thus not making it completely planar for thick substrates. Also, for thicker substrates, the increased probe length makes the input impedance more inductive, leading to matching problems.

3.2.1.3 Aperture Coupled Feed

In this type of feed technique, the radiating patch and the micro strip feed line are separated by the ground plane as shown in Figure. Coupling between the patch and the feed line is made through a slot or an aperture in the ground plane.

The coupling aperture is usually centered under the patch, leading to lower cross polarization due to symmetry of the configuration. The amount of coupling from the feed line to the patch is determined by the shape, size and location of the aperture. Since the ground plane separates the patch and the feed line, spurious radiation is minimized. Generally, a high dielectric material is used for the bottom substrate and a thick, low dielectric constant material is used for the top substrate to optimize radiation from the patch. The major disadvantage of this feed technique is that it is difficult to fabricate due to multiple layers, which also increases the antenna thickness. This feeding scheme also provides narrow bandwidth.

3.2.1.4 Proximity Coupled Feed

This type of feed technique is also called as the electromagnetic coupling scheme; the two dielectric substrates are used such that the feed line is between the two substrates and the radiating patch is on top of the upper substrate. The main advantage of this feed technique is that it eliminates spurious feed radiation and provides very high bandwidth (as high as 13%), due to overall increase in the thickness of the micro strip patch antenna. This scheme also provides choices between two different dielectric media, one for the patch and one for the feed line to optimize the individual performances.

Matching can be achieved by controlling the length of the feed line and the width-to-line ratio of the patch. The major disadvantage of this feed scheme is that it is difficult to fabricate because of the two dielectric layers which need proper alignment. Also, there is an increase in the overall thickness of the antenna.

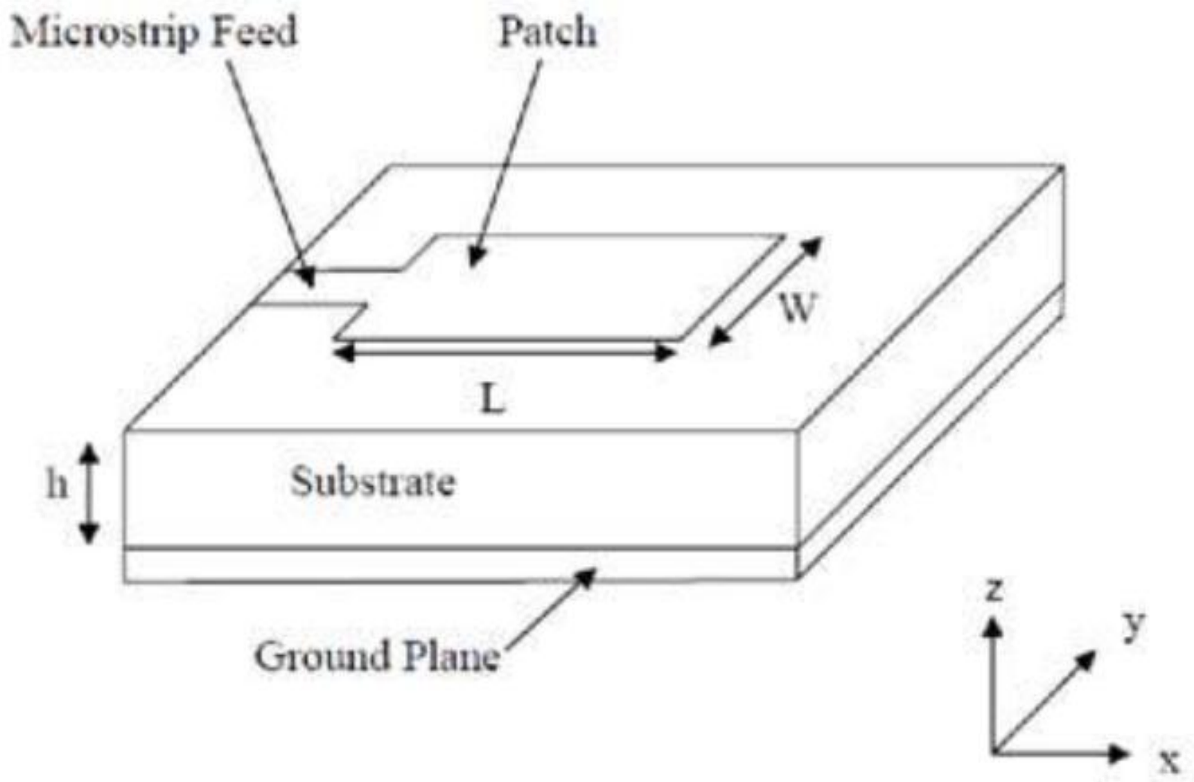

Figure 6. micro strip antenna part

3.2.1 The procedure Design and mathematical analysis parameters as follow :

The three essential parameters for the design of a rectangular Microstrip Patch Antenna are:

- ✓ The dielectric constant εr=4.4
- ✓ The resonance frequency f=10.5 GHz
- ✓ The height of substrate 1.6 mm

Step 1: calculate Width of the patch

For an efficient radiator, a practical width that leads to good radiation efficiencies is [3]

$$W=\frac{1}{2f_{r\sqrt{\mu 0 \varepsilon 0}}}\sqrt{\frac{2}{\varepsilon r+1}} \quad \text{......3.1}$$

Step 2: The Effective Dielectric Constant.

$$\varepsilon_{\varepsilon ff}=\frac{\varepsilon r+1}{2}+\frac{\varepsilon r-1}{2}\left[1+12\frac{h}{w}\right]^{-\frac{1}{2}} \quad \text{......3.2}$$

Step 3: The effective length

$$L_{\varepsilon ff}=\frac{c}{2f\sqrt{\varepsilon_{\varepsilon ff_f}}} \quad \text{……3.3}$$

Step 4: The length extension ΔL

$$\Delta L=\frac{0.412(\varepsilon ff+0.3)(\frac{w}{h}+0.264)}{(\varepsilon ff-0.258)(\frac{w}{h}+0.8)} \quad \text{……3.4}$$

Step 5: Actual length of the patch

$$L=L_{\varepsilon ff}\_2\ \Delta L \quad \text{……3.5}$$

Step 6: Length (Lg) and width (Wg) of ground plane:

The transmission line model is applicable to infinite ground planes only. However, for practical considerations, it is essential to have a finite ground plane. It has been shown by [2] that similar results for finite and infinite ground plane can be obtained if the size of the ground plane is greater than the patch dimensions by approximately six times the substrate thickness all around the periphery. Hence, for this design, the ground plane dimensions would be given as:

$$Lg=6h+L \quad \text{……3.6}$$

$$wg=6h+w \quad \text{……3.7}$$

Step 7: Calculation of feed width

$$\frac{Wf}{h}=\{\frac{8e^{A}}{e^{2A-2}}\frac{Wo}{h} \quad \text{……3.8}$$

$$=\frac{2}{\pi}\left\{B-1-\ln(2B-1)+\frac{\varepsilon r-1}{2\varepsilon r}\left[\ln(B-1)+0.39-\frac{0.61}{\varepsilon r}\right]\right\}\frac{Wo}{h}\geq 2 \quad \text{……3.9}$$

Where:

$$A=\frac{Z_o}{60}\sqrt{\frac{\varepsilon r+1}{2}+\frac{\varepsilon r+1}{\varepsilon r-1}\left(0.23+\frac{0.11}{\varepsilon r}\right)}$$

$$B=\frac{377\pi}{2Zo\sqrt{\varepsilon r}}$$

Step 9: Calculation of notch gap (g)

Resonant frequency of patch antenna depends on the notch gap (g). Expression which relates notch gap and resonant frequency is given by

$$g=\frac{vo}{\sqrt{2*\varepsilon reff}}\frac{4.65*10^{-12}}{f_o(in\ GHz)} \quad \text{……3.10}$$

Step 10: the length of feed

$$L_f = \frac{\lambda}{4 * \sqrt{er}} \quad \text{.......} 3.11$$

To achieve 50Ω characteristic impedance, the required feed width to height ratio is computed as

3.3 HFSS DESIGN MODEL

By using the above parameters we design the Array antenna for RADAR applications
at the operating frequency of 10.5 GHZ in the HFSS, and we finally get the design model as shown in figure below.

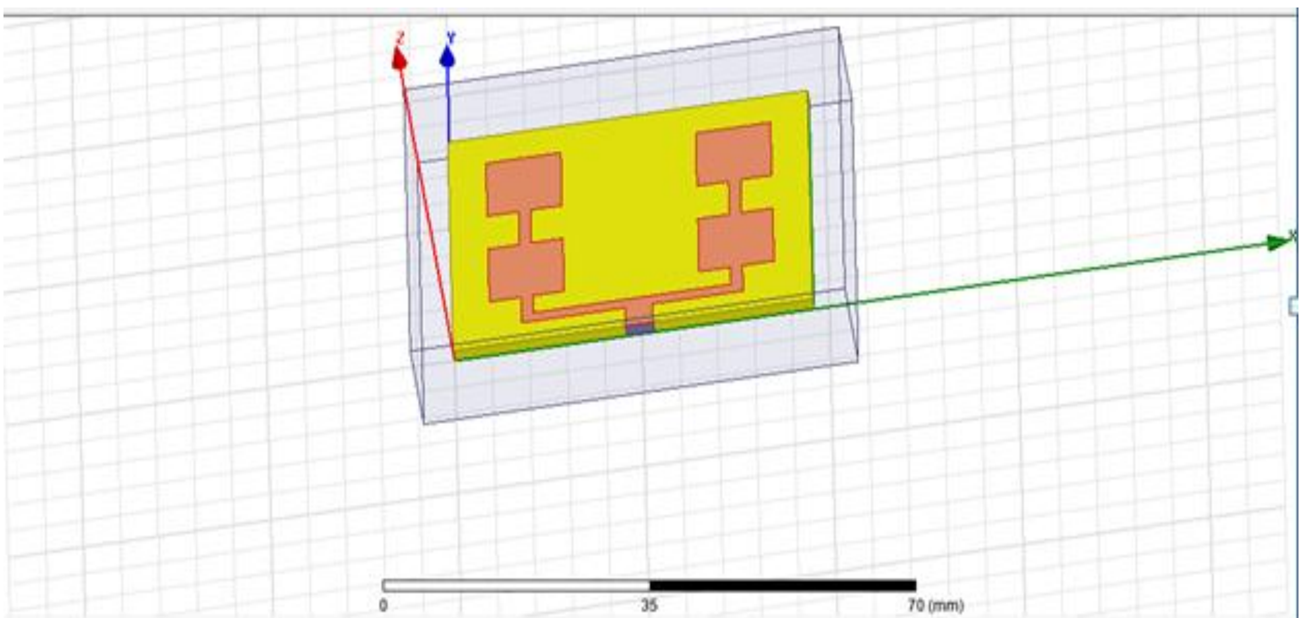

Figure 7.2x2 Array micros trip patch antenna

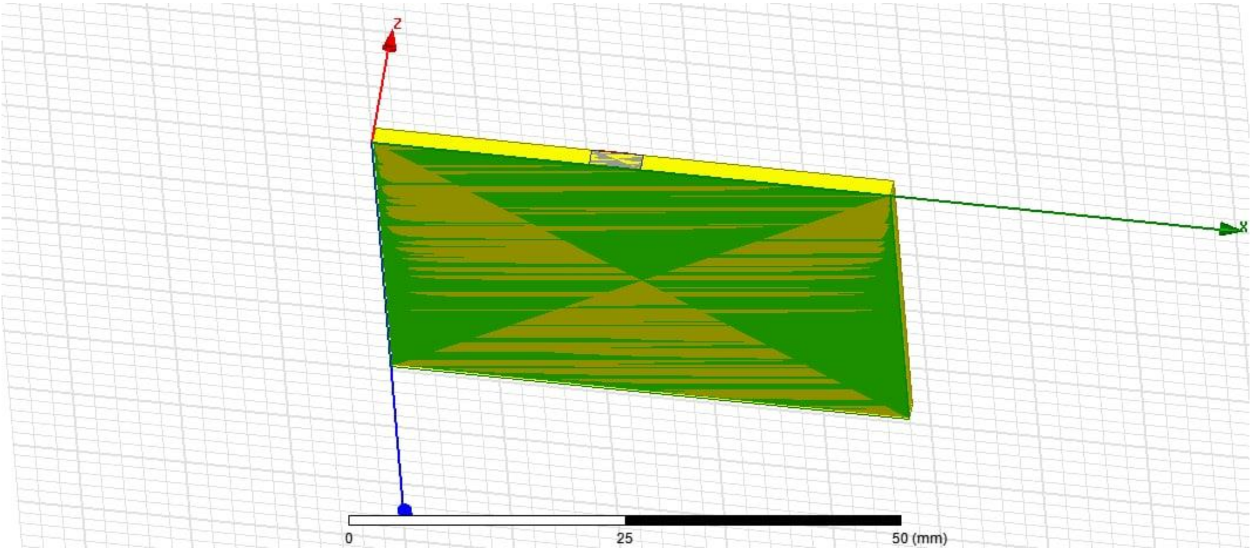

Figure 8.2x2 Array micros trip patch antenna the indicates of ground parts

Table 1.Each element of antenna value:

No	Width(in mm)	Length(in mm)	Height(in mm)
Substrate	48	39.4	1.6
Patch	38	29.4	1.6
Array	10	10	1.6
Ground	48	39.4	1.6
Port	3.733	1.6	1.6
Feed	3.733	3.4	1.6
Line of connecter	1.6	6.4	1.6
Gap of Array	18	6.4	1.6
Line of connecter array to line	1.6	3	1.6

Chapter Four

4. Result and Discussions

In this chapter, the results obtained from the HFSS simulations are demonstrated, from these results RL, VSWR, the radiation pattern plot that means the gain and directivity are discussed.

4.1 Return Loss and Antenna Bandwidth Calculation and VSWR

The proposed antenna consists of rectangular patch etched on top of the substrate and a ground plane on the other side. The parametric studies have been performed by using Parameter Sweep option in HFSS to obtain the suitable position and width of the ground plane.

We will observed that the changing dimension, length and position of the inset-feed or feed line, and gap cause noticeable changes in antenna performance; that means improved bandwidth and decreased return loss which indicated better impedance matching.

Bandwidth is calculated in the s-parameter plot or RL graph at -10dB, which is the range frequency between higher and lower frequency and the operating frequency is placed at the center.

Bw=F_m-F_l

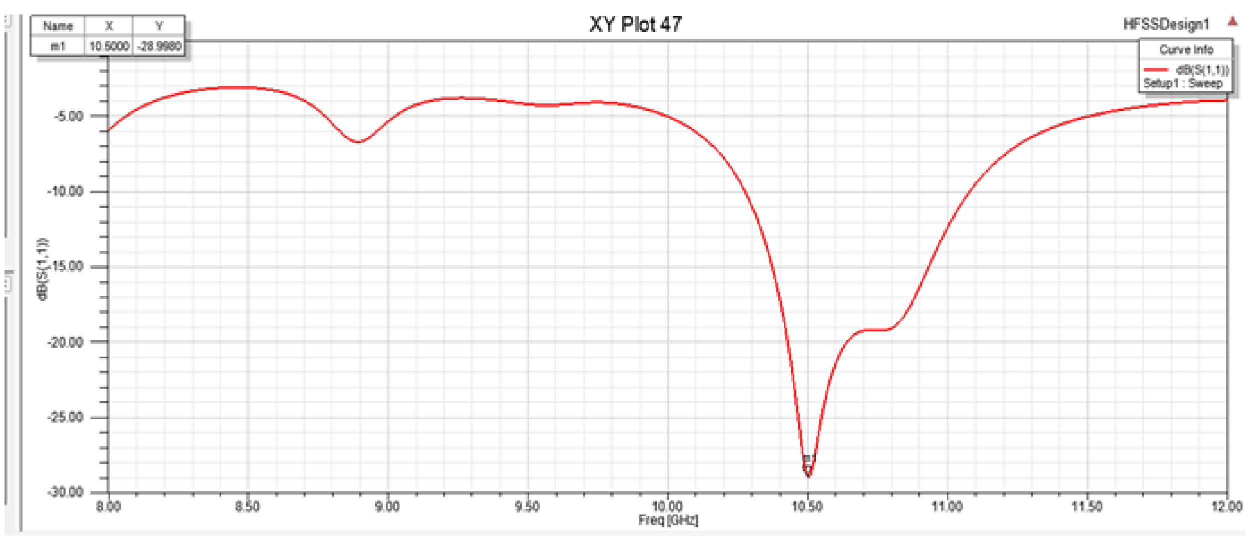

Figure 8.Results of return loss vs. Frequency in 2x2 array antenna

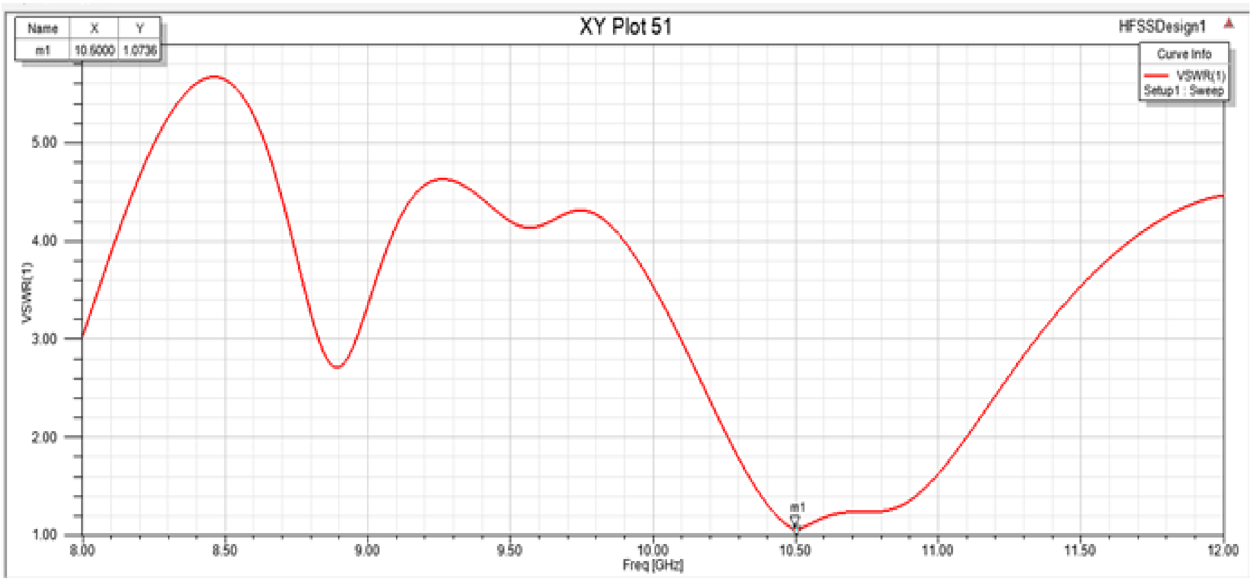

Figure 9.Results of VSWR vs frequancy 2x2 array antenna

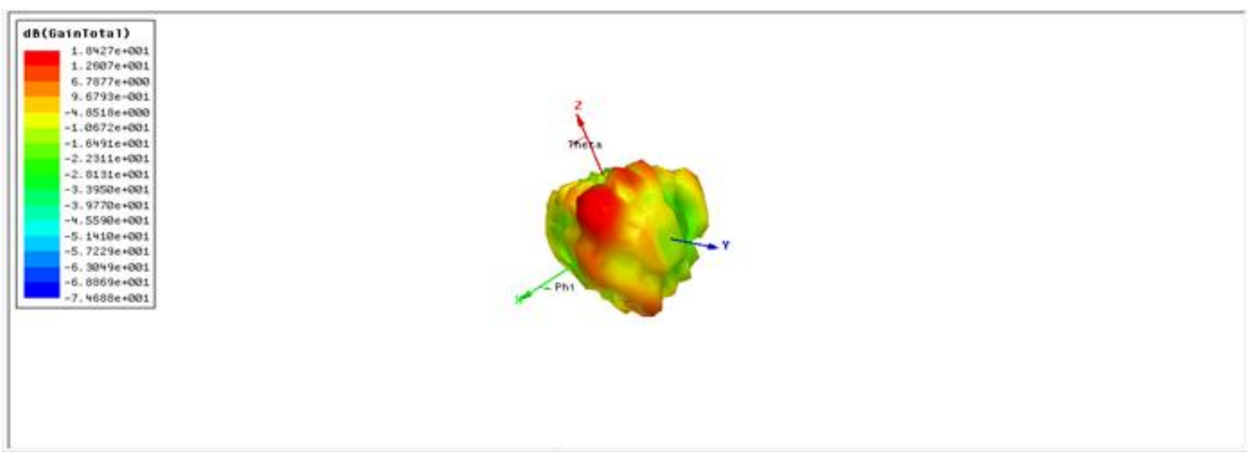

Figure 10.Gain of antenna in 3D polar plot

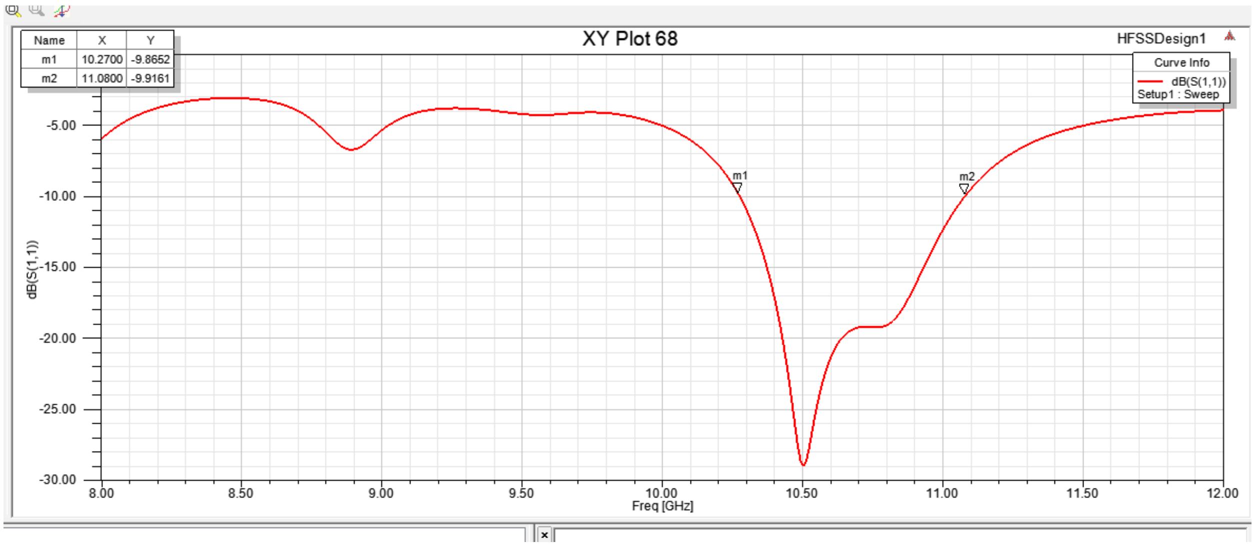

Figure 11.Bandwidth indicator

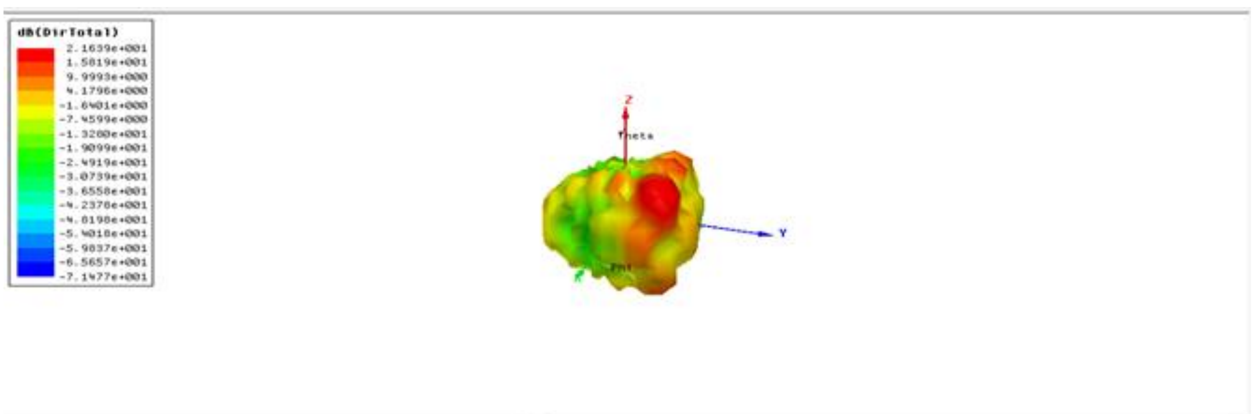

Figure 12.directivity of antenna in 3D polar plot

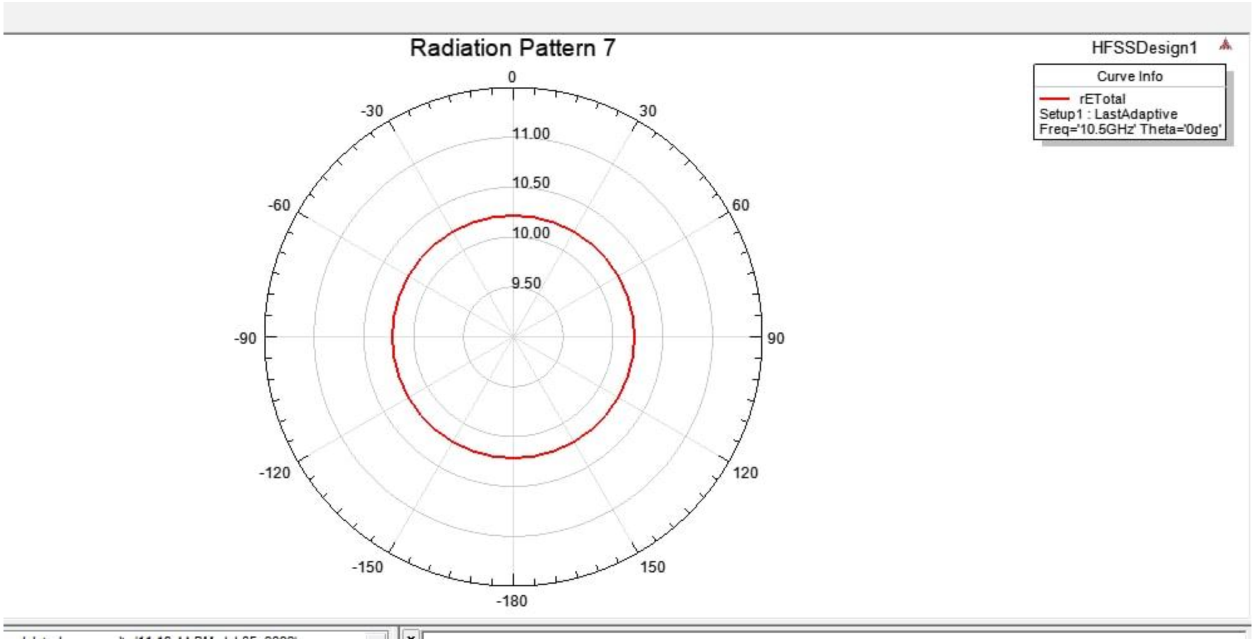

Figure 13. Radiation rate

The proposed antennas designed properly considering all the dimensions, positions, lengths, widths, and all the design parameters of ground plane, substrate, patch, gap, and feed line. Therefore in the above figure 4.1 is the RL of this project, S-11 at m1 is –28.9980 dB at 10.5 GHz, εr=4.4and h=1.6mm. the bandwidth (BW) at figure 4.6

BW = m1-m2 = 11.08 GHZ-10.27 GHZ = 0.81 GHZ = 810 MHZ

The VSWR obtained in figure 4.2 is 1.0736 at frequency 10.5 GHZ, which is indicates proper design because the VSWR is almost unity this indicates there is no loss. Generally from the above results and discussions we obtained these parameters: such as the RL,VSWR, BW, gain, directivity , and radiation efficiency of the design in array antennas for radar application at the operating frequency of 10.5GHZ:

- RL = -28.9980dB
- VSWR = 1.0736
- BW = 810MHZ
- Gain =1.8427dB
- Directivity =2.1639dB
- Antenna efficiency percentage=Gain/Directivity=1.8427/2.1639=0.852=85.2%

CHAPTER 5

CONCLUSION AND FUTURE SCOPE

5.1 CONCULUSION

It has been designed planner array micro strip patch antennas operating at 10.5GHZ for radar application and the characteristics of proposed antennas have been investigated through different parametric studies using HFSS. The design array antennas have achieved better operating bandwidth of 810 MHZ, considerable reduction in return loss which is – 28.9980 dB and VSWR is 1.0736 which indicated better impedance matching, stable radiation patterns, unity gain is 1.8427 , directivity is 2.1639, and the antenna efficiency is 85.2% in transmission line model as method of analysis for lower substrate dielectric materials of FR4 epoxy

5.2 Future Scope and Recommendation

As it is an established fact, that research project is never ending process. In future we are going to study further in antenna and extend this project to enhance bandwidth of micro strip patch array for many applications for instance radar application, cellular phones, remote sensing and communications etc.

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