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Electrical and Computer Engineering

USING A MICROSTRIP PATCH ANTENNA TO IMPROVE GAIN AND BANDWIDTH

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Master's Thesis

Supervisor

Asst. Prof. Dr. Sefer KURNAZ

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This thesis titled USING A MICROSTRIP PATCH ANTENNA TO IMPROVE GAIN AND BANDWIDTH" prepared by SAWASH AZEEZ ALDAMIRJEE and submitted on 12/8/2022 has been **accepted unanimously** for the degree of Master of Science in Electrical and Computer Engineering.

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Sawash Azeez ALDAMIRJEE

Signature

DEDICATION

To my Parents, the reason of what I become today. To my sister & brothers. A special thanks to Prof. Dr. Sefer KURNAZ for his support, worth notes and close follow up.

ABSTRACT

USING A MICROSTRIP PATCH ANTENNA TO IMPROVE GAIN AND BANDWIDTH

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In several significant wireless implementations, the MSP antennas. In the C-pass filter, a pair H-slot patchwork pass filter antennas is used. in this article. The radiation productivity, including radiation patterns, antenna benefits, VSWR and rerouting losses, was simulated and described using ANSOFT HFSS Ver. 17.2. The design of this antenna is easier than other 3-band antennas and only consists of a substratum, a soil and a coaxial feeder string. I handle in C-band (4-8 GHz) and we have 3 frequencies in the sector. The spreading patch on the Telecoms RT/duroid 5880/r 2.2 is tumbled and the Hight is 15748mm for the substratum pattern. The fifty-ohm antenna is fed with coaxial feeding technology. The lack of return of the Antenna improved to 27.13 dB (4.01 GHz) and 5.81 GHz (-21.78 dB), while 7.754 dB (6.55 GHz) and 4.01 GHz, 8.357dB (5.81 GHz) and 7.232 dB (6.55 GHz) suggested the return loss for that Antenna. Simultaneously.

Keywords: RL, Impedance, ANSOFT HFSS ver.17.2

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LIST OF ABBREVIATIONS

MPA	:	Microstrip Patch Antenna
WiMAX	:	Worldwide Interoperability for Microwave Access
Wi-Fi	:	Wireless Fidelity
WLAN	:	Wireless Local Area Network
MAN	:	Metropolitan Area Network
RP	:	Radiation Pattern
SARS	:	Synthetic Aperture Radar System
HPBW	:	Half Power Beamwidth
FNBW	:	First Null Beamwidth
RL	:	Return Loss
GPS	:	Global Positioning System
LED	:	Light Emitting Diode
VHF	:	Very High Frequency
UHF	:	Ultra-High Frequency
HFSS	:	High Frequency Structure Simulator
FEM	:	Finite Element Method
PDE	:	Partial Differential Equations

LIST OF SYMBOLS

Γ	:	Reflection Coefficient.
ε_r	:	Relative Permittivity.
ε_{eff}	:	Effective Dielectric Constant.
L_{eff}	:	Effective Length.
λ_o	:	Wavelength.

1. INTRODUCTION

In a wireless networking system antenna plays a very important function. The uncertainty is reduced by a well-built antenna that increases the efficiency of the receiver. Depending on the use and operational frequency of the antenna, the size, shape and layout of the antenna will be used. Wireless networks have played a very important role in achieving the needs of wireless services across their broadband architecture. Worldwide Microwave Connectivity Interoperability (WiMAX)/WLAN offers lightweight mobile internet service and cellular television and digital subscriber lines supplement. Recently, owing to its benefits such as low cost, fast set-up, easy output, mechanical strength and conformity with integrated circulation, the microstrip patch antenna was a nominee for an antenna manufacturing. Microstrip antennas are suitable for high frequency application, since the antenna size relies depending on the resonance's wavelength and frequency In wireless communication, a multi-band antenna is crucial [1]. The micro strip sum is simulated and researched in order to satisfy working strips of the common WiMAX bands (Worldwide Interoperability for Microwave Access) 2,5/3,5/5,5 GHz. WiMAX has various benefits in data and communications networks. Furthermore, installing optical fiber lines in remote areas is challenging, but WiMAX solves these problems by cutting the cable and adding to the wireless cell system. This is a 30 m wireless service from the conventional local WiFi network which provides a 50-km signal range for a MAN (Metropolitan Area Network). Wi-Fi and WiMAX are frequently utilized in mobile devices such tiny laptops and tablets [2].

Both of these methods are widely recognized as practical, expense, and increased data connectivity. that enables versatility by designing a modern WLAN interface and the design of the antenna focusses on a broad range of lightweight, easy-to-produce architectures. Adapting for WiMAX applications to the complex and varying Wi-Fi and WiMAX environments has changed. Three operating bands have been developed for WiMAX technologies, and are called low band (2.5-3,8 GHz), medium band (3.2-3.8 GHz) and large band (5,2-5,8GHz), respectively. Today, many realistic wireless network implementations utilize a broad variety of Multiband indexes [3].

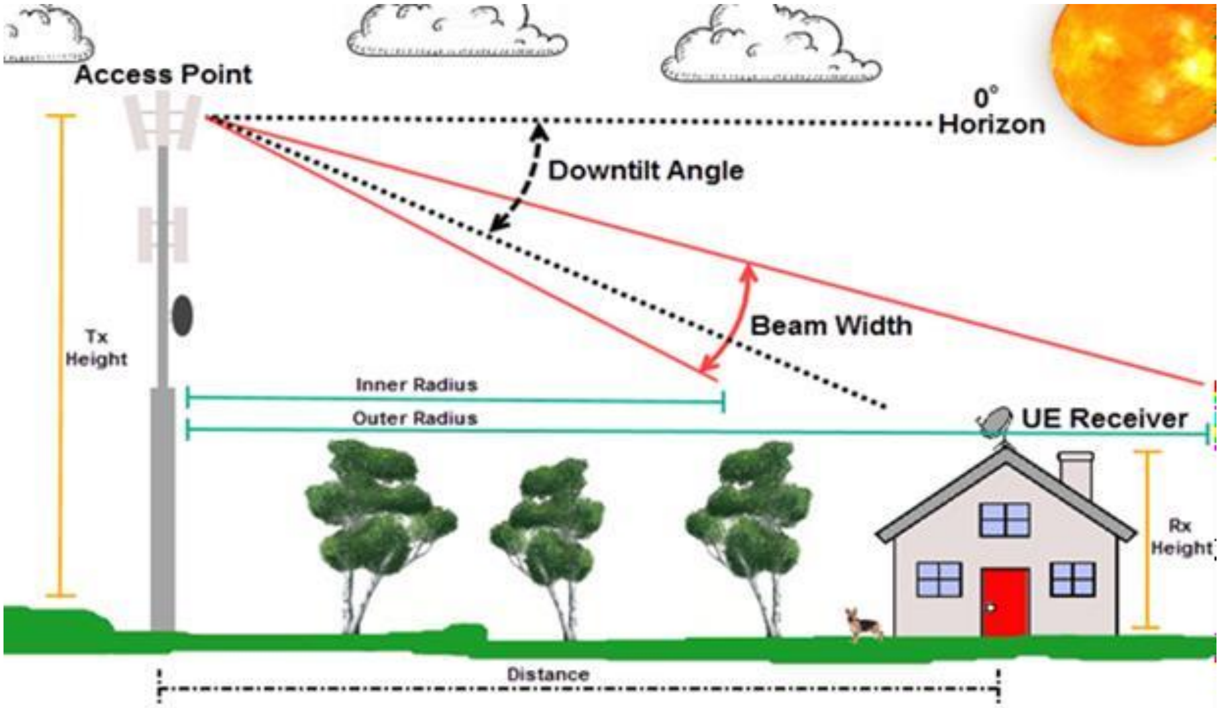

Figure 1. 1: Radiation spread distribution of antenna.

1.1 BACKGROUND

Broadband foundation is now famous and assumes a significant part in the prerequisites for remote correspondence frameworks. Mobile networks (WiMAX / Wi-Fi) include the broadband, mobile, interactive cable and telephone lines alternative. In advanced wireless networking networks, the demands of open multi-band antenna network technologies played a major role. In handheld applications, including laptops and smartphones, Wi-Fi and WiMAX have been frequently used. Both approaches are generally accepted as a practical and cost-effective solution, whereas high-speed data networks enable users to use cellular progress through an accelerated connectivity network. A lightweight, simple to produce small structures and several large scales is the basis of the antenna Architecture. The exact and varying requirements of the WiMAX device modified rapidly. WLAN offers multi-band operation and highly preferred microstrip panels antennas. Microstrip is of considerable interest to antenna designers because of the benefits of low cost, simple configuration, easy output, compatible with integrated circuits and flush electronics. For frequency and higher recurrence use, microstrip radio wires are ideal. The recurrence relies upon the size of the radio wire. Both microstrip fix radio wires and WiMAX programming are intended for various applications [4].

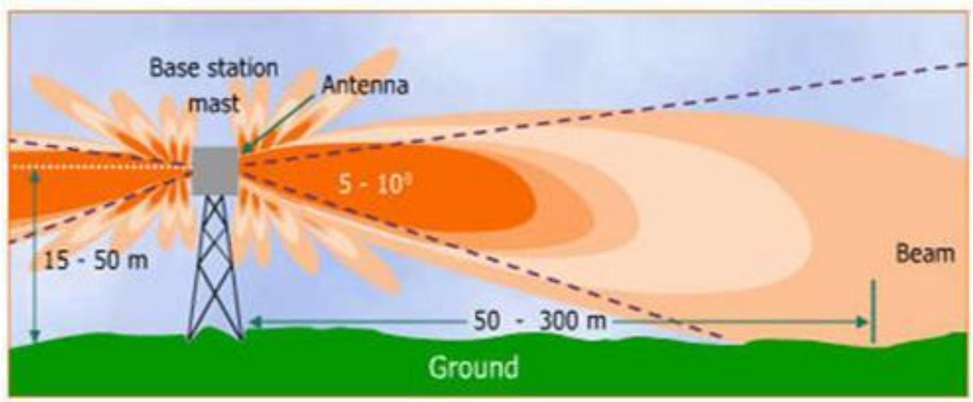

Figure 1. 2: The Radiation Patten of Antenna from Base Station.

The proposed design is tested using the ANSOFT version 17.2 of the HFSS program, and then modifies the antenna design for successful performance. Electrical capacities are planned and illustrated, including return misfortune, reception apparatus material, radiation test and VSWR. The receiving wire access is smoother than most radio wires intended to satisfy the three attributes of the substrate gathering, ground and coaxial feed. The equivalent goes from the base station, yet there are various signs demonstrating multi-client issues.

1.2 PROBLEM STATEMENT

In the microstrip patch antenna there is a weakness in the antenna gain, the lack of bandwidth and the size of the large antenna. This weakness in parameters is a major problem faced by the microstrip patch antenna, in order to improve these parameters, a double H-slot antenna will be made with appropriate dimensions to achieve better results, increase the gain, as well as increasing antenna gain

1.3 OBJECTIVES

The aims of this work are to create a a double H slot microstrip patch antenna that gives good results and high gain, and to enhance the antenna bandwidth, the antenna operates at three frequencies within the C-band. After that, this project will focus on antenna performance analysis.

1.4 PROJECT SCOPE

The development's objectives are to investigate the update's shape. and the slot for the antenna from several published papers and books and the design of the double slot H MPA that operates with three frequencies within a C-Band.

1.5 THESIS OUTLINE

There are five chapter explain in this thesis:

Chapter 1

Include the introduction of the thesis, problem statement, objectives, then finally the Project scope.

Chapter2

include the Literature review for the antenna type, with parameters to design antenna the related word of our thesis.

Chapter3

Include the methodology of our project, the HFSS program, justification of the program and the producer of the design antenna.

Chapter4

The simulation of the results and the discussions for each result.

Chapter5

The outcome, as well as the research that will be done in the future.

2. LITERATURE REVIEW

2.1 BASIC PARAMETERS OF ANTENNA

In order to avoid confusion on antenna efficiency, antenna parameters are necessary. An antenna is a device used for the transmission and reception of electromagnetic waves. Certain aspects should be considered when purchasing an antenna. The antenna parameters include Radiation pattern, return loss, gain, and other aspects, beamwidth, polarization, directivity, bandwidth, and antenna efficiency [5].

2.1.1 Radiation Patterns

The antenna's heightened competition to the angular orientation of the antenna and radial distance from the antenna was defined. This article explains how the antenna concentrates its electricity. The far-field directional co-ordinate is determined and defined according to the RP.

Qualities of the radiation include density of power distribution, radiation density, field strength as well as directional or polarization processes. The multiple components of the SARS radiation model are called lobes, but can be split into three parts.

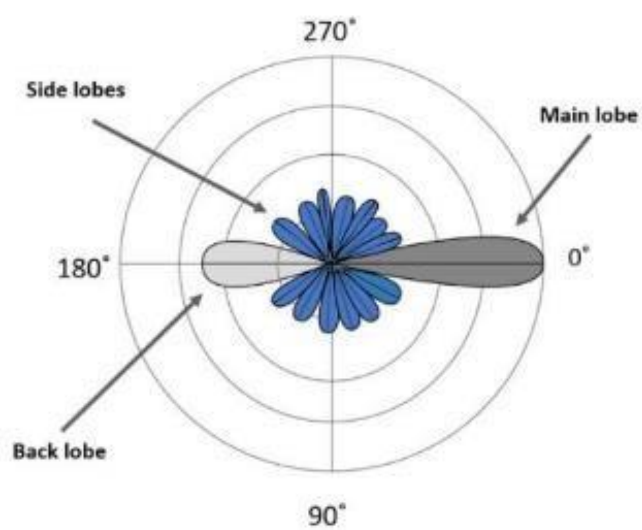

Figure 2. 1: Antenna emission praise and sequence.

The first component is represented by the dotted line in Figure 2.1 above. The main antenna lobe is a major part of the antenna's radiation pattern. This is the medial side lobe. There are small lobes that are essentially whole lobes. This anomaly should be corrected so as to maximize antenna efficiency. It is the front lobe. The horizontal axis is 90 degrees relative to the main lobe of the antenna [6].

2.1.2 Pattern Beamwidth

A beam width of the pattern will describe the angular distance between the two lines on the diameter of the pattern. The width of the beam is very critical, and is often used as a compromise between the antenna gain and the antenna side lobes. Due to the reduction in the beam diameter, the value of a side lobe rises.

Also, beamwidth was often used for identifying the antenna's resolution capacity.

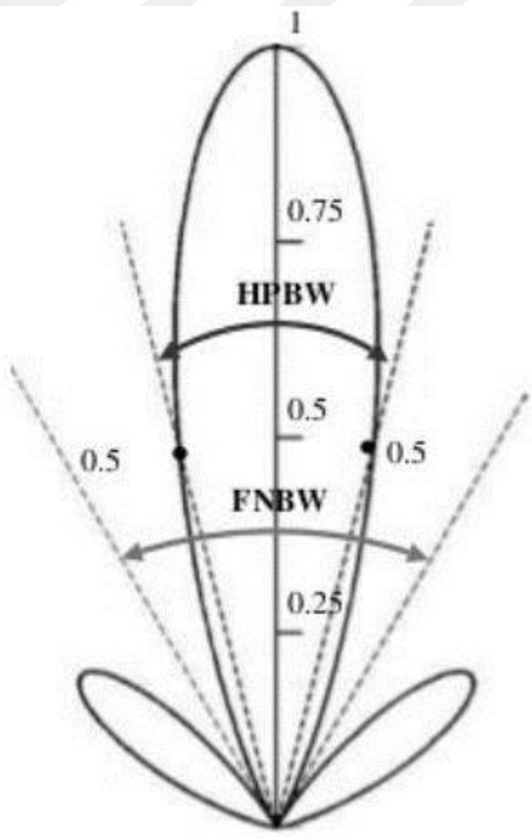

Figure 2. 2: The Pattern Beamwidth of An Antenna.

As shown in Figure 2.2 above, the RP of the antenna is split into two. The beams retain 75% of the power delivered to them. Half Power Beamwidth (HPBW) means the angle formed from the base of the pattern and traveled across all main lobe spots where the radiation intensity gets half its limit.

Although the 1st null BW is the angle between these two vectors, whose traveling direction leads from the center of the pattern and tangent towards the main beam at the base of the main beam. It is reported that:

$$FNBW = 2.HPBW \tag{2.1}$$

2.1.3 Return Loss

A RL is a component that shows how much power the system loses. The loudness can be described in decibels unit as follows:

$$RL = -20\log|\Gamma| \tag{2.2}$$

$$|\Gamma| = \frac{Vr}{Vi} = \frac{ZL - Zo}{ZL + Zo} \tag{2.3}$$

Where;

Γ = Reflection Coefficient.

Vr = Reflected Voltage.

Vi = Incident Voltage.

ZL = Load Impedance.

Zo = Characteristics Impedance.

For the antenna to have a perfect match with the transmitter, two vital criteria must be met: The reflection coefficient must be zero and the return loss must be infinite. Only when the reflectivity coefficient is equal to one, the return loss will be zero [7].

2.1.1 Voltage Standing Wave Ratio

Between the transmitter and the antenna, a great radiative quality is accomplished with a maximum power transfer. If the antennas complement the transmitter, the full power transfer takes place.

When the transmitting antenna impedance is a dynamic conjugation between the receiving antenna's impedance and vice versa, the maximal power may be transmitted. If the matching requirement is not met, some power is reflected, and hence standing waves are produced that are determined by the current (VSWR) [8].

The following VSWR is an inverse of the gamma function (2.4):

$$VSWR = \frac{1 + |\Gamma|}{1 - |\Gamma|} \tag{2.4}$$

Where;

Γ = Reflection Coefficient.

2.1.5 Bandwidth

In this way, the antenna bandwidth is defined as the frequency range during which the antenna meets its settings. The amplitude and width of the coaxial cable can be calculated by the VSWR parameter. The bandwidth of the GPS-linked distance transmission radio waves is shown in Figure

2.3. The bandwidth is the percentage of the central frequency to the end frequency. Bias in the percentage amount can be determined by using the below formula:

$$BW_{narrowband} = \frac{f_H - f_L}{f_c} \times 100 \tag{2.5}$$

$$BW_{broadband} = \frac{f_H}{f_L} \tag{2.6}$$

Where;

f_H = High Frequency.

f_L= Lower Frequency.

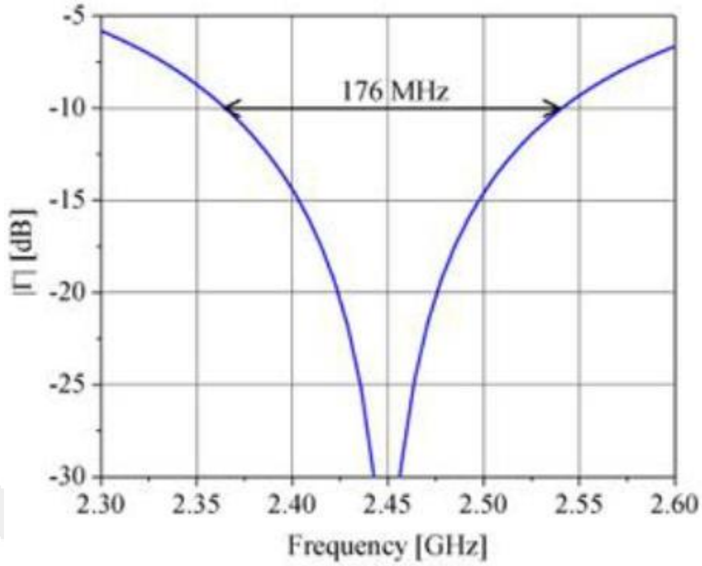

Figure 2. 3: Antenna Bandwidth with Respect to Return Loss Measurement.

2.1.6 Gain

The antenna gain parameter will calculate the performance of the antenna. The antenna radiation capacity may be set. An antenna gain is a relative gain defined by the power gain ratio to the power gain of the antenna in the same direction. You will note changes when you equate the test antenna with a normal antenna. Usually, an isotropic or dipole antenna is the commonest antenna.

From theory, the isotropic antenna radiates similarly in all directions. It is an imaginary case. The dipole offers a convenient and realistic appearance of the actual antenna. The antenna gain relative to an isotropic antenna will be written as 6dB. That means it is determined at the isotropic antenna. This equation can be used to calculate the output from the antenna.

$$G = eD \tag{2.7}$$

Where;

G = Gain.

e = Antenna Efficiency.

D = Directivity.

2.1.7 Directivity

Directionality is one of the features of an antenna which enables it to concentrate energy in a particular direction or axis. After defining the directionality of the antenna, In the specified direction the radiation intensity is measured from the antenna. Directivity D can usually be obtained by using equation (2.8) as seen below:

$$D = \frac{G}{e} \tag{2.8}$$

Where;

G = Gain.

e = Antenna Efficiency.

D = Directivity.

Antennas are measured based on their directivity. An isotropic antenna has 100% directive gain in all directions.

Diversity is a tool to increase the performance of a receiver by allowing the optimal use of time varied signals. Signal fading may be somewhat different from one location to another, sometimes at a wavelength very similar to each other. To allow the full use of this, two antennas are put at a distance from one another. At every given moment, the one that has the maximum magnitude of signal is sent to the receiver. This will just really operate with the reception. In this application, electronics will also be part of the antenna device. A larger definition of diversity is created through adaptive antennas. This radio antennas typically consist of more than two components. The adaptive antenna will change its radiation pattern to send out radio waves. Alternatively (or simultaneously), the same method can be used to evaluate the position of the unacceptable signal.

2.1.8 Efficiency

The antenna efficiency is the ratio between total loss of antenna and the input ports. In order to guarantee 100% efficiency of the antenna, the input power is converted 100% to radiated power. Thus, efficiency of the antenna can be measured using Equation 2.9 as seen below.

$$e = \frac{P_r}{P_a} \tag{2.9}$$

Where;

e = Antenna Efficiency.

Pr = Total Radiated Power.

Pa = Total Input Power.

2.2 FEEDING TECHNIQUES

There are various ways for transferring electromagnetic energy to a microstrip. There are many options when it comes to researching the cable types of the data transmission lines. Figure 2.4 illustrates one of these scenarios. The RLC for complementary metal oxide finish (CMF) refers to the loss associated with the ground plane conductors and the patch and substrate.

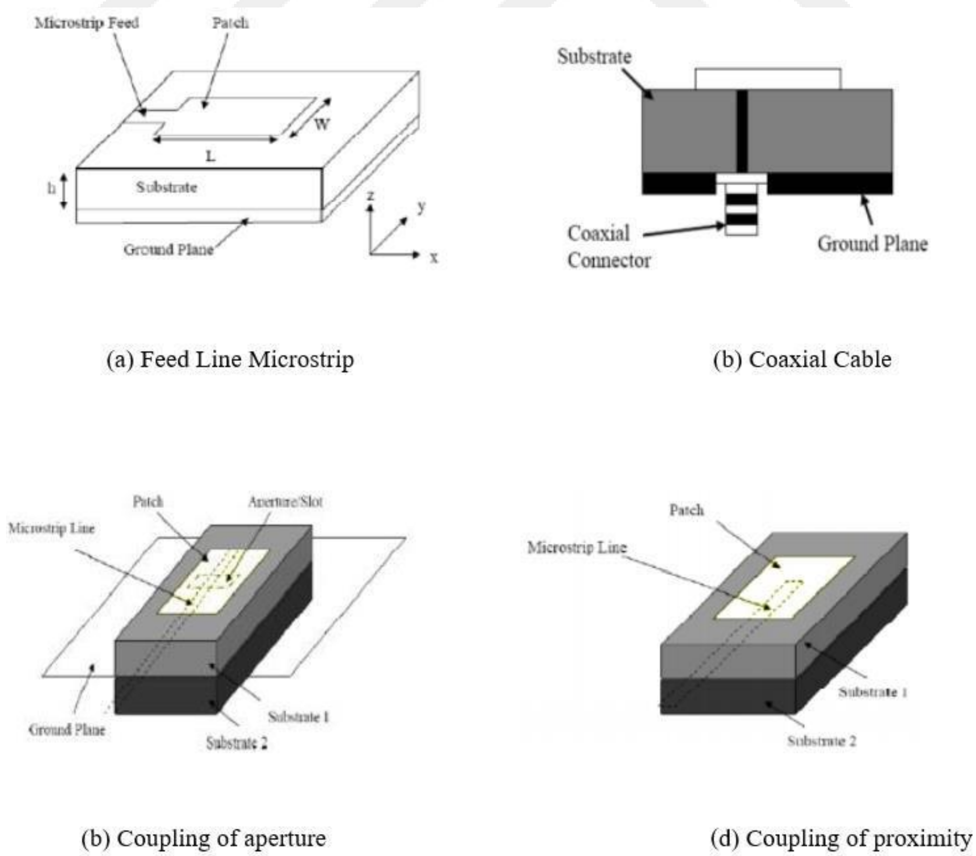

Figure 2. 4: Method of Feeding.

One type of feeding technique which is simple to accomplish is the coaxial probe and microstrip transmission line. Both methods utilize physical proximity for instigation. The adjustable point of excitation helps the constructor to control the impedance between the feed and the antenna, polarization of the antenna, mode of activity and frequency of the excitation.

Generally, the optimal impedance balance is obtained when the touch point is off-center. These higher order modes are the product of patch excitation asymmetries [9]. As the higher order modes allow a cross-polarized portion to be removed from the main plane antenna patterns, a reduced output is observed. Test and error approach is widely used to select the right contact hardware for direct message broadcasting.

Direct contact feeds suffer from a variety of efficiency problems which seriously constrain the development of their networks. Coaxial and microstrip feeds are tailored to certain impedances with a certain frequency range. Service outside these limits decreases the performance of the antenna due to the inherent disparity between the antenna and the final load [10].

2.2.1 Coaxial probe feed

In this way, a longitudinal feeder is the most active. The line feed is connected to the radiated metal by means of a SMA connector. Feed should have limited power loss. For phased-array antennas, this method is not successful [11].

The internal driver of the coaxial connection continues to be sold to the radiation patch. All the insulators are fixed to the ground plane. The feed system is quick, effective and low cost as well. This process, however, induces relatively low channel capability for thin-film transistors with polysilicon silicon or other top-gate transistor materials.

Puchong is the most common method of eating. Here, the plane geometry is defined as shown in Figure 2.4. (b). This feed has a resistance of 50 ohms. However, feed frequency of the antenna can vary in each location. To prevent impedance mismatching, feed location should be set to fifty ohms of tip to body. There are multiple connectors one may use depending on the occasion. For eg, OSSM, OS-50, or K-connector are being considered for this reason since we work wave meters.

2.2.2 Microstrip Line Feed

This instrument utilizes a mechanical transmission line that interfaces the feed line to the connection or sheet (A). The feeder is restricted in width however not the same as the adjustment. This kind of taking care of design has numerous points of interest.

We can evidently interface a mechanical gadget to the microwave transmission line. Normally the opposition toward the finish of the adjustment is around fifty ohms. The quarter feed pivot technique can be utilized to make an interpretation of the information voltage into a 50-ohm input gathering.

2.2.3 Coupled opening feed

The ground plane separates the radiation patch and the micro stream cable for this kind of assessment. The command subsystem referred to in the preceding paragraph should be shown in Figure 2.4(c). Patch/feed line matches in the ground plane through the slot or port. Coupling from the first to the second plate was defined by the form, size and location of the opening.

A tiny patch antenna with one side of the floor might be used to activate a broad-stage patch antenna on the other. This slot-to-pin interface may eliminate the need for needless soldering [11].

2.2.4 Proximity Coupled Microstrip Feed Line

This project will use the electromagnetic connection technique. In Figure 2.4(d), an L-contour of two dielectrically substrates is placed at the head of the upper substrates the radiating patch is sandwiched between the two substrates.

An open patch transmission line may be utilized to feed a patch antenna through close-to-closure connection. It can be located parallel and closer to the boundary of the pattern. You will achieve enjoyment by utilizing a fringe-field pairing. Actually, both of these approaches are preventing any soldering connection, which in certain circumstances might be considered to be more sturdily produced.

2.3 ARRAYS AND FEED NETWORKS

However, the usage of only one radiating factor would be inadequate in some transmission applications. This is attributable to a concern for maximum transmission gain. One way to rectify this problem is to incorporate any additional radiating components into the antenna series. A more exact shape of side lobe can be achieved by using the procedure suggested in this report.

Feed networks are structured such that that it can include the intensity and distribution of excitation and phases. These variables are called beam forming a network since the intensity of the excitation factors and the phases influence the shape and the path of the beam [12].

Arrays can be fed serially or concurrently. As seen in Figure 2.5, the feed network in the satellite feed system is fed by a single transmission line, while the feed network in the corporate feed system is fed by several transmission lines as seen Figure 2.6.

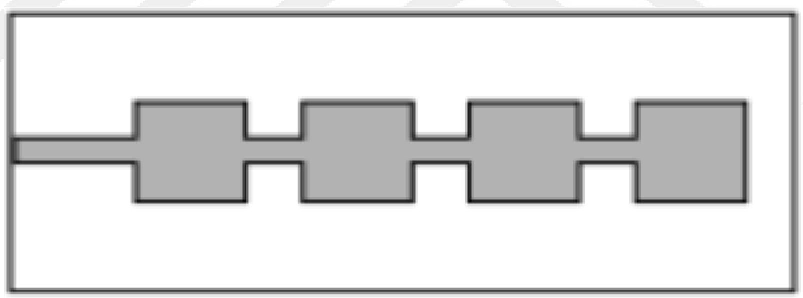

Figure 2. 5: Microstrip Series of Feed Network.

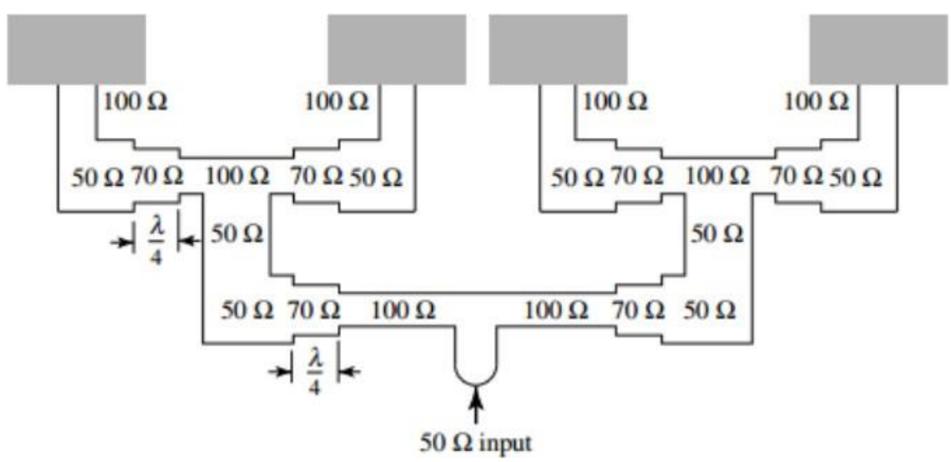

Figure 2. 6: Microstrip Corporate Feed Network.

2.4 MICROSTRIP ANTENNA

The commonest patch antenna is a radiating pad on the opposite side with a floor plane. The "printed antennas" of the microwave microstrips is also a small band wider-beam antenna Patch Antenna.

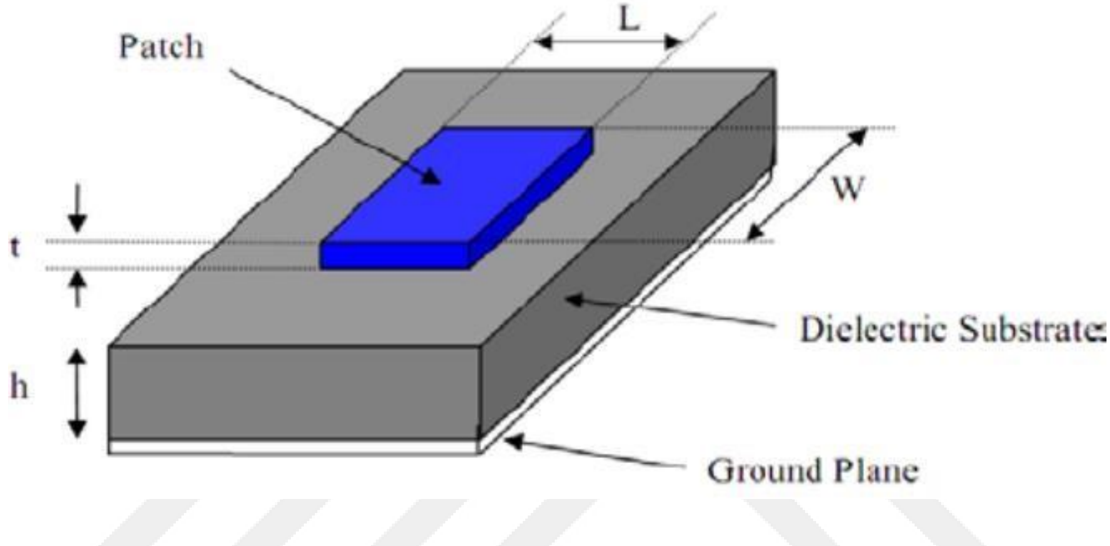

Figure 2. 7: Dimensions of Patch Antenna.

The antenna needs to be fed along the centerline for symmetry and minimizing the leakage of the unwanted electricity. The microstrip antenna is quick to manufacture and can exist on curved surfaces. It's available in various forms, including rectangle, square, triangle and circle.

For great antenna efficiency, a thick insulator with a low εr is suitable [13].

2.4.1 Geometries of the Basic Microstrip Patch Antenna

The concept of a MSP surfaced with the application of printed circuit technology on all building materials and transmission lines, and not only transmitting cables. This concept was first suggested by Deschamps. No attention has been given to this topic until the 1970s. Antennas of this type earned much study and functional growth since then. The simple configurable antenna design as shown in Figure 2.8. The interconnection consists of a thin metallization area that is supported by a thin dielectric layer above the ground plane and ate to the ground at an acceptable site. The exact form of the patch can be arbitrary, but in reality, the shape of the patch is usually rectangle, circle, equilateral, and circular [8].

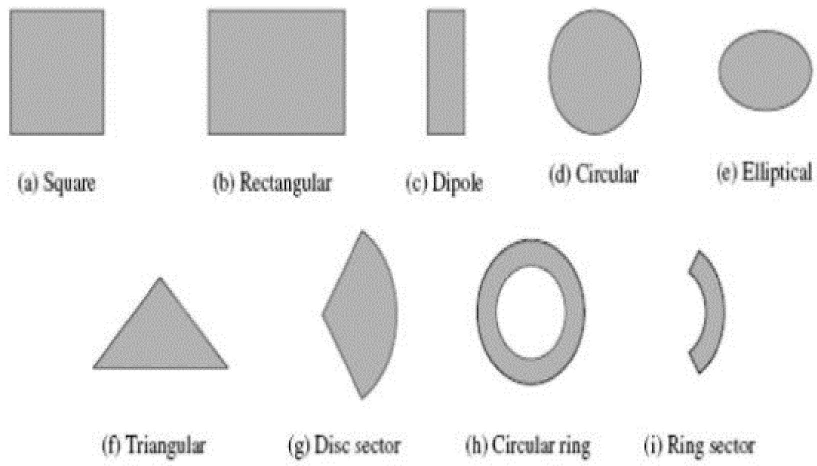

Figure 2. 8: Patch Antenna's basic structure.

2.4.2 Benefits of Microstrip Patch Antenna

The microstrip patch antennas provide a lot of options. Everything of them is horizontal. And if it is non-conformal, it can be made similarly to its predecessor. Secondly, it has low profile, low-radar cross-section, decent efficiency and stable attribute.

In this way, the technology is customizable and easily created. It can be combined with other circuits. In addition to these, the layer may also be used for single polarization or multi-frequency operations. With the advantages of the microstrip patch antenna, it is suitable for helicopters, space craft and warheads. New car antennas cannot influence the aerodynamics of the cars. The microstrip patch antenna has been used for industrial cell and wireless networking systems because of its advantages [14].

2.4.3 Microstrip Patch Antenna Drawbacks

There are a few detriments related with microstrip fix radio wires, which are essential for the moderate plan, where the opposition is under 5%. There are several forms of rising the bandwidth of different networks today. Studies has shown that certain approaches function as large as 40 percent bandwidth widen. Often, microstrip patch antennas will only operate with very low RF. That is attributed to radiating patch and the ground plane are partially removed. And only a few tens of watts are covered at average power.

In general, microstrip antenna arrays possess high resistance than other antenna arrays and its aperture duration. The back projection antennas are also different since they are only one and a half wave high. This is most generally seen at one end up or other end up of the microstrip line feeder and power splitting circuits [15].

2.4.4 Remedies for Microstrip Patch Antenna

In today's times, there are avenues to address the drawbacks of microstrip patch antenna. The antenna problem can be addressed if you have an array antenna. Nevertheless, there is an array surface wave suppression that occurred of interest. This suppression of surface waves will result in decreased transmitting efficiency, increased antenna coupling and decreased antenna gain.

Micromachining Technology may be used to diminish the influence of substrate and gain by maximizing surface waves.

2.4.5 Consideration of products

The metal patch typically consists of a small coil of copper. A mechanical tampon for the radiation elements is provided in the substrate sheet. It is still required to separate the patch from its ground plane The layer thick ness is 0,01 to 0,05 freer space wavelengths for the basic geometry [16].

The dielectric constant increases (1-10) and is divided into three groups:

I. Those with a dielectric 1.0 to 2.0 relative (relative permissibility). Sunlight, Polystyrene or dielectric wax may include this sort of material.
II. Those with a dielectric relative’s constant between 2.0 and 4.0. This kind of content primarily consists of Teflon fiberglass.
III. There are relatively dielectric 4.0 to 10.0 constants. Ceramic, quartz or aluminum may be of this type.

When choosing a substrate material, there are trade-off factors such as expense, power loss, and how the substrate's output would be when used. For e.g., a single patch or some array components may be produced on short-cost substrate material at L-band spectrum, whereas higher-cost substrate with low tangent loss characteristics can be needed for tens of array elements at mm-wave frequencies. Higher dielectric constants, however, also reduce bandwidth and radiation efficiency. Normally, copper patch is constructed of thin copper sheet. The substrate layer offers protection for the components in the antenna. It helps maintaining a proper ground separation with the patch. The layer thickness for the basic geometry is between 0.1 and 5 microns [16].

2.4.6 Radiation Mechanisms

Antenna radiation is caused by the area extending from the conductors and the ground plane. The microstrip is disposed above the ground plane in the diagram. There is no modification of the current configuration of the radiator in the illustration.

Depending on the wavelength and the intensity of the field, the field differs over the duration of the patch. Radiation originates from the uncovered tip of the antenna. The capacities rely on that which gets on the line from patches [17].

2.5 MICROSTRIP ANTENNA ARRAY

The microstrip antenna array is considered a single strip of tiles. There will be many antennas. The performance can be enhanced by combining individual antennas together. The antenna array is taking the transmission line form of radar. The first and second Advantages of this Antenna are high gain and multi-band activity. It can also be remembered that this device cannot compensate errors of the electrical capacity.

2.5.1 Mutual Coupling

Mutual coupling is the association between both of the antennas. The best signal is not influenced by the short distance collection. This analysis would change the radiation pattern, diverse range and antenna-corresponding properties of the array.

The present from antenna 1. attaches to current at antenna 2. Coupling between buildings occurs regularly when EM energy is exchanged between two buildings. It occurs when two radiating elements are related and it can have an effect on the antenna due to intense space frequency radiation and surface wave excitation.

Mutual coupling is very powerful feature of antenna collection. The antenna triggered a non-zero voltage at the terminals of the other devices, also triggering malfunction in some computers [17].

In the design of the microstrip antenna arrays, the technical guide should be taken into consideration. If the coupling among the radiating elements is small, then the input impedance of those elements is the same as those of the actual radiating device. Electrical performance, such as radiation patterns, gain and bandwidth, can be conveniently applied by utilizing LED lamps. Also, accidents should not be inflicted or reciprocating. This research is required in order to enhance cross-linking of microstrip patches antenna components [18].

This graph depicts that the reciprocal form of coupling existed in the antenna. Because of this, bad output and illegal inputs will result. It will be evaluated on the relationship between two rectangular antennas feed and two U-slot antennas feeding patch antennas in the next section.

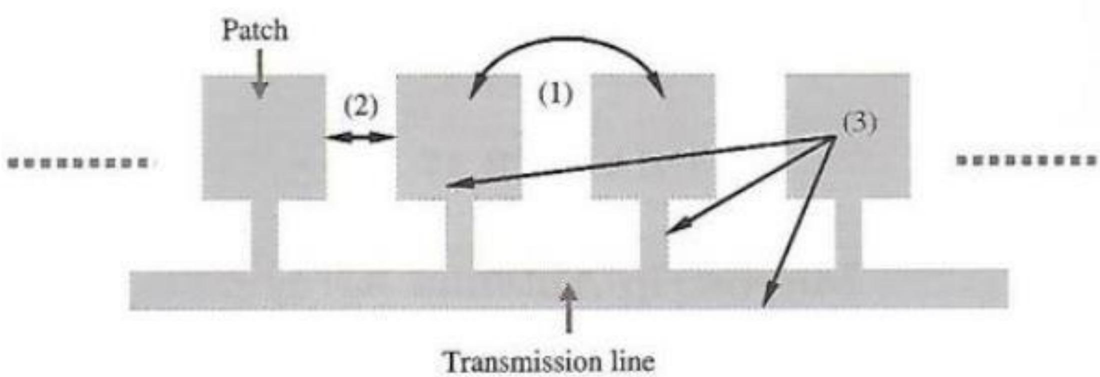

Figure 2. 9: Mutual Coupling Visualization in an Antenna Array.

2.5.2 Surface Wave Current

Surface waves are those that pass without radiated radiation. The electromagnetic fields of Surface Electromagnetic Waves are excited by different causes.

Some strategies may be used to keep the waves form propagating. The absence of clear methods to examine surface waves is becoming a growing problem in the question of their suppression [18].

Surface waves are directed (transverse) and transverse modes. These modes can be defined as a frequency loss over cutoff and lateral spreading. The phase surface velocity is very high on the water and albumen material. Figure indicates that how the surface waves occurred in the microstrip antenna.

2.6 MONOPOLIES AND DIPOLE

It is most viable choice for LMR applications by utilizing vertical dipole or its electromagnetic analogue monopole. It is increase in a horizontal plane omnidirectional and has a 1.64 (or G = 2.15 dBi). The figure 5 depicts the vertical dipole center-feed. (a). It's an easy and unassuming antenna, but it's really challenging to install on masts or cars. Figure 2.10: Perfect vertical monopoly (b). It is part of a dipole but the boundary surface is indescribably maneuverable and cyclic.

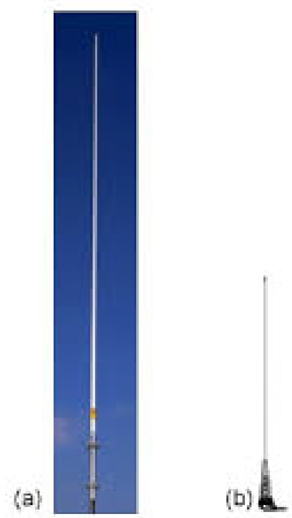

Figure 2. 10: Perfect vertical monopoly.

This is logically equivalent to the monopole, with equal benefits, patterns, etc. A plane with a radius the same as the diameter of the disk part is very efficient and practical. It is important that a car has at least a flat ground plane. Base station antennas and mobile apps are shown in Figure 2.11.

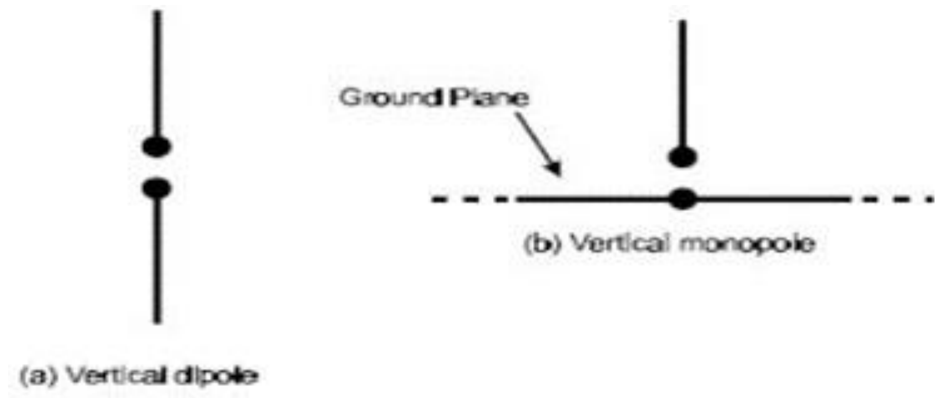

Figure 2. 11: Base station antennas and mobile apps.

2.6.1 Applications for Base-Station

There are two simple real-world uses of the methodology (where an omnidirectional pattern is desired). The first forms of antenna are as seen in Figure 2.12. (A) Sleeve antenna is a vertical dipole it we be with a feed coming from one of the ends of the line [19].

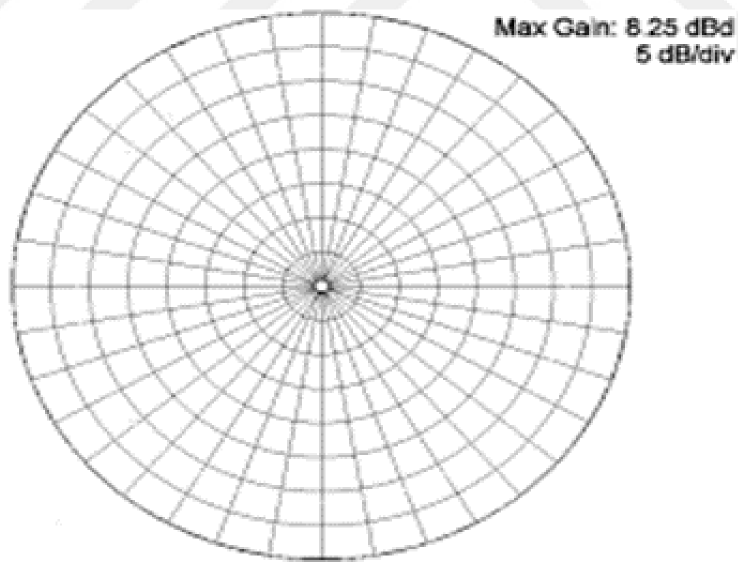

Figure 2. 12: Omnidirectional pattern.

It's a thin part. The second form is one for one connection to a land aircraft. (b) A monopoly uses a series of four wire components to shape the ground plane. Figure 2.13 demonstrates the standard trend of single carrier business.

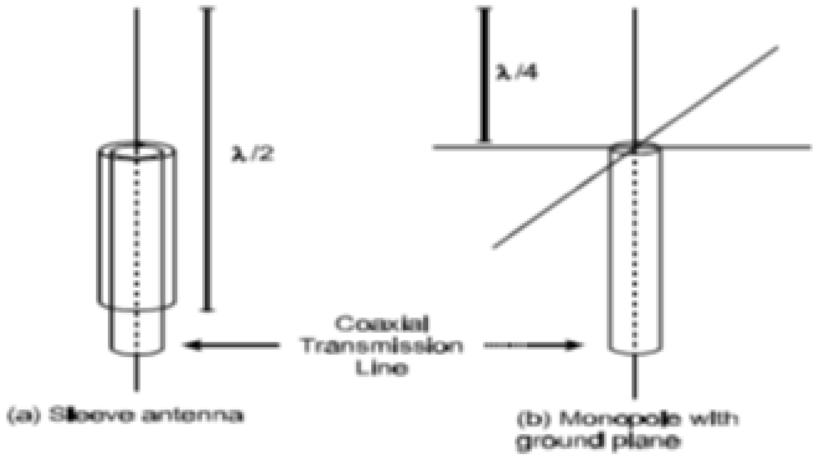

Figure 2. 13: Standard trend of single carrier business.

The folded dipole is one of many common types of dipole antennas. Being close to basic dipole, it has similar impedance and higher bandwidth.

2.6.2 Mobile Applications

Almost all vehicle antenna panels are installed on a smooth body board (as described above). Monopolies are also regarded as "whip" antennas. At the lowest range VHF, the quarter-wave monopole may be possible 2.5 m long. Since of the inductor (coil) at the grounds base of the antenna has an additional electrical length, the antenna's real duration would be shorter. However, these benefits will be limited because of "loaded" antenna. The option of mounting the smaller antenna in the center of a comfortable ground level compensates for the disadvantage (e.g., the roof or trunk of the vehicle). Figure 2.14 provides an example of this antenna (a).

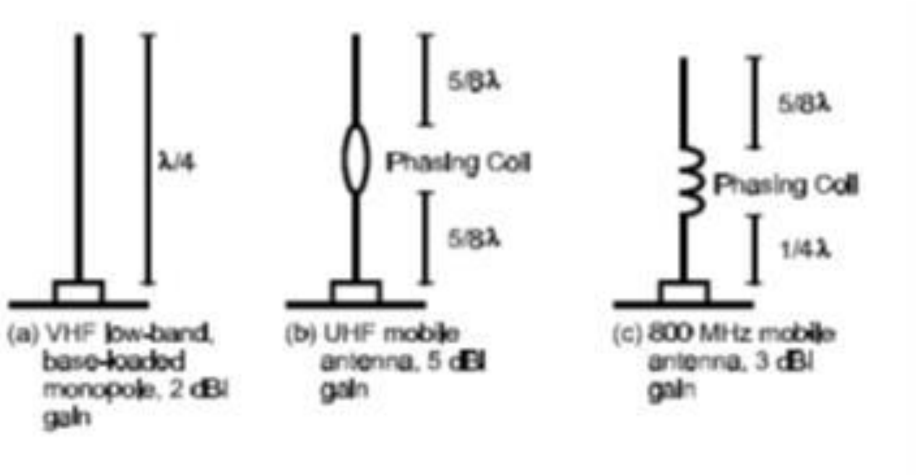

Figure 2. 14: Examples of Antennas.

Most VHF high-band antennas are a quarter-wave monopoly. This indicates that it will need whip antennas at 150 megahertz. Half-wave and five-eighths waves may also be used, but some type of matching network (such as inductors and/or capacitors) is required to align the impedances of the antenna to the transmission line. These antennas have an estimated 3 dBi gain [20].

Quarter-wave whip for UHF signals is roughly 15 cm (6 in) long. From the time of his passing.

This configuration may be adjusted to maximize successful performance. Two 5/8 wave spools with incremental spin sheets can "stacked" between them, as shown in Figure 2.14(b). This can be interpreted as an overall antenna array with a rise of approximately 5 dBi. The quarter wave monopoly is not operating properly at 800 Megahertz (MHz), so the Commission accepts to stack two monopolies to fulfill the necessity. The antenna is shaped like a handheld antenna and has an output of around 3 dBi. The 'azimuth paradigm' is accepted by both monopolies.

This is the perfect pattern. Also, in this sense, the angle of gain and direction of the field is unchanged in the horizontal plane. In fact, the pattern is not necessarily horizontal. Even though it is horizontal, there can be obstructions to the car. The horizontal plane design of the 830 MHz radio frequency whip in the middle of the vehicle roof. The dotted line in the table indicates the optimistic effects on the figure. Light pole fixed on the edge [21].

2.6.3 Corner of the reflector

A dipper-composed antenna in front, such seen in figure 2.15, comprises one or more dipole parts. A traditional horizontal facial image.

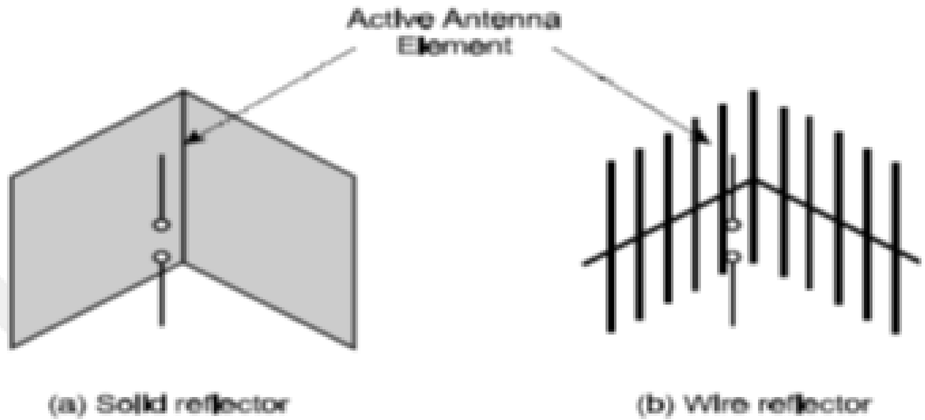

Figure 2. 15: dipole elements in front of the corner reflector.

This beam has a pretty high gain; however, its primary gain is much higher than its otherwise gain. As seen in figure 2.16, this is termed the front-by-back ratio.

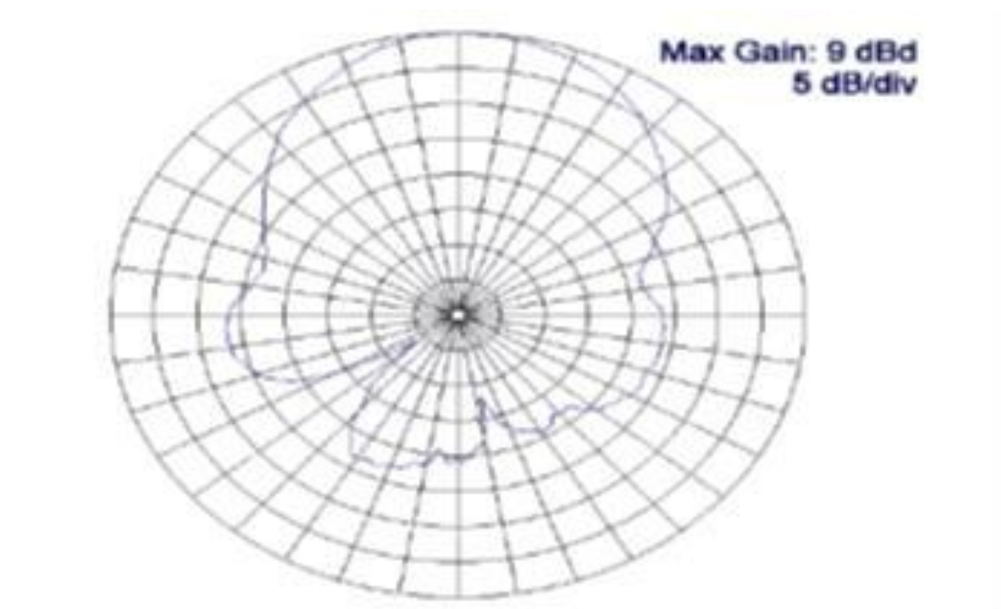

Figure 2. 16: The front-to-back ratio.

2.6.4 Active Antennas

An operational antenna contains circuitry which can enhance the incoming signal without relying on the transmission line structure. The meaning in Figure 2.17. The input to the amplifier is via the "element" antenna. It allows output of output.

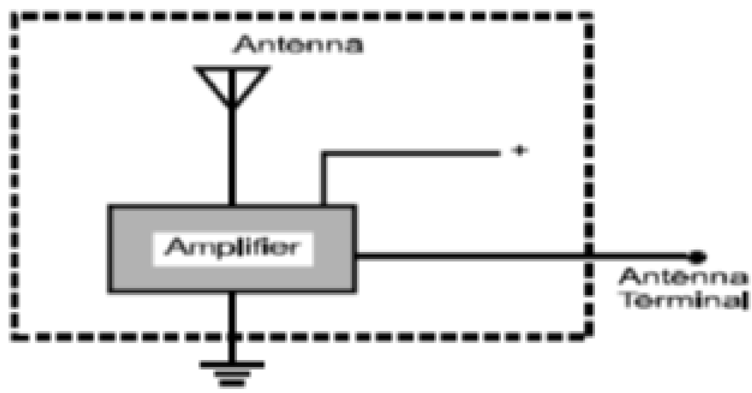

Figure 2. 17: The operational antenna contains circuitry.

The amplifier's operating antenna is the operational device terminals. The active portion of the antenna is included with the corresponding amplifier.

An alternative object of the active antenna is the random source impedance adjustment to a constant value which approximates the transmission line's characteristic impedance. This function is important for complex antenna designs where a specific pattern cannot be accomplished without a peculiar impedance response. The reaction antenna cannot be transmitted [22].

2.7 C-BAND ANTENNA

In aerospace technology, C-band is a significant frequency because of its vital nature in radio communications. The C-band is utilized for a range of satellite communications, Wi-Fi apps, cables and weather radar systems.

C-band was the first frequency channel assigned to commercial satellite communications. This has also been attempted in the area of satellite telecommunications networks. For the downlinks and 5.925 to 6.425 GHz for the uplinks, satellite transmissions use frequency ranges from 3.7 to 4.2 GHz. For many radars, the C band is employed.

The C-band satellites will place several links simultaneously. Each transponder only uses about 36 MHz (The 4.0 MHz of guard band between pairs of transponders in this case is due to effect of microwave, etc.).

One use of the C-band is for satellite communication, satellite television full-time or raw feed. The Incumbent provider utilizes a direct-to-home satellite infrastructure that is entirely divorced from the consumer satellite dish. The C-band part of the satellite constellation is connected with the satellite receiver-only tv.

2.8 RELATED WORKS

Microstrip antenna has undergone massive developments in the past decade thanks to its features such as bright weight, compact size, flat structure, ease of manufacture for mass production and is very attractive for radar application.

Several studies have shown that when a gap is made inside the microstrip antenna, it can greatly enhance the antenna performance in terms of antenna gain, directional and return loss graph as well as reducing the antenna size. In the current research, the researcher has designed an inverted F-slot microstrip tri-band patch antennas. And it has been observed that there is a significant improvement in contractual conditions of its gain and steering performance [23].

It very well may be seen that the shape and size of the hole are significant in improving the radio wire. The flow analyst planned the receiving wire to be furnished with a rectangular connector with two L-formed openings. Change the - 10 dB data transfer capacity for recurrence misfortune from 2 to 6 GHz, cover some WiMAX and WLAN groups, and discover an improvement in the radio wire execution. It does the trick to meet our prerequisites to be based on devices that can be utilized when required [24].

The researcher invented and simulated a dual C-slot microstrip antenna for the frequency spectrum between 2,5 and 2,69 GHz in order to decrease the size of the antenna and boost its performance. The single supplied C-slot antenna is extended by this antenna. He compared the findings and decided that the dual antenna had a rise of 6,46 db and was 37% smaller than a traditional square antenna [25].

Through studying the above research, it was found that it is possible to work on improving the antenna by changing the slot of antenna into a double H-slot and changing the dimensions, I was able to improve the antenna greatly as it obtained three frequencies, with increases gain, better return loss and enhance bandwidth, compared to other designs.

3. METHODOLOGIES

3.1 OVERVIEW

This section shows in details the flow of work from beginning to the end of the whole project. It includes how to design and simulate the microstrip patch antenna. Next, it will explain on how the integration of double H-slot in microstrip patch antenna structures takes place. This chapter would also explain the methods and software used to carry out the project. This project focuses only on the simulation of applications. In order to accomplish the desirable results from the experiment, the right procedure and the exact measurement will be carried out.

3.2 DESIGN PROCESS

In this chapter of the research, an explanation of the project will be given from the beginning to the end, and this will be shown in the clear figure (3.1) below. Which includes in the first stage the literature review of the program (HFFS) used for the simulation and how to justify it, and in the second stage the procedure of antenna design used to obtain the results and the last analysis of the results in the form of drawings.

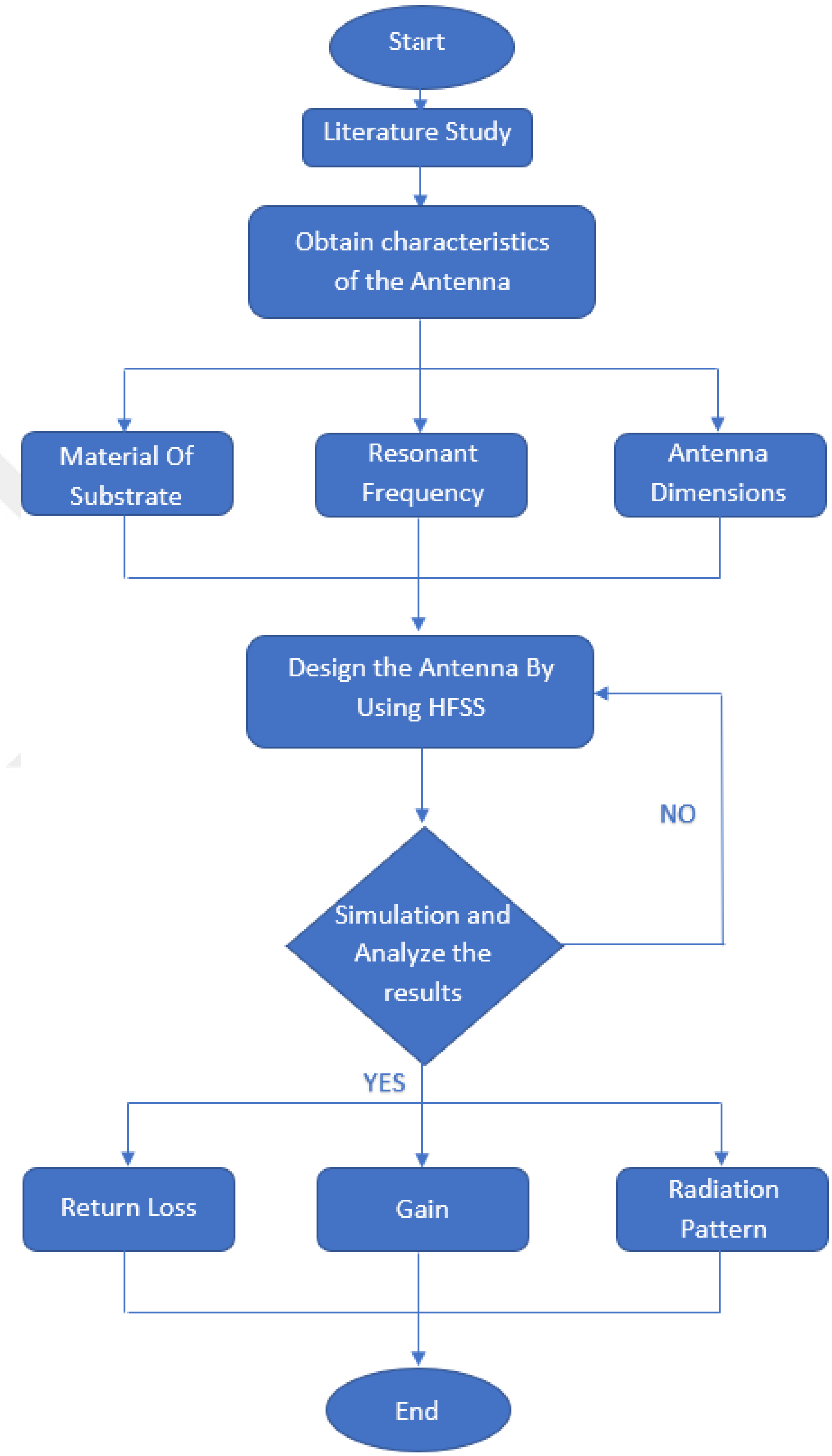

Figure 3. 1: Project Methodology Flow Chart.

The project starts with an analysis of the existing project and the design that is applicable to the project. After investigating the related project, it is time to begin a literature analysis of the related project to learn more about the MPA. Based on the analysis of the relevant project, it is easy to know what substrate is appropriate for this project, which refers to the millimeter wave wavelength. This is because, when studying another project, the writers will implicitly offer an idea or suggestion depending on the subject of their concern. For example, on the basis of this project, it is proposed that the board be used by Rogers RT/duroid 5880, since this board is offering the highest possible performance. It is claimed that the antenna will achieve its efficiency at 85 percent or higher by using this board.

3.3 PROCEDURE OF ANTENNA DESIGN

3.3.1 Design Procedure

To begin the design, microstrip antenna is first to design. After deep understanding about all antennas‟ properties, it is time to consider on how to design and develop operate at three frequencies microstrip patch antenna. In this subtopic, the parameters will be match with the specification that needs. The requirements are important to set as a benchmark before any method of designing can be implemented. This not only includes the software platforms that are used but also components.

The first measures are to choose the form of material, its thickness and then its relative permittivity for the dielectric substrate. This is very critical when choosing a suitable dielectric substratum with a suitable thickness. Many vendors provide acceptable substrates in varying thicknesses and a number of coverings. The thickness and relative permittivity of this type of antenna are wisely chosen depending on which the frequency required for the millimeter wave can be optimized.

The microstrip radio wire was intended to perform three turns in the C-band. For this plan, the most extreme force hardware was a Rogers RT/duroid 5880 (εr = 2.2) with dielectric extraction (tan 9) of 0.009 and a pinnacle tallness (h) of 1.5748mm. The microstrip receiving wire is energized by the coaxial perception that the objective locale is a good way off (taking care of Y) from the fix. All definite portrayals are appeared in Table 3.1 beneath:

Table 3. 1: Parameter of Substrate used.

Name of Substrate	Rogers RT/duroid 5880
ε_r	2.2
Thick ness of Substrate (h)	1.5748mm
Thickness of Copper (t)	0.035mm
Loss Tangent	0.009
Type of Ground	PEC

3.3.2 Design Calculation

The first steps in making a microstrip antenna is to start designing an antenna patch. Based on the table shown below, to get those parameters, we will find steps by using these calculation steps as shown in the subtopic after this.

Table 3. 2: Parameter of Microstrip Patch Dimension.

Parameters	Values in (mm)
Length of The Ground Substrate Dimension, L-sub	81
Width of The Ground Substrate Dimension, W-sub	69
Length of the Patch, L-p	28.8
Width of the Patch, W-p	32.3
Length of the slot H1, L-s	1.75
Width of the slot H1, W-s	31.3
Length of the slot H2, L-ss	1.25
Width of the slot H2, W-ss	12.5
M	17.4

N	5.15
Feed-Y	11.15

Microstrip antenna measurements are separated into three parts, which are the Patch Microstrip Antenna and the Double H-slot in the patch. The feed point and feed network estimation will also be used in both parts to display the full process in detail. Any of these equations will be merged later. The patch dimension can be measured manually using all previous hypotheses that have been discussed. Figure 3.3 indicates the precise dimensions of the patch, substrate, and slots.

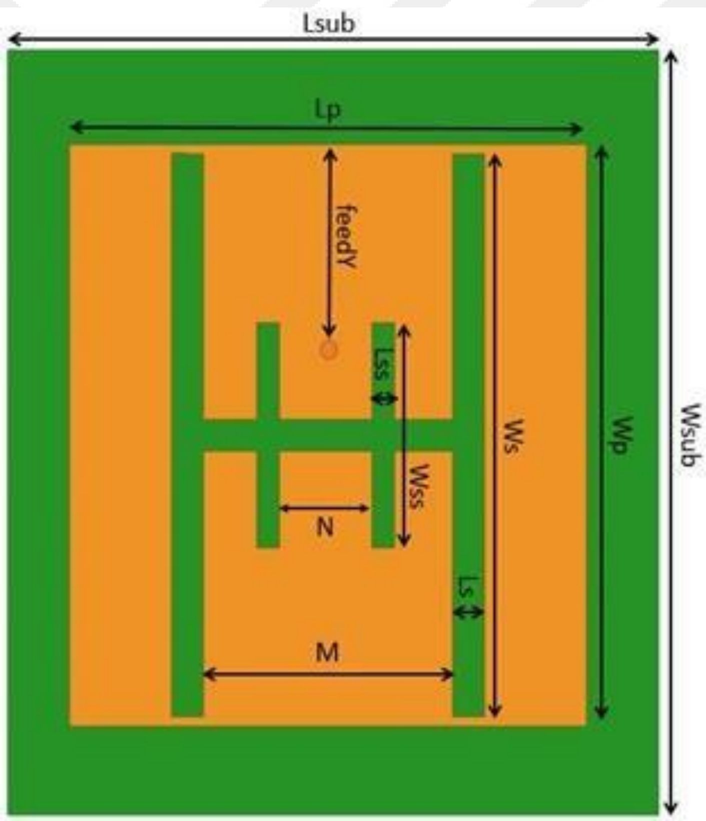

Figure 3. 2: Exact Antenna Double H-Slot Patch Dimension.

All the measurements that have been made are based on the details on the substrate already discussed above, where all the relevant parameters are set in this project as shown in Table 3.3 as follows:

Table 3. 3: Constant Parameter for Designing Microstrip Patch

Velocity of Free Space, C	3 × 108 m/s
Relative Permittivity, ε_r	2.2
Height of Substrate, h	1.5748mm

Calculation details are seen in steps 3.1 to 3.7 of the equations below:

Step 1: Calculation of the patch’s width, W

$$W = \frac{c}{2f_r\sqrt{\frac{\varepsilon_r + 1}{2}}} \quad (3.1)$$

Where;

c = Free Space Velocity of Light, 3 x 108 m/s.

fr = Frequency of Operation.

εr= Dielectric Constant.

Step 2: Calculation of the Effective Dielectric Coefficient, ε_{eff}

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{W}\right]^{-1/2} \quad (3.2)$$

Where;

εr= Dielectric Constant.

h = Height of Dielectric Substrate.

W= Width of the patch.

Step 3: Calculation of the Effective Length, $\mathbf{L}_{\boldsymbol{eff}}$

$$L_{eff} = \frac{c}{2f_r\sqrt{\varepsilon_{eff}}} \tag{3.3}$$

Where;

c = free space velocity of light, 3 x 108 m/s.

fr = Frequency of Operation.

ε_{eff}= Effective Dielectric Constant.

Step 4: Calculation of Length Extension, ΔL

$$\Delta L = 0.412h\frac{(\varepsilon_{eff} + 0.3)\left(\frac{W}{h} + 0.264\right)}{(\varepsilon_{eff} - 0.258)\left(\frac{W}{h} + 0.8\right)} \tag{3.4}$$

Step 5: Calculation of actual length of the patch, L

$$L = L_{eff} - 2\Delta L \tag{3.5}$$

Step 6: Calculation of substrate dimension

$$L_{sub} = 6h + L \tag{3.6}$$

$$W_{sub} = 6h + W \tag{3.7}$$

Step 7: Calculation of The Feed Point of Single Patch Antenna

In this project, the feed point is calculated by using the equation from 3.8 to 3.12 as below:

$$Z_{in} = 90\,\frac{\varepsilon_r^{\,2}}{\varepsilon_r - 1}\left(\frac{L}{W}\right)^2 \tag{3.8}$$

$$Z_T = \sqrt{(Z_o)\,Z_{in}} \tag{3.9}$$

$$L_T = \frac{\lambda_g}{4} = \frac{\lambda_o}{4\sqrt{\varepsilon_{reff}}} \tag{3.10}$$

$$\lambda_o = \frac{c}{f} \tag{3.11}$$

$$L_f = \frac{\lambda_g}{2} = \frac{\lambda_o}{2\sqrt{\varepsilon_{reff}}} \tag{3.12}$$

3.4 SIMULATION IN HFSS PROGRAM

3.4.1 Introduction

The key resource for the configuration of the antennas for this study is the Ansys/Ansoft High Frequency Structure Simulator (HFSS) (version 17.2). HFSS is a 3-D chock-full wave EM field simulation program used to solve Maxwell's partial differential equations (PDE) for complex tangible structures. HFSS used the Finite Element Method (FEM) that solves problems by splitting the problem structure into a large number of elements and then applying Maxwell's theorem to solve them. HFSS splits the complete geometric pattern into a huge number of tetrahedrons. Each tetrahedron is a four-sided pyramid. HFSS provides a variety of state-of-the-art solver technologies, each of which is built on a validated finite element system.

For this study, the FEM alternative has been chosen to overcome the antenna structures that have been built. FEM operates by meshing the arrangement with the tetrahedron elements and by solving PDEs, and HFSS uses an adaptive mesh to achieve convergence. In the case of antenna structures in this study, the meshing was defined to be λ/10 at the maximum operating frequency.

Figure 3. 3: ANSYS High Frequency Structure Simulator (HFSS V.17.2).

3.4.2 The Justifications

HFSS is being used to solve Maxwell's partial differential equations (PDE) for complex tangible structures. HFSS applied the Finite Element Method (FEM) which solves by splitting the problem structure into huge number of elements then will be applied Maxwell's equation to solve them. HFSS splitting the whole geometric model into huge number of tetrahedra. Each tetrahedra is a four-sided pyramid. In addition to offerings made on a proven finite element system, HFSS provides numerous advanced solver technology.

4. SIMULATIONS OF RESULTS AND DISCUSSIONS

4.1 OVERVIEW

This section presents the design specifications and the results obtained from the mathematical computation as described in the methodology and from the design of the HFSS software simulation respectively. The antenna is designed with a patch and double H slot. After that, the results will be analyzed and discussed.

Based on the theoretical calculation shown in Chapter 3. The shape of the patch is listed as shown as Figure 4.1 as follows. The rectangular patch is simulated on a Rogers 5880 substrate which has the thickness, relative permittivity and loss tangent of certain value which is listed previously. This double H-slot patch microstrip antenna is designed with the help of excitation from microstrip feed line.

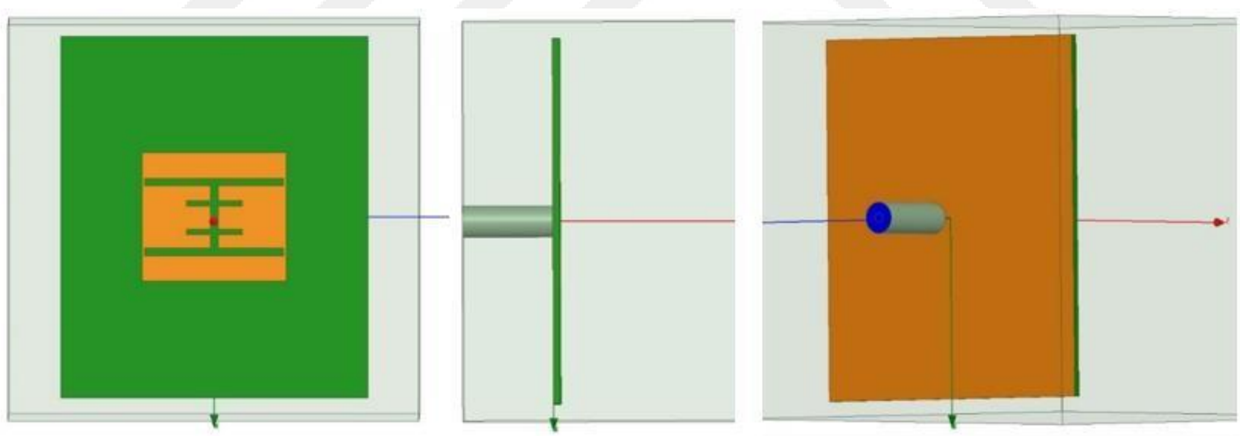

Figure 4. 1: Microstrip Patch Antenna Design.

4.2 RESULTS AND DISCUSSION

The proposed three-band double H-Slot patch antenna is simulated and evaluated in this segment using ANSOFT HFSS 17.2 edition. Parametric effects of these simulations. The experiments are being done. In this portion, the gain, the VSWR and the RL are simulated and evaluated. Impedance matches of the suggested antenna for 3.95-4.05 GHz frequency ranges, 5.75-5.88 GHz and 6.5-6.61 GHz were greater than -10 return missing. The planned antenna has an operational frequency, which was planned to fall within the spectrum of C-Band (4-8GHz).

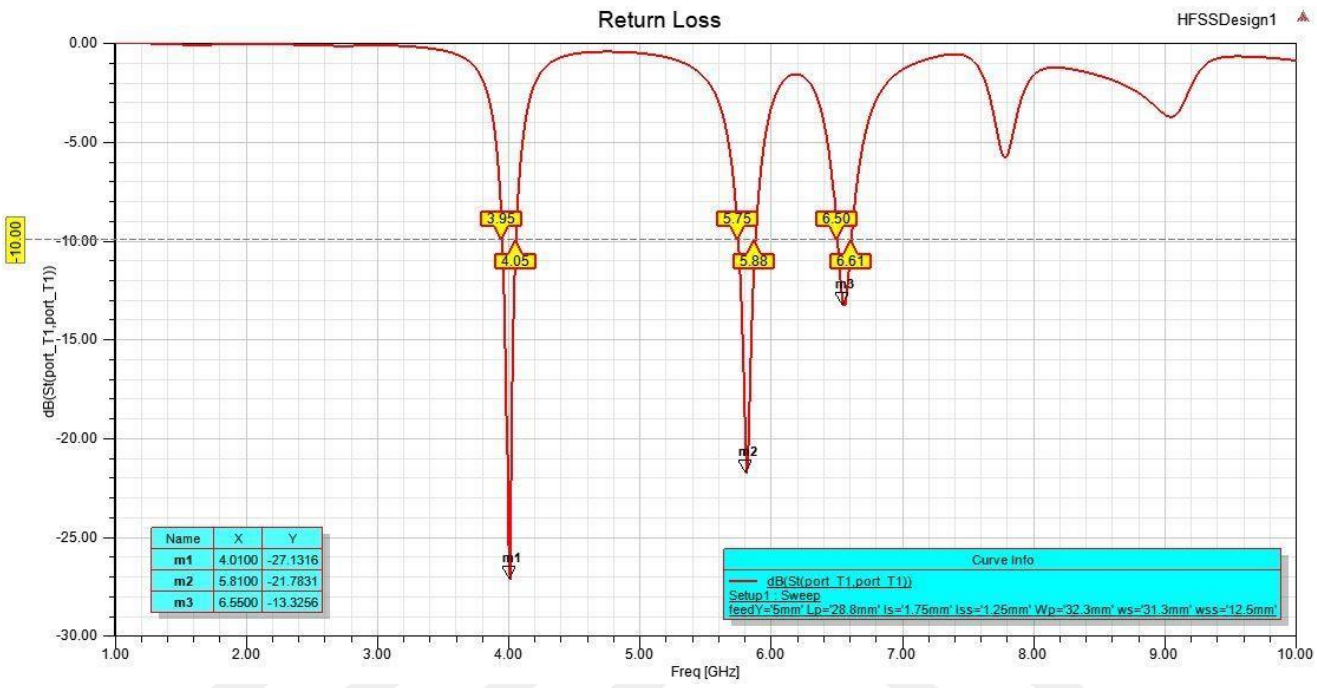

Figure 4. 2: Return. Loss Graph of Microstrip Patch Antennas Design

Based on the Figure 4.2, the return loss simulation results shows that this patch antenna design drop at desired frequencies.

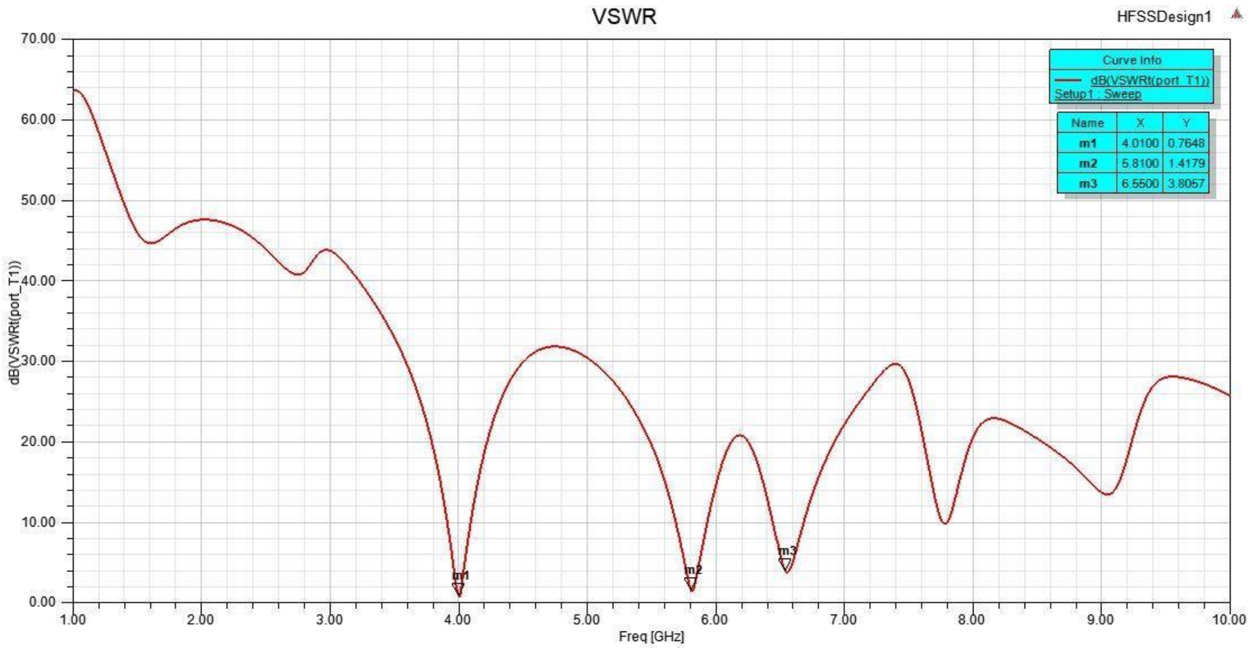

Figure 4. 3: VSWR Graph of Microstrip Patch Antenna Design.

The consequences of this Input impedance modeling show a VSWR value less than two in the 3.95-4.05 GHz, 5.75-5.88 GHz, and 6.5-661 GHz ranges, as shown in Figure 4.3. As indicated in the diagram, the antennas exhibit VSWRs of 0.7648dB for 4.01GHz, 1.4179dB at 5.81GHz, and 3.857dB at 6.55GHz. This is significant because the lower the VSWR, the better the directional antennas success is a function of radiating energy or ’s arrival.

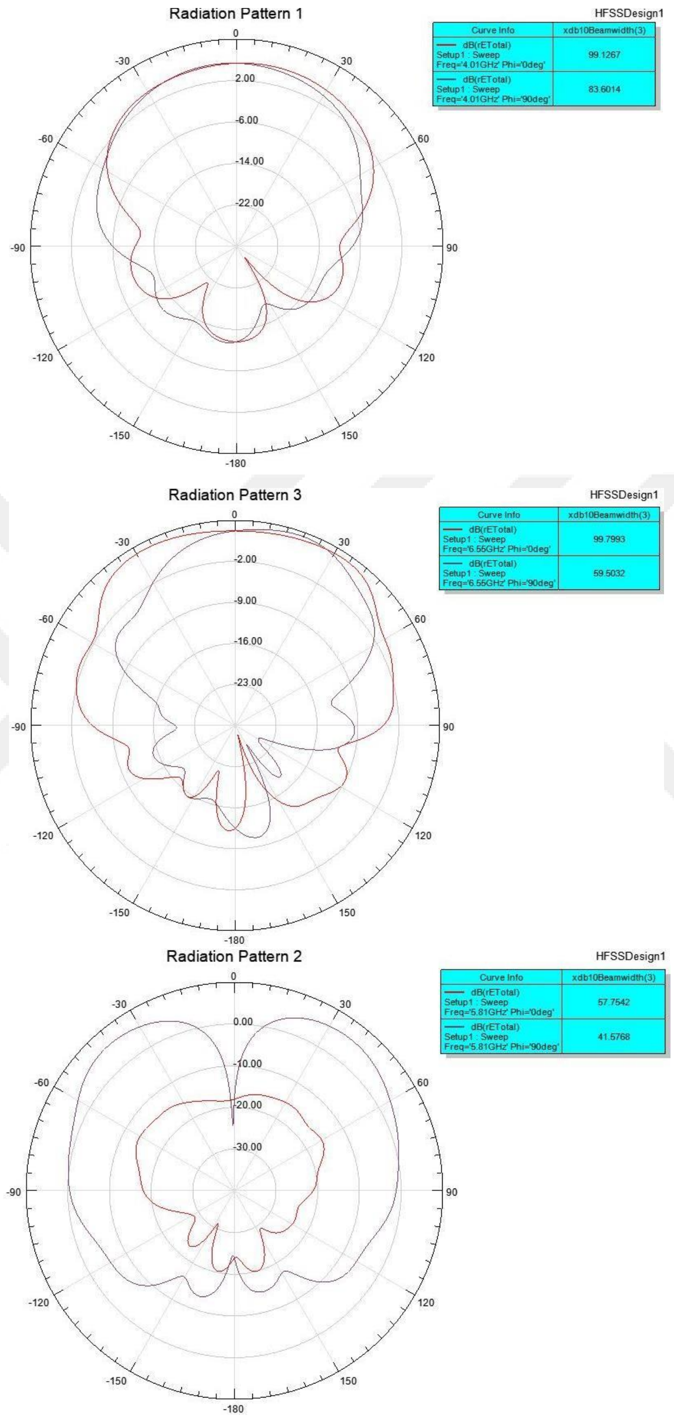

Figure 4. 4: Fairfield Radiation Pattern of Microstrip Patch Antennas Design.

Figure 4.4 above shows the RP for the proposed Antenna. It is shown the E-field in red and H-field in blue. It is shown that the Beamwidth level for E-field is 99.126dB and H-field is 83.6014dB at the 1st frequency, E-field is 57.754dB and H-field is 41.5768dB at the 2nd frequency and E-

field is 99.7993dB and H-field is 59.5032dB at the 3rd frequency. This is an acceptable, in order for the radiation to dissipate to the major lobe.

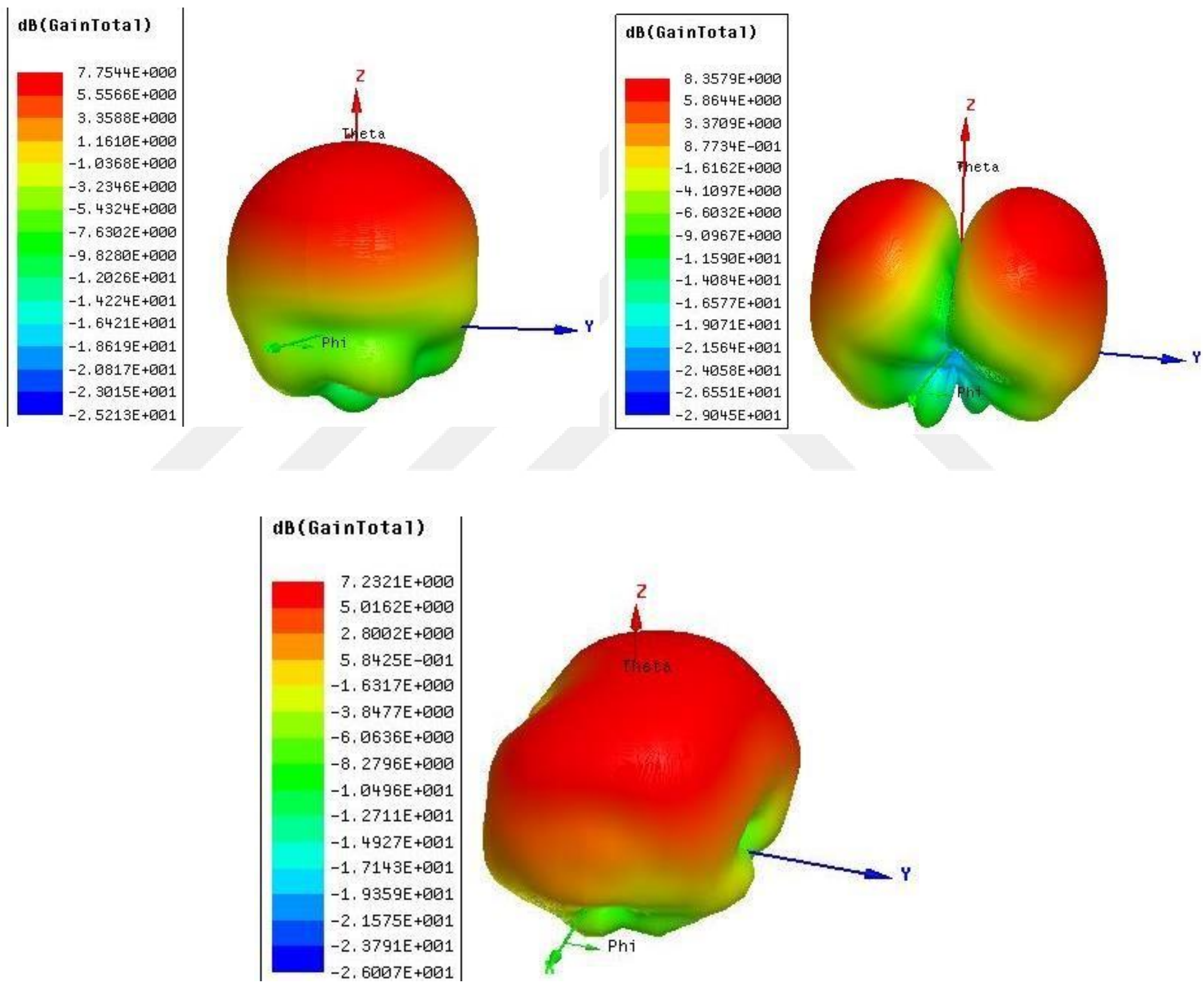

Figure 4. 5: 3D Radiation Pattern and Gain of Microstrip Patch Antennas Design.

Figure 4.5 above shows the Gain for the proposed Antenna. The benefit at 4.01GHz is 7.75dB, at 5.81GHzen at 8.35dB and at 6.55GHz at 7.23dB. These results good to achieve excellent performance of the antenna, The red spot as shown in the major lobe above figure indicates that the radiation has the highest value at the major lobe, and in order to know the gain value, it can simply refer to the red top most scale beside this far field pattern.

5. CONCLUSIONS

In this paper, a solution was proposed in a different way to overcome the problems surrounding the transfer of data from one point to another, as well as the path to the way in which the industry took streaking. In this research, new results were recorded indicating the aspect of institutional profit. As the antenna was manufactured by using the advanced HFSS program and by the method of IMF in the method in the pant range.

Through studying the above research, it was found that it is possible to work on improving the antenna by changing the slot of antenna into a double H-slot and changing the dimensions, I was able to improve the antenna greatly as it obtained three frequencies, with increases gain, better return loss and enhance bandwidth, compared to other designs. The following results were obtained through the C-Band I made three frequencies from our double H-slot antenna (6.55 GHz,

5.81 GHz, 4.01 GHz).

For the Future Work, it Plans and create aperture partnered patch antennas conducted at different frequencies with various surface materials fitting the mentioned literature. The numerical study may be performed with the aid of EM theory. Compare the output of related microstrip fed, probe fed, and pupil tied patch antennas.

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