Design and Analysis of a Wideband Microstrip Antenna for High Speed WLAN

A Project and Thesis submitted in partial fulfillment of the requirements for the Award of Degree of
Bachelor of Science in Electrical and Electronic Engineering

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Certification

This is to certify that this project and thesis entitled **"DESIGN AND ANALYSIS OF A WIDEBAND MICRO-STRIP ANTENNA FOR HIGH SPEED WLAN"** is done by the following students under my direct supervision and this work has been carried out by them in the laboratories of the Department of Electrical and Electronic Engineering under the Faculty of Engineering of Daffodil International University in partial fulfillment of the requirements for the degree of Bachelor of Science in Electrical and Electronic Engineering. The presentation of the work was held on 07 January 2020.

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The project and thesis entitled **"DESIGN AND ANALYSIS OF A WIDEBAND MICRO-STRIP ANTENNA FOR HIGH SPEED WLAN"** submitted by **Farhad Hossain**, ID No: 161-33-276**, Raihan uddin** ID No: 161-33-276 Session: Fall 2019 has been accepted as satisfactory in partial fulfillment of the requirements for the degree of **Bachelor of Science in Electrical and Electronic Engineering** on 19 December 2019.

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Dedicated to

Our Parents

DECLARATION

We hereby declare that this thesis is based on the result found by ourselves. The materials of work found by other researchers are mentioned by reference. This thesis is submitted to Daffodil International University for partial fulfillment of the requirement of the degree of B.Sc. in Electrical and Electronics Engineering. This thesis neither in whole nor in part has been previously submitted for any degree.

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LIST OF SYMBOLS AND ABBREVIATIONS

ε_r	Dielectric Constant
LAN	Local Area Network
WLAN	Wireless Local Area Network
Wi-Fi	A popular synonym for "WLAN"
GHz	Giga Hertz
IEEE	Institute of Electrical and Electronics Engineers
Mbits/s	Mega Bits per Second
MMIC	Millimeter-wave Integrated Circuits
IE3D	Moment of Method Based EM Simulator
HTS	High Temperature Superconductor
PCB	Printed Circuit Board
3D	Three Dimensional
2D	Two Dimensional
BW	Bandwidth
RL	Return Loss
VSWR	Voltage Standing Wave Ratio
MIC	Microwave Integrated Circuits
Q	Quality Factor
RF	Radio Frequency

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DESIGN AND ANALYSIS OF A WIDEBAND MICRO-STRIP ANTENNA FOR HIGH SPEED WLAN

Abstract

The wired neighborhood is turning out to be remote step by step. The assignment of recurrence range for this Wireless LAN is diverse in various nations. This shows a horde of energizing chances and difficulties for plan in the interchanges field, including receiving wire structure. The rapid WLAN has numerous norms and most receiving wires accessible don't cover every one of the guidelines. The goal in proposal is to structure an appropriate reception apparatus that can be utilized for fast WLAN application. The essential objective is to plan receiving wire with littlest conceivable size and better polarization that covers all the rapid WLAN benchmarks extending from 4.90 GHz to 5.82 GHz.

Numerous works are going on all through the world in field of reception apparatus planning. Ongoing deals with this field is contemplated in this proposal to discover most reasonable reception apparatus shape for the particular application. Zeland's IE3D reenactment programming has been utilized to structure and mimic receiving wire for WLAN recurrence band. A parametric report has been introduced in procedure to the planned receiving wire for a successful data transfer capacity of 4.9- 5.825 GHz. Return misfortune - 10 dB or lower is taken as worthy point of confinement.

At long last single E shape microstrip fix receiving wire having a component of 24×19 mm2 is shown with a recurrence band of 4.89 GHz to 5.83 GHz. The radio wire exhibits a decent present dissemination and radiation design for every one of the four norms of WLAN that falls inside this recurrence run.

CHAPTER 1
INTRODUCTION

1.1 Wireless Local Area Network (WLAN)

Remote neighborhood (WLAN) is an innovation that connections at least two gadgets utilizing remote conveyance technique and as a rule giving an association with the more extensive web. This gives clients the versatility to move around inside a neighborhood inclusion territory and still be associated with the system. WLANs have gotten prevalent in the home because of simplicity of establishment and in business buildings offering remote access to their clients; frequently for nothing. Enormous remote system ventures are being set up in many significant urban areas around the world. Most present day WLANs depend on IEEE 802.11 benchmarks, showcased under the Wi-Fi brand name.

WLANs are utilized worldwide and at various locale of world distinctive recurrence groups are utilized. The original WLANs IEEE 802.11b and IEEE 802.11g norms use the 2.4 GHz band [1]. It underpins generally low information rates, simply up to 10 Mbits/s contrasted and wired partners. As a rule this recurrence band is sans permit, subsequently the WLAN gear of this band experiences obstruction different gadgets that utilization this equivalent band. The current quickest and powerful WLAN standard IEEE 802.11a work in the 5–6 GHz band, which can give solid rapid network up to 54 Mbits/s. The 802.11a standard is a lot of cleaner and created to help fast WLAN. Be that as it may, USA, Europe and some different nations utilize diverse recurrence groups for this fast 802.11a standard. Among the two prevalent groups utilized for IEEE 802.11a standard; USA utilizes 5.15–5.35 GHz band and Europe utilizes 5.725–5.825 GHz band. A few nations permit the activity in the 5.47–5.825GHz band. Another new band of 4.9–5.1 GHz has been proposed for WLAN framework as IEEE 802.11j in Japan [1]. A large portion of the present receiving wires accessible at the point bolsters just one or at max two of those models. So individuals need to utilize distinctive handsets for various area in view of this assortment of recurrence band except if we can plan a reception apparatus that can cover the entire rapid WLAN scope of 4.9 – 5.825 GHz. Our principle objective in this theory is to locate an appropriate radio wire that can do as such.

Distinctive kind radio wires and their appropriateness in the WLAN applications have been examined all through the writing audit. At last a coaxial test nourished, single stacked, E – molded microstrip fix receiving wire has been decided for the particular case. At that point a thorough parametric examination has been performed on the radio wire so as to improve the reception apparatus for the referenced wide transfer speed. A receiving wire with a transmission capacity of 925 MHz beginning from 4.890 GHz to 5.825 GHz and size of 26×19 mm2 is discovered which is a lot littler than other accessible radio wires. As the principle objective is fulfilled, reenactments for current dissemination and radiation designs have been analyzed at various frequencies inside that data transfer capacity to watch the receiving wires conduct in general recurrence. At that point a short examination with other accessible receiving wire with the proposed reception apparatus is portrayed alongside an outline of the parametric investigation. At long last degrees for future works are referenced in end.

1.2 Microstrip Patch Antenna

In recent years, the current trend in commercial and government communication systems has been to develop low cost, minimal weight, low profile antennas that are capable of maintaining high performance over a large spectrum of frequencies. This technological trend has focused much effort into the design of microstrip patch antennas. With a simple geometry, patch antennas offer many advantages not commonly exhibited in other antenna configurations. For example, they are extremely low profile, lightweight, simple and inexpensive to fabricate using modern day printed circuit board technology, compatible with microwave and millimeter-wave integrated circuits (MMIC) and have the ability to conform to planar and non-planar surfaces. In addition, once the shape and operating mode of the patch are selected, designs become very versatile in terms of operating frequency, polarization, pattern, and impedance. The variety in design that is possible with microstrip antennas probably exceeds that of any other type of antenna element. However, standard rectangular microstrip patch antenna also has the drawbacks of narrow bandwidth. Researchers have made many efforts to overcome this problem and many configurations have been presented to extend the bandwidth.

Our primary objective is to find out the most suitable antenna shape applicable to be used in the multi-standard WLAN applications around the globe. Different shapes and their use in various fields of wireless communications [1-12] have been studied in the literature review portion. The most suitable shape for WLAN application based on different advantages and disadvantages mentioned in the literatures is found through the study.

Once the most suitable shape is found, an antenna is chosen based on the best option available for the WLAN band. Then the antenna is designed in IE3D simulation software. IE3D is a general purpose electromagnetic simulation and optimization package that has been developed for the design and analysis of planar and 3D structures encountered in microwave and MMIC, high temperature superconductor (HTS) circuits, microstrip antennas, Radio frequency (RF) printed circuit board (PCB) and high speed digital circuit packaging. Based upon an integral equation, method of moment (MoM) algorithm, the simulator can accurately and efficiently simulate arbitrarily shaped and oriented 3D metallic structures in multi- layer dielectric substrates. It is very popular and recognized software for antenna simulation. This software can be used to examine different parameters, 2D, 3D radiation patterns and current distributions inside the antenna. We can also easily compare the output of different antennas in the same graph/window allowing us to take decisions regarding the best antenna.

Then IE3D is used to carry out a comprehensive parametric study to understand the effects of various dimensional parameters and to optimize the performance of the antenna. An insight on how different design parameter affects operating frequency, bandwidth and other output parameters is also found. Finally based on the comparison we can select a perfect antenna for WLAN application with
wider bandwidth and multi-band capability.

1.3 Contribution of the Thesis

A radio wire for rapid WLAN benchmarks covering a transfer speed from 4.90 GHz to 5.82 GHz has been planned and mimicked in this theory. A parametric investigation of E shape radio wire has likewise been displayed which can be exceptionally helpful to comprehend the impacts of different parameters on the transmission capacity.

1.4 Organization of the Thesis

The dissertation is mainly divided into five chapters. Introduction to WLAN, microsrtip antenna and main objectives of the thesis have already been expressed in Chapter 1.

Chapter 2 provides some information about basic properties of antenna and the literature review done in the process. Based on the literature review an antenna is taken for optimization. Optimization is done by simulating the antenna with variable parameters. The effects of this parametric study and the final optimized design are discussed in Chapter 3.

The average and vector current distributions, 2D and 3D radiation patterns of the final optimized antenna for all basic 802.11 standards in 5-6GHz range are shown and discussed in Chapter 4. Also the effects of parametric study have been summarized to understand the effect of different parameters on bandwidth, resonance and return loss. A comparison with existing antennas and proposed antenna is also briefly discussed in this chapter.

Finally conclusive discussion and scope for future works are described in the fifth and the final chapter.

CHAPTER 2
BACKGROUND

2.1 Antenna Characteristics

A receiving wire is an electrical gadget which changes over electric flows into radio waves, and the other way around. It is normally utilized with a radio transmitter or radio recipient. In transmission, a radio transmitter applies a wavering radio recurrence electric flow to the reception apparatus' terminals, and the receiving wire emanates the vitality from the flow as electromagnetic waves (radio waves). In gathering, a radio wire captures a portion of the intensity of an electromagnetic wave so as to create a small voltage at its terminals, which is applied to a recipient to be enhanced. A receiving wire can be utilized for both transmitting and accepting. So to put it plainly, receiving wire is a gadget that is made to productively transmit and get transmitted electromagnetic waves. There are a few significant radio wire attributes that ought to be viewed as while picking a receiving wire for a specific application, for example,

- Bandwidth (BW)
- Return Loss (RL)
- Gain
- VSWR
- Radiation Pattern
- Polarization

As an electro-attractive wave goes through the various pieces of the reception apparatus framework it might experience contrasts in impedance. At every interface, contingent upon the impedance coordinate, some portion of the wave's vitality will reflect back to the source, shaping a standing wave in the feed line. The proportion of most extreme capacity to least power in the wave can be estimated and is known as the standing wave proportion (SWR). The SWR is typically characterized as a voltage proportion called the VSWR. The VSWR is constantly a genuine and positive number for radio wires. The littler the VSWR is, the better the reception apparatus is coordinated to the transmission line and the more power is conveyed to the radio wire. The base VSWR is 1.0. For this situation, no power is reflected from the radio wire, which is perfect. As the VSWR expands, there are 2 fundamental downsides. The first is self-evident: more power is reflected from the receiving wire and accordingly not transmitted. In any case, another issue emerges. As VSWR builds, more power is reflected to the radio, which is transmitting. A lot of reflected power can harm the radio. Generally a VSWR of ≤ 2 is worthy for radio wires. The arrival misfortune (RL) is another method for communicating befuddle. It is a logarithmic proportion estimated in dB that looks at the power reflected by the radio wire to the power that is encouraged into the receiving wire from the transmission line. The RL is legitimately related with the VSWR.

$$RL = -20\log\left(\frac{VSWR-1}{VSWR+1}\right) dB$$

In practice, the most commonly quoted parameter in regards to antennas is S_{11}. S_{11} is actually nothing but the return loss (RL). If S_{11} = 0 dB, then all the power is reflected from the antenna and nothing is radiated. If S_{11} = -10 dB, this implies that if 3 dB of power is delivered to the antenna, -7 dB is the reflected power. The acceptable VSWR of ≤ 2 corresponds to a RL or S_{11} of -9.5 dB or lower. In this thesis RL of -10 dB or lower is taken as acceptable.

2.2 Characteristics of Basic Microstrip Patch Antenna

In its basic form, a Microstrip Patch antenna consists of a radiating patch on one side of a dielectric substrate which has a ground plane on the other side as Shown in Figure 2.1.

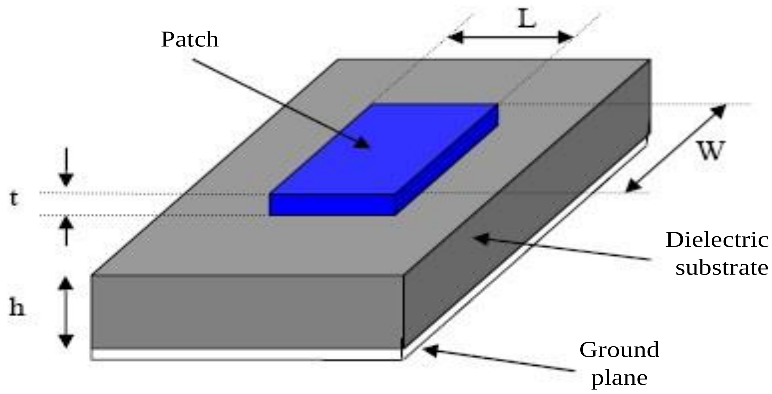

Figure 2.1: Basic Microstrip Patch Antenna

The fix is typically made of directing material, for example, copper or gold and can take any conceivable shape. The emanating patch and the feed lines are typically photograph scratched on the dielectric substrate. So as to improve investigation and execution estimation, by and large square, rectangular, roundabout, triangular, and circular or some other basic shape patches are utilized for planning a microstrip receiving wire. For our situation we are going to structure E shape fix reception apparatus in light of its double resounding attributes which brings about more extensive data transfer capacity. The microstrip fix receiving wires emanate principally on account of the bordering fields between the fix edge and the ground plane. For good execution of reception apparatus, a thick dielectric substrate having a low dielectric steady is vital since it gives bigger transmission capacity, better radiation and better productivity. In any case, such an ordinary design prompts a bigger radio wire size. So as to diminish the size of the Microstrip fix reception apparatus, substrates with higher dielectric constants must be utilized which are less effective and bring about thin transfer speed. Henceforth an exchange off must be acknowledged between the radio wire execution and reception apparatus measurements.

Microstrip fix radio wires are for the most part utilized in remote applications because of their position of safety structure. Consequently they are very perfect for installed reception apparatuses in handheld remote gadgets, for example, mobile phones, pagers and so forth.

A portion of the chief points of interest are given underneath:

- Light weight and less volume;
- Low fabrication cost, therefore can be manufactured in large quantities;
- Supports both, linear as well as circular polarization;
- Low profile planar configuration;
- Can be easily integrated with microwave integrated circuits (MICs);
- Capable of dual and triple frequency operations;
- Mechanically robust when mounted on rough surfaces;

Some of their major disadvantages are given below:

- Narrow bandwidth;
- Low efficiency;
- Low gain;
- Low power handling capacity etc.

Microstrip fix receiving wires also have a high gathering device quality factor (Q). It addresses the hardships related with the gathering contraption where a tremendous Q prompts tight transmission limit and low adequacy. Q can be decreased by growing the thickness of the dielectric substrate. Be that as it may, as the thickness extends, a growing piece of the hard and fast power passed on by the source goes into a surface wave. This surface wave responsibility can be viewed as an unwanted influence setback since it is in the long run dispersed at the dielectric turns and causes defilement of the receiving wire characteristics.

2.3 Feeding Techniques

Microstrip fix receiving wires can be empowered by an arrangement of strategies. These techniques can be described into two classes coming to and non-coming to. In the arriving at technique, the RF control is reinforced authentically to the transmitting patch using an interfacing segment, for instance, a microstrip line. In the non-arriving at plan, electromagnetic field coupling is done to move control between the microstrip line and the radiating patch. The four most understood feed methodology used are the microstrip line, coaxial test (both arriving at plans), whole coupling and closeness coupling (both non-arriving at plans).

In microstrip line feed method, a leading strip is associated legitimately to the edge of the microstrip fix. The leading strip is littler in width when contrasted with the fix and this sort of feed course of action has the bit of leeway that the feed can be scratched on a similar substrate to give a planar structure. However, this bolstering procedure prompts undesired cross enraptured radiation and misleading feed

Radiation which therefore hampers the data transfer capacity.

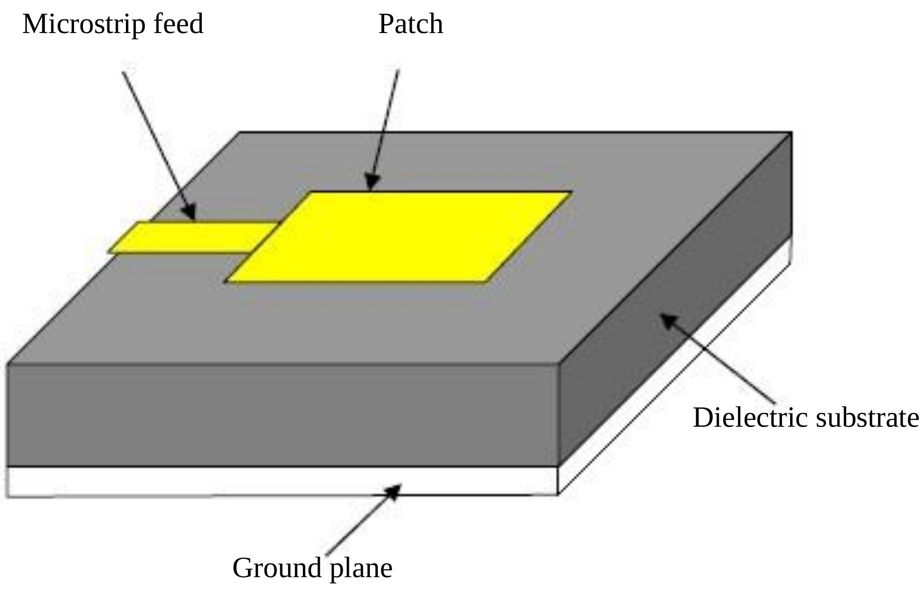

Figure 2.2: Microstrip Line Feed

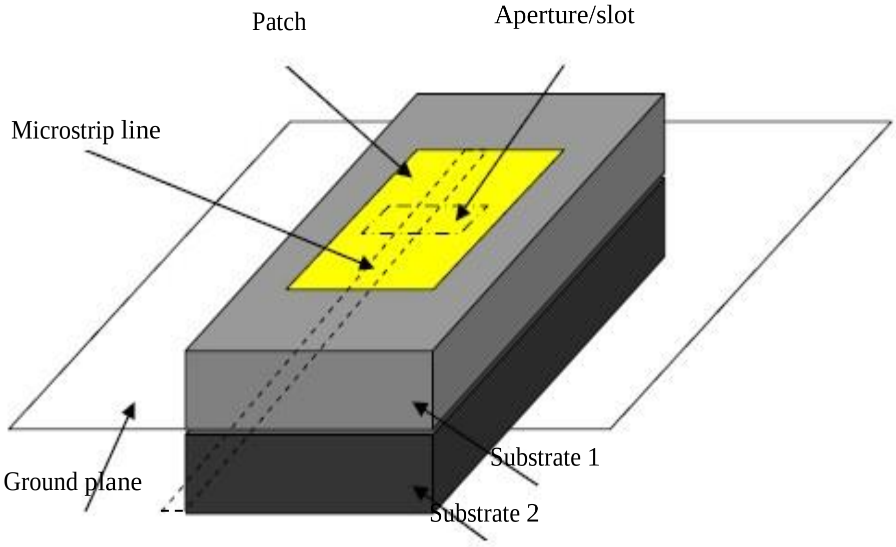

Figure 2.3: Aperture-coupled Feed

In opening coupled feed system coupling between the fix and the feed line is made through a space or a gap in the ground plane. Both cross-polarization and misleading radiation are limited in this nourishing method. The significant detriment of this feed strategy is that it is hard to create because of numerous layers, which additionally expands the receiving wire thickness. This sustaining plan additionally gives thin data transfer capacity.

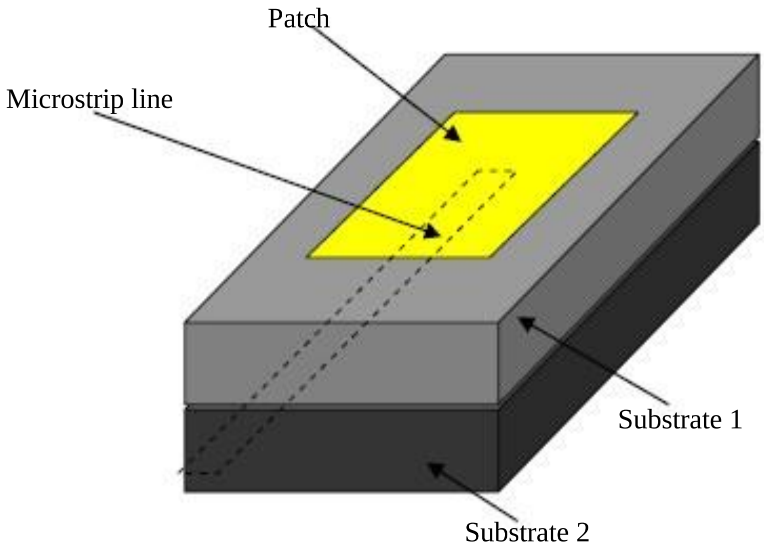

Figure 2.4: Proximity-coupled Feed

In Proximity coupled feed, two dielectric substrates are used with the ultimate objective that the feed line is between the two substrates and the radiating patch is over the upper substrate. The essential favored situation of this feed framework is that it clears out bogus feed radiation and gives amazingly high information move limit. In any case, it is difficult to make because of the two dielectric layers which need fitting course of action. Also, there is an extension in the general thickness of the receiving wire.

The Coaxial feed or test feed is an exceptionally basic strategy utilized for nourishing microstrip fix reception apparatuses. As observed from Figure 2.9, the inward conduit of the coaxial connector stretches out through the dielectric and is welded to the emanating patch, while the external conveyor is associated with the ground plane. The primary preferred position of this kind of sustaining plan is that the feed can be set at any ideal area inside the fix so as to coordinate with its info impedance. This feed technique is anything but difficult to create and has low deceptive radiation. Among all these encouraging strategies coaxial test feed has been decided for the proposed receiving wire for its

Focal points.

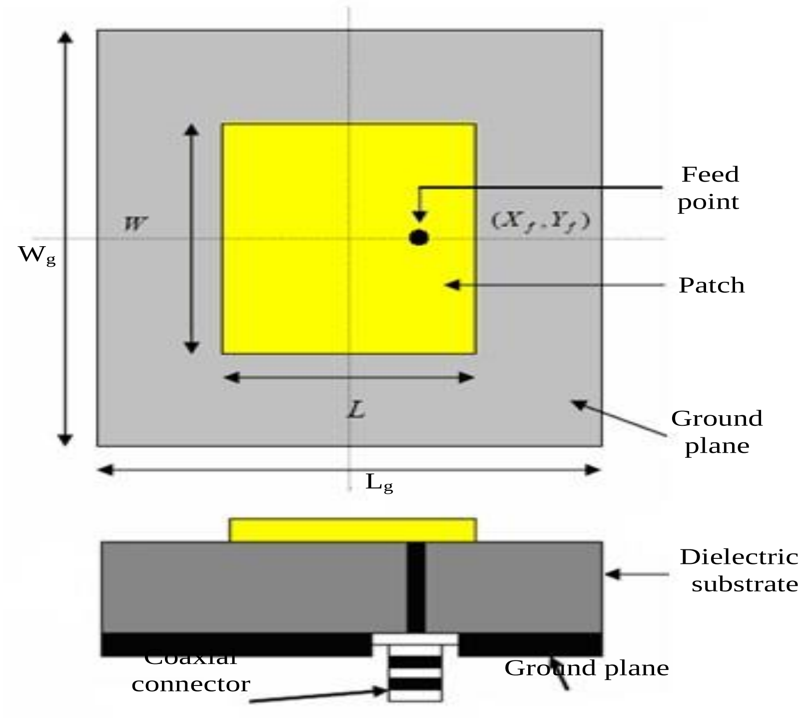

Figure 2.5: Coaxial Probe Feed

Generally for a rectangular patch antenna resonant length determines the resonant frequency. But for specially modified patches like U shape, V shape and E shape patches the relation between the resonant frequency and length or width becomes much complex because their multiple resonance characteristics and complex geometry.

CHAPTER 3
PROPOSED ANTENNA

3.1 Specifications

Our primary objective is to design an antenna that can serve all the hi-speed WLAN standards available throughout the world in the 5-6 GHz ranges. More specifically our antenna should support:

- 802.11a (USA) or 5.15-5.35 GHz band;
- European 802.11a or 5.725-5.825 GHz band;
- Middle-eastern WLAN or 5.47–5.825 GHz band;
- Newly approved IEEE 802.11j or 4.9-5.1 GHz band;

So by and large my proposed plan ought to give at any rate - 10 dB return misfortune for the complete band of 4.90-5.825 GHz. As a matter of fact the data transmission of the reception apparatus can be said to be those scope of frequencies over which the RL is not exactly - 9.5 dB (- 9.5 dB relates to a VSWR of 2 which is a satisfactory figure). Be that as it may, to play it safe here - 10 dB return misfortune is taken as worthy. Late chips away at the E formed fix reception apparatus gives us that receiving wire measurements for 5-6 GHz band was restricted by 33.2x22.2 mm2. The streamlined radio wire ought to have littler measurements.

Articulation for reverberation recurrence of an E-molded microstrip receiving wire has been found in [23]. Here the reverberation frequencies are determined by likening its territory to an equal region of a rectangular microstrip fix radio wire. An articulation for viable dielectric consistent is given for the E-molded microstrip fix reception apparatus. The new articulation of reverberation frequencies indicated a decent concurrence with estimated result. Here in this postulation those articulations are utilized to discover various elements of the E shape fix receiving wire for lower reverberation recurrence of 4.95 GHz and higher reverberation recurrence of 5.77 GHz. Substrate dielectric consistent is picked as 2.2 and tallness as 5 mm. Parameters found from the count are: W = 33.89 mm, L = 18.69 mm, W1 = 10.45 mm, W2 = 8.87 mm, L1 = 12.66 mm and Ls = 13.81 mm. As a beginning reference we are going to utilize these parameters to plan a most straightforward type of the E shape radio wire. At that point improvement is finished by changing a few parameters to discover the most appropriate radio wire for our specific activity. To watch the reverberation condition, return misfortune S11 parameter is considered. In the wake of discovering the parameters which can deliver an adequate return misfortune reaction for 4.9-5.82 GHz go, we continue to watch radiation example and current conveyance of the discovered reception apparatus at various working recurrence.

3.2 Optimization

As expressed before radio wire measurements have been discovered utilizing exact articulations from [23]. To keep the structure basic the parameters are gathered together to the closest whole numbers. So the radio wire measurements are W = 34 mm, L = 19 mm, W1 = 10 mm, W2 = 9 mm, L1 = 13 mm and Ls = 13.8 mm. Substrate Dielectric Constant, εr = 2.2 and H = 5 mm. presently a solitary reception apparatus with these measurements is planned and reenacted utilizing IE3D.

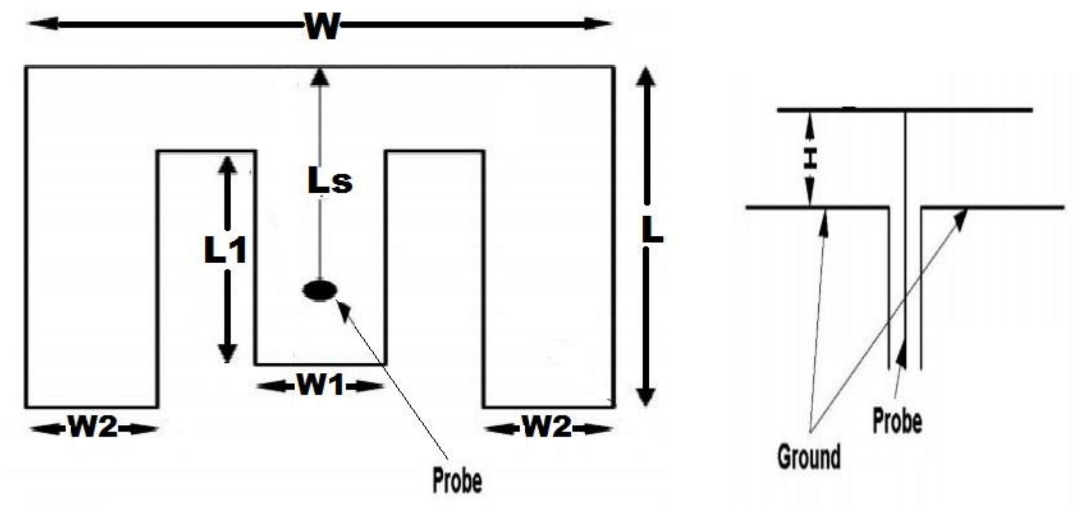

Figure 3.1: Primary Antenna

Return loss of the structured reception apparatus shows us a thunderous condition at 4.9 GHz. This is because of the irregularity in the articulations utilized in the estimation. Those articulations were streamlined for E shape fix receiving wire for lower recurrence band of 2-3 GHz band. In spite of the fact that reverberation recurrence of this reception apparatus isn't what we want, yet as a beginning reference point this radio wire is sufficient for parametric investigation so as to improve the receiving wire into our ideal recurrence band of 4.9 GHz to 5.82 GHz.

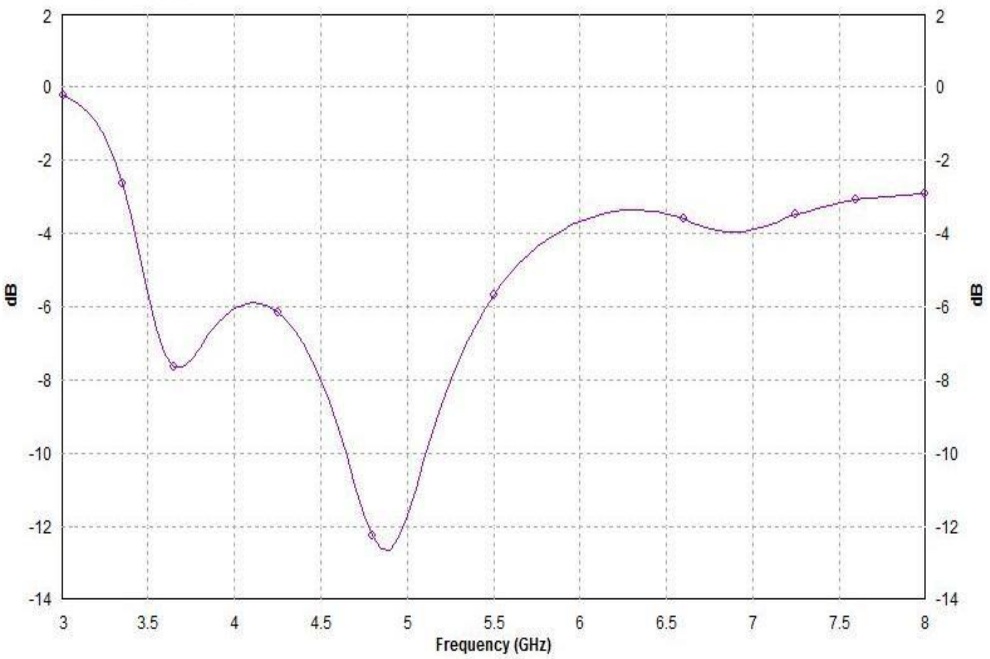

Figure 3.2: Return loss of the primary antenna

Now we are going to observe and comment on the return loss found for the change of the antenna parameters W, L, L1, W1 and Ls. First W is changed to higher value.

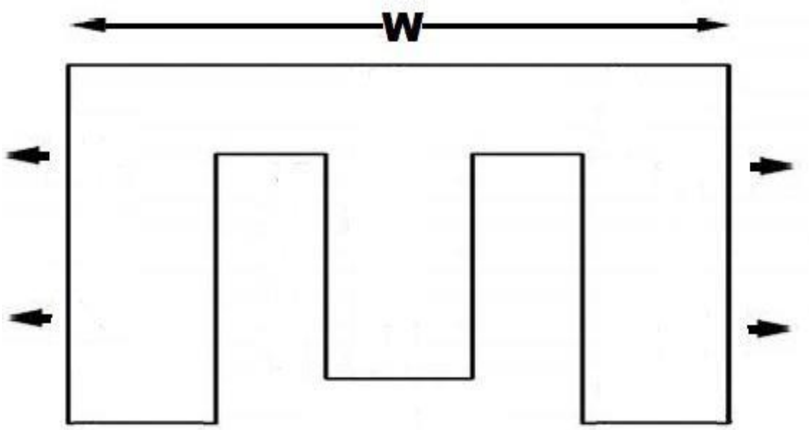

Figure 3.3: Increasing W

The width W is increased from 34 mm to 36 mm and 38 mm to see the effect on the frequency response.

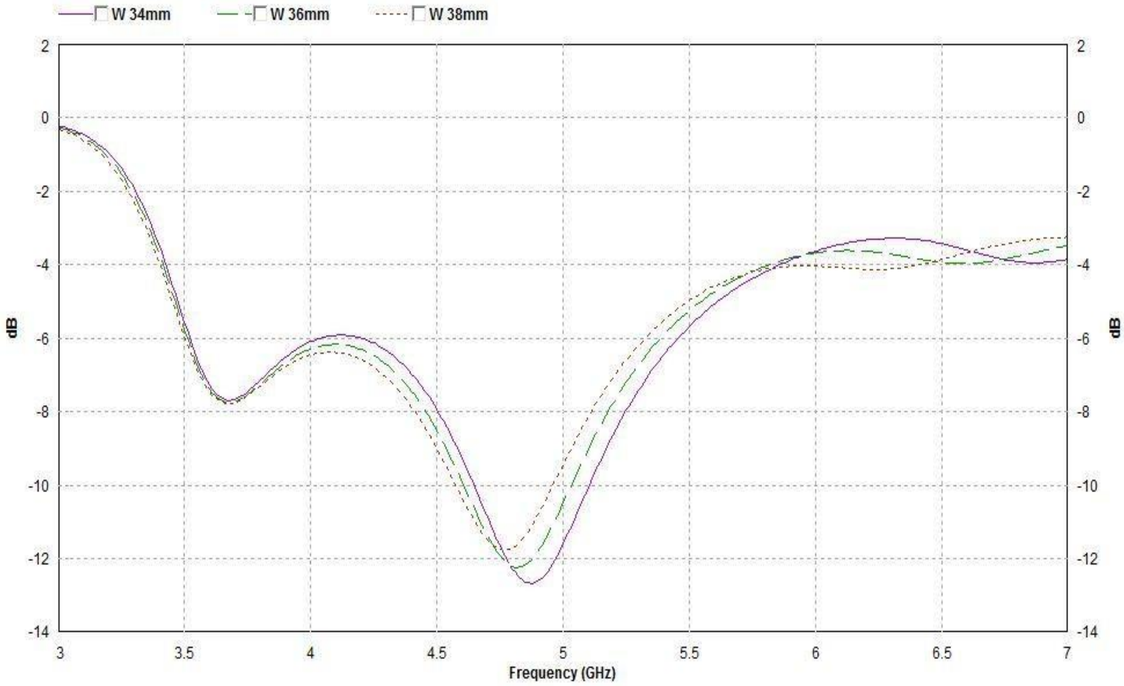

Figure 3.4: Frequency Response for W = 34, 36, 38 (mm)

As the W is expanded from 34 mm, the resounding recurrence moving to one side and the arrival misfortune is likewise corrupting. Both them are undesirable situations. So now we should diminish W from 34 with the goal that resounding recurrence movements on its right side until return misfortune arrives at its most reduced conceivable worth.

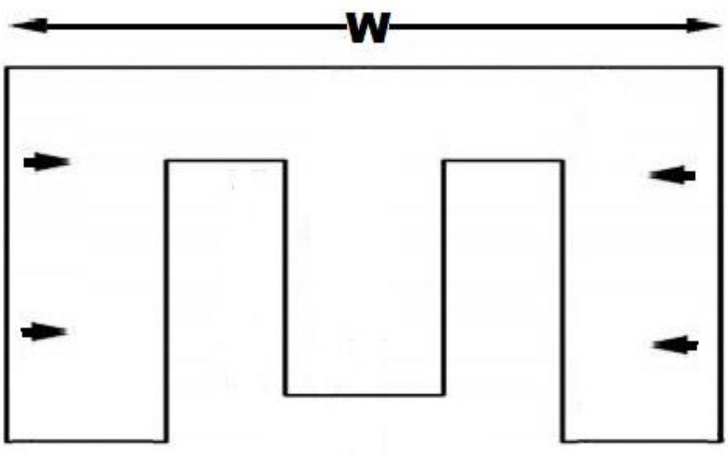

Figure 3.5: Decreasing W

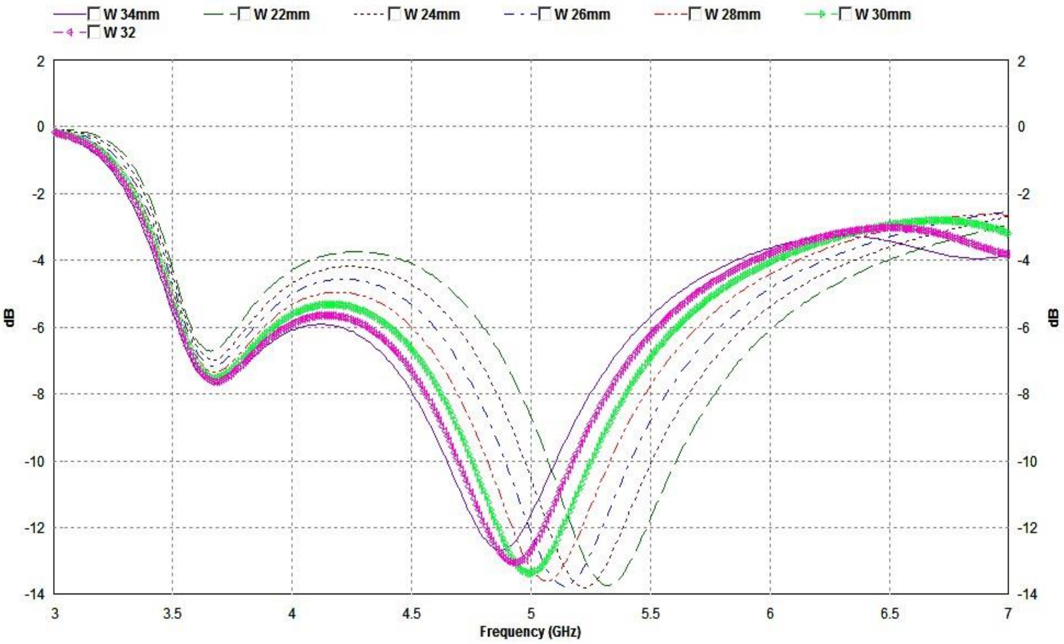

Figure 3.6: Frequency Response for W = 34, 32, 30, 28, 26, 24, 22 (mm)

So from Figure 3.6 we can see as we were diminishing the estimation of W, the RL improves until W = 26 mm. For W = 26 mm, 24 mm RL are practically equivalent, while at W = 22 mm it begins expanding which is unwanted. Again at W = 26 mm, - 10 dB return misfortune covers 4.89-5.416 GHz where for W = 24 mm, -10 dB RL crosses our lower point of confinement of 4.9 GHz. So now W is fixed at 26 mm.

Next set of simulations are done with the width of the middle arm W1. In original antenna W1 = 10 mm. Now let's observe the frequency response for W1 = 12 mm.

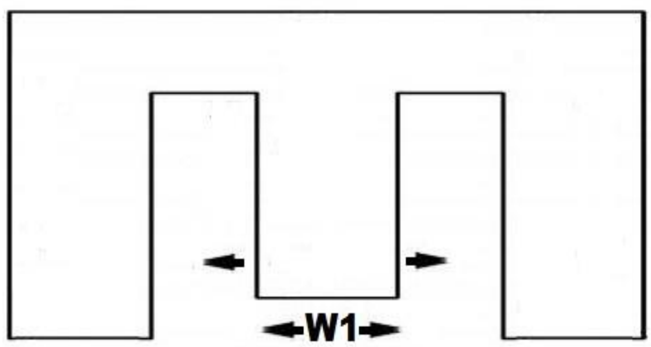

Figure 3.7: Increasing W1

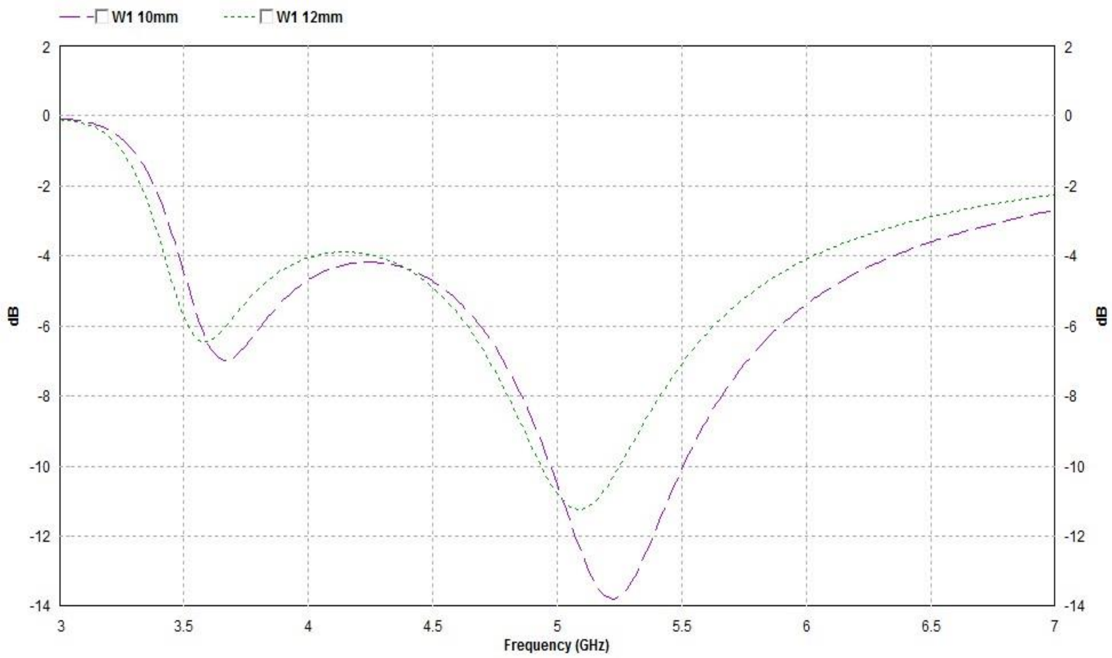

Figure 3.8: Frequency Response for W1 = 10, 12 (mm)

So expanded W1 is debasing our recurrence reaction. Presently we should diminish W1 to improve reaction. Figure 3.10 shows the recurrence reaction of the receiving wire for W1 = 10 mm, 8 mm, 6 mm, 5 mm and 4 mm. Diminishing W1 from 10 mm to 4 mm augments the data transfer capacity to an ever increasing extent, yet at W1 = 4 mm the reaction bends moves far right than our ideal band. So W1 = 5 mm gives the best return loss of - 44 dB at 5.54 GHz with higher than - 10 dB return misfortune for recurrence scope of 5.12-6.01 GHz.

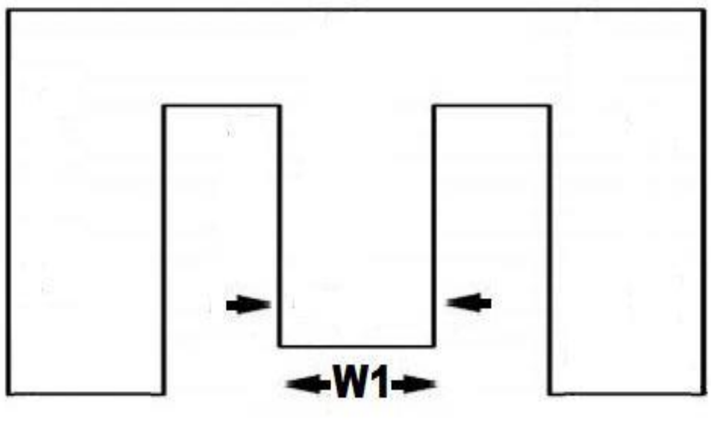

Figure 3.9: Decreasing W1

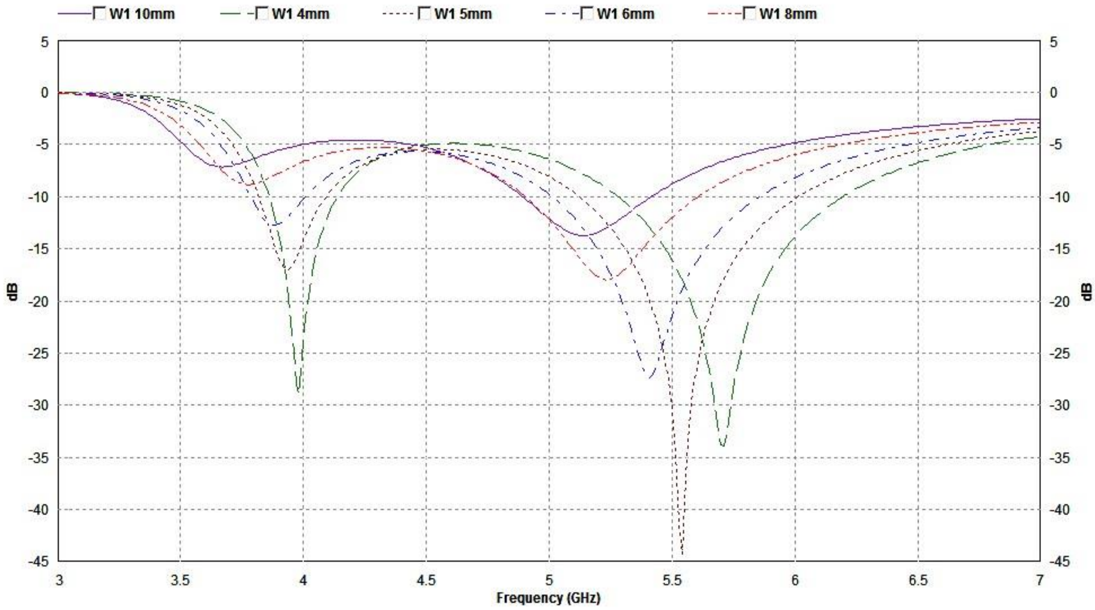

Figure 3.10: Frequency Response for W1 = 10, 8, 6, 5, 4 (mm)

So for the next phase we proceed with W1 = 5 mm. Now we are going to change length L to see its effect on frequency response. At first L is changed by moving the top boundary up and down by 1 mm.

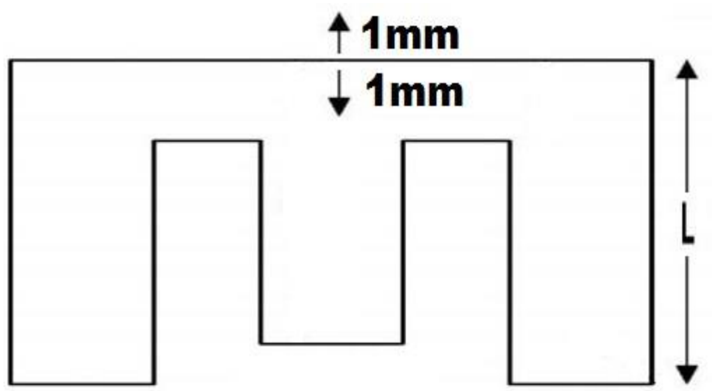

Figure 3.11: Changing L from the top

From Figure 3.12 we observe that both increasing and decreasing of L from the top side results in more return loss and lower bandwidth. So we can go back to L = 19 mm. Now L can be changed from the downside to observe its effect on bandwidth and return loss. It should also be noted that increasing L from top moves the curves leftwards and decreasing L moves the curves in opposite direction.

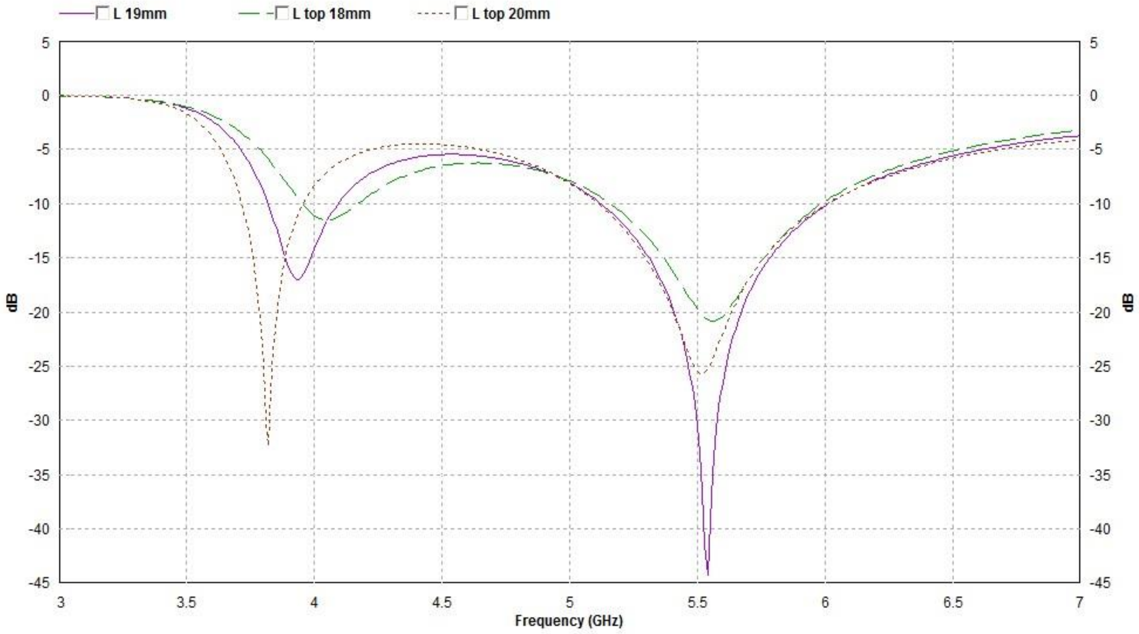

Figure 3.12: Frequency Response for L = 19, 18, 20 (mm)

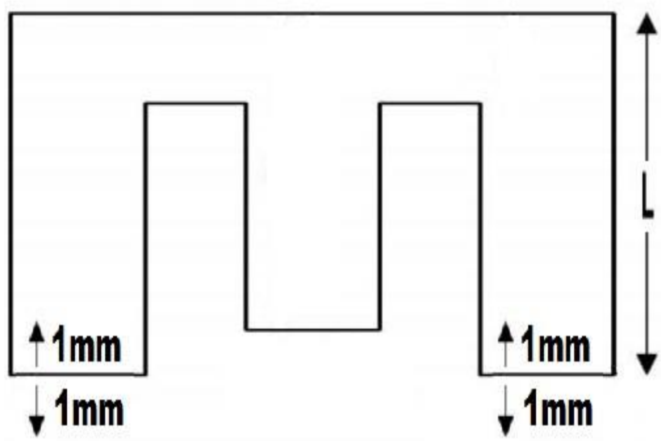

Figure 3.13: Changing L from the bottom

Figure 3.14 shows us that changing L from the bottom also degrades our frequency response by increasing return loss. And again loss just like the previous case decreasing L from top moves the curves rightwards and decreasing L moves the curves in opposite direction.

So our length L is now optimized for best output as L = 19 mm. Any change of length from 19 mm hampers the RL significantly.

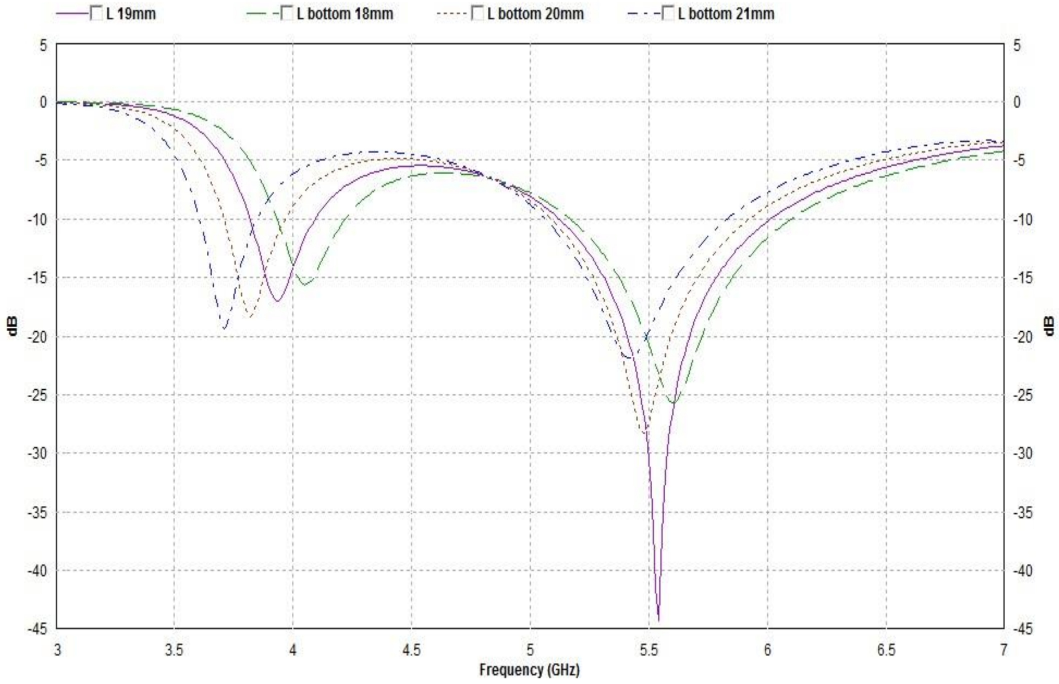

Figure 3.14: Frequency Response for L = 19, 21, 18, 20 (mm)

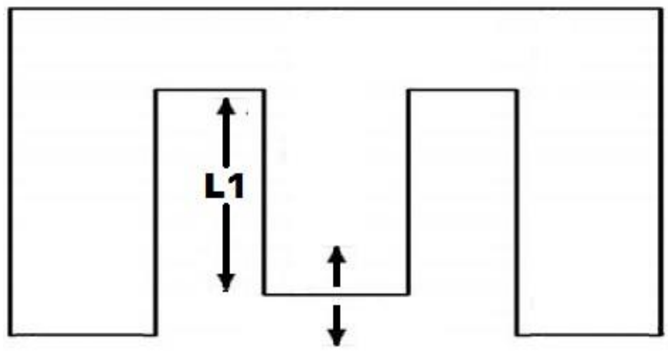

Figure 3.15: Changing L1

So far three parameters L, W, W1 have been optimized for a frequency range of 5.12 GHz to 6.01 GHz. The primary objective is to get frequency range of 4.9 GHz to 5.825 GHz. Next phase of optimization is done with the non- optimized parameter L1.

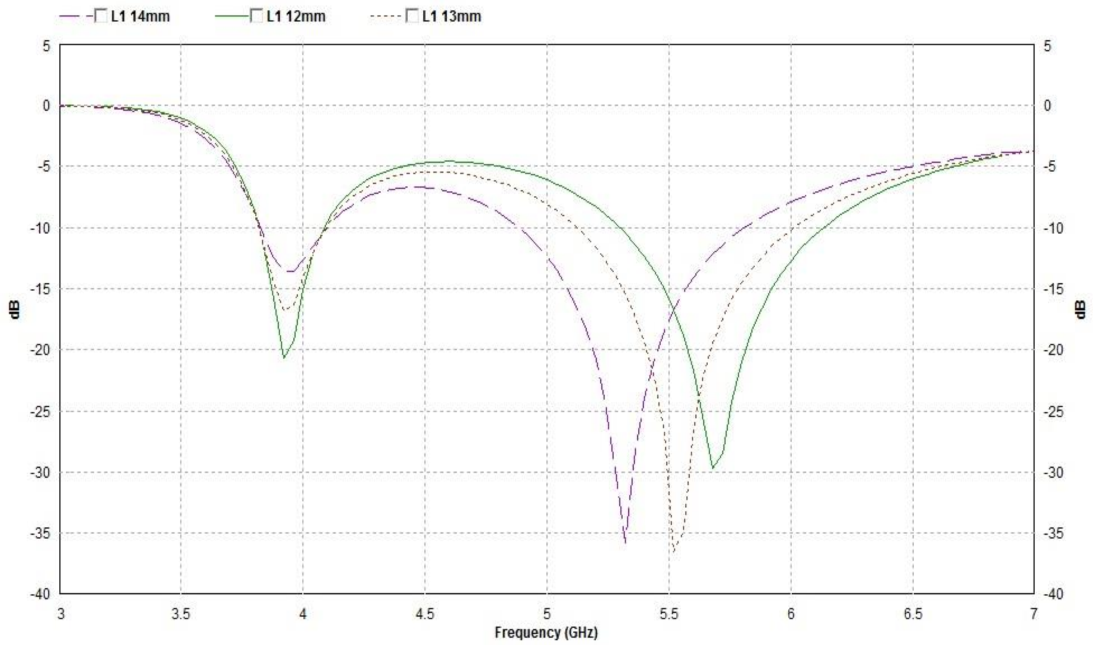

Figure 3.16: Frequency Response for changing L1

So in the Figure 3.16 we can see changing L1 from 13 to 12 increases the return loss and moves the resonant frequency to the right. While increasing L1 from 13 to 14 keeps the RL almost same but moves the resonant frequency to left. At L1= 14 the frequency range having greater than -10dB return loss becomes 4.88-5.811 GHz which almost covers the desired band.

Next W2 is changed from 9 mm to 8 mm and 10 mm to observe the effect on return loss and bandwidth.

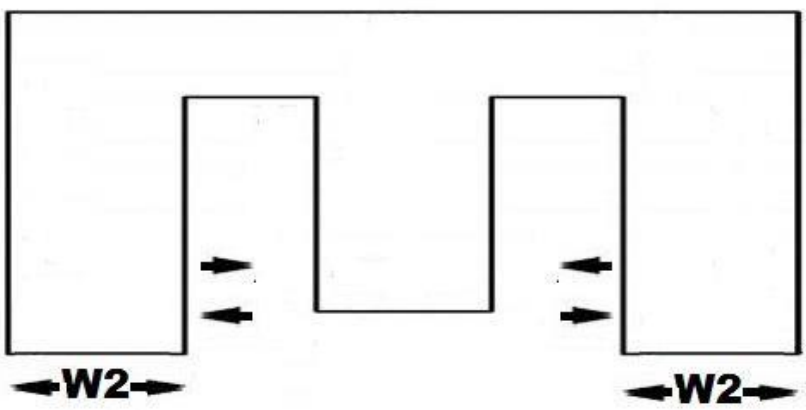

Figure 3.17: Changing W2

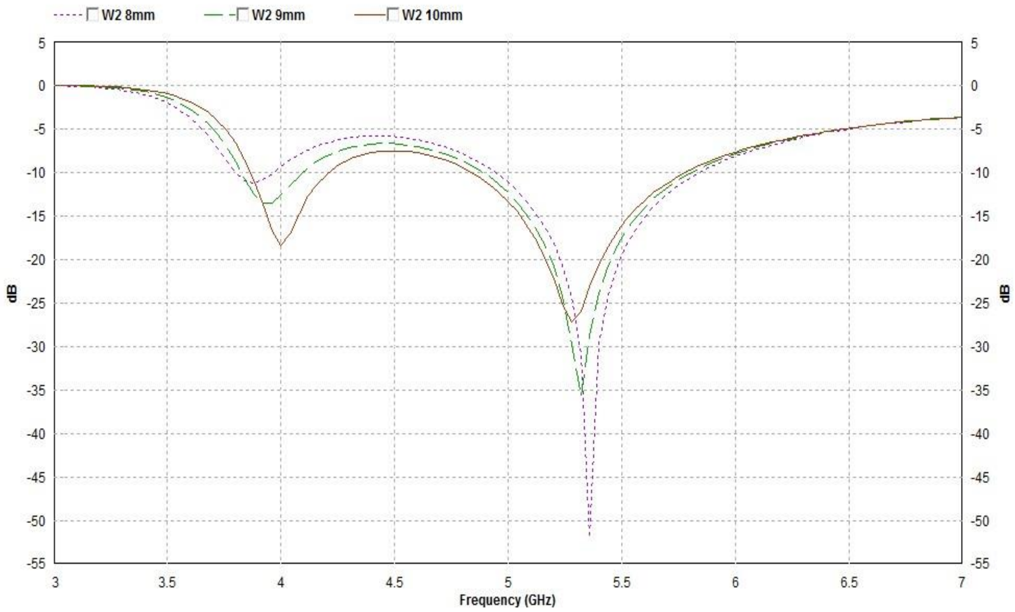

Figure 3.18: Frequency Response for changing W2

So we can see expanding W2 moves the reaction leftwards and corrupts the arrival misfortune while diminishing W2 moves the reaction rightward and improves the arrival misfortune. In any case, in spite of the fact that arrival misfortune is lower we can't take it on the grounds that the lower - 10dB recurrence crossing our limit of 4.9 GHz. So W2 = 9 mm is best alternative. Ls is last parameter to think about. Ls is change from 13.8 mm to 12.8 mm and 14.8 mm. Correlation between their arrivals misfortunes versus recurrence bend is demonstrated as follows.

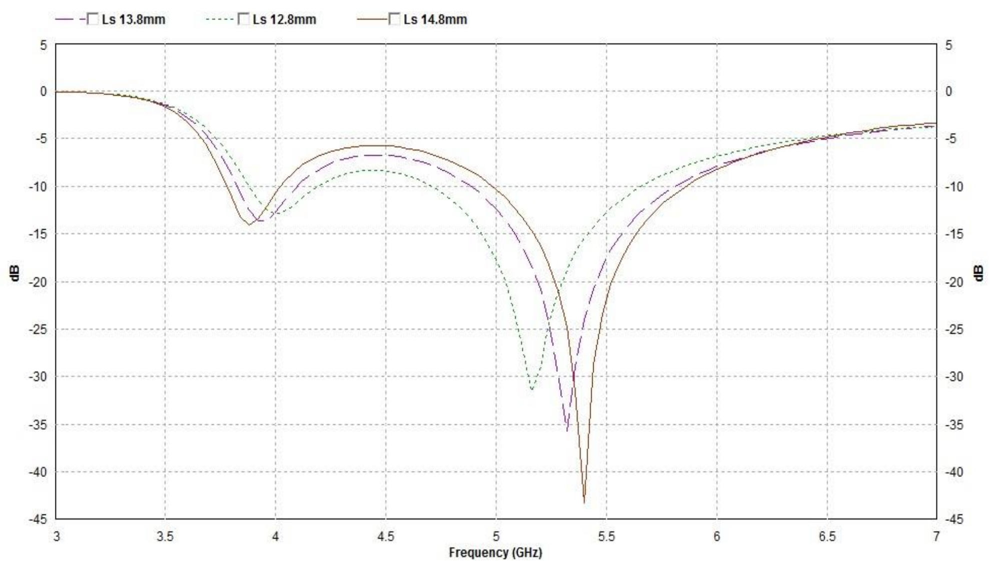

Figure 3.19: Return loss for changing Ls

Changing Ls changing the resonant frequency which is worse than the situation L1 = 14 mm of Figure 3.16. Any change in resonant frequency moves the whole coverage bandwidth with it. So Ls is not changed from 13.8.

Now to satisfy the primary objective many points between L1 = 14 mm and L1 = 13.8 mm were simulated. And finally for L1 = 13.94 mm a frequency response was found where the whole range from 4.8966 GHz to 5.8258 GHz achieved more than -10 dB amplification. So our desired criterion is achieved. And final antenna dimension is W = 26 mm, L = 19 mm, W1 = 5 mm, W2 = 9 mm, L1 = 13.94 mm and Ls = 13.8 mm.

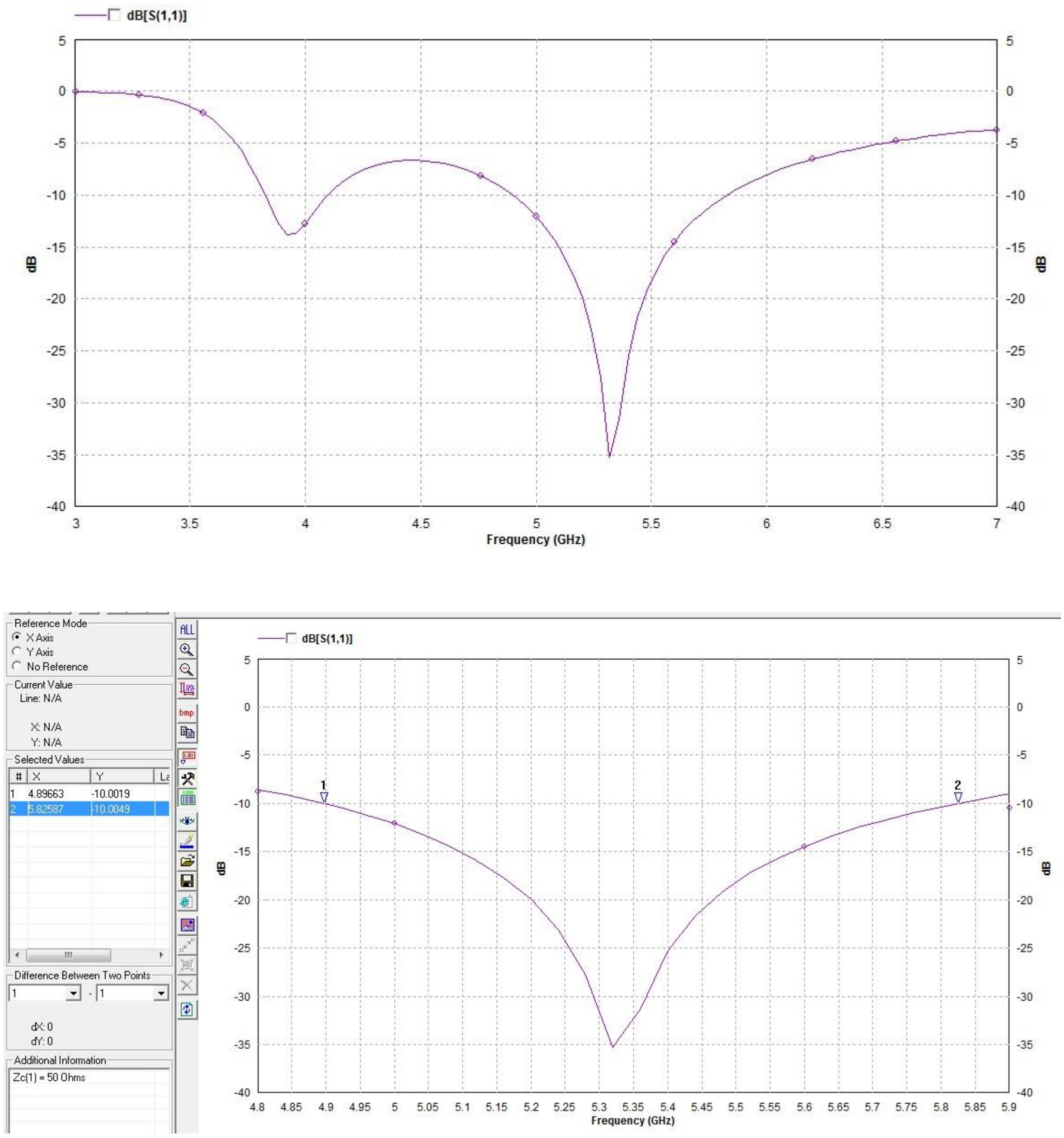

Figure 3.20: Final outcome with desired bandwidth

CHAPTER 4

RESULTS AND SIMULATIONS

In the past section a concentrated reenactment has been done to advance the receiving wire for the recurrence scope of 4.9-5.825 GHz. Subsequently we have discovered a radio wire having a zone of 26x19mm2 with lower than - 10 dB return misfortune for a recurrence band of 4.8966 GHz to 5.8258 GHz. Another extra band going from 3.8 GHz to 4.1 GHz has additionally been found under - 10 dB return misfortune which can be valuable for savvy gadgets that utilization GPS signals from C band satellites. The receiving wire size is littler than any of the reception apparatus found in the writing audit for the IEEE 802.11a USA and European WLAN benchmarks. Aside from numerous complex stacked structures for E shape fix receiving wire a solitary component single substrate layer radio wire has been planned with wide transfer speed. A large portion of the radio wire found in writing survey utilized stacked arrangement for substrate layer to improve the transmission capacity and to lessen receiving wire size. Be that as it may, stacked setup makes the reception apparatus precisely helpless in some application. The straightforwardness of planned receiving wire makes it strong and helpful for those tasks.

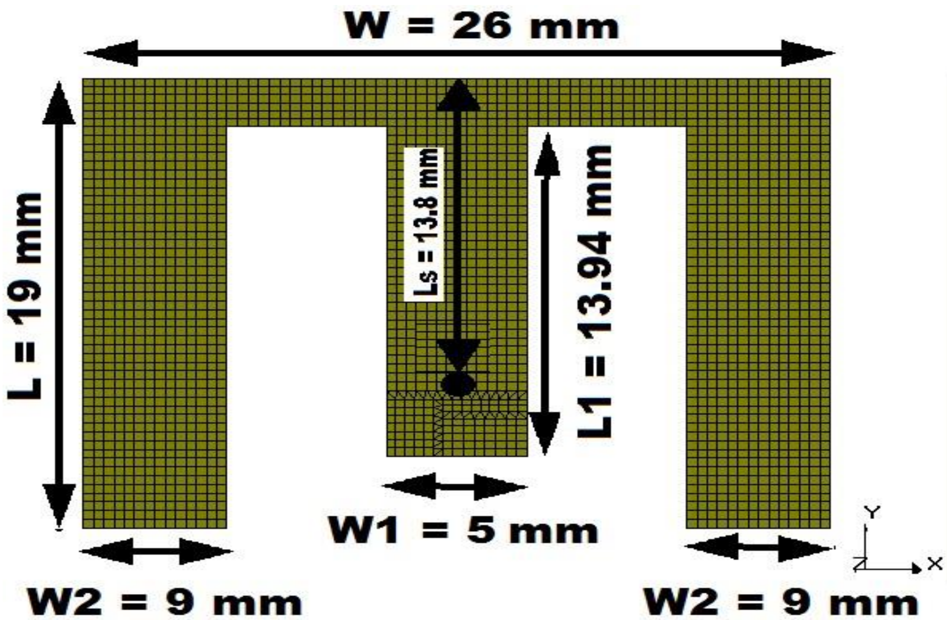

Figure 4.1: Structure view of the final antenna with dimension

Presently as our mimicked and advanced reception apparatus covers North American WLAN standard running from 5.15 to 5.35 GHz, European WLAN standard extending from 5.725–5.825 GHz, Asian and Middle-eastern WLAN 5.47–5.63 GHz and the recently affirmed Japanese WLAN standard running from 4.9 to 5 GHz recurrence groups; we ought to inspect our receiving wire activity in every one of the principles by our reception apparatuses normal current dissemination, vector current appropriation, 2D, 3D radiation examples for a recurrence in every band. The present dispersion gives us an understanding into the reception apparatus structure by demonstrating the thickness and the heading of current development inside the fix at various frequencies. It additionally gives us how extraordinary piece of the receiving wire acts for various working frequencies. 2D and 3D radiation example gives us how receiving wire transmits its yield signal. 2D radiation profile gives data about the addition and polarization of E-H fields where as 3D radiation examples can show the directivity and emanation style. On the off chance that all the circulation and example at all working frequencies are discovered agreeable at exactly that point we can continue to future works with this recreated model.

For 4.9-5 GHz band, we have determined the normal current conveyance, vector current appropriation, 2D, 3D radiation examples for f = 5 GHz. For 5.15-5.35 GHz band the normal current dissemination, vector current appropriation, 2D, 3D radiation examples has been determined for f = 5.25 GHz; f = 5.5 GHz has been decided for 5.47–5.63 GHz. At last for 5.725-5.825 GHz band 5.775 GHz is picked for design estimations.

4.1 Average Current Distribution

So now we will simulate our antenna four different frequencies f = 5 GHz, 5.25 GHz, 5.5 GHz and 5.775 GHz with 70 cells per wavelength for better precision. Then we will observe the average current distribution over the antenna surface.

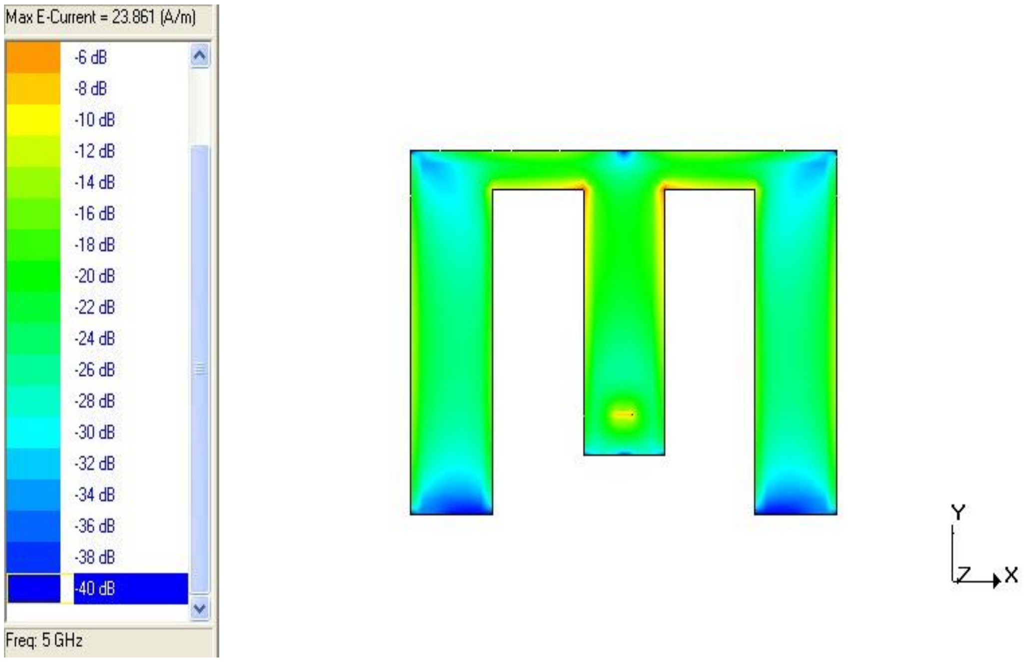

Figure 4.2: Average Distribution of Current 5 GHz

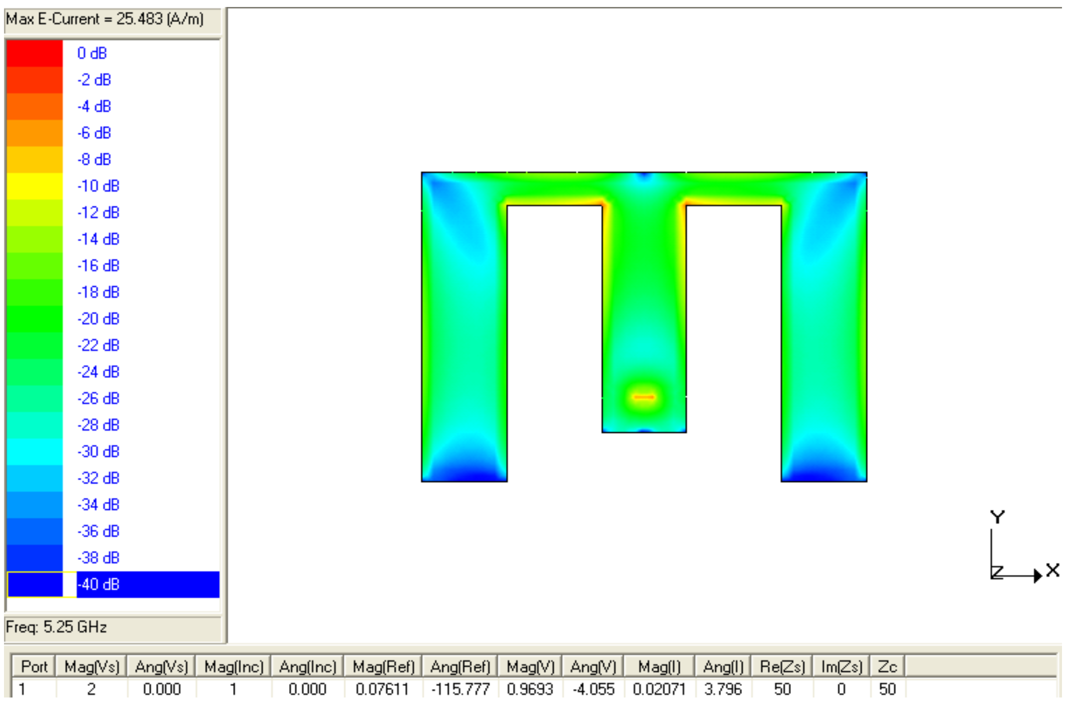

Figure 4.3: Average Distribution of Current 5.25 GHz

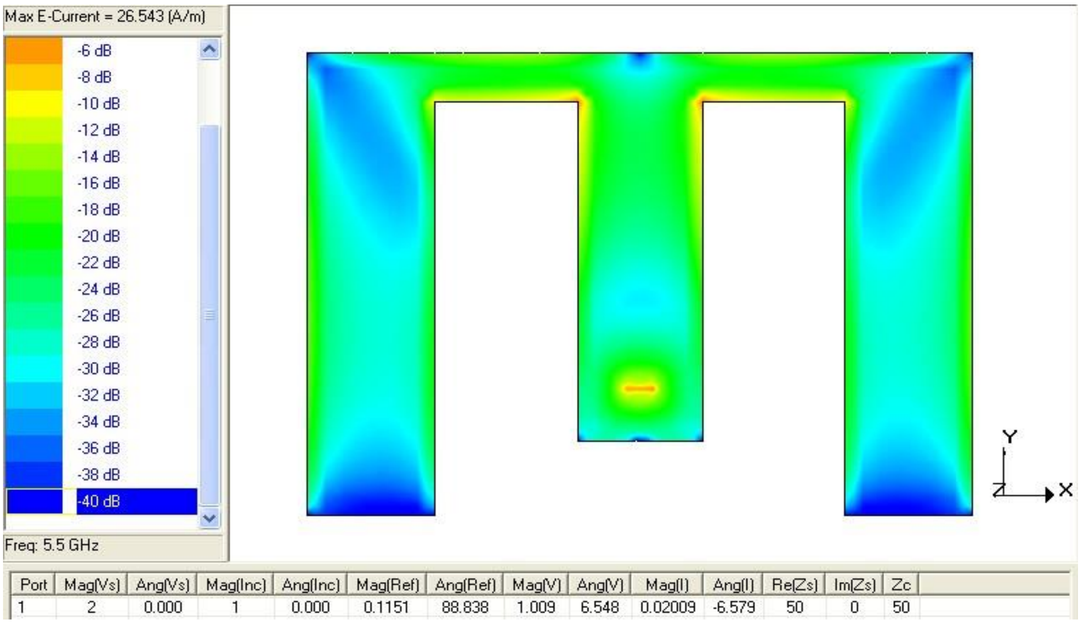

Figure 4.4: Average Distribution of Current 5.5 GHz

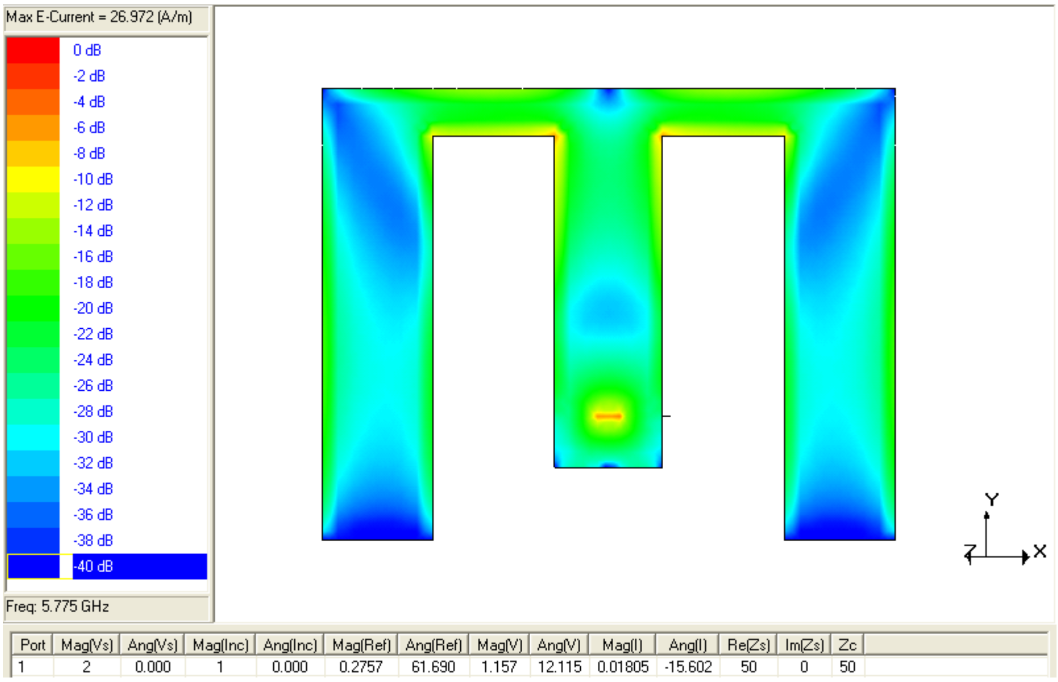

Figure 4.5: Average Distribution of Current 5.775 GHz

Above figures show us the average current distribution over the surface of our optimized patch at different frequencies. For all frequencies current distribution are mostly in green or in blue color corresponding to an amplification of from -20dB to -40dB. Which means for all frequencies in the range of 4.9-5.825 GHz our antenna can work smoothly as a transmitter or a receiver.

4.2 Current Vector Distribution

For same frequencies we will now compare the current vector distribution on the surface of patch to understand the frequency response better. Vector distribution of current can give us insight to the pathway and the movement of current at the resonant frequency over the patch surface. It can also show us the density of current at different frequencies.

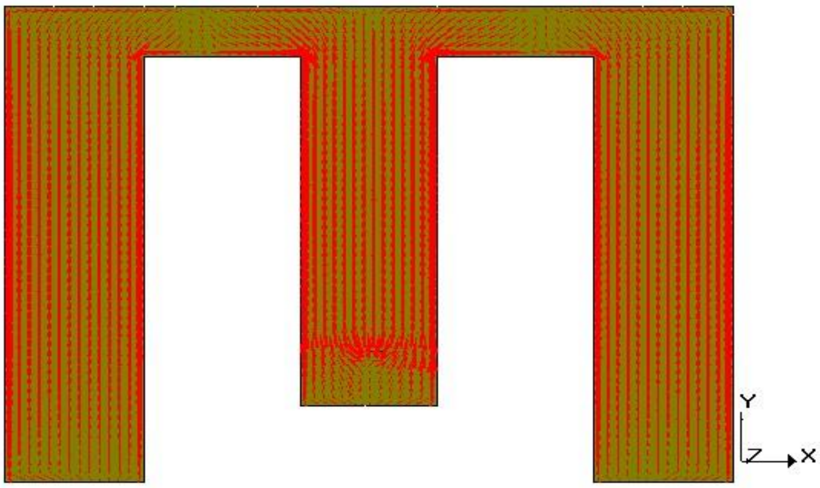

Figure 4.6: Distribution of Current Vectors at 5 GHz

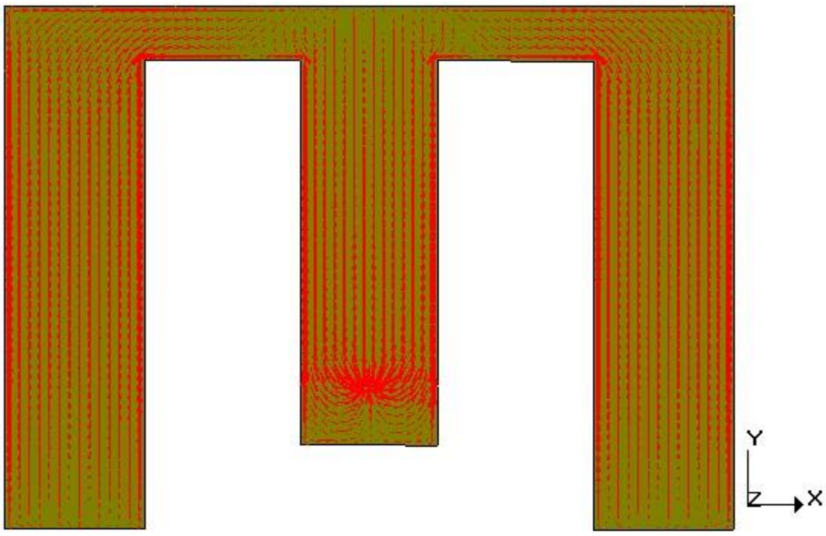

Figure 4.7: Distribution of Current Vectors at 5.25 GHz

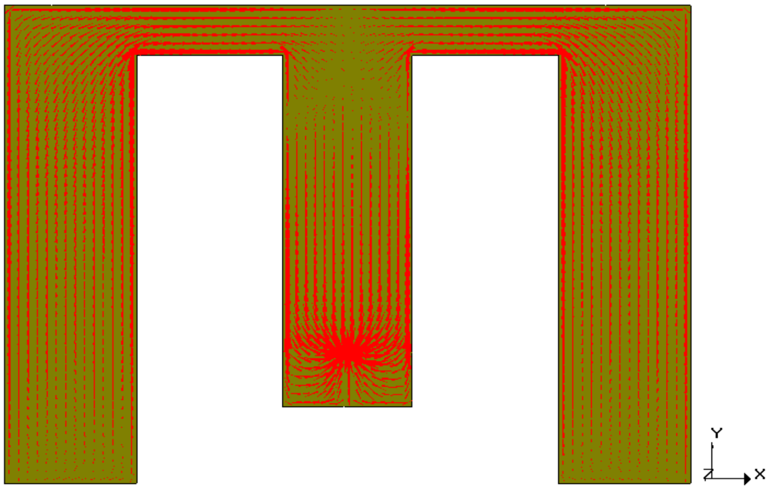

Figure 4.8: Distribution of Current Vectors at 5.5 GHz

Figure 4.9: Distribution of Current Vectors at 5.775 GHz

The vector distributions of the current over the surface of patch are shown in the above figures. For all four different frequencies current vectors directions are almost similar but in the lower frequencies we can observe the density is higher on the side wings where as in the higher frequencies density is high in the central arm and in the body. But for all frequencies the distribution represents resonant condition which means even in terms of vector distribution our antenna works fine in the WLAN range.

4.3 2D Radiation Pattern

A good antenna should maintain its radiation pattern and polarization throughout the frequency range that it covers. So for our antenna all four frequencies the 2D radiation pattern should similar to each other.

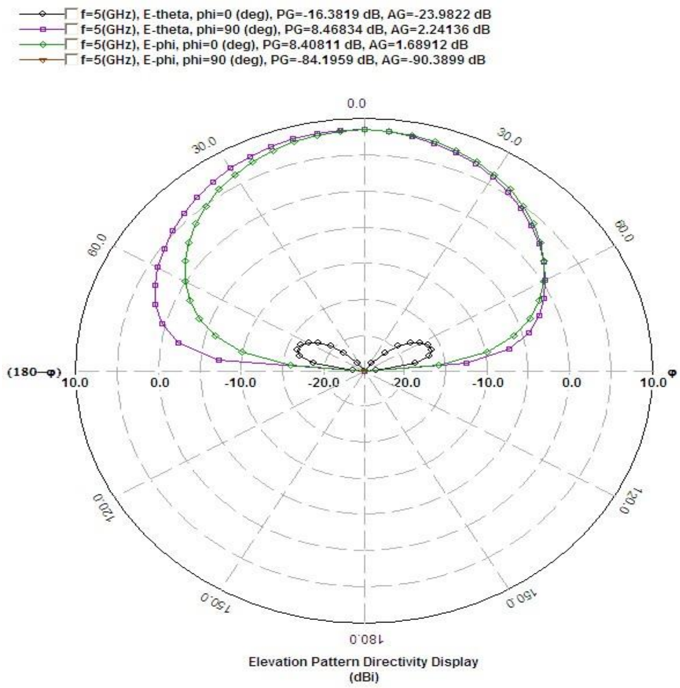

Figure 4.10: 2D Radiation Pattern at 5 GHz

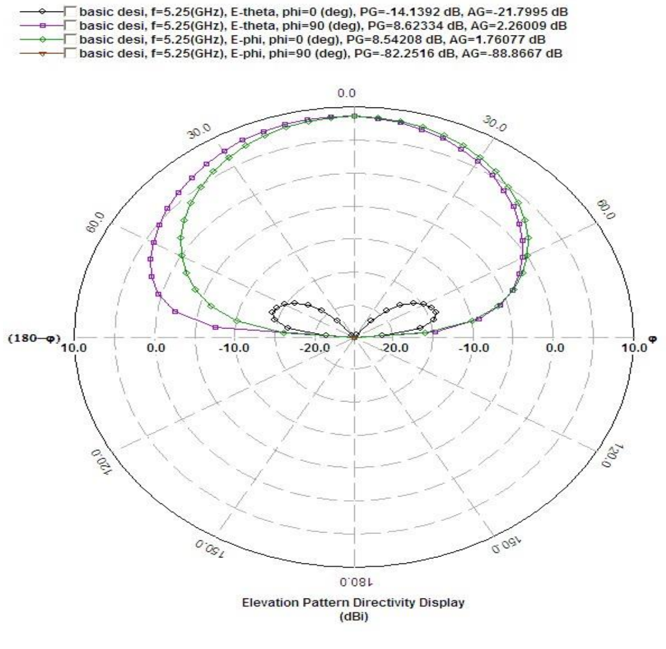

Figure 4.11: 2D Radiation Pattern at 5.25 GHz

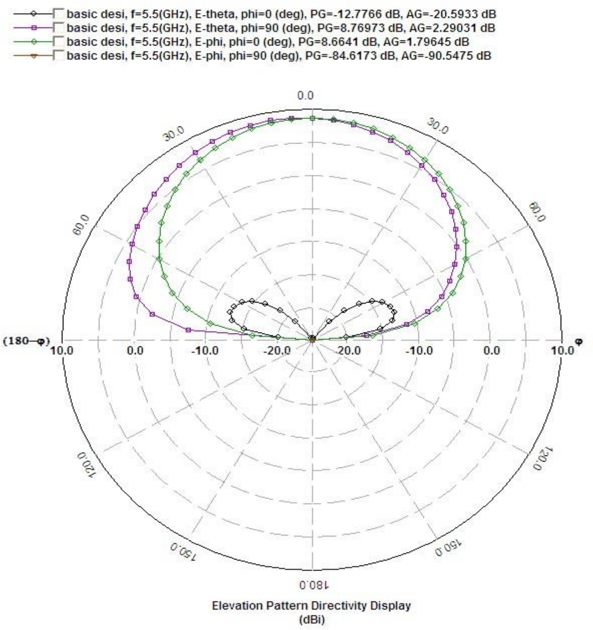

Figure 4.12: 2D Radiation Pattern at 5.5 GHz

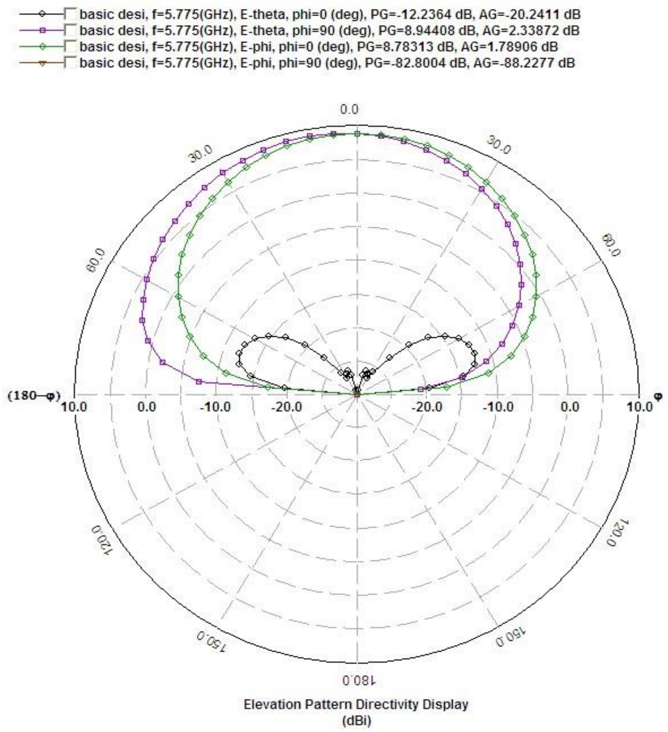

Figure 4.13: 2D Radiation Pattern at 5.775 GHz

2D radiation pattern of all four different frequencies are almost the same indicating that our antenna provides a good radiation pattern and similar polarization for the entire band of 4.9 to 5.825 GHz.

4.4 3D Radiation Pattern

Just like the 2D radiation pattern a good antenna should also maintain its 3D radiation pattern throughout the frequency range that it covers. So for our antenna all four frequencies the 3D radiation pattern should similar to each other.

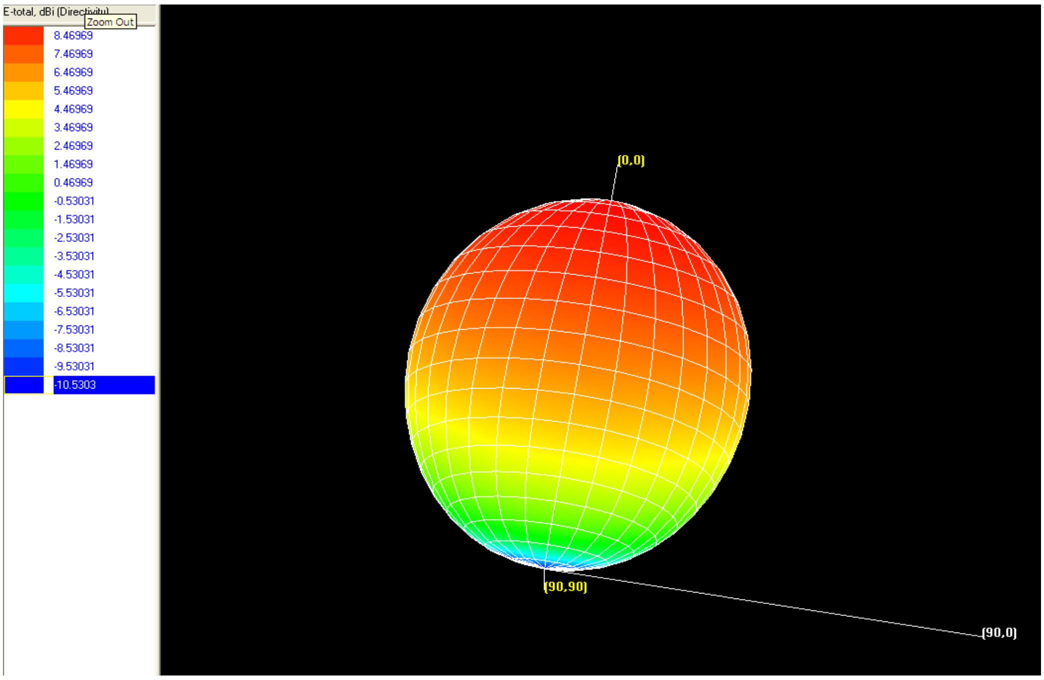

Figure 4.14: 3D radiation pattern at 5 GHz

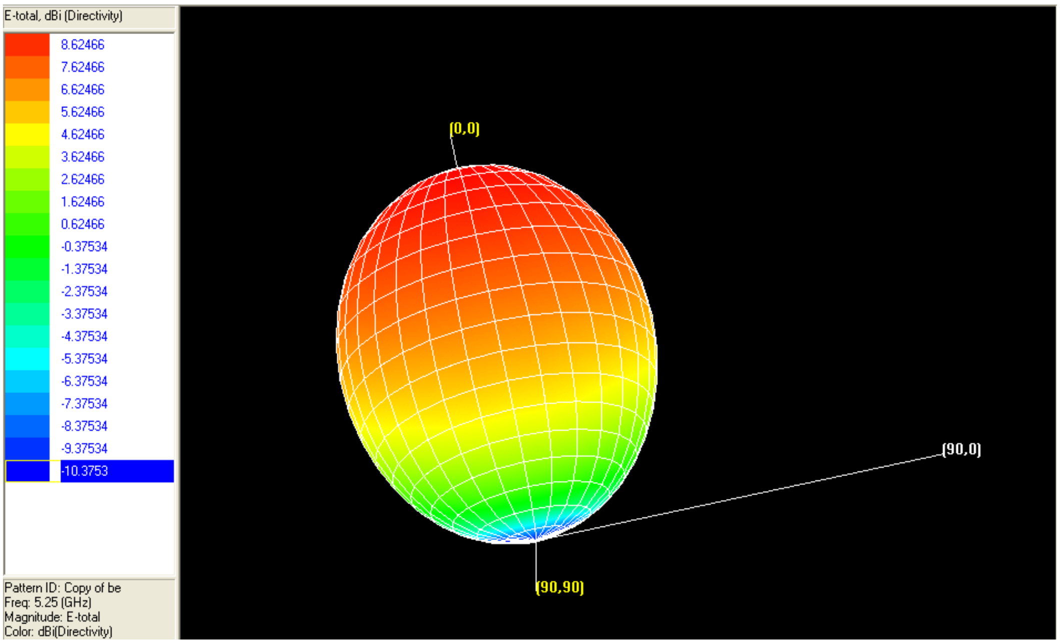

Figure 4.15: 3D radiation pattern at 5.25 GHz

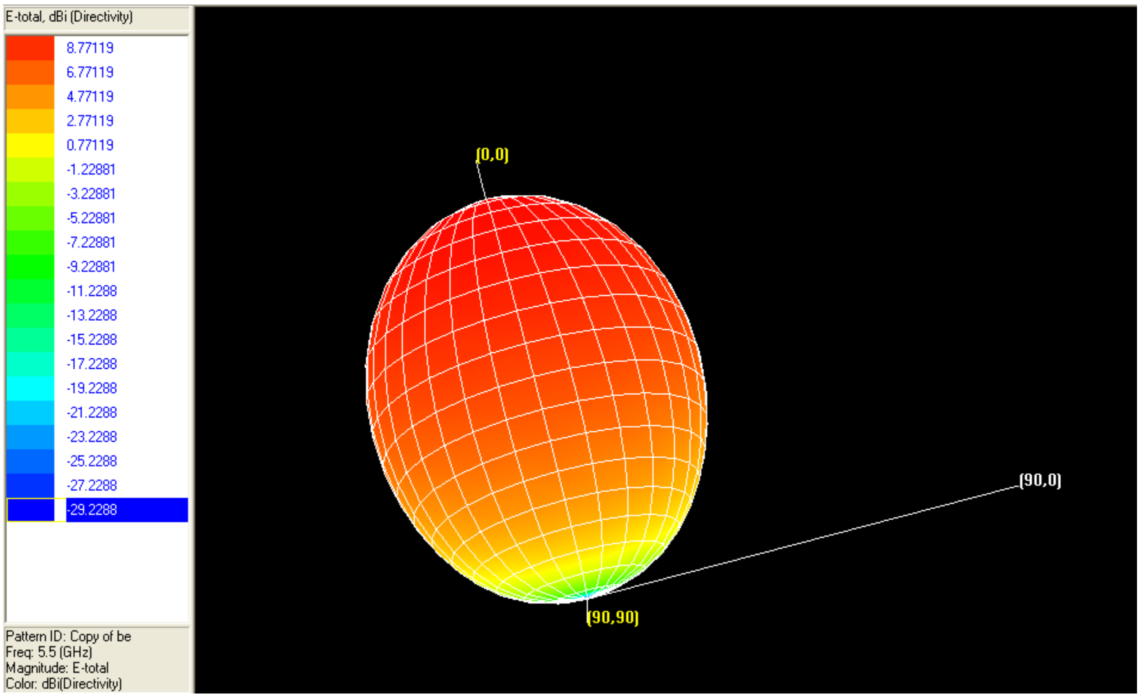

Figure 4.16: 3D radiation pattern at 5.5 GHz

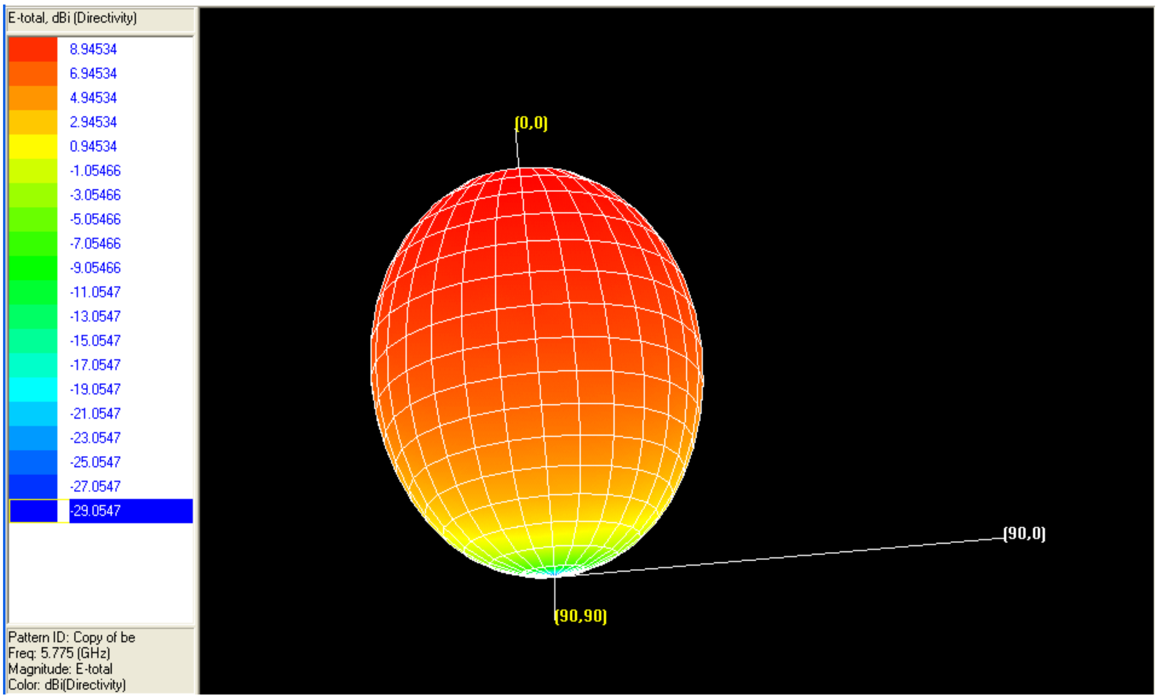

Figure 4.17: 3D radiation pattern at 5.775 GHz

Just like the 2D radiation patterns, 3D radiation profile of our antenna for all four different frequencies are almost the same indicating that our antenna provides a good radiation pattern and similar polarization for the entire band of 4.9 to 5.825 GHz.

4.5 Comparison of the designed antenna with existing antennas

Very little work has been done to structure radio wire that can work acceptably over all the rapid WLAN gauges. In [21], a radio wire is intended for 3.1 – 4.9 GHz extend covering just a solitary American particular reason WLAN standard 802.11y where our reception apparatus underpins 802.11a, 802.11n, 802.11ac and 802.11j principles. Likewise our reception apparatus gives an extensive decrease in radio wire size and range from [21]. Another E formed reception apparatus is exhibited with a transfer speed of 380 MHz with a focal recurrence of 5.58 GHz [8] where as our radio wire gives a colossal data transfer capacity of 925 MHz with recurrence band extending from 4.90 – 5.825 GHz. A receiving wire to cover two 802.11a guidelines is structured in [7] with a size of 33.2×22.2 mm2, where our proposed reception apparatus covers all models including these two and have a size of just 26×19 mm2. So near examination shows that proposed reception apparatus gives better yields as far as data transfer capacities, inclusion and measurements than the accessible radio wires.

4.6 Insight into Parametric Study

In this thesis we have worked with the E shape patch antenna. In rectangular patch antenna the relation between length, L and width, W with the frequency response, bandwidth and return loss can be easily understood and realized. But in the case of E shape patch antenna, we have a lot of parameters including L and W. For instance we have already optimized the antenna by varying L, W, W1, L1 and W2 of the patch antenna. As the number of parameters increases the relations becomes very complex.

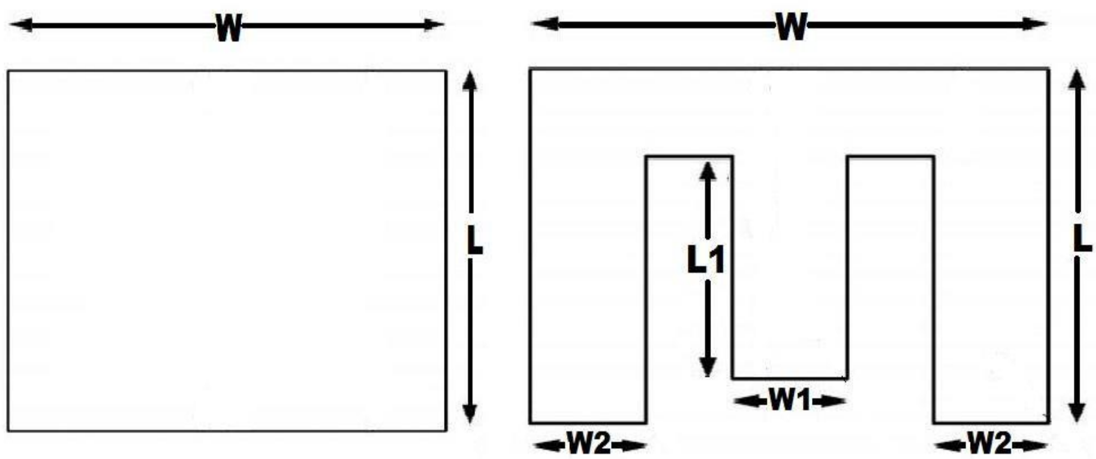

Figure 4.18: Parameters of rectangular antenna and E shaped patch antenna

We have already tried to apply empirical formulation to design our E shape antenna, but those formulas are not very accurate because our optimized design is much changed from the calculated design. So our parametric study can show effect of different parameters on the return loss, bandwidth and resonant frequency which can be very useful to optimize any E shape antenna in future.

Now the effect of various parameter changes on the return loss, frequency range and bandwidth found in this thesis are summarized in the next table

Table 4.1. Summary of Parametric Study

	Decreasing	**Parameters**	**Increasing**
Return loss	Increasing until W= 24mm	**W** (Original=34mm) **(Final=24mm)**	Decreasing
Primary Resonant Frequency	Increasing		Decreasing
Bandwidth	Slightly Increasing		Almost Similar
Return loss	Increasing until W1= 5mm	**W1** (Original=10mm) **(Final=5mm)**	Decreasing
Primary Resonant Frequency	Increasing		Decreasing
Bandwidth	Increasing until W1= 5mm		Decreasing
Return loss	Decreasing	**L** (L=19mm)	Decreasing
Primary Resonant Frequency	Increasing		Decreasing
Bandwidth	Almost Similar		Almost Similar
Return loss	Decreasing	**L1** (Original=13mm) **(Final=13.94mm)**	Almost Similar upto L1=14mm then decreasing
Primary Resonant Frequency	Increasing		Decreasing
Bandwidth	Almost Similar		Almost Similar
Return loss	Increasing abruptly	**W2** **(W2=9mm)**	Decreasing Abruptly
Primary Frequency	Decreasing		Increasing
Bandwidth	Almost Similar		Almost Similar
Return loss	Increasing	**Ls** **(Ls=13.8mm)**	Decreasing
Primary Resonant Frequency	Decreasing		Increasing
Bandwidth	Decreasing		Decreasing

CHAPTER 5
CONCLUSION

In this proposition a solitary component, coaxial test encouraged, single stacked, E molded microstrip fix reception apparatus has been plan and improved for a recurrence band of 4.9- 5.825 GHz. The radio wire demonstrated good reproduction results for all the fast WLAN measures accessible all through the world. The proposed radio wire indicated improvement as far as transfer speed, return misfortune and size from any of the current reception apparatus in this recurrence band. A parametric report has been done to comprehend the impact of different parameters on the resounding recurrence, return misfortune, increase and transfer speed. An expansion in data transfer capacity has been accomplished by which now this single receiving wire can be utilized a handset all through world for some WLAN measures including IEEE 802.11a, IEEE 802.11n and IEEE 802.11j. A decrease of receiving wire zone has been accomplished as our proposed reception apparatus needs just 26x19mm2 region which is a lot littler than the radio wires found in writing audit. The aftereffects of the parametric investigation is outlined in table which can be utilized as a source of perspective in any future works in the field of E-molded microstrip patches.

All these streamlining have performed utilizing Zeland's IE3D electromagnetic reenactment programming. For future works the extra band might be evacuated for increasingly exact activity just in WLAN extend. Creation of this receiving wire can be performed to watch continuous execution of the radio wire. Further improvement can be accomplished by utilizing clusters. Utilizing numerous layer of substrate in stacked setup can likewise improve return misfortune and data transfer capacity essentially. On the off chance that fruitful this can be delivered industrially to be utilized in all WLAN applications all through the globe.

APPENDIX A

RESONANCE FREQUENCY OF E- SHAPED ANTENNA

Double reverberation recurrence assumes a significant job in the improvement of the data transfer capacity of microstrip radio wires. In an E-Shaped microstrip fix reception apparatus, two reverberation frequencies are coupled to give a wide data transmission. Thus, assurance of the two reverberation frequencies is a significant examination for the E-molded radio wire. For the assurance of the reverberation recurrence of such a receiving wire, the general investigation includes utilizing the essential electro-attractive limit esteem issue. Another route is to illuminate the essential conditions utilizing Green's capacity either in space or the unearthly area. Arrangement of these conditions generally utilizes the technique for minutes (MoM). During the final numerical arrangement, the decision of the test work and the way of reconciliation are generally basic. In this manner, it includes thorough scientific definition and broad numerical methodology. Here an identical - territory technique is utilized to decide the thunderous recurrence, in which the E-Shaped receiving wire is changed over to an equal rectangular microstrip reception apparatus (RMSA) by likening its region to that of the RMSA. The outcomes are contrasted and the distributed trial and reproductions results, which are in generally excellent concurrence with hypothetical model.

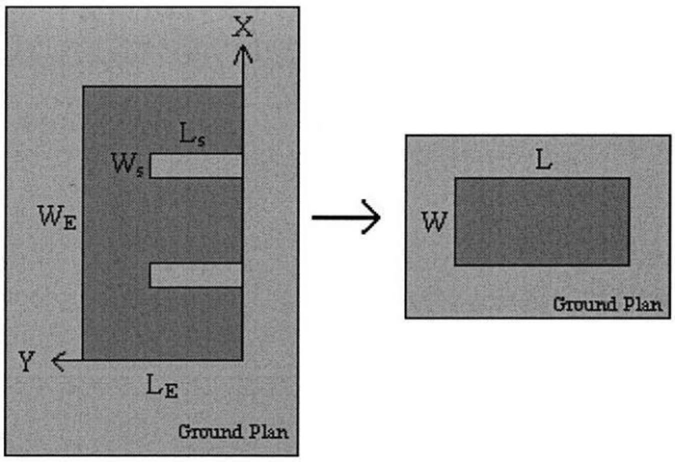

Figure A-1: Diagram for equating the area of the E-Shaped antenna with RMSA

To determine the resonance frequency at the dominant mode and higher-order modes, the area of the E-Shaped microstrip patch antenna is equated to that of a RMSA. Figure A-1 shows the E- shaped microstrip patch antenna and its equivalent RMSA.

The length L of the RMSA is taken as equal to the length of the E-shaped antenna. The width W of the RMSA is calculated as follows:

$$W = \frac{(L_E W_E - 2L_s W_s)}{L},$$

Where L_E and W_E are the length and width of the E-Shaped patch antenna, respectively.

Considering width W and length L of the equivalent RMSA, the effective dielectric constants ε_{eff} (W) and ε_{eff} (L) are calculated after accounting for the dispersion effect. Now, for the equivalent RMSA with parameter h as the thickness of the substrate, ε_r is the dielectric constant and t is the thickness of the strip conductor, the frequency dependent formula used for the computation of effective dielectric constant ε_{eff} (W) is calculated as

$$\varepsilon_{eff}(W) = \varepsilon_r - [(\varepsilon_r - \varepsilon_{eff}(0))/(1 + P)],$$

Where ε_{eff} (0) is the static effective dielectric constant, given by

$$\varepsilon_{eff}(0) = \frac{1}{2}\{(\varepsilon_r + 1 + (\varepsilon_r - 1)G\},$$

$$G = (1 + 10h/W)^{-AB} - [(\ln 4/\pi)(t(Wh)^{-1/2})],$$

$$A = 1 + \left\{\frac{(Wh)^4 + W^2/(52h)^2}{(Wh)^4 + 0.432}\right\} + \frac{1}{18.7}\ln\{1 + [W/(18.1h)]^3\},$$

$$B = 0.564 \exp[-0.2/(\varepsilon_r + 0.3)].$$

$$P = P_1 P_2[(0.1844 + P_3 P_4) f_n]^{1.5763},$$

$$P_1 = 0.27488 + [0.6315 + \{0.525/(1 + 0.0157 f_n)^{20}\}]u - 0.065683 \exp(-8.7513u),$$

$$P_2 = 0.33622[1 - \exp(-0.03442\varepsilon_r)],$$

$$P_3 = 0.0363 \exp(-4.6u)\{1 - \exp[-(f_n/38.7)^{4.97}]\},$$

$$P_4 = 1 + 2.751\{1 - \exp[-(\varepsilon_r/15.916)^8]\},$$

$$f_n = 47.713kh, \quad \text{where } k = 2\pi/\lambda_o,$$

$$u = [W + (dW - W)/\varepsilon_r]/h,$$

$$dW = W + (t/\pi)[1 + \ln\{4/(t/h)^{1/2} + (1/\pi)^2/(W/t + 1.1)^2\}].$$

The effective dielectric constant ε_{eff} (L) corresponding to width equal to L, is computed by replacing W with L in all above equations. The effective dielectric

Constant is calculated using

$$\varepsilon_{eff}(f) = [\varepsilon_{eff}(W)\varepsilon_{eff}(L)]^{1/2}.$$

The effective width Weft and effective length Left of the equivalent RMSA

is calculated as follows

$$W_{eff} = W + 2\Delta l_1,$$
$$L_{eff} = L + 2\Delta l_2,$$

Where l1 and l2 are edge extensions of side L and W of the equivalent RMSA respectively, and are calculated using ε_{eff} (L) and ε_{eff} (W). The edge extension l_2 for the width W of the equivalent RMSA is determined in a similar way as [16]:

where

$$\xi_1 = 0.434907 \frac{\varepsilon_{eff}(W)^{0.81} + 0.26(W/h)^{0.8544} + 0.236}{\varepsilon_{eff}(W)^{0.81} - 0.189(W/h)^{0.8544} + 0.87},$$

$$\xi_2 = 1 + \frac{(W/h)^{0.371}}{2.358\varepsilon_r + 1},$$

$$\xi_1 = 0.434907 \frac{\varepsilon_{eff}(W)^{0.81} + 0.26(W/h)^{0.8544} + 0.236}{W^{0.81} - 0.189(W/h)^{0.8544} + 20.1167},$$

$$\xi_4 = 1 + 0.0377 \arctan[0.067(W/h)^{1.456}] \times [6 - 5\exp\{0.036(1 - \varepsilon_r)\}],$$

$$\xi_5 = 1 - 0.218\exp(-7.5W/h).$$

Similarly, l_1 is calculated by replacing W by L and ε_{eff}(W) by ε_{eff}(L) in above equations. Using the all the equations, the resonance frequency for E- shaped microstrip antenna is calculated as, the lower resonance frequency: [17]:

$$f_{lower} = \frac{v_0}{2l_{eff}\sqrt{\varepsilon_{eff}}}.$$

and the higher frequency of E-shaped microstrip antenna, formula is modified appropriately as

$$f_{higher} = \left(\frac{0.36\,v_0}{W_{eff}\sqrt{\varepsilon_{eff}}}\right),$$

Where v_0 is the velocity of light in free space.

APPENDIX B

ANTENNA SIMULATION IN IE3D

Step by step procedure to design an E shape patch antenna with dimensions = 34 mm, L = 19 mm, W1 = 10 mm, W2 = 9 mm, L1 = 13 mm and Ls = 13.8 mm is discussed here with corresponding screenshots.

1. Run Zeland Program Manager. Click on MGRID.

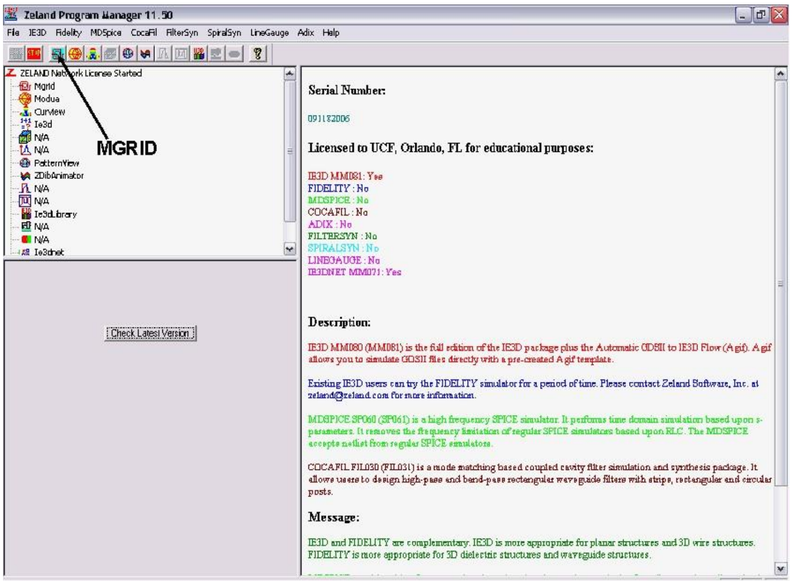

Figure B-1: Zeland Program Manager

2. MGRID window opens. Click the new button as shown below (🗋).

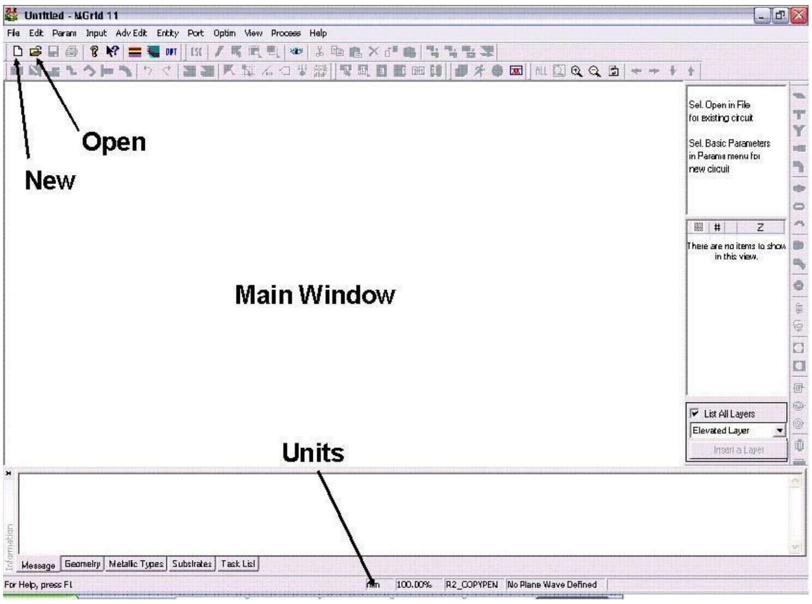

Figure B-2: MGRID window

3. The basic parameter definition window pops up. In this window basic parameters of the simulation such as the dielectric constant of different layers, the units and layout dimensions, and metal types among other parameters can be defined by users. In “Substrate Layer” section two layers are automatically defined. At z=0, the program automatically places an infinite ground plane (note the material conductivity at z = 0) and a second layer is defined at infinity with the dielectric constant of 1.

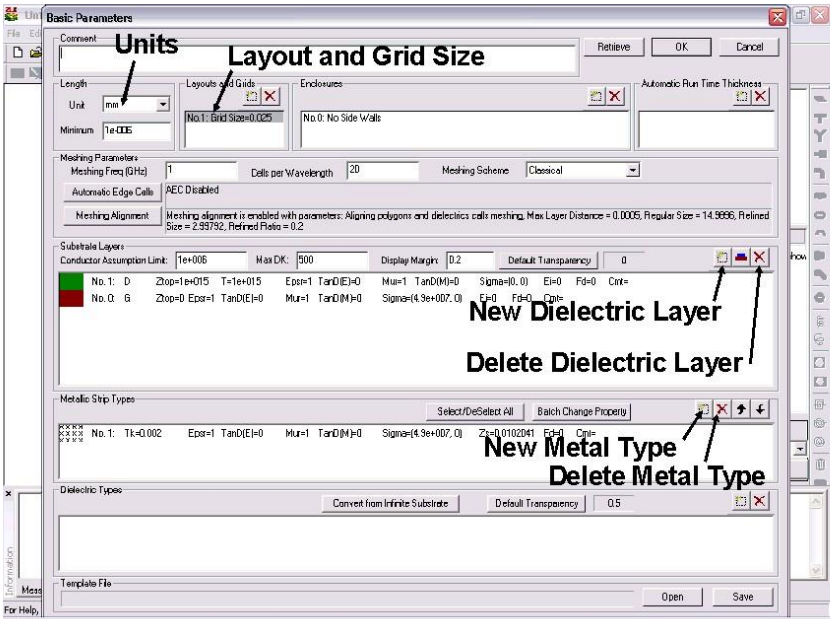

Figure B-3: Basic Parameter

4. Click on “New Dielectric Layer” button ( ). Enter the basic dielectric parameters in this window: Ztop: 5; Dielectric Constant: 2.2, Loss tangent: 0.002. Click OK.

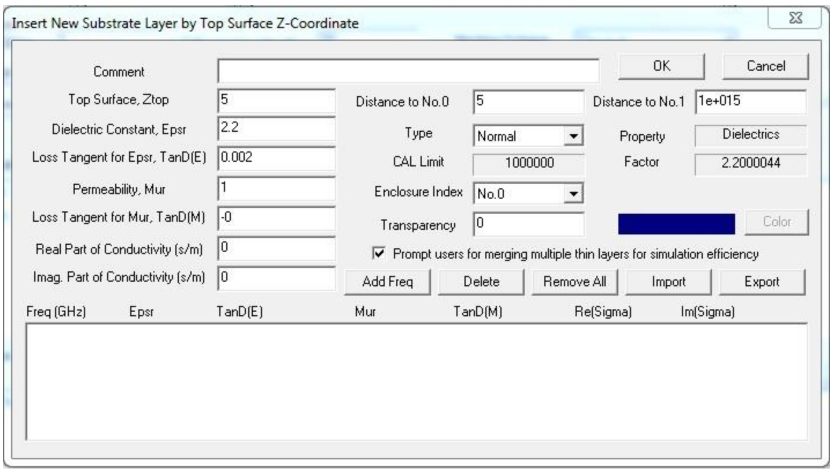

Figure B-4: New Substrate Layer Dialog box

5. Click OK again to go back to MGRID window. In Menu bar click Entity>Rectangle. Rectangle window pops up, enter Length 34, width 3 and click OK,

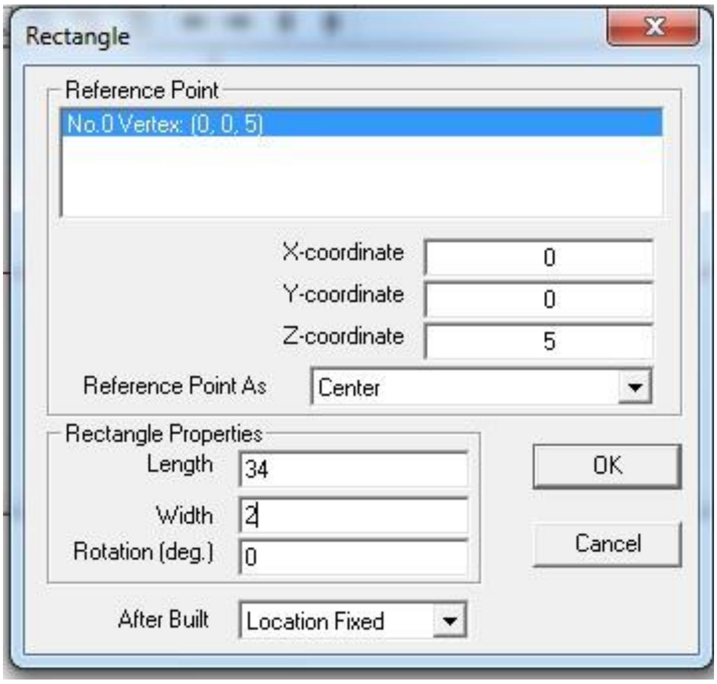

Figure B-5: Rectangle Dialog box

6. Click ALL button to see the whole structure. Select two lower vertices. Click Adv. Edit>Continue Straight Path. Continue Path on Edge window pops up. Enter Path Length 13, Path Start Width 10, Click OK.

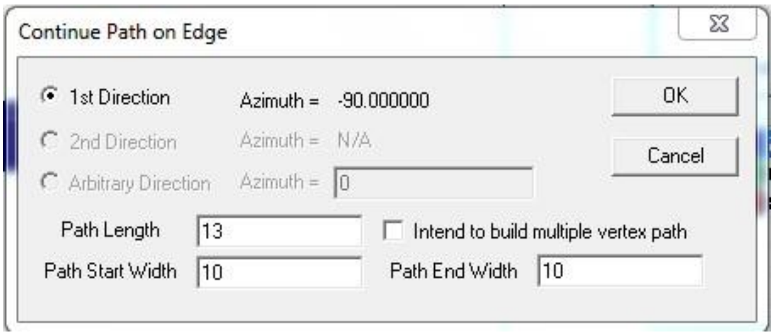

Figure B-6: Continue Straight Path Dialog box

7. Click ALL to see the whole structure. The main body with the middle arm has been created.

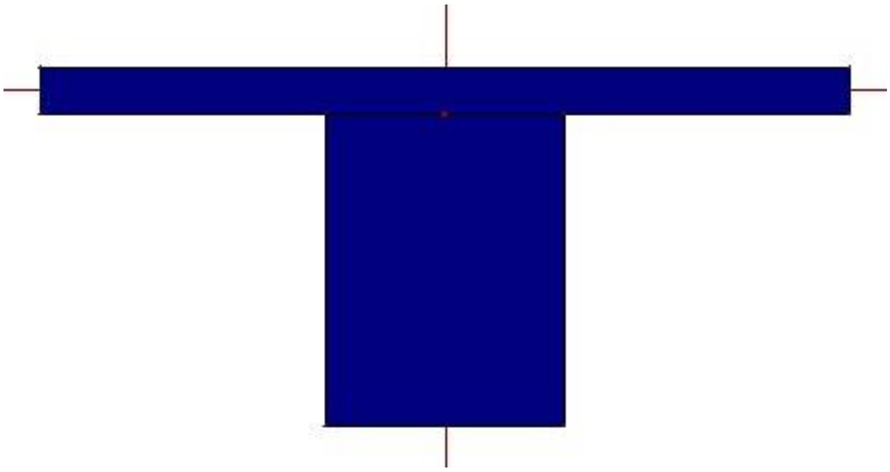

Figure B-7: Main body of antenna with middle arm

8. Click Input>Key in Absolute Location. New window pops up, enter X coordinate -17, Y coordinate -1.5. Click OK. Program would ask to connect, always click YES. Then click Input>Key in Relative Location. Another window pops up, enter X coordinate 9, Y coordinate 0. Click OK. Then again click Input>Key in Relative Location and enter X coordinate 0, Y coordinate -17. Click OK. Press Shift +F or Input>Form Rectangle. Left side arm of the E has now been created.

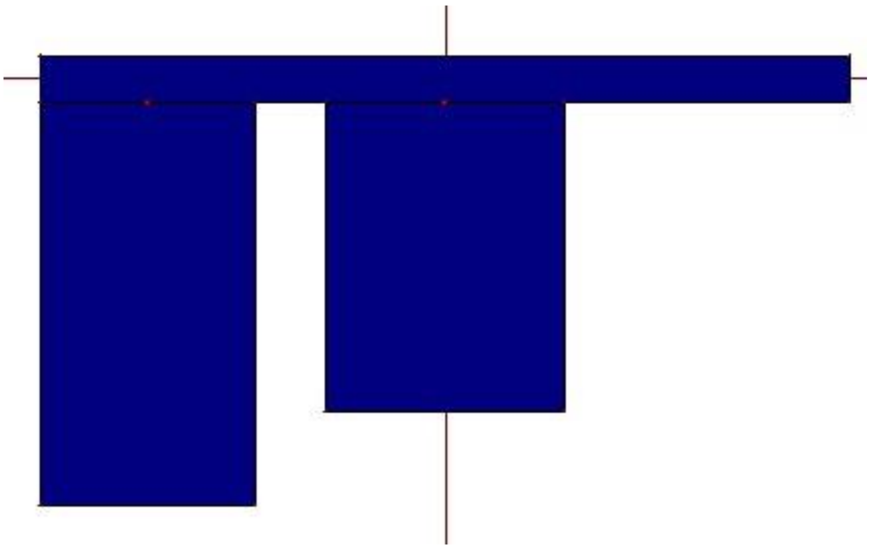

Figure B-8: Antenna Structure with two arms

9. Now click Edit>Select Polygon, click on the left arm. Right click on it, from the menu click Copy. Click right mouse button it anywhere in the MGRID panel and

Click Paste. Click again in the panel. A window pops up. Enter X offset 25, Y offset 0, Click Ok. Antenna structure is now complete. Next we need to connect the feed line to the antenna.

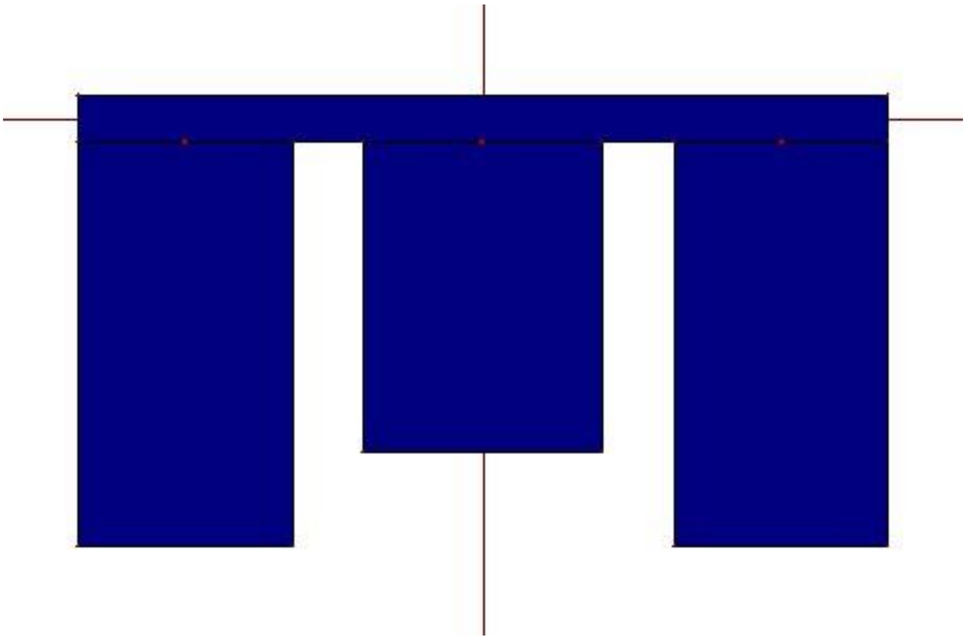

Figure B-9: Complete antenna structure

10. Click Entity>Probe Feed to Patch. Enter (0, -12.8) as feed coordinate and click OK. The antenna is now ready for simulation.

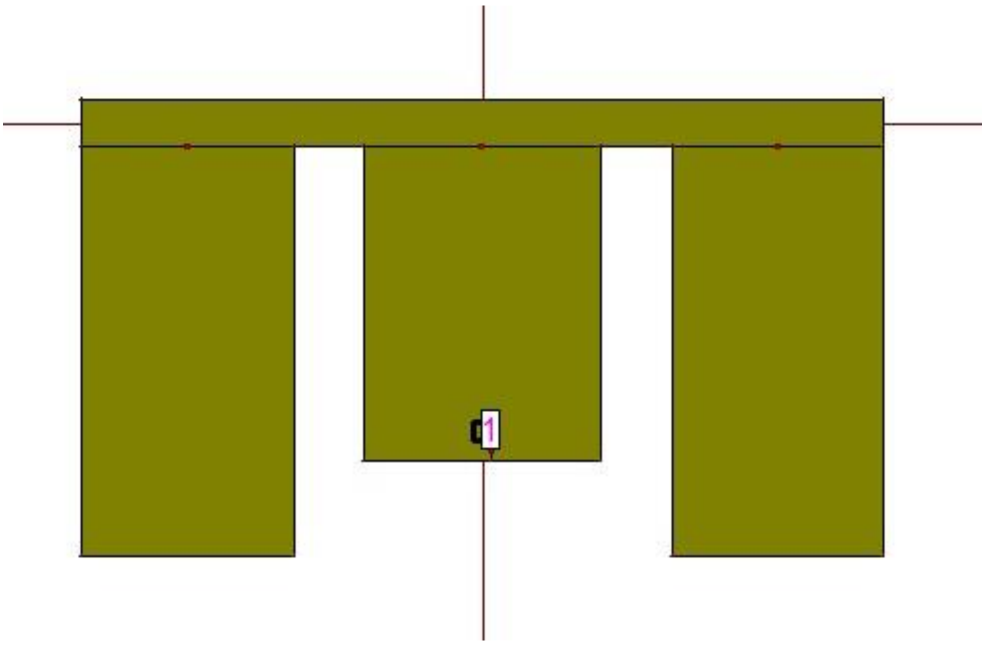

Figure B-10: Antenna Structure with feeding Probe

APPENDIX C

MESHING PARAMETERS AND SIMULATION

For simulation of the antenna, first meshing should be performed. In IE3D this meshing is used in the Method of Moment (MoM) calculation. Click on Process>Display Meshing. The "Automatic Meshing Parameters" menu pops up.

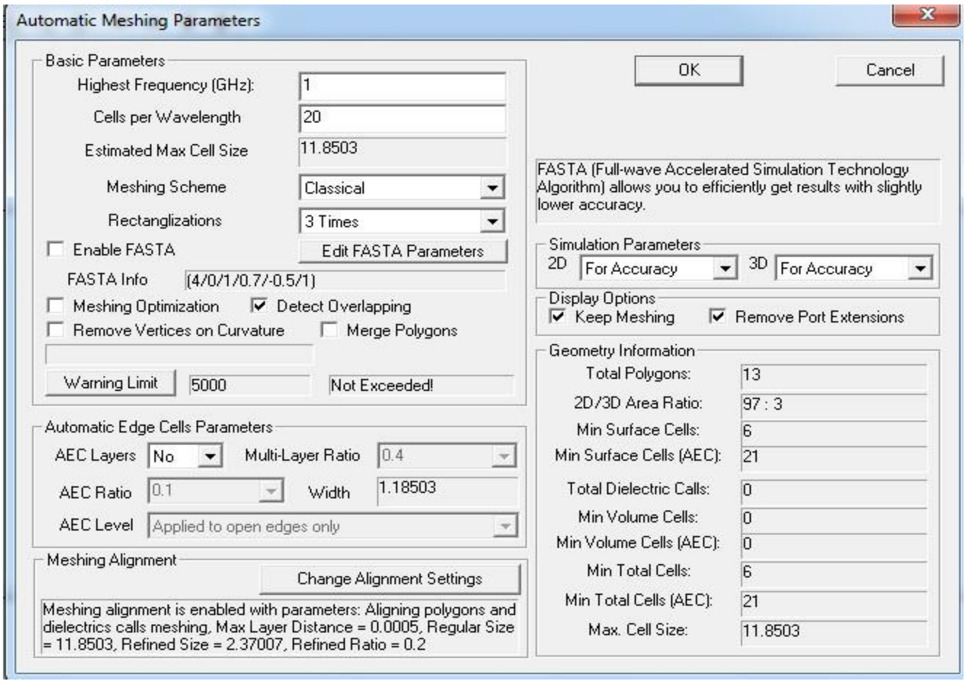

Figure C-1: Automatic Meshing Parameter dialog box

Here the most elevated recurrence is ought to be characterized as the greatest working recurrence. In this postulation recreations are finished with 9 GHz in the "Most elevated Frequency" field and 30 in the "Cells per Wavelength" field. The quantity of cells/wavelength decides the thickness of the work. In strategy for minute reproductions, less than 10 cells for every wavelength ought not to be utilized. The higher the quantity of cells per wavelength, the higher the exactness of the reenactment. Be that as it may, expanding the quantity of cells builds the absolute reproduction time and the memory required for reenacting the structure. In the vast majority of the reproductions utilizing 20 to 30 cells for every wavelength ought to give enough precision. In any case, this can't for the most part be summed up and is diverse in every issue; press OK, another window springs up that shows the measurements of the work; press OK again and the structure will be coincided.

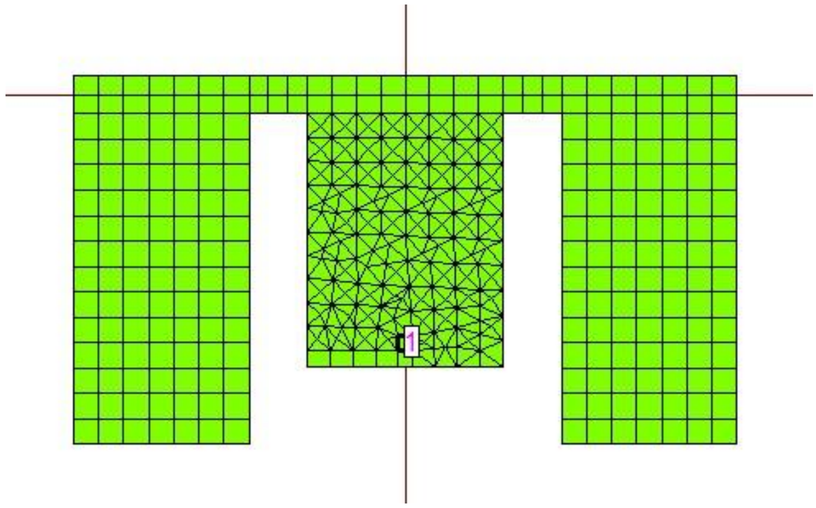

Figure C-2: Meshed Antenna for MoM calculation

Now to get S11 parameters of the antenna, Click on Process>Simulate. Simulation Setup window pops up. Here range of frequency should be entered as 3 GHz to 7 GHz with 0.01 in the Step Hertz field.

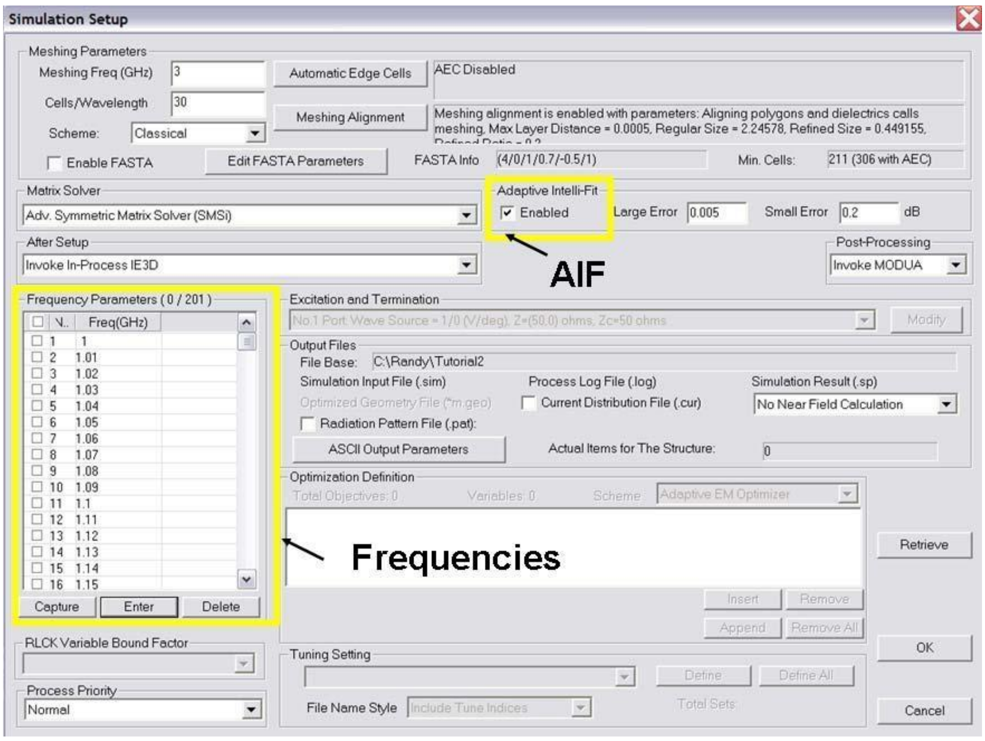

Figure C-3: Simulation Setup dialog box

The “Adaptive Intelli-Fit” check box should be checked so that the program does not perform simulations at all of the specified frequency points.

It automatically selects a number of frequency points and simulates the structure at these particular points and interpolates the response based on the simulated points. Press OK and the structure will be simulated. The simulation progress window shows the progress of the simulation. It will only take a couple of seconds for the simulation to finish. After the simulation is completed, IE3D automatically invoked MODUA and shows the S parameters of the simulated structure. MODUA is a separate program that comes with the IE3D package. This program is used to post process the S-parameters of the simulated structure.

From the Control Menu of MODUA the display graph can be defined. Click Control>Define Display Graph. Display Parameter window pops up with many option. Any needed data can be chosen for display.

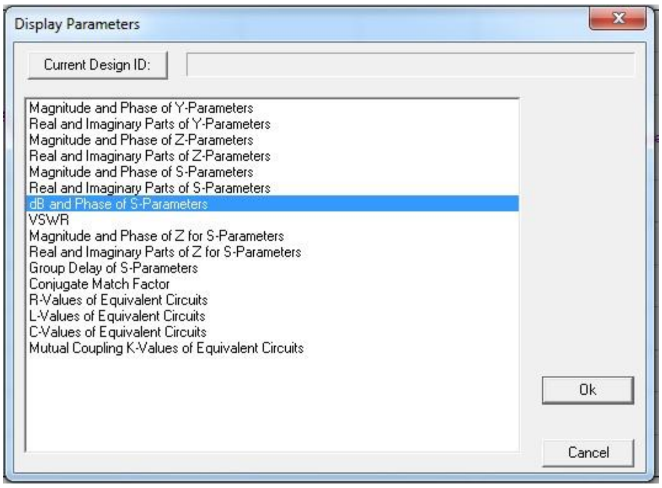

Figure C-4: Display Parameter

For simulation of the current distribution and radiation pattern, Simulation Setup dialog should be modified. Cell per wavelength should be higher for better accuracy; a value of 50 to 70 is enough. A single frequency should be given for which current distribution or radiation pattern would be observed and current distribution file check box must be checked.

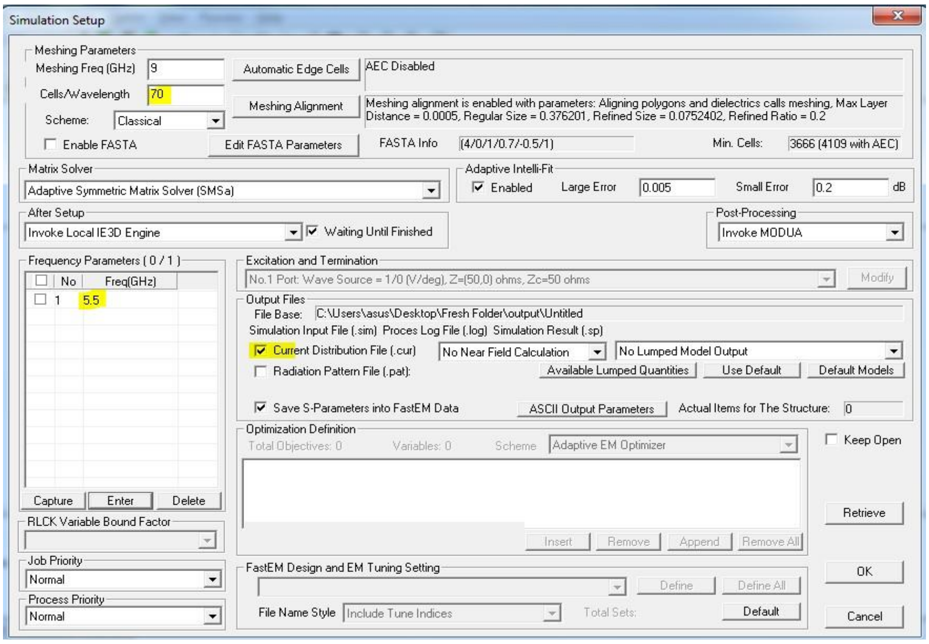

Figure C-5: Simulation Setup parameters for Current Distribution and Radiation Pattern

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