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Improved Microstrip Antenna Design for LTE Advanced Applications

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Abstract

Over the years a lot of research has taken place in the field of Micro strip patch Antennas, specially looking at their use in the mobile communications. Long Tern Evolution (LTE) is the future of cellular communications which works typically at 700 MHz frequency band. LTE is leading cellular communications towards fourth generation networks and was originally conceived for the improvement of the capacity of the network and its speed. LTE provides downlink capacity of 100 Mbps and has the uplink capacity of 50 Mbps.

Micro strip patch antennas are widely used in the LTE networks because of their size and efficiency. The research work involves the designing and simulation of a micro strip patch antenna in specific operating frequencies which will have improved gain and is efficient.

Keywords: Micro strip Patch Antenna, Long Term Evolution.

1.1. Introduction

Over the years, wireless technology has penetrated almost every sphere of life with its vast collection of applications. With the growing mobility of the users, the access to high speed connectivity's is increasing with every passing day. Long Term Evolution (LTE) is primarily designed to cater for high data rates over the wireless medium. The evolutionary stages of LTE [1] are shown below;

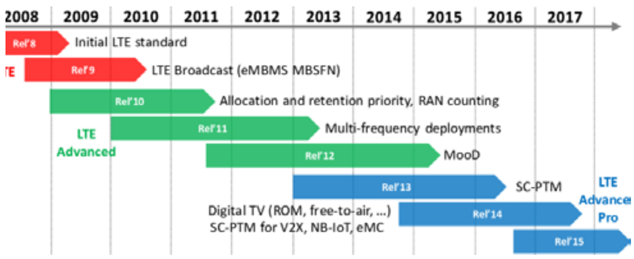

Figure 1.1: LTE Evolution
(Source: https://www.researchgate.net/figure/Point-to-Multipoint-Evolution-in-4G-LTE-LTE-Advanced-Rel10-11-and-12-and_fig1_324469200)

Its various variants/releases have come up since 2008 with rapid technological developments taking place over the years with the introduction of LTE Advance pro being widely deployed in the industry. The industry mobile technology trends, while moving towards LTE are shown below;

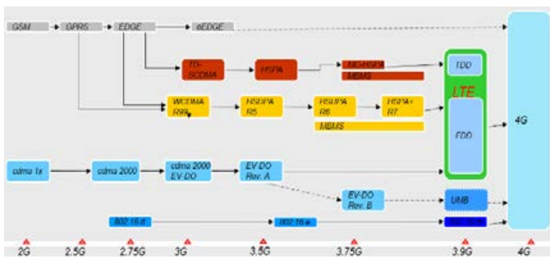

Figure 1.2: Cellular Technology Evolution Roadmap
(Source: Investaura Ltd, 2018)

A typical network architecture of LTE is shown below.

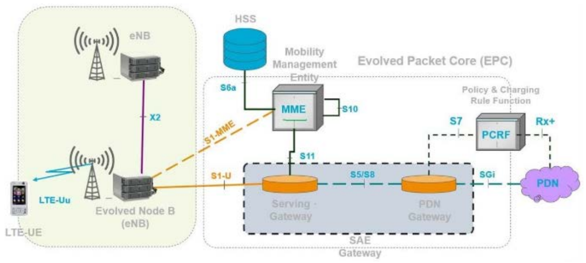

Figure 1.3: LTE Network Architecture
(Source: https://www.youtube.com/watch?v=6dt9xVMvtB8)

The LTE network gives the following benefits to the users;

- Enhanced Coverage
- Peak Data Rate
- Less Latency
- Less OPEX
- Less CAPEX
- Variety of Bandwidth
- Enhanced Spectrum Efficiency

LTE uses various frequency bands [2] which are summarized below;

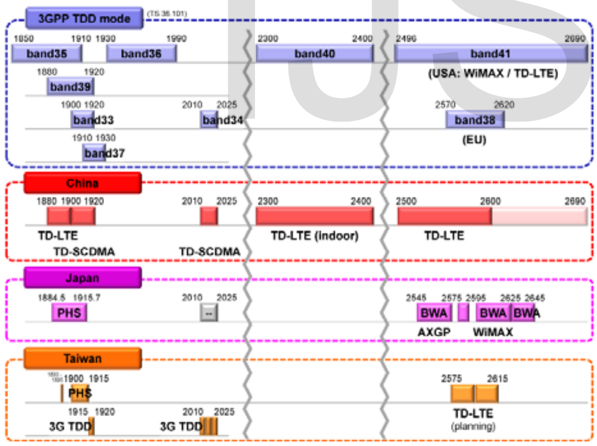

Figure 1.4: LTE Spectrum
(Source: https://www.xgpforum.com/new_XGP/en/001/TDD_band.html)

When we are talking about wireless communications, the antenna is the main unit which has critical functionalities. The challenge for the researchers has always been to design antennas which are smaller in size, are very light, less pricy and have improved performance. These can be achieved with the use of patch antennas. Following are the functions of the antenna;

- Converting electromagnetic radiations into electric current and vice versa.
- Transmission of radio signals.
- Reception of radio signals.
- Coupling electrical connection to the electromagnetic field.
- Carrying of electromagnetic signals in air.

The wireless transmission performance is heavily and primarily dependent on the antenna designed and based on its different parameters.

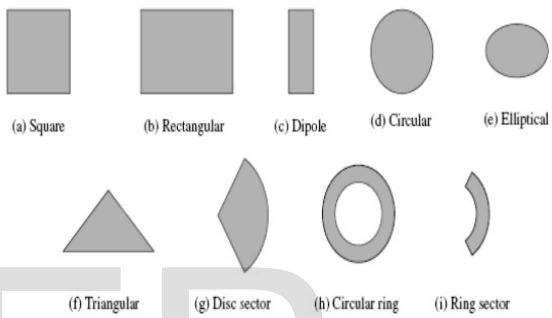

Figure 1.5: Patch Antenna Shapes

Micro strip patch antennas [3] come in various shapes, as shown above and the most suitable one is selected based on the specific application and considering the design requirements. The basic purpose of the antenna in wireless communications is to provide a mechanism or path for the transmission and receiving of the electromagnetic waves.

A typical Micro Strip Patch Antenna has the following design.

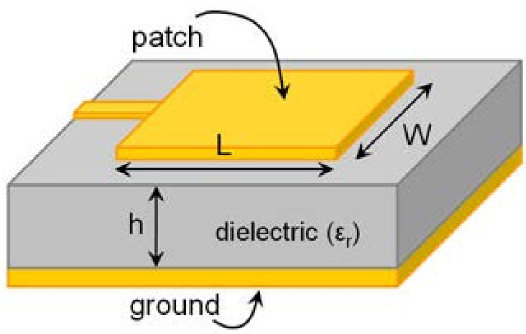

Figure 1.6: Generic PA

Antenna consists of center patch with length "L" and width "W". There is a dielectric material between the ground and the upper patch. There are many types of micro strip patch antennas [4] which are being used. Generally, two methods are used.

- Single Multiband Micro Strip Antenna (narrow bands)
- Single Wide Band Antenna (all LTE bands)

In this research work, more stress will be placed on the design of internal antennas imbedded in the mobile devices [6]. The process of fabrication involves the following flow chart processes for an effective design.

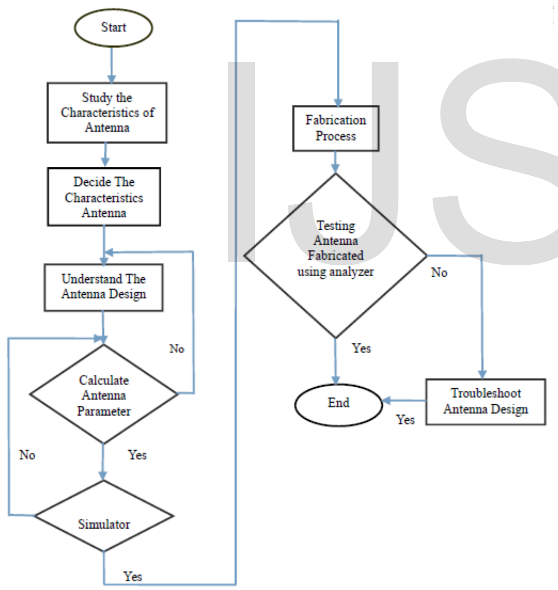

Figure 1.7: Antenna Fabrication Flow Chart

Before we start the process, it is important to study the characteristics of the antenna which we intend to design. In our case it is the small size micro strip patch antenna [5]. Then comes as to how this can be designed to fit our conceived application or utility. Once done, the antenna parameters need to be calculated so as to achieve maximum efficiency depicted through the simulation results. After this fabrication is done and the outcome tested.

1.2. The Research Problem

To design a compact antenna for LTE applications is a challenge. With different operating frequencies, the designing becomes a challenge. In the lower LTE bands (0.70 GHz to 3.50 GHz), it becomes difficult because of the large antenna size, hence unsuitable to be used in the smart devices around. This problem can only be handled with the use of small size patch antennas. Furthermore, in addition to size reduction, there is a need to look at the gain improvement, increased bandwidth, return loss and voltage standing wave ratio improvement.

1.3. Purpose

To design a micro strip patch antenna which has smaller size with better gain, VSWR, return loss and bandwidth enhancement. Return loss and gain will be optimized with the aid of HFSS (High Frequency Structure Simulator).

1.4. Objectives of Study

- To come up with a Novel design of micro strip patch antenna.
- To design an antenna that is smaller in size vs gain with bandwidth enhanced.
- To improve size, gain, VSWR, Efficiency (bandwidth and return loss) and comparative analysis of simulated results.

1.5. Research Questions

Following are the research questions.

- How to design an innovative micro strip patch antenna?

- How can the size, gain and bandwidth be enhanced?

- How to improve the performance of the antenna?

1.6. Simulator

The software that will be used for simulation is High Frequency Structure Simulator (HFSS). Return loss and gain can be optimized with the aid of HFSS.

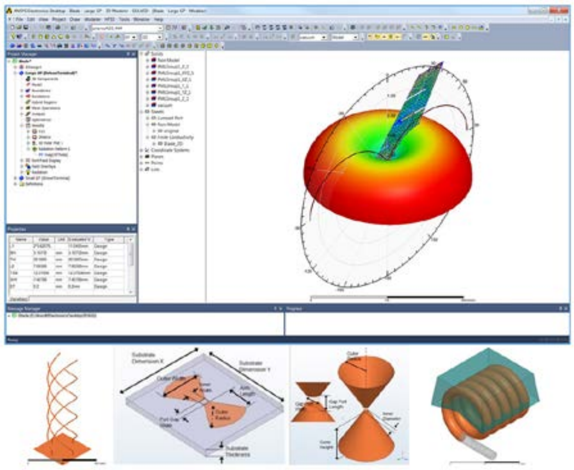

Figure 1.8: HFFS Simulator Screenshot

The simulation will follow the following steps as per the design glow chart.

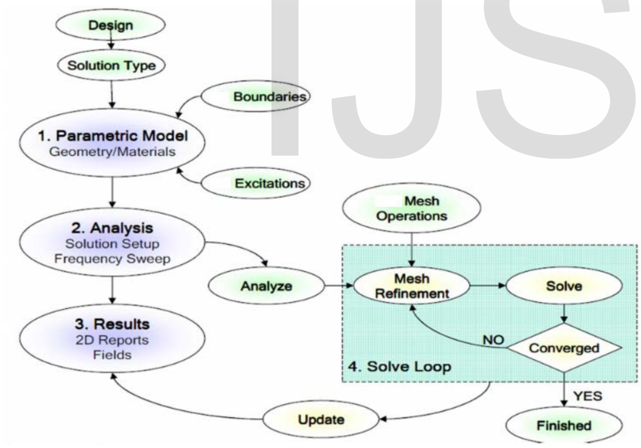

Figure 1.9: HFFS Design/Simulation Flow Chart

2.1. Antenna Design

In order to do the simulation, we first need to design the antenna [7]. The designed antenna top view is shown below.

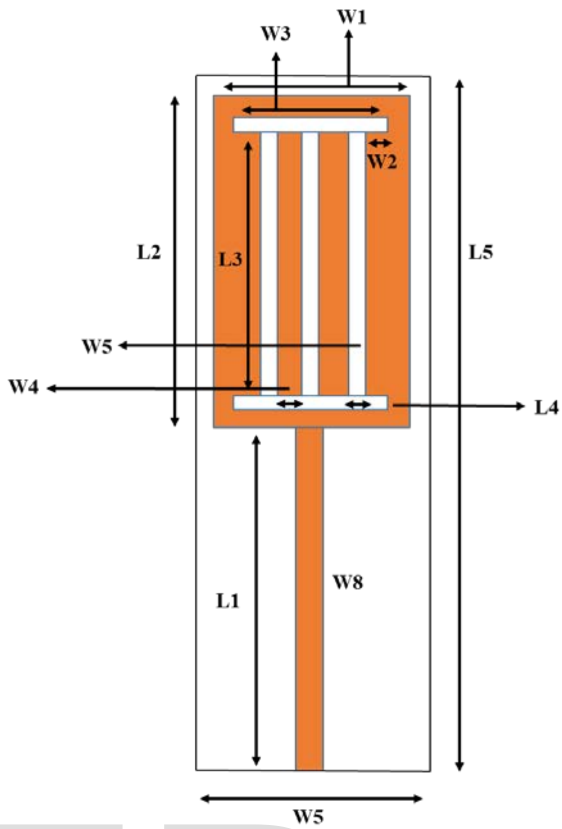

Figure 2.1: Antenna Design (Top View)

The designed antenna bottom view is as under.

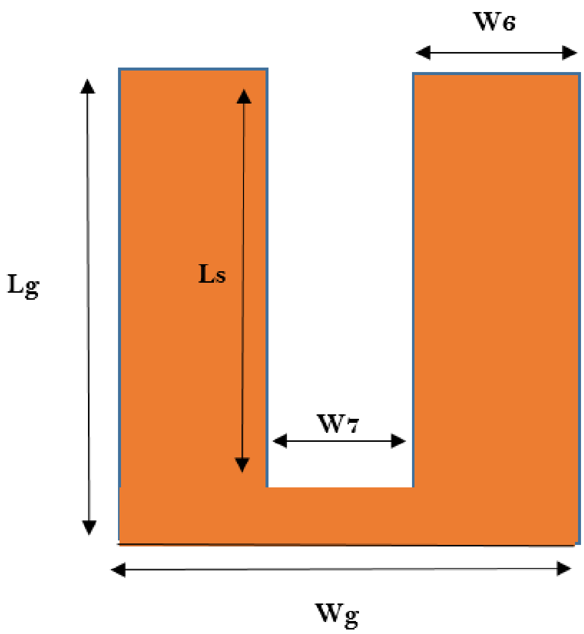

Figure 2.2: Antenna Design (Bottom View)

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Following are the dimensions of the proposed antenna.

L1	=	68 mm
L2	=	60 mm
L3	=	52 mm
L4	=	2 mm
L5	=	42 mm
Ls	=	134 mm
Lg	=	47 mm
W1	=	26 mm
W2	=	6.4 mm
W3	=	22 mm
W4	=	2 mm
W5	=	2 mm
W6	=	13 mm
W7	=	4 mm
W8	=	2 mm
Ws	=	31 mm
Wg	=	31 mm

As we can see, the designed antenna consists of different patches [8] with varied shapes/dimensions. Impedance of the antenna is 50 Ω. Flame retardant (FR) substrate is used. The designed antenna will operate between 696.50 – 783.80 MHz with voltage standing wave ratio less than two providing a bandwidth of 83.7 MHz. The antenna has been conceived so as to increase the efficiency of the LTE networks. The following traditional simulation study model will be used. The antenna simulated can be fabricated at a minimum cost.

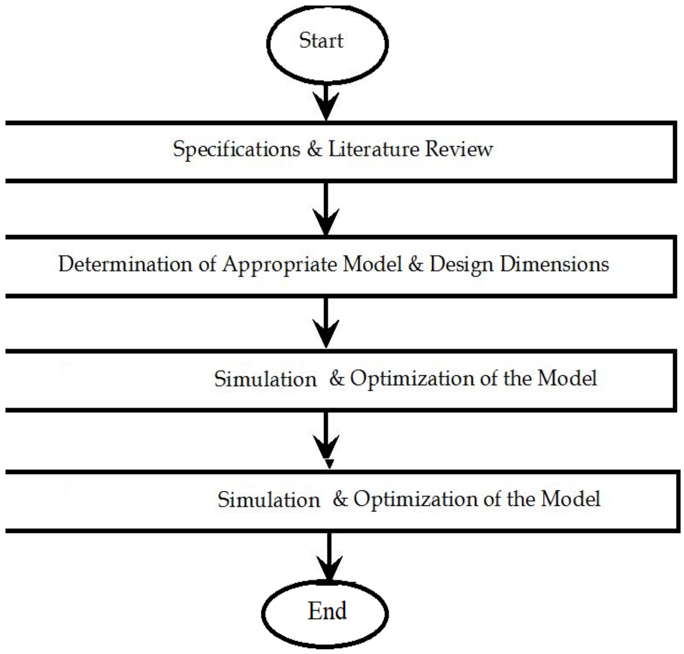

Figure 2.3: Generic Simulation Model

Data Analysis & Research Findings

Through simulation we can look at various parameters, which include;

- RL-Return Loss & Bandwidth
- VSWR
- Impedance (Z)
- Gain
- Radiation Pattern

Now we will analyze them one by one.

- **RL & Bandwidth**

The figure below shows the return loss of the antenna.

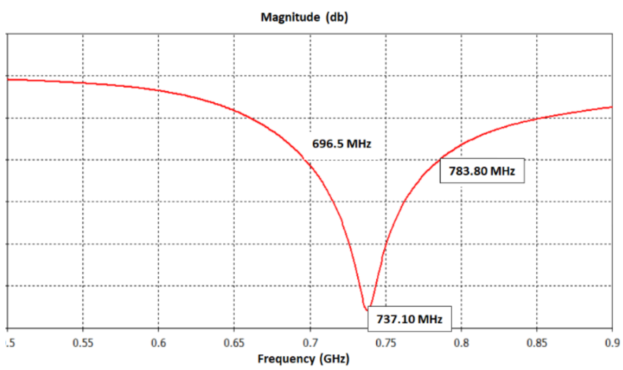

Figure 3.1: Return Loss

The frequency band at which the designed antenna works is from 696.50 – 783.80 MHz. In order to calculate the total bandwidth, the difference between upper and lower frequencies is done.

Upper Frequency = 783.80 MHz
Lower Frequency = 696.50 MHz
Bandwidth = (783.80) – (696.50) = 87 MHz (approximately)

- VSWR

VSWR at 696.70 MHz is found to be 1.9213878. As the value of voltage standing wave ration is less than 2, hence it follows the criteria set.

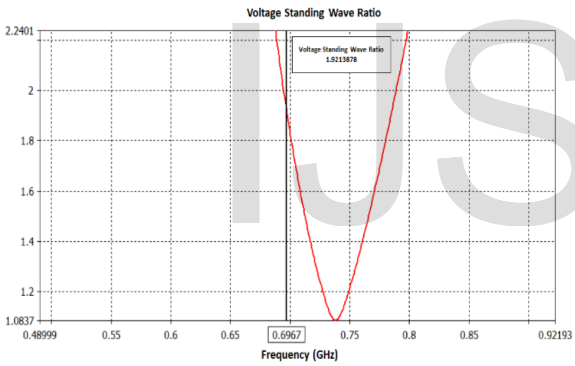

Figure 3.2: Voltage Standing Wave Ratio (696.70 MHz)

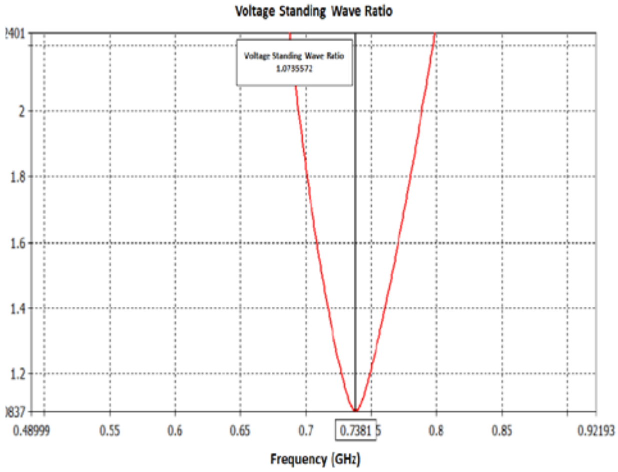

Figure 3.3: Voltage Standing Wave Ratio (738.10 MHz)

It is also seen above that at frequency of 738.10 MHz, the value of voltage standing wave ratio is 1.0735572 which shows that the antenna works extremely well at this point. However, at frequency of 783.60 MHz, decline as far as the antenna performance quality is observed which owes to the higher value of voltage standing wave ratio of 1.976597. However, as it is still below the threshold value of 2, hence won't be an issue.

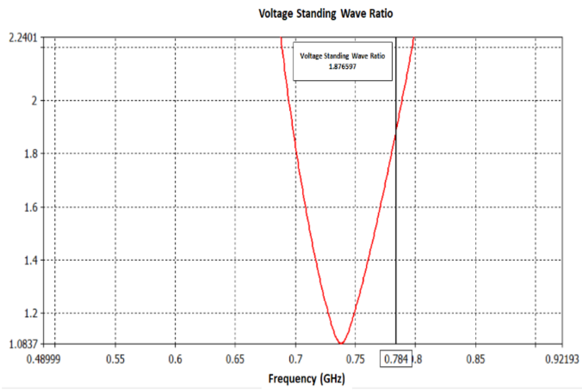

Figure 3.4: Voltage Standing Wave Ratio (783.80 MHz)

- Gain

As shown in the figure below, the gain has many values between the frequency range of 696.g MHz and 783.80 MHz. The gain of the antenna at 696.50 MHz is found to be 1.535 dB.

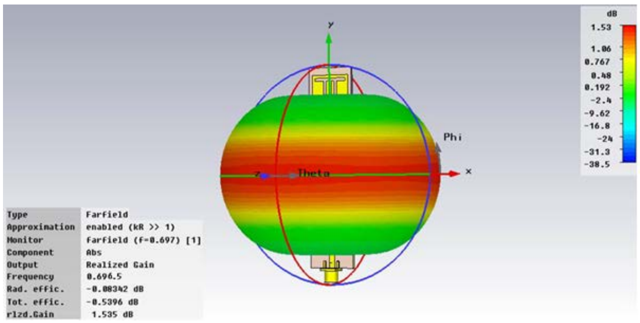

Figure 3.5: Gain (696.50 MHz)

- Radiation Pattern

The radiation patterns for E and H planes are shown below.

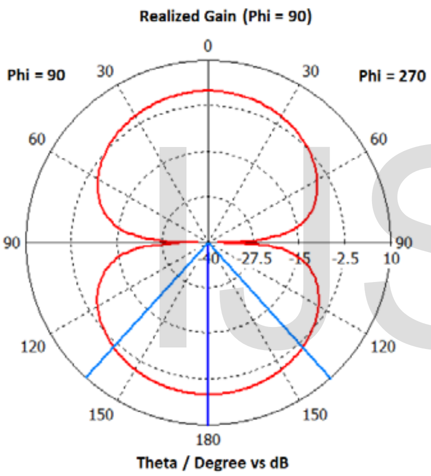

Figure 3.6: Radiation Pattern (E-Plane 696.50 MHz)

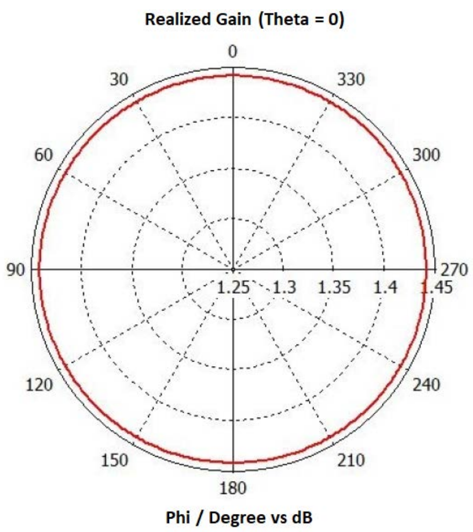

Figure 3.7: Radiation Pattern (H-Plane 696.50 MHz)

At 783.80 MHz, antenna gain comes to 2.093 dB as shown below.

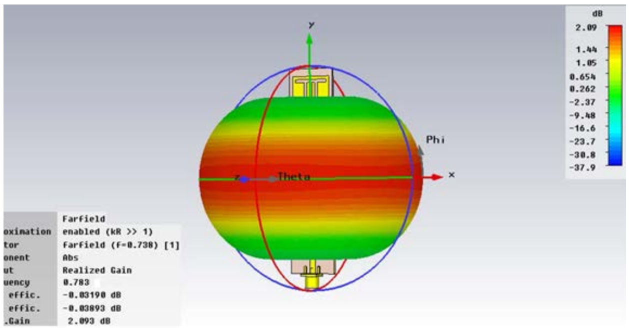

Figure 3.8: Gain (738.10 MHz)

It is seen from the results that the highest gain is observed at the frequency of 783.80 MHz and the voltage standing wave ratio at this point is the lowest. Similarly, the antenna gain, is highest at the frequency of 738.10 GHz. That depicts the best efficiency at this frequency. Omnidirectional radiation pattern can be seen.

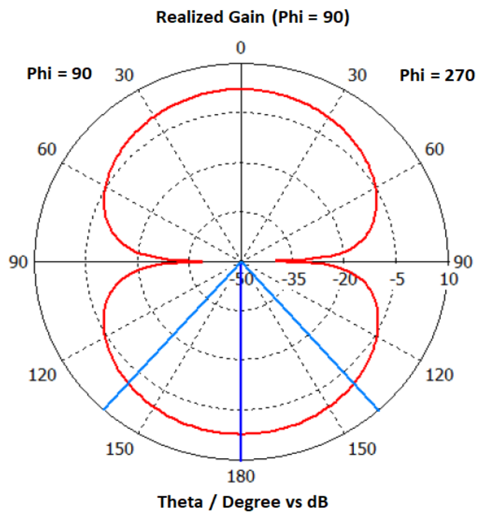

Figure 3.9: Radiation Pattern (E-Plane 738.10 MHz)

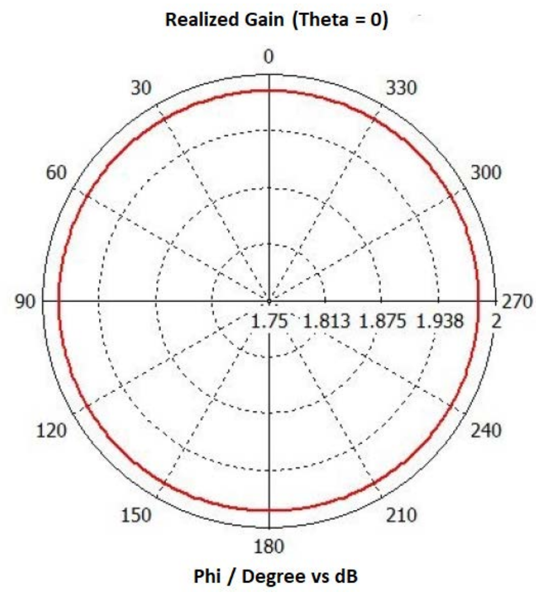

Figure 3.9: Radiation Pattern (H-Plane 738.10 MHz)

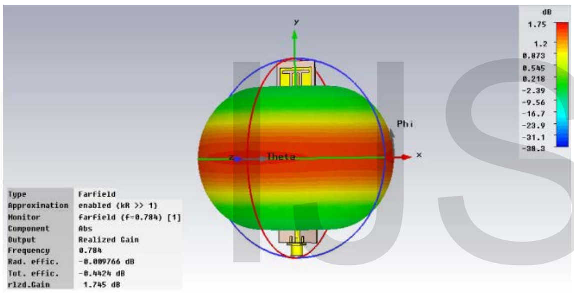

Figure 3.10: Gain (H-Plane 783.80 MHz)

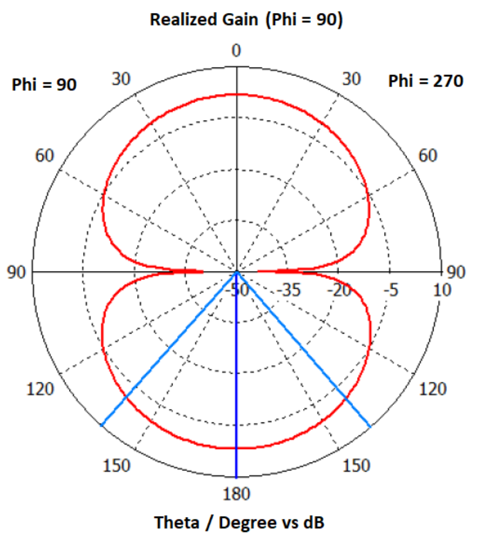

Figure 3.11: Radiation Pattern (E-Plane 783.80 MHz)

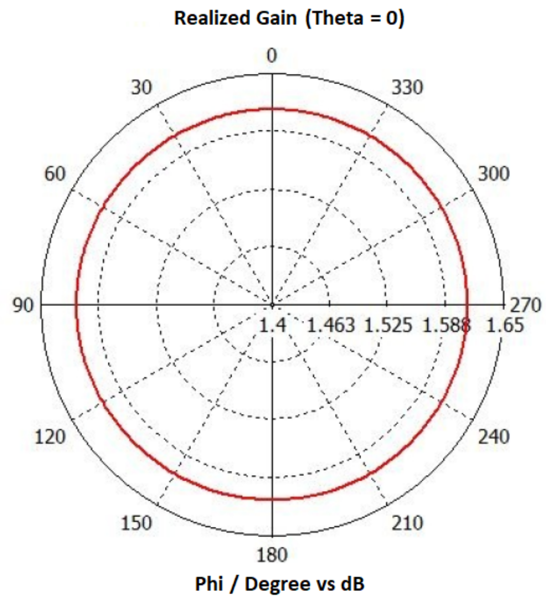

Figure 3.12: Radiation Pattern (H-Plane 783.80 MHz)

To summarize the above simulation results, below are the voltage standing wave ratio and the gain findings.

- **Frequency of 696.50 MHz**

Frequency = 696.50 MHz
Voltage Standing Wave Ratio = 1.9213878
Gain (dB) = 1.535 dB

- **Frequency of 738.10 MHz**

Frequency = 738.10 MHz
Voltage Standing Wave Ratio = 1.0735572
Gain (dB) = 2.093 dB

- **Frequency of 783.80 MHz**

Frequency = 783.80 MHz
Voltage Standing Wave Ratio = 1.876597
Gain (dB) = 1.745 dB

4.2. Conclusion

Following are the conclusions based on the simulation results.

- Frequency ranges in which the antenna was designed were from 696.50 MHz to 783.80 MHz.

- The return loss is less than -10 dB.

- VSWR is less than 2.

- Calculated antenna gains range from 1.535 to 2.093 dB.

- The highest gain is observed at the frequency of 738.10 MHz when the voltage standing wave ratio reaches 1.073.

- The analyzed antenna pattern was for an Omni-directional antenna having monopole characteristics.

- The antenna dimensions simulated are less than the previously researched ones (smaller size) with better-improved results.

- As the designed antenna frequency band is in 700 MHz, hence it can be easily used for LTE applications.

4.2. Contribution to Knowledge (Academic Contribution)

This research work has come up with an antenna design having size reduction with gain improvement and bandwidth enhancement.

4.3. Statement of Significance (Practical Contribution)

These research findings set a base for future antennas to be designed for handheld devices. It can be further taken to next step of designing a single antenna that covers complete bands of LTE advanced having good impedance matching as well, hence playing its part for facilitating the future needs of 5G networks.

References

[1] Salim, Ali. (2015). Design of Compact Dual-band Antenna for 4G LTE Wireless Devices. Engineering and Technology Journal.

[2] Yong-Ling Ban ; Yun-Fei Qiang ; Zhi Chen ; Kai Kang "A Dual-Loop Antenna Design for Hepta-Band WWAN/LTE Metal-Rimmed Smartphone Applications" Antennas and Propagation, IEEE Transactions on Volume:63 , Issue: 1 pp. 48 – 58 Jan. 2015.

[3] Ying, Zhinong. (2012). Antennas in Cellular Phones for Mobile Communications. Proceedings of The IEEE - PIEEE. 100. 2286-2296. 10.1109/JPROC.2012.2186214.

[4] Loveleen Cheema, Krishan Kumar Sherdia "Microstrip Patch Antenna with Defected Ground Plane for UWB Applications" International Journal of Advanced Research in Computer and Communication Engineering Vol. 2, Issue 7, July 2013.

[5] Songsong Xiao, Tao Sun, Chaowei Wang and Weidong Wang "A compact and dual-band microstrip MIMO antenna for LTE mobile terminals" Inf. & Electron. Technol. Lab., Beijing Univ. of Posts & Telecommun., Beijing, China Communications in China (ICCC), 2014 IEEE/CIC International Conference, 10.1109/ICCChina.2014.7008324 Shangai 13-15 Oct. 2014.

[6] Wagle, Shyam S. & Ade, Minesh & Ghazanfar Ullah, M. (2010). Network Transition from WiMax to LTE. 3.

[7] C. A. Balanis, Antenna theory, 3rd edition, John Wiley, New York, 2005.

[8] Groun Mejda. Multiband Microstrip Patch Antenna for 4G (LTE). Mohamed Khider University of Biskra.June 2018.