DESIGN OF MICROSTRIP PATCH ANTENNA ARRAY USING HFSS

A Technical Seminar Report
submitted in partial fulfillment of
the requirement for the B.Tech.
under Biju Patnaik University of Technology, Rourkela.

Submitted By

DEEPANJALI SUBUDHI **Regd No. # ETC 1901109311**

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Under the guidance of

Mr. ASHISH KUMAR SARANGI

Parala Maharaja Engineering College, Sitalapali
Berhampur, Ganjam, Odisha – 761003

Estd. – 2009
A Government Engineering College
E-mail – pmecbam@gmail.com
Website – www.pmec.ac.in

PARALA MAHARAJA ENGINEERING COLLEGE

(A constituent college of Biju Patnaik University of Technology, Odisha, Rourkela)

SITALAPALLI: BERHAMPUR: DIST.:-GANJAM: PIN – 761003 (ODISHA)

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CERTIFICATE

It is certified that the seminar work entitled "**DESIGN OF MICROSTRIP PATCH ANTENNA ARRAY USING HFSS**" submitted by **Deepanjali Subudhi (1901109311)**, for the partial fulfillment of B. Tech degree is based on her own work carried out under my guidance.

Deepanjali Subudhi
1901109311

Mr. Ashish Kumar Sarangi
Asst. Prof. Dept. of ETC
Parala Maharaja Engineering College
Sitalapalli, Berhampur, Odisha - 761003

ABSTRACT

A rectangular microstrip patch antenna is designed using HFSS software. The designed antenna has a resonating frequency of 2.4 GHz which is applicable to Wireless Local Area Network (WLAN). The design considerations of the proposed antenna as well as the simulated results of the same. The design is made on FR-4 Epoxy, aluminum & polyester materials are used as a dielectric material with its dielectric constant 4.4 and thickness of 1.5mm. Also the comparison between three materials are done to know which one is good. Horn antenna was designed by implementing a procedure in HFSS. Simulation & optimization of the horn was carried out in HFSS. The reason to simulate the horn in HFSS is the fact to achieve optimum gain and radiation pattern. The design is made on FR-4 Epoxy materials are used as a dielectric material with a resonant frequency of 5GHz.

ACKNOWLEDGEMENT

I would like to express my immense sense of gratitude to my guide, **Mr. Ashish Kumar Sarangi**, for his valuable instructions, guidance and support throughout my seminar.

I again owe my special thanks to **Dr. Dinesh Kumar Dash**, Technical Seminar Coordinator, Head of the Department for giving me an opportunity to do this report.

And finally thanks to **Prof. R. K. Swain**, Principal, PMEC for his continued efforts for enhancing the quality in everything that happens at PMEC. This report is a dedicated contribution towards that greater goal.

DEEPANJALI SUBUDHI

Regd No. # ETC 1901109311

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1. INTRODUCTION

ANSYS HFSS is a 3D Electromagnetic Simulation (EM) tool that is a leader in the market for high frequency and high speed electronic components. It highlights several antenna-related applications with emphasis on antennas placed around or around other structures. With multiple simulation technologies and a powerful and automated adaptive mesh refinement that provides gold standard accuracy, HFSS can help antenna designers who are constantly faced with the challenge of deploying designs in more and more frequency bands within a decreasing space. With these additional technical challenges coupled with declining time in the market, simulation with HFSS is a necessity in the process of integration and antenna design.

In recent years, the rapid growth of IoT technology in the medical field has been observed. Introduced to support large-scale reconstruction of the global health system, this technology in many ways leads to changes in medical and population services provision. This development is part of a general area known as "telemedicine" that enables remote diagnosis of patients and seeks the advice of a specialist. Telemedicine is the remote distribution of healthcare services, such as health estimation or consultations, over the telecommunications framework. Telemed Icine also helps to ensure preventive monitoring of high-risk patients by prescribing therapies or procedures and procedures to monitor the patient's situation. The choice of this emergency pre-hospital system differs from the simplicity of system implementation and its effectiveness, compared to other works. The proposed antenna transmits the data from the biosensors and receives them through the Zigbee module on one side. On the other hand, the data sent by the hospital via the wimax/3.5G connection, that is one of our effective bands are received by a second antenna that is placed outside the ambulance.

1.1 Microstrip Antenna

Antenna is a transducer which transmits or receives electromagnetic waves. Microstrip antennas have several advantages over conventional microwave antenna and therefore are used in a variety of practical applications. Microstrip antenna in its simplest design is shown in Figure 1.1. It consists of a radiating patch on one side of dielectric substrate (Єr≤10), with a ground plane on other side.

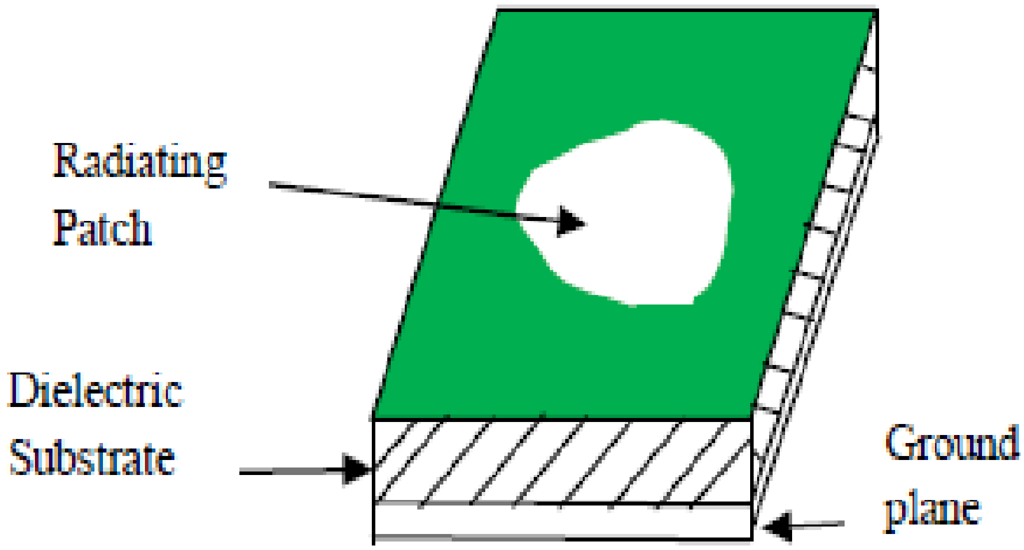

Figure 1.1: Microstrip antenna configuration

1.2 Microstrip Patch Antenna

A microstrip patch antenna (MPA) consists of a conducting patch of any non-planar or planar geometry on one side of a dielectric substrate and a ground plane on other side. It is a printed resonant antenna for narrow-band microwave wireless links requiring semi-hemispherical coverage. Due to its planar configuration and ease of integration with microstrip technology, the microstrip patch antenna has been deeply. The rectangular and circular patches are the basic and most commonly used microstrip antennas.

1.3 Horn Antenna

A Horn antenna is a type of aperture antenna which is specially designed for microwave frequencies. The end of the antenna is widened or in the horn shape. Because of this structure, there is larger directivity so that the emitted signal can be easily transmitted to long distances. Horn antennas operate in microwave frequency, so the frequency range of these antennas is super high or ultra-high which ranges from 300 MHz – 30 GHz.

2. FEEDING TECHNIQUES

Different methods are available to feed microstrip patch antennas. These methods can be contacting and non-contacting methods. In the contacting method, the RF power is fed directly to the radiating patch using a connecting element such as a microstrip line. In the non-contacting method, power is transferred between the microstrip line and the radiating patch through electromagnetic coupling. There are many feed techniques but the four most popular feeding techniques used are microstrip line, coaxial probe (both contacting schemes), aperture coupling and proximity coupling (both non-contacting schemes).

2.1 Microstrip Line Feed

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

2.2 Coaxial Feed

In this, the inner conductor of the coaxial connector extends throughout the dielectric and is soldered to the radiating patch, while the outer conductor is coupled to the ground plane. The major advantage of this is that the feed can be placed at any of the desired 26 locations inside the patch in order to match with its input impedance. The disadvantage is that it provides narrow bandwidth and is complex to model.

2.3 Aperture Coupled Feed

In this technique, the radiating patch and the microstrip feed line are separated by the ground plane. The patch and the feed line is coupled through a slot in the ground plane. The coupling slot is centered below the patch, leading to low cross polarization due to symmetry of the configuration. Since the ground plane separates the patch and the feed line, spurious radiation is minimized. The main disadvantage of this feed technique is that it is difficult to fabricate due to multiple layers, which also increases the antenna thickness.

2.4 Proximity Coupled Feed

This type of feed technique is also called as the electromagnetic coupling scheme. Two dielectric substrates are used and the feed line is between the two substrates. The radiating patch is on top of the upper substrate. The main advantage of this feed technique is that it eliminates spurious feed radiation and provides very high bandwidth (as high as 13%). The major disadvantage of this feed scheme is that it is difficult to fabricate because of the two dielectric layers which need proper alignment.

3. MATERIALS AND METHODS

3.1 Microstrip Patch Antenna

In telecommunications, a microstrip antenna (also known as a printed antenna) usually means an antenna manufactured using microstrip techniques on a printed circuit board (PCB). The most prevailing type of microstrip antenna is the patch antenna. Microstrip antennas are comparatively inexpensive to manufacture and design due to simple two-dimensional physical geometry. An advantage inherent to patch antennas is the ability to have polarization diversity. A microstrip patch antenna array can improve the gain in order to use our antenna in emission for the wimax band thus ensuring the transmission of data from the ambulance to the hospital. The radiating element and the feed line are constructed with the material PEC (Perfect Electric Conductor) of 0.035 mm thick. They are engraved on an Epoxy FR-4 substrate, with a relative permittivity $\mathcal{E}r$= 4.4, thickness h = 1.6 mm, with the resonance frequency fr = 2.45 GHZ. Epoxy FR-4 is chosen as the substrate material because it is very affordable in terms of cost and has superior and outstanding mechanical properties, making it suitable for a wide range of applications on an electronic component.

3.2 Proposed Antenna Design For Microstrip Patch Antenna

The proposed dual band microstrip patch antenna array consist of a substrate material, ground plane, patch, feedline and port. Here, we choose FR-4 epoxy as the substrate material which has a thickness of 1.6mm. FR-4 glass epoxy is a popular high-pressure thermoset plastic laminate grade having good strength to weight ratios. The material is known to retain its high mechanical value and electrical insulating qualities in both dry and humid conditions. These properties, along with good fabrication characteristics gives utility to this grade for a wide variety of electrical and mechanical applications, with relative permittivity of 4.4. The conducting components such as radiating element and feed line are in different planes. Here, we are using inset feed because of its simplicity and ease of fabrication. It also helps to improve the bandwidth and return loss of the antenna.

3.3 Proposed Antenna Design For Horn Antenna

A pyramidal horn antenna is designed keeping in view some certain specifications. The frequency range is of the main parameters. This horn is required for C-Band uplink frequency range (5.925GHz-6.425GHz) with center frequency at 6.175GHz. The required gain of the horn is 15dB. The waveguide adapter used to excite the horn covering our desired frequency range is WR137. The inner dimensions of this adapter are 3.4849cm x 1.5799cm. The larger and smaller dimensions are represented by “a” and “b”, respectively.

4. STRUCTURE OF ANTENNA

4.1 STRUCTURE OF MICROSTRIP PATCH ANTENNA

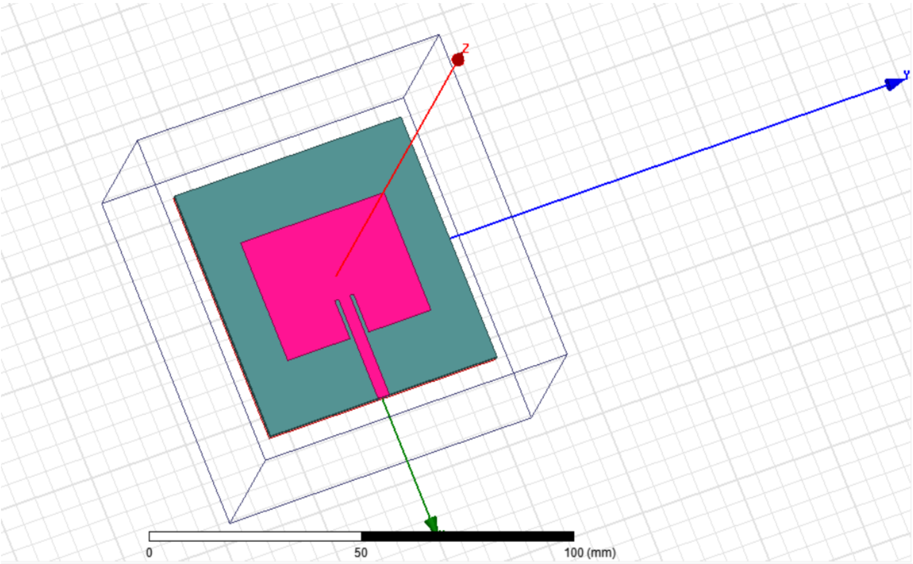

Figure 4.1.1: Front view of microstrip patch antenna array.

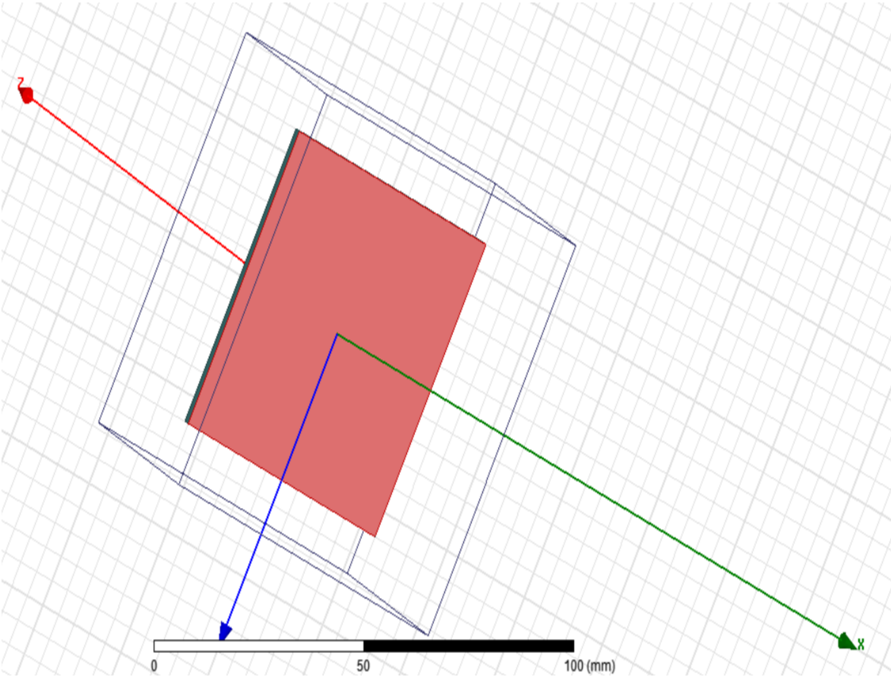

Figure 4.1.2: Bottom view of microstrip patch antenna array.

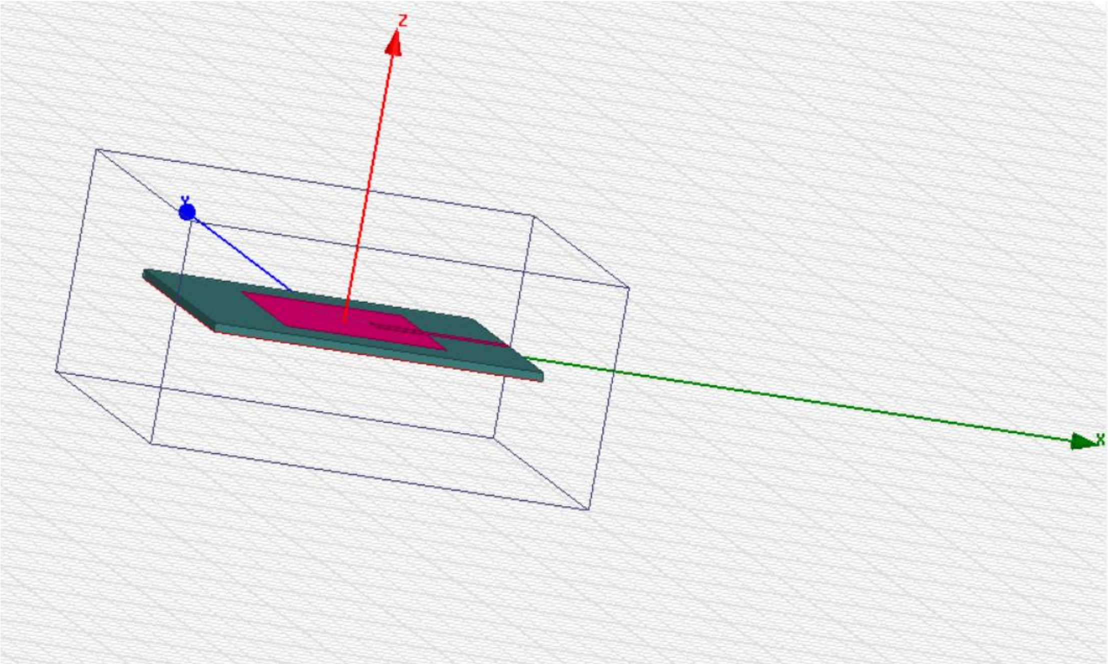

Figure 4.1.3: Side view of dual band microstrip patch antenna array.

4.2 STRUCTURE OF HORN ANTENNA

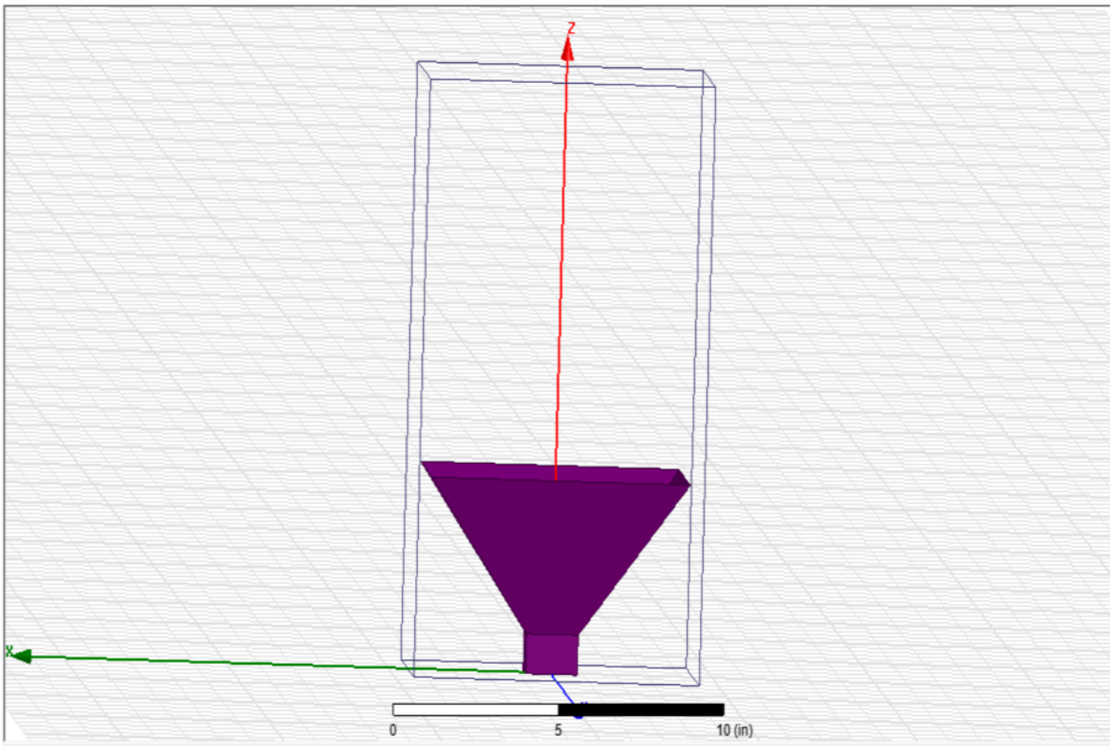

Figure 4.2.1- Front View of Horn Antenna.

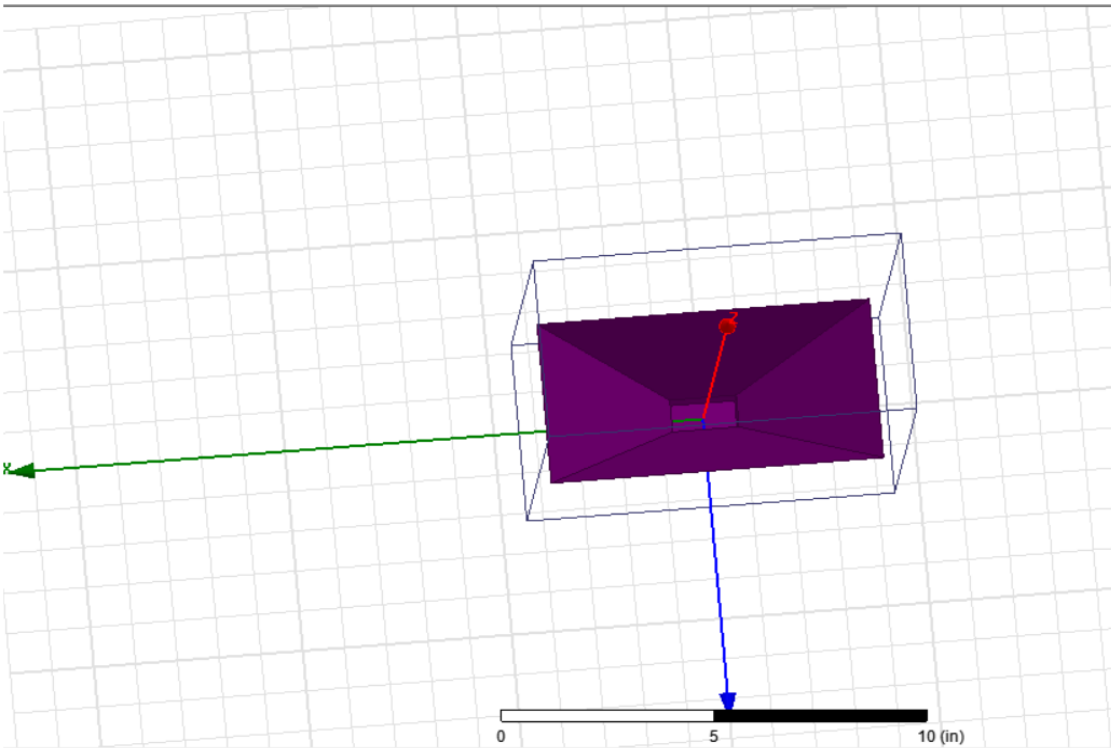

Figure 4.2.2- Top View of Horn Antenna.

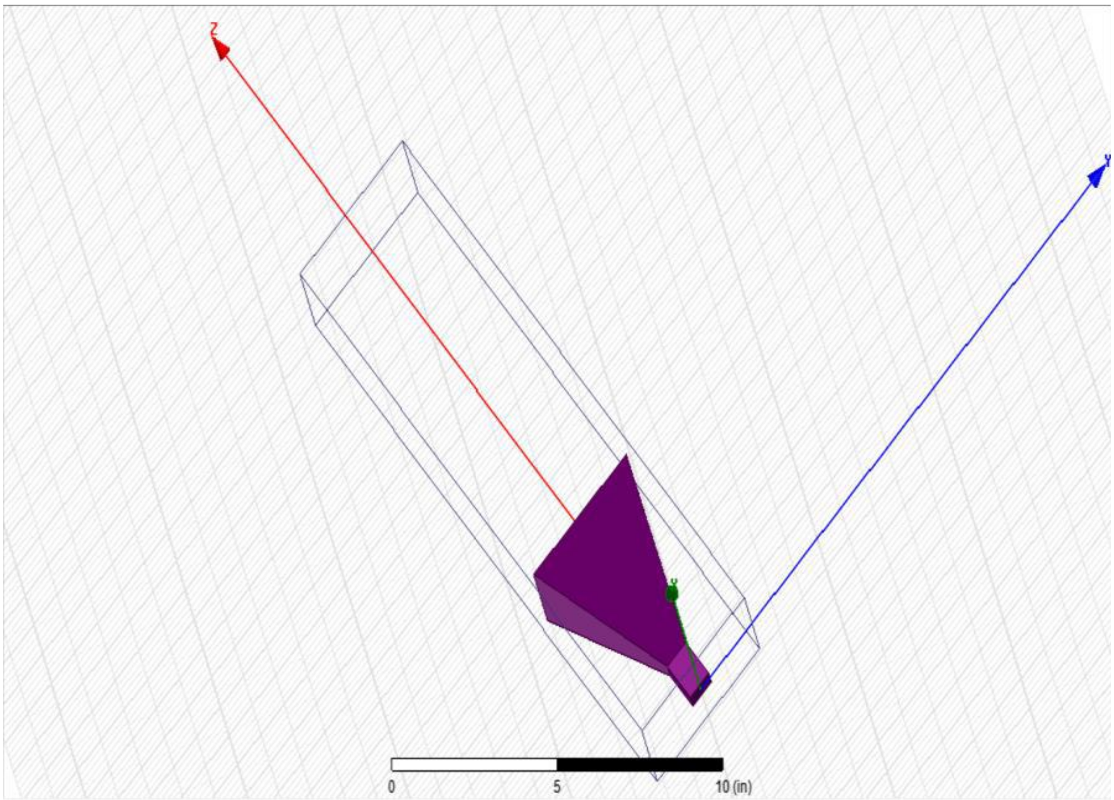

Figure 4.2.3- Side View of Horn Antenna.

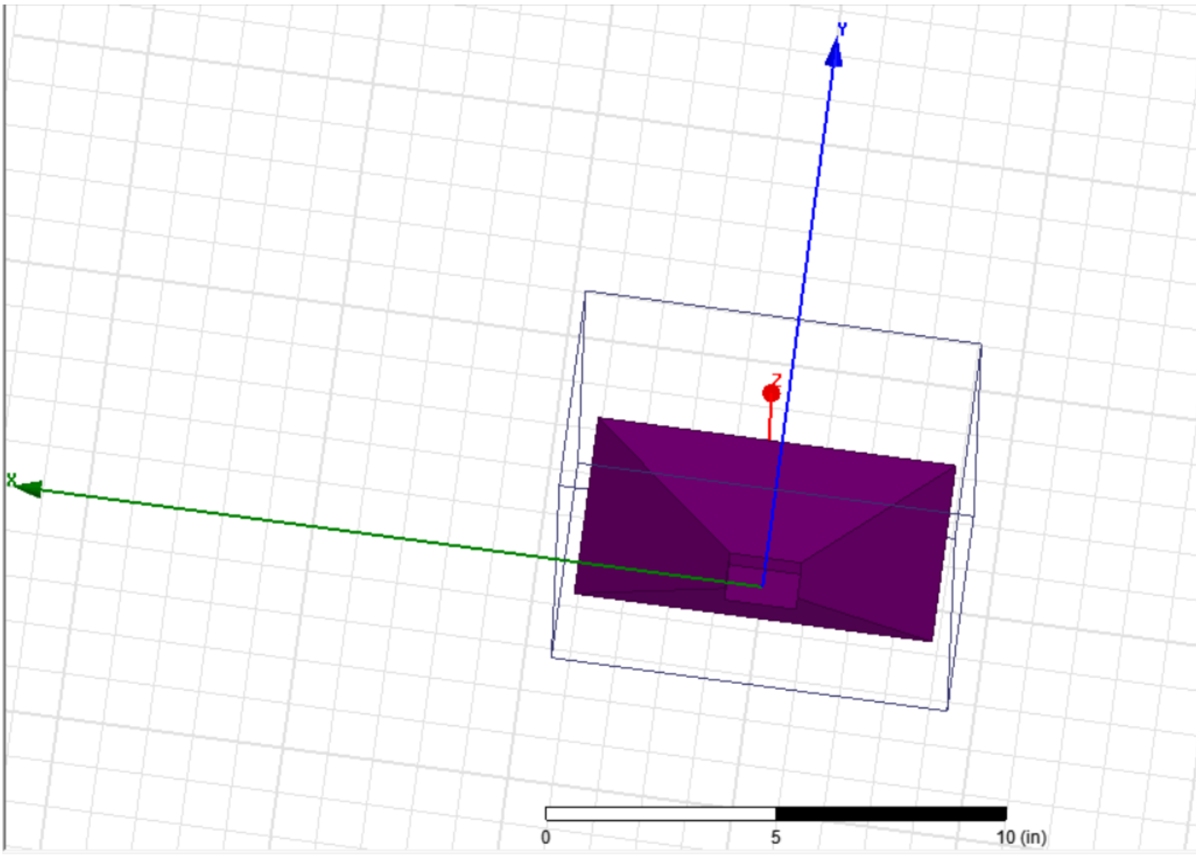

Figure 4.2.4- Bottom View of Horn Antenna.

5.RESULT

The simulations results are focused on the adaptation parameters such as the return loss, the VSWR. It also focused on far field radiation characteristics including gain, directivity.

5.1 S Parameter Graph Of Microstrip Patch Antenna

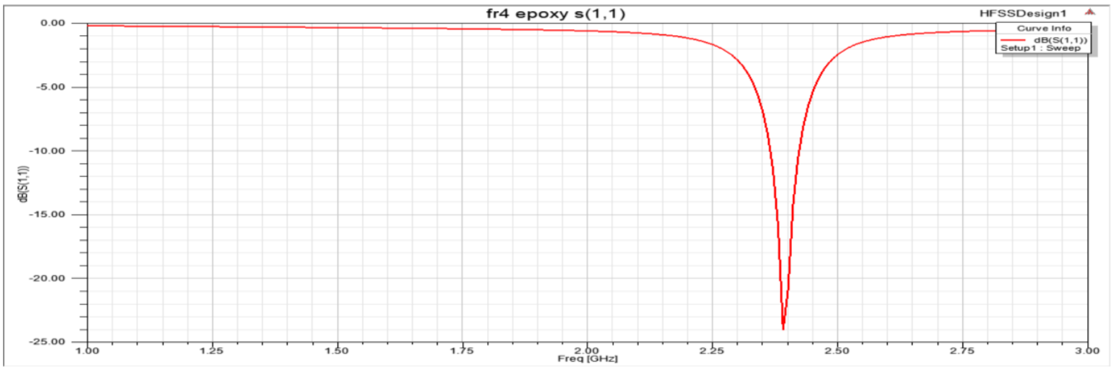

Figure 5.1.1: S Parameter Graph of Microstrip Patch Antenna with Fr4 Epoxy

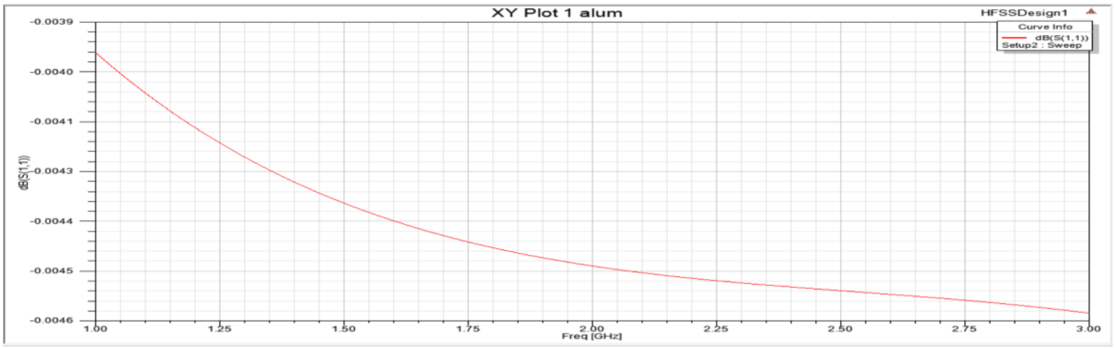

Figure 5.1.2: S Parameter Graph of Microstrip Patch Antenna with Aluminium

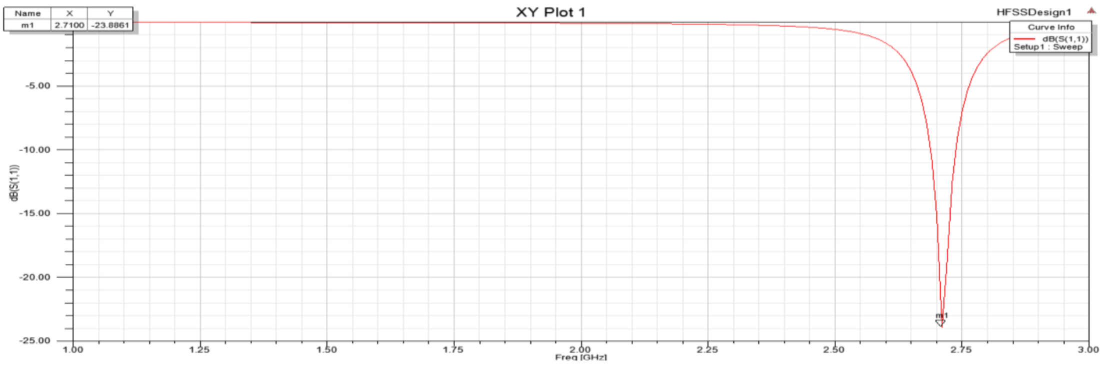

Figure 5.1.3: S Parameter Graph of Microstrip Patch Antenna with Polyester

5.2 Gain Of Microstrip Patch Antenna

It is the ratio of maximum radiation intensity in given direction to the maximum radiation intensity from the reference antenna produced in the same direction with the same power input. In general, antenna gain indicates how strong a signal can be send or received by an antenna in a specified direction. It also explains the radiation behavior of the antenna in far fields. The proposed antenna array has a gain value of 2.81dB, which shows that the antenna is well radiating.

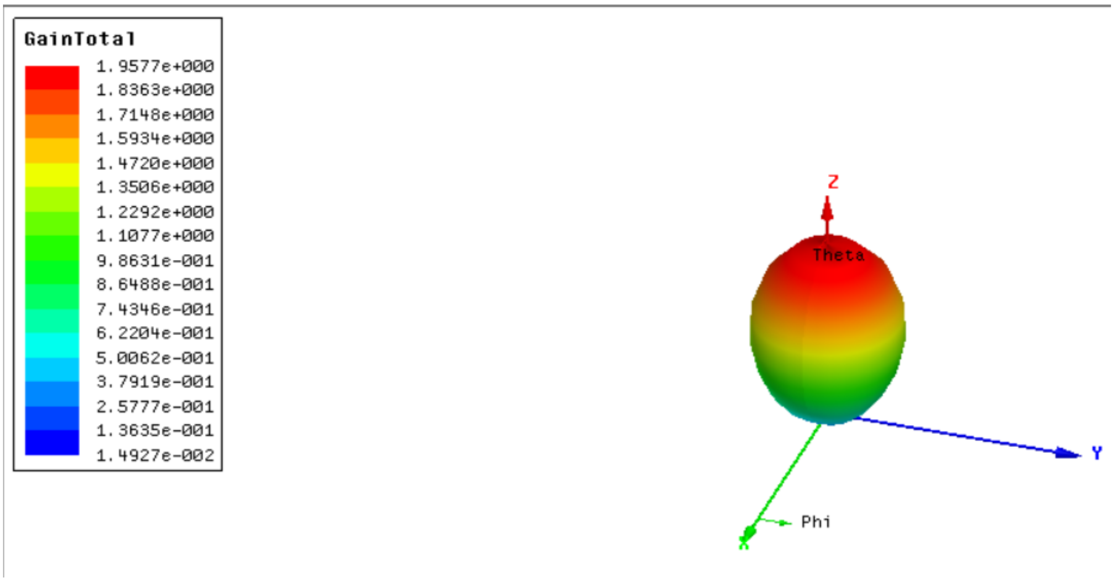

Figure 5.2.1: Gain of Microstrip Patch Antenna with Fr4 Epoxy

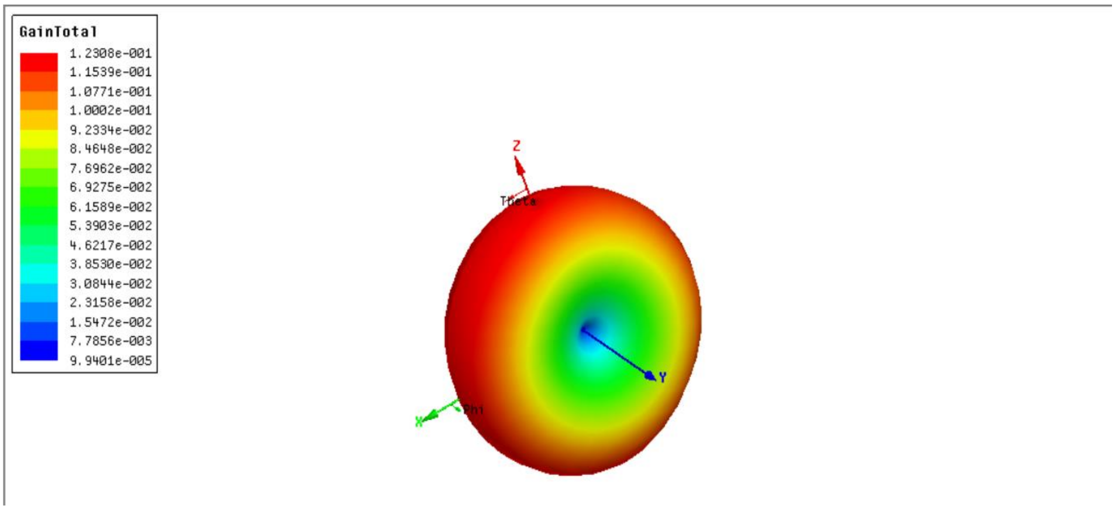

Figure 5.2.2: Gain of Microstrip Patch Antenna with Aluminium

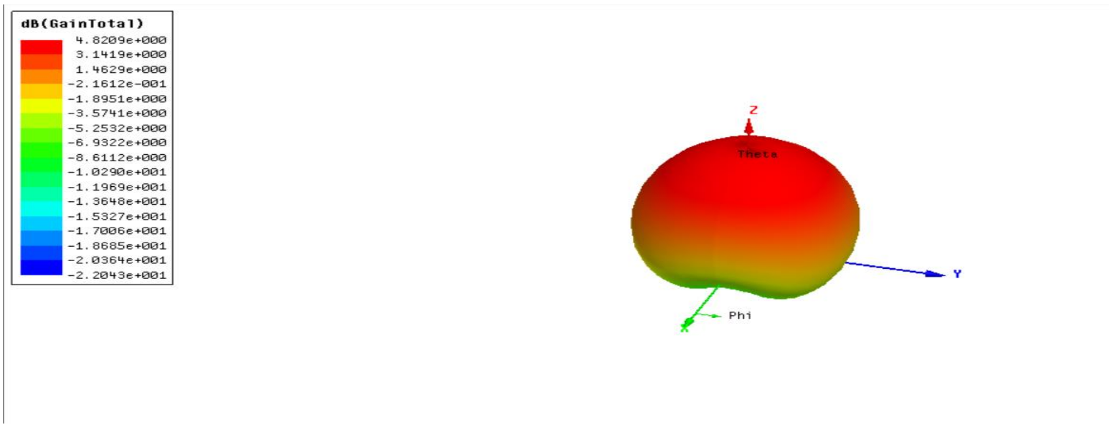

Figure 5.2.3: Gain of Microstrip Patch Antenna with Polyester

5.3 Directivity Of Microstrip Patch Antenna

Directivity is a fundamental antenna parameter. Directivity is the ratio of the radiation intensity in a given direction from the antenna to the radiation intensity averaged over all directions. It is a measure of how directional an antennas radiation pattern is. From Fig 5.3, we can say that the directivity of the proposed antenna is 2.68dB. Directivity must be always greater than one.

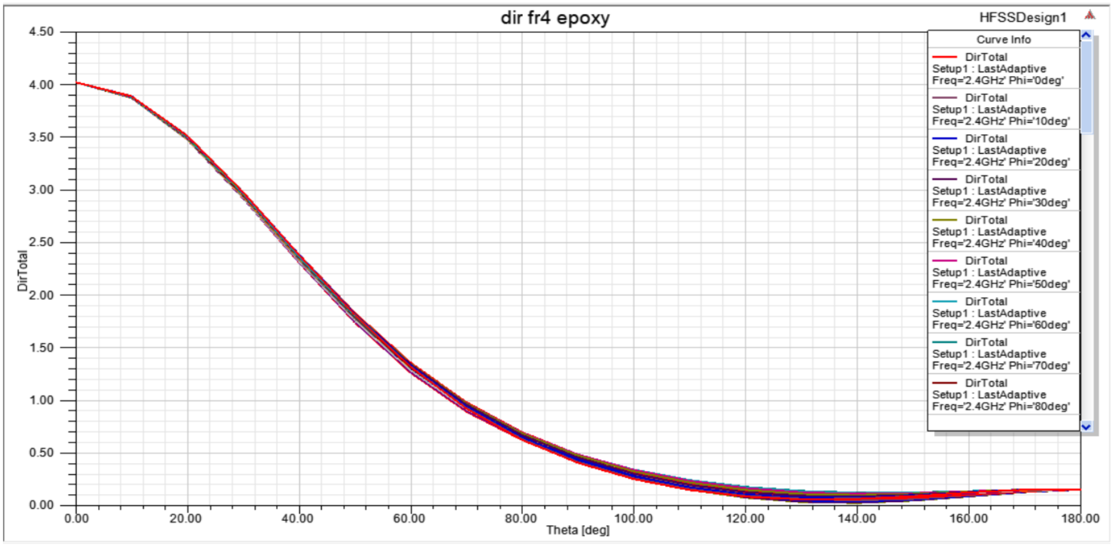

Figure 5.3.1: Directivity of Microstrip Patch Antenna with Fr4 epoxy

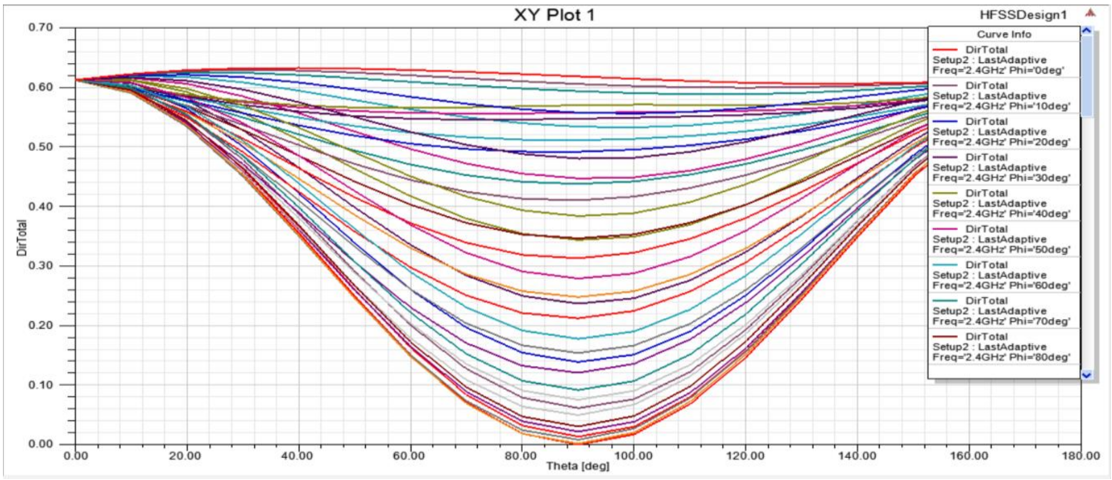

Figure 5.3.2: Directivity of Microstrip Patch Antenna with Aluminium

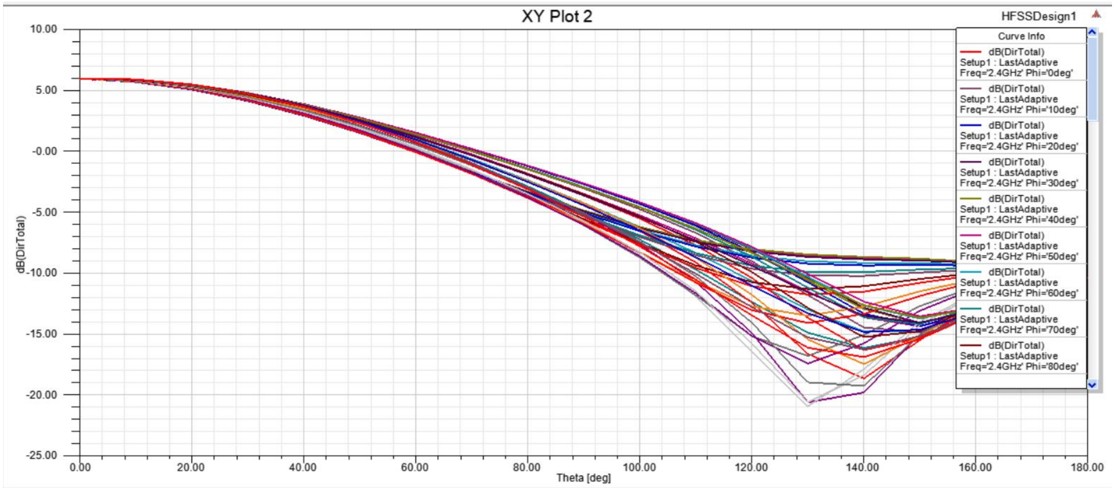

Figure 5.3.3: Directivity of Microstrip Patch Antenna with Polyester

5.4 Radiation Pattern Of Microstrip Patch Antenna

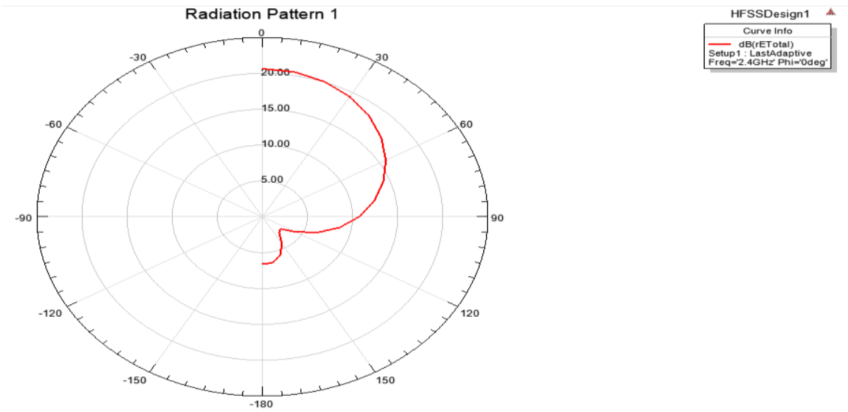

Figure 5.4.1: Radiation Pattern of Microstrip Patch Antenna with FR4 epoxy

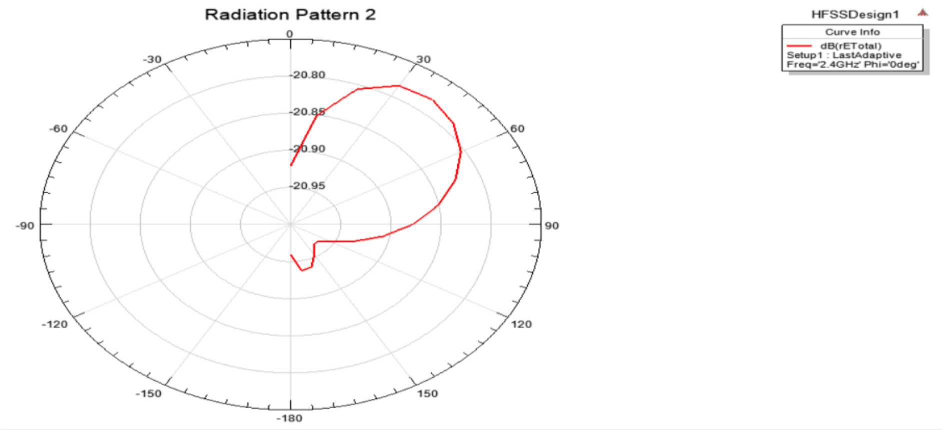

Figure 5.4.2: Radiation Pattern of Microstrip Patch Antenna with Aluminium

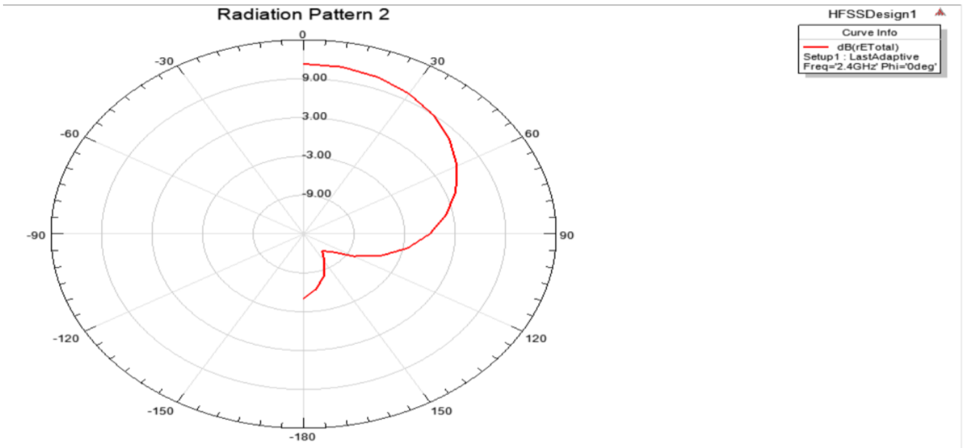

Figure 5.4.3: Radiation Pattern of Microstrip Patch Antenna with Poly ester

5.5 S Parameter Graph Of Horn Antenna

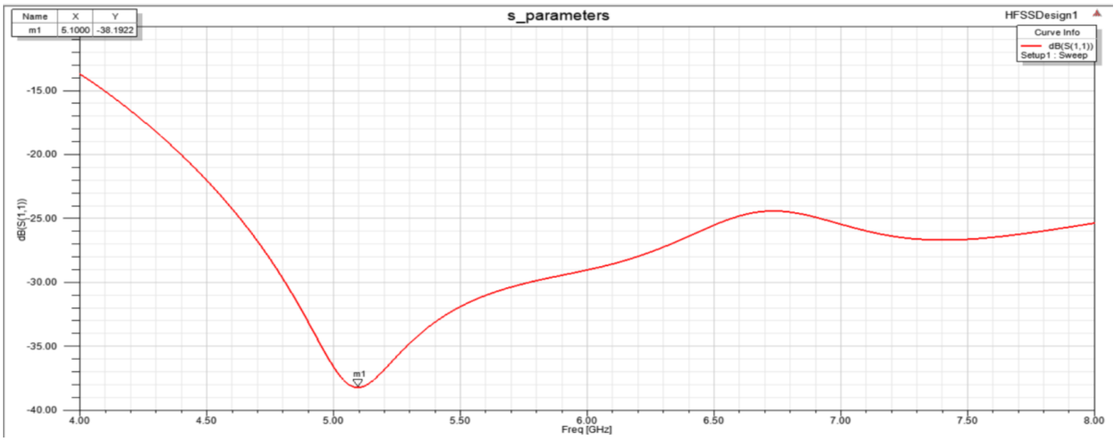

Figure 5.5.1: S Parameter Graph of Horn Antenna

5.6 Gain Of Horn Antenna

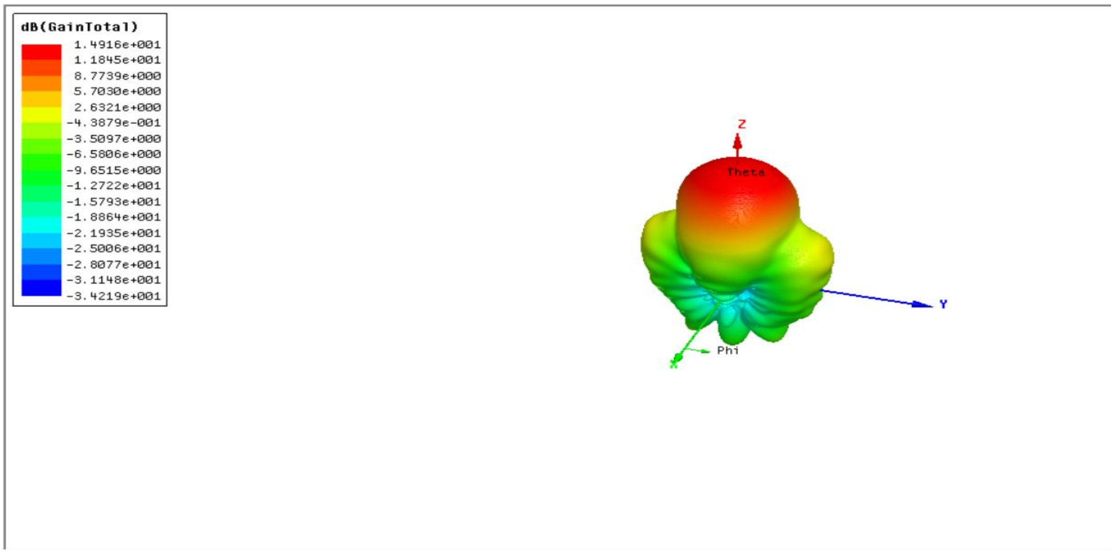

Figure 5.6.1: Gain of Horn Antenna

5.7 Radiation Pattern Of Horn Antenna

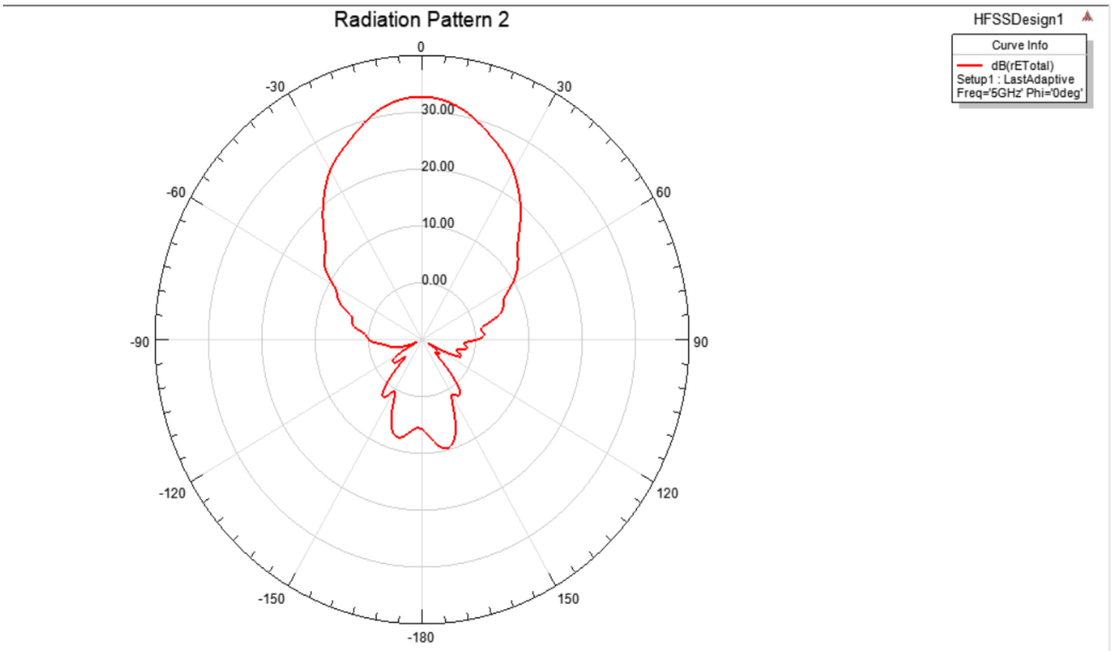

Figure 5.7.1: Radiation Pattern of Horn Antenna

6. APPLICATIONS

6.1 Applications Of Microstrip Patch Antenna

Microstrip patch antenna has a number of applications. Some of these applications are:

- Mobile and Satellite Communication
- Radio Frequency Identification (RFID)
- Interoperability for Microwave Access (WiMax)
- Radar Application
- Global Positioning System Applications

6.2 Applications Of Horn Antenna

The applications of horn antenna include the following.

- These are used mainly for astronomical studies.
- These are used in microwave-based applications.
- These can be used as feed elements.
- These are used in laboratories to measure different antenna parameters.
- At microwave frequencies, these are used wherever moderate gains are adequate.
- The horn dimensions must be high for high gain to use in moderate gain operations.
- These types of antennas are applicable in speed enforcement cameras to keep away from reflections that interrupt the desired response.
- Parabolic reflectors can be excited by feeding elements like horn antennas. So the higher directivity provided through this antenna permits it to light up the reflector.

7.CONCLUSION

We had design microstrip patch antenna with three different substrates i.e., FR4 epoxy, aluminum & polyester. By comparing these three material we get to know that FR4 epoxy is good for substrate material in terms of frequency and return loss. Also we had design horn antenna having FR4 epoxy substrate material. We had designed horn antenna to compare with microstrip patch antenna. And we got that the return loss of horn antenna is less than that of microstrip patch antenna.

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