Design of a Dual-band MIMO Antenna for 5G Smartphone Application

Submitted in partial fulfilment of the requirements of the degree of

Bachelor of Engineering

in

Electronics and Telecommunication

by

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Under the guidance of

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University of Mumbai

2019-2020

CERTIFICATE

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University of Mumbai

2019-2020

This is to certify that the project entitled Design of a **Dual Band MIMO Antenna for 5G Smartphone Application** is a Bonafede work **Suleman Mir (17DET49), Faizan Khan (17DET44), Maaz Mulla (16ET23)** submitted to the university of Mumbai in partial fulfilment of the requirement or the award of the degree of Bachelor of Engineering in Department of Electronics and telecommunication Engineering. Submitted to the University of Mumbai to the in the partial fulfilment of the requirement for the award of the degree of Bachelor of Engineering in Department of Electronics and Telecommunication Engineering. The said work has been assessed by us and satisfied that same is up to standard envisaged for the level of the course.

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Name: ______________________
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Project Report Approval for Bachelor of Engineering

This project entitled **"Design of a Dual Band MIMO Antenna for 5G Smartphone Application"** by **Suleman Mir (17DET49), Faizan Khan (17DET44), Maaz Mulla (16ET23)** is approved for the degree of Bachelor **of Engineering Electronics and Telecommunication.**

Examiner

....

Supervisor

…………………………..

Date:

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We declare that this written submission represents my ideas in our own words and where others ideas or words have been included, we have adequately cited and referenced the original sources. We also declare that we have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in my submission. We understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

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Date:

Acknowledgments

It is our great pleasure to present this report, a written testimonial of a fruitful experience. It would be unethical on my art to claim complete credit for the project. We therefore take this opportunity to express acknowledgement to all those individuals who helped in making our project a success. First and foremost, we would like to thank **Prof. Afzal Shaikh (HOD- Electronics & Telecommunication Department)** working with whom is a delightful and wholesome learning experience highly indebted to **Prof. Rahul Khadase** for guidance and constant supervision as well as for providing necessary information regarding the project.

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Abstract

In this project, we are designing a low- profile micro strip patch antenna for next generation 5G devices. The proposed antenna consists of four antennas, it operating at 3300-3600 MHz and 4800-5000Mhz the antenna designed in this letter are different from traditional 5G antenna. It can be applied to the popular full screen mobile phone. In order to meet the modern 5G wireless communication system. Study of the 5G Smartphone antenna has greater application value. With the development of mobile 4G communication system, peoples' requirements for the speed of mobile communication are rapidly increase. The research and development of the fifth-generation antenna has been carried out. The antenna offers the possibility of high- speed data transmission. An 8 element PIFA based MIMO antenna system was proposed. it only covers a single 3.5 GHZ band and the minimum isolation between the various antenna element only 7.4db.

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Keywords and Glossary

Keywords

1. Smart phone
2. 5g operation
3. MIMO antenna
4. Patch antenna
5. Gain
6. Return loss
7. Dielectric material

Glossary

MIMO antenna: Multiple input, multiple output is an antenna technology for wireless communication in which is multiple antennas are used at both the source and the destination to minimize error and optimize data speed.

Patch: A patch antenna is a type of radio antenna with a low profile, which can be mounted on the flat surface. It consists of a rectangular sheet or “patch” of metal, mounted over a larger sheet of metal called a ground plane [5].

Gain: Antenna gain is usually defined as the ratio of the power produce by the antenna from a far field source on the antennas beam axis to the power produced by a hypothetical lossless isotropic antenna, which equally sensitive to signals from all direction [5].

Return loss: in telecommunication, return loss is the loss of power in the signal returned/reflected by the discontinuity in a transmission line or optical fiber [5].

Dielectric material: A dielectric material is an electrical insulator that can be polarized by an applied electric field [5].

Chapter 1

Introduction

With the development of wireless communication techniques, multiple inputs multiple outputs (MIMO) technology is attracting. It knows MIMO operation can highly improve the data rate, capacity, and link reliability of wireless communication system. MIMO technology currently used in fourth generation (4G) user equipment with frequency band of 2.6 GHZ and is going to be used in the future fifth generation (5G) portable device. the 3.6 GHZ frequency band appears promising for sub-6 GHZ MIMO 5G communication [1].

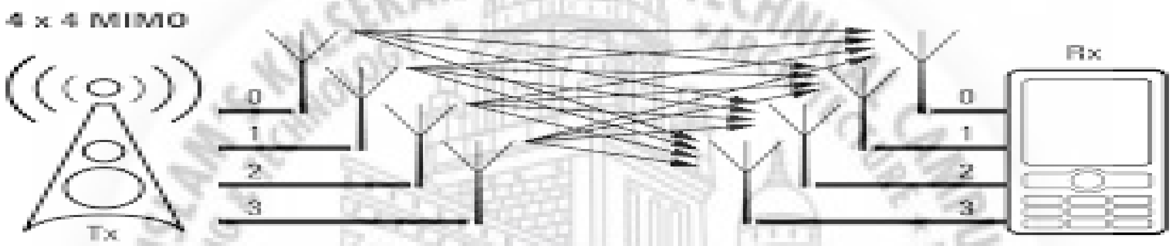


Figure1: multiple inputs and multiple outputs (MIMO)

The problem of a current framework, investigation of the 5G mobile phone reception equipment has extraordinary application esteem. With the advancement of versatile 4G correspondence frame work, individual wants for the speed of versatile correspondence area unit quickly increase these problems innovating work of the fifth radio wire has been send out. Multi-units add the 3400-600MHZ single band standard 5G receiving wire was proposed. An 8 component PIFA based MIMO radio wire framework as projected in its simple cover a solitary 3.5 GHZ band [1].

Dual band equipment is capable of transmitting in either of two different standard frequency ranges. Modern wi-fi home networks feature dual band broadband route that support both 2.4GHZ and 5GHZ channels. Dual band MIMO antenna which consist of four elements. The antenna not only can operate in the dual frequency band of 300-3600MHZ and 4800-5000MHz.but also a 12db of isolation is obtain, the four antenna are disposed along two side edges of the smart phone, meet the requirement of a full screen smart hone antenna design, in line with current trend of full screen smart phone[1].

1.2 Motivation

Today wireless communication has become more of a necessity in various applications. One more use of wireless system is one that connect the mobile network to connect to the satellite ex. GPS system where device need to be within the range of 3 or more satellite. In many scenarios where the wire system is impractical or almost impossible to be implemented. Wireless system has been readily replaced. Many systems are actually required to transmit a message and receive it with minimal error in a wireless system. Recently use of meta-materials and dielectric resonators the antenna size has been reduced to very small size for actual practical application [4].

1.3 Objective

Micro strip patch antennas are small antennas that are fabricated over a Printed Circuit Board and can be used in embedded systems and applications as such. In this, our aim is to provide a solution for the various demanding parameters in the micro strip patch antenna for reduction in size apart from large bandwidth and higher data rates. The objective is to study the different antenna parameters and come up with a comparative study on why met material- based antenna are better than the conventional antenna. We have also created an interactive Graphical User Interface (GUI) that would help in calculation of antenna parameters [3].

1.4 Scope

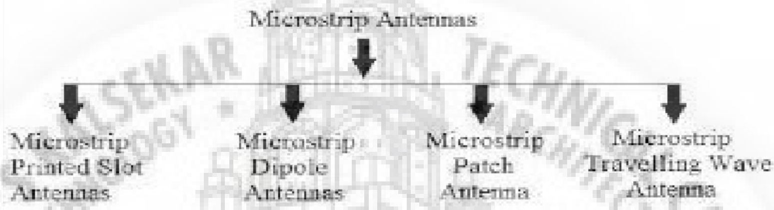
Global 5g technology industry is expected to witness significant growth over from 2016 to 2024.rising worldwide adoption of internet-enable devices will drive the industry. Mobile service providers believe that 5G service will be rolled out by 2020 to meet customer and business demand.
Surging demand for extensive network coverage and high- s p e ed internet from various industry application will proper market growth. these include autonomous driving, distance learning, video conferencing and multi-user gaming, telemedicine and opera live streaming.5G improve the mobile network performance it can also play a key role in establishing foundational infrastructure [6].

Chapter 2

Literature Review

Paper Title:
Design of a Dual Band MIMO Antenna for 5G Smartphone Application

2.1 Different types of Microstrip Antenna



There are three types in micro strip antenna:

Microstrip patch antenna

Microstrip dipole antenna

Printed slot antenna

Microstrip traveling wave antennas

2.2.1 Microstrip patch antenna

A microstrip patch antenna (MPA) consist of a conducting patch of any planer or nonplanar geometry on one side of a dielectric substrate with aground plane on other side .it is a popular printed resonant antenna for narrow band microwave wireless inks that required semi hemisphere coverage the rectangular and circular patches are basic and most commonly used microstrip antennas[5].

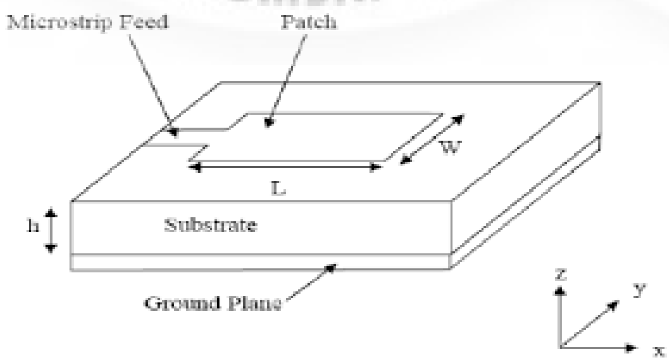


Figure 2: Microstrip patch antenna

2.2.2 Microstrip dipole antenna

Microstrip dipole antenna are frequently used in today wireless communication system tanks to their low profile, they can be mounted t the wall of buildings, to the fuselages of airplanes or the reverse side of mobile phone.

2.2.3 Printed slot antenna

Slot antennas consist of a metal surface, usually a flat plate, with one more holes or slot cut out. When the plate is driven as an antenna by driving frequency, the slot radiates electromagnetic wave in a way similar to the dipole antenna.

2.2.4 Microstrip traveling wave antennas

Travelling wave antennas are a class of antenna that use a travelling wave on a guiding structure as the main radiating mechanism it is well known that antennas with the open-ended wires where the current must go to zero.

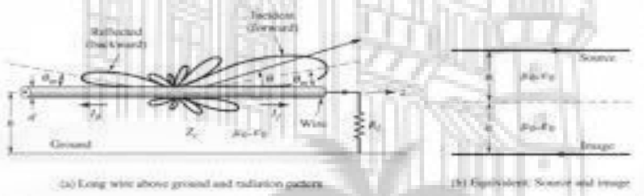


Figure 3: Microstrip traveling wave antenna

2.3 PIFA (planer inverted F antenna) antenna

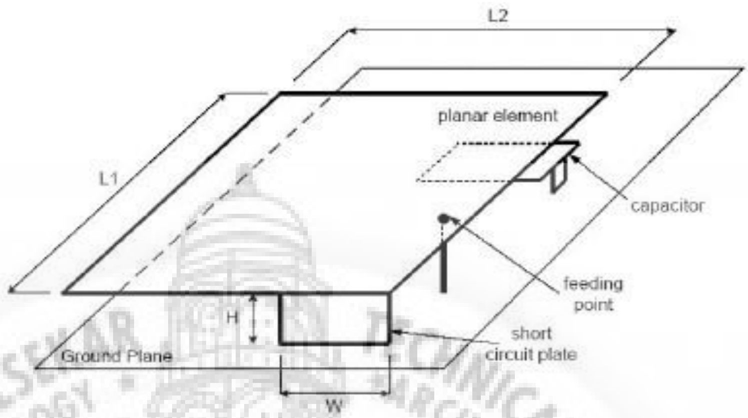


Figure 4: PIFA antenna

Planer inverted F antenna (PIFA) is a linear inverted F antenna (IFA).in order to increase the bandwidth and resonant frequency, the radiator element is replaced by a plate. PIFA which has reduced backward radiation enhance antenna performance in terms of gain and minimize the wave produced due to power absorption. It has maximum gain I term of polarization state like horizontal and also vertical. By changing the height, length, width of the ground plane the bandwidth to be tuned .to decrease the quality factor and to boost the bandwidth, many slits can insert in the ground plane. In medical application, the main aim is to reduce the size of PIFA antenna maximum [1].

2.4 Dielectric material

A dielectric is an electric insulator that can be polarized by an applied electric field. Dielectric material is electrically non conducting material such as glass, ebonite, mica, rubber, wood, and paper.al dielectric material is insulating material. The different between a dielectric and an insulator lies in their application. If the main function of non-conducting material is to provide electrical insulator, then they are called as insulator. On the other hand, if the main function of non-conducting material is to store electrical charges then they are called as dielectrics. Generally, the dielectrics are non-metallic material of high resistivity. They have a very large energy gap. All the electrons in the dielectrics are tightly bound to their parent nucleus. They have negative temperature coefficient of resistance and high isolation resistance [2].

2.4.1 Permittivity (ε)

The permittivity represents the dielectric property of a medium. It indicates easily polarized nature of material. Its unit is farad/meter [2].

2.4.2 Dielectric constant (ε_r)

A dielectric characteristic of a material is determined by its dielectric constant. It is measure of polarization of the dielectrics.
It is the ratio between absolute permittivity of the medium and permittivity of free space.
Dielectric constant=absolute permittivity (ε)/permittivity of free space (ε_0)

$$\varepsilon_r = \varepsilon / \varepsilon_0$$

Polarization

The process of producing electric dipoles inside the dielectric by the application of an external electrical field is called polarization in dielectrics.

Polarizability

It is found that the average dipole moment field (E)

Polaris ability is defined as the ratio of average dipole moment to the electrical field applied.
Its unit is farad m^2.[5].

2.5 Fringing effect

It is the fringing fields that are responsible for the radiation. Note that the fringing field near the surface of the patch antenna are both in the y direction. Hence, the fringing E- field on the edge of the microstrip antenna add up in phase are produced the radiation of the microstrip antenna. The current adds up in phase on the patch antenna as well an equal current but with opposite direction is on the ground plane which cancel the radiation's microstrip antenna radiation arises from the fringing field which are due to advantages voltage distribution.

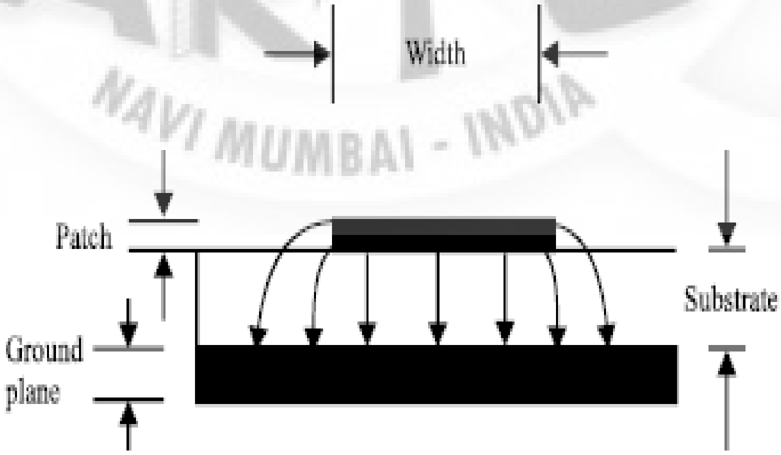


Figure 5: Fringing field

2.6 Feeding techniques of microstrip antenna

The four most popular technique used are the microstrip line, coaxial probe (both contacting schemes), aperture coupled and proximity coupling (both non contacting schemes) strip line feeding

In this line feed technique, 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. The kind of feed arrangement has the advantages that the feed can be etched on the same substrate to provide a planer structure. An insert cut can be incorporated into the patch in order to obtain good impedance matching without the need for any additional matching element. This is achieved by properly controlling the insert position [5].

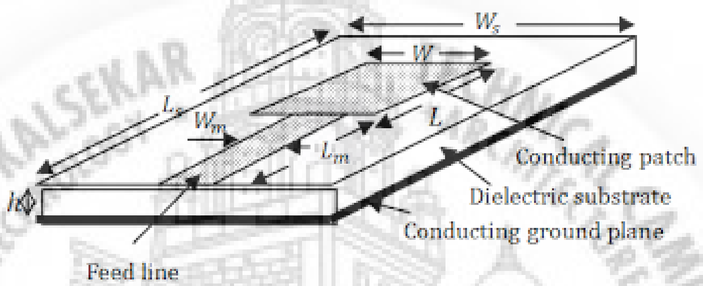


Figure 6: Microstrip line feeding

2.6.1 Coaxial feeding

The coaxial feed or probe feed one of the most common technique used for feeding microstrip patch antennas the inner conductor of the coaxial connector extends through the dielectric and is soldered to the radiating patch, while the outer conductor is connected to the ground plane The main advantage of these type of feeding scheme is that the fed can be placed at any desired position inside the patch is order to obtain impedance matching. The feed methods are easy to fabricates and low spurious radiation effects.

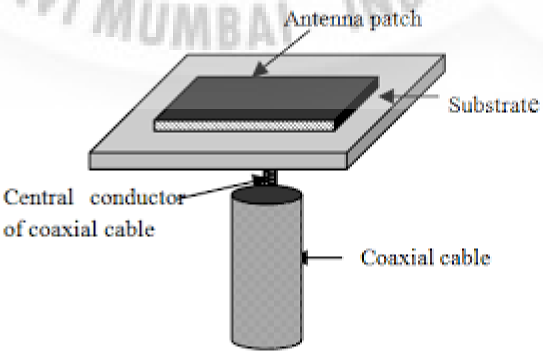


Figure 7: coaxial feeding

2.6.2 Aperture coupled feeding

In aperture coupling the radiating microstrip patch element is etched on the top of the antenna substrate, and microstrip feed line is etched on the bottom of the feed substrate in order to obtain aperture coupling. The thickens and dielectric constant of these two substrates may thus be chosen independently to optimize the distinct aperture I usually cantered under the patch, leading to lower cross polarization due to symmetry of the configuration. The amount of coupling from the fed line to the patch is determined by the shape, size and location of the aperture. Since the separate the patch and feed line, spurious radiations minimize.

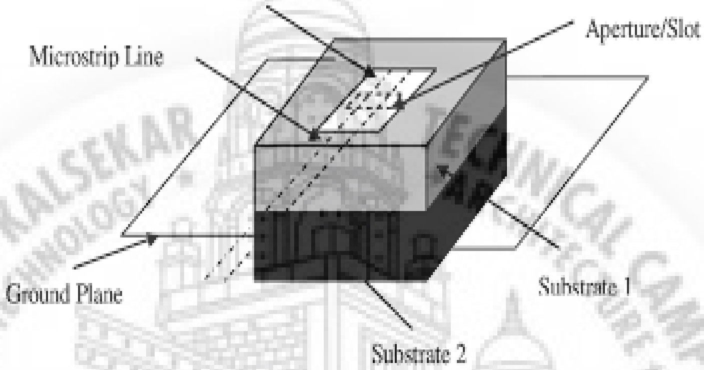


Figure 8: Aperture coupled feed

2.6.3 Proximity coupled feeding

This type of feed technique is also called as the electromagnetic coupling scheme. Two dielectric substrates are used such that the feed line is between the two substrate and the radiating patch is on top of the upper substrate. The main advantage of this feed technique is that is eliminating spurious feed radiation. The main advantage of this feed radiations and provides very high bandwidth of about 13%, due to increase in the electric thickness of the microstrip patch antenna this scheme also provides choices between two different dielectric media, one for the patch and one for the feed line optimize the individual performance.

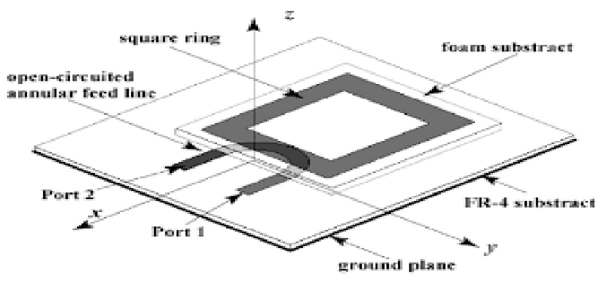


Figure 9: Proximity coupled feed

Chapter 3

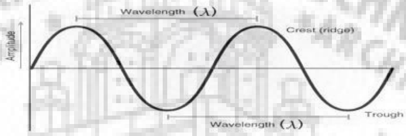
Technical Details

3.1 Methodology

For designing of a microstrip patch antenna, we have to select the resonant frequency and a dielectric medium for which antenna is to be designed. The parameters to be calculated are as under [5].

1. Wavelength

The wavelength can be defined as the distance between two successive crests or troughs of a wave. It is measured in the direction of the wave.



$$\lambda = C/F.$$

Substituting C= 3x10^8, F=3.5GHZ

$$\lambda = 0.08565m.$$

2. Calculation Width of patch

The width of the patch is calculated using the following equation

$$W = \frac{c}{2f_o\sqrt{\frac{(\varepsilon_r + 1)}{2}}}$$

Substituting C=3x10^8, F=3.5GHZ, ε_r= FR4 4.4

W=26.08m

3.Calculation of the effective length

Calculation of the effective dielectric constant. This is based on the height, dielectric constant of the dielectric and the calculated width of the patch antenna. The effective refractive index value of a patch is an important parameter in the designing procedure of a microstrip patch antenna.The radiations traveling from the patch towards the ground pass through air and some through the substrate (called as fringing). Bath the air and the substrates have different dielectric values, therefore in order to account this we find the value of effective dielectric constant. The value of the effective dielectric constant (r) is calculated using the following equation

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

Substituting $\varepsilon_{r=}$ FR4 4.4, height =1.4mm, width=26.08m

ε_{eff} = 4.436

4.Calculate the effective length

$$L_{eff} = \frac{c}{2f_o\sqrt{\varepsilon_{eff}}}$$

Substituting ε_{eff} =4.436, c=3x10^8, f=3.5GHZ

Leff = 18.43m

5.Calculation of extension length

Due to fringing, electrically the size of the antenna is increased by an amount of (ΔL). Therefore, the actual increase in length (ΔL) of the patch is to be calculated using the following equation

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

Substituting ε_{eff} = 4.436, width =26.08m, height=1.4mm

ΔL=6x10^4

6.Calculation actual length of patch

The length (L) of the patch is now to be calculated using the below mentioned equation

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

Substituting Leff = 18.43m, ΔL=6x10^4

L=-59.98mm

7. Calculation of the ground plane dimensions

Now the dimensions of a patch are known. The length and width of a substrate is equal to that of the ground plane. The length of a ground plane (Lg) and the width of a ground plane (Wg) are calculated using the following equations.

$$L_g = 6h + L$$
$$W_g = 6h + W$$

Substituting Length=, height=1.4mm, width=26.08m

Lg = 68.38mm

Wg=26.08

3.2 Project requirement

3.2.1 Software required:

HFSS software (high frequency software simulation)

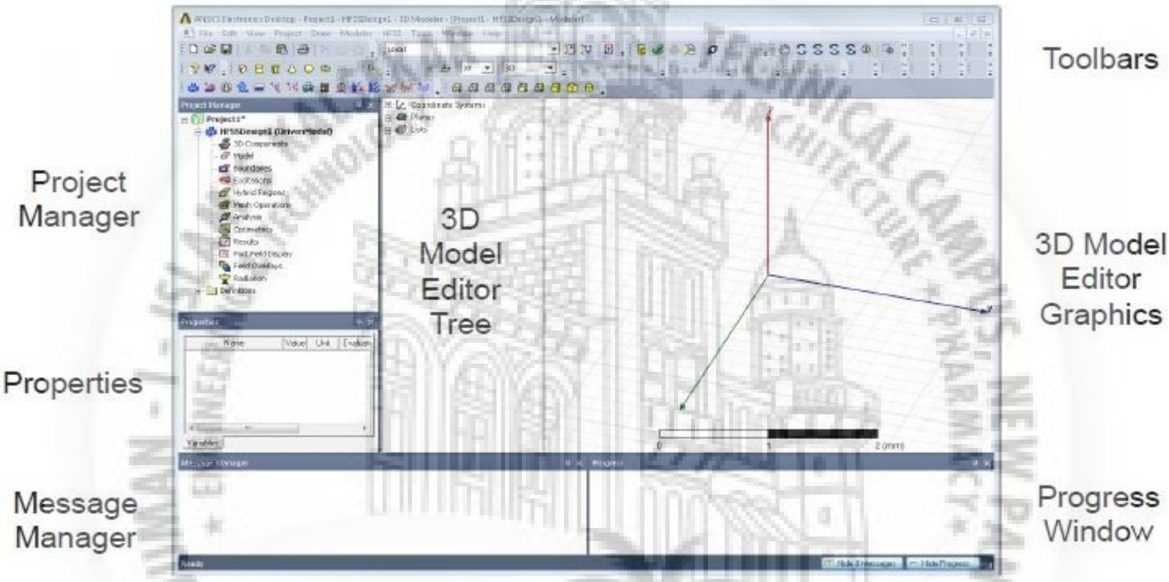


Figure.10: Hfss software

HFSS is a high-performance full wave electromagnetic (EM) field simulator for arbiter 3d volumetric passive device modelling that take advantage of the familiar Microsoft user graphical user interface. It integrates simulation, visualization, solid modelling, and automation in an easy to learn environment where solution to your 3D EM problems are quickly and accurate obtained. Ansoft HFSS employs the Finite Element Method (FEM), adaptive, meshing, and brilliant graphics to give you unparalleled performance and insight to all of your 3D EM problems
Ansoft HFSS can be used to calculate parameter such as S-parameter, resonate frequency, and fields [1].

Getting start with HFSS:

- Create new project:
  Click File>New.
  A new project is listed in the project tree in the project manager window.

- Inserting HFSS design:

Click project>insert HFSS design insert HFSS-IE design.
The new design is listed in the project tree. It is named HFSS design.
The 3D modeler window appears to the right of the project manager.

Selection the solution type
Click HFSS>Solution type.
Select one of the following solution types.
1. Driven mode
2. Driven terminal
3. Eigen mode

- Assigning material
  1. Select the object to which you want to assign a material.
  2. Click modelled>Assign Material
- Assigning HFSS-IE boundaries.
- Adding ground
- Adding substrate
- Adding patch
- Coax cable
- Create the coax
- Assign wave port
- Create a probe
- Select the menu item HFSS >Analysis setup. Add solution setup.

Save project
1. In an Ansoft HFSS window, select menu item File>save as.
2. From the save as window type of file name select file.

Analyse

3.2.1 Hardware requirement

1.Di electric material

Dielectric substrate FR4 high loss, low gain antenna, cheap, easy availability. Low loss and low permittivity. Dielectric material uses to improved electrical and mechanical stability are used to reduce the size of the antenna and used to produce displacement current time varying magnetic field. Microstrip line and ground are copper, silver, and gold. Silver are higher conductivity than copper or gold but copper is much harder than the other two.

2. Vector network analyser (VNA)

In antenna, the most common measurement is the resonant frequency, bandwidth, impedance, VSWR, radiation pattern, antenna gain and efficiency. For these mainly two kinds of equipment of setup are used. Antenna impedance measurement is done using Vector Network Analyzer (VNA). this is a measuring tool that can be used to to measure the input impedance as a function of frequency.

3. Printed circuit board

Copper cladded PCB board was drilled to provide the feed point and the drilled portion provided with n connector to feed power.

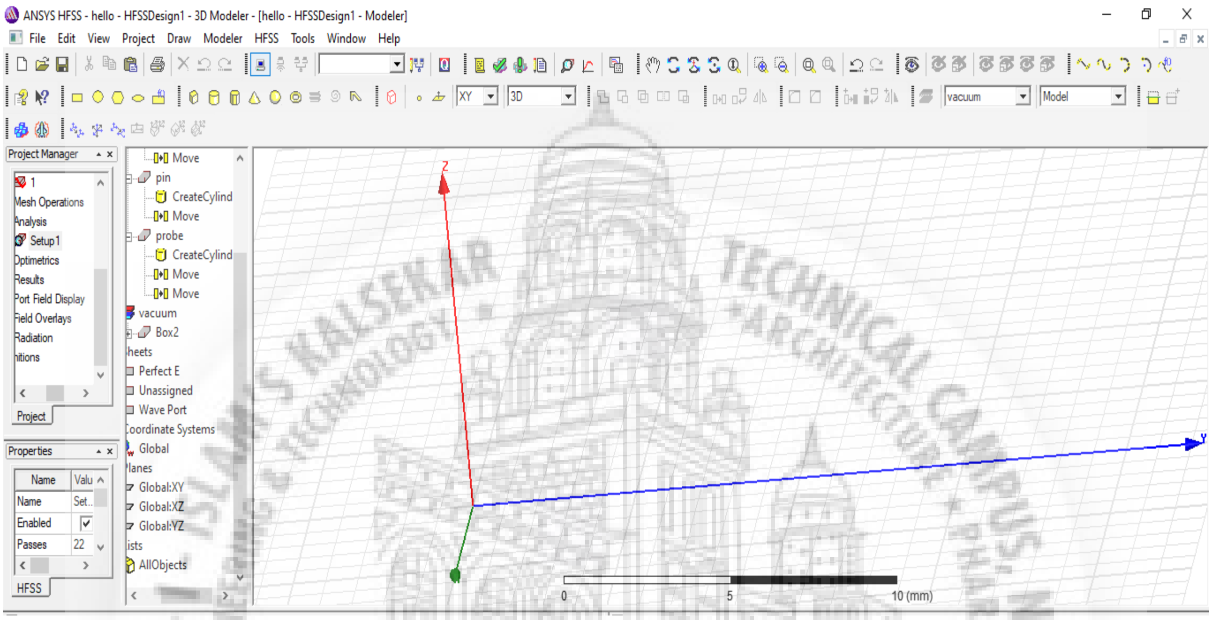
4. Signal generator

A signal generator is piece of test equipment that produces an electrical signal into of a wave. This is used as a stimulus for the item being tested. Signal generator in all their forms are widely used within test the development system, being used with other test instrument.

3.3 Simulation Steps of Dual-Band MIMO Antenna

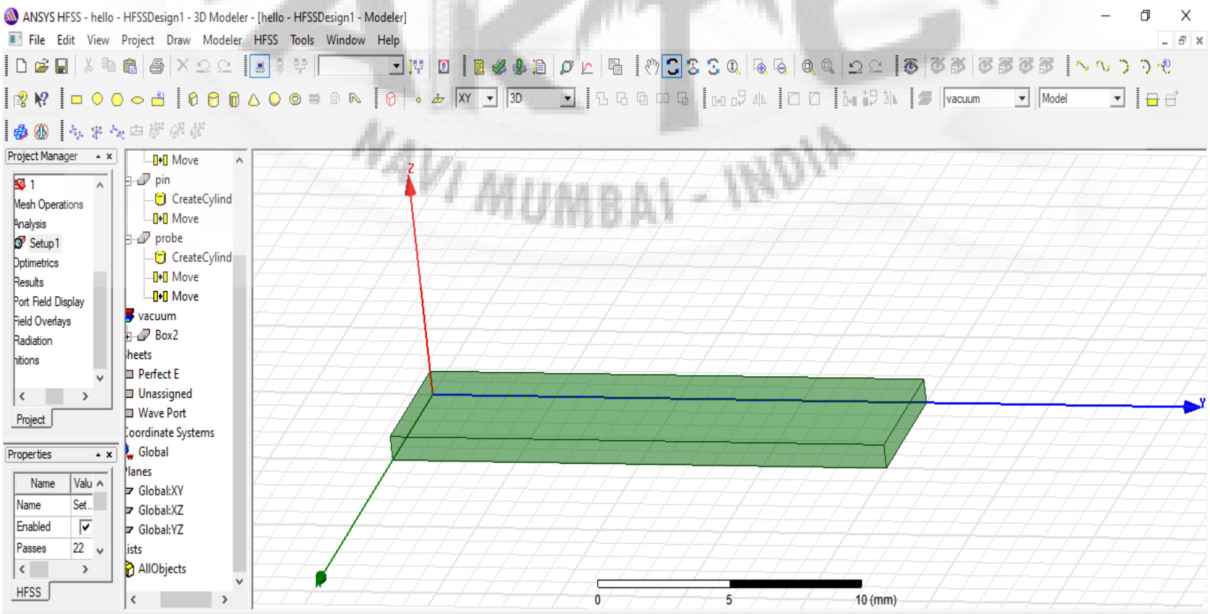
Step1: Create model/geometry

- Before creating model, we have to select insert HFSS design, which opens the window in which model is to be drawn:



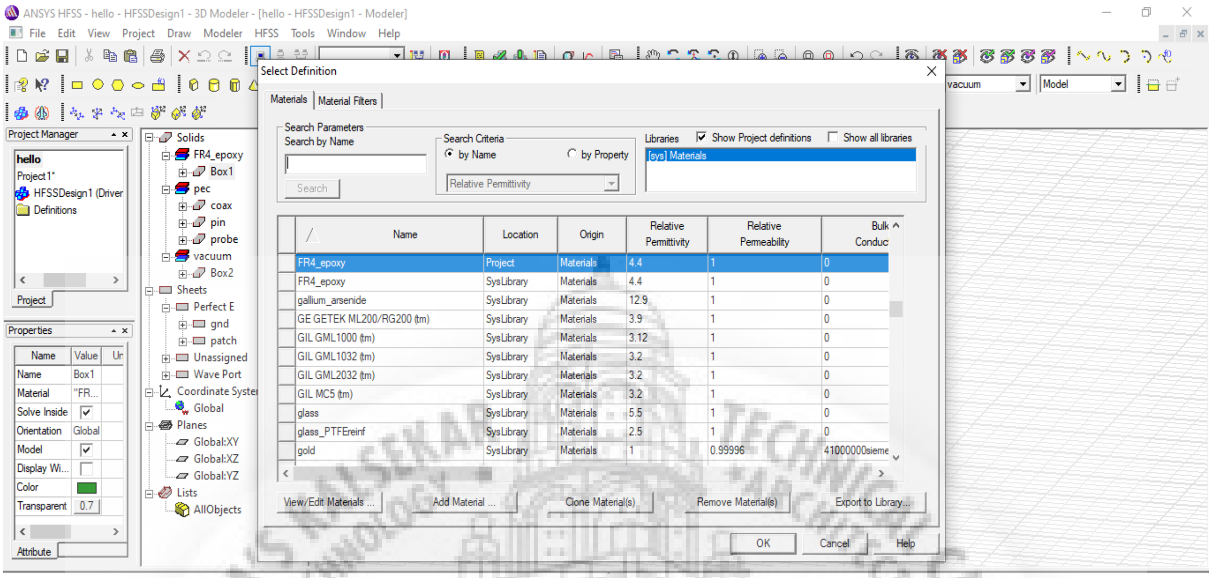
- Placing Substrate in the drawing window.

Select "Draw box" - Place in the drawing window.



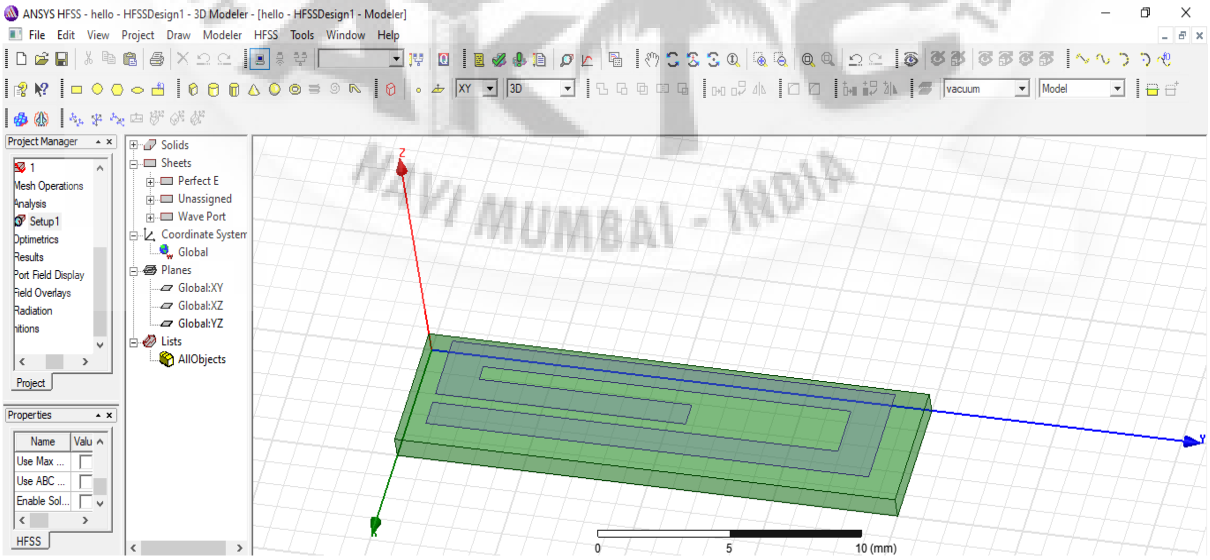
➢ Setting box properties (Name, Material, Color and transparency)

Right click on Box Properties Material FR4_epoxy Ok.



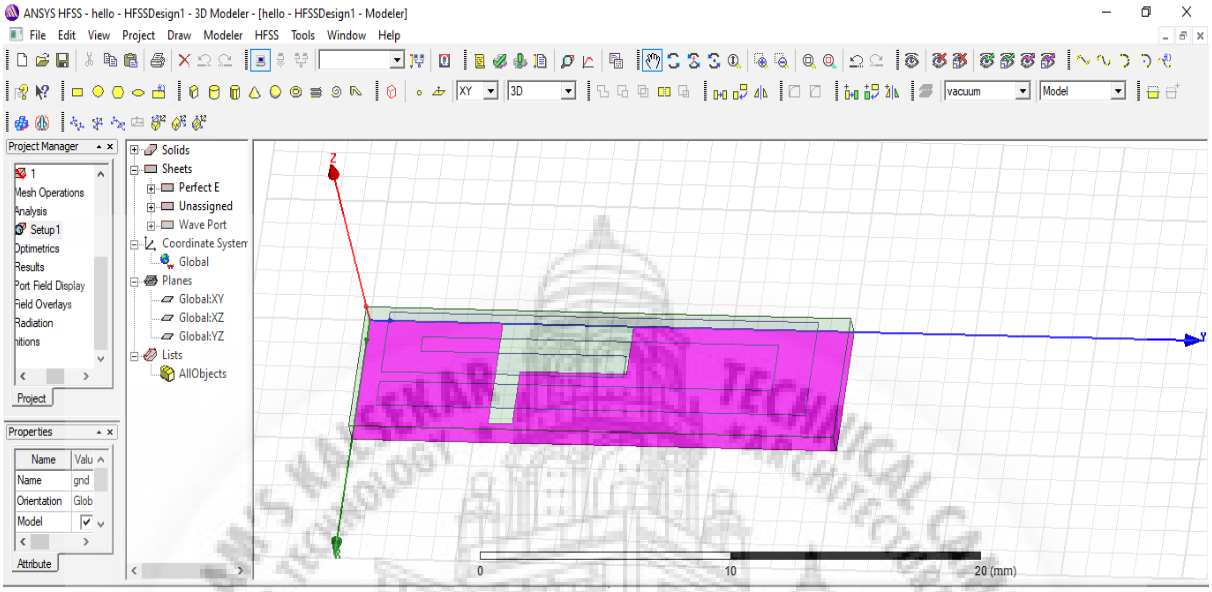
➢ After setting "Name", "Color" and "transparency" the size and position of the substrate is edited.
➢ Now placing patch.

From tool bar, select "Draw Rectangle" Place it in the Window. Right click on "Rectangle1" Properties Edit Name, Color & Transparency. Right click on "Create Rectangle" Properties Edit Size & Position.



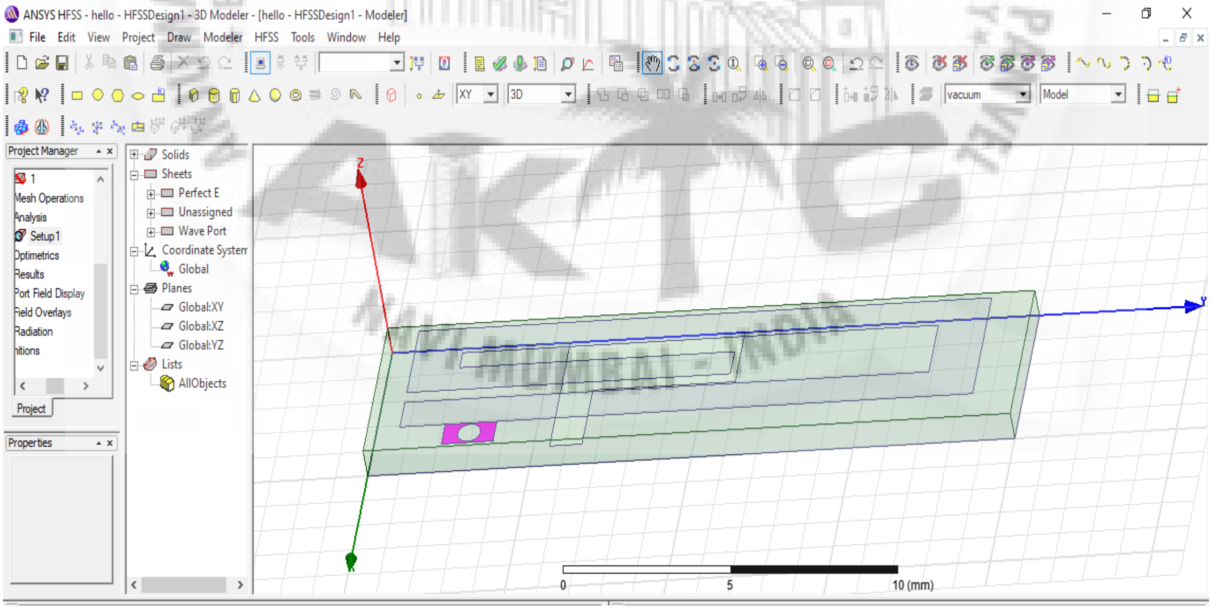
- Now placing patch on back side same way.

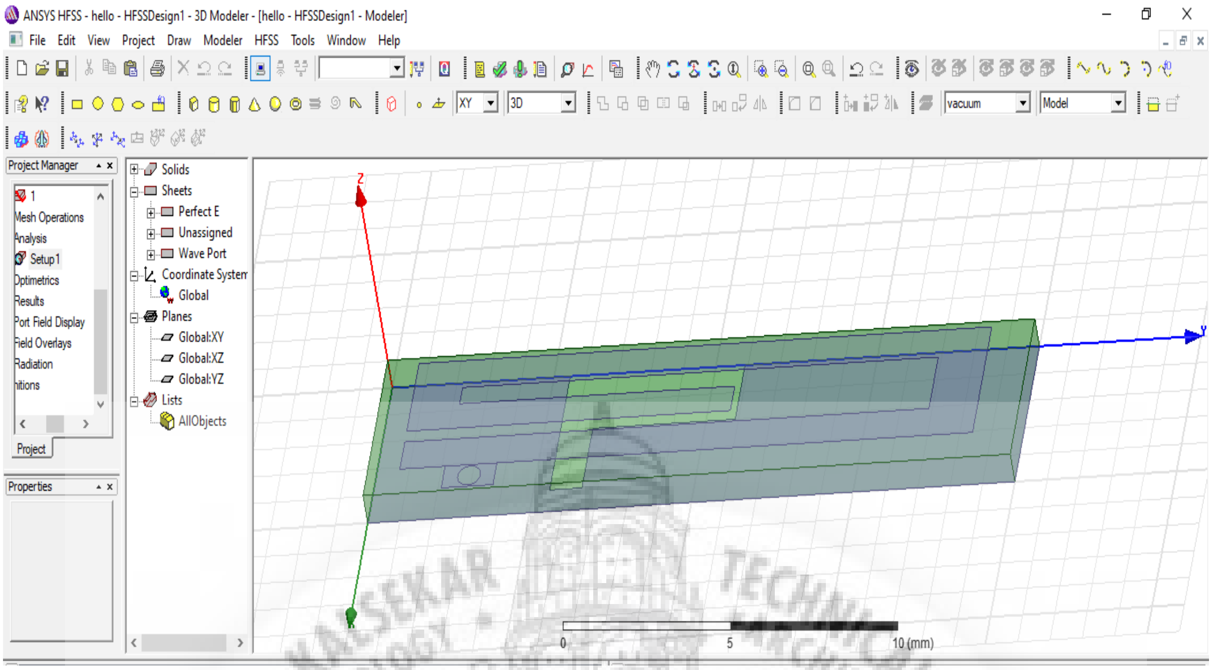
Placing patch on backside with minus coordinates.



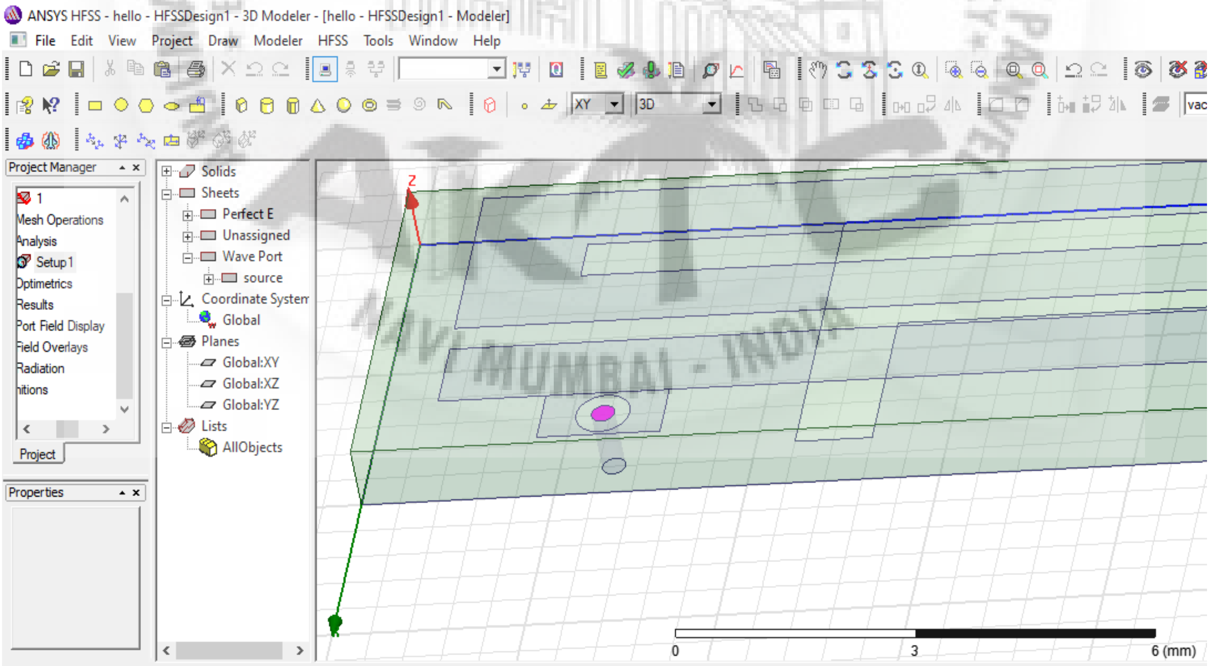
- Now there must be circular cut in the ground plane where coaxial pin is to be inserted and slot cuts on the patch for meandering.

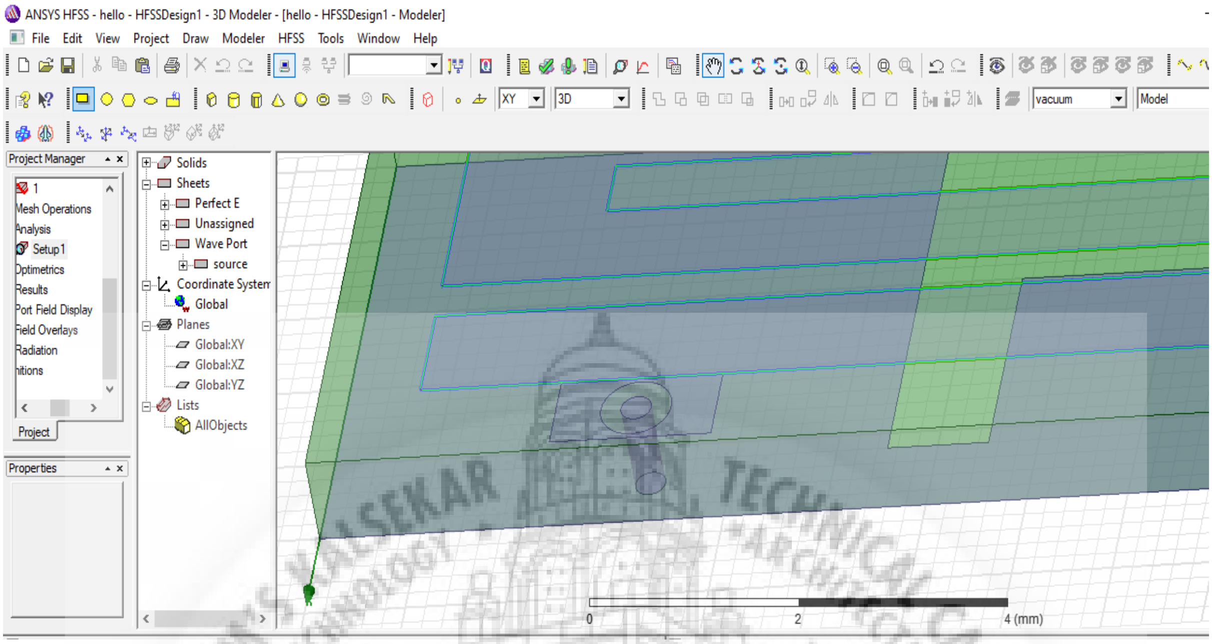
First we make a small rectangle and make a cut in middle of rectangle.



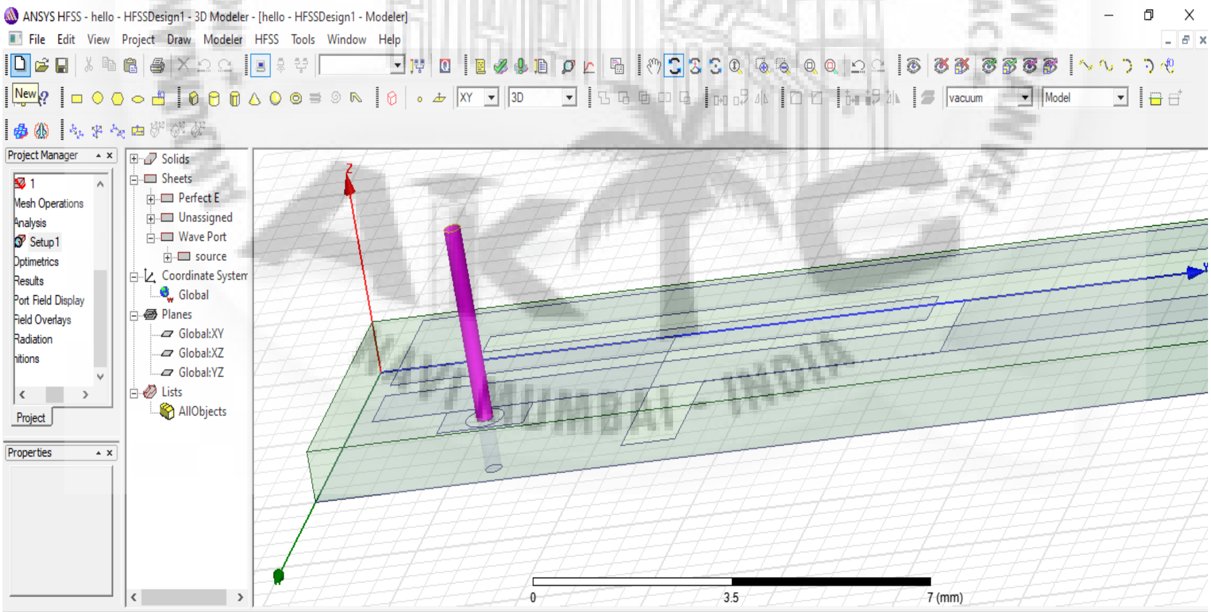


- ➤ Making coaxial connector using cylinders ("Draw Cylinder") and placing a circle at the back of it. The central Cylinders is to be assign "pec" material. And outer cylinder is assigned "vacuum".

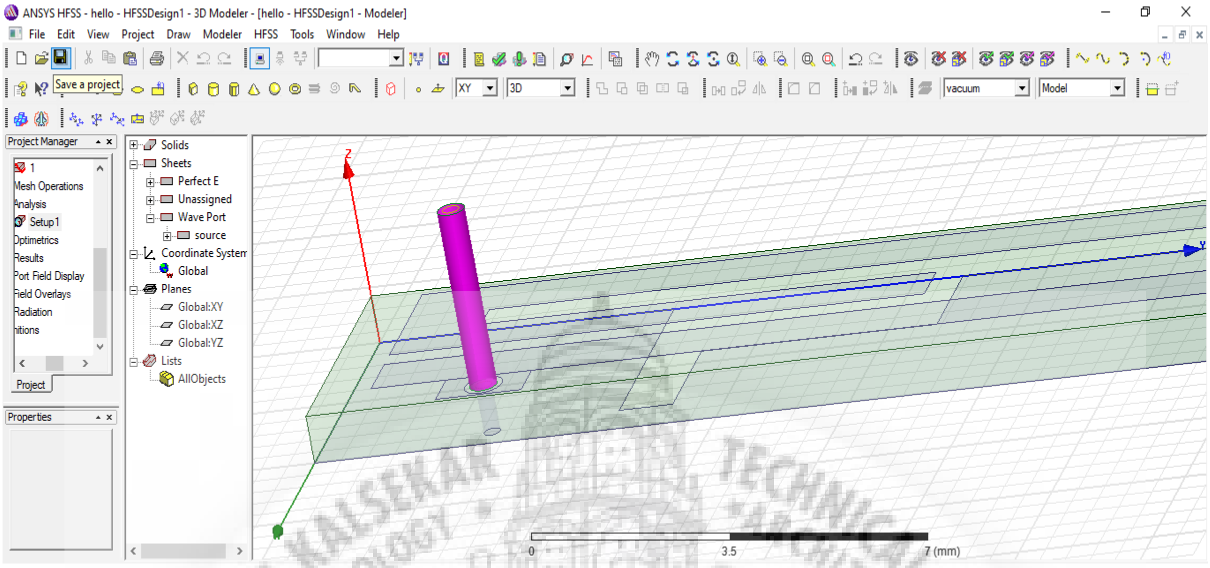


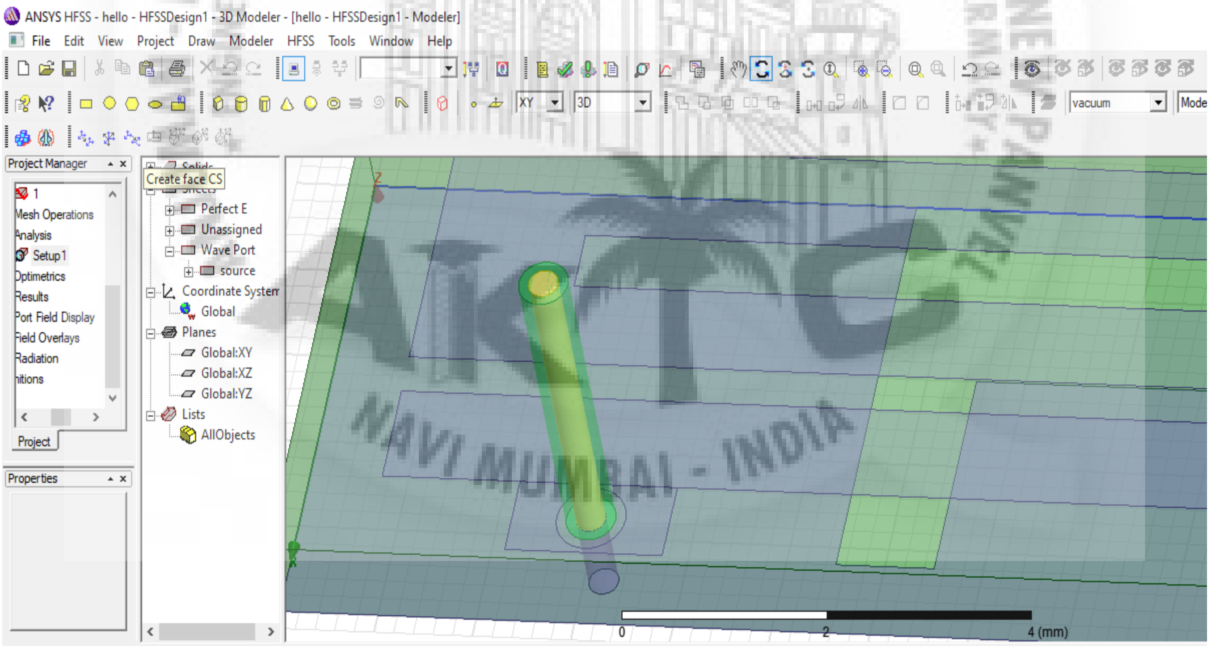


Next step will be to make a long Cylinder upon small cylinder. Basically, that will be a “Pin”.

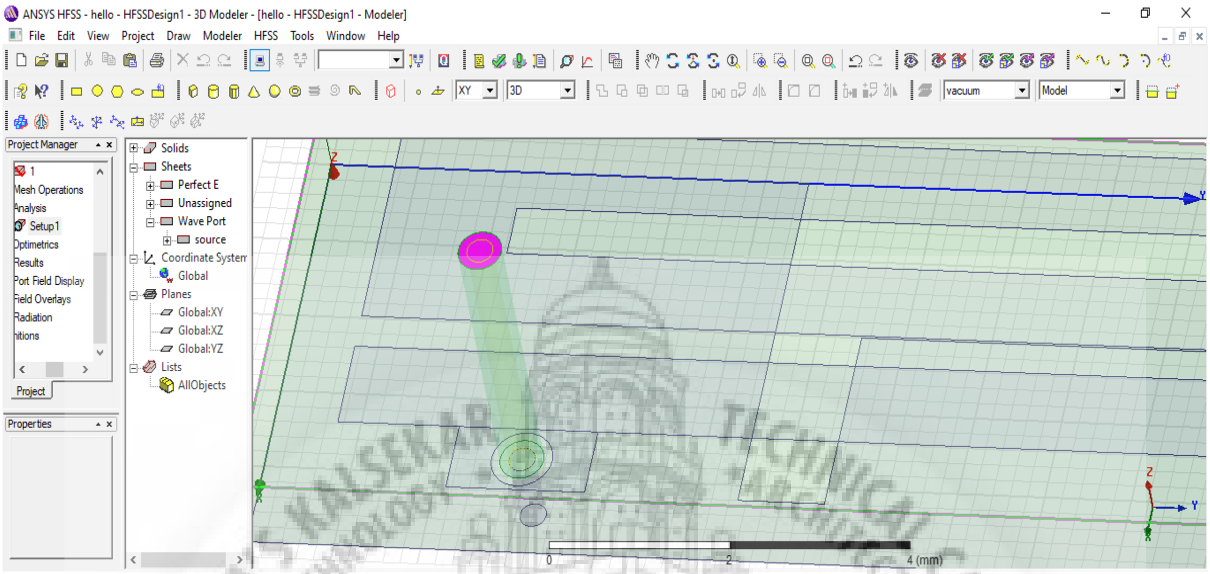


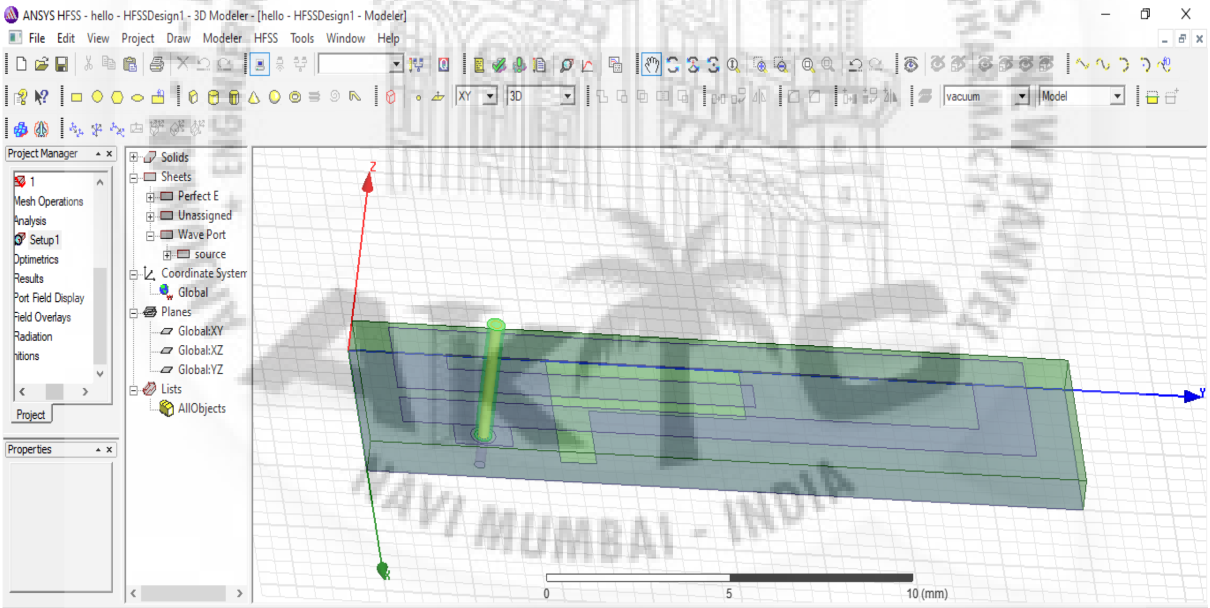
➢ Next will be placing “Coax” upon that “Pin”.



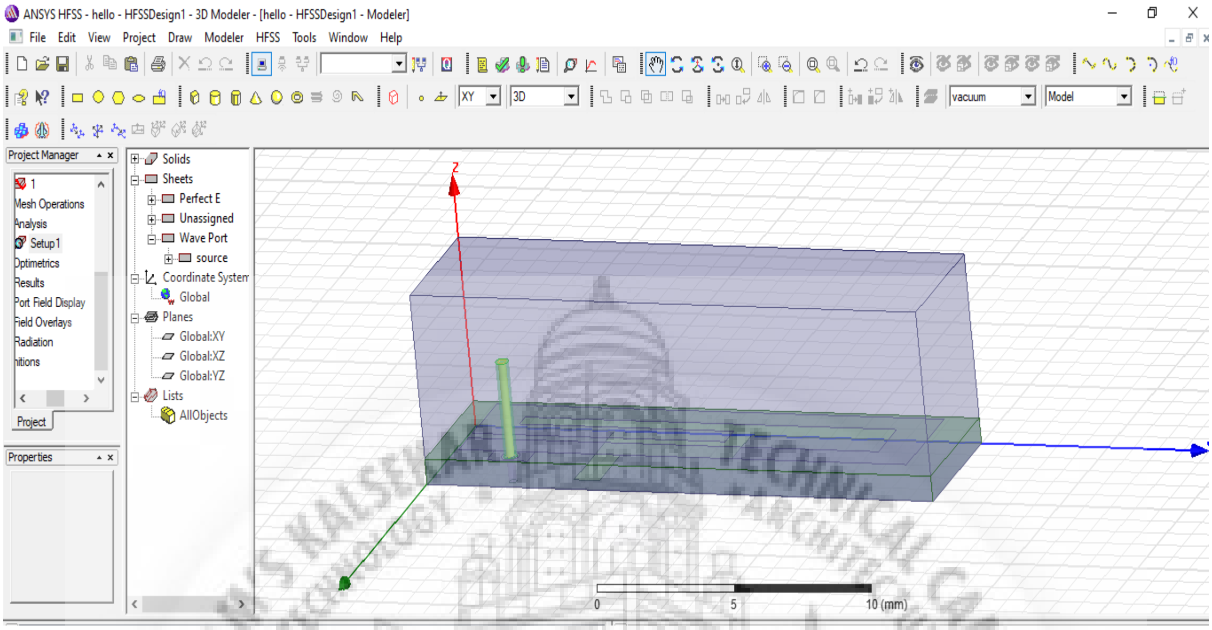


➢ After creating Pin and Coax now there should a source.





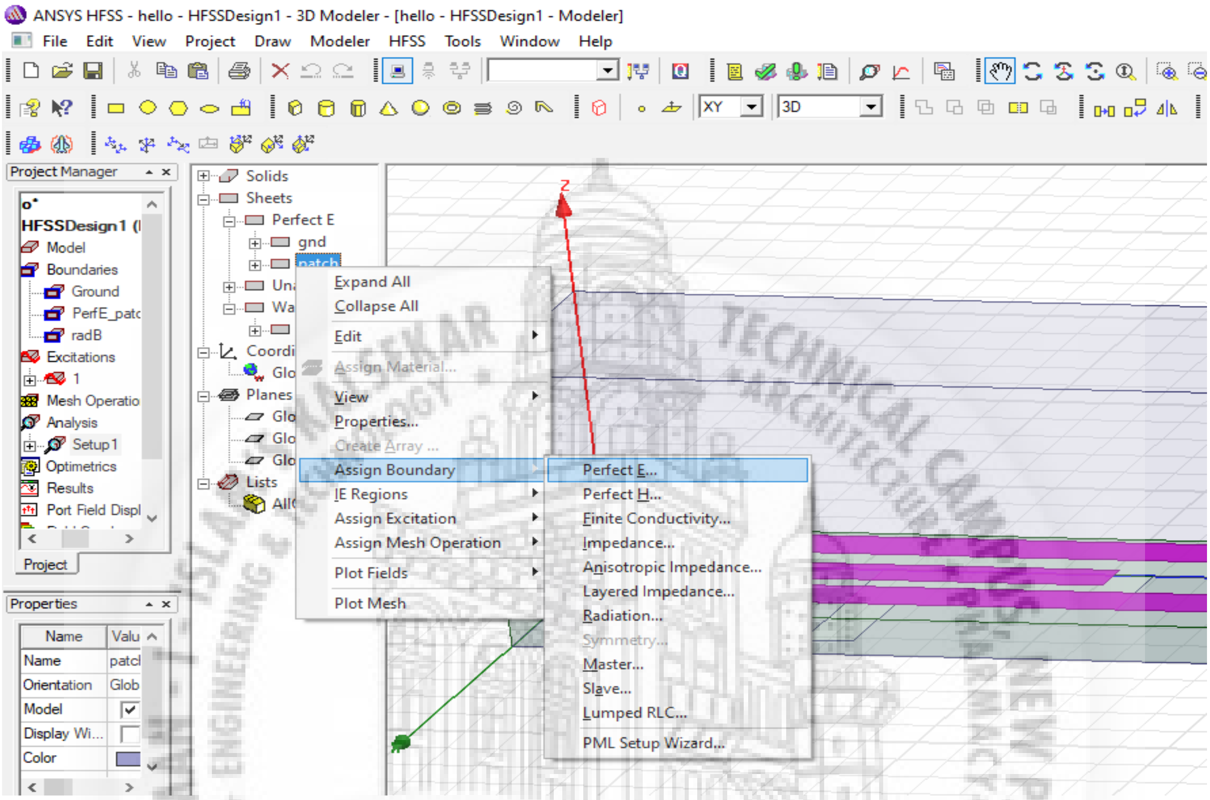
- Drawing air box by selecting “Draw box” and assigning it Material “air”. And editing its properties (Name, Color, and Transparency).

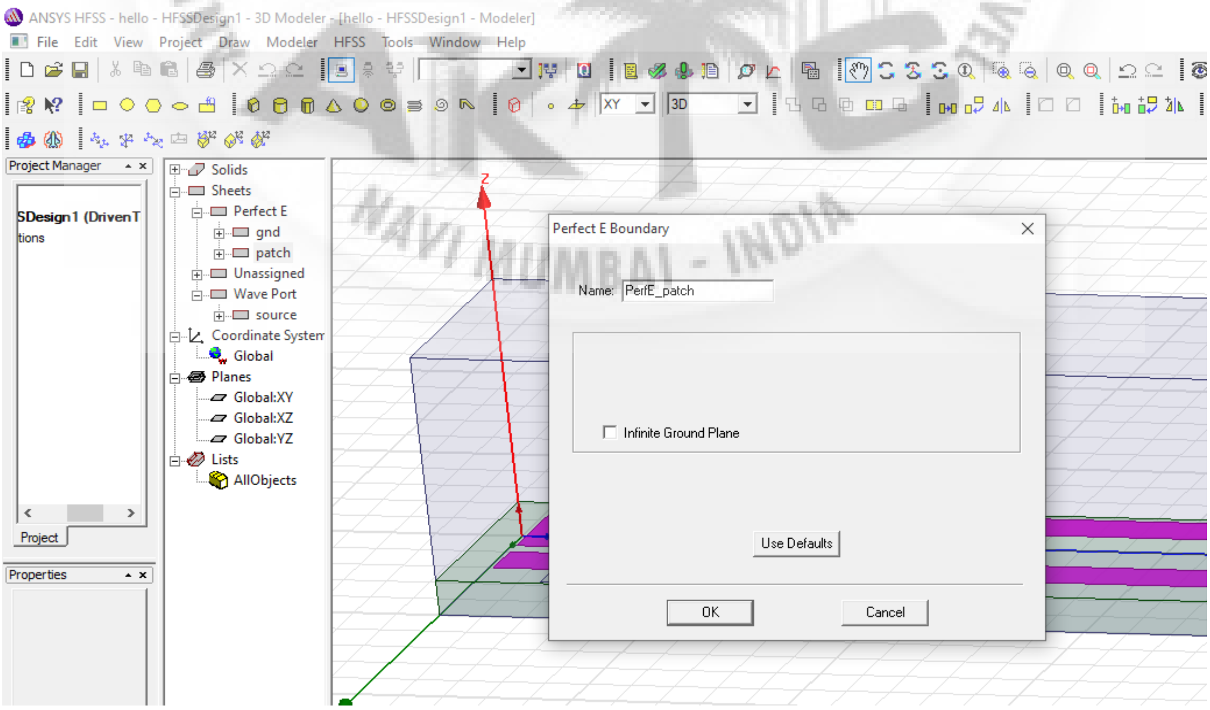


Now the model of the microstrip antenna sensor is completed i.e. Step 1.

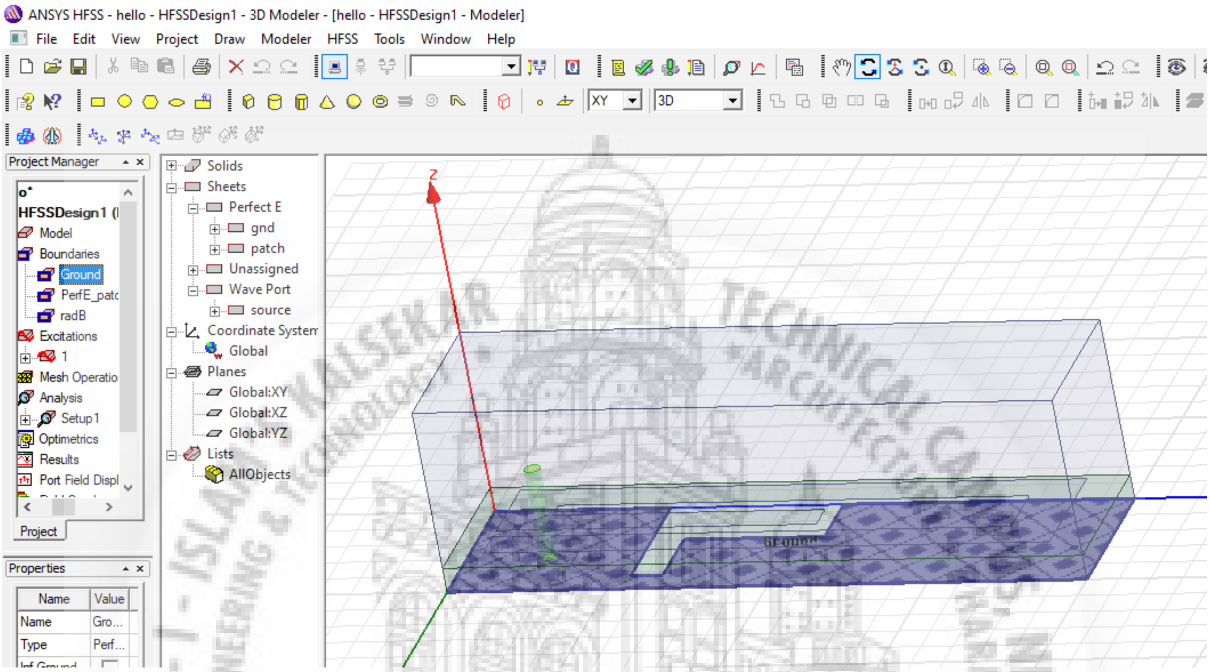
Step2: Assign boundaries

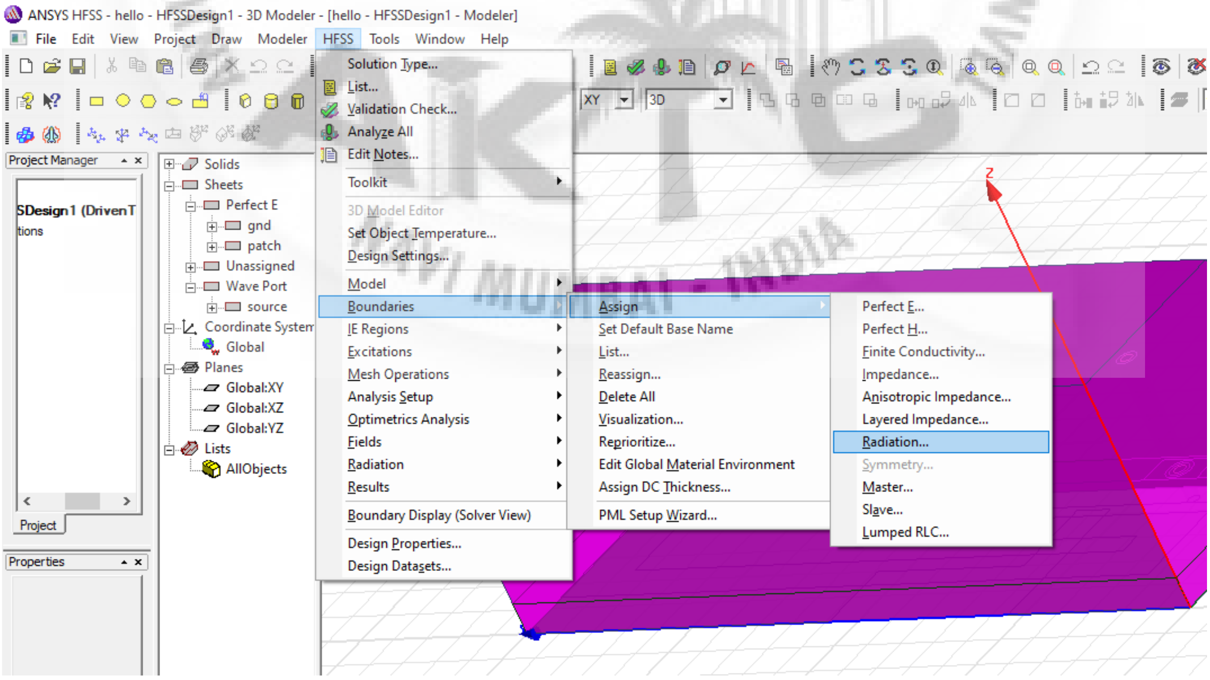
- We had to assign boundary condition to patch, ground and air box. Right click on "patch" Assign Boundary Perfect E. Then, Save it as Name "PerfE_patch".

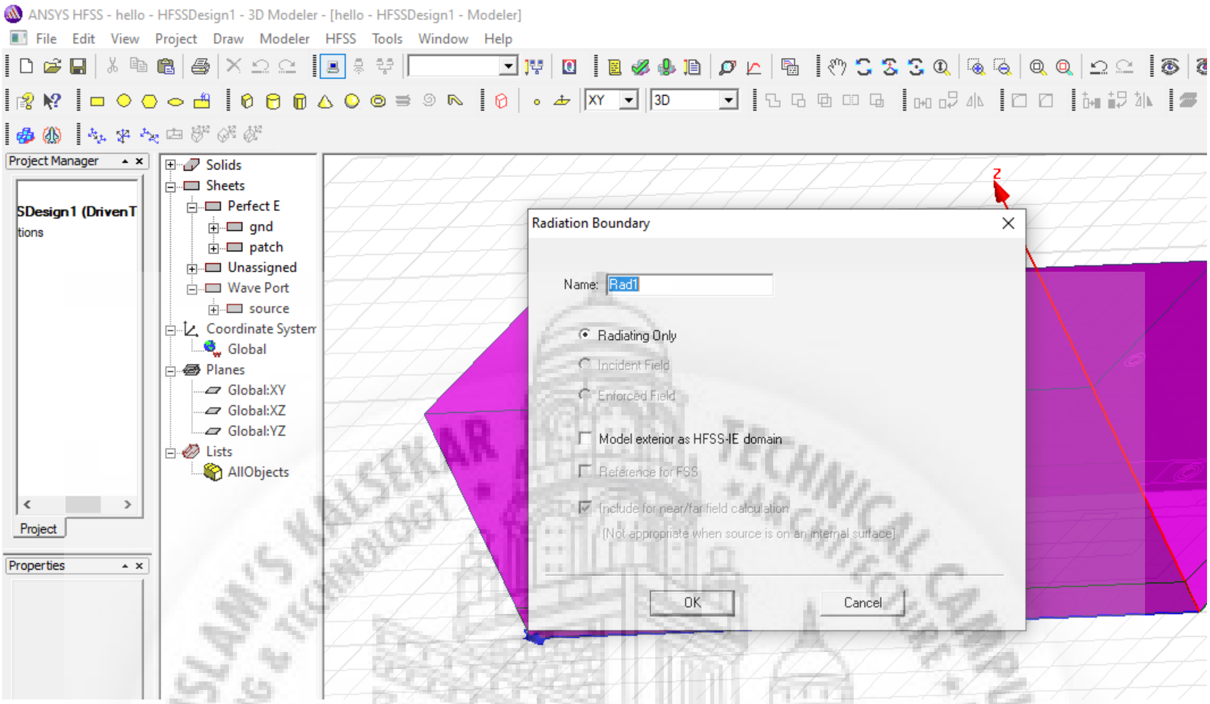




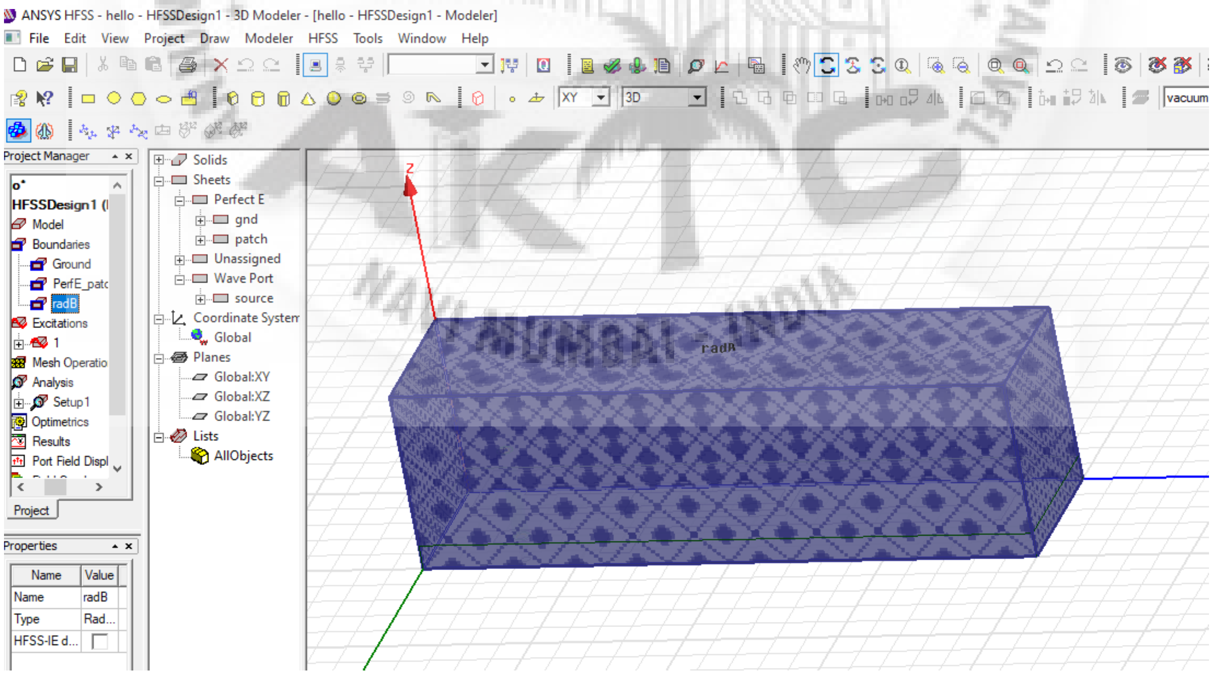
- ➢ Similarly repeat steps for Ground & Shorting Post.
- ➢ Select Faces of the air box except the face where there is microstrip antenna is present and assign it “radiation boundary”.





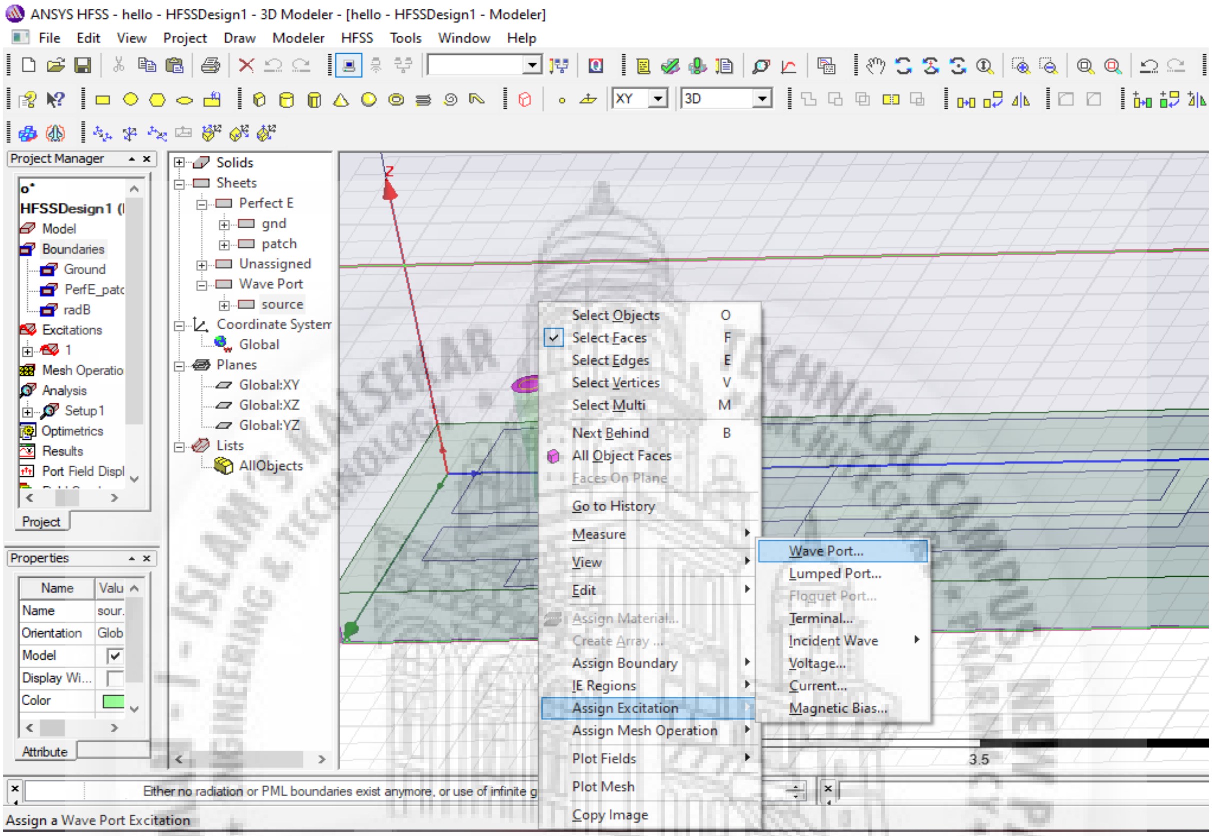


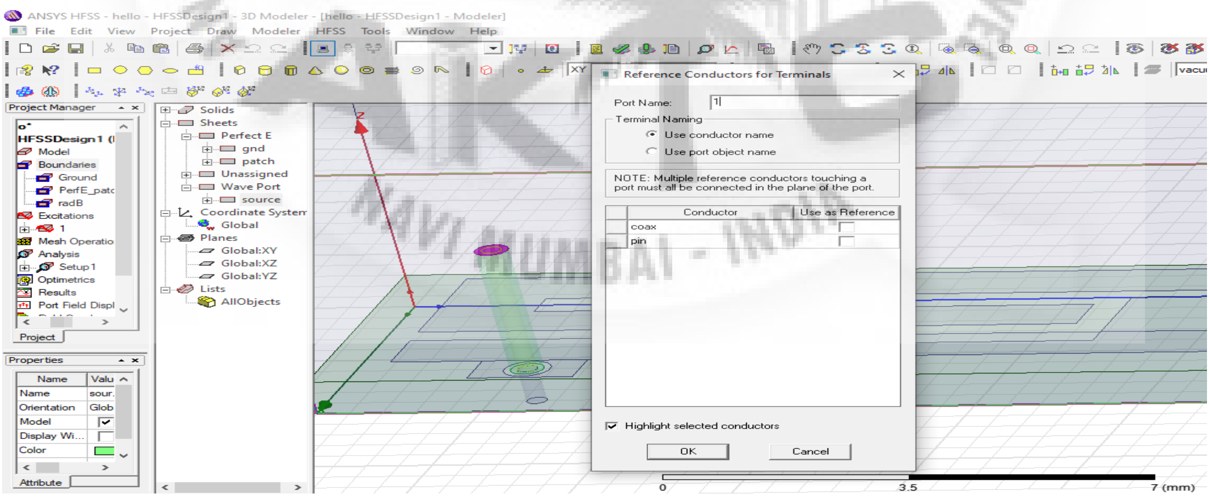
➢ Now the boundaries have been assigned.

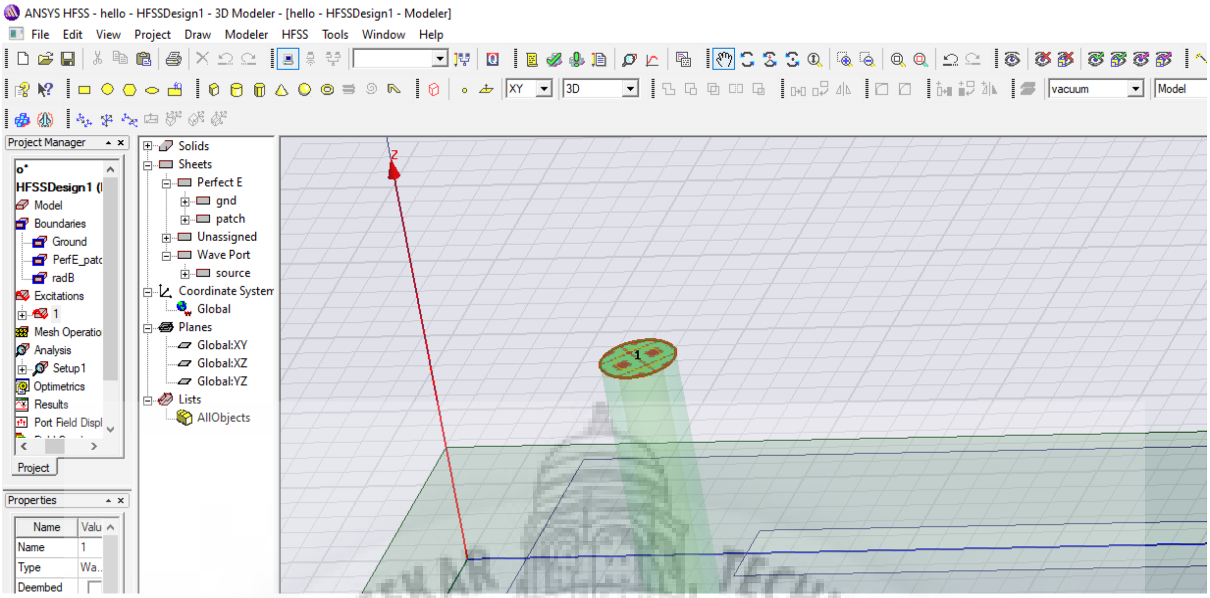


Step3: Assign excitation.

The excitation is assigned to the circle placed at the back of the coaxial connector drawn. Right Click on "Circle2" Assign excitation Wave Port Enter Ok.



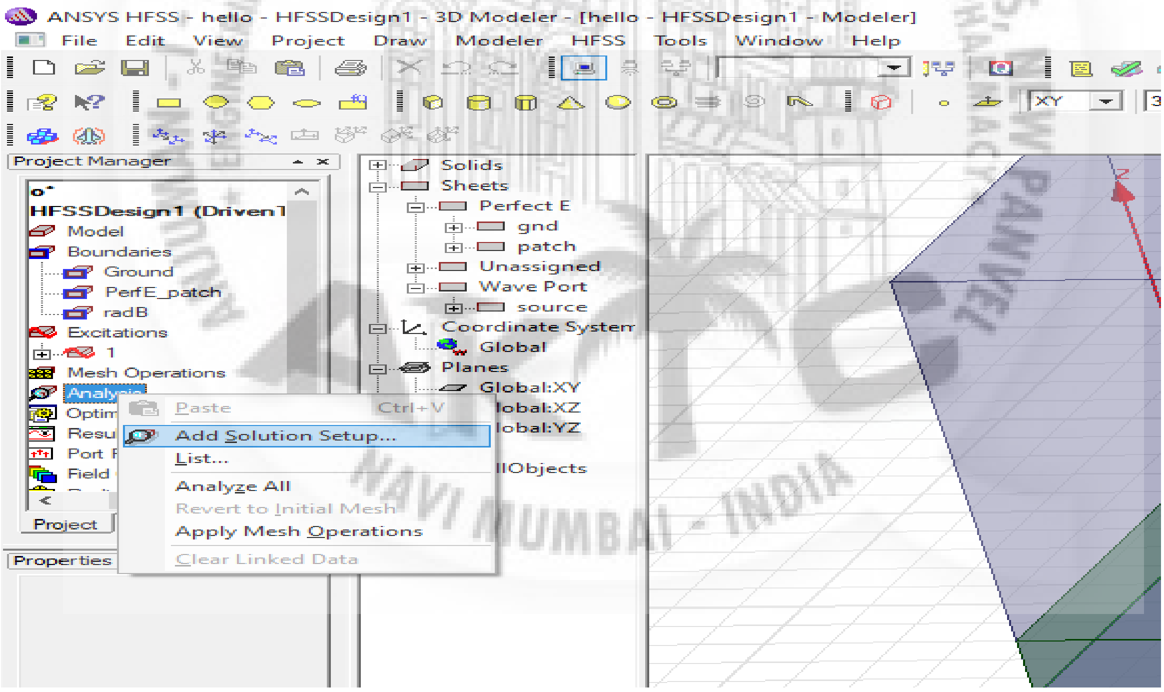


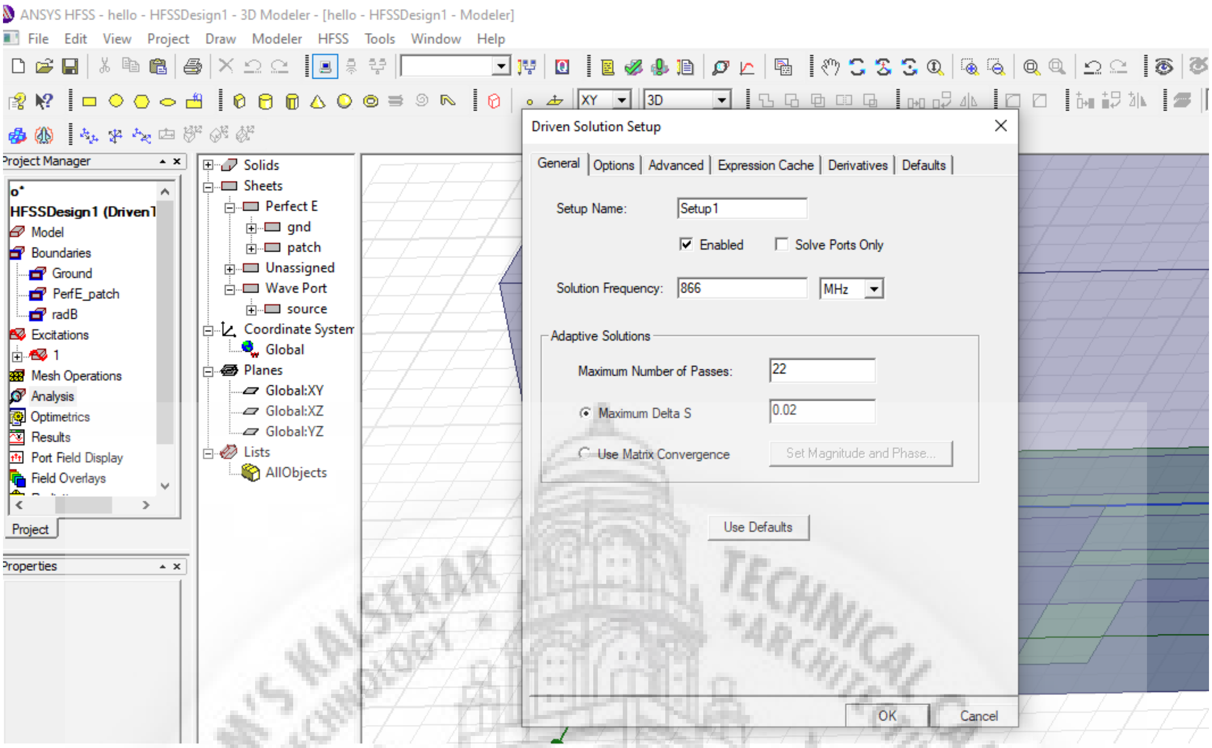


Step4: Setup the solution

➢ In this step a solution setup and sweep frequency is added.

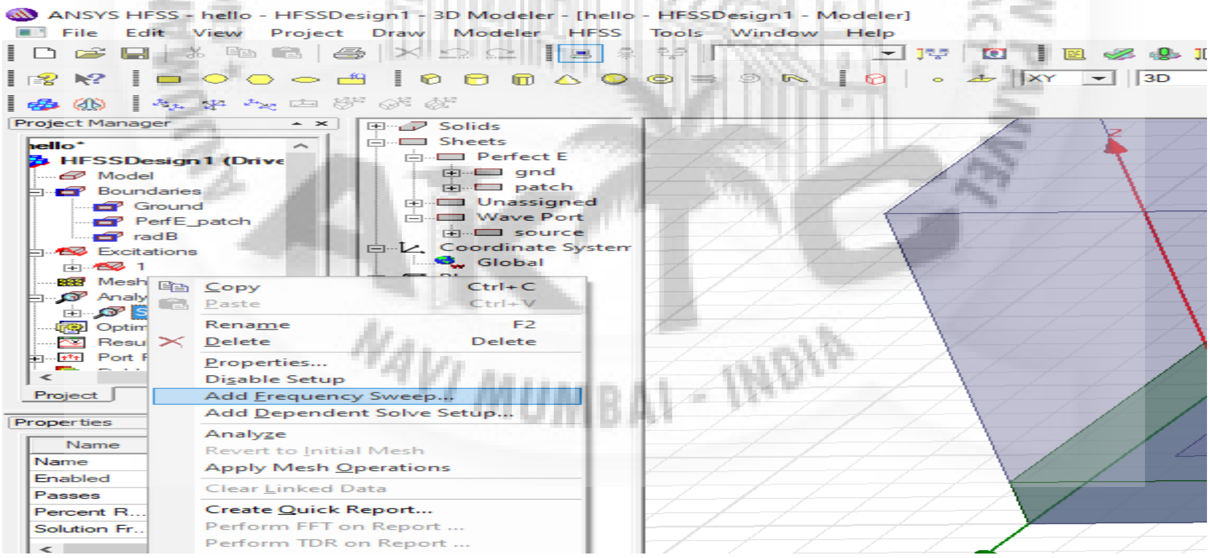
In project manager window, Right click on “Analysis” Add Solution Setup enter solution frequency (866MHz) & No. of passes 22.

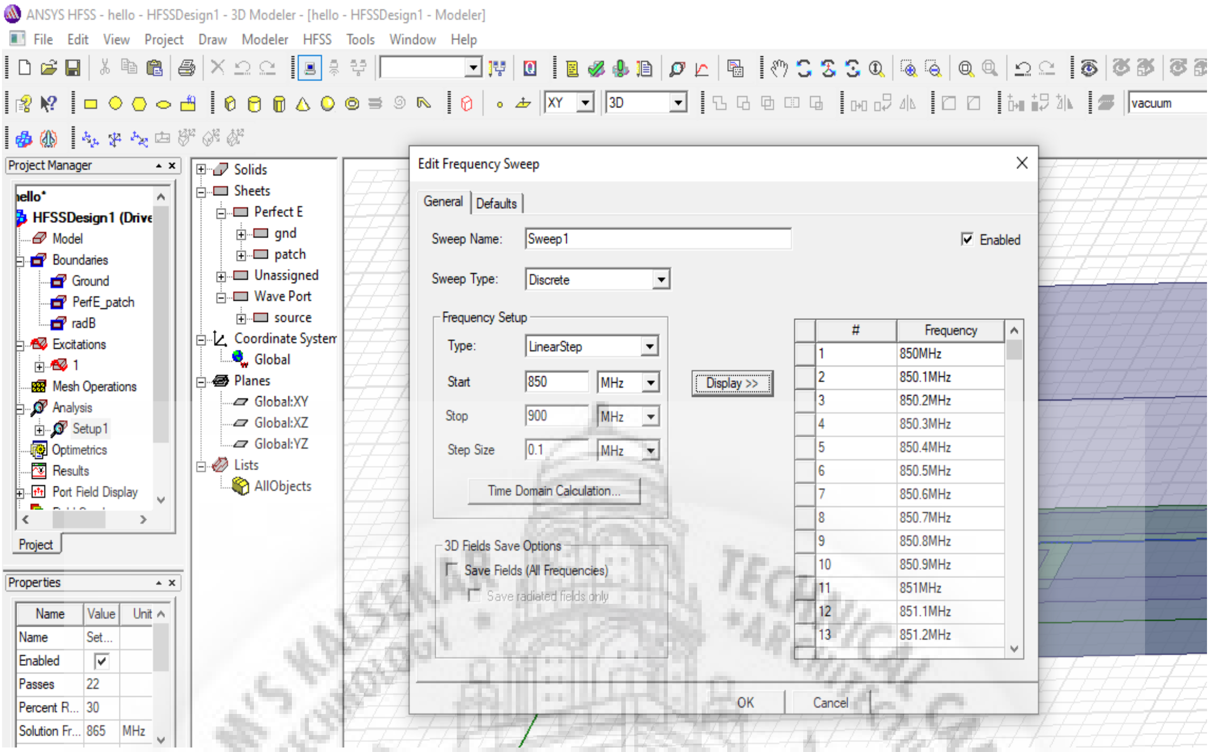




Now including sweep frequency

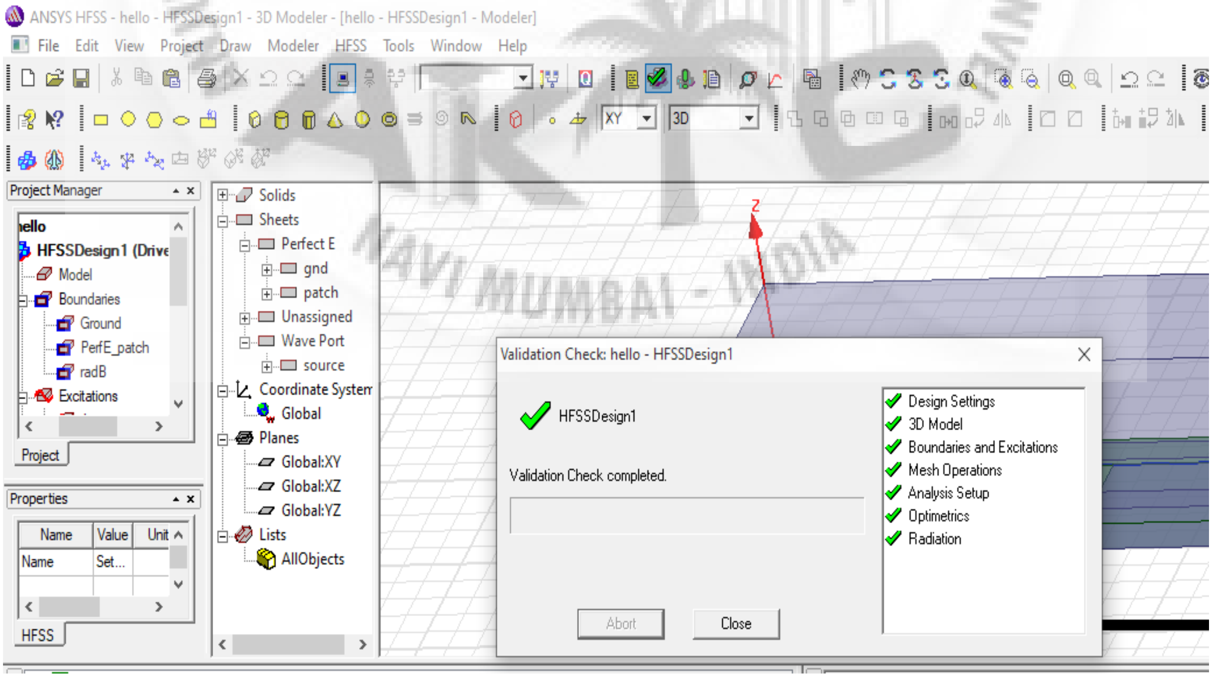
Expand Analysis Right click on Setup1 Add Frequency Sweep Edit Sweep type “Discrete”, Enter Start & End Frequency, and Step size.





Step5: Solve

- After adding solution setup, we will do "validation" & execute our model by clicking on "Analyze".



Step6: Post processing the Results

The stimulated result as performed with the help of HFSS software. Fig.1 shows the S parameters for the purposed antenna. It shows the reflection coefficients (S11, S22, S33, S44) are four antennas having less then 6 dB in the frequency range between 3.3-3.6 GHz and 4.8-5.0GHz. It indicates that acceptable impedance matching is obtained. The transmission coefficient between antenna are introduced in Fig.2, it shows a plunge (about - 15 dB) at about 3.5GHz and not exactly - 12dB at about 4.9 GHz and is not exactly - 10 dB for frequencies in the operating band, which is acceptable for smartphone applications. For the antenna efficiency shown in Fig.3, it is all above 50% in the operation band.

The obtained ECC is all much less than 0.1 in the operation band which is shown in Fig.4 and that is acceptable for the MIMO operation. The result recommend that the proposed reception apparatus cluster are appropriate for reasonable MIMO activity and can be utilized as a structure block in shaping the MIMO cluster with at least eight receiving wires in the future cell phones.

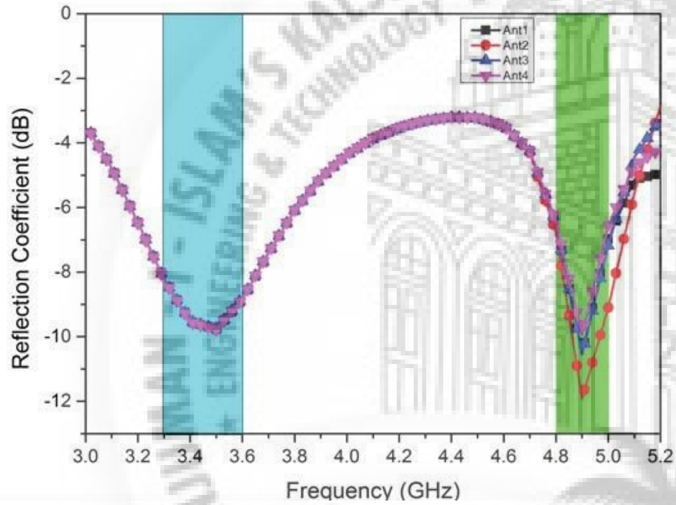


Fig.1 Reflection Coefficient

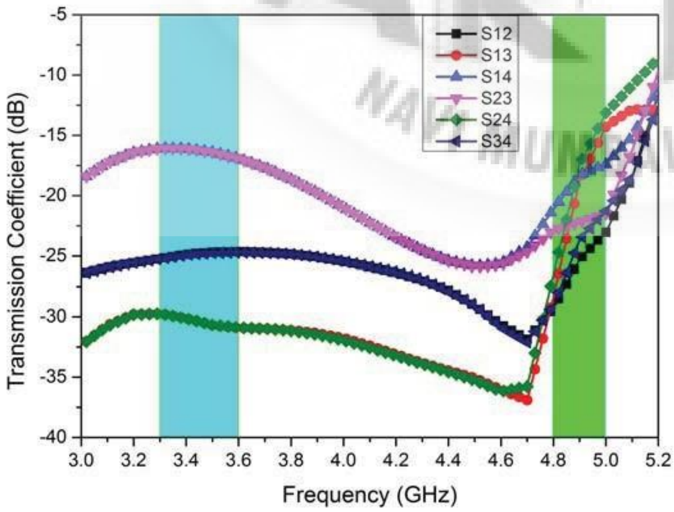


Fig.2 Transmission coefficient

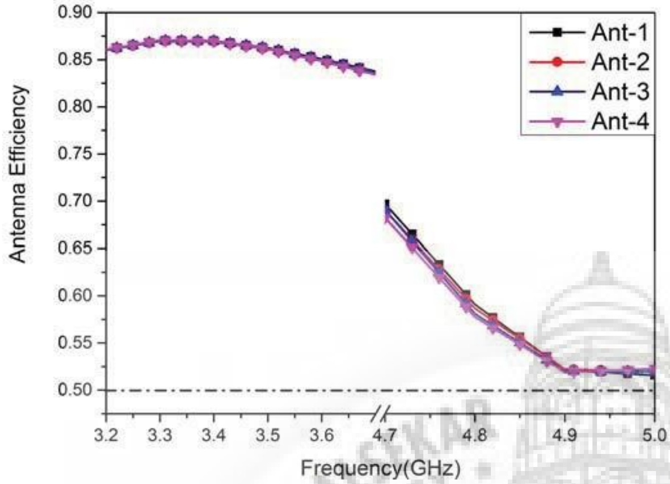


Fig.3 Antenna efficiency

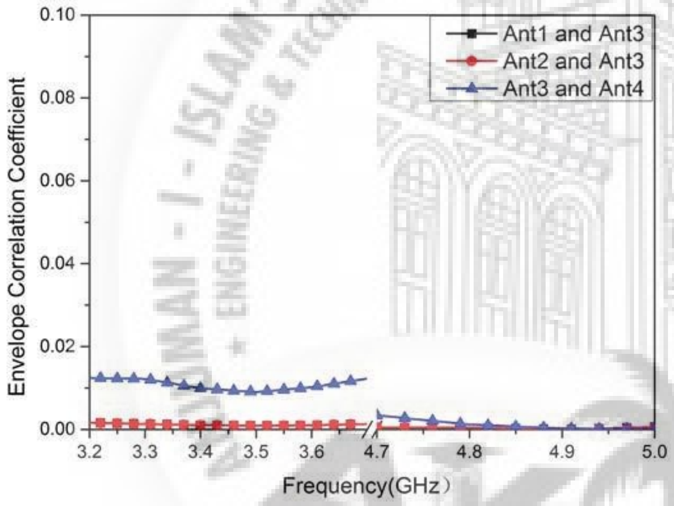


Fig.4 ECC of the MIMO antenna

Chapter 4
Market Potential

4.1 Market Potential of Project

The MIMO market is projected to reach USD20.91 billion by 2026 at a CAGR of 41.60% between 2018 and 2016. The key factor derive in the growth of the MIMO market is the using importance of software implementation in a communication network. High signal to noise ratio and link reliability. The 5G segment is expected to witness the faster growth from 2020-2026. With future 5G development massive MIMO is expected to enable new high frequency band that suffer high propagation path. Losses to deliver similar coverage as low frequency.
5G is expected to offer significant in gain to accommodate more user at high data with better reliability while consuming less power. The MIMO in APAC is expected to grow at the highest CAGR during the forecast period. The presence of leading massive MIMO such as Huawei, ZTE, china mobile, and Samsung and china unicorn is key factor driving the MIMO market in Asia pacific [3]

4.2 Competitive Advantages of Project

Higher data rate can be achieved with the help of MIMO antenna. this helps in achieving higher down link and up link through-put.
Its helps in achieving reduction in BER (Bit Error Rate) due to application of signal processing algorithm on the received data symbols by multiple antennas.
The technique such as STBC (Space Time Block Coding) BF (Beam Forming) when employee in MIMO system helps in achieving extension coverage.
The system with help MIMO offers quality of service increase spectral efficiency and data rate [6].

Chapter 5
Conclusion and Future Scope

5.2 Conclusion

A dual-band four antenna MIMO array for 5g Smartphone application is proposed. the proposed antenna is located in the side frame, in line with the trend of a full screen Smartphone antenna design, in the premise of the reflection coefficient to meet the requirements, to achieve a relatively high isolation the antenna size is relatively small ideal for today's ultra- thin Smartphone communication [1].

5.1 Future Scope

A small microstrip patch antenna has been proposed for 5G wireless standard. The stupendous increase in mobile data, technologies are approaching from 4G i.e., fourth generation to fifth generation. The antenna resonates at 3.5GHz with a return loss of -6 dB and can be used in future 5G wireless devices.

Mobile communication requires small, low-cost, low-profile antennae. in some mobile handsets, semiconductor-based diodes or detectors are used as antennae. they are much like p-n diode photo-detectors but work at microwave frequency. many times, omnidirectional antenna is used in mobile phones. there are different kinds of antennae like planar inverted-f antenna, folded inverted conformal antenna and mono pole. also, retractable whip antenna is commonly used in handsets

In the treatment of malignant tumours, microwave energy is said to be the most effective way of inducing hyperthermia. the radiator to be.

used for this purpose should be light-weight, easy to handle and rugged. only a patch radiator fulfils these requirements

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