Design and Analysis of Dual Band Double Slot Loaded Microstrip Patch Antenna

B.E. Dissertation

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by

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and is submitted in the partial fulfillment of the requirement for the degree of

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Certificate of Approval by Examiners

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Abstract

A Dual Band Double Slot Loaded Microstrip Patch Antenna is designed. Diagonal Co-axial feeding tecnique is used to feed the antenna. The dielectric used is FR4 with its dielectric constant 4.4 and permittivity 2.2. Rectangular Patch is used as a radiator on which two narrow slots are made. These slots make the antenna frequency and polarisation reconfigurable. The gain is 7.8 dB at 4.9GHz and 7.1 dB at 4GHz. The antenna is analyzed and stimulated using HFSS software. The proposed antenna provides circular polarisation both LHCP and RHCP. This antenna has an overall dimension and the dimension of slots created over patch is which is very compact compared to the conventional antenna.

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Chapter 1

Introduction

1.1 Introductions

Nowadays the use of the microstrip antenna for many applications like wireless local area network (WLAN), WiMAX and cellular mobile communication system is used extensively because of their inherent ability of low cost and small size along with very high gain .The microstrip antenna is incorporated with printed strip line feed networks and active devices. But it is well known that the bandwidth of Microstrip antennas is very small (typically 1-2percent) which reduces its extensive use in most of the applications. Todays researchers who work in this domain have the main focus to improve its bandwidth by retaining mentioned features. A number of different techniques has been implemented by using different parasitic elements and low permittivity layers. Other techniques using for bandwidth enhancement are dual band antenna. The need for dualband antennas in wireless communication systems is to use two bands of frequencies, i.e. Wi-Fi, and WiMax simultaneously because it works like two different antennas, which miniaturize the size, cost, and complexity to design antenna. Dual band antenna also has advantages over the ultra wideband antenna (UWA) by rejecting intervention from the surrounding signals of the spectrum . For now, the slot antenna, that becomes more popular for very low cost and small size antennas, is intended to offer dual resonance. In this communication, it has proposed a diagonal coaxial feed dual band slot loaded antenna for dual circular polarization (i.e. LHCP and RHCP) having both frequency and polarization diversity . Here both single slot-loaded patch antenna and double slot loaded patch antenna are investigated. We use , HFSS 17.0 software from Ansoft Corporation for the design and optimization of the work. The performance comparison is based on radiation pattern, bandwidth, return loss and gain.

1.2 Introduction to Antenna

ANTENNA is a transducer designed to transmit or receive electromagnetic waves.In the radio and Electronics,an Antenna is an electrical device which converts electric power into radio waves and vice-versa.Antenna are basic component of any electrical circuit as they provide interconnecting link between transmitter or between free space and receiver. There are different types of antenna some of them are as listed below:-

1. Log Periodic Antennas.
2. Travelling Wave Antennas.
3. Reflector Antennas.
4. Microwave Antennas.

1.2.1 Log Periodic Antennas

A log-periodic antenna (LP), also known as a log-periodic array or log-periodic aerial, is a multi-element, directional, antenna designed to operate over a wide band of frequencies. It was invented by Dwight Isbell and Raymond DuHamel at the University of Illinois in 1958. The most common form of log-periodic antenna is the log-periodic dipole array or LPDA, The LPDA consists of a number of half-wave dipole driven elements of gradually increasing length, each consisting of a pair of metal rods. The dipoles are mounted close together in a line, connected in parallel to the feedline with alternating phase. Electrically, it simulates a series of two or threeelement Yagi antennas connected together, each set tuned to a different frequency. LPDA antennas look somewhat similar to Yagi antennas, in that they both consist of dipole rod elements mounted in a line along a support boom, but they work in very different ways. Adding elements to a Yagi increases its directionality, or gain, while adding elements to a LPDA increases its frequency response, or bandwidth. One large application for LPDAs is in rooftop terrestrial television antennas, since they must have large bandwidth to cover the wide television bands of roughly 5488 and 174216 MHz in the VHF and 470890 MHz in the UHF while also having high gainfor adequate fringe reception. One widely used design for television reception combined a Yagi for UHF reception in front of a larger LPDA for VHF. The log periodic antenna was invented by Dwight E. Isbell, Raymond DuHamel and variants by Paul Mayes. The University of Illinois at Urbana-Champaign had patented the Isbell and Mayes-Carrel antennas and licensed the design as a package exclusively to JFD Electronics in New York. Channel Master and Blonder-Tongue ignored the patents and produced a wide range of antennas based on this design. Lawsuits regarding the antenna patent which the UI Foundation lost, evolved into the Blonder-Tongue Doctrine. This precedent governs patent litigation. The LPDA normally consists of a series of dipolesknown as quot;elementsquot; positioned along a support boom lying along the antenna axis. The elements are spaced at intervals following a logarithmic function of the frequency, known as d or sigma. The length of the elements correspond to resonance at different frequencies within the antenna39;s overall bandwidth. This leads to a series of ever- shorter dipoles towards the quot;fronquot; of the antenna. The relationship between the lengths is a function known as tau. The ever-decreasing lengths makes the LPDA look, when viewed from the top, like a triangle or arrow with the tip pointed in the direction of the peak radiation pattern. Sigma and tau are the key design elements of the LPDA design.Every element in the LPDA design is quot;activequot;, that is, connected electrically to the feedline along with the other elements, though at any one frequency most of the elements draw little current from it. Each successive element is connected in opposite phase to the active connection running as a transmission line along the boom. For that reason, that transmission line can often be seen zig-zagging across the support boom holding the elements.One common design ploy is to use two booms that also acts as the transmission line, mounting the dipoles on the alternate booms. Other forms of the log-periodic design replace the dipoles with the transmission line itself, forming the log-periodic zig-zag antenna.Many other forms using the transmission wire as the active element also exist. The Yagi and the LPDA designs look very similar at first glance, as both consist of a number of dipole elements spaced out along a support boom. The Yagi, however, has only a single dipole connected to the transmission line, usually the second one from the back of the array. The other dipoles on the boom are passive elements, with their two sides shorted, acting as directors or reflectors depending on their slightly different lengths and position relative to the driven element. The difference between the LPDA and Yagi becomes obvious when examining their electrical connections; Yagi39;s lack the zig-zag connection between the elements. Another clear difference is the length of the dipoles; LPDA designs have much shorter dipoles towards the front of the antenna, forming a triangular shape as seen from the top, whereas the difference in lengths of Yagi elements is less noticeable or non-existent. Another visible difference is the spacing between the elements, which is normally constant in the Yagi, but becomes exponentially wider along the LPDA. Although both directional, the LPDA is intended to achieve a very wide bandwidth, whereas the Yagi has a very narrow bandwidth but achieves greater gain. In general terms, the log-periodic design operates somewhat similar to a series of three-element Yagis, where each set of three consecutive elements forms a separate antenna with the driven element in the center, a director in front and reflector behind. However, the system is somewhat more complex than that, and all the elements contribute to some degree, so the gain for any given frequency is higher than a Yagi of the same dimensions as any one section of the log-periodic. However, it should also be noted that a Yagi with the same number of elements as a log-periodic would have far higher gain, as all of those elements are improving the gain of a single driven element. In its common use as a television antenna, it was common to combine a log-periodic design for VHF with a Yagi for UHF, with both halves being roughly equal in size. This resulted in much higher gain for UHF, typically on the order of 10 to 14 dB on the Yagi side and 6.5 dB for the logperiodic.But this extra gain was needed anyway in order to make up for a number of problems with UHF signals. It should be strictly noted that the log-periodic shape, according to the IEEE definition,does not provide with broadband property for antennas. The broadband property of log-periodic antennas comes from its selfcomplementarity. Y found, for what he termed quot;the simplest selfcomplementary planar antenna,quot; a driving point impedance of 0/2=188.4 at frequencies well within its bandwidth limits.

The above chart displays the increase in the number of connected devices till 2025 The increasing demands in the IoT technology and future trends it has motivated us to contribute towards regulating and monitoring environment through IoT.

1.3 Advantages

They have very wide bandwidths. Log periodic antennas have much broader frequency bandwidths than Yagi antennas. One log periodic antenna may work for both HF and UHF frequencies. A log periodic antenna can be used for EMC measurements, when it is necessary to scan a wide band of frequencies. Log periodic antennas have the same radiation resistance over their frequency range. This gives it the same SWR whether at the low point of its frequency range or the high end. LP antennas also have the same gain and back to front ratio, and they have high forward gain. In contrast, a yagi antenna would experience degradation of its gain factor or front to back ratio as the frequency shifted from the one the antenna was optimized for. Three to six dB gain over a 2:1 bandwidth is reasonable with a log periodic antenna. Their feed point impedance is mostly constant. Because log periodic antennas have elements of different lengths as part of their design, it is easy to make changes in its frequency with relatively little impact on its electrical characteristics. Adding elements to a log periodic dipole antenna increases its bandwidth. Log periodic antennas typically have low SWR, rarely greater than 2:1. You may be able to achieve an SWR level better than 1.3:1. Since a log periodic antenna electrically acts like an array of yagi antennas, using a single log periodic antenna can replace multiple yagis.

1.4 Disadvantage

They have very low gain. They have less gain than a yagi antenna of the same size. And they have low gain per unit of weight or wind load. In order for a log periodic antenna to have very good VSWR performance, it needs to be very large. For smaller log periodic antennas, the VSWR performance is not very good. This can be offset by adding a yagi antenna to the receiving array.

1.5 Application

The log periodic antenna is used in many areas wide bandwidth levels are needed along with directivity and gain. There are several areas where the antenna is used: HF communications: Log periodic antenna arrays are often used for diplomatic traffic on the HF bands. Log periodic antennas perform well because embassies and other similar users will need to operate over a wide selection of frequencies in the HF bands, and it is often only feasible to have one antenna. A single log periodic antenna will give access to a sufficient number of frequencies over the HF bands to enable communications to be made despite the variations in the ionosphere changing optimum working frequencies. UHF Terrestrial TV: The log periodic antenna is sometimes used for UHF terrestrial television reception. As television channels may be located over a wide portion of the UHF spectrum, the log periodic enables a sufficient bandwidth to be covered. EMC measurements: EMC is a key issue for all electronic products. Testing requires frequency scans to be undertaken over wide bands of frequencies. When testing for radiated emissions an antenna that is able to provide a flat response over a wide band of frequencies is needed. The log periodic is able to offer the performance required and is widely used in this form of application. Other applications: There are many other applications where log periodic antennas can be used. Any applications where directivity and a wide bandwidth are needed are ideal applications for this form of RF antenna design. In view of its size and lower gain than the Yagi, the log periodic dipole array tends not be used as widely as the Yagi. Yet the LPDA comes into its own when wide bandwidths are needed.

Travelling Wave Antennas

In radio and telecommunication, a traveling-wave antenna is a class of antenna that uses a traveling wave on a guiding structure as the main radiating mechanism. Their distinguishing feature is that the radio-frequency current that generates the radio waves travels through the antenna in one direction. This is in contrast to a resonant antenna, such as the monopole or dipole, in which the antenna acts as a resonator, with radio currents traveling in both directions, bouncing back and forth between the ends of the antenna. An advantage of traveling wave antennas is that since they are nonresonant they often have a wider bandwidth than resonant antennas. Common types of traveling wave antenna are the Beverage antenna and the rhombic antenna. Traveling-wave antennas fall into two general categories: slow-wave antennas, and fast-wave antennas. Fast-wave antennas are often referred to as leaky-wave antennas. Traveling-wave antennas are a class of antennas that use a traveling wave on a guiding structure as the main radiating mechanism.Traveling-wave antennas fall into two general categories,slow-wave antennas and fast-wave antennas, which are usually referred to as leaky-wave antennas. In slow-wave antenna, the guided wave is a slow wave, meaning a wave that propagates with a phase velocity vph that is less than the speed of light in free space.Such a wave does not fundamentally radiate by its nature, and radiation occurs only at discontinuities (typically the feed and the termination regions).The propagation wavenumber of the traveling wave is therefore a real number (ignoring conductors or other losses).Because the wave radiates only at the discontinuities, the radiation pattern physically arises from two equivalent sources, one at the beginning and one at the end of the structure.This makes it difficult to obtain highly-directive single-beam radiation patterns.However,moderately-directive patterns having a main beam near endfire can be achieved, although with a significant sidelobe level. For these antennas there is an optimum length depending on the desired location of the main beam.Examples include wires in free space or over a ground plane, helixes, dielectric slabs or rods, corrugated conductors.An independent control of the beam angle and the beam width is not possible. By contrast, the wave on a Leaky-Wave Antenna (LWA) may be a fast wave, with a phase velocity greater than the speed of light.This type of wave radiates continuously along its length, and hence the propagation wavenumber kzis complex, consisting of both a phase and an attenuation constant.Highly-directive beams at an arbitrary specified angle can be achieved with this type of antenna, with a low sidelobe level.The phase constant of the wave controls the beam angle (and this can be varied changing the frequency), while the attenuation constant controls the beamwidth.The aperture distribution can also be easily tapered to control the sidelobe level or beam shape. Leaky-wave antennas can be divided into two important categories, uniform and periodic, depending on the type of guiding structure. A uniform structure has a cross section that is uniform (constant) along the length of the structure, usually in the form of a waveguide that has been partially opened to allow radiation to occur.The guided wave on the uniform structure is a fast wave, and thus radiates as it propagates. a directional antenna in which a traveling wave of electromagnetic oscillations is propagated along its geometric axis. Traveling- wave antennas are made either with discrete radiators placed along the axis at a certain distance from one another or in the form of a continuous radiator that extends in the direction of the axis. (The latter is considered as the sum of discrete radiators adjoining one another.) The Yagi antenna and the helical antenna belong to the first category; the dielectric rod antenna and the Beverage antenna belong to the second. There are also traveling-wave antennas consisting of several elements, each of which is a traveling-wave antenna of the second type (the rhombic antenna and others). This type of antenna is used in receiving and transmitting installations for all wavelengths of the radio band. The traveling-wave antenna has its maximum radiation (reception) in the direction of its axis. The directivity is D = kl/ where / is the length of the antenna, is the wavelength, and k is a coefficient that depends on the directivity of the individual radiating element, the phase velocity of the traveling wave, the relationships of the current amplitudes in the radiating elements, and other factors. The value of k usually lies in a range from 4 to 8. The directivity reaches a maximum when the phase velocity v of the traveling wave is somewhat less than the velocity of light c and equal to v = c 2l/(2/ +) The typical characteristics of a traveling-wave antenna are the axially symmetrical shape of its threedimensional radiation pattern (that is, the shape of the pattern is the same in any plane passing through the antennas axis) and the maintenance of adequate directivity (in the majority of travelingwave antennas) over a broad wavelength range. The first characteristic becomes increasingly evident with an increase in the ratio l/ and the axial symmetry of the radiation pattern of each radiating element.

Advantages:

1. It is wideband device due to use of non-resonant wave circuits. It operates from 300 MHz to 50 GHz range.
2. It is low noise device.
3. It provides higher gain. The gain levels upto 40 dB can be achieved with single device.
4. It delivers moderate peak power and average peak power.
5. Coupled cavity TWT can deliver efficiencies upto 60per and gain upto 70 dB. Moreover it can provide peak power ouput from tens of KW to thousands of KW and average power upto tens of KW.

Disadvantages

1. It operates at lower efficiencies.
2. In coupled cavity TWT, coupling effect takes place between the cavities.
3. Helix TWT has limitation on high peak power due to helix wire thickness. This lim-

itation can be overcome by using coupled cavity TWT. This TWT type uses series of coupled cavities arranged axially along the beam instead of helix.

1.5.1 Reflector Antennas

An antenna reflector is a device that reflects ectromagnetic waves. Antenna reflectors can exist as a standalone device for redirecting radio frequency (RF) energy, or can be integrated as part of an antenna assembly. The parabolic reflector antenna which is often called the dish antenna provides an antenna solution applicable for VHF and above where high gain and directivity are needed. The parabolic reflector or dish antenna is the form of antenna which finds many uses in domestic satellite television reception, terrestrial microwave data links, general satellite communications and many more. Its size means that it is generally limited to use above 1GHz, although larger antennas may be used for frequencies down to about 100MHz. The parabolic reflector antenna or dish antenna is known for its distinctive shape, its high gain, and narrow beamwidths. It is the performance which can be achieved by using one is the reason it is so widely used at higher frequencies. There are two main elements to any parabolic reflector antenna: Radiating system: The radiating element within the parabolic reflector antenna can take a variety of forms. In some antennas it may be a simple dipole, in others a horn. Its aim is to illuminate the second element of the antenna, the reflector with an even density of radiation with the minimum spillage or radiation missing the reflector and being radiated elsewhere. Reflector: The reflector is the distinctive part of the parabolic reflector antenna. The parabolic shape is key to the operation of the RF antenna because the paths taken from the feed point at the focus to the reflector and then outwards are in parallel. However more importantly the paths taken are all the same length and therefore the outgoing waveform will form a plane wave and the energy taken by all paths will all be in phase. This enables the antenna to perform in a particularly effective manner. The parabolic shape of the reflector surface of the antenna enables a very accurate beam to be obtained. In this way, the feed system forms the actual radiating section of the antenna, and the reflecting parabolic surface is purely passive. For most domestic systems like those used for satellite television reception, a small reflector combined with a focal point feed are used, providing the simplest and most economical form of construction. These antennas may not always look exactly like the traditional full dish antenna. For mechanical and production reasons the feed is often offset from the centre and a portion of the paraboloid used, again offset from the centre as this provides mechanical advantage.

Advantages

1. It can be used both as transmitting antenna and receiving antenna due to principle of reciprocity.
2. The feed can be used in various modes with parabolic reflector viz. centre feed, cassegrain feed or offset feed. Each of these configurations have their respective benefits and applications.
3. Smaller size and low cost.

Disadvantages

1. Feed antenna and reflector disc block certain amount of radiation from the main parabolic reflector antenna. This is about 1 to 2percent
2. The design of parabolic reflector is a complex process.
3. Inspite of feed horn at focus and uniform illumination, certain amount of power from feed is bound to slop over the edges of parabolic reflector. This power is responsible to form side lobes in the radiation pattern.
4. Surface distortions can occur in very large dish. This is reduced by using wide mesh instead of continuous surface.
5. In order to achieve best performance results, feed should be placed exactly at the focus of the parabolic reflector antenna. This is difficult to achieve practically.

Applications

There are many areas in which the parabolic dish antenna is used. In some areas it is the form of antenna that is used virtually exclusively because of its characteristics.

Direct broadcast television Direct broadcast or satellite television has become a major form of distribution for television content. The wide and controllable coverage areas available combined with the much larger bandwidths enable more channels to be broadcast and this makes satellite television very attractive. The drawback is that satellites cannot broadcast very high power levels and combined with the path loss from geostationary orbit the signal levels are low. This means that directive antennas must be used to provide sufficient gain while being able to receive signals from only one satellite several satellites could be visible from one location and broadcasting on the same frequencies. The parabolic reflector antenna is able to meet these requirements and has the added advantage that it would not be as long as a Yagi for an equivalent level of gain and directivity.

Microwave links Terrestrial microwave links are used for many applications. Often they are used for terrestrial telecommunications infrastructure links. One of the major areas where they are used these days is to provide the backhaul for mobile telecommunications systems.

Satellite communications Many satellite uplinks, or those for communication satellites require high levels of gain to ensure the optimum signal conditions and that transmitted power from the ground does not affect other satellites in close angular proximity. Again the ideal antenna for most applications is the parabolic reflector antenna.

Radio astronomy Radio astronomy is an area where very high levels of gain and directivity are required. Accordingly the parabolic reflector antenna is an ideal choice. In all these applications very high levels of gain are required to receive the incoming signals that are often at a very low level. For transmitting this type of RF antenna design is able to concentrate the available radiated power into a narrow beamwidth, ensuring all the available power is radiated in the required direction.

1.5.2 Microwave Antenna

A microwave antenna is a physical transmission device used to broadcast microwave transmission between two or more locations. These antennas are used in a wide range of applications and it has been further classified:

A. Rectangular Microstrip antenna

B. Planar Inverted-F Antennas.

Rectangular Microstrip Antenna

Microstrip antenna in their simplest form consist of a conducting radiating patch on one side of the substrate and a conducting ground plane on the other side. The electromagnetic waves are radiated through radiating patch to which electrical signal is feed. The top view and side view of rectangular microstrip antenna is shown in Figure1.1. The top layer is conducting patch and the bottom layer is conducting ground plane. In middle there is a substrate with permittivity or dielectric constant r.

The microstrip antenna radiates at a particular resonant frequency and has narrow bandwidth. Due to its size, weight, ease of manufacturing it is used in various fields such as aerospace, defence, conducting ground plane. Besides communication, recent researches shows that the microstrip antennas can also be used as a sensor for detection of temperature, strain, dielectric, etc.

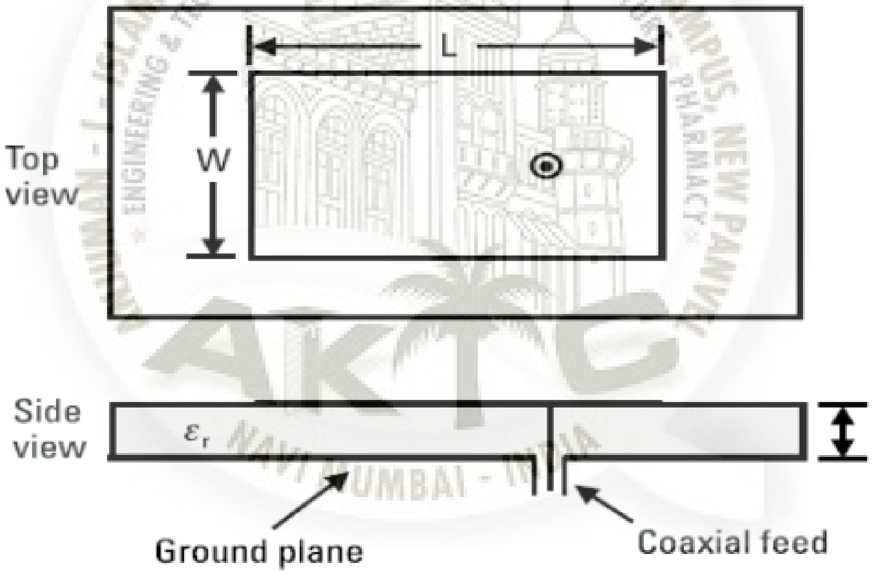


Figure 1.1: Microstrip Antenna

Types of Patches used in Microstrip Antenna

Microstrip antennas has different shapes of patch, most commonly used patch is rectangular. Circular and triangular patches also used widely. Microstrip antennas can be classified according to the shape of their patch. Different shapes of microstrip patches is shown in Figure.

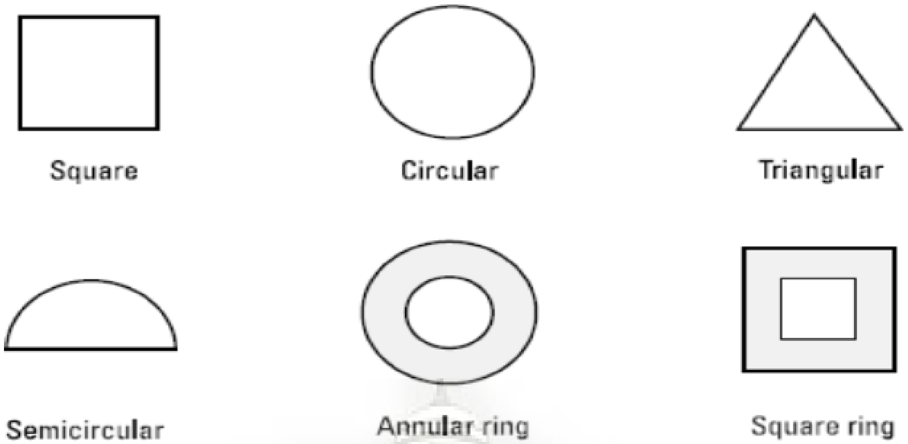


Figure 1.2: Different shapes of patches

1.5.3 Planar Inverted-F Antenna

When the patch of microstrip antenna is shorted to the ground plane it size reduces to 50Figure1.3 PIFA Now the microstrip antenna becomes Planer Inverted-F Antenna (PIFA). PIFA is used in mobile phones because of its compactness. The Planer Inverted-F Antenna (PIFA) are printed Inverted-F Antenna which monopole antenna running parallel to ground and shorted to ground at the end. It is a quarter wavelength shorted patch with limited ground plane and dielectric substrate in between. The PIFA design is shown in Figure1.3.

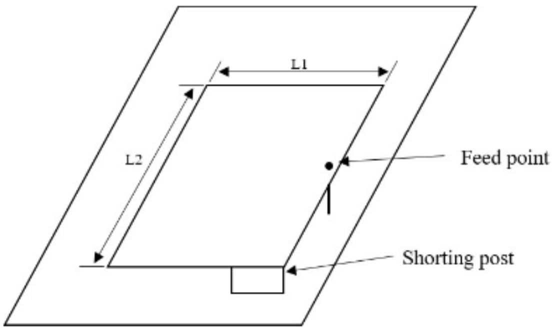


Figure 1.3: PIFA

Feeding Techniques:

The MSA can be excited directly either by a coaxial probe or by a microstrip line. It can also be excited indirectly using electromagnetic coupling or aperture coupling and a coplanar waveguide feed, in which case there is no direct metallic contact between the feed line and the patch. Feeding technique influences the input impedance and characteristics of the antenna, and is an important design parameter. The coaxial or probe feed arrangement is shown in Figure1.1. The centre conductor of the coaxial connector is soldered to the patch. The main advantage of this feed is that it can be placed at any desired location inside the patch to match with its input impedance. The disadvantages are that the hole has to be drilled in the substrate and that the connector protrudes outside the bottom ground plane, so that it is not completely planar. Also, this feeding arrangement makes the configuration asymmetrical. A patch excited by microstrip line feed is shown in Figure 1.4(a). This feed arrangement has the advantage that it can be etched on the same substrate, so the total structure remains planar. The drawback is the radiation from the feed line, which leads to an increase in the cross- polar level. Also, in the millimeter-wave range, the size of the feed line is comparable to the patch size, leading to increased undesired radiation.

For thick substrates, which are generally employed to achieve broad BW, both the above methods of direct feeding the MSA have problems. In the case of a coaxial feed, increased probe length makes the input impedance more inductive, leading to the matching problem. For the microstrip feed, an increase in the substrate thickness increases its width, which in turn increases the undesired feed radiation. The indirect feed, discussed below, solves these problems. An electromagnetically coupled RMSA is shown in Figure 1.4(b). The electromagnetic coupling is also known as proximity coupling. The feed line is placed between the patch and the ground plane, which is separated by two dielectric media. The advantages of this feed configuration include the elimination of spurious feed-network radiation; the choice between two different dielectric media, one for the patch and the other for the feed line to optimize the individual performances; and an increase in the BW due to the increase in the overall substrate thickness of the MSA. The disadvantages are that the two layers need to be aligned properly and that the overall thickness of the antenna

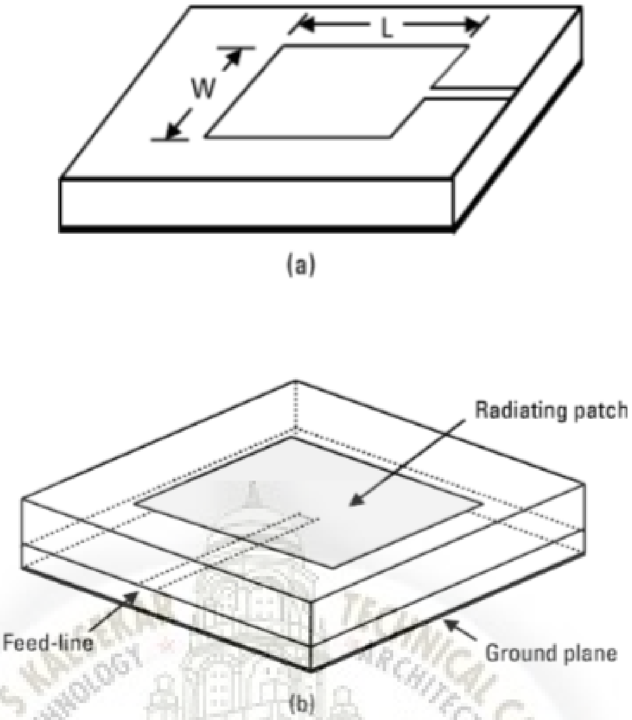


Figure 1.4: PIFA

Another method for indirectly exciting a patch employs aperture coupling. In the aperture-coupled MSA configuration, the field is coupled from the microstrip line feed to the radiating patch through an electrically small aperture or slot cut in the ground plane, as shown in Figure 1.4(c). The coupling aperture is usually centered under the patch, leading to lower cross-polarization due to symmetry of the configuration. The shape, size, and location of the aperture decide the amount of coupling from the feed line to the patch. The slot aperture can be either resonant or nonresonant. The resonant slot provides another resonance in addition to the patch resonance thereby increasing the BW at the expense of an increase in back radiation. As a result, a non-resonant aperture is normally used. The performance is relatively insensitive to small errors in the alignment of the different layers. Similar to the electromagnetic coupling method, the substrate parameters of the two layers can be chosen separately for optimum antenna performance. This feeding method gives increased BW.

The coplanar waveguide feed, shown in Figure 1.3(d), has also been used to excite the MSA. In this method, the coplanar waveguide is etched on the ground plane of the MSA. The line is excited by a coaxial feed and is terminated by a slot, whose length is chosen to

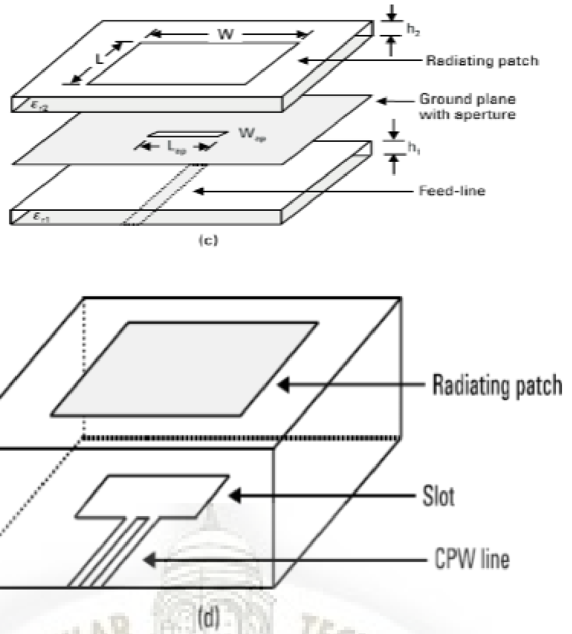


Figure 1.5: Rectangular MSA fed by (a) microstrip line, (b) electromagnetic coupling,(c) aperture coupling, and (d) coplanar waveguide (CPW).

be between 0.25 and 0.29 of the slot wavelength. The main disadvantage of this method is the high radiation from the rather longer slot, leading to the poor front-to- back ratio. The front-to- back ratio is improved by reducing the slot dimension and modifying its shape in the form of a loop.

Chapter 2

Review of Literature

2.1 Review on Single Band Dual Fed Circular Polarisation Microstrip Antenna for RFID Application

2.1 Introduction

Radio frequency identification (RFID) is technology that depends on the radio wave communication to transfer and receive data for tracking and identification process. In other words, it is a contactless method for data transfer in object identification. RFID systems have been gaining more and more popularity in areas such as supply chain management, automated identification systems, and any place requiring identifications of products or people. RFID technology is better than barcode in many ways, and may totally replace barcode in the future if certain technologies can be achieved such as low cost and protection of personal privacy. RFID consists of two parts; which are the readers and the tags. It operates by sending an interrogation signal from the readers to the tags, and the tags will send a back-scattered modulated signal to the readers. Most of the RFID tags consist at least two parts; one is the integrated circuit to store and process information while the other part is the antenna to transmit the signal Many types of antenna have been used for RFID tags application during these past few years. A lot of research has been carried out to increase the performances of these antennas. Lots of designs and innovations have been introduced. Inverted F antennas (IFA) are one of the mostly used antennas for RFID tags.

2.2 conclusion

The new circularly polarized perpendicular dual-feed and truncated patch antenna has been demonstrated. The proposed antenna has been simulated thoroughly using CST-MWS software. The simulation and measurement results of the antenna have shown that the antenna has an acceptable return loss with 12.09dB. The axial ratio of the proposed antenna is 1.11dB, which satisfy the rule of AR and lt;3dB in circular polarization antenna in practice.

2.2 Review on Single Band MIMO Antenna for WLAN and WiMax Applications

2.3 Introduction

In conventional wireless communication ,a single antenna is used at the source and destination. In some cases this gives rise to problem with multipath effects .When an electromagnetic wave travels from source to destination ,it is obstructed by hill, buildings and utility wires etc. The wave fronts are scattered and thus they take many paths to reach the destination. Fading cutout and intermittent reception many paths to reach. These effects can cause a reduction in data speed and increase in the number of errors. Thus the use of two or more antennas along with the transmission of multiple signal at the source and destination eliminate the trouble caused by and even take advantage of this effect. MIMO technology has aroused interest because of its possible applications in digital television (DTV).wireless local area networks (WLANS), Metropolitan Area Network(MANs) and mobile communication. Wi- Fi or Wireless Fidelity has a range of about 100m and supports faster data transfer rate at the speed of 10-54 MBPS .There are three different standards under WiFi,802.11a,802.11b,802.11g.The Institute of electrical and electronic engineers set 802.11 as the wireless standard set .Wi-Fi is used to create Wireless local area network. The IEEE 802.11 g is expected to grow rapidly. These two standards are relatively expensive and can be found providing wireless connectivity in railway stations, airports. restaurants and other public places.

2.4 Result and Discussion

1. Reflection Coefficient

It shows the reflection coefficient of the single band MIMO antenna. According to maximum power transfer theorem ,the maximum amount of power will be transferred when there is perfect match between devices. Transfer between the feedline antenna takes place when the input impedance of antenna must identically match with characteristic impedance of feed line .If any mismatch in impedance results in return of energy back to the source called return loss. An antenna is said to be efficient if the return loss is below -10 dB. In the figure given below the return loss is below -10 dB for 2.4889 GHz to 2.611 GHz .The bandwidth obtained is 12.

2.VSWR

The VSWR measurement describes the voltage standing wave pattern that is present in the transmission line due to the phase addition and subtraction of the incident and reflected wave. It is also defined as the ratio of maximum radio frequency voltage to the minimum radio frequency voltage along line .For the obtained frequency the VSWR value is 1.1.The VSWR value should be less than 2.When the VSWR value exceed 2,the transmission line has significant loss in it.

3.Radiation Pattern.

The radiation pattern or antenna pattern is the graphical representation of the radiation properties of the antenna as a function of space .That is the antennas pattern describes how the antenna radiates energy out in the space.

4.Envelop Correlation Coefficient

Envelop correlation coefficient is an important parameter to be analyzed in MIMO antenna .A correlation value below 0.3 -0.4 is usually considered a good value for MIMO antenna .A value of 0 denotes that the antenna is highly uncorrelated and a value of 1 denotes that antenna is short circuited.

2.4.1 conclusion

Thus a single band MIMO antenna which operates from 2.3 GHz to 2.5 GHz is proposed which is not only used for WLAN application but also for other wireless application.

Thought the proposed antenna is just a single band antenna, it is an MIMO antenna which satisfies the demand for high data rates and spectral efficiencies when compared to conventional antenna. The structure of the proposed antenna is a bowtie antenna which is an another advantage since it falls under the category of frequency independent antennas. The peak gain of the antenna is 1.6..Making the antenna resonate at multiple frequencies may be the future works of the paper.
2.3 Review on Slot Loaded Microstrip Patch Antenna for WLAN and WiMax Applications

2.5 Introduction

Microstrip patch antennas are the most widely utilized antennas for wireless communication applications such as in WLAN and WiMax. This is primarily because they present light weight, low cost, low profile and ease of integration characteristics. However, at the same time they exhibit a narrow bandwidth characteristic. In past years researchers have reported several wideband configurations of microstrip patch antennas for use in wireless communication systems. In, a broadband E-shaped microstrip patch antenna operating in the 5-6 GHz frequency band for wireless networks was proposed. In, a broadband multi-slotted microstrip patch antenna for wireless communication in 1.82-2.41 GHz band was demonstrated by the authors. In Peng, Ruan and Wu proposed an asymmetrical M-shaped microstrip patch antenna for operation in 2.4/5.2/5.8 GHz WLAN triple band. In, Deshmukh and Ray had proposed a wideband microstrip patch antenna using quarter wavelength resonant slots. In this article, a single aperture fed dual loop-shaped slotted microstrip patch antenna operating in a wideband is proposed.

2.5.1 conclusion

A compact dual loop-shaped slotted square microstrip antenna with an aperture coupled feed is studied and its results presented. The proposed antenna geometry showed a very broad 2:1 impedance bandwidth of 30.10percent. A gain of more than 6.4 dBi is obtained over the 2:1 VSWR frequency band. The proposed antenna geometry finds application in wireless systems such as WLAN and WiMax in the frequency range of 2.4-2.7 GHz.

Chapter 3

Design of Microstrip Antenna

The design of microstrip antenna for this project has certain stages which includes both design by using formulae as well as design by using iteration method.

3.1 Formula for Design of Reactangular Microstrip Antenna

Following Formulas cab be used for Rectangular Microstrip antenna:

1.Wavelength

$$\lambda = \frac{c_0}{f.\sqrt{\varepsilon_r}}$$

2.Width of Patch

$$W = \frac{c}{2f_0\sqrt{\frac{(\varepsilon_r+1)}{2}}}$$

3.Effective Dielectric

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

4.Extension in Length

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

6. Actual Length of Patch

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

Chapter 4

Methodology

The design of microstrip antenna sensor for this project include calculation and simulation, sometime in the process of design both calculation and simulation going simultaneously and also when iterations are carried out. The software used for simulation is HFSS (High Frequency Simulation Software). The iteration method is carried in the HFSS simulation method to get the expected results. In the proceeding section introduction to HFSS is given which is followed by the simulation procedure in HFSS.

4.1 Introduction to HFSS

HFSS is an interactive software package for calculating the electromagnetic behavior of a structure. The software includes post-processing commands for analyzing this behavior in detail. The work window of HFSS software is shown in Figure . Using HFSS, we can compute:

1 Basic electromagnetic field quantities and, for open boundary problems, radiated near and far fields.

2 Characteristic port impedances and propagation constants.

3 Generalized S-parameters and S-parameters renormalized to specific port impedances.

4 The eigenmodes, or resonances, of a structure. We are expected to draw the structure, specify material characteristics for each object, and identify ports and special surface characteristics. HFSS then generates the necessary field solutions and associated port characteristics and S-parameters.

HFSS uses a numerical technique called the Finite Element Method (FEM). This is a procedure where a structure is subdivided into many smaller subsections called finite elements. The finite elements used by HFSS are tetrahedra, and the entire collection of tetrahedra is called a mesh. A solution is found for the fields within the finite elements, and these fields are interrelated so that Maxwells equations are satisfied across inter-element boundaries. Yielding a field solution for the entire, original, structure. Once the field solution has been found, the generalized S-matrix solution is determined. **The six general steps in an HFSS simulation** There are six main steps to creating and solving a proper HFSS simulation. They are:

1. Create model/geometry
2. Assign boundaries
3. Assign excitations
4. Set up the solution
5. Solve
6. Post-process the results

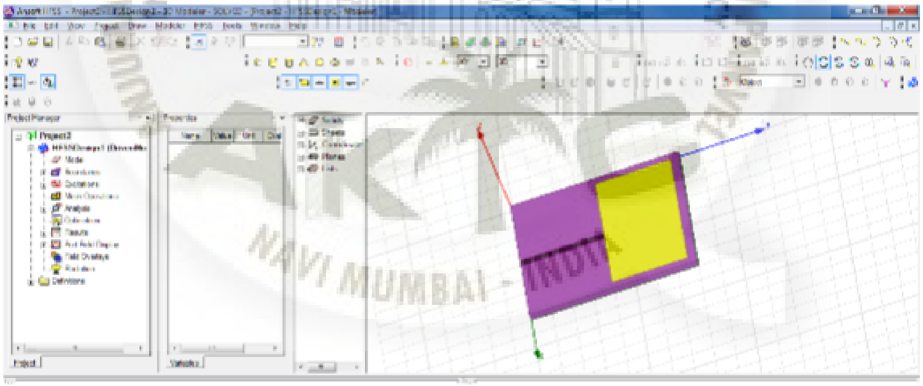
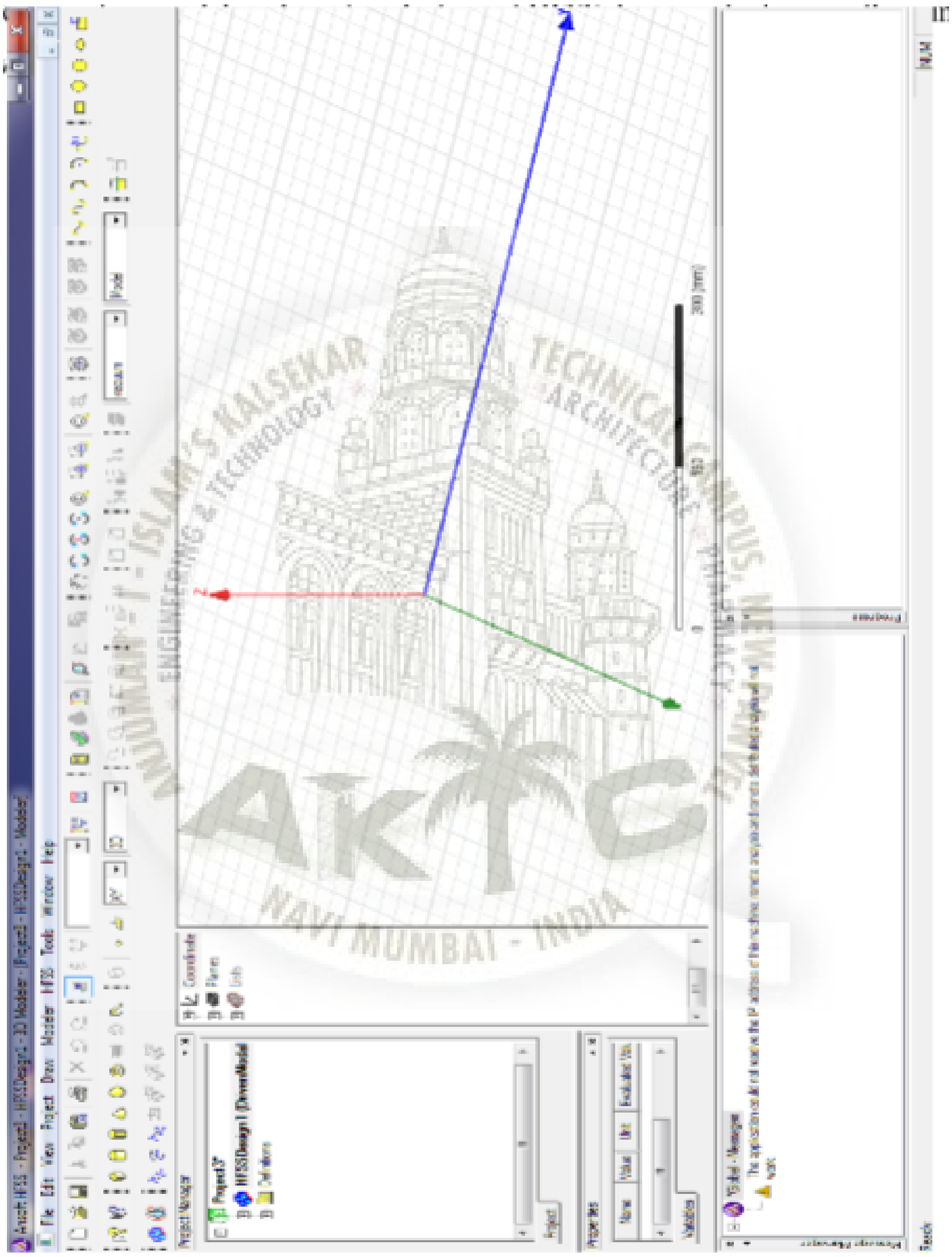


Figure 4.1: HFSS Window

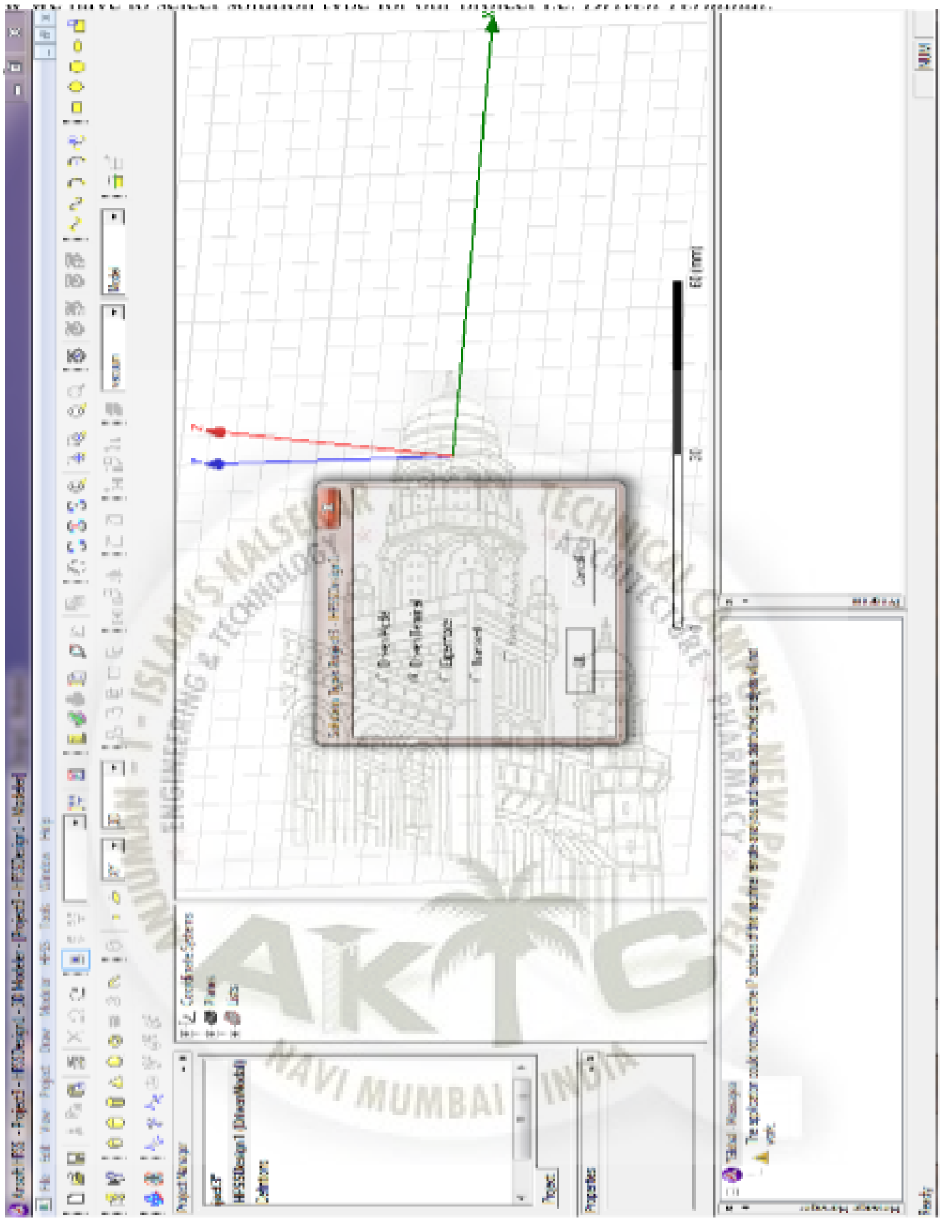
4.2 Simulation Steps of Microstrip Antenna Sensor

Step 1: Create model/geometry

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

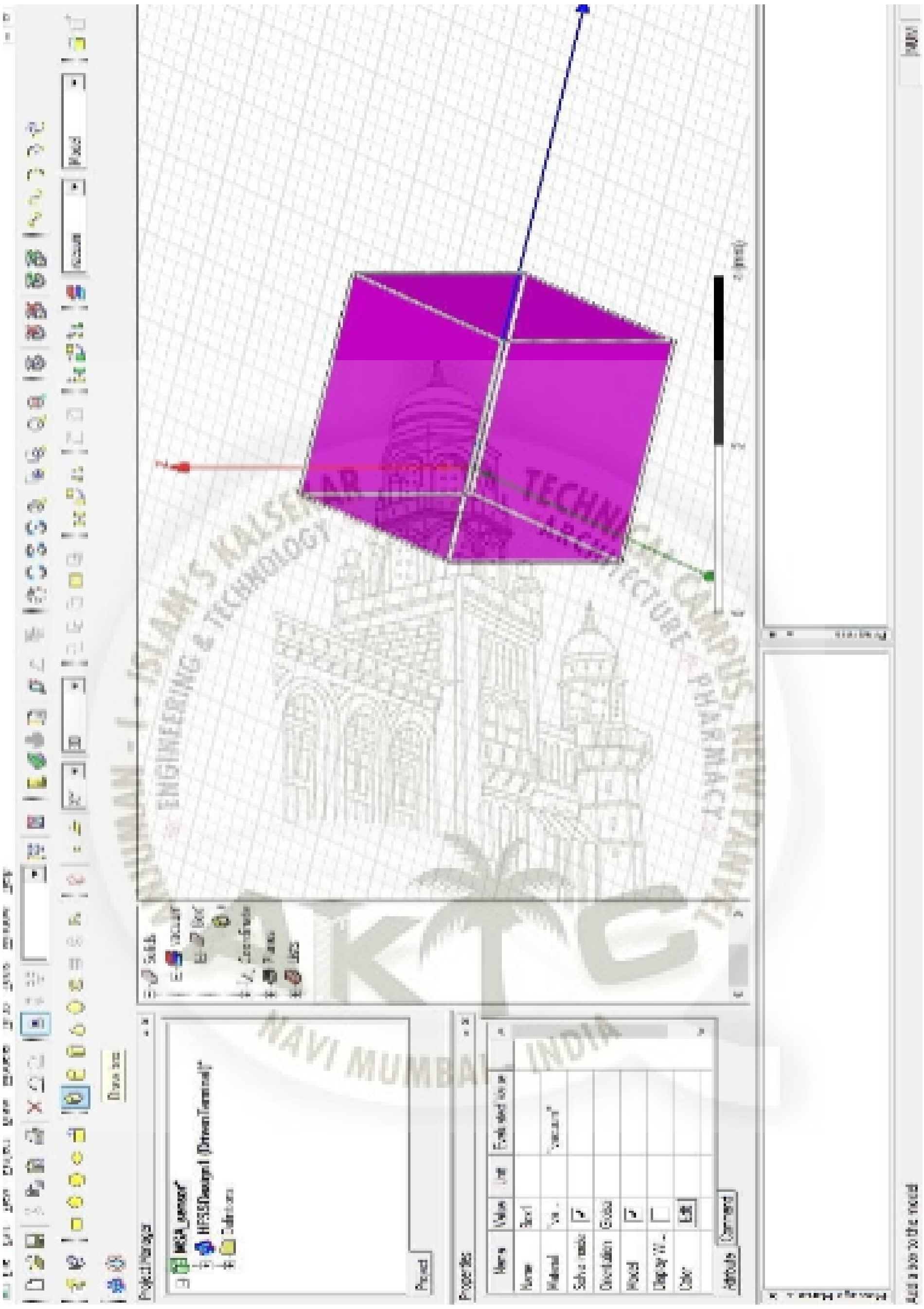


Now we have to select solution type for our project i.e. Driven Terminal. Go to HFSS→ $Solutiontype \rightarrow SelectDrivenTerminal \rightarrow Ok$.



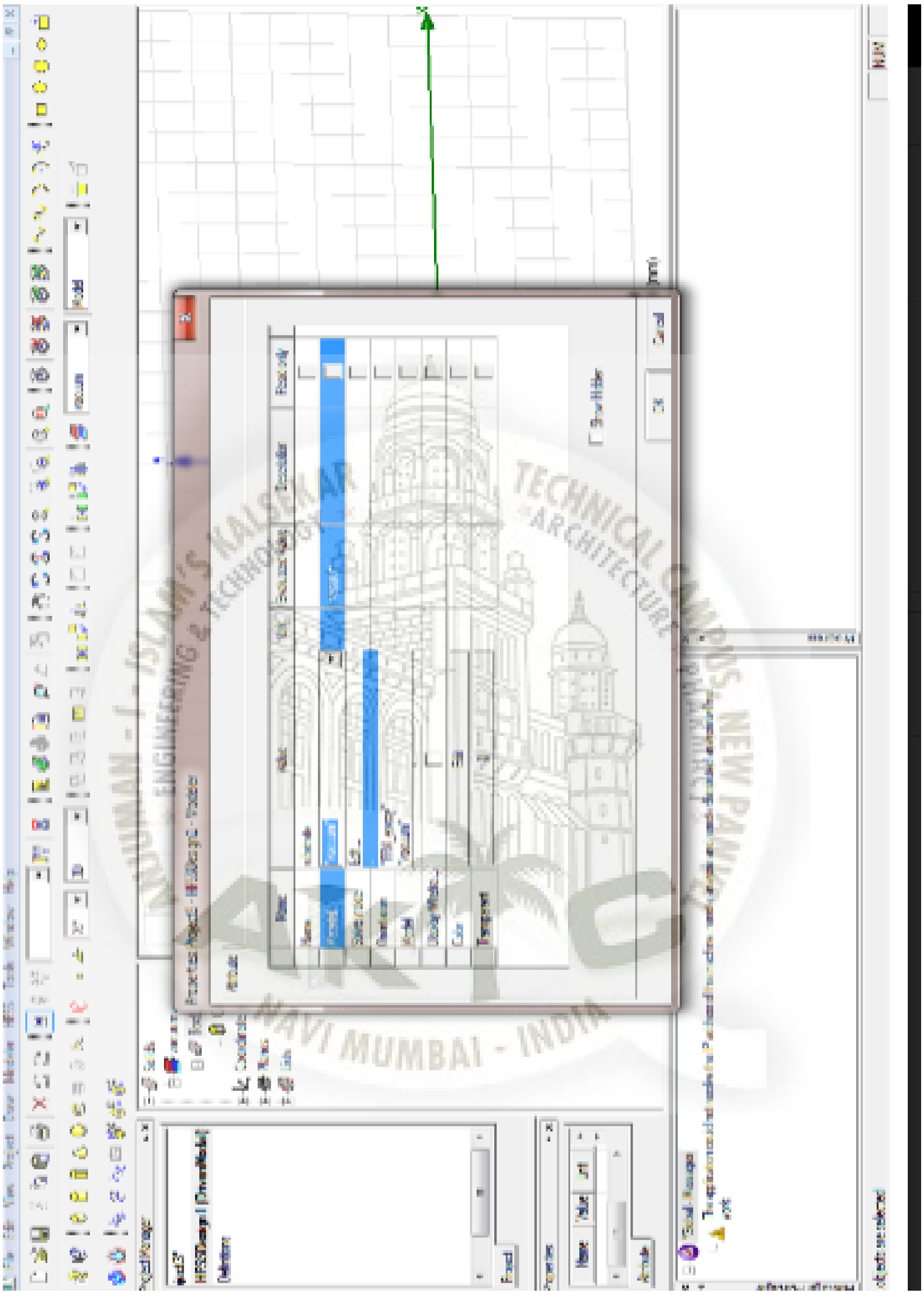
Placing Substrate in the drawing window.

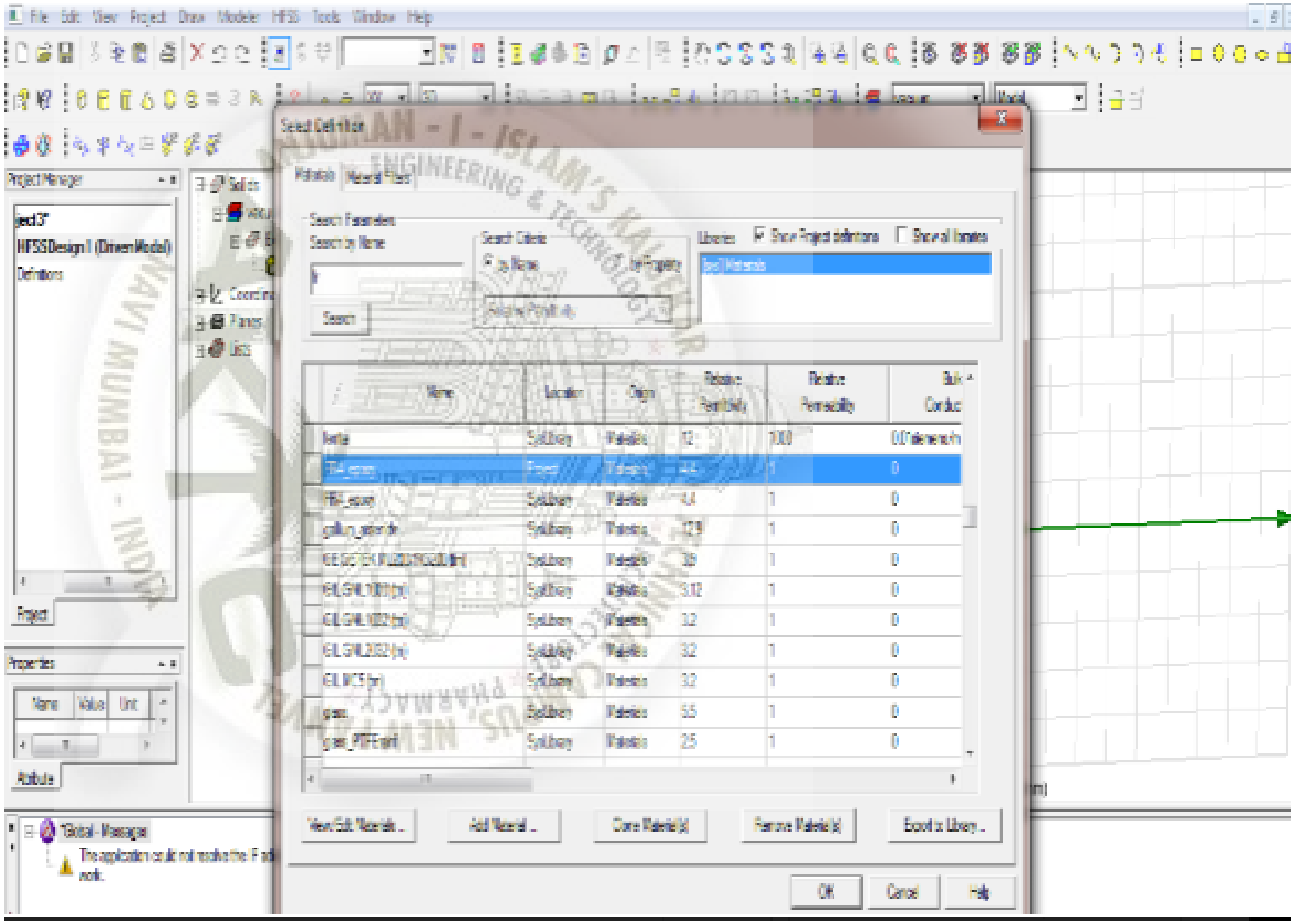
Select Draw box→ *Placeinthedrawingwindow*



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

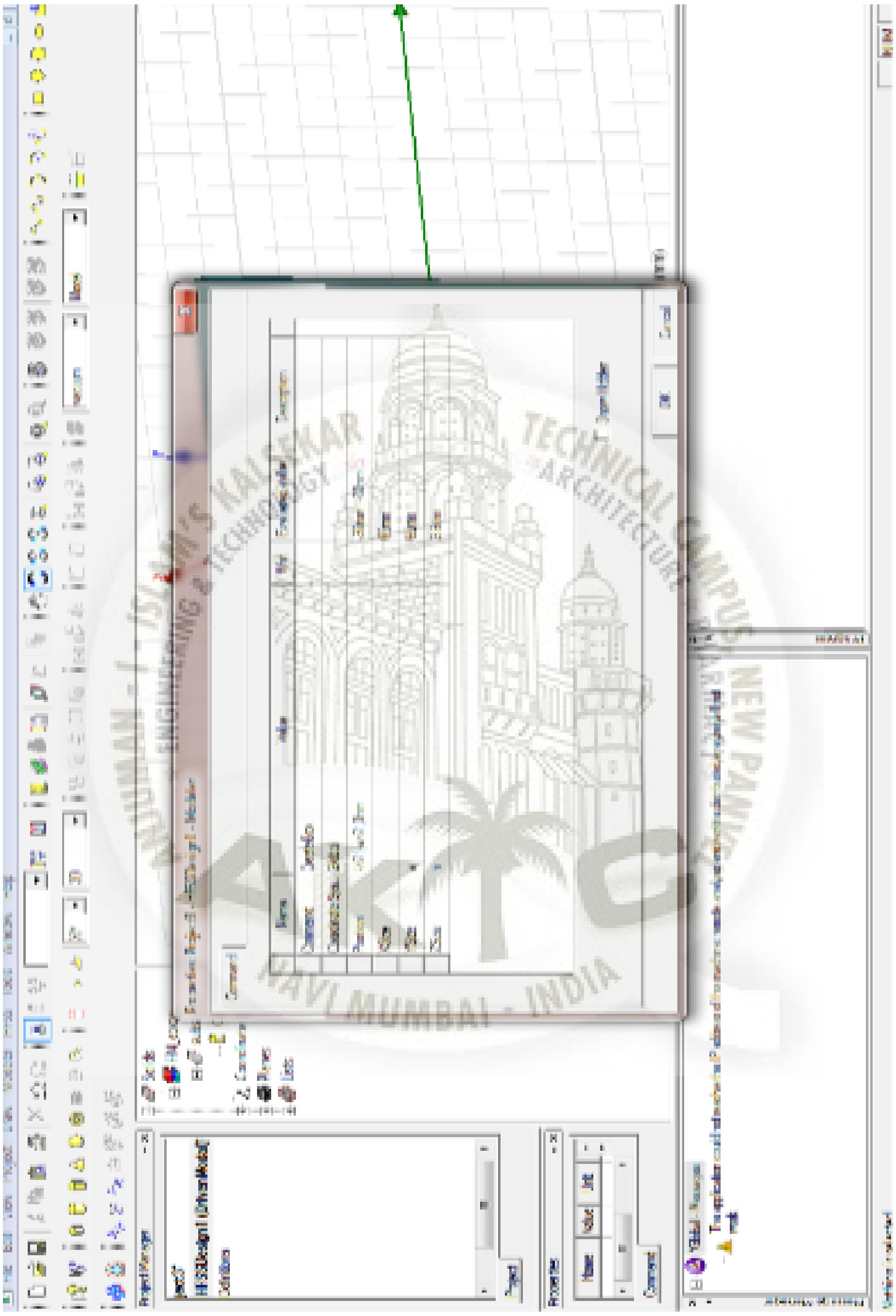
Right click on Box1$\rightarrow Properties \rightarrow Material \rightarrow FR4_epoxy \rightarrow Ok.$



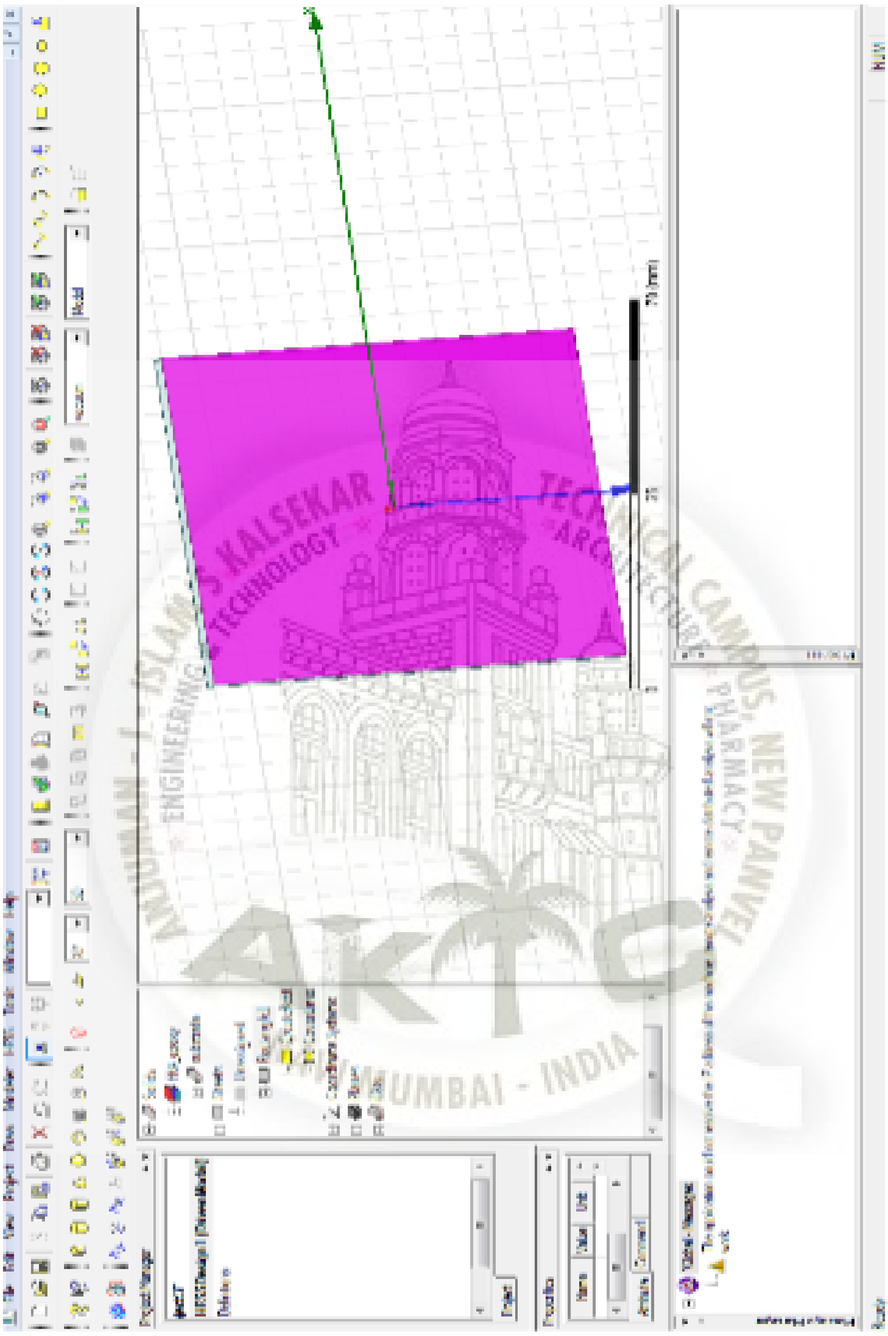


After setting Name, Color and transparency the size and position of the substrate is edited.

Right click on create box→ $Properties \rightarrow editx, y, zposition \rightarrow editX, Y, Zsize \rightarrow ok.$



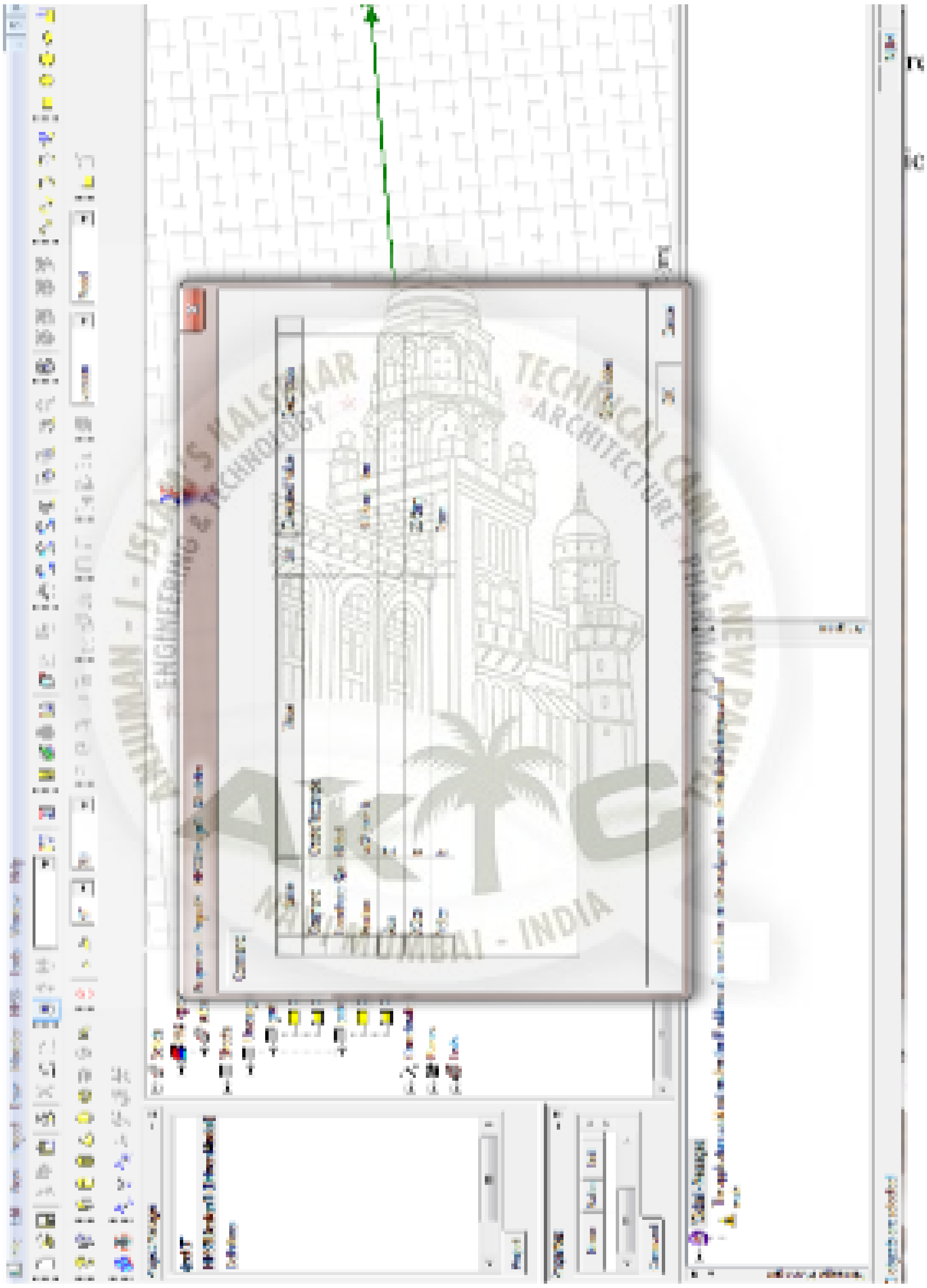
Now we have to place ground, which is a rectangle, in the window. From tool bar, Select Draw Rectangle→ *Placeinthewindow*.



Now edit properties of the rectangle drawn (Name, Color, and Transparency). And then its size and position

Right click on Rectangle1 $\rightarrow Properties \rightarrow EditName, ColorTransparency$

$RightclickonCreateRectangle \rightarrow Properties \rightarrow EditSizePosition$

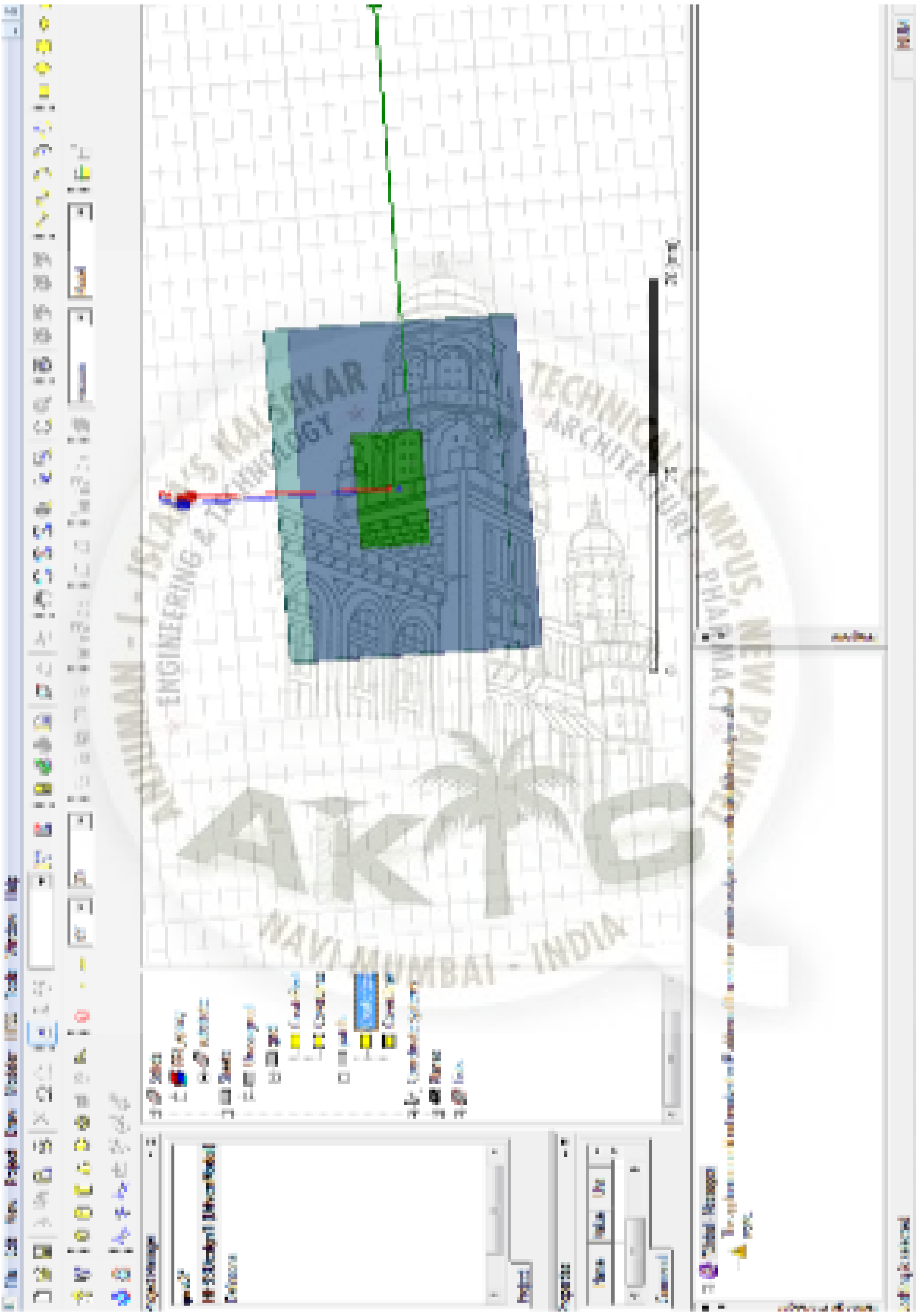


Placing rectangle for patch.

From tool bar, Select Draw Rectangle→ $PlaceitintheWindow.$

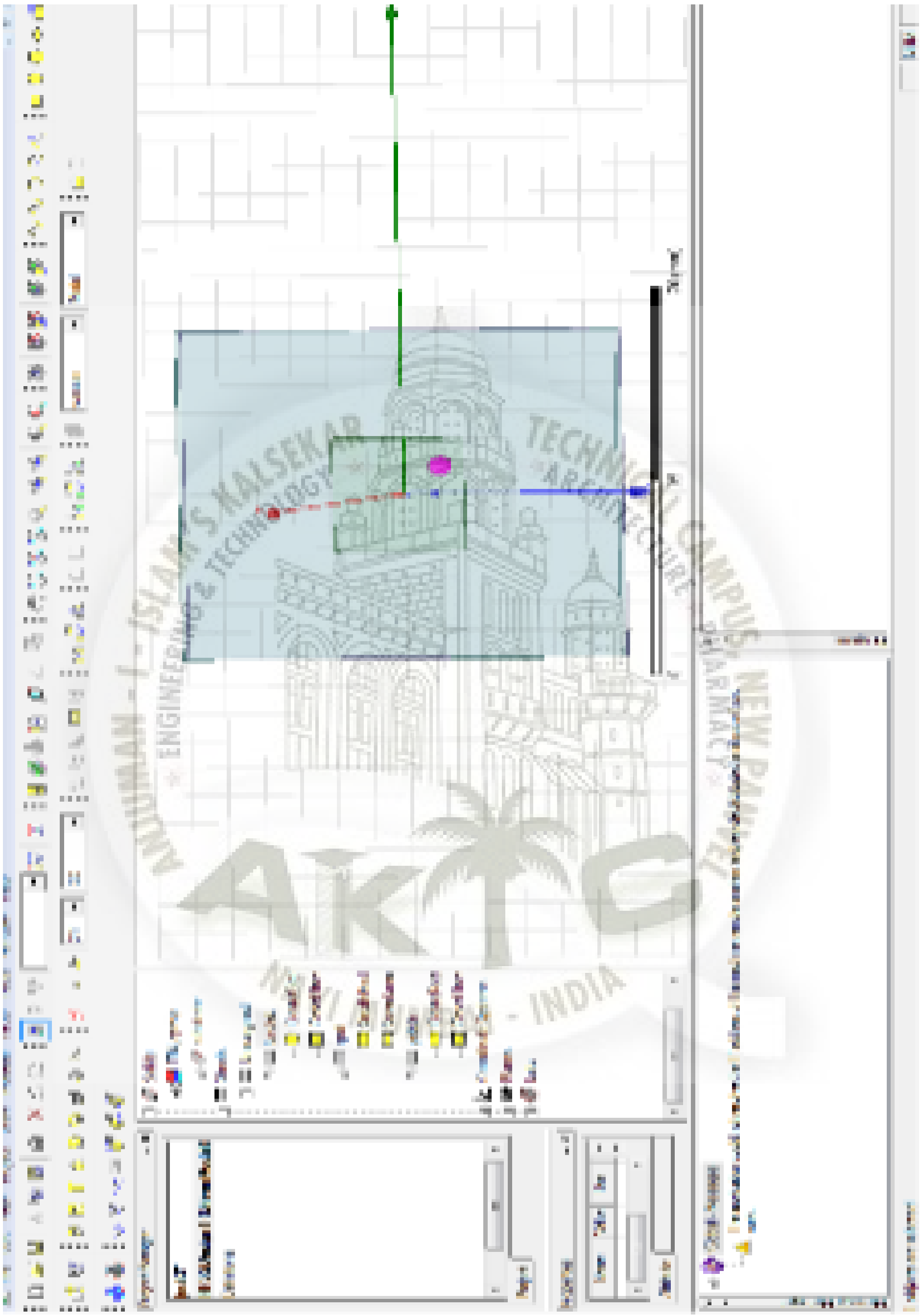
$RightclickonRectangle1 \rightarrow Properties \rightarrow EditName, ColorTransparency.$

$RightclickonCreateRectangle \rightarrow Properties \rightarrow EditSizePosition.$

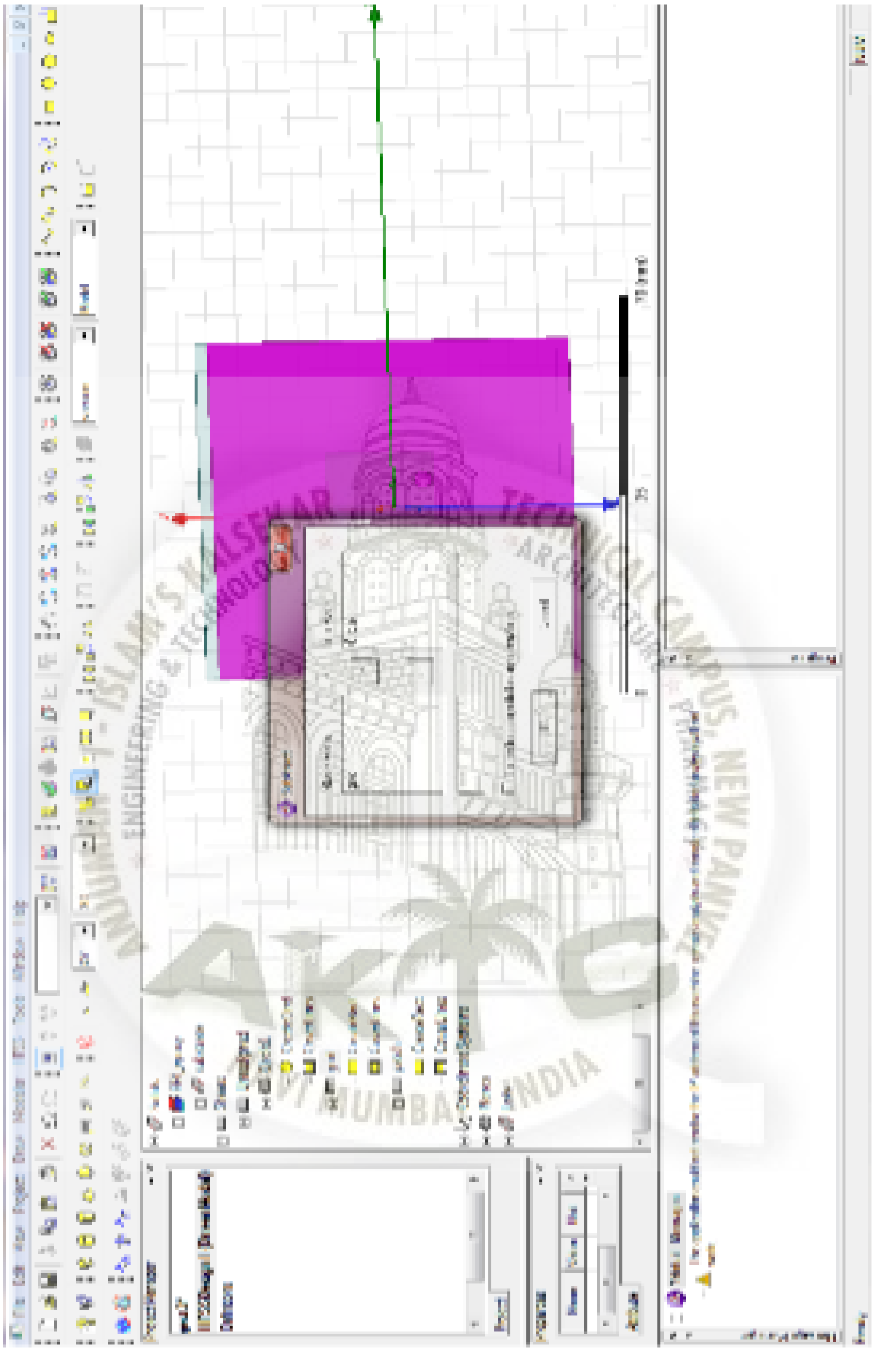


Now there must be circular cut in the ground plane where coaxial pin is to be inserted and slot cuts on the patch for meandering.

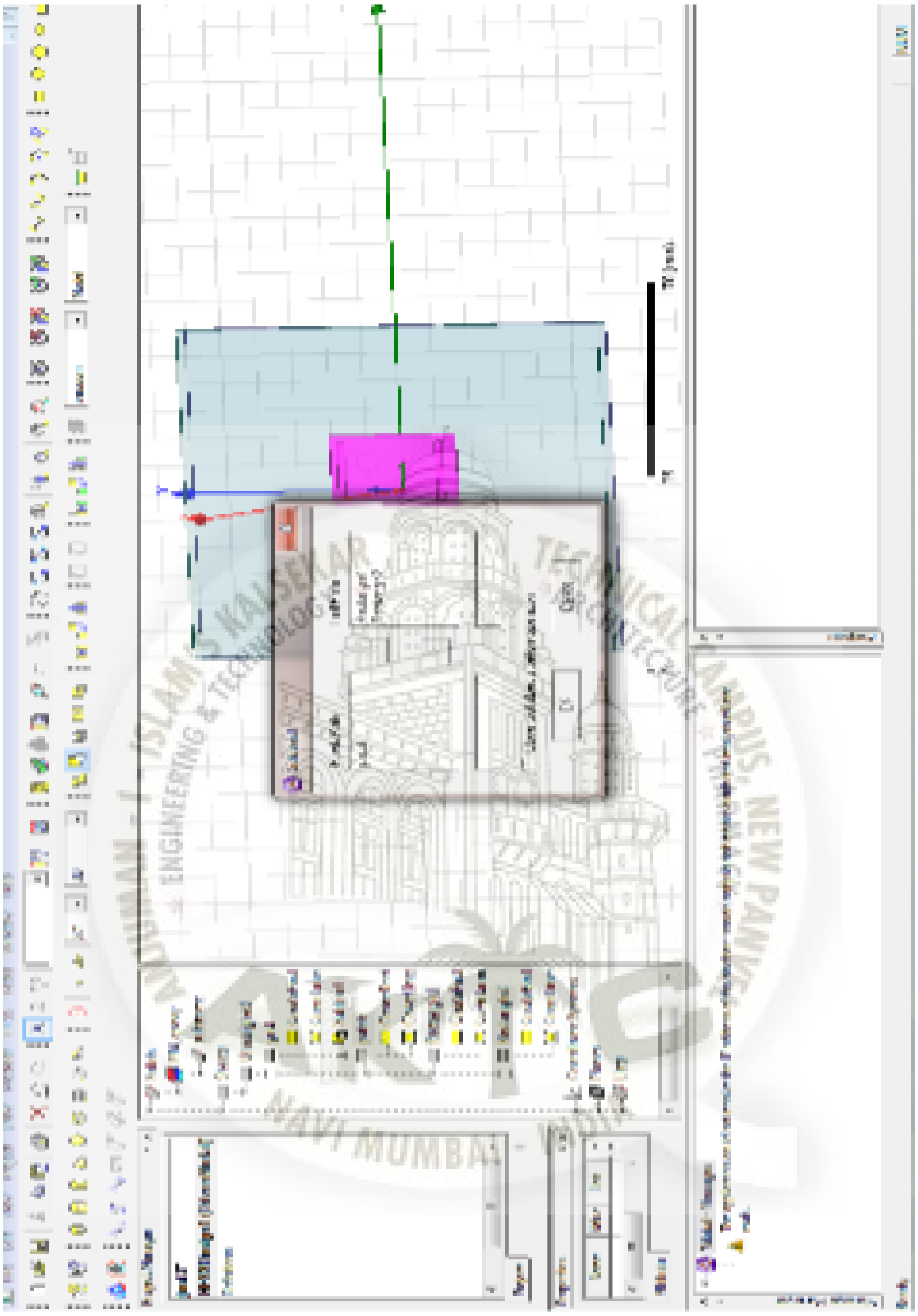
Select Draw Circle→ $Placingitatthepositionofcircularcut \rightarrow Edititsdimension.$



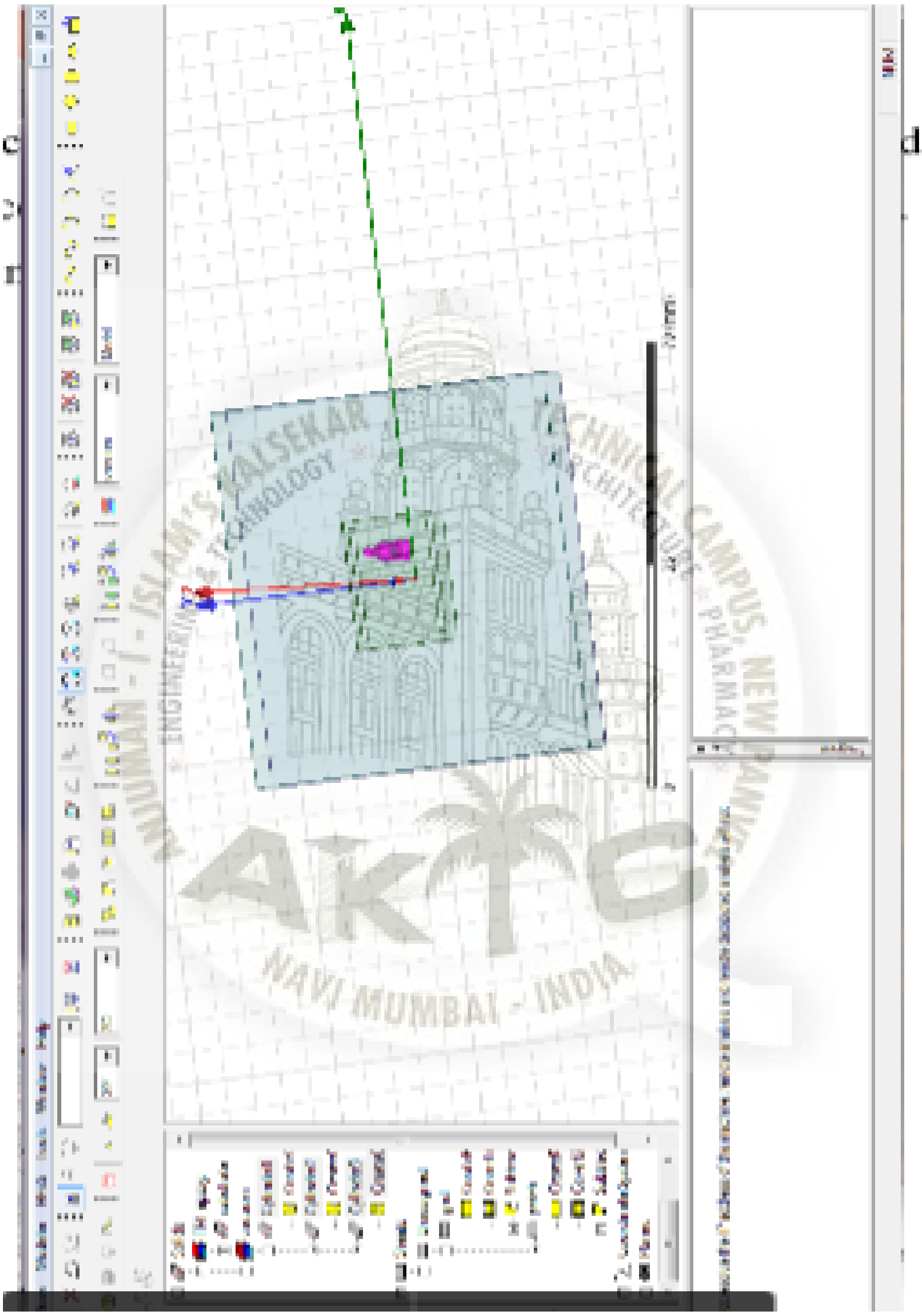
Select Ground $\rightarrow Ctrl + SelectCircle1 \rightarrow SelectSubtract \rightarrow Ok$.



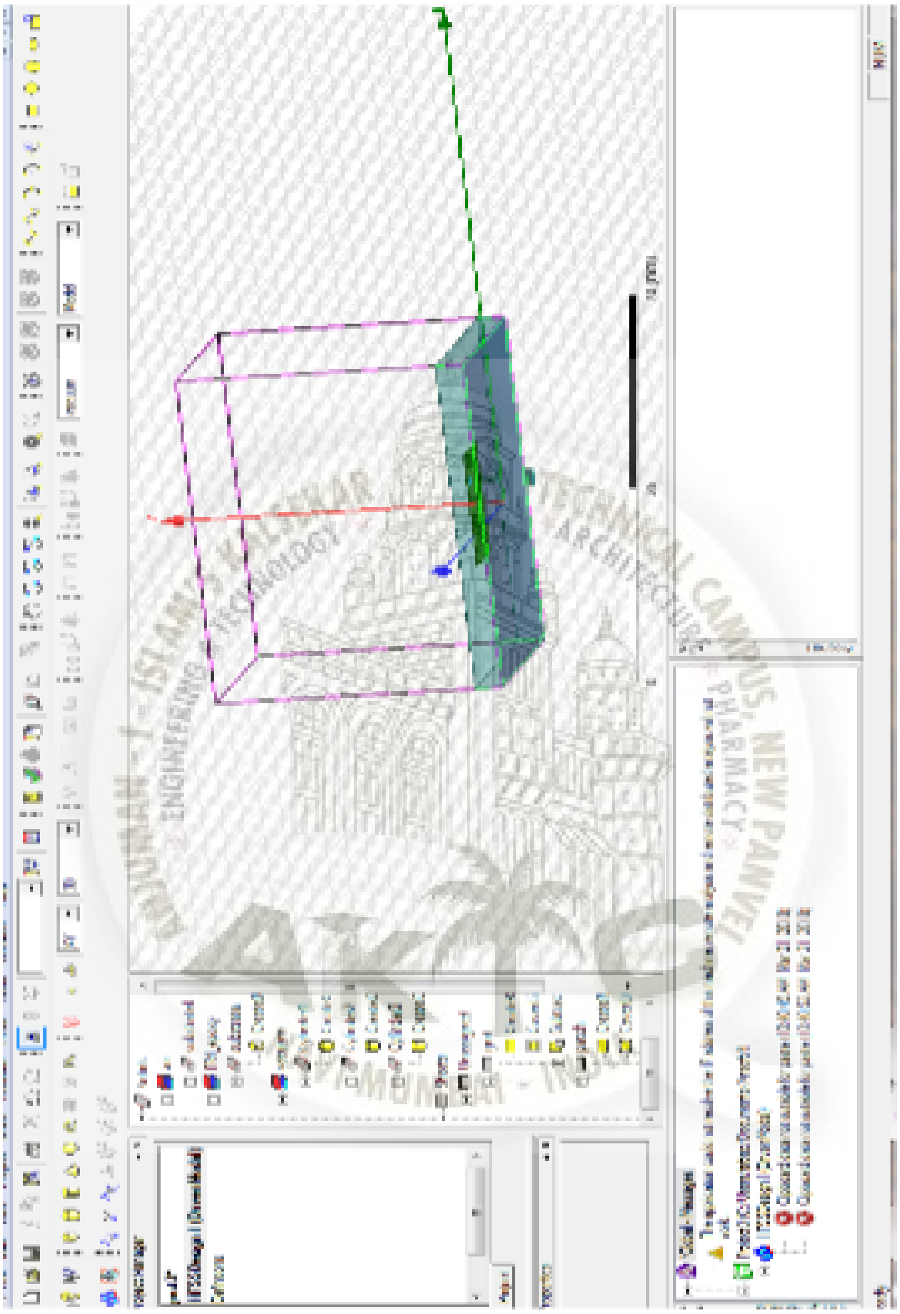
Similarly slot rectangles are made and subtracted from Patch.



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.



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

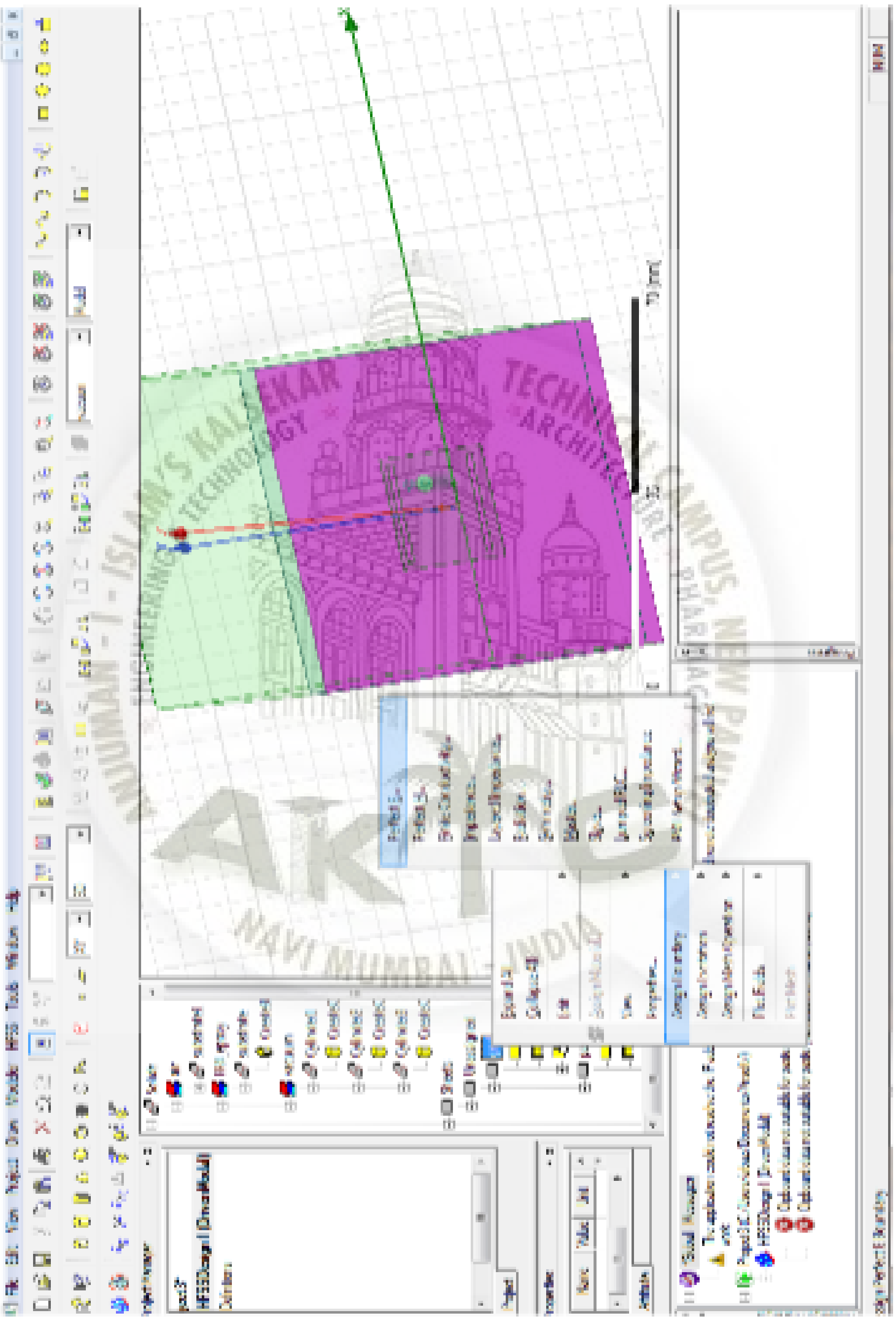


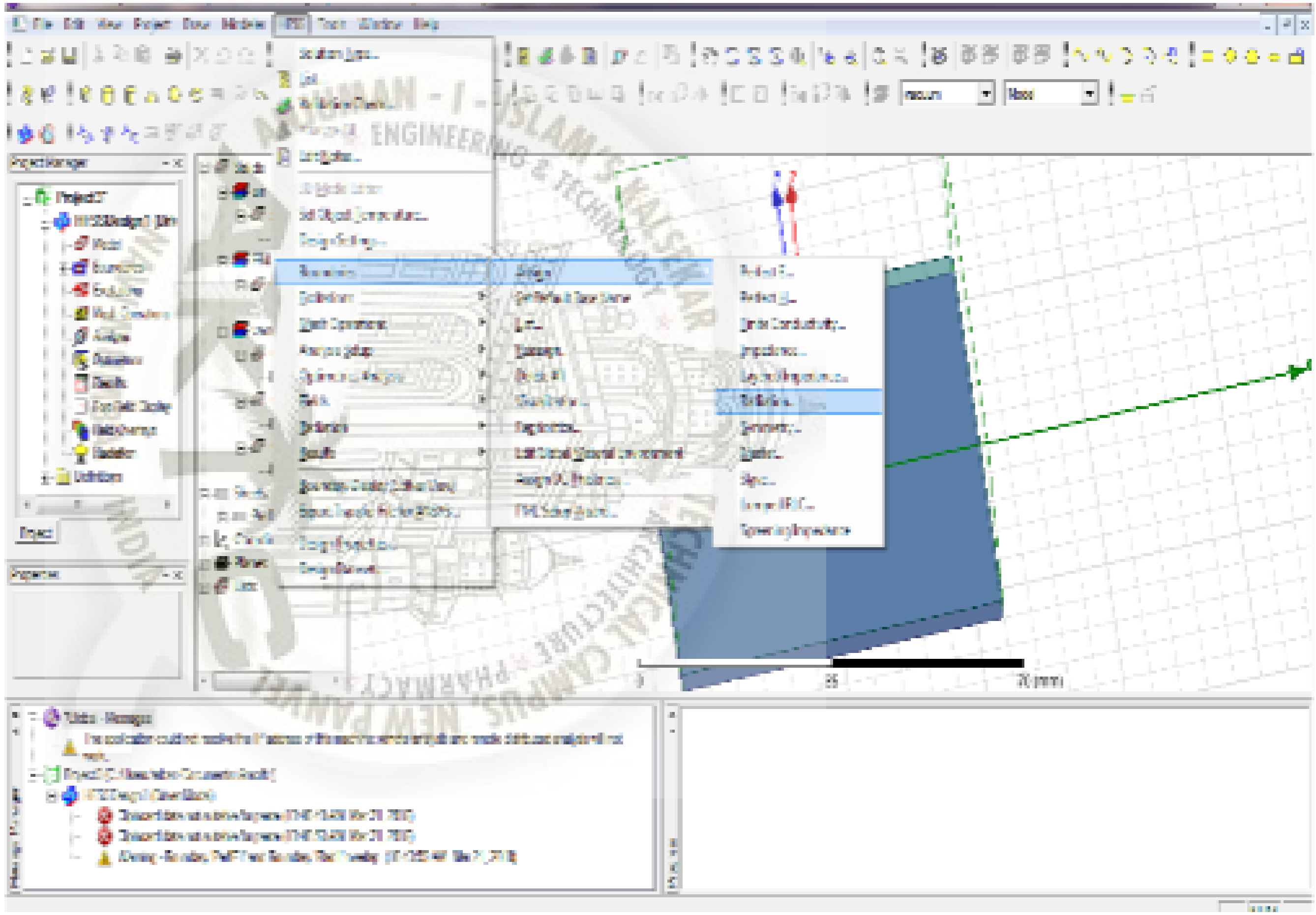
Step 2 : Assign boundaries

We had to assign boundary condition to patch, ground and air box.

Right click on patch→ $AssignBoundary \rightarrow\rightarrow PerfectE.$

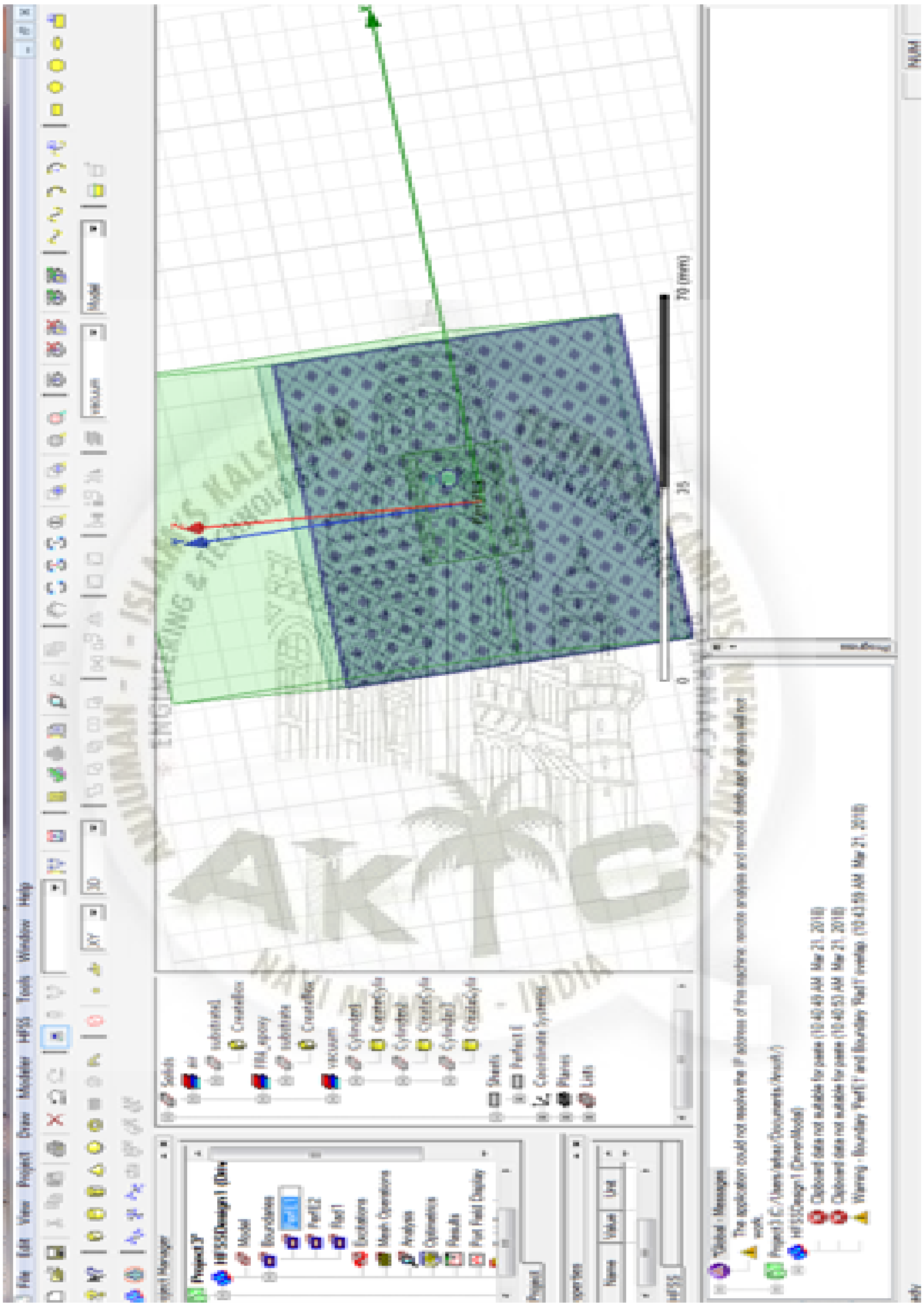
$Then, SaveitasNamePerfE - patch.$

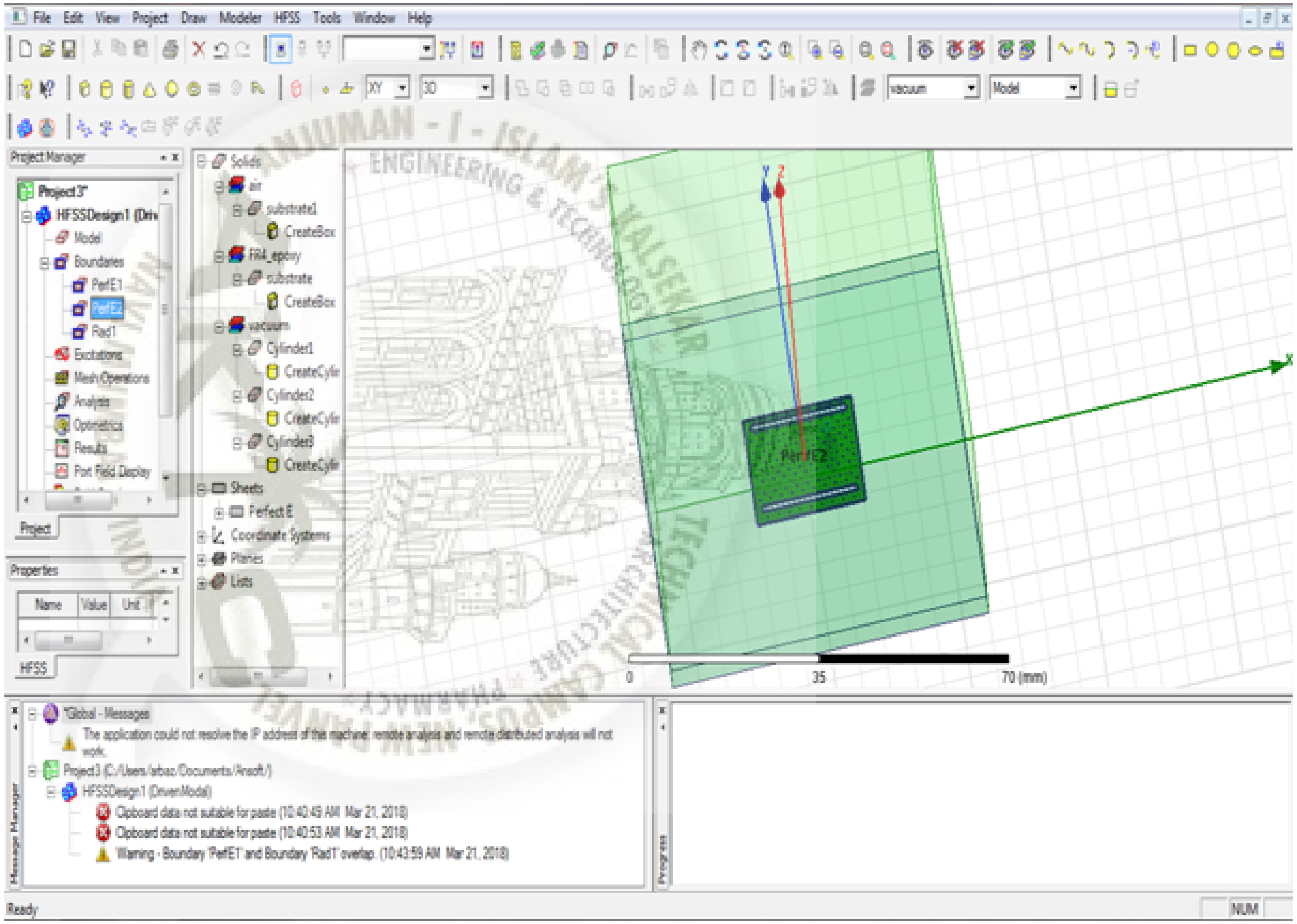



0
35
70 (mm)

Similarly repeat steps for Ground Shorting Post.

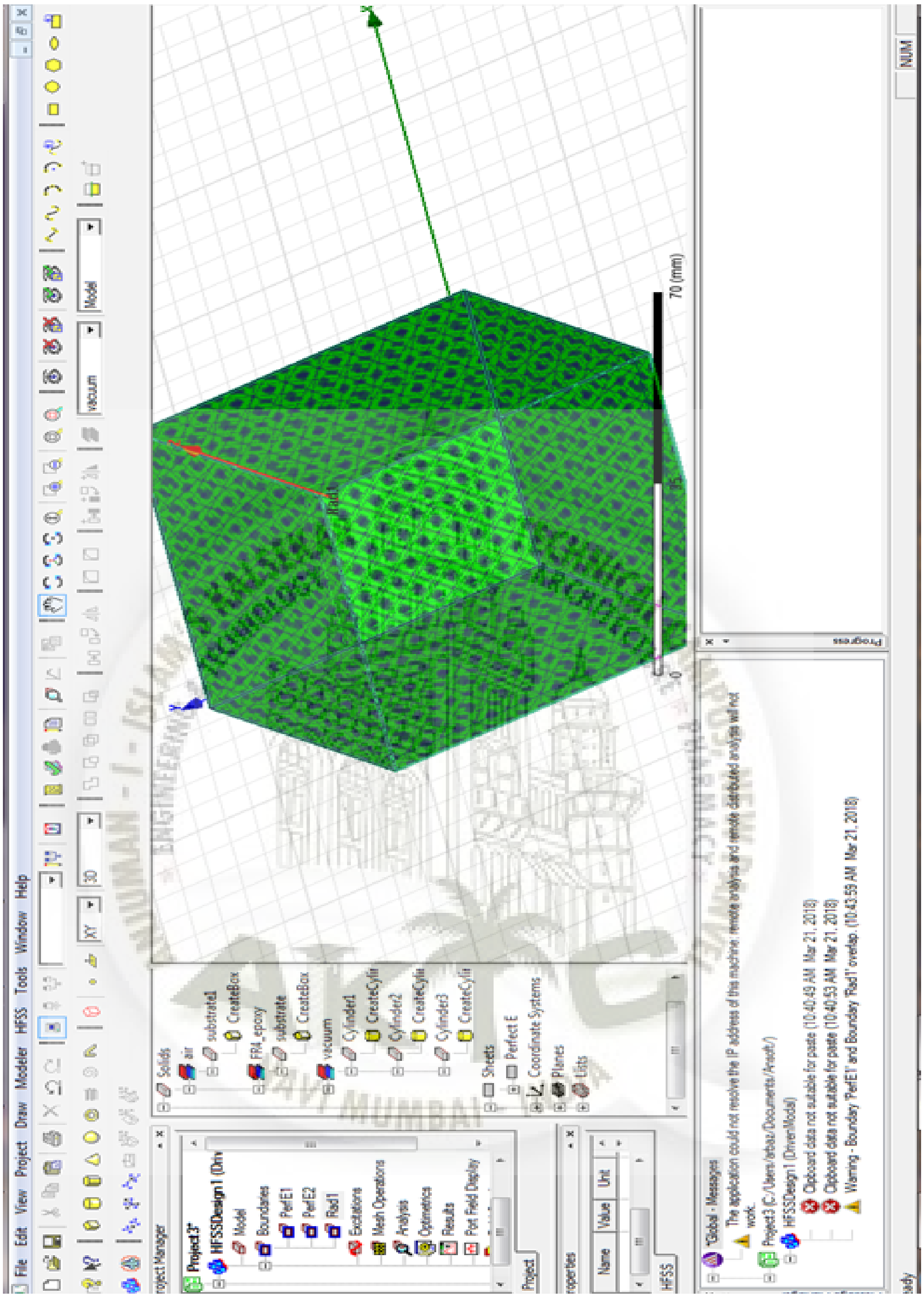
Select Faces of the air box except the face where there is microstrip antenna is present and assign it radiation boundary.





```
*Global - Messages
    The application could not resolve the IP address of this machine; remote analysis and remote distributed analysis will not work.
Project3 (C:/Users/arbaz/Documents/Ansoft/)
    HFSSDesign1 (DrivenModal)
        Clipboard data not suitable for paste (10:40:49 AM  Mar 21, 2018)
        Clipboard data not suitable for paste (10:40:53 AM  Mar 21, 2018)
        Warning - Boundary 'PerfE1' and Boundary 'Rad1' overlap. (10:43:59 AM  Mar 21, 2018)
Ready
```

Now the boundaries have been assigned.



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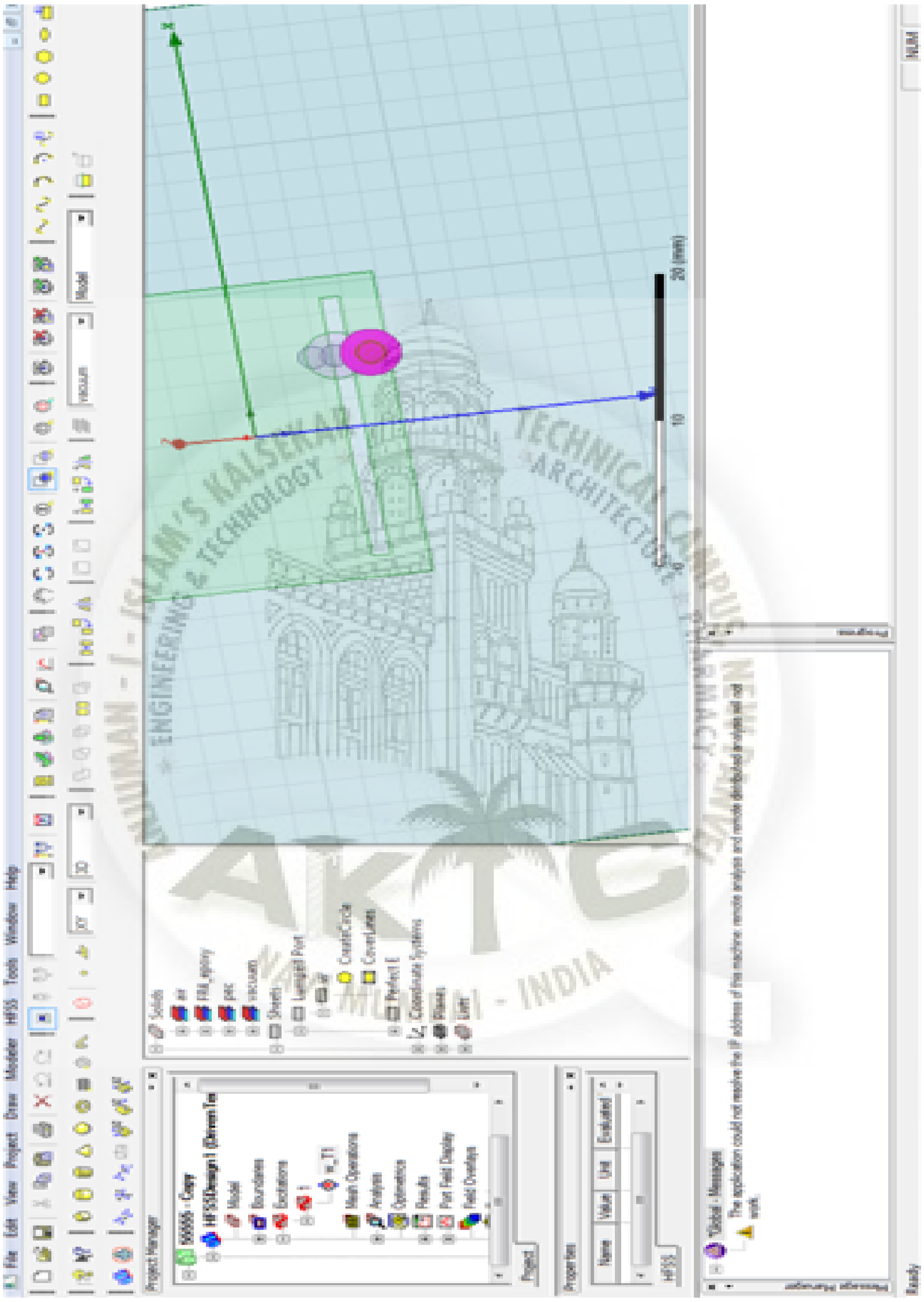
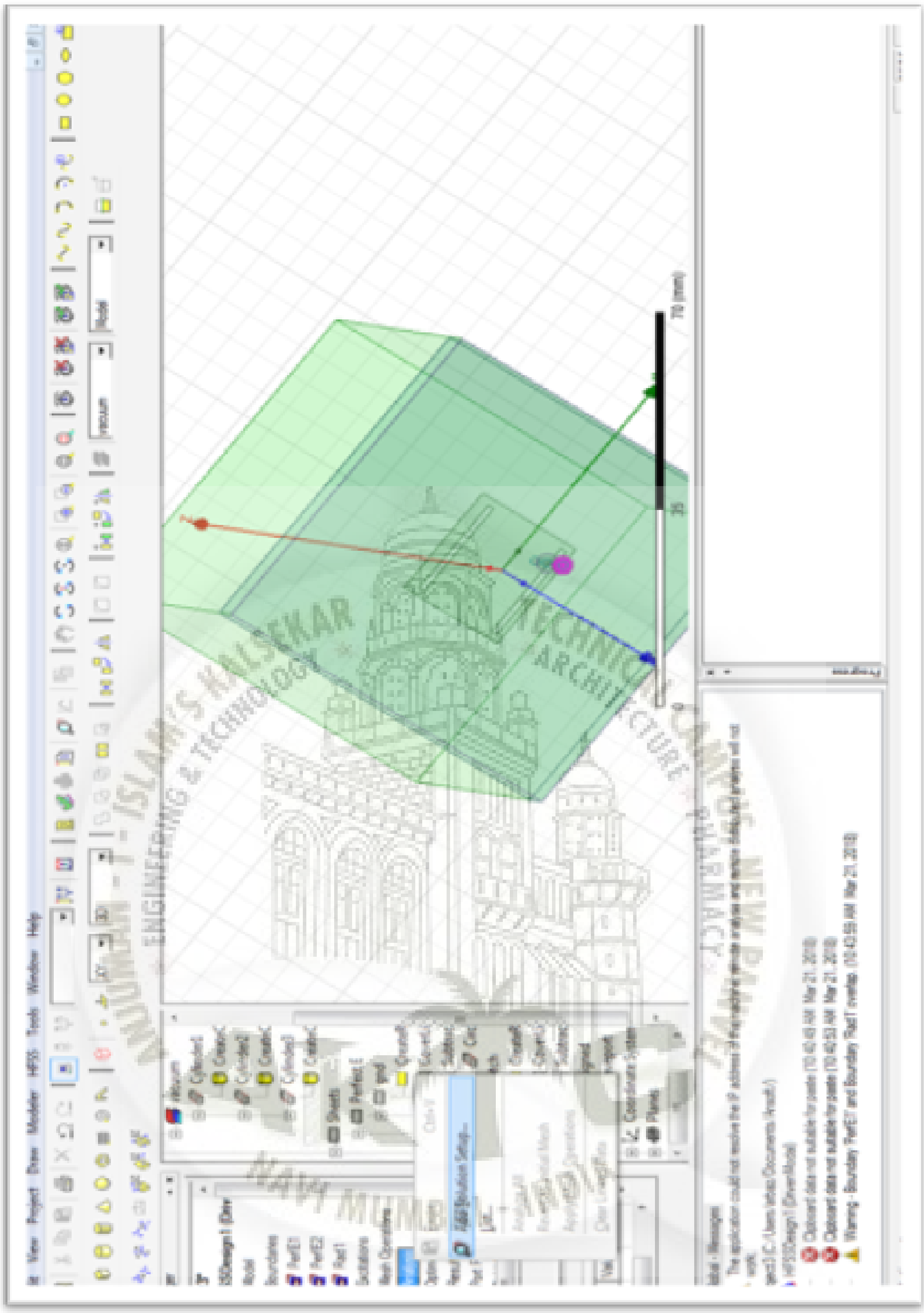
*Global - Messages
    The application could not resolve the IP address of this machine: remote analysis and remote distributed analysis will not
    work.
Project3 (C:/Users/arbaz/Documents/Ansoft/)
  HFSSDesign1 (DrivenModal)
      Clipboard data not suitable for paste (10:40:49 AM  Mar 21, 2018)
      Clipboard data not suitable for paste (10:40:53 AM  Mar 21, 2018)
      Warning - Boundary 'PerfE1' and Boundary 'Rad1' overlap. (10:43:59 AM  Mar 21, 2018)
```

Step 3 : Assign excitation

he excitation is assign to the circle placed at the back of the coaxial connector drawn. Right Click on Circle2$\rightarrow Assignexcitation \rightarrow WavePort \rightarrow Enter \rightarrow Ok$.

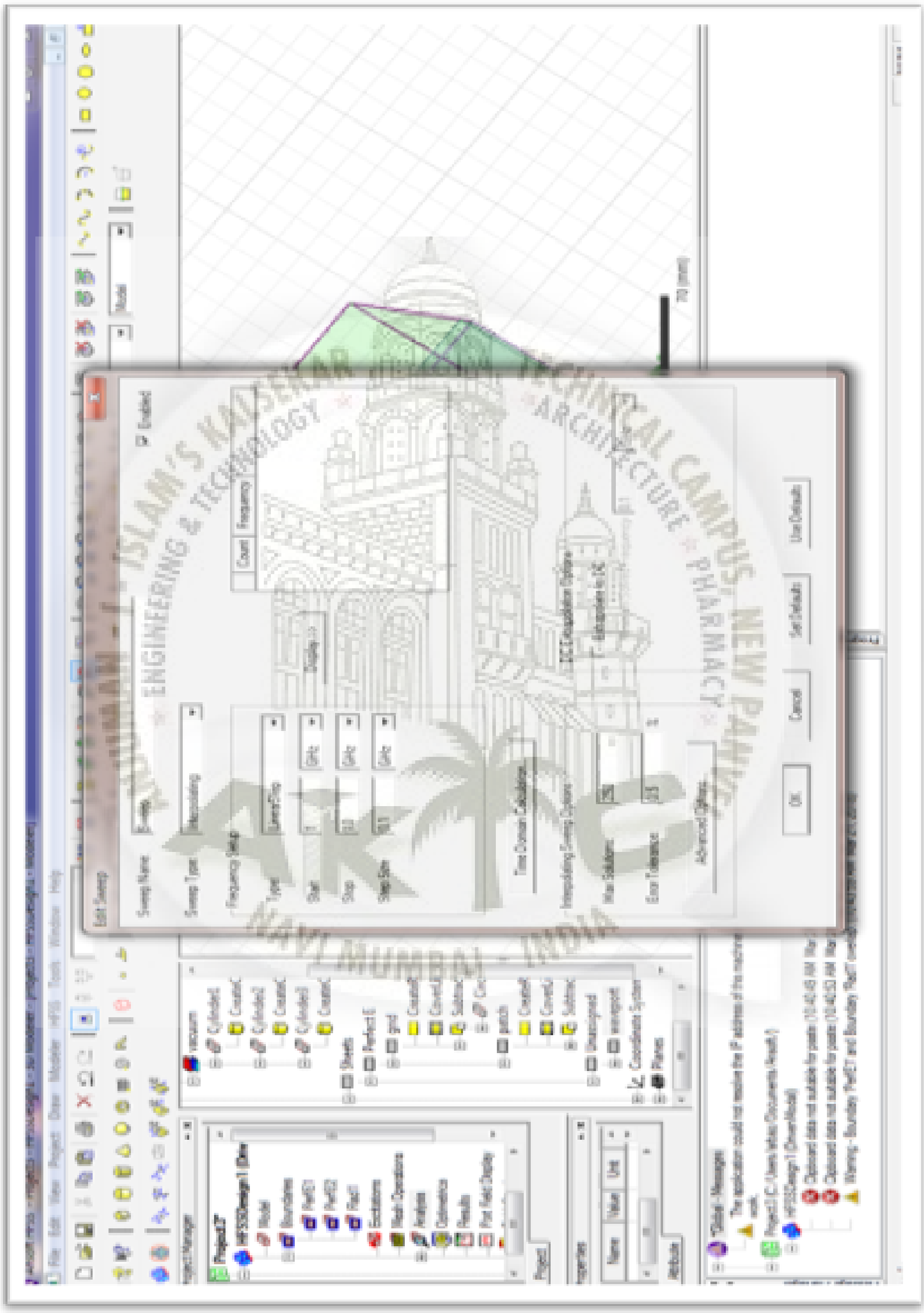



View Project Draw Modeler HFSS Tools Window Help
vacuum
Model
70 (mm)
35
0

Step 4 : Setup the solution

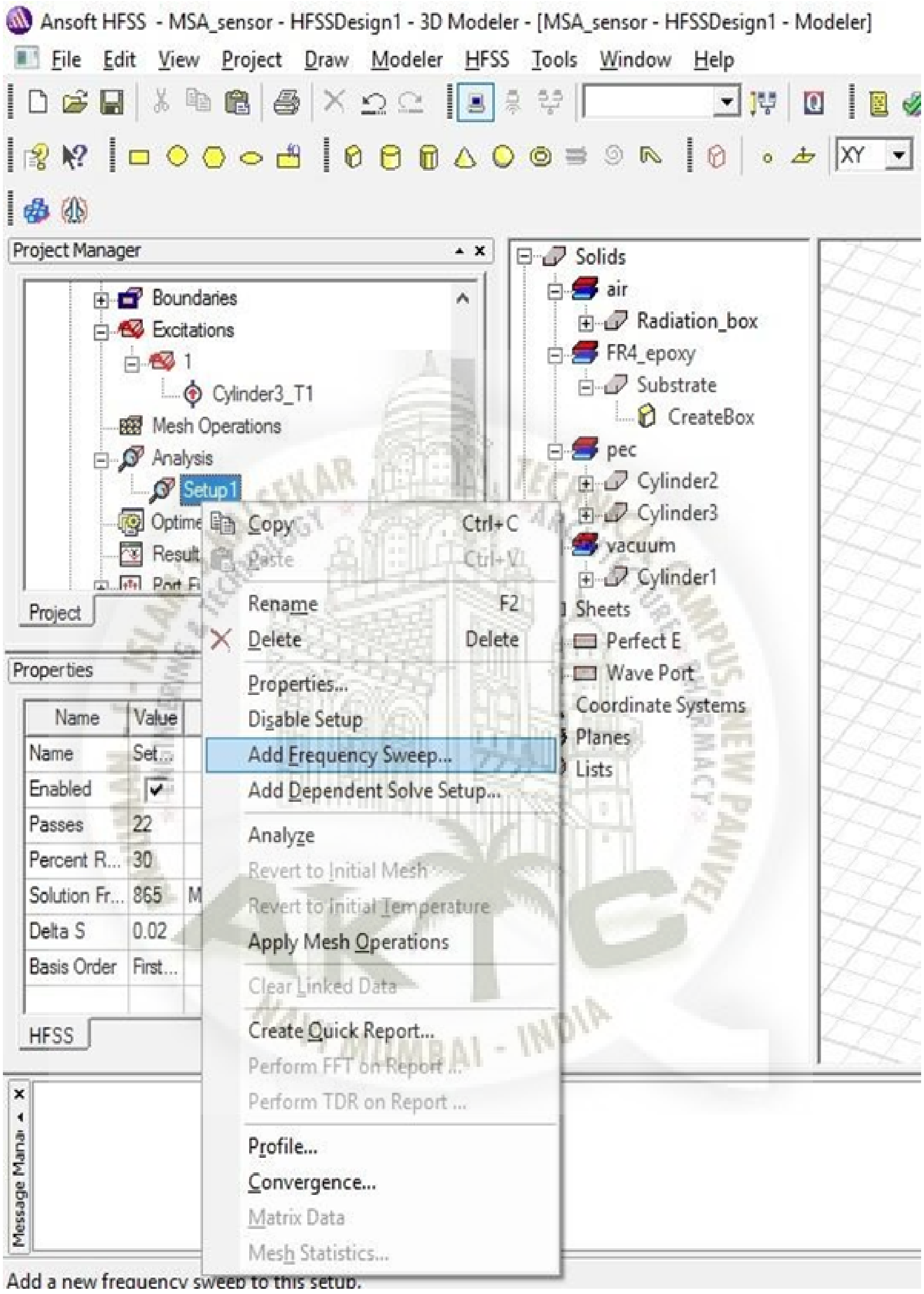
In this step a solution setup and sweep frequency is added.

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→ $RightclickonSetup1 \rightarrow AddFrequencySweep \rightarrow EditSweeptypeDiscrete, Enter$

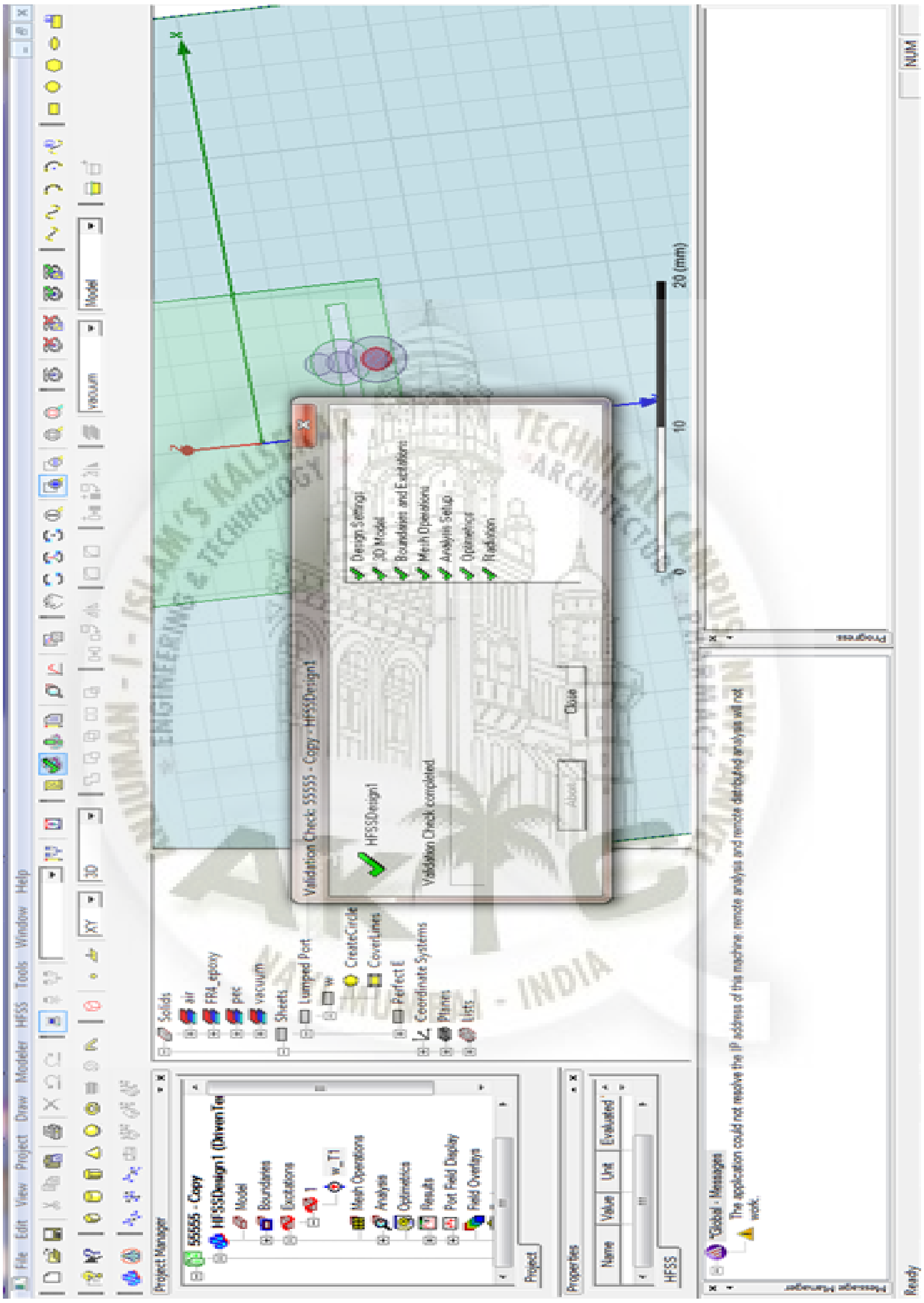


Name	Value
Name	Set...
Enabled	☑
Passes	22
Percent R...	30
Solution Fr...	865 M
Delta S	0.02
Basis Order	First...

Add a new frequency sweep to this setup.

Step 5 : Solve

After adding solution setup we will do validation execute our model by clicking on Analyse.



Validation Check: 55555 - Copy - HFSSDesign1

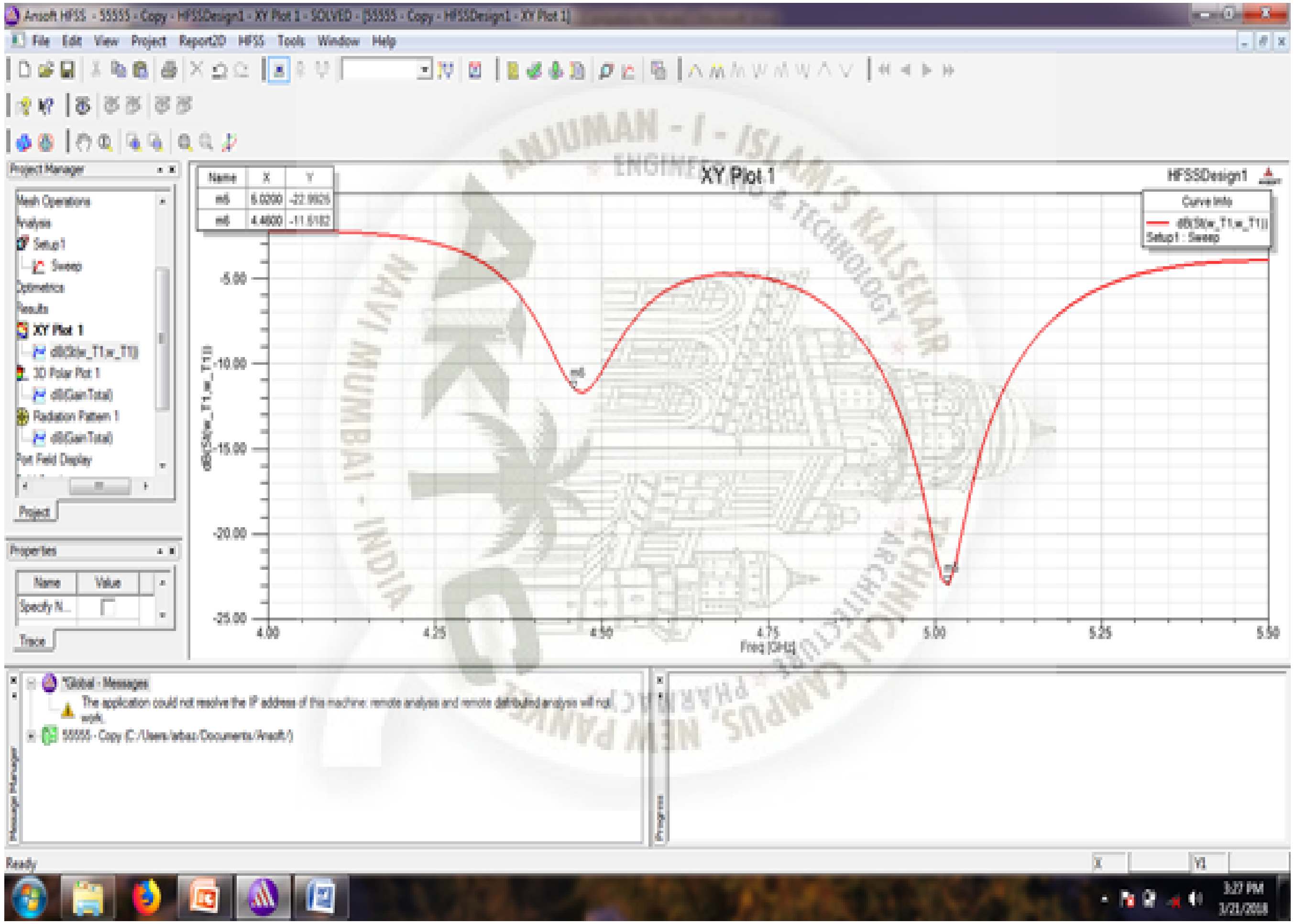
HFSSDesign1

- ✓ Design Settings
- ✓ 3D Model
- ✓ Boundaries and Excitations
- ✓ Mesh Operations
- ✓ Analysis Setup
- ✓ Optimetrics
- ✓ Radiation

Validation Check completed.

"Global - Messages

The application could not resolve the IP address of this machine: remote analysis and remote distributed analysis will not work.



Name	X	Y
m5	5.0200	-22.9926
m6	4.4600	-11.6182

*Global - Messages

The application could not resolve the IP address of this machine: remote analysis and remote distributed analysis will not work.

55555 - Copy (C:/Users/arbaz/Documents/Ansoft/)

Chapter 5

Result and Discussion

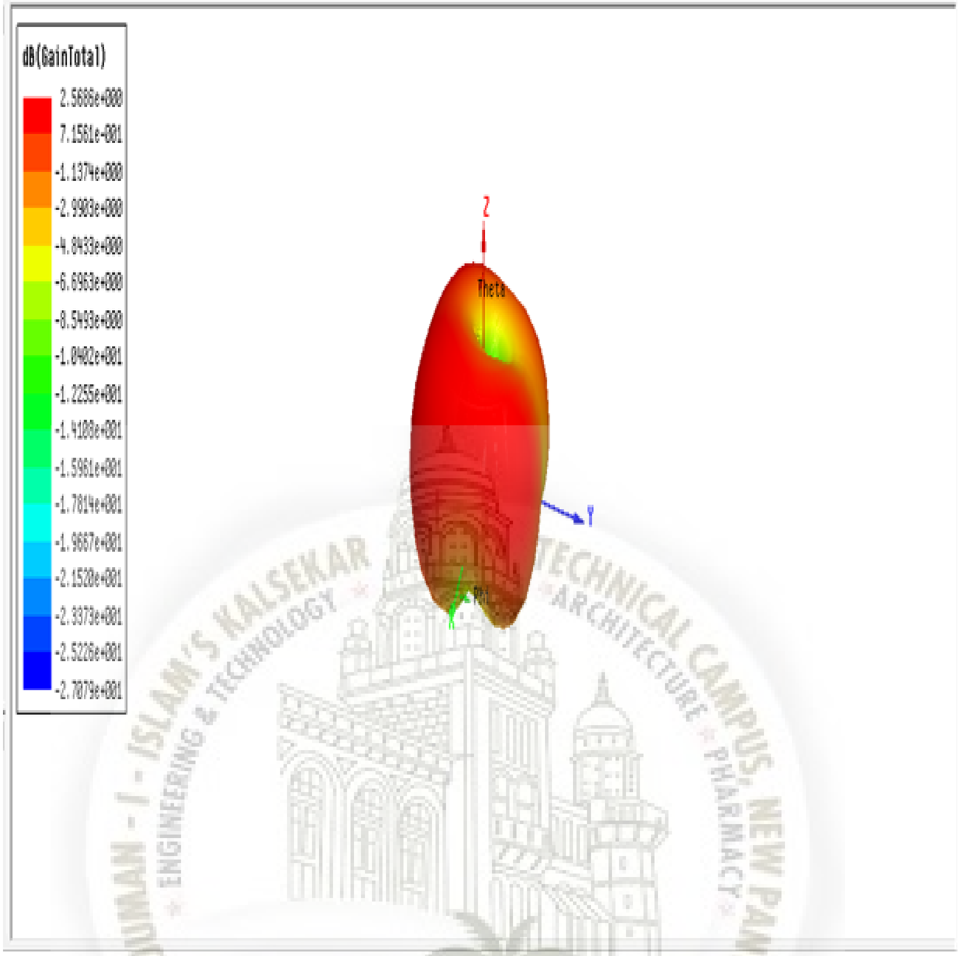
5.1 Expected Outcome

A rectangular patch antenna of Size 6cm x 6cm Frequency 4Ghz and 4.9Ghz Return loss : -17dB at 4Ghz and -22.5 at 4.9Ghz Gain : 7.8dBi at 4 Ghz and 7.1dBi at 4.9Ghz

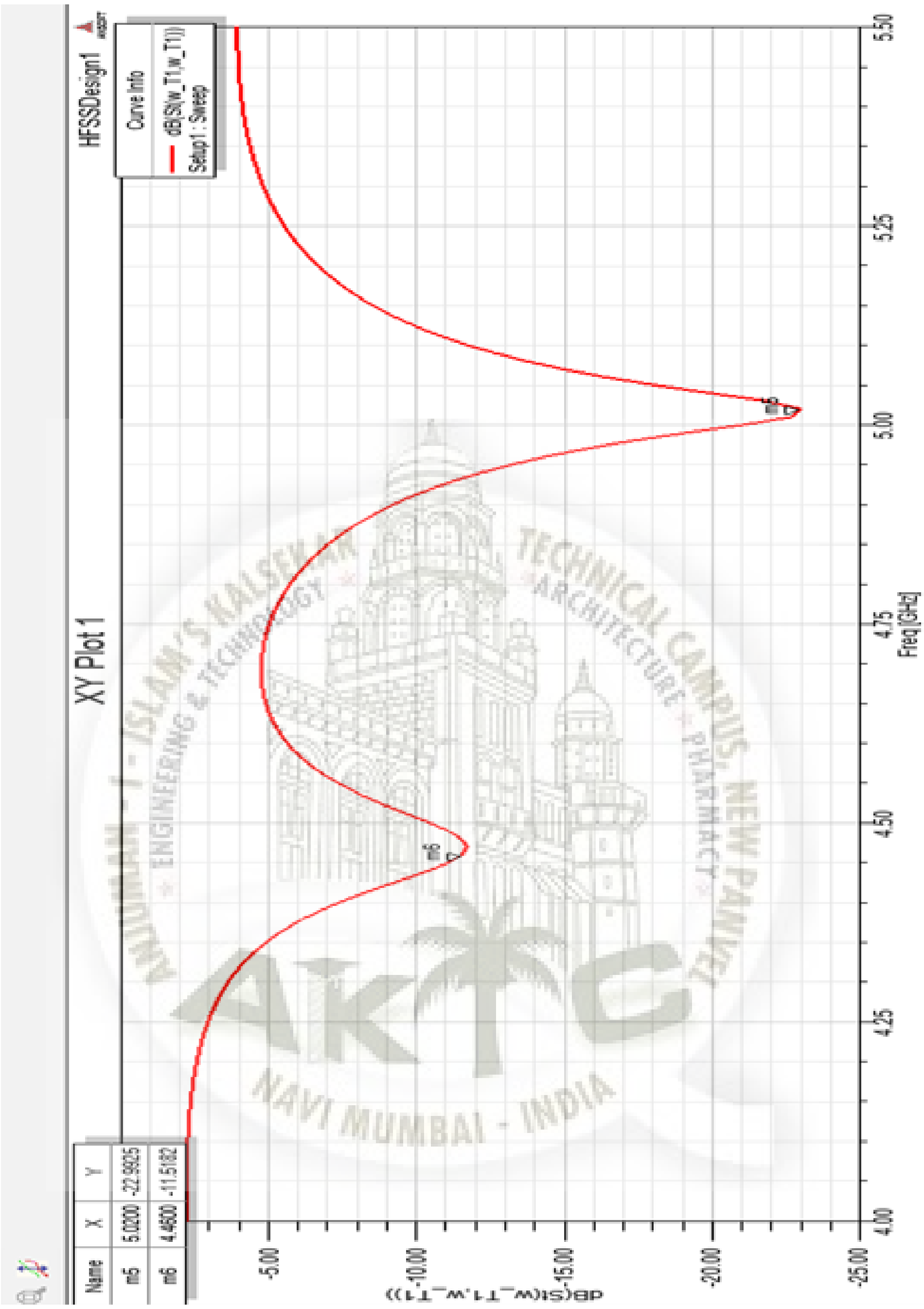
5.2 Simulated Output

A rectangular patch antenna of Size 6cm x 6cm Frequency 4.47Ghz and 5Ghz Return loss : -12.5dB at 4.47Ghz and -22.95 at 5Ghz Gain : 7.8dBi at 4 Ghz and 7.1dBi at 4.9Ghz The result of simulation are as per expectation upto certain extent. The S11 plot which is reflection coefficient shows a good plot.

3D Polar Plot



S11 Plot

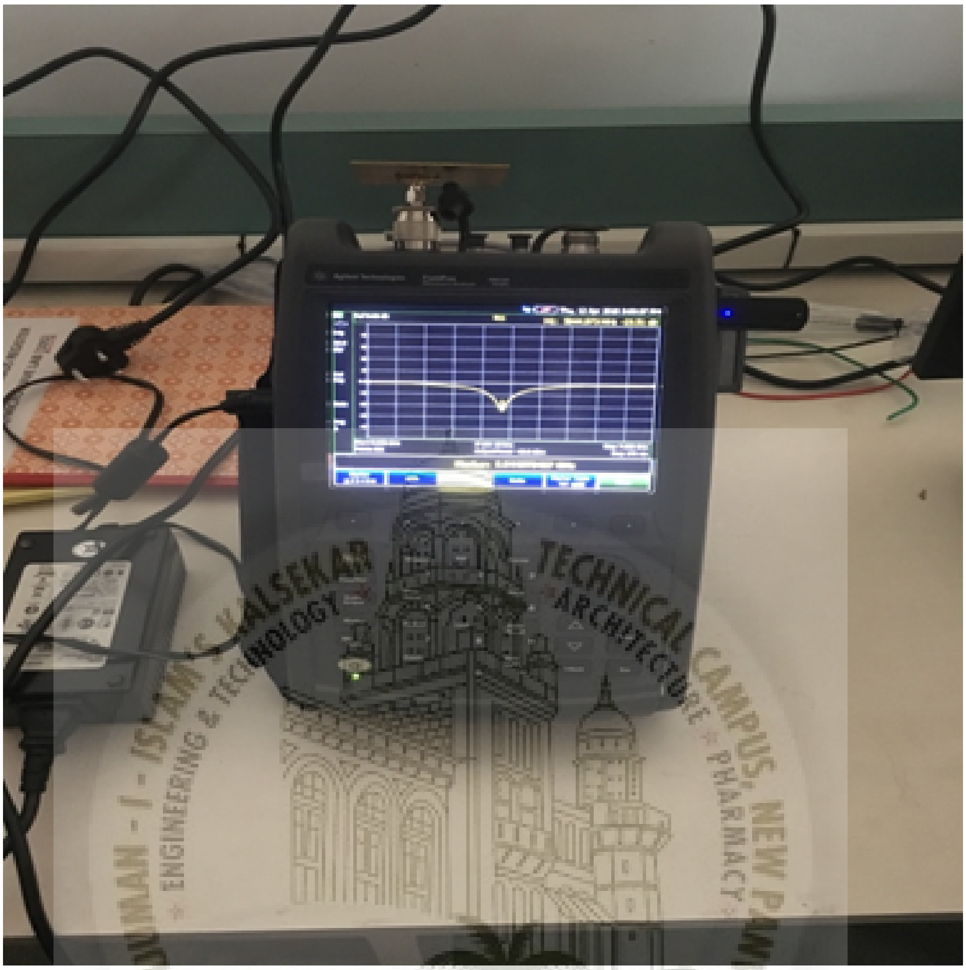


The simulated output are as per the outcome . The S11 plot which is the reflection coefficient shows a good plot. The reflection coefficient at 4.4 GHz is -11 dB and at 5.02 GHz is -22.95 dB which is good enough as per the aim of the project.

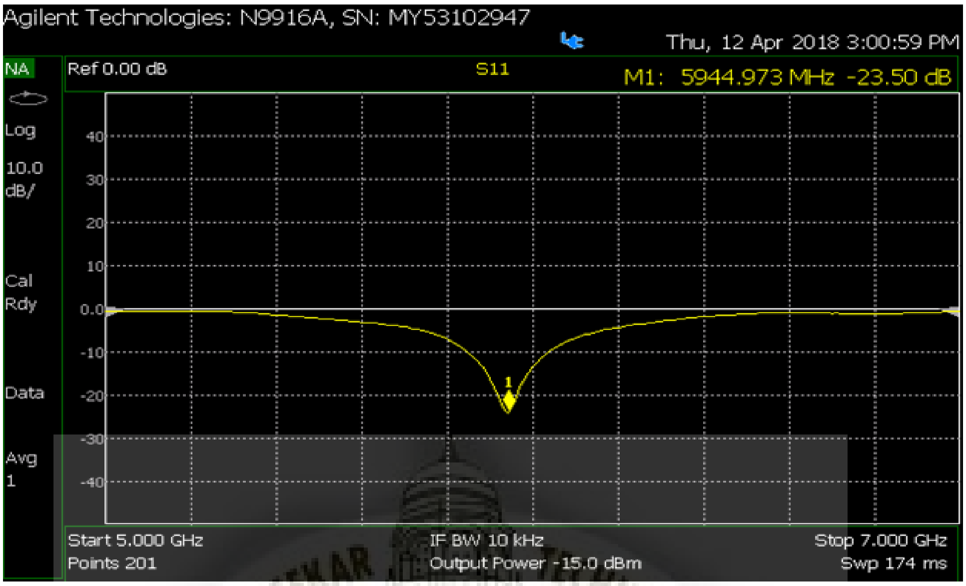
5.3 Practical Result

Hardware result

Micro-strip patch Antenna and Setup



S11 Parameter


Agilent Technologies: N9916A, SN: MY53102947

Thu, 12 Apr 2018 3:00:59 PM

Ref 0.00 dB S11 M1: 5944.973 MHz -23.50 dB

Log 10.0 dB/

Cal Rdy

Data

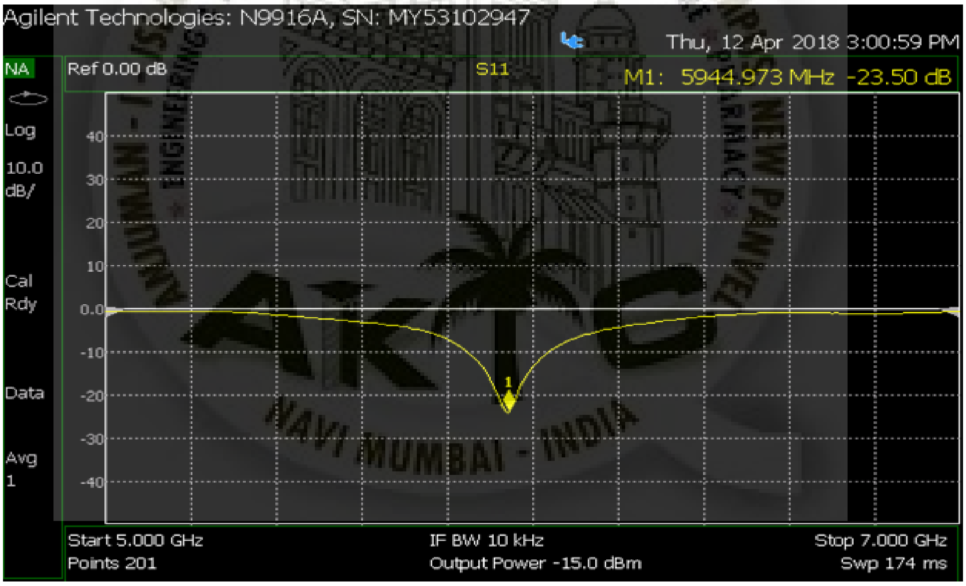
Avg 1

Start 5.000 GHz Points 201

IF BW 10 kHz Output Power -15.0 dBm

Stop 7.000 GHz Swp 174 ms

VSWR


Agilent Technologies: N9916A, SN: MY53102947

Thu, 12 Apr 2018 3:00:59 PM

Ref 0.00 dB S11 M1: 5944.973 MHz -23.50 dB

Log 10.0 dB/

Cal Rdy

Data

Avg 1

Start 5.000 GHz Points 201

IF BW 10 kHz Output Power -15.0 dBm

Stop 7.000 GHz Swp 174 ms

The hardware output dont match with the simulated antenna .The main reason could be miniaturization and for not using perfect technique for fabricating the antenna . The S11 parameter shows -23.5 dB at 5.99 GHz where as in simulated result we get output at different frequency. The VSWR is 1.143 which is good for antenna.

Chapter 6

Conclusion

6.1 Conclusion

As we previously analyzed the gain and bandwidth of single and double slot loaded patch anenna, an improved design is built that mesured and operated at 4.4 GHz and 5GHz respectively.

So that this information can be transmitted in two different ways by using the same antenna which offers better Frequency,Gain and Bandwidth.

There is still hope to improve the perfoemance of antenna with the proposed structure through further adjusting the design parameters and optimizing the feeding networks.

6.2 Future Scope

The explosive growth in the demand for wireless communication and information transfer using handsets and personal communications (PCS) devices has created the need for major advancements of antenna designs as a fundamental part of any wireless system. One type of antennas that fulfills most of the wireless systems requirements is the microstrip antennas. These antennas are widely used on base stations as well as handheld devices. Microstrip antennas have a variety of configurations and are currently the most active field in antenna research and development. The microstrip antennas, due to their great advantages, have increasingly wide range of applications in wireless communication systems as handheld mobile devices, satellite communication systems, and biomedical applications.

Micro strip patch antenna can be used for various application such as for mobile and satellite communication, GPS , RFID , WiMax , Radar application . It can be used for Rectenna application and for Telemedicine application

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