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MULTILAYER MICRO STRIP PATCH ANTENNA FOR BROADBAND APPLICATIONS

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ABSTRACT

In this study, a multilayer microstrip patch antenna's design and modelling utilising the HFSS are presented. The proposed antenna is small and made for broadband applications. A substrate, a patch layer, and a ground plane make up the antenna. The performance of the antenna is evaluated using a Vector Network Analyzer (VNA), and the acceptable range of performance traits like Directivity, return loss, and VSWR is specified. The simulation outcomes demonstrate that the proposed antenna has a broad bandwidth between 3 and 5.5 GHz, which spans both the WLAN and WiMAX frequency bands. The antenna offers a low VSWR of less than 1.5 over the full operational bandwidth, good directivity of 8.5 dBi, and low return loss of -20 dB.The proposed antenna can be used for many different applications involving wireless communication due to its small size, broad bandwidth, and acceptable performance criteria.

Keywords: *Multilayer microstrip patch antenna, HFSS, VNA, VSWR, Directivity and Return loss.*

1. INTRODUCTION

Antennas direct signals towards other stations to enable wireless communication between two or more stations. "A means of transmitting or receiving radio waves" is the concept of an antenna [1].The fact that an antenna can be utilised for both transmission and reception of electromagnetic waves is also noted. Focusing and modifying the radiated power in space is an antenna's key ability [2]. For effective transmission and reception, the current communication system utilises microwave frequencies. The term "microwave" refers to radiation having frequencies between 1GHz and 300GHz. In the late 1970s, microstrip antenna technology began to advance quickly. Early in the 1980s, fundamental microstrip antenna elements and arrays had a good foundation regarding design and simulation, researchers shifted their attention to expanding the technology's applications and enhancing antenna performance characteristics (such as bandwidth) [3].

One of the different kinds of microwave antennas is the microstrip patch antenna (MPA). Due to its capacity to satisfy the demands for tiny size, cheap price and light weight, microstrip antennas have grown in popularity in contemporary wireless communication systems. These are essentially planar antennas made of a ground plane on the bottom and a metallic patch atop a dielectric substrate [4].Microstrip antennas have the benefit of being able to be built in a way that conforms to the mounting hosts, which makes them perfect for usage in portable electronics like smartphones, tablets, and wearables. They are appropriate for use in situations with limited space because they may be made to be very thin and low profile [5].

Many conducting layers separated by dielectric substrates make up a multilayer microstrip patch antenna, a particular kind of antenna [6]. Because of its capacity to operate over a broad frequency range, it is frequently utilised for broadband applications. The outline of a multilayer microstrip patch antenna (MPA) for a broadband application requires deciding on the right substrate materials as well as the patch's and ground plane's sizes [7]. The substrate's thickness and dielectric constant dictate the antenna's impedance and bandwidth, and the patch's and ground plane's dimensions influence the antenna's resonant frequency. [8].Several resonant modes can be incorporated, the patch's shape can be changed, slots or other types of perturbations can be used, and other methods can also be used to produce broadband functioning [9]. Furthermore, by adding more resonant modes through the stacking of many layers of patches, the bandwidth can be increased. Multilayer microstrip patch antennas have the benefit of being small and low profile, which makes them ideal for incorporation into small electronic devices. They can also be produced using inexpensive printed circuit board (PCB) technology, making them an affordable option for a variety of uses [10].

One of the most significant parts of a wireless communication system is the antenna. So, a well-designed antenna can enhance the performance of the entire system. In its most basic form, a micro strip antenna (MSA) is made up of a ground plane on one side and a radiating patch on the other on a dielectric substrate [11]. However, additional forms are also employed, including circular, semi-circular, triangular, annular ring, square and sectoral. The desirable qualities of microstrip antennas, likecheap cost, low weight, and low-profilesimplicity of production, and ability to be combined with RF equipment, make them very popular [12]. Low gain and a very small bandwidth are two main drawbacks of micro strip antennas. A ground plane is located on the opposing side of a dielectric substrate in MPA. For applications including wireless communications systems, mobile phones, pagers, radar systems, and satellite communications systems, the tiny strip patch antenna is a great choice [13].

As they are able to operate across a wide frequency spectrum, multilayer microstrip patch antennas are increasingly utilized in broadband applications. The multilayer design provides greater bandwidth and higher gain when compared to typical single-layer microstrip antennas, making them appropriate for usage in a variety of applications, including satellite communication, wireless communication systems, radar systems, and more [14]. A variety of design strategies, including the use of layered patches, the use of parasitic elements, or the incorporation of slotting or cutting techniques in the patch structure, are used to achieve the broadband characteristics of multilayer microstrip patch antennas. These methods aid in lowering the surface wave and raising the energy radiated, resulting in a wider bandwidth [15].

The main objectives of this research are:

- Design and simulate multilayer micro strip antenna operating in ISM band. (i.e., 2.2 GHz to 5.9 GHz)
- Design Antenna Model can be fabricated and testing should be carried out by using VNA.
- The performance metrics such as Directivity, return loss and VSWR are analysed.

2. LITERATURE SURVEY

Kushwaha, R.K., et al[16] have investigated and evaluated the performance and strategy features of a patch microstrip antenna with a PBG and homogeneous substrate design. Assessed and contrasted with other designs were the suggested antenna's radiation characteristics. Together with varying the patch's curvature radii and the height of the substrate structure, they also looked at the impacts of the photonic crystal. The suggested antenna's directivity and gain were measured to be 8.612 dBi and 7.94 dBi, correspondingly.

VincentiGatti, R., et al [17] have presented a simple yet effective design strategy for microstrip patch antennas relying on the fusion of conventional single-resonance patch designs. They displayed two unique-looking MPA elements with an integrated feed. Both radiators are constructed on a single-layer substrate that is less thick could be identified via their wideband behaviour. When the antenna prototypes were produced quickly and inexpensively, the measured results supported the models.

Chopra, R. and Kumar, G., [18] have developed a multilayer, multi-resonator microstrip antenna (MSA) that is inexpensive, broad, and high-gain.The MSA was composed of one metallic feed patch at the bottom layer and two round (1B2 T) patches imprinted on the bottom side of the top, air-suspended FR4 substrate layer. The bottom patch of the elliptical and circular forms was used to compare two layouts. The antenna design parameters were determined to offer a uniform gain with a maximum BW.

Cao, Y., et al [19] have developed a brand-new, broadband, high gainMPA. By combining a mushroom-shaped structure and two radiating edges with the primary radiating patch, they were able to attain wide impedance bandwidth and create a new quasi-TM30 mode. The improved impedance bandwidth covered the whole Ku-band and was greater than 40%, the researchers' measurements revealed. Additionally, the suggested antenna showed consistent radiation patterns in the broadside direction across the operating frequency range. Moreover, the antenna maintained flat gains throughout the frequency band with high gains about 10 dBi.

Del-Rio-Ruiz, R., et al [20] have suggested a creative method for building multilayer lab-scale MPA. The procedure combined a quick intra-layer attachment technique using thermally activated adhesive films with a laser-cut wood frame alignment approach for exact layer alignment. By producing an electromagnetic coupling rectangular microstrip patch textile antenna that performed in the 2.45 GHz ISM band, the researchers were able to confirm this lab-scale manufacturing method. To verify the viability of the suggested construction process, the procedure was repeated eight times.

Karami, F., et al [21] have developed a new class of SIW cavity fed MPAs in the Ku-band as a reliable choice, taking into account the low cost, high gain,simple integration, light weight, compactness, and high efficiency needed for long-distance communication. The array's measurements revealed that its impedance bandwidth is 19.35%, and its return loss is 10 dB.(11.2-13.6 GHz).

Patel, S.K., et al [22] have developed a MPA for gain improvement that was equipped with multilayer liquid metamaterialradome (superstrate) structures. SRR (Split Ring Resonator) metamaterial with three rings was loaded into the antenna superstrate. To enhance gain and safeguard the traditional MPA, two multilayer radome structures were employed. Three-ring SRR was used to create the first multilayer structure, which had six equal layers, and four log periodic layers for the second multilayer structure. The standard microstrip patch antenna and the multilayer SRR radome-loaded microstrip patch antenna was compared.

Karami, F., et al [23] haveestablished the suppressed cross-polarization over the whole operating bandwidth. For each of the major orientations, it was discovered that the cross-polarization level was under 30 dB. The proposed 2x2 array can be utilised as a sub-array to create a huge array with a 0.5 λ0 element gap. The suggested array may therefore be beneficial in applications that call for a close element spacing, a large operating bandwidth, and low levels of cross-polarization.

Li, W.T., et al [24] have demonstrated a bandwidth-enhanced, inexpensive, small, flexible and conformal devices can use a multilayer microstrip fractal antenna array that has been inkjet printer.Two layers of patches made up the antenna, with the first layer being inkjet imprinted precisely onto a 0.12mm polyimide substrate made of Kapton. A layer of SU-8 polymer that was 0.12 mm thick was placed on top of it. To obtain the required downsizing and good impedance fit, a second layer of inkjet-printed Minkowski fractal geometry patch was applied on top of the SU-8 polymer.

Aliqab, K., et al [25] have demonstrated a brand-new multiple frequency band operating superstratemetamaterial-loaded MPA with square teeth. The designed tooth-based metamaterial antenna offered improved directivity and gain. The varied patch and tooth geometries were explored numerically for four antenna configurations. These suggested structures were manufactured, measured, and contrasted for the 3 GHz to 9 GHz frequency range. The manuscript also analyses the SSR's electrical equivalent model. In terms of many bands, VSWR, bandwidth, reflectance response andgain, a comparative assessment of all the proposed structures was done.

2.1 Problem statement

High-speed wireless communication systems have seen a dramatic increase in demand over the past few years. This has prompted the creation of numerous types of antennas capable of high-speed data transfer rates. One such antenna that has been discovered to be appropriate for broadband applications is the multilayer microstrip patch antenna. However, due to the inherent constraints of the MPA in terms of radiation efficiency, bandwidth, and gain, building an effective multilayer microstrip patch antenna for broadband applications poses a substantial problem.Designing and improving a multilayer MPA with a high gain, broad bandwidth, and good radiation efficiency for broadband applications is the main purpose of this study. This will involve researching and fine-tuning the many antennae performance-affecting factors, such as substrate material, patch geometry, feed position, and layer count, in order to achieve the desired performance.

3. PROPOSED METHODOLOGY

Microstrip antennas are widely used because of their lightweight, low profile, simple to integrate with other microwave components, and inexpensive to manufacture. The patch shape, substrate dimensions, and feeding method all play a role in a microstrip antenna's geometry, which affects how well it performs. The physical dimensions of the antenna that will produce the appropriate electrical performance are identified mathematically when designing microstrip antennas.

3.1 Multilayer Microstrip Antenna

A multilayer microstrip antenna is one that has more than one patch covering the dielectric substrate. Multilayer Microstrip antenna gives engineers who are primarily RF/microwave circuit designers fundamental knowledge on patch antenna construction and operation.In high performance missile, spacecraft, aircraft, and satellite applications where performance, weight, cost, aerodynamic profiles and size are crucial, low-profile antennas may be essential. Multilayer MPA are employed to satisfy these specifications. The antenna element design is printed in metal trace bonded to an electrically insulating substrate, and a continual multi-metal layer is enclosed to the other side of the substrate to form a ground plane to create narrowband, broad beam antennas.Similar to the method used to create single patch microstrip antennas, photolithography is utilised to create multilayer microstrip antennas. Using a mask and a chemical solution, the design for each patch is first etched into the metal trace on the substrate. Typically, a feed network—which may be a coaxial cable or a microstrip line—is used to join the patches together.In order to

attain the desired performance, design parameters like patch dimensions, substrate thickness, and feed network can be optimised using the simulation findings. The figure 1 shows the schematic diagram of multilayer patch antenna.

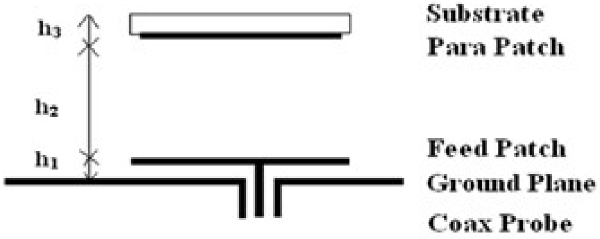


Figure 1.A schematic diagram of Multilayer patch antenna.

3.2.Design of multilayer patch antenna

The construction of the antenna consists of a dual rectangular MPA with four corner notches, a coaxial feed line joining both patches and the source, and a rectangle array of microstrip patch elements. Several slots are created in a patch to increase gain. A substrate substance serves as a dielectric between the metal surfaces that make up the patches and ground and the patches themselves. The substrate materials for this antenna are FR4 epoxy and ROGERS RT/DUROID5880(tm), with dielectric constant values of 2.2 and 4.4, respectively. Impedance of 50 ohms is thought to be the best impedance to be established between the feed line and patch. The impedances of patch and feed line are matched using the impedance matching technique. Based on VSWR, radiation pattern, gain and return loss, the performance of the proposed design is assessed.

Two patches and a ground plane constructed of a metal plane make up a multilayer patch antenna. On a patch, different number slots are indented according to the intended use. A ground plane and a patch are stimulated by a source connected via a transmission line and having an input impedance of 50. It emits electromagnetic waves in a manner akin to that of a dipole antenna. The resonating frequency is dependent on the patch's length. The frequency range in which the slot antenna is applied is in the UHF (ultra-high frequency) range. Each patches have a coaxial feed line attached to them in order to excite the antenna. Between the ground plane and patch, current is applied. As the antenna is powered up, electromagnetic waves are created and energy is emitted along the edges of the metal patch.

3.3 Antenna design

To model a microstrip patch antenna that performs at its best, a number of aspects must be taken into account. The operating frequency, substrate dielectric constant, and substrate height are among the crucial characteristics.

To achieve effective electromagnetic wave transmission and reception, the antenna's resonant frequency, or frequency of operation (f_o), must be carefully chosen. For instance, the resonant frequency used for design must be 2.4 GHz if the antenna is intended for use in the 2.4 GHz frequency band.

The dielectric constant ($\in_r$) of the substrate also has a sizable impact on the antenna's performance. The dielectric constant of a substance indicates how well it can store electrical energy in an electric field. Glass epoxy, which has a dielectric constant of 4.4, was chosen as the dielectric material for a microstrip patch antenna. The dielectric constant affects the effective length and width of the patch, which in turn affects the impedance matching and resonant frequency of the antenna.

Another important factor in the creation of a MPA is the height (h) of the dielectric substrate. It is crucial for the antenna to be lightweight in order to be used in cell phones. Hence, 1.6 mm, which is a typical thickness for many electronic devices, is chosen as h of the dielectric substrate. The antenna's efficiency, radiation pattern, and impedance matching are all impacted by its height.

Based on resonant frequency, an antenna's dimensions are selected. The following equation is employed to calculate the patch's dimensions:

$$w = \frac{C}{2f_r}\sqrt{\frac{2}{\in_r + 1}} \tag{1}$$

Where f_r is the resonant frequency and C is denoted as the velocity of light.The effective dielectric constant is calculated using the following equations.

$$\in_{eff} = \frac{\in_r + 1}{2} + \frac{\in_r - 1}{2}\left[1 + 12\frac{h}{w}\right]^{\frac{-1}{2}} \tag{2}$$

In this case, $\in_{eff}$ is the effective dielectric constant, substrate's dielectric constant is denoted as $\in_r$. $w$is the patch's width and$h$ is the dielectric substrate's height

The length extension (ΔL) is represented as

$$\Delta L = \frac{0.412\left(\in_{eff} + 0.3\right)\left(\frac{w}{h} + 0.264\right)}{\left(\in_{eff} - 0.258\right)\left(\frac{w}{h} + 0.8\right)} \tag{3}$$

The following equation is the effective length as a result of fringing:

$$L_{eff} = \frac{c}{2f_o\sqrt{\epsilon_{eff}}} \tag{4}$$

Hence, the patch's length is:

$$L = L_{eff} + \Delta L \tag{5}$$

The figure 2 (a), (b) and (c) displayed the bottom, side and top view of the proposed antenna.

The fabricated antenna is depicted inthe figure 2 (d).

Figure 2 (a) Bottom view

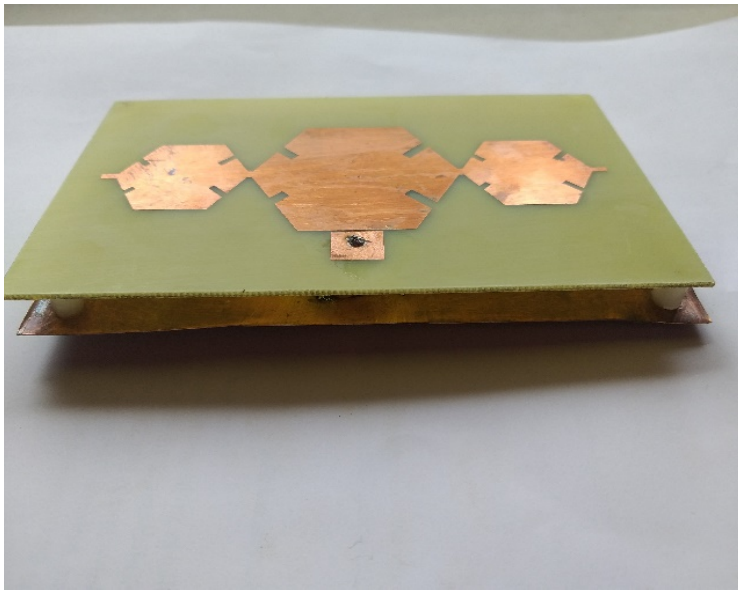


Figure 2 (b) Side view

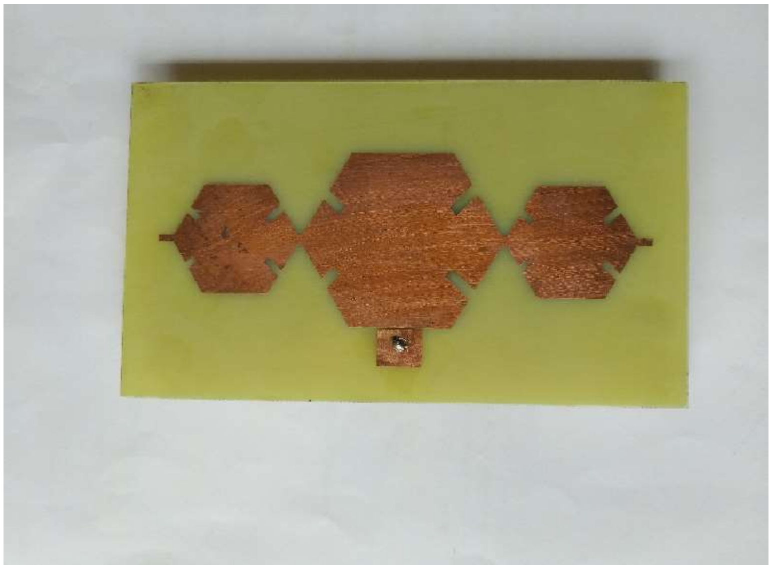


Figure 2(c) Top view

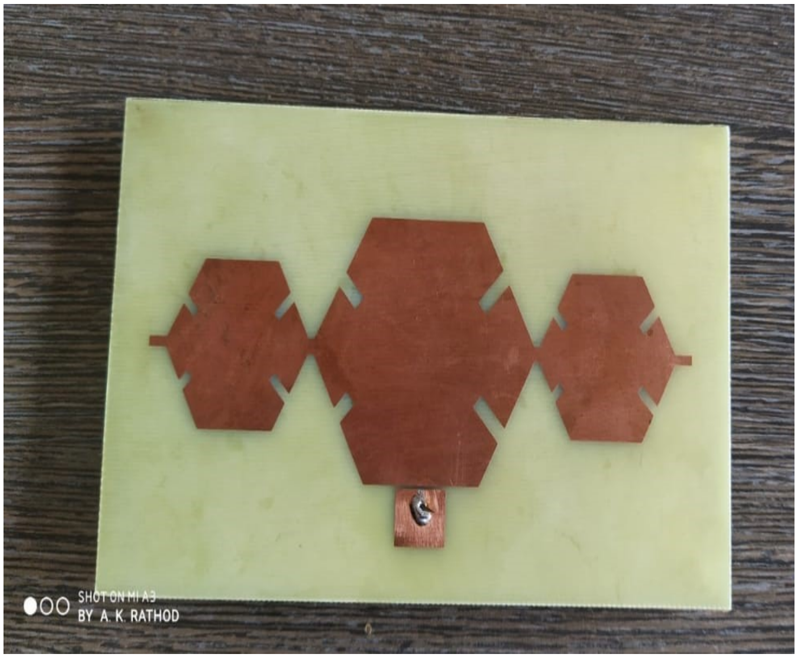


Figure 2 (d) Fabricated antenna

3.4 Antenna parameters

A microstrip antenna's performance is normally evaluated through the design and analysis of numerous factors. Antenna gain, return loss, antenna efficiency ,VSWR, bandwidth and directivity are some of these factors.

(i). Antenna Gain

Antenna gain is a metric of the rise in power density relative to an isotropic radiator in a specific direction. Typically, it is given in dBi (decibels relative to isotropic). A higher antenna gain denotes a more focused radiation pattern.

$$G = \frac{4\pi . U\ (\theta,\varphi)}{P_{in}} \tag{6}$$

Where the intensity of a given direction is denoted as$U\ (\theta, \varphi)$ and the input power is the P_{in}.

(ii). Directivity

Directivity is the proportion of a radiation's intensity in one direction to its total intensity. It assesses the antenna's capacity to focus the energy radiated in a particular direction. A higher directivity indicates a more directed radiation pattern.

$$D = \frac{4\pi\ U}{P_{rad}} \tag{7}$$

Where U is the radiation intensity and P_{rad} is the radiation power.

(iii). Radiation pattern

The radiation pattern is a mathematical or graphical expression of the radiation characteristics of the antenna as a function of geographical coordinates.

(iv). VSWR (Voltage Standing Wave Ratio)

VSWR is a measurement of the antenna's ability to reflect electromagnetic waves. It measures the difference between the standing wave's maximum and minimum amplitudes. A high VSWR signifies a poor impedance match between the antenna and transmission line.

$$VSWR = \frac{V_{max}}{V_{min}} \tag{8}$$

Where V_{min} andV_{max} are the minimum and maximum amplitudes of the standing wave.

(v). Return loss

The amount of power that an antenna reflects back to a transmission line is measured as return loss. The ratio of incident power to reflected power is used to compute it. Impedance matching is better and signal loss is decreased when the return loss is higher.

$$RL = -20 \log_{10} \left[\frac{VSWR-}{VSWR+}\right] \tag{9}$$

(vi). Antenna Efficiency

An antenna's ability to convert electrical power into electromagnetic radiation is known as its efficiency. It is determined through dividing the input power with the radiated power. A better antenna efficiency indicates less power loss in the antenna.

$$Efficiency = \frac{P_{rad}}{P_{in}} \times 10 \tag{10}$$

Where P_{in} is the input power and the radiated power is the P_{rad} .

3.5 Fabrication of antenna

In the production of semiconductors, photolithography is used to etch complex designs into a substrate. The construction of antenna models also employs it. In this procedure, a substrate is coated with a photosensitive substance known as a photoresist. The photoresist reacts chemically when the substrate is subjected to a patterned light source, such as a mask or laser. The unexposed regions are then removed from the photoresist, leaving the desired pattern on the substrate.The ideal antenna pattern is initially created using computer-aided design (CAD) software in order to produce an antenna model utilising photolithography. The design is then transferred to a mask, which is a glass plate with a thin chromium coating. The photoresist-coated substrate is topped with the mask, and then the complete assembly is irradiated to ultraviolet light. Depending on the variety of photoresist employed, the photoresist responds to the light by either hardening or softening. The desired pattern is then left behind once the mask has been removed and the photoresist has been generated to eradicate the unexposed parts.The substrate is subsequently subjected to additional processing in order to create the antenna model. This can entail utilising a method like sputtering or electroplating to deposit a metal layer on top of the printed substrate. The required antenna shape is subsequently patterned onto the metal layer using a related photolithographic technique.

3.6 Software:

- **HFSS (high frequency structural simulator):**

Engineers and researchers use the High-Frequency Structure Simulator (HFSS), a potent electromagnetic simulation tool, to study and create a variety of electromagnetic parts and systems. For high-frequency electromagnetic research and development, it is widely acknowledged as the industry standard tool.The automated solution procedure of HFSS is one of the important elements that contribute to its success and popularity. Users of HFSS need simply enter the geometrical characteristics of the structure, the material characteristics, and the desired output; the programme handles the rest. In particular, HFSS automatically creates a suitable, effective, and accurate mesh to solve the issue.The electromagnetic fields (H and E field), current, S-parameters, and near and far radiation fields are just a few of the analysis tools offered by HFSS. Several techniques, such as 2D and 3D charts, animations, and graphs, can be used to view and interpret these results.

- **CAD FEKO**

The CAD FEKO software application combines FEKO's electromagnetic analysis capabilities with CAD (Computer-Aided Design) software. It is a potent electromagnetic simulation tool. Engineers and researchers can more correctly and efficiently examine electromagnetic fields and antennas in intricate 3D constructions because to this integration.The ability for engineers and researchers to conduct electromagnetic simulations directly on CAD models without the requirement for a separate CAD file conversion is one of the main advantages of CAD FEKO. These speeds up the simulation process and lowers the possibility of errors. For the import and export of CAD files from a variety of formats, such as CATIA, Pro/Engineer, and SolidWorks, CAD FEKO also offers a number of utilities.Engineers and researchers may quickly and easily set up simulations and analyse findings with CAD FEKO's user-friendly interface. Moreover, a large variety of post-processing tools, such as 2D and 3D charts, animations, and graphs, are included for viewing and interpreting simulation results.

3.7 Hardware:

- **PCB Substrate:**

The choice of printed circuit board (PCB) substrate is essential to the success of electronic circuits. There are numerous PCB substrate materials on the market, and each one has distinctabilities that make them appropriate for a variety of applications. Dielectric constant, loss tangent, and their variations with temperature and frequency, as well as stability, thickness, chemical resistance, and flexibility, should all be taken into account when choosing a PCB substrate.Fiberglass, ceramics, and plastic are just a few of the materials that can be used to create PCB substrates; each has distinct features. The most typical substrate used in the production of PCBs is FR-4, a fibreglass fabric and epoxy resin composite. FR-4 is an inexpensive, easily accessible substrate that can be used for the majority of general-purpose applications.A key component of the PCB is the PCB substrate, and choosing the proper substrate material is essential to achieving the best performance and dependability for the intended application.

- **Vector Network Analyser (VNA):**

An electronic test tool called a VNA is utilized to gauge the effectiveness of electrical networks and devices. VNAs are widely utilised in the development, manufacture, and upkeep of electronic parts and systems.A VNA's primary purpose is to measure a network's or device's S-parameters while it is being tested (DUT). S-parameters, which are complex numbers, define how the phase and amplitude of signals that enter and depart the DUT are related. These variables are utilised to describe the behaviour of the DUT, as well as its frequency response, impedance, and other crucial features.

Following the generation of a test signal, a VNA measures the signal's amplitude and phase at the input and output ports of the DUT. With this information, the VNA may then determine the DUT's S-parameters. VNAs may assess both passive and active devices and typically work over a broad frequency range, from a few kilohertz to several hundred gigahertz.High accuracy, speed, and the capacity to test a number of parameters concurrently are only a few benefits of VNAs. They are frequently employed in processes like amplifier characterisation, filter design, and antenna testing. In order to accommodate a range of applications and price points, VNAs are available in a variety of configurations, including tabletop, portable, and handheld variants. The VNA setup of this work is shown in the figure 3.

Figure 3. The VNA setup

4. RESULT

The results obtained from the proposed antenna is discussed in this section. The antenna factors like directivity, radiation pattern, VSWR and return loss for the proposed antenna is analysed. The proposed multilayer antenna is devised through simulation employing the HFSS software. The simulated multilayer antenna is illustrated in the figure 4.

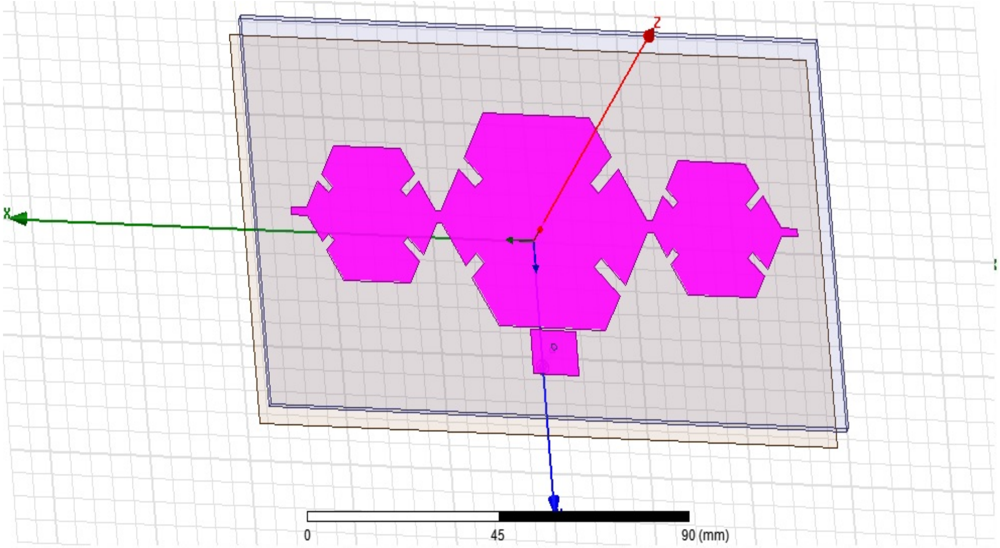


Figure 4. Multilayer microstrip patch antenna

An antenna's gain is inversely relative to its directivity. Directivity is the degree to which an antenna concentrates energy in one direction relative to another directions. An antenna would be an isotropic radiator if it had a directivity equal to gain ratio of one hundred percent. All antennas will release more energy in one direction rather than in another, hence gain is referred to as the quantity of energy that may be obtained in one direction at the cost of power losses in all other directions. Any antenna's radiation pattern is a fundamental characteristic since it displays how the aerial distributes energy throughout space. This radiation pattern raises concerns for the values of phi and theta. The directivity and the radiation pattern of the proposed antenna outcome is displayed in the figure 5 and 6 correspondingly.

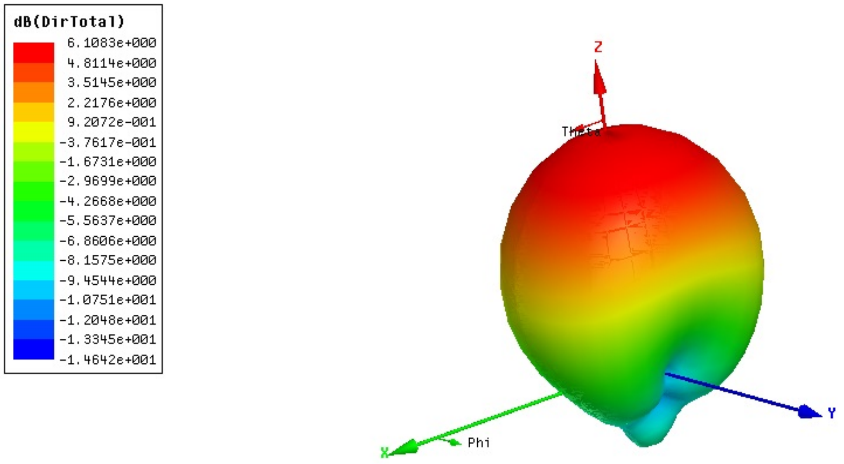


Figure 5. Directivity of the proposed antenna

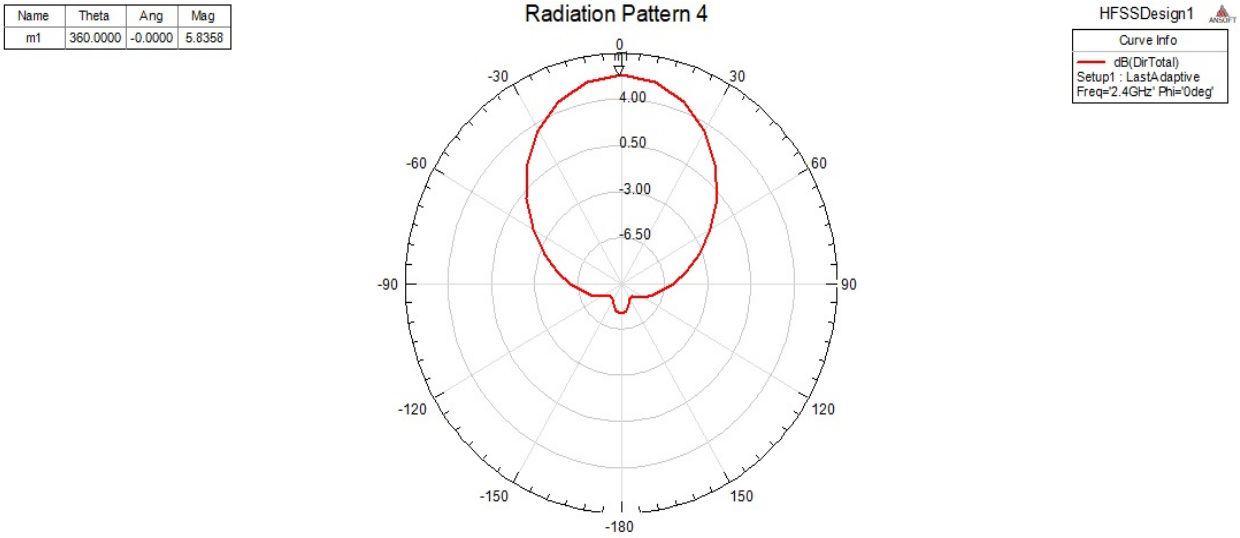
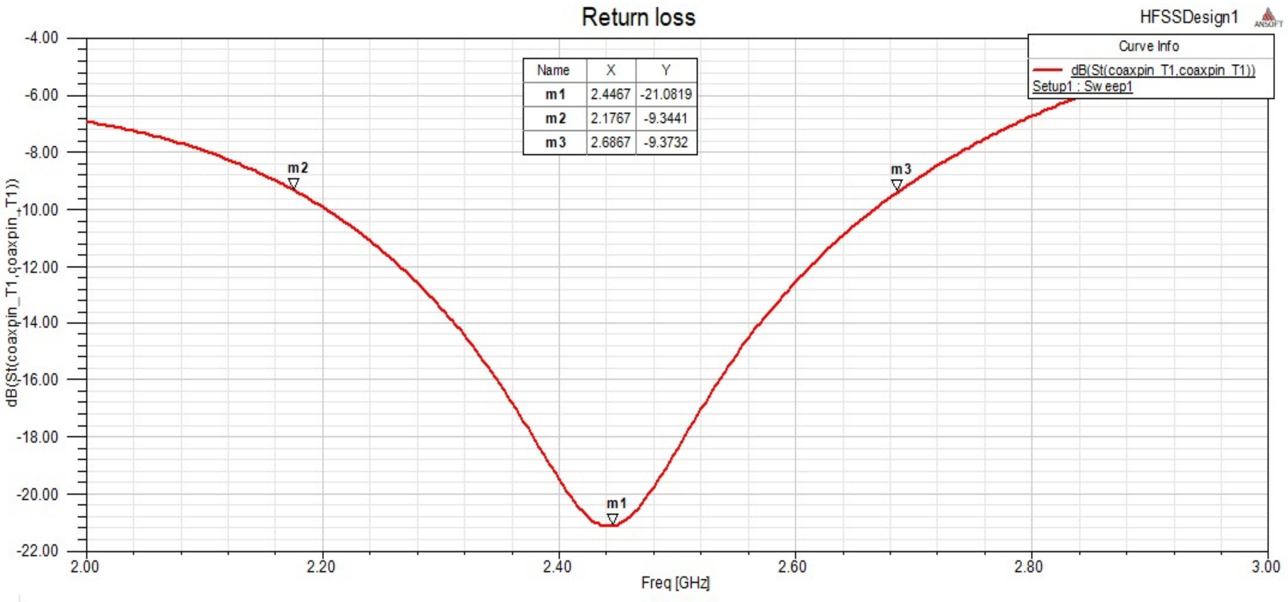


Figure 6. Radiation pattern outcome

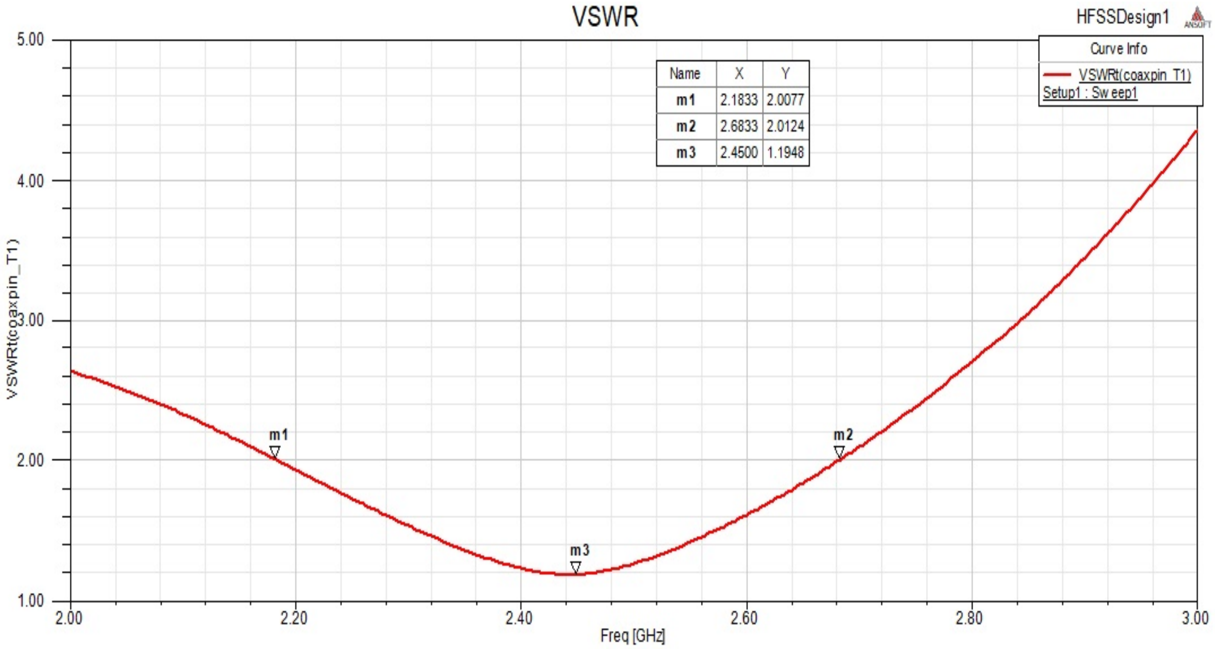
Return loss is a measurement of the impedance bandwidth at which the antenna and its input transmission line are well-matched, with at most 10% of the incident signal being lost to reflections. Impedance bandwidth testing also include VSWR and return loss characterization for the entire band of interest. The value of the return loss at 2.4 GHz is -21.0 as displayed in the figure7.



Name	X	Y
m1	2.4467	-21.0819
m2	2.1767	-9.3441
m3	2.6867	-9.3732

Figure 7. Return loss of the proposed antenna

The varied VSWR of several frequency bands are displayed in Fig.8. It is a measurement of the standing waves that a mismatch causes to form in a feeder. The standing wave ratio is another name for it. The majority of aircraft applications are thought to be suitable with VSWR values close to 1. The value of VSWR at 2.4 GHz is 1.1 as shown in the given figure.



Name	X	Y
m1	2.1833	2.0077
m2	2.6833	2.0124
m3	2.4500	1.1948

Figure 8. VSWR of the proposed antenna

5. CONCLUSION

In the proposed work, the HFSS software was used to simulate the various sizes, shapes, thicknesses, and dielectric substrates of multilayer microstrip antennas. A promising option for several wireless communication systems, including Bluetooth, RFID, PCS, Mobile Satellite Communications, DBS-TV, and WLANs, is the Microstrip antenna. This antenna is quite popular because of its numerous appealing characteristics, including its low profile, light weight, and affordable price, which allow for mass manufacture. The proposed study to simulate and create various Microstrip antenna configurations utilising cutting-edge software tools and specialised test equipment would help to design Microstrip antennas that are more effective and dependable. By improving performance and cost-effectiveness, the research's findings will help a variety of wireless communication systems. The proposed antenna performance is assessed employing a variety of performance metrics, including bandwidth, gain, directivity, return loss, VSWR, and radiation pattern. Utilizing specialised test tools like VNA, these parameters will be measured. A multilayer microstrip patch antenna operating at different frequencies may be the subject of additional research. To satisfy the demands for various distance communications, this will further develop antennas with highly directional features or high gains.

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