DESIGN OF PLANAR INVERTED F ANTENNA FOR 5G COMMUNICATIONS

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Abstract:- A single feed PIFA running at 5GHz is designed and presented. Then, we add many models. The antenna should resonate for multiple frequencies in mobile applications. Since mobile communications use PIFA Antenna the most, it should be Multi-Model. Due to factors including cost, demand, and manufacture, PIFA is more comfortable than patch antennas. It has compact low profile design and shows omnidirectional radiation pattern with minimal hand effect. Planar inverted F antenna is designed at frequency of 2.45GHZ. This paper is a comprehensive theoretical study of Planar Inverted F Antenna . Research and experiments done on PIFA structures are discussed and categorized in the paper . The conventional PIFA has an inherent narrowband that is not desirable in most modern handheld devices. Some methods to improve the bandwidth, efficiency and reducing the dimensions of the PIFA are also discussed in this study.

Keywords: Multi-Model , PIFA, Patch

1 Introduction

An antenna is a metallic structure that captures and/or transmits radio electromagnetic waves. Antennas come in all shapes and sizes from little ones that can be found on your roof to watch TV to really big ones that capture signals from satellites millions of miles away.

The antennas that Space Communications and Navigation (SCAN) uses are a special bowl- shaped antenna that focuses signals at a single point called a parabolic antenna. The bowl shapeis what allows the antennas to both capture and transmit electromagnetic waves. These antennas move horizontally (measured in hour angle/declination) and vertically (measured in azimuth/elevation) in order to capture and transmit the signal bandwidth.

Whether it be radio, LAN, or otherwise, an antenna is extremely important. The antenna's primary function is to transmit and receive clear signals between multiple wireless points. It is safe to say that an effective and efficient wireless network will require antennas to operate properly. Euclidean geometries, fractal geometries have in many circumstances or applications.In the field of communication systems, whenever the need for wireless communication arises, there occurs the necessity of an antenna. Antenna has the capability of sendingor receiving the electromagnetic waves for the sake of communication, where you cannot expect to lay down a wiring system.In order to contact a remote area, the wiring has to be laid down throughout the whole route along the valleys, the mountains, the tedious paths, the tunnels etc., to reach the remote location.

The sole functionality of an antenna is power radiation or reception. Antenna (whether it transmits or receives or does both) can be connected to the circuitry at the station through a transmission line. The functioning of an antenna depends upon the radiation mechanism of a transmission line.A conductor, which is designed to carry current over large distances with minimum losses, is termed as a transmission line. For example, a wire, which is connected to an antenna. A transmission line conducting current with uniform velocity, and the line being a straight one with infinite extent, radiates no power. Due to their space-filling capabilities, ractals can be utilised to miniaturise wire and patch parts . A patch element can have its electrical length lengthened using the same reasoning. You can think of the patch antenna as a Microstrip transmission line. Therefore, the area needed to fill the resonant transmission line can be decreased if the current can be made to follow a fractal's complicated course rather than a straight Euclidean path. Patch antennas have been used with this approach in a variety of ways in daily life.

The evolution of the quarter wave monopole antenna frequently uses a planar inverted F antenna. It consists of a parallel-to-the-ground monopole antenna. As a result of its space-saving qualities, it is most frequently used as a PIFA in mobile wireless devices. Based on price, production, and demand, PIFA is preferred over patch antennas. Typically, it consists of a rectangular planar element above known as a planar inverted F antenna or a short-circuited microstrip antenna because it resembles an inverted F. It has strong gain, multiple frequency support, and a bright future for wireless technology.. At 2.45 GHz, a planar inverted F antenna is designed. By adding slots 1 and 2 to the patch, the resonance frequency is greatly enhanced. By inserting slot 3, a lower resonant frequency is attained. Slot 3 had a wider opening than the other two. For a good bandwidth, a fourth slot is added. Zeeland Software is used to design the antenna. Due to the fact that theresonant frequency in this case is inversely related to the top patch's dimensions, it is a little lower than in the basic PIFA.

In comparison to a standard rectangular PIFA, the Specific Absorption Rate is reduced in tapered T-PIFA. Wideband capabilities and great performance are displayed by the tapered planar inverted F antenna. The suggested antenna consists of a FR-4 substrate sandwiched between the ground plane and the radiating plate, and a radiating plate connected to the ground plane via a cylindrical shorting. This PIFA component can operate in the 2.31 GHz to 2.71 GHz frequency range, making it suitable for use with Wi-Fi (2.45 GHz), Bluetooth (2.4 GHz), and the two LTE bands (2.3 GHz and 2.5 GHz). We experiment with the different settings to see how they affect the PIFA's resonance frequency, bandwidth size, and radiation pattern.

2 Substrate Details

Air is the substrate at a height of 9.276 mm above the ground plane. The substrate used ranges in thickness from 9.276 to 10.8mm.The antenna is made of RO4003C hydrocarbon ceramic, has a thickness of 1.524 mm, a loss tangent of 0.027, and a dielectric constant of 3.33. Additionally, these dimensions are chosen to provide resonance frequency in applications like ISM, Bluetooth, and Wi-max. As a result, the antenna gain is decreased, but the patch antenna retains the same fundamental characteristics as a half wavelength patch despite being 50% smaller in area.

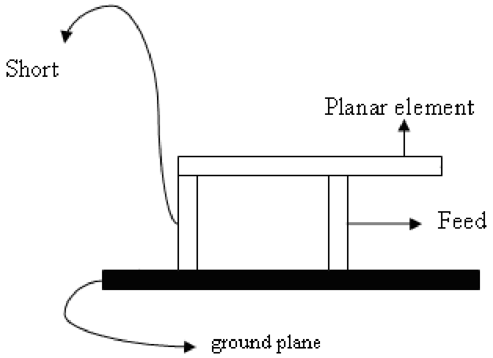


Fig 1 . Structure of PIFA

The substrate material used in PIFA (Planar Inverted-F Antenna) antennas can vary depending on the specific design requirements and desired performance characteristics. Here are some commonly used substrate materials for PIFA antennas:

FR4 (Flame Retardant 4): FR4 is a widely used substrate material in printed circuit boards (PCBs) and PIFA antennas. It is a fiberglass-reinforced epoxy laminate material, which offers good electrical properties, mechanical strength, and cost-effectiveness.

Rogers: Rogers Corporation produces a range of high-performance substrate materials specifically designed for RF and microwave applications. These substrates, such as Rogers RO4000 series or RO3000 series, offer low dielectric loss, excellent high-frequency performance, and good dimensional stability.

Duroid:Duroid is another type of high-performance substrate material commonly used in PIFA antennas. Duroid substrates, such as Duroid 5870 or Duroid 6002, have low dielectric constant and loss tangent, making them suitable for high-frequency applications.

Teflon (PTFE): Polytetrafluoroethylene (PTFE), commonly known as Teflon, is a low-loss dielectric material with excellent electrical properties. PIFA antennas using Teflon substrates offer low dielectric losses and high power-handling capabilities, making them suitable for high-performance applications.

It's important to note that the choice of substrate material for a PIFA antenna depends on various factors, including operating frequency, bandwidth, power handling, size constraints, and cost considerations. Designers select the most suitable substrate material based on the specific requirements of the antenna design and its intended application.

3 Existing System

The study of the specific absorption rate (SAR) of a rectangular-shaped planar inverted-F antenna (PIFA) at 2.6 GHz is presented in this article. The design antenna is first provided with a parametric analysis of the ground plane, substrate, shorting plate, and antenna patch length dimensions. The suggested PIFA antenna has a gain of 2.383 dB and a reflection coefficient of -20.46 dB. The antenna gain and excitation power are associated with the SAR of the PIFA. The analysis demonstrates that a lower SAR value is caused by a higher gain. While a greater SAR value results from a larger excitation power.

Wireless devices are crucial for establishing constant connections between many users, which necessitates a low-profile antenna. The planar inverted-F antenna (PIFA) is one of the lowest profile antennas commonly used in handheld wireless devices. It offers a number of benefits including a straightforward design, a compact footprint, ease of fabrication, and a cheap cost of production.

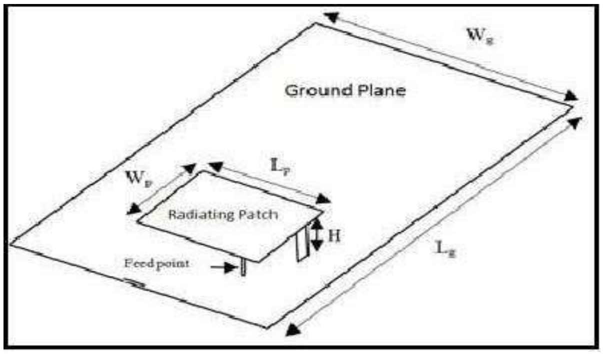


Fig 2 . Basic Design & Dimension Of Planar Inverted F-Antenna

Additionally, PIFA is smaller than monopole, rod, and helix antennas, making it simpler to position and align the components. There are a number of studies on the PIFA antenna for mobile phone applications that are presented in, all of which have considerable sizes. The implementation of an F-shaped slot in a PIFA antenna with a total huge dimension of 314 x 157 mm on an 800 MHz-operated RT/Duroid 5880 substrate is shown.

The PIFA antenna has a dimension of 120 x 60 mm and is designed with a few slots that operate between 3.1 and 10.6 GHz. The electromagnetic (EM) wave is emitted by the antenna that is built into wireless devices. The human body is exposed to and absorbs this EM wave. Specific absorption rate (SAR) is a measurement of the EM wave's absorption power rate. SAR measures how much EM field radiation from wireless devices, such mobile phones, is taken in by the human body.

The maximal rate of radio frequency (RF) energy absorption by a user's body when using a wireless device is calculated using the SAR rate of the device. The Federal Communications Commission (FCC) of the United States has set a limit on SAR exposure for the general population of 1.6 watts per kilogram (1.6 W/kg). In order to obtain FCC certification and be sold in the US, the mobile device's SAR rate must not be higher than 1.6 W/kg. The upper limit for exposure in Europe is 2.0 W/kg, calculated as an average across a volume of 10g of tissue. To avoid any negative health effects, the maximum safety limit should not be exceeded. The size of the average volume affects SAR value.

4 Proposed System

For use in mobile handsets, a low-profile a planar inverted f antenna (PIFA) is suggested. The antenna has the appearance of an inverted f because it is made up of rectangular planar elements that are elevated above a ground plane. It has strong gain, multiple frequency support, and a bright future for wireless technology. The 2.45GHz resonant frequency is used

This particular microstrip antenna uses pin shorting in several places to increase performance. There are a few benefits to shorting pins, including size reduction, multi-frequency resonance, gain improvement, and desired radiation pattern. It is a quarter-wave length resonant and has good SAR (specific absorption rate) characteristics.

In the market for mobile phones, the planar inverted F antenna (PIFA) is being employed more and more. The antenna often has strong SAR qualities and is resonant at a quarter wavelength, which reduces the amount of space needed on the phone.

Designers of antennas are constantly considering innovative strategies to raise performance. The introduction of shorting pins (from the patch to the ground plane) at various positions is one technique utilised in patch antenna design. Two examples—the quarter-wavelength patch antenna and the planar inverted f antenna (PIFA)—will be used to demonstrate how this might be useful. At the further end, a region of a quarter wavelength shorted.

The current at the end of the patch antenna is no longer forced to be zero because the patch is shorted at the end. The current-voltage distribution of this antenna is actually identical to that of a half wave patch antenna. Its low profile and omnidirectional pattern make the Planar Inverted-F Antenna popular. The position of the feed, which is sandwiched between the open and shorted ends, determines the input impedance. The distance from the feed to the short pin (D) can be used to modify the PIFA's impedance. The impedance will reduce the closer the feed is to the shorting pin.

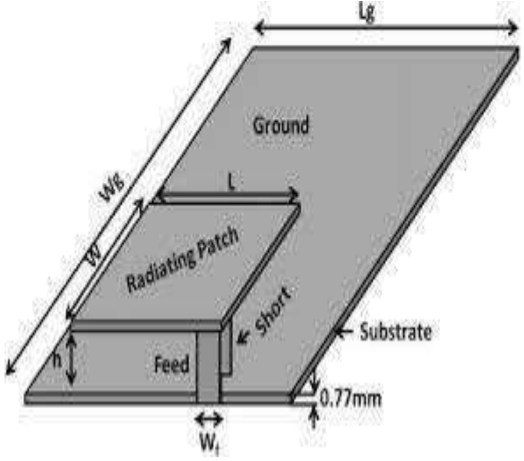
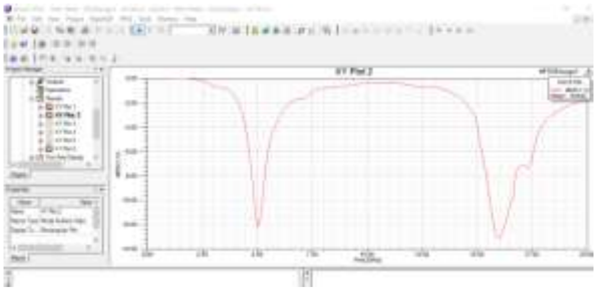


Fig 3 . Quarter wavelength patch with shorting pin at end.

5 Results and Observations

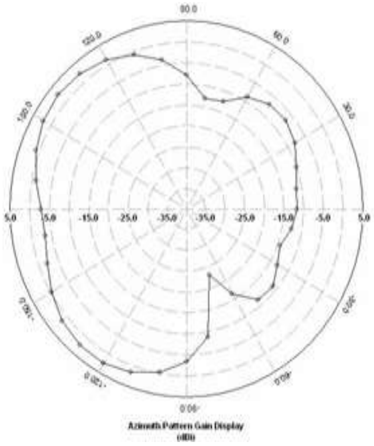
S Parameter Output: S-parameters, or scattering parameters, are commonly used to characterize the performance of antennas, including PIFA antennas. S-parameters describe how electromagnetic waves are transmitted and reflected at the input and output ports of the antenna.

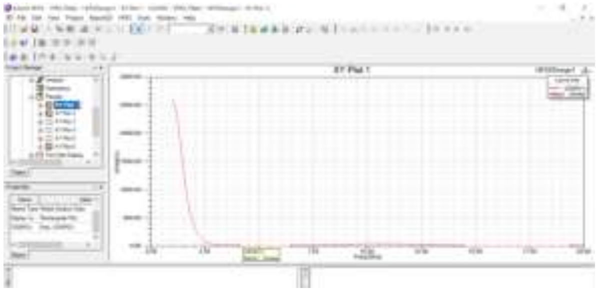
Fig.4 S Parameters



VSWR Output: VSWR (Voltage Standing Wave Ratio) is a measure of how well an antenna is matched to the transmission line or system it is connected to. It quantifies the amount of reflected power due to impedance mismatch. The VSWR of a PIFA (Planar Inverted-F Antenna) can be determined using its S11 parameter, which represents the input reflection coefficient.The VSWR is calculated as the ratio of the maximum voltage amplitude to the minimum voltage amplitude along the transmission line.

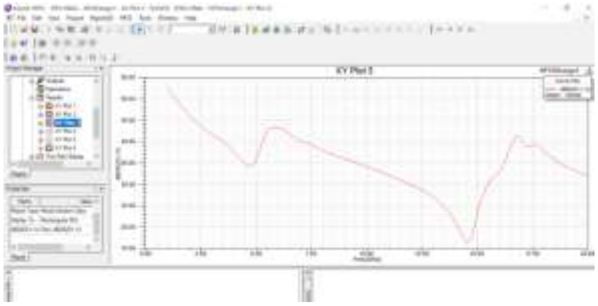
Fig 5.VSWR





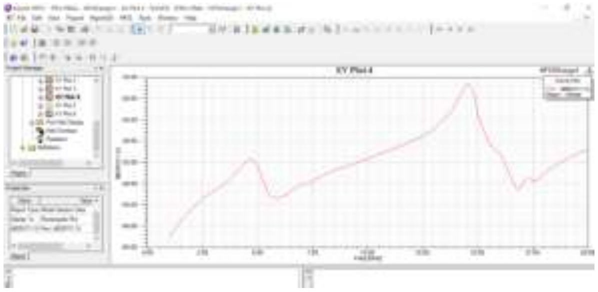
Y Parameter Output: Y-parameters, also known as admittance parameters, are an alternative set of parameters used to characterize the behavior of antennas, including PIFA (Planar Inverted-F Antenna) antennas. The Y-parameters describe the relationship between the input and output currents and voltages of the antenna.

Fig 6. Y Parameters



Z Parameter Output: Z-parameters, also known as impedance parameters, are a set of parameters commonly used to characterize the behavior of antennas, including PIFA (Planar Inverted-F Antenna) antennas. The Z-parameters describe the relationship between the voltage and current at the input and output ports of the antenna.

Fig 7. Z Parameters



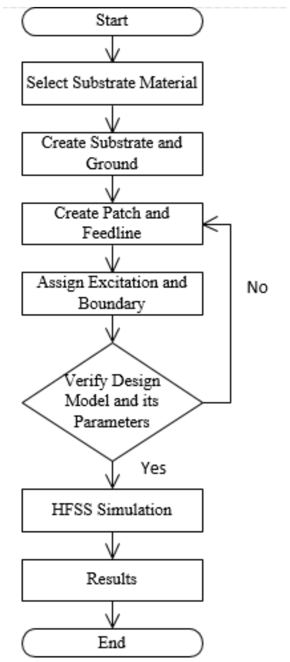
Radiation pattern Output: It is nearly Omni directional radiation pattern in azimuth plane and peak gain 2.1, 2.9 dBi occurs at θ=45º for antenna. Simulation results of PIFA I has a gain of -10dBi in the horizontal field (θ=0º). E_θ is maximum at θ=45º with the peak gain of +3.5 dBi. These radiation characteristics will be useful for NLOS (non line of sight) application.

Fig 8. Radiation Pattern at 3.54 GHz

6 Flow Chart

The High-Frequency Structure Simulator (HFSS) is used to create and simulate the suggested antenna. Here is a general flow chart describing the steps involved in using HFSS 13 software, a popular electromagnetic simulation tool, for antenna design and analysis:

Start :
1.Start by creating a new project in HFSS 13.
2.Draw the geometry of the PIFA antenna using the available modelling tools.
3.Specify the dimensions, shapes, and material properties of the antenna structure. Fig 9: Steps to design planar inverted F Antenna



Select Substrate Material:
1.Assign material properties to the different parts of the antenna structure.
2.Specify the dielectric constants, conductivity, and loss tangent of the substrate and other components.

Set Up Excitation:
1.Select the desired excitation method for the antenna, such as a voltage source or a wave port.

2.Specify the location and characteristics of the excitation point, such as the frequency, amplitude, and phase.

Configure Solver Settings:
1.Define the simulation settings, such as the frequency range, meshing parameters, and convergence criteria.
2.Adjust the mesh density to accurately capture the antenna's features and wavelength-dependent effects.

Solve the Simulation:
1.Run the simulation using HFSS 13 to calculate the electromagnetic field distribution and antenna performance.
2.Monitor the convergence of the solution and adjust settings if needed.

Analyze Results:
1.Post-process the simulation results to obtain the desired antenna characteristics.
2.Evaluate parameters such as S-parameters, radiation patterns, impedance bandwidth, and efficiency.
3.Visualize and interpret the results using HFSS 13's built-in tools or export the data for further analysis.

Optimize and Refine:
1.If the antenna performance does not meet the design requirements, iterate and refine the antenna geometry or other parameters.
2.Modify dimensions, shapes, or material properties based on the insights gained from the analysis.
3.Repeat the simulation and analysis steps until the desired performance is achieved.

It's important to note that the specific steps and options within HFSS 13 may vary slightly depending on the software version and the complexity of the antenna design.

7 Conclusion

In conclusion, the Planar Inverted-F Antenna (PIFA) is a popular and versatile antenna design that offers several advantages for wireless communication applications. Here are the key points to summarize the PIFA antenna:

Compact Design: PIFA antennas are planar and compact, making them suitable for integration into small devices like mobile phones, tablets, and IOT devices.

Wideband Operation: PIFA antennas can be designed to operate over a wide frequency range, providing flexibility for multi-band or broadband applications.

Omnidirectional Radiation Pattern: PIFA antennas typically exhibit a radiation pattern with good omnidirectional coverage in the azimuth plane, making them suitable for applications where signal coverage needs to be distributed evenly in all directions.

Easy Integration: PIFA antennas can be easily integrated into the circuit board of electronic devices, allowing for efficient use of available space and simplifying the manufacturing process.

Ground Plane Sensitivity: PIFA antennas require a ground plane to function effectively. The size, shape, and proximity of the ground plane can affect the antenna's performance, making proper design considerations crucial.

Impedance Matching: Achieving impedance matching between the antenna and the feeding transmission line is essential for optimizing the antenna's performance. Proper matching helps minimize reflection and maximize power transfer.

Performance Trade-offs: The design parameters of a PIFA antenna, such as substrate material, dimensions, and shape, have an impact on various performance characteristics, including bandwidth, gain, efficiency, and radiation pattern. Optimizing these parameters involves trade-offs to meet specific design requirements.

Simulation and Analysis: Electromagnetic simulation tools like HFSS can be used to analyze and optimize PIFA antenna designs. These tools enable designers to evaluate parameters such as impedance matching, radiation pattern, and efficiency before fabrication.

Overall, the PIFA antenna is a versatile and compact design option that offers wideband operation, omnidirectional radiation pattern, and ease of integration. Its performance can be optimized through careful design and simulation analysis, making it suitable for a wide range of wireless communication applications.

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