Designing of Inverted F Antenna and Utilizing of Blockchain in Vehicle Systems

RAED DARAGHMA[1], EMAN DARAGHMI[2], YOUSEF DARAGHMI[3], HACENE FOUCHAL[4]
[1]Department of Communication Engineering and Technology,
Palestine Technical University (PTUK),
Tulkram,
PALESTINE

[2]Department of Computer Science,
Palestine Technical University (PTUK),
Tulkram,
PALESTINE

[3]Department of Electrical and Computer Engineering,
Palestine Technical University (PTUK),
Tulkram,
PALESTINE

[4]Department of Mechanics and Computer Science,
University de Reims Champagne-Ardenne,
REIMS,
FRANCE

Abstract: - This paper is the first to integrate a blockchain system to improve the manufacturing efficiency and reliability of 5G F Inverted antennas. The recommended antenna is constructed from a single side of a premium aluminum conductor, the width of the radiator is 0.564 mm, the thickness of the conductor is 0.77 mm ground plane is 29.3 x 29.3 mm^2 dimension. The antenna is designed to work at a frequency of 5.9 GHz, therefore it can be used for vehicle applications. It is designed to be inserted as an integrated antenna into an IOT device and is composed of Microstrip F shapes. Therefore, a rectangular Microstrip patch F antenna was built and its performance was examined in this work. 5.9 GHz is the antenna's resonance frequency range, which is suitable for vehicle applications. The simulation software for this work was Computer Simulation Technology (CST) software. Antenna performance was compared concerning gain, bandwidth, and return on loss. By enhancing the production efficiency and reliability of 5G Inverted F antennas, our study sets a new benchmark for the integration of blockchain and smart contract technologies, paving the way for ground-breaking advancements in manufacturing techniques. The relevance of creating an inverted F antenna for the Vehicle Systems environment is increased by this research. Typically, rod antennas are found in automobiles. However, the Vehicle Systems industry's requirements for meeting the demands of human resources with a variety of applications at different frequencies are not met by the rod antenna now in use. Because of their important characteristics, which include wideband matching, omnidirectional pattern, high efficiency, and compact size, microstrip patch Inverted F antennas are highly favored in the Vehicle Systems industry.

Key-Words: - IOT, F Inverted antenna, Vehicle, Bandwidth, Blockchain, Gain, Microstrip, CST.

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1 Introduction

In paper [1], a low profile slotted planar inverted F antenna (PIFA) for multiband use is shown in this research paper on a reactive impedance surface (RIS). The quad-band frequency antenna for wireless applications operates at 2.4 GHz (WLAN), 4.2 GHz (C-band satellite downlink), 7.1 GHz (C-band satellite uplink), and 9 GHz (X-band). The antenna demonstrates the advantages of multiple PIFA by displaying radiation pattern, gain, and impedance matching over their operational bandwidths. In paper [2], the 225 and 450 MHz bands are used by the suggested antenna for operation.

Data on input impedance and return loss as a function of different antenna characteristics are provided, demonstrating that tuning can be optimized by adjusting the parameters. Data on the radiation pattern of the antennas installed on the roofs of two different kinds of cars are provided. While the high-frequency band pattern is directional and normal to the antenna surface, the low-frequency band pattern is omnidirectional. This antenna can be appropriate for dual-band GSM 900/1800 MHz phone applications with the right scaling.

In the paper [3], a small microstrip inverted F antenna design is showcased for GPS purposes. The suggested type is an Inverted-F antenna that can pick up all of the GPS receiver operating frequencies, which are used in cars and range from 1.176 GHz to 1.575 GHz. To accomplish circular polarization and preserve the axial ratio of 2dB to 3dB, the antenna structure is constructed. FR4: Fiber Glass (Epoxy), which has a Dielectric Constant of 4.4, is utilized as the substrate. One type of radiating element is copper. Version 13 of the HFSS (High-Frequency Structure Simulator) program simulates the parameters of the suggested model, including frequency, return loss, VSWR, impedance, radiation pattern, and directivity.

In paper [4], for small-size dual-wideband operation in mobile communication devices, particularly thin tablet PCs, a coupled-fed Inverted-F antenna is suggested for long-term evolution/wireless wide-area network (LTE/WWAN) operation. An Inverted-F coupling feed and a folded radiating strip make up the antenna. The former capacitive is grounded to the device ground plane and is excited by the Inverted-F coupling feed. The antenna generates two broad working bands in the 704–960 and 1710–2690 MHz bands to support LTE/WWAN operation.

In paper [5], the small high gain Microstrip antenna with a split ring resonator, a set of Inverted-F slots, and a matching stub for sub-6 GHz 5G applications is designed, optimized, manufactured, and measured in this work. In this study, inverted F slots, a split ring resonator, and a matching stub in the transmission line are used to display various iterations. Precisely 2.1 GHz, 3.3 GHz, and 4.1 GHz resonances are displayed by the specified antenna. The suggested antenna is appropriate for 5G bands such as the n78 band (3.3 GHz), n77 band (4.1 GHz), and LTE band (2.1 GHz). Every band yields a gain that is greater than 5 dB.

In paper [6], the suggested antenna is only 17.1x17.8x0.933 mm^3 and is constructed on a single side of a premium Teflon substrate. Due to its 5.9 GHz operating frequency, it can be utilized for Internet of Things applications. It is designed to be installed as an integrated antenna into an IoT device and is composed of a range of H shapes. Three key performance metrics were evaluated between these two antennas: bandwidth, gain, and return on loss. The main findings of this study show that, in comparison to a conventional antenna, the antenna with an improved array-shaped enhanced bandwidth, gain, and return on loss. Furthermore, the improved antenna attained an operating frequency of 5.9 GHz, making it appropriate for IOT applications.

In paper [7], the incorporation of blockchain technology enables meticulous documentation and monitoring throughout the entire production process, thus strengthening data integrity and augmenting traceability.

Moreover, the integration of smart contracts simplifies operations through process automation, facilitating the prompt detection and resolution of problems. The improved study results show the enormous potential of using cutting-edge technology in manufacturing, providing a strong framework for maintaining industry competitiveness in a world that is becoming more digital and networked.

In paper [8], agriculture systems can be improved by a promising method that uses diverse and multiple data sources, such as cattle, crops, or—even better—mixed farming systems with AI capabilities. These technologies promise users accessibility, customization, and precision, and they aim to change farmers' daily lives, but they also have serious drawbacks. Specifically, security, integrity, and auditability have emerged as critical concerns that require attention. Distributed ledger technologies (DLT), like blockchain, are one method to address the aforementioned.

In the paper [9], the authors suggest using blockchain technology, which is still in its infancy but provides cryptographically secure accounting while protecting participant privacy. We show that the use of mobile blockchain techniques enables an increase in the offloading gains that are not incremental through system-level evaluations. This indicates that the described concept has the potential to be a successful mechanism in the upcoming B5G systems.

In the paper [10], the role of UAVs in the SAGIN is reviewed by the authors. Subsequently, three use cases for the UAV network envisioned by blockchain are shown via multiple categories. There is also a description of upcoming difficulties and the related open research areas.

In the paper [11], the authors suggest a blockchain-based infrastructure that is energy-intensive for managing drone operations while guaranteeing security and confidence for all stakeholders. This work aims to investigate the degree of sensitivity of Unmanned Aerial Vehicles (UAVs) to misleading Global Navigation Satellite System (GNSS) signals by defining the prerequisites for UAVs using GPS (Global Positioning System) spying.

In paper [12], an overview of the blockchain's integration with aerial communications (BAC) is presented in this study. First, the authors examined the security problems that currently plaguing aerial communication networks, blockchain technology's advantages, and the viability and potential of using the blockchain to address these problems. Subsequently, the authors categorized the solutions and evaluated and contrasted them. Lastly, they suggested a few lines of inquiry for further study.

In the paper [13], a 900 MHz RFID-linked sensor with a small feature size was created and tested for real-time sensor data gathering. Every time, a tamper-proof digital database of the food packets is created with the help of the blockchain architecture. A thorough security analysis was conducted to find out how vulnerable the suggested architecture would be to various cyberattacks.

In paper [14], presenting a compact dual-band planar Inverted-F antenna operating in the Worldwide Interoperability for Microwave Access band (3300–3800 MHz) and GPS (Global Positioning System) band (1565–1585 MHz) is an inverted L-shaped parasitic and decreased ground-plane structure. Strict space criteria for portable devices are met by the antenna. It is made up of several branches that have been appropriately spaced and dimensioned to produce resonances at the necessary frequencies.

In paper [15], a genuine PIN-diode-based frequency reconfigurable planar Inverted-F antenna (PIFA) is described for global mobile microwave access (m-WiMAX) applications. This antenna uses PIN-diode switching to change the WiMAX's frequency band. It also uses a capacitive load inside a FR4 dielectric constant substrate to provide a compact profile. The antenna operates over the global m-WiMAX bands of 2.3–2.4, 2.5–2.7, and 3.4–3.6 GHz depending on whether the diodes are on or off. The suggested antenna's entire set of measured and simulated data is shown, and they all exhibit excellent agreement.

In paper [16], for a radar application operating at 94GHz, a 3x4 Microstrip patch antenna array has been developed. And analyzed in this study. The operating frequency, 94GHz, is chosen using CST and MATLAB. For radar applications, this is the higher frequency range. The array size is kept at 3 by 4, or a total of 12 elements. The rectangular arrays employ the antenna array configuration. Four distinct metrics have been analyzed: resistance, reactance, voltage standing wave ratio, and S-parameter. It displays the Scattering-parameter response. When the threshold value is -10 dB, it can be seen that the maximum bandwidth for the s-parameter is between 9.0 and 9.2 GHz bandwidth. VSWR has a minimum value of 3V and a maximum value of 58V.

In the paper [17], it is suggested to build a ten-element multi-antenna terminal with wide impedance bandwidth (IBW) for huge multiple-input multiple-output (MIMO) in the fifth-generation (5G) sub-6 GHz. An Inverted-F stub connected to a hybrid loop antenna element is fed by a grounded coplanar waveguide. The lowest measured isolation of 18 dB was reached. The results show that the maximum simulated envelope correlation coefficient is about 0.21 and the minimum antenna effectiveness is 78.4%. Each element is printed on a 1.52 mm thick Rogers 4003 substrate with $\epsilon r = 3.38$ and $\tan \delta = 0.0027$, and has a shape factor of 17.2 × 3.8 mm2 ($0.018\lambda^2$ g).

In paper [18], an integrated Triple-Inverted-F antenna (TIFA) with three radiating strips and two hybrids (inductive and capacitive) shorting strips with a compact structure is presented. This allows for triple-wideband operation in smartphones for (4G/5G) communications. The integrated TIFA can cover the 4G long-term evolution low band (LTE LB) in 617–960 MHz, the 5G bands in 3300–4200 MHz, and the 4G LTE middle/high bands (LTE M/HB) in 1710–2690 MHz Because the proposed TIFA features three integrated Inverted-F antenna structures (IFA1, IFA2, and IFA3) that may independently regulate the three bands, it is easy to manufacture for practical use. Furthermore, the necessary isolation between the LTE LB, LTE M/HB, and 5G bands is achieved by positioning two TIFAs at the top and bottom short edges of the smartphone, which improves multi-input multi-output performance for 4G/5G applications.

A ten-element multi-antenna terminal with a wide impedance bandwidth (IBW) is proposed in the paper [19] for massive multiple-input multiple-output (MIMO) in the fifth-generation (5G) sub-6 GHz. A grounded coplanar waveguide feeds a hybrid loop antenna element via an Inverted-F stub. The lowest measured isolation of 18 dB was reached. The results show that the maximum simulated envelope correlation coefficient is about 0.21 and the minimum antenna effectiveness is 78.4%. Every element has a form factor of 17.2 × 3.8 mm2 (0.018λ2 g) and is printed on a 1.52 mm thick Rogers 4003 substrate with ϵr = 3.38 and tan δ = 0.0027.

As stated in the publication [20], this study describes the design, optimization, fabrication, and measurement of a compact, high-gain Microstrip antenna for sub-6 GHz 5G applications. It features a split ring resonator, a set of Inverted-F slots, and a matching stub. This study displays different iterations using inverted F slots, a split ring resonator, and a matching stub in the transmission line. Precisely 2.1 GHz, 3.3 GHz, and 4.1 GHz resonances are displayed by the specified antenna. The suggested antenna is appropriate for 5G bands such as the n78 band (3.3 GHz), n77 band (4.1 GHz), and LTE band (2.1 GHz). Every band yields a gain that is greater than 5 dB.

Numerous experts have evaluated and analyzed several types of car communication antennas. The goal of this research project is to create an Inverted F Microstrip antenna that is smaller, lighter, and more affordable to produce in large quantities.

The study's primary contribution is to:

- Create a microstrip planar and rectangular Inverted F-shaped coplanar antenna that can be used in microwave band applications by applying thorough mathematical calculations and taking design considerations into account to optimize the various antenna parameters.
- The unique Microstrip patch F Inverted antenna model was the subject of thorough parametric research to produce the best possible antenna design for superior impedance matching.
- We outline the intricate blockchain architectures that are employed in the 5G Inverted F antenna fabrication process, which is meticulously designed. The tight specifications for efficiency, security, and interoperability required in a high-tech manufacturing environment have been carefully considered in the design of these combinations.

The structure of the paper is as follows. Part II covers the general aspects of Microstrip patch F Inverted Antenna Design. In Part III, suggested antennas are analyzed and simulated. Part V concludes with conclusions, while Part IV displays the findings and conversations.

2 Antenna Design

In this section, we describe the complex blockchain structures that have been closely created and used in the production of Inverted F antennas. These configurations have been carefully designed to satisfy the strict requirements for efficiency, security, and interoperability that are necessary in a high-tech manufacturing setting. As shown, integrating blockchain technology into the 5G Inverted F antenna production process offers a strong answer to today's manufacturing problems.

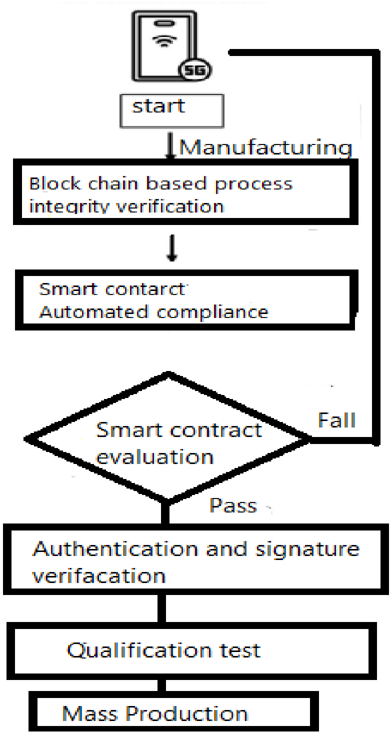

Fig. 1: Analysis for 5G Inverted F antenna manufacturing

In Figure 1, we present a blockchain-based business model created especially for the production of 5G inverted F antennas. This paradigm differs from conventional methods in that it guarantees data integrity and streamlines the supply chain, utilizing blockchain's intrinsic security and transparency to meet contemporary industrial difficulties. We used the same model as in [7] in this section, but we applied 5G using an inverted F antenna. We present a blockchain-enabled manufacturing process where blockchain-based process integrity verification supports every stage of the process. This improvement raises the bar for auditability and data integrity right now. After production, smart contracts provide real-time, unchangeable recording of each antenna's conformance to predetermined quality standards, automating compliance monitoring and simplifying operations. If a product fails at any point, the smart contract starts an assessment procedure to identify remedial actions before moving forward, improving responsiveness to quality problems. The proposed antenna is printed on a Teflon substrate with a thickness of 0.933 mm and has a loss tangent (d) of 0.002. The planned antenna prototype and measurement setup are shown in Figure 2. The ground plane length was calculated using the parametric study and is shown in Figure 2. The planned antenna works at 5.9 GHz. This frequency is dedicated to applications for the Wireless Access Vehicular Environment (WAVE). The parameter for antennas with the recommended work is covered in Table 1.

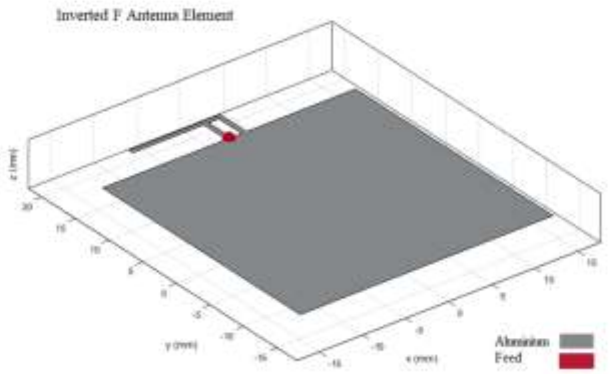

Fig. 2: Structure of designed antenna.

3 Simulations and Analysis

An innovative patch Microstrip Inverted F antenna designed for automotive communications is examined in this article. The radiator and feeder widths of an inverted F coplanar antenna are 0.564 mm^2 and 0.564 mm^2, respectively. The suggested microstrip Inverted F antenna configuration has a ground plane of 0.0293 x 0.0293 mm^2 and is made of high-conductivity aluminum with a thickness of 0.77 mm^2. Table 1 covers the parameters for antennas with the given word.

Figure 3 shows the characteristics of the proposed antenna. For the simulated s-parameter, there is just one resonance available (5.8 GHz–6 GHz). The measured results of the simulation for return loss are shown in Figure 3. The return loss is -16 dB at 5.9 GHz and -14 dB at 5.8 GHz. Furthermore, the antenna operates at S11< -10 dB at 0.2 GHz (5.8–6 GHz), as can be seen. Figure 4 shows the surface current distributions at 5.9 GHz to explain the Patch microstrip Inverted F antenna's UWB responses. The surface current is mostly concentrated along the linearly tapered feeding line with a high current value.

Table 1. Simulation parameter

Parameter	Configuration
Width of radiator (mm)	0.564
Width of the feeder (mm)	0.564
Shorting Arm width (mm)	0.564
Length to open end (mm)	8.83
Length to short end (mm)	1.7
Ground Plane Length (mm)	29.3
Ground Plane Width (mm)	29.3
Conductor Type	Aluminum
Conductivity (S/m)	37700000
Thickness of conductor (mm)	0.77

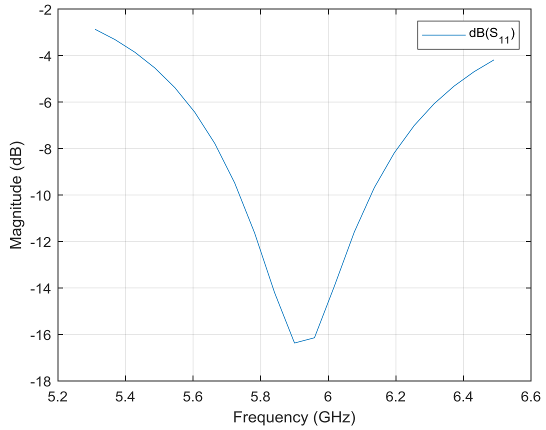

Fig. 3: Simulated S- Parameter Results.

As seen in Figure 4. At this resonance frequency of 5.9 GHz, it is found that the current is not followed at the upper patch of the radiating patch, functioning as a frequency function.

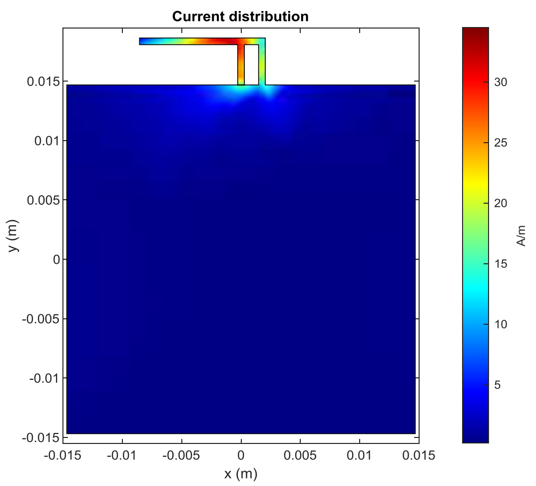

Fig. 4: Current follow concentrations at frequency 5.9 GHz

Figure 5 shows the measured and analyzed radiation patterns of the proposed antenna. The gain was around 3.86 dBi.

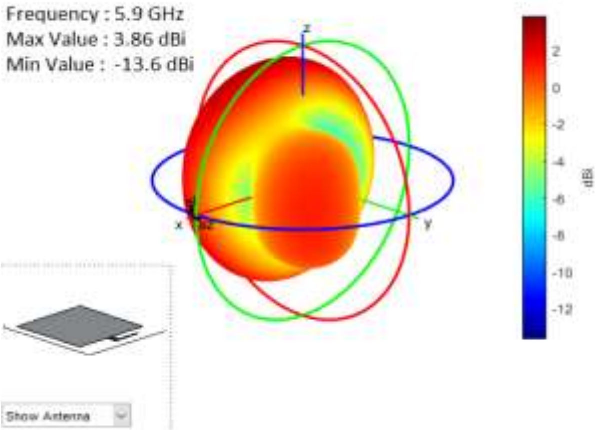

Fig. 5: 3D Radiation pattern

Figure 6(a) and Figure 6(b), respectively, display the azimuth and elevation radiation patterns for Microstrip Inverted F antennas operating at 5.9GHz. The antenna's maximum gain is approximately 3.8 dB in azimuth and -0.65 dB in elevation patterns.

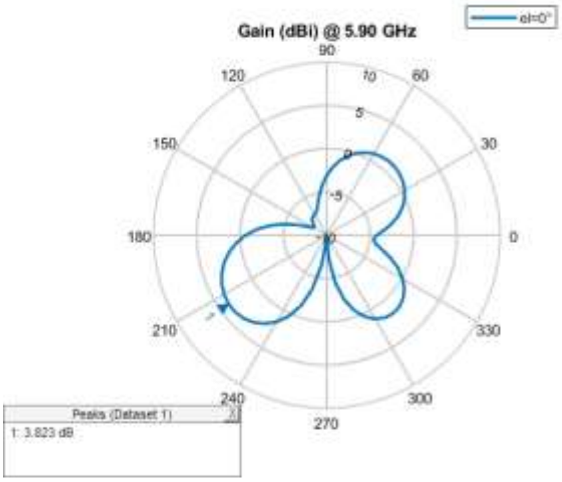

Fig. 6(a): Azimuth plane pattern.

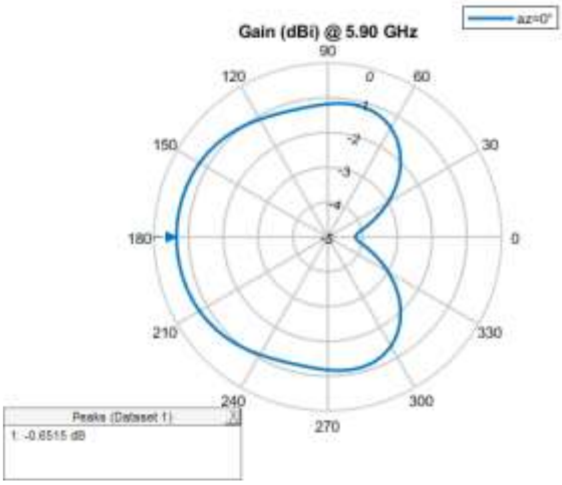

Fig. 6(b): Elevation plane pattern

Figure 7 shows that our design antenna is good since the resistance (blue line) should be about 50 Ω and the reactance (red line) should be zero at the operating frequency of 5.9 GHz.

The radiation pattern of the patch Microstrip Inverted F antenna is shown in Figure 7. The enhanced gain of the improved antenna was 11 dBi. Because of its higher gain value, the optimized antenna can be classified as a powerful signal antenna that can transmit or receive strong signals in a particular direction.

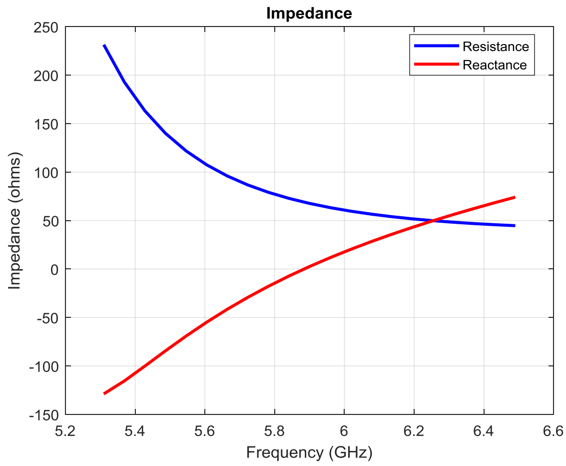

Fig. 7: Impedance versus frequency

4 Results and Discussion

The low-profile antenna is designed to operate at the 5.9 GHz resonant frequency, which is suitable for vehicle communication. Using the arrays enhanced the bands' impedance bandwidth and higher frequency range. The recommended antenna is dependable and versatile for usage in vehicle communication situations due to its total size reduction, performance enhancement. The F Inverted antenna is stacked in an orthogonal configuration to minimize dimensions, enhance isolation, and produce an 11 dBi maximum gain. It proves that the agreement is reasonable in a driving context. Measurements are made of the S-parameter and radiation pattern simulation findings at matching frequencies.

Given the specifications, an 11 dB diversity gain is attained for the suggested design. Furthermore, an examination of onboard simulation is conducted, and the outcomes are confirmed.

The work initially proposes the basic Microstrip patch Inverted F antenna. The return loss and gain characteristics are used to verify the suggested antenna's performance. At 5.9 GHz, the highest gain is 7 dBi, while the return loss is less than -10 dB. As a result, building an antenna with the essential features listed above is necessary. With the transition of all other technologies to 5G technology for communications, the millimeter waves and sub-6 GHz frequencies of 5G are now well recognized. Bands of operation in-vehicle communication. Through the establishment of communication across an unlicensed 5.9 GHz national information infrastructure, the V2N platform improves road safety and traffic efficiency.

5 Conclusion

This studies thorough investigation clarifies important insights into the manufacturing process optimization of the 5G Inverted F antenna, which represents a major advancement in the telecommunications industry.

While many researchers have investigated various ways to enhance the performance of Microstrip The performance of the microstrip Inverted F structure is assessed using a variety of metrics, such as radiation patterns. The blockchain is considered the security layer where accessing data can be performed through smart contracts embedded inside the F-inverted antenna. We offer a thorough analysis of our research strategy, emphasizing the creative fusion of technological and analytical techniques to progress the production of 5G Inverted F antennas.

Diversity strategies increase the number of antennae that must be carried onto the vehicle's body because newer cars have more spots where antennas can be attached while using the diversity strategy for the best radio signal reception. To avoid hurting the car's appearance or any nearby radiators, it is imperative to determine which parts of the vehicle can accommodate the antennae. The antennas used for diversity reception must be far enough apart to ensure good diversity performance. This implies that the antennas should be at least one wavelength apart to ensure good spatial diversity. To study simulation software, the last recommended antenna is installed on the car.

About the intended operating frequency, the patch's length should be half its wavelength. For radiating to produce efficient radiation. In a different dimension, the patch's breadth regulates the antenna's input impedance. The sections of modern cars where antennas can be integrated while utilizing the diversity strategy for the best radio signal reception are those with the highest radiation levels. This study presents the Inverted F antenna, which is intended to handle 5G/Wi-Fi for vehicular communication. The design approach's noteworthy characteristic is how tiny the radiator's overall dimensions 0.564×0.564 mm^2 are. The consistency between the simulated and measured results for gain, radiation patterns, and S-parameters is good. Furthermore, it is noted that among the structure's antenna elements, the S-parameter is attained below -10 dB. For this reason, the suggested design is a good fit for automotive applications.

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Contribution of Individual Authors to the Creation of a Scientific Article (Ghostwriting Policy)

- Raed daraghma, carried out the simulation and the optimization.
- Eman Daraghmi has implemented the Algorithm at Figure 1.
- Yousef Daraghmi has organized and executed the experiments of Section 3.
- Hacene Fouchal was responsible for the technical writing.

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Conflict of Interest

The authors have no conflicts of interest to declare.