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# Performance Analysis of Microstrip Patch Array Antenna for High-Frequency Radar Applications

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**ABSTRACT:**The research in microstrip patch antennas has grown significantly in recent years. Microstrip antennas offer more substantial advantages and improved possibilities compared to conventional antennas. They are lighter, have a smaller volume, cost less, have a lower profile, and are easier to build. Radio waves can be transmitted or received using an array of many antennas that work together to form a single antenna. This Paper presents the Performance Analysis of the Microstrip Patch Array Antenna with a frequency 94GHz for radar application. The array of three by four (3x4) patch microstrip antenna was used. This Paper processed Simulation analysis to evaluate the performance parameters such as directivity, impedance behavior, and S-parameter using MATLAB for the radar application environment. The result shows that the maximum bandwidth for S-parameter is between 9.0 and 9.2 GHz, and the value of directivity for 94GHz frequency is between 10.3 dBi and -30.3 dBi. Moreover, impedance behavior for resistance and reactance is 60 and 40 ohms.

**KEYWORDS:** Microstrip patch antenna, directivity, S-parameters, impedance.

## I. INTRODUCTION

Currently, radar is being used in a variety of ways. Satellite communication is an example of a use case for this technology. Measurements of distances and objects are made using electromagnetic waves in the system. An 8 to 12 GHz waveguide should be used for the radar frequency. Antennas are becoming smaller and lighter as technology advances, and this has led to the development of new trends in antenna design. Radar applications necessitate an antenna system, as the antenna serves as the primary means of communication in radar. The correct substrate, such as FR4, is first selected to create the antenna. The substrate has a dielectric constant of 4.6 and a height of 1.6mm the simulation is carried out using the Advance design system software program to obtain the radiation pattern and the simulated graph. Antennas that must be compact, light, and inexpensive to manufacture rely on microstrip technology microstrip patch antennas are well-suited to radar applications because of their many unique characteristics. A rectangular form patch is considered because of its strong polarization and directivity. Antennas with a rectangular form factor have excellent Omni-directionality. Improved performance is achieved using a Microstrip patch antenna array with four patch antenna radiating elements. With four arrays rather than a single, the antenna gain and directivity can be increased[1, 12].

### a) RADAR

Radio waves are used to determine an object's length, angle, or velocity through a tracking equipment known as radar. In a radar system, a transmitter produces electromagnetic waves in the radio or microwave frequency range, a sending antenna, a receiving antenna, and a receiver and processor that determines the attributes of the object being detected. Data about the item's position and speed is provided by the transmitter's radio waves that bounce off the object and return to the receiver [1,14].

### b) APPLICATIONS

The gain of a microstrip patch antenna array is increased two antennas make up the array antenna's structure [2].patches of the same material on the same surface

Antenna design development can be used for the following purposes:

- Access to the internet at a very high speed via Wi-Fi/Wi-max.
- Wireless LAN (WLAN) configuration.
- Cars that don't need a human to drive.
- Remote patient monitoring in the healthcare industry.
- Home automation is referred to as "smart."
- Useful for both transmitting and receiving data from a satellite.

**c) ANTENNAS**

Structures connected with the transition between a directed and unguided wave are commonly referred to as antennas.as well as a wave in space, or the reverse. An antenna receives electromagnetic energy from a source and transmits it. Sent by a coaxial cable or waveguide, and received by an antenna. The transmission line is used to send electromagnetic energy that has been collected from an incident wavein ideal circumstances, the source's energy should be completely transferred to the recipient. Due to conduction-dielectric losses, this entire transfer of energy is not attainable in practicewith the antenna's lossy transmission line a problem with the transmission line can also occur.There will be reflection losses at the interface if the antenna is properly matched to it as a result, the antenna's impedance must be matched to the antenna's characteristic impedance.The antenna is one of the most important components in wireless communication systems well-thought-outSystem efficiency and effectiveness can both be improved with an antenna. To ensure the ever-increasing demand for mobile and wireless communication systemsAntenna engineering has seen a lot of progress during the previous few decades, several generations[3].

**d) TYPES OF ANTENNAS**

In radio and television broadcasts, there are a variety of antennas available.
There are a wide variety of additional types of wireless communications as well, like applications In this part, only a handful of the most prevalent antenna forms and types will be discussed.

- **WIRE ANTENNAS:** Wire antennas can be found on cars, buildings, ships, and aircraft, as well as other objects in our daily lives. Wire a variety of antenna configurations, such as the straight wire (dipole), the loop, and the helix, are seen in figure 1.1 loop antennas can be rectangular, square, or elliptical in shape figure 1 show the wire antennas[3].

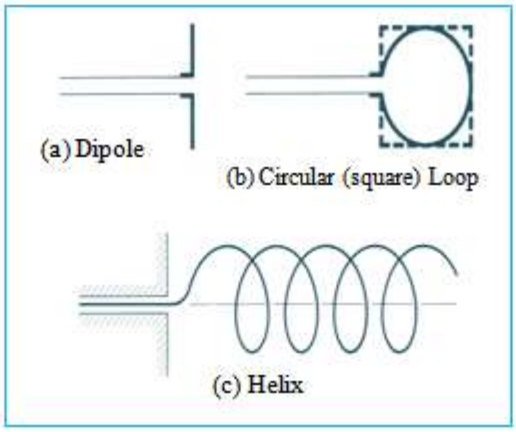


Figure 1: Wire antennas.

- **APERTURE ANTENNAS:** Because of the growing need for more advanced antennas and the increased use of higher frequencies, frequencies in modern times, the aperture antenna is more prevalent. Displayed here are a variety of aperture antennas, because they may be flush-mounted, they are used in aircraft and spaceship applications or spacecraft's exterior. In addition, appropriate dielectric materials can be used to cover themto safeguard them from the potentially harmful circumstances of space and air travel operate figure2 shows the hornantenna[3].

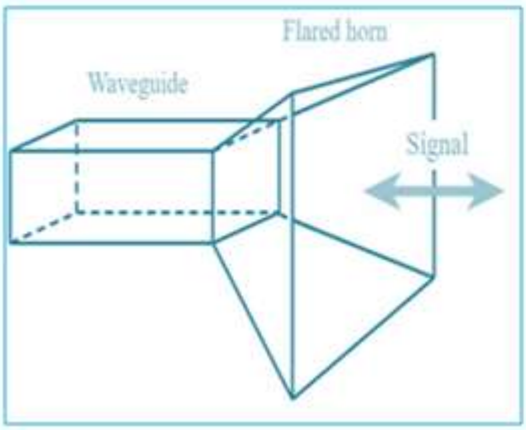


Figure2:Horn antenna.

- **MICROSTRIP ANTENNAS:** In the 1970s, microstrip antennas were quite popular, especially for use in spacecraft. Currently, they arein a wide range of different official and business contexts. Typically, they're made up of a metallic in later chapters, we'll cover various configurations of the patch on a

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grounded substrate. It's easy to analyze rectangular and circular patches, as shown in Figure 3, which are the most common. fabrication and radiation-attractive properties in terms of size, microstrip antennas are the smallest and most flexible. using contemporary printed circuit boards, it is easy and inexpensive to create both planar and non-planar surfaces technology. High-performance aircraft, spacecraft, satellites, missiles, vehicles, and even mobile phones can all have them installed. Because of these advantages, microstrip antennas are expected to become increasingly popular[3**].**

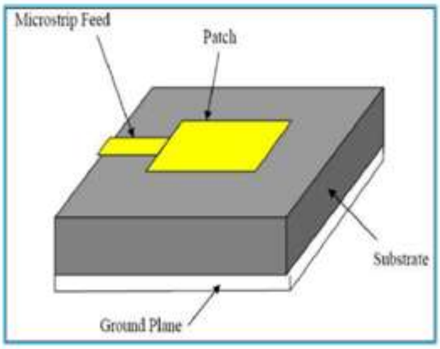


Figure 3: Microstrip antennas.

- **ARRAY ANTENNAS:** Numerous radiating elements are required in many applications to attain the desired radiation characteristics. Radiation can be generated by placing the elements in a specific configuration.

pattern. It is called an array when such elements are arranged in this way, and its primary purpose is to produce radiation. A pattern that is oriented in one or more certain directions. Arrays of antennas are employed in cellular networks, as will be explained later. creating directional patterns with only the specified area as a focus using base stations Antennas of this type include Sectored or directional refers to a cellular system's array of 4–12 elements.Antennas are arranged in a panel array. Figure 4 depicts some typical arrays[3].

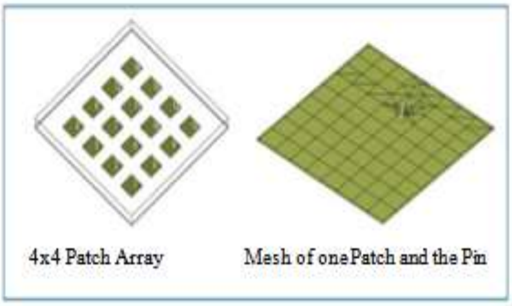


Figure 4: Antenna Array.

## II. LITERATURE REVIEW

A Critical Analysis of the Literature The best findings were obtained by doing a unique literature survey for this Paper.

For radar applications, a rectangular microstrip patch antenna with an operating frequency of 9.6 GHz was created. The antenna array is constructed from four patch radiating elements. The dielectric constant is 4.6, and the substrate height is 1.6 millimeters. Four radiating elements are utilized in the construction of this antenna array[1].To increase gain and directivity, these radiating elements are employed here a comparison of the dielectric constants, height, and loss tangent values for several substrates is necessary to arrive at the best design solution for the given frequency range. The FR4 substrate was selected for its cost and performance efficacy. The antenna array's gain and directivity have both been improved in this design. The antenna array is designed and simulated using the Advanced Design System software.

CP microstrip antenna arrays for the next generation are described in this [4]. study An application for a small satellite in the Ku-band has been modeled, planned, and built. An iterative application of the SR phase feeding network underpins the array's construction. For all of the parts at the 8.15 GHz design frequency, the C-to-C distance is 0.535l0 the International Business Weight (IBW) In terms of design, it's more than 19.5 percent, and in terms of AR, it's 8.8 percent. In a calculated approach at 8.25 GHz, a maximum gain of 15.5 dBi is reached. The flat gain of the design ranged from 15.5 dBi to 15.5 dBi in the intended frequency range of 8.05-8.5GHz Furthermore, measured angular widths in the Ku-band for gain and AR confirmed that the gain was larger than 12 dBi and AR was below the threshold of 10 dB. A dBi of 1.5 dB. Measurements are made of the X-pol and co-pol radiation patterns at five differentfrequency samples in a band in which the simulated results are confirmed.

An attempt has been undertaken to investigate the 94GHz radar application Microstrip patch antenna array at a higher frequency. A frequency of 94GHz was used in this study [5], making it the highest frequency in the radar application range at the time the array is restricted to a size of 3x4, resulting in a total of 12 elements. CST and MATLAB tools are used to analyze several factors, including resistance, reactance S-parameter, and voltage standing wave ratio

(VSWR). CST and MATLAB are used to verify all of the parameters. The CST outperforms MATLAB in terms of performance, but the two tools are comparable.

Dual polarized microstrip has been demonstrated in this [6].Study Features strong inter-port isolation, a patch antenna with two feeds is shown to you. A dual linear polarization antenna is featured here. sent using a single cable for the Tx and Rx ports, respectively a create a high level of isolation, a 180-hybrid coupler was employed and the coupler size is reduced to reduce the structure's size. Passed from one layer to the next and became closer to each other As much as possible, adhere to the patch. The size of the object is referred to as Overall, the planned antennas have dimensions of 68 mm 60 mm. reducing the size of work in comparison to earlier ones is more significant. More than 60% of the population. For the 80 MHz, the measured isolation level was over 68 dB of bandwidth. The E-measured plane's value of each polarization has a cross-polarization level of more than 57 dB. Port. Antenna fabrication yields a gain of approximately 4 dB. for each one of the aforementioned ports. Antennae such as this one are appropriate for Wi-Fi and Bluetooth transceivers that utilize IBFD technology frequency spectrum.

Symmetrically shaped antennas are examined extensively in this [7].Study measuring and modeling parameters such as the dimensions of the antenna and the materials used for its dielectric coating tools and how they can be put to use. In this article, we'll discuss flower shape, leaf shape, tree shape, fan shape, Pi shape, and more talk of fractal and monopole antennas, as well as wearable antennas, multiband, butterfly antennas, and bat antennas, in addition, a review of previously reported microstrip bandwidth augmentation methods introduction of a thicker and lower permittivity substrate, similar to patch antenna slots and notches, substrate, parasitic elements defective ground, shorting wall, and shorting pin Split Ring Resonator Structure Based on Metamaterials, Fractal Geometry, and Composite right/left-hand transmission lines are shown. These methods' physics and the circuit theory model approach have been examined at great length.

The development of microstrip patch antennas in wireless technology is discussed in this [8] study. Microstrip antennas have been developed by renowned experts to fulfill market demands. Before the literature analysis, this paper provides an overview of wireless technology and microstrip patch antennas, both of which are useful in wireless communication due to their small size and multiband/wideband capabilities. Various studies based on antenna performance factors such as return loss, bandwidth, gain, etc., have had their findings discussed.

There is a microstrip antenna design that can be implanted [9]. was demonstrated to resonate in the MICS frequency range to use medical telemetry apps, (402-405 MHz.). Planned action in the center of the design is two concentric squares coaxial feeder and a metal pad in the middle cable. As well as shorting the outer annular pin a fundamental component of miniaturization is the ground plane. the antenna We've done some research into the implications. concerning a few key aspects of the planned antenna performance. Using this type of architecture leads to a significant reduction in antennas. size. Compared to the designs that were previously accessible. operating in the MICS frequency range. The resulting data transfer rate is at the resonance frequency, the return loss is reduced to -6.5 percent. 32.58%. eventually revealed that there is a flaw in the antenna design a medical wireless communication link can be established using these implanted systems that can be used in a variety of ways to be successful in achieving.

In this [10,15] study, a variety of antenna-enhancing approaches have been examined and summarized. Various methods include the insertion of frequency selective surfaces (FSS), metallic reflectors, parasitic patches, superstrate, shorting pins, and partial substrate removal, amongst other possibilities. There is a thorough examination of numerous strategies for increasing gain and making microstrip antennas easier to implement in this study. Antenna gain increase for microstrip systems is addressed in this study.

This [11,14].The paper shows how to use Simulink and the antenna toolboxes in MATLAB to design and simulate a 2.45 GHz square patch microstrip antenna. Microstrip patch antennas' advantages and disadvantages will be discussed in detail in the introductory portion of this Paper's brief history of the development of antennas for wireless communication systems. It discusses the design of the rectangular microstrip patch antenna, its coding, and its performance findings. A viable structure for future communication is the microstrip patch antenna array applications. Array pattern study is a prominent topic among antenna

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scientists at the moment. A variety of ways Mobile phones and other electronic devices use antenna array designs such as 1X2, 2X2, 3X2, 2X2, 2X3, 4X4, and so on. applications. mm, waves refer to the upper end of the Ka-band, which is defined as anything over 18GHz.

According to the findings of this [2] study, research on millimeter-wave microstrip patch arrays for future 5G wireless networks the return loss, radiation pattern, bandwidth, directivity, and antenna gain are all features of antennas. Radiation efficiency and other topics are also investigated.

## III. SIMULATION RESULT

We processed; Simulation analysis in this Paper to resolve and evaluate the performance parameters, for example,directivity, impedance behavior, and S-parameter. Throughout at microstrip patch,the antenna array is designed for radar applications. Meanwhile, simulation results inthe designs of the graphs against required performance parameters. Simulations are continued as indicated by the situations, by experiment, accompanying conclusion on limited extraction of the simulations results. Table 1 shows the design parameters of the antenna.

Table 1: Design parameters ofthe antenna.

| S. No | Parameters | Unite |
|---|---|---|
| 1 | 3D Directivity, Pattern | -30 to 15 dBi |
| 2 | Directivity, Pattern | -30 to 10 dBi |
| 3 | Impedance | 10 to 34 Ohms |
| 4 | Scattering- parameter | -10 dB |
| 5 | Array size | 3*4 |
| 6 | Frequency | 94GHz |

Figure 5 shows a 3D directivity pattern.The designed frequency is 94 GHz which is a higher frequency range for radar applications. The array size is kept to be 3x4, i.e., 12 elements in the array. Analysis has been done for three different parameters directivity, impedance behavior, and S-parameter.

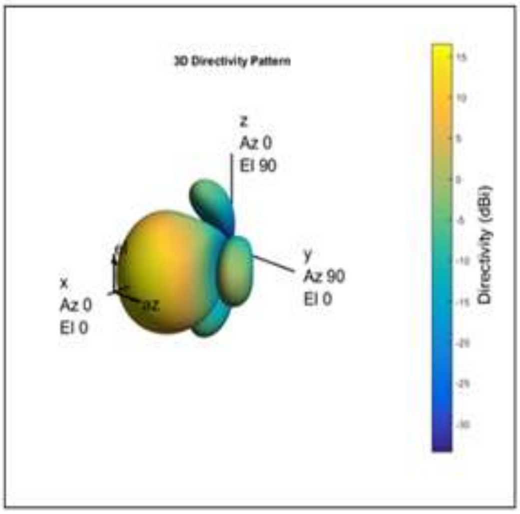


Figure 5: 3D Directivity Pattern.

Figure 6 shows the directivity pattern. Which operates with 94GHz frequency is the higher frequency range for radar application. The value contains two portions maximum and minimum value for directivity. The maximum directivity value for 94GHz frequency is 10.3 dB, and the minimum value is -30.3 dBi.

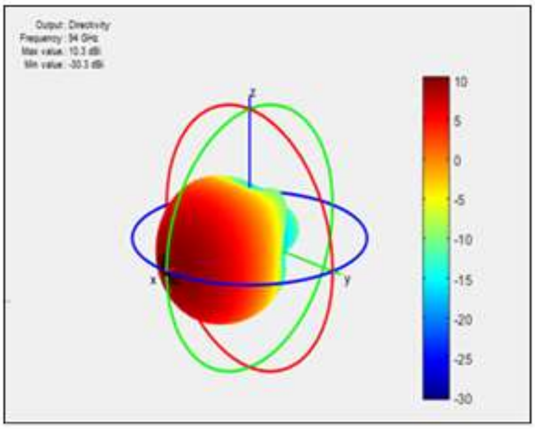

Figure 6: Directivity, Pattern

Figure 7 shows impedance behavior for resistance and reactance. It is noticed that the maximum amplitude for resistance is 60 ohms while that of reactance is 40 ohms. The solid line shows resistance, whereas the dashed line is for reactance. Resistance is between 90 and 92GHz while reactance is also between 90 and 92GHz bandwidth.

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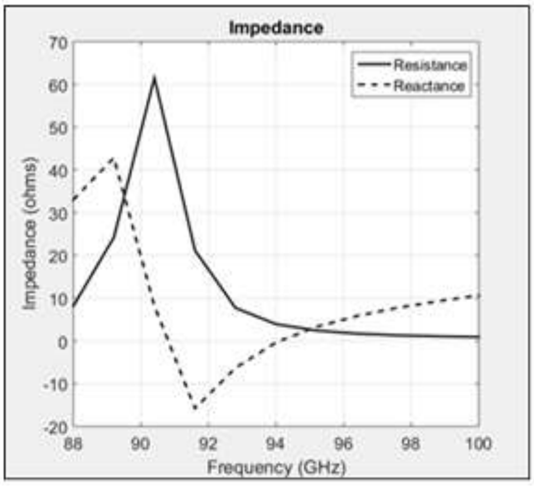


Figure 7: Impedance Behavior.

The Scattering- parameter response is shown in figure 8, the threshold value is -10 dB It is seen that the maximum bandwidth for the s-parameter is between 9.0 and 9.2 GHz. the dashed line showing S-parameter.

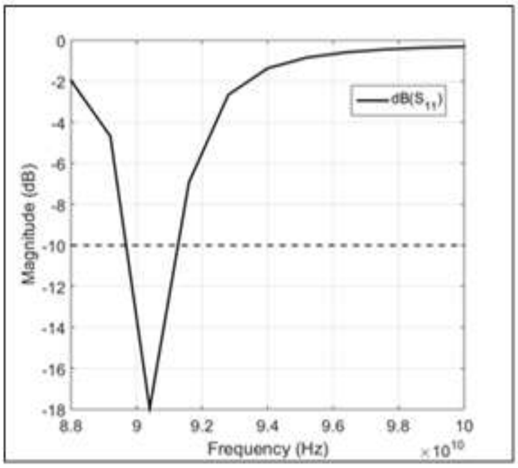


Figure 8: S-Parameter

## IV. CONCLUSION

This paper proposes an antenna array for 94 GHz using MATLAB simulation software. An effort has been made to analyze the analysis of microstrip patch antenna array at 94GHz radar application at a higher frequency. This research's operating frequency is 94GHz, the higher frequency range for radar applications. The number of the array element is kept to be 3x4, i.e., 12 elements in the array. Four different parameters, such as directivity, impedance behavior, and S-parameter, are investigated, and results are obtained. The first case focuses on directivity patterns. It is seen that the minimum value of directivity for 94GHz frequency is 30.3dBi, and the maximum value is 10.3 dBi. In the second case shown impedance behavior for resistance, the maximum amplitude for resistance is 60 ohms while that of reactance is 40 ohms. In the third case, the Scattering – parameters response is shown the threshold value, which is -10dB. It is seen that the maximum bandwidth for S-parameters is between 9.0 and 9. 2GHz.The results show that a microstrip antenna array for 94 GHz is a feasible option for radar applications.

## REFERENCES

[1]. B. Nataraj, K. R. Prabha, K. Shivani, and K. C. Sujithra, "Design of an Antenna Array for Radar Application,"Annals of the Romanian Society for Cell Biology, pp. 3966–3973, 2021.

[2]. K. Prasad and B. Chourasia, "Survey of Millimeter-Wave Microstrip Patch Antenna Array for 5G Applications".

[3]. M. A. AL-Amoudi, "Study, Design, and Simulation for Microstrip Patch Antenna,"International Journal of Applied Science and Engineering Review (IJASER), vol. 2, no. 2, pp. 1–29, 2021.

[4]. M. Elahi, S. Trinh-Van, Y. Yang, K.-Y. Lee, and K.-C. Hwang, "Compact and High Gain 4$\times$ 4 Circularly Polarized Microstrip Patch Antenna Array for Next Generation Small Satellite,"Applied Sciences, vol. 11, no. 19, p. 8869, 2021.

[5]. M. S. Niazy, F. Masood, B. Niazi, M. Rokhan, and R. Ahmad, "Analysis of 3x4 Microstrip Patch Antenna Array for 94GHz Radar Applications".

[6]. A. Maleki, H. D. Oskouei, and M. Mohammadi Shirkolaei, "Miniaturized microstrip patch antenna with high inter-port isolation for full-duplex communication system,"International Journal of RF and Microwave Computer-Aided Engineering, vol. 31, no. 9, p. e22760, 2021.

[7]. B. Mishra, R. K. Verma, N. Yashwanth, and R. K. Singh, "A review on microstrip patch antenna parameters of different geometry and bandwidth enhancement techniques,"International Journal of Microwave and Wireless Technologies, pp. 1–22, 2021.

[8]. N. Bisht, "Microstrip Patch Antenna for Wireless Application: A Review,"Pulse, vol. 2, no. 2, 2021.

[9]. S. Azzaz-Rahmani, H. Zerrouki, and L. Dekkiche, "Novel Microstrip Patch Antenna for implantable medical telemetry devices,"Journal of Applied Science and

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 4 Apr 2022, pp: 790-796 www.ijaem.net ISSN: 2395-5252

Engineering, vol. 24, no. 6, pp. 853–860, 2021.
[10]. A. Kumar, R. Khandelwal, S. Singh, A. Kumar, and A. Makhdumi, "A review on gain enhancement techniques of microstrip antenna," in 2021 2nd International Conference on Intelligent Engineering and Management (ICIEM), 2021, pp. 476–479.
[11]. B. Gireesha and L. Ali, "MATLAB/Simulink based Design and Simulation of Square Patch Microstrip Antenna,"Journal of Computational Information Systems, 15 (1), 143, vol. 149, 2019.
[12]. H. Abdullah, M. Mabrouk, A. Abd-Elnaby Kabeel, and A. Hussein, "High-Resolution and Large-Detection-Range Virtual Antenna Array for Automotive Radar Applications,"Sensors, vol. 21, no. 5, p. 1702, 2021.
[13]. B. Tütüncü, "Compact low radar cross-section microstrip patch antenna using particle swarm optimization,"Microwave and Optical Technology Letters, vol. 61, no. 10, pp. 2288–2294, 2019.
[14]. S. Yang, L. Zhang, J. Fu, Z. Zheng, X. Zhang, and A. Liao, "Design and optimization for 77 GHz series-fed patch array antenna based on genetic algorithm,"Sensors, vol. 20, no. 11, p. 3066, 2020.
[15]. P. Yang, J. Liu, and Z. Li, "The Application of Artificial Magnetic Conductors in the Broadband Radar Cross Section Reduction of the Microstrip Antenna Array.,"Progress in Electromagnetics Research M, vol. 104, 2021.