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REGULAR ARTICLE

Investigation on Six Element Dipole Array Antenna for ISM Band Wireless Communication Applications

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In this research, the effectiveness of six element uniform circular uniform dipole array is designed. To determine the most productive design for the ISM Band, numerous array antenna topologies are tested in this work. The proposed antenna is appropriate for the ISM, IEEE 802.11, Bluetooth, as well as Zigbee, WiMAX, and WiFi applications. We first set up a 6-element dipole linear array for this, after which we switched to a rectangular array using a combination of triangular and rectangular lattice arrangements. The identical 6-element dipole antenna was then configured in a circular fashion, and the results appear to be excessively good when compared to all previous configurations. The symmetrical arrangement of a uniform circular array design allows the phasing of array antennas to operate azimuthally with little variation in its wavelength and side lobe intensities. There are 6 isotropic components in this uniform circular array design. To adjust the antenna to shifting surroundings, complicated values of the antennas array components are calculated. The correlation effect between various elements were analysed. In this work a return loss of – 35 dB was obtained as a maximum value for circular array configuration at 2.45 GHz. The goal of employing array antennas is to provide increased efficiency and broad band capabilities, allowing for usage in a variety of everyday applications.

Keywords: Antenna array, Correlation coefficient, Rectangular lattice, Triangular lattice.

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1. INTRODUCTION

A significant issue in circular array antenna (CAA) construction is side lobe suppression. In order to accomplish this, several tedious and sometimes traditional numerical strategies are presented, a majority of them fail to tackle multidimensional issues. Certain degrees of freedom, specifically amplitude alone and amplitude spacing, are modified by the synthesis method under consideration here. Initial designs called for a 6-element linear array. For greater clarity, the relationships between the components were examined. The antenna correlation coefficient (ACC), which assesses the degree of autonomy of nearby antennas, is a crucial antennae metric. The antennae become more isolated from one another the lower the ACC. Consequently, at a high transmission information rate, broad signals might have a greater degree of freedom [1]. The ACC was first estimated using intricate radiation distributions that provide knowledge of amplitude and polarisation in all circumferential directions. It takes an extended period of time and costs a lot of money to analyse the radiation spectrum of each antennas in an array. Hence [2] suggested a technique to estimate the ACC by employing the scattering parameters (S-parameters) in order to streamline the procedure. Then, it is applied as a typical technique in many structures. The Figure1 describes how the correlation properties are influenced by the three important antenna variables of antenna impedance, dimensions and complex radiation patterns. The correlation properties can be converted directly from the impedance properties. Additionally, the correlation properties instantly convey the complicated pattern [3]. Through altering the gains patterns of these individual elements, we demonstrate how the loss of correlation impacts the array antenna performance. The material qualities of the array antenna and the scattered properties affect the fading correlation [4]. Future radio networks will aspire to increase data rates to support various programmes and application services that require large amounts of resources. Therefore, it will be crucial when building transmission networks to extract as many data bits possible given the geographical limits [5]. In this proposed work, initially 2 element array were designed and then by adding up sequentially a 6-element antenna array in circular direction were constructed. Massive arrays are necessary for certain applications, like radar, in order to get the appropriate throughput. Enormous

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antenna arrays, however, need complicated transceiver systems, intense computing, and substantial energy consumption. Therefore, the amount of power utilisation, zoning demand, processing capacity, and cost for massive arrays may be a constraint on current beam forming techniques. As array antennas may boost the strength of transmission and bandwidth capacity of wireless networks in multipath situations without having to invest in power resources, the number of consumer systems that include them is expanding nowadays.

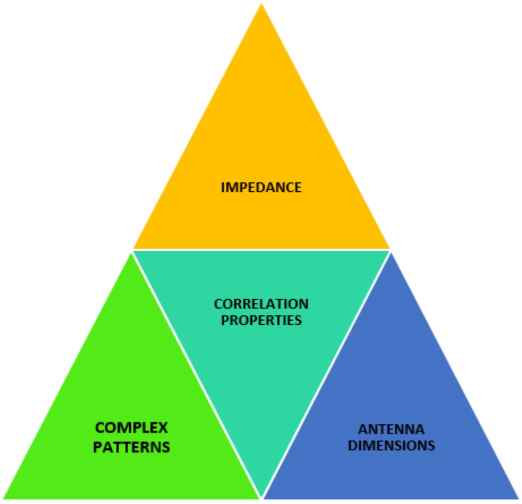

Fig. 1 – Antenna characteristic's vs. correlation

Numerous strategies are put up to produce high directivity without changing the antenna's actual length. One method is assuming appropriate reflector shape, but the most trustworthy method is the idea of antenna arrays. An antenna array is a collection of comparable antenna components that work together to radiate energy as a single unit. The use of antenna arrays leads in increased directivity because the electrically powered size, which is proportionate to the total length of the array, is expanded while the physical length of each individual element in the array remains unchanged. To produce an arrangement that has a suppressed side lobe level, an evenly spaced or regular array can be thinned by switching off part of its components. As no particular component of the array is disrupted in this instance, the operating frequency remains unchanged. With their distinct properties, antenna arrays play a vital role in contemporary systems for wireless communication. For broadband and portable WLAN applications, a novel linked monopole-based multi-antenna design is introduced in this research. The rest of the paper is divided into the following sections. Section 2 provides a full geometric description of the designs for the array antenna systems that are suggested. Following a discussion of the simulation and measurement findings in Section 3, the work concluded in Section 4. With the current developments in mobile communications, circular arrays have gained popularity. Circular array construction requires complicated calculations, but because it naturally contains beam guiding, it is a good choice for beam formation. Three parameters namely excitation magnitude, direction, and inter element spacing define every component in the cyclic array. In arrays design, these three are referred to as guiding variables. They have the ability to change the electromagnetic spectrum of the arrays. They are referred to as having three degrees of freedom from a synthesis perspective. For every component of the array, this circular array design challenge entails determining weights for one or more of these steering parameters so that the resulting radiation pattern is almost identical to the desired one. The array layout is shown in Fig. 2. In this the correlation between two elements at different combination were taken into consideration. The effect of location of array element (adjacent/opposite) plays a vital role in determining the results. The inability of linear arrays to follow the radiation in multiple directions is one of its fundamental drawbacks. Due to this, array with planar geometry is used in the majority of real-world applications for massive phased array antennas.

2. ANTENNA DESIGN

The dimensions of the proposed six-element circular array antenna are 57.511 × 12.236 × 1.65 mm^3.The precise procedures used in the design are shown in detail in Fig. 2. For our research, we used a 6-element dipole antenna array, and this work analyses several parameters. The antenna components are initially placed linearly and later at various lattices. The circular array produced the best results. The linear configurations of the antenna are shown in Fig. 2(a). In which the correlation effect was examined and the antenna elements (dipoles) were linearly and uniformly separated at a spacing of 0.028 mm. The influence of the successive array elements exhibits a stronger radiation pattern than the elements of the alternate array.

The next configuration uses a horizontal rectangular array in a rectangular lattice with an arrangement of [2, 3] lattice elements in Fig. 2(b). The correlation coefficient in this case reaches its greatest at the 1, 6 element and opposing elements. The following design uses a vertical rectangular array in a rectangular lattice with an arrangement of [2, 3] lattice elements shown in in Fig. 2(c). At the edge elements in this, the correlation coefficient is greatest. Since the elements in triangular configurations are diagonal, the correlation is not very significant. The vertical layouts are the same in Fig. 2(d) and (e). Circular correlation is the final configuration, in which all circular dipoles are positioned at identical intervals of 0.16 mm and with radii of 4.85 mm shown in Fig. 2(f). All of the output results for this arrangement are superior to all other arrangements, and the correlation appears to be too excellent for this configuration.

3. RESULT AND DISCUSSION

The Radiation pattern of six element array antenna configurations is shown in the Fig. 3. The elevation and azimuth angle are shown in the Fig. 4. The Table 1 shows the Reflection coefficient for ISM band for different array configuration. The reflection coefficient (S_{11}) is excellent for circular array around – 35 dB and the comparison graph is given in Fig. 5. The radiation pattern is directional only for Fig. 3 (d) and it is elevated at edges for Fig. 3 (b), (c) and (e).

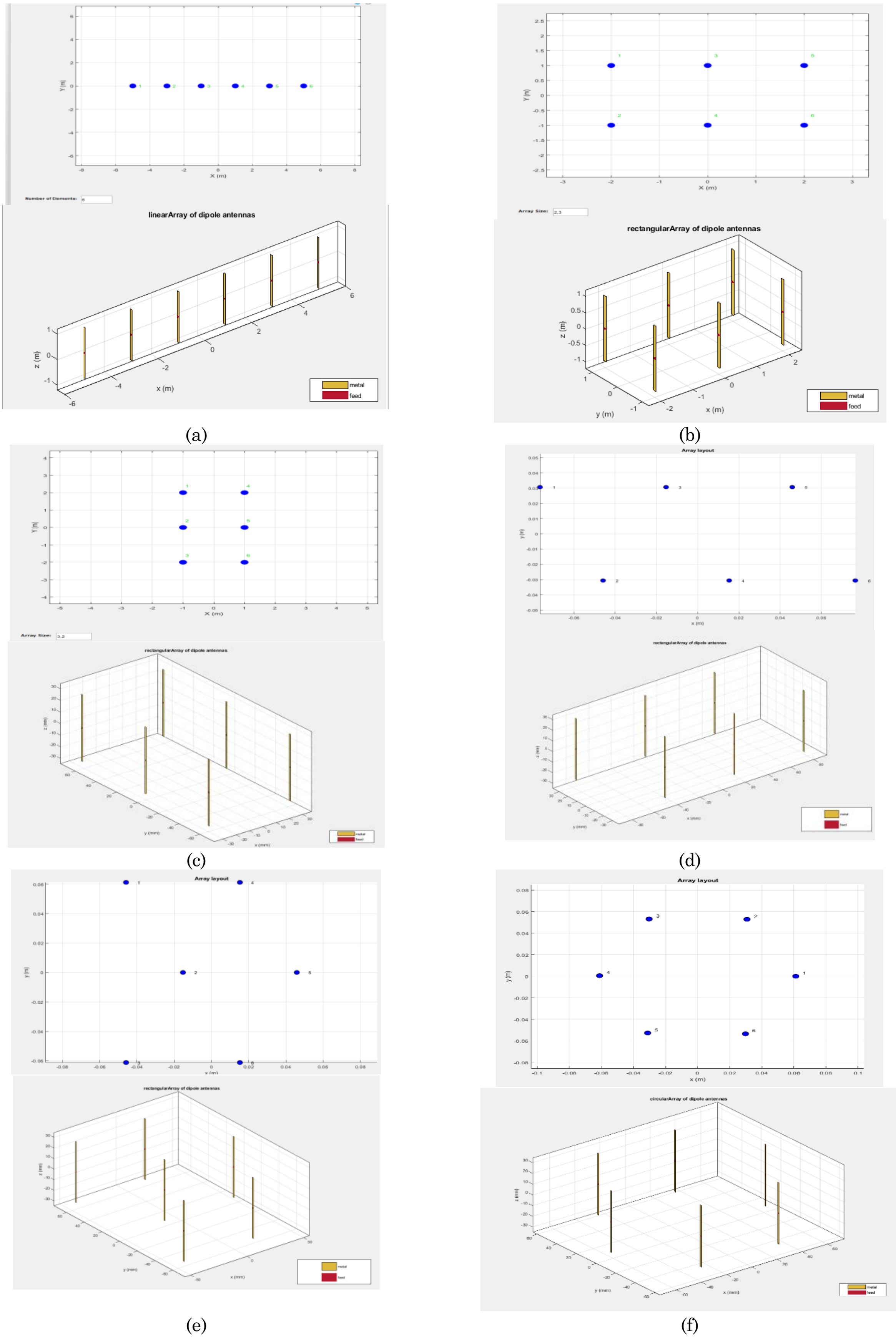

Fig. 2 – Layout of (a) Linear array, (b) Horizontal Rectangular (Rectangular lattice), (c) Rectangular (Triangular lattice), (d) Vertical Rectangular (Rectangular lattice), (e) Rectangular (Triangular lattice), (f) Circular array

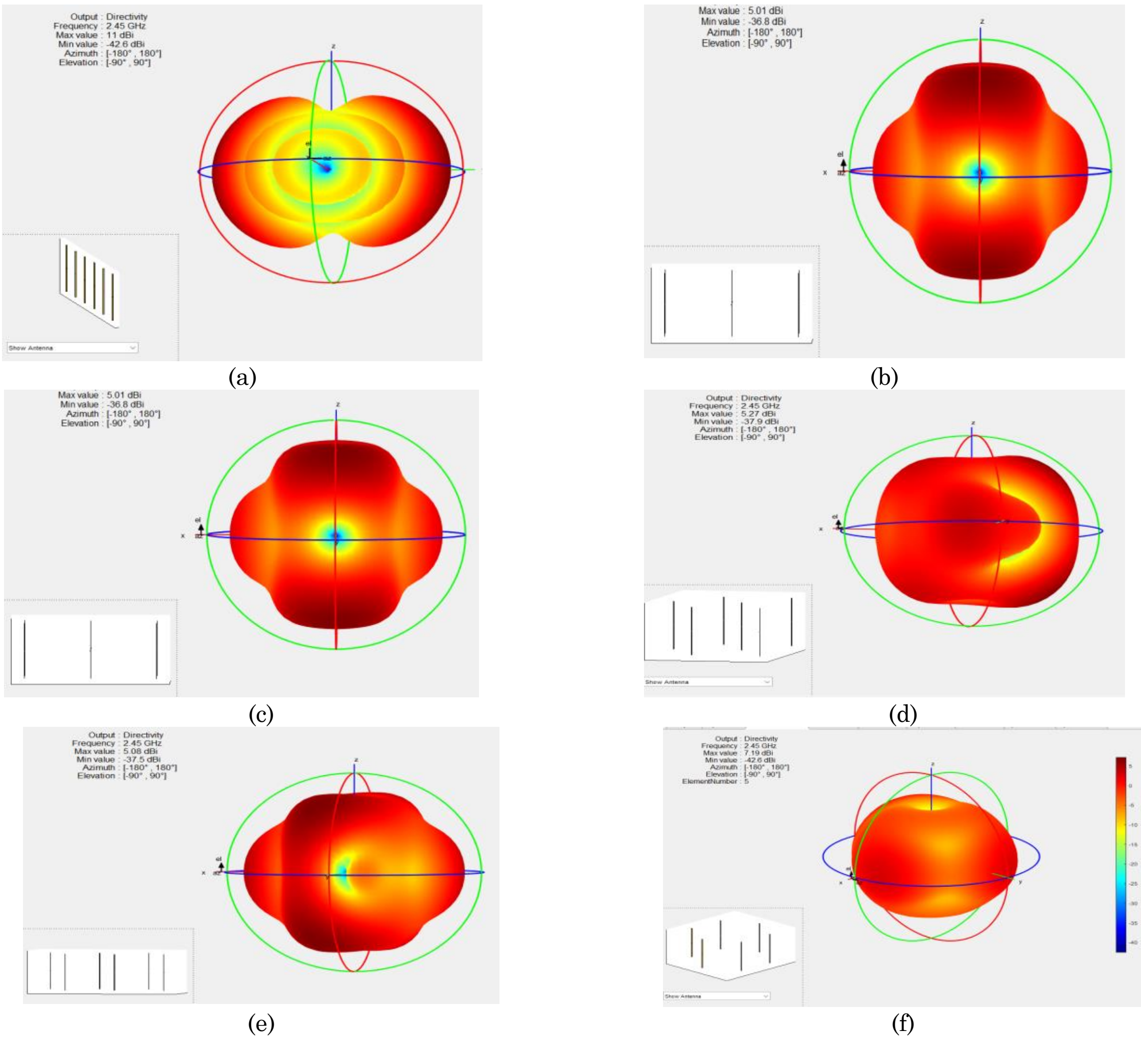

Fig. 3 – Radiation pattern of (a) Linear array, (b) Horizontal Rectangular (Rectangular lattice), (c) Rectangular (Triangular lattice), (d) Vertical Rectangular (Rectangular lattice), (e) Rectangular (Triangular lattice), (f) Circular array

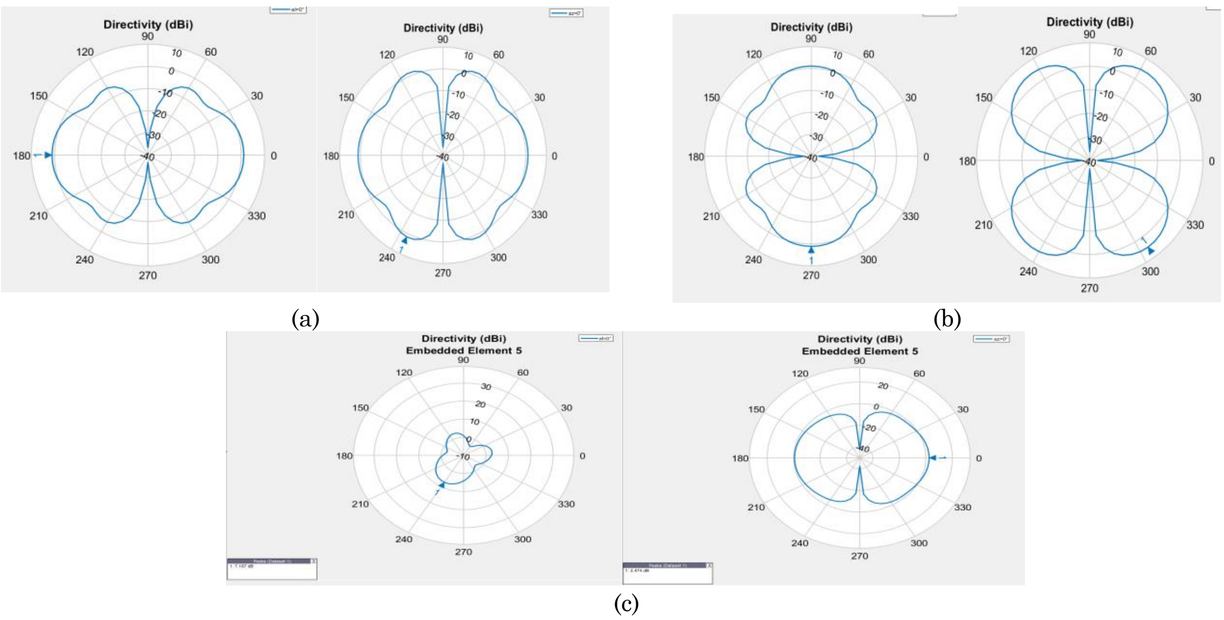

Fig. 4 – (a) Linear array azimuth and elevation plot, (b) Rectangular array azimuth and elevation plot Horizontal Rectangular (Rectangular lattice), (c) Circular array azimuth and elevation plot

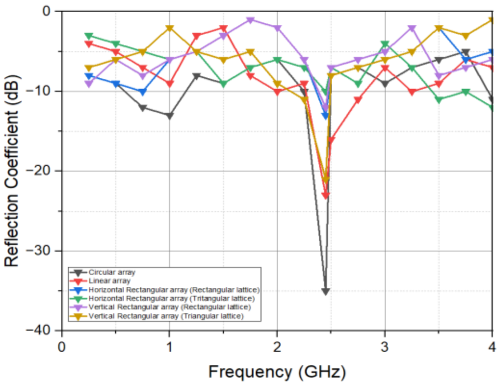

Fig. 5 – Reflection coefficient comparison for proposed array configurations

The greatest reflection coefficient is for a circular array, and the next highest value for a linear array is – 23 dB. The other reflection coefficient values at 2.45 GHz are – 13 dB, –10 dB, –12 dB, –21 dB Rectangular lattice (2,3) Rectangular array, Triangular lattice (2,3) Rectangular array, Rectangular lattice (3,2) Rectangular array, Triangular lattice (3,2) Rectangular array respectively.

4. CONCLUSION

In this work different array configurations are presented. We conclude that among all array configuration the circular array configuration stands on the top based on the performance in terms of reflection coefficient of – 35 dB. Similar to a diode element array, this may be used for different antenna. Due of its size, circular antenna arrays are preferable to rectangular ones (triangular and rectangular lattice). In comparison to all other array configurations, the circular array arrangement takes up extremely little space.

REFERENCES

1. N. Honma, K. Murata, *Correlation in MIMO Antennas Electronics* **9** No 4, 651 (2020).
2. Da-Shan Shiu, G.J. Foschini, M.J. Gans, J.M. Kahn, *IEEE Trans. Commun.* **48** No 3, 502 (2000).
3. Y. Huang, P. Karadimas, A.P. Sohrab, *IEEE Trans. Wireless Commun.* **22** No 8, 5129 (2023).
4. W. Shi, Y. Li, L. Zhao, X. Liu, *IEEE Access* **7**, 6412 (2019).
5. R.L. Haupt, Y. Rahmat-Samii, *IEEE Antenna. Propag. Magaz.* **57** No 1, 86 (2015).
6. P.M. Preethi, P. V. Yalini Shree, N.M. Shaqeeb, C. Kavya, K.C. Raja Rajeshwari, *Narrow Band 5G Antenna. In International Conference on Modeling, Simulation and Optimization*, 397 (Singapore: Springer Nature Singapore: 2022).

Дослідження шестиелементної дипольної антени для додатків бездротового зв'язку діапазону ISM

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Розроблено ефективну шестиелементну рівномірну круглу дипольну решітку. Для визначення найбільш продуктивної конструкції для діапазону ISM, у роботі тестуються численні топології антенних решіток. Запропонована антена підходить для додатків ISM, IEEE 802.11, Bluetooth, а також Zigbee, WiMAX і WiFi. Спочатку була розроблена 6-елементна дипольна лінійна решітка, потім - прямокутна решітка, використовуючи комбінацію трикутної та прямокутної решіток. Ідентична 6-елементна дипольна антена була потім налаштована круговим способом, і результати виявилися дуже хорошими в порівнянні з усіма попередніми конфігураціями. Симетричне розташування однорідної круглої конструкції ґрат дозволяє фазувати антенну решітку для роботи по азимуту з невеликою зміною довжини хвилі та інтенсивності бічних пелюсток. Є 6 ізотропних компонентів у цій уніфікованій круглій конструкції масиву. Для налаштування антени на мінливе середовище, розраховуються складні значення компонентів антенної решітки. Проаналізовано кореляційний ефект між різними елементами. У роботі було отримано зворотні втрати – 35 дБ як максимальне значення для конфігурації кільцевої решітки на 2,45 ГГц. Метою використання антенних решіток є забезпечення підвищеної ефективності та широкосмугових можливостей, що дозволяє використовувати їх у різноманітних повсякденних програмах.

Ключові слова: Антенна решітка, Коефіцієнт кореляції, Прямокутна решітка, Трикутна решітка.