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Implementation Method for Circularly Polarized Omnidirectional Antenna

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Abstract

In practical, it is a challenge to design an antenna with circular polarization and omnidirectional patterns simultaneously. For convenient design, four detail methods for circularly polarization omnidirectional antenna are summarized and analyzed referencing the reported theses and papers. The summarized method can provide a direct guideline for researchers and engineers, which is useful for design efficiency improvement.

Keywords: Circularly polarized, method, omnidirectional antenna;

1. Introduction

Omnidirectional antennas, which radiate isotropic energy in a specific plane, have been widely used in the fields of digital television, point-to-point communication system and wireless communication [1]. Circularly polarized omnidirectional antennas not only have omnidirectional patterns, but also radiate circularly polarized wave. These two properties have great potential in the wireless communication, radar systems, exploration remote sensing,

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electronic reconnaissance and electronic interference [2].

In space communication systems, remote systems and celestial equipment system, the circularly polarized omnidirectional antennas are core devices to decrease signal loss. Also, it can eliminate the polarized distortion caused by Faraday rotation effect in the ionosphere efficiently. In electronic reconnaissance field, the circularly polarized omnidirectional antennas can detect and disturb all electromagnetic wave but pure anti-directional circularly polarization wave. The circularly polarized omnidirectional antennas can receive all wireless signal in equipment with high speed and strenuous vibration, such as spacecrafts, naval ships, airplanes and cars. In broadcast systems, the circularly polarized omnidirectional antennas can enlarge the signal covered scale and can overcome the double images and double voice. Besides, the circularly polarized omnidirectional antennas can improve the timeliness and credibility in communication systems [2][3]. In all, it has great value to analyzed and study the circularly polarized omnidirectional antennas.

2. Implementation Methods

Ranking the directional elements can't achieve the circularly polarized omnidirectional antenna. Also, compositing the segregated and passed linear polarization of omnidirectional antenna is not a suitable method. Besides, some parameters such as gain, axis ratio, and reflection coefficient should be taken into consideration. Interaction between them increases the difficulties in antenna design. Practically, the balance between these indicators is a core part for circularly polarized omnidirectional antennas design. Always, individual indicator has to be guaranteed for the whole required properties [2]. In this paper, the implementation methods for the circularly polarized omnidirectional antennas are classified and the related papers are concluded in detail.

Many methods have been proposed for circularly polarized omnidirectional antenna. Here, antennas are classified as linearly polarized directional antenna (Type-Ⅰ), linearly polarized omnidirectional antenna (Type-Ⅱ), circularly polarized directional antenna (Type-Ⅲ) and circularly polarized omnidirectional antenna (Type-Ⅳ), according to the beam coverage and the polarization. The relationship between these four-type antennas are illustrated in Figure 1.

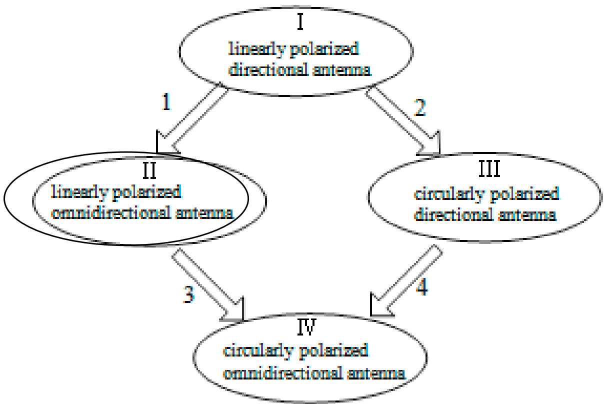

Fig. 1 Relationship between four-type antennas

Different from antenna in type-Ⅰ, type-Ⅱ, and type-Ⅲ, antenna in type-Ⅳ can't be design directly. Generally, it is be realized through the following methods based on the previous three ones.

Method 1: obtaining an omnidirectional pattern based on linearly polarized directional antenna, and then realizing the circularly polarized omnidirectional pattern, namely, $\text{Ⅰ} \xrightarrow{1} \text{Ⅱ} \xrightarrow{3} \text{Ⅳ}$.

Method 2: obtaining a circular polarization based on linearly polarized directional antenna, and then realizing the circularly polarized omnidirectional pattern, namely, $\text{Ⅰ} \xrightarrow{2} \text{Ⅲ} \xrightarrow{4} \text{Ⅳ}$.

Method 3: realizing the circularly polarized omnidirectional radiation based on the linearly polarized omnidirectional antenna, namely, $\text{II} \xrightarrow{3} \text{IV}$.

Method 4: realizing the circularly polarized omnidirectional radiation based on the circularly polarized directional antenna, namely, $\text{III} \xrightarrow{4} \text{IV}$.

According to the previous reports, omnidirectional antenna usually radiates linearly polarized wave, and circularly polarized antenna usually radiates omnidirectional wave. Less antennas, which has circular polarization and omnidirectional patterns simultaneously, have been reported [4][5~12]. Base on the above methods, the reported circularly polarized omnidirectional antenna can be summarized as follows.

No1, method 1 and its representatives.

In this method, an omnidirectional antenna should be initially designed based on linearly polarized antenna, and then circularly polarized omnidirectional antenna can be achieved by means of feeding circularly polarized wave. Generally, monopole antennas, dipole antennas, conical antennas or their improvements present linearly polarization. A linearly polarized wave can be resolved into two orthogonal waves with equal amplitude. In far filed, these two waves can be composited a circularly polarized wave. In [5], a omnidirectional circularly polarized antenna was designed based on biconical horn structure. Diagonal gaps were notched in side wall of cylindrical resonator, the currents in side wall are cut by these gaps and the vertical and horizon electric field components. TE01 wave and TEM wave are excited by these two components respectively. With proper dimension of biconical horn, 90° phase shift are obtained. As a result, the omnidirectional circularly polarized wave is realized. Hengda microwave company in xi'an develop a product named "Lighthouse type broadband high gain circularly polarized omnidirectional antenna",this antenna can operate in muti-band[6].

No2, method 2 and its representatives.

In this method, a kind of circularly polarized antenna is initially designed based on linearly polarized antenna, and arranging the designed circularly polarized antennas in array so that the circularly polarized antenna in specific position can radiate wave in a degree of scale. Thus, a circularly polarized omnidirectional antenna array can be achieved. The main design process can be concluded as follows. Designing a circularly polarized antenna element is the first step. In practical, microstrip patch antenna, dipole antenna, V-typed dipole and orthogonal metal slots are typical approaches to achieve circular polarization. To synthesis the array, a proper feeding network is necessary, a series network or shunt network can ensure that all elements radiate waves in phase and equal amplitude. In [7], an antenna array based on V-typed dipole antenna is proposed. Two orthogonal V-typed dipole antennas are combined as a sub-array. The distance of these two antennas are λ0/4. The electric field in far has equal amplitude and 90° phase shift, so the same rotation in two directions obtained. Besides, the property of circular polarization in horizon can be improved through positing a sub-array in perpendicular direction.

No3, method 3 and its representatives.

The method 3 is another way to realize circularly polarized omnidirectional antenna. It mainly based on the omnidirectional radiation antenna element. In [8], a broadband circularly polarized omnidirectional antenna is proposed. The radiator is a biconical dipole antenna. Sixteen diamond metal parasitic elements are put around. The parasitic elements can radiate the energy coupling from the dipole. Because the phases of the energy in parasitic elements are shift, a circularly polarized wave can be achieved as the energy overlapping with the energy from the dipole. However, this antenna is complex and it can be used in low frequency only. In [9], a circularly polarized omnidirectional antenna is designed by a dipole and three inclined parasitic elements. The parasitic elements are put around the dipole and get energy from the dipole. As the same in [8], the phases of the energy in parasitic elements are 90° shift and a circularly polarized wave can be achieved. However, the structure of this antenna has a circularly polarized wave can be achieved a circularly polarized wave can be achieved a circularly polarized wave can be achieved a circularly polarized wave can be achieved a circularly polarized wave can be achieved a circularly polarized wave can be achieved low radiation efficiency and worse circular polarized property.

No 4, method 4 and its representatives.

Based on the circularly polarized antenna, the circularly polarized omnidirectional antenna can also be designed. One of the simple ways is that organizing antenna array using directional circularly polarized antenna. The property of omnidirectional is decided by the beamwidth of element and the number of elements in circle. Usually, the number is larger than three. In some reports, researches tried to use two elements for the whole covering in horizon. In [10], a circularly polarized microstrip antenna with an omnidirectional pattern is designed. It consists of two rectangular patches with perturbation segments, which are arranged back to back relative to a Coplanar Waveguide

(CPW) on a ground plane. The beam coverage is enhanced by decreasing the dimensions of ground plane. The out-of-roundness of this antenna is less than 4dB in azimuth plane and axial ratio less than 4dB. In [11], an antenna at Ku band is designed base on the structure in [10]. The omnidirectional property of this antenna is not good enough because it uses two elements only. Besides, it is the difficulty to decrease the dimensions of CPW in frequency higher than Ku-band, which results in worse omnidirectional property. In [12], a broadband circularly polarized omnidirectional for television is designed. It consists of four axial die helical antennas and its out-of-roundness is smaller than 3dB.

3. Conclusion

Four methods to design circularly polarization omnidirectional antenna are summarized and analyzed in detail. The advantages and disadvantages of these methods are given. In our opinion, the summarization in this paper can provide a guideline for research and design the antenna with circular polarization and omnidirectional patterns simultaneously.

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