Using the Pattern Function of Angular Momentum Improve the Directivity of Binary Antenna Array

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Abstract—Building solar power stations in space are concerned by international. In the process of electricity transmission to need to make the solar cell array always orient for the sun. The microwave beam of transmitting antenna must point to ground receiving antenna, which requirement the antenna has the very good directivity. In this article, under the condition of the pattern function of angular momentum deduced the directivity coefficient of binary antenna array. Using Matlab software simulation probed the situation of binary antenna array directivity improvement. The simulation results show that in some specific values the directivity of binary antenna array get enormously improvement. In some specific areas the directivity of binary antenna array get obvious improvement. The maximum value of directivity coefficient is 283.11.

Keywords-pattern function; quantization; binary antenna array; directivity

I. INTRODUCTION

The sunlight intensity in space five to ten times greater than the ground. Solar power generation technology can provide constant energy without pollution. Space solar power mainly includes three parts: solar launchers device, energy conversion and launchers device, ground receiving and conversion device. Energy conversion device convert energy into microwave. Using the energy launchers device will microwave launch back ground. Launch device is made using the antenna. Microwave beam of the auncher antenna must point to ground receiving antenna, which requires the antennah as the very good directivity[1]. Directivity coefficient as a parameter is used to represent the antenna to a certain direction concentration degree for the radiation of electromagnetic wave (that is the sharp degree of the directivity diagram). With the development of the antenna theory, there are a number of array antenna directivity researches. In recent years, the emergence of a variety of numerical integration method [2,3,4,5,6] can synthesis irregular array, and get the specified sidelobe envelope, but these methods are not under the condition of control the sidelobe and to consider implementing optimal array directivity at the same time. Sanzgiri and Bulter [7] based on eigenvalue decomposition method, under the condition of the binary antenna array optimization array directivity and control the sidelobe pattern at the same time . But the method convergence is slow and there is no limit of sidelobe phase which has a great influence on the final result. Yong-feng Chen, Xing-zhong Huang a piece work in 2007[8], quadratic synthetic method , the constraint optimization synthesis, Dolph-Chebyshev three synthesis methods were introduced in detail and finally suggests that no matter from the point of flexibility or calculation accuracy binding optimization method can better solve the comprehensive problem of antenna sidelobe constraint conditions and efficiency conditions. Although people put forward to kinds of optimizations of antenna directivity, but the array antenna directivity coefficient not got enormously improvement. With the advent of quantum communication, antenna will also be toward "quantum" the direction development, using the method of quantized directional coefficient optimized antenna array have great significance.

At first, this paper under the condition of the angular momentum of the pattern function deduced the directivity coefficient of binary antenna array. Then used the Matlab software simulation to explore the improvement situation of the dual antenna directivity. Founding binary array antenna directivity get unprecedented improvement.

II. THE DIRECTION FUNCTION OF THE ANGULAR MOMENTUM

THE BINARY ARRAY ANTENNA DIRECTIVITY COEFFICIENT

N yuan array antenna directivity function

\[ S(\theta, \phi) = \sum_{n=0}^{N-1} \sum_{l=-n}^{n} Y_{n}^{*} Y_{l}^{\ast} \cos \theta \]

(1)

According to the [9]

\[ e^{jk\cos \theta} = \sum_{l=0}^{n} (2l+1) P_{l}(\cos \theta) P_{l}(j) \]

\[ = \sum_{l=0}^{\infty} \left( \frac{4\pi}{2l+1} \right) ! j^{2+l} Y_{l}^{*}(\theta) \]

(2)

The angular momentum of the eq (1) is changed into

\[ S(\theta, \phi) = \sum_{n=0}^{N-1} \sum_{l=0}^{m} \frac{4\pi}{2l+1} ! j^{l}(l\mid Z_{n}) Y_{l}^{\ast}(\theta) \]

(3)

Among them \( l = 0,1,2, \ldots \). Antenna directivity coefficients
\[ D = \frac{4\pi}{\Omega A} = \iint S(\theta, \varphi) S^* (\theta, \varphi) \sin \theta d\theta d\varphi \]  

(\theta_o, \varphi_0) \text{ is main lobe location} 

III. THE BINARY ARRAY ANTENNA DIRECTIVITY COEFFICIENTS

Binary antenna array model is displayed in figure I.

\[ S(\theta, \varphi) = I_0 [ j_0(kr) + 3j_1(kr) \cos \theta ] + I_1 [ j_0(kr_1) + 3j_1(kr_1) \cos \theta ] \]  

(5)

Making \( \theta_o = 0 \) is main lobe location. The binary array antenna directivity coefficients is changed into

\[ D_1 = \frac{4\pi}{\Omega A} = \iint S(\theta, \varphi) S^* (\theta, \varphi) \sin \theta d\theta d\varphi \]  

(6)

\[ S(\theta, \varphi) = I_0 [ j_0(kr) + 3j_1(kr) ] + I_1 [ j_0(kr_1) + 3j_1(kr_1) ] \]  

(7)

\[ S^* (\theta, \varphi) = I_0 [ j_0(kr_0) - 3j_1(kr_0) \cos \theta ] + I_1 [ j_0(kr_1) - 3j_1(kr_1) \cos \theta ] \]  

(8)

\[ S^* (\theta, \varphi) = I_0 [ j_0(kr_0) - 3j_1(kr_0) \cos \theta ] + I_1 [ j_0(kr_1) - 3j_1(kr_1) \cos \theta ] \]  

(9)

Make(5), (7), (8) into (6) and get \( \theta_o = 0, \varphi_0 = 0 \)

The directivity coefficients of pattern function without changing is \( D_2 \) and get \( \theta_o = 0, \varphi_0 = 0 \)

\[ D_2 = \frac{4\pi}{\Omega A} = \iint S(\theta, \varphi) S^* (\theta, \varphi) \sin \theta d\theta d\varphi \]  

(10)

\[ S^* (\theta, \varphi) = \sum_{n=0}^{N-1} I_n e^{-jkZ} \]  

(11)

\[ S(\theta, \varphi) = \sum_{n=0}^{N-1} I_n e^{jkZ} \]  

(12)

\[ S^* (\theta, \varphi) = \sum_{n=0}^{N-1} I_n e^{-jkZ} \cos \theta \]  

(13)

Make(1), (11), (12), (13) into (10) can to get \( D_2 \).

IV. THE MATLAB SIMULATION RESULTS AND DISCUSSION

When \( \theta_0, \varphi_0, r_0, r_1 \) take fixed value using Matlab software to draw the simulation diagram of \( D_1, D_2 \) with the change of \( \theta \) is shown in figure II. Through figure II known when \( \theta \) get 0 ~ 28.8, 47.80 ~ 58.78, 75.52 ~ 81.61, 90.50 ~ 104.60, 121.30 ~ 132.27, 151.30 ~ 180 degrees these areas \( D_1 \) is obviously improved.

FIGURE II. WITH THE CHANGE OF \( \theta \) THE SIMULATION DIAGRAM OF \( D \)
When the \( \theta_0, \phi_0, \varphi_0, \beta_0 \) take fixed value using Matlab software to draw the simulation diagram of \( D_1, D_2 \) with the change of \( \theta \) is shown in figure III. Through figure III known when \( \eta \) get value in \( 2.2740 \sim 2.3493, 2.7663 \sim 2.8481 \), these areas directivity coefficient \( D_1 \) far bigger than \( D_2 \) and when \( \eta \) get value \( 1.3142, D_1 \) the maximum value 283.11 is 51.47 times of \( D_2 = 5.5 \). When \( \eta \) get value \( 1.8168, D_1 = 57.164 \) is six times of \( D_2 = 9.5 \). When \( \eta \) get value \( 2.3195, D_1 \) is 2.71 times of \( D_2 = 9.5 \).

When the \( \theta_0 = 0, \phi_0 = 0, \varphi_0 = 0, \beta_0 = 1.3142 \) take fixed value using Matlab software to draw the simulation diagram of \( D_1, D_2 \) with the change of \( \theta \) is shown in figure IV. According to the figure IV know when get \( \theta_0 = 0, \phi_0 = 0, \varphi_0 = 0, \beta_0 = 1.3142 \) wherever the direction function of the angular momentum of the binary array antenna directivity \( D_1 \) with \( \theta \) varying from 0 to \( \pi \) bigger than \( D_2 \), the direction function of not angular momentum the directivity coefficients of binary antenna array.

2) When the \( \theta_0, \phi_0, \varphi_0, \beta_0 \) set value, in certain area \( D_1 \) with \( \eta \) varying from 0 to \( \pi \) bigger than \( D_2 \).

3) When the \( \theta_0 = 0, \phi_0 = 0, \varphi_0 = 0, \beta_0 = 1.3142 \) set value, wherever with \( \eta \) varying from 0 to \( \pi \) far bigger than \( D_2 \).

Conclusion 3) has important meaning for actual antenna design, as long as taking \( \eta = 1.3142 \) the directivity coefficients of binary antenna array \( D_1 \) can bigger dozens of times than \( D_2 \) conventional the directivity coefficients of binary antenna array.

**REFERENCES**


