Characteristics of Gain and SINR of Adaptive Polyhedron Antennas

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Abstract

In this paper, adaptive controls are adopted on the polyhedron antenna to obtain constant gain regardless of the direction and to prevent the deterioration of communication quality. It was shown that the gain in the direction of the desired wave by using beam-forming control was increased more than 3dB compared with switching elements control. By using null-forming control, the gain in the direction of the desired wave was obtained 15dBi and SINR was obtained 58dB when 60 antenna elements and the angular difference was 6 degrees.

Keywords : Polyhedron Antenna Adaptive Control Interference Suppression DCMP

1. Introduction

A conformal array antenna arranged on a curved surface features to steer a beam in the hemisphere. As such a conformal array antenna, a polyhedral array arranged on a polyhedron has been studied, so as to apply to maritime satellite communications [1] [2]. However, a gain may vary with the direction by the switching element control. In addition, stationary satellite for satellite communications is located on a geostationary orbit at equal angular difference. Therefore, quality of satellite communications may deteriorate by adjacent satellite interference. In this paper, the adaptive controls are adopted on polyhedron antenna to obtain constant gain regardless of direction and to prevent the deterioration of communication quality. The gain and SINR characteristics are evaluated. Here, a dodecahedron, an icosahedron, a truncated icosahedron, a polyhedron with 60 triangles, and a polyhedron with 80 triangles are used in the analysis.

2. Analysis Models and Adaptive Controls

2.1 Analysis Models

Figure 1 shows the polyhedron antennas and the locations of the antenna elements used in the analysis. The antenna elements are shown as closed circles in Fig.1. Figure 2 shows the coordinate system for the polyhedron antenna and for the elements. The parameter r is a diameter of each polyhedron antennas. It is supposed that the elements radiate only the outside of the polyhedron. In addition, the directional pattern (electric pattern) is expressed by $\cos^n u$. Here, parameter n is fixed 1 in the analysis. It is also supposed that a desired wave and an interference is received respectively. The direction of the respective wave is changed independently. Intensity of both arrivals are the same (SIR=0dB). SNR of desired wave is 40dB. The performance is evaluated by using the gain in the direction of desired wave and SINR.

2.2 Adaptive Controls

2 types of adaptive controls described below are used for polyhedron antennas.

- Beam-forming Control

  The signals received by respective antenna elements are controlled so as to become in phase. As the results, the mainbeam of the polyhedron array is formed toward the desired wave.
- Null-forming Control

To suppress the interference from adjacent satellite, DCMP (Directionally Constrained Minimization of Power) are adopted on the polyhedron antenna [3]. Thus, the interference can be rejected while maintaining the gain toward the desired wave.

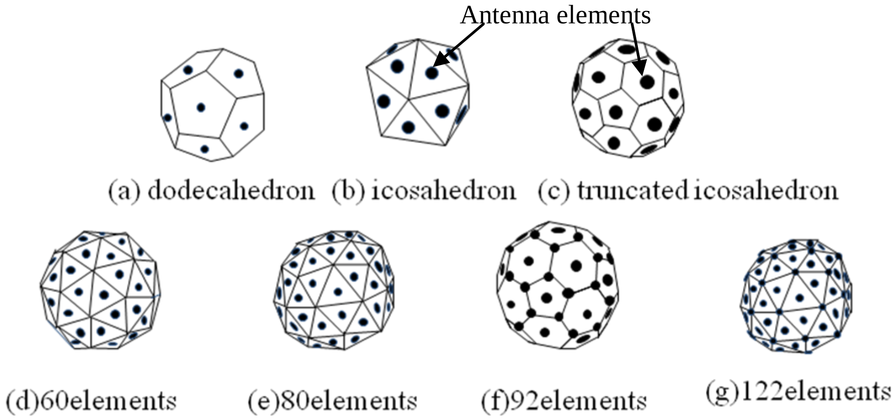

Figure 1: Polyhedron Antennas and Location of Elements

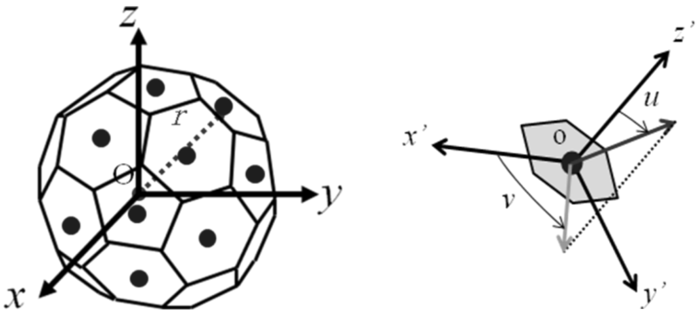

Figure 2: Coordinate System for Elements of Polyhedron Antenna

3. Gain Characteristics of Polyhedron Antennas

3.1 Gain Characteristics of Beam-forming Polyhedron Array

Figure 3 shows the effect of number of antenna elements on the gain in the direction of the desired wave. Solid line shows the gain in the direction of desired wave in case of beam-forming control and dashed line shows the gain in the direction of the desired wave in case of one by one switching elements control. The gain in the direction of the desired wave increases with the increasing number of the elements. Moreover, the gain in the direction of the desired wave is increased by beam-forming control more than 3dB compared with the case of switching elements control. To obtain 15dBi of gain, more than 32 elements are required as antenna elements of polyhedron antenna.

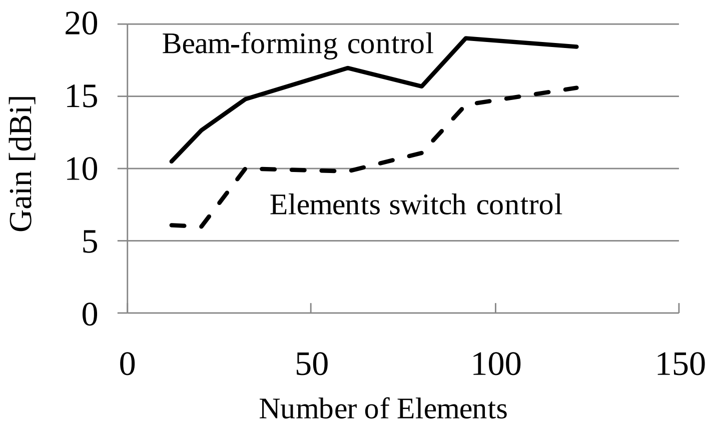

Figure 3: Effect of Number of Elements on Gain in Direction of Desired Wave in case of Beam-forming

3.2 Gain Characteristics of Null-forming Polyhedron Array

Figure 4 shows the effect of the angular difference between the desired wave and the interference on gain in the direction of the desired wave. The parameter in the figure is number of elements. The gain increases with increasing the number of elements. In the case of 32 elements array, the gain is converged to 14dBi when the angular difference is more than 9 degrees. On the other hand, in the case of 60 elements array, the gain is converged to 15dBi when the angular difference is more than 6 degrees. In contrast, when the angular difference equals 0 degree, null point cannot be formed because the interference arrives in the same direction to the desired wave. When the angular difference equals 3 degrees, the gain is decreased because of the null point.

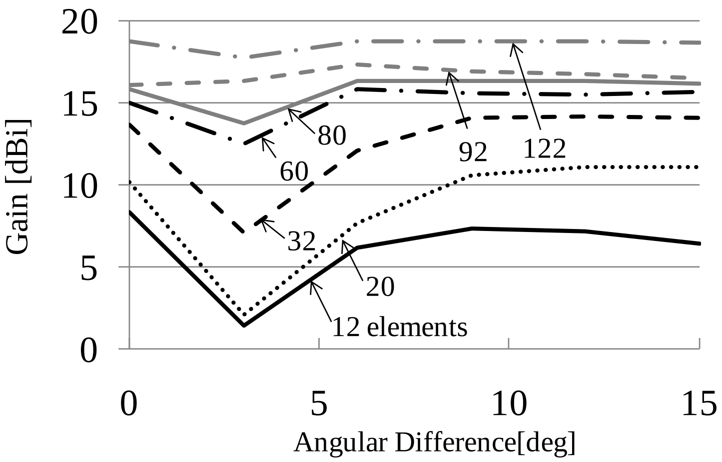

Figure 4: Effect of Angular Difference on Gain in Direction of Desired Wave in case of Null-forming

4. SINR Characteristics of Polyhedron Antennas

4.1 SINR Characteristics of Polyhedron Array with Beam-forming Control

Figure 5 shows the effect of the angular difference between the desired wave and the interference on SINR in case of beam-forming control. SINR is increased with the angular difference is increased. When the angular difference is 0 degree, the gain for both waves is the same. Hence, SINR nearly equals 0dB. SINR is reduced when the angular difference is small because the interference is also received in the case of beam-forming control. It can be said that SINR cannot be obtained enough compared with input SNR (input SNR = 40dB) when the angular difference is small.

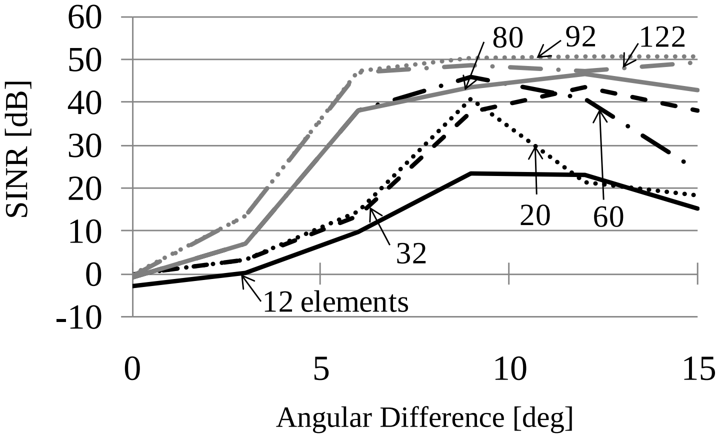

Figure 5: Effect of Angular Difference on SINR in case of Beam-forming

4.2 SINR Characteristics of Polyhedron Array with Null-forming Control

Figure 6 shows the effect of the angular difference between the desired wave and the interference on SINR in case of null-forming control. SINR is increased with the number of elements is increased. Moreover, SINR is increased with the angular difference is increased. In contract, when angular difference equals 0 degree, null point cannot be formed because direction of the desired wave and the interference are the same. In the case of 32 antenna elements, SINR is converged to 55dB when the angular difference is more than 9 degrees. On the other hand, in the case of 60 antenna elements, SINR is converged to 58dB when the angular difference is more than 6 degrees.

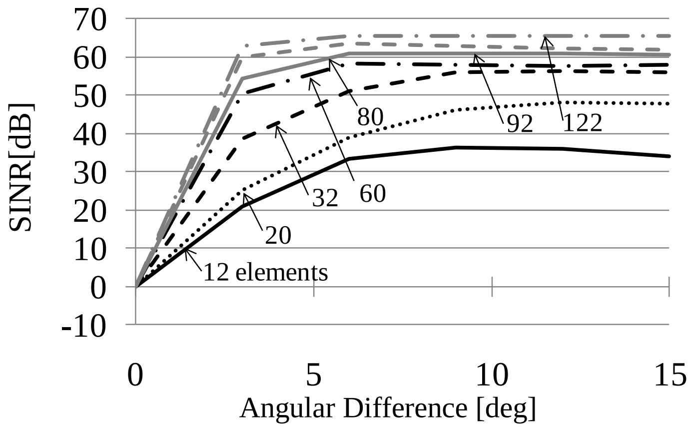

Figure 6: Effect of the Angular Difference on SINR in case of Null-forming

5. Conclusion

Adaptive controls were adopted on polyhedron antenna to obtain constant gain regardless of the direction and to prevent the deterioration of communication quality. By using beam-forming control, the gain in the direction of desired wave was increased more than 3dB compared with the case of element switch control. By using null-forming control, the gain in the direction of desired wave was obtained 15dBi and SINR was obtained 58dB when 60 antenna elements and angular difference was 6 degrees.

References

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