Beamforming characteristics of a phased array reflector using a log periodic dipole antenna as an array element

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***Abstract* – This paper proposes beamforming characteristics of a phased array reflector using a log periodic dipole antenna as an array element. To confirm beamforming capability of the proposed antenna, 4-elements LPDA array are conducted as the feeder of the reflector, and the beamforming capability is observed according to the steering angle. The results demonstrated that the proposed antenna is suitable as phased array-fed reflector antenna for achieving multibeam capability.**

***Index Terms* — Antennas, log-periodic antenna, reflector antenna, phased array-fed reflector antenna.**

1. Introduction

Multibeam antennas using array-fed reflectors can be found in many applications. One of their notable applications is to receive the small signal at a geostationary orbit (GEO, 35,800 km) when the signal is transmitted from earth surface or low earth orbit (LEO, 1000 km). Two of the most common options for high-gain multibeam antennas are direct radiating array (DRA) and the array-fed reflector antenna [1]. Although the DRAs can steer the angle of the beam over a wide scan range, they have drawbacks such as increased design complexity and physical size. The array-fed reflector antenna can communicate with multiple users simultaneously using the proper scanning angles. However, the scan angle is limited to some specific directions, and the scan loss characteristic can be more severe than that of DRA [2, 3]. To compromise the two technologies, hybrid antennas using phased array-fed reflectors (PAFRs) are recently proposed [4]. The PAFR offers the several benefits such as a low-cost feed array, high beam resolution, and smaller array size [4].

In this paper, the beamforming capabilities of the PAFR are investigated according to the F/D ratio of reflector, array configuration of the feeder, and individual elements of the array. Resulting beam patterns are also observed by varying the steering angle.

2. Array-fed reflector antenna

Fig. 1 presents the schematic view of an array-fed reflector antenna. The reflector has a parabolic structure with a diameter of 1.6 m and a F/D ratio of 0.82. The array feeder consists of phased array antennas with individual elements of an LPDA antenna to obtain the multibeam scanning. The amplitude and phase of feeder are adjusted using phase shifters. The most important design parameter of the LPDA antenna is the log-period $1/\tau = L_{n+1}/L_n$, (L_1 = 155 mm), and spacing between dipoles is S_1 = 40 mm. The number of dipoles is 25 to obtain broadband characteristics (1 GHz ~ 7 GHz). Fig. 2 shows the reflection coefficient of the LPDA antenna, which is less than −10 dB in the entire operating frequency (average value of −21.5 dB). Fig. 3 represents the gain of the LPDA arrays in the bore-sight direction. The peak gain is 14.3 dBi at 1.96 GHz, and the average gain is 14 dBi in the operating frequency.

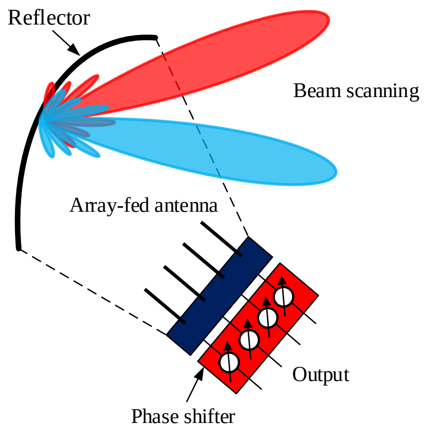


Fig. 1. Schematic view of an array-fed reflector antenna with multibeam capability.

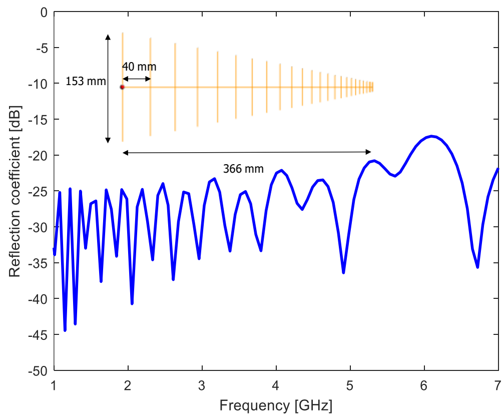


Fig. 2. Reflection coefficient of the LPDA antenna.

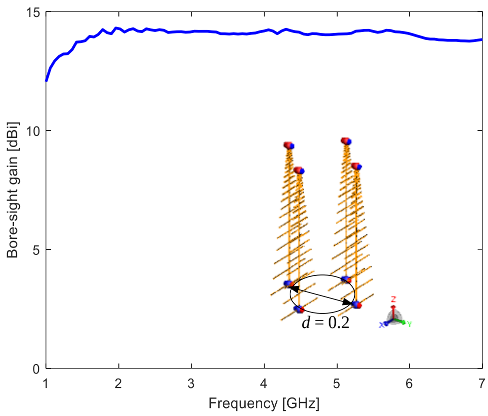
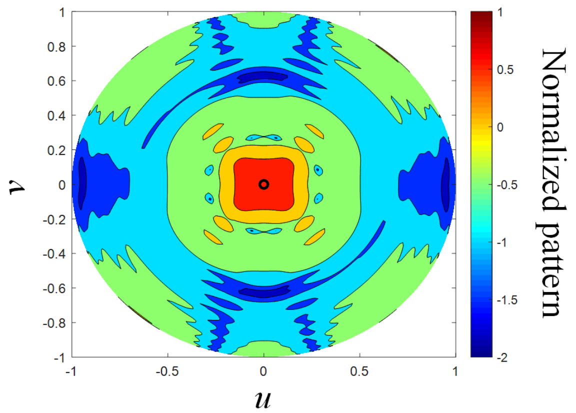
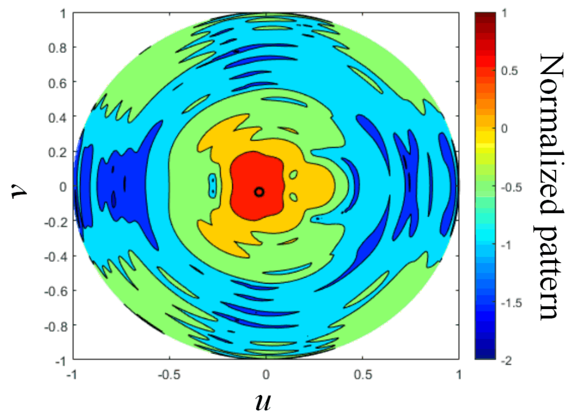


Fig. 3. Bore-sight gain of the LPDA array.

Fig. 4 presents the beamforming performance of the proposed PAFR antenna. The beam pattern is illustrated when the proposed antenna steers 0° as shown in Fig. 4(a). Fig. 4(b) shows the beam pattern when the amplitude and phase values of the array feeder are adjusted to steer the beam at 2°. The results confirm that the proposed antenna is suitable as a phased array-fed reflector with multibeam capability.



(a) Theta = 0°, Phi = 0°



(b) Theta = 2°, Phi = 0°

Fig. 4. Beamforming performance of PAFR antenna.

3. Conclusion

We have investigated the design of a phased array-fed reflector antenna using a log periodic dipole antenna to confirm the beamforming capability. The reflector was built to obtain high gain, and the feeder consists 4-elements LPDA array. The average value of reflection coefficients was –21.5 dB, and the average gain was 14 dBi in the operating frequency (from 1 GHz to 7 GHz). The beamforming capability of the phased array-fed reflector antenna was observed according to the steering angle ($\theta = 0°$ and 2°). The results demonstrated that the proposed antenna is suitable as phased array-fed reflector antenna for achieving multibeam capability.

Acknowledgment

This work was supported by the research fund of Signal Intelligence Research Center supervised by Defense Acquisition Program Administration and Agency for Defense Development of Korea.

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