Design of a non-uniform 8-element array for passive coherent location systems

Doyoung Jang[1], Jun Hur[1], Junsik Park[2], Hongsuk Shim[2], Junil Ahn[3], and Hosung Choo[1]
[1]School of Electronic and Electrical Engineering, Hongik University, Seoul, Republic of Korea
[2]Hanhwa System, Pangyo, Republic of Korea
[3]Agency for Defense Development, Daejeon, Republic of Korea

***Abstract* - This paper proposes a non-uniform 8-element array antenna to maximize the beamforming performance of FM based PCL systems. The proposed non-uniform array has two elements groups with different distances from the center to element. Beamforming performances such as PSLR and HPBW are compare with a uniform circular array, and the result demonstrates that the proposed non-uniform array has a HPBW narrower than a uniform circular array while maintaining a high PSLR.**

***Index Terms* — passive coherent location, array antenna, non-uniform array configuration.**

1. Introduction

Passive coherent location (PCL) systems are often adopted to detect a target location in military applications since the system is less vulnerable to radio wave exposure than an active radar system [1]. The receive antenna of the PCL system using FM broadcast signals needs to generate a reference channel to acquire the required FM broadcast signals. The antenna pattern of the reference channel should have a high peak to sidelobe ratio (PSLR) with a narrow half power beamwidth (HPBW) to minimize the effects of clutter signals [2-4]. In the previous researches of the array antenna for PCL systems, the number and separate distance of the array elements are analyzed to improve the array performance [5]. However, these studies have attempted to improve the array performance with a limited array configuration, and the research on various array configurations to maximize the beamforming performances is insufficient yet.

In this paper, we propose a non-uniform array configuration to maximize the beamforming performance of the FM based PCL system. The proposed non-uniform array consists of eight dipole elements, and each optimum separate distance between elements is optimized by using the genetic algorithm (GA). The results demonstrate that the proposed non-uniform array can effectively achieve a higher PSLR with a narrower HPBW.

2. Geometry and performance of non-uniform array

Fig. 1 presents the proposed 8-element non-uniform array configuration for the PCL system. The proposed non-uniform array has two element groups (inner and outer layers) with different distances of d_1 and d_2 from the center to element. The elements of the inner and outer layers have the same distance between each layer element. However, the position of the first element of each layer has the offset rotation angle of ϕ_e. The array elements are designed to operate in the FM band, and the optimum design parameters of the proposed non-uniform array configuration are listed in Table 1.

Figs. 2a and 2b present the radiation patterns of the proposed non-uniform array and the conventional uniform circular array, respectively. The radiation patterns are observed at 88 MHz, 98 MHz, and 108 MHz when the steering angle (ϕ) is fixed at 225°. The average HPBW of the proposed non-uniform array achieves 45°, which improves more than 8° compare to the uniform circular array while PSLR maintains above 22.8 dB. The results demonstrate that the proposed non-uniform array can effectively enhance the array performance for the PCL system.

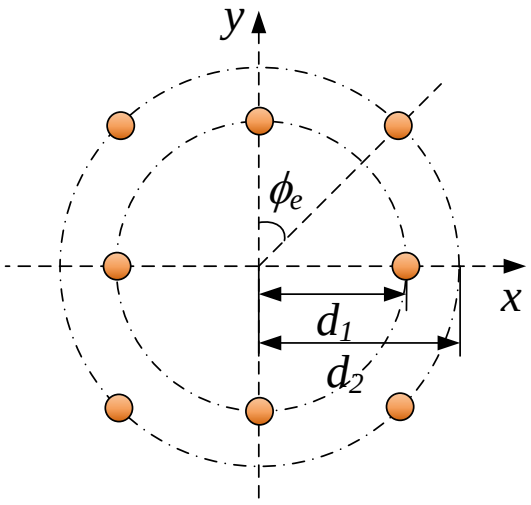
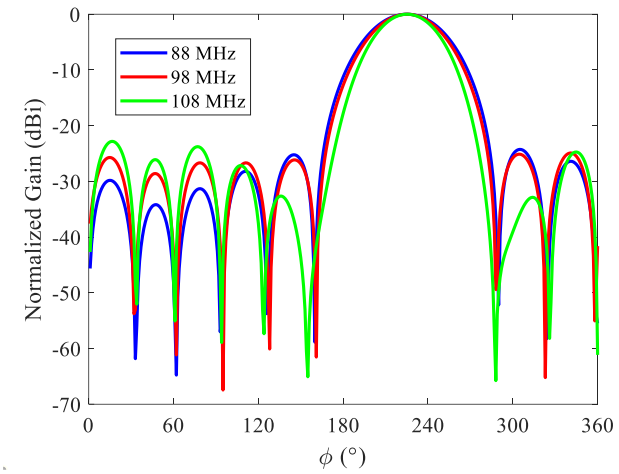


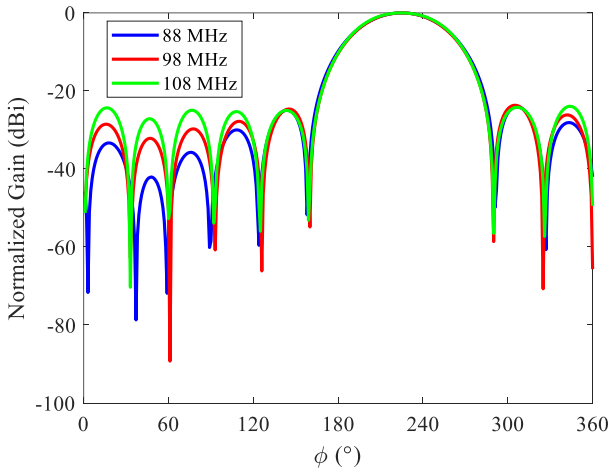
Fig. 1. Geometry of the proposed non-uniform array configuration.

TABLE I
Optimized values of the proposed nun-uniform array.

Parameters	Values
d_1	0.45λ
d_2	0.59λ
ϕ_e	45°



(a)



(b)

Fig. 2. Comparison of beamforming performance, (a) Proposed non-uniform array, (b) Uniform circular array.

TABLE II
Array performance according to the array configuration.

	Proposed array		**Uniform array**	
Frequency	**PSLR**	**HPBW**	**PSLR**	**HPBW**
88 MHz	24.3 dB	49°	24.1 dB	53°
98 MHz	24.9 dB	46°	23.7 dB	53°
108 MHz	22.8 dB	40°	23.9 dB	55°

3. Conclusion

The non-uniform array configurations have been investigated to maximize the beamforming performance of the FM based PCL system. The proposed non-uniform array had two element groups with different distances of d_1 and d_2 from the center to element. Beamforming performances such as PSLR and HPBW were compared with a uniform circular array. The average PSLR and HPBW of the proposed non-uniform array were 24 dB and 45°, respectively. The proposed non-uniform array has a HPBW that is 8° narrower than a uniform circular array while maintaining a high PSLR.

Acknowledgment

This work was supported by a grant-in-aid of HANWHA SYSTEMS.

References

[1] G. -H. Park, D. -G. Kim, H. J. Kim and H. -N. Kim, "Maximum-likelihood angle estimator for multi-channel FM-radio-based passive coherent location," IET Radar, Sonar, Navigation, vol. 12, no. 6, pp. 617-625, May. 2018.

[2] F. Colone and P. Lombardo, "Polarimetric passive coherent location," *IEEE Trans. Aeros. Electr. Syst.*, vol. 51, no. 2, pp. 1079-1097, Apr. 2015.

[3] F. Colone, R. Cardinali, and P. Lombardoy, "Cancellation of clutter and multipath in passive radar using a sequential approach," *IEEE Radar conference*, 2006, Rome, Italy, pp. 1-7.

[4] C. Bongioanni, F. Colone, S. Bernardini, L. Lelli, A. Stavolo, and P. Lombardo, "Passive radar prototypes for multifrequency target detection," *Photonics Applications in Astronomy, Communications, Industry,and High-Energy Physics Experiments*, pp. 1-12, Dec. 2007.

[5] M. Villano, F. Colone, and P. Lombardo "Antenna Array for Passive Radar: Configuration Design and Adaptive Approaches to Disturbance Cancellation," *International Journal Aantenn. Propag*, pp. 1-16, Oct. 2013.