Design of a periodic structure to improve isolation using ferrite mateiral for small CRPA arrays

Jun Hur
School of Electronic and Electrical Engineering
Hongik University
Seoul, Korea
gjwns0@naver.com

Gangil Byun
Research Institute of Science and Technology
Hongik University
Seoul, Korea
kylebyun@gmail.com

Hosung Choo
School of Electronic and Electrical Engineering
Hongik University
Seoul, Korea
hschoo@hongik.ac.kr

***Abstract*—This paper proposes a periodic structure to improve isolation using ferrite materials for small controlled reception pattern antenna arrays. The periodic structure is composed of metal and ferrite plates with high permeability, and the ferrite material is used as a replacement of the perfect magnetic conductor in the soft surface to reduce the size of the corrugated geometry. This structure improves the isolation between array elements by eliminating the tangential components of electric and magnetic fields on the surface of metal and ferrite plates, respectively. The result shows that the proposed structure is capable of improving the isolation in extremely small arrays.**

Keywords—isolation, soft surface, ferrite, controlled reception pattern antenna (CRPA).

I. INTRODUCTION

A controlled reception pattern antenna (CRPA) array is used to form adaptive patterns to mitigate the effect of unwanted interferences [1]-[3]. However, the patterns are easily distorted by the mutual coupling effect, thus, isolation between array elements should be taken into account as an important design parameter to maximize the capability of interference mitigation. To improve the isolation, the soft surface has been introduced in [4] and is inserted into the ground platform between array elements [5]. The soft surface has a periodic structure that is composed of metal and perfect magnetic conductor (PMC) plates and improves the isolation by reducing the tangential components of the electric and magnetic fields on the surface of the metal and PMC plates, respectively. The PMC area is usually replaced with the corrugated structure having a depth of about a quarter wavelength to equivalently realize the similar properties. However, this corrugated surface is not suitable for small CRPA arrays because of its bulky structure.

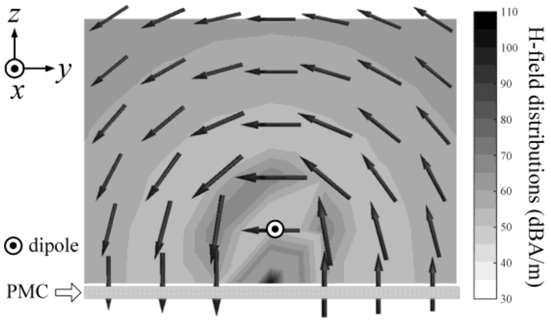
In this paper, we propose a periodic structure to improve the isolation using ferrite material for small CRPA arrays. The proposed structure replaces the corrugated structure of the soft surface with ferrite plates and is placed between two identical antennas. To examine the electromagnetic properties of the ferrite material, we observe the magnetic field distributions for an electric dipole and compare the result with that obtained from the PMC. Then, the number, length, and width of the periodic structure are adjusted to maximize the isolation. The results show that the proposed structure is capable of improving the isolation in extremely small arrays.

II. PROPOSED PERIODIC STRUCTURE

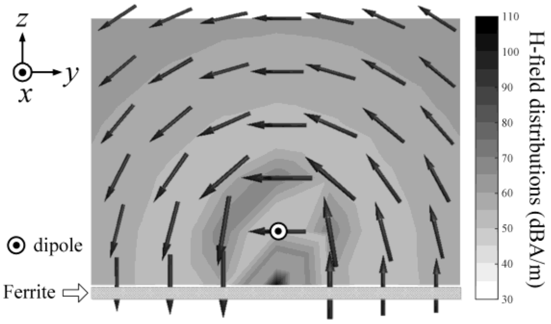
To verify the electromagnetic behavior of the ferrite material, we observe the magnetic field distributions when an electric current source is placed above an infinite ferrite plate (*xy*-plane) at a height of 1 mm, and the direction of the source is parallel to the *x*-axis. The distributions of the ferrite on the *yz*-plane are compared to those of the infinite PMC ground in FEKO EM simulator [6], as illustrated in Fig. 1(a) and (b). Since the amplitude of the tangential magnetic fields is zero at the PMC boundary, only the normal components exist at $z = 0$. These distributions can also be observed in case of the ferrite plate because the tangential magnetic fields are significantly decayed when the magnetic loss tangent of the material is large enough.

Fig. 2 shows the proposed periodic structure, and a commercial ferrite plate of FSF501 manufactured by MARUWA is used [7]. The width w, gap g_f, and length l of the structure are adjusted to maximize the isolation between two identical antennas having circular polarization. The detailed parameters of the sample geometry are provided in Table 1.

Fig. 3 shows a comparison of the mutual coupling according to the existence of the periodic structure. The inter-element spacing between antennas is 40 mm (0.2λ), and the periodic structure occupies 7 mm (0.03λ). The solid line indicates the mutual coupling without any structure, and the dashed line shows the curve of the proposed structure. As can be seen, the mutual coupling with proposed structure is improved from –17.3 dB to –23.4 dB at 1.575 GHz.



(a) PMC



(b) Ferrite

Fig. 1. Magnetic field distributions according to the plate materials.

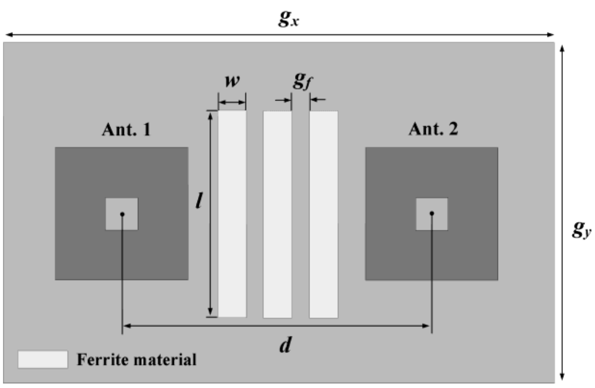


Fig. 2. Geometry of the proposed periodic structure.

TABLE I. DESIGN PARAMETERS OF THE PERIODIC STRUCTURE

Parameters	w	l	g_f	g_x	g_y	d
Values	2	40	0.5	80	50	40

a. Unit: mm

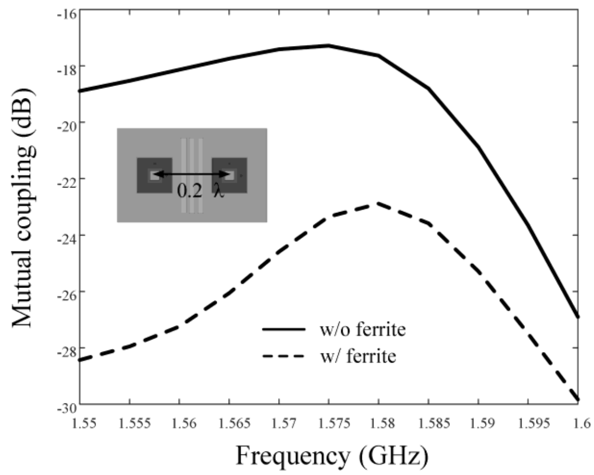


Fig. 3. Mutual coupling of the array with the proposed structure.

III. Conclusion

This paper proposed the periodic structure to improve the isolation characteristic for small CRPA arrays. The proposed structure was composed of metal and ferrite plates, and the ferrite material was used as a replacement of the corrugated structure of the soft surface to avoid its bulkiness. Then, a sample geometry was provided to verify the feasibility, and the results demonstrated that the proposed structure can improve the isolation by 6 dB for two antennas with the inter-element spacing of 0.2λ.

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