Exploiting Glide Symmetry in Planar EBG Structures

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Abstract. Periodic structures such as electromagnetic band gap (EBG) structures can be used to prevent the propagation of electromagnetic waves within a certain frequency range known as the stop band. One of the main limitations of using EBG structures at low frequencies is their relatively large size. In this paper, we investigate the possibility of using glide symmetry in planar EBG structures to reduce their size. Simulated results demonstrate that exploiting glide symmetry in EBG structures can lead to size reduction.

1. Introduction

Electromagnetic band gap (EBG) structures are well-known for controlling the propagation of electromagnetic waves in a certain frequency band. Via holes, or short-circuits, are conventionally employed to produce these EBGs [1]. However, these vias increase the cost of manufacturing. To overcome this drawback, a completely planar EBG structure made of metallic patches only without via holes was proposed in [2] for mutual coupling reduction in patch antenna arrays.

Higher symmetries in periodic structures was first introduced in the 70’s [3]. Glide symmetry is a type of higher symmetries in which a unit cell is translated half its period and mirrored in a glide plane [4–7]. The interesting properties of glide-symmetric structures have been recently investigated for a number of applications such as: gap-waveguide technology [8, 9], ultra wide band lens antennas [10, 11]. Moreover, the recent discoveries in the field of glide symmetries has promoted new research in other higher symmetries, as twist symmetry [12].

In this paper, a planar EBG structure with glide symmetry is proposed and compared to the case with no glide symmetry.

2. Proposed structure and simulated results

The unit cell of the proposed glide-symmetric EBG structure is shown in Fig. 1. The structure is made of square metallic patches similar to those used in [2] for comparison purposes. Two layers of a high permittivity material ($\epsilon_r = 10$) of thickness $t = 1.27$ mm are assumed. The dimensions of the unit cell were initially selected to be $d_x = d_y = 25$ mm and $p_x = p_y = 15$ mm. For the case of no glide symmetry, the square patches are placed on the upper layer with no patches on the first layer as shown in Fig. 2 in order to keep the thickness of the substrate constant in both cases.

Figure 3a shows the dispersion diagram of the EBG structure in the $x$ direction in both cases with and without glide symmetry. These dispersion diagrams have been calculated with the
eigenmode analysis of commercial software. These dispersion diagrams shows that in the case of glide symmetry, the first mode is degenerated into two modes which are connected in Brillouin zone. This is a characteristic of higher-symmetric structures [7]. A finite structure of size $5 \times 5$ unit cells was then simulated with a transient solver, including in this case two physical ports. The results for the transmission coefficient $S_{21}$ are shown in Fig. 3b. These simulation results show that the stop band of the glide-symmetric structure has a lower frequency appearance than the one with no glide symmetry for the same dimensions. Meaning that, a more compact EBG structure can be used with glide symmetry to obtain the same stop band.

![Figure 1: Unit cell of the glide-symmetric periodic structure](image1)

![Figure 2: Unit cell of the periodic structure with no glide symmetry](image2)

![Figure 3: Dispersion diagram of the EBGs](image3)

![Figure 3: Transmission coefficient ($S_{21}$) for a 5 unit cells finite structure](image4)

Figure 3: Simulation results obtained for EBGs made of patches with and without glide symmetry.
3. Conclusions

A planar EBG structure with glide symmetry was proposed in this paper and compared to the case with no glide symmetry. The dispersion diagram as well as the transmission coefficient for a finite structure were presented showing that glide symmetry can be applied to planar EBG structures to miniaturize their size.

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