Eigenstate Equivalent Circuit for Perpendicular-Slot Bi-Periodic Scatterers

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The design of bi-periodic scatterers, such as frequency selective surfaces, transmitarrays, reflectarrays, or rasorbers, is a relevant challenge for the antenna community. The analysis and synthesis of these structures are usually performed by FEM or FDTD full-wave electromagnetic simulation. However, the use of an equivalent circuit has obvious advantages in terms of speed and efficiency, but usually needs a good previous understanding of the structure performance. Some of the authors proposed an equivalent-circuit topology, the Eigenstate Lattice Network (ELN) that allowed the decomposition in eigenstates for bi-periodic scatterers. The circuit can provide physical insight into complex structures and separate their quasi-even and quasi-odd modes. An analytical method to obtain this circuit for single-slot unit cells was proposed in [1]. In this work, it is shown that by separation of the quasi-even and quasi-odd modes by this equivalent circuit, it is possible to greatly simplify the design and analysis of unit cells made of two perpendicular slots.

A crossed-slot unit cell is shown in Fig. 1(a). To simplify the design using this circuit, the slots must be orthogonal, but can be placed within the cell with an arbitrary orientation, φ. Slots are assumed very thin, and etched in perfect electric conductor. Other assumptions are, normal incidence, zero-thickness metallization, and operating frequencies below the diffraction regime. Incidence can be decomposed into two orthogonal polarizations (vertical and horizontal polarizations) and each of these polarizations can be treated as separate ports, as shown in Fig. 1(b). The resulting 4-port network can be analyzed from an eigenstate point of view and its ELN equivalent circuit can be extracted, leading to the one shown in Fig. 1(c). It was found that φ is equivalent to ϕ, λ_1 is only dependent on the length of the first slot, L_1, and λ_2 is only dependent on L_2. This relationship is the same as the one found in [1] for single slots, and the same method can be used to their computation by considering only one of the slots for each immittance. Since the behavior of lossless and zero-thickness structures such as this one is described with only three parameters, having a model that separates them into three physical dimensions independently allows for a very simple design procedure using basic math.

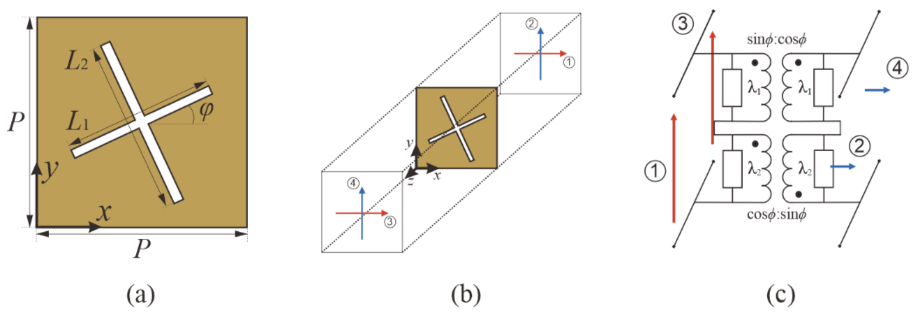

Figure 1. Perpendicular, crossed slots. (a) Unit cell. (b) Sketch of the polarizations. (c) ELN equivalent circuit.

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1. A. Hemández-Escobar, F. Mesa, J. Esteban, E. Abdo-Sanchez, T. M. Martín-Guerrero, and C. Camacho-Peñalosa, "Analytical Eigenstate Equivalent Circuit for Narrow-Slot Bi-Periodic Scatterers," *2023 IEEE International Symposium on Antennas and Propagation and USNC-URSI Radio Science Meeting (USNC-URSI)*, Portland, OR, USA, 2023, pp. 1895-1896.