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Exact Scattering by an Arbitrarily Perforated Planar Sheet Illuminated by Two Plane Waves

To the memory of Thomas B. A. Senior

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This work is to honor the memory of Professor Thomas B. A. Senior who, as Associate Director of the Radiation Laboratory at the University of Michigan, was the work supervisor of the author for the seven-year period 1963-1970. During that period, Senior and the author collaborated on papers and co-edited a book on scattering [1]. In keeping with Prof. Senior's preference for theoretical research on boundary-value problems, this work presents the exact solution of a simple electromagnetic scattering problem.

The structure considered herein is a planar sheet of vanishing thickness made of a material that is either a perfect electric (PEC) or a perfect magnetic (PMC) conductor, in which any number of holes of arbitrary shapes and dimensions have been made. In a complementary manner, one may consider any number of PEC or PMC thin disks of different shapes and dimensions, all lying in the same plane. The analysis is conducted in the phasor domain with a time-dependence factor $exp(+j\omega t)$ omitted throughout.

There are two incident plane waves on the sheet structure, that are the image of each other across the sheet. As a consequence, the total incident field has an electric field (for the PEC case) or a magnetic field (for the PMC case) that is perpendicular to the sheet and has a constant amplitude across the sheet, meaning that the edges of the sheet structure are not excited and that the total field everywhere is simply the sum of the two incident plane waves.

This simple result is verified on two structures for which an exact solution under single plane wave excitation is available [1]: a half plane for which a closed-form solution involves Fresnel integrals, and a strip for which an exact solution involves an infinite series of elliptic-cylinder wavefunctions.

As an application of the general result obtained herein, consider a parallel-plate waveguide containing a PEC thin sheet with arbitrary perforations, equidistant from the plates. Particular cases of such configuration have been examined recently (see, e.g., [2]). For a TM_{2n} (n = 0, 1, 2, etc.) mode, the electric field in the plane of the sheet has constant amplitude and is perpendicular to the sheet; hence, the metal edges in the sheet do not scatter, and the sheet does not perturb the mode.

References

[1] J.J. Bowman, T.B.A. Senior and P.L.E. Uslenghi, eds., *Electromagnetic and Acoustic Scattering by Simple Shapes*, pp. xvii + 728, North-Holland Publishing Co., Amsterdam, 1969. Revised printing by Hemisphere Publishing Corp., New York, 1987.

[2] E.F. Kuester and N. Krull, "Modal analysis of a parallel-plate waveguide containing an internal perforated sheet", *IEEE Trans. Antennas Propag.*, **68**, 5, pp. 3945-3952, May 2020.