SCATTERING FROM AN INFINITE ARRAY OF TRIPOLES IN FREE-SPACE

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Introduction

The use of dichroic or frequency selective surfaces in a wide variety of applications has attracted a significant amount of attention in recent years. These structures are, in general, comprised of a periodic array of metallic patches printed on a dielectric substrate, or of periodic apertures in a conducting screen. Volume and weight constraints imposed by satellite system launch vehicles require that a satellite antenna be capable of multi-frequency band operation and the use of frequency selective surfaces in either the main reflector or the sub-reflector has the potential for meeting this requirement. Another important application is in the area of antenna spatial filtering, which allows an incident wave to pass if it is within the filter's angular passband and rejects those waves that are incident on the surface at angles outside the passband.

In this paper we shall describe our theoretical and experimental investigations into the scattering of a plane wave from an infinite periodic array of tripolar conducting elements and tripolar slots in free space. Furthermore, since an important aspect in the practical implementation of such a surface is the sensitivity of the surface to angle of incidence and polarisation we shall pay particular attention to the transmission response for plane polarised waves at perpendicular and parallel incidence and over a wide range of angles of incidence.

Analysis

The tripole geometry is shown in Figure 1. The problem is to determine the transmission characteristics of an infinite planar array of conducting tripolar elements. The dual problem of transmission through an infinite array of slots in an infinitely thin metal conductor is obtained by invoking the principle of duality. We consider an incident wave on a tripole element array that induces currents on the elements which cancel the tangential electric field at the boundary surface. The induced current gives rise to a scattered field, which by symmetry is the same in the backward and forward directions, and the transmitted wave, therefore, is given by the superposition of the incident and scattered fields.

In order to determine the current distribution on the tripole arms we expand the current in a set of basis functions and by enforcing the boundary conditions on the tripolar elements we obtain the unknown current coefficients using the method of moments. Fourier components were used as the basis functions with current flowing along the arms from the tripole centre. This model leaves a negative line charge across the centre of the tripole which can be smoothed using the patch technique of Rao et al [1].

Having specified the current we determine the scattered field by expanding the field from the periodic array in an infinite set of Floquet modes with unknown coefficients. The amplitude of each mode is found by using orthogonality and applying Amperes theorem to a small element on the current plane and integrating over a periodic unit cell.

Results

Predicted and measured results are presented for tripoles arranged on an equilateral triangular lattice as shown in Figure 1 with a periodicity of 15.5 mm and an arm length and width of 8.5 mm and 3.3 mm respectively. Measurements were made of the transmission characteristics, in both phase and amplitude, as a function of frequency using a free-space bridge arrangement [2]. Figure 2 shows predicted results for two angles of incidence, 0^{o} and 30^{o}. The plane of incidence is the zy-plane and the incident wave is considered polarised parallel to the plane of incidence. Of course if we were to consider an array of magnetic tripoles, that is slots in an infinite conducting screen, then the incident H field would be parallel to the plane of incidence.

Since our experimental measurement of the transmission response of a tripole grid is more accurate than the reflection response it is more useful to measure the response of a tripole element array. Figure 3 shows the phase and amplitude characteristics of a grid of elements for a normally incident wave polarised in the z-direction. Results remain substantially unchanged over a broad range of incidence angles when the plane of incidence is the xy-plane.

Conclusion

Predicted and measured results show excellent agreement over a broad angular and frequency range for different polarisations.

Acknowledgement

We would like to acknowledge the assistance of Mr A W Powell in producing the bulk of the measured results.

References

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2. J.G. Gallagher and D.J. Brammer, "Electromagnetic scattering by an infinite array of periodic broken wires buried in a dielectric sheet", Proceedings 13th European Microwave Conference, Nuremberg, West Germany (September 1983).

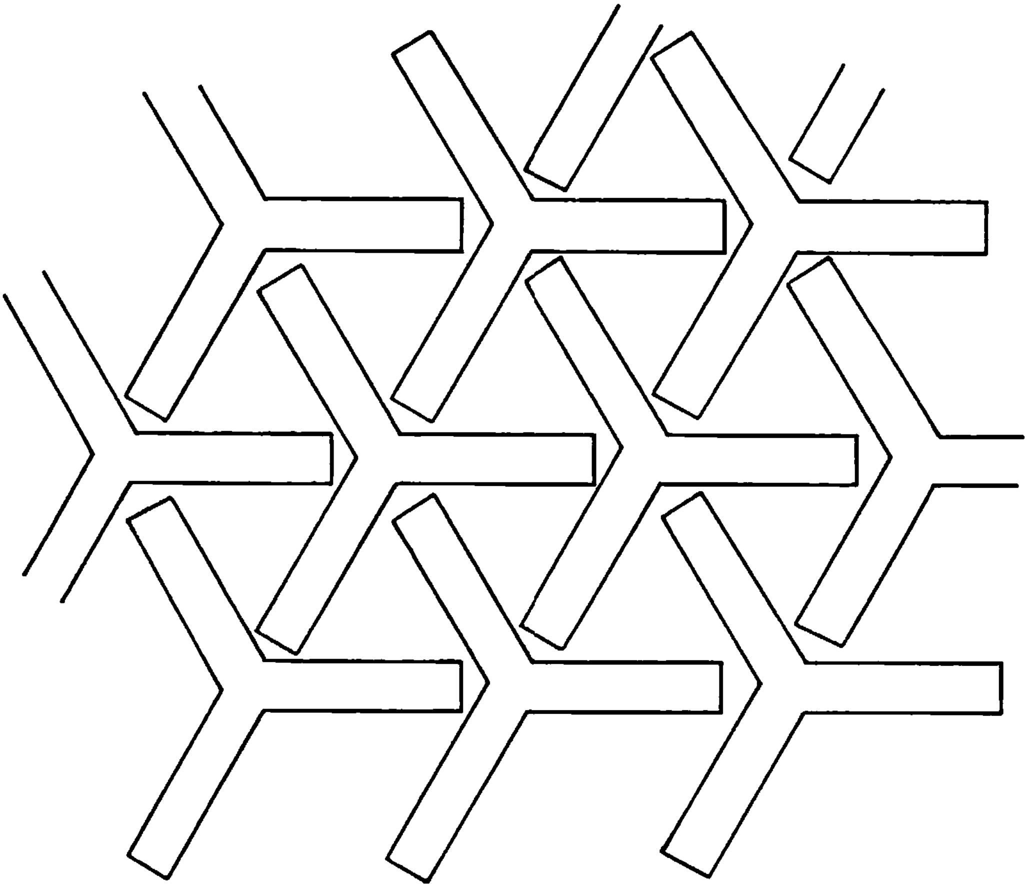

FIG.1 GEOMETRY OF TRIPOLE ARRAY

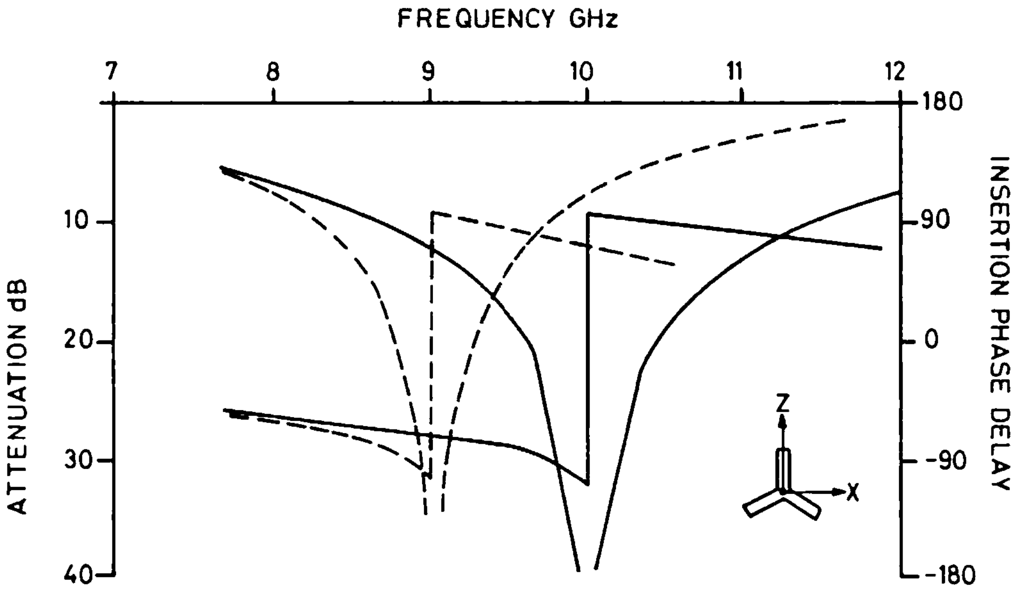

FIG. 2 TRANSMISSION RESPONSE OF TRIPOLE ELEMENT ARRAY AT NORMAL INCIDENCE (SOLID CURVES) AND 30° (BROKEN CURVES)

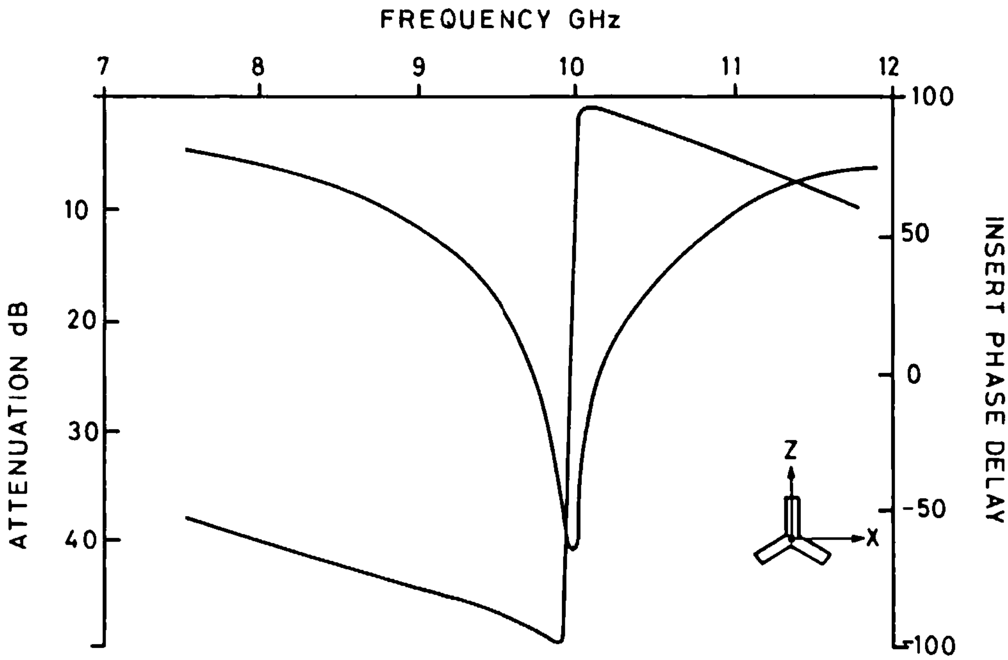

FIG.3 TRANSMISSION RESPONSE OF TRIPOLE ELEMENT ARRAY NORMAL INCIDENCE