2-1 C4

MULTI-FREQUENCY MULTI-FUNCTION ARRAY ANTENNAS

J. H. Provencher and J. E. Boyns

Naval Electronics Laboratory Center
San Diego, California 92152 USA

INTRODUCTION

The concept of using the same area or aperture space to perform several antenna functions has received limited attention. Recently, as the crowding of antennas on operational vehicles becomes more critical, especially, on spacecraft, interest has risen for practical solutions involving the development of an integrated antenna system. Benefits resulting from an integrated antenna are: (1) improvement in system performance due to reduction of mutual interactions between many separated antennas; and (2) more antennas can have a clear look into space.

The feasibility of integrating several functions at different frequencies into one antenna must be investigated in order to outline areas requiring a concentrated study effort. This problem involves considerably more than one antenna configuration since the integrated array antenna design will be more complicated than the conventional array. This paper describes one approach to the integrated array; specifically, that of interlacing several frequency bands into a single aperture. Several problems are evident in the interlaced element approach to any array configuration:

1. Mutual interactions between closely spaced elements operating at different frequencies will be strong.
2. Isolation between the transmit and receive functions must be high for receiver protection.
3. Some elements must be overdesigned to withstand the coupled power radiated by other elements operating at higher frequencies.

APPROACH

Examination of the commonly used antenna functions shows that wavelengths in the 30 cm, 10 cm, 5 cm, and 1 cm bands are commonly used for many functions, using various beam shapes and polarizations. These considerations and the constraints imposed by array element spacing suggest a multiple periodicity type of configuration, which could accommodate three frequency bands that are approximate multiples of each other.

The requirement imposed on the element-to-element spacing to suppress the grating lobes (i.e., D<λ) must be satisfied for the highest operating frequency. When the element configuration is judiciously chosen, three waveguides can be interlaced as shown in figure 1.

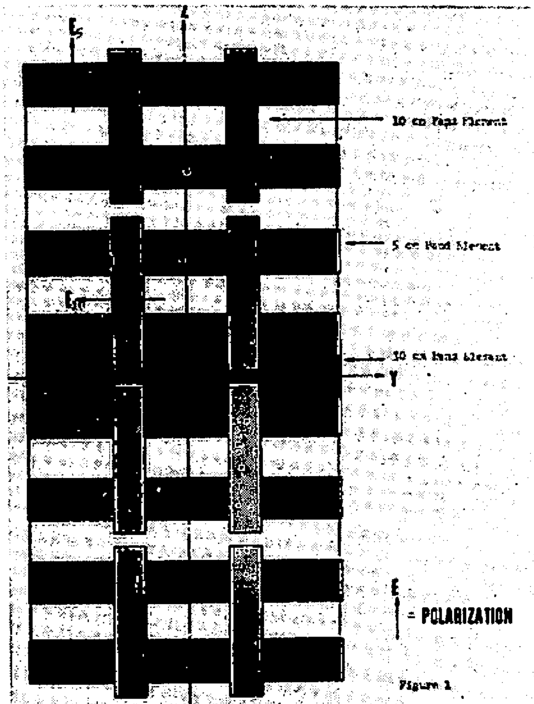

Figure 1

BASIC MODULE FOR MULTIFREQUENCY ARRAY

Some configurations of radiating elements, overall array geometry, and polarization can be used to minimize the effects of mutual coupling. For example, adjacent elements of different frequencies can be cross-polarized. Different sectors of the array can also be used (i.e., by wide separation) to reduce mutual coupling effects, between subarrays. Since a fan beam requires only a few rows of elements and a small part of the overall array, another sector of the array can be used for another function in the same frequency band, but at a different polarization.

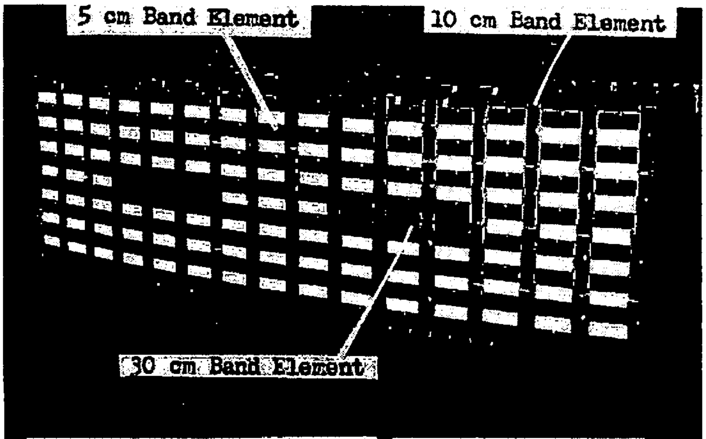

Figure 2 Experimental Multifrequency Array

The choice of array geometry is arbitrary, since the interlacing technique is applicable to either planar or large-radii curved surfaces. There are some advantages to the use of a curved surface and have been discussed in the literature.

DISCUSSION

For array design, knowledge of the interelement coupling parameters or the element pattern in the array environment is desirable. In large planar arrays, the element pattern is essentially identical and is amenable to mathematical manipulation.

For circular arrays, this is not the case. Since the various element patterns maximize in different directions, the element factor cannot be factored out of the array expression and consequently influences the realized gain and sidelobe levels. Once the amplitude and phase characteristics of the pattern are known, patterns can be synthesized by superposition. A recent theory by Sureau and Hessel can be used to determine the amplitude and phase of the pattern. Extension of this method to the multifrequency array would allow prediction of array behavior from element pattern analysis.

Another problem is the effect of coupling between the radiating elements and the propagation of undesired higher-order modes. A judicious choice of waveguide dimensions can reduce the undesired modes.

EXPERIMENTAL ARRAY

This paper describes an experimental array antenna containing three subarrays of interlaced elements with operating wavelengths in the 30-, 10-, and 5-cm bands. The array elements are oriented to take advantage of cross-polarization, to reduce the effects of mutual interactions, and is shown in figure 2.

The array consists of two vertically polarized elements in the 30 cm band; 64 horizontally polarized elements in the 10 cm band; and 120 vertically polarized elements in the 5 cm band.

The elements are arrayed on a partial cylinder 5m. in diameter. The feed systems provide a uniform distribution and phase correction for aperture curvature is included in the design of the power dividers. Since this array is on a large radius curved surface, the results are a good approximation to the planar array.

CONCLUSION

The integration of several microwave antennas into a single area presents considerable design and engineering problems. Some problem areas and techniques that may be useful for seeking a practical solution are discussed. An experimental array for three frequency bands has been designed.