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Broadband TEM Horn Array for FOPEN Radar

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ABSTRACT : This paper describes the analysis, design and test of a broadband TEM horn array for airborne Foliage Penetrating (FOPEN) Radar. Measured results are shown for a 2 x 26 prototype array mounted on a l/l6th scale model of a DeHavilland DASH-7 aircraft. A detailed evaluation of the array performance including platform multipath is discussed.

Key – Word : Antenna – Radar – Fopen – Aircraft – Array - DASH7

1. Introduction

The antenna array described in this paper is designed for airborne FOPEN radar. The array is required to operate over the 216-450 MHz band, with azimuth scanning to +45˚ & -45˚. Because the radar operates from an airborne platform, the antenna elements must be low-profile to minimize drag. A candidate platform, the DeHavilland DASH-7 aircraft, has space for a 2 x 26 array to be mounted on the fuselage. The element spacing was chosen to avoid grating lobes at the highest frequency and scan angle. Scattering from the aircraft wings and propellers degrades the radar performance, and has been quantified by means of scale model measurements.

2. Broadband TEM Horn Design

As is well known, there is a trade-off between bandwidth, volume and efficiency in the design of broadband antennas. This is particularly true for elements in an rray, since they must fit within the spacing required to avoid grating lobes over the frequency and scanning range. Several flared, broadband array elements were considered in this study, including the flared notch, the Bunny-ear, and the TEM horn. The TEM horn [1] was chosen because it employs flaring in two-dimensions, thereby allowing it to be shorter in height than a one-dimensional flare for the same cutoff frequency. Figure 1 shows apicture of a 3 element TEM horn array. The flares are fed at the base via coaxial lines which are 180˚ out of phase.

To begin with, an infinite array FEM/boundary element model [2] was used to design a linearly polarized TEM horn array with the desired capabilities. The infinite array model is efficient for array analysis, since it utilizes periodic boundary conditions. The unknown fields are solved for one unit cell, and all mutual coupling effects are included. In broadband arrays, mutual coupling is particularly significant at the low end of the band, where element spacings are typically less than one half-wavelength. As a result, the coupling environment and resulting input impedance can vary locally for elements near an array edge or corner.

In order to study the non-uniform coupling effects in a finite array, an MIT Lincoln Laboratory integral equation analysis code was used. The starting point for the element-by-element analysis was the infinite array design. The finite array element design was made approximately 50% deeper than the infinite array element in order to function at the same lowest frequency, presumably due to differences in mutual coupling. The resulting element is 30cm deep. It was also determined that the addition of terminated elements at the ends of the array made significant improvements in the matching of the outer active elements.

3. Experimental Results

A series of experimental measurements were made to verify the performance of the array design. Figure 2 shows a plot of the measured and calculated VSWR with respect to 50R for a TEM horn in a full scale 1 x 3 array. There is good agreement between theory and experiment. The measured element patterns in azimuth and elevation for a 1/16‘hscale 2 x 5 array on a 2’ x 2’ ground plane at 7 GHz are shown in Figure 3.

In order to quantify the effects of platform scattering and propeller modulation, a $1/16^{th}$ scale model of a DeHavilland DASH-7 aircraft was fabricated. A picture of the model aircraft with a 2 x 26 array mounted on the fuselage is shown in Figure 4.

4. Conclusion

This paper describes the development of a broadband array for an airborne FOPEN radar application. The array meets the requirements for an airborne array operating from 216-450 MHz, scanning to +45˚& -45˚ in azimuth, and with a moderately low profile (30 cm). The effects of non-uniform element pattern ripple and time-modulated scattering from the propellers on radar performance are currently being assessed, and will be discussed in the presentation.

ACKNOWLEDGEMENTS

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References:

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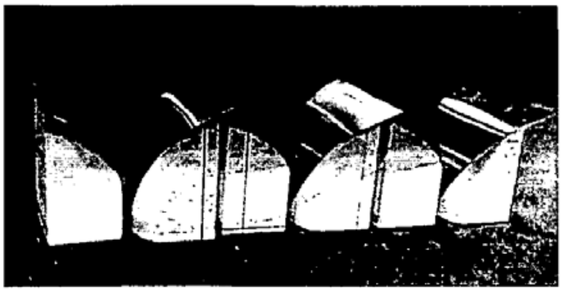

Fig. 1 Prototype 1 x 3 element linearly polarized TEM horn array

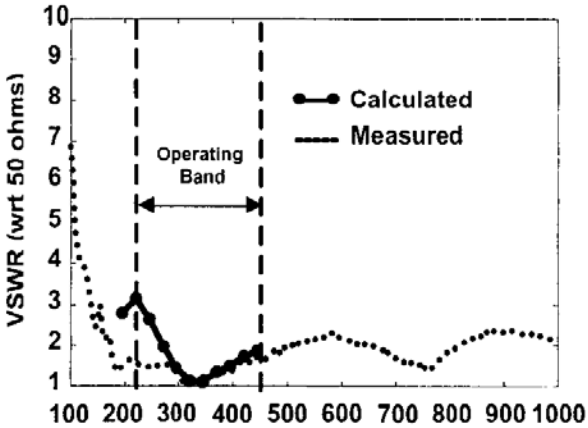

Fig. 2 VSWR vs frequency for center element 1x3 TEM horn array.

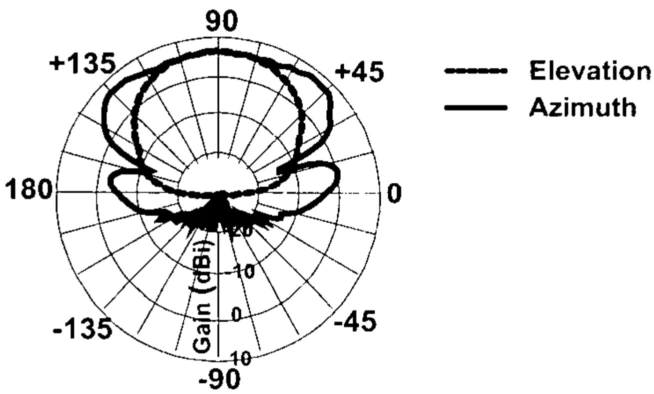

Fig. 3 measured patterns for center column of l/l6th scale 2 x 5 array of TEM horns at 7GHZ on 2` x 2` ground plate .

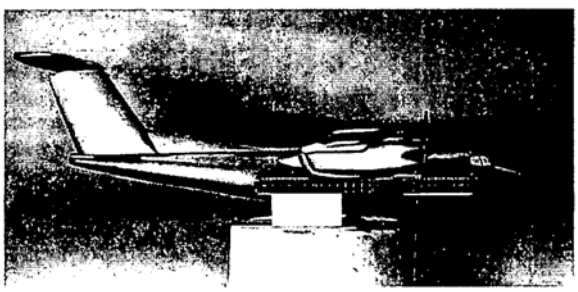

Fig. 4 l/l6th scale model of DASH-7 with 2x 26 array on fuselage.

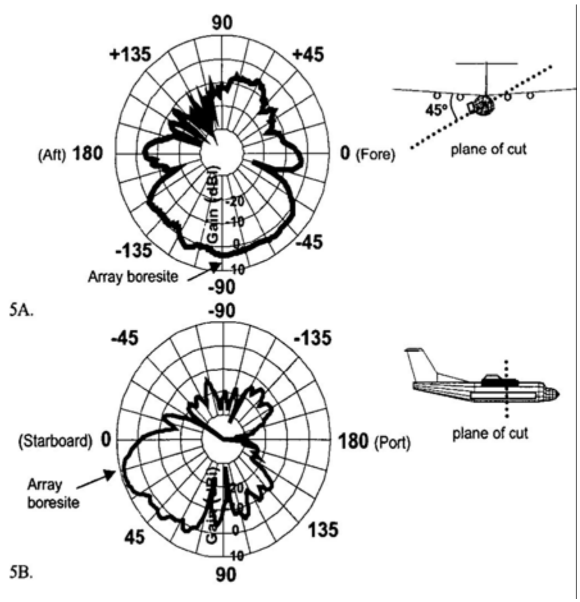

Fig. 5 shows the measured patterns in elevation and azimuth for a 2-element column directly under the wing at 7 GHz. Ripple due to platform multi-path is evident in both planes, with a more pronounced effect in the elevation cut.