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A DUAL-POLARIZED, X-BAND, ELECTRONICALLY SCANNED PHASED ARRAY

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Introduction

A 10.69 GHz electronically scanned phased array, to be used as part of an airborne radiometric sensor system, is described herein. This radiometric system generates two-dimensional brightness temperature maps of the earth's surface in the horizontal and vertical polarization. To provide this two-dimensional coverage a phased array is used to scan a dual-polarized pencil-beam over a ±35 degree field of view along a constant conical surface. The complementary scan is provided by the motion of the aircraft. To remove the angular dependence of the emissive properties of the earth, a constant beam incidence angle with respect to the earth's surface normal is maintained throughout the scan.

To observe how the conical scan can be implemented with a phased array, let us consider an array with a separable aperture distribution. The array factor can be expressed by

$$S(\theta,\phi) = \left(\sum_{-N_x}^{N_x} V_m \exp\left[jm(kd_x \sin\theta\cos\phi \cdot \Delta\Psi_x)\right]\right) \times \left(\sum_{-N_z}^{N_z} V_n \exp\left[jn(kd_z \cos\theta \cdot \Delta\Psi_z)\right]\right) \quad (1)$$

where the array is centrally located in the x-z plane with equal element spacing d_x and d_z, respectively. There are $2N_x+1$ elements along the x-axis and $2N_z+1$ along the z-axis. A linear phase progression $\Delta\Psi_x$ in the z direction, and $\Delta\Psi_x$ in the x direction is also introduced. The peak of the beam, therefore, lies at the intersection of the individual array factors

$$\theta_o = \cos^{-1}\left(\frac{\Delta\Psi_z}{kd_z}\right) \quad (2)$$

and

$$\phi_o = \cos^{-1}\left[\left(\frac{1}{\sin\theta_o}\right)\left(\frac{\Delta\Psi_x}{kd_x}\right)\right] \quad (3)$$

If the array is designed such that $\Delta\Psi_z$ and, therefore, θ_o is fixed, then a change in the linear phase progression $\Delta\Psi_x$ along the x-axis allows one to scan in ϕ along a constant conical surface θ_o. A conical scan can, therefore, be achieved by vertically mounting a planar array with a fixed linear phase progression along this axis to produce the desired beam incidence angle, and by varying the phase progression $\Delta\Psi_x$ along the horizontal axis to produce the desired ϕ scan.

Antenna Description

The antenna configuration shown in Figure 1 is a planar array composed of 51 traveling wave array elements. Each element consists of a section of a nearly square waveguide with 59 crossed-slot pairs milled along one face. By centering each slot pair on the waveguide centerline, the transverse slot only couples into the TE_{10} waveguide mode, and the longitudinal slot to the TE_{01} mode, thereby maintaining polarization isolation. Slot coupling is controlled by adjusting the length of each slot. The slots are, therefore, non-resonant and introduce phase errors to the incoming radiation. Any phase perturbations that tend to separate the two orthogonally polarized beams can be

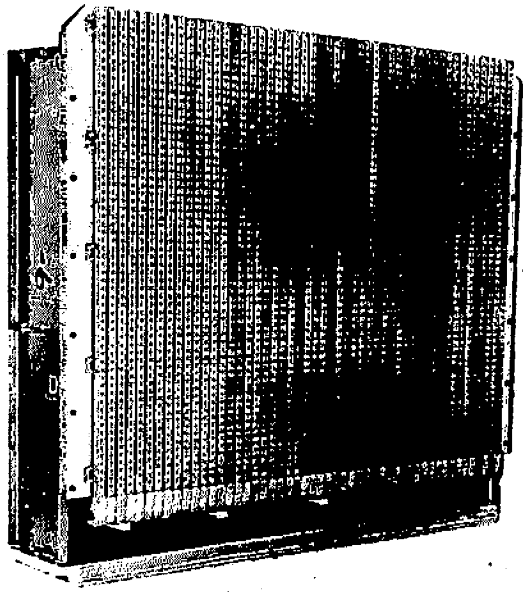

Figure 1. Dual-Polarized Array

compensated for by adjusting the waveguide cross-section such that the beams are coincident. The waveguide size is also selected to provide the proper phasing to achieve the desired beam incidence angle. Since the array acts as a leaky waveguide, 10 percent of the input power is dissipated in an end termination.

A transducer section, that includes an orthogonal mode transducer with horizontal and vertical output ports, is attached to the end of each array element. The transducer separates the two polarized signals from each element and transfers this energy to two separate and identical feed arrays.

A set of Reggia-Spencer ferrite phase shifters is placed in the ports of each feed array. With the antenna mounted vertically, the imposition of a varying linear phase distribution by the ferrite phase shifters allows both polarized beams to be scanned in unison, maintaining a constant beam incidence angle. Because scanning is accomplished electronically, high scan speeds can be attained.

The aperture size of 43.86 inches in the array element direction, and 36.58 inches in the feed array direction, is designed to produce a 3.0-degree by 1.8-degree half-power beamwidth, respectively, at the central beam position. A -35 dB sidelobe Taylor distribution is incorporated along both array directions.

Summary

The phased array described has been fabricated and is currently undergoing laboratory and range tests. Preliminary data indicates that the array is performing in accordance with stated design principles. A full complement of data will be available in a few months.

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