

**' N78-30464**

**A DUAL POLARIZED ANTENNA SYSTEM  
USING A MEANDERLINE POLARIZER**

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Certain applications of synthetic aperture radars, e.g., aerial crop surveying, require transmitting on one linear polarization and receiving on two orthogonal linear polarizations for adequate characterization of the surface. To meet the current need at minimum cost, it was desirable to use two identical horizontally polarized shaped beam antennas and to change the polarization of one of them by a polarization conversion plate. The plate was realized as a four-layer meanderline polarizer designed to convert horizontal polarization to vertical (see Figure 1).

Meanderline polarizers have been used before to convert linear polarization to circular.<sup>[1, 2]</sup> The linear wave is conceptually split into two components which are separated in phase by 90 degrees to yield circular polarization. If the phase shift is increased to 180 degrees, linear polarization results in the orthogonal sense from the original wave.

The mechanism used for splitting and separating the components is the meanderline circuit. A plane containing a regular pattern of circuits will be a reactive surface to an incident wave, appearing inductive to any E-field component parallel to the run of the lines and capacitive to any component perpendicular to the lines. A series of such sheets can be modeled as a pair of periodically loaded transmission lines where the capacitive or inductive loadings act to retard or advance the phase of the incident wave. By adjusting the reactance values, the spacings between the sheets, and the angle of the meanderlines with respect to the incident wave E-field, any input polarization may be converted to any output polarization.

**The question of nonnormal incidence arises because of the present application. All of the available theory assumes normal incidence on the plane containing the circuits. However, in calculating the effects of wave passage across a dielectric boundary, the properties of the boundary are constant. The incident wave is considered to travel across normal to the surface, and the effects of nonnormal incidence angles are accounted for in the propagation constant and in the free space impedance. Dielectric material properties are invariant with incidence angle. It is therefore reasonable to consider that the same would apply to reactive surfaces.**

**Laboratory tests have confirmed that the circuit susceptance is independent of incidence angle, at least over the range of angles observed. Tests were made with a standard flat-panel testing table where the phase and amplitude of the transmitted wave were monitored as a function of incidence angle. The measured insertion phase difference was compared with computed insertion phase differences assuming that the susceptance of the surface is a constant. The results were virtually identical and well within experimental error (see Figure 4).**

**A polarizer was constructed using four layers of meanderline sheets separated by precisely machined foam spacers. Because bandwidth was not a criterion in this application, all four layers were identical. The spacers were chosen for the best impedance match for up to 30 degrees incidence angle, considering all glue layers, mylar substrates, etc. The polarizer was then attached to the shaped beam antenna at about a 20-degree angle, as shown in Figure 1.**

**The performance of the polarizer was very much as expected, except for a high cross-polarized energy level (see Figures 2 and 3). The effect of the conversion on the shape of the shaped beam was negligible, as was the effect on the VSWR. The cross-polarized energy proved to have two sources. One source was a result of the small yet significant reflection**

from the polarizer returning to the antenna. As the reflection is also rotated in polarization, some of this energy is reflected from the face of the antenna again, giving rise to a very low Q cavity. Radiation ultimately occurred at the undesired polarization. This component was removed by including a resistive card mode suppressor between the polarizer and the antenna, and actually manufactured as part of the polarizer assembly.

The second source of cross-polarized energy was traced to the existence of surface waves on the polarizer. Two dominant waves could be expected, and these could be expected on the outside of the finished assembly as well as between the sheets. These modes leaked and manifested themselves as a grating lobe structure in the cross-polarized response. Various efforts were made to reduce these modes, including absorber along the edges, staggering the circuit elements, etc., but none had any beneficial effect. Because this response was sensitive to the angle of the polarizer with respect to the antenna, an angle was ultimately selected which minimized the cross-polarized energy.

The two antennas of the dual polarized system were arranged one above the other. Because the shaped beam looked down, the modified antenna was placed on top to avoid interception of energy from the adjacent antenna. This arrangement resulted in a higher cross-polarization level in the modified antenna, but still within acceptable limits.

This research was performed for Johnson Space Center under NASA contract NAS 9-15007.

#### References:

1. Blakney, T.L., Burnett, J.R., Cohn, S.B.: "A Design Method for Meanderline Circular Polarizers." 22nd Annual Antenna Symposium, October, 1972.
2. Young, L., Robinson, L.A., Hacking, C.A.: "Meander-Line Polarizer." IEEE Transactions on Antennas and Propagation, May, 1973.

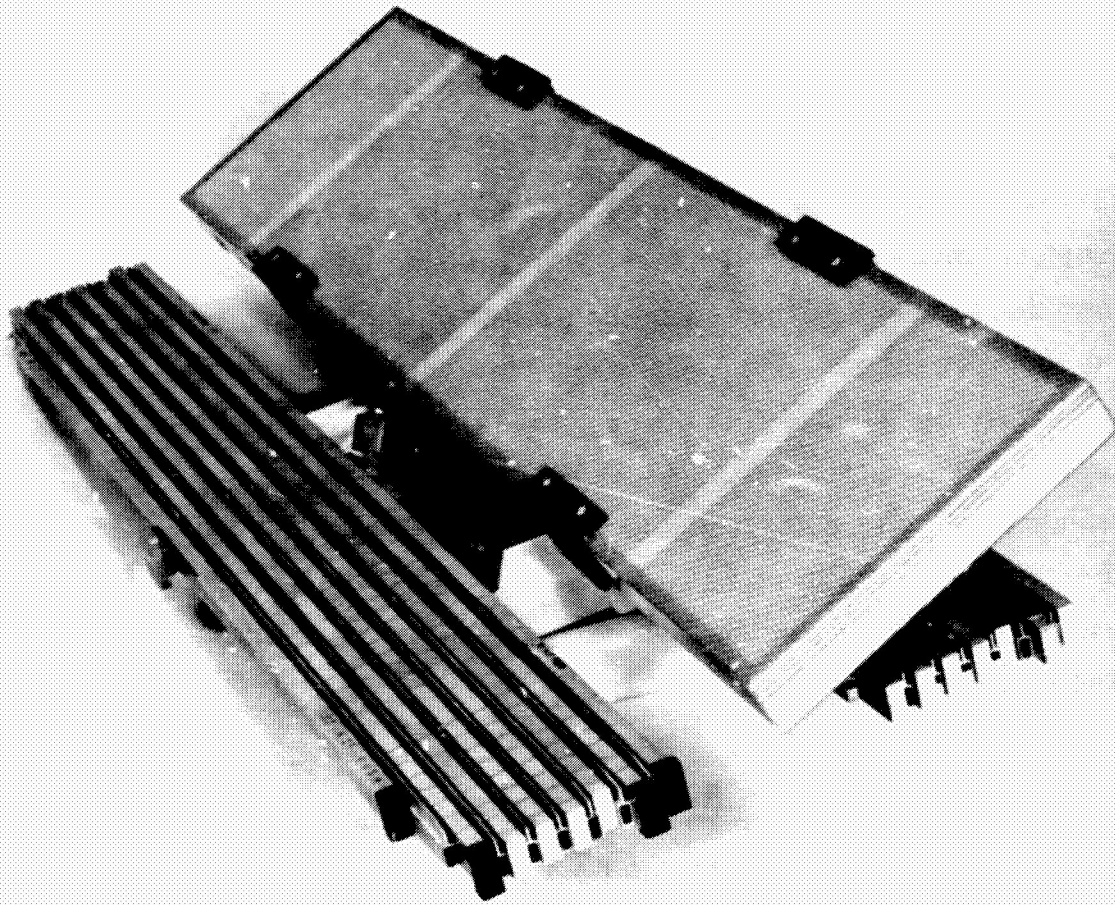


Figure 1 - Dual Polarized Antenna Assembly

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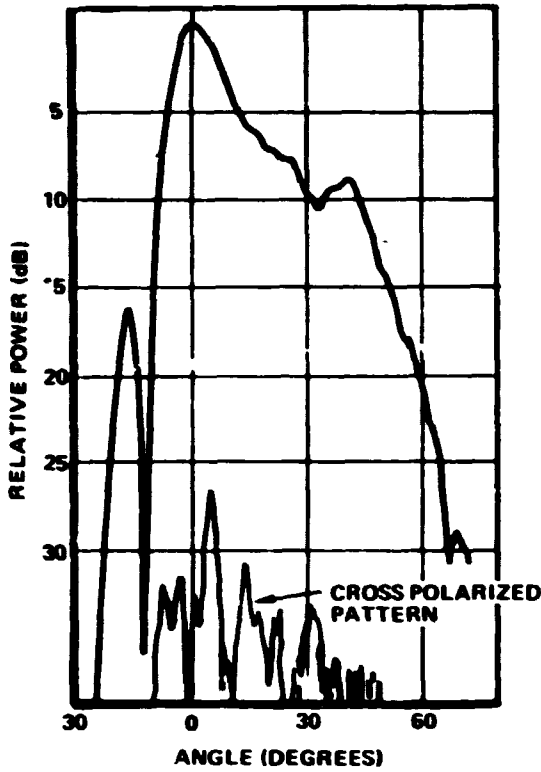


Figure 2 - Horizontally Polarized Array Elevation Pattern (Bottom Array)

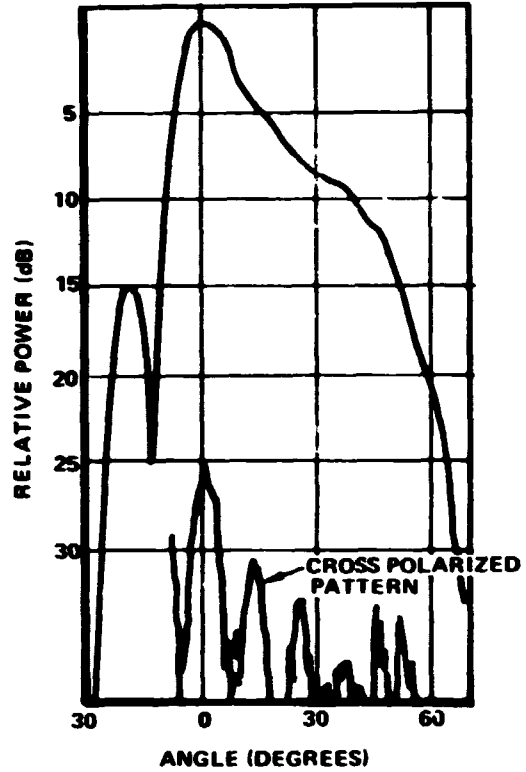


Figure 3 - Vertically Polarized Array Elevation Pattern (Top Array with Polarizer)

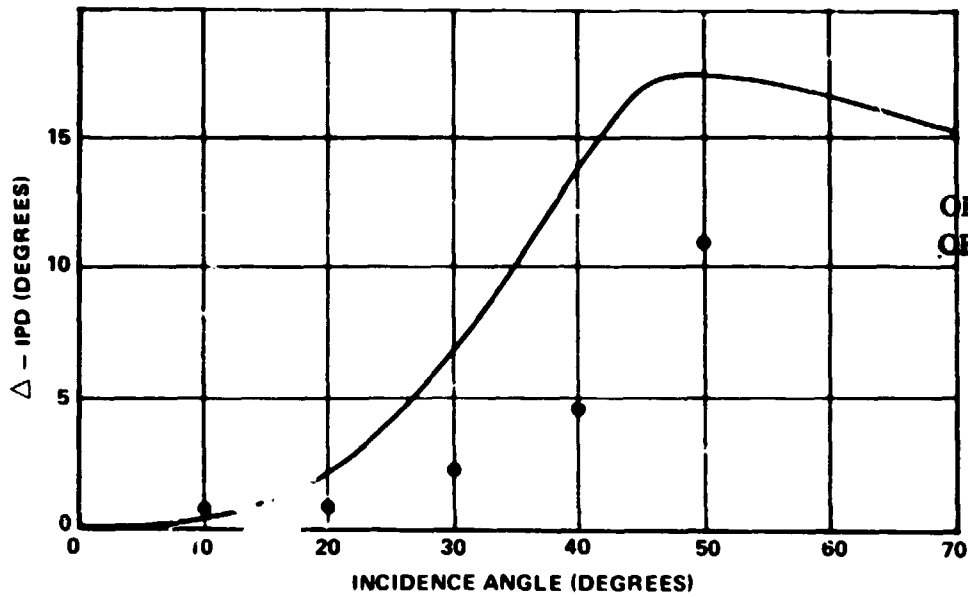


Figure 4 - Expected and Measured Change of Insertion Phase Difference with Incidence Angle of A Representative Sandwich Assembly

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THURSDAY, MARCH 9, 1978

V. DATA PROCESSING (1:30 - 5:20), Chairman: F. T. Barath, Jet Propulsion Laboratory

- 1330 1. "Effects of Range Bin Shape and Doppler Filter Response in a Digital SAR DATA Processor," C. R. Griffin . . . . . V-1-1
- 1400 2. "A Pipeline Array Processor Architecture for Polynomial Transform Implementation of SAR Image Processing," T. A. Kriz and D. F. Bachman . . . . . V-2-1
- 1420 3. "Electronic SAR Processors for Space Missions," C. Wu . . . . . V-3-1
- 1510 4. "Custom Large Scale Integrated Cirucits for Space-Borne SAR Processors," V. C. Tyree, . . . . . V-4-1
- 1540 5. "Real-Time SAR Image Processing Onboard a Venus Orbiting Spacecraft," W. E. Arens . . . . . V-5-1
- 1610 6. "The Modification of the SAPPHIRE Processor for use with Earth Imaging Radar," L. R. Moyer . . . . . V-6-1
- 1640 7. "Application and Limitation of Very Large Scale Integration In SAR Azimuth Processing," D. Kuhler . . . V-7-1
- 1700 8. "The Effect of Weighting on Time Sidelobe Suppression," A. Di Cenzo . . . . . V-8-1