A NEW KIND OF FEED WITH TWO ORTHOGONAL POLARIZATIONS

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INTRODUCTION

A new kind of feed with two orthogonal polarizations over a wide bandwith is described in this paper. The feed operates with a novel splashplate design that acts both as a secondary reflector and a mode converter. The feed obtains good isolation of two orthogonal linear polarizations. It is suitable for applications where polarization reuse or discrimination is important; for example, satellite communications and radar.

CONSTRUCTION AND OPERATION THEORY

The feed is shown in Figure 1. It consists of a circular splashplate with skirt, screw, a square waveguide transition, and a dielectric loading section. A wave is traveling from the source into the dielectric transition and then up to the tip of the screw. At the screw the mode is converted into another mode shown in Fig. 1(b). The wave cannot go through the gap between splashplate and aperture in the H plane, the left or right of Figure 1(a). The walls of the waveguide short out the E field. However, the wave in the E-plane can go easily between the splashplate and waveguide into space. The skirt of the splashplate reflects the wave back down the sides of the waveguide and to the main reflector.

The feed shown is used to terminate a square waveguide which mounts along the center line of the antenna. The waveguide can carry either vertical or horizontal polarization, or it can carry both polarizations simultaneously for frequency reuse applications or for cross-polarization radars. The square guide can also carry circular polarization (V plus H 90° out of phase) for either right-hand or left-hand polarization or both simultaneously.

As described, the splash and screw together act as a mode converter. Adjusting the length of the screw improves the return loss in the feed. The skirt of the splash plate is used to change direction of the wave to return it to the reflector and to control the pattern of the feed. The polystyrene insert is used to support the splashplate. Its main electrical function is to reduce the size of the aperture of the waveguide by dielectric loading. The reduced waveguide size reduces blockage of the main reflector by the feed and guide.

The feed has good isolation between the two linear polarizations. The mode converter concentrates energy in the E plane as shown in Fig. 1(b). The gap between the splashplate and the waveguide wall is so small that the cut-off wavelength is shorter than the operating wavelength when the E field is parallel to the wall of waveguide. The wave will not go through the gap. The wave, whose E field is perpendicular to the wall of the waveguide, can easily go through the gap. The gap is like a space filter. Because two waves with two orthogonal polarizations go different ways in space, as shown in Figure 2, the feed has good isolation between the two linear polarizations. The feed is suitable for some satellite communications and radar where two pure linear polarizations or circular polarizations are required.

DESIGN PROCEDURE

The most important parameters of the feed are its radiation pattern of feed and its return loss (or VSWR). The design procedure is to optimize these two parameters.

The first step of design is to choose the aperture size of the pyramidical waveguide (the top of the tapered square waveguide section). The aperture should be as small as possible because the guide causes blockage to the wave as it travels back from the splash plate to the main reflector and affects the pattern of the feed. But the aperture cannot be too small because the wave will not go through it if the operating wavelength is greater than the cut-off wavelength. To minimize the size, the aperture is fully filled with polystyrene. The polystyrene tapers to a point as it goes back down the square waveguide. This taper provides a smooth transition to the air-filled guide; its dimensions are not critical. Alternative designs could have the entire waveguide filled with dielectric.

The second step is to choose the diameter, cone angle, and length of screw. These dimensions mainly affect the return loss. Diameters from 0.5 inches to 0.7 inches were used successfully in the experiments (the frequency is 3.75 to 4.25 GHz). Smaller diameters were not able to achieve satisfactory return loss. Cone angles from 60° to 120° were used satisfactorily. The screw length was best when the tip of the screw just goes into the aperture of the pyramidical waveguide.

The third step is to choose the diameter of the splash. It is about 1 , but would vary with the F/D of the antenna. The distance between the splashplate and the aperture of the waveguide is adjusted to minimize return loss. The form of skirt is chosen to make the pattern of the feed suitable for the F/D ratio of the reflector. The distance between the splashplate, the aperture, and the length of the screw are the main factors affecting return loss. The shape of the splashplate, skirt, and screw used were round. However, it is expected that these components could be square in cross-section with similar results.

The design of the transition or pyramidical waveguide is complicated. At the top aperture, the waveguide is fully filled with polystyrene. The polystyrene tapers to a point as e square waveguide widens. The taper shown in Fig. 1 was found to be satisfactory; reflections are negligible over the required bandwidth. A more rapid taper was not satisfactory. A more gradual taper is safer if the length of waveguide that is available can stand a longer taper section. This will depend on the F/D ratio and on other uses of the guide; for example, for polarizer or feed points.

EXPERIMENT RESULTS

The feed shown was tested. Its return loss is better than -20 dB over the band from 3.7 GHz to 4.2 GHz. The feed with a polarizer in the square waveguide section and reflector together compose a system. The ellipticity of the antenna was about -1 dB (ellipticity of the polarizer alone was -0.7 dB). The whole antenna system was successfully used in Rome, Italy, for the Intergovernmental Bureau of Informatics (IBI), providing reception of Intelsat transmissions on 1.2 M diameter antennas. The transmissions were spread-spectrum data.

REFERENCES

[1] R. C. Johnson, "Design of linear double tapers in rectangular waveguide," IRE Trans. Microwave Theory and Techniques, Vol. MTT-7, pp. 374-378, July 1979.

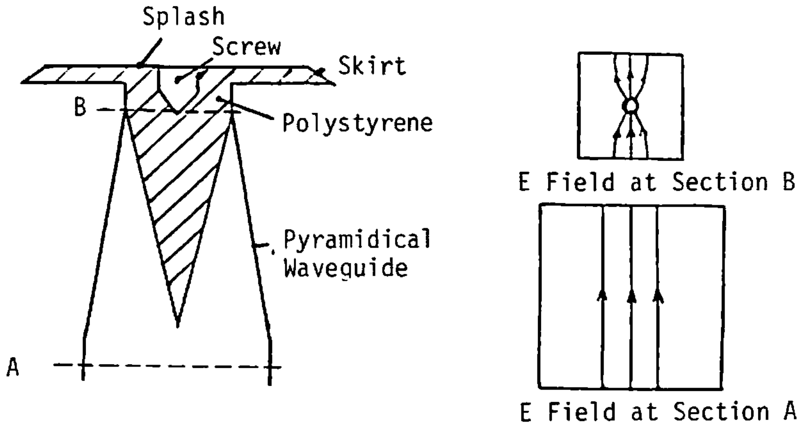

Figure 1. Feed Geometry and E-Field Modes

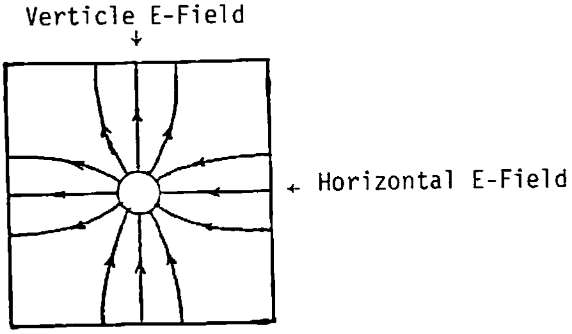

Figure 2. Orthogonal E-Field Modes in the Waveguide Feed