NASA TECH BRIEF

Dielectric Prisms Would Improve Performance of Quasi-Optical Microwave Components

The problem:

Use of conventional, single-mode, rectangular waveguide in the millimeter and submillimeter range is accompanied by large waveguide losses, which increase with frequency. One way of minimizing these losses is to use oversize waveguide for various functional elements such as attenuators, couplers, and phase shifters. In these cases the microwave signals behave in a quasi-optical manner, permitting the use of many standard optical components and techniques. In one technique, a double prism has been used as the basic element in conjunction with oversize waveguide. In this technique the input signal is split at the air gap between the two prisms, part of the signal being reflected as one output and part transmitted as a second output. The energy division depends on the gap distance and the wavelength. Reflection losses occur at the input and output surfaces, making it necessary to use impedance matching methods to reduce the VSWR. One way of accomplishing the reduction is to use a fine comb structure cut into the input and output faces of the prisms. This double-prism approach has a number of disadvantages, which include the following: (1) The comb structure is narrowband, and becomes increasingly difficult to fabricate as the frequency increases. Other impedance-matching methods are either narrowband, or lossy, or both. (2) The parallelism of the inner surfaces of the prisms must be accurately maintained as the gap is varied in order to have accurate and repeatable performance. This requirement presents a mechanical alignment problem. (3) The energy division is frequency dependent.

The solution:

The properties of the Brewster angle (the one angle of incidence of a polarized light wave in the plane of incidence at a dielectric interface for which the reflected signal is zero) and internal reflection in a dielectric prism are proposed as the basis of a new type of element for use in oversize waveguide. Precision broadband attenuators, phase shifters, and directional couplers can be constructed on the basis of these properties. In principle, the performance of these devices depends only on the geometrical configuration and the dielectric constant of the constituent material. Because this constant is nearly independent of wavelength over a waveguide bandwidth, the devices should be inherently broadband. With the input and output signals at the Brewster angle, reflection losses would be at a minimum, and no impedance matching networks should be required. The overall reflectance and admittance may be calculated directly by means of the Fresnel equations. Low-loss dielectric materials (plastics, ceramics, quartz) commonly used in microwave devices are suitable for the dielectric prisms. For an amplitude modulator, the dielectric prism would consist of a ferrite.

Note:

Inquiries concerning these devices may be directed to:

Technology Utilization Officer
Electronics Research Center
575 Technology Square
Cambridge, Massachusetts 02139
Reference: B67-10416

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

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Category 01

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