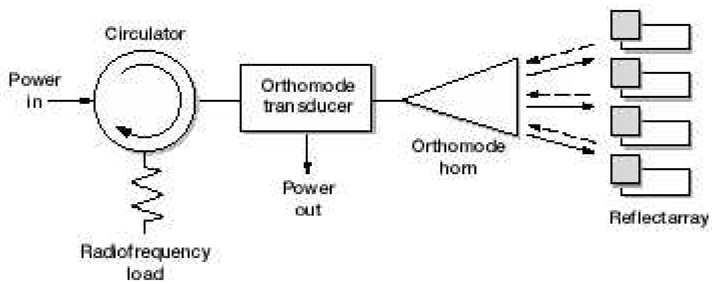
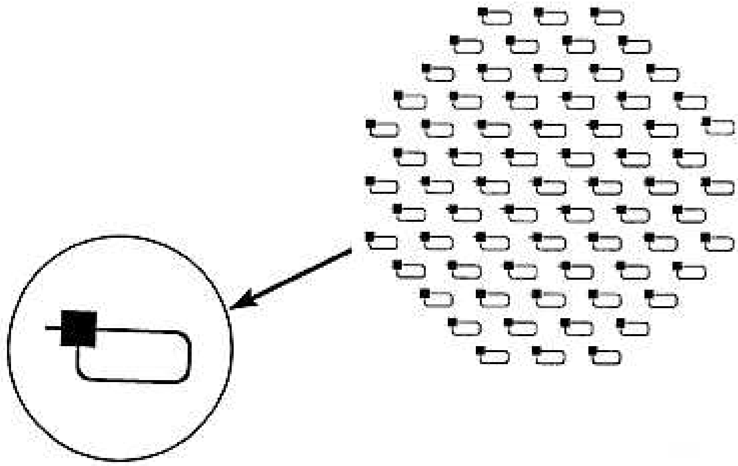
Reflectarray Demonstrated to Transform Spherical Waves Into Plane Waves

The development of low-cost, high-efficiency array antennas has been the research focus of NASA Lewis Research Center's Communications Technology Division for the past 15 years. One area of current interest is reflectarray development. Reflectarrays have generally been used to replace reflector antennas. In this capacity, different configurations (such as prime focus and offset) and various applications (such as dual frequency and scanning) have been demonstrated with great success. One potential application that has not been explored previously is the use of reflectarrays to compensate for phase errors in space-power-combining applications, such as a space-fed lens and power-combining amplifiers. Recently, we experimentally investigated the feasibility of using a reflectarray as an alternative to a dielectric lens for such applications. The experiment involved transforming the spherical waves from an orthomode horn to plane waves at the horn aperture. The reflectarray consists of square patches terminated in open stubs to provide the necessary phase compensation.



Horn/planar array power-combining arrangement.

The preceding diagram illustrates the conceptual layout of a horn/planar array power-combining arrangement. An orthomode horn was used to transmit vertically polarized fields to a planar array of patch radiating elements, each connected to a feedback loop of microstrip line as shown. The following figure shows the reflectarray and one of its patch elements. The phase-compensating devices were stubs or open-circuit transmission lines. The stub electrical length for a patch at the aperture center was adjusted in relation to the one displaced from the center such that it produced a phase delay that converted the spherical wave front to a planar wave front. The vertically polarized field received by the patches was phase delayed and then retransmitted to the horn in horizontal polarization. An orthomode transducer at the horn input isolated the two polarized waves.



Reflectarray and its radiating element.

For comparison, the absolute transmission scattering parameter S_{12} was measured at the horizontal port of the orthomode transducer for an identical array without phase compensation and for the same array with a three-layer dielectric lens for phase compensation. The lens was placed inside the horn about 2 inches from the horn aperture. The array was mounted at the horn aperture against an aluminum plane that was securely bolted to the rim of the horn. For frequencies ranging from 16.0 to 17.5 GHz, the maximum reradiated horizontally polarized electric field from the array was on the average about -13 dB without phase compensation across the aperture; whereas the measured S_{12} when the phase was corrected by a reflectarray improved 4 dB on the average, and the measured S_{12} when the phase was corrected with a lens improved about 8 dB on the average. Although the difference between these two results indicates that more accurate phase information is needed to optimize the performance of the reflectarray for proper phase compensation, the feasibility of the reflectarray concept has been established as an alternative to using a dielectric lens in space power combining.

Although the reflectarray demonstrated for this space-power-combining application was passive, this concept is being extended to an active reflectarray where each antenna element is integrated with a solid state power amplifier. Some advantages of using an active reflectarray include smaller aperture sizes and a higher power-combining efficiency due to lower power combiner loss.

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