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MICROSTRIP REFLECTARRAY AND ITS APPLICATIONS

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1. Introduction: Microstrip reflectarray antenna has recently been investigated by several institutions. It has been found that this antenna, as a high-gain radiator in many instances, performs electrically, as well as mechanically, better than a parabolic reflector. This antenna consists of a very thin, flat reflecting surface and an illuminating feed, as shown in Figure 1. On the reflecting surface, there are many isolated microstrip patch elements and no power division network. A feed antenna illuminates these microstrip elements, which are designed to scatter the incident field with the phases required to form a planar phase front. This operation is similar in concept to the use of a parabolic reflector, which naturally forms a planar phase front when a feed is placed at its focus. Hence the term "flat reflector" is sometimes used to describe the microstrip reflectarray. The name "reflectarray" represents an old technology [1]. However, the low-profile printed microstrip reflectarray is a fairly new concept [2,3,4] which combines some of the best features of the microstrip array technology and the traditional parabolic reflector antenna. Its potential applications in the commercial area, space, and military are abundant.

2. Advantages: The advantages of a microstrip reflectarray, when compared with a parabolic reflector or a conventional array, are many folds: a) Surface mountable: The antenna's thin and flat reflecting surface can be flush mounted onto its mounting structure, such as a mobile vehicle, a spacecraft, or a building with less supporting structure mass and volume as compared to a curved parabolic reflector. The antenna's reflecting surface can also be mounted conformally onto a slightly curved structure (either concave or convex). The phase deviation of the slightly curved structure can be compensated for in the design of each patch element's delay phase. b) Scannable beam: The main beam of the antenna can be designed to point at a large fixed angle (up to 60°) from the broadside direction, while the parabolic reflector can only have limited beam tilt (a few beamwidths). The main beam of the microstrip reflectarray can be electronically scanned by implanting phase shifters into the phase delay lines as shown in Figure 2 or mechanically scanned [5] by miniature motors as depicted in Figure 3. With the mechanical scanning technique, complicated beamformer and high-cost T/R modules are no longer needed. c) High reliability: Since all the elements in the reflectarray are isolated from each other, the failure of a few elements will have insignificant impact on the performance of the antenna with thousands of elements. If 1/10 of the total elements fail to function, the loss in antenna gain is only 0.5 dB. Graceful degradation is certainly one significant advantage of this antenna. d) Low manufacturing cost: The reflectarray, being in the form of a printed microstrip antenna, can be fabricated with a simple and low-cost etching process, especially when produced in large quantities. e) Very large aperture antenna: Due to the fact that no power divider is needed, the resistive insertion loss of thousands of microstrip patches in the reflectarray is the same as that of a few patch elements. Thus, the reflectarray can achieve relatively good efficiency as an electrically large array antenna system. There is one shortcoming associated with the microstrip reflectarray when compared to the parabolic reflector -- its narrow bandwidth. Calculations [5] have indicated that, with special attention paid to the design, a 10% bandwidth is achievable by the microstrip reflectarray. Another performance factor that generally concerns the designers is the antenna efficiency. Recent work [6] has indicated that an efficiency in the range of 50% to 70% is achievable by this type of antenna.

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3. Applications: Due to its low profile, small mass, and low cost, the microstrip reflectarray has several potential applications. One is the Ku-band Direct Broadcast Satellite (DBS) antenna. The flat reflectarray can be surface mounted on a building's side wall or rooftop as that depicted in Figure 4. Not only does it take less space, but it is also aesthetically more appealing. The other application will be for the DBS mobile vehicle antenna. The antenna can be mounted on the rooftop of a large vehicle, such as a van or an RV, for satellite television reception. The antenna, shown in Figure 5, has an elliptical aperture and is mechanically steered in azimuth to track the satellite as the vehicle moves about. The elliptical aperture is intended for wider elevation beamwidth so that slight yaw or pitch motion of the vehicle will not cause significant signal fade. The third possible application is that, due to its flat reflecting surface, the printed reflectarray can be easily deployed to form a large aperture for space application as that depicted in Figure 6. The deploying mechanism can be the simple folding type with spring-loaded hinges. For spacecraft applications, very often both the antenna and the solar array panels are very large structures. It is thus advantageous to combine the two large structures into one. One technique is to use the back of the flat reflectarray for solar array. However, when both the solar array and the antenna are required to be placed on the same side of the panel, the approach of using reflectarray with printed dipoles [7], instead of patches, can be used. As illustrated in Figure 7, most of the sun light will penetrate through the dipole and meshed ground plane layers and illuminate the solar array effectively. Another important application is that, because the amplitude and phase of the antenna aperture can be adjusted by varying the sizes of the patch elements or by varying the phase delay line lengths, the reflectarray, as a spacecraft antenna, can provide configurable shaped beams for different Earth coverages. Since thousands of elements are generally needed in a reflectarray with reasonable aperture size, the degree of freedom in adjusting the amplitudes and phases are tremendously higher than that of a parabolic reflector. Thus, a configurable beam can be more precisely synthesized and achieved by a reflectarray than by a parabolic reflector.

References:

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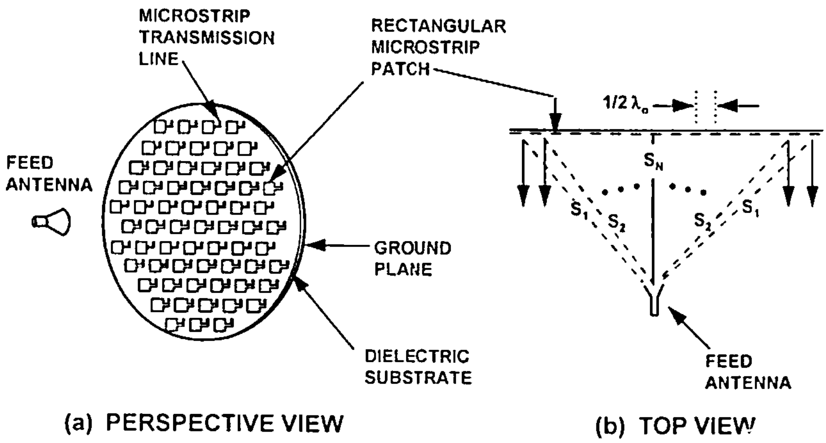

Figure 1. Microstrip reflectarray configuration.

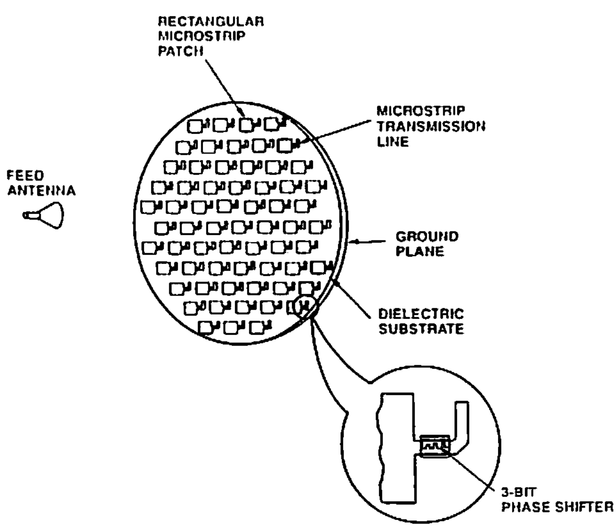

Figure 2. Electronically scannable microstrip reflectarray.

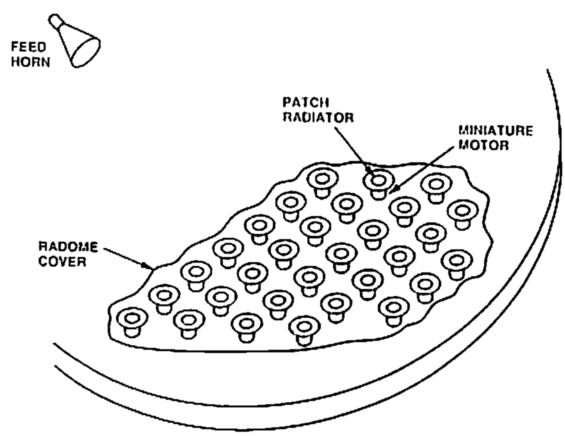

Figure 3. Mechanically scannable microstrip reflectarray.

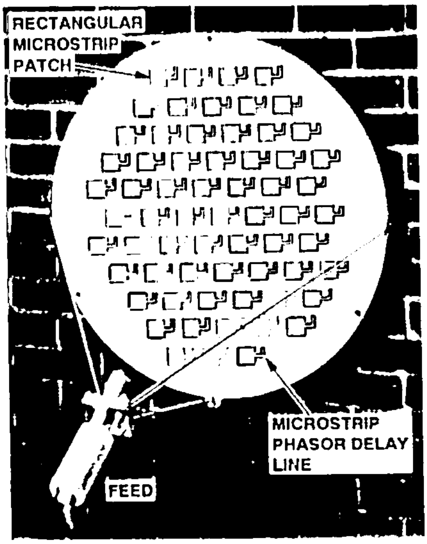

Figure 4. Flat reflectarray for DBS application.

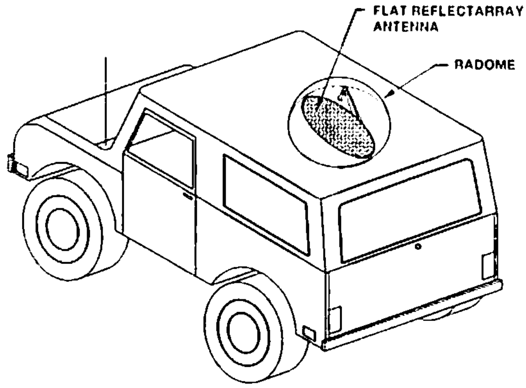

Figure 5. Satellite tracking mobile reflectarray.

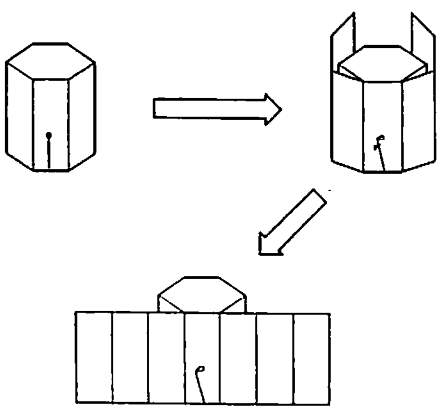

Figure 6. Large deployable reflectarray for spacecraft application.

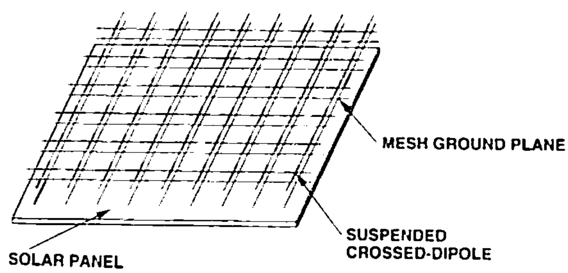

Figure 7. Concept of integrated solar array/ reflectarray panel.