A Comparison of Two Techniques for Making Transparent Microstrip Antennas for CubeSats

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Wire antennas that require mechanical deployment are often used on CubeSats, and can be made quite sophisticated. Microstrip patch antennas are low profile and can be made reconfigurable, and are a good candidate for CubeSats to replace wire antennas to improve mission reliability. In one approach the microstrip antenna (including the patch surface, the antenna ground plane, and the substrate) is designed to be transparent. The antenna can then be placed directly on top of a solar panel without blocking the light.

There are two methods for fabrication of a transparent patch antenna that have been explored in the past: using transparent metal and using a wire-mesh design. The transparent metal ITO (indium tin oxide) has a comparatively high sheet impedance, which makes the antenna less efficient. Also, there is a trade-off between conductivity and transparency with ITO. The wire-mesh structure can have a high transparency and a high efficiency. However, its fabrication may be more expensive than for a conventional patch antenna, since for transparent materials like quartz there is no copper cladding surface. Hence, the conducting wires have to be deposited directly onto the quartz instead of being etched or milled from a copper surface as they would be for a conventional substrate.

Another, less expensive, approach that is proposed here is based on standard substrate board materials like Rogers Duroid with top and bottom surface cladding. Holes are drilled through the structure in order to achieve a partially transparent patch, ground and substrate. Hence, the substrate becomes an artificial substrate whose relative permittivity depends on the permittivity of original substrate and the filling factor, i.e., the ratio of the remaining substrate volume relative to the total volume.

Simulations at 2.4 GHz are done using linearly-polarized microstrip antennas. Both a silver epoxy meshed patch printed on quartz and a patch with an artificial substrate are tested. The relationship between transparency and efficiency are explored for each case, and the two approaches are compared.

One disadvantage of this type of structure is that the transparency will vary with incident angle of the sunlight, since the substrate and copper are not transparent. Broadside incidence will have the largest transparency, and grazing incidence will have the lowest transparency. This disadvantage can be alleviated by using a thinner substrate and larger holes.