UHF Deployable Antenna Structures for CubeSats

J. Costantine[(1)], Y. Tawk [(2)], F. Ayoub [(2)], C. G. Christodoulou*[(2)] , G. Olson [(3)], S. Pellegrino[(3)]

(1) Electrical Engineering Department, California State University Fullerton, Fullerton, CA 92834

(2) Configurable Space Microsystems Innovations and Applications Center (COSMIAC), The University of New Mexico, Albuquerque, NM 87131

(3) Graduate Aerospace Laboratories, California Institute of Technology, Pasadena, CA 91125

Antenna design for small satellites such as CubeSats constitute a challenge for designers especially at UHF frequencies. The small size of the CubeSat (10 cm x 10 cm x 10 cm) imposes several constraints on the antenna design. Extreme packaging ratios and advanced deployment mechanisms have to be employed to cater for UHF antennas on a CubeSat platform.

Many types of deployable antennas have been used on orbit. Reflector types constitute their widest category. Other deployable structures made with folded hoops or ribs are also used for space communications. Other researchers have resorted to tape springs and neutrally stable material to design their structures.

An example of potential CubeSat deployable antenna candidates is a log periodic crossed dipole antenna array. The log periodic crossed dipole antenna array, constructed with a bi-stable composite material, exhibits a directive beam with a wide bandwidth. The characteristics of the bi-stable composite material allow a more efficient antenna deployment mechanism. A log periodic crossed dipole antenna array can extend up to 55 cm for UHF frequency operation with the longest element being around 60 cm.

Another potential antenna candidate is the conical log spiral antenna. The conical log spiral antenna typically fed at its apex exhibits a circular polarization with a wide bandwidth. This antenna radiates outwards from the direction of the antenna's apex and thus, it has to deploy in a manner to radiate away from the satellite. A typical conical log spiral antenna's height can extend up to 62 cm with a bottom circular base of radius 23 cm and a top radius of 5 cm. Other configurations of the conical log spiral antenna can also be proposed to satisfy various constraints such as a narrower base or a bigger height. A bottom fed conical log spiral antenna deployed on top of a ground plane is another possible candidate. One of the main benefits of this topology is an easier feeding mechanism after deployment. In this case the antenna still radiates upward and away from the satellite due to the presence of a significant ground plane under its base.

Another candidate for deployment on CubeSat is a Quadrifilar Helix antenna. This antenna built with beryllium copper deploys on top of a ground plane that has a square shape with a side of 1.25λ. The antenna is fed by multiple power dividers and phase shifters to allow a progressive 90° phase shift between the four elements constituting the antenna. This antenna achieves a gain around 8 dB at UHF frequencies with a circular polarization performance. The antenna however exhibits a narrower bandwidth than the previously discussed conical log spiral antenna.

Finally there are many possible candidates for antenna deployment on CubeSats as long as these candidates satisfy desired constraints. On the other hand, a deployable UHF antenna for CubeSats imposes an additional storage constraint due to size limitation.