

UHF Deployable Helical Antennas for CubeSats

J. Costantine, Y. Tawk, I. Maqueda, M. Sakovsky, G. Olson, S. Pellegrino, C. G. Christodoulou

Abstract—The design process and the deployment mechanism of a quadrifilar helix antenna and a conical log spiral antenna are presented. The two antennas are proposed to operate in the UHF frequency band. They are composed of conductors that are embedded and supported by innovative structural techniques. This allows efficient folding, packaging and deployment once in space. The conductors in the quadrifilar helix antenna are composed of beryllium copper and are supported by helical arms of S_2 glass fiber reinforced epoxy. The conical log spiral antenna, on the other hand, has conductors that are made out of a mesh of phosphor bronze and incorporated inside thin insulators composed of continuous fiber composites. The new aspects of these designs lie in their structures and deployment mechanisms. The deployment mechanisms for both antennas include helical pantographs and origami patterns such as Z-Folding configurations. Both antennas are fabricated and tested for both deployment and radiation performance. A comparison is executed between both designs and their potential deployment possibilities from CubeSats is also investigated.

Index Terms—Helical Antennas, Quadrifilar Helix Antenna, Conical Log Spiral Antenna, Deployable Antennas, CubeSat, Space Communications, Balun, Helical Pantograph, Z-Folding, Origami.

I. INTRODUCTION

The design of novel space antenna concepts that cover different frequency ranges constitutes a major challenge. There is a rise in the development of nano-satellites such as CubeSats, due to their ease of fabrication and low cost. The push for CubeSat designs has forced antenna designers and aerospace engineers to seek solutions for deployable antennas that have to be stowed inside the CubeSat limited space and deploy from its platform once in space. The antennas proposed have to be folded in order to fit inside a CubeSat. 1 U CubeSats are of the dimensions 10 cm x 10 cm x 10 cm. In this paper the antennas presented are designed to deploy from a 6U CubeSat and need to be folded to fit inside a 2U CubeSat.

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The challenge of deploying antennas from a CubeSat is amplified by the requirements to design antennas that are operational at UHF frequencies. Lower frequencies impose larger antenna sizes. This fact forces the use of extreme packaging ratios and advanced deployment mechanisms.

Many types of deployable antennas have been used on orbit. Reflector types constitute the widest category [1, 2]. These are commonly based on Truss types to constitute a synthetic aperture radar that can be mounted on any spacecraft as discussed in [3]. Folded structures that resort to hoops or ribs have been proposed for space communications in [4]. Accordion or spring shaped tunable antenna structures can also be used on satellite platforms [5-7]. Tape springs and neutrally stable material have constituted a major contributor to deployable antenna structures designs as discussed in [8].

Despite the advancement in antenna structure design, the most common antennas deployed on CubeSats remain mainly dipoles that are arrayed in various configurations [9]. Helical antennas are also a popular choice of CubeSat antennas due to their natural circular polarization and wide bandwidth [10]. Patch antennas printed on CubeSat sides are good potential candidates for use on small satellites as discussed in [11].

Deployable antennas for CubeSats can also be designed using log periodic structures such as a log periodic crossed dipole antenna array [12]. The log periodic crossed dipole antenna array can be built using a bi-stable composite material. This type of antennas, exhibits a directive beam and an acceptable bandwidth [12]. Another logarithmically scaled antenna can be the conical log spiral antenna that is typically fed at its apex. This antenna satisfies all the imposed constraints of CubeSat communication operation such as circular polarization, large bandwidth and efficient gain. Other configurations of the conical log spiral antenna can also be utilized to satisfy various constraints such as a narrower base or a bigger height. For example, a bottom fed conical log spiral antenna deployed on top of a ground plane is a possible candidate [13].

This paper discusses antennas with an objective to establish an earth-space satellite link that is operational for transmit and receive between 300 MHz and 600 MHz within the UHF band. The antennas presented are proposed to be circularly polarized since circular polarization is required due to Faraday rotation effects in the ionosphere. This paper considers two classical antenna designs for the CubeSat series of satellites, one narrow band antenna and one wideband antenna. The narrow band antenna is a Quadrifilar Helix Antenna (QHA)

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CubeSat Antenna Design Nacer Chahat, 2021-01-07 Presents an overview of CubeSat antennas designed at the Jet Propulsion Laboratory JPL CubeSats nanosatellites built to standard dimensions of 10cm x 10 cm x cm are making space based Earth science observation and interplanetary space science affordable accessible and rapidly deployable for institutions such as universities and smaller space agencies around the world CubeSat Antenna Design is an up to date overview of CubeSat antennas designed at NASA s Jet Propulsion Laboratory JPL covering the systems engineering knowledge required to design these antennas from a radio frequency and mechanical perspective This authoritative volume features contributions by leading experts in the field providing insights on mission critical design requirements for state of the art CubeSat antennas and discussing their development capabilities and applications The text begins with a brief introduction to CubeSats followed by a detailed survey of low gain medium gain and high gain antennas Subsequent chapters cover topics including the telecommunication subsystem of Mars Cube One MarCO the enabling technology of Radar in a CubeSat RainCube the development of a one meter mesh reflector for telecommunication at X and Ka band for deep space missions and the design of multiple metasurface antennas Written to help antenna engineers to enable new CubeSat NASA missions this volume Describes the selection of high gain CubeSat antennas to address specific mission requirements and constraints for instruments or telecommunication Helps readers learn how to develop antennas for future CubeSat missions Provides key information on the effect of space environment on antennas to inform design steps Covers patch and patch array antennas deployable reflectarray antennas deployable mesh reflector inflatable antennas and metasurface antennas CubeSat Antenna Design is an important resource for antenna microwave engineers aerospace systems engineers and advanced graduate and postdoctoral students wanting to learn how to design and fabricate their own antennas to address clear mission requirements

Antenna Design for CubeSats Reyhan Baktur, 2021-12-31 A CubeSat is a miniaturized modular satellite that can be constructed from off the shelf components With advancements in digital signal processing power electronics and packaging technology it is feasible to fit science instruments and communication devices that were traditionally carried on larger satellites on CubeSat constellations This not only reduces mission cost repair risk but also provides more precise and real time science data Their low cost and versatility allow for CubeSats to be used to test technologies that are planned to use on larger satellites to collect point to point data in space when launched as CubeSat constellations or to monitor health of larger spacecrafts This comprehensive reference explores CubeSat standards launching methods and detailed design guidelines for antennas specially made for CubeSat applications Deployed CubeSat antennas such as low gain antennas high gain wire based antennas and horn and dish antennas as they relate to the technology are explored Conformal CubeSat Antennas including those that are independent of CubeSats and those integrated in CubeSat solar panels are discussed An antenna design guideline is provided to demonstrate the basics of a CubeSat link budget which

is transitionally published in signal and system community Written by an expert in the field this book enables readers to read antenna specifics when choosing communication front end

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