A Novel Bio Inspired Pattern Reconfigurable Quasi-Yagi Helical Antenna using Origami DNA

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***Abstract*—A novel bio inspired pattern reconfigurable origami quasi-Yagi helical antenna is proposed based on DNA structure. The antenna consists of a DNA shaped driven element, a DNA based reflector and a director. A DNA contains double helical chain and its length is few microns in the folded state, which can be varied up to 2 m by unfolding. These folding-unfolding features are utilized to design a pattern reconfigurable origami antenna at 2.2 GHz. Parasitic element in the folded state acts as a director, meanwhile other parasitic element in the unfolded state serve as a reflector. In first two states pattern can be reconfigured from -30° to 30° by switching the role of parasitic reflector and director by folding and unfolding them. In the third state, both the parasitic elements are folded and serve as directors to direct main beam towards 0°. In the fourth state, both the parasitic elements are unfolded to serve as reflectors which results dual beam radiation pattern directed towards -50° to 50°. The presented design was manufactured by using a copper film on DNA shaped folded polyethylene terephthalate (PET) substrate. The interesting features of the proposed antennas like low cost, flexible designing procedure, compact packaging, efficient folding, and easy deployment procedure makes it suitable for space technologies.**

Keywords—*DNA, PET substrate, quasi-Yagi, helical antenna, pattern reconfigurable antenna.*

I. Introduction

Deoxyribonucleic acid (DNA) is a well know molecule, which comprises minute genetic information of all the living organisms. A DNA structure consist of a double helical chain, whose length is few microns in the folded state and can be varied up to 2 meter while unfolding. This key feature has been realized in this paper to implement an origami based reconfigurable helical antenna.

Origami stands for paper folding technology and it has drawn considerable research attention in various domains, including energy harvesting, architecture, medical devices, space-borne applications, and so forth. This origami technique has recently been used for antenna applications owing to its low cost, flexible designing method, and deployment procedure. Various complex antenna geometries can be easily realized by using origami concept. In [1], a circularly polarized origami antenna has been presented for military field deployment. With the advent of technologies, origami antennas have been reported with switchable characteristics [2]-[5]. However, most of the existing origami antennas have been realized by folding the paper substrate, which suffer from robustness and unstable for repeatedly folding and unfolding.

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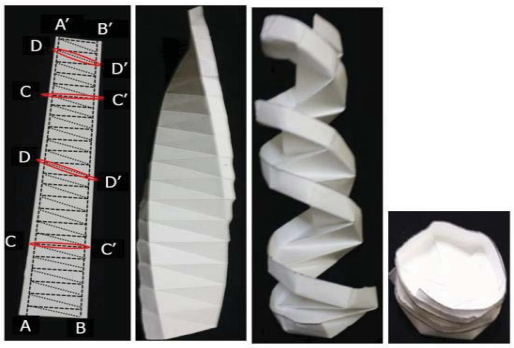
In this paper, a bio inspired pattern reconfigurable quasi-Yagi helical antenna is presented by using origami DNA structure. The proposed pattern reconfigurable antenna comprises DNA shaped driven element, a DNA reflector and DNA based director. The pattern can be reconfigured by switching the role of reflector and director. Owing to low weight and small volume in the folded state, the proposed antennas can be conveniently transported and deployed.

II. DNA Inspired Antenna Design and Performance

The proposed antennas have been realized through a multiple number of steps. Initially, a paper sheet with rectangular shape has been considered, whose dimension is 400 mm × 53 mm. Four dashed lines AA′, BB′, CC′, and DD′ are marked in the paper as illustrated in Fig. 1(a). Then the sheet has been folded along these lines step by step. First, the paper is folded and unfolded along AA′ and BB′ to make creases around these lines. The sheet is again folded-unfolded along all the horizontal segments marked by CC′, such that the paper can be divided into sixteen rectangular segments. In the next step, the paper has been further folded and unfolded along all the diagonal dashed lines, indicated by DD′. This final step creates the creases in such a way that each rectangular section gets divided into two equilateral triangular segments. The overall sheet, with all the creases, is depicted in Fig. 1(b). This folded paper is then twisted from top to realize the proposed DNA-shaped origami geometry that can be repeatedly folded-unfolded. Figs. 1(c) and 1(d) illustrate the complete unfolded and folded versions, respectively, of the proposed origami antenna. Since paper is fragile and relatively unstable, the above mentioned steps have been repeated with a flexible polyethylene terephthalate (PET) substrate to fabricate the sample, as shown in Fig. 2. PET substrate, owing to its robustness, offers high mechanical stability to the proposed antenna for repetitive operation, unlike the earlier reported origami antennas.

The conductor part of the helical antenna is realized by using a copper film having the dimensions and conductivity of 400 mm× 12 mm × 0.1 mm and 4.4×10^5 S/m respectively and it is bonded on the DNA shaped PET substrate.

A conductor backed dielectric (FR4) having the dimensions of 130 mm × 130 mm is served as the ground plane of the proposed antenna. In order to measure the performance of the proposed antenna an SMA connector is soldered to the driven element of the antenna.



(a) (b) (c) (d)

Fig. 1. (a) Folding pattern of origami DNA (b) Paper after rectangular and triangular creases (c) Origami DNA in unfolded form (d) Origami DNA in folded form.

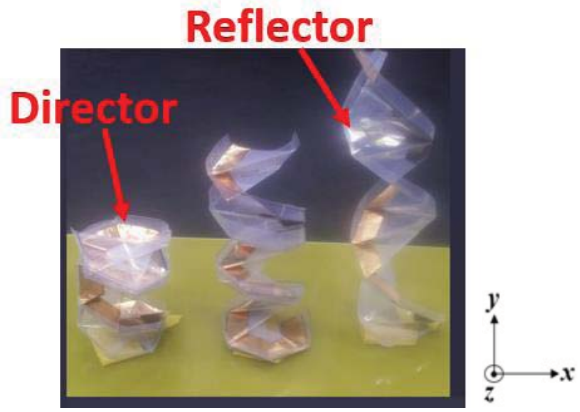


Fig. 2. Prototype of pattern reconfigurable antenna (State#1)

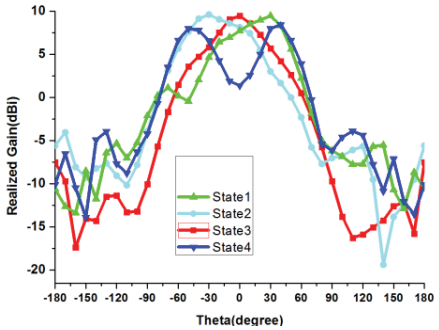


Fig.3. Rectangular plot of radiation pattern for four different states at 2.2 GHz

The folding and unfolding DNA feature is utilized to design a pattern reconfigurable antenna. Antenna can have four different states. The prototype of pattern reconfigurable antenna (state1) is illustrated in Fig 2, in which a parasitic director is designed by folded origami DNA and parasitic reflector is made of unfolded origami DNA. The main beam is directed towards 30°. In the state#2, the role of director and reflector is switched by unfolding the director and folding the reflector of the state#1 and main beam is directed towards -30°.In state#3, both the parasitic elements are folded to act as directors and main beam is directed towards 0°, while in state#4, both the parasitic elements are working as reflectors and dual beam radiation pattern is achieved directed towards -50° and 50°. The radiation patterns of four different states at 2.2 GHz are presented in Fig.3.

III. Conclusion

A low cost bio inspired pattern reconfigurable antenna is designed by using origami DNA. The folding and unfolding feature of DNA is utilized to implement a pattern reconfigurable antenna. The proposed antenna has various interesting features like low cost, easy designing procedure, compact packaging, efficient folding and easy deployment procedure. The above mentioned features makes the proposed antennas suitable for space technologies. As a future work, origami DNA will be folded and unfolded by linear actuator.

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