Military Field Deployable Antenna Using Origami

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***Abstract*— In this paper, origami antennas are proposed for military field deployment. A high gain tetrahedron origami antenna (antenna #1) is introduced and then extended to circularly polarized antenna (antenna #2) for military satellite applications. Both the antennas are realized on paper substrate by using origami tetrahedron structure. The radiating aperture of antenna #1 comprises a triangular shaped monopole and two strip directors. The fabricated antenna #1 demonstrates a peak gain of 9.6dBi at 2.6 GHz with impedance bandwidth of 66% (2-4 GHz). The circular polarization characteristics of antenna #2 is achieved by exciting two identical triangular shaped monopole elements. Both the elements are fed by a T-junction divider with a phase difference of 90°. The 3-dB axial-ratio bandwidth and impedance bandwidth of the proposed antenna #2 are found to be 8% (3.415 to 3.7 GHz), and 70.2% (2.4 to 5 GHz), respectively.**

Keywords*— *Origami antenna, high gain antenna, circularly polarized antenna

I. INTRODUCTION

A military field deployable antenna plays a vital role for soldier's communication. Conventionally walkie-talkie is used for military communication, however, it is very easy for 'tapping in' to be conducted with radio communication. Secondly, obstacle shorten the range of walkie-talkie. In such a scenario, satellite communication is a better option for the soldier's communication in the areas where cellular networks have not been deployed. The conventionally used antennas for satellite communication are bulky and can be transported only by helicopter or by other vehicles.

A light weight and quickly deployable origami antenna can provide a potential solution for the aforementioned scenario. Origami is a Japanese word used for paper folding. In literature, few antennas are proposed using origami concept [1-3].An origami deployable antenna is well suited for military applications, because it can be carried out by the military personnel in the form of light weight paper sheets and copper tape. Unlike the conventional antennas, the origami antenna can be easily and instantly fabricated by just folding the paper substrate without requiring any additional lab facilities.

Therefore, in this paper, a high gain tetrahedron origami antenna (antenna #1) is presented and then extended to CP antenna (antenna #2). Both the antennas are built on the paper substrate by using an origami tetrahedron structure. The designed antenna #1 consists of a triangular shaped monopole and two parasitic strip directors. Two directors play an important role to increase antenna's peak gain.

The antenna #2 consists of two triangular shaped monopole fed by a T-junction divider with a phase difference of 90degree. Because the proposed antennas are built on the paper substrate, it provides low cost, light weight, fast and easy fabrication procedure.

II. ANTENNAS DESIGN AND PERFORMANCES

The proposed antennas are designed on paper substrate in an origami tetrahedron shape. The designed antenna #1 consists of a triangular shaped monopole (the driven element), a reflector, and two directors. The origami antenna design and folding process can be divided in several steps. Firstly, four different square paper sheets with the same area (270 mm × 270 mm) and a thickness of 0.25 mm are employed. These paper sheets are labeled I, II, III and IV. Secondly, sheet I is selected as the substrate and the driven triangular patch as well as the two antenna directors are realized. A 135 mm × 135 mm copper film is attached on a quarter section of sheet I to serve as the reflector for the antenna. This paper is folded to make a star like shape which consists of four pockets.

In a second step, sheets II, III and IV are utilized. Two copper films with different dimensions (270 mm × 135 mm and 135 mm × 135 mm) are attached to one half section of sheet II and a quarter section of sheet III, respectively, to serve as the reflector in the final antenna #1 design. Sheets II, III and IV, are folded to make three additional stars. At the end of step 2, we will therefore have four different stars, which can be labeled as stars 1, 2, 3, and 4 for paper sheets I, II, III and IV, respectively.

In a third step, stars 1, 2, 3, and 4 are joined, and cutting off the unnecessary portion of paper to complete the prototype of the antenna #1, as displayed in Fig.1 (k).

The proposed antenna #2 is also fabricated by taking four paper sheets and repeating the folding procedure as mentioned for antenna #1.However for antenna #2, instead of directors, we have an additional triangular monopole on paper sheet # I and a T-junction divider on paper sheet # II. Copper film is attached on two triangular sections of sheets II and III to serve as ground plane of antenna. The prototype of antenna #2 is shown in Fig. 1(l).

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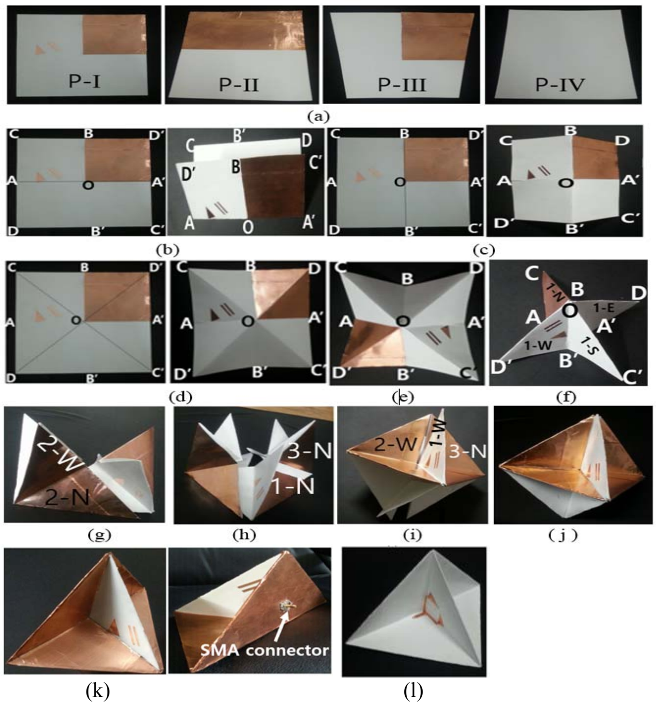

Fig. 1 Origami setup. (a) Four paper sheets (b) Step 1a: folding and unfolding along AA'. (c) Step 1b: folding and unfolding along BB'. (d) Step 1c: folding and unfolding along CC' and DD'. (e) Creased sheet. (f) Step 1d: folding for complete star. (g) Step 3a: joining stars #1 and #2. (h) Step 3b: joining star #3. (i) Three joined stars #1, #2, and #3. (j) After joining star #4. (k) Antenna prototype top view. (k) Antenna prototype front view, side view and back view. (l) Prototype of CP antenna (antenna#2).

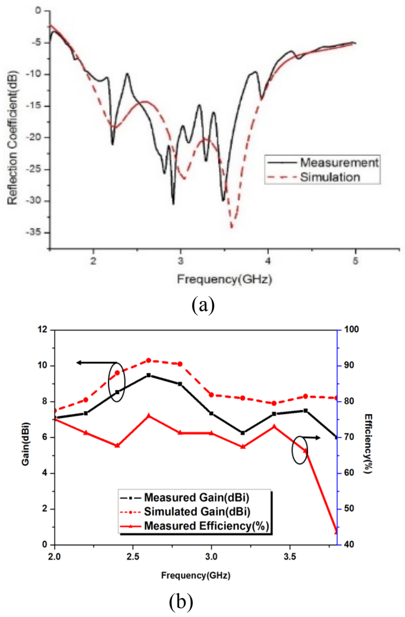

Fig. 2. (a) Simulated and measured reflection co-efficient of proposed antenna #1 (b) Simulated and measured peak gain and efficiency of the antenna #1 as a function of frequency.

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In order to expect its performances, ANSYS high frequency structure simulator (HFSS) is used for the design and simulation of the proposed antennas. The dielectric constant and dielectric loss tangent of the paper are considered as 2.1 and .02 respectively. In order to measure its performances, a SMA connector is mounted at the port of the each antenna.

In Fig. 2(a), the simulated and measured reflection coefficients of the proposed antenna #1 are presented. 10 dB impedance bandwidth is achieved from 2 GHz to 4 GHz which corresponds to 66%. There is a slight difference between simulated and measured results due to fabrication errors. The measured antenna's peak gain is plotted in Fig. 2(b) for different frequencies. At 2.6 GHz, the antenna's peak gain is 9.5 dBi. The 10 dB impedance bandwidth of circularly polarized antenna (antenna #2) is 70.2 %(2.4 to 5 GHz) and 3 dB axial ratio bandwidth is 8% (3.415 to 3.7 GHz) as presented in Fig.3.

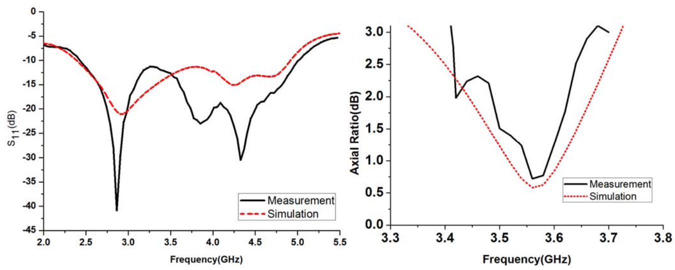

Fig. 3. (a) Simulated and measured reflection coefficients of the proposed origami antenna#2 (b) Axial ratio of antenna #2 as a function of frequency

III. Conclusion

A high gain tetrahedron origami antenna (antenna #1) is presented on paper substrate and then extended to circularly polarized antenna (antenna #2) for military field deployment. The fabricated antenna #1 shows a peak gain of 9.6 dBi at 2.6 GHz with impedance bandwidth of 66% (2-4 GHz), while antenna #2 shows axial ratio bandwidth of 8% (3.415 to 3.7 GHz) and impedance bandwidth of 70.2% (2.4 to 5 GHz).
Due to paper folding origami, the proposed antennas show low cost, easy and fast manufacturing process, therefore suitable for military satellite applications in the area where cellular networks have not been deployed. As the proposed antennas are made by joining four paper sheets, therefore these antennas have reasonable strength. However, antenna covers can be used for out-door applications in rainy day.

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