A Low Weight S-Band Quadrifilar Helical Antenna for Satellite Communication

A. Chapari, Z. H. Firouzeh, R.Moini, and S.H.H Sadeghi
Electromagnetic Research Lab, Electrical Engineering Dept.
Amirkabir University of Technology (Tehran Polytechnic)
Tehran, Iran
amin_ch82@aut.ac.ir

Abstract –**In this paper, a new design of an S-band, self-phased, one-turn quadrifilar helical antenna (QHA) has been presented. The antenna has been analyzed in purpose of desired radiation pattern by numerical method. A new matching techique has been used to improve VSWR of the QHA. The eperimental results show the radiation pattern has Nadir null of about 6dB and Axial Ratio is better than 1dB. In addition, VSWR is less than 2 in frequency bandwidth of 120MHz. The anttena has low weight, size and cost which is suitable for satellite communication systems.**

Keywords-quadrifilar helical antenna; low weight; circular polarization; satellite communication

I. INTRODUCTION

Quadrifilar helical antennas are extensively used for space communication satellites because of its proper properties such as conical beam, low weight, size, radiation pattern and circular polarization. A large numbers of GPS receivers make use of the QHA but it is not only popular for receiving purposes. Lightweight construction and non requirement of reference (ground) plane makes it suitable for use as a transmitting antenna in satellites.

The first detail investigation of QHA was done by Kilgus [1]-[3]. He showed shaped-conical radiation patterns can be realized by extending the resonant fractional-turn quadrifilar helix to an integral number of turn [4]. As mentioned earlier, size reduction of QHA is interest subject particularly for satellite communications systems. Self-phased in half turn half wavelength QHA [5], optimization algorithm for printed QHA [6], size reduction technique in broadband printed QHA [7] meander line technique [8] and introducing a gap at the center of the helical sections [9] have been offered. Impedance matching is also important in these antennas. A ring arrangement of four wires has been suggested [10]. Effect of turn angle on impedance in half wavelength QHA [11] and impedance matching in two frequency bands [12] have been studied.

The purpose of this paper is to design of a low weight, size, and high performance QHA in 2.1 GHz. One-turn QHA has been analyzed numerically due to realizing conical beam radiation pattern. Infinite balun method of feeding and self-phased technique has been used to compact structure of antenna. After implementation, radiation specifications has been measured and compared to the numerical results.

Measurements show that the bandwidth of the antenna for VSWR < 2 is 120 MHz and 120º beamwidth with Nadir null radiation pattern. The weight of the implemented antenna is less than 300 grams which is proper for satellite applications.

II. ANTENNA DESIGN AND CONFIGURATION

Fig.1 shows the one-turn right-hand QHA structure. The conventional QHA consists of four wire helices equally spaced circumferentially on an imaginary cylinder and fed with equal amplitude signals with relative phases of 0º, 90º, 180º, and 270º [13]. In this work, the two helices with different diameters have been wound directly over each other. The diameter of the internal helix is D1 and that of the external one is D2. The axial length of two helices is equal to Lax.

The feed system has been realized by use of infinite balun. The infinite balun uses semi-rigid coaxial cable instead of one wire of external bifilar as shown in Fig. 1. At the top of QHA, the central conductor of the coax is soldered to the opposite wire to prepare one bifilar, illustrated in Fig. 2.

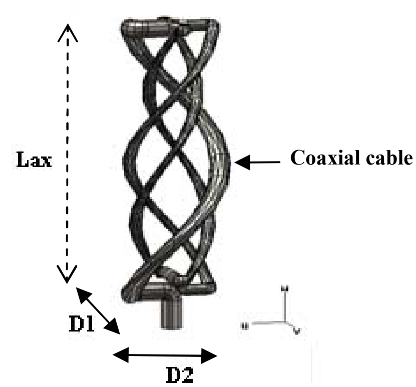

Figure 1. One-turn right-hand QHA

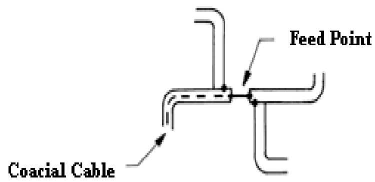

Figure 2. Infinite Balun method of feeding

Self-phased method is another technique has been used to compact the structure of QHA. The desired 90-degree phase difference has been achieved when one bifilar is larger relative to the desired resonant frequency length while the other bifilar is smaller.

By using these methods, there are no need additional external elements such as power splitter, hybrid coupler and phase shifter (to produce required 90-degree phase difference). Consequently, the size and weight of the antenna are reduced but impedance is affected by using two unequal bifilar helices. Stub matching can be used to have 50Ω impedance. Two crescent pieces of semi-rigid coaxial cable have been prepared for stub matching. One of them has been soldered to the outer conductor of the coax of the external bifilar and the other one to the wire of this bifilar as shown in Fig.3. This capacitive stub matching configuration compensates self-inductive properties of helices.

The desired QHA has been designed in 2.1GHz with the geometrical parameters according to Table I. Fig.4 shows the implemented QHA. Numerical and measurement results have been presented in the following section.

TABLE I
Parameters of the QHA in terms of λ

Lax	D1	D2	R1	RC
0.9λ	0.14λ	0.21λ	0.008λ	0.012λ

R1 : Wire radius
RC: Outer cable radius

Figure 3. Tow crescent pieces of stub matching

Figure 4. The implemented QHA

III. NUMERICAL AND MEASURED RESULTS

The antenna has been analyzed with Method of moment. VSWR and radiation patterns of the QHA without stub matching have been depicted in Fig. 5 and Fig. 6, respectively. Fig. 5 shows VSWR at 2.1GHz is about 6. The Nadir null is nearly 6dB as shown in Fig. 6. After using stub matching, VSWR has been improved to 1.1 at 2.1GHz and it is less than 2 in frequency bandwidth of 120MHz. Fig. 6 indicates some differences between numerical and measurement results because of stub matching current distribution. Polarization pattern is another important factor of the right-hand QHA. The fluctuations of absolute of Axial Ratio (|AR|) has been depicted in Fig. 7. It is better than 1dB in the 120º beamwith. Therefore, the presented QHA has proper antenna characteristics for satellite communications.

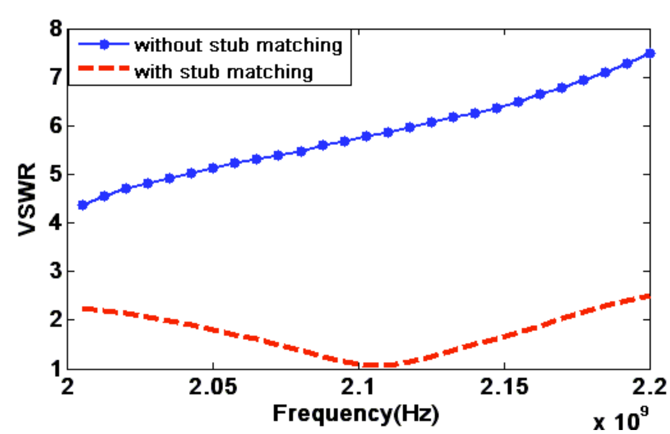

Figure 5. VSWR measurement results

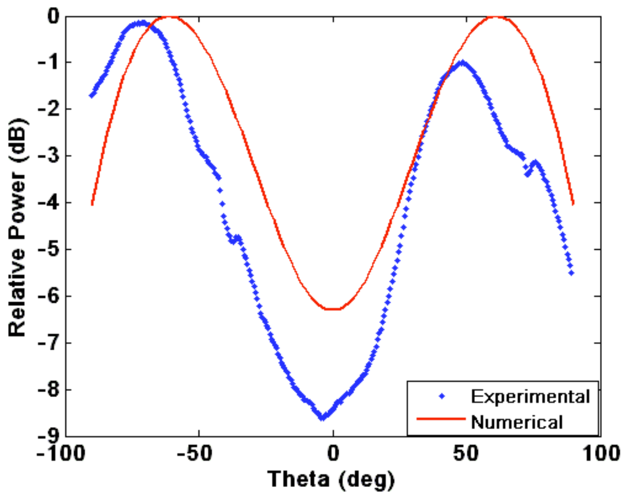

Figure 6. Measured and simulated relative power in elevation plane

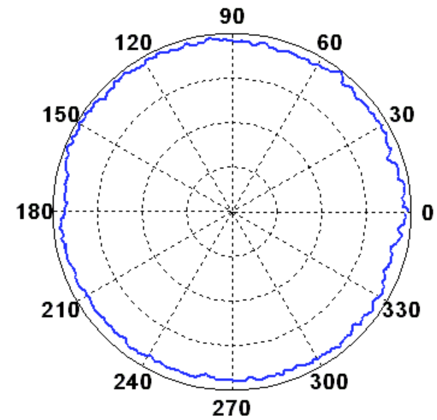

Figure 7. Polarization pattern of the QHA

IV. CONCLUSION

A low weight, self-phased, one-turn QHA has been designed, implemented and measured in S-band. Axial ratio is better than 1dB and VSWR is less than 2 in frequency bandwidth of 120MHz. The conical radiation pattern with Nadir null of about 6dB has been realized at 2.1GHz. As a future work, new impedance matching method can be studied in order to reducing undesirable effects on radiation pattern.

ACKNOWLEDGMENT

This work was supported in part by Iran Telecommunication Research Center (ITRC).

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