# A Compact and Wideband Quadrifilar Helical Antenna Designed for RFID Readers

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*Abstract* — in this work, a design of quadrifilar helical antenna with characteristics of compact, wideband and circular polarization is presented. It is achieved by combining the ways of tuning the different dimensions of the pairs of bifilars, and a feeding structure for providing the self-phasing technique. Both of simulated and measured results are reported in this study.

*Keywords* — Quadrifilar Helical Antenna (QHA), RFID reader, Circular polarization, Wideband

## I. INTRODUCTION

Since it was emphasized again in the supply chain [1], the RDIF technologies have attracted more attention; even it had been invented during the World War II already [2]. Moreover, in the past decades, it has been applied into many proprietary systems, for example, animal control, portal control, and traffic ticket control, etc. RFID is a kind of technology, which combines Information Technology (IT) with the wireless communication. Tag and reader are the key devices in charge of the wireless communication for the data access from the goods or moving lives. Considering the effectiveness of its wireless access communication, antenna design is a crucial part both for tags [3] and readers [4]. Depending on the application scenarios, different specifications may be put on the reader antenna design. In the current industry, a wideband characteristic of reader antenna seems the first one, because it needs to work in different area of the world, and where the spectrum assigned for RFID wireless access are different. For instance, they are: 866–869 MHz in Europe, 902–928 MHz in North and South America, and 950–956 MHz in Japan and some Asian countries. And it is 902-928 MHz in Taiwan.

On the other hand, the radio channel of the RFID access is quite complex, where multipath reflection and random polarization is often generated. For not losing the receiving gain, the antenna with circular polarization is proposed to be used by reader.

Quadrifilar Helical Antenna (QHA) [5][6] is a kind of antenna for providing circular polarization and complete hemispherical radiation/reception. It is relatively of compact size and excellent circular polarization properties with axial ratio of less than 3 dB which is common.

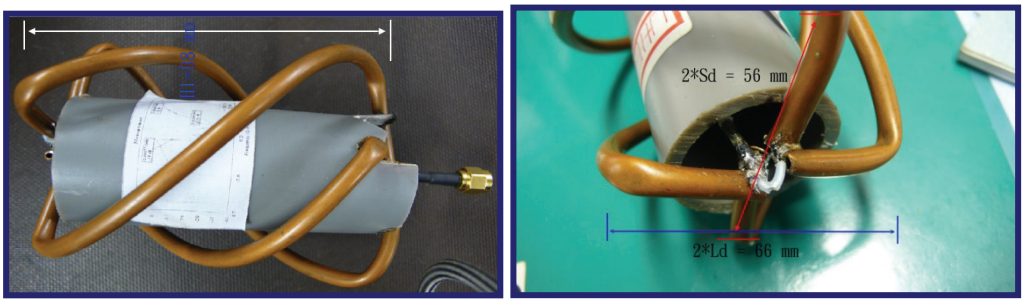



Fig. 1 Construction of the present quadrifilar helical antenna and its detailed dimensions

QHAs generically employ two bifilar helix antennas with orthogonal radius (a quadrafilar helix) fed in phase quadrature with a folded balun. It is easy to construct after design, even it looks complex. When it is employed for the RFID reader, it offers the advantages of capability to receive the wave with random polarization raised in the radio channel.

In this work, a design of quadrifilar helical antenna, referring to Fig. 1, which not only has the original advantages of QHAs but also owns the improvement of its bandwidth for RFID reader. It is achieved by combining the ways of tuning the different dimensions of the pairs of bifilars for self-phasing. Both of simulated and measured results are reported in this study.

## II. Design of Antenna

Feeding the quadrifilar with a single, unbalanced coaxial line requires special efforts. Because the individual bifilar loops are balanced-input devices, a form of balun is required to provide balanced currents to the terminals of each bifilar. In addition, the two bifilar loops require separate excitations having a relative phase difference of 90° to obtain the function of quadrifilar. Further, the sense of the 90° phase relationship determines from which end the quadrifilar radiates. Several different balun and quadrature-phase circuit arrangements are available for feeding the quadrifilar, such as the folded balun, the split-sheath balun, or a combination of 90° and 180° hybrids. The 90-degree phase relationship between bifilars needed to implement the quadrifilar can be achieved by either of two methods. The more direct method is to feed two identical orthogonal bifilars with a quadrature hybrid using a balun. However, this way may be at the expense of losing power to the hybrid, adding the hybrid weight to the system and requiring two cables to feed these two bifilars. The second method is using technique of self-phasing [7] for the quadrifilar helix antenna. A self-phasing technique requires only one coaxial cable for feeding, as shown in Fig. 2.

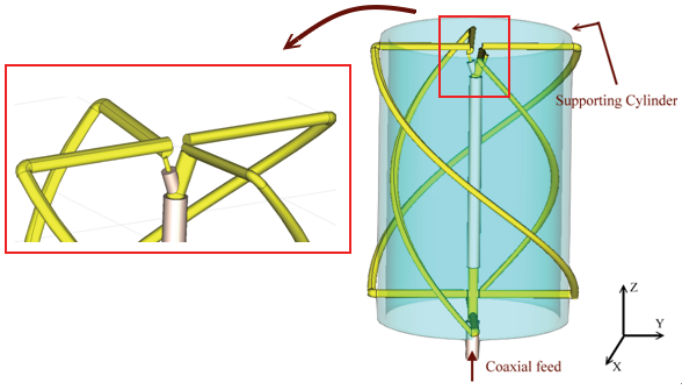



Fig. 2 Feeding structure of the present antenna

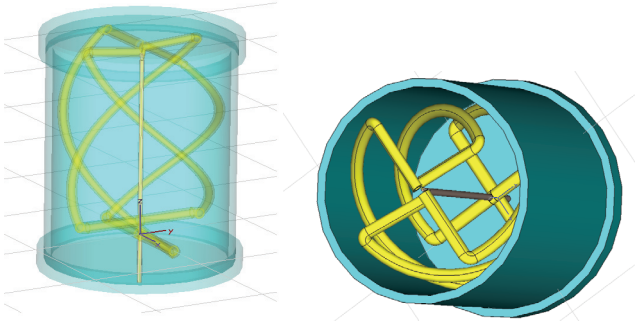


Fig. 3 3D simulation model of the quadrifilar helical antenna

Namely, the desired circular polarization of 90-degree phase difference is obtained by designing the orthogonal bifilars such that one bifilar is larger relative to the desired resonant length which is capacitive, while the other bifilar is smaller to be inductive. As a side effect, because of the characteristics of self-phasing method, it may be tuned the diameters of larger or smaller bifilar to improve the bandwidth without losing of the circular polarization and radiation pattern characteristics at desired frequency.

Fig. 1 shows the realized antenna and its detailed dimensions. This quadrifilar helical antenna is fed by the structure as shown in Fig. 2. As seen in Fig. 1 too, the antenna is supported by a plastic tube and is formed as a rigid body. During the design procedure, the electromagnetic simulation package CST [8] is used as the tool, by which the 3-dimensional antenna, see Fig. 3, can be modeled for simulation.

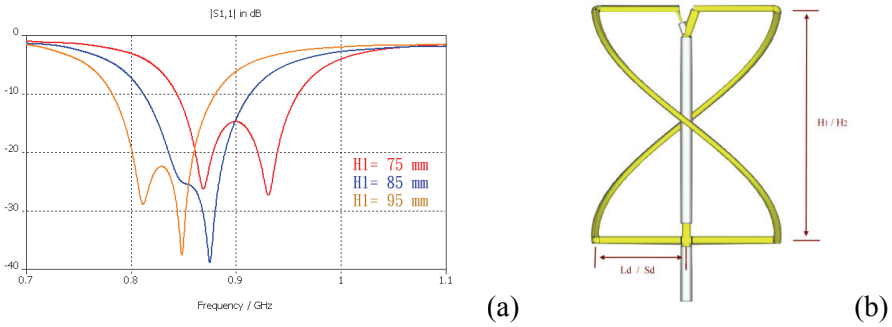



Fig. 4 Simulated performance of band shift and axial ratio when the antenna height is adjusted

By the 3-D simulation capability of CST, performance of the antenna under design is allowed to predict. As shown in Fig. 4, by adjusting the antenna height, the band shift and corresponding axial ratio vs. frequency are calculated in advance. The characteristic of the wideband is gained by creating two proximate modes in frequency, and which are generated by the different bifilars' size (radius and height) when carrying the self-phasing simultaneously.

## III. Measurement and Analysis

Fig. 5 shows the measured return loss being compared with the simulated one. Referring to the – 10dB criterion, which is quite acceptable in industry, the simulated bandwidth is from 844MHz to 959MHz, more than 100MHz. On the other hand, the measured bandwidth is from 878MHz to 959MHz. It seems that, the lower mode of frequency is not low enough to cover the RFID band used in Europe (866–869 MHz). This is the room of improvement of this presented antenna. Anyway, it does cover all other RFID bands used in the world.

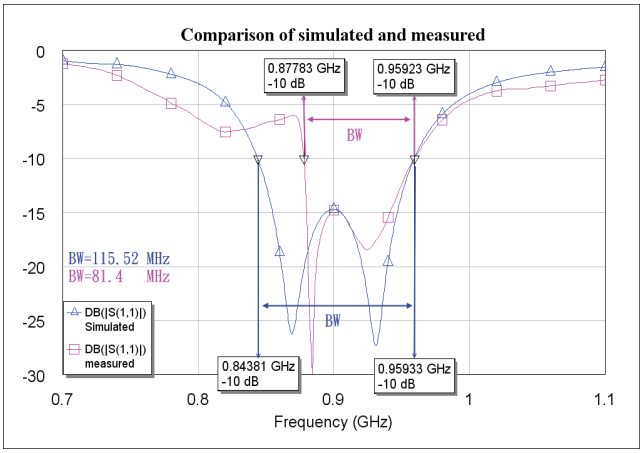
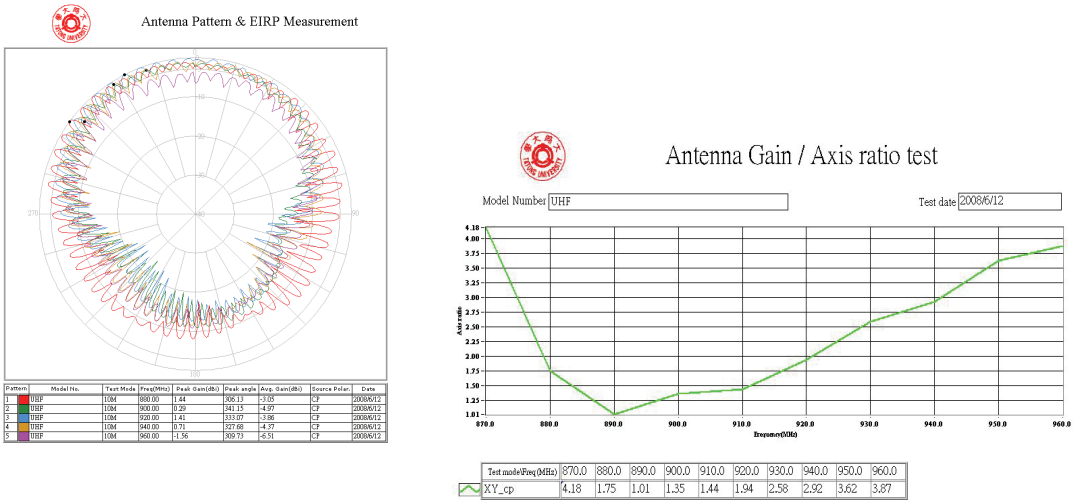



Fig. 5 Measured results of return loss with and without the pasted patch




(a) (b)

Fig. 6 (a) Measured radiation patterns, and (b) measured axial ratio vs. frequency

Fig. 6(a) shows the measured radiation patterns of the designed antenna considering the feature of circular polarization. Patterns of different frequencies are measured, and different corresponding gains are calculated. The measured curves of axial ratio are not symmetrical in terms of frequency as shown in Fig. 6(b). The best axial ratio happens around the frequency 890MHz.

## IV. CONCLUSION

A compact and wideband quadrifilar helical antenna used for a RFID reader is reported in this paper. The self-phasing technique is employed to achieve the design targets while leaving the feeding structure simple. Using a pair of orthogonal bifilar antennas with different size, the characteristics of compact, wideband and circular polarization are met.

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