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A miniature dielectrically loaded Spiral Folded Printed Quadrifilar Helix Antenna for GPS Dual-BandApplications

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1. Introduction

Owing to its good circular-polarization (CP) radiation characteristics, the printed quadrifilar helical antenna (PQHA) has been shown to be a very promising candidate for broadcasting satellite. It has also many attractive features such as light weight, hemispherical coverage and no requirement of ground plane with reasonable front to back (F/B) ratio [1]-[2]. The antenna can be used on satellite platform as well as on hand held devices which require communicating or receiving data from satellite [3]. For this purpose, several related designs of the PQHA with a reduced antenna height providing dual band behaviour have been developed and reported [4,5], using meander line technique to obtain square spirals helix arms giving 43% of size reduction of a 3λ/4 conventional PQHA arm length or using coaxially mounted two dielectrically loaded PQHA to obtain 49% of size reduction of a λ/4 conventional PQHA arm length.

In this paper, we investigated the combination of meander line technique and dielectrically loading technique to reduce the size of the conventional PQHA while maintaining a suitable radiation pattern, efficiency, axial ratio and obtaining dual band behaviour. The axial length of a conventional PQHA is miniaturized by about 73% and the total wire length of the Spiral Dielectrically Loaded Folded PQHA (called SDL-FPQHA) is adjusted such that it exhibits the two separate resonant frequencies for L1/L2 GPS application. Details of the proposed SDL-FPQHA are described, and the simulated as well as experimental results of the antenna are presented and discussed.

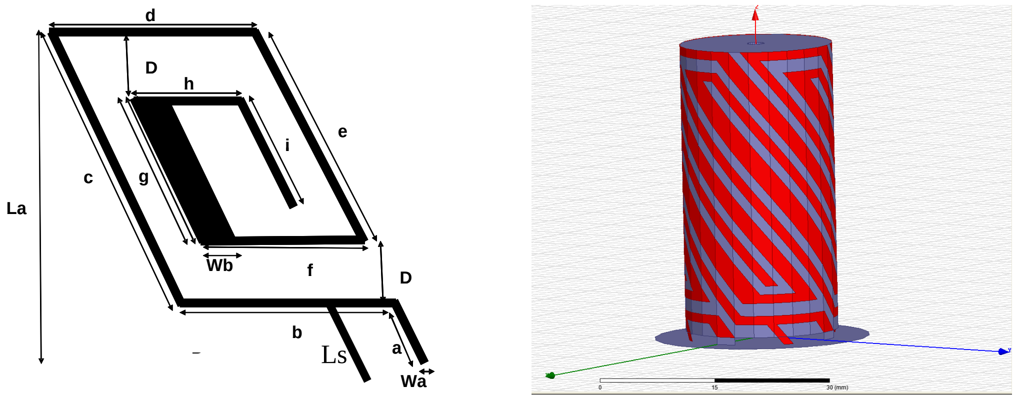
2. Antenna Design

The configuration of the dual-band antenna proposed is shown in Figure 1. It is based on the antenna presented in [4] where the four helix-shaped radiating elements are printed on a thin dielectric substrate [Fig. 1(a) and (b)], wrapped around a cylindrical dielectric support, and mounted on a small ground plane. Each helix element consists of meandering and turning the helix arms into the form of square spirals.
The antennas with folded arms tend to resonate at frequencies much lower than single antenna elements of equal length. By meandering and introducing a dielectric core of relative permittivity 10 we increase the effective length of each arm in order to shorten its overall element height.
Here, the aim is to obtain an antenna operating at the same frequencies as L1/L2 GPS frequencies band. As the insertion of such a dielectric material into S-PQHA results in a frequency shift down of 54% , the strip length of SDL-PQHA is reduced by the same rate [6].
The radius of this antenna is equal to 10 mm, with an axial length La= 39 mm, a constant pitch angle (α) of 50° and an arm width (Wa) of 1mm. To improve the impedance matching of the antenna, the stub Ls is shorted to the circular ground plane. The other physical characteristic of the SDL-FPQHA is given in Table I. As there are a lot of design parameters in the antenna, computer

simulations and optimizations are carried out by using HFSS code [7] to obtain the optimum design of the SDL-FPQHA to cover the L1/L2 GPS frequencies band.

Table 1: Geometrical parameters of SDL-PQHA

a	3.91 mm	**f**	12 mm
b	14 mm	**g**	36 mm
c	46 mm	**h**	9 mm
d	14 mm	**i**	34 mm
e	42 mm	**Wb**	4 mm



a) b)

Figure 1: The unwrapped (a) and 3D (b) representation of the SDL-PQHA

3. Experimental and simulation Results:

This antenna is printed on a thin Neltec substrate of relative permittivity εr = 2, 2 and a thickness of 0,127 mm. The dielectric rod is made of Alumina of relative permittivity εr = 10. The final configuration of the antenna, assembled on a ground plane of radius R = 25mm, is shown in Fig.5.

Figure 2 : A picture of the SDL-PQHA prototype

In Figure 3, the measured reflection coefficient versus frequency of the SDL-FPQHA is presented and compared to the simulation results. As expected, we obtain dual band behaviour with F1 = 1.17 GHz and F2= 1.56 GHz. The bandwidth of the antenna is about 0,66% to 0,5 % for these two frequencies respectively.

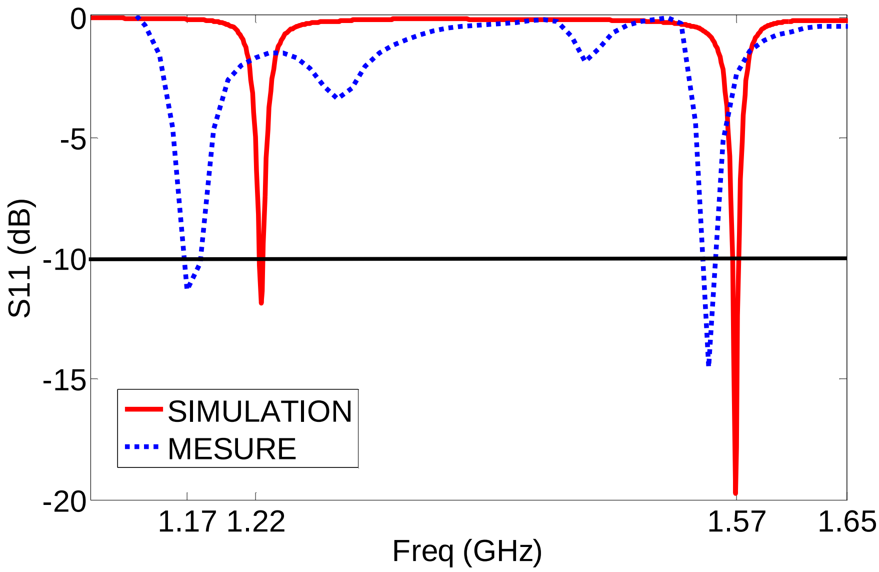


Figure3 : Measured and simulated reflection coefficient versus frequency of the SDL-PQHA

We can note three resonant frequencies: F1=1.22 GHz, F2=1.58 GHz, and F3=1.83 GHz.

The far-field radiation patterns of magnitude and phase for linear polarizations were measured in an anechoic chamber and combined to give the circular polarization are shown in Figure 4 at frequencies of 1.17 and 1.56 GHz.

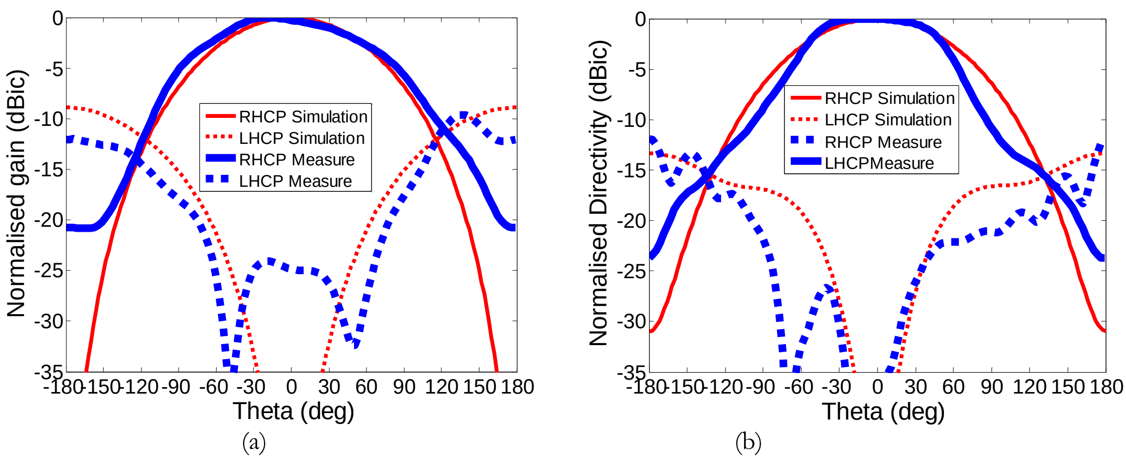


Figure 4: Measured and simulated radiation pattern in circular polarization of the SDL-PQHA at (a) F= 1.17GHz) and (b)F=1.57GHz

We can note that the radiation patterns remain stable with frequency. The measured maximum gain is greater than 0 dBic in the three frequencies bands, as shown in Figure 5.

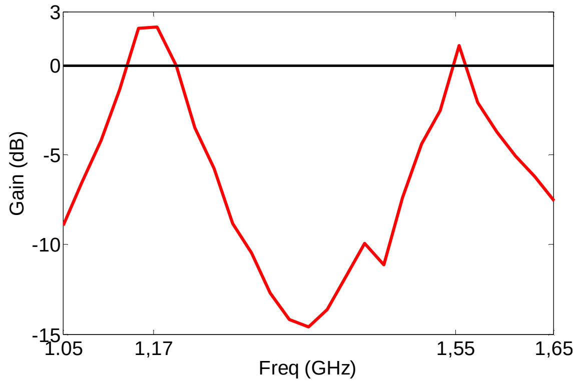


Fig. 8. Measured maximum gain versus frequency of SDL-FPQHA

The performances of this antenna are resumed in Table 2.

	SDL-FPQHA	
Frequency (GHz)	1.17	1.54
Gain (dBic)	2.22	1.15
BW (%)	0.66	0.5
Beamwidth at -3dB (°)	126	120

Table 2. Measured results of SDL-FPQHA

Conclusion

In this paper, a new Spiral-Folded and dielectrically loaded, Printed Quadrifilar Helical Antenna design is presented. A prototype of the SDL-FPQHA operating in an L-band is realized. It provides a 73% reduction in size for the axial length of the QHA structure, to satisfy space limitations of a mobile satellite terminal, with good performances. These properties make the antenna a good candidate to cover the dual frequency bands of global positioning systems.

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