[Parsha., 3(5): May, 2016] ISSN 2349-4506
Impact Factor: 2.265

Global Journal of Engineering Science and Research Management

OPEN ENDED QUADRIFILAR HELIX SUITABLE FOR GPS RECEPTION

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DOI: 10.5281/zenodo.51761

KEYWORDS: Quadrifilar Helix, GPS Antenna, GPS receiver.

ABSTRACT
In this paper, an open ended Quadrifilar Helical Antenna (QHA) is proposed. A Quadrifilar Helical Antenna with parasitic helical strips for circular polarization. The mutual coupling effect between the grounded helical strips and the feeding helical arms provides a good impedance match and wider hemispherical coverage. The impedance ranges from 40Ω to 70Ω for the frequencies 2.28 GHz to 2.52 GHz. The 3dB Bandwidth obtained is 1400. This antenna works well for wi- fi signals reflected off from building and moving vehicles. This antenna is also suitable for GPS receiving purpose. This antenna is small in size, low cost, and light in weight. Quadrifilar helix antennas are used in the lower microwave band, from L-band to X- band. Typical applications are for TT&C-links in satellites and narrow band data links. The other applications are in GPS- receivers, both in satellite based and ground based systems.

INTRODUCTION
Gerst invented the Quadrifilar Helix. But initially he called it as Multifilar Helix[1]. The Quadrifilar helix antenna can transmit and receive circular polarized signals over a large angular region. Its radiation characteristics are determined mainly by the shape of the helices, i.e. the number of turns, pitch angle, antenna height and antenna diameter, and for conical shaped helices also the cone angle. Quadrifilar Helix Antenna (QHA) consists of four helices fed with equal amplitude and in phase quadrature of 0°, 90°, 180° and 270° as shown in Fig 1[2]. Phase quadrature is obtained by using microstrip lines. A branch line coupler produces two equal magnitude outputs $\pm 90^0$ out of phase and could be used in combination with a $\pm 180^0$ or rat race hybrid which produces two equal magnitude outputs ±180 out of phase to produce the desired phase shift. The top view of QHA is shown in fig 2. These are typically fixed in space by winding them on some substrate of dielectric material, or by etching them on a substrate which is then formed into a cylinder. Helical antennas offer many advantages over dipole structures. Helical antennas are compact because of its cylindrical geometry .The antenna's which offers good gain factor and can operate over wideband. The unique property of circular polarized radiation pattern makes them more suitable for satellite communication. A helical antenna can also be used as a feed for a parabolic dish for higher gains.

THEORY
The QHA, while typically fed as an unbalanced antenna, is best considered a balanced structure. The opposing filars tend to form a dipole like structure. The two separate pair of filars fed in phase quadrature forms a hemispherical circular polarized radiation pattern. It is capable of radiating a cardiod shaped, circularly polarized pattern. There are a number of different types QHA including the multi-turn backfire, self-resonant and fractional-turn QHA. Fractional turn helices are used on-board satellites due to their cardiod shaped and circularly polarized radiation patterns. The backfire helix can be realized by extending the multi-turn QHA to an integral number of turn's results in excellent circular polarization as well as shaped beam. The QHA can either be shorted at the top of the antenna or left open. Almost all helical antennas are designed with uniform diameter and turn spacing. Long helical antennas requires variations in diameter and spacing over the length of the antenna, similar to the optimized Yagi- Uda antenna for very high gain which has varied element lengths and spacing in between the elements . Antenna radiation characteristics can be changed by varying the antenna's physical parameters and using various materials in helical antenna design. Helical antenna provides good axial ratio and precisely measures the polarization of the received signal due to immunity of the circularly polarized wave to Faraday rotation of the signal propagating through the ionosphere. In addition to circular polarization, helical antennas offer the advantage of high gain in axial direction over a wide range of frequencies which makes them suitable for applications in

broadband satellite communications.

DESIGN OF QHA

The QHA design can be done with different parameters, all are fitting to give a desired output. The parameters include [3] .

1. **Number of Turns the** number of turns that each filar of QHA uniformly makes is denoted by N, called Number of Turns. Generally it is desired to be less. Higher the number of turns lesser the VSWR
2. **Pitch:** The distance between the same points on the consecutive turns of each element is called pitch and generally its value should be 0.5λ to 0.6λ or even less.
3. **Radius Rh** The radius of the circle on which four filars are based is denoted by Rh in the fig. It is also called as QHA radius.
4. **Radius Rg** This is the radius of the total ground plane on which QHA is based which is show in the same figure.
5. **Center frequency fo** The frequency at which the QHA operates is called the center frequency.
6. The transmitting polarisation that was used is Right Hand Circular (RHC).
7. Input resistance for the QHA used is 50Ω
8. QHA height is H_h, This is the height of the helix from its ground plane.
9. Height of the feed-points is the small height above ground plane upto

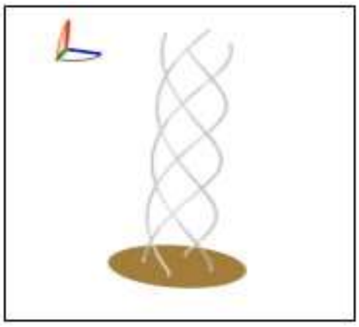

Fig 1. Open Ended Quadrifilar Helix

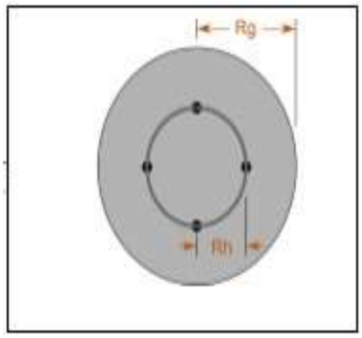

Fig 2. Top View of QHA

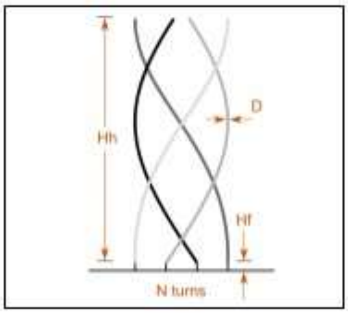

Fig 3. QHA indicating Hh, Hf, D

ISSN 2349-4506
Impact Factor: 2.265

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Where the feeds will go as shown in figure below. D is the diameter of the wire which is used for making helix filars.

1. Length of one volute is the length of one spiral wire (or) one filar
2. Width of the antenna is equal to the two ground planes radius.
3. The height of the antenna is the sum of the helix height, feed height and half of the wire diameter.

Fig 1. Shows open ended Quadrifilar helical Antenna which shows ends are Open. Fig 2. Shows the Topview of Fig 1. And it also indicates Rh and Rg very clearly. Fig 3 shows the side view indicating helical height and feed height.
Figure also shows the diameter of the wire.

The table below shows the result of the design when the antenna is simulated in Antenna Magus. Center frequency at which it was designed is 2.4 GHz. However the plot of Impedance versus frequency shown in Fig 7. Uses frequencies from 2.28 GHz to 2.5GHz. But at the center frequency 2.4GHz, the input impedance obtained was 50Ω and the 3dB beam width obtained is 140^0 which makes this Antenna quite suitable for GPS applications, especially for receiving purposes.

The impedance ranges from 40Ω to 70Ω for the frequencies 2.28 GHz to 2.52 GHz. The number of turns, as described earlier, of the proposed antenna is only N= 1.018 i.e slightly more than a single turn.

Fig 4. Shows the radiation pattern having its backlobe at 180^0. Major direction is at 0^0. Closer observation of the figure gives us a 3dB beamwidth of 140^0. Same 3-dimensional radiation pattern is shown in Figure 6. Color gradually come from pure red to blue which indicates the gain of the antenna. Fig 5. Shows the phase pattern. Fig 7 indicates the graph between Impedance versus frequency. At 2.4GHz, which is the designed operating frequency, the input impedance obtained is 50Ω, which is suitable for its design.

Table 1. Objectives and Results for the design of Open-Circuited Quadrifilar helix (O-C QHA)

Type	Description	ShortName	Value	Unit
Objective	Centre frequency	f_0	2.40E+09	Hz
	Polarisation (transmitting)	P	RHC	
	3dB beamwidth	bw	140	°
	Input resistance	Rin	50	Ω
Parameter	Polarisation (transmitting)	p	RHC	
	Number of turns	N	1.018181818	
	QHA radius	Rh	8.67E-03	m
	Ground plane radius	Rg	1.73E-02	m
	QHA height	Hh	7.01E-02	m
	Height of the feed-points	Hf	1.33E-03	m
	Wire diameter	D	6.67E-04	m
Derived	The width of the antenna (2 ground plane radius)	X	3.47E-02	m
	The width of the antenna (2 ground plane radius)	Y	3.47E-02	m
	The height of the antenna (helix height + feed height + 1/2 wire diameter)	Z	7.18E-02	m
	Length of one volute	Lw	8.94E-02	m

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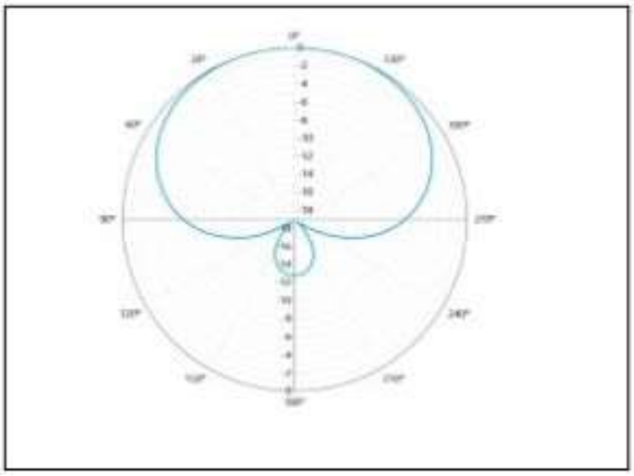

Fig 4. Radiation Pattern which shows 3dB beam width of exactly 1400 at half power points

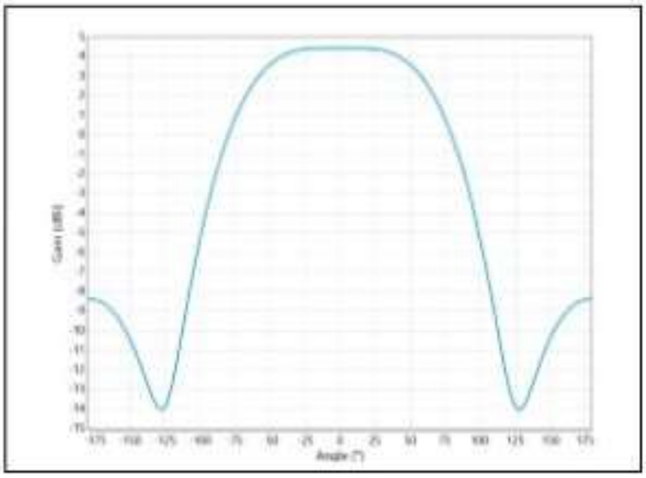

Fig 5. Its corresponding Phase pattern

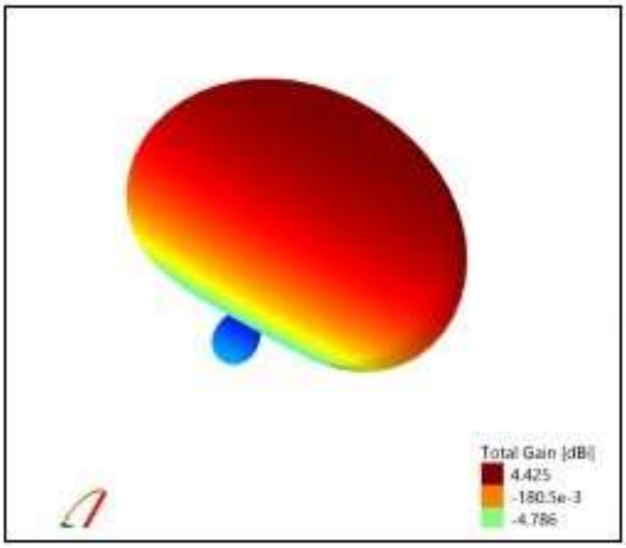

Fig 6. Dimensional Radiation

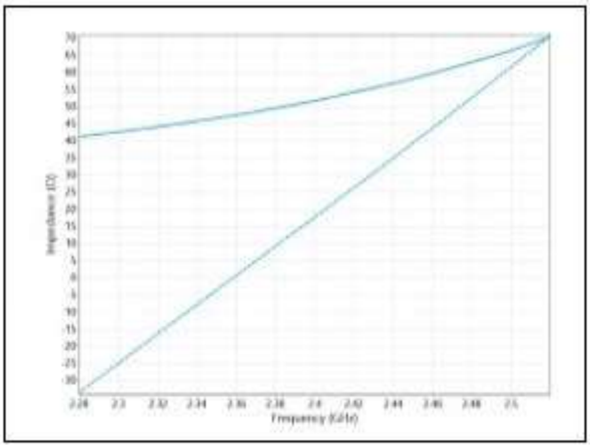

Fig 7. Graph between Input Impedance and Frequency.

CONCLUSION

This paper clealy explains the parameters involved in the design of the Quadrifilar Helical Antenna. Simulation results of the O-C QHA by using Antenna Magus Software are shown in the Table. 3-dB Beamwidth of QHA obtained is 140^0. The Impedance at the center frequency of QHA is 50Ω. Antenna is simulated for frequencies 2.28 GHz to 2.52GHz, and its variation of Impedance over these frequencies are plotted. These results show that it is quite suitable for the GPS receiving purpose.

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