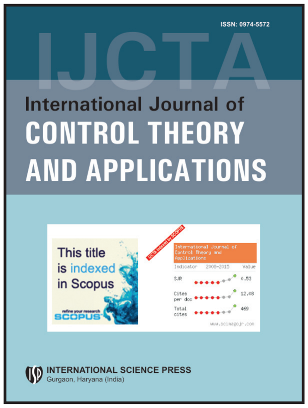

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Design and Simulation of a Novel Bifilar Helix Antenna Combining GPS, GLONASS, IRNSS and S-Band Communications

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Abstract: Most Communication Systems require more than one band to solve the antenna problem. Commercial, Amateur Radio and Military Communication are especially likely to need either multiple antennas or a multiband antenna that operates on any number of different bands. For some satellite applications, performance and size both are trade-offs. In Low – Earth Orbit Satellite Communication, size is not a constraint but a good performance is required. A Low-Earth Orbited requires a broad beam width and the gain should be maximum in the directions of maximum path loss. The backfire bifilar helix antenna is the most suitable for this requirement because of this antenna has the advantages such as high efficiency, a convenient size at S-band and extreme simplicity. In this paper, the design of novel backfire bifilar helix antenna is proposed for low earth orbit satellite communications to cover the various bands such as GPS, GLONASS, IRNSS, and S-band Communication. Apart from this, the proposed antenna will be simulated for its characteristics such as VSWR, Gain, Axial Ratio and Radiation patterns.

Keywords: Backfire bifilar Helix Antenna, Global Positioning System, Global Navigational Satellite System, Indian Regional Navigation Satellite System, LEO Satellite Communication, Side lobe level.

1. INTRODUCTION

Today, Satellite Systems are using Worldwide in almost every aspect of radio communication from narrow band to broadband including telecommunication, positioning and broadcasting. There are so many types of Satellites which are used for radio communication. Out of them the most useful type of satellites are LEO satellites. These LEO satellites are used for photos, telecommunication, scientific and military applications. The helical antenna is the most accepted antenna for satellite applications due to its broadband characteristics and circular polarization. There are modified forms of the helical antenna such as monofilar, bifilar, quadrifilar and octofilar. The modified form of helical antenna can be used based on specific application and its requirements. For LEO satellite applications, the backfire bifilar helix antenna is the most suitable because of which is compromised between performance and size. So far, many authors were studied and designed the backfire bifilar helix antenna for different applications based on the requirement.

Backfire bifilar helix is the suitable for low earth orbiting space craft with earth oriented stabilizations system. Back fire bifilar helix antenna has been using on APL satellites. The balanced mode equation of a backfire bifilar helix can be achieved with an infinite balun. The infinite balun technique and the input impedance of the bifilar helix did not match each other's. To avoid the matching problem for bifilar helix, planer conductors are used which are usually Pie - shaped soldered to the radiation portion of the elements at the feed region. By empirically adjusting the size and positions of these pieces, a good impedance match can be obtained with the large radius helical geometrics that produce broad bandwidth radiation palters [1]. The radiation characteristics of bifilar and quadrifilar truncated spherical helix antennas were analyzed using the FDTD method. By using the multi arm structure and changing the feeding geometry, a symmetrical circular polarization, broad beam radiation and conical radiation patterns were obtained [2]. The F/B ratio and axial ratio both are improved with tapered feed end for backfire bifilar helix antenna. A backfire bifilar helical antenna with tapered feed and has the highest power gain when compared with the conventional and conical backfire bifilar helical antenna [3]. The conical radiation pattern of the bifilar helix antenna was obtained by changing the helix parameters. A bandwidth of more than 40% was obtained with the conical radiation pattern. Conical shaped bifilar helix antenna is the most suitable for measurement and control communication between Satellite and Earth [4]. The side- fed bifilar helix antenna with Omni-directional pattern was designed to get wide AR beam width (for AR ≤ 3dB). The design was achieved by equating the area of loop equal to the product of pitch and radian length [5]. The F/B ratio of backfire bifilar helix antenna had improved and reduced the reflected currents by flaring of the open end of the helix antenna. This flared open end helix antenna has a wideband characteristics and constant input impedance [6]. In bifilar helical antenna, the beam direction in an elevation plane moves according to frequency change. This movement of beam direction is the draw back when it is used as vehicle antenna for AMSE/TMI systems. This drawback was eliminated by using linear array antenna using two bifilar helical elements. Moreover the linear array antenna compared with a conventional bifilar helical antenna in terms of beam directions at different frequencies [7]. The backfire bifilar helical antenna was studied, analyzed and designed based on current distribution in a helix structure. It is concluded that the beam width can be increased by increasing the frequency [8]. The side-fed quadrifilar hemispherical helix and top- fed bifilar hemispherical helix antennas were studied, designed and simulated [9]. The backfire bifilar helix antennas size was reduced by using the dielectric rod in the helix structure. It is found that size reduction by a dielectric rod with higher permittivity, but at the expense of gain and the bandwidth. 50% of Teflon dielectric and 70% of macor dielectric were used for the size reduction of backfire bifilar helix antenna [10].

2. ANTENNA DESIGN

Helical antennas have been widely used in a various applications due to their low weight and low profile conformability, easy and cheap realization. The wideband width, simplicity, highest directivity and circular polarization of helical beam antenna have made it indispensible for space communication. Helical antenna can be modified into various forms such as bifilar, resonant quadrifilar helical antenna, printed quadrifilar helical antenna and counter quadrifilar helical antenna. In this paper the backfire bifilar helix antenna is proposed and designed based on design parameters. The bifilar helix consists of two wire elements formed into a helical geometry and displaced by 1800 phase difference. The backfire bifilar helix antenna has the following advantages.

- No ground plane is required, making the antenna attractive for Satellite applications.
- Bifilar helix is not a resonant and it does not require quadrature hybrid circuit.
- The backfire bifilar helical antenna can also be used as a better feed element for parabolic reflector.

Circular polarization can be achieved in bifilar helix antenna by balancing the current distribution in both arms of helical antenna. The turn angle of bifilar helix antenna is a factor that defines the performance characteristics of the bifilar helix antenna. It has import on the performance parameters like gain, bandwidth, beam width, cross polarization, Axial Radio and front to back ratio.

A. Design Parameters of GPS/GLONASS/IRNSS Bifilar Helix Antenna

CG Coordinate Axis: X = 0

Y = 31.47 mm

Z = 0

Dimensions: L = 95.7 mm

D = 90 mm

Mass of the Antenna: 0.35kg

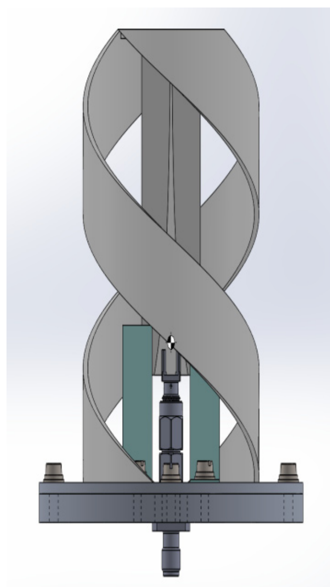


Figure 1: GPS/GLONASS/IRNSS Bifilar helix antenna

B: Integrated S-band SATCOM and GPS/GLONASS/IRNSS Bifilar Helix Antenna Design Parameters

- Ground plate diameter: 140 mm.
- Ground plate Material: Teflon.
- Feed position: Horizontal and vertical
- Diameter of first bifilar helix antenna: 34 mm
- Diameter of second bifilar helix antenna : 50 mm
- Length of first bifilar helix antenna: 70.19 mm
- Length of first bifilar helix antenna: 69.70 mm

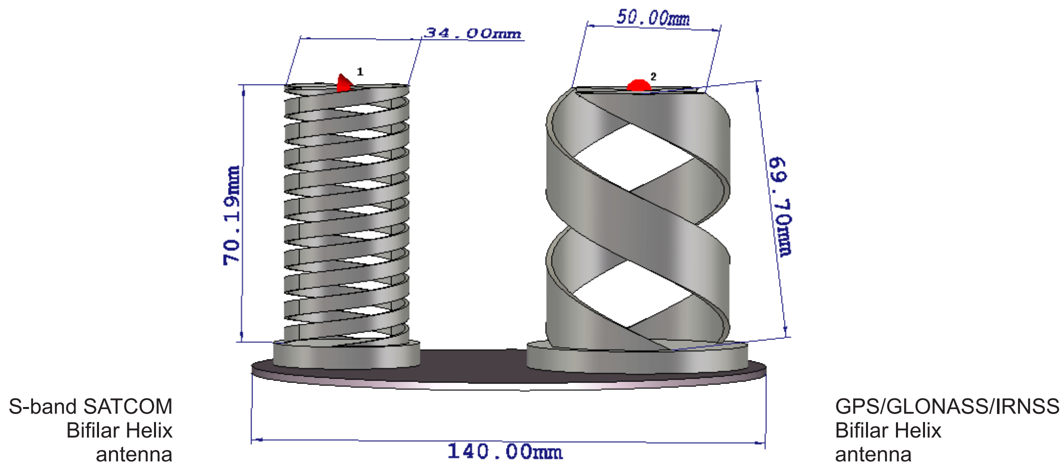
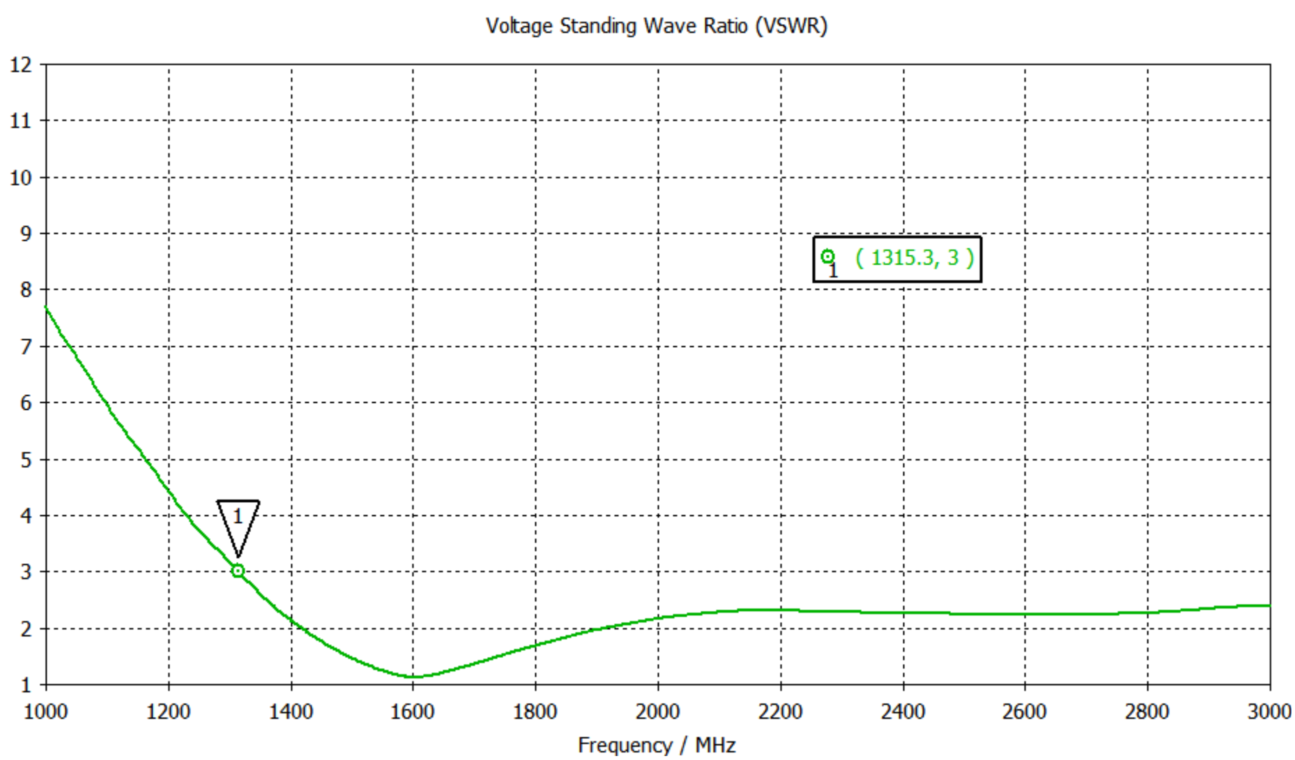


Figure 2: Integrated S-band and GPSGLONASS/IRNSS Helix Antenna

3. SIMULATION RESULTS

The Simulation results show that the characteristics of Novel bifilar helix antenna in terms of VSWR, Gain, Axial ratio and Radiation patterns. From Figure 3 to Figure 5 shows that VSWR, Gain and Axial ratio of a Novel backfire bifilar helix antenna. Figure 6 shows that the radiation patterns of Novel backfire bifilar helix antenna at the various frequencies such as 1175MHz, 1200MHz,1570MHz, 1610MHz, 2500MHz and 2700MHz.Table 1 to Table3 shows that VSWR, Gain, Axial ratio values at different operating frequencies. Table 4 shows that Main lobe magnitude, Main lobe direction, Angular width and Side lobe level at various operating frequencies. Overall Simulation results shows that Novel backfire bifilar helix antenna is appropriate for multiband antenna because of which covers various communication systems such as GPS,GLONASS,IRNSS AND S-band. Moreover the sufficient Gain was obtained at the operating frequencies of various communication systems.



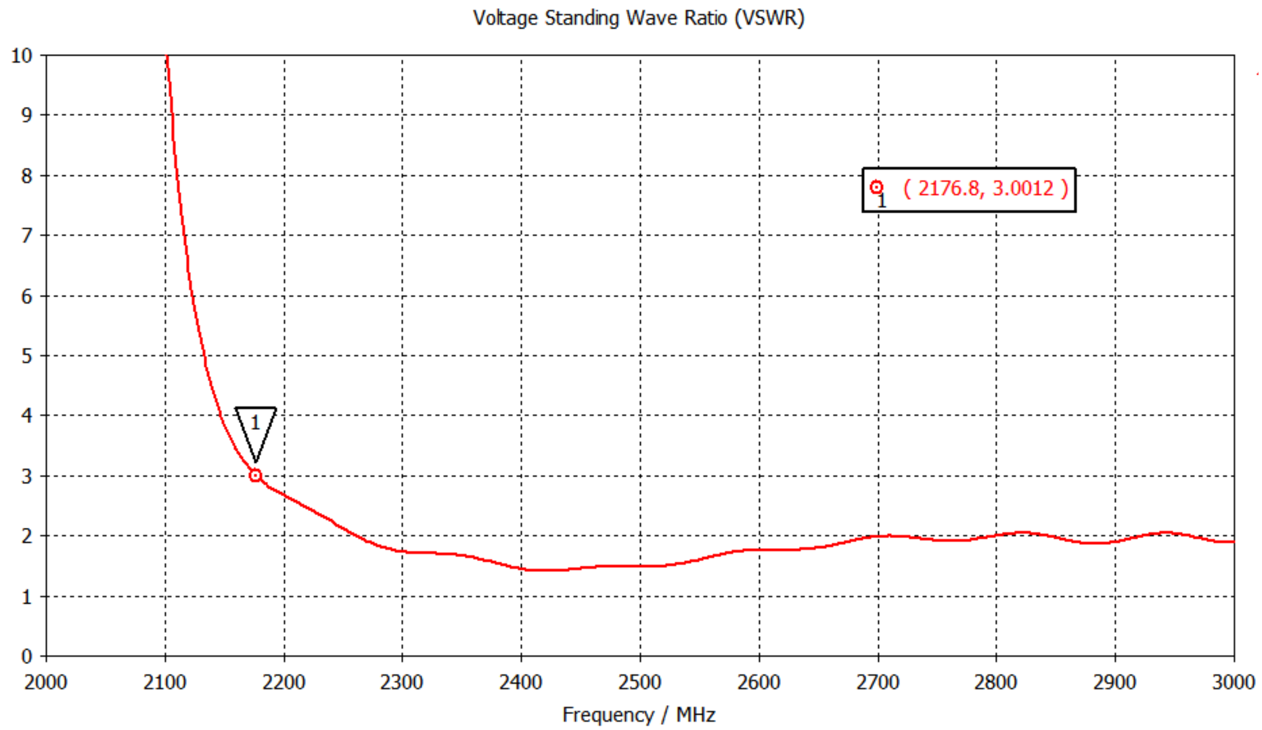
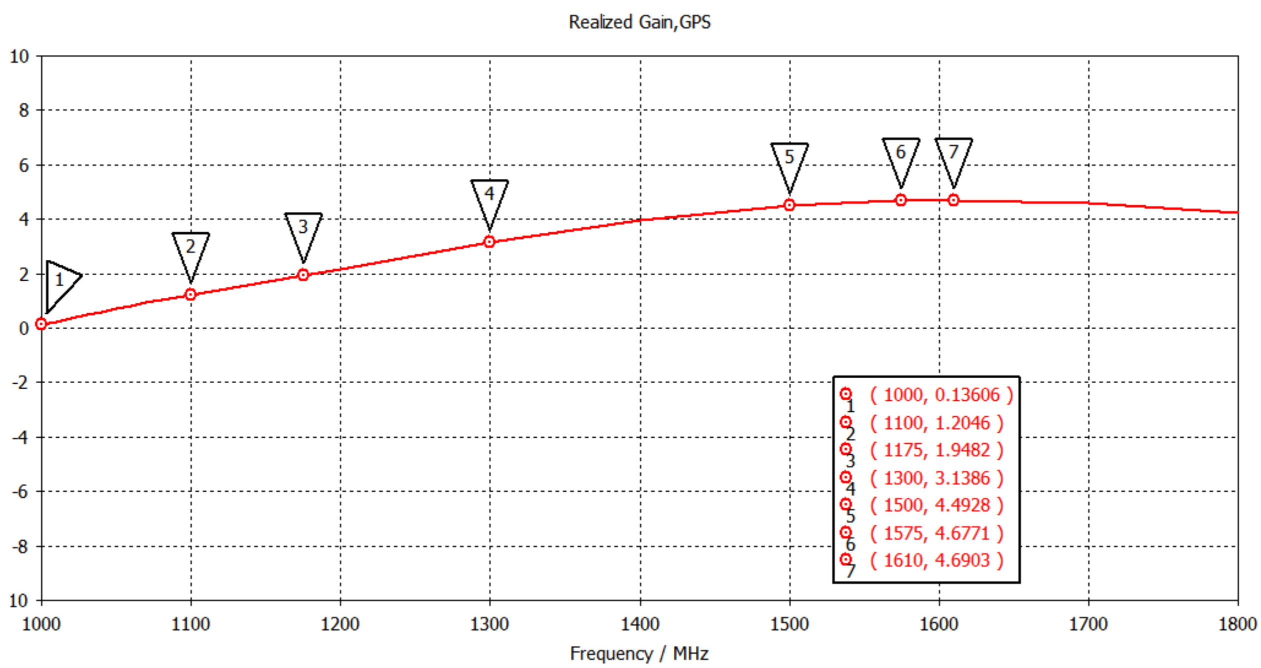


Figure 3: VSWR of GPS/GLONASS/IRNSS and S-band Antenna

Table 1
VSWR at two frequencies

Frequency (MHz)	*VSWR*
1315.3 MHz	3
2176.8 MHz	3.0012



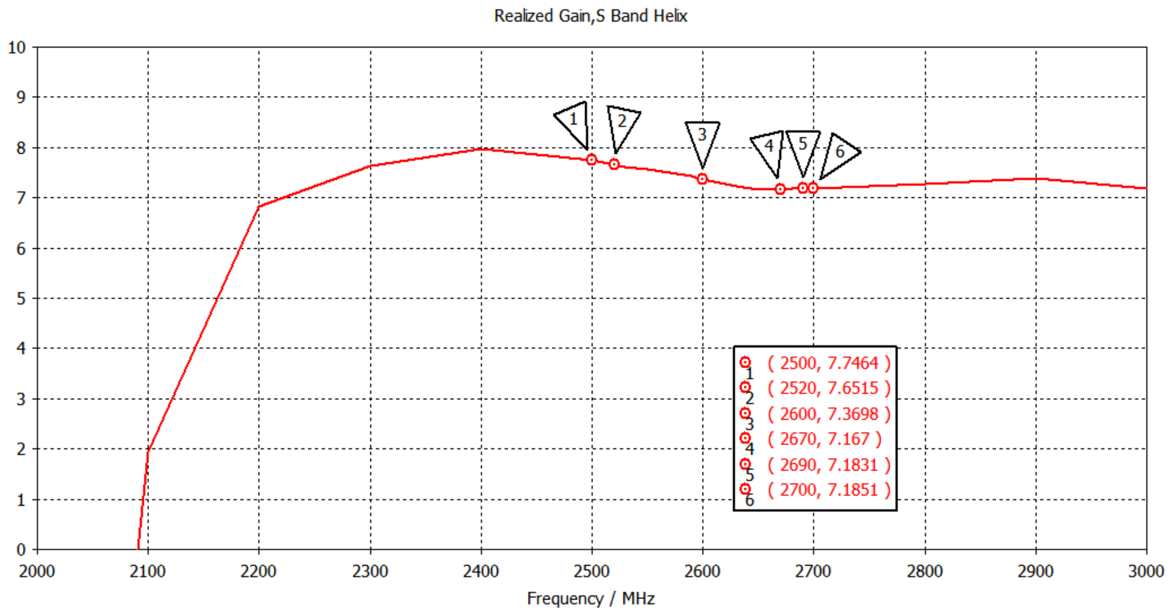
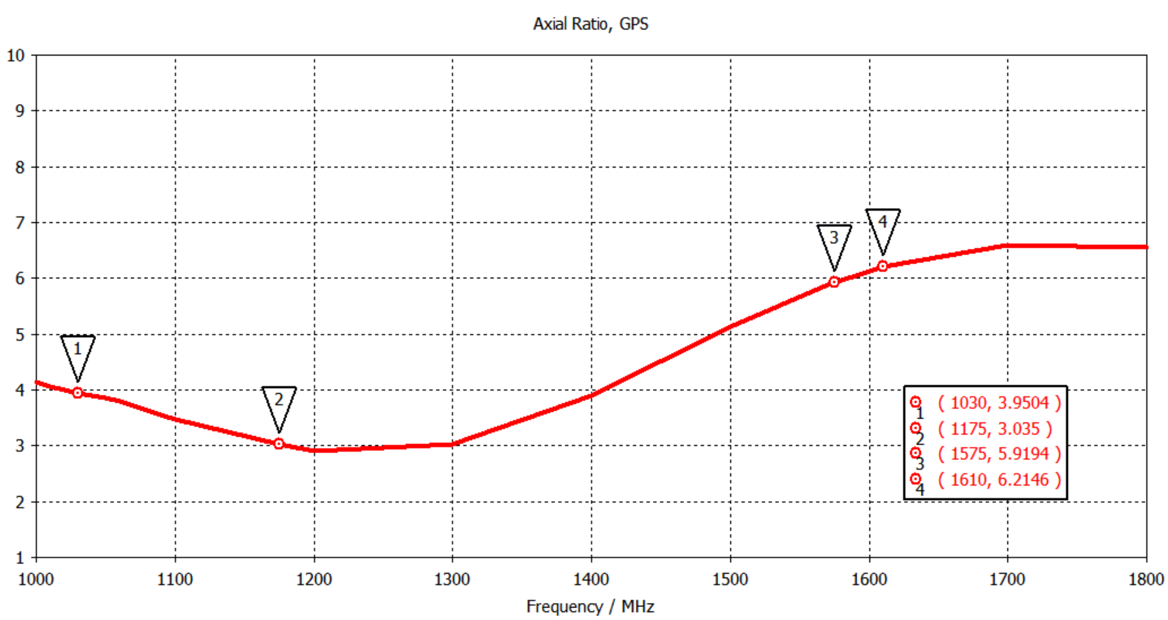


Figure 4: Gain of GPS/GLONASS/IRNSS and S-band Antenna

Table 2
Gain at various operating frequencies

Frequency (MHz)	*Gain*
1175MHz	1.9482
1300 MHz	3.1386
1575 MHz	4.6771
1610 MHz	4.6903
2500 MHz	7.7464
2700 MHz	7.1851



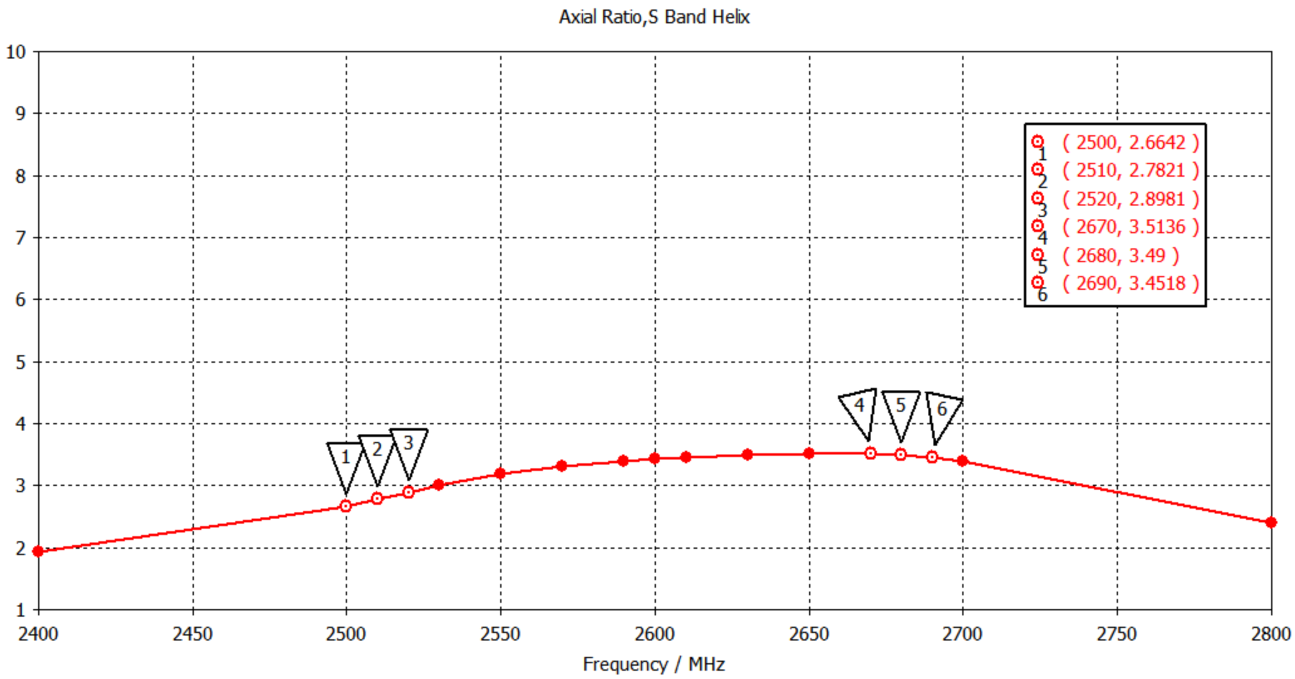
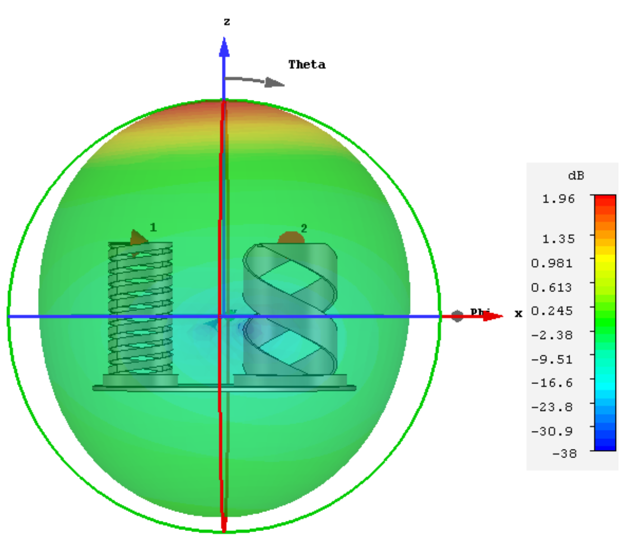


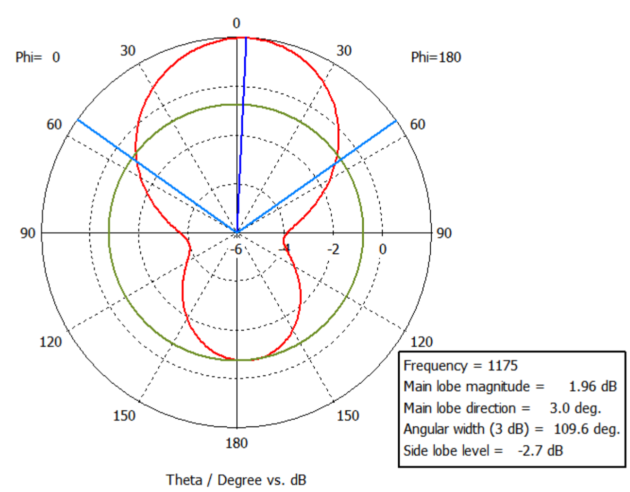
Figure 5: Axial Ratio of GPS/GLONASS/IRNSS and S-band Antenna

Table 3
Axial Ratio at various frequencies

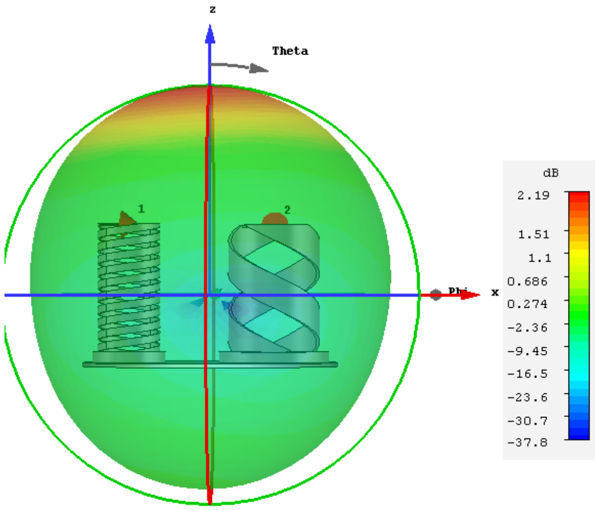
Frequency (MHz)	*Axial Ratio*
1175MHz	3.035
1575MHz	5.9194
1610MHz	6.2146
2500MHz	2.6642
2690MHz	3.4518



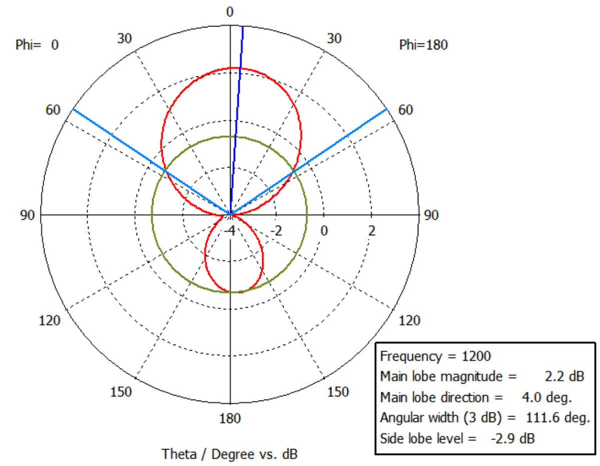
3-D Pattern @1175 MHz



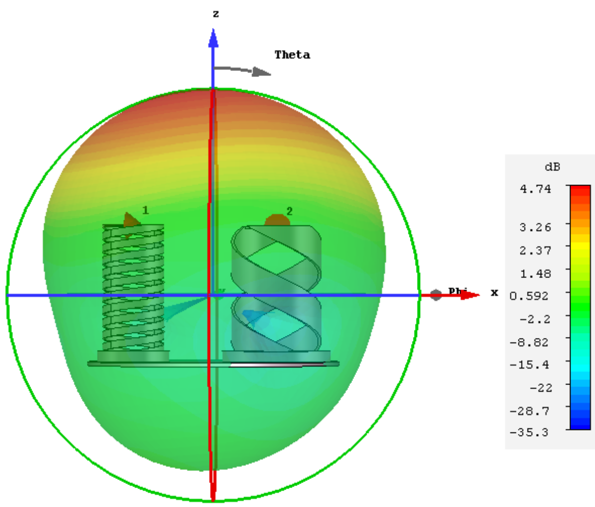
Elevation Cut @1175 MHz



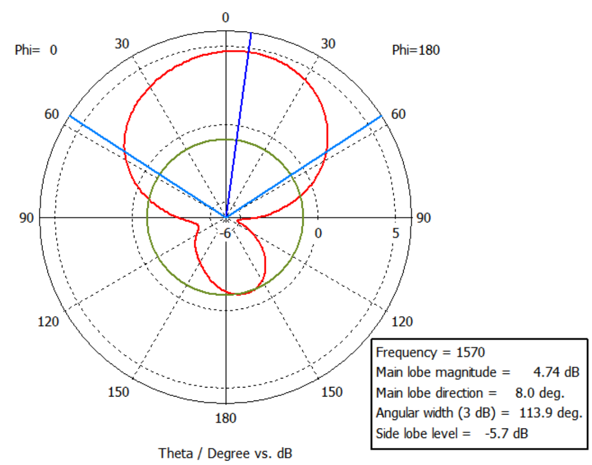
3-D Pattern @1200 MHz



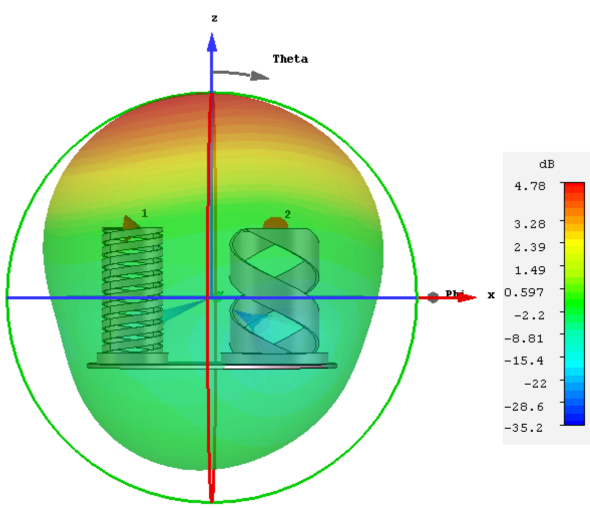
Elevation Cut @1200 MHz



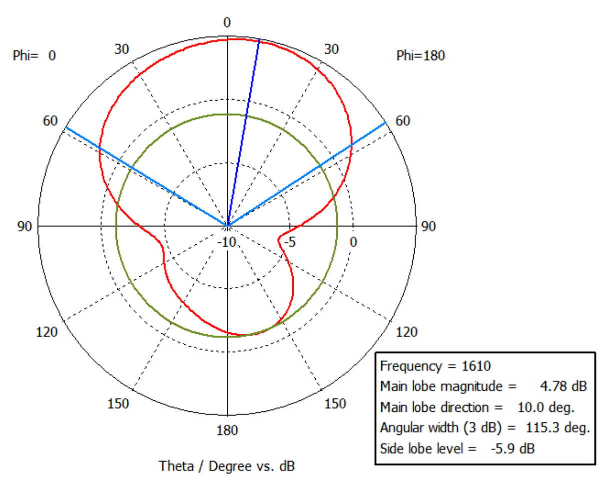
3-D Pattern @1570 MHz



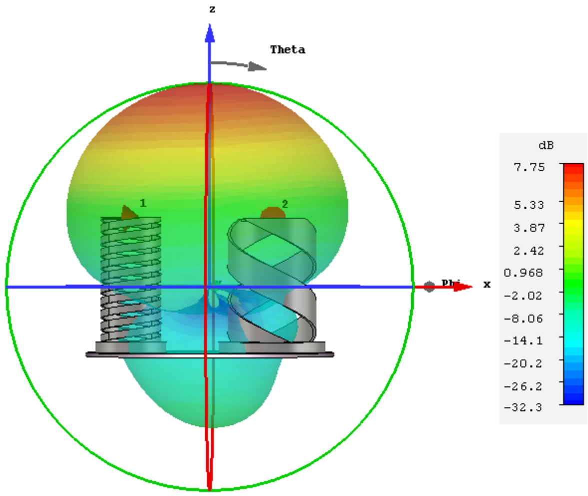
Elevation Cut @1570 MHz



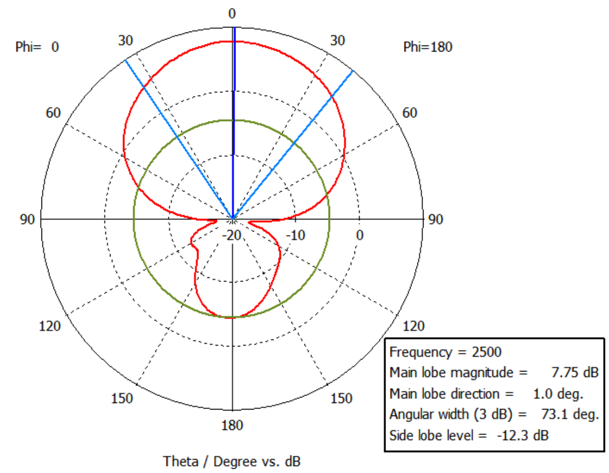
3-D Pattern @1610 MHz



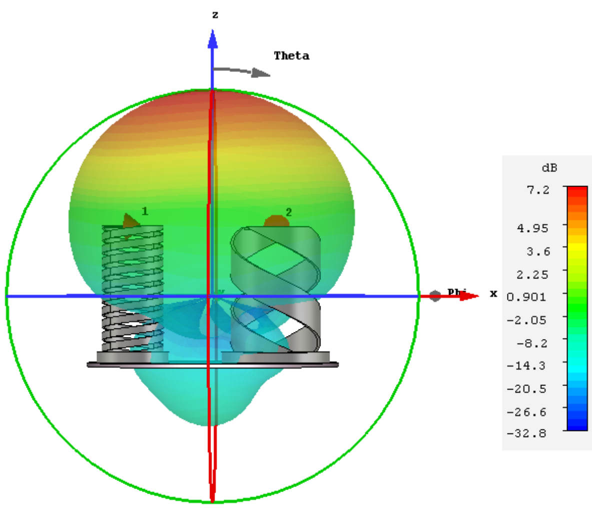
Elevation Cut @1610 MHz



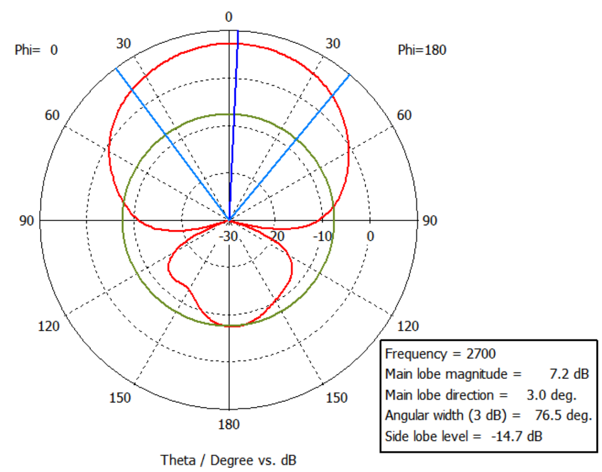
3-D Pattern @2500 MHz



Elevation Cut @2500 MHz



3-D Pattern @2700 MHz



Elevation Cut @2700 MHz

Figure 6: Radiation patterns of GPS/GLONASS/IRNSS and S-band Antenna at various frequencies

Table 4
Main lobe Magnitude, Main lobe direction, Angular width and Side lobe level at various frequencies

Frequency (MHz)	*Mainlobe Magnitude (dB)*	*Main lobe direction (Degrees)*	*Angular width (3dB)*	*Side lobe level (dB)*
1175MHz	1.96dB	3.0	109.6	-2.7
1200 MHz	2,2 dB	4.0	111.6	-2.9
1570 MHz	4.74 dB	8.0	113.9	-5.7
1610 MHz	4.78 dB	10.0	115.3	-5.9
2500 MHz	7.75 dB	1.0	73.1	-12.3
2700 MHz	7.2 dB	3.0	76.5	-14.7

4. DISCUSSIONS

In the current day communication systems, especially for submarine applications, single antenna should meet the requirement of GPS, GLONAS, IRNSS, S-Band SATCOM, etc,. After studying many antennas like crossed dipole, patch antenna, etc., only helical antenna is suitable for such applications. The look angles and the gain requirements of the antenna shall be the prime important for such applications as the location of satellite is fixed with respect to the earth orbit and therefore, an extensive study has been made to meet the gain requirement at ±45° points and the tilt angle of the beam. In both the requirements, the derivative of helix antenna is suitable, i.e, bifilar helix. Similarly in UHF band, though the gain requirement is less due to the operating frequency range, the beam width is very critical. Thus the antennas in these bands were designed and simulated in CST studio and the results are very encouraging in the entire band of operations. Hence the first author would like to manufacture these antennas to confirm the suitability for the intended applications. Further, there is a scope to study on high pressure radome for such applications, which can be developed by potential researchers.

5. CONCLUSION

A Novel backfire bifilar helix antenna was designed by integrating the two backfire bifilar helix antennas with different dimensions. The same antenna was simulated for its characteristics such as VSWR, Gain, and Axial ratio and Radiation patterns at various frequencies of various communication systems like GPS, GLONASS, IRNSS and S-band. The simulation results showed that a Novel backfire bifilar helix antenna is suitable for multi-use antenna or multiband antenna to cover the various communication systems such as GPS, GLONASS, IRNSS and S-band SATCOM. Moreover the required Gain was obtained at these frequency bands to avoid maximum path loss in LEO Satellite Communication

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