DESIGN AND TESTING OF C-BAND HELICAL ANTENNA

Pooja V, Nivetha R, Sahana Kumari, Basavaraj SM

Abstract— **The scope of the paper is to design, simulate and test helical antennas in the C-BAND at 4.2 GHz & 6.4 GHz. Currently the WIPL-D software is used for optimizing the Radiation parameters to suit the stringent Satellite communication requirements. These helices will be fabricated using simple fabrication techniques and tested in the RF ANEHOIC Chamber. Antennas will be characterized for the critical antenna parameters like radiation pattern, polarization and gain. Conical cup reflector will be used to reinforce the side and back lobe to increase the efficiency and gain of the helical Antenna.**

Index Terms— **C-BAND, WIPL-D, RF ANEHOIC CHAMBER**

I. INTRODUCTION

Helical antennas are widely being used for over the past 5 decades in various applications because of their simplicity in construction, wider frequency bandwidth with good polarization purity. There are many wide variety of helical Antenna that have been developed in the recent past meeting the specific antenna characteristics. Cylindrical, tapered, partial tapered etc. are some of the interesting designs to suit the specific gain and radiation parameters.

The helical antenna is a hybrid of two simple radiating element, the dipole and loop antennas. A helix becomes a linear antenna when its diameter approaches zero or pitch angle goes to 90 degree. On the other hand helix of fixed diameter can be seen as a loop antenna when the spacing between the turns vanishes.

The rigorous analysis of a helix is extremely complicated. Therefore radiation properties of the helix such as gain, far field pattern, acceleration and input impedance have been investigated using experimental methods, approximate analytical techniques and numerical analysis.

II. GEOMETRY OF A HELICAL ANTENNA

A. Geometry of helix

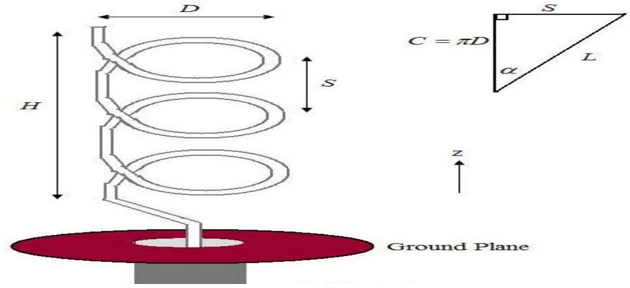

Fig.1 geometry of helical antenna

[3]The geometry of a typical helical antenna is as shown in Fig.1. Common parameters of helical antennas used in the paper are defined as follows:

C = Circumference of the helix
D = Diameter of the helix
N = Number of turns
S = Gap spacing in-between turns
L = Length of one turn
α = Pitch angle
A = Axial Length
H = height of the antenna

Helical antenna is a copper wire wound in the form of a helix. The feed line is provided between the ground plate and the bottom of the helix.

The uplink antenna operates at 6.4GHz and downlink antenna at 4.2Ghz.These antennas operates in the axial mode. They are monofilar antennas. The main reason why these antennas constitute an asset in applications concerning satellite and space communications generally is its circular polarization. Circular polarization is used here because it has left circular polarization (LCP) as well as right circular polarization (RCP) due to which it can transmit and receive signals in all the directions (360°).

B. Geometry of cup

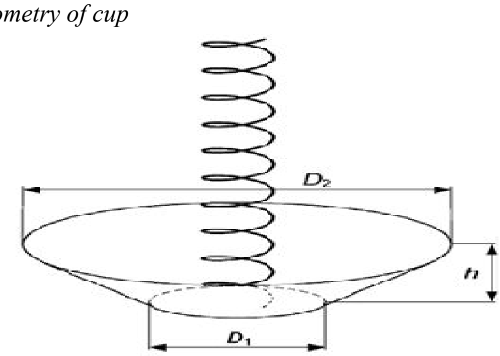

Fig. 2 conical cup

[1] D1 represents the lower base diameter of the cup, D2 upper diameter and h represents the height of the cup. The

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Pooja V, Dept of Telecommunication Engineering , Dayananda Sagar College of Engineering, Bangalore, Karnataka, India
Nivetha R, Dept of Telecommunication Engineering , Dayananda Sagar College of Engineering, Bangalore, Karnataka, India
Sahana Kumari, Dept of Telecommunication Engineering , Dayananda Sagar College of Engineering, Bangalore, Karnataka, India
Basavaraj SM, Dept of Telecommunication Engineering , Dayananda Sagar College of Engineering, Bangalore, Karnataka, India

optimal dimensions of the cup for D1 =0.75 λ, D2 =2.5λ and h=.75 λ. The conical cup ground plane suppresses the side lobes in directions that are close to the horizontal axis because of which the back radiations will be reduced. The cup not only acts as the reflector but it also acts like a horn antenna that creates its own radiation pattern which will be favorable for the pattern of the helical antenna.

III. NFA SPECIFICATIONS

Type	Axial Mode Helix
Downlink frequency	4.2GHz
Uplink frequency	6.4GHz
Downlink gain	10 dBi ± 1dB
Uplink gain	10 dBi ± 1dB
Downlink	LHCP
Uplink	RHCP
Beam width	±45^0 (for -10 dB level)
Return loss	Better than 15 Db

IV. BLOCK DIAGRAM

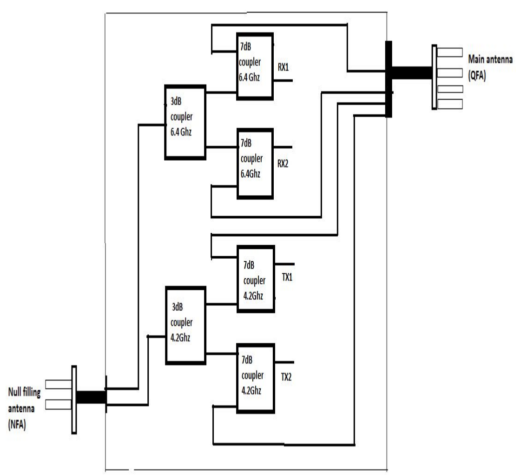


Fig. 3 TTC omni antenna RF system

The satellites operating in the geo synchronous orbit require an omni-directional coverage TTC (telemetry and telecommand) antenna for both the uplink and downlink. The TTC Omni antenna system is a combination of the Main Antenna and the Null Filling Antenna tailored to meet the various operating conditions of the satellite.

The main antenna is a fractional turn Quadrifilar helix chosen considering its wide beam-width requirement, gain, polarization and weight. The null- filling antenna is an axial mode helix with a conical cup reflector and is used to fill the major null region created by the main antenna. Thus it's given a name null filling antenna. The main and null filling antennas are fed in 10:1 ratio by a suitable coupler. The main antenna has two uplink and two downlink antennas for backup purposes in case of any failures.

As the up and down links are quite apart, separate units are used for the both links There are two staggered frequency transmitters and receivers and hence each transmitter is independently catered by a main antenna but the null filling antenna is shared by the transmitters because it has only one uplink and one downlink antenna. Similarly each receiver is separately connected to a main antenna but the null filling antenna is common for both the receivers. The main and null filling antennas are connected using a 7dB coupler and 3 dB power combiner/divider combination.

V. RADIATION COVERAGE REQUIRMENT

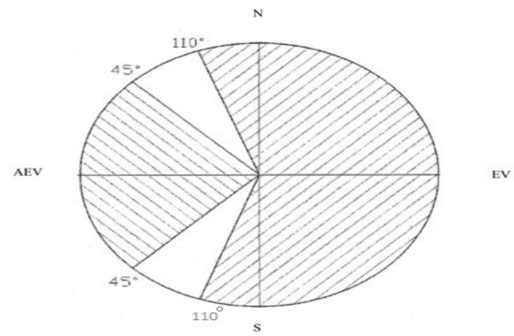


Fig. 4 coverage pattern

The design of Null Filling Antenna (NFA) is carried out at uplink and downlink frequencies to fill up the nulls created by the main antenna. The main antenna elements will be pointing towards earth view (EV) and the null filling antenna elements will be pointing towards anti earth view (AEV) direction. The mounting ensures the near omni radiation coverage for both transfer and on orbit operations.

The near Omni uplink pattern is achieved by the combination of two antennas mounting on two opposites faces of the spacecraft, uplink with RHCP polarization and downlink with LHCP polarization. In this configuration Main antenna provides ±110^0 coverage and NFA provides ±45^0 with uplink in right hand circular polarization (RCP) and the downlink in left hand circular polarization (LCP).

VI. SIMULATION RESULTS

The software which we have used for designing the uplink and downlink antennas is WIPL-D Pro version 6.4. WIPL-D stands for wires plates and dielectrics. It is a privately owned company and has been established for over 20 years.

A..Uplink – 6.4Ghz

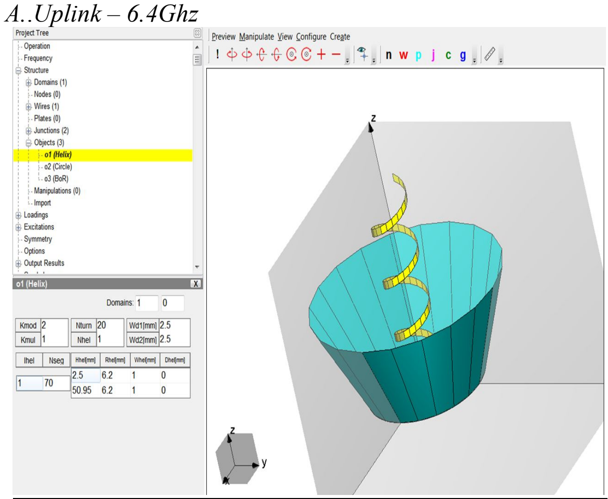


Fig. 5 WIPL-D design module for 6.4 GHz

[2] The helix which we have designed has 3.5 turns with D=12.4mm, S=11.7mm and H=50.95mm.

The plate diameter is 36mm.

The cup dimensions are D1=36mm, D2=60mm and h=25.5mm.

Right circular polarization(RCP)

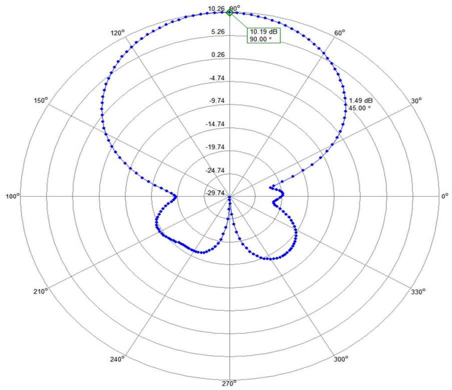


Fig. 6 RCP for 6.4Ghz

Left circular polarization (LCP)

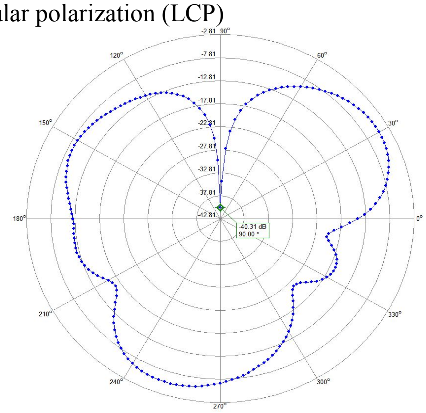
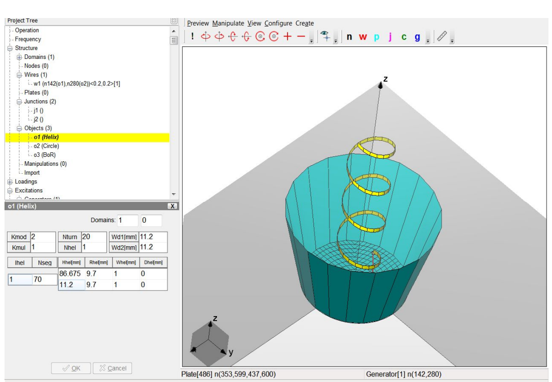


Fig. 7 LCP for 6.4Ghz

[4]As per our specifications uplink antenna is right hand circularly polarized, it has its co polarization in RCP which contains the main data and cross polarization in LCP which contains the cross data. The value at the 90° in RCP represents the gain . The difference between RCP and LCP should be more than 20dB to clearly distinguish between the data in co-pol and cross-pol. As per our simulation results, the difference obtained is 50.5dB

Fig.8 WIPL-D design module for 4.2 GHz



B Downink 4.2Ghz

[2]The helix which we have designed for downlink has 3.5 turns with D=19.4mm, S=17.85mm and H=86.675mm.

The plate diameter is 46mm.The cup dimensions are D1=46mm, D2=80mm and h=33.2mm.

Left circular polarization(LCP)

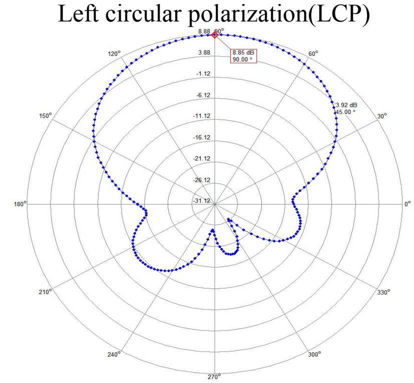


Fig. 9 LCP for 4.2 GHz

Right circular polarization(RCP)

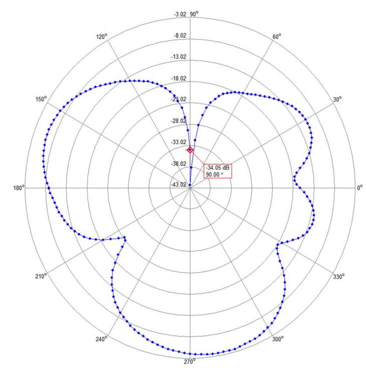


Fig. 10 RCP for 4.2 GHz

[4]As per our specifications downlink antenna is left hand circularly polarized, it has its co polarization in LCP which contains the main data and cross polarization in RCP which contains the cross data. The value at the 90° in LCP represents the gain. Hence, the difference between RCP and LCP should be more than 20dB to clearly distinguish between the data in co-pol and cross-pol. As per our simulation results, the difference obtained 42.9dB.

VII. ANTENNA TESTING SETUP

Anechoic chamber

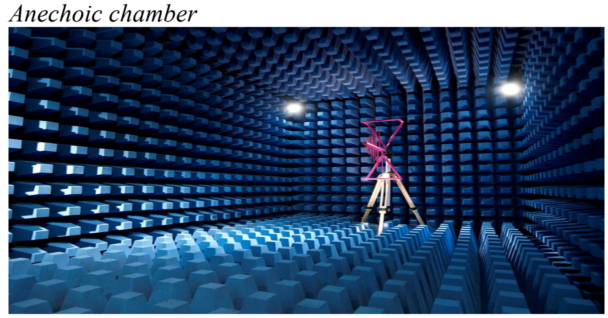


Fig. 11 anechoic chamber

Anechoic chamber is a room designed to reduce internal reflections of electromagnetic waves within the chamber as well as to insulate from exterior sources of electromagnetic noise. The combination of both of these aspects means that anechoic chambers simulate an electromagnetically quiet, open-space environment of infinite dimension. Anechoic chambers accomplish this by lining the interior walls with a material that absorbs an electromagnetic waves incident energy, thus simulating infinite free space.

B .Basic antenna testing setup

Testing devices within the chamber requires a number of different pieces of equipment. A typical setup for testing the gain of an unknown antenna requires the following components:

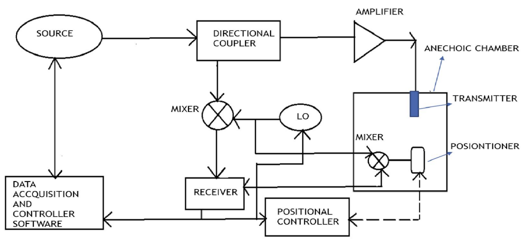


Fig. 12 Block diagram for basic antenna testing

The antenna to be tested is placed in the posiontioner, a signal of 4.2Ghz is generated at the source. This signal is given to a directional coupler in which it sends the signal to the amplifier and the mixer. The signal might have undergone losses across directional coupler , to overcome this loss the signal is boosted by passing it through the amplifier. This signal is fed into transmitter.

Local Oscillator generates a signal of frequency 4.245Ghz this signal is subtracted with the 4.2Ghz signal in the mixer which produces 45Mhz signal which is fed to the receiver.The antenna at the transmitter is a standard antenna whose parameters are known to us. The signal sent by the transmitter is rceived by the posiotioner which is given to mixer in the anechoic chamber, the same signal from the LO is given to mixer as another input, the oupput of it is given to the receiver. If the frequency of signal from both the mixer matches, the reciever will be locked and the required measurements can be taken.

The antenna under test is rotated in 360° by positional controller to obtain the desired values. Data accqusition and controller software is used to produce the polar plot on the system by using these values. In a similar manner the 6.4 GHz antenna is tested.

VIII. ANTENNA MEASURED RESULTS

Radiation pattern – 6.4Ghz

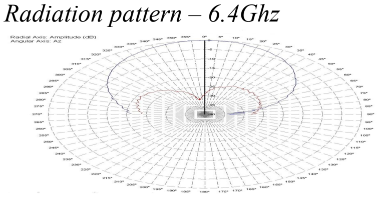


Fig. 13 cross-polarization for uplink antenna (6.4 GHz)

The polarization purity of the antenna can be analyzed by measuring the co-to cross polar isolation. Cross polarization plot is shown in Fig. 13. It can be seen that a cross polar discrimination of about 29dB is obtained. Thus the measured results have a very close match with the simulated values.

B Radiation pattern-4.2Ghz

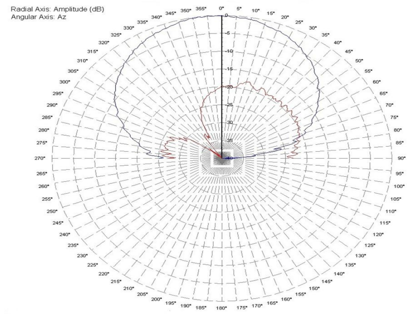


Fig. 14 cross-polarization for downlink antenna (4.2 GHz)

The polarization purity of the antenna can be analyzed by measuring the co-to cross polar isolation. Cross polar plot is shown in Fig. 14. It can be seen that a cross polar discrimination of about 20dB is obtained. Thus the measured results have a very close match with the simulated values.

CONCLUSION

Helical Antennas has been extensively used in the current space communication and also for the Ground Station Earth terminals. In this paper the requirement for NFA antenna is discussed along with its electrical specifications and design. A circular ground plate and conical cup reflector is used to improve the gain of the given antenna. The use of NFA in telemetry and telecommand is one of its main application . It is seen that there is good match between the simulated and measured results and is meeting the requirements.

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REFERENCES

[1] Antonije R. Djordjevic, Alenka G. Zajic , Enhancing the Gain of Helical Antennas by Shaping the Ground Conductor, IEEE ANTENNAS AND WIRELESS PROPAGATION LETTERS, VOL. 5, 2006, 138-140

[2] WIPL-D Pro user's manual, version 6.4

[3] John.D.Kraus and Ronald J.Marhefka,"Antennas:for all applications ",third edition,2002,McGraw-Hill higher education

[4] HAROLD A. WHEELER," A Helical Antenna for Circular Polarization", 1947,IRC,1484-1489

BIBLIOGRAPHY

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Pooja V is pursuing Final year B.E in Telecommunication Engineering, Dayananda Sagar College of Engineering, Bangalore.
Nivetha R is pursuing Final year B.E in Telecommunication Engineering, Dayananda Sagar College of Engineering, Bangalore.
Sahana Kumari is pursuing Final year B.E in Telecommunication Engineering, Dayananda Sagar College of Engineering, Bangalore.
Basavaraj S M is Asst.professor in Telecommunication Engineering, Dayananda Sagar College of Engineering, Bangalore.