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Helical Antenna Design and Analysis for S Band down Link Applications

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Abstract – **In this paper a helical antennas is designed for S band in the frequency range 2.025 to 2.110 GHz. This antenna is well suited for payload and telemetry downlink data for Earth Observation and space science missions. Helical antennas are widely used to achieve high gain and circular polarization over a wide band width. The antenna is designed and simulated in CST microwave studio. The antenna has obtained a peak gain of 29.42 dBi for downlink. The gain of the helical antennas is increasing by reducing the gap between the turns of coil and also increasing the number of turns in the helical antenna.**

Keywords: **Helix, Circular polarization, Axial mode, RHCP, LHCP, downlink.**

I. INTRODUCTION

Helical Antenna was invented by John Kraus in 1946 [1].It is also called as helix as it consists of conducting wire wound in the form of helix ..Helical antennas are mounted over a ground plane,usually a dielectric cylinder [2].the feed line is provided between bottom of the helix and ground plane.Helical antenna can be operate in two modes [3][4]:Normal mode and axial mode.In normal mode maximum radiation takes place in the direction perpendicular to helix axis.When the circumference of helix is of the order of one wave length, the maximum radiation occurs in the direction of helix axis,tis mode is known as axial mode.Axial mode helical antennas have much significance in Wireless communication,Radar communication and Space communication ,because, they provide high gain and circular polarization [7][8]over a wide band width with out using a polarizer..When ircumferenec (C) and high pitch angle (α) are in the range of $\frac{3\lambda}{4} < C < \frac{4\lambda}{3}$ and $12^0 < \alpha < 15^0$,te radiation characteristics of axial mode antenna remain relatively constant[6].circular polarization occurs when two signals are equal in magnitude and having 90^0 phase shift.Circular polarization is possible Left and Circular polarization (LHCP) (Wave rotates in anti clock wise direction) or Right Hand Circularly Polarization (RHCP)(wave rotates in clock wise direction)[8].High gain is essential for helical antennas to use in Satellite and Space communication.Antenna performance can be optimized by varying antenna geometrical parameters, such as, reducing the gap between the turns of the coil (S),Reducing the size of the antenna , number of turns,diameter of ground plate and distance between the bottom of helix and ground plate.Antennas can be mounted on different conducting planes [8] like infinite ground plane,square ground conductor,cylindrical cup and truncated cone.

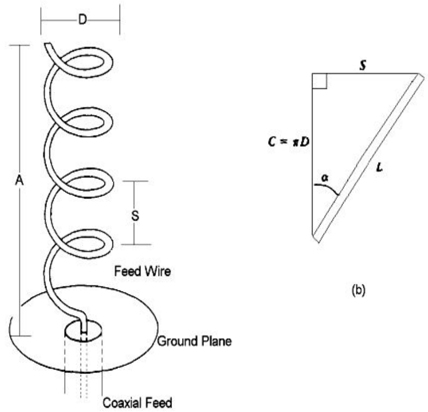

Fig. 1 The structure of helical antenna

II. LITERATURE SURVEY

Yazdan Khan et al [4] have designed a helical antenna for satellite and space communication. In their work helix is placed over a square wave conductor and reduced the gap between the turns of the coil .They have achieved 8.75% improvement in gain .

Appala Raju et al [5] have designed a Spiro Helical Antenna (SHA) by making little modifications to General Helical Antenna (GHA).The size of SHA is almost 3 times smaller than GHA with te same radiation characteristics . SHA consists of double helical geometry. This antenna has improved gain, axial ratio, band width and circular polarization over wide band width .

Nimisha N Rajput et al [6] have designed an axial mode helical antenna using longer helical wire at an operating frequency of 1.5 GHz. This antenna has improved gain and provides reliable communication. Rao SSSR et al [7] have designed a helical antenna for Ku band, which is used in satellite applications. In this work they have achieved a peak gain of 11.3 dBi by increasing the number of turns and by reducing the gap between the turns of the coil.

Venkateswara Rao et al [8] have designed a helical antenna for L band applications. In their work they have achieved comparatively good gain by using band width improvement methods. In their work they have optimized the diameter of ground plate and distance between the bottom of the helix and ground plate.

III. PROPOSED ANTENNA

The main purpose of this antenna is to receive information to the ground either for telemetry to decide the condition of soundness of the shuttle or as the result of the payload

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frameworks for handling and examination. This arrival of information is upheld by the radio frequency interface amongst shuttle and ground station. The receiving antenna might have the capacity to be advanced to limit impacts on the connection of such attributes as evolving range. In this paper we have studied the effect of frequency ,spacing and number of turns on S band helix receiving antenna (for payload downlink)In this paper statistical performance of helical antenna is carried in S band for space communication particularly for uplink and down link applications. Antenna supports payload and telemetry downlink data for Earth Observation and space science missions. Different frequency ranges in S band

2.025 to 2.110 GHz for uplink
2.110 to 2.120 GHz for deep space uplink
2.200 to 2.290 GHz for down link and
2.290 to 2.300 GHz for deep space downlink

parameters for general uplink are given below-
operating frequency =2.0675 GHz
Wave length $\lambda = \frac{c}{f} = 0.1451\, m$
for circular polarization $\lambda \approx C$
Diameter of Helix $D = \frac{c}{\pi} = 0.0462\, m$
spacing between turns $S = \frac{\lambda}{4} = 0.0362\, m$
Pitch angle $\alpha = tan^{-1}\left(\frac{s}{c}\right) = 14.02\, degres$
Height of the antenna $H = N.S$
Axial ratio $(A.R) = \frac{2N+1}{2N}$
Aperture $A_e = \frac{c\lambda^2}{4\pi}$
Impedance $R = 140\frac{c}{\lambda}$
gain $G = \frac{15\, NSc^2}{\lambda^2}$
$G_{dB} = 10.8 + 10\, log\left(\frac{NSc^2}{\lambda^2}\right)$
$HPBW = \frac{52}{c}\sqrt{\frac{\lambda^2}{NS}}$
$BWFN = \frac{115}{c}\sqrt{\frac{\lambda^3}{NS}}$

IV. RESULT ANALYSIS

From figure 3 it is observed that the designed helical antenna is resonating at a frequency 2.067 GHz with 34.8dB return loss and VSWR is 1.18(figure 4). Figure 2 depicts RHCP helical

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antenna at S-band .Figure 5 represents radiation characteristics of RHCP helical antenna at S-band .The designed antenna is showing good performance at resonating frequency. We further studied the effect of spacing and number of turns on the antenna performance.

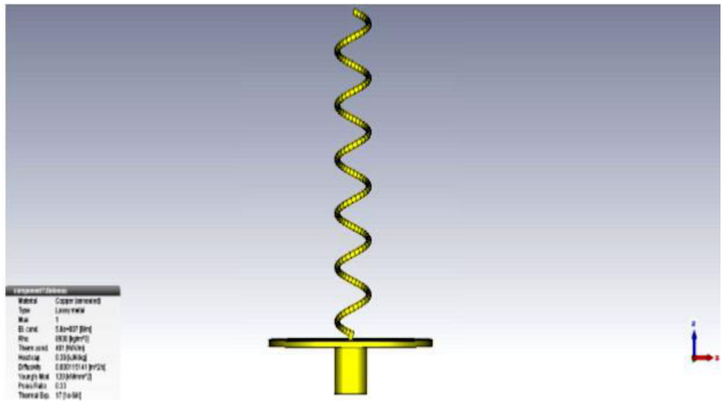

Fig. 2 Simulated Helical antenna design

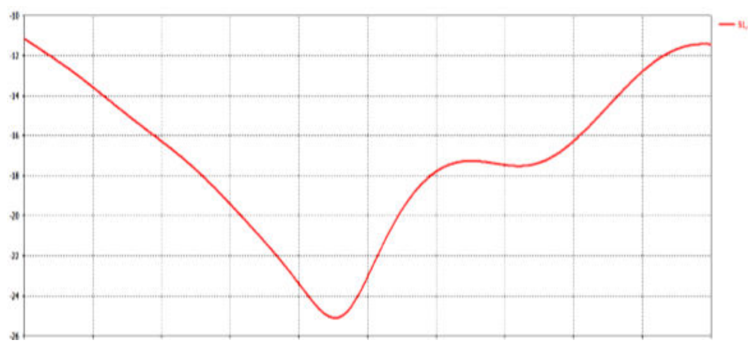

Fig. 3 return loss of the designed helical antenna

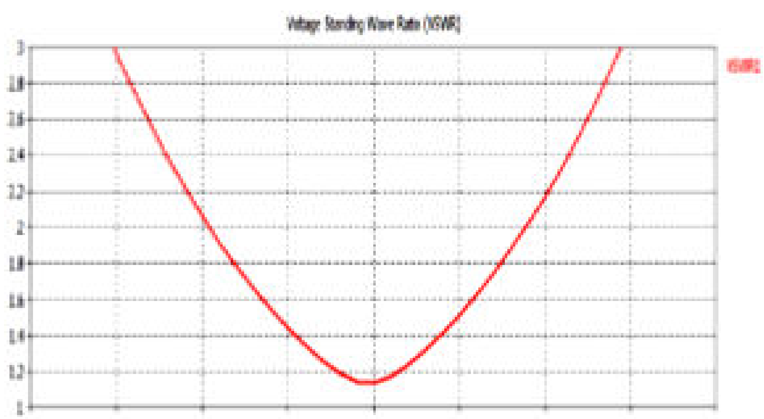

Fig. 4 VSWR of the designed helical antenna

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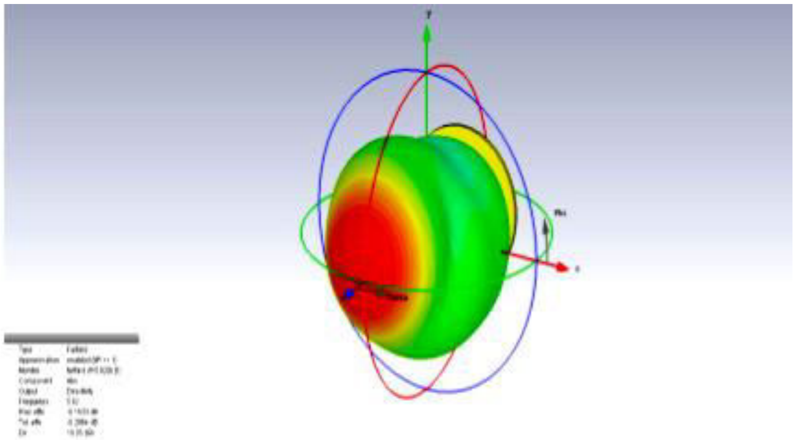

Fig. 5 Radiation characteristics of helical antenna

In table 1 number of turns are gradually increased at a fixed spacing between the turns .Highest gain (23.44 dBi) is achieved when number of turns is 14.As number of turns increases the band width is slightly reduced and beam width is halved. The increase in number of turns have substantially increased band width and decreased beam width.

TABLE I EFFECT OF NUMBER OF TURNS ON GAIN

No of turns	Spacing in lambda	Gain in dBi	-3 dB Band Width	-3 dB Beam Width in degrees
3	0.0362	8.83	1.36	157.7
4	0.0362	11	1.24	136.6
5	0.0362	12.82	1.18	127.2
6	0.0362	14.41	1.15	111.5
7	0.0362	15.84	1.13	103.2
8	0.0362	17.14	1.12	96.6
9	0.0362	18.35	1.11	91.1
10	0.0362	19.48	1.1	86.4
11	0.0362	20.54	1.09	82.4
12	0.0362	21.55	1.09	78.8
13	0.0362	22.52	1.08	75.8
14	0.0362	23.44	1.08	73

In table 2 numbers of turns are fixed but spacing between the turns is altered .As spacing decreases between the turns the gain is gradually increasing. When spacing is 0.01 lambda highest gains (29.42) is achieved. The gap between the turns has not shown much impact on band width and beam width .When gap between the turns increase the gain started decreasing.

TABLE II EFFECT OF SPACING ON GAIN

No of turns	Spacing in lambda	Gain in dBi	-3 dB Band Width	-3 dB Beam Width in degrees
14	0.0362	23.57	1.08	74
14	0.0352	23.62	1.08	75.1
14	0.0342	23.71	1.08	76.2
14	0.0332	23.84	1.08	77.4
14	0.0322	23.99	1.08	78.6
14	0.0312	24.13	1.08	80.2
14	0.03	24.31	1.08	87.8
14	0.025	25.16	1.08	98.2
14	0.020	26.2	1.08	105.4
14	0.015	27.54	1.07	113.4
14	0.01	29.42	1.07	138.9
14	0.0372	23.31	1.08	72
14	0.0382	23.19	1.08	71.1
14	0.0392	23.07	1.08	70.1
14	0.04	22.98	1.08	69.4
14	0.045	22.43	1.08	65.5

V. CONCLUSION

A Helical antenna is designed for at a resonating frequency of 2.067 GHz for payload and telemetry downlink data. High gain is achieved by increasing number of turns and reducing the gap between the turns .As number of turns increase the gain increases. When spacing is 0.01 lambda at 14 turns we have achieved 29.42 dBi gain .In this paper we mainly focused on the improvement of gain .In the future work one should carry their work to further improve band width.

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AUTHOR BIOGRAPHY

Mr Reddy has submitted his doctoral thesis on wireless communications. His research interests include Image and signal processing ,wireless communications ,microwave engineering ,VLSI and Internet of things .He has authored more than 20 research papers in reputed journals and 3 books on communication Engineering .Currently he has focused on 5G antennas design and channel modeling.