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REVIEW ON DESIGN AND DEVELOPMENT OF DUAL BAND HELICAL ANTENNA FOR LoRa APPLICATIONS

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Abstract - In the growing world of wireless communication, designing multiband antennas with low volume has become a practical interest for telecommunications. Helical antenna or helix antenna is the antenna in which the conducting wire is wound in helical shape and connected to the ground plate with a feeder line. In this context, several methods to design dual band helical antenna is discussed for LoRa (Long Range) applications which enables very-long-range transmissions of more than 10km with low power consumption.

I. INTRODUCTION

An antenna is a conductor or an array of conductors, electrically connected to the receiver or transmitter. Antennas can be designed to transmit and receive radio waves in all directions equally (omnidirectional antennas), or preferentially in a particular direction (directional or high gain antennas). An antenna may include parasitic elements, parabolic reflectors or horns, which serve to direct the radio waves into a beam or other desired radiation pattern.

Antennas have an arrangement of metallic conductors with an electrical connection to receivers or transmitters. Current is forced through these conductors by radio transmitters to create alternating magnetic fields. These fields induce voltage at the antenna terminals, which are connected to the receiver input. In the far field, the oscillating magnetic field is coupled with a similar oscillating electric field, which defines electromagnetic waves capable of propagating the signal for long distances. Radio waves are electromagnetic waves that carry signals through air at the speed of light without any transmission loss

Helical antenna or helix antenna is the antenna in which the conducting wire is wound in helical shape and connected to the ground plate with a feeder line. It is the simplest antenna, which provides circularly polarized waves. It consists of a helix of thick copper wire or tubing wound in the shape of a screw thread used as an antenna in conjunction with a flat metal plate called a ground plate. One end of the helix is connected to the center conductor of the cable and the outer conductor is connected to the ground plate. The radiation of helical antenna depends on the diameter of helix, the turn spacing and the pitch angle.

Helical antennas can operate in one of two principal modes: normal mode or axial mode. In normal mode of radiation, the radiation field is normal to the helix axis. The radiated waves are circularly polarized. This mode of radiation is obtained if the dimensions of helix are small compared to the wavelength. The radiation pattern of this helical antenna is a combination of short dipole and loop antenna. In axial mode of radiation, the radiation is in the end-fire direction along the helical axis and the waves are circularly or nearly circularly polarized. The radiation pattern is broad and directional along the axial beam producing minor lobes at oblique angles.

LoRa stands for Long Range Radio. LoRa is a patented digital wireless data communication technology. This technology will enable public or multi-tenant networks to connect multiple applications running in the same network. This LoRa technology will fulfil to develop smart city with the help of LoRa sensors and automated products/applications. LoRa uses license-free sub-gigahertz radio frequency bands like 169 MHz, 433 MHz, 868 MHz (Europe) and 915 MHz (North America). LoRa enables very-long-range transmissions (more than 10 km in rural areas) with low power consumption.

II. RELATED WORK

Helical antenna is a fundamental form of antenna which has limited loops and straight wires [1]. Radiation is maximum i.e. normal to the helix axis when the helix is small compared to the wavelength. The radiation may be elliptical, circular or plane polarized based on the geometry of the helix.

In considering the helix as an antenna, it is important that it be regarded, not as a unique or special form of antenna, but rather as a basic type of which the more familiar loop and straight-wire antennas are merely special cases. Thus, a helix of fixed diameter collapses to a loop as the spacing between turns approaches zero, and, on the other hand, a helix of fixed spacing straightens into a linear conductor as the diameter approaches zero. The peak gain occurs at $c/\lambda = 1.55$ for N=5 (number of turns) and $c/\lambda = 1.07$ for N=35. Peak gain is not proportional to the number of turns. Doubling the number of turns does not yield 3dB gain.

Bandwidth decrease as the axial length of the helix increases [2].

The antenna was made by winding 3/16-in. diameter copper tubing around a Styrofoam cylindrical form. The helix diameter is defined as the center-to center distance of the copper wire. A 1.125-in. diameter aluminium tubing was inserted coaxially into the foam to provide mechanical rigidity. A microstrip transformer, constructed from a teflon-fiberglass printed circuit board and placed on the bottom of the cavity (inside), was used to match the helix impedance with a uniform diameter.

The helix with a smaller pitch angle (more turns per unit length) yields a higher peak gain and a lower cut off frequency. The gain slope depends on the antenna length. The gain-HPBW product is not constant but depends on ***N*** and frequency [3].

Basic design of dual band antenna is to use two pieces of wire for generating two resonant frequencies. Though the dual band antenna with two wire elements can provide the dual frequency needed, the cost of antenna manufacturing would be high. The total length of wire constituting the helix determines the lower resonance frequency. The second resonance frequency can be tuned by changing the capacitive coupling between the turns of the helix that is by changing pitch angle or radius for some turns. By varying the total length of the wire and the pitch angle, the dual frequencies can be tuned to any dual frequency desired [4,5].

When RF current is driven on to helical antennas, the current is distributed on the helix just as on straight conductors. With a sinusoidal signal the current is distributed sinusoidal along the helix with the magnitude of the current at the open end of the helix is always at minimum. Given sufficient length, a few maxima and minima of currents can be observed along a helix. Here the distance between two points of current minima is considered one half wave length.

The normal mode occurs for circumferences in the range 0.66λ-2λ. In this region, 3dB and l0dB beam widths are typically 70^0 and 120^0 respectively. The axial-null mode occurs over the approximate range of 2λ -2.8λ [6].

The maximum gain of the antenna depends on the type of application (narrowband or broadband). For the narrowband application, the antenna parameters are optimized at a single frequency, by maximizing the gain. The gain of the narrowband antenna is maximum at the design frequency (fc). For broadband applications, the antenna properties are optimized for a range of frequencies. The antenna analysis is much simpler and more efficient if the ground plane is taken to be infinite [8].

The helical antenna is often located above a conducting ground plane. The plane can be very large (theoretically infinite) or be on the order of one wavelength (finite dimensions). The antenna is fed by a generator connected at the antenna base, between the antenna and the ground plane. The feed is located on the periphery of the cylinder over which the axis of the helical conductor is wrapped, though it can be located elsewhere.

Antenna bandwidth is inversely proportional to radiation resistance, capacitive reactance and Q factor. Antennas with 'ka' ('k' is the free space wave number and 'a' is the radius of an imaginary sphere which circumscribes the whole antenna) less than 0.5 exhibit low radiation resistance, high capacitive reactance and high Q factor. Spherical antennas potently have higher effective volume if compared to other small antennas with maximum dimension equal to 'a'. The input impedance and the radiation pattern of an antenna are proportional to the total current at the feeding port and on the antenna body, respectively [9].

Quadrifilar Helix Antenna (QHA) [11] has four helix-shaped radiating arms wrapped around a thin dielectric substrate and mounted on a small ground plane. Four pairs of slots are embedded close to the edges of the radiating arms respectively. Two slots are chosen to be identical for symmetry. These slots are resonant at one frequency, and the radiating arms are resonant at the other frequency. Since the polarization of the slots and the radiating arms are the same, this antenna can be used for dual-band operation with the same polarization. By cutting two parallel slots close to the edge of the radiating arms, the antenna has a dual-band resonance property. The radiation pattern at the two different resonant points keep the same, which is not the case for the conventional PQHA as well as most prior dual band designs

Dual band QHA is formed by the combination of two bifilar helical antennas (BHA) [10]. The antenna possess the hemispherical radiation pattern, dual-band operation, circular polarization. The antenna parameters are adjusted to determine the optimum condition for the circularly polarized radiation and hemispherical radiation pattern at each frequency by mutual coupling between primary and secondary loops.

Hybrid of two simple radiating elements, the dipole and loop antennas form a helical antenna [12]. When the diameter of the helix approaches zero or pitch angle goes to 90^0, a helix becomes a linear antenna. The antenna has transmission and radiation (normal an axial) modes of operation.

High power dual-branch helical antenna is obtained by dividing the path of radiation into two [13]. The dual-branch helical antenna shows a smaller maximum E-field value over the single-branch helical antenna.

The antenna consists of two short helixes with the same polarization but a relative rotation angle. As the high frequency current on the antenna is divided into two paths, its power capacity is much higher than conventional helical antenna.

III. COMPARISION

AUTHORS AND YEAR	TITLE	CONTRIBUTION
J. D. Kraus 1947	Helical beam antenna	Helical antenna is a fundamental form of antenna which has limited loops and straight wires
H. E. King and J. L. Wong 1978	Gain and Pattern characteristics of 1 to 8 Wavelength Uniform Helical Antennas	Bandwidth decrease as the axial length of the helix increases
Howard E King and Jimmy L Wong, 1980	Characteristics of 1 to 8 Wavelength Uniform Helical Antennas	The gain slope depends on the antenna length.
Guangping Zhou 2000	A Non-Uniform Pitch Dual Band Helix Antenna	Basic design of dual band antenna is to use two pieces of wire for generating two resonant frequencies.
Antonije R. Djordjevic, Alenka G. Zajic, Milan M. Ilic, and Gordon L. Stüber, 2006	Optimization of Helical Antennas	The maximum gain of the antenna depends on the type of application (narrowband or broadband).
Rassamitut Pansomboon ,Chuwong Phongcharoen panich and Ravipat Phudpong, 2011	Design of a Dual-Band Quadrifilar Helical Antenna for Radio Beacon Receiver	Dual band QHA is formed by the combination of two bifilar helical antennas (BHA)
Tariq Rahim 2015	Theory of Helix Antenna	Hybrid of two simple radiating elements, the dipole and loop antennas form a helical antenna
Yuan Liang, Jianqiong Zhang, Qingxiang Liu, and Xiangqiang Li 2018	High Power Dual Branch Helical Antenna	High power dual-branch helical antenna is obtained by dividing the path of radiation into two

Comparision above can be used to design and develop a dual band helical antenna.

IV. TOOLS THAT CAN BE USED

Out of several designing tools such as CST, IE3D, HFSS, FEKO, CST can be used for the complete design of antenna. Choosing a proper designing tool depends mainly on the geometry of the structure and the required accuracy of the solution. The interface of IE3D is not quite suitable to include very fine details on the geometry of the structure. The part of FEKO is used for large structures like reflector antennas. HFSS and CST have much better interface which enable the user to include very fine details in the geometry of simulated structure.

CST offers correct, economical process solutions for magnetic force style and analysis. Standard time 3D EM simulation computer code is easy and permits to decide on the foremost acceptable technique for look and optimization of devices for operation in a very wide selection of frequencies. Microwave studio part of the CST studio is one of the important application of CST STUDIO SUITE. RF design engineers make use of the CST MWS STUDIO is for the designing of antennas, filters and couplers due its promising performance in the field of microwaves.

CST MWS STUDIO has a lot to offer in convergent thinker technologies, it is operative in both the time and frequency domain. It is also capable in mistreatment surface meshes and tetrahedral volume meshes.

V. Applications

The designed antenna can be used in

- Wireless microphones
- Smart meters
- Radio Frequency Identification Devices (RFIDs)

VI. CONCLUSION

Antennas are required by any radio receiver or transmitter to couple its electrical connection to the electromagnetic field. As a substitute to globally specified single band antennas, dual band antennas can be designed having different specifications for different countries. Rather than using a monopole antenna, a helical antenna fulfils all

the functionalities as of a monopole antenna and also saves the area.

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