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Helicoidal Antenna In River Core Device For The Emergency Water Information Network;

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Abstract— This article presents the analysis, design, simulation, construction and characterization of an axial radiation helical antenna with medium gain (11dbi) and circular polarization as a proposed use for the emergency water information network. Due to its application in the earth station, there are no dimensional limits. The parameters and results for an operating frequency of 915 mhz are presented.

***Keywords*— Antenna arrays; Antenna theory; Helical antennas; UHF antennas.**

I. Introduction

Floods are a growing global problem, and Mexico is making an effort to control the impact they cause in the country. Of the natural hazards capable of causing disasters, floods are the deadliest. Many developing countries have poor water monitoring infrastructure, but have very efficient mobile phone infrastructure [1].Establishing flood warning systems near any sizable body of water or outlet provides vital information that can protect property and save lives. The most effective flood warning methods extend beyond the installation of gauges and telemetry equipment; employ qualified staff, carefully designed procedures and algorithms to provide early warning of when a flood can be expected, when it occurs, and an estimate of how severe it may be.

An effective flood warning system should be based on the regular collection of local rainfall, water level, and streamflow data. The development of a flood warning system requires attention to three basic factors: data collection, data processing, and the dissemination of flood hazard information [2].

For stationary applications, RIVERcore can be used to measure river current flow, depth, local rainfall amount, wind speed and direction, as well as other electrochemical variables that are relevant to this application. It uses wireless communication standards to send information over cellular networks (1G to 4G) or using the IEEE 802.11 (WiFi) protocol. An essential part of the RIVERcore device is the antenna, they must be circular polarized, medium gain to have a greater range and low mass to be supported in the device. Figure 1 shows the RIVERcore application, where the structure is assembled into a bridge.

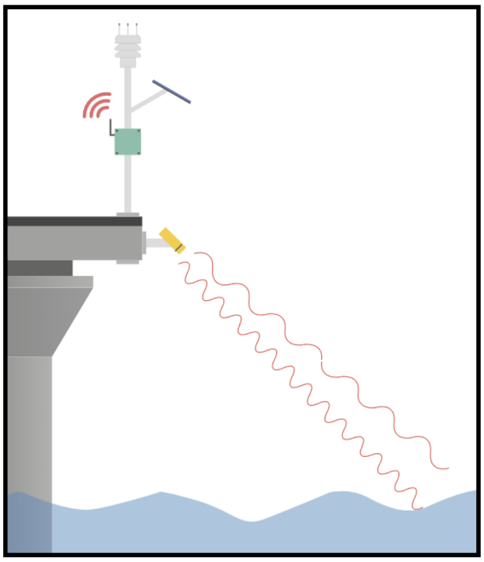

Fig. 1. Antenna in RIVERcore device.

Helical antennas are modified, simulated and their prototypes built in order to improve or refine existing designs. This type of modification can be carried out freely, as well as a combination of techniques, it all depends on what the designer requires to be able to use it in his system, whether he seeks to minimize its size, greater or lesser bandwidth, profit, lower cost, etc.Of course, the design and characterization bring with them problems that must be solved. This work presents the design, simulated and measured results of an axial radiation helical antenna for the UHF band. Due to its application, the antenna must present a radiation pattern in the direction of the helix and have circular polarization.

HELICAL ANTENNA

The helical antenna was invented by John Kraus more than 70 years ago [3], who considered that it represented any wire antenna, because the extended helix is straight and the collapsed one is circular.

For the analysis and design of the antenna, Kraus constructed a chart that relates the dimensions of the antenna (diameter, spacing between turns and pitch angle) with the radiation mode (Figure 4). Dimensions are expressed both in rectangular form for spacing S_λ($S_\lambda = S/\lambda$) and the circumference C_λ ($C_\lambda = C/\lambda$) and in polar coordinates times the length of one lap L_λ ($L_\lambda = L/\lambda$) and the pitch angle α. The ordinates represent the turns because the spacing is zero (α=0), while the abscissa indicates a diameter of zero (α=90) which makes the antenna a straight conductor [4]. The shaded areas they mark the way in which the antenna radiates, for the axial mode the area
T_1R_1.

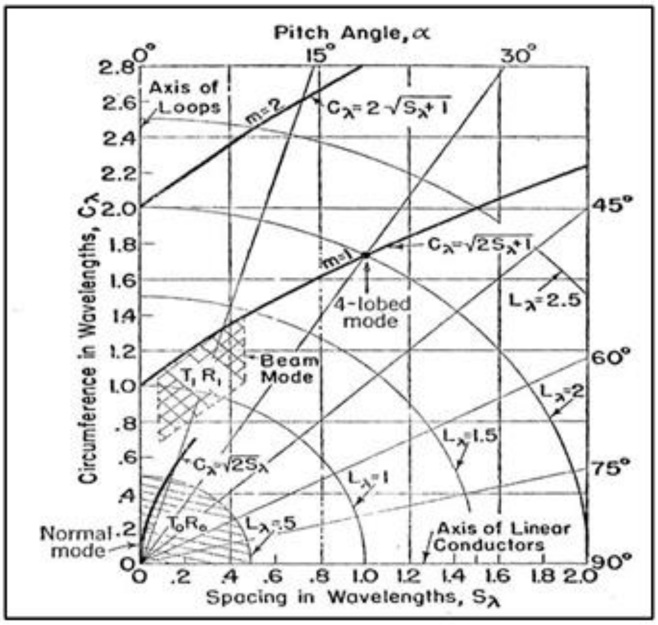

Fig. 2. Design Letter.

The helix basically consists of 3 geometric shapes. The helix wire in a uniform cylinder turns into a straight wire when we unwind it on a surface. Viewed from the top, the propeller projects the shape of a circle. Thus, the helix combines the geometric shapes of a straight line, circle and cylinder [5].

The helix is characterized by the parameters shown in figure 3:

D = helix diameter (center to center of conductor)

C = helical circumference perimeter = πD

S = space between turns (center to center of the conductor)

α= elevation angle = tan-1(S / π D)
L = length of a turn
n = number of turns
A = axial length = nS
d = helix conductor diameter

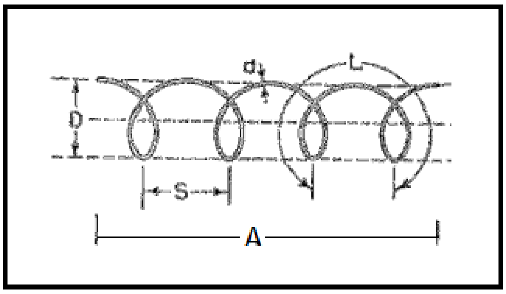

Fig. 3. Helical dimensional parameters.

La antena helicoidal tiene varios modos de radiación (Figura 4), pero el más útil es el de radiación axial. El modo de radiación normal se presenta cuando la longitud de onda es mucho mayor a las dimensiones de la antena, produciendo un campo de radiación máximo en el plano perpendicular al eje y mínimo en el eje de la antena.

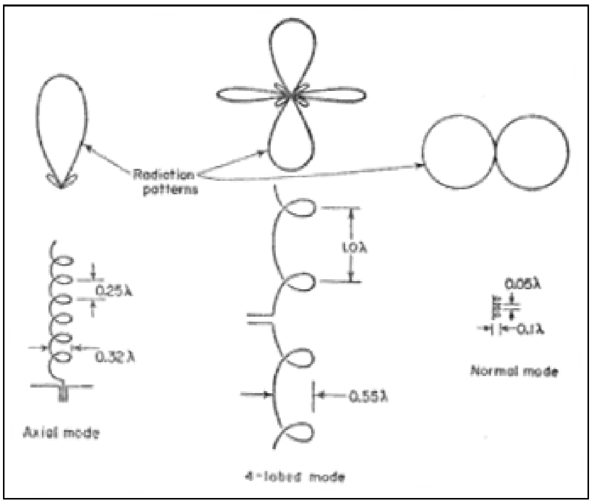

Fig. 4. Radiation modes.

Special care is taken with the sensitivity of the pattern with the phase speed, as shown in figure 5. In particular, when there is a small difference in phase speed, there are very noticeable changes in the patterns, which will notably affect the project performance [2].

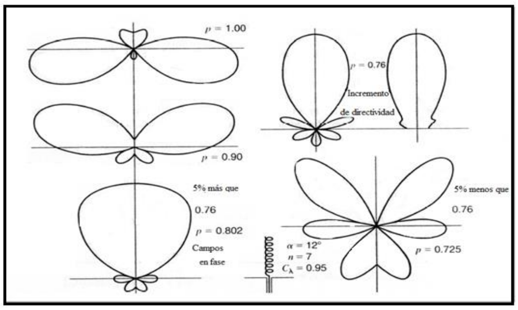

Fig. 5. Phase velocity and radiation pattern.

II. Optimización de antena helicoidal:-

Due to the complexity in the structure of some antennas, such as the case of the helical antenna, simulation programs capable of determining the current distribution in the geometry of the antenna structure are necessary. The parametric study of the helical antenna is carried out using the CST MWS (Computer Simulation Technology Microwave Studio) simulation program, this software is a tool specialized in the analysis of electromagnetic devices at high frequencies, it performs its simulation analysis based on the technique of the Finite Integral.

The antenna that RIVERcore proposes for the Water Information Emergency network is a 10-turn helix on a ground plane, which works in the UHF band, it is expected to have an approximate gain of 11 dBi. Using the aforementioned Kraus theory, we proceed to perform the optimization of each of its parameters. Figure 6 shows the scheme of the designed antenna.

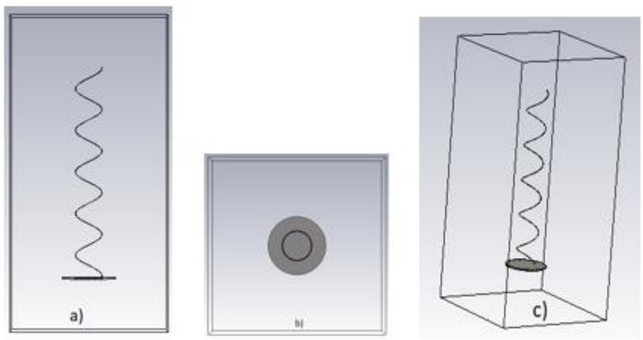

Fig. 6 Helical antenna designed normal mode. a) front view, b) top view, c) profile view.

A fundamental part of the analysis made to the structure was to determine the diameter of the helix; The simulations were carried out by varying the circumference from 0.75 λ until 1.15 λ , observing a gain behavior of up to 13.1dBi from C λ = 1, The larger the propeller diameter, the S11 parameters shift to lower frequencies. Figure 7 shows the radiation pattern in polar form, the greater the helix diameter, the greater the gain.

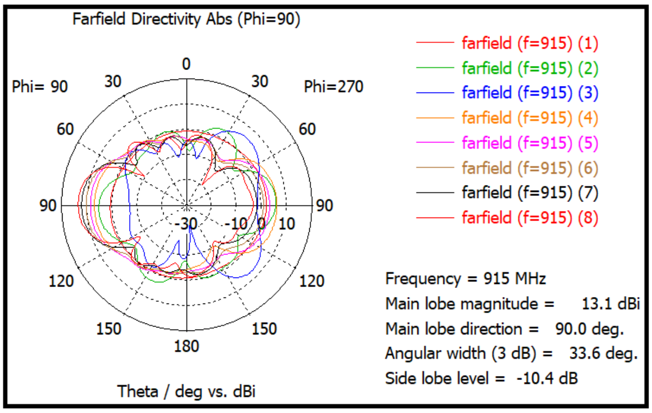

Fig. 7 Propeller diameter optimization.

The turn spacing or spacing can vary from 0.01λ to 0.5λ [6], to be within the axial radiation área, observing a gain behavior of 7.36dBi from a separation of 0.15λ. At greater helix spacing, the S11 parameters shift to lower frequencies. Figure 8 shows the radiation pattern in polar form for different separations between turns, the greater the separation, the greater the gain, although it is not

Frequency	f (MHz)	915
Wavelength	λ(cm)	32.78
Circumference	C	1 λ
Spacing	S(cm)	8.17
Diameter	D (cm)	10.43
Pitch angle	α	14°
Number of turns	N	10
Length	L (cm)	32.78
ground plane diameter	D_{PT} (cm)	24
Axial Length	A (cm)	81.7
Helix to ground plane clearance	h (cm)	1
conductor diameter	d (cm)	0.05
SMA connector dielectric diameter	D_{SMA}(cm)	0.27

To optimize the number of turns, a helix from 4 turns to 16 is analyzed, observing that increasing the turns increases the gain, the increase is not linear and the desired radiation pattern is deformed. The maximum gain obtained is 12.4dBi. Figure 9 shows the different radiation patterns in polar form.

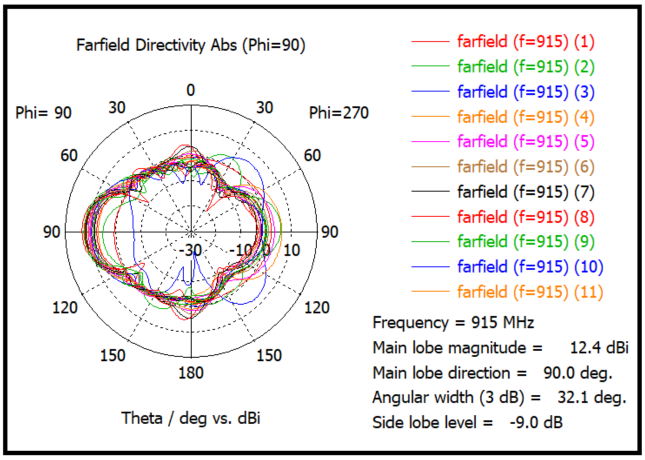

Fig. 9 Optimization number of turns.

III. HELICAL ANTENNA CHARACTERIZATION

Multiple analyzes have been carried out varying different parameters of the helix, trying to optimize its structure, in order to determine the best geometric configuration as well as the effects that occur in the radiation pattern, gain and coupling. The dimensions of the proposed helical antenna (figure 6) are shown in table I.

A simulation stage is developed based on the optimization, the analysis is done on a bandwidth between 900MHz and 930MHz, for coupling using the parameter S_{11} (a suitable value is -10 dB or less), the radiation pattern, and the gain. Figure 10 shows the result of the simulation of the dispersion parameter S_{11}.

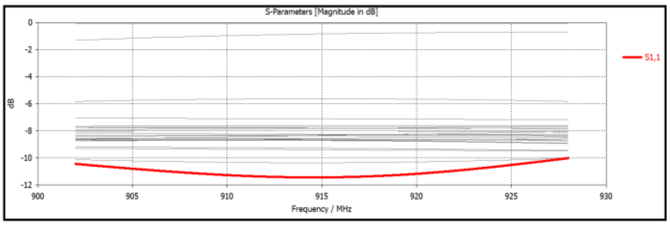

Fig. 10. Simulated S_{11} parameters

The radiation pattern, both volumetric and ϴ plane, is shown in Figures 11(a) and 11(b). The simulation shows a gain of 10.8 dBi for 915MHz. Which is desired for its application, since increasing the gain of the antenna increases its directivity and therefore decreases its coverage with secondary lobes.

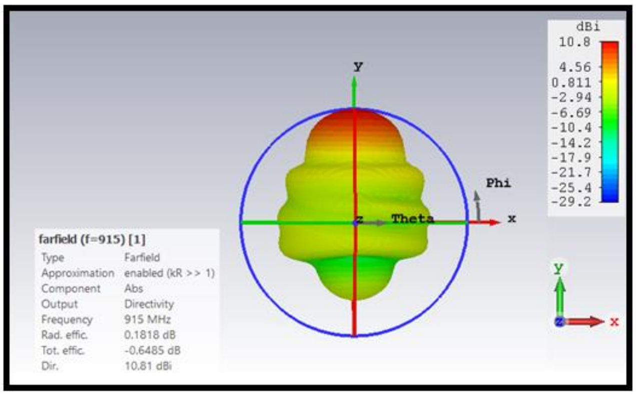

Fig. 11(a) Volumetric Radiation Pattern.

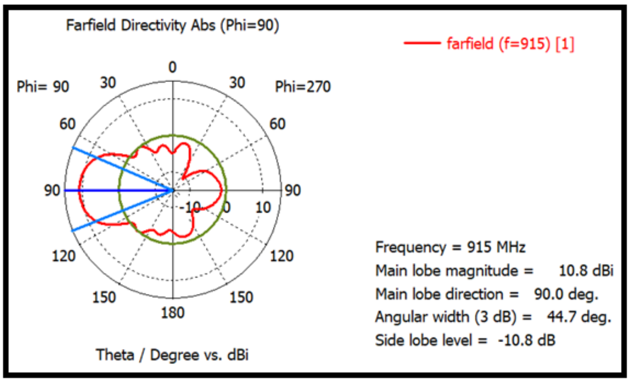

Fig. 11(b) Radiation pattern in Polar form.

The simulated antenna with the obtained results is suitable for the RIVERcore device as part of the EWIN multidisciplinary project. There are no problems with the length of the antenna, it has a gain of 10.8 dBi and with an axial radiation pattern in the direction of the propeller shaft with a main lobe opening of 60°.

We proceed to build the antenna, for this we have to look for a material that has enough elasticity and firmness to be able to be modified, the material chosen to build the helical antenna is brass. The helical radiation antenna can be made in the form of a spring with a constant diameter and constant pitch between turns. Once the helix is built, the housing of the SMA connector is soldered to the ground plane (flat surface of some conductive material, a FR4 phenolic plate was used for printed circuit) and the pin of the connector to the helix.

2 equal antennas are built to measure one in front of the other with a spectrum analyzer, the data exported from the analyzer is plotted in a software called KaleidaGraph. Figure 12 shows the measured radiation pattern.

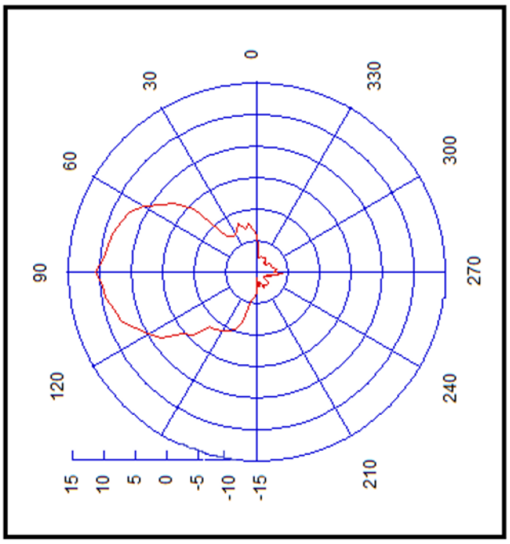

Fig. 12 Radiation pattern measured in Polar form.

A comparison between the measured radiation pattern and the simulated radiation pattern is shown in Figure 13.

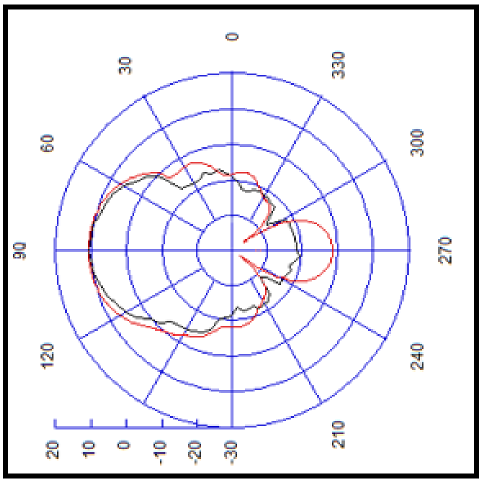

Fig. 13 Radiation pattern measured (black) and simulated (red) in Polar form.

The simulated results are comparable with the measured results, and the practical usefulness of the antenna is confirmed.

IV. Conclusions

In this work, the use of a helical antenna for a RIVER core device within the EWIN water monitoring project has been proposed. In the simulated results by computer, it is observed that its use is feasible. The gain of 10.8 dBi and the circular polarization make it very suitable for use in this type of device at a resonant frequency of 915MHz.

The parametric analysis was carried out as the number of helices and the distance between each of them increased. The greater the number of propellers and the greater the distance, the gain increases, although the increase is not linear. Emphasis was placed on the shape of the resulting radiation pattern since a axial mode radiation pattern is needed for the project, radiation at the propeller shaft.

This antenna is easy to build and low cost, it can be implemented in the emergency water network in a satisfactory way, the bandwidth will be determined once the antenna is coupled in parameters $S_{1,1}$ (-10dB). The dimensions of the antenna even allow the use of arrays, to decrease side lobes and increase the gain. To couple the antenna to the operating frequency, an impedance matching method (STUB) will be used, with which the antenna can be coupled to the operating frequency (915MHz) and increase the gain.

The dimensions of the antenna even allow the use of arrays, to reduce side lobes and increase gain, however the mutual effects could alter performance.

Conflicts of Interest:-

The authors declare that they have no conflicts of interest.

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References

[1] R. Edwards, R.A Santos, P. Lepper, O. Mendoza-Cano, I. Pattison, V.Rangel, F. Jimenez, E. Adegoke, B. Clark, J. Davis, A. Falahati, A. Khouakhi 'Emergency Water Information Network (EWIN)', Loughborough University, http://ewin.corporativostr.com/en/, Issue 1, August 2019.

[2] C. Moreno et al., "RiverCore: IoT Device for River Water Level Monitoring over Cellular Communications," Sensors, vol. 19, no. 1, pp. 1–21, Jan. 2019, doi: 10.3390/s19010127.

[3] J.D. Kraus y D.A. Fleish, "Electromagnetismo con Aplicaciones", Ed.McGraw-Hill Interamericana, 1999.

[4] J. D. Kraus, "Helical beam antennas," Electronics, vol. 20, pp. 109-111, April 1947

[5] M. Chahoud, Y. Tawk, J. Costantine and C. G. Christodoulou, "A miniaturized 3D printed quadrifilar helix antenna with a conical ground plane," 2017 IEEE International Symposium on Antennas and Propagation & USNC/URSI National Radio Science Meeting, 2017, pp. 2541-2542, doi: 10.1109/APUSNCURSINRSM.2017.8073313.

[6] J. D. Kraus, "Helical beam antennas," Electronics, vol. 20, pp. 109-111, April 1947