International Journal of Engineering Research and General Science Volume 3, Issue 2, March-April, 2015
ISSN 2091-2730

Design of helical antenna using 4NEC2

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Abstract— an antenna is a system of elevated conductors, which matches the receiver or transmitter to free space. Antennas are metallic structure designed for radiating and receiving electromagnetic energy. There are many types of antennas used for communication. A helical antenna is an antenna in which a conductor connected to ground plane, is wound into a helical shape. The helix is the simplest antenna which generates circular polarized waves. This paper shows using the design and simulation of helical antenna using 4NEC2 software. Gain, Efficiency, Impedance, Standing Wave Ratio (SWR) and other parameters are analyzed. Thus, a suitable helical antenna is designed and simulated which provides better radiation pattern for effective communication and for use into satellite communication.

Keywords— Helical antenna, 4NEC2, Satellite communication, Gain, Efficiency, Impedance, SWR.

INTRODUCTION

An antenna acts as an interface between a guided wave and a free-space wave. The wire antennas are made of thin, conducting, straight or curved wire segments or hollow tubes and are very easy to construct. It is suspended above the ground and the radius of the wire is very small compared to the operating wavelength of the radio waves used. The dipole and monopole are examples of straight wire antennas. The loop antenna is an example of curved wire antenna. The loop antenna is a radiating coil of any convenient cross section of one or more turns carrying radio frequency current. It may assume any shape like rectangular, square, circular, etc. The circular loop antenna is one of the easiest to construct as well as to analyze. Helical antenna is designed from the loop antenna and many small loop antennas joined together forms the helical antenna. It consists of thick copper wire or tubing wound in the shape of helix or screw thread and used as an antenna in conjunction with flat metal plate called a ground plate. The ground plane is made of sheet or screen of radial and concentric conductors. It exhibits circular polarization. The helical antenna operates in axial and normal modes with respect to the helix diameter. The helical antenna has high directivity (i.e.), its ability to concentrate radiated power in a certain direction. It is used in radio astronomy, satellite and space probe communication. [10]

SIMULATION TOOL

4NEC2 (Numerical Electric Code) is a simulation method for wire antennas, developed by the Lawrence Livermore Laboratory in 1981 for the Navy. To realize this, an antenna is divided into "short segments" with linear variation of current and voltage. The results are very convenient and the standard for this simulation technique is NEC2. The demerit of NEC2 is that the simulation errors occur when wires are crossing in a very short distance or when using buried wires were overcome with 4NEC2. 4NEC2 offers a huge amount of possibilities and options and it was programmed by Arie Voors. Its main advantages are the optimizing tools and the parameter sweeps. It can be found and downloaded free of charge from the Internet. It is open source software. In 4NEC2, the frequency, wavelength, length, radius can be changed and the radiation pattern, smith chart is generated accordingly. Also the efficiency is calculated for the obtained radiation pattern. [13]

The helical antenna should be designed by considering various parameters. Some of the important parameters which describe the geometry of helical antenna are:

Diameter of the helix= D
Spacing between turns= S
Circumference of helix = C
Pitch angle ∞ =tan-1(s/D)
Length of one turn L0= (S2+C2)1/2
Total length of the antenna L=NS

When the pitch angle, ∞ is $0^o < \infty > 90^0$ a helix geometry is formed. There are two modes of operation of helical antenna – normal and axial mode. The parameters on which the mode of radiation depends are the diameter of helix and turn spacing. When the helix diameter is very small as compared to the wavelength, then the helical antenna operates in the normal mode and exhibits broadside radiation. When the helix diameter is large compared to the wavelength, then the helical antenna operates in the axial mode and exhibits end fire radiation. The normalized field pattern is given by:

$$E = \sin\left(\frac{\lambda}{2N}\right) cos\theta . \frac{\sin(\frac{N_\phi}{2})}{\sin(\frac{\Psi}{2})}$$

Here, we design a helical antenna of frequency 150MHZ with a wavelength of 1.999m. The diameter is small compared to the wavelength (diameter of the helical antenna is 63.6cm), so we get a helical antenna with normal mode of radiation.

$$D = \lambda/\pi = 1.999/3.14 = 63.6cm$$

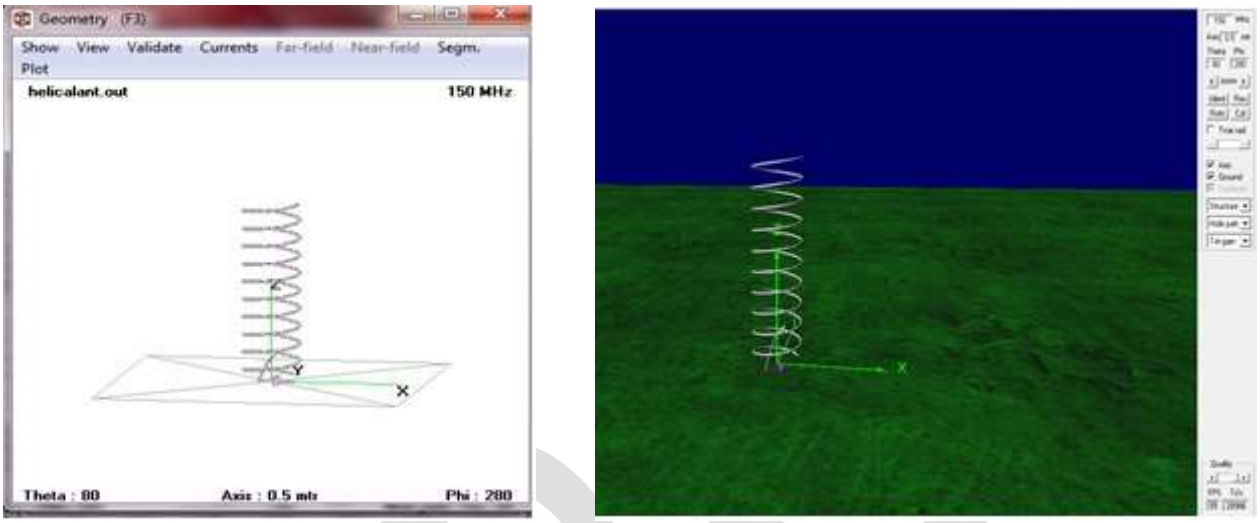

Fig 1: 2D and 3D radiation pattern

APPROXIMATION OF ANTENNA CALCULATION

The various parameters of the helical antenna are calculated using wavelength, frequency, no. of. Turns and spacing between the turns. The input power given to the helical antenna is 100W and the output power or radiated power is also 100W. Therefore, the efficiency is 100% without any loss. Also the radiation efficiency (power loss) is minimum (i.e.) 17.24%. Thus, the calculated parameters match with the simulation results and the newly designed helical antenna is best approximated. It provides good radiation pattern and efficiency for efficient communication.

INPUT:

Wavelength	1.999m
Frequency	150Mhz
No. of. Turns	3
Spacing between the turns	2.25m

Using the above input parameters, other metrics like antenna gain, characteristic impedance, diameter, Half Power bandwidth and effective aperture are calculated using the following relations.

$$Gain = 10.8 + 10*\log10\ ((C/lambda)^2 * N * (S/lambda))$$
$$Impedance = 150/sqrt(C/lambda)\ Ohm$$
$$Diameter = lambda\ /Pi$$
$$Half\ Power\ Bandwidth = 52/\ ((C/lambda)*sqrt\ (N*(S/lambda)))$$
$$Effective\ aperture = D*lambda^2/\ (4*PI)$$

THEORETICAL OUTPUT:

Gain	19.1 dB
Impedance	150 Ohms
Diameter	63.6 cm
Half Power Bandwidth	20^0
Effective aperture	25.8 m^2
Efficiency of the helical antenna	100%

SIMULATION RESULTS

The 4NEC2 software generates the Far field, Near field pattern of the helical antenna designed in it. These patterns can be viewed in 2D and 3D plots. The helical antenna is designed at 150MHZ frequency because the range of frequency used for satellite communication broadcast is (109-173) MHZ frequency. The radiation pattern, smith chart, plot of impedance of helical antenna designed at 150MHZ frequency is given below:

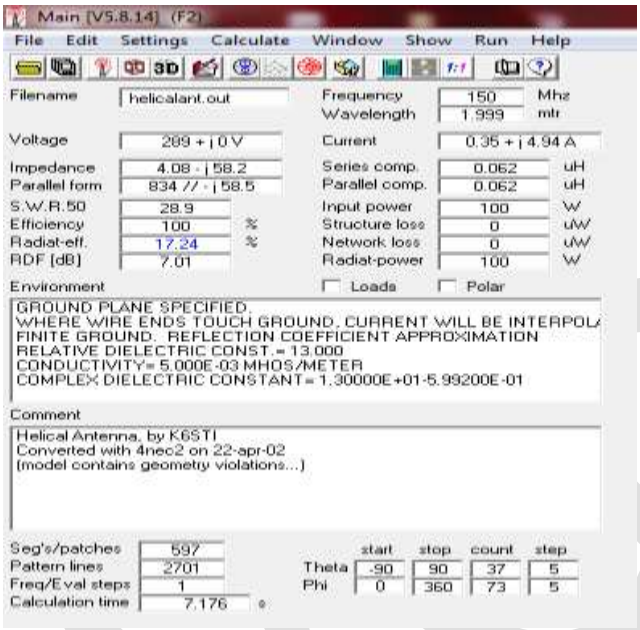

Fig 2: Main window showing various parameters

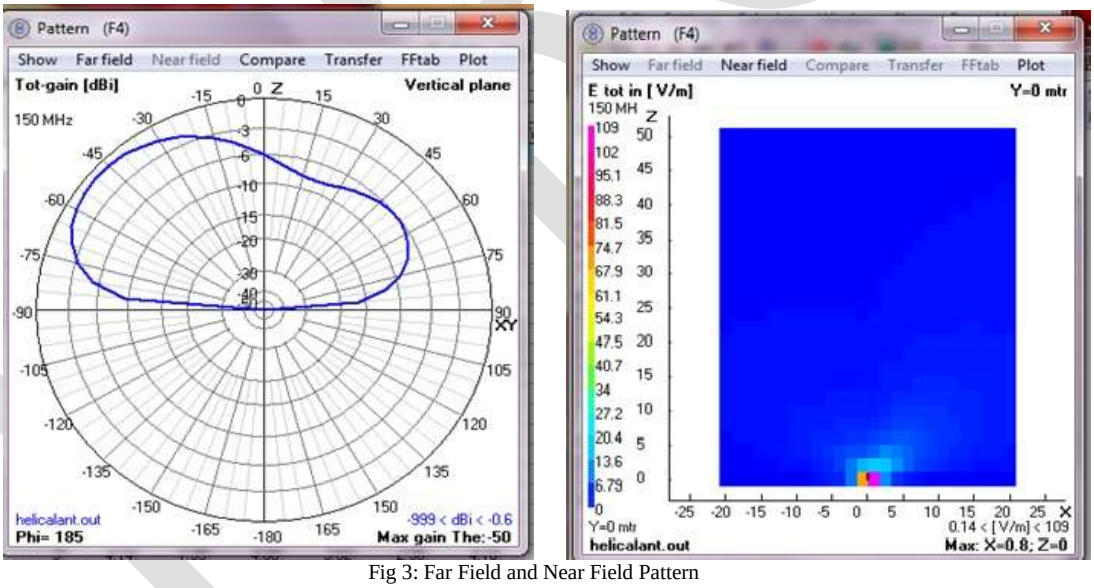

Fig 3: Far Field and Near Field Pattern

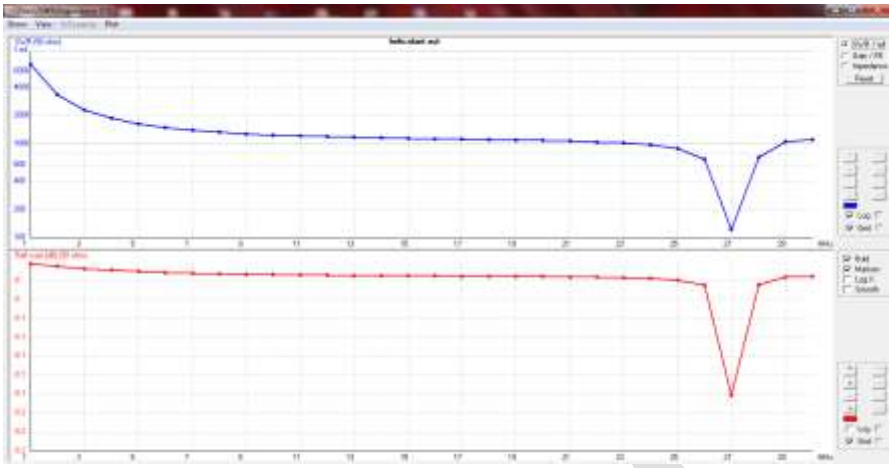

Fig 4: Impedance Plot

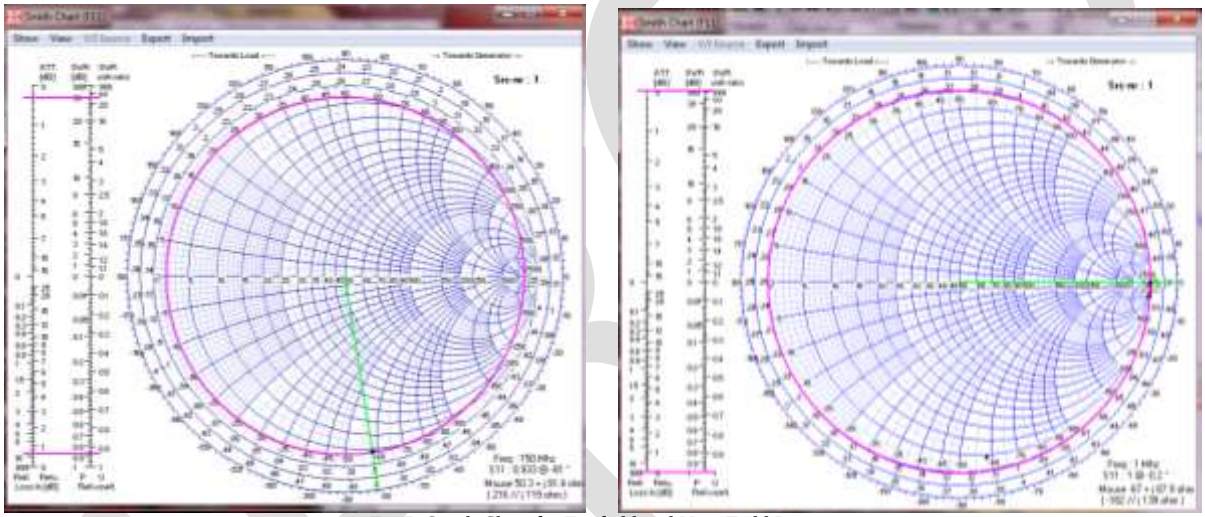

Fig 5: Smith Chart for Far field and Near Field Pattern

CONCLUSIONS

Thus the helical antenna is successfully simulated using 4NEC2 software. It has achieved a maximum efficiency of 100% for efficient and flawless communication at a frequency of 150MHZ without any loss. The main goal of this work is to design a suitable helical antenna and analyze its parameters for better gain. The simulated antenna at 150MHZ frequency can be fabricated and used in satellite communication.

SUMMARY

Lakshmi Kumar, Nilay Reddy. K [nilay.forall@gmail.com] and Suprabath. K [suprabath.kristam@gmail.com], Undergraduate students from Department of Electronics and Communication Engineering working in this paper will be carrying out the design and fabrication of antenna as future work. They work under the guidance of Ms. Puthanial. M [Puthanial@gmail.com] who is pursuing her PhD in Wireless communication related work in the area of smart antennas under the guidance of Dr. P. C. Kishore Raja, Professor and head, Department of Electronics and Communication Engineering, Saveetha School of Engineering, Saveetha University, Chennai.

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