Helical Feed Manipulation for Parabolic Reflector Antenna Gain Control

Zohair Mohammed Elhassan Hussein, Abdelrasoul jabar kizar alzubaidi

Abstract Helical antennas have long been popular in applications from VHF to microwaves requiring circular polarization, since they have the unique property of naturally providing circularly polarized radiation. One area that takes advantage of this property is satellite communications. Where more gain is required than can be provided by a helical antenna alone, a helical antenna can also be used as a feed for a parabolic dish for higher gains. The helical antenna can be an excellent feed for a dish, with the advantage of circular polarization. One limitation is that the usefulness of the circular polarization is limited since it cannot be easily reversed to the other sense, left- handed to right-handed or vice-versa. This paper deals with applying an electronic technique to control the helical feed of the parabolic reflector feed. The control of the helical feed leads to the control of the antenna gain .The proposed design is based on implementing a microcontroller connected to an interface to control stepper motor.

Keywords: Helical Antenna, Parabolic Dish feed, parabolic helical feed reflector, antenna, antenna gain, microcontroller, interface, stepper motor

I. HELIX ANTENNA

John Kraus is the originator of the helical-beam antenna. His book, antennas is the classic source of information. The recent third edition, Antennas for All applications, has significant additional information.

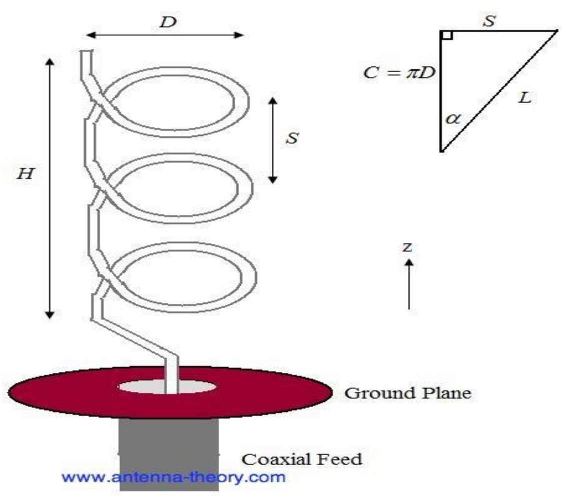

Figure (1) sketch of a typical helical antenna

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A sketch of a typical helical antenna is shown in Figure (1). The radiating element is a helix of wire, driven at one end and radiating along the axis of the helix. A ground plane at the driven end makes the radiation unidirectional from the far (open) end. There are also configurations that radiate perpendicular to the axis, with an unidirectional pattern. W e shall only consider the axial-mode configuration.
Typical helix dimensions for an axial-mode helical antenna have a helix circumference of one wavelength at the center frequency, with a helix pitch of 12 to 14 degrees. Kraus defines the pitch angle α as:

$$\alpha = tan^{-1}\frac{S}{\pi D} \quad \ldots\ldots\ldots\ldots\ldots\ldots..(1)$$

Where;
S is the spacing from turn to turn.
D is the diameter. (the circumference divided by π
The triangle in figure (2) illustrates the relationships between the circumference, diameter, pitch, turn spacing, and wire length for each turn:

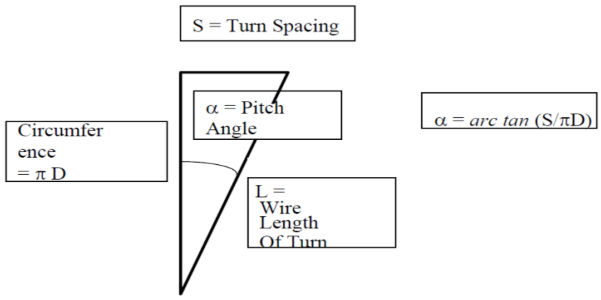

Figure (2) relationships between the circumference, D, pitch, turn spacing, and λ for each turn

The gain of the helical antenna is also proportional to the number of turns. The gain curves show the gain increasing with helix length with no apparent limit. However, experiments with long helical antennas are invariably disappointing. S i m u l a t i o n s of various length helical antennas are made and showed that the gain approaches a limit of about 15 dB, for a length of around 7 wavelengths. For higher gains, arrays of multiple helixes are needed.

$$G = \frac{6.2C^2NS}{\lambda^3} = \frac{6.2C^2NSf^3}{c^3}$$

Where:
G is helical antenna gain
C is Circumference = πD
N is NO of turns of helical antenna
S is turn spacing
f is frequency used
c is light speed

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Almost all helical antennas have been made with uniform diameter and turn spacing. Long helical antennas might require variations in diameter and spacing over the length of the antenna.
Satellites and others require more than 15 dB gain with circular polarization for good reception. L ong helix with a parabolic dish is often a good choice. While a large dish can provide gains upward of 30 dB. A small dish can easily provide the 20 to 25 dB gain needed for many satellite applications. The beam width of a small dish is broader than the beam of a large dish, making tracking less difficult. Of course, the dish needs a feed antenna, and a short helix is a good choice for circular polarization.

II. SYSTEM COMPONENTS

1. Personnel computer (PC): PC computer is used as the master controller of the system. The C++ language is used to program the personnel computer.
2. HD74LS373 Latching IC: The HD74LS373 is eight bit is register IO mapped used as a buffer which is` used for storage of data. Different types of latches are available HD74LS373 octal D-type transparent latch will be used in this system. This type of latch is suitable for driving high capacitive and impedance loads.
3. ULN 2803A Darlington IC: The ULN2803A is a high-voltage, high-current Darlington transistor array. The device consists of eight NPN Darlington pairs that feature high-voltage outputs with common-cathode clamp diodes for switching inductive loads. The collector-current rating of each Darlington pair is 500 mA. The Darlington pairs may be connected in parallel for higher current capability.
4. Microcontroller: Atmega 32 microcontroller will be used as a means of control of the stepper motors.
5. Stepper motor: A five wires stepper motors will be used .One wire is for power supply to the stepper motor and the other four wires are connected to the windings of the stepper motor.
6. Twelve keys matrix keypad: The key pad supplies the Atmega 32 microcontroller with the number of step angles required to rotate the stepper motors.
7. LCD: LCD is used to display the data entry and the real time data during the system processing.
8. Gear and toothed shaft: The gear and toothed shaft together are to move the helix feed upwards and downwards.

III. HARDWARE DESIGN

The hardware design of the system is based on using a microcontroller as a processor. Interface circuits are connected to the microcontroller. A matrix keypad is connected to the microcontroller for data entry .An LCD is connected to a port of the microcontroller to display data. A stepper motor is connected to the interface circuit in order to control the number of turns in the helical feed of the antenna. Figure (3) shows the block diagram of the system design.

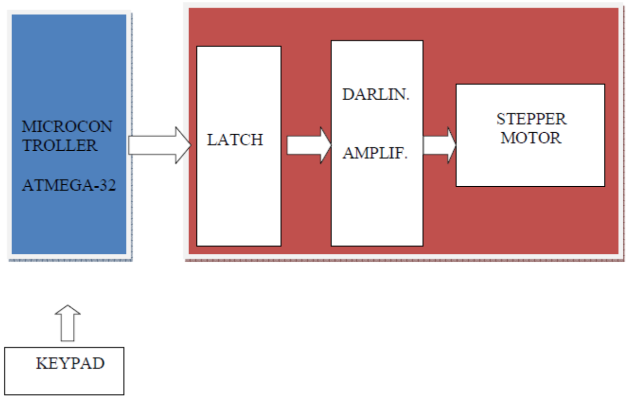

Figure (3) block diagram of the system design.

IV. SOFTWARE IMPLEMENTATION

The software design is performed by programming the main controller circuit (atmega32) which is connected to an interface circuit designed to drive the stepper motor, ,.The software package used here is BASCOM. BASCOM is an Integrated Development Environment (IDE) that supports the 8051 family of microcontrollers and some derivatives as well as Atmel's AVR microcontrollers. Figure (4) shows the interconnection for programming the microcontroller.

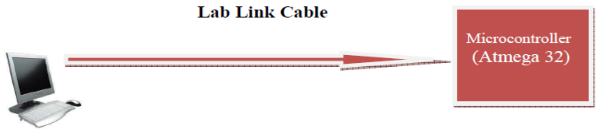

Figure (4) Connection for programming the microcontroller

V. ALGORITHM

The personnel computer algorithm includes a sequence of steps for the operation of the system. The system design is focused on controlling the number of steps in the stepper motor both clockwise and anti-clockwise .The stepper motor controls the number of turns in the helix feed of the parabolic antenna. The algorithm is ;

Start
- Initialization :
- Put the stepper motor at initial state.
- Wait for an input from the keypad.

--- Enter data from the keypad:
- Enter the number of steps in clockwise direction. (direction = 1)
- Enter the number of steps in anti-clockwise direction. . (direction = 2)
- If the (entry data = *), Go to end of program.

--- Go to enter data from the keypad.
- If the (direction = 1) , call subroutine of stepper motor clockwise .
- If the (direction = 2) , call subroutine of stepper motor anti-clockwise

--- End.

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--- Subroutine of stepper motor clockwise:
- Apply calculations to specify the number of step angles required.
- Rotate the stepper motor one step clockwise.
- Wait for few seconds.
- Decrement the number of steps.
- If the number of steps becomes zero, terminate the subroutine.

--- Return.
--- Subroutine of stepper motor anti-clockwise:
- Apply calculations to specify the number of step angles required.
- Rotate the stepper motor one step anti-clockwise.
- Wait for few seconds.
- Decrement the number of steps.
- If the number of steps becomes zero, terminate the subroutine.

--- Return.

VI. RESULTS

Table (1) shows the results obtained when implementing the design and running the program. It is assumed that the initial gain of the helical antenna is equal approximately (100 or 20dB). Any step the stepper motor makes changes the gain by (± 10%).

Table (1) results when running the program

No. of outwards steps	No. of inwards steps	Helical antenna gain (G) in dB
1		19.5
2		19
3		18.6
4		18.1
	1	21
	2	21.32
	3	21.5
	4	21.65

VII. CONCLUSION

The structure of the helical feed parabolic antenna is made of a parabolic dish and a helix feed .A stepper motor is mounted with a mechanical gears to drive the helix outwards or inwards. This movement changes the helix diameter and hence changes the number of turns.. This leads to a change of the antenna gain.

This means that the helical feed parabolic antenna gain is flexible and can be varied by manipulating the number of turns of the helix.

REFERANCES:

1. Kraus, J.D., (W8JK), "A Helical-Beam Antenna without a Ground Plane," IEEE Antennas and Propagation Magazine, April 1995, p. 45.
2. Kraus, J.D. & Marhefka, R.J., Antennas: for All Applications, third edition, McGraw-Hill, 2002.
3. Emerson, D., AA7FV, "The Gain of the Axial-Mode Helix Antenna," Antenna Compendium Volume 4, ARRL, 1995, pp. 64-68.
4. Nakano, H., Yamauchi, J., & Mimaki, H., "Backfire Radiation from a
5. Nakano, H., Mikawa, T., & Yamauchi, J., "Investigation of a ShortConical Helix Antenna," IEEE Transactions on Antennas and Propagation, October 1985, pp. 1157-1160.
6. Kraus, J.D., "A 50-Ohm Impedance for Helical Beam Antennas," IEEE Transactions on Antennas and Propagation, November 1977, p. 913.
7. Balanis C. A.(1997) ,"Antenna Theory: Analysis and Design, 2nd ed., New York: John Wiley and Sons.
8. Stutzman, Warren L.; Gary A. Thiele (2012).
9. Straw, R. D., ed., The ARRL Antenna Book, American Radio Relay League,Newington, Connecticut, 20th edition, 2003, chapter 19.

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