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Dual Gain control of the helical feed parabolic Reflector antenna

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***Abstract:* -** A helical feed parabolic antenna is an antenna that uses a parabolic reflector with a helical feeder The curved surface of the parabola is to direct the radio waves. The most common form is shaped like a dish and is popularly called a dish antenna or parabolic dish. The main advantage of a parabolic antenna is that it is highly directive; it functions similarly to a searchlight or flashlight reflector to direct the radio waves in a narrow beam, or receive radio waves from one particular direction only. Parabolic antennas have some of the highest gains, that is they can produce the narrowest beam width angles, of any antenna type. In order to achieve narrow beam widths, the parabolic reflector must be much larger than the wavelength of the radio waves used, so parabolic antennas are used in the high frequency part of the radio spectrum, at UHF and microwave (SHF) frequencies, at which wavelengths are small enough that conveniently sized dishes can be used.
Parabolic antennas are used as high-gain antennas for point-to-point communication their other large use is in radar antennas, which need to emit a narrow beam of radio waves to locate objects like ships and airplanes. A helical antenna can 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
This paper deals with applying an electronic technique to control the dimensions of the parabolic reflector plus controlling the helical feed position .The control of the parabolic reflector diameter and the helical feed lead to the control of the antenna gain .The proposed design is based on implementing a microcontrollers connected to an interface for the control of five stepper motors.

Keywords: - *parabolic reflector, helical feed, antenna, antenna gain, microcontroller, interface, stepper motor.*

I. INTRODUCTION

The idea of using parabolic reflectors for radio antennas was taken from optics, where the power of a parabolic mirror to focus light into a beam has been known since long time ago the first parabolic antenna used for satellite communications was constructed in early sixties, to communicate with the satellite. The advent in the seventies of computer programs capable of calculating the radiation pattern of parabolic antennas has led to the development of sophisticated asymmetric, multi reflector and multi feed designs in recent years. The helical feed parabolic antenna meets many applications. There is a possibility to control the parabolic dish dimensions as well as the helical feed position. Applying the two controls give a change of the antenna gain. Hence an automatic antenna gain control will be produced.

II. HELICAL FEED PARABOLIC REFLECTOR ANTENNA

The reflector can be of sheet metal, metal screen, or wire grill construction, and it can be either a circular "dish" or various other shapes to create different beam shapes. To achieve the maximum gain, it is necessary that the shape of the dish be accurate within a small fraction of a wavelength, to ensure the waves from different parts of the antenna arrive at the focus in phase. Helical feed is implemented for the antenna .Figure (1) shows the geometry of the helical feed parabolic antenna.

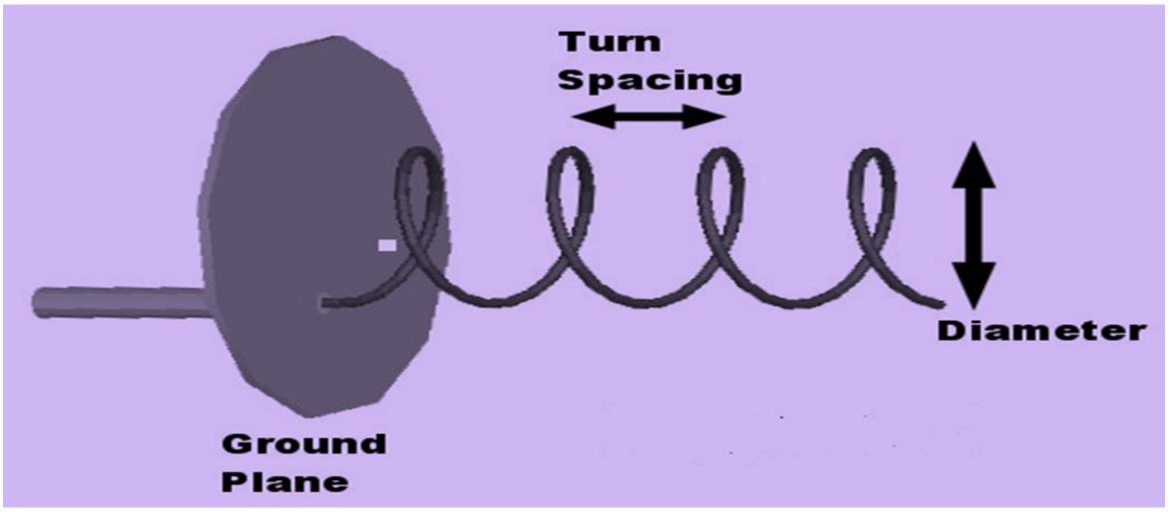

Figure (1) helical feed parabolic antenna

We have two gains of the helix feed parabolic antenna to be considered. These two gains are:

1. The gain related to the parabolic reflector dimensions:
Here the gain is the ratio of the power received by the antenna from a source along its beam axis to the power received by a hypothetical isotropic antenna. The gain of a parabolic antenna is:

$$G = \frac{4\pi A}{\lambda^2} e_A = \frac{\pi^2 d^2}{\lambda^2} e_A \quad \text{........ (1)}$$

Where:
A is the area of the antenna aperture, that is, the mouth of the parabolic reflector
D is the diameter of the parabolic reflector
λ is the wavelength of the radio waves.
e_A is a dimensionless parameter between 0 and 1 called the aperture efficiency. The aperture efficiency of typical parabolic antennas is 0.55 to 0.70.

2. The gain related to the number of turns in the helix feed of the antenna:
The gain is produced due to control the shape of the feeder of parabolic reflector by changing the spacing between turn (S) which affects directly the helical antenna gain and therefore will affect the overall system gain. Equation (2) below shows the antenna gain produced when manipulating the helix feed of the antenna.

$$G = \frac{6.2C^2NS}{\lambda^3} = \frac{6.2C^2NSf^3}{c^3} \quad \text{.......................(2)}$$

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

III. SYSTEM COMPONENTS

1. Personal computer (PC):
PC computer is used for programming the microcontrollers.
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.

IV. 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. Four stepper motors are connected to the interface circuit in order to control the four sectors of the parabolic reflector of the antenna. A stepper motors is connected to the interface circuit in order to control the helix feed of the antenna Figure(2) shows the block diagram of the system design.

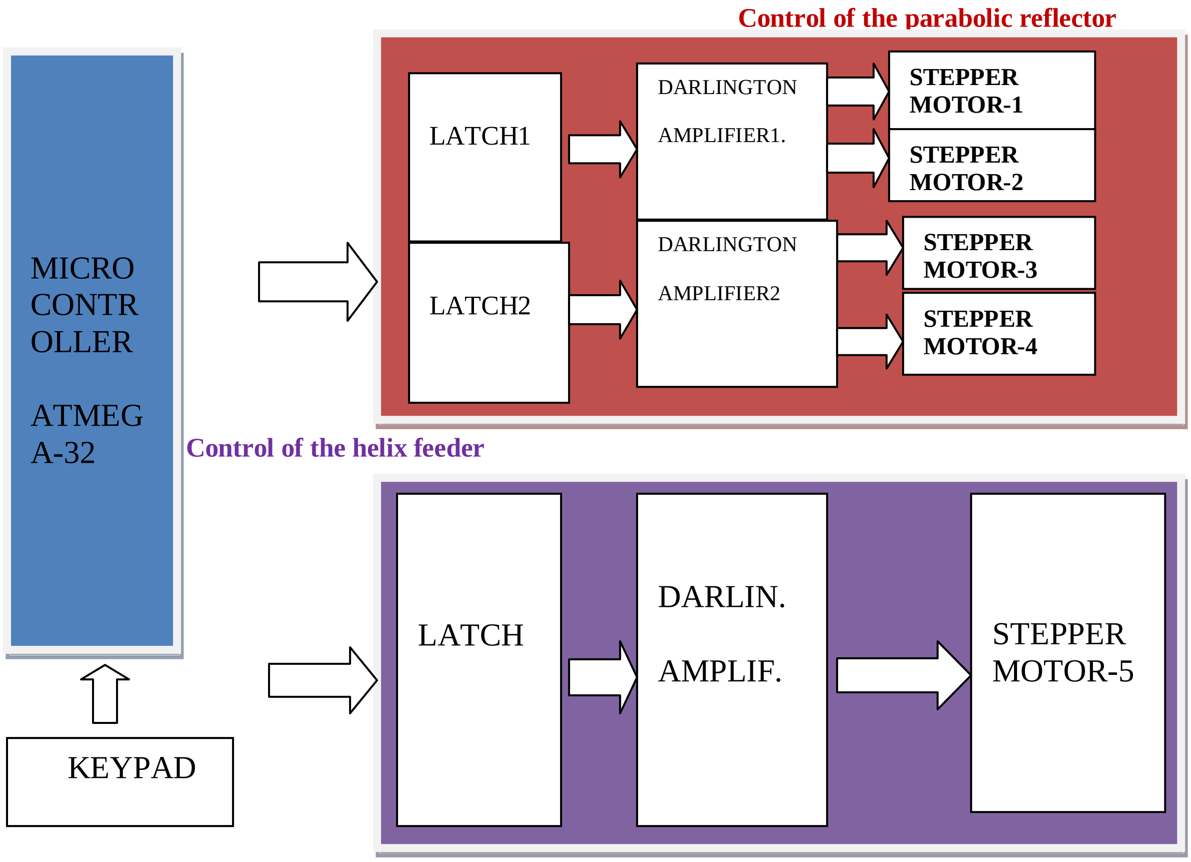

Figure (2) block diagram of the system design.

V. 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 motors .The software package used here is BASCOM. BASCOM is an Integrated Development Environment (IDE) that supports the Atmel's AVR microcontrollers. Figure (3) shows the interconnection for programming the microcontroller.

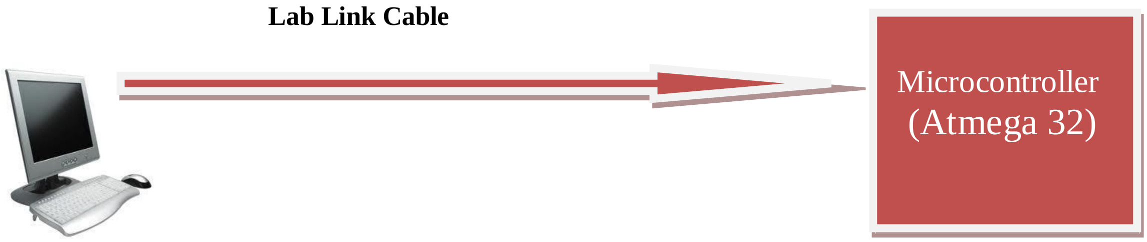

Figure (3) Connection for programming the microcontroller

VI. ALGORITHM

The system design includes five stepper motors divided into two parts. Part one is concerned with the control of the parabolic reflector while part two controls the helix feeder of the antenna .In part one; each stepper motor controls a sector of (90 degrees) of the parabolic antenna. In part two, the stepper motor control the helix feeder of the parabolic antenna. The algorithm is ;

Start
- Initialization :

\- Put all stepper motors at initial state.
\- Wait for an input from the keypad.

--- Enter data from the keypad:
\- Enter the number of steps for stepper motor-1.
\- Enter the number of steps for stepper motor-2.
\- Enter the number of steps for stepper motor-3.
\- Enter the number of steps for stepper motor-4.
\- Enter the number of steps for stepper motor-5.
\- If the (address = *) , Go to end of program.
--- Check the addresses of the stepper motors:
\- If the (address = 1) , call subroutine of stepper motor-1.
\- If the (address = 2) , call subroutine of stepper motor-2.
\- If the (address = 3) , call subroutine of stepper motor-3.
\- If the (address = 4) , call subroutine of stepper motor-4.
\- If the (address = 5) , call subroutine of stepper motor-5.

--- Go to enter data from the keypad.
--- End.

--- Subroutine of stepper motor-1:
\- Apply calculations to specify the number of step angles required.
\- Rotate the stepper motor one step.
\- Wait for few seconds.
\- Decrement the number of steps.
\- If the number of steps becomes zero, terminate the subroutine.
--- Return.
--- Subroutine of stepper motor-2:
\- Apply calculations to specify the number of step angles required.
\- Rotate the stepper motor one step.
\- Wait for few seconds.
\- Decrement the number of steps.
\- If the number of steps becomes zero, terminate the subroutine.
--- Return.

--- Subroutine of stepper motor-3:
- Apply calculations to specify the number of step angles required.
- Rotate the stepper motor one step.
- Wait for few seconds.
- Decrement the number of steps.
- If the number of steps becomes zero, terminate the subroutine.
--- Return.
--- Subroutine of stepper motor-4:
- Apply calculations to specify the number of step angles required.
- Rotate the stepper motor one step.
- Wait for few seconds.
- Decrement the number of steps.
- If the number of steps becomes zero, terminate the subroutine.
--- Return.

--- Subroutine of stepper motor-5:
- Apply calculations to specify the number of step angles required.
- Rotate the stepper motor one step.
- Wait for few seconds.
- Decrement the number of steps.
- If the number of steps becomes zero, terminate the subroutine.
--- Return.

VII. RESULTS

Table (1) shows the results obtained when implementing the design and running the program. It is assumed that the initial diameter of the parabolic antenna is equal (100 Cm.) and (λ = 10 Cm.). Applying equation (1) ,we get the gain equal approximately (225 = 23.52 dB) . When the four stepper motors move one step inwards or outwards, the parabolic antenna gain increases or decreases by (10 %) respectively.

Table (1) **results** when running the program

Stepper Motors	**No. of INWARD Steps**	**No. of OUWARDS steps**	**The gain (G) In (dB)**
ALL	**1**		**23**
ALL	**2**		**22.6**
ALL	**3**		**22.1**
ALL	**4**		**21.7**
ALL		**1**	**23.9**
ALL		**2**	**24.3**
ALL		**3**	**24.7**
ALL		**4**	**25.1**

Table (2) below 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 (2) **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**

VIII. CONCLUSION

The structure of the parabolic antenna is made of four interlaced sectors .A stepper motor is mounted on each sector to control its movement inwards or outwards. Now when the four
stepper motors move the dish sectors inwards or outwards, the antenna diameter gets changed. According to the change in the diameter the parabolic antenna gain will change. This means that the parabolic antenna gain is flexible and can be varied by changing its diameter.
The fifth stepper motor is mounted with a mechanical gear to drive the helix outwards or inwards. This movement changes the helix diameter and hence changes the number of turns.. This also leads to a change in the antenna gain.

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