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Design and implementation of a controlled gain parabolic antenna

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Abstract: - A parabolic antenna is an antenna that uses a parabolic reflector, a curved surface with the cross-sectional shape of a parabola, 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 beamwidths, the parabolic reflector must be much larger than the wavelengthof 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, in applications such as microwave relay links that carry telephone and television signals between nearby cities, wireless WAN/LAN links for data communications, satellite and spacecraft communication antennas, and radio telescopes. 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. With the advent of home satellite television dishes, parabolic antennas have become a ubiquitous feature of the modern landscape.

This paper deals with applying an electronic technique to control the dimensions of the parabolic reflector .The control of the parabolic reflector diameter leads to the control of the antenna gain .The proposed design is based on implementing a microcontroller connected to an interface to control four stepper motors.

Keywords: - *parabolic reflector, 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 classical antiquity. The physicistHertz constructed the world's first parabolic reflector antenna in 1888. The antenna was a cylindrical parabolic reflector made of zinc sheet metal supported by a wooden frame, and had a spark-gap excited dipole along the focal line. Its aperture was 2 meters high by 1.2 meters wide, with a focal length of 0.12 meters, and was used at an operating frequency of about 450 MHz With two such antennas, one used for transmitting and the other for receiving, Hertz demonstrated the existence of radio waves which had been predicted by Maxwell years earlier. Further developments have been made later on. 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, multireflector and multifeed designs in recent years.

II. PARABOLIC REFLECTOR

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. Figure (2) shows the geometry of the parabolic antenna.

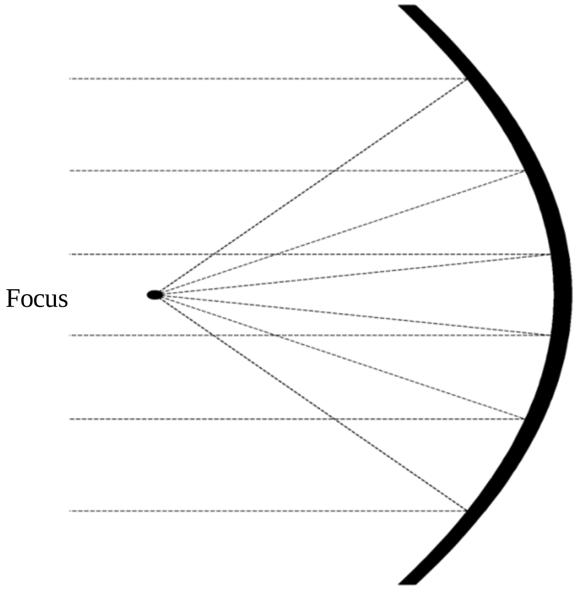


Figure (2) Geometry of Parabolic Dish Antenna

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.

III. 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:

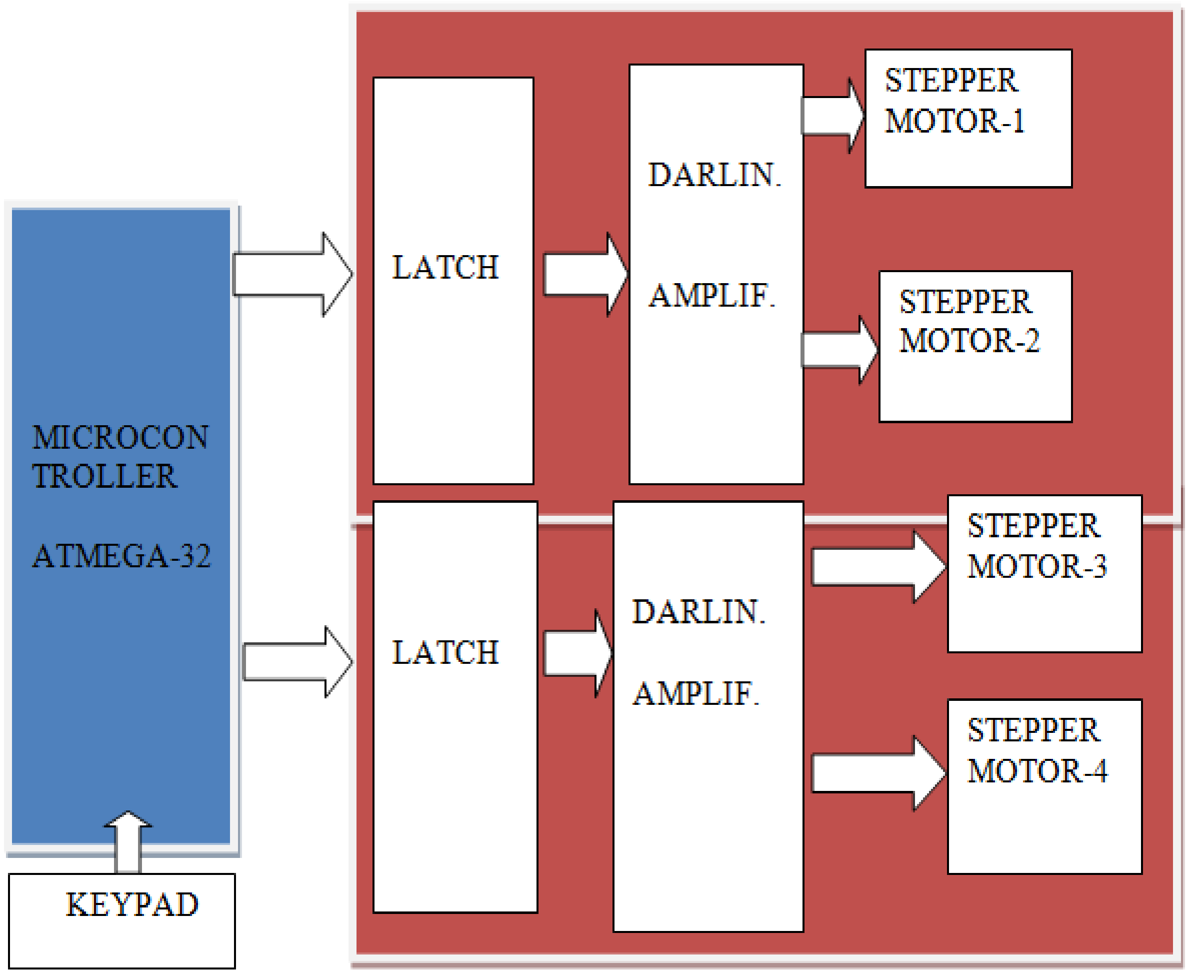
The key pad supplies the Atmega 32 microcontroller with the number of step angles required to rotate the stepper motors.

7. LCD :

LCD is used to display the data entry and the real time data during the system processing.

IV. HARDWARE DESIGN

The hardware design of the system is based on using a microcontroller as aprocessor. 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 antenna.Figure (2) shows the block diagram of the system design.



Figure(2) block diagram of the system design.

V. SOFTWARE IMPLEMENTATION

The softwaredesign 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 8051 family of microcontrollers and some derivatives as well as Atmel's AVR microcontrollers. Figure (3) shows the interconnection for programming the microcontroller.

Lab Link Cable

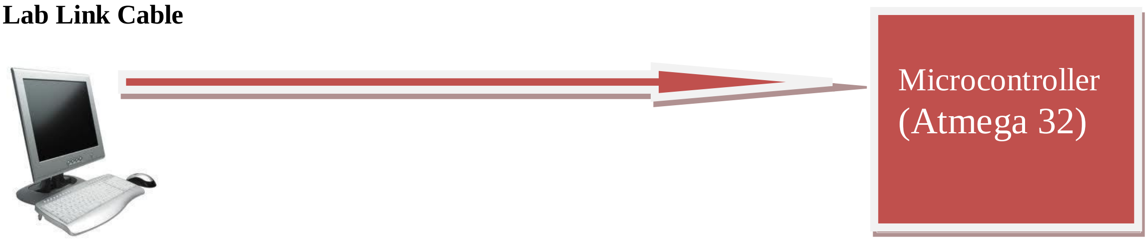


Figure (3) Connection for programming themicrocontroller

VI. ALGORITHM

The personnel computer algorithm includes a sequence of steps for the operation of the system. The system design includes four stepper motors .Each stepper motor controls a sector of (90 degrees) 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.
- 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.

--- 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 second.
- 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 second.
- 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 second.
- 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 second.
- Decrement the number of steps.
- If the number of steps becomes zero, terminate the subroutine.

--- Return.

VII. RESULTS

Table (1) shows theresults 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 = 23.52dB). 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

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.

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