Orientation of Radar Antenna

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Abstract: *A Radar PPI display is considered to display a dummy blip (target) in order to perform orientation procedure on it. Several works have been done in the area of radar antenna orientation and control system using stepper motor control . In order to speed up the data rate, the antennas are required to operate at higher radio frequencies. The increased frequency requires more precise antenna pointing system and the need of pointing control is to counteract the effects of external disturbances which includes wind gust, terrain profile etc. All these factors demand an embedded system engineer to design a more accurate antenna control system. This paper describes the control system engineering principles used in designing, testing and implementing, a control and measurement system on an antenna orientation. The control system is modeled to monitor and control the antenna in the azimuth (Horizontal axis). The system is also stabilized with the help of level sensor.*
Keywords: *Radar, antenna, azimuth, PPI, blip, orientation, embedded system.*

I. Introduction

The antenna azimuth position control system turns the input command in output position. This system is widely used in antennas, robots, and computers disks. In this work the system presented is managed with azimuth antenna. Figure (1) below shows how the system works and how its performance can be improved. The purpose of this system is the input angle to be turned into an output angle of the antenna.
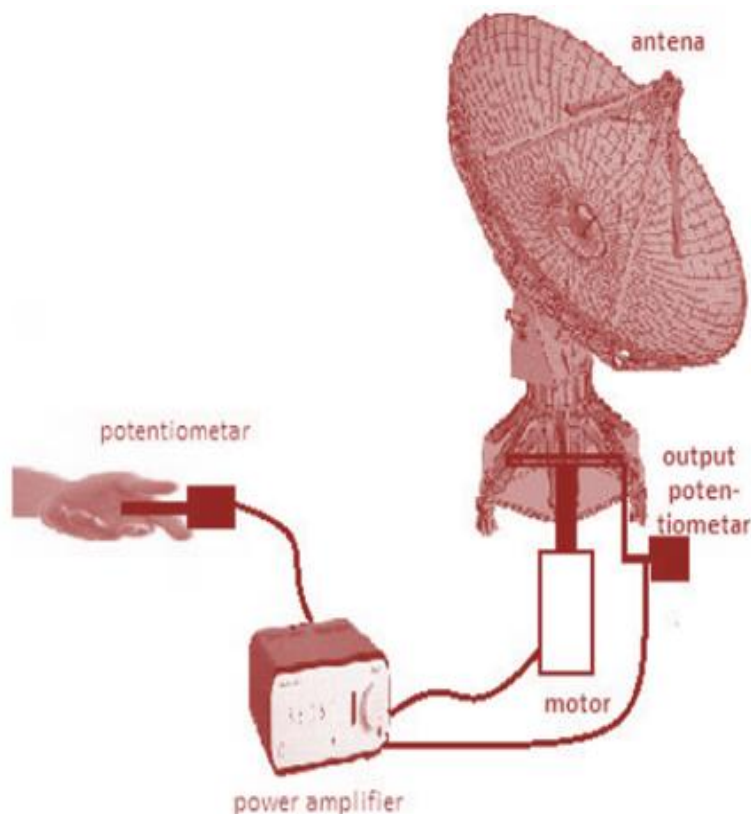

Figure (1) Antenna position control

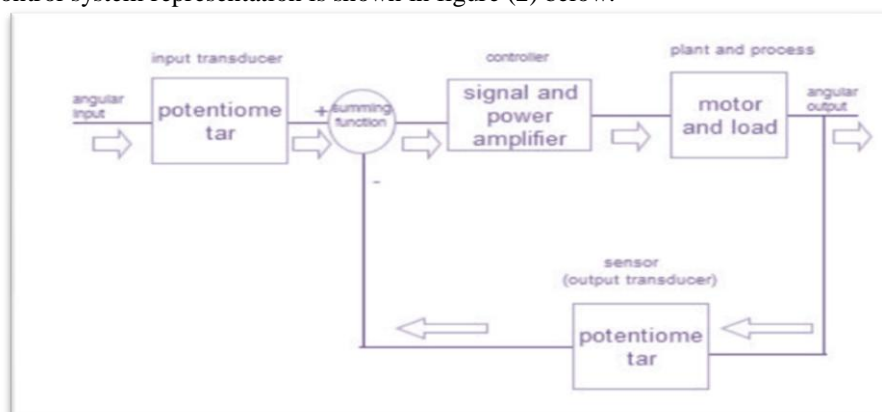The antenna control system representation is shown in figure (2) below.

Figure (2) antenna control system

For improving the control system , an approach of micro-stepping control for the step motors based on field programmable gate array (FPGA) is presented after the micro-stepping driving theory of the step motor with a constant torque was discussed deeply. And then the relative control system is schematically designed, mainly includes the internal logic design of the FPGA, the communication interface design of the microcomputer, the design of the power driving circuit, and the design of the interface circuit between the electrical sources. At last, it is verified by some experimental investigations that the control theory and approach presented are corrective, and the control system designed is very good to get a high precision of position control and high control repeatability. Therefore, the technology questions from the producing reality are resolved and the product quality is promoted.

An open loop stepper motor driver using a FPGA is also feasible. The model of the current controller is described and gains of the controller are selected at optimal values. In this design, the FPGA is used to build a high performance open loop driver without using a DSP; furthermore it is compatible with ASICs and mass production methods. The experimental results verify the performance of the driver. In addition, stepper motor controller is used to drive the stepper motor. A Very High Speed Integrated Circuit Hardware Description Language (VHDL) is implemented on SPARATAN Field Programmable Gate Array (FPGA). The Proposed motor controller is a set of Darlington amplifiers thus giving very high precision. Due to high torque of stepper motor, it is capable of handling the big industrial automation system. In this system, a potentiometer technique will be designed to give the control parameter to the FPGA, which in its turn controls the stepper motor.

II. Methodology

This paper describes a stepper motor control algorithm designed using VHDL and implemented in FPGA. The system is capable of controlling the stepper motor in terms of a very small step angle. In addition to this, we can make it to rotate at different speeds, displacement clockwise and anticlockwise directions. Here a potentiometer is used for inputting the control parameter to faithfully control the antenna azimuth angle by rotating the stepper motor clockwise and anticlockwise.

One of the major advantages of the design is its precision. It is user-friendly reduces programming complexity and errors can be easily identified and rectified . The main block diagram is based guiding the signal from Plane Position Indicator of the Radar (PPI) to the FPGA. Figure (3) below shows the block diagram of the system design.
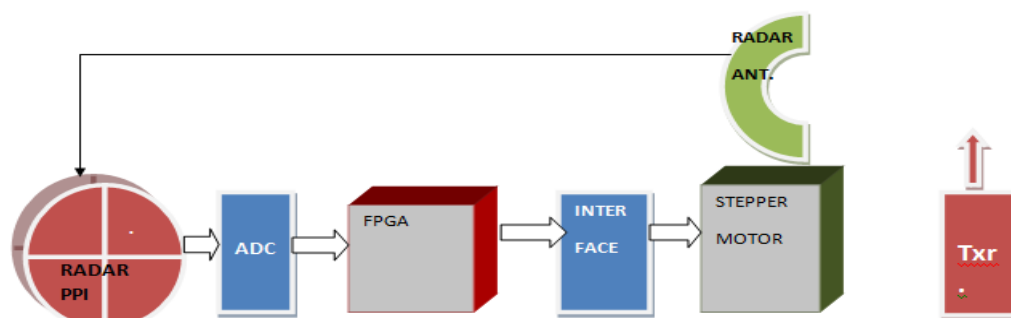

Figure (3) the block diagram of the system

Hardware component

The hardware components for the electronic circuit design are:

Breadboard:

Breadboard (protoboard) is a construction base for a one-of-a-kind electronic circuit, a prototype. Because the solder less breadboard does not require soldering, it is reusable, and thus can be used for temporary prototypes and experimenting with circuit design more easily. A variety of electronic systems may be prototyped by using breadboards.

Potentiometer:

It is used as a means of pointing to the blip on the PPI of the Radar.

ADC8080:

It is used to transform the analog signal from the PPI of the Radar into digital format to be fed to the FPGA for processing.

HD74LS373 Latching IC:

The HD74LS373 is eight bit is register I/O mapped used as a buffer, which stores signals for future use. 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.

ULN 2893A 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.

Lab link cable:

The lab link cables are used as a connection means in the circuit right from the PPI of the Radar up to the stepper motor.

Stepper motor:

A stepper motor is used for the procedure of orientation of the antenna of the Radar .The number of steps of the stepper motor is (200 steps / revolution). Equation (1) gives the value of the step angle of the stepper motor.

$$\text{Step angle} = \frac{\text{One revolution}}{200} = \frac{360^0}{200} = 1.8 \text{ Degree} \quad \text{-------------- (1)}$$

III. Algorithm

The algorithm is based on supplying the FPGA through the ADC with the azimuth angle appeared on the PPI of the Radar in the digital format .The FPGA in its turn processes the data and issues a correction command to the stepper motor in order to align the antenna to the geographical north (0^0) . The orientation procedure of the Radar antenna is as follows;

.. The transmitter issues a signal.

.. The PPI of the Radar displays the transmitter signal as a dummy target on the PPI.

.. A potentiometer points to the blip (target) to convey the azimuth angle.

.. The ADC transforms the DC voltage into digital format.

.. The FPGA processes the digital data.

.. The FPGA issues correction command to the stepper motor through the interface.

.. The stepper motor aligns the antenna to the geographical north (0^0).

VHDL programming language is used for programming the FPGA by the computer the algorithm is:

Start

Initialization:

… Program port (A1) of FPGA as input.

… Program port (A2) of FPGA as output.

--- Put transmitter mode to (OFF).

--- Adjust the plane position indicator (PPI) of the Radar to the geographical north (0^0).

--- Clear output to stepper motor.

Processing:
--- Put transmitter mode to (ON).
---- Call orientation subroutine.
End
Orientation subroutine:
Blip detection:
--- Observe the blip on the PPI of the Radar.
… Move the slide of the potentiometer to coincide with the blip on the PPI.
… Check the incoming azimuth value of the blip.
--- If the azimuth value equals zero, then go to terminate the subroutine.
--- If the azimuth value does not equal zero, then go to antenna position correction.
… Go to blip detection.

Antenna position correction:
… If the azimuth value is positive, then rotate the stepper motor one-step anticlockwise.
… If the azimuth value is negative, then rotate the stepper motor one-step clockwise.
--- Go to blip detection.
Terminate:
Return.

IV. Results

A transmitter tuned to the Radar receiver frequency is used to generate a blip (dummy target) on the PPI display of the Radar. when applying the algorithm in paragraph (III) above, we observe the location of the blip on the PPI .Based on the blip azimuth angle, the program in the FPGA performs the alignment of the antenna with the blip appearance on the PPI of the Radar .The alignment processing continues till we get the antenna exactly heading to the geographical north (0 Degrees). Each step movement of the stepper motor makes an antenna azimuth angle correction of (1.8 Degrees) .A mechanical gearing mechanism is implemented to enhance the stepper motor angle resolution up to of (0.18 Degrees). Table (1) below shows the results obtained from the generation of four different dummy blips (targets) on the PPI display of the Radar and performing antenna orientation procedure on them

Table (1) the results obtained from generating a blip (target) on the PPI display of the Radar

Blip azimuth angle on PPI (Degrees)	No. of steps of stepper motor	Alignment result
+ 18^0 East	100 anticlockwise	Geographical north (0^0)
-9^0 West	50 clockwise	Geographical north (0^0)
+ 27^0 East	150 anticlockwise	Geographical north (0^0)
-13.5^0 West	75 clockwise	Geographical north (0^0)

Note: The alignment (orientation) can be done by pointing towards (East, South, and West) As well.

V. Conclusion

The functionality of the design starts with activating a transmitter tuned to the Radar frequency. A dummy blip (target) appears on the PPI display of the Radar. Any antenna azimuth angle deviation from the geographical north will be subjected to correction procedure. Based on the blip appearance on the PPI, the FPGA program performs the correction by commanding the stepper motor to rotate clockwise or anticlockwise. The processing outcome is to put both the antenna and the PPI display on (0^0). The alignment procedure (orientation) makes us avoiding azimuth data capture errors by the Radar.

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