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Error Minimization Controlling in Antenna Position

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***Abstract*—** MFs are the main constituents of fuzzy sets. Also the structure of MF put an impact on the inference of system. Various shapes like trapezoidal, triangular & Gaussian are included. The main condition of MF is that value lies in 0 & 1. In this paper, a straightforward approach for designing a Fuzzy PID based controller is presented to evaluate, and presents the performance comparison of fuzzy logic controller with PID controller. The PID controller is implemented using three gains, and the same gain is used for both the input and output variables. The response was analyzed and compared and it shows that the gain is similar in response in terms of rise time and overshoot for both Π/3 and Π/6. According to Fuzzy PID controller system is getting improve in terms of stability. The stability time of the system is getting reduced.

Keywords: *PID Controller, Fuzzy Control, Hybrid Control, Antenna Azimuth position.*

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I. INTRODUCTION

An antenna (plural antennae or antennas), or aerial, is an electrical device which converts electric power into radio waves, and vice versa. It is usually used with a radio transmitter or radio receiver. In transmission, a radio transmitter supplies an electric current oscillating at radio frequency (i.e. a high frequency alternating current(AC)) to the antenna's terminals, and the antenna radiates the energy from the current as electromagnetic waves (radio waves). In reception, an antenna intercepts some of the power of an electromagnetic wave in order to produce a tiny voltage at its terminals, That is applied to a receiver to be amplified.

Antennas are essential components of all equipment that uses radio. They are used in systems such as radio broadcasting, broadcast television, two-way radio, communications receivers, radar, cell phones, and satellite communications, as well as other devices such as garage door openers, wireless microphones, Bluetooth-enabled devices, wireless computer networks, baby monitors, and RFID tags on merchandise.

Typically an antenna consists of an arrangement of metallic conductors (elements), electrically connected (often through a transmission line) to the receiver or transmitter. An oscillating current of electrons forced through the antenna by a transmitter will create an oscillating magnetic field around the antenna elements, while the charge of the electrons also creates an oscillating electric field along the elements. These time-varying fields radiate away from the antenna into space as a moving transverse electromagnetic field wave. Conversely, during reception, the oscillating electric and magnetic fields of an incoming radio wave exert force on the electrons in the antenna elements, causing them to move back and forth, creating oscillating currents in the antenna.

Antennas can be designed to transmit and receive radio waves in all horizontal directions equally (omni directional antennas), or preferentially in a particular direction (directional or high gain antennas). In the latter case, an antenna may also include additional elements or surfaces with no electrical connection to the transmitter or receiver, such as parasitic elements, parabolic reflectors or horns, which serve to direct the radio waves into a beam or other desired radiation pattern.

II. DESIGN DESCRIPTION

Fuzzy logic idea is similar to the human being's feeling and inference process unlike classical control strategy, which is a point-to-point control, fuzzy logic control is a range-to-point or range-to-range control. The output of a fuzzy controller is derived from fuzzi fications of both inputs and outputs using the associated membership functions. A crisp input will be converted to the different members of the associated membership functions based on its value. From this point of view, the output of a fuzzy logic controller is based on its memberships, which can be considered as a range of inputs. The idea of fuzzy logic was invented by Professor L. A. Zadeh of the University of California at Berkeley in 1965 [1] .This invention was not well recognized until Dr. E. H. Mamdani [2] who is a professor at London University, applied the fuzzy logic in a practical application to control an automatic steam engine in, which is almost ten years after the fuzzy theory was invented. Then, in 1976, Blue Circle Cement and SIRA in Denmark developed an industrial application to control cement kilns. That system began to operation in 1982. More and fuzzier implementations have been reported since the 1980s, including those applications in industrial manufacturing, automatic control, automobile production, banks, hospitals, libraries and academic education [3]. The main aim is to design a control system that will ensure good transient and steady state response of the system.

III. MEMBERSHIP FUNCTION

A membership function (MF) is a curve that defines how each point in the input space is mapped to a membership value (or degree of membership) between 0 and 1. The input space is sometimes referred to as the universe of discourse. Or, the membership function is a graphical representation of the magnitude of participation of each input. The rules use the input membership values as weighting factors to determine their influence on the fuzzy output sets of the final output conclusion. Once the functions are inferred, scaled, and combined, they are defuzzified into a crisp output which drives the system.

For any set X, a membership function on X is any function from X to the real unit interval [0, 1]. The membership function which represents a fuzzy set is usually denoted by μA. For an element x of X, the value μA(x) is called the membership degree of x in the fuzzy set. The membership degree μA(x) quantifies the grade of membership of the element x to the fuzzy set. The value 0 means that x is not a member of the fuzzy set; the value 1means that x is fully a member of the fuzzy set. The values between 0 and 1 characterize fuzzy members, which belong to the fuzzy set only partially. A fuzzy set is completely characterized by its membership function (MF). Since most fuzzy sets in use have a universe of discourse X consisting of the real line R, it would be impractical to list all the pair defining a membership function. A more convenient and concise way to define an MF is to express it as a mathematical formula. The definition of the membership functions is a very delicate point in the design of the FC, because the only restriction that a membership function has to satisfy is that its values must be in the [0, 1] range. A fuzzy set can therefore, unlike a crisp one, be represented by an infinite number of membership functions.

The simplest membership functions are formed using straight lines. Due to their simple formulas and computational efficiency, both triangular MFs and trapezoidal MFs have been used extensively, especially in real-time implementations. However, since the MFs are composed of straight line segments, they are not smooth at the corner points specified by the parameters. [4, 5]. The most common types of MF are:

1. Triangular MFs
2. Trapezoidal MFs
3. Gaussian MFs
4. Generalized bell MFs
5. π- Shaped Membership Function
6. S- Shaped Membership Function

The list of MFs introduced in this section is by no means exclusive; other specialized MFs can be created for specific applications if necessary. In particular, any type of continuous probability distribution functions can be used as an MF here, provided that a set of parameters is given to specify the appropriate meanings of the MF.

IV. FUZZY LOGIC CONTROLLER FOR ANTENNA AZIMUTH POSITION CONTROL SYSTEM

After explaining the most popular types of membership functions that are widely used in the design of the fuzzy controller in the previous section, we will show the effect of using various types of membership functions on the performance of the fuzzy logic controller and corresponding change in the system output when we change the type of the membership function on the same system. Due to the large number of known types of membership functions , we will use only three types of most used types in design which are the triangular, Trapezoidal (which are linear membership functions) and the Gaussian membership function (Non-linear).Our system in concern will be controlling the azimuth position of an antenna. We will design a FLC using the three types of membership functions and compare the response of the system in terms of speed and steady- state error for each type of membership function. The design and simulation are done using MATLAB V7.6 / Simulink software.

The antenna azimuth control system currently available on the market is described as a servo controlled antenna through the use of gears and feedback potentiometers. The current design lacks any sort of compensator controller that would provide stability control. Norman S. Nise investigates the design of a control system for an antenna [6]. The basic idea is that someone, from a control tower, can adjust a simple potentiometer by hand and ultimately move a large antenna. The antenna control system physical layout is shown in Figure. 1 and the block diagram of the system is shown in Figure .2, this block diagram will be used in the design and simulation for the control system [7].

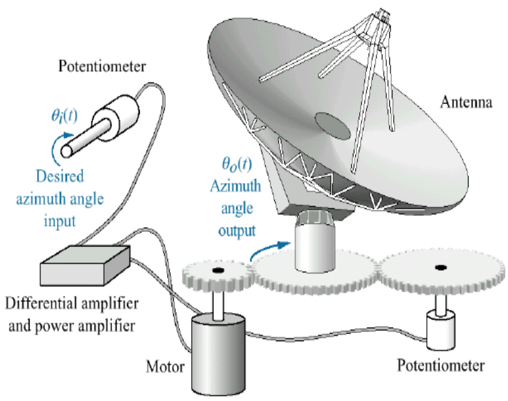

Figure 1:- Physical Layout of the Antenna Azimuth Control System position control system

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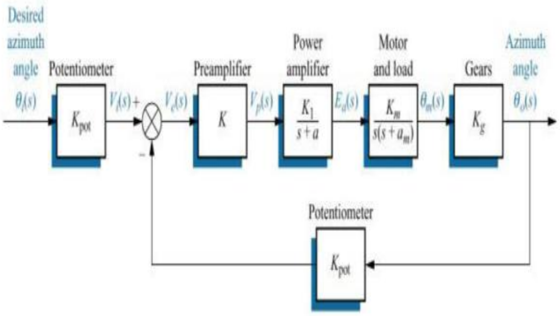

Figure 2:- Block Diagram of the Antenna Azimuth Closed-Loop Control System

The azimuth position antenna control system can be controlled by adjusting the firing angle of motor that is driving the antenna, thus the fuzzy controller is designed to control the system by adjusting the firing angle of the motor due to the change in the output angle [8, 9]. First it is to be said that the PI-like fuzzy controller is chosen for this job (the PI adds a pole at the origin, which increase the stability of the system at the steady-state). The controller contains two inputs and single output, the controller receives the difference between the reference angle and the actual system (motor) angle and this forms the first input which is called "error". Because the PI-like fuzzy controller is used, the second input must be the "integral" of the error, but sometimes it's difficult to formulate rules depending on an integral of error, because it may have very wide universe of discourse, thus the output of a controller can be integrated and not it's input [10]. In this case the inputs to the controller should be "error" and "change-of-error" (derivative of the error) and still realizing the PI-like controller In this case; to obtain the value of control output variable u (t), the change of control output Δu (t) is added to u (t-1). The block diagram of a PI-like fuzzy controller. For the fuzzy controller structure design, we used two inputs which are (Error & Change of Error) and one output which is named (Control Action). Both, the inputs and the output were designed to have 7 membership functions, which are designated as (NL, NM, NS, ZE, PS, PM, PL), and then the rules were derived for the controller.

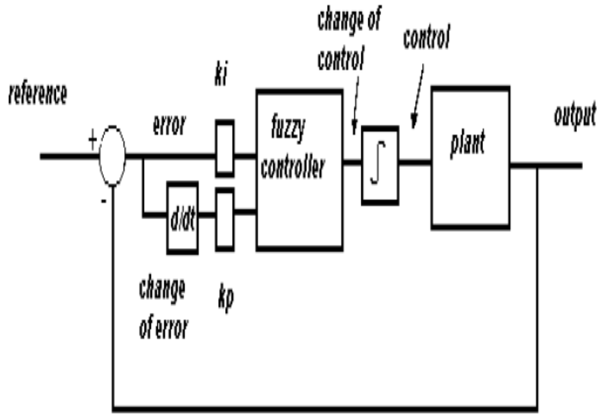

Figure 3:- Block Diagram of PI- Like Fuzzy Control System (Using Integral of the Output)

e / Δe	NL	NM	NS	ZE	PS	PM	PL
NL	NL	NL	NL	NL	NM	NS	ZE
NM	NL	NL	NL	NM	NS	ZE	PS
NS	NL	NL	NM	NS	ZE	PS	PM
ZE	NL	NM	NS	ZE	PS	PM	PL
PS	NM	NS	ZE	PS	PM	PL	PL
PM	NS	ZE	PS	PM	PL	PL	PL
PL	ZE	PS	PM	PL	PL	PL	PL

Table 1:- The Rule Base Table of the Fuzzy Controller

V. MEMBERSHIP FUNCTIONS OF THE SYSTEM

As mentioned before, we will change the type of the membership function used in the design of the FLC. Then we will compare the effect of this change on the control action and the response of the system as a result. We choose the universe of discourse for both input and output variables as: -Error (-200 to 200) degree -Change of Error (-100 to 100) degree -Control Action (-1 to 1) Volt The simulation results using MATLAB/ Simulink and the discussion of the response of the system using the three types of the membership function will be given later.

VI. TRIANGULAR MEMBERSHIP FUNCTION

The input and output membership functions of the proposed FLC using Trapezoidal MF.

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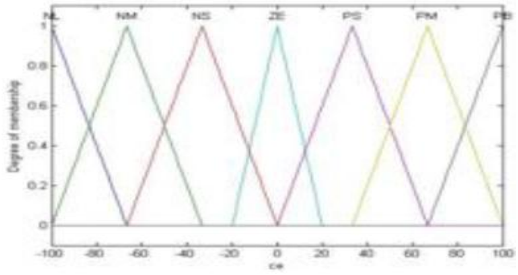
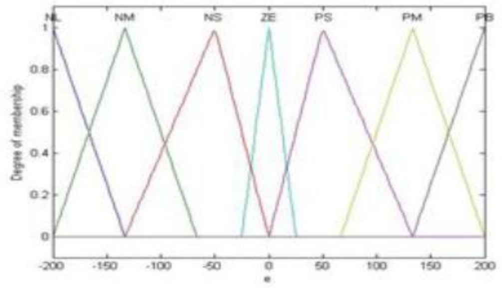
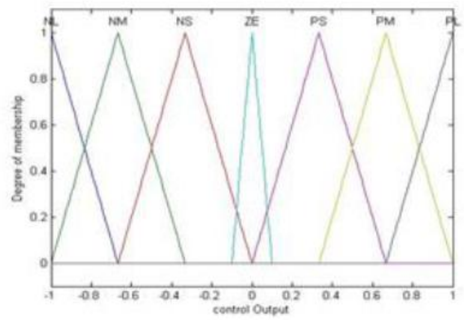


(a)



(b)



(c)

Figure 4:- Input and output MF using Triangular MF (a) Error, (b) Error change, (c) Control action

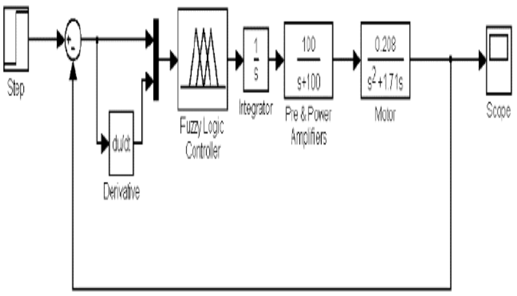


Figure 5:-Existing System Model in MatLab/Simulink

VII. PROBLEM STATEMENT

For the control position of the Antenna in the base design fuzzy logic is using. But the output is not controlling as they require position. The output is giving some error in position control of the system. The position is controlling for Π/3 and Π/6. The position control error is coming 2.7 sec for Π/6 and 3.2 for Π/3. We have to improve the performance of the system by use PID controller. As the fuzzy logic controller output is showing the position time for Π/3 and Π/6 systems. Timing is too much for achieve the position of the system.

VIII. PROPOSED METHODOLOGY

A proportional-integral-derivative controller (PID controller) is a control loop feedback mechanism (controller) widely used in industrial control systems. A PID controller calculates an *error* value as the difference between a measured process variable and a desired set point. The controller attempts to minimize the *error* by adjusting the process through use of a manipulated variable.

FUZZY PID CONTROL DESIGN SYSTEM FOR Π/6

PID controller is using for improve the performance of the stability time . The stability time in the fuzzy logic was going at 2.7 sec but in the PID controller stability time is going 2.69 sec . That by the PID controller system is getting more fast stable as compare to fuzzy logic .

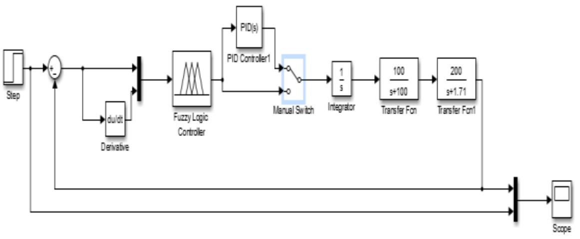


Figure 6:- System design for PID controller by use position Π/6

FUZZY PID CONTROLLER DESIGN SYSETM FOR Π/3

The system stable time is 3.2 sec for Π/3 position control. The system get stable in time of 2.7 for Π/3 position control by use PID controller.

IX. RESULTS

FUZZY CONTROLLER RESULTS FOR Π/6

As compare to existing design fuzzy logic is using. According to the image system is stable after 2.7 sec.

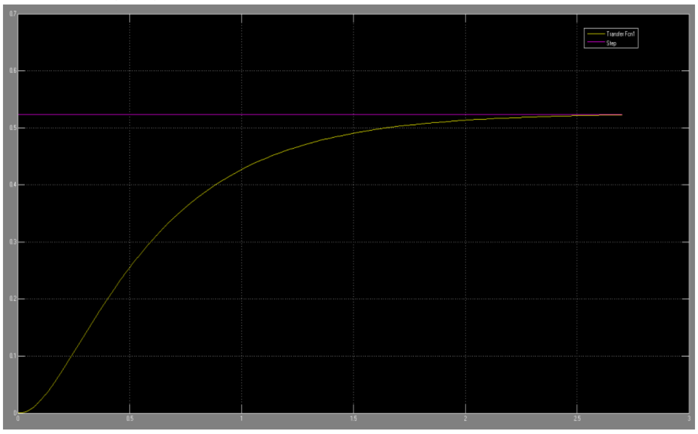


Figure 7:- Stability graph for fuzzy logic

FUZZY PID CONTROLLER RESULTS FOR Π/6

As compare to proposed design PID controller is using. According to the image system is stable after 2.69 sec.

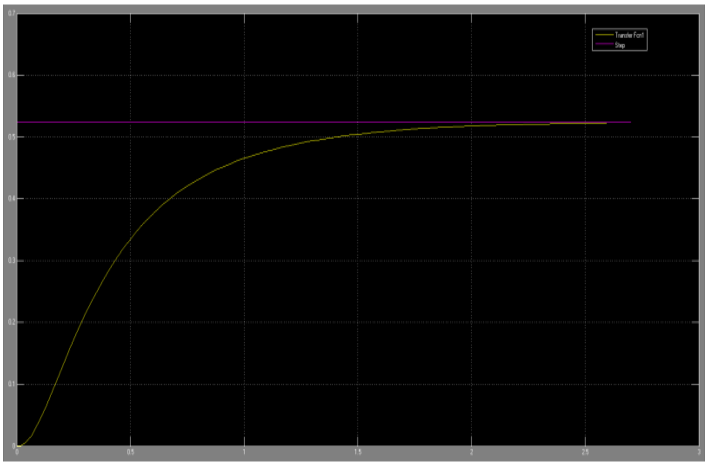


Figure 8:- Stability graph for PID controller

• Type	• M_p	• T_p	• E_{ss}	• T_s
• Fuzzy Controller	• 0.55	• 2.7	• 0.002	• 2.7
• Fuzzy PID Controller	• 0.52	• 2.7	• 0.0001	• 2.69

Table 2:- Stability control for existing and proposed for Π/6

FUZZY CONTROLLER RESULTS FOR Π/3

As compare to existing design fuzzy logic is using. According to the image system is stable after 3.2 sec.

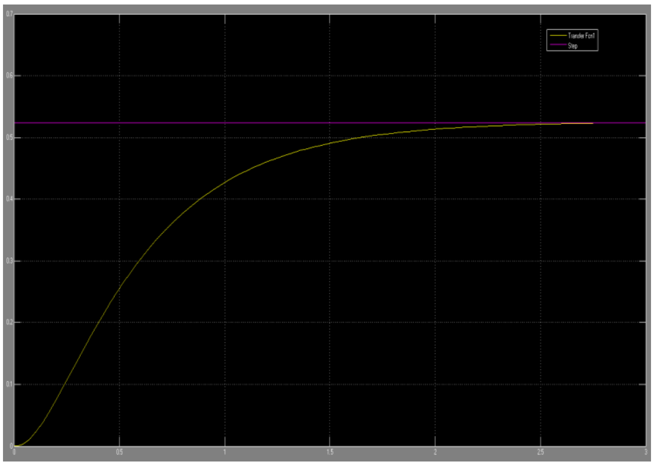


Figure 9:- Stability graph for fuzzy logic

FUZZY PID CONTROLLER RESULTS FOR Π/3

As compare to proposed design PID controller is using. According to the image system is stable after 2.7 sec.

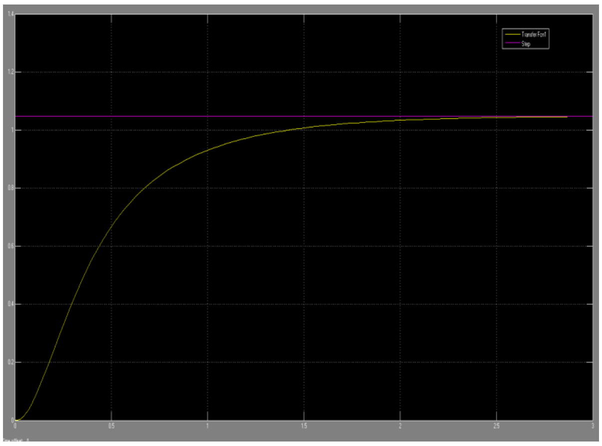


Figure 10:- Stability graph for PID controller

• Type	• M_p	• T_p	• E_{ss}	• T_s
• Fuzzy Controller	• 1.04	• 3.3	• 0.0004	• 3.2
• Fuzzy PID Controller	• 1.04	• 3.3	• 0.00001	• 2.7

Table 3:- Stability control for existing and proposed for Π/3

X. CONCLUSION

This work has been successfully demonstrated effect of various membership functions in the Fuzzy PID control of antenna azimuth position. The PID controller is implemented using three gains, and the same gain is used for both the input and output variables. The response was analyzed and compared and it shows that the gain is similar in response in terms of rise time and overshoot for both Π/3 and Π/6. According to Fuzzy PID controller system is getting improved in terms of stability. The stability time of the system is getting reduced.

In the future we can reduce the stability time by PID controller. By apply Neural Network we can also improve the performance of the system.

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