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# Comparison between PID and Fuzzy Logic Control in the Position of Stepper Motors

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**Abstracts**

This paper dealt with the use of Fuzzy controlled logic to improve response the position of step motor to reach the jump less time, and study relied on modeling using environment Mat lab to achieve position response using open loop, and will compare the results of each of the controlled traditional and Fuzzy controlled with the case open loop system.

This paper also dealt with multiple applications systems positioning and that applied to stepper motor, which is characterized by the presence of the windings in the stator, which leads to dissipate heat outside the body of the motor, while in the DC motor be windings in the rotor, causing high temperatures and problems in heat dissipation outside the body of the motor, and show the delay in properties of position response step and bad breaking cause jump that is Taken into account in the properties design, and this property lead to unstable in the normal operation of the stepper motor under specific cases.

## 1. Introduction

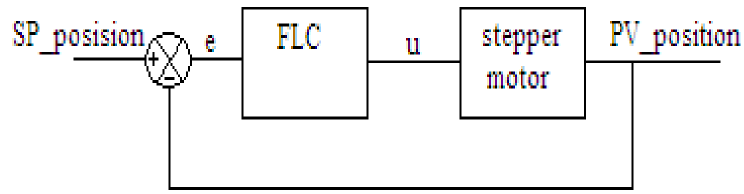
Fuzzy control is derived from the fuzzy logic and fuzzy set theory that were introduced in 1965 by L. A. Zadeh[5]. Zadeh showed that fuzzy logic unlike classical logic could realize values between false and true. In classical set theory the definition of the membership, function does not matter, but the number belongs to or does not belong to the set, 0 or1 takes on the value. During the last two decades, FLC has been one of the most techniques, active and fruitful research areas. It has-been successfully employed in a wide verity of applications such as: economic and engineering applications and other areas involves high grade of complexity, uncertainty, and non linearity [2]

The advantage of using fuzzy logic as compared to the conventional control approach resides as number and type of membership functions, constructing rule base, fuzzification and defuzzification methods. Fuzzy systems are suitable for uncertainties and it deals with the controlled system as a black box. This means the mathematical model of the system is difficult or too complex to derive [6]

## 2. Fuzzy Logic Controllers

Fuzzy logic control is used in wide spread system nowadays. It is an automatic control and a self-acting mechanism that controls an object in accordance with a desired behavior. Fig. 1 shows a block diagram of the controller system. The two inputs of the fuzzy controller are the error e and change of error $\Delta e$. [8]

**Figure 1:** Block diagram of fuzzy logic controller




## 3. Fuzzification

Fuzzification is the first block inside the controller, which scale the input crisp value e and Δ e into normalized universe of discourse U. then converts each crisp input to degrees of membership function

A µ (u). Each membership function is identified by a linguistic variable like small, big and positive big. There are several types of membership functions used in FLC such as triangular, trapezoidal, and Gaussian. In this paper, a triangular membership function is used. [5]

## 4. Rule Base

Rule base is the core of the FLC [3] ; it is a set of rules in the form of IF-THEN statement that describe the state and the behavior of the control system. Fuzzy control rules express the relation between inputs; it may use several variables usually in the form of conditional statements that have the following form:

IF e is A ANDΔ e is B THEN u is C.

Where the input variables are e and Δ e, and u is the output variable.

## 5. Inference Mechanism

Inference mechanism is obtaining the relevant control rule at the current time and then decides what the controller output should be. The membership function value for each rule for controller input is calculated by the fuzzy inference mechanism.

Several ways for implementing fuzzy inference method are used, but the most widely used in control applications are Mamdani method “min-max.

## 6. Defuzzification

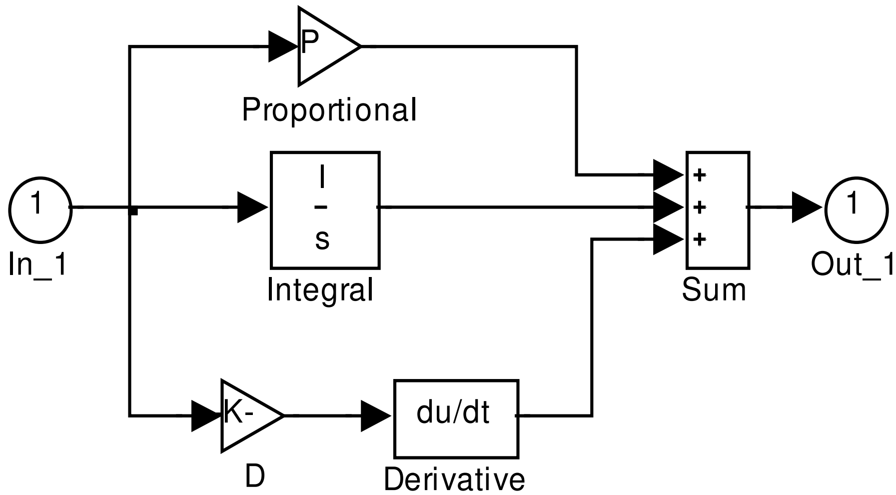
Defuzzification method is the final stage of the fuzzy logic control. After the inference mechanism is finished, the defuzzification method converts the resulting fuzzy set into crisp values that can be sent to the plant as a control signal. Generally several methods used for defuzzification methods such as centroid of area (COA), maximum method (MM), mean of maximum (MOM), and bisector of area (BOA) [9] .

### PID Controllers

PID traditional controller consist three parameters proportional, differential and integral as in Figure (2) controller structure and represent the following mathematical relationship form final mathematical of the controller.

$$\text{u(t)} = \text{MV(t)} = K_p e(t) + K_i \int_0^t e(\tau) d\tau + K_d \frac{d_e}{dt}$$

**Figure 2:** PID controller




Where: Kp, Ki,and Kd are proportional ,integral and derivative gain respectively. There are several methods for tuning PID parameters [4]

The three parameters of PID controller values are obtained using to

Adjustments integrated gain to cancel any value changed suddenly.

## Stepper Motor Modeling

Mathematical equation described the dynamics of stepper motor:

$$\frac{di_a}{dt} = \frac{1}{L}[V_a - R_a \cdot i_a - K_m \cdot \omega \cdot \cos(\omega p)] \tag{1}$$

$$\frac{di_b}{dt} = \frac{1}{L}[V_b - R_b \cdot i_b - K_m \cdot \omega \cdot \cos(\omega p - \frac{\pi}{2})] \tag{2}$$

$$\frac{d\omega}{dt} = \frac{1}{J}[K_m \cdot i_a \cdot \cos(\omega p) + K_m \cdot i_b \cdot \cos(\omega p - \frac{\pi}{2}) - B \cdot \omega - T] \tag{3}$$

$$\frac{d\theta}{dt} = \omega \tag{4}$$

These variables represented in stepper motor properties where:

$\omega$ : the rotor speed.

$\theta$ : the motor position.

$i_a$, $i_b$, and $V_a$, $V_b$: the current and voltages in the phases A and B.

L and R : the inductance and resistance of each phase winding.

$K_m$ : the motor torque constant.

p : the number of rotor teeth.

J : the rotor inertia.

B : the viscous friction constant.

T : the load torque.

**Figure 3:** Represented block diagram for stepper motor elements depend on mathematics relationship written up that's described stepper motor dainamic by using Matlab\Simulink.

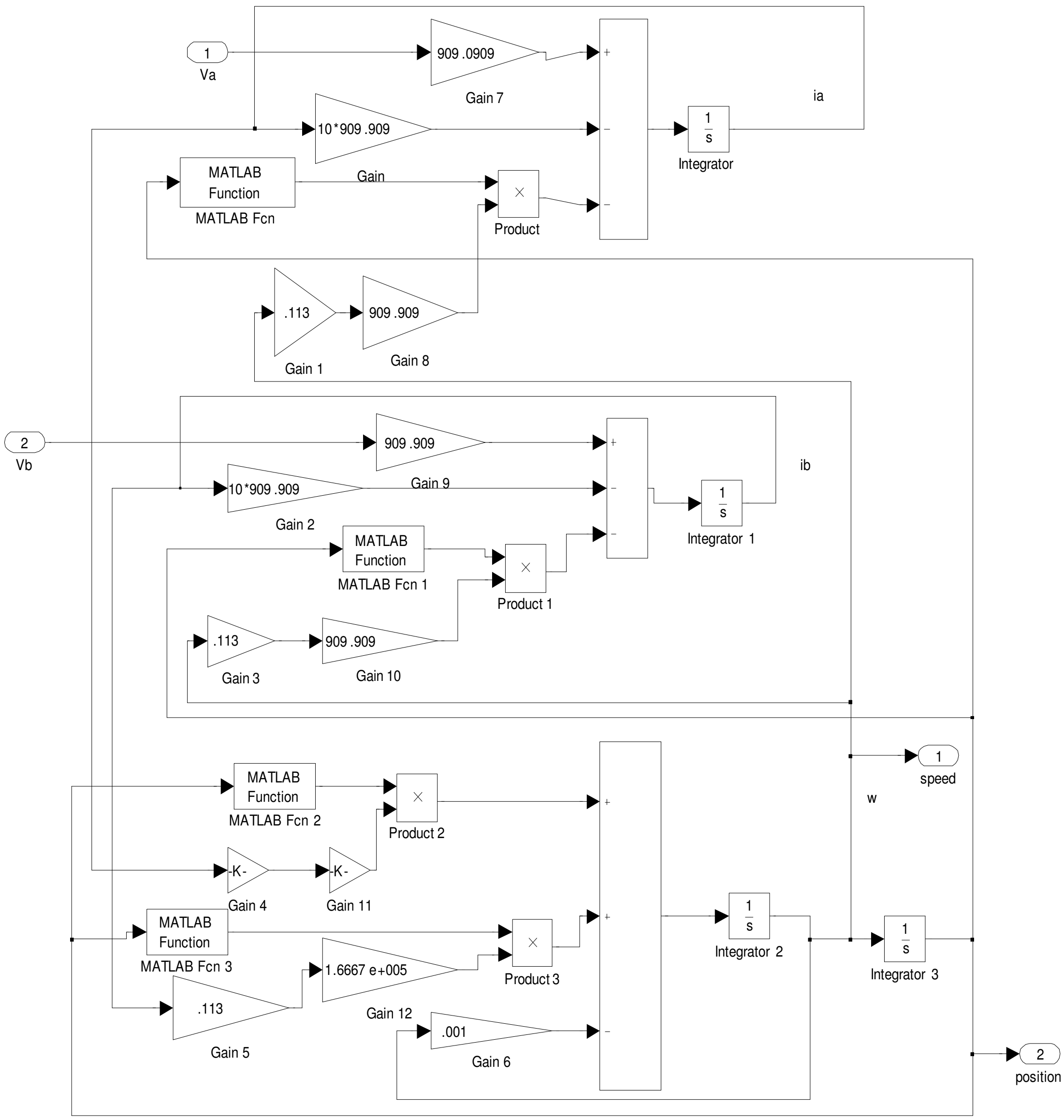



Figure (4) illustrated the structure of stepper motor control systems by using three methods of control.

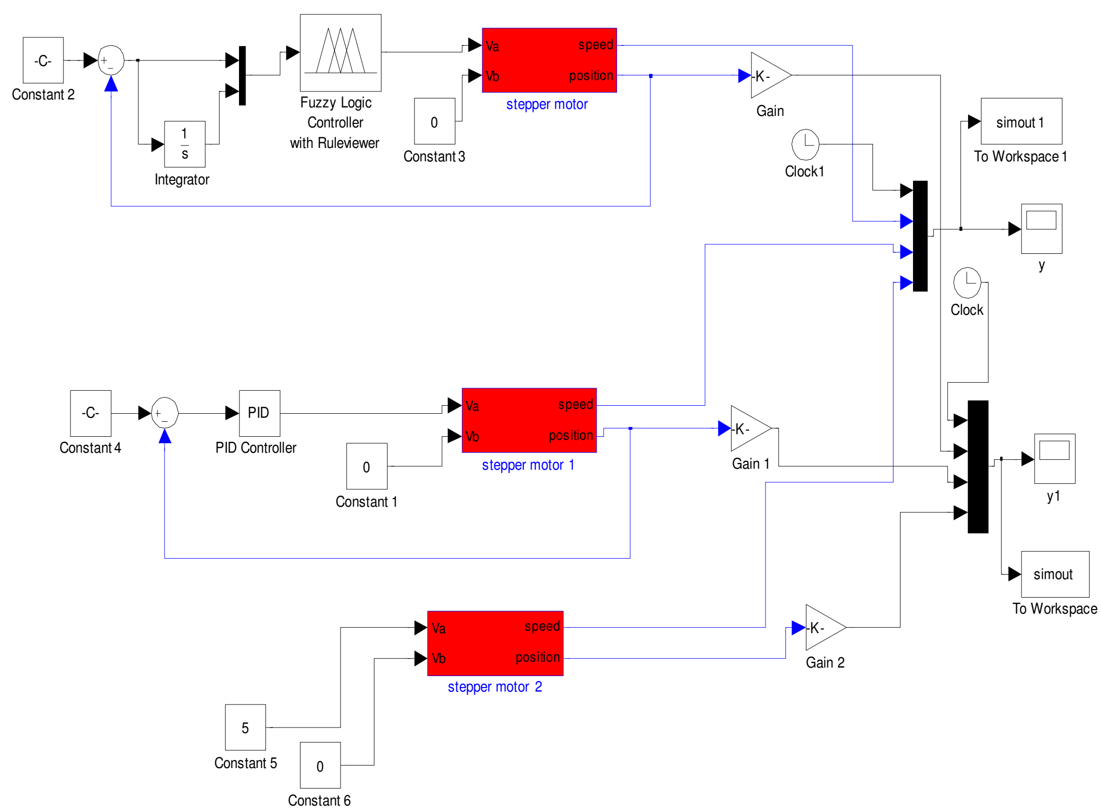
First: fuzzy logic controller used two input signal error a integral error.

Secondly: Traditional controller PID for control the step position of Stepper **motor**.

Thirdly: used open loop systems.

Block diagram by matlab Simulink for three type of controller fuzzy logic controller, PID controller and open loop controller, where used to control of speed and step position for Stepper motor.

**Figure 4:** Simulink block diagram used three method of controller




We used triangular membership function in fuzzy operation as illustrate in fig. 5

And there is 5 memberships for input variable, membership function limited the degree of membership for input variable value in fuzzy group known as inputs.

**Figure 5:** Membership function for input

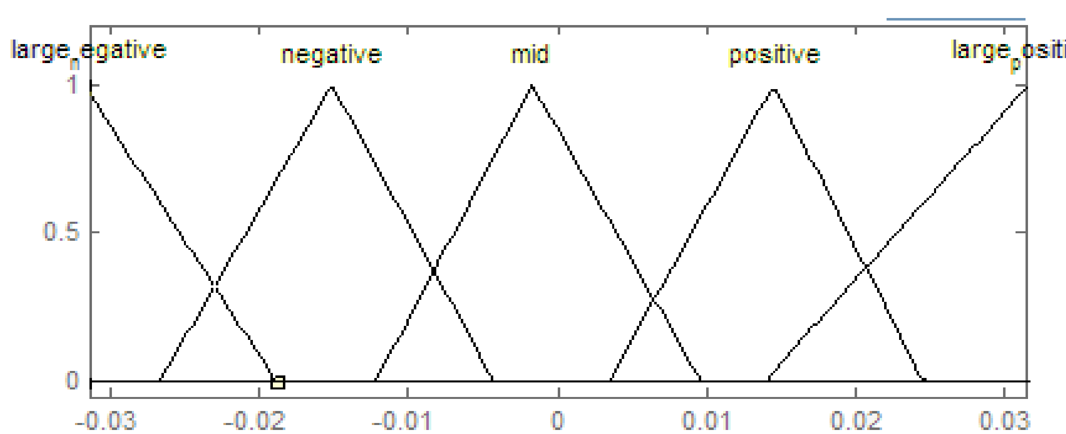



Figure 6 illustrated the result of simulation for the value of input and output variable.

**Figure 6**

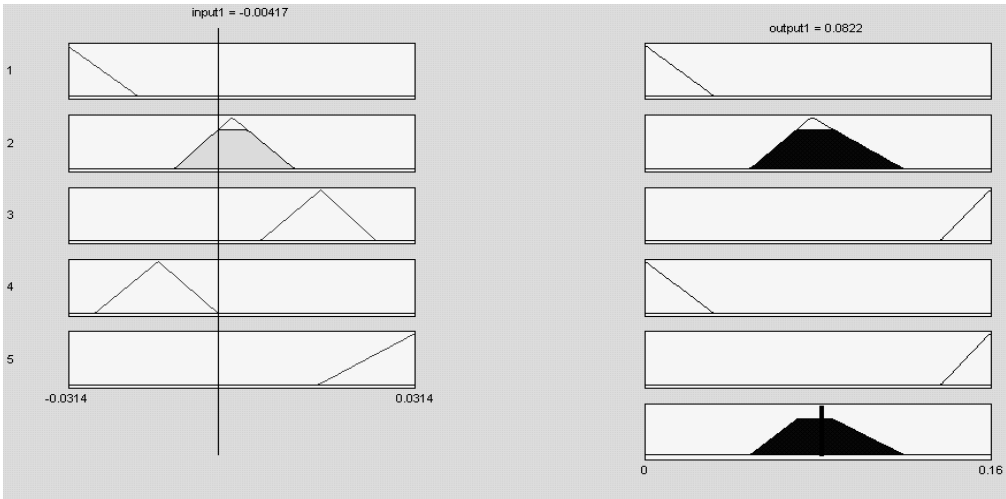
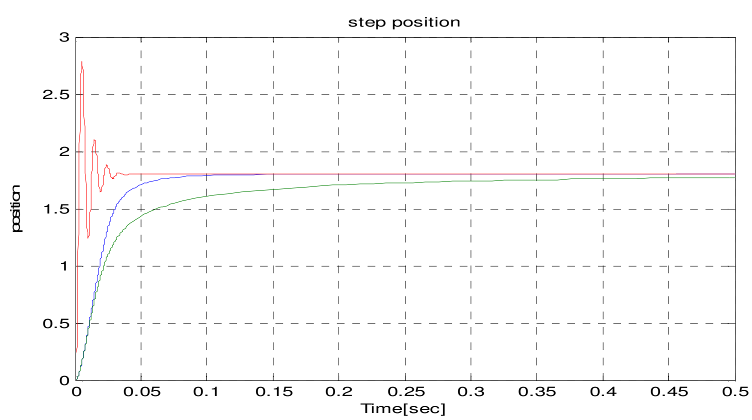


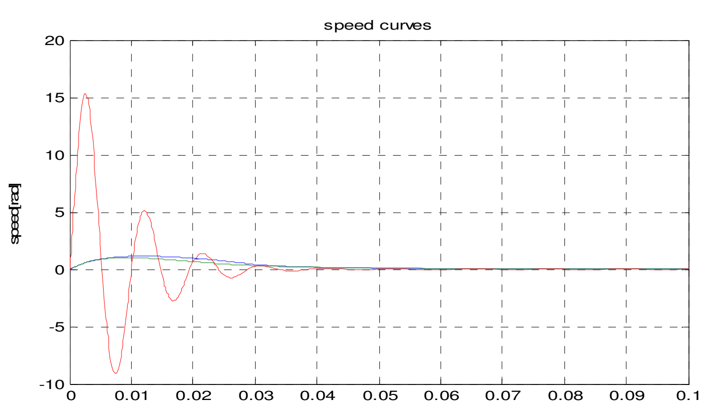

Figure (7) shows the cases of position control curves for fuzzy, PID and open loop controller. The curves appear the step position response time for three controllers in stepper motor, to compare which type of them best to reach nominal step position at less time. The curves give us the result 0.1s the time response for fuzzy controller since 0.3s for others type.

**Figure 7:** Position response curve for step motor



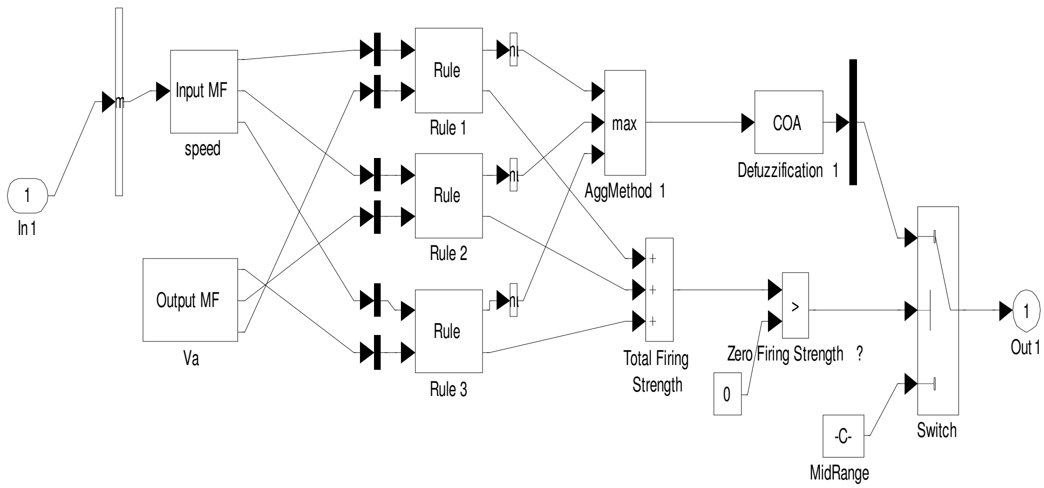

We have seen in fig.(8) Speed response curves for three cases of controllers fuzzy, PID and open loop.

**Figure 8:** Speed response curves



We have used in modeling centroid of area (COA), maximum method(MM),it's one of Defuzzification methods ,figure shows block diagram below gives elements , input and output member ship, and the adding operation(Inference mechanism).

**Figure 9:** The operation results in defuzzification unit




## Results and Dissection

Modeling stepper motor and simulate it by mat lab give us good results that can we see it in curves when we compare simulation results for PID and some of inelegant type (Fuzzy logic controller).

We have the ability to modeling stepper motor based on mathematical equations that mentioned in the introduction parts of my search.

## Conclusions

We have get from simulation that done for control the step position and speed to stepper motor by using: PID, fuzzy and open loop controllers.

1. Verify the step position response time up to 40% faster in fuzzy control compared with the other two methods.
2. Similar access to nominal speed in the case of fuzzy control and conventional control.

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