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AVR IMPLEMENTED BY ADAPTIVE FUZZY PD

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ABSTRACT

Automatic Voltage Regulator (AVR) assume to be an important part in terminal voltage profile outline process in a generator load state changing as dynamic system behaviour will change the present stream in the generator system that outcome in armature voltage and terminal voltage change. For the palatable operation of AVR, ideal tuning of Proportional Derivative (PD) controller parameters is important. This paper shows a way using Fuzzy Logic to deal with optimising the parameters of PD controller in AVR system. The proposed approach has brought about PD controller with great transient response. In this paper Sugeno Fuzzy system is used to obtain optimal gain of PD controller which is able to work in different conditions. The proposed perspective for tuning the PD controller has been manifested via MATLAB simulations for AVR system.

Keywords: *PD controller, AVR, Sugeno Fuzzy Logic.*

I. INTRODUCTION

An automatic voltage regulator comprises of a few segments, for example, diodes, capacitors, resistors and potentiometers or even microcontrollers, all put on a circuit board. This is then mounted close to the generator and associated with a few wires to gauge and confirm the generator. The AVR screens the yield voltage and controls the given input voltage for the exciter and the generator. By raising or restraining the generator control voltage, the yield voltage of the generator increments or abatements in like manner. The AVR figure out the amount of voltage must be sent to the exciter various times each second, consequently settling the output voltage to a foreordained set point. Whenever two or more generators are controlling the same system (parallel operation) the AVR gets data from more generators to match all output[1] [2].

The fundamental target of the AVR is to maintain the terminal voltage and this is done by altering the generator as well as exciter voltage [7]. The AVR has to monitor the terminal voltage across generator continuously and also under any cumbersome condition, running to keep this voltage inside preset up breaking points. Regardless of noteworthy studies in the improvement of cutting edge control conspires, the established PD controllers remain the controllers of decision to monitor the AVR as a result of its basic anatomy and power to varieties of the system parameters. For the agreeable operation of AVR, true determination of the parameters for PD controller is important. Generally, the PD controller parameters are assessed by utilizing Ziegler–Nichols (ZN), and Cohen Coon techniques. In both these techniques, the parameters of the controller are gotten for a working point where the model can be viewed as linear. This infers there is sub-optimal tuning when a procedure works outside the legitimacy zone of the model.The AVR system has to operate in various conditions and to for these online tuning of parameters of the PD controller is implemented by Fuzzy logic approach[8] [9].

II. DESIGNING OF AUTOMATIC VOLTAGE REGULATOR SYSTEM

In a synchronous generator, the terminal voltage is kept steady at various levels by using an AVR. The AVR system includes four essential parts, specifically Amplifier, Exciter, Generator and Sensor.Figure1 shows the block diagram of adaptive Sugeno Fuzzy Model for AVR. The transfer functions of the individual part are given in Table 1 close by purposes of restriction of parameters. A development in the responsive power store of the generator is joined by a drop in the terminal voltage size. The voltage degree is recognized by a sensor. This voltage is differentiated and a dc set point sign to create the gaffe signal. A PD controller is used to diminish the botch and to upgrade the dynamic response. The PD controller is a mix of the relative, fundamental and subordinate control instruments that when used together satisfactorily offset the controlled variable at the set point. The PD controller transfer function is given by the AVR quality effects the voltage level in the midst of enduring state operation besides diminishes the voltage movements in the midst of transient periods, affecting the general system soundness. In this paper, linear quadratic controller has been utilized to actualize AVR. Be that as it may, these methodologies require a legitimate choice of weighting element and require tuning over and over to get acceptable response.

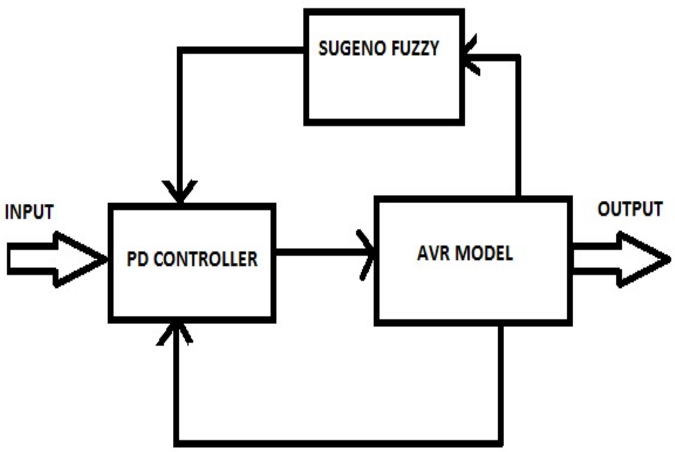

Figure 1. Block Diagram of Adaptive Sugeno Fuzzy Model

TABLE 1. AVR Component list

Peripheral	Their respective Transfer function	Parameter limits
Amplifier	TF amplifier = $K_a/(1+\tau_a*s)$	$10<K_a<40$ $0.02s<\tau_a<1s$
Exciter	TF exciter=$K_e/(1+\tau_e*s)$	$1<K_e<10$ $0.4s<\tau_e<1s$
Generator	TF generator=$K_g/(1+\tau_g*s)$	K_g depends upon the load (0.7-1) $1s<\tau_g<2s$
Sensor	TF sensor=$K_s/(1+\tau_s*s)$	$0.001s<\tau_s<0.06s$

III. SUGENO FUZZY MODEL

LOFTI A. ZADEH is the famous mathematician to invent Fuzzy logic in period of 1960s to give a numerical premise to mankind thinking [4]. Fuzzy logic utilizes Fuzzy set hypothesis, in which its variable is an individual from single or more than single set, with a predetermined level of participation in the form of membership. The degree of membership that can be said as probability, in a set is communicated by a number from0 to 1. 0 implies that it does not belongto set, 1 implies that it belongs to set, and a number in the middle of means in part of it in the set. Numerically, a Fuzzy set *B* in the universe of discourse *y* is characterized to be an arrangement of requested sets

$$B=\{(y, \mu_a(y)) \mid y\in Y\}$$

where $\mu_a(y)$ is called the membership function of y in *B*[3].Traingular membership functions and trapezoidal membership functions are extremely used for the given of given parameter of the defined. Fuzzy logic when connected to PCs permits them to imitate the human thinking process, measure uncertain data, and settle on choices in view of ambiguous and fragmented information, yet by applying a "defuzzification" process, land at distinct conclusions.

Mamdani, Sugeno and Tsukamoto are three main types of Fuzzy logic systems [3]. In theSugeno Fuzzy model, which is followed in this paper, the Fuzzy rule is expressed as

If p is C and q is D then z = f (p, q)

where*p* and *q* are input variables, *A* and *B* are Fuzzy sets in theantecedent and *f(p, q)* is a crisp function in the subsequent.The Fuzzy sets of each variable are described by appropriatemembership functions. A set of such rules form the depthof the Fuzzy logic system.

For a specific input signal condition, the Fuzzy systemspecifies the rules to be triggered and then computes theefficacious output. For this, first the minimum of themembership functions of the inputs weights (w_i) is retrieve foreach of the rules. This value is the firing value for aparticular rule [5] [6]. Then the overall output is determined byweighted average of individual rule outputs given by

$$z = \frac{\sum w_i z_i}{\sum w_i}$$

In the present paper, the Sugeno Fuzzy system is used toestimate the parameters of the PDcontroller under variousoperating conditions. Figure 2 represent the Simulinkblock diagram of Adaptive Sugeno Fuzzy model for automatic tuning of PD controller on the basis of exciter parameter. Here we have used three different input for the given input and studied their responses.

IV. RESULT OF SIMULATION

The methodology presented in this paper for automatic tuning of PD controller was tested on an AVR system. By applying ZN tuning following values of K_p and K_d are found

K_p= 3.43 and K_d= 0.049

The Unit Step Response of PD controller, PID controller, LQR and adaptive Fuzzy PD are shown in Figure 3, Figure 4, Figure 5 and Figure 6 respectively. Table 2 shows the comparison result of proposed three methodologies.

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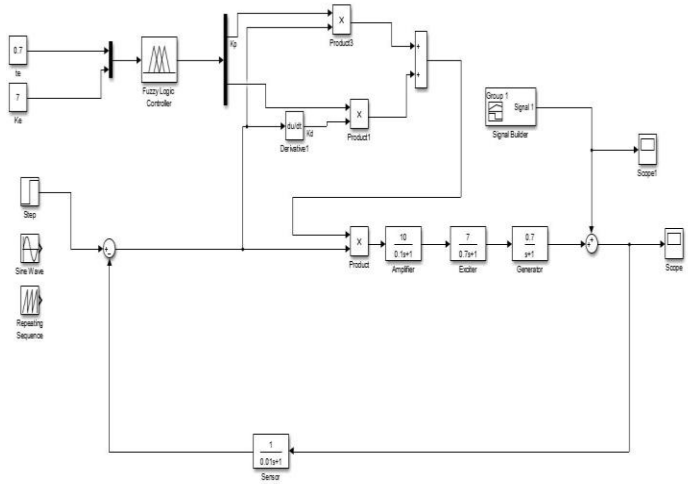

Figure 2. Simulink Diagram

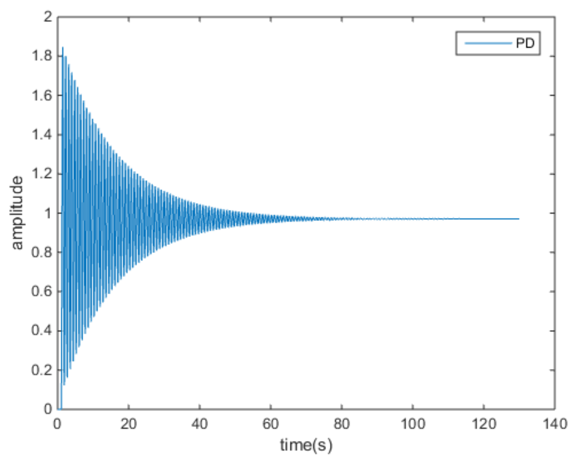

Figure 3. Unit Step Response of PD Controller

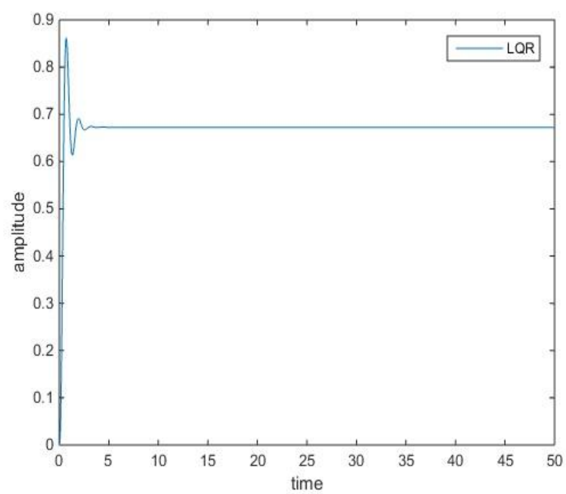

Figure 4. Unit Step Response of LQR Controller

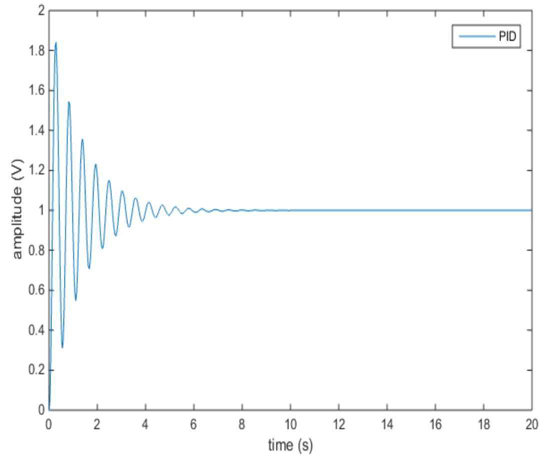

Figure 5.Unit Step Response of PID Controller

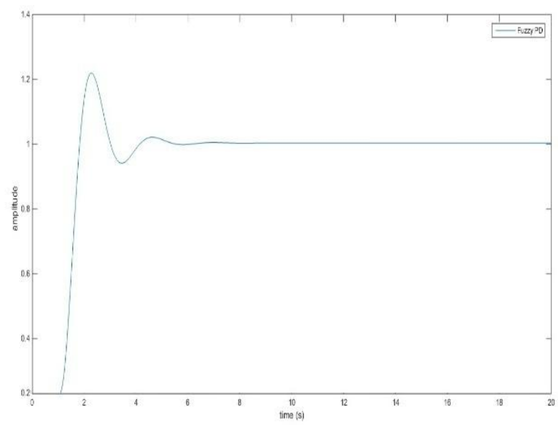

Figure 6.Unit Step Response of Fuzzy PD Controller

TABLE2.. Comparison Table

METHOD	SETTLING TIME (s)	OVERSHOOT (V)	ERROR
PD	160	1.85	0.20
PID	11	1.85	0.01
LQR	6	0.86	0.33
FUZZY PD	9	0.995	0.18

V. CONCLUSION

This paper presents the adaptive Fuzzy PD controller for AVR system. In this paper, three different algorithms statements are presented which are PID, PD, LQR and adaptive Fuzzy PD. The outcomes of these algorithm to obtain the optimal values for parameters of PD controller under various operating conditions has been analyzed and observed through MATLAB simulation. From the simulation result, it is clear that the Sugeno Fuzzy system are able to produce the optimal values of parameters of PD controller and solves all the problem associated with the help of advance computational technique on applying to online application.

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