Automatic Voltage Control For Power System Stability Using Pid And Fuzzy Logic Controller

Mr. Omveer Singh[1], Shiny Agarwal[2], Shivi Singh[3], Zuyyina Khan[4],

[1]Assistant Professor-EEE, GCET,
[2]B.tech 4th Yr EEE,[3]B.tech 4th Yr EEE, [4]B.tech 4th Yr EEE

Abstract:- This works aims to develop a controller based on PID Controller and fuzzy logic controller to simulate an automatic voltage regulator in transient stability power system analysis. The PID controller and the fuzzy logic controller is developed to improve the performance of the Automatic Voltage Regulator. The controller is designed based on the mathematical model of the system using Matlab simulation techniques in graphical interface using simulix. It was simulated a one machine control to check if the PID controller and the fuzzy logic controller implementation was possible. After that the controller developed was applied in field excitation system to show its behaviour, which results were compared to the results obtained with the AVR itself. The AVR quality influences the voltage level during steady state operation,and also reduce the voltage oscillations during transient periods, affecting the overall system stability

Keywords:PIDController,fuzzy logic controller,Transient stability,Transient period, Dynamic Performance

I. INTRODUCTION

In recent years, the scale of power systems has been expanded, and with that stability and constancy of nominal voltage level in an electric power grid is becoming more important. One of method for increasing stability and achieving nominal voltage level in an electric power grid is raising the voltage or employing series capacitors in power transmission lines, but controlling of generator exciter by using of Automatic Voltage Regulator (AVR) is attracting attention because of its inherent cost advantage. The generator excitation system maintains generator voltage and controls the reactive power flow using an automatic voltage regulator. The task of an AVR system is to hold the terminal voltage magnitude of a synchronous generator at a specified level. Thus, the stability of the AVR system would seriously affect the security of the power system. Despite the potential of the modern control techniques with different structure, Proportional Integral Derivative (PID) type controller is still widely used for AVR system. This is because it performs well for a wide class of process. Also, they give robust performance for a wide range. It is shown that the appropriate selection of PID controller parameters results in satisfactory performance during system upsets. Thus, the optimal tuning of a PID gains is required to get the desired level of robust performance.[1]For better performances a fuzzy logic controller is used which improves stability manifolds.

II. TRANSIENT STABILITY ANALYSIS

In an electrical system reliability there is a demand at synchronous generators working in parallel and with adequate capacity to satisfy the load demand. At certain cases the generator looses synchronism with the rest of the system, significant voltage and current fluctuation can occur and transmission lines can be automatically removed from the system configuration Another demand is in maintaining power system integrity.

The high voltage transmission system connects the generation sources to the load centre which requires the power system topology study, where all electrical systems are connected to each other. At normal load condition in power system there is a disturbance in synchronous machine voltage angle rearrangement. At each occurrence of disturbances an unbalance is created between the system generation and load, so a new operation point will be established and consequently there will be voltage angle adjustments. The system adjustment to its new operation condition is called "transient period" and the system behaviour during this period is called "dynamic performance". It can be said that the system oscillatory response during the transient period, short after a disturbance is damped and the system goes in a definite time to a new operating condition, so the system is stable. This means that the oscillations are damped, that the system has inherent forces which tend to reduce the oscillations. In a power system the instability can be shown in different ways, according to its configuration and its mode of operation, but it can also be observed without synchronism loss. Automatic devices control generators in its voltage output and frequency, in order to keep them constant according to pre-established values.[2]

The automatic devices are:

- Automatic voltage regulator
- Governor

The governor is slower in is action loop than AVR. This is associated mainly to its final action in the turbine. The main objective of the automatic voltage regulator is to control the terminal voltage by adjusting the generators exciter voltage. It must keep track of the generator terminal voltage all time and under any load condition, working in order to keep the voltage within pre-established limits. Based on this it can be said that AVR also controls the reactive power generated and the power factor of the machine once these variables are related to the generator excitation level.

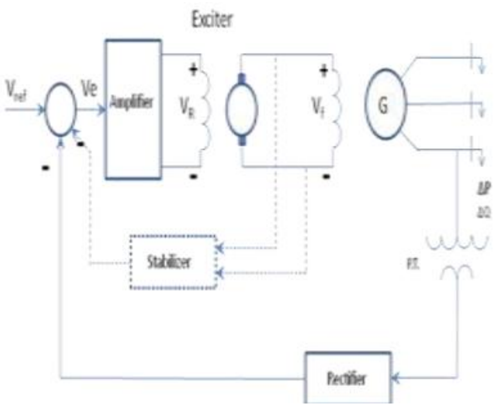


Fig 1. Typical arrangement of simple AVR[6]

III. PID CONTROLLER

The pid controller is simple and easy to implement. It is widely used in industries to solve various control problems. It is used to improve dynamic response as well as to reduce or eliminate steady state error. The derivative controller adds a finite zero to the open-loop plant transfer function and improves the transient response. The integral controller adds a pole at the origin, thus increasing system type by one and reducing the steady state error due to a step function to zero.

The PID controller transfer function is,

$E(s) / U(s) = Kp + Ki / s + Kd .S$

Kp is the proportional gain, Ki is the integration gain, and

Kd is the derivative gain.

The proportional part of the PID controller reduces error responses to disturbances. The integral term of the error eliminates the steady state error and the derivative term of the error dampens the dynamic response and thereby improves the stability of the system.[7]

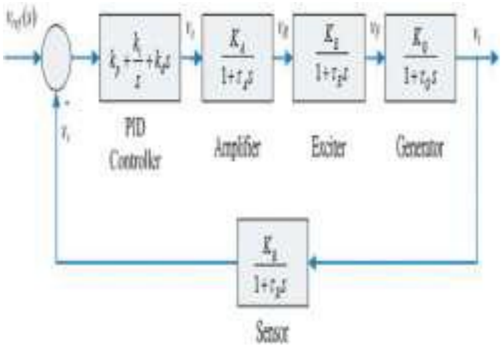


Fig 2. Closed loop block diagram of AVR with PID controller

IV. PID CONTROLLER RESULTS IN A ONE MACHINE SYSTEM

The block diagram shown below for a synchronous machine for which output voltage is controlled by an AVR applied to the excitation system, in the Matlab simulation.It is very interesting to investigate the effects of each PID controller parameters Kp, Ki, and Kd on terminal voltage response that exists on the excitation system only.
Tuning the PID controller by setting the proportional gain Kp to 1, and setting different values of Kp and Kd. From these responses and the tuning method, the best values of PID controller parameters for the excitation and governing systems are selected as
Kp = 1, Ki = .25 and Kd = 0.28
For the governing system the values of Kp, Ki and Kd are
set as,
Kp = 1, Ki = .25, Kd = 0.28

The simulation models and voltage response are shown as:

Without PID controller:

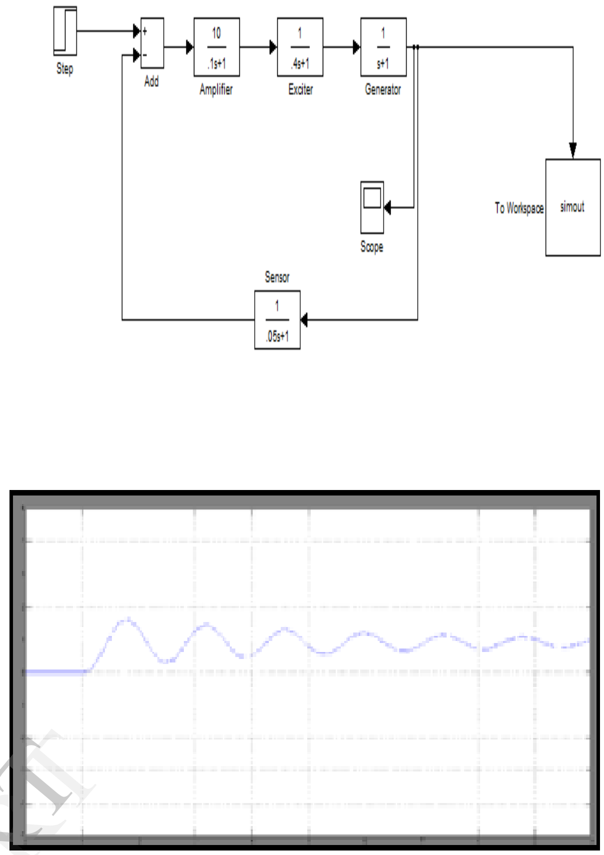
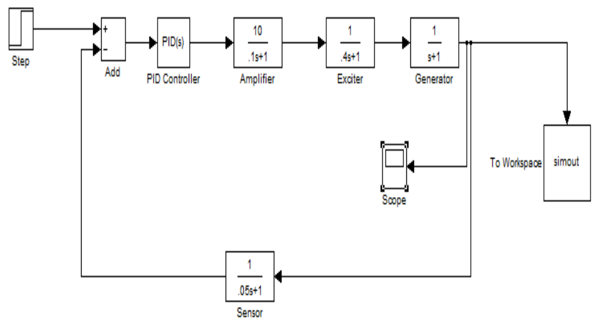


Fig 3. Block diagram and its response of simulation of an AVR system without a PID Controller[8]

With PID controller:



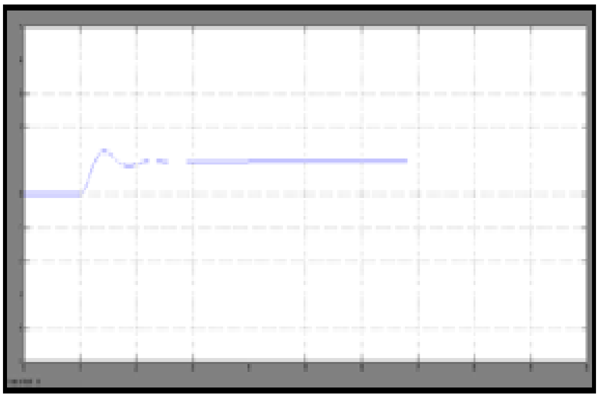


Fig 4. Block diagram and its response of simulation of an AVR system with a PID Controller

VI. ARTIFICIAL INTELLIGENCE AND FUZZY LOGIC CONTROLLER

At the controlling complex systems highly non-linear has shown to be very difficult using conventional control theory. The artificial intelligence with its natural language has proven to be useful in cases as it deals with uncertainties, what brings it closer to human being logic thought. In artificial intelligence fuzzy logic was the chosen one.

VI.I. FUZZY SET

In the fuzzy logic controller data the fuzzy set is a distinct element collection with a relevancy or inclusion variable degree which characteristic function known as membership function, determines its relevancy degree. The fuzzy set also acts as a generalization of a regular set in which the membership has only two values {0,1}. The fuzzy set U can be represented as an ordinate pair set of a generic element U and its membership function degree µF.

VI.II. THE FUZZY CONTROLLER

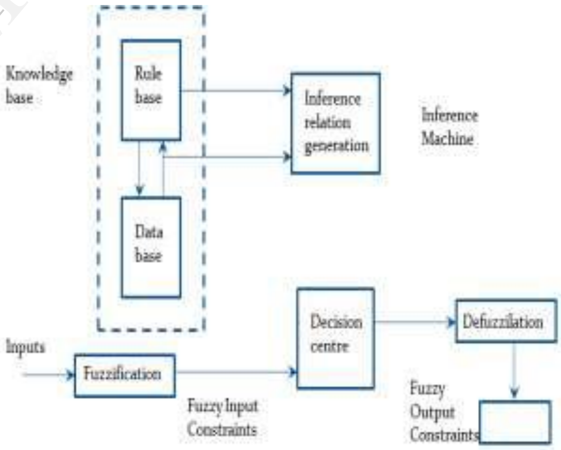
At the linguistic control conversion strategies the controllers are based on the fuzzy logic from expert knowledge in automatic control strategies. The recent fuzzy logic controller applications are, used in water quality control, train operation automatic system, elevators control, nuclear reactor control and in fuzzy computers shows an efficient way for using the fuzzy control in complex process which can be controlled by a skilful human being without knowing its dynamic.The fuzzy logic controller consists of a linguistic proportions and rule sets, which defines individual control action.

VI.III. FUZZY CONTROLLER PROJECT

In the development of the control system based on fuzzy logic involves the following steps:

- Fuzzification Strategy
- Data Base Building
- Rule Base Elaboration
- Interference Machine Elaboration
- Defuzzification Strategy.

VII. FUZZY LOGIC CONTROLLER RESULTS IN A ONE MACHINE SYSTEM



VII.I. KNOWLEDGE BASE

It comprises the definitions of fuzzy membership functions for the input and output variables and the necessary control rules which specify the control action by using the linguistic terms.

VII.II. RULE BASE

a.Choice of process state(input) variables and (control) variables of fuzzy control rules.

b.Source and derivation of fuzzy control rules.

A fuzzy system is characterized by a set of linguistic statements based on the expert knowledge.The expert knowledge is in the form of “if-then” rules which are easily implemented by fuzzy conditional statements in fuzzy logic.

VIII.SIMULATION MODEL OF AN AVR SYSTEM WITH A FUZZY LOGIC CONTROLLER.

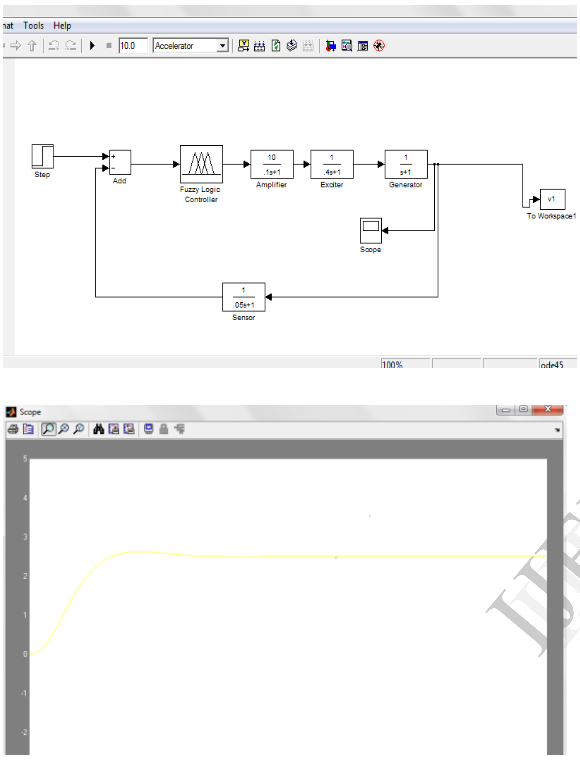


Fig 5. Block diagram and its response of simulation of an AVR system with a Fuzzy Logic Controller.

IX. COMPARISON AMONG AN AVR SYSTEM ALONE,WITH PID AND WITH FUZZY LOGIC CONTROLLER.

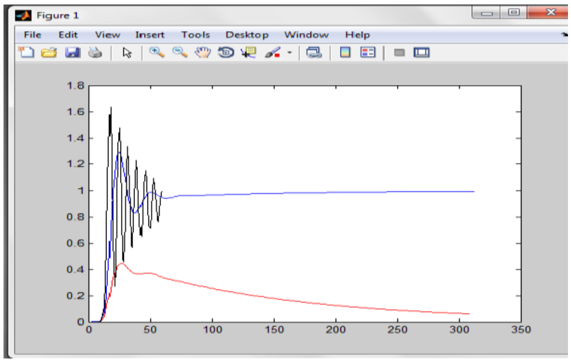


Fig 6. Response of simulation of an AVR system without a controller(black),with PID controller(blue) and Fuzzy Logic Controller(red).

	Without a controller	With PID Controller	With fuzzy logic Cntrl
Peak Overshoot	1.632	1.289	0.446
Peak Overshoot Time	18ms	24ms	29ms
Settling time	Undefined	70ms	54ms

X. CONCLUSION

It is observed for both the studies (Matlab simulation and stability program simulation) an excellent response of the PID controller and fuzzy logic controller and with no oscillations, while the AVR response presented a ripple in both studies and some oscillations before reaching the steady state operation point. It is shown that an excellent performance of the PID controller and fuzzy logic controller over the conventional one for the excitation control of synchronous machines could be achieved.

XI. REFERENCES

[1] International Journal of Engineering and Advanced Technology (IJEAT) ISSN: 2249 – 8958, Volume-1, Issue-5, June 2012

[2] Clerc,M.and Kennedy,J., “The Particle Swarm Explosion,Stability, and Convergence in a Multidimentional Complex Space,” IEEE Transactions on Evolutionary Computation, (2002)

[3] Gaing,Z.L., “ A Particle Swarm Optimization Approach for Optimum Design of PID Controller in AVR System,” IEEE Transactions on Energy Conversion, (2004)

[4] P.M. Anderson and A.A. Fouad, “ Power System Control and Stability”, IEEE press (1995)

[5] Hadi Saadat. 1999. “Power System Analysis”, Tata McGraw-Hill

[6] C.L. Brasca & M.A. Johnson, “ On Automatic Voltage Regulator Design for Synchronous Generator”, IEEE International Conference on control and Appilications, (1994)

[7] Mukherjee, S.P. Ghoshal, “Intelligent particle swarm optimized fuzzy PID controller for AVR system”, Electric Power Systems Research, Vol. 77, pp.1689-1698, 2007

[8] MATLAB User Guide Version 1, "Power System Blockset for use with Simulink", electronic copy from http://www.mathworks.com