OPEN ACCESS

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

Fuzzy And Pid Excitation CONTROL System With AVR In Power System Stability Analysis

S.Vasanthi, M.Gopila, I.Gnanambal

Abstract:- This works aims to develop a controller based on PID and Fuzzy Logic Controller to simulate an automatic voltage regulator in transient stability power system analysis. It was simulated a one machine control to check if the Fuzzy and PID controller implementation was possible. After that the controller developed was applied in field excitation system to show its behavior, which results were compared to the results obtained with the AVR itself.

Keywords:- Fuzzy and PID controller, system to show its behavior.

1. INTRODUCTION

At the view of power system, the excitation system must contribute for the voltage control and enhancement of system stability. It must be able to respond quickly at any occurrence of disturbances enhancing the transient stability and the small signal stability. In the excitation control system the synchronous generator consists of boiler, governor, and exciter controls. In present days the exciter is a dc generator driven by either steam turbine or an induction motor. The voltage regulator in an excitation system control the output of the exciter so that the generated voltage and reactive power change in the desired way. Automatic voltage regulator (AVR) is a controller that senses the generator output voltage and then initiates corrective action by changing the exciter control in the desired direction. AVR is of great interest in studying stability with its speed, because of high inductance in generator field winding, it is difficult to make rapid changes in field current. There will a considerable lag in control function and a major obstacle to overcome in designing a regulating system. The purpose of this work is the development of a pid and fuzzy logic controller inorder to simulate the automatic voltage regulator behavior

2. 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.

Manuscript published on 30 June 2012.
***** Correspondence Author (s)
S.Vasanthi, M.E Power System Engg – Sona College of Technology
M.Gopila, M.E.,(Ph.D) Assistant Professor - Sona College of Technology
Dr.I.Gnanambal, Associate Professor – Govt College of Engg - Salem

The high voltage transmission system connects the generation sources to the load center 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 behavior 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.
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.

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

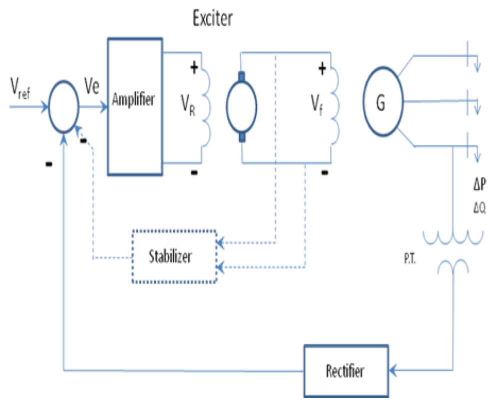


Fig: Typical arrangement of simple AVR

3. 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.

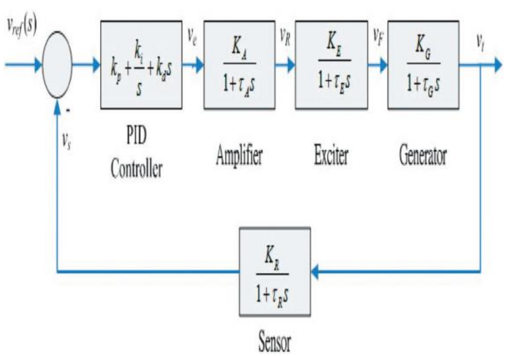


Fig: closed loop block diagram of AVR with

PID controller

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.

PID Controller Design For AVR System

It is an important matter for the stable electric power service to develop automatic voltage regulator (AVR) of the synchronous generator with a high efficiency and fast response. Until now the analog PID controller is generally used for the AVR because of its simplicity and low cost. There are five models as follows:

- PID controller model
- Amplifier model
- Exciter model
- Generator model
- Sensor model

4.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.

4.1 Fuzzy Logic Controller Data

In recent years the fuzzy logic use has received a lot of attention of its usefulness in reducing the models complexity in the problem solution, it employs linguistic terms that deals with the causal relationship between input and output constraints.

The fuzzy set theory was motivated mainly by the conviction that the traditional analysis methods were inadequate to describe phenomena whose constraints were not related by differential equations. This theory provides a way of representing the vague notions through the element and its membership in this set.

4.1.1 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.

4.2 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

4.2.1 Fuzzy Controller Project

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

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

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

5.RESULTS

The graphs shown in the subsection below will provide the comparative performance results between the PID controller and the fuzzy logic. Two different situation were analyzed, the AVR with PID controller and the AVR with fuzzy logic controller at a one machine excitation control done with Matlab Software.

5.1 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, Ki to 0.5 and Kd to 0.005 then the frequency deviation step response $\Delta\omega$ has similar response.

Also the time taken for the terminal voltage to reach the value of 1 p.u is now 0.8sec, it found that these settings of Kp, Ki, and Kd don't produce an overall response. From these responses and refer to tuning method, the best values of PID controller parameters for the excitation and governing systems are selected as

Kp = 1, Ki = 2 and Kd = 0.005

For the governing system the values of Kp, Ki and Kd are set as,

Kp = 0.8, Ki = 0, Kd = 0.6

The simulation diagram for the PID controller are as shown below:

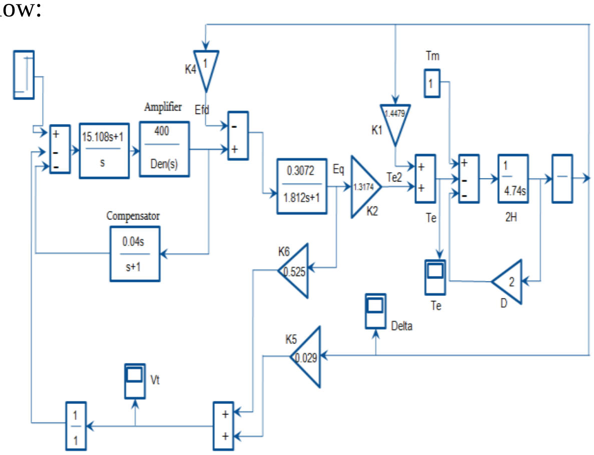


Fig: Simulink Model Of One Synchronous Machine With AVR Using PID Controller

RESULTS

Graph For Simulation Of PID Controller **(Electrical Torque of One machine Analysis)**

5.2 Fuzzy Results In A One Machine System

Fuzzy logic is a derivative from classical Boolean logic and implements a soft linguistic variables on a continuous range of truth values to be defined between conventional binary. Since fuzzy logic handles approximate information in a systematic way, it is a deal for controlling non-linear systems and for modeling complex systems where an inexact model exists. A typical fuzzy system consists of rule base, membership functions and an interference procedure.

Fuzzy logic is a superset of conventional Boolean logic that has been extended to handle the concept of truth values between " completely true" and "completely false"

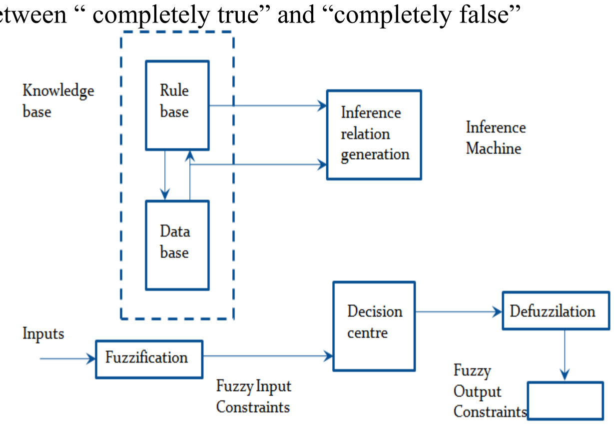
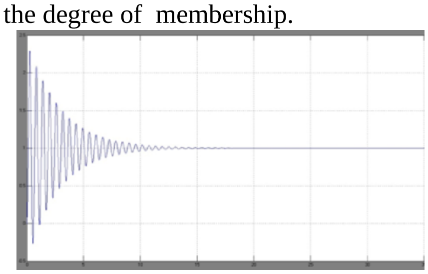


Fig : Basic Configuaration Of Fuzzy Controller

5.2.1 Fuzzyfication

It maps from the crisp input space to fuzzy sets in certain input universe of discourse, so for a specific input value it is mapped to the degree of membership.



5.2.2 Inference Mechanism

It plays an essential role and consists of a set of fuzzy if-then rules such as, if X is A, Y is B and Z is C, where r, y and z are linguistic variables representing two input variables, and one control output. A, B and C are linguistic values.

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

5.2.3 Knowledge Base

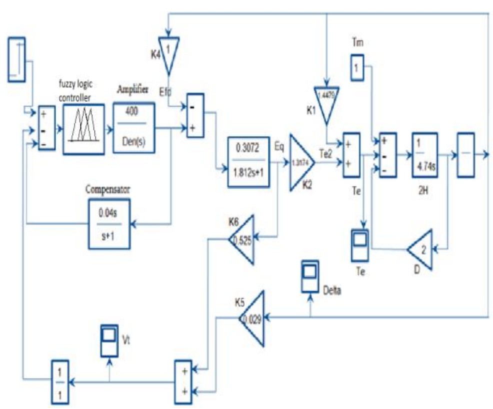
It comprises the definitions of fuzzy membership functions for the input and output variables and the necessary control rules which specify the control action by using the linguistic terms.

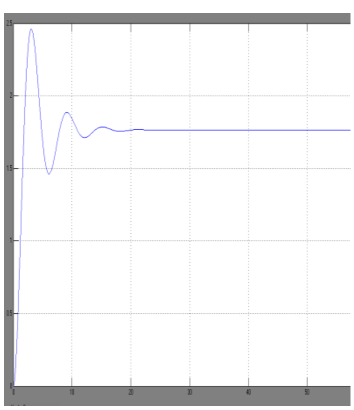
5.2.4 Defuzzyfication

It converts the linguistic variables deterministic numerical values. The various defuzzification methods are,

- Centroid Average (CA)
- Maximum Center Average (MCA)
- Mean Of Maximum (MOM)
- Smallest Of Maximum (SOM)
- Largest Of Maximum (LOM)

The simulation diagram of Fuzzy logic Controller are as shown below:





	AVR WITHOUT CONTROLLER	AVR WITH PID CONTROLLER	AVR WITH FUZZY LOGIC CONTROLLER

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.

*Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)*

	ELECTRICAL TORQUE	LOAD ANGLE	TERMINAL VOLTAGE	ELECTRICAL TORQUE	LOAD ANGLE	TERMINAL VOLTAGE	ELECTRICAL TORQUE	LOAD ANGLE	TERMINAL VOLTAGE
Over Shoot Time	2.45	1.20	1.25	2.35	0.98	1.195	2.30	0.93	1.180
Settling Time	18 sec	17.5 sec	16 sec	17 sec	16 sec	14 sec	16sec	15.5 sec	13 sec

REFERENCES

1. Clerc,M.and Kennedy,J., “The Particle Swarm Explosion,Stability, and Convergence in a Multidimentional Complex Space,” IEEE Transactions on Evolutionary Computation, (2002)
2. Gaing,Z.L., “ A Particle Swarm Optimization Approach for Optimum Design of PID Controller in AVR System,” IEEE Transactions on Energy Conversion, (2004)
3. P.M. Anderson and A.A. Fouad, “ Power System Control and Stability”, IEEE press (1995)
4. Hadi Saadat. 1999. “Power System Analysis”, Tata McGraw-Hill
5. C.L. Brasca & M.A. Johnson, “ On Automatic Voltage Regulator Design for Synchronous Generator”, IEEE International Conference on control and Appilications, (1994)
6. E.H Mamdani and S.Assilian, “ An experiment in linguistic synthesis with a fuzzy logic controller”, Int.J.Man Mach. Studies,vol.7, no 1,pp 1- 13, 1975.
7. C.C. Lee, “ Fuzzy logic in control systems”, IEEE transactions on systems, Man and cybernetics, vol. 20, no 2, MARCH/APRIL 1990.
8. L.A. Zadeh, " Fuzzy Sets”, Informat Control, vol. 8, pp. 338-353 , 1965,

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)