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AUTOMATIC GENERATION CONTROL FOR TWO AREA SYSTEM USING ARTIFICIAL NEURAL NETWORK BASED NARMA-L2 CONTROLLER

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Abstract: *One of the important issues in the operation of power system is Automatic Generation Control (AGC). It helps in supplying adequate and consistent electric power with good quality. It is secondary control in LFC which re-establishes the frequency to its nominal value (50 Hz). This project the methods of artificial intelligence is to study for the AGC of interconnected two area thermal power system using PI controller and Artificial Neural Network (ANN). The proposed control has been designed for a two area interconnected power system that two area include steam turbines, ANN controller, which controls the inputs of each area in the power system together is considered. The working of the controller is simulated using MATLAB/SIMULINK package. The controller is simulated using MATLAB and compared the results of simple PI controller with ANN based NARMA-L2 controller. From this controller we can control the frequency deviation and tie line power transfer. Advantages of this controller on a wide range of operating conditions will be shown. Nonlinear autoregressive moving average NARMA model is an exact representation of input-output behavior of a finite –dimensional and nonlinear discrete time dynamic plant in neighbor hood of the equilibrium state. Simulation results using MATLAB/SIMULINK will be carried out.*

Keywords: *ALFC control, pi control method, NARMA-L2 controller, Comparison of PI and ANN.*

I. INTRODUCTION

The role of AGC is to divide the loads among the system, station and generator to achieve maximum economy and accurate control of the scheduled interchanges of tie-line power while maintaining a reasonability uniform frequency. (salgotra, 2012)

The primary purpose of the AGC is to balance the total system generation against system load and losses so that the desired frequency and power interchange with neighboring systems are maintained. Any mismatch between generation and demand causes the system frequency to deviate from scheduled value. This high frequency deviation may lead to system collapse. Power system operation at a lower frequency affects the quality of power supply and not allowed because of following:

When operating at frequencies below 49.5 Hz, some types of steam turbines undergo excessive vibration in certain turbine rotor stages with resultant metal fatigue and blade failure

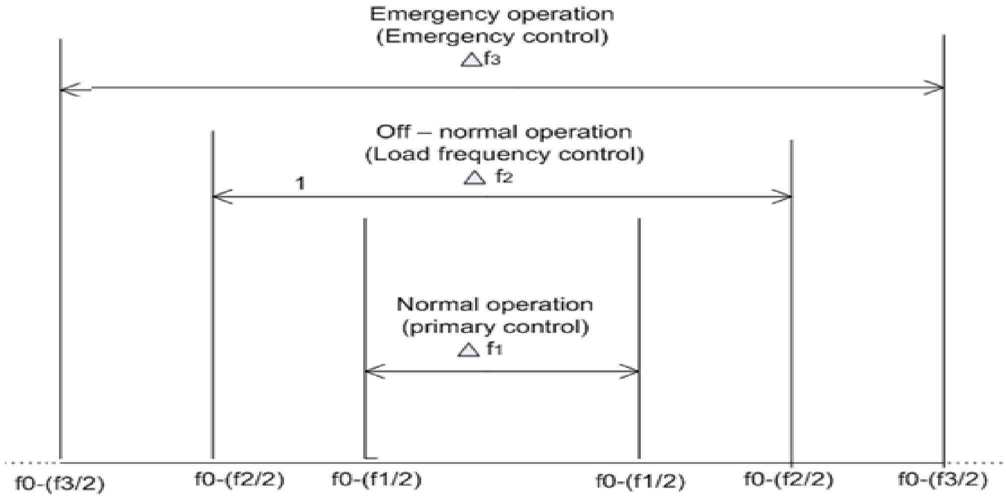
II. Power system frequency control

Frequency deviation is a direct result of the imbalance between the electrical load and the active power supplied by the connected generators. A permanent off-normal frequency deviation directly affects power system operation, security, reliability, and efficiency by damaging equipment, degrading load performance, overloading transmission lines, and triggering the protection devices.

Depending on the frequency deviation range, as shown in Figure 1.1, in addition to the natural governor response known as the primary control, the supplementary control (AGC), or secondary control, and emergency control may all be required to maintain power system frequency

There are three types of control for frequency deviation in the power system which are as follows:

(1)Primary control
(2)Supplementary control



(3)Emergency control

Figure.1 Frequency deviations and associated operating controls

III. Automatic load frequency control

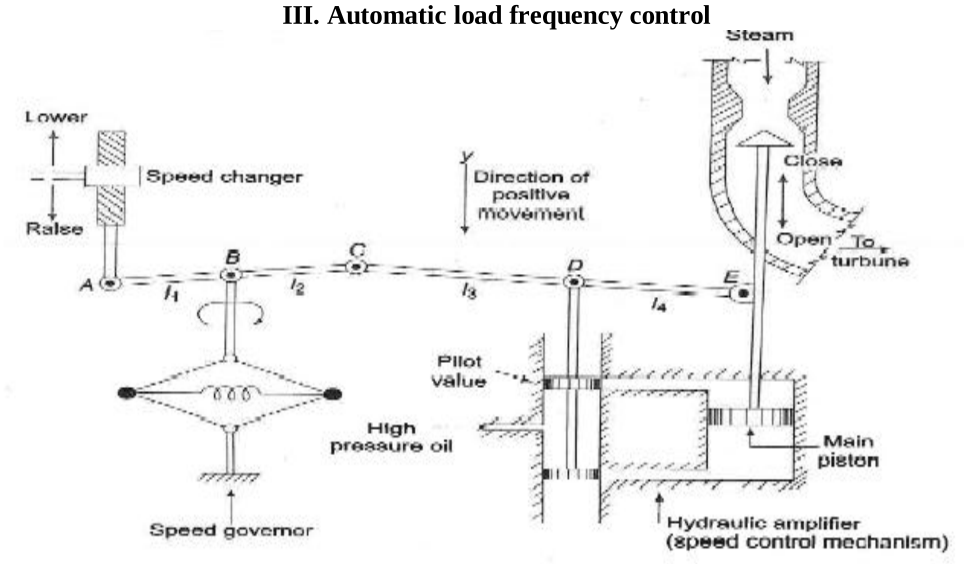


Figure.2 speed governing system

As shown in figure.2 there are four major components in speed governing system. Which are as follows:
(1)Speed governor
(2)Linkage mechanism
(3)Hydraulic amplifier
(4)Speed changer
This method to control the frequency deviation has considerable droop when its used for coherent generator. So it is necessary to provide one continous method for control, which is conventional PI method.

IV Proportional plus integral control (AGCLoop)

In primary ALFC loop, the speed governing system installed on each machine, the steady load frequency characteristic for a given speed changer setting has considerable droop. System frequency specifications are stringent and, therefore, so much change in frequency will be zero. While steady state frequency can be brought back to the scheduled value by adjusting speed changer setting, the system could undergo intolerable dynamic frequency changes with change in load. It leads to the natural suggestions that the speed changer setting be adjusted automatically by monitoring the frequency changes. For this purpose, a signal from ΔF is fed through an integrator to the speed changer resulting in the block diagram configuration shown in figure given below. The system now modifies to a proportional plus integral controller, which as is well known from control theory, gives zero steady state error. ΔF steady state=0

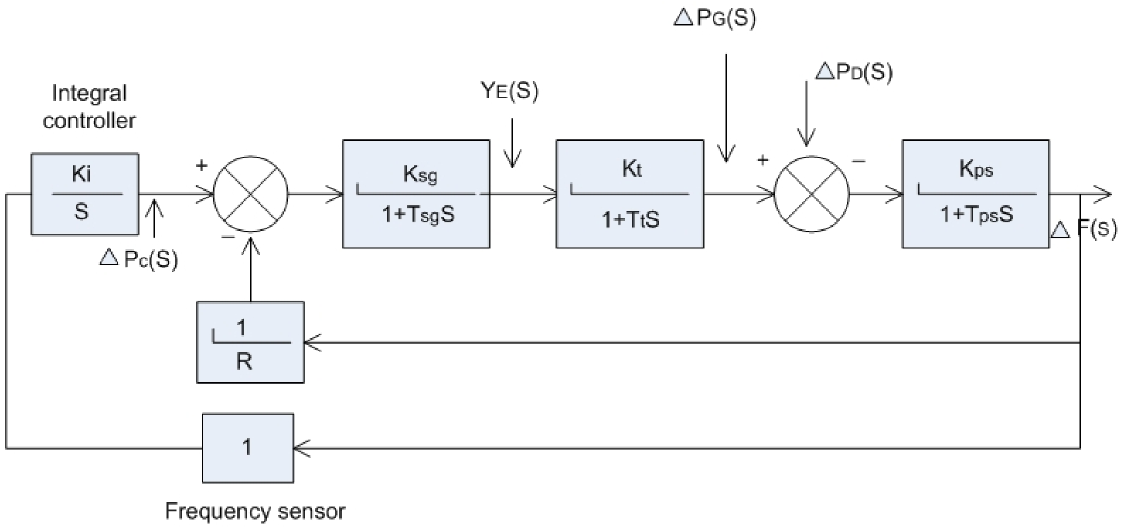


Figure.3 Proportional plus integral load frequency control

Where,

- Time constant , Tsg= 1/ k4 k5
- Regulation constant or setting R=k2/ k1
- Speed governor gain Ksg= k2 k3/ k4
- Kt- turbine gain
- Tts- turbine time constant
- Tps= 2H /Bf0 = power system time constant
- Kps= 1/B =power system gain
- YE(s)- output from governor
- ΔPG(s) – Output from turbine
- ΔPD(s) – Change in load
- ΔF(s) – Change in frequency

Why ANN required?

By using PI method we can control the frequency deviation with adjustment of gain. But when system becomes more and more complex, we required one intelligence system for controlling the frequency deviation. For this Artificial Neural Network (ANN) method is very effective.

VI. Artificial Neural Network

Neural networks which are simplified models of the biological neuron system, it is a massively parallel distributed processing system made up of highly interconnected neural computing elements that have the ability to learn and thereby acquire knowledge and make it available for use. Various learning mechanisms exist to enable the NN architecture that have been classified into various types based on their learning mechanisms and other features. Some classes of NN refers to this learning process as training and the ability to solve a problem using the knowledge acquired as inference.

NNs have simplified limitations of the central nervous system, and obviously therefore, have been motivated by kind of a human brain termed as neurons are the entities, which perform computations such as cognition, logical inference, pattern recognition and so on. Hence the technology, which has been built on a simplified limitation of computing by neurons of brain, has been termed ARTIFICIAL NEURAL SYSTEM or ARTIFICIAL NEURAL NETWORK (ANN).

NARMA Controller:

ANN controller architecture employed here is Nonlinear Auto Regressive Model reference Adaptive (NARMA). It is a standard model that is used to represent general discrete-time nonlinear systems. It is simply a rearrangement of the neural network plant model which is used to assist in the controller training. This controller requires the least computation. The only online computation is a forward pass through the neural network controller.

It consists of reference, plant output and control signal. The plant output is forced to track the reference model output. The plant model is used to predict future behavior of the plant, and an optimization algorithm is used to select the control input that optimizes future performance.

For NARMA-L2 control, the controller is simply a rearrangement of the plant model. For model reference control, the controller is a neural network that is trained to control a plant so that it follows a reference model.

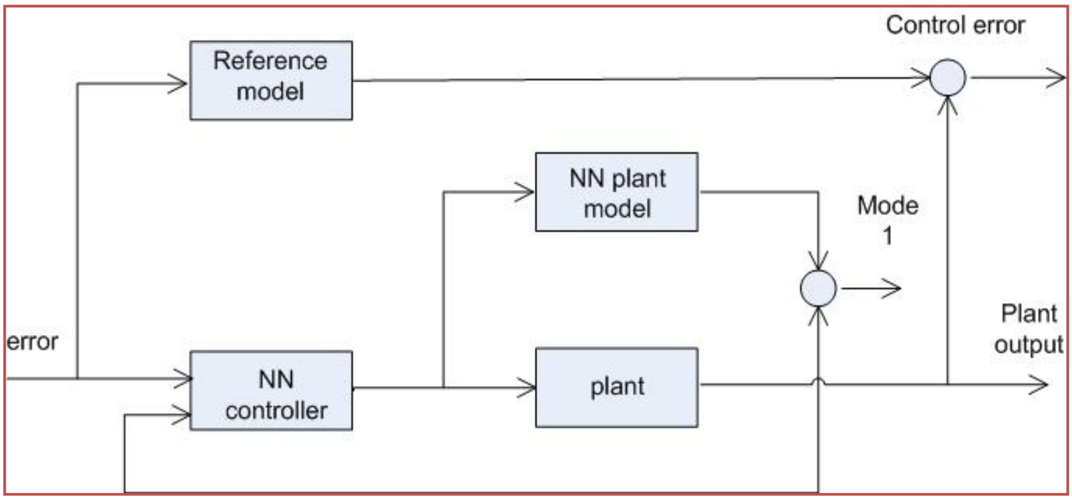


Figure.4 NARMA Controller

NARMA-L2 Controller

NARMA model is an exact representation of input output behavior of a finite dimensional and nonlinear discrete time dynamic plant in neighbor hood of the equilibrium state. This non-linearity property, its implementation for real time control systems makes difficult. To overcome computational complexity related to use of this type of ANN, two classes of NARMA are introduced in: NARMA-L1 and NARMA-L2. The latter is more convenient to practically implemented using multi-layer neural networks. Nonlinear autoregressive moving average (NARMA) is used to represent discrete time nonlinear systems.

The main idea of a NARMA-L2 controller is to transfer nonlinear system dynamics into linear dynamics by repealing the nonlinearities. NARMA-L2 is simply a rearrangement of the neural network of the system to be controlled, which is trained offline. The first stage in using NARMA-L2 controller is plant identification.

The block diagram at Fig.5 shows the structure of NARMA-L2 controller applied to load frequency control. As previously mentioned, two multilayer neural networks are used to approximate the functions f and g. The blocks labelled Delay are tapped delay lines that store past values of input and output signals.

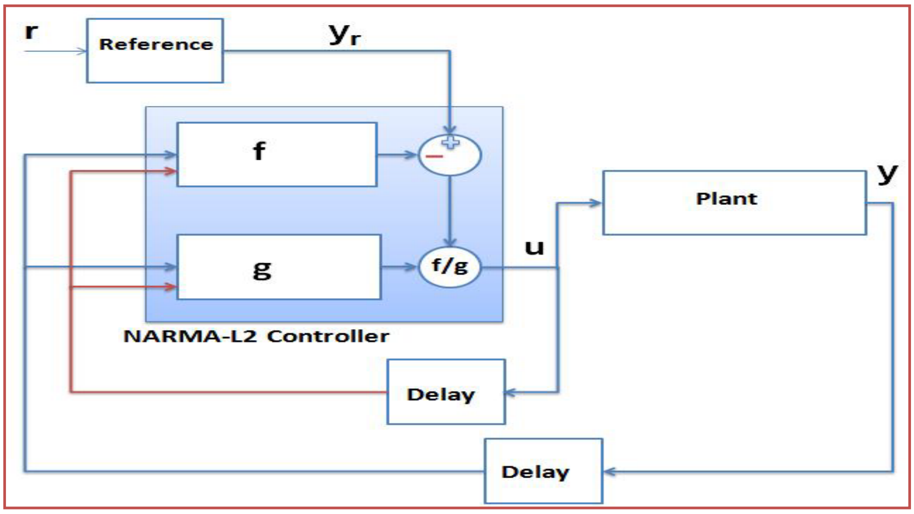


Figure.5 Block diagram of applying NARMA-L2 controller for load frequency control

VII. SIMULATIONS AND RESULTS

(a) AGC loop with PI Controller

Sr no.	parameters	values
	For Area-1	
1	k_p	1
2	k_i	1
3	T_{sg}	0.08
4	T_t	0.4
5	K_{sg}	1
6	K_t	1
7	k_{ps}	120
8	T_{ps}	20
	For Area-2	
1	K_p	1
2	K_i	1
3	T_{sg}	0.085
4	T_t	0.5
5	K_{sg}	1
6	K_t	1
7	K_{ps}	120
8	T_{ps}	20

Table.1 Simulation configuration table

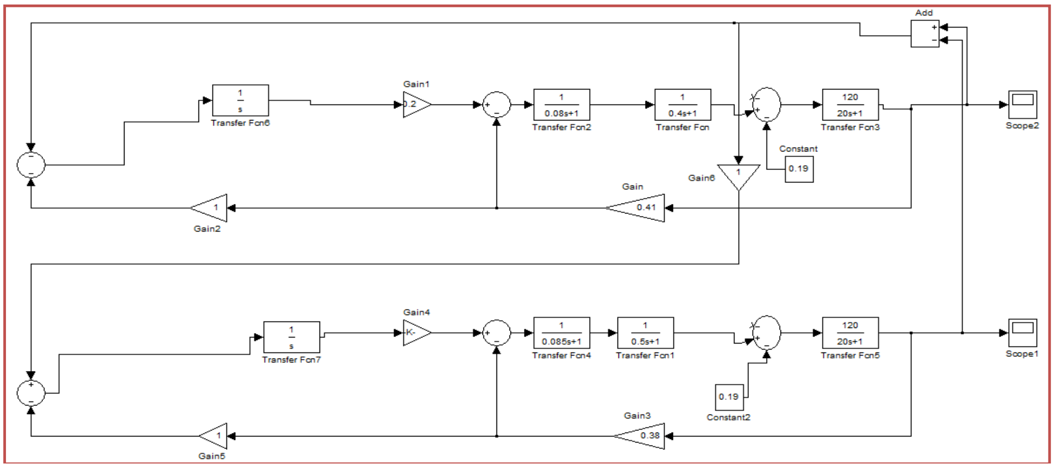


Figure.6 simulation model of AGC with PI controller

(b) Simulation result of AGC with PI controller

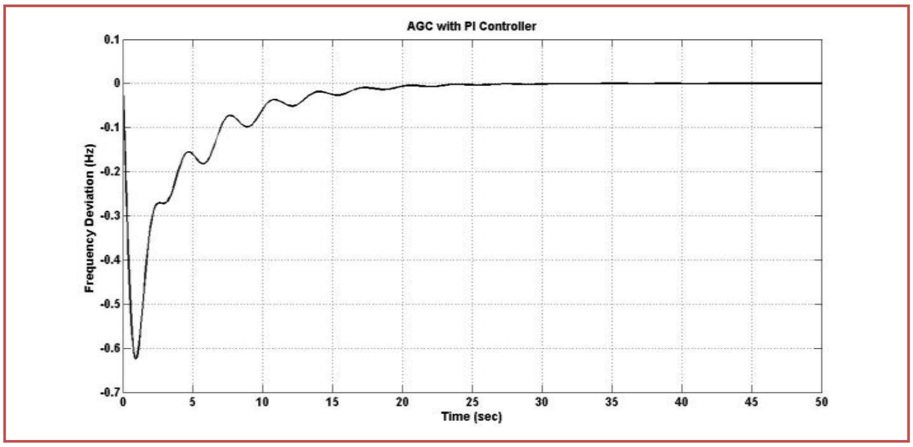


Figure.7 Simulation result of AGC with PI controller

(c) AGC loop with NARAMA-L2 Controller

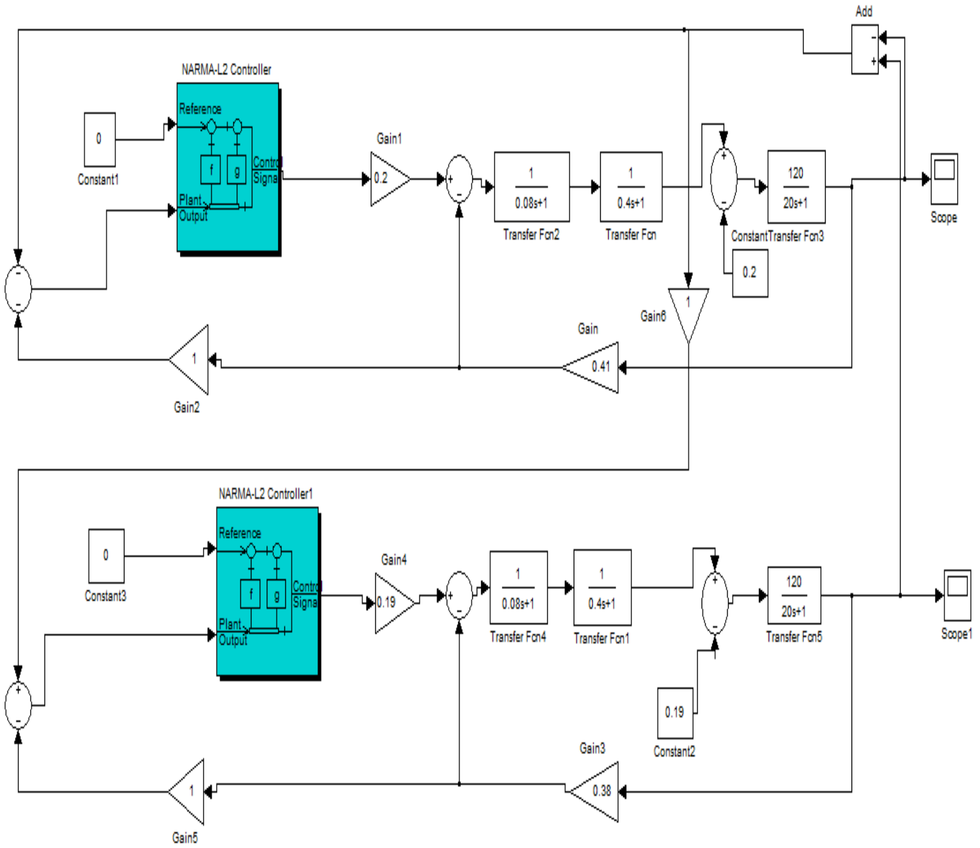


Figure.8 AGC loop with NARAMA-L2 Controller

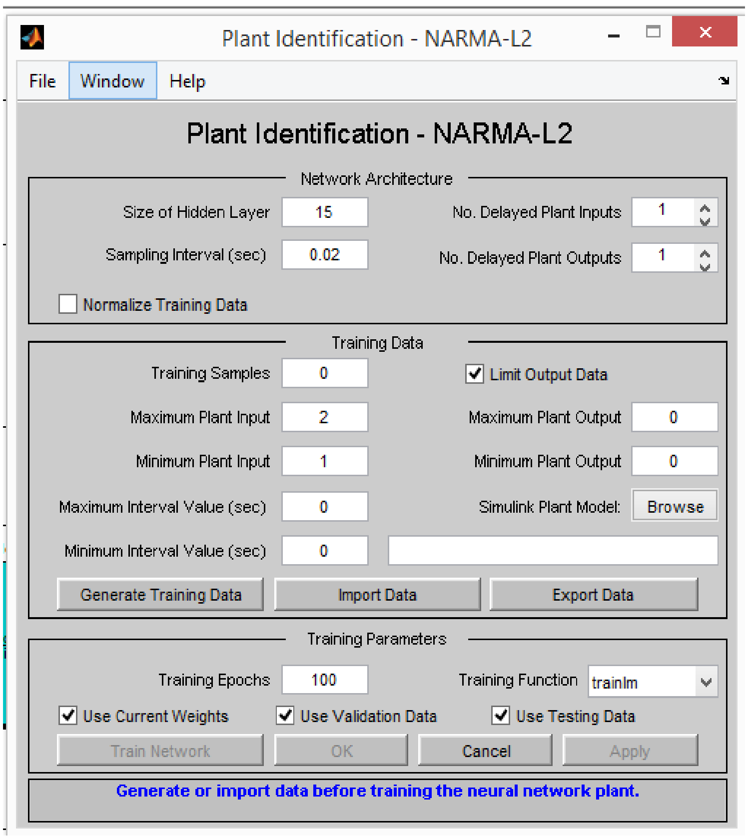


Figure.9 Plant identification of NARMA-L2 conroller

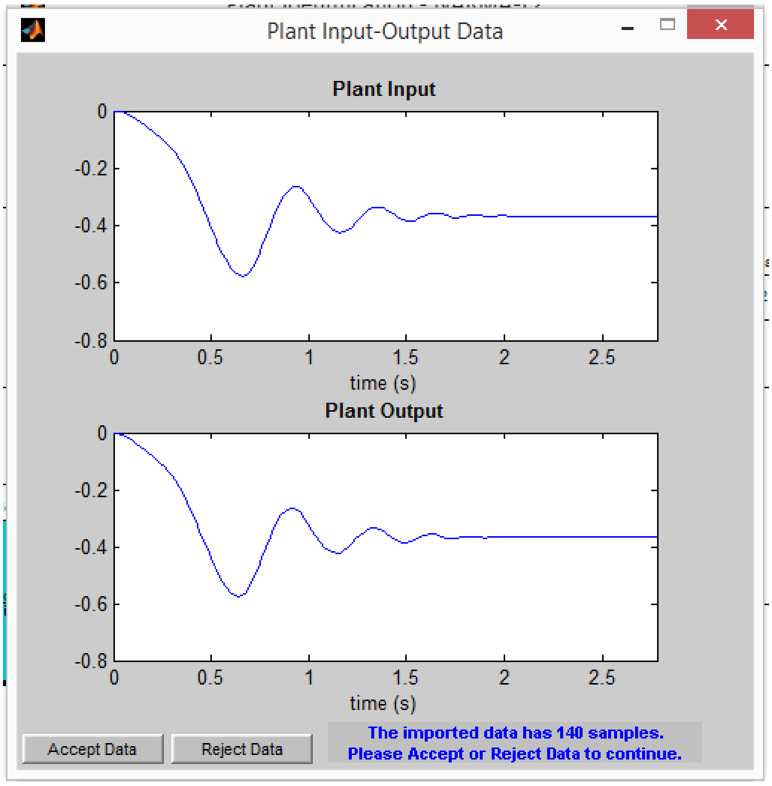


Figure.10 Plant input and output

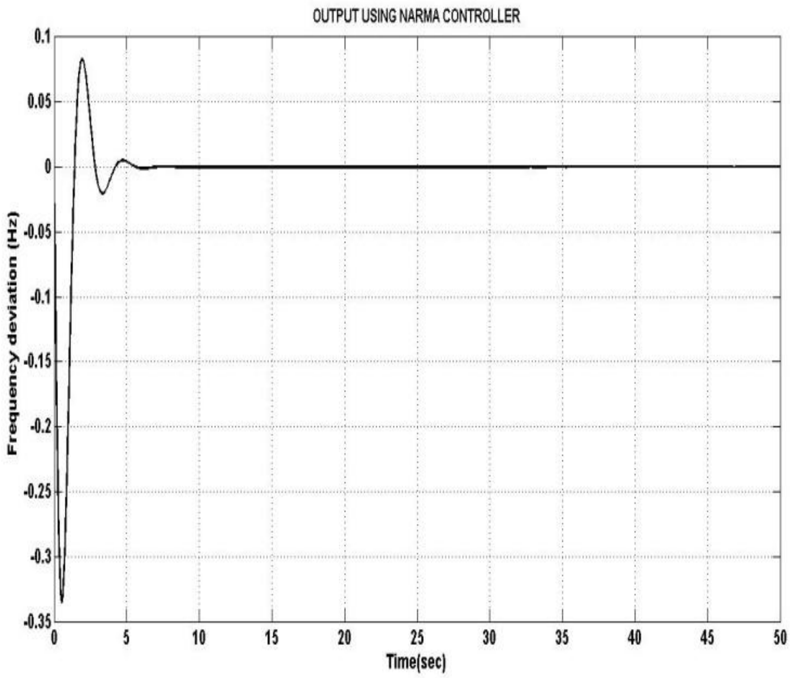


Figure.11 Simulation result of AGC with NARMA-L2

VIII. CONCLUSION

After simulating Automatic Generation Control (AGC) with PI controller and ANN based NARMA-L2 controller, settling time taken by the NARMA-L2 controller is comparatively less than time taken by PI controller. So for more complex network NARMA model gives better performance then Convention PI controller.

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