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ANN Controller For Load Frequency Control

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***Abstract*— In this paper the Artificial Neural Network (ANN) Controller for load frequency control of Multi area power system is presented. The performances of ANN Controller and conventional PI controllers are compared for Single area and Multi area power system with non-reheat turbines. The effectiveness of the proposed controller is compared by applying load disturbances. The dynamic response of the load frequency control problem is studied using MATLAB Simulink package. The results indicate that ANN Controller exhibits better performance.**
***Keywords*— Load Frequency Control(LFC), Automatic Generation Control(AGC), ANN Controller, Area Control error(ACE), Tie-line, MATLAB / SIMULINK.**

I. INTRODUCTION

Load Frequency Control (LFC) as a major function of Automatic Generation Control(AGC) is one of the important control problems in electric power system design and operation. Because of the increasing size, changing structure and complexity of power systems, LFC is becoming more significant today. A large frequency deviation can damage equipment, corrupt load performance and can interfere with system protection schemes, ultimately leading to an unstable condition for the electric power system. Maintaining frequency and power interchanges with neighboring control areas at the scheduled values are the two main primary objectives of a power system LFC [1]. Many control strategies for Load frequency control in electric power systems have been proposed by researchers over the past decades. Different types of controllers based on classical linear control theory have been developed in the past. Because of the inherent non-linearity in system components and synchronous machines, neural network techniques are considered to build non-linear ANN controller with high degree of performance. In this simulation study, Single area, two area and three area power systems are chosen and load frequency control of this system is compared for conventional PI controller and ANN controller.

II. DESCRIPTION AND MODELING OF SINGLE AND MULTI AREA POWER SYSTEMS

A generator driven by a steam turbine can be represented as a large rotating mass with two opposing torques acting on the rotation. As shown in Figure 1, T_{mech}, the mechanical torque, acts to increase rotational speed whereas T_{elec}, electrical torque, acts to slow it down.

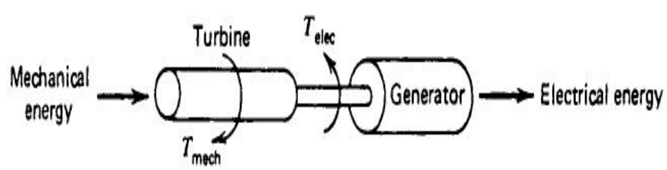

Fig.1 Mechanical and electrical torques in a generating unit

When T_{mech} and T_{elec} are equal in magnitude, the rotational speed, ω, will be constant. If the electrical load is increased so that T_{elect} is larger than T_{mech}, the entire rotating system will begin to slow down. This will damage the equipment. Therefore the mechanical torque T_{mech} should be increased to restore equilibrium. This will bring the rotational speed back to an acceptable value and speed is held constant. This process must be repeated constantly on a power system because the loads change constantly. Furthermore, because there are many generators supplying power into the transmission system, some means must be provided to allocate the load changes to the gnerators. To accomplish this, a series of control systems are connected to the generator units. A governor on each unit maintains its speed while supplementary control, usually originating at a remote control center, acts to allocate generation. The governor, turbine and the loads are modeled as presented in Figure.2.

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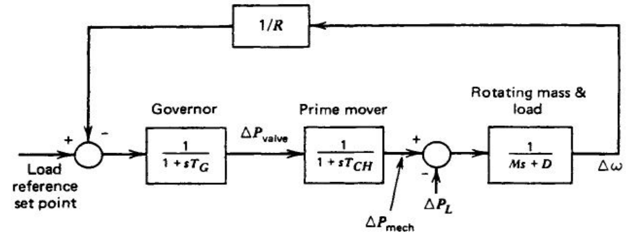

Fig.2 Block diagram of governor, prime mover, and rotating mass.

In an interconnected power system, the individual areas are connected via a tie line as shown in Figure.3.

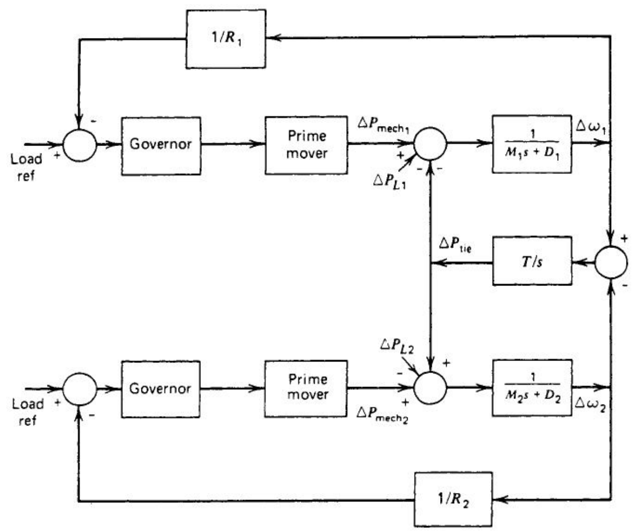

Fig.3. Block diagram of interconnected areas

In an isolated power system, the function of AGC is to restore frequency to the specified nominal value. This is accomplished by adding a feedback controller at the feedback. The integral controller helps in achieving zero steady state error. Here, the purpose of the controller is to regulate the frequency and the tie-line interchange. In an interconnected power system purpose of controller is to maintain frequency at scheduled value and also the net power exchange at scheduled value.

III. ARTIFICIAL NEURAL NETWORKS

After ANN controller architecture employed here is Non linear Auto Regressive Model reference Adaptive Controller(NARMA). It consists of reference, plant output and control signal. The plant output is forced to track the reference model output. Here the effect of controller changes on plant output is predicted and controller parameters are updated. The frequency deviations, tie-line power deviation and load perturbation of the area(s) are chosen as the neural network controller inputs. The outputs of the neural network are input signals to the governors. The data required for the ANN controller training is obtained by designing the Reference Model Neural Network and applying to the power system with step response load disturbance. The ANN model used for training is a three-layer perceptron with one input, 10 neurons in the hidden layer, and one output. The proposed network has been trained by using back propagation algorithm. Learning algorithms causes the adjustment of the weights so that the controlled system gives the desired response. Simulink model of two area interconnected with non-reheat turbines is shown in Figure.4.

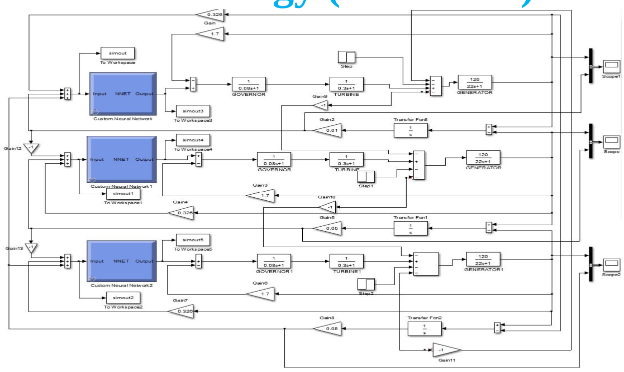

Fig.4 Block diagram of three area power system with Neural Controller

IV. DESIGN OF ANN CONTROLLER

The range over which error signal is in transients state, is observed. Responding values of the proportional, integral and derivative constants are set. This set is kept as target. Range of error signal is taken as the input. This input- target pair is fed and new network is formed using "nntool" in the MATLAB Simulink software. Weights and biases obtained are fed to back propagation algorithm using approximation. Steepest descent method. Thus the neural network is well trained. Updated weights and biases are given to a fresh neural network. Now the neural network is ready for operation. The error signal is given as input to the neural network. Desired target for each input value is obtained. The above neural network is written as program and is incorporated in the MATLAB function tool, in Simulink diagram.

V. SIMULATION AND RESULTS

In this presented work, different models of single area, two area and three area thermal non-reheat interconnected power system have been developed . ANN and PI controllers have been implemented to illustrate the performance of load frequency control using MATLAB/SIMULINK package.

Dynamic responses of single area, two area and three areas power system using PI and ANN controllers are given below.Simulation is carried out on single area, two area and three areas using PI Controller for a step load increase of 10%. The ANN controllers are trained for the same mentioned areas. The ANN controllers are trained using nntool in MATLAB. Quantitative and Qualitative comparisons are done for 10% and 20% load perturbations. The results are tabulated.

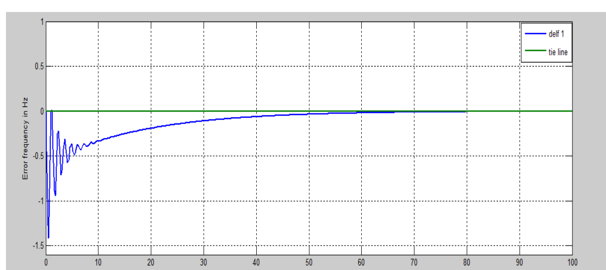

Fig. 5 Change in frequencies and tie line power in Area 1 for three area power system – with PI controller

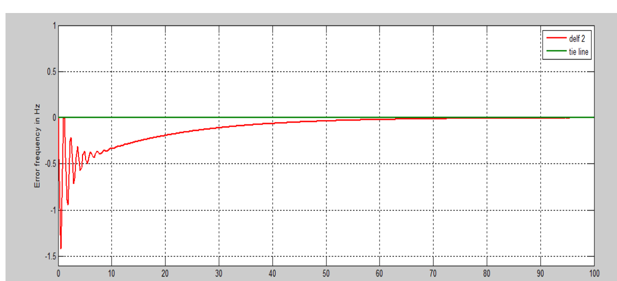

Fig. 6 Change in frequencies and tie line power in Area 2 for three area power system – with PI controller

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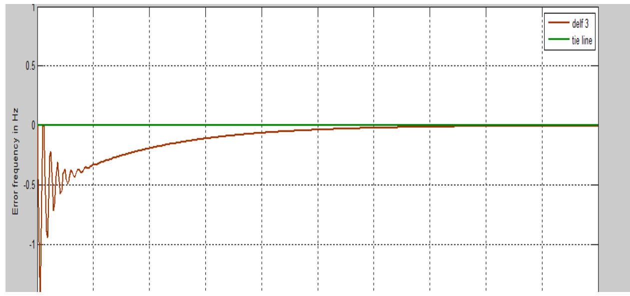

Fig.7 Change in frequencies and tie line power in Area 3 for three area power system – with PI controller

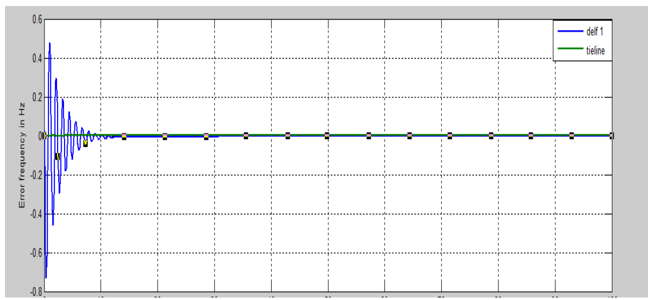

Fig.8 Change in frequencies and tie line power in Area 1 for three power system- with ANN controller

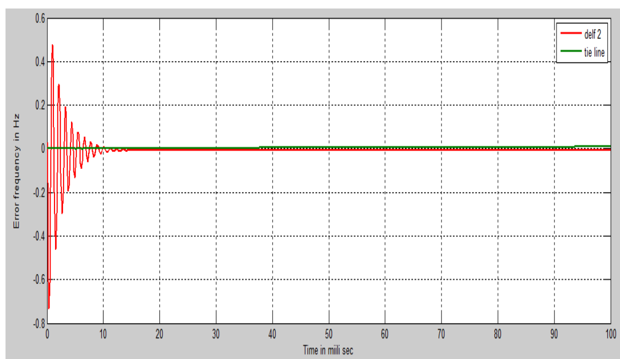

Fig.9 Change in frequencies and tie line power in Area 2 for three power system- with ANN controller

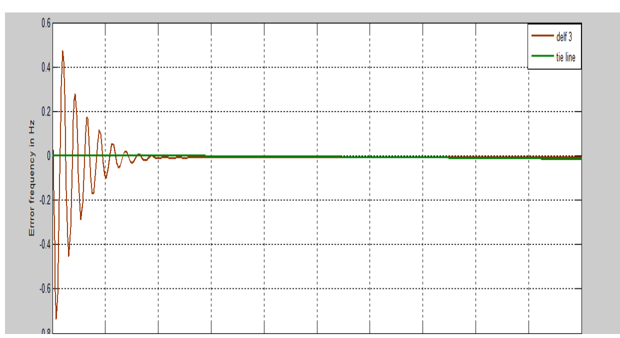

Fig.10 Change in frequencies and tie line power in Area 3 for three power system- with ANN controller

VI. QUANTITATIVE COMPARISON OF RESULTS

TABLE I. THREE AREA POWER SYSTEM

	PI Controller			ANN based Controller		
	IAE	ISE	ITAE	IAE	ISE	ITAE
Δf_1	2.703	1.045	0.003741	0.001575	0.9999	2.866e-06
Δf_2	1.237e05	1.03	0.001115	0.2525	0.7729	0.0009344
Δf_3	1.323e05	1.035	0.001129	0.507	0.6023	5.568e-15
$\Delta ptie_{12}$	0.01118	1.01	0.02949	0.007609	1.008	7.536e-05
$\Delta ptie_{23}$	0.03718	1.037	0.009094	0.01108	1.011	8.387e-05
$\Delta ptie_{31}$	0.2455	1.278	0.01262	0.07864	0.9242	0.0007387

VII. CONCLUSION

In this paper, the LFC control using ANN has been proposed for an interconnected three area power system. From the simulation studies it is clear that ANN based controller can effectively damp out the oscillations and reduce the settling time.

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