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Automatic load frequency control of Three-area power System using ANN controller with Parallel Ac/Dc Link

Emad Ali Daood[1], A.K. Bhardwaj[2]

[1]Department of Electrical Engineering, SSET, SHIATS, Allahabad, U.P, India

[2]Professor, Department of Electrical Engineering, SSET, SHIATS, Allahabad, U.P, India

Abstract

This paper introduces optimal AGC regulator design of deregulated power system formed on the full state feedback control strategy. The 3 area interconnected power system of similar nature comprising of non-reheat turbine is considered for the research. The area-interconnection of the power system via parallel EHVAC/HVDC transmission link and without HVDC link is considered. The planned controller is used to 3-area interconnected power system and its viability is shown by investigating the dynamic reply plots acquired several system states of the power system models under concern. The performance of the power system is simulated by using ANN controller and comparison with conventional PID. By comparing the results for both cases, the performance of ANN controller is better than PID.

Keywords: AGC, Deregulated power system, ANN, interconnected power system, parallel EHVAC/HVDC.

1. INTRODUCTION

AGC (Automatic Generation Control) is one of the important issues in the operation of power system. It supports in providing adequate and reliable electric power with good quality. It is the secondary control in LFC which re-establishes the frequency to its nominal value (50 Hz) and in case of more than one control area it endures the interchange of power between those areas. Regarding this the load demand in the generator prime mover set is improved or reduced in the form of kinetic energy, which results in change of frequency.. The primary and tertiary control is executed by speed governors and economic dispatch respectively. The transient in primary, secondary and tertiary control is of the order of seconds and minutes respectively. To maintain the scheduled system frequency or to establish the interchange with other areas within predetermined limits [ii], the AGC (Automatic generation control) is defined as the directive of power output of controllable generators within a suggested area in response to change in system frequency, tie-line loading or a relation of these to each other. Therefore, a plan is required to sustain the frequency and desired tie line power flow also to achieve zero steady state error. The most common of the controllers engaged for AGC (Automatic Generation Control) is Integral controller. Integral Controller is very easy to implement and provides well performance. But when the system becomes more and more complex its performance goes down. Hence, Artificial Intelligent Controllers like Neural Control approach in spite of Integral Controller is more appropriate in this respect as it is having advance adaptive control configuration [iii]. This paper will show the performance evaluation of Artificial Neural controller for 3 areas interconnected thermal-thermal-thermal power plant. The establishment of artificial intelligence techniques continuing of neural networks has illuminated many difficulties. This technology mainly assists in those types of systems which operate nonlinearly over the operating range. ANN has also been used in frequency controller design for Multi area AGC scheme in deregulated electricity market [iv], [v]. This network has been used for function approximation, pattern recognition, time series prediction and classification problems for quite some time. Even, ANNs have successfully been applied to the AGC problem with somewhat promising results [vi], [vii], [xv].In this paper, the 3 area interconnected power system [1] is selected and using an ANN controller the LFC (Load Frequency Control) of this system is done [vii], [viii], [xv]. Each area desires its system frequency to be controlled [ix], [x], [xi]. ANN (Artificial Neural Network) doesn’t require any decision support software in case of a failure as this controller has advanced adaptive control configuration, faster control [iii] and continues to function. The performance of ANN controller is equated with Conventional Integral controller.

2. HVDC link

To transmit electric power for long distance the HVDC link is used. With HVDC system the exclusion of the effect of line reactance and no charging current makes it likely to have permanence without any consideration of the line length [12]. For underground and submarine cable transmission over long distance at high voltage the HVDC is also preferred. In case of AC cable the temperature increases because of charging current forms a limit for loading. That is beyond certain limit because of thermal limit AC cable cannot be used and the HVAC interconnection among the power systems produces many difficulties mainly in case of long distance transmission [17-19]. By the usage of HVAC lines, big oscillations are produced which make frequent tripping and rises fault current level. The overall system dynamic performance reduces these problems.

The above difficulties are reduced and the dynamic performance of the system is also upgraded when the HVDC link is used in parallel with the HVAC line. Fast controllability of line power and improvement of transient stability in HVAC lines is the important features of HVDC transmission lines. HVDC system has 3 basic parts i.e. AC to DC converter station, transmission line and DC to AC converter station. Converters used in both ends are much expensive and HVDC transmission system is economical for lengthy distances and also converters produce lots of harmonics which may cause interference with communication lines needing filters which raises the cost. The transfer function model of HVDC link is mentioned below:

$$\frac{\Delta P_{dc}}{U_{dc}} = \frac{K_{dc}}{1+sT_{dc}} \qquad (1)$$

Where

K_{dc} - Gain associated with DC link

T_{dc} -Time constant of DC link

3. ARTIFICIAL NEURAL NETWORKS

The foundation of Artificial neural networks(ANN) are the simple models for neurons and their links can be successful for learning and decision making if the model is pattern based (the Perceptron model) and/or is memory storing and recall process (the Hopfield network). They have numerous applications even outside of neuroscience. Some basic features of neural networks are:

1) Noisy data can be used in the problem.
2) The network can `trained' on set of sample solutions for producing good performance.

ANN is a system having elements called as neurons which processes the information and this information is transmitted by means of connecting links associated with weights, which is multiplied to the incoming signal (net input) for any typical neural net, and the output signal is obtained by applying activations to the net input. The block diagram of system added ANN architecture is shown in fig.1.

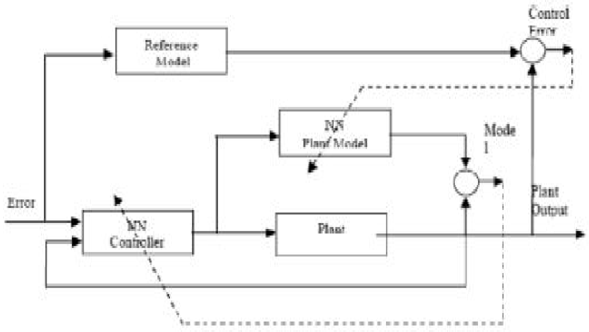

Figure 1: ANN Architecture

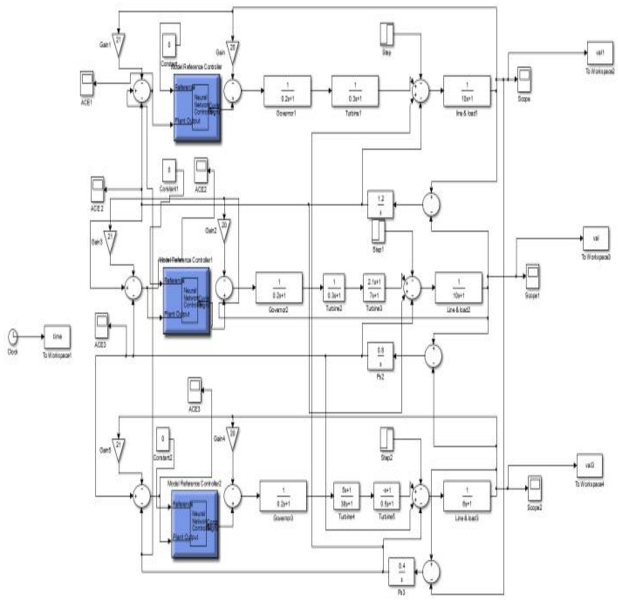

Figure 2: Three area Power system with neural network without HVDC link

3.1 Narma-L2 Control ANN controller architecture engaged here is Non-linear Auto Regressive Model reference Adaptive Controller [xiii]. Working out required for this controller is pretty less. It is only a rearrangement of the neural network plant model, which is taught offline, in batch form. It embraces of reference, plant output and control signal. The plant output is required to track the reference model output. The effect of controller changes on plant output is predicted here. It allows the updating of controller parameters. In the study, the frequency deviations, tie-line power deviation and load perturbation of the area are selected as the neural network controller inputs. Control signals applied to the governors in the area perform as the outputs of the neural network. The data needs for the ANN (Artificial Neural Network) controller training is gotten by designing the Reference Model Neural Network and put on to the power system with step response load disturbance. ANN controller which we have used is a 3-layer perceptron with 1 input, 15 neurons in the hidden layer, and 1 output. ANN Plant model is a 3-layer perceptron with 1 input, 15 neurons in the hidden layer, and 1 output. Train-lm function is the activation function of the networks neurons. To train 10 numbers of epochs, 100 training samples have been taken. The planned network has been skilled by using the learning performance. Learning algorithms causes the alteration of the weights so that the controlled system provides the desired response, (Fig. 3).

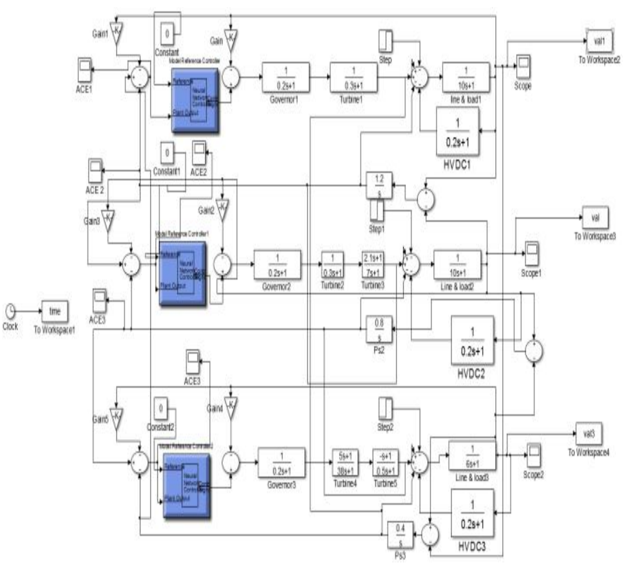

Figure 3: Three-area interconnected Neural system with parallel EHVAC/HVDC

4. SIMULATION RESULTS

In the present work, a 3-Area interconnected power system has been developed using ANN controllers and integral controllers to demonstrate the performance of change in load frequency control using MATLAB/SIMULINK environment. Figure 4, 5, 6respectively represent the plots of change in system frequency and tie-line power respectively for 1% step load variation for all the three area.

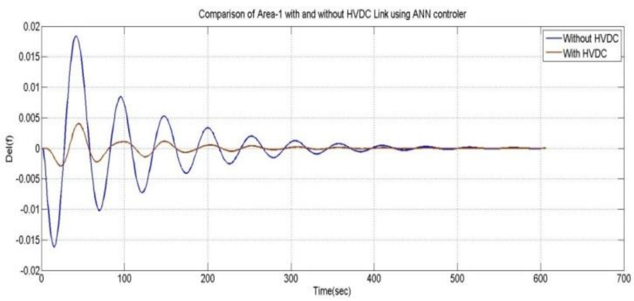

Figure 4: Area-1 del f Comparison with and without EHVAC/HVDC link

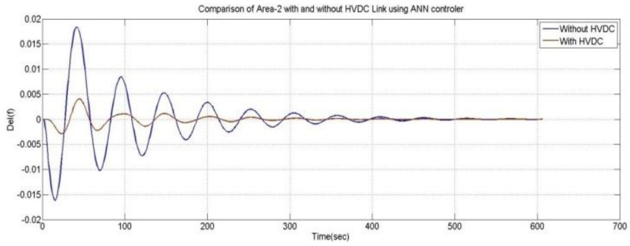

Figure 5: Area-2 del f Comparison with and without EHVAC/HVDC link

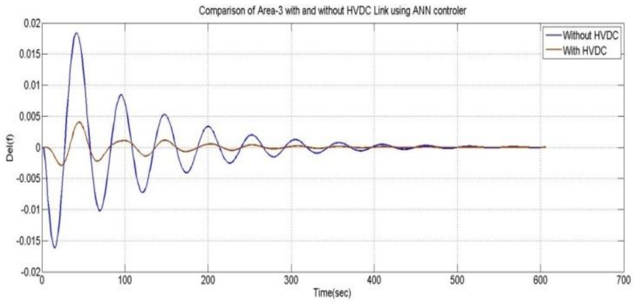

Figure 6: Area-3 del f Comparison with and without EHVAC/HVDC link

Table 1: Settling Time comparison

Configuration	Area 1(sec)	Area 2 (Sec)	Area 3(sec)
With EHVAC link only	6	6	6
With EHVAC/HVDC link	5	5	5

Table 2: Deviation comparison of Change in frequency (Δf)

Configuration	Area 1(sec)	Area 2 (Sec)	Area 3(sec)
With EHVAC link only	0.0122	0.0122	0.0123
With EHVAC/HVDC link	0.0032	0.0031	0.0031

Then Import Data from Array & Structure with sampling interval (0.02 sec) with input array (simout1) & output array (simout2) with 100 training samples.

4.1 PLANT IDENTIFICATION OF WINDOW

Then Import Data from Array & Structure with sampling interval (0.02 sec) with input array (simout1) & output array (simout2) with 100 training samples shown in figure 7.

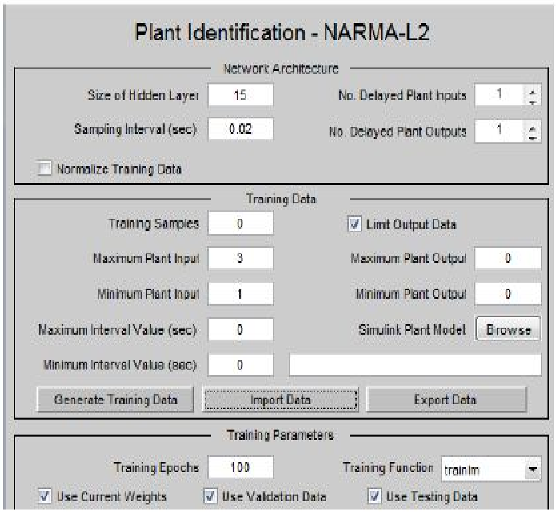

Figure7: Plant identification of controller

4.2 IMPORT DATA WINDOW

Here simout1 act as an input array and simout2 act as a output array. Then import data from array and structure with sampling interval (0.02 sec) with input array (simout1) and output array (simout2) with 100 training. These terms import from workspace.

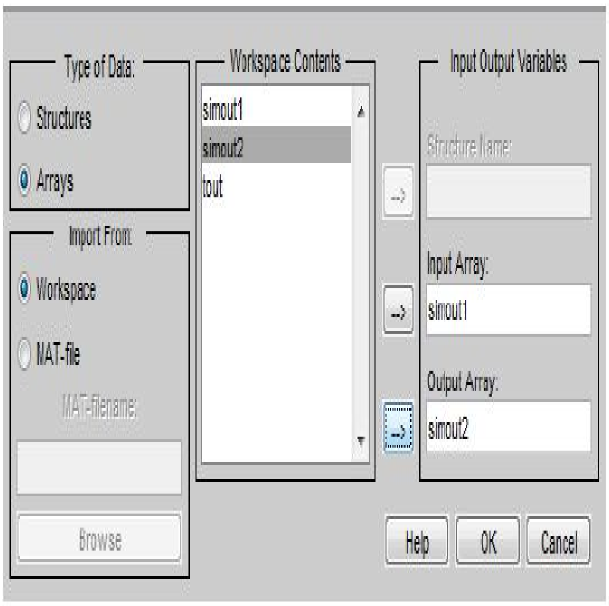

Figure 8: Import Data collector

4.3 NEURAL NETWORK TRAINED TOOL WINDOW

According to this parameter in figure 8 all the contents are observable and it also illustrate Performance, Training state and Regression. Here epochs of this parameter showing 1 epoch during plot interval.

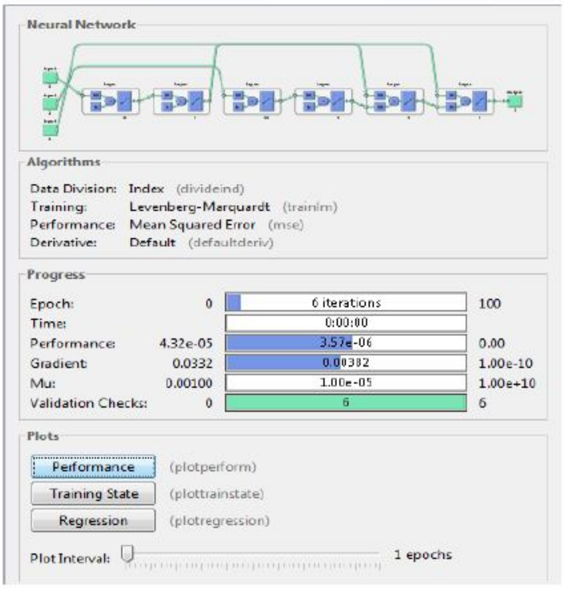

Figure 9: Neural Network Trained tool controller

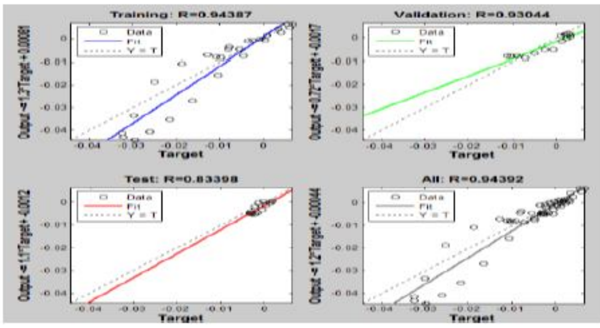

Figure 10: Regression Controller

5. CONCLUSION

Achieved results shows that the use of ANN controller increase dynamic performance and decreases the overshoots with regard to frequency deviation in each of the areas. Thus, the intelligent control approach using ANN conception is more accurate and faster.

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AUTHOR

Emad Ali Daood. He has completed B.SC. in Electrical Engineering from University of Baserah, Iraq.He received the M.Tech degree in Electrical& Electronic Engineering (power system) from Sam Higginbottom Institute of Agriculture,Technology& Sciences at Allahabad U.P,India.Currently he is persuing PH.D from SHIATS Allahabad U.P India. Presently he is working as Asst. Lecture in Electrical Department Branch Power in Technical Institute Basrah Iraq. His field of interest includes power system operation ,distribution,&control,Intelligent controllers.

Dr A K Bhardwaj is working as Professor in the Department of Electrical Engineering, Faculty of Engineering & Technology of Sam Higginbottom Institute of Agriculture, Technology & Sciences (SHIATS), deemed to be University (Formerly AAI-DU) Allahabad after doing MTech from IIT Delhi, India. He is PhD in Electrical Engineering from SHIATS.India, Earlier he was Assistant Professor in department of Electrical and Electronics Engineering, with IMS Engineering College Ghaziabad, UP, India and also worked as faculty for 6 years with IIT Ghaziabad, india. He has practical experience with top class multinational companies. He has published more than Five dozen research papers in his field. His research interest includes power management, energy management, reactive power control in electrical distribution system.