Neural Network Based Approach for System Control

T. Rathimala, M. Kamarasan

Abstract: This paper work presents the intelligent technique taken in to study the load-frequency control of a reheat thermal two area interconnected power system. In this proposed method, a control methodology of system is made using Modified Dynamic Neural Network (MDNN) for the planning of P-I controller. The managing of control strategy of power system is to be assured such that the steady state error of frequencies. The output response of the P-I controller and MDNN controller based methods determined the superb attitude of proposed MDNN based approach over P-I controller for different loading condition of variations like 1% and 5% step load. The simulation results are comparing and evaluate the performance study in terms of the settling time and peak over shoot of the output response of the power system has been discuss and tabulated.

Keywords: Modified Dynamic Neural Network (MDNN) Controller, Load-Frequency Control (LFC), P-I Controller, Area Control error (ACE).

1. INTRODUCTION

Load Frequency Control is a very required issue in power system operation and control for supplying acceptable and good quality of electric power. During the past years, the various control methods for LFC have been proposed [1-3]. The main objective is to balance the output power of every generator at decided levels while keeping the frequency variations within pre-defined limits and the extension to research work is due to the fact that an important process on power system operation. The control schemes have been created [4] to deal with transformation in system parametric value under the LFC strategies. The different new technices has been created in to improve the performance of multi-area power systems. It has been shown in [5-7] that a group of basic controllers with tuning parameters can guarantee the overall system stability and performance. It is necessary to planing a LFC system that not only controls the power generation but also the active power transfer through tie lines. In conventional LFC applications, proportional integral (P-I) controllers are most familiar used, but it is difficult to obtain the proper gain parameters of the PI controller frequency within a certain aim is realized through maintaining the total power input of the tie-line bias control of power system. The NN based controller for a two area interconnected system with reheat turbine [9] has been designed. The NN controller inputs are the system state variables and the disturbance vector. Design of constant gain controllers are normal working conditions and failure to provide good control performance over a broad range of various working conditions. So it is to maintain system function is optimal value, this is advisable to go the working conditions and updated parameters to evaluate the control.

In this study, a Modified Dynamic Neural Network (MDNN) controller was designed for the LFC application in two-area power system to ensure good and reliable supply. The proposed controller performance was compared with that of conventional PI controller, and it was found that the proposed MDNN controller has a better performance than the proportional-integral controller.

2. DESIGN OF A TWO AREA POWER SYSTEM.

In LFC, small adjustment of the load is during simple operation, a strait area model can be used for the load-frequency control. The Figure-1 shows the block diagram of the two areas reheat thermal interconnected power system. The two area load-frequency control state space equations can be written as follows

$$\Delta F_1(s) = \frac{Kps_1}{1+sTps_1}\left[\Delta Pg_1(s) + Kc_1.\Delta Pc_1(s) - \Delta Pd_1(s) - \Delta Ptie(s)\right] \quad (2.1)$$

$$\Delta Pg_1(s) = \frac{1+sKr_1Tr_1}{1+sTr_1}\Delta Pt_1'(s) \quad (2.2)$$

$$\Delta Pt_1'(s) = \frac{1}{1+sTt_1}\Delta Xe_1(s) \quad (2.3)$$

$$\Delta Xe_1(s) = \frac{1}{1+sTg_1}\left[\Delta Pc_1(s) - \frac{1}{R_1}\Delta F_1(s)\right] \quad (2.4)$$

$$\Delta Ptie(s) = \frac{2\pi.T_{12}}{s}\left[\Delta F_1(s) - \Delta F_2(s)\right] \quad (2.5)$$

$$\Delta F_2(s) = \frac{Kps_2}{1+sTps_2}\left[\Delta Pg_2(s) + Kc_2.\Delta Pc_2(s) - \Delta Pd_2(s) - a_{12}.\Delta Ptie(s)\right] \quad (2.6)$$

$$\Delta Pg_2(s) = \frac{1+sKr_2Tr_2}{1+sTr_2}\Delta Pt_2'(s) \quad (2.7)$$

T. Rathimala is currently pursuing phd degree program in Computer and Information science in Annamalai University, Annamalai Nagar.608002, India. E-mail: rathimalat@gmail.com.
M. Kamarasan is currently Asst. Professor in Computer and Information science in Annamalai University, Annamalai Nagar.608002, India. E-mail: smkrasan@yahoo.com.

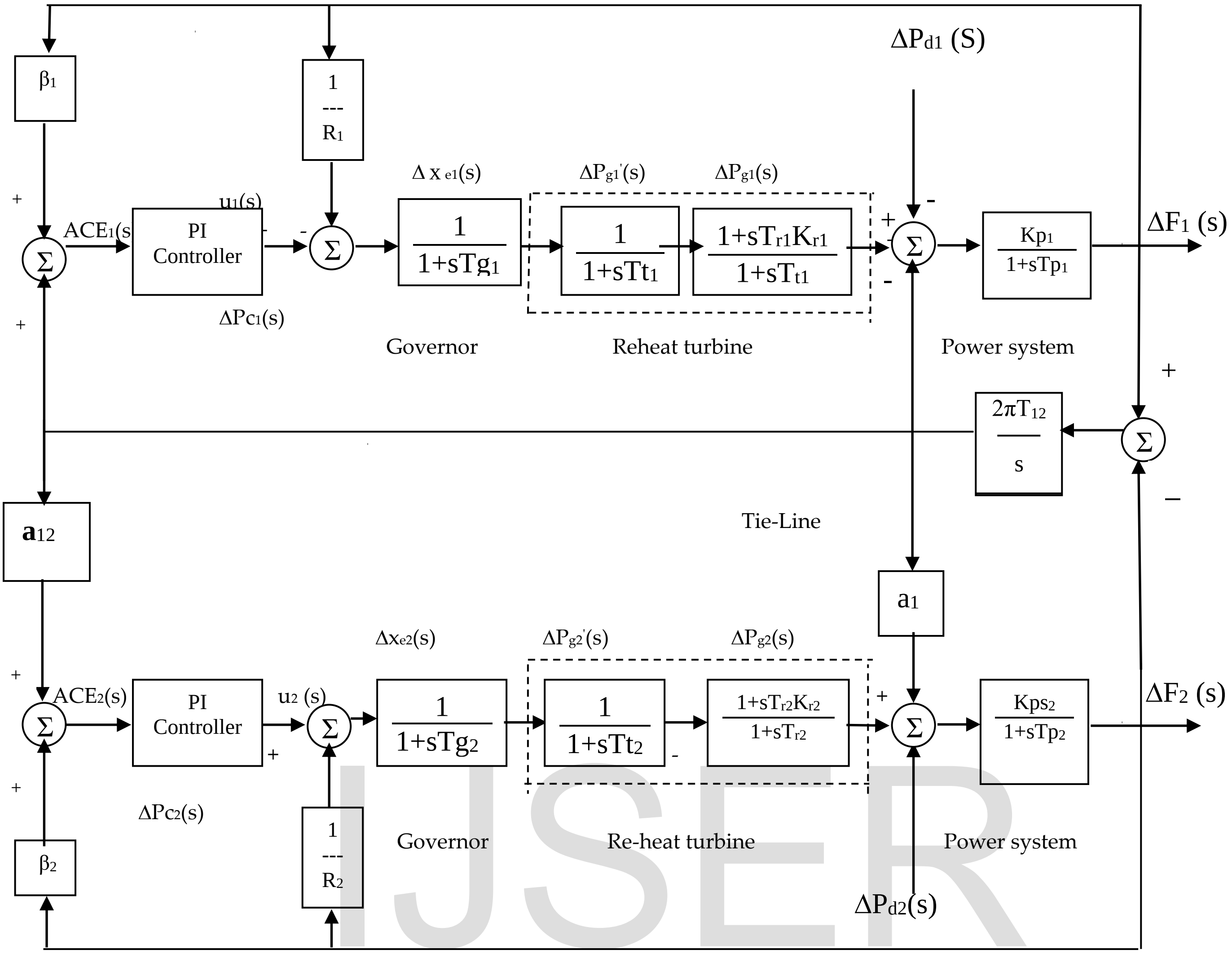

Fig. 1 Block diagram of a thermal two area power system with P-I controller

$$\Delta Pt_2'(s) = \frac{1}{1+sTt_2}\Delta Xe_2(s) \qquad (2.8)$$

$$\Delta Xe_2(s) = \frac{1}{1+sTg_2}\left[\Delta Pc_2(s) - \frac{1}{R_2}\Delta F_2(s)\right] \qquad (2.9)$$

The system state space equations are developed as

$$\dot{X} = Ax + Bu + \Gamma d \qquad (2.10)$$

Where, x, u and d are the state, control and disturbance vectors. The control and disturbance vectors are given by

Control input vector $u = \begin{bmatrix} u_1 \\ u_2 \end{bmatrix} = \begin{bmatrix} \Delta P_{c1} \\ \Delta P_{c2} \end{bmatrix}$

Disturbance vector $d = \begin{bmatrix} d_1 \\ d_2 \end{bmatrix} = \begin{bmatrix} \Delta P_{D1} \\ \Delta P_{D2} \end{bmatrix}$

Where,

The system matrix $\overline{A} = \begin{bmatrix} 0 & C \\ 0 & A \end{bmatrix}$

System control input matrix $\overline{B} = \begin{bmatrix} 0 & B \end{bmatrix}$

disturbance matrix $\overline{\Gamma} = \begin{bmatrix} 0 & \Gamma \end{bmatrix}$

output matrix $\overline{C} = \begin{bmatrix} 0 & C \end{bmatrix}$

The two state vectors are ∫ ACE_1 and ∫ ACE_2 combined in the augmented state matrix and 11 state variables are presented.

$$\int ACE_i = \int \beta_i \, \Delta f_i + \Delta P_{tie} \qquad i=1, 2 \qquad (2.11)$$

Substituting the value,

$$\begin{bmatrix} \bar{Y} \\ \dot{\bar{X}} \end{bmatrix} = \begin{bmatrix} 0 & C \\ 0 & A \end{bmatrix} \begin{bmatrix} \int ACE.dt \\ \bar{X} \end{bmatrix} + \begin{bmatrix} 0 \\ B \end{bmatrix} U \qquad (2.12)$$

II.A. Design of Proportional-Integral gain optimization

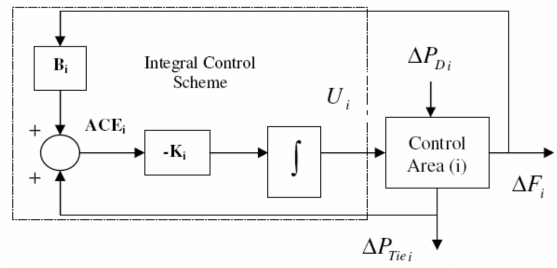

Fig.2. P-I control scheme on ith area

The objective function of the optimization of the performance of the system [3] is given in equation (2.13).

$$C = \int_0^\infty \{\alpha(\Delta P_{\text{tie,error}})^2 + \beta[(\Delta f_1)^2 + (\Delta f_2)^2]\}\,dt \tag{2.13}$$

The constant gain controllers which are arrangement at simple operating conditions fall to provide best control work over a wide range of operating conditions. But it is desirable value to keep system performance near its optimum value.

3. NEURAL NETWORK CONTROLLER

The Neural Network controller diagram employed here is a Model Reference Neural Network, which is shown in Fig.3. The controller trained and the plant output track to a reference model output. The plant output is used to predict the effect of controller changes on, which allows the updating of controller parameters. The Model network can be trained off-line using historical plant measurements. In this class, the frequency deviations, tie-line power deviation and load perturbations of the area are selected as the neural network controller inputs. The solution of the neural network are the control signals, which are activated to the governors in the areas. The data needed for the NN controller training collected from the designing the Reference Model Neural Network and applying to the power system with step response load disturbance. It is a three-layer perceptron with five inputs, 13 neurons in the hidden layer, and one output in the NN controller. Also, in the NN Plant model, it is a three-layer perceptron with four inputs, 10 neurons in the hidden layer.

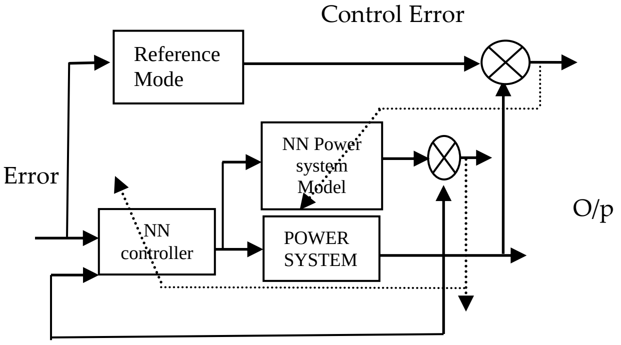

Fig.3. block of Neural Network system

4. DESIGN OF MDNN CONTROLLER

The MDNN controller designed to the two-area interconnected Power system. This scheme is depicted in Figure-4. As can be seen from block diagram, the MDNN controllers are designed for each area separately. These controllers has 4 units in the input layer, 5 dynamic neurons in hidden layer, and one conventional neuron in the output layer. The input direction of MDNN controller is:

$$\text{Input}(i) = [F_i(t), \Delta F_i(t), ACE_i(t), \Delta ACE_i(t)] \qquad i=1, 2$$

The main objective of this controller in every area is to control reduce the system frequency change and the change in the tie-line power by generating the proper control signals, U.

The MDNN controller consists of three layers are input, hidden and output. The input layer of MDNN is two parts, Initiatory (negative) and excitatory (positive) inputs. The Hidden layer neurons subsist of *DN*, which has two output layers. These layers are conventional neurons.
The MDNN solution can be written as follows

$$O_1^n(t) = F(O_T^n(t)) \tag{4.1}$$

$$O_2^n(t) = W(O_1^n(t)) \tag{4.2}$$

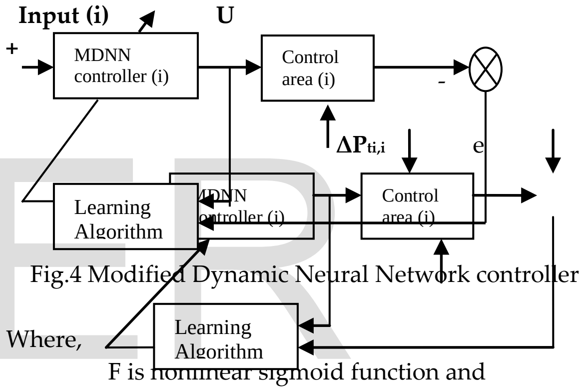

Fig.4 Modified Dynamic Neural Network controller

Where,
F is nonlinear sigmoid function and
W is weightage of the function.

The MDNN performance function for each control area is

$$E = 1/2(y_d - y)^2 = 1/2(e^2) \tag{4.3}$$

Where y_d defines the reference signals, y represents the actual output. It is charming to find a settled of weights in dynamic and conventional neurons are minimize the E. Generally and useful way to solve this is a gradient descent method. All settled of weights are learning in MDNN controller by occupying the gradient descent method [11].

5. SIMULATION RESULTS AND OBSERVATIONS

In View of this work, a two area thermal reheat interconnected power system has been considered. The PI Controller and MDNN controllers are designed to find the pursuance of the load frequency control in the power system. The parameters used for simulation are given in appendix. The frequency deviations, tie-line power flow deviation and control input deviations with PI and MDNN controllers for 1% and 5% step load disturbances are presented in Fig. 5-10. With 1% and 5% step load changes in a two area both thermal reheat power systems with PI controller and MDNN controller, the Settling time and maximum peak overshoot/undershoot of change in frequency and change in tie-line power flow are given in table 1 and 2 respectively.

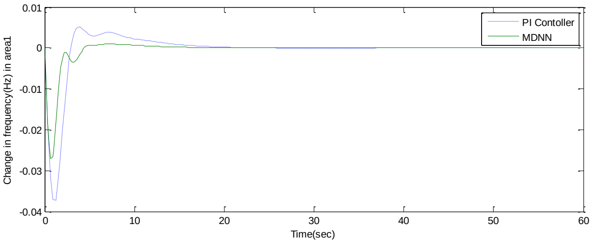

Fig-5: Frequency change (Hz) in area 1 for a two area thermal power system with P-I and MDNN controllers considering 1% step load in area 1

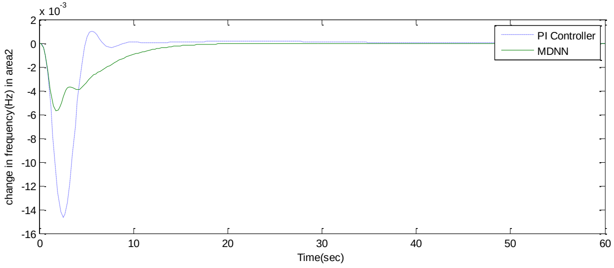

Fig-6: Frequency change (Hz) in area 2 for a two area thermal power system with P-I and MDNN controllers considering 1% step load in area 1

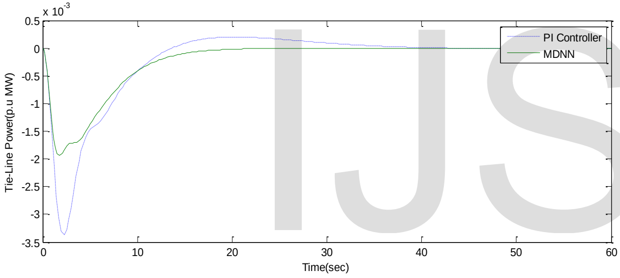

Fig-7: Tie-line power deviation (p.u MW) in a two area thermal power system with P-I and MDNN controller considering 1% step load in area 1

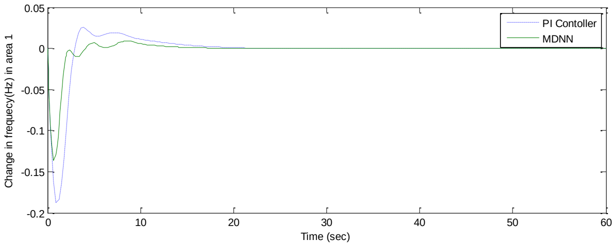

Fig-8: Frequency change (Hz) in area 1 for a two area thermal reheat power system with P-I and MDNN controllers considering 5% step load in area 1

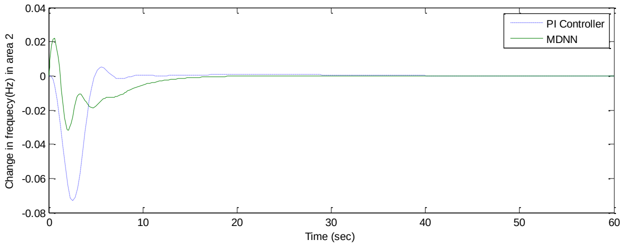

Fig-9: Frequency change (Hz) in area 2 for a two area thermal reheat power system with P-I and MDNN controllers considering 5% step load in area 1

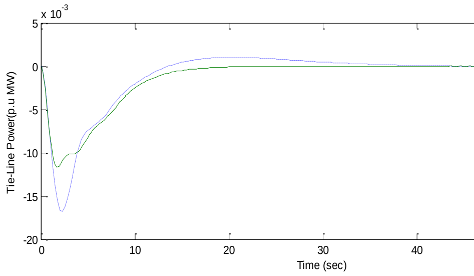

Fig-10: Tie-line power deviation (p.u MW) in a two area thermal reheat power system with P-I and MDNN controller for 5% step load in area 1

TABLE.1

COMPARISON OF THE PERFORMANCE WITH VARIOUS CONTROLLERS FOR 1% STEP LOAD DISTURBANCE IN AREA1

Two area thermal reheat inter connected power system	**Settling Time (t_s)in seconds**			**Peak overshoot/ Undershoot**		
	ΔF 1 in HZ	**ΔF 2 in HZ**	**Δtie in puMW**	**ΔF1 in HZ**	**ΔF2 in HZ**	**Δtie in puMW**
PI controllers	22	37.4	40.2	0.038	0.014	0.0035
MDNN controllers	14.5	19.5	26.0	0.025	0.005	0.0020

TABLE.2

COMPARISON OF THE PERFORMANCE WITH VARIOUS CONTROLLERS FOR 5% STEP LOAD DISTURBANCE IN AREA1

Two area thermal reheat inter connected power system	**Settling Time (t_s)in seconds**			**Peak overshoot/ undershoot**		
	ΔF 1 in HZ	**ΔF 2 in HZ**	**Δtie in puMW**	**ΔF1 in HZ**	**ΔF2 in HZ**	**Δtie in puMW**
PI controllers	22.2	35.0	42.81	0.182	0.071	0.016
MDNN controllers	15.2	18.3	22.26	0.135	0.031	0.013

6. CONCLUSION

The MDNN Controller performances have been investigated for load-frequency control of a two area reheat power systems. For this purposed of work, first, the P-I controller is designed and then the MDNN controller was designed. the suggested MDNN controller is very powerful and active significant development in power system performance. In addition, the proposed controller is very simple and easy to implementation to system. Since, it does not require much information about system parameter.

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Appendix-1

Data for the two- area power system [4].
Rating of each area=2000 MW
Base power=2000 MVA
$B_1 = B_2 =$ 0.425 pu MW/Hz
$R_1 = R_2 =$ 2.4 Hz/pu MW
$T_{g1} = T_{g2} =$ 0.08 sec
$T_{t1} = T_{t2} =$ 0.3 sec.
$T_{p1} = T_{p2} =$ 20 sec
$K_{p1} = K_{p2} =$ 120 Hz/pu MW
f = 60 Hz

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AUTHORS PROFILE

T. Rathimala Received her M.C.A., Degree in Computer Application from Bharathidhasan University, India, in 2002 and M.phil in Computer Science from Annamalai University, India in 2005. She is currently doing research in computer science and faculty Member in the Department of Computer and information Science, Faculty in science, Annamalai University, India. Her main research interests and Experience are related to Neural Networks. She also life Member of Computer Society of India

Dr. M. Kamarasan Received the MCA Degree from Annamalai University. Chidambaram, India, in 1999 and M.phil in computer science from Annamalai University in 2005 and PhD in Computer Science from Annamalai University in 2015 . He is a Assistant Professor of Department

of Computer and Information Science, Annamalai University, Tamil nadu, India. His research interest includes Multimedia. Data Mining And Image Analysis, Scene analysis, and Computer Vision and Machine learning. He also life Member of Computer Society of India.