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Modular Modified DynamicNeural Network Controller for Load Frequency Control

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Abstract*In this paper the* Modular Modified Dynamic Neural Network *(MMDNN) Controller for load frequency control of two area power system is presented. The performances of MMDNN Controller and conventional MNN controllers are compared for Single area and two 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 MMDNN Controller exhibits better performance*

Keywords— *Load Frequency Control(LFC), Automatic Generation Control(AGC), MMDNN Controller, Area Control error(ACE), Tie-line, MATLAB / SIMULINK.*

1 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 MMDNN controller with high degree of performance. In this simulation study, Single area, two area power systems are chosen and load frequency control of this system is compared for conventional PI controller and MMDNN controller

2 DESCRIPTION AND MODELING OF SINGLE AND TWO 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, *Tmech*, the mechanical torque, acts to increase rotational speed whereas *Telec*, electrical torque, acts to slow it down.

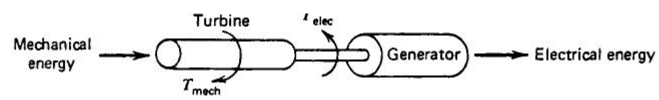

Fig.1 Mechanical and electrical torques in a generating unit

When *Tmech* and *Telec* are equal in magnitude, the rotational speed, ω, will be constant. If the electrical load is increased so that *Telect* is larger than *Tmech*, the entire rotating system will begin to slow down. This will damage the equipment. Therefore the mechanical torque *Tmech* 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 generators. 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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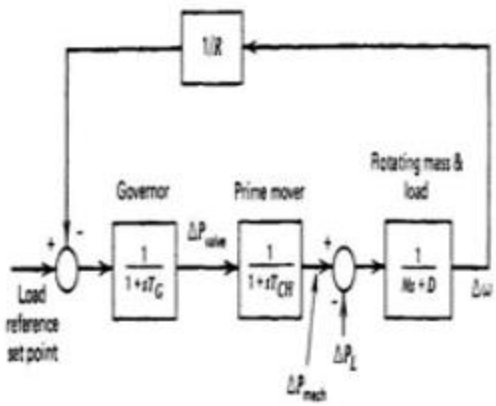

Fig.2 Block diagram of governor, prime mover, and rotating mass.

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

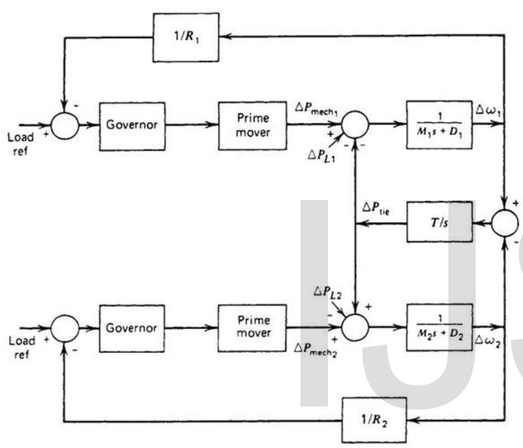

Fig.2 Block diagram of two area thermal power system

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

3 MODULAR MODIFIED DYNAMIC NEURAL NETWORKS

After MMDNN 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. A **modular neural network** is an artificial neural network characterized by a series of independent neural networks moderated by some intermediary. Each independent neural network serves as a module and operates on separate inputs to accomplish some subtask of the task the network hopes to perform. This scheme is depicted in Figure-4 The **MDNN** controller designed to the two-area interconnected Power system.. 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:

Input (i) = [Fi (t), ΔFi (t), ACEi (t), ΔACEi (t)] (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

O1n (t) =F (OTn (t)) (1)

O2n (t) =W (O1n (t)) (2)

The intermediary takes the outputs of each module and processes them to produce the output of the network as a whole. The intermediary only accepts the modules' outputs—it does not respond to, nor otherwise signal, the modules. As well, the modules do not interact with each other. The proposed network has been trained by using modified dynamic neural network. 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 modular modified neural network Figure.4.

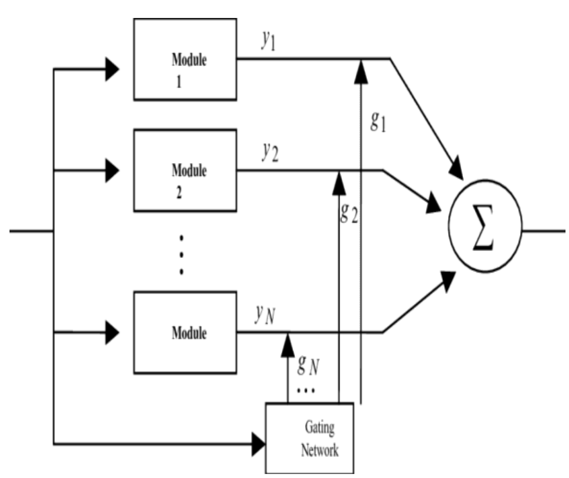

Fig.4 Block diagram of MMDNN Controller

4. DESIGN OF MMDNN 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 "Modular modified neural network tool" in the MATLAB Simulink software. Inputs and Weights obtained are fed to MMDNN Concept using approximation steepest descent method. Thus the neural network is well trained. Updated weights and inputs are given to a fresh neural network. Now the neural network is ready for operation. The error signal is given as input to the Modular modified neural network. Desired target for each input value is obtained. The above Modular modified neural network is written as program and is incorporated in the MATLAB function tool, in Simulink diagram.

5. SIMULATION AND RESULT

In this presented work, different models of single area, two area thermal non-reheat interconnected power system have been developed . MMDNN and MNN controllers have been implemented to illustrate the performance of load frequency control using MATLAB/SIMULINK package. Dynamic responses of single area, two areas power system using MNN and MMDNN controllers are given below.Simulation is carried out on single area, two area and three areas using MNN Controller for a step load increase of 1%. The MMDNN controllers are trained for the same mentioned areas. The MMDNN controllers are trained using nntool in MATLAB. Quantitative and Qualitative comparisons are done for 1% and 5% load perturbations. The results are tabulated..

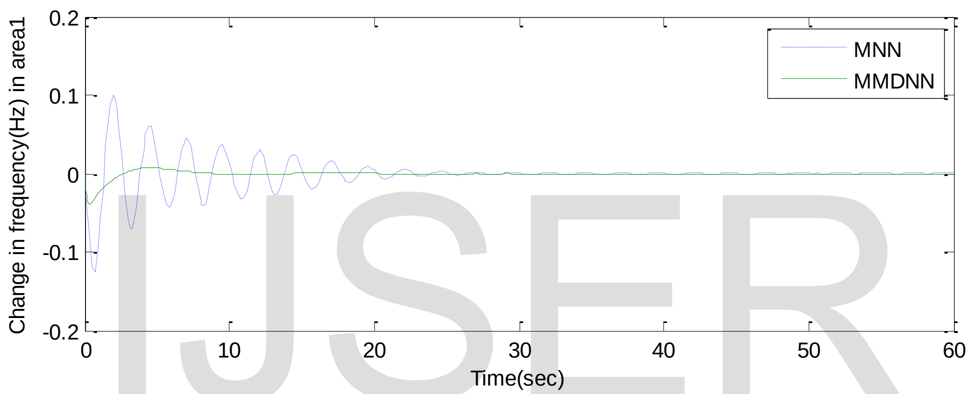

Fig 5.8: Frequency deviations (Hz) in area 1 of a two area interconnected thermal reheat power system with MNN Controller and MMDNN Controller for 1% step load disturbance in area 1

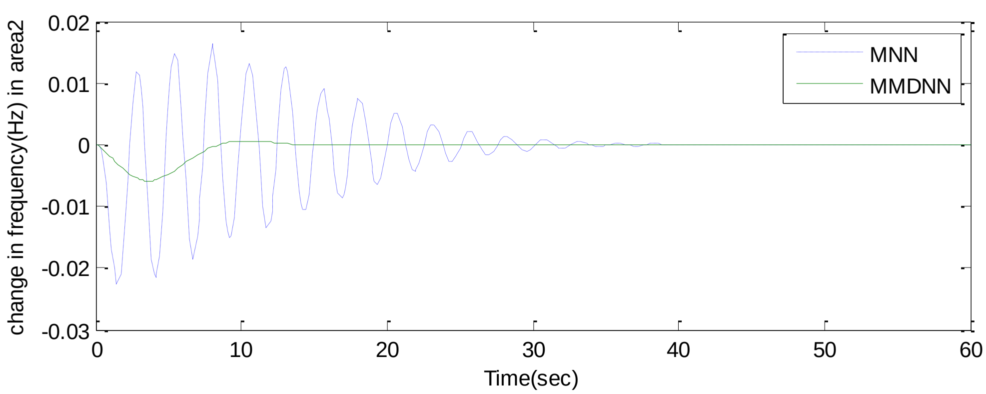

Fig 5.9: Frequency deviations (Hz) in area 2 of power system with MNN Controller and MMDNN Controller for 1% step load disturbance in area 1

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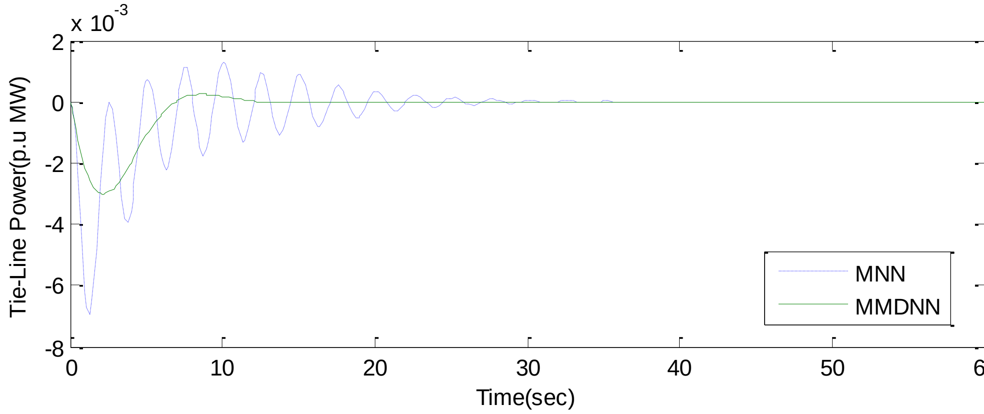

Fig 5.10: Tie-line power deviation of power system with MNN Controller and MMDNN Controller for 1% step load disturbance in area 1

Table-1 Comparison between MNN and MMDNN controllers

Two area thermal interconnected power system considering various Techniques	K_P and K_I Gain	**Settling Time (t_s) in seconds**			**Peak overshoot/ undershoot**		
		ΔF_1 in HZ	ΔF_2 in HZ	$\Delta P_{tie\ 1,2}$ in p.u.MW	ΔF_1 in HZ	ΔF_2 in HZ	$\Delta P_{tie\ 1,2}$ in p.u.MW
Modular Neural Network controller	K_P=0.85 K_I=0.27	31.0	27.3	31.2	0.099	0.004	0.0032
Modular Modified Dynamic Neural Network controller	K_P=0.81 K_I=0.22	12.4	14.6	12.8	0.056	0.002	0.0012

7. CONCLUSION

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

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