LOAD FREQUENCY CONTROL IN A SINGLE AREA POWER SYSTEM BY ARTIFICIAL NEURAL NETWORK (ANN)

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Abstract: *In this study, an artificial neural network (ANN) application of load frequency control (LFC) of a single area power system by using a neural network controller is presented. The study has been designed for a single area interconnected power system. The comparison between a conventional Proportional and Integral (PI) controller and the proposed artificial neural networks controller is showed that the proposed controller can generate the best dynamic response for a step load change. For this application, MATLAB-Simulink software is used.*

1. INTRODUCTION

In a power system, load-frequency control (LFC) obtains an essential role to allow power exchanges and to supply better conditions for the electricity trading. Also, time delays in such systems can reduce system performance and even cause system instability on frequency or other parameters [1]. The dynamic behavior of many power systems and resulted in industrial loads heavily depends on disturbances and in particular on changes in the operating point [2]. Load frequency control in power systems is very important in order to supply reliable electric power with good quality. The goal of the LFC is to maintain zero steady state errors in a multi area interconnected power system. In addition, the power system should fulfill the proposed dispatch conditions. Power systems are divided into control areas connected by tie lines. All generators are supposed to constitute a coherent group in each control area. From the experiments on the power system, it can be seen that each area needs its system frequency to be controlled [3].

In this study, a single area power system is chosen and load frequency control of this system is made by a ANN controller and a conventional PI controller comparatively. Basically, single area power system consists of a governor, a turbine, and a generator with feedback of regulation constant. System also includes step load change input to the generator. This work mainly, related with the controller unit of a single area power system. Simple block diagram of a single area power system with the controller is shown in Figure 1.

A lot of studies have been made in the past about the load frequency control. In the literature, some control strategies have been suggested based on the conventional linear control theory [4]. These controllers may be unsuitable in some operating conditions due to the complexity of the power systems such as nonlinear load characteristics and variable operating points. To some authors, variable structure control [5] maintains stability of system frequency.

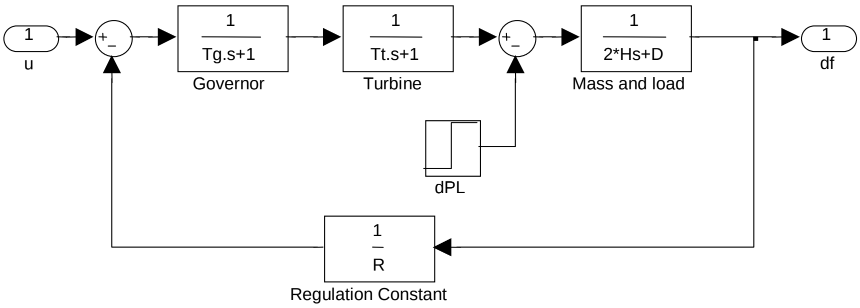

Fig. 1. A single area power system with the controllers (ΔPL = 0.01)

However, this method needs some information for system states, which are very difficult to know completely. Also, the growing needs of complex and huge modern power systems require optimal and flexible operation of them. The dynamic and static properties of the system must be well known to design an efficient controller. On the other hand, to handle such a complex system is quite complicated [6]. Recently the LFC systems use the proportional-integral (PI) controllers in practice [7]. Since the dynamic behavior even for a reduced mathematical model of a power system is usually nonlinear, time-variant and governed by strong cross-couplings of the input variables, special care has to be taken for the design of the controllers. Gain scheduling is a controller design technique used for non-linear systems. Therefore, a gain scheduling controller can be used for this purpose. In this method, since parameter estimation is not required, control parameters can be changed very quickly. In addition, gain scheduling application is easier than both automatic tuning and adaptation of controller parameters methods [2]. However, the transient response for this controller can be unstable because of abruptness in system parameters. Besides, it can not be obtained accurate linear time variant models at variable operating points [2]. To solve all these problems in the above mentioned papers, an ANN controller is proposed in this study. The ANN controller has been established to apply a single area power system in the different operating points under different load disturbances by using the learning capability of the neural Networks to improve the stability of the overall system and also its good dynamic performance achievement [8].

In this study, it is shown that the overshoots and settling times with the proposed ANN controller are better than the outputs of the other controller.

2. USAGE OF ARTIFICIAL NEURAL NETWORK (ANN) CONTROLLER

The ANN controller architecture employed here is a Model Reference Neural Network, which is shown in Fig. 2. As with other techniques, the Model Reference Adaptive Control configuration uses two neural networks: a controller network and a model network. The Model network can be trained off-line using historical plant measurements. The controller is adaptively trained to force the plant output to track a reference model output. The model network is used to predict the effect of controller changes on plant output, which allows the updating of controller parameters. In the study, the frequency deviations, tie-line power deviation and load perturbation of the area are chosen as the neural network controller inputs.

The outputs of the neural network are the control signals, which are applied to the governors in the area. The data required for the ANN controller training is obtained from the designing the Reference Model Neural Network and applying to the power system with step response load disturbance. After a series of trial and error and modifications, the ANN architecture shown in Fig. 2 provides the best performance. It is a three-layer perceptron with five inputs, 13 neurons in the hidden layer, and one output in the ANN controller. Also, in the ANN Plant model, it is a three-layer perceptron with four inputs, 10 neurons in the hidden layer, and one output. The activation function of the networks neurons is hyperbolic tangent. The proposed network has been trained by using back-propagation algorithm. The root mean square (RMS) error criterion is being used to evaluate the learning performance. Learning algorithms cause the adjustment of the weights so that the controlled system gives the desired response [8].

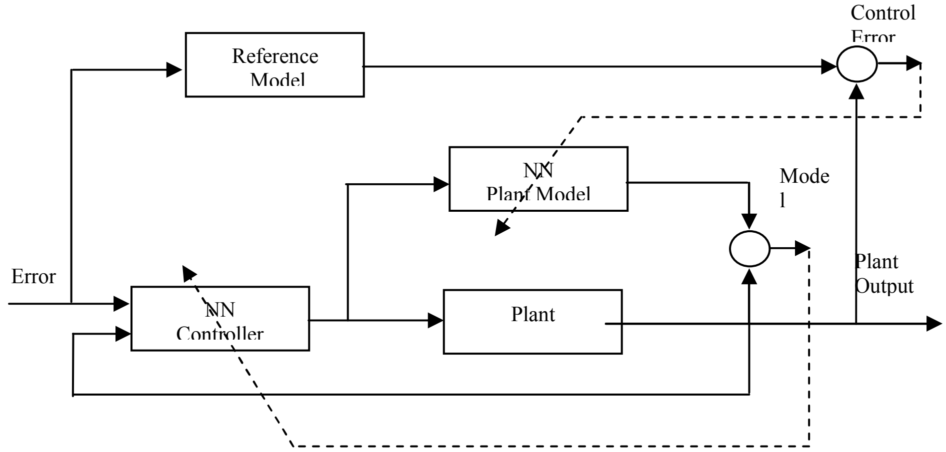

Fig. 2. The system added artificial neural network architecture

3. SIMULATION STUDY

The single area power system's parameters are given in Table 1. System block scheme and simulation results for the single area power system are shown in Figure 3 and 4. As can be observed, the settling time and overshoots with the proposed ANN controller are much shorter than that with the conventional PI controller.

From the figure, it is shown that the settling time of conventional PI controller is much longer than the proposed ANN controller and the overshoots of the proposed controller is almost 85% better than the PI controller's. Therefore, the proposed ANN controller provides better performance than conventional I controller for the single area power system.

Table 1. Parameters of the single area power system

Tg=0.2	Tt=0.5	R=0.05	D=0.8	H=5	Ki=7	Kp=10

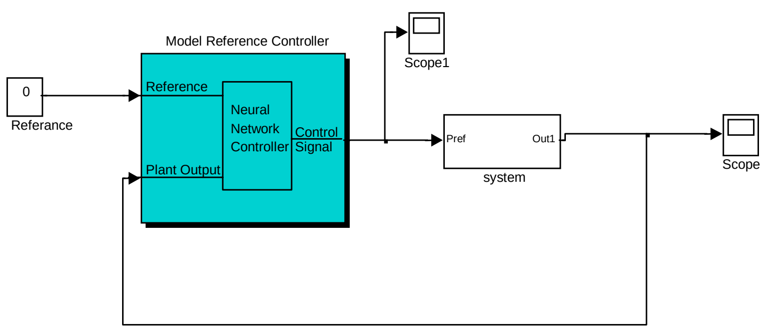

Fig. 3. System block scheme

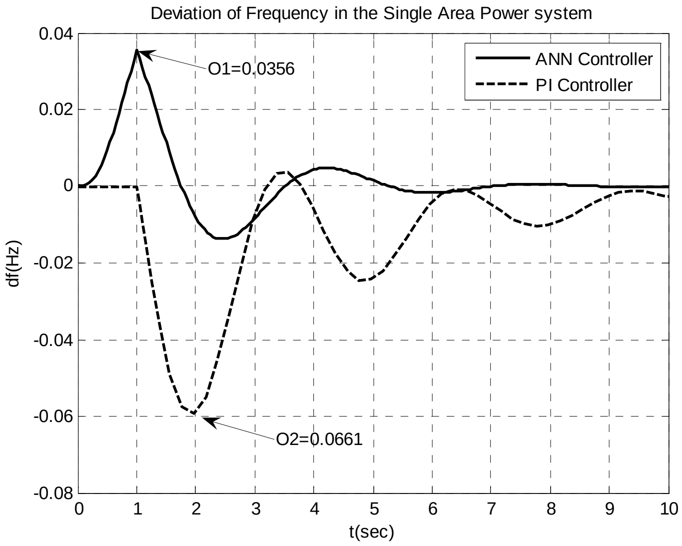

Fig. 4. Deviation of frequency of the single area power system (DPd,i=0.01 p.u.)

4. CONCLUSIONS

In this study, a new artificial neural networks controller has been investigated for automatic load frequency control of a single area power systems. For this purpose, first, a ANN controller was designed for improvement sensitivity of the system. Also, a conventional PI controller was applied to the system for comparison. It has been shown that the proposed control algorithm is effective and provides significant improvement in system performance. Therefore, the proposed ANN controller is recommended to generate good quality and reliable electric energy. In addition, the proposed controller is very simple and easy to implement since it does not require many information about system parameters. Two area power system operation will be investigated in next time. Also, comparison of the proposed ANN controller with fuzzy logic controller subject to the future work.

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