Automatic load frequency control in single area power systems using narma-l2 controller

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Abstract: In this paper Single Area power system is studied and system dynamic response has been improved. Also the load frequency control is improved by the application of NARMA-L2 Controller. The settling time, overshoot and frequency error are considered while doing simulation of the Model with NARMA Controller. The tuning of NARMA-L2 Controller is done by trial and error method and by many permutations. MATLAB/SIMULINK software is used in this paper.

Keywords: ACE, AGC, ALFC, NARMA Controller, Neural Networks (NNs).

I. INTRODUCTION

Small Signal stability is the property of the power system to retain its synchronism under small disturbances. These disturbances occur continuously on the power system due to small variations in load and generation [1].

These disturbances give rise to oscillations which must be damped to maintain system stability. Instability can be of two forms: (i) Steady increase in rotor angle due to lack of sufficient synchronizing torque that results in Non-Oscillatory instability. (ii) Rotor oscillations of increasing amplitude due to shortage of sufficient damping torque that produce Oscillatory instability [1].
Oscillations can occur in two modes:
(i) Local plant mode Oscillations: These are associated with units at generating station swinging with respect to the rest of the system. The frequencies of these oscillations lie in the range of (0.8- 2) Hz.
(ii) Inter Area Oscillations: These are associated with swinging of many machines in one part of the system against machines in other parts. The frequencies of these oscillations lie in the range of (0.1 – 0.7) Hz.
ACE is change in area frequency which when used with tuned PID Controllers helped in bringing system frequency error to zero [2].
AGC helps in maintaining the balance between the generation and demand of a particular power system [3].
In this paper fully automatic control strategy has been used and applied to Single Area power system. The frequency change and incremental tie line power has been observed and rectified to improve the system stability and ensuring good and non-interrupted power quality. The error being reduced to null point at a quick time. Also with the incorporation of NARMA-L2 Controller, the appearance of Non-linearities and uncertainties in the system is removed or overcome quickly.

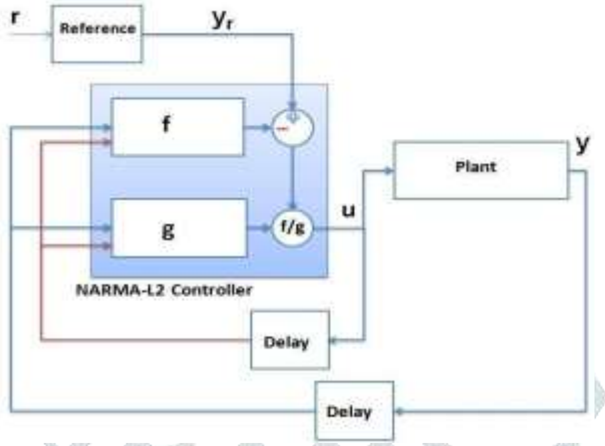
II. PERFORMANCE OF AGC

Under usual standard conditions with each area able to carry out its control obligations, steady state corrective action of AGC is confined to the area where the deficit or excess of generation occurs. Inter area power transfers are maintained at scheduled levels and system frequency is held constant.[6] Four basic objectives of power system operation during normal operating conditions are associated with automatic generation control (AGC):

- ✓ Matching total system generation to total system load;
- ✓ Regulating system electrical frequency error to zero;
- ✓ Distributing system generation among control areas so that net area tie flows match net area tie flow schedules;
- ✓ Distributing area generation among area generation sources so that area operating costs are minimized.

III. NARMA-L2 CONTROLLER

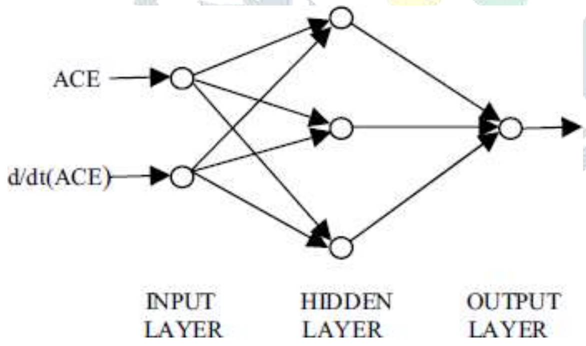
Various learning mechanisms exist to enable the NN architecture that has been classified into various types based on their learning mechanisms and other features. Some classes of NN refer to this learning process as training and the ability to solve a problem using the knowledge acquired as inference [9]. NNs have simplified limitations of the central nervous system, and obviously therefore, have been motivated by kind of a human brain termed as neurons are the entities, which perform computations such as cognition, logical inference, pattern recognition and so on. Hence the technology, which has been built on a simplified limitation of computing by neurons of brain, has been termed.



IV. ARTIFICIAL NEURAL SYSTEM

ANN controller architecture employed here is Nonlinear Auto Regressive Model reference Adaptive (NARMA). It is a standard model that is used to represent general discrete-time nonlinear systems. It is simply a rearrangement of the neural network plant model neural network plant model is used to assist in the controller training. This controller requires the least computation. The only online computation is a forward pass through the neural network controller [4].

Artificial Neural Networks (ANNs) are relatively crude electronic models based on the neural structure of the brain. Artificial neural networks try to mimic the functioning of brain. In this study feed forward model is used, which contains three layers; input, hidden and output layer. The ANN controller takes two real valued inputs; ACE and change in ACE, and gives a real valued output. Figure shows the structure of the controller. The controller is



It consists of reference, plant output and control signal. The plant output is forced to track the reference model output. The plant model is used to predict future behavior of the plant, and an optimization algorithm is used to select the control input that optimizes future performance [5-6].

For NARMA-L2 control, the controller is simply a rearrangement of the plant model. For model reference control, the controller is a neural network that is trained to control a plant so that it follows a reference model.

The drawback of this method is that the plant must either be in companion form, or be capable of approximation by a companion form model. For training the ANN Levenberg- Marquards back propagation (TRAINLM) optimization technique is used which is the fastest back propagation algorithm and highly recommended for supervised algorithm, however, it requires more memory for iterations. 1000 epochs are used for iteration in this simulation. Activation function used in the simulation is logsigmoidal.

V. CIRCUIT DESCRIPTION

An electric power system is a network of electrical components deployed to supply, transfer, and use electric power. An example of an electric power system is the grid that provides power to an extended area. An electrical grid power system can be broadly divided into the generators that supply the power, the transmission system that carries the power from the generating centres to the load centres, and the distribution system that feeds the power to nearby homes and industries. Smaller power systems are also found in industry, hospitals, commercial buildings and homes.

The basic structure of a power system is shown in Fig. 1.1.

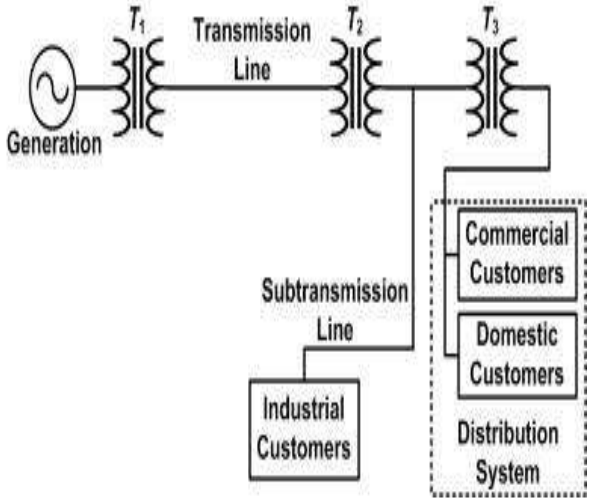


Fig. 3.

It contains a generating plant, a transmission system, a sub transmission system and a distribution system.. Let us consider some typical voltage levels to understand the functioning of the power system. The electric power is generated at a thermal plant with a typical voltage of 22 kV (voltage levels are usually specified line-to-line). This is boosted up to levels like 400 kV through transformer T_1 for power transmission. Transformer T_2 steps this voltage down to 66 kV to supply power through the sub transmission line to industrial loads that require bulk power at a higher voltage. Most of the major industrial customers have their own transformers to step down the 66 kV supply to their desired levels. Distribution systems are designed to operate for much lower power levels and are supplied with medium level voltages.

Fig.4. Shows the simulink model of single area power systems equipped with Narma-L2 controller. The basic components of the simulink are governor, turbine and power system blocks. The frequency error is seen in scope block.

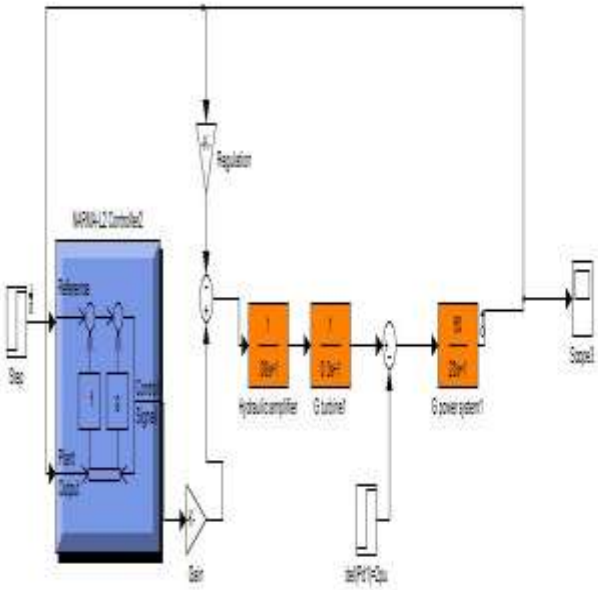
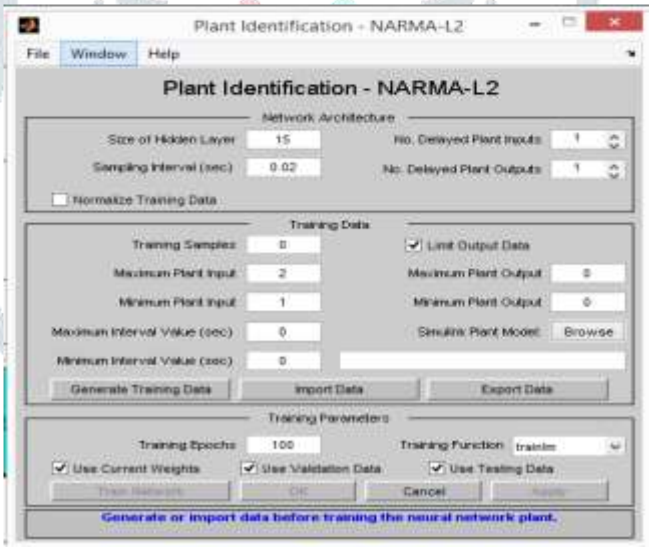


Fig. 4.

Area Control Error



A suitable linear combination of frequency and tie line power changes for area i , is known as the area control error.

Actually ACE is the difference between scheduled and actual electrical generation within a control area on the power grid, taking frequency bias into account.

VII. CONCLUSION

In this paper, Single Area Power Systems have been studied. The requency error is minimized by using NARMA-L2 Controller. After tuning the controller with the proposed system, the error is minimized in almost 4 seconds as shown in the Graph.

With the application of this contoller, it is seen that the error is reduced to zero in quick time as it is not in case of other Conventional controllers like PID etc.The error reduction time in case of PID is little more, and we know that if error is not minimized in quick time,it may lead to power failure and system collapse, Thus stability of the power system is disturbed. So NARMA-L2 Controller has improved the system stability by reducing error in quick time.

Also memory required by NARMA controller is less than the conventional controller. Settling time taken by the NARMA controller is comparatively less than time taken by Conventional controller.

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