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Research Paper

Engineering

AUTOMATIC GENERATION CONTROL FOR TWO AREA SYSTEM USING ARTIFICIAL NEURAL NETWORK BASED CONTROLLER

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ABSTRACT

One of the important issues in the operation of power system is Automatic Generation Control (AGC). It helps in supplying adequate and consistent electric power with good quality. It is secondary control in LFC which re-establishes the frequency to its nominal value (50 Hz). This project the methods of artificial intelligence is to study for the AGC of interconnected two area thermal power system using PI controller and Artificial Neural Network (ANN). The proposed control has been designed for a two area interconnected power system that two area include steam turbines, ANN controller, which controls the inputs of each area in the power system together is considered. The working of the controller is simulated using MATLAB/SIMULINK package. The controller is simulated using MATLAB and compared the results of simple PI controller with ANN based controller. From this controller we can control the frequency deviation and tie line power transfer. Advantages of this controller on a wide range of operating conditions will be shown. Simulation results using MATLAB/SIMULINK will be carried out.

KEYWORDS : ALFC control, pi control method, Artificial Application, Comparison of PI and ANN.

INTRODUCTION

The role of AGC is to divide the loads among the system, station and generator to achieve maximum economy and accurate control of the scheduled interchanges of tie-line power while maintaining a reasonability uniform frequency. (salgotra, 2012)

The primary purpose of the AGC is to balance the total system generation against system load and losses so that the desired frequency and power interchange with neighboring systems are maintained. Any mismatch between generation and demand causes the system frequency to deviate from scheduled value. This high frequency deviation may lead to system collapse. Power system operation at a lower frequency affects the quality of power supply and not allowed because of following:

When operating at frequencies below 49.5 Hz, some types of steam turbines undergo excessive vibration in certain turbine rotor stages with resultant metal fatigue and blade failure.

When frequency falls below 49Hz, turbine regulating devices fully open and the generating units becomes completely loaded, a further decrease in frequency reduces the efficiency of the auxiliary mechanisms at the thermal power stations, especially feed pumps. The result in case of prolonged operation at a lowered frequency is a drop in the generated output and further loss of power. The decrease in power system frequency may assume an avalanche nature which can stop the power stations for a prolonged outage.

- As the frequency decreases, the generators exciter loss their speed and generator emf falls, the voltage in power system unit drops. This brings the danger of a "voltage avalanche" and disconnection of consumers.

- A frequency avalanche drop aggregated by a voltage avalanche drop causes grave breakdown in the power system and complete stoppage of the paralleled station or division of power system in to separately operating sections with interruption of power supply of many consumers. The function of automatic frequency control to prevent the power system frequency from approaching a critical value, when loss of active power occurs, by disconnecting part of the loads thereby keeping power stations and there auxiliaries operative .In this case he power system supplies to majority of consumers suffer no interruption and system to disconnect load can be restored within a fairly short period of time.

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II. POWER SYSTEM FREQUENCY CONTROL

Frequency deviation is a direct result of the imbalance between the electrical load and the active power supplied by the connected generators. A permanent off-normal frequency deviation directly affects power system operation, security, reliability, and efficiency by damaging equipment, degrading load performance, overloading transmission lines, and triggering the protection devices.

Since the frequency generated in the electric network is proportional to the rotation speed of the generator, the problem of frequency control may be directly translated into a speed control problem of the turbine generator unit. This is initially overcome by adding a governing mechanism that senses the machine speed, and adjusts the input valve to change the mechanical power output to track the load change and to restore frequency to a nominal value.

Depending on the frequency deviation range, as shown in Figure 1.1, in addition to the natural governor response known as the primary control, the supplementary control (AGC), or secondary control, and emergency control may all be required to maintain power system frequency.

There are three types of control for frequency deviation in the power system which are as follows:

(1)Primary control

(2)Supplementary control

(3)Emergency control

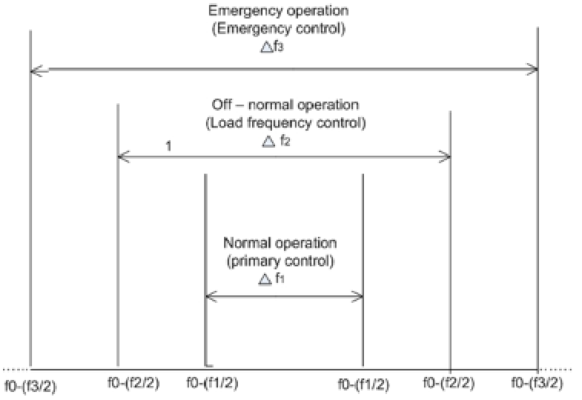

Figure.1 Frequency deviations and associated operating controls

(1) Primary Control

Depending on the type of generation, the real power delivered by a generator is controlled by the mechanical power output of a prime mover such as a steam turbine, gas turbine, hydro turbine, or diesel engine. In the case of a steam or hydro turbine, mechanical power is controlled by the opening or closing of valves regulating the input of steam or water flow into the turbine. Steam of overall system input to generators must be continuously regulated to match real power demand. Without this regulation, the machine speed will vary with consequent change in frequency. For nearly constant speed governor senses the change in speed (frequency) via the primary control loop.

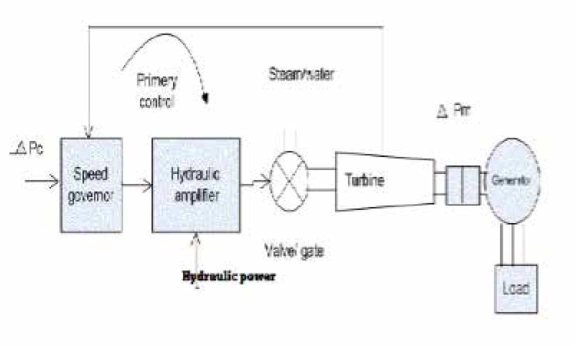

Figure.2 primary frequency control

In fact, primary control performs a local automatic control that delivers reserve power in opposition to any frequency change. The necessary mechanical forces to position the main valve against the high steam (or hydro) pressure is provided by the hydraulic amplifier, and the speed changer provides a steady state power output setting for the turbine. The speed governor on each generating unit provides the primary speed control function, and all generating units contribute to the overall change in generation, irrespective of the location of the load change, using their speed governing. However, as mentioned, the primary control action is not usually sufficient to restore the system frequency, especially in an interconnected power system, and the supplementary control loop is required to adjust the load reference set point through the speed changer motor

(2) Supplementary Control

In addition to primary frequency control, a large synchronous generator may be equipped with a supplementary frequency control loop. A schematic block diagram of a synchronous generator equipped with primary and supplementary frequency control loops is shown in Figure.

The supplementary loop gives feedback via the frequency deviation and adds it to the primary control loop through a dynamic controller. The resulting signal is used to regulate the system frequency. In real-world power systems, the dynamic controller is usually a simple integral or proportional integral (PI) controller. Following a change in load, the feedback mechanism provides an appropriate signal for the turbine to make generation (Δ Pm) track the load and restore system frequency.

(3) Emergency Control

Emergency control, such as load shedding, shall be established in emergency conditions to minimize the risk of further uncontrolled separation, loss of generation, or system shutdown. Load shedding is an emergency control action to ensure system stability, by curtailing system load. The load shedding will only be used if the frequency (or voltage) falls below a specified frequency (voltage) threshold. Typically, the load shedding protects against excessive frequency (or voltage) decline by attempting to balance real (reactive) power supply and demand in the system. The load shedding curtails the amount of load in the power system until the available generation can supply the remaining loads. If the power system is unable to supply its active (reactive) load demands, the under-frequency (under-voltage) condition will be intense. The number of load shedding steps, the amount of load that should be shed in each step, the delay between the stages, and the location of shed load are the important objects that should be determined in a load shedding algorithm. A load shedding scheme is usually composed of several stages. Each stage is characterized by frequency/ voltage threshold, amount of load, and delay before tripping. The objective of an effective load shedding scheme is to curtail a minimum amount of load, and provide a quick, smooth, and safe transition of the system from an emergency situation to a normal equilibrium state.

III Automatic load frequency control

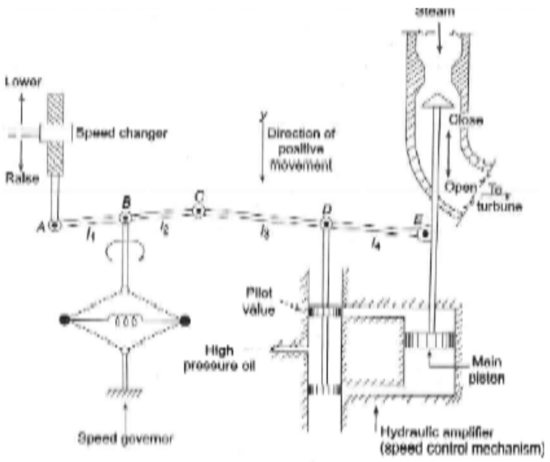

Figure.3 speed governing system

As shown in figure.3 there are four major components in speed governing system. Which are as follows

(1)Speed governor
(2)Linkage mechanism
(3)Hydraulic amplifier
(4)Speed changer

IV Proportional plus integral control (AGC Loop)

In primary ALFC loop, the speed governing system installed on each machine, the steady load frequency characteristic for a given speed changer setting has considerable droop. System frequency specifications are stringent and, therefore, so much change in frequency will be zero. While steady state frequency can be brought back to the scheduled value by adjusting speed changer setting, the system could undergo intolerable dynamic frequency changes with change in load. It leads to the natural suggestions that the speed changer setting be adjusted automatically by monitoring the frequency changes. For this purpose, a signal from ΔF is fed through an integrator to the speed changer resulting in the block diagram configuration shown in figure given below. The system now modifies to a proportional plus integral controller, which as is well known from control theory, gives zero steady state error. ΔF steady state=0

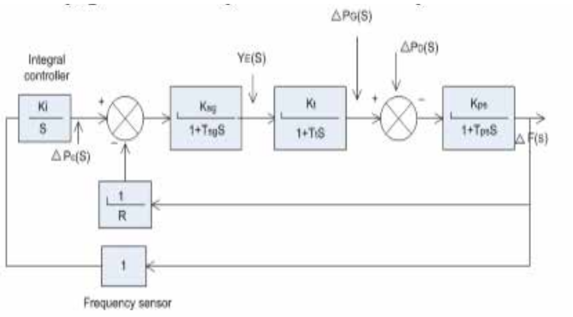

Figure.4 Proportional plus integral load frequency control

V Automatic Generation Control in two area system

A power system comprising of two control areas interconnected by a weak lossless tie-line is considered. Each control area is represented by an equivalent generating unit interconnected by a Tie-line with reactance X12. Each area is represented by a voltage source behind an equivalent source reactance. Under steady state operation, the transfer of power over the Tie-line P12 can be written as,

Type equation here.$P_{12}=(|V_1||V_2|/X_{12})\sin(\delta_1-\delta_2)$

Where V1 and V2 are the magnitudes of the end voltages of control areas 1 and 2 respectively, and δ1 and δ2 are the voltage angles of V1 and V2, respectively.

For a small change Δδ1 and Δδ2 in voltage angles, the change in Tie-line power, ΔP12 is shown as $V_1||V_2|/X_{12})\cos(\delta_1-\delta_2)(\Delta\delta_1-\Delta\delta_2)$

$P_{12}=(|$ Synchronizing coefficient,

$T_{12}=(|V_1||V_2|/X_{12})\cos(\delta_1-\delta_2)$

Since incremental power angles are integral of incremental frequencies,

$P_{tie,1}=2\pi T_{12}\ (\int\Delta f_1 dt-\int\Delta f_2 dt)$

Taking Laplace transform

$P_{tie,1}(s)=(2\pi T_{12}/s)\ (\int\Delta F_1(s)-\int\Delta F_2(s))$

Similarly tie line power output for area 2 is given by,

$P_{tie,2}=2\pi T_{21}\ (\int\Delta f_2 dt-\int\Delta f_1 dt)$

Where

$T_{21}=(|V_1||V_2|/X_{12})\cos(\delta_1-\delta_2)=(P_{r1}/P_{r2})T_{12}$

so that,

$T_{21}=a_{12}T_{12}$

Taking Laplace transform

$P_{tie,2}(s)=(-2\pi a_{12}T_{12}/s)\ (\int\Delta F_1(s)-\int\Delta F_2(s))$

Block diagram can be given by:

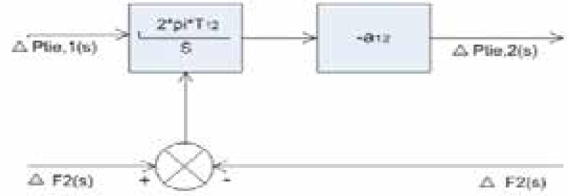

Figure.5 Tie line power flow diagram

VI Artificial Neural Network

Neural networks which are simplified models of the biological neuron system, it is a massively parallel distributed processing system made up of highly interconnected neural computing elements that have the ability to learn and thereby acquire knowledge and make it available for use.

Various learning mechanisms exist to enable the NN architecture that have been classified into various types based on their learning mechanisms and other features. Some classes of NN refers to this learning process as training and the ability to solve a problem using the knowledge acquired as inference.

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 ARTIFICIAL NEURAL SYSTEM or ARTIFICIAL NEURAL NETWORK (ANN).

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 designed with one input layer of two neuron, Hidden layer with three neurons and output layer with one neuron.

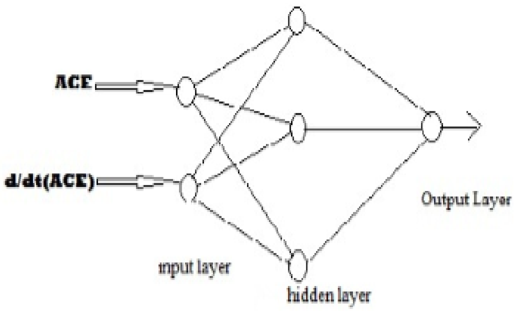

Figure.6 ANN structure

Application of ANN in AGC to reduce Overshoot in waveform and it reduce the settling time.

VII Simulations and Results

1.AGC loop with PI Controller

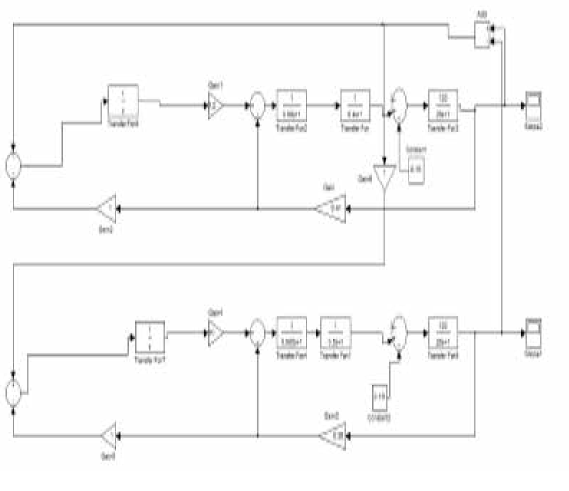

Figure.7 simulation model of AGC with PI controller

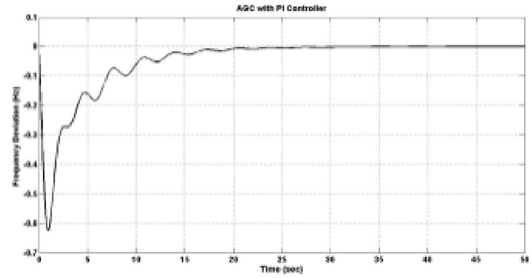

Figure.8 Simulation result of AGC with PI controller

2. AGC loop with ANN Controller

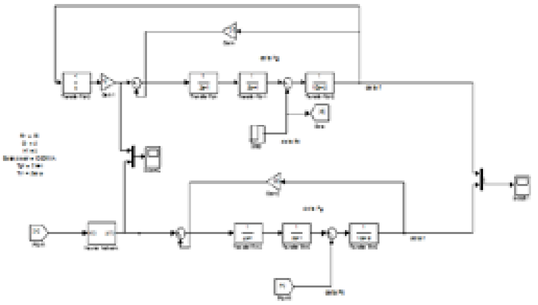

figure.9 Simulation model of Single area ALFC with PI and ANN method

Simulation result of Single Area ALFC with PI and ANN method

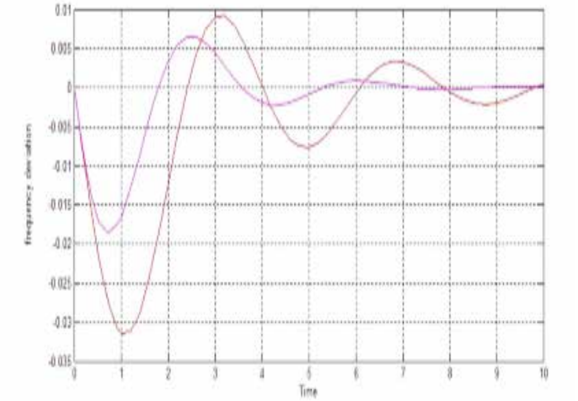

Figure.10 Simulation result of Single area ALFC with PI and ANN method for frequency deviation

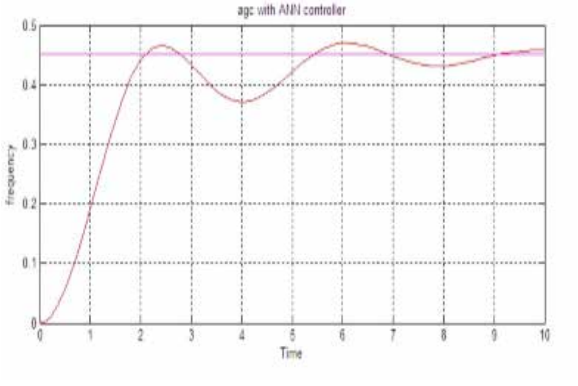

Figure.11 Simulation result of Single area ALFC with PI and ANN method for tie line power deviation

VII. CONCLUSION AND FUTURE ENHANCEMENT

After simulating Automatic Generation Control (AGC) with PI controller we can show that frequency deviation is controlled in specific time period which we can see in simulation result. this settling time period can be reduced by the ANN method with the help of NARMA controller which improves the reliability of the power system in two area connected thermal station.

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