Automatic load frequency control of multi-area power system using ANN controller and Genetic algorithm

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ABSTRACTS

In this paper work we analyze and design Automatic load frequency control of two areas power system using Genetic Algorithm and also for four area power system using artificial neural network (ANN), generation control is becoming increasingly important in view of increased load demand & reducing generating resources. The increasing load demands are posing serious threats to reliable operation of power systems. As we all that Maintaining power system frequency at constant value is very important for the health of the power generating equipment and the utilization equipment at the customer end. The job of automatic frequency regulation is achieved by governing systems of individual turbine-generators and Automatic Generation Control (AGC) or Load frequency control (LFC) system of the power system. The healthy and undamaged operation of generator needs the control of the following parameters: (a) Frequency to be maintained constant i.e. at 50 Hz (b) the tie line power to be maintained between specified limits. If the above parameters are maintained with in desired limits the generation control is said to be most effective. There are so

Many techniques for automatic load frequency control like integral controller, PID controller. The main objective of automatic generation control is to maintain the balance between the generation and demand of a particular power system.

Keyword: Load Frequency Control (LFC), Automatic Generation Control (AGC), Four and Two area power system, ANN Controller, Genetic algorithm.

INTRODUCTION

For large scale power systems which consists of inter-connected control areas, then it is important to keep the frequency and inter area tie power near to the scheduled values. The input mechanical power is used to control the frequency of the generators and the change in the frequency and tie-line power are sensed, which is a measure of the change in rotor angle. A well designed power system should be able to provide the acceptable levels of power quality by keeping the frequency and voltage magnitude within tolerable limits Changes in the power system load affects mainly the system frequency, while the reactive power is less sensitive to changes in frequency and is mainly dependent on fluctuations of voltage magnitude. So the control of the real and reactive power in the power system is dealt separately. The load frequency control mainly deals with the control of the system frequency and real power whereas the automatic Voltage regulator loop regulates the changes in the

reactive power and voltage magnitude. Load frequency control is the basis of many advanced concepts of the large scale control of the power system.

Automatic generation control (AGC) is very important issue in power system operation and control to ensure the supply of sufficient and reliable electric power with good quality. Owing to the continuous growth of electrical power system in size and complexity with increasing interconnections, the problem of power and frequency oscillations due to unpredictable load changes, has become increasingly serious. These random load changes result in power generation-consumption mismatch, which in turn, affects the quality and reliability of electric power. These mismatches have to be corrected because generation and distribution of sufficient.

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 the secondary control in LFC which re-establishes the frequency to its nominal value (50 Hz) and sustains the interchange of power between areas (in case of more than one control area). For this the load demand in the generator prime mover set is increased or decreased in the form of kinetic energy, resulting in change of frequency. The transient in primary, secondary and tertiary control is of the order of seconds and minutes respectively Automatic generation control is to provide control signals to regulate the real power output of various electric generators within a prescribed area in response to changes in system frequency and tie-line loading so as to maintain the scheduled system frequency and established interchange with other areas. In other words the design of automatic generation controller depends upon various energy source dynamics involved in the AGC of the area.

Automatic Generation Control

If the load on the system is increased suddenly then the turbine speed drops before the governor can adjust the input of the steam to the new load. As the change in the value of speed diminishes the error signal becomes smaller and the positions of the governor and not of the fly balls get closer to the point required to maintain the constant speed. One way to restore the speed or frequency to its nominal value is to add an integrator on the way. The integrator will unit shall monitor the the average error over a period of time and will overcome the offset. Thus as the load of the system changes continuously the generation is adjusted automatically to restore the frequency to the nominal value. This scheme is known as automatic generation control. In an interconnected system consisting of several pools, the role of the AGC is to divide the load among the system, stations and generators so as to achieve maximum economy and reasonably uniform frequency

MATHEMATICAL MODELING OF SYSTEM

1. Mathematical modeling for Generator

Applying the swing equation of a synchronous machine to small perturbation, we have:

$$\frac{2H}{\omega}\frac{d^2\,\Delta\delta}{dt^2} = \Delta P_m - \Delta P_e \ \dots\dots\dots\dots (1)$$

Or in terms of small deviation in speed

$$\frac{d\Delta\frac{\omega}{\omega_s}}{dt} = \frac{1}{2H}(\Delta P_m - \Delta P_e)\dots\dots\dots\dots\dots (2)$$

Taking Laplace Transform, we obtain

$$\Delta\Omega(s) = \frac{1}{2H_s}[\Delta P_m(s) - \Delta P_e(s)\dots (3)$$
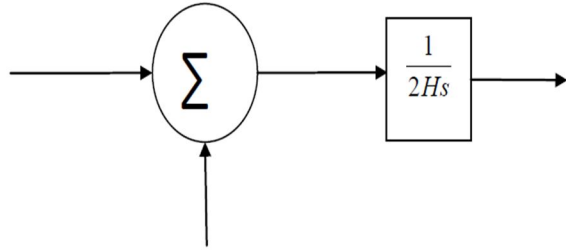
Fig.1 Represent the Block diagram of Generator

2. Mathematical Modeling of Load

The load on the power system consists of a verity of electrical drives. The equipments used for lighting purposes are basically resistive in nature and the rotating devices are basically a composite of the resistive and inductive components. The speed-load characteristic of the composite load is given by

ΔPe=ΔPL+DΔω

where ΔPL is the non-frequency- sensitive load change, DΔω is the frequency sensitive load change.
D is expressed as percent change in load by percent change in frequency
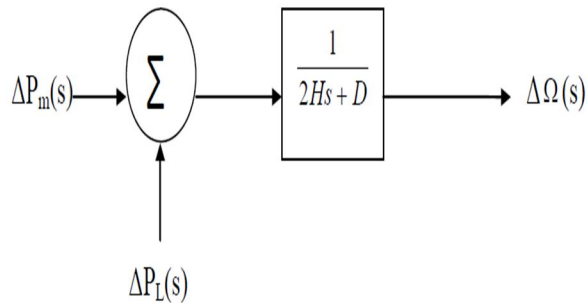

Fig .2 Represent the Block diagram of Load

3. Mathematical Modelling For Governor

When the electrical load is suddenly increased then the electrical power exceeds the mechanical power input. The slope of the curve represents speed regulation R. Governors typically has a speed regulation

of 5-6 % from no load to full load
ΔPg=ΔPref -$\frac{1}{R}\Delta f$ ....(4)
Or in s- domain

   ΔPg(s)= ΔPref - $\frac{1}{R}\Delta f$ ......(5)

The command ΔPg is transformed through hydraulic amplifier to the steam valve position command ΔPV. We assume a linear relationship and consider simple time constant we have the following s-domain relation.

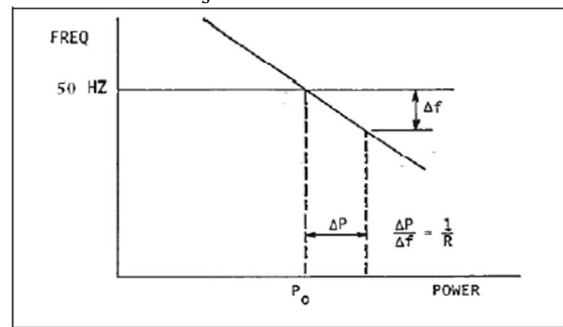$$\Delta PV(s)=\frac{1}{1+\tau_s}\Delta P_e(s) \quad .... \ (6)$$

Fig.3 Graphical Representation of speed regulation by governor

4. Interconnected areas in a power system

The four area power system model identified in the present study has the following configuration;
(i) It is a four area interconnected power system consisting of identical single stage reheat thermal turbines.
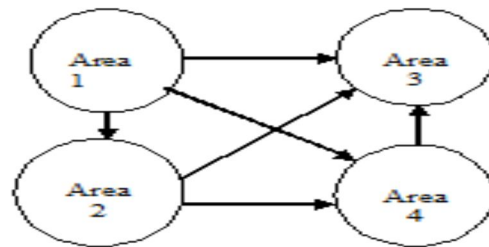(ii) The four areas are interconnected via HVAC tie line in parallel with HVDC link.

Fig4. Tie-lines connected with four area

Let

ACE1 = Area control error of area 1

ACE2 =Area control error of area 2

ACE3 = Area control error of area 3

ACE4 = Area control error of area 4

In this control, ACE1, ACE2, ACE3 and ACE4 are made linear combination of frequency and tie line power error**.**

Artificial Neural network

Neural networks process information in a similar way the human brain does. The network is composed of a large number of highly interconnected processing elements (neurons) working in parallel to solve a specific problem. Neural networks learn by example. They cannot be programmed to perform a specific task**.**

ANN controller used is a three-layer perceptron with x input, k neurons in the hidden layer, and one output. ANN Plant model is a three-layer perceptron with x input, k neurons in the hidden layer, and one output. The activation function of the networks neurons is train function. N-training samples have been taken to train m-number of epochs. The proposed network has been trained by using the learning performance.

NARMA-L2 Control

ANN controller architecture employed here is Non linear Auto Regressive Model reference Adaptive Controller [13]. Computations required for this controller is quite less. It is simply a rearrangement of the neural network plant model, which is trained offline, in batch form. 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. It permits 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. Control signals applied to the governors in the area act as the outputs of the neural network. 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.

NARMA-L2 is one of the neural network architecture that has been implemented in the MATLAB for prediction and control. NARMA-L2 controller design is performed by two stages. 1. System identification and 2. Control design

Implementation of NARMA L-2 Neural controller.

The Implementation of NARMA L2 Neural Controller for AGC FOUR AREA, equation Consider the nonlinear change of coordinates

$x_1 = f$

$x_2 = \frac{1}{2H_s}[\Delta P_m(s) - \Delta P_e(s)$

$\frac{dx_1}{dt} = x_2$

$\frac{dx_2}{dt} = \frac{1}{2H_s}\left[\frac{d[\Delta P_m(s) - \Delta P_e(s)]}{dt}\right]$

$\Delta Pg(s) = \Delta Pref - \frac{1}{R}\Delta f$

Resulting in the linear system

$\frac{dx_1}{dt} = x_2$

$\frac{dx_2}{dt} = u$

Where u is a new control input

Let

$x_1 = y$

$\dot{x}_1 = x_2 = \dot{y}$

For n-dimensional

y^(k +d) = f [y(k), y(k −1),... ...y(k -n +1),u(k -1),.... ..u(k -m +1)]+ g[y(k),y(k -1),.. …

y(k-n+1),u(k -1),.. …,u(k -m +1)].u(k)…

Simulation and result

In this section we study the automatic generation control of four area using Artificial neural network of control of load frequency with variation of load across generator. Figure 5 is showing of frequency response of four area system with respect to load. To vary the load across generator we get the differrent response with different settling time.

Hence an attempt was made to extend the optimal control design to a two are network. The assumption taken under consideration strictly followed that the system operation was normal throughout and the simulation were obtained without the presence of the integral controllers.
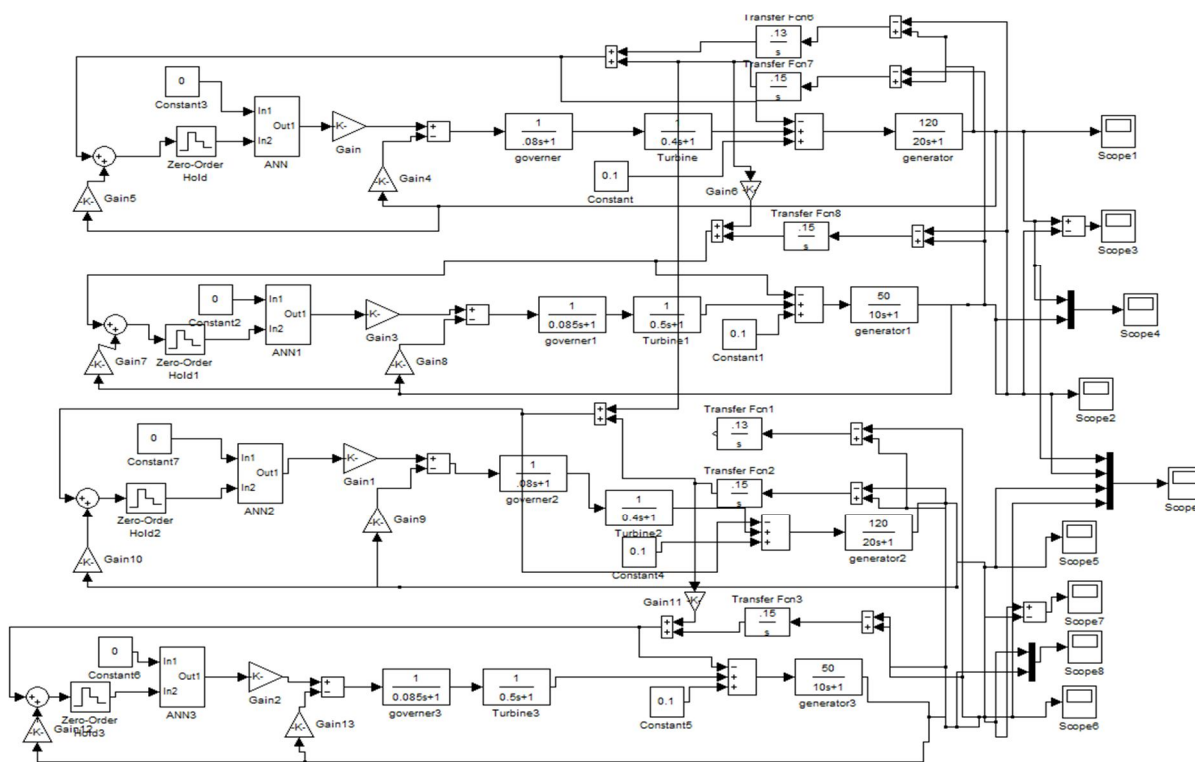

Fig.5 simulink block diagram of four area automatic generation control with ANN.
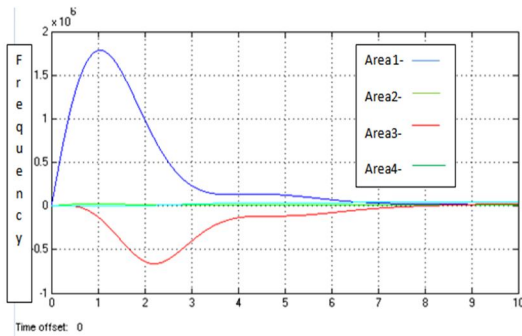
Fig.6 load frequency of AGC .4-area

The above figure show the load frequency of 4- area response of AGC using ANN with 20% load.

GA AND ITS APPLICATION IN AGC

An optimal AGC strategy based on the linear state regulatory theory requires the feedback of all state variables of the system for its implementation, and an optimal control feedback law is obtained by solving the non-linear Riccati equation using suitable computational technique. To illustrate the effectiveness of the proposed control design and the algorithm to tune the feedback gains to the controller, a two area Restructured power system having two GENCOs and two DISCOs in each area is considered. The time-invariant state space representation as:

$$\dot{X} = A.X + B.U \qquad (6)$$
$$Y = C.X$$

Where X is the state vector and, U is the control vector and Y is the output variable.

$$U = [\ \Delta PL1\ \Delta PL2\ \Delta PL3\ \Delta PL4\ \Delta Pd1\ \Delta Pd2]^T \qquad (7)$$

For the system defined by the Eq.(6) and (7), the feedback control law is given as,

$$U = -K.Y$$

Where K is the feedback gain matrix. In this paper Evolutionary Genetic algorithms is used to optimize the feedback gains of the controller. Genetic algorithm (GA) is an optimization method based on the mechanics of natural selection. In nature, weak and unfit species within their environment are faced with extinction by natural selection. The efficiency of the GA gets increased as there is no need to encode/decode the solution variables into the binary type.

Steps in genetic algorithm

I) reproduction.

II) crossover.

III) mutation.

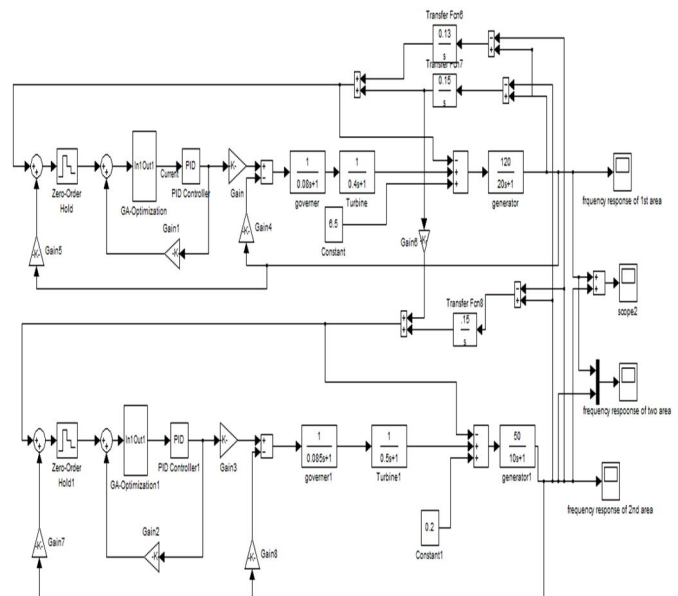## SIMUALTION DIAGARM FOR TWO AREA POWER SYSTEM USING GENETIC ALGORITHM.

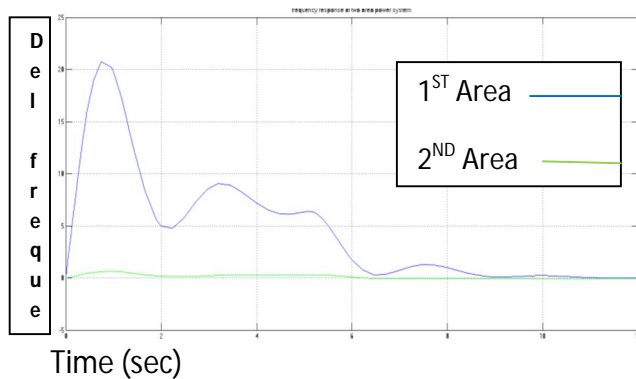**Fig.-9 simuation diagram of two area power system using G.A.**

Time (sec)

Fig- 10 Result of two area power system using G.A

CONCLUSION

In this paper we study the Load Frequency Control of automatic generation control four area network using neural network and of two area power system using genetic algorithm for different loads , the system stability and performance drastically over the pole placement method with extensively depended on trial and error process. In fact there is a huge scope of improvement in this area where the power system study can be extended to a multi-area system that shall ensure stability in closed loop system. And we obtain the different settling time for neural approach and for genetic algorithm approach. We observe that with ANN the settling is approx 16 sec and with genetic algorithm the setteling time is 11 sec

To varying the load across the generator of % of 5, 10 ,15,20 respectively we get the response with different settling time .

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