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GENERATION OPTIMIZATION USING TWO AREA CONTROL

DISSERTATION II

Submitted in partial fulfillment of the

Requirement for the award of the degree

Of

MASTER OF TECHNOLOGY

IN

Power systems

By

Ramneet Kour

Under the Esteemed Guidance of

Mr. Sanjeev Kumar Bhalla

INDIA'S LARGEST UNIVERSITY*

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School of Electrical & Electronics Engineering
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May 2015

CERTIFICATE

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This is to certify that **Ramneet Kour** bearing Registration no. 11307057 has completed objective formulation of thesis “**GENERATION OPTIMIZATION USING TWO AREA CONTROL”** under my guidance and supervision. To the best of my knowledge, the present work is the result of her original investigation and study. The contents of this Thesis, in full or in parts, have neither been taken from any other source nor have been submitted to any other Institute or University for award of any degree or diploma and the same is certified.

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DECLARATION

I **Ramneet Kour**, student of M-Tech under Department of Electronics & Electrical Engineering of Lovely Professional University, Punjab, hereby declare that all the information furnished Dissertation-II report is based on my own intensive research and this is genuine.

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ABSTRACT

This paper presents that the use of electricity and its need has been increased. Thus, in order to ensure the consumers with reliable and continuous supply during the increase of demand, need of interconnection between the different generating areas are required and due to this reason the concept of Automatic Generation Control is taken into consideration which is then used for adjusting the output power of various generators at different power plants in an electric power system. A controller based on Particle Swarm Optimization has been designed in order to keep the frequency deviations due to change in load minimum i.e. by keeping the frequency at its set value of 5o Hz and power transfer through tie-line uniform.

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ABBREVIATIONS

AGC = Automatic Generation Control.

PI = Proportional Integral.

PID = Proportional Integral Derivative.

ACE = Automatic Control Error.

ACEN = New Area Control.

ANN = Artificial Neural Networks

GRC = Generation Rate Constraints.

GA = Genetic Algorithm.

ISE = Integral Square Error.

IAE = Integral Absolute Value of error.

ITSE = Integral Time Multiple Square Error.

ACO = Ant Colony Optimization.

HNFC – Hybrid Neuro-Fuzzy logic controller

CHAPTER 1

INTRODUCTION

In 21st century, the use of electricity has been increased so much that it has become vital and important part of life. Domestic, Commercial and Industrial purpose use of electric power has been increased which has forced to provide bulk electric power economically and optimally. This can be only achieved by using power producing units called as Power Plants and these are of various types like Thermal, Hydro, Diesel and many more. The structure of power plant must have important aspect like optimal, reliable and continuous power flow to the consumers. In today's world, power systems are in huge demand and are provided over wide areas so it contains major parts like Generators, Transformers, Transmission and Distribution line. All these components together provide us with continuous and uninterrupted power supply. Large capacity power equipment and complex interconnection use has been necessary due to the increase in demand which has led to burden on the system, so it must to have Economic Scheduling of power plants and Optimal Power Flow.

Due to change in demand or load, power flow between the areas connected by the tie line and system frequency is greatly affected and thus to provide users with consistent and excellent supply of electric power, power system have to maintain balance between power demand and power generation. Thus now days for providing stable operation of the power system and minimizing the frequency deviation, Automatic Generation Control is provided.

1.1 Automatic Generation Control (AGC)

As we know, main function of the Power System is to convert natural energy into electrical energy and then transmitted this power to the load centers with the help of transmission lines. Thus for optimized performance of the electrical equipment, good and reliable amount of power is required and usually electricity is transmitted in the form of ac. At generating and load end in order to transfer efficient amount of power both the powers i.e. reactive and active power must be balance.

This balance relates to two stability facts:

- Control of frequency.
- Control of voltage.

These stability points will lift up, whenever anyone of them is distorted and thus set up a new level or position in a power system. Requirement of the efficient and excellent power system during its operation is to supply the users or consumers with above two facts i.e. both frequency and voltage in a set range. Load on the power system varies in wide range of varieties. Without considering the control strategies, it is almost difficult to preserve the stability of both the active and reactive power. Changing of loads often led to change of system frequency and voltage variations due to non-balancing. Thus there is always requirement of such a system which cancels out the effects of load changes which occurs arbitrarily, such a system refers to as a control system and this system retain the system frequency and voltage at desired range of value as required by a particular system.

For adjusting the output power of various generators at different power plants in an electric power system, in response to change in load, a system called as Automatic generation controlled is employed. AGC also denoted as Load frequency control. Adjustments to output of generators and moment by moment balancing of load and generation are prime requirements of the power grid. By measuring the system frequency we can judge the balance of the system i.e. if the system frequency is increasing there is generation of more power than used one and there is acceleration of all the machines in the system. If it is decreasing, all the system generators are slowing down and there should be more loads on the system than the instantaneous generation can provide.

In a system, one generating unit would be designed as the regulating unit and to control the balance between generation and load to maintain system frequency at desired level, it would be manually adjusted before the use of Automatic Generation Control. With speed droop to proportion their share of the load according to their ratings the remaining units can be controlled. In an automatic system, many units can participate in stability, economy, regulation, reducing wear and tear on a single unit controls and improving system efficiency.

For adjacent control areas grid has tie line interconnections and to maintain the power interchanges over the tie-line at scheduled levels, Automatic Generation Control is used. Automatic Generation Control can take into account such matters as the most economical units to adjust, the coordination of hydroelectric, thermal and other generation type and even constraints related to the stability of the system and capacity of interconnections to other power grids with the help of computer based solutions and multiple inputs.

To control the allocation of the generator so as to maintain frequency and net interchange of power through transmission lines are the main functions of AGC under sudden varying load conditions. Digital flow data of loading of generator tie lines flows and frequency values are required for their operation. It sends raise of lower commands to the generator unit under control through concern running technologies.

1.2 EXISTING AUTOMATIC GENERATION CONTOL (AGC) SOLUTIONS

Integral controllers are broadly used for decades as Automatic Generation Controller. Usually PI controllers are used but PID controllers are also developed with enhanced properties for AGC or load frequency control. These controller attempts to minimize the error by adjusting the process control output. But these are conventional types of controllers.
Now days, Fuzzy logic controllers are widely used. These are based on fuzzy set theory which takes values of fuzzy logic variables between 0 and 1 instead of true and false. Artificial Neural

Network (ANN) and Particle Swarm Optimization (PSO) techniques founded controllers are also used for balancing the frequency deviations and tie –line power. These controllers are based on pattern recognition and classification and use algorithms like back propagation, orthogonal least square, finding of P_{best} and G_{best} particles.

1.3 DYNAMICS OF POWER GENERATION SYSTEM

For understanding the concept of Automatic Generation Control (AGC), we have to consider a power system and perform its modeling. The modeling of a typical power generating system for AGC includes speed turbine governing system, turbine model etc.

1.3.1 GOVERNING SYSTEM OF A SPEED TURBINE

Governing system of a turbine is shown in the figure1 and it consists of following elements:

- Speed changer.
- Hydraulic amplifier.
- Fly ball speed governor.
- Linking mechanism.

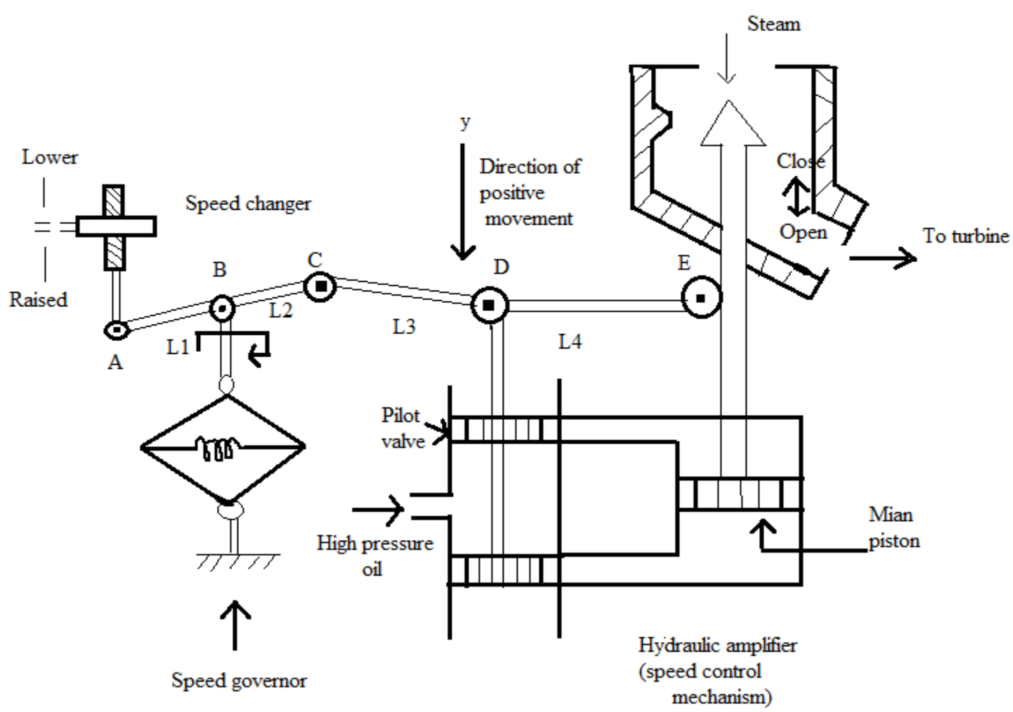


Figure 1.1: Speed Turbine Governing System.

Speed Changer: As the name suggested speed changer of a steam turbine provides steady state output settings. Under steady state condition, its downward movement led to open the upper pilot valve so that bigger amount of steam is acknowledged by the turbine and hence more secure power output is obtained. After the operation of the speed governor, it is possible to preserve the frequency to its desired value with the help of speed changer.

Fly ball: Change in speed (frequency) is sensed by the fly ball and said to be the heart of the system. Whenever there is increase in speed, fly ball moves outwards and linear mechanism moves downwards at point B as shown in figure and if there is decrease in speed, a reverse process may happen.

Hydraulic Amplifier: Whenever a hydraulic servomotor is interposed between governor and valve, there is formation of hydraulic amplifier. It consists of two parts namely as main piston and pilot valve as shown in figure. Conversion of low level pilot valve into level main piston is necessary for opening and closing of steam valve against raised pressure.

Linking Mechanism: ABC is a rigid link pivoted at B and CDE is other rigid link pivoted at D. In order to control valve in fraction to speed changes, this is provided by linking mechanism. Feedback for steam valve movement (at link 4) is also provided by the linking mechanism.
Pilot valve position can be change in three altered positions with the help of linking mechanism and are discussed as below:

- A decrease in steady state output or reference value occurs if there is little movement of upward point A, this refer to when speed is changing directly.
- Whenever there is change in main piston through feedback, this refers to change in speed indirectly.
- Position changes in linking point E whenever there is change in speed also refers to indirect mode.

1.3.2 SPEED GOVERNING SYSTEM MODEL

We can assume initially that under stable conditions, system is operating and under this condition linking mechanism would stayed in stationary position and pilot valve is in closed operation, a definite magnitude led to the opening of the steam valve, turbine is moving in a uniform speed with turbine power output balancing the load supplied by the generator. Let us considering the following characterized working situations:

f° = speed i.e. frequency of the system.

P_G° = output of the generator = turbine output, if we neglect the losses.

Y_E° = setting of the steam valve.

By utilizing these operating characteristics we can obtain a linear incremental model

At point A in figure 1.1, there is downward motion of the linking mechanism by small amount Δy_A and thus there is change in turbine power output due to this command. The equation for this is mentioned as:

$$\Delta y_A = k_C \, \Delta P_C$$

Where, ΔP_C = commanded increase in power.

Sequences of motion are set up by the commanded power signal ΔP_C (i.e. Δy_E) – there is upward movement of pilot valve, downward movement of the main piston as there is movement of high pressure oil on its top surface, increase in the opening of steam valve, speed of turbine generator consequently grows i.e. value of frequency is higher up. Now let us represents these sequences of events in a form of equations.

There are basically dual factors which contribute to the movement of C point:

1. - $(L_1/ L_2) \, \Delta y_A$ or – $k_1 \, \Delta y_A$ of - $k_{1C} \, \Delta P_C$ is added by $\Delta y_{A.}$

2. There is outer movement of fly ball whenever there should be rise in frequency value Δf, there should be downward movement of B by an amount of $k_2' \, \Delta f$.

Therefore by considering the above two points, net C position is given as:

$$\Delta y_C = - k_1 k_C \, \Delta P_C + k_2 \, \Delta f$$

Then, Δy_D which is the combination of Δy_C and Δy_E at the opening of the pilot value is written as:

$$\Delta y_D = (L_4 / L_3 + L_4) \, \Delta y_C + (L_3 / L_3 + L_4) \, \Delta y_E$$

$$= k_3 \, \Delta y_C + k_4 \, \Delta y_E$$

Δy_E is the opening of valve whenever high pressure is admitted due to the downward movement of Δy_D. By dividing the volume of the oil and cross section area of the piston Δy_E is obtained and can be expressed as under:

$\Delta y_E = - k_5 \int_o^t (-\Delta yD)\ dt$

By taking Laplace transform, we get:

$\Delta y_C\ (s) = - k_1 k_C\ \Delta P_C\ (s) + k_2 \Delta f\ (s)$

$\Delta y_D\ (s) = k_3\ \Delta y_C\ (s) + k_4\ \Delta y_E\ (s)$

$\Delta y_E\ (s) = - k_5\ 1/s\ \Delta y_D\ (s)$

Now, $\Delta y_E\ (s) = \frac{k3k1kC\ \Delta PC\ (s) - k3k2\Delta f\ (s)}{k3+\frac{s}{k5}}$

$= [\Delta P_C\ (s) - 1/R\ \Delta F(s)\ ] \times (\ K_{sg}/\ 1+ T_{sg}\ s)$

Here, $R = k_1 k_C/k_2$ = regulation of the governor.

$K_{sg} = k_1 k_C k_3/k_4$ = gain of governor.

$T_{sg} = 1/\ k_4 k_3$ = governor time constant.

The above equation may be represented in the form of block diagram:

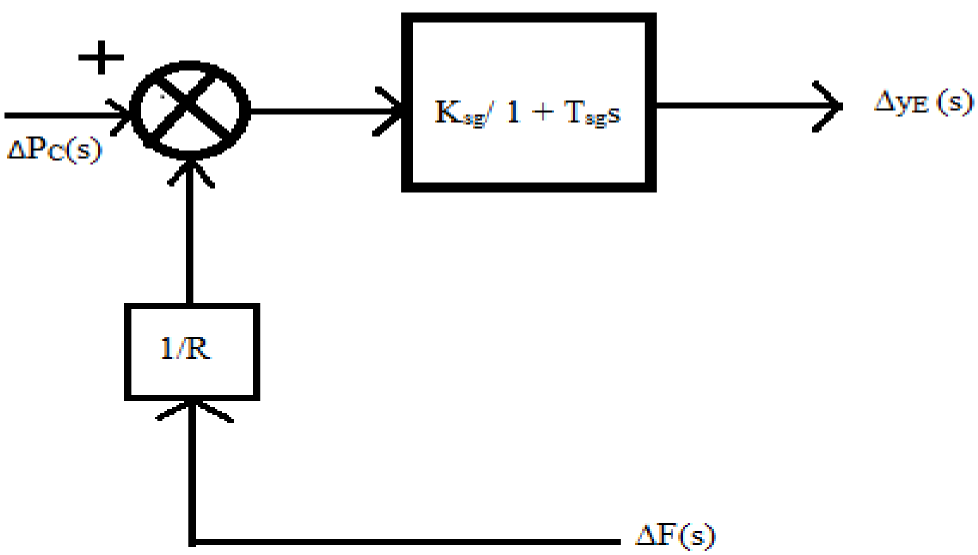


Figure 1.2: Block diagram of governing model.

Droop compensation is provided by the feedback loop in case any disturbance occurs in the system to prevent the bursting of the penstock.

1.3.3 TURBINE MODEL

Active response of a speed turbine in this case is related in terms of power changes in steam valve opening. Steam turbine with two stages and a reheater connected is shown in figure 1.3.

There are many two factors which largely influence the dynamic response of steam turbine.

- Steam between the final stage of the turbine and inlet steam valve.
- In order to get efficient results, Reheated storage action is needed which led to change of low pressure stage output which generally lags behind high pressure stage.

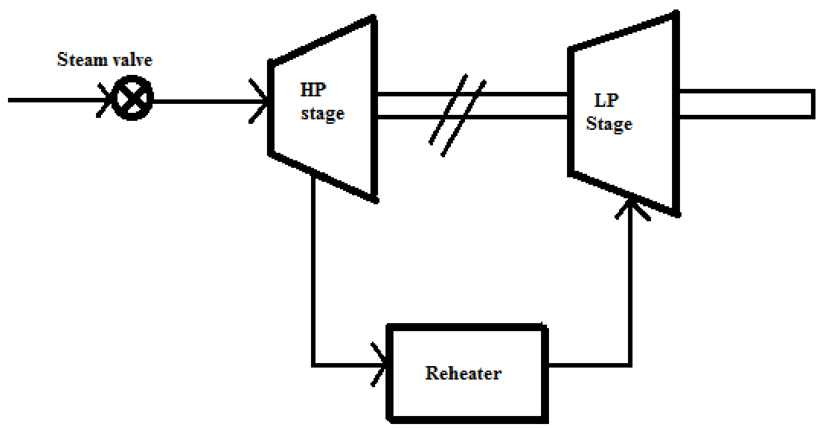


Figure 1.3: Steam Turbine with Reheater Unit.

Transfer function of a turbine is thus considered by constants and in this case for simplicity the turbine is modeled to have equivalent time constant. Time constant in this case varies from .2 to 2.5 sec and its transfer function is shown by figure 1.4.

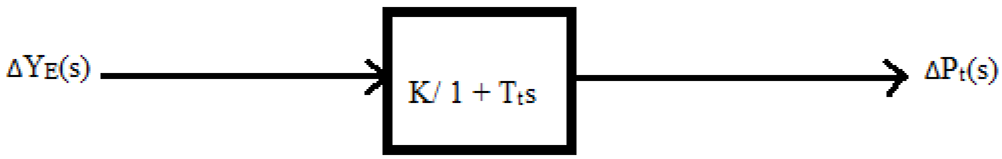


Figure 1.4: Transfer Function of Turbine Model

1.3.4 GENERATOR LOAD MODEL

Let ΔP_G - ΔP_D be the incremental power to the generator load system.

Where ΔP_D is the incremental load and $\Delta P_G = \Delta P_T$ turbine incremental output when the generator incremental loss is assumed to be negligible. There are two methods accounted for the increment in power output of the system.

1. At scheduled frequency f°, the stored kinetic energy in generator rotor is increased by a rate which is given as :

$$W^{\circ}_{ke} = H \times P_r \, kW = sec \text{ (kilojoules)}$$

Now, we know that kinetic energy is proportional to the square of the frequency and is given by

$$W_{ke} = W^{\circ}_{ke} (f^{\circ} + \Delta f^{\circ} / f^{\circ})^2$$

$$= HP_r (1 + 2\Delta f^{\circ} / f^{\circ})$$

Therefore kinetic energy changes at what rate is given by:

$$d/dt \; W_{ke} = 2HP_r/f^{\circ} \; d/dt \; (\Delta f)$$

2. There is change in motor load as frequency changes and thus rate of change of load can be written as:

$$(\partial Pd/\partial f)\ \Delta f = B.\ \Delta f$$

Where B is a constant and it is positive for motor load.

Then the power balance equation may be written as:

$$\Delta P_G - \Delta P_D = 2HP_r/f^{\circ}\ d/dt\ (\Delta f) + B.\ \Delta f$$

By dividing whole equation by P_r and rearranging the equation we get

$$\Delta P_G\ (pu) - \Delta P_D\ (pu) = 2HP_r/f^{\circ}\ d/dt\ (\Delta f) + B\ (pu)\ \Delta f$$

By taking Laplace transform equation in terms of ΔF(s) can be written as

$$\Delta F(s) = \Delta P_G\ (s) - \Delta P_D\ (s) \times K_{ps} / (1+ T_{ps})$$

Here, $T_{ps} = 2H/\ B\ f^{\circ}$ = Time Constant of power system.

$K_{ps} = 1/\ B$ = Gain of power system.

Generator load block diagram is shown as under:

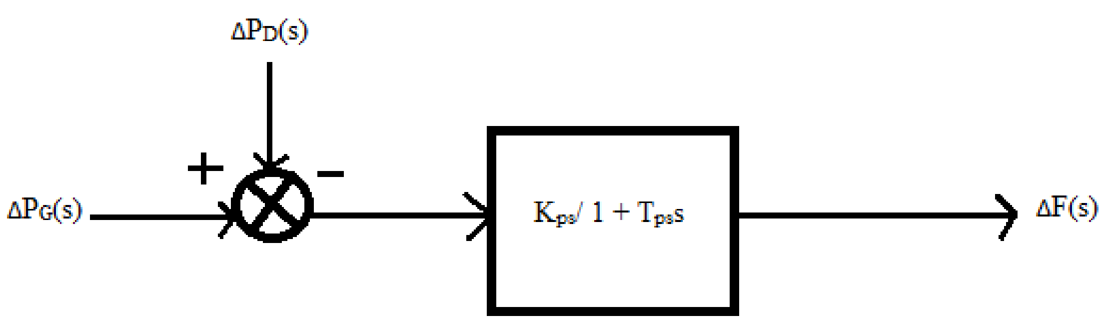


Figure 1.5: Generator- Load Model

The complete block diagram of an isolated power system with load frequency control is shown in figure 1.6 and it comprises of various block diagrams of different component models like turbine, generator and generator load model. It also consists of a feedback loop.

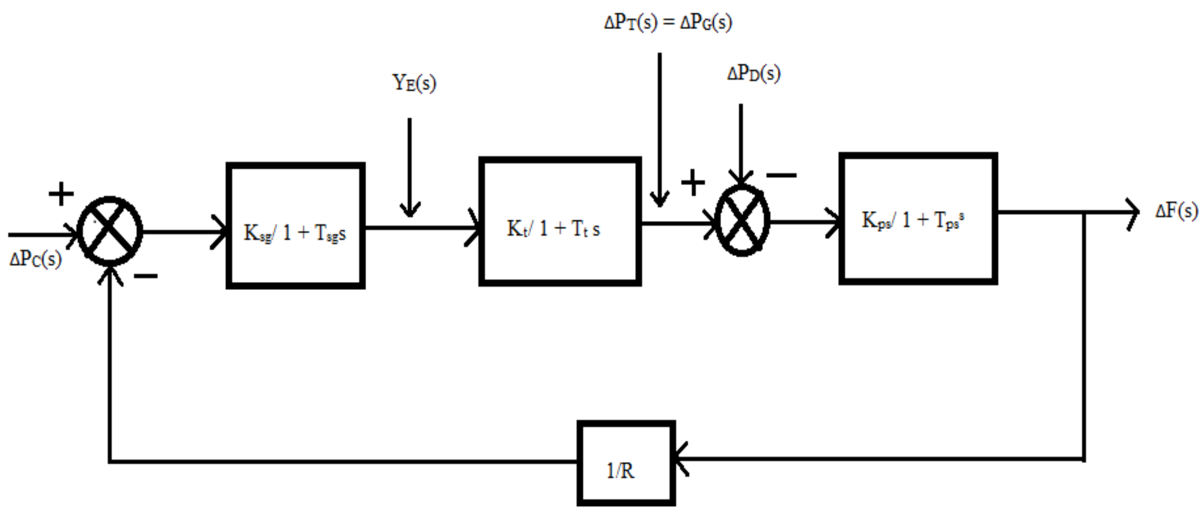


Figure 1.6: Complete Model of a Power System.

1.3.5 CONTROL AREA CONCEPT

There is only one turbo generator in a simple case which is used for supplying power to an isolated load but now days there are numbers of generating stations and load centers, so it is important for the utility companies to supply that much increase in power according to the consumer requirements. For proper scheduling and distribution of the generated electricity, the extended power system is divided into sub areas in which there is tightly coupling ogf the generators in order to form Coherent group. In coherent group, if there is change in load or speed changer settings then all the generators of the coherent group are to respond correspondingly.

Such a coherent group in which all the generators assumed to operate at same frequency in static and dynamic conditions is referred to as Control Area. Control area can be reduced to load system, single speed governor and turbo generator for the purpose of developing control strategies. Control Strategies can be developed for single area or multiple areas.

1.3.6 LOAD FREQUENCY CONTROL OF TWO AREA

A complete power system is divided into numbers of different sub areas and load frequency control areas which are then connected with one another by means of tie lines or there is interconnection between various areas for the proper utilization of the generated power. Figure describes a two area case in which the two areas are connected through tie lines without loss of generality.

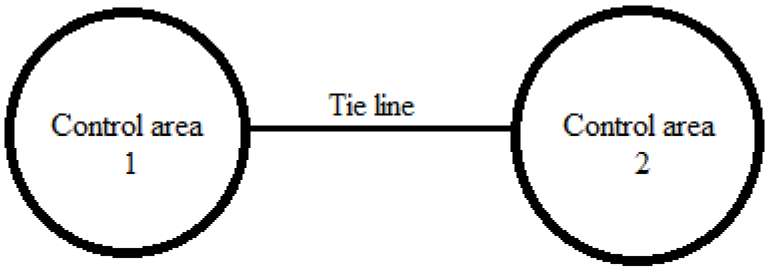


Figure 1.7: Tie-Line connection.

To regulate the tie line power as per inter-area power contracts and simultaneously to regulate the frequency of each area are the main objectives of the tie line interconnection. A proportional plus integral controller is installed in case of frequency so as to give zero steady state error in tie line power flow as compared to the contracted power.

Each control area is assumed to be consisting of an equivalent turbine; generator and governor system. Symbol use with suffixes 1 and 2 refers to area1 and 2 respectively. The incremental power (ΔP_G - ΔP_D) in an isolated control area case accounted for increase in the load area caused by increase in frequency and by rate of increase of kinetic energy. In an incremental power balance equation of each area, this fact must be accounted that a tie line supplies power out or in an area.

1.4 CONTROL OF GENERATION

There are basically three major objectives of the generator control system and are discussed as below:

- Hold the frequency of the system very or at close to a specified nominal value i.e. 50 Hz.
- Each generation units should be maintaining at the most economical value.
- Correct value of power interchange should be maintained between control areas.

1.4.1 NEED OF SUPPLEMENTARY CONTROL ACTION

We may assumed that there is only a single generating unit that is used for supplying load to an isolated power system in order to understand the above three objectives. Whenever a change in load occurs frequency also changes according to the change in magnitude that depends on the droop characteristics of the governor and frequency characteristics of the system load. Thus there is requirement of a restoring system called as supplementary control to restore the frequency to its nominal value i.e. 50 Hz for India. In figure a reset (integral) control is provided to the governor for accompanied this task.

By adjusting speed reference set point, the supplementary control reset action will force the frequency error to zero.

1.4.2 TIE LINE CONTROL

Tie line control is one of the important considerations, whenever the utilities companies have to interconnect their systems and they do this because of several reasons like to sell and buy power with the adjacent utilities whose operating cost are reasonable and profitable. Further it also supplies power to the other utility in case of generating loss and frequency variations thus helping to restore frequency. Tie line control system is having two parts of information i.e. net power which flows internally or externally over the tie line and second one is frequency of the system. Following things can be recognized by such a control scheme:

- An increase in load takes place outside the system whenever there is decrease in frequency and also there is increase in the net interchange power leaving the system.
- An increase in load takes place inside the system whenever there is increase in frequency and also there is decrease in the net interchange power leaving the system.

Following definitions are made in cases where there is increase in frequency

$P_{net\ int}$ = Total actual net interchange.

$P_{net\ int\ sched}$ = desired value of interchange.

$\Delta P_{net\ int} = P_{net\ int} - P_{net\ int\ sched}$

1.4.3 GENERATOR ALLOCATION

In simple case, the control area of an interconnected system consists of only a single generating unit which is sufficient to provide net tie line interchanges and frequency stability but in practical there are many generating units with output in a power system which is to be settled according to economics. Thus for this purpose there is addition of economic dispatch calculation to the control mechanism which led to know that about how much level of area control is required for each individual unit.

Since the load on the system varies according to consumer's need and desires, one should remember that for a long time there is no particular value of the total generation exists. Therefore it is almost impossible to do such quick calculations manually, which include calculation of economic dispatch for each unit and then give to the control mechanism such calculation become easier if there is use of computer based control systems these computer based control system, particularly an analog computer provides instantaneous calculation of allocation of generators and economic dispatch in an area by means of function generators set to equal the units incremental heat rate curves.

Over a range of total generation values the allocation of individual generator output is accomplished by using participation factors and base points. When the total generation is equal to sum of the present values of unit generation, there is execution of economic dispatch calculation and this calculation results in setting up a base-point generations whose value is equal to the economic output of each generating unit. Unit participation factor (pf) may be defined as the rate of ach unit output in accordance with change in total generation.

It should be noted that the sum of participation factor is unity. The generation allocation in a direct control scheme would be running through a computer code that was programmed according to the above equations.

1.4.4 FEATURES OF AUTOMATIC GENERATION CONTROL (AGC)

As we know that automatic generation control is most popular now a day for the frequency control of the interconnected systems. Some of its features are discussed as under:

1. Ramp control: At a specified rate of change in input, special logic allows the AGC to provide ramp to a unit from one output to another. In bringing units online and up to full output this technique is useful.

2. Telemetry failure logic: When there is fall in telemetry value, logic must be provided to ensure that the AGC will not take any wrong action. When this condition happens all the AGC actions are suspended in usual design.

3. Filtering of ACE: Changes in ACE may let to noises that are not desired by the generator units. For filtering out such random noises most of the AGC programs uses elaborate adaptive nonlinear filtering schemes.

4. Unit control modes: Manual, base load and regulating are the various special control modes are provided to many units in power systems which are not under full AGC control. For example regulating units and base loads are set according to their base load value but move according to assist action and are then store to base load value.

5. Unit control detection: Sometimes in case of lower raised pulses a generator unit will not respond and for overall control sake this logic must be taken into account by AGC. Suspended control logic should be provided to the units which are not following raised / lower pulses and thereby increasing the control action of AGC on other units also.

6. Rate limiting: in the design considerations of AGC it must be noted that all the units output in the system are not changing to rapidly. During fast load changes, AGC designs in such a way that it reduces the rate of change of this units and specially applied in case of thermal units where thermal and mechanical stress have to be reduced.

1.4.5 VARIOUS STATEGIES EMPLOYED FOR AGC

For employing the users with higher efficient amount of electric power is one of the most important considerations for distributing of the generated electric power. For connecting the various large power systems interconnections are provided and to ensure accurate transfer between these power systems, AGC is employed. There are various strategies which are employed for control purposes and some of them are discussed as below:

AGC STATEGIES BASED ON CLASSICAL APPROACH:

Major function in this approach is to design the closed loop properties in terms of loop which is opened. It mainly employs the use of control system designs such as Bode Plot, Nyquist, and Root Locus for solving the issues related to the AGC interconnected system. Any disturbance in the interconnected system like closed loop disturbance led to deviation of the frequency and large overshoot. Single input, single output (SISO) is said to be the chief difficulty in this type of schemes. The problem of interconnected area in AGC using regular and non-regular mode can be briefly studied by M.L. Kothari.

AGC STATEGIES BASED ON MODERN APPROACH:

With the increase in population rate requirement for electricity on the daily basis is raised up and the classical approach for AGC therefore cannot handle this increase in demand or the modern power system which has multiple inputs and multiple outputs refer as MIMO. Thus various control strategies are used for the efficient working of modern power system and some of them are discussed as below:

- AGC STATEGIES BASED ON OPTIMAL CONTROL: Multivariable problem is solved by using the AGC strategy based on optimal control. In this scheme AGC regulator based on optimal technique have been developed by various scientists. In order to estimate the requirement of demand an algorithm based on the performance index for AGC regulators is developed by M.L. Kothari and J. Nanda and response of the reheat system in a two area interconnected system is taken into consideration for designing of optimal feedback controller by K.P.S. Parmar.

- AGC STRATEGIES BASED ON CENTRALISM SYSTEM: Centralized strategy was the early one which is employed in the LFC system and it works according to the class of transients. A state variable model is developed by using new feedback control in order to estimate those disturbances and it is suggested by Elgerd and Fosha.

- AGC STRATEGIES BASED ON DE-CENTRALISM SYSTEM: The main problem with the centralized systems are that they are not able to transfer information in very far way geographical control areas due to their complex storage. In order to understand this category of control scheme many papers have been developed for regular and non-regular power plants which are of bigger capacity. There is development of simple PI controller for excellent working of the LFC system by Aldeen and Marah. In order to improve the efficiency of multiple connected areas, a decentralized controller based on robust technique is developed.

- AGC STRATEGIES BASED ON SELF-TUNING AND ADAPTIVE: In order to obtain the efficient control scheme and performance of the system on the basis of optimal form, it is important to maintain the track of the operating point in the today's power system which is quite a difficult task. In order to achieve this task of maintaining the track of operating point adaptive control scheme is developed. For investigation of the multiple connected areas an algorithm based on multilevel adaptive type has been developed.

- AGC STRATEGIES BASED ON INTELLIGENCE: Robust techniques are required by the bigger power plants for construction and reshaping. Many computing based technique are employed now days for overcoming these problems in the AGC interconnected systems. These techniques involved PSO, Fuzzy logic, Genetic algorithms and many more. Various controllers based on these techniques have been developed in order to ensure the proper working of the interconnected power systems.

CHAPTER 2

LITERATURE SURVEY

Proper utilization of the generated power is required in this modern world for satisfying various need of the consumer and for this purpose proper scheduling of the equipment of required. In a literature review of this thesis report, I studied many papers regarding to automatic generation control using two areas, multiple connected areas and particle swarm optimization technique applied in automatic generation control. Some of the papers are discussed below:

[1] M.L.Kothari , J.Nanda, D.P.Kothari and D.Das [1989], Discrete mode AGC of two area reheat thermal system with New Area Control Error. This paper manages discrete mode AGC of an interconnected warm framework considering a New Area Control (ACEN) taking into account tie-power deviation, recurrence deviation, time slip and unintentional exchange. Ideal basic and relative fundamental controllers utilizing the idea of security edge and ISE system have been acquired with traditional ACE and NEW ACE and their element execution analyzed for a step load unsettling influence. The controller in light of new AGC insurances zero enduring state slip of incidental trade and time mistake aggregations which is so coveted dissimilar to if there should be an occurrence of controller in view of routine ACE. PI controller gives better reaction as looked at than different controllers.

[2] H.L. Zeynelgil, A. Demiroren, N.S. Sengor [2001], The application of ANN technique to AGC for multi-area power systems. This article contributes a use of layered Artificial Neural Controller (ANN) to study Automatic Generation Control (AGC) issue in a four territory interconnected force frameworks that has three zones incorporates steam turbines and different territories incorporates a hydro turbines. The warm impact of steam turbine is display on every region of steam turbine in the framework and the zone of hydro turbine incorporates upper and lower obliges of generator rate. The inputs of every zone in the force framework together are utilized by proliferation through time calculation execution of ANN controllers is high and vastly improved than traditional controllers when results for both cases are analyzed.

[3] Hossein Shayeghi and Heider Ali Shayanfar [2004], Automatic Generation Control (AGC) of interconnected power system using ANN technique based on µ-synthesis. This paper is in view of µ-combination for AGC of force frameworks vicinity in non-direct Artificial Neural Networks (ANN Controller). Because of multi variable burden/working conditions and burden changed force frameworks and mechanical arrangements have a few instabilities and deviations and because of this reason, the thought of µ-combination hypothesis is utilized as a part of configuration of ANN controller. The inspiration of utilizing µ- based hearty controller for preparing the proposed controller is to consider the vast parametric instabilities and demonstrating mistake in such a path, to the point that both the strength of the general framework and great execution have been attained to for a permissible vulnerabilities. The ANN controller is viable and gives great element reaction even in the vicinity of Generation Rate Constraints (GRC) is indicated amid the recreation of two zone power frameworks. ANN controller is better than the routine PI and μ-based vigorous control.

[4] K.S.S.Ramakrishna, Pawan Sharma and T.S. Bhatti [2010], the Automatic Generation Control of interconnected power system with diverse sources of power generation. In this paper, AGC of two interconnected force framework with different wellsprings of force era is examined. AGC of two regions power framework having force era from hydro, thermal and gas sources in region one and from hydro and warm in territory two have been considered. Speed governors prepared all the force era units from diverse sources. For the investigation of element reaction for little hub aggravation a nonstop time exchange capacity model of the framework is being spoken to. Power era from warm and gas sources can be just gotten by applying a Proportional Integral Derivative (PID) programmed era control plan. With just speed representative control, power era from hydro source is permitted to work at its planned level. For diverse ostensible stacking condition the two territory power framework is reenacted. Hereditary Algorithm (GA) is utilized to acquire the optical PID picks up for different cases utilizing necessary square blunder in addition to essential time supreme mistake (ISE+ITAE) execution record for wellness development. Because of step unsettling influence in the framework a portion of the transient reactions are demonstrated for troublesome ostensible stacking conditions.

[5] Swasti R Khuntia and Sidhartha Panda [2010], Comparative Study of Different Controllers For Automatic Generation Control of an Interconnected Hydro-Thermal with Generator Rate Constraints. This paper relates us with diverse sorts of controllers like Conventional necessary, fuzzy and cross breed neuro-fuzzy for AGC interconnected framework. Essentially this paper prompted utilization of different generator rate requirements that are utilized with a specific end goal to enhance transient execution after the aggravation in an interconnected framework. Reenactment results demonstrates to us that execution of the interconnected framework with most recent form of half and half neuro-fuzzy issues us more precise results when contrasted with traditional ones.

[6]Akansha Sharma, K.P. Singh Parmar and Dr. S.K. Gupta [2012], Automatic Generation Control of multi-area power system using ANN controller. In this paper for AGC of a five interconnected force framework with warm turbines and Artificial Neural Network (ANN) base controller is exhibited. Relentless state slip of the zone frequencies and unintentional trade of tie lines are kept up in a given resistance level assurances the control plan. The data of every zone in the force framework is controlled by ANN controller. In this study for neural system learning governs back engendering is spent by contrasting and ordinary basic controller execution of the force framework is assessed. ANN controller gives numerous proficient and viable results when contrasted with that of essential controller.

[**7] Naimul Hasan, Ibraheem and Shuaib Farooq [2012],** Real Time Simulation of Automatic Generation Control for Interconnected Area. This Paper presents the working of the controller in the real time environment by considering the two areas which are not even matching at all and are connected by an EHVAC transmission line. In order to test the algorithm in conditions where it really works, we firstly designed a digital controller depending upon the sampling time in a non-real environment and then convert it into real environment. Thus, the discrete controller is employed in order to check the performance analysis of AGC system in real working conditions.

[8] Naimul Hasan [2012], an overview of AGC strategies in power systems. This paper exhibits a thorough writing survey of methods of insight of programmed era control (AGCs of force framework) . The article perspective is to highlight the different control and auxiliary parts of AGC utilized as a part of force framework. Taking into account power framework models and control procedures AGC plans are checked on. Deal with AGC has likewise been audited by consolidating parallel ACE-HVDC connects as framework interconnection. In this paper work reported in the writing in the zone of AGC has been seen basically.

[9] Ibraheem and Omveer singh [2012], Design of PSO based AGC regulator with different cost functions. This paper concerns the tuning parameters of three regions interconnected force arrangement of AGC. With corresponding necessary (PI) controller regions of the force framework comprises of warm turbines. To streamline the controller parameters PSO calculation has been connected to it. In view of variety in Area Control Errors (ACES) of every last one of regions viability of distinctive expense work through PSO is examined. Some expense capacities like Integral Square Error (ISE), Integral Absolute Value of the mistake (IAE), and Integral Time Multiplied Square Error (ITSE) are examined. Execution of the proposed streamlining calculation is contrasted and conventional Zieglor Nichols (ZN) strategy for the AGC issues.

[10] Mukta and Balwinder Singh Surjan [2013], Load frequency control of interconnected power system in deregulated environment: A Literature Review. This article shows the procedure and requirements used to obtain Grid Stability. In the Grid Stability, AGC, requirement for intelligent controller, grid stability requirements, fuzzy logic controller and interconnected system and high voltage HVDC transmission are discussed with their own usage.

[11] P. Subbaraj, K. Manickavasagam [2013], Automatic Generation Control (AGC) of Multi-Area Power System with Generator Rate Constraints Using Computational Intelligence Techniques. In a substantial between associated frameworks, huge and little creating stations are synchronously joined and thus all stations must have the same frequency. The framework recurrence deviation is the delicate marker of realpower unevenness. The fundamental destinations of AGC are to keep up constant frequency and tie-line mistakes with in endorsed breaking point. This paper shows two new methodologies for Automatic Generation Control utilizing i) joined Fuzzy Logic and Artificial Neural Network Controller (FLANNC) and ii) Hybrid Neuro- Fuzzy Controller (HNFC) with gauss enrollment capacities. The reproduction model is made for four-territory interconnected force framework. In this four range framework, three ranges comprise of steam turbines and one zone comprises of hydro turbine. The parts of ACE, recurrence deviation (_F) and tie line lapse (_Ptie) are acquired through reproduction model and used to deliver the obliged control activity to accomplish AGC utilizing i)FLANNC and ii) HNFC with gauss enrollment capacities. The reenactment results demonstrate that the proposed controllers conquer the disadvantages connected with routine necessary controller, Fuzzy Logic Controller (FLC), Artificial Neural Network controller (ANNC) and HNFC with gbell participation capacities.

[12] Jeevithavenkatachalam, Rajlaxmi.S [2013], AGC of two area interconnected power system using Particle Swarm Optimization. PSO has been effectively connected to tune the parameters of AGC arrangement of the indispensable and fundamental in addition to corresponding sort. Two range are warm framework was accepted to show system. The indispensable square of the mistake (ISE) and essential of time reproduced total estimation of slip (ITAE) were utilized as target capacities. The prevalence of the ITAE in the damping and setting of transient reaction was illustrated. The outcome demonstrates that proposed PSO controller is having enhanced element reaction in the meantime speedier than customary one.

[13] Geoffrey Eappen and Dr.Sandeep Bhongade [2013],Optimized Automatic Generation control scheme including SMES in an interconnected power system. In this paper by utilizing molecule swarm enhancement (PSO) in a two territory framework an endeavor had been made to control recurrence deviations. PSO systems and GA both are contrasted and each other. Examination of AGC with vitality stockpiling unit like super leading attractive vitality stockpiling framework has been examined in this study. PSO has been utilized around advance the parameters of super leading attractive vitality stockpiling unit to get better result. Contrasted and hereditary calculation (GA) the proposed technique was without a doubt more proficient and vigorous in enhancing the step reaction of an AGC framework.

[14] Omveer singh, Prabhakar Tiwari, Ibraheem and Arunesh Kr. Singh [2013], A Survey of Recent Automatic Generation Control Strategies in Power Systems. This article contributes towards the general circumstance of AGC plan which have been report in writing. In this article an endeavor is made to show writing audit and a late and completely far reaching rundown on AGC of force framework. In light of systems and parameters AGC plan is examined. Concerning the AGC issue different control methods have been highlighted. Itemized and cautious examinations on AGC framework fusing RES, offbeat tie lines and deregulated situations have been investigated. In conclusion taking into account variable structure, powerful, versatile, self-tuning, advanced/discrete and keen control AGC techniques have additionally been incorporated. It not just incorporates late and advanced method in view of ahead of schedule phases of improvement of AGC techniques. GA, PSO, ACO, ANN are critical methodologies of keen techniques and mixture models of the application to plan AGC of force framework are distinguished.

[15] Naresh Kumari and A N Jha [2013], Effect of Generation Rate Constraint on load frequency control of Multi-Area Interconnected Thermal Systems. This article contributes towards the general circumstance of AGC plan which have been report in writing. In this article an endeavor is made to show writing audit and a late and completely thorough rundown on AGC of force framework. Taking into account routines and parameters AGC plan is talked about. Concerning the AGC issue different control procedures have been highlighted. Itemized and cautious examinations on AGC framework fusing RES, non-concurrent tie lines and deregulated situations have been investigated. In conclusion in light of variable structure, strong, versatile, self-tuning, advanced/discrete and savvy control AGC methodologies have likewise been incorporated. It not just incorporates late and current strategy in view of right on time phases of advancement of AGC procedures. GA, PSO, ACO, ANN are imperative methodologies of wise strategies and half and half models of the application to outline AGC of force framework are recognized.

[16] Naresh Kumari and A N Jha [2013], Particle Swarm Optimization and Gradient Descent Methods for Optimization of PI Controller for AGC of Multi-area Thermal-Wind- hydro Power Plants. In this paper both the methods i.e. PSO and GD are utilized keeping in mind the end goal to enhance the execution investigation of AGC associated framework. Essentially a PI controller is composed on the premise of these two strategies for the three deficient ranges which are specified in the paper. In the greater part of the traditional routines Integral Square blunder Technique and numerous more utilized for determination of parameters for AGC, they utilized hit and trail strategy which is drawn out. In this way, PI controller in view of PSO procedure issues us quick reaction and element execution of the framework is likewise enhanced by the utilizing Gradient Descent method and for reenactment purposes MATLAB is utilized.

[17] Kirpal Grag and Jaspreet Kour [2014], Particle Swarm Optimization based Automatic Generation Control of Two Area Interconnected Power System. The recurrence and tie-line force of control territories are being aggravated from their planned quality which is undesirable this happens because of the nonstop change in burden. With a specific end goal to adjust produced power and request in every control territory so as to keep up the framework recurrence at ostensible esteem and tie line power at its planned worth, a crucial system in electric force is required i.e. AGC. This adds in enhancing a precise and quick acting controller to keep up consistent ostensible estimation of recurrence. Indispensable (I) and Proportional Integral (PI) are indicated and have absence of productivity in taking care of framework lapse that is the reason they are the confinements of customary controllers. Prior, For AGC of two territory interconnected force framework controller utilized were Integral (I) and Proportional Integral (PI). Presently PSO based controllers are utilized and different reactions because of different controllers have been looked at in MATLAB reenactments exhibits the reaction of the proposed systems. The top overshoot and setting time is diminished if there should arise an occurrence of PSO based controllers.

[18] Parag Chourey, yogesh Manekar and Aushtosh Kashiv [2014], Optimization of AGC PID Controller with reheat in two area system using BB-BC. In the current situation of Indian power system, biggest challenge is to maintain the frequency at nominal value (i.e. 49.70 to 50.20 Hz). Frequency is called as controlling parameter for any power system which shows the load versus generation balance. Right now in Indian power system RGMO/FGMO scheme is being used up which maintains frequency in the required range. In this report, for thermal generator unit with reheat system to optimize the PID controller gains, techniques applied on single and double area of AGC is Big Ban, Big Crush optimization. After the development of UI rate in India, every power sectors of India are well aware of controlling frequency for that purpose optimization of governor output becomes more important. To study the AGC for controlling the frequency distribution MATLAB model of thermal unit with reheat system is used. In this paper Big Bang, Big Crush algorithm is used to obtain the optimum design of controller for AGC system.

[19] Ibraheem and Omveer Singh [2014], Current Philosophies of Intelligent Techniques based AGC for interconnected Power Systems. This paper demonstrates the operation and control of complex interconnected force frameworks with Automatic Generation Control (AGC). Operations of interconnected force framework, the control capacities utilized at diverse control levels are dead set and talked about keeping in view the present situation of force frameworks in India. Late change in control procedures like the utilization of keen system is considered in the force framework. Indian power frameworks operational and control rationalities are compressed considering the AGC examination finished in the range of AGC is exhibited.

[20] Asma Aziz, Amanullah Mto, Alex Stojsevski [2014], AGC of Multi generation power system. Everywhere throughout the globe Load Frequency Control (LFC) is utilized for a long time as a feature of AGC in force framework. In a blended force framework, it is utilized to discover a zone directed by hydro era interconnected to another region managed by warm era or ignition of both. In this study, on the premise of how recurrence inclination setting impacts AGC reaction and in attentive trade, execution of AGC for Thermal, hydro and warm turbines based force framework is analyzed. MATLAB Simulink programming aides in recreation and investigation of controller essential total slip has been utilized as execution model. Speedier streamlining of controller addition can be accomplished by essential tine supreme mistake

(ITAE) as execution list.

[21] Priyanka Sharma [2014], AGC Strategies- A Review. Literature review of control scheme for AGC of power system is discussed in this paper. LFC issues are concerned by the different setups of force framework models and control ways. Ultimately in view of different structures, hearty, versatile, self-tuning and shrewd control AGC systems have likewise been consolidated. This paper reports the work in writing in the territory of AGC has been surveyed discriminatingly.

[22] Lalit Chandra Saikia, Asmita Paul, Puja Dash, N.B. Dev Choudhury [2014], AGC of an Interconnected Multi-Area Hydrothermal System Using A neuro- Fuzzy Controller. This paper manages programmed era control of a multi-range hydro-thermal area. The exhibitions of some usually utilized traditional controllers are analyzed and dynamic exhibitions are contrasted with acquire the best. A three info neuro-fuzzy controller is proposed without precedent for the framework. Examinations uncover that the three data neuro-fuzzy controller gives preferable execution over two inputs controller. The execution of the three data neuro-fuzzy controller has been contrasted and that of the best regularly utilized established controller, which uncovers that the neuro-fuzzy controller is better. The strength of the three information neuro-fuzzy controller has been tried for distinctive stacking. Correlation of the element reactions of neuro-fuzzy controller and the best established controller at distinctive stacking conditions likewise uncover the predominance of the proposed neuro-fuzzy controller.

CHAPTER 3

PROJECT WORK

3.1 PROBLEM FORMATION

As we know the demand of electricity is increasing day by day due to the increase in consumer's needs and desires, so it is essential for the electrical utilities companies to generate power in bulk amount. The generated power should be transferred without losses from one place to another but in practice it is not possible because of various conditions like sudden load change, generation loss, switching operations etc. Also there is presence of active and reactive power which is not steady in nature and continuously changes with rising or falling trend.

In this thesis work, we mainly considered about the frequency changes and how it restore to its desired value. As we know frequency of a power system wholly depends upon the speed at which the generators are rotated by their prime movers. Therefore frequency control is basically a matter of speed control of machines in the generating stations. Prime movers of all the turbines like steam or hydraulic are provided with speed governors in order to control the speed (frequency) at rated value.

In the AGC interconnected system with two areas, varieties of AGC schemes are employed like control, optimal, self-tuning and adaptive, intelligent. These schemes are usually employed in order to decide the parameters of the controllers and then this controller is employed in the model to ensure less deviation of the frequency from its set value and also to ensure proper transferring of power between the two interconnected areas.

Numerous types of controllers like PI, PID and Conventional controllers are provided to ensure proper working of the system which is interconnected but the problem related to these controllers is that they are very lazy in handling the disturbances which occurs in the system due to various conditions. Thus to avoid the problem related to these type of controllers, a controller is designed on the basis of PSO technique which proven to be perform better than these one's.

3.2 OBJECTIVES

In India, we know that the normal operating frequency is 50 Hz and if the system is subjected to various sudden changes like load changes, generation loss it lead to change in frequency i.e. either increase or sudden decrease in frequency. In both the cases change in frequency causes various hazards to the operating system like damage of various equipment in the power system and also effects the relation between frequency and motor speed. Maximum tolerance level up to which frequency changes does not harm the system is ±1% and beyond this level system becomes unstable. Thus main objective of this work is to maintain the frequency at nominal value and some other points are enlisted as under:

- To design a controller based on optimized parameters which are obtained from Particle Swarm Optimization (PSO) algorithm. These parameters restrict the value of frequency to a set value or almost constant value against any variation in load demand.

- After designing the parameters based on PSO technique for controller, model is simulated using MATLAB SIMULINK

- Check the results with and without controller.

- Power flow in each area which is connected by a tie-line must be maintained to its set value.

- Minimizing the error which occurs in the system.

3.3 RESEARCH METHODOLOGY

3.3.1 Particle Swarm Optimization Technique (PSO) - Introduction

Basically Particle Swarm Optimization is a technique which can be employed for various fields of engineering like electrical for developing of efficient controllers and also in computer engineering field. In both the fields, solution of a given problem is optimized and a best possible solution is suggested from number of possible solutions in order to meet the desired characteristics in a power system. This PSO technique worked on the problem by considering the particle’s position and velocity from the number of possible solutions.

Based on the movement and clustering of birds and fishes, Eberhert and James Kennedy in 1995 give the concept of Particle Swarm Optimization (PSO). It usually employs the problem with a solution based on the societal communication. The main aim of the scientists is to check the behavior, movement and gathering of birds and fishes around the food items and then start developing an algorithm which is basically a computer based software simulation. The basis of PSO is group cleverness and its effort of moving for a particular food source and finding the more efficient and quick way to the food items. It is a computational evolutionary idea for exploring the space which is to be searched.

Although PSO is very easy algorithm but it sounds very complex in some aspects. Various enhanced problems like non-regulating, loud and time changing are overcome by using PSO method for optimization. A flock of variables may have their own values adjusted closer to the member whose value is closest to the target at any given moment at the end of numerous iterations. Suppose a source of food is smelled by a gathering of birds which is out of sight is considered as an example for the description of the PSO technique. There is swinging of birds in the direction of the bird's sound which is nearby to the food. Bird's sound becomes more and louder if another group of birds came closer to the food item. Therefore, it is very modest and confortable to employ PSO as an algorithm. As in PSO technique very less amount of parameters are to be adjust so it is said to be very appealing technique in order to employed for AGC connected system.

There are usually three global variables of which this algorithm is to be taken into consideration:

- Target conditions or values.
- Global best ($G_{best)}$ is used to determine the particle which is presently nearer to the goal or target.
- If the target isn't found, the algorithm is stopped with the help of stopping value.

Each particle in the PSO technique may comprise of:

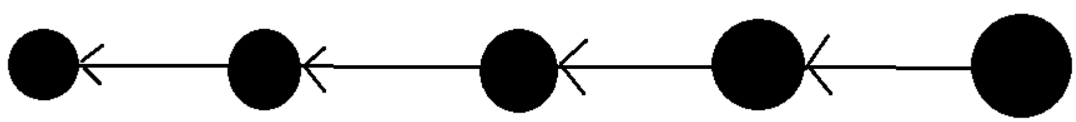
- A possible solution is represented by the data.
- How much there is change in data is indicated by the velocity value.
- A Personal best ($P_{best)}$ value indicating the closest the particles data has ever come to the target.

X, Y, Z consider to be the coordinates of each bird in the above description of gathering of birds and considering to be the particle information. The individual coordinates of each bird tries to move closer to the other coordinates of birds which is closer to the foods coordinates ($G_{best).}$ When a data is pattern or sequence then the data is manipulated of the individual pieces with the pattern matches the target pattern.

On the basis, how far an individual's data is from the target the velocity value is calculated. The value of velocity totally depends on the distance it is. Farer it is velocity will be larger and vice – versa. In the example of flocking of birds, the individuals farthest from the food would make an effort to keep up with the other by flying faster toward the global best bird. When the data is a pattern or sequence then how different the pattern is from the target is discussed and thus to match the target how much it needs.

P_{best} value of the particle only indicates that how much data is come closer to the target since the algorithm started. When any particle P_{best} value comes closer to the target than only the G_{best} value changes. G_{best} value gradually moves closer and closer to the target until one of the particles reach the target at each end of the iteration value in the algorithm.

A PSO algorithm commonly uses the population topologies or neighborhoods, which can be the smaller, localized subjects of G_{best} value. There are two or more than two particles in neighborhoods which are predetermined to act together, or subjects of the search space. Use of this neighborhood would help the algorithm to not get struck in local minima.



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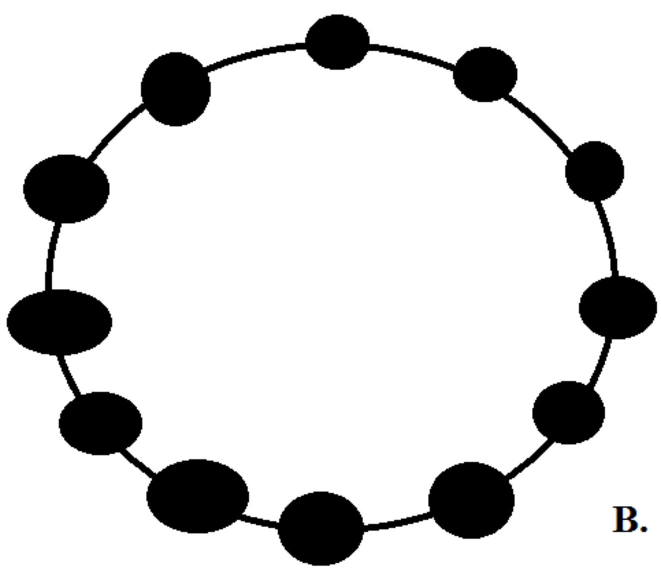

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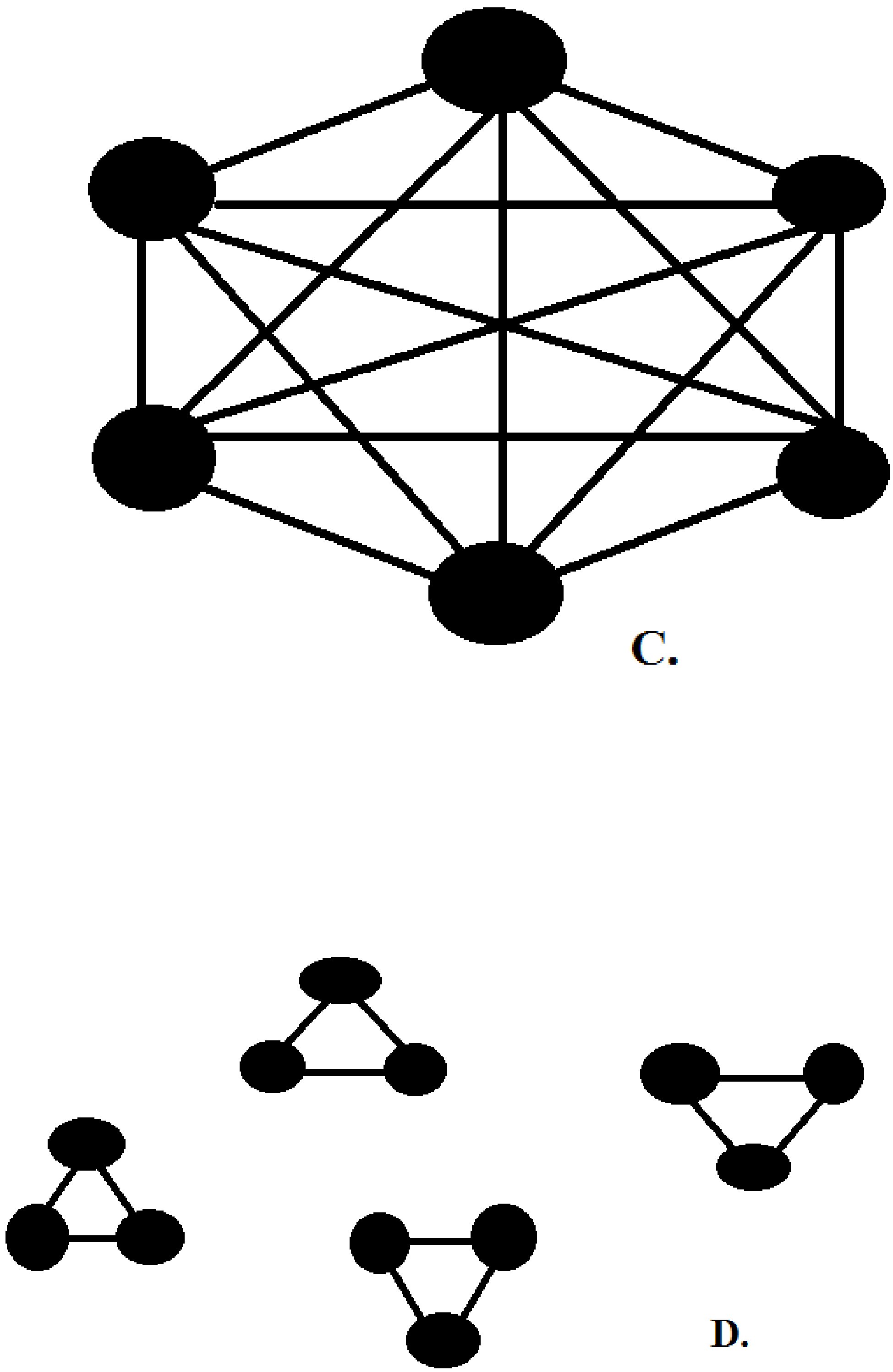


Figure 3.1: A Common Population Topologies (neighborhoods).

3.3.2 BASIS OF PSO:

PSO is in view of two basic orders: social science and software engineering. Also, PSO utilizes the swarm intelligence concept, which is the property of a framework, where by the aggregate practices of unsophisticated operators that are interacting locally with their surroundings make familiar to worldwide useful examples. In this manner, the foundations of PSO can be depicted as takes after.

- **Social Concepts:** It is known that "human intelligence results from social interaction." Evaluation, comparison, and imitation of others, as well as learning from experience allow humans to adapt to the environment and determine optimal patterns of behavior, attitudes, and suchlike. In addition, a second fundamental social concept indicates that "culture and cognition are inseparable consequences of human sociality." Culture is generated when individuals become more similar due to mutual social learning. The sweep of culture allows individual to move towards more adaptive patterns of behavior.

- **Principles of Swarm Intelligence:** There are five basic principles on the basis of which swarm intelligence can be described and are enlisted as below:

  Proximity Principle: The populace ought to have the capacity to do basic space and time calculations.

  Quality Principle: The populace ought to have the capacity to react to quality considers the environment.

  Diverse Resource Principle: The populace ought not to confer its action along exorbitantly limited channels.

  Stability Principle: The populace ought not to change its method of conduct each time the earth environment changes.

  Adaptability Principle: The populace ought to have the capacity to replace its conduct mode when it is justified regardless computational cost.

In PSO, the expression "particles" alludes to populace individuals which are mass-less and volume-less (or with a discretionally little mass or volume) and are liable to speeds and increasing velocities towards a superior method of conduct.

3.3.3 VARIANTS IN PSO TECHNIQUE

Various variations of even an essential PSO calculation are conceivable. Case in point, there are diverse approaches to introduce the particles and speeds (e.g. begin with zero speeds rather), how to hose the speed; just upgrade pi and g after the whole swarm has been upgraded, and so on. New and more refined PSO variations are likewise persistently being acquainted in an endeavor with enhance enhancement execution. There are sure patterns in that exploration; one is to make a half and half improvement system utilizing PSO consolidated with different enhancers, e.g., the fuse of a successful learning strategy. Another exploration pattern is to attempt and lighten untimely merging (that is, enhancement stagnation), e.g. by switching or bothering the development of the PSO particles.

3.3.4 PARAMETER, NEIGHBOURHOODS AND TOPOLOGIES IN PSO

- Choosing of parameters in a PSO technique is considered to be very important in order to fulfill the desired need of the interconnected area and have great effect on the parameter design. A meta-optimization concept is used for deciding the parameters of controller for optimal purposes and for various research works.

- Local Minima can easily trap the PSO technique. The term Topology is defined as the set of relations which builds graphs, communication networks in order to transfer the information between the two interconnected systems.

3.3.5 PSO EMPLOYED WITH OTHER COMPUTATIONAL TECHNIQUES

There are various other computational techniques which are sometimes employed by AGC in comparison with Particle Swarm Optimization (PSO) and are enlisted as under:

- **PSO and Genetic Algorithm (GA) are distinguishes as:** GA basically relates with crossover, mutation of the particles and internal velocity which led to updating of the particles internally whereas PSO doesn't have such processes. These particles have memory which is essential for the algorithm to work out. PSO shared different information technique as compared to GA, as in GA information is transferred according to chromosomes exchange and in PSO information is transferred by considering the G_{best} value of the particles i.e. only best value is chosen.

- **PSO and Artificial Neural Networks (ANN) are distinguishes as:** whenever we considered the structure of the brain and the back propagation algorithm, it led to the development of Artificial Neural networks. Involvement of one or more than one features for Artificial Neural Networks which led to the development of the evolutionary methods for computations. For more accurate and high speed results most of the papers exchange the back propagation with PSO technique. This technique also avoids the disturbances which occur in GA technique. Thus PSO is considered to be the more efficient technique for deciding the parameters for controller design.

3.3.6 GENERAL PSO ALGORITHM

The two main equations of the PSO algorithms are given as below:

1. Velocity Modified Equation

$$V_i^{k+1} = W\,V_i^k + C_1 rand_1 \times (P_{besti} - S_i^k) + C_2 rand_2 \times (G_{besti} - S_i^k)$$

Where, V_i^k = Velocity of agent I at iteration k

W = Weighing function.

C_1 = Weighing factor.

$rand_1$ = Random number between 0 and 1.

P_{besti} = P best of agent i.

G_{besti} = G best of the group.

S_i^k = Current position of agent I at iteration k.

First term: $W\,V_i^{k+1}$ are the inertia component responsibility for the movement of paticle in the direction it was previously heading “W” has a vital impact on speed of its value and is less than speed up the convergence otherwise encouraging the exploration.

Second term: $C_1 rand_1 \times (P_{besti} - S_i^k)$ is the cognitive component acts as a particle memory.

Third term: $C_2 rand_2 \times (G_{besti} - S_i^k)$ is the social component which is the reason why the particle move to best region found safer by the swarm.

Once the calculation for velocity of each particle is done then the position can be updated using equation of position modification.

2. Position Modification Equation

$$S_i^{k+1} = S_i^k + V_i^{k+1}$$

Where, S_i^{k+1} and S_i^k represents modified and search points respectively.

And, V_i^{k+1} = Modified velocity.

This process is repeated until and unless some stopping criteria are applied.

3.3.7 FLOWCHART OF PSO ALGORITHM

General flowchart for the PSO algorithm is shown as under:

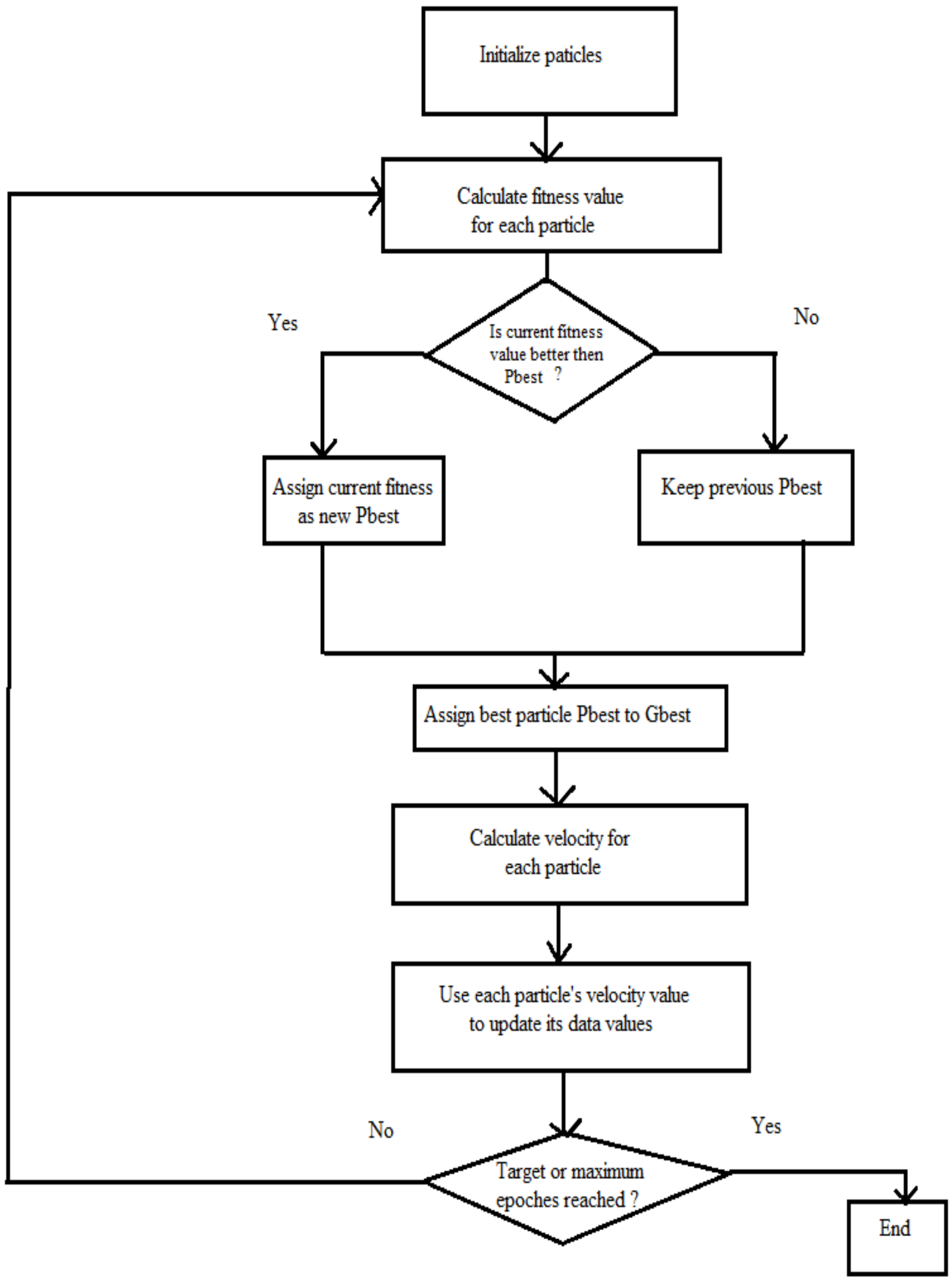


Figure 3.2: Flowchart.

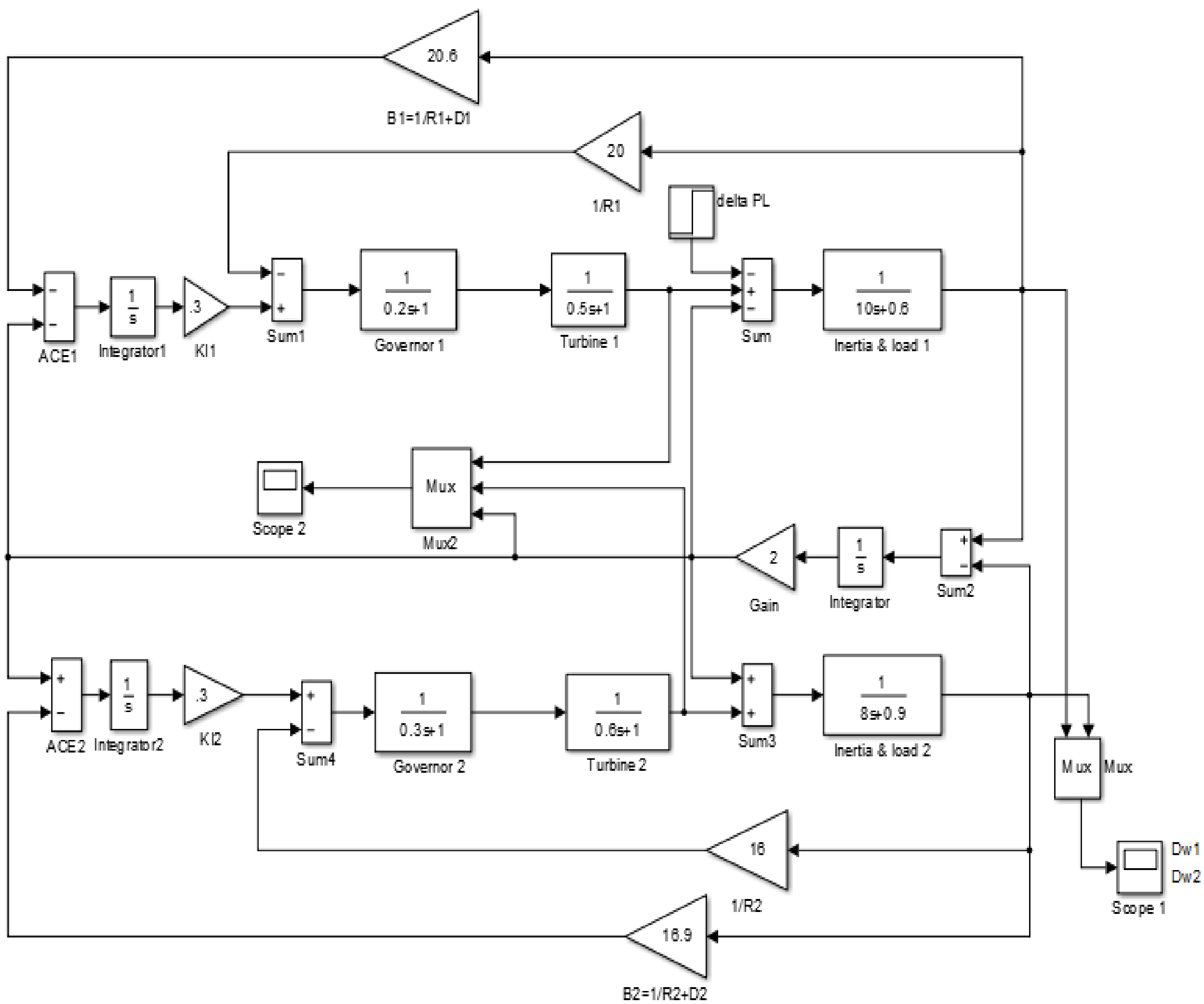
CHAPTER 4

RESULTS AND DISCUSSIONS

The response of the controller based on the Particle Swarm Optimization Technique (PSO) is designed and results are found out with the help of MATLAB/SIMULINK tool. Automatic Generation Control Of the two interconnected areas is required in order to improve the efficiency, frequency deviations due to change in load and to maintain the tie line power over the connected areas.

1. MODEL OF TWO INTERCONNECTED AREA

In this model, we consider two areas which are connected with the help of a tie line connection shown as:



2. DECIDED PARAMETERS:

Parameters decided for the particular areas i.e. area-1 and area-2 on the basis of PSO technique are given in the table as:

PSO parameters	B_1	R_1	Ki1	T_{sg}	T_{st}
Area-1	20.6	20	0.3	0.2	0.5

Table 4.1: PSO based parameters for Area-1.

PSO parameters	B_2	R_2	Ki2	T_{sg}	T_t
Area-2	16.9	16	0.3	0.3	0.6

Table 4.2: PSO based parameters for Area-2.

3.2 SIMULATION RESULTS:

After the modeling of two interconnected area i.e. after the deciding of the controller parameters based on the proposed scheme it can be seen that the frequency deviations in the system due to change in loading conditions can be reduced to large extent and power through the tie line is also maintained.

- **RESULTS WITH AND WITHOUT CONTROLLER**

  In the below graph, we can see that whenever variation i.e. change in load occurs occurs in the interconnected area, there must be large frequency deviations. However, after the implementation of controller based on proposed schemes these frequency deviations are seen to be in lesser amount.

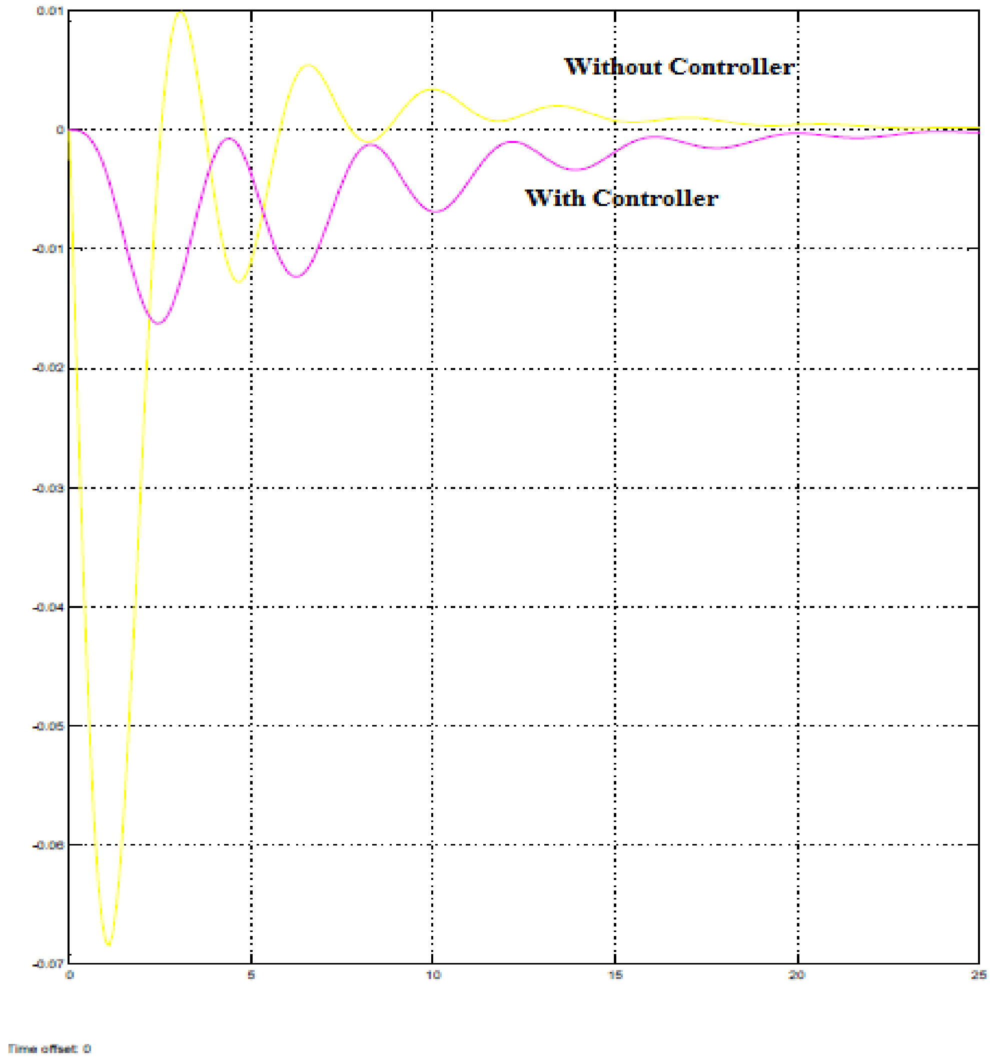


Figure 4.1: Simulation results with and without controller.

- **RESULTS WHEN SUDDEN CHANGE IN ONE OF THE AREA OCCURS**

Below figure gives us the simulation results of an interconnected area, whenever sudden disturbance or transient in one of the area occurs due to generation loss and frequency deviations can be minimized when controller based on proposed scheme is applied.

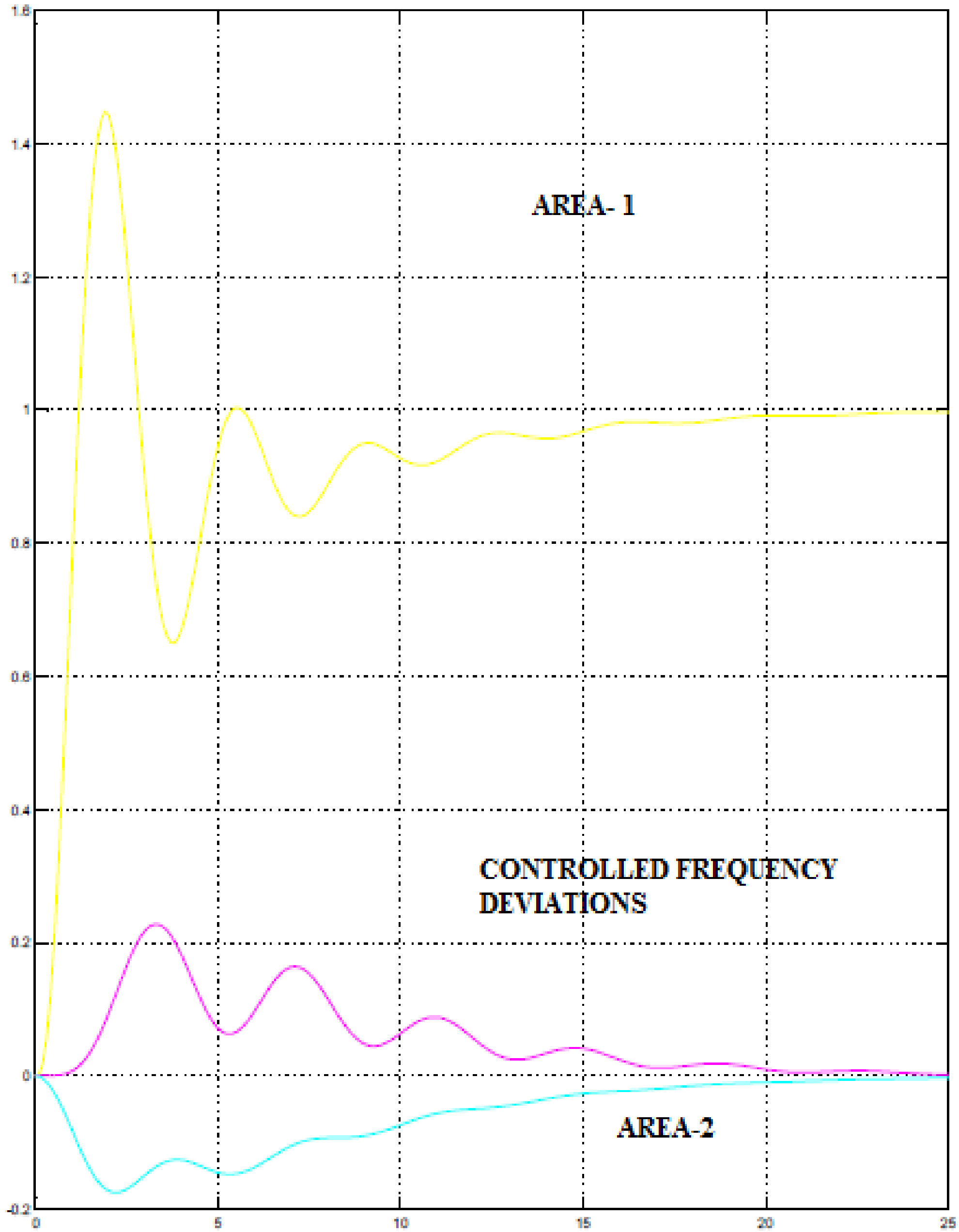


Figure 4.2: When change occurs in one of the area.

CHAPTER 5

CONCLUSION

In this thesis work, a controller based on Particle Swarm Optimization Technique (PSO) is designed and results are analyzed with the help of MATLAB/ SIMULATION in order to justify the proposed scheme.

- Initial step is to consider two areas which are connected with the help of a tie-line.
- By applying proposed scheme, optimized parameters of the controller are decided.
- Then, Model of the two interconnected areas is developed with the help of MATLAB.
- Results are taken with and without the use of controller and shows that with controller the frequency deviations are prone to be less for the interconnected areas.

FUTURE SCOPE

In this work, only PSO algorithm is applied in order to study the generation optimization of two areas. Along with the PSO algorithm some another suitable algorithms can also be employed in order to design a controller. Moreover, this can also be employed for multiple connected areas.

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