# AUTOMATIC GENERATION CONTROL USING GENETIC ALGORITHM

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***Abstract:*** *The generation control is becoming increasingly important in view of increased load demand and reducing generating resources. The increasing load demands are posing serious threats to reliable operation of power systems. This is because the increasing load demand leads to lowering of turbine speed ($N_s$) and therefore reduction of frequency (f) of output voltage of the generator. The healthy operation of generators feeding powers to various types of load is filled with challenges as the generating resources are cooping up to keep pace with increasing load demand. Under the situation a great care is needed in maintaining load under the size of generating capacities on the one hand and also maintaining healthy and undamaged operation of generators on the other hand. Working singularly or in parallel with other unit, the healthy and undamaged operation of generator needs the control of the following parameters: frequency to be maintained constant; the tie line power to be maintained between specified limits.*

***Keywords****: crossover, economic operations, frequency, genetic algorithm, mutation, reproduction.*

## 1. INTRODUCTION

There are many reasons, which justify that frequency of the power systems be maintained constant at 50 Hz [8]. The most serious effect of Subnormal frequency is on the operation of thermal power plants. With reduced frequency the blast by ID and the FD fan decreases, as a result of which the generation also decreases & thus it becomes a cumulative action & may result in complete shut-down of the plant if corrective measures like load Shedding is not taken up well in time. Load shedding is done with the help of under frequency relay, which automatically disconnects at a relatively higher frequency and vice-versa. This justifies the need for constant speed.

Further to meet the changes in load demand in particular area. The tie line load frequency controller adjusts the frequency to a particular value, for a given tie line power flow or tie line loading. This in turn decides the size of power which any particular generator in the interconnected system to raise its output for meeting the load demand in any area at the interconnected system. It is therefore necessary to maintain the power flow through tie line to some correct value. If the power flow is not maintained at predetermined value, it will cause any particular generator to give power output beyond its capacity to meet the increased load demand for restoration of normal frequency. As a result there is every possibility that the generator may over exert & get damaged. It is therefore always necessary to maintain a tie-line load bias. This is achieved through load frequency controller, which adjusts the operating frequency for a given tie line load bias power level. This in turn provides a great safety provider to costly generators [20]. It is therefore necessary to maintain the tie line power flow to some correct value.

The tie line power works as governor characteristic for maintaining constant frequency at desired power demand in an interconnected system. It takes into account the changes in load that takes place in a load area irrespective at the power generator, which is feeding the load. Also the economic load dispatch is one of the vital criteria that need to be satisfied for economic operation of any power station. This justifies the need for tie line control.

Studies have revealed that the economic operation when the multi generators in a particular area is feeding the load demand, requires all the units maintain the ratio of increment in fuel supply to increment in power output should be equal i.e.

$$\frac{dF_1}{dP_1} = \frac{dF_2}{dP_2} = ... = \frac{dF_n}{dP_n} = \lambda \quad (1)$$

This condition is required to be achieved for most economical operation of power system [22].

This needs proper allocation of loads to all the generators working to meet the entire load demand. Thus it can be concluded that the generation control is needed to ensure the power system stability. This justifies the need of economic operation generators.

## 2. PROBLEM

It is aimed to develop a programmable logic, which leads control of:

1. Frequency,
2. Tie line power and
3. Economic load dispatch, within prescribed limits, when they fail to be in such limits due to abnormal changes in loading. However the necessity of Automatic Generation Control is realized.

## 3. SOLUTION

A system, which issues command of control action to ensure:

1. Frequency control,
2. Tie line power control and
3. Economic load dispatch has been developed using a programmable logic and genetic algorithm. Also the same when tested gives better results over the mathematical approach.

## 4. STEPS OF SOLUTION

1. Collection of data from sub-station.
2. Development of software for implementation of proposed controls.
3. Testing of software and its comparison with mathematical approach.

## 5. WHY GENETIC ALGORITHM

- The genetic algorithm is preferred over traditional methods because they work with coding and are free from limitations like continuity, derivation and un-modality.
- It provides a model free approximation of the problem and has proved to be best technique in obtaining the best solutions.
- Genetic algorithm searches from population of point rather than a single point. It is known as build as well as robust tool for maxima.
- Genetic algorithm use payoff information not derivation or other auxiliary knowledge.
- Genetic algorithm use probabilistic transmission rules instead of deterministic ones. Therefore it can search a non-convex area to find the global optimum.

## 6. WORKING OF GA

GAs work from a rich database of points simultaneously (a population of strings), climbing many peaks in parallel; thus, the probability of finding a false peak is reduced over methods that go from point to point[10]. The mechanics of a simple genetic algorithm involves nothing more complex than to copy strings and swap partial strings. The explanation of why this simple process works is subtle and yet it is extremely powerful. Simplicity of operation and the power of the effect (speed and accuracy) are two of the main attractions of genetic algorithms. A simple genetic algorithm that yields good results in many practical problems is composed of three operators [5]:

1. Reproduction;
2. Crossover;
3. Mutation.

**Reproduction** is a process in which individual strings are selected according to their objective function value f (biologists call this function - the fitness function). Intuitively, we can think of the function f as some measure of profit, utility, or goodness that we want to maximize. Selecting strings according to their fitness values means that strings with a higher value have a higher probability of contributing offspring to the next generation.

After reproduction, **crossover** proceeds in two steps. First, members of the newly reproduced strings in the mating pool are mated at random.

Second, each pair of strings undergoes crossover as follows: an integer position k along the string is selected uniformly at random between 1 and the string length less one [1, l-1]. Two new strings are created by swapping all characters between position k+1 and l inclusively. Mutation plays a decidedly secondary role in the operation of genetic algorithms.

**Mutation** is needed because, despite the fact that reproduction and crossover search and recombine existent notions, occasionally they may lose some potentially useful genetic material.

The mutation operation involves periodically selecting one individual at random, selecting one position on the chromosome string and transposing it from 0 to 1 or vice-versa.

Mutation restores diversity but does not provide a logical approach to optimization. Its use should be restricted to situations where a local minimum (or maxima) has trapped the algorithm and a new population member is required to trigger the crossover operator on to a better result. Fig. 1 shows the general flow chart for GA.

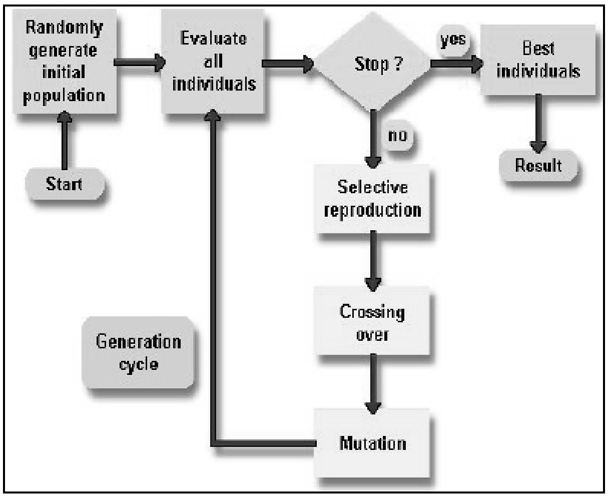



Fig. 1 General Flowchart of Genetic Algorithm

**Algorithm for AGC**

**Step 1:** Set the values of $\omega_{scheduled}$ and $P_{tie}$;

**Step 2:** Get the values of $\omega_{actual}$ and $P_{tie\ actual}$ and then calculate $\Delta\omega$ and $\Delta P_{tie}$;

**Step 3:** With the values of $\Delta\omega$ and $\Delta P_{tie}$ decide the control action to be taken;

**Step 4:** Send the control action in the particular area and apply Economic Load Dispatch using Genetic Algorithm;

**Step 5:** Represent the problem variable domain as a chromosome of a fixed length, choose the size of a chromosome population N, the crossover probability pc and the mutation probability pm;

**Step 6:** Define a fitness function to measure the performance, or fitness, of an individual chromosome in the problem domain. The fitness function establishes the basis for selection of chromosomes that will be mated together during reproduction;

**Step7:** Randomly generate an initial population of chromosomes of size N: $x_1$, $x_2$,…, $x_N$;

**Step 8:** Calculate the fitness of each individual chromosome: $f(x_1)$, … , $f(x_N)$;

**Step 10:** Create a pair of offspring chromosomes by applying genetic operator's crossover and mutation;

**Step 11:** Place the created offspring chromosomes in the new population;

**Step12:** Repeat Step 9 until the size of the new chromosome population becomes equal to the size of the initial population, N;

**Step 13:** Replace the initial (parent) chromosome population with the new (offspring) population;

**Step 14:** Go to Step 8, and repeat the process until the termination criterion is satisfied.

Check the feasibility of the solution corresponding to the satisfaction of the equality constraint.

## 7. ILLUSTRATION

Fuel inputs for generators G1&G2 of AREA 1, G3&G4 of AREA 2 are given below:

**Area 1:**

$F_1 = 0.2P_1^2 + 40P_1 + 120$Rs. per hour (2)

$$F_2 = 0.25P_2^2 + 30P_2 + 150 \text{Rs. per hour} \quad (3)$$

**Area 2:**

$$F_3 = 0.15P_3^2 + 30P_3 + 90 \text{Rs. per hour} \quad (4)$$

$$F_4 = 0.2P_4^2 + 25P_4 + 120 \text{Rs. per hour} \quad (5)$$

Maximum generating capacity of G1 & G2 is 100MW each & of G3 & G4 is 60MW each. Max. & Min.

Load on each generator of AREA 1 is 100 MW & 25MW respectively. Max. & Min. Load on each generator of AREA 2 is 60MW & 10MW respectively. Transmission losses are neglected. Assume that tie line power flow is from area1 to AREA 2 & of 10MW constantly.

To determine the control action, load allocation to individual generator and most economical cost of generation for economic load dispatch, when the system frequency, tie line power is changed due to changes in load as per case I and II. System frequency is scheduled at 50Hz, so $\omega_{sched} = 314.16$ rad.

Table 1 Parameters (P) - Case I: At time: 14 Hrs.

| P / State | ω (rad.) | $P_{tie}$ (MW) | Total Load (MW) | Load on A 1 (MW) | Load on A 2 (MW) |
|---|---|---|---|---|---|
| Expected Conditions | 314.16 | 10 | 250 | 150 | 100 |
| Actual Condition | 326.7 | 15 | 245 | - | - |

Table 2 Parameters - Case II: At time: 18 Hrs.

| P / State | ω (rad) | $P_{tie}$ (MW) | Total Load (MW) | Load on A 1 (MW) | Load on A 2 (MW) |
|---|---|---|---|---|---|
| Expected Conditions | 314.1 | 10 | 190 | 110 | 80 |
| Actual Condition | 301.6 | 5 | 195 | - | - |

## 8. RESULT COMPARISON

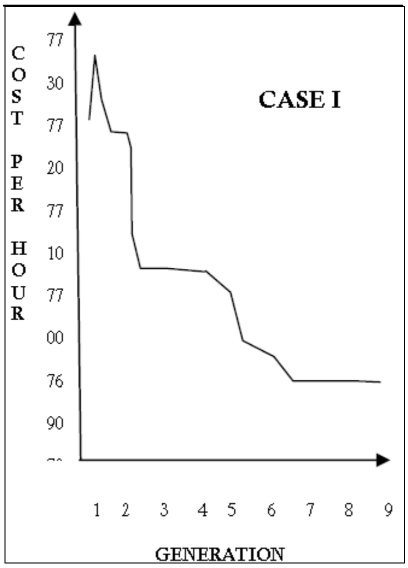
**Case I**

Cost from mathematical approach = = 7706.19 Rs./hour = 7706.19*24Rs./day = = 184948.56 Rs. /day.

Cost from Genetic Algorithm approach = = 7639.24 Rs./hour = 7639.24*24Rs./day = = 183341.76 Rs./day.

Net Saving per day = 184948.56-183341.76 = 1606.8 Rs.

**Net saving per year = 1606.8*365 = = 586482 Rs.**



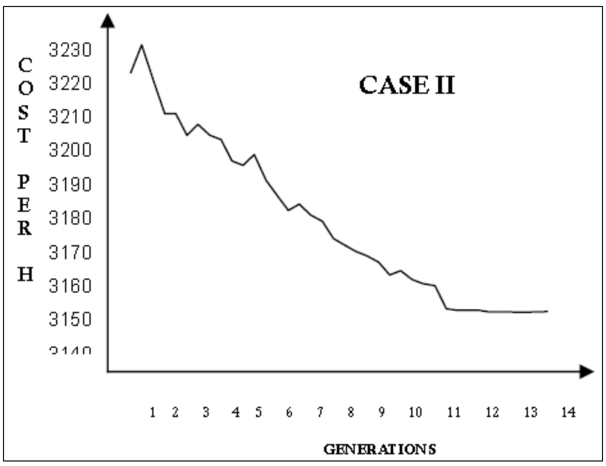

**Case II**

Cost from mathematical approach = = 3178.82 Rs. /hour = 3178.82*24 Rs. /day = = 76291.68 Rs. /day.

Cost from Genetic Algorithm approach = = 3116.92 Rs. /hour = 3116.92*24 Rs. /day = = 74806.08 Rs. /day.

Net Saving per day = 76291.68-74806.08 = = 1485.6 Rs.

**Net saving per year = 1485.6*365 = = 542244 Rs.**



## 9. CONCLUSIONS

The Present research work has been aimed to provide comprehensive control strategy for generators working in a particular area, so that the conditions caused by unusual changes in load is met by the generators without becoming inoperative. The outcomes of the present work are:

- A programmable logic has been developed and tested for varying load conditions to ensure automatic generation control.
- The three parameters viz frequency (f), tie line power flow ($P_{tie}$) and economic load dispatch have been maintained within prescribed limits without shutdown of generators under varying load conditions.
- The control strategies have been presented in the algorithm as well as flow chart form. This has given a rich base for development of programmable logic.
- The results have been obtained by mathematical as well as programmable logic control.
- The concept of genetic algorithm has been applied to obtain economic load dispatch conditions. This goes a long way in improving the economy, as the solution provided by it is global one vis-a-vis the local one as provided by the mathematical approach.

Using the techniques of soft computing and artificial intelligence it is possible to improve the smartness and reliability of controls to be exercised for automatic generation control.

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