Micro Genetic Algorithm Based Optimal Power Flow

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ABSTRACT In this work, Micro Genetic Algorithms and Genetic algorithm for the solution of the optimal power flow (OPF) is studied. Traditionally, classical optimization methods were used to effectively solve OPF. But more recently due to incorporation of Flexible A.C. Transmission System (FACTS) devices and deregulation of a power sector, the traditional concepts and practices of power systems are superimposed by an economic market management. So OPF have become complex. In recent years, Artificial Intelligence methods (MGA etc) have emerged which can solve highly complex OPF problems. IEEE 26-bus system has been studied to show the effectiveness of the algorithm.

Keywords: Micro Genetic Algorithms (MGA), Genetic Algorithm (GA),Flexible A.C. Transmission System (FACTS), Optimal Power Flow (OPF)

I.INTRODUCTION

In OPF[2,3] the main objective is to minimize the cost of meeting the load demand for the power system while satisfying all the security constraints. Since OPF is a non-linear problem, decouple of the control parameter of the FACTS device[1]is a highly nonlinear problem so that Micro Genetic algorithm and Genetic algorithm is used as a methodology to solve. In this context, more control facilities may complicate the system operation. As control facilities influence each other, a good coordination is required in order to bring all devices to work together, without interfering with each other. It has also been noted that the OPF problem with series compensation may be a non-convex and non-linear problem, which will lead the conventional optimization method stuck into local minimum

Micro Genetic algorithms and Genetic algorithm [9] offer a new and powerful approach to these optimization problems made possible by the increasing availability of high performance computers. These algorithms have recently found extensive applications in solving global optimization searching problems when the closed-form optimization technique cannot be applied. Genetic algorithms are parallel and global search techniques that emulate natural genetic operators.

The GA is more likely to converge toward the global solution because it, simultaneously, evaluates many points in the parameter space.

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The method is not sensitive to the starting points and capable to determining the global optimum solution to the OPF for range of constraints and objective functions. In this paper a simple Micro genetic algorithm is applied to the problem of optimal power flow. To accelerate the processes of MGAOPF, the controllable variables are decomposed to active constraints that effect directly the cost function are included in the Micro Genetic algorithms process and passive constraints which are updating using a conventional load flow program.

II. PROBLEM FORMULATION

The economic dispatch problem [12] is to simultaneously minimize the overall cost rate and meet the load demand of a power system. The power system model consists of *n* generating units already connected to the system. The economic dispatch problem can be expressed as the most commonly used objective in the OPF problem[14,15] formulation is the minimization of the total cost of real power generation. The individual costs of each generating unit are assumed to be function, only of active power generation and are represented by quadratic curves of second order. The objective function for the entire power system can then be written as the sum of the quadratic cost model at each generator.

$$\text{Min} \sum_{i=1}^{N_g} \left(F_i(P_i) \right)$$

$$F_i(P_i) = \left(a_i + b_i P_{gi} + c_i P_{gi}^2 \right) \quad (1)$$

Where a_i, b_i and c_i are the cost coefficients of i-th generator and **n** is the number of generators committed to the operating system. P_i is the power output of the i-th generator. The economic dispatch problem subjects to the following constraints

$$P_i^{\min} \le P_i \le P_i^{\max} \quad \text{for i=1,……n} \quad (2)$$

$$\sum_{i=1}^{N_g} (P_i) - (P_D) - (P_L) = 0 \quad (3)$$

$$\text{Where } P_L = [P_1 \; P_2 \ldots\ldots P_n] \begin{pmatrix} & \cdots & \\ \vdots & \ddots & \vdots \\ & \cdots & \end{pmatrix} \begin{bmatrix} P_1 \\ \cdot \\ \cdot \\ P_{n1} \end{bmatrix}$$

$$[P_1 \; P_2 \ldots\ldots P_n] + \begin{bmatrix} B_{01}/2 \\ \cdot \\ \cdot \\ B_{0n}/2 \end{bmatrix} B_{00} \quad (4)$$

Where $P_i^{\min}$ and $P_i^{\max}$ are the minimum and maximum generating limits respectively for the plant *i*. P_D is the load demand and P_L represents the transmission losses. B_{ii} and B_{oi} are the loss coefficients.

III.Micro genetic algorithm

Genetic algorithms are simple, robust, flexible, and able to find the global optimal solution. They are especially useful in finding solution to problems for which other optimization techniques encounter difficulties [8]. A basic genetic algorithm is constituted by a random creation of an initial population and a cycle of three stages, namely:

- evaluation of each chromosome;
- chromosomes selection for reproduction;
- genetic manipulation to create a new population, which includes crossover and mutation. Each time, this cycle is completed, it is said that a generation has occurred.

A.Standard Micro genetic algorithm

The disadvantage of GAs is the high processing time associated. That is due to their evolutionary concept, based on random processes that make the algorithm quite slow. However, different methods for reducing processing time have already been proposed, such as more appropriate choice of solution coding and reduction of search space using the specialist knowledge. One alternative method known as micro genetic algorithms, whose processing time is considerably smaller, is shown in [11] .

Most GAs produce poor results when populations are small, because insufficient information is processed about the problem and, as a consequence, premature convergence to a local optimum occurs. Population size generally varies from 30 to 300 individuals. In contrast, MGAs explore the possibility to work with small populations (from five to 20 individuals usually) in order to reduce the processing time. From a genetic point of view, it is known that frequent reproductions inside a small population may disseminate hereditary diseases rarely found in large populations. On the other hand, small populations can act as natural laboratories where desirable genetic characteristics quickly can emerge. In MGAs, mutations are unnecessary because after a certain number of generations, the best chromosome is maintained and the rest are substituted by randomly generated ones. On the other hand, it requires adoption of some preventive strategy against loss of diversity in population.

The MGA implemented in the present work is reported in the following algorithm:

1) Select a population of n randomly generated individuals. Alternatively, n-1 individuals may be generated randomly together with one good individual obtained from previous search

2) Evaluate fitness and determine the best individual which is always transferred to the next generation. This “elitist” strategy guarantees against the loss of good information embedded in the best individual produced thus far

3) Select individuals for reproduction with the tournament selection strategy (for example with k=2)

4) Apply crossover with probability equal to 1 to favor exchange of genetic information among the population

5) Check for convergence by measuring the amount of diversity left in the population (by counting the total number of bits which are unlike those possessed by the best individual). If population diversity has fallen under a preselected threshold, go to Step 1; otherwise, go to Step 2.

OPF problem is a nonlinear optimization problem whichits goal is minimizing objective function subject to equality and inequality constrains. There are many methods to optimize non linear problems. In this study Micro genetic algorithm(MGA) is applied in solving the OPF problem.

IV.GENETIC ALGORITHM

Genetic algorithms[10] are search algorithms based on the process of biological evolution. In genetic algorithms, the mechanics of natural selection and genetics are emulated artificially. The search for a global optimum to an optimization problem is conducted by moving from an old population of individuals to a new population using genetics-like operators. Each individual represents a candidate to the optimization solution. An individual is modeled as a fixed length string of symbols, usually taken from the binary alphabet. An evaluation function, called fitness function, assigns a fitness value to each individual within the population. This fitness value is measure for the quality of an individual. The basic optimization procedure involves nothing more than processing highly fit individuals in order to produce better individuals as the search progresses. A typical genetic algorithm cycle involves four major processes of fitness evaluation, selection, recombination and creation of a new population.

Although the binary representation is usually applied to power optimization problems, in this paper, we use the real valued representation scheme for solution. The use of real valued representation in the GA is claimed by Wright to offer a number of advantages in numerical function optimization over binary encoding. Efficiency of the GA is increased as there is no need to convert chromosomes to the binary type; less memory is required as efficient floating-point internal computer representations can be used directly; there is no loss in precision by discretisation to binary or other values; and there is greater freedom to use different genetic operators. For the real valued representation, the *k*-th chromosome C_k can be defined as follows:

$$C_k = [P_{k1},\ P_{k2}, \ldots\ P_{k3}]\quad k=1,2,\ldots\ldots \text{pop size}$$

Where *popsize* means population size and Pki is the generation power of the *i*-th unit at *k*-th chromosome. Reproduction involves creation of new offspring from the mating of two selected parents or mating pairs. It is though that the crossover operator is mainly responsible for the global search property of the GA. We used an arithmetic crossover operator that defines a linear combination of two chromosomes. Two chromosomes, selected randomly for crossover, C_{igen} and C_{jgen} may produce two offspring, C_{igen+1} and C_{jgen+1} may produce two offspring, C_{igen+1} and C_{jgen+1}, which is a linear combination of their parents i.e.,

$$C_i^{gen+1} = \text{a}.\, C_i^{gen} + (1\text{-a}).\, C_j^{gen}$$

$$C_j^{gen+1} = (1\text{-a}).\, C_i^{gen} + \text{a}.\, C_j^{gen}$$

Where *a* is a random number in range of [0, 1].

The mutation operator is used to inject new genetic material into the population and it is applied to each new structure individually. A given mutation involves randomly altering each gene with a small probability. We generate a random real value which makes a random change in the *m*-th element selected randomly of the chromosome. The objective function[11] is used to provide a measure of how individuals have performed in the problem domain. In the case of a minimization problem, the fit individuals will have the lowest value of the associated objective function. The fitness function is normally used to transform the objective function value into a measure of relative fitness. The fitness function is defined as Fit(x) = g (f (x)) where f(x) is the objective function, g transforms the value of the objective function to non-negative number. An elitist which GA search is used guarantees that the best solution so far obtained in the search is retained and used in the following generation, n and thereby ensuring no good solution already found can be lost in search process.

V.APPLICATION STUDY

This paper proposes an application of genetic algorithm and Particle Swarm Optimization to solve the Economic Dispatch problems. In this paper transmission losses are included by calculating the B coefficients of transmission losses. The results are taken on 26 bus system (fig-2) to test the effectiveness of the proposed method. The system consists of 46 lines and 6 generators, bus one is taken as reference bus, others are taken as load buses. The initial angle at respective buses is assumed as zero degree

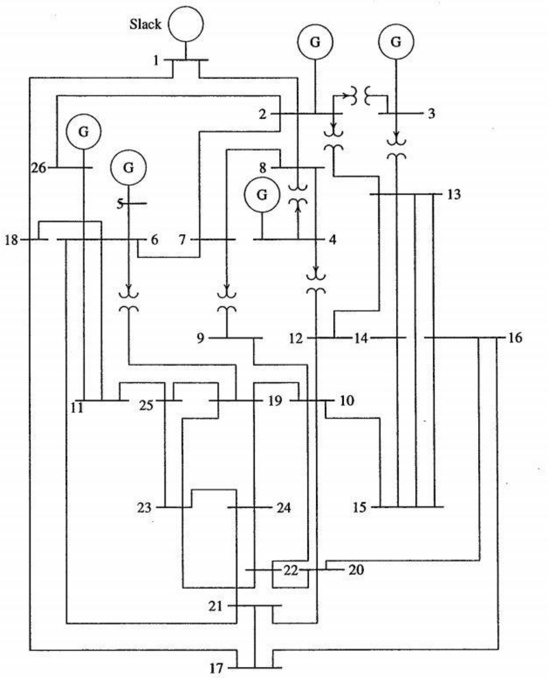

Fig-2: 26-bus power system network

Generator Operating Costs in \$/h, with P_i MW are as follows

$$C_1=240+7.0\,P_1+0.0070\,P_1^2$$
$$C_2=200+10.0\,P_2+0.0095\,P_2^2$$
$$C_3=220+8.5\,P_3+0.0090\,P_3^2$$
$$C_4=200+11.0\,P_4+0.0970\,P_4^2$$
$$C_5=220+10.5\,P_5+0.0080\,P_5^2$$
$$C_{26}=190+12.0\,P_{26}+0.0075\,P_{26}^2$$

Generator	Minimum (MW)	Maximum (MW)
1	100	500
2	50	200
3	80	300
4	50	150
5	50	200
26	20	120

Economic Dispatch Using Micro Genetic Algorithm and Genetic Algorithm including Transmission Losses

To Find The Loss Coefficients

A. First a power solution is obtained for the initial operating state. This provides the voltage magnitude and phase angles at all buses.

From these results load currents are obtained.

B. Bus matrix is found.

C. Transformation matrices are found.

D. Finally B coefficients are evaluated.

The B coefficients are the functions of the system operating state. If a new scheduling of generation is not drastically different from the initial operating condition, the loss coefficients may be assumed constant. B =

0.0014	0.0015	0.0009	-0.0001	-0.0004	-0.0002
0.0015	0.0043	0.0050	0.0001	-0.0008	-0.0003
0.0009	0.0050	0.0315	-0.0000	-0.0020	-0.0016
-0.0001	0.0001	-0.0000	0.0029	-0.0006	-0.0009
-0.0004	-0.0008	-0.0020	-0.0006	0.0085	-0.0001
-0.0002	-0.0003	-0.0016	-0.0009	-0.0001	0.0176

B0= -0.0002 -0.0008 0.0067 0.0001 0.0000 0.0012

B00=0.0056

Total system Loss=15.53MW

Total generation cost = 16760.73 \$/h

Optimal Dispatch using Genetic algorithm Genetic algorithm is used to calculate optimum value of generation taking the condition $P=P_D+P_L$

P_1 **=472.10**

P_2 **=171.96**

P_3 **=193.77**

P_4 **=150.00**

P_5 **=196.38**

P_6 **=103.73**

Total generating cost = 15599\$/h

Thus it can also be seen that the total generation cost per hour comes down by 16760.73 - 15599 = 161.73 \$/h as a result of optimal dispatch using genetic algorithm.

Optimal Dispatch using Micro genetic algorithm

Micro genetic algorithm is used to calculate optimum value of generation taking the condition $P=P_D+P_L$

P_1 **=444.8835**

P_2 **=172.5925**

P_3 **=268.7010**

P_4 **=123.8442**

P_5 **=173.4232**

P_6 **=95.0846**

Total generating cost = 15483 $/h

Thus it can also be seen that the total generation cost per hour comes down by 16760.73 - 15483 = 277.73 $/h as a result of optimal dispatch using Micro genetic algorithm.

VI. CONCLUSION

In this paper a new method with Micro Genetic Algorithm and Genetic Algorithm is presented to solve the optimal power flow problem of power system. Application of these techniques to Optimal Power Flow has been explored and tested. The simulation results show that this simple algorithm can give a good result using only simple modifications. A case study on IEEE-26 Bus 6 Generator Model test system shows the potential for application of MGA& GA to determine optimal dispatch of generation with FACTS devices.

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