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A New Attempt to Optimize Optimal Power Flow based Transmission Losses using Genetic Algorithm

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***Abstract* — This paper presents a new method using GADS Toolbox in MATLAB (A Genetic Algorithm Approach) to find the optimal solution of optimal power flow based transmission losses. Optimal power flow (OPF) is a key area of concern in electric industries. The basic OPF solution is obtained with objective function as production cost minimization while satisfying a set of system operating constraints. For reactive power optimization the OPF problem is formulated as minimization of system active power losses and improvement in voltage stability of the system. In this paper GA based optimal power flow solution is presented for IEEE 30-bus test power system with objective as transmission losses minimization and optimal results by GA are also compared with solution obtained by using Particle Swarm Optimization Technique.**

***Keywords*— Genetic algorithm (GA), optimal power flow (OPF), Particle Swarm Optimization (PSO).**

I. INTRODUCTION

Carpentier first defined the OPF problem in early 1960s and OPF soon many researchers were attracted towards this artistic area of research. Optimal Power Flow problem of power system operation and planning is a constrained nonlinear and occasionally combinatorial optimization problem. Since its introduction by Carpentier, many investigators have attempted to solve this problem of OPF [1]. With the advancements in computing technologies, it is becoming possible to consider many aspects of the OPF problem more vigorously as it progressively became easy to formulate and solve complicated large-scale problems.

Many classical optimization techniques such as Linear programming [1], Quadratic programming [2], Dynamic programming [3], Lagrangian Relaxation approaches and Gradient methods as well as Artificial Intelligence Techniques such as Genetic Algorithm [4], Evolutionary algorithms [5], Particle Swarm Optimization, Simulated Annealing, adaptive Tabu Search, Harmony Search etc. are being applied in the area.

Classical optimization methods suffer from drawback of getting trapped in a local minima and premature convergence. Although some of the Meta-heuristic methods are successful in locating the optimal solution yet they also are rather slow in convergence.

This paper describes a new approach using Genetic Algorithm to optimize transmission losses using optimal power flow. In doing so, GADS Toolbox in MATLAB is used. The proposed method has been tested on IEEE 30-bus test power system.

Controlled voltage magnitude, Generator MW power, reactive power injection from reactive power sources and transformer tap setting etc. are the controllable parameters in power system. The objective in OPF problem is to optimize the total transmission loss by optimizing the controllable variables within their limits. Hence, during normal system operating conditions there is no violation on other system parameters viz. MVA flow of transmission lines, load bus voltage magnitude, generator MVAR etc.

The organization of the paper is as follows: Section II explains OPF problem objective function, equality and inequality constraints; Section III describes the Genetic Algorithm procedure to solve non-linear optimization problems; PSO is discussed in Section IV. A comparison of simulation results obtained using GA and PSO for IEEE 30-bus system is presented in Section V.

II. OPTIMAL POWER FLOW PROBLEM

The general optimal power flow problem can be described as a constrained non-linear optimization problem as under:

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Minimize $f(y)$
Subject to- $a(y) = 0$, equality constraints
$b(y) \geq 0$, inequality constraints

A. Objective function

The objective function for total power transmission loss can be constituted as mentioned below [6,7]:

$$F = \sum_{n=1}^{N} \sum_{m=1}^{N} g_{n,m} \{V_n^2 + V_m^2 - 2V_n V_m \cos(\delta_n - \delta_m)\}$$

Where,
V_n is the voltage magnitude at bus *n*.
N is the total number of transmission lines.
δ_n is the voltage angle at bus *n*.
$g_{n,m}$ is the conductance of line *n-m*.

B. System Constraints

The system constraints as equality and inequality constraints are as under [8].

1) *Equality constraint:* Power flow equations:

For Real Power balanced,

$$P_{Gn} - P_{Dn} - \sum_{m=1}^{N_B} |V_n||V_m||Y_{n,m}| \cos(\theta_{n,m} - \delta_n + \delta_m) = 0$$

For Reactive Power balance,

$$Q_{Gn} - Q_{Dn} + \sum_{j=1}^{N_B} |V_n||V_m||Y_{n,m}| \sin(\theta_{n,m} - \delta_n + \delta_m) = 0$$

Where,
n is 1, 2, 3,……….. N_{bus-1}.
P_{Gn} is the real power generation at bus n.
Q_{Gn} is the reactive power generation at bus n.
P_{Dn} is the real power demand at bus n.
Q_{Dn} is the reactive power demand at bus n.
N_B is the total number of buses.
$\theta_{n,m}$ is the angle of bus admittance element *n,m*.
$Y_{n,m}$ is the magnitude of *Y* bus element *n,m*.

2) *Inequality constraint:* Variable limits as inequality constraints are as follows:

$$V_n^{min} \leq V_n \leq V_n^{max}$$

$$T_n^{min} \leq T_n \leq T_n^{max}$$

$$Q_n^{min} \leq Q_n \leq Q_n^{max}$$

$$P_{Gn}^{min} \leq P_{Gn} \leq P_{Gn}^{max}$$

Where,
V_n^{min}, V_n^{max} are upper and lower limits of voltage magnitude at bus *n*.
T_n^{min}, T_n^{max} are upper and lower limits of tap position of transformer *n*.
Q_n^{min}, Q_n^{max} are upper and lower limits of reactive power source *n*.
$P_{G,n}^{min}, P_{G,n}^{max}$ are upper and lower limits of power generated by generator *n*.
The penalty function can be constituted as under:

$$P(y) = F_T + \beta_P + \beta_Q + \beta_C + \beta_T + \beta_V + \beta_G$$

Where,

$$\beta_P = \rho \sum_{n=1}^{H_B} \{P_{Gn} - P_{Dn} - \sum_{n=1}^{H_B} |V_n||V_n||Y_{n,m}| \cos(\theta_{n,m} - \delta_n + \delta_n)\}^2$$

$$\beta_Q = \rho \sum_{n=1}^{H_B} \{Q_{Gn} - Q_{Dn} - \sum_{m=1}^{H_B} |V_n||V_n||Y_{n,m}| \cos(\theta_{n,m} - \delta_n + \delta_m)\}^2$$

$$\beta_C = \rho \sum_{n=1}^{H_C} \{max(0, Q_n - Q_n^{max})\}^2 + \rho \sum_{n=1}^{H_C} \{max(0, Q_n^{min} - Q_n)\}^2$$

$$\beta_T = \rho \sum_{n=1}^{H_T} \{max(0, T_n - T_n^{max})\}^2 + \rho \sum_{n=1}^{H_T} \{max(0, T_n^{min} - T_n)\}^2$$

$$\beta_V = \rho \sum_{n=1}^{H_B} \{max(0, V_n - V_n^{max})\}^2 + \rho \sum_{n=1}^{H_B} \{max(0, V_n^{min} - V_n)\}^2$$