

## Chapter 56

# Application of Meta-Heuristic Optimization Algorithms in Electric Power Systems

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### ABSTRACT

*Optimization of solutions on expansion of electric power systems (EPS) and their control plays a crucial part in ensuring efficiency of the power industry, reliability of electric power supply to consumers and power quality. Until recently, this goal was accomplished by applying classical and modern methods of linear and nonlinear programming. In some complicated cases, however, these methods turn out to be rather inefficient. Meta-heuristic optimization algorithms often make it possible to successfully cope with arising difficulties. State estimation (SE) is used to calculate current operating conditions of EPS using the SCADA measurements of state variables (voltages, currents etc.). To solve the SE problem,*

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*the Energy Systems Institute of Siberian Branch of Russian Academy of Sciences (ESI of SB RAS) has devised a method based on test equations (TE), i.e. on the steady state equations that contain only measured parameters. Here, a technique for EPS SE using genetic algorithms (GA) is suggested. SE is the main tool for EPS monitoring. The quality of SE results determines largely the EPS control efficiency. An algorithm for exclusion of wrong SE calculations is described. The algorithm using artificial neural networks (ANN) is based on the analysis of results of the calculation performed solving the SE problem with different combinations of constants. The proposed procedure is checked on real data.*

## **INTRODUCTION**

Phasor measurement units (PMUs) are employed in EPS both to solve the local problems and to obtain a general picture of EPS state which is further used for solution of control problems. Placement of PMU for solution of the problems of the first group is very specific and is determined by individual features of the problems to be solved. To solve the problems of the second group, including SE problems, the universal methods are necessary to place PMUs and SCADA to provide the best properties of the SE problem, such as observability of the studied network, identifiability of bad data and accuracy of obtained estimates.

As criteria for PMU placement several criteria are used: absence of critical measurements and critical sets in the system, maximum quantity of measurements received as compared to the initial one, maximum accuracy of estimates, minimum cost of PMU placement, transformation of the network graph into tree. GA allows different PMU placement criteria to be combined. The proposed algorithm is validated by simulation.

Also the problem of PMU placement is suggested in such a way that the volume of initial information based on the SCADA and PMU measurements is sufficient to determine all the state vector components for load flow calculations without iterations. The PMU number in this case should be minimal. The problem of PMU placement is solved by the simulated annealing (SA) method.

The problem of multi-criteria reconfiguration of distribution network with distributed generation according to the criterion of minimum power

loss under normal conditions and the criterion of power supply reliability under post-emergency conditions is considered. Efficient heuristic Ant Colony algorithm is used to solve the problem. Demonstration studies have been carried out for the Central Power System of Mongolia.

To improve the accuracy of short-term forecasting two-stage intelligent approach is proposed. On the first stage the initial data is decomposed by Hilbert-Huang transform (HHT), and the second stage involves ANN model optimized with SA algorithm and Neuro-Genetic Input Selection (NGIS). To train and build the optimal structure of ANN the optimization block “NGIS-SA” is used. The results show a solid improvement in the accuracy of short-term forecast for different non-stationary processes.

To enhance transient stability in large EPSs an application of fuzzy logic power system stabilizers (FLPSS) is presented. A two-stage technology of FLPSS adaptation is considered taking into account the real conditions of a power system. Self-organizing ANN is used for clusterization of the test disturbances. GA is applied to tuning parameters of FLPSS. ANN is used on-line to adapt FLPSS to changes in operating conditions of EPS. The studies have been conducted using the models of a 14-bus multi-machine power system and regional Siberian power system as the study cases. The results obtained are presented.

Optimization of solutions on expansion of electric power systems and their control plays a crucial part in ensuring efficiency of the power industry, reliability of electric power supply to consumers and power quality.

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