Multi-Objective Optimal Power Flow using BAT Search Algorithm with Unified Power Flow Controller for Minimization of Real Power Losses

B. Venkateswara Rao, Department of Electrical and Electronics Engineering, GITAM University, Visakhapatnam, India

G. V. Nagesh Kumar, Department of Electrical and Electronics Engineering, GITAM University, Visakhapatnam, India

ABSTRACT

In this paper a multi objective optimal power flow (OPF) is obtained by using BAT search algorithm (BAT) with Unified power flow controller (UPFC). UPFC is a voltage source converter type Flexible Alternating Current Transmission System (FACTS) device. It is able to control the voltage magnitudes, voltage angles and line impedances individually or simultaneously. UPFC along with BAT algorithm is used to minimize the total real power generation cost, real power losses in OPF control. The BAT algorithm based OPF has been examined and tested on a 5 bus test system and modified IEEE 30 bus system without and with UPFC. The results obtained with BAT algorithm are compared with Differential Evaluation (DE).

Keywords: BAT Algorithm, FACTS Device, Newton Method, Optimal Power Flow, UPFC

1. INTRODUCTION

Due to economic growth the demand of electric power has been increased drastically which needs optimal operation in Power systems. Optimal power flow is the one strategy for minimizing the real power generation cost and losses in transmission lines. The transmission line losses can be further reduced by installing FACTS controllers (see Figure 1). The variables and parameter of the transmission line, which include line reactance, voltage magnitude, and phase angle are able to be controlled using FACTS controllers in a fast and effective way. Controlling power flows is the main function of FACTS controllers (Acha et al., 2004; Jirapong, 2013). According to the IEEE definition, FACTS is defined as “The Flexible AC Transmission System (FACTS)
is a new technology based on power electronic devices which offers an opportunity to enhance controllability, stability and power transfer capability of AC Transmission Systems” (Hingorani, 2000; Edris, 2000).

The Flexible AC Transmission System (FACTS) is a transmission system which use reliable high-speed thyristor based controllable elements such as SVC, TCSC, and UPFC etc. are designed based on state of the art developments in power semiconductor devices. Issues include increased utilization of existing facilities such as secure system operation at higher power transfers across existing transmission lines which are limited by stability constraints, the development of control designs for FACTS devices, and determination of functional performance requirements for FACTS components. The reactive power compensation of AC transmission systems using fixed series or shunt capacitors can solve some of the problems associated with AC networks. However the slow nature of control using mechanical switches (circuit breaker) and limits on the frequency of switching imply that faster dynamic controls are required to overcome the above mentioned problems. Hammons and Lim (1997) presented a review literature, which addresses the application of FACTS, concepts for the improvement of power system utilization and performance. Recent developments involving deregulation and restructuring of the power industry is feasible only if the operation of AC transmission systems is made flexible by introducing FACTS devices.

The optimal power flow (OPF) is a power flow problem in which certain variables are adjusted to minimize an objective function such as cost of the active power generation and the real power losses (Tinney, 1967). Over the last three decades, many successful OPF techniques have been developed such as, the generalized reduced gradient method (Stagg, 1968), linear programming solution, quadratic programming, the Newton method (Carpentier, 1979), the

Figure 1. Block diagram of FACTS controllers
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