A Computational Comparison of Swarm Optimization Techniques for Optimal Load Shedding under the presence of Unified Power Flow Controller to Avoid Voltage Instability

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ABSTRACT

Voltage instability has become a serious threat to the operation of modern power systems. Load shedding is one of the effective countermeasures for avoiding instability. Improper load shedding may result in huge technical and economic losses. So, an optimal load shedding is to be carried out for supplying more demand. This paper implements BAT and Firefly algorithms for solving the optimal load shedding problem to identify the optimal amount of load to be shed. This is applied for a multi objective function which contains minimization of amount of load to be shed, active power loss minimization and voltage profile improvement. The presence of with and without Unified Power Flow Controller (UPFC) on load shedding for IEEE 57 bus system has been presented and analyzed. The results obtained with BAT and Firefly Algorithms were compared with Genetic Algorithm (GA).

Keywords: Flexible Alternating Current Transmission Devices, Load Shedding, Under Voltage Load Shedding, Unified Power Flow Controller (UPFC), Voltage Stability

1. INTRODUCTION

Nowadays, voltage instability has been considered as one of the reason for the blackouts all over the world. Blackouts occurs due to contingency, such as the outage of an important transmission line or the outage of a major generator, or insufficient reactive power support at important buses due to a high loading condition or a combination of both the aspects. The
requirement for improved efficiency at the same time as maintaining system stability necessitates the development of improved system analysis approaches and the improvement of advanced technologies. The Load shedding is a type of emergency control that is designed to ensure system stability by curtailing system load to match generation. It is an effective corrective control action in which a part of the system loads are disconnected according to certain priority in order to protect the power system. Load shedding is considered as the last resort tool for use in that extreme situation and usually the less preferred action to be adopted, but in this kind of problem it is vital to prevent the system from collapsing (Kundur, 1993). Loadshedding schemes are mainly classified into two types those are under frequency load shedding scheme and under voltage loadshedding scheme. Under frequency loadshedding scheme have been used, to protect the power system stability from major disturbances. However, the analysis of recent blackouts suggests that voltage collapse and voltage-related problems are also important concerns in maintaining system stability. For this reason, voltage also needs to be taken into account in load shedding schemes. This type of scheme is called under voltage loadshedding scheme.

Flexible AC Transmission System (FACTS) controllers could be a suitable alternative to provide reactive power support at the load centres locally and hence keep the voltages within their safe operating limits to minimize the load shedding (Hingorani & Gyugyi, 2000). Out of the several FACTS devices UPFC is one of the most important shunt-series connected FACTS devices to improve voltage stability and minimize the amount of load to be shed (Acha & Fuerte-Esquivel, 2004; Padiyar & Uma Rao, 1999; Lashkar Ara & Kazemi, 2012).

To deal with the above problem a new methodology has been proposed, in this paper UPFC has been considered for the study to minimize the load curtailment. The effectiveness of the proposed method has been tested on IEEE 57-bus system without and with UPFC. Optimal Power Flow (OPF) problem has been formulated with an objective to minimize the load curtailment and satisfying all operating constraints along with active power losses and voltage deviation. Optimal Power Flow can be effectively solved by using metaheuristic optimization methods because of there execution flexibility and controlling ability. This paper applies BAT and Firefly Algorithms for solving the load shedding optimization problem, the obtained results are compared with Genetic algorithm. To show the effective ness of the algorithms, their population size and parameters are varied. In this paper voltage stability has been analysed using line based voltage stability index called ‘Fast Voltage Stability Index’ (FVSI).

2. UNIFIED POWER FLOW CONTROLLER

Gyugyi proposed the UPFC concept is used for real time control and dynamic compensation of the ac transmission system (Tiwari & Sood, 2012; Ghahremani & Kamwa, 2013). UPFC provides multifunctional flexibility required to solve many of the problems in the power system. The UPFC is able to control simultaneously or selectively all the parameters affecting power flow in the transmission line (i.e. voltage magnitude, line impedance and phase angle). This capability signifies the term ‘unified’ in the UPFC (Radu, 2006; Padiyar & Kulakarni, 1998).

The UPFC consists of two voltage-source converters, one connected in shunt and one connected in a series. The series converter of the UPFC injects an AC voltage with the controllable magnitude and phase angle in a series with the transmission line via a series connected coupling transformer. The basic function of shunt converter is to supply or absorb the real power demanded by the series converter at the common DC link. It can also generate or absorb controllable reactive power and provide independent shunt reactive compensation for the line which is shown in Figure1. Thereby, the UPFC can fulfil the functions of reactive...
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