FACTS Devices Allocation to Congestion Alleviation Incorporating Voltage Dependence of Loads

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Abstract: This paper presents a novel optimization based methodology to allocate Flexible AC Transmission Systems (FACTS) devices in an attempt to improve the previously mentioned researches in this field. Static voltage stability enhancement, voltage profile improvement, line congestion alleviation, and FACTS devices investment cost reduction, have been considered, simultaneously, as objective functions. Therefore, multi-objective optimization without simplification has been used in this paper to find a logical solution to the allocation problem. The optimizations are carried out on the basis of location, size and type of FACTS devices. Thyristor Controlled Series Compensator (TCSC) and Static Var Compensator (SVC) are utilized to achieve the determined objectives. The problem is formulated according to Sequential Quadratic Programming (SQP) problem in the first stage. This formulation is used to accurately evaluate static security margin with congestion alleviation constraint incorporating voltage dependence of loads in the presence of FACTS devices and estimated annual load profile. The best trade-off between conflicting objectives has been obtained through Genetic Algorithm (GA) based fuzzy multi-objective optimization approach, in the next stage. The IEEE 14-bus test system is selected to validate the allocated devices for all load-voltage characteristics determined by the proposed approach.

Keywords: Congestion Alleviation, FACTS, Fuzzy, Genetic Algorithm, Optimal Location, Voltage Stability.

1 Introduction

These days, high efficiency, maximum reliability, and security in the design and operation of power systems are more important than ever before. The difficulties in constructing new transmission lines due to limits in rights for their paths make it necessary to utilize the maximum capacity of transmission lines. Therefore, it is difficult to provide voltage stability, even in normal conditions [1] and [2]. The fact that the main duty of generation units in deregulated environment is based on the active power generation requirements rather than the reactive power compensation makes the problem more serious. Power system deregulation which is translated into a separation of generation, transmission and distribution has been developed to increase competition between suppliers. As a result, consumers can seek the best combination of price, reliability and customer service.

It should be noted that the constraints regarding the transmission security should not prevent any generator from operating at peak load demand. In doing so and also to provide fair competition of generators and secure power transfer transactions between distant regions, both the owners of transmission system and operators should properly plan and control the system. Power exchanges in deregulated systems must be under control in order to avoid line overloading, known as congestion [3], on any path and therefore the full capacity of transmission lines may not be used. So, it is significant to get rid of line congestion to be able to use the full capacity of a network in the restructured electricity environment.

Removing line congestion and carrying higher power, close to lines thermal limit, over long distance in a power system without diminished stability and security margin, can be achieved through fast power flow control in a transmission system. Recently, Flexible AC Transmission Systems (FACTS) have been introduced as a well known term for higher

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