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Fuzzy multi-objective reactive power clearing considering reactive compensation sources

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ABSTRACT

This paper presents a fuzzy multi-objective approach for clearing the reactive power market. The objective functions that have been studied are the total payment function (TPF), voltage stability and the voltage deviation of the buses. All of the objective functions are transformed to membership functions and then a pseudogoal function is derived to express a unique objective function. In this work initially the reactive power compensation devices are assumed to compete in an integrated market with the generators but after probing the problems of this type of market a separate reactive power market is proposed. Fuzzy adaptive PSO (FAPSO) has been used to solve the optimization problem and determine the amount of reactive power that each generator has to provide. Also the reactive power generated by the reactive compensation devices and adjustment tap settings of transformers are specified. The proposed reactive market is implemented to the IEEE 30-bus system.

1. Introduction

In the last decade power systems have been restructured in many countries to create competition between different parts of the system. In the new environment generation, transmission and distribution parts of the former vertically integrated system are separated and are under the supervision of autonomous companies (known as GenCo, TranCo and DisCo). In this system an independent system operator exists which is indeed the coordinator of the system. One of the responsibilities of ISO is to provide adequate ancillary services to assure the security and reliability of the system. In [1] it mentions that reactive power supply is one of the ancillary services that has to be provided by the transmission operator. Reactive power has an important influence on the bus voltages and voltage stability of the system (especially in systems with a high ratio of X/R), therefore sufficient reactive power provision seems to be inevitable for the secure and reliable operation of the system. There are many reports of blackouts that that have been occurred as a consequence of insufficient reactive power procurement such as blackouts in Sweden and Denmark (September 2003) and also the United States (August 2003).

Although reactive power does not consume energy but its generation and transmission causes energy losses and leads to costs. So it seems necessary to organize a scheme to account these costs while providing the reactive power for the consumers. Recently many models have been introduced for modeling the reactive power market. In [2] reactive power pricing is investigated considering economic and technical issues. In [3] different OPF models under various objective functions are used to study the effects on reactive power prices. Ahmad [4] proposes an annual cost model. In [5] the authors introduce a market clearing price scheme regarding the total payment for reactive power as the objective function. Also in [6] a multi-objective framework is introduced. A localized reactive power clearing method using the concept of voltage control areas is suggested in [7]. El-Samahy [8] represents a reactive procurement market model considering system security and [9] takes the reactive market clearing problem to a stochastic framework. A pay as bid market is compared with the market clearing price market in [10]. El-Samahy [11] exhibits an optimal reactive power dispatch in a deregulated market. A genetic algorithm is implemented to the allocation problem of reactive power in a deregulated environment in [12].

Sufficient reactive power providing is an important issue for the operation of power systems. For the loads in the system reactive power is required proportional to the characteristics of these loads operating in the system. During different operational hours the level of reactive power demanding changes. When the demand of reactive power is low in the system the line capacitors generate

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