



Optimal location and sizing of Unified Power Flow Controller (UPFC) to improve dynamic stability: A hybrid technique



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ABSTRACT

In this paper a hybrid technique based optimal location and sizing of UPFC to improve the dynamic stability is proposed. Here, the maximum power loss bus is identified at the most favorable location for fixing the UPFC, because the generator outage affects the power flow constraints such as power loss, voltage, real and reactive power flow. The optimum location has been determined using the Artificial Bees Colony (ABC) algorithm. Depending on the violated power flow quantities the Gravitational Search Algorithm (GSA) optimizes the required quantity of the UPFC to recover the initial operating condition. Then the proposed work is implemented in the MATLAB/simulink platform and the performance is evaluated by using the comparison, at different techniques like ABC and GSA. The comparison results demonstrate the superiority of the proposed approach and confirm its potential to solve the problem.

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Introduction

Around the world, Electric power systems have been compelled to work to more or less their full capacities owing to the environmental and economic constraints to erect novel generating plants and transmission lines [2,3]. By safety and steadiness constraints, the amount of electric power that can be passed on among two positions through a transmission network is restricted [1]. Power flow in the lines and transformers should not be permitted to raise to a level where a random event could cause the network fall down as cascaded outages [4,5]. The system is said to be dammed when such a limit reaches. Managing congestion to reduce the limitations of the transmission network in the aggressive market has, therefore, turn into the central movement of systems operators [6]. It has been scrutinized that the inadequate management of transactions could raise the congestion cost which is a surplus burden on customers [7].

For controlling the power transmission system, Flexible Alternating Current Transmission System (FACTS) is a stationary tool that is used [8,9]. FACTS is identified as “a power electronic based system and other stationary tool that offer control of one or more AC transmission system parameters to improve controllability and amplify power transfer capability” [10]. The different kinds of FACTS tools accessible for this purpose comprises Static Var

Compensator (SVC), Thyristor controlled series Capacitor (TCSC), Static Synchronous series compensator (SSSC), Static Synchronous Compensator (STATCOM), Unified Power Flow Controller (UPFC) and Interlink Power Flow Controller (IPFC) [12]. UPFC is one of the FACTS tools among them, that can manage the power flow in transmission line by inserting active and reactive voltage component in series with the broadcasting line [11,13].

Novel opportunities for controlling power and improving the utilizable capacity of surviving transmission lines are released by the appearance of FACTS devices [14]. An optimal location of UPFC tool permits to control its power flows for a meshed network and as a result the system load ability is raised [15]. On the other hand, a limited number of tools, beyond which this load ability can never be enhanced [16]. The optimal location and optimal capacity of a specified number of FACTS in a power system is a setback of combinatorial study [18,19]. Dissimilar kinds of optimization algorithm have been applied to work out this sort of problem, such as genetic algorithms, simulated annealing, and tabu search [17,20]. However, hybridization of more than one algorithm has been proven from basic general problems [24] to power system issues, for its outstanding performance [20,26].

In this paper a hybrid technique based optimal location and sizing of UPFC to improve the dynamic stability is proposed. Here, the maximum power loss bus is identified at the most favorable location for fixing the UPFC, because the generator outage affects the power flow constraints such as power loss, voltage, real and reactive power flow. The optimum location has been determined using

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the Artificial Bees Colony (ABC) algorithm. Depending on the violated power flow quantities the Gravitational Search Algorithm (GSA) optimizes the required quantity of the UPFC to recover the initial operating condition. The rest of the paper is organized as follows: the recent research works is analyzed in 'Recent research work: a brief review'; the proposed work brief explanation is explained in 'Problem formulation'; the suggested technique achievement results and the related discussions are given in 'Results and discussion'; and the paper ends in 'Conclusion'.

Recent research work: a brief review

Numbers of associated works are obtainable in literature, which is based on enhancing the power transfer competence of power system. A few of them are assessed here. For improving the safety of power systems under single line contingencies, the efficiency of the optimal location of UPFC has been examined by Shaheen et al. [21]. Based on the emergency choice and ranking process, determinations of the severest contingency scenarios were executed. One of the latest computational intelligence methods, namely: DE has been effectively employed to the problem under concern. Maximization of power system security was regarded as the optimization principle. The presentation of DE was compared with that of GA and PSO. Moreover, they were carried out as two case studies by means of an IEEE 14-bus system and an IEEE 30-bus system.

Under single line contingencies, to detect the optimal placement and parameter setting of UPFC for improving power system security, a strategy based on differential evolution method has been offered by Shaheen et al. [22]. Initially, to find out the most rigorous line outage contingencies regarding line overloads and bus voltage limit violations as a performance index, they execute a contingency study and ranking procedure. Secondly, they use different evolution method to detect the optimal location and parameter setting of UPFC under the decided contingency scenarios. They carry out simulations on an IEEE 14-bus and an IEEE 30-bus power systems. They attained results point out that installing UPFC in the location optimized by DE could considerably improve the safety of power system by removing or minimizing the overloaded lines and the bus voltage limit violations.

To get the optimal location of UPFCs for attaining minimum total active and reactive power production, cost of generators and minimizing the installation cost of UPFCs, the requests of hybrid immune algorithm has been offered by Taher et al. [23]. The UPFC can supply control of voltage magnitude, voltage phase angle and impedance. As a result, it was employed successfully in this document to raise power transfer capability of the existing power transmission lines and diminish operational and investment costs. UPFC furthermore presents a mechanism that might assist traditional congestion mitigation techniques and in some cases might avert generators to run in and out of merit order and hence may prevent load shedding or curtailment that was generally necessary to sustain system security. They were executed simulations on IEEE 14-bus and 30-bus test system.

Nireekshana et al. [25] have examined the exploit of FACTS tools, like SVC and TCSC, to take full advantage of power transfer transactions during normal and contingency conditions. ATC was computed by means of Continuation Power Flow (CPF) technique regarding both thermal limits and voltage profile. To find out the location and control parameters of SVC and TCSC, Real-code Genetic Algorithm (RGA) was applied as an optimization device. The proposed methodology was experimented on IEEE 14-bus system and as well on IEEE 24-bus dependability test system for usual and dissimilar contingency cases.

Using Fuzzy logic and Real Coded Genetic Algorithm, an approach for appointment and sizing of shunt FACTS controller

has been suggested by Phadke et al. [26]. A blurry presentation index based on distance to encumber node bifurcation, voltage profile and capacity of shunt FACTS controller is suggested. In order to find the most efficient location, the suggested method can be applied and optimal size of the shunt FACTS tools can be used. The suggested strategy has been used on IEEE 14-bus and IEEE 57-bus test systems.

Ravia et al. [27] have suggested an Improved Particle Swarm Optimization (IPSO) was advised for optimizing the power system presentation. Lately, to work out power engineering optimization problems giving improved results than classical techniques, the Particle Swarm Optimization (PSO) technique has been used. Owing to unhurried convergence and local minima, particle swarm optimization fails to offer global results. For optimal sizing and distribution of a Static Compensator (STATCOM) and diminish the voltage variations at all the buses in a power system, they give the application of enhanced particle swarm optimization to overcome these disadvantages. This algorithm gets an optimal settings for current infrastructure with optimal locations, sizes and control settings for Static Compensator (STATCOM) units.

A novel strategy for optimal placement of PWM based Series Compensator (PWMSC) in huge power systems have been brought in by Safari et al. [28]. This strategy was based on the Selective Modal Analysis (SMA) and dynamics index to soggy out the inter-area fluctuation modes. Consequently, primary, SMA was applied to compute the low frequency modes of oscillation and then Most Dominant Line (MDL) Table based on the dynamic index was suggested which demonstrates the pressure of active power flows of the transmission lines on inter-area modes of the power system. The parameters of the PWMSC damping controller were planned by optimization based strategy for the purpose of damping inter-area oscillations in practical system. Optimal PWMSC placement was authenticated by comparing dissimilar candidate appointments based on the total damping that they offer for system.

The heavily loaded lines, sustain the bus voltages at desired levels and enhance the stability of the power network are increased at uncontrolled exchanges in power systems. For that reason, power systems need to be supervised in sequence to make use of the obtainable network competently. FACTS devices depends on the advance of semiconductor technology released positive latest prospects for controlling the power flow and expanding the loadability of the accessible power transmission system. Among the FACTS devices, the UPFC is one of the most promising FACTS devices for load flow control seeing as it can either concurrently manage the active and reactive power flow alongside the lines in addition to the nodal voltages. As per the characteristics of the UPFC, scheduling the implementations, it has some practical concern for finding the optimal location. In practical, the optimal location of UPFC tends not by randomly, and the matching methodical exploration is not frequently adequate. Several researches have put effort to solve the optimal location of UPFCs with respect to different purposes and methods. For determining the optimal location, the operating condition of UPFC must be pre-assigned which can be taken as simultaneously. Some of the optimization algorithms are introduced to determine the location and size of UPFC such as genetic algorithm, particle swarm optimization, and differential evaluation. This cannot be utilized to find the capacity and location at the same time so that the hybrid approach is needed. The proposed method is briefly described in the following section.

Problem formulation

Power flow studies of UPFC

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