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DEVELOPMENT OF MULTI-OBJECTIVE CHAOTIC IMMUNE SYMBIOTIC ORGANISMS SEARCH (CISOS) ALGORITHM FOR FACTS DEVICE INSTALLATION IN VOLTAGE SECURITY CONTROL

MOHAMAD KHAIRUZZAMAN BIN MOHAMAD ZAMANI

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ABSTRACT

Increase in energy demand has caused a power system to be operated near its stability limit. In order to mitigate this problem, Flexible AC Transmission System (FACTS) devices can be installed in a power system. However, non-optimal installation of FACTS devices can lead to ineffective compensation on power system. Hence, this thesis presents a new metaheuristic optimisation technique for solving optimal FACTS devices allocation problem for voltage security control. In this study, Chaotic Immune Symbiotic Organisms Search (CISOS) optimisation technique was developed with the aim of enhancing the searching capability of Symbiotic Organisms Search (SOS) technique to produce higher quality solutions. The CISOS integrates the element of Chaotic Local Search and cloning into the original SOS algorithm. The performance of proposed CISOS technique has been assessed by using various benchmark test functions in terms of its ability to find the actual global minimum point of the test functions as well as the computational time required to find the minimum point. Performance assessment of CISOS in finding the global minimum point of the test have revealed superior performance in terms of global minimum point found by CISOS as well as the computational time required to find the point. The proposed CISOS algorithm is subsequently employed to solve the allocation of Flexible AC Transmission System (FACTS) devices for the purpose of multi-objective voltage security problem. The study was divided into 3 phases, involving the implementation of CISOS to determine the optimal allocation of Static VAr Compensator (SVC), optimal allocation of Thyristor Controlled Series Compensator (TCSC), as well as simultaneous optimal allocation of SVC and TCSC in a power system. The capability of CISOS in solving the optimal allocation problem has been demonstrated in 2 power transmission system models, namely IEEE 26-Bus Reliability Test System (RTS) and IEEE 118-Bus RTS. Several case studies were also subjected to the optimal FACTS device allocation problem to observe the variation of results when the power system is operating at different conditions. Comparative studies were also conducted with respect to other existing optimisation techniques namely Symbiotic Organisms Search (SOS), Particle Swarm Optimization (PSO) and Evolutionary Programming (EP). The comparative studies conducted in this study includes the performance assessment of SOS, PSO and EP using benchmark test functions as well as the results of solving optimal FACTS device allocation problem for voltage security control. Results revealed that the proposed CISOS technique is superior compared to SOS, PSO and EP in terms of performance benchmarking. The performance of the proposed CISOS technique in solving multi-objective voltage security problem as compared to SOS, PSO and EP is very significant. It is proposed that CISOS technique is used to solve other optimisation problems for future research.

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MOHAMAD KHAIRUZZAMAN BIN MOHAMAD ZAMANI

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CHAPTER ONE
INTRODUCTION

1.1 Research Background

In power system operation, it is desirable for a power system to maintain a healthy and secure operation. Due to several factors such as increase in population as well as advancement in technologies, global energy demand has increased significantly. The increase in energy demand causes a power system to operate close to its stability limit. When a power system is operating near its stability limit, there is a tendency for voltage collapse to occur. Voltage collapse can be described as an incident in a power system initiated by voltage instability condition, which in turns would cause monotonic reduction of voltage, consequently would results to power outage or blackout [1][2]. Several literatures have reported various cases of power outages which were caused by voltage collapse [3], weather such as lightning strike and storm [3][4], short circuit [3][5], and equipment failures [3]. Power outage phenomenon are undesirable since it would cause various problems such as economic losses [6], interruption in communication channel [3], and disturbance on critical services [3].

Flexible Alternating Current Transmission System (FACTS) devices can be installed in power systems to improve the voltage security of a power system. FACTS devices are capable of providing a relatively fast compensation to power system, which would help to improve the voltage security and prevent voltage instability without the need of power system expansion [7]. The effectiveness of FACTS devices in providing compensation to power system has been recognised by various studies which has been outlined in [8].

This study proposes the development of Chaotic Immune Symbiotic Organisms Search (CISOS) optimisation technique which is inspired by the hybridisation of chaotic local search and immunisation elements into the original Symbiotic Organisms Search (SOS) optimisation technique. The proposed CISOS technique is developed with the aim to improve the searching capability of the SOS technique in terms of solution quality. In this study, 2 types of FACTS devices will be used for compensation process, namely Static VAr Compensator (SVC) as well as Thyristor Controlled Series Compensator (TCSC). These devices are chosen over other FACTS devices such as