UNIVERSITI TEKNOLOGI MARA

COMPUTATIONAL INTELLIGENCE BASED POWER SYSTEM SECURITY ASSESSMENT AND IMPROVEMENT UNDER MULTI-CONTINGENCIES CONDITIONS

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ABSTRACT

This thesis presents new techniques for voltage stability assessment and improvement in power system under multi-contingencies. A line-based voltage stability index termed as Static Voltage Stability Index (*SVSI*) was used to evaluate the voltage stability condition on a line. The value of *SVSI* was computed to identify the most sensitive line and corresponding weak bus in the system. The results obtained from the voltage stability analysis using *SVSI* were utilized to identify most sensitive line corresponds to a load bus and estimate the maximum loadability and operating margin in the system. The *SVSI* was consequently used as the line outage severity indicator in the implementation of contingency analysis and ranking. The application of *SVSI* was extended for the evaluation of the constrained power planning (CPP) and Flexible AC Transmission Systems (FACTS) devices installation using Evolutionary Programming (EP) by considering multi-contingencies occurrence in the system. The minimizations of *SVSI* and transmission loss are used as two separate objective functions for the development of optimization technique. The effect of reactive power load variation on transmission loss in the system is also investigated. Consequently, the EP optimization technique is extended for the evaluation of the operating generator scheduling (OGS) to be applied on reactive power control in power system. The results obtained from the study can be used by the power system operators to make a decision either to achieve minimal *SVSI*, minimal transmission loss or minimal installation cost. This has also avoided all generators to dispatch power at the same time. Finally, a novel multi-objective Constrained Reactive Power Control (CRPC) algorithm using the state-of-the-art of EP for voltage stability improvement has been developed. A performance comparison with Artificial Immune System (AIS) in terms of *SVSI* and loss minimization was made and it is found that the proposed algorithm has been able to produce better results as compared to AIS. The contributions of the studies among the others are the development EP and AIS engine for CPP considered multi-contingencies *(N-m)*, the development of EP and AIS engine for FACTS installation considered multi-contingencies *(N-m)* for the determination of FACTS placement using *SVSI* and optimal sizing of FACTS using EP and AIS, the development of new technique for OGS based on EP optimization technique and the development of multi-objective EP and AIS engines for CRPC considered multi-contingencies *(N-m)*.

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CHAPTER ONE
INTRODUCTION

Nowadays, the power transmission systems have been changed a lot. The voltage deviation due to load variation and power transfer limitation was experienced due to reactive power unbalance which has drawn attention to better utilize the existing transmission line. The shortage of reactive power can cause the generator and transmission line failure leading to blackout or collapse in a system [1]. It also causes a higher impact on power system security and reliability [6]. Hence, the electrical energy demand increases continuously from time to time. This increase is due to the fact that few problems could appear with the power flows through the existing electric transmission networks. If this situation is uncontrollable, some lines located on the particular paths might become overloaded [2]. Due to the overloaded conditions; the transmission lines will have to be driven close to or even beyond their transfer capacities. Consequently, the transmission line outage in a power system was reported to be the main issue towards voltage instability as well as generator outage contingency [3-4]. The line outage may cause violations on bus limit, transmission line overloads and lead to system instability [5]. While, the generator outage can be caused by failure of generator; this may interrupt system delivery and lead to system instability [6].

1.1 PROBLEM STATEMENT

Voltage stability has become a concern in power system operation when it involves heavy load and contingencies. It is highly dependent upon the system limits, which leads to the restriction of loading capability of a network. Therefore voltage stability study becomes an important issue in power system planning and operation since it was reported in [7-12] that this problem is a progressive issue which receives major concern. The increment in load demands will decrease the reactive power and voltage, which leads to voltage collapse in the system. Therefore, the system consumes more reactive power to raise the voltage level and improve the voltage stability condition in