FAST VOLTAGE STABILITY INDEX FOR VOLTAGE STABILITY ASSESSMENT IN POWER NETWORK

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To my beloved father, mother and sister.

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ABSTRACT

This project is conducted to assess the method which can monitor and provide an early detection of voltage instability of the power system network. Voltage stability assessment carried out for different operating scenarios and the status of the network stability were monitored using FVSI index. A modified IEEE 6 bus feeder was used in this assessment with seven different scenarios were tested in Power World software. This scenarios includes the normal operation, contingencies and load shedding. The FVSI for all the scenarios were compared and effectiveness of the load shedding conducted were also assessed. A range of index threshold were determined in order to group the stability of the network and it is a determining factor for load shedding. This FVSI index assessment is able to monitor the status of the network pre and post load shedding.

ABSTRAK

Projek ini dijalankan untuk menilai kaedah yang boleh memantau dan menyediakan pengesanan awal ketidakstabilan voltan rangkaian sistem kuasa. Penilaian kestabilan voltan dijalankan untuk senario operasi yang berbeza dan status kestabilan rangkaian dipantau menggunakan indeks FVSI . Bas IEEE 6 yang telah diubahsuai digunakan dalam penilaian ini dengan tujuh senario yang berbeza yang telah diuji dalam perisian Power World. Senario-senario ini termasuk operasi biasa , luar jangkaan dan penyisihan beban. Indeks FVSI untuk semua senario dibandingkan dan keberkesanan penyisihan beban yang dijalankan juga dinilai. Pelbagai ambang indeks ditentukan untuk penentuan kumpulan kestabilan rangkaian dan ia adalah faktor penentu untuk penyisihan beban. Penilaian indeks FVSI ini dapat memantau status pra rangkaian dan pasca penyisihan beban.

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LIST OF ABBREVIATIONS

FLS	-	Fast Load Shed
FVSI	-	Fast Voltage Stability Index
IEEE	-	Institute of Electrical and Electronics Engineers
RED	-	Relative Electrical Distance
SVSI	-	Simplified Voltage Stability Index
UFLS	-	Under Frequency Load Shedding
UTM	-	Universiti Teknologi Malaysia
UVLS	-	Under Voltage Load Shedding
VSI	-	Voltage Stability Index
VSM	-	Voltage Stability Margin

LIST OF SYMBOLS

F_{ji}	-	element in row j and column i of matrix F (taken from Y bus matrix)
g	-	number of generator buses
n	-	total number of buses of the network
Q_j	-	reactive power at receiving end
V_i	-	voltage at bus i or sending end voltage
V_j	-	voltage at bus j
V_g	-	voltage phasors at the nearest generator
V_l	-	voltage phasors at the analysed load bus
X	-	line reactance
Z	-	line impedance
[A]	-	matrix with size (n – g) x g
$\alpha 1$	-	set of load buses
αG	-	set of generator buses

LIST OF APPPENDICES

CHAPTER 1

INTRODUCTION

1.1 Introduction

Power shortage in an electrical network is noted to be a very complex and an undesired event. This is due to the extensive effect it brings to various parties such as the utility companies, industrial consumers, oil and gas production, hospitals, country's safety and etc. The major effect of voltage collapse causing the entire system to breakdown or also known as blackout is in terms of cost and safety, whereby it would be a humongous loss of production to the consumers.

However, to minimize these vital effects, load shedding system is applied to ensure the availability of electrical power to all essential and most critical loads in the network. The load shedding scheme shall fulfill the following objectives which are to prevent collapse of the electrical power system during insufficient power source available at the national grid or smart grid; and it shall act fast and reduce loads according to the availability of power source, before the electrical upset leads to overloading and protective tripping of the remaining sources and eventually the total radial distribution network blackout. Load shedding scheme is also prominent to minimize disturbance to the process of production in industries, hence, it shall shed only the amount of loads that are necessary to compensate the power deficiency according to a pre-defined priority order quickly.

Eventually, these has raised an alarming concern on load shedding scheme which has to be precise and rapid to respond to the unplanned events of power supply shortage to protect the electricity power system from a total blackout. As swift respond is expected, a real time on - line monitoring of power system stability has become an important factor for electric power utilities. Numerous analysis method were developed and implemented throughout the years in order to produce an effective and immediate load shed practice as the last resort to prevent from causing further damages. An early detection indicating unusual activities of the system's stability is required in order for a prompt activation of load shedding scheme. Referring to previous works, system stability detection methods were clearly explained. There are also many studies on monitoring the system stability which is capable to assist in load shedding scheme activation. These monitoring and optimization methods to activate load shedding and estimate the minimum amount of loads to be shed are for instance, Fast Load Shed (FLS), Voltage Stability Margin (VSM) and Gravity Search Algorithm and so on. This project will analyze another real time online monitoring method by utilizing a suitable voltage stability index such as Fast Voltage Stability Index (FVSI). The effectiveness of this index to monitor the system's stability pre and post load shedding can be tested for a power system network using simulation software Power World and Microsoft Excel. Hence, the FVSI figured from the computational method used, it is expected to enhance the reliability and speed of load shedding scheme.

1.2 Problem Statement

The load shedding scheme shall act fast and reduce loads according to the availability of power source, before the electrical upset leads to overloading and eventually the total network blackout. A rapid respond is expected and a real time on - line monitoring of power system stability is required to promptly detect and execute load shedding. Thus, continuous monitoring and quick indicator of a possible system voltage instability event is needed to kick start load shedding.

1.3 Scope of Work

The scope of work for this project involves selecting a suitable IEEE test feeder which can be modified and allows to manipulate the reactive load demand. Computing the FVSI index formula for the respective system is also part of this project. Besides that, the manipulation of the reactive power demand is required in addition to the observation of changes in FVSI index. The comparison of the outcome of FVSI method with different operating scenarios is one of the scope of work. In addition to these, a thorough analyses of the results and grouping of the branches according to the threshold value is required. Finally, a conclusion of the stability status of the branches also is involved in this project.

1.4 Objectives

The first objective of this projects is to estimate the proximity to stability problems in a power system network using voltage stability schemes. The second objective is to locate voltage sensitive branches which would have the highest contribution towards voltage instability for a power system network. The third objective is to analyse variation of FVSI index for pre and post load shedding for different operating scenarios.

1.5 Project Outline

This project report consists of five main chapters which are the introduction, literature review, methodology, results and discussion and finally, the conclusion.

Chapter 1 of this report will concentrate on the general overview of the system which undergoes voltage instability. This covers the problem of the system faced and the objective of this project report which can assist it mitigation process of the problem to occur.

Chapter 2 of this report will discuss on the literature review of the power system network, voltage stability indices and also the load shedding system. It gives a brief overview of each system and methods.

Chapter 3 is the methodology which gives the step by step explanation of the modeling and simulation done in this project. It also shows the index calculation for each scenarios.

CHAPTER 5

CONCLUSION AND FUTURE WORKS

5.1 Conclusion

In conclusion, this project is able to estimate the proximity to stability problems in a power system network using voltage stability scheme, FVSI. Besides that, the voltage sensitive branches which would have the highest contribution towards voltage instability in a network was also located by following the threshold values set. This project also analysed the effect of reactive power of the load and voltage of the source on the stability of the network. The efficiency of FVSI to monitor and indicate the status of the system was verified by the load shedding scenario.

5.2 Future Work

As a future recommendation, this stability assessment can be developed together with other system such as Electrical Network Monitoring System (ENMCS), power management scheme and others. It can also be implemented in a micro grid or smart electrical energy network. This method can become a monitoring device of the stability for a standalone network in a green building, home or remote area.

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