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研　究　主　論　文　抄　録

論文題目

REAL TIME MONITORING AND ASSESSMENT OF VOLTAGE STABILITY
(電圧安定性の実時間モニタリングと評価)

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主論文要旨

Power System monitoring is very important for such preventive action since the parameter of the system could move uncontrolled and would get in to the unstable state . Therefore, for a given operating information should measures as fast as possible regarding stability assessment. A number of methods to analyze voltage stability have been proposed using the static approach such P-V curve, smallest singular value from reduced Jacobian Matrix of the system and also using index stability criteria. All of these methods base on the load flow calculation (off-line) meaning that analysis done after the all data in the system are collected.　However in real power system operation, parameter of the system always change dynamically regarding the demand and supply. Therefore, the actual problem is how fast the operator can get the recent information in term of system monitoring for system analysis or protection action for such abnormal operation which could be happen during operation.　In this thesis, our research study is explained starting from Chapter 2 to Chapter 5.

Chapter 1 presents the short introduction about power system, problem in power system related to the voltage stability and information about traditional method used for analyzing voltage stability in the system. The objectives and structure of thesis also explained in this chapter

Chapter 2 presents the method to analyze the system by simplified the network into two port equivalent network. The concept of developing simple two-bus equivalent network comes up to obtain a faster assessment of voltage states of power system operation. In some area in power system, it is not necessary for operators to analyze all the system

because they only need the information for particular area. Therefore to get real time information and/or predict the next state operation on the specific area, it can be done by a simplified model of the area which is considered and also the time taken for analyze this system will be faster. Power System Network can be represented as Impedance matrix formulation. On this method, reduction network was developed by extracting the impedance component of the system related to the certain busses which should be kept for analysis. The reduction process is starting with selection of the generation and load bus chosen to be kept. All generator and load beyond those two buses are converted to impedances. The reduced network originally from driving point impedance and transfer impedance of remaining generator and load bus. This impedances still contain all interactions between all buses in the original network matrix.

In this study the implementation of this reduction will be applied to evaluate the voltage stability at particular buses by using PV curve and index stability. Simulations are performed on three different network model and the results showing the similarity responses of incremental load simulation on reduction system compare to the original one.

Chapter 3 presents a new method to analyze the voltage at particular bus by implementing phase angle measurement techniques. Phase angle difference between two busses in load flow analysis can be seen as direction of load flowing between the buses. The higher difference of phase angle, the greater load flows. Therefore phase angle difference can give good information of system loading/stress. In the simulation, during incremental load at particular bus, the phase angle difference between two busses can be transferred in to a simple conversion and trigonometric wave signal. This signal has different frequency for certain range of load. Using Discrete Fourier Transform (DFT), the signal will be transformed into the spectral frequency. Subsequently, we can analyzed the signal from lowest load up to the highest load to get the spectral frequency during loading The proposed technique will analyzed current condition by visualized the level of stress and proximity to voltage stability limit in the system based on the change of spectral frequency . In order to investigate the effectiveness of the proposed method, we involved contingency analysis. In this study, only single line outage case (n-1 contingency) was demonstrated. To select which line to be outage, the most severe outage of line from contingency ranking was chosen. The main advantages of the proposed method is it provides continuous monitoring of current condition entire system for stress analysis, implication of any topology changes directly observable, and has more capabilities to analyzed voltage collapse proximity comparing to some classic voltage stability analysis. This method can also be used at wide area network by implementing phasor measurement units.

Chapter 4 presents a method to analyze the voltage stability by implementing the Neural Network algorithm. One of the methods which widely used for assessing Voltage Stability is Index Stability (L-index). The index obtained from fundamental Kirchhoff Law which is simple in numerical calculation for steady state load flow analysis. If load bus increases and the system approach the voltage stability limit, the L-index will be approached to unity. As a result, for voltage stability assessment in the system, giving the L-index value can be used as indicator for the distance of every load bus to the maximum loading point. In the simulation, input parameters for index calculation taken from Phasor Measurement Units (PMUs) in the system which provides real time data. In practice, due to the uneconomical reason and unnecessary to place one bus for one PMU, therefore optimization placement has been applied. However, the selection of PMUs locations can be seen as a reduction of input parameters which require for index stability calculation. To solve the lack of input parameters problem, a trained data of Artificial Neural Network has been used to predict index stability. Two most widely used type of Neural Network in Power System particularly on Load flow calculation are Multilayer perceptron (MLP) and Radial Basis Function (RBF). Base on past result researchers experiences, they conclude that RBF NN should be preferred to MLP NN for online load flow analysis due to the training time and output estimation. Therefore in this study, RBF NN has been used for data training. Finally, study results show that this method is good enough to predict the index stability even for minimum requirement of PMU placement.

Chapter 5 presents a voltage stability assessment in real time operation using Linear Discriminant Analysis (LDA). To identified the level of voltage stability operation, Index Stability (L-Index) has been used) which similar method as using in chapter 4. The index generated from numerical calculation for steady state load flow the load adding up to the maximum load operation.

To define a voltage stability border above, the index stability which range from zero to unity is divided into n groups. The more number of n, the groups are more specify. However, if there are many groups within the stability range, unfortunately for some classes have no meaning between them regarding the load increasing in the system.

On this study, the groups which has been used have criteria as follow:

1. For Safe Operation condition, 0-70% of index stability range are used,
2. For Alert Condition, 70-90% of index stability range are used,
3. For Alarm Situation, 90%-100 of index stability range are used.

To distinguish the groups, Linear Discriminat Analysis has been used.

The input data from limited number of PMU treated as LDA input data training and grouped it based on index calculation. This study using 14 bus IEEE system to test the proposed method and the result presents the performance of the method is sufficient to measured the stability criteria in real time.

Also in this chapter, we propose a method as a combination of two methods from chapter 3 and 4 respectively for the visualization of power system operation and voltage analysis working together in same time. The methods from chapter 3 is difficult to determine the exact point of collapse when using only spectral frequency, therefore the index stability can be used to determined the boundary of stability limit including the collapse point. However, the spectral frequency can be used as good indicator to determine the stress system (when the loading increase) for entire bus in the system.

Chapter 6 presents the conclusion of the thesis and the recommendation for future work.