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Effect of line contingency on static voltage stability and maximum loadability in large multi bus power system

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ABSTRACT

Voltage instability is the phenomena associated with heavily loaded power systems. It is normally aggravated due to large disturbance. Due to deregulation of power system, the system has to cater for the load bids in open access. This may cause the increased transaction level leading to more stress on the power system. It has become an urgent need of today to address the voltage stability problems to keep the voltage profile under control. Several incidences of voltage instability have occurred worldwide recently. In the event of contingency, the most serious threat to operation and control of power system is insecurity. The estimation of the power system state under contingency is an essential task for the power system engineers. The contingency analysis technique is a prerequisite to predict the effects of various contingencies like failure of transformers, transmission lines, etc. It helps to initiate necessary control actions to maintain power system security, reliability and stability. In the present work, two kinds of performance indices viz. active power performance index and reactive power performance index are computed for a large power system using a special code written in MATLAB environment. Furthermore, a novel idea of static voltage stability analysis by incrementing the load in proportion to the original load on load buses along with the most vulnerable line outage using Newton Raphson (N–R) load flow is presented.

Introduction

Voltage collapse is the process by which the sequence of events accompanying voltage instability leads to a low unacceptable voltage profile in a significant part of the power system. Under contingency the reactive power demand on power system may increase suddenly. This additional demand must be met by the reactive power reserves of the generators and the shunt compensators. Owing to insufficient reserves, the combination of the events may lead to voltage instability. In deregulated environment the power system usually operates under stressed condition [2]. The heavily loaded systems are more prone to the voltage instability and the maximum loadability of the system is greatly affected. Several incidences of voltage instability have occurred worldwide recently in France, Japan and USA. It has become an urgent need of today to address the voltage stability problems to keep the voltage profile under control [2,3], Modal analysis technique provides an accurate estimate of the system proximity to the voltage stability limit and correctly predicts the critical buses and the weakest branches in the transmission system [4]. Voltage stability is a vital factor which needs to be taken into consideration during various stages of planning, operation and control of power systems in order to avoid voltage collapse and subsequently partial or full system blackout. The modal analysis and singular decomposition methods can identify the weakest areas of power system [5]. During the last decade, a number of control devices under the term flexible AC transmission systems (FACTS) technology have been proposed and utilized for significant improvement in voltage stability [6]. A robust control for PWM based dc–dc buck power converter in presence of uncertain parameters is suggested in [7]. By adjusting the design parameters the output voltage of the hybrid closed loop dc–dc-buck converter system will tend to desired value. The modal analysis method based on eigen value decomposition technique can evaluate critical eigen value which corresponds to weakest mode in power system. This critical eigen value can be used further to calculate bus participation factor which identifies weak buses in power system The bus participation factors can be used to implement the remedial measures for improvement of voltage stability [8]. The contingency analysis technique is a prerequisite to predict the effects of various

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contingencies like failure of transformers, transmission lines, etc. It helps to initiate necessary control actions to maintain power system security, reliability and stability. For a large power system the number of components are more therefore, the task of individual off line contingency analysis becomes quite tedious. Also only some of the contingencies have serious implications on the operation of power system. It is imperative to identify severe contingencies and analyze them. The process of identifying these severe contingencies is referred as contingency selection and this can be done by calculating performance indices for each contingencies.

Two performance indices namely power performance index and voltage performance index can adjudge the severity of the contingency [9]. In a simple way the AC load flow analysis can be used for the security analysis of power system for each possible generator, transmission line and transformer outage [10,11]. In [12,13], distribution factors are calculated to predict the changes in the line flows due to an outage of generator or transmission line. The application of ANN for determining the voltage stability margin under contingency situation has been discussed in [14,15]. The use of sensitivity analysis framework to determine the voltage stability status of the power system due to the occurrence of each contingency and stability margin or instability depth of the post-contingency state along with the contingency ranking is illustrated in [16]. In other words, a severity index is obtained for each voltage contingency and so the contingencies can be ranked. A re-definition function based on real-time network connectivity to take into account the actual response of protection subsystem on the power system equipment is suggested in [17]. Identifying the breaker for isolating the contingency equipment can help in improving the accuracy for calculating post contingency results. The contingency analysis is then carried out by simulating the tripping of corresponding circuit breaker. The correct remedial action schemes to be employed can be ensured by considering the impact of the simulated contingency on power system. A two block technique is suggested in [18]. First block filters out dangerous contingency. The second block assesses it for severity based upon performance index. This is called as consistency filtering and assessment for maintaining power quality and voltage stability.

In this paper an attempt is made to carry out the contingency selection by calculating the two kinds of performance indices: active performance index (PIP) and reactive power performance index (PIV) for single transmission line outage. Firstly, contingency ranking is made based on calculation of performance index. During a transmission line contingency both the active power flow limit and the reactive power limit which in particular affects the bus voltage gets altered. The change in active power flow and reactive power flow limits over the transmission lines due to line outage must be predicted as these have serious implications on thermal limits of transmission lines and the bus voltages. An algorithm for contingency analysis using N–R load flow has been developed with the main focus on the contingency selection for line outage for multibus power systems. Furthermore, a novel idea of static voltage stability analysis by incrementing the load in proportion

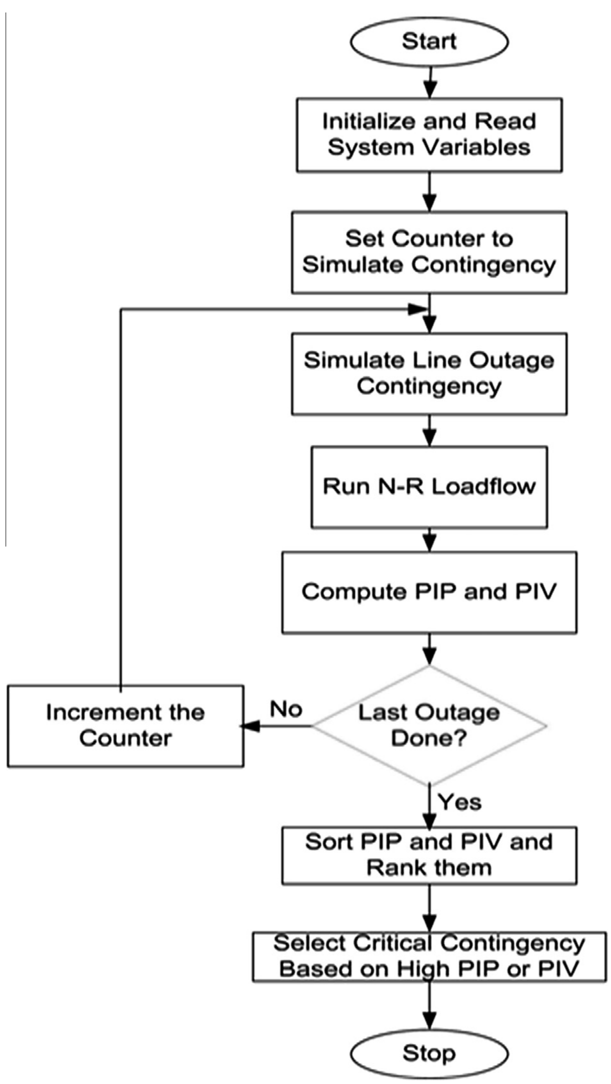

Fig. 1. Flow chart for contingency selection.

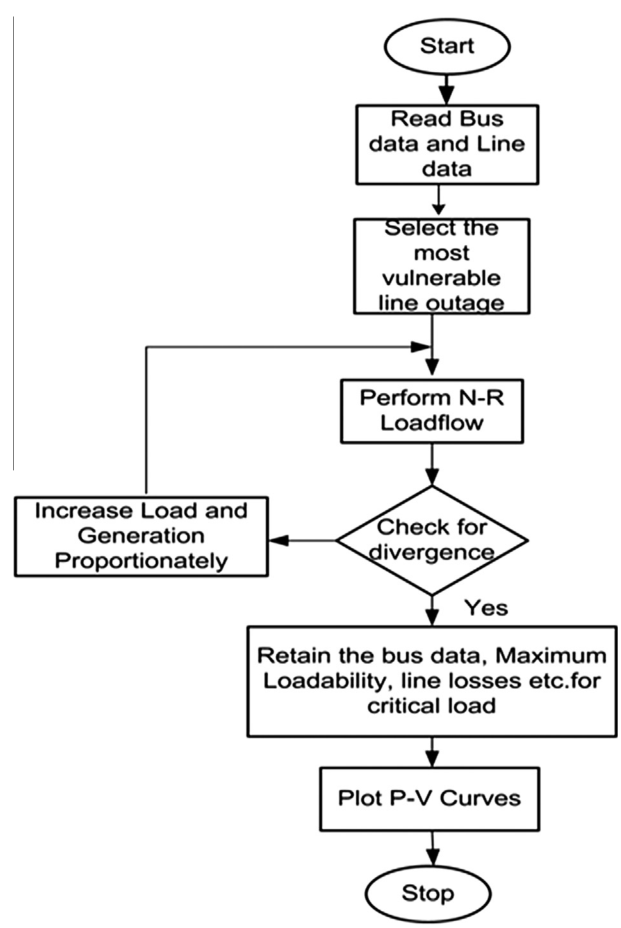

Fig. 2. Flow charts of the methodology of analysis.