CONTINGENCY RANKING ANALYSIS OF REAL TIME RADIAL DISTRIBUTION SYSTEM

A.SUNANTHA[1], JANGARI SRUJAN[2], CHEEMALA YAMINI[3], GUDA SRIDHAR REDDY[4]

[1](Assistant Professor ,Department of Electrical & Electronics Engineering and ACE Engineering College, Ghatkesar,Telangana,Email:sunantha.a@gmail.com)

[2] (Student, Department of Electrical &Electronics Engineering and ACE Engineering College Ghatkesar,Telangana,Email:21ag5a0207@gmail.com)

[3](Student, Department of Electrical &Electronics Engineering and ACE Engineering College Ghatkesar,Telangana,Email:20ag1a0209@gmail.com)

[4](Student, Department of Electrical &Electronics Engineering and ACE Engineering College Ghatkesar,Telangana,Email:20ag1a0214@gmail.com)

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Abstract:

To predict the effect of outages in power system the technique called contingency analysis is done. Contingency like failures of equipment, transmission line etc. The off line analysis to predict the effect of individual contingency of a power system is done, and power system contains large number of components. Practically only selected contingencies will lead to severe conditions in power system like violation of voltage and active power limits. The process of identifying these severe contingencies is referred as contingency selection and this can be done by calculating performance indices for each contingency. In this paper, the contingency selection by calculating two kinds of performance indices; voltage performance index (PIV) and Line performance index (PIF) for single transmission line outage have been done with the help of Fast Decoupled method in MiPower software. The ranking of most severe contingency has been done based on the values of performance indices. Simultaneously the value of bus voltages and active power flow before and after the most severe transmission line contingency has been analyzed. The effectiveness of the method has been tested radial distribution system with 5 bus systems. It can be seen from the results that, based on the knowledge of PIF and PIV the most severe transmission line contingency can be identified.

Keywords: **contingency, contingency selection, voltage performance index, Line performance index.**

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I. INTRODUCTION

A . Introduction to Contingency Ranking Analysis

Contingency analysis is becoming an essential task for power system planning and operation. Power system security analysis forms an integral part of modern energy management system. Security is a term used to reflect a power system's ability to meet its load without unduly stressing its apparatus or allowing variables to stray from prescribed range under the apparatus or allowing variables to stray from prescribed range under certain pre-specified credible contingencies. The contingencies are in the form of network outage such as line or transformer outage or in the form of equipment outage. The outage considered here is line outages. Outages which are important from limit violation view point, are branch flow for line security or MW security and bus voltage magnitude for voltage security. The conventional methods for security assessment are based on load flow solution where full ac load flow is made to run for all contingencies. The results obtained were accurate but these methods were found to be slow, as for all contingencies the load flow had to be run. But in the present day, due to large interconnection and stressed operation power utilities are facing severe problems of maintaining the required security. Today more emphasis is made on the greater utility of generation and transmission capacity, which has made the system to operate much closer to their limits. So, it has become, indispensable to do voltage security assessment accurately and instantaneously, to avoid the system from voltage collapse. The concept of security in system operation may be divided into three components, monitoring, assessment and control. Security monitoring starts with measurement of real time system data to provide up to date information of the current condition of power system. Security assessment is the process whereby any violation of the actual system operating states. The second much more demanding function of security assessment is contingency analysis. Operations personnel must know which line or generation outages will cause flows or voltages to fall outside limits. To predict the effects of outages, contingency analysis techniques are used. Contingency procedure model single failure events (i.e., two transmission lines, one transmission line plus one generator etc.) one after another in sequence until "all credible outages" have been studied. For each outage tested, the contingency analysis procedure checks all lines and voltages in the network against their respective limits. Load flow analysis performs static security analysis for a given system so that the system is operated defensively. Due to contingency, the system may enter an emergency state, wherein the operator has to tale fast actions to restore the system back to normal. Here the status of all the elements selected as contingency cased under contingency analysis section are made and outage study is performed. The output of the program alarms the user of any potential overloads or out of limit voltages. The contingency analysis is based on the computation s of voltage performance and overload performance indices. In this paper it computes the voltage performance index (PIV) and Line flow performance index (PIF) for the given operating condition and provides security status. Compute the voltage performance index and Line flow performance index for all the possible line outage conditions and the critical contingencies having index values greater than "1" (contingency screening) is identified and the contingency ranking is done in the descending order according to the order of severity based on PIV. Any power system operates on satisfying the demand from the generation. And also, on the contingency state the power system should operate by giving alarm or to inform the insecurity to the operator, also to diagnose the faulty bus and preventive measures should be taken to handle the contingency. There for contingency study is very important in the load-flow analysis. The performance index is calculated for every line outage for radial distribution system with 5-bus test system to implement the module for power system static security assessment. The security classification, contingency selection and ranking are done based on the performance index which is capable of accurately differentiating the secure and non-secure cases. Here in this project for radial distribution system-5 bus and load flow analysis and performance index is done in MiPower software.

II. CONTINGENCY ANALYSIS

Contingencies are defined as potentially harmful disturbances that occur during the steady state operation of a power system. Load flow constitutes the most important study in a power system for planning, operation and expansion. The purpose of load flow study is to compute operating conditions of the power system under steady state. These operating conditions are normally voltage magnitudes and phase angles at different buses, line flows (MW and MVAR), real and reactive power supplied by the generators and power loss. In a modern Energy Management power system security monitoring and analysis form an integral part but the real time implementation is a challenging task for the power system engineer. A power system which is operating under normal mode may face contingencies such as sudden loss of line or generator, sudden increase or decrease of power demand. These contingencies cause transmission line overloading or bus voltage violation. In electrical power systems voltage stability is receiving special attention these days. During the past two and half decades it has become a major threat to the operation of many systems. The transfer of power through a transmission network is accompanied by voltage drops between the generation and consumption points. In normal operating conditions, these drops are of the order of few percents of the nominal voltage. One of the principle tasks of power system operators is to check that under different operating conditions and/or following credible contingencies (e.g.: tripping of a single line) all bus voltages remain within bounds. In such circumstances, however in the seconds or minutes following a disturbance, voltages may experience large progressive falls, which are so prominent that the system integrity is endangered and power cannot be delivered to the customers. This catastrophe is referred to as voltage instability and its calamitous result as a voltage collapse. Large violations in transmission line flow can result in line outage which may lead to cascading effect of outages and cause over load on the other lines. If such over load results from a line outage there is an immediate need for the control action to be initiated for line over load alleviation.

A. Load Flow Analysis

The objective of power flow study is to determine the voltage and its angle at each bus, real and reactive power flow in each line and line losses in the power system for specified bus or terminal conditions. Power flow studies are conducted for the purpose of planning (viz. short, medium and long-range planning), operation and control. The other purpose of the study is to compute steady state operating point of the power system, that is voltage magnitudes and phase angles at the buses. By knowing these quantities, the other quantities like line flow (MW and MVAR) real and reactive power supplied by the generators and loading of the transformers can also be calculated. The conditions of over loads and under or over voltages existing in the parts of the system can also be detected from this study.

The different mathematical techniques used for loadflow study are

- Gauss Seidel method
- Newton Raphson method
- Fast Decoupled method
- Stott's fast decoupled method

B. Voltage performance index

$$\text{PIV} = \left[\sum_{i=0}^{nb} \text{Wi}\ \frac{|\text{V i}|\text{new} - |\text{V i}|\text{spec}}{\nabla \text{V i max}}\right]^2$$

Where,

Nb: Number of buses, Wi: Weightage factor for bus i, |V i| new: post outage voltage magnitude at bus i, |V i| spec: Specified voltage magnitude at bus i (1.0 p.u.) Vi max: Maximum allowable voltage change, which is computed as the difference between maximum voltage and difference between minimum voltage and specified voltage, if the voltage magnitude is less than the specified voltage. The significance of the weightage is to give lower ranking (higher severity) for poor voltage at specific buses.

C. Line flow performance index:

$$\text{PIF} = \sum_{i=0}^{nl} \text{Wi}\ \left[\frac{\text{P i new}}{\text{P i limit}}\right]^2$$

Where,

Nl: Total number of series equipment, Wi: Weightage factor for series element I, Pi new: New real powerflow in the line, Pi limit: Real power flow limit of the line.

The contingency can be ranked depending on the importance of a line. If it is desired not to overload a particular line, then that line weightage is assigned a high value.

Contingency analysis is done in this project bus2 to bus3 critical contingency. The system consists of 2 generating units. The purpose of this project is to develop an static security in power system. Critical contingency screening and ranking is carried out for different line outages using MiPower and the prediction of the security state for a particular operating condition as well as screening and ranking is based on the PIV and PIF. Here PIF & PIV are calculated by considering the outage of only one line sequentially and the calculated indices are summarized. Here r base case load flow of contingency ranking is considered, and contingency is created for the outage of line between buses then load flow analysis is executed.

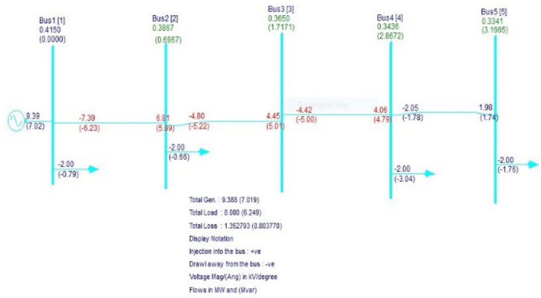

Fig 1. Single line diagram of 5-bus test system

Bus voltages, transformer and line loadings are tabulated. Contingency ranking analysis is executed. Record PIF and PIV from the report. Same procedure is followed for each transmission line where only single line is considered for one contingency analysis.

III.SOFTWARE USED

A. Introduction of MiPower:

MiPower is a software tool for power system analysis and design. It was developed by PRDC Infotech in the Year of Establishment 1994, a company based in India. MiPower has a history of several decades, starting from the times of DOS. It was one of the few products that had a graphical front-end during those times. MiPower is built over expertise earned over four decades of system operation, consulting and R&D in a country with one of the world's largest and most complex networks. MiPower covers various aspects of power system studies from steady state analysis to stability and security assessment, including reliability and protection. The software caters to the needs of power system planners and operations engineers. It has a Windows based platform that makes it highly interactive and user-friendly. It also has a professionally designed GUI and centralized databases that add to the efficacy of the software tool.

Some of the features of MiPower include:

- Power system database manager
- Graph utility
- Free programmable blocks
- Applications
- COMTRADE viewer
- Ground grid design
- AutoCAD interface
- Automatic single line diagram generation
- DC network solution
- Battery sizing

MiPower can be used for various applications such as load flow analysis, short circuit analysis, optimal power flow, transient stability, harmonic analysis, relay coordination, contingency analysis, etc. MiPower has been used by many researchers and engineers for various power system studies and projects. For example, one paper used MiPower to analyze the load flow of existing EHV networks and validated the simulation results analytically.

B. Tools used in MiPower:

Contingency ranking analysis is a method of assessing the impact of various possible failures or outages in a power system. It helps to identify the most critical contingencies and take preventive or corrective actions to maintain the system security and stability. MiPower is a software tool that can perform contingency ranking analysis using different methods, such as:

- Fast Decoupled Load Flow (FDLF) method: This method uses a simplified linearized model of the power system to solve the load flow equations faster and more efficiently. It calculates two performance indices, PIP (active power performance index) and PIV (reactive power performance index), which reflect the severity of contingencies based on the changes in active and reactive power flows and bus voltages.
- Performance Index (PI) method: This method ranks the contingencies based on the summation of PIP and PIV. It considers both active and reactive power effects of contingencies. The higher the PI value, the more severe the contingency.
- Voltage Stability Index (VSI) method: This method ranks the contingencies based on the voltage stability margin of the system. It uses a continuation power flow technique to trace the voltage collapse point for each contingency.

The lower the VSI value, the more severe the contingency. MiPower has a user-friendly graphical interface that allows the user to create and edit power system models, perform load flow and contingency analysis, view and export results, and customize various settings and options. MiPower also has a database manager, a graph utility, a COMTRADE viewer, an AutoCAD interface, and other features that enhance its functionality. MiPower can be used for various applications such as load flow analysis, short circuit analysis, optimal power flow, transient stability, harmonic analysis, relay coordination, etc. MiPower is a software tool for power system analysis and simulation. It can perform various studies such as load flow, short circuit, contingency analysis, optimal power flow, harmonic analysis, etc. It can also generate reports and documentation for the results of the studies. MiPower has a graphical user interface that allows the user to create and edit power system models, run simulations, and view the results in different formats. One of the applications of MiPower is to perform contingency analysis and ranking on radial distribution systems. Contingency analysis is a method to assess the impact of possible failures or outages of power system components, such as lines, transformers, generators, etc. Contingency ranking is a way to prioritize the contingencies based on some performance indices, such as active power, reactive power, voltage, etc. 12 Contingency analyse and ranking can help to identify the critical components and scenarios that may affect the security and reliability of the power system.

C. Steps for contingency ranking analysis on radial distribution systems using MiPower:

To perform contingency analysis and ranking on radial distribution systems using MiPower, the following steps can be followed:

• Create or import a power system model of the radial distribution system in MiPower. The model should include the details of the buses, branches, loads, generators, etc.
• Run a load flow study to obtain the base case solution. The load flow study can be performed using different methods, such as Newton-Raphson, Fast Decoupled, etc. The load flow results will show the voltage magnitude and angle, active and reactive power flows, losses, etc. for each bus and branch in the system.
• Run a contingency analysis study to simulate the effects of different contingencies on the system. The contingencies can be defined by the user or selected from a predefined list. The contingency analysis study will show the changes in the load flow results due to each contingency. The changes can be expressed in absolute or percentage values.
• Run a contingency ranking study to rank the contingencies based on some performance indices. The performance indices can be defined by the user or selected from a predefined list. The performance indices can be based on the changes in the voltage magnitude, active power flow, reactive power flow, losses, etc. due to each contingency. The contingency ranking study will show the ranking of the contingencies in ascending or descending order based on the performance indices.
• Generate a report and documentation for the contingency analysis and ranking results. The report and documentation can be customized by the user to include the desired information and format. The report and documentation can be exported in different formats, such as PDF, Excel, Word, etc.

SL NO.	FROM NAME	FROM NAME	PIV	RANK	VOLT LESS	PIF	RANK	LOAD MORE
1	BUS1	BUS2	0.000e +000	2	0	0.000e +000	2	0
2	BUS2	BUS3	9.250e -002	1	0	3.891e -001	1	0

Table 1: Result of PIF and PIV at line outage condition.

IV. CONCLUSION

In this paper, the calculation of PIV and PIF for contingency selection has been done using FDLF. From the results of PIF and PIV it can be concluded that for the transmission line contingency in line number is the most critical contingency. An outage in these lines has the highest potential to make the system parameters to go beyond their limits. It can be further concluded that these lines require extra attention which can be done by providing more advanced protection schemes or load shedding scheme. The contingency selection and ranking which are important for contingency analysis have been done by evaluating two important performance indices namely active and reactive power performance index (PIF&PIV). These indices were calculated for various test bus system. Since the since the for the contingency ranking, Overall Performance Index (OPI) is calculated which is the summation of two severity indices namely Active power performance index and Voltage performance index using Newton-Raphson load flow method. In order to predict the. Overall Performance Index, contingency ranking analysis real time radial distribution have been considered. The simulation result shows the superiority of the MiPower over. The proposed techniques have been tested on Radial distribution system 5 bus system in MiPower environment.

V. FUTURE SCOPE

The followings can be taken up for further study and analysis:

- The training for large systems like 30-Bus system and the structure of RBF-ANN like, neurons in hidden layer need to be investigated further.
- To perform the contingency analysis and the contingency selection considering a multiple line or equipment failures.
- Implement a hardware model for the neural network so that it can be used for online applications in power system contingency analysis.

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