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Research paper

Contingency Ranking and Screening of an IEEE Bus-6 Case System with Distributed Generation

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Abstract

Power System is a large system that is very sensitive to damage and failure especially in line and power outages, to assess the system security, contingency analysis allows systems to be operated. Many problems that occur on a power system cause serious trouble if not accounted and must be solved quickly. The objective is to create a program on how to have a quicker response on every contingencies. To solve this problem, the researchers had developed an algorithm for ranking and screening the contingencies for every line and power outages of an IEEE 6-Bus case system. Newton Raphson Load Flow (NRLF) was used to determine the line contingencies in the system and Performance Index (PI) ranked the contingencies based on their severity. The researchers were able to make a contingency analysis with a time of at least 10 minutes for computation.

Keywords: *Power System, System Security, Contingency Analysis, NRLF, IEEE 6-Bus*

1. Introduction

Power System is a large system that is very sensitive to damage and failure especially in line and power outages, most common causes of these outages are faults at power stations, damage to transmission lines, generator outages, or due to overloading, etc [1-2]. The effect is a short or long term loss of electricity in an area. To avoid and lessen the instance of power failure, system security is a key factor in the operation of a power system. Power System Operation is costly and standards must be followed to avoid scenarios such as system blackout. System security can be a solution which involves monitoring and simulation of possible contingency cases [3]. If any event occurs on a system that leaves it operating with violations, other components or the entire system will be out of service which influences the service of the power system.

To assess the system security, contingency analysis allows systems to be operated. Many problems that occur on a power system cause serious trouble if not accounted and must be solved quickly. Contingency analysis simulates line outage and its results to the power system thus helping the operator to make a quick action when an actual line outage occurs [4]. Most research regarding contingency analysis develops an algorithm that can simulate the line outages and power outages as quick as possible. Performance Index (PI) is used because of its ability to rank the most critical contingency and to assess the impact outage to the power system [5-6].

Studies had developed an algorithm for ranking contingencies for every line and power outages according to its severity. But in this research, some of these studies did not screen the critical & non critical case which is important in power system security analysis. Contingency screening will limit the outages from the most severe line down to the non-severe lines. Newton Raphson Load Flow (NRLF) will be used to determine the power flows in the system and compute for the Performance Index (PI). Performance Indices will rank the contingencies based on their severity and another algorithm will be formed for screening the ranked contingencies [6].

The main objective of this study was to be able to develop a simulation program for an IEEE 6-Bus Case System with Distributed Generation (DG). In order to achieve this, the researchers aimed to (1) create a Newton Raphson Load Flow simulation program, (2) simulate all possible line and generator contingencies, (3) create an algorithm for contingency analysis using the PI method, (4) integrate NRLF and PI method algorithm, (5) To adapt a method for screening the contingencies used by the authors of “Neural network approach to contingency screening and ranking in power systems.”, (6) assess and evaluate the developed algorithm.

Here the algorithm will greatly help the power system operators to avoid every possible damages or failures in the line and generator. The reason for developing this algorithm is for faster simulation of the contingencies and to have a quicker response on every outage with distributed generation identified by the program. The algorithm will be tested on the IEEE 6-Bus Case System. The study will be focusing on ranking and screening of the most critical contingencies in the power system. Furthermore, IEEE 6-bus system will be used for testing the proposed method. For the iteration process, the tolerance is set to 0.00001. The number of Contingencies is limited to (n-1) & (n-2) outages. This is for the practical or typical number of contingencies needed to assess. The purpose is to have an algorithm that can identify the critical contingencies as soon as possible.

2. Materials and Methods

The first step for the proposed method is to gather the line data and the bus data of the IEEE 6-bus system with DG to perform the load flow analysis for the post contingency case. Load flow analysis will be performed for every outage conditions using Newton-Raphson Load Flow (NRLF) in MATLAB. Power and line outages will be identified and hence be used in computation for the Performance Index (PI). Severity of a line or bus will be determined in this process and therefore can be ranked according to the computed PI values. Overall Performance Index (OPI) which consists of Active Power Performance Index (PIP) and Voltage Performance Index (PIV) will be computed. The severity of the line contingencies will be classified from non-severe to the most severe lines or busses and therefore must be screened accordingly. All identified line outages must be verified, in order to have an accurate result load flow analysis for ranking and screening, if not, simulation will operate again for more clarification. Ranking the contingencies will refer to the Overall Performance Index (OPI) and will be performed using Microsoft Excel, the highest value will represent as the most severed contingency. After the ranking process, the most critical contingencies will be separated from the non-severed contingencies thus, it will be screened. The screening will limit the ranking process for precision as well.

3. Results and Discussion

Figures 1 and 2 shows the process of the whole research while Table 1 shows the result for the computation of the overall performance index (OPI) for each cases. OPI was computed using the algorithm of performance index using MATLAB where the algorithm depends on the Loadflow computation results. The cases are the possible outages for power system with 'n-2' and 'n-1' conditions. OPI is the total of the voltage performance index (PIv) and Power Performance Index (Pip) The ranking of the cases was based on the computed OPI. The output was sent to MICROSOFT EXCEL using a MATLAB function, then it was sorted accordingly. Another function of MATLAB was used in order to take the sorted or ranked values and display on GUI. This process was done for every cases, hence, the computation for the OPI takes more time.

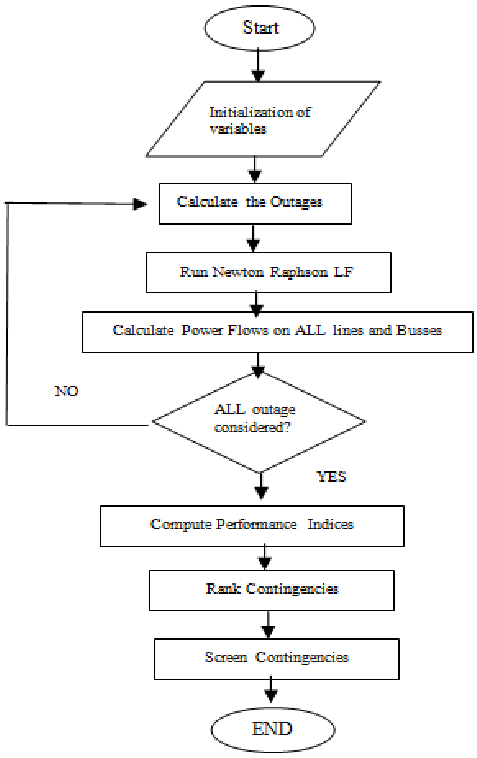

Figure 1:. Program Flowchart

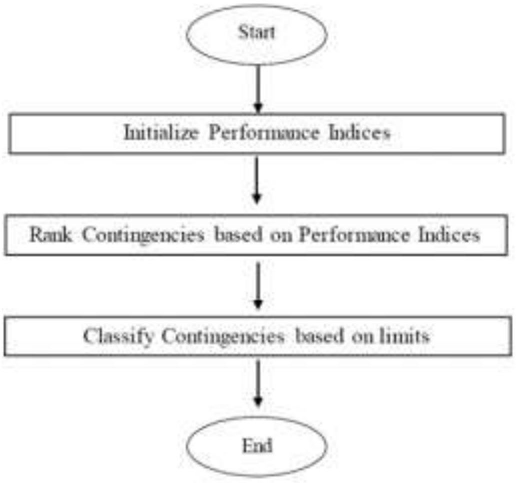

Figure 2:. Screening Flowchart

Shown in Table 2, the outages were classified based on their sensitivity and ranked. Most critical, critical, probably critical, and non-critical are the classification. The ranking of the cases was based on the computed OPI. The output was sent to MICROSOFT EXCEL using a MATLAB function, then it was sorted accordingly. Another function of MATLAB was used in order to take the sorted or ranked values and display on GUI. This process was done for every cases, hence, the computation for the OPI takes more time. Table 3 shows the screening table of the contingencies [7].

Table 1. Results of Perfornance Index

Cases (Outages)	PIv	Pip	OPI
Bus 1 and Bus 2	0.01078	0.00924	0.02002
Bus 1 and Bus 3	0.02004	0.01172	0.03176
Bus 1 and Line 1-2	0.01078	0.00417	0.01495
Bus 1 and Line 1-4	0.25304	0.01691	0.26996
Bus 1 and Line 1-5	0.14725	0.01183	0.15908
Bus 1 and Line 2-3	0.01193	0.00390	0.01583
Bus 1 and Line 2-4	0.42193	0.00862	0.43055
Bus 1 and Line 2-5	0.07043	0.00594	0.07637

Table 2. Results of Ranking & Screening

RANK	OUTAGE NAME		CLASSIFICATION	OPI
1	-	Line 3-6 and Line 5-6	MOST CRITICAL	2.47389
2	-	Line 3-5 and Line 3-6	MOST CRITICAL	1.97204
3	-	Line 1-5 and Line 3-6	MOST CRITICAL	1.86890
4	Line 1-4 and Line 3-6	-	MOST CRITICAL	1.65919
5	-	Line 2-3 and Line 3-6	CRITICAL	1.28378
6	Line 1-4 and Line 1-5	-	PROBABLY CRITICAL	1.15037
7	-	Line 2-4 and Line 3-6	PROBABLY CRITICAL	1.12413
8	Bus 2 and Line 3-6	-	PROBABLY CRITICAL	1.04641
9	Line 1-2 and Line 3-6	-	PROBABLY CRITICAL	1.04056
10	-	Line 2-4 and Line 3-6	PROBABLY CRITICAL	1.03773
11	Bus 3 and Line 3-6	-	PROBABLY CRITICAL	1.03322
12	-	Line 3-6 and Line 4-5	PROBABLY CRITICAL	0.92099

Table 3. Table of Ranking & Screening [7]

PI_P and PI_V Line Flow Violation Performance Index				
Indices	Non Critical (Class IV)	Probability Critical (Class III)	Critical (Class II)	Most Critical (Class I)
PIv	0.00 – 0.39	0.40-0.59	0.60 – 0.79	0.80 – 0.90
PIp	0.00 – 0.39	0.40-0.59	0.60 – 0.79	0.80 – 0.90
OPI	<0.80	0.80 - 1.19	1.2 - 1.59	$\geq$ 1.6

4. Conclusions

The researchers were able to create a Newton Raphson Load Flow simulation program for the contingencies. The codes were created using a high level language programming which is MATLAB. The generated cases were simulated simultaneously and data logging was done using Microsoft Excel. Data such as bus profile and line flows and losses can be seen to the Load flow results. For checking the accuracy of the created algorithm, the Load flow result of the base case was compared to the Load flow result of the base case using a third party power system simulation software, Power World. Simulation of all the possible line and generator contingencies were done. Using the combination command in MATLAB for finding the n-2 and n-1 cases, all of the possible combination of outages were found. Combination of outages is dependent to the number of the slack bus, PV bus and the lines. For the IEEE 6-bus system, with n=14 (Slack Bus=1, PV bus=2, lines=11), the n-2 cases and n-1 cases numbered to 91 and 14 respectively.

An algorithm for contingency analysis using the Performance Index (PI) method was created and integrated to the NRLF in MATLAB. Integration made the simulation process easier to operate. By running the program, the following steps were set to execute. NRLF section takes longer execution time but the following parts operates in normal executing time. A method was adapted for screening the contingencies. The computed OPI from MATLAB is transferred to the MS excel for data logging for ranking and screening. The OPI is compared to the range of the critical limits and then classified if it is most critical, critical, probably critical, and non-critical. It was found out that 4 out of 105 cases were the most critical cases and therefore it must be the focus of analyzation.

5. Recommendations

The researchers recommend upgrading the algorithm for faster computation of performance indices and Loadflow analysis. Faster workstation is recommended wherein high specification computers must be used in simulating the program in order to analyze the Load flow and performance faster in a short period of time. Including the screening of the contingencies in the GUI is important for faster identification of the critical contingencies which need immediate corrective measures. The algorithm can be used to screen and rank contingencies based on its overall performance index to other bus cases as long as the user provides data for the bus and line and other parameters for NRLF respectively. After the generation of ranked contingencies another method can be produced using PIQ method. In this research PIv and PIp was used so another method can be use in determining the performance of the power system which is PIQ method that is based on the reactive power of the system.

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