International Journal of Scientific Research & Engineering Trends
Volume 7, Issue 4, July-Aug-2021, ISSN (Online): 2395-566X

Contingency Analysis

Asst. Prof. Vishal V. Mehtre, Shubham Saket, Siddharth Gautam
Department of Electrical Engineering,
Bharati Vidyapeeth (Deemed to be University)
College of Engineering,
Pune, Maharashtra, India.

Abstract- **A dependable, continuous supply of electrical energy is a necessary component of today's advanced societies. Hence to maintain the power system security and reliablity is one of the inmportant tasks for system engineers. The security assessment is an important task because it provides information related the state of the system in the case of a contingency. Contingency like sudden loss of line or generator or increase/decreased in power demandcause voilation of bus voltage or transmission line overloading. Hence to keep the system safe and continuity of supply contingency analysis is important. Different terms related to contingency including FDLF is reviewed in this paper.**

Keywords- **FDLF , Electrical Energy etc.**

I. INTRODUCTION

A power system is a collection of a complex network made up of many devices such as generators, transformers, transmission lines, projecting devices, and distributed loads. Failure of any component of the power system during operation damages and reduces the reliability of the system. Such fault or disturbance occurs in a steady-state operating power system that can cause adverse effects known as contingencies.

Power system working in normal condition may encounter Contingency such as sudden loss of line, sudden change in generation, sudden change in load value, abrupt surge or decrease in power demand. Such conditions may cause transmission line overloading or bus voltage violation.

Contingency analysis allows us to predict which contingencies affect the system used to calculate violations by using iterative load flow solutions for each component failure. It provides tools to build, manage, analyze, and reporting list of contingencies and associated infringement. Contingency analysis is part of the safety analysis applications in an electric utility control center.

II. CONTINGENCY SELECTION

To select contingencies, prepare a list of which are the most likely contingencies in the system and which generator disturbance is most often considered high priority through the use of historical or backup data.

Selection is set for the most likely contingencies, preferably consists of selecting a set of most likely contingencies in the preferred.

Contingencies can be divided into two broad categories:

- A power outage, and
- Disconnecting the network

1. A power outage includes:

- The loss of a power unit.
- A sudden change in load that could cause the problem of stability or fluctuation.
- A sudden change in power flow in the internetwork, which implies a sudden increase in generation in one area and loss of generation in another.

2. Network outage included:

- Transmission line disconnection.
- Failure of the transformer.

III. METHODS OF CONTINGENCY ANALYSIS

Following are the method use to analyse the contingency:

- AC load flow methods
- DC load flow method.
- Z-bus contingency analysis.
- Performance Index method

1. AC Load Flow Method:

The AC load flow method is useful where VAR flow is predominant, for example in underground cables. At this point, we cannot use any other method for contingency analysis such as sensitivity factor as it only gives information about MW but fails to give information about MVAR current and bus voltage.

AC load flow is preferred as a contingency analysis method because it provides information about the MVAR flow and bus voltage in the system. The method using AC power flow will accurately determine overload and voltage limit violations.

International Journal of Scientific Research & Engineering Trends
Volume 7, Issue 4, July-Aug-2021, ISSN (Online): 2395-566X

The only drawback with this method is that the program takes longer to execute and if there are multiple outages then the total time to test for all the outages may be too long. Power flow studies are conducted for the purpose of planning operation and control.

The following are the mathematical techniques used for load flow studies:

- Gauss Seidel Method
- Newton Raphson Method
- Decoupled Method.
- Stott's Fast Decoupled Method.

2. DC Load Flow Method:

This equation is N-1 in number, where N is the number of buses. In this method, line resistances are not taken into account, only the real power flow is simulated without taking into account the reactive power flow. This leads to the creation of a linear network model to facilitate handling multiple accidental outages using the principle of superposition.

Each transmission line is indicated by its susceptance Bij.

$$\mathbf{Z = r + jx \rightarrow \; 1}$$

$$\mathbf{Y = G + jB \rightarrow \; 2}$$

Where,
Z = Impedance
Y = Inverse of impedance

$$G = \; r/ (r^2 + x^2) \approx 0 \qquad \rightarrow \; 3$$

$$B = -x/ (r^2 + x^2) \approx -1/x \qquad \rightarrow \; 4$$

This method takes into account only the real part of the equations of power flow, i.e. the effect of reactive power Q is neglected and all the bus voltages are assumed to be 1 p.u. the Matrix B' is calculated assuming that all resistances are zero from the equation;

$$\mathbf{B'\,ik = -\,B\,'ij = 1 / xij}$$

Where,
xij = the reactance of the line connecting the i and j buses
The angles and real powers are solved by iterating Equation

$$\delta = [B']^{-1}\,\Delta P$$

3. Z-Bus Contingency Analysis:

Methods include inverting the Y bus matrix or admittance matrix and injecting a fictitious current into one of the buses connected to the element to be removed, such that the current flowing through the element is equal to the flow in the base case, all other bus currents are set to zero.

IV. FLOW CHART FOR CONTINGENCY ANALYSIS USING FAST DECOUPLED LOAD FLOW

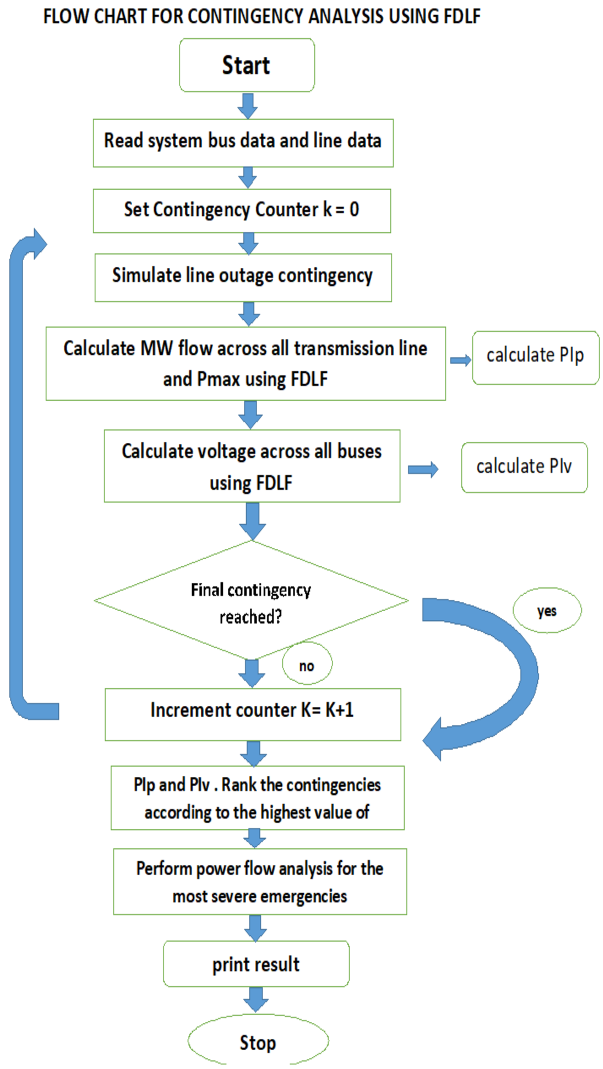

Fig 1. Flow Chart For Contigency Analysis.

Algorithm steps for contingency analysis using a FDLF solution are given below:

- **Step 1:** Read the system line data and bus data.
- **Step 2:** Set the counter to zero before simulating line contingencies.
- **Step 3:** Simulate a line contingency.
- **Step 4**: Calculate the active current in the remaining lines and the maximum current PMax**.**
- **Step 5:** Calculate the active power performance index PIP, which indicates a violation of the active power limit.
- **Step 6:** Calculate the voltages on all load bars according to the line contingency.
- **Step 7:** Calculate the reactive power index, PIV, which gives the overvoltage limit on all busbars in the load due to a line fault.

International Journal of Scientific Research & Engineering Trends
Volume 7, Issue 4, July-Aug-2021, ISSN (Online): 2395-566X

- **Step 8**: Make sure this is the last line outage to be simulated; if not, steps (3) to (7) are calculated until the last line of the bus system is reached**.**
- **Step 9:** The contingencies are ranked after the entire above process is calculated in accordance with the values of the obtained performance indicators.
- **Step 10:** Conduct a power flow analysis for the most severe contingency case and print the results.

V. 5-BUS SYSTEM

The study for the 5-bus system was conducted. A slack bus numbered 1 and 4 and load buses are numbered as 2, 3, 4 and 5 is depicted on Fig. This base case analysis also refers to precontingency state and consists of a total of seven transmisson lines and the active power flow of each FDLF transmission line, which corresponds to the basic loading condition.

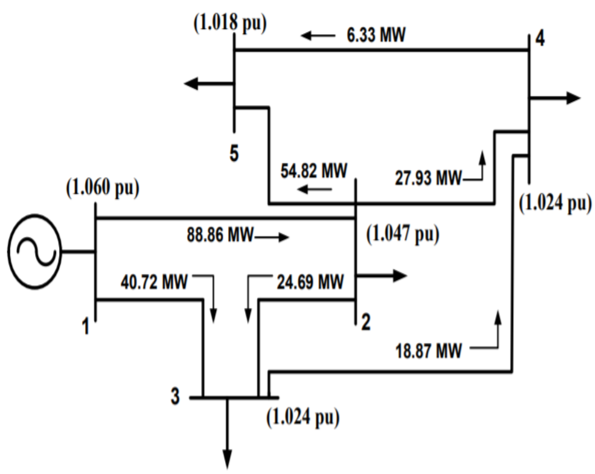

Fig 2. Pre Contingency state of 5-Bus System.

The load flow analysis starts by taking the single line outage contingency at a time. The PIP & PIV (Active and Reactive performance Indixes) are calculated sequentially and the indices are noted down. On the basis of the PIV value the ranking of the line outage contingency is determined. The higher the PIV value, the higher the rank and severity level.

Table 1. Performance indices and contingency ranking using FDLF for 5-bus System.

Outage Line	PIp	PIv	Ranking
1	0.2802	3.1918	1
2	0.3619	0.2701	6
3	0.3378	0.6559	4
4	0.3792	0.6175	5
5	0.4223	0.2655	7
6	0.2996	0.8601	3
7	0.3038	0.8801	2

According to the table (1), the outage of line number one is the most vulnerable, and its failure will have a significant impact on the entire system; the highest value of PIV for this outage indicates that special attention should be paid to this line during the operation.

Table 2. Bus voltages in pre and post contingency state.

Bus Number	Pre-contingency voltage (pu)	Post-contingency voltage (pu)
1	1.061	1.061
2	1.048	0.891
3	1.024	0.887
4	1.024	0.880
5	1.019	0.862

It can be seen that the contingency in the line connecting buses (1-2) results in the highest value of the reactive power performance index, and thus it is selected first for contingency selection; thus, the post contingency state of the system relating to this contingency has been examined. Because the value of PIV indicates the severity of the problem in the system as a result of a voltage limitviolation, the pre and post contingency voltages at the system's buses are detailed in Table 2.

Table 3. Active flow in the pre and post contingency state.

Line No.	Start Bus	End Bus	Pre contingency MW flow	Post contingency MW flow
1	1	2	88.87 MW	0 MW
2	1	3	40.74 MW	146.63 MW
3	2	3	24.69 MW	15.34 MW
4	2	4	27.93 MW	4.00 MW
5	2	5	54.82 MW	39.07 MW
6	3	4	18.87 MW	66.80 MW
7	4	5	6.34 MW	22.23 MW

Now thet table (3) shows the MW flows associated with the pre-contingency and post-contingency states,through this table (3) we can can compare the pre contingency and post contingency state of 5-Bus system.

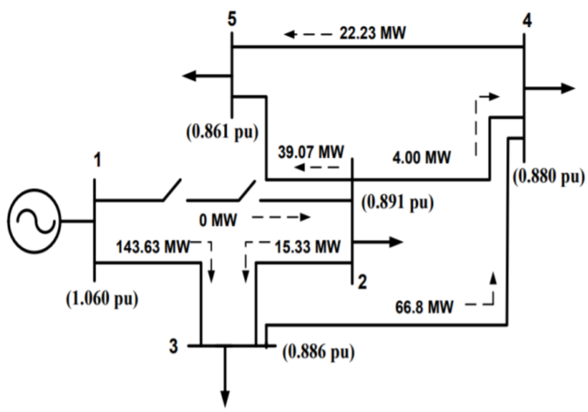

Fig 3. Post Contingency state of 5-Bus system.

The power flows and bus voltages in the system after the most severe contingency, which is the outage of the transmission line connecting buses (1-2), are depicted in Fig 2.

Based on the results, it is possible to conclude that calculating performance indices provides a good measure of the severity of all possible line contingencies that may occur in the system. The indices with the highest values represent a severe case which abruptly system parameter by pushing it beyond the limit.

As a result, the most the most severe contingency case was selected from a list of various line contingencies and the post-contingency analysis for this contingency has been completed where the mostImportant system parameters, such as bus voltages and MW flows, have been computed.Before the power system is turned on, a list of the most serious contingencies is created.

VI. CONCLUSION

In this review paper we have highlighted the important terms related to Contingency Analysis. It is an analysis that enables operators to be better prepared to respond to disruptions through the use of pre-planned recovery scenario. Selection criteria and methods of contingency analysis are described in this paper.

Contingency analysis was carried out by analysing two critical performance indices, ie, the active and reactive power performance indexes (PIP & PIV). These indices were computed for the test bus systems using the Fast Decoupled Load Flow (FDLF). The calculation of performance indices provides a good estimate of the severity of all possible line contingencies that may arise in the system.The methods of contingency analysis using sensitivity factors and AC power flow have been described; with the analysis with AC power flow using FDLF being found to be the most appropriate.The approach of contingency selection plays a critical role as the possible contingency list for power system network is very large.

In case of emergency it is extremely important that the entire process of contingency analysis be completed in the shortest amount of time as a result, in order to accelerate the overall contingency analysis process, the computing speed in the selection process needs to be increased.

REFERENCE

[1] Albuyeh F, Bose A and Heath B, “Reactive power consideration in automatic contingency selection”, IEEE Transactions on Power Systems.
[2] Stott B, Alsac O and Monticelli A.J, “Security Analysis and Optimization”, Proc. IEEE.
[3] IEEE TF Report, “Proposed terms and definitions for power system stability,” IEEE Trans. Power Apparatus and Systems, vol. PAS-101.
[4] D.P.Kothari and J.S.Dhillon, Power System Optimization, Prentice-Hall of India Private Limited, New Delhi.
[5] Brandwjn V and Lauby M.G, “Complete bounding method for a.c contingency screening”, IEEE Transactions on Power systems.
[6] Anant Oonsivilai and Kenedy A. Greyson – “Power System Contingency Analysis Using Multiagent Systems”; World Academy of Science, Engineering and Technology.
[7] John J. Grainger, William D. Stevenson J., Power System Analysis.
[8] Albuyeh F, Bose A and Heath B, “Reactive power consideration in automatic contingency selection”, IEEE Transactions on Power systems.
[9] C. Singh, and R. Billinton, System Reliability Modeling and Evaluation, London, U.K., Hutchinson Educational.
[10] R. Billinton, and W. Li, “A Novel Method for Incorporating Weather Effects in Composite System Adequacy Evaluation,” IEEE Trans. Power Syst., vol. 6, no. 3, pp. 1154–1160, Aug. 1991.
[11] Stott B, Alsac O and Monticelli A.J, “Security Analysis and Optimization”, Proc. IEEE.
[12] S.N. Talukdar and F.F. Wu, "Computer Aided Dispatch for Electric Power Systems" Proc. of the IEEE.
[13] B. Stott, "Review of Load Flow Calculation Methods" Proc, IEEE, Vol. 62, pp. 916-929, July 1974.
[14] Chiang, H.D., Jin, L., Varghese, M., Ghosh,S. and Li,H., “Linear and Nonlinear Methods for Contingency Analysis in On-Line Voltage Security Assessments”, Power & Energy Society General Meeting, July 2009.
[15] Medicherla, T.K.P. and Rastogi, S.C., “A Voltage-Criterion Based Contingency Selection Technique”, IEEE Trans. on Power Apparatus and Systems.