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Transmission Line Contingency Analysis in Power system using Fast Decoupled Method for IEEE-14 bus Test system.

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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 contingencies. 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 on IEEE-14 bus test 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

I. INTRODUCTION

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 statusCompute 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 andThe 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 IEEE 14-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 IEEE-14 bus and load flow anaylsis 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 violations. 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. Therefore contingency analysis is one of the most important tasks to be met by the power system planners and operation engineers. But on line contingency analysis is difficult because of the conflict between the accuracy in solution of the power system problem and the speed required to simulate all the contingencies. The simulation of contingency is complex since it results in change in configuration of the system.

*A*Load flow methods:

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.

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The different mathematical techniques used for load flow study are

1. Gauss Seidel method
2. Newton Raphson method
3. Fast Decoupled method
4. Stott's fast decoupled method

III. Performance index

A. Voltage performance index:

$$\mathrm{PIV} = \left[\sum_{i=0}^{nb} \mathrm{Wi}\ \frac{|\mathrm{V\ i}|\mathrm{new} - |\mathrm{V\ i}|\mathrm{spec}}{\nabla \mathrm{V\ i\ max}}\right]^2 \qquad (1)$$

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.

B. Lineflow performance index

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

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.

IV. Tests and Results

Results of IEEE 14-test bus system are discussed in the following section.

A. IEEE 14-bus test system

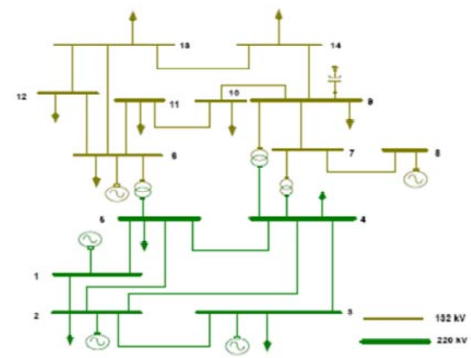

Fig 1.Single line diagram of IEEE 14-bus test system

Contingency analysis is done for IEEE 14-bus test system. The system consists of 2 generating units, 17 transmission lines and 3 transformers.

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 in Table 1.The effectiveness of the method is tested for IEEE 14-bus test system

Here r base case load flow of IEEE-14 bus system is considered, and contingency is created for the outage of line between buses then load flow analysis is executed.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.

V. Results

Output result is shown below in the tabular column

Outage Line No.	PIF	PIV	Ranking	Security Status
1	1.1693	7.3022	8	Insecure state
2	0.9807	7.6696	9	Alarm state
3	1.1654	10.0014	5	Insecure state
4	0.9999	7.3213	10	Alarm state
5	0.9820	8.8756	7	Alarm state
6	0.9640	13.2572	2	Alarm state
7	0.9915	0.3566	16	Alarm state
8	1.0747	1.1753	14	Insecure state
9	0.9807	10.5776	3	Insecure state
10	1.2396	1.6047	13	Insecure state
11	1.0142	9.5907	6	Insecure state
12	1.0127	1.8089	12	Insecure state
13	1.0569	1.3669	15	Insecure state
14	1.0072	10.4518	4	Insecure state
15	1.0759	0.0844	17	Insecure state
16	**1.0114**	**13.3464**	**1**	**Insecure state**
17	1.0164	2.3482	13	Insecure state

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

VI. Conclusion

In this paper, the calculation of PIV and PIF for contingency selection has been done using FDLF for IEEE-!$ bus test systems. From the results of PIP and PIV it can be concluded that for the transmission line contingency in line number 16 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 schemes.

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