Artificial Neural Network Approach for Contingency Analysis in Power System

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ABSTRACT

Contingency analysis is one of the most important tasks encountered by the planning and operation engineers of bulk power system. Power system engineers use contingency analysis to examine the performance of the system and to assess the need for new transmission expansions due to load increase or generation expansions. The security evaluation is a crucial venture because it offers the statistics regarding the system state within the occasion of a contingency. Contingency analysis technique is being widely used to are expecting the result of outages like failures of kit, conductor etc., and to require essential movements to live the facility device cozy and dependable. A new approach using Artificial Neural Networks has been proposed in this paper for real-time network security assessment. Security assessment has two functions the first is violation detection in the actual system operating state. The second, much more demanding, function of security assessment is contingency analysis.

Keyword: - *Artificial Neural Network, Power System Security, performance Index (PI), Contingency.*

1. INTRODUCTION

Secure operation of electric power systems is a vital requirement which imposes drastically a large system analysis burden on the energy management system. Security assessment consists of predicting the vulnerability of the system to possible events like outage of a transmission line, transformer or a generating unit. Contingency analysis as a main computational tool plays a dominating role on the security assessment. Conventionally, contingency analysis is carried out by analytically modeling the power system, and solving the power flow equations on a computer sequentially for each outage from the contingency list. This is a time-consuming task particularly for an on-line application environment. The concept of pattern recognition has long been considered as a possible means for speeding up of security assessment. Recently neural network technique has received a more interest and research in the field of security assessment and contingency analysis.

Voltage stability is defined as the ability of a power system to maintain steadily acceptable bus voltage at each node under normal operating conditions, after load variation following a change in system configuration or when the system is subjected to contingencies like line outage or generator outage. Single or multiple contingencies cause voltage violations which are known as voltage contingencies. The line outages may lead to the most severe violations in line flow which necessitates the line over load alleviation of the network.

The three basic elements if real-time security analyses are, Security monitoring, Security assessment. The problem of predicting the static security status of a large power system is a computationally demanding task [2] and it requires large amount of memory. In online contingency analysis, it has become quite common to screen contingencies by ranking them according to some severity index.

Thus, contingency selection is defined as the process of identifying these critical contingencies. Thus, contingency selection/screening or contingency ranking is projected so in order to rank those outages which will violate the normal operating condition. Contingency selection methods are based on Performance Index (PI) that may represent a line overloading or bus voltage drop limit violation. Then sorting of performance index is done in such a way contingencies are ranked according to their severity. In these last few years, a lot of work has been done in this part which consists of selection of the potential contingencies cases by using ranking methods or screening methods. Bounding methods Distribution methods Expert and new method for contingency selection, Neural Network and other latest mathematical techniques have been used in the indirect calculation of MW flow violation ranking. The recent developments using Artificial Neural Network have brought lot of advancement in the speed of contingency screening.

As a consequence, contingency choice is defined because the system of identifying those crucial contingencies. As a consequence, contingency selection/screening or contingency rating is projected so that you can rank those outages to be able to violate the everyday running situation. Contingency selection strategies are based totally on overall performance Index (PI) that can represent a line overloading or bus voltage drop restrict violation.

Artificial Neural Networks (ANNs) concerned many researchers and engineers from power device region to look for the solutions to some of complicated issues to improve the speed in security degree. It has been proved that those ANNs are able to learning from raw information and that they can be used to become aware of internal dating within raw statistics no longer explicitly given or even recognized by means of human specialists and there may be no want to assume any linear relationship among information. This approach is preferred as it calls for no calculation based on mathematical model. Most current ANNs used for fixing strength gadget problems have been designed using actual numbers. In energy engineering packages which includes load go with the flow, contingency evaluation, evaluation, signal and photo processing involves complex statistics to be processed. However, the utility of ANN approach in processing of complex values continues to be an open problem. The very best solution could be to do not forget a conventional realvalued community wherein the complicated input and output indicators are replaced by using pairs of impartial actual-valued alerts.

2. ARTIFICIAL NEURAL NETWORKS

Artificial neural networks (ANN) are massively parallel inter connected networks of simple elements known as artificial neurons and their connectivity is intended to interact with the objects of real world, in a similar manner as the biological nerves systems do.

The simple neuron model is shown in fig-1. ∑ unit multiplies each input 'x' by a weight 'w' and sums the weighted inputs. The output of the figure is

NET = $x_1w_1 + x_2w_2 + \ldots + x_nw_n$: OUT = f(NET)

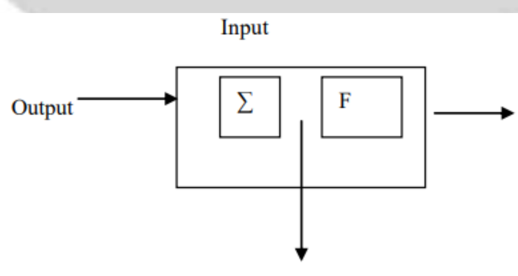

Fig-1 simple neuron model

The Radial Basis Function is similar to the Gaussian function, which is defined by a center and a width parameter. The Gaussian function gives the highest output when the incoming variables are closest to the center apposition and decreases monotonically as the rate of decrease.

Where X = an input vector
u_i = weight of vector of hidden layer neuron I
$D_i^{\,2} = (x - u_i)^r (x - u_i)$, x and u are column vectors

3. METHODS OF CONTINGENCY ANALYSIS

There are various methods used for contingency analysis purpose. Methods based on AC power flow calculations are considered to be deterministic methods which are accurate compared to DC power flow methods. In deterministic methods line outages are simulated by actual removal of lines instead of modeling. AC power flow methods are accurate but they are computationally expensive and excessively demanding of computational time. Because contingency analysis is the only tool for detecting possible overloading conditions requiring the study by the power system planner computational speed and ease of detection are paramount considerations. A brief description of these methods is given below.

3.1 DC LOAD FLOW METHOD OF CONTINGENCY ANALYSIS

This method is based on DC power flow equation to simulate single or multiple contingencies. These equations are N-1 in number, where N is the number of buses. In this method the line resistances are neglected, only real power flows are modeled ignoring the reactive power flows. This results in a linear model of the network to facilitate performing multiple contingency outages using the principle of Super position.

3.2 VOLTAGE STABILITY INDEX (L-INDEX) COMPUTATION

The Voltage Collapse Proximity Indicator (VCPI) was introduced by Kessel and Glavitch for a two-bus system model and was generalized for a multi node system using a hybrid model for the power system. This indicator utilizes the information obtained from a normal load flow solution. The method can be used to determine local indicators corresponding to each load bus. The indicator L varies in the range between 0 (no load of system) and 1 (voltage collapse) values close to one indicate proximity to power flow divergence. Based on the concept, various models are derived which allow the predicting of voltage instability or the proximity of a collapse under various contingencies such as loss of generators or lines as well as load variations. The advantage of the method lies in the simplicity, reliability and it can give a good indication about the critical power a system can maintain before collapse over the whole region and for all the cases studied. A local indicator j L for each node j can be calculated as explained below

Consider a system where n be the total number of buses with 1, 2,…,g be the generator buses, and g+1,…,g+s, be switchable VAR compensator (SVC) buses, g+s+1,…, n be the remaining (n-g-s) load buses. Using the load flow results, the L-index value, computed at load buses is given as

$$\mathrm{Lj} = \sum_{i=1}^{i=g} Fji \times Vi \div Vj$$

The value of L-index lies between 0 and1. An L-index value less than 1 (unity) and close to 0 (zero) indicates an improved voltage stability margin. The values Fji are obtained from the Y-bus matrix given by ([F_{LG}])

4. CONTINGENCY ANALYSIS USING NEWTON RAPHSON METHOD

A clean way to conform to the conference paper formatting requirements is to use this file as a template and surely kind your text into it. Here on this chapter algorithm for Newton Raphson technique, contingency ranking the use of NR technique has been discussed. This traditional technique had been proposed on IEEE buses, five Bus. The outcomes received using this approach have been used similarly in determine the overall performance indices, lively power overall performance index and voltage energy overall performance index. After obtaining the overall performance indices, the contingency rating is carried out with the overall performance index which is the summation of those two overall performance indices. The one with higher basic overall performance index is ranked first and is arranged in descending order quantifying the severity of contingency

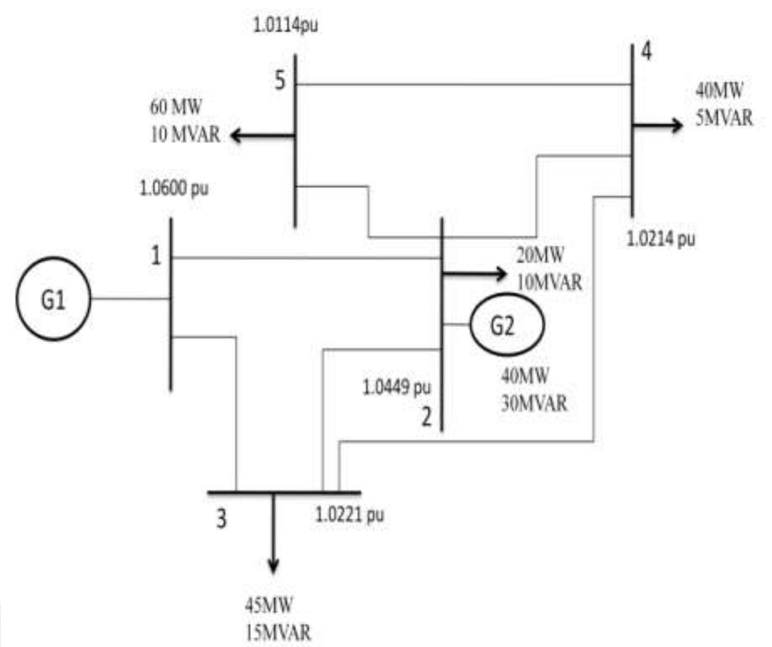

Fig-2 IEEE 5-Bus System

TABLE I PERFORMANCE INDICES & CONTINGENCY RANKING USING NR METHOD FOR IEEE 5-BUS SYSTEM

Line outage number	PIp	PIv	OPI	Ranking
1-2	0.2800	3.1916	3.4716	1
1-3	0.3619	0.2699	0.6318	6
2-3	0.3377	0.6557	0.9934	4
2-4	0.3790	0.6173	0.9963	5
2-5	0.4221	0.2653	0.6874	7
3-4	0.2995	0.8599	1.1594	3
4-5	0.3036	0.8799	1.1899	2

TABLE II PERFORMANCE INDICES & CONTINGENCY RANKING USING BACK PROPAGATION METHOD FOR IEEE 5-BUS SYSTEM

Line outage number	PIp	PIv	OPI	Ranking
1-2	0.2908	3.7433	4.0341	1
1-3	0.3755	0.2773	0.6528	7
2-3	0.3302	0.6739	1.0041	5
2-4	0.3926	0.7281	1.1207	4
2-5	0.4149	0.3945	0.8094	6
3-4	0.3021	0.9203	1.2240	2
4-5	0.3047	0.8791	1.1838	3

5. CONTINGENCY ANALYSIS USING ARTIFICIAL NEURAL NETWORK

On this section, the effects of contingency analysis problem the use of lower back Propagation neural community have been supplied. The algorithms are carried out in MATLAB for the above. The main objective is to decide the energetic and reactive power overall performance indices which form a critical part of contingency evaluation for IEE five-bus systems. The results of energetic power performance index PIp and reactive power performance indices PIv for the base case loading situation of 1650 MW is obtained via using the lower back Propagation neural community has been given in table II.

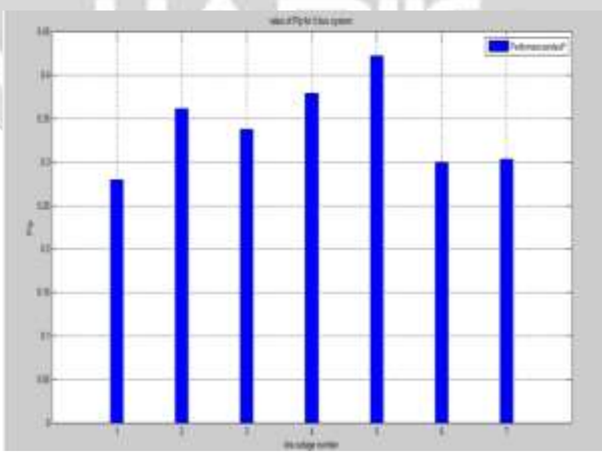

Fig-3 Graphical representation of PIp using NR method

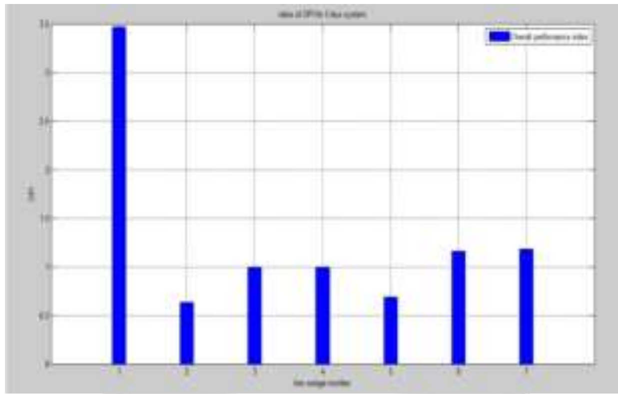

Fig-4 Graphical representation of OPI using NR method

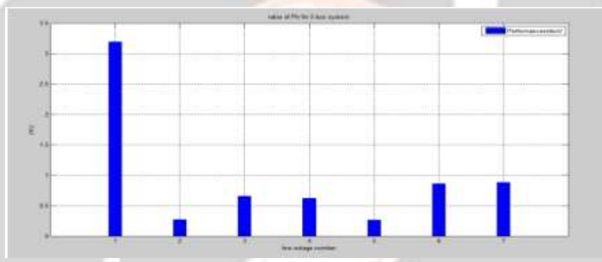

Fig-5 Graphical representation of PIp using NR method

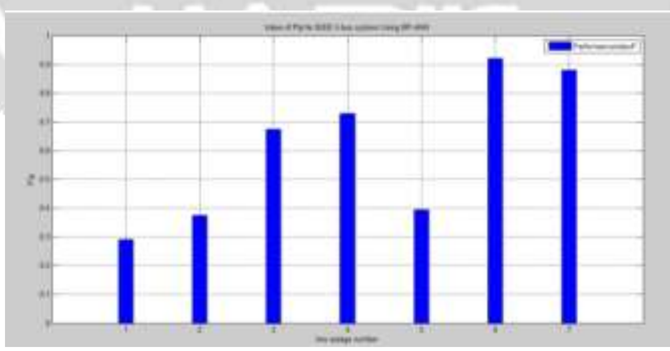

Fig-6 Graphical representation of PIp using BP-ANN method

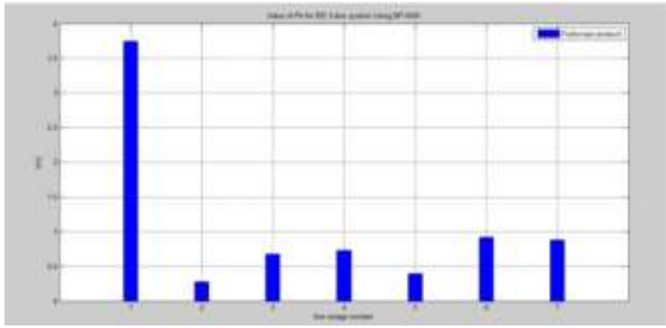

Fig-7 Graphical representation of PIv using BP-ANN method

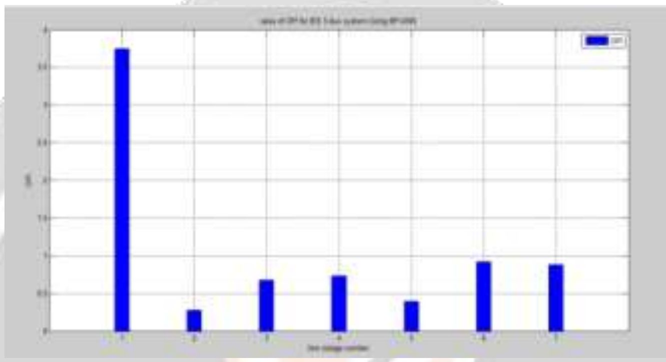

Fig-8 Graphical representation of OPI using BP-ANN method

The load flow analysis is accomplished by considering the one-line outage contingency at a time. The energetic and reactive energy overall performance indices also are calculated considering the outage of only one line sequentially and calculated indices are summarized in table II. The rating of the line outage contingency has been decoded on the premise of OPI. The higher the OPI vale shows better rank and higher degree of severity. From table II it can be inferred the outage of line 1 is the most susceptible one and its outage will result a fantastic effect at the entire gadget. Fig (6), Fig (7) and Fig (8) shows the graphical representation of these performance indices for each outage cases.

6. CONCLUSION

In this work, the contingency selection and rating which are vital for contingency analysis had been performed by evaluating two essential overall performance indices particularly; energetic and reactive power overall performance index (PIP & PIV). These indices were calculated for widespread 5 bus structures the use of the Newton Raphson load go with the flow set of rules and additionally by using again propagation Neural community in MATLAB environment. The following conclusions are drawn:

- The severity of a single line outage is correctly indicated by way of the numerical values of PIP and PIV respectively.

- The indices are predicted in off line way for a single loading situation by using NRLF. The calculation of those indices using NRLF set of rules proves to be time consuming.

- The contingency selection by using BP-ANN proves to be efficient in phrases of accuracy and time. It has the potential to calculate the performance indices following a contingency for any loading case once it is efficaciously educated

REFERENCES

[1] A.J. Wood and B.F. Wollenberg, Power Generatzon, Operatzon and Control, John Wiley &Sons Inc.,1984 [2] Vykuka, R.; Nohacova, L., "Sensitivity factors for contingency analysis," Electric Power Engineering (EPE), 2015 16th International Scientific Conference on, vol., no., pp.551,554, 20-22 May 2015

[3] Sekhar, P.; Mohanty, S., "Power system contingency ranking using Newton Raphson load flow method," India Conference (INDICON), 2013 Annual IEEE, vol., no., pp.1,4, 13-15 Dec. 2013

[4] Stott B.; Alsac, O., "Fast Decoupled Load Flow," Power Apparatus and Systems, IEEE Transactions on, vol.PAS-93, no.3, pp.859,869, May 1974doi: 10.1109/TPAS.1974.293985

[5] Hussain, Zakir Zhe Chen Thogersen, P., "Fast and precise method of contingency ranking in modern power system," Applied Electrical Engineering and Computing Technologies (AEECT), 2011 IEEE Jordan Conference on, vol., no., pp.1,7, 6-8 Dec. 2011

[6] Lee, C.-Y.; Nanming Chen, "Distribution factors of reactive power flow in transmission line and transformer outage studies," in Power Systems, IEEE Transactions on, vol.7, no.1, pp.194-200, Feb 1992 doi: 10.1109/59.141703

[7] Sood, P.; Tylavsky, D.J.; Qi, Y., "Improved dc network model for contingency analysis," in North American Power Symposium (NAPS), 2014

[8] Sachan, S.; Gupta, C.P., "Analysis of contingent conditions in power system," Engineering and Systems (SCES), 2014 Students Conference on, vol., no., pp.1,5, 28-30 May 2014

[9] Chicco, G.; Napoli, Roberto; Piglione, Federico, "Neural networks for fast voltage prediction in power systems," in Power Tech Proceedings, 2001 IEEE Porto, vol.2, no., pp.5 pp. vol.2-, 2001 doi: 10.1109/PTC.2001.964743

[10] Khazaei, Mohammad; Jadid, S., "Contingency ranking using neural networks by Radial Basis Function method," in Transmission and Distribution Conference and Exposition, 2008. T&D. IEEE/PES, vol., no., pp.1-4, 21-24 April 2008doi: 10.1109/TDC.2008.4517045

[11] A. Alessandri, S. Grillo, S. Massucco, F. Silvestro and G. Vimercati ANN Application for On-Line Power System Security Assessment 9th International Conference on Probabilistic Methods Applied to Power Systems KTH, Stockholm, Sweden - June 11-15, 200