IJREAT International Journal of Research in Engineering & Advanced Technology, Volume 3, Issue 2, April-May, 2015
ISSN: 2320 – 8791 (Impact Factor: 2.317)
www.ijreat.org

Contingency Based Voltage Stability Improvement

Dr.Venu Yarlagadda[1], Spandana Bitla[2]

[1]**EEE Department, VNR VJIET, Hyderabad, Telangana, India**
[2]**EEE Department, ARTI, Warangal, Telangana, India**

Abstract

Voltage stability has recently become a challenging problem of interconnected power systems. Voltage instability is one phenomenon that could happen in power system due to its stressed condition. The result would be the occurrence of voltage collapse which leads to total blackout to the whole system Investigation and online monitoring of power system stability have become vital factors to electric utility suppliers. Contingency screening and ranking (CS&R) is one of the important components of voltage stability assessment. The objective of CS&R is to quickly and accurately select a short list of critical contingencies from a large list of potential contingencies and rank them according to their severity. Suitable preventive control actions can be implemented considering contingencies that are likely to affect the power system performance. An effective method for contingency ranking is proposed in this paper. This method calculates the voltage stability margin considering line outages. The basic methodology implied in this technique is the investigation of each line of the system through calculating line stability indices. The point at which VSI close to unity indicates the maximum possible connected load termed as maximum load ability at the point of bifurcation. Contingency table have been drawn for (n-1) contingencies and ranked them based on voltage magnitudes at all buses. Identified the severe most contingency based on voltage stability analysis. Voltage stability of the system has been enhanced by providing reactive power compensation at two ill buses. The voltage stability of the power system has been improved for the severe most contingency in order to maintain system redundancy.

Keywords: Voltage Stability Enhancement, Contingency Analysis, System Security, Contingency Ranking, Voltage Stability Improvement for most severe contingency, Reactive power control, Optimal placement of compensation device.

1. Introduction

The Since the industrial revolution man's demand for and consumption of energy has increased steadily. The invention of the induction motor by Nikola Tesla in 1888 signaled the growing importance of electrical energy in the industrial world as well as its use for artificial lighting. A major portion of the energy needs of a modern society is supplied in the form of electrical energy. Industrially developed societies need an ever-increasing supply of electrical power, and the demand on the North American continent has been doubling every ten years.

Requirements of a Reliable Electrical Power Service

Successful operation of a power system depends largely on the engineer's ability to provide reliable and uninterrupted service to the loads. The reliability of the power supply implies much more than merely being available. Ideally, the loads must be fed at constant voltage and frequency at all times. In practical terms this means that both voltage and frequency must be held within close tolerances so that the consumer's equipment may operate satisfactorily. For example, a drop in voltage of 10-15% or a reduction of the system frequency of only a few hertz may lead to stalling of the motor loads on the system. Thus it can be accurately stated that the power system operator must maintain a very high standard of continuous electrical service.

Statement of the Problem

Power system faults may likely to occur unpredictably and therefore it leads to outage of lines or generators well known as Contingency. The post contingency condition may leads to voltage collapse subsequently blackout of the part of the system or sometimes total blackout due to lack of effective reactive power support and control. To avoid this situation one should maintain system stability and security against severe most contingency. Hence it is highly desirable to have sufficient reactive power support and as well as its effective control during post contingency in order to maintain system redundancy to ensure system security.

This paper focused on the contingency analysis and maintaining system stability against severe most contingency by providing required reactive power compensation with its effective control. In the first part contingency ranking has been made using voltage stability indices. Voltage stability margin has been enhanced using required reactive power support and control at the weakest bus but the effect of shunt compensation is spread all over the control area which may be treated as relatively global in that control area.

Primitive definition of stability

Having introduced the term "stability," we now propose a simple nonmathematical definition of the term that will be satisfactory for elementary problems. Later, we will provide a more rigorous mathematical definition. The problem of interest is one where a power system operating under a steady load condition is perturbed, causing the readjustment of the voltage angles of the synchronous machines. If such an occurrence creates an unbalance between the system generation and load, it results in the establishment of a new steady-state operating condition, with the subsequent adjustment of the voltage angles.

Other stability problems

While the stability of synchronous machines and tie lines is the most important and common problem, other stability problems may exist, particularly in power systems having appreciable capacitances. In such cases arrangements must be made to avoid excessive voltages during light load conditions, to avoid damage to equipment, and to prevent self-excitation of machines.

text must be in English. Authors whose English language is not their own are certainly requested to have their manuscripts checked (or co-authored) by an English native speaker, for linguistic correctness before submission and in its final version, if changes had been made to the initial version. The submitted typeset scripts of each contribution must be in their final form and of good appearance because they will be printed directly. The document you are reading is written in the format that should be used in your paper.

II. Power System Stability Classification

Power system stability is classified above as rotor angle and voltage stability. A classification of Power system stability based on time scale and driving force criteria is presented in Table 2.1.The driving forces for an instability mechanism are named generator-driven and load-driven. The time scale is divided into short and long term time scales.

Table .1 Classification of Power System Stability

Time scale	**Generator-driven**	**Load - driven**
Short term	**Rotor angle stability**	**Short-term voltage stability**
	small signal & transient	
Long term	**Frequency stability**	**Long-term voltage stability**

Rotor Angle Stability:

The rotor angle stability is divided into small-signal and transient stability. The small-signal stability is present for small disturbances in the form of undamped electromechanical oscillations. The transient stability is due to lack of synchronizing torque and is initiated by large disturbances. The time frame of angle angle stability is that of the electromechanical dynamics of the power system. This time frame is called short-term scale, because the dynamics typically last for a few seconds.

Rotor angle stability refers to the ability of synchronous machines of an interconnected power system to remain in synchronism after being subjected to a disturbance. Rotor angle instability occurs due to angular swings of some generators leading to their loss of synchronism with other generators. Dependson the ability to maintain/restore equilibrium between electromagnetic torque and mechanical torque of each synchronous machine. At equilibrium, input mechanical torque of each generator. In case of any disturbance the above equalitydoesn't hold leading to acceleration/deceleration of rotors of machines.

Frequency stability:

Frequency stability refers to the ability of power system to maintain steady frequency following a severe system upset resulting in a significant imbalance between generation and load. Frequency instability leads to tripping of generating units and/or loads.A frequency stability analysis is normally performed on a single device, not a population of such devices. The output of the device is generally assumed to exist indefinitely before and after the particular data set was measured, which are the (finite) population under analysis. A stability analysis may be concerned with both the stochastic (noise) and deterministic properties of the device under test. It is also generally assumed that the stochastic characteristics of the device are constant.

Voltage Stability:

Voltage stability is concerned with the ability of a power system to maintain acceptable voltage at all buses in the system under normal conditions and after being subjected to disturbance.Power system stability may be broadly defined according to different operating conditions an important problem which is frequently considered is the problem of voltage stabilization.Voltage stability has become one of the most important and urgent problems in modern bulk power supply systems due to the significant number of serious failures. A system enters a state of voltage instability when a disturbance, increase in load demand, or change in system condition causes a progressive and uncontrollable decline in voltage.

Instability that may result occurs in the form of a progressive fall or rise of voltages of some buses. A possible outcome of voltage instability is loss of load in an area, or tripping of transmission lines and other elements by their protective systems leading to cascading outages. Loss of synchronism of some generators may result from these outages or from operating conditions that violate field current limit.A situation causing voltage instability occurs when load dynamics attempt to restore power consumption beyond the capability of the transmission network and the connected generation.The driving force for voltage instability is usually the loads. In response to a disturbance, power consumed by the loads should be restored.Voltage stability problems normally occur in heavily stressed systems. While the disturbance leading to voltage collapse may be initiated by a variety of causes, the underlying problem is an inherent weakness in the power system. One of the most important problem is Contingency and its ranking based on voltage and losses.

III. CONTINGENCY ANALYSIS

Disturbances that might happen on a power system:

- Loss of a line
- Loss of a transformer
- Loss of a generating station
- Loss of a major load

Line outage in power system lead to the voltage collapse which implies the contingency in the system. Line outage contingencies are ranked so that the line which highly affects the system when there is an outage occurs in this line in terms of voltage instability could be identified. The contingency ranking process can be conducted by computing the line stability index of each line for a particular line outage and sort them in descending order. The contingency which is ranked the highest implies that it contributed to system instability.

One of the most important factors in the operation of a power system is the desire to maintain system security. System security involves practices designed to keep the system operating when components fail. Also, if a transmission line is damaged and taken out by relaying, the remaining transmission lines can take the increased loading. Many possible outage conditions could happen to a power system. Thus, there is a need to have a mean to study a large number of them, so that operation personnel can be warned ahead of time if one or more outages will cause serious overload on other equipments. The problem of studying all possible outages becomes very difficult to solve since it is required to present the results quickly so that corrective actions could be taken. Contingency analysis procedures model single failure events, one after the other in sequence until all credible outages have been studied. The most difficult problem is the selection of these credible outages.

"The worst single contingency is the one that causes the largest decrease in the reactive power margin". Contingency screening and ranking is one of the most important components of VSA. The purpose of contingency screening and ranking is to determine: which contingencies may cause power system limit violations and/or system instability according to voltage stability criteria. The margin between the voltage collapse point and the current operating point is used as the voltage stability criterion.

Contingencies are ranked according to their margins to voltage collapse. A margin to voltage collapse is defined as the largest load change that the power system may sustain at a bus or collection of buses from a well defined operating point. The operating point may be obtained from a real-time operating condition or from a postulated condition computed from a system simulation. The margin may be measured in MVA, MW, or MVAR.

Here is this paper IEEE 9 Bus Test System and simulated in power world software. The test system is simulated for all possible contingencies and ranked them using voltage stability indices. For the severe most contingency shunt compensation is provided at weakest bus which has the considerable effect on voltage stability improvement.

IV.Case Study: Results

IEEE 9 Bus Test System

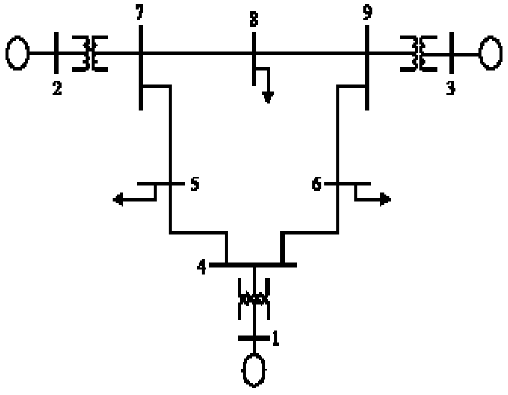
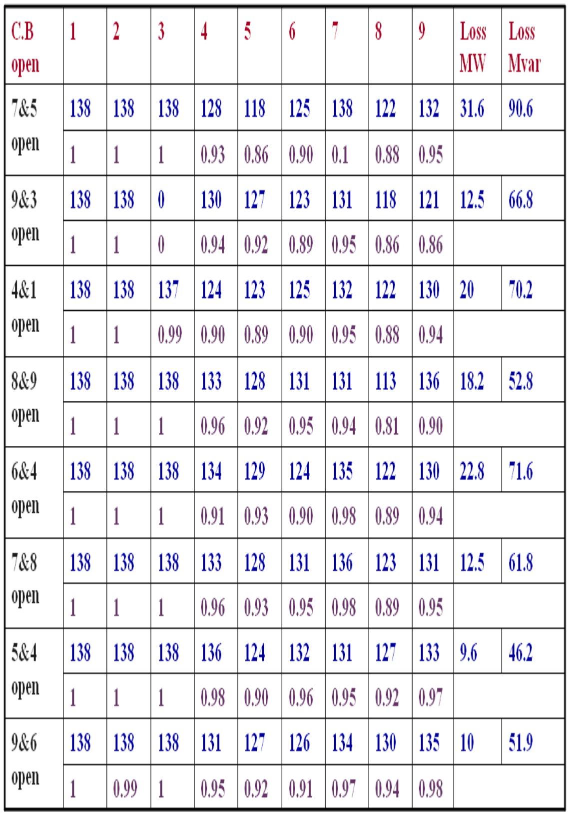


Fig.1 IEEE 9 Bus Test system

Table.2: Base case results

Bus no.	PU Voltage	Bus Voltage (KV)	Total Losses
1	1.00	138.0	Active Power Loss is 31.6MW Reactive Power Loss is 90.6 Mvar
2	1.00	138.0	
3	1.00	138.0	
4	0.93	128.5	
5	0.86	118.6	
6	0.90	125.1	
7	1.00	138.1	
8	0.88	122.4	
9	0.95	132.0	

Table3: Contingency ranking based on their voltage stability margins



C.B open	1	2	3	4	5	6	7	8	9	Loss MW	Loss Mvar
7&5 open	138	138	138	128	118	125	138	122	132	31.6	90.6
	1	1	1	0.93	0.86	0.90	0.1	0.88	0.95		
9&3 open	138	138	0	130	127	123	131	118	121	12.5	66.8
	1	1	0	0.94	0.92	0.89	0.95	0.86	0.86		
4&1 open	138	138	137	124	123	125	132	122	130	20	70.2
	1	1	0.99	0.90	0.89	0.90	0.95	0.88	0.94		
8&9 open	138	138	138	133	128	131	131	113	136	18.2	52.8
	1	1	1	0.96	0.92	0.95	0.94	0.81	0.90		
6&4 open	138	138	138	134	129	124	135	122	130	22.8	71.6
	1	1	1	0.91	0.93	0.90	0.98	0.89	0.94		
7&8 open	138	138	138	133	128	131	136	123	131	12.5	61.8
	1	1	1	0.96	0.93	0.95	0.98	0.89	0.95		
5&4 open	138	138	138	136	124	132	131	127	133	9.6	46.2
	1	1	1	0.98	0.90	0.96	0.95	0.92	0.97		
9&6 open	138	138	138	131	127	126	134	130	135	10	51.9
	1	0.99	1	0.95	0.92	0.91	0.97	0.94	0.98		

Table.4: Results of severe most contingency case

Bus no.	PU Voltage	Bus Voltage (KV)	Total Losses
1	1.00	138.0	Active Power Loss is 8.7MW Reactive Power Loss is 40.9 Mvar
2	1.00	138.0	
3	1.00	138.0	
4	0.96	133.7	
5	0.94	129.9	
6	0.94	130.9	
7	0.97	134.8	
8	0.92	133.7	
9	0.96	133.7	

Severe most Contingency Case with compensation

Table.5: Results with shunt at 8thbus

Bus no.	PU Voltage	Bus Voltage (KV)	Total Losses
1	1.00	138.0	Active Power Loss is 31.2 MW Reactive Power Loss is 82.6 Mvar
2	1.00	138.0	
3	1.00	138.0	
4	0.94	120.8	
5	0.91	125.8	
6	0.91	126.2	
7	1.00	138.3	
8	0.89	122.9	
9	0.96	132.8	

Table.6 Results with shunt Compensation at 5th& 8th buses

Bus no.	PU Voltage	Bus Voltage (KV)	Total Losses
1	1.00	138.0	Active Power Loss is 30.9MW Reactive Power Loss is 77.1Mvar
2	1.00	138.0	
3	1.00	138.0	
4	0.95	131.4	
5	0.91	126.5	
6	0.92	127.5	
7	1.01	140.3	
8	0.92	127.6	
9	0.97	134.2	

Table7: voltage stability enhancement after providing reactive power compensation

Bus no	PU(volt)	Volt(kv n)	Loss (Mw)	Loss (Mvar)
Severe Contingency Case				
5	0.860	118.69	31.6	90.6
8	0.887	123.49		
With Shunt Compensation at 5th bus				
5	0.912	125.8	31.2	82.6
8	0.89	122.95		
With Shunt Compensation at 5th & 8th buses				
5	0.912	126.5	30.9	77.2
8	0.92	127.6		

V. Conclusion

IEEE 9 Bus Test System is simulated in power world software with base case and (n-1) contingencies.Contingency table have been drawn for (n-1) contingencies and ranked them based on voltage magnitudes at all buses.Identified the severe most contingency based on voltage stability analysis.Voltage stability of the system has been enhanced by providing reactive power compensation at two ill buses. The results shows that the bus voltages have been improved for the severe most contingency case with shunt compensation at weakest buses. Further the active power losses and reactive power losses have been decreased with compensation as listed in Table 7.

Acknowledgements

We are immensely thankful to Management and Principal of VNR VJIET for providing R&D lab and other facilities to carryout this work.

References

1. N.G. Hingorani and L. Gyugyi, *Understanding FACTS*, IEEE Press, New York, USA, 1999
2. A Study on Static Voltage Collapse Proximity Indicators by Renuga Verayiah and Izham Zainal Abidin.
3. Dynamic Voltage Collapse Prediction on aPractical Power System Using Power TransferStability Index Muhammad Nizam, *Student Member, IEEE*, Azah Mohamed, *Senior Member, IEEE*, Aini Hussain, *Member, IEEE.*
4. Evaluation of Voltage Stability Indices (VSI) Using Genetic Algorithm,2010 IEEE International Energy Conference by Muhammad Tami Al-Hajri and M. A. Abido.
5. M Tagare, *Reactive Power Management,*McGraw-Hill Publication, India,1982.
6. IEEE Power Engg. Society/CIGRE, "FACTS Overview", Publication 95 TP 108, IEEE Press, New York, 1995.
7. P. Kundur, *Power System Stability and Control*, McGraw-Hill, Inc., New York, 1994.
8. IEEE Power Engineering Society, "FACTS Applications", Publication 96 TP 116-0, IEEE Press, New York, 1996
9. W.A.Lyon, *Transient Analysis of Alternating–Current Machinery,* Chapter 2, John Wiley, New York, 1954.
10. D.Irwin, *Basic Engineering Circuit Analysis*. 4th Ed., Mac-milan , New York 1993.
11. Jack R. Smith ,*Programming the PIC* microcontroller. , McGraw-Hill Publication, India, 2005.
12. John J. Paserba, *Fellow, IEEE*, has proposed "Introduction to FACTS Controllers", 2005.
13. Abdelaziz chaghi, Ahmed Louchene, Rafik Bensaadi has proposed "A microcontroller-based static var compensator for unbalanced loads", IEEE Press, India, 2008.
14. Taufik and Bryan Paet are presented "A small scale Static VAR Compensator (SVC) for Laboratory Experiment". IEEE Press, India, 2009.
15. T. Ahmed, K. Nishida, K. Soushin and M. Nakaoka are presented "Static VAR compensator-based voltage control implementation of single-phase self-excited induction generator". IEEE Press, India, 2008.