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New Techniques for the Prevention of Power System Collapse

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New Techniques for the Prevention of Power System Collapse

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Abstract: From voltage stability point of view, maximum permissible loading limits must not be exceeded in the operation of power systems. The risk of cascading outages in power systems manifests itself in a number of ways like loss of generation units, breaker failures, common tower and common right-of-way circuit outages, combination of system conditions and events. With the advent of structured competitive power markets, and with the lack of needed investment in the transmission grid, electric power systems are increasingly being operated close to their limits. When a power system is subjected to large disturbances control actions need to be taken to steer the system away from severe consequences and to limit the extent of the disturbance. The main factor, which causes these unacceptable voltage transients, is the inability of the distribution system to meet the demand for reactive power. The major research in dealing with voltage collapse is the proper diagnosis of the underlying factors causing low voltage. These disturbances often result in voltage collapse of the system, which in turn causes huge losses in the system as well as monetary losses. This paper deals with some newer techniques for the prevention of the voltage system collapse for voltage system collapse, which may have a very large economic impact on the society. It also focuses on right initiation at right time to ease control action to enhance stability, reliability and security of the power system so as to provide a preventive plan to minimize the chances of failure in power system as possible.

Keywords : Pv Curves, Voltage Collapses, Secondary Line Design Of System.

I. INTRODUCTION

Voltage control problems are not new to the utility industry but the problems in the past were Primarily associated with the transfer of power from remote generation sites to load centers. These problems were addressed by specific control and/or protection schemes dedicated to the particular transmission systems. The phenomenon of voltage collapse has created significant interest and much research. The major research in dealing with voltage collapse is the proper diagnosis of the underlying factors causing low voltage. Proper coordination of protective schemes and system controls during declining or low voltage conditions is essential. The phenomenon of voltage collapse has been observed in many countries and has been analyzed extensively in recent years. Several major network collapses caused by voltage instability problems were reported in France, Belgium, Sweden, Japan and the United States. After analyzing the various blackout causes, it was noted that cascading failures may occur due to the loss of generation units, breaker failures, common tower and common right-of-way circuit outages, combination of system conditions and events. The common cascading processes consist of system state before blackout, cascaded events, and post-blackout state. A voltage experiences a state of voltage instability when there is a progressive or uncontrollable drop in voltage magnitude after a disturbance, increase in load demand or change in operating condition. The main factor, which causes these unacceptable voltage profiles, is the inability of the distribution system to meet the demand for reactive power. Under normal operating conditions, the bus voltage magnitude (V) increases as Q injected at the same bus is increased. However when V of any one of the systems buses decreases with the increase in Q for that same bus, the system is said to be unstable.

II. CURVES

II.I PV CURVES

When considering voltage stability, the relationship between transmitted P and receiving end V is of interest (as shown in figure 1). The voltage stability analysis process involves the transfer of P from one region of a system to another, and monitoring the effects to the system voltages, V. This type of analysis is commonly referred to as a PV study. It represents the variation in voltage at a particular bus as a function of the total active power supplied to loads or sinking areas.

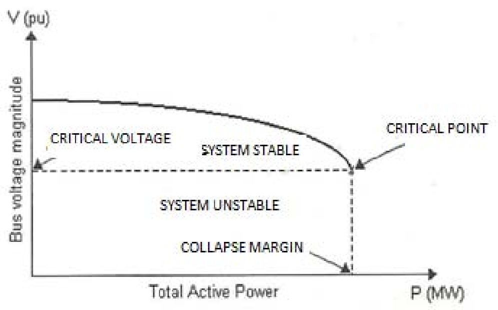


Figure 1 : Typical PV Characteristics

II.II QV CURVES

The influence of reactive power characteristics of devices at the receiving end (loads or compensating devices) is more apparent in a QV relationship (as shown in figure 2). It shows the sensitivity and variation of bus voltages with respect to reactive power injections or absorptions.

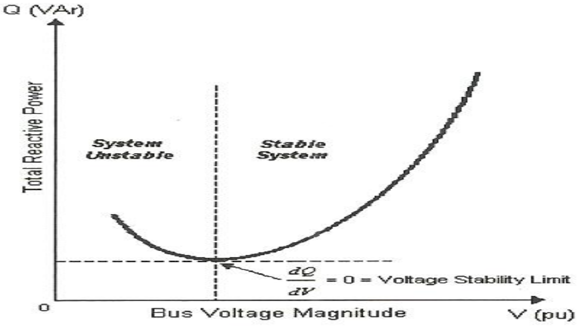


Figure 2 : Typical QV Characteristics

Figure shows a voltage stability limit at the point where the derivative dQ/dV is zero. This point also defines the minimum reactive power requirements for a stable operation. An increase in Q will result an increase in voltage during normal operating conditions. Hence, if the operating point is on the right side of the curve, the system is said to be stable. Conversely, operating points in the left side of the graph are deemed to be unstable.

III. VOLTAGE COLLAPSES

The main symptoms of voltage collapse are- low voltage profiles, heavy reactive flows, inadequate reactive support, and heavily loaded systems. The collapse is often precipitated by low-probability single or multiple contingencies. The consequences of collapse often require long system restoration, while large groups of customers are left without supply for extended periods of time. Schemes, which mitigate against collapse, need to use the symptoms to diagnose the approach of the collapse in time to initiate corrective action.

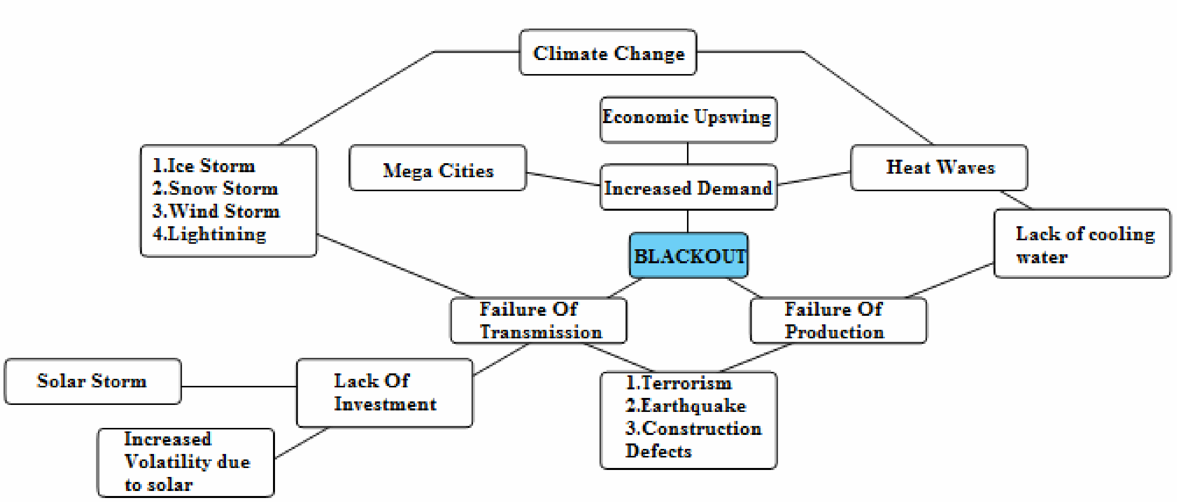
There are several power system changes known to contribute voltage collapse. They are as follows

- Increase in loading
- Generators, synchronous condensers, or SVC reaching reactive power limits
- Action of tap changing transformers
- Load recovery dynamics
- Line tripping
- Generator outages

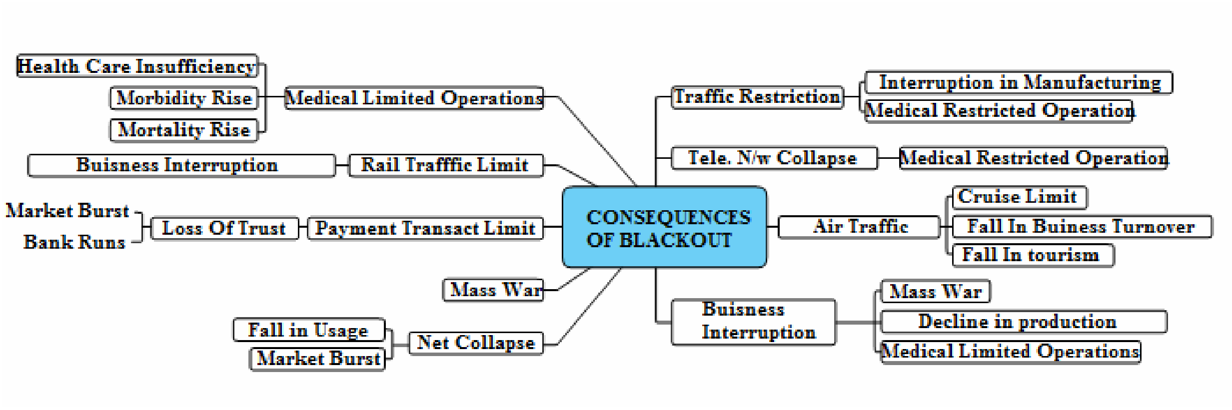
Table 1- MAJOR VOLTAGE COLLAPSES

S.NO	DATE	LOCATION	LOAD INTERRUPTED	MILLIONS AFFECTED
1	November 9, 1965	Northeast	20,000 MW	30
2	July 13, 1977	New York	6,000 MW	55
3	December 22, 1982	West Coast	12,350MW	87
4	January 17, 1994	California	7,500MW	97
5	December 14, 1994	Wyoming, Idaho	9,336MW	50
6	July 2, 1996	Wyoming, Idaho	11,743MW	4
7	August 10, 1996	Western Interconnection	30,489MW	5
8	June 25, 1998	Midwest	950MW	3.5
9	January 2, 2001	India	24,500MW	2260
10	August 14, 2003	Northeast	61,800MW	55
11	November 4, 2006	South West, Europe	10,000MW	150
12	November 10, 2009	Brazil	14,500MW	870
13	February 4,2011	Brazil	10,500MW	530

1V.CAUSES AND ITS CONSEQUENCES



POTENTIAL CAUSES OF BLACKOUT



CONSEQUENCES OF BLACKOUTS

V.I CONTROL ACTIONS

Some of the control actions used as counter measures against voltage collapse are as follows.

- Switching of shunt capacitors
- Blocking of tap-changing transformers
- Redispatch of generation
- Rescheduling of generator and pilot bus voltages
- Secondary voltage regulation
- Load shedding

V.II Flow Chart for Cascading Failure Power System Model

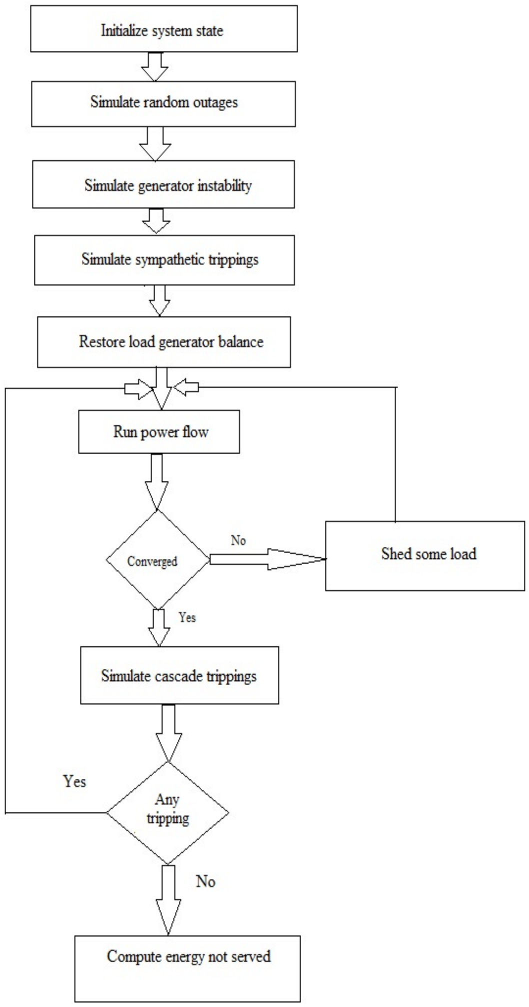


Figure. 3 Cascading failure of power system model

V1. CORRECTIVE MEASURES

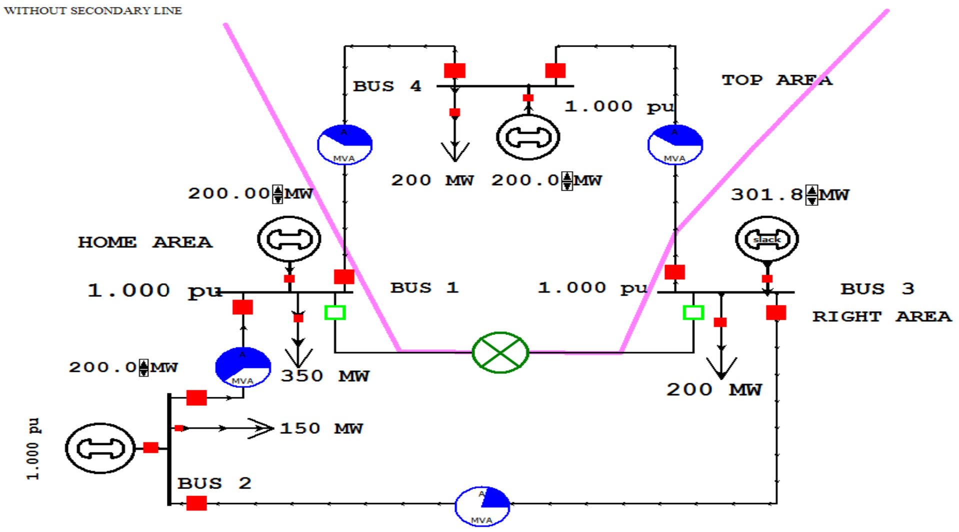


Figure 4

V1.I USE OF SECONDARY LINE DESIGN OF SYSTEM

In the example (figure 4) we find that load of the industries are set to 900MW. All the lines are uncontrolled current flow. The 4 generators share the load of 900MW. The generator of the bus 1 is the prime generator, which is supplying the power demands of the load of bus 2. The system continues to work normally. This load causes a stress on the line between the bus 1 and bus 3 but as long as the load changes slowly there is no problem. All the 4 generators are adequate for supplying continuous power to the loads of the system.

In (figure 5), the secondary line added between the bus 1 and bus 3 is done so as to facilitate the flow of current from the generator of the bus 1 easily so as to reduce the stress on one line. The secondary line also facilitates the flow of reactive power with more number of capacitor banks for providing the reactive power.

As seen in the diagram we can see that the load of current on the line is between the bus 2 and bus 4 are highly reduced but the addition of the secondary line. The secondary line is added between the bus 2 and bus 1 so as to bring the second generator into play.

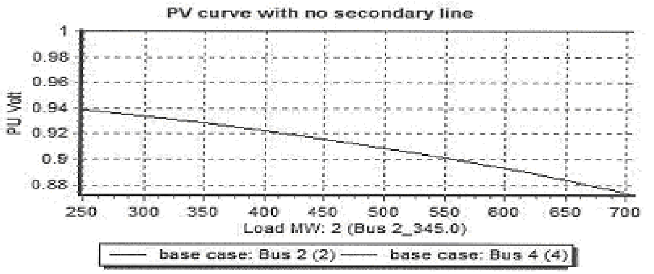


Figure5 : PV Curve without Secondary Line

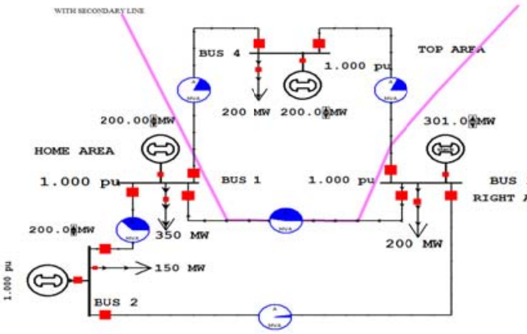


Figure 6

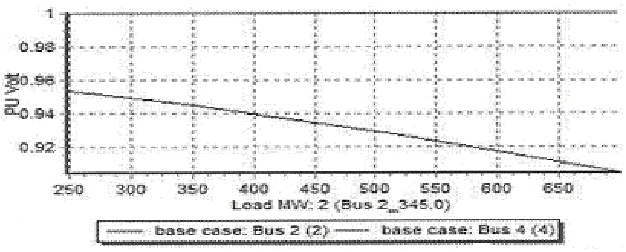


FIGURE 7: PV CURVE WITH SECONDARY LINE

V1.II. LOAD SHEDDING

Load shedding is an option that is becoming more widely used as a final means of avoiding system wide voltage collapse. This option is only considered when all other effective means of avoiding collapse are exhausted. This option may be the only effective option for various contingencies especially if the collapse is in the transient time frame, and if load characteristics result in no effective load relief by transformer load taps changer control. Load shedding results in high costs to electricity suppliers and consumers; therefore, power systems should be designed to require such actions only under very rare circumstances. Load may be shed either manually or automatically depending on the rate of voltage drop.

V1.111 SELF RESTORATION MECHANISM IN THE NEW CONCEPT OF FRAMEWORKING A NEW MODEL

It is observed that whenever a cascading failure occurs, it leads to a split of phase in the system. When a system splits its one part becomes power deficient and a frequency decrease takes place there whereas for the other part a power surplus takes place in the other part with the frequency increase. The part with power surplus might be slightly elevated in frequency which could retard the merging process. So to overcome this device called AUFLS1 which responds to the frequency decrease or the rate of its variation stops the frequency fall. Owing to the time delays in the operation of automatic devices, during this operation other stages begun to act which additionally disconnects the consumer’s lines, as a result of power surplus the frequency slightly increases. The restoration of frequency to the normal level is performed by the AUFLS2 whose successful operation is ensured by the retiming setting at the rated frequency level.

V11. CONCLUSION

This paper on the techniques for the prevention of voltage system collapse provides a preventive plan to minimize the chances of failure in the power system as possible. To identify the system vulnerability in the network, the power system simulations are performed. Many aspects are analyzed to understand the constraints on the system and select the appropriate methods to solve the problem efficiently. This paper is a case study of power system study and implementation on the preventive measures to enhance the stability, reliability and security of the power system.

V1II. FUTURE SCOPE

There is an international tendency to increase the power transfer limit in the network and to improve the efficiency of existing power plants. The reason are on the one hand the huge economical cost for new investments and the growing environmental concern, and on the other hand the considerable economic benefit be gained. This will raise the requirements for more sophisticated plan and models and there will be ongoing efforts to maintain and to improve the reliability in the power system. Therefore the need to improve planning and operation in power system, underline the importance of future work in voltage stability field.

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