VOLTAGE STABILITY IMPROVEMENT BY STATIC VAR COMPENSATOR

RAJA SARDAR, A. ANANDHI CHIRSTY

Abstract— **The responsibility and maintenance of the electrical power system has become a major aspect now a days. Voltage instability problem has become a prime issue in the emerging world of technologies. As the incremental load demand and non linearity in load leads the voltage collapse phenomenon is gradually increasing. When national wide blackout comes in India the one and only reason was the Voltage collapse problem. Flexible AC Transmission Systems (FACTS) devices have been used in power systems for improvement of its dynamic performance. The paper presents the developments in voltage stability improvement by using FACTS controllers. Voltage stability and instability problems also been focused in this paper. To recover the instability problem or the distortion problem SVC has been used.**

In SIMULINK the SVC model is established, a dynamic simulation tool in MATLAB, is taking a simple power system with SVC and without SVC comparisons with their simulation result.

Index Terms—**Voltage Instability, Voltage Collapse, FACTS Device, SVC.**

I. INTRODUCTION

Modern electric power systems have three separate components - generation, transmission and distribution. Electric power is generated at the power generating stations by synchronous alternators that are usually driven either by steam or hydro turbines. Most of the power generation takes place at generating stations that may contain more than one such alternator-turbine combination. Depending upon the type of fuel used, the generating stations are categorized as thermal,

hydro, nuclear etc. Many of these generating stations are remotely located. Hence the electric power generated at any Such station has to be transmitted over a long distance to load centers that are usually cities or towns. This is called

the power transmission. The power transmission towers and transmission lines are very common sights in rural areas.

Modern day power systems are complicated networks with hundreds of generating stations and load centers being interconnected through transmission lines. Electric power is generated at a frequency of either 50 Hz or 60 Hz.

In an interconnected ac power system, rated generation frequency of all units should be same. In India the frequency is 50 Hz.

In this paper, a 11kV transmission line has been shown and under 3 phase fault how the FACTS device that is SVC is recovering the voltage distortion problem is written. The presented method for voltage stabilization system transient analysis is implemented in MATLAB/SIMULINK.

II. BASIC STRUCTURE OF POWER SYSTEM

The structure of power system is shown in Fig. 1.

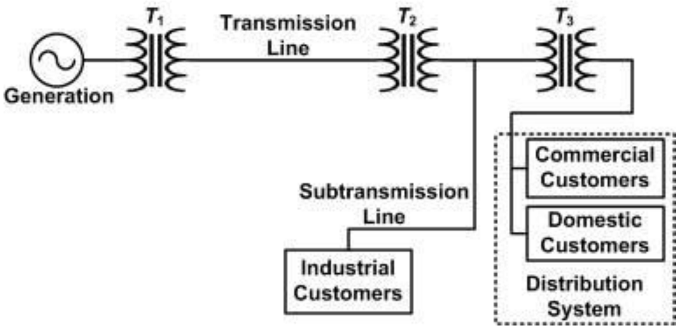

Fig. 1 Line Diagram of Power System

It contains a generating plant, a transmission, a sub transmission and a distribution system. These subsystems has been interconnected through transformers T1 , T2 and T3 . Let us consider some typical voltage levels to understand the functioning of the power system. A typical voltage that is 11 kV (voltage levels are usually specified Line-to-line) is generating in thermal power plant. This is boosted up to levels like 400 kV through transformer T1 for power transmission. Then the step down Transformer T2 steps this voltage down to 66 kV to supply power through the sub transmission line to industrial loads that require bulk power at a higher voltage. Many industrial customers have their own transformers to step down the 66 kV supply to their desired levels. This way for these voltage changes is to minimize transmission line cost for a given power level. Distribution systems are designed for much lower power levels and are supplied with medium level voltages. Where transmission line is designed with high range of power lines.

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The category of voltage level diagram is shown in figure 2

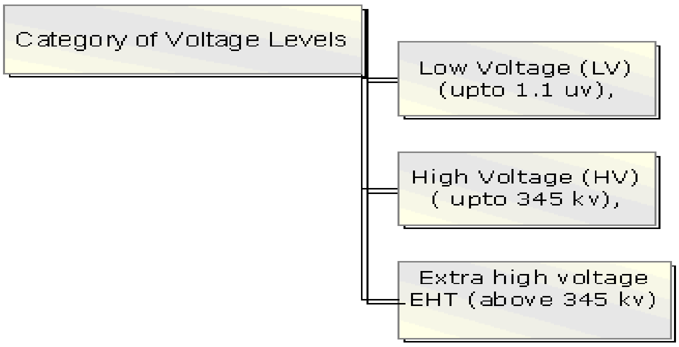

Fig. 2 Category of voltage level diagram

III. Power system voltage stability

Present day power systems are being operated closer to their stability limits due to economic and environmental constraints. For maintaining a stable and secure operation of a power system is therefore a very important and challenging issue. Voltage collapse has been given much attention by power system researchers and planners now a day, and is being regarded as one of the major sources of power system insecurity. Voltage collapse phenomena is the one in which the receiving end voltage decreases well below its normal value and does not come back even after setting restoring mechanisms such as VAR compensators, or continues to oscillate against the disturbances. Voltage collapse is the process where the voltage becomes low; as a result voltage instability comes [1]. Main factors causing voltage instability of a power system are now well explained and understood. The concepts of voltage stability and some of the conventional methods of voltage stability analysis are presented in this chapter. Simulation test results on power systems are presented to illustrate the problem of voltage stability and the conventional methods to analyze the problem.

So the voltage stability is concerned with the ability of the power system to maintain acceptable voltages at all the buses in the system under the normal conditions and after being subjected to a disturbance [2].

IV. CLASSIFICATION OF VOLTAGE STABILITY

The classification of voltage stability is shown below.

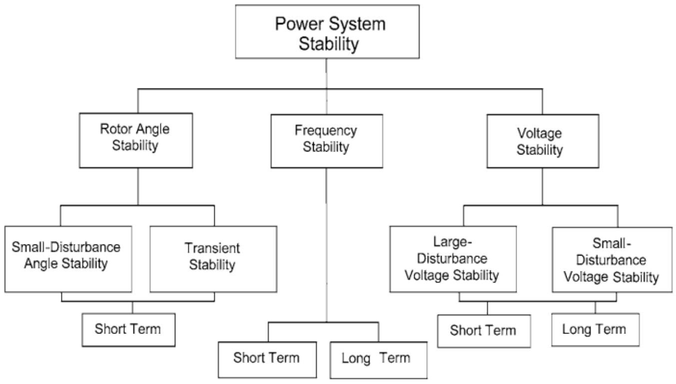

Fig. 3 Classification of Voltage Stability

V. VOLTAGE INSTABILITY IN POWER SYSTEMS

Voltage instability usually occurs on power system which is heavily loaded or faulted or has shortage of the reactive power. Voltage instability is a problem involving many power system components. In fact, a voltage collapse may involve an entire power system. Voltage instability is typically associated with reactive power demand of load not being met due to insufficient supply of reactive power in the system.

A system is voltage unstable if for at least one bus in the system, the bus voltage decreases as the reactive power injection at the same bus is increased. It implies that if, V-Q sensitivity is positive for every bus the system is voltage stable and if V-Q sensitivity is negative for at least one bus, the system is voltage unstable. In fact the term where voltage collapse is also often used for voltage instability conditions. It is the process, in which, the sequence of events following voltage instability leads to abnormally low voltages or even a black out in a large part of the system.

A major factor contributing to voltage instability is the voltage drop in the line impedances when active and reactive powers flow through it. As result, the capability of the transmission network for power transfer and voltage stability reduces. Voltage stability of a system is endangered when a disturbance increases the reactive power demand beyond the sustainable capacity of the available reactive power resources.

VI. FLEXIBLE AC TRANSMISSION SYSTEM DEVICE

A flexible alternating current transmission system (FACTS) is a system composed of static equipment used for the AC transmission system in power system. It can able to enhance controllability and increase power transfer capability of the network. It is basically a power electronics device.

FACTS is defined by the IEEE as "a power electronic based system and other static equipment that provide control of one or more AC transmission system parameters to enhance controllability and increase power transfer capability."

VII. STATIC VAR COMPENSATOR

A static VAR compensator is a set of electrical devices for providing a fast-acting reactive power on high voltage electricity transmission networks. SVCs are part of the Flexible AC transmission system device family, regulating voltage, power factor, harmonics and stabilizing

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the system. A SVC is a automated impedance matching device, which is designed to make the system near unity power factor. The SVC is basically used in two situations. First of all it is connected to the power system to regulate the transmission voltage and is connected near large industrial loads to improve power quality. Among the FACTS controllers, Static Var Compensator (SVC) provides fast acting dynamic reactive compensation for voltage support during contingency events
which would otherwise depress the voltage for a significant length of time. SVC also dampens power swings and reduces system losses by optimized reactive power control.

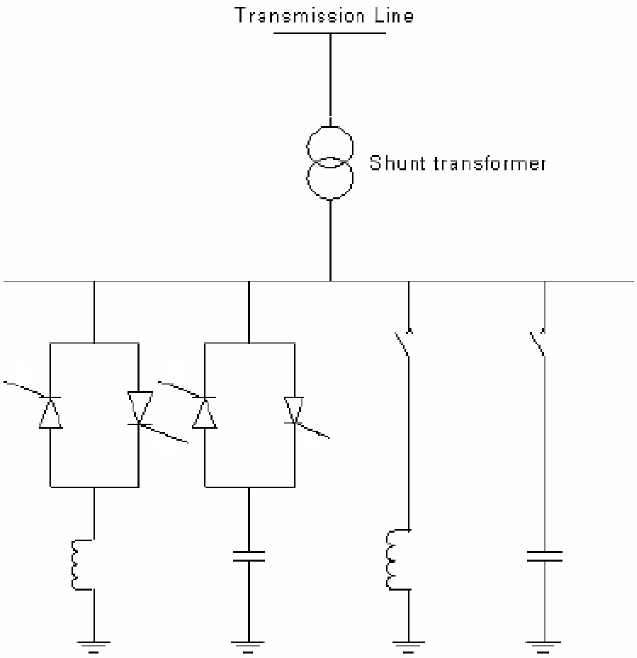

Fig. 4 Single Line Diagram of SVC

The equivalent circuit of STATIC VAR COMPENSATOR is given below:-

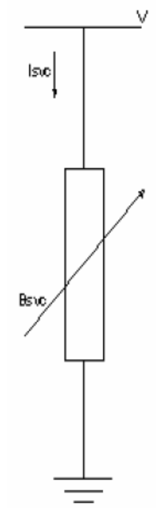

Fig. 5 Equivalent Circuit Diagram of SVC

VIII. WORKING PRINCIPLE

Static Var Compensator is "a shunt-connected static Var generator or absorber whose output is adjusted to exchange capacitive or inductive current so as to maintain or control specific parameters of the electrical power system (typically bus voltage)". SVC is based on thyristors without gate turn-off capability. The operating principal and characteristics of thyristors realize SVC variable reactive impedance. SVC includes two main components and their combination: Thyristor-controlled and Thyristor-switched Reactor (TCR and TSR); and Thyristor-switched capacitor (TSC). TCR and TSR are both composed of a shunt-connected reactor controlled by two parallel, reverse-connected thyristors. TCR is controlled with proper firing angle input to operate in a continuous manner, while TSR is controlled without firing angle control which results in a step change in reactance. Thyristor switched reactor and Thyristor Switched Capacitor both are trying to stable the voltage instability problem by generating and absorbing the reactive power in the system. By doing this simultaneous absorption and discharge of reactive power this FACTS device is stabilizing the voltage.

IX. OBJECTIVE FUNCTION

Due to nonlinearity of the load, on load tap changing or insufficient supply of reactive power the voltage instability phenomenon may occur [10]. In this paper the main objective is to recover the voltage instability problem by the use of SVC. Hence the simulation model with and without using SVC are given.

X. SIMULATION RESULTS

System where SVC is not been used is given below

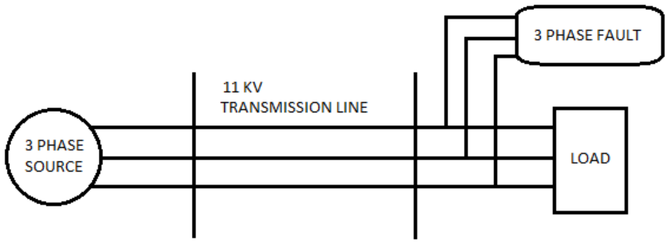

Fig. 6 Single line diagram of a 3phase faulty transmission line

As there is no FACTS controller is used the simulation result is

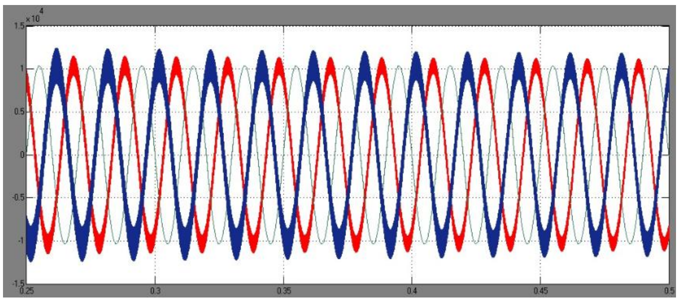

Fig. 7 Output voltage

The supply voltage is 11kV but due to nonlinearity of the load or due to insufficient supply of reactive power voltage distortion is coming.

When the FACTS device SVC is connected in the system this instability problem is solved. The system where SVC is Connected.

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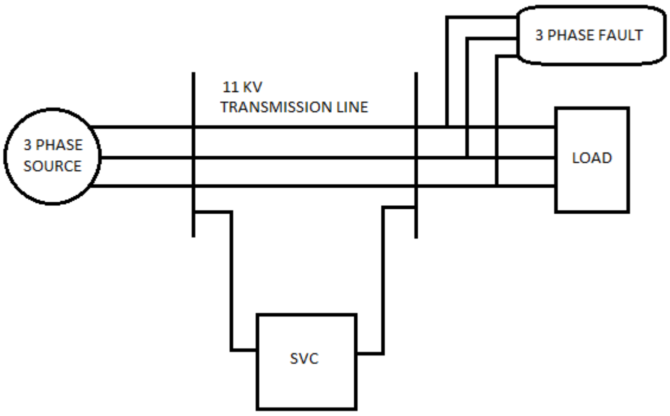

Fig. 8 Transmission line connected with SVC

As SVC is connected in the system the simulation result is rectified

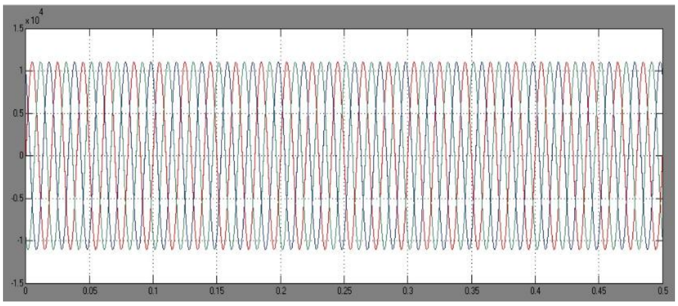

Fig. 9 output voltage

Here constant 11kv supply is present.

XI. CONCLUSION

The system and studying the results have given an indication that SVC are very useful when it comes to organize and maintain power system. SVC is the dynamic simulation system where it can adjust the distribution the system power flow among the transmission line quickly and smoothly, and there is no significant impact to other operating parameters of the system. At the same time, SVC can improve system's stability, to keep down the instability and line oscillation problem.

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