AENSI Journals

**Australian Journal of Basic and Applied Sciences**

ISSN:1991-8178

Journal home page: www.ajbasweb.com

# Investigation of Effect on Voltage crumples Phenomenon in Power System Circuit for stagnant Synchronous Compensator

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**ARTICLE INFO**

***Article history:***
*Received 8 August 2014*
*Received in revised form*
*12 September 2014*
*Accepted 25 September 2014*
*Available online 2 November 2014*

***Keywords:***
*Flexible AC Transmission System, Static Synchronous Compensator, Shunt Compensation, and Voltage Collapse*

**ABSTRACT**

Simple method for detecting and predicting stability problems such as the voltage collapse are useful analysis tools for planning and operating engineers in power utilities. A detailed steady state model with control of a Flexible AC Transmission System (FACTS) controller namely, STATCOM (Static Synchronous Compensator), to study its effect on voltage collapse phenomena in power system the circuit model for STATCOM is developed using voltage source converter. The proposed methodology has been applied under simulated condition on 14- bus test system to illustrate the proposed methodology. The Mat lab simulation results are presented to validate the model.



**To Cite This Article:** V. Karthikeyan, Dr. T.V.P.Sundrarajan, V.J.Vijayalakshmi A.Vinod and M. Menaka., Investigation of Effect on Voltage crumples Phenomenon in Power System Circuit for stagnant Synchronous Compensator. ***Aust. J. Basic & Appl. Sci.,*** *8(16): 34-39, 2014*

## INTRODUCTION

The power-transfer capability of long transmission lines are usually limited by large signals ability. Economic factors, such as the high cost of long lines and revenue from the delivery of additional power, give strong incentives to explore all economically and technically feasible means of raising the stability limit. On the other hand, the development of effective ways to use transmission systems at their maximum thermal capability has caught much research attention in recent years. Fast progression in the field of power electronics has already started to influence the power industry. This is one direct outcome of the concept of Flexible AC Transmission Systems (FACTS) aspects, which has become feasible due to the improvement realized in power-electronic devices. In principle, the FACTS devices could provide fast control of active and reactive power through a transmission line. The Static Synchronous Compensator (STATCOM) is a member of the FACTS family with very attractive features is reported by Muthukrishnan and Nirmalkumar (2010). Modern power systems are facing several problems regarding stability and control owing to their increasing complexity, changes in network topology and ever increasing load demands brought about by economic and environmental pressures. Reports of the occurrence of voltage collapse are becoming more frequent and this problem has been an area of great interest to power system researchers.

Van Custem (1991) Stated that Voltage collapse is a local phenomenon and it occurs at a bus within an area of high loads and low voltage profile. The remote buses usually have very little influence to improve the voltage stability of the affected bus. However, the voltage problem of the affected bus may cause a series of line outages and the ultimate result is system blackout. It is well recognized that voltage collapse normally occurs when there exists a large demand of power especially reactive power, but at exactly what load level the failure will occur, is not easily predicted. Practical systems subjected to sudden load changes and contingencies require a fast, simple and efficient real-time method to determine the condition of the system state and to predict the occurrence of voltage instability so that necessary measures can be taken to prevent it in due time. Voltage stability analysis

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often requires examination of lots of system states and many contingency scenarios. For this reason, the approach based on steady state analysis is more feasible, and it can also provide insights of the voltage or reactive power problems. Flexible AC Transmission System (FACTS) was launched to solve the emerging system problems. It identifies alternating current transmission systems incorporating power electronic based controllers to enhance the controllability to increase power transfer capability. These controllers are used to regulate power flow, transmission voltage and through rapid control action can mitigate dynamic disturbances. A 14-bus test system has been used to illustrate the application of proposed concept is reported by Muthukrishnan and Nirmalkumar (2010)

***Flexible AC Transmission System (FACTS):***

Today's power systems are large and widely interconnected, probably the most complex man-built systems. The purpose of the transmission network is to pool power plants and load centers in order to supply the load at a required reliability and maximum efficiency at a lower cost. As power transfers grow, the power system can become increasingly more difficult to operate, and the system becomes more insecure with unscheduled power flows and higher losses. In this context, the Electrical Power Research Institute has put forward a concept called Flexible Alternating Current Transmission Systems (FACTS). The objective of FACTS technology is to bring a system under control and to transmit power as ordered by the control center; it also allows increasing the usable transmission capacity to its maximum thermal limits. The FACTS is a concept based on power electronic controllers, which enhance the value of transmission network by increasing the use of their capacity. As these controllers operate very fast, they enlarge the safe operating limits of a transmission system without risking stability. Gradually, the use of FACTS has given rise to new controllable systems. Power Systems of today by and large are mechanically controlled. With mechanical devices, such as circuit breakers, control cannot be initiated frequently because mechanical devices tend to wear out quickly compared to static devices. The central technology of FACTS involves high power electronics, a variety of thyristor devices, microelectronics, communications and advanced control centers Power flow through an AC line is a fraction of phase angle, line end voltage and line impedance, and there is little or no control over any of these variables. The consequences of this lack of fast, reliable control are stability problems power flowing through other than the intended lines, the inability to fully utilize the transmission resources, undesirable VAR flows, higher losses, high or low voltages, cascade tripping and long restoration times. With FACTS devices one can control the phase angle, the voltage magnitude at chosen buses and/or line impedances. Power flow is electronically controlled and it flows as ordered by the control center. Alternating current transmission system incorporating power electronic based and other static controllers to enhance controllability and increase power transfer capability are called Flexible AC Transmission System. A power electronic based system and other static equipment that provides control of one or more AC transmission system parameters is called FACTS controller. In this paper shunt connected controller is used for improving power quality. The following are some of the possible benefits from FACTS technology. These benefits support the FACTS technology's effectiveness on present day's interconnected power systems (Hingorani and Gyugyi (1999).

***Proposed Method of Static Synchronous Compensator (STATCOM):***

The STATCOM is a shunt connected reactive power compensation device that is capable of generating and or absorbing reactive power and in which the output can be varied to control the specific parameters of an electric power system. It is in general a solid state switching converter capable of generating or absorbing independently controllable real and reactive power at its output terminals. By use of high frequency Pulse Width Modulation (PWM), it has become possible to use a single converter connected to a standard power transformer via air-core phase reactors. The core parts of the plant are located inside a prefabricated building. The outdoor equipment is limited to heat exchangers, phase reactors and the power transformer. For extended range of operation, additional fixed capacitors, thyristor switched capacitors or an assembly of more than one converter may be used. The semiconductor valves in a STATCOM respond almost instantaneously to a switching order. Therefore the limiting factor for the complete plant speed of response is determined by the time needed for voltage measurements and the control system data processing. A high gain controller can be used and a response time shorter than a quarter of a cycle is obtained. The high switching frequency used in the IGBT based STATCOM concept results in an inherent capability to produce voltages at frequencies well above the fundamental one. This property can be used for active filtering of harmonics already present in the network. The STATCOM then injects harmonic currents into the network with proper phase and amplitude to counteract the harmonic voltages. By adding storage capacity to the DC side of STATCOM, it becomes possible not only to control reactive power, but also active power. As storage facility, various kinds of battery cells can be used, depending on the requirements on the storage facility. A STATCOM is analogous to an ideal synchronous machine, which generates a balanced set of three sinusoidal voltages-at the fundamental frequency-with controllable amplitude and phase angle. Thus, a STATCOM controller provides voltage support by generating or absorbing reactive power at the point of common coupling without the need of large external reactors or

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capacitor banks. A Static Compensator consists of a voltage source converter, a coupling transformer and controls (Fig. 1).

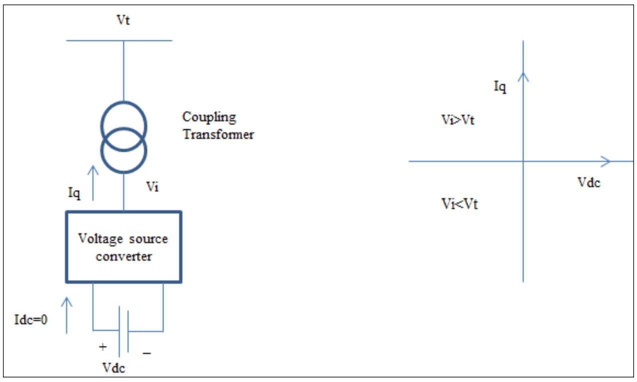


**Fig. 1:** Block Diagram of STATCOM

In Fig.1, *Iq* is the converter output current and it is perpendicular to the converter voltage *Vi*. The magnitude of the converter voltage and thus the reactive output of the converter (Q) are controllable. If *Vi*>*Vt*, the STATCOM supplies reactive power to the ac system. If VI<VT, the STATCOM absorbs reactive power. It is controlled reactive power source. Adjusting the phase shift between converter output voltage and the ac system voltage can similarly control the real power exchange between the converter and the ac system. The VSC has the same rated- current capacity when it is operated with the capacitive or inductive reactive current. The VSC may be a 2-level or 3-level type, depending on the required output power and voltage. The power exchange between STATCOM and AC system is shown below in Figure.2.

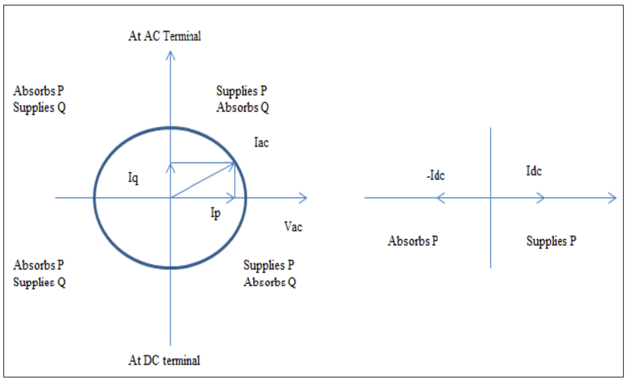


**Fig. 2:** the power exchange between the STATCOM and AC system

A STATCOM is always connected in shunt with the ac system through some magnetic coupling, namely, the coupling transformer or interface reactor. A typical STATCOM connection is shown in Figure.3.

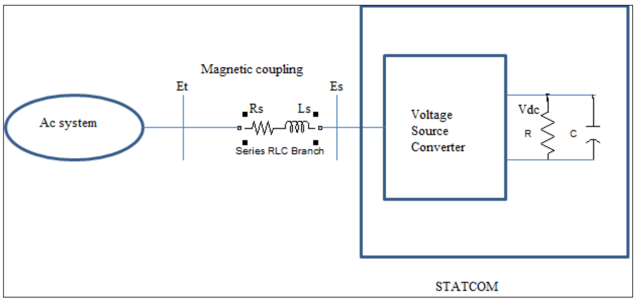


**Fig. 3:** Typical STATCOM connection to AC bus

Fig.3 consists of VSC using either a GTO or IGBT as a switching device, and a capacitor C, on DC side as an energy storage device. The resistance, R, in parallel with C represents both the capacitor losses and switching losses. The STATCOM is connected to ac system through magnetic coupling, represented by leakage

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inductance Ls, and resistance, Rs [6].

## RESULTS AND DISCUSSION

Digital simulation is done using the blocks of Mat lab/Simulink and the results are presented here. Figure 4 shows Simulation model in MATLAB/Simulink Environment. The output voltage at weak bus is shown in Figure 5. The Simulink Model/diagram for 14-bus test network with STATCOM in MATLAB/Simulink Environment developed is shown in the Figure 6. The loads are represented by series RL combination. The output voltage at weak bus with STATCOM is shown in Figure 7. The injection transformer which is present in the subsystem of Figure.4 is shown in Figure.8.

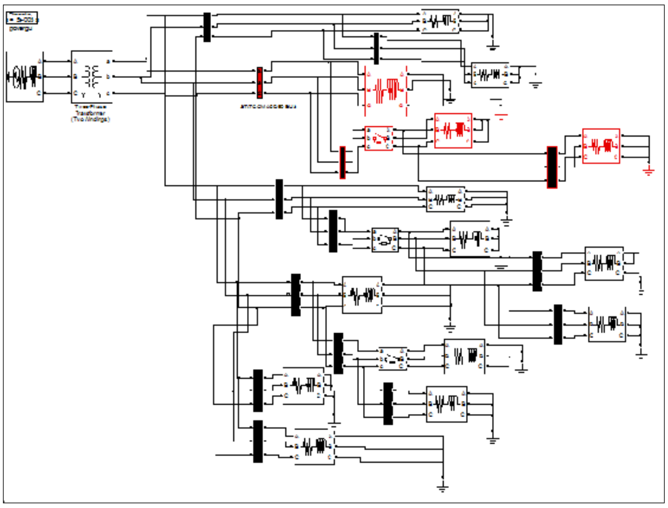

**Fig. 4:** Simulation model without STATCOM

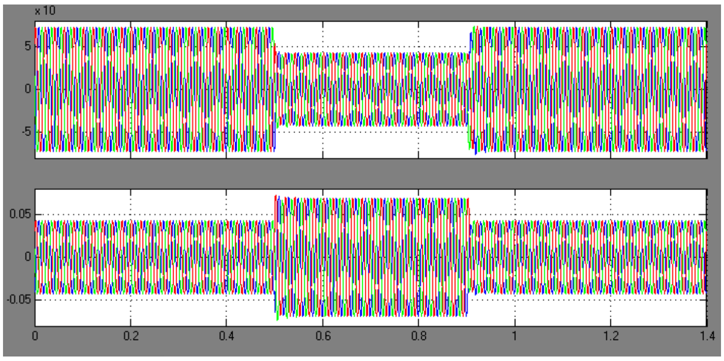


**Fig. 5:** Output Voltage waveform of Weak Bus

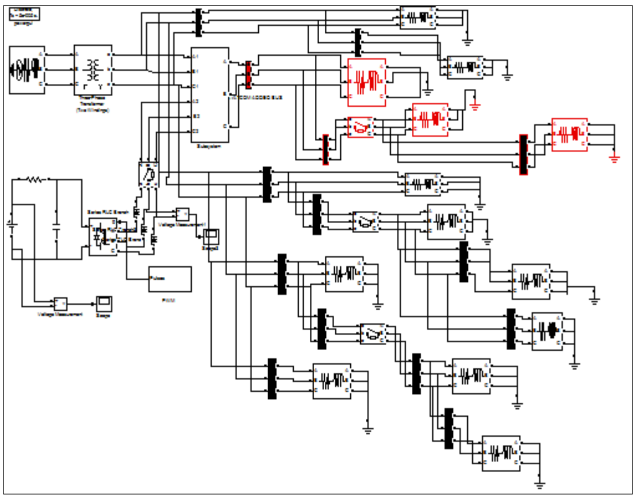

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**Fig. 6:** Simulation model with STATCOM

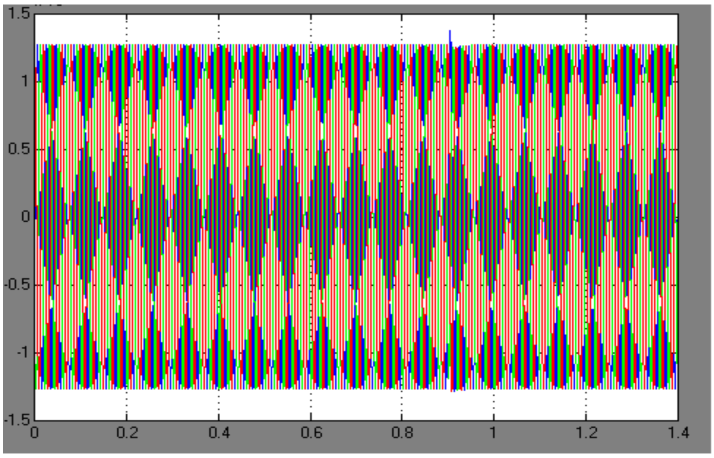


**Fig. 7:** Output Voltage with STATCOM

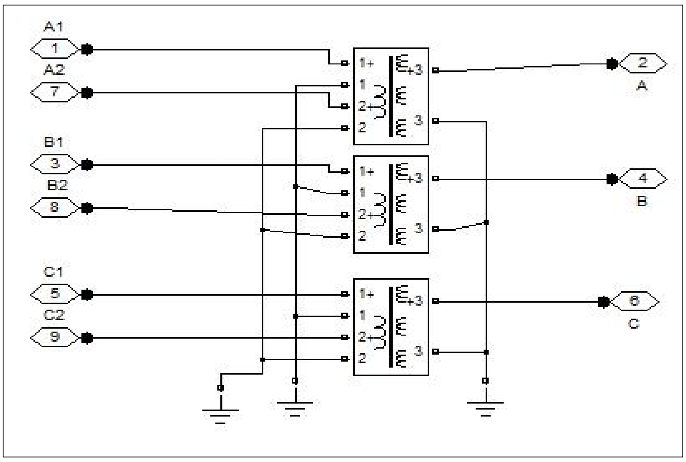


**Fig. 8:** Injection Transformer

***Conclusion:***

In this paper, the optimal location of one kind of FACTS devices, namely STATCOM, is used in order to improve the Voltage Source margin, reduce power losses and minimized the load voltage deviation. The simulation results clearly demonstrated that the representation of any multi bus power network in an equivalent domain is very useful to evaluate the overall voltage stability status of the system. In establishment of steady state model of STATCOM in load flow analysis helps to examine their effect in equivalent domain and therefore in global voltage stability which in due course helps the system operator to select proper FACTS devices for a particular voltage stability related problem.

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