ISSN: 2278 – 7798
International Journal of Science, Engineering and Technology Research (IJSETR)
Volume 1, Issue 5, November 2012

Transient Stability and Power Flow Models of STATCOM coordination Controllers with ULTC transformer for Voltage Stability improvement

A. K. Kori[1], Ratnesh Singh[2]

1. Associate professor, Deptt.Of electrical engg. Jec Jabalpur (M.P.)
2. M.E. Student, Deptt. Of electrical Engg. Jec Jabalpur (M.P.)

Abstract: This paper presents transient stability and power flow models of Voltage Sourced Inverter (VSI) based Flexible AC Transmission System (FACTS) Controllers. Models of the Static synchronous Compensator (STATCOM) with ULTC transformer appropriate for voltage stability improvement are discussed in detail. Validation procedures obtained for a test system with a detailed as well as a simplified STATCOM model are also presented and discussed.

Keywords: FACTS, STATCOM, simulation, models, controls, transient stability, power flow.

I. INTRODUCTION

The development and use of STATCOM FACTS controllers for power transmission systems has led to the application of these controllers to improve the stability of power networks [1, 2]. Many studies have been carried out and reported in the 1iterature on the use of these controllers in a variety of voltage stability applications, proposing diverse control schemes and location techniques for enhancing voltage oscillation control [2]. Several distinct models have been proposed to represent FACTS controller in static and dynamic analysis [3]. It is common to install a ULTC (Under Load Tap Changer) at the distribution substation to regulate load voltage against the variation of load demand [7]. This report describes in detail of the most appropriate model available for this studies is static synchronous compensator (STATCOM) represented in the system. These STATCOM coordination models allow the engineer to accurately and reliably carry out power flow and transient Stability studies of such system with its controllers. The latter is demonstrated in this paper by means of a comparative study in a typical transient stability problem on a test system using a detailed STATCOM model and the corresponding reduced model presented here. Assuming balanced, fundamental frequency voltages, the controller can be accurately represent in transient stability studies using the basic model shown in fig. 9. Recently STATCOM (Static Synchronous Compensator) is a mature technology ready to be adopted to complement the existing shunt capacitor or synchronous condenser for its versatile control capability [8]. It is a fast acting static reactive power compensator, which can damp out the power oscillations and cope with the voltage problem due to reactive power deficit. Section VI discusses in detail the models for VSC based controllers, namely the STATCOM. Finally Section VII briefly summarizes and material presented in this

All Rights Reserved © 2012 IJSETR

paper as well as discussing the applications of these models.

II. STATCOM OVERVIEW

A static synchronous compensator (STATCOM), also known as a "static synchronous condenser" ("STATCON"), is a regulating device used on alternating current electricity transmission networks. It is based on a power electronics voltage-source converter and can act as either a source or sink of reactive ac power to an electricity network. If connected to a source of power it can also provide active ac power. It is a member of the FACTS family of devices. Usefully a STATCOM is installed to support electricity networks that have a poor power factor and often poor voltage regulation and the most common use is for voltage stability. A Static synchronous compensator is a voltage source converter based device, with the voltage source behind a reactor. The voltage source is created from a DC capacitor and therefore a Static synchronous compensator has very little active power capability. However, STATCOM active power capability can be increased if a suitable energy storage device is connected across the dc capacitor. The reactive power at the terminals of the Static synchronous compensator depends on the amplitude of the voltage source. For example, if the terminal voltage of the voltage source converter (VSC) is higher than the ac voltage at the point of connection, the STATCOM generates reactive current and when the amplitude of the voltage source is lower than the ac voltage, it absorbs reactive power. The response time of a STATCOM is shorter than that of a static Var compensator (SVC), mainly due to the fast switching times provided by the IGBTs of the voltage source converter. The STATCOM also provides better reactive power support at low ac voltages than an SVC, since the reactive power from a STATCOM decreases linearly with the ac voltage (as the current can be maintained at the rated value even down to low ac voltage).

III. STATCOM V-I CHARACTERISTIC

A V-I characteristic of a STATCOM is depicted in Fig. 1. As can be seen, the STATCOM can supply both the capacitive and the inductive compensation and is able to independently control its output current over the rated maximum capacitive or inductive range irrespective of the amount of ac-system voltage. That is, the STATCOM can provide full capacitive-reactive power at any system voltage even as low as 0.15 pu. The characteristic of a STATCOM reveals strength of this technology: that it is capable of yielding the full output of capacitive generation almost independently of the system voltage (constant-current output at lower voltages). This capability is particularly useful for situations in which the STATCOM is needed to support the system voltage during and after faults where voltage collapse would otherwise be a limiting factor.

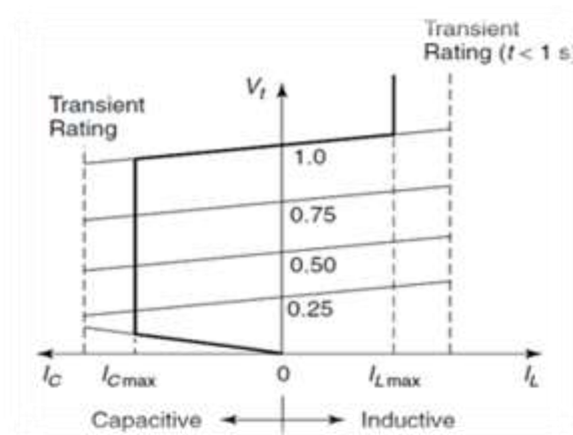

Figure1. Typical steady state V-I characteristics of a STATCOM [8].

IV. Advantages of using STATCOM

All Rights Reserved © 2012 IJSETR

ISSN: 2278 – 7798
International Journal of Science, Engineering and Technology Research (IJSETR)
Volume 1, Issue 5, November 2012

1. ULTC of transformer used less often because STATCOM regulate the bus voltage during daily load builds up.

2. Transformer failure mostly by ULTC so it decreases. So, expected life of transformer should be significantly extended because STATCOM provide both device reactor and capacitor bank function.

3. 84 MVAR is a switchable bank of capacitor will be installed with the STATCOM the switching of capacitor bank will be controlled by the STATCOM. These combinations become an SVC with 100 MVAR inductive to 184 MVAR capacitive.

V. PROPOSED STATCOM COORDINATION COTROLLER WITH ULTC POWER TRANSFORMER [9] [10]

Figure 2 shows the scheme of the proposed coordination controller.

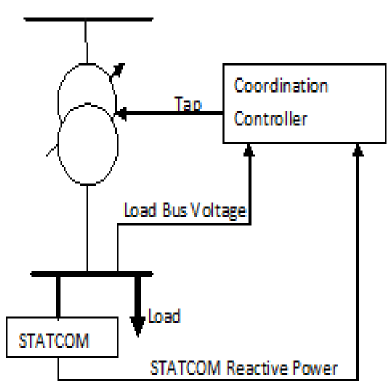

Figure2. Proposed coordination Controller Scheme

After a load change as a disturbance, the STATCOM supplies/absorbs required reactive power very quickly (nearly within 3 millisecond.) to keep the load bus voltage at the specified value, and then stabilizes at a steady-state operating point. In order to make the STATCOM available for further system changes, the coordination controller forces the ULTC to activate and be set at a tap position appropriate to nearly zero STATCOM output, while keeping the load bus voltage at the desired value.

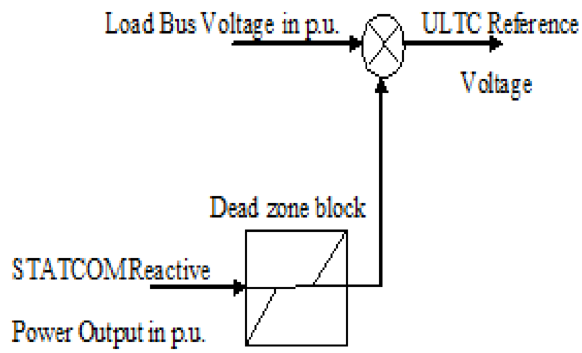

Figure 3 Coordination Controller Flow Diagrams

Figure 3 shows the coordination controller flow diagrams. As can be seen from this figure, a dead zone block is used to prevent oscillatory operation around the desired operating point. The Dead Zone block generates zero output within a specified region, called dead zone of dead zone block. The upper and lower limits of the dead zone are specified as the End of dead zone and Start of dead zone parameters. The block output depends on the dead zone and input:

a. If the input is within the dead zone (greater than the lower limit and less than the upper limit) then the output is zero.

b. If the input is greater than or equal to the upper limit then the output is the input minus the upper limit.

c. If the input is less than or equal to the lower limit then the output is the input minus the lower limit.

The reference voltage of the power transformer is the load bus voltage that needs to be kept at a desired value, for example 1pu. When STATCOM output is nearly zero, the reference voltage is the load bus voltage, otherwise, the reference voltage is higher or lower than the load bus voltage, and hence the ULTC is forced to

All Rights Reserved © 2012 IJSETR

compensate the reactive power already supplied by STATCOM. By each tap changing, STATCOM decreases its output, so the final reference value approaches the load bus voltage.

VI. WORKING MODEL WITH SIMULATION RESULTS

The test system in Figure 4 is used to validate the implementation of the STATCOM model operating under steady state condition. The STATCOM operation in Figure 4 is simulated in MATLAB/SIMULINK by using Sim Power System Block. A typical 25 KV and +/-100 MVAR STATCOM connected at the load bus of the power system is shown in figure 4.

Figure 5 shows the simulation results of the working model of operation of ULTC and STATCOM without coordination. At t=20 Sec, the breaker closes and an 18MW/5Mvar load connects to the load bus; this causes the voltage of bus B4 decreases. Here STATCOM doesn't generates the required capacitive reactive power to keep the bus voltage at the desired value causes voltage level of load bus fluctuates and disturb the voltage stability.

Figure 6 shows the simulation results of the working model of operation of ULTC and STATCOM with coordination. At t=20 Sec, the breaker closes and an 18MW/5Mvar load connects to the load bus; this causes the voltage of bus B4 decreases and STATCOM generates the required capacitive reactive power to keep the bus voltage at the desired value. After some delay, the proposed coordination controller instructs ULTC of power transformer to change and STATCOM decreases its output which maintain the voltage stability of typical system.

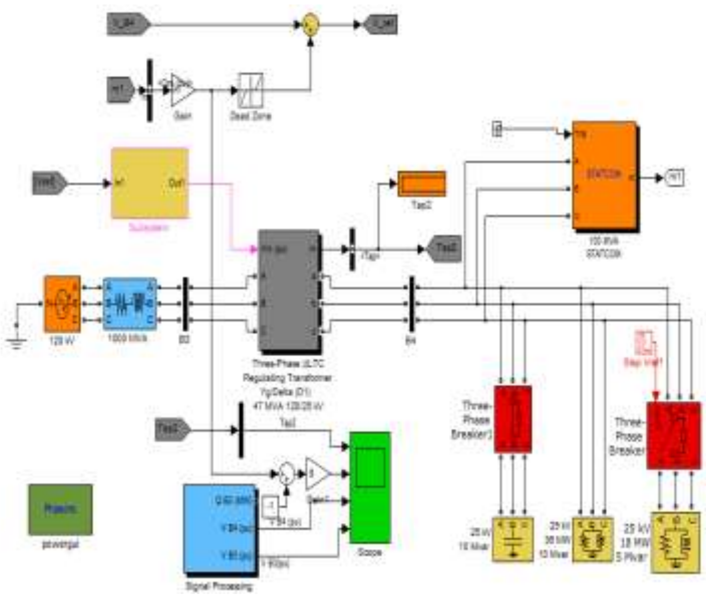

Figure 4- single line diagram of coordinated controlled ULTC transformer with STATCOM

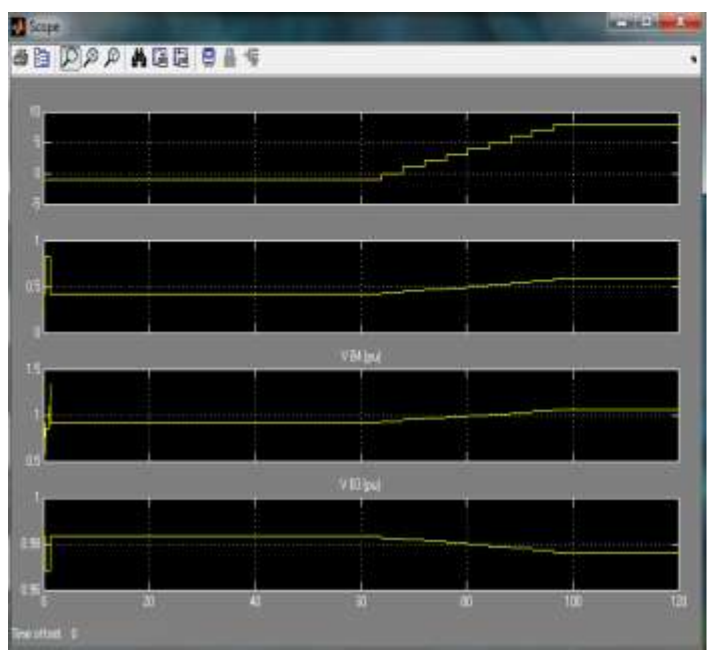

Figure 5- operation of ULTC and STATCOM without coordination

All Rights Reserved © 2012 IJSETR

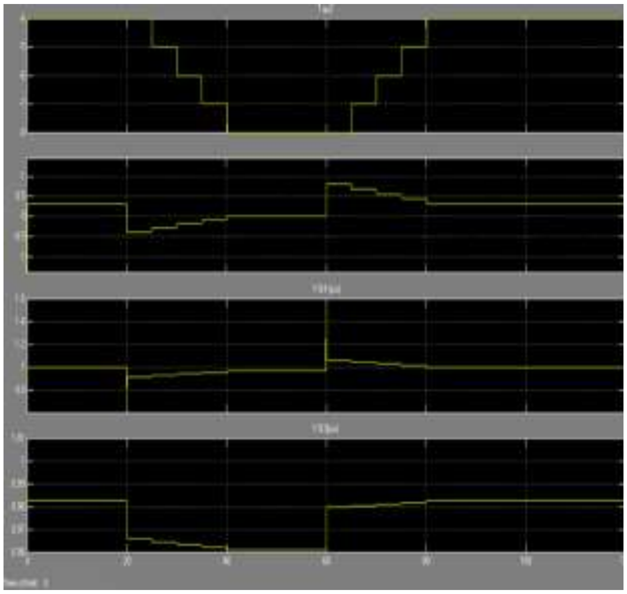

Figure 6- operation of ULTC and STATCOM with coordination

VII. CONCLUSIONS

The transient stability and power flow models presented here are based on models that have been proposed on the current literature and can be considered to be simple Adequate models for voltage stability studies of networks with STATCOM coordination controllers. These models are all based on the assumption that voltages and currents are sinusoidal, balanced and operate near fundamental frequency, which are the typical assumptions in transient stability and power flow studies. The proposed coordinated control system in this paper has the following merits over the conventional system-

1. It can reserve the STATCOM operating margin without increasing the tap operation.
2. The load voltage profile and quality are improved.

This Paper Shows the Additional Benefits That Is The coordinated control avoids ULTC oscillatory operation by applying a dead zone block.

VIII. ACKNOWLEDGEMENTS

The author would like to thank to all the faculty members and technicians of electrical engineering department of jabalpur engineering college jabalpur for its direct support of the research discussed in this paper and specially thank to our guide Mr. A.K. kori (Associate Professor) for providing your valuable time and helpful guidance for this research.

VIII. REFERENCES

[1]N. G. Hingorani. "Flexible AC Transmission Systems," IEEE Spectrum, April 1993. pp. 40-15.

[2]. "FACTS Applications," technical report 96TP116-0. IEEE PES, 1996.

[3]. Convener Terond, "modeling of Power Electronics Equipment
(FACTS) in Load Flow and Stability Programs: A Representation Guide for Power System Planning ancl Analysis," technical report TF 38-01-08. CIGRE. September 1998.

[4]. E. Uzunovic. C. A. C'ariizares, and .J. Reeve. "Fundamental Frequency model of Static Synchronous Compensator," Proc. N...lPS, Laramie, LVyoming, October 1997. pp. 49-54.

[5]. C. A. Caiiizares, E. IJzunovic, J. Reeve. And B. E;. Johnson, "Transient Stability? Models of Shunt and Series Static Synchronous Compensators, submitted for publication in IEEE Trans. Power Deliuery and available upon request. December 1998.

[6]. D. N..." h,lodeling Synchronous voltage Source Converters in Transmission System Planning Studies," IEEE Terms. Power Delivery, vol. 12. no. 2. April 1997, pp. 947-9.52.

[7]. M. S. Calovic. "Modeling and Analysis of Under Load Tap Changing Transformer Control System" IEEE Trans. on Power Apparatus and Systems. Vol. PAS-103 No.7, pp. 1909-1915. 1984. 1.

All Rights Reserved © 2012 IJSETR

[8]. Hingorani, N. G. and Gyugy, L., "Understanding FACTS", Concepts and Technology of Flexible AC Transmission System. New York: Inst. Elect. Electron. Eng., Inc., 2000.
[9]. Kim, G. W. and Lee, K. Y., "Coordination Control of ULTC Transformer and STATCOM Based on an Artificial Neural Network," IEEE Trans. Power Sys., vol. 20, no. 2, pp. 580-586, May 2005.
[10]. Abdel-Rahman, M. H., Youssef, F. M. H., Saber, A.A., "New Static Var Compensator Control Strategy and Coordination with an Under-Load Tap Changer," IEEE Trans. Power Del., vol. 21, no. 3, pp. 1630–1635, July 2006.

APPENDIX

The data for various components used in the MATLAB model of Fig. 4. (All data are in pu unless specified otherwise; the notations used are as in Sim-Power System toolbox):

SOURCES: Base voltage: 120 kV, Phase to phase rms voltage: 500 kV x 1.078, Frequency: 50 Hz, 3 phase short circuit level at base voltage (VA): 1000MVA, X/R ratio: 8

TWO LOADS: Nominal phase to phase voltage: 25 kV, Configuration: Y (grounded), Active power: 36 MW and 18 MW, reactive power: 10 Mvar and 5 Mvar, Frequency: 50 Hz

LINE: No. of phases: 3, Line length (km): 30, Resistance per unit length (ohms/km): [0.01755 0.2758], Inductance (H/km): [0.8737x10-3 3.220x10-3], Capacitance (F/km): [13.33x10-9 8.297x10-9], frequency = 50 Hz.

STATCOM parameters: 25 kV, ±100 MVAR, R = 0.071, L = 0.22, Vdc = 1 kV, Cdc = 750 μ F, Vref = 1.0, Kp = 5, Ki = 1000, frequency = 50 Hz.

ULTC transformer parameter: 47 MVA, 120/25 kv, tap selection time = 4sec, Vref = 1 pu, min/max tap position = -8/+8, voltage/tap = 0.018375 pu, frequency = 50 Hz.

All Rights Reserved © 2012 IJSETR