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Simulation and Modelling of 6-pulse STATCOM in PSCAD to Regulate the Bus Voltage at Load End

Bal Krishna Jadon[1] Pooja Jain[2] Anjali Jain[3]
[1]M.Tech Scholar [2,3]Assistant Professor
[1]Department of Power System Engineering [2,3]Department of Electrical & Electronics Engineering
[1,2,3]SKIT Jaipur

Abstract— Nowadays, power systems are facing major challenges related to voltage instability. This paper presents the voltage instability problems in the power system that occurs due to various factors such as unbalanced load, disturbances in the line and other type of fault in the system or we can say the contingency problem. Prevention of this type of instability, we use FACTS as a controller and the effect of STATCOM on a generalized power system will be studied in this paper. The STATCOM is added to provide the transient stability margin to the power system which need for that particular system at the time of increment the load. The simulation was carried out by using PSCAD/EMTDC software under study and detailed results are shown to access the performance of STATCOM at load increases at the bus.

Key words: STATCOM, PSCAD, Bus Voltage at Load End

I. INTRODUCTION

Power transmission is a complex factor of the power system which depends on load end as well as the supply end. The variation of the load fluctuates system stability of the power line. The stability is one of the major criteria which decides the system operation.

According the IEEE definition of the stability, "Power system stability is the ability of an electric power system, for a given initial operating condition, to regain a state of operating equilibrium after being subjected to a physical disturbance, with most system variables bounded so that practically the entire system remains intact".

The disturbances of the system stability occur either sudden increment or decrement of the load, lightning or the short circuit in the lines. By continuous decrease the magnitude of voltage at an area or a particular location decides the voltage instability and finally it will go the entire network to voltage collapse. The generated reactive power is very useful for the load but because of the transmission losses and variation of the load, the generated reactive power is not utilized. The reactive power used for the load is compensated by the load end compensated devices and the sub-station used controllers. The entire AC power system has two limits, such as static and dynamic limits [1- 2]. Today's changing power system creates a growing need for reliability, flexibility and accuracy in the power generation, transmission and consumption.

Stability in power system improves by most recent developed devices called Flexible AC Transmission System (FACTS) controllers [3], [4]. FACTS are power electronics devices that capable of altering phase angle, voltage and impedance in power systems. The fast response of FACTS offers the system stability enhancement for flow control. Static Synchronous Compensator (STATCOM) is most used FACTS device which provides the fast acting dynamic reactive compensation for voltage support during contingency events [5].

In this paper, Power System Computer Aided Design /Electromagnetic Transients including DC (PSCAD/EMTDC) have been used to conduct simulations of the voltage and reactive power at the point of connection of STATCOM to the system.

II. LITERATURE REVIEW

In recent years, many studies have been conducted on FACTS devices using MATLAB, PSCAD and many other simulation software. John J. Paserba et al. [6] analysed the benefits of FATCTS controller and author presents paper sponsored by the DC and FACTS Group, under the "DC and FACTS Subcommittee of the T&D Committee". Paper concluded that FACTS controllers provided with a focus on their system performance characteristics. S. Mori. et al. presented a paper [7] on techniques for improving power system stability and concluded that IGBTs, has been successfully applied in a number of installations world-wide for Static Synchronous Compensators (STATCOM). G. Reed et al. [8] worked on VELCO 115 kV system in the vicinity of the Essex STATCOM-Based Project and conclude that the STATCOM technology that uses advanced power semiconductor switching techniques to provide dynamic voltage support, power system stabilization, and enhanced power quality, there are several recently completed STATCOMs in the U.S., in the states of Vermont. K. Karthik discussed a paper [9] on the effect of FACTS device STATCOM on a 12-bus multi-machine power system and concluded that the STATCOM improves dynamic power flow control for the transmission lines and also improves power oscillation damping and transient stability. Compensation of Reactive Power of eight bus system using D-STATCOM is evaluated by P. Venkata Kishore et al. [10]. Paper concluded that Voltage stability is improved by using D-STATCOM and the also improved the reliability and power quality. Balwant K. Mehta et al. worked on [11] IEEE 6-bus test system with STATCOM using Newton Raphson method for static voltage stability improvement and conclude that STATCOM give slightly higher MLP and better voltage profiles compared to without compensation.

III. POWER QUALITY

Power quality involves waveform, frequency and voltage. It can be defined as a steady supply voltage that stays within a defined range. it is the key factor that maintains the synchronism between the electric outlet and load. It improves by FACTS devices. [12]

Power quality problems occur at transmission line:

1) The Reactive Power Consumption at the Heavy Loads.

2) Reverse Operation of ON Load Tap Changer (OLTC).
3) Occurrence of Contingencies.
4) Poor coordination between the multiples of FACTS controllers.
5) Voltage sources are far from load centres.
6) Under the Heavy Loads the Transmission of Reactive power is difference
7) It Presences of Constant Power Load.

IV. VOLTAGE STABILITY

One of the most important parameter in the power system is voltage. According to IEEE definition: "Voltage stability refer to the ability of power system to maintain steady voltages at all buses in the system after being subjected to a disturbance from a given initial operating point."

The whole power systems is interconnected with grid which is operated for power transfer between little coordinated areas for exchange the desired power by transmission line. If case of heavy fluctuation, voltage collapse may occur. The voltage collapse is the continuous fall in the voltage of the system.

V. REACTIVE POWER CONTROL

In power systems, the reactive power is required to balance electric fields of capacitors and magnetic fields of inductors in loads. Earlier, the reactive power in the system was delivered by compensation at load buses by compensating devices such as shunt capacitors, synchronous condensers. There are two side effects of reactive power transmission those are transmission losses and voltage drops. When the load voltage is lower, both the transmission losses and voltage drops are higher, which cause the voltage at the load bus more decreased. Voltage at the receiving side is improved by using end shunt capacitors and these elements feed the reactive power which is not significant by the generator side. It reduces the transmission losses. After a disturbance, there is a sudden increase of reactive power demand. If the demand is not met, the disturbance leads to voltage collapse, causing a major breakdown of part or all of the system.

To avoid the major problem called as voltage collapse, we take a control method for develop the good power quality. To achieve reliable and more efficient operation of any power system, the flow of reactive power should be minimized so as to reduce the losses. The coordination and proper selection of equipment for reactive power control are the major challenges of power system engineering [13]. The new ideas came in existence to reduce these difficulties regarding to reactive power control. There is need for control as well as compensate the reactive power, we have to use such devices which are very efficient in all perspective. There is a family of reactive power controlling sources used at substation called as FACTS devices (advancement of power electronics). In facts, the most used devices are SVC and STATCOM. Our mainly focus in this paper is to improvement the system stability, to improve transient stability we use STATCOM as FACTS device. In the three phase system, we analyse the of voltage problem which are frequently occurs and to overcome this problem we use a new development in the bus system for the voltage regulation using STATCOM [14].

VI. STATCOM

STATCOM is a shunt device of FACTS family connected at the bus, which uses to control power flow in the transmission line as well as the transient stability improvement on the grids. The STATCOM regulates the voltage at terminal by controlling the amount of reactive power injected into or absorbed from the power system [15]. Generally, it is a solid-state switching converter which is capable of absorbing or generating independently real and reactive power control at its output terminals when it is delivered from an energy source at its input terminals [16].

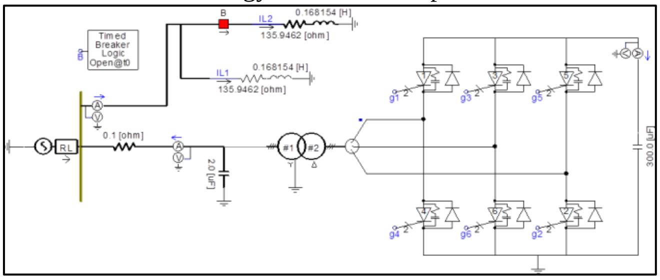

Fig. 1: System model with STATCOM

VII. SYSTEM MODEL DESCRIPTION

The system used in this paper comprises of an 115kV three-phase power system which represents with an infinite voltage bus-bar connected to the variation of load as shown in the fig 1. A two-level VSC-based 6 pulse STATCOM is connected with system provide instantaneous voltage support at the load point. A 300 μF capacitor on the dc side provides the STATCOM energy storage capabilities. The breaker controls the connection of the secondary load connected into the system. The aim of the STATCOM is to provide voltage regulation at the load point and alleviate the voltage sag when the load is increased. The system is considered to be operating under balanced conditions and both loads are linear. The second load is inserted into the system at 1.0 sec time.

A. Voltage Control Loop

This loop is used for generation of angle order based on voltage error. Where Qm and Vpu are measured reactive power and measured rated voltage. We use a PI controller. The output of PI controller is the angle order, it represents the required shift between system voltage and voltage generated by STATCOM; the shift determines the direction and amount of real power flow. The system is shown in the fig 2.

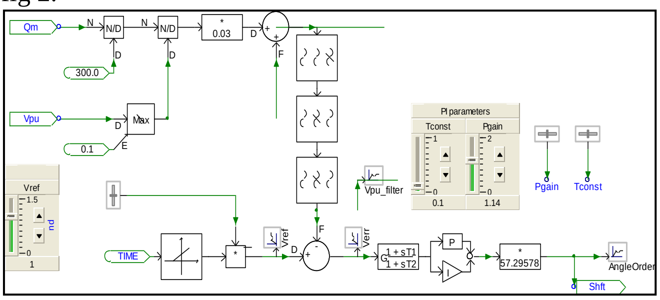

Fig. 2: Voltage control loop

B. Generation of Carrier Signal

This arrangement of the components generates triangular waveforms which synchronized with system AC voltage. We multiplied the factor 33.0 to theta for angle giving to resolver. The number defines the carrier frequency, it is a multiplication of fundamental frequency, its value has to be divisible by three. This arrangement is shown in fig 3.

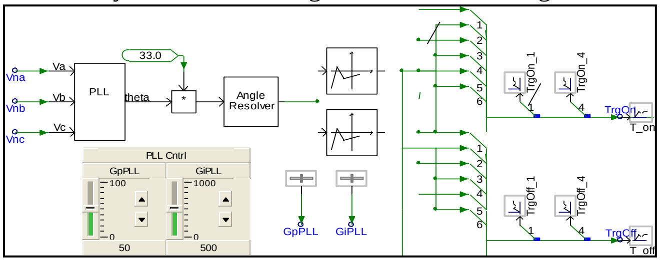

Fig. 3: Generation of carrier signal

C. Generation of Reference Signal

The second part of the generation of reference waveforms synchronized with system AC voltage and shifted by the angle order shown in fig 4. The angle shifts to 30 degrees for star-delta configuration of transformer.

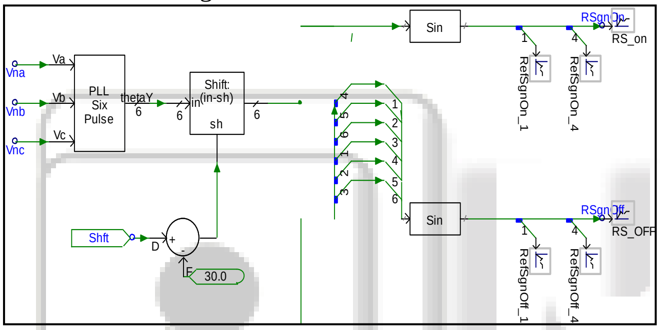

Fig. 4: Generation of reference signal

D. Generation of Firing Pulses

In the system, firing pulses of 6-pulse STATCOM are generated using comparison of reference signals to triangular signals as shown in fig 5. Two sets of signals (reference and triangular ones) are needed, one set for turning on and the second one (a negation of the first set of signals) for turning off - see PWM control parts 1 and 2. Two signals are being sent to each switch, the first one tells to turn on or off, the second one determines an exact moment of switching and is used by interpolation procedure which allows for switching between time steps.

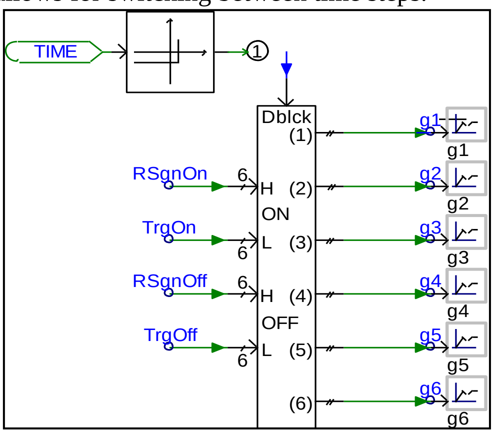

Fig. 5: Generation of firing pulses for STATCOM

VIII. SIMULATION

A. Without STATCOM

We use the power system model for the analysis and add the load at bus with circuit breaker. The operating time of the breaker is 1 sec. and after that the breaker is permanently close the simulation result is giving as shown in fig 6.

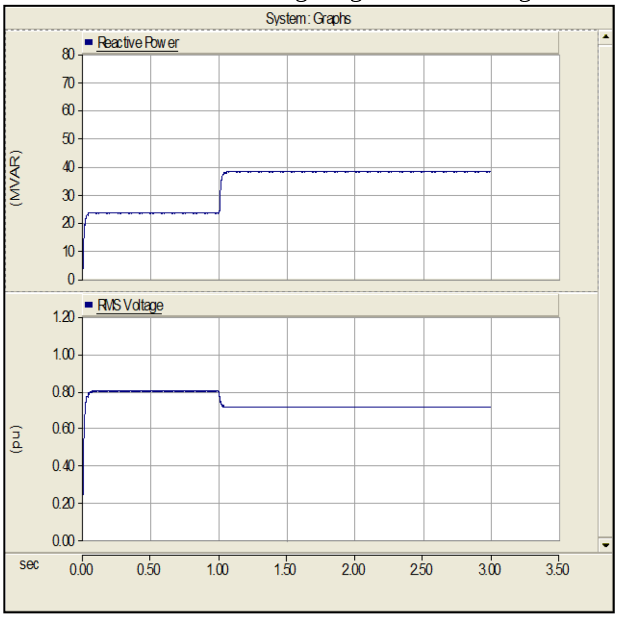

Fig. 6: Simulated waveform without STATCOM

B. With STATCOM

The STATCOM improves the quality of the system parameters. We analyse only two parameters, as the giving fig 7, STATCOM compensates the reactive power and RMS voltage. The variation of the waveform decided by the capacitor used in STATCOM.

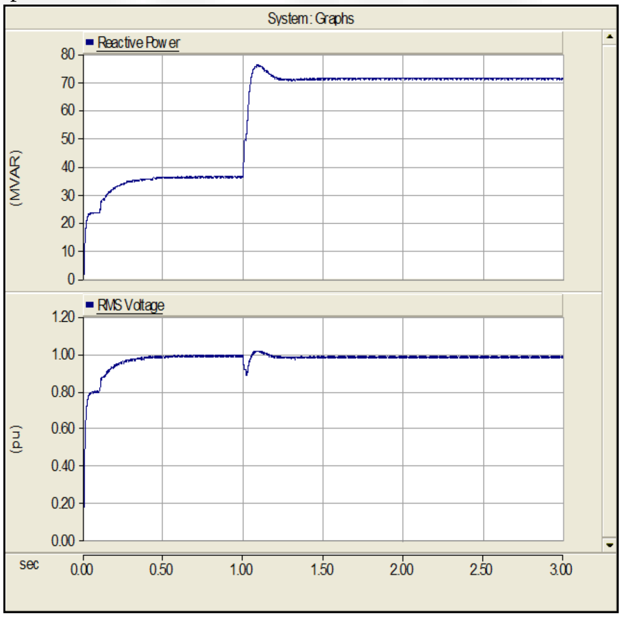

Fig. 7: Simulated waveform with STATCOM

IX. RESULT

The table given below the desired value of RMS voltage and reactive power with and without compensation. The load 2 (135.9462+j0.16815) is insertion at 1 sec.

	RMS Voltage (pu)		Reactive Power (MVAR)	
	Before Load 2 Insertion (at 0.89 sec)	After Load 2 Insertion (at 1.5 sec)	Before Load 2 Insertion (at 0.89 sec)	After Load 2 Insertion (at 1.5 sec)
Without STATCOM	0.797	0.71	23.64	37.97
With STATCOM	0.989	0.982	36.2	70.89

Table 1: Reactive Power and Bus Voltage

X. CONCLUSION

The FACTS controller is implemented in this paper to improve the system reliability and stability. After installing STATCOM in this system as shown in fig 1, the bus voltage gets improved and becomes nearly equal to the rated voltage. Reactive power of the system improved twice after the compensation. The result is simulated by PSCAD software because of flexible, powerful and relatively less costly simulation program.

REFERENCES

[1] Hasan Fayazi Boroujeni, Mehran Amani and Mostafa Abdollahi, "Dynamic Stability Improvement by Using STATCOM in a Multi Machine Environment", *Research Journal of Applied Sciences, Engineering and Technology, Iran*, Vol. 4(18), September 15, 2012.

[2] Furini, M.A., A.L.S. Pereira and P.B. Araujo, "Pole placement by coordinated tuning of Power System Stabilizers and FACTS-POD stabilizers", *International Journal Of Electrical Power & Energy System.*, Vol. 33(3): pp.615-622, 2011

[3] N G Hingorani, "FACTS-Flexible AC Transmission System", *Proceedings of 5th International Conference on AC and DC Power Transmission-IEEE Conference*, pp 1-7, Sep 1991

[4] N G Hingorani, "Flexible AC Transmission", *IEEE Spectrum*, pp 40-45, Vol 30, April 1993.

[5] Y. Cheng, C. Qian, M. L. Crow, S.Pekarek,S. Atcitty, "A Comparison ofDiode Clamped and Cascaded MultilevelConverters for a STATCOM with EnergyStorage," *IEEE Trans.on Industrial Electronics*, Vol. 53, No. 5, pp.1512-1521,2006.

[6] John J. Paserba, "How FACTS controllers benefit AC transmission systems - phases of power system studies", IEEE *PES Transmission and Distribution Conference and Exposition*, *New Orleans, LA, USA*, pp. 1-8, 2010

[7] S. Mori, K. Matsuno, T. Hasegawa, S. Ohnishi, M. Takeda, M. Seto, S. Murakami and F. Ishiguro, "Development of a Large Static Var Generator Using Self-Commutated Inverters for Improving Power System Stability," *IEEE Transactions on Power Systems*, Vol. 8, No. 1, pp. 371-377, February, 1993.

[8] G. Reed, J. Paserba, T. Croasdaile, M. Takeda, Y. Hamasaki, T. Aritsuka, N. Morishima, S. Jochi, I. Iyoda, M. Nambu, N. Toki, L. Thomas, G. Smith, D. LaForest, W. Allard and D. Haas, "The VELCO STATCOM-Based Transmission System Project," *Proceedings of the 2001 IEEE PES Winter Power Meeting, Columbus, OH*, January/February 2001.

[9] K. Karthik, "Effect of FACTS Devices STATCOM and SSSC on Wind Farms*", IOSR Journal of Engineering (IOSRJEN)*, Vol. 3, Issue 7, pp 15-26, July, 2013.

[10] P. Venkata Kishore and Prof. S. Rama Reddy, "Compensation of Reactive Power Using D-STATCOM", *IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE)*, Vol. 9, Issue 1 Ver. I, pp 17-27, Jan, 2015.

[11] Balwant K. Mehta and Asso. Prof. P. J. Patel, "Static Voltage Stability Improvement In Power System Using Statcom Facts Controller", *Journal Of Information, Knowledge And Research In Electrical Engineering*, Volume – 02, Issue – 02, Nov 12 To Oct 13.

[12] G.Srinivas and T. Santosh Chaitanya, "Power Quality Improvement Using Facts Device (STATCOM)", *Technical Research Organization*, VOLUME-2, ISSUE-5, 2015.

[13] Proceedings of NSF Workshop on Bulk Power System Voltage Phenomena-Voltage Stability and Security. *Deep Creek Lake, MD*, August 4-7, 1991.

[14] Nishad, Avinash Kumar, and Ashish Sahu. "Development and Simulation of Voltage Regulation System of AC Transmission lines using Static Synchronous Compensator (STATCOM)." 2015.

[15] NaveenGoel, R.N. Patel,Saji and T. Chacko , "Genetically Tuned STATCOM for Voltage Control and Reactive Power Compensation", *International Journal of Computer Theory and Engineering*, Vol. 2, No. 3, June, 2010.

[16] Champa Nandi, Sumita Deb, Minakshi Deb Barma, and A.K. Chakraborty, "Study and Simulation of the SVC and STATCOM Effect on Voltage Collapse and Critical Fault Clearing Time", *International Journal of Modeling and Optimization*, Vol. 2, No. 4, August 2012.

