International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 06 Issue: 06 | June 2019 www.irjet.net p-ISSN: 2395-0072

Voltage Stability Improvement and Reactive Power Compensation using STATCOM in MATLAB

Shivam B Getme[1]

[1]*PG Student (Power System), Dept. of Electrical Engineering, Veermata Jijabai Technological Institute (VJTI), Mumbai, Maharashtra, India 400019*

Abstract - *Due to heavy urbanization and industrialization, the power is becoming interconnected and more complex in nature. This leads to reduced power quality and lack of controllability of power flow in the existing transmission line. This paper deals with enhancing the voltage in the transmission line by management of reactive power. The scheme used for reactive power management is FACTS technology in which shunt connected device STATCOM is used. MATLAB software is used for the simulation of a three phase single circuit transmission line when additional load is added in the system.*

Key Words: **Power flow control, voltage stability, reactive power, STATCOM, MATLAB**

1. INTRODUCTION

Power industries are restructured to cater more users at lower prices and better power efficiency. Power systems are becoming more complex as they become inter-connected. Load demand also increases linearly with the increase in users. This result makes the reactive power insufficient in existing supply power systems as well as in future distributed generation systems, and causes serious problems just like unstable load voltage and decrease power transfer efficiency. Since stability phenomena limits the transfer capability of the system, there is a need to ensure voltage stability and reliability of the power system due to economic reasons [1]. The main function of power system is to transfer power from one location to another.

The main objectives of power system are-

- To transfer power with reliability
- Economical power transfer
- Security of power system

To maintain quality of supply, voltage profile of system should be maintained constant. Voltage control of transmission line is basically provided by reactive power control in transmission line [2].

Reactive power is generated by-

- Synchronous Generator and synchronous motor
- Synchronous Condenser
- Distributed capacitance of overhead line and cables

Reactive power is consumed by-

- Synchronous machine
- Inductive static loads
- Induction motor
- Transformer
- Distributed inductance of overhead line and cables.

The power produced in any power station is transmitted through transmission network at high voltages over long distances using transformers. When the electrical power is being used by loads, active and reactive power can be drawn depending on the types of load. Even when the load is resistive, some reactive power is still needed for the long transmission lines, which acts some times as inductive loads, in this respect to control reactive power requirement an efficient control technique is needed. This paper focuses on the mitigation of voltage sag in the system for which STATCOM is used and the simulation work is done using MATLAB SIMULINK.

2. PROBLEM FORMULATION

The power produced in any power station is transmitted through transmission network at high voltages over long distances using transformers. When the electrical power is being used by loads, active and reactive power can be drawn depending on the types of load. even when the load is resistive, some reactive power is still needed for the long transmission lines, which acts some times as inductive loads, in this respect to control reactive power requirement an efficient control technique is needed.

The power system industry is a field where there are constant changes. Due to sudden switching of loads, the reactive power demanded by the load gets changed resulting in voltage variation of transmission line. If the major load get suddenly switch OFF, the voltage in transmission line get rapidly increase above the rated limit and can affect the voltage stability and damage the transmission system. Similarly, if any load gets suddenly switch ON, the voltage magnitude get reduce because as the current drawn by the load get increase. Due to variation in voltage, the transmission line is affected and transmission side equipment's get damage. There are different power quality factors such as voltage imbalance, voltage sag, voltage swell, flicker which occurs due to change in the load.

As discussed above, the behavior of transmission line get affected due to voltage imbalance, voltage sag, voltage swell, and flickers, etc. The project is to study the voltage profile when there is sudden change in load demand [3],[4],[5].

3. MATLAB MODEL OF TRANSMISSION SYSTEM

The single line diagram shown below represents a simple 132 KV transmission system. This system has a total transmission line length of 300 Km. The system has been supplied by a three phase source having phase to ground voltage of 132 KV and frequency 50 Hz. Two three phase series R-L load of 50MW and 20 MW are connected to system. Load-1 is directly connected at the receiving end of the transmission line while load-2 is connected to system via a circuit breaker. The circuit breaker is initially under open condition. The transition time of circuit breaker is 0.2 and 0.4. The total simulation time is 0.5

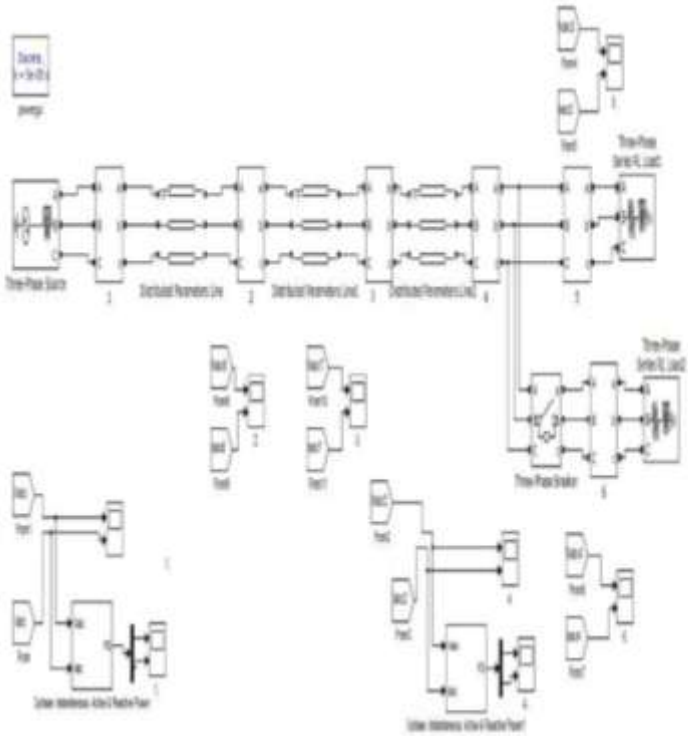

Fig -1: MATLAB simulation model of test transmission system

4. SIMULATION RESULTS WITHOUT COMPENSATION

The MATLAB simulation for given model gives the waveform of current, voltage and power at source and load side of the system.

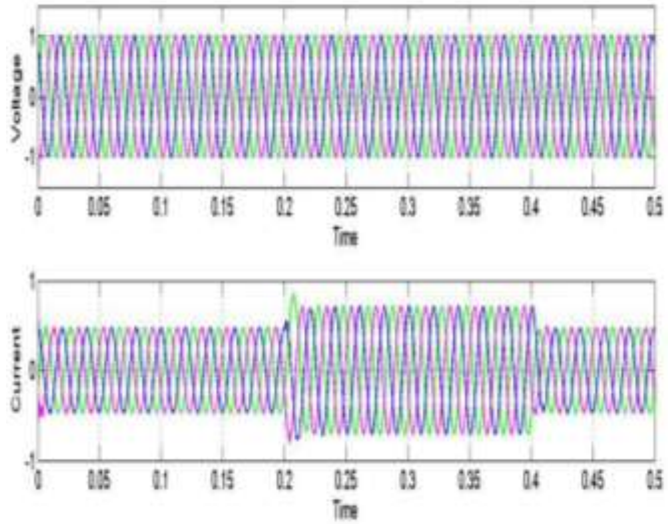

Fig -2: Voltage and current at source side

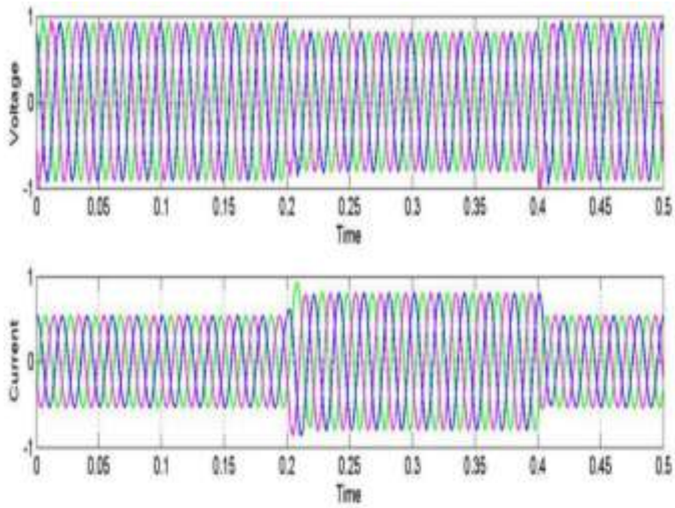

Fig -3: Voltage and current at load side

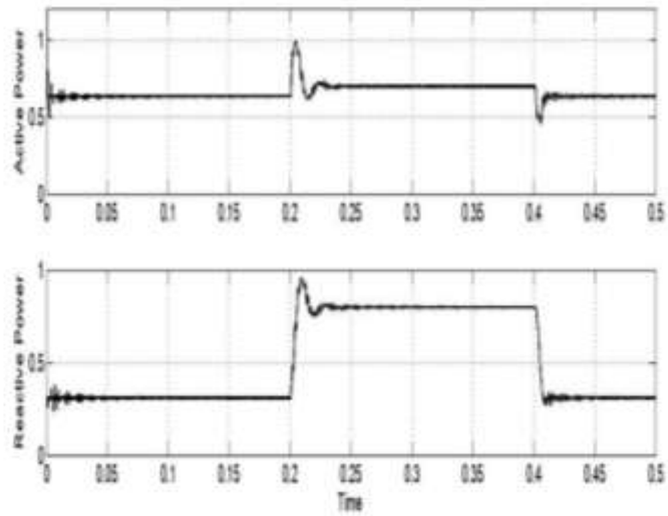

Fig -4: Active and reactive power at source side

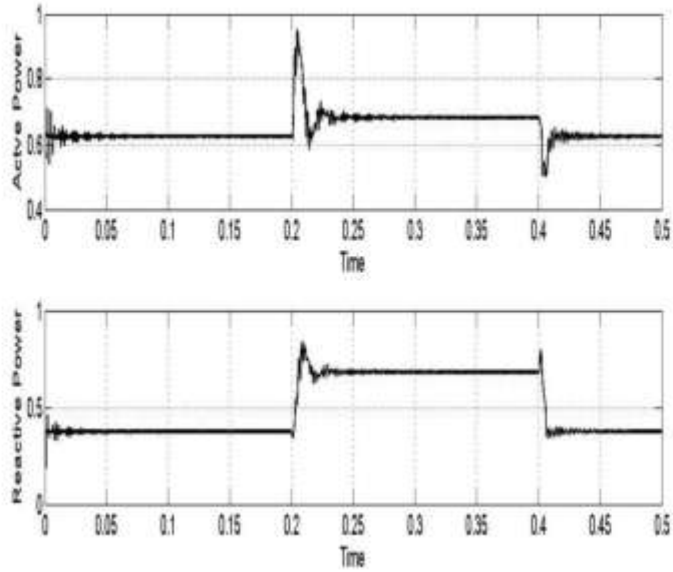

Fig -5: Active and reactive power at load side

5. COMPENSATION TECHNIQUES

Reactive power compensation for voltage profile enhancement can be done by using various devices.

Traditional compensating devices used for voltage profile enhancement in a power system are-

- Series capacitor
- Tap changing transformer
- Shunt Reactors
- Synchronous condenser
- Inductive regulators
- Synchronous phase modifier
- Static VAR System (SVS)
- shunt capacitor

These devices have slow time response in voltage control of transmission line. The above traditional devices are bulky in size and complexity increases. Reactive power cannot control over wide range by using traditional devices.

The FACT technology has received much attention in last two decades. It uses power electronic devices for stability and voltage control of transmission system. The FACTS technology has advantages over other method that, it enhances the real power handling capacity of line at much lower cost than the building of a second transmission line of same capacity. FACT devices has recognized as smooth control of reactive power over wide range to maintain constant transmission line voltage [2],[4].

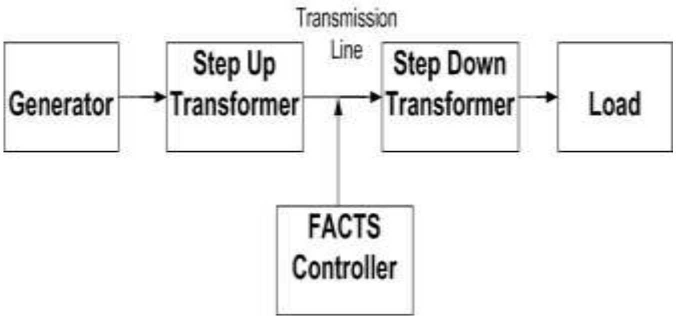

Fig -6: Block diagram of compensation scheme

FACTS technology has advantages over conventional method-

- Smooth control of reactive power
- Fast time response
- Enables current carrying capacity closed to its thermal limit
- Reliability of transmission system increases
- Transient and dynamic stability of the system increases
- Increased quality of supply for large industries

FACTS devices such as STATCOM (Static Synchronous Compensator), SVC (Static VAR Compensator), SSSC (Static Synchronous Series Compensator), UPFC (Unified Power Flow Controller), IPFC (Interline Power Flow Controller) can be connected to transmission line in various ways such as in series, shunt and a combination of series and shunt [3],[6].

6. MATLAB MODEL WITH COMPENSATION

The voltage sag or swell is compensated by using SPWM technique. SPWM output should change in accordance with the reactive power demanded by the load. To determine the magnitude of reactive power compensation required by the system, the reactive power on source side is compared with the zero value. This value is known as error . The error is fed to the controller such as PI controller whose proportional gain (Kp) is set to 0.1 & integral gain (Ki) to 2. This gives the value of delta(δ) which is then combined with 'wt' generated through discrete three phase PLL block. This combination is fed to three different sine trigonometric functions having phase shift 0, -120, 120 deg. respectively. The generated sine wave is then compared with the repeating signal having frequency 4Khz and amplitude of [0 1.5 0 -1.5 0] . This leads to the generation of gate pulses required for the operation of two level three phase inverter. Here, I am using MOSFET as switches in inverter. Inverter is supplied with the 25 kV dc voltage which is further connected to the transmission line via zig-zag transformer [7],[8],[9].

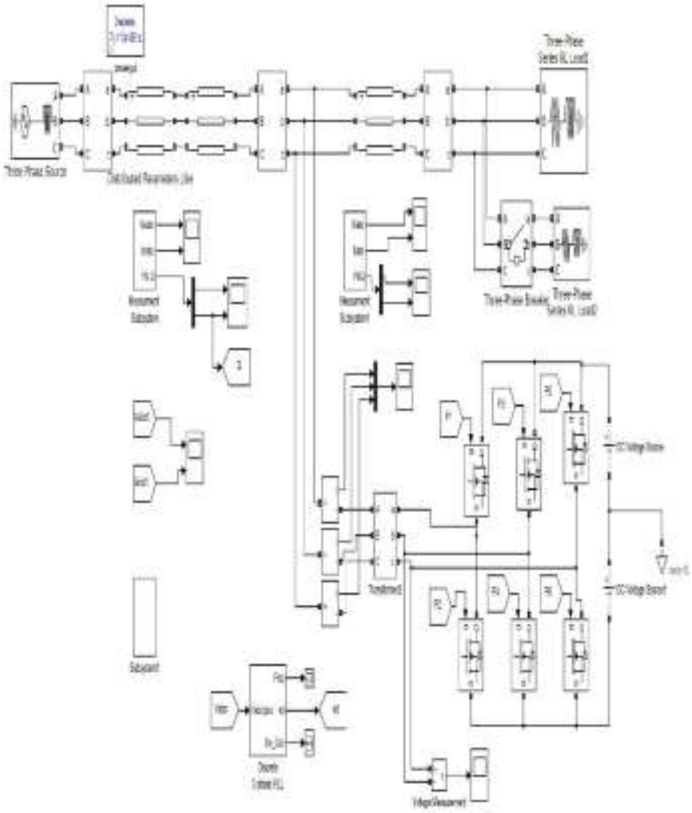

Fig -7: MATLAB simulation model using STATCOM

7. SIMULATION RESULTS AFTER COMPENSATION

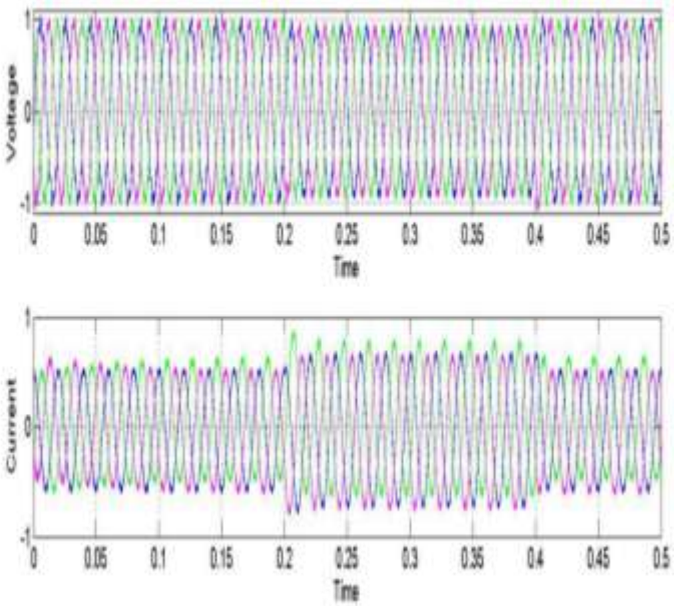

Fig -8: Voltage and current at load side after compensation using STATCOM

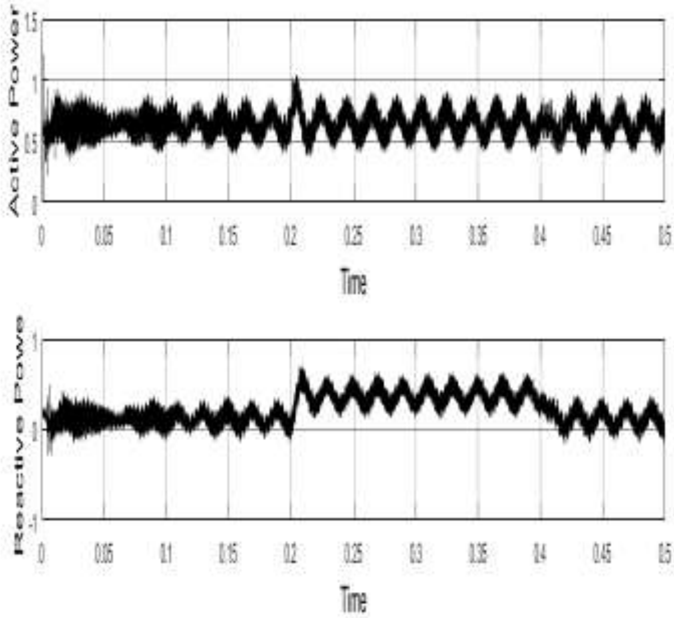

Fig -9: Active and reactive power at source side

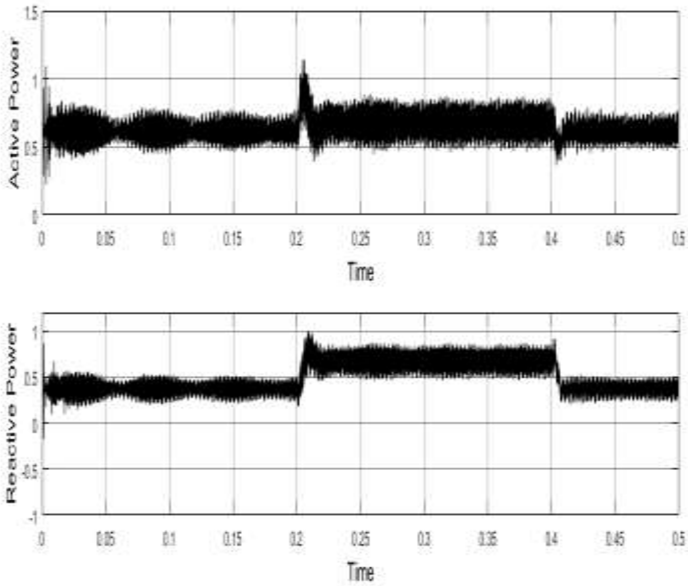

Fig -10: Active and reactive power at load side

From the above figures, I came to know that the drop of voltage in transmission line during the transition time i.e. from 0.2 to 0.4 sec is getting compensated to some extent by application of STATCOM. The sag in voltage of transmission line due to sudden switching ON of load 2 is getting mitigated to some amount by injecting a reactive power in the transmission line. In the transition time i.e. from 0.2 to 0.4 sec, as the reactive power demand gets increases suddenly, as I see in the figure, STATCOM provides the reactive power demand, so that the voltage sag occurred during transition of load 2 is getting mitigated automatically and approximately constant voltage is maintained through the line.

8. CONCLUSION

The model of a STATCOM was analyzed and developed for use in MATLAB with various power system block sets. Here a control scheme i.e. SPWM is designed in MATLAB Simulink. STATCOM can control real time power and also regulate the bus voltage. Hence the power system performance is improved. Here waveform of simulation results after compensation shows the performance of STATCOM in a distribution system by varying an inductive load at some amount. I can observe that STATCOM can regulate load side voltage approximately constant which shows the voltage stability of STATCOM.

REFERENCES

[1] Arti Pateria, NitinSaxena, Manoj Tiwari, "Transfer Capability Enhancement of Transmission Line using Static Synchronous Compensator (STATCOM)," International Journal of Advanced Computer Research (ISSN (print): 2249-7277 ISSN (online): 2277-7970) Volume-2 Number-4 Issue-7 December-2012.

[2] J. J. Paserba, Fellow, "How FACTS controller benefits AC transmission system", IEEE transaction.

[3] N.G.Hingorani, L. Gyugyi, "Understanding FACTS, concept and technology of flexible AC transmission system", IEEE Press, ISBN: 978-81-265-3040-3, pp. 1-26, Copyright: 2000, reprint: 2013.

[4] K.R. Padiyar, "FACTS controller in power transmission & distribution," Published by New Age international, ISBN(13): 978-81-224-2541-3, pp. 1-16,36-41 , Copyright: 2007.

[5] Raunak Jangid, Kapil Parkh, PradeepAnjana, "Reducing the Voltage Sag and Swell Problem in Distribution System Using Dynamic Voltage Restorer with PI Controller",International Journal of Soft Computing and Engineering (IJSCE),ISSN: 2231-2307, Volume-3,Issue-6, January 2014.

[6] Prince Hooda, Prof. Aziz Ahmed, Prof. Tanmoy Deb, Vikalendu, "Voltage stability and Power flow improvement using STATCOM and TCSC," International journal of innovative research in electrical, electronics, instrumentation and control engineering, Vol. 2, ISSN (Online) 2321 – 2004, ISSN (Print) 2321 – 5526Issue 8, August 2014.

[7] Ravilla Madhusudan, Student Member, IEEE, G. Ramamohan Rao, "Modeling and Simulation of a Distribution STATCOM (D-STATCOM) for Power Quality Problems-Voltage Sag and Swell Based on Sinusoidal Pulse Width Modulation (SPWM)",IEEE- International Conference On Advances In Engineering, Science And Management (ICAESM -2012) March 30, 31,2012.

[8] Tzeng-ShongYeh, Huang-Fu Jhu, Hsiao-Wei Sung,"Modeling and Control of Three-Phase Multilevel Inverter-Based STATCOM ",2010 2nd IEEE International Symposium on Power Electronics for Distributed Generation Systems.

[9] G.Uma Devi, P.Manikandan, A.Thimotheu, S. Prabakaran, "Implementation Of Multilevel Inverter Using Sinusoidal Pulse Width Modulation Technique", ISSN: 2278 – 7798, International Journal of Science, Engineering and Technology Research (IJSETR), Volume 2, Issue 7, July 2013.

BIOGRAPHIE

Shivam B Getme - He received his Diploma in Electrical Engineering from Government Polytechnic, Nagpur in 2013 and Bachelor's degree in Electrical Engineering (E&P) from RTM Nagpur University in 2016. Presently he is pursuing his M. Tech. in Power System from VJTI, Mumbai, MH, India. He has Electrical Supervisor License received from Energy Dept., Govt. of Maharashtra in 2016 based on his technical experience of about two years. His areas of interest are Power System, Power Quality, Renewable Energy Sources.