

Power Quality Improvement Using Statcom in Ieee 30 Bus System

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Abstract:

Both electrical utility and end users of electrical power are becoming increasingly concerned about the power quality. The term Power quality has become one of the most prolific buzzwords in the power industry now-a-days. In this paper we have discussed the challenges against Power quality and the importance of Reactive Power management in this process. Importance of FACTS devices in reactive power control has been discussed. STATCOM undoubtedly has an upper hand over other FACTS devices like SVC. Load flow analysis of IEEE 30 bus system has been carried out using Newton-Raphson Method with and without STATCOM. Comparative result of Load flow analysis between with and without STATCOM have shown improvement in Power quality with the use of STATCOM in the system.

Keywords: STATCOM, FACTS Devices, SVC, VAR Generators and Power Quality.

1. Introduction

Power Generation and Transmission is a complex process, requiring the working of many components of the power system to maximize the output. One of the main components to form a major part is the reactive power in the system is heavy inductive loads. It is required to maintain the voltage to deliver the active power through the lines. Loads like motor loads and other loads require reactive power for their operation.

To improve the performance of ac power systems, we need to manage this reactive power in an efficient way and this is known as reactive power compensation. There are two aspects to the problem of reactive power compensation: load compensation and voltage support. Load compensation consists of improvement in power factor, balancing of real power drawn from the supply, better voltage regulation, etc. of large fluctuating loads. Voltage support consists of reduction of voltage fluctuation at a given terminal of the transmission line.

The development and use of Flexible AC Transmission System (FACTS) controllers in power transmission systems had led to many applications of these controllers to improve the stability of power networks. Various flexible ac transmission system (FACTS) devices, such as static synchronous compensators (STATCOMs), static synchronous series compensators (SSSCs), and unified power-flow controllers (UPFCs) are increasingly used in power systems because of their ability to stabilize power transmission systems and to improve power quality in power distribution systems. STATCOM technology is gradually employed to increase power transfer capability and provide voltage support fast acting solid state, thyristor switches of the FACTS devices are known to improve both the transient as well as dynamic performance of a power system. *STATCOM* (*Static Synchronous compensator*) is one of the most important Flexible AC transmission system (FACTS) devices because of its ability to regulate voltages in transmission lines, to improve transient stability and to compensate variable reactive power. These devices are also interesting at the distribution level, where fast compensation of large, fluctuating industrial loads (such as electric arc furnaces and rolling mills) can be achieved, substantially improving upon the performance achievable with conventional thyristor-based converters.

STATCOM is an active device, which can control voltage magnitude and, to a small extent, the phase angle in a very short time and, therefore, has the ability to improve the system damping as well as voltage profiles of the system. It has been reported that STATCOM can offer a number of performance advantages for reactive power control applications over the conventional SVC because of its greater reactive current output at depressed voltage, faster response, better control stability, lower harmonics and smaller size, etc.

Power quality is ultimately a consumer-driven issue, and the end user's point of reference takes precedence. Therefore, the following definition of a power quality is established.

The ultimate reason that we are interested in power quality is economic value. There are economic impacts on utilities, their customers, and suppliers of load equipment. The quality of power can have a direct economic impact on many industrial consumers. There has recently been a great emphasis on revitalizing industry with more automation and more modern equipment. This usually means electronically controlled, energy-efficient equipment that is often much more sensitive to deviations in the supply voltage than were its electromechanical predecessors.

2. FACTS Device

2.1 IEEE Definition

It is a Power Electronic based system and other static equipment that provide control of one or more transmission system parameters to enhance control ability and to increase Power transfer capability.

Uses of FACTS Devices

1. To enhance the control ability of the transmission Network.
2. To increase the power transfer capability of transmission Network.

Opportunities of FACTS

1. FACTS technologies opens up new opportunities for controlling power and enhancing the usable capacity of present as well as new and upgraded transmission lines .
2. FACTS controller controls the inter-related parameter that governs the operation of transmission lines including series impedance, Shunt impedance, current, voltage, Phase angle etc.
3. FACTS technologies also leads to extending usable transmission limits in step by step manner with incremental investment as and when required .

Flexible AC transmission system or FACTS devices used are:

1) VAR generators.

- a) Fixed or mechanically switched capacitors.
- b) Synchronous condensers.
- c) Thyristorized VAR compensators.
 - (i) Thyristors switched capacitors (TSCs).
 - (ii) Thyristor controlled reactor (TCRs).
 - (iii) Combined TSC and TCR.
 - (iv) Thyristor controlled series capacitor (TCSC).

2) Self Commutated VAR compensators.

- a) Static synchronous compensators (STATCOMs).
- b) Static synchronous series compensators (SSSCs).
- c) Unified power flow controllers (UPFCs).
- d) Dynamic voltage restorers (DVRs).

Need for Reactive Power Compensation

The main reason for reactive power compensation in a system is:

- 1) the voltage regulation;
- 2) increased system stability;
- 3) better utilization of machines connected to the system;

- 4) reducing losses associated with the system; and
- 5) to prevent voltage collapse as well as voltage sag.

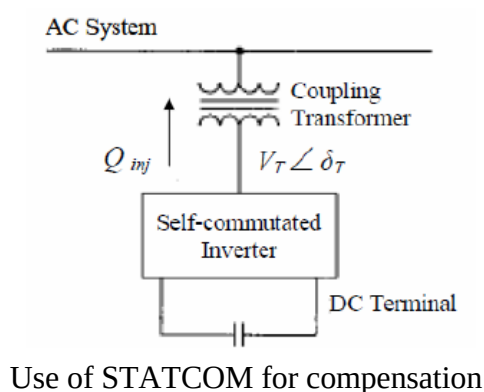
Benefits of FACTS Controller

1. It increases the loading capability of the lines to their thermal capabilities.
2. It provides secured tie-line connections to the neighbouring utilities.
3. It provides greater flexibility in setting new generations.
4. It helps in upgrading the transmission network.
5. It increases the utility of lowest cost generation.
6. It reduces Reactive Power flow thus allowing the lines to carry more active Power.

STATCOM

One of the many devices under the FACTS family, a STATCOM is a regulating device which can be used to regulate the flow of reactive power in the system independent of other system parameters. STATCOM has no long term energy support on the dc side and it cannot exchange real power with the ac system. In the transmission systems, STATCOMs primarily handle only fundamental reactive power exchange and provide voltage support to buses by modulating bus voltages during dynamic disturbances in order to provide better transient characteristics, improve the transient stability margins and to damp out the system oscillations due to these disturbances.

A STATCOM consists of a three phase inverter (generally a PWM inverter) using SCRs, MOSFETs or IGBTs, a D.C capacitor which provides the D.C voltage for the inverter, a link reactor which links the inverter output to the a.c supply side, filter components to filter out the high frequency components due to the PWM inverter. From the d.c. side capacitor, a three phase voltage is generated by the inverter. This is synchronized with the a.c supply. The link inductor links this voltage to the a.c supply side. This is the basic principle of operation of STATCOM.



Use of STATCOM for compensation

Comparison between SVC and STATCOM

1. The STATCOM is essentially an alternating voltage source behind a coupling Reactance whereas SVC is composed of thyristor switched capacitors and reactors.
2. The ability of STATCOM to maintain full capacitive output current at low system voltage makes it more efficient than SVC in improving the transient stability.
3. Attainable response time and band width of the closed voltage regulation loop of STATCOM are significantly better than that of SVC.
4. STATCOM can store more energy and hence have high capability to exchange real power as compared to SVC.
5. STATCOM can operate better in unbalanced AC System
6. STATCOM not only controls but also internally generate the Reactive output Power(both Inductive and Reactive) which results in significant reduction of overall size.

Problem Formulation and Programming

STATCOM is a voltage source inverter based FACTS controller and also Shunt connected Reactive Compensation equipment, which is capable of generating or absorbing Reactive Power. The STATCOM provides operating characteristics similar to a Rotating synchronous compensator without the mechanical inertia.

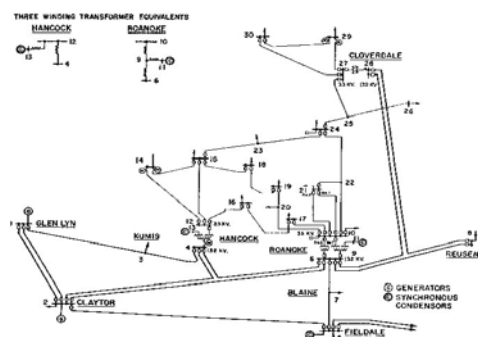


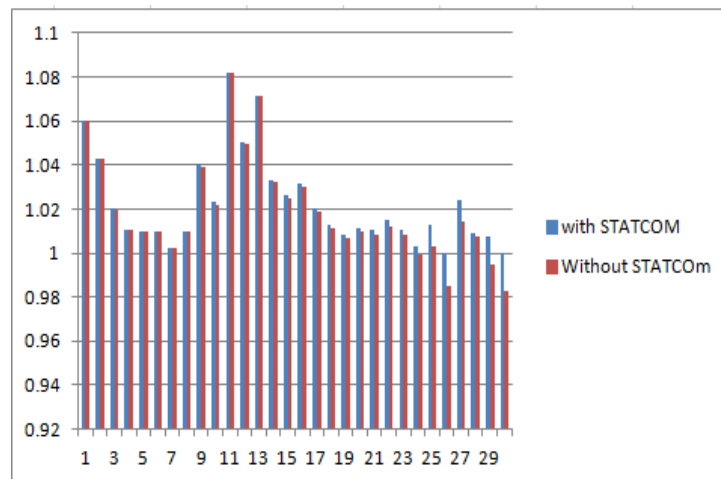
Diagram of the IEEE 30- bus test system

The 30 Bus system above describes a transmission line network. The load data, Voltage magnitudes, generation schedule and the Reactive Power limits for the busses are tabulated in the appendix.

Bus 1 with the voltage specified is taken as the slack bus, and accounts for all losses associated with the transmission line as well as generators. All the resistances, reactances, susceptances and other parameters are calculated on the bases of 100. The 30 bus Data and line data is used as IEEE Standard 30 Bus data. MATLAB programming is done for calculating Y Bus matrix. Newton- Raphson Method programming is performed using MATLAB for load flow analysis and results are

obtained..Now STATCOM is used in the systems and again MATLAB programming is done using Newton-Raphson Method for load flow analysis.

3. Graphical Comparision between the Results of Voltage Profile in A 30 Bus System with and Without Statcom



* Y AXIS : V (PU)

* x axis : the bus number

4. Conclusion

Reactive power compensation is performed using a STATCOM. A Power flow model of the STATCOM is attempted and it is seen that the modified load flow equation helps the system to perform better. The results have shown clearly the improvement in POWER QUALITY like Voltage profile using STATCOM on a IEEE 30 Bus system.

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