# A Review on Reactive Power Control in Transmission Line Using Various Methods

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***Abstract* - The increasing power requirement has led to the wide expansion and development of power system nowadays. The reason behind this technological improvement is the inadequate energy sources that impose limitations on power generation. Moreover many companies are forced to make use of the already present resources which increases load on the transmission lines. This leads to the poor stability and voltage-regulation. These problems have made the power system planners to enhance the power system performance for bulk power transfer. To improve the performance of ac power systems, the reactive power is managed in an efficient way and this is known as reactive power compensation. This has led to the use of power electronic devices of which FACTS is gaining more interest today. The Static VAR Compensation is one of the FACTS device, that can be used for the reactive power control. Also, static synchronous compensator plays a very important role in control of voltage in AC Transmission Systems. Out of different FACT devices, UPFC is the one which is gaining much popularity these days. The most important feature of UPFC is that it has the ability to provide series compensation, shunt compensation, phase angle control altogether.**

***Keywords* - reactive power, transmission line, FACTS.**

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## I. INTRODUCTION

Power system is the interconnection of more than one control areas through tie lines. For maintaining the frequency and relative power angles for both dynamic and static conditions, the generator in a control area vary their speed. In an interconnected power system, if the loads occur in a control area then there will be frequency deviation as well as tie line power deviation. If there is a sudden change in load in a single area power system operating at set value of frequency then it creates inequality in power both for generation and demand. Power system is a system of electrical component which is normally used to transfer, supply and utilize electrical power. Power system generally divided into three parts i.e. the generation system, transmission system and distribution system. Generation system is a system which supplies the power; a generator is a device which converts mechanical energy into electrical energy. In electrical power system, the transmission system is a system that transmits the power from the generating station to the load centers. Power generated at the generating station is in low voltage level and it has some economical values. Low voltage power generation is more efficient than the high voltage power generation. In low voltage level, the insulation is less in the alternator and it reduces the cost and size of the alternator. The power cannot be transmitted directly to the consumer end at low voltage level power transmission and it is not at all economical. Therefore the low voltage electrical power transmission is not economical but the low voltage power generation is economical. Electrical power system is directly proportional to the product of current and voltage of the system. Electrical power transmit from one place to another, if the voltage of the power is increased then the current of this power is reduced. The voltage regulation of the power transmission line can be improved by reducing the current which will decrease $I^2R$ losses in the system. Also by decreasing the cross-sectional area of the conductor the capital involvement will be decreased.
The transmission line mainly consists of three parameters namely resistance, inductance and capacitance which are uniformly distributed throughout its entire line. Resistance and inductance form the series impedance while the capacitance takes the shunt path that introduces many complications in making calculations. Depending on capacitance, the transmission lines can be classified as short transmission line, medium transmission line and long transmission line. The two basic models that represent the transmission lines are pi-method and T-method. In an AC transmission line, the model is used at a frequency of 50-60 Hz. Transmission lines have shunt parameters i.e. leakage conductance and charging capacitance and the series parameters i.e. resistance and the inductance and they are distributed along with the entire transmission line. If the shunt capacitance is on the higher side then the nominal $\pi$ method is better. Due to the differing degree of approximation, the solution of nominal T and $\pi$ methods for a given data will not give the same result. Though nominal $\pi$ method is normally used in modeling and it also recommended. The main reason is that the T method creates a new node (bus) but the $\pi$ method does not create. It is the clear advantage in the power system studies where you have to model many lines and in the final stage there is a distribution system, the distribution system distributes the power to the nearby homes and industries.

### Transmission line compensation

The effects of shunt and series line compensation on the transmission line voltage, power transferred and losses for diverse loads can be analyzed. For calculating the series or shunt compensated transmission line load voltage, a simple model is developing.

For two different line models, the different series and shunt compensation levels are used by several voltage sensitive load models. It is noticed that the compensation level is affected by the voltage sensitivities of loads. For the selection of the shunt and series capacitor sizes, the voltage level of the transmission line is an important issue, when the load voltage dependency is used. For the class-E amplifier which is a parallel circuit a transmission-line compensation model has been proposed to maximize the actual frequency. The theory formulas are derived to determine the values of the required circuit elements. A class-E PA using the developed theory has been planned. The results demonstrate the soundness of the projected network, when contrasted with the already present literature.

## II. RELATED WORK:

### Reactive power compensation

Reactive Power can be stated as the amount of "unused" power that is developed by reactive components, such as inductors or capacitors in an AC circuits. For improving the performance of a ac power system, the reactive is to be managed in a efficient way, 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 comprises of the improvement of power factor, balancing of the real power drawn from the supply, better voltage regulation, etc. of large fluctuating loads. Voltage support consists of reduction in voltage fluctuation at a given terminal of the transmission line. There are two types of compensation that can be used: series and shunt compensation. These modified the parameters of the system to give improved VAR compensation. These quite suitably do the job of absorbing or generating reactive power with a faster time response and which come under Flexible AC Transmission Systems (FACTS). This will allow to increase the transfer of apparent power through a transmission line, and much better stability by the adjustment of parameters that govern the power system i.e. current, voltage, phase angle, frequency and impedance. In order to control the power flow in the system, it is necessary to control the reactive power in the transmission line. There are many different FACTs devices that are used to compensate the reactive power in transmission line. The Various FACTs methods are Static Var Compensator (SVC), Static Synchronous Series Compensator (SSSC), Static Synchronous Compensator (STATCOM)and Unified Power Flow Controller (UPFC) etc., bus voltages, phase angles and line impedances in the power system can be regulated rapidly and flexibly. Hence, FACTS devices can develop the power transfer capability, facilitate the power flow control, reduces the generation cost and improve the stability and security of the system.

Static Synchronous Series Compensator (SSSC) is a FACT device which is connected in series with the power system. It operates as a controllable series inductor and series capacitor. One of the main features of SSSC is that its injected voltage is managed separately and is not in any case related to the intensity of line. This allows SSSC to work suitably with the lower loads as well as higher loads. The UPFC is associated with FACTS devices which has striking features. It has the ability to manage the entire the parameters that affect the flow of power in the transmission line. It is considered as the most refined power flow control technique. It comprises of a series and a shunt converter connected by a dc link capacitor, that can all together complete the role of transmission line real/reactive power flow control. The UPFC bus voltage and shunt reactive power is controlled by shunt converter. While the transmission line real and active power is controlled by series converter by injecting a series voltage of changeable magnitude and phase angle. The parallel part which is a STATCOM injects a sinusoidal current of variable magnitude. Static Var Compensator is a part of FACTs device which regulates the voltage, harmonics, power factor and stabilizing the system. SVC is a automatic impedance matching machine which is used to designed to take the system closer to unity power factor. There are two main situations where SVCs are used, when connected to the power system for regulating the transmission voltage and when connected close to the large industrial loads for the improve of power quality. SVC use thyristors controlled reactor to lowers the voltage and consume reactive power from the system in case of capacitive (leading). In inductive case (lagging) , capacitors bank are automatically switch in and provide a higher voltage. The result is constantly variable leading or lagging by connecting the thyristor-controlled reactor along with the capacitor bank.
A Static Synchronous Compensator (STATCOM) is a modifiable device which is used on alternating current transmission network. It works as a source or sink of reactive AC power. STATCOM is also called as static synchronous condenser (STATCON). It based on the voltage source converter. There is a new approach in which solid-state synchronous voltage sources are engaged for the actual time control of power transfer in transmission systems and the dynamic compensation. The accomplishment of the synchronous voltage source is made possible by a multi-pulse inverter with gate turn-off thyristors [1]. With this it generates the reactive power that is essential for network compensation, and also interfaces with a suitable energy storage device to settle real power trade with the ac system. This creates a widespread management of power flow control for series compensation, shunt compensation, and phase angle control [1]. To improve the system safety Flexible AC Transmission Systems (FACTS) devices are being used to control the Power Flow device which provides the chance to control voltages and power flows [2]. Since the previous years static synchronous compensator plays an important role in regulation of voltage within AC Transmission Systems. In the three phase A.C. transmission lines , a analysis of voltage irregulation problem frequently occurs and its solution by taking forward, development of a voltage regulation system using a FACTS device static synchronous compensator (STATCOM) have been discussed[2].

To create the transmission system flexible and independent in operation, FACTS devices are used to increase the transmission capability [3]. In transmission system the stability and the loading capability of the system can be improved by its thermal limit. Shunt connected FACTS devices can be used to smooth control of reactive power. Shunt connected FACTS devices i.e. Static VAR Compensator (SVC) is used in the reactive power compensation [3]. To attain smooth, better and adaptive control of reactive power in transmission systems, the simulation and design of the fuzzy logic control can vary the firing angle of the SVC [3]. The UPFC is used to improve the power transfer capacity through the transmission line. Due to the presence of the UPFC the improvement of bus voltage along with the decrease of power losses is also planned. The fuzzy logic has been use to develop the series and shunt controllers of UPFC. Also SPWM method is used to produce the switching signals for the switches of the converter [4]. In power system, transmission line is the main part. Fault occurs in the line not only on the area fed by them but also the neighboring area due to outages of power. The safety of the line is very important. The protection scheme requires changes for the protection of the transmission line. Nowadays controlled and uncontrolled series compensation are used to transfer the maximum amount of the power. Moreover a new technique for transmission line analysis which is based on half cycle post fault three- phase current data is used. This technique is equipped with thyristors controlled series compensator for the series compensation of transmission line[5]. STATCOM play an important role for reactive power compensation in transmission and generation, when the reactive power compensation take place at distribution side for different load condition. STATCOM decreases the harmonics, improves the power factor also minimize the reactive power loss. With the help of STATCOM, the variation of voltage in the transmission line is also minimized. To minimize the reactive power loss a reference voltage is produced having sinusoidal PWM pulse by using PI controller [6]. The reliability model has been used to analyses the effect of series and parallel compensation on reliability of transmission line. It has been seen that the reliability level of the transmission line can be increased by both series and parallel compensation technique. Also it is found that series compensation is more effective than shunt compensation when the lines are operated for heavy duty service [7].

**Control algorithm for reactive power**

Optimal reactive power dispatch is a nonlinear and mixed integer optimization problem which includes both discrete and continuous control variables [8]. To find the situation of the control variables such as generator voltages, tap position of the tap changing transformer and the amount of reactive compensation devices the planned algorithm is used to optimize a certain purpose. The power transmission loss, voltage profile and voltage stability are optimized discretely. A large quantity of harmonic current still remains in source current when the active filter was started. It means that the “pure” passive filters provide inadequate performance in term of harmonic filtering. The source current becomes nearly sinusoidal when the active filters were started and the active filter will improve the filtering performance of the passive filter [9]. In both the cases, the result proves that the performance of the shunt active power filter with hybrid-fuzzy controller is better to that with conventional P-I controller. The transient response of power system network has been improved greatly and the dynamic response becomes faster by using hybrid-fuzzy controller. Nowadays for compensation of reactive power, the Fixed Capacitor-Thyristor Controlled Reactor (FCTCR) is used that is control by the neural network. The algorithm which is used to instruct the neural networks is the Back-propagation. In the lagging power-factor, the TCR gives constantly controllable reactive power. A fixed-capacitor bank is connected in shunt with the TCR, to expand the dynamic controllable range to leading power-factor. By selecting a suitable quantity of inductive/capacitive, the reactive power can compensated. The rapid and dynamic balancing of the system is possible by having a control circuit that makes use of computer based neural network rather than traditional discrete load switching. The neural network based FCTCR can give quick response to the reactive power of the system.

In long transmission line, Reactive power plays an important role in voltage stability and power transfer capability in power system. For controlling the reactive power in long transmission line, the shunt connected compensators are usually used. Under light load condition, the Thyristor controlled reactor is used for the controlling of reactive power. The reactive power in the transmission lines can be controlled by controlling the firing angle of thyristors. In the system, the thyristors control reactor introduce the harmonic current[10]. The harmonics in current can be brought within the particular limit by managing the reactive power injection. A Fuzzy Logic Controller is implemented to acquire best possible management of reactive power of the compensator to uphold voltage and harmonic in current within the prescribed limits[10]. An algorithm which optimizes the firing angle in each fuzzy sub-set is estimated for the construction of rules in Fuzzy Logic Controller. The uniqueness of the algorithm is that it uses an easy error formula for the control of the rank of the possible firing angles in each fuzzy subset. PID controllers is the simplest and the most widely used control method, but the main problem occur from tuning the PID parameters is that to meet the desired specifications for a wide range of operating conditions. For different loading conditions for the self tuning Artificial Neural Network-Proportional Integral Derivative (ANN-PID) controller is compared with the Artificial Neural Network (ANN) controller. It observed that the ANN based PID controller is faster, with less peak overshoot and settling time than the ANN controllers[11].

## III. CONCLUSION:

In this paper a widespread review of some of the important works associated with this topic has been done. This paper describes some of the techniques that have been used to compensate for the reactive power in transmission lines. It also mentions some of their results and limitations. It has been seen that lot of work has been done for the control of reactive power. Nowadays, more interest is being giving to unified power flow control because of its wide range of applications in the development of the power system. This paper provides a general analysis of all the works related to this topic that has been done in the recent past.

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