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POWER QUALITY IMPROVEMENT IN DISTRIBUTION POWER SYSTEM USING STATCOM

Mudasir Hussain Sheikh[1], Navdeep Kaur Brar[2]

[1]Student, Dept. of Electrical Engineering, Baba Banda Singh Bahadur Engineering College, Fatehgarh Sahib, India
[2]Professor, Dept. of Electrical Engineering, Baba Banda Singh Bahadur Engineering College, Fatehgarh Sahib, India

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Abstract - *Power demand has increased very large while an expansion of power generation, transmission has several limits due to its cost considerations and limited resources and environmental issues. An electrical distribution system's aim is to supply quality power to its consumers. Power quality involves voltage, frequency, and waveform. The power flow should have a purely sinusoidal waveform and it should remain within specified voltage and frequency. If any of them distorted there will be a huge problem in system operation. Good power quality saves money and energy. In this paper investigates the enhancement in power quality and power factor improvement in the power system with the help of Static synchronous Compensator (STATCOM). A simple single-phase distribution system is modeled in MATLAB/SIMULINK environment. In this, the load flow is first obtained under the uncompensated system and the voltage, current, power factor and power quality are studied. Then the same system is compensated and the results are compared with the results of the uncompensated system to show the enhancement in power quality.*

Key Words*: POWER QUALITY, FACTS, STATCOM, POWER FACTOR IMPROVEMENT, *REACTIVE POWER.

1. INTRODUCTION

Modern power systems consist of large, complex interconnected and involve several numbers of buses, generators, transformers, transmission line and different types of load such as linear – nonlinear and dynamic loads. Power systems are much more loaded than before. This causes power systems to be operated near to stability limits. Electrical energy is the beating heart of industries, commerce, and development, maintaining a quality status in the flow of electricity is vital. Any power problem manifested in voltage, current or frequency deviations the result in failure and malfunction of customer equipment. Therefore, it is very difficult to frame a new generation plant and transmission system due to expensive and take a considerable amount of time and also the environment and energy problem.

Voltage collapse occurs in the power system when system is heavily loaded or faulted, and there is an increase in the demand for reactive power. Voltage instability is the primary cause of system voltage collapse. Voltage collapse occurs when system voltage decays to a level from where it is unable to recover. The consequences of voltage collapse are partial or full power interruption in the system. One of the main causes of voltage instability in a system is the reactive power imbalance in the system. Reactive power imbalance occurs when there is a sudden increase or decrease in reactive power demand, the only way to prevent from the occurrence of voltage collapse is either to reduce the reactive power load or to provide the system with additional reactive power supply before the system reaches the point of voltage collapse. This can be done by introducing sources of reactive power, (shunt capacitors or Flexible AC Transmission System) controllers at appropriate locations in the system.

There are various benefits of employing FACTS device: improvement of the dynamic and transient stability, voltage stability and security improvement, less active and reactive power loss, voltage and power profile improvement, increasing power flow capability through the transmission line, voltage regulation and efficiency of power system operation improvement, steady-state power flow improvement, loss minimization, line capacity and load-ability of the system improvement [1]. The Development of power electronics-based devices helps to improve transmission loss and increase the power transfer capability in the power system. Parameters like voltage, real and reactive power flow can be controlled by using these FACTS devices in the transmission line.

Flexible AC Transmission (FACT) devices are static equipment's which help not only for reactive power compensating but also control one or more AC transmission parameters. Two types of compensation can be used: series and shunt compensation. These modify the parameters of the system to give enhanced Var compensation [2].

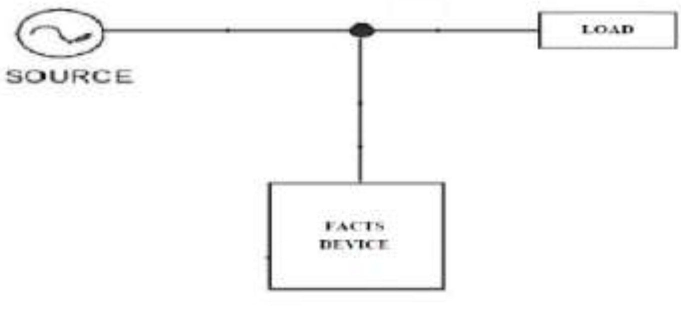

Fig 1: Block Diagram of Reactive Power Compensation Technique

Flexible AC Transmission Devices include Static synchronous compensator, Thyristor switched reactor, Static synchronous series compensator, Thyristor switched series reactor, Thyristor switched capacitor, etc. All these equipment are static instruments, so there is no dynamic effect [3]. In this paper, Static Synchronous Compensator (STATCOM), have been used to verify the performance and determine the power transfer quality.

1.1 Basic description of static synchronous compensator (STATCOM)

The static synchronous compensator (STATCOM) is a shunt connected GTO based FACTS device. It is a static synchronous generator operated as a static VAR compensator that can inject lagging or leading Var into the system. By controlling the reactive power injected into or absorbed from the power system. When system voltage is low, STATCOM generates reactive power (STATCOM capacitive). When the system voltage is high, it absorbs reactive power (STATCOM inductive). Fig 2: shows a simple diagram of STATCOM based on a voltage source converter.

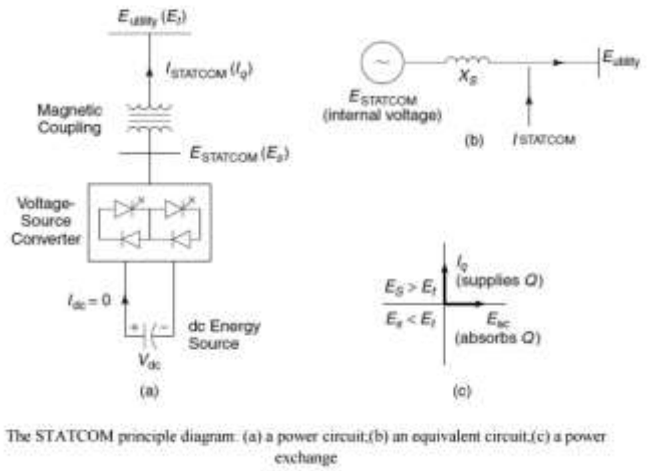

Fig 2: Static Synchronous Compensator

The voltage converter converts dc voltage to ac voltage by using power electronics devices such as GTO, Thyristors, MOSFET and the ac voltage inserted into the line through a transformer. In this, a single DC link capacitor is used for compensation. The capacitor will act as an input for an inverter. By varying the pulse width of the inverter compensation was achieved. If the output of STATCOM is more than the line voltage, the converter will supply lagging reactive power to the transmission line. If line voltage is more than STATCOM output voltage then STATCOM will absorb lagging reactive power from the system if the output voltage of converter is equal to line voltage, then the STATCOM is in floating condition and this device does not supply or absorb reactive power to the system or from the system [4]. If the load is purely resistive, then it doesn't need to worry about the reactive power. However, most of the loads are not purely resistive. It may be moreover inductive or capacitive, for this type of loads, reactive power compensation is required. Active power is producing work measured in watts (W), kilowatts (kW) for higher Megawatts (MW), and this power is also called Real power. Reactive power is not used to do work but we can't say it's useless all the motors need magnetic field and this is achieved from reactive power and is measured in Volt-Amperes-reactive (Var), (kVar) for higher (MVar).

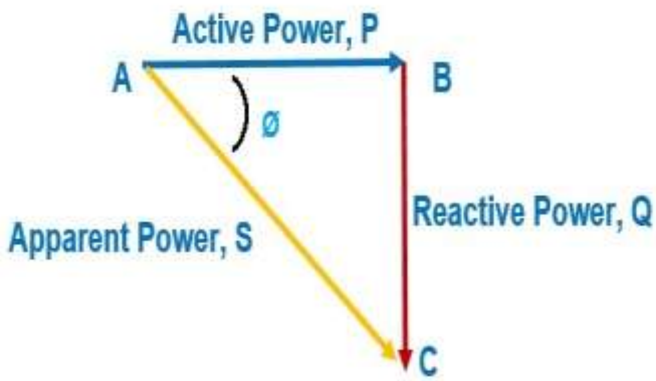

Fig 3: Power Triangle

$$S=P+jQ$$

From the power triangle, it is clearly known that compensation of reactive power decreases apparent power and it is near equals to the real power. Thus, the total consumption of apparent power is also reduced and it makes the power factor of the system near to unify, due to which it reduces the payment of bill in HT service connection (two-part tariff).

2. Objective

- The main objective of this paper is to implement STATCOM in a distribution system for increasing the flow of real and reactive power to the load and improvement in the power factor of the utility.
- In this, it is tried to show the application of STATCOM in the distribution system for compensation of reactive power.

3. System Parameters:

Grid	
Voltage	11 kV
Frequency	50 Hz
Source Resistance	0.01Ω
Source Inductance	1mH
Transmission line	
Frequency	50 Hz
R	0.01273Ω per unit length

L	0.9337mH per unit length
Length	10Km
R-L Load	
Nominal Voltage	11 kV
Nominal Frequency	50 Hz
Active Power	10MW
Reactive Power	60 MVAR

Table -1: System Parameters

4. CIRCUIT DIAGRAM

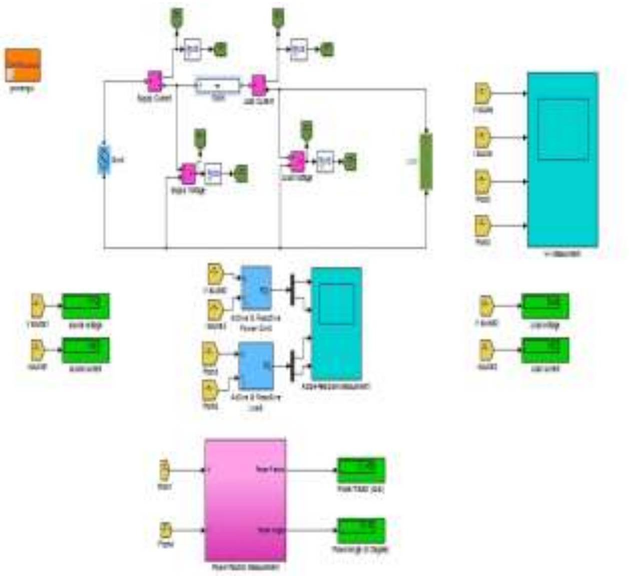

Fig 4: simulation model of single phase Load

The above diagram shows the model of an uncompensated system. The system is modeled in MATLAB/SIMULINK environment. The load is kept constant at 10 MW and 60 MVAR. In the above figure, two scopes are provided: one displays the source voltage, source current, and Load voltage, load current the other displays Active and Reactive Power at the receiving end and Sending end. The results obtained after simulation are shown below:

Table 2: Parameters before compensation

	Active Power (P in MW)	Reactive Power (Q in MVAR)	Power factor (Load)
Grid	1.137	12.252	0.145
Load	0.814	4.910	

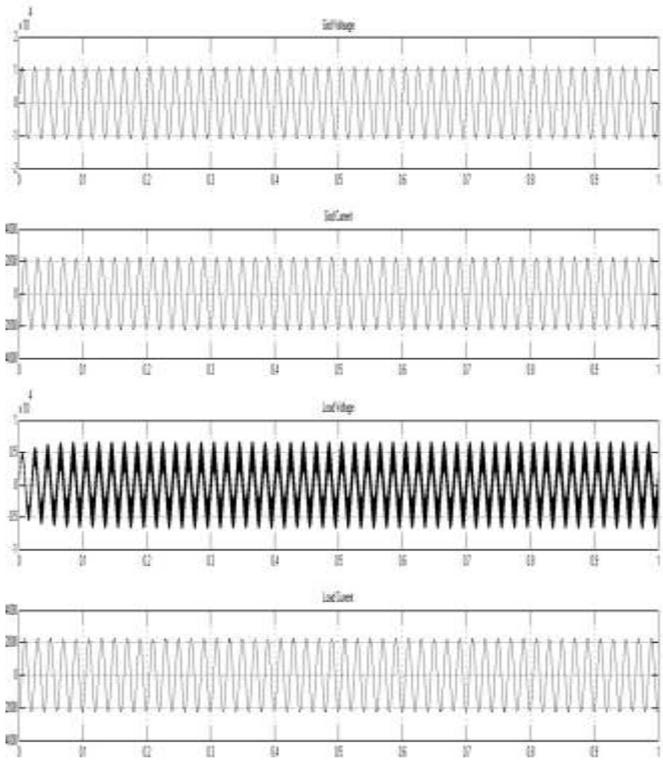

Fig5: voltage and current of source and load before compensation.

The above figure 5: shows the voltage and current of source and load before the compensation condition. It's also seen that the current and voltage are out of phase and their phase angle is 81.63 degree and the power factor is 0.1456 which is very low due to highly inductive load.

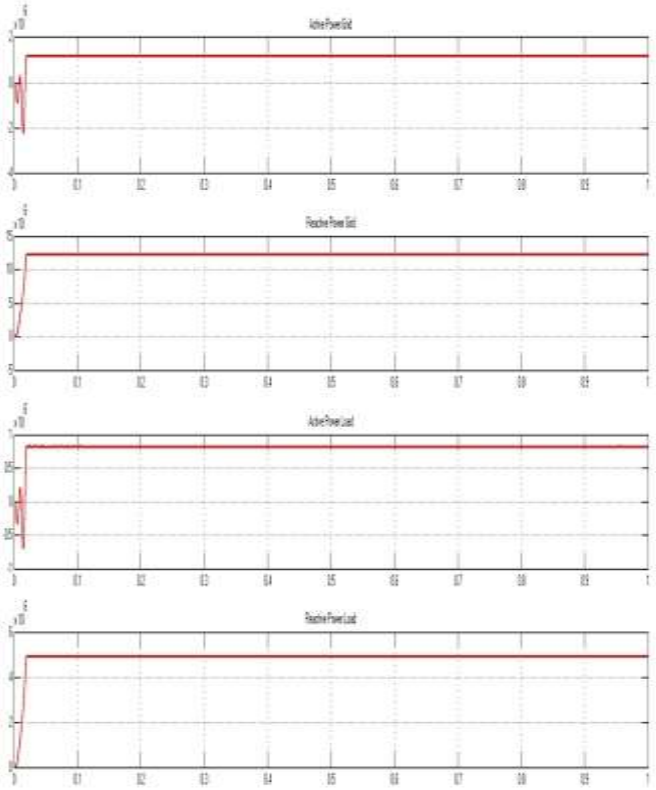

Fig 6: Real power, Reactive power of supply and load side.

The voltage stability is dependent on reactive power. So, if we can provide the reactive power to meet the demand, then we can improve the voltage profile of the system to prevent it from dipping below the margin as well we can also improve the power factor. In this paper, compensation for reactive power is carried out using STATCOM.

5. Simulink Result with STATCOM

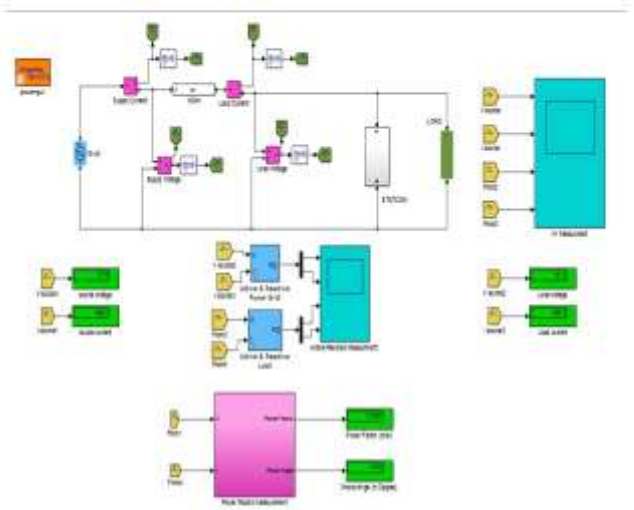

Fig 7: Simulink Model of the system using STATCOM

The simulation was done by using SIMULINK in MATLAB. A static synchronous compensator (STATCOM) is used to regulate voltage on a 11KV distribution network .Feeders (10km) transmit power to loads.

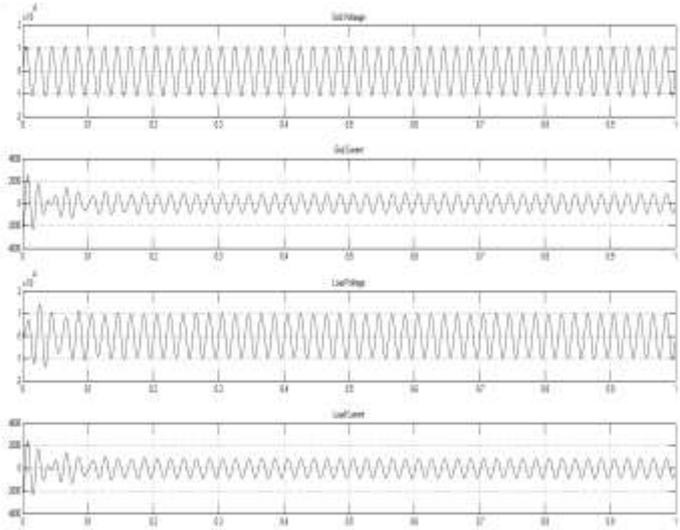

Fig 8: voltage and current wave form of the grid and load side after reactive power compensation.

In the above figure it's shown that the voltage and current are in phase the phase angle is 16.49 degree and the power factor is near to unity ie. (0.997), when the STATCOM is connected in the system.

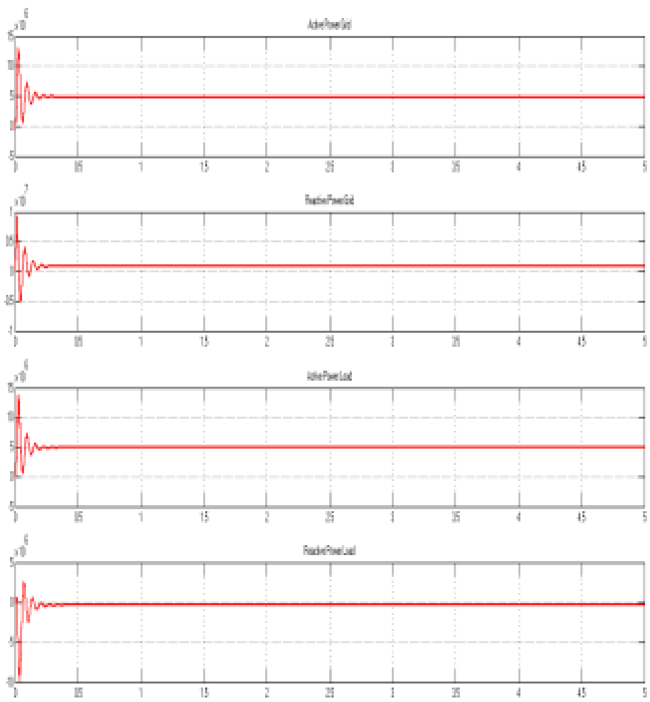

Fig 9: Real and Reactive power of grid side and load side after compensation.

It is seen from above results that with the increase in capacitance, power flow to the load is increased. The power factor at supply and grid end has also increased. Power factor at the supply end has improved due to increase in value of the capacitance. The flow of active power at supply end is increasing while the reactive power is decreasing.

SNO.	Capacitor value	Active Power Source(MW)	Reactive Power Source(MVar)	Active Power Load	Reactive Power Load(MVar)	Power Factor
1	100uF	1.185	11.93	0.882	4.960	0.175
2	200uF	1.240	11.58	0.955	5.002	0.187
3	500uF	1.464	10.37	1.233	5.051	0.237
4	1000uF	2.190	7.433	2.063	4.521	0.415
5	1200uF	2.729	5.748	2.643	3.785	0.573
6	1500uF	4.137	2.295	4.089	1.210	0.959
8	1600uF	4.887	.7933	4.835	-0.395	0.997

Table 3: Parameters after compensation with change in value of capacitor

6. CONCLUSION

In the nominal system, there are transmission losses and power flow to the load is very low. Grid is supplying power to load at a very poor power factor. Hence reactive power compensation is required for the system to improve the system profile. In this paper, the reactive power compensation for the single-phase distribution system with RL load has been implemented using a single-phase shunt connected voltage source converter [VSI]. The VSI is made to act as the STATCOM. STATCOM is providing better power quality under the variation of source voltage and when the system is suddenly loaded. The load is highly inductive nature and it required reactive power which is delivered from STATCOM, not from the source. When STATCOM is connected in the system then the grid power factor starts improving also the voltage and current profile improve as compared to without compensation as the value of a capacitor is increasing. But care has to be taken while determining the rating of the compensating devices in order to make the system stable as well as cost effective.

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