Effectiveness of Power flow by Shunt Compensation on Power Transmission

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Abstract: This paper is to develop a program to determine the required shunt compensation and after which, conduct power system analysis using simulation to evalute load voltage at fixed sending end voltage. The purpose of reactive power compensation is to change electrical characteristic of transmission line and make more compatible with load demand. The effect of change in length of transmission line on voltage profile is analyzed. This paper presents an analysis of the effect of shunt compensation level on the line voltage profile, transfered power capability, power factor and transmission losses. For this purpose simple model is developed to calculate the shunt compensated transmission line load voltage. The model is designed and simulated using MATLAB. The results show the effectiveness of shunt compensation on power transmission. It gives basic mechanism of shunt compensation, also highlight its benefits for power system.

Key words: Shunt compensation, transmission system, compensation level, voltage, power.

I. INTRODUCTION

In AC power transmission system compensation is the management of reactive power to improve the quality of power supply in power system. To increase the system reliability, stability, efficiency, cost effectiveness by means of compensation. The shunt compensator is functionally a controlled reactive current source which is connected in parallel with the transmission line to control its voltage. As the injected current are in phase quadrature with the line voltage, the shunt compensator only supplies or consumes variable reactive power. In our power system most of the load has inductive nature which adversely affect on power system. Due to inductive load voltage profile is reduced, that power system has low power factor which increase the losses and wastage of power so there is need to provide external reactive power supply. By providing shunt compensation voltage profile, power factor are increased also losses are decreased. Increase in power factor usually means the practice of generating reactive power as close as possible to load which requires it rather than supplying it in a remote station. Compensation means the modification of the electrical characteristics of a transmission line in order to increase its power transmission capacity while satisfying the fundamental requirements for transmission. Compensation system ideally performs following functions:-

1. It helps to produce a substantially flat voltage profile at all levels of power transmission.

2. It improves stability by increasing the maximum transmittable power.

3. It provides an economical means for meeting the reactive power requirements of the transmission system.

In this paper two bus power system is used and analyzed for different conditions which includes line length, load, compensation level. To show the effectiveness of compensation system shown in Fig.1 has been selected.
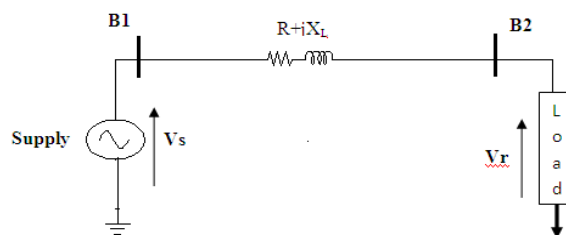

Fig.1 Two bus power system

I. BASIC MECANISM

A. Shunt compensation

In shunt compensation, capacitors are connected in parallel with the transmission line or load as shown in Fig.2 In electrical power systems, shunt capacitive compensation is widely employed to reduce the active and reactive power losses and to ensure satisfactory voltage levels during excessive reactive loading conditions.
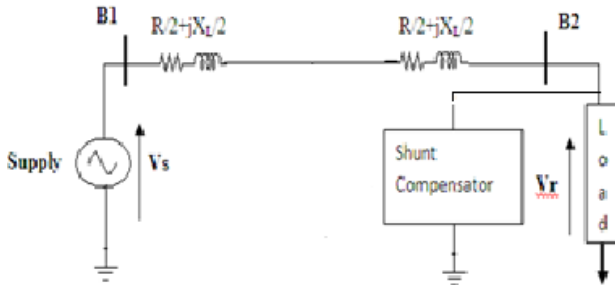

Fig.2 Shunt Compensation

The Shunt capacitive compensation devices are normally distributed throughout transmission or distribution systems so as to minimize losses and voltage drops. In the shunt compensation, a current is injected into the system at the point of connection. This can be implemented by varying shunt impedance, a voltage source, or current source. As long as the injected current is in phase with the line voltage, the shunt compensator only supplies or consumes variable reactive power. Shunt capacitor compensation or power factor correction is the most common form of compensation used in the power system. Large industrial customers are commonly required by electricity supply authorities to maintain their power factor above a specified limit. Power factor control is often achieved in this case with shunt connected power factor correction capacitors. Electricity supply authorities also use shunt connected capacitors in critical parts of their networks to control reactive power flows. With shunt compensation the line impedance is remains unchanged. The shunt capacitor increases the effective load power factor towards unity by generating reactive power for the load. The effectiveness of shunt compensation is not limited by the line inductive reactance. The ultimate limitation in shunt compensation is line resistance. In practical shunt compensation schemes the power factor may be lifted from say 0,75 lagging up to 0.9. it would be rare and generally uneconomic to provide sufficient compensation to bring the power factor up into the range 0.95 to 1.

- Advantage
    a. No inherent ferroresonance risk.
    b. Capacitor do not carry line fault current
    c. Reduced line currents.
- Disadvantage
    d. Automatic regulation is only possible with expensive control gear
    e. Switchgear and control equipment generally equipped
    f. Voltage and VAR changes in discrete steps.
    g. Inability to respond to rapid load fluctuations.
    h. Risk of over current damage from load generated harmonics

III. SHUNT CAPACITORS

The function of a shunt capacitor is to supply lagging KVAR to the system at the point where they are connected to counteract the out-of phase component of current required by an induction motor or load. The shunt capacitors can often defer or eliminate investments in feeders, substation, sub transmission lines, transmission lines and generating units where overload slightly more than allowable occur. The capacitors should be operated at or near rated voltage. The shunt capacitors connected at the load end of a circuit, supplying a load of lagging power factor, may have one or more of the following reasons for the applications:

- To reduce the lagging component of the circuit current.
- To increase the voltage of the load.
- To improve voltage regulation or power factor.
- To reduce KVA demand and the cost of the power.

A. Calculation of shunt capacitor

For leading reactive VAR, the capacitors values for compensation are calculated as follows,

$$KVAR = \frac{V^2}{Xc} \qquad 1$$

$$Xc = \frac{1}{2\pi fc} \qquad 2$$

$$KVAR = 2\pi fc \times V^2 \qquad 3$$

IV. POWER SYSTEM.

Effects of reactive power flow in line network

Poor transmission efficiency**:** Losses in all power system elements from the power station generator to the utilization devices increase due to reactive power drawn by the loads, thereby reducing transmission efficiency.

*Poor voltage regulation***:**Due to the reactive power flow in the lines, the voltage drop in the lines increases due to which low voltage exists at the bus near the load and makes voltage regulation poor.

*Low power factor***:** The operating power factor reduces due to reactive power flow in transmission lines.

*Need of large sized conductor***:** The low power factor due to reactive power flow in line conductors necessitates large sized conductor to transmit same power when compared to the conductor operating at high power factor.

Increase in KVA rating of the system equipment:

The reactive power in the lines directly affects KVA rating of the system equipment carrying the reactive power and hence affects the size and cost of the equipment directly.

*Reduction in the handling capacity of all system elements***:**

Reactive component of the current prevents the full utilization of the installed capacity of all system elements and hence reduces their power transfer capability. A power system is expected to operate under both normal and abnormal conditions and under these conditions it is desired that the voltage must be controlled for system reliability, the transmission loss should be reduced and power factor should be improved. In this paper the effect of line reactive power flow on transmission efficiency, voltage regulation and power factor with and without shunt compensation techniques are analyzed and presented.

For the analysis of shunt compensation single phase system shown in Fig.1 has been selected and it is scaled down model of actual transmission line. The line has resistance 0.0048Ω/Km and inductance of 0.1 mH/Km. For analysis voltage profile with respect to line length, the length is varied from 0 to 400 km. To see the effect of load, static load model has been selected.

V. SIMULATION RESULTS

A. With and Without Shunt Compensation

When we considering system with and without compensation, Fig3.Shows the typical power transfer of 300 km transmission line with a lumped load at the load. When the length of transmission line is increased, voltage is goes on decreasing shown in fig. 6. Fig 4and5 shows as the powe factor with and without shunt compensation at receiving end. Load varies from light load to full load there is substantial voltage difference. It is the difference between light load and full load voltage that in many cases limits the capacity of line.Fig.7 with increase in compensation level voltage profile is increases.It is clears that as compensation increases reactive power requirement of system decreases due to that active power increases.
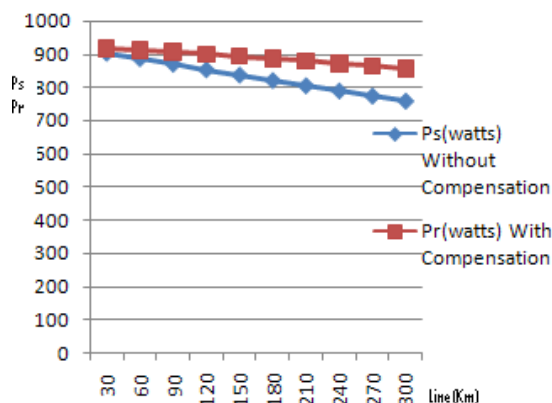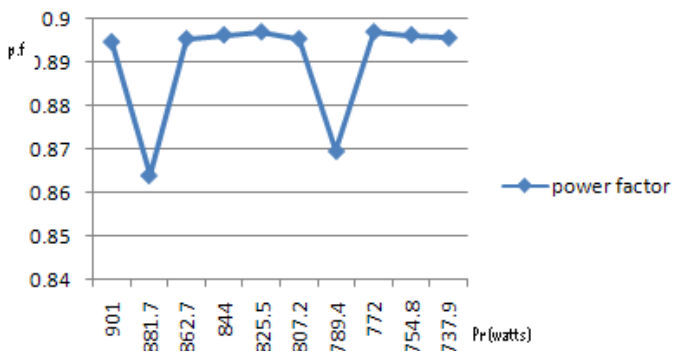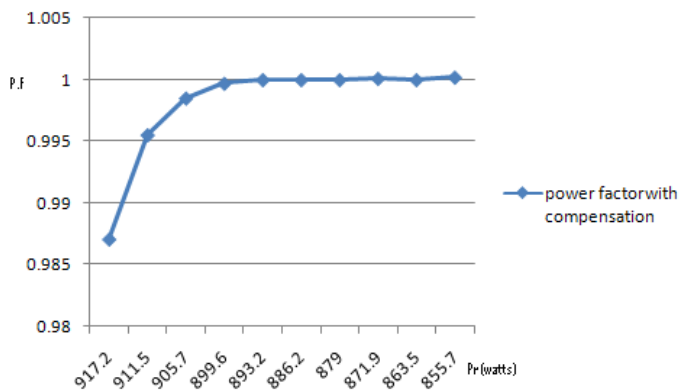
Fig.5 Power factor with compensation.

Fig.6 Effect of change in length on voltage profile

Fig.3 Effect of with and without compensation on power transfer.

Fig.7 Effect with compensation level voltage.
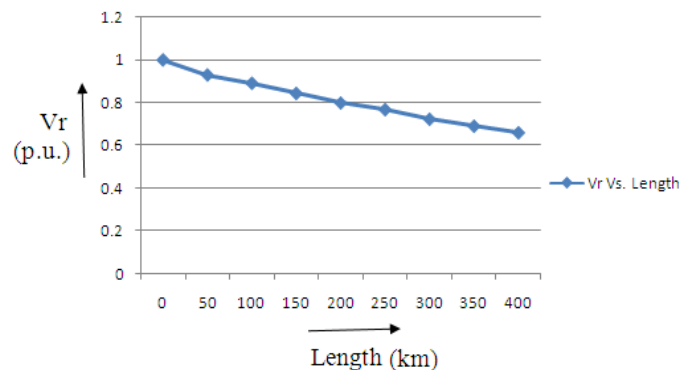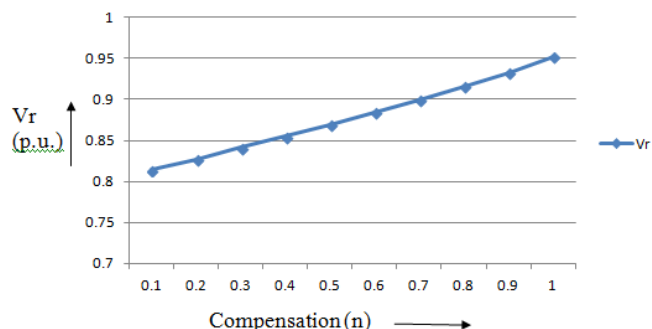
Fig.4 Power factor without compensation.

V. CONCLUSION

Shunt compensation is the effective means of improving electrical characteristics of transmission line. Voltage profile, power transmission capability, power factor, etc are enhanced due to compensation. The simulation of a two bus power system and analysis with and without shunt compensation with respect to change in length and effect of change in compensation level using MATLAB/SIMULINK has been studied.

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