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"ENHANCING THE PERFORMANCE OF LONG TRANSMISSION LINES USING SERIES COMPENSATION AND SVC"

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Abstract - In the present scenario the power system are operated near to their stability limits due to economic and environmental reasons. Nowadays a stable and secure operation of a power system is therefore a very important and challenging issue. Efficiency is very much essential transmission of voltage and stable operation of the power system is the stability has been given much attention by power system researchers and planners in recent years, and is being regards as one of the major sources of power system problems and insecurity to compensate these problems the transmission system svc is used[1]. A static VAR compensator is chosen as a low cost solution to replace a conventional capacitor bank, thus allowing a continuous and flexible nodal voltage adjustment . due to simplest structure, easy designing and low cost , PI controller is used in SVC as voltage regulator is used to regulate the voltage in most industries[2]. In this paper FACTS device SVC is used in transmission line for improving the voltage profile and stability[3].

Key Words: SVC, compensation equipments, compensator, MATLAB

1.INTRODUCTION

The use of series capacitors in long distance EHV Transmission has become very common, since it offers an effective and economical means of improving stability limits and the transmission lines are capable of carrying large blocks of power over long distances. [4]They are also highly valuable in other respects such as voltage regulation reactive power balance, load distribution etc. while the shunt reactors improve the voltage control, facilitate line energization and reduce temporary and transient over voltages[5].

Due to practical and economical reasons, the compensating elements are located at few points along the line instead of being distributed over the entire length of the line. Location, circuit schematic of series capacitor and shunt reactor stations are the deciding factors for maximum power transfer capability, voltage control conditions and efficiency of power transmission of the compensated transmission system[6].

Due to above considerations, in the present work various symmetrical schemes of series and shunt compensation are considered for investigation. The analytical expressions for maximum receiving end power for various schemes are derived in terms of capacitive reactance used, sending end and receiving end voltages and generalized line constants. The optimum value of compensation for each scheme has been determined[7]

In the present study, an analytical approach is presented for comparative study of series and shunt compensation schemes of long EHV transmission lines based on maximum power transfer capability without and within voltage stability limit[8].

2.COMPENSATION EQUIPMENTS

The long distance EHV transmissions system requires the uses of series capacitors and shut rectors in addition to circuit breakers, isolators CTs PTs and other usual equipment[9]. The purpose of these equipments is to artificially reduce the transfer impedance and the shunt susceptance of the shunt susceptance of the lines so as to improve system stability and stability and voltage control, increase the efficiency of transmission, facilitate line energization and reduce temporary and transient over voltage. It follows that at times of peak loads; the VARS demanded by the loads greatly exceed the VARs which can be transmitted over the lines from the consideration of voltages drop[10]. Therefore additional equipment of the consumers. If this in not done the system voltage at some of the buses is likely to become lower than the nominal voltage . The shunt capacitance of the line absorbs the leading VARs produced by the lines are much larger than that required by the consumers loads .

An application of compensation equipment in a system has the following effects.

1. Reduction in reactive component of circuit current.
2. Maintenance of voltage component of circuit current.
3. Improvement in power factor of generators.
4. Reduction in KVA demand charges for larges consumers.

Long EVH transmission lines need intermediate switching substations to enable installation of series capacitors and shut reactors[11]

SERIES COMPENSATORS

(a) PASSIVE SERIES COMPENSATOR

The series capacitors, used for line length compensation, when connected with the line reduces the inductive reactance of the transmissions line thereby reducing the voltages drop by an inductive load. This increase the maximum power transfer capability one drawback of series capacitor is the high voltage produced across a long transmission line These static series compensators are variable series compensators, highly effective in maximum power transfer capability voltage stability.

(b) ACTIVE SERIES COMPENSATORS

Active series compensators are static series compensators and have no rotating sectioning[12]. Static series compensators are of following types:

A. VARIABLE IMPEDANCE TYPE SERIES COMPENSATORS

I. GTO Thyristor-controlled series capacitor (GCSC)

It was first proposed by Karady etnl in 1992. It consist of a fixed capacitor in parallel with a GTO thyristor (or equivalent) value (or switch) that has the capacity to turn off upon command. This compensator scheme is the perfect combination of the TCR having the unique capability of directly varying the capacitor voltage by delay angle M control. Apart from the theoretical interest, the technique has some operational merits and it may be incorporated into some series compensator schemes in the futures, when larger GTO thyristor become available.

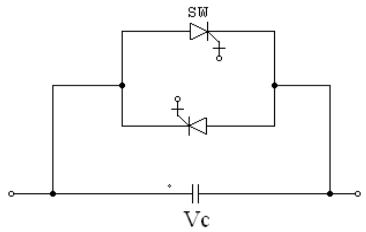

Fig 1: GTO Thyristor-controlled series capacitor (GCSC)

II. Thyristor- switched series capacitor (TSSC)

It consist of a number of capacitors, each shunted by an approximately rated bypass value composed of a string of a reverse parallel connected thyristors, in series. The basic circuit of TSSC is similar to the sequentially operated GCSC but its operation is different due to the imposed switching restrictions of the conventional thyristor value . TCSC can be applied for power flow control and for damping power oscillation where the required speed is moderate

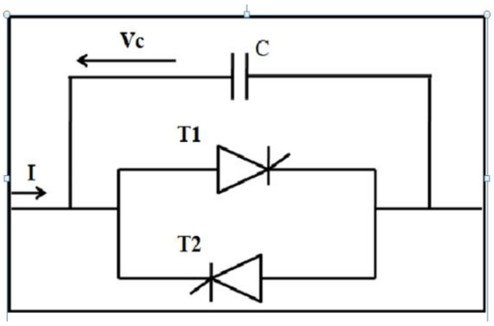

Fig 2: Thyristor- switched series capacitor (TSSC)

III Thyristor controlled series capacitor (TCSC)

The basic scheme was proposed in 1986 by Vithayathil etal as a method of "rapid adjustment of network impedance ". It consists of the series compensating capacitor shunted by a thyristor controlled reactor. In a practical implantation several such basic operating characteristics The TCSC presents a tunable parallel LC circuit to the line current that is substantially a constant alternating current source. In the TCSC scheme , the TCR is connected in shunt with a capacitor, Instead of a fixed voltage source.

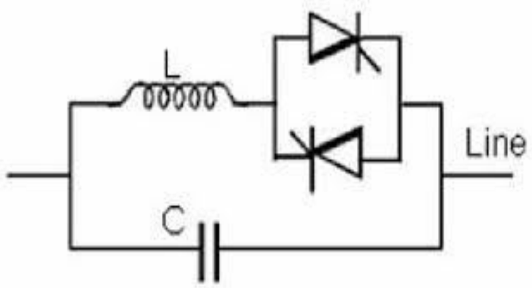

Fig 3 :Thyristor controlled series capacitor (TCSC)

B. SWITCHING CONVERTER TYPE COMPENSATORS

A voltage sourced convert with its internal control can be considered as a synchronous voltage source (SVC) analogous to an ideal electromagnetic generator which can

- Produce a set of (three) alternating sinusoidal voltages at the desired fundamental frequency with controllable amplitude and phase angle
- Generate, or absorb, reactive power
- Exchange real (active) power with the ac system when its de terminals are connected to a suitable electric dc energy source of storage. Thus, the SVC can be operated
- With a relatively small dc storage capacitor in a self-sufficient manner, like a static VAR generator to exchange reactive power with the ac system, or
- With an external dc power supply like controllable real power

OBJECTIVE AND SCOPE OF PAPER

The objective and scope of the thesis is to study and analysis (in MATLAB) the series compensated 400kv long transmission line (without SVC) of 600 km length. Here my objective is to find the optimal location of the series compensation and expression for maximum receiving end power compensation efficiency and optimal value of series compensation to be developed in terms of the lines constants and capacitive reactance used for different schemes of series compensation. Based upon the steady state performance analysis it is to determine that the compensation scheme in which series compensation and SVC are located at the midpoint of the transmission line yields maximum compensation efficiency.

ANALYSIS OF SERIES COMPENSATION SCHEMES

In this paper a comparison criteria based upon the maximum power transfer over the long transmission line has been developed. The generalized expressions for the maximum receiving and power $P_{R(max)}$ in terms of the capacitive reactance used are developed. The optimum value of series compensation has been determined for various locations of series compensation without and with static VAR system. Also the effectiveness of series compensation has been studied by using the compensation efficiency criterion. The generalized expression for the optimum value of series compensation as well as compensation efficiency has been developed. Based upon the comparative study the midpoint location of the series compensation and SVC is recommended for a given 400KV, 600km long transmission line.

Maximum Receiving End Power The receiving end complex power in terms of generalized $A_0B_0C_0D_0$ (Appendix A) constants is given by

$$P_R = \frac{|V_S||V_R|}{B_0}\cos(\beta-\delta) - \frac{|A_0|}{B_0}|V_R|^2\cos(\beta-\alpha)$$

where $A_0 = |A_0|\angle\alpha,\ \ B_0 = |B_0|\angle\beta$

P_R will be maximum at $\delta = \beta$

such that,

$$P_R = \frac{|V_S||V_R|}{B_0} - \frac{|A_0|}{B_0}|V_R|^2\cos(\beta-\alpha)$$

In practical situations α is very small.

Therefore, neglecting α

$$P_R = \frac{|V_S||V_R|}{|B_0|} - \frac{A_0}{B_0}|V_R|^2\cos\beta$$

Substituting $|V_S| = K|V_R|$

$$P_R = \frac{|V_R|^2}{B_0}(K - |A_0|\cos\beta)$$

The generalized expressions based upon the equation are derived in terms of the series capacitive reactance (X_C) used for each case. The optimum value of series capacitive reactance $X_{C(opt)}$ is determined by:

$$\frac{dP_{R(max)}}{dXc} = 0$$

Compensation Efficiency

The compensation efficiency M_C is defined as the ratio of net reduction in transfer reactance to the series capacitive reactance (X_C) used. Thus the effective series capacitive reactance X'c (as compared to the actual value of Xc) is given by:

$$X'c = \eta c\ X_C$$

Therefore,

$$\eta c = \frac{\text{Net reduction in transfer reactance}}{\text{Series capacitive reactance used}}$$

Based upon the equation, the generalized expressions for the compensation efficiency are derived for each series and shunt compensation location

CASE 1: SERIES CAPACITOR AT THE SENDING END OF THE TRANSMISSION LINE

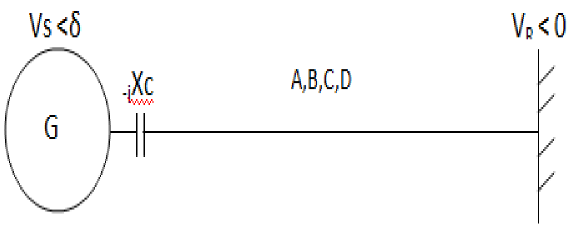

Fig 4: series compensation scheme without SVC

In this case we used a series capacitor at the sending end of the transmission line. sending end is connected to the generator and the receiving end is connected to the transmission line here we used the ABCD parameters for its calculation in this the SVC is not connected to the line. Final result is obtained by the MATLB programming calculation and at the last the plot is obtained.

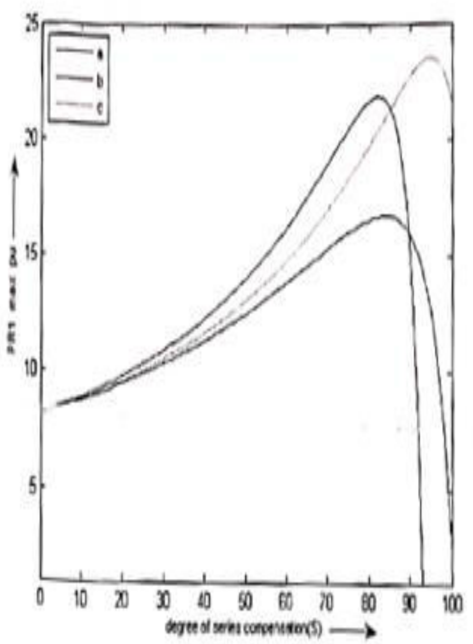

Fig 5: Variation of maximum receiving end power with degree of series compensation for case 1

CASE 2: SERIES CAPACITOR AT THE SENDING END OF THE TRANSMISSION LINE

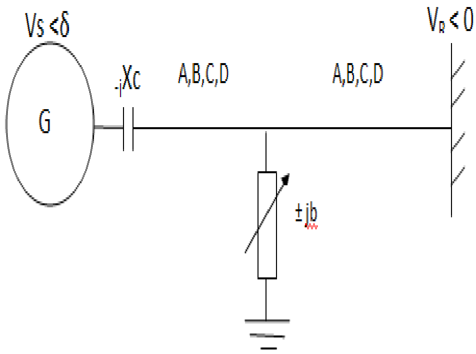

Fig 6: Scheme with series compensation at sending end and SVC at mid point

In this case, we used a series capacitor at the sending end of the transmission line. sending end is connected to the generator and the receiving end is connected to the transmission line. Here we used the ABCD parameters for its calculation in this case the SVC is connected at the mid point to the line. Final result is obtained by the MATLB programming calculation and at the last the plot is obtained.

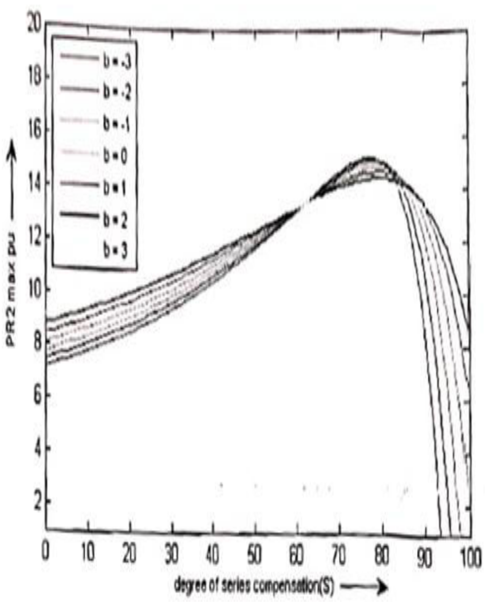

Fig 7 : Variation of maximum receiving end power with degree of series compensation for case 2

BENEFITS OF UTILIZING FACTS DEVICES

The benefits of utilizing FACTS devices in electrical transmission system are as follow:

- Better utilization of existing transmission system assets.

- Increased transmission of system reliability and availability.
- Increased dynamics and transients grid
- stability and reduction of loop flows.
- Increased quality of supply for sensitive industries.
- Environmental benefits better utilization of existing transmission.

CONCLUSION

In my paper, comparison is based upon the maximum power transfer PR(max) over the line has been developed. The generalized expressions, for $P_{R(max)}$ in terms of A,B,C,D constants and the capacitive reactance (Xc) are derived for the series compensated line. The generalized expressions for optimum value of series compensation have been derived and hence the optimum value of series compensation has been determined for various cases of series compensation. The criteria of $P_{R(max)}$ and compensation efficiency have been utilized for assessing the optimal location of series and shunt compensation.

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