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VAR Control and Reduction in Transmission Loss By Realization Of Svc And Tcsc In Power System – A Review

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Abstract :- **This project is primarily concerned with the reduction of transmission power loss in the electrical power system with the optimal reactive power flow, using the FACTS devices (i.e. Static VAR Compensator (SVC) and Thyristor Controlled Series Compensator (TCSC)).**

Covered the basics of the power system components, definitions, descriptions and representation of the electrical power transmission system with its components, theory & modeling of the Flexible AC transmission system (FACTS) devices (i.e. Static VAR Compensator (SVC) and Thyristor Controlled Series Capacitors (TCSC)).

This project deals with the problem formulation for reactive power control with reduction of transmission power loss and its MATLAB programming along with this it also deals with the Simulation and Results of reactive power control with reduction of transmission power loss.

Keyword: Reactive power, SVC, TCSC

I. INTRODUCTION

An Electric power is generated, transmitted and also distributed and consumed in an AC network. There are two kinds of power first is real power (watts) and reactive power (var). Real power accomplishes useful work. Reactive power is use to supports the voltages for system reliability.

To improving the Voltage profile by controlling the Reactive power control throughout the network. Reactive power flows are minimized so as to reduce system losses.

Transmission losses can be calculated based on the properties of components in the power system: resistance, reactance, capacitance, voltage, current, and power, which are routinely calculated by utility companies as a way to specify what components will be added to the systems, in order to reduce losses and improve the voltage levels.

The centralized control of voltage reactive one such control which can help to keep the system voltages within specified limits and also balance the reactive power for security and to reduced the transmission losses for the system operation efficiently.

Under steady state conditions Power flow solution is a solution of the network subjected to certain constraints under which the system operates. The power flow solution gives the nodal voltages and phase angle given a set of power injections at all buses and specified voltages. By controlling the production, absorption and flow of reactive power, Voltage regulation is achieved throughout the network. Reactive power flows are minimized so as to reduce system losses. Sources and sinks of reactive power, such as shunt capacitors, shunt reactors, rotating synchronous condensers and SVC's are used for this purpose. Thyristor Controlled series Compensators are versatile devices that controls the reactive power injection at a bus using power electronic switching components. A combination of reactors and capacitors is use as reactive source.

The power flow algorithm is proposed for reduction in transmission loss by using TCSC and SVC devices in the system. The Newton-Raphson technique. And its algorithm is used for reduced Transmission losses.

II. POWER FLOW CONTROL

The power transmission line can be represented in power system from bus "p" to"q".

The active power transmitted betweens bus p and q is given by:

$$P = \frac{Vp\,Vq}{X}\sin(\delta p - \delta q) \qquad \ldots(1)$$

The reactive power transmitted betweens bus p and q is given by:

$$Q = \frac{Vp^2}{X} - \frac{VpVq}{X}\cos(\delta p - \delta q) \qquad \ldots(2)$$

Where V_p and V_q are the voltages at the buses, (δ_p-δ_q) is the angle between the voltages and X is the line impedance.

The power flow is depend upon altering the voltages at a node, the impedance between the buses and the angle between the end voltages.

NEWTON-RAPHSON TECHNIQUE

The Newton- Raphson technique has proved most successful owing to its strong convergence characteristics. Newton-Raphson algorithm is expressed by using Jacobian matrix.

$$\begin{bmatrix}\Delta P\\ \Delta Q\end{bmatrix} = \begin{bmatrix}J1 & J2\\ J3 & J4\end{bmatrix} * \begin{bmatrix}\Delta\delta\\ \Delta V\end{bmatrix} \qquad \ldots(3)$$

Jacobian is the matrix of partial derivatives of real and reactive power with respect to the voltage magnitude and angles.

Where ΔP and ΔQ are bus active and reactive power mismatches, while δ and V are bus magnitude and angle, respectively.

III. LITERATURE REVEIW

The power generation of the system has to increase with the increase in consumer load demand, so the transmission losses of the system increases due to bulk power flow in transmission network. Transmission losses are naturally occurring losses (caused by actions internal to the power system) and consist mainly of power dissipation in electrical system components such as transmission lines, power transformers, measurement systems etc due to their internal electrical resistance. The transmission losses are calculated in terms of bus voltages, associated angles and line parameters. It is not possible to achieve zero losses in a power system, but it is possible to keep them at minimum. It can observe that, losses are becoming higher when the system is heavily loaded and transmission lines are transmitting high amount of power. The transmitted power for this case consists of active and reactive power. Necessity of reactive power supply together with active power is one of the disadvantages of the power generation, transmission and distribution with alternating current (AC). Reactive power can be leading or lagging. It is either generated or consumed in almost every component of the power system. In AC system, Impedance consists of two components, resistance and reactance. Reactance can be either inductive or capacitive, which contribute to reactive power in the circuit. In general most of the loads are inductive and they should be supplied with lagging reactive power.

In reactive power compensation, we need to release the power flow in transmission lines for partially solving of problem of losses as well as other problems like Voltage collapse, blackout etc. We can't do anything with active power flow, but we could supply the reactive power locally, where it is highly consumed in a system. In this way the loading of lines would decrease. It would decrease the losses also and, with this action the problem of voltage drops could be solved. By means of reactive power compensation transmission system losses can be reduced as shown in many papers e.g., [2]-[3]. It has also been widely known that the maximum power transfer of the transmission system can be increased by shunt reactive power compensation, typically by FACTS devices placed in between transmission lines or at the load terminals [4]. Therefore, planning of reactive power support would give benefits to the users of the transmission systems, in terms of loss reduction, among other technical benefits, such as improving steady-state and dynamic stability, improve system voltage profiles, etc., which are documented in [5]. The reactive power planning problem involves optimal allocation and sizing of reactive power sources at load centers to improve the system voltage profile and reduce losses.

The book Edited by T. J. E. Miller [6] contains perfect summary of why we must use reactive compensation. The transmission of active power requires a difference in angular phase between voltages at the sending and receiving end, whereas the transmission of reactive power requires a difference in magnitude of these same voltages (which is feasible only within very narrow limits). But why should we want to transmit reactive power anyway? Is it not just a troublesome concept, invented by the theoreticians, that is best disregarded? The answer is that reactive power is consumed not only by most of the network elements, but also by most of the consumer loads, so it must be supplied somewhere. If we can't transmit it very easily, then it ought to be generated where is needed. The reactive power compensation techniques are given in [7].In the book by N. G. Hingorani, [8] the introduction of FACTS devices and the basic concepts along with principal of working and characteristics of the FACTS devices are explained. The FACTS devices in the programming with the power flow solution using the different methods are explained by Enrique Acha [9]. The data of the proposed system is taken from the [10] and IEEE website.

IV. MODELING OF SVC

The Static VAR Compensator (SVC) is the FACTS controller connected in shunt use to regulate the voltage at a given bus by controlling its continuous variable susceptance, which is adjusted in order to achieve a specified voltage magnitude while satisfying constraint conditions. SVC wIth total susceptance model shown in Fig. A. A changing susceptance B_{svc} represents the fundamental frequency equivalent susceptance of all shunt modules making up the SVC.

The SVC Susceptance Model Representation as:

The SVC can be an adjustable reactance with reactance limitin system. The equivalent circuit shown in figure is used to derive SVC nonlinear power equation and the linearised equation required by Newton`s method.

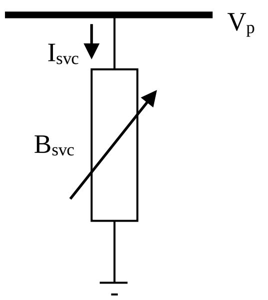

Fig A .Variable shunt SVC susceptance

Current drawn by the SVC is

$$I_{svc} = jB_{svc}\, V_p \qquad \ldots(4)$$

The reactive power drawn by the SVC, which is injected reactive power at bus *p*

$$Q_{svc} = Q_p = -V^2 B_{svc} \qquad \ldots(5)$$

The equivalent susceptance Bsvc is taken to be

$$\begin{bmatrix} \Delta Pp \\ \Delta Qp \end{bmatrix} = \begin{bmatrix} 0 & 0 \\ 0 & Qp \end{bmatrix} x \begin{bmatrix} \Delta\delta p \\ \Delta Bsvc/Bsvc \end{bmatrix} \qquad \ldots(6)$$

The variable susceptance Bsvc is updated according to

$B^{(i)}_{svc}=B^{(i-1)}_{svc} +(\Delta Bsvc/Bsvc)^{(i)} \times B^{(i-1)}_{svc}$ …(7)

The changing susceptance represents the total SVC susceptance necessary to maintain the nodal voltage magnitude .

V. MODELING OF TCSC

The TCSC is based on the concept of a variable series reactance, the value of which is adjusted automatically to constraints the power flow across the branch to specified value. The amount of reactance is determined efficiently using Newton's method. The changing X_{TCSC} is shown in fig B.

The TCSC model representation as:

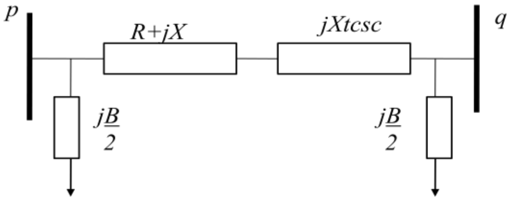

Fig B. TCSC model with series reactance

The transfer admittance matrix of the variable series compensator is given by

$$\begin{bmatrix} Ip \\ Iq \end{bmatrix} = \begin{bmatrix} jBpp & jBpq \\ jBqp & jBqq \end{bmatrix} x \begin{bmatrix} Vp \\ Vq \end{bmatrix} \quad \ldots(8)$$

For the inductive operation

$$Bpp = Bqq = -\frac{1}{Xtcsc} \quad \ldots(9a)$$

$$Bpq = Bqp = \frac{1}{Xtcsc}. \quad \ldots(9b)$$

for bus P The Active and Reactive power equation are

$$P_p=V_pV_q\,B_{pq}\sin(\delta_p-\delta_q) \quad (10a)$$

$$Q_p=-V_p^2B_{pp}-V_pV_qB_{pq}\cos(\delta_p-\delta_q) \quad (10b)$$

The series reactance ΔX_{tcsc} is the increamental change in the reactance.

$$\Delta X_{tcsc}=X^{(i)}_{tcsc} – X^{(i-1)}_{tcsc} \quad (11)$$

Updating the X_{TCSC} of the series reactance is given by

$$X^{(i)}_{tcsc} = X^{(i-1)}_{tcsc} + (\Delta X_{tcsc}/X_{tcsc})^{(i)}\, X^{(i-1)}_{tcsc} \quad \ldots(12)$$

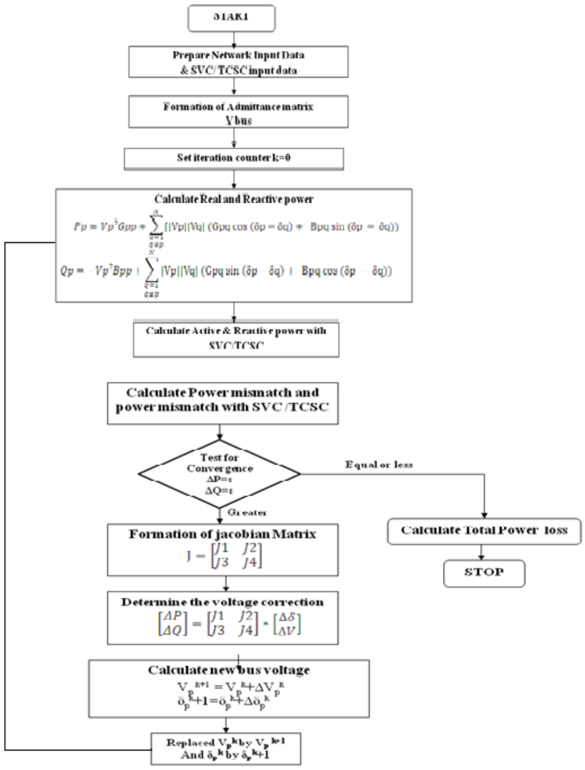

Fig C. Flow chart

VI. CONCLUSION

The VAR control and transmission loss reduction with SVC and TCSC device is applied to IEEE 9-bus and IEEE 14 bus system from the result the following conclusion can be drawn.

With realization of SVC and TCSC in the power system the total active power loss can be achieved. Thus improvement in voltage profile can be achieved using SVC and TCSC device. In the system, SVC and TCSC device is used to control the power flow and transmission loss.

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