VOLTAGE STABILITY ENHANCEMENT IN POWER SYSTEM USING SVC

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Abstract

The vital component of the power system response is voltage which is a major aspect of system steadiness and its safety. Outcome of voltage imbalance is results in monotically declining voltage. Hence, to perk up the performance of power system Flexible Alternating Current transmission system devices play a imperative role in upgrading the functioning of power system so need to be placed optimally. Up-gradation of reactive power handling capability of the system to improve system voltage by using Static Volt –ampere Compensator throughout immense disturbance is the area of study. This paper introduces weakest bus of the system which is to be find out by line stability index method where Static Volt ampere reactive compensator is to be placed optimally for increasing voltage magnitude.

Keywords: *Power flow, Static Volt-ampere reactive Compensator, IEEE 5 bus system, L-index.*

1. Introduction

Modern power system are sustaining under stressed conditions due to increasing demand of electricity. Higher demand makes the system operate closer to their operating limits. The demand for high quality and reliable supply is felt with escalation in capacity of power transmission and distribution. Because of growing necessity and boundaries on building new lines, the transmission network of present power system is becoming gradually stressed. The difficult duty is to keep stability with safe and sound operation of a power system. The focal concern is voltage imbalance. System voltage dives off to a point due to voltage breakdown that is objectionable. Deficiency of reactive power results in voltage imbalance. Flexible Alternating Current Transmission System devices abridged these difficulties.

Impedance, voltage, phase angle are the variables can be altered by means of power electronics base equipments. Flexible Alternating Current Transmission System equipments helps to curtail flow in excessively burdened lines, budding a boost in loadability, small system loss, improved steadiness of the network, minimize production cost in the network through which the power flow. Control facilities are provided in steady state and dynamic stability control. Series, shunt or a combination of series and shunt are the different ways of connecting Flexible Alternating Transmission System equipments to transmission network.

2. Static Volt Ampere Reactive Compensator (SVC)

Static Volt ampere reactive Compensator is shunt connected Flexible Alternating Current Transmission System equipment. It is to be found in parallel with a bus. Schematic representation of Static Volt ampere reactive Compensator is shown in figure.1 Switched reactor, TCR, TSC, Harmonic Filter and mechanically switched capacitor are the devices composing in Static Volt ampere reactive compensator. TCR consume Volt ampere reactive's as well as decrease the system voltage if the load is capacitive. Capacitor banks are switch on to deliver Volt ampere reactive's and increase system voltage if load is inductive. Reactive power and voltage are the two parameters which is controlled by static volt ampere reactive compensator.

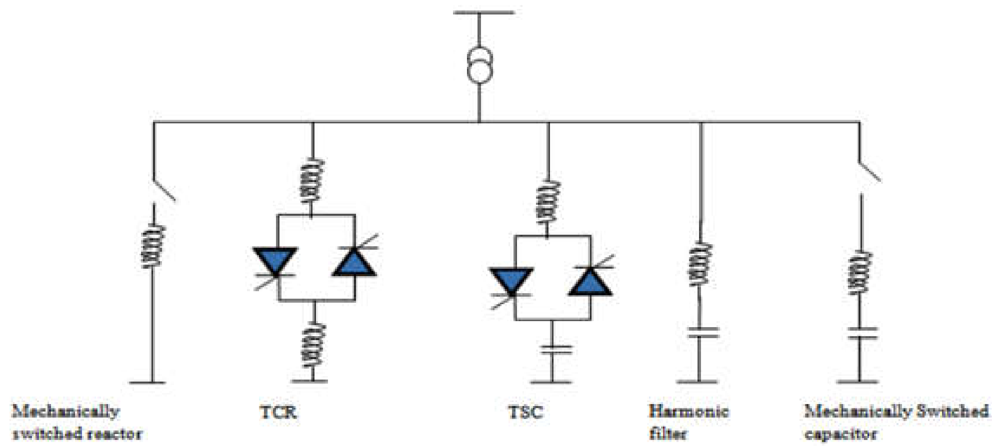

Fig:1 Static VAR Compensator

3. Modelling Of Static Volt ampere reactive Compensator

Static Volt ampere reactive Compensator can be taken with either reactance limits or firing angle limits.

By referring fig. 1, the variable shunt compensator has admittance equation is,

$I = jB_{svc}V_k$

The reactive power equation for static volt ampere reactive compensator is,

$Q_k = -V_k^2 B_{svc}$

Total susceptance Bsvc is taken as state variable for this representation. The linear equation of the Static Volt ampere compensator is written as,

$$\begin{bmatrix} \Delta Pk \\ \Delta Qk \end{bmatrix} - \begin{bmatrix} 0 & 0 \\ 0 & Qk \end{bmatrix} \begin{bmatrix} \Delta \theta K \\ \Delta Bsvc/Bsvc \end{bmatrix}$$

$$\begin{bmatrix} \Delta Pk \\ \Delta Qk \end{bmatrix}^i = \begin{bmatrix} 0 & 0 \\ 0 & Qk \end{bmatrix}^i \begin{bmatrix} \Delta \theta k \\ \Delta Bsvc / Bsvc \end{bmatrix}$$

The variable shunt susceptance Bsvc is upgraded at the end of iteration is,

$$B^{I+1}svc = B^{I+1}svc + \left[\frac{\Delta Bsvc}{Bsvc}\right]^{I} B^{I}svc$$

Maintaining nodal voltage magnitude at the specified value with the help of changing susceptance which represents total static volt ampere reactive compensator. The firing angle required to achieve compensation level as it has been resolved can be calculated as

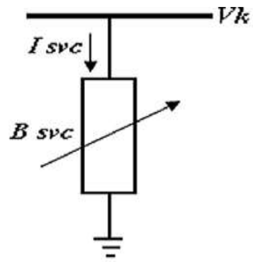

Fig.2 Variable Susceptance Model of Static Volt ampere reactive compensator

4. Voltage Sensitivity Approach

In virtue of economic consideration, identifying the best location for installing flexible alternating current transmission system device is also essential. The evaluation of optimal location of Static Volt ampere reactive Compensator can be resolved by carrying the voltage stability investigation at each bus in large complex network with static concept as well as dynamic concept. Static Volt ampere reactive Compensator of adequate rating is to be installed at bus which is more vulnerable in terms of voltage sensitivities and this study has to be iterated to find bus voltage to place Static volt ampere reactive compensator.

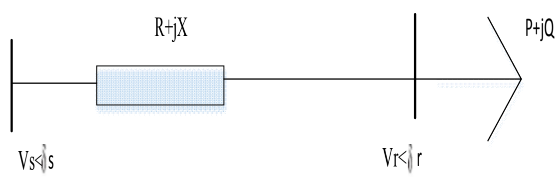

Fig.3 Single Line Diagram

Here,
Sending end voltage-Vs
Receiving end voltage-Vr.
Impedance-R+jX.
Apparent power-P+jQ

$$I = \frac{V_s < \delta_s - V_r < \delta_r}{R + jX} --(1)$$

$$P - jQ = Vr * I --(2)$$

$$P - jQ = \frac{VsVr < (\delta s - \delta r) - Vr}{R + jX} --(3)$$

$$(P - jQ)(R + jX) = VsVr < (\delta s - \delta r) - V_r^2 --(4)$$

The equation 4 has real part as,

$$VsVr * \cos(\delta s - \delta r) = V_r^2 + (RP + XQ) --(5)$$

The equation 4 has imaginary part as,

$$VsVr * \sin(\delta s - \delta r) = XP - RQ$$

Solving the above equation

$$Lmn_{p.u} = 4 * \left[\left[\frac{PX - RQ}{V_s^2} \right]^2 - \left[\frac{PX + RQ}{V_s^2} \right] \right] --(6)$$

5. Test System

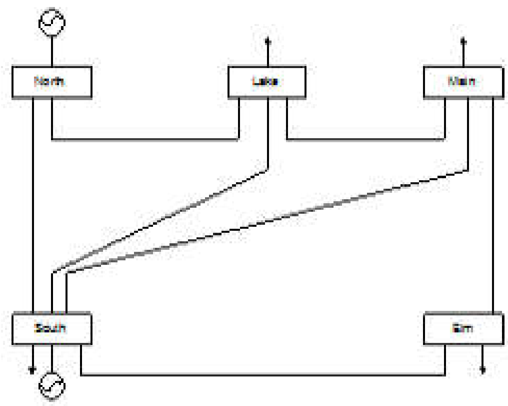

Fig.4 IEEE 5 Bus System

Where,

Reference bus is refer as Bus 1, real power bus is refer as Bus 2, load bus is refer as Bus 3, generation bus is refer as Bus 4.

Bus Data

Bus Number	Voltage Magnitude in per unit	Angle in degrees
1	1.061	0.000
2	1.000	0.000
3	1.000	0.000
4	1.000	0.000
5	1.000	0.000

Generator Data

Bus Number	Real power generation in Megawatt	Reactive power generation in Mega volt ampere reactive	Mininimum Reactive Power	Maximum Reactive Power
1	0	0	50	50
2	40	0	30	30

Load Data

Bus Number	Load	
	Real load Bus in Per Unit	Reactive load bus in Per Unit
1	000.2	000.1
2	00.45	00.15
3	000.4	00.05
4	000.6	000.1

Transmission line Data

Branch Number.	Sending end Bus	Receiving end Bus	Resistance in Per Unit	Reactance in Per Unit	Line Charging in Per Unit
1	2	2	00.02	00.06	00.06
2	3	3	00.08	00.24	00.05
3	3	3	00.06	00.18	00.04
4	4	4	00.02	00.18	00.04
5	5	5	00.04	00.12	00.03
6	4	4	00.01	00.03	00.02
7	5	5	00.08	00.24	00.05

6. L-INDEX for 5 Bus System

On the basis of power transmission theory line stability index is derived which gives the idea about system strength in an interconnected network. Line stability index is calculated for 5 bus system is as shown in Table.In this table bus 3 shows higher sensitivity factor which is the best optimal location for placing Static Volt-ampere reactive Compensator**.**

Here L = stability index.

Line Stability Index

Bus number- 1	Bus number- 2	Bus number- 3	Bus number- 4	Bus number- 5
L=0.0000	L=0.6240	L=1.620	L=0.9640	L=1.2480

7. Results

Table shows the magnitude of bus voltage with Static Volt-ampere reactive Compensator and without Static Volt- ampere reactive Compensator. Bus 3 has highest L- index where Static Volt-ampere reactive Compensator is placed to increase voltage. Prior to positioning of Static Volt-ampere reactive compensator, bus 3 is having voltage magnitude 0.9847 per unit and it will become1 per unit subsequent to positioning of Static Volt-ampere reactive compensator.

Voltage Magnitude before and after positioning of SVC

Bus Number	Before positioning of Static Volt Ampere Reactive Compensator	After positioning Static Volt Ampere Reactive Compensator
	Voltage Magnitude in Per Unit	Voltage Magnitude in Per Unit
1	1.06	1.06
2	1	1
3	0.9847	1
4	0.9815	0.9936
5	0.9688	0.9730

8. Conclusion

In this paper, simplified methodology for analyzing voltage stability problem in interconnected system is studied. Using voltage sensitivity approach line stability index is determined. The values of line stability index decides relative strength of transmission line which is useful to placed Static volt ampere reactive compensator to enrich the voltage level as well as enhance more loading capacity.

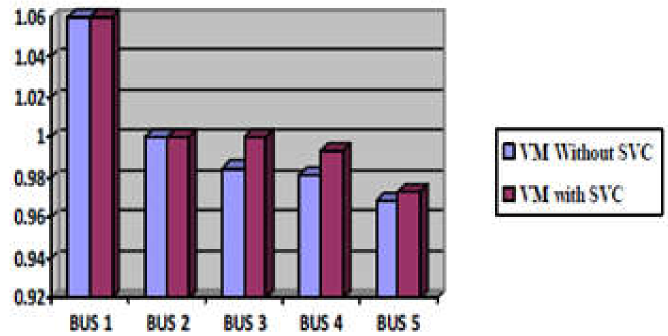

Fig.5 Voltage magnitude with SVC and without SVC

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