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The Impact of Optimal SVC Installation for Congestion Management and Voltage Profile in Electrical Power System

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Abstract: Transmission congestion must be managed, so that transmission capacity is utilized as efficiently as possible with minimal social welfare loss-usually by system operator. Congestion management must provide incentives for investments in transmission network and generation capacity in the right areas. Minimizing the risks associated with different congestion management methods are important task for every market participant who is trading between different areas. The idea for solving this problem is the use of FACTS devices, especially the use of Static Var Compensators (SVC). In this study, the study of SVC with its various modes of operation is investigated. Finally, by help of modeling of a power system in MATLAB/PSAT toolbox and by installing SVC in transmission line, its use as power flow controller and voltage injection is seen. Conclusion is made on different results to see the benefit of SVC in power system.

Key words: FACTS, power flow controller, MATLAB/PSAT toolbox, voltage control, congestion management

INTRODUCTION

In recent years with the deregulation of the electricity market, the traditional concepts and practices of power systems are changed. This led to the introduction of Flexible AC Transmission System (FACTS), such as thyristor Controlled Series Compensations (TCSC), Thyristor Controlled Phase angle Regulators (TCPR), Unified Power Flow Controllers (UPFC) and Static Var Compensator (SVC).

These devices controls the power flow in the network, reduces the flow in heavily loaded lines there by resulting in an increase loadability, low system losses, improved stability of network and reduced cost of production (Hingorani, 1993; Gotham and Heydt, 1998; Preedavichit and Srivastava, 1998; Leung and Chung, 2000). It is important to ascertain the location of these devices because of their significant costs provides an idea regarding the optimal locations of fact devices, without considering the investment cost of FACTS device and their impact on the generation cost (Cai and Erlich, 2003) later studied about the optimal location considering the generation cost of the power plants and investment cost of the devices. Baskaran and Palanisamy (2005), discussed optimal location problem by power loss reduction.

SVC is member of FACTS family that is connected in shunt with the system. Even though, the primary purpose of shunt FACTS devices are to support bus voltage by injecting (or absorbing) reactive power, they are also capable of improving the transient stability by increasing (decreasing) the power transfer capability when the machine angle increases (decreases) which is achieved by operating the shunt FACTS devices in capacitive (inductive) mode.

Previous researches on the topic prove that shunt FACTS devices give maximum benefit from their stabilized voltage support when sited at the mid-point of the transmission line. The proof of maximum increase in power transfer capability is based on the simplified model of the line neglecting line resistance and capacitance. However, for long transmission lines when the actual model of the line is considered, the results may deviate significantly from those found for the simplified model.

The primary objective of our project is to find the maximum power and the corresponding location of the shunt FACTS devices when the actual line model is considered. Based on the simplified line model, it has been proved that the centre or midpoint of a transmission line is the optimal location for shunt FACTS devices.

When the actual model of the line is considered, it is found that the FACTS device needs to be placed slightly off-centre to get the highest possible benefit.

This study deals with the location of a shunt FACTS device to improve transient stability in a long transmission line with predefined direction of real power flow. It has been, observed that the FACTS devices when placed slightly off-centre towards sending-end give better performance in improving transient stability and the location.

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There is various solution approaches for OPF available which include interior point methods. In this study, the optimal power flow problem with SVC is solved by Newton Method.

MATERIALS AND METHODS

Transmission line model: In this study, the transmission line is modeled by a two-port, 4 terminal networks as shown in Fig. 1. Transmission lines are operated with a balanced three phase load, the analysis can therefore proceed on a per phase basis. A transmission line on a per phase basis can be regarded, as a two port network where in the sending end voltage V_s and current are related to the receiving end voltage V_r and current I_r through ABCD constants as:

$$V_S = AV_R + BI_R,\ I_S = CV_R + DI_R \qquad (1)$$

The ABCD constants of a line of length l having a series impedance of z Ω km^{-1} and shunt admittance of y S km^{-1} are given by: A = D = cos h (γ l); B = Zc sin h (γ l); C = Sin h (γ l):

$$Z_C = \sqrt{\frac{z}{y}}\quad \gamma = \sqrt{zy}$$

Where:

Z_C = Characteristic impedance of the line
γ = Propagation constant of the line
z = Series impedance/unit length/phase
y = Shunt admittance/unit length/phase to neutral
l = Transmission line length
α = Attenuation constant
β = Phase constant

Power flow through a transmission line for an actual line model: The principle of power flow through a transmission line is illustrated through a single transmission line (2-node/2-bus system) (Fig. 2).

Let us consider receiving-end voltage, as a reference phasor (|Vs|∠0) and let the sending end voltage lead it by an angle δ is known as the torque angle. The complex power leaving the receiving end and entering the sending end of the transmission line can be expressed as:

$$S_r = P_r + jQ_r = V_r I_r^*,\ S_S = P_S + jQ_S = V_S I_S \qquad (2)$$

Receiving and sending end currents can be expressed in terms of receiving and sending end voltages:

$$\begin{aligned} I_r &= \left|\frac{1}{B}\right||V_S|\angle(\delta-\beta) - \left|\frac{A}{B}\right||V_r|\angle(\alpha-\beta) \\ I_S &= \left|\frac{D}{B}\right||V_S|\angle(\alpha+\delta-\beta) - \left|\frac{1}{B}\right||V_r|\angle-\beta \end{aligned} \qquad (3)$$

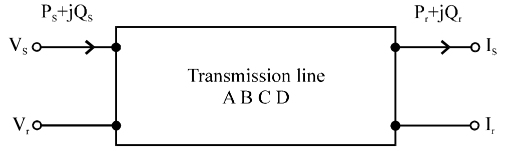

Fig. 1: Two port four terminal model of a transmission line

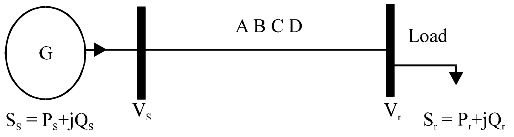

Fig. 2: A 2 bus system

Researchers can write the real and reactive powers at the receiving-end and the sending end as:

$$\begin{aligned} P_S &= C_1\cos(\beta-\alpha) - C_2\cos(\beta+\delta) \\ P_R &= C_2\cos(\beta-\delta) - C_3\cos(\beta-\alpha) \\ Q_S &= C_1\sin(\beta-\alpha) - C_2\sin(\beta+\delta) \\ Q_R &= C_2\sin(\beta-\delta) - C_3\sin(\beta+\delta) \end{aligned} \qquad (4)$$

Power flow in a transmission line with facts devices

Shunt FACTS devices in a power system: Consider that the line is transferring power from a large generating station to an infinite bus and equipped with a shunt FACTS device at point m. A parameter k is used to show the fraction of line length at which the FACTS device is placed (Fig. 3).

For a simplified model: The power transfer through the line for given values of S_E and R_E voltage magnitude is given by Eq. 8 and can be written as:

$$P = P_m \sin\delta_m \qquad (5)$$

Here, the maximum power P_m is V_S V_R/X. When a shunt FACTS device is connected to the line both P_m and δ_m are increased and their values depend on the k factor. The power transfer through the line is then given by:

$$P = \frac{V_S V_m}{kX_L}\sin\delta_S = \frac{V_R V_m}{(1-k)X_L} \qquad (6)$$

Here, the S_E power is equal to the R_E power because the line is lossless:

$$P = \frac{P_0\sin\delta_S}{k} = \frac{P_0\sin\delta_R}{1-k} \qquad (7)$$

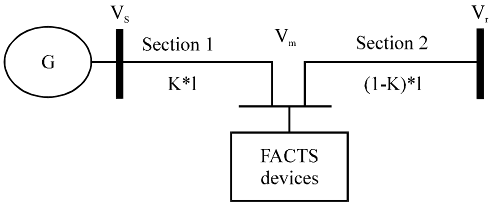

Fig. 3: Transmission line with the FACTS device

Table 1: S_E and R_E real and reactive power with the shunt FACTS devices

Section 1	Section 2
$P_S = C_1 \cos(\beta-\alpha)-C_2 \cos(\beta+\delta_S)$	$P_S = C_1 \cos(\beta-\alpha)-C_2 \cos(\beta+\delta_R)$
$Q_S = C_1 \sin(\beta-\alpha)-C_2 \sin(\beta+\delta_S)$	$Q_S = C_1 \sin(\beta-\alpha)-C_2 \sin(\beta+\delta_R)$
$P_R = C_2 \cos(\beta-\delta_S)-C_3 \cos(\beta-\alpha)$	$P_R = C_2 \cos(\beta-\delta_S)-C_3 \cos(\beta-\alpha)$
$Q_R = C_2 \sin(\beta-\delta_S)-C_3 \sin(\beta+\delta)$	$Q_R = C_2 \sin(\beta-\delta_R)-C_3 \sin(\beta+\delta)$

From Eq. 7, the value of transmission angle for a particular value of k can be given by $\boldsymbol{\delta} = \boldsymbol{\delta}_S + \boldsymbol{\delta}_R$:

$$\delta = \sin^{-1} k \frac{p}{p_0} + \sin^{-1}(1-k)\frac{p}{p_0} \tag{8}$$

For actual line model: The ABCD constants of a line of length l having a series impedance of z Ω km^{-1} and shunt admittance of y S km^{-1} with FACTS devices the active and reactive power flows at the S_E and R_E of the line can be shown in Table 1.

Mathematic model of SVC: The power-injected model is a good model for FACTS devices because it will handle them well in load flow computation problem. Since, this method will not destroy the existing impedance matrix Z, it would be easy while implementing in load flow programs. In fact, the injected power model is convenient and enough for power system with FACTS devices.

The power flows of the line connected between bus-i and bus-j having series impedance z and without any FACTS controllers can be written as (Burade and Helonde, 2010; Reddy *et al*., 2009):

$$z = r_{ij} + jx_{ij}\left(=\frac{1}{(g_{ij}+jb_{ij})}\right) \tag{9}$$

$$P_{ij} = V_i^2 g_{ij} - V_i V_j \left(g_{ij}\cos\delta_{ij} + b_{ij}\sin\delta_{ij}\right) \tag{10}$$

$$Q_{ij} = -V_i^2\left(b_{ij} + B_{sh}\right) - V_i V_j \left(g_{ij}\sin\delta_{ij} - b_{ij}\cos\delta_{ij}\right) \tag{11}$$

Where, V_i, V_j, δ_{ij} are the voltage magnitudes at bus-i and bus-j and voltage angle difference between bus-i and bus-j, where:

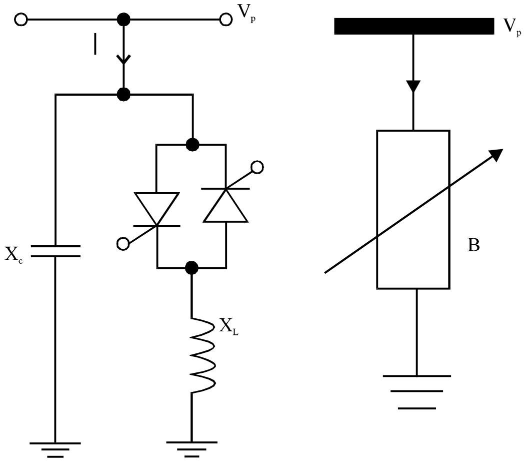

Fig. 4: SVC structure, SVC as variable shunt susceptance

$$g_{ij} = \frac{r_{ij}}{r_{ij}^2 + x_{ij}^2}, b_{ij} = \frac{-x_{ij}}{r_{ij}^2 + x_{ij}^2} \tag{12}$$

Similarly, the real power (P_{ij}) and reactive power (Q_{ij}) flows from bus-j to bus-i in the line can be written as:

$$P_{ji} = V_j^2 g_{ij} - V_i V_j \left(g_{ij}\cos\delta_{ij} - b_{ij}\sin\delta_{ij}\right) \tag{13}$$

$$Q_{ji} = -V_j^2\left(b_{ij} + B_{sh}\right) + V_i V_j \left(g_{ij}\sin\delta_{ij} + b_{ij}\cos\delta_{ij}\right) \tag{14}$$

The mathematical model of the SVC is developed mainly to perform the steady-state research. The SVC is modeled using the power injection method (Gerbex *et al*., 2001).

Static representation of SVC: The primary purpose of SVC is usually control of voltages at weak points in a network. This may be installed at midpoint of the transmission line (Fig. 4).

The SVC load flow models can be developed treating SVC susceptance as control variable. Assuming that SVC is connected at node-p to maintain the bus voltage at V_p. The reactive power injected by the controller is given by output of an SVC can be expressed as follows (Reddy *et al*., 2009):

$$Q_{PSVC} = -V_P^2 B_{PSVC} \tag{15}$$

The linearized load flow models make use of Eq. 17 to modify the corresponding Jacobian elements at SVC bus. The SVC load flow model can be developed treating SVC total susceptance as control variable (BSVC). Or the reactive power output of an SVC can be expressed as follows:

$$Q_{SVC} = V_i \frac{(V_i - V_r)}{X_{sl}} \qquad (16)$$

Where:

X_{sl} = The equivalent slope reactance in p.u. equal to the slope of voltage control characteristic

V_r = Reference voltage magnitude

The exact loss formula of a system having N number of buses is (Elgrd, 1971; Singh and David, 2001):

$$P_{ltc} = \sum_{j=1}^{N}\sum_{k=1}^{N}\left[\alpha_{jk}\left(P_jP_k + Q_jQ_k\right) + \beta_{jk}\left(Q_jP_k - P_jQ_k\right)\right] \qquad (17)$$

Where:

P_j, P_k = Real power injected at bus-j

Q_j, Q_k = Reactive power injected at bus-j

α_{jk}, β_{jk} = The loss coefficients:

$$\alpha_{jk} = \frac{R_{jk}}{V_iV_k}\cos\left(\delta_j - \delta_k\right), \beta_{jk} = \frac{R_{jk}}{V_iV_k}\sin\left(\delta_j - \delta_k\right) \qquad (18)$$

Where, R_{jk} is the real part of the j-kth element of (Z bus) matrix. The total loss if a SVC, one at a time is used can be written as follows (Singh and David, 2001):

$$P_{1k} = \left(P_{1kc} - \left[P_i(\text{com}) + P_j(\text{com})\right]\right) \qquad (19)$$

More than one device used at time can be expressed as:

$$P_{1k} = \left(P_{1kc} - \sum_{d=1}^{Nd}\left[P_i(\text{com}) + P_j(\text{com})\right]\right) \qquad (20)$$

Where, Nd is number of device is to be located at various lines.

Modeling and simulation of SVC on at wscc 9-bus system: In this study, emphasis is laid to project the use of SVC in Western System Coordinating Council (WSCC) 9-bus system shown in Fig. 5, to increase the power flow and to get better the voltage profile of the system with MATLAB/PSAT toolbox.

Model block of single line diagram: Using the concept of the control system a power system is taken to implement the application of SVC. The SVC total susceptance model is simulated in PSAT toolbox to see the effect of SVC on a power system. Investigation is carried out to verify the utility of FACT device. Figure 5 illustrates application study the steady-state and dynamic performance of a SVC used to relieve power congestion and improve power flow in a transmission system. The load flow analysis and the single line diagram simulation are done on power flow simulator. This software helps to calculate the power flow, the voltage magnitude and voltage angle at each bus and the each transmission lines of the system.

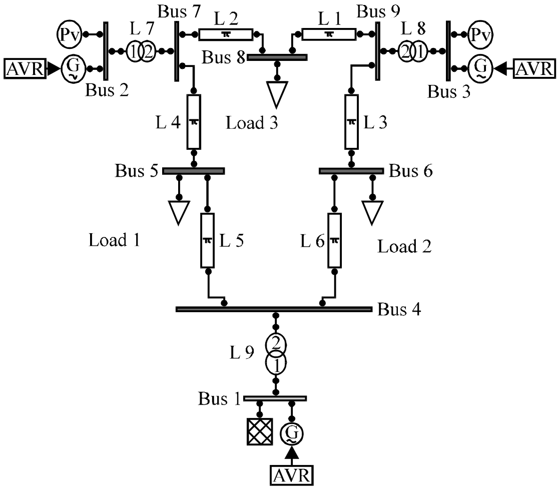

Fig. 5: Test WSCC (9-bus, 3-machine) power system

A SVC is used to control the power flow and maintain voltage in a test WSCC (9-bus, 3-machine) power system. This system, connected in a loop configuration, consists essentially of 9 buses (B1-B9) interconnected through six transmission lines (L1-L6) and three 18/230 KV transformer banks with power rated = 100 MVA. The 3 specifications of synchronous machines connected to buses 1-3 on the 16.5, 18, 13.8 KV buses, respectively that generate a total loads of 315 MW (Fig. 5) which their data are presented. Each plant model includes a speed regulator, an excitation system, as well as a Power System Stabilizer (PSS). In normal operation, most of the 215 MW generation capacity of power plant No. 2 is exported to the 18 KV equivalents through transformers connected between buses.

The single line diagram illustrated in Fig. 5 is implemented on MATLAB/PSAT toolbox to check the validity of the SVC controller. This system with SVC is shown in Fig. 6. The model of SVC is based upon the simulations at total susceptance control mode. The important keys to note in the block diagram are:

- Use of bypass breaker: Used to connect or disconnect SVC block from power system
- The reference voltage V_{dref}: Reference for voltage injection
- Power flow analysis at load flow indicated by arrows: Comparison with and without SVC

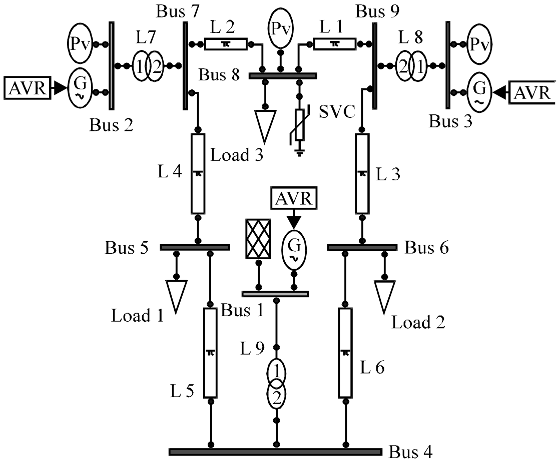

Fig. 6: Installing SVC on WSCC (9-bus, 3-machine) power system

Table 2: Bus data

Bus No.	Rating voltage
1	16.5
2	18.0
3	13.8
4	230.0
5	230.0
6	230.0
7	230.0
8	230.0
9	230.0

For this illustration, researchers consider a contingency case where only 2 transformers out of 3 are available (T_r2 = 2*100 MVA). The load flow shows that most of the power generated by plant No. 3 is transmitted through the 200 MVA transformer bank (140 MW out of 200 MW) and that rest of power is circulating in the loop. Transformer T_r2 is, therefore overloaded by 99 MVA. This will now illustrate how a SVC can maintain voltage buses at reference and how can relieve this power congestion.

The SVC connected at the power system is used to congestion management by regulate voltage profile and control reactive powers injection.

Voltage and reactive power flow control with the SVC: Parameters of the SVC are given. Initially the bypass breaker is closed and the resulting natural power flow at bus B8 is -100 MW and -22.127 Mvar, the voltage is increased from 1.0159-1.0250 p.u. The V_{ref} of SVC connected at bus B8 is programmed at 1.0262 p.u. with an initial reactive power injection of 0.12873 p.u. corresponding to the natural power flow.

Table 3: Loads data

Load No.	Power (MVA)	Voltage rate (KV)	Active power (p.u.)	Reactive power (p.u.)
1	100	230	1.25	0.50
2	100	230	0.90	0.30
3	100	230	1.00	0.35

Table 4: Transmission lines data

Line No.	Power (MVA)	Voltage (KV)	R	X	B/2
1	100	230	0.0119	0.1008	0.1045
2	100	230	0.0085	0.0720	0.0745
3	100	230	0.0390	0.1700	0.1790
4	100	230	0.0320	0.1610	0.1530
5	100	230	0.0100	0.0850	0.0880
6	100	230	0.0170	0.0920	0.0790

Table 5: Transformers data

Trans. No.	Power rate (MVA)	Primary voltage	Secondary voltage	R	X
In line 7	100	18.0	230	0	0.0625
In line 8	100	13.8	230	0	0.0586
In line 9	100	16.5	230	0	0.0576

Table 6: Slack bus connected to bus 1 data

Specification of PV bus	Values
Power rate (MVA)	100.00
Voltage rate (KV)	16.50
Voltage magnitude (p.u.)	1.04
Reference phase (rad)	0.00
Q_{max} (p.u.)	99.00
Q_{min} (p.u.)	-99.00
V_{max} (p.u.)	1.10
V_{min} (p.u.)	0.90
Active power guess (p.u.)	0.80

Table 7: PV bus for load flow data

	PV buses	
Specification of PV bus	Connected to bus 2	Connected to bus 3
Power rate (MVA)	100.000	100.000
Voltage rate (KV)	18.000	13.800
Active power	1.630	0.850
Voltage magnitude	1.025	1.025
Q_{max} (p.u.)	99.000	99.000
Q_{min} (p.u.)	-99.000	-99.000
V_{max} (p.u.)	1.100	1.100
V_{min} (p.u.)	0.900	0.900

Table 8: Characteristics of SVC

Specification of PV bus	Values
Power rate (MVA)	100.00
Voltage rate (KV)	230.00
Frequency	60.00
Reference voltage (p.u.)	1.00
Capacitive reactance Xc (p.u.)	0.10
Inductive reactance Xl (p.u.)	0.20
Bmax (p.u.)	1.00
Bmin (p.u.)	-1.00

Grid characteristics: The information of test power system including buses data, transmission lines data and power plants data loads data and transformer and slack and PV buses are listed in Table 2-9.

Table 9: Synchronous machine data

Specification of synchronous	Synchronous machine Connected to bus 1	Connected to bus 2	Connected to bus 3
Power rate	100	100	100
Voltage rate	16.5	18	13.8
Ra	0	0	0
X1	0	0	0
Xd	0.146	0.8958	1.3125
X’d	0.0608	0.1198	0.1813
X”d	0	0	0
T’d0	8.96	6	5.89
T”d0	0	0	0
Xq	0.0969	0.8645	1.2578
X’q	0.0969	0.1969	0.25
X”q	0	0	0
T’q0	0.310	0.5350	0.6
T”q0	0	0	0
M = 2H	2*23.64	12.80	6.02

RESULTS AND DISCUSSION

The results are in compliance with the SVC characteristics. When the SVC is connected at power system, the net capacitive reactive power Q_c output of the SVC (vars generated by the SVC) was then constant at 12.87 Mvar.

Initially, the bypass breaker is closed and the resulting natural power flow at bus B8 is -100 MW and -22.127 Mvar and the voltage is increased from 1.0159-1.0250 p.u. The V_{ref} of SVC connected at bus B8 is programmed at 1.0262 p.u. (Table 10).

With an initial reactive power injection of 0.12873 p.u. corresponding to the natural power flow. Then, the voltage profile and real power flow in power system transmission with SVC are increased in line 2, 3 and line 6 while reactive power flow in all transmission line is increased which causes a decrease in congestion in the other line.

The increase in voltage buses and the reactive power led to decrease in congestion on bus 5 and 8. This can be seen by the power variation at every bus. Relating to the total power results is transmission line, the total active power loss is decreased. The main concern lies at the SVC controllable region. The region defined in the graph is such that the SVC can only act under these conditions, the voltage levels were also increase so to meet the real power demand.

The results of power flow as real and reactive power are listed and descried in Table 10. For better understanding of effect of SVC the results of power flow as real and reactive are shown in Fig. 7-10.

Table 10: Active and reactive power flow results in transmission line without and with SVC

From bus	To bus	Line	Active power flow (p.u.) Without SVC	With SVC	Reactive power flow (p.u.) Without SVC	With SVC
9	8	1	0.24183	0.24152	0.03120	-0.03026
7	8	2	0.76380	0.76388	-0.00797	-0.08183
9	6	3	0.60817	0.60848	-0.18075	-0.17503
7	5	4	0.86620	0.86612	-0.08381	-0.07467
5	4	5	0.40680	-0.40676	-0.38687	-0.37513
6	4	6	-0.30537	-0.30499	-0.16543	-0.15756
2	7	7	1.63000	1.63000	0.06654	0.00155
3	9	8	0.85000	0.85000	-0.10860	-0.16350
1	4	9	0.71641	0.71587	0.27046	0.24814
8	9	10	-	-0.24079	-	-0.18546

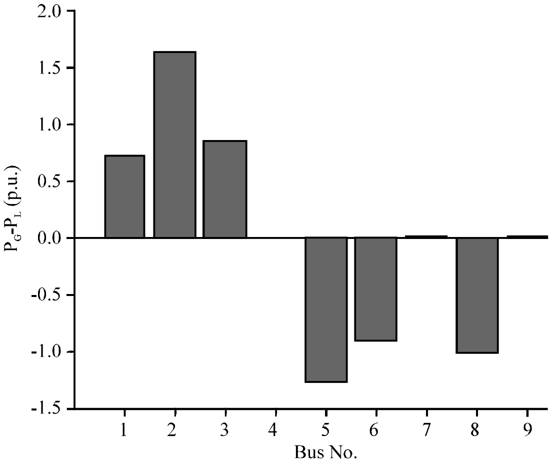

Fig. 7: Changing active power in buses system without SVC

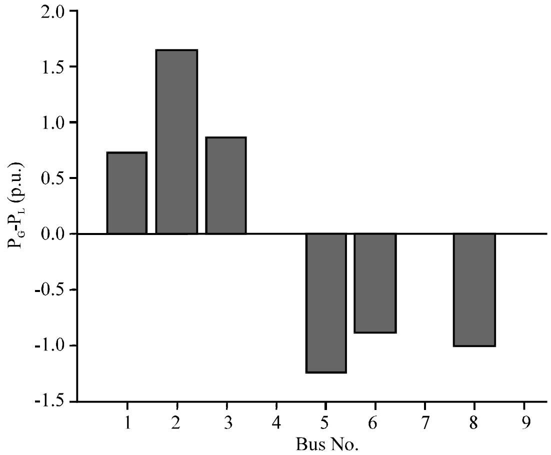

Fig. 8: Changing active power in buses system with SVC

Voltage injection using SVC: The voltage is injected by increase in magnitude, as well as angle to meet the characteristics as in Fig. 5. Considering SVC controllable region, during this mode the results get verified in accordance with Fig. 5. Also, the voltage level increases sharply. This shows that the voltage profile of the system

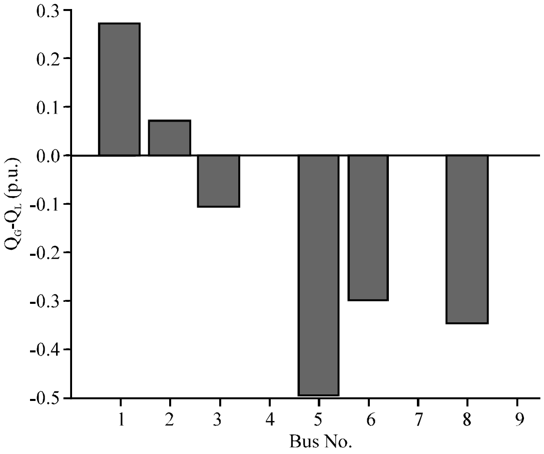

Fig. 9: Changing reactive power in buses system with SVC

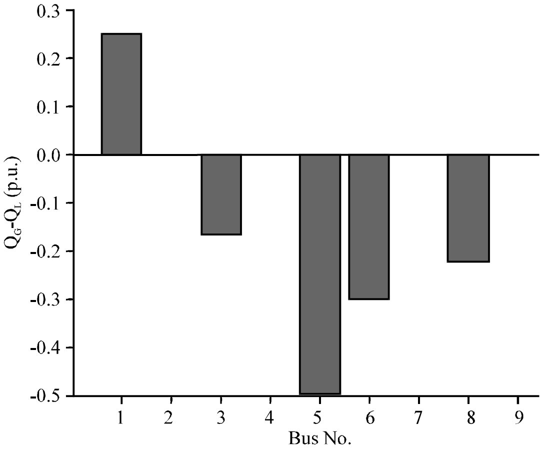

Fig. 10: Changing active power in buses system with SVC

Table 11: Bus voltage magnitude and angle with and without SVC

	MAG of voltages (p.u.)		Angle of voltages (rad)	
Bus No.	Without SVC	With SVC	Without SVC	With SVC
1	1.04000	1.04000	0.00000	0.00000
2	1.02500	1.02500	0.16197	0.16049
3	1.02500	1.02500	0.08142	0.08063
4	1.02580	1.02700	-0.03869	-0.03861
5	0.99563	0.99797	-0.06962	-0.06955
6	1.01270	1.01470	-0.06436	-0.06430
7	1.02580	1.02970	0.06492	0.06382
8	1.01590	1.02500	0.01270	0.01166
9	1.03240	1.03550	0.03433	0.03368

has gets better which increases the net power flow between transmission lines by injected reactive power. These results are listed and presented in Table 11.

The increase in voltage buses and the reactive power led to decrease the total active power loss results in transmission line. The results of power loss as real and reactive power are listed and descried as Table 12 and 13. For better understand of SVC on profile voltage the changing magnitude and angle of voltage are shown in Fig. 11-14.

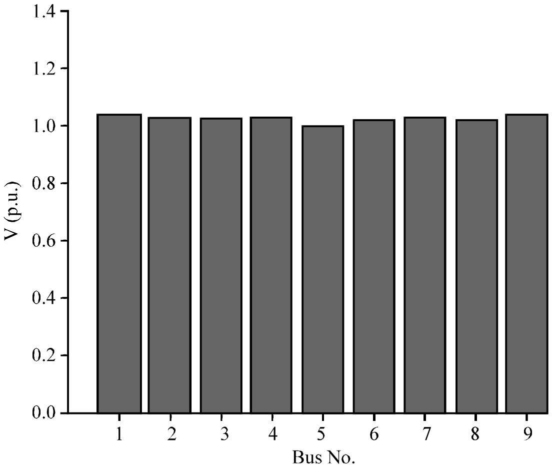

Fig. 11: Voltage buses without SVC

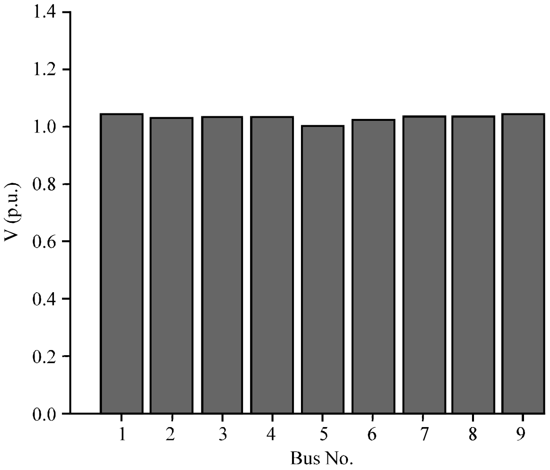

Fig. 12: Voltage buses with SVC

Table 12: Active and reactive power loss results in transmission line without and with SVC

			Active power loss (p.u.)		Reactive power loss (p.u.)	
From bus	To bus	Line	Without SVC	With SVC	Without SVC	With SVC
9	8	1	0.00088	0.00072	-0.21176	-0.21573
7	8	2	0.00475	0.00468	-0.11502	-0.11764
9	6	3	0.01354	0.01348	-0.31531	-0.31747
7	5	4	0.02300	0.02287	-0.19694	-0.19954
5	4	5	0.00258	0.00249	-0.15794	-0.15929
6	4	6	0.00166	0.00163	-0.15513	-0.15583
2	7	7	0	0	0.15832	0.15805
3	9	8	0	0	0.04096	0.04179
1	4	9	0	0	0.03123	0.03057

Table 13: Total power results in transmission line without and with SVC

		Total generation (p.u.)		Total loss (p.u.)	
Total power	Total load (p.u.)	Without SVC	With SVC	Without SVC	With SVC
Real	3.15	3,19641021	3,19587095	0,04641021	0,04587095
Reactive	1.15	0,22839875	0,21492299	-0,92160125	-0,93507701

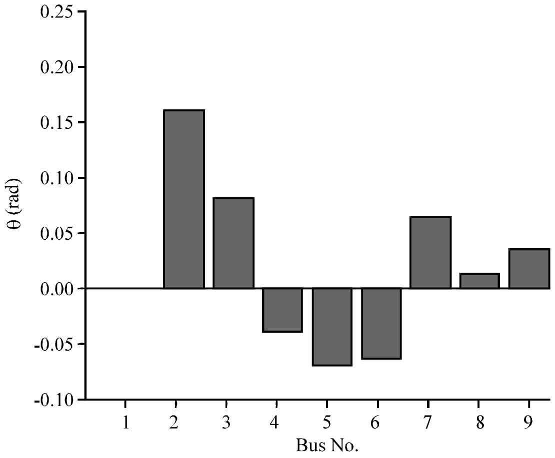

Fig. 13: Teta angle of buses voltage without SVC

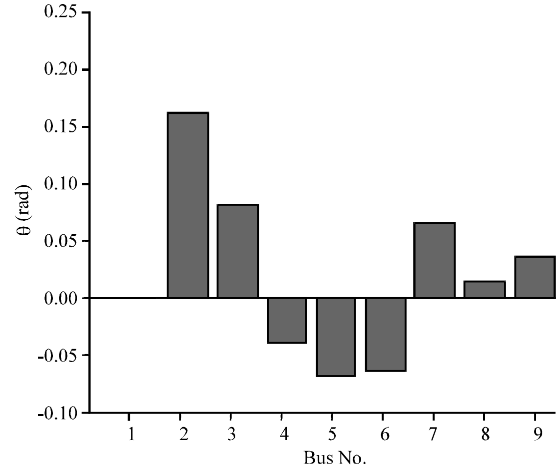

Fig. 14: Teta angle of buses voltage with SVC

CONCLUSION

Congestion management is an important issue in deregulated power systems. FACTS devices such as SVC by controlling the voltage and reactive power in the network can help to reduce the flows in heavily loaded lines. Because of the considerable costs of FACTS devices, it is important to obtain optimal location for placement of these devices.

The results presented in this research show the effect of SVC to maintain the voltage magnitude, reactive power control in power system transmission. Therefore to control the power from one end to another end, this concept of reactive power flow control and voltage injection is applied. Modeling the system and investigating the results have given an indication that SVC are very useful when it comes to organize and maintain power system. Following conclusions are made:

- Power flow control is achieved and congestion is less
- Transient stability is improved
- Faster steady-state achievement
- Improved voltage profile

REFERENCES

Baskaran, J. and V. Palanisamy, 2005. Optimal location of FACTS device in a power system network considering power loss using genetic algorithm. Academic Open Internet J., 15: 9-16.

Burade, P.G. and J.B. Helonde, 2010. By using genetic algorithm method for optimal location of FACTS devices in the deregulated power system. J. Theor. Applied Inform. Technol., 17: 64-71.

Cai, L.J. and I. Erlich, 2003. Optimal choice and allocation of facts devices using genetic algorithms. Proceedings of Intelligent Systems Application to Power Systems, August 31-September 3, 2003, Lemnos, Greece, pp: 1-6.

Elgrd, O.I., 1971. Electric Energy System Theory: An Introduction. McGraw Hill, New York.

Gerbex, S., R. Cherkaoui and J.A. Germond, 2001. Optimal location of multi-type FACTS devices in a power system by means of genetic algorithms. Power Syst. IEEE Trans., 16: 537-544.

Gotham, D.J. and G.T. Heydt, 1998. Power flow control and power flow studies for system with FACTS devices. IEEE Trans. Power Syst., 13: 60-65.

Hingorani, N.G., 1993. Flexible AC transmission. IEEE Spectrum, 30: 40-45.

Leung, H.C. and T.S. Chung, 2000. Optimal power flow with a versatile FACTS controller by Genetic algorithm approach. Proceeding of the International Conference on Advances in Power System Control, Operation and Management, October 30-November 1, 2000, Sheraton Hong Kong, pp: 178-183.

Preedavichit, P. and S.C. Srivastava, 1998. Optimal reactive power dispatch considering FACTS devices. Electric Power Syst. Res., 46: 251-257.

Reddy, S.S., M.S. Kumari and M. Sydulu, 2009. Congestion management in deregulated power system by optimal choice and allocation of FACTS controllers using Multi-objective genetic algorithm. J. Elect. Eng. Technol., 4: 467-475.

Singh, S.N. and A.K. David, 2001. Congestion management by optimizing FACTS device location. Electr. Power Syst. Res., 58: 71-79.