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GÜÇ SİSTEMİNDE STATİK GERİLİM KARARLILIĞININ SVC VE TCSC İLE İNCELENMESİ

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Özet

Bu çalışmada, 4 baralı bir güç sisteminin sürekli yük akışında yük barasındaki statik gerilim kararlılığı Statik Var Kompanzatör (SVC) ve Tristör Kontrollü Seri Kompanzatör (TCSC) ile incelenmiştir. Bu benzetim çalışması güç sistemi analizi programı (PSAT) ile yapılmıştır. Sürekli yük akışında sistemde SVC ve TCSC bağlı olduğunda maksimum yüklenme parametresi gerilim ilişkisi grafikleri çizdirilmiştir. Ayrıca sistemin normal çalışması, SVC ve TCSC kullanılması ile elde edilen maksimum yüklenme parametre değerleri tablolar halinde verilmiştir. Güç sisteminde SVC ve TCSC kullanılması ile statik gerilim kararlılığının iyileştiği görülmüştür.

Anahtar Kelime: gerilim kararlılığı, SVC, TCSC

THE INVESTIGATION OF STATIC VOLTAGE STABILITY IN POWER SYSTEM BY SVC AND TCSC

Abstract

In this study, the static voltage stability of load buses in the constant power flow into 4 a bus system has been examined through Static Var Compensator (SVC) and Thyristor Controller Series Compansator (TCSC). This simulation study has been conducted through Power System Analysis Toolbox (PSAT). Maximum loading parameter voltage curves in load buses of constant power flow in the base case have been compared to the curves in maximum loading parameter voltage when SVC and TCSC are connected in the system. Moreover, the values maximum load parameters take on by using base case, SVC and TCSC different compensation values at the end of load flow have been given in table. It has been observed that the use of SVC and TCSC improves the static voltage stability in the power system.

Keyword: Voltage Stability, SVC, TCSC

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1.Introductıon

One of the major problems in studies under unfavorable conditions on power systems is voltage stability. In power system studies and planning, voltage stability is studied in two levels, as in proximity and mechanism. Proximity deals with how voltage instability can be eradicated while mechanism deals with solutions as regards how low voltages can be corrected under buses at which voltage instability occurs. In the improvement of those two important elements, the automatic voltage regulators of the generators can meet the needs to certain thermal values. However, in excess of thermal values, instability problem may lead to voltage collapse in the power system. Voltage collapse problem is important in terms of restructuring of power system. Because the process of restructuring will take long time, the controller systems to prevent voltage collapse in power systems have been developed in recent years (Gao B, 1992). The elements of flexible AC transmission system (FACTS**)** are used in controlling the system in power systems with reactive power. They have certain application scopes of FACTS devices in power systems.
Some are as follows.FACTS devices have been studied in accord with the results of voltage stability based on thermal limitations in the lines identifying the optimal placement points and optimisation algoritms in power systems, minimization of line loss and changes in load voltage (Biansoongnern S, 2006, Kumar G.R, 2008). In power systems, in bifurcation and eigenvalue analysis, SVC and TCSC have been used. In system loading, it has been observed that SVC and TCSC use improve the stability of the system compared to the base case (Kazemi A, 2004, Mithulananthan N., 1999). In transient stability studies of power systems, it is expected that the system should take on stability within a short time. In changes on account of fault analysis or loading, damping oscillations occur. Overloaded bus load transfer capacity of the system is used in the development of SVC and TCSC. SVC and TCSC in the system will be improved with the voltage stability (Ou. Y., 2001).With the use of SVC and TCSC**,** the system takes on stability within a short time (Yu T., 2000). Active power and voltage control using static state load flow analysis was conducted SVC and TCSC (Osman Hassan M., 2009). In this study, the voltage stability of load buses in the constant power flow of a 4-bus-radial system in Turkey has been examined through SVC and TCSC. Also power system stability which studies in the literature most imported load bus stability. In the load bus stability examine static voltage stability of systems. This simulation study has been conducted through PSAT (Milano F., 2005). Active voltage power curves in load buses of continuous power flow in the base case have been compared to the curves in active voltage power when SVC and TCSC are connected in the system. Moreover, the values maximum load parameters take on by using base case, SVC and TCSC different compensation values at the end of load flow have been given in table.

2.Static Var Compansator (SVC)

SVC has been designed for reactive power control against dissipation and fast voltage control. In most of its application fields, SVC has been designed for reactive power generation and control. Moreover, it is used for voltage control. It can be used for, power flow controlling, transient stability and reducing power oscillations, as well. The fundamental function of SVC is to control bus voltage for reactive power control in the area into which it is installed. SVC circuit model has been shown on Fig.1 (Ertay M.M., 2006).

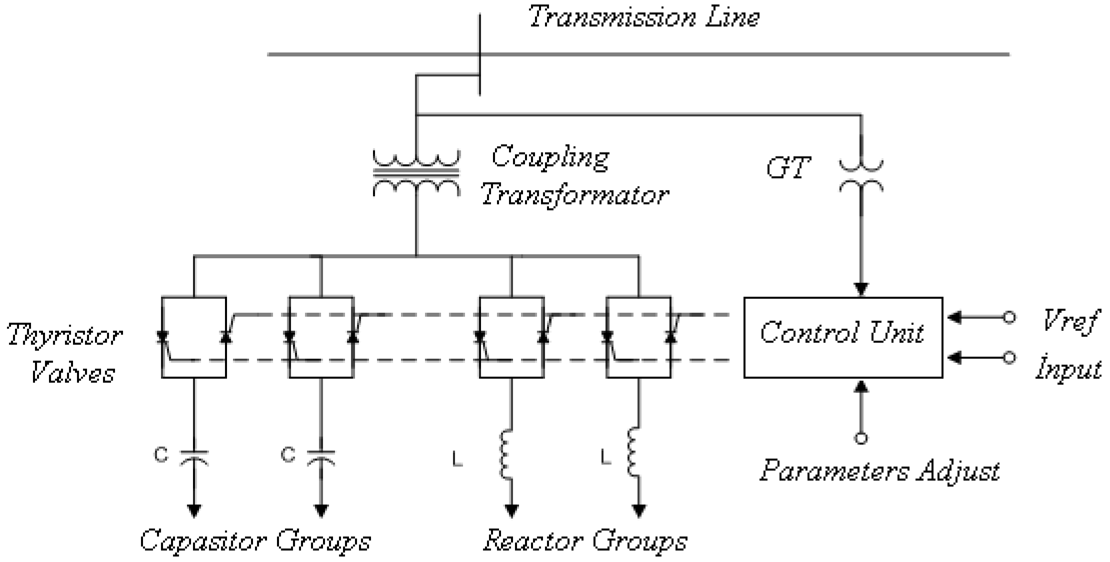

Fig. 1 Systematic study of SVC

In general, SVC consists of Thyristor Controlled Reactor (TCR) and thyristor switching compensators (TSC) (Masood T., 2006). Depending on operating conditions of the circuit, the trigger angles of thyristors have been identified and they have been introduced into the circuit. In Forward and backward operation of the circuit, the triggering angles are set during the operation and reactors and capacitors are introduced into the circuit. A capacitive and inductive working situation supplies the variable of the inductance. This inductance value is calculated as follows.

$$X_v = X_L = \frac{\pi}{2(\pi - \alpha) + \sin 2\alpha} \tag{1}$$

Total equivalent impedance of the controller can be representing as:

$$X_e = X_c \frac{\pi / r_x}{\sin 2\alpha - 2\alpha + \pi(2 - \frac{1}{r_x})} \tag{2}$$

Where, $r_x = \frac{X_c}{X_L}$ limit of the controller are given by the firing angle limits, which are fixed by design (Eminoğlu U., 2004). SVC control model has been show Figure 2.

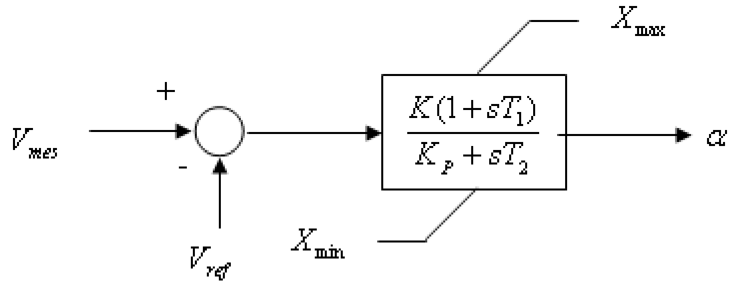

Fig. 3. SVC Control Model

Error value, the difference between the measured bus voltage and the reference voltage, is the input of the control unit. The thyristor are fired related to these values

The reactive power output of SVC may be defined can be written as

$$Q_c = \frac{V^2}{X_v} - \frac{V^2}{X_c} \tag{3}$$

Where, V line voltage, X_v inductor reactance and X_c capacitor reactance.

3. Thyristor Controller Series Compensator (TCSC)

As TCSC provide a continuously variable capacitance by controlling the firing angle delay TCS connected in parallel with a fixed capacitor. Besides controlling power flow, transient stability, damping oscillation and fault current reduction. TCSC circuit model has been shown on Fig.3 (Ertay M.M., 2006)..

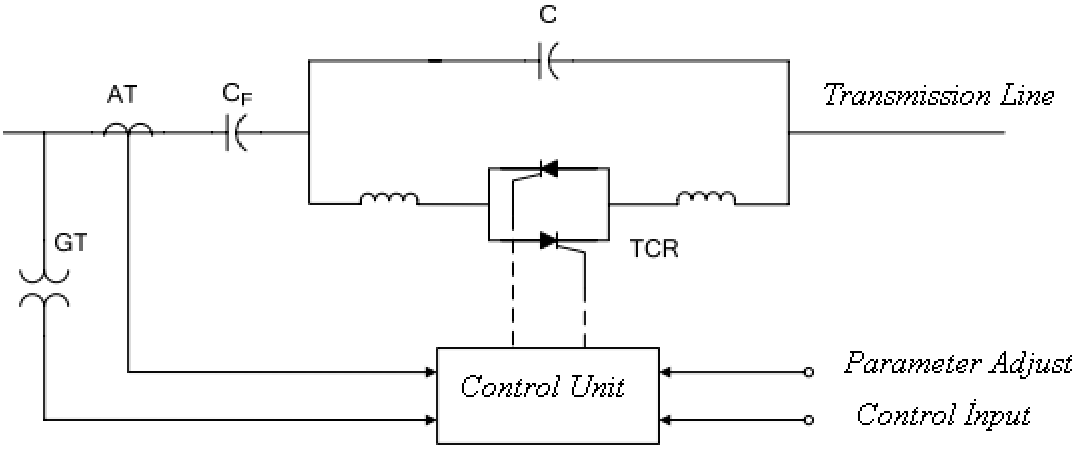

Fig. 3 Systematic study of TCSC

Thyristor controlled series capacitor (TCSC) provides a series compensation component that consists of a series capacitor bank shunted by thyristor controlled reactor. With firing control of the thyristors. (TCSC) are beginning to find applications as adjustable series capacitive compensators. TCSC can adjust its apparent reactance smoothly and rapidly. The resistance of the line is neglected, transmitted active and reactive power can be defined as

$$P = \frac{V_s V_r}{X_v} \sin\delta \tag{4}$$

$$Q = \frac{1}{X_v}(V_s V_r \cos\delta - V_S^2) \tag{5}$$

Where, Vs and Vr are sending and receiving line voltages, X_v is the equivalent series reactance of the compensated line, and δ is the angular difference between line voltages. TCSC control model has been show Fig. 4(Eminoğlu U., 2003).

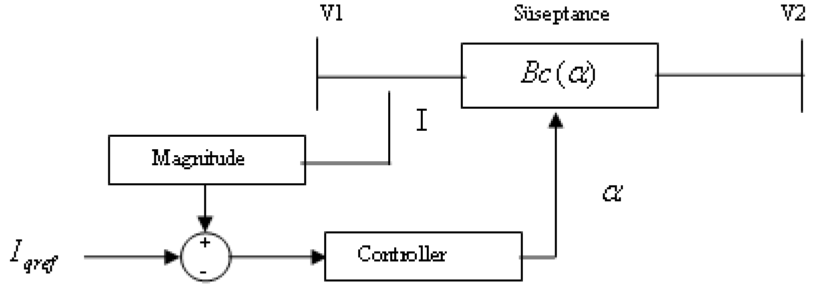

Fig. 4. TCSC control model

The firing angles of thyristors are determined based on the syncronism in phase locking loop comparing the measured flow and voltage values to referance value. With those firing angles, the suseptance need of the system is met.

4. Simulation

4 bus radial systems were used to try models control strategies discuss in this paper. There are 2 generators and 2 load bus in the system. The generators are models as standard maximum loading parameter-Voltage (λ-V) buses with P and Q thermal limit. These loads given constant. Active and reactive load power defined as

$$P_L = P_{LO}(1+\lambda) \tag{6}$$

$$Q_L = Q_{LO}(1+\lambda) \tag{7}$$

Where, P_{LO} and Q_{LO} base case loading conditions, λ maximum loading parameters (Talebi N., 2004). Circuit model 4 buses have been show 5.

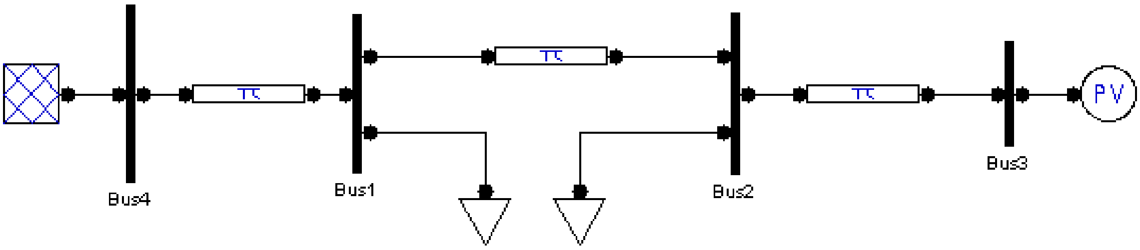

Fig. 5 Simulation System

In the system whose single line schema has been given, number 4 bus is a slack bus, number 3 bus is a generator bus, and number 1 and 2 buses are load buses. The values the buses take on are given in table 1. (Yalçın M.A., 1995)

Table I. Buses Values

Bus Type	Bus Number	Voltage(V)	Angle(δ)	Active Power (MW)	Reactive Power (MVAr)
Slack	4	1	0	-	-
Generator	3	1	-	20	-
Load	2	-	-	10	5.8
Load	1	-	-	10	5.8

In the study whose simulation will be carried out, λ-V will be drawn based on the loading parameters of number 1 and 2 load buses enabling constant load flow of base case. In the second level, SVC has been connected to load buses one by one and λ-V curves will be examined accordingly. In the last level, there will emerge some comments drawing λ-V curves at the time of TCSC series connection to the line.

5. Simulation Results

λ-V curve of the number 1 and number 2 buses in the continuous load flow of the base case has been given in Fig. 6.

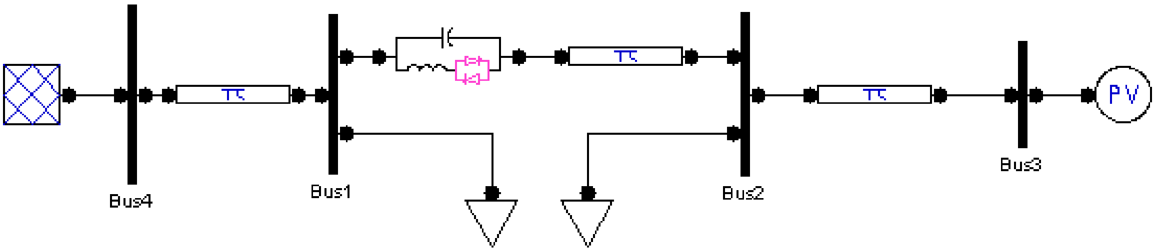

Fig. 6. Simulation System with TCSC

Maximum loading parameter (λ) value has been found to be 5.0723. TCSC is connected to transmission line between number 1 and 2 buses is shown figure 7.

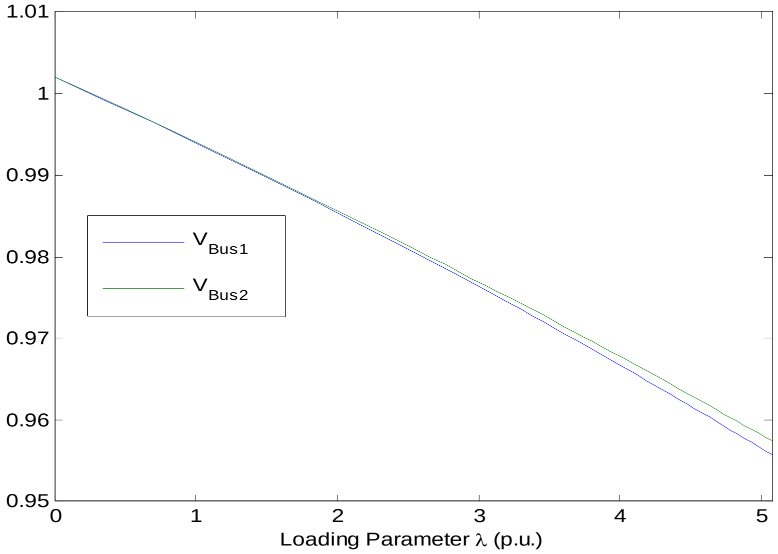

Fig. 7. λ -V curves of load bus when case base study

λ -V curve obtained when TCSC is connected to transmission line between number 1 and 2 buses is shown on figure 8 and 9.

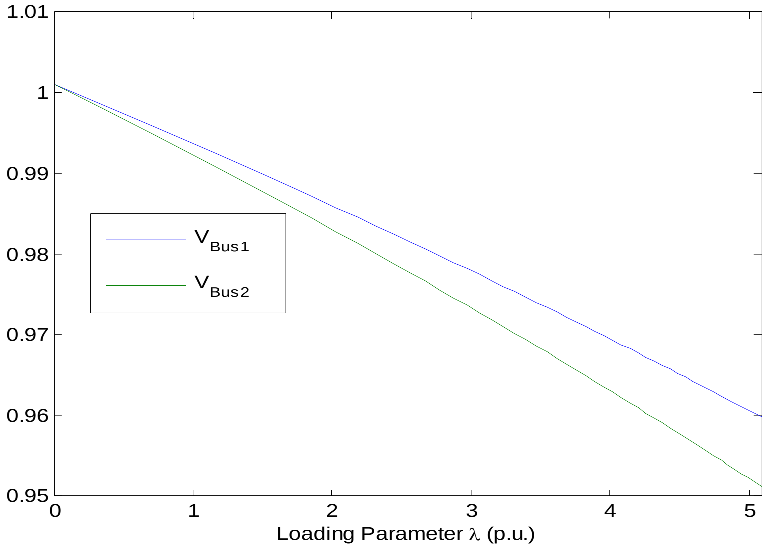

Fig. 8. λ -V curves of load buses when compensation is 20 % in TCSC between line 1–2.

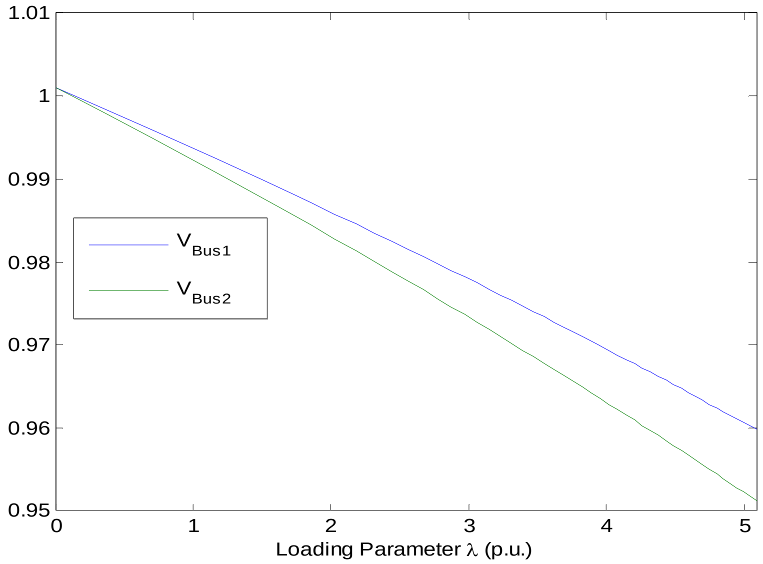

Fig. 9. λ-V curves of load buses when compensation is 40 % in TCSC between line 1-2.

In the continuous power flow conducted through TCSC, maximum loading parameter value has been found to be 5.086 for 20% compensation while it is 5.088 for 40 % compensation. SVC is connected to number 1 and 2 buses one by one has been shown on figure 10. and figure 11.

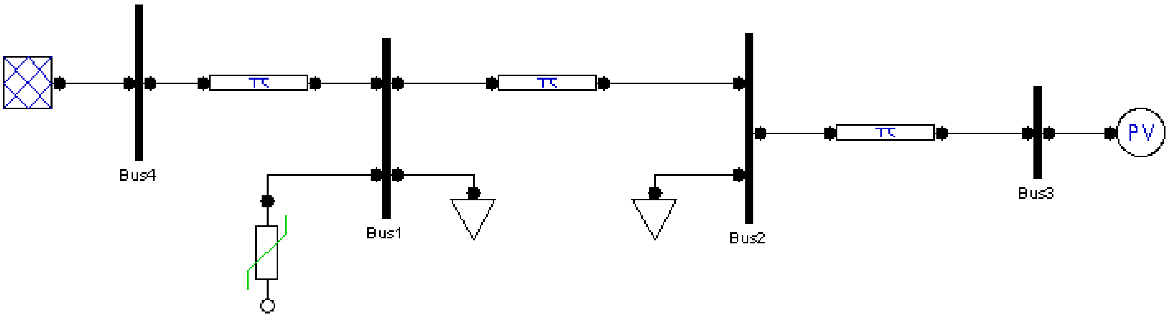

Fig. 10. Simulation System with SVC connected Bus 1

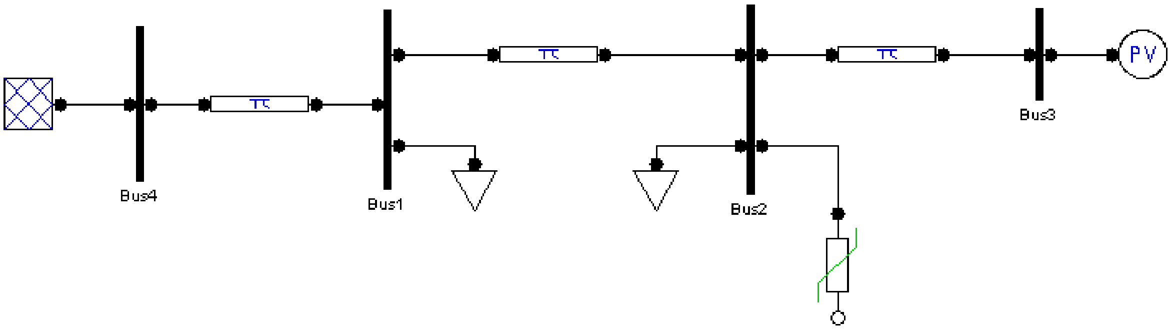

Fig. 11. Simulation System with SVC connected Bus 2

λ-V curve obtained at the end of continuous power flow when SVC is connected to number 1 and 2 buses one by one has been shown on figure 12 and 13.

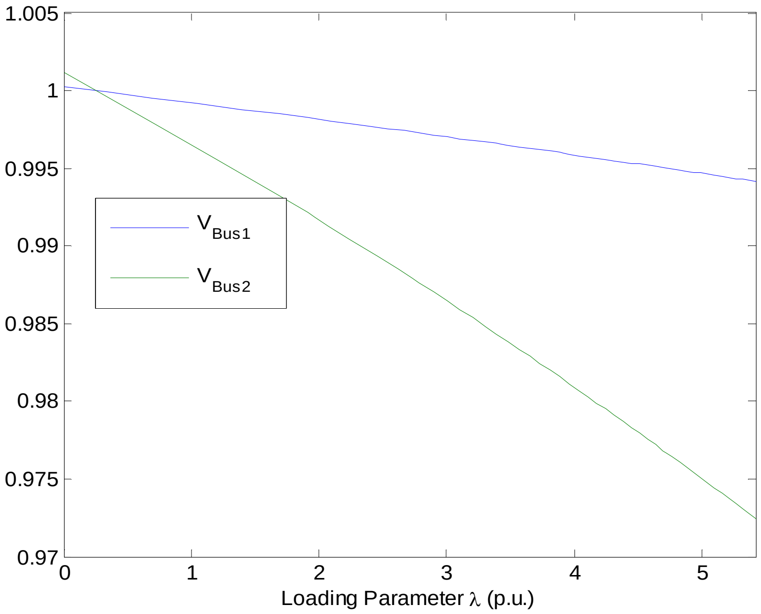

Fig 12. λ-V curves in case of SVC in number 1 load bus

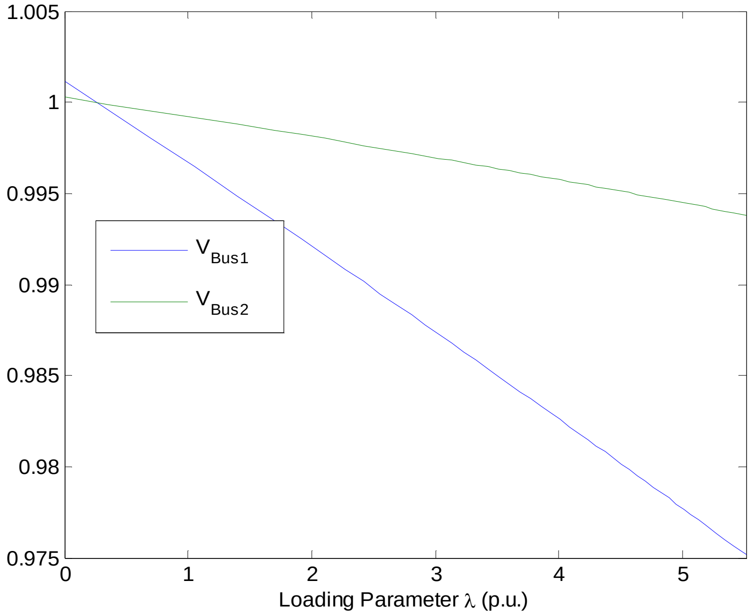

Fig. 13. λ-V curves in case of SVC in number 2 load bus

In continuous power flow conducted through SVC, Maximum Loading parameter has been found to be 5.4196 when connected to number 1 bus while it has been found to be 5.5122 when connected to number 2.

Maximum loading parameter results obtained through SVC, TCSC and base case are shown on table 2. and table 3.

Table 2. Results of case base and SVC maximum loading parameter

	with case base	with SVC
λ_{max} (p.u)	5.0723	5.419 (with connecting 1 bus)
λ_{max} (p.u)	5.0723	5.512 (with connecting 2 bus)

.

Table 3. Results of case base and TCSC maximum loading parameter

λ_{max}	Reactance compensation of line connecting buses 1-2
5.086	%20
5.088	%40
5.090	%60
5.093	%80

6. Conclusion

In the continuous load flow improvement in term of security using both series and parallel FACTS devices was seen this simulation study. The results presented in this study show that how SVC and TCSC can be used to increase system loadability in power systems. Simulation results obtained in the study both SVC and TCSC control strategies can increase system loadability or margin to voltage collapse. This study results indicate TCSC reactance compensation control can increase maximum loading parameter in the system. However, it has been determined in this simulation study that there is a rise of very low value in maximum loading parameter as a result of increase in compensation value. It has been found that maximum loading parameter value is much higher in SVC compared to TCSC. As a result can said to growth system operation range from and increase values voltage and maximum loading parameter with SVC and TCSC on voltage stability studies.

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