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A Comparison Study on Thyristor Controlled Series Capacitor (TCSC) and Static Synchronous Series Compensator (SSSC) for Minimizing Power Loss

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ABSTRACT: In recent years, power demand has increased rapidly but the expansion of power generation and transmission has been limited due to limited resources and environmental restrictions. As a consequence, some transmission lines are heavily loaded and the system stability becomes a power transfer-limiting factor. Flexible AC transmission systems (FACTS) controllers have been mainly used for solving various power system steady state control problems. In this paper the main problems of comparative active and reactive power losses in several lines between buses have been detected and a method using FACTS controller has been developed for overcoming those problems that will help to enhance the power system stability. Several technical issues related to FACTS installations have been highlighted and performance comparison of Thyristor Controlled Series Capacitor (TCSC) and Static Synchronous Series Compensator (SSSC) has been analyzed. In addition, some of the utility experience, real-world installations, and semiconductor technology development have been reviewed and summarized.

KEYWORDS: Flexible AC transmission systems (FACTS), Thyristor Controlled Series Capacitor (TCSC), Static Synchronous Series Compensator (SSSC), Static Synchronous Compensator (STATCOM), Independent power producers (IPP).

I. INTRODUCTION

Flexible AC transmission systems (FACTS) controllers have been mainly used for solving various power system steady state control problems. This paper presents a comprehensive analysis on power system stability enhancement using FACTS damping controllers. Several technical issues related to FACTS have been analyzed in power system development. There are several cases of voltage instability leading to voltage collapse. The need of the hour is, therefore, to operate the high power transmission grid in a way that it is able to carry more Power (ideally close to its thermal limit) over long distance without sacrificing its stability and security margins. The above task can only be accomplished when there is proper fast control over power flow in a transmission system. FACTS controllers, by virtue of their fast controllability, are expected to maintain the stability and security margin of highly stressed power systems. A number of control strategies for FACTS controllers have been suggested for this purpose. However, to achieve the good performance of these controllers, proper placement of the controlling devices in the grid is as important as an effective control strategy. Hence, it is imperative that proper placement strategy must precede the installation of any such device. There are several indices/methods proposed in literature for placement of FACTS devices from voltage stability/small signal stability viewpoint. Various other techniques such as residue method bus participation factor and location index for effective damping (LIED) have been used for placement of FACTS devices.

This paper presents a comprehensive analysis on research and developments in the power system stability enhancement using FACTS controllers.

II. RELATED WORK

With the emergence of high power semiconductor switches, a number of control devices under the generic name of flexible ac transmission system (FACTS) have come under active consideration to achieve the above objective. Many researchers have been proposed various kind of FACTS controller, TCSC and SSSC in their power system. Maruf, M. N. I., Mohsin, A. S. M., Shoeb, M. A., Islam, M. K. and Hossain, M. M. (2010) have discussed about the thyristor controlled series capacitor (TCSC) as a useful FACTS device. In their research they have used TCSC as a FACTS controller for minimizing power system loss [2]. Liu, Q., Vittal, V. and Elia, N. (2006) have also implemented a LPV

supplementary damping controller design. In their system a thyristor controlled series capacitor (TCSC) device is used to enhance power stability [3]. R.M. Mathur and R.K. Varma proposed a design methodology to improve power flow of the system using Thyristor-Based FACTS Controllers for Electrical Transmission Systems [4]. Vinkovic, A. and Mihalic, R. (2008) have implemented a current-based model of the static synchronous series compensator (SSSC). In their research work they have proven the effectiveness of SSSC [8].

The above mentioned paper motivated us to use those FACTS controller, TCSC and SSSC in power system. This paper mainly presents a comprehensive analysis on the research and developments in the power system stability enhancement using FACTS damping controllers.

III. LITERATURE REVIEW

Due to ever increasing load demand and reduced rights of way, modern power transmission systems are forced to carry increasingly more power over long distances. Consequently, the Transmission system becomes more stressed, which, in turn, makes the system more vulnerable to stability and security problems.

A. Overview of power generation in Bangladesh:

Power generation is the most important part of the power system. Bangladesh Power Development Board (BPDB), Independent Power Producers (IPPs) and Electricity Generation Company of Bangladesh Ltd. (EGCB) generates power in Bangladesh. Different types of power plants generate electricity and synchronize it with the national grid. There are some isolated diesel power stations at remote places and islands which are not connected with the national grid. At present, BPDB operates 133 power stations (Including IPP) with a total installed capacity of 19536 MW. In Bangladesh the following agencies distribute electricity among the consumers: Bangladesh Power Development Board (BPDB), Dhaka Electric Supply Company Ltd. (DESCO), Dhaka Power Division Company Ltd. (DPDC), Rural Electrification Board (REB) through rural electric Cooperatives called PalliBidyutSamati (PBS) and West Zone Power Distribution Company Ltd. (WZPDC). Besides that North Zone Power Distribution Company Ltd. (NZPDC). For the development of distribution system in the urban areas, BPDB takes different Town Distribution Projects (TDP) and Rural Electrification Board (REB) develops distribution system in the rural areas through different rural Electrification Program. The distribution system expanded dramatically. In 1972 there was only 9010 km of distribution lines and total consumer was over 250000 where 2020 the total distribution line is above 560,000 km and the consumer number is about 37300000 [6][7].

B. Various FACTS Controllers:

In the late 1980s, the Electric Power Research Institute (EPRI) formulated the vision of the Flexible AC Transmission Systems (FACTS) in which various power-electronics based controllers regulate power flow and transmission voltage and mitigate dynamic disturbances. Generally, the main objectives of FACTS are to increase the useable transmission capacity of lines and control power flow over designated transmission routes. Hingorani and Gyugyi proposed the concept of FACTS. Edris proposed terms and definitions for different FACTS controllers. There are two generations for realization of power electronics-based FACTS controllers: the first generation employs conventional thyristor-switched capacitors and reactors, and quadrature tap-changing transformers, the second generation employs gate turn-off (GTO) thyristor-switched converters as voltage source converters (VSCs). The first generation has resulted in the Static Var Compensator (SVC), the Thyristor-Controlled Series Capacitor (TCSC), and the Thyristor-Controlled Phase Shifter (TCPS) the second generation has produced the Static Synchronous Compensator (STATCOM), the Static Synchronous Series Compensator (SSSC), the Unified Power Flow Controller (UPFC), and the Interline Power Flow controller (IPFC). The two groups of FACTS controllers have distinctly different operating and performance characteristics.

C. Thyristor Controlled Series Capacitor (TCSC)

A TCSC is a capacitive reactance compensator, which consists of a series capacitor bank shunted by a thyristor controlled reactor in order to provide a smoothly variable series capacitive reactance [1]. Even through a TCSC in the normal operating range is mainly capacitive, but it can also be used in an inductive mode. The power flow over a transmission line can be increased by controlled series compensation with minimum risk of sub-synchronous resonance (SSR) [1]. Yarlagadda, V., Ram, B. S. and Rao, K. R. M. (2012) have proposed an Automatic control of thyristor controlled series capacitor (tcsc). They have shown how to improve power stability in power system [5]. TCSC is a second generation FACTS controller, which controls the impedance of the line in which it is connected by varying the firing angle of the thyristors. A TCSC module comprises a series fixed capacitor that is connected in parallel to a thyristor controlled reactor (TCR) i. e. Shown in Fig.1. A TCR includes a pair of anti-parallel thyristors that are connected in series with an inductor. In a TCSC, a metal oxide varistor (MOV) along with a bypass breaker is

connected in parallel to the fixed capacitor for overvoltage protection. A complete compensation system may be made up of several of these modules.

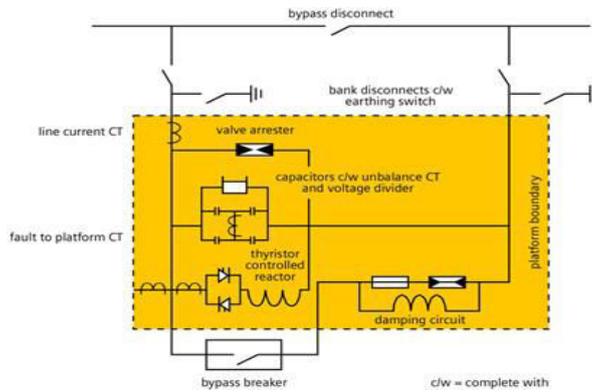


Fig. 1. Thyristor controlled series compensator (TCSC)

D. Static Synchronous Series Compensator (SSSC)

A SSSC is a static synchronous generator operated without an external electric energy source as a series compensator whose output voltage is in quadrature with, and controllable independently of the line current for the purpose of increasing or decreasing the overall reactive voltage drop across the line and thereby controlling the transmitted electric power. Faridi, M., Maeiat, H., Karimi, M., Farhadi, P. and Mosleh, H. (2011, March) proposed power system stability enhancement system. Static synchronous series compensator (SSSC) is used in their system [9]. The SSSC may include transiently rated energy source or energy absorbing device to enhance the dynamic behavior of the power system by additional temporary real power compensation, to increase or decrease momentarily, the overall real voltage drop across the line [1]. An SSSC incorporates a solid state voltage source inverter that injects an almost sinusoidal voltage of variable magnitude in series with a transmission line. The SSSC has the same structure as that of a STATCOM except that the coupling transformer of an SSSC is connected in series with the transmission line. The injected voltage is mainly in quadrature with the line current. A small part of injected voltage, which is in phase with the line current, provides the losses in the inverter. Most of injected voltage, which is in quadrature with the line current, emulates a series inductance or a series capacitance thereby altering the transmission line series reactance. This emulated reactance, which can be altered by varying the magnitude of injected voltage, favorably influences the electric power flow in the transmission line. Fig. 2. mentioned Static Synchronous Series Compensator (SSSC) is given below.

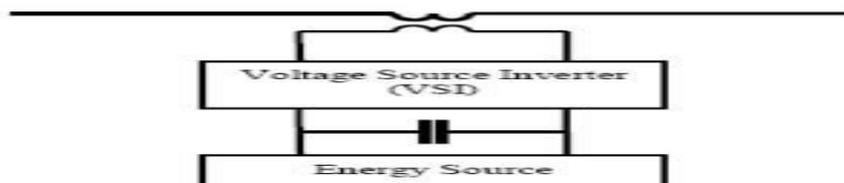


Fig. 2. Static Synchronous Series Compensator (SSSC)

IV. PROPOSED STRATEGY AND METHOD

Many powerful software packages are available for analyses of power system stability. Some of them are fully developed commercial tools, while others are open source programs. PSAT, a freely distributed Matlab-based power system analysis program developed by Dr. Federico Milano stands out among those open source programs for its relatively complete functionality. It includes principal code routines for power flow, continuation power flow, optimal power flow, small-signal stability analysis, and time-domain simulation. The core of PSAT is the power flow routine, which also takes care of state variable initialization. Once the power flow has been solved, further static and/or dynamic analysis can be performed through the following additional routines:

1. Continuation power flow (Bifurcation Analysis);
2. Optimal power flow;
3. Small signal stability analysis;
4. Time domain simulations;
5. Phasor measurement unit (PMF)

For example, in a static analysis, a synchronous generator can be modeled as a slack bus or a PV bus placement PSAT is also provided with a complete set of user friendly graphical interfaces and a Simulink-based editor of one-line network diagrams, Basic features, algorithms, and a variety of case studies.

The IEEE 14 bus system modeled in PSAT software is shown in Fig. 4. It consists of 5 generators, 14 Transmission lines, 11 static loads and 4 transformers. Base MVA is taken as 100 and base system voltage is 69KV. Complete system data is shown in Appendix showing complete generator data including transient reactance, inertia constants and time constants.

The method used to find the weakest bus and critical line of the system is CPF. The load flow solution for IEEE 14 bus system has been modeled in MATLAB power system analysis tool box. All the results are analyzed under ill condition system, and with FACTS devices. Figure.4 shows the modeled IEEE 14 bus system, which contained 5 generators, 11 loads, 4 transformers, 20 transmission lines, operating at 50 Hz frequency and base is 100 MVA. The power flow solution after the simulation is given in the Table I. The real and reactive power generation and demand at each bus, total real and reactive power losses in the system are obtained.

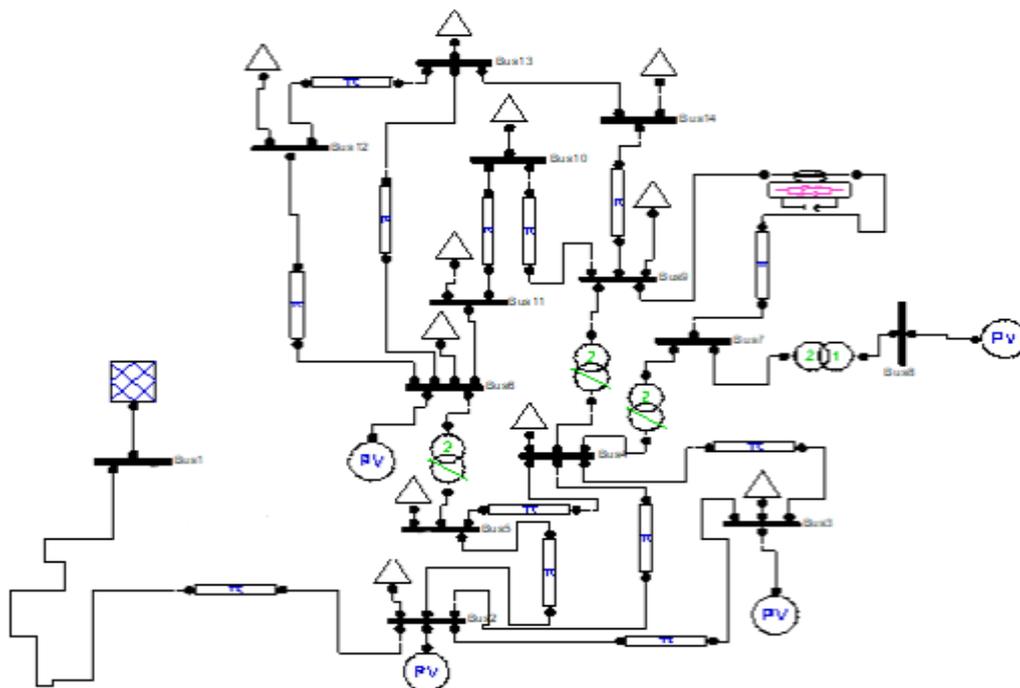


Fig. 4. IEEE 14 Bus system is modeled in MATLAB (PSAT)

V. EXPERIMENTAL RESULTS AND DISCUSSION

A. Simulation Result:

To examine static voltage stability under different loading conditions, at first we performed continuation power flow, using PAST software, for normal condition of the system which all the component of the system are employed accurately. Then upon power plant unit outage, continuation power flow program is executed for the new structure and the obtained results are evaluated. This simulation is evaluated for three cases.

Continuation power flow is applied again on IEEE 14-bus test system and critical regions are identified. In Fig. 5, Fig. 6, Fig. 7, Fig. 8; it is shown that buses 14, 5, 4 and 9 have the most loading compared to other buses. As we can see, bus 14, is identified as the weakest bus, in which voltage declines abruptly with the increase of power demand and exposes to further static instability. In this system, we have 1024 MW active power consumption and 322 MW reactive power consumption at maximum loading point which is distributed over 11 load buses. Fig. 5 Voltage magnitude profile for all buses in case one for IEEE 14-bus test system.

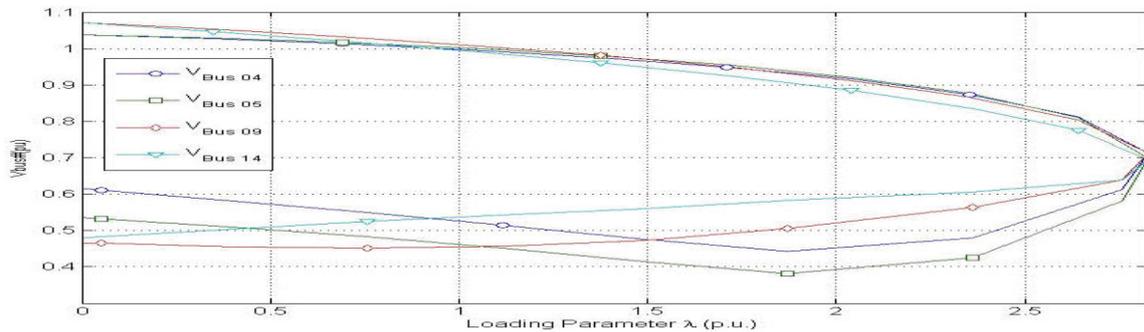


Fig. 5. p-v curves for obtaining lowest bus voltage.

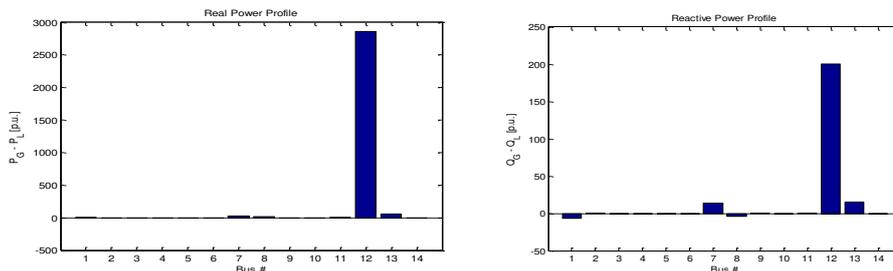


Fig. 6. Active and reactive power loss curve without FACTS

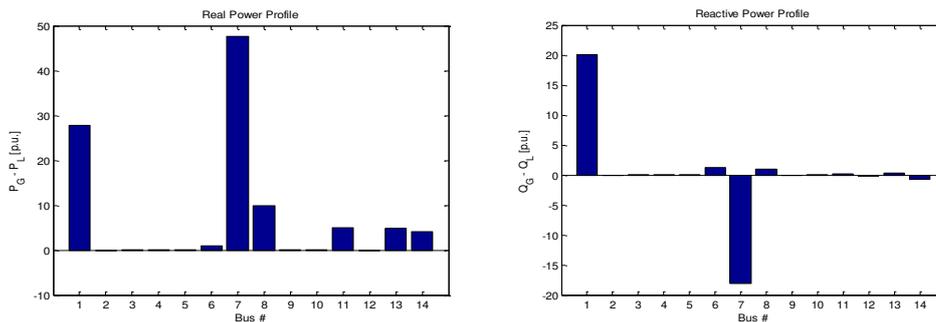


Fig. 7. Active and reactive power loss curve with TCSC

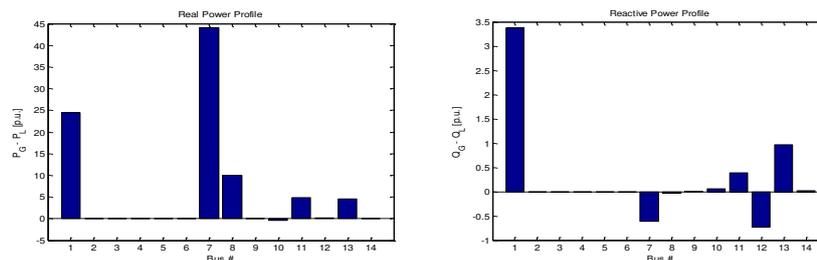


Fig. 8. Active and reactive power loss curve with SSSC

Power flow results(without FACTS)

The total real power demand is 0 (p. u) against real power generation in system is 111.6855 (p. u) and real power loss is 111.6855 (p. u). The total reactive power demand is 0 (p. u) against total reactive power generation in system is 10.2341 (p. u) and reactive power loss 10.2341 (p. u). In this system the active and reactive power limits violation in line 13 (connected between buses 12-6) are observed, which have been selected to connect the FACTS devices in the system. To minimize limit violation as well as losses in the system, the FACTS (SSSC, TCSC) are used, which help the transmission line to maintain within the limits, minimize losses, and increase transmission line transfer capabilities. The results of system without and with FACTS devices are analyzed in the subsections.



B. Performance Evaluation:

A comparative performance analysis of active and reactive power and their losses in different lines between buses is given below.

Table 1. Power flow results (Without FACTS) using PSAT simulation

Bus	V [p.u]	Phase [rad]	P gen [p.u]	Q gen [p.u]	P load [p.u]	Q load [p.u]
Bus1	1	0	10.2362	4.7233	0	0
Bus10	0	15549896492	0.00674	-0.00674	0	0
Bus11	0.00393	15529865709	0.00015	0.0135	0	0
Bus12	1.0001	-687504.89	0	0	0	0
Bus13	1.0001	-687504.89	0	0	0	0
Bus14	0	15902806744	0.00674	0	0	0
Bus2	1	-0.37897	20.7035	-0.39789	0	0
Bus3	1	-0.48979	9.9419	0.00122	0	0
Bus4	0.01635	393879.0691	-0.20618	-0.36359	0	0
Bus5	0	-49634.5774	0.0135	0.00674	0	0
Bus6	1	-687504.89	4.9845	0.24937	0	0
Bus7	0	14524670258	0.00674	-0.00674	0	0
Bus8	1	14524669012	4.9875	0.24938	0	0
Bus9	1.3268	15560835953	61.0378	5.7722	0	0

Line flows

From Bus	To Bus	Line	P Flow [p.u]	Q Flow [p.u]	P Loss [p.u]	Q Loss [p.u]
Bus12	Bus13	1	0	-0.0005	0	-0.001
Bus10	Bus9	2	-0.00674	0.00674	1.743	17.4291
Bus10	Bus11	3	0	0	0.0135	0.00015
Bus14	Bus9	4	0	0.00674	1.743	17.4291
Bus4	Bus3	5	-0.12319	-0.10334	0.96693	9.6688
Bus4	Bus2	6	-0.13415	-0.08904	0.96955	9.695
Bus9	Bus7	7	1.743	17.4291	1.743	17.4291
Bus5	Bus4	8	0	0	0.00026	0.00265
Bus1	Bus2	9	3.7332	0.33571	0.1405	1.404
Bus5	Bus2	10	0	0.00674	0.9901	9.9005
Bus2	Bus3	11	1.1011	-0.04926	0.01215	0.12047
Bus12	Bus6	12	0	0.0005	0	-0.001
Bus13	Bus6	13	0	0.0005	0	-0.001
Bus8	Bus7	14	0.24938	4.9875	0.24938	4.9875
Bus4	Bus7	15	0.04717	0.00133	0.04717	0.00133
Bus5	Bus6	16	0	0	0.24938	4.9875
Bus4	Bus9	17	-0.10658	-0.01778	0.43664	8.7327

Line flows

From Bus	To Bus	Line	P Flow [p.u]	Q Flow [p.u]	P Loss [p.u]	Q Loss [p.u]
Bus13	Bus12	1	0	-0.005	0	-0.001
Bus9	Bus10	2	1.743	17.4291	1.743	17.4291
Bus11	Bus10	3	0.0135	0.00015	0.0135	0.00015
Bus9	Bus14	4	1.743	17.4291	1.743	17.4291
Bus3	Bus4	5	1.0901	9.7722	0.96693	9.6688
Bus2	Bus4	6	1.1037	9.784	0.96955	9.695
Bus7	Bus9	7	-0.00674	0.00674	1.743	17.4291
Bus4	Bus5	8	0.00026	0.00265	0.00026	0.00265
Bus5	Bus1	9	0.00674	0.00674	0.9901	9.9005
Bus2	Bus1	10	-3.5927	1.0683	0.1405	1.404
Bus2	Bus5	11	0.9901	9.9005	0.9901	9.9005
Bus3	Bus2	12	-1.0889	0.16973	0.01215	0.12047
Bus6	Bus12	13	0	-0.0015	0	-0.001



Bus6	Bus13	14	0	-0.0015	0	-0.001
Bus7	Bus8	15	0	0	0.24938	4.9875
Bus7	Bus4	16	0	0	0.047	0.00133
Bus6	Bus5	17	0.24937	4.9875	0.24938	4.9875
Bus9	Bus4	18	0.54322	8.7505	0.43664	8.7327

Global summary report

Total generation

Real power [p.u.] 111.6855

Reactive power [p.u.] 10.2341

Total load

Real power [p.u.] 0

Reactive power [p.u.] 0

Total losses

Real power [p.u.] 111.6855

Reactive power [p.u.] 10.2341

Table 2. Power flow results (with SSSC) using PSAT simulation

Bus	V [p.u]	Phase [rad]	P gen [p.u]	Q gen [p.u]	P load [p.u]	Q load [p.u]
Bus1	1	0	24.4692	3.3712	0	0
Bus10	0.01292	26270318882	0.00366	-0.00072	0	0
Bus11	0	24721998709	0	0	0	0
Bus12	1.0001	-70938.2601	0	0	0	0
Bus13	1.0001	-70938.2601	0	0	0	0
Bus14	0	53071329995	0	0	0	0
Bus2	1	-2.8678	43.9919	-0.61445	0	0
Bus3	1	-2.9724	10.0575	-0.03826	0	0
Bus4	0	-109033.591	-0.00674	0.0135	0	0
Bus5	0.03499	11175.6739	-0.33035	0.06206	0	0
Bus6	1	-70938.2601	4.885	0.39299	0	0
Bus7	0.17113	11751646482	0.18678	-0.72924	0	0
Bus8	1	11751679570	4.5196	0.96444	0	0
Bus9	0.00863	52376718656	-0.00113	0.01553	0	0

State variables

vcs_Sssc_1 0.48875

Other algebraic variables

v0_Sssc_1 0.00863

pref_Sssc_1 0.48875

Line flows

From Bus	To Bus	Line	P Flow [p.u]	Q Flow [p.u]	P Loss [p.u]	Q Loss [p.u]
Bus12	Bus13	1	0	-0.0005	0	-0.001
Bus10	Bus9	2	-0.00089	0.00201	0.00029	0.00289
Bus10	Bus11	3	0.00017	0.00165	0.00017	0.00165
Bus14	Bus9	4	0	0	0.047	0.00074
Bus4	Bus3	5	0.00674	0	0.9901	9.9005
Bus4	Bus2	6	0.00674	0	0.9901	9.9005
Bus9	Bus7	7	0.01426	-0.00312	0.02859	0.28585
Bus5	Bus4	8	0.00121	0.01212	0.00121	0.01212
Bus1	Bus2	9	3.3712	24.4692	0	48.9384
Bus5	Bus2	10	0.21336	-0.2639	0.94086	9.4081
Bus2	Bus3	11	1.0392	-0.04976	0.01082	0.10723
Bus12	Bus6	12	0	0.0005	0	-0.001
Bus13	Bus6	13	0	0.0005	0	-0.001
Bus8	Bus7	14	0.96444	4.5196	0.21357	4.2713



Bus4	Bus7	15	0	0	0.0073	0.14606
Bus5	Bus6	16	-0.15252	-0.07857	0.24047	4.8095
Bus4	Bus9	17	0	0	0.0135	0.00037

Line flows

From Bus	To Bus	Line	P Flow [p.u]	Q Flow [p.u]	P Loss [p.u]	Q Loss [p.u]
Bus13	Bus12	1	0	-0.0005	0	0.001
Bus9	Bus10	2	0.00117	0.00088	0.00029	0.00289
Bus11	Bus10	3	0	0	0.00017	0.00165
Bus9	Bus14	4	0.047	0.00074	0.047	0.00074
Bus3	Bus4	5	0.99009	9.9005	0.9901	9.9005
Bus2	Bus4	6	0.99009	9.9005	0.9901	9.9005
Bus7	Bus9	7	0.01433	0.28897	0.02859	0.28585
Bus4	Bus5	8	0	0	0.00121	0.01212
Bus2	Bus1	9	-3.3712	24.4692	0	48.9384
Bus2	Bus5	10	0.72749	9.672	0.94086	9.4081
Bus3	Bus2	11	-1.0284	0.15699	0.01082	0.10723
Bus6	Bus12	12	0	-0.0015	0	-0.001
Bus6	Bus13	13	0	-0.0015	0	-0.001
Bus7	Bus8	14	-0.75087	-0.24825	0.21357	4.2713
Bus7	Bus4	15	0.0073	0.14606	0.0073	0.14606
Bus6	Bus5	16	0.39299	4.888	0.24047	4.8095
Bus9	Bus4	17	0.0135	0.00037	0.0135	0.00037

Global summary result

Total generation

Real power [p. u.] 87.7821
 Reactive power [p. u.] 3.4236

Total load

Real power [p. u.] 0
 Reactive power [p. u.] 0

Total losses

Real power [p.u.] 87.7821
 Reactive power [p.u.] 3.4236

Table shows results of line flows with SSSC connected in the system. Without SSSC the losses in the system is 111.6855 (p. u) and 10.2341 (p. u). With SSSC connected in the line 9 (between buses 1-2), the real power loss reduced from 111.6855(p. u) to 87.7821(p. u) and the reactive power loss reduced from 10.2341 (p. u) to 3.4236 (p. u) .SSSC can minimize both real power and reactive power losses, and limit violation in the system.

Table 3. Power flow results (with TCSC) using PSAT simulation

Bus	V [p.u]	Phase [rad]	P gen [p.u]	Q gen [p.u]	P load [p.u]	Q load [p.u]
Bus1	1	0	27.8326	20.0073	0	0
Bus10	0	-1260991035	0	0	0	0
Bus11	0.05509	-12610417744	0.03004	0.003	0	0
Bus12	1.0001	-12598768083	0.0135	0.0001	0	0
Bus13	1.0001	-12598768083	0.0337	0.00011	0	0
Bus14	0.34751	-12607996800	0.92115	1.273	0	0
Bus2	1	-12598768089	47.6331	-18.0274	0	0
Bus3	1	-12598768089	9.9	0.99011	0	0
Bus4	0	-12598768090	0	-0.0135	0	0
Bus5	0	-12598768088	0.00674	0.00674	0	0
Bus6	1	-12598768083	4.9845	0.24916	0	0
Bus7	0.04212	-12609066914	-0.07351	-0.17247	0	0



Bus8	1	-12609066923	4.7818	0.29337	0	0
Bus9	0.34289	-12609286850	4.1057	-0.67968	0	0

State variables

x1_Tcsc_1 1.0029
 x2_Tcsc_1 -11628903248

Other algebraic variables

x0_Tcsc_1 0.34289
 pref_Tcsc_1 -11628903248

Line flows

From Bus	To Bus	Line	P Flow [p.u.]	Q Flow [p.u.]	P Loss [p.u.]	Q Loss [p.u.]
Bus12	Bus13	1	0	-0.00051	0	-0.001
Bus10	Bus9	2	0	0	0.11641	1.164
Bus10	Bus11	3	0	0	0.003	0.03004
Bus14	Bus9	4	1.1273	0.92115	0.20447	2.0445
Bus4	Bus3	5	-0.00674	0	0.9901	9.9005
Bus4	Bus2	6	-0.00674	0	0.9901	9.9005
Bus9	Bus7	7	0.24316	1.2318	0.13409	1.3409
Bus5	Bus4	8	0	0	0	0
Bus1	Bus2	9	20.0076	27.8326	0	55.6652
Bus5	Bus2	10	0.00674	0.00674	0.9901	9.9005
Bus2	Bus3	11	0	-0.0005	0	-0.001
Bus12	Bus6	12	0.0001	0.00053	0	-0.001
Bus13	Bus6	13	0.0001	0.00054	0	-0.001
Bus8	Bus7	14	0.29337	4.7818	0.22952	4.5904
Bus4	Bus7	15	0	0	0.00044	0.00885
Bus5	Bus6	16	0	0	0.24938	4.9875
Bus4	Bus9	17	0	0	0.02932	0.5864

Line flows

From Bus	To Bus	Line	P Flow [p.u.]	Q Flow [p.u.]	P Loss [p.u.]	Q Loss [p.u.]
Bus13	Bus12	1	0	-0.00049	0	-0.001
Bus9	Bus10	2	0.11641	1.164	0.11641	1.164
Bus11	Bus10	3	0.003	0.03004	0.003	0.03004
Bus9	Bus14	4	-1.0686	1.1234	0.20447	2.0445
Bus3	Bus4	5	0.99011	9.9005	0.9901	9.9005
Bus2	Bus4	6	0.99011	9.9005	0.9901	9.9005
Bus7	Bus9	7	-0.10907	0.10908	0.13409	1.3409
Bus4	Bus5	8	0	0	0	0
Bus2	Bus1	9	-20.0076	27.8326	0	55.6652
Bus2	Bus5	10	0.99009	9.9005	0.9901	9.9005
Bus3	Bus2	11	0	-0.0005	0	-0.001
Bus6	Bus12	12	-0.0001	-0.00153	0	-0.001
Bus6	Bus13	13	-0.0001	-0.00154	0	-0.001
Bus7	Bus8	14	-0.06385	-0.19144	0.22952	4.5904
Bus7	Bus4	15	0.00044	0.00885	0.00044	0.00885
Bus6	Bus5	16	0.24937	4.9875	0.24938	4.9875
Bus9	Bus4	17	0.02932	0.58641	0.02932	0.5864

Global summary result

Total generation

Real power [p.u.] 100.1153
 Reactive power [p. u.] 3.9369



Total load

Real power [p. u.] 0
 Reactive power [p.u.] 0

Total losses

Real power [p. u.] 100.1153
 Reactive power [p. u.] 3.9369

Without TCSC the losses in the system is 111.6855 (p. u) and 10.2341 (p. u) . With TCSC connected in the line 9 (between buses 1-2) the real power loss reduced from 111.6855(p. u) to 100.1153 (p. u) and the reactive power loss is also reduced .TCSC here maximize real power and reactive power losses, and limit violation in the system.

A Comparison result between TCSC with SSSC is given in Table 4.

Table 4. Comparison Results

FACTS	Buses B/W 1-2 (Line 9)	
	P loss(p. u)	Q loss(p. u)
TCSC	100.1153	3.9369
SSSC	87.7821	3.4236
Comparison result between TCSC with SSSC	12.3332	0.5133

Table 4.shows results of comparison between TCSC and SSSC. The actual real and reactive power losses in the system is **111.6855 (p. u)** and **10.2341 (p. u)** . For case 1, if the TCSC is connected in the line 9 the real and reactive power losses in the system are **100.1153 (p. u)** and **3.9369 (p. u)** . For case 2, if the SSSC is connected in the line 9 the real and reactive power losses in the system are **87.7821 (p. u)** and **3.4236 (p. u)** , Comparing TCSC with SSSC, SSSC can reduce more real **12.3332 (p. u)** and reactive **0.5133 (p. u)** . So, we can conclude that, both for minimizing active and reactive power loss Static Synchronous Series Compensator (SSSC) is much better than Thyristor Controlled Series Capacitor (TCSC).

VI. RECOMMENDATION

Future developments will include the combination of existing devices, e.g. combining a STATCOM with a TSC (Thyristor switched capacitor) to extend the operational range. In addition, more sophisticated control systems will improve the operation of FACTS devices. Improvements in semiconductor technology (e.g. higher current carrying capability, higher blocking voltages) could reduce the costs of FACTS devices and extend their operation ranges. Finally, developments in superconductor technology open the door to new devices like SCCL (Super Conducting Current Limiter) and SMES (Super Conducting Magnetic Energy Storage). There is a vision for a high voltage transmission system around the world – to generate electrical energy economically and environmentally friendly and provide electrical energy where it’s needed. FACTS are the key to make this vision live.

VII. CONCLUSION

With the history of more than three decades and widespread research and development, FACTS controllers are now considered a proven and mature technology. The operational flexibility and controllability that FACTS has to offer will be one of the most important tools for the system operator in the changing utility environment. In view of the various power system limits, FACTS provides the most reliable and efficient solution. The high initial cost has been the barrier to its deployment, which highlights the need to device proper tools and methods for quantifying the benefits that can be derived from use of FACTS. The current status of power system stability enhancement using TCSC and SSSC controllers has been discussed and scrutinized. The essential features of FACTS controllers and their potential to enhance system stability has been addressed. The location and feedback signals used for design of FACTS-based damping controllers (TCSC and SSSC) have been discussed. The coordination problem among different control schemes has also been considered. Performance comparison of different FACTS controllers has been reviewed. The likely future direction of FACTS technology, especially in restructured power systems, was discussed as well. In



addition, utility experience and major real-world installations and semiconductor technology development have been summarized.

REFERENCES

- [1] Hingorani, N. G., & Gyugyi, L., "Understanding FACTS: concepts and technology of flexible AC transmission systems", IEEE press 2000.
- [2] Maruf, M. N. I., Mohsin, A. S. M., Shoeb, M. A., Islam, M. K., & Hossain, M. M., "Study of thyristor controlled series capacitor (TCSC) as a useful FACTS device", International Journal of Engineering, Science and Technology, 2(9), 4357-4360, 2010.
- [3] Liu, Q., Vittal, V., & Elia, N., "LPV supplementary damping controller design for a thyristor controlled series capacitor (TCSC) device", IEEE transactions on power systems, 21(3), 1242-1249, 2006.
- [4] Mathur, R. M., & Varma, R. K., "Thyristor-based FACTS controllers for electrical transmission systems", John Wiley & Sons, 2002.
- [5] Yarlagadda, V., Ram, B. S., & Rao, K. R. M., "Automatic control of thyristor controlled series capacitor (tcsc)", International Journal of Engineering Research and Applications (IJERA), 2(3), 444-449, 2012.
- [6] Bangladesh Power Development Board. [Online]. Available: <https://www.bpdb.gov.bd>
- [7] Ministry of Power, Energy and Mineral Resources. [Online]. Available: <https://www.mpemr.gov.bd/>
- [8] Vinkovic, A., & Mihalic, R., "A current-based model of the static synchronous series compensator (SSSC) for Newton-Raphson power flow", Electric Power Systems Research, 78(10), 1806-1813, 2008.
- [9] Faridi, M., Maeiiat, H., Karimi, M., Farhadi, P., & Mosleh, H., "Power system stability enhancement using static synchronous series compensator (SSSC)", In 2011 3rd International Conference on Computer Research and Development (Vol. 3, pp. 387-391). IEEE 2011.



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