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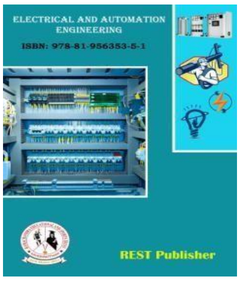

The Impact of Serial Controllable FACTS Devices on Voltage Stability

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Abstract. *As the world's population continues to grow, the demand for electricity is also increasing rapidly. Ensuring the quality of power supply, voltage stability, unity power factor, and minimizing power losses is essential for delivering power to every user end. In order to achieve this, compensation techniques are needed. This project focuses on Serial controllable Flexible AC Transmission Systems (FACTS) devices, such as Controllable Series Compensator (CSC) and Static Synchronous Series Compensator (SSSC), which have a significant impact on the voltage and power stability of an electric power system (EPS). The mathematical derivation of the voltage dependency of CSC and SSSC is extracted for the single-load infinitive-bus model (SLIB). New analytical equations are developed to compare the impact of CSC and SSSC on voltage stability in a five-bus system. The results of the analysis are expected to reveal that CSC has a crucial role to play in enhancing voltage stability, and its impact is greater than that of SSSC when considering equal CSC and SSSC MVA ratings. When it comes to voltage controllability, SSSC (Static synchronous series compensator) is superior to CSC (Controllable Series Compensator), especially in situations where there are having low voltages or having low loads.*

Keywords: *FACTS Device, SSSC, CSC, voltage stability, power stability, Power system.*

1. INTRODUCTION

The current power system is facing significant challenges to meet the high demand for power, resulting in various issues. The current transmission system cannot support the vast demand for power, leading to voltage instability, which is a significant concern when operating a power system. Therefore, understanding the maximum permissible load is critical in operating the system which is in a stable state. Stability in terms of voltage (voltage stability) pertains to the power system's capacity to maintain acceptable voltages at all its buses under normal circumstances and in case of faults or system breakdown. Voltage instability is caused by an increase in load demand, a shift in the system's state, and voltage drops in heavily demanded power systems. Assessing voltage stability is essential in identifying the security of a specific system. Techniques employed to analyze voltage stability include static strategies based on load flow dynamic analysis and timedomain simulation analysis. Various stability indices have been developed, including P-V and Q-V curve-based indices, Jacobian matrix singularity indices, and power flow solution pairs. Soft computing methods have also been utilized to perform voltage stability analysis, with Load Flow solution being carried out in MATLAB. The power system operator's interest is to equip the system's weak buses with a FACTS device to increase voltage stability, reduce power system loss and control power flow under normal and abnormal conditions. However, the impact of FACTS devices on security, load ability, and reliability should be investigated for adequate control purposes. Serial controllable FACTS devices such as a Controllable Series Compensator (CSC) and a Static Synchronous Series Compensator (SSSC) can significantly impact the voltage stability of an electric power system. This work presents a mathematical derivation for the voltage dependency of a CSC and SSSC in a single-load infinite-bus paradigm. the study validates new analytical equations by comparing how a CSC and SSSC affect voltage stability in a five-bus system. The study shows that each device has advantages in voltage controllability, but an SSSC is superior to a CSC in dealing with low voltages or light loads. It is essential to study power system dynamics under disturbances to ensure power system stability. Stability refers to the ability of a power system to resume normal or steady performance following exposure to disturbances. Power system instability can result from a loss of synchronism when the system is exposed to a specific disturbance.

2. LITERATURE CEITED

The electric power industry is undergoing the fast changes in all over the world. Restructuring of an electrical power industry involves transition from natural monopolies with centralized unit to the electric markets that subject to competition. This contributes towards the welfare of the consumer side …A summary of the different studies on market power that have been done. The development of several market power measurement indices over the past 30 years and their significance are reviewed together with a bibliographical survey of the relevant background material. The assessment of market power in terms of reactive power and the effects of visualizing the level of market power have received attention from several studies [1]. [2] States that the system inverter interfaced DGs on voltage stability and transient behavior of the power system. It was demonstrated that the synchronous generator interfaced DGs enhance the frequency of rotor speed deviation but have little effect on the maximum rotor speed deviation of the primary synchronous generators. The output power and terminal voltage of DFIG are oscillatory in nature, just like the wind. STATCOM keeps the voltage at the coupling point and handles synchronization problems. According to the modelling results, the impact of DFIG diminishes the strain on SG in terms of cost of generation, coal savings, reduction in environmental emissions, and performance at the lowest possible level of pollution[3].Numerous stakeholders, including network companies (both distribution and transmission), the owners and operators of DG units, other end- users of the power grid (including regular consumers like you and me), and not least policy makers and regulatory agencies, are impacted by the the introduction of new sources of energy like wind power, solar power, simple generation, or combined heat and electricity in the power grid[4]. Researchers and planners who work on the power system have recently focused a lot of attention on voltage instability, which is one of the main causes of insecurity in the power system [5]. The paper [6] presents, since electricity is generated exceptionally close to where it is used, distributed generation (DG) lowers the amount of energy lost during transmission.[7] refers for analytical studies, the paper develops a static load model for the EV loads. A battery energy storage system plus a charging device makes up an EV load. When the voltages are regulated, its constant power component is greater than the negative exponential power component.[8] paper presents a flowchart for the calculation of the PV curve for SLIB with a CSC or a SSSC. Voltage collapse occurs when the load factor λtakes the maximum value $\lambda = \lambda$ max.. The negative value of the reactance XCSC means that the CSC operates in the capacitive mode. Power electronics technology is quickly evolving, opening us interesting prospects to create new power system equipment for improved system utilization. The phrase "flexible ac transmission systems" (FACTS) technology has been used to describe a variety of control systems that have been suggested and put into use over the past ten years[9]. In paper [10], states The CPF and RPF methods offer greater ATC computation accuracy than the Continuous current flow, but the computational time required is high due to the involvement of numerous iterations to realize contingencies such as lines outages, generator outages, etc. While addressing the connections between particle-swarm optimization, advanced robotics etc[11]. An innovative evolving algorithm-based method for designing multi machine power- system stabilizers (PSSs) is suggested in this research. The suggested method uses the particle-swarm-optimization (PSO) technique to look for the optimal PSS system parameters [12]. Paper [13] gives idea about the electrical market is moving toward deregulation and an open market, which is fostering competitive forces. By managing the power flows in the network, FACTS devices can be used as an option to minimize the flows in severely loaded lines, leading to an increased load capacity, low system loss, improved network stability, lower production costs, and the fulfillment of agreed standards. [14] states by introducing a 3-phase defect on bus 4, which was promptly repaired, the transient stability analysis for a six-bus system was improved. As a result, the system is still in stable operational state. The outcome indicates that the generator was initially operating steadily, and that after the fault was introduced, there was an oscillation in the output, which indicated that the generator had lost its system frequency and was out of phase. Power electronics technology is quickly evolving, opening us interesting prospects to create new power system equipment for improved system utilization.[15]. This study examines an actual voltage collapse occurrence that took place in Chile’s interconnected power grid. In a digital simulation environment where the key players in the process are identified, the occurrence is replicated. Additionally, a thorough examination of reactive compensation is also covered as the voltage collapse phenomenon develops. It has been discovered that the timing of the reactive compensation's application to the network has a significant impact on its efficacy [16]. The phenomena of voltage instability and collapse are clearly described in Voltage Stability of Electric Power Systems. It covers cutting-edge techniques and presents a consistent and cohesive theoretical analysis framework [17]. The use of a moving average filter and anticipating overex citation limiter activation are two examples of useful improvements. Also demonstrated are robustness to load behavior, non-updated. topology, and un observability. Theven in impedance matching criterion comparison is presented as a last step [18]. The paper [19] includes every facet of VSA, from fundamental theoretical ideas to typical business and research procedures to a thorough explanation of some of the tools and software programs are now employed in the field. The many VSA ideas, analysis strategies, and real-world studies covered in this document are shown with a variety of straightforward and realistic examples. [20] The efficacy, selectivity, and dependability of the suggested monitoring system are amply proved, enabling its incorporation into a direct load shedding System Protection Scheme. [21] provides all computational requirements for voltage stability Based on this book, the author has created web-based simulation tools that we can utilize to model test systems as large as200 buses. Here, a method for computing the VSM in real time and for predicting the TE impedance from multiple bus system—like the Korean power system—was proposed [22]. In order to reduce delayed voltage recovery, this work attempts to create a multi-phase under voltage load shedding (MUVLS) technique that efficiently sheds the load (DVR). The dynamic properties of induction motor (IM) loads are the primary cause of the DVR phenomena [23]. Motors draw extremely high current while attempting to reaccelerate after a fault has been cleared with a transmission outage, and if the power system is poor, they may stall. Voltage collapse can be avoided by quick load shedding, quick reactive power support devices (SVC, STATCOM, SMES), or quick generator excitation controllers [24]. In order to examine voltage collapse phenomena in power systems, this work presents in-depth steady-state models with controls of two Flexible Transmission System (FACTS) controllers, namely Static Var Compensators (SVCs) and Thruster Controlled Series Capacitors (TCSCs) [25]. To verify the rising load ability, a simulation of the IEEE-14 bus system is used. The voltage stability of the test system is examined, and bifurcation points are identified, using the PSAT's continuing power flow capability and an exact model of these controllers [26]. The Newton-Raphson approach was used in this study's power flow analysis together with a MATLAB simulation. The steady state condition was used to acquire data on power flow and line losses [27]. The purpose of the research paper is to examine the impact of a unified power flow controller (UPFC) on the improvement of a longitudinal power system's transient stability margin [28]. The efficacy, selectivity, and dependability of the suggested monitoring system are amply proved, enabling its incorporation into a direct load shedding System Protection Scheme. It is demonstrated that, if implemented at the time of the event, the suggested instability detection and control technique might have avoided the voltage collapse [29]-[30].

3. FACT DEVICES

A flexible alternating current transmission system (FACTS) is a collection of static components used for transmitting electrical energy through alternating current (AC). These systems are designed to enhance the controllability and power transmission capacity of networks. Typically, power electronics serve as the foundation of these systems, and they are commonly used to improve the stability and controllability of AC systems while also increasing their power transfer capabilities. The term "FACTS" refers to a group of devices that leverage power electronics to enhance the controllability and stability of AC systems, as well as to improve their power transmission capacity. To create numerous schemes and configurations of FACTS devices, power electronics components are combined with conventional power system elements such as transformers, reactors, switches, and capacitors. These components include various types of transistors and thrusters, which are used to create efficient and effective FACTS systems that can meet the diverse needs of different power transmission applications. By leveraging power electronics and other advanced technologies, FACTS systems can help to improve the efficiency and reliability of AC power transmission networks, providing significant benefits to consumers.

Types of Facts devices

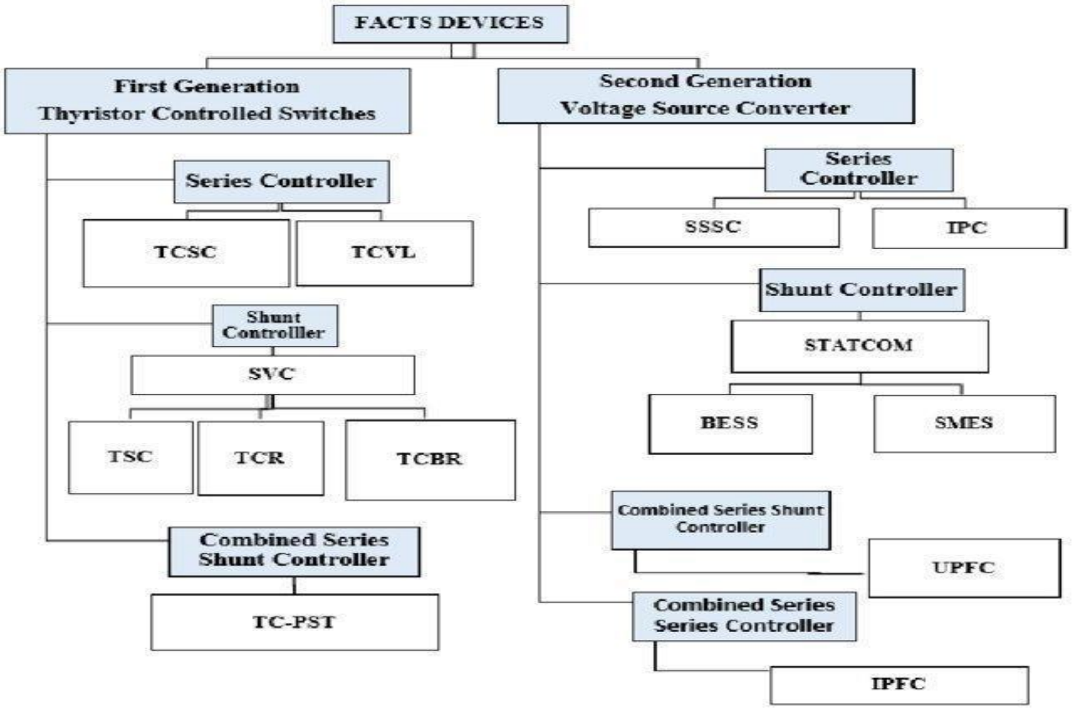

FIGURE 1. Types of fact devices

In this project, we have employed a Static Synchronous Series Compensator (SSSC) device

Advantages of Facts devices: One of the primary goals of modern power transmission systems is to enhance their power transfer capabilities. This can be achieved through the implementation of advanced systems like the FACTS devices that provide direct control over the flow of electricity through selected transmission lines. By giving operators this level of control, they can better manage the flow of electricity and ensure that it travels along the designated transmission channels, thus minimizing the risk of power outages or other disruptions. Additionally, these systems can help boost the lines' capacity for loading, allowing them to handle greater levels of electrical current without exceeding their thermal capacities. This can help improve the overall efficiency and reliability of power transmission networks, providing a range of benefits to consumers and businesses alike. With the increasing demand for electrical power in today's world, it is essential that we continue to invest in these advanced systems to ensure that we can meet our energy needs in a sustainable and reliable manner.

4. MODELLING OF BUS SYSTEM

In order to design a bus system, the following components are required. Components Involved: a)
Bus bars
b) Asynchronous generator
c) Transmission lines
d) FACTS device (SSSC) ***Bus bars*:**

In a power system, a bus is a vertical line that connects various parts of the system, including generators, loads, and feeders. These buses are an essential component of power systems, as they help to ensure that electrical power is distributed effectively throughout the network. Buses are connected to four different parameters that determine the performance of the power system. These parameters include the magnitude of the voltage, the phase angle, the active or real power, and the reactive power. Voltage magnitude refers to the strength of the electrical potential at the bus, while phase angle refers to the difference in phase between the voltage at the bus and a reference voltage. Active power, also known as real power, represents the actual power being delivered to the load, while reactive power represents the power needed to maintain the voltage at the bus. Together, these four parameters help to ensure that the power system operates effectively, delivering reliable electrical power to consumers while maintaining the stability of the network. As such, buses play a critical role in power systems and are an essential consideration for power system engineers and operator

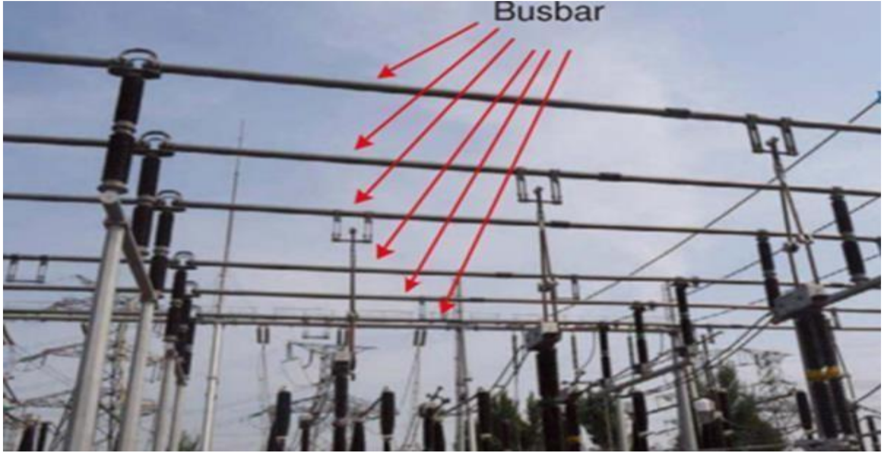

FIGURE 2. Bus bar

An AC synchronous generator, also known as an alternator, that converts mechanical power into AC electric power through electromagnetic induction. A specific generator with a 200 MVA, 13.8 kV, 112.5 rpm rating is connected to a 230 kV, 10,000 MVA network via a 210 MVA Delta-Y transformer. A three-phase to ground fault occurs at t = 0.1 s on the 230 kV bus and is cleared after 6 cycles (t = 0.2 s).

Transmission Lines: A transmission line is a conductive system that carries electrical signals and can be modeled as a two-port linear network. It can also generate electricity by converting mechanical energy, and the Transmission Line block allows it to be modeled as a stub or stubbles line. Compensating transmission lines using series capacitors can provide several advantages to the power system. One of the most significant benefits is an increase in the base-power flow and load ability of the series-compensated line. By reducing the inductive reactance of the transmission line, series capacitors can enhance the line's power transfer capacity. This increase in base-power flow can enable the system to support more load without the need for costly lineup upgrades. However, there are additional losses in the compensated line due to the improved power flow. The series capacitor increases the line's loading, which leads to an increase in the line's resistance losses. Therefore, when designing the series compensation system, it is essential to consider the trade-off between increased power transfer capability and increased losses carefully. By optimizing the design of the series compensation system, power system operators can achieve the best balance between increased power transfer capacity and acceptable levels of losses, resulting in a more efficient and reliable power system. Series compensation offers several advantages to power systems, including enhanced power transfer capability, improved voltage stability, and increased system resilience in case of line outages. Moreover, it can maintain power flow stability in case of line outages by enabling quick rerouting of power to other lines while keeping voltage stability intact, thereby increasing the responsiveness of power flow. Nonetheless, the possible downside of increased losses in the compensated line should also be considered when assessing these benefits.

FACTS device:

Introduction to SSSC: SSCCs belong to the group of series controllers that are categorized under FACTS devices. There are two types of SSCCs available: the first one is the traditional SSSC that connects to the transmission line through a transformer, while the other is the transformer less SSSC that links to the transmission line using multilevel inverters, like modular transformer less SSSIs.

Basic Principle: The SSSC, a FACTS device used for power quality improvement, involves a VSC that is connected to the transmission line through a transformer or multilevel inverters. As opposed to the STATCOM, which is connected in shunt, the SSSC is a series device belonging to the FACTS family that employs power electronics to regulate power flow and enhance power oscillation damping on power grids. By injecting a voltage Vs in series with the transmission line, the SSSC can maintain effective control over power flow.

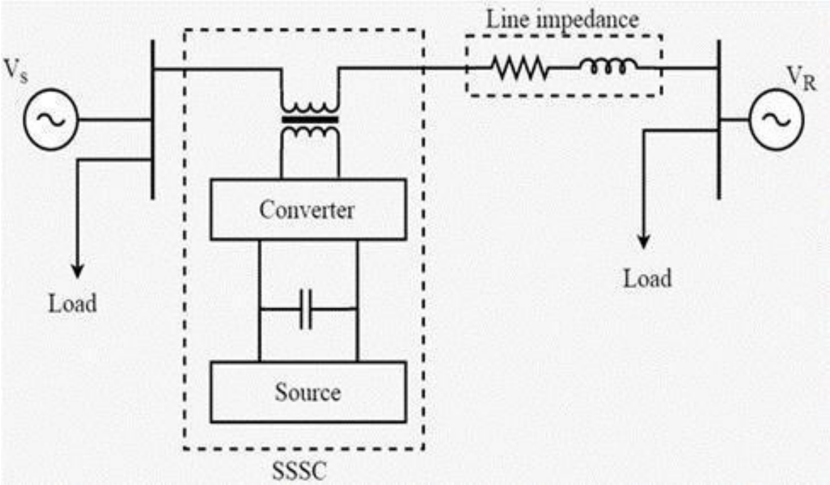

FIGURE 3. A Simple circuit diagram of SSSC device

Working operation: Load flow analysis is employed to assess the voltage profile of a power system, ensuring that every generator operates optimally while meeting the load demand without exceeding capacity. If a three-phase fault occurs, the system's stability may be compromised due to the reduction of voltage at the buses. By introducing a Static Synchronous Series Compensator (SSSC), power transfer capability, voltage control, and power flow control can be improved at the weak bus, resulting in better system stability.

5. SPECIFICATIONS

Generator ratings:

System 1: Sn = 3000MVA, Active Power (P) =1210MW System 2: Sn = 1200MVA, Active Power (P) =950MW System 3: Sn = 1300MVA, Active Power (P) =1076MW

Bus voltages:At normal conditions,

1 : BUS_1 V= 1.011 pu/400kV 0.17 deg
2 : BUS_2 V= 1.012 pu/400kV 0.14 deg
3 : BUS_3 V= 1.015 pu/400kV 0.07 deg
4 : BUS_4 V= 1.02 pu/408kV 0.00 deg ; Swing bus
5 : BUS_5 V= 1.011 pu/400kV 0.20 deg ;
6 : BUS_6 V= 1.010 pu/400kV 0.22 deg

7 : BUS_7 V= 1.012 pu/400kV 0.18 deg
SSSC rating: 100 MVA, 400kv

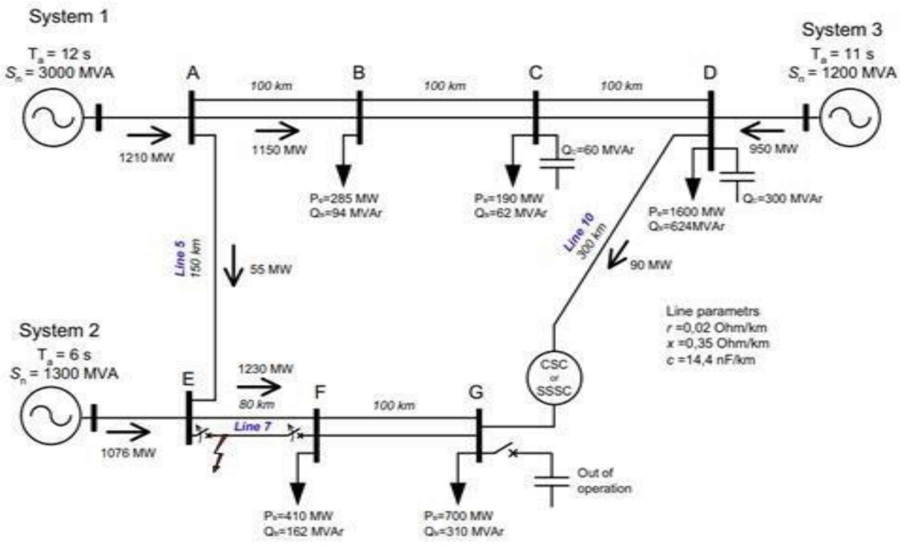

FIGURE 4. Single line diagram of a 7 bus system

6. FACT DEVICE (SSSC)

The static synchronous series compensator (SSSC) is a power quality FACTS device that employs a VSC and is connected in series to a transmission line using a transformer or multilayer inverters. Like the STATCOM, the SSSC utilizes voltage control techniques but differs in that it uses a serial connection rather than a shunt. By generating a series-injected voltage that can simulate controlled inductive or capacitive reactance based on the lag or lead of the line current, the SSSC can effectively modify the equivalent line impedance and improve the line's active power transmission capacity.

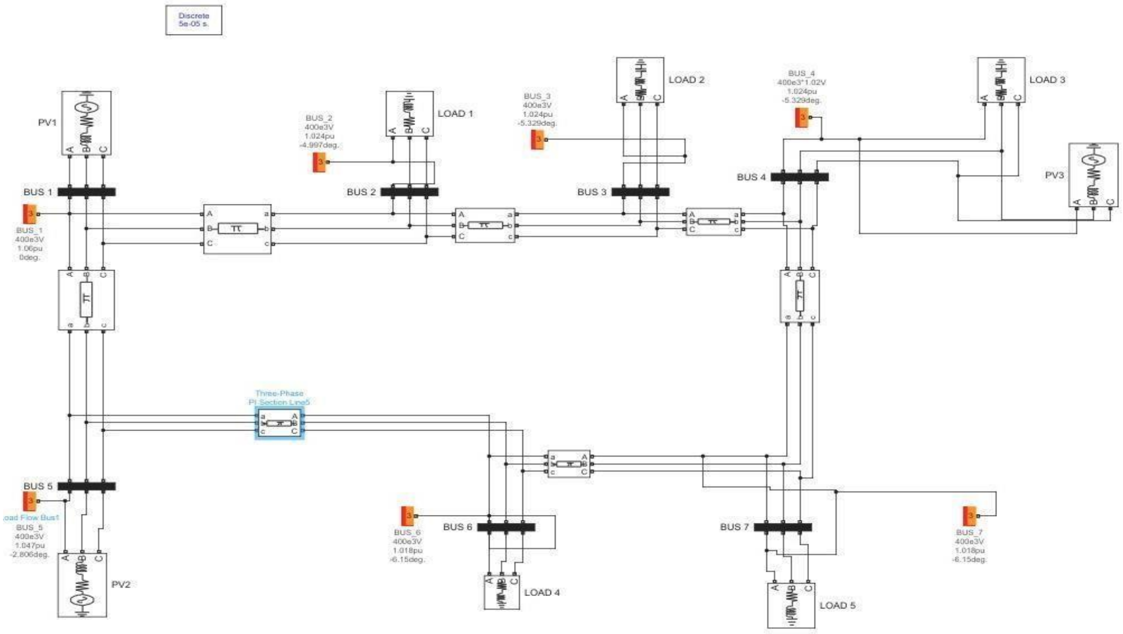

FIGURE 5. Simulation model of 7 bus system without fault

Benefits and areas of application:

The benefits of using Static Synchronous Series Compensators (SSSCs) in load flow management, while other technologies such as PST and TCSC using series reactors can aid in load flow management, the use of Static Synchronous Series Compensators (SSSCs) offers distinct advantages. SSSCs provide superior power flow controllability in both directions, voltage regulation in weaker networks, power oscillation damping, regional network voltage regulation, and phase balancing. These exclusive features make SSSCs a more effective solution for managing power systems and optimizing load flow management. In summary, SSSCs are a valuable tool for managing power systems due to their unique benefits and superior performance. A The simulation model for a 7-bus system was used to analyze system stability in the absence of any faults. The system consisted of three generators providing active power to the load. A representation of the model is shown in the figure. To further analyze system stability, a three-phase fault was created on transmission line L5-6. The voltage levels and power flows were then observed to determine the effects of the fault on system stability. Figures below show the representation of the fault created on the transmission line L5-6. This analysis is crucial in identifying potential issues in the system and taking appropriate measures to maintain system stability. By simulating faults, system operators can observe the behavior of the system and identify any potential threats to stability. This allows them to take corrective actions such as adjusting the system parameters or implementing protective measures to ensure stable power transmission.

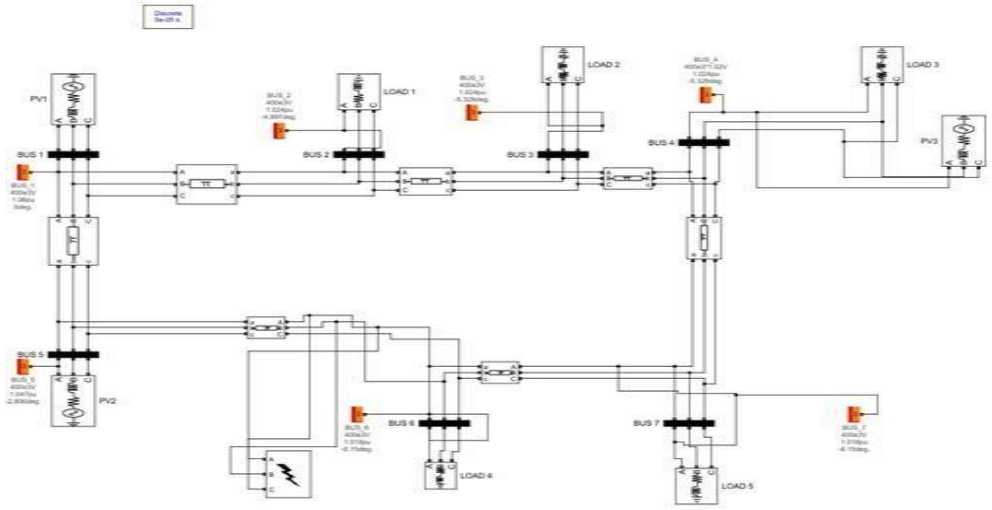

FIGURE 6. 7-bus system Simulation Model with Three-Phase Fault

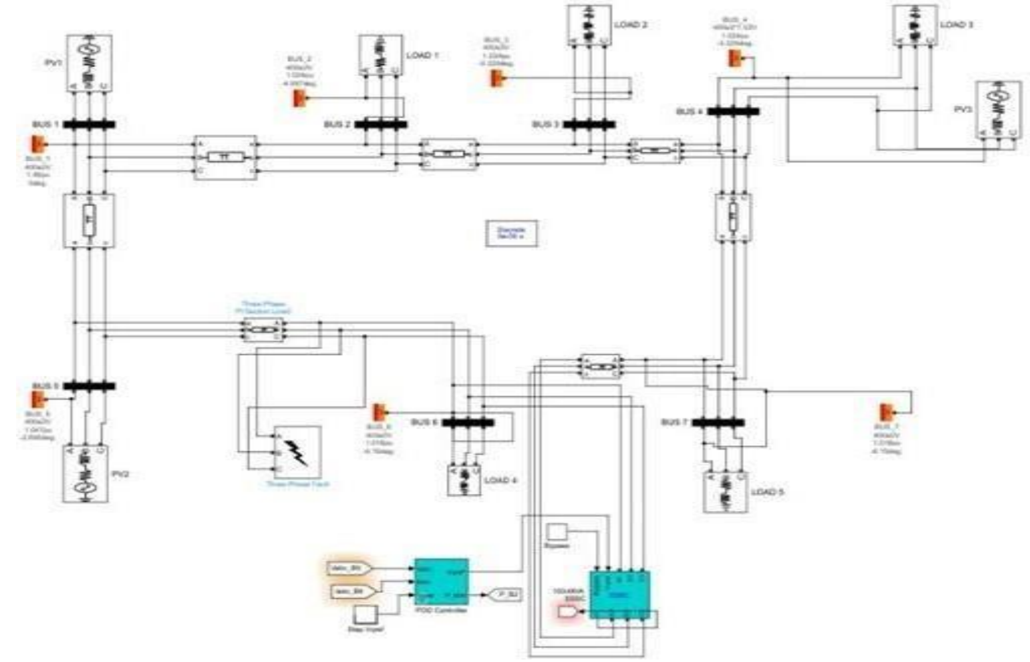

FIGURE 7. 7-bus system Simulation Model with Three-Phase Fault and compensation

7. RESULTS & DISCUSSION

Summary for 7-Bus system:

System with a fault:

			P(MW)	Q(Mvar)
	Total generation		3235.082	811.7619
	Total PQ load		3184.998	891.9994
	Total Z shunt		0.142883	-4.6E-06
	Total ASM		0	0
	Total losses		50.084	-80.2375
1 : BUS_1 V= 0.983 pu/400kV -11.68 deg ; Qmin limit reached on PV voltage source (-0.00 Mvar)				
			P(MW)	Q(Mvar)
	Generation		1209.9	-0.0096
	PQ Load		0	0
	Z shunt		1.19E-11	-6.2E-11
	BUS_2		-121.057	-53.8647
	BUS_5		122.2662	53.86372
2 : BUS_2 V= 0.988 pu/400kV -10.38 deg				
			P(MW)	Q(Mvar)
	Generation		0	0
	PQ Load		284.9999	93.99994
	Z shunt		-2E-12	2.45E-11
	BUS_1		121.1812	-5.49716
	BUS_3		-406.181	-88.5028
3 : BUS_3 V= 1.005 pu/400kV -6.11 deg				
			P(MW)	Q(Mvar)
	Generation		0	0
	PQ Load		190.0003	1.999989
	Z shunt		5.07E-11	1.25E-11
	BUS_2		407.5468	56.38619
	BUS_4		-597.547	-58.3862
4 : BUS_4 V= 1.020 pu/408kV 0.00 deg ; Swing bus				
			P(MW)	Q(Mvar)
	Generation		950.00	811.756
	PQ Load		1600	324
	Z shunt		-2E-11	1.01E-11
	BUS_3		600.3555	57.52536
	BUS_7		997.1533	430.2306
5 : BUS_5 V= 0.966 pu/400kV -12.99 deg ; Qmax limit reached on PV voltage source (0.01 Mvar)				
			P(MW)	Q(Mvar)
	Generation		1075.182	0.006863
	PQ Load		0	0
	Z shunt		-2.8E-11	3.33E-11
	BUS_1		-122.084	-110.527
	BUS_6		123.1597	110.5338
6 : BUS_6 V= 0.945 pu/400kV -14.06 deg				
			P(MW)	Q(Mvar)
	Generation		0	0
	PQ Load		409.9971	161.9997
	Z shunt		0.142883	-4.6E-06
	BUS_5		-122.933	-152.13

	BUS_7		-287.207	-9.86927
7 : BUS_7 V= 0.945 pu/400kV -10.68 deg				
			P(MW)	Q(Mvar)
	Generation		0	0
	PQ Load		700.0007	309.9997
	Z shunt		1.42E-11	1.69E-12
	BUS_4		-987.942	-279.564
	BUS_6		287.9416	-30.4362

System under compensation:

			P(MW)	Q(Mvar)
	Total generation		3235.082	811.7619
	Total PQ load		3206.3078	871.8623
	Total Z shunt		0.142883	-4.6E-06
	Total ASM		0	0
	Total losses		28.6922	-59.8611
1 : BUS_1 V= 1.003 pu/400kV -7.24 deg ; Qmin limit reached on PV voltage source (-0.00 Mvar)				
			P(MW)	Q(Mvar)
	Generation		1209.9	-0.0096
	PQ Load		0	0
	Z shunt		1.19E-11	-6.2E-11
	BUS_2		-121.057	-53.8647
	BUS_5		122.2662	53.86372
2 : BUS_2 V= 1.011 pu/400kV -5.85 deg				
			P(MW)	Q(Mvar)
	Generation		0	0
	PQ Load		284.9999	93.99994
	Z shunt		-2E-12	2.45E-11
	BUS_1		121.1812	-5.49716
	BUS_3		-406.181	-88.5028
3 : BUS_3 V= 1.015 pu/400kV -6.11 deg				
			P(MW)	Q(Mvar)
	Generation		0	0
	PQ Load		190.0058	1.99231
	Z shunt		5.07E-11	1.25E-11
	BUS_2		407.5468	56.38619
	BUS_4		-597.547	-58.3862
4 : BUS_4 V= 1.020 pu/408kV 0.00 deg ; Swing bus				
			P(MW)	Q(Mvar)
	Generation		950.00	811.756
	PQ Load		1600	324
	Z shunt		-2E-11	1.01E-11
	BUS_3		600.3555	57.52536
	BUS_7		997.1533	430.2306
5 : BUS_5 V= 1.019 pu/400kV -1.99 deg ; Qmax limit reached on PV voltage source (0.01 Mvar)				
			P(MW)	Q(Mvar)
	Generation		1075.182	0.006863
	PQ Load		0	0

	Z shunt		-2.8E-11	3.33E-11
	BUS_1		-122.084	-110.527
	BUS_6		123.1597	110.5338
6 : BUS_6 V= 0.995 pu/400kV -4.06 deg				
			P(MW)	Q(Mvar)
	Generation		0	0
	PQ Load		418.1561	153.234
	Z shunt		0.142883	-4.6E-06
	BUS_5		-122.933	-152.13
	BUS_7		-287.207	-9.86927
7 : BUS_7 V= 0.995 pu/400kV -4.68 deg				
			P(MW)	Q(Mvar)
	Generation		0	0
	PQ Load		712.1460	298.637
	Z shunt		1.42E-11	1.69E-12
	BUS_4		-987.942	-279.564
	BUS_6		287.9416	-30.4362

The following are the simulation results obtained using load flow analyzer for a 7- bus system, when the system is simulated using load flow analyzer via MATLAB Simulink, with standard test system ratings and under abnormal conditions, the voltage (p.u.) are within safe limits ensuring that the system is in healthy condition and safe to transmit the power from source to load.when the system is connected to a single three-phase fault, it has created a drop in voltage (p.u.) at each bus and the total power loss is high. The bus voltages are unstable, making the system lose its voltage stability and reduced performance in the overall system. When the system undergoes a compensation technique i.e., series FACTS device, for weak buses, there is a significant rise in p.u. voltage levels of that bus making the system reliable to transmit the power flow one from end to another end and relatively losses are also reduced.

Suitable graphs are plotted using MATLAB for voltage deviations at each bus

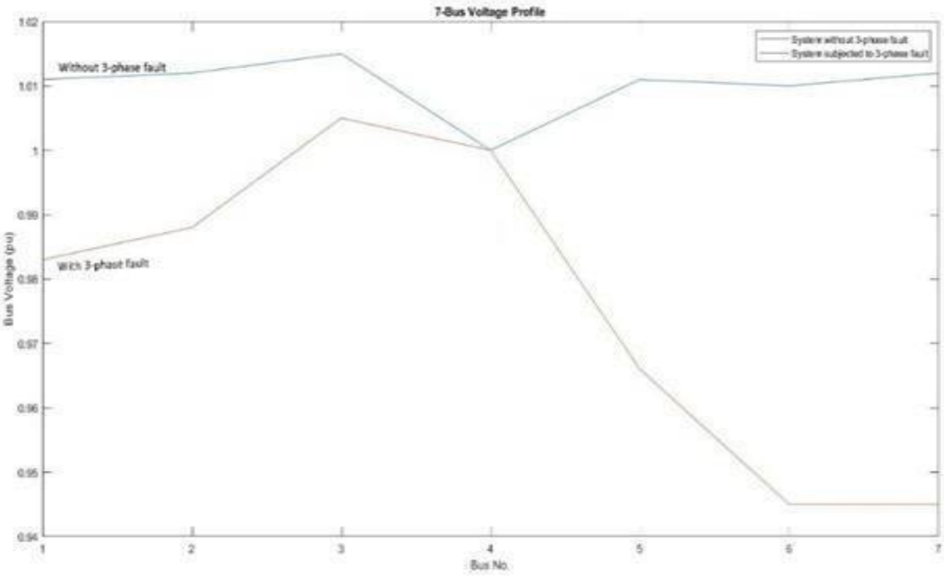

FIGURE 8. Graphical representation for voltage deviation of a 7-bus system

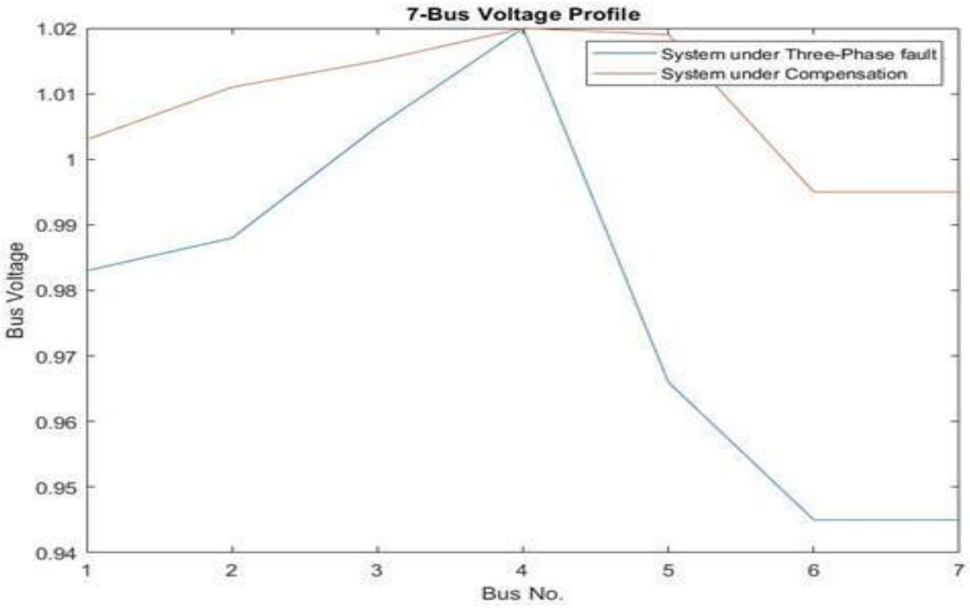

FIGURE 9. Graphical representation for voltage deviation of a 7-bus system

8. CONCLUSIONS AND FUTURE SCOPE

As per the performed experiment, that the utilization of a series FACTS device such as the Static Synchronous Series Compensator (SSSC) results in an improved voltage profile. Specifically, the voltage of the weakest bus is enhanced when the SSSC is positioned nearest to it, compared to when it is placed elsewhere within the power system. The magnitude of the source voltage of the Static Synchronous Series Compensator (SSSC) is an important parameter in determining its effectiveness in voltage regulation. In the study conducted on a three-machine, seven-bus power system, it was observed that the source voltage magnitude of the SSSC was greater than unity when raising the bus voltage to 1 per unit (pu) and less than unity when lowering it to 1 pu. This indicates that the SSSC can inject reactive power into the system to raise the voltage of the weakest bus, which in turn improves the overall voltage profile of the system. To further evaluate the efficacy of the SSSC, a three-machine, seven power system was simulated, and the results revealed that voltage regulation was successfully achieved, resulting in better voltage profiles for all buses. Therefore, the SSSC was deemed a suitable solution for voltage management and reactive power compensation in the power system, and was able to effectively control the system's power flow. In the future, the SSSC may be implemented in a more complex power system to address issues involving multiple power systems. In conclusion, the SSSC is an effective series FACTS device for improving power system voltage profiles, particularly in weak networks. Proper placement and consideration of the source voltage magnitude are essential for maximum benefits. The study's outcomes prove the SSSC's success in controlling power flow and improving voltage profiles, creating opportunities for further research and development in this field. Acknowledgement We wish to express the sense of gratitude to our guide Dr. B. VIJAY KUMAR Assoc. Professor, Electrical & Electronics Engineering Department, Kakatiya Institute of Technology & Science, Warangal, who guided us at every moment during our entire major project & giving us valuable suggestions. His continuous encouragement at each of work and effort to push the work through are gratefully acknowledged. We are indebted to Dr. G. Rajender, Associate Professor and Head of the Department, Electrical & Electronics Engineering. We also extend our gratitude to all the faculty members of the department without whose support at various stages this report will not be materialized. We wish to express our sincere thanks to Dr. D. RAKESH CHANDRA, Assistant Professor, EEE department for his inspiration and being our project coordinator. Also, we offer our sincere admiration to Prof. K. ASHOKA REDDY, Principal, Kakatiya institute of Technology & Science, Warangal for his kind patronage and permission to utilize the resource of institute to carry out the work. Last but not the least we wish to thank our friends, seniors who helped us directly or indirectly in the successful completion of this work.

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