

Power Flow Control using Fact Devices in Power System with Simulink Software

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Abstract— The demand for electricity is rising. speedily and installation of latest transmission lines is tough owing to factors relating to the environment and conjointly its not economical specially in full space wherever right of means is a problem as putting in new lines decrease the change of state of the world. In Asian nation the put in capability is bigger than the overall demand, the most reason is that the poor gear mechanism and therefore the power flow capability of the prevailing conductor to be exaggerated that is completed by victimization compensation devices. Recently, new advancement in versatile AC gear mechanism (FACTS) technology that is employed for reactive power compensation. Static synchronous series compensator belongs to FACTS family. It controls the flow of power in conductor and injects the voltage in construction with the conductor current. During this analysis, a 132 potential unit conductor returning from Kohat grid station to Gurguri grid station is chosen as a check system as a result of there's a voltage stability issue and high demand in summer months of June, July and august throughout now the losses will increase and cargo shedding phenomena become a typical issue. to realize voltage stability and enhance power flow within the network Static Synchrons Series Compensation (SSSC) technique has been during this analysis work. The check Simulink is used to simulate the model. for varied situations and therefore the results of active power ,voltage , current are examined while not victimization SSSC and with SSSC within the check system. The check system was conjointly simulated underneath a typical 3 section contact fault and therefore the result shows that by victimization SSSC the oscillations damped terribly compared to the circuit, fast while not victimization SSSC and therefore the Stability is preserved.

Keywords— Power Transmission, Power Flow Control, Voltage Stability,

I. INTRODUCTION

The electric energy grid is made up of components of electricity, parts that ar accustomed generate and provide, transfer, store wattage as shown within the fig 1. A grid that provides power to enlarged space is that the example of electrical installation Generators, storage, and delivery systems are common categories for electrical grid installation. Generators offer the ability. The transmission system that transports power from generators to loads. The distribution system offers the ability to homes or industries. In trade, hospital, business buildings and houses, smaller installation are found. consistent with the supply from that cause The following are some of the most common classifications for power plants that obtain steam:

- A. *Hydro Power plant*
- B. *Plant of thermal energy*
- C. *Plant of nuclear energy*
- D. *Diesel Power Station.*

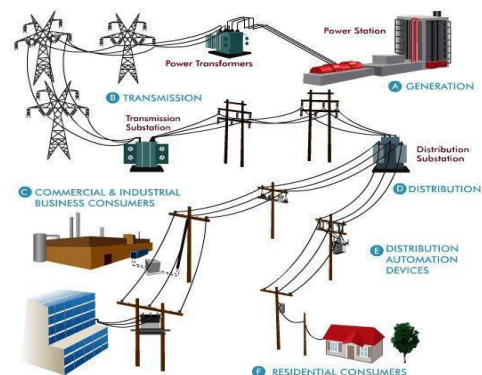


Figure 1. Power flow of transmission system

Modern wattage systems even have 3 parts i.e generation, transmission and distribution. At power generating centers, wattage is generated by synchronous alternators that are usually driven by either steam or hydro turbines. At generating stations, most of the facility generation takes place that will contain quite one such alternator-turbine combination. The generating stations are unit classified relying upon the sort of fuel used, like thermal, hydro, nuclear etc. These generating station are unit remotely settled. Power transmission is that the transmission of electrical power generated at any station over long distances to the load centers in cities or cities. In rural areas, power transmission towers and transmission lines are very typical [1]. Power transmission lines connect generating stations and cargo centres in modern power systems, which are advanced networks. Wattage is provided at either a 50Hz or 60Hz frequency.

Power demand has more than doubled in the last ten years, limiting the growth of power generation and transmission due to a shortage of energy and environmental constraints. Some transmission lines are unit powerfully loaded thanks to high load demand within the space. The system stability becomes an important issue for power transfer. For overcoming this example, installation become interlinked and sophisticated. therefore installation can't be analyzed simply. one amongst the important issues in wattage system is that the management of uncontrolled oscillation. Uncontrolled oscillation causes total or partial installation suspension. a lack of sufficient damping in the system is that the vital think about case of sustained or growing oscillation. installation stabilizer is that the initial live that has been wont to increase damping. FACTS devices are progressively used. To optimize each the steady state and dynamic performance of system,

FACTS devices are used. For dynamic reactive compensation, the primary generation thyristor controlled FACTS device, like static power unit compensator (SVC) and thyristor controlled series electrical device (TCSC) are utilized in power grid. FACTS devices would like absolutely rated electrical device or reactor bank to provide or absorb reactive power. by using self-commutated voltage sourced shift converters to appreciate static synchronous voltage sources at harmonic The second generation FACTS instruments are the static synchronous sequence compensator (SSSC) and combined power flow controller (UPFC). These limitations have an effect on the quality of electricity generated. The case study of PESCO is the subject of this article. The PESCO Company has 132kV grid stations, all of which are interconnected.

A Research Problem

On the 132kV line between Kohat and Gurguri, increased power flow and transient stabilisation are needed because voltage at Gurguri bus and Tall bus fall to dangerously low levels during peak hours, causing current to rise and the system to become overloaded, causing not only power interruptions but also loss to PESCO. to beat overload, forced load shedding is allotted. so as to beat losses and compelled voltage profile, load shedding ought to be increased to boost the the flow of energy system. because it is known that improvement in power demand, useful corporations need to

create Their network is also expandable. As a result, power flow control is critical for the capacity system's stability. Any modern AC cable, even though it is inexpensive to instal and modify, necessitates the construction of a new line. it'll need heaps of value in thronged areas. it's lucky that power physics technology improvement, quick governable versatile AC gear (FACTS) devices to save lots of the required flexibility.

E. Objective of Research

The basic objectives of this research work are:

- To Increase the transmission potential of the power grid
- To Enhancement of the voltage profile
- Increasing the power system's transient reliability

F. Contribution of Results

Following square measure the most contributions of this analysis work:

- a. to spotlight the angle applications of SSSC in Asian nation organization.
- b. Insight issues of grid associated with voltage profile and power losses developed.
- c. This analysis work also will be helpful for utility corporations.

The analysis result work are often used by PESCO, as Kohat, Gurguri and Tall Grid station square measure their authority in terms of providing intellectual profit to the cable, transmission potential.

G. Paper Overview

This study is divided into five chapters, each of which is divided into five sections. is organized in the manner described below. The introduction to the analysis work is mentioned in the first chapter. In the second chapter, FACTS technology is mentioned. This chapter briefly mentions the power flow construction in transmission lines, power flow management methodology, and FACTS technology square measure. The SSSC is mentioned in the third chapter. The fourth chapter concludes the execution of the case study in MATLAB. Chapter 5 discusses the outcomes of possible scenarios. The sixth chapter contains the conclusion and future work.

II. LITERATURE REVIEW

Before we get into FACTS Technology, there are a few topics that will help us understand the FACTS concepts.

A. Principal of power transimission

To build a simulation of the procedure a conductor are often shown for point are shown in the diagram. The equivalent impedance ($j X/2$) of every Thevenin equivalent, as shown in Figure 2, represents the "short-circuit resistivity" on each side of the point.

Assume that the amplitude of the terminal voltages, $V_s = V_r = V_m = V$, remains constant and necessary. Two voltages at the terminals are often represented in rectangular coordinates using phasor notations, as shown below.

$$V_s = v e^{j\delta/2} = V \left(\frac{\cos \delta}{2} + j \frac{\sin \delta}{2} \right) \dots\dots\dots(1)$$

$$V_r = V e^{-j\delta/2} = V \left(\frac{\cos \delta}{2} - j \frac{\sin \delta}{2} \right) \dots\dots\dots(2)$$

Where do V_s and V_r meet to shape an angle? As a result, the average value of V_s and V_r is equal to the middle phasor voltage V_m , as calculated by

$$V_m = \frac{V_s + V_r}{2}, V_m e^{j0} = V \cos \frac{\rho}{2} < 0^\circ \dots\dots\dots(3)$$

A line's current phasor is given by,

$$I = \frac{V_s - V_r}{X} \dots\dots\dots(4)$$

$$\frac{2V}{X} \sin \frac{\rho}{2} < 90^\circ \dots\dots\dots(5)$$

$I = 2V/X \sin/2$ is a formula for calculating the magnitude of I. And if a line is lost, the power remains the same. As a result, the active real power P as given by is active at both ends and in the centre. The receiving end's reactive power Q_r is equal to and opposite to the origins' reactive power Q_s . The letter of the alphabet for the road is given below:

$$P_{\max} = \frac{V^2}{X} \quad \text{and} \quad Q_{\max} = \frac{2V^2}{X} \dots\dots\dots(6)$$

If the line electrical phenomenon X is kept constant, the transmitted active power P may be varied, but any change in active power P changes the demand for reactive power on both the causing and receiving ends.

B. Related Work

FACTS controller are widely employed in AC gear to scale back or dampen the system oscillations and to extend power transfer capability. The summarized results of various researchers are mentioned intimately.

The main swing and resulting oscillation equilibrium limit of a system with SSSC and STATCOM one by one, were stated by the authors in [7], with the soundness of the system greatly accrued in each case. STATCOM significantly increased the first swing limit of stability, as shown by the results, but within the ulterior swings SSSC was a lot of emotive. In Transient State, this paper is deficient in device response.

SSSC is discovered by Authors in [8]; that belongs to FACTS devices. The voltage supply converter (VSC) touched through electrical device serial with the line in SSSC. It injects the voltage in construction with the road current. For the development of voltage stability and power flow, SSSC was used. This paper conjointly contains the negative feedback circuit of PWM controlled SSSC. It was clear from the resultant waveforms that increased most power flow at numerous buses once system is connected with SSSC as in comparison to the current system while not SSSC.

Authors in [9] mentioned that once disturbance occurs the decrease within the rate of transient energy was used as an index of facility damping. Additional damping provided by SSSC or STATCOM decided by exploitation that index, and therefore the additional damping issued by each device was compared.

The use of SSSC reduces the energy of transients at a faster rate than STATCOM, according to simulation data.

In paper [10] authors mentioned regarding some technical problems that Subsynchronous resonance is one of them, protecting equipment's and responsibility of capacitors. Historically used series electrical condenser couldn't get rid of these technological issues, therefore a brand new series compensation device known as In transmission, a synchronous series compensator that is static was used. The system consists of a synchronous voltage supply, a voltage supply converter exploitation IGBT or a gate turn-off supported power needs to eliminate these issues. The premise for Voltage supply nature provided superior operation and efficiency of static synchronous series compensator.

Authors in [11] mentioned regarding active and reactive power so as to extend the number of The line's power output, authors conjointly mentioned regarding compensation ways. Performance of facility is formed higher by exploitation technique of sequence compensation which boosts the ability flow. In future some a lot of cooking pan may be worn. The aim of this paper is to model the SSSC in terms of how to manage the system's real and reactive power flow.

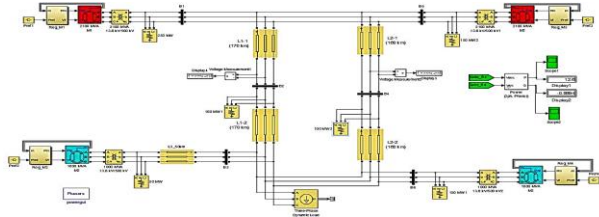
In paper [12] PTL (Power Transmission Line) enterprise SSSC were brought to bear with the road's electrical parameters. It absolutely was undemanding from the results that PI and PID

(The FACTS family (SSSC) has established a system for control to a large degree (fuzzy logic-controlled devices).

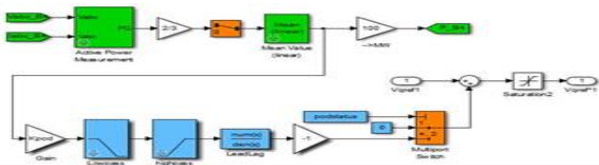
The necessity of true power and reactive power flow within the line was stated by the authors in [13] to explain Once the IPF Controller was used as a stand-alone SSSC, it was able to compensate and improve the power transfer capacity of a line. Over the course of this article, an action was bestowed, and the numerical results demonstrated that the efficiency and eligibility of the compensation device on cable were unquestionable.

The SSSC was modelled and sculpted. The SSSC injected voltage is curved and variable in magnitude in the review paper [14]. SSSC is serial with the road. The inserted volts square measure in construction with the road amps. The road is serial with the electrical phenomenon electrical phenomenon and inductive electrical phenomenon. The operation and dealing of a completely unique management theme designed each for SSSC and the Authors described STATCOM in [15]. A type of 48-pulse GTO voltage supply electrical converter was used to support the theme. The authors investigated voltage stability and reactive power compensation in the electrical grid network. A full digital simulation of the planned theme containing SSSC and STATCOM within the power grid was performed..

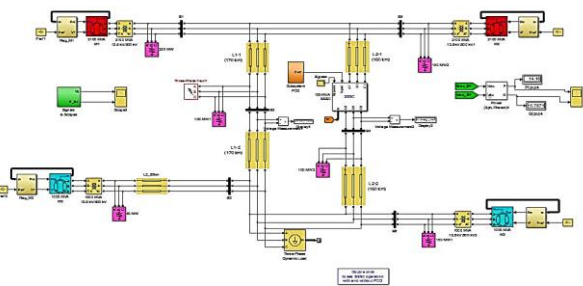
In paper [16], the SSSC injected voltage is modulated using the lead-lag form. Gain block, washout block, and a two-stage lead-lag block are all examples of gain blocks. are the three main blocks in this style. Oscillations are dampened by a gain blockTwo stage blocks have phase-lead characteristics by compensating for output signals that are lagging behind the symbol. Block 3 is a high pass filter, also known as a wash out



(a)



(b)



(c)

Figure 1. (a) Without the SSSC, a four-machine device is possible. (Simulink model) [16], (b) Simulink model of a POD controller [16], and (c) SSSC is used in a four-machine configuration. (Simulink model) [16]

The author has depicted the four machine systems with and without the use of SSSC in this paper. It is obvious from simulation that using SSSC active power improves performance. oscillation is reduced, conjointly by victimization SSSC oscillation damps out quicker as compared to the mode while not victimization SSSC, and transient stability of the system becomes higher. any by putting in POD controller with SSSC it are often seen that voltage stability will increase and oscillations square measure utterly damped out compared with the system that isn't victimization POD. [16]

In paper [17], a two-space 11-bus check scheme As a result, we have two zones, Zones 1 and 2 are utilised to assess the sequence compensator's effectiveness. A static synchronous series compensator linked to buses 9 and 10., is the real family unit that is used for series compensation. Voltage sources of (13.8) kilovolts are wired to a (290) kilometre grid using a

three-phase electrical system. This transformer has a 500KV output voltage and power in square measurea-1 and area-2 of 1000MVA and 4200MVA, respectively. In each square measurea-1 and square measurea-2, there are hundreds of people. measurea-2 are 30KW that are The truth flow of power on the route is from zone-1 and 2, with the associated load utilising both truth and reactive power may be a perform of the system volts. For all the calculations during this paper POD controller is often in ON state, It reduces device oscillations and produces the voltage (V reference) signal needed to regulate the SSSC. SSSC controls time from 0 to 10 seconds, and time from 2 to 6 seconds. From time $t=6\text{sec}$ to 10sec , SSSC acts as an electrical unit, absorbing electricity, and from time $t=6\text{sec}$ to 10sec , it acts as an electrical condenser, supplying power.

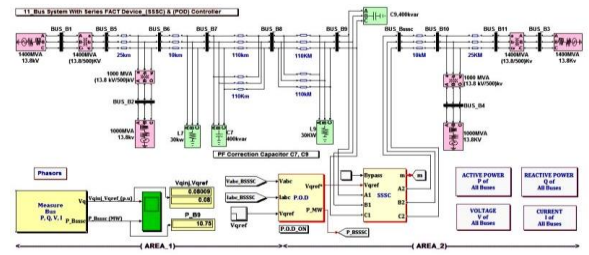


Figure 2. Bus 8 is equipped with a synchronous series compensator (Simulink model) [17]

This system has a Controlling the correct power flow in all buses, a FACTS family serial compensation unit (SSSC) was placed. SSSC boosted overall true power by 62.02MW, which is calculated through all buses. In capacitive mode, the total At all buses, the reactive power flow controlled by the static synchronous series compensator is 1723MVA.

The author mentioned SSSC in his paper [18], which is made composed of a transformer that couples or connects two wires the system to the transmission line in sequence, as well as an inverter (VSC) and a capacitor. With SSSC, the inserted series volts V are controlled in a way that changes the line's impedance. As a result, true power and reactive power of the line can be regulated.

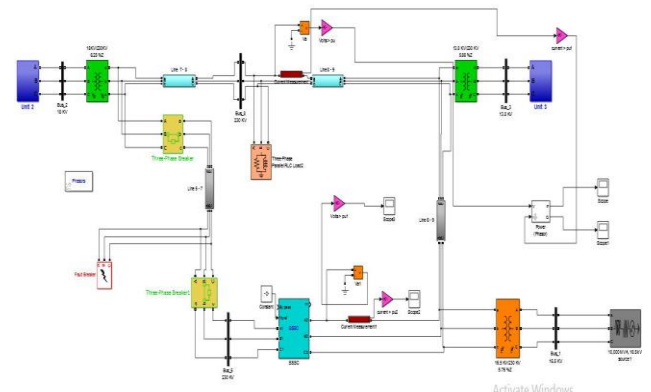


Figure 3. With a synchronous sequence compensator that is static (Simulink model) [18].

The author of paper [19] suggests that SSSC may be a voltage supply converter. By the the volts through the road's

electric resistance, the road amps and transmitted power increase. For electrical phenomenon The output volts lag as a result of compensation. the road amps by ninety degree. The output volts ar reversed by voltage supply convertor by straightforward management action and create line current lead or lag by ninety degree. Energy device is put in and it helps in exchanging real power, while not energy device exchanging real power isn't economical. Superconductor

SMES is a magnetic energy storage system that injects or absorbs active or reactive fuel. Figure 1 shows a single line diagram of a multi-area test method..

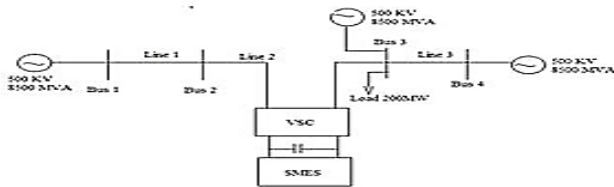


Figure 4. SSSC is used to test the device. [19]

III. FACT TECHNOLOGY

Traditional strategies for resolution issues, fastened and automatically switched series and shunt capacitors, reactors and synchronous generators ar used. because The derived response has not been successful because of the slow response, mechanical component injury. The invention of thyristor devices led to the creation of power electronic converters. It's a primarily based controller that provides wrinkle-free, continuous, at a good pace, and repeatable installation management efficiency.

FACTS is an electronic transmission system that integrates power electronic devices. FACTS are AC transmission systems that have an impact electronic controller as well as various static controls. FACTS devices ar wont to enhance the controllability yet as power transfer capability. for enhancing the power of electrical networks by managing active and reactive power these devices ar used. The definition of IEEE for FACTS controller is declared as, it's an influence electronic primarily based system and different static gears that keep the limit of 1 or a lot of AC transmission measurable factors for instance V, impedance, power cycle and Watt.

Power will be regulated to the required amount and transmitted through inscribed transmission routes and transmission line arrangements that are close to thermal, steady-state, and dynamic limits. Enhancing the ability to exchange data between interconnected transmission lines, expanding the range of services available to sensitive industries, and improving transmission efficiency and usability by restricting the impact of various flaws. The FACTS may be a set of power physics-based devices designed to improve AC system controllability, stability, and power transfer.

The model of various schemes and configuration of FACTS devices would dependant on combination of ancient grid elements specified electrical device, reactors, switches and capacitors, with power physics components like different types of junction transistor and thyristors. Current rating has

increased to larger values for thyristor within the last years. It created powe physics capable of tens of thousands of megawatts in high-power systems .

FACTS devices, due to their speed and resiliency, may provide transmission with some advantages. Improved transient stability, power oscillation damping, voltage stability, and management are some examples. the device's type and rating, as well as the basic voltage

level, a transmission capability improvement of up to four-hundredth to five hundredth is also obtained by FACTS parts. currently days the elemental abstractions to the mixing of those promising innovations ar price, quality and responsibility problems.

FACTS technology will help with today's grid problems. It will improve the capacity to pass electricity. It also improves continuous voltage profile control, device damping, and loss minimization, among other things. With its real-time operative management, FACTS devices have high power physics-based instrumentality. 2 teams of FACTS controllers that relies on completely different technical approaches, leading to controllers capable to unravel transmission issues.

Reactive impedances or tap-charging transformers with thyristors switches as controlled parts is that the initial cluster. Self-commutated voltage sourced switch converters is that the second cluster. for each teams It is common to have good management and a swift response. Static volt-ampere compensator (SVC), Thyristor Controlled Series Electrical Condenser (TCSC), and segment shifter are the three main controller classes. Compensator for static synchronisation (STATCOM). Static synchronous series compensator (SSSC), unified power flow controller (UPFC), and interline power flow controllers make up the second cluster of controllers (IPFC)

A. Types of FACT Controllers

Define abbreviations and acronyms the first time they are used in the text, even after they have been defined in the abstract. Abbreviations such as IEEE, SI, MKS, CGS, sc, dc, and rms do not have to be defined. Do not use abbreviations in the title or heads unless they are unavoidable.

- **Shunt Controllers**

The system shunt controllers inject current At the purpose of association. It causes a variable current flow once variable shunt electric resistance is connected to the road voltage and therefore shows current injection into the road Only reactive power is offered or consumed by the shunt controller. As long as the injected current is somewhat proportional to the road voltage. with the other part relationship between voltage and current can involve Handling of real power also. Shunt controllers embrace TSR, TSC, STATCOM, TCR and TCBR

- **Series Controllers**

A series controller is nonparallel with the path to inject voltage. The voltage is proportional to the current on the lane. So long as the series controller is solely responsible for supplying or consuming reactive electricity. Real-

power handling may also include a section Voltage and present have a friendship. It includes the TSSC, TCSC, TCSR, SSSC, IPFC, and TSSR.

- **Combined Series-Series Controllers**

It is a controller in which series controllers have freelance series reactive compensation for each thread. It also moves actual power between the lines. The ability to transfer real power is transferred by series-series controls, brought up as IPFC, makes it to balance each real and reactive power flow within the lines. It enhances the use of the gear.

- **Combined Series-Shunt controllers**

For the shunt portion of the controller, combined shunt and series controllers inject current into the device and voltage serial inside the line with the series part of the controllers. The \$64000 power will be exchanged between the series and shunt controllers until the shunt and series controllers are unified. A thyristor-controlled phase regulator is used in the combined series-shunt controllers. TCPAR is a non-profit organisation that promotes

- **Static Synchronous Compensator STATCOM**

STATCOM may be a compensator for static power units. Electrical phenomena or inductive output current can be controlled. The AC machine voltage is individualistic. STATCOM is related to the AC system in terms of bus voltage magnitude or reactive capacity. The new that was added by STATCOM is either fits management the bus voltage magnitude or the reactive power injected at the bus.

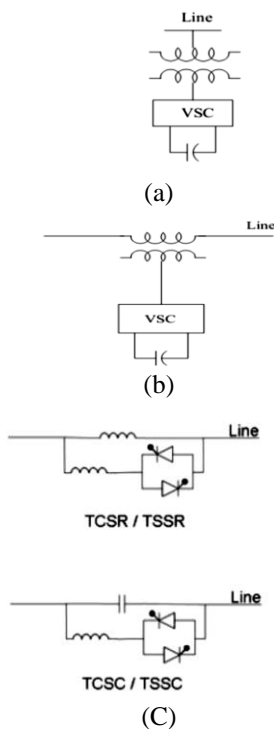


Figure 5. (a) Shunt connected STATCOM [2], (b) SSSC linked in series [3], and (c) Schematic Diagram of TCSC&TCSR.

- **Static VAR compensator SVC**

A shunt-connected power unit generator or absorbent is what it is. Its output is changed to change electrical phenomena or inductive current in order to maintain the bus voltage. SVC is a thyristor-based FACTS controller from the first century. SVC addresses complex By providing high-performance, fast dynamic voltage control in both steady and dynamic environments, we can solve voltage problems. Due to its accuracy, availability, and rapid response, SVC has been used to improve conductor for many years. The most significant benefits of SVC are the ability to dampen power spikes. It also reduces device errors by optimising reactive power control. SVC is used to improve transient reliability.

- **Static synchronous series compensator (SSSC)**

The AC system and the SSSC are related in order. It's a synchronous generator that runs at a constant speed. The output voltage is in phase with the line current when regulating transferred electric power. The modified output current is used to monitor the magnitude of nodal or bus reactive force.. The schematic diagram of typical SSSC in show in Fig 2.3.

- **Thyristor controlled reactor TCR.**

TCR may also be a thyristor-controlled inductance with a shunt connection. The thyristor valve's partial-conduction management changes its successful physical phenomenon on a continuous basis..

- **Thyristor switched capacitor TSC.**

TSC may also be a thyristor-switched electrical unit with a shunt link. The thyristor valve's efficient physical phenomenon is modified in a stepwise manner by complete- or zero-conduction action.

- **Thyristor switched reactor TSR.**

TSR may also be a thyristor-switched inductance with a shunt link. The thyristor valve's efficient physical phenomenon is modified in an extremely stepwise fashion by absolute- or zero-conduction action.

- **Thyristor controlled braking resistor TCBR.**

TCBR may also be a thyristor-switched system with a shunt link. in the midst of disruptions The TCBR intends to feature associate effect device stabilisation or reduce generation unit power acceleration..

- **Thyristor Controlled series capacitor TCSC.**

TCSC is a physical phenomenon compensator in the most fundamental sense. It consists of a series condenser bank that is shifted by a thyristor-controlled reactor, resulting in the production of a smoothly variable series physical phenomenon.

- **Thyristor switched series capacitor TSSC.**

TSSC is also a physical phenomenon physical phenomenon compensator . It consists of a sequence capacitance bank that is switched by a thyristor..It is

accustomed provide a stepwise management of series physical phenomenon physical phenomenon

- **Thyristor controlled series reactor TCSR.**

The TCSR is primarily a compensator for inductive electrical phenomena. It comprises of a thyristor-powered series reactor. that produces a swimmingly variable series inductive electrical phenomenon.

- **Thyristor switched series reactor TSSR.**

TSSR is an inductive reactance compensator. It consists of a series reactor shunted by a thyristor-controlled reactor. It is used to provide a stepwise control of series inductive reactance.

- **Thyristor controlled phase shifting transformer TCPST.**

TCPST provides rapidly variable phase angle. It is a phase-shifting transformer adjusted by thyristor. This controller is also referred to as TCPAR.

- **Unified power flow controller UPFC.**

planned UPFC is one among the FACTS devices which offer coincident management of The STATCOM and SSSC are related in such a way that they share a common dc condenser in the Unified Power Flow Controller. SSSC and STATCOM are regulated to produce simultaneous true and reactive series line compensation when there is no external electrical energy source. UPFC is the most robust FACTS voltage and power flow controller management in a single thread. Prior to dynamic compensation, all specific grid parameters (transmission voltage, line resistance, and segment angle) must be set. of grid. UPFC will fulfill the functions of STATCOM, SSSC and section shifter. A typical diagram of UPFC.

- **Generalized unified power flow controller GUPFC.**

GUPFC can monitor device parameters such as bus voltage and actual and reactive power flows in the line. It can control five variables: a bus voltage, as well as freelance active and reactive power flows between the two tracks. A regular dc connection switches the \$64000 power between shunt and series converters.

- **(S)Inter phase power controller IPC.**

Any part of an IPC may be a series-connected controller with inductive and electrical phenomenon branches. to use dominant component changes and/or branch impedances to control reactive and active power Mechanical and electrical switches are used in IPC.

- **(T)Thyristor controlled voltage limiter TCVL**

TCVL is a metal-oxide varistor with a thyristor switch. It is used to limit the voltage across its terminals under transient conditions.

- **(U)Thyristor controlled voltage regulator TCVR**

TCVR is a thyristor-controlled transformer. It can provide variable in-phase voltage with continuous control.

- **(V)Interline power flow controller IPFC**

IPFC may be a mixture of two or more SSSCs. IPFCs are connected to the SSSC's ac terminals through a normal dc connection, allowing for bi-directional real-time power flow. These are managed to generate freelance reactive compensation for the modification of actual power flow in each line and to ensure the necessary reactive power flow distribution among the lines.. If a STATCOM is connected to the IPFC common dc connection, it provides shunt reactive compensation. It compensates for or absorbs the conjoined SSSC's overall actual power deficit. The aim of installing this controller is to address the issue of transmission line range at a station. Two converters are seen schematically in this diagram. IPFC is shown in fig 6.

Different transients occur in power systems, which can disrupt the overall system's output. The use of FACTS controls will improve the system's accuracy. The table below lists certain power system controls and their FACTS controller solutions.

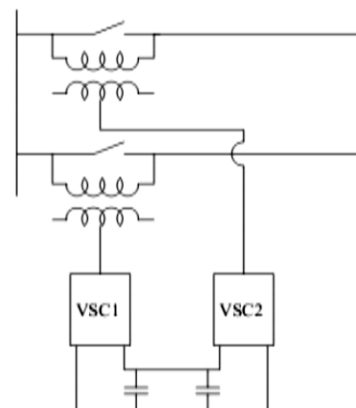


Figure 6. IPFC [6].

IV. STATIC SYNCHRONOUS SERIES COMPENSATOR (SSSC)

This section covers the static synchronous sequence compensator (SSSC). We'll take a look at some series compensation techniques. to get a better understanding of how the SSSC works.

Historically, series capacitors were used in long cables to maximise power transfer and compensation. Capacitors are the most cost-effective solution for this. The disadvantage of using a condenser in a shunt is subsynchronous resonance (SSR). Using a synchronous resonance-free road area system to mount a condenser in a shunt. The positioning of the condenser in the shunt has a significant impact on its installation. Shunt capacitors are normally mounted at the cable's end. There are no such requirements for series capacitors. to achieve a degree of power parity improvement, shunt condenser can want higher rating. Qsh represents Shunt condenser is an example, and Qse is the series condenser ranking. Equation 3.1 illustrates the relationship between Qsh and Qse

$$\frac{Q_{se}}{Q_{sh}} = \tan^2\left(\frac{\delta_{max}}{\delta}\right) \dots\dots\dots(6)$$

The equation 3.1 describes the transmission of an equivalent a certain level of power a wire. exemplify the sharpest angular difference between the cable's ends. Series electrical condensers have a lower compensation benefit than shunt electrical condensers. As opposed to series electrical condensers, the price per unit volt-ampere of a shunt electrical condenser is 0.5. Series electrical condenser rating can nearly be 100% of shunt electrical condenser rating.

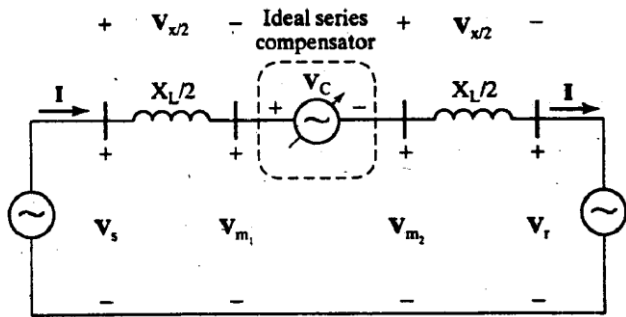


Figure 7. In the transmission line, there is an Series compensator that's ideal.

A. Principal Of Series Compensation

The movement of current would be controlled by introducing a voltage in parallel with the transmission. Between the causation and receiving finish of wire, the capacity will be regulated. The voltage supply VC is attached at the cable's intermediate point. as shown in Figure 3. A perfect series compensator is represented by 1. line current flowing in transmission line is given by 9

$$I = \frac{V_s - V_r - V_c}{jX} \dots\dots\dots(7)$$

In a transmission line, a Only reactive power may be supplied or absorbed by a voltage source. since a series compensator cannot supply or absorb actual power [4]. Capacitive or inductive impedance, as seen in equation 3.3, takes its place.

$$X_{eff} = X - X_{comp} \dots\dots\dots(8)$$

Inductive or electrical phenomena are represented by Xcomp, and absolute cable impedance is represented by X. The efficient electrical phenomenon is described by Xeff. By using a 90o inductive mode, current leads voltage.. once the need is to decrease the facility flow within the cable inductive compensation is finished. Power isn't absorbed/generated by the voltage supply (VC) put in in inductive and electrical phenomenon modes. electrical phenomenon mode of compensation is often used[4].

B. Applications of Series Compensation

As a result of voltage sags, or spikes, or some other form of interruption. Power grid disturbances and oscillations have a noticeable impact on machine-controlled manufacturing processes. a couple of unit of time disturbances will stop entire system. currently a days

the standard of power is extremely a lot of necessary. top quality power is needed for industrial and industrial purposeBecause of a lack of supply or damage to goods, the trade suffers monetary damages. To protect critical masses from the effects of unsafe electricity quality, semiconductor technology and power physics technology have been used to accomplish similar goals to those accomplished by series capacitors [4]. For management of power flow, voltage stability and therefore the phase stability we are able to use SSSC. SSSC will induce series electrical phenomenon and inductive voltages on a line [5]. A SSSC has the potential to increase or decrease cable ability flow. Since the power supply is detrimental to the system's soundness, the SSSC has a chance to amortise mechanical unit oscillation in relation to the installed capacitors [5].

C. Static Synchronous Series Compensator (SSSC)

Static synchronous series compensator could be a third generation series compensation device. it's a voltage supply converter (VSC) device connected nonparallel with line through coupling electrical device as shown in figure. In power grid, third-dimensional management of power is given by VSC. usually condenser Reactors and banks There was a time when SSSC was used, but now it has been replaced by SSSC. It's a voltage supply change convertor with self-control that provides a voltage that's influenced by line current in part. SSSC is used to control reactive and active power in a line. SSSC is also used to dampen device oscillations. The image and equivalent circuit of SSSC are seen in the figures.

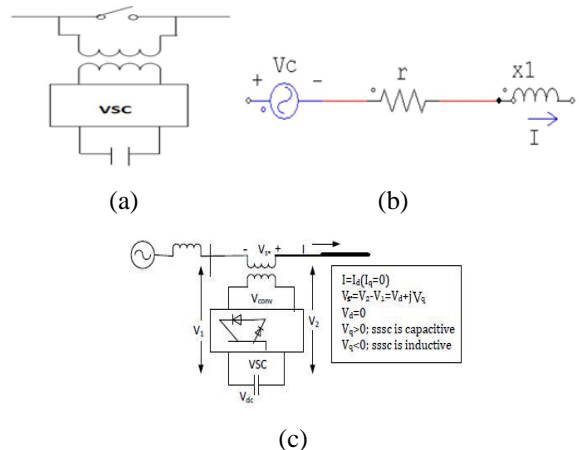


Figure 8. (a) SSSC symbol(b) SSSC equivalent circuit, and (c) The transmission line is connected to the SSSC

Above figure shown as in 4.4 however SSSC is connected with the line within the installation, coupling electrical device is employed to attach SSSC serial with the line, electrica The condenser is attached to the circuit's DC side and is continuously charged by drawing tiny currents. A DC to AC transformer serves as the control block. I, which

may be an insulated-gate bipolar transistor (IGBT). The power flow equation is given in its simplest form. as:

$$P = \frac{V_s V_r}{X_L} \sin(\delta_s - \delta_r) = \frac{V^2}{X_L} \sin \delta \quad \dots\dots\dots(7)$$

$$Q = \frac{V_s V_r}{X_L} (1 - \cos(\delta_s - \delta_r)) \quad \dots\dots\dots(8)$$

$$= \frac{V^2}{X_L} * (1 - \cos \delta) \quad \dots\dots\dots(9)$$

Since SSSC will simulate a compensating reactance Xq (both inductive and capacitive) in series with the transmission line inductive reactance XL, the power flow expressions become:

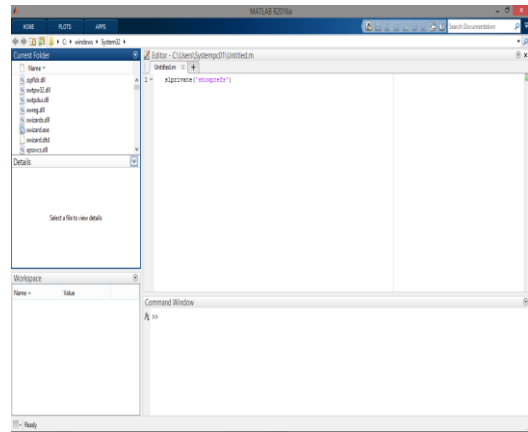
$$P_q = \frac{V^2}{X_{eff}} \sin \delta = \frac{V^2}{X_L(1 - \frac{X_q}{X_L})} \sin \delta \quad \dots\dots\dots(10)$$

$$Q_q = \frac{V^2}{X_{eff}} (1 - \cos \delta) = \frac{V^2}{X_L(1 - \frac{X_q}{X_L})} (1 - \cos \delta) \quad \dots\dots\dots(11)$$

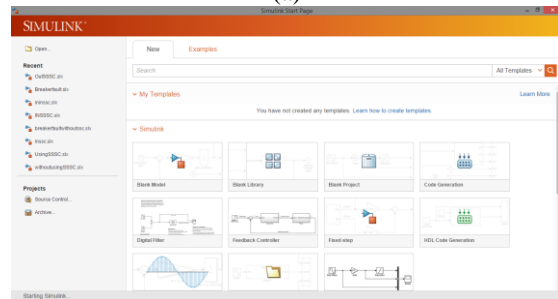
Xeff is an electrical anomaly that occurs in the cable at the causation and receiving ends. It also has an emulated vector electrical anomaly Xq inserted by the injection voltage supply of the SSSC in equations three and four.

V. MODELLING OF CURCUIT IN MATLAB SIMULINK

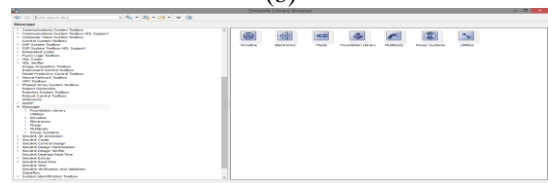
This chapter's primary purpose is to add, explain, and set all of the SSSC parameters., with modelling done in the MATLAB/Simulink kit. In a grid network, SSSC is used for compensation. The circuit is implemented in MATLAB, a fourth-generation programming language for manipulating matrices, plotting functions and information, and implementing algorithms, among other things. Version R2016a of MATLAB is used to simulate expected function. employed during this analysis as shown in figure 5.1. To fill in the gaps in Simulink's surroundings, open the MATLAB tool strip and select the Simulink library option as shown. in fig5. 2. By way of the void library As seen, the simulation process is begun. in figure 5.3. There area unit range of libraries. in keeping with demand of model style correct library is chosen. Here 1st simscape library is chosen, by choosing simscape library, the below figure window opened. Sim power grid, sim fluid mechanics, sim natural philosophy etc. will be seen in simscape any in figure5.4.Simscape create offered Associate in Nursing atmosphere for modeling and simulating physical systems. It includes mechanical, electrical, hydraulic, and different physical domains. power grid is chosen because it is that the needed library. there are further different blocks as The window of power system shows that, namely application libraries, power electronics, electrical sources, power gui etc.The power guiblock is shown in figure 6.2. , which is needed for any Simulink model simulation. It includes advanced technology blocks for the Sim Power Grid.



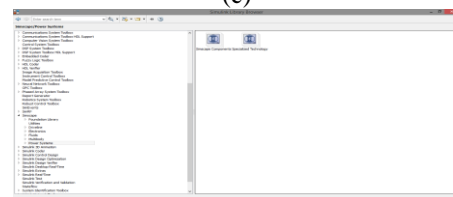
(a)



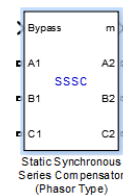
(b)



(c)



(d)



(e)

Figure 9. (a) MATLAB R2016a window, (b) Simulink start page, (c) Simulink library, (d) Grid of control in Simscape, and (e) . SSSC model in Matlab/Simulink

A. Modelling Of SSSC In MATLAB/Simulink

The two types of SSSC parameters are as follows: Awareness and control conditions of great power. to pick out the cluster of parameters that ar to envisioned show list box is employed. A1, B1 and C1 ar three input terminals and A2, B2 and C2 ar the 3 output terminals. By pass breaker ar set to

external management. once parameters are Simulink signal is used when external management is selected. When the input is low or empty, bypass breakers open. and the other way around. There are seventeen SSSC internal signals in Simulink output vectors. These are either voltage or current phasors or management signal. they'll be approached by mistreatment the bus selector block, MATLAB/Simulink model of SSSC is shown. they'll be separately hand-picked by using the Bus Selector block.

1. Power Data

Figure 4 shows the Power tab. Nominal frequency and voltage, series convertor rating, series convertor starting line current, and the nominal voltage of DC Link are all examples of these values, and DC link gross equivalent capacitance, should be measured meticulously for SSSC modelling. Here is a detailed description of each one.

1.1. Nominal voltage and frequency

The nominal line-line voltage (Vres) is measured in hertz, and the frequency unit is hertz. The nominal line-line voltage in our test system is 123KV, and the frequency is fifty cycles per second.

1.2. Series Converter rating

The maximum price of the pumped T/F in PV of nominal component to ground voltage V_{conv} on the voltage supply device axis in the series system nominal rating in (VA.). Default is [100e6, 0.1]

1.3. Series Converter impedance

The nominal convertor rating and nominal voltage were provided by the importance of positive-sequence resistance and inductance in per unit. The resistance and discharge inductance of the coupling electrical system located between the conductor and the voltage source converter, as well as the resistance and inductance of the series filtering inductors attached at the voltage source converter output, are represented by R and L.. Default is [0.16/30, 0.16].

1.4. Series Converter initial current

The magnitude and importance of the phasor current. of that is in per unit and introduce degrees is shown by this parameter. If the initial price of this in an exceedingly circuit is thought with reference to the SSSC in operation purpose could specify it so as to start out simulation in steady state. If initial price isn't identified, then mark them each zero [0 0]. once a brief transient the system can reach steady state. Default is [0, 0].

1.5. DC link nominal voltage

The DC link's nominal voltage in volts. Its default setting is 40000.

1.6. DC link total equivalent capacitance

The price/value of DC relation capacitance, as well as the value in farads, are shown in this parameter. This figure is based on the SSSC converter's ranking and the DC's nominal voltage. connector. A change in the nominal voltage of the DC connection or the converter rating may change the value of capacitance in a variety of ways. The

DC link's entire capacitance is measured in faradsThe value of the capacitance is proportional to the SSSC converter rating and the nominal voltage of the DC connection.

2. Controller Tab

The figure depicts the Controller tab. For SSSC simulation, The injected voltage regulator V_{qref} , bypass breaker, and DC voltage regulator gain levels should all be carefully considered. defined. Each one is explained in detail below.

2.1. Bypass Breaker

The bypass breaker's state is defined by this parameter. It's either transparent management, closed management, or external management. In external power, the by pass is controlled by an external signal.

2.2. Injected voltage reference V_{qref}

It is the atomic number that specifies the quadrature-axis portion of the voltage injected on the voltage device component of the coupling electrical device. 94.Default is 0.05.

2.3. Maximum rate of change for V_{qref}

It is the V_{qref} voltage's maximum rate of transition, its value is in pu/second. Default is 3.

2.4. Injected voltage regulator gains: [Kp Ki]

The price of injected transformer gains is the PI regulator gain that manages the injected voltage. The series unit resistivity parameters are used to calculate forward gain. The integral gain is k_i , and the proportional gain is k_p

2.5. Vdc regulator gains: [Kp Ki]

The PI regulator gain of DC voltage regulates the voltage around the DC side capacitor. Its values are calculated on a per-unit basis.

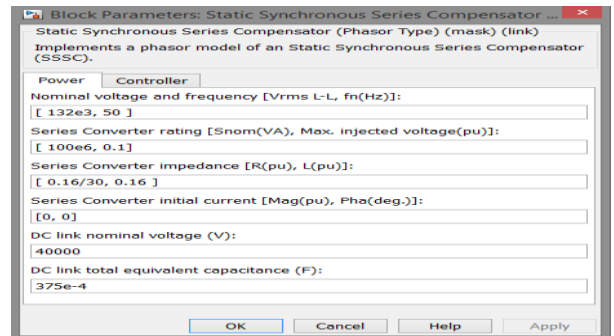


Figure 10. Control Screen/SSSC Parameter

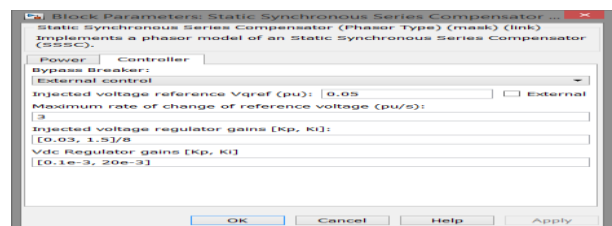


Figure 11. Control parameters/SSSC parameters

VI. SIMULATION AND CASE STUDY

The model is implemented in MATLAB/Simulink in this chapter. The method's results with and without SSSC are compared. The model was chosen from the swat space because low voltages are a problem in this region, particularly during peak load in the months of June, Gregorian calendar month, and August. We will increase the voltage profile, the power flow, and the system's transient stability by using SSSC..

In this paper we have a tendency to study the case study of city electrical provide company. PESCO has many range of 132 potential unit, sixty six potential unit and 132 potential unit grid stations and every one ar associated with one another. With relation to transmission and distribution facet the ability system has bound limitations in PESCO. The emphasis here is on a line case study. The current status of the case study is on line. Figure 5.1 depicts the current state of affairs for the case study, which includes Kohat, Gurguri, and Tall 132 future unit grid stations. Low voltage issues arise during peak load, especially in the months of Gregorian calendar month, Gregorian calendar month, and August, and the system becomes overloaded, as seen in tablea single Once there is a high prevalence of major faults in transmitting electricity, the problem of transient stability would become the limiting factor. SSSC is located near Gurguri grid station to improve capacity transfer capabilities and expand voltage reliability under overloaded and fault situations. The likelihood of blackouts can be reduced by increasing voltage stability at the patron finish. ar reduced during this space forced load shedding that is taken into account as an enormous loss for the utility firms is avoided.

In MATLAB/Simulink, the test device is simulated under overloaded conditions. As seen in figures 5.2 and 5.3, the outputs of the test device with and without SSSC in the circuit are evaluated..

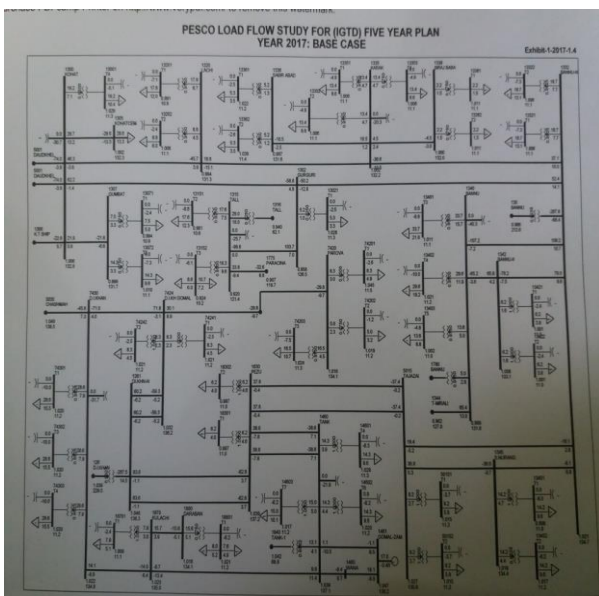


Figure 12. System for Testing

A. System without Using SSSC

In this device, a three-section programmable voltage supply is shaped like a 132 kilovolt Kohat grid station in MATLAB/simulink. This system makes use of three buses: the Kohat bus, the Gurguri bus, and the Tallbus. These are shaped like a three-section V-I activity. The cable between the grids is intended by the dispersed line parameter block gift in areas of the power grid.. In Simulink check system is shapely while not SSSC. Under overloaded conditions, the findings are analysed.

B. System Using SSSC:

From Kohat to Gurguri, there is a 132 kilovolt conductor. As seen in Figure 5.3, SSSC is placed near the Gurguri bus. Since the line length varies between medium conductors, SSSC can be used. The SSSC is used to meet the need for a check method. The check method is simulated with SSSC in Simulink, and the effects are also analysed..

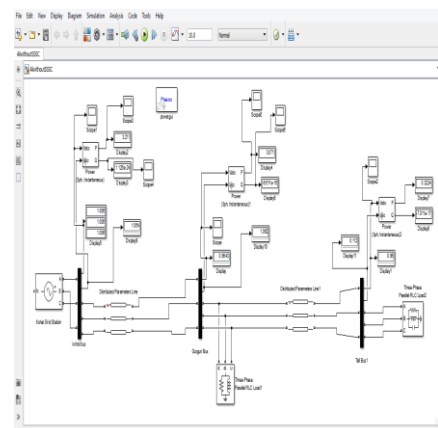


Figure 13. Without using SSSC, build a Simulink model of a test device

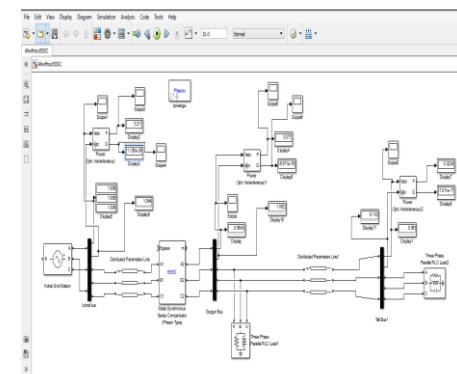


Figure 14. Simulink is a programming language that allows you to create SSSC model of a test device

C. Discussion on Results

Table three and Table four, respectively, demonstrate the outcomes of simulations with and without SSSC. The findings show that the voltage profile at Gurguri and Kohat buses has risen. The active and reactive power of the system are also

compounded. The values are given in per unit, in accordance with PESCO zero. 95 Pu is beyond the safe voltage range; beyond this, the circuit becomes overloaded.

At peak hours, the voltage on the Gurguri and Kohat buses falls below the safe voltage cap, causing current to rise inside the circuit, increasing losses and causing the battery to become overloaded, resulting in load shedding, which is a loss to PESCO.

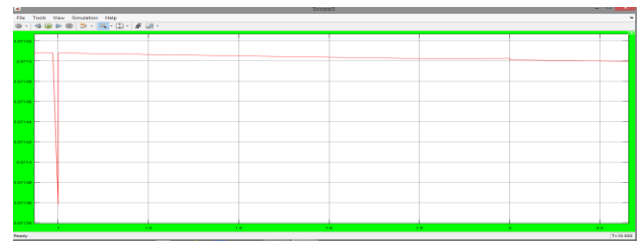
FACTS technology series compensator SSSC is installed inside the device to minimise losses and extend the flow of electricity. After simulation, it would be clear that the voltage profile has been changed and compounded on top of zero. Every Kohat and Gurguri bus costs 95 Pu. In addition, the flow of active and reactive power inside the device has increased. Figures 5.16 and 5.17 show the consequences of reactive and active control for both the SSSC-free and SSSC-enabled test systems, and the simulation findings show that the system without SSSC oscillates rather than the system with SSSC. As seen in Figures 5.18 and 5.19, using SSSC in the system causes oscillations to be damped easily and the system to become stable.

TABLE I. TABLE TYPE STYLES

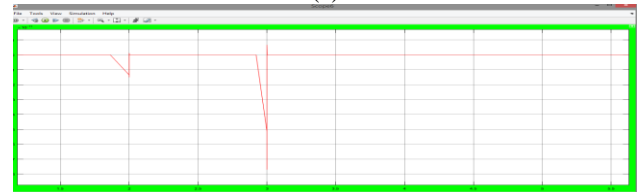
Bus	Voltage per unit (pu)	Current per unit (pu)	Active Power per unit (pu)	Reactive power per unit (pu)
Kohat bus	1.007	1.020	1.201	0.9596
Gurguri Bus	0.9424	1.031	1.207	0.8255
Tall Bus	0.9181	0.1871	0.2010	0.1922

TABLE II. TABLE TYPE STYLES

Bus	Voltage per unit (pu)	Current per unit (pu)	Active Power per unit (pu)	Reactive Power per unit (pu)
Kohat Bus	1.061	1.065	3.212	2.973
Gurguri Bus	0.9644	1.063	3.072	2.959
Tall Bus	0.961	0.113	0.3225	0.1989

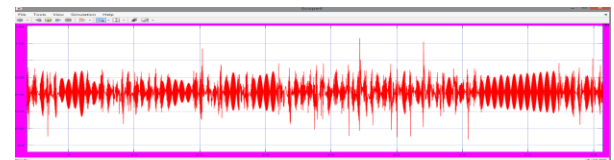


(a)

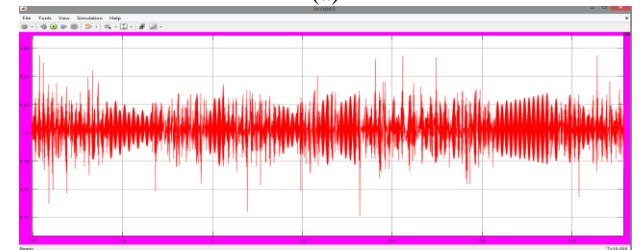


(b)

Figure 15. (a) Under overloaded conditions, active power flow in a test device using SSSC (b) Figure 27. Under overloaded conditions, SSSC is used to simulate the flow of reactive control in a test environment.



(a)



(b)

Figure 16. (a) Under overloaded conditions, reactive control flow in the test system without the use of SSSC, and (b) Under overloaded conditions, active power flow in the test device without the use of SSSC is possible.

CONCUSLION

For grid reactive power compensation, SSSC has recently emerged as the most powerful and required system.. The cost of installing new transmission lines is usually low. It's also very time consuming, disrupts power supply, and costs a lot of money in maximum space. Because of the construction of the most recent transmission lines, the status of the realm has changed. is lost SSSC is used to increase voltage stability and expand the ability flow. It's the most cost-effective way to improve power transfer. The 132Kv conductor returning from Kohat to Gurguri is used as a case study in the PESCO room in Kohat. Voltage stability is not preserved in overloaded situations, especially during the months of Gregorian calendar month, Gregorian calendar month, and august. Losses will rise, forcing load shedding, which will result in a significant reduction in the capacity to deliver services. The grid network

is in desperate need of compensation. SSSC is used in this research study to achieve voltage consistency and improve power transfer within the network. Simulink enforces the check model with two very separate scenarios. While being victimised even while not being victimised SSSC is an acronym for "Standardized The effects of current, voltage, active control, and reactive power are analysed in this method. The first section of the check method was simulated in its entirety. When comparing simulation results, it's obvious that using SSSC inside the circuit improves the voltage profile significantly. In addition, the victimisation of power flow capacity has grown. SSSC is an acronym for "Standardized Standardized The check mechanism was simulated under a typical three-section tangency fault in the second section, and the results indicate In contrast to the circuit without SSSC, the oscillation was damped remarkably quickly using SSSC, and stabilisation was achieved. was sustained.

In Pakistan, SSSC can be deployed on more complex networks, ensuring future stability. The voltage profile and power flow regulation in MATLAB/Simulink are investigated. Via further machine studies, the location of SSSC should be configured for network.

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