INVESTIGATION OF SSSC CONTROLLER EFFECT ON POWER SYSTEM USING ADVANCED TECHNIQUE

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IN

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By

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ABSTRACT

Present days the requirement of electrical power has been increasing day by day. Due to some environmental effect it is very difficult to make new transmission networks and production systems. There is a problem in the control of energy transmission system is reactive power compensation. Due to heavy loads in transmission line there is more losses in the transmission line to compensate these losses the Static Synchronous Series Compensator (SSSC) is used to decrease the synchronous oscillations in series capacitor compensated power system. A long transmission line requires controllable series as well as shunt compensation. Due to use this compensation there is power flow control and voltage regulation. This can be done by combination of passive and active FACTS controllers. Electrical power system is very important as the electrical load demand increase all over the countries. Due to this it is much difficult to provide stability and control in power system. It is become more correct increase the transmission line capacity. And this is control by providing reactive power compensation. To reduce the losses in the transmission line and improve the reactive power compensation the static synchronous series compensator (SSSC) is used. Due to these FACTs controllers increase the static load limits. The study utilized rapid responding SSSC (Static Synchronous Series compensator) that are formed by power electronic elements. The effect of these devices on voltage stability on the power carried on the lines and the losses that occur on the lines were investigated with the simulation and its result. MATLAB/SIMULINK is used as a simulation tools.

TABLE OF CONTENTS

Chapter-1: Introduction 1-15

1.1 Introduction 1

1.2 FACTs controllers generations 4

1.3 Two types of compensation in FACTs system 5

1.3.1: Series compensation 5

1.3.2: Shunt compensation 6

1.3.3: Shunt Capacitive Compensation 6

1.3.4: Shunt inductive compensation 7

1.4 Benefits of utilizing FACTS devices 7

1.5 Static synchronous series compensator (SSSC) 8

1.6 V-I Characteristics of SSSC 10

1.7 General diagram of SSSC power flow control 11

1.8 Power flow control for SSSC 13

1.9 SSSC controller model for stability studies 13

Chapter-2: Review of Literature 15-23

Chapter-3: Present Work 24-34

3.1 Scope of study 24

3.2 Objective 25

3.3 Research Methodology 26

3.3.1: Static Synchronous Series Compensator (SSSC) 26

3.3.2: Power Flow Controller for SSSC 27

3.3.3: SSSC controller model for Stability studies 27

3.3.4: SIMULINK Modeling of SSSC 28

3.3.5: PI Power Flow controller of SSSC 28

3.3.6: Fuzzy logic controller (FLC) design methodology 29

3.3.7: FLPOD controller along with PIPF Controller of SSSC 31

3.3.8: Use of fuzzy logic 33

Chapter-4: Result and Discussion 35-40

4.1: MATLAB SIMULATIONS AND RESULTS 36

4.2: Subsystem used as a series controller 38

4.3: Fuzzy logic controller 38

4.4: The FFT analysis of THD (Total Harmonic Distortion) 40

Chapter-5: Conclusion and Future Scope 41-42

5.1: Conclusion 41

5.2: Future Scope 42

References 43-44

List of Figures

Figure1.1: Diagram of series compensation 5
Figure1.2: Diagram of shunt compensation 6
Figure1.3: Diagram of SSSC 9
Figure1.4: Diagram of four-quadrant of SSSC 10
Figure1.5: Diagram of V-I Characteristics of SSSC 11
Figure1.6: General Control diagram of SSSC for power flow control 12
Figure1.7: Diagram of Power flow controller diagram for SSSC 13
Figure1.8: Diagram of SSSC controller model for stability studies 14
Figure1.9: SSSC configuration 26
Figure1.10: Power flow controller diagram for SSSC 27
Figure1.11: PIPF Controller block diagram of SSSC 28
Figure1.12: FLPOD controller along with PIPF controller block diagram of SSSC 29
Figure1.13: Sample fuzzy logic controller 30
Figure1.14: Five fuzzy sets of the input 30
Figure1.15: Five fuzzy sets of the output 31
Figure1.16: Diagram of FLPOD for SSSC 32
Figure1.17: Two bus system without SSSC 36
Figure1.18: Voltage Sag without SSSC 36
Figure1.19: Current increment without SSSC 37
Figure1.20: SSSC MATLAB SIMULATION 37
Figure1.21: Subsystem of SSSC 38
Figure1.22: Fuzzy logic controller 38
Figure1.23: Output voltage waveform 39
Figure1.24: Output current waveform 39
Figure1.25: THD analysis 40

CHAPTER-1

Introduction

1.1 Introduction

Currently, the demands of power have enlarged. Due to several environmental effects it is not simple to arrangement new transmission networks and generating centers. The trouble arise in power system is reactive power. The reactive power increases the victims in transmission line; reduce the power in the transmission lines. At the closing stages of line the voltage amplitude is tainted. It is compulsory to offer reactive power compensation to boost transmittable power, lessen losses and afford voltage stability. The reactive power compensation is extremely constructive method for transmission capacity and voltage immovability. Electrical power conveys capability of elevated transmission lines is controlled by stability contemplation. Diminish the effective reactance of lines by means of series compensation is enlarge the transmission capability. The static synchronous series compensator (SSSC) is series controller, which is given that the reactive power compensation to power system by involving sequence with the transmission lines. The static synchronous series compensator (SSSC) is enhancing the transmittable power and reduces the losses in lines. By adjust the phase angle the reactive power flow can be prohibited. Here days the necessity of electricity is ordinary rising. It is extremely not easy to build innovative transmission networks owing to a little environmental circumstance and achieve. Owing to extra load in three phase lines there are extra voltage fall and deep losses, to recompense these losses the Static Synchronous Series Compensator is used. By means of this compensation there is power flow control in soaring transmission lines. Power system is extremely significant as the electrical load demand enlarge all over world. Unpaid to this it is tricky to make available stability and manage in electrical system. The static synchronous series compensator is additional accurate increase the transmission ability. This control is providing by reactive power reimbursement to the transmission system.

The electricity surge of line depends on dissimilar parameters, voltage magnitude, transmission line impedance and phase angle among the busses. The controllers direct one or more parameter to enlarge routine of the system by means of facts controllers. It get better the parameters like transient stability, little signal stability, damping of power system oscillation, a smaller amount active power loss, voltage profile, excellence of the power

system operations, efficiency of the power system operations, dynamic performance of power system, power shift ability from end to end the lines and load excellence of the power system network as well enlarge.

The FACTs devices are very good quality controller in electrical system enlarge the system concert It decreases the victims in transmission network. The FACTs are the devices utilize to raise the voltage summary of the power system by means of the adding up of the controller. These devices used for power flow organize in lines and FACTs controller as well utilize for damp power fluctuation. Due to little reaction of comparative integral power surge series the FACTs devices are not a location of in actual fact damp the power scheme oscillation. It requires some secondary system to progress the recital of series fact devices damp power scheme fluctuation. Flexible AC transmission system facts offer the resolution to troubles which are introduce in power scheme with preface of power electronic manage foundation for reactive power. The AC transmission system is definite as "Alternating current transmission scheme power electronic based and enlarges power transport competence". The FACTs system expertise creation use of power electronics gives the control to the transmission lines. It will enhance load of the line. The line capacity is thus increases which recover the system reliability. The growing Industrialization, urbanization of life style has gone ahead to increasing dependency on the electrical energy. This has resulted into rapid development of PSs. This rapid development has resulted into few reservations. Power disruptions and individual power outages are one of the major tribulations and affect the economy of any country. In difference to the rapid changes in technologies and the power necessary by these technologies, transmission systems are being

Pushed to operate more rapidly to their stability limits and at the same time reaching their thermal limits due to the fact that the escape of power have been growing. The main problems faced by power industries in found the match between supply and demand is:

Transmission & Distribution; supply the electric require without beyond the thermal limit.

In large PS, stability problems causing power disruptions and blackouts leading to huge losses.

These constraints distress the quality of power delivered. However, these constraints can be suppressed by ornamental the PS control. One of the top methods for reducing these constraints is FACTS devices. With the quick growth of power electronics, FACTS devices have been projected and implemented in PSs. FACTS devices can be utilized to control power flow and develop system stability. Predominantly with the deregulation of the electricity market, there is a growing interest in using FACTS devices in the procedure and control of PSs. A superior utilization of the existing PSs to enlarge their capacities and controllability by installing FACTS devices becomes necessary. FACTS devices are cost effective alternatives to new transmission line construction. Due to the current situation, there are two main aspects that be supposed to be considered in using FACTS devices: The first aspect is the flexible power system operation according to the power flow control ability of FACTS devices. The other aspect is the advance of transient and SSVS of PSs. FACTS devices are the correct equipment to gather these challenges.

- Combined Series‐series Connected ‐FACTS Device:

It is arrangement of separate series FACTS devices, which are controlled in a corresponding manner.

- Combined Series‐shunt Connected ‐FACTS Device:

Combined series-shunt FACTS device is a grouping of separate shunt and series devices, which are controlled in a corresponding manner or one device with series and shunt elements. Control attributes for a range of FACTS Controllers

The Control Attributes for Various FACTS Controllers

- Possible Benefits from FACTS Technology

In the important system security guidelines, the devices allow the transmission system to get one or more of the following revenue: Control of power flow as ordered. This is the main function of devices. The use of power flow control may be to follow an agreement meet the utilities' own desires, make sure optimum power flow, ride through urgent situation conditions, or a combination of them.

Enhance utilization of lowest cost generation. One of the principal reasons for transmission interconnections is to utilize the lowest cost generation. When this cannot be done, it follows that there is not sufficient cost-effective transmission capacity. Cost-effective development of capacity will therefore allow increased use of lowest cost generation.

- Enlarge the loading capability of lines to their thermal capabilities, including short term and seasonal demands.
- Improved system reliability.
- Elimination or deferral of the need for new transmission lines.
- Added flexibility in siting new generation
- Provide secure tie-line connections to nearest utilities and regions thereby decreasing overall generation reserve needs on both sides.
- Upgrade of transmission lines.
- Increased system security.
- Reduce RP flows, thus allowing the lines to carry more AP.

1.2: FACTs controller generation

For the development of FACTs controllers:

a. First generation of FACTs controllers:

There are a number of FACTs controllers Thyristor Controlled Series Capacitor (TCSC), Static Var Compensator (SVC). And the Thyristor Controlled Phase Shifting Transformer (TCPST) is in the first generation.

b. Second Generation of FACTs controllers:

There is a number of controllers such as Static Synchronous Series Compensator (SSSC), Static Synchronous Compensator (STATCOM), Interline Power Flow Controller (IPFC) are developed in the second generation.

FACTs devices

A flexible alternating current transmission system is a system composed of static equipment used for the AC transmission of electrical system. It will defend controllability and enlarge power transfer of the network. This system is based on the power electronic. The FACTs is also defined as it is a power electronic based system that provides control of one and more AC transmission system parameters to enlarge controllability and power transfer capability.

The use of FACTS devices from new compensation methods gains importance when we consider their rapid response time. FACTS devices are power electronic based in term of control, they can provide fast responses. These devices are increase the stability limits of

transmission lines. The FACTS have two main purposes to enlarge the stability. The first purpose is to enlarge the transfer power of the transmission systems and the second purpose is to control the power flow on the lines. The most commonly use once are static VAR compensator (SVC), Thyristor controlled series capacitor (TCSC), Static Compensator (STATCOM), Unified power flow controller (UPFC), Phase Shifter and Static Synchronous Series Compensator (SSSC).

1.3: Two types of compensation in FACTs system

1.3.1: Series compensation

These devices are connecting in series with the transmission lines these device workings as controllable voltage source and series inductance having in all AC transmission lines. In the long transmission lines, when the huge current flows, in this case there is very huge voltage fall in the transmission lines. To balance these voltage drops, series capacitor are joined to reduce the effect of the inductance on transmission lines in power system.

Series FACTS devices could be variable impedance, such as capacitor, reactor, etc., or power electronics based variable source of main frequency, sub synchronous and harmonic frequencies (or a combination) to serve the desired need. In principle, all series FACTS devices inject voltage in series with the transmission line.

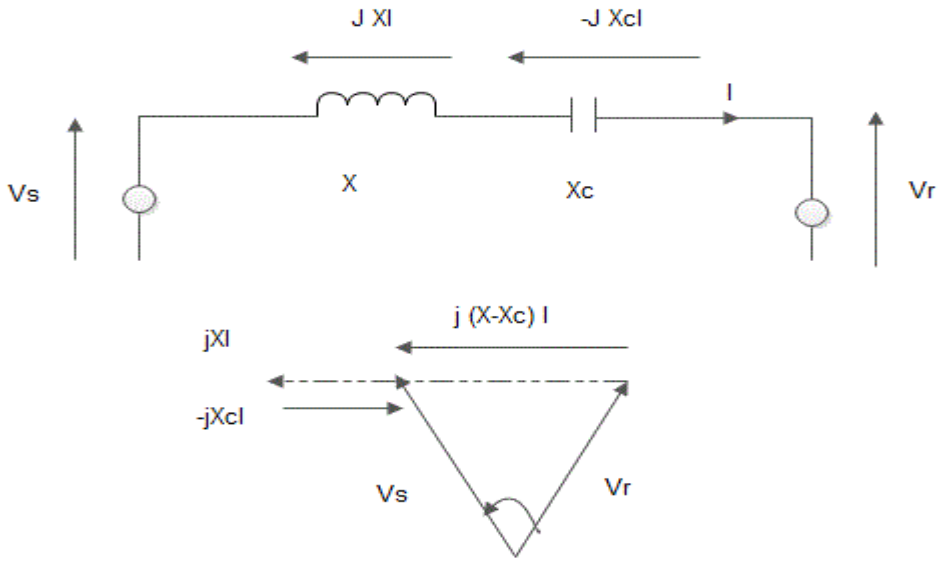

Figure1.1: Series compensation

1.3.2: Shunt compensation

In this flexible AC transmission, the FACTs devices are linked parallel with the transmission lines. And these shunt compensation workings controlling current source. This compensation is of different types.

Shunt FACTS devices may be variable impedance, variable source, or a grouping of these. They add current into the system at the point of connection.

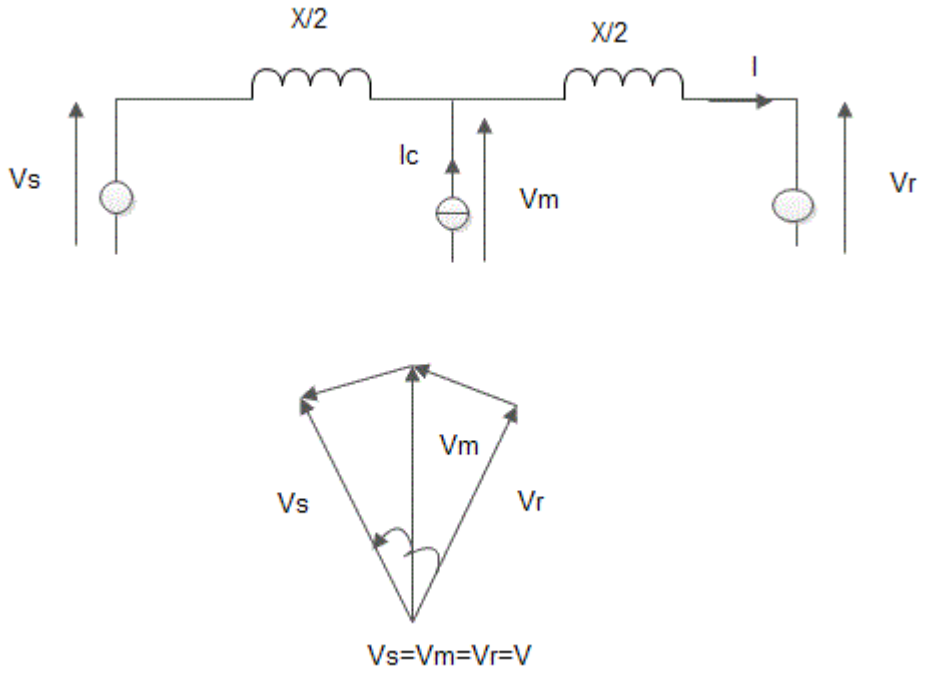

Figure1.2: Shunt compensation

1.3.3: Shunt Capacitive Compensation

To get better the power factor shunt capacitive compensation is used. Inductive load is connected to the transmission line in the power system, power factor lags. A shunt capacitor is connected and this shows leading current the voltage source. The absolute thing is to development power factor due to connected this shunt capacitive compensation.

1.3.4: Shunt Inductive Compensation

Charge the line there is low load at the receiving end, shunt compensation is used. No load conditions very minute current travel in transmission lines. Shunt capacitance in the power system line due to voltage amplification. The receiving voltage doubles to the sending end voltage in case of long transmission line. The shunt inductors are connected to the transmission line.

1.4: Benefits of utilizing FACTs devices

The upsides of utilizing FACTS gadgets as a part of electrical transmission frameworks are depicted underneath.

- More usage of existing transmission framework
- Reliability of Transmission framework increments.
- More Increased transient and element steadiness of the framework.
- Increased more nature of supply for expansive commercial enterprises
- Beneficial for Environment.

A. More utilization of existing transmission system in all the countries, the power demand is increasing day by day

Day to exchange the electrical power and controlling the heap stream of the transmission framework is exceptionally essential .this can be attained to by more load focuses which can change often. Expansion of new transmission line is excessive to take the expanded load on the framework; all things considered FACTS gadgets are much sparing to meet the expanded load on the same transmission lines.

B. More Increased transient and dynamic stability of the system

The Long transmission lines are between joined with frameworks to retain the changing the stacking of the transmission line and it is likewise seen that there ought to be no line issue makes in the line/ transmission framework. By doing this the force stream is decreased and transmission line can be trek. By the utilization of FACTS gadgets high power exchange limit is expanded in the meantime line tripling deficiencies are likewise decreases.

C. Increased more quality of supply for large industries

New commercial enterprises needs great nature of electric supply, consistent voltage with less change and wanted recurrence as specified by power office. Decrease voltage, variety in recurrence or loss of electric force can diminish the assembling of the business and reason to high sparing misfortune .FACTS gadgets can serves to give the obliged nature of supply.

D. Beneficial for Environment

Actualities gadgets are getting to be ecologically cordial. Realities a gadget does not deliver any sort of waste risk material so they are without contamination. These gadgets help us to convey the electrical power all the more financially with better utilization of existing transmission lines while diminishing the expense of new transmission line and producing more power.

E. Increased transmission system reliability and availability

Transmission framework dependability and accessibility is influenced by various elements. Despite the fact that FACTS gadgets had capacity to decrease such variables and enhances the framework unwavering quality and accessibility.

1.5: Static Synchronous Series Compensator (SSSC)

In (SSSC) synchronous voltage source appended to transmission line. The SSSC changes the line by gave that voltage to the transmission line proper to the stage edge. The static synchronous arrangement compensator can substitute dynamic and receptive power alongside the line. In the event that the voltage connected to the line and the stream secured from the line are both tremendous in the meantime there is supplant of dynamic force. At the point when the edge between the stream and the voltage is 90°, the force move will be as receptive force supplant. Receptive force is furthermore given to or plausible from the framework relying upon the forward or in reverse status of the stream. The SSSC is an arrangement remuneration gadget. It is utilizing force hardware in view of the voltage source converter (VCS) to control force stream transmission lines. It is likewise get improved transient security in force framework. The SSSC controls the force stream in transmission lines and by controlling the size and stage point of infused voltage (Vse) in arrangement with the transmission line where SSSC is associated. The trading of genuine and receptive power

in the middle of SSSC and force framework relies on upon the greatness and stage uprooting as for transmission line current.

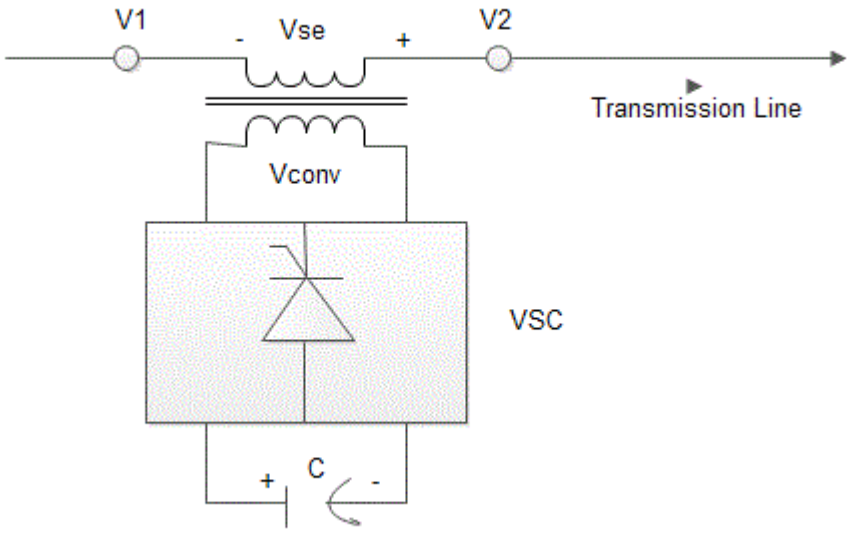

Figure.1.3: SSSC diagram

The SSSC is an arrangement remuneration of the controller's family the force stream in transmission line and upgrade steadiness in force framework. By controlling the size and stage edge of infused voltage (Vse) in arrangement with the transmission line where SSSC is associated. The supplant of genuine and receptive force including SSSC and force framework relies on upon the extent and stage dislodging with adoration to transmission line current.

The Fig. demonstrates the four-quadrant methodology of SSSC. The line current I, is taken as introduction phasor even as the arrangement infused voltage phasor Vse of SSSC is worthy to interchange around the midpoint of the circle unmistakable by the most extreme embedded voltage Vse-max. There is in Capacitive method of operation, the arrangement infused voltage Vse of SSSC is finished slack by 900 among transmission line current. For this situation the SSSC works like arrangement capacitor with variable capacitance kXC, i.e., Vse = - kXC*I, where k is variable. By this activity the aggregate reactance of transmission line is minimal while the voltage over the line is progressed.

This prompts amplify in the line current and accordingly the transmitted force. Where on account of inductive method of operation, the arrangement infused voltage Vse of SSSC is finished to lead by 900 with transmission line current, i.e., Vse = kXC*I.

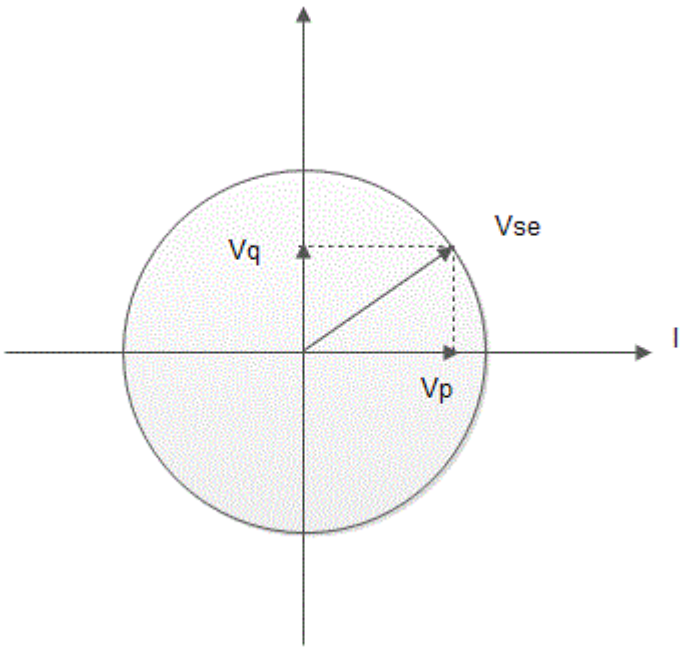

Figure.1.4: Four-quadrant operation of SSSC

This prompts upgrade in the transmission line reactance, which result in reduce in line current and accordingly the transmitted force. The above mathematical statement demonstrates that the extent of Vse is specifically corresponding to the line current (I) size, this is valid for arrangement capacitance, other than not for SSSC. Basically the arrangement embedded voltage Vse is situated by the SSSC control is free of the line reactance. The SSSC can deal with the force course through the transmission line by computing the greatness of Vse and infusing in qudarture with transmission line current I.

1.6: V-I Characteristics of SSSC

The SSSC can offer capacitive voltage and inductive voltage up to its specific most astounding current rating. The SSSC can create an advantageous repaying capacitive or

inductive voltage, which infers that the amount of transmittable force can be enhanced and in addition diminished from characteristic force.

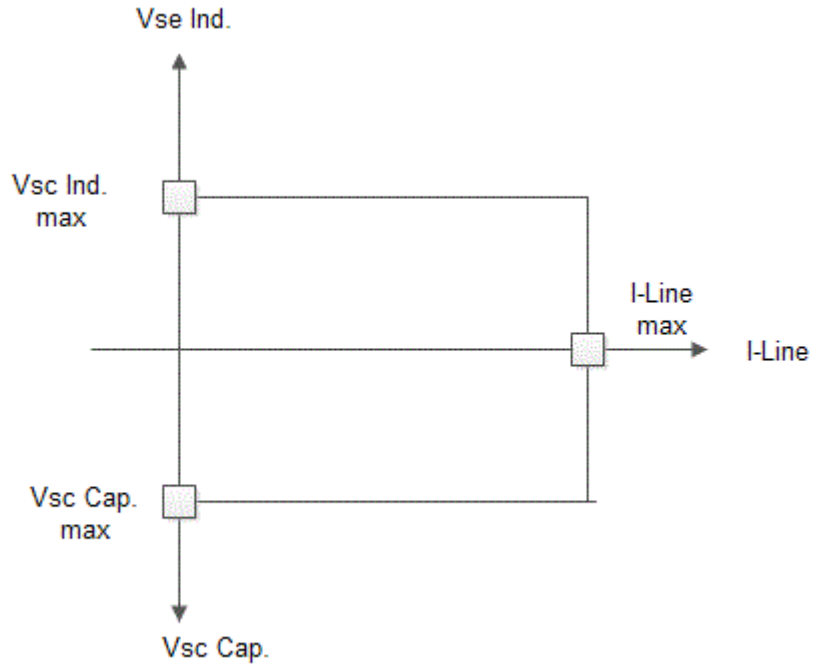

Figure.1.5: V-I Characteristics of SSSC

1.7: General diagram of SSSC for power flow control

Oftentimes utilized working methods of SSSC are

i) Constant voltage infusion mode.

ii) Constant impedance imitating mode.

iii) Constant force control mode

The Fig.4.12 demonstrates the general outline of SSSC for force stream control. This control framework is working in light of the force reference values. It comprises of

- PI controller: Two different PI controllers are utilized to control dynamic and responsive power in the transmission line. The yields of PI controllers are d, q parts of the arrangement infused voltage.

• Power estimation square: It figures the dynamic and responsive force move through the transmission line.

• SSSC arrangement infuse voltage reckoning square: This piece figures the SSSC yield voltage size and the point relies on upon the yields of PI control

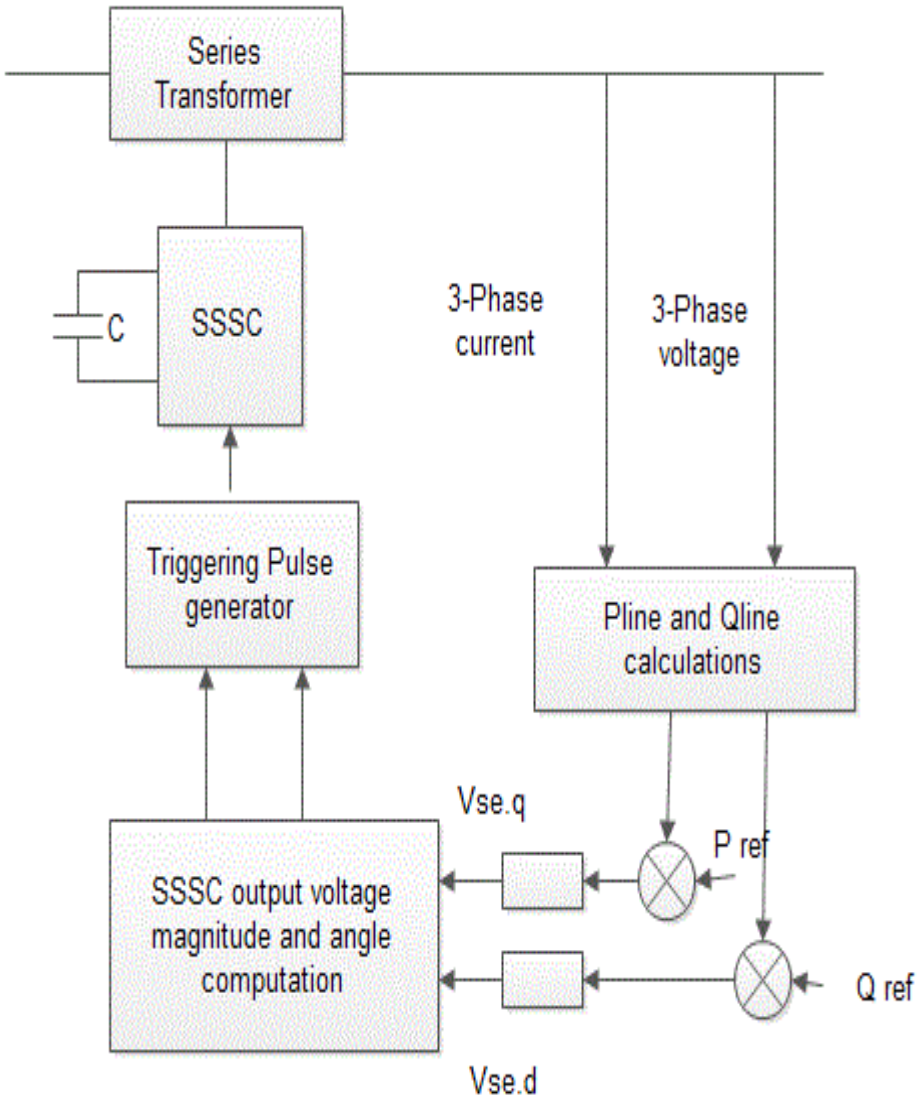

Figure.1.6: General Control diagram of SSSC for power flow control

1.8: Power Flow Controller for SSSC

In this postulation, the force stream controller is consistent genuine force stream controller. Structure for the force stream controller of SSSC works in consistent force control mode, Vseq is controlled to take care of the force demand in the line set by the reference force set point (Pref). The information signs to this controller are reference power (Pref) sign and real power moving through line (Pm). The yield is the suitable arrangement infused. Voltage (Vseq) needed by the framework according to the reference power (Pref).

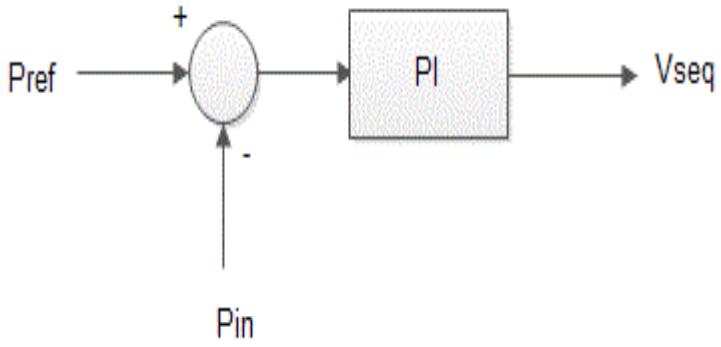

Figure.1.7: Power flow controller diagram for SSSC

1.9: SSSC controller model for Stability studies

The Fig. demonstrates the general piece outline of the SSSC controller for dynamic and enduring state solidness studies. It comprises of Power stream controller and soundness controller. Force stream controller is utilized to control force stream in the transmission line under consistent state condition by contrasting force stream in transmission line and reference force set point. On the off chance that this controller is ease back because of the huge time steady of PI controller or in the event that it is physically worked, the yield (Vseq0) of force stream controller is to be consistent amid extensive unsettling influences, due to this force motions increment. To lessen power motions the SSSC must be in a position

to give greatest pay level instantly after the deficiency is cleared. This is accomplished by adding the solidness control circle to power stream control circle.

The dependability controller gives tweak arrangement infused voltage (Vseqm) amid transient or element periods. The entirety of two yields (Vseq0) of force stream controller and (Vseqm) of the steadiness controller yields the Vseq‟‟ which is the last estimation of infused arrangement voltage needed by the framework amid transient and element periods.

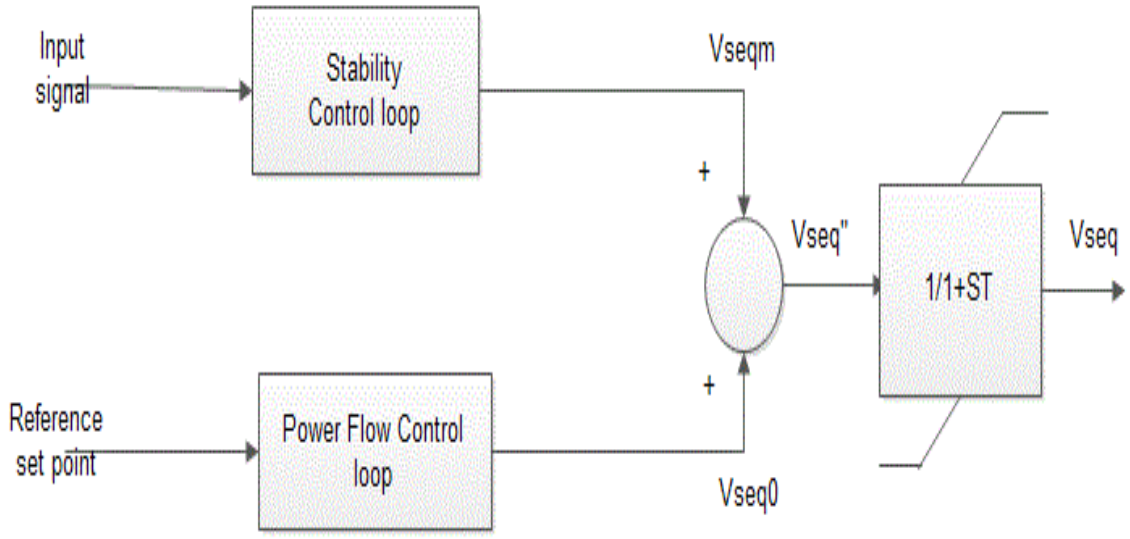

Figure.1.8: SSSC controller model for stability studies

CHAPTER-2

Review of Literature

Metin Dogan1 *et. al.* (2011) the thyristor controlled arrangement compensator (TCSC) and a static synchronous arrangement compensator (TCSC) is utilized to minimize the swaying in arrangement capacitor remunerated electrical force framework. The force framework expanding because of increment the interest and diverse burdens and it is harder to give steadiness and control. It is conceivable to expand line transmission limits and control by giving responsive force pay. Truths gadgets utilized as receptive force remuneration components. The TCSC and SSSC gadgets are shaped by force electronic components. The gadgets build the voltage strength and lessen the misfortunes. (Dogan, Tosum, Ozturk, & Dosoglu, 2011)

M. A. Abido *et. al.* (2009) the force interest has expanded due the different burden request in electrical force framework. In the electrical force framework some transmission in more stacked and framework steadiness get to be diminishes. The FACTS controller utilized for figuring distinctive force framework relentless state control issues. The diverse sorts of late studies demonstrate the certainty controllers upgrade power framework dependability notwithstanding their primary capacity of force control. There are numerous specialized issues contrasted with adaptable transmission framework establishment. (Abido, 2008)

B. M. Naveen Kumar Reddy1 *et. al.* (2013) there is explores the issues of adjusting force stream in force framework transmission line utilizing synchronous static arrangement compensator (SSSC). This paper examining about PWM procedures controlled for SSSC. Also, considers about static synchronous arrangement compensator (SSSC) is utilization to control the dynamic and responsive powers and damping force motions. The DC connection can supply or assimilate the dynamic and responsive force. In this paper the reenactments have been done in MATLAB/SIMULINK. The consequence of reenactment got for chose transport 2 in two machine power frameworks. (Reddy, Rajeshakar, & Goyal, 2013)

Venna Ramya Krishna *et. al.* (2014) in this paper the controlling of force stream in transmission lines with the assistance of arrangement FACTS controllers gadgets. The force stream control relies on upon the different burdens requests. The arrangement Flexible gadgets in this paper are thyristor controlled stage shifter (TCPS), thyristor controlled arrangement capacitor (TCSC) and static synchronous arrangement compensator (SSSC). In this paper the demonstrating of arrangement FACTS gadgets. By utilizing Newton-Rapshon (NR) technique is utilized for unraveling the nonlinear mathematical burden stream comparisons in the heap stream issues. An orderly strategy for arrangement FACTS gadgets inside the NR burden stream calculation is comprehending. The writing computer programs is utilizing for the arrangements of arrangement controllable branches. This model is finished by utilizing MATLAB programming. What's more, analyze the proficiency SSSC, TCSC and TCPS (Krishna & Raju, 2014)

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KumaresanE *et. al.* (2014) long transmission line needs controllable arrangement and additionally shunt remuneration for force stream control and voltage regulation. This can be attained to by suitable mix of inactive components and dynamic Flexible air conditioning transmission controllers. The approach of arrangement FACTS controllers the Thyristor Controlled Series Capacitor (TCSC) and Static Synchronous Series Compensator (SSSC) has made it conceivable not just for the quick control of force stream in a transmission line additionally for the relief of Sub Synchronous Resonance (SSR) in the vicinity of settled

arrangement capacitors. The MATLAB/Simulink was utilized to effectively investigation and reproduction studies. (KumaresanE, ParthasarathyS, & VidyaB, 2014)

G. Maheswaran *et. al.* (2013) a static synchronous arrangement compensator (SSSC) and thyristor controlled arrangement compensator (TCSC) is utilized to lessen the synchronous wavering in arrangement capacitor remunerated force frameworks. To attain to a successful damping, a supplementary sub synchronous damping controller (SSDC) is consolidating to the SSSC. The reference sign to the compensator is taken as the rotor speed deviation to create the regulation list for controlling the infused voltage of the compensator. The fundamental target is to soggy the sub synchronous reverberation (SSR) brought about by the arrangement capacitor in the line utilizing SSSC and TCSC. It is think about the recreation result got utilizing MATLAB. By utilizing the SSDC joined at the transmission line it has the capacity soggy the SSR. The principal arrangement of IEEE second benchmark model is utilized to assess the viability of SSDC on the torsional motions. The few recreations are utilized to exhibit the prevalent capacity of SSSC in damping the SSR when contrasted and TCSC. (Maheshwaran & Naidu, 2013)

Viresh kumar G. Mathad *et. al.* (2013) in recent years, power demand has increased substantially while the expansion of power generation and transmission has been severely limited due to limited resources and environmental restrictions. Transient stability control plays a significant role in ensuring the stable operation of power systems in the event of large disturbances and faults and is thus a significant area of research. (FACTS) controllers have been mainly used for solving various power system steady state control problems. FACTS devices are capable of controlling the active and reactive power flows in a transmission line. This paper presents a review of comparison of different FACTS controllers in the power system for stability enhancement. (Mathad, Ronad, & Shetti, 2013)

Ajit Kumar Verma *et. al*. (2013) this paper proposes an enhancement model to use in composite force framework dependability assessment system joining the effect of FACTS gadgets. The customary dc stream based straight programming model utilized as a part of composite framework unwavering quality assessment system I changed over into a non-direct advancement model to incorporate the effect of FACTS gadgets on dependability of force framework. The proposed model is tried on 24-transport IEEE-unwavering quality test framework (RTS). Annualized unwavering quality records are computed utilizing the model

and contrasted and the lists ascertained without considering FACTS gadgets. (Verma, Srividya, & Deka, 2013)

D. Murali *et. al.* (2010) Advancement of the current force framework has prompted an expanding intricacy in the investigation of force frameworks This paper examines the change of transient soundness, utilizing UPFC (Unified Power Flow Controller). Certainties (Flexible AC Transmission System) gadget is controlling the dynamic and receptive force streams in a transmission line. Recreations are done in Matlab/Simulink. There is two-region power framework model with UPFC to examine the impacts of UPFC on transient steadiness execution of the framework. The execution of UPFC is contrasted and different FACTS gadgets, for example, Static Synchronous Series Compensator (SSSC) and Thyristor Controlled Series Capacitor (TCSC), and Static Var Compensator (SVC) individually. The reproduction results exhibit the viability of the proposed UPFC on transient security change of the framework.(D. Murali *et. al.* (2010)

ANJU MEGHWANI and A M KULKARNI (2008) this paper displays the execution of Static Synchronous Series Compensator (SSSC) controller on Real Time Application Interface (RTAI) for Linux Operating System (OS). RTAI gives constant ability to Linux General Purpose Operating System (GPOS) far beyond the capacities of non ongoing Linux environment, e.g. access to TCP/IP, graphical show and windowing frameworks, document and database frameworks. Both Type II controllers, DC voltage and current planning controllers are actualized in RTAI. To make an easy to use environment, Graphical User Interface (GUI) is created in Linux OS in client space (non continuous) utilizing a product accessible from Quasar Technologies (Qt). The controller is tried on a little scale research center model of a Voltage Source Converter (VSC) joined in arrangement with a transmission line. The constant controller performs well in both inductive and capacitive districts. A stable and totally operational controller for the SSSC has been actualized utilizing RTAI of Linux. Results acquired affirm hypothetical forecasts of the controller ability and usefulness. It is watched that while executing ongoing applications, one can get to non continuous Linux environment e.g. TCP/IP, graphical presentation, and so on without influencing its execution. The controller is working in its inductive and capacitive locales for both voltage and current control modes. Changing from voltage to current control mode and the other way around has been made jitterless. A GUI for SSSC controller has additionally

been actualized on Linux environment. The realtime application are regularly needed to be run in piece space so as to sidestep Linux portion and its interfere with handlers, as a result of which the reaction time of undertakings can be limited. GUI is a client space application, which is non, continuous and used to show information of the constant assignments. To impart information in the middle of genuine and non constant undertaking imparted memory has been utilized, which gives palatable results in information exchange. ANJU MEGHWANI and A M KULKARNI (2008)

Sidhartha Panda, N. P. Padhy (2007) the utilization of a Static Synchronous Series Compensator (SSSC) controller to enhance the transient steadiness execution of a force framework is altogether researched in this paper. The outline issue of SSSC controller is planned as an advancement issue and Particle Swarm Optimization (PSO) Technique is utilized to look for ideal controller parameters. By minimizing the time-space based target capacity, in which the deviation in the oscillatory rotor edge of the generator is included; transient solidness execution of the framework is progressed. The proposed controller is tried on a week after week joined force framework subjected to distinctive extreme aggravations. The non-straight reenactment results are displayed to demonstrate the adequacy of the proposed controller and its capacity to give proficient damping of low recurrence motions. It is additionally watched that the proposed SSSC controller enhances enormously the voltage profile of the framework under serious aggravations. In this paper, transient dependability execution change by a SSSC controller is introduced. For the proposed controller outline issue, a non-liner reproduction based target capacity to expand the framework damping was created. At that point, the molecule swarm enhancement procedure was executed to hunt down the ideal controller parameters. The viability of the proposed SSSC controller for enhancing transient security execution of a force framework and its plan by the strategies proposed in the paper is exhibited by a feebly associated sample power framework subjected to distinctive serious aggravations. Sidhartha Panda, N. P. Padhy (2007)

Nagarjun Donipala, R. Suresh Babu (2014) In this examination we are examine the controlling and upgrading or tweak force stream in a transmission line utilizing a static synchronous arrangement compensator (SSSC). At present studies it incorporate point by point PWM strategies controlled for SSSC, are directed in control circuits. In this proposed system we are study a static synchronous arrangement compensator is utilized to research the

gadget in controlling dynamic and responsive power and damping force framework motions in th transient mode. This SSSC DEVICE IS EQUIPPED WITH A SOURCE ENERGY IN TH dc LINK can watch or supply the dynamic and receptive energy to or supply the dynamic and responsive energy to or from the line. This application has been done in MATLAB/SIMULINK environment. The reenactment results are gotten from a chose transport 2 in two machine power framework shows and proficiency of this compensator is one of the actualities gadget as a part in force stream controller to accomplish fancied worth for dynamic, responsive powers and damping motions fittingly, In our proposed strategy the SSSC is a fit for controlling the stream of force at a specific point in the transmission line. Furthermore it watched that the SSSC to infuse a quick dynamic changing voltages in arrangement with the line independent of the stage and extent of the line current. In this examination the SSSC is accustomed to damping the force swaying on a framework force taking after a three stage deficiency in light of got reenactment results and the execution of the SSSC has been utilized as a part of a basic two machine framework effectively chose transport 2 and this SSSC application will be reached out in future exploration to a complex and multi machine framework to research the issues identified with the different plans of force wavering in the force framework. Nagarjun Donipala, R. Suresh Babu (2014)

K. Kalyan Kumar, V. Shararth Babu, M. Hari Babu, R. Bhaskar (2013) In this examination we are examine the controlling and upgrading or tweak force stream in a transmission line utilizing a static synchronous arrangement compensator (SSSC). At present studies it incorporate point by point PWM strategies controlled for SSSC, are directed in control circuits. In this proposed system we are study a static synchronous arrangement compensator is utilized to research the gadget in controlling dynamic and responsive power and damping force framework motions in th transient mode. This SSSC DEVICE IS EQUIPPED WITH A SOURCE ENERGY IN TH dc LINK can watch or supply the dynamic and receptive energy to or supply the dynamic and responsive energy to or from the line. This application has been done in MATLAB/SIMULINK environment. The reenactment results are gotten from a chose transport 2 in two machine power framework shows and proficiency of this compensator is one of the actualities gadget as a part in force stream controller to accomplish fancied worth for dynamic, responsive powers and damping motions fittingly, In our proposed strategy the SSSC is a fit for controlling the stream of force at a

specific point in the transmission line. Furthermore it watched that the SSSC to infuse a quick dynamic changing voltages in arrangement with the line independent of the stage and extent of the line current. In this examination the SSSC is accustomed to damping the force swaying on a framework force taking after a three stage deficiency in light of got reenactment results and the execution of the SSSC has been utilized as a part of a basic two machine framework effectively chose transport 2 and this SSSC application will be reached out in future exploration to a complex and multi machine framework to research the issues identified with the different plans of force wavering in the force framework. Nagarjun Donipala, R. Suresh Babu (2014)

B. M. Naveen Kumar Reddy, Mr. G. V. Rajashekar, Dr. Himani Goyal (2013) This paper explores the issue of controlling and adjusting force stream in a transmission line utilizing a Synchronous Static Series Compensator (SSSC). The studies, which incorporate point by point PWM systems controlled for SSSC, are directed and the control circuits are introduced. In this study, a static synchronous arrangement compensator (SSSC) is utilized to explore the impact of this gadget in controlling dynamic and receptive powers and damping force framework motions in transient mode. The SSSC furnished with a wellspring of vitality in the DC connection can supply or assimilate the receptive and dynamic energy to or from the line. Reenactments have been done in MATLAB/SIMULINK environment. Reenactment results got for chose transport 2 in two machine power framework demonstrates the viability of this compensator as one of the FACTS gadgets part in controlling force streams, attaining to the craved worth for dynamic and responsive powers, and damping motions fittingly. It has been observed that the SSSC is fit for controlling the stream of force at a fancied point on the transmission line. It is likewise watched that the SSSC infuses a quick changing voltage in arrangement with the line regardless of the size and period of the line current. This paper, the SSSC is utilized to sodden force swaying on a force matrix taking after a three-stage deficiency Based on got recreation comes about the execution of the SSSC has been analyzed in a basic two-machine framework basically on the chose transport 2, and utilizations of the SSSC will be stretched out in future to a complex and multi machine framework to examine the issues identified with the different methods of force wavering in the force frameworks. B. M. Naveen Kumar Reddy, Mr. G. V. Rajashekar, Dr. Himani Goyal (2013).

Habibur Rahman,Jewel Rana,Harun-Or-Rashid (2012) This paper exhibits the model of a Static Series Synchronous Compensator (SSSC) which is controlled remotely by a recently composed Power System Controller(PSC) for the changes of force framework soundness and damping impact of an on line power framework. The proposed PSC comprises of two controllers(PID & POD).PID parameters has been upgraded by Triple Integral Differential(TID) close circle tuning system. Both single stage and three stage (L-L) issues have been considered in the examination. In this paper, A force framework system is considered which is reenacted in the phasor reenactment technique & the system is reproduced in three stages; without SSSC, With SSSC however no remotely controlled, SSSC with Power System Controller. Reenactment result demonstrates that without SSSC, the framework parameters get to be insecure amid issues. Once more, when SSSC is controlled remotely by PSC controllers, then framework parameters(V,P,Q) gets to be stable in quicker route then without controller. It has been watched that the SSSC appraisals are just 15 MVA with controllers and 100 MVA without controllers. In this way, SSSC with PSC controllers are more powerful to upgrade the voltage steadiness and builds power transmission limit of a force framework .The force framework motions is additionally diminished with controllers in contrasted with that of without controllers. So with PSC controllers the framework execution is significantly upgraded. This paper displays the force framework security change i.e. voltage level, machine swaying damping, genuine & responsive power in a force framework model of SSSC without or with proposed Power System Controller for distinctive sorts of blamed conditions. PSC is additionally an exceptionally effective controller at that points others for SSSC to improve the force framework dependability. From above results, this proposed Triple Integral Differential(TID) close circle tuning system for selecting PID controller parameters & POD ,In consolidate, Power System Controller may be profoundly suitable as a SSSC controller as a result of shorter dependability time, straightforward planned, minimal effort & profoundly effective controller. May be that, If PSC controller is utilized then just little evaluating of SSSC gets to be sufficient for adjustment of vigorous force framework inside extremely most limited conceivable time for both consistent state & element conditions. Habibur Rahman,Jewel Rana,Harun-Or-Rashid (2012)

S.C.Swain , Srikanta Mahapatra, Sidhartha Panda, Susmita Panda (2012) This paper displays the force framework security change i.e. voltage level, machine swaying damping, genuine & responsive power in a force framework model of SSSC without or with proposed Power System Controller for distinctive sorts of blamed conditions. PSC is additionally an exceptionally effective controllerat that point others for SSSC to improve the force framework dependability. From above results, this proposed Triple Integral Differential(TID) close circle tuning system for selecting PID controller parameters & POD ,In consolidate, Power System Controller may be profoundly suitable as a SSSC controller as a result of shorter dependability time, straightforward planned, minimal effort & profoundly effective controller. Maybe that, If PSC controller is utilized then just little evaluating of SSSC gets to be sufficient for adjustment of vigorous force framework inside extremely most limited conceivable time for both consistent state & element conditions. These proposed Power System Controller can be petitioned any interconnected multi-machine power framework system for strength change. S.C.Swain , Srikanta Mahapatra, Sidhartha Panda, Susmita Panda (2012)

CHAPTER-3
PRESENT WORK

3.1: Scope of Study

The main scope of my research is that when we are using SSSC in the distribution lines and by using the software MATLAB Simulink, the power quality will improve, provide fast reactive compensation, provide better voltage regulation, losses will reduce and efficiency will improve at different parameters by using MATLAB Simulink. The application of SSSC to such distribution system can improve system controllability as well as power quality immensely.

We will give better utilization to the existing system assets with the help of comparison which will give us effective result in the field of FACTS controller. Our focus will also be to increase the efficiency of voltage profile. This work will lead to be helpful in the world of energy transmission system by establishing a new transmission network and production system. As we know voltage is a big issue so it is important to improve it. To increase the power transfer capability using Fuzzy logic technique, we have used the following research methodology:

The following tools which are used in my research methodology are:

- MATLAB which means Matrix Laboratory is a special type of computer program to perform computer programming and calculations. It is a high performance language used.
- Fuzzy logic technique helps to analyse the waveform both in time and frequency duration.
- Stored the signals more accurately as compared to Fourier transform.

3.2: Objectives

- The main objective of my research work is to improve the power quality in transmission lines by using Fuzzy logic technique.
- To study the use of Fuzzy logic analysis technique in transmission lines using software MATLAB simulink by analysing voltage and current parameters.
- To analysis the power quality by using Fuzzy logic technique.
- To study the use of SSSC in distribution line by using software MATLAB Simulink at different parameters.
- To analyze the results and performances SSSC on simulation result.
- To learn the modelling of FACT devices.
- To study the performances of distribution lines with or without using SSSC.
- The main objective of my research work is to improve the power quality in distribution line by using SSSC. Using MATLAB simulation the performance of SSSC will be analyzed by the addition of fuzzy logic technique.
- The various wave forms of controller (SSSC) will be observed scope.
- MATLAB which means Matrix Laboratory is a special type of computer program to perform computer programming and calculations. It is a high performance language used.
- Fuzzy logic technique helps to analyse the waveform both in time and frequency duration.
- Stored the signals more accurately as compared to Fourier transform.

3.3: Research Methodology

3.3.1: Static Synchronous Series Compensator (SSSC)

The static synchronous arrangement compensator can substitute dynamic and receptive power alongside the line. In the event that the voltage connected to the line and the stream secured from the line are both tremendous in the meantime there is supplant of dynamic force. At the point when the edge between the stream and the voltage is 90°, the force move will be as receptive force supplant. Receptive force is furthermore given to or plausible from the framework relying upon the forward or in reverse status of the stream.

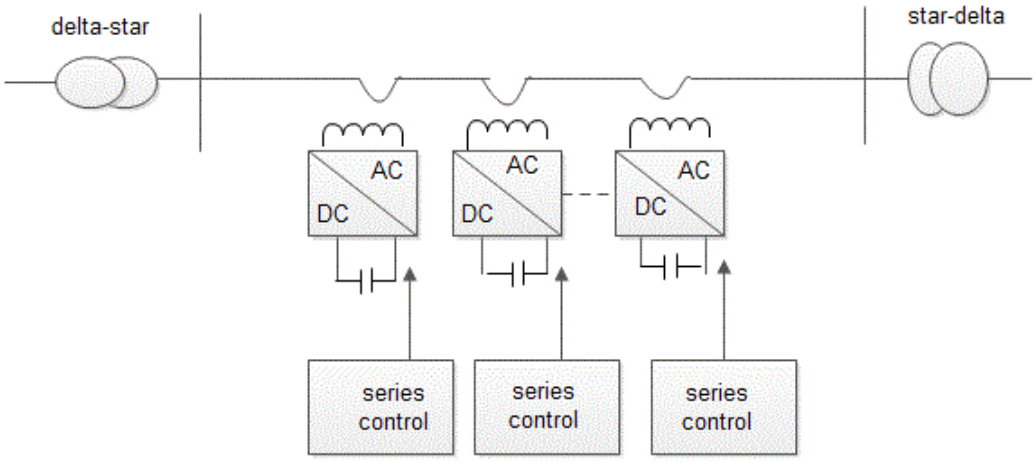

Figure.1.9: SSSC configuration

The SSSC is an arrangement remuneration gadget. It is utilizing force hardware in view of the voltage source converter (VCS) to control force stream transmission lines. It is likewise get improved transient security in force framework. The SSSC controls the force stream in transmission lines and by controlling the size and stage point of infused voltage (Vse) in arrangement with the transmission line where SSSC is associated. The trading of genuine and receptive power in the middle of SSSC and force framework relies on upon the greatness and stage uprooting as for transmission line current.

The line current I, is taken as introduction phasor even as the arrangement infused voltage phasor Vse of SSSC is worthy to interchange around the midpoint of the circle unmistakable by the most extreme embedded voltage Vse-max. There is in Capacitive method of operation, the arrangement infused voltage Vse of SSSC is finished slack by 900 among transmission

line current. For this situation the SSSC works like arrangement capacitor with variable capacitance kXC, i.e., Vse = - kXC*I, where k is variable. By this activity the aggregate reactance of transmission line is minimal while the voltage over the line is progressed. This prompts amplify in the line current and accordingly the transmitted force.

3.3.2: Power Flow Controller for SSSC

In this postulation, the force stream controller is consistent genuine force stream controller. Structure for the force stream controller of SSSC works in consistent force control mode, Vseq is controlled to take care of the force demand in the line set by the reference force set point (Pref).

The information signs to this controller are reference power (Pref) sign and real power moving through line (Pm). The yield is the suitable arrangement infused. Voltage (Vseq) needed by the framework according to the reference power (Pref).

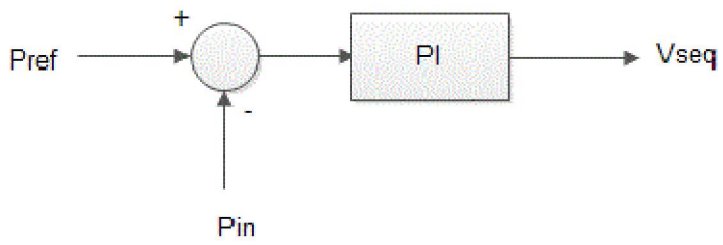

Figure.1.10: Power flow controller diagram for SSSC

3.3.3: SSSC controller model for Stability studies

It comprises of Power stream controller and soundness controller. Force stream controller is utilized to control force stream in the transmission line under consistent state condition by contrasting force stream in transmission line and reference force set point. On the off chance that this controller is ease back because of the huge time steady of PI controller or in the event that it is physically worked, the yield (Vseq0) of force stream controller is to be consistent amid extensive unsettling influences, due to this force motions increment. To lessen power motions the SSSC must be in a position to give greatest pay level instantly after

the deficiency is cleared. This is accomplished by adding the solidness control circle to power stream control circle.

The dependability controller gives tweak arrangement infused voltage (Vseqm) amid transient or element periods. The entirety of two yields (Vseq0) of force stream controller and (Vseqm) of the steadiness controller yields the Vseq‟ which is the last estimation of infused arrangement voltage needed by the framework amid transient and element periods.

3.3.4: SIMULINK Modeling of SSSC

The SIMULINK SSSC block developed as a phasor model, to perform dynamic and transient stability studies in 3-Ph power systems. The SSSC inject series injected voltage (Vq) is controlled to meet the power demand in the line set by the reference power set point (Pref).

3.3.5: PI Power Flow controller of SSSC

The SIMULINK model for PIPF controller of SSSC is shown in Fig.4.15. This controller gives the appropriate series injected quadrature voltage required by the system as per the reference Power (Pref).

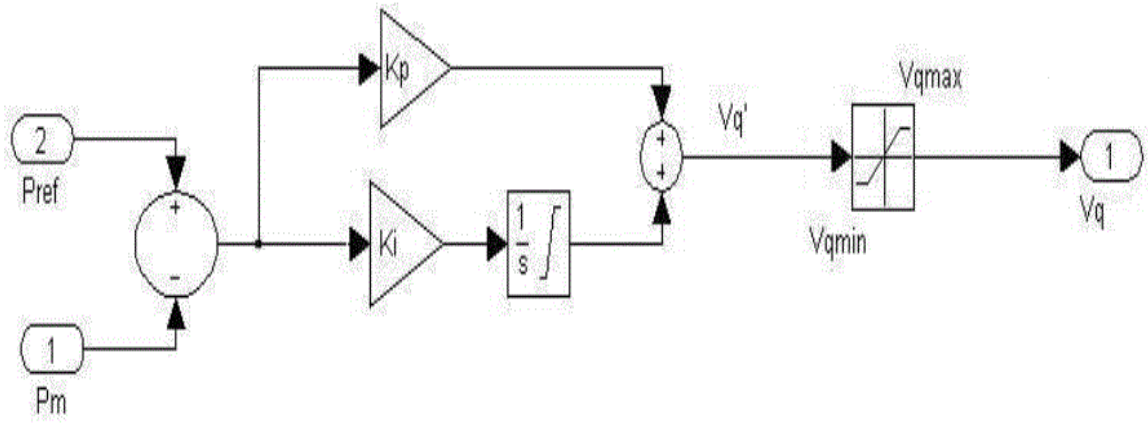

Figure.1.11: PIPF Controller block diagram of SSSC

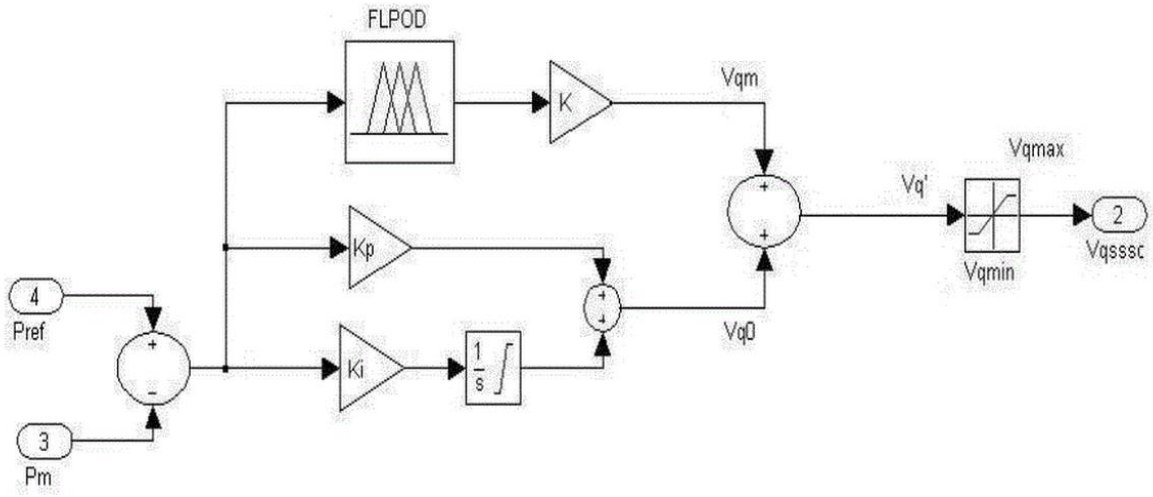

Figure.1.12: FLPOD controller along with PIPF controller block diagram of SSSC

3.3.6: Fuzzy logic controller (FLC) design methodology

For the innovation and development of better control systems, the design and implementation of intelligent systems has become an essential factor. Some of them are fuzzy logic and neural network techniques. These two techniques were applied in the proposed system. Fuzzy logic, which is the logic on which fuzzy control is based, is much closer in spirit to human thinking and natural language than the traditional logical systems. The experiences, preferences and thoughts of human are implemented through membership functions and fuzzy rules in fuzzy logic. A fuzzy logic controller uses a set of control rules and an inference mechanism to determine the control action for a given process state. Fuzzy membership functions can have different shapes depending on the designers preference and / or experience[2]. The disadvantage of PI controller is its inability to react to abrupt changes in the error signal, e, because it is only capable of determining the instantaneous value of the error signal without considering the change of the rise and fall of the error, which in mathematical terms is the derivative of the error signal, denoted as _e.

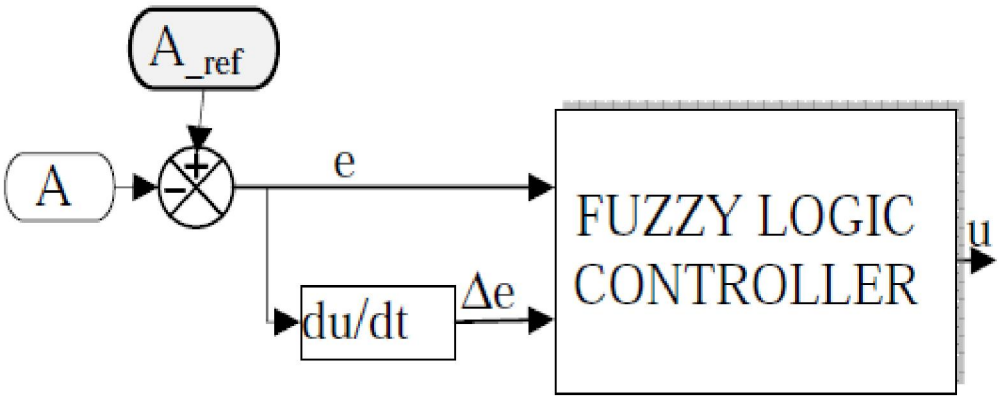

Figure.**1.13:** Sample fuzzy logic controller

Each of the two linguistic variables is defined over a universe of discourse namely Ue and UDe respectively. Letthe universe of discourse for each of the input linguistic variable be divided into 5 fuzzy sets namely, Positive Big (PB), Positive Medium (PM), Zero (ZE), Negative Medium (NM), and Negative Big (NB). Each of the fuzzy set has a definite support. Each fuzzy set can be triangular, or trapezoidal or sigmoid. In this case, triangular fuzzy sets are used. Let the universe of discourse for the error be {-0.02 0.02}. Let the universe of discourse for the rate of change of error be {-0.006 0.006}.

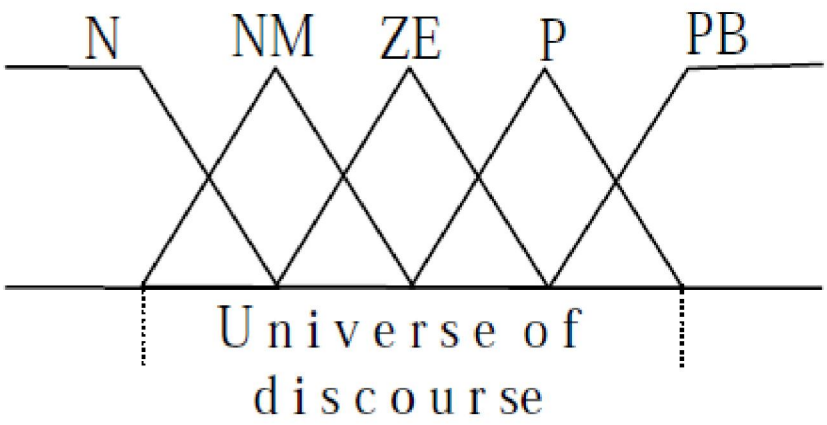

Figure.1.14: Five fuzzy sets of the input

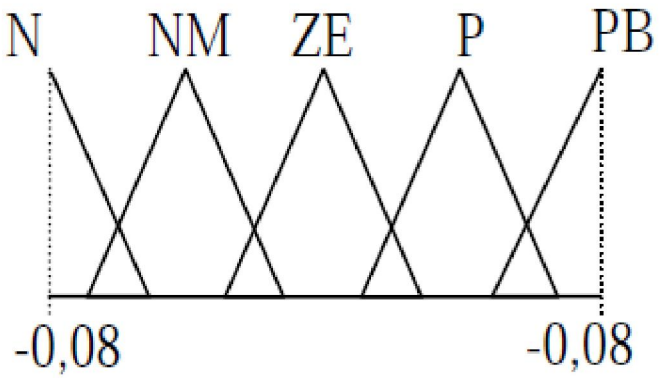

Figure.1.15: Five fuzzy sets of the output

The expert knowledge is generally given in the following format. "IF (e set of conditions) THEN (u set of consequent can be inferred)". These statements contain a set of conditions and a set of decisions to be inferred. The set of decisions could be fuzzy sets.\

A FUZZY KNOWLEDGE BASE

e / Δe	NB	NM	ZE	PM	PB
NB	NB	NM	NM		
NM	NM	NM	ZE		
ZE	NM	NM	ZE	PM	PM
PM			ZE	PM	PM
PB			PM	PB	PB

3.3.7: FLPOD controller along with PIPF Controller of SSSC

The SIMULINK model block diagram for FLPOD controller along with PIPF controller of SSSC, FLPOD controller is fed by one input that is change in power or difference in power (DP). This gives the appropriate injected series voltage (Vqm)

Required by the system in dynamic condition; under steady state condition it gives zero injected series voltage. The PIPF controller gives injected series voltage (Vq0) as per the setting of Pref.

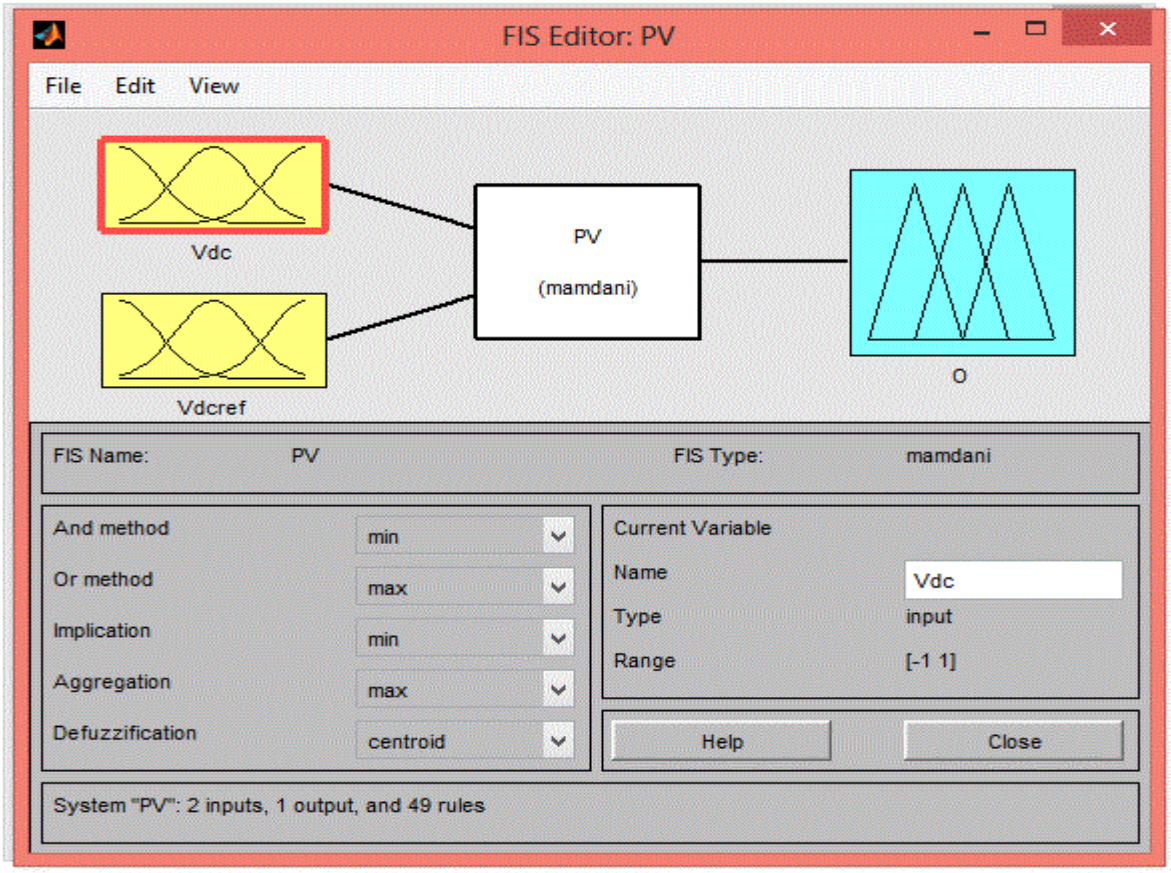

Figure.1.16: Diagram of FLPOD for SSSC

The FIS Editor GUI tool allows you to edit the highest level features of the fuzzy inference system, such as the number of input and output variables, the defuzzification method used, and so on. Refer to the FIS editor for more information about how to use the GUIs associated with fuzzy. The FIS Editor is the high-level display for any fuzzy logic inference system. It allows you to call the various other editors to operate on the FIS. This interface allows convenient access to all other editors with an emphasis on maximum flexibility for interaction with the fuzzy system.

3.3.8: Use of fuzzy logic

Here is a list of general observations about fuzzy logic:

- Fuzzy logic is conceptually easy to understand.

  The mathematical concepts behind fuzzy reasoning are very simple. Fuzzy logic is a more intuitive approach without the far-reaching complexity.

- Fuzzy logic is flexible.

  With any given system, it is easy to layer on more functionality without starting again from scratch.

- Fuzzy logic is tolerant of imprecise data.

  Everything is imprecise if you look closely enough, but more than that, most things are imprecise even on careful inspection. Fuzzy reasoning builds this understanding into the process rather than tacking it onto the end.

- Fuzzy logic can model nonlinear functions of arbitrary complexity.

  You can create a fuzzy system to match any set of input-output data. This process is made particularly easy by adaptive techniques like Adaptive Neuro-Fuzzy Inference Systems (ANFIS), which are available in Fuzzy Logic Toolbox software.

- Fuzzy logic can be built on top of the experience of experts.

  In direct contrast to neural networks, which take training data and generate opaque, impenetrable models, fuzzy logic lets you rely on the experience of people who already understand your system.

- Fuzzy logic can be blended with conventional control techniques.

  Fuzzy systems don't necessarily replace conventional control methods. In many cases fuzzy systems augment them and simplify their implementation.

- Fuzzy logic is based on natural language.

  The basis for fuzzy logic is the basis for human communication. This observation underpins many of the other statements about fuzzy logic. Because fuzzy logic is built on the structures of qualitative description used in everyday language, fuzzy logic is easy to use.

CHAPTER-4

Result and Discussion

The main scope of my research is that when we are using SSSC in the distribution lines and by using the software MATLAB Simulink, the power quality will improve, provide fast reactive compensation, provide better voltage regulation, losses will reduce and efficiency will improve at different parameters by using MATLAB Simulink. The application of SSSC to such distribution system can improve system controllability as well as power quality immensely.

- To improve the power quality and reduce the losses in transmission lines by using advanced techniques.
- To provide the reactive power compensation by using the series controller.
- To provide the better voltage regulation by using the fact controller.

In my work I have design the simulation model of SSSC has been modeled. Till now I have designed basic transmission model in which we connect various fact devices to get the desired waveforms. The system was examined in terms of voltage stability; improvements related to power increase are detected.

4.1: MATLAB SIMULATIONS AND RESULTS:

The MATLAB SIMULATION of without SSSC as shown below,

Step 1: Initially without SSSC, the load voltage and load current waveforms will be change as shown in below figure from (scope 3 and scope 4)

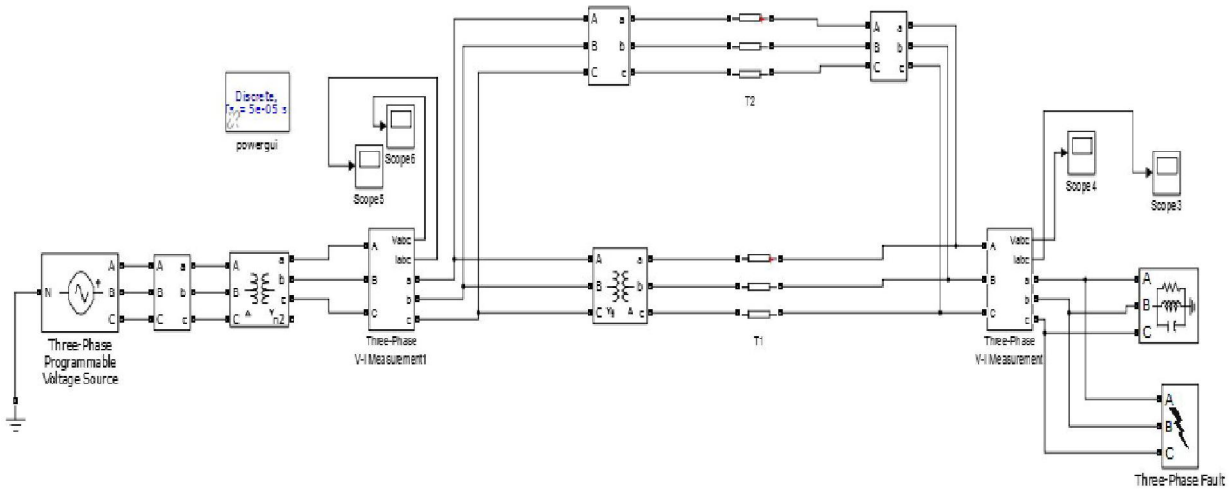

Figure1.17: Two bus system without SSSC

First of all we have to create a 3-phase fault as shown in the below figure.

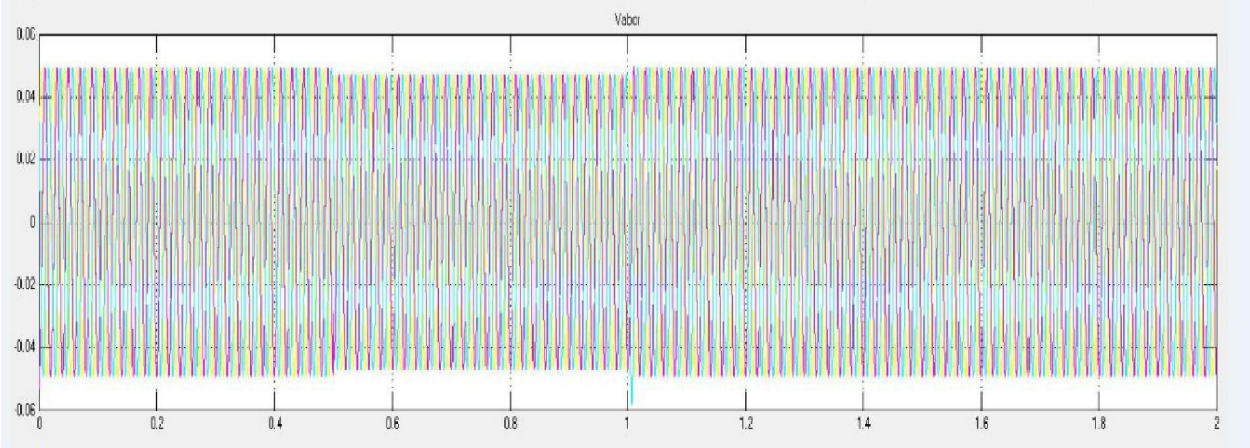

Figure1.18: Voltage Sag without SSSC

Scope 4 figure above shows the decrement in the voltage as shown above because of fault in 3-phase ground fault.

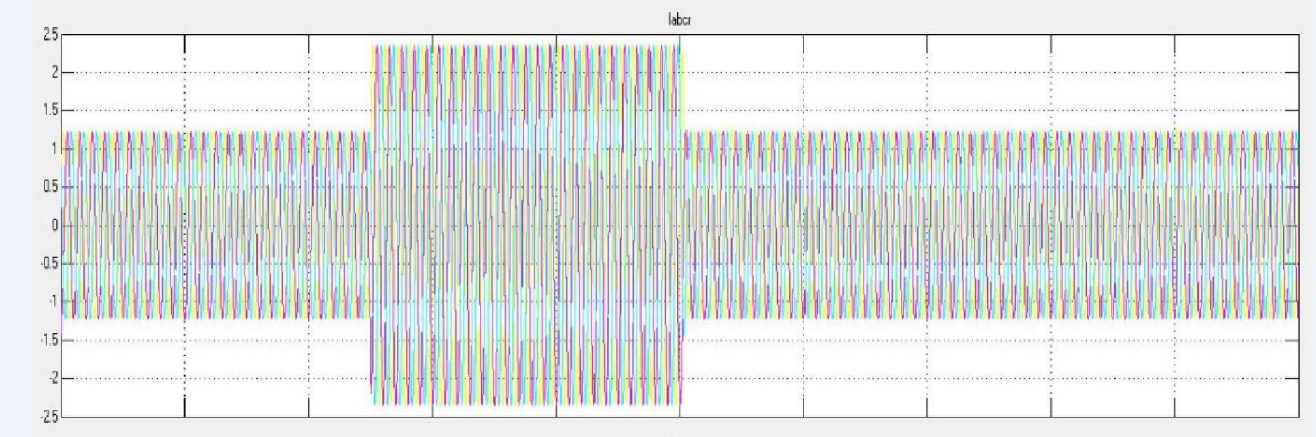

Figure1.19: Current increment without SSSC

Scope: 3 above shows that there is a increment in the short circuit current for 3-phase ground fault with fault resistance 100 ohms. Now to avoid this change in the voltage (this voltage change occurred because of many things like may be fault occurrences, voltage drop in transmission lines, loads increment), SSSC is used. This can be as follows:

Step-2: Two bus system using SSSC in transmission line as shown below

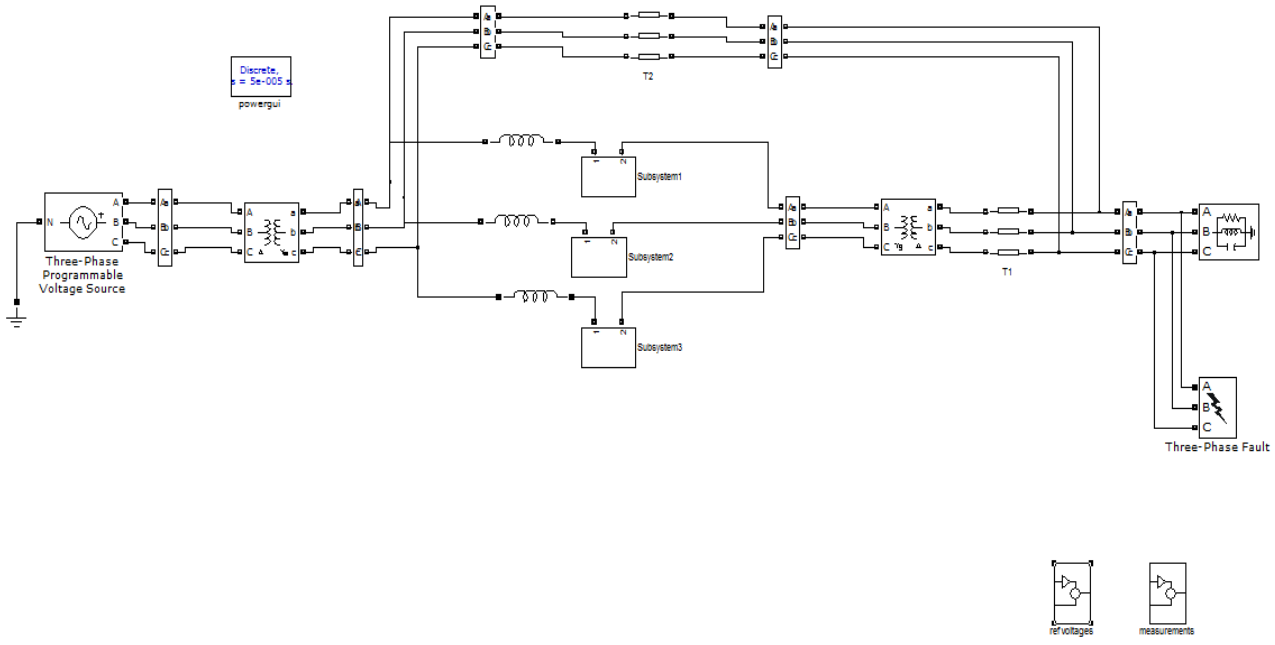

Figure1.20: SSSC MATLAB SIMULATION

4.2: Subsystem used as a series controller

In this subsystem SSSC is used as series controller. The fuzzy logic technique is applied to compensate the power in transmission line to get the exact outputs.
The subsystem is shown as

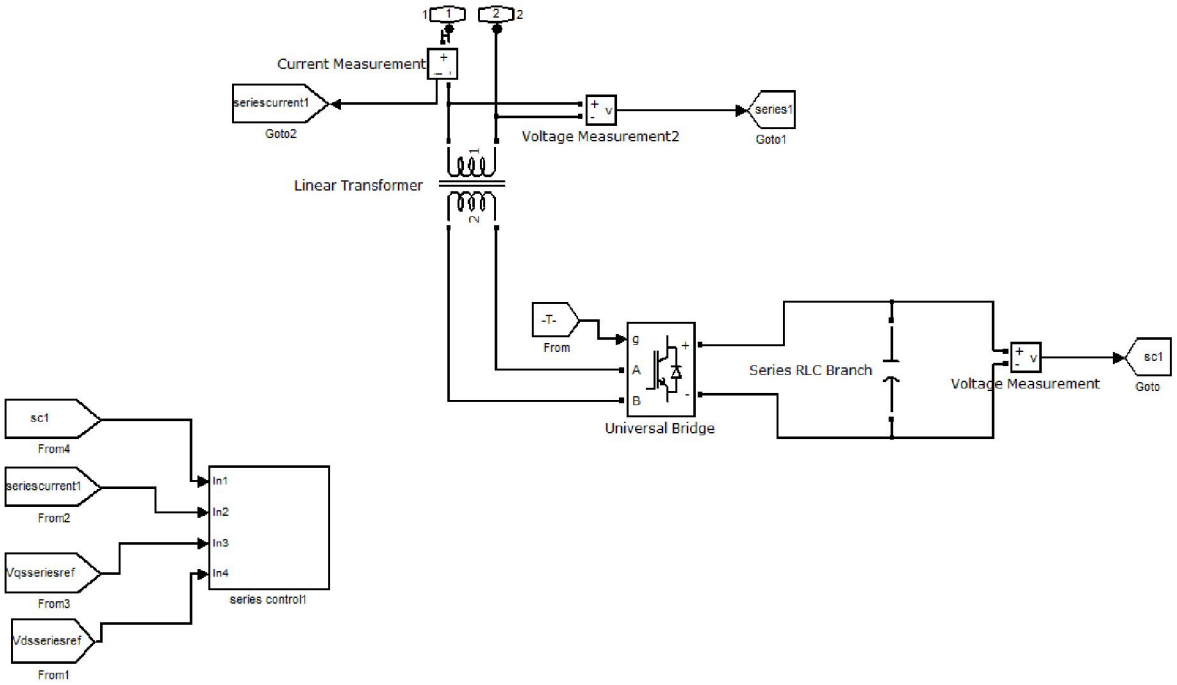

Figure1.21: Subsystem of SSSC

4.3: Fuzzy logic controller

For the innovation and development of better control systems, the design and implementation of intelligent systems has become an essential factor. Some of them are fuzzy logic and neural network techniques. These two techniques were applied in the proposed system. Fuzzy logic, which is the logic on which fuzzy control is based, is much closer in spirit to human thinking and natural language than the traditional logical systems. The experiences, preferences and thoughts of human are implemented through membership functions and fuzzy rules in fuzzy logic.

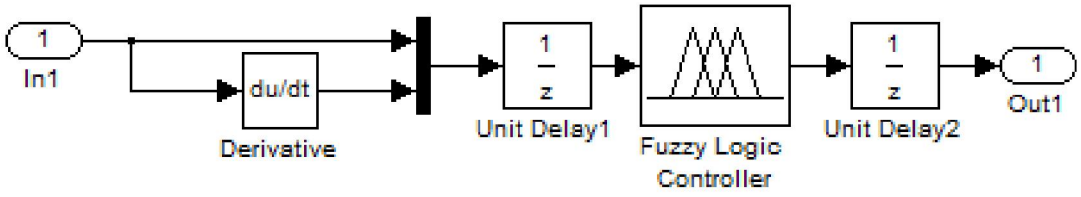

Figure1.22: Fuzzy logic controller

The following are the Three Phase Voltage, Current and THD waveforms:
The voltage waveform for three phases,

Output voltage waveform

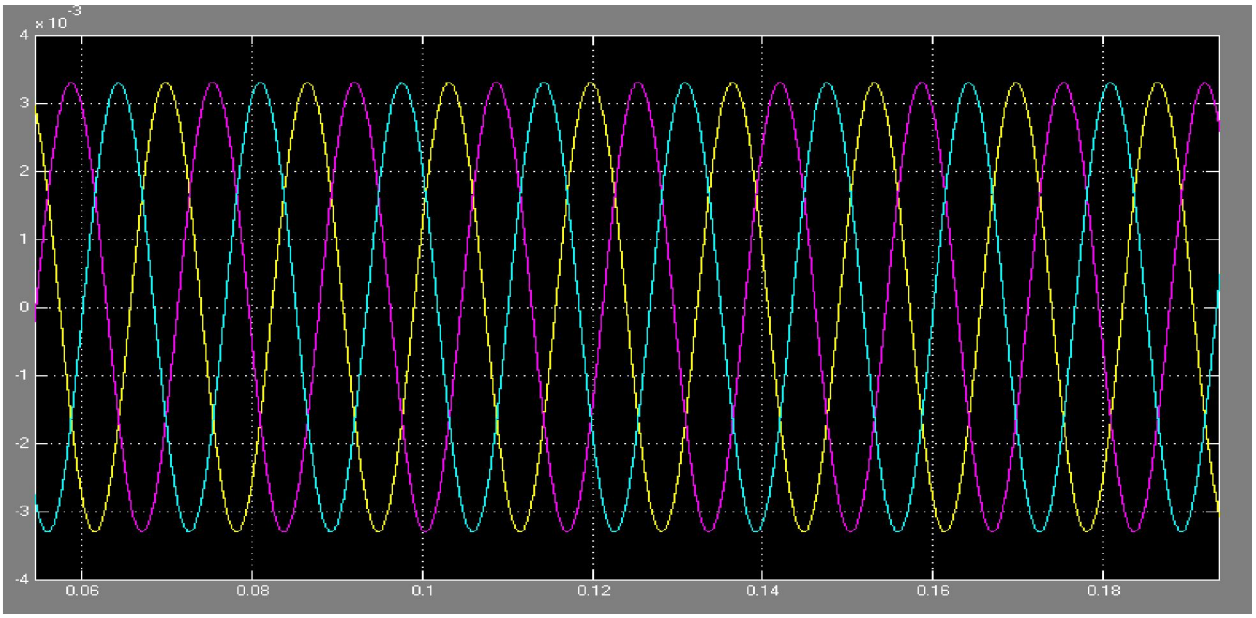

Figure1.23: Output voltage waveform

The Current waveform for three phases

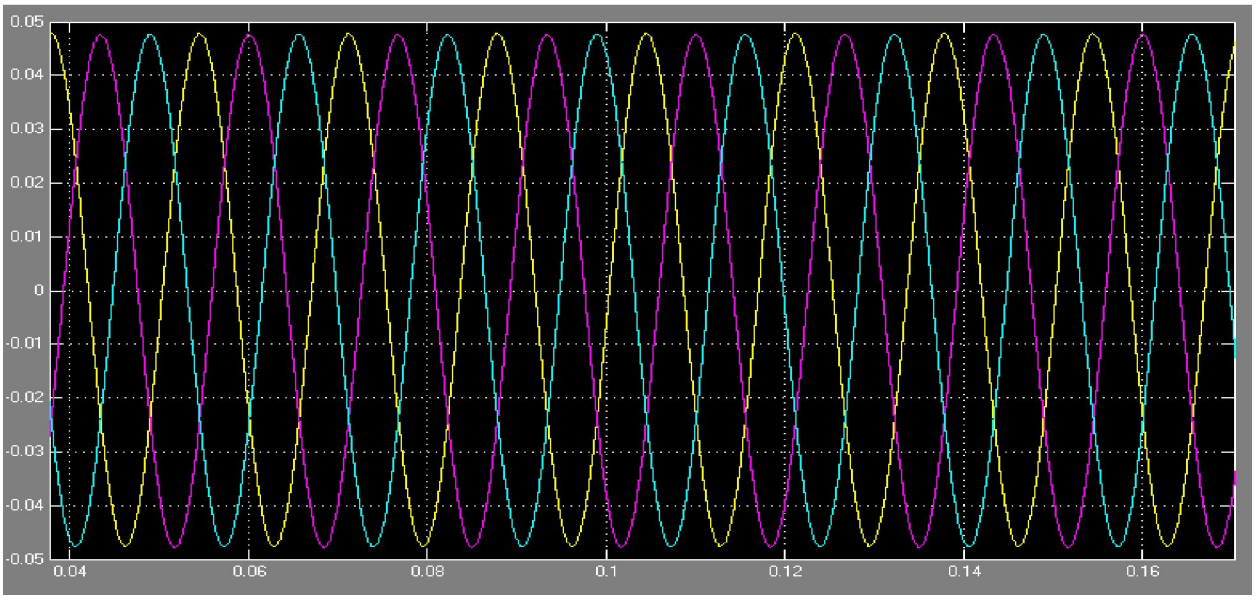

Figure1.24: Output current waveform

4.4: The FFT analysis of THD (Total Harmonic Distortion):

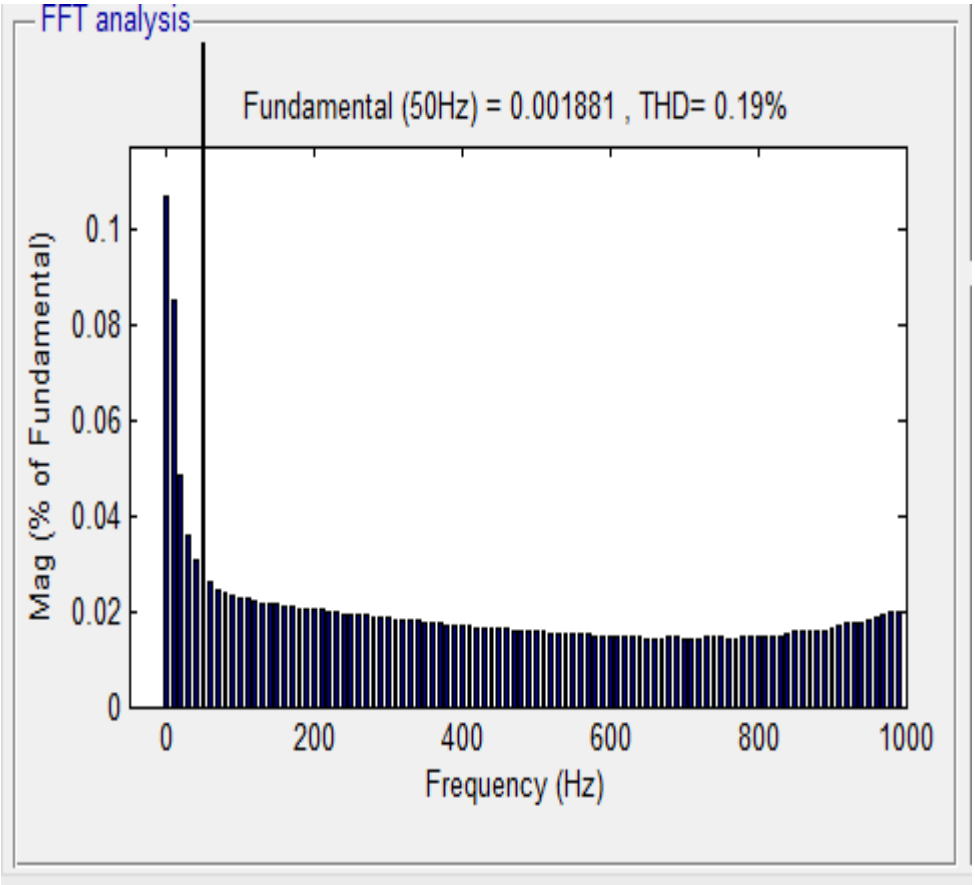

Figure1.23: THD analysis

CHAPTER-5

Conclusion and Future Scope

5.1. Conclusion

When the signal is generated in the system and we have to apply the Fuzzy logic technique and the type of Fuzzy logic we used to the system for the improvement the power transfer quality in transmission system. With the help of controller power quality is improved, we can provide to the system and the stabilty to tha system it will increase the performance of the system

The main goal of our work is to have comparative study of different FACTS controllers used for the enhancement of voltage stability and improvement of voltage profile. The advantage of FACTS is to have better utilization, increased stability, quality, reliability and availability of transmission system.

- It is investigated that the FACTS controller is powerful to control network power flow in a very fast manner.
- FACTS consists of number of devices and these devices utilize rapid responding's for SSSC (Static Synchronous Series Compensator) is a device that are formed by power electronics elements.
- These devices effects voltage stability, on the powers carried on the lines and the losses that occur on the lines were investigated with the simulation and its results.

We will give better utilization to the existing system assets with the help of comparison which will give us effective result in the field of FACTS controller. Our focus will also be to increase the efficiency of voltage profile. This work will lead to be helpful in the world of energy transmission system by establishing a new transmission network and production system. As we know voltage is a big issue so it is important to improve it.

5.2: Future Scope

The advancement of technology made easy to control the power flow by introducing different control techniques. Among all the controllers we have discussed the controllers like PI, Fuzzy logic which are explained in earlier section.

It will be seen on the voltage stability curves that voltage stability limits are rather favorable when same capacity load is transferred. In the light of these observations, positive improvements were found that were caused by SSSC controllers, FACTS devices, in the increase of energy transmission lines capacity and amplifying voltage stability limits.

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