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# IMPROVEMENT IN STABILITY OF MULTI-MACHINE POWER SYSTEM BY POWER SYSTEM STABILIZER AND STATCOM USING MATLAB /SIMULINK

Shakir Manzoor[1], Neena Godara[2]
[1]M.Tech Student, Power System,
[2]Assistant Professor, Department of Electrical and Electronics Engineering
[1,2]Al-Falah School of Engineering & Technology, Al-Falah University, Haryana, India

***ABSTRACT: This paper presents the improvement of transient stability of a multi-machine power system with a STATCOM. Transient stability improvement is essential from the view point of maintaining system security that is the incidence of a fault should not lead to tripping of generating unit due to loss of synchronism. Static synchronous compensator is widely used in power system to control power by injecting appropriate reactive power into the system. STATCOM has the capability of improving stability and damping by dynamically controlling it's reactive power output. The STATCOM is modelled by a voltage source connected to the system through a coupling transformer. The transient stability improvement of the multi-machine power system at different fault condition is investigated in this work. To illustrate the performance of the FACTS controller (STATCOM), a two machine, three bus power System has been considered.***
***Keywords: STATCOM,PSS,***

## I. INTRODUCTION

Transmission systems of present power frameworks are winding up logically more focused on in light of expanding interest and impediments on building new lines. One of the results of such a focused on framework is the danger of losing dependability following an unsettling influence. Adaptable air conditioning transmission framework (FACTS) gadgets are observed to be exceptionally productive in a focusing on transmission arrange for better use of its current offices without yielding the coveted solidness edge. Adaptable AC Transmission System (FACTS) controllers, for example, Static Synchronous Compensator (STATCOM) and Static Var Compensator(SVC) utilizes the most recent innovation of intensity electronic exchanging gadgets in electric power transmission frameworks to control voltage and power stream, and assume a vital part as a solidness help for and transient unsettling influences in an interconnected power frameworks. The writing demonstrates an expanding enthusiasm for this subject throughout the previous two decades, where the improvement of framework security utilizing FACTS controllers has been widely researched. Regularly control program solidness is ordered into enduring state, transient and dynamic strength. Consistent state soundness reports are constrained to little and dynamic enhancements in the machine working conditions. In that we on a very basic level focus on decreasing the transport streams close for their ostensible qualities. We additionally ensure that stage sides between two transports are not very vast and dependably check for the over-burdening of the power hardware and sign lines. These checks are regularly done utilizing power development contemplates. Transient strength includes the investigation of the power program completing a noteworthy unsettling influence. Doing a major aggravation, the synchronous alternator the gadget control (stack) point of view enhancements as a result of snappy speed of the rotor shaft. The point of the transient solidness study is decide if the heap viewpoint profit to a steady value following an endorsement of the unsettling influence. The capacity of an electric program to keep up security. underneath persistent little unsettling influences is researched underneath the title of dynamic soundness (likewise alluded to as little flag dependability). These little unsettling influences happen due arbitrary variances in masses and innovation levels. In an interconnected power program, these irregular varieties can lead calamitous disappointment as this could drive the rotor point of view to enhance relentlessly. In that stage we will talk about the transient steadiness part of an electric framework.

## II. RESEARCH OBJECTIVES

For single phase fault

- To study transient stability analysis of two machine system with power system stabilizer but without STATCOM

For three phase to ground fault

- To study transient stability of two machine system with power system stabilizer but without STATCOM
- To study transient stability of two machine system with power system stabilizer and with STATCOM

## III. MODELING OF STATCOM AND PSS

STATCOM:

STATCOM or Static Synchronous Compensator is a power electronic gadget utilizing power commutated gadgets like IGBT, GTO and so on to control the responsive power course through a power organize and in this way expanding the steadiness of intensity arrange. STATCOM is a shunt gadget i.e. it is associated in shunt with the line. A Static Synchronous Compensator (STATCOM) is otherwise called a Static Synchronous Condenser (STATCON). It is an individual from the Flexible AC Transmission System

  

(FACTS) group of gadgets.
The essential electronic square of the STATCOM is the voltage sourced inverter that changes over an info dc volta ge into a three stage yield voltage at major recurrence. In its least complex shape, the STATCOM is comprised of a coupling transformer, a voltage-sourced inverter and a dc capacitor. In this plan, the unfaltering state control trade between the gadget and the air conditioner framework is essentially receptive. A useful model of the STATCOM is appeared in fig.1

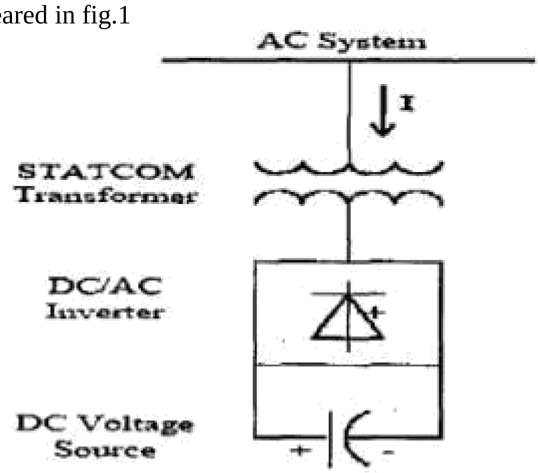


Fig.1 STATCOM functional model

Directing the abundance of the STATCOM yield voltage controls the responsive power trade of the STATCOM with the air conditioner framework. On the off chance that the amplitudes of the STATCOM yield voltage and the air conditioner framework voltage are equivalent, the responsive current is zero and the STATCOM does not produce assimilate receptive power. In the event that the adequacy of the STATCOM yield voltage is expanded over the abundancy of the air conditioner framework voltage, the present moves through the transformer reactance from the STATCOM to the air conditioner framework, and the gadget produces responsive power (capacitive). On the off chance that the adequacy of the STATCOM yield voltage is diminished to a level beneath that of the air conditioner framework, at that point the present streams from the air conditioner framework to the STATCOM, bringing about the gadget retaining responsive power (inductive). Since the STA'I'COM is producing/retaining just receptive power, the yield voltage and the air conditioner.

PRINCIPLE OF REACTIVE POWER CONTROL

The principle of control reactive power via STATCOM is well known that the amount of type (capacitive or inductive) of reactive power exchange between the STATCOM and the system can be adjusted by controlling the magnitude of STATCOM output voltage with respect to that of system voltage. The reactive power supplied by the STATCOM is given as:

$$Q = \frac{V_{STATCOM} - V_S}{X} V_S$$

Where: Q is the reactive power.
VSTATCOM the magnitude of STATCOM output voltage.
Vs is the magnitude of system voltage.
X is the equivalent impedance between STATCOM and the system.
When Q is positive the STATCOM supplies reactive power to the system. Otherwise, the STATCOM absorbs reactive power from the system.

Power System Stabilizer

One of the major problems in power system operation is related to small signal instability caused by insufficient damping in the system. The most effective way of countering this instability is to use auxiliary controllers called Power System Stabilizers, to produce additional damping in the system Power transactions are increasing day by day in restructured power systems. Restructured power system is therefore, expected to be operated at a greater variety of operating points and closer to their operating constraints. The “low frequency oscillations” is one of the operational constraints which limit bulk power transmission through power network. In such scenario, power system controls plays significant role. Power system controls can contribute either positive or negative damping. Generation control and particularly the generator voltage regulation can be significant sources of negative damping. High gain in the generator voltage regulation can lead to poor or negative damping of the oscillation. This problem has lead to the implementation of Power System Stabilizer (PSS) to damp out the oscillations.

Power system stabilizers are of two types

- Generic power system stabilizers
- Multiband power system stabilizers

Generic power system stabilizer

The Generic Power System Stabilizer (PSS) can be utilized to add damping to the rotor motions of the synchronous machine by controlling its excitation. The unsettling influences happening in a power framework prompt electromechanical motions of the electrical generators. These motions, likewise called control swings, must be successfully damped to keep up the framework steadiness. The yield flag of the PSS is utilized as an extra info (Vstab) to the Excitation System square. The PSS input flag can be either the machine speed deviation, dw, or its increasing speed power,Pa = Pm – Peo (distinction between the mechanical power and the electrical power).
The Generic Power System Stabilizer is demonstrated by the accompanying nonlinear framework;

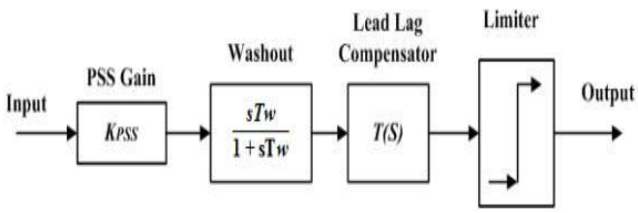


Fig.2 Generic Power System Stabilizer

  

Multiband power system stabilizer

The aggravations happening in a power framework initiate electromechanical motions of the electrical generators. These motions, additionally called control swings, must be effective0ly damped to keep up the framework's dependability. Electromechanical motions can be grouped in four principle classifications:

Local motions: between a unit and whatever is left of the producing station and between the last mentioned and whatever is left of the power framework. Their frequencies commonly go from 0.8 Hz to 4.0 Hz.

Interplant motions: between two electrically close age plants. Frequencies can fluctuate from 1
Hz to 2 Hz.

Inter zone motions: between two noteworthy gatherings of age plants. Frequencies are ordinarily in a scope of 0.2 Hz to 0.8 Hz.

Global swaying: described by a typical in-stage wavering of all generators as found on a disengaged framework. The recurrence of such a worldwide mode is commonly under 0.2 Hz.

As its name uncovers, the MB-PSS structure depends on numerous working groups. Three separate groups are utilized, individually devoted to the low-, middle of the road, and high-recurrence methods of motions: the low band is regularly connected with the power framework worldwide mode, the halfway with the entomb territory modes, and the high with the nearby modes.

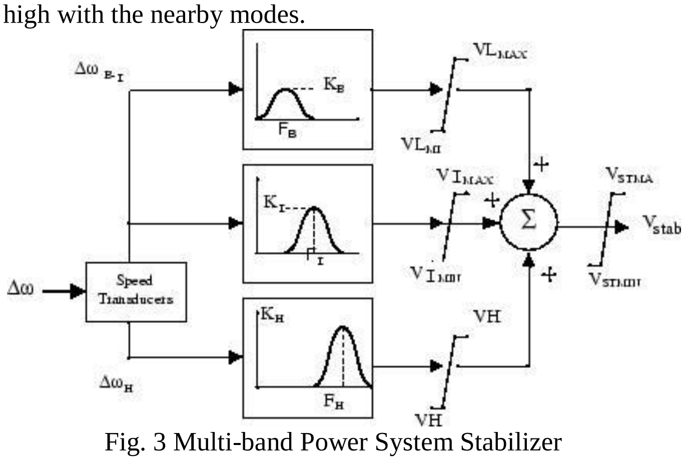


Fig. 3 Multi-band Power System Stabilizer

Inputs and outputs:

The input is the synchronous machine speed deviation $d_w$ signal

The output is the stabilization voltage, in pu, to connect to the $V_{stab}$ input of the Excitation System block used to control the terminal voltage of the block.

Description of the Transmission System

The single line diagram shown below represents a simple 400 kV multi-machine transmission system

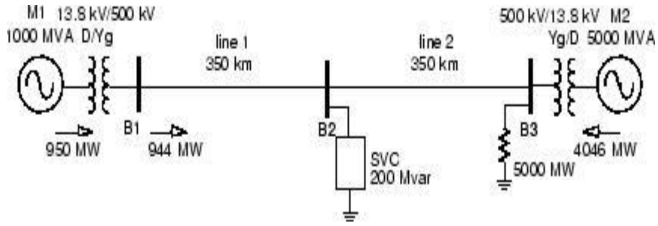


Fig.4 Single line diagram of 500kv transmission system

A 1000 MW pressure driven age plant (M1) is associated with a heap focus through a long 400 kV, 700 km transmission line. The heap focus is demonstrated by a 5000 MW resistive load. The heap is bolstered by the remote 1000 MVA plant and a nearby age of 5000 MVA (plant M2).

A heap stream has been performed on this framework with plant M1 creating 950 MW so plant M2 produces 4046 MW. The line conveys 944 MW which is near its flood impedance stacking (SIL = 977 MW). To keep up framework steadiness after issues, the transmission line is shunt remunerated at its inside by a 100 Mvar static Synchronous compensator (STATCOM). The two machines are furnished with a pressure driven turbine and senator (HTG), excitation framework, and power framework stabilizer (PSS). Two kinds of stabilizers can be associated on the excitation framework: a non-specific model utilizing the increasing speed control (Pa= distinction between mechanical power Pm and yield electrical power Peo) and a Multiband stabilizer utilizing the speed deviation (dw).

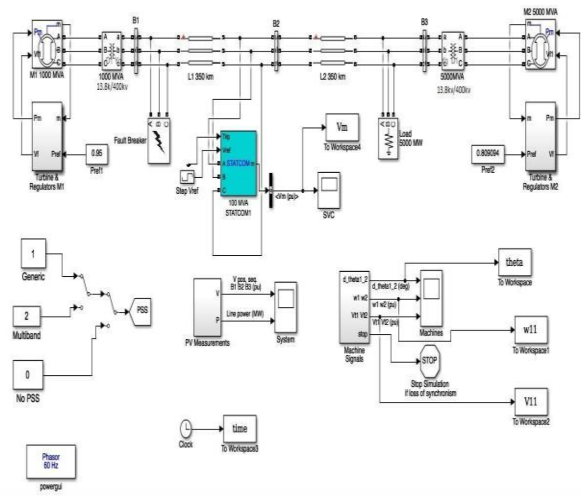

Fig. 5 Simulink model of model of 400kv transmission system with STATCOM and PSS

## IV. DISCUSSION

A load flow has been performed on this framework with plant M1 creating 950 MW so plant M2 produces 4046 MW. The line conveys 944 MW which is near its flood impedance stacking (SIL = 977 MW). To keep up framework soundness after flaws, the transmission line is shunt remunerated at its inside by a 100 Mvar static Synchronous compensator (STATCOM). The two machines are furnished with a water driven turbine and representative (HTG), excitation framework, and power framework stabilizer (PSS). Inside the two Turbine and Regulators subsystems the HTG and the excitation framework are executed. Two sorts of stabilizers can be associated on the excitation framework: a bland model utilizing the increasing speed control (Pa= distinction between mechanical power Pm and yield electrical power Peo) and a Multiband stabilizer utilizing the speed deviation (dw). These two stabilizers are standard models of the Fundamental Blocks/Machines library. Manual Switch squares enable us to choose the sort of stabilizer utilized for the two machines or put the PSS out of administration.

In STATCOM talk encase check the Power data parameters that the SVC rating is +/ - 100 Mvar. A Fault Breaker square is related at transport B1. We will use it to program unmistakable sorts of inadequacies on the 400kv structure and watch the impact of the PSS and STATCOM on system soundness.

To start the entertainment in tenacious express, the machines and the controllers have been in advance presented by techniques for the Machine Initialization utility of the Power GUI square. Load stream has been performed with machine M1 portrayed as a PV age transport (V=13800 V, P=950 MW) and machine M2 described as a swing transport (V=13800 V, 0 degrees). After the store stream has been enlightened, the reference mechanical powers and reference voltages for the two machines have been subsequently invigorated in the two predictable squares related at the HTG and excitation system inputs: Pref1 =0.95 pu (950 MW), Vref1=1.0 pu; Pref2 =0.8091 pu (4046 MW), Vref2 =1.0 pu.

## V. RESULTS

CASE 1,

Single-Phase Fault — Impact of PSS — No STATCOM

Fig.6 on the Machines scope shows the rotor point refinement d_theta1_2 between the two machines. Power trade is most outrageous when this point accomplishes 90 degrees. This banner is a not too bad indication of structure security. In case d_theta1_2 outperforms 90 degree, the machines will lose synchronism and the system goes unstable.

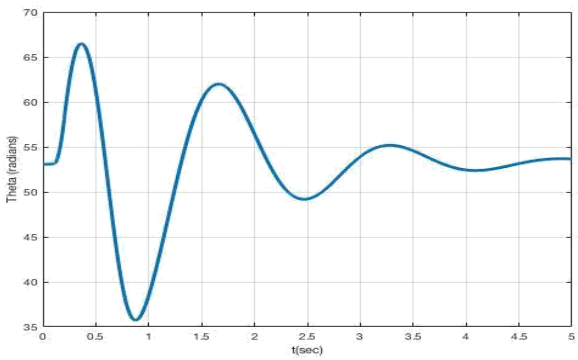


Fig.6 Rotor angle difference for single phase fault

Fig.7 exhibits the machine speeds. Notice that machine 1 speed increases in the midst of the fault in light of the way that in the midst of that period its electrical power is lower than its mechanical power

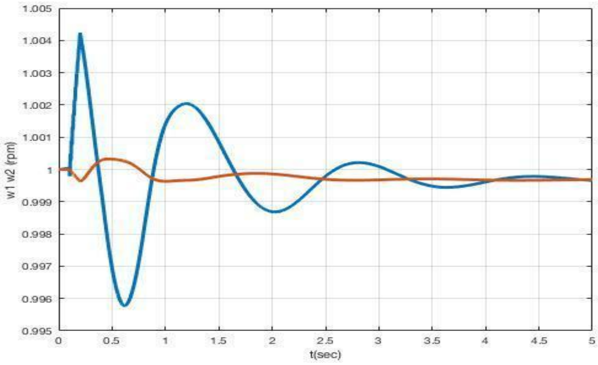


Fig. 7 Machine speeds for single phase fault

By simulating over a broad stretch of time (50 seconds) we furthermore observe that the machine speeds falter together at a low repeat (0.025 Hz) after accuse clearing as showed up in fig 8 and fig 9

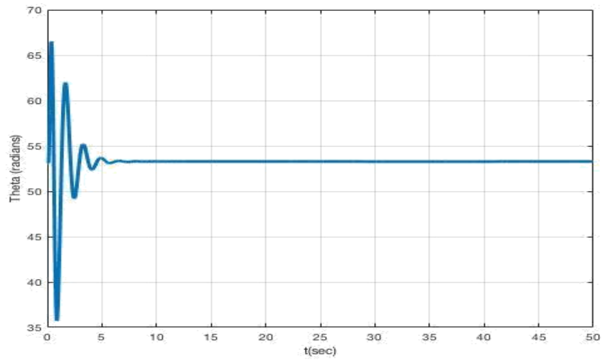


Fig.8 Rotor angle difference when simulated for 50sec

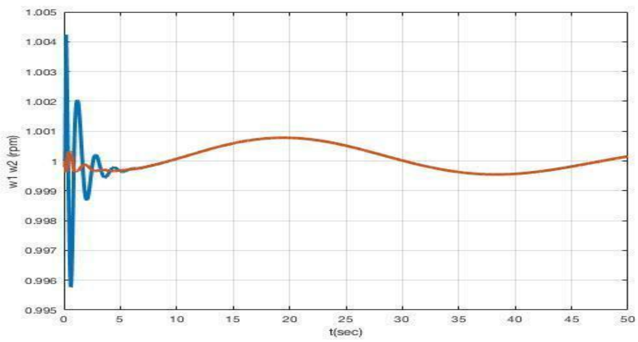


Fig.9 Speed of machines when simulated for 50sec

Case 2,

Three-Phase Fault — Impact of STATCOM — PSS in Service

We will now apply a 3-stage blame and watch the effect of the STATCOM for balancing out the system amid an extreme possibility.

First put the two PSS (Generic Pa create) in advantage. Rethink the Fault Breaker square to apply a 3-phase to-ground fault.

Start the Simulation. By taking a view at the d_theta1_2 movement in fig.10, we watch that the two machines quickly drop out of synchronism after accuse clearing. All together not to look for after futile reenactment, the Simulink Stop square is used to stop the diversion when the edge refinement accomplishes 360 degrees

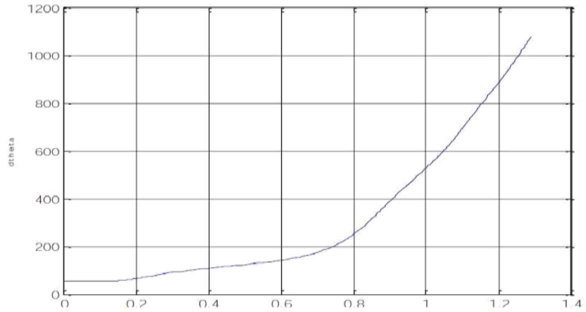


Fig. 10 Rotor angle difference for 3 phase fault when PSS is in service but not STATCOM

We can see from the diagram in fig.11, that the speed of machines isn't steady. At the point when the fault happen at 0.1sec ,after fault clearing at 0.2sec the machine speed ought to have come to stable state yet as we have not utilized STATCOM the machines free synchronism after blame clearing.

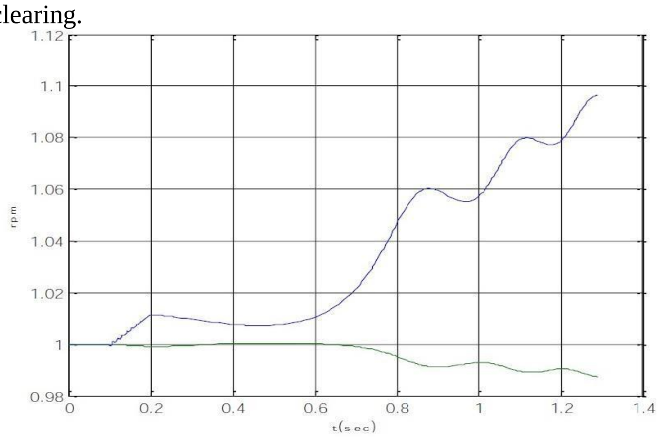


Fig.11 Speed of machines when PSS in service but not STATCOM

Restart simulation and observe that the system is now stable with a 3-phase fault.

Fig.12 on the Machines scope shows the rotor angle difference d_theta1_2 between the two machines. This signal is a good indication of system stability.

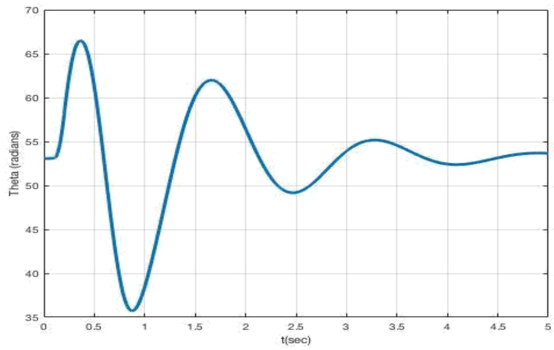


Fig.12 Rotor angle difference when STATCOM in use

Fig.13 shows the machine speeds. Notice that machine 1 speed increases during the fault because during that period its electrical power is lower than its mechanical power.

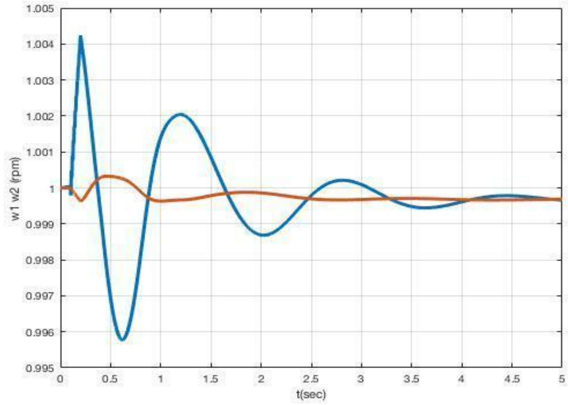


Fig.13 Speed of machines when STATCOM in use

For three phase fault we have calculated positive sequence voltage at all the three busses, with and without STATCOM as shown in fig.14 and fig.15respectively, and also we have calculated line power at bus B1 with and without STATCOM as fault has occurred at bus B1 as shown in fig.16 and fig 17 respectively.

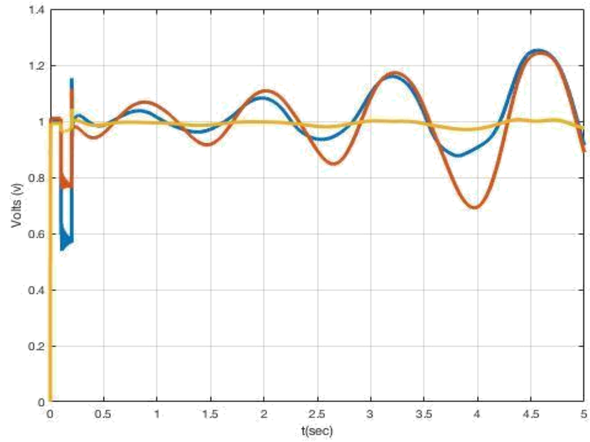


Fig.14 Positive sequence voltages without STATCOM

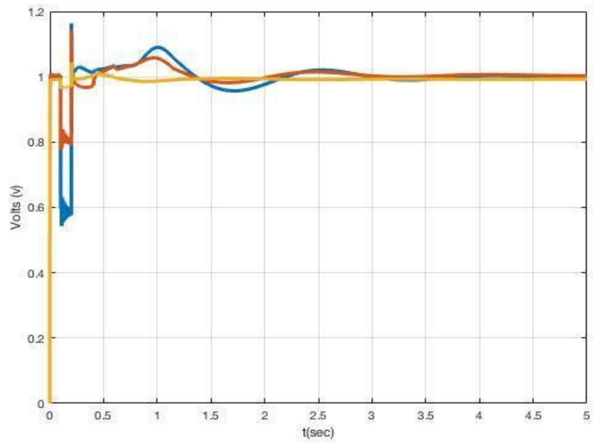


Fig 15 Positive sequence voltages with STATCOM

  

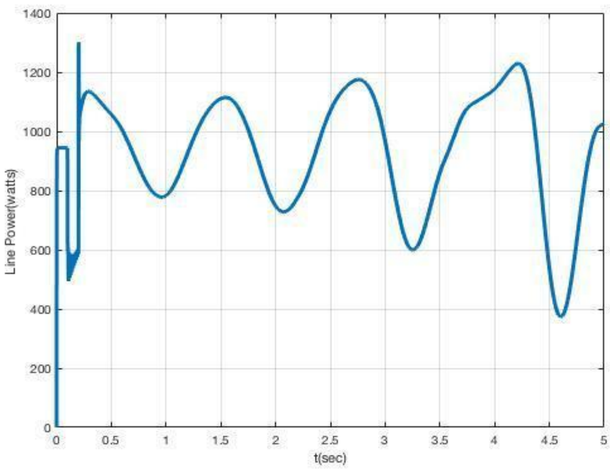


Fig.16 Line power at Bus1 without STATCOM

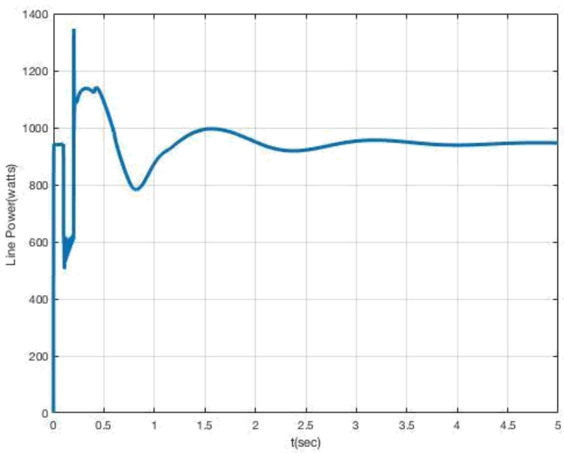


Fig.17 Line power at Bus 1 with STATCOM

## VI. CONCLUSION

The supportiveness of STATCOM has been pondered in upgrading the transient security of the above communicated framework. It is found in the examination that the transient trustworthiness of the system is extremely affected by STATCOM. In the wake of clearing the accuse high vagabonds had appeared in rotor edge difference of two machines, in transmission line voltage and power when STATCOM was not related in the line. In any case, in the wake of interfacing STATCOM in the line, transient period has decreased to a tremendous motivator for above parameter of transmission line. Along these lines it can be construed that the transient strength of two district control system improves by using STATCOM.

The transient quality of a two machine system was gotten by using the Static Synchronous Compensator and power structure stabilizer. The stabilizer improved the damping of movements made in the machine by the three-organize fault and the open power change was done by static synchronous controller by mixing responsive power in the system or tolerating the open power by the controller. It may be watched that transient change is basically encountering the kind of an issue, in like manner that the essentialness program examiner should toward the start of an alter take a gander at choose this factor.

Our target ought to be to improvise frameworks to help transient soundness. A phase has been proficient in building where the techniques for growing parity have quite recently been crushed for their limits. With the headway to diminish contraption dormancies there's a procedure with require to learn access, feasibility and fittingness of new strategies for supporting and growing trustworthiness.

## VII. FUTURE SCOPE

Interchange FACTS contraptions like static synchronous compensator (STATCOM) are the second time of FACTS controllers that has an uncommonly promising future application. STATCOM has a couple of central purposes of being pretty much nothing/negligible, high response speed. The other is static course of action synchronous compensator (SSSC) is a correlative second time FACTS controller, which is only a game plan type of STATCOM. The bound together power stream controller (UPFC) is the most adaptable one that can be used to improve transient unfaltering quality. The examination can be made with these FACTS devices shutting which device is more versatile for transient trustworthiness change. The examinations can be connected with control factor change by using FACTS contraptions.

There is the probability that system wind up shaky after first swing reliability. The examination can be connected past first swing dauntlessness to ensure that the structure will be enduring after first swing.

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