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Simulation and Performance Analysis of FACTS Controllers in Transmission line

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ABSTRACT:*Now a day, Electrical engineers are currently facing challenges to enhance the power transfer capabilities of existing transmission system.This is where the Flexible AC Transmission Systems (FACTS) technology comes into effect.FACTS devices use power electronic components to improve system performance. FACTS devices are able to control all the parameters which affecting the power flow in transmission line. This paper represents the comparison between the uncompensated system and compensated system using FACTS devices. Simulation and performance analysis of Fixed Capacitor Thyristor Controlled Reactor (FC-TCR), Static synchronous compensator (STATCOM) andThyristor controlled Series Capacitor (TCSC) have been presented in this paper. All the simulations are carried out by using MATLAB/SIMULINK software.*

Keywords- *FACTS, FC-TCR, STATCOM, TCSC.*

INTROPDUCTION

Today power systems are highly complex and require careful design of new devices, taking into consideration the already existing equipment, especially for the transmission systems in a new deregulated electricity market. In the late 1980s the EPRI (Electric Power Research Institute) introduced a new approach to solvethe problem of designing and operating power systemthe proposed concept is known as Flexible AC transmission Systems (FACTS).The two main objectives ofFACTS is to increase the transmission capacity andcontrol the power flow over designated transmission route.

In recent years, power demand has increased substantiallywhile the expansion of power generation and transmission has been severely limited due to limited resources and environmental restrictions. As a consequence, some transmission lines are heavily loaded and the power system stability becomes a power transfer-limiting factor. FlexibleAC Transmission Systems (FACTS) controllers have beenmainly used for solving various power system steady statecontrol problems. However, recent studies reveal that FACTS controllers could beemployed to enhance power systemstability in addition to their main function of power flow control.
To provide cheaper electricity, present power system is deregulated, under which power is produced byseparate generation, transmission and distribution system. Electric power demand is growing day by day. Thus it is necessary to rely on utilization of existing generating unit and to load the existing transmission line to their thermal limits and to maintain stability also. It is also necessary to operate power system with minimum loss in the transmission line. Flexible AC Transmission System (FACTS) devices play an important role in controlling power and enhancing the usable capacity of existing lines. FACTS devices use power electronic component to enhance controllability and increase power transfer capability.Futureelectric transmissionsystem can be smart by using FACTS devices.

FACTS controller includes Static SynchronousCompensator (STATCOM), Thyristor Controlled SeriesCapacitor (TCSC), Static Series SynchronousCompensator (SSSC), Static VAR Compensator (SVC),which are capable of controlling the network condition in a very fast manner to improve voltage stability and powerquality. When the system is unable to meet the reactivepower demand, voltage instability occurs in the powersystem. Reactive power imbalance occur when thesystem is faulted, heavily loaded and voltage fluctuation is there. Reactive power balance can be done byusing FACTS devices in the transmission line, which caninject or absorb reactive power in the system as perrequirement.

BRIEF LITERATURE REVIEW

There are a lot of analysis methods for determining voltage stability of power system. For[1] finding optimal location of SVC and TCSC, saddle node bifurcation analysis is applied and power flow is used to evaluate the effect of FACTS devices on system load ability.Modelling[5] and simulation of SSSC multi- machine system for power system stability enhancement is studied. Now[3] a day's voltage collapse is a major problem in power system which occurs due to the voltage instability.

Research work is going on to find new concepts for minimising voltage collapse by increasing voltage stability (Transient Stability, Steady State Stability). There[6]are a lot of analysis methods for determining voltage stability of power system. Various[4] types of FACTS controller and their performance characteristics have been described.

BASIC CONCEPT OF FACTS

The recent development of power electronics introduces the use of Flexible AC Transmission System (FACTS) controllers in power system. Flexible AC TransmissionSystems (FACTS) is a concept proposed by Hingoranithatinvolves the application of high power electronic controllers inAC transmission networks which enable fast and reliablecontrol of power flows and voltages. FACTS technology iscollection of high power electronic controllers, which can beapplied individually or in co-ordination with others to controlone or more of the interrelated system parameters.Thethyristor or high-power transistor is the basic element for avariety of high-power electronic Controllers.

FACTS is defined by the IEEE as “a power electronic based system and other static equipment that provide control of one or more AC transmission system parameters to enhance controllability and increase power transfer capability”. Flexible AC Transmission Systems, called FACTS, got in the recent years a well-known term for higher controllability in power systems by means of power electronic devices.

FACTS technology provides the opportunity to,
- Increase loading capacity of transmission lines.
- Prevent blackouts.
- Improve generation productivity.
- Reduce circulating reactive power.
- Improves system stability limit.
- Reduce voltage flicker.
- Reduce system damping and oscillations.
- Control power flow so that it flows through thedesignated routes.

FACTS controllers are capable of controlling the followingparameters
- Solve power transfer limit and stability problems
- Thermal limit
- Voltage limit
- Stability limit
- Transient stability limit
- Small signal stability limit
- Voltage stability limit
- Increase power transfer capability of a line
- Power quality improvement
- Load compensation
- Limit short circuit current
- Increase the loadability of the system

BASIC DESCRIPTION

A. Fixed Capacitor Thyristor Controlled Reactor (FC-TCR)

FC-TCR (Fixed Capacitor Thyristor Controlled Reactor)-Static VAR systems are used in the transmission lines for rapid control of voltage at weak point in the static VAR compensators(SVC) are shunt connected static generated/absorbers whose outputs are varied to control voltage of the power system. The use of SVC in transmission line is to provide high performance in steady state and transient voltage stability control, to dampen power swing, to reduce system loss and to control real and reactive power flow .FC-TCR type SVC is shown in figure.

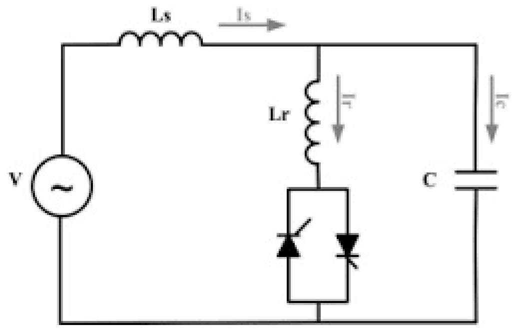


Fig 1: Fixed Capacitor Thyristor Controlled Reactor

In FC-TCR a, capacitor is connected in parallel with a Thyristor controlled reactor. The fixed capacitor is substituted fully or partially by a filter network that has the capacitive impedance at the fundamental frequency to generate the reactive power .In FC-TCR type VAR generator consists of a variable reactor and the reactor current is varied by the method of firing delay angle control. The reactor current is increased by decreasing the delay angle alpha to decrease the capacitive output when the capacitive and inductive currents becomes equal,both the VAR cancel out and gives zero VAR output with further decrease in angle alpha the inductive current becomes lower than the capacitive current and gives inductive output.

B. STATCOM

A STATCOM or Static Synchronous compensator is regulating devices used on alternating current electricity transmission network. It is based on power electronic voltage source and can act as either a source or sink or reactive ac power of electricity network compensator that is mostly used in power system for improving the power quality from one source to load. static shunt compensation is used to influence the natural Electrical chartearstics of transmission line to increases the steady state transmitted power and to control the voltage profile along line. In the principle of shunt controller inject additional current into the system at point of common coupling through the mean voltage source convertor. STATCOM is shunt connected static VAR through which capacitive or inductive output current can be controlled of ac system voltage .DC voltage is converted into ac voltage by using GTO and voltage source convertor. The voltage source converter converts dc voltage to ac voltage by using GTO and the ac voltage is inserted into the line through the transformer. If the output of the VSC is more than the line voltage, converter supplies lagging VAR to the transmission line. If the line voltage is more than the converter output voltage then converter absorbs lagging VAR from the system. Fig.2 shows a simple one line diagram of STATCOM based on a voltage source converter.

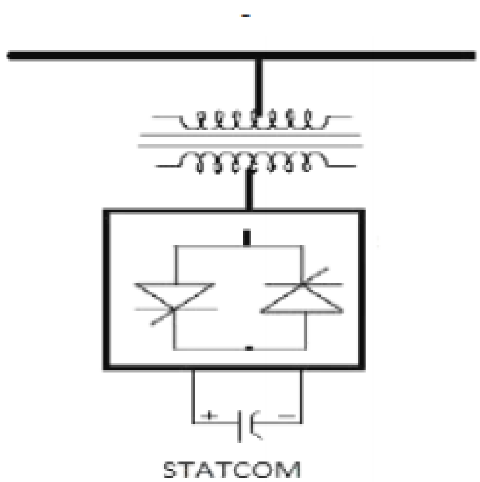


Fig.2 shows a simple one line diagram of STATCOM based on a voltage source converter.

D.Thyrister controlled series capacitor (TCSC)

Thyristor Controlled Series Compensation (TCSC) is used in power systems to dynamically control the reactance of a transmission line in order to provide sufficient load compensation. TCSC is composed of a series capacitor which has a parallel branch including a thyristor controlled reactor. TCSC operates in three modes such as Bypass Mode, Inserted with Thyrister Valve Blocked Mode &Inserted with Vernier Control Mode.

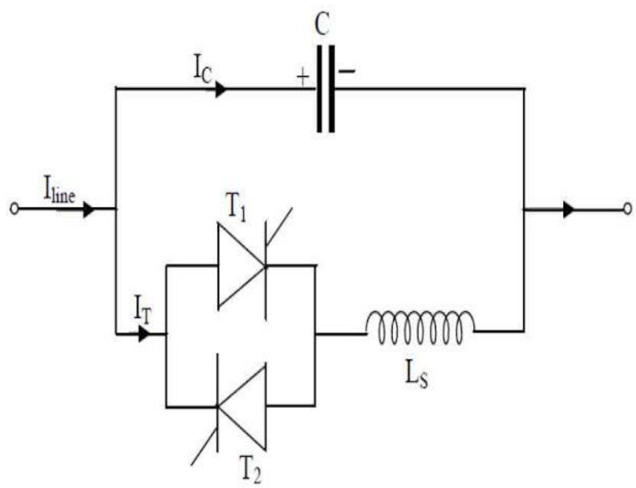


Fig 3: Thyrister controlled series capacitor (TCSC)

The TCSC is based on thyristor without gate turn-off capability. In TCSC a variable thyristor controlled reactor is connected across a series capacitor. When the firing angle of the TCR is 180 degrees, the reactor becomes non conducting and the series capacitor has the normal impedance. As the firing angle is decreased below 180 degree the capacitive reactance increases.

When the firing angle is 90 degrees, the reactor becomes fully conducting and the total impedance becomes inductive. With the 90 degrees firing angle, The TCSC helps in limiting fault current.

DESCRIPTION OF THE SYSTEM

A basic transmission (11KV) model has been employed in Matlab/Simulink program to study about th FACTS devices in detail. A single line diagram of the sample power transmission system. 11KV voltage is supplied from the ac voltage source to the system. The transmission line is considered to be a short transmission line hence capacitance of the line is neglected. The resistance of the line is 5Ω and the inductance is 0.06mH. The source impedance is (0.01+0.001) Ω and the load is kept constant at 25MW and 50MVAR .The current and voltage measurement blocks are used to measure the voltage and current at source. By the use of Active and Reactive Power Measurement Block, the real and reactive power in the load is measured.

RESULT

A.UNCOMPENSATED SYSTEM
The SIMULINK model of uncompensated system isshown below

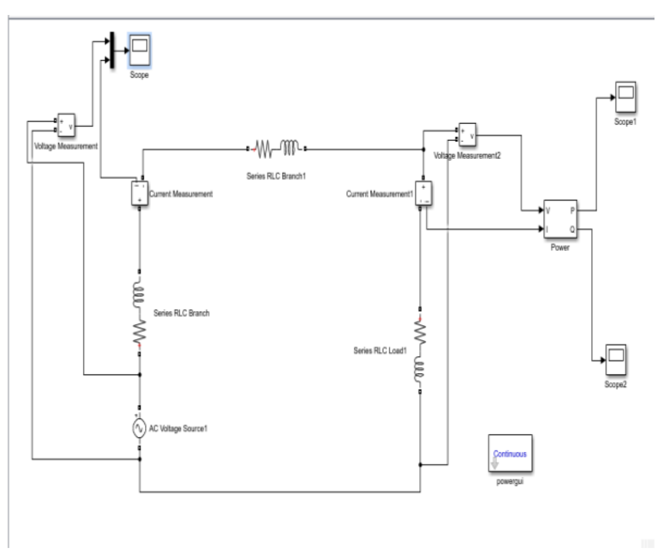


Fig:4- Uncompensated System

Results obtained after simulation is shown below.

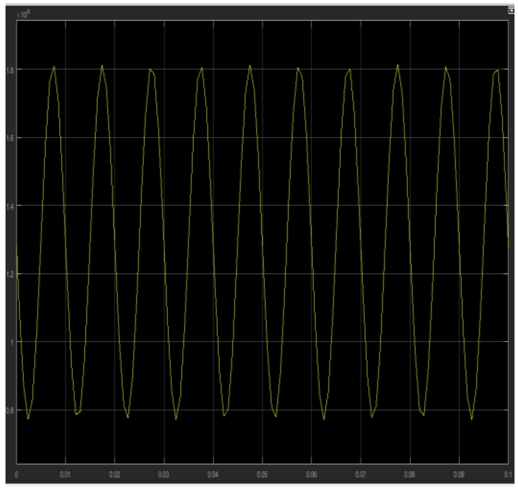


Fig4.1:- Real Power Flow

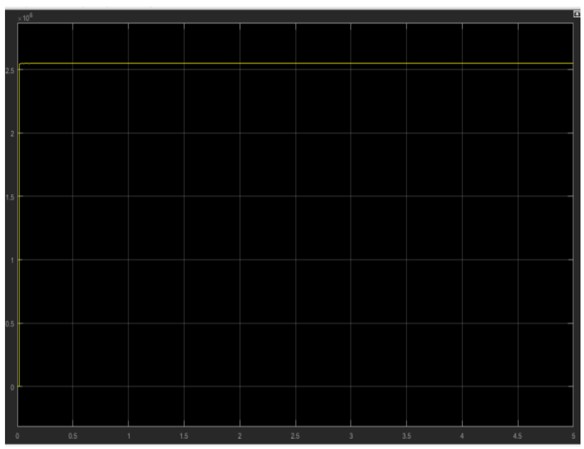


Fig4.2: - Reactive Power Flow

FC-TCR Compensated System

The SIMULINK model of FC-TCR is shown below.

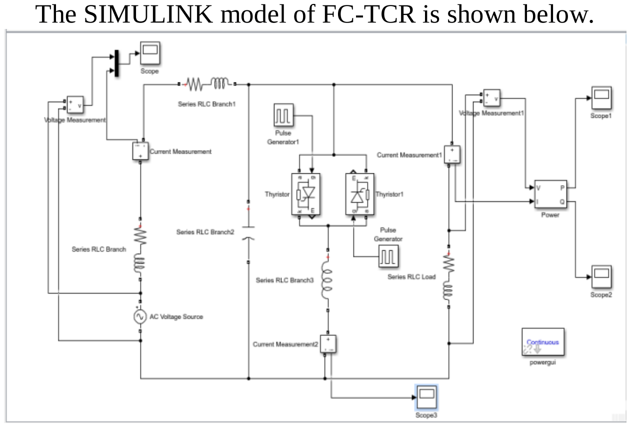


Fig5- FC-TCR Compensated System

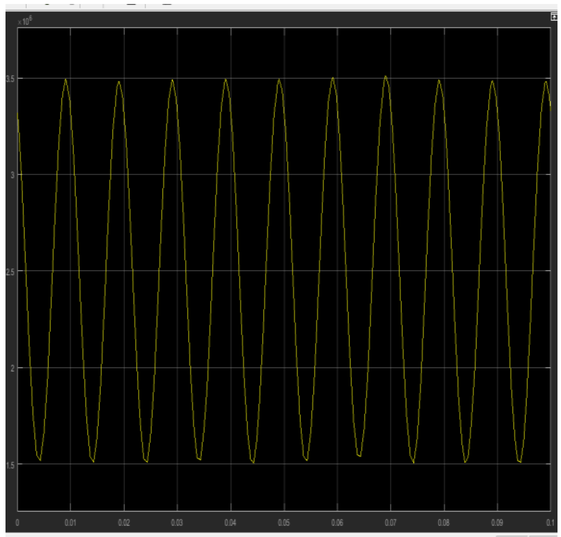


Fig5.1:- Real Power Flow

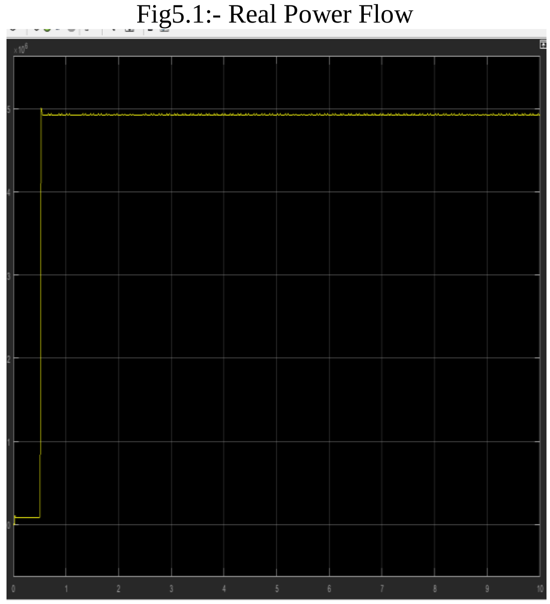


Fig5.2- Reactive Power Flow

Table1

Variation of power flow with change in Capacitances

Sr. NO	Capacitances	Real Power(MW)	Reactive power(MVAR)
1	100	1.428	2.747
2	200	1.587	2.958
3	300	1.762	3.183
4	400	1.95	3.422
5	500	2.148	3.671
6	600	2.386	3.929
7	700	2.606	4.19
8	800	2.867	4.449
9	900	3.088	4.697
10	1000	3.318	4.923
11	1100	3.697	5.279
12	1200	3.848	5.436

TCSC Compensated System

The SIMULINK model of TCSC is shown below

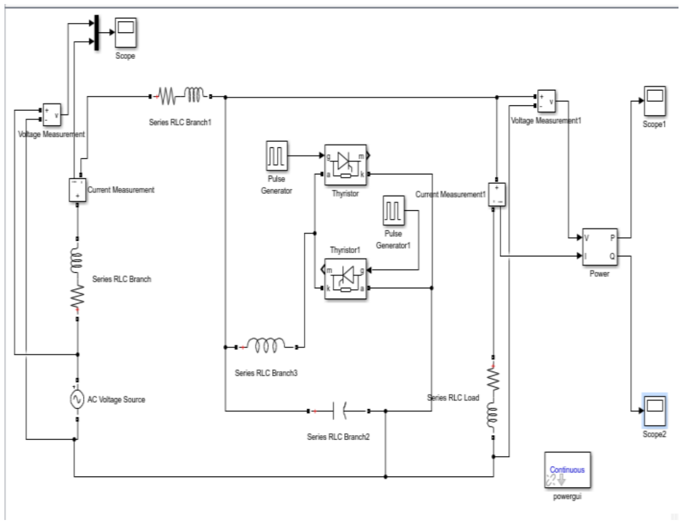


Fig6:-TCSC Compensated System

Results obtained after simulation is shown below.

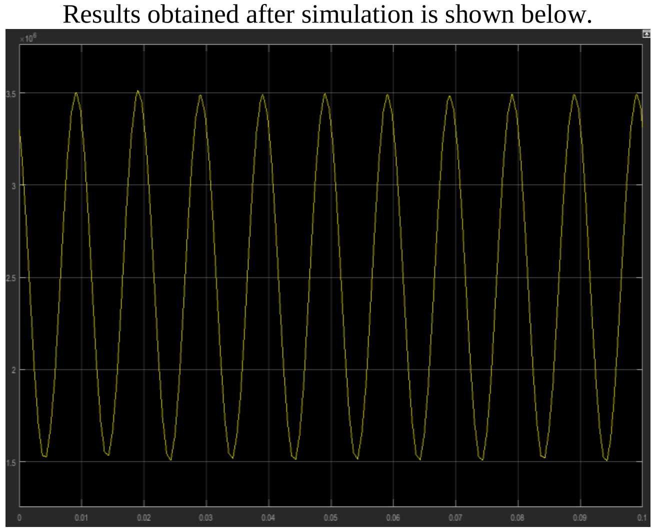


Fig6.1:-Real Power Flow

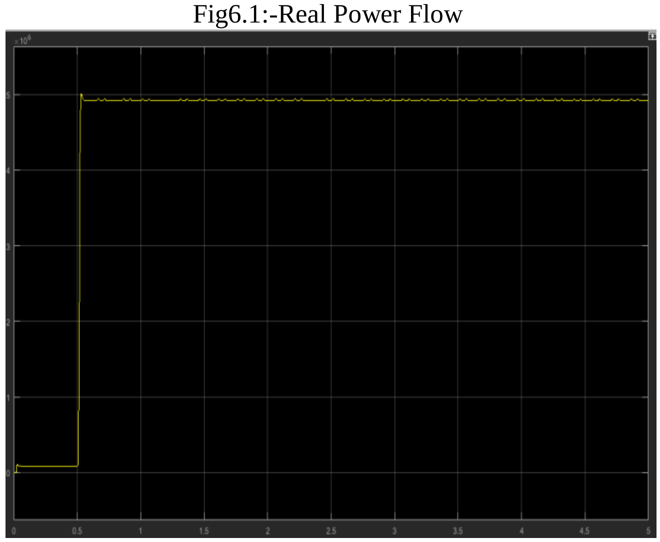


Fig6.2:- Reactive Power Flow

Table2
Variation of power flow with change in Capacitances

Sr.No	Capacitances	Real Power(MW)	Reactive power(MVAR)
1	100	1.424	2.746
2	200	4.585	2.957
3	300	1.762	3.483
4	400	1.95	3.421
5	500	2.149	3.627
6	600	2.368	3.928
7	700	2.607	4.191
8	800	2.866	4.448
9	900	3.087	4.697
10	1000	3.088	4.924
11	1200	3.698	5.279

STATCOM Compensated System

The SIMULINK model of STATCOM compensatedsystem is shown below

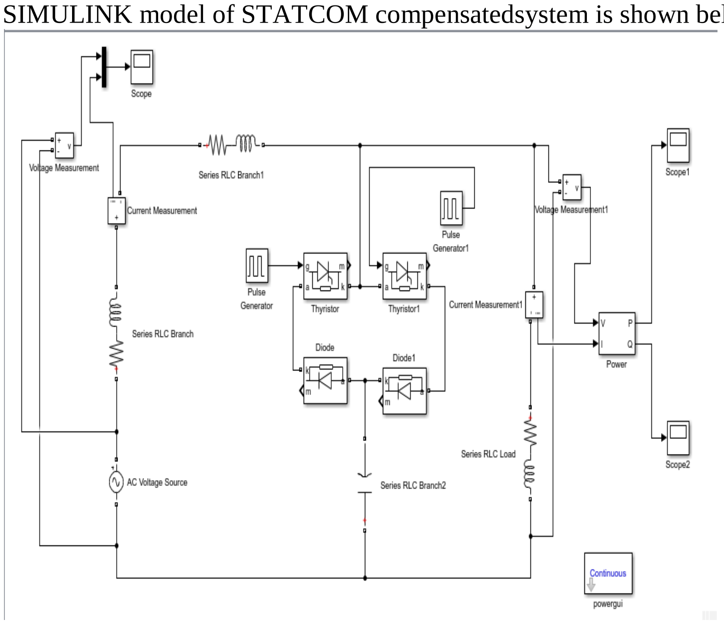


Fig7:- STATCOM Compensated System

Results obtained after simulation is shown below.

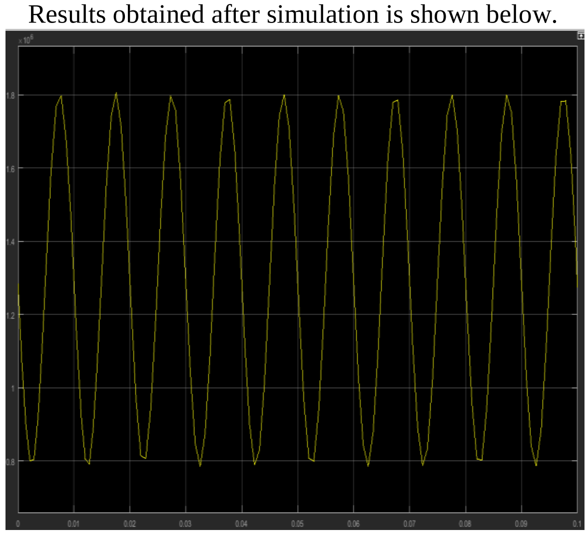


Fig7.1:- Real Power Flow

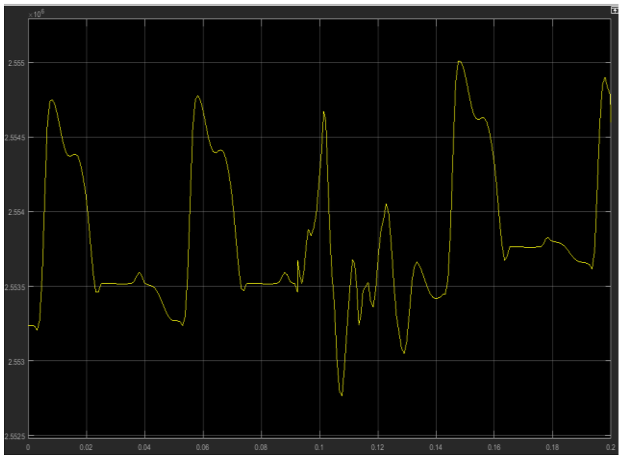


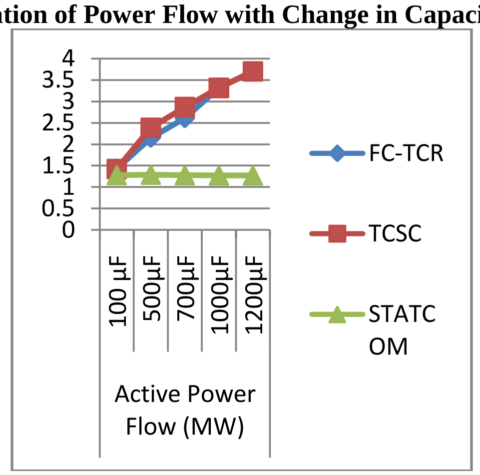
Fig7.2:- Reactive Power Flow

Table3

Variation of Power Flow with Change in Capacitance

Sr.No	Capacitances	Real Power(MW)	Reactive power(MVAR)
1	100	1.28	2.552
2	500	1.29	2.555
3	600	1.276	2.554
4	800	1.289	2.554
5	900	1.276	2.554
6	1000	1.273	2.555
7	1200	1.274	2.55
8	1500	1.294	2.553
9	2000	1.295	2.553
10	3000	1.286	2.552

Variation of Power Flow with Change in Capacitance



OBJECTIVE

The main objective of this paper is the simulation and performance analysis of FACTS controller in transmission line.

ADVANTAGES OF FACTS

Following are the benefits of FACTS devices.

➢ Improve power transmission capability

- Improve power quality
- Minimize environmental impact
- Various applications in power transmission and distribution which involves FACTS devices.
- Control of power flow both active and reactive, as desired and within the limits is possible.
- Reduction of reactive burden on line allows more flow of power in the lines.
- Reduction of voltage drop in power lines is possible.
- Voltage stability and voltage security are enhanced.
- Flicker mitigation.

APPLICATION OF FACTS

The basic applications of FACTS devices are:

- Power flow control
- Increase of transmission capability
- Voltage control
- Reactive power compensation
- Stability improvement
- Power quality improvement
- Power conditioning
- Flicker mitigation
- Interconnection of renewable and distributed generation andstorages

Conclusion:

Thus we have studied in this project using matlab/simulink using 11kv simple transmission line. This project presents performance analysis of FC-TCR,STATCOM, TCSC and FACTS devices ingraphical form.Real and Reactive power flow profile areseen to improve with all the compensating devices.Results show that in case of FC-TCR compensation,reactive power flow improves proportionally with increasing capacitance and is maximum at maximum value of capacitance (1500µF here). In case of STATCOM compensation a capacitor rating 1000µF yield best result.

REFERENCES

- K. R. Padiyar, “FACTS controllers in power transmission and distribution”,New Age Int. Publisher, 2007.
- AhadKazemi and BabakBadrezadeh, “Modelling and Simulation of SVC and TCSC to Study their Effects on Maximum Loadabilitypoint”, EPRI technical report EL-4365, April 1987.
- N. G Hingorani& Laszlo G yugyi, “Understanding FACTS: concepts and technology of flexible AC transmission System”, IEEE Press, New York(2000).
- CIGRE, “FACTS Overview”, IEEE Power Engineering Society, 95 TP 108, April 1995.
- S. Meikandasivam, Rajesh Kumar Nema and Shailendra Kumar Jain, “Behavioral Study of TCSC Device-A mat lab/Simulink Implementation”, World Academy of Science, Engineering and Technology 45, 2008.
- S.Muthukrishnan&Dr.ANirmalKumar, “Comparison of Simulation and Experimental Results of UPFC used for Power Quality Improvement”, International Journal of Computer and Electrical Engineering, Vol 2, No.3, June 2010.
- MehrdadAhmadiKamarposhti and MostafaAlinezhad, “Comparison of SVC and STATCOM in Static Voltage Stability Margin Enhancement”, World Academy of Science, Engineering and Technology 50, 2009.
- SamimaAkter, AnulelkhaSaha and prof. Pryananath Das, “Madelling , Simulation and Comparison of various FACTS devices in Power System”, International journal of Engineering Research & Technology in Vol.! Issue 8,October – 2012.