

**COMPARISON OF FACTS DEVICES FOR TWO AREA POWER
SYSTEM STABILITY ENHANCEMENT**

**A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE
REQUIREMENTS FOR THE DEGREE OF**

MASTER OF TECHNOLOGY

IN

CONTROL AND INSTRUMENTATION

BY

MAYUR PAUL

(12/C&I/2010)

Under The Supervision Of:

J.N RAI



DEPARTMENT OF ELECTRICAL ENGINEERING

DELHI TECHNOLOGICAL UNIVERSITY

NEW DELHI

CERTIFICATE

This is to certify that thesis entitled “**Comparison Of FACTS Devices For Two Area Power System Stability Enhancement**” submitted by Mayur Paul, University Roll no-12/C&I/2010, in the partial fulfillment of the requirement for the degree of Master in Technology in Control and Instrumentation, Department of Electrical Engineering, Delhi Technological University, New Delhi, is an authentic work carried out by him under my supervision. To the best of my knowledge the matter embodied in the thesis has not been submitted to any other university/institute for the award of any degree or diploma.

Date:

Sh. J.N.RAI

Department of Electrical Engineering,

Delhi Technological University,

New Delhi

ACKNOWLEDGEMENT

A project report is the result of not only work of the student but also a symbol of guidance, encouragement and help given by many people. This is actually a teamwork done by many people including research guide and friends. So before presenting the work I would like to serve my sincere regards and thanks to all those people who have helped me during my Project.

I wish to express my sincere gratitude to My Advisor Sh. Jitendra Nath Rai for his help and guidance regarding the work carried out in this thesis. I have learned a tremendous amount of work from him and gently value the time that we had spent working together. Also, I would like to thank the faculty of Electrical Engineering Department specially Prof. Madhusudan Singh, HOD (EE) for creating a positive learning environment around me and rest of the students. I would also like to thank my friends and colleagues here at Delhi Technological University, Delhi for their encouragement and companionship.

Finally I want to thank my family members for their love and constant support of my academic pursuits.

ABSTRACT

Transmission networks of modern power systems are becoming increasingly stressed because of growing demand and restrictions on building new lines. One of the consequences of such a stressed system is the threat of losing stability following a disturbance. Flexible ac transmission system (FACTS) devices are found to be very effective in a transmission network for better utilization of its existing facilities without sacrificing the desired stability margin. Flexible AC Transmission System (FACTS) such as Static Synchronous Compensator (STATCOM) and Static VAR Compensator (SVC), employ the latest technology of power electronic switching devices in electric power transmission systems to control voltage and power flow. A static synchronous compensator (STATCOM) and Static Var Compensator (SVC) is the shunt device of the flexible AC transmission systems (FACTS) family. When system voltage is low, STATCOM generates reactive power and when system voltage is high it absorbs reactive power where as the Static Var compensator provides the fast acting dynamic compensation in case of severe faults. In this Thesis, the performance of SVC is compared with the performance of STATCOM. Proposed controllers are implemented using MATLAB/SIMULINK. Simulation results indicate that the STATCOM controller installed with two machine systems provides better damping characteristics in rotor angle as compared to two machine system installed with SVC. Thus, transient stability enhancement of the two machine system installed with STATCOM is better than that installed with SVC.

CONTENTS

CERTIFICATE	ii
ACKNOWLEDGEMENT	iii
ABSTRACT	iv
LIST OF FIGURES	viii
LIST OF TABLES	x
LIST OF ACRONYMS	xi
 CHAPTER	
1. INTRODUCTION	1
1.1 Introduction	1
1.2 Power System Constraints	2
1.3 Introduction of FACTS Devices	2
 2. LITERATURE REVIEW	5
3. POWER SYSTEM STABILITY	11
3.1 Introduction	11
3.2 Rotor Angle Stability	12
3.3 Voltage Stability	14
3.4 Frequency Stability	16
3.5 Power Angle Curve.....	16
3.6 Power-Angle Equation	16
3.7 Power-Angle Equation	17
3.8 Equal Area Criteria	17
3.9 Swing Equation.....	19
3.10 Swing Curve	20
 4. FACTS CONTROLLERS	21
4.1 Types of Facts Controllers	21
4.2 Compensation Techniques used by FACTS Controllers	21
4.3 Static Var Compensator	23
4.4 Operating Principal of SVC.....	23
4.5 Advantages of SVC	24

4.6	Static Synchronous Compensators	24
4.7	Operating Principal of STATCOM	25
4.8	V-I Characteristics of STATCOM	27
4.9	Operating modes of STATCOM	28
4.10	Advantages of STATCOM over SVC.....	28
4.11	Static Synchronous Series Compensators	28
4.12	Operating Principal of SSSC	29
4.13	Operating Mode of SSC.....	29
4.14	Advantages of SSC	30
4.15	Thyristor Controlled Series Capacitor (TCSC).....	30
4.16	Operating Principal of TCSC.....	30
4.17	Advantages of TCSC	31
4.18	Unified Power Flow Controller	31
4.19	Operating Principal of UPFC.....	32
4.20	Operating Modes of UPFC	33
4.21	Advantages of UPFC	34
4.22	Interline Power Flow Controller (IPFC).....	34
4.23	Under Developed FACTS Devices	35
4.24	Generalized Unified Power Flow Controller	35
4.25	Advantages of GUPFC	36
4.26	Convertible Static Compensator (CSC).....	36
4.27	Capabilities of Different FACT Controllers	37
4.28	Benefits of FACTS Devices	38
5.	SIMULATION AND RESULTS.....	39
5.1	Two Machine System	39
5.2	Single line diagram of two machine system	39
5.3	Simulink model of two machine system	40
5.4	Simulation Results	46
5.5	Comparison between FACT Devices	52
6.	Conclusion and Future Scope	56
6.1	Conclusion	56
6.2	Future Scope	57

REFERENCES	58
APPENDIX A	62

LIST OF FIGURES

FIGURE	CONTENTS	PAGE
3.1	Classification of power system stability	12
3.2	Power angle curve	18
3.3	Swing Curve	20
4.1	Functional model of SVC	23
4.2	Functional model of STATCOM	25
4.3	V-I characteristics of STATCOM	27
4.4	Operating modes of STATCOM	28
4.5	Functional diagram of SSSC	29
4.6	Functional diagram of TCSC	30
4.7	Functional diagram of UPFC	32
4.8	Functional diagram of IPFC	34
4.9	Functional diagram of GUPFC	35
4.10	Functional diagram of CSC	36
5.1	Two area interconnected system	39
5.2	SLD of two machine system	40
5.3	Two machine system installed with three phase fault	41
5.4	Two machine system installed with SVC and PSS	42
5.5	Two machine system installed with STATCOM and PSS	43
5.6	Simulink model of turbine and regulator	44
5.7	Simulink model of PSS installed with excitation system	45
5.8	Deviation of rotor angle with time	46
5.9	Deviation of terminal voltage with time	46
5.10	Variation of bus voltage with time	47
5.11	Variation of line power with time	47
5.12	Deviation of rotor angle with time(SVC)	48
5.13	Deviation of terminal voltage with time	48
5.14	Variation of voltage at SVC bus with time	49
5.15	Variation of bus voltage with time	49
5.16	Variation of line power with time	50

FIGURE	CONTENTS	PAGE
5.17	Deviation of rotor angle with time(STATCOM)	50
5.18	Deviation of terminal voltages with time	51
5.19	Deviation of bus voltages with time	51
5.20	Variation of line power with time	52
5.21	Deviation of rotor angle with time	52
5.22	Deviation of terminal voltage with time	53
5.23	Deviation of rotor angle with time	53
5.24	Deviation of terminal voltages with time	54
5.25	Deviation of rotor angle with time(SVC)	54
5.26	Deviation of rotor angle with time(STATCOM)	55

LIST OF TABLES

TABLE	CONTENTS	PAGE
4.1	Comparison among FACTS Controllers	21
4.2	Capabilities of different FACTS Controllers	37
5.1	Comparison between STATCOM and SVC	55
A1	Synchronous machine data	62
A2	Excitation System data	62
A3	Transformer data	63
A4	Load data	63

LIST OF ACRONYMS

AC	Alternating Current
DC	Direct Current
IEEE	Institute of Electrical and Electronics Engineers
FACTS	Flexible Alternating Current Transmission System
STATCOM	Static Synchronous compensator
VSC	Voltage Source Converter
GTO	Gate Turn-off Thyristor
IGBT	Insulated Gate Bipolar Transistor
SVC	Static Var Compensator
SSSC	Static Synchronous Series Capacitor
TCSC	Thyristor Controlled Series Capacitor
UPFC	Unified Power Flow Controller
IPFC	Interline Power Flow Controller
GUPFC	Generalized Unified Power Flow Controller
CSC	Convertible Static Capacitor