

**FLEXIBLE AC TRANSMISSION SYSTEMS (FACTS)
CONTROLLERS FOR DAMPING POWER SYSTEM
OSCILLATIONS**

By

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DEPARTMENT OF ELECTRICAL ENGINEERING

Submitted

in fulfilment of the requirements of the degree of

DOCTOR OF PHILOSOPHY

to the



**INDIAN INSTITUTE OF TECHNOLOGY, DELHI
INDIA**

SEPTEMBER, 2003

Dedicated

to

My parents Mr. and Mrs. Tambey

and

My parent-in-laws Mr. and Mrs. Jambhrunkar

ACKNOWLEDGEMENTS

I take this opportunity to express my deep sense of gratitude to my research supervisor Prof. M.L. Kothari, Department of Electrical Engineering, Indian Institute of Technology, Delhi for his invaluable guidance, advice, thought provoking suggestions, constant encouragement and inspiration at every stage of this research work. He has been a principal motivating force behind this research work.

It has been my proud privilege to work with Prof. M.L. Kothari, a luminary in the field of power system engineering. His excellent and aesthetic oriented guidance has helped immensely in shaping up this thesis. I shall remain obliged and indebted to him forever. I also thank Mrs. M.L. Kothari for her caring attitude, encouragement and advice received from her at some difficult moments during this research work.

I express my indebtedness to Prof. P.R. Bijwe, Dr. Sanjay Roy and Prof. D. P. Kothari for their valuable technical suggestions.

I am thankful to Dr. N.T. Khobragade, Principal, Shri Ramdeobaba Kamla Nehru Engineering college, Nagpur for his encouragement and moral support during my research work.

I am thankful to all research scholars, especially to Dr. Avdhesh Sharma, Mrs. Sushma Gupta, Mr. Sumit Ghatak Chowdhary, Mr. Alok kanti Deb and Mrs. Shubhi Purwar for their help and support during my research work.

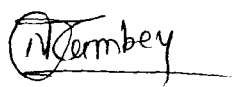
My sincere thanks to Mr. and Mrs. Wankhede, my uncle-aunty for their love, care and all kind of support during my stay in Delhi.

My Parents Mr. and Mrs. Tambey, my brother Mr. Pravin , my sister and Brother-in-law, Mr. and Mrs. Rahate and my parent-in-laws, Mr. and Mrs. Jambhrunkar have been the main inspiring and driving force in this endeavor for which no word of thanks would be sufficient.

Thanks are due to all my relatives, friends and colleagues who have contributed directly and indirectly to the completion of this work.

Above all, I am extremely grateful to my husband Sharad, for his sacrifice and excellent co-operation during my research work. His loving, caring and sacrificing attitude has been the driving force in this endeavor and no words of thanks are enough.

August 2003


(Neelima Tambey)

ABSTRACT

The thesis deals with the design of FACTS controllers for damping power system oscillations. Investigations have been carried out considering Thyristor Controlled Series Capacitor (TCSC), Static Synchronous Series Compensator (SSSC) and Unified Power Flow Controller (UPFC). The linear dynamic models of the system (known as modified Heffron-Phillips models) with TCSC, SSSC and UPFC have been used. A comprehensive approach for optimizing the FACTS controllers is presented considering conventional techniques (i.e. Gradient type Newton algorithm and Multi-modal decomposition technique) and Genetic and Evolutionary Algorithm (GEA). The dynamic interaction between the power system stabilizers (PSS) and FACTS based damping controller has been investigated.

The effect of variation of apportioning a total specified degree of series compensation to a conventional fixed compensation and TCSC on the optimum parameters of the TCSC based damping controller and system dynamic performance has been investigated in the presence of a PSS. Studies show that whereas optimum gain setting of the damping controller decreases significantly, the time constants remain more or less unaffected with the increase in contribution of TCSC to the total series compensation. However, variations in apportioning of the total series compensation to fixed and TCSC hardly affect the damping of the system oscillations provided the corresponding optimum damping controllers are considered.

A systematic approach for the design of SSSC controllers (i.e. power flow

controller, DC voltage regulator and damping controller) for a single machine infinite bus (SMIB) system has been presented using conventional techniques and GEA. The effect of variation in loading condition on the constants of the system model and hence on the optimum parameters of the SSSC based damping controller and dynamic performance of the system has been investigated. The detailed studies reveal that although the model constants and the optimum parameters of the damping controller vary widely with the variations in loading condition, the dynamic performance of the system with nominal optimum SSSC based damping controller is quite robust to wide variations in loading condition. Investigations reveal that the variation in apportioning of the total series compensation to conventional fixed compensation and SSSC, results into wide variation in model parameters and optimum settings of damping controller. However, the dynamic performance of the system remains more or less unaffected following variations in apportioning of the total compensation to SSSC and conventional fixed capacitor, provided the corresponding optimum damping controllers are considered. Studies show that the dynamic responses of the system obtained with SSSC controllers optimized simultaneously applying GEA are slightly better than those obtained with sequentially optimized SSSC controllers by GEA and conventional techniques.

A comprehensive approach, for optimizing the UPFC controllers (i.e. power flow controller, DC voltage regulator and damping controller) for a SMIB system using conventional optimization techniques has been presented. The power flow and DC voltage regulators are designed by applying Gradient type Newton Algorithm and the damping controllers by applying multi-modal decomposition and phase compensation techniques. Studies reveal that the damping gets adversely affected with the incorporation

of DC voltage regulator. Investigations have been carried out to understand the relative effectiveness of modulation of the UPFC control signals (m_B , δ_B , m_E and δ_E) on damping of the system oscillations using a controllability index. Investigations show that the effect of modulation of the control parameter $\Delta\delta_B$ is quite insignificant in damping the oscillations. A novel dual damping controller based on simultaneous modulation of UPFC control signals m_B and δ_E has been proposed.

Investigations reveal that the optimum TCSC, SSSC and UPFC based damping controllers designed using linear models also assist in improving transient stability of the system.

UPFC controllers for a multimachine system have been designed in the presence of PSS. An approach for optimum location of PSS using residue technique has been presented. The optimization of PSS has been carried out using multi-modal decomposition and phase compensation techniques. Studies reveal that the UPFC based damping controllers modulating control parameter m_B is most effective in damping the oscillations. UPFC controllers for a multimachine system have been optimized using conventional optimization techniques and GEA.

The dynamic performance of the system with UPFC controllers optimized sequentially using conventional techniques, has been compared with those obtained applying GEA. The studies reveal that the overall dynamic performance of the system with UPFC controllers optimized simultaneously using GEA is better as compared to that obtained with UPFC controllers optimized sequentially using GEA and by conventional optimization techniques.

Studies are carried out to understand the effect of number of subpopulations and number of individuals on the convergence of GEA. The studies reveal that although the initial convergence rate is somewhat affected by the number of individuals and number of subpopulations, the GEA converges in more or less same number of generations.

Investigations reveal that the PSS and UPFC based damping controller cooperate with each other in enhancing the system damping.

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CERTIFICATE

This is to certify that the dissertation entitled, "**FLEXIBLE AC TRANSMISSION SYSTEMS (FACTS) CONTROLLERS FOR DAMPING POWER SYSTEM OSCILLATIONS**" being submitted by **Neelima Tambey** to the Indian Institute of Technology, Delhi for the award of the degree of **Doctor of Philosophy in Electrical Engineering**, is a record of bonafide research work carried out by her. She has worked under my supervision and guidance and has fulfilled the requirement for submission of the thesis. The matter embodied in this thesis has not been submitted elsewhere in part or full for award of any other degree or diploma.

Date : 19.9.03


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