TRANSMISSION NETWORK EXPANSION PLANNING

by

ASHU VERMA
Department of Electrical Engineering

Submitted
In fulfillment of the requirements for the degree of
DOCTOR OF PHILOSOPHY

to the

INDIAN INSTITUTE OF TECHNOLOGY, DELHI
HAUZ KHAS, NEW DELHI-110016
INDIA
DECEMBER 2009

CERTIFICATE

This is to certify that the thesis entitled "**TRANSMISSION NETWORK EXPANSION PLANNING**" which is being submitted by Ms. Ashu Verma to the Indian Institute of Technology Delhi, for the award of Doctor of Philosophy, is a bonafide research work carried out by her. She has worked under our supervision and guidance and has fulfilled the requirements for the submission of this thesis. The thesis, in our opinion, has attainted a standard required for a Ph. D degree of this institute. The results contained in this thesis have not been submitted else where in part or full for the award of any degree or diploma.

PROF. P. R. BIJWE

Department of Electrical Engineering
Indian Institute of Technology Delhi
New Delhi-110016

DR. B.K. PANIGRAHI

Department of Electrical Engineering
Indian Institute of Technology Delhi
New Delhi-110016

ACKNOWLEDGMENTS

It gives me immense pleasure to express my sincere gratitude to Prof. P.R. Bijwe and Dr. B.K. Panigrahi, for sparing their valuable time and providing me invaluable guidance for successful completion of this thesis work. I am highly thankful to Prof. P.R. Bijwe for his constant encouragement and support throughout my tenure at I.I.T Delhi without which it would have been impossible for me to carryout this work.

I am thankful to Head, Electrical Engg. Department, I.I.T. Delhi for the facilities he provided during this work.

I am also thankful to my student research committee members, Prof. Bhim Singh, Dr. Sukumar Mishra and Prof. T.S. Bhatti for their valuable suggestions and advice given to me from time to time during the period of this work. I must thank Dr. N. Sen Roy and Dr. A.R. Abhiyankar for sparing their valuable time with me, for discussions, whenever necessary.

I wish to give my sincere thanks to staff members of power system simulation laboratory for providing me the laboratory facilities during this work.

Thanks are also due for Teri University for providing me time for the end stage completion of this work.

I must acknowledge my friends and colleagues Mr. Ravi, Ms. Stuti Shukla, Dr. G.K. Viswanadha Raju, Dr. C.N. Bende, Ms. Anita Khanna, Ms. Padma Gandha, Mr. Surender, Dr. Priyanka, and Dr. V.V.N. Kishore for their kind co-operation and support.

Last but not the least, I am highly indebted to my husband Harish for his unconditional support, encouragement, and understanding, provided to me throughout the tenure. Special thanks to my son Aryan who came as a blessing in my life. I am highly thankful to my parents, my sisters and my mother in law who were always there to help me.

Date: (Ashu Verma)

ABSTRACT

Transmission network expansion planning (TNEP) is an important component of power system planning. Its task is to determine the optimal set of transmission lines to be constructed such that the cost of expansion plan is minimum and no network constraints are violated during the planning horizon. The problem is very complex due to large number of options to be analysed and the discrete nature of the optimization variables. The challenges have increased even more because of deregulated system operation. Hence, more efficient techniques are required for TNEP. Uncertainties in load specifications must also be incorporated in TNEP as the chances of their occurrence are more due to its long range nature. In this dissertation, an attempt has been made to develop new algorithms and models for TNEP in certain and uncertain environment.

The highlights of the research work carried out in this dissertation are as follows.

A new simple and efficient heuristic algorithm has been developed for TNEP with and without security constraints. The presented method utilizes single/double line compensation approach for a single/double line modification simulation. The proposed approach is very efficient as it does not require refactorization of Jacobian matrix which is the most time consuming part in a power flow simulation.

A TNEP model for handling uncertainties in load forecast has been developed. Boundary DC power flow is utilized to model the non statistical uncertainties in load specifications. The TNEP is solved with two methods: 1) Basic Binary Genetic Algorithm (GA), 2) the compensation based heuristic method developed for TNEP in crisp environment has been extended to include the uncertainties in load forecast. The

proposed heuristic approach is very efficient as it does not require refactorization of Jacobian matrix.

A metaheuristic method known as bacteria foraging-differential evaluation algorithm (BF-DEA) has been presented for TNEP. Comparison of results has been made with the ones obtained with basic binary GA and particle swarm optimization (PSO).

The effectiveness of an improved harmony search (IHS) algorithm has been demonstrated for TNEP. The comparison of results has been carried out with the ones obtained with BF-DEA and basic binary GA. Also, a hybrid method having combination of heuristic method (proposed earlier) and metaheuristic method (IHS) has been proposed for TNEP.

The application of IHS for dynamic transmission network expansion planning (DTNEP) has been presented. The importance of DTNEP over static transmission network expansion planning (STNEP) has been illustrated. Also, a rolling window based approach for DTNEP has been presented.

Results for various sample test systems have been obtained which validate the proposed algorithms.

CONTENTS