ON SOME ASPECTS OF A FEW FAST LOAD FLOW ALGORITHMS

By

P. S. NAGENDRA RAO

Thesis Submitted in Partial Fulfilment of
the Requirements for the Degree of
DOCTOR OF PHILOSOPHY

DEPARTMENT OF ELECTRICAL ENGINEERING

INDIAN INSTITUTE OF TECHNOLOGY, DELHI

JULY, 1981

C E R T I F I C A T E

Certified that this work 'On Some Aspects of a few Fast Load Flow Algorithms' by Shri P.S.Nagendra Rao, has been carried out under our supervision and this work has not been submitted elsewhere for a degree.

Dr.K.S.P.Rao,
Assistant Professor,
Centre for Energy Studies,
Indian Institute of Tech.,
New Delhi-110016

Dr. J.Nanda,
Professor
Department of Electrical Engineering
Indian Institute of Technology,Delhi
New Delhi-110016

ACKNOWLEDGEMENTS

I acknowledge with great pleasure , the encouragement, guidance and cooperation I received from my supervisors Professor J.Nanda and Dr. K.S. Prakasa Rao, throughout the course of this work.

I deem that it was my privilege to work with Professor J. Nanda, a luminary in the area of Power Systems Engineering. His vast experience, and realistic approach have been of great help to me in percieving new ideas in their proper perspective.

Dr. Prakasa Rao has been the motive force behind this work. But for his untiring persuasion and exemplary attitude towards academic growth, I would never have even thought of doing anything beyond the 'daily grind' of teaching. Dr. Rao has not been just a mentor in my research pursuits, but he has been my 'friend, philosopher and guide' in every sense of of the phrase. I would cherish for ever, our close association of over five years.

I thank M/S J.N.Saini and Padmanabhan Nambiar for their monumental patience in typing my 'impossible' scripts and always producing excellent end products.

- P.S. NAGENDRA RAO

ABSTRACT

This thesis presents the results of the investigations on some existing and some new fast load flow methods. The reliability of the Fast decoupled load flow (FDLF) method for systems having lines of large R/X ratios and/or capacitive series branches (ill-conditioned systems) is investigated on the basis of a large number of sample system studies. The poor reliability of the FDLF method as observed from the studies is further established by a theoretical investigation of the FDLF model. An empirical criterion for convergence of the FDLF method is suggested and a practically viable technique is proposed for applying this reliability criterion while solving large size power flow problems by the FDLF method. A new load flow method is proposed combining the features of the FDLF and ε-coupling methods in order to achieve improved reliability and high computational efficiency. Eventhough this new load flow method exhibits improved convergence behaviour in some situations, no specific improvement in reliability is observed. In view of this two more load flow techniques are proposed in the thesis. One of them is a second order load flow method in rectangular coordinates and the other is a hybrid version of Z-bus and second order load flow methods. System studies reveal that these algorithms are highly reliable In addition, the time and memory requirements for these methods compare quite favourably with the FDLF method in general. These

methods are essentially constant matrix approaches. Hence a new technique is proposed for handling the generator Q limits without sacrificing the computational efficiency of these methods. Moreover, this Q limit handling procedure can be used with any other constant matrix load flow methods. An analytical investigation based on the iteration functions for various load flow algorithms is presented in an attempt to highlight the reliability of the proposed second order load flow model. In this context a conjectured condition for the absolute convergence of the Newton's method in rectangular coordinates is also presented. In order to facilitate the use of the proposed fast load flow algorithms amenable to small computers with limited memory, extremely efficient exact piecewise approaches are developed. The generality of the proposed piecewise methodologies is demonstrated by using them to develop a new piecewise approach for the FDLF method. Further, several existing load flow techniques have been closely studied in the process of the development of the proposed techniques. Details of some of these studies are also presented which provide new insight into the behaviour of some of the existing techniques or help to clarify some of the prevalent misconceptions in the field of load flow calculation methods.

C O N T E N T S