ON SOME ASPECTS OF LOAD FLOW AND OPTIMAL LOAD FLOW OF INTERCONNECTED POWER SYSTEMS

by

SURESH CHANDRA SRIVASTAVA

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CERTIFICATE

This is to certify that the thesis entitled "On Some Aspects of Load Flow and Optimal Load Flow of Interconnected Power Systems" which is being submitted by Shri Suresh Chandra Srivastava 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 him. He has worked under our joint supervision and guidance and has fulfilled the requirements for the submission of this thesis. The thesis, in our opinion, has attained the standard required for a Ph.D degree of this institute. The results contained in this thesis have not been submitted elsewhere in part or full for the award of any degree or diploma.

(J.NANDA)
Professor and Head
Department of Electrical Engg.
Indian Institute of Technology
New Delhi - 110016

D P Kothari
(D.P.KOTHARI)
Professor of Electrical Engg.
Centre for Energy Studies
Indian Institute of Technology
New Delhi - 110016

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ABSTRACT

This thesis deals with two important problems of power system studies viz. load flow and optimal load flow studies.

Fast decoupled load flow method of Stott and Alsac [22] is one of the most popular methods used by utilities for load flow studies, which is well known for its speed of solution, reduced memory requirement and reliable convergence. In FDLF model, Stott and Alsac have considered certain additional assumptions like omission of line series resistances, transformer taps and shunt reactances etc., while forming [B'] matrix in order to improve the convergence behaviour of the method. However, neither they nor any other researcher have provided any study to examine the individual weightages of these assumptions or the effect of considering them in the formation of [B"] on the convergence property of the load flow solution. An attempt has therefore been made to explore clearly, through detailed system studies, the justification, relative importance and weightages of such additional assumptions in formulating both [B'] and [B"] matrices on the convergence pattern of FDLF method.

With increased popularity of small computers having limited memory available with utilities, companies and research and development organizations, the need exists for development of a simple and reliable method requiring minimal storage, that can handle power flow solutions of large scale power systems on such

computers. A piecewise load flow algorithm suggested by Nanda et.al.[34] for such applications requires minimal memory, which is almost independant of system size. Although the method appears to be attractive, its convergence behaviour, however, has not been tested for various system conditions. Hence, an attempt has been made to explore the convergence behaviour of the method through extensive system studies on sample test systems performing under various normal and under various ill-conditioned situations. It has been observed that the piecewise method is as reliable as FDLF method.

Works on second order load flow methods were in the direction of achieving more exact models for reliable and faster solution. Various second order load flow methods in polar and rectangular co-ordinates developed in the past could not prove their superiority over first order models as they require more computational time and memory space. Fast decoupled load flow method, though extremely powerful yet exhibits poor convergence in certain cases of ill-conditioned situations. Hence, an attempt has been made to develop an efficient second order decoupled load flow algorithm in polar co-ordinates aiming to achieve memory at par with FDLF and better convergence property for ill-conditioned situations. This has been achieved by prudently injecting the elements of Hessian matrix into the elements of Jacobian and considering the useful assumptions made in formulating FDLF model.

Amongst various optimization techniques used for solving economic/optimal load dispatch problems, classical techniques are simpler and provide faster solutions. Classical co-ordination equations using B-coefficients are still a superb tool available with utilities and widely used for solving economic load dispatch problem. Surprisingly no one has developed and used any classical technique based on co-ordination equations for solving optimum reactive power dispatch problem. Hence a new algorithm for both optimum real and reactive power dispatch using classical co-ordination method has been developed. New formulations for total system real power loss and also for reactive power loss have been suggested, the loss coefficients of which are computed very elegantly using the sensitivity properties of the Jacobian matrix elements available at the end of base load flow alongwith a perturbation technique.

Linear and quadratic programming methods are gaining more attention in recent time because of their inherent simplicity, ability to handle various constraints effectively and speed of solution as compared to nonlinear programming methods. For solving optimal load flow problems, it seems more appropriate to use quadratic programming (Q.P.) methods instead of linear programming (L.P.) as L.P.involves additional efforts and approximations in linearizing the objective functions and in many situations provides zigzagging of solution causing convergence problem. Some L.P. based Q.P. methods have been applied by many researchers for solving only economic load dispatch problem. Amongst them Beale's Q.P.method [133] is found to be superior and attractive. Contaxis et.al. [123] are possibly the first to use Beale's Q.P. method for solving both economic load dispatch and optimal reactive power subproblems and demonstrated that it provides better results and faster solution than L.P. based on revised simplex method. A Q.P.method developed by Fletcher [139] and another approach based on quadratic differential (Q.D) method [135] do not need any linear programming subroutine and hence appear to have potential and promise for application to optimal power flow problems. Although both Flecher's Q.P. and Q.D.methods are claimed to be superior to Beale's Q.P. method, their relative performance as applied to optimal power flow problems are yet to be examined and established. In view of this, a maiden attempt is made in the present work to apply both Fletcher's Q.P. and Q.D.methods to the solution of optimal power flow problem for a few test systems. The algorithms developed consider various system operating constraints including transfermer taps, line flow limits, bus voltage limits, limits on real and reactive power generations etc. New approaches for formulating and linearizing these constraints are suggested. System studies carried out reveal that Fletcher's Q.P.method is distinctly superior to quadratic differential method in solving optimal power flow problems.

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