STATIC STATE ESTIMATION ALGORITHMS USING HESSIAN MATRIX APPROACH

by

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DEDICATED

TO

LORD AYYAPPA

CERTIFICATE

This is to certify that the thesis entitled, "Static State Estimation Algorithms Using Hessian Matrix Approach", which is submitted by Mr. Durg Singh Chauhan for the award of the Degree of Doctor of Philosophy of the Indian Institute of Technology, New Delhi, is a bonafide record of research work carried out by him over the last three years under our guidance and supervision.

The candidate has fulfilled the requirements of all the regulations relating to the degree. The results obtained in the thesis have not been submitted to any other University or Institute for the award of a degree or diploma.

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ABSTRACT

The thesis presents the results of research carried out by the author in the area of power system state estimation over the period, July 1982 to August 1985, at the Indian Institute of Technology, Delhi, India.

The thesis consists of seven chapters of which the first one is introductory and the last one is the conclusion. The review is described in Chapter II and the results of this investigation are described in Chapters III through VI. The basic theme of the investigation is to develop an algorithm which is computationally efficient and versatile. Specifically, we have utilized the concept of the Hessian matrix approach in the framework of existing WLS estimator. A brief description of the content of chapters is as follows:

Chapter I : This chapter is a brief introductory chapter which attempts to elaborate the importance of the static state estimation in the control room operation with specific features of the present day estimation techniques.

Chapter II : This chapter deals with the detailed mathematical models of estimation algorithms available in the literature. Standard WLS estimator, decoupled estimator in polar coordinate and exact second order estimator in cartesian coordinate are fully derived. Bad data suppression estimators in lumped and decoupled form based on non-quadratic cost function are presented.

Chapter III : This chapter deals with the Hessian matrix approach incorporated in the well known WLS methods in polar as well as cartesian coordinates. Ill-conditioning of information matrix is often a problem in the weighted least square estimation and it could be solved with nominal computational effort using the following methodology.

Using the Hessian matrix approach the information matrix

$$[M] = [M_1] + [M_2]$$

where

$[M_1]$ = the information matrix of WLS method

$[M_2]$ = the matrix of second order derivative of functions.

If we ignore the second order terms, the algorithm becomes unfit in ill-conditioned or bad conditioned case. Proposed Hessian matrix approach does not affect the sparsity of the information matrix used in the WLS method.

Chapter IV : This chapter completely describes the tracking state estimation algorithm using the proposed apporach. Bad data suppression algorithm using the Hessian matrix in decoupled version is described. Prefiltering is incorporated to filter out gross measurement errors. A tracking of states from the nominal base case to final operating condition has been done in 40 samples by using all the aforesaid techniques. The proposed technique tracks the state on the curvature of the cost function.

Chapter V : This chapter deals with the analysis of power system observability. Making use of simple measurement graph and its spanning tree algorithm, critical measurement graph and its spanning tree algorithm, critical measurement algorithm and pseudo measurement placement algorithms are developed. Observability of power system is an essential aspect of processing the measurement vector. The proposed algorithm has computational superiority over other algorithms available in the literature.

Chapter VI : Multiple bad data identification using sensitivity matrix is a new approach. This chapter describes the use of new sensitivity matrix of the proposed Hessian matrix estimator in finding effect of bad data in the residual vector of the estimate. Normalized sensitivity matrix approach is exploited to estimate the random noise vector of suspected bad data, as normalized residual is best judged in identification of single bad data. Bad data effect spread on normalized residual has linear relation with normalized sensitivity matrix. It can give best correction factor. This theme is presented in this chapter with test results conducted on a 30-bus well-conditioned power system.

Chapter VII : This chapter is devoted exclusively to comments on achievements of the investigations reported in earlier chapters and future scope of the research work.

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