DEVELOPMENT OF A STATE ESTIMATOR FOR BPDB (BANGLADESH POWER DEVELOPMENT BOARD) GRID SYSTEM

A THESIS

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CERTIFICATE

This is to certify that this work was done by me and it has not been submitted elsewhere for the award of any degree or diploma.

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ABSTRACT

Bangladesh Power Development Board (BPDB) is considering implementation of a computer aided monitoring and control system for its grid network. With this objective ahead it has already installed telemetering instruments at some of its grid substations. The measurements on line flow, nodal injections and voltages acquired through telemetry are inherently error corrupted. To obtain a reliable and consistent set of information on system state from the raw telemetered data an algorithm known as State Estimator is required.

In the present research work a computationally efficient program has been developed for a fast decoupled bad data suppression state estimation algorithm. In this algorithm the usual and random measurement errors have been minimized in least square sense using weighting factors chosen on the basis of statistical properties of the errors. The gross measurement errors have been suppressed using a reweighting technique. The measurements have been grouped into active and reactive sets to take advantage of decoupled characteristics of a high voltage power transmission system. Sparsity was exploited in computations involving matrices.

The developed program has been tested extensively on

BPDB grid system choosing a number of measurement configurations and simulating various sets of errors. The Monte Carlo technique was adopted for simulation test. The results of the comprehensive study on robustness, accuracy of estimates and bad data processing capability of the algorithm have been analysed using established performance indices.

LIST OF PRINCIPAL SYMBOLS

J	Objective function
M	Number of measurements
N	Number of state variables
WLS	Weighted Least Square
LP	Linear Programming
BDS	Bad Data Suppression
[Z]	Measurement Vector
[Δ Z]	Measurement residual vector
[X]	State vector
[$\hat{X}$]	Estimate of state vector
[V]	Voltage magnitude vector
[θ]	Phase angle vector
[ξ]	Measurement-error vector
[R]	Measurement error covariance matrix
σ	Measurement error standard deviation
[h(.)]	Vector of functions of (.)
[H]	Jacobian matrix
[G]	Gain matrix

Superscripts

i	iteration counter
T	transpose
*	conjugate of a complex quantity

Abbreviations

BPDB	Bangladesh Power Development Board
BUET	Bangladesh University of Engineering and Technology
IBM	International Business Machines
CPU	Central Processing Unit

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CHAPTER 1

INTRODUCTION

1.1 General Considerations

A growing demand for electrical energy has constrained the present day power utilities in both developing and developed countries with the vital problem of ensuring an uninterrupted and low-cost delivery of power with negligible fluctuation in the frequency and in the voltage. A basic prerequisite for such a secure and economic operation of a power system is frequent and quick monitoring of the current state of operation. In order to help the operator for monitoring the system operator and then take decision for appropriate control action, a large amount of on-line data is acquired from the system and telemetered to the dispatch centre. The data mainly consists of measured values of line power flows, nodal injections and voltage magnitudes at various nodes of the system. The raw telemetered data is corrupted by inherents random measurement noise and also by large or gross errors. The random noise mainly results from current and potential transformer errors, meter inaccuracies, analogue to digital conversion error and noise in communication channels or interference noise. Gross errors, also called bad data, are the outcome of faults or failures in metering and data communication systems which may also give rise to the situation of missing data. Obviously an algorithm is required to process the raw data to compensate for its various uncertainties and produce a consistent and reliable set of information on the current operating state of the system. The algorithm used for this purpose is called the State Estimator[1].

1.2 Approach of State Estimation

A state estimator is a computer software whose input data is a redundant set of measured quantities and the output is the best possible estimate of the state variables i.e. busbar voltages and phase angles which are used to obtain the computed values of measured,unmeasured and missing quantities. Redundant means that the number of measurements is more than the number of state variables. For the best estimate the state estimator uses a suitable statistical criterion, for instance sum of weighted squares of the difference between observed values of the measurements and their computed values, with a view to minimising the effect of errors in the telemetered measurements. An iterative procedure is involved in state estimation algorithm. In the first iteration the computed values may be obtained from a flat start i.e. unity voltage magnitudes and zero phase angle.

The mathematical model of the system network required for state estimator is formed on the basis of the telemetered status of circuit breakers at different nodes of the system. State estimation is usually performed at prespecified time periods of a daily routine or whenever a major change in the system operating conditions or network configuration takes place.

State estimation differs from a load flow analysis in the following way.

i) While state estimation processes a redendant set of on-line measurements on injections, line flows and bus voltages and compensates for the errors in them, load flow has nothing to do with measurements. Load flow requires that the magnitudes of a set of only nodal injections equal to the number of nodes be available and does not care for the uncertainties, source or reliability of the input data so that the results of load flow calculation can be seriously affected.

ii) In on-line and real-time control[2-5] of a power system, the values of injections are computed more accurately using the estimates of bus voltage and phase angles obtained from the state estimator and then made available for performing a load flow. From this point of view load flow is a secondary outcome of state estimation.

1.3 Applications of State Estimation

The output of the state estimator is accessed by other on-line functions[6] like security control and the economic dispatch, through a data base. Security control requires reliable information on the system's present state to predict in a very short time i.e. real time the effects of contingencies such as generator tripping, line outage, fault occurence, loss of load etc. upon the customers demand, nodal voltage limits, generator loading limits, transmission line thermal limits, minimum spinning margin and so on. Economic dispatch function determines the best allocation of generation requirements among the available generating units so that the demanded load can be satisfied within the above mentioned constraints imposed by security considerations at a minimum cost. To this end an optimal power flow problem requiring accurate information on system state, particularly on bus injections is involved. State estimator produces the best estimates of them by using the estimated bus voltages and phase angles.

The state estimator also identifies the grossly erroneous measurements and hence can provide the locations of suspect measurements so that remedial actions can be taken quickly in the field on the faulty components of instrumentation and data communication system.

1.4 Background and Purpose of the Present Work

It is almost two decades since the state estimation theory has been first reported[1] for application in power systems. Mainly three approaches - static, tracking and dynamic state estimation were proposed in the literature.[1,7,8] The first one uses only a single snapshot of measurements to estimate the states of a system at a particular instant of time. The last two consider the time variation of system state in addition to a particular measurement snapshot. Yet the method of static state estimation is preferred[9] in practice because of its simplicity in modelling compared to the other two.

For the method of static state estimation two basic algorithms have been proposed so far. The first suggested[1,9] one is based on minimisation of a weighted least square (WLS) criterion. Later research work[10] has suggested another algorithm based on a linear programming (LP) technique to minimise a linear criterion.

Although the LP based state estimator was found to show better performance in processing bad data compared to the basic WLS estimator, the former requires[11] more computer time and storage than the latter.

A number of research work devoted to further improving the computational as well as bad data performance of basic WLS estimators gave rise to three versions namely Fast Decoupled[12] WLS, Line-Only[13] WLS and Bad Data Suppression[11,14] (BDS) algorithms. The fast decoupled one takes advantage of the well known weak coupling among active and reactive quantities of a power system and makes a grouping of the measurements into active and reactive sets. Eventually a decoupled algorithm with constant Jacobian matrices incurring less computer storage and time per iteration can be derived. The line-only algorithm was developed only to process a measurement set consisting of only complex line flows. The Bad Data Suppression algorithm was developed by modifying the WLS criterion to assign less weight to the suspect measurements according to an efficient non-quadratic criterion e.g. quadratic square root criterion. The suppression technique can be incorporated in any WLS based estimator at the cost of a trivial change in computer program, time and storage requirements. In general, the fast decoupled WLS estimator is applicable for a metering configuration comprising all types of measurements and when incorporates BDS technique it has been reported[11] as the most efficient algorithm in terms of both computational and bad data performance.

In Bangladesh its only public utility - Bangladesh power Development Board (BPDB) has just stepped into the process of computerizing its central load despatch centre (CLDC) with the installation of telemetering system at some selected grid substation . In course of phase by phase implementation of the project a computer is expected to be installed at CLDC by 1991. This has become an incentive for the researches at BUET to investigate into different aspects of state estimation and make an initial assessment of its applicability for the monitoring and control of the nationalgrid system. Part of the task is the object of the present research work.

The main areas in which the present work contributes are as follows :

1) A state-of-the-art review of state estimation algorithms has been carried out in order to choose which one would be the most suitable.

2) A computer program has been developed for the WLS state estimation algorithm incorporating fast decoupling and bad data suppression techniques. Also a highly efficient sparsity[15] exploitation program has been interfaced with it.

3) The developed program has been tested extensively on BPDB grid system using Monte Carlo simulation[16] technique.

1.5 Organisation of the Thesis

The presentation of the material studied in the research work is organised as follows.

Chapter 2 describes the WLS state estimation algorithm together with fast decoupling and bad data suppression techniques.

Chapter 3 presents the programming details of the fast decoupled BDS algorithm.

Chapter 4 presents the results of simulation tests of the developed computer program.

Chapter 5 provides a summary of the main results obtained in the present research work and suggest some areas for further research.

The appendices include supporting materials to different chapters of the thesis.

CHAPTER 2

METHOD OF FAST DECOUPLED WLS STATIC STATE ESTIMATION

2.1 Introduction

The weighted least square (WLS) algorithm[9] estimates the state variables by minimizing an objective function which is the sum of squares of a number of terms with each term corresponding to a measurement acquired from the system and weighted by a factor chosen on the basis of statistical properties of the measurement error. The minimization of the objective function is formulated as an iterative process based on the Newton-Raphson technique which involves the inversion of a matrix known as gain matrix to update the state variables in each iteration. The iterative process stops when the change in each of the state variables between two successive iterations is less than some prespecified value termed as tolerance margin.

The WLS algorithm in its basic form involves a large amount of computer storage and excessive computing time due to evaluation and inversion of the gain matrix in each iteration. These difficulties have been overcome in another version of WLS algorithm known as fast Decoupled estimator[12] taking advantage of decoupling characteristics and a number of simplifications based on physical properties of high voltage power transmission system and engineering judgement.

The measurements to be processed by a state estimator are in general corrupted by usual errors called measurement noise which are of random nature and reported[17] to be governed by

Gaussian[18] (normal) probability distribution law. This noise is inherently filtered i.e. compensated by a WLS estimator. Apart from the noise, for a number of reasons mainly malfunctioning or failure of transducers and telemetry, one or more data in the measurement input can be bad containing gross errors which do not follow the Gaussian law. In order to process gross measurement error effectively WLS estimators are modified as Bad Data Suppression (BDS) algorithm[14] in which only the suspect measurements are reweighted to suppress their effects. The quadratic square root[14] criterion is used for reweighting.

It is necessary to check whether the available number of measurements in a system would be enough to determine its state variables. This possibility is known as observability which depends upon the network as well as metering configurations. Observability of a system needs to be determined prior to performing state estimation and remains valid as long as the network and the measurement configurations remain unchanged.

2.2 Basic WLS Static State Estimator[1,9]

The method of static estimation estimates the state variables from a single snapshot of measurements taken at a specified instant of time. A simple model relating the measurement (nodal injections, line flows and voltage magnitudes) to the state variables and network parameters is given by

$$[Z] = [h(x)] + [\xi] \qquad (2.1)$$

where

[Z] - MX1 vector giving observed (telemetered) values of measurements

[X] - NX1 state vector comprising state variables

[h(x)]- MX1 vector of nonlinear functions in state variables providing the true but unknown values of the measured quantities. These functions are shown in section A.1 of Appendix-A.

x - an element of state vector [X]

[ξ] - MX1 vector of measurement errors.

M - number of measurements

N - number of state variables, i.e. voltage magnitudes and phase angles to be estimated.

M/N > 1- redundancy ratio

The weighted least square algorithm uses this model and minimizes the sum of the squares of the difference between the observed values and true values of the measurements, with each term weighted by a factor w. Equation (2.2) shows the WLS objective function.

$$J(x) = \sum_{m=1}^{M} w_m (z_m - h_m(x))^2 \qquad (2.2)$$

where m denotes measurement serial.

The successive linearisation and minimization of equation (2.2), as shown in section A.2 of Appendix A, leads to an expression for the optimum estimate of the state vector as in equation (2.3).

$$[\hat{X}]^{i+1} = [\hat{X}]^{i} + [G]^{-1}[H]^{T}[R]^{-1}[\Delta Z]^{i+1} \qquad (2.3)$$

where

$[\hat{X}]$ - estimate of state vactor

i - iteration counter

$$[G] = [H]^{T}[R]^{-1}[H] \qquad (2.4)$$

is gain matrix of dimension NXN

$$[H] = \left.\frac{\partial h}{\partial x}\right|_{x=\hat{x}^{i}} \qquad (2.5)$$

is Jacobian matrix of dimension MXN

$[R]$ - measurement error covariance matrix of dimension MXM which is diagonal with constant elements as shown in section 2.2.1

T as superscript denotes transpose

$$[\Delta Z]^{i+1} = [Z] - [h(\hat{x}^{i})] \qquad (2.6)$$

is measurement residual vector.

If all the measured quantities are linear functions of state variables, e.g. nodal currents and branch currents, equation (2.3) reduces to a simple non-iterative form as in equation (2.7)

$$[\hat{X}] = [G]^{-1} [H]^{T}[R]^{-1}[Z] \qquad (2.7)$$

where all the matrices are with constant elements i.e. independant of state variables. A linear case of the state estimation problem is not the practical one. Because in a power system measuring the nodal power injections and line power flows (which are nonlinear functions of state variables) is the usual practice and also provides an easier means for estimating the unconventional quantities like phase angles of the buses.

However an example using a simple d.c. network with nodal current and branch current measurements has been produced in section 2.2.2 just to show the basic principle of the WLS state estimation algorithm.

2.2.1 Weighting Factors

The measurement errors represented by the vector $[\xi]$ in equation (2.1) are mainly due to current and potential transformers' errors, inaccuracies of metering instruments (transducers), errors of analogue-to-digital (A/D) converters, noise in communication channels or interference noise. Consequently these errors are of random nature and termed measurement noise. The best measure of the uncertainty associated with any particular measurement is the standard deviation of its error. The weighting factors w used in equation (2.2) can be computed in terms of the standard deviations by assigning a probability law to the measurement noise. It has been reported[17] that the measurement noise usually follows the normal (Gaussian)[18] distribution with zero mean and a known standard deviation σ , and is independent of another measurement noise. Equations (2.8) and (2.9) respectively show these statistical properties of the noise of the m-th measurement.

$$E(\xi_m) = 0 \tag{2.8}$$

$$E(\xi_m \xi_m^T) = \sigma_m^2 \tag{2.9}$$

where,

E - statistical expectation operator

σ_m - standard deviation of the noise of m-th measurement.

The smaller the standard deviation the greater is the confidence which can be placed in the observed value of the corresponding measurement. Therefore, the weight of the term corresponding to the m-th measurement in equation (2.2) can be set as inverse of the square of standard deviation i.e. inverse of variance as in equation (2.10)

$$w_m = \frac{1}{\sigma_m^2} \tag{2.10}$$

The variance (σ^2) terms for all the measurements are usually assembled as the elements of a diagonal matrix [R] known as measurement error covariance matrix as in equation (2.11).

$$[R] = \begin{bmatrix} \sigma_1^2 & & & \\ & \sigma_2^2 & & \\ & & \ddots & \\ & & & \sigma_m^2 \end{bmatrix} \tag{2.11}$$

Equations (2.10) and (2.11) can be combined as:

$$[R]^{-1} = \begin{bmatrix} w_1 & & & \\ & w_2 & & \\ & & \ddots & \\ & & & w_m \end{bmatrix} \qquad (2.12)$$

In both the equations (2.11) and (2.12), the matrices are of dimension MXM i.e. m = 1 to m = M; the total number of measurements being M as mentioned is section 2.2.

2.2.2 Example of WLS State Estimation

In Figure 2.1 a 2-bus d.c. network with two nodal current measurements z_1 and z_2 and a branch current measurement z_3 has been shown.

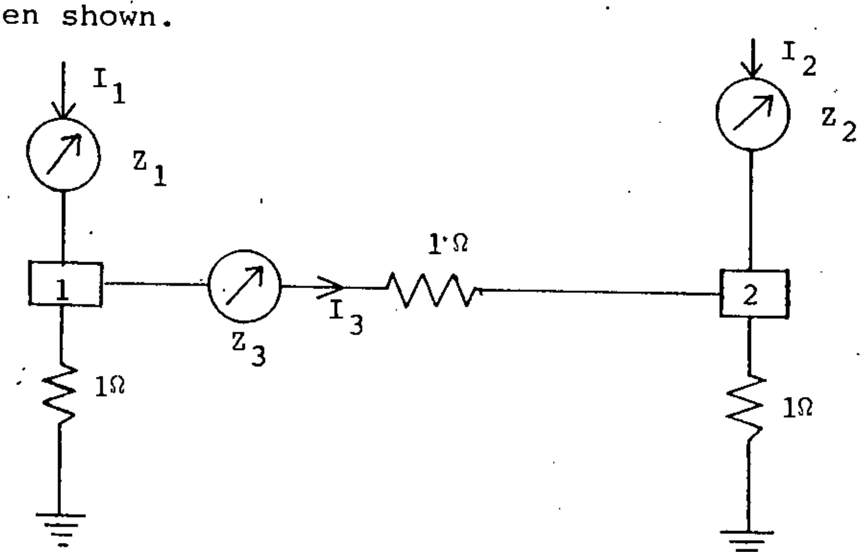


Figure 2.1: A 2-bus d.c. network.

The observed values of measurements have been assumed as

$$z_1 = 4 \text{ ampere}$$

$$z_2 = -1.5 \text{ ampere}$$

$$z_3 = 2.5 \text{ ampere}$$

The weight for each of the measurements has been assumed to be unity so that

$$[R]^{-1} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \qquad (2.13)$$

It is required to estimate the nodal voltages.
In this case the state variables are

$$[X] = \begin{bmatrix} v_1 \\ v_2 \end{bmatrix} \qquad (2.14)$$

while the equations relating the true values of measurements to the state variables are linear and can be derived applying kirchhoff's law as follows:

$$\begin{aligned} h_1 &= I_1 = 2v_1 - v_2 \\ h_2 &= I_2 = -v_1 + 2v_2 \\ h_3 &= I_3 = v_1 - v_2 \end{aligned} \qquad (2.15)$$

Equations (2.15) can be stated in matrix form as in equation (2.16)

$$[H] = \begin{bmatrix} 2 & -1 \\ -1 & 2 \\ 1 & -1 \end{bmatrix} \tag{2.16}$$

The observed measurement values can be expressed as

$$[Z] = \begin{bmatrix} 4 \\ -1.5 \\ 2.5 \end{bmatrix} \tag{2.17}$$

Now the gain matrix [G] is

$$[G] = [H]^T [R]^{-1} [H]$$

$$= \begin{bmatrix} 2 & -1 & 1 \\ -1 & 2 & -1 \end{bmatrix}^T \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 2 & -1 \\ -1 & 2 \\ 1 & -1 \end{bmatrix}$$

$$= \begin{bmatrix} 6 & -5 \\ -5 & 6 \end{bmatrix} \tag{2.18}$$

Then applying equation (2.7)

$$[\hat{X}] = [G]^{-1} [H]^T [R]^{-1} [Z]$$

$$= \begin{bmatrix} 6 & -5 \\ -5 & 6 \end{bmatrix}^{-1} \begin{bmatrix} 2 & -1 & 1 \\ -1 & 2 & -1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 4 \\ -1.5 \\ 2.5 \end{bmatrix}$$

$$= \frac{1}{11} \begin{bmatrix} 6 & 5 \\ 5 & 6 \end{bmatrix} \begin{bmatrix} 2 & -1 & 1 \\ -1 & 2 & -1 \end{bmatrix} \begin{bmatrix} 4 \\ -1.5 \\ 2.5 \end{bmatrix}$$

$$= \frac{1}{11} \begin{bmatrix} 7 & 4 & 1 \\ 4 & 7 & -1 \end{bmatrix} \begin{bmatrix} 4 \\ -1.5 \\ 2.5 \end{bmatrix}$$

Or, $$[\hat{X}] = \begin{bmatrix} 2.23 \\ 0.27 \end{bmatrix} \quad (2.19)$$

is the required estimate of nodal voltages.

2.3 Fast Decoupled WLS Algorithm[12]

The basic WLS algorithm defined by Equation (2.3) has the following main disadvantages.

a) A large amount of computer storage is required because the gain matrix [G] has a size 2n x 2n when n is the number of nodes such that N = 2n; N being the number of state variables.

b) The computing time is excessive due to evaluation of the gain matrix using the state vector dependent Jacobia matrix [H] and its inversion in each iteration.

To overcome the above mentioned difficulties a grouping of the measurements into active $[Z_p]$ and reactive $[Z_q]$ sets [equations (2.20) and (2.21)] is made so as to express the Jacobian matrix [H] of equation (2.3) in partitioned form as in equation (2.22).

$$[Z_p] = [h_p(\theta, v)] + [\xi_p] \quad (2.20)$$

$$[Z_q] = [h_q(\theta, v)] + [\xi_q] \quad (2.21)$$

$$[H(\theta,v)] = \begin{bmatrix} [H_{pp}(\theta,v)] & [H_{pq}(\theta,v)] \\ & \\ [H_{qp}(\theta,v)] & [H_{qq}(\theta,v)] \end{bmatrix} \tag{2.22}$$

$$[H_{pp}(\theta,v)] = \frac{\partial h_p}{\partial \theta}, \quad [H_{pq}(\theta,v)] = \frac{\partial h_p}{\partial v} \tag{2.23}$$

$$[H_{qp}(\theta,v)] = \frac{\partial h_q}{\partial \theta}, \quad [H_{qq}(\theta,v)] = \frac{\partial h_q}{\partial v} \tag{2.24}$$

In the Jacobian matrix of equation (2.22) the off-diagonal blocks i.e. submatrices $[H_{pq}]$ and $[H_{qp}]$ can be neglected on the basis of weak coupling which exists

i) between change in phase angles and that in reactive powers and ii) between change in voltage magnitudes and that in active powers.

Using the decoupled Jacobian

matrix $\begin{bmatrix} [H_{pp}(\theta,v)] & \\ & [H_{qq}(\theta,v)] \end{bmatrix}$

and two measurement sets ($[Z_p]$, $[Z_q]$) as in equations (2.20) and (2.21), the equation (2.3) can be expressed as:

$$[A_{pp}(\hat{\theta}^i,\hat{v}^i)][\Delta\hat{\theta}]^{i+1} = [H_{pp}(\hat{\theta}^i,\hat{v}^i)]^T[R_{pp}]^{-1}[\Delta Z_p]^{i+1} \tag{2.25}$$

$$[A_{qq}(\hat{\theta}^i,\hat{v}^i)][\Delta\hat{V}]^{i+1} = [H_{qq}(\hat{\theta}^i,\hat{v}^i)]^T[R_{qq}]^{-1}[\Delta Z_q]^{i+1} \tag{2.26}$$

In equations (2.25) and (2.26) the state vector [X] has been expressed in terms of voltage magnitude vector [V] and phase angle vactor [θ]. Also,

$$[A_{pp}(\hat{\theta}^i,\hat{V}^i)] = [H_{pp}(\hat{\theta}^i,\hat{V}^i)]^T[R_{pp}]^{-1}[H_{pp}(\hat{\theta}^i,\hat{V}^i)] \qquad (2.27)$$

$$[A_{qq}(\hat{\theta}^i,\hat{V}^i)] = [H_{qq}(\hat{\theta}^i,\hat{V}^i)]^T[R_{qq}]^{-1}[H_{qq}(\hat{\theta}^i,\hat{V}^i)] \qquad (2.28)$$

$$[\Delta Z_p]^{i+1} = [Z_p] - [h_p(\hat{\theta}^i,\hat{V}^i)] \qquad (2.29)$$

$$[\Delta Z_q]^{i+1} = [Z_q] - [h_q(\hat{\theta}^i,\hat{V}^i)] \qquad (2.30)$$

$$[\Delta\hat{\theta}]^{i+1} = [\hat{\theta}]^{i+1} - [\hat{\theta}]^i \qquad (2.31)$$

$$[\Delta\hat{V}]^{i+1} = [\hat{V}]^{i+1} - [\hat{V}]^i \qquad (2.32)$$

It has been shown in section A.3 of Appendix A that based on a number of simplifications known as fast docoupling techniques, equation (2.27) and (2.28) can be refined to provide an algorithm with state vector independant Jacobian matrices. This algorithm is termed fast decoupled WLS Algorithm and expressed as in the equations (2.33) and (2.34)

$$[H_{pp}]^T[R_{pp}]^{-1}[H_{pp}]([\hat{\theta}]^{i+1}-[\hat{\theta}]^i) = [H_{pp}]^T[R_{pp}]^{-1}([Z_p]-[h_p(\hat{\theta}^i,\hat{V}^i)])$$

(2.33)

$$[H'_{qq}]^T [R_{qq}]^{-1} [H'_{qq}] ([\hat{V}]^{i+1} - [\hat{V}]^i)$$

$$= [H'_{qq}]^T [R_{qq}]^{-1} ([Z'_q] - [h'_q(\hat{\theta}^{i+1}, \hat{V}^i)]) \qquad (2.34)$$

where the Jacobian and measurement error covariance matrices are with constant elements.

2.3.1 Computational Aspects of Fast Decoupled Algorithm

a) The active Jacobian Matrix $[H_{pp}]$ and the reactive Jacobian matrix $[H'_{qq}]$ are independent of state variables and evaluated before the start of the iterative process. Hence the corresponding gain matrices are also constant and inverted only once . Hence the time per iteration and overall computing time of this method are greatly reduced compared to those of the basic WLS algorithm.

b) In an iteration (i+1) firstly the vector $[\hat{\theta}]$ is updated using active measurement residuals $[\Delta Z_p]$ evaluated at both $[\hat{\theta}]$ and $[\hat{V}]$ of previous iteration i. Then $[\hat{V}]$ is computed in the same iteration (i+1) using the reactive measurement residuals $[\Delta Z'_q]$ evaluated at $[\hat{V}]$ of previous iteration i and updated $[\hat{\theta}]$ of current iteration (i+1).

c) The algorithm stops the iterative process when all the elements of both $[\Delta \hat{\theta}]^{i+1} = [\hat{\theta}]^{i+1} - [\hat{\theta}]^i$ and $[\Delta \hat{V}]^{i+1} = [\hat{V}]^{i+1} - [\hat{V}]^i$ are less then or equal to the tolarance margin. This may happen either at the end of a number of full iterations or a number of full iterations plus a half which does not require updating of $[\hat{V}]$.

d) The storage requirement is largely reduced as only two diagonal blocks of the gain matrix [G] and two submatrices of the Jacobin Matrix [H] are to be stored.

2.4 Bad Data Suppression

In this technique[11,14] each of the computed measurement residuals is checked against a carefully chosen threshold (breakpoint) value λ . If the residual exceeds the threshold the corresponding measurement is a suspect one and is assigned less weight else the same weight as in the WLS criterion. This process of reweighting can be confined to only the right hand side of the equation (2.3) which defines a basic WLS algorithm. As a result the general expression for a WLS estimator transformed into a Bad Data Suppression (BDS) algorithm can be written as:

$$[\hat{X}]^{i+1} - [\hat{X}]^{i} = [G]^{-1}[H]^{T}[R]^{-1}[D]^{i+1}[\rho]^{i+1} \qquad (2.35)$$

where the notations have their usual significance excepting

[D] - a diagonal matrix with elements (d_m) as a function of corresponding measurement residual $r_m = z_m - h_m(\hat{x}^i)$

[ρ] - a vector with elements (ρ_m) as function of r_m

m - 1, 2, ... M denotes measurement serial

A fast decoupled BDS algorithm results when equation (2.35) is extended to equations (2.33) and (2.34) representing the fast decoupled WLS algorithm.

The quadratic square root criterion[14] used for reweighting expresses the elements d_m in the matrix [D] and ρ_m in the vector [ρ] by equations (2.36) and (2.37).

If $\left|\frac{r_m}{\sigma_m}\right| > \lambda$ then

$$d_m = \left(4\left|\frac{r_m}{\lambda\sigma_m}\right| - 3\right)^{-1/2} \left|\frac{r_m}{\lambda\sigma_m}\right|^{-\frac{1}{2}} \tag{2.36}$$

$$\rho_m = \pm\ \lambda\sigma_m\left(4\left|\frac{r_m}{\lambda\sigma_m}\right| - 3\right)^{1/2}$$

else

$$d_m = 1$$

$$\rho_m = r_m \tag{2.37}$$

In equation (2.36) positive sign is used for ρ_m when r_m is positive while negative when r_m is negative.

The choice of the threshold λ determines the size of suspect bad data to be suppressed. Since the usual measurement noise obeying Gaussian distribution law are within $\pm 3\ \sigma_m$ range[18] for a probability of 99.7%, the bad data with errors outside, this range will be suppressed for a value chosen for λ not much greater than 3.0. The higher the value of λ the less is the suppression effect.

2.5 Observability[19]

The observability of a system is defined as the possibility of determining its state variables using the available measurements. The concept of observability can be understood by explaining the relation between metering configuration and the network configuration.

Let k, l, m and r be four nodes with r chosen as the reference node as in Figure 2.2.

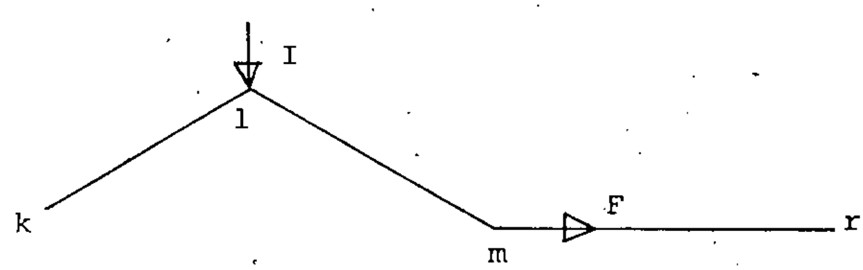


Figure 2.2: Demonstration of relation between measurement locations and network configuration

Let an injection measurement I and a flow measurement F be respectively placed at nodes l and m. Then the measurement I at node l provides a direct or an indirect path (connection) between any two nodes of the group k, l, m. The flow measurement F at node m provides a path between m and the reference node r. Since m is already measurement-connected to nodes k and l it can be said that each of the nodes k, l and m has a path to the reference node either directly or indirectly.

Similarly if all the nodes of a system under consideration are measurement-connected to the reference directly or indirectly then in the Jacobian matrix [H] none of the columns, each of which corresponds to a node with unknown state variable, will have completely zero elements. As a result the inverse of the gain matrix $[G] = [H]^T[R]^{-1}[H]$ will exist and the equation (2.3) defining the basic WLS estimator can also be solved.

For a fast decoupled WLS estimator the observability is determined by considering the active set (active injections and line flows) and the reactive set (reactive injections, reactive flows and voltage magnitudes) of measurements separately corresponding to two gain matrices: active and reactive. If any one set fails the test for observability, the system as a whole is unobservable.

2.6 Conclusions

The basic weighted least square algorithm though provides the most accurate estimates, takes excessive computing time and storage. The fast decoupled WLS algorithm has been reported to take on average a few iterations more than the basic WLS algorithm but produces results with an accuracy close to that of basic WLS as well as adequate for practical purpose involving less computer storage and taking a less overall computing time due to a reduced time per iteration.

The usual random measurement noise obeying Gaussian probability distribution is inherently filtered by a WLS estimator due to the processing of a redundant measurement set and use of weighting factor equal to the inverse of the square of the standard deviation of the corresponding measurement noise. But the gross measurement errors outside the Gaussian distribution require to be suppressed incorporating a reweighting criterion known as quadratic square root criterion with a WLS estimator.

CHAPTER 3

DEVELOPMENT OF COMPUTER PROGRAM

3.1 Introduction

The main computations involved in a fast decoupled BDS algorithm can be classified as fixed computations, iterative calculations together with bad data suppression and output of the estimation results.

In an on-line environment, when a state estimator is implemented on the computer of a power system control (despatch) centre, the measurements are directly acquired from the system and fed as input to the state estimation program. The state estimator is also interfaced with two more on-line softwares namely network configurator and the data base. The former provides information on the current configuration of system network while the latter provides network parameters and information on meter placements i.e. locations of the acquired measurements. Also the output of the state estimator is stored in the data base for accession by other application programs.

Before on-line implementation of a software for power system control, it is a common practice to test the developed prototype using simulated data. Simulation test of the computer code developed for a state estimation algorithm is done adopting Monte Carlo approach[16]. A metering pattern comprising active and reactive nodal power injections, line power flows and voltage measurements at various nodes is selected. The 'true' values of the measurement quantities are obtained from a load flow solution of the test system. Also the values of network parameters used by load flow program are accessed by the state estimation program through common blocks. The standard deviation for each of the measurements is provided to a Gaussian random number generation subroutine[16] to obtain a quantity which represents a zero mean random error. This quantity is added with the 'true' value of the corresponding measurement to simulate telemetered raw data. Some of the measurement values are made largely erroneous to simulate bad data. Then this simulated set of 'telemetered' and 'erroneous' measurements is provided to the developed state estimator as input. In this way the selected metering pattern is tested many times, for instance, 30, using different sets of errors to corrupt 'true' values of measurements in each simulation.

3.2 Computer Program for Simulation Test of the Fast Decoupled State Estimator

The basic scheme for interfacing various groups of subroutines written for Monte Carlo simulation test of the fast decoupled BDS algorithm has been presented in the form of a flow chart in Figure 3.1. The main program and all the subroutines were written in standard FORTRAN 77 language.

3.2.1 Computation of Measurement Weighting Factors

Use of standard deviations is required not only in simulating measurement errors but also in computing the weights

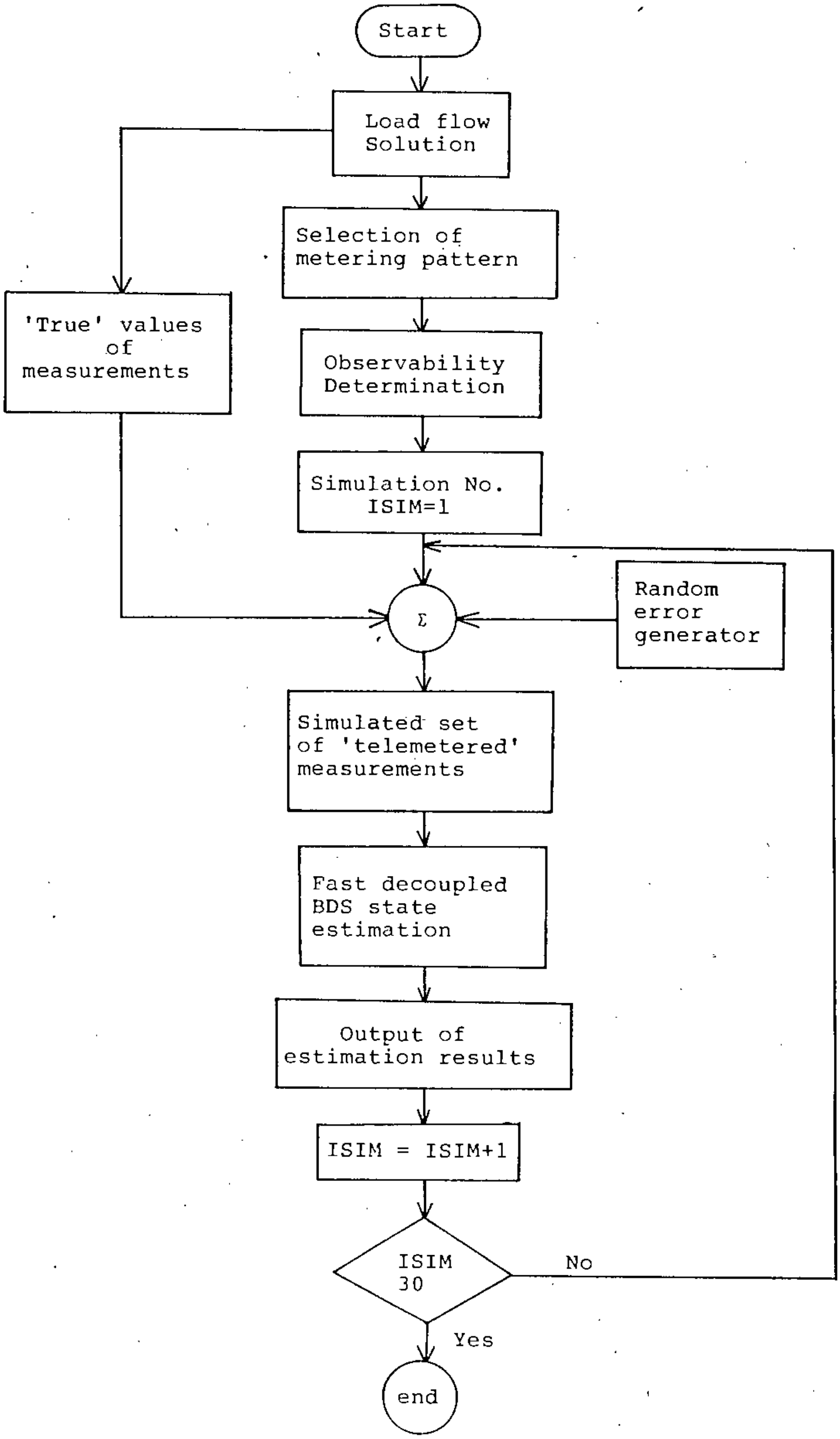


Figure 3.1: The basic scheme for Monte Carlo simulation test of the fast decoupled BDS estimator.

for the measurements of the selected metering pattern. The numerical values of σ can be calculated from the knowledge of the accuracy of the instrumentation and the telemetry system. The accuracies are presented by the manufacturers as the maximum expected errors. Under a Gaussian distribution the maximum error will fall within a range of ±3 σ (3 standard deviations) for a probability of 99.7%. Therefore, using typical accuracies the standard deviation σ_m for the m-th measurement, if it is a line flow measurement, can be calculated[20] as

$$\sigma_m = 1/3 \; (a_1 |S| + a_2 D + a_3 D) \tag{3.1}$$

where,

S - complex quantity (MVA) representing 'true' flow value

D - full scale (MVA) deflection corresponding to rated transducer output

a_1= 2% to 12% due to current and potential transformer errors

a_2= 0.25% to 0.35% due to transducer error

a_3= 0.1% due to A/D converters

σ_m= in units of MVA

In the present work it has been considered that

a_1 = 3%

a_2 = 0.25%

a_3 = 0.1%

D = 1000 MVA

So that equation (3.1) becomes

$$\sigma_m \simeq (0.01 \left| S \right| + 1.2) \tag{3.2}$$

where

σ_m - in units of MVA

If all the quantities in equation (3.2) are expressed in per unit (p.u.) with a base MVA equal to 'MVABASE' then σ_m can be computed in p.u. as in equation (3.3)

$$\sigma_m = 0.01 \left| S \right| + F \tag{3.3}$$

where

$$F = 1.2/\text{MVABASE} \tag{3.4}$$

σ_m and S are in p.u.

It is a practice to calculate the standard deviation (in p.u.) corresponding to an injection measurement as in equation (3.5)

$$\sigma_m = F \tag{3.5}$$

where F is as in equation (3.4)

For voltage measurements the standard deviation is

$$\sigma_m = 0.001 v_m \tag{3.6}$$

where v_m is the 'true' magnitude of the corresponding voltage measurement in p.u.

It is worth mentioning that during on-line implementation as the measurements are not a simulated set rather directly acquired from the system the 'true' values are not available and instead typical observed (measured) values are used.

3.2.2 Observability Determination

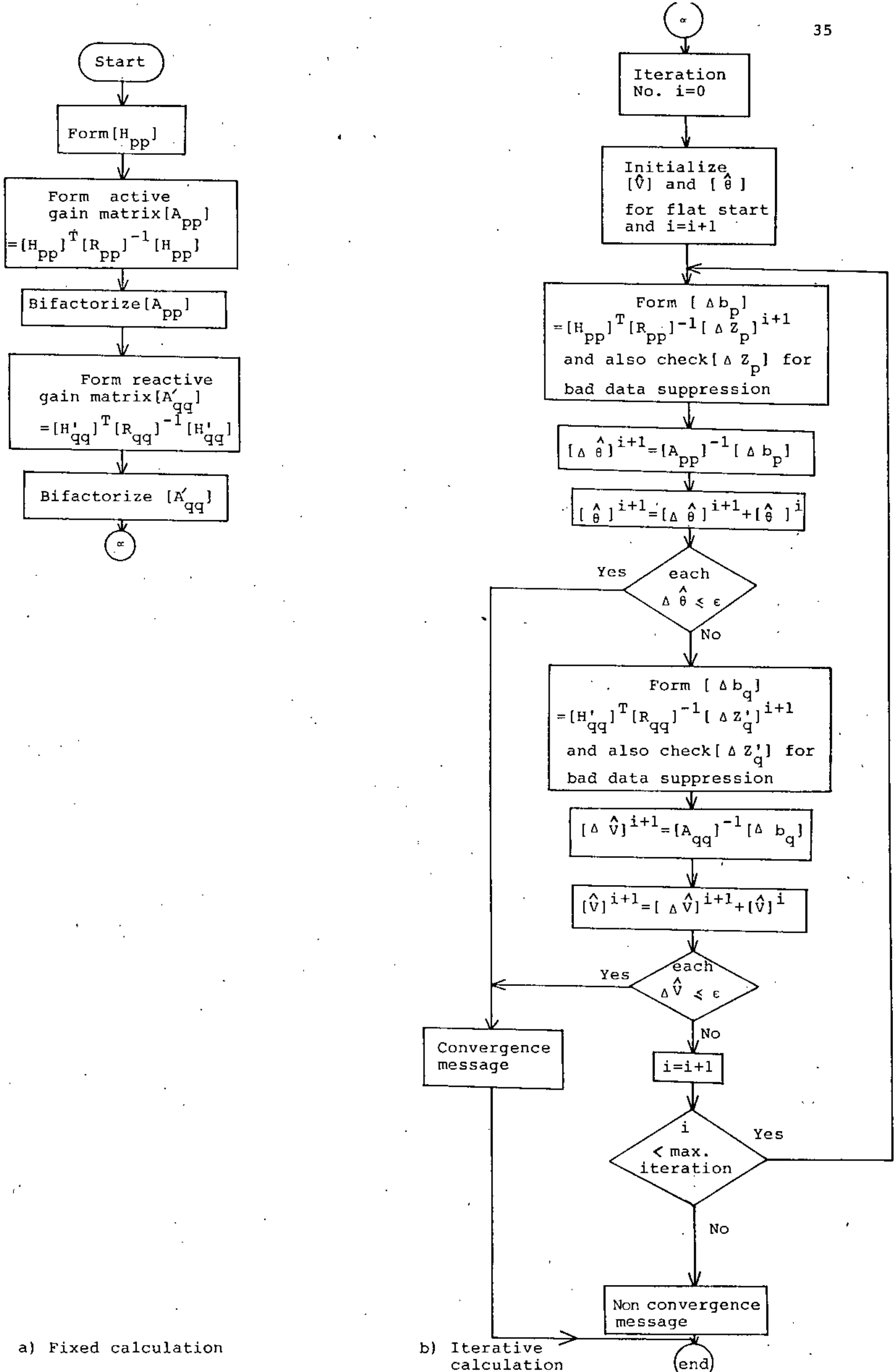
The test for observability has been done by assigning a code number to any one of the nodes. Then the group of nodes connected to this node directly or indirectly through measurements were identified and given the same code. In this way a check was made if all the nodes of a system attained a common code and the system became observable. The test has been conducted twice by considering the active and reactive sets of measurements separately for the fast decoupled estimator. It should be noted this method of observability test is a simple and quick one involving only logical statements and no floating point calculations.

3.3 Flow Chart for the Fast Decoupled BDS' State Estimation

Various steps of the fast decoupled BDS state estimation algorithm have been programmed by the present research work according to the flow chart presented in Figure 3.2.

3.3.1 Fixed Calculations

Fixed calculations refer to those computations which need to be accomplished only once and remain valid as long as the measurement configuration and network topology remain unchanged.



a) Fixed calculation b) Iterative calculation

Figure 3.2: Flow chart for fast Decoupled BDS State Estimation Algorithm.

These are mainly formation of active and reactive Jacobian matrices respectively $[H_{pp}]$ and $[H'_{qq}]$, and corresponding gain matrices as in equations (2.33) and (2.34). All these matrices have constant parameter elements and are predominently sparse i.e. the greater proportion of the elements are zero. Therefore, in the present research work, storage of Jacobian matrices and inversion of the gain matrices have been done using sparsity oriented programming.

In the sparsity[15] exploited scheme only the nonzero elements are recorded using row and column index arrays instead of conventional two dimensional matrices. Moreover instead of conventional inversion technique a more efficient method called sparsity directed bifactorization[15] is used. This saves both computer storage and time.

3.3.2 Iterative Calculations

Iterative calculations refer to the computations required to be made in each iteration. These are mainly formation of active and reactive measurement residual vectors $[\Delta Z_p]$ and $[\Delta Z'_q]$, check of residuals for bad data suppression, updating state variables ($[\hat{\theta}]$ and $[\hat{V}]$) and convergence test.

3.4 Conclusions

The computer code developed for the fast decoupled BDS algorithm in the present research project is by nature a program to make use of simulated data. During on-line implementation only the program for the state estimator together with that for observability is to be adapted for interfacing with the data base and network configurator on a power system control computer.

Applications of sparsity exploitation techniques in the developed program has enhanced its efficiency in terms of computer storage and time.

CHAPTER 4

PRESENTATION OF RESULTS

4.1 Introduction

The computer program developed by the present research work for simulation test of the fast decoupled BDS state estimation algorithm has been applied on the BPDB grid system (as of June 1989) using the mainframe computer IBM 4331/KO2 at BUET.

The simulation test has been done extensively to evaluate various performance such as convergence characteristics, accuracy of estimates and bad data processing of the algorithm on BPDB system corresponding to a number of metering configurations. The test system consisting of two interconnected zones viz: east and west, comprises a total of 81 nodes (buses) and 114 lines. The metering pattern was varied by choosing locations of injection (difference between generation and load at a bus), flow and voltage magnitude measurements at various nodes. The estimation has been performed only after the test system was proved observable with respect to the selected measurement configuration. Each metering pattern was tested 30 times using different sets of random errors in the way explained in sections 3.1 and 3.2 of Chapter 3.

The results of the comprehensive simulation study made by the present work have been presented in the following sections in the form of general comments together with typical selected numerical values to illustrate the average performance of the developed estimator.

The test system data and some sample results have been shown respectively in Appendix B and Appendix C.

4.2 Measurement Configurations

Some typical metering patterns used in the simulation test are shown in the Table 4.1.

Table 4.1: Typical measurement configurations.

Measurement Configuration No.	Location of measurements			Total No. of measurements M	Redundancy ratio $\eta = \frac{M}{N}$
	Injection	Flow	Voltage		
1	at B2	at SE	at GB	287	1.79
2	at GB	at SE	at GB	303	1.89
3	at GB and SB	at SE	at GB and SB	321	2.01
4	-	at SE and RE	-	456	2.85
5	-	at SE and RE	at GB	481	3.01

The significance of various symbols used in Table 4.1 are as follows:

B2 : each of the buses having 2 lines connected to it; there are 17 such buses in the BPDB system.

GB : each of the buses having generator connected to it; there are 25 such buses in the BPDB system.

SB : each of the buses having no generator or load connected to it; these are termed as switching bus and there are 6 such buses in the BPDB system.

SE : sending end of each line.

RE : receiving end of each line.

N : number of state variables for 81-bus BPDB system is 160; this includes the voltage magnitude and phase angle of each node excepting the one which has been treated as the reference node with a voltage magnitude assumed to be known and a zero phase angle.

Each of the injection and flow measurements was considered in the form of both active (MW) and reactive (MVAR) components.

4.3 Convergence Characteristics

The fast decoupled BDS algorithm was tested using a tolerance margin of 10^{-6} between the estimates from two successive iterations and a flat start $v\angle\theta = 1.0\angle 0$ in the first iteration. Table 4.2 provides some typical results on the convergence property of the algorithm in terms of number of iterations when all the measurements were corrupted with random errors.

Table 4.2: Results on convergence of the fast decoupled BDS estimator.

Metering pattern No.	Redundancy ratio	No. of iterations
1	1.79	10.0
2	1.89	9.0
3	2.01	9.5
4	2.85	10.0
5	3.01	8.5

In table 4.2, the number of iterations in some cases are a whole number plus a half (e.g. 8.5) to imply that the estimation for voltage magnitudes was not required in the last iterations.

In general, simulation tests of the selected metering patterns have shown that the algorithm took on average 8 to 10 iterations depending upon the redundancy ratio, amount of errors and locations of measurements. Although in some cases metering patterns having a higher redundancy ratio converged in less number of iterations in other cases metering patterns with a lower redundancy ratio but with the measurements placed uniformly around each node, have shown better convergence.

4.4 Accuracy of Estimates

The accuracy and quality of estimates provided by the test algorithm is judged[20] by computing the post-estimation value of WLS objective function $J(\hat{x})$ as follows:

$$J(\hat{x}) = \frac{1}{M} \sum_{m=1}^{M} w_m (z_m - h_m(\hat{x}))^2 \qquad (4.1)$$

where

M - number of measurements

z_m - observed value of the m-th measurement

w_m - weighting factor for the m-th measurement

$h_m(\hat{x})$ - value of the m-th measurement computed from the corresponding analytical expression using obtained estimates of the state variables.

In simulation test z_m is the value specified for the m-th measurement after corrupting it with error.

If the computed value of $J(\hat{x})$ is less than the corresponding threshold value than the results of estimates are accurate and valid. If all the measurement errors follow the Gaussian distribution then $J(\hat{x})$ will have a chi-square distribution[17] with (M-N) degrees of freedom. Since the Gaussian measurement errors are within ±3 standard deviations for a probability of 99.7% the corresponding threshold value[20] of $J(\hat{x})$ is

$$J(\hat{x})_{threshold} = \frac{(M-N) + 3\sqrt{2(M-N)}}{M} \tag{4.2}$$

Table 4.3 shows some typical average values of $J(\hat{x})$ obtained in simulation tests conducted with only random noise corrupted measurements.

Table 4.3: Computed post-estimation vs. threshold values of $J(\hat{x})$ in presence of random measurement noise.

Metering pattern No.	Degrees of freedom M-N (N=160)	$J(\hat{x})$	
		computed value in p.u.	Threshold value in p.u.
1	127	0.3427	0.6091
2	143	0.4535	0.6393
3	161	0.4922	0.6692
4	296	0.6384	0.8091
5	321	0.6929	0.8253

The computed values of $J(\hat{x})$ were found to be less than the respective thresholds implying the acceptability of estimation results interms of accuracy and quality.

At simulation stage few more performance indices[20] as shown by equations (4.3) through (4.5) can also be used to assess how close to the 'true' values are the estimates.

$$J_t(x) = \frac{1}{M} \sum_{m=1}^{M} w_m((z_m)_{true} - h_m(\hat{x}))^2 \qquad (4.3)$$

$$\mu_v = \frac{1}{N} \sum_{i=1}^{N} \left| (v_i)_{true} - \hat{v}_i \right| \qquad (4.4)$$

$$\mu_\theta = \frac{1}{N} \sum_{i=1}^{N} \left| (\theta_i)_{true} - \hat{\theta}_i \right| \qquad (4.5)$$

Table 4.4 shows the post-estimation and threshold values of the index $J_t(x)$ for the typical measurement configurations used in the present work.

The estimation results were close to the 'true' values and acceptable as evident from the computed values of the index $J_t(x)$ which were less than the respective thresholds.

The threshold values of $J_t(x)$ shown in Table 4.4 were

Table 4.4: Typical computed vs. threshold values of $J_t(x)$ in presence of random measurement noise.

Metering pattern No.	$J_t(x)$	
	Computed Value in p.u.	Threshold value in p.u.
1	0.6321	0.7444
2	0.4459	0.7051
3	0.4064	0.6656
4	0.3146	0.4685
5	0.2920	0.4442

obtained[20] using equation (4.6).

$$[J_t(x)]_{threshold} = \frac{N+3\sqrt{2N}}{M} \qquad (4.6)$$

N was 160 for the BPDB system.

Table 4.5 includes the typical values obtained for the other two indices μ_v and μ_θ

Table 4.5 : Typical values of performance indices μ_v and μ_θ in presence of random measurement noise.

Metering pattern No.	μ_v in p.u.	μ_θ in radian
1	0.0015	0.0028
2	0.0010	0.0017
3	0.0009	0.0019
4	0.0017	0.0016
5	0.0011	0.0018

Very low values obtained for the performance indices μ_v and μ_θ imply that the estimates of state variables $v\angle\theta$ were close to the 'true' values.

The closeness of the estimates to the 'true' values can also be assessed by a comparison of the estimated quantities directly with their 'true' values.

Table 4.6 shows sample results on comparison of the estimates of voltages and phase angles at some of the nodes of BPDB grid system. Also typical values of estimates of some of the measurements have been shown in Table 4.7. The sample results shown in both the Tables were obtained for the metering pattern No. 1 in presence of random measurement noise.

The results shown in Table 4.6 and Table 4.7 confirm the closeness of estimated values to 'true' values and also an improvement over the specified (measured) values.

Table 4.6: Typical values of estimated voltages and phase angles at some of the nodes of the BPDB system for metering pattern No. 1

Node name	'True' voltage (p.u)	Estimated voltage (p.u.)	Est.-'True' voltage (p.u.)	'True' phase angle (degrees)	Estimated phase angle (degrees)	Est.-'True' phase angle (degrees)
KPTI2X40	1.0299	1.0290	-0.0009	3.0545	3.1432	0.0887
KHLN1X60	1.0299	1.0304	0.0005	-37.2741	-37.1378	0.1363
KAPTAI13	1.0020	1.0015	-0.0005	-1.7925	-1.5705	0.2220
SHJIBZ13	1.0170	1.0179	0.0009	-0.0804	-0.0859	-0.0055
GHRASL23	1.0252	1.0258	0.0006	-4.0673	-3.9397	0.1276

Table 4.7: Typical values of estimates of some of the measurements at selected nodes of the BPDB system for metering pattern No. 1

Node name	Type of measurement	'True' value	Specified value	Estimate value	Sp. - Est. values	Est.-True value
CHNRO13	Active injection	-18.89 (MW)	-17.95 (MW)	-18.43 (MW)	0.48 (MW)	0.46 (MW)
FRIDPR13	Reactive flow	11.85 (MVAR)	7.89 (MVAR)	11.11 (MVAR)	-3.22 (MVAR)	-0.74 (MVAR)
ULLONL13	Active flow	-40.00 (MW)	-40.64 (MW)	-40.12 (MW)	-0.52 (MW)	-0.12 (MW)
GHRASL13	Active flow	-63.76 (MW)	-61.48 (MW)	-63.15 (MW)	1.67 (MW)	0.61 (MW)

4.4.1 Accuracy vs. Redundancy

In general simulation tests have revealed that accuracy of estimates increased with the redundancy ratio of the measurement configuration. A quick assessment of accuracy vs. redundancy has been provided in Figures 4.1 and 4.2 by plotting the computed and threshold values of performance indices $J(\hat{x})$ and $J_t(x)$ respectively taken from Table 4.3 and Table 4.4.

It is evident from the Figures 4.1 and 4.2 that the computed value of performance index $J(\hat{x})$ increases with redundancy while that of $J_t(x)$ decreases. This is because of the fact that the former measures the difference between specified and estimated values of measurements while the latter assesses the difference between the 'true' and estimated values. As the redundancy increased the estimates became closer to the 'true' values and hence better than the specified i.e. erroneous values.

The increase in the threshold values of the index $J(\hat{x})$ with redundancy was consistent with the equation (4.2) which shows that higher the number of measurements higher will be the threshold. On the otherhand the threshold value of the index $J_t(x)$ which is inversely proportional to the number of measurements as in the equation (4.6), decreased with redundancy.

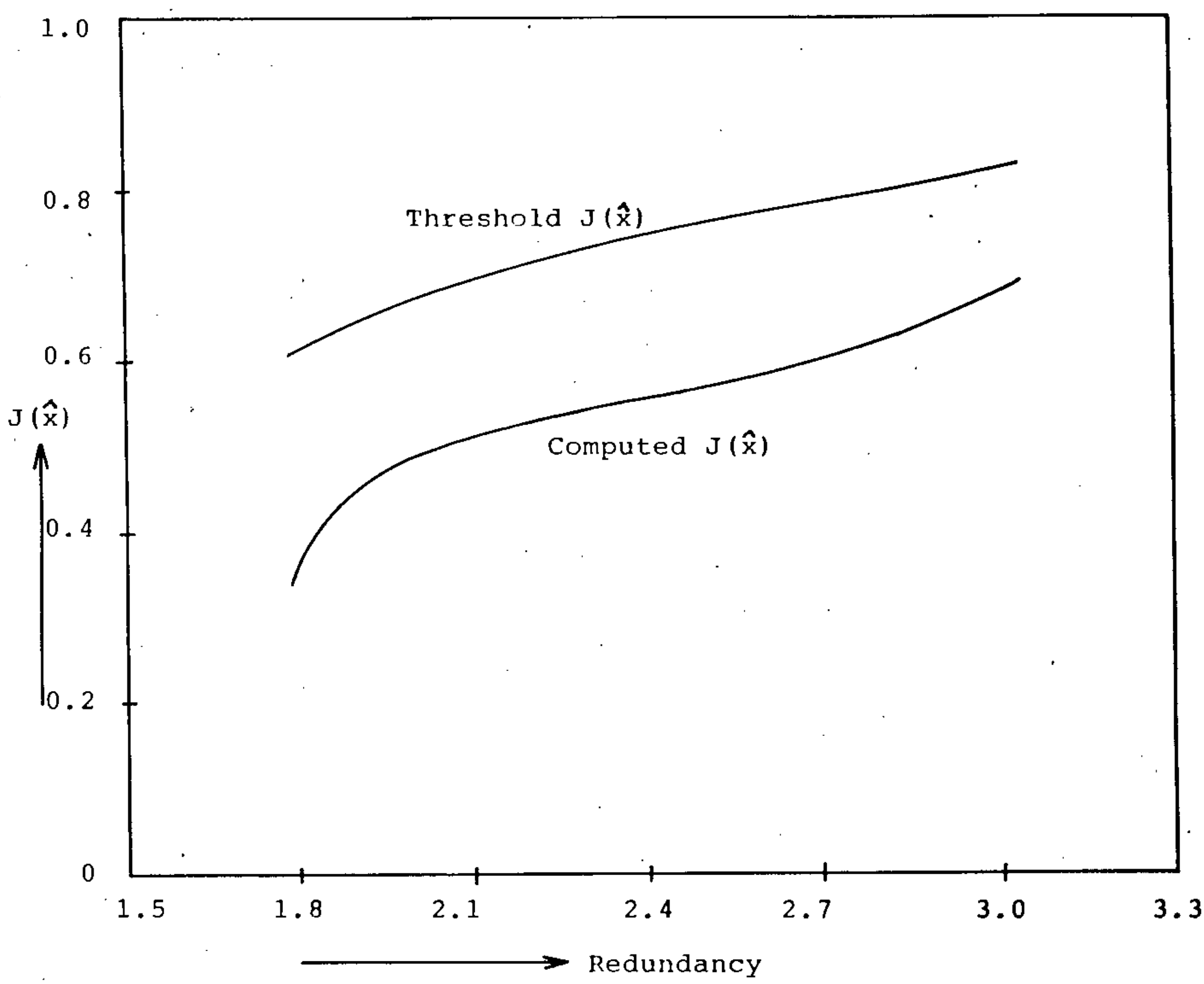


Figure 4.1: Variation of performance index J($\hat{x}$) with redundancy.

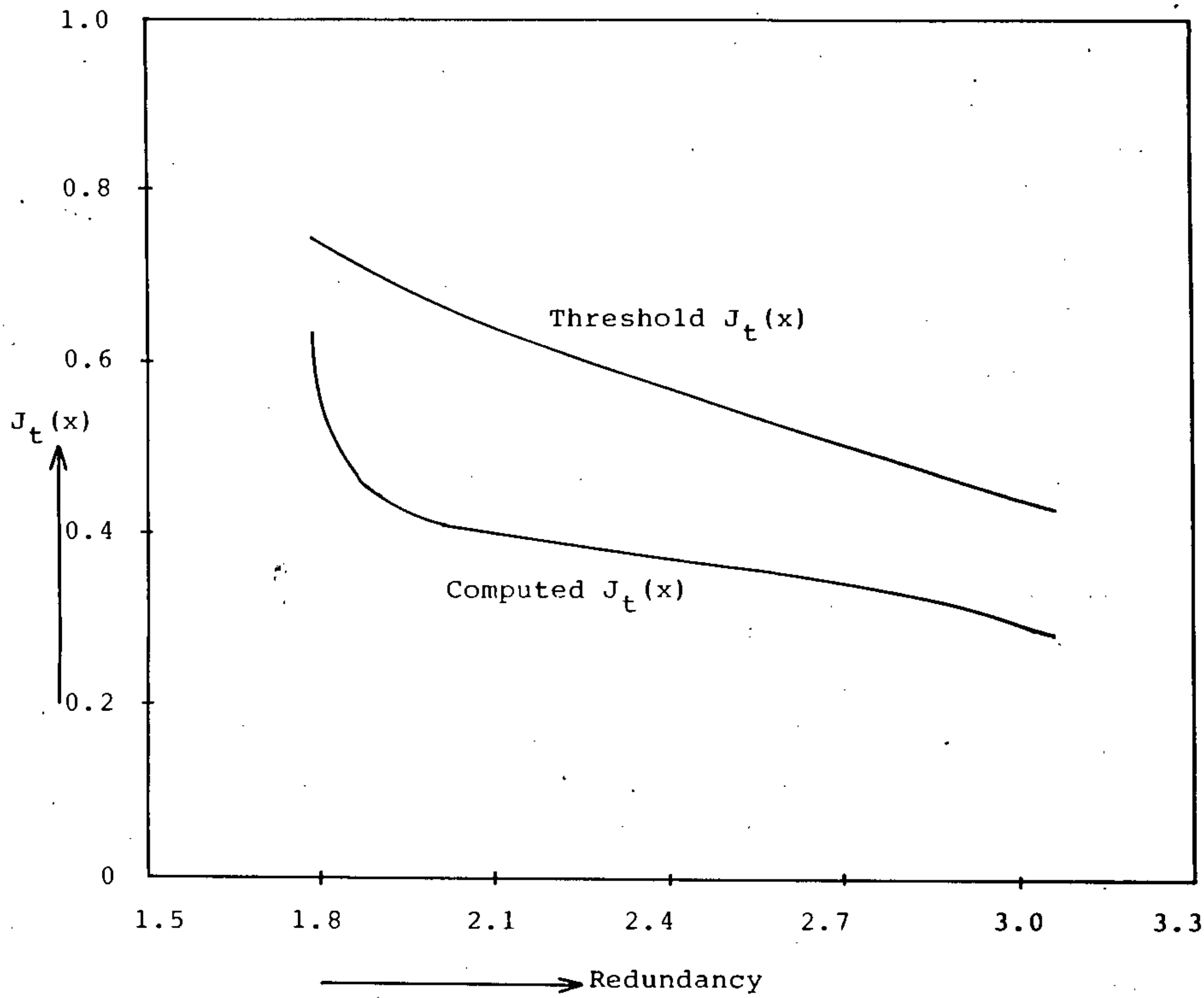


Figure 4.2: Variation of performance index $J_t(x)$ with redundancy.

4.5 Bad Data Performance

The algorithm was also tested by specifying zero values for some of the injection and flow measurements whose 'true' values were non zero. The rest of the measurements were random error corrupted.

Table 4.8 shows the performance of the algorithm for a typical case of bad data. The results were obtained with a value of 4.0 for the breakpoint explained in section 2.4 of Chapter 2. The tolerance margin used in the iterative process was 10^{-6}.

In general, the algorithm was able to suppress the bad data and produce estimates close to the 'true' values as evident from the value of the performance index $J_t(x)$ cited in Table 4.8. The computed value of the other index $J(\hat{x})$ was in excess of the threshold levels by a large margin, because the errors of some of the measurements were gross so that $J(\hat{x})$ did not have a chi-square distribution and also the specified values of those measurements (bad data) were widely different from the 'true' and hence estimated values.

The number of iterations required by the algorithm to converge was larger because of the presence of gross measurement errors in addition to random noise.

Table 4.8: Bad data performance for a typical case.

Metering pattern No.	Bad data Location	'True' Value	Specified Value	No.of itera-tion	Estimated Value	Performance indices in p.u.
5	An active and a reactive flow measurements at node CHNDRO13	-41.68 (MW) -22.37 (MVAR)	0.0 0.0	29.0	-39.91 (MW) -22.95 (MVAR)	$J(\hat{x})$ Computed: 2.2398 Threshold: 0.8253 $J_t(x)$ Computed : 0.3302 Threshold: 0.4442

4.6 Computer Storage and Time

The approximate core memory requirements of the program developed in FORTRAN 77 for the fast decoupled BDS algorithm was worked out in terms of decimal words. The IBM 4331/K02 computer used for simulation tests in the present research has 32 bits word length.

The length of the program area was about 5500 words. The size of the data area was calculated considering the size of the test system i.e. 81 buses and 114 lines , and a maximum measurement redundancy ratio of 3.5. The integer type data area was approximately 8100 words and that for real type data was about 3240 words. It should be noted that the IBM 4331 computer has integer variable packing facility so that each word of 32 bit length can store more than one integer type data.

As regards to the computing time required for execution of the developed program it is worth mentioning that the program has been run from a time shared terminal system interfaced with the computer so that the CPU time recorded varied at different parts of the day and week depending upon job traffic. On average the total execution time of the state estimation program was about 10 seconds of which 3 seconds for fixed computations, 2 seconds for calculations in all the iterations and 5 seconds for writing the output on peripheral device. In general, it was observed that the total CPU time requirement of the program varied insignificantly with redundancy ratio.

4.7 Conclusions

The performance of the fast decoupled BDS state estimator on a practical system i.e. BPDB grid network has been evaluated by conducting Monte Carlo simulation tests extensively using various metering patterns with different redundancies.

The ability of the algorithm to converge with various sets of random and gross measurement errors has established its robustness. Use of a number of performance indices to assess the validity of the estimates has given positive results. The algorithm was successful in handling the bad data problem.

The variation of convergence, accuracy and computer time with redundancy has also been studied. Although CPU time varied insignificantly with redundancy the accuracy was found to increase with the same.

The convergence characteristics depended not only upon the redundancy but also on the uniformity of placing the measurements with respect to each node of the test system and magnitudes of measurement errors. The requirement of a small time per iteration made it allowable for the algorithm to converge in a comparatively large number of iterations in presence of bad data.

The computer time and storage requirement of the developed state estimator can be considered suitable for on-line implementation even on a mini or microcomputer with available memory capacity. Had sparsity exploitation techniques not been applied, the developed program would have required more time and memory.

CHAPTER 5

GENERAL CONCLUSIONS

5.1 Conclusions

These days a computer based monitoring and control scheme is considered by the electric utilities as the only viable means to ensure an economic and secure power supply to their customers. The basic prerequisite to carry out any computer analysis and take correct decision is the provision of a reliable and consistent information on system state. To this end a set of redundant raw data (measurements) acquired from the system through telemetry is processed by an algorithm known as state estimator.

Bangladesh Power Development Board has just undertaken a project on the installation of a computer aided despatch centre for the on-line monitoring and control of the national grid system. Keeping in view the requirement of sophisticated software alongside the computer hardware, the present research work has attempted an investigation into various aspects involved in the initial stage of implementing a state estimation software responsible for performing a primary function in the on-line control. This investigation has covered the choice of an algorithm which would take computer storage and time acceptable from on-line standard point of view and identification of the metering patterns which would be suitable for the chosen algorithm interms of convergence, accuracy of estimates and bad data (gross error) processing capability.

The Fast Decoupled Bad Data Suppression algorithm has been chosen and tested extensively on the BPDB grid system adopting Monte Carlo simulation approach. The algorithm has been programmed exploiting sparsity so as to preserve its computational efficiency. The simulation tests performed with a number of selected metering configurations has established its robustness and ability to give accurate estimates in presence of both random and gross measurement errors.

5.2 Suggestions for Further Research

The computer code developed for the state estimation algorithm in the present research is by nature a program to make use of simulated data. Hence an investigation should be made into its adaptation for on-line operation which involves its interface with network configurator, data base and man-machine interface.

Also an investigation into the provision of some pre-estimation procedure for identifying some of the measurements corrupted by very large errors, can be considered. The identified measurements may be replaced by pseudo-measurements with values chosen from past knowledge. As a result the overall accuracy of estimates can be expected to improve and also the task of post-estimation bad data processing will be easier.

Investigations should also be made into identification of network modelling error due to inconsistency in the information on circuit breaker status.

The design of a single metering pattern which would be optimum in terms of number, type and location of measurements, accuracy requirement and cost of the instrumentation system with respect to the fast decoupled BDS state estimator, can be an interesting point for further investigation.

REFERENCES

1. F.C. SCHWEPPE, J. WILDES and D.B. ROM,
"Power System Static - State Estimation, Part 1: Exact Model, Part II: Approximate Model, and Part III: Implementation", IEEE Transactions on Power Apparatus and Systems, Vol. PAS-89, No. 1, pp. 120-135, January 1970.

2. J. CARPENTIER,
"The French National Control Centre Present State and Developments", IEEE Transactions on Power Systems, Vol. PWRS-1, No. 4, pp. 42-48, November 1986.

3. J. BISTROM and K. LINDSTROM,
"Finnish Power System Control Centre", IEEE Transactions on Power Systems, Vol. PWRS-1, No. 4, pp. 49-56, November 1986.

4. N.S. VAN NIELEN,
"New Energy Management System for the Dutch Power Pool", IEEE Transactions on Power Systems, Vol. PWRS-2, No. 1, pp. 58-64, February 1987.

5. F. McDYER and K. HERGER,
"The New National Control Centre, Ireland", IEEE Transactions on Power Systems, Vol. PWRS-2, No. 1, pp. 85-91, February 1987.

6. T. E. DY LIACCO,
"An Overview of Power System Control Centres", The IEEE Tutorial Course - "Energy Control Centre Design", pp. 5-16, PES Summer Meeting, Mexico City, 1977.

7. A.S. DEBS and R.E. LARSON,
"A Dynamic Estimator for Tracking the State of a Power System", IEEE Transactions on Power Apparatus and Systems, Vol. PAS-89, No. 7, pp. 1670-1678, September/October 1970.

8. D.M. FACCAO, P.A. COOKE and A. BRAMELLER,
"Power System Tracking State Estimation and Bad Data Processing", IEEE Transactions on Power Apparatus and Systems, Vol. PAS-101, No. 2, pp. 325-333, February 1982.

9. F.C. SCHWEPPE and E.J. HANDSCHIN,
"Static State Estimation in Electric Power Systems", Proceedings of the IEEE, Vol. 62, No. 7, pp. 972-982, July 1974.

10. M.R. IRVING, R.C. OWEN and M.J.H. STERLING,
"Power System State Estimation Using Linear Programming", Proceeding IEE, Vol. 125, No. 9, pp. 879-885, September 1978.

11. D.M. FALCAO, S.H. KARAKI and A. BRAMELLER,
"Nonquadratic State Estimation: A Comparison of Methods", Proceedings of the 7th Power System Computation Conference, pp. 1002-1006, July 1981.

12. L. RADU and A.M. SASSON,
"Fast State Estimation - Results of a Systematic Investigation of Decoupled Weighted least Square Methods",

Proceedings of the 6th IFAC Symposium on Identification and System Parameter Estimation, Vol. 2, pp. 1535-1540, June 1982.

13. J.F. DOPAZO, O.A. KLITIN, G.W. STAGG and L.S. VAN SLYCK, "State Calculations of Power System from Line Flow Measurements", IEEE Transactions on Power Apparatus and Systems, Vol. PAS-89, No. 7, pp. 1698-1708, September/October 1970.

14. H.M. MERRILL and F.C. SCHWEPPE, "Bad Data Suppression in Power System Static State Estimation", IEEE Transactions on Power Apparatus and Systems, Vol. PAS-90, No. 6, pp. 2718-2725, November/December 1971.

15. K. ZOLLENKOPF, "Bi-Factorisation - Basic Computational Algorithm and Programming Techniques", Conference on Large Sets of Linear Equations, Oxford, U.K., 1970.

16. B.S. GOTFRIED, "Elements of Stochastic Process Simulation", Prentice-Hall Inc., New Jersey, 1984.

17. J.F. DOPAZO, S.T. EHRMANN, A.M. SASSON and L.S. VAN SLYCK, "The AEP State Estimation Monitoring and Security System ", Proceeding of the International Symposium: Computerized Operation of Power Systems (COPOS), 1975, Brazil,

edited by S.C. Savulescu, Elsevier Scientific Publishing Company, 1976, pp. 74-103.

18. M.R. SPIGEL,
"Theory and Problems of Statistics", Schaum's Outline Series, McGraw-Hill Book Company, New York, 1972.

19. E. HANDSCHIN and C. BONGERS, "Theoretical and Practical Considerations in the Design of State Estimators for Electric Power Systems", Proceedings of the International Symposium: Computerized Operation of Power Systems (COPOS) 1975, Brazil, pp. 104-136.

20. J.F. BERMUDEZ and A. BRAMELLER,
"State Estimation in Power Systems: A Comparison of Methods", Proceedings of the 6th Power System Computation Conference, 1978, Vol. 2, pp. 783-790.

APPENDIX A

MATHEMATICAL EXPRESSIONSS AND DERIVATIONS FOR THE BASIC AND THE FAST DECOUPLED WLS STATE ESTIMATORS

A.1 Nonlinear Functions of State Variables

The expressions h(x) for a nodal injection and a line flow have been shown in Table A.1 in relation to an elementary network branch model and in terms of associated state variables together with the branch parameters.

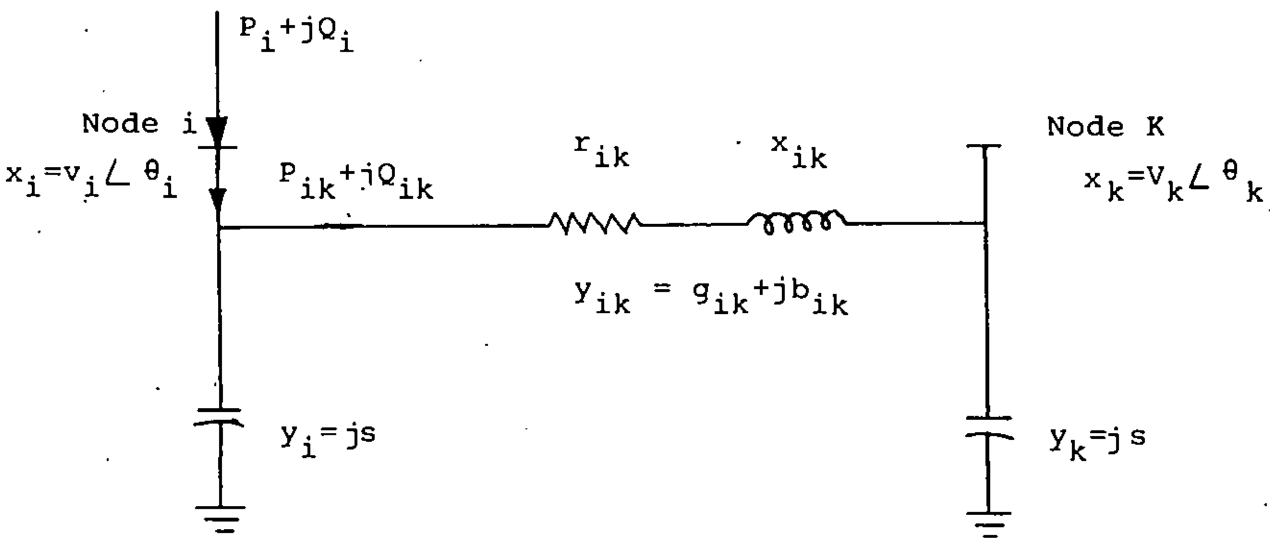


Table A.1: Expressions for a line flow and a nodal injection.

		h(x)
Line flow	P_{ik}	P_{ik}=Real part of $\{x_i \ (x_i y_i+(x_i-x_k)y_{ik})^*\}$ Or, $P_{ik}=v_i v_k[-g_{ik}\cos\theta_{ik}-b_{ik}\sin\theta_{ik}]+v_i^2 g_{ik}$
	Q_{ik}	Q_{ik}=Imaginary Part of $\{x_i \ (x_i y_i+(x_i-x_k)y_{ik})^*\}$ Or, $Q_{ik}=v_i v_k[-g_{ik}\sin\theta_{ik}+b_{ik}\cos\theta_{ik}]-v_i^2(b_{ik}+s)$
Nodal injection		$P_i=\sum_{k\in\alpha_i} P_{ik}$ $\quad$ $Q_i=\sum_{k\in\alpha_i} Q_{ik}$

The meanings of some of the symbols used in Table A.1 are as follows. Other symbols carry their usual significance.

X_i	-	state variable of node i
y_i	-	shunt susceptance of node i
Y_{ik}	-	series admittance of line i-k
r_{ik}	-	series resistance of line i-k
x_{ik}	-	series reactance of line i-k
g_{ik}	=	$\frac{r_{ik}}{r_{ik}^2 + x_{ik}^2}$ is series conductance of line i-k
b_{ik}	=	$-\frac{x_{ik}}{r_{ik}^2 + x_{ik}^2}$ is series susceptance of line i-k
j	-	imaginary operator
s	-	half of the charging susceptance in line i-k
θ_{ik}	-	difference between phase angles at nodes i and k : $\theta_i - \theta_k$
$k \epsilon \alpha_i$	-	set of nodes k connected to node i by lines

A.2 Derivation of Equation (2.3)

Let the equation (2.2) be reconsidered as equation (A.1)

$$J(x) = \sum_{m=1}^{M} w_m (z_m - h_m(x))^2 \qquad \text{(A.1)}$$

Equation (A.1) can be rewritten in matrix form as:

$$J = ([Z] - [h(x)])^T [R]^{-1} ([Z] - [h(x)]) \qquad \text{(A.2)}$$

where the inverse of the matrix [R] is diagonal with elements independent of state variables and equal to weighting factor w_m for m-th measurement as also stated in equation (2.12)

The nonlinear functions in vector [h(x)] can be linearised by Taylor's series expansion about an initial estimate point $[X^o]$ with higher order terms neglected.

$$[h(x)] = [h(x^o)] + [H]([X] - [X^o]) \qquad \text{(A.3)}$$

where

$$[H] = \left. \frac{\partial h(x)}{\partial x} \right|_{x=x^o}$$

By subtracting both sides of equation (A.3) from the vector [Z] it can be written as:

$$[Z] - [h(x)] = [Z] - [h(x^o)] - [H]([X] - [X^o]) \qquad \text{(A.4)}$$

Equation (A.4) can be written as:

$$[Z] - [h(x)] = [\Delta Z] - [H][\Delta X] \tag{A.5}$$

where

$$[\Delta Z] = [Z] - [h(x^{o})] \tag{A.6}$$

$$[\Delta X] = [X] - [X^{o}] \tag{A.7}$$

Substituting equation (A.4) for ([Z] - [h(x)]) into equation (A.2) the WLS objective function J can be stated as:

$$J = ([\Delta Z] - [H][\Delta X])^{T}[R]^{-1}([\Delta Z]-[H][\Delta X]) \tag{A.8}$$

Differentiating the function J in equation (A.8) with respect to the state vector [X] gives:

$$\frac{\partial J}{\partial x} = 2(\frac{\partial}{\partial x}([\Delta Z] - [H][\Delta X])^{T})[R]^{-1}([\Delta Z] - [H][\Delta X]) \tag{A.9}$$

Taking transpose of both sides of equation (A.4) and then differentiating with respect to [X] gives:

$$\frac{\partial [h(x)]^{T}}{\partial x} = [H]^{T} \tag{A.10}$$

Taking transpose of both sides of equation (A.5) and then differentiating with respect to [X] gives:

$$- \frac{\partial [h(x)]^T}{\partial x} = \frac{\partial}{\partial x}([\Delta Z]-[H][\Delta X])^T \quad \text{(A.11)}$$

Combining equation (A.10) and (A.11) gives

$$\frac{\partial}{\partial x}([\Delta Z] - [H][\Delta X])^T = - [H]^T \quad \text{(A.12)}$$

Substituting equation (A.12) for $\frac{\partial}{\partial x}([\Delta Z]-[H][\Delta X])^T$ into equation (A.9) gives:

$$\frac{\partial J}{\partial x} = -2[H]^T[R]^{-1}([\Delta Z]-[H][\Delta X]) \quad \text{(A.13)}$$

Equating the derivative of objective function J shown in equation (A.13) to zero gives an expression for optimum estimate $[\hat{X}]$ of the state vector

$$[H]^T[R]^{-1}[H][\Delta \hat{X}] = [H]^T[R]^{-1}[\Delta Z] \quad \text{(A.14)}$$

$$\text{Or, } [\Delta \hat{X}] = ([H]^T[R]^{-1}[H])^{-1}[H]^T[R]^{-1}[\Delta Z] \quad \text{(A.15)}$$

$$\text{Or, } [\Delta \hat{X}] = [G]^{-1}[H]^T[R]^{-1}[\Delta Z] \quad \text{(A.16)}$$

where

$$[\Delta \hat{X}] = [\hat{X}] - [X^o] \quad \text{(A.17)}$$

$$[G] = [H]^T[R]^{-1}[H] \quad \text{(A.18)}$$

It is to be noted that the estimate $[\hat{X}]$ has been obtained after linearizing the nonlinear functions $[h(x)]$ about an initial point $[X^o]$. Not necessarily will $[\hat{X}]$ be the desired estimate close to the 'true' value. Therefore the estimation process is to be repeated using $[\hat{X}]$ as the next point of linearisation to obtain a better solution. In this way the process defined by equation (A.16) can be iterated until each of the elements of $[\Delta X]$ is less than or equal to a prespecified small quantity termed tolerance margin. Equation (A.19) shows the general expression of the iterative algorithm.

$$[\Delta \hat{X}]^{i+1} = [G]^{-1}[H]^T[R]^{-1}[\Delta Z]^{i+1} \qquad \text{(A.19)}$$

$$\text{Or, } [\hat{X}]^{i+1} = [\hat{X}]^{i} + [G]^{-1}[H]^T[R]^{-1}[\Delta Z]^{i+1} \qquad \text{(A.20)}$$

where,

$$[H] = \left.\frac{\partial h}{\partial x}\right|_{x=\hat{x}^i} \qquad \text{(A.21)}$$

$$[G] = [H]^T[R]^{-1}[H] \qquad \text{(A.22)}$$

$$[\Delta Z]^{i+1} = [Z] - [h(\hat{x}^i)] \qquad \text{(A.23)}$$

Equation (A.20) is the required expression of the basic WLS state estimation algorithm defined by equation (2.3).

A.3 Fast Decoupling Techniques

Equations (A.24) to (A.30) shows the simplifications known as fast decoupling techniques.

1) The reactive set of measurement equations are divided by the voltage magnitude v_i at the bus i at which the corresponding measurement was taken. This results in the disappearance of the dependence of the related Jacobian terms on voltage magnitudes.

$$[Z'_q] = [h'_q(\theta , v)] + [\xi'_q] \qquad (A.24)$$

where,

$$(z'_q)_m = (z_q/v_i)_m$$

$$(h'_q)_m = (h_q/v_i)_m \qquad (A.25)$$

$$(\xi'_q)_m = (\xi_q/v_i)_m$$

m=1,2,..........number of reactive measurements.

2) Due to reformulation as in equation (A.24) the weighting matrix of reactive measurement residuals $[R_{qq}]^{-1}$ changes to $[R'_{qq}]^{-1}$ such that:

$$[R'_{qq}]^{-1} = [R_{qq}]^{-1} \frac{1}{V^2}$$

For practical purpose v can be approximated to be 1.0 per unit to make the weight independant of state variable without any substantial effect on the estimation. Equation (A.26) is the result of this approximation.

$$[R'_{qq}] = [R_{qq}] \tag{A.26}$$

3) For line flow in any branch i-k the assumption

$$\text{Cos} \ \theta_{ik} = 1.0 \tag{A.27}$$

$$g_{ik} \sin \theta_{ik} << b_{ik} \text{Cos} \ \theta_{ik} \tag{A.28}$$

and for active power flow a further approximation

$$v_i v_k \approx 1.0 \tag{A.29}$$

are made.

4) Series resistance of a line i-k is neglected compared to its series reactance to obtain b_{ik} as

$$b_{ik} \approx \frac{1}{X_{ik}} \tag{A.30}$$

Table A.2 shows the state vector independant elements of the

Jacobian matrices $[H_{pp}]$ and $[H'_{qq}]$.

In the computations of active measurement residuals $[\Delta Z_p]$, none of the simplifications are applied, while for reactive measurement residuals

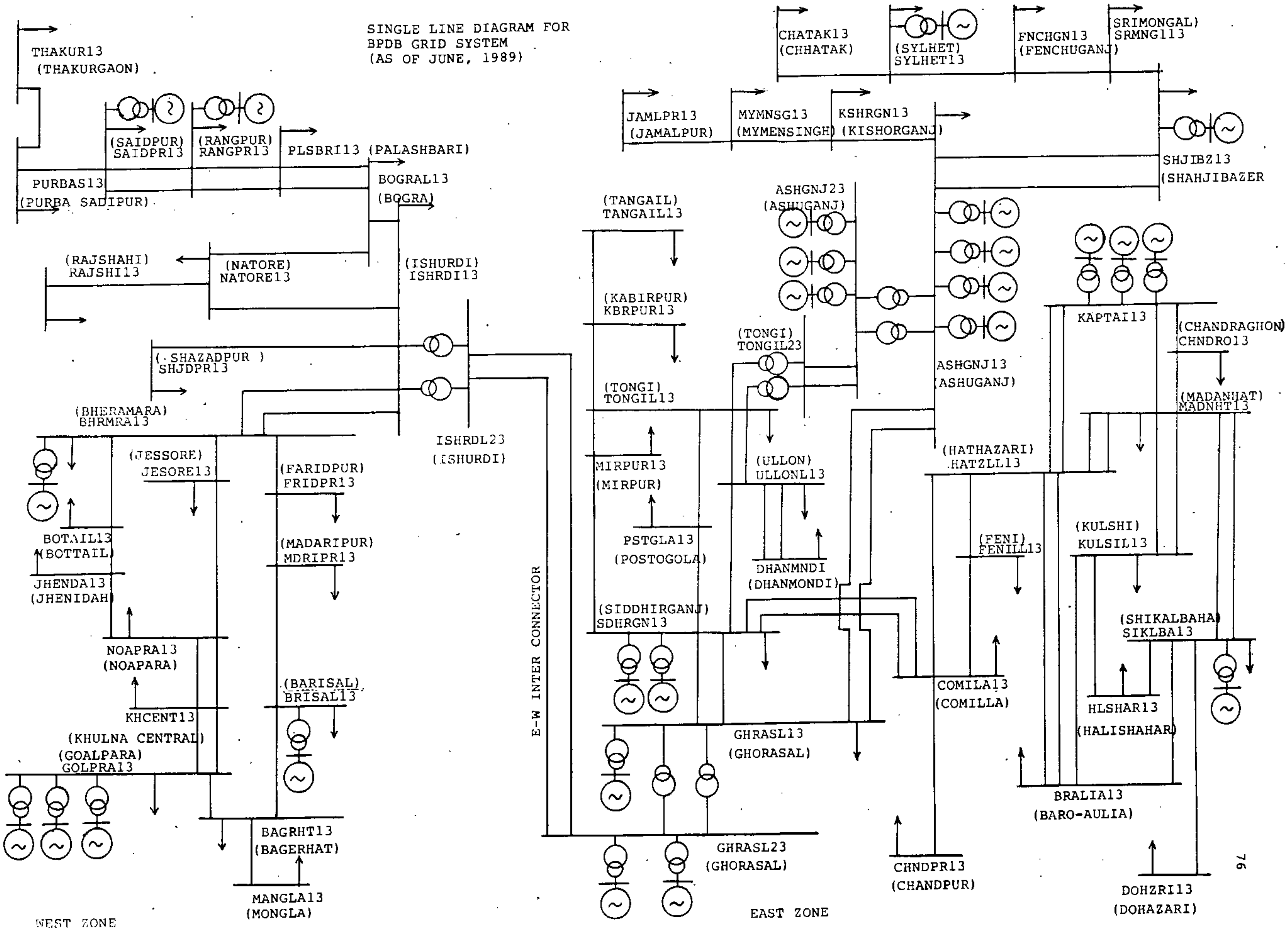
$$[\Delta Z'_q] = [Z'_q] - [h'_q(\theta, v)]$$

the simplification (1) is applied. Also, the Taylor's expansion, truncated after the third term for sine and cosine functions and the exact expressions for g_{ik} and b_{ik} are used for both the vectors $[\Delta Z_p]$ and $[\Delta Z'_q]$ to improve accuracy and save computation time.

Table A.2: State vector independant elements of active and reactive Jacobian matrices.

Active Jacobian $[H_{pp}]$	$\frac{\partial P_{ik}}{\partial \theta_i} = -b_{ik}$	$\frac{\partial P_{ik}}{\partial \theta_k} = b_{ik}$
	$\frac{\partial P_i}{\partial \theta_i} = \sum_{k \epsilon \alpha_i} - b_{ik}$	$\frac{\partial P_i}{\partial \theta_k} = b_{ik}$
Reactive Jacobian $[H'_{qq}]$	$\frac{\partial Q'_{ik}}{\partial v_i} = -b_{ik} - s$	$\frac{\partial Q'_{ik}}{\partial v_k} = b_{ik}$
	$\frac{\partial Q'_i}{\partial v_i} = -\sum_{k \epsilon \alpha_i} (b_{ik} + s)$	$\frac{\partial Q'_k}{\partial v_k} = b_{ik}$
	$\frac{\partial v_i}{\partial v_i} = 1.0$	

APPENDIX B
BPDB GRID SYSTEM DATA



SINGLE LINE DIAGRAM FOR BPDB GRID SYSTEM (AS OF JUNE, 1989)

BPDB GRID SYSTEM
BASE MVA =100
REFERENCE NODE IS GRS1U210

NODE NO.	NODE NAME	SPECIFIED VOLTAGE P.U.	SPECIFIED GENERATION P MW	Q MVAR	SPECIFIED LOAD P MW	Q MVAR
1	KPTI2X40	1.030	30.0	55.0	1.5	0.75
2	KPTI1X50	1.030	40.0	30.0	0.8	0.40
3	KPTI2X50	1.030	95.0	65.0	1.5	0.75
4	SKLSTXBM	1.030	75.0	55.0	5.2	2.60
5	SDSH3X10	1.030	20.0	15.0	1.4	0.70
6	SDSH3X33	1.030	95.0	80.0	3.0	1.50
7	ASGN2X64	1.030	60.0	40.0	4.2	2.10
8	ASGN1U60	1.030	55.0	40.0	2.0	1.00
9	ASGN1X30	1.030	30.0	20.0	2.0	1.00
10	ASGN2U60	1.030	00.0	00.0	0.0	0.00
11	ASG1U150	1.030	130.0	100.0	11.0	5.40
12	ASG2U150	1.030	130.0	100.0	11.0	5.40
13	ASG3U150	1.030	130.0	100.0	11.0	5.40
14	GRSL2X55	1.030	95.0	75.0	7.5	3.70
15	GRS1U210	1.050	210.0	170.0	15.0	7.00
16	GRS2U210	1.050	150.0	140.0	15.0	7.00
17	SHJBZGT	1.030	00.0	00.0	0.0	0.00
18	SYLH1X20	1.030	20.0	17.0	0.5	0.25
19	KHL1X110	1.030	40.0	40.0	7.0	3.40
20	KHLN1X60	1.030	00.0	00.0	0.0	0.00
21	KHLNBRPP	1.030	20.0	18.0	0.8	0.40
22	BRSL2X20	1.030	00.0	40.0	1.5	0.75
23	BMRA3X20	1.030	00.0	45.0	1.4	0.70
24	SDPR1X20	1.030	12.0	15.0	1.0	0.50
25	RNGP1X20	1.030	20.0	15.0	1.0	0.50
26	KAPTAI13				0.0	0.00
27	CHNDRU13				18.9	8.90
28	MADNHT13				50.0	24.20
29	SIKLBA13				6.2	3.00
30	HATZLL13				0.0	0.00
31	DOHZRI13				14.8	7.20
32	KULSIL13				61.7	29.90
33	ILSHAR13				40.0	19.4
34	BRALIA13				35.0	17.0
35	FENILL13				31.3	15.2
36	COMILA13				34.9	16.9
37	CHNDPR13				9.7	4.7
38	SJIRGN13				72.8	35.3
39	ULLONL13				73.7	35.7
40	DHANMNDI				38.2	18.5
41	TONGIL13				77.2	37.4
42	MIRPUR13				61.0	29.6
43	PSTGLA13				70.7	34.3
44	KARPUR13				16.0	7.8
45	INJAIL13				22.4	10.9
46	SHRASL13				44.7	21.7
47	ASHGNJ13				21.5	10.4

48	SHJIBZ13	7.0	3.4
49	SRMNGL13	10.0	4.8
50	PNCHGH13	7.0	3.4
51	SYLHET13	19.7	9.6
52	CHATAK13	7.2	3.5
53	KSHRGN13	12.3	6.0
54	MYMNSG13	24.3	11.8
55	JAMLPR13	13.6	6.6
56	GOLPRA13	1.8	.9
57	KHGEMT13	70.4	34.1
58	NOAPRA13	10.2	4.9
59	JESORE13	35.0	17.0
60	JHENDA13	18.9	9.2
61	BJTAIL13	21.9	10.6
62	BHRMRA13	16.0	7.8
63	ISHRDI13	26.4	12.8
64	NATORE13	8.9	4.3
65	RAJSHI13	29.7	14.4
66	SHJDPR13	10.8	5.2
67	BOGRAL13	33.0	16.0
68	PLSBRI13	8.7	4.2
69	RAIGPR13	22.8	11.0
70	SAIDPR13	21.0	10.2
71	PURBAS13	13.0	6.3
72	THAKUR13	13.0	6.3
73	BAGRHT13	10.0	4.8
74	MANGLA13	2.0	1.0
75	BRISAL13	22.5	10.9
76	MDRIPR13	10.5	5.1
77	FRIDPR13	13.7	6.6
78	ASHGNJ23		
79	GHRASL23		
80	TONGIL23		
81	ISHRDL23		

LINE NO.	SENDING END	RECEIVING END	R P.U.	X P.U.	SUSCEPTANCE P.U.
1	KAPTAI13	CHNDRG13	.0047	.0177	.0041
2	KAPTAI13	MADNHT13	.0226	.0861	.0200
3	KAPTAI13	HATZLL13	.0222	.0258	.0202
4	KAPTAI13	HATZLL13	.0222	.0258	.0202
5	CHNDRG13	MADNHT13	.0179	.0683	.0159
6	MADNHT13	SIKLBA13	.0094	.0348	.0085
7	MADNHT13	SIKLBA13	.0094	.0348	.0085
8	MADNHT13	KULSIL13	.0074	.0301	.0061
9	MADNHT13	KULSIL13	.0074	.0301	.0061
01	MADNHT13	HATZLL13	.0050	.0186	.0046
11	MADNHT13	HATZLL13	.0050	.0186	.0046
12	HATZLL13	FEHILL13	.0516	.1712	.0474
13	FEHILL13	COMILA13	.0282	.1046	.0259
14	HATZLL13	COMILA13	.0793	.2958	.0733
15	SIKLBA13	HLGHAT13	.0036	.0223	.0058
16	SIKLBA13	DOHZRI13	.0133	.0717	.0165
17	HATZLL13	BRALIA13	.0070	.0258	.0064
18	HATZLL13	BRALIA13	.0070	.0258	.0064

19	KULSIL13	HLSHAR13	.0079	.0321	.0065
20	KULSIL13	BRALIA13	.0075	.0309	.0061
21	COMILA13	SDHRGN13	.0510	.1888	.0468
22	COMILA13	SDHRGN13	.0510	.1888	.0468
23	COMILA13	CHNDPR13	.0372	.1431	.0298
24	SDHRGN13	ULLDHL13	.0089	.0363	.0073
25	SDHRGN13	GHRASL13	.0259	.0946	.0236
26	SDHRGN13	GHRASL13	.0258	.0946	.0236
27	ULLDHL13	DHANMDI	.0031	.0034	.1054
28	ULLDHL13	DHANMDI	.0031	.0034	.1054
29	ULLDHL13	TONGIL13	.0112	.0427	.0099
30	ULLDHL13	TONGIL13	.0112	.0427	.0099
31	TONGIL13	MIRPUR13	.0084	.0342	.0069
32	TONGIL13	PSTGLA13	.0251	.1026	.0207
33	SDHRGN13	MIRPUR13	.0261	.1234	.0250
34	PSTGLA13	SDHRGN13	.0124	.00559	.0112
35	TONGIL13	KBRPUR13	.0123	.0464	.0109
36	GHRASL13	ASHGNJ13	.0254	.0932	.0232
37	GHRASL13	ASHGNJ13	.0254	.0932	.0232
38	KBRPUR13	TNGAIL13	.0273	.1130	.0265
39	ASHGNJ13	SHJIBZ13	.0392	.1112	.0277
40	ASHGNJ13	SHJIBZ13	.0392	.1112	.0277
41	SHJIBZ13	SRMNGL13	.0212	.0806	.0188
42	SRMNGL13	FNCHGN13	.0286	.1087	.0254
43	FNCHGN13	SYLHET13	.0133	.0697	.0162
44	SYLHET13	CHATAK13	.0197	.0720	.0166
45	ASHGNJ13	KSHRGN13	.0391	.1143	.0269
46	KSHRGN13	MYMNSG13	.0343	.1299	.0305
47	MYMNSG13	JAMLPR13	.0321	.1211	.0284
48	GOLPRA13	KHCENT13	.0006	.0018	.0091
49	GOLPRA13	KHCENT13	.0006	.0018	.0091
50	KHCENT13	NOAPRA13	.0168	.0491	.0109
51	KHCENT13	NOAPRA13	.0168	.0491	.0109
52	NOAPRA13	JESORE13	.0194	.0566	.0126
53	NOAPRA13	JHENDA13	.0543	.1585	.0353
54	JESORE13	BHRMRA13	.0361	.2511	.0559
55	JHENDA13	BOTAIL13	.0337	.0993	.0219
56	BOTAIL13	BHRMRA13	.0175	.0509	.0113
57	BHRMRA13	ISHRDI13	.0074	.0212	.0049
58	BHRMRA13	ISHRDI13	.0074	.0212	.0049
59	GOLPRA13	BAGRHT13	.0336	.1050	.0204
60	BAGRHT13	BRISAL13	.0515	.1609	.0312
61	BAGRHT13	MANGLA13	.0244	.0762	.0148
62	BRISAL13	MDRIPR13	.0437	.1294	.0280
63	MDRIPR13	FRIDPR13	.0499	.1480	.0320
64	FRIDPR13	BHRMRA13	.0809	.2400	.0521
65	NATORE13	BOGRAL13	.0518	.1511	.0338
66	ISHRDI13	NATORE13	.0275	.0799	.0179
67	ISHRDI13	BOGRAL13	.0723	.2310	.0517
68	NATORE13	RAJSHI13	.0311	.0948	.0193
69	BOGRAL13	PLSBRI13	.0332	.1134	.0254
70	BOGRAL13	PLSBRI13	.0332	.1134	.0254
71	PLSBRI13	RAIGPR13	.0407	.1184	.0265
72	PLSBRI13	RAIGPR13	.0407	.1184	.0265
73	RAIGPR13	SAIDPR13	.0318	.0926	.0208

74	SAIDPR12	SAIDPR13	.0318	.0225	.0208
75	SAIDPR13	PURBAS13	.0162	.0474	.0105
76	PURBAS13	THAKUR13	.0377	.0383	.0219
77	ISHRDI13	SHJDPR13	.0558	.1705	.0347
78	ASHGNJ23	TONGIL23	.0197	.0507	.1095
79	ASHGNJ23	TONGIL23	.0197	.0507	.1095
80	GHRASL23	ISHRDL23	.0272	.1304	.2778
81	GHRASL23	ISHRDL23	.0272	.1304	.2778
82	KPTI2X40	KAPTAI13	.0	.1111	.0
83	KPTI1X50	KAPTAI13	.0	.2250	.0
84	KPTI2X50	KAPTAI13	.0	.0890	.0
85	SKLSTX8M	SIKLBA13	.0	.0976	.0
86	SDGHBX10	SDHRGN13	.0	.1271	.0
87	SDGHBX33	SDHRGN13	.0	.1000	.0
88	ASGN2X64	ASHGNJ13	.0	.1100	.0
89	ASGNIU60	ASHGNJ13	.0	.1700	.0
90	ASGN1X30	ASHGNJ13	.0	.3560	.0
91	ASGN2U60	ASHGNJ13	.0	.1700	.0
92	ASG1U150	ASHGNJ23	.0	.0700	.0
93	ASG2U150	ASHGNJ23	.0	.0700	.0
94	ASG3U150	ASHGNJ23	.0	.0700	.0
95	GRSL2X65	GHRASL13	.0	.0335	.0
96	GRS1U210	GHRASL23	.0	.0450	.0
97	GRS2U210	GHRASL23	.0	.0450	.0
98	SHJBZST	SHJIBZ13	.0	.0800	.0
99	SYLH1X20	SYLHET13	.0	.4428	.0
100	KHL1X110	GOLPRA13	.0	.0950	.0
101	KHLN1X60	GOLPRA13	.0	.1486	.0
102	KHLNBMPP	GOLPRA13	.0	.2243	.0
103	BRSL2X20	BRISAL13	.0	.1500	.0
104	BMRA3X20	SHRMRA13	.0	.1405	.0
105	SDPR1X20	SAIDPR13	.0	.4430	.0
106	RNGP1X20	RANGPR13	.0	.5357	.0
107	ASHGNJ23	ASHGNJ13	.0	.1057	.0
108	ASHGNJ23	ASHGNJ13	.0	.1057	.0
109	GHRASL23	GHRASL13	.0	.0774	.0
110	GHRASL23	GHRASL13	.0	.0774	.0
111	TONGIL23	TONGIL13	.0	.0577	.0
112	TONGIL23	TONGIL13	.0	.0577	.0
113	ISHRDL23	ISHRDL13	.0	.0577	.0
114	ISHRDL23	ISHRDL13	.0	.0577	.0

APPENDIX C

SAMPLE RESULTS

APPENDIX C.1

SAMPLE OUTPUT FOR STATE ESTIMATION IN PRESSENCE OF RANDOM ERRORS IN THE MEASUREMENTS

FAST DECOUPLED STATIC STATE ESTIMATOR
RESULTS FOR A CASE OF RANDOM NOISE CORRUPTED MEASURMENTS IN
[illegible]PDS GRID SYSTEM

SIMULATION NUMBER= 7

****GENERAL INFORMATION***

NO.OF ITERATIONS TO CONVERGE	=10.00
TOLERANCE	=0.00000100
TOTAL ACTIVE MEASUREMENTS	= 131
TOTAL REACTIVE MEASUREMENTS	= 156
TOTAL NO. OF NODES IN THE SYSTEM	= 81
TOTAL NO. OF STATE VARIABLES	= 160
REDUNDANCY RATIO	= 1.79375

ESTIMATED VOLTAGES AND PHASE ANGLES AT NODES

NODE	NODE NAME	ESTIMATED VOLT(P.U.)	ESTIMATED THETA(DEG)	TRUE VOLT(P.U.)	TRUE THETA(DEG)	(EST.-TRUE) VOLT(P.U.)	(EST.-TRUE) THETA(DEG)
1	KPTI2X40	1.02907467	3.1432695	1.02999973	3.0545053	-0.00092506	0.08876419
2	KPTI1X50	1.03178501	3.5207964	1.02999973	3.1313076	0.00178528	0.38948877
3	KPTI2X50	1.03088284	2.8962870	1.02999973	2.7797127	0.00088310	0.11657429
4	SKLSTX0M	1.03125000	0.7628616	1.02999973	0.6173577	0.00125027	0.14550393
5	SDGN3X10	1.03084850	-3.3383455	1.02999973	-3.4836759	0.00084877	0.14533043
6	SDGH3X33	1.02926540	0.3387728	1.02999973	0.4832414	-0.00073433	-0.14446855
7	ASGM2X64	1.03000631	4.4640874	1.02999973	4.3271322	0.00000658	0.13695521
8	ASGH1U50	1.02922725	5.9243212	1.02999973	5.9020882	-0.00077248	0.02223301
9	ASGN1X30	1.03045177	6.0386993	1.02999973	6.3782112	0.00045204	-0.33951187
10	ASGM2U50	1.03136063	9.9263857	1.02999973	9.9681557	0.00136089	-0.04176997
11	ASG1U150	1.02868652	8.3856142	1.02999973	8.4380865	-0.00131321	-0.05247234
12	ASG2U150	1.03083093	8.3561554	1.02999973	8.4380865	0.00083120	-0.08193111
13	ASG3U150	1.03034687	8.5020304	1.02999973	8.4380865	0.00034714	0.06394386
14	GRSL2Y53	1.02966308	1.7832737	1.02999973	1.5796938	-0.00033665	0.20357979
15	GRS1U210	1.05000017	0.0000000	1.05000017	0.0000000	0.00000000	0.00000000
16	GRS2U210	1.04911232	-0.6581382	1.05000017	-0.8324414	-0.00088787	0.17430323
17	SHJ37GT	1.03011513	-0.0427352	1.02999973	-0.0804765	0.00011539	0.03774137
18	SYLH1X20	1.02806568	2.8990921	1.02999973	2.6591425	-0.00193405	0.23994965
19	KHL1X110	1.03013134	-35.4138174	1.02999973	-35.5009155	0.00013161	0.08709717
20	KHLM1X50	1.03042793	-37.1378021	1.02999973	-37.2741241	0.00042820	0.13632202
21	KHLN8MP2	1.02942467	-34.6589374	1.02999973	-34.8372211	-0.00057507	0.17828369
22	BRSL2X20	1.03097057	-33.7565542	1.02999973	-34.0817261	0.00097084	0.32517187
23	BMRA3X20	1.03149128	-25.7446447	1.02999973	-26.1872411	0.00149155	0.44259644
24	SDPR1X20	1.02714538	-34.3803253	1.02999973	-34.4029846	-0.00285435	0.02265930
25	RNGP1X20	1.02951622	-30.5133515	1.02999973	-29.9047852	-0.00048351	-0.60856628
26	KAPTAI13	1.00154209	-1.5506319	1.00209904	-1.7729406	-0.00055695	0.22230871
27	CHNDRD13	0.99555886	-1.9290171	0.99617302	-2.1562433	-0.00061417	0.22722626
28	MADNHT13	0.98223681	-2.7004299	0.98233540	-2.9179926	-0.00009859	0.21756258
29	SIKLBA13	0.98592430	-2.5693918	0.98594654	-2.8345089	-0.00002223	0.26511710
30	HATZLL13	0.98263245	-2.5051745	0.98318636	-2.7012947	-0.00055391	0.19612026
31	DOHZRI13	0.97858751	-3.2660007	0.97835785	-3.3932438	0.00022966	0.12724304
32	KULSIL13	0.97743344	-3.1046797	0.97696376	-3.3205995	0.00046968	0.21591990

33	HLSHAR13	0.97910572	-3.1662260	0.97783235	-3.4140644	0.00026537	0.24776840
34	BRALIA13	0.97860628	-2.3613332	0.97891778	-3.0487394	-0.00031149	0.18685627
35	FENILL13	0.95135444	-6.0115231	0.94934847	-6.0605421	0.00150597	0.04911900
36	COMILA13	0.95599657	[illegible]	[illegible]	-6.0954790	0.00105263	0.10834438
37	CHNDPR13	0.94349472	[illegible]	[illegible]	-6.8345013	0.00067765	-0.02518654
38	SDHRGN13	0.97398832	-4.6917315	0.97341317	-4.7816095	0.00057572	0.08987808
39	ULLONL13	0.95541635	[illegible]	[illegible]	-5.2772255	0.00008714	0.10699463
40	DHANMNDI	0.95461702	[illegible]	0.95455164	-5.3093653	0.00005539	0.10473824
41	TONGIL13	0.95911962	-4.0900727	0.95335391	-4.1877251	0.00025761	0.10745239
42	MIRPUR13	[illegible]	[illegible]	[illegible]	-5.2355680	0.00019924	0.10119915
43	PSTGLA13	0.95339332	[illegible]	[illegible]	-4.7055454	0.00040680	0.08373165
44	KBRPUR13	0.94527769	[illegible]	[illegible]	-5.1992666	-0.00022203	0.10275550
45	TNGAIL13	[illegible]	[illegible]	[illegible]	-5.6563358	-0.00123739	0.14356975
46	GHRASL13	1.00725555	-2.3371071	[illegible]	-2.4645185	0.00145675	0.07741642
47	ASHGNJ13	1.01858902	[illegible]	1.01707542	0.9681557	0.00151253	0.03140950
48	SHJIBZ13	1.01793289	[illegible]	[illegible]	-0.9304265	0.00784591	-0.00541687
49	GRMNGL13	[illegible]	[illegible]	[illegible]	-1.0780206	0.00070667	0.03471565
50	FNCHGN13	0.99699879	-1.9395220	0.99556314	-1.9190426	0.00043565	0.07951355
51	SYLHET13	[illegible]	[illegible]	[illegible]	-2.1840239	0.00067937	0.11012173
52	CHATAK13	0.93985893	-2.3337743	[illegible]	-2.4570141	0.00026166	0.12303925
53	KSHRGN13	0.97725457	[illegible]	[illegible]	-2.0357370	0.00139207	0.11954880
54	MYMNSG13	0.94399154	-4.5772462	0.94932997	-4.7987566	0.00365247	0.21981239
55	JAMLPR13	0.93021738	-5.5233173	[illegible]	-5.7663794	0.00243092	0.24306202
56	GOLPRA13	0.98296735	-37.1135017	[illegible]	-37.2741241	-0.00055506	0.15052246
57	KHLENT13	[illegible]	-37.1143424	[illegible]	-37.2740784	-0.00065094	0.15972900
58	NOAPRA13	0.96871365	-35.2222575	[illegible]	-35.3833618	-0.00044578	0.15110229
59	JESORE13	0.95220757	-35.2153051	0.95171379	-35.3856049	0.00049435	0.15979980
60	JHENDA13	0.94275624	[illegible]	0.94323915	-32.2471313	-0.00087291	0.27893066
61	BOTAIL13	0.94454592	-28.2371663	0.94437492	-28.5631561	0.00017130	0.32398987
62	BHRMRA13	0.95633211	-25.7741357	0.95587367	-26.0745677	0.00095844	0.30038452
63	ISHRDI13	0.95708155	[illegible]	0.95567834	-24.6190796	0.00140321	0.28208923
64	NATORE13	0.92139677	[illegible]	0.91749397	-28.2574005	0.00190292	0.56747437
65	RAJSHI13	[illegible]	[illegible]	[illegible]	-29.7243774	0.00093637	0.51811218
66	SHJDPR13	[illegible]	[illegible]	[illegible]	-25.6605988	0.00264454	0.04310608
67	BOGRAL13	[illegible]	[illegible]	[illegible]	-32.9403290	0.00181693	0.45040344
68	PLSBRI13	[illegible]	[illegible]	[illegible]	-34.2344971	0.00220418	0.48585510
69	RANGPR13	[illegible]	[illegible]	[illegible]	-35.1611533	0.00153959	0.48664856
70	SAIDPR13	[illegible]	[illegible]	[illegible]	-37.4047072	0.00053787	0.48365784
71	PURBAS13	[illegible]	[illegible]	[illegible]	-38.1522884	0.00096786	0.42858887
72	THAKUR13	[illegible]	[illegible]	[illegible]	-30.2563223	0.00258726	0.37638855
73	BAGRHT13	0.97792255	[illegible]	[illegible]	-38.3673706	-0.00063734	0.17515564
74	MANGLA13	0.97610777	[illegible]	[illegible]	-37.4544373	-0.00122315	0.12079590
75	BRISAL13	[illegible]	[illegible]	[illegible]	-38.9532195	0.00039378	0.29960632
76	MDRIPR13	[illegible]	[illegible]	0.97355951	-36.8755188	0.00123751	0.43153381
77	FRIDPR13	0.94507279	-33.0745155	0.94523764	-33.5071564	-0.00015885	0.43254089
78	ASHULL23	1.01261133	[illegible]	[illegible]	3.8526249	0.00101280	0.03776741
79	GHRASL23	1.02492232	[illegible]	[illegible]	-4.0573656	0.00054264	0.12758827
80	TONGIL23	0.97766433	0.3571133	0.97733933	0.3117088	0.00012656	0.05322450
81	ISHRDL23	[illegible]	[illegible]	[illegible]	-18.0740356	-0.00033970	0.38414001

MEASUREMENT ESTIMATES AND COMPUTED RESIDUALS

MEASUREMENTS INCLUDE COMPLEX INJECTION AND FLOW, VOLTAGES
LEGEND FOR TYPE AND UNITS OF MEASUREMENTS:
TYPE 1 VOLT(V)[illegible]

TYPE 2:ACTIVE INJECTION (P) AT A NODE IN M.W.
TYPE 3:REACTIVE INJECTION (Q)AT ANODE IN M.VAR.
TYPE 4:ACTIVE LINE_FLOW(PL) IN MW
TYPE 5:REACTIVE LINE FLOW(QL) IN MVAR

MEAS. NO.	MEAS. TYPE	NODE NO.	NODE NAME	TRUE VALUE	SPECIFIED VALUE	ESTIMATED VALUE	SP.-EST. VALUE	SP.-TRUE VALUE	EST.-TRUE VALUE
1	2	27	CHMDRD13	-18.999963	-17.95059	-18.43223	0.481724	0.949465	0.4677415
2	2	33	HLSHAP13	-39.999969	-38.94659	-39.55478	0.618231	1.053410	0.4351795
3	2	35	FEMILL13	-31.299973	-32.42895	-32.96078	0.531834	-1.128976	-1.6608114
4	2	40	DHAMMD13	-38.199997	-40.34214	-39.95666	-0.385493	-2.142160	-1.7566681
5	2	42	MIRPUR13	-60.999969	-61.45144	-61.26231	-0.189137	-0.451475	-0.2623379
6	2	43	MSIDLA13	-70.699965	-72.47943	-72.45025	-0.028223	-1.779507	-1.7502785
7	2	44	KAMPUR13	-15.999990	-16.84317	-16.72963	-0.113534	-0.843185	-0.7296503
8	2	49	[illegible]	-9.999990	-9.93407	-9.84839	-0.085765	0.065915	0.1516819
9	2	50	ENCHGH13	-6.999993	-7.44537	-7.19251	-0.253856	-0.445379	-0.1925230
10	2	53	KSHRGH13	-12.299991	-13.34990	-12.64343	-0.705369	-1.049310	-0.3434420
11	2	54	MYMNSG13	-24.300003	-22.77795	-22.89523	0.117278	1.522040	1.4047623
12	2	59	JTSDRG13	-34.999969	-35.02865	-35.11609	0.087440	-0.028575	-0.1161158
13	2	60	JHENDA13	-19.899963	-19.54309	-19.83219	0.289105	0.355876	0.0677705
14	2	61	CHTAIL13	-21.899963	-21.15174	-20.86819	-0.283545	0.749223	1.0317678
15	2	71	PURBAS13	-12.999993	-12.74436	-14.00136	1.257007	0.255632	-1.0013752
16	2	76	MORIPR13	-10.499999	-7.99327	-8.50620	0.512927	2.506714	1.9937868
17	2	77	FRIDPR13	-13.699990	-13.46353	-13.35125	-0.112283	0.235457	0.3487408
18	4	26	KAPTAI13	41.797465	42.00357	41.34903	0.659549	0.215102	-0.4434466
19	4	26	KAPTAI13	26.699363	27.12364	26.63410	0.489521	0.425064	-0.0644565
20	4	26	KAPTAI13	71.357727	72.50621	72.29614	0.210075	1.148491	0.9384155
21	4	26	KAPTAI13	71.357727	72.38473	72.29614	0.088576	1.027011	0.9384155
22	4	27	CHMDRD13	22.787476	21.27444	22.81407	-1.539629	-1.513021	0.0266075
23	4	28	MADNHT13	-6.309700	-7.94454	-8.56009	0.615423	-1.634961	-2.2503853
24	4	28	MADNHT13	-6.309700	-9.10565	-8.56009	-0.545573	-2.795958	-2.2503853
25	4	28	MADNHT13	25.248795	23.13705	24.86018	-1.723122	-2.111738	-0.3886163
26	4	28	MADNHT13	25.248795	25.41237	24.86018	0.552186	0.170570	-0.3886163
27	4	29	MADNHT13	-19.367325	-17.52504	-16.94287	-0.582170	1.842343	2.4245138
28	4	29	MADNHT13	-19.367325	-15.87397	-16.94287	1.068889	3.493404	2.4245138
29	4	30	HATZLL13	31.219745	32.84962	32.14549	0.704139	1.648384	0.9447455
30	4	35	FEMILL13	-0.667572	-2.04360	-1.40457	-0.639109	-1.376109	-0.7369995
31	4	30	HATZLL13	22.817463	23.34640	23.15183	0.196564	0.529933	0.3333688
32	4	29	SIKLDA13	36.111306	38.26741	37.04042	1.227021	2.157139	0.9301186
33	4	29	SIKLDA13	14.851189	17.82907	17.82913	-0.000059	2.977383	2.9779434
34	4	30	HATZLL13	25.199745	25.80799	25.50668	0.301313	0.609254	0.3079414
35	4	30	HATZLL13	25.199745	26.12972	25.50668	0.623037	0.927978	0.3079414
36	4	32	KULSIL13	3.959133	3.21243	2.59447	0.618008	-0.747652	-1.3656616
37	4	32	KULSIL13	-15.276432	-14.12041	-13.18073	-0.939685	1.156013	2.0956993
38	4	36	COMILA13	-12.841770	-13.52203	-12.65296	-0.869035	-0.680303	0.1897321
39	4	36	COMILA13	-12.841709	-11.78322	-12.65296	0.869970	1.057702	0.1887321
40	4	36	COMILA13	9.779993	11.10570	11.10591	-0.000017	1.325970	1.3259888
41	4	38	CHTGNG13	32.140953	31.77940	31.74057	0.037920	-0.761852	-0.3997803
42	4	38	CHTGNG13	-47.199913	-47.53721	-47.29599	-1.240222	-1.350003	-0.1097798
43	4	38	CHTGNG13	-47.187219	-44.25931	-47.29599	3.038674	2.928894	-0.1097798
44	4	39	ULLDRH13	19.114995	20.10003	17.99763	0.121553	1.005046	0.8834839
45	4	39	ULLDRH13	19.105004	19.21115	19.99762	-1.174028	-0.290514	0.8834839
46	4	39	ULLDRH13	-40.003949	-39.77855	-40.12719	0.354615	0.431293	-0.1233220
47	4	39	ULLDRH13	-40.003949	-40.64349	-40.12719	-0.516313	-0.639635	-0.1233220

48	4	41	TONGIL13	51.205319	51.39081	52.24827	-0.367458	-0.024515	0.3429532
49	4	41	TONGIL13	5.791115	9.21226	7.11650	1.095759	-1.421153	0.3253937
50	4	38	SDHRGN13	9.456635	9.26888	9.38320	-0.314313	-0.387746	-0.0734329
51	4	43	PGTGLA13	-63.935952	-65.15335	-65.35644	0.198084	-1.222509	-1.4205933
52	4	41	TONGIL13	38.950472	39.04106	39.24942	-0.208354	0.190573	0.3989279
53	4	46	SHRASL13	-63.756256	-61.49949	-63.15422	1.664733	2.276789	0.6120563
54	4	46	SHRASL13	-63.756264	-62.77206	-63.15422	0.375151	0.987207	0.6120563
55	4	44	KBRPUR13	22.607300	22.43291	22.26791	0.164902	-0.174498	-0.3394008
56	4	47	ASHGNJ13	15.??2587	17.10446	16.64485	0.459617	1.211588	0.7519722
57	4	47	ASHGNJ13	[illegible]	16.17328	16.64485	-0.459563	0.292409	0.7519722
58	4	48	SHJIBZ13	24.626?01	23.74267	23.96903	-0.125355	-0.884133	-0.7577777
59	4	49	[illegible]	14.480?41	13.67715	13.88969	-0.212538	-0.812585	-0.6001472
60	4	50	[illegible]	[illegible]	[illegible]	5.63471	0.288218	-0.501139	-0.7893562
61	4	51	SYLHET13	7.211926	7.36746	7.05949	-0.000029	-0.142031	-0.1420021
62	4	47	ASHGNJ13	51.???	49.24456	50.77571	-1.531148	-2.634441	-1.1032934
63	4	53	[illegible]	[illegible]	[illegible]	37.20874	1.426554	0.090084	-1.4164801
64	4	54	MYMSG13	13.672595	13.57732	13.72442	-0.147098	-0.102371	0.0447273
65	4	55	GOLPRA13	16.510010	[illegible]	17.10205	-0.178754	0.413286	0.5920410
66	4	55	GOLPRA13	[illegible]	17.29324	17.10205	0.197202	0.789243	0.5920410
67	4	57	KHCENT13	-18.674???	[illegible]	-18.81761	0.528055	0.385379	-0.1426756
68	4	57	KHCENT13	-18.674???	-19.12707	-18.81761	-0.311470	-0.454145	-0.1426756
69	4	58	MDAPRA13	[illegible]	-16.34955	-15.87153	0.521981	-0.196814	-0.7187963
70	4	58	MDAPRA13	[illegible]	-32.53171	-32.81135	0.179635	-0.722265	-0.9019017
71	4	59	JESORE13	[illegible]	[illegible]	-52.28976	1.803083	0.982491	-0.8205533
72	4	59	JHENDA13	[illegible]	[illegible]	-52.75125	-1.465160	-2.356331	-0.8901715
73	4	61	BOTAIL13	[illegible]	[illegible]	-74.79744	0.590515	0.703138	0.1126230
74	4	62	BHRMRA13	[illegible]	[illegible]	-95.50296	2.629238	2.982752	0.3535151
75	4	62	BHRMRA13	[illegible]	[illegible]	-95.50296	-2.629297	-2.275782	0.3535151
76	4	56	GOLPRA13	17.41???	[illegible]	17.15306	-0.349700	-0.615026	-0.2653956
77	4	73	BAGRHT13	5.31?157	3.53173	3.99654	-0.454761	-1.780367	-1.3256073
78	4	73	BAGRHT13	2.001170	1.94333	1.94339	-0.000063	-0.057856	-0.0577927
79	4	75	BRISAL13	-18.703217	-20.15662	-20.43809	0.281393	-1.450777	-1.7321701
80	4	76	MDRIPR13	-27.526495	-31.02160	-29.36439	-1.657211	-1.425188	0.2320230
81	4	77	FRIDPR13	[illegible]	-44.34124	-43.39646	-0.945502	-0.373393	0.5721092
82	4	64	NATORE13	35.540465	37.14200	36.64025	0.401753	1.501536	1.0997829
83	4	63	ISHRDI13	76.426771	71.72247	71.47702	0.345450	-4.604303	-4.9497538
84	4	63	ISHRDI13	[illegible]	48.23777	49.67790	-0.737228	-1.712023	-0.9727955
85	4	64	NATORE13	30.115204	31.18867	31.13867	0.000000	1.073461	1.0734615
86	4	57	BOGRAL13	25.273502	24.15331	24.79771	-0.644415	-0.920205	-0.2757907
87	4	57	BOGRAL13	[illegible]	25.44121	24.79771	0.644189	0.369398	-0.2757907
88	4	63	PLSBRI13	[illegible]	21.75482	20.63130	1.123592	1.356673	0.2330899
89	4	69	PLSBRI13	[illegible]	19.50767	20.63130	-1.123635	-0.890547	0.2330899
90	4	67	[illegible]	[illegible]	19.10445	17.64079	0.553667	0.938475	0.3348076
91	4	69	[illegible]	[illegible]	18.00712	19.64079	-0.553673	-0.158865	0.3848076
92	4	70	SATDRA13	[illegible]	[illegible]	27.50796	1.921540	3.181927	1.2603874
93	4	71	[illegible]	13.015033	11.77344	13.33375	-1.566308	-1.315587	0.2507210
94	4	63	ISHRDI13	12.871221	12.72721	12.72702	-0.000011	1.846015	1.8460274
95	4	78	ASHULI23	129.516923	132.76295	129.50859	3.261290	3.252897	-0.0083923
96	4	78	ASHULI23	129.516933	128.37132	129.50859	-1.137256	-1.145647	-0.0083923
97	4	72	SHRAGL23	182.602475	185.35653	185.50096	-0.145530	-3.253936	-3.1084061
98	4	72	SHRAGL23	185.618675	186.54363	185.50096	0.145626	-2.952780	-3.1094061
99	4	1	[illegible]	[illegible]	76.23597	76.23597	0.000000	-2.263733	-2.2539332
100	4	2	KPTI1X59	[illegible]	49.55962	49.55962	-0.000006	1.369648	1.3696547
101	4	3	KPTI2X59	93.499353	91.37571	91.37571	-0.000005	-2.124154	-2.1241494
102	4	4	SKLSTX59	[illegible]	57.45429	57.45429	0.000000	-2.335599	-2.3355894

103	4	5	SDSM3X10	[illegible]	19.42197	19.42186	0.000017	0.821983	0.8219659
104	4	6	SDSM2X33	[illegible]	87.70460	87.70458	0.000023	-4.094999	-4.0950232
105	4	7	ASSM2X64	55.799765	57.63710	57.63707	0.000017	1.937223	1.9372059
106	4	8	ASSM1J50	[illegible]	52.94047	52.94044	0.000023	-0.059384	-0.0594079
107	4	9	ASSM1X30	27.999978	26.15325	26.15325	0.000000	-1.846653	-1.8466530
108	4	10	ASSM2U50	0.000000	-0.78926	-0.78926	0.000000	-0.789260	-0.7892604
109	4	11	ASS1U150	118.999981	116.37153	116.37153	0.000000	-2.627944	-2.6279449
110	4	12	ASS2U150	118.999981	116.11499	116.11489	0.000000	-2.884573	-2.8845787
111	4	13	ASS3U150	118.999981	119.83766	117.83766	0.000000	0.838184	0.8381844
112	4	14	GPSL2X50	[illegible]	[illegible]	90.32631	-0.000006	2.826911	2.8269167
113	4	15	GPS1J210	169.685312	164.45922	164.45922	0.000000	-5.227083	-5.2270899
114	4	16	GPS2J210	134.999965	136.90365	136.90365	0.000000	1.904201	1.9042015
115	4	17	SHJ?70T	[illegible]	[illegible]	[illegible]	0.000000	0.997315	0.9973157
116	4	18	SYLH1X70	[illegible]	[illegible]	20.27812	0.000006	0.738167	0.7381618
117	4	19	KHL1X110	32.999726	31.61666	31.61662	0.000041	-1.383066	-1.3831072
118	4	20	KHN1X60	[illegible]	-0.28786	-0.28788	0.000019	-0.287965	-0.2879852
119	4	21	KHLN?70?	19.199914	19.31604	19.31602	0.000017	0.116227	0.1162112
120	4	22	GPSL2X20	-1.500011	-1.18978	-1.18977	-0.000008	0.310225	0.3102336
121	4	23	BMRA3X20	-1.399979	0.34020	0.34019	0.000013	1.740178	1.7401648
122	4	24	SOPR1X20	10.999966	[illegible]	9.29167	-0.000011	-1.708298	-1.7082863
123	4	25	PMSP1X20	18.999932	15.70311	15.70313	-0.000011	-3.296834	-3.2968216
124	4	78	ASHULL23	43.999912	46.41131	49.21286	-2.801543	-2.571392	0.2301514
125	4	78	ASHULL23	48.932712	50.06056	49.21286	0.847697	1.077848	0.2301514
126	4	79	GHRASL23	-37.266933	-36.33010	-36.17250	-0.157600	0.935847	1.0944481
127	4	79	GHRASL23	-37.266953	-36.01495	-36.17250	0.157558	1.252007	1.0944481
128	4	80	TMMSIL23	127.573578	128.95420	125.09947	2.864742	1.380634	-1.4841080
129	4	80	TMMSIL23	127.573578	125.61562	126.09947	-0.473976	-1.959084	-1.4841080
130	4	31	ISHPDL23	179.899215	185.37510	182.88525	2.489852	5.475902	2.9860497
131	4	31	ISHPDL23	179.899215	180.39590	182.88525	-2.487948	0.496101	2.9860497
132	3	27	CHMDR313	-9.899999	-9.33512	-10.08636	0.751239	-0.435125	-1.1863642
133	3	33	HLSHAR13	-12.999963	-12.00813	-12.27525	0.267118	0.391835	0.1247168
134	3	35	FEVILL13	-15.199995	-13.10000	-13.29186	0.191861	2.099990	1.9081287
135	3	40	DHAMMMDI	-13.499969	-13.30569	-13.11172	-0.193905	0.194340	0.3882469
136	3	42	MIRPJ213	-29.599976	-29.88314	-30.02612	0.142979	-0.233163	-0.4261434
137	3	43	PSTGLA13	-34.299973	-34.14651	-33.90828	-0.237548	0.153452	0.3910005
138	3	44	KBRPJ213	-7.799999	-7.11899	-7.74223	0.623309	0.681060	0.0577509
139	3	47	[illegible]	[illegible]	[illegible]	-4.79461	-0.439563	-0.434181	0.0053819
140	3	50	FMLJ2M13	-3.199999	-3.09227	-3.96326	0.870994	0.307722	-0.5632717
141	3	53	KSHPGR13	[illegible]	[illegible]	-7.05959	-0.494652	-2.354056	-1.8595943
142	3	54	MYMISS13	[illegible]	-9.76511	-9.70435	-0.060755	2.034879	2.0956335
143	3	57	[illegible]	[illegible]	[illegible]	-15.62754	0.385339	1.958775	1.5724354
144	3	60	JHLMDA13	[illegible]	[illegible]	-10.32862	0.378292	-0.759416	-1.1287098
145	3	61	[illegible]	[illegible]	[illegible]	-11.32750	-0.208038	-1.005547	-0.7975101
146	3	71	PJRMASI?	[illegible]	[illegible]	-5.59127	-0.058972	-0.358247	-0.2992749
147	3	75	MORIPA13	[illegible]	[illegible]	-4.12678	0.618936	1.592153	0.9732172
148	3	77	[illegible]	[illegible]	[illegible]	-1.15464	0.453376	-1.101255	-1.5546436
149	5	25	KAPTAI13	[illegible]	[illegible]	22.77931	1.267154	1.638283	0.4211187
150	5	26	KAPTAI13	13.199973	16.57476	14.62641	1.948355	1.422702	-0.5256534
151	5	26	KAPTAI13	[illegible]	[illegible]	10.69456	0.727205	-0.105663	-0.8288741
152	5	26	KAPTAI13	[illegible]	[illegible]	10.69456	-2.044617	-2.873492	-0.8288741
153	5	27	CHMDR313	12.479997	[illegible]	12.70942	-1.757884	-2.524685	-0.7668019
154	5	28	[illegible]	[illegible]	[illegible]	-8.35759	0.536882	0.934785	0.3979027
155	5	28	[illegible]	[illegible]	-8.46955	-8.35759	-0.111951	0.285941	0.3979027
156	5	28	MADHHE13	[illegible]	9.86989	9.51329	0.355696	-1.404827	-1.7615137
157	5	28	MADHHE13	[illegible]	[illegible]	9.51320	-1.203215	-2.959729	-1.7615137

158	5	28	MADNHT13	0.730405	2.33594	2.53755	0.359291	2.106440	1.7471485
159	5	28	MADNHT13	0.730405	2.59324	2.53755	0.055690	1.802839	1.7471485
160	5	30	HATZLL13	7.771004	6.35187	6.02518	0.325688	-0.919127	-1.2448149
161	5	35	FENILL13	-5.606174	-5.22236	-5.01536	-0.205995	0.383812	0.5908087
162	5	30	HATZLL13	1.006074	0.50273	0.40530	0.097429	-0.501298	-0.5987279
163	5	29	SIKLBAL13	22.731013	22.90144	21.65583	1.245605	0.170439	-1.0751657
164	5	29	SIKLBAL13	5.823094	4.71162	4.71159	0.000028	-1.091578	-1.0916071
165	5	30	HATZLL13	9.191335	9.37432	9.17760	0.196713	-0.917573	-1.0142860
166	5	30	HATZLL13	9.191303	9.14074	9.17760	-0.036865	-1.051151	-1.0142860
167	5	32	KULSIL13	-3.944007	-3.20770	-2.99193	-0.215867	0.736690	0.9525582
168	5	32	KULSIL13	-2.725229	-0.93480	-0.77406	-0.160740	1.790418	1.9511595
169	5	36	COMILAL13	-7.872023	-8.28327	-7.70503	-0.578242	-0.401252	0.1769900
170	5	36	COMILAL13	-7.872023	-7.16343	-7.70503	0.541602	0.818592	0.1769900
171	5	36	COMILAL13	2.186775	1.84702	1.84794	0.000076	-0.339755	-0.3398315
172	5	38	SOHRGNL13	40.362769	41.05767	41.79310	-0.735414	0.695157	1.4305796
173	5	33	SOHRGNL13	-20.716354	-20.31913	-21.63221	1.313077	0.397223	-0.9158552
174	5	33	SOHRGNL13	-20.716354	-22.71667	-21.63221	-1.084452	-2.000308	-0.9158552
175	5	39	ULLONL13	-0.360107	-1.26700	-0.55252	-0.714481	-0.906899	-0.1924176
176	5	39	ULLONL13	-0.360107	-0.37406	-0.55252	0.178461	-0.013956	-0.1924176
177	5	39	ULLONL13	2.546592	4.16226	2.19552	1.966744	1.615574	-0.3511693
178	5	39	ULLONL13	2.546592	-0.51629	2.19552	-2.711819	-3.062989	-0.3511693
179	5	41	TONSIL13	12.741089	13.02477	12.86112	0.163656	0.283689	0.1200318
180	5	41	TONSIL13	-6.437114	-8.14946	-6.65630	-1.493167	-1.710354	-0.2171874
181	5	38	SOHRGNL13	15.460119	16.29452	15.78927	0.505258	0.834429	0.3291607
182	5	43	PSTGLAL13	-38.917064	-38.97112	-38.74388	-0.227314	-0.058239	0.1690745
183	5	41	TONSIL13	17.094421	19.14704	17.98916	1.157879	2.052634	0.8947551
184	5	46	SIRASL13	5.993366	5.61712	5.70871	-0.091512	-0.375165	-0.2846539
185	5	46	SIRASL13	5.993366	6.90888	5.70871	1.200144	0.915491	-0.2846539
186	5	44	KARPUZ13	9.364035	9.37460	10.28722	-0.902622	0.018566	0.9211898
187	5	47	ASIGNJ13	-5.602551	-5.29122	-5.18903	-0.102186	0.311328	0.4135147
188	5	47	ASIGNJ13	-5.602551	-4.87327	-5.18903	0.315764	0.730279	0.4135147
189	5	48	SHIISTI13	6.967067	6.59859	7.33304	-0.734454	-0.364470	0.3699839
190	5	49	SUNNGL13	3.566551	5.54350	3.96996	1.573544	1.976958	0.4034135
191	5	50	ENCHOTL13	2.463665	1.28201	2.32140	-1.039470	-1.181563	-0.1430776
192	5	51	SYL[illegible]	1.917309	2.57600	2.57604	0.000013	0.613749	0.6137352
193	5	47	ASIGNJ13	22.817833	22.18302	23.19610	-1.113074	-0.729799	0.3832757
194	5	53	ASIGNJ13	15.856077	15.29336	14.50975	0.783610	-0.570911	-1.3545208
195	5	54	MYNGIL13	4.420062	5.46676	5.39066	0.076024	1.046101	0.9700073
196	5	56	SOLPAL13	49.210793	49.19164	48.78840	0.403257	-0.027066	-0.4303336
197	5	56	SOLPAL13	49.210793	48.38871	48.78840	-0.399571	-0.829005	-0.4303336
198	5	57	KIGITH13	33.013901	33.48070	32.63568	0.845122	0.466989	-0.3782332
199	5	57	KHGTH13	33.013901	31.55052	32.63563	-1.085072	-1.463305	-0.3782332
200	5	33	[illegible]	39.077431	38.73279	37.70211	1.030665	-0.340855	-1.3716209
201	5	58	MDARCAL13	26.627371	26.17073	27.27725	-1.101517	-0.452034	0.6486833
202	5	59	JUTPTL13	19.317217	19.79374	18.55729	1.025445	1.270525	0.2440810
203	5	59	[illegible]	17.135100	14.51209	15.23786	-2.517783	-3.166037	-0.6482542
204	5	61	[illegible]	5.537256	2.77741	4.05715	-0.277741	-1.809460	-1.5307073
205	5	62	[illegible]	35.252154	34.11295	33.69409	0.418752	-1.745295	-2.1640472
206	5	62	[illegible]	35.252154	32.93167	33.69409	-0.762414	-2.925462	-2.1640472
207	5	56	SOLPAL13	-1.182670	-2.07721	-1.21462	-0.862586	-0.894564	-0.0319779
208	5	72	[illegible]	-3.939900	-5.15073	-4.03249	-1.118244	-1.214823	-0.0965800
209	5	73	[illegible]	-2.611110	2.47557	2.47553	0.000039	0.878085	0.8980453
210	5	75	[illegible]	21.175391	21.03173	21.17033	-0.088560	-0.142729	-0.0541687
211	5	76	[illegible]	17.567794	16.84127	18.38301	-1.541029	-0.705421	0.8356094
212	5	77	[illegible]	11.856556	7.85954	11.11565	-3.223109	-3.964012	-0.7409036

213	5	54	[illegible]	-3.[illegible]	-4.[illegible]	-3.93423	-0.883747	-1.121747	-0.2379994
214	5	53	ISHPOI13	13.4[illegible]	1[illegible].53305	13.32122	-0.788182	0.051051	0.8392334
215	5	63	ISHPOI13	4.2[illegible]	4.34[illegible]	4.32741	0.017395	0.057569	0.0481840
216	5	54	HATORE13	14.[illegible]17	14.[illegible]321	14.33323	-0.000017	0.754600	0.7546186
217	5	67	BJGPAL13	-8.[illegible]	-7.[illegible]	-3.75174	0.792151	0.563490	-0.2286613
218	5	67	B[illegible]AL13	-8.[illegible]	-10.11594	-8.75174	-1.364105	-1.592766	-0.2286613
219	5	58	PLS[illegible]13	-[illegible]	-10.[illegible]	-9.05966	-1.528614	-1.108175	0.4204392
220	5	58	PLSORI13	-[illegible]	-8.1[illegible]	-9.05966	0.962275	1.382714	0.4204392
221	5	59	RAMG[illegible]13	-3.6[illegible]	-2.11144	-2.75524	0.640799	1.435401	0.8546020
222	5	59	RAM[illegible]	-[illegible]	-2.[illegible]	-2.75524	-0.881204	-0.026602	0.8546020
223	5	70	SALO[illegible]13	1[illegible].7[illegible]	3.44[illegible]1	3.53373	-0.091719	-1.307042	-1.2173233
224	5	71	PJRBAS13	[illegible]	3.36215	3.28830	0.073856	-1.464674	-1.5385313
225	5	53	ISHPOI13	[illegible]	1.07[illegible]	1.07411	0.000021	-1.249673	-1.2497005
226	5	73	ASHULL23	36.7[illegible]	33.30623	39.55233	-0.546050	1.252443	1.7984982
227	5	78	ASHULL23	35.75[illegible]	3[illegible].54437	39.55233	-0.007963	1.790535	1.7984982
228	5	79	GHPASL23	25.036[illegible]	[illegible]	25.63055	-0.049454	0.545072	0.5945265
229	5	79	GHRASL23	25.03607[illegible]	26.64524	25.63055	1.014685	1.609211	0.5945265
230	5	1	KPTI2X40	[illegible].1[illegible]415	[illegible].17962	28.64004	0.539444	-0.009930	-0.5483747
231	5	2	KPTI1X50	14.6[illegible]	14.39526	15.61055	-0.714538	0.475010	1.2095285
232	5	3	KPTI2X50	36.3[illegible]327	36.74473	37.93510	-1.190173	0.356537	1.5467167
233	5	4	SKLSTX[illegible]	[illegible]3.[illegible]	[illegible].45759	55.32113	1.135433	2.555496	1.4200621
234	5	5	SO[illegible]X10	47.[illegible]	46.72598	48.23411	-1.509122	-1.219206	0.2889156
235	5	6	SO[illegible]X33	[illegible].513[illegible]	64.23365	60.75572	3.477948	1.720047	-1.7579012
236	5	7	ASG[illegible]X64	13.7[illegible]	8.3[illegible]21	12.43403	-4.044912	-5.347316	-1.3025045
237	5	8	ASG[illegible]	10.11[illegible]	[illegible].98760	9.71731	1.270287	-0.125539	-1.3958273
238	5	9	ASG[illegible]X30	5.074[illegible]	5.68[illegible]	4.59606	1.092070	0.614108	-0.4779629
239	5	10	ASG[illegible]	7.8[illegible]	7.1726[illegible]	7.74885	-0.575174	-0.656986	-0.0808120
240	5	11	ASG1J150	31.[illegible]	30.75[illegible]	29.18061	2.577594	-1.082389	-3.6599751
241	5	12	ASG2J150	31.[illegible]	31.61[illegible]7	31.43284	0.185740	-0.222015	-0.4077554
242	5	13	ASG3J150	31.[illegible]	30.[illegible]	30.73064	-0.331825	-1.241766	-0.9099424
243	5	14	G[illegible]X55	[illegible]	31.1[illegible]	30.92015	0.274624	-1.758775	-2.0334892
244	5	15	GRS1J210	[illegible]	[illegible].27713	62.05696	3.220170	1.585429	-1.6347408
245	5	16	GRS2J210	61.677[illegible]	[illegible]	58.20414	-1.717427	-4.992938	-3.2735109
246	5	17	[illegible]	16.[illegible]	15.47500	15.68677	-0.211762	-1.149915	-0.9381473
247	5	18	SYL[illegible]X70	[illegible]	[illegible]	8.39072	0.387829	-0.170355	-0.5581856
248	5	19	KIL1X110	[illegible]	[illegible]	51.61059	-0.719219	0.100070	0.8182893
249	5	20	KIL[illegible]X50	[illegible]	31.[illegible]	32.31096	-0.920707	-0.155735	0.7649720
250	5	21	KIL[illegible]	21.7[illegible]	21.[illegible]16	21.73512	-0.482954	-0.452399	0.0305653
251	5	22	[illegible]	34.721[illegible]	35.[illegible]	35.28259	0.234687	0.725537	0.4908502
252	5	23	[illegible]	[illegible]	[illegible]	54.31163	0.953700	1.423076	0.4691959
253	5	24	SO[illegible]1Y20	[illegible]	30.[illegible]	29.77276	1.393854	0.443762	-0.9500921
254	5	25	[illegible]	[illegible]	[illegible]	23.99987	1.252966	0.522548	-0.7304192
255	5	73	ASHULL23	[illegible]	-1.[illegible]	-4.43471	2.639807	2.162858	-0.4759486
256	5	78	ASHULL23	[illegible]	-3.[illegible]	-4.43471	-0.403837	-0.879795	-0.4759486
257	5	79	GHRASL23	[illegible]	24.3[illegible]	25.19716	-0.722719	-1.964896	-1.2421730
258	5	79	GHRASL23	[illegible]	[illegible]	25.19716	1.104205	-0.137972	-1.2421730
259	5	80	TONGIL23	33.[illegible]17	34.34726	38.06034	-3.713094	-4.049955	-0.3368616
260	5	80	TONGIL23	33.3[illegible]17	41.19407	38.06034	3.133737	2.795876	-0.3368616
261	5	81	IS[illegible]L23	[illegible]	[illegible]	3.09270	0.587280	-2.036130	-2.6234102
262	5	81	IS[illegible]L23	[illegible]	[illegible]	3.09270	-0.234471	-2.857881	-2.6234102
263	1	1	KPTI2X40	1.[illegible]	1.0[illegible]	1.03397	-0.000120	-0.001045	-0.0009251
264	1	2	KPTI1X50	[illegible]	1.03121	1.03172	0.000124	0.001010	0.0017853
265	1	3	KPTI2X50	1.0[illegible]	1.03117	1.03088	0.000297	0.001170	0.0008831
266	1	4	SKLSTX[illegible]	1.[illegible]	1.03[illegible]	1.03125	-0.000307	0.000743	0.0012503
267	1	5	SO[illegible]X10	1.[illegible]	1.03[illegible]	1.02986	0.000433	0.001281	0.0008489

258	1	6	SDSH3X33	1.030000	1.02262	1.02325	-0.000669	-0.001403	-0.0007343
267	1	7	ASSN2X64	1.030000	1.03121	1.03000	0.001203	0.001210	0.0000067
270	1	8	ASSN1J60	1.030000	1.02997	1.02922	-0.000253	-0.001025	-0.0007725
271	1	9	ASSN1X30	1.030000	1.03039	1.03045	-0.000143	0.000309	0.0004520
272	1	10	ASSN2J60	1.030000	1.03157	1.03136	0.000213	0.001574	0.0013609
273	1	11	ASS1U150	1.030000	1.02904	1.02968	-0.000641	-0.001955	-0.0013132
274	1	12	ASS2U150	1.030000	1.03083	1.03098	-0.000045	0.000835	0.0008812
275	1	13	ASS3U150	1.030000	1.03043	1.03034	0.000083	0.000430	0.0003471
276	1	14	GRSL2X55	1.030000	1.02959	1.02966	-0.000073	-0.000410	-0.0003366
277	1	15	GRS1U210	1.030000	1.04872	1.05000	-0.001274	-0.001274	0.0000000
278	1	16	GRS2U210	1.030000	1.04767	1.04711	0.000558	-0.000329	-0.0008879
279	1	17	SYUS2ST	1.030000	1.03026	1.03011	0.000145	0.000261	0.0001154
280	1	18	SYLM1X20	1.030000	1.02792	1.02806	-0.000044	-0.001978	-0.0019341
281	1	19	KHL1X110	1.030000	1.03027	1.03013	0.000239	0.000371	0.0001316
282	1	20	KHLM1X50	1.030000	1.03070	1.03042	0.000276	0.000704	0.0004282
283	1	21	KHLM2X20	1.030000	1.02752	1.02742	0.000100	-0.000474	-0.0005751
284	1	22	DRSL2X20	1.030000	1.03070	1.03097	-0.000066	0.000904	0.0009708
285	1	23	BHRA3X20	1.030000	1.03126	1.03149	-0.000228	0.001262	0.0014915
286	1	24	SDPP1X20	1.030000	1.02700	1.02714	-0.000141	-0.002995	-0.0028543
287	1	25	RNGP1X20	1.030000	1.02941	1.02951	-0.000104	-0.000588	-0.0004835

VALUES OF PERFORMANCE INDICES

PERFORMANCE INDEX AS A FUNCTION OF:	COMPUTED VALUE P.U.	THRESHOLD VALUE P.U.
1. (SP.-EST.)	0.34725273	0.50219147
2. (EST.-TRUE)	0.52555310	0.74447250

APPENDIX C.2

SAMPLE OUTPUT FOR STATE ESTIMATION IN PRESENCE OF BOTH RANDOM AND GROSS ERRORS IN THE MEASUREMENTS

FAST DECOUPLED STATIC STATE ESTIMATOR
RESULTS FOR A CASE OF BOTH RANDOM NOISE AND GROSS
ERROR CONTAMINATED MEASUREMENTS IN GRID SYSTEM

GENERAL INFORMATION

NO.OF ITERATIONS TO CONVERGE	=29.00
TOLERANCE	=0.00000100
TOTAL ACTIVE MEASUREMENTS	= 228
TOTAL REACTIVE MEASUREMENTS	= 253
TOTAL NO. OF NODES IN THE SYSTEM	= 81
TOTAL NO. OF STATE VARIABLES	= 160
REDUNDANCY RATIO	= 3.00625

ESTIMATED VOLTAGES AND PHASE ANGLES AT NODES

NODE	NODE NAME	ESTIMATED VOLT(P.U.)	ESTIMATED THETA(DEG)	TRUE VOLT(P.U.)	TRUE THETA(DEG)	(EST.-TRUE) VOLT(P.U.)	(EST.-TRUE) THETA(DEG)
1	KPTI2X40	1.02921200	3.1139965	1.02999973	3.0545053	-0.00078773	0.05949116
2	KPTI1X50	1.03039265	3.0430250	1.02999973	3.1313076	0.00039291	-0.08828259
3	KPTI2X50	1.02979279	2.7517881	1.02999973	2.7797127	-0.00020695	-0.02792454
4	SKLSTX81	1.02935123	0.5214027	1.02999973	0.6173577	-0.00064850	-0.09595495
5	SDSN3X10	1.03091717	-3.5444431	1.02999973	-3.4836769	0.00091743	-0.06076622
6	SDSN3X33	1.03062248	0.5125297	1.02999973	0.4832414	0.00062275	0.02928829
7	ASGN2X54	1.02893543	4.2203732	1.02999973	4.3271322	-0.00106430	-0.10675907
8	ASGN1J60	1.03084278	5.7985220	1.02999973	5.9020882	0.00084305	-0.10356617
9	ASGN1X30	1.02981853	6.4159985	1.02999973	6.4282112	-0.00018120	-0.01221275
10	ASGN2J60	1.02917671	0.1816083	1.02999973	0.2681557	-0.00082302	-0.08654743
11	ASG1U150	1.03057194	3.5060301	1.02999973	3.4380865	0.00057220	0.06794357
12	ASS2U150	1.03012943	8.4191975	1.02999973	8.4380965	0.00012970	-0.01889896
13	ASS3U150	1.02995682	8.4515553	1.02999973	8.4380865	-0.00004292	0.01346874
14	GRSL2X55	1.02998829	1.6262493	1.02999973	1.5796938	-0.00001144	0.04655552
15	GRS1U210	1.05000012	0.0000000	1.05000012	0.0000000	0.00000000	0.00000000
16	GRS2U210	1.04985523	-0.7799349	1.05000019	-0.8324414	-0.00014496	0.05250645
17	SHJBZG1	1.03030014	-0.1234877	1.02999973	-0.0804765	0.00030041	-0.04301119
18	SYL41X20	1.03106117	2.9726276	1.02999973	2.6591425	0.00106144	0.31348515
19	KHL1X110	1.03015614	-35.2437237	1.02999973	-35.5003155	0.00015640	0.25659180
20	KHLN1X50	1.02958393	-36.9423675	1.02999973	-37.2741261	-0.00041580	0.33175659
21	KHLN3HPP	1.03109741	-34.5161914	1.02999973	-34.8372211	0.00109768	0.32102966
22	GRSL2X20	1.02777767	-38.6641541	1.02999973	-39.0817261	-0.00222206	0.41757202
23	DMRA3X20	1.03073502	-25.9646606	1.02999973	-26.1890411	0.00073528	0.22438049
24	SDPR1X20	1.03002453	-34.2940926	1.02999973	-34.4029946	0.00002480	0.10890198
25	KTSP1X20	1.03112221	-28.9456317	1.02999973	-29.2047352	0.00112247	0.25910350
26	KAPTAI13	1.00220013	-1.7431199	1.00209904	-1.7225406	0.00010109	-0.02057934
27	CHNDR013	0.99625611	-7.1571836	0.99617302	-7.1562433	0.00008309	-0.00094032
28	MADNHT13	0.98249496	-2.9645061	0.98238630	-2.9179926	0.00010866	-0.04651356
29	SIKLBA13	0.99638731	-2.8802042	0.99594654	-2.8345089	0.00044078	-0.04569530
30	HATZLL13	0.99322463	-2.7491274	0.99318636	-2.7012949	0.00003827	-0.04783249
31	DOHZRI13	0.97909373	-3.3436384	0.97844785	-3.3237438	0.00064588	-0.01989460
32	KULSIL13	0.97734070	-3.3657555	0.97696376	-3.3205996	0.00037694	-0.04515593
33	HLSHAR13	0.97788322	-3.4784250	0.97783935	-3.4140644	0.00004387	-0.06436062
34	BRALIA13	0.97392467	-3.9925369	0.97391778	-3.9487394	0.00000695	-0.04379749

35	FENILL13	0.94932036	-6.0676727	0.94934847	-6.0605421	-0.00052011	-0.00713062
36	COMILA13	0.95347494	-6.1394063	0.95493394	-6.0954790	-0.00145900	-0.04292774
37	CHNDPR13	0.94122225	-6.8152454	0.94281727	-6.8345013	-0.00159502	0.01945591
38	SDHRGH13	0.97336600	-4.7541303	0.97341317	-4.7816095	-0.00004709	0.02752876
39	ULLONL13	0.95590767	-5.2476816	0.95532972	-5.2772255	0.00057995	0.02954388
40	DHANMNDI	0.95516580	-5.2781449	0.95455164	-5.3093653	0.00061417	0.03120041
41	TONGIL13	0.95747262	-4.1423371	0.95695391	-4.1877251	0.00051941	0.04538727
42	MIRPUR13	0.95006933	-5.1964340	0.94930711	-5.2355680	0.00116122	0.03913403
43	PSTGLA13	0.96308047	-4.6903076	0.96228659	-4.7055454	0.00009388	0.01523781
44	KBRPUR13	0.94653729	-5.1462559	0.94549972	-5.1702666	0.00103748	0.02401161
45	TNGAIL13	0.92747215	-6.5077243	0.92606937	-6.6563358	0.00141078	0.14861107
46	GHRASL13	1.00629097	-2.4270042	1.00579980	-2.4645185	0.00051117	0.03751373
47	ASHGNJ13	1.01714897	0.9036607	1.01707649	0.9631557	0.00007248	-0.05949497
48	SHJIBZ13	1.01880169	-0.1119066	1.01708698	-0.0804965	0.00171471	-0.03148800
49	SRMNGL13	1.00706196	-1.0924215	1.00582409	-1.0980206	0.00123787	0.00559902
50	FNCHGN13	0.99527017	-1.9527636	0.99555314	-1.9190426	-0.00028294	-0.03372097
51	SYLHET13	0.99347675	-2.1749315	0.99292415	-2.1840239	0.00055259	0.00909233
52	CHATAK13	0.98952281	-2.4372549	0.98959726	-2.4570141	-0.00007445	0.01975918
53	KSHRGN13	0.97435917	-1.9501762	0.97586252	-2.0357370	-0.00150335	0.08556090
54	MYMNSG13	0.93753201	-4.7704217	0.94032907	-4.7987566	-0.00279707	0.02832794
55	JAMLPR13	0.92661536	-5.8273659	0.92848146	-5.7663794	-0.00186610	-0.06099652
56	GOLPRA13	0.93522407	-37.0724182	0.93362291	-37.2741241	0.00160116	0.20170593
57	KHLSNT13	0.93421478	-37.0750732	0.93261339	-37.2740734	0.00160140	0.19900513
58	NOAPRA13	0.97031933	-36.1615295	0.96916443	-36.3833618	0.00115490	0.22183229
59	JESORE13	0.95300702	-35.1675568	0.95171320	-35.3856049	0.00129181	0.21804810
60	JHENDA13	0.94465934	-32.2126617	0.94323915	-32.2471313	0.00141919	0.03446760
61	BOTAIL13	0.94759065	-28.3706970	0.94437462	-28.5631561	0.00321603	0.19245911
62	BHRMRA13	0.95756614	-26.2084167	0.95597367	-26.3745697	0.00159247	0.16615295
63	ISHRDI13	0.95733759	-24.4579163	0.95567824	-24.6190776	0.00165915	0.16116333
64	NATORE13	0.92152917	-28.1273941	0.91940397	-28.2574005	0.00212520	0.13009644
65	RAJSHI13	0.97820509	-29.6351318	0.97423935	-29.9243774	0.00396794	0.28924561
66	SHJDPR13	0.94699746	-25.5539940	0.94250751	-25.6605988	0.00448995	0.10670471
67	BOGRAL13	0.90740973	[illegible]31.9317322	0.90517799	-32.0403290	0.00223184	0.10859680
68	PLSBRI13	0.90672976	[illegible]34.1059412	0.90443975	-34.2344971	0.00229001	0.12855530
69	KAUSPR13	0.90773178	[illegible]35.0662994	0.90677780	-35.1611633	0.00100398	0.09486389
70	SAIDPR13	0.90425003	-37.2934816	0.90340155	-37.4047072	0.00084847	0.11442566
71	RUNGAG13	0.90491329	-38.0529064	0.90290696	-38.1599884	0.00200623	0.10719176
72	THAKUR13	0.89490427	-37.8716125	0.89177900	-37.9563293	0.00312527	0.08471680
73	DAGNHT13	0.97376036	-38.0936279	0.97305989	-38.3673706	0.00070047	0.27374268
74	MAJGLA13	0.97823141	-33.2092433	0.97732046	-33.4544373	0.00090295	0.24519348
75	BRISAL13	0.97962569	-37.7426164	0.97833417	-37.9537185	0.00129151	0.21150208
76	MORLPR13	0.95143717	-36.6422119	0.95855951	-36.8755188	-0.00287765	0.23330698
77	FRIDPR13	[illegible]	-33.3702733	0.96623166	-33.5071564	0.00603712	0.13078308
78	ASHULE23	1.01256657	3.9521614	1.01159959	3.9526047	0.00096798	-0.00044346
79	GHRASL23	1.02514553	-4.0337745	1.02528667	-4.0673666	-0.00014114	0.03349209
80	TONGIL23	0.97219534	0.3134551	0.97553877	0.3112088	0.00056660	0.00353700
81	ISHRDL23	0.95376613	-17.2777736	0.95290452	-17.0743356	0.00088151	0.17676208

MEASUREMENT ESTIMATES AND COMPUTED RESIDUALS

MEASUREMENTS INCLUDE COMPLEX INJECTION AND FLOW,VOLTAGES
LEGEND FOR TYPE AND UNITS OF MEASUREMENTS:
TYPE 1 VOLT(V)IN PU.
TYPE 4:ACTIVE LINE_FLOW(PL) IN MW
TYPE 5:REACTIVE LINE FLOW(QL)IN MVAR

MEAS. NO.	MEAS. TYPE	NODE NO.	NODE NAME	TRUE VALUE	SPECIFIED VALUE	ESTIMATED VALUE	SP.-EST. VALUE	SP.-TRUE VALUE	EST.-TRUE VALUE
* 1	4	27	CHUDPO13	-41.687469	0.00000	-39.91622	39.915229	41.687469	1.7712526
2	4	28	MADNHT13	-26.479507	-26.53108	-26.96398	0.432908	-0.051569	-0.4844785
3	4	30	HATZLL13	-70.195007	-72.57386	-71.34857	-1.225297	-2.378862	-1.1535645
4	4	30	HATZLL13	-70.195007	-71.37577	-71.34857	-0.027215	-1.180779	-1.1535645
5	4	28	MADNHT13	-22.656898	-24.24453	-23.71463	-0.529909	-1.587640	-1.0577316
6	4	29	SIKLBA13	6.320285	4.77625	6.59761	-1.821360	-1.544032	0.2773285
7	4	29	SIKLBA13	6.320286	6.76899	6.59761	0.171381	0.448709	0.2773285
8	4	32	KULSIL13	-25.189377	-23.23319	-24.98092	1.747727	1.956188	0.2084613
9	4	32	KULSIL13	-25.189377	-27.75286	-24.98092	-2.771949	-2.563488	0.2084613
10	4	30	HATZLL13	19.336932	20.37635	19.18487	1.191490	0.989419	-0.2020717
11	4	30	HATZLL13	19.336932	20.39447	19.18487	1.209598	1.007526	-0.2020717
12	4	35	FENILL13	-30.632187	-29.83767	-30.36851	0.528842	0.792521	0.2636790
13	4	36	COMILA13	0.674057	-0.27072	-0.04577	-0.224944	-0.944777	-0.7198334
14	4	36	COMILA13	-17.670563	-17.93687	-17.73771	-0.199157	-0.266301	-0.0671446
15	4	33	HLSHAR13	-36.042121	-35.91531	-37.27388	1.358556	0.126874	-1.2316818
16	4	31	DOHZRI13	-14.799976	-14.52654	-14.18037	-0.346171	0.273430	0.6196022
17	4	34	BRALIA13	-25.146103	-23.67977	-24.93295	1.253175	1.466321	0.2131462
18	4	34	BRALIA13	-25.146103	-26.80064	-24.93295	-1.867687	-1.654541	0.2131462
19	4	33	HLSHAR13	-3.957653	-6.68728	-5.08651	-1.600766	-2.729630	-1.1288643
20	4	34	BRALIA13	15.295419	13.23618	15.15264	-1.916456	-2.059221	-0.1427650
21	4	38	SOHRGN13	12.902709	13.75365	13.63609	0.117570	0.850945	0.7333755
22	4	38	SOHRGN13	12.902709	13.65798	13.63608	0.021898	0.755274	0.7333755
23	4	37	CHUDPR13	-9.699217	-8.71141	-9.15174	0.440329	0.988501	0.5481720
24	4	39	ULLOHL13	-31.887694	-30.95436	-31.43910	0.484746	0.933247	0.4485011
25	4	46	GHRASL13	47.898179	46.56592	48.24073	-1.675045	-1.332288	0.3427565
26	4	46	GHRASL13	47.898179	51.04341	48.24073	2.802457	3.145223	0.3427565
27	4	40	DIAMMODI	-20.088745	-19.85517	-19.20220	-0.652274	0.233560	0.8865356
28	4	40	DIAMMODI	-20.088745	-20.60075	-19.20220	-1.398556	-0.512021	0.8865356
29	4	41	TUNGIL13	40.201447	40.72435	40.83088	-0.106042	0.523394	0.6294370
30	4	41	TUNGIL13	40.201447	43.00654	40.83088	2.175652	2.805090	0.6294370
31	4	42	MIRPUR13	-51.643372	-51.36305	-51.66053	0.297480	0.280314	-0.0171661
32	4	43	PSTGLA13	-6.770037	-7.07253	-7.33566	0.263124	-0.302499	-0.5656242
33	4	42	MIRPUR13	-9.355546	-9.17694	-9.03301	-0.143933	0.178599	0.3225327
34	4	38	SOHRGN13	64.680481	65.78784	64.35241	1.435434	1.107370	-0.3280640
35	4	44	KORPUR13	-39.668745	-39.19417	-39.13793	-0.056237	-0.597052	-0.5308151
36	4	47	ASHGNJ13	64.800337	65.27464	62.95918	2.315461	0.474304	-1.8411570
37	4	47	ASHGNJ13	64.800337	61.17192	62.95918	-1.787263	-3.628426	-1.8411570
38	4	45	TNGMIL13	-22.399684	-19.94240	-20.80954	0.867158	2.457302	1.5901442
39	4	48	SHUJB213	-15.813541	-13.59196	-15.03906	1.447115	2.221595	0.7744789
40	4	48	SHUJB213	-15.813541	-16.66462	-15.03906	-1.625578	-0.851100	0.7744789
41	4	49	SAMBGL13	-24.489380	-25.71178	-23.93464	-1.777141	-1.222491	0.5547404
42	4	50	FUCHRO13	-14.413752	-14.81847	-15.35779	0.539314	-0.404727	-0.9440422
43	4	51	SYLHET13	-7.411858	-5.70782	-6.13012	0.422277	1.704034	1.2817383
44	4	52	CHATAK13	-7.199953	-8.37469	-7.17477	-1.199913	-1.174736	0.0251770
45	4	53	KSHRGN13	-50.895222	-49.12603	-49.13827	0.012247	1.769202	1.7569554
46	4	54	MYMNSG13	-37.979675	-36.45689	-38.69609	2.239196	1.522785	-0.7164121
47	4	55	JAMLPR13	-13.600063	-13.67501	-14.40229	0.727278	-0.074952	-0.8022308
48	4	57	KHCENT13	-16.491692	-19.07247	-18.80645	-0.265027	-2.580785	-2.3147583
49	4	57	KHCENT13	-16.491692	-19.46835	-18.80645	-0.661903	-2.976661	-2.3147583
50	4	58	NOAPRA13	18.931562	20.06298	19.42547	0.637513	1.131421	0.4939079
51	4	58	NOAPRA13	18.931562	19.27765	19.42547	-0.147819	0.346083	0.4939079

52	4	[illegible]	JESORE13	14.469576	14.25711	14.47551	-1.538401	-1.512461	0.0259399
53	4	50	JHENDAI13	32.960322	29.62303	31.37454	-1.631500	-3.267842	-1.5863419
54	4	62	[illegible]AI13	54.429467	57.06512	54.31006	2.756142	2.665715	-0.0704262
55	4	61	BOTAIL13	53.910947	56.27437	56.02436	-0.814974	2.259029	3.0840034
56	4	62	SIRMAAL13	76.019611	74.03313	74.75672	0.366411	-1.185470	-1.2518816
57	4	53	ISHRDI13	27.721741	27.60419	27.68029	0.723922	0.692449	-0.0414729
58	4	53	ISHRDI13	27.721741	26.92202	27.68028	-0.758242	-0.799715	-0.0414729
59	4	73	BAGRHI13	-17.313904	-17.16911	-16.55406	-0.615054	0.143879	0.7589340
60	4	75	[illegible]AL13	-5.272465	-6.30027	-5.78546	-0.514811	-1.006811	-0.4920006
61	4	74	[illegible]AI13	-2.939941	-3.32970	-2.47590	-0.135702	-0.680658	-0.4949570
62	4	76	[illegible]13	19.096377	19.22515	19.72435	-1.769202	-1.071208	0.6979942
63	4	77	FRIDPR13	39.268546	31.12951	30.16413	1.016366	0.911855	-0.1045108
64	4	52	[illegible]AI13	45.227332	43.10583	45.25780	2.148025	2.208488	0.0604630
65	4	57	BOGRAL13	-36.762833	-35.22303	-35.08462	-0.138419	-0.460201	-0.3217816
66	4	64	NATORE13	-74.555664	-73.36723	-75.19253	1.824599	1.187722	-0.6368697
67	4	57	BOGRAL13	-42.333372	-42.22231	-43.80007	-0.022727	-0.438827	-0.4161000
68	4	65	RAJSHI13	-29.629707	-29.37234	-27.19821	-1.881634	0.619852	2.5014877
69	4	68	PLSBRI13	-24.742322	-24.41970	-24.63455	0.223837	0.337695	0.1138568
70	4	68	PLSBRI13	-24.742322	-25.44124	-24.63455	-1.314400	-1.700544	0.1138568
71	4	67	RANGPR13	-20.155334	-21.27963	-20.82489	-0.184738	-0.923752	-0.7390141
72	4	69	RANGPR13	-20.155884	-22.17002	-20.82489	0.724804	-0.014209	-0.7390141
73	4	70	SAIDPR13	-19.124081	-15.72852	-17.93803	1.203437	1.395403	0.1859665
74	4	70	SAIDPR13	-13.124003	-20.76254	-17.92803	-2.831518	-2.645551	0.1859665
75	4	71	DURBAS13	-25.995122	-25.94375	-25.69817	-0.155193	0.242662	0.3977656
76	4	72	TAKUR13	-13.019011	-14.77763	-13.03987	-1.737754	-1.777618	-0.0398636
77	4	65	SIJDPR13	-10.729920	-10.20261	-10.85538	0.852769	0.797361	-0.0554085
78	4	30	TOMSIL23	-127.575302	-127.65022	-127.78758	0.135661	-0.075626	-0.2122879
79	4	30	TOMSIL23	-127.575302	-124.77353	-127.78758	3.412056	3.199768	-0.2122879
80	4	31	ISHRDL23	-179.899527	-180.51271	-178.00865	-2.504062	-0.613117	1.8909454
81	4	31	ISHRDL23	-179.899527	-178.40728	-178.00865	-0.398635	1.492309	1.8909454
82	4	26	KAPTAI13	-78.499593	-78.47591	-79.74058	1.266574	0.025904	-1.2406702
83	4	26	KAPTAI13	-39.199266	-39.13454	-38.68093	-0.153601	0.365424	0.5190253
84	4	26	KAPTAI13	-93.499363	-92.33360	-93.34057	1.001965	1.161253	0.1592875
85	4	22	SIKLBAI13	-69.799981	-70.31161	-68.77227	-1.539325	-0.511723	1.0276012
86	4	33	SYHPSN13	-18.599984	-15.12744	-17.34239	1.219940	2.470445	1.2505054
87	4	33	SYHPSN13	-21.999693	-24.08856	-22.08142	-1.999133	-2.080952	-0.0818193
88	4	47	ASHGNJ13	-55.799963	-54.24089	-54.26269	0.013891	0.851064	0.8371830
89	4	47	ASHGNJ13	-52.999847	-53.71562	-52.57434	-1.141285	-0.715774	0.4255116
90	4	47	ASHGNJ13	-27.999993	-28.72261	-28.23870	-0.283902	-0.522702	-0.2388000
91	4	47	ASHGNJ13	0.000002	0.99437	0.29074	0.703635	0.994379	0.2907429
92	4	79	ASHULI23	-118.999421	-119.03733	-120.95307	1.915741	-0.037860	-1.9536018
93	4	79	ASHULI23	-119.999401	-120.16153	-118.64994	-1.511573	-1.162052	0.3495216
94	4	79	ASHULI23	-119.999401	-118.79622	-119.96907	1.182079	0.712490	-0.4695892
95	4	66	CHRASL13	-97.499993	-99.45771	-97.73351	-1.719914	-1.957827	-0.2389133
96	4	77	CHRASL23	-169.626310	-170.32441	-153.25347	-2.055931	-0.638103	1.4178276
97	4	77	CHRASL23	-134.999661	-133.74167	-137.75486	0.013160	-0.742244	-0.7554054
98	4	43	CHUJ[illegible]13	0.000000	1.99953	0.26332	0.729620	0.992504	0.2638835
99	4	51	SYLH[illegible]13	-19.499969	-22.05233	-20.75524	-1.297085	-2.552366	-1.2552795
100	4	36	[illegible]AI13	-32.999975	-34.64997	-34.09149	-0.566577	-1.648342	-1.0817642
101	4	36	[illegible]AI13	0.000000	-1.17723	-1.54940	0.371467	-1.177237	-1.5494070
102	4	36	[illegible]AI13	-19.199915	-21.13531	-20.12384	-0.241467	-1.235493	-0.9940267
103	4	75	[illegible]SAL13	1.000911	0.20475	-2.41764	1.421222	-0.996429	-2.4176531
104	4	52	[illegible]AI13	1.322272	-0.23547	0.68249	-0.924970	-1.635439	-0.7104706
105	4	70	SAIDPR13	-10.929265	-9.91233	-10.99031	1.077961	1.087611	0.0096500
106	4	67	RANGPR13	-12.999939	-13.14127	-12.53956	0.327670	-0.141954	-0.5396247

107	4	47	ASHGNJ13	[illegible]	[illegible]	-50.03605	0.279367	-0.773972	-1.0533390
108	4	47	ASHGNJ13	[illegible]	-53.03247	-50.03605	-3.003423	-4.056763	-1.0533390
109	4	46	GIRASL13	37.260253	36.10013	37.37428	-1.294153	-1.186823	0.1073301
110	4	46	GIRASL13	37.334963	37.29031	37.37428	-0.064981	0.042342	0.1073301
111	4	41	TNGAIL13	-127.573572	-127.47432	-126.54446	-0.929927	0.099182	1.0291100
112	4	41	TNGAIL13	-127.573573	-125.33281	-126.54446	0.204658	1.233768	1.0291100
113	4	53	ISHRDI13	-172.932216	-172.74816	-131.35472	2.611637	1.156044	-1.4555931
114	4	53	ISHRDI13	-172.832216	-183.16677	-131.35472	-1.811981	-3.267574	-1.4555931
115	4	26	KAPTAI13	51.792667	50.62064	49.01635	0.474292	-1.301818	-1.7761106
116	4	2?	KAPTAI13	[illegible]	[illegible]	27.18827	0.372363	1.462286	0.4397237
117	4	26	KAPTAI13	71.357727	73.43217	72.54638	0.885790	2.074449	1.1886597
118	4	26	KAPTAI13	71.757727	71.32091	72.54638	-1.225566	-0.035207	1.1886597
119	4	27	CHTRDH13	[illegible]	21.47510	23.85253	-2.357422	-1.292359	1.0650635
120	4	28	MADNHT13	-6.322701	-7.73286	-6.58502	-1.154839	-1.430165	-0.2753258
121	4	28	MADNHT13	-6.329700	-7.55613	-6.58502	-0.971156	-1.246481	-0.2753258
122	4	28	MADNHT13	25.249715	25.27595	25.03735	0.237199	0.726252	-0.2109468
123	4	28	MADNHT13	25.249725	26.28707	25.03795	1.249218	1.238271	-0.2109468
124	4	28	MADNHT13	-12.357325	-12.12322	-12.15560	0.242307	0.244092	0.2017856
125	4	28	MADNHT13	-12.367325	-13.54673	-12.15560	0.518846	0.720632	0.2017856
126	4	30	HATZLL13	31.202761	31.12134	30.93164	0.261694	-0.007408	-0.2691031
127	4	35	ETHILE13	-0.667872	-0.23398	0.05025	-0.333338	0.384492	0.7178307
128	4	30	HATZLL13	[illegible]	20.24502	20.07178	0.153297	0.225616	0.0733197
129	4	22	SIKLBA13	36.110706	38.10781	37.34721	0.760608	1.227524	1.2369156
130	4	22	SIKLBA13	14.851197	13.38433	14.22796	-0.343626	-0.966852	-0.6232262
131	4	30	HATZLL13	25.122746	26.29090	24.93512	1.305794	1.092171	-0.2136230
132	4	30	HATZLL13	25.123746	20.77473	24.98512	-4.210376	-4.423999	-0.2136230
133	4	32	KULSIL13	3.960133	2.86942	5.03256	-1.220068	-0.090633	1.1294365
134	4	32	KULSIL13	-15.276432	-14.71584	-15.13423	0.418394	0.560597	0.1421928
135	4	36	COMILA13	-12.841792	-13.53580	-13.56086	0.024986	-0.694179	-0.7191658
136	4	36	COMILA13	-12.841702	-13.44285	-13.56086	0.117992	-0.601166	-0.7191658
137	4	36	COMILA13	2.772230	2.66122	2.22594	0.435286	-0.118702	-0.5532894
138	4	38	SDHRGH13	32.140352	31.26413	31.67733	-0.413203	-0.876212	-0.4630089
139	4	38	SDHRGH13	-47.187219	-47.60022	-47.51634	-1.083963	-1.413088	-0.3291249
140	4	38	SDHRGH13	-47.187219	-46.28443	-47.51634	1.231902	0.902777	-0.3291249
141	4	37	ULLOHL13	12.104093	16.51364	18.21746	-1.701813	-2.588349	-0.8865356
142	4	37	ULLOHL13	17.104296	17.03318	18.21746	-0.284278	-1.170813	-0.8865356
143	4	39	ULLOHL13	-40.093745	-40.19535	-40.62709	0.430744	-0.192493	-0.6232381
144	4	39	ULLOHL13	-40.093945	-39.91513	-40.62707	0.711959	0.088721	-0.6232381
145	4	41	TNGAIL13	51.905319	51.72772	51.91888	-0.191085	-0.177532	0.0135541
146	4	41	TNGAIL13	6.721115	6.39992	7.35778	-0.957421	-0.392818	0.5666733
147	4	32	SDIRGH13	9.456675	10.19300	9.12456	0.279340	0.647270	-0.3320694
148	4	43	PSTGLA13	[illegible]	-62.34152	-63.63057	1.285129	1.593305	0.3051758
149	4	41	TNGAIL13	[illegible]	[illegible]	32.29106	-0.056368	0.475215	0.5315840
150	4	46	GIRASL13	-63.766265	-63.13314	-61.98300	-1.147132	0.636130	1.7832632
151	4	46	GIRASL13	-63.766265	-61.41287	-61.98300	0.570136	2.353399	1.7832632
152	4	44	KHPRPR13	22.617399	21.85586	20.97329	0.861877	-0.751441	-1.6133184
153	4	47	ASHGNJ13	15.892687	14.26250	15.11449	-0.844927	-1.623385	-0.7783890
154	4	47	ASHGNJ13	15.892687	15.77989	15.11449	0.564325	-0.113993	-0.7783890
155	4	43	SHIJIZ13	24.626991	22.29329	24.06334	-1.770054	-2.328515	-0.5584598
156	4	42	SRMNGL13	14.439341	15.98007	15.44580	0.534248	1.490211	-0.9559631
157	4	50	FNCHGN13	7.424068	6.55642	6.13822	0.418263	-0.867575	-1.2858391
158	4	51	SYLHTT13	7.211694	5.92722	7.13692	-1.189757	-1.214265	-2.0245094
159	4	47	ASHGNJ13	51.878222	50.09663	50.08430	0.002349	-1.792359	-1.7947073
160	4	53	KSHRGN13	37.625214	41.62649	39.37454	2.251940	3.001254	0.7493138
161	4	54	MYMNSG13	13.672591	15.20452	14.42717	0.719428	1.526904	0.8074760

162	4	56	GULPRA13	16.510010	18.39436	18.82324	-0.738871	1.574360	2.3132324
163	4	56	GOLPRA13	16.510010	18.65014	18.82324	-0.173091	2.140140	2.3132324
164	4	57	KHOEMI13	-19.674727	-20.82523	-19.15339	-1.673531	-2.151995	-0.4784644
165	4	57	KHOEMI13	-19.674727	-16.21849	-19.15339	2.334904	1.856439	-0.4784644
166	4	58	NOAPRA13	-16.152760	-17.73249	-16.18212	-1.550352	-1.579737	-0.0293851
167	4	58	NOAPRA13	-31.909432	-31.42419	-30.40513	-1.018977	0.485336	1.5043135
168	4	59	JESORE13	-51.459709	-49.79945	-51.40170	2.602249	2.669756	0.0675082
169	4	60	JHENDA13	-51.861067	-55.17732	-54.83599	-0.342005	-3.316913	-2.9748077
170	4	61	BOTAIL13	-74.819962	-73.32647	-73.69432	0.367838	1.583576	1.2157373
171	4	62	CHURPA13	-26.855675	-25.92602	-26.81797	0.893843	0.932455	0.0386119
172	4	62	CHURPA13	-26.855675	-27.74531	-26.81797	-0.927442	-0.888830	0.0386119
173	4	56	GOLPRA13	17.419457	15.75092	16.65048	-0.899559	-1.667540	-0.7679820
174	4	73	BAGPHI13	5.312157	4.91550	5.80854	-0.892949	-0.395562	0.4963875
175	4	73	BAGRHT13	2.001177	2.31170	2.49681	-0.185105	0.310518	0.4956245
176	4	75	BRISAL13	-19.705217	-21.55378	-19.41117	-2.142607	-2.847962	-0.7052541
177	4	75	MORIPR13	-29.526409	-29.03912	-29.53343	0.477308	0.557295	0.0579774
178	4	77	FRIDPR13	-43.262592	-42.33501	-44.00329	1.168274	1.133561	-0.0347137
179	4	54	NATORE13	35.540466	34.87331	35.87359	-1.050274	-0.717151	0.3331244
180	4	63	ISHRDI13	75.426773	79.17109	77.07977	1.071313	1.744297	0.6529868
181	4	63	ISHRDI13	50.699705	52.74502	51.27394	1.651185	2.095222	0.4440367
182	4	64	NATORE13	30.115204	25.65971	27.54734	-1.887637	-4.455494	-2.5678568
183	4	67	BOGRAL13	25.073502	24.23596	24.95555	-0.718575	-0.835533	-0.1179576
184	4	67	BOGRAL13	25.073502	24.06901	24.95555	-0.886529	-1.004487	-0.1177576
185	4	68	PLSRRI13	20.399790	20.76345	21.14543	-0.381276	0.365232	0.7472157
186	4	68	PLSRRI13	20.398202	22.07330	21.14543	0.928372	1.675537	0.7472157
187	4	69	RANGPR13	18.255227	18.72189	19.05649	0.655374	0.465899	-0.1894951
188	4	69	RANGPR13	18.255227	17.79113	18.05649	-2.285367	-2.474862	-0.1894951
189	4	70	SAIDPR13	26.247574	25.69156	25.83703	-0.155462	-0.566005	-0.4105449
190	4	71	PURBAS13	13.036933	11.39577	13.12160	-1.724832	-1.689260	0.0355721
191	4	53	ISHRDI13	11.881001	11.77344	12.73168	0.841760	0.391542	0.0497818
192	4	78	ASHULL23	129.516293	133.36451	129.73851	3.826046	4.047584	0.2215385
193	4	78	ASHULL23	129.516293	128.35592	129.73851	-1.383425	-1.161956	0.2215385
194	4	79	SHRASL23	189.692475	185.50395	187.42636	-1.992416	-4.104518	-2.1121025
195	4	79	SHRASL23	189.692475	186.36337	187.42636	-1.132488	-3.244590	-2.1121025
196	4	1	KOTI2X40	78.470903	81.03594	79.74059	1.295256	2.535926	1.2406702
197	4	2	KOTI1X30	39.190066	38.57517	38.68023	-0.155779	-0.674795	-0.5190253
198	4	3	KOTI2X30	93.409757	94.36775	93.24957	1.027156	0.867873	-0.1592875
199	4	4	SKLSTX[illegible]	69.799951	67.17562	68.77227	-1.595653	-2.624255	-1.0276012
200	4	5	[illegible]3X10	17.599931	18.51051	17.24930	1.261227	0.010722	-1.2505054
201	4	6	[illegible]X31	91.989601	90.27295	92.09142	-2.107074	-2.027255	0.0818193
202	4	7	ASSM2X60	55.731945	54.97771	54.95260	0.914025	-0.923159	-0.8371830
203	4	8	ASSMH16	53.599947	51.42413	52.57434	-1.150203	-1.575719	-0.4255116
204	4	9	[illegible]	[illegible]	27.27364	21.23379	-0.285257	-0.046467	0.2388000
205	4	10	[illegible]	3.810000	3.41376	-0.29074	0.704711	0.413968	-0.2907429
206	4	11	ASSIH[illegible]	118.999621	122.70690	120.75307	1.950931	3.904533	1.9536018
207	4	12	[illegible]	[illegible]	117.11062	112.64394	-1.532325	-1.883947	-0.3495216
208	4	13	[illegible]	118.992431	120.67730	119.45907	1.203823	1.673412	0.4695892
209	4	14	[illegible]	97.499893	95.98409	97.73891	-1.754724	-1.515811	0.2389133
210	4	15	[illegible]	[illegible]	156.15309	160.25347	-2.115440	-3.533268	-1.4178276
211	4	16	[illegible]	134.999466	135.76350	135.75486	0.013637	0.759043	0.7554054
212	4	17	[illegible]	[illegible]	[illegible]	-0.26388	0.730850	0.466967	-0.2638835
213	4	18	[illegible]	[illegible]	[illegible]	20.75524	-1.311429	-0.055217	1.2552795
214	4	19	KHLIX11	32.999775	33.49749	34.08149	-0.584042	0.497722	1.0817642
215	4	20	KHLHX60	[illegible]	[illegible]	1.54940	0.378629	1.928105	1.5494070
216	4	21	[illegible]	[illegible]	[illegible]	20.19334	-0.958144	0.035882	0.9940267

217	4	22	DSLZXZ0	-1.599011	2.37092	2.21764	1.453182	3.870835	2.4176531
218	4	23	BURABX20	-1.399071	-1.55742	-0.58742	-0.967929	-0.257459	0.7104706
219	4	24	SDPR1Y20	19.999966	17.12584	10.99031	1.135527	1.125877	-0.0096500
220	4	25	PUDPIX20	13.999930	19.25762	12.53956	0.418055	0.257673	0.5306247
221	4	78	ASHULL23	52.322710	48.75575	50.03605	-1.080286	-0.026947	1.0533390
222	4	78	ASHULL23	43.922710	47.45545	51.03605	-0.581580	0.471758	1.0533390
223	4	72	GIRASL23	-37.264953	-37.57642	-37.37428	-0.220191	-0.327521	-0.1073301
224	4	72	GIRASL23	-37.264953	-38.52786	-37.37428	-1.153557	-1.260888	-0.1073301
225	4	30	TUNSIL23	127.577592	121.43386	126.54446	-3.110599	-4.139709	-1.0291100
226	4	30	TUNSIL23	127.577592	127.62576	126.54446	1.081275	0.052166	-1.0291100
227	4	31	ISHPDL23	177.822216	133.22509	181.35479	2.532196	3.987789	1.4555931
228	4	31	ISHPDL23	172.822216	177.51747	181.35479	-1.735305	-0.279712	1.4555931
* 229	5	27	CUDD2713	-22.372437	0.10001	-22.85753	22.957534	22.372436	-0.5851090
230	5	28	MADNIEL13	-16.276272	-15.00295	-16.14338	1.140444	1.283985	0.1435399
231	5	30	HATZLL13	-12.165733	-11.43431	-11.38563	-0.048673	0.731521	0.7801950
232	5	30	HATZLL13	-12.165733	-13.23529	-11.38563	-1.849644	-1.069450	0.7801950
233	5	28	MADNHT13	-14.734022	-13.19763	-14.20576	1.009123	1.336455	0.3273308
234	5	29	SIKLBA13	7.272717	9.29885	8.34250	1.056354	1.925141	0.8697867
235	5	29	SIKLBA13	7.272717	8.25545	8.34250	-0.587046	0.282740	0.8697867
236	5	32	KULSIL13	-11.616516	-9.49929	-10.80442	1.315104	2.127128	0.8120239
237	5	32	KULSIL13	-11.616516	-9.25571	-10.80442	1.548778	2.360802	0.8120239
238	5	30	HATZLL13	-1.162779	-1.86493	-1.47927	-0.385653	-0.702211	-0.3165580
239	5	30	HATZLL13	-1.162779	0.14111	-1.47927	1.620394	1.303835	-0.3165580
240	5	35	FENILL13	-9.593773	-7.05215	-9.95133	2.899175	2.541613	-0.3575623
241	5	35	CUMILA13	3.259356	2.58339	2.51552	0.068380	-0.595442	-0.6648302
242	5	35	CUMILA13	-6.592231	-6.92815	-7.04219	0.114035	-0.328832	-0.4428685
243	5	33	HLGHA213	-22.735576	-23.72205	-23.82946	0.107383	-1.055486	-1.1638699
244	5	31	DUHTPI13	-7.133355	-7.14002	-7.02583	-0.044184	0.059932	0.1041174
245	5	34	BRALIA13	-9.611511	-9.57559	-9.78834	0.212752	0.035917	-0.1768351
246	5	34	BRALIA13	-9.611511	-10.23785	-9.78834	-0.449508	-0.625343	-0.1768351
247	5	33	HLGHA213	3.335571	2.53927	2.60078	-0.061508	-0.796294	-0.7347863
248	5	34	BRALIA13	2.221683	2.32794	1.08444	1.243498	0.106169	-1.1372385
249	5	38	SDHPSH13	3.943368	5.10329	4.48458	0.618705	1.152421	0.5437169
250	5	38	SDHPSH13	3.943368	5.31499	4.48458	0.829416	1.373132	0.5437169
251	5	37	CHUBPR13	-4.639373	-6.72574	-5.03753	-1.889213	-2.225750	-0.3375370
252	5	39	ULLTULL13	-40.011527	-38.40557	-38.49833	0.092744	1.605993	1.5132484
253	5	46	GHRASL13	21.011239	23.55682	21.53555	2.021270	2.545592	0.5243123
254	5	46	GHRASL13	21.011239	24.57505	21.53555	3.039508	3.563820	0.5243123
255	5	40	DHANUDI	-9.234612	-8.76590	-9.10333	0.337535	0.468814	0.1312792
256	5	40	DHANUDI	-9.234612	-9.44820	-9.10333	-0.344865	-0.213587	0.1312792
257	5	41	TUNSIL13	-2.699230	-5.70635	-2.75824	-2.948114	-3.007083	-0.0589691
258	5	41	TUNSIL13	-2.699230	-1.45226	-2.75824	1.305297	1.245317	-0.0589691
259	5	42	[illegible]	12.293162	-11.19122	-10.81911	-0.379109	1.104732	1.4840422
260	5	43	PSTGLA13	4.612773	4.25198	4.26268	-0.010807	-0.351041	-0.3502343
261	5	42	HIRPUP13	-17.294361	-17.04777	-16.45803	-0.589746	0.247085	0.8368313
262	5	39	SHIGGH13	32.394271	37.35422	34.42743	-1.052454	-2.875284	-1.7658291
263	5	44	KOPRUP13	-17.164612	-15.10951	-15.19771	0.087201	1.064091	0.7768903
264	5	47	ASHGHU13	-4.577358	-6.74727	-4.65759	-2.070378	-2.175104	-0.0847250
265	5	47	ASHGHU13	-4.577358	-4.11029	-4.65759	0.532398	0.454583	-0.0847250
266	5	45	INSAIL13	-12.509116	-10.52156	-11.08135	0.557724	0.378555	-0.1812398
267	5	48	SHUJI213	3.029392	2.21473	4.30877	-0.494043	0.785531	1.2805738
268	5	48	SHUJI213	3.029392	3.02792	4.30877	-0.711621	0.363383	1.2805738
269	5	49	SUNGL13	-9.364561	-8.99457	-9.13963	0.145053	-0.629711	-0.7747650
270	5	50	FNCHGHL13	-5.581752	-7.56539	-6.99492	-0.570458	-1.703625	-1.1331673
271	5	51	SYLHET13	-6.091352	-6.93961	-3.17520	-1.764414	-0.918256	0.8461587

272	5	52	CHATAKI3	[illegible]	-2.10269	-4.36396	2.159273	1.290290	-0.8689821
273	5	53	KSHPSHI3	[illegible]	-25.18872	-23.72877	-1.360022	-3.224479	-1.8644571
274	5	54	MYMMSSI3	[illegible]	-16.47285	-16.85020	0.377351	-0.252109	-0.6294608
275	5	55	JAMLPRI3	[illegible]	[illegible]	-5.63254	-0.665565	0.301981	0.7675469
276	5	57	KHSENTI3	[illegible]	-50.15327	-49.35490	-0.808388	-0.114470	0.6939173
277	5	57	KHSENTI3	[illegible]	-50.53273	-49.35490	-1.177823	-0.483906	0.6939173
278	5	58	HDAPRAI3	[illegible]	[illegible]	-34.37335	-3.452570	-4.525256	-1.0725851
279	5	58	HDAPRAI3	[illegible]	-33.65951	-34.37335	0.713849	-0.358736	-1.0725851
280	5	59	JHSSRTI3	[illegible]	-36.65473	-35.13319	0.479458	0.657522	0.1790643
281	5	60	JHMDAI3	[illegible]	[illegible]	-26.24446	-3.665387	-3.121625	0.5437613
282	5	62	GIRMRAI3	[illegible]	-15.27326	-14.71056	-2.263414	-2.123933	0.1394808
283	5	61	BITAILI3	[illegible]	-17.49976	-15.39072	-2.118241	-1.272356	0.9459853
284	5	62	GIRMRAI3	[illegible]	-7.26778	-5.81091	-0.055866	-2.481354	-2.4249878
285	5	63	ISHPDII3	-33.922632	-32.90733	-33.95752	1.960199	1.815289	-0.1449108
286	5	57	ISHPDII3	-33.922632	-34.69182	-33.95752	-0.634282	-0.779123	-0.1449108
287	5	73	BAGHITI3	-2.439706	-1.23971	-1.53908	-0.373121	-1.481593	-1.1093822
288	5	75	DRISALI3	1.005977	1.53400	1.52680	0.007197	0.528923	0.5217258
289	5	74	MANGLAI3	-1.010927	-1.43892	-0.58260	-0.855218	-0.438091	0.4174169
290	5	76	[illegible]	-22.64747	-25.62997	-21.74642	-3.673649	-2.772604	0.9010434
291	5	77	ERIOPPI3	-17.476653	-16.58614	-15.51126	-0.174874	1.770502	1.9453764
292	5	62	GIRMRAI3	-10.947379	-14.40525	-12.54653	-1.358717	-3.557973	-1.6991615
293	5	67	BDSRALI3	3.219543	2.56790	3.37651	-0.314512	-0.649543	0.1659691
294	5	64	MATOPRI3	[illegible]	-13.22357	-13.91631	-2.007204	-1.303410	0.7937933
295	5	67	BTSRALI3	-2.159977	-1.12712	-1.79349	0.565363	1.032854	0.3664907
296	5	55	RAJSHII3	[illegible]	-14.70359	-13.65174	-0.356852	-0.109693	0.7481694
297	5	68	PLSBRII3	7.321357	6.97896	7.38500	-0.406944	-0.413292	-0.0063479
298	5	69	PLSBRII3	7.321357	6.75157	7.38500	-0.633430	-0.639779	-0.0063479
299	5	69	RANGPRI3	9.021359	7.36703	7.30431	2.062719	1.345692	-0.7170379
300	5	69	RANGPRI3	9.021359	6.27843	7.30431	-1.025879	-1.742917	-0.7170379
301	5	70	SAIDPRI3	2.292772	2.43673	2.05329	0.373454	0.146964	-0.2264894
302	5	70	SAIDPRI3	[illegible]	0.21706	2.05329	-1.846219	-2.072709	-0.2264894
303	5	71	PURPASI3	-11.175193	-10.23197	-9.11763	-1.114236	0.893312	2.0075493
304	5	72	TIKRUPI3	-6.999973	-4.71791	-5.31486	0.596945	1.582053	0.9851090
305	5	55	SHUDPRI3	5.000007	-2.69565	-3.64990	0.953252	2.514351	1.5510998
306	5	80	TONGIL23	-33.399743	-37.99543	-39.17593	1.180093	0.403271	-0.7768035
307	5	80	TONGIL23	[illegible]	-31.39714	-39.17593	5.779401	5.001598	-0.7768035
308	5	81	ISHRDL23	[illegible]	-0.09161	-5.91986	5.829255	5.612886	-0.2153690
309	5	81	ISHRDL23	-5.736499	-5.41636	-5.91986	-2.496499	-2.711868	-0.2153690
310	5	26	KAPTAII3	-21.943887	[illegible]	-22.23569	-0.554317	0.353866	0.9081841
311	5	26	KAPTAII3	[illegible]	-12.66697	-11.86187	-1.605098	-1.780765	-0.1756668
312	5	26	KAPTAII3	[illegible]	-31.79992	-27.70391	-0.887012	-0.551110	0.3359020
313	5	29	SIKIBAI3	[illegible]	[illegible]	-45.33575	-0.160933	0.981495	1.1424236
314	5	38	SOIPGHI3	[illegible]	[illegible]	[illegible]	3.462474	2.667973	-0.7946014
315	5	39	SOIPGHI3	[illegible]	-55.76626	-51.49627	-5.270569	-5.214860	-0.6442904
316	5	47	ASHSHUI3	-11.313416	-9.55263	-9.30975	-0.249385	0.753779	1.0036649
317	5	47	ASHSHUI3	[illegible]	[illegible]	[illegible]	-2.257622	-2.757405	-0.4997830
318	5	47	ASHSHUI3	[illegible]	-3.59113	-2.25162	-1.327512	-1.234033	0.0954792
319	5	47	ASHSHUI3	-7.739107	-6.58579	-7.19634	0.510555	1.046311	0.5357563
320	5	77	ASHULI23	-21.926721	[illegible]	-21.13024	0.600475	1.096975	0.6964803
321	5	78	ASHULI23	-21.926721	-22.82695	-20.67378	-2.152305	-0.997361	1.1529446
322	5	78	ASHULI23	-21.926721	-20.19933	-20.35762	0.157280	1.636385	1.4691048
323	5	46	SHRAGHI3	[illegible]	[illegible]	-25.44219	-0.434118	0.195319	0.6304383
324	5	79	SHRASL23	[illegible]	-48.39261	-50.67570	1.807093	1.392143	-0.4149497
325	5	79	SHRASL23	-52.596919	-53.91174	-52.43357	-1.478159	-1.416933	0.0612259
326	5	49	SHUISTI3	[illegible]	-15.31996	-14.66334	-0.659121	1.103788	1.7729101

327	5	11	[illegible]	[illegible]	[illegible]	-7.49946	1.452740	1.447095	-0.0106454
328	5	36	[illegible]	[illegible]	-42.12472	-46.05430	-2.070426	-0.617259	1.4531670
329	5	55	[illegible]	[illegible]	[illegible]	-29.40893	-0.747495	0.541573	1.2890692
330	5	55	[illegible]	[illegible]	[illegible]	-19.59902	-0.570654	-0.340455	0.2301991
331	5	75	[illegible]	[illegible]	-23.99767	-30.02493	1.937270	4.089456	2.2521849
332	5	57	[illegible]	[illegible]	-48.39907	-43.95726	1.475178	2.037244	0.5620659
333	5	70	[illegible]	[illegible]	[illegible]	-25.38554	0.084471	0.227534	0.1430631
334	5	59	[illegible]	[illegible]	-20.91792	-17.80420	-1.013088	-0.228652	0.0144362
335	5	47	[illegible]	[illegible]	7.66915	5.69523	1.954746	1.156025	-0.9089210
336	5	47	[illegible]	[illegible]	[illegible]	5.69523	-0.129285	-0.938205	-0.9089210
337	5	46	[illegible]	[illegible]	-22.19537	-23.97746	1.702083	2.619778	0.8376956
338	5	46	[illegible]	[illegible]	[illegible]	-23.97746	1.077705	1.915400	0.8376956
339	5	41	[illegible]	[illegible]	-25.44313	-27.72155	1.278435	1.256035	-0.0223994
340	5	41	TONGILI3	[illegible]	-25.99186	-27.72155	1.722702	1.707303	-0.0223994
341	5	63	ISIRDII3	[illegible]	17.52710	15.31953	1.207262	2.645778	1.4385157
342	5	63	ISIRDII3	[illegible]	15.50417	15.31953	-0.815659	0.622856	1.4385157
343	5	26	KAPTAII3	[illegible]	23.13746	22.92630	0.211173	0.778770	0.5675972
344	5	26	KAPTAII3	[illegible]	15.42905	15.02789	0.402057	0.277876	-0.1241803
345	5	26	KAPTAII3	[illegible]	[illegible]	10.73416	2.132754	1.400424	-0.7322704
346	5	26	KAPTAII3	[illegible]	[illegible]	10.73416	-1.672135	-2.411406	-0.7322704
347	5	27	[illegible]	13.475227	12.37776	13.17524	-0.937177	-1.135463	-0.2292869
348	5	28	[illegible]	[illegible]	-9.39600	-9.62015	0.224149	-0.640511	-0.8645607
349	5	28	[illegible]	[illegible]	-9.68198	-9.62015	0.938165	0.073504	-0.8646607
350	5	28	MADNHII3	11.274712	9.66127	10.45069	-1.787403	-2.613431	-0.8240283
351	5	28	MADNHII3	11.274712	12.97760	10.45069	2.527910	1.703882	-0.8240283
352	5	28	MADNHII3	[illegible]	2.07578	1.10938	0.965400	1.285377	0.3189780
353	5	28	MADNHII3	0.722405	1.55793	1.10938	0.448600	0.767578	0.3189780
354	5	30	HATZLLI3	7.271094	3.71492	7.61064	1.103357	1.442927	0.3395372
355	5	35	FENILLI3	-5.606174	-5.55253	-4.94330	-0.609231	0.053641	0.6628726
356	5	30	HATZLLI3	1.034973	3.82994	1.47955	2.341387	2.816918	0.4755307
357	5	29	SIKLBAI3	22.731919	24.24043	23.24023	1.000195	2.209418	1.2092229
358	5	29	SIKLBAI3	5.603204	5.53866	5.58272	-0.044065	-0.164547	-0.1204818
359	5	30	HATZLLI3	9.191905	7.97122	9.36775	-1.496434	-1.320570	0.1758635
360	5	30	HATZLLI3	9.191905	11.78651	9.36775	2.418756	2.594612	0.1758635
361	5	32	KILSILI3	[illegible]	-3.37392	-3.20779	-0.666087	0.070515	0.7366031
362	5	32	KILSILI3	[illegible]	-1.50211	-1.57271	0.083595	1.216102	1.1325073
363	5	36	[illegible]	[illegible]	-10.04971	-9.36505	-1.674657	-2.158689	-0.4840314
364	5	36	[illegible]	[illegible]	-5.39162	-8.36505	2.977433	2.493401	-0.4840314
365	5	36	[illegible]	2.186775	0.63391	2.52068	-1.885771	-1.551864	0.3339078
366	5	38	[illegible]	[illegible]	40.05416	39.72165	1.262795	-0.308376	-1.5710931
367	5	38	[illegible]	[illegible]	-20.75974	-21.12165	0.432908	-0.042394	-0.4752934
368	5	38	[illegible]	[illegible]	-20.71734	-21.12165	0.474113	-0.001180	-0.4752934
369	5	39	[illegible]	[illegible]	-0.70519	-0.50467	-0.201503	-0.346072	-0.1445689
370	5	39	[illegible]	[illegible]	-0.30999	-0.50467	0.194680	0.050112	-0.1445689
371	5	39	[illegible]	[illegible]	3.35099	2.62940	0.722590	0.804299	0.0817094
372	5	39	[illegible]	[illegible]	1.45991	2.62940	-1.167599	-1.087390	0.0817094
373	5	41	TONGILI3	[illegible]	11.25734	11.24099	-0.183037	-1.683240	-1.5002012
374	5	41	TONGILI3	-6.637114	-7.59472	-5.09564	-1.609094	-1.255613	0.3534709
375	5	38	[illegible]	15.460119	13.59310	14.97529	-1.052188	-1.937001	-0.8848131
376	5	63	[illegible]	[illegible]	[illegible]	-37.15994	-2.165676	-0.409562	1.7570133
377	5	41	[illegible]	[illegible]	16.79697	16.11204	0.097927	-0.897531	-0.9753585
378	5	46	[illegible]	[illegible]	5.67679	5.85442	-0.189633	-0.318572	-0.1289390
379	5	46	[illegible]	5.933365	1.83751	5.85442	-4.024910	-4.153849	-0.1289390
380	5	44	[illegible]	[illegible]	10.02027	9.45321	0.567054	0.654239	0.0871837
381	5	47	[illegible]	[illegible]	[illegible]	[illegible]	-1.702896	-3.001993	-1.2991064

382	5	47	[illegible]	[illegible]	-6.26753	-6.72165	0.534121	-0.664985	-1.2991065
383	5	48	[illegible]	6.969762	9.39590	7.71939	0.375510	1.132845	0.7563353
384	5	49	[illegible]	3.566551	4.43323	4.74105	-0.307760	0.866748	1.1745081
385	5	50	[illegible]	[illegible]	[illegible]	1.59222	-1.594510	-2.466701	-0.8621916
386	5	51	[illegible]	1.212398	4.13225	2.73418	2.149065	3.019944	0.8718781
387	5	47	[illegible]	[illegible]	23.14173	24.57664	-1.434950	0.328764	1.7638140
388	5	53	[illegible]	[illegible]	[illegible]	16.47063	0.397533	1.153899	0.7663667
389	5	54	[illegible]	[illegible]	2.22052	3.49539	-0.654853	-1.600133	-0.9352807
390	5	56	[illegible]	[illegible]	[illegible]	48.53999	-0.532615	-1.211762	-0.6791472
391	5	56	[illegible]	[illegible]	47.19114	48.53959	-1.398430	-2.067577	-0.6791472
392	5	57	[illegible]	33.013916	33.14756	34.12572	-0.979149	0.133563	1.1128120
393	5	57	[illegible]	33.013916	33.44744	34.12572	-0.679272	0.433540	1.1128120
394	5	53	[illegible]	[illegible]	35.75798	34.98203	0.875037	0.683432	-0.1916051
395	5	58	[illegible]	26.629571	24.66767	25.83702	-1.169335	-1.960890	-0.7915556
396	5	59	[illegible]	18.313217	17.74287	18.99086	-0.147998	-0.370341	-0.2223432
397	5	60	[illegible]	[illegible]	16.75962	17.05081	-0.300115	-0.837433	-0.5373180
398	5	61	[illegible]	5.537364	9.01315	7.90522	1.106729	3.425288	2.3183584
399	5	62	[illegible]	[illegible]	35.57573	35.98762	-0.311690	-0.182217	0.1294732
400	5	62	[illegible]	[illegible]	38.33586	35.98762	2.449249	2.577721	0.1294732
401	5	56	[illegible]	[illegible]	-0.16670	-0.10739	-0.059307	1.015949	1.0752563
402	5	73	[illegible]	[illegible]	-4.09813	-4.45007	0.414942	-0.099221	-0.5141638
403	5	73	[illegible]	[illegible]	-1.58281	-0.82943	-0.853392	-1.271307	-0.4179250
404	5	75	[illegible]	21.174309	17.69541	20.24018	-2.544772	-3.479086	-0.9343147
405	5	76	[illegible]	[illegible]	[illegible]	15.43643	1.199774	-0.912195	-2.1109695
406	5	77	[illegible]	11.856556	14.32025	13.59416	0.726097	2.463709	1.7376118
407	5	64	[illegible]	-3.736237	[illegible]	-3.22248	1.346539	1.200293	-0.1462460
408	5	63	[illegible]	[illegible]	[illegible]	17.81951	-0.189113	-0.852609	-0.6634891
409	5	63	[illegible]	[illegible]	1.74061	2.97743	-2.236815	-2.540617	-0.3038019
410	5	54	[illegible]	14.072617	[illegible]	13.11771	-0.881040	-1.941938	-0.9608984
411	5	67	[illegible]	[illegible]	[illegible]	-8.53276	-0.911166	-0.927823	-0.0166774
412	5	67	[illegible]	[illegible]	-8.26537	-8.53276	0.274384	0.257705	-0.0166774
413	5	68	[illegible]	[illegible]	[illegible]	-8.75680	0.775128	1.508432	0.7333040
414	5	68	[illegible]	[illegible]	[illegible]	-8.75680	0.681918	1.415222	0.7333040
415	5	69	[illegible]	[illegible]	-5.04447	-3.37663	-1.647795	-1.434531	0.2131637
416	5	69	[illegible]	[illegible]	-3.22723	-3.39668	0.168745	0.381909	0.2131637
417	5	70	[illegible]	[illegible]	7.57705	8.70362	-1.126557	-3.173988	-2.0474310
418	5	71	[illegible]	[illegible]	4.41746	3.81895	0.599513	-0.409363	-1.0078735
419	5	53	[illegible]	[illegible]	1.69350	0.73559	0.958001	-0.630313	-1.5893150
420	5	78	[illegible]	[illegible]	36.63971	37.55871	-0.923991	-0.119030	0.8048713
421	5	78	[illegible]	[illegible]	[illegible]	37.55871	1.990259	2.795127	0.8049713
422	5	79	[illegible]	[illegible]	[illegible]	24.17221	-1.262927	-2.125741	-0.8638144
423	5	79	[illegible]	[illegible]	21.82907	24.17221	-2.343141	-3.206955	-0.8638144
424	5	1	[illegible]	[illegible]	26.86193	28.45414	-1.590177	-2.324479	-0.7342815
425	5	2	[illegible]	[illegible]	15.03035	14.49372	0.536441	0.629407	0.0929654
426	5	3	[illegible]	36.398397	33.95594	36.00987	-2.042924	-2.421438	-0.3785133
427	5	4	[illegible]	[illegible]	[illegible]	52.52725	0.023114	-1.357706	-1.3738213
428	5	5	[illegible]	[illegible]	51.64215	49.77491	2.367345	3.676766	0.9296192
429	5	6	[illegible]	[illegible]	51.31653	53.24485	-1.928221	-1.176980	0.7312417
430	5	7	[illegible]	[illegible]	12.14712	12.61491	-0.466805	-1.589410	-1.1225157
431	5	8	[illegible]	10.117144	[illegible]	10.94953	0.101518	0.536205	0.4353881
432	5	9	[illegible]	[illegible]	[illegible]	5.07320	0.895858	0.836047	-0.0508189
433	5	10	[illegible]	[illegible]	[illegible]	7.29164	-0.351093	-0.899106	-0.5480230
434	5	11	[illegible]	[illegible]	[illegible]	31.42332	-2.345670	-2.753944	-0.4172742
435	5	12	[illegible]	[illegible]	28.28322	30.57704	-2.788824	-3.552376	-1.2635527
436	5	13	[illegible]	[illegible]	[illegible]	30.30530	-2.158391	-3.613692	-1.4953003

437		5	14	GRSL2X50	32.[illegible]	32.[illegible]273	32.32473	1.164284	0.536090	-0.6288946
438		5	15	GRS1U210	63.621711	64.32495	63.92028	0.404667	0.633251	0.2285839
439		5	16	GRS2U210	61.477561	59.78862	61.50534	-1.715720	-1.589040	0.0276804
440		5	17	SHUJFST	14.6[illegible]	14.08252	14.80361	-0.726091	-2.542393	-1.8163023
441		5	18	SYLH1X20	9.44[illegible]	10.07815	9.69458	0.393575	0.629245	0.2356709
442		5	19	KIL1X110	39.73[illegible]	42.23297	42.26676	-1.033927	-2.559339	-1.5253420
443		5	20	KILH1X50	39.1[illegible]	39.77[illegible]3	39.73690	0.133734	-1.274457	-1.4081959
444		5	21	KILH1900	21.70[illegible]	22.56342	21.53829	1.105206	0.938728	-0.1662791
445		5	22	BRSL2X20	34.791733	35.09210	32.30357	2.783608	0.300455	-2.4831533
446		5	23	BRRA3X20	[illegible]	53.[illegible]	53.67346	-0.378514	-1.042586	-0.6630719
447		5	24	SDRR1X20	29.722353	29.60189	29.53150	0.070387	-0.120967	-0.1913548
448		5	25	RNSP1X20	24.730201	21.55329	24.93677	-3.283499	-3.177004	0.1064837
449		5	78	ASHULL23	-4.0[illegible]763	-3.19[illegible]	-3.10410	2.718874	3.823630	0.9047557
450	*	5	78	ASHULL23	-4.00[illegible]763	-2.42642	-3.10410	0.673517	1.584372	0.9047557
451		5	79	SHRASL23	26.340335	2[illegible].20729	25.48461	3.023290	2.159570	-0.8647203
452		5	79	SHRASL23	26.340335	2[illegible].73722	25.48461	0.247527	-0.617122	-0.8647203
453		5	80	TONGIL23	38.337217	38.17436	38.24029	-0.065428	-0.222337	-0.1569092
454		5	80	TONGIL23	38.337217	34.98699	38.24029	-3.253329	-3.410309	-0.1569092
455		5	81	ISHRDL23	5.706120	3.23276	4.55673	-1.323972	-2.473353	-1.1493807
456		5	81	ISHRDL23	5.706120	3.56124	4.55673	-0.995490	-2.144870	-1.1493807
457		1	1	KPTI2X50	1.030000	1.02243	1.02221	0.000225	-0.000562	-0.0007877
458		1	2	KPTI1X50	1.030000	1.03000	1.03039	-0.000384	0.000009	0.0003929
459		1	3	KPTI2X50	1.030000	1.03006	1.02979	0.000268	0.000061	-0.0002069
460		1	4	SKLSTX[illegible]	1.030000	1.02229	1.02235	-0.000053	-0.000701	-0.0006485
461		1	5	SDGH5X10	1.030000	1.03119	1.03091	0.000265	0.001182	0.0009174
462		1	6	SDGH5X33	1.030000	1.02986	1.03062	-0.000762	-0.000139	0.0006227
463		1	7	ASSN2X64	1.030000	1.02899	1.02893	0.000062	-0.001001	-0.0010647
464		1	8	ASSH1160	1.030000	1.03036	1.03084	-0.000480	0.000362	0.0008430
465		1	9	ASSH1X30	1.030000	1.02952	1.02981	-0.000293	-0.000474	-0.0001812
466		1	10	ASSN2150	1.030000	1.02249	1.02917	0.000322	-0.000500	-0.0008230
467		1	11	ASS1J150	1.030000	1.03126	1.03057	0.000687	0.001259	0.0005722
468		1	12	ASS2J150	1.030000	1.03014	1.03012	0.000015	0.000145	0.0001297
469		1	13	ASSDU150	1.030000	1.03053	1.02995	0.000579	0.000535	-0.0000429
470		1	14	GRSL2X50	1.030000	1.02955	1.02979	-0.000437	-0.000449	-0.0000114
471		1	15	GRS1U210	1.050000	1.05161	1.05000	0.001611	0.001611	0.0000000
472		1	16	GRS2U210	1.050000	1.04990	1.04985	0.000052	-0.000092	-0.0001450
473		1	17	SHUJFST	1.030000	1.03033	1.03030	0.000032	0.000332	0.0003004
474		1	18	SYLH1X20	1.030000	1.03119	1.03106	0.000131	0.001193	0.0010614
475		1	19	KIL1X110	1.030000	1.02275	1.02315	-0.000397	-0.000241	0.0001564
476		1	20	KILH1X50	1.030000	1.02330	1.02358	-0.000277	-0.000693	-0.0004159
477		1	21	KILH3400	1.030000	1.03074	1.03109	-0.000353	0.000743	0.0010977
478		1	22	BRSL2X20	1.030000	1.02754	1.02777	-0.000232	-0.002454	-0.0022221
479		1	23	BRRA3X20	1.030000	1.03122	1.03073	0.000492	0.001227	0.0007359
480		1	24	SDRR1X20	1.030000	1.03092	1.03092	0.000003	0.000028	0.0000249
481		1	25	RNSP1X20	1.030000	1.03129	1.03112	0.000174	0.001297	0.0011225

THE MEASUREMENTS MARKED WITH ASTERISK(S) ARE SIMULATED AS BAD DATA

VALUES OF PERFORMANCE INDICES

PERFORMANCE INDEX AS A FUNCTION OF:	COMPUTED VALUE P.U.	THRESHOLD VALUE P.U.
1. (SP.-EST.)	2.2399123[illegible]	1.2[illegible]
2. (EST.-TRUE)	0.33020687	0.44421130