Effect of Bad measurements on IEEE-14 Bus System in Power System State Estimation

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INTRODUCTION

The static state estimation is defined as the data processing algorithm for converting redundant meter readings and other available information into an estimate of the state vector, while measured data are taken to be time invariant and static model of the power system is considered. In the field of power systems, the objective is to provide a reliable and consistent data base for security monitoring, contingency analysis and system control. To meet the above objectives, SE is required to [1].

- Produce a “best” estimate of the bus voltage magnitudes and angles.
- Detect, identify and suppress gross measurement errors.
- Produce an estimate of non-metered or lost data points.

A major factor in the success of producing a good estimate of the system state is the ability to handle errors that exist in the input to the estimation process. Such errors may be classified as:

- Measurement noise.
- Gross measurement errors.
- Topological errors.
- Model parameter errors.

BAD DATA PROCESSING CYCLE

The ability of power system state estimator to detect and identify noise in the measurement data enables it to provide a dependable data base for power system operation and control. If one or more of the telemetered measurements are contaminated with gross errors (bad data), the estimated system state and the corresponding data base will be biased. Bad data may occur as a single bad measurement or multiple bad measurements; therefore, the main objective of the power system state estimation is to minimize the bias in the data base [2].

Bad data processing in conventionally performed in three steps:

i. A detection procedure to determine whether bad data present.
ii. An identification procedure to pinpoint the bad data elements in the measurement set and their location in the system.
iii. An elimination step to get rid of the influence of bad data on the state estimate.

Fig. 1: Conventional bad data processing cycle

ERROR ESTIMATION

Computer simulations such as power-flow studies provide exact answers, but in reality never know the absolutely true state of a physically operating system. Even when great care is taken to ensure accuracy, unavoidable random noise enters into the measurements process to distort more or less the physical results. However, repeated measurements of the same quantity under carefully controlled conditions reveal certain statistical properties from which the true value can be estimated [3].
The measured values are plotted as a function of their relative frequency of occurrence, a histogram is obtained to which a continuous curve can be fitted as the number of measurements increases (theoretically, to an infinite number). The continuous curve most commonly encountered is the bell-shaped function $p(z)$ as shown in figure 2. The function $p(z)$, called the Gaussian or normal probability density function, has the formula

$$p(z) = \frac{1}{\sigma \sqrt{2\pi}} e^{-\frac{(z-\mu)^2}{2\sigma^2}}$$  \hspace{1cm} \ldots(1)$$

And the variable representing the values of the measured quantity along the horizontal axis is known as the Gaussian or normal random variable $z$. Areas under the curve give the probabilities associated with the corresponding intervals of the horizontal axis. In the probability that $z$ takes on values between the points $a$ and $b$ in the shaded area given by

$$p(a < z < b) = \int_a^b p(z) \, dz = \frac{1}{\sigma \sqrt{2\pi}} \int_a^b e^{-\frac{(z-\mu)^2}{2\sigma^2}} \, dz$$

The weight matrices $W$ and $R$ are asymmetric. The gain matrix $G$ then becomes

$$W = R^{-1} = \begin{bmatrix} \frac{1}{\sigma_1^2} & \ldots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \ldots & \frac{1}{\sigma_N^2} \end{bmatrix} \hspace{1cm} \ldots(5)$$

And the gain matrix $G$ then becomes

$$G = H^T R^{-1} H \hspace{1cm} \ldots(6)$$

**CIRCUIT MODEL OF THE SYSTEM**

System has 5 generation buses and 11 loads. Simulated test data has 41 number of measurements i.e. ($N_m$), and there are 27 state variables i.e. ($N_s = 2N - 1$), where $N$ is the number of nodes. Redundancy or degree of freedom in the measurement is 14 i.e. ($N_m - N_s$) There are 13 i.e. ($N - 1$) angles $\theta$ and 14 voltages $V$ to be determined in the test case.
Table 1 presents the actual voltages and angles and estimated voltages and angles also their relative % error in voltage is presented and in the figure 4 plots between buses no. Vs voltage magnitude (p.u) by without error is shown. [5]

Table 1: Estimated states without noise and their % errors

<table>
<thead>
<tr>
<th>Bus No</th>
<th>True V (p.u)</th>
<th>True Angle (degrees)</th>
<th>Measured V (p.u)</th>
<th>Angle Degree</th>
<th>% Error in V(p.u)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.060</td>
<td>0</td>
<td>1.0068</td>
<td>0</td>
<td>0.1298</td>
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<td>2</td>
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<td>0.9989</td>
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<td>-12.750</td>
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<td>0.0453</td>
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<td>-13.238</td>
<td>1.0287</td>
<td>-14.751</td>
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<td>8</td>
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<tr>
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<td>-16.073</td>
<td>0.9758</td>
<td>-16.748</td>
<td>0.0526</td>
</tr>
</tbody>
</table>

**Fig. 4: Plot Between Buses No. V vs Voltage Magnitude (p.u)**

**CONCLUSION**

Test results of IEEE-14 bus system have been presented. These test systems are categorized in two parts. First part discusses the results of without bad data containing without noise in the measurements. Results of estimated voltages in (p.u) and angles in (degrees) as well as the % error in voltages are given. In part 2 the state estimate without bad data containing but with 5% noise in the measurement vector are presented. After comparing between result without and by adding noise in the measurements we see the whole state of the system will affected.
REFERENCES


