Weight Set Of State Estimation Based on Partition

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***Abstract*—In power system state estimation, bad data of local area can make state estimation difficult, and accuracy of measurement can also have great influence on the result of state estimation. Based on grid partition, this paper forms a lot of independent sub area, then measurement weights are adjusted using the state estimation result of sub area. This overcomes the defects of uniform weights distribution, and improves the accuracy of state estimation**

Keywords-component; State Estimation, Multiple Bad Data, Partition, Weight Set

I. INTRODUCTION

The existence of bad data may cause great difficulty to state estimation of power system. And even insult the failure of estimation. Therefore, the detection and identification of bad data occupies important position in power system state estimation. But until now, there is still not a perfect identification method.

At present, there are two major categories of bad data identification. One kind of the detection methods is based on the detection of relative value of measurement residuals. These methods are simple in calculation and intuitive in process, but there are "residual pollution" problem when there are multiple bad data. The other kind of the detection methods based on the measurement predictive value. The limitation is that when some loads of the system changes rapidly, the detection accuracy will be greatly reduced. In addition, the number of redundant measurement cannot be used for mutual check, and the reliability of bad data detection reliability is low when there are multiple bad data [1-2].

Using the innovation graph approach can identify a single measurement of bad data [3], but when there are multiple bad data the effectiveness of this method remains to be verified. The linear correlation of the measurement in the given system is derived by graph theory method, it makes full use of the mutual check of the measurement, and this improves the reliability of multiple bad data identification [4]. Based on the minimum degree of topology search, the original network can be decomposed to radiation subnet, simple ring and complex ring network, then multiple independent sub region come into being [5] . This improves the effective of multiple bad data identification, but in the separate sub regions, multiple bad data problem may still exist. Using the measurement information of station, suspicious measurement are given different weights according to different combinations of estimation and identification [6]

As the existing methods can not effectively identify multiple bad data, this article proposed a new bad data identification method based on grid partition. Then measurement weights are amended by using the sub area state estimate result. The amended measurement weights eventually improve the state estimation reliability.

II. WEIGHT SET AND STATE ESTIMATION BASED ON PARTITIONS

A. *The Reason and Method of Grid Partition*

The regular bad data identification algorithm use nonlinear residual equation. In the process of identification multiple state estimation are required, so the calculation work is great. And in addition, this method often cause error identification phenomenon in the case of multiple bad data, so recognition effect is influenced. Based on grid partition, the smaller the partition is, the less calculation work is needed. As multiple bad data is assigned to different regions, "residual pollution" problem is avoided. And the regional mutual check can be used.

The calculation of bad data detection in the partition is about square relationship to measurement quantity. So the smaller of the partition is the smaller of the calculation will be. And small partition has advantage in mutual check. In order to ensure that the bad data detection, each region should have a certain degree of redundancy. These two respects are opposite to each other. When the partition is reduced to a certain extent, the redundancy will become insufficient even make the partition unobservable.

This paper uses branch power measurement and the terminal voltage to establish the partition. If the node voltage and branch power are all measured, then each branch can form a partition. What is more, the partitions have less measurement and meet redundancy requirements. That is to say in full measurement system, the number of partitions are equal to the number of branches. The partition of iEEE 5 nod system is shown as the figure 1. The partition does not include node injection measurement.

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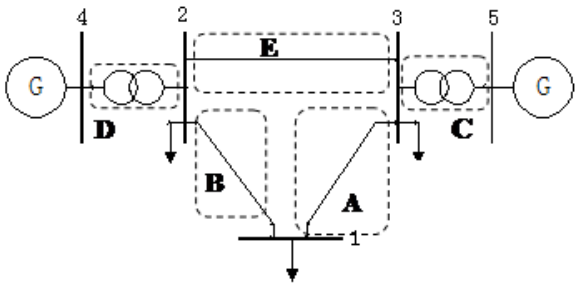

Figure 1. the partition of iEEE 5

But the real power system can not guarantee that all the power and voltage are measured, and it is not necessary to do so. Thus there are less measurement in the partition, and the redundancy may not meet requirements. The partition that can't meet the redundant requirements can be combined with its surrounding the partition to form larger partition, until meet the redundant requirements. For example if power measurement near the 3rd node in A partition does not exist, the power measurement near the 1st node can combine with node injection measurement and B partition, thus forms a new partition as shown in figure 2.

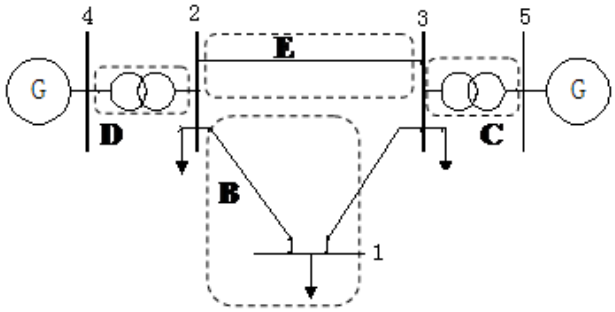

Figure 2. recombined partition

B. *Estimation of Sub Pation*

Given the network, branch parameters and the measurements data of the Ith sub region, the measurement formula of power injection (not including the injection power boundary node), branch power and voltage amplitude can be established as formula 1.

$$\min J(x) = (z - Hx)^T R^{-1} (z - Hx) \qquad (1)$$

Where z is the measurement vector, x is the state vector, H is the nonlinear function vector, R^{-1} is the weight of the diagonal matrix that the system gives.

For the objective function, This paper use the basic least-square method.

Because the sub region is relatively small, and the regional measurement is relatively small, the information matrix is small. Thus in each small sub region the calculation work of bad state estimation is very small, and the total work of all sub regions is still relatively small in contrast to the work of the whole net. And small sub partitions have contribution to regional mutual check. To ensure the state estimation and bad data detection, a certain degree of redundancy is needed for each sub region. These two respects are opposite to each other. In general, if a sub region is reduced to a certain degree, the redundancy of the region may not sufficient, and the region might be unobservable.

This paper uses branch power measurement and the terminal voltage to establish the initial partition. If the measurement is complete, each branch can form a partition. And the partition has the characteristic of less measurement and required a certain redundancy. That is to say in a full measurement power net, the number of partitions are as many as the number of branches.

C. *Partition Re-combination Method for Bad Data Identification.*

Based on the robust theory[7], this paper a method that use the square to set measurement weight., in which the reciprocal get from the relative residual of measurement and estimation.

Residual equation of power system is shown in formula 2.

$$r = z - h(\hat{x}) = z - \hat{z} \qquad (2)$$

Where r is the residual, $\hat{z}$ is the m-dimensional power system measurement estimated vector; $\hat{x}$ is the n-dimensional state estimated vector.

Based on the robust theory, this paper propos a method that use the square to set measurement weight., in which the reciprocal get from the relative residual of measurement and estimation. The details are as follows.

In the First, according to the Ith measurements z_i and the corresponding estimation Value $\hat{z}_i$, Calculate the absolute value of residuals of the measurement $r_i = |z_i - \hat{z}_i|$.

In the second, relative value of the measurement α_i can be calculated according to the absolute value of residual r_i.

$$\alpha_i = \left| \frac{r_i}{z_b} \right| \qquad (3)$$

Where z_b is the reference value of corresponding measurement.

In the last, measurement weight is set.

$$R^{-1'} = \begin{cases} R^{-1} & \alpha_i < 0.01 \\ \dfrac{R^{-1}}{100\alpha_i} & \alpha_i > 0.01 \end{cases} \qquad (4)$$

D. *Process of Partitioning Identification.*

In the first, the partition should be formed based on the principle of this paper, and redundancy of the partition should be verified, If redundancy is not satisfied, the partition should be re-combined to form a new partition, until redundancy meet the requirements.

In the second, In the second, state estimation of each sub partition can be made according to formula (1). then The

measurement residuals can be calculated, and According to equation (3) (4) to form the measurement weight.

In the last, according to the given network, branch line parameters and measurements data, the whole network estimation can be made.

Identification processes is shown in Figure 3.

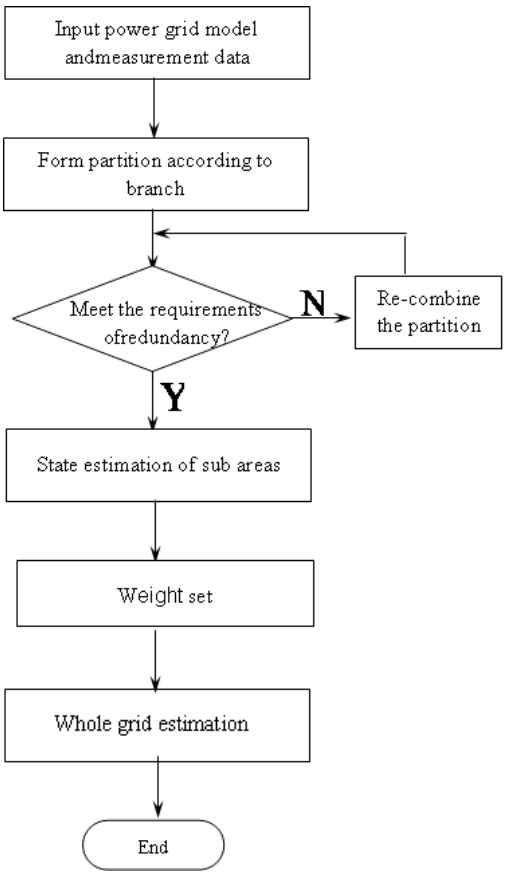

Figure 3. Identification processes

III. THE EXAMPLE ANALYSIS

In order to verify the validity of the method, the paper use IEEE 5 node system as example for simulation calculation. Let's suppose that all the node voltage and power injection and branch power have measurement.

A. The Result of Partition

According to the partition principle, the IEEE 5 node system is divided into 5. If the branch measurements or the node voltage measurements are insufficient, partition number will decrease.

B. Identification of the Results.

When there are bad data In sub partition D and C respectively. The result precision of whol grid state estimation is low Due to the influence of bad data. After the partition, the measurement weight with larger residual is smaller so the influence is smaller. It makes the results more accurate.

IV. CONCLUSION

In the process of power system state estimation, if there are multiple bad data, there can be "residual pollution" problem. In view of this problem, the paper proposes a method for bad data detection and identification based on grid partition and partition re-combination. The method has the following characteristics:1) After the partition, each region contains little measurements, so the calculation work is very small.2) According to the residual, each measurement is weighted again, when the measurement weight deviate seriously from the normal value. It can be considered as bad data and can be discarded. When multiple bad data separately exist in the different regions, the method can effectively detect the presence of bad data in the region without affected by the bad data in the other region.3)To further improve the accuracy，repartition is needed. That is using the lower accuracy of measurement and the other measurements around it to form the new partition, and then measurement weight can be set again. Partition re-combination is essentially the use of regional mutual check. That is using the region that doesn't include bad data to test the region that include bad data. Thus the" residual pollution" problem is overcome.

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