State Estimation using Active elements for Electrical Distribution Network

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Abstract

As the world thrives for its need to complete its energy demand and supply challenges, the state estimation in distribution systems remains a key factor at online observing and controlling in Energy Management Technology. As the world is advancing towards an advance era in order to fulfill its energy supply different sources whether traditional or renewable online monitoring of Distribution of state estimation is becoming more challenging and demandable. In this letter, a concept for state estimation is offered. The accountability for SE is surrogate to indigenous means in secondary substations. By means of past statistics and probabilistic models the substation bad statistics charts knowledge is gathered. Topology and observability analysis as well as bad data identification are performed. Data not performing well is identified using topology tools is accomplished with a perfunctory that crosses the secondary substations of the primary substation feeders.

Keywords: Electrical Distribution Network, Active elements, routing packets, Secondary substation, Primary Station

I. Introduction

In State estimation of power system refers to the monitoring of power in those parts of system on which meters are not installed. Power distribution in network is vital and a task to be handled with great care. Circuit breakers, Protective relays, digital measurements and decades of research work in transmission line theory network has empowered observability and state estimation performance. Computers have been used since from their birth in order to monitor the voltage levels and for on-line load analysis.

A power system can be vast from several meters to several thousand kilometers, the monitoring and fault detection is necessary at each interval in the system. For this purpose it can be divided into small areas with its own managerial governing epicenter collecting data and its extents from far-flung lethal points positioned on substations in area, after which SE controls can be performed on basis of gathered data. In distributed tactics, disintegration and
designation of SE errands befall at control center. In accumulation, while the SE extent calculations have been modified to disperse and asynchronous computation location, original properties counting the slightest square estimator method is kept.

As SE has been limited with availability of load models, the information available regarding in electric system grows the necessity of model intellectment and dispensation is growing. Different authors and designers have proposed solutions like load monitoring using rear end controller for avoiding resource inundation. As modern power technology is moving towards conventional passive users to active markets, installation of renewable resources urges to handle power efficiently with novel SE algorithms. Using SE a power system efficiency can be enhanced up to maximum extent as productivity and consistency can be measured by it. Active markets components, in articles have been shown to be useful in improving system performance by means of maintenance, transmission, consistency and controllability [I-VI]

Following article presents, a notion centered on local agents used in SE of electrical distribution systems. The system area measured is the one of a primary substation and the secondary substations of its feeder branches. The method is not based on the breakdown of traditional SE algorithms. Secondary substation agents participate instead in a novel state estimation method that is mainly using only locally available information, statistical calculations and interaction with neighbors. Area wide topology, observability and bad data analysis are performed with a token passing mechanism that is initiated and controlled by the primary substation.

II. System Planning

In figure 1 general concept of boundary of primary substation layout is given from where it can be clearly seen that secondary ones are merely copies of primary substations. The next coming figure is external view. In figure 1 (b) it is clear that substation can interconnect surrounding elements, on condition that it not connects unavoidably straightly with main substation. The communication done here is performed by steering packets from secondary base to host.
Figure 1. (a) Primary and Secondary station. Sec.st 2 can be viewed as copies of st.1 
(b) Interconnected Secondary station with surrounding elements using routing path.

The ISS body structure has 2 individuals: course established in (classes) demonstrating substation hardware (as shown in Fig. 2), and acutely adept of separately implementing errands signifying the object comportment. The intelligence program communicates with surrounding neighbours in order to screen, control and interrupt.

Performing parameter functions are performed at base station using nominal method in order to direct activities capable of making a power distribution project efficient [VII-X]. Nominals also lever arrangement and supervision of circulated functions i-e safety precautions and distributions. Fault liability will be dealt with high priority then distributing unless liability is accomplished [XI].

Method is performed in following manner. Nominal Variable is sended from base station to nearest station with a command which is in general is of three way named A, B, C where A is approval, the B is accompanying function ID, and C is host allotting an approval.
When the hosting station receives the executing command, it executes command A and attach its results and process it further to other stations and every station has its own ID (C) allocated so that in a network one command is not executed multiple times and without it also this will lead to distortion since some of the substations will not receive commands as well [XII-XIII]

### III. Distributed State Planning.

In SE four steps are the core steps first identification of network topology after which comes examination and observations followed by SE computing and in last is bad data recognition. In proposed method, these steps are executed by nominal variables containing command tasks.

![Figure 3(a) Sketch of variable command path (b) Substation, surrounding neighbors, and sensors usage at SE process.](image)

Primary substation task is to analyze nominal variable and pass it to nearest substation which according to studies can take up to eight minutes. The station also observes load profiles based on previously obtained data and can caught suddenly abnormal load profiles due to any reasons.

Topology shows the path life time of a command in a manner whether it will be executed in the end of the network chain or will result back to station 1 in case of a loop. Then it goes back to primary station. Observability in SE shows the handiness of data so that zone extensive SE can be completed.

This observation is done by the nominal variable solely responsible for this purpose which gathers all of this data during its life time which is from the start of primary to end of the topology tree. Figure 3 (a) shows the data collecting procedure. SE procedure is processed in two steps, an independent procedure effected in secondary substations, and an area wide procedure that is well-ordered with variable. As shown in Fig. 3 b with a secondary Substation B and its nearby neighbors A, C, and D, and with sensor sites manifest by totaled gray circles. Numbers 0 to 6 signify medium voltage line
sensors that measure current, voltage and phase angle. Number 7 depicts the transformer top-oil temperature sensor and Number 8 the substation ambient temperature sensor. Black arrows denote the power flow direction. The nominal variable in every eight to twelve minutes take the measurement readings from the sensors and store all its readings in its memory. This relation can be described in the following relations.

\[ \Delta I_B(N) = S_1(N) - S_2(N) - S_3(N) - S_4(N) \]  
\[ \Delta I_{A,B}(N) = S_a(N - \Delta N) - S_1(N) \]

Delta N presents the postponement which can occur in a communication connection.

The data obtained in memory stored is a chain of sets in which every set included in chain has its mean and variance which is assumed to conform the normal distribution through the help of which bad data identification takes place. Bad data can occur due to any reason known as errors and it is confronted by mean and variance of standard time.

IV. Model Study

Our proposed model is tested under study of following system shown in figure 4. With three branches connected having changing current (in percentage % shown) minutely due to shunt phenomena. Sensors were placed to monitor current levels and sensor 1 caught up variation in its graph in late 3\textsuperscript{rd} hour while other sensors worked just fine which are shown in fig 5 a,b,c,d.

![Figure 4 Model with connected three branches.](image-url)
Figure 5. Sensor input (a) 0 to 1 (b) 2 to 5 (c) 3 to 8 (d) 4 to 7

The mean and variance without time reference is shown in table I while Table 2 covers specific time slot of 10 minutes with Table 3 of failing sensor probability.

Table 1. Start to end of 3rd hour Data

| Parameter | Mean | Variance |
|-----------|------|----------|
| $\Delta I_B$ | 36.99 | 09.81 |
| $\Delta I_{A,B}$ | 59.79 | 09.73 |
| $\Delta I_{B,C}$ | 29.31 | 05.83 |
| $\Delta I_{B,D}$ | 09.69 | 07.31 |
| $\Delta I_{B,E}$ | 21.72 | 02.45 |
Table 2. Data in the last 10 minutes of 3rd hour.

| Parameter | Mean | Variance |
|-----------|------|----------|
| $\Delta I_B$ | 21.99 | 19.81 |
| $\Delta I_{AB}$ | 23.79 | 39.73 |
| $\Delta I_{BC}$ | 24.31 | 25.55 |
| $\Delta I_{BD}$ | 06.69 | 56.42 |
| $\Delta I_{BE}$ | 45.72 | 12.34 |

Table 3. Data in the last 10 minutes of 3rd hour.

| The Last 10 min of 3rd Hour | S1   | S2   | S3   | S4   |
|-----------------------------|------|------|------|------|
| Minute 0                    | 29.11| 29.31| 26.40| 21.90|
| Minute 1                    | 32.41| 33.22| 46.44| 59.82|
| Minute 2                    | 88.67| 2.298| 5.987| 6.763|
| Minute 3                    | 88.76| 22.10| 12.70| 9.876|
| Minute 4                    | 88.88| 0.993| 1.234| 4.356|
| Minute 5                    | 88.88| 0.000| 0.000| 0.000|
| Minute 6                    | 88.88| 0.000| 0.000| 0.000|
| Minute 7                    | 88.88| 0.000| 0.000| 0.000|
| Minute 8                    | 88.88| 0.000| 0.000| 0.000|
| Minute 9                    | 88.88| 0.000| 0.000| 0.000|

IV. Conclusion

In this paper, SE using nominal variable is used. The variable was introduced in a network topology and it was communicated via channel link. The bad data identification was covered using mean and variance with delay response. On any disturbance the variable on the primary controlling base can generate an alarm in order to shut down the fault line or to use circuit breakers. The proposed model is well ordered but with smaller amount of disturbance can go under notice. This system proposed worked well with one sensor failing at one time which in future can be improved if more than one sensor gets un responsive.

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