International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878 (Online), Volume-8 Issue-2, July 2019

Robust Power System State Estimator using Projection Statistics for IEEE systems

K. Sathish Kumar, Basavaraja Banakara, B. V. Sanker Ram

Abstract: ***In Real-time applications like measurement noise in distributed power system. From model of Gaussian frequently deviates or unknown are obtained and estimated in terms of impulse pulse of noise. Under such situations, the efficiency behavior changes. State estimation (SE) methods which are conventional which have both measured and estimated values with the noise consideration is greatly depleted. In this paper, state estimation methods are used in power systems to reduce the error and noise either in two stages of operation. To achieve a linear property of the estimated output by using adjustment of weights and its measurements. The estimator considers the limits and statistical data with a good efficiency even with and without noise effects and disturbances. Tu understand the behavior of SE methods, IEEE test bench of 14-bus and 30- buses are considered. the results are simulated in MTALAB-SIMULINK environment. Index Terms: Load flow study, IEEE 14 and 30 Bus systems, Statistics, GM-estimator, MATLAB, M file.***

I. INTRODUCTION

Robust estimation for input and output state of power systems, which has a major role in monitoring applications and control. Based on our experience, it is found that the (GM)-estimator of robust in nature and generalized like maximum-likelihood using statistics projection with one of the best method in the literature.

To multiple interacting and conforming bad data as well as some types of cyber attacks are also done earlier. In addition, its computing efficiency is high [1]. All the estimation and observation algorithms are used for estimation methods like conventional and latest to reduce the bad measurements and Gaussian noise and also the error and to get the statistical analysis of the error in terms of mean and standard deviation. The error may be too high or low and the variation is estimated time-to-time in estimation methods. The type of programming in terms of objective function for minimizing the error is of several types like convex and non-convex programming, liner and non-linear programming, stochastic and deterministic and etc. [5]–[7]. One of them is considered in powers system analysis like AC power or DC power flow analysis with different loads. Formulation of statistical analysis by using least square and Newton methods. [11]–[15].

In particular, one step utilizes information of system and state topology historically which changes. Next bad or not useful data is removed by accurate measurements. While simulation results are used to estimate state or output for instant to instant with time consuming and high measurement of power. The new method faces all previous data with comparison with present data and computed with large computations, especially in a large electric power grid. Considering offline simulation when compared to online estimation process. [13].

II. ESTIMATION OF STATES IN POWER SYSTEM

The problem in power systems by estimating state with several problems like linear, nonlinear, static and dynamic conditions and state estimation is a nonlinear to be solved. In general several optimization and repetitive algorithms are used in present real-time scenarios, which Static is usually assumed in static estimation for AC power model [8]:

$$z = h(x) + w, (1) \qquad (1)$$

x is a state vector, which includes the transpose of the vector

$$x = (|v_1|e^{j\delta_1}, |v_2|e^{j\delta_2}, \cdots, |v_n|e^{j\delta_n})^T \qquad (2)$$

Where w is an m × 1 matrix which consists of vector plus additive and bad noises of measurement. Variables of random in nature with zero statistical mean values which are Gaussian, i.e., u ∼ h (·) is a vector with nonlinearity of functions, which indicates the present and past states of x to the measurements z.

N (0, Σ), where 0 is the initial value and Σ is a diagonal matrix. With z is an vector with m×1 indicating the set of accurate measurements.

1) WLS State Estimation
2) Problem setup

The proposed Robust Data Mathematically, driven estimation algorithm which is of two parts:

- An Approach with nearest and closest Neighbors statistically, which includes with nearest network with good and bad measurements.
- Data; Minimization problem with data sets of unbiased in nature, where a set of many small distance data points are estimated.

Revised Manuscript Received on 30 July 2019.

* Correspondence Author

Mr. K. Sathish Kumar*, research scholar in Ph.D in JNTU, Hyderabad. India.

Dr. Basavaraja Banakara is a senior IEEE member. He completed his B.Tech (EEE) Degree, Gulbarga University and M.Tech, Karnataka University, India.

Dr. B. V. Sanker Ram, B.E (EEE) Degree, OU campus and M.Tech, OU campus, Hyderabad, India.

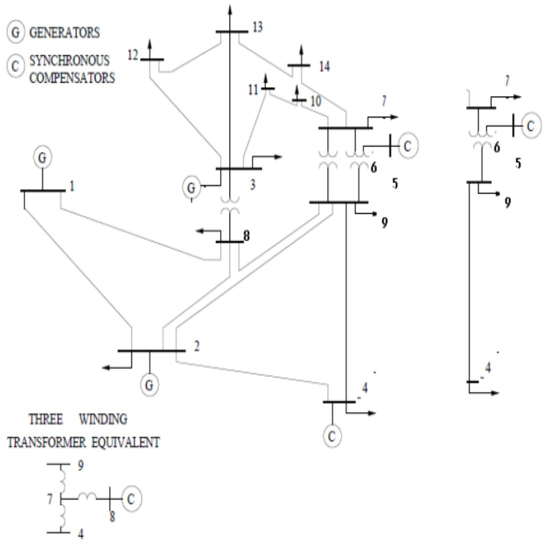


Fig 1: Single Line diagram of IEEE test system for 14 buses

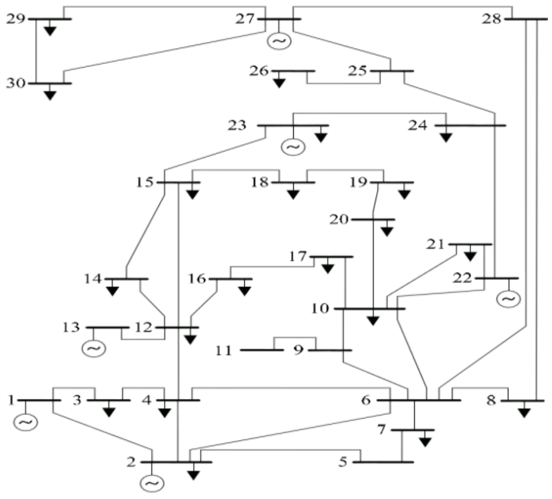


Fig 2: Single Line diagram of IEEE test system for 30 buses

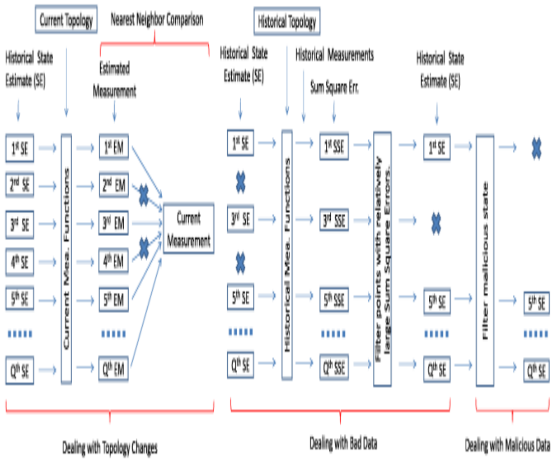


Fig 3: Historical approach for estimated data by statistics

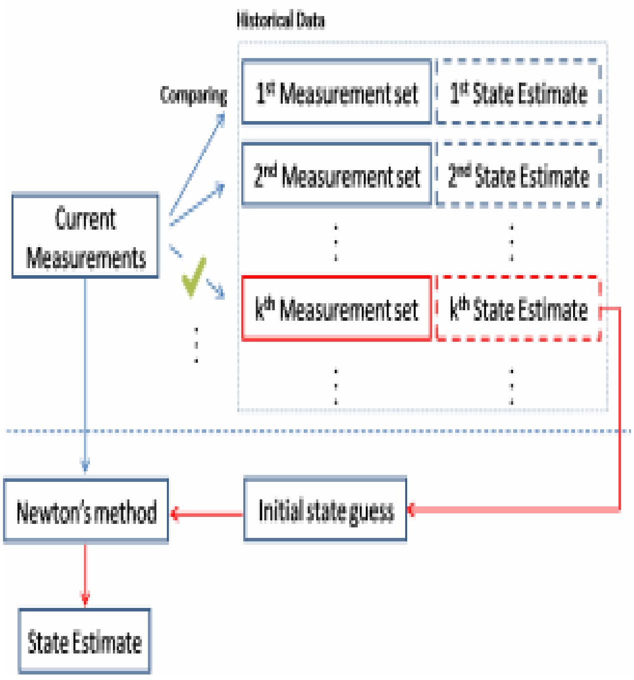


Fig 4: Algorithm for state estimation by using statistics

Data Initialization: MATLAB environment tool boxes, which are adopted for calculating and understanding the actual behavior of the IEEE power systems. To understand the power flow in the power systems, to simulate and understand the behavior and analysis of the power system for offline and online load profiles, state estimation methods are used with respect to the load data and profile. To generate power system true states by estimating sets of true measurement with Gaussian noises (parameters measured are mean and standard deviations) [9]. The IEEE bus systems include bad and good measurements like: 1) power injection 2) line power flows 3) magnitudes of the voltage; 4) some measurements in terms of phase angle.

Data consideration: the data estimated from the estimation methods are robust and used to detect the bad measurements and remove the errors in power systems in terms of voltage and angle error. Depending upon the measurement parameters the adjustment of the generated data is considered:

- Bad Data of estimation
- Attack in terms of Malicious
- Training Period
- Validation Period
- Testing Period

To obtain the error minimum, different estimation methods are used like Mean square error, standard deviation and etc.

$$\mathrm{MSE} = \frac{1}{m}\sum_{i=1}^{m}\left(\frac{z_i - h_i(\hat{x}_{\mathrm{current}})}{\sigma_i}\right)^2. \qquad (3)$$

Here, the MATLAB code of the GM-estimator to all researchers. The code attached is to implement the GM-estimator. The test systems include IEEE 14-bus, 30-bus and extended to 118-bus systems.

III. M-FILE Programming

<u>IEEE 14 Bus System</u>

```
nbus =     14
        -------- Estimation of States in power system ---
                    | No |    pu    | Degree  |
                  |  Bus |  V |  | Angle
                    -------------------------
                      1   1.0600    0.0000
                      2   1.0450   -4.9800
                      3   1.0100  -12.7200
                      4   1.0186  -10.3200
                      5   1.0203   -8.7800
                      6   1.0698  -14.2200
                      7   1.0619  -13.3700
                      8   1.0900  -13.3700
                      9   1.0561  -14.9500
                     10   1.0511  -15.1000
                     11   1.0569  -14.8000
                     12   1.0550  -15.0800
                     13   1.0502  -15.1600
                     14   1.0356  -16.0400
     ---------------------------------------------
Max_voltage_estimation_error =   4.1307e-004
Max_angle_estimation_error =  6.7613e-004
Voltage_error_mean_estimaion =  1.4550e-004
Angle_error_mean_estimaion =  7.8571e-004
```

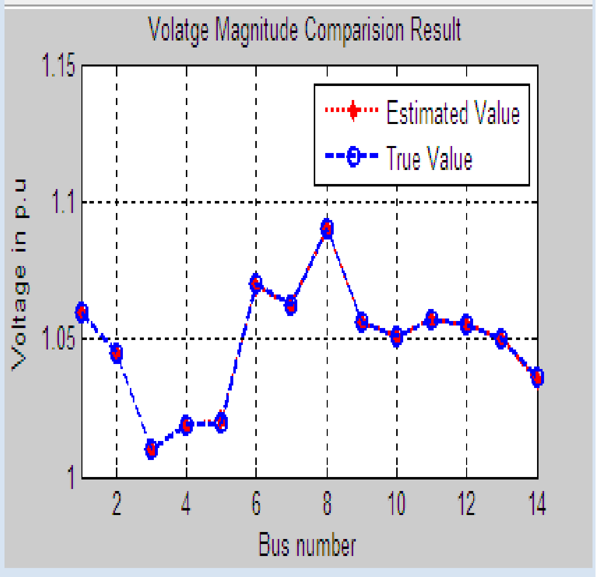


Fig 4: Voltage magnitude Versus Bus number for IEEE 14 Bus system

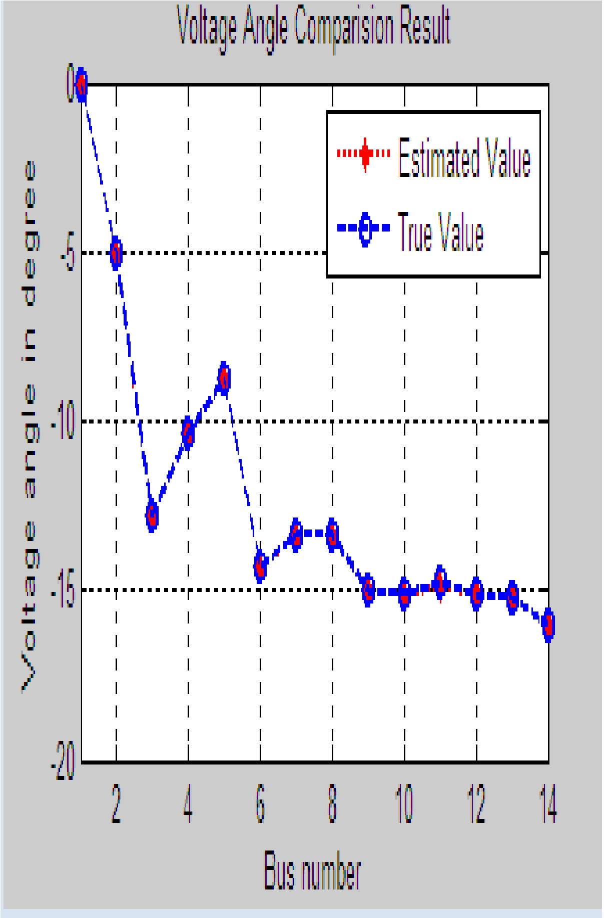


Fig 5: Voltage angle Versus Bus number for IEEE test system of 14 bus

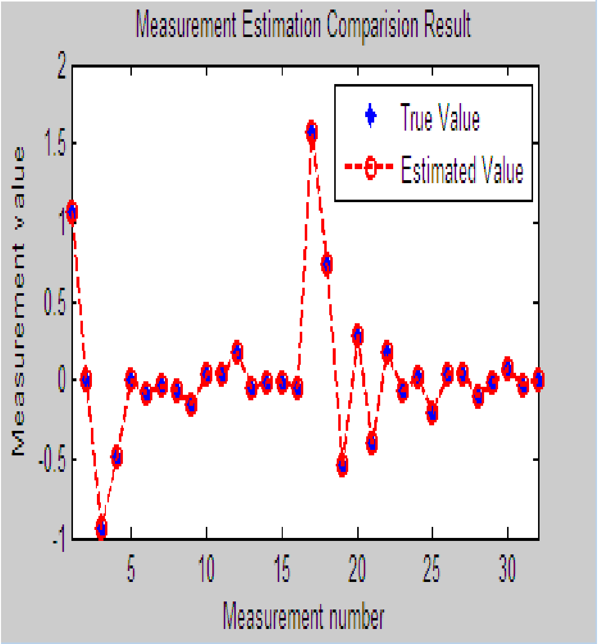


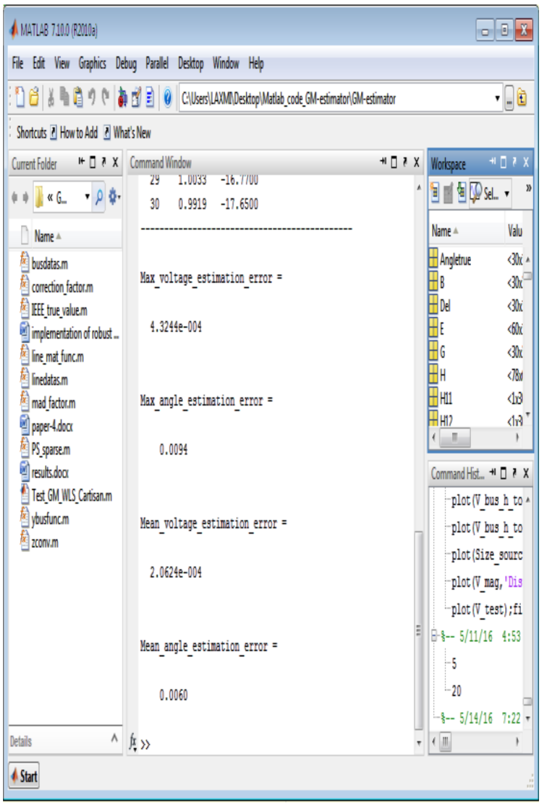
Fig 6: Measurement estimation Versus Measurement number for IEEE 14 Bus system

<u>IEEE test system for 30 bus:</u>

```
nbus =     30
   -------- Estimation of States in test system --------------
        | Bus No |    Voltage (Per unit)   | Angle (degrees) |
            1                        1.0600
-0.0000
            2                        1.0431
-5.3500
```

3	1.0207	-7.5300
4	1.0118	-9.2800
5	1.0100	-14.1700
6	1.0102	-11.0600
7	1.0024	-12.8600
8	1.0100	-11.8100
9	1.0509	-14.1100
10	1.0451	-15.7000
11	1.0820	-14.1100
12	1.0571	-14.9400
13	1.0710	-14.9400
14	1.0423	-15.8400
15	1.0377	-15.9300
16	1.0444	-15.5300
17	1.0399	-15.8600
18	1.0281	-16.5400
19	1.0256	-16.7200
20	1.0297	-16.5200
21	1.0327	-16.1400
22	1.0333	-16.1300
23	1.0272	16.3200
24	1.0216	-16.4900
25	1.0173	16.0600
26	0.9996	-16.4800
27	1.0232	-15.5400
28	1.0068	-11.6900
29	.00333	-16.7700
30	0.9919	-17.6500

Max_voltage_estimation_error = 4.3244e-004
Max_angle_estimation_error = 0.0094
Voltage_error_mean_estimaion=2.0624e-004
Angle_error_mean_estimaion = 0.0060



```
  29    1.0033   -16.7700
  30    0.9919   -17.6500
 --------------------------------------------


Max_voltage_estimation_error =

  4.3244e-004


Max_angle_estimation_error =

    0.0094


Mean_voltage_estimation_error =

  2.0624e-004


Mean_angle_estimation_error =

    0.0060

fx >>
```

```
plot(V_bus_h_to
plot(V_bus_h_to
plot(Size_sourc
plot(V_mag,'Dis
plot(V_test);fi
%-- 5/11/16  4:53
5
20
%-- 5/14/16  7:22
```

Fig 7: Results in command window by using Robust Power System State Estimator using Projection Statistics

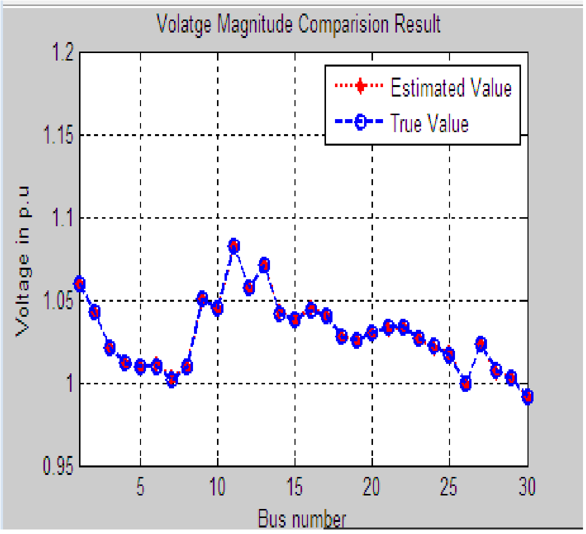


Fig 8: Voltage magnitude Versus Bus number for IEEE test system with 30 buses

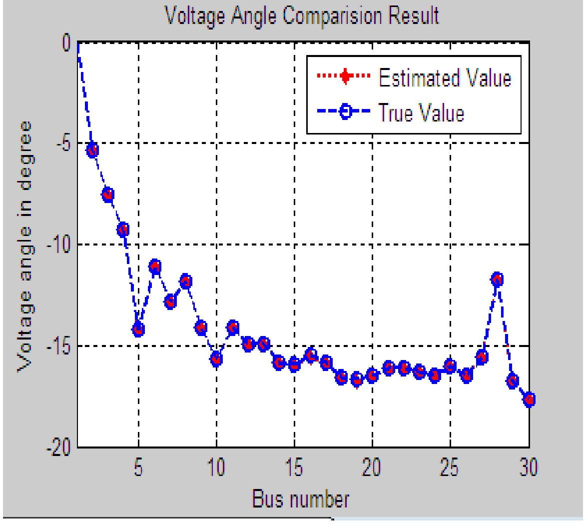


Fig 9: Voltage angle Versus Bus number for IEEE 30 Bus system

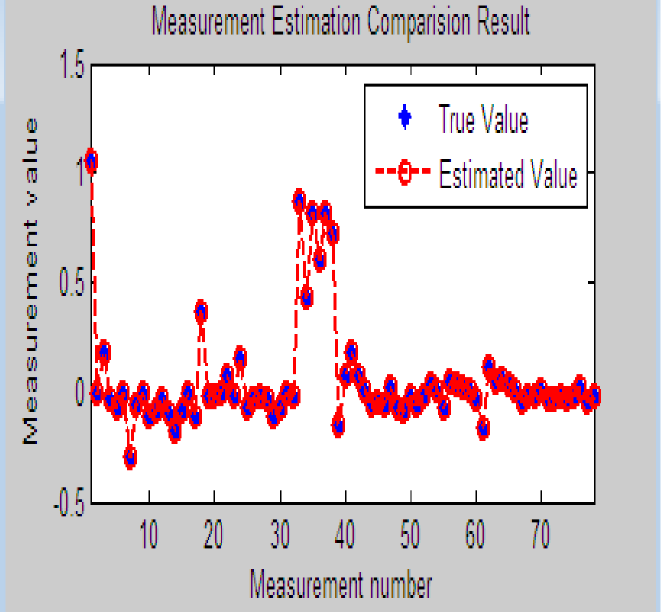


Fig 10: Measurement estimation Versus Measurement number for IEEE 30 Bus system

Table 1: Comparison Table for IEEE 14 and 30 Bus system

Statistics Analysis	Test System	
	IEEE 14 Bus	IEEE 30 Bus
Maximum Voltage estimation error	4.1307e-4	4.3244e-4
Maximum angle estimation error	6.7613e-4	0.0094
Mean Voltage estimation error	1.455e-4	2.0624e-4
Mean Voltage estimation error	7.857e-4	0.0060

Analysis: By comparing test benches of test bus systems like 14 and 30, maximum voltage estimation error and estimating error of the mean values of voltages when estimated are low in IEEE 14 bus system. Error estimation for maximum angle and mean angle error estimation are low in IEEE 30 bus system.

IV. CONCLUSIONS

To obtain the data as per the state estimation in power system requires several methods are adapted to the robust data by estimating all the possible states in power system. To estimate initial State Estimate and considering as a search problem by using minimum distance and for regression Bayesian is used. In some cases, reduction of dimension in terms of size and indexing in an efficient way the simulated results are compared with conventional estimation methods within a less time as mentioned in IEEE benchmark systems.

REFERENCES

1. A. G. Exposito and A. Abur, “Power system state estimation: Theory and implementation,” CRC Press, March 2004.
2. M. Montagna, G. P. Granelli, and. S. Gastonia, “Robust state estimation procedure based on the maximum agreement between measurements,” IEEE Transactions on Power Systems, p. 2038, Nov. 2004.
3. J. Wildes, F. C. Schweppe, and D. B. Rom, “Power system static state estimation.” IEEE Transactions on Power Apparatus and Systems, p. 120, Jan. 1970.
4. F. C. Schweppe, J. Kohlas, E. Handschin, and A. Fiechter, “Bad data analysis for power system state estimation,” IEEE Transactions on Power Apparatus and Systems, p. 329, Apr. 1975.
5. Y. Weng, R. Negi, Q. Liu, and M. D. Ilic, “Robust state-estimation procedure using a least trimmed squares pre-processor,” IEEE Innovative Smart Grid Technologies, pp. 1–6, Jan. 2011
6. L. Mili, M. G. Cheniae, N. S. Vichare, and P.J.Rousseeuw, “Algorithm for least median of squares estimation of power systems,” Proc. 35-th Midwest Symp. Circuit and Systems, pp. 1276–1283, Aug. 1992.
7. Y. Weng, Q. Li, R. Negi, and M. D. Ilic, “Semi definite programming ´ for power system state estimation,” IEEE Power and Energy Society General Meeting, Jul. 2012.
8. F. F. Wu, “Power system state estimation: A survey,” International Journal of Electrical and Power Engineering, vol. 12, pp. 80–87, 1990.
9. H. Zhu and G. B. Giannakis, “Estimating the state of ac power systems using semi definite programming,” Proceedings 43rd North America Power Symposium (NAPS), pp. 1–7, Aug. 2011.
10. A. G. Exposito, A. Abur, A. V. Jaen, and C. G. Quiles, “A multilevel state estimation paradigm for smart grids,” Proceedings of the IEEE, p. 952, Jun. 2011.
11. A. Monticelli, “The impact of modeling short circuit branches in state estimation,” IEEE Transactions on Power Systems, vol. 8, no. 1, pp. 364–370, Feb. 1993.
12. Weng, Q. Li, M. Ilic, and R. Negi, “Distributed algorithm for sdp state estimation,” IEEE Innovative Smart Grid Technology Conference, Aug. 2013.
13. R. C. Pires, A. S. Costa, L. Mili, "Iteratively reweighted least-squares state estimation through givens rotation," IEEE Trans. Power Syst., Vol. 14, no. 4, pp. 1499--1507, 1999.
14. A. P. S. Meliopoulos, B. Fardanesh, and S. Zelingher, “Power system state estimation: modeling error effects and impact on system operation”, Jan. 2001.
15. R. C. Pires, L. Mili, F. A. Becon Lemos, ``Constrained robust estimation of power system state variables and transformer tap positions under erroneous zero-injections," IEEE Trans. Power Syst., vol. 29, no. 3, pp. 1144--1152, May 2014.
16. B. V. Tuykom, J. C. Maun, and A. Abur, “Use of phasor measurements and tuned weights for unbalanced system state estimation,” North American Power Symposium (NAPS), p. 1, Sep. 2010
17. L. Mili, M. Cheniae, N. Vichare, and P. Rousseeuw, ``Robust state estimation based on projection statistics," IEEE Trans. Power Syst, vol. 11, no. 2, pp. 1118--1127, 1996.

AUTHORS PROFILE

Mr. K. Sathish Kumar research scholar in Ph.D in JNTU, Hyderabad. He obtained M.Tech degree from JNTUCEA, Anantapur and working currently in VJIT, Hyderabad as an Associate Professor, Telangana. His interested areas are Power Quality, Power Systems and FACTS.

Dr. Basavaraja Banakara is a senior IEEE member. He completed his B.Tech (EEE) Degree, Gulbarga University and M.Tech, Karnataka University, India. He got awarded Doctorate, NITW, and Warangal and presently working in Department of EEE as Professor at BDT College of Engineering, Karnataka. His interested areas consist of Adjustable Speed drives, EMTP, high voltage Engineering micro grids and applications.

Dr. B. V. Sanker Ram, B.E (EEE) Degree, OU campus and M.Tech, OU campus, Hyderabad, India. He received his Doctorate degree from JNTUH, Hyderabad. Presently working as in JNTUH, Hyderabad as Professor in EEE Department. His interested areas consist of Power Systems, FACTS, Power Electronics,and Power Quality.