International Journal of Engineering Sciences & Research Technology

(A Peer Reviewed Online Journal)
Impact Factor: 5.164

IJESRT

Website: www.ijesrt.com Mail: editor@ijesrt.com

Correspondence Address: 116, Sukhdev Nagar Ext-1, Airport Road, Indore – 452005, Madhya Pradesh, INDIA

RESEARCHERID
THOMSON REUTERS
[Chaudhary* *et al.*, 10(4): April, 2021]
IC™ Value: 3.00
ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

IJESRT
INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

OPTIMAL PLACEMENT OF PHASOR MEASURING UNIT IN POWER SYSTEM

Shikha Chaudhary, Kuldeep Singh Kooner, Baljeet Singh
Department of Electrical Engineering, Guru Nanak Dev Engineering Collage, Ludhiana, India

DOI: https://doi.org/10.29121/ijesrt.v10.i4.2021.5

ABSTRACT.
This paper present different methods for optimal placement of phasor measuring unit (PMU) in power system for complete observability of the system. For smooth and efficient working of the system installation of phasor measuring unit become necessity. But due to high cost of PMU, it is not feasible to place it on every bus system. So, optimization becomes the crucial need. In present work for optimization power system toolbox (PSAT) is used. The proposed methods have been used and verified on IEEE-6, IEEE-9 bus system.

KEYWORDS: phasor measuring unit (PMU), PSAT, observability.

1. INTRODUCTION
In recent years demand of electricity increasing because of advancement of technology and improvement in living standard of people. Power system works at their full capacity which needs close monitoring of system to avoid outages and faults. To make system more reliable and advanced new monitoring systems are being implemented in the system like wide area measurement system where PMU is the key monitoring system. In earlier time traditional monitoring system like SCADA (supervisory control and data acquisition) system is used. But it has many limitations like slow duty cycle and observe system only in steady state.
New technology phasor measuring unit (PMU) is developed in recent years. Its GPS based device which provide time stamped phasor data. Real time-based monitoring can ensure more stable and reliable operation of the system. Data obtained from the PMU is used for complete analysis of the system by using different software at the control centre. PMUs are placed at the buses of the system to measure voltage, current and phase angle. Major constraint in PMU implementation is its cost. Due to very high cost, it's not feasible to place PMU at each bus because of economic and design reason. Therefor optimal placement of PMUs is needed to make system complete observable

1.2 PHASOR MEASURING UNIT (PMU)
Phasor measuring unit(pmu) is synchronized device. It is combination of hardware and software used for measuring phasor angle, voltage and current. PMU provide time stamped data. Time synchronization is done by GPS.Resulting measurement provided by PMU is known as 'synchrophasor'. some applications of PMU as following:

1. Wide area monitoring/measuring system: key system for implementation of smart grid, real time information,
2. Protection: prevention of outages & blackouts
3. State estimation of system
4. Automated control of system

ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

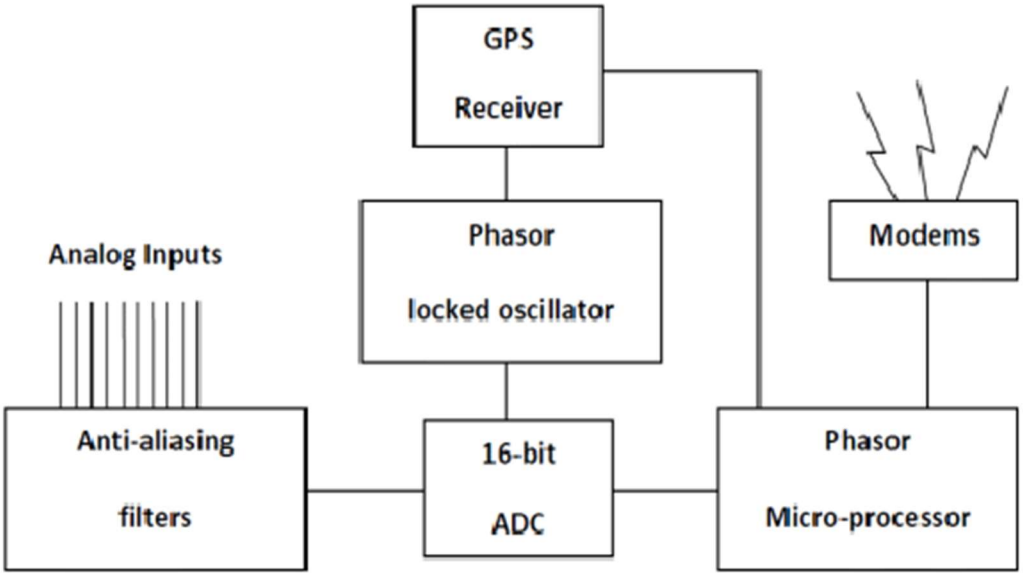

Figure 1. internal structure of pmu

Analog inputs from CT/PT fed to anti-aliasing filters. Filters is used to attenuate frequency above the standard limit of analog to digital converter. Then analog data fed to ADC which convert it to digital form and GPS provide time synchronization. Then timestamped data fed to micro-processor. Sampled data send to modem. Which is utilized at controlled centre using different software's. PMU provide 50-60 samples per cycle.

1.3 RULES FOR PMU PLACEMNET

The following PMU placement rules were proposed in [Baldwin et al.1993]

1. Firstly, assign one voltage measurement to bus where PMU has been placed and one current measurement to each connected branch to the bus.
2. Next assign one voltage pseudo measurement to each node reached by another node which equipped with PMU.
3. Then assign one current pseudo measurement to each branch which connects two buses where voltages are known.
4. Last assign one current pseudo measurement to each branch where current can be directly measured by KCL. It applies when current balance at node is known.

2. CASE STUDY

Simulation of phasor measuring unit placement have been carried out for IEEE 6 and IEEE 9 bus system using PSAT (power system analysis tool box). In this software depth first search, simulated annealing method, graphic theoretic procedure, (N-1) spanning tree method is used for optimal placement.

2.1 IEEE-6 BUS SYSTEM

This model consists of 6 buses,11 connecting lines,3generators ,3 loads,3 supplies,3 demands.

ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

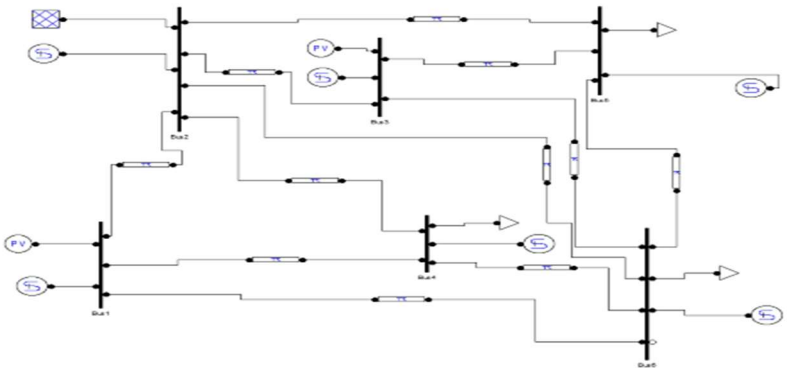

Figure 2. IEEE-6 BUS model

Table 1: Comparison of different method used for optimal placement of PMU for IEEE-6 bus system

Software used	*Method*	*Elapsed time*	*No. of PMU*	*Bus no.*
PSAT	*Depth first search*	*0h 0m 0.0225s*	*1*	*6*
	Graph theoretic procedure	*0h 0m 0.021447s*	*1*	*6*
	Annealing method	*0h 0m 0.07843s*	*1*	*6*
	Minimum (N-1) spanning tree	*0h 0m 0.03743s*	*3*	*2,4,6*

2.2 IEEE-9 BUS SYSTEM

This model consists of 9 buses,6 connecting lines,3 transformers, 3 generators and 3 loads.

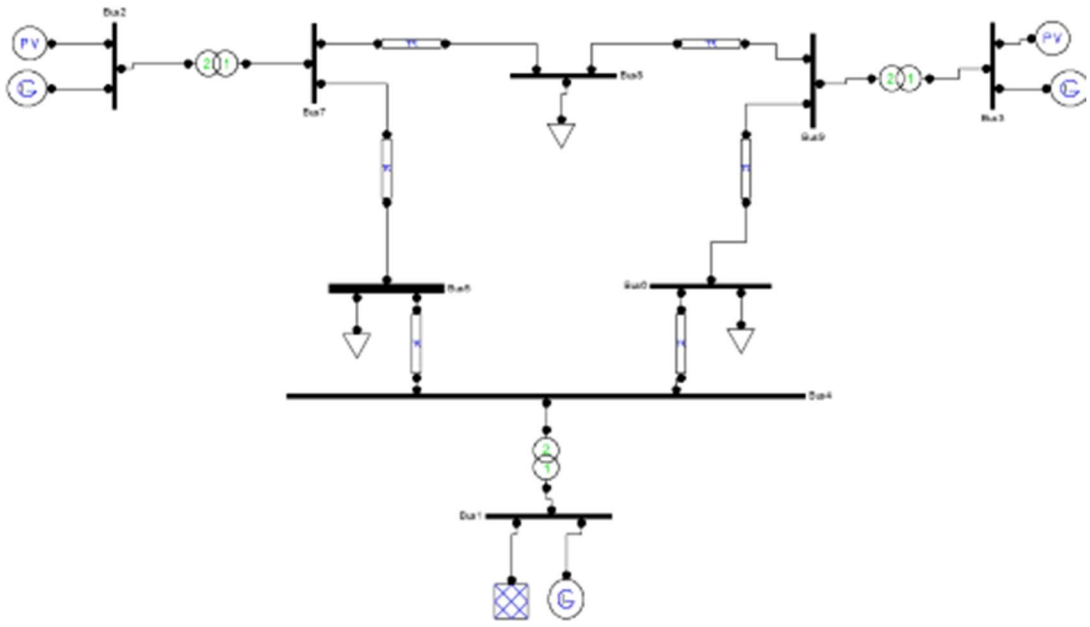

Figure 3. IEEE-9 BUS model

ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

Table 2: comparison of different methods used for optimal placement of PMU for IEEE-9 bus system

Software used	*Methods*	*Elapsed time*	*No. of PMU*	*Bus no.*
PSAT	*Depth first search*	*0h 0m 0.02607s*	*3*	*4,7,9*
	Graph theoretic procedure	*0h 0m 0.020473s*	*3*	*4,7,9*
	Annealing method	*0h 0m 0.03869s*	*2*	*2,1*
	Minimum (N-1) spanning tree	*0h 0m 0.03658s*	*3*	*4,7,9*

3. CONCLUSIONS

Phasor measuring unit is new technology that has potential to improve grid operations and conduct real time analysis. The optimal PMU placement decreases the no. of PMUs to be placed and make system fully observable with minimum no. of PMUs.

A methodology and software used to determine minimum no. of PMUs is presented in this paper. As per result comparison annealing method give minimum no. of PMUs but has slow speed. Graph theoretic procedure gives good speed and optimal no. of PMUs. So, it can be considered best amongst the all-other methods.

REFERENCES

[1] Cai, T.-T., & Ai, Q. (2005). Research of PMU Optimal Placement in Power Systems. 2005 World Scientific and Engineering Academy and Society Int. Conf, 2005, 38–43.

[2] Pegoraro, P. A., Tang, J., Liu, J., Ponci, F., Monti, A., & Muscas, C. (2012). PMU and smart metering deployment for state estimation in active distribution grids. 2012 IEEE International Energy Conference and Exhibition, ENERGYCON 2012, 873–878. https://doi.org/10.1109/EnergyCon.2012.6348274

[3] Rahman, N. H. A., & Zobaa, A. F. (2016). Optimal PMU placement using topology transformation method in power systems. Journal of Advanced Research, 7(5), 625–634. https://doi.org/10.1016/j.jare.2016.06.003

[4] Amare, K., Centeno, V. A., & Pal, A. (2015). Unified PMU placement algorithm for power systems. 2015 North American Power Symposium, NAPS 2015. https://doi.org/10.1109/NAPS.2015.7335254

[5] Chauhan, N. A., & Prajapati, M. (2014). Optimal placement of Phasor Measurement Unit in Smartgrid Optimal placement of Phasor Measurement Unit in Smartgrid. April. https://doi.org/10.13140/2.1.5000.3207

[6] Sudheendra, H. R., Jadoun, V. K., Jayalakskmi, N. S., & Agarwal, A. (2020). Latest Trends in PMU Placement Techniques. 2020 International Conference on Power Electronics and IoT Applications in Renewable Energy and Its Control, PARC 2020, 340–345. https://doi.org/10.1109/PARC49193.2020.236622

[7] Abd el-Ghany, H. A. (2020). Optimal PMU allocation for high-sensitivity wide-area backup protection scheme of transmission lines. Electric Power Systems Research, 187(June), 106485. https://doi.org/10.1016/j.epsr.2020.106485

[8] Appasani, B., & Mohanta, D. K. (2018). A review on synchrophasor communication system: communication technologies, standards and applications. Protection and Control of Modern Power Systems, 3(1). https://doi.org/10.1186/s41601-018-0110-4

[9] Zhu, X., Wen, M. H. F., Li, V. O. K., & Leung, K. C. (2019). Optimal PMU-Communication Link Placement for Smart Grid Wide-Area Measurement Systems. IEEE Transactions on Smart Grid, 10(4), 4446–4456. https://doi.org/10.1109/TSG.2018.2860622

[10] Sudheendra, H. R., Jadoun, V. K., Jayalakskmi, N. S., & Agarwal, A. (2020). Latest Trends in PMU Placement Techniques. 2020 International Conference on Power Electronics and IoT Applications in Renewable Energy and Its Control, PARC 2020, 340–345. https://doi.org/10.1109/PARC49193.2020.236622

ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

[11] Nanda, P., Panigrahi, C. K., & Dasgupta, A. (2017). PMU implementation for a Wide Area Measurement of a power system. Proceedings of 2nd International Conference on 2017 Devices for Integrated Circuit, DevIC 2017, 690–694. https://doi.org/10.1109/DEVIC.2017.8074038