*International Journal Of Engineering Research And Development*
*e- ISSN: 2278-067X, p-ISSN: 2278-800X, www.ijerd.com*
*Volume 20, Issue 6 (June, 2024), PP. 01-05*

# PMU-Installed 330kv Buses Replacing the SCADA System Panacea Due To Power Grid Failure in Nigeria

Ebinowen Tusin Dayo[1,2]
[1] *School of Electrical & Electronic Engineering, Universiti Sains Malaysia, 14300 Nibong Tebal.*
[2] *Federal Polytechnic EEE Department Ile-Oluji, Ondo State, Nigeria*

***ABSTRACT***
*Nigeria's severe issue is its intricate electrical grid and steadily rising power usage, which causes the adoption of contemporary monitoring and control technologies. Nonetheless, Phase Measurement Units are necessary for the extensive use and efficient running of international power networks. The present Supervisory Control and Data Acquisition (SCADA) systems are evaluated in this paper as possible strategic replacements for the installation of Phasor Measurement Units (PMUs) on 330kV buses. By providing a robust and dependable solution that improves the power grid's real time monitoring and control capabilities, it looks to reduce the frequency of power grid breakdowns. The study looks at the critical nodes and transmission corridors in the 330kV Nigerian grid network that require prioritized placement of Phasor or Measurement Units (PMUs) for enhanced monitoring and control. Also, how does the best placement of PMUs contribute to improving voltage stability and power flow control within the 330kV grid network, and the specific technical challenges associated with these improvements? Nevertheless, the shortcomings of the power grid in terms of speed, accuracy, and real time data synchronization become clear. Incase of grid disruptions, the deployment of PMUs eases enhanced situational awareness, quicker fault detection, and more effective decisionmaking. The outcome proves that power systems' dynamics, stability, and control have greatly improved, which has made it easier to build the techniques and equipment needed for the dependable and secure operation of contemporary electrical networks.*

***Keywords**: Breakdown, 330kv grid, dependability, supervisory control, and data gathering, phasor measuring d evice.*

---

Date of Submission: 25-05-2024 Date of Acceptance: 06-06-2024

---

## I. INTRODUCTION

The PMU serves as the brains of the system, delivering information such as voltages and phase angle evaluations. An addedgoal is to estimate the status using synchro-phasor technology todetermine the optimal number of PMUs to install in the system for power system analysis and system economic advantages Penshanwar et al. (2016). While the use of PMUs for online power system monitoring eases the construction of such devices in a WAMS, full observability requires further investigation of the communication system's observability problem Bashian et al. (2019). SCADA and WAMS are the two main measurement technologies used in contemporary transmission networks. The many advantages of adding WAMS readings to conventional Synchro-phasor readings are widely used in SCADA and SE algorithms. SE is an essential part of Energy Management Systems (EMS) because it provides electricity system managers with detailed information about the current state of the electricity system and aids in keeping the resilience and dependability of the electrical grid Zolin et al. (2021). The SCADA system is designed to supply voltage levels across busbars, active power through subsidiaries, and reactive power through subsidiaries. A subsidiary can be both a power transformer and a transmission wire. It should be mentioned that step-up transformers, which link a generator to a load, and step-down transformers, along with the downstream electrical network they are connected to, can both be thought of as loads Dobakhshari et al. (2020). PMU is a more sophisticated kind of SCADA that is used to synchronize time to calculate voltage and current. Its main purpose was to guarantee the observability of the complete power system. The advantage of the PMU is that it can evaluate the voltage and current coming from connected buses and note their magnitudes and slopes. They were used in many countries, and techniques for phasor measurement, PMU installation costs, synchronization, PMU and WAMS application, model validation, and parameter identification were used. It also plays a significant role in the WAMS and has the enhanced feature of monitoring Gopalakrishnan (2023). PMUs are favored for installation at susceptible buses in electrical energy grids, therefore finding the weak buses and deciding the best PMU locations are essential to ensuring network observability. The voltage failure nearness needle, cable resilience directory, rapid voltage resilience index, and a rejuvenated voltage equilibrium indicator using load flow compliance are all used to decide where to deploy the most PMUs at the most vulnerable buses in the electrical network. The effectiveness of the presented method is tested and confirmed by an analysis technique that depends on the binary buses-to-buses connectivity matrix and yields the number of PMU locations needed to display the power grid Babu et al. (2020).Digital microprocessor technology is widely used in modern dispatching, as shown by the introduction of WAMS and the global growth of power systems. With the ability to eliminate or minimize restrictions on the flow of electricity, one of the highest priorities is WAMS. Information gathered from PMUs can be used to save money and increase the efficiency of keeping the electrical network in an operational state. WAMS employs a well-researched technique for quantifying angular data in many remotely found electrical system components Chakrabarti et al. (2009) PMU is an advanced metering device that precisely checks the voltage harmonics and electrical current of circuits in the grid station it is directly connected to. This measurement is synchronized and done in real-time. To provide time-synchronized evaluation using GPS, the tool is connected to the busbars of the electrical network in both the distribution and transmission processes; however, the electrical utilities are not able to cover the costs of equipment installation and maintenance; To handle the best placement of PMU issues and reduce the worldwide price by providing full electrical coverage, many optimization strategies have been devised recently Angioni et al. (2017). PMUs are a deliberate choice because of their exceptional ability to provide correct bus voltage and current phasor readings. However, because PMUs are expensive and require communication connections, it is common to deploy just a small number of them in a system. Modern electrical systems are made to support the installation of traditional meters and extremely precise PMUs, which will enhance network control, surveillance, and security; One popular intelligent optimization technique, the genetic algorithm (GA), is used to find the best set of PMUs Shahriar et al. (2018). SE is an essential part of energy management systems (EMS), providing power system operators with a thorough awareness of the energy system's present operating circumstances to help them keep the security and dependability of the grid. In modern electrical fields, both the SCADA and WAMS principal measuring frameworks are used. There are several advantages of adding synchro-phasor assessment from the grid to conventional SCADA and SE processes Ghasemkhani et al. (2015). A data-driven method for enhancing situational awareness in power distribution networks is presented in this paper. It employs data from PMUs to classify the various types of recurring events that are captured in distribution feeders through analysis.

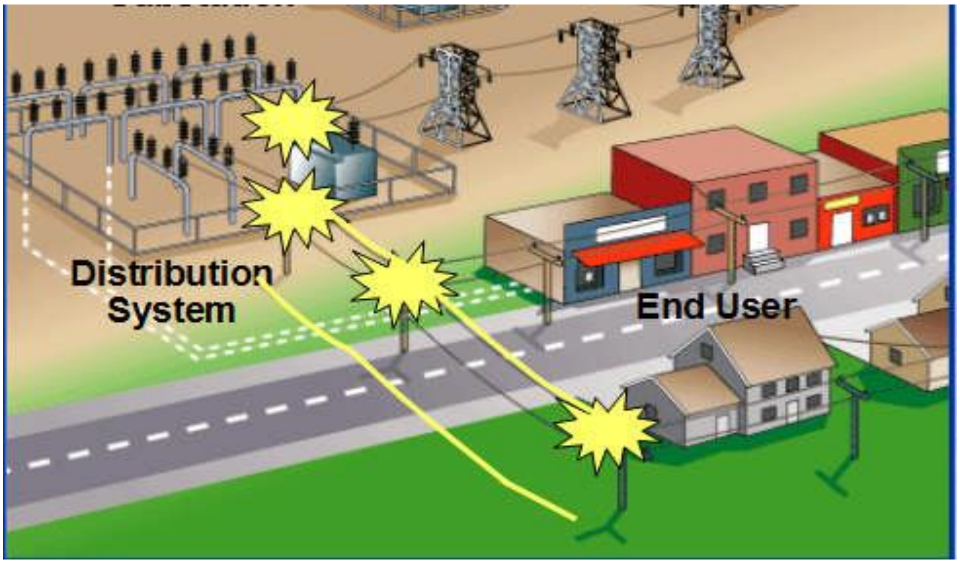
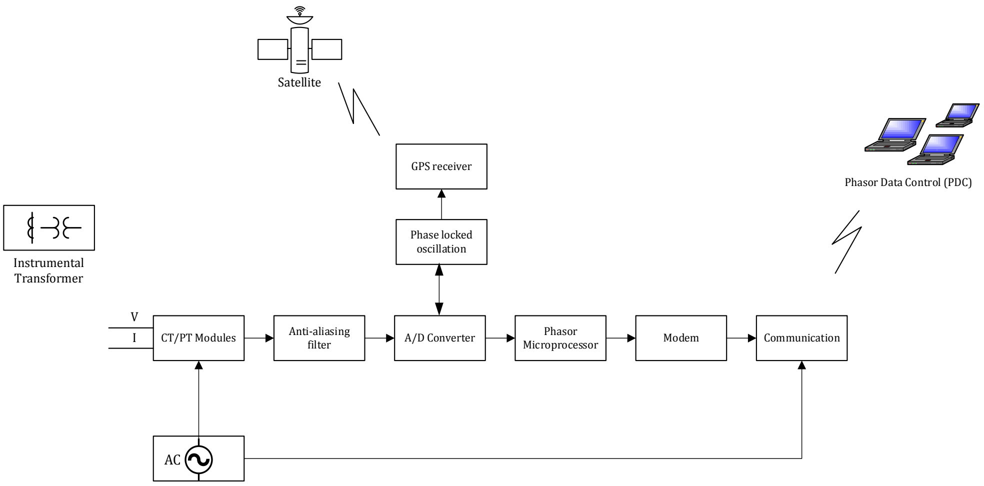



**Fig. 1** Power Grid Topology




**Phasor Measurement Unit (PMU) Architecture**

**Fig. 2:** Phasor Measurement Unit (PMU) Architecture

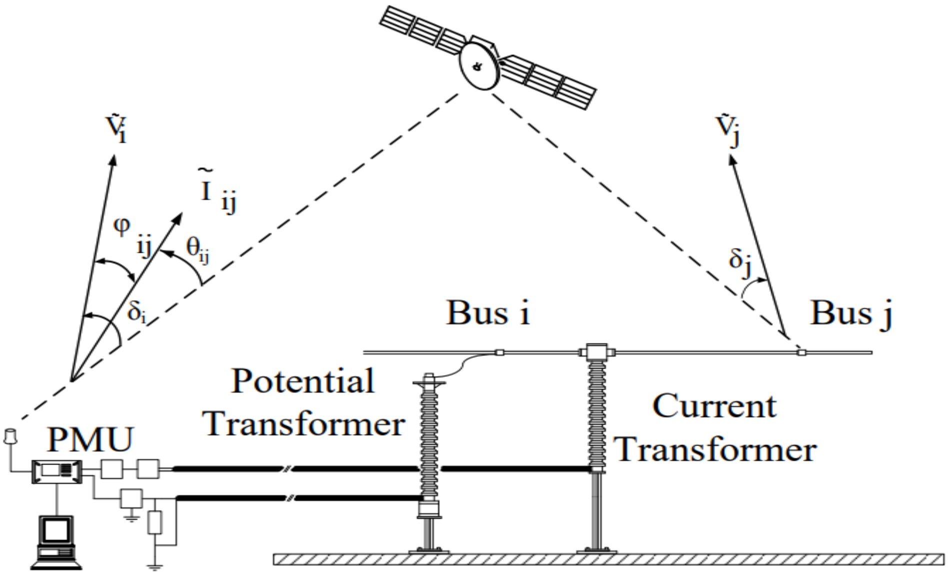



**Fig. 3:** Instrumental Transformer Link to BusBar

## II. MATERIALS AND METHODS

Power System Software Engineering (PSSE), Power System Analysis Toolbox (PSAT), MATLAB Simulink toolbox 2022b, E-Tap, Core i5 PC with 16GB RAM, and dedicated SSD capacity of 512GB. The following is a list of the steps that will be taken tocarry out the goals and aims of this research project:

**Step 1:** Evaluation of Correlated Literature: Perform a comprehensive analysis of the body of research on PMU placement in power systems to decide the most recent developments, approaches, and placement-related difficulties.

**Step 2**: Data gathering and analysis of Nigeria's major grid collapse over the previous 30 years and their causes.

**Step 3:**Data about the current 330kV transmission network in Nigeria is gathered from the National Control Center (NCC) in Oshogbo via the Transmission Company of Nigeria's (TCN) System Operator unit.

**Step4:**The 330kV ringed transmission network in Nigeria and its ten (10) regional networks should be modelled and subjected to load flow analysis todecide the real and reactive power flowing in each line as well as the bus voltages, phase angles, line currents, and other dynamic state basic parameters of the synchronous system.

**Step 5:**Data collection: Compiling pertinent data on the topology of the network, load profiles, generation patterns, and past system events related to the 330kV Nigerian power system; also, learning about the presence and functionality of PMU installations.

## III. RESULTS

Optimal PMU Placement Strategy: The goal of the research is to show the best locations for PMU installation to enhance system monitoring capabilities and maximize grid observability. Anticipation: By generating a set of suggestions for the ideal PMU placement, the developed algorithm will increase the grid'sresilience and dependability.

2. Improved Grid Stability and Resilience:The purpose of the research is to improve the overall PMU placement and strategically enhance the 330kV AC grid's reliability and resilience in Nigeria. Expectation: Using the recommended PMU installation strategy will boost grid stability and accelerate fault

3. Better Decision-Making: PMUs' fast data collection speeds up and improves the quality of decisions made during grid outages. Consequently, issues can be resolved more quickly and effectively, minimizing the impact of disruptions, and ensuring a more seamless operation of the electrical system.

4. Scientific Progress: One example of technical advancement is the employment of PMUs in power grid monitoring and control. This study has the potential to position Nigeria as a leader in the continent's modern grid infrastructure and hasten the adoption of cutting-edge technologies in the country's energy sector.

## IV. DISCUSSION AND CONCLUSION

Achieving comprehensive system observability, ensuring that at least one PMU checks every bus in the network, and minimizing the overall cost of deploying PMUs to the lowest possible level are the main objectives of the OPP problem. The limitation value for the OPP problem for the N-bus distribution system is as follows:

$$Min \sum_{i=1}^{N} Ci \times Oi$$

$Ci$ Oi illustrates each bus's visibility and is defined as follows: reflects the total capital cost of the PMU placed at bus-i.

$$0 = \begin{cases} = 1 \;\; bus\ i\ is\ observable \\ = 0 \;\; bus\ i\ is\ unobsevable \end{cases}$$

In a radial distribution system, the price of each PMU is decided by the number of branches connected to the bus, which is based on the total number of channels. The above-constrained optimization function is used to deploy PMUs as little as possible. For maximum system redundancy, the cost of each -PMU is taken to be equal, changing the goal function to benefits related to resilience and reliability. Reducing the duration and impact on customers of outages enhances the dependability and resilience of distribution networks. It also helps reduce the time it takes to restore service by enabling faster line reclosing, forensic investigation, black-start, island resynchronization, and generation synchronization, as well as fault location and location identification. One can minimize disruptions by finding oscillations and restoring network stability. By finding potential equipment problems and addressing them before they happen, one can also reduce the frequency of outages Eto et al. (2014). Phase angle can be used to check and improve the speed and accuracy of generator synchronization and line reclosing. When distribution network disruptions occur, PMU data can be used to assess the events that happen and help the operator decide the root cause. Numerous events occur in distribution networks, however, the conventional models used to check distribution networks are not able to predict the behaviour of the network with any degree of accuracy under different network disturbance scenarios. PMUs are essential tools for continuous monitoring, control, and surveillance of electrical networks, as this critical literature review research proves. They offer synchronized measurements of phasors, which can be used for real-time monitoring and observation of the state of the electrical power grid network. They measure electrical power grid values, such as voltage and current signals, at each location on the grid network. The goals of this paper are to provide an overview of electrical power grid systems, smart grid technologies, SCADA, PMUs, and the global development of PMUs, including their cost, installation cost, range of applications, quality assurance, fault identification and evaluation, reliability of electricity monitoring and control, and more.PMUs are also made operational by a variety of techniques, including global positioning systems for time synchronization, communication technologies, and analog-to-digital converters.

## REFERENCES


[1]. Angioni, A., Lipari, G., Pau, M., Ponci, F., & Monti, A. (2017). A Low-Cost PMU to Monitor Distribution Grids. IEEE, 1–6.

[2]. Babu, R., Raj, S., & Bhattacharyya, B. (2020). Weak bus-constrained PMU placement for complete observability of a connected power network considering voltage stability indices. Protection and Control of Modern Power Systems, 8, 1–14.

[3]. Bashian, A., Assili, M., Anvari-Moghaddam, A., & Catalão, J. P. S. (2019). Optimal design of a wide area measurement system using hybrid wireless sensors and phasor measurement units. Electronics (Switzerland), 8(10), 1–1. https://doi.org/10.3390/electronics8101085

[4]. Chakrabarti, S., Kyriakides, E., Bi, T., Cai, D., & Terzija, V. (2009). Measurements Get Together. IEEE Power and Energy Magazine, 7(1), 41–49. https://doi.org/10.1109/MPE.2008.930657

[5]. Dobakhshari, A. S., Azizi, S., Abdolmaleki, M., & Terzija, V. (2020). Linear LAV-based state estimation integrating hybrid SCADA / PMU measurements. The Institution of Engineering and Technology, 14, 1583–1590. https://doi.org/10.1049/iet-gtd.2019.1850

[6]. Eto, J., Yang, S., & Lesieutre, B. (2014). Improving Reliability Through Better Models. Ieee Power & Energy Magazine, 44–51.

[7]. Ghasemkhani, A., Monsef, H., Rahimi-Kian, A., & Anvari-Moghaddam, A. (2015). Optimal Design of a Wide Area Measurement System for Improvement of Power Network Monitoring Using a Dynamic Mult objective Shortest Path Algorithm. IEEE Systems Journal, 11(4), 2303–2314. https://doi.org/10.1109/jsyst.2015.2469742

[8]. Gopalakrishnan, R. (2023). Phasor Measurement Unit Across the World and Variables Influencing the Cost of Installing a Phasor Measurement Unit. International Conference on Sustainable Computing and Data Communication Systems (ICSCDS-2023), 994–999.

[9]. Penshanwar, M. K., Gavande, M., & Satarkar, M. F. A. R. (2016). Phasor Measurement unit technology and its applications review. International Conference on Energy Systems and Applications, ICESA 2015, Icesa, 318–323. https://doi.org/10.1109/ICESA.2015.7503363

[10]. Shahriar, M. S., Habiballah, I. O., & Hussein, H. (2018). Optimization of phasor measurement unit (PMU) placement in supervisory control and data acquisition (SCADA)-based power system for better state-estimation performance. Energies, 11(3), 1–15. https://doi.org/10.3390/en11030570

[11]. Zolin, D. S., Ryzhkova, E. N., & Federation, R. (2021). Wide Area Monitoring System (WAMS) Application in Smart Grids. International Youth Conference on Radio Electronics, Electrical and Power Engineering, 1, 1–6.