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Phase Measurement Unit Installation On 330kv Buses To Displace Scada System: A Triumph To Power Grid Failure In Nigeria

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ABSTRACT:
Nigeria's acute problem is its continuously increasing power consumption and complex electrical grid, which causesthe employment of modem monitoring and control technology. However, Phase Measurement Units are essential to the widespread deployment and effective operation of global power networks. The installation of -Phasor Measurement Units on 330kV buses is examined in this paperwork as a potential strategic replacement for the current Supervisory Control and Data Acquisition systems. Its goal is to minimize the frequency of power grid breakdowns by offering a durable and dependable solution that enhances the power grid's real time monitoring and control capabilities. However, the power grid's speed, accuracy and real- time data synchronization deficiencies become increasingly clear. This study examines the technical elements of Phasor Measurement unit integration on 330kV busses, emphasizing the real-time synchronized data-collecting capabilities of these devices. Phase Measurement Units offer a more sophisticated and reliable solution since they can correctly and quickly check voltage and current phasors. The deploymentofPhase Units eases improved situational awareness, faster fault detection, and more making in case of grid disturbances. The result shows that the dynamics, Measurement efficient decision- stability, and control of power systems have significantly improved, and eased the development of methods and tools necessary for the dependable and safe functioning of modem electrical networks.

Keywords: phasor measurement unit; supervisory control and dataacquisition; breakdown; 330kv-grid; reliability.

I. INTRODUCTION

The electrical grid is the system tying together the distribution, transmission, and generation facilities or power grid. It delivers electrical power from generators from the electricity plants to the transmission system, the distribution system, and finally to the residences, businesses, and offices of consumers where the electricity runs their appliances and machinery. The integration of electrical grid components with information infrastructure is commonly referred to as a "smart grid," and it has several advantages for both power producers and users. The electrical energy design is a man-made network that is incredibly large and complicated, the operation, control, and monitoring of such networks now face additional difficulties due to the rising demand for electricity and the restructuring of power systems. To keep things stable and the network's integrity there is consideration to the deployment of a Supervisory Control and Data Acquisition device. Typically, SCADA systems do not support synchronous data sets. Additionally, such systems have low sampling rates. Consequently, the information provided by the SCADA network shows the semi-stable condition of the system, and the command base workers lack the necessary knowledge of the dynamism of the system characteristics (Chen et al., n.d.). The SCADA system's drawbacks have led to the development of the wide-area measurement system (WAMS), which enables correct data assessment(Patrick et

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al., 2013). The fundamental constituent of a WAMS is the Phasor Measurement Unit. The preceding drawbacks could be overcome by measuring the voltage and current angles, as well as by boosting the sampling rate and simultaneous measurement capacity(Mousavi-Seyed et al., 2014). The electricity utility's main goal is to protect the system from severe breakdowns and outages and to send electricity repeatedly and uninterruptedly. The power of supply identification is carried outusing power network analysis. The complexity of the enormous organization causes fluctuations, defects, power outages, and erratic conduct in the electricity source, so it's crucial to spot the problem early on before it gets worse and negatively impacts how the framework and component's function(Hojabri et al., 2019). State Estimation (SE) performs an essential role in evaluating the electricity network's existing fitness by cutting errors and inconsistencies with the help of surveillance instruments such as SCADA and PMUs; SCADA The framework is crucial to the electrical system since it is dependable and easy to use, even if novel obstacles are present. To estimate the present state of the electrical system's performance, proactive oversight is needed in the distribution and transmission grid using system analysis tools, using contemporary tools, low sample rates, sluggish error detection, and a lack of time synchronization signals were discovered as problems with the SCADA system performance(Darmis & Korres, 2023). The SCADA applications in industry, a network sends and receives information or data from any events of supervising, billing, evaluating, doing monitoring of operational components, such as electrical devices, sensor devices, and communication. In the energy scheme by using SCADA, the whole electrical plant can be controlled remotely over long-distance communication links. SCADA can also be used for remote transitioning, and telemetering of grid networks, it is also used for message resolution with a web control Centre (NCC) with other stations with the producing stations (Apagu, n.d.). The development of these devices in WAMS results from the PMUs being capable of tracking the electrical system instantaneously, but electricity framework observability can't be achieved solely through the deployment of PMUs; instead, the infrastructure for communication (IC), is a crucial part of the WAMS, which must be efficiently developed and put into operation to collect data from PMUs and deliver it to command centre.

1.1 PHASORS MEASUREMENT UNITY (PMU)

A PMU is an electronic device used in the power system to measure and analyze electrical quantities such as voltage, current, frequency, and phase angle, among others. The IEEE defines a PMU " as a tool that generates coordinated phasors, frequency, and rate of change of frequency (ROCOF), and infers a time-matching signal from both voltage and current signals, The difficulties can be successfully overcome by using a newly designed PMU which can deliver up to 120 time-tagged observations per second, but those PMUs must have the required features connected to the distribution system's vulnerability factors. The PMU can provide highly accurate and synchronized measurements of these quantities in real time, which is essential for the efficient and reliable operation of the power system(Muhayimana & Toman, 2022). PMUs obtain and decide the analogue signal spectrum as required by taking readings from instrument transformers (CTs and PTs) and sending them to neighbouring PDCs via an aliasing mixer. To acquire the desired digital signal, data are then sent through an analog-to-digital converter in the central processing unit, where the signals' magnitude, as well as phase, are determined and data time is coordinated by a random sampling clock. following the GPS receiver signal(Biswal & Mathur, 2015).

Phasor and its visual interpretation:

1.2 POWER SYSTEM OBSERVABILITY

When calculating the bus voltage phasors at all the system's buses using Kirchhoff's and Ohm's law's known or fictitious measurements, the power system is taken to be entirely observable. Topological and numerical observability are two different types of system observability. By measuring the Jacobian matrix's entire rank, the earlier one is ensured. The latter, though, explicit revelations are made. The system's overall observability in this study is calculated by accounting for topological observability. A distribution network must be observable to function securely and effectively to boost the network's accuracy and dependability. All the bus voltages and line current phasors must be independently proved to be considered completely observable. The installation bus's voltage phasors and the event's lines' current phasors are measured by the PMU. Lines variables and Ohm's law can be used to decide the voltage phasors of buses that are close to the current bus. All buses connected to the bus-installed -PMU are hence observable. For example,

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the installed bus's voltage phasors and the lines' 1-2, 2-3, and 2-4 current phasors are directly measured by a -PMU when it is installed at bus 1 in Figure 1. The voltage phasors of buses 1, 3, and 4 are then decided using these measurements.

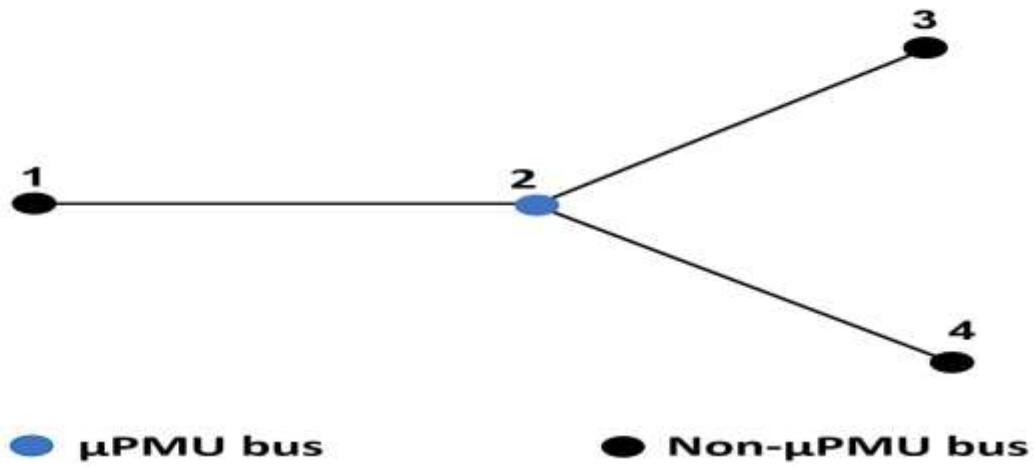

Fig:1a; Measurement of Voltage and Curretnt Phasors.

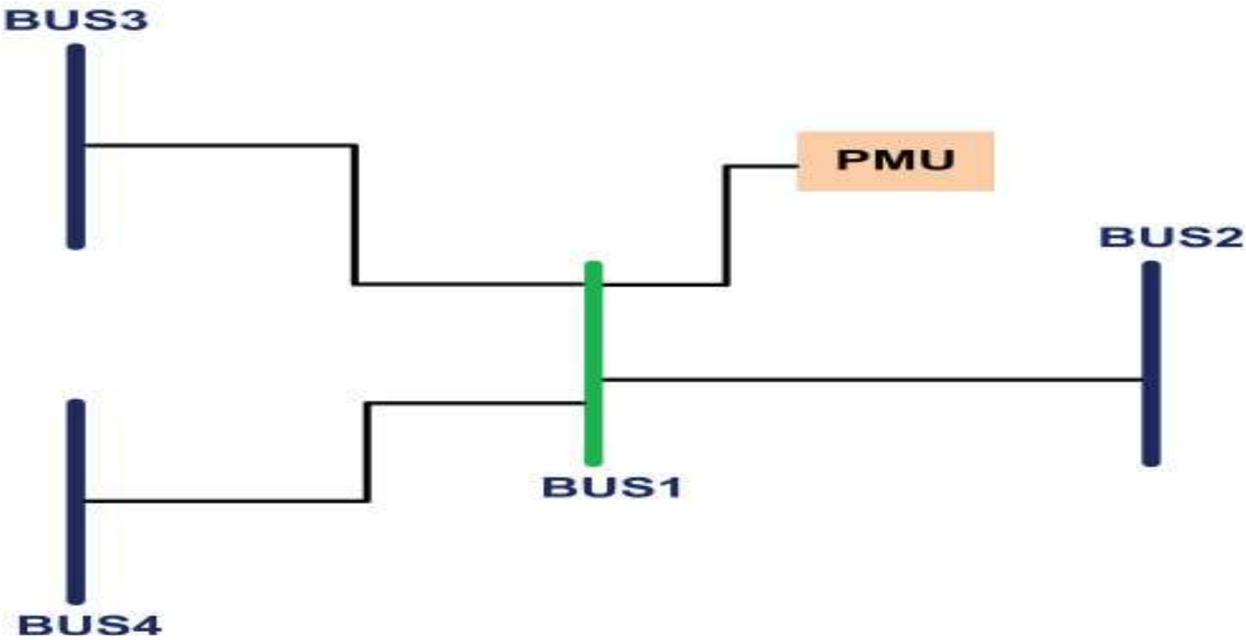

Fig. 1b: **Graphical representation of 4 buses with PMU**

To show the PMU sees the bus voltage phasor at where it is situated as well as the current phasors across the branches linked to that bus, as illustrated in Fig. 2. That improves the system's overall observability. A PMU can at once measure the voltage phasor of bus 1 as well as the current phasors of lines 1-2, 1-3, and 1-4 once it is connected to the bus. Bus 1 is said to be at once observable because of this. The KVL and Ohms laws, along with known information, can be used to decide the voltage phasors of buses 2, 3, and 4. The result is, that these buses are indirectly observable, making the entire system visible(Kotha et al., 2022).

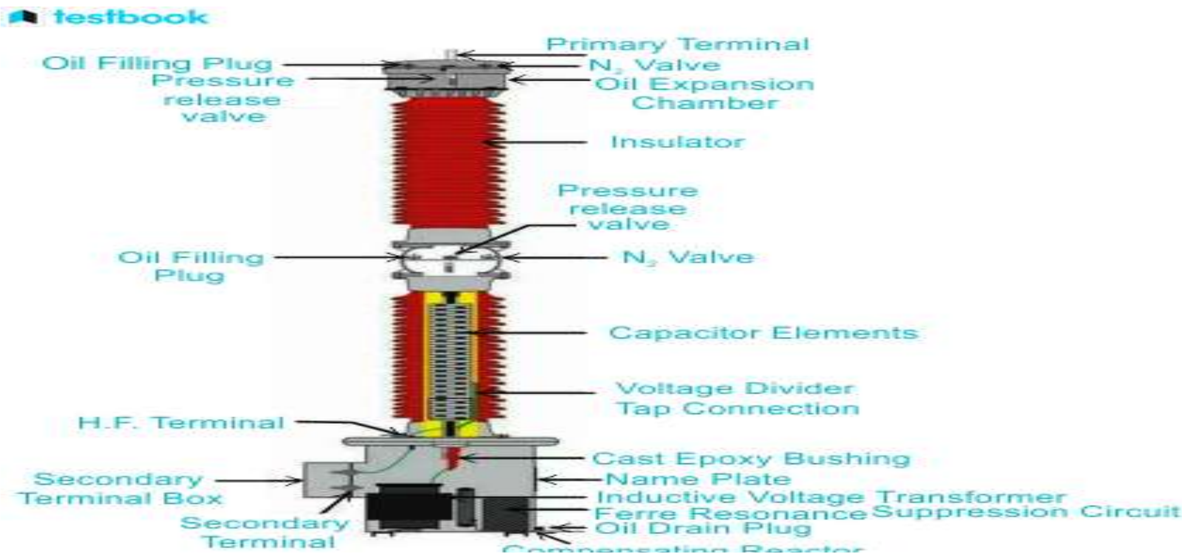

Fig. 3: Potential Transformer

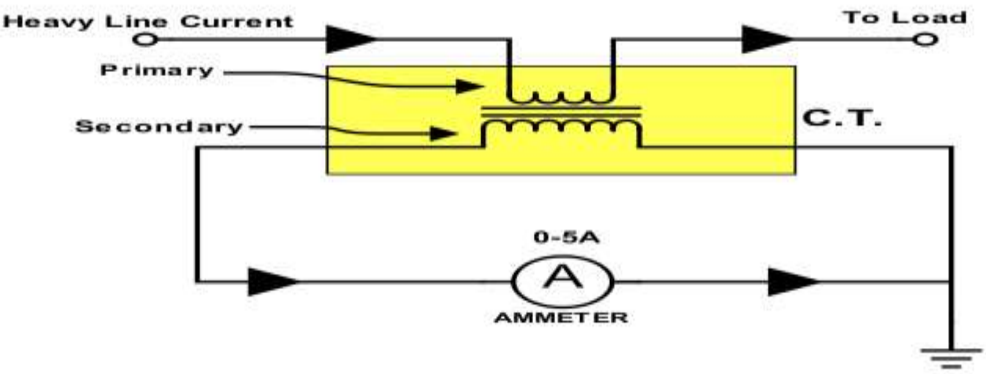

Fig. 4: Current Transformer

Suppose considering a pure sinusoidal quantity that is

$$x(t) = \sqrt{2} \times \sin(\omega t + \varphi) \quad (1)$$

ω being the angular frequency of the signal in radians per second, and φ being the phase angle in radians.

Equation (1) can also be written as

$$x(t) = \mathrm{Re}\{Xe^{j(\omega t+\varphi)}\} \quad (2)$$

The sinusoid of Eq. (1) is represented by a complex number X* known as its phasor representation.

$$xt) = \left(\frac{X}{\sqrt{2}}\right) e^{j\emptyset} = \frac{X}{\sqrt{2}}(\cos\emptyset + \sin\emptyset) \quad (3)$$

The choice of the axis at t = 0 decides the phasor's phase angle, which is arbitrary. The sinusoid's root mean square value is the same as the length of the phasor. It is claimed that only a pure sinusoid can have a phasor representation. Many signals with different frequencies might distort a waveform, making it necessary to isolate the signal's single-frequency part. Then, using a Fourier transform is possible to extract the wavelength partthat a phasor stands for.

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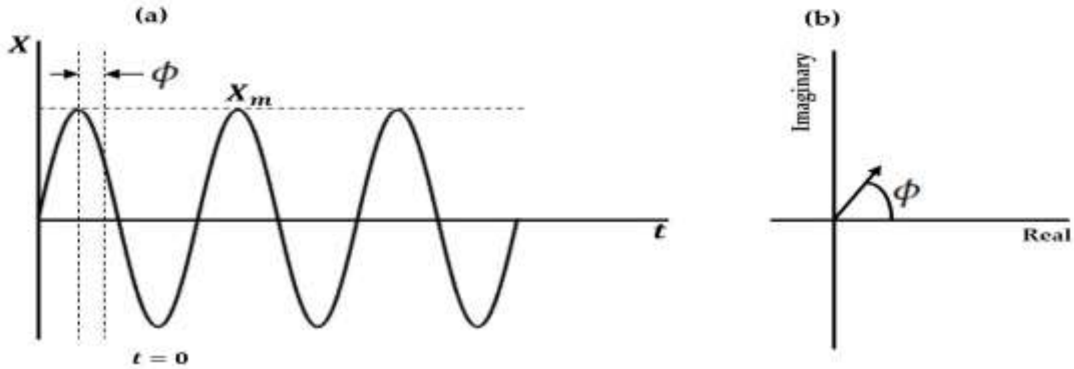

Fig 5: (a) Sinusoidal waveform; (b) phasor representation

II. MATERIALS AND METHODS

The phasor prediction model's goal is to obtain the phasor representation. Usually, the basic frequency of the electrical system's configuration frame is one period, Sample waveform data are assembled transversely. Commercial PMUs now sample at rates that are noticeably higher than the first standard of 12 cycles per second. The phase angle, or angle across the value of the moment and the highest point of the input signal, is decided using the root mean square (RMS) values of the input signal. The input signal was expected to have been filtered using the Nyquist criterion for the chosen sample rate, and the angular If the input signal's frequency deviates from the actual frequency, corrective and amplification should be applied to compensate for it. The fractional process frame is not necessary for phasor estimating in the multiple-cycle window when the estimator of the data window needs to be moved from one period to another PMU (Gopalakrishnan, 2023). Additionally, synchronization signals can be transmitted viaterrestrial fibre-optic networks. PMUs, which employ the precision time protocol to synchronize clocks over computer networks with precision down to the sub-microsecond range, may also be synced. The IEEE Standard 1588 - 2019 quantifies Precision Time Protocol version 2, and the IEEE Standard C37.238 - 2011 specifies its outline for use in power systems. A grandmaster clock found at the top of each system synchronizes the various clocks to establish a universal time(Alghamd & Schukat, 2020).

A comprehensive analysis of the body of research on PMU installation in power systems was carried out with the recognition of the most recent developments, approaches, and difficulties in PMU placement.Recognize the various factors that go into the best possible placement of PMUs. Essential information about the power system, such as load profiles, generation patterns, network structure, and past system eventswas collected. The functionality of the PMU installations that are currently in place was equally found out. The power system that is being studiedwas simulated and modelled using power system simulation tools (MATPOWER) to assess how the location of PMUs affects system performance and observability. Smell Agent Optimization method was used to figure outthe best places to put the PMUs while considering financial restrictions, communication infrastructure , and regional constraints.

III. RESULTS AND DISCUSSION

PMUs give operators a more complete understanding of the dynamics of the grid by supplying precise and synchronized real-time data, which helps the early detection and resolution of possible problems.The integration of PMUs greatly increases Nigeria's electricity grid's dependability.Situational awareness and quicker fault identification are enhanced whichminimizes downtime during power system outages. Timely fault isolation and identification speed up restoration efforts and reduce the financial losses brought on by extended outages. This paper has achieved its purpose as it has improved the overall stability and resilience of the Nigerian 330kV AC grid by strategically placing PMUs. Also, it has increased the grid stability, quicker fault identification, and better disturbance response. It also offers insightful recommendations to policymakers and grid operators, helping them in making defensible choices on the deployment of PMUs for improved grid monitoring and control. The use of PMUs in power grid monitoring and control has led to technical progress and gives the potential to accelerate the adoption of cutting-edge technologies in Nigeria's electricity industry and establish the nation as a pioneer in the continent's contemporary grid infrastructure.

IV. CONCLUSION

PMUs are crucial tools for continuous monitoring, control, and surveillance of electrical networks, as this critical assessmentdemonstrates. They provide 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 every given place on the grid network.

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