Optimum Placement of PMU for Total Observability of Power Grid

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***Abstract*- Phasor Measurement Unit is expected to play a vital role in monitoring the behavior of the power grid. In this paper, we propose a novel algorithm for optimal placement of PMU in power grid so that the observability of the grid can be enhanced. We present an algorithm for calculating the locations for optimal placement of PMU such that the entire grid is observable. The proposed algorithm is tested on the power grid of Orissa and the results are reported.**

Keywords— Phasor Measurement Unit ;Standard Busbar; Synchro Phasor.

I. INTRODUCTION

In the era of modern Technology every system needs to be reliable. Power is an essential source in the modern systems and its reliable supply is important for proper operation of these systems. Phasor Measurement Unit (PMU) [1] was invented to fulfil this purpose. A PMU is the device use to extract phasor of voltage and current signal in Power System. A PMU can also estimate the frequency and rate of change of frequency of measured signals in order to optimize energy distribution and to assure. They are considered to be one of the most important measuring devices in the future of power systems. However, the PMU is an expensive device and should be used with extreme care. It is necessary to find the optimal locations for placement of the PMU such that the entire power grid is observable for reliable operation of the power grid.

In this paper, we propose a novel algorithm for optimal placement of the PMU's. The algorithm is implemented in MATLAB® and it is tested on the power grid of Orissa [2]. The results are also reported.

The organization of the paper is as follows. The next section gives a description of the PMU. In the third section the proposed algorithm is presented and is tested on the power grid of Orissa. Finally, the conclusion is presented in the last section.

II. PHASOR MEASUREMENT UNIT

A device which measures the electrical waves on an electricity grid using a common time source for synchronization is known as a Phasor Measurement Unit (PMU). For synchronized real-time measurements of multiple remote system, time synchronization is used on the power grid. The result of the measurement is known as a synchro phasor. In the future of power systems, PMUs are considered to be one of the most important measuring devices. A PMU can be a dedicated device, or the PMU function can be incorporated into a protective relay or other device.

Synchro phasors are time synchronized and updated at a faster rate, so they are superior to SCADA. A phasor data concentrator (PDC) at the LDC collects the data, aligns the data according to time tags, and sends the processed data to applications and archives. These systems may be further linked to higher level PDCs to provide a wide-area view of the power system.

A PMU can measure 50/60 Hz AC waveforms (voltages and currents) at a rate of 48 samples per cycle (2880 samples per second for 60Hz systems). Now Analog to Digital converter is used to digitize the analog AC waveform for each phase. A phase-lock oscillator along with a Global Positioning System (GPS) reference source provides the needed high-speed synchronized sampling with 1 microsecond accuracy. The resultant time tagged phasors can be transmitted to a local or remote receiver at rates up to 60 samples per second. [3]

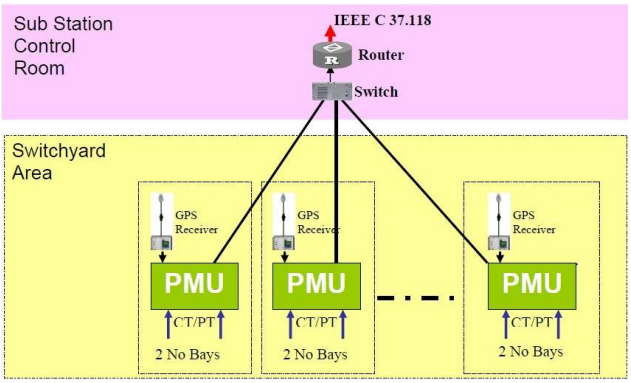

Fig.1. Communication architecture between Substation & Control Centre

After all the data collected from local sub stations, these data are furthered relayed to sub control room where data are compiled with a timing mark on it. They help in detection of fault. The communication architecture is shown in Fig.1.

A.) Communication system for PMU

1. The communication system for PMU should be based on Fiber Optics and should have physical route redundancy. The communication infrastructure, strengthening should be taken on priority for PMU project.

2. Sampling rates for the PMU to be as 25 samples per second, but should have provision for 50 samples per second.

3. Levels of hierarchies in the PMU data flow should be minimized to achieve least latency. (100 milliseconds)

4. PMU's shall record minimum 1 set of 3-phase Bus voltages and 3-phase currents of all feeders.

5. RLDC PDC needs to have the facility of data interface with the SCADA / EMS system apart from collecting data from different PMUs.

6. Work can be initiated on applications of PMU data in the following areas:
• Transfer Capability Assessment
• Analysis of sustained oscillations
• CT/CVT validation
• Vulnerability of relay characteristic.

III. PROPOSED ALGORITHM AND RESULT

The proposed algorithm is tested on the power grid of Orissa, which is shown in Fig. 2. The algorithm is implemented in MATLAB® and the locations for optimal placement of PMU's is determined.

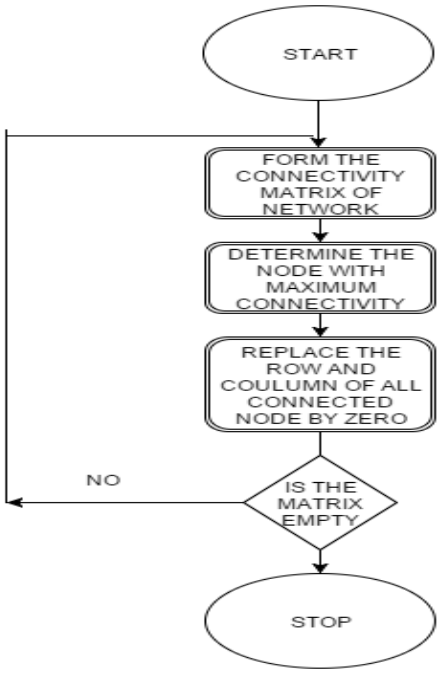

Fig. 2. Flowchart for optimum placement of PMU

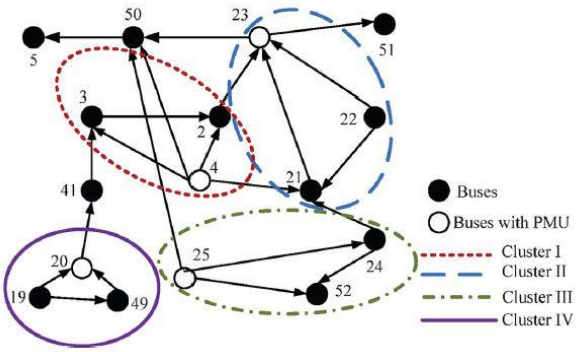

Fig. 3. Power Grid of Orissa [2]

The node with PMU is shown with white circle while black represents without PMU.

IV. APPLICATION OF PMU's

1. Power system automation, as in smart grids.

2. Load shedding and other load control techniques such as demand response mechanisms to manage a power system. (i.e. Directing power where it is needed in real-time)

3. Increase the reliability of the power grid by detecting faults early, allowing for isolation of operating system, and the prevention of power outages.

4. Increase power quality by precise analysis and automated correction of sources of system degradation.

5. Wide area measurement and control through state estimation, in very wide area super grids, regional transmission networks, and local distribution grids.

6. Phasor measurement technology and synchronized time stamping can be used for Security improvement through synchronized encryptions like trusted sensing base.

V. CONCLUSION

The PMU is the advanced method for protection of power systems. They are not only fast, but are also reliable. The main advantage is that it conveys digital signals at a faster rate that makes it far better than traditional SCADA.

REFERENCES

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