PHASOR MEASUREMENT UNIT AND ITS APPLICATION TO SMART GRID

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ABSTRACT:

Power system is the integral part of our daily life. It is available everywhere in the form of simple or complex. In this technical era it is has grown mandatory for industries to avail the faultless power continuously and in a secured manner. It has become the basic necessity for every person on this earth hence it is mandatory to develop the efficient models with smart fault controlling options. This paper reviews the latest Phasor Measurement Unit (PMU) technology development and applications in power system. The reviewed technology can be utilized and combined in the future to address power system online dynamic simulation, control and protection.

Keywords: PMU, Smart Grid, Wide area Monitoring and Control, Real Time Data, Fault Diagnosis, Cascading Failure.

[1] INTRODUCTION

A smart Grid uses two way digital communication with advanced sensors to collect and analyze data for transforming the existing electric grid into intelligent, dynamic self-healing, self-optimizing transmission and distribution grid. As critical grid events often require real-time recognition and real time response. A smart grid uses IP-based, open standard, intelligent communication to measure real-time events such as congestion, system stability, equipment performance, outages and demand response events.

Phasor Measurement Unit (PMU) technology provides phasor information (both magnitude and phase angle) in real time. The advantage of referring phase angle to a global reference time is to get the overview of the power system. It is necessary to learn the effective utilization of this technology as it provides its applications in mitigating blackouts and learning the real time behavior of the power system. With the increase interest in the Wide Area Monitoring, Control and Disturbance Analysis, and to minimize the future black outs caused due to the
cascade tripping, there is a growing interest in the microprocessor based relays and disturbance recorders to provide an additional Phasor Measurement Unit (PMU) measurement and reporting. The reporting rate of the PMU limits the maximum modulation frequency that the PMU can accurately measure.

[2] BASIC PMU ARCHITECTURE
The samples from the voltage and current inputs are collected by the A/D (Analog to digital converter) at the rate of 48 samples/cycle but independent of the 1pps input. The sampling interval is controlled by a well proven frequency tracking algorithm in order to respond dynamically to changes in system frequency. This data is sent to the measurement processors which handle the GPS and IRIG-B inputs and provides synchronized phasor measurements. In addition to that a communication processor handles the Ethernet communication. [Figure 1] below shows the basic PMU architecture.

![PMU Architecture Diagram](image)

**Figure: 1 PMU Architecture**

[3] ADVANTAGES OF SMART GRID
i) Enables active participation by of consumers by providing choices and incentives to modify electricity purchasing patterns and behavior.
ii) Autonomous control actions to enhance reliability by increasing resiliency against component failures and natural disasters actions.
iii) Efficiency enhancement by maximizing asset utilization.
iv) Resiliency against malicious attacks by virtue of better physical and IT security protocols.
v) Integration of renewable resources including solar, wind, and various types of energy storage.
vi) Real-time communication between the consumer and utility.
vii) Improved market efficiency. It enables new products, services, and markets through a flexible market providing cost benefit tradeoffs to consumers and market participants.
viii) Higher quality of service – free of voltage sags and spikes as well as other disturbances and interruptions – to power an increasingly digital economy.
ix) Consumers have more control over the source of their power and the price they pay for it [1], [2].
[4] APPLICATION OF PMU
A) PMU in Power System Protection
1. Control of Backup Relay performance
   • False tripping of relays might occur during system disturbances.
   • PMUs can be used for supervisory control of distance relays to overcome this problem
2. Adaptive out-of-step protection
   • Out-of-step relays used to determine if the generators are going out of step
   • Wide-area measurements of positive sequence voltages and swing angles can directly determine stability
3. Security-dependability
   • Failure modes of relay-trips when it should not or fails to trip when it should.
   • Supervisory control can ensure that more than one relay sees a fault before breaker is actuated
4. Improved control
   • Control can be based on measurement values of remote quantities.
   • System can react to threatening situations without employing continuous feedback control.
   • Addition of PMU controllers to local controllers will add robustness [4].
5. Loss of Mains (LOM)
   • LOM or islanding occurs when a part of utility with at least one distributed generator is separated from the system.
   • Phase angle variation from the grid supply substation and distributed generators rarely exceeds 50.
6. Fault Event Monitoring
   • Advantageous to monitor transmission system events at lower voltage levels.
   • PMUs implemented at 400 kV, 132kV and 400 V level.
   • Events initiated and data analyzed.
   • PMUs at lower voltage levels provide accurate monitoring events and good observability of higher voltage level system
B) State estimation (SE):
   • Provides the complex voltage at every bus (state of system).
   • Essential for real time monitoring.
   • Provides input for advanced applications of control like ED, AGC, AVC etc.
Challenges faced in SE:
   • Input data is noisy due to errors.
   • Challenges in network observability.
   • High computational time requirements.
   • Detection and suppression of bad data.
C) Post-Disturbance Analysis
The main objective of post-disturbance analysis is investigation of the system dynamics during large disturbances and analyzing the system sequential events caused by those disturbances. To achieve this, power system analysts collect and assemble the data recordings from various data...
recorders that are at different and remote positions throughout the entire network. However, the considerable amount of the data that has been used for many years is not synchronized. Therefore, it has been extremely difficult and time-consuming to reconstruct this data on the same time axis. This reconstruction is a prerequisite for understanding the sequential events that have occurred during and after the disturbance [6].

Application of Phasor Measurement Technology allows all of the data gathered during the system disturbance to be time tagged based on the same synchronizing GPS signal. Therefore, it is much easier to reconstruct the sequence of events after the disturbance has occurred. Simplifying the reconstruction process will allow the time spent analyzing the vast amount of data to be reduced from months, to days or even hours.

D) Wide Area Phase Angular and Power Flow Monitoring
Since PMUs can directly measure the phase angle differences across power transmission lines, they have an inherent advantage when system operators want to monitor the real time power transfer stress on the power transmission network. This real time monitoring allows the system operators a greater degree of confidence when managing critical transmission corridors; allowing operation closer to the real stability limit of the corridor, whilst still maintaining a safe security level.

E) Wide Area Frequency Monitoring
Power system frequency is one of the most valuable information for on-line assessment of system stability, since the system frequency is the direct measure of the balance between generation and demand. During large disturbances, in particular, the system frequency is rapidly varying and very different in different parts of a bulk system. In the next generation of power systems, one of the biggest changes will be the high integration of renewable generation resources. This will reduce the system’s ability to provide frequency control services, because generation from renewable sources tends to be less controllable than conventional synchronous generators. Therefore, power system operators require an accurate wide-area frequency measurement system, and adaptive emergency frequency control scheme for remaining system frequency stability after power system being subjected to a large disturbance e.g. a sudden outage of large generator. The high data reporting rate offered by PMUs has afforded an opportunity for power system operators to obtain accurate measurements of the dynamic system frequency. If the entire power network is monitored by a synchronized frequency measurement system, then the dynamic frequency behavior of the system can be precisely captured. The most important application of such wide area frequency information is the analysis of system disturbances (e.g. outage of a large generator), which includes the identification of disturbance locations and the estimation of the magnitude of disturbances. The results of such an analysis serve as the preliminaries for the power system emergency load shedding scheme [3], [7].

F) Inter-Area Oscillation Monitoring
The typical frequency range of inter-area oscillations is from 0.2 Hz to 0.8 Hz. Hence, it is extremely difficult to capture inter area oscillations by using conventional EMS, due to its low refresh rate. A wide area monitoring system (WAMS) that consists of PMUs can offer a great opportunity to monitor the dynamic behavior of power systems, and identify the inter-area oscillatory modes the high data reporting rate of PMUs and the availability of fast communication links are the primary enablers of this opportunity to monitor the inter-area oscillations.
[5] CONCLUSION

i) Rising fuel costs, under investment in an aging infrastructure, and climate change are all converging to create a turbulent period for the electrical power-generation industry. As utility companies prepare to meet growing demand, greenhouse gas emissions from electricity generation with committed generation capacity may soon surpass those from all distributed energy sources with micro grids.

ii) Smart grid benefits for Advanced smart metering, high power quality, accommodates generation options, load adjustment, wide area measurement and control with PMUs and SCADA system, consumer participation, Demand response support, cyber security and many more for fulfilling consumers demand.

iii) Synchrophasor technology has the potential to greatly improve operator's ability to conduct real time grid operations and detect and respond to potential disturbances. Phasor systems and data will help operators and planners to improve accuracy.

iv) The Static report provides power flow through different methods and state variables, total P,Q and plots of angles ,frequency, voltage magnitude are calculated for IEEE 14 bus system. The optimal PMU Placement decreases number of PMUs that reduces cost of system [5]. Using PMU in smart grid increases reliability of power system stability. Therefore it is possible to monitor the power system observability by using PMU.

REFERENCES


