# PHASOR MEASUREMENT UNIT: - A Revolution in Power System

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**Abstract-***The emergence of phasor measurement unit in power system is revolutionizing the regular grid approach to smart grid. Synchro phasor measurement technology is real-time monitoring in actual system conditions in wide area measurement system. The PMU is a power system device, capable of measuring the synchronized voltage and current phasor in a power system. This paper based on the PMU with pdc (phasor data concentrator) and draw attention towards benefits of pmu in real time monitoring . In other word we can say that pmu is backbone of power system. The purpose of this type tool to assess data and automatically take decision in less and real time.*

***Keywords:- Wide area measurement and control and synchronized phasor measurement unit, optimal placement of Phasor measurement unit, PDC, smart grid and GPS, SCADA.***

## 1. INTRODUCTION

From the time two electricians built the world's first power system at Godalming, England in 1881.later, Thomas Edison gave supply to lamp in irregular alter*n*ation in 1882. Electric power industry has continuously work in field to improve the efficiency and availability of electricity. Revolutionary way to advance in technology for electrical power industry. It has increase the utilisation of energy what we produce, deliver and consume power today. Smart grid is a system to for provide that can monitor energy flow and adjust grid accordingly to demand and supply for providing efficient and economical with an information infrastructure to offer no of benefits for both the generator and consumers of electricity. It is a smart way to connects all transmission line grid, and substation through a two way communication system. The backbone of a successful smart grid system consist of control, automation technology that provides reliable, efficient safe and cost effective.

The elements of the grid and they were connected through wireless protocol. Participating in the decision making that delivers in supply and demand

## 2. FEAUTER OF SMART GRID

i) It can also called as combination of information technology and smart grid .Increase reliability and quality by using sensor network and communication.

ii) Efficiency enhancement by better control and resource management in real time.

iii) Automatically detect and response to malicious attacks by virtue of better physical and IT security protocols.

iv) Expanding deployment in renewable resources including solar, wind etc.

v) Real-time information exchange between the consumer and utility.

vi) Improved market efficiency by reducing losses , voltage deviation and increase reliability of system

vii) Free of voltage sags and spikes as well as from harmonics.

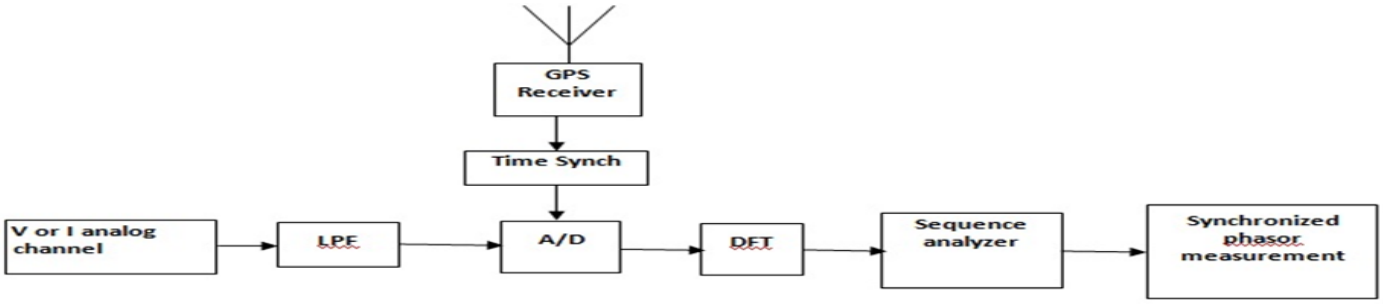


**Fig -1:** Control System in WAMS

**3. Application Domains**

**3.1 Wide-area monitoring system**

Wide-area monitoring system (WAMS) in power grid this involves gathering data from and controlling a large section of the grid through the use of time synchronized and GPS. It is to collect all over grid and extract result from it .It help in monitor whole power system by identifying stability and weakness. By this helps in taking order to implement counter measures.

**Components of WAMs**

1 Phasor measurement unit (pmu).

2. Phasor data concentrator (pdc)

3. Global positioning system (GPS)

4. Communication channel (mostly optical cable fibre).

5. Visualisation and analysis tool (for accurate result from data)

**4. Wide Area Monitoring System for Smart Grid Application**

1 . Less greenhouse gas by supporting and promoting electrical vehicle and generation of renewable energy of low carbon.

2. By increasing customer choices by developing smart energy saver devices and using smart meter infrastructure.

3. Self-healing property of smart grid and decision support software which increase efficiency.

4. Evaluating power system to prepare for combinations of uneven events, prevent wide-area blackouts and fast recovery from an emergency state.

**4.1 SMART METERING:**

This can be called as AMI (advanced metering infrastructure) which enables two way communications which help in provide electric price to customer on consumption including time and electricity consumed.

The function and application

1. Power quality recording

2. Automatic meter reading.

3. Setting of normal supply limit.

**5. SYNCHRONISED PHASOR MEASUREMENT UNITS**

Synchronized phasor measurement is device to measure voltage/current's phasor (i.e its amplitude and phase). The phasor measurement units provide real time measurement of voltage and current within a microsecond. This has been made possible by the availability of Global Positioning System (GPS) and the sampled data processing techniques developed for computer relaying applications. Accuracy for synchro phasor is measured by value termed the "total vector error" or TVE.

The total vector error which must be < 1% under steady state condition. It can also define as square root of difference squared between the real and imaginary parts of theoretical of actual phasor .It can be presented as a percentage. PMU is customized to measure harmonics, negative and zero sequence quantities. Synchro phasor technology make valuable contribution in power system for better real time tools that enhance system operators. A synchronized phasor measurement unit allow high resolution and high speed measurement of voltage / current at particular time and collect and deliver synchronized high speed grid condition data along with analysis. Other hand it provide another level of dynamic security protocol.

### 5.1 NEED OF SYCHROPHASOR

- Real time operations applications
- Wide area situational awareness
- Frequency stability monitoring
- Oscillation monitor for damage control
- Voltage monitoring
- Alarming
- Manage 'big data'
- Capturing various type of data for analysis
- Potential backup to system or scada
- Provide data to improve accuracy
- Operations planning
- Wide area controls

In area of SCADA system synchro phasor technology allow the collection and sharing of high speed and real time .the asynchronous data cannot provide accurate data for analysis. But synchronous data can be used to create wide area monitoring system across the power system for accurate analysis and react to situation of grid.

## 6. SYNCHROPHASOR TECHNOLOGY

An AC waveform can be mathematically represented by the equation:

$$V = Vm*\cos(wt+\varphi)$$

Where: Vm = magnitude of the sinusoidal waveform

$\omega = 2 * \pi * f$ where f is the instantaneous frequency

$\varphi$ = angular starting point for the waveform

It represents both magnitude and phase of electrical wave. They are measured by high speed monitor called phasor measurement unit (PMU).Synchro phasor technology is used real time operation which increase efficiency and lower operating cost.

Wide area monitoring utilize synchro phasor measurement which help to create reliable and efficient improve in power grid. It can help in predicting, understanding and control over power infrastructure in real time. In a phasor notation this waveform is typically represented as:

$$P=Xm/2½<\pm ø$$

Since in the Synchro phasor definition correlation with the equivalent RMS quantity. A scale factor of $1/\sqrt{2}$ must be applied to the magnitude.

In the real world the power system operates at exactly the normal frequency. As such the calculation of the phase angle $\theta$ needs to take into account the frequency of the system at the time of measurement. For example if the nominal frequency of operating at 59.5Hz on a 60Hz system(or 50 Hz) the period of the waveform is 16.694ms instead of 16.666ms a difference of 0.167%.

## 7. PHASOR DATA CONCENTRATOR

It receives and time synchronization phasor data as input from multiple Phasor measurement unit to produce real time and time aligned as output data stream over GPS. A pdc can exchange data with other pdc at different location (diff geographical region). Through this. of no. of pdc connect across common node of synchro phasor data system. This help to maintain data quality, timing and cyber security and also have secure VPN form communication centre.

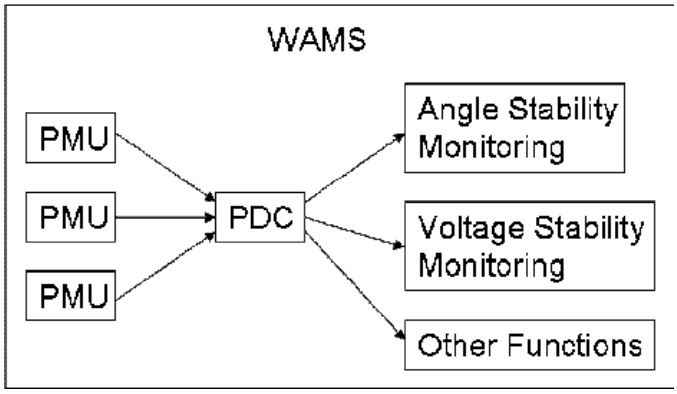


**Fig-3:** Typical PDC in WAMS

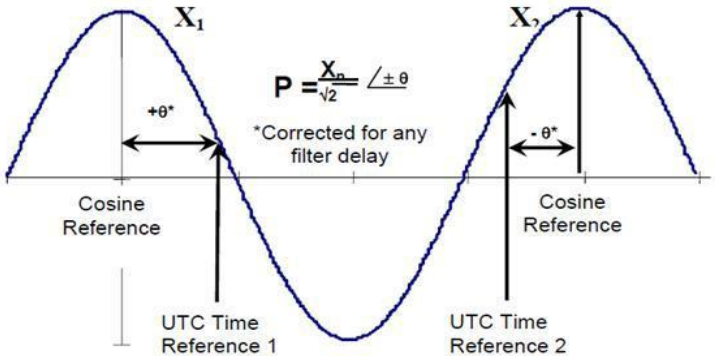


**Fig- 2***:* Synchro phasor

## 8. PMU IN INDIA

To keep power grid stable and reliable all the time is very critical to Indian power system operators or any grid operator. Hence, grid operators need reliable and accurate visualization of the grid. Due to complex and dynamic nature of the Indian power system, the characteristics of the power system changes randomly in real time due to events such as generation loss, line trips (line-ground, line-line faults etc.).The system operator to implement emerging new technologies for grid monitoring. Consequently, Indian grid operators started adopting synchro phasor technology with the implementation of Wide Area Measurement System (WAMS) project in India. First pilot project in India is in northern region in 2010. In 2011, an Indian origin vendor came up with an indigenously designed PDC and installed it in a demo project in Southern Region (SR) along with four PMUs. PMU provide data can utilised for real time dynamic analysis, this help in prediction of frequency of power supply and active and reactive power profile.WAMs technology utilized for uneven blackout and understanding working of power system. Phasor Data Concentrator (PDC) and other associated equipment have been installed at Northern Regional Load Despatch Centre (NRLDC), New Delhi.

## 9 . ISSUES IN WAMS

i) Waiting time PDC have maximum time waiting time of 2-4 sec, to allow for all pmu data to be collected for aggregated output. If data from all PMU reaches PDC on time output data goes right away for monitor.

ii) Attack in WAMS Diff. type of method is use for protecting against the vulnerability like analogue microwave, SONET (synchronous optical network) and VPN (virtual private network.

iii) High investment required.

iv) Sudden variation in measured quantities.

v) Delay- late arrival of data either discards or goes to data store which create problem in synchronize data for better output.

**10. PMU IMPLEMENTATION**

Phasor measurement units are predicted to become a very vital part of power systems state estimation. As such the measurements from PMUs are proven to increase the observability of power systems by strategic placing of a min. Number of phasor.

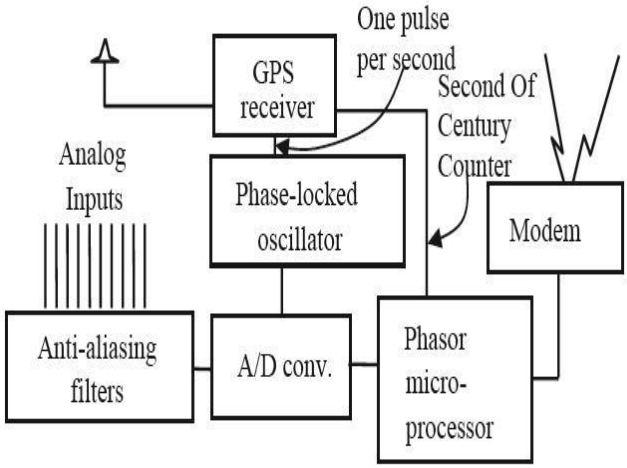


**Fig-4:** Major element of PMU

As in many relay designs one may use a high sampling rate called oversampling with corresponding high cut-off frequency of the analogue Anti-aliasing filters. This step is then followed by a digital decimation filter which converts the sampled data to a lower sampling rate thus providing a digital anti-aliasing filter concatenated with the analogue anti-aliasing filters. The advantage of such a scheme is obtain the effective anti-aliasing filters made up of an analogue front end and a digital decimation filter are more stable.

Aging and temperature variations are concerned. This ensures that all the analogue signals have the same phase shift and attenuation thus by measuring the phase angle differences and relative magnitudes of the different signals. As an added benefit of the oversampling technique if there is a possibility of storing raw data from samples of the analogue signals they can be of great benefits for analysis.

The sampling clock is phase locked with the GPS clock pulse. Even higher sampling rates are certainly likely in the future to more accurate phasor estimates since higher sampling rates do lead to improved estimation accuracy.

But some of problem arises in implementation of pmu in wide area monitoring (WAM) like communication delay in receiving signals from different places at time of monitoring and this is one of major problem of pmu. Secondly highly calculation and computational is require give out exact steady state of power system in high frequency in real time and some of problem are harmonic waveform make difficult to analysis manage large amount of data and very difficult to handle it.

**11. CONCLUSIONS**

1) The future power system will face more stressful for improved protection.

2) PMU is easily support wide area monitoring system (WAMS) with synchronized data that help in enhancement of power system stability.

3) PMU and SCADA help in power system protection, Security and advanced monitoring.

4) Power quality maintenance is imp. Aspect in economic operation of system So, pmu is help to maintain quality.

5) It helps in troubleshooting the state estimator and improves quality.

6) Present power grid increasingly dependent upon information and communication technology for operation and control.

7) Reliable communication required for phasor measurement unit .

8) Phasor systems and data will help operators and planners to improve accuracy.

9) Smart grid benefits for advance smart metering ,load adjustment wide area measurement and control with PMU and SCADA.

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