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Importance of Phasor Measurement unit in Indian Power System

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***Abstract*—Phasor Measurement Unit (PMU) technology affords the phasor information in real time. The advantage to refer phase angle to a global position time is to develop the all sight of the power system. It is necessary to gain the effective utilization of Phasor Measurement Unit technology as it provides its applications in making less severe blackouts and gain the real time behavior of the power system. Disturbance recorders to provide an additional Phasor Measurement Unit (PMU) measurement and reporting the synchrophasors outlines certain exact requirements in terms of how to in exact terms measure the phase angle with respect to the worldwide time reference the coordinated universal time, and how to report the phasor details. The standard also identifies clearly the Total Vector Error allowed in evaluating the phasor for district compliance level to allow interoperability into different vendor PMUs. The reporting rate of the PMU limits the extreme modulation frequency which is the PMU can exactly measure. When the modulation frequency gets as far as half of the PMU reporting rate, the Nyquist frequency, the PMU cannot calculate the modulation parameters. This is the process for one of the requirements in the Standard. When testing PMUs for higher frequency modulation wanted, the PMUs must unacceptable this modulation and the "true" phasor is the phasor of the signal fundamental, which is not change its amplitude and frequency.**

1. INTRODUCTION

1.1) what is Phasor?

The voltage and current produced from the generator is alternating in nature. Hence the all transmission and distribution system voltage and current are alternating in nature. If we will start solving AC circuits using the equations then it will be very difficult to solve the large AC circuit problems. An idea of phasor is used to simplify any AC circuit problem. The beauty is that any sinusoidal wave can be constituted by a phasor. The phasor is as vector. It has magnitude and arrow direction as shown in Fig-1. Note that current or voltage is not vectors. Phasor is a mathematical implement which has complete calculations in electrical engineering simple. If there are two voltage waves then they can be constituted by two phasors, the length of each phasor corresponding to the magnitude of respective voltage as shown in Fig-1 red and green phasors relational to red and green sinusoidal waves separately. Here in case we have taken the magnitude of green phasor regarding half which of red phasor and the green phasor is 60 degrees at the red phasor.

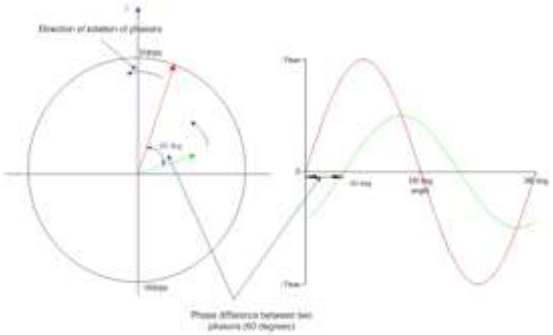

Fig.1 Sinusoidal waves and the corresponding phasors

As the phasors at all time rotate in anticlockwise direction, from the phasor diagram it is clear that the green phasor is to the far side of the red phasor. Carefully estimate both the sinusoidal and phasor representation. In simple AC circuits the phase difference into voltage and current waves get due to reactive circuit elements like inductors and capacitors. The phase angle difference is able to on the numerical values of the reactive elements and active elements (resistance).

1.2) Why Phasor are Important?

The process of the LTI system on a complex sinusoid is thus make smaller to a calculation have only phasors, which are simply complex numbers. Sinusoids can be expressed as phasors and calculations can be performed simply. Thus, reducing the task Phasors allow a simple and easy method to constitute and accomplish calculations on a waveform. Phasors provide information of the wave at that instant i.e. amplitude (RMS value) and direction (phase angle). By behaving towards polyphase AC circuit quantities as phasors, balanced circuits can be making simpler and unbalanced circuits can be behave as an algebraic combination of symmetrical circuits. This approach greatly making simple the work required in electrical designs of voltage drop, power flow, and short-circuits currents. The technique of synchrophasors takes digital instruments to measure the phasors amount to transmission system voltages at extensive points in a

transmission network. Small variation in the phasors is quick to detect indicators of power flow and system stability.

2. LITERATURE SURVEY

Krish Narendra, Tony Weekes *et al* in [1] this paper shares the utility knowledge of the PMU data communication features. A microprocessor created DFR with a PMU ability, mounted at a substation is considered for the learning. The PMU statement and its contact will be the attention of this impact. The effect of transfer the real time PMU data packets above the network with extra routine network activities in a Utility situation will also be studied and discussed. Related to routine network traffic, the PMU data packets traffic is slight.

Ruchi Verma, Balram Timande *et al* [2] Power system is the essential part of any business. It is accessible all over in form of simple or complex form. In which technical time it is has developed required for industries to increase the perfect power regularly and in a safe method. It has developed the basic need for each person on this earth hence it is compulsory to grow the capable models with smart fault controlling options.

Chandarani Sutar, Dr. K. S. Verma *et al* [3] A smart grid uses IP-based, open normal, smart communication to extent real-time actions such as congestion, system constancy, equipment act, outages and demand reply events. Synchrophasor measurement skill is exact and real-time observing with high resolve of real system situations in wide area. The planned methods has been proved, compared and calculated using PSAT Software which shared passed time, speed, observability of buses in full system for optimal location of Phasor Measurement unit.

Bindeshwar Singh, N.K. Sharma, A.N. Tiwari, K.S. Verma, and S.N. Singh *et al* [5] this paper presents a critical analysis on dissimilar application of Phasor Measurement Units (PMUs) in electric power system grids integrated with FACTS regulators for progressive power system monitoring, defense, and control. Also this paper

Presents the recent status of the study and changes in the field of the applications of PMUs in electric power system grids incorporated with FACTS controllers. Authors strongly believe that this study article will be very far suitable to the researchers for outcome the relevant references in the field of the applications of PMUs in electric power system grids integrated with FACTS controllers.

C.Anil Kumar, K.Lakshmi *et al* [11] this paper presents the fault recognition and classification in power system by Phasor Measurement Units (PMU). PMU senses the fault in less than seconds and it also gives a time synchronized ideals of current and voltage in digital form and it is given to limited Phasor Data Concentrator (PDC). Once main disturbance similar brownouts occur, the safety and control activities have to be started against the power system poverty, that in turn restore the system to a normal state and minimize the effect of the disturbance. Wide Area Measurement System (WAMS) is initial now for monitoring and control the power system acts.

3. CURRENT SCENARIO

3.1) Role of frequency

It is known that three phase AC is both the voltage and frequency to be set at choose values irrespective of distortion in loads that occurs in any way. It is in actually impossible to keep up both active and reactive power without control which would result in defection of voltage and frequency levels. To cancel the effect of load deflection and to maintain frequency and voltage level fixed a control system is needed. After all the active and reactive powers have a combined result on the frequency and voltage, the control method of the frequency and voltage can be separated. Frequency is mainly dependent on the active power and voltage is mainly dependent on the reactive power. Thus the concern of to control power systems can be separated in two independent problems. The active power and frequency control is known as load frequency control used in transportation of electricity. At the time of transportation, both the active and reactive power proportion must be control in the generation and utilization this use of tie-line power set up a new fault in the control problem. When quickly variation in active power load occurs to an area, the area will achieve its energy through tie-lines from another area. After all the area that is subject to the variation in load should balance it without external support.

3.2) Load Frequency Problems

If set frequency is essential the operator can arrange the velocity of the turbine by changing the characteristics of the governor when essential. If a variation in load is taken care by two generating stations running parallel then the complex nature of the system access. Another way of divided the load is that both regulate their generations to keep the frequency constant. This is known parallel frequency regulation. The next possibility is that the variation in the frequency of a specific area is taken care of by the generator of that area thereby keep the tie-line loading. This method is called as flat tie-line loading control. In choosy Frequency control each system in a group is taken care of the load variation on its own system and doesn't help another system, the group for changes outside its own limits. In Tie-line Load-bias maintain all the power systems in the interconnection aid in regulating frequency indifferent of where the frequency change originates.

3.3) Importance of Voltage control

When the load on the supply system varies, the voltage at the consumer's terminals also varies. The changes of voltage at the consumer's terminals are improper and essential be keep within chosen limits. In case of lighting load, the lamp characteristics are very sensitive to variation of voltage. In case, if the supply voltage to glowing lamp decreases by 6% of fixed value, then incandescent power may decrease by 20%. In other way, if the supply voltage is 6% above the fixed value, the life of the lamp may be decrease by 50% due to fast degeneration of the filament.

3.4) Voltage control problems

Determining AVR fixed points and supplementary input signals: The Automatic Voltage Regulator fixed points for voltage control are usually not now concluded by any global system action for some optimal conduction. Supplementary signals to improve stability at the time of disturbances are also placed primarily on local considerations. There is a requirement to formulate a global action for voltage control and reactive power dispatch for both static and dynamic location. Modeling what actually happens when excitation systems strike limits: The mathematical models for excitation modifier and associated defensive relaying essential to be integrated in safety study simulations. In many cases the excitation limit controls have some steps which return dissimilar output in terms of what is controlled at what time.

4. PLUS POINT OF PMU

4.1) Wide Area Monitoring Systems

The profits of assembling phasors for post-analysis calculations are certainly standard by some institutions, but the utmost important WAMS use is the on-line calculation of the power system permanence. The checking systems created on synchrophasor measurements agree utilities to well understand the performance and restraints of their power systems, and to make well remedial activities for coming applications. Run-time presentations created on such measurements currently are at present obtainable for observing. The synchrophasors can be connected to SCADA systems in direction to increase. The progressive application of WAMS will allow the system load sharing to be straight measurable, permitting maximum harmless load transfer. The system division, load and shunt impedances can be openly proved to confirm system models and correct system state for projected possibilities can be suddenly computed and ready for irregularities. Also, the WAMS sanctions safe contact to these data at all classified levels of the power system network, i.e. in the substation, utility area centers, utility processes centers, Liberated System Operator centers, and equal at national or central grids, where data can be proceeded upon so in real-time or automatically, and archived for future planning or event analysis. Succeeding the skill increased with wide area monitoring systems, the wide area controller and defense systems are slowly coming as a normal growth results from the application point of view. The wide area monitoring with control takes other alternatives to increase equal further the operation of the power system. The wide area monitoring system delivers access functionality for the exchange of PMU data with other utilities as shown in Figure 4.1.

The delays of synchrophasor created observing and control may contain wide area protection too. The full set of these functions are regularly stated as WAMPACS (Wide Area Monitoring, Protection and Control Systems). It means that WAMPACS can act straight or by inducing the local defenses to protect substances within the power system or the whole power system. Since the wide area range will yield extra time related to the same wild local defense. There may be considerations on whether extensive area functions are actually defense functions. The opportunities for defense functions are given. Falling of lines, load and generator cracking at grid level, islanding, monitoring the power flow with oscillations and lastly the calculation of network permanence by WAMPACS achieve obviously these potentials for protection. The last aim of the WAMS is the aptitude of providing instant suggestion of the power system position founded on synchrophasor measurements and results of the on-line applications. By way of any other system, the early placement of WAMS can usage two altered approaches: Bottom-up: PMUs are available first, and the applications are advanced or combined future Top-down: PMUs are stated and mounted next the application supplies The main example is found when PMUs are mounted earlier the placement of the applications.

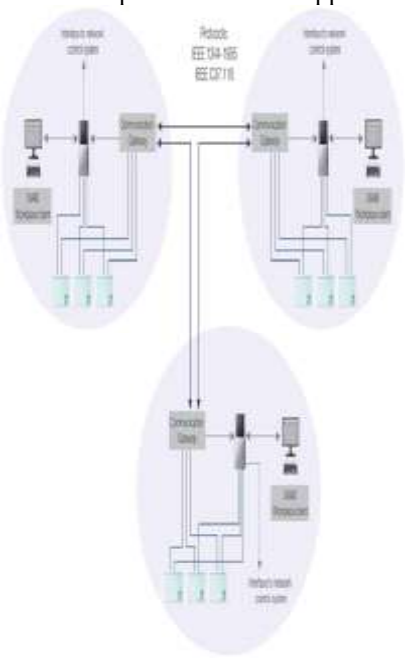

Figure 4.1: Exchange of PMU data among utilities and SCADA/EMS systems

For example the device unit given that the core information to the WAMS, the PMUs situation demands some reflections, with the extent of devices essential for the planned monitoring functionality. For example, if the pre-study specifies that selected transmission lines are expected to present excess throughout certain situations, and that this congestion is to be observed through the Line Thermal Monitoring (LTM) use from WAMS, before the direct conclusion is that these lines will need the putting in of PMUs in every of the line-ends. If the main attention of the synchrophasor applications is upcoming disposition of more progressive and upgraded state estimator created on WAMS, formerly the numbers of PMUs in the system can growth intensely, and their distribution will possibly essential to be blowout beside the power system. Thus, every application can take its individual requirement for the place and number of the PMUs in the power system. Moreover, one necessity notices that the putting in each PMU has similarly to take the physical features of local surroundings into consideration.

More exactly, the obtainable metering (protection) CT middles have to be assessed for the applications. The CT relation and the secondary assessment of 1A or 5A will instant take supplies on the equivalent channels of the PMUs, as well. The number of equivalent channels obtainable, or essential, in each PMU essential also considered.

Various PMUs are feeder slanted towards, and more PMUs are essential to cover definite amount of feeders, while specific PMUs are station-oriented, import that more analog stations are obtainable to allow the assembly of extra feeders in the identical PMU. The time synchronization appliance is similarly of significance. Every PMUs present the probability of inside GPS receiver, though further PMUs want external GPS receivers. Between further essential features for the application of the WAM technology are the progresses in the field of telecommunication. In line for the detail that single of the benefits of this skill is made on incorporated data achievement, its consistency and accessibility is very dependent on a stable on-line link between PMUs and data concentrator.

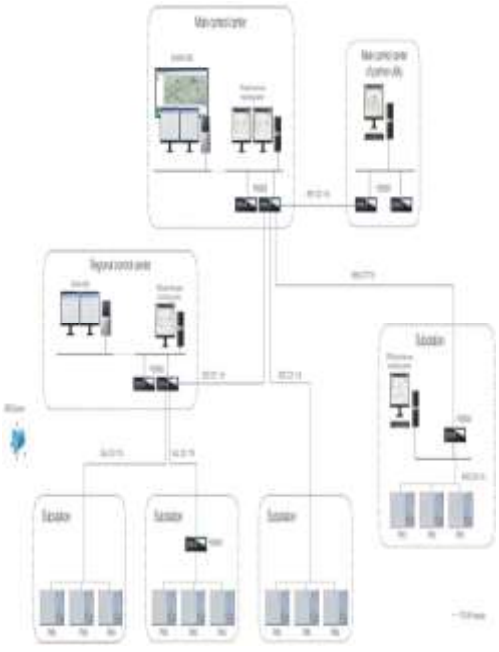

Figure 4.2 WAMS architecture and deployment

4.2) Time synchronization

Data delivered by the PMUs are very perfect and allow system experts to regulate the exact order of actions which have run to the brownouts, and support evaluate the sequence of events that supports identify the particular causes and malfunctions that may have added to the catastrophic failure of the power system. As per practice by WAMS is expanded, it is natural that further uses of phasor measurements will be initiate. In specific, important works already exists that deals by application of phasor measurements to system observing, safety, and control.

A pure sinusoidal waveform will be characterized by a single complex number identified as a phasor. Consider a sinusoidal signal

$$X(t) = X_m\cos(\omega t+\phi) \quad \ldots\ldots(1)$$

The phasor illustration of this sinusoid is assumed by

$$X=\frac{Xm}{\sqrt{2}}\,\varepsilon^{j\Phi}=\frac{Xm}{\sqrt{2}}(\cos\Phi+j\sin\Phi) \quad \ldots\ldots(2)$$

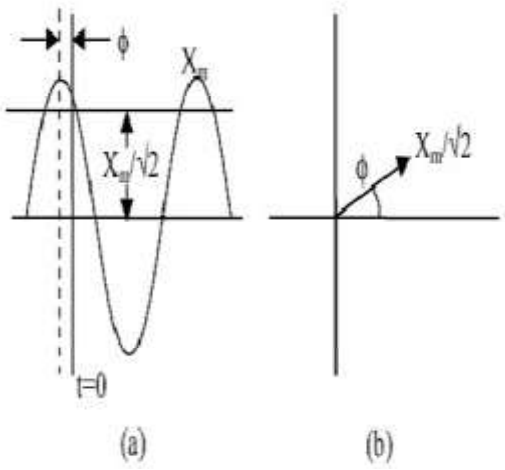

Fig.4.4 Phasor representation of sinusoidal signal

Note that the signal frequency ω is not clearly specified in the phasor illustration. The magnitude of the phasor is the RMS value of the sinusoid, $\frac{Xm}{\sqrt{2}}$ and its phase angle is ϕ, the phase angle of the signal in equation (1). The sinusoidal signal and that one phasor illustration specified by equation (1) and (2) are shown in Fig.4.4 Note that positive phase angles are stately in a counter circular direction since the real axis. Then the frequency of the sinusoid is contained in the phasor description, it is clear that all phasors which are involved in a single phasor figure essential have the equal frequency. Phasor illustration of the sinusoid indicates that the signal remains fixed at all times, leading to a fixed phasor illustration. These ideas essential be changed when practical phasor measurements are to be passed out once the input signals are not continuous and their frequency can be a adjustable. While a constant phasor suggests a static sinusoidal waveform, in preparation it is compulsory to compact with phasor measurements that consider the input signal above a fixed data window. In several PMUs the data window in use is one period of the important frequency of the input signal.

If the power system frequency is not equivalent to its token value, the PMU uses a frequency tracing stage and therefore evaluations the period of the important frequency element earlier the phasor is assessed. It is clear that the input signal either harmonic or non harmonic mechanisms. The undertaking of the PMU is to discrete the essential frequency element and find its phasor demonstration. Synchrophasor is a term used to define a phasor that has been predictable at direct called as the time label of the synchrophasor. In direction to find coinciding

measurement of phasors through a wide area of the power system, it is essential to synchronize these time labels, so that all phasor measurements be appropriate to the similar time label are actually simultaneous. Consider the indication t=0 in Fig.4.4 is the time label of the measurement. The PMU essential then offer the phasor certain by equation (2) using the tasted data of the input signal. Note that here anti aliasing filters existing in the input to the PMU that create a phase interruption depending upon the filter typical. Still, this interruption will be an occupation of the signal frequency. The duty of the PMU is to recompense for this delay for the reason that the sampled data are occupied after the anti aliasing delay is presented through the filter. The synchronization is completed by using a sample clock that is phase-locked to the one pulse- per-second signal providing by a GPS receiver. The receiver might be made in the PMU, or might be mounted in the substation and the synchronizing pulse circulated to the PMU and to some further device that requires it. It must also be noted that the common result of the PMU is the positive system voltage and current phasors. In several cases the PMUs are similarly able to deliver phasors for separate phase voltages and currents.

5. CONCLUSION

In this paper, it is clear that PMU systems will be implementing in most important transmission networks. To a wide range extent the success of this to achieve a goal depends upon sticking to the industry standard governing the PMUs. This paper has been also speak to a survey on phasor measurement units (PMUs) in power system for improvement in quality of power system stability such as frequency constancy in coordinated power system networks. Also in this paper talk about the current status of the research and advancement in the field of the applications in PMUs in power systems for improvement of power system stability such as, frequency constancy improvement in combined power system networks. Synchrophasor technology has the capacity to very much improve operator‘s ability to organize real time grid processes and reply to potential disturbances. Phasor systems and data will help operators and planners to make better accuracy

6. SCOPE FOR FUTURE WORK

A generator supplying a single load will represent the power system achieved in the laboratory. At both the generator and the load, measurements of the voltage and the current phasor will be accomplished by a PMU. A measurement combine will be developed in Lab aspect, and utilize the PMU Recorder Light to access the measurements from the PMU. The application will be accurately designed for this power system set-up. Some control parameters, though, will be provided in order to define from which measurement points the PMU is connected. Integrate components, for calculating and expecting power flows, voltage stability index and phasor diagrams, will be elaborated as part of complaining the measurement integrate. This will present to someone as a state estimator, based on voltage and current measurements calculated from the system. The system will be cause to events where either the power demand at the load is increased, or the system impedance is increased, which may be a result of break the connection load-supplying power lines.

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