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REVIEW ON PHASOR MEASUREMENT UNIT IN SMART GRID SYSTEM

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ABSTRACT:

In recent trends, Smart grid technology is developing dreadfully due to its cyber security, controlling, automation and storage of massive data with the extension of digital metering. This paper gives on overview on data collection and storage by using new technologies like Very small Aperture Terminal (VSAT) technology and power line carrier communication in smart grid system which is extensively active at the time of major blackouts and severe faults when it occurs at any remote localities. To amend the system stability and resolution, these new technologies should coordinate with Phasor Measurement units (PMU) which provides time synchronization, wide area monitoring and measurement by electrical phasor quantities such as voltage, current and rate of change of frequency by Global positioning system in grid with high rigor. The Future challenge is to deploy and integration of PMU's in all sub-stations to provide dynamic model validation.

INTRODUCTION

Smart grid evolutes the standards for communication, demand response by deployment of advanced energy storage devices contrast to conventional grid because it has pandemic control and malleable over the system at the time of power outages or Blackouts. Smart grid increases the energy, operational productivity, power reliability and quality due to Advanced Metering system (digitalization), cyber security (controlling and protection), designing and planning for automation to handle the massive data intelligently by using the new technologies like amalgamation of renewable Energy sources[1] to control

demand response and Geographical information systems(GIS)[1]to manage the Big Data.

Integration of Renewable EnergySources

- Approaching of Block chain in the market for energyconversion.
- Management at demand side/ consumer side.
- Hybrid Electric Vehicles (Vehicle -Grid and Grid-Vehiclesystem)
- Devicecontrollers.
- Fore-casting of Weather condition/ Information.

Geographical Information Systems

- Cybernetics.
- Supervisory Control and Data Acquisition (SCADA).
- Advanced Metering Infrastructure (AMI).
- Approaching of trending electric storage devices.
- Micro-grid system.

SMART GRID PILOT PROJECTS

In India, 14 smart grid pilot projects [1] are approved by Government of India for advanced metering infrastructure, peak load management, power quality management, outage management and distributed generation are implemented for many states like Karnataka, Tripura (SECL), Kerala (SEB),Haryana (BVN), Rajasthan (JVVNL), Telangana (TSSPDCL) etc.,

Case Study of Smart grid pilot project in Telangana-Jeedimetla [2]: By the National smart grid mission (NSGM), Ministry of Power, Government of India, this project is implemented in Industrial area in Jeedimetla (JIA) on October 2014 by Mr.G.Raghuma Reddy, CMD of TSSPDCL. Under this project, 11,904 consumers were instructed to install the smart meters (single phase, 11KV feeder) for continuous supply with cost of Rs.41.82 Crores and MoP (Ministry of Power) share is Rs.20.91 Crores funded by Integrated Power development scheme (IDPS) with project time line of 18 Months. The area of this project covers under the scheme of Restructured Accelerated power Development and reforms programme (RAPDRP) for DAS, IT andSCADA implementation.

Advanced metering infrastructure (AMI), peak load management, outage management and power quality measurement are adopted under this project. With this project, Purchase Cost of power at peak hours and Aggregate technical and commercial losses (AT&C) willreduces.

VSAT TECHNOLOGY & PLCC

The main objective/challenge in recent smart grid system is to maintain stability without losing any synchronism. If the system lost its synchronism, it will leads to overloading at demand side, cascading problems and major blackouts which results in instability in grid. So, to maintain the grid stable, data should be communicated effectively by replacing power line carrier communication (PLCC) with VSAT technology.

Case Study of Karnataka state using VSAT Technology over PLCC: By the Retd. Chief Engineer Adiseshan (instrumental in implementing VSAT) of

Karnataka state Electricity board, the usage of VSAT technology instead of conventional PLCC. The main variance between this is VSAT technology (satellite) gives the data of sub-station even after power line failure but from PLCC (Power lines), data will not be retrieved.

In July 30, 2012 major blackout is happened and this result in power outage of 72 hours, due to this 700 billion was affected and lost of 32GW power. North eastern grid couldn't analyze the problem (No data) from the power lines. So, they decide to move for VSAT with more critical uptime, because, if any outage occurs in any remote area irrespective of power lines, data can be retrieved through satellite at any time. The main disagree point from VSAT is create an own hub or sharing with others for effective data communication and creating a channel cabinet for only data (separate channel for voice). Moving for own hub is a better option due to multitasking (All RTO's can work at a time because these are totally independent in nature) and used at high frequency(Baud-Rate) communications.

In other countries, they are using out-sourcing communications (data &voice) because, optical fiber which they are using are anti-dust, anti- pollution and anti-ice. So, they do not prefer to go VSAT. In VSAT data can be updated very fast due to IEC6080-501 Asynchronous protocol which provides/ synchronized the data within 10 seconds (Example of 4 RTO's) only. We can coordinate many RTO's (each one has specific time to activate) in the channel depending upon the data. This will not be possible in terrestrial power line carriercommunication.

ANALYZING THE DATA BY USING PHASOR MEASUREMENT UNITS (PMU'S)

Steadily, power system is expanding in the view of Generation, Transmission and sub- Transmission data is transferred to grid (Grid connected micro grid to isolated grid) with the help of SCADA and this system is called Transmission system operator (TSO). So, in grid, by using SCADA, the system should be automatically controlling and monitoring (Energy Management system) if any disturbances occur. When this system is enhanced with phasor measurement units (PMU's) then the system is said to be Wide area Monitoring System (WAMS).This WAMS is the enlargement of conventional SCADA system for data acquisition, controlling and monitoring with vigorous response to upgrade the system stability in transmission and distributionside.

Currently, PMU's are used in some grids to retrieve the data precisely, by that always system should be in synchronous nature. Phasor Measurement unit (PMU's) furnishes the voltage, current phasor and frequency synchronized with the time said to be Global Positioning system (GPS). Mainly phase angle should be separated for dynamic observability (10-60 samples per second) and wide area monitoring forsystem.

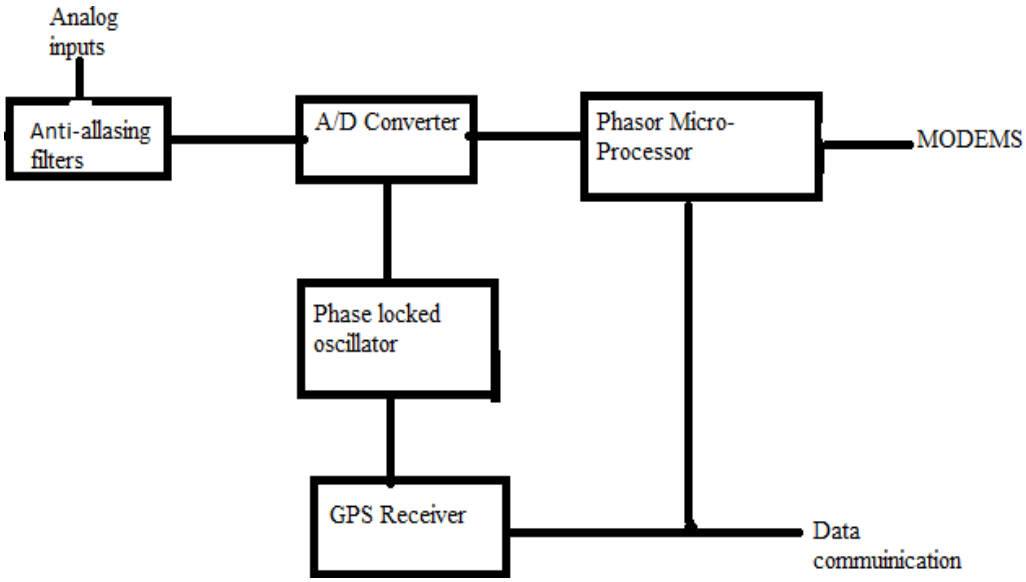

Figure 4.1 Block Diagram of PMU

As per Block diagram of PMU, input is voltage or current in phasor which is analog in nature to anti-aliasing filter as a sampling ($F_S>2F_m$). Here Micro-Processor acts as phasor Estimation technique by the input and it connected to GPS receiver UTC which transfers the data. This can be measured in Time domain, frequency domain and Time-frequency domain as per the standards of IEEE C37.118.a-2014.As per this IEEE standard, PMU's are used for application tests like to measure any quantity, total vector error (TVE) - 1 to 3%, Frequency measurement error (FE) – 5mHz to 30mHz i.e., Rate of change of frequency (ROCOF) – 0.1Hz/s to 14Hz/s and Magnitude tests to characterize the input and output. Phasor Data Concentrator (PDC) will install at central location in grid which collects data from PMU's and immediately it will provide alert at emergency conditions and also facilities development of different analytics for smooth operation of grid in realtime.

Installing of PMU's all over the India is increasing in span of 4 years (2010-2014). In 2010, 4 PMU's were used and it is increased to 62 PMU's in 2014. Under Unified Real Time Dynamic State Measurement (URTDSM) scheme, central government planned to install 1700 PMU's, 32 Phasor Data Concentrator (PDC's) nearly at 1300 locations with 6.5 billion INR all over generating stations and Substations in India. In Andhra Pradesh, specially Mamidipally sub-station have 5 feeders i.e., Ghanapur, Khammam 1&2, SLBPH 1&2, 400KV sub-station and it consists of 3 PMU's with existing of optical fiber. Srisailam LPH has 5 feeders i.e., Kurnool, Maimadapally 1&2, VTS stage-4 1&2 with 3 PMU's and availability of optic fiber.Vemagiri Sub-Station (Gautami, Nunna, Konaseema, Kalpaka, Gazuvaka, Jegrupadu Extn) have 16 feeders with 8 PMU's. KTPS sub-station (220KV) with 8 feeders and 4 PMU's and availability of optic fibre.

Overview of PMU's Data in Southern Region as Per URTDSM.[3]

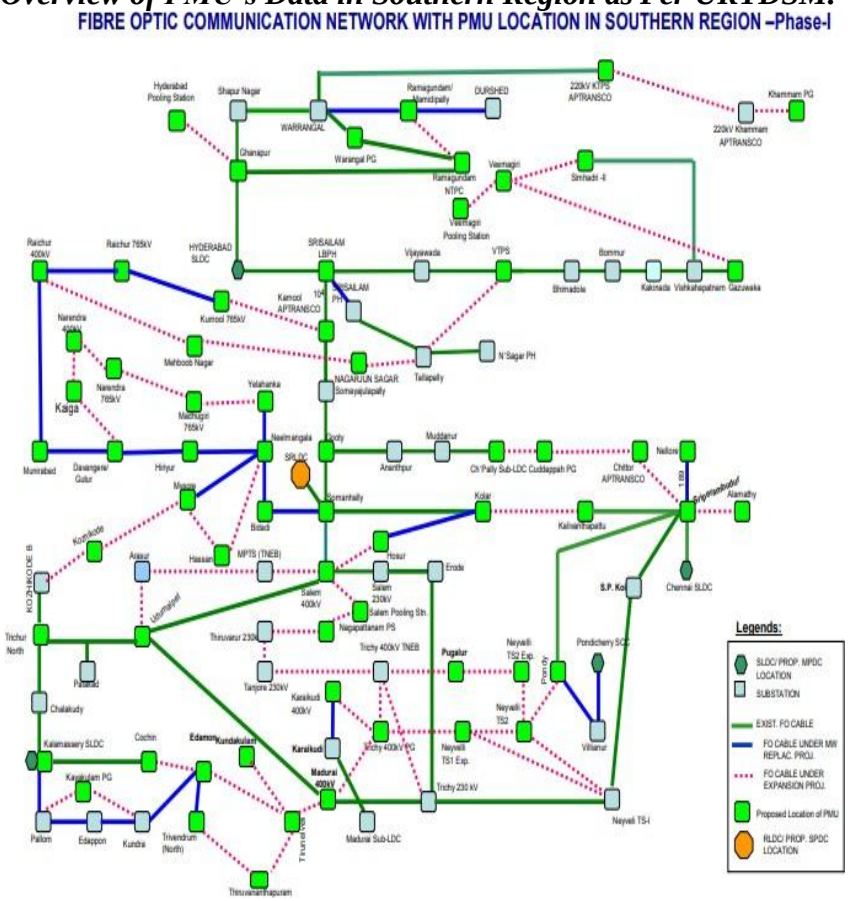

Figure 4.2 Fibre Optic Communication Network with PMU's All Over Southern Region

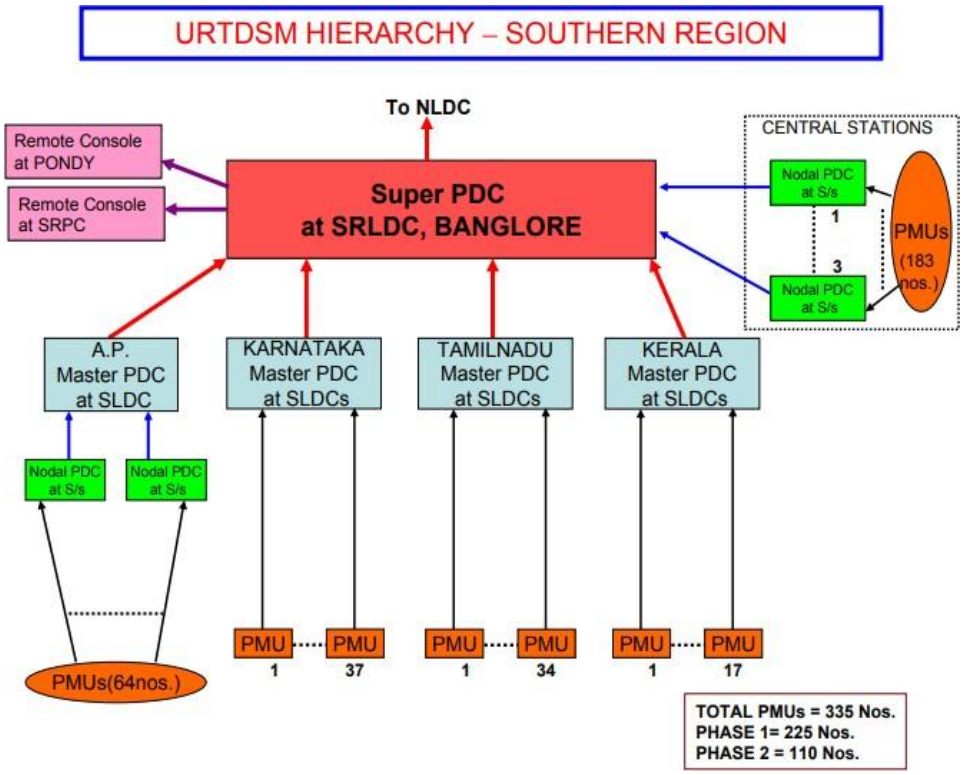

Figure 4.3PDC's and PMU's Data as Per URTDSM

Utilization of PMU Data

A phase Data concentrator (PDC) should install with PMU's to retrieve the data accurately from the grid to utilize this data for critical conditions. Phasor data from each PMU is sampled up to 30 samples per each second and transferred to PDC (as like as existing SCADA system) along with Global Positioning system (GPS). Communication between the PMU's at various locations (sub-stations) and PDC at grid or central location takes place as per IEEE C37.118 standard. Phase angle separation of Voltages, power flow and rate of change of frequency (Synchro phasor data) is analyzed from the data accurately.

If any differences/disturbances in the synchro data or from phasor units mostly that can be seen in frequency which leads to system transients and it occurs power outages in generating units. The small frequency difference (amplitude will be large) is not detected through SCADA system due to small resolution. In some conditions, faulty voltages and currents can be retrieved. By analyzing this data, problem can be identified easily to avoid major blackouts in anyarea.

Data which is getting from PMU's can be differentiated in 4 ways like in volume (PMU's store approx 1GB data per day), Velocity (PMU's generates the 60 samples of data per second), variety (Getting of data from different sources), Veracity (quality and Reliability of data from PMU"S) and Values. With the data and PMU enabled generating stations will give more accurate (data analyzing for micro seconds also) in grid operation. So, Deployment of PMU's should increase of due to faster response of reducing outages and stability of grid.

Applications of PMU's

- Real Time monitoring and controlling in Powersystem.
- Fault Detection/Location in anylocality
- Protection/Security from faults in power system.
- Operation and planning of powersystem
- Usage of Facts devices/controllers
- State Estimation and voltagestability
- Power system Oscillations
- Harmonic Measurementoscillations.

CONCLUSION

In all smart Grids, deployment of Phasor Measurement Units (PMU's) with Phasor Data Concentrator (PDC) rapidly growing due to its precise phasor data and continuous data processing. Some Specific generating units only, these PMU's are enabled and mostly are enabled with SCADA system. To enhance the grid stability in real time with Cyber-security (controlling and monitoring), these units should integrate with all devices to analyze different types of data to prevent major blackouts and Power outages. In future, main challenge is to install PMU's in all generating units (66KV 11KV, 400KV, 200KV) to get Explicit data for GridFirmness.

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