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ROLE OF ICT in Power System

by

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SUMMARY

Existing grid essentially consists of centralized generation, transmission of power over long distances and distribution in the load centres with unidirectional power flow. Due to its inherent nature, it has certain limitations such high as T & D losses, poor quality and reliability of supply.

ICT has revolutionized every field; power sector is not an exception. The objective of this paper is to explore role of ICT in power sector, to discuss various challenges associated and its application.

Integrating ICT into existing grid opens up a realm of possibilities for improving supply reliability and for putting more options for energy efficiency. Environmental concerns have necessitated enhanced RE generation. But RE generation such as wind and solar power has its own limitation of infirm nature and hence the need for more sophisticated control system has become apparent to facilitate the connection of these sources to the grid. Further, the energy demand can be matched with available supply with bi-directional communication for flow of information between utility, consumers and system operator, for which ICT has an important role to play.

Communication challenges for smart grid:-.
The smart grid communication systems must be robust enough to accommodate new media, as they emerge from the communication industries. There are a number of challenges for ICT based applications in power grid such as development of interoperable communication protocols for each domain of the smart grid, as well as, harmonize these communication protocols for inter-domain information exchange, Identification of suitable communication technologies for smart grid communication infrastructure, cyber security for all communication interfaces.

WAMs and use of PMUs for developing Analytics:-
Power flow limits across transmission lines are based on the phase difference between voltages at both ends. Existing measurement technology does not feature phase angle measurements due to the technical difficulties associated with the synchronization of measurements at remote locations which is possible with GPS technology in Phasor Measurement Units (PMU).

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WAMS is one of the recent technology using PMUs for synchronized measurements of phasor quantities of voltages and currents at several points spaced hundreds or thousands of kilometers apart.

PMU technology is instrumental in improving early warning systems, System Integrity Protection Scheme, detecting and analyzing thermal limits; and angular, voltage, and small signal stability; faster system restoration post-disturbance data analysis, etc. For data analysis and angular stability warning, PMUs offer means and benefits not possible with any other technology.PMUs facilitate the dynamic, real time capture of system operating conditions which allows operator to anticipate and detect problems during abnormal system conditions to take corrective actions.

Managing quality of service with high level of DER:-

ICT has a major role to play in the expansion of distributed generation. High level of DER penetration will manage quality of service with the applications such as Feeder Relief, Transformer bank relief, Reactive support for the T/D Grid, Serve remote loads, Power Quality, Peak management , Energy needs and Ancillary Services, Loss reduction, and effective grid asset utilization.

Role of ICT in Power System

Information and Communications Technology, better known as ICT, is the integration of information processing, computing and communication technologies. The advancements in ICT have transformed the ways human activities are being performed, ranging from areas in learning and working to living in general. ICT is increasingly being given an integral role in the proper functioning of various sectors, such as Power sector, Manufacturing, Healthcare, Education and many others.

Existing power grid essentially consists of centralized generation, transmission of power over long distances and distribution in the load centers with unidirectional power flows. Due to its inherent nature and 20th century design standards, it has many limitations as enumerated below:-

- High T & D losses
- Poor quality and reliability
- Lack of focus on energy efficiency
- Adverse environmental impact
- Prone to security threats due to centralized nature of operation
- Interdependency of grid components
- Introducing further advancements and efficiencies

Information Technology has already became an integral part of the Power Sector for better planning, supervision, operation, maintenance, monitoring, control of all activities related to Power generation, transmission and distribution and commercial operations. The IT applications includes:-

- Energy Management System
- Distribution Automation System
- Planning and Energy Accounting System

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- Metering and Billing Systems
- Training Systems
- Maintenance Management System
- Management Information System
- Power Plant Control System
- SCADA System

Inspite of above, the power sector is in need of becoming more efficient and intelligent in view of following driving factors:-

- Deployment of renewable generation technologies
- Peak monitoring and load shifting
- More load control at consumer end
- Future enhancement in distributed generation
- Deployment of plug-in Hybrid vehicles
- Need for more information to ensure energy efficiency for carbon emission reduction

Smart Grid is seen as a solution for many of the issues current faced by the Power sector. Fundamentally, smart grid is an amalgam information and communication technology and power system technology, where there is two way communication, where not only power but information is also transported, where there are numerous intelligent devices continuously interacting with each other.

Smart Grid is the transformation from a centralized producer-controlled network to one that is less centralized and more consumer-interactive. Smart Grid is an application of technologies, tools and techniques available for making the grid work far more efficiently.
Smart Grid is an automated, widely distributed energy delivery network. It is characterized by a two way flow of electricity and information and will be capable of monitoring the network right from power plants upto individual appliances at consumer ends. It incorporates into the grid the benefits of distributed computing and communications to deliver real time information and enable the near-instantaneous balance of supply and demand at the device level.
Smart Grid is an enabling engine for

- Allowing seamless integration of RE sources such as wind
- Making large scale energy storage possible
- Making use of solar energy 24 hours a day
- Enabling use of plug in hybrid electric vehicles
- Allowing consumer to manage their consumption efficiently
- Exploring the use of green building standards

Smart Grid is

- Is capable of sensing system overloads and re-routing power to prevent of minimize a potential outage
- Is capable of meeting increased consumer demand without adding infrastructure

- Can accept virtually any fuel source including solar, wind, coal, natural gas, energy storage technologies etc.
- Enables real time communication between consumer and utility to allow consumer to tailor their demand
- Is ensuring reliability and quality of power
- Is increasingly resistant to attack and natural disasters as it becomes more decentralized and reinforced with Smart Grid security protocols
- Offers a path towards significant environmental improvement

Major smart grid applications include following:-

- Automatic Meter Reading
- Remote Disconnect and Reconnect
- Outage Monitoring and Evaluation
- Mini SCADA
- Demand Side Management and Load Management
- Renewable Energy
- Distributed, standby, mini-grids, and off- grid generation
- Time-of-use rates
- Islanding
- Capacitor control
- Demand Response
- Advanced Metering Infrastructure (AMI)
- Phase Measurement Unit (PMU)

Communication challenges for smart grid:-.

The smart grid communication systems must be robust enough to accommodate new media, as they emerge from the communication industries. There are a number of challenges for ICT based applications in power grid such as development of interoperable communication protocols for each domain of the smart grid, as well as, harmonize these communication protocols for inter-domain information exchange, Identification of suitable communication technologies for smart grid communication infrastructure, cyber security for all communication interfaces.

WAMS and Use of PMUs for developing Analytics:-

Phase measurement Unit (PMU) is a device which, by using satellite technology, allows power system measurement, synchronized on a global basis. With this, it provides better mechanisms for power system monitoring, protection, analysis and control. Real time system monitoring is necessary as it enables system operators to take decisions in real time having situational awareness derived from the data / information available with them in real time.

Significance of phase angle measurement:-

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If one part of a power grid becomes seriously out of synchronism with the rest, the whole network can become unstable and shut itself down. This is how a blackout occurs. It is therefore necessary to monitor the phases (relative to each other) of all the voltages and currents throughout their grid in real time. The relative phase position of AC voltages and currents in different parts of an electric power system determines the stability and the dynamic performance of the system.

Why PMUs / WAMS are useful

Angular separation between coherent groups of generators within a synchronous grid is representative of grid stress. Measurement of angular separation and its telemetry at the control centre level has limitations. The load angle is either estimated from available SCADA data or the angular separation between a pair of substations is derived offline with the help of power flow on the line, impedance of the line, respective terminal voltages. Both these methods have their limitations due to data latency, skewdness and inaccuracies inherent in SCADA/ EMS.

What is WAMS:-

The synchrophasor technology along with the high speed wideband communication infrastructure from substation to control centre has now overcome the above limitation. These schemes based on synchrophasor technology are also known as wide area measurement system (WAMS). With WAMS, it is now possible to monitor the phase angles at the control centre.

In addition, WAMS enables visualization of magnitude and angle of each phase of the three voltage/current, frequency, rate of change of frequency and angular separation at every few millisecond interval (say 40 ms) in the load dispatch centres. Thus the transient/dynamic behavior of the power system can be observed in real time at the control centre.

In the past, a lack of adequate computing power and the huge difficulties involved in collecting, coordinating and synchronizing the grid data made this impossible. However, new technology now available has radically changed this situation. . The introduction of numerical technology in protection and control, equipment together with digital communication, has enabled accurate phasor measurement at various locations. Being able to determine phasors across the power system at a fixed point in time has the potential to solve these problems.

Principles of WAMS:-

PMU is the basic building block of WAMS. The PMU measures system state viz. voltage and angle of a particular location at a high sampling rate (say 25 samples per second). This data is time stamped through a common reference and transmitted to the Phasor Data Concentrator (PDC) installed at a nodal point, through high speed communication medium such as Optical fibre. World over, synchrophasor technology is increasingly being used for supplementing the conventional SCADA/EMS for providing a wide area visibility.

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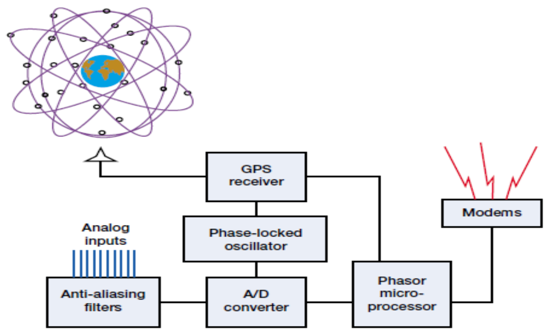
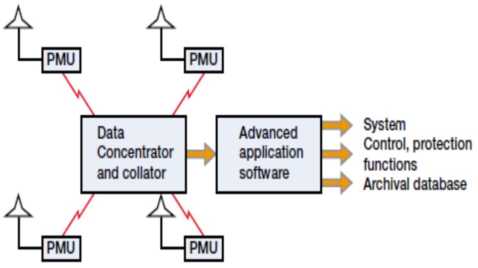


1 Block diagram of the Phasor Measurement Unit



2 PMU utilization in a power system

PMUs rely on a GPS time signal for extremely accurate time-stamping of the power system information. A GPS satellite receiver provides a precise timing pulse, which is correlated with sampled voltage and current inputs - typically the three phase voltages of a substation and the currents in lines, transformers, and loads terminating at the substation. From these data samples, positive-sequence voltages and currents are calculated [1] and timestamped so that the exact microsecond when the phasor measurement is taken is permanently attached to it. The device
assembles a message from the time stamp and the phasor data in a format defined in IEEE standard 1344 [2], which can then be transmitted to a remote site over any available communication link. Positive-sequence phasor data from all substations equipped with such devices are collected at an appropriate central site using a data concentrator or exchanged between local units for protection/control applications.

Applications of PMU

Applications of the synchronized phasor measurement technology can be conveniently grouped as follows:
_ Power system monitoring
_ Advanced network protection
_ Advanced control schemes

Power system monitoring

Power system monitoring involves state estimation of the power system from real-time measurements. The state of the power system is defined as the collection of the positive-sequence voltages at all the network buses obtained simultaneously. The synchronized phasor measurements provide high rate of sampling rate and fast computation.

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Advanced network protection

Another category of applications of synchronized phasor measurements is that of enhancing the effectiveness of power system protection. This involves equipment and system protection, as well as remedial action schemes. In future, PMUs could be utilized to provide a protection which is as reliable as the differential protection. This also has the potential to limit the damage that can be caused to the power system by catastrophic events. For example, the status of certain circuit-breakers and switches, power flows in key transmission lines, voltages at critical buses, power output of key generators, etc, could be used to formulate a strategy of responses if these parameters should fall within 'dangerous' patterns.
Using real-time measurement of phasor angles at key locations in the network, and using concepts from transient stability analysis, it is possible to design improved out-of-step relays.

Advanced control schemes

Controllable devices include power system stabilizers, static VAR compensators (SVCs), HVDC links, universal power flow controllers, etc. These controllers use locally derived signals as feedback. These controllers depend upon a mathematical model of the control process, the system dynamics and the relationship between the local variables and system state. Synchronized phasor measurements offer a unique opportunity to bring in the remote measurements of system state vector to the controller, and thus remove from the control loop the uncertainty associated with the mathematical model. Thus, the controller becomes primarily feedback-based, rather than model based, in its implementation.

PMU technology is instrumental in improving early warning systems, System Integrity Protection Scheme (SIPS), detecting and analyzing thermal limits; and angular, voltage, and small signal stability; faster system restoration post-disturbance data analysis, etc. For data analysis and angular stability warning, PMUs offer means and benefits not possible with any other technology.

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Conclusion:- ICT is an integral part of future grid. The future grid enabled with ICT has a great potential to allow communication in both directions, manage grid efficiently and optimize utilization of recourses.

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