Wide area Protection and Monitoring in Smart-power-grid

Adeel Saleem
Department of Electrical Engineering
The University of Lahore
Lahore, Pakistan
adeel.saleem@ee.uol.edu.pk

Rabia Arshad
Department of Electrical Engineering
The University of Lahore
Lahore,Pakistan
rabia.arshad@ee.uol.edu.pk

Danista Khan
Department of Electrical Engineering
The University of Lahore
Lahore,Pakistan
danista.khan@ee.uol.edu.pk

Abstract-The smart-power-grid brings opportunity and challenges to the power system protection and control. In previous century, there has nothing variation in the fundamental structure of the electrical power grid and vehicle networks. Rapid progress in communication and measurement techniques sharpens progress of Wide area Protection depend on the wide area measurement system. Smart-power-grid is considered as modern electric power grid basic physical and organizational structure and facilities for good efficiency and reliability. It is through automatic control high power converters, modern communications infrastructure, sensing and metering technologies and modern energy management techniques depend on demand energy and network availability. In this paper, the background of smart-power-grid is explained. Smart-power-grid latest technologies It provide the non-conventional instrument transformer clock synchronization and data synchronization offer great opportunities for development of Wide area Protection. According to this the concept the content and promote the Wide area Protection. Some of the key technologies like wide area measurement system and wide area communication system are analyze. At the end development of Wide area Protection in smart-power-grid are prospected.

Keywords: Smart-power-grid, Wide area Protection, Phasor measurement unit (P.M.U.),Wide area measurement system, International Electro technical CommissionI.E.C.(61850), Advanced metering infrastructure (A.M.I.), communication technologies, Smart-power-grid, standards.

I. INTRODUCTION

With the global resource and environmental pressures are increasing w.r.to time and the society demands for Environmental protection, able to be defended development are improving. Modern smart-power-grid is the most complex human made system in which it is monitored by wide area monitoring system (W.A.M.S.). The Process of electricity market is constantly become deep or deep and the smart-power-grid able to provide more protected, reliable, clean and high quality electricity supply. Distributed generation systems with very different energy, which have the advantages of low pollution, high reliability, and flexible location will be strong supplies supports to big power grid in the future.

Security algorithms for power grid need to consider both performance and energy efficiency through code techniques on encryption and decryption. Now a day's different countries represented by United States and the European Union, propose to build a flexible, clean, safe, economical, and friendly smart-power-grid, and regard the smart-power-grid in the future.

The largest user of primary energy power industry has responsibilities for reducing green house gas emissions and weather impact in China. One of important of China's smart-power-grid is to strength of the backbone of power grid construction. That is establishing a smart-power-grid with a backbone grid of ultra high voltage (U.H.V.) power grid, with highest degree of coordination at all levels of power grid development. Expand the power grid scale and construction of U.H.V. grid will lead to very small current increasing. It affects the operations of electrical equipment and the system reliableness.

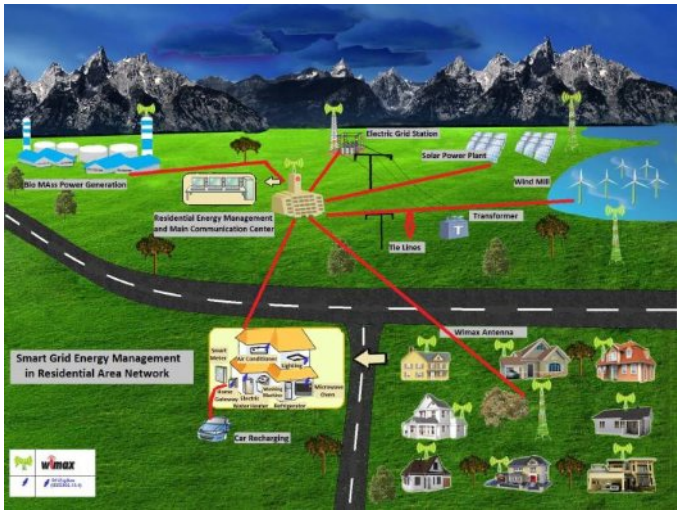

Figure 1: Smart-power-grid distribution

The architecture consists of different area loads therefore Residential, Commercial, Farm, Agriculture, and Industrial. The residential and commercial load consists of the resistive and inductive loads, farm load, Agriculture load

and Industrial load consisting of resistive, inductive and three-phase motor loads. These loads are control by wide area manager and further clients of each load are control by a local area manager (L.A.M.). Network reconfiguration distributed power system and development of micro grid technology will cause problems such that importance of backup protections the system impedance changes multi way power flows and so on. Power system error cause changes in power system frequency and voltages due to the waste of generation or load. These changes depend on the power system robust and its ability to respond to these changes in a very short time. Every power system is a unique dynamic A.M.I. behavior. It is depends on factor such as network transmission topology load location generation capacity. The phenomena involved during power system disturbance can be classified in 5 main classes:

1. Voltage collapse,
2. Frequency collapse,
3. Loss of synchronism,
4. Large power swings
5. Cascade of overloads.

These will lead difficulties for conventional relay protection setting and operation [2]. At present researches and applications on new technologies of Non-Conventional Instrument Transformer clock synchronization and information synchronization, computer data, fiber communications are deeper, in which supply broader space for the protection and control development. Therefore with the deepening studies of smart-power-grid the Wide area Protection is caught more and more attention.

II. WIDE AREA PROTECTION AND ITS ADVANCEMENT

Studies on W.A.P.S. are focused on two fields: one is security and stability control and the other is relay protection. In the security and stability control field, BertilIngelsson said that W.A.P.S. is used to prevent long term voltage fail suddenly and completed. It is set up on basis of the supervisory control and data acquisition (SCADA) system, with decision made structure, non-real time data collection, and slow data refresh frequency. The communication system does not need fast real time data exchange. After that W.A.P.S. is position as a system protection and control method between conventional protection and SCADA. Proposed control concepts described here are all wide area controls. Although local controls continue to be improved using new technologies the conceptual functionality of these local controls will remain the same. The wide area controls presented will often take care of the local controllers but the main objective is to improve the overall stability of the power system. The concepts are presented in the order of increasing complexity also imply that the ones presented. First would be easier to implement. The control measurements include automatic reactive power control, low frequency, voltage load shedding, remote load shedding, generator shedding, and flexible ac transmission. Compared to the traditional strategies of stability control, W.A.P.S. involves a wider geographical scope and requires more complex calculations in the processes of getting data made control strategies and carries out control measures. In the relay protection field, reference proposed to use globe positioning system (G.P.S.) signals for time synchronization, and a dedicated fiber channel for multipoint current data transmission based on that a wide area current differential backup protection is being an apart. This method less the problem that single electrical component oriented current differential protections cannot provide quick backup protection. In regard to applications the France electricity power company has established a W.A.P.S. The stability control system judges the system stability by phase measurements of different areas. Hydro Quebec Power Company of Canada uses the phase measurement data as the power system stabilizer (P.S.S.) control input for generators and it improves the system oscillation damping. The wide area measurement system of includes 79 acquisition devices, 49 of which are dedicated phase measurement devices, 21 are phase measurement devices based on personal computers, and the rest are other measurement devices. The purpose of W.A.M.S. is the system disturbance monitoring, and the main functions are real time continuous measurement and event logging. The W.A.M.S. has been carried out in East China Power Grid for many years. This system continuously monitors the performance of East China Power Grid including the unusual frequency, low frequency oscillations, and the dynamic A.M.I. characteristics during and after different disturbances.

III. KEY TECHNOLOGY OF WIDE AREA PROTECTION IN SMART-POWER-GRID

➢ WIDE AREA MEASUREMENT TECHNOLOGY

The current power systems are usually set up the SCADA systems for measuring and monitoring the system stability and the fault recorder systems for measuring the fault transient process. However it is now difficult to monitor and analyze the dynamic A.M.I. response of the whole system because of SCADA can only provide steady low sampling density and asynchronous power network data at different moments. A wide area measurement system consists of advanced measurement technology, data tools, and operational infrastructure that are facilitating the understanding and management of the increasingly complex behavior by large power systems. Its present form a W.A.M.S. may be used as a standalone infrastructure that complements the grid conventional (SCADA) system. As a complementary system a W.A.M.S. is expressly designed as enhance the operators real time “situational awareness"

that is necessary for safe and reliable operation. The wide area synchronized phasor measurement technology can explain the system dynamic A.M.I. responses which make it to have more covering applications in the power system. Such that the state estimation Adaptive protection online prediction and fault recorder.

Phasor Measurement Unit (P.M.U.) is the basic equipment of synchronized phasor measurement and is installed in selected locations in the power system. It can be measure the system real time voltage, current, and frequency, phase and amplitude data accurately and send the data to a center for comparing evaluation and other treatment A.T.M... The typical structure of P.M.U. is shown in Fig.2.

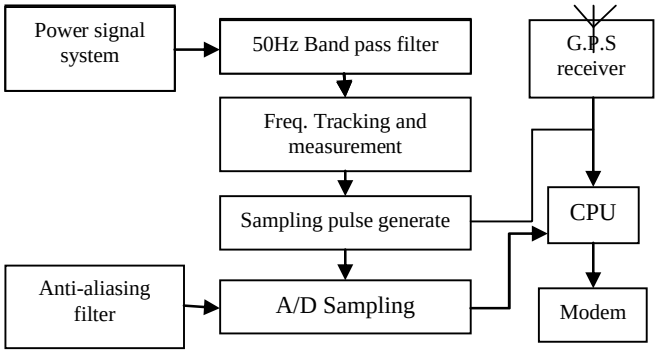

Figure 2:.Typical Structure of Phaser measurement unit (P.M.U)

The P.M.U. based W.A.P.S. has a covering application prospect. Some applications are following

A) Real time monitoring and fault recording: Recording the fault data can be used to reproduce the fault process, and the performance of control and protection system to improve the system security level.

B) State estimation: Traditional state estimation has disadvantages of poor real time long calculating time non synchronous remote sensing value, all of which cause state estimation infringement. After using phase measurement the synchronized phase values from P.M.U. will be combined in the dispatch centers and the real time accurate state values can be obtained. The state estimation accuracy can be greatly improved.

C) Self adaptive protection: The self adaptive protection can automatically adjust the settings and action equations to satisfy sensitivity and safety requirements of the new operating conditions with changed data including current, voltage and phase [4].

D) Stability prediction: The systems operating status can be assessed by using P.M.U. measurement data with this is protection and control system can improve the system transient stability.

E) This type of control system like frequency control is relatively slow and so the conveniently done of the control and communication is not an issue. The main problem has been the selection of input and output variables of the controller that can handle all the varied operating conditions of that the power system bears. Thus this challenge is a classical one of developing a practical robust controller.

- Wide Area Communication System

Wide area measurement technology is the basis of W.A.P.S., thus it is needs a secure and efficient communication system. From few past years the communication technologies were growing rapidly. Ethernet is gradually replacing the industrial field bus. In many areas synchronous digital hierarchy optical fiber rings are laid between substations or the substation local area networks are connected into power system wide area networks.

According to the status of the development of wide area communications choice of fiber as a medium and the communication network in which the SDH0 carries A.T.M. can meet the communication requirements of W.A.P.S... Different communications technologies supported by two main communications media, that it's wired and wireless can be used for data transmission between smart meters and electric utilities. In some distance, wireless communications have some advantages over wired technology such that low cost infrastructure and connection to difficult or unreachable areas. However the nature of the transmission path may cause the signal to reduce. On the other hand wire solutions do not have interruption problems and their function is not depending on batteries as well as wireless solutions often do. Basically two types of data> infrastructure are needed for dataflow in a smart-power-grid system. The first flow is from sensor and electrical appliances to smart meters and the second is between smart meters and the utility's data centers. Suggested in the first data flow can be accomplished through power line communication or wireless communications such that Zig Bee, 6LowPAN, Z-wave, and others [6, 10]. For a second data flow cellular technologies or in the Internet can be used. Not other than there is key limiting factors that should be taken into account in the smart metering spread out process, such that time of deployment, operational costs and the availability of the technology and rural or urban or indoor/outdoor environment etc. This technology select that fits one environment may not be suitable for the other. Currently when the most electric power companies construct or reconstruct the power private communication networks the A.T.M. modes approved. And communication media is mainly optical fiber which lays material foundation for W.A.P.S... Power line communication (P.L.C.) is a technique that uses the existing power lines to transmit high speed (2–3 Mb/s) data signals from one device to other. The P.L.C. has been the first choice for communication with the electricity meter due to direct connection with the meter and successful execution of A.M.I. in urban areas where other solutions struggle to meet the needs of utilities.

P.L.C. systems based on the L.V. distribution network have one of the research topics for smart-power-grid applications in China. In the typical P.L.C. network smart meters are connected to the data concentrator through power lines and data is transferred to the data center through cellular network technologies. Example any electrical device such that a power line smart transceiver based meter can be connected to the power line and used to transmit the metering data to central location. France has launched the "Lanky meter project" that includes updating 36 million meters to Lanky smart meters P.L.C [1].Technology is chosen for data communication between the smart meters and the data concentrator while G.P.R.S. technology is used for transferring the data from data concentrator to the utility's data center. P.L.C. technology to transfer smart meter data to nearest data concentrator and G.S.M. technology to send the data to data centers the Italian electric utility.

- Wide Area Data Exchange

Communication system for data exchange is the key technology for smart-power-grid.

Wide area measurement and data exchange is the critical basis for W.A.P.S. based on smart-power-grid. Protection intelligent electronic device (IED) in W.A.P.S. must be able to efficient and accurate exchange data.

Measurements send the acquire data to substation process buses with I.E.C.(61850) protocol. Protections get digital data of measurement units from buses and find if the fault is happened. There is a fault0 switch-gears are ordered to trip. Wide area data is introduced into protection systems and local substation data is sent to control centers in which can be realize protection and control with multiple components in this power grid.

IV. Trends of Wide area Protection in Smart-power-grid

- Combined With Adaptive Protection

One characteristic of the smart-power-grid is self healing and adaption in which brings up higher requirements for selectivity, reliability, speed and sensitivity of protections. This development of wide area measurement and high-speed wide area network technologies made the adaptive protection based on the whole network data possible. Adaptive protection system switches between the pre calculated "trusted" setting groups based on the actual operating state of the micro grid using standard communication. Adaptive protection may increases availability of local generation and reduces outage time for the customers without a need to change existing hardware With higher speed wide area networks W.A.P.S. can be not only accurately obtain current operating data in real time and analyze operation conditions but also can be change protection scheme to matches grid operation modes and which will greatly improve the protection performance. Smart substation should contain fully intelligent decentralized controllers for auto restoration, remedial actions, or predictive actions or normal optimization [8]. Automatic voltage controllers based on local measurement data in substation will be coordinated by control centers. Voltage instability conditions can be access much faster based on local P.M.U. measurement data. Further detail the results of voltage stability assessment calculations can be directly incorpor0ated into remedial action schemes to improve the power system security. Great improvement is that the settings of protective relays can be remotely modified in real time to adapt to changes in grid configuration. Smart substation will serve as an intelligent unit of special protective schemes (S.P.S.) to improve reliability of power grid. In advanced protective relay algorithms based on travelling waves are under development.

- Combined With Agent

Agent is a dynamic A.M.I. that can make inferences or decisions alone under little guidance of human and also a computer system under certain environment. The Multi agent system (M.A.S.) can coordinate intelligent behaviors among various agents. All of the agents can feel environmental changes and they are able to judge each other's working states. The circuit breaker position, the protection and operation data of collaborators, and whether there is any fault in line [8]. It is also having skills such that communication, comprehensive judgment, and breaking switch. M.A.S. coordinate the intelligent behaviors, it also should be obey some principles. The M.A.S. mainly has two structures: hierarchical distribution and peer mode. The **hierarchical distribution** structure has good local autonomy with low real time requirements. But when the system is large and there are lots of agents, coordination models are complex. The M.A.S. based on **peer mode** simplifies the complexity of communication and control; it can better to achieve the goal of global optimization. The W.A.P.S. has high requirements for real time transferring of wide area data, so that peer consultation mode is its good choice.

- Wide area System Communication Based on I.E.C.(61850)

Testing will be also done on new devices that use advanced communications such that International Electro technical Commission (I.E.C.) (61850). Because of different functions of W.A.P.S. requirements for their communication system function are different. With the object oriented modeling technology and future communication oriented extensible architecture, the I.E.C.(61850) protocol standard can realize the "One World, One Technology One standard" goal [6].

The Wide area communication system is supporting platform for wide area relay protection (W.A.R.P.) exchanging data, which includes not only visible physical communication equipment and links but also communication protocols and other upper communication services. The W.A.R.P. communication has become an important issue in W.A.R.P. practical applications, but it has not described in I.E.C.(61850)standards. To solve this issue this paper firstly presents the general steps of W.A.R.P. modeling according to the layer upon layer modeling methods of I.E.C.(61850) standard then proposes a tree structure model of M.A.S. gestation and affiliate stations with data interaction model between M.A.S. tar station and affiliate stations following I.E.C.(61850) by taking a 220kV smart substation and W.A.R.P. algorithm on fault voltage distribution. Example finally establishes a communication model of W.A.R.P. that includes client transfer model electrical value transmission model and logical status variables transmission model. Fundamental purpose of constructing the communication model is to implement interoperability between W.A.R.P. I.E.D. (W.A.R.P. Intelligent Electronic Devices) and other I.E.Ds in a smart substation. This is become the basis for realization of intelligent substations, and all the data modeling and exchange of different intelligent substation equipment will be under the framework of I.E.C.(61850) [10]. For W.A.P.S. no matter manufacturers or device models are the same or not, data must be quickly and reliably exchanged.

V. Conclusions

The whole paper has discussed contents, developments, and a key of technologies of Wide area Protection. In other words to explain a reliable and stable smart-power-grid operation, article also focus on the system reliability analysis and failure in protection mechanism. Similar to the smart-power-grid enable power grid to unpowered with intelligent and advanced capabilities, it's also opens up many new challenges and risks. With increased availability of data synchronization, phasor measurements, and communication technologies applied in smart-power-grid and they can provide high precision synchronous information acquisition meet at the real time and reliability of data transmission and it provide basic support to Wide area Protection principles and applications. Improved protection will produce power services by providing accurate and highly efficient electric energy production and transportation. Indeed, self healing protection systems that can include fault localization, isolation, and restoration will help monitor the system by immediately making repairs and responding to improve power efficiency and quality of smart grid. It is seems to be a great potential for Wide area Protection to combined with the adaptive protection multi agent technology and I.E.C. ((61850)) protocol. The Wide area Protection is the currently research of hotspot in the power system and significant progress has already achieved. Within the deep studies on smart-power-grid the Wide area Protection technologies will be further developed.

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