PHASE MEASUREMENT BASED WIDE AREA PROTECTION WITH DAMPING-A REVIEW

Neeraj Priyadarshi,Sandeep Raj,Umesh Gupta,Uday Kumar
Department of Electrical Engineering,GITS,Udaipur(Rajasthan)

***Abstract*—** The electricity supply industries need tools for dealing with system-wide disturbances that often cause widespread blackouts in power systems. When a major disturbance occurs, protection and control measures assume the greatest role to prevent further degradation of the system, restore the system to a normal state, and minimize the impact of the disturbance. Continuous technological development in communications and Instrumentation Technologies have promoted the utilization of Phasor Measurement Unit (PMU) based Wide-Area Measurement Systems (WAMS) in power system protection and control for better management of the system security through advanced control and protection strategies.

***Index Terms*—**PMU,WAMS

I. INTRODUCTION:

Modern power systems are in the process of continuous development which has lead to complex interconnected networks. Financial pressure on the electricity market and on grid operators forces them to maximize the utilization of high voltage equipment, which very often lead their operation closer to their loading limits. This approach of ensuring economic operation is possible provided the system is equipped with a well designed and coordinated protection and control strategies to deal with wide spread disturbances in the system. Traditional power system protection and control measures are based on local measurements. However, it is quite difficult to maintain the stability and security of the system on the whole, if only local measurements are employed in the protection and control schemes. One promising way is to provide a system wide protection and control, complementary to the conventional local protection strategies. While it is not possible to predict or prevent all contingencies that may lead to power system collapse, a wide-area monitoring and control system that provides a reliable security prediction and optimized coordinated action is able to mitigate or prevent large area disturbances. The main tasks, which can be accomplished through wide-area based monitoring and control system, are early recognition of large and small perturbation instabilities, increased power system availability through well coordinated control actions, operation closer to the thermal loading limits through flexible relaying schemes, fewer load shedding events and minimization of the amount of load shedding. The main disadvantage of the present conventional method of system monitoring is the inappropriate system dynamic view, or the uncoordinated local actions, like that in decentralized protection devices. Solution to the above can be achieved through dynamic measurement system using synchronized phasor measurement units. A system comprising of synchronized phasor measurements and performing the tasks of stability assessment with adaptive relaying is called a Wide-Area Monitoring and Control (WAMC) system [1].In weak power systems with remote generation, power oscillations indicating insufficient damping is one factor often limiting the output power of these plants. There are two general ways to increase the line power transfer capacity and thereby fully exploit the production resources. The first and most traditional is to build new lines. This is very costly and increasingly difficult due to environmental/right of way constraints. An attractive alternative is to move the stability limit towards the thermal limit by introducing power system controls, thus improving the utilization of the transmission system. In the case of insufficient damping, stability is usually improved by continuous feedback controllers. The most common type is the Power System Stabilizer (PSS), which modulates generator output by adding a signal to the voltage regulator set point. The inputs to the PSS is a measured quantity with a high content of the modal frequency that is to be damped. The main task of the PSS is to provide additional damping in the frequency range of power system oscillations, typically 0.2-2 Hz. Candidate input signals have traditionally been shaft speed, real power output and network frequency, that are all locally available at the power plant.The development in communication systems has made it feasible to also use remote signals as PSS inputs [9, 10]. Signals to be communicated include local signals in other plants, but also signals provided by Phasor Measurement Units (PMUs)[3]. These units primarily provide globally synchronized measurements of voltage and current phasors, frequency and rate of change of frequency. The synchronization makes is possible to create system-wide data sets in a time frame appropriate for damping purposes.PMU placement at all substations allows direct measurement of the state of the network. However, PMU placement on each bus of a system is difficult to achieve either due to cost factor or due to non existence of communication facilities in some substations. Moreover, when a PMU is placed at a bus, neighbouring busses also become observable [6]. This implies that a system can be made observable with a lesser number of PMUs than the number of busses. Reference [4] has dealt with the problem of optimum PMU placements. Work on optimal PMU placement using an integer linear programming (ILP) approach has been pioneered by Abur [5].

II. REQUIREMENTS FOR A WIDE AREA PROTECTION SYSTEM

Wide-area protection system is employed to fulfill the two main objectives of increasing transmission capability as well as system reliability. Closer analysis on the above two broad objectives require the focus on the following [1]:

* Identification of critical situations and determining appropriate remedial actions with regard to the following phenomena:

  a. Transient instability

  b. Small signal angle instability mainly due to poor damping

  c. Frequency instability

  d. Short-term voltage instability

  e. Long-term voltage instability

* Coordination with existing local protection system with a view to enhance the system reliability and security by appending the protection system with system wide information

* Optimal Multistage Scheduling of PMU Placement

III.TRENDS IN WIDE AREA PROTECTION

The meaning of wide area protection, emergency control and power system optimization may vary dependant on people, utility and part of the world. Therefore standardized and accepted terminology is important. Since the requirements for a wide-area protection system vary from one utility to another, the architecture for such a system must be designed according to what technologies the utility possesses at the given time. Also, to avoid becoming obsolete, the design must be chosen to fit the technology migration path that the utility in question will take. The solution to counteract the same physical phenomenon might vary extensively for different applications and utility conditions. The potential to improve power system performance using smart wide area protection and control, and even defer high voltage equipment installations, seems to be great. The introduction of the Phasor Measurement Unit (PMU) has greatly improved the observability of the power system dynamics. Based on PMUs different kinds of wide area protection, emergency control and optimization systems can be designed. A great deal of engineering, such as power system studies, configuration and parameter settings, is required since every wide area protection installation is unique. Custom-made wide area protection systems against large disturbances, designed to improve power system reliability and/or to increase the transmission capacity, will therefore most likely be common in the future. These systems will be based on reliable high-speed communication and extremely flexible protection devices, where power system engineering will become an integrated part of the final solution. This type of high performance protection schemes will also be able to communicate with traditional SCADA systems to improve functions like demand side management (DSM), distribution automation (DA), EMS and state estimation. As the electricity market is restructured all around the world, the nature of utility companies is changed. In particular, the downsizing of the staff makes it difficult or impossible for the utility to perform many R&D functions. As a result, there is a trend in the industry where utilities collaborate with vendors to cope with issues related to the grid. The utility can view its partnering vendor as a substitute for its vanishing R&D department to perform tasks that its existing staff cannot handle. The vendor sees the partnering utility as the "sounding board" for its product development and the place to demonstrate its latest products. This closed-loop collaboration, which already exists in the form of pilot projects in wide-area protection, is found to be fruitful to both parties.

Traditionally, remedial action schemes have been hub based, i.e. all measurements and indicators are sent to a central position, e.g. a control center, for evaluation and decision. From this central position, action orders are then sent to different parts of the power system. Such a centralized system is very sensitive to disturbances in the central part. With the ring based (or WAN) communication system, a more robust system can be achieved. One communication channel can for example be lost without any loss of functionality. If one system protection terminal fails in a flat de-centralized solution, a sufficient level of redundancy can be implemented in the neighboring terminals. In other technological areas the decision power is moving closer to the process, with increasingly more powerful sensors and actuators, for decisions based on rather simple criteria. Such an independent system protection scheme, based on powerful terminals, can also serve as a backup supervision system, that supplies the operator with the most critical power system data, in case of a SCADA system failure. The system protection terminal will probably be designed from a protection terminal to fulfill all requirements concerning mechanical, thermal, EMC, and other environmental requirements for protection terminals. Design and interfaces of a system protection terminal is shown in Figure 1:

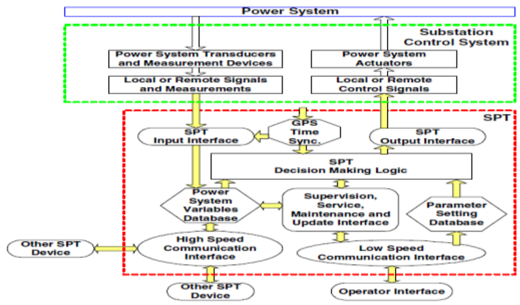

Figure 1. System protection terminal, design and interfaces.

The terminal is connected to the substation control system, CTs and VTs as any other protection terminal. For applications that include phasors, i.e. phase angles for voltages or currents, a GPS antenna and synchronization functions are also required. The system protection terminal comprises a high-speed communication interface to communicate power system data between the terminal databases. In the data base all measurements and binary signals recorded in that specific substation are stored, and updated, together with data from the other terminals, used for actions in the present terminal. The ordinary substation control system is used for the input and output interfaces towards the power system process. The decision making logic contains all the algorithms and configured logic necessary to derive appropriate output control signals, such as circuit-breaker trip, AVR-boosting, and tapchanger action, to be performed in that substation. The input data to the decision making logic is taken from the database, and reflects the overall power system conditions. A low speed communication interface for SCADA communication and operator interface should also be available. Via this interface phasors can be sent to the SCADA state estimator for improved state estimation. Any other value or status indicator from the database could also be sent to the SCADA system.

Actions ordered from SCADA/EMS functions, such as optimal power flow, emergency load control, etc., could be activated via the system protection terminal. The power system operator should also have access to the terminal, for supervision, maintenance, update, parameter setting, change of setting groups, disturbance recorder data collection, etc. It can be concluded that there is a the great potential for wide area protection and control systems, based on powerful, flexible and reliable system protection terminals, high speed, communication, and GPS synchronization in conjunction with careful and skilled engineering by power system analysts and protection engineers in co-operation.

IV.CONCLUSIONS

There are numerous existing applications of wide area protection and control systems. Most of the implementations use simple (local) measurements. In other cases, the measurements and actions use wide area information and communications systems. The more complex decision processes employ SCADA for information gathering, which only allows a time frame of several seconds for actions. Higher speed wide area protection systems required to prevent transient instability or fast voltage collapse (e.g. direct load or generator rejection), respond primarily to contingencies identified in off-line planning studies, and are limited in effectiveness against unforeseen disturbances.

Better detection and control strategies through the concept of advanced wide area disturbance protection offer a better management (than existing) of the disturbances and significant opportunity for more reliable system performance under higher power transfers and operating economies. This advanced protection is a concept of using system-wide information together with distributed local intelligence and communicating selected information between separate locations to counteract propagation of the major disturbances in the power system. With the increased availability of sophisticated computer, communication and measurement technologies, more "intelligent" equipment can be used at the local level to improve the overall emergency response. There seems to be a the great potential for wide area protection and control systems, based on powerful, flexible and reliable system protection terminals, high speed, communication, and GPS synchronization in conjunction with careful and skilled engineering by power system analysts and protection engineers in co-operation.

V.REFERENCES:

[1] M.Zima, M.Larsson, P.Korba, C.Rehtanz and G.Anderson, " Design aspects for wide-area monitoring and control systems," Proc. of the IEEE, vol. 93, No.5, May 2005.

[2] J. Bertsch, C. Carnal, D. Karlsson, J. Mcdaniel and K. VU, "Wide-area protection and power system utilization," Proc. of the IEEE, vol. 93, no. 5, pp. 997-1003, May 2005.

[3] A. G. Phadke, "Synchronized phasor measurement in power systems," IEEE Computer Applications in Power, April 1993, pp. 10-15

[4] T. L. Baldwin, L. Mili, M. B. Boisen, and R. Adapa, "Power system observability with minimal phasor measurement placement," IEEE Trans. Power Syst., vol. 8, no. 2, pp. 707-715, May 1993.

[5] A. Abur and F. H. Magnago, "Optimal meter placement for maintaining observability during single branch outages," IEEE Trans. Power Syst., vol. 14, no. 4, pp. 1273-1278, Nov. 1999.