Securing supply from a distance

Petra Reinhardt and Cédric Carnal of ABB Switzerland outline how wide area monitoring (WAM) technology can detect power system instabilities and optimise asset utilisation.

Potentially, the application of wide area monitoring (WAM) technology could offer a number of benefits to utility providers. It could provide enhanced transmission capacity and security achieved by online monitoring of the system safety or stability limits and capabilities. Additionally it could reinforce. power systems and associated investment planning based on feedback obtained during analysis of system dynamics.

The introduction of a co-ordinated approach for the execution of stabilising actions in case of severe network disturbances is also possible via WAM, as too is the activation of other functions. These include VAR compensation, improved understanding of a system's dynamic behaviour and the installation of an early warning system designed to prevent potential power disturbances.

Creating such a system requires data with higher accuracy and faster update rates than those usually provided by traditional SCADA systems. In addition, it must be synchronised over a wider geographical area than that provided by traditional protection systems.

The introduction of phasor measurement units (PMUs) combined with advances in communication systems and computational equipment has now made it possible to monitor the stability of the power systems online, and with a wide area perspective.

Changing technologies

WAM systems are essentially based on new data acquisition technology. Unlike conventional control systems – which use remote terminal units (RTUs) to acquire non-synchronised RMS values of currents and voltages – a WAM system acquires GPS-synchronised current, voltage and frequency phasor data measured by PMUs at selected locations in the power system.

The measured quantities include both magnitudes and phase angles, being time-synchronised via GPS receivers with an accuracy of one microsecond.

Until now, critical nodes in transmission grids have usually been monitored using static or quasi-dynamic data based on RMS measurements gathered cyclically. Phasors, measured at the same time, provide instant snapshots of the status of the monitored nodes. By comparing these snapshots, both the steady and the dynamic state of critical nodes in transmission and sub-transmission networks can be observed. The result is dynamic condition monitoring of the power systems.

A key feature of WAM systems is the central acquisition of data from PMUs, enabling utilities to make us of phasor information wherever it is needed. ABB's PSGuard WAM system, as an example, provides the following customised forms of data utilisation.

Monitoring dynamic system behaviour

At present power system operation tends to be based on static or quasi-dynamic information extracted from RMS measurements, mostly using SCADA systems. Phasor measurements at important nodes help system operators gain a dynamic view of the power system and initiate any necessary stabilising measures in good time.

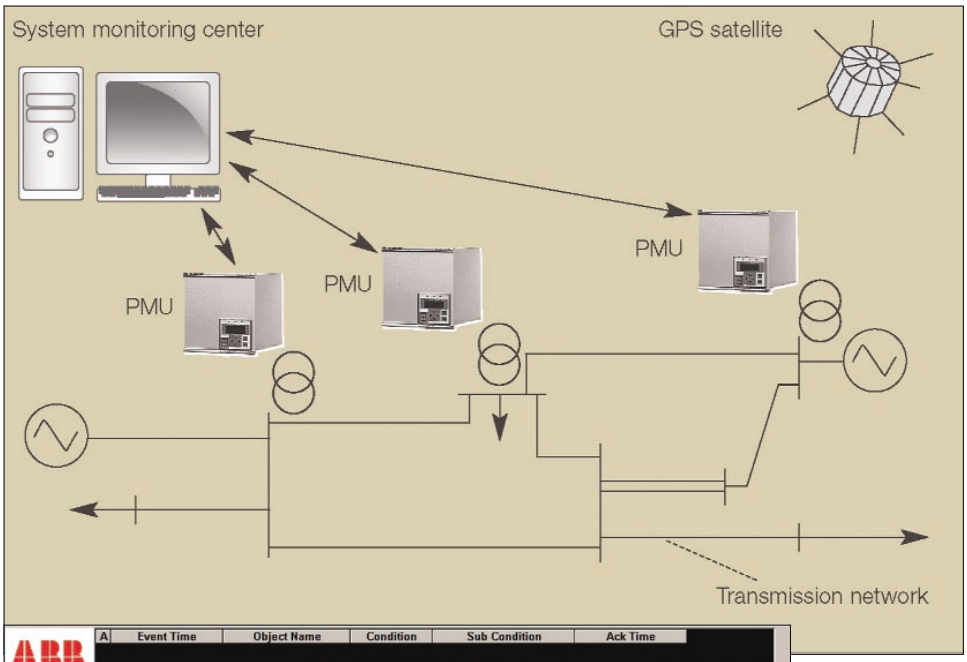
Significant support is provided by stability assessment algorithms designed to take advantage of the phasor measurement information. This increases the efficiency of power system operations and helps to maintain security at the desired level.

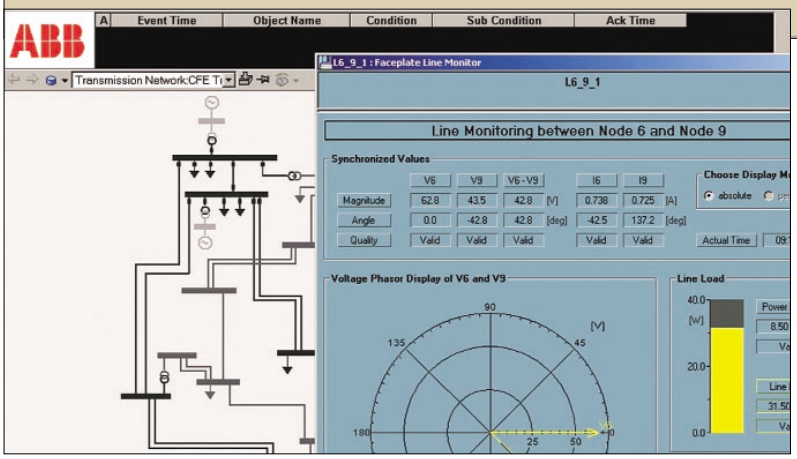
Monitoring of transmission corridors

Energy is often traded over the transmission corridors interconnecting power systems – an activity that adds significantly to the cost and therefore price of energy in liberalised markets. However, the transmission capacity of such corridors is often constrained by stability concerns arising from uncertainty about the underlying system status.

The traditional solution – to reinforce transmission path capacity by installing new lines – has the advantage of offering high availability. However, it also has the substantial disadvantage that line construction is both time consuming and requires huge amounts of new investment.

An alternative solution is to significantly improve asset utilisation through WAM. This reduces uncertainties and consequently the operational risks. Under certain conditions, such as lower than assumed ambient temperatures and cooling provided by the wind for





Above left: configuration of a wide area monitoring system with synchronised phasor measurements from PMUs used as input for the system monitoring centre.

Left: example of typica; WAM system graphical user interface. The popup line monitoring faceplate (on right) compares voltage phasors.

example, a significant capacity increase could be achieved at minimal risk.

The smaller investment can make a WAM solution far more cost effective than installing new lines. WAM is therefore also an important decision support tool for congestion management as well as investment planning.

Disturbance analysis & planning

The continuous data storage functionality provided by these systems is a valuable source of information for the analysis of incidents and disturbances occurring in the power system.

But, aside from improving the efficiency of power system analyses, it also helps to determine and consequently eliminate the actual causes of such incidents. This accurate identification provides a sound basis for the planning of system expansions and future system reinforcements.

PMUs are placed in substations to allow the power system to be observed under differing operating conditions such as network islanding and line or generator outages amongst others. Some redundancy is provided to secure this information in the event of certain data being unavailable due to PMU outage or communication failure.

The measured data is then sent via dedicated communication channels to what is called the system monitoring centre (SMC). This is a central computational unit in which the collected data is synchronised and organised, providing snapshots of the power system's states.

In the case of meshed network topologies, the snapshot is then processed by the basic monitoring (BM) package, part of the SMC. BM denotes the set of algorithms included in all installations of the wide area platform as the basis for different software applications. This solution package has the following capabilities:

- Ability to provide consistent input data for all PSGuard applications
- Fast execution, leaving sufficient time to run additional applications within the sampling interval
- Robustness – the system is resistant to the poor quality of some of the input data (availability, range, etc).

Software applications, linked to the BM output, address various dynamic phenomena occurring in power systems. They predict the state of the power system and suggest appropriate action to be taken by the system operators when an emerging instability is detected. An ergonomic graphical user interface (GUI) will display output information.

Historical data can also be accessed, allowing phasor data to be retrieved for subsequent analysis. A navigation facility is provided for easy selection and display of the required information.

Advanced software

To take full advantage of a WAM system, a step-wise approach is recommended.

First the utility and supplier should carry out an initial study to identify typical network problems and the most endangered of the areas in which the system should be deployed. Afterwards the appropriate monitoring algorithms and most suitable locations for installing the PMUs can be chosen.

The fundamental software modules include a GUI (with single-line diagram, pop-up windows, trend displays), easily scalable PMU connectivity package, data storage capability and export functions for further analysis.

The modular system allows selective implementation of hardware and software. Function packages to optimise transmission capacity and to maintain grid integrity by increasing operational and planning safety can be combined with special protection and control schemes at any time. Such schemes can initiate automated preventive or remedial actions and support operators, such as avoiding cascading effects.

WAM experience

Several systems with up to 16 PMUs have already been installed or engineered for practical application in high-voltage power grids.

During the summer of 2004, ABB transferred Europe's first WAM system into commercial operation for ETRANS. The company co-ordinates the Swiss extra high voltage grid as well as the UCTE south grid, using the WAM system to monitor the impact of heavy power transfers on the country's' main north-south transmission corridor.

To date customers have said that there is greater opportunity to achieve cost efficiency, grid utilisation, facilitated by online monitoring of critical nodes and that there was better detection and elimination of causes of power quality problems, made possible by the high accuracy of the underlying system of measurement.

Other benefits were the ability to carry out thorough investigations of critical incidents, and the provision of additional strategic information for the utility's grid planning department. MEE