Synchronised phasor measurement for improved power system performance

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. The introduction of numerical technology in protection and control equipment, together with digital communication, has enabled accurate phasor measurement at various locations. Synchronized measurements based on an accurate time reference, e.g. GPS (Global Positioning System), provide the missing link now allowing more efficient utilization of phasor data.

The introduction of phasor measuring units (PMUs) in power systems significantly improves the possibilities for monitoring and analyzing power system dynamics. A number of synchronized RES 521 Phasor Measurement Terminals, installed in different locations of a power system provides important information about different AC quantities e.g. voltages, currents, active and reactive power, all of them based on the same GPS time reference. Synchronized measurements make it possible to directly measure phase angles between corresponding phasors in different locations within the power system. Improved monitoring and remedial action capabilities allow network operators to utilize the existing power system in a more efficient way. Improved information allows fast and reliable emergency actions, which reduces the need for relatively high transmission margins required by potential power system disturbances. Instead of merely surviving the worst credible contingency the power system should survive the worst credible contingency followed by remedial actions initiated by various new functions based on phasor measurement.

Phasor measurement opens a wide range of new applications, e.g.

- Monitoring and recording of power system dynamics
- Improved state estimation
- Systemwide power oscillation mitigation

Monitoring and recording

The increased utilization of electric power systems is of major concern to most utilities and grid operators today. Advanced control and supervision systems allow the power system to operate closer to its technical limits by increasing power flow without violating reliability constraints. The introduction of phasor measuring units is the first step towards more efficient and reliable network operation.

A number of ABB's RES 521 terminals, connected to a centrally located data concentrator, provide relevant phasor data for off-line studies and post-event analysis. Typically, each PMU has 10 or 20 analog input channels for voltages and currents and, in addition, it is capable of handling a practically unlimited number of binary information signals. The terminals transmit information to the data concentrator up to 60 times a second. Based on the stored data in the data concentrator, extensive off-line studies and post-event analyses can be performed.

Improved state estimation

RES 521 terminals and specific application software enable improved power network state estimation. It is now possible to eliminate the inaccuracy and delays of traditional SCADA-based schemes. RES 521 provides accurate time-tagged measurements from all over the power system to be used as the basis for the state estimation. Complete monitoring of the power system with PMUs installed on approximately one third of the buses, allows instant calculation of the power system state.

Based on fast and reliable state estimation or, actually, state calculation, a variety of system stability indices is available on-line to the system operator. Different stability programs for a number of contingencies can then be run to evaluate risks and margins. Such applications contribute to optimizing the power system operation process.

Systemwide power oscillation mitigation

In weak power systems with remote generation, power oscillations caused by insufficient damping often limit the available transmitted power. There are two ways to increase the transmission capacity and in that way fully exploit the generation resources. The traditional way is to build new power lines, but this is costly and increasingly difficult due to environmental constraints. A more attractive alternative is to move the stability limit closer to the thermal limits of the power lines by introducing extended power system control, thus improving the utilization of the entire transmission system.

In case of insufficient damping, stability is usually improved by continuous feedback controllers. The most common type of controller is a power system stabilizer, which controls generator output by influencing the set point of the voltage regulator. Traditionally, only locally available input signals such as shaft speed, real power output and network frequency have been used for closed-loop control purposes.

Advanced communication system technology has made it feasible to enhance the performance of power system stabilizers with remotely available information. This type of information, e.g. active and reactive power flow, frequency and phasors, is provided by PMUs. Synchronized measuring provides systemwide data sets in time frames appropriate for damping purposes. Systemwide communication makes it possible to decide where to measure and where to control. The actuator and the measuring points can then be selected independently. In such a case, modal controllability and modal monitoring are maximized.

Author: Daniel Karlsson, ABB in Sweden