Powerful and stable

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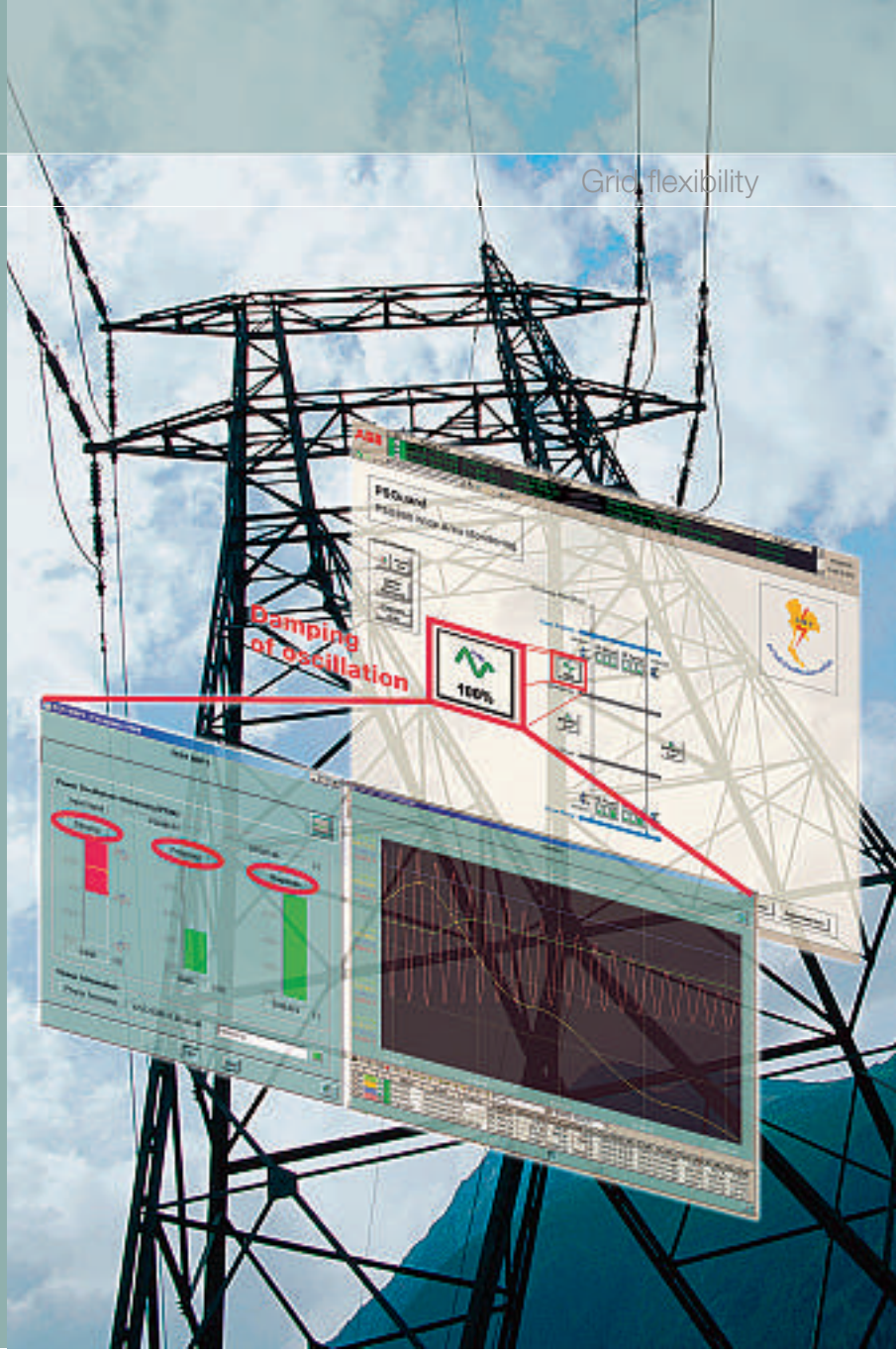


Crucial to the safe and secure performance of a national electricity grid is voltage stability, phase angle monitoring and now also the dampening of oscillations occurring in transmission corridors. This most recent feature has been implemented in the network of Thailand controlled by EGAT, its Electricity Authority.

The Electricity Generating Authority of Thailand (EGAT) is the very first Asian utility to apply Wide Area Monitoring (WAM). The main purpose of the WAM application is to monitor power oscillations that sometimes occur on a transmission corridor between the southern and central regions as a result of the transmission of power imported from Malaysia.

EGAT's mission is to ensure the efficient, least cost, and environmentally friendly production, purchase, and transmission of electrical energy.

Power Oscillation Monitoring

The main function of the EGAT PSGuard WAM is Power Oscillation Monitoring (POM). Power oscillations (often also referred to as swings) are created by interactions between generators in power systems. These interactions are caused by the different responses of generators to changes in system conditions. If these oscillations are poorly damped, they may lead to severe consequences, such as the loss of synchronism of generators, tripping of lines etc. and finally to the collapse of the system resulting in blackouts. Therefore it is of crucial importance to monitor them, if they occur, and especially to monitor their damping.

Thailand normally receives energy from Malaysia via a DC link. In Thailand, this results in power flows from the southern region to the central region via a transmission corridor with limited capacity. Sometimes this creates a power oscillation problem on the lines between the Bang Saphan (BSP) and Surat Thani (SRT) substations, which both are part of this corridor 1. The dominant oscillation frequency is 0.47 Hz and the power flow between the regions is about 400 MW.

EGAT

EGAT was founded in 1969, and builds, owns and operates several types of power station throughout Thailand. With a total installed capacity of 25,800 MW, EGAT accounts for about 60% of the country's total generation. It also owns, develops, and operates the national transmission network, which covers the entire country and which operates at voltage levels of 115 kV, 230 kV, and 500 kV. The network is presently linked to Laos by 115 kV and 230 kV lines, and to Malaysia by 132 kV and the new 300 kV HVDC lines.

To help with this problem, a static Var compensator was installed at the BSP substation for the purpose of power oscillation damping and voltage control of the BSP bus.

The PSGuard Wide Area Monitoring System

PSGuard is a new and unique system for the acquisition and processing of data for determining the status and health of power systems. In contrast to conventional control systems, where RTUs (remote terminal units) are used for the cyclic acquisition of the RMS (root mean square) values of currents and voltages, the PSGuard system acquires real-time GPS-synchronized current and voltage phasor measurements from critical locations of the power system. These synchronized phasor measurements allow comparisons to be made between different locations of the network and to determine its dynamic behavior. This information is very useful in the detection and analysis of power system oscillations with cycle times in the order of seconds, such as those that occur in the EGAT network.

The EGAT Wide Area Monitoring System

The EGAT PSGuard installation comprises Phasor Measurement Units (PMUs) installed in the BSP and SRT substations for the dynamic measurement of the phase angles at each end of the critical transmission corridor 2. The PMUs measure the vector values (magnitude and phase angle) of the voltage and current. These measurements are synchronized by the GPS to an accuracy of less than 1 microsecond and are acquired every 100 milliseconds.

Synchronized phasor measurements allow comparisons to be made between different locations of the network and to determine its dynamic behavior.

The phasor data is transmitted to the System Monitoring Center, which is located at the head office at Nonthaburi. The power system operators are provided with real-time information enabling them to monitor the power transfer, and the voltage and current phase angles.

The Power Oscillation Monitoring function 3 computes the frequency and damping of oscillations in the measured values by using adaptive Kalman filtering techniques. Oscillation frequencies between 0.1 Hz and 0.5 Hz are detected. The output of POM is displayed and recorded in logs.

The damping, frequency, and magnitude of the dominant oscillation are shown in a graphic display 4. In addition, an alarm is displayed if the damping of the oscillation is less than a predefined value, and another alarm if the magnitude of the oscillation exceeds a predefined value.

Phase angle monitoring

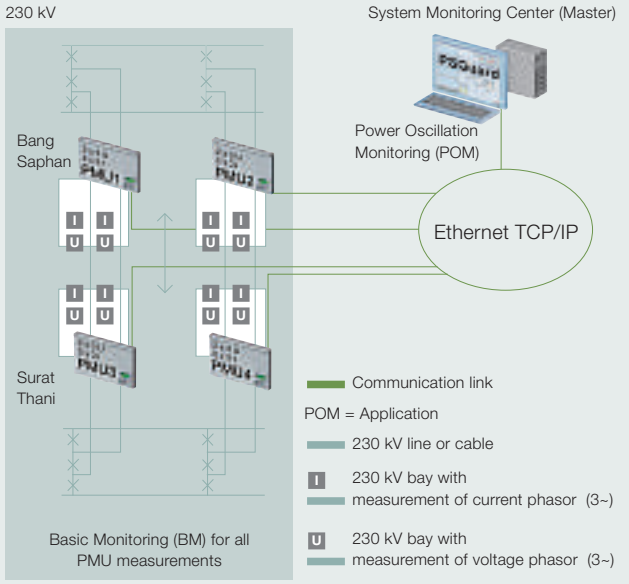
A further function within the framework of Wide Area Monitoring is Phase Angle Monitoring (PAM). PAM monitors the differences in the phase angles between critical locations of the network in real-time. This gives an indication of the stress in the network as a result of heavily loaded lines and is crucial for the successful re-closing of transmission lines.

The phase angle difference between two selected locations and the active and reactive power at selected locations are displayed graphically.

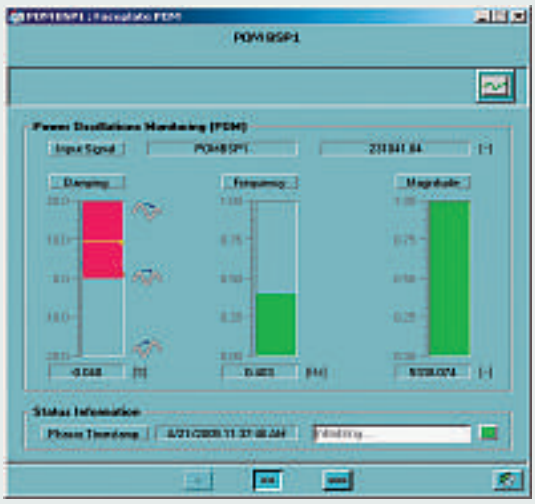
There are warnings and alarms if the phase angle difference exceeds predefined values. This information is intended as a decision support for operators. Actions that an operator may take to improve the network stability

1 Transmission corridor between Surat Thani and Bang Saphan.

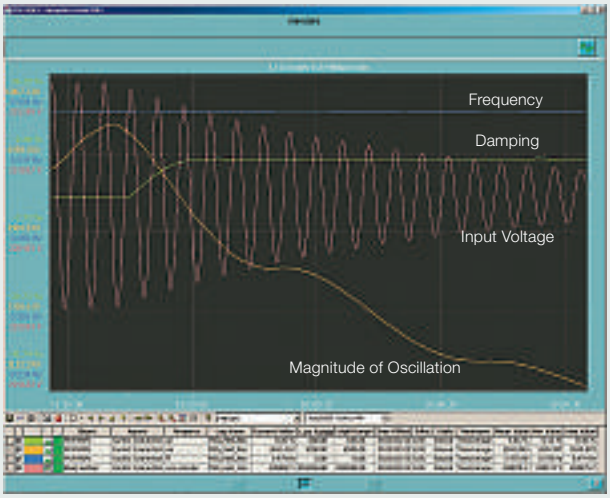
2 Physical set-up of the PSGuard installation.



3 The POM display: damping, frequency and magnitude in one view.



4 PSGuard on-line display: estimation of frequency, damping and magnitude.



may range from generation rescheduling, actions to change the system reactive power compensation, blocking of transformer tap changers in the load area, to load shedding in extreme cases.

Benefits of Wide Area Monitoring for EGAT

WAM provides the following operational benefits for EGAT:

- The operator is immediately aware of any oscillations that are present in the power system and can see the urgency of the situation.
- The operator is given information about the frequency of the oscillation, which may then be compared with existing known oscillation modes of the power system, ie the operator can distinguish between a local or an inter-regional oscillation mode.
- The POM function enables EGAT to optimally load the important supply corridor from Malaysia by minimizing the risk of power oscillations.
- Using the recorded data, long-term statistics can be generated and evaluated for the purpose of improving the power system, eg the retuning of power system stabilizers to damp the frequencies that are considered to be most critical.

The benefits of ABB's PSGuard WAM system for EGAT are:

- Support for the operators in maintaining the integrity of the network and for optimizing the power flow.
- Dynamic monitoring of the status of the network with early warning to prevent the spreading of disturbances.
- Improved operation of the transmission network through applications such as power oscillation monitoring.
- High quality data for modeling the grid for the future enhancement of control measures.
- Support for least-cost generation decisions.

Mr. Chanin, the EGAT PSGuard project manager, remarks:
"PSGuard provides us with very useful on-line information for operation, protection and control. This helps us to optimize transmission as well as to detect and counteract power system instabilities. Furthermore, the information is used to perform off-line studies and grid modeling, which enables us to improve stabilizing and control measures to avoid major disturbances in the future."

The EGAT project and future plans

The project is divided into two phases. The first phase comprises two of the lines, and the second phase covers the entire transmission corridor of four lines. The system supplied is pre-engineered for both phases.

The first phase has been successfully commissioned and is in operation since August 2005. The second phase has already been pre-commissioned and will go into operation in 2007.

EGAT is currently evaluating the extension of the WAM installation by the Voltage Stability Monitoring function. The purpose of this function is to detect potential instabilities in the network that could lead to a voltage collapse so that countermeasures can be initiated in good time.

The full scope of voltage stability, phase angle monitoring and oscillation damping would then be implemented in one and the same network.

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