THE EFFECTS OF SYSTEM EXTENSION ON INTER-AREA OSCILLATIONS

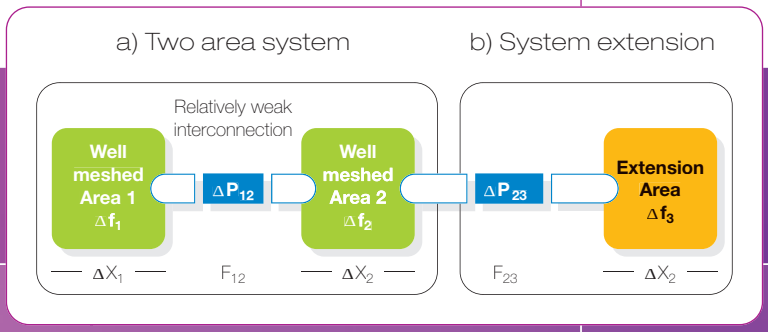
UCTE is experiencing the phenomena of inter-area oscillations – like other large synchronously interconnected power systems world-wide, too. This phenomenon has an increasing meaning in extended power systems, especially if they are loaded by high power transits. It has to be tackled in an adequate manner as otherwise the risk of instability may arise in certain system conditions with serious consequences for the system security.

The origin of inter-area oscillations can be illustrated by a spring-mass system, which is a mechanical analogue of a two area power system, see Fig. 1 a. The masses represent the aggregated inertias of the rotating generators and turbines of both areas, each having a well meshed grid inside the areas. The spring corresponds to a relatively weak interconnection line.

The two masses may oscillate against each other causing spring forces. The oscillations Δx_1 and Δx_2 of the two masses correspond to the local frequency deviations Δf_1 and Δf_2 in the two areas. The spring force F_{12} is the analogue of the oscillating power exchange ΔP_{12} between the two areas.

Fig. 2 shows recordings of inter-area-oscillations in the UCTE system stimulated by a generation outage. The frequency oscillations of the border areas are in phase opposition, which shows that the border areas Spain and Poland/Hungary are swinging against each other as illustrated in principle by the (very simplified) two mass model. The power flow corresponding to the spring force in the centre of the system is also shown in the diagram. During this incident, the oscillations disappear after around two cycles and do not affect system security.

The damping of the oscillation depends on the system loading, the load characteristics and generator/turbine control. A poor damping my be a severe security risk for the whole system. Insufficient damping may become a problem especially for systems with such oscillation frequencies which are not damped by the generators and their standard control systems. Unfortunately, an oscillation frequency ($\approx 0{,}26$ Hz) exists in the UCTE system, which lies in this critical range of poor natural system damping. Therefore, damping had to be improved by optimising parameter



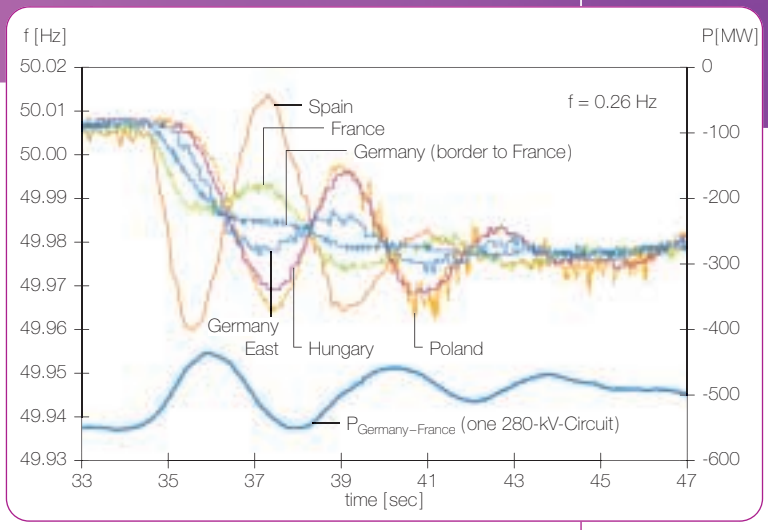


Fig. 1 a) Mechanical analogue (spring-mass system) interarea oscillations
b) Extension of the system by interconnection with an adjacent power system

Fig. 2 Inter-area oscillations after a power plant outage in Spain, 900 MW, 17.01.1997

settings of generator voltage control and implementation of Power System Stabilisers (PSS).

The mechanical model illustrates that the supra-regional structure of the system is the main factor regarding the basic dynamic system characteristic, whereas the regional grid design has only little influence. It is evident that the system dynamics will change significantly in case of interconnection with a further area, see Fig. 1 b. The new system configuration may lead to new frequencies of possible oscillations.

This aspect is presently an important issue dealt with by the UCTE Working Group on System Development. While the UCTE system has grown more or less gradually in the past, UCTE is now faced with requests to extend the synchronous area in relatively large steps through interconnection with other existing interconnected power systems. UCTE has to investigate carefully the effect on the dynamic system behaviour before synchronising an adjacent system.

To this end, UCTE uses a complete dynamic model for the synchronous area representing the 380/220 kV grid and all large generation units including their generator and turbine control functions. This model is validated by recordings from the real system. This process is also required from the extension area: modelling on the basis of dynamic data and validation by recordings collected during isolated operation. The technical requirements are defined by investigations of the whole extended synchronous area. Using modern techniques for power system analysis and control, UCTE meets its obligation to maintain the system security, and enables the technical means to be optimally used for reliable parallel operation with new partners. <<<