Dynamic performance of generators

System dynamics and control of oscillations

At a glance

One important task in power system operation is the damping of inter-area oscillations. Reliable solutions can be found by simulating the respective network and performing an eigenvalue analysis of the installed controlling devices.

Siemens Power Technologies International (Siemens PTI) can support you with:

- world class power system planning software from the PSS® product suite for detailed simulation and calculation results
- high-quality power system consulting and long-term support, including specialized training
- tailored and innovative technical solutions

The challenge

In electrical systems, a variety of control tasks need to be performed, including voltage and frequency control, as well as the damping of oscillations of generators among one another or among coherent groups (inter-area oscillations). To this end, control systems must be modeled along with the generators and a number of analyses must be performed, e.g. turbine and voltage control. The controllers represent the exact transient behavior of the generator (closed-loop speed control, speed capacity control). They must take into account the reserve behavior of the system (primary and secondary reserve) to evaluate the control response in case of an outage and to adjust the settings or change the controlling strategies when required.

This is also true for other controlling devices in the system, such as controllers for HDVC systems, series compensation in transmission lines or static compensators to initiate or coordinate controlling tasks in the network (active power, voltage, damping, reactive power, current etc.).

Our solution

The design and testing of the controlling devices is usually carried out by means of eigenvalue analysis of the controlling devices in the frequency domain, and simulation of the small signal range (control response) and large signal range (limit control) of the controllers, either individually, or system interconnection in the respective time domain.

We have powerful simulation tools at our disposal which can simulate networks with several thousand generators. The eigenvalue analysis is performed with an automatic linearization which offers the possibility of directly evaluating the linearized small signal range within the time domain. By analyzing the right and left eigenvectors, the basic control characteristics (observability and controllability) can be assessed. When comparing the two eigenvectors, the delta identifies the optimum position of the controllers in the network or the controllers which should be modified. The simulation of the large signal range within the time domain allows for a consideration of all non-linearities resulting from control restrictions and shows the effectiveness of the controlling strategies and concepts on the entire system.

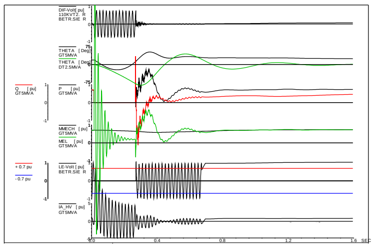

Figure 1: Time-dependent dynamic simulation

Application example

Figure 2 shows a Combined Cycle Power Plant (CCPP), where the gas turbine is output-controlled at 5% variable speed. In the case of short circuits, it becomes apparent that system stability is limited. If the control is modified in case of failure to reach full closed-loop speed control, the system can remain stable even in severe cases of fault.

Such changes in controlling concept have to be discussed in detail with the turbine / generator producer to ensure a reliable solution.

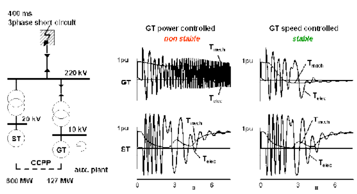

Figure 2: Change in control concept for the stabilization of a CCPP (T_{mech}: mechanical torque, T_{elec}: electrical torque)

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