Stability Analysis of Modern Power Systems

Key words: hybrid/nonlinear systems, power system stability, control

Context:
As for any dynamic system, stability is an important matter for power grids. However, several types of stability have been defined in power systems literature: transient, voltage and small-signal stability. Despite the fact that each of them is well defined, the check for stability is usually done by numerical simulations and analytical results are very difficult to provide on realistic (i.e., large-scale) grid situations. This is the case for transient and voltage stability. This is a limitation, for example, for the synthesis of nonlinear control laws and to prove their stability in several grid conditions.

The difficulties mentioned above are due to several facts. First, power systems are nonlinear systems. They contain physical nonlinear dynamics but most of the nonlinearities come from saturations and dead-bands which are systematically integrated in each regulator in order to protect the material. Next, transient stability is defined with respect to a critical event of the system – usually a short-circuit - which is eliminated in a given laps of time. This kind of event produces modification of the topology of the grid. Finally, other modifications of the power system may come from the new mechanisms of the electricity markets which are more and more present in power systems the last decade and in future perspective. As an example, the so-called *merit-order* mechanism selects actuators for the secondary frequency control according to the price signals and the (dynamic) state of the system. This leads in this case of changes of the structure of one control loop of the grid.

Research subject, general work plan:

The idea is to use recent analysis techniques from control theory to:

- Obtain analytical characterization of transient stability and of stability margins
- Explain how the commutations mentioned above for power systems can be taken into account either to prove stability or to ensure robustness domains
- Synthesize stabilizing control laws in the actual and future context of the transmission grids
- Deal with the large-scale of the power systems

Framework:
This work is proposed in a general framework of collaboration with RTE –