Modal Analysis, Model Order Reduction and Uncertainty Quantification for Large-scale Power Systems

Key words: eigencalculation, parameterization, large-scale, grid oscillations, uncertainty quantification, reduced bases (POD/PGD), model order reduction

Context:
Computation of the eigenvectors and eigenvalues of a linearized representation dx/dt=Ax of the grid is a main task of the analysis of power systems. Indeed, several structural properties and phenomena like, e.g., the inter-area oscillations can be characterized in this way.

The large-scale (about 40000 state-space variables, i.e., dim{x}=40000) is a challenge which led us to *selective* eigencalculation. This means that the research of the eigenvectors and eigenvalues must be an iterative process well guided by the a priori knowledge of the particularities and properties of the power system. The massive integration of power electronics in the modern and future grids is a new difficulty to overcome.
Next, the renewable energy and the new kind of loads like the electrical vehicles bring uncertainty into the system which must be carefully quantified and taken into account in the modal analysis.
Finally, the distributed generation need aggregation into parameterized mathematical models. The dependency of the dynamic properties of the power systems on these parameters as well as on usual variations of the operation point, load level, etc must be integrated in the new methods of modal analysis.

Research subject, general work plan:

Several levels of investigation are envisaged:
- Selective eigensolvers for grids with high level power electronics
- Parameterization of the eigenvalues and eigenvectors: algebraic approach
- Quantification of the uncertainty: algebraic and/or statistical approach

Framework:
This work is proposed in a general framework of collaboration with RTE – the French Transmission System Operator – and it is thus connected to real needs of the interconnected power systems. Realistic tests and validations of the theoretic developments mentioned above are possible on grid models and scenarios provided by RTE. The Control of Power Grids chair (http://chairerte.ec-nantes.fr/) which exists between Ecole Centrale Nantes and RTE R&D guarantees the direction and the financial founding of this work. Several subjects are to be treated for this general theme in a temporary position (post doctoral or research engineer). The content and the duration are to be refined according to the competences/availability and motivation of the candidate.

The work will be carried out in Nantes-France.

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