

Robust and Structured Control of Power Electronic Elements inserted into Modern Power Transmission Grids

Key words: robust/structured/H infinity control, non smooth/non convex optimization, interaction and coordination, power converters, HVDC, inter-area oscillations, small-signal stability

Context:

Power electronics is more and more used on the power transmission grids. Indeed, all wind and photovoltaic generation is connected to the grid by converters. Also, the reinforcement of the grid is frequently done with High-Voltage Direct Current (HVDC) lines which consist of 2 power converters into a back-to-back connection and a DC cable. This tendency will be extended in future in order to ensure the transition towards decarbonized energy systems as formulated, for example, in Europe.

This new technology based on power electronics is active in the sense that it provides several degrees of freedom for the power and voltage control. Thus, it has an impact on the dynamics of the neighbour AC power system. In particular, the small-signal and the transient stability depend on the way in which the regulators of the converters are synthesized. This raises several control questions:

- how to improve the transient stability of the neighbour zone?
- how to quantify and diminish the interactions between two close HVDC ?
- how to damp inter-area modes (i.e., low frequency electromechanical oscillations of the power grid) via power-modulation control of the HVDC?

Research subject, general work plan:

A new control framework should be proposed in order to take full advantage for robustness and performances. Transient and small-signal stability are envisaged. Specific control methods will be used to answer the specifications, particularly:

- robust control to take into account the neighbour grid and the interactions between active elements
- structured/non-interacting control to avoid the use of distant measures between several HVDC
- nonlinear approaches to directly take into account the nonlinear behaviour of the system
- switched systems formalism to directly take into account the short-circuits

Competences needed :

(at least) 2 paths are envisaged at this stage:

- the system is addressed in linear approximation via linear robust control (like H-infinity/H2) based on LMIs, structured control and non convex/non smooth optimization.
- The system is addressed as non linear and switched. Stability margins as well as control methods to enhance them will be envisaged in this formalism.

The candidate should have experience in automatic control/analysis in one of the 2 directions mentioned above. Knowledge on power systems/power converters would be a plus but it is not mandatory. The candidate should only be motivated to discover this field with the help of experts from the recipient team.

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://chairrte.ec-nantes.fr/>) which exists between Ecole Centrale Nantes and RTE R&D guarantees the direction and the financial founding of this work. The work will be carried out in Nantes-France.

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