How Computing Exact Planar Invariance Kernels Could Help Wind Turbines Calm the Grid

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A wind turbine is actually a very controllable energy conversion device, even if its prime mover is variable and uncertain. Wind turbines and farms therefore offer possibilities to support frequency regulation objectives in the power system. The oscillatory modes of the power system can be damped if we command the extraction of a counteracting power flow from suitably located wind farms. However, the imposition of both wind power variations and grid power variations together produce deviations in the rotational speed and the electromagnetic torque of the wind turbine. We don't really care what specific values these quantities take on but if we can not ensure they will be confined to a specified region of the state space, the amount of support given to the grid can't be quantified.

In this talk, I will show how the concept of invariance kernels offers a natural solution to this type of problem. I will introduce some mathematical objects and results that allow us to exactly determine "safe" regions in the planar state space of a nonlinear system. I'll then explain with an example how we can develop a disturbance margin that informs us about how much wind turbines and farms can contribute to oscillation mode damping, and point out some of the assumptions and issues surrounding the research.