

The effect of HVDC lines in power-grids via Kuramoto modelling

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We present a numerical study on the synchronization and cascade failure behaviour by solving the adaptive second-order Kuramoto model on a large high voltage (HV) European power-grid. This non-perturbative analysis takes into account non-linear effects, which occur even when phase differences are large, when the system is away from the steady state, and even during a blackout cascade. Our dynamical simulations show that improvements in the phase synchronization stabilization as well as in the cascade sizes can be related to the finite-size scaling behaviour of the second-order Kuramoto model on graphs with $d_s < 4$ spectral dimensions. On the other hand, drawbacks in the frequency spread and Braess effects also occur by varying the total transmitted power at large and small global couplings, presumably when the fluctuations are small, causing a freezing in the dynamics. We compare simulations of the fully AC model with those of static or adaptive High Voltage Direct Current (HVDC) line replacements. The adaptive (local frequency difference-based) HVDC lines are more efficient in the steady state, at the expense of very long relaxation times.

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