RWTH AACHEN UNIVERSITY

E.ON Energy Research Center
ACS | Institute for Automation of Complex Power Systems

Bachelor/Master Thesis:

Frequency-Adaptive Power System Modelling for Dynamic Simulation in the Phasor Domain

Context:
The simulation of modern power systems requires the accurate representation of grid dynamics emerging due to additionally installed components such as distributed energy resources with low-inertia characteristics. Besides, large-scale simulations of scenarios with a high number of grid nodes allow to understand specific dynamic phenomena and to include as well lower voltage levels, but they are computationally more expensive.
To enable large-scale simulations with highest possible accuracy, the *Institute for Automation of Complex Power Systems* develops a power system simulator named *DPsim*. The power system simulator allows for conventional Static Phasor (SP) simulations as well as for the application of a new approach called Dynamic Phasor (DP) simulation, which is based on shifted frequency analysis.

In SP domain, a constant frequency $\boldsymbol{f_s}$ of the voltage and current sine waves is used in order to derive the SP dynamic equations of the power system component models. In DP domain, the frequency shift is introduced based on a constant frequency $\boldsymbol{f_s}$, in order to derive the DP dynamic equations of the power system component models.

SP inductor equation: $V_L = j2\pi \boldsymbol{f_s} L I_L$

DP inductor equation: $V_L(t) = L\frac{dI_L(t)}{dt} + j2\pi \boldsymbol{f_s} L I_L(t)$

In reality, the power system frequency is not constant but rather time varying ($\boldsymbol{f_s(t)}$). The constant frequency of the sine waves in SP and constant frequency shift in DP is an acceptable assumption for conventional power systems, where the frequency deviations are rather minimal and slow. The transition from conventional generation (e.g. fossil, hydro and nuclear) to converter-interfaced generation (e.g. solar photovoltaic and wind) has a significant effect on frequency dynamics in the grid. It leads to faster and higher frequency fluctuations caused by a decrease of the total inertia in the system. Therefore, it become more important to consider frequency variations in phasor domain simulations.

This thesis targets an accuracy improvement of simulations in the phasor domain by developing a frequency-adaptive modelling approach. Such an approach will incorporate time

varying frequency in the power system component models and will allow a more accurate representation of grid dynamics.

Task:
The scope of the thesis can be adapted to be suitable for bachelor or master thesis. The key elements of the work will be:

- Literature research on frequency-adaptive dynamic simulation in the phasor domain
- Integration of a common frequency estimation technique into an existing simulator
- Adaption of grid component models for frequency-adaptive simulations
- Performing dynamic simulations.
- Comparison of simulation results obtained with a constant frequency and frequency-adaptive simulation in the phasor domain

Basic knowledge of C++ is mandatory. Experience in power system modeling and simulation is desired.

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