École Polytechnique Fédérale de Lausanne
Distributed Electrical Systems Laboratory
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Student project proposal

Project title

Development of Electro-Magenetic Transient (EMT) models of low-inertia power systems for real-time simulation

Project type

☒ MSc thesis ☐ BA semester project ☒ MSc semester project

Project Responsible and e-mail

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Project description

Modern power systems are in the midst of a major de-carbonization marked by the increasing substitution of highly controllable conventional synchronous based generation with intermittent stochastic renewable converter interfaced energy resources. Among the many challenges this paradigmatic shift poses to system operators, the reduction of total system inertia and its associated faster, more frequent and more severe dynamics are one of them [1].

These phenomenon include frequency ramps, steps as well as bandwidth modulations [2], during which the conventional assumption of phasorial (RMS) simulation tools, where all power is considered to be transmitted at a single frequency, close to nominal, no longer holds [3].

This project seeks to deepen the understanding of power system behavior during such conditions by developing Electro-Magenetic Transient (EMT) models of low-inertia networks and their subsequent evaluation and simulation on a real-time simulator (RTS). The project is suitable for both MSc semester projects and MSc Thesis and for which additional scope and tasks are considered.

Tasks of the student

Semester Project:

- Model an IEEE test case (eg. 9 bus, 14 bus) power system using the Simulink Simscape Electrical EMT library [4] considering an adjustable system inertia.
- Adapt and deploy the model to the Real-Time simulator (RTS) platform using RT-Lab [5] in order to simulate the relevant dynamics of modern grids for different inertia levels.
- Analyze the spectrum of transmitted power.

Additional Tasks if taken as a MSc Thesis:

- Conduct a literature review on state-of-the-art estimation methods, identify the limits of current grid models for monitoring and control, and outline possible pathways to improve estimation accuracy, reliability, or other relevant metrics.
- Estimate the grid state in normal and dynamic conditions, assessing and comparing the

estimation accuracy.

Expected outcomes

- Understand the impact of renewable energy sources integration in the grid at system level, with hands-on experience.
- Identify the limits of state-of-the-art estimation methods and explore other approaches.

Requirements

- Proficiency with MATLAB/Simulink
- Experience with version control systems (Git).
- Fundamentals of Power Systems (related courses: Power System Analysis, Smart Grid Technologies).
- Additional knowledge of RTS systems (e.g. Opal-RT, dSPACE) is a merit.
- Experience with EMT simulation software is a merit.

References

[1] F. Milano, F. Dörfler, G. Hug, D. J. Hill, and G. Verbič, "Foundations and challenges of low-inertia systems (invited paper)," in *2018 Power Systems Computation Conference (PSCC)*, 2018, pp. 1–25.

[2] "Ieee/iec international standard - measuring relays and protection equipment - part 118-1: Synchrophasor for power systems - measurements," *IEC/IEEE 60255-118-1:2018*, pp. 1–78, 2018.

[3] A. Derviškadić, G. Frigo, and M. Paolone, "Beyond phasors: Modeling of power system signals using the hilbert transform," *IEEE Transactions on Power Systems*, vol. 35, no. 4, pp. 2971–2980, 2020.

[4] The MathWorks, Inc., *Simscape Electrical (formerly SimPowerSystems and SimElectronics)*, version R2025a, Natick, Massachusetts, United States, 2025.

[5] OPAL-RT Technologies, Inc., *RT-LAB Real-Time Simulation Environment*, version latest, Montréal, Québec, Canada, 2025.