A Library to Support Learning Power Systems Modeling with OpenModelica and OMEdit

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Scope of the PowerGrids Library

- Modelling of power transmission and distribution systems
- Scale: from small academic examples to full pan-european models
- Quasi-static E/M behaviour of transmission lines → phasors
- Balanced 3-phase systems

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- Dynamic phenomena: 0.1 to 10 s
  - Inertia of rotating synchronous generators
  - Internal electrical dynamics of synchronous generators
  - Governors, AVRs, PSSs
  - Islanding transients
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  - Always close to nominal (50/60 Hz) frequency
- Full open-source paradigm
  - Modelica language
  - Open source tools (although commercial ones are also fine)
  - Open source solvers
  - Full access to all the details, no hidden/secret/proprietary

Typical Design Rationale of Modelica Libraries

- Models are written by seasoned Modelica experts,
  with many years experience
- Abstraction, replaceable classes, multiple inheritance are used cleverly
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Libraries are easy to *use*

Extensive Modelica training to adapt existing models or develop new ones

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  - Fortran/C/C++ code
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- Model/solver separation is often a cultural shock
- A few dedicated Modelica enthusiasts are found, but selling Modelica to the entire community is a very difficult task
- Usually, people have more important things to do than learning Modelica!

Design Rationale of the PowerGrids library – II

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- Models of innovative equipment
  Multi-domain modelling possible
- *Modelica should be used to make source code easy to understand, develop,and maintain*
- *Keep the learning curve for domain experts as low and smooth as possible*

Design Rationale of the PowerGrids library – III

Use the power of Modelica

to make the source code
easier to understand

not to make it arcane or obscure!

Library design: Quantities

- Use Complex variables for phasors
  - The original equations are written using complex numbers
  - Modelica tools should handle them with zero performance penalty!

- Use SI units for connectors and basic physical models
  - Scaling performed automatically via *nominal* attribute
  - Avoid the confusion of having p.u. vars with multiple base quantities
  - Use p.u. *locally* when textbook equations also do for better clarity (e.g. synchronous machine models)

Library Design: Ports and Base Classes

- PortAC: basic object bound to connector current&voltage
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Domain experts can focus on
high-level equation-based modelling
with minimal effort

Live Demo with OMEdit

https://www.github.com/powergrids

Tutorial on PowerGrids with OMEdit

Tomorrow morning @MODPROD Workshop

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⇨ Guarantee of convergence once power flow solution is known

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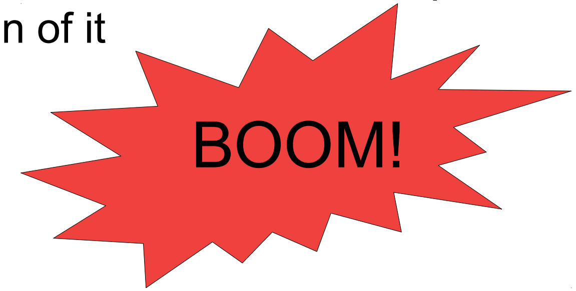

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- Open problems
  - How to make sure the correct solver setup is automatically obtained?
  - Are new standarized annotations required?

Solver Issue: DAE mode

- The DAEs describing power systems with phasors are sparse
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- The corresponding ODEs instead are dense
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Efficient event detection and handling (currently based on causalized equations) needs new research

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- The toolchain is complete, including power flow and graphical editor and is 100% open source free software
- Excellent for teaching purposes
- The source code of component models is easily understood and written also by Modelica novices
- Could also be expanded for serious use on large-scale systems when better support for such systems is provided by OpenModelica

Thank you for your kind attention!