ELECTRIC POWER LIBRARY

Overview

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AGENDA

- ❑ About Electric Power Library
- ❑ Key Benefits
- ❑ Key Capabilities
- ❑ Key Applications
- ❑ Library Contents
- ❑ Modelon Compatibility

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ABOUT ELECTRIC POWER LIBRARY

- Simulation of electric power systems for
  - Testing of new control strategies
  - Development and verification of new designs
  - Commissioning
  - Analysis of dynamics
  - Failure investigation

- From generation to consumption of electric power
  - Including transmission and distribution

- Developed together with power expert Hans-Juerg Wiesmann (ABB), Switzerland

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KEY BENEFITS

- Well-suited for control design applications where simulations early in the design process are valuable
- Multi-domain capabilities – power electronics, mechanics and thermal dynamics can be captured in the same tool, saving time and simplifying modeling
- Enables safe planning and commissioning tests by initial practice in a virtual environment
- Get quick insights with fast and robust simulations
- Equation based, state-of-the-art representation of physics provides accurate results
- Easy to integrate into any application domain

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KEY CAPABILITIES

For use in a **wide range of electric applications** in multiple industries:

- Power generation systems and grids
- Autonomous electrical systems: aircraft, ships, trains, hybrid vehicles
- Wind power and renewables
- Power Electronics
- Islanding power generation
- Electrical drive systems, variable frequency drives
- Compatible with Thermal Power Library and Hydro Power Library
- Real-time capable

Flexible fidelity level ensures appropriate time frame resolution

- Average and switched inverter models
- Dynamic and steady-state

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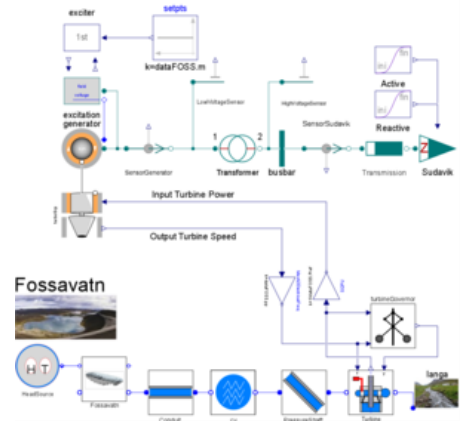
KEY APPLICATIONS

CASE STUDY

Stabilizing Hydro Power for the Electrical Grid

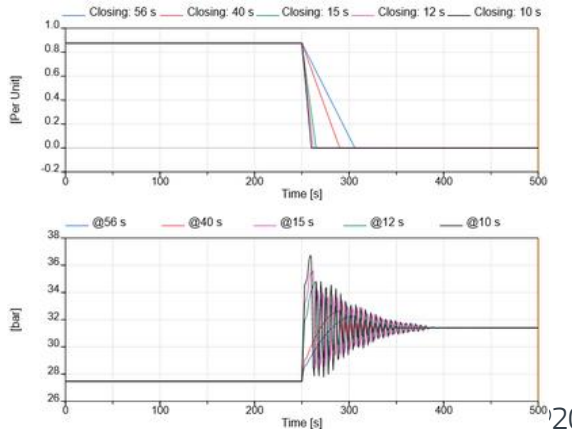
Objective

Using Modelon's Hydro and Electric Power Library, engineers set out to improve the understanding of Iceland's Fossarvirkjun power plant by investigating load rejection and exploring worst-case scenarios during complete plant shut downs.



Results

- Electrical grid that is better prepared to handle disturbances and safety critical scenarios
- Improved operation with a lower closing time limit, enabling faster reactions to critical disturbances



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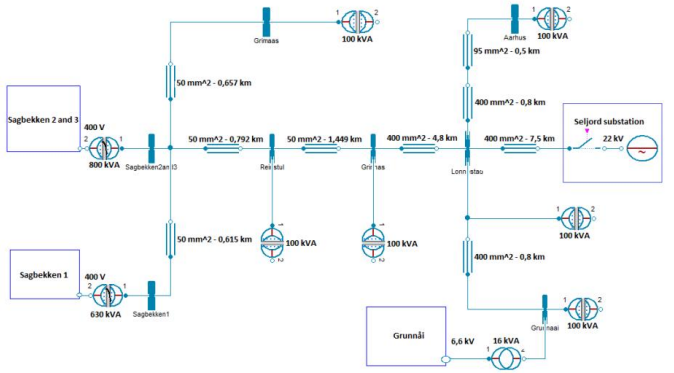
CASE STUDY

Over-Voltage Failure Investigation

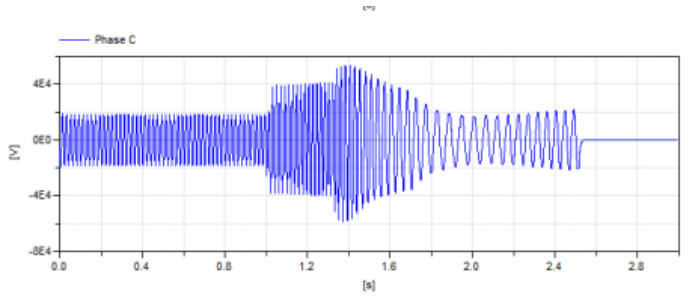
Objective

Using Modelon's Electric Power Library, researchers set out to find the root-cause of an over-voltage phenomenon in the Grunnåi power station in Norway, which caused damage on the equipment.



Results

- Simulations bring understanding of the system dynamics – the reactive power in the grid is large enough to initiate self-excitation of the asynchronous generators
- Correct protection relay settings crucial to ensure safe operation and prevent over-voltages



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CASE STUDY

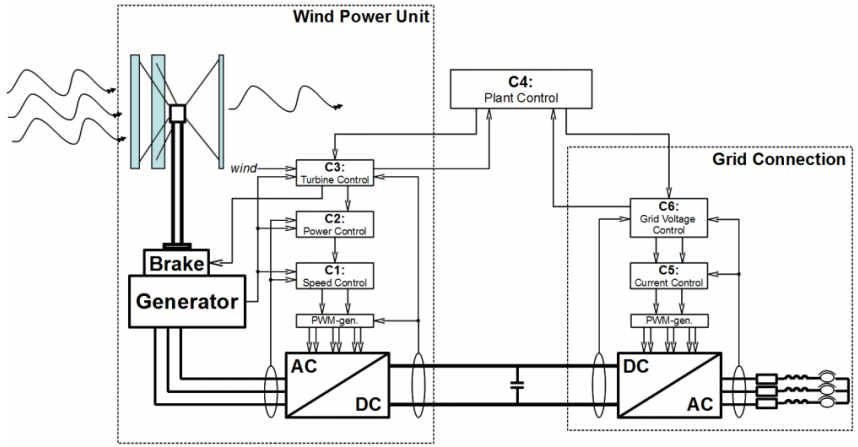
Verify Wind Power Plant Control

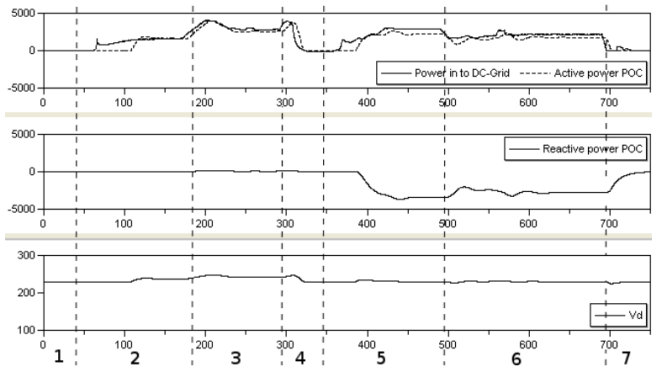
Objective

Evaluate and verify wind power control implementation to meet the Swedish grid code requirements.

Results

- Control implementation verified – passing all grid code tests
- Original control code (written in C++) interfaced with Modelica





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IEA

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CASE STUDY

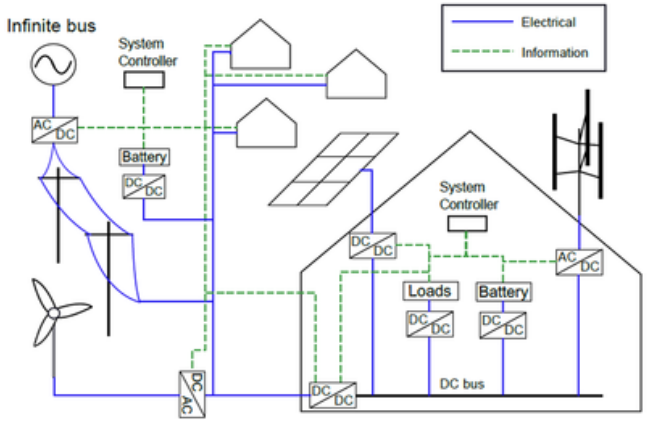
Smart Grid – Optimizing Production

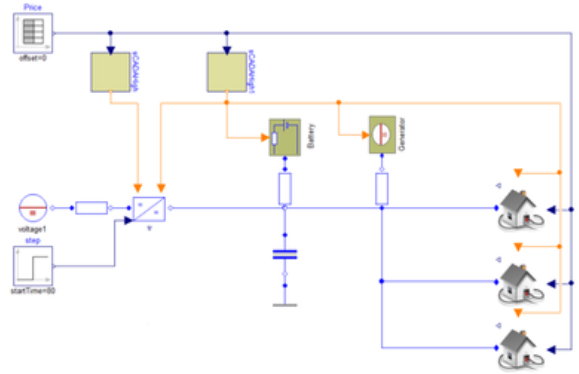
Objective

Evaluate production planning strategies in a conceptual smart grid, taking pricing trends and consumption behavior into account.

Results

- Medium voltage grid battery storage able to reduce costs by charging during times of low electricity price and discharge during times of high price.
- Reduced total electricity cost by delaying non-essential loads and charging electric vehicle during the night.





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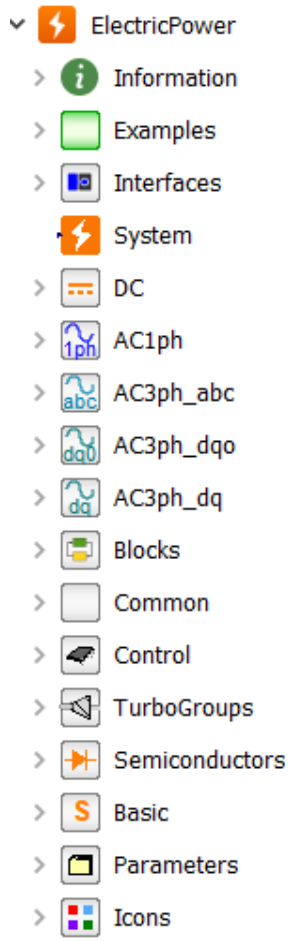
LIBRARY CONTENTS

LIBRARY CONTENTS

- DC components
- AC 1-phase components
- AC 3-phase
  - abc (non-transformed)
  - dqo (transformed)
  - symmetric dq (transformed)
- Exciters, governors, modulation
- Mechanical components
- Ideal semiconductors and phase modules



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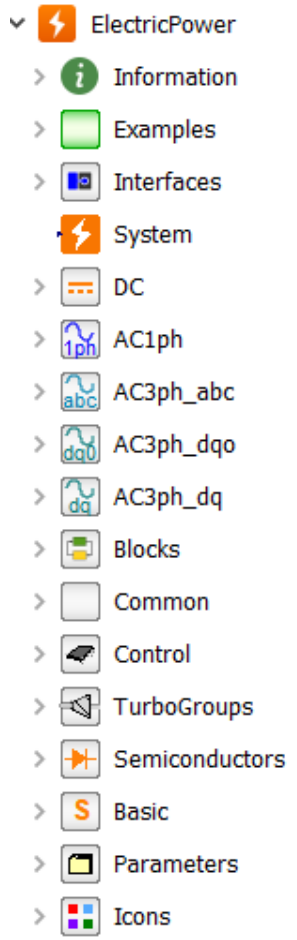
LIBRARY CONTENTS

- 3-phase representations
  - abc
    - Most common, non-transformed
    - Does not allow fast integration (AC is periodic), except in special cases
  - dqo
    - Using Park-transformed signals
      - Rotating reference frame
    - Fast integration of linear systems without loss of transient information
  - dq
    - Similar to dqo, but assumes *balanced* three phase currents
      - Omitting zero component



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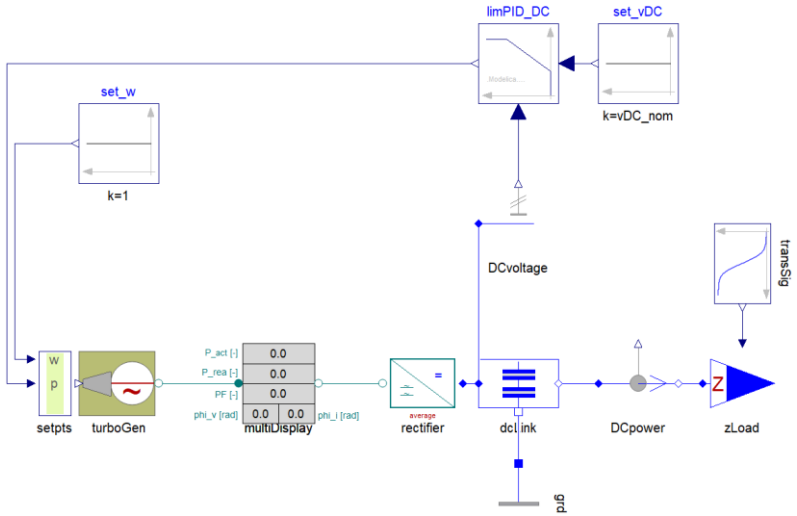
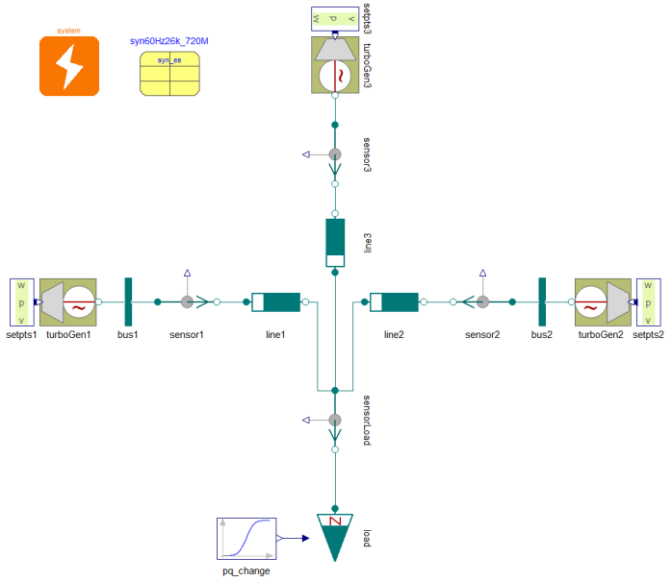
LIBRARY CONTENTS

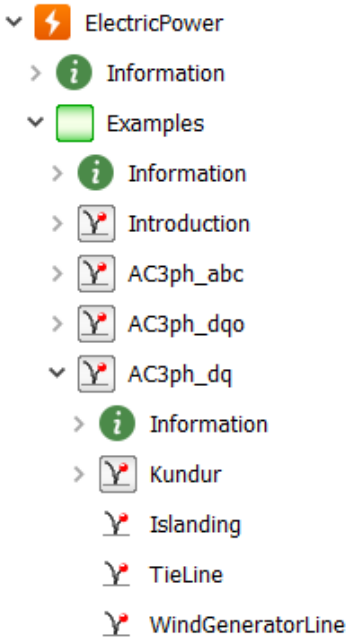
- Examples displaying typical use-cases and capabilities



Islanding



Tie line



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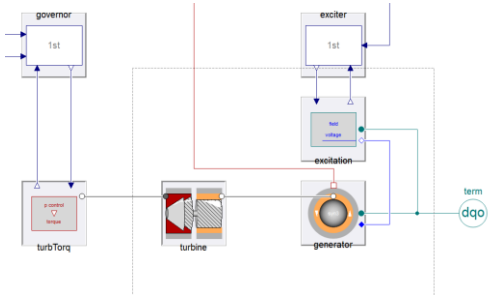
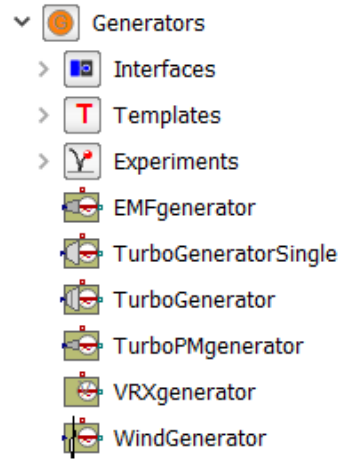
LIBRARY CONTENTS

- Generators
  - Turbine-generator systems
  - Include electrical and mechanical models
  - Replaceable architecture makes it possible to choose appropriate fidelity level





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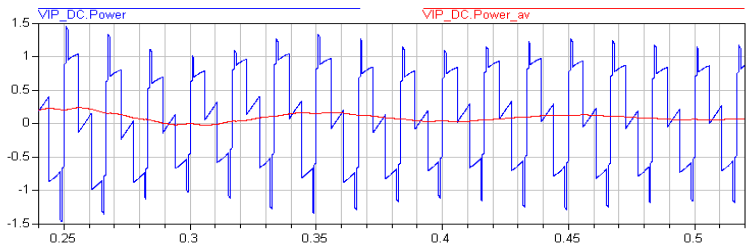
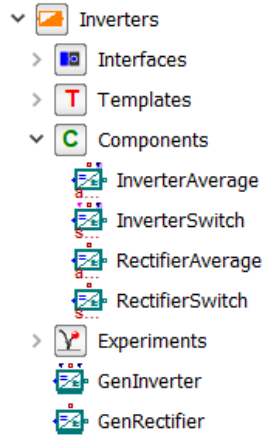
LIBRARY CONTENTS

- Inverters and Rectifiers
  - User can choose appropriate fidelity level:
    - Switched
    - Time averaged
      - Switched details of current and voltage ignored
      - Fast simulations suited for longer simulations and system studies





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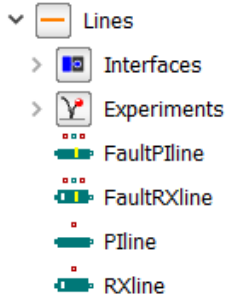
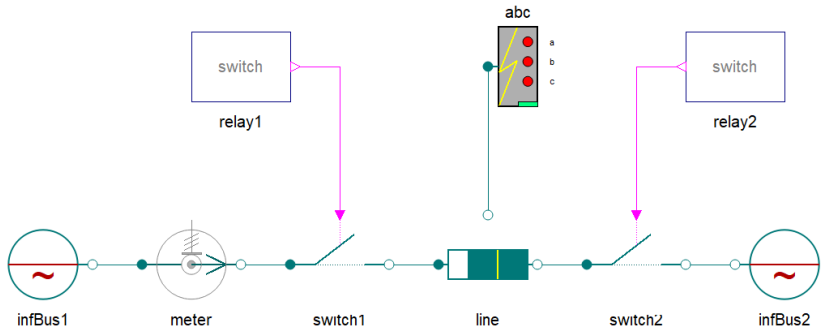
LIBRARY CONTENTS

- Lines
  - Various transmission line models:
    - PIline
      - Transmission line modelled as discretized telegraph-equation, 'pi-elements'
    - RXline
      - Switched details of current and voltage ignored
      - Fast models suited for longer simulations and system studies
  - Support of fault simulation along the lines





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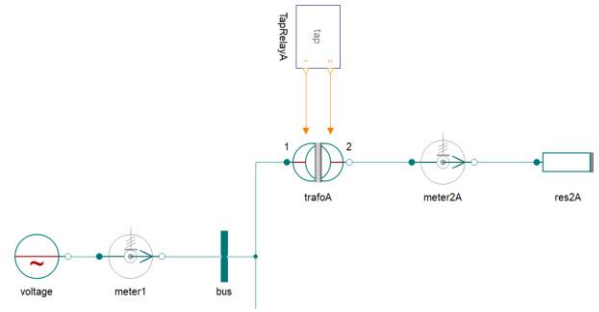
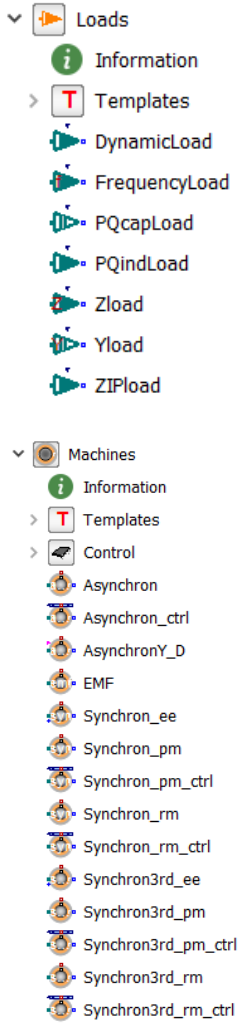
LIBRARY CONTENTS

- Loads
  - Lumped electrical power loads
  - Various versions of capacitive, inductive adn resistive loads
- Machines
  - Asynchronous and synchronous electrical machines
- Transformers
  - 2 and 3-windings
  - Ideal and non-ideal with saturation effects





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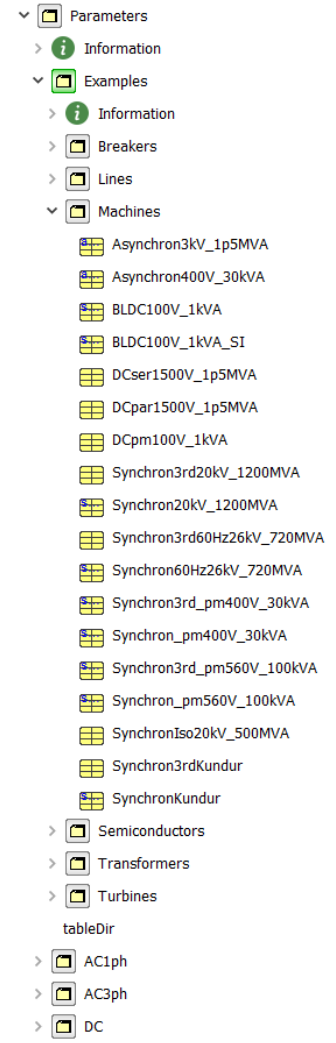
LIBRARY CONTENTS

- Predefined data configurations
  - Quickly set-up a system
  - Cover standard components
    - Breakers, lines, machines, semiconductors, transformers and turbines
  - SI or in pu- ('per unit') units option



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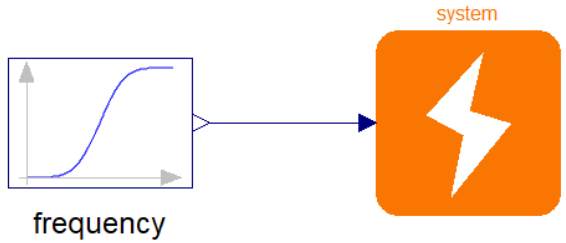
LIBRARY CONTENTS

- System component
  - System wide settings
  - Transient or steady-state simulation mode
  - Frequency type: parameter, signal, or average (machine-dependent) system frequency
  - Lower and upper limit-frequencies



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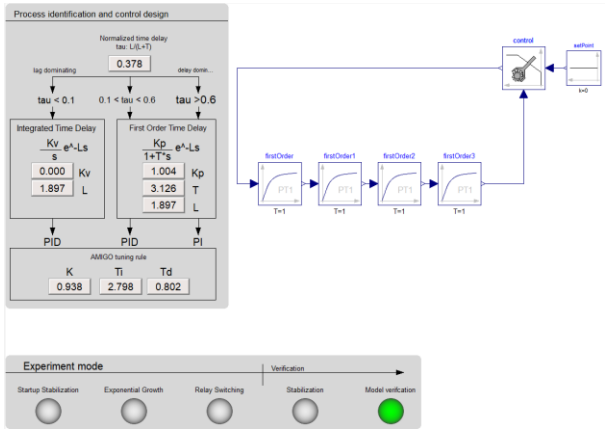
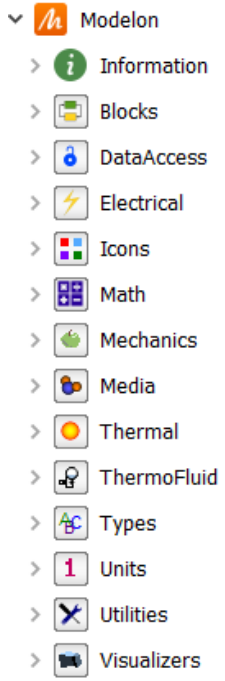
LIBRARY CONTENTS

- Electrical Power Library is delivered together with Modelon Base Library
- Tools and models from Modelon Base Library which extend the capability of Electric Power Library include
  - Thermal components for cooling applications
  - Energy storage models (batteries, table based fuel cells, etc.)
  - Auto-tuner for automatic control design





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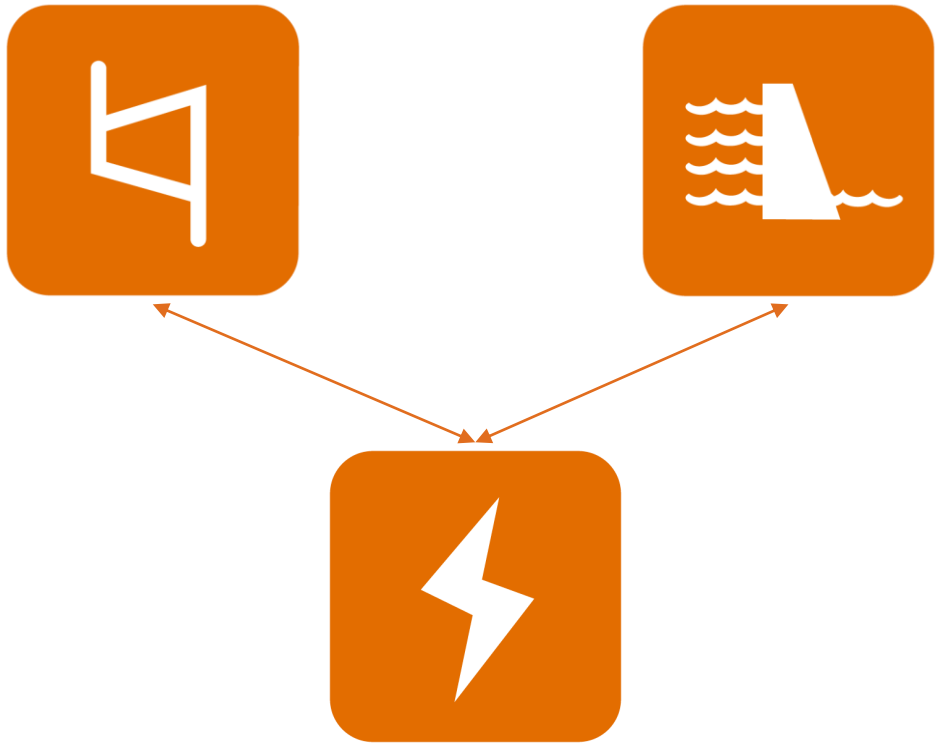
MODELON COMPATIBILITY

RECOMMENDED MODELON LIBRARY COMPATIBILITY

- Thermal Power Library
- Hydro Power Library



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LATEST RELEASE

RELEASE:2021.2

Enhancements

- Version 2.10 is updated for use with Modelon Base Library 3.7

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