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InMotion

Presentation of the textbook

Modeling and Simulation in Engineering using Modelica

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Rationale and objective

Rationale

- Produced within the Erasmus+ InMotion project
- Master's level course of 3 ECTS
- Elaborated from teaching materials currently used in UNED Master courses

Learning objective

As a result of studying this textbook, students should be able to:

- Design and develop model libraries in Modelica
- Understand the analyses and manipulations performed on the model by the Modelica modeling environments

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Structure and content (1/3)

Part 1. Continuous-time modeling

1. Object-oriented modeling methodology and tools

   The physical modeling paradigm. Principles of modular, hierarchical and object-oriented modeling. Capabilities of Modelica modeling environments. Getting started with Dymola and OpenModelica.

2. Continuous-time atomic models

   Types. Variables. Equations and algorithms. Functions. Development of atomic models in the electrical, mechanical, thermal and hydraulic domains with Modelica.

3. Model libraries

   Inheritance and composition. Library design for model reuse. Packages. Development of Modelica libraries in the electrical, mechanical, thermal and hydraulic domains.

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Structure and content (2/3)

Part 2. Simulation of continuous-time models

4. Computational causality of DAE systems
   Structurally singular systems of differential and algebraic equations (DAE). Partition algorithm. Overdetermined and underdetermined DAE systems.
5. Index and initialization of DAE systems
   Index of DAE. Hidden constraints and index reduction.
6. Systems of simultaneous equations
   Symbolic manipulation of algebraic loops. Solution during simulation initialization. Tearing of nonlinear algebraic loops.
7. Selection of the state variables
   Symbolic manipulation of the DAE system. Dynamic selection by the modeling environment. Selection by the model developer.
8. Numerical solution of ODE and DAE systems
   Numerical methods for ODE. DASSL. Inline and mixed-model integration.

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Structure and content (3/3)

Part 3. Hybrid system modeling and simulation

9. Hybrid system specification
   The OHM formalism. Relationship between formal specification, simulation algorithm and Modelica description.
10. Detection and handling of events
    Crossing function. Restart problem. Simultaneous events. Chattering.
11. Hybrid system modeling in Modelica
    Multi-mode system modeling. State and time events. Models with a variable structure. Event modeling.
12. Model initialization
    Initialization of continuous-time and discrete-time variables in Modelica.
13. Experimenting with Modelica models
    Scripting language for experimenting with Modelica models. Model calibration. Model validation.

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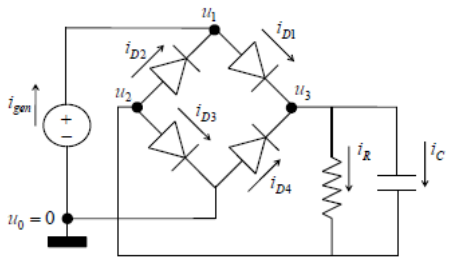
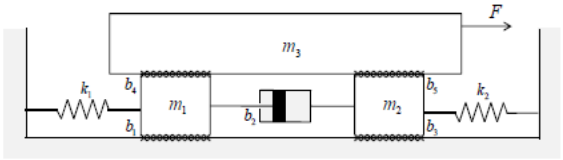
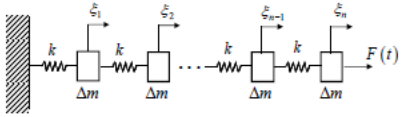
Some examples discussed in the textbook

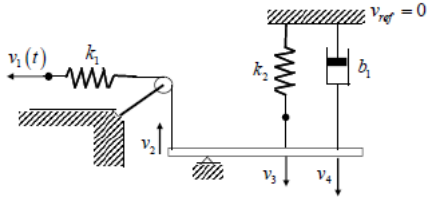
Electrical domain

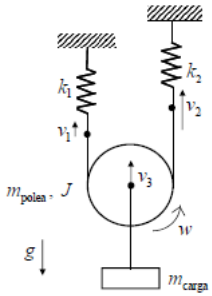


Mechanical domain

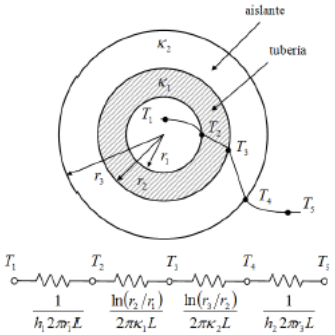


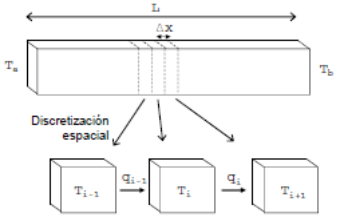






Thermal domain





Hydraulic domain