Modelling of Multi-Domain Systems

MATLAB
CONFERENCE 2015

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What Is This?

\[ V_{in} = K_b \omega + i_m R_m + L_m \frac{di_m}{dt} \]

\[ T = K_i i_m - b_m \omega - J \frac{d\omega}{dt} \]
Three Key Takeaways

- Build physical models to test for integration issues early
- Improve your design efficiency using domain-specific modelling
- Choose the modelling strategy suited to your task
The Challenge

- Product Innovation
- ‘Going Smart’
- Model-Based Design: a Smart Design Process for Smart Products
Model-Based Design

- RESEARCH
- REQUIREMENTS

ANALYSIS – SPECIFICATION- DESIGN

MODEL
- Architecture
- Environment
- Algorithms
- Constraints
- Schematics
- Physical Domains

IMPLEMENTATION
- C, C++
- VHDL, Verilog
- Structured Text
- MCU
- DSP
- FPGA
- ASIC
- PLC
- PAC

TEST & VERIFICATION

TEST CASES

INTEGRATION

TEST CASES

Smart Product
Model-Based Design

RESEARCH

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Smart Product
What does Multi-Domain mean?

- Programming/modelling style
- Time and frequency
- Continuous and discrete
- Multiple physical domains
Relative Effort of Plant Model Representations

- Plant Specification
  - Domain Expertise
  - Programming Effort
  - C, C++, FORTRAN
  - Mathematical Code
- MATLAB and Simulink
  - Domain Expertise
  - Programming Effort
  - Data Flow Representation
- Physical Modelling Tools
  - Domain Expertise
  - Programming Effort
  - Physical Structure

Duration
Modelling Approaches

- First Principles Modelling
  - Programming
  - Block Diagram
  - Modelling Language
  - Symbolic Methods
- Data-Driven Modelling
  - Physical Networks
  - Statistical Methods
  - System Identification
  - Neural Networks
  - Parameter Tuning
Physical Network Concept
Through & Across Variables

- All nodes have the same pressure (across variable)
- Sum of flows (through variables) at a node is zero
- Each component must specify an equation involving the through and/or across variables at its boundary
Physical Modelling with Simscape

- Domain-specific modelling: Models that reflect structure of physical system
- Common basic concept: Bidirectional flow of power between components
- Custom domains and components
- Libraries and special technology add-ons
- Co-simulate with FEM-tools
Model Diagram Examples

Pneumatic-mechanical model

Hydraulic-mechanical model

Thermal model (detail)

Electrical model
Multi-Domain Model: Wind Turbine
Multi-Domain Model: Wind Turbine
Wind Turbine – Architectural Base Model
Wind Turbine – Basic Functional Models
Wind Turbine – Elaboration, Exploration, Integration
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