Vom Konzept zum Modell physikalischer Systeme
Smarter Modellieren mit Simscape™

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Key Take-Aways

- Create accurate, reusable plant models quickly and easily

- Intuitive and easy to read multi-domain modeling approach

- Optimize system performance
  - Develop in a single environment
Model-Based Design
Development Process

Requirements

System Design
- Environment
- Physical Components
- Algorithms

System-Level Specification

Component Design

Research
- Data Analysis
- Algorithm Development

Subsystem Design

Execution
Specifications

Design
with Simulation

Automatic Code Generation

Continuous Test and Verification

User Acceptance Testing

Complete Integration & Test

Integration testing

System-Level Integration & Test

Code Verification and Validation

Subsystem Integration & Test

Subsystem Implementation

Implementation

Embedded Software
- C, C++

Digital Electronics
- VHDL, Verilog

MCU, DSP

Integration

DSP, FPGA, ASIC

C, C++

Data Modeling
Model-Based Design
Multi-Domain Modeling and Algorithm Development

Methods for modeling systems in different domains

- Data Flow (Block diagram)
- Physical Modeling (Schematic)
- Event-Driven Systems
- Programing Language (Textual)

Research
Data Analysis
Algorithm Development
Data Modeling

System-Level Specification
Requirements

System-Level Integration & Test
Complete Integration & Test
User Acceptance Testing
What Is This?

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

\[ T = K_t i_m - D \omega - J \frac{d\omega}{dt} \]
How To Model This System?
How To Model This System?
Fast and Efficient Plant Modeling

- Simulink is best known for signal-based modeling
  - Causal, or input/output

- Simscape enables bidirectional flow of power between components

- System level equations:
  - Formulated automatically
  - Solved simultaneously
  - Cover multiple domains
Through & Across Variables

- Abstract to a physical network
- 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 Systems in Simulink

- Multibody mechanics (3-D)
- Mechanical systems (1-D)
- Fluid power and control
- Electromechanical and electronic systems
- Multidomain physical systems

Simscape
- Mechanical
- Hydraulic
- Electrical
- Thermal
- Liquid
- Pneumatic
- Magnetic
- Custom Domains via Simscape Language

MathWorks
MATLAB, Simulink

SimPowerSystems
SimMechanics
SimHydraulics
SimDriveline
SimElectronics

Simscape
Mechanical
Hydraulic
Electrical
Thermal
Liquid
Pneumatic
Magnetic

Custom Domains via Simscape Language

Electrical power systems
Multibody mechanics (3-D)
Mechanical systems (1-D)
Fluid power and control
Electromechanical and electronic systems
Simscape Add-on Libraries

- **SimDriveline™**
  - Gears, leadscrew, clutches, tires, engines

- **SimElectronics®**
  - Actuators, sensors, and semiconductors

- **SimHydraulics®**
  - Pumps, actuators, pipelines, valves, tanks

- **SimMechanics™**
  - Multibody systems: joints, bodies, frames

- **SimPowerSystems™**
  - Three-phase electrical networks
Physical Modeling Best Practice

- Structure your system and componentize it
- Get familiar with the available blocks
- Build incrementally
- Write test scripts/harnesses
- Use appropriate level of fidelity
- Add dampers, fluid volumes or capacities to un-stiffen the system
DC Motor Modeling Options

- Pre-build components

- Equivalent circuit model with Simscape components

- Define a custom component using Simscape language
Viewing Simscape Simulations Results

ssc_explore

- Explore simulation results from entire physical network
  - Select multiple signals
  - Overlay or separate plots
  - Arrange plots
  - Extract plot to separate window

- Spend more time analyzing, less time simulating

- Download from MATLAB Central

Developing Control Systems

- Implement high-fidelity nonlinear plant models
- Extract linear model for use with linear control theory
- Explore interaction between control system and plant
- Optimize system performance
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Backup
Simscape Editing Modes

- Share models with other Simscape users
  - Simulate, analyze, generate code without purchasing extra licenses

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<th>Function</th>
<th>Full Mode</th>
<th>Restricted Mode</th>
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Model Developer
Purchases Simscape and add-on products

Model Users
Purchases Simscape
Add-on product *installed*,
No add-on purchases required
Backup

Simscape Equation Formulation and Simulation

- Simscape performs several steps before starting a simulation
  - Diagram parsing
  - Symbolic simplification
  - Index reduction

- These steps are performed automatically to ensure robust and quick simulations