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
- Component Design
- Research
  - Data Analysis
  - Data Modeling
  - Algorithm Development
- Subsystem Design
- System-Level Specification
- Continuous Test and Verification
- Automatic Code Generation
- Executable Specifications
- Design with Simulation
- Integration testing
- Code Verification and Validation
- User Acceptance Testing
- Complete Integration & Test
- System-Level Test Integration & Test

Implementation
- Embedded Software
  - C, C++
- Digital Electronics
  - VHDL, Verilog
- MCU
- DSP
- FPGA
- ASIC

Generated Models
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)
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

Multidomain physical systems

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

Simscape

SimMechanics

Multibody mechanics (3-D)

SimPowerSystems

Electrical power systems

SimHydraulics

Fluid power and control

SimElectronics

Electromechanical and electronic systems

SimDriveline

Mechanical systems (1-D)
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
Key Take-Aways

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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>Restricted Mode</th>
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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