MATLAB EXPO 2016
Power On!
Modeling Electric Systems With Simscape
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Presentation Roadmap

- Traditional System Modeling
- Physical System Modeling
- Physical Modeling in Industry and Research
Modeling Approach: Traditional
MATLAB and Simulink
Traditional System Modeling
Traditional System Modeling

System Layout

Derive Equations
Traditional System Modeling

System Layout

Derive Equations

\[ U_R = R \cdot i \quad (\theta) \]

\[ U_L = L \frac{di}{dt} \quad (\theta) \]

\[ i = C \frac{du_c}{dt} \quad (\theta) \]

\[ \sum U = 0 \quad (\theta) \]

\[ i_R = i_L = i_c = i \quad (\theta) \]
Traditional System Modeling

System Layout

Derive Equations

\[ U_R = R \cdot i \quad \& \quad \sum U = 0 \]

\[ U_L = L \frac{di}{dt} \]

\[ i_c = C \frac{du_c}{dt} \]

\[ u_H(t) = u_R + u_L + u_C \]

\[ = R \cdot i + L \frac{di}{dt} + u_C \]
Traditional System Modeling

System Layout

Derive Equations

\[ U_R = R \cdot i \quad (1) \]

\[ U_L = L \frac{di}{dt} \quad (2) \]

\[ i_c = C \frac{du_c}{dt} \quad (3) \]

\[ \sum U = 0 \quad (4) \]

\[ i_R = i_L = i_c = i \quad (5) \]

\[ U_{in}(t) = U_R + U_L + U_c \]

\[ = R \cdot i + L \frac{di}{dt} + U_c \quad (6) \]

\[ U_{in}(t) = CR \frac{du_c}{dt} + \]

\[ + L \frac{d^2u_c}{dt^2} + U_c \quad (5) \]

\[ 2 \text{nd Order} \]
Traditional System Modeling With MATLAB/Simulink

Implementation using Block Diagrams

Implementation using Symbolic Math

+ Have full ownership of equations
- Solving/deriving equations time consuming
- Network adaptions require re-running of process chain
- Experience required to read and debug complex setups

```
DUcDt = diff(Uc);
D2UcDt2 = diff(Uc,2);
% Define differential equation for linear RLC circuit
RLC_DE = L*C*D2UcDt2 + R*C*DUcDt + Uc*(1 + kappa*Uc^2) == Uin;
% Set initial conditions
Uc0 = Uc(0) == 0;
DUc0 = DUcDt(0) == 0;
% Solve differential equation and display
Uc_sym = dsolve(RLC_DE, Uc0, DUc0);
```
Modeling Approach: PhysMod

Simscape
Modeling Process With Simscape

RLC Oscillator

- Implementation as easy as drawing the network
- Integration with classical Simulink toolchain, incl. C-code generation
- No direct access to solved differential equations
Modeling Process With Simscape

LC Transistor Oscillator

- Implementation as easy as drawing the network
- Integration with classical Simulink toolchain, incl. C-code generation
- No direct access to solved differential equations
- Easy network adaptations
Easy Domain Interaction With Simscape

**LC Transistor Oscillator**

**Electro-Thermal Exchange**

+ Implementation as easy as drawing the network

+ Integration with classical Simulink toolchain, incl. C-code generation

- No direct access to solved differential equations

+ Easy network adaptations and interaction with different domains
Utilize The Full Power Of Simscape Language

Customization and Adaptation

- Write and share your own components
- Use foundation domains or define your own
- Utilize foundation library components as templates
- Transform symbolic math to Simscape equations
Modeling Approach: PhysMod

Industry and Research Examples
Simscape For Automatic Grid Generation

Route Network Salzburg

Simulation Grid

with friendly approval of Kruen
Click-and-Go Parameter Optimization

DC Motor with H-Bridge

H-Bridge Subsystem

DC Motor Subsystem
Click-and-Go Parameter Optimization

Precondition

Optimized

Design Optimization
Example Consulting References

Customer Success Stories

- DCNS Models and Simulates SAMAHE Helicopter Handling System
- Haldex Reduces Braking and Stability System Development Time by 50%

Proven Solutions

- Battery Simulation and Controls
- Electrical Power Systems Simulation
- Thermal Systems Modeling
- Motor Control Development