Presentation Roadmap

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

System Layout
Traditional System Modeling

System Layout

Derive Equations

![Electrical Circuit Diagram](image)
Traditional System Modeling

1. System Layout

Derive Equations

\[ U_R = R \cdot i \quad \text{(1)} \]
\[ U_L = L \frac{d}{dt} i \quad \text{(2)} \]
\[ i_c = C \frac{du_c}{dt} \quad \text{(3)} \]
\[ \sum U = 0 \quad \text{(4)} \]
\[ i_R = i_L = i_c = i \quad \text{(5)} \]
Traditional System Modeling

System Layout

Derive Equations

\[ U_R = R \cdot i \quad (1) \]
\[ U_L = L \frac{di}{dt} \quad (2) \]
\[ i_c = C \frac{du_c}{dt} \quad (3) \]
\[ \sum U = 0 \quad (4) \]
\[ i_R = i_L = i_c = i \quad (5) \]

\[ U_{in} = U_R + U_L + U_c \]
\[ = R \cdot i + L \frac{di}{dt} + U_c \]
\[ = R \cdot i + L \frac{di}{dt} + u_c \quad (6) \]
Traditional System Modeling

System Layout

Derive Equations

\[ U_R = R \cdot i \quad (\text{1}) \]
\[ U_L = L \frac{di}{dt} \quad (\text{2}) \]
\[ i_c = C \frac{du_c}{dt} \quad (\text{3}) \]
\[ \sum U = 0 \quad (\text{4}) \]
\[ i_R = i_L = i_c = i \quad (\text{5}) \]

\[ U_n(t) = U_R + U_L + U_c \quad (\text{6}) \]

\[ U_n(t) = CR \frac{du_c}{dt} + \quad (\text{5}) \]
\[ L \frac{d^2u_c}{dt^2} + U_c \quad (\text{6}) \]

2nd 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 adaptations 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**

- 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

**Electro-Thermal Exchange**
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 KAECHEN
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

MATLAB EXPO 2016
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