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

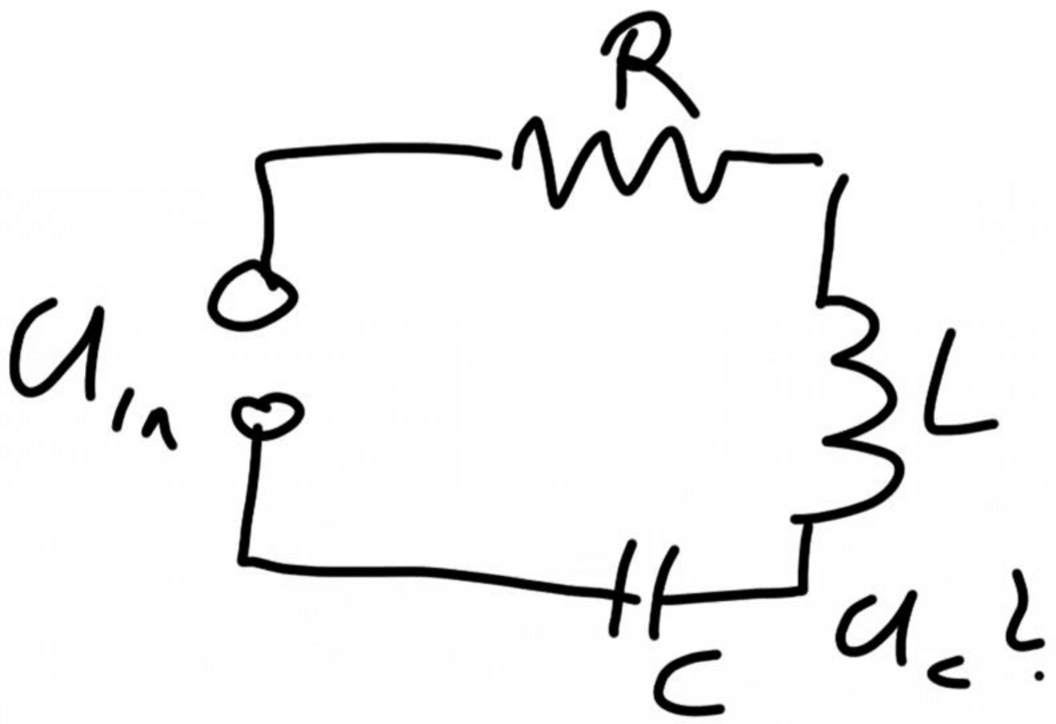
MATLAB and Simulink

Traditional System Modeling

System Layout

Traditional System Modeling

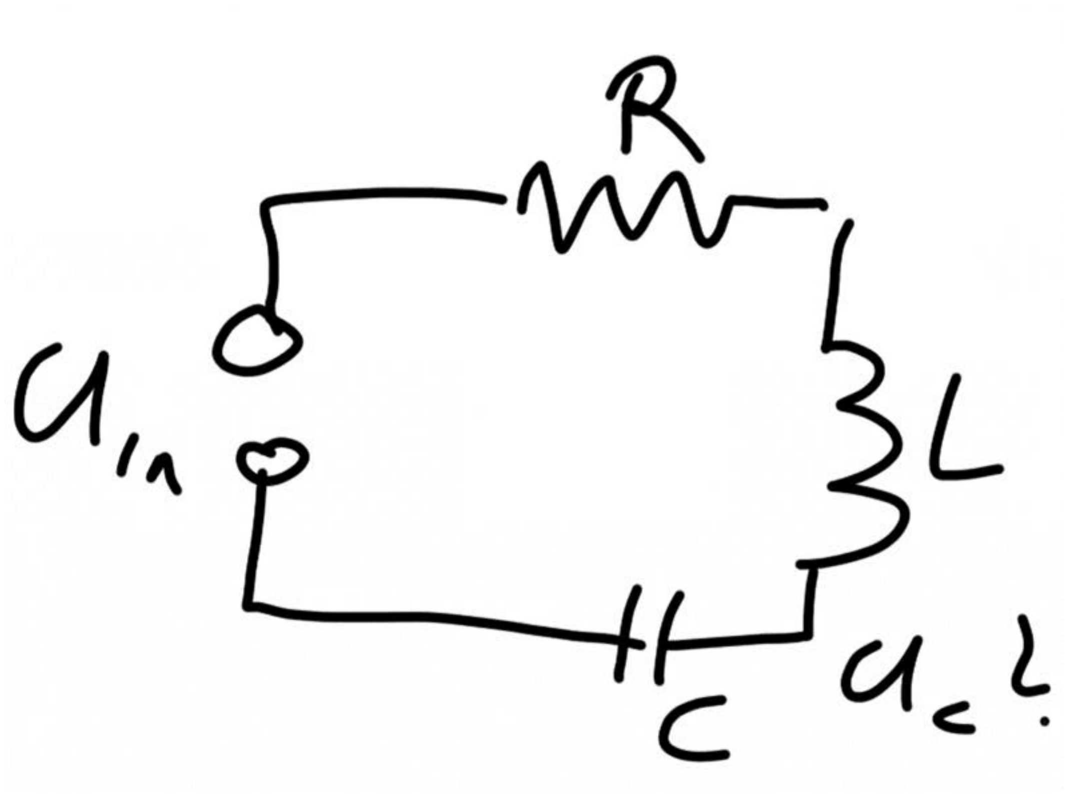
System Layout



Derive Equations

Traditional System Modeling

System Layout



Derive Equations

$$u_R = R \cdot i \quad (1)$$

$$u_L = L \frac{di}{dt} \quad (2)$$

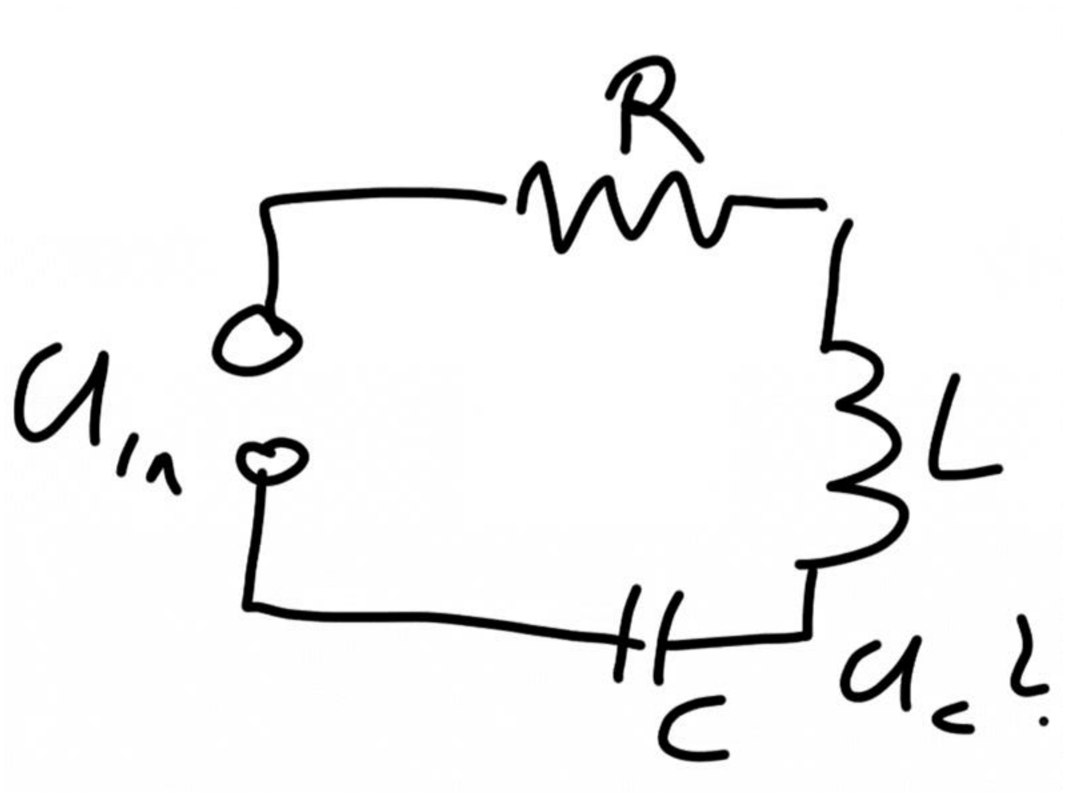
$$i_c = C \frac{du_c}{dt} \quad (3)$$

$$\sum u = 0 \quad (4)$$

$$i_R = i_L = i_c = i \quad (5)$$

Traditional System Modeling

System Layout



Derive Equations

$u_R = R \cdot i$ (1)

$u_L = L \frac{di}{dt}$ (2)

$i_C = C \frac{du_C}{dt}$ (3)

$\sum u = 0$ (4)

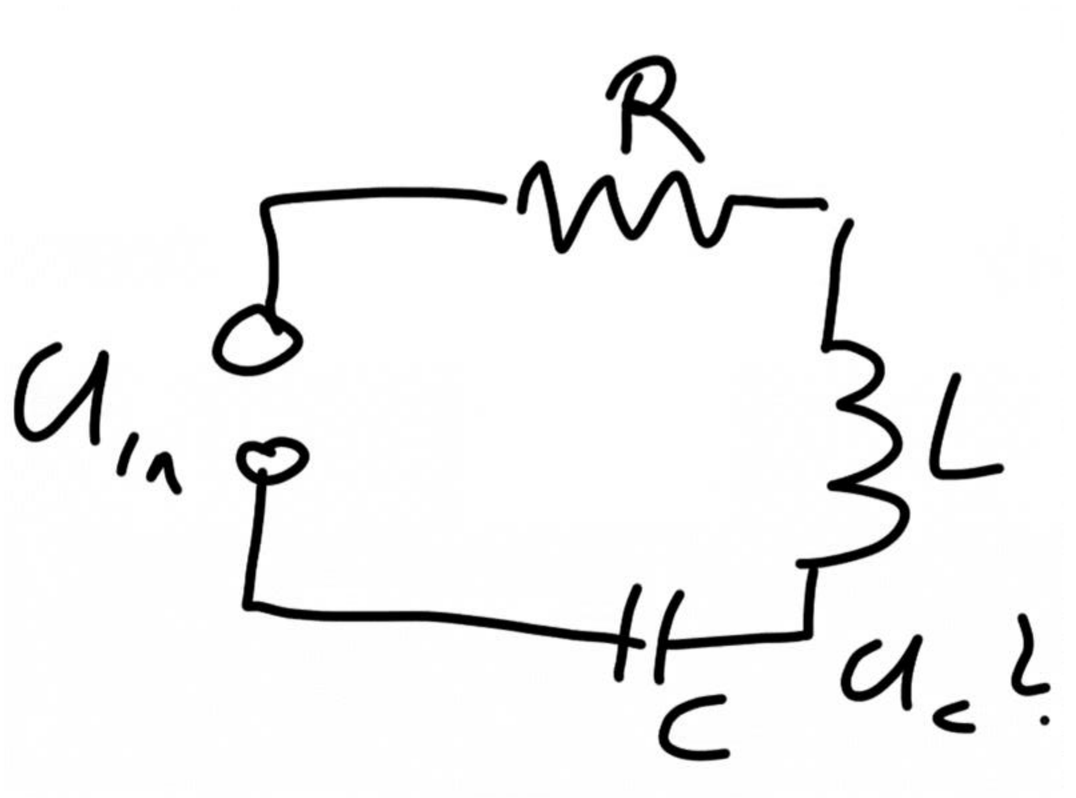
$i_R = i_L = i_C = i$ (5)

$u_{in}(t) = u_R + u_L + u_C$

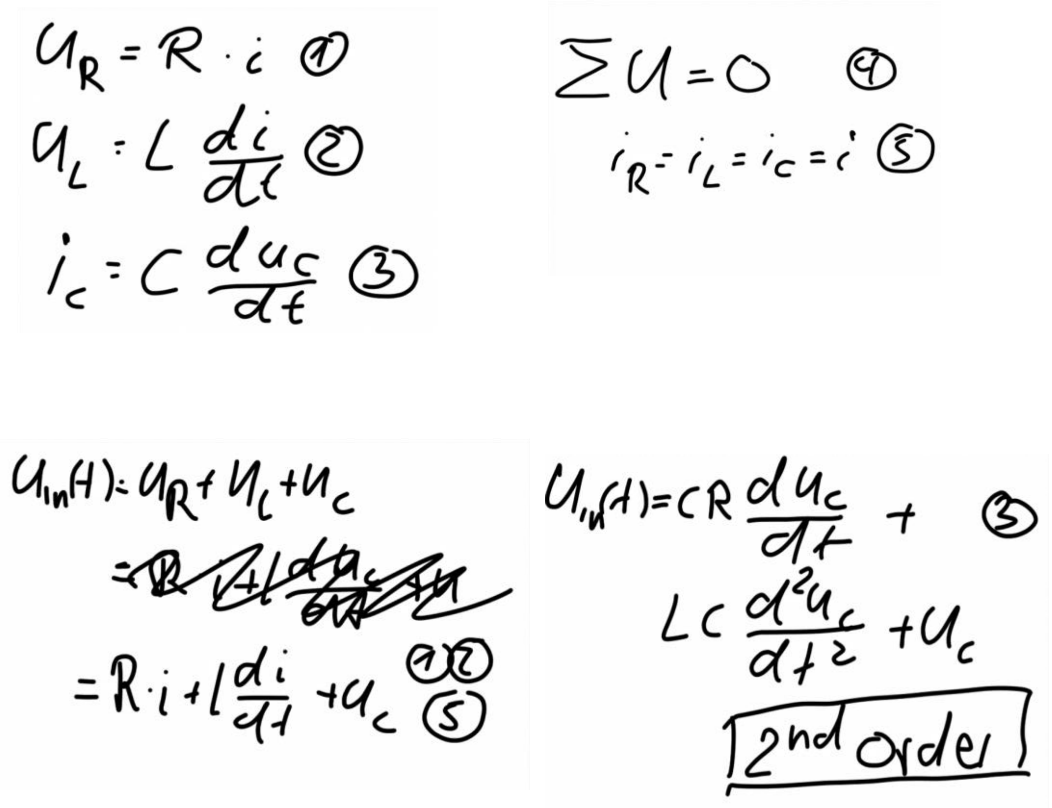
$= R \cdot i + L \frac{di}{dt} + u_C$ (1)(2)(5)

Traditional System Modeling

System Layout

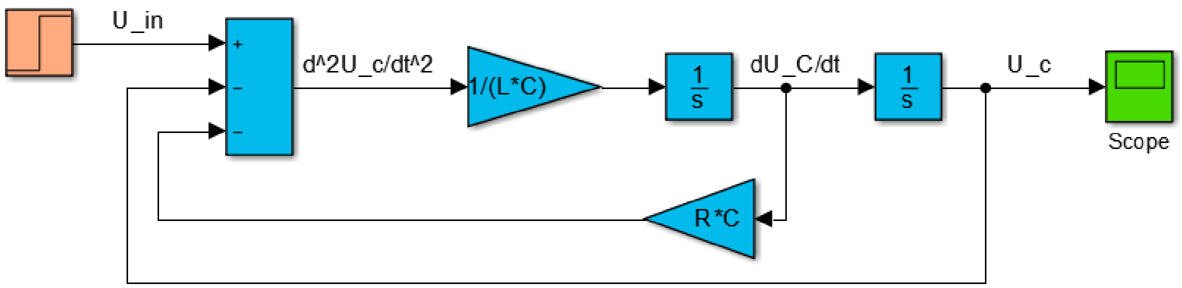


Derive Equations



Traditional System Modeling With MATLAB/Simulink

Implementation using Block Diagrams



Implementation using Symbolic Math

```
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);
```

+ Have full ownership of equations

- Solving/deriving equations time consuming

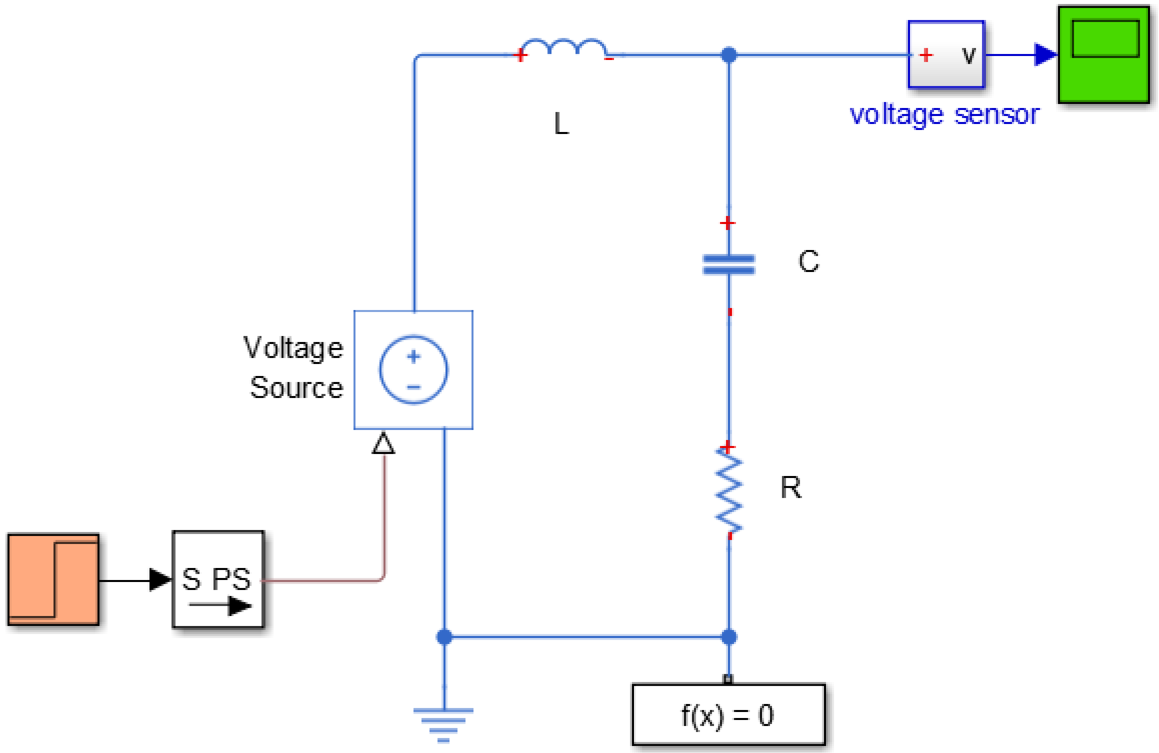
- Network adaptions require re-running of process chain

- Experience required to read and debug complex setups

Modeling Approach: PhysMod
Simscape

Modeling Process With Simscape

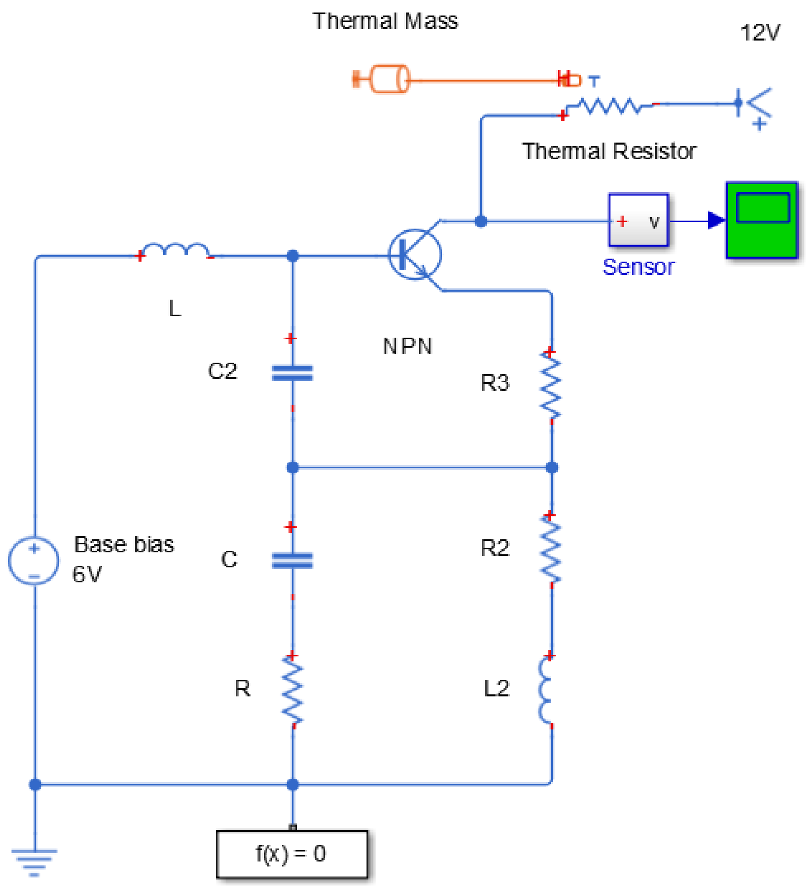
RLC Oscillator



+ 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

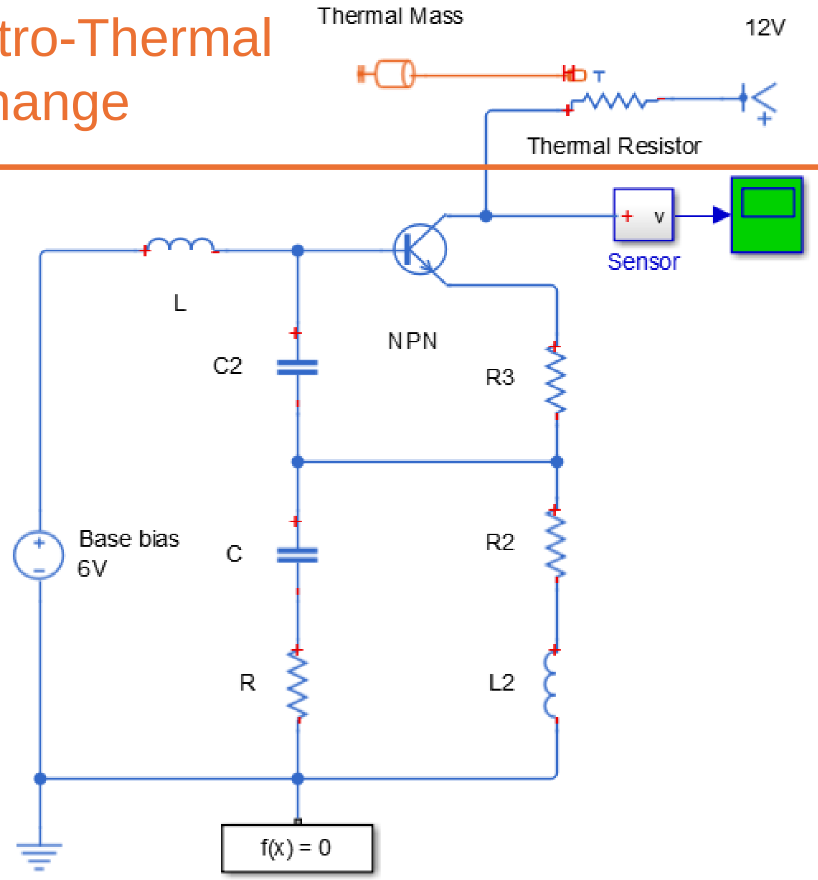


- \+ Implementation as easy as drawing the network
- \+ Integration with classical Simulink toolchain, incl. C-code generation
- \- No direct access to solved differential equations
- \+ Easy network adaptions

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 adaptions and interaction with different domains

Utilize The Full Power Of Simscape Language

Customization and Adaptation

MATLAB

Editor - C:\+MyComponents\LossyUltraCapacitor.ssc

```
component LossyUltraCapacitor
% Lossy Ultracapacitor
% Models an ultracapacitor with resistive losses.
  nodes
    p = foundation.electrical.electrical; % +:top
    n = foundation.electrical.electrical; % -:bottom
  end
  parameters
    C0 = { 1, 'F' };     % Nominal capacitance C0 at V=0
    Cv = { 0.2, 'F/V'}; % Rate of change of C with voltage V
    R = {2, 'Ohm' };     % Effective series resistance
    Rd = {500, 'Ohm' }; % Self-discharge resistance
  end
  variables
    i = { 0, 'A'   }; % Current through variable
    v = { 0, 'V'   }; % Voltage across variable
    vc = { 0, 'V'  }; % Capacitor voltage
  end
```

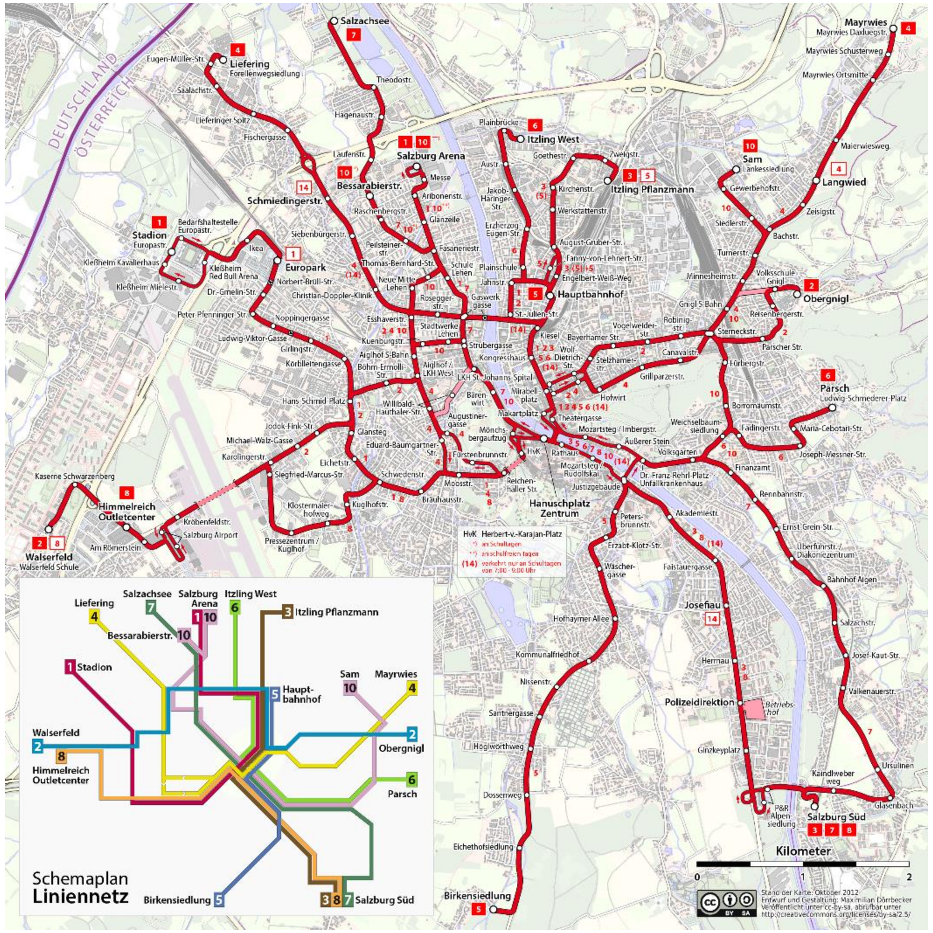
- Write and share your own components
- Use foundation domains or define your own
- Utilize foundation library components as templates
- Transform symbolic math to Simscape equations

Modeling Approach: PhysMod

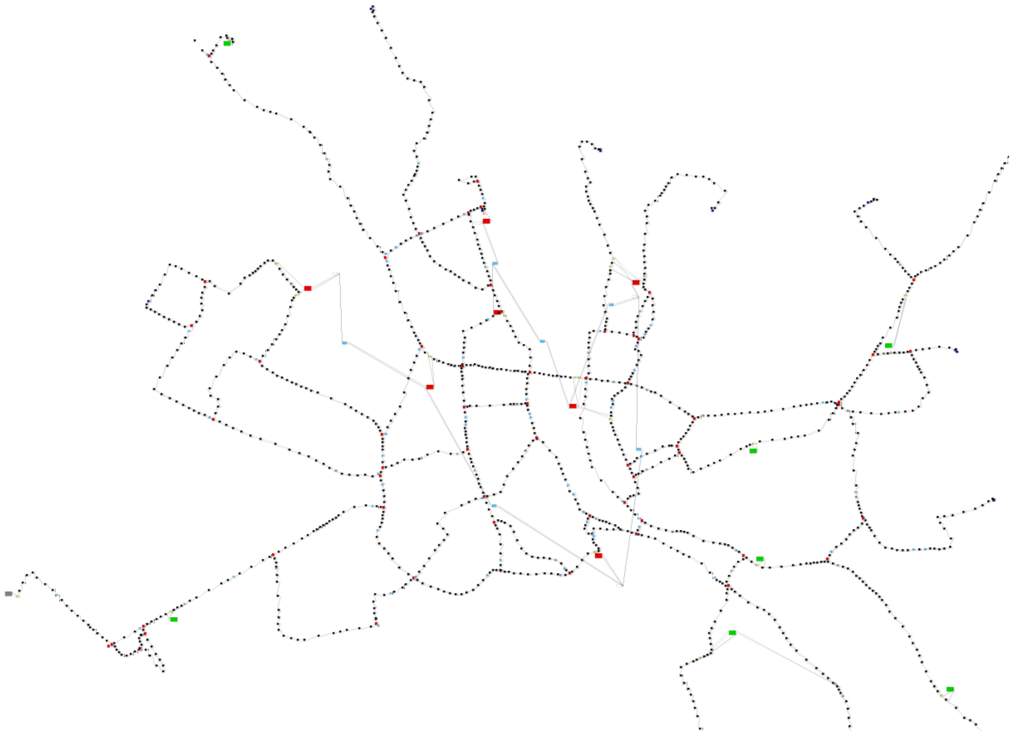
Industry and Research Examples

Simscape For Automatic Grid Generation

Route Network Salzburg



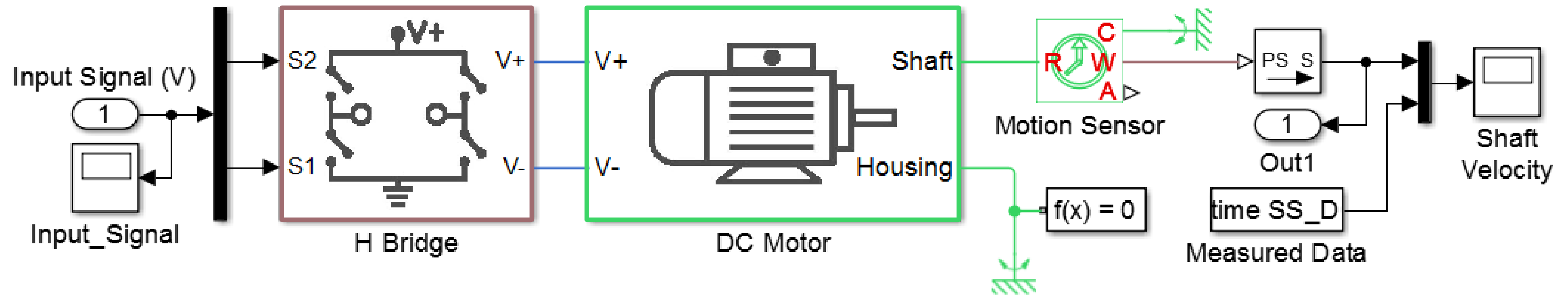
Simulation Grid



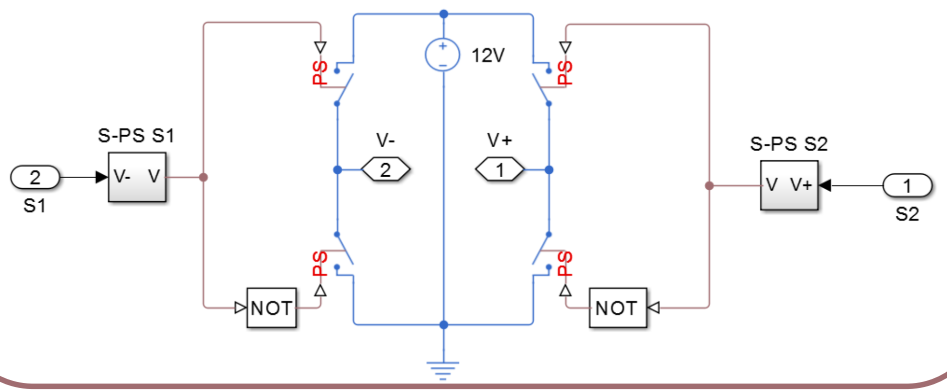
with friendly approval of KRUCH

Click-and-Go Parameter Optimization

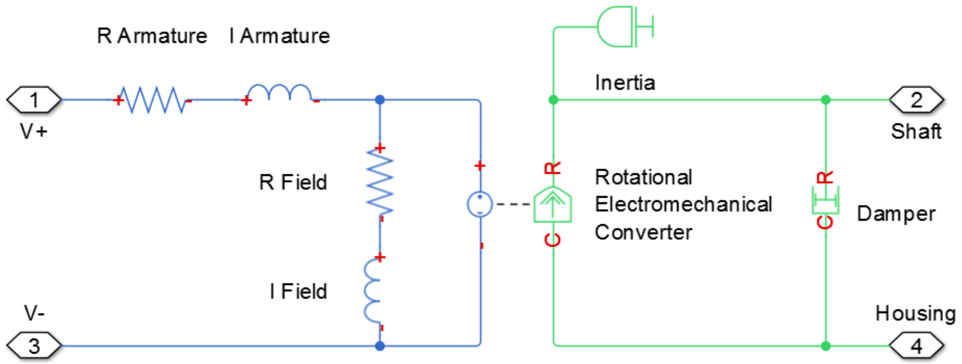
DC Motor with H-Bridge



H-Bridge Subsystem

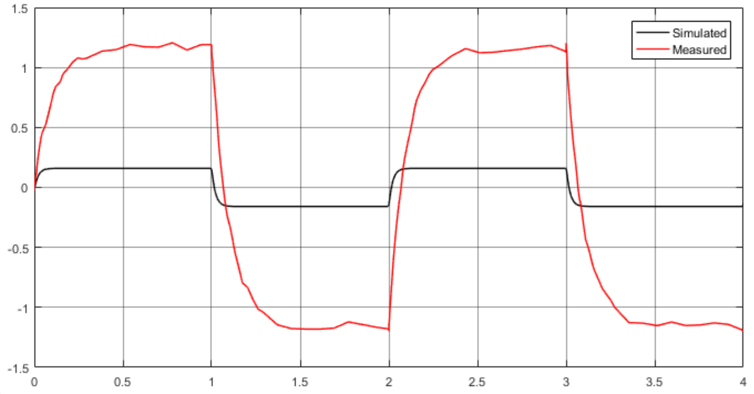


DC Motor Subsystem

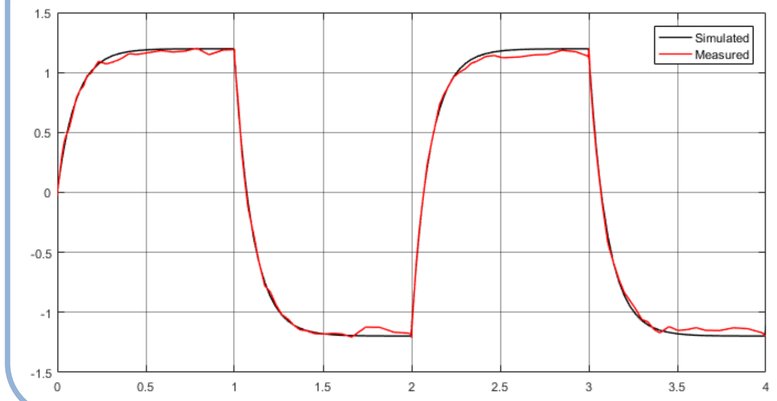


Click-and-Go Parameter Optimization

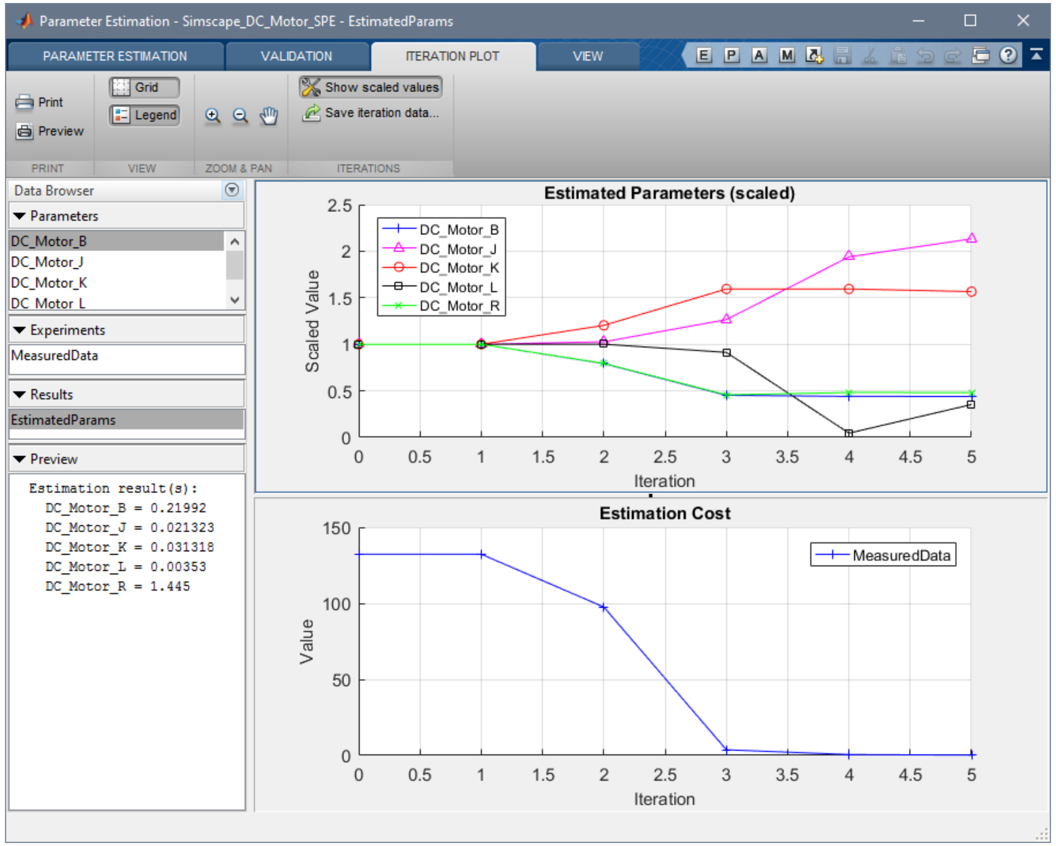
Precondition



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