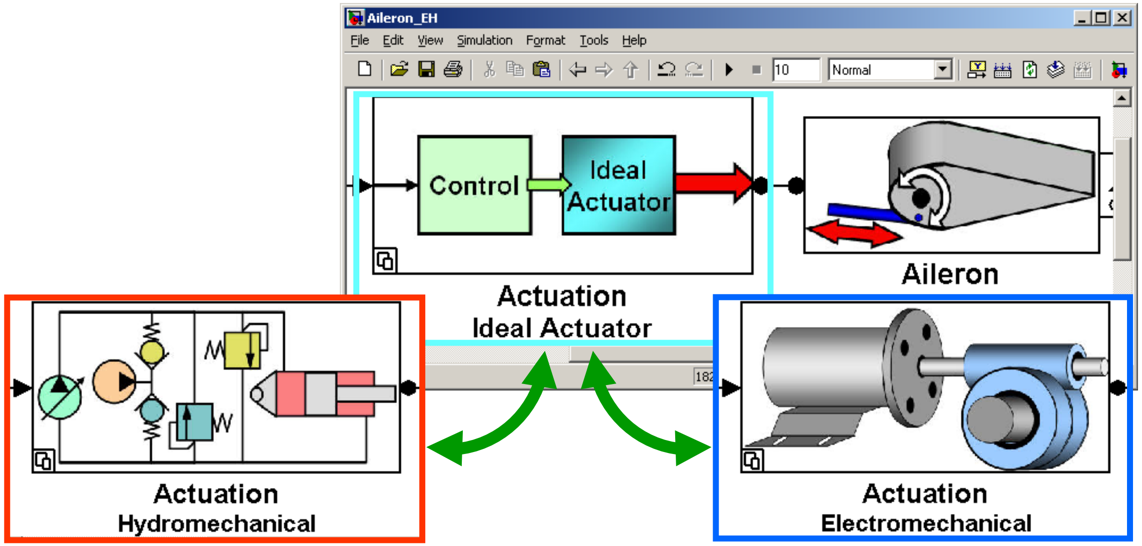
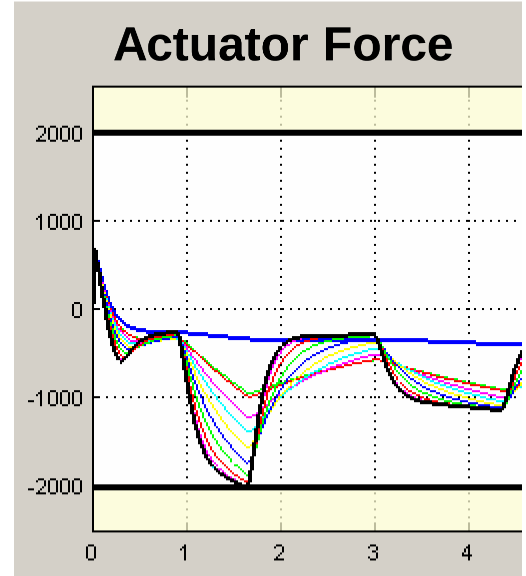
The MathWorks

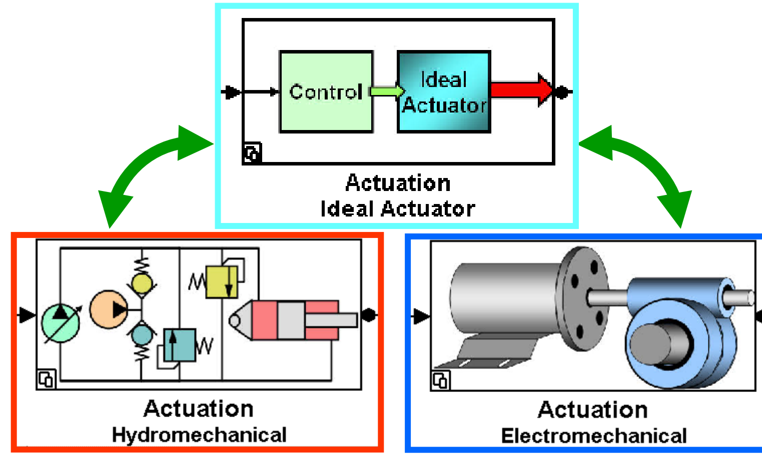
MATLAB®&SIMULINK®



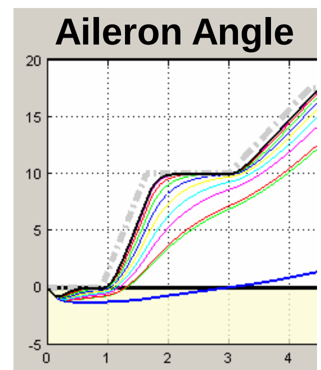


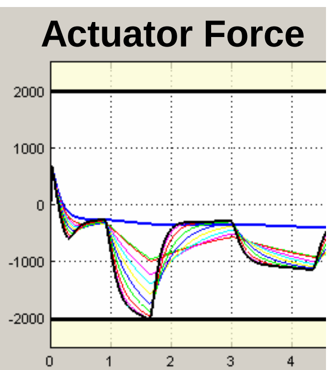
Using Physical Modeling Tools to Design Power Optimized Aircraft

Key Points

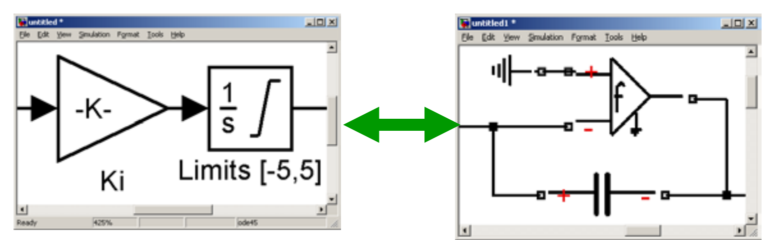


1. Testing different actuator designs in one environment saves time and encourages innovation





2. Optimizing systems with respect to design requirements leads to optimal design choices



3. Simulating at different levels of fidelity is required to see effects of design implementation

Agenda

- Trends in the aerospace industry — 10 min
  - Industry trends
  - Strategies for improvement
  - How simulation can help
- Example: Flight Actuation System — 15 min
  - Model explanation
  - Tradeoff study
  - System optimization
  - Assess implementation effects
- Conclusions

Industry Trends

> ***"With 5-6°C warming … existing models … estimate an average 5-10% loss in global GDP."***

Head of the Government Economic Service UK, 2006

- System needs
  - Aircraft must produce less pollution
  - Aircraft must be more efficient
- Example goals
  - Clean Sky (for year 2020)
    - 50% reduction of CO_2 emissions
    - 80% reduction of nitrous oxide emissions
  - Power Optimized Aircraft (POA)
    - 25% cut in peak non-propulsive power
    - 5% reduction in fuel consumption
- Strategies include aircraft-level optimization, technology

CLEANSKY

Research project, EU and industry

Strategies for Improved Aircraft Design

- Technology: Electrical actuation
  - Fewer losses than hydraulic actuation
  - Only needs to be turned on when in use
  - Tend to be more reliable, cleaner, and safer

Boeing 787 Electrical Systems
Brakes
Ice protection
Engine start
Environmental controls
Electrohydraulic pumps

- Aircraft-level optimization
  - Consolidation of power electronics
  - Localize hydraulic actuation

Airbus 380 Electrical Systems
Primary flight control actuators
Thrust reverser actuation
Horizontal stabilizer backup

- Simulation can help with each of these strategies

How Simulation Can Help

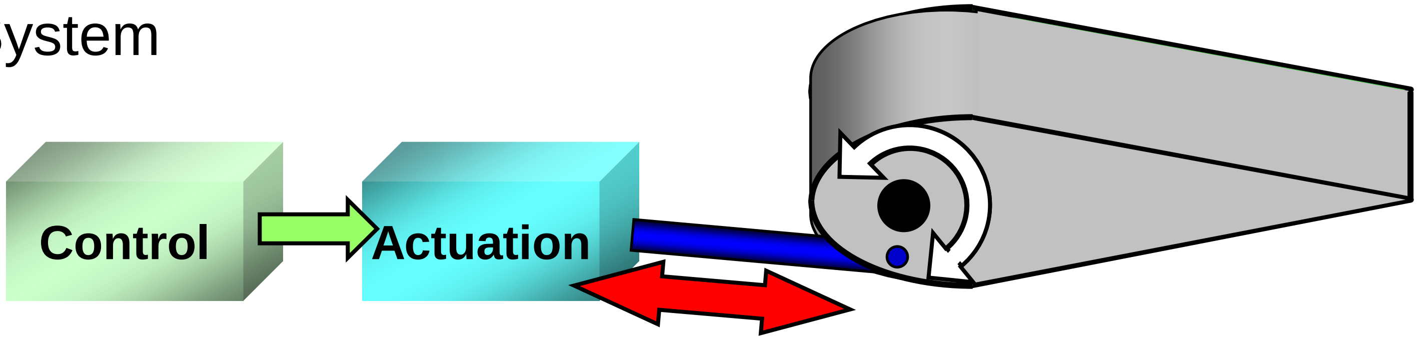
1. Tradeoff studies to test electrical and hydraulic systems
   - Determine actuator requirements
   - Test hydraulic and electrical actuator designs

2. System-level models
   - Must be done at aircraft level to optimize architecture
   - Few key parameters and quick simulation

3. Simulating at different levels of fidelity
   - Need to easily add fidelity to see impacts of implementation
   - Reuse work done at system level (Model-Based Design)

Example: Aileron Actuation System

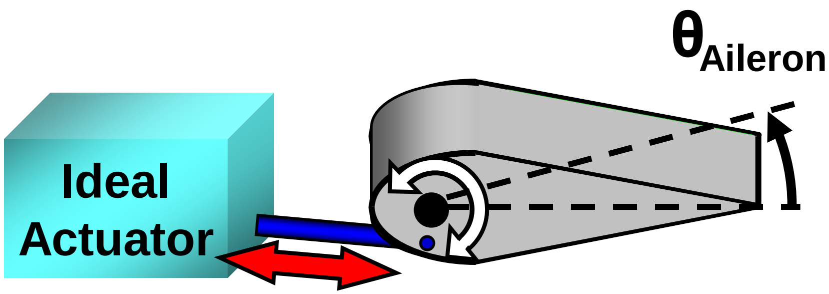
- System

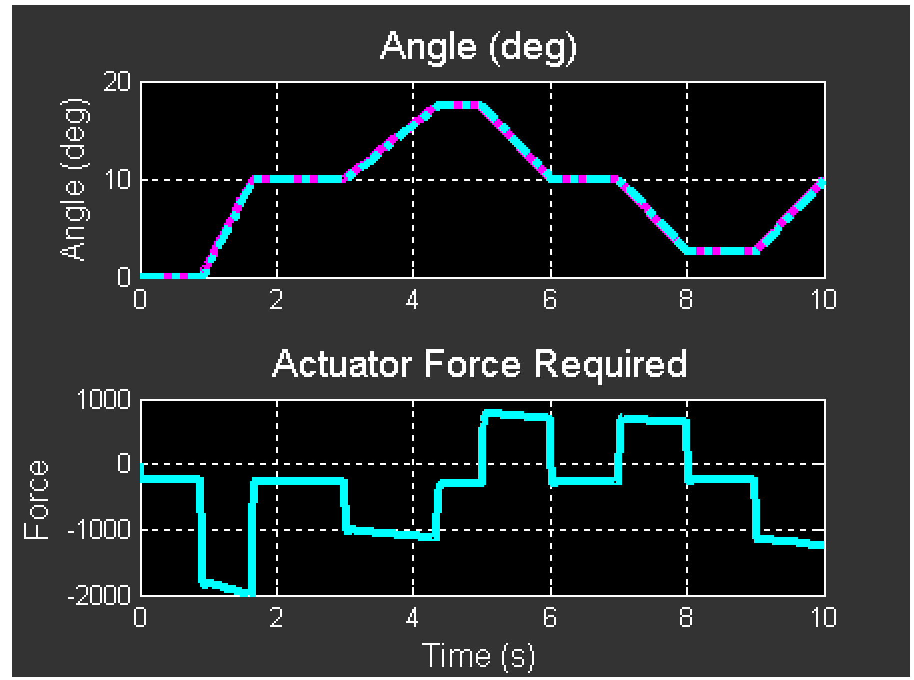


- Simulation goals
  1. Determine requirements for actuation system
  2. Test performance with electrical or hydraulic actuation
  3. Optimize the actuation system
  4. Assess effects of system implementation

Determining Actuation Requirements

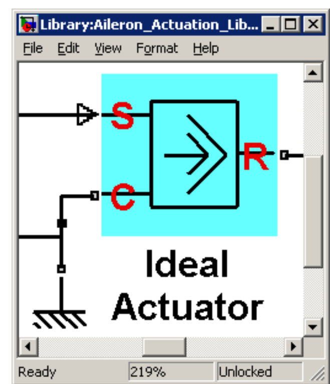
Model:

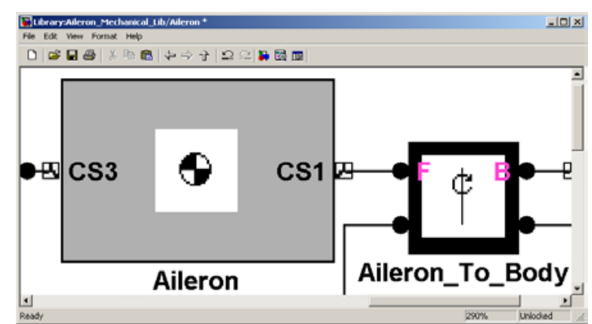




Problem: Determine the requirements for an aircraft aileron actuator

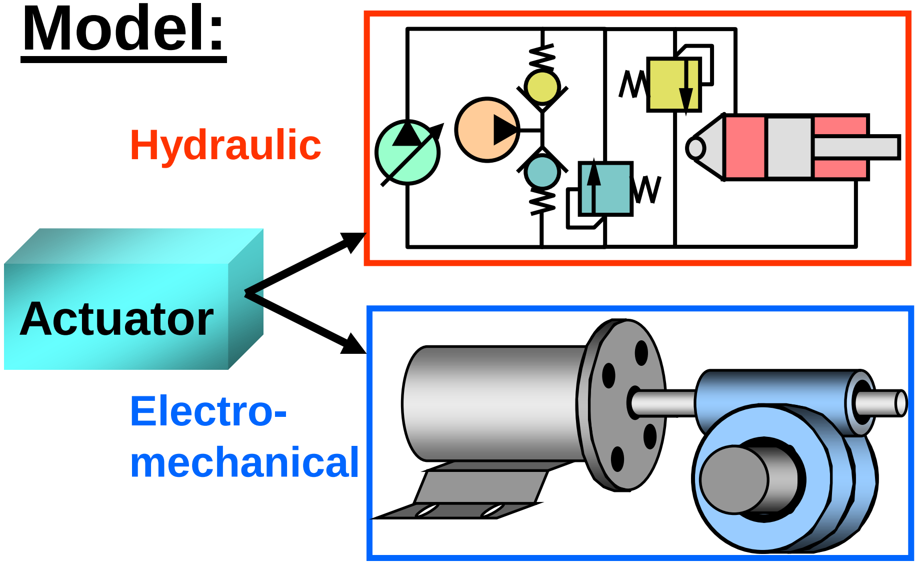
Solution: Use [SimMechanics]() to model the aileron and [Simscape]() to model an ideal actuator

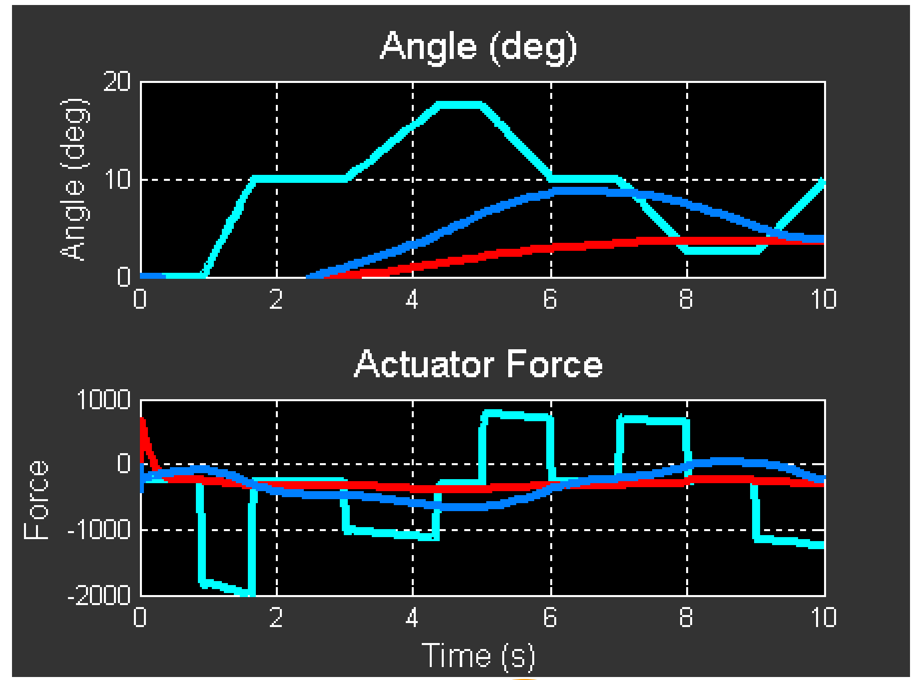




Test Electrical and Hydraulic Designs

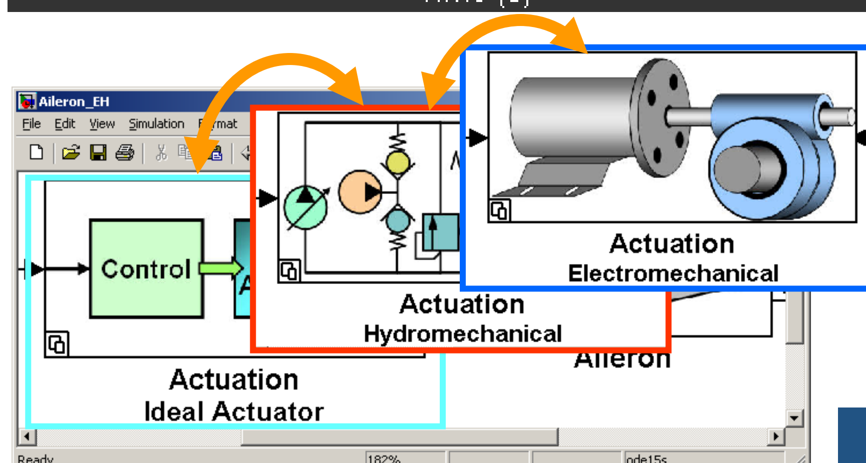
Model:





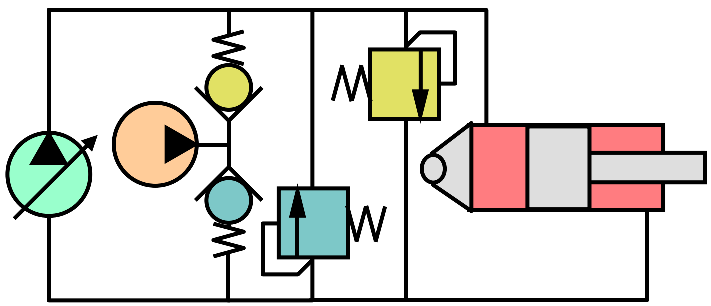
Problem: Test different actuator designs in the system

Solution: Use SimHydraulics and SimElectronics to model the actuators, and configurable subsystems to exchange them



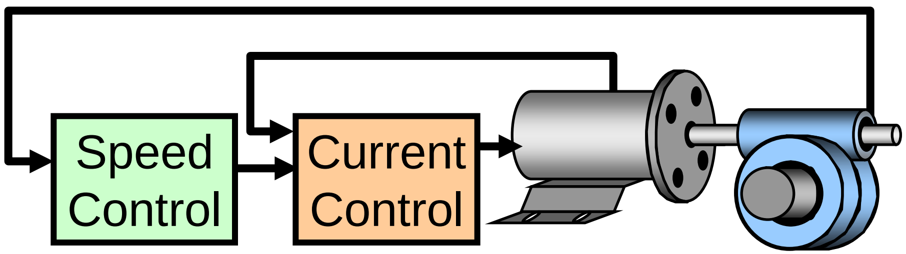
Actuator System-Level Designs

- Hydrostatic transmission



  - Variable-displacement pump
  - Double-acting hydraulic cylinder
  - Replenishing valves
  - Pressure-relief valves
  - Charge pump
  - Speed controller

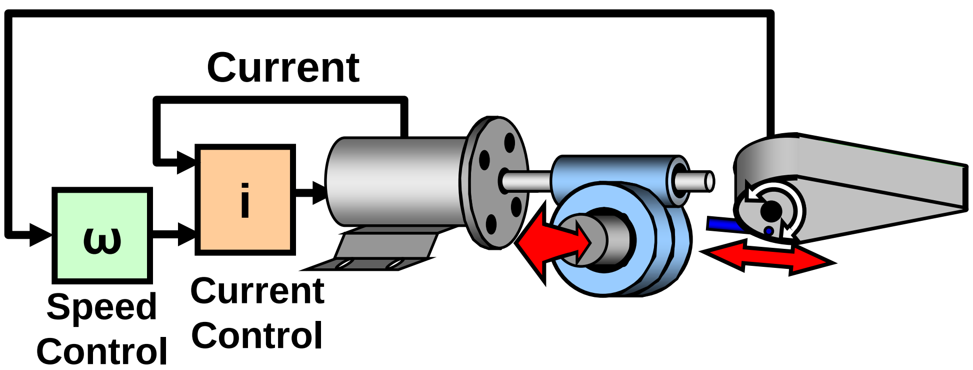
- Electromechanical system

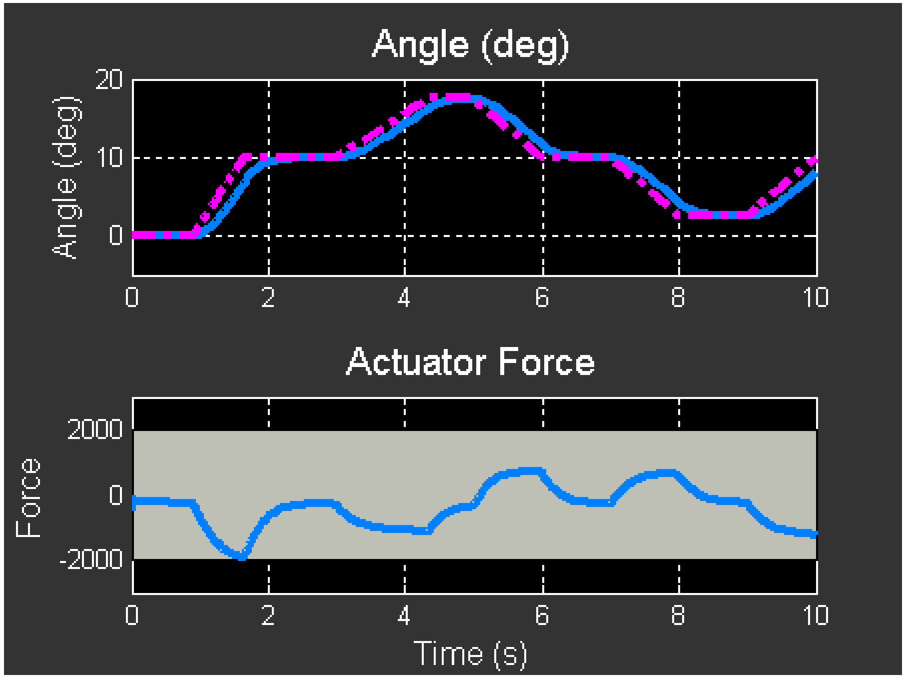


  - DC Motor
  - Worm gear
  - Current sensor and current controller
  - Hall effect sensor and speed controller
  - PWM and H-bridge driver

Optimize System Performance

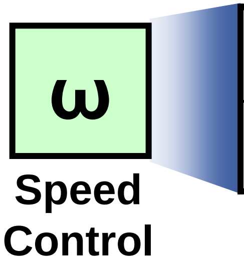
Model:





Problem: Optimize the speed controller to meet system requirements

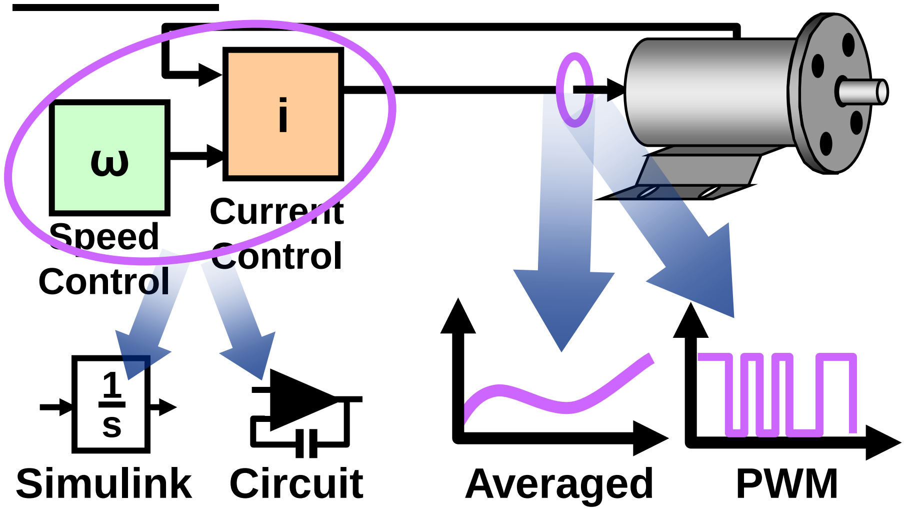
Solution: Use [Simulink Design Optimization]() to tune the controller parameters

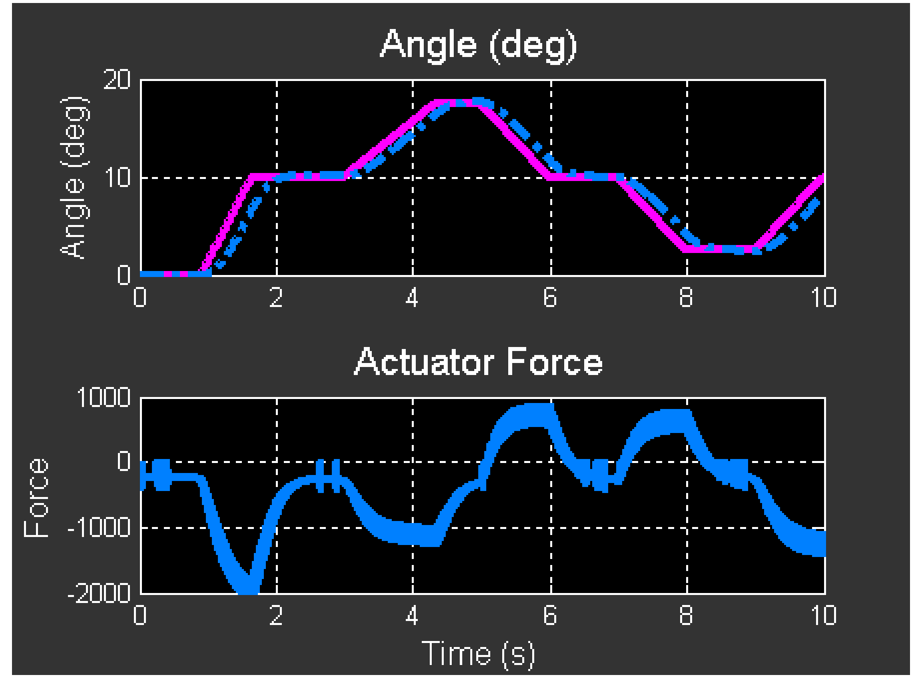


K_p	K_i
23.4	3.67

Assess Implementation Effects

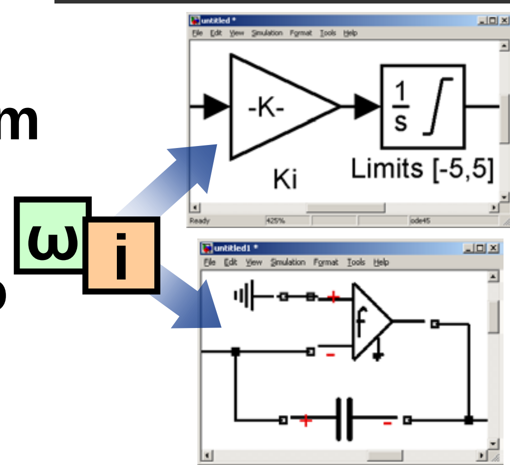
Model:

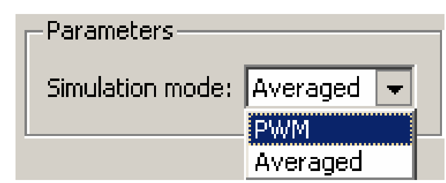




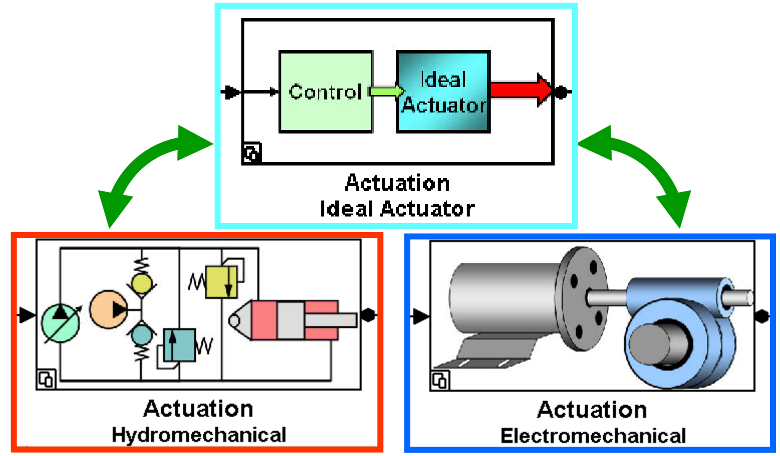
Problem: Assess the effects of design implementation on system performance

Solution: Use SimElectronics to add a PWM signal and analog circuit implementation





Conclusion



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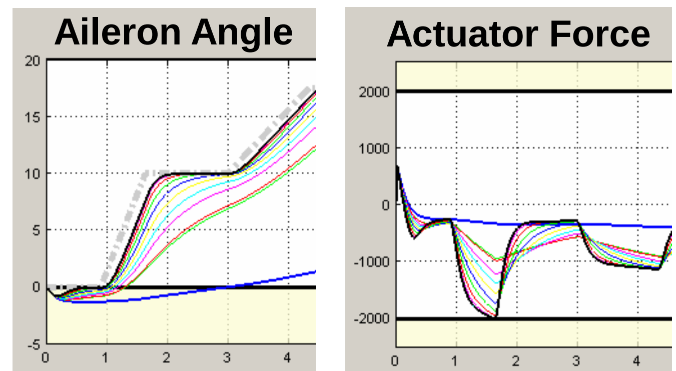

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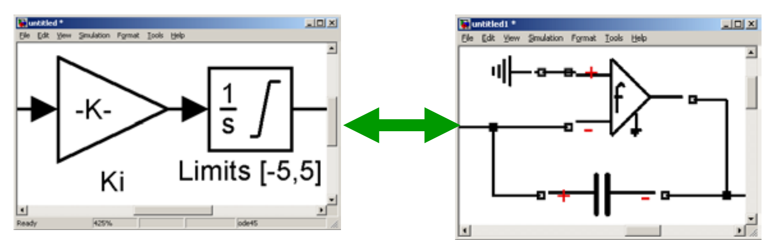
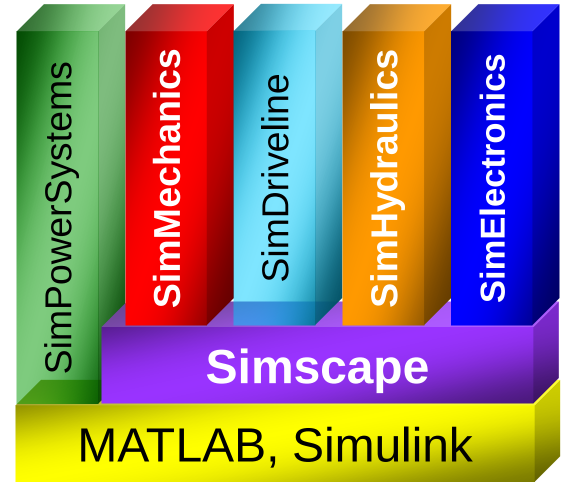
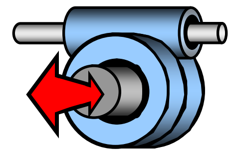


3. Simulating at different levels of fidelity is required to see effects of design implementation

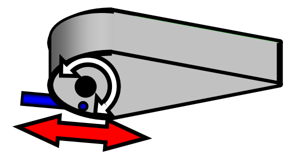
MathWorks Products Used



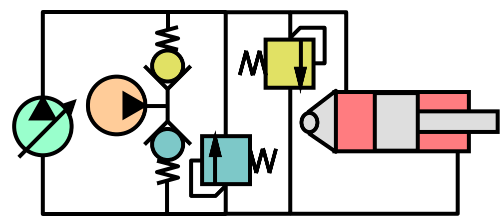
- Simscape
  - Multidomain physical systems



- SimMechanics
  - 3-D mechanical systems



- SimHydraulics
  - Hydraulic (fluid power) systems



- SimElectronics (new)
  - Electronic and electromechanical systems
- Simulink Design Optimization