Designing Mechatronic Systems

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Key Points

- Create intuitive models that all teams can share
- Simulate system in one environment to
  - Perform tradeoff studies
  - Optimise system performance
- Test without prototypes
Agenda

- Example: Flight actuation system
  - Benefits of Model-Based Design
- Actuator design
  - Modeling the mechanical system
  - Determining actuator requirements
  - Testing Electrical and Hydraulic Designs
- Optimising System-Level Design
- HIL testing
Example: Aileron Actuation System

- **System**

  - Desired Angle → Controller → Actuator Force → Measured Angle

- **Simulation goals**
  1. Determine requirements for actuation system
  2. Test actuator designs
  3. Optimise system performance
  4. Run simulation on real-time hardware for HIL tests
Traditional Design Process

**Requirements**

Cannot validate design against requirements

**Design**

Cannot test or optimise fully integrated design

Can only find problems using hardware prototypes

**Implementation**

Manual coding is slow, buggy, and hard to verify

**Integration and Test**

- Control
- Mechanical
- Electrical

- Emb. Code
Model-Based Design

- **Requirements**
  - Cannot validate design against requirements.
  - Manual coding is slow, buggy, and hard to verify.
  - Can only find problems using hardware prototypes.

- **System Level Design**
  - Cannot test or optimize fully integrated design.

- **Implementation**
  - Control
  - Mechanical
  - Electrical

- **Test & Verification**
  - Lower costs using HIL tests.
  - Optimize design in a single simulation environment.

- **Integration and Test**
  - Detect errors right away with continuous verification.
  - Save time by automatically generating embedded code.
Agenda

- **Example: Flight actuation system**
  - Benefits of Model-Based Design

- **Actuator design**
  - Modeling the mechanical system
  - Determining actuator requirements
  - Testing Electrical and Hydraulic Designs

- Optimising System-Level Design
- HIL testing
Modeling the Mechanical System

System:

Problem: Model the mechanical system within Simulink

Solution: Import the mechanical model from CAD into Simscape Multibody
Determining Actuator Requirements

**Problem:** Determine the requirements for an aircraft aileron actuator

**Solution:** Use Simscape Multibody to model the aileron and Simscape to model an ideal actuator
Testing Electrical and Hydraulic Designs

**Problem:** Test different actuator designs in the system

**Solution:** Use Simscape Fluids and Simscape Electronics to model the actuators, and variant subsystems to test them
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Optimising System Performance

Problem: Optimise the speed controller to meet system requirements

Solution: Tune controller parameters with Simulink Design Optimization

Model:

\[ \omega \quad \text{Speed Control} \]

\[ i \quad \text{Current Control} \]

\[ \omega \quad \text{Angle} \]

\[ K_p \quad 0.3 \quad K_i \quad 0.29 \]

Aileron Angle

Actuator Force
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- Optimising System-Level Design

- HIL testing
Configuring an Electrical Actuator for HIL Testing

**Problem:** Configure solvers to minimize computations and convert to C code for real-time simulation

**Solution:** Use Simscape local solvers on stiff physical networks and Simulink Coder™ to generate C code
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Requirements

1. Mechanical System