Design of Simulink®-based Electromechanical Control Workstation for Load Disturbance Testing (EMCW)
Presentation Outline

- Summary
- Previous Work
- High Level Block Diagram
- Important System Components
  - Hardware
  - Software
- Major Project Objectives
  - Modeling
  - Controller Design
  - Graphical User Interface (GUI) Development
  - Performance Specifications
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Summary

- To design in Simulink® an electromechanical control workstation to examine the effects of load disturbance on the GM9236C534-R2 Pittman DC-geared motor.

- The controller’s response to various load disturbances will be tested by coupling a second motor to the first to act as a DC generator.
Summary

- Modeled in SimMechanics® as well as Simulink®. Various experiments and motor/clutch datasheets will be used for system ID.

- Graphical User Interface (GUI) will be developed to allow for easy variation of system parameters, command signals, and loads.
Previous Work

- **Linear Motor Model**
  - Developed during Mini-Project Fall 2006.
Previous Work

- Linear Motor Model
  - Developed during Mini-Project Fall 2006.
Previous Work

- Linear Motor Model
  - Developed during Mini-Project Fall 2006.
Important Components

- **The Hardware**
  - GM9236C534-R2 Pittman Motor
  - Reell EC15 Coupler

- **The Software**
  - Simulink for Electrical & Mechanical Systems
  - Matlab’s “Guide” for GUI development
  - SimMechanics for Mechanical Systems
The Software cont’d

- Matlab’s “Guide”
  - A Matlab GUI development tool.
  - Allows the user to create complex interfaces by simply specifying layout.
  - Automatically generates layout code.
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The Software

- About SimMechanics
  - A feature of Simulink.
  - Enables the user to model mechanical systems based on components’ physical properties and location in a coordinate system.
The Software

Pendulum Tutorial
Major Project Objectives

- Modeling: The following will be modeled in both SimMechanics and Simulink.
  - Motor
  - DC Generator
  - Coupler

- Controller Design

- Graphical User Interface (GUI) Development
The Motor

- Unlike previous models of the Pittman DC motor the model used will be nonlinear.

- Our Model will take into account various nonlinear frictions.

See following slide for nonlinear frictions.
Models

Nonlinear Frictions of the Motor

Static Friction

Coulomb Friction

Viscous Friction

Combined Friction
Models

- The DC Generator
  - Another Pittman motor driven by the first.
  - Rheostat across generator terminals varies load seen by motor.
    - Open circuit corresponds to smallest load.
    - Short circuit corresponds to largest load.
Models

The Coupler

- A coupler between the motor and generator.
- Model must take into account,
  - Added inertia and friction.
  - Time delay caused by spring mechanism.
- Designed method to observe transient response of coupler.
Transient Response

Command Signal for Clutch

Generator Response (Inconsistent)
Controller Design

- Upon verifying the models, controller design will begin.

- Initially, a single loop velocity controller will be used, with more advanced designs to follow.
The GUI

- Will allow the user to adjust:
  - Controller Gain/Type
  - Frictions & Inertias
  - Coupler Status
  - The Load

- Graphing capabilities will also be included for various outputs and inputs.
## System Specifications

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Primary Objectives</th>
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<tbody>
<tr>
<td>Controller</td>
<td>- Nonlinear characteristics of motor must be accounted for.</td>
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<tr>
<td></td>
<td>- X% overshoot with Y load.</td>
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<td>- ___ settling time with Y load.</td>
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<tr>
<td></td>
<td>- ___ rise time with Y load.</td>
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<td>- Regulation range: 0rpm – 500rpm.</td>
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<tr>
<td>DC Motor Model</td>
<td>- Initial model parameters accurate.</td>
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<tr>
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<td>- Motor model based on measured parameters accurate to within X% (velocity, current).</td>
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<td>- All model parameters should be variable using GUI.</td>
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<tr>
<td>Clutch</td>
<td>- Experimental time delay accurately depicted in clutch model.</td>
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<td>- Clutch model engaged/disengaged through GUI.</td>
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<td>- Model only works in one direction.</td>
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<td>- All model parameters should be variable using GUI, including inertia, friction, and spring constant.</td>
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<tr>
<td>DC Generator Model</td>
<td>- Initial model parameters accurate.</td>
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<tr>
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<td>- Generator model based on measured parameters accurate to within X% (voltage, current).</td>
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<td>- All model parameters should be variable using GUI.</td>
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<td>- Load varied/connected/disconnected through GUI.</td>
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<tr>
<td>GUI</td>
<td>- Aesthetically pleasing and intuitive layout.</td>
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<td>- Outputs of interest displayed and graphed vs. command inputs.</td>
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# The Schedule

<table>
<thead>
<tr>
<th>Week</th>
<th>Laith Slaton</th>
<th>Adesegun Sun-Basorun</th>
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</thead>
<tbody>
<tr>
<td>1-3</td>
<td>Coupler System ID</td>
<td>Motor System ID</td>
</tr>
<tr>
<td>4-5</td>
<td>Validation of models</td>
<td></td>
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<tr>
<td>6</td>
<td>Single loop velocity control</td>
<td></td>
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<tr>
<td>7-8</td>
<td>GUI design</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Two-loop velocity/acceleration</td>
<td>Single-loop feed-forward</td>
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<tr>
<td>10</td>
<td>Serial interface between Simulink and physical system</td>
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<tr>
<td>11-12</td>
<td>Advanced Controllers (Optimum Phase Margin, Disturbance Rejection, State-variable, Three-loop with torque control, Nonlinear controller, Adaptive Feed-Forward Control)</td>
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</tbody>
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Questions?