SAE AERO DESIGN PROJECT
PROPULSION & P.I CONTROL SYSTEMS
UNION COLLEGE FLIGHT CLUB

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Advisor John Spinelli, Ph.D
SAE Aero Design Team

• Society of Automotive Engineers
• Team of five, two EE’s and three ME’s
• Regular and Advanced Class Competitions
Regular Class Competition Summary

- Design, build, and test an R/C aircraft
  - Carry max pay loads within 200 ft runway
  - Max combined L,W,H of 175 inches
  - Electric Propulsion System
  - Power limiter (1000W)

- Scoring
  - Bonus Points
  - Penalties Include
    - Power consumption >1000W
    - Bad take off/landing
    - Design modifications after submitting design Report

\[
FFS = \sum_{n}^{n} R_n - \sum T + B_{n(max)}
\]
OPTIMIZING POWER CONSUMPTION OF SAE AERO AIRCRAFT

By Ervin Meneses
Motivation

Last years competitors!
Presentation Overview

- Design Requirements
- Goals
- Propulsion Systems
- Testing
- Future Work
Design Requirements

- Single electric motor configuration
- Use of one COMMERCIAL Li-Po Battery
  - Min. Req. of 3000mAh @ 25C
- Use of 2015 Power Limiter
- Install Red Arming Plug
Goals

• Competition
  • Provide the team with an aggressive electric propulsion system (EPS) that complies with SAE Aero Rules and provides more that 11 lbf of thrust

• Senior Project
  • Design and implement a P.I controller that will serve as a pre limiting device
2014 EPS

Battery → Electronic Speed Controller → Motor → Propeller

SAE Power Limiter 1000W

Rx

Power
PWM Signal
Battery, Propeller, Motor, & ESC Selection

• Enough energy for flight
• Propeller with greatest thrust
• Same motor and ESC from last year

1lb 6oz

1lb 2oz
Control Signal

![PWM of throttle positions](image)

<table>
<thead>
<tr>
<th>Throttle Position</th>
<th>PWM IN Rx (45 Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-3</td>
<td>908 us</td>
</tr>
<tr>
<td>-2</td>
<td>1.052 ms</td>
</tr>
<tr>
<td>-1</td>
<td>1.272 ms</td>
</tr>
<tr>
<td>0</td>
<td>1.508 ms</td>
</tr>
<tr>
<td>1</td>
<td>1.660 ms</td>
</tr>
<tr>
<td>2</td>
<td>1.844 ms</td>
</tr>
<tr>
<td>3</td>
<td>2.004 ms</td>
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</tbody>
</table>
2015 EPS
What is a P.I Controller?

\[ \text{Set point} \rightarrow + \rightarrow \text{Error} \rightarrow Kp \rightarrow + \rightarrow Ki \int \rightarrow + \rightarrow \text{System} \rightarrow + \rightarrow \text{Output} \]
P.I control Algorithm Block Diagram
P.I Control Results
Limiter Effect
P.I Controller Effect
Data Collection Tools

- Use of Thrust Test Bed
- Oscilloscope
- Current Probe
- BNC to alligator Clip connector
- Xplorer GLX Graphing Data Logger
- Dual Load Cell Amplifier

<table>
<thead>
<tr>
<th>Propeller</th>
<th>Average Thrust (lbf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>17x12E</td>
<td>11.26</td>
</tr>
<tr>
<td>18x8</td>
<td>12.57</td>
</tr>
<tr>
<td><strong>18x8E</strong></td>
<td><strong>12.97</strong></td>
</tr>
<tr>
<td>18x10E</td>
<td>11.69</td>
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<tr>
<td>19x8</td>
<td>12.27</td>
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<tr>
<td>19x10</td>
<td>11.73</td>
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<tr>
<td>20x8E</td>
<td>12.11</td>
</tr>
<tr>
<td>20x10E</td>
<td>12.13</td>
</tr>
</tbody>
</table>
17x12E Prop

Subplots of 17x12E-prop-3200-castle-Trial-1

- Voltage (V)
- Current (A)
- Power (W)
- Thrust (lbf)

Time (s)
18x8 Prop

Subplots of 18x8-prop-3200-castle-Trial-1

Voltage (V)

Time (s)

Current (A)

Time (s)

Power (W)

Time (s)

Thrust (lbf)

Time (s)
18x8E Prop

Subplots of 18x8E-prop-3200-castle-Trial-1

Voltage (V)

Time (s)

Current (A)

Time (s)

Power (W)

Time (s)

Thrust (lb)

Time (s)
Engaging Limiter
Future Work

- Keep Testing P.I Controller
- Test more propellers with different pitches
- Use Ecalc as a reference for future testing
- Find lighter motor for future use
- Find a replacement EE
Acknowledgments

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Questions?