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

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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

Round	R_n	B_n	T	FFS
1	10.70	0.00	5.00	
2	0.00	0.00	0.00	
3	16.40	4.00	3.00	
4	17.85	8.00	0.00	
5	18.02	19.00	0.00	
6	16.41	4.00	0.00	
SUM=	**79.38**	**19.00**	**8.00**	**90.38**

$$FFS = \sum_{1}^{n} R_n - \sum T + B_{n(max)}$$

OPTIMIZING POWER CONSUMPTION OF SAE AERO AIRCRAFT

By Ervin Meneses

Motivation

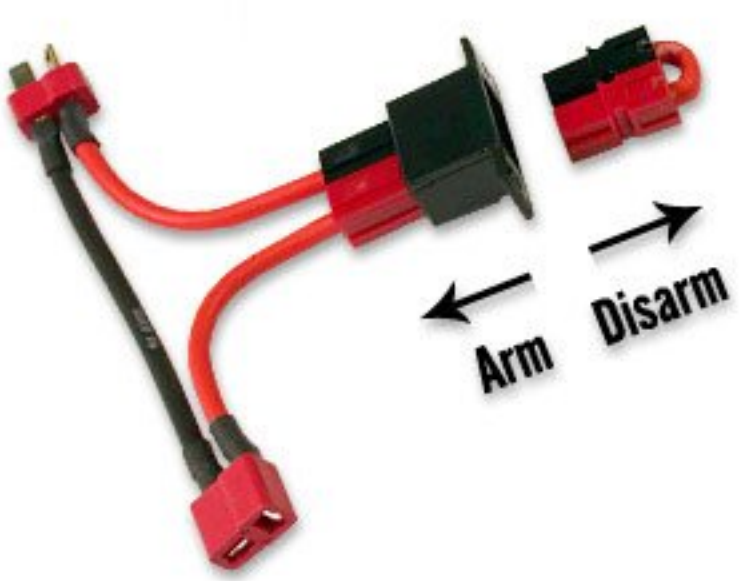
Last years competitors!

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



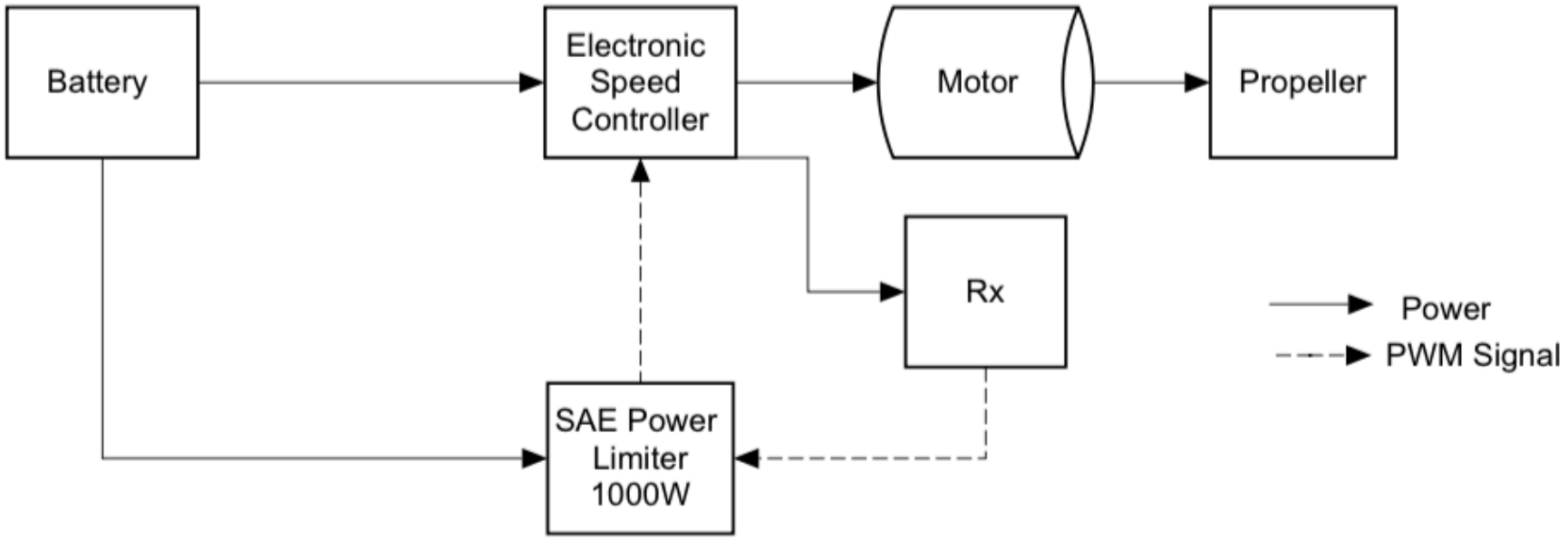
Goals

- 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

SAE AERO

UNION COLLEGE

2014 EPS


Battery
Electronic Speed Controller
Motor
Propeller
Rx
SAE Power Limiter 1000W
Power
PWM Signal

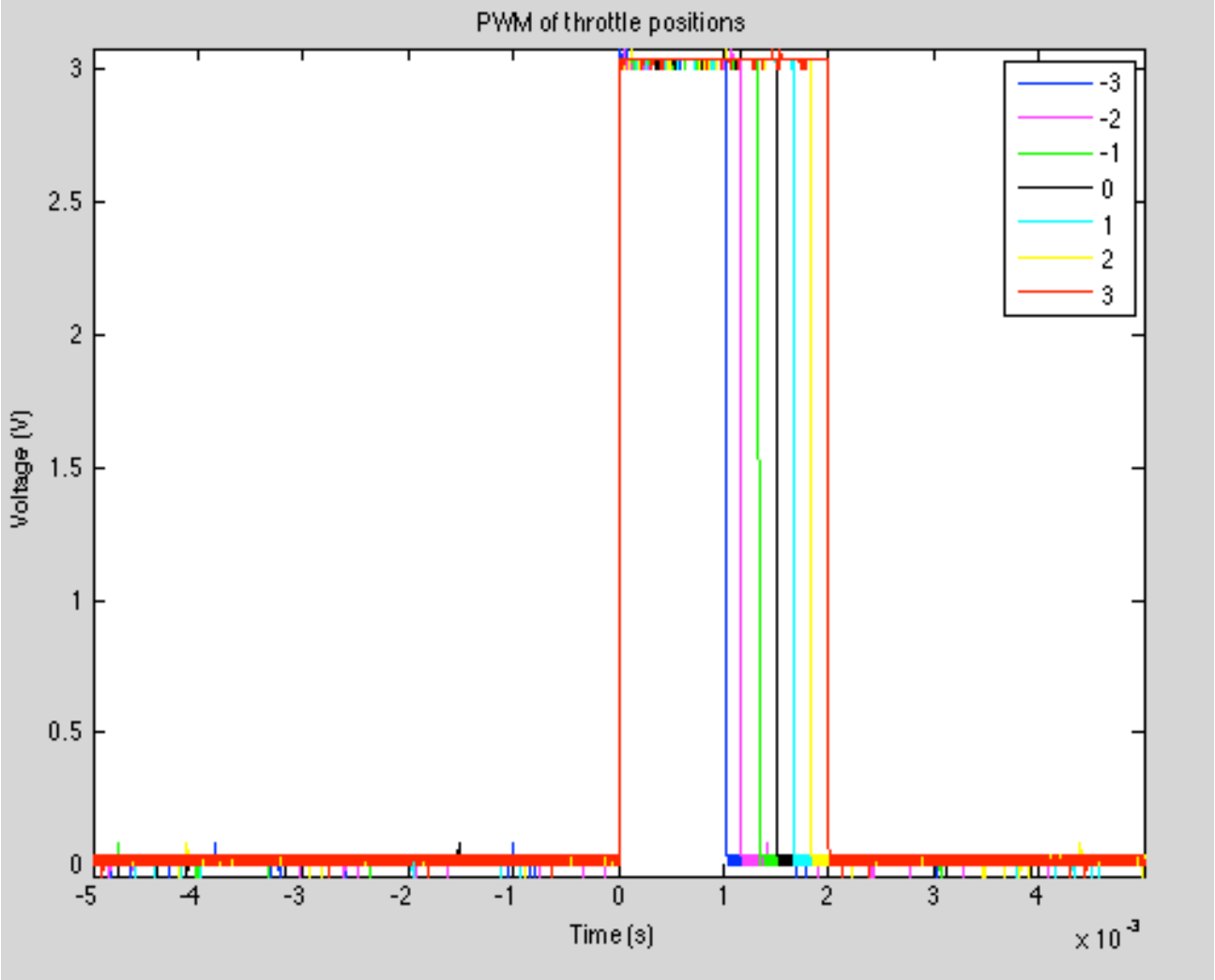
Battery, Propeller, Motor, & ESC Selection

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

1lb 6oz

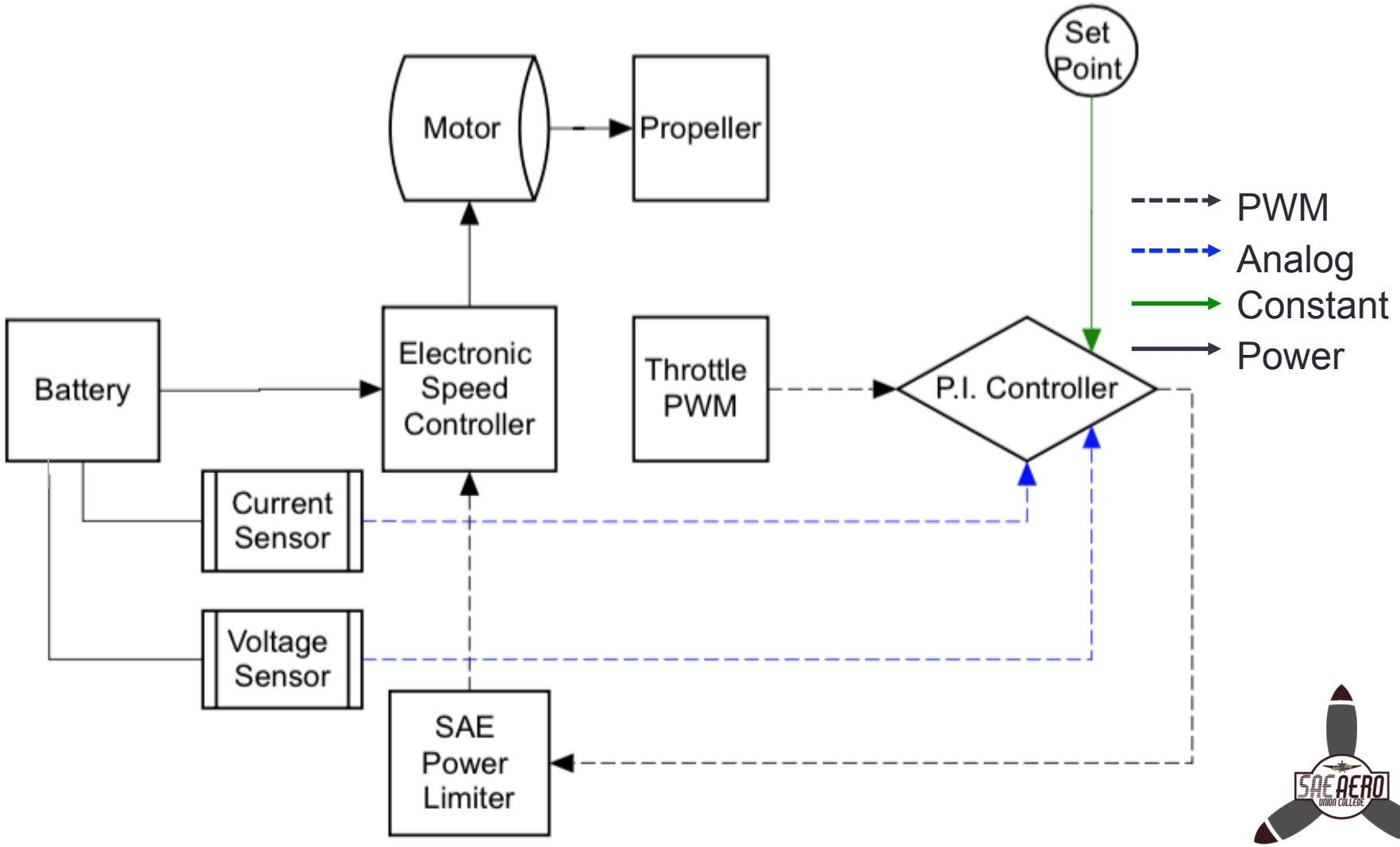
1lb 2oz

Control Signal

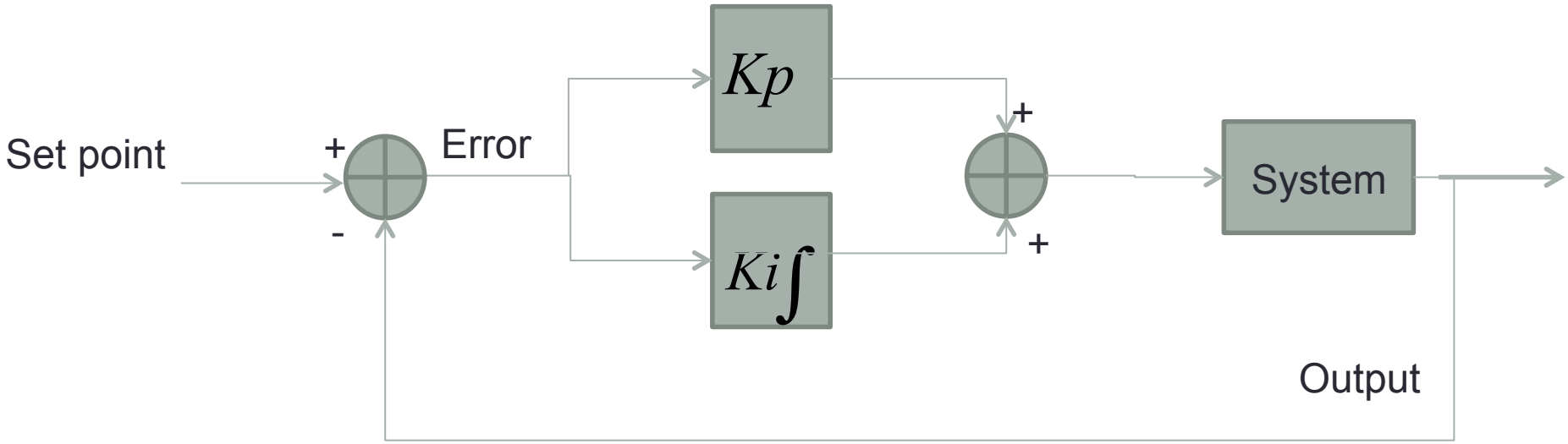


Throttle Position	PWM IN Rx(45 Hz)
-3	908 us
-2	1.052ms
-1	1.272ms
0	1.508ms
1	1.660ms
2	1.844ms
3	2.004ms

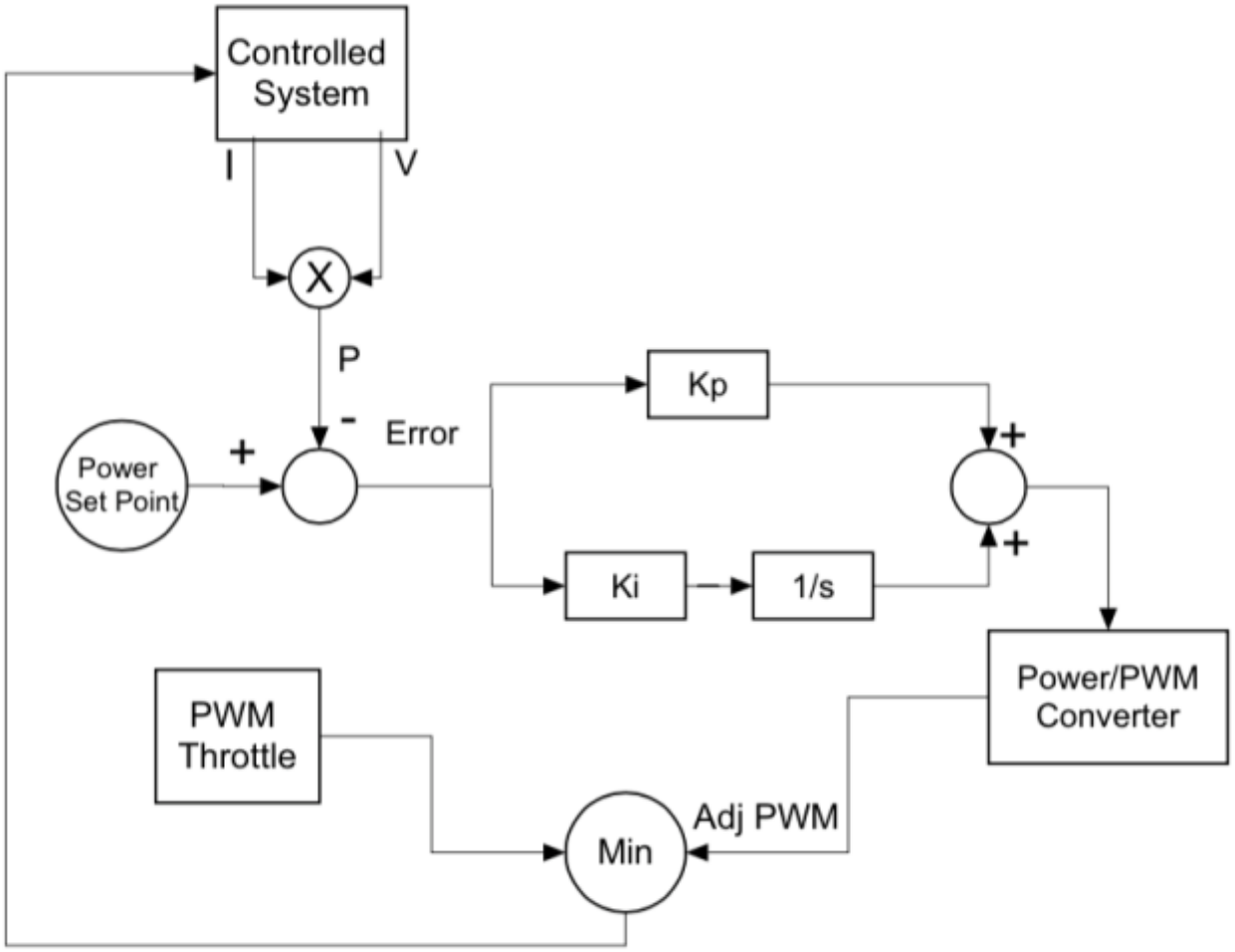
2015 EPS


Set Point
Motor
Propeller
PWM
Analog
Constant
Power
Battery
Electronic Speed Controller
Throttle PWM
P.I. Controller
Current Sensor
Voltage Sensor
SAE Power Limiter

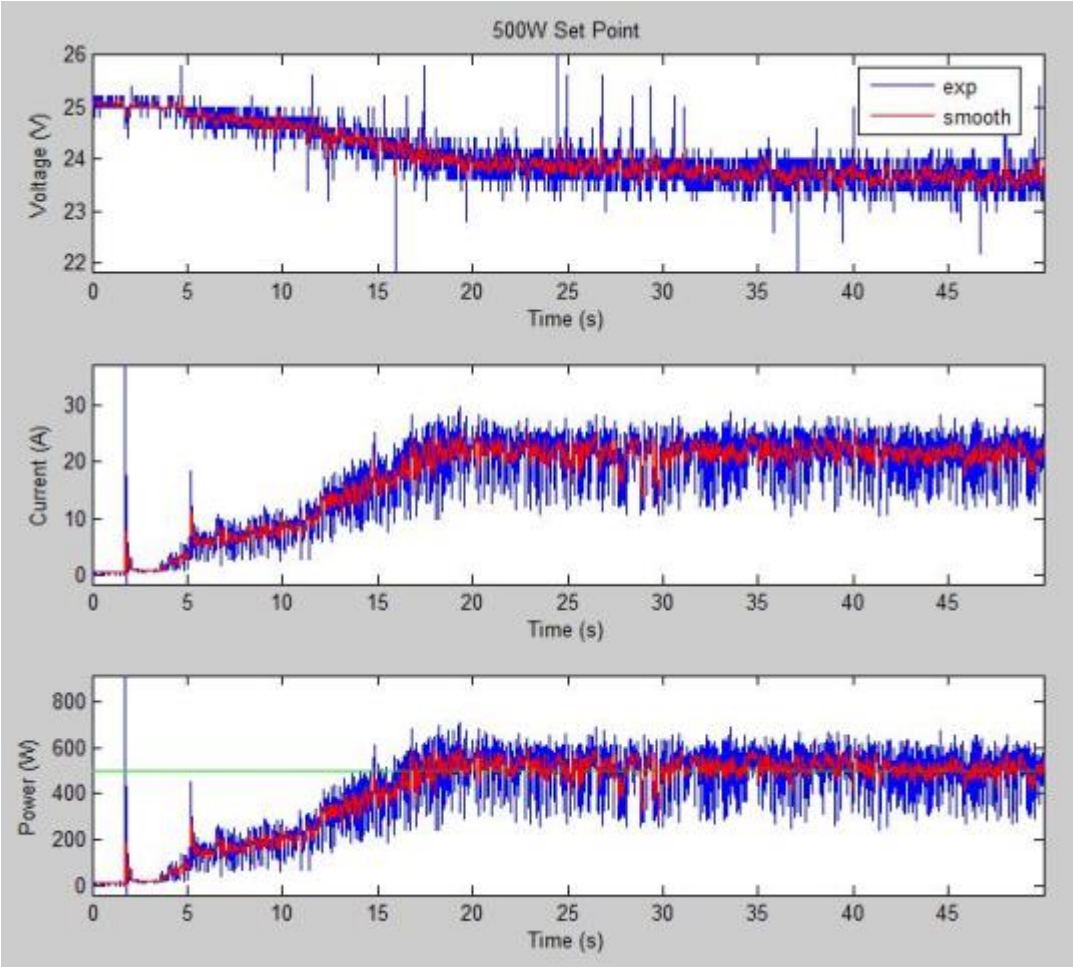
What is a P.I Controller ?



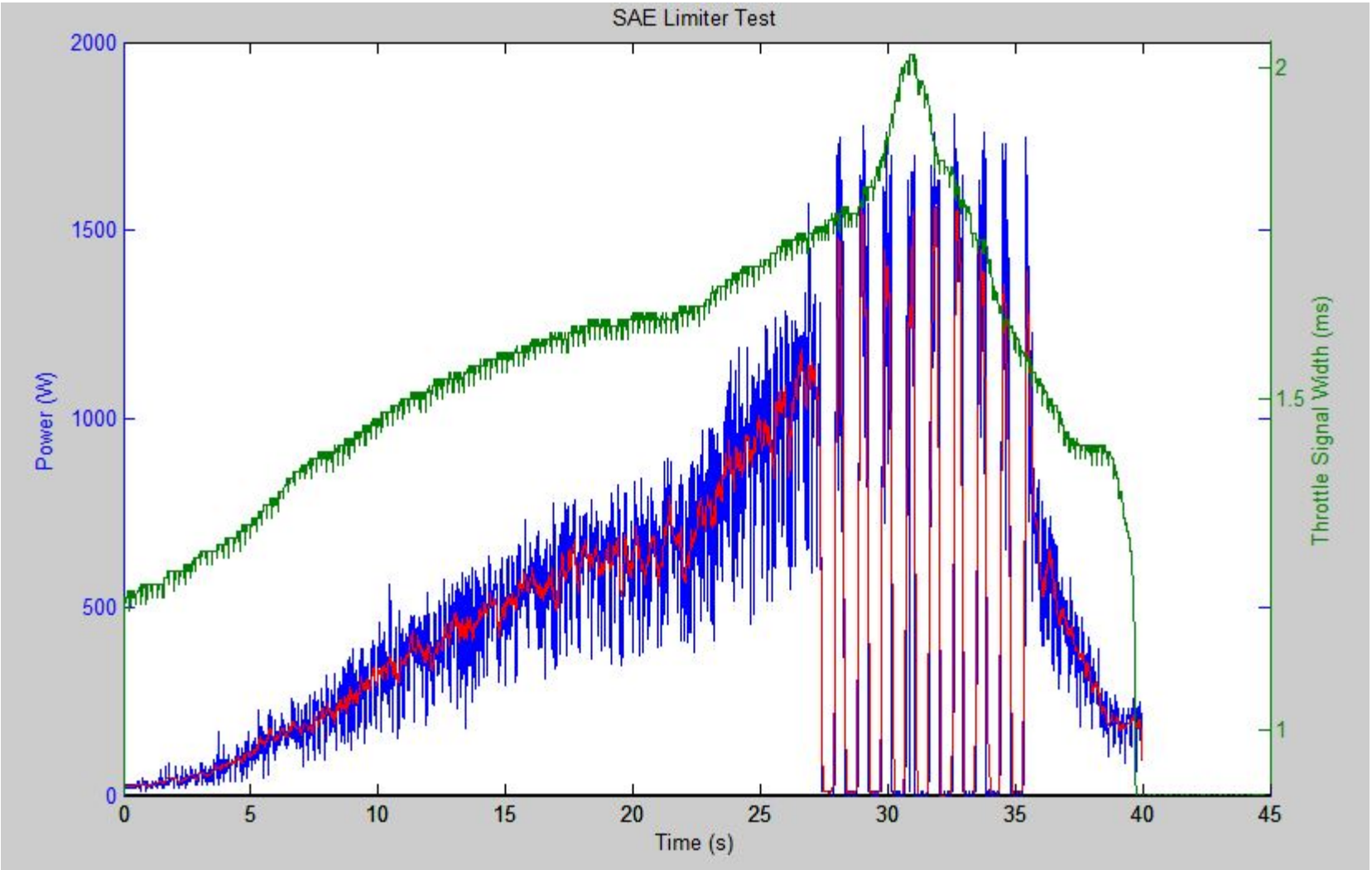
P.I control Algorithm Block Diagram



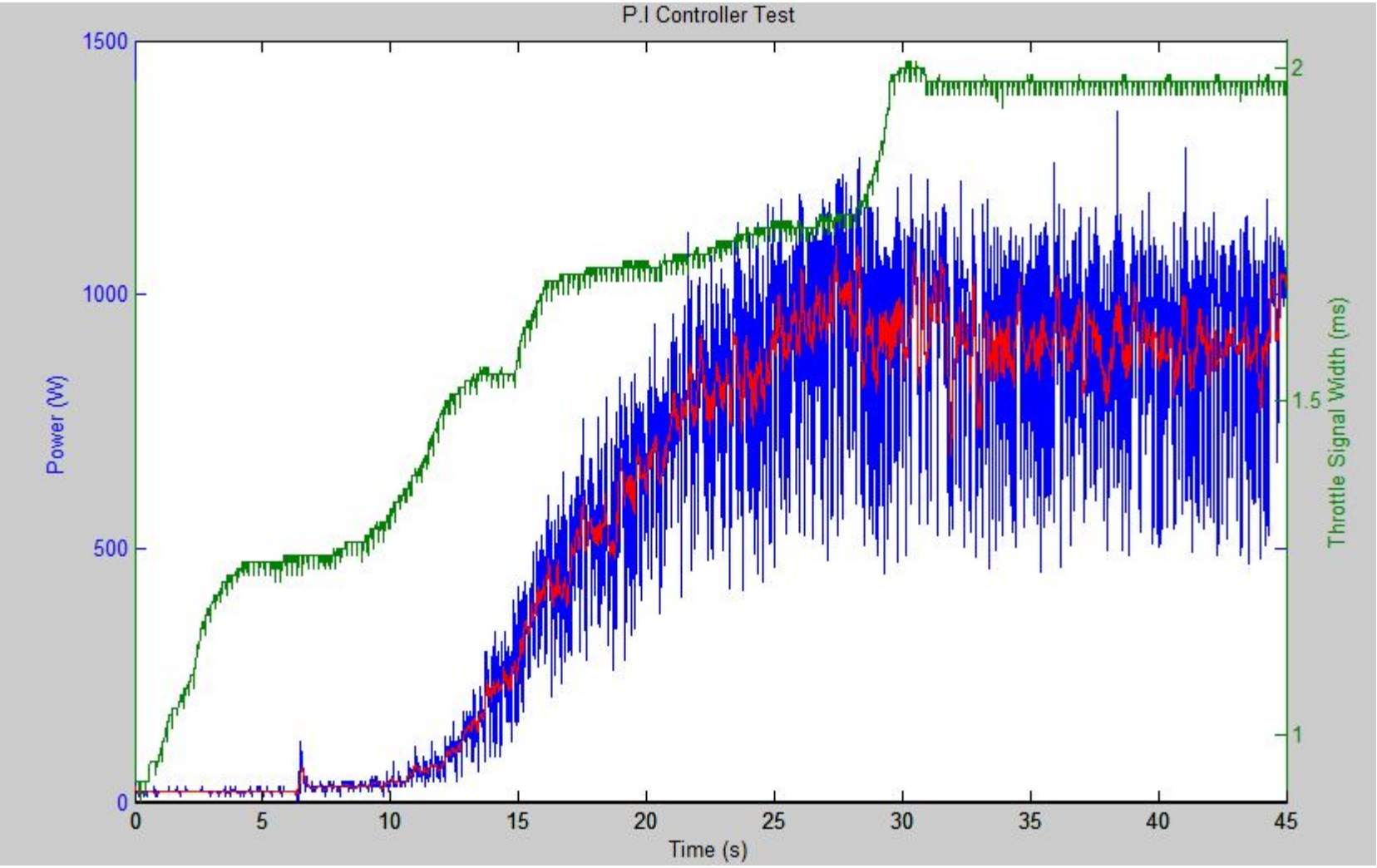
P.I Control Results



Limiter Effect



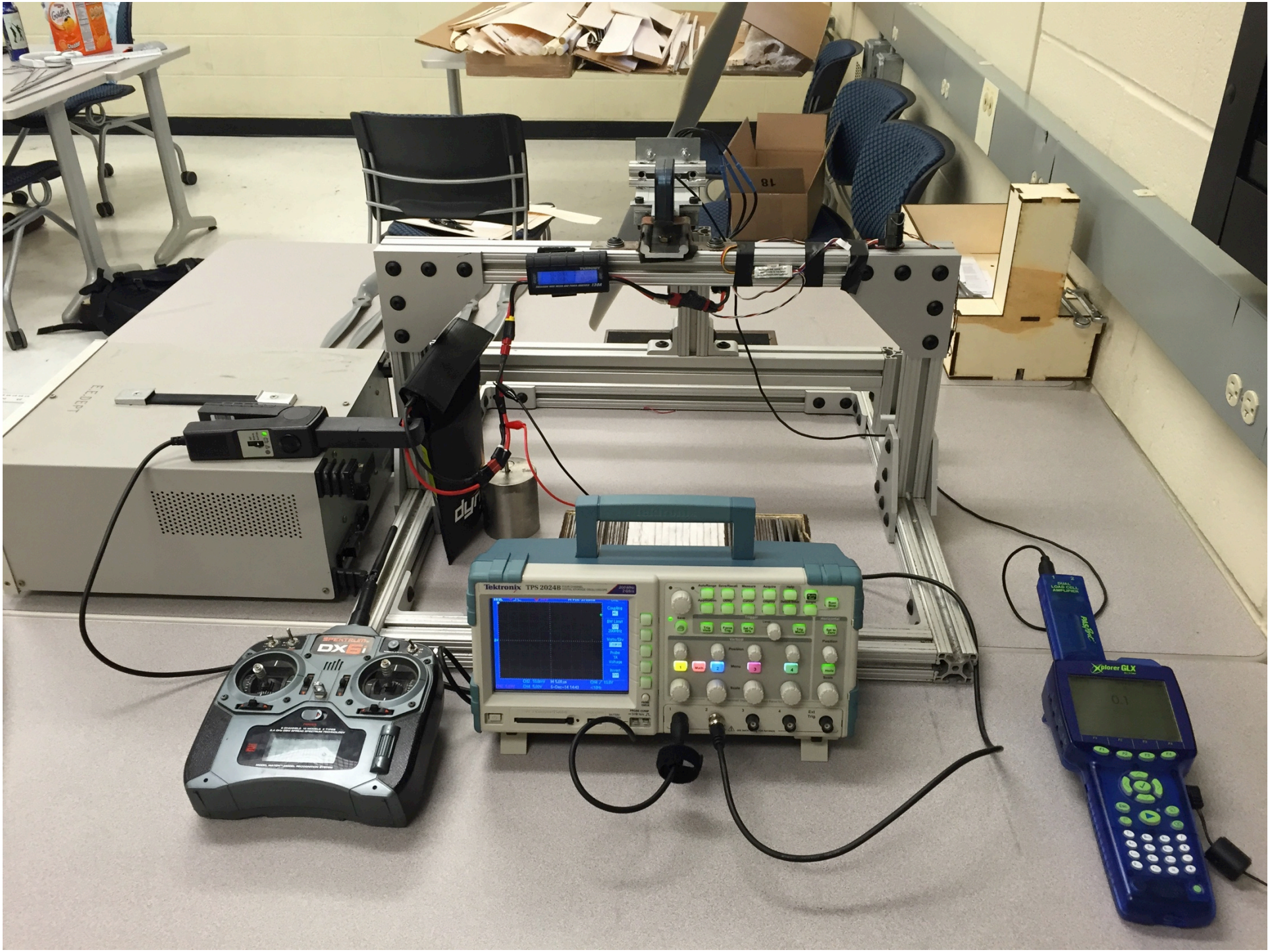
P.I Controller Effect

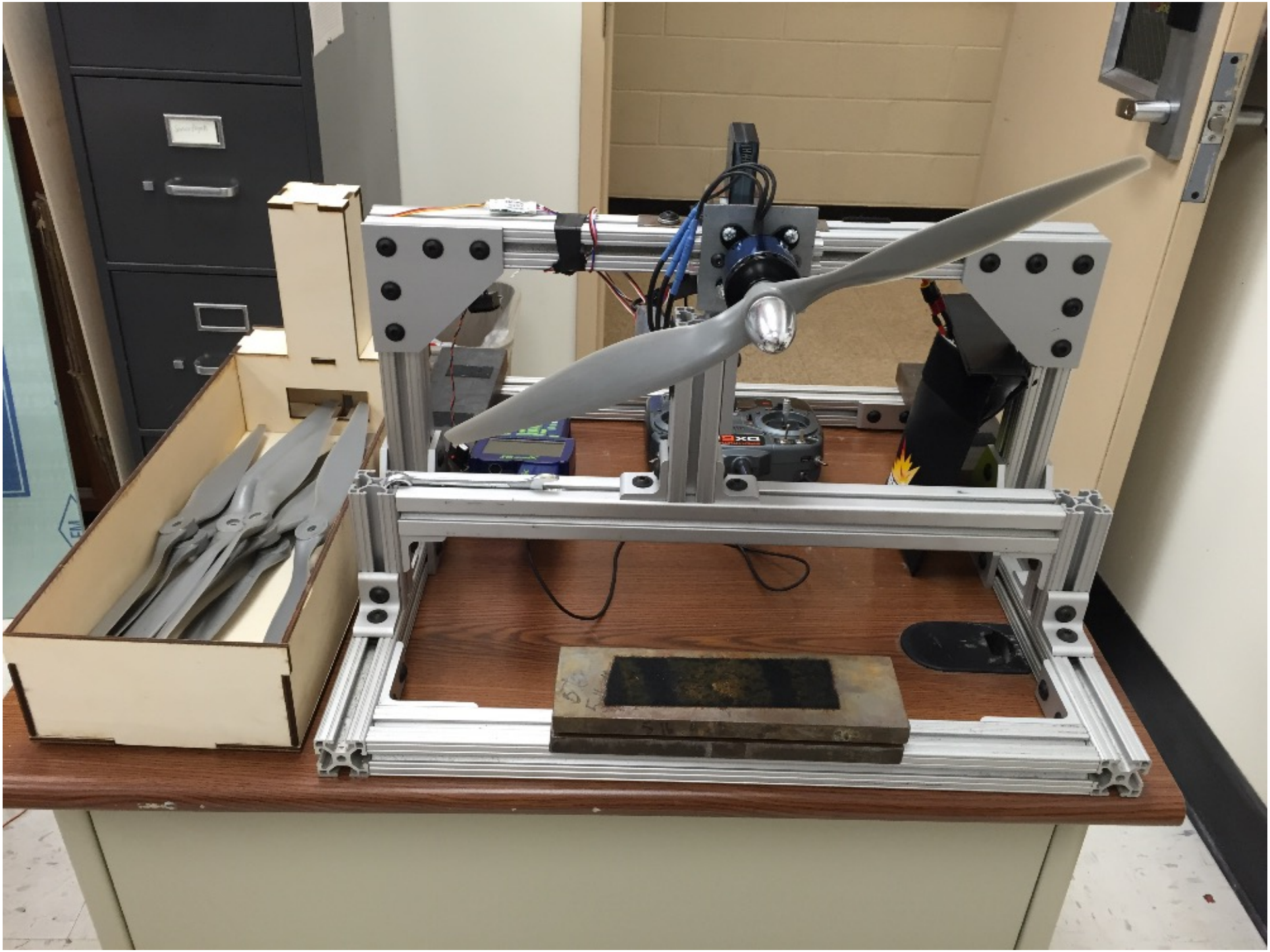


Data Collection Tools

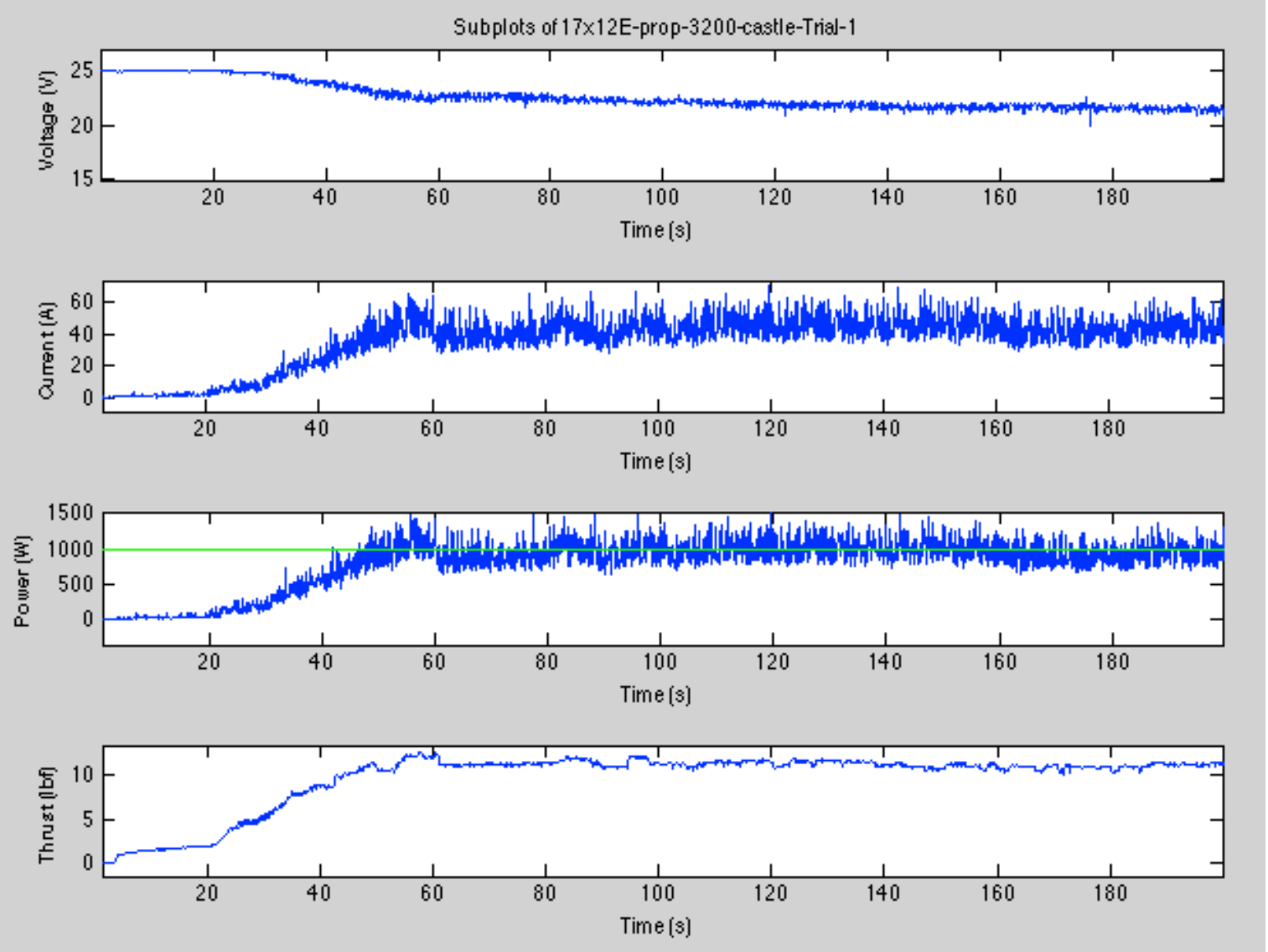
- Use of Thrust Test Bed
- Oscilloscope
- Current Probe
- BNC to alligator Clip connector
- Xplorer GLX Graphing Data Logger
- Dual Load Cell Amplifier

Propeller	Average Thrust (lbf)
17x12E	11.26
18x8	12.57
18x8E	12.97
18x10E	11.69
19x8	12.27
19x10	11.73
20x8E	12.11
20x10E	12.13

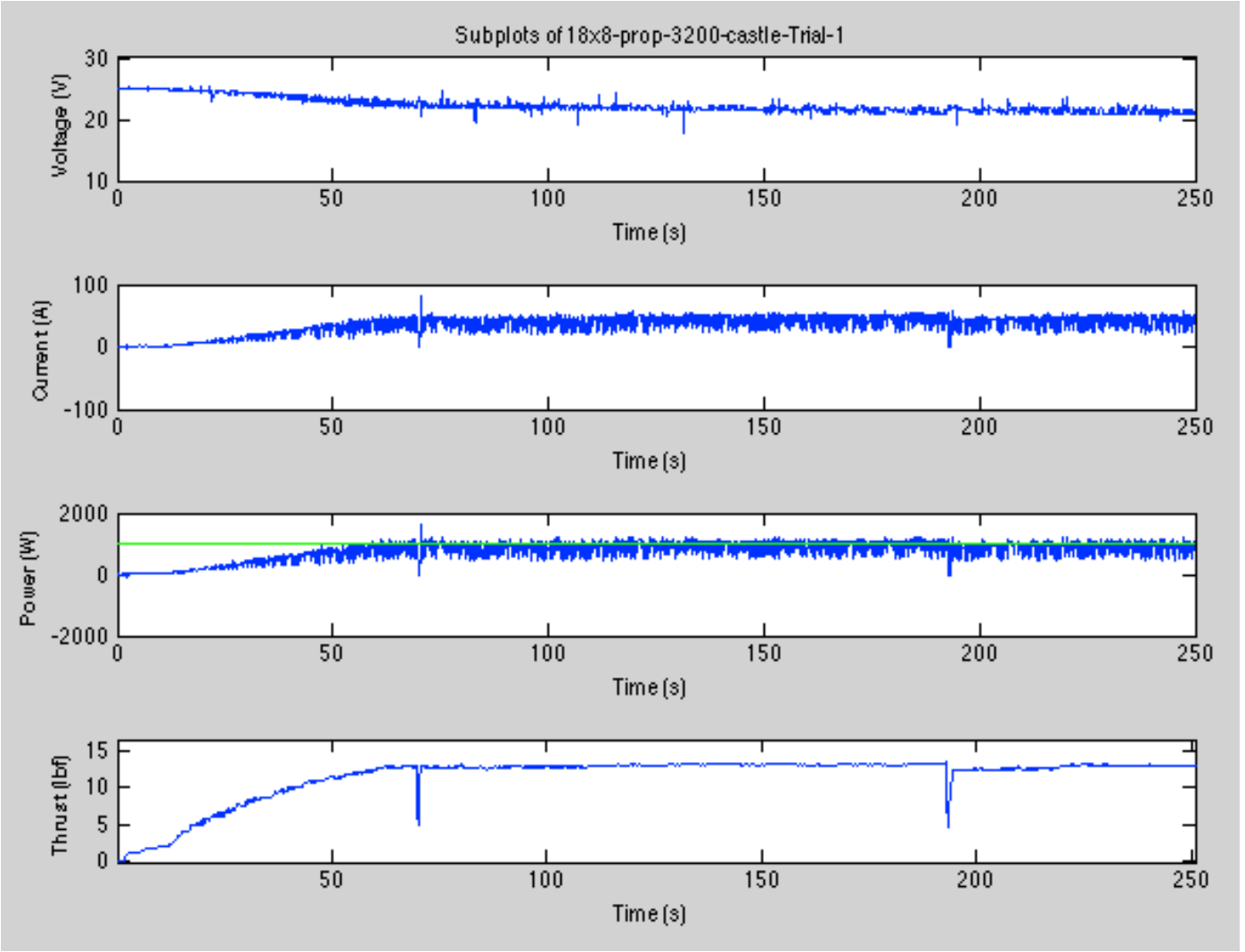

Tektronix TPS 2024B
DX5i
Xplorer GLX



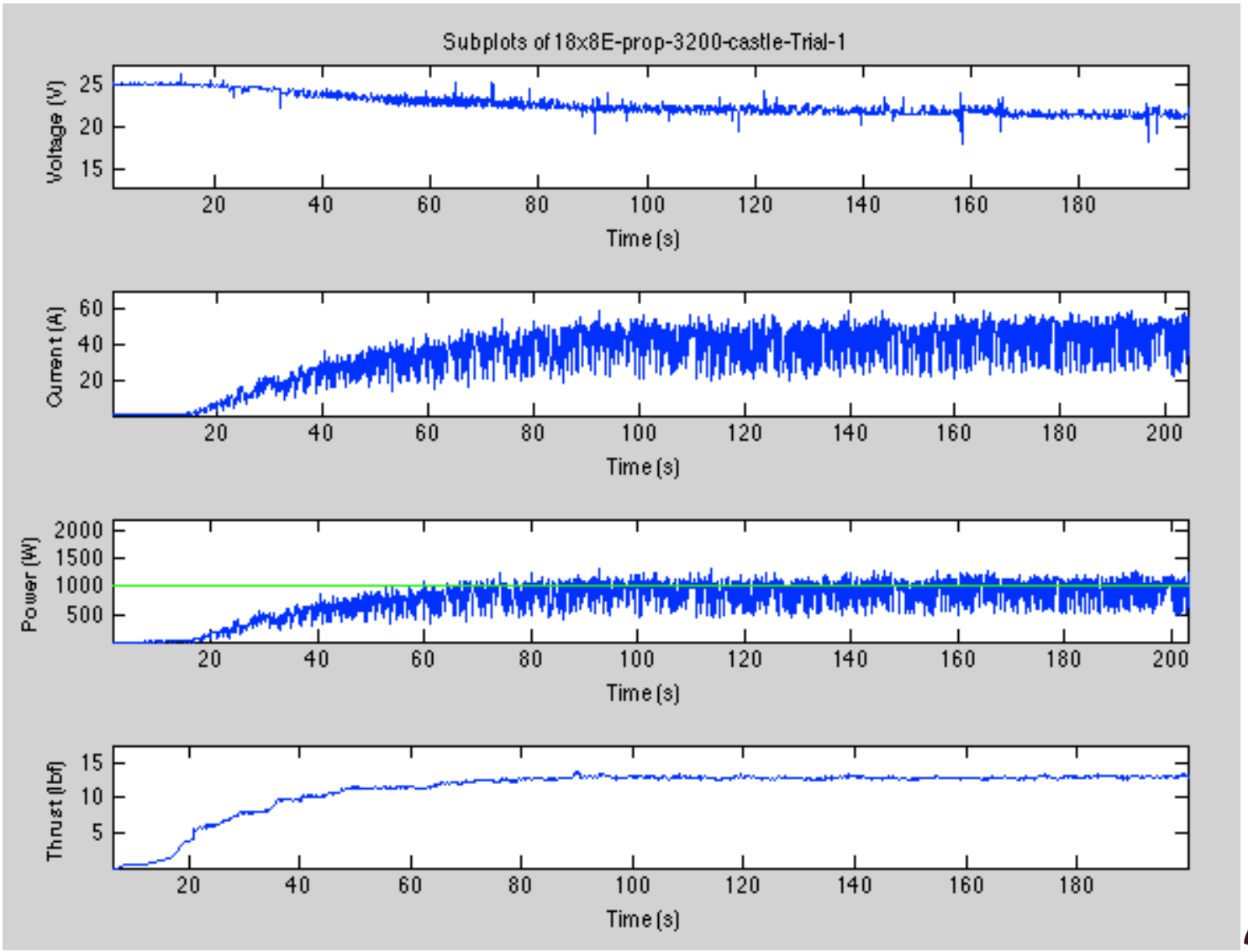
17x12E Prop


Subplots of 17x12E-prop-3200-castle-Trial-1
Voltage (V)
25
20
15
20
40
60
80
100
120
140
160
180
Time (s)
Current (A)
60
40
20
0
20
40
60
80
100
120
140
160
180
Time (s)
Power (W)
1500
1000
500
0
20
40
60
80
100
120
140
160
180
Time (s)
Thrust (lbf)
10
5
0
20
40
60
80
100
120
140
160
180
Time (s)

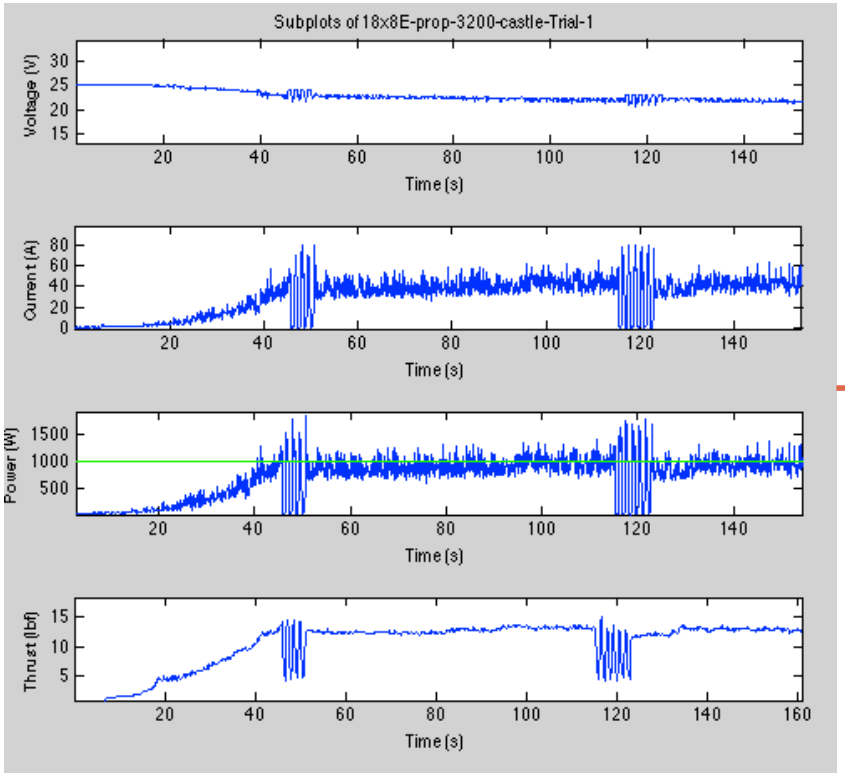
18x8 Prop

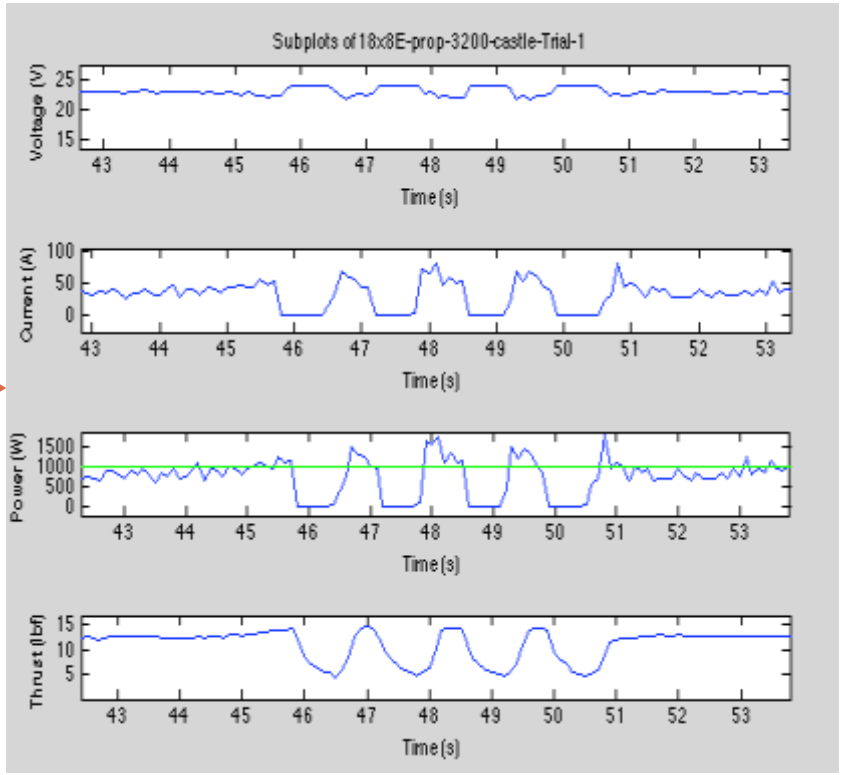

Subplots of 18x8-prop-3200-castle-Trial-1
Voltage (V)
30
20
10
0
50
100
150
200
250
Time (s)
Current (A)
100
0
-100
0
50
100
150
200
250
Time (s)
Power (W)
2000
0
-2000
0
50
100
150
200
250
Time (s)
Thrust (lbf)
15
10
5
0
50
100
150
200
250
Time (s)

18x8E Prop


Subplots of 18x8E-prop-3200-castle-Trial-1
Voltage (V)
25
20
15
20
40
60
80
100
120
140
160
180
Time (s)
Current (A)
60
40
20
20
40
60
80
100
120
140
160
180
200
Time (s)
Power (W)
2000
1500
1000
500
20
40
60
80
100
120
140
160
180
200
Time (s)
Thrust (lbf)
15
10
5
20
40
60
80
100
120
140
160
180
Time (s)

Engaging Limiter



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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?