2016 Collegiate Wind Competition:
Tunnel Electrical Team
Meet the Team

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  o Team Lead

• Zachary Sabol
  o Budget Liaison

• Michael Evans
  o Software Expert

• Jess Robinson
  o Controls Expert

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  o Power Electronics Expert

• Scott Muente
  o Load Expert
Outline

• What is the CWC?
• Project Description
• Electrical Layout
• Competition Requirements
• Power Electronics
• Controls & Software
• Load
• Manufacturing
• Testing Results
What is the CWC?

Collegiate Wind Competition (CWC): Undergraduate student competition sponsored by the U.S. Department of Energy. Consists of 2 challenges:

1. **Marketable Turbine**
   - Identify viable market
   - Design turbine for market
   - Prepare a business plan to enter market

2. **Tunnel Turbine**
   - Design turbine for wind tunnel testing
   - Compete against 12 other Universities in these tests
   - Have a design link between tunnel and market turbines
Project Description

1. Design turbine for wind tunnel testing
   - Electrical:
     - Power Electronics
     - Software
     - Controls
     - Load

Sponsors

Advisors
- David Willy
- Karin Wadsack
- Dr. Venkata Yaramasu
- Dr. Tom Acker
- Dr. Marc Chopin
- Ross Taylor
- John Sharber
Layout of Turbine Electrical Components

Figure 3: Electrical block diagram
Competition Requirements

1. **Power Curve Performance Test**
   - Measure power versus wind speed

2. **Control of Rated Power and Rotor Speed Test**
   - Measure power output and RPM versus wind speed

3. **Safety Test**
   - Aim for 90% reduction in RPM when brakes are turned on

Figure 4: Component testing in Flagstaff

Figure 5: A previous year's competition tunnel [1]
Power Electronics

• Rectifier
  ◦ Converts AC power to DC power
  ◦ Passive model
  ◦ Operates without a control signal

• DC/DC Converter
  ◦ Buck-Boost topology
  ◦ Step-up or Step-down input voltage through control of transistor
  ◦ PSpice simulations to confirm calculations

Figure 6: The Passive Rectifier Model

Figure 7: A DC/DC Converter Simulation
Controls - Software

• Power Curve
  ◦ States 1 – 4

• States 1 through 3
  ◦ Arduino ZERO
  ◦ Using DC/DC converter
  ◦ Closed loop PWM control

Figure 9: State 2 and 3 Block Diagram

Figure 8: Example of wind turbine power curve
Controls - Hardware

• Brakes
  ◦ AC and DC brakes
  ◦ Turbine shutdown
  ◦ Manual shutdown switch
  ◦ Load disconnect

• Arduino ZERO Microcontroller
  ◦ Activation of brakes
  ◦ Sensing voltage

Figure 10: DC Brake Board

Figure 11: Arduino ZERO Microcontroller
Load

• Load
  ◦ The basic load for dissipating power from the generator
  ◦ Uses an adjustable power resistor that can dissipate up to 300 watts

• Bonus Challenge Load
  ◦ Relates to deployment design
  ◦ As more power is produced, more lights turn on

Figure 12: Variable Resistor
Figure 13: Bonus Load CAD Model
Manufacturing

• Prototyping
  ◦ Moved from small sections to full circuit

• Manufacturing
  ◦ Tested one part at a time as team mounted and connected components
  ◦ Revisited designs as the team tested their components

Figure 13: AC Brake Prototype
Figure 14: AC Brake Manufacturing
Figure 15: Rectifier Board
Figure 16: DC/DC Converter
Testing Results

• Connected components to turbine output, measured values and recorded for later analysis.
  ◦ Brakes worked effectively up to 12 m/s wind speed
  ◦ Rectifier has a voltage loss of 1.25 V and is ~85% efficient
  ◦ DC/DC Converter bugs led to redesigns
  ◦ Bonus Load operational
  ◦ Software code redesigned to match new changes

Figure 17: A still from a recorded tunnel test
References


Questions?