IPRO 324-Power Measurement in Road Bicycles

"No Strain, No Gain…"

Final Presentation

December 4th, 2009

Team Organization

- Mechanical
  - Team Leader
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  - Team Members
    - Ross Allen
    - Sara Claxton
    - Gregory Herbert
- Electrical
  - Team Leader
    - Dan Shaffer
  - Team Members
    - Luis Adrianzen
    - Chris Antonio
    - Mark Callan
    - Patrick Tagny Diesse
    - Matthew Gaylord

Why Power Measurement?

- Measures output of power into the bicycle
  - Instant feedback
  - Cyclists can train at different levels
  - Strain gauges on power meter
  - Calculation of applied torque
  - Better than just measuring heart rate

What is Power?

Force (lbs)	Angle (°)	RPM	Torque (ft-lb)	Power (Watt)
90	125	60	41.72	355.48
65	35	60	21.10	179.77
120	70	45	63.82	407.80

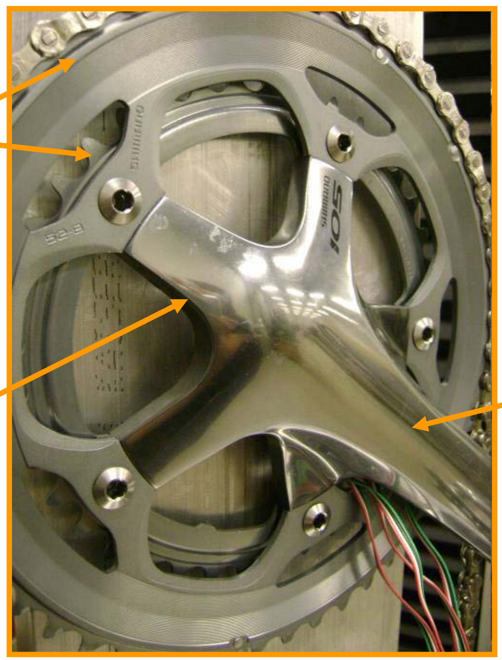
- Power is the work per unit time
- Power is computed from the torque applied to the crank and the rate of pedaling
- Torque is rotational force applied to the axis of rotation through a lever arm

Background

- Existing products are too expensive
  - Cost of current products
    - Power Tap ($999.00)
    - SRM ($2,607.80)
    - Quarq CinQo ($1,495.00)

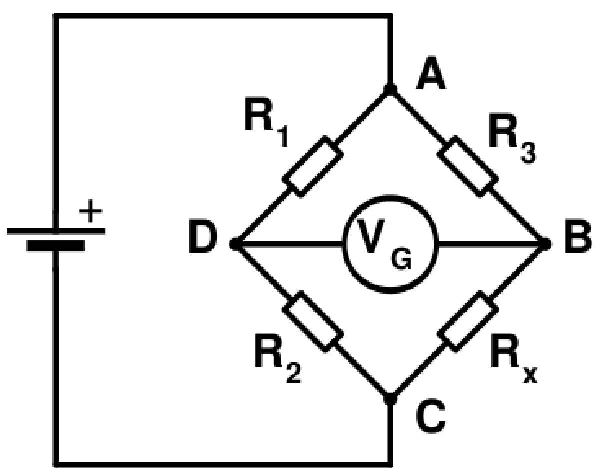
Crankset Power Measurement Setup

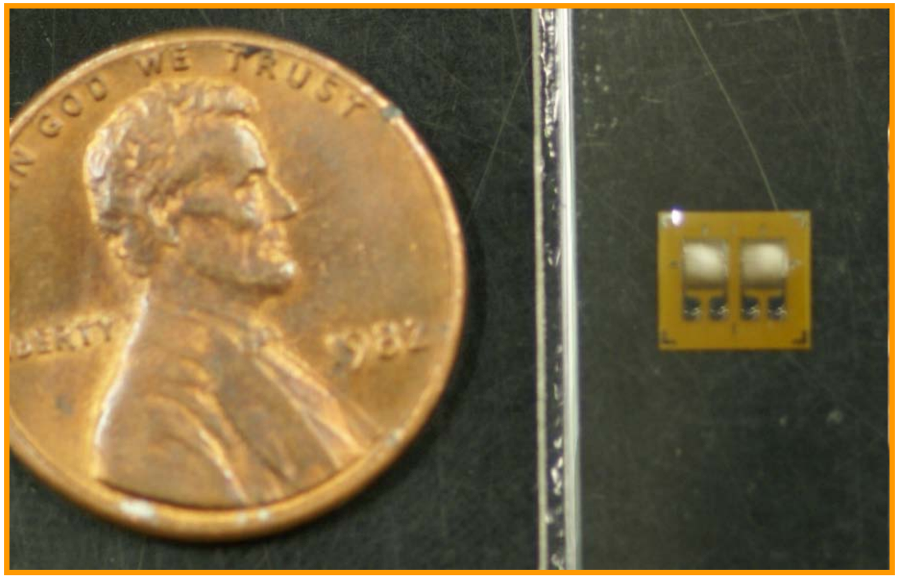
- Strain Gages and Angle Sensor
- Power Measurement Circuit
- Wireless Transmission Protocol
  - ANT+
- Bicycle Computer
  - Garmin Edge 705



Our Approach

- Use the strain in the crankset (spider) to find torque
- Torque increases linearly with the strain
- Strains can be multiplied by coefficients to find torque at different crank angles
- Strain gauges are used to find strain by finding change in resistance through voltage drop across Wheatstone bridge



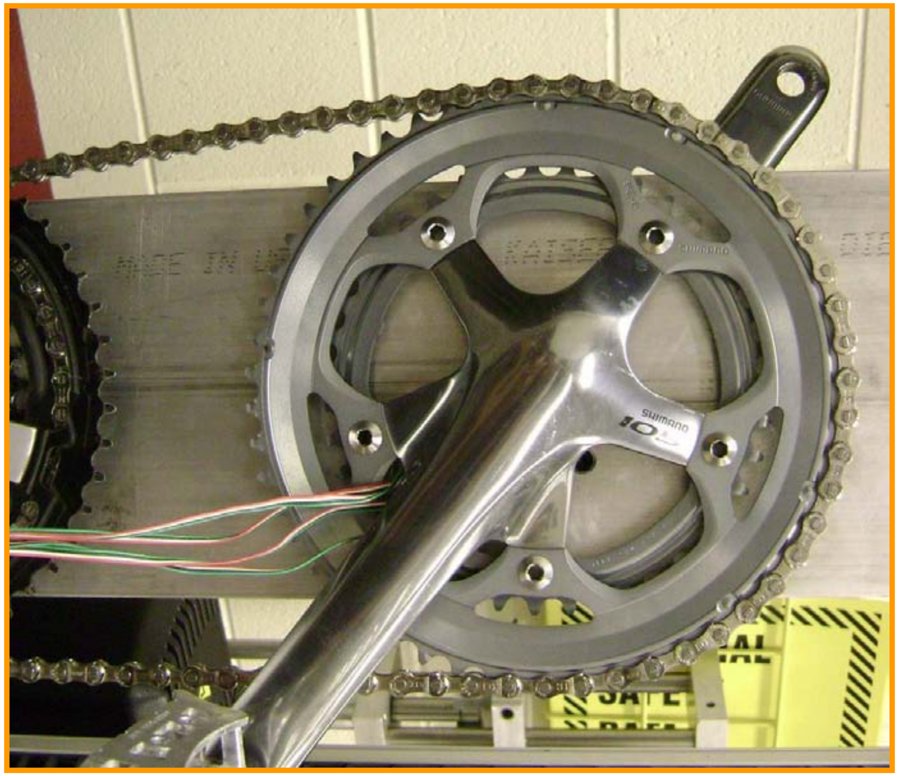


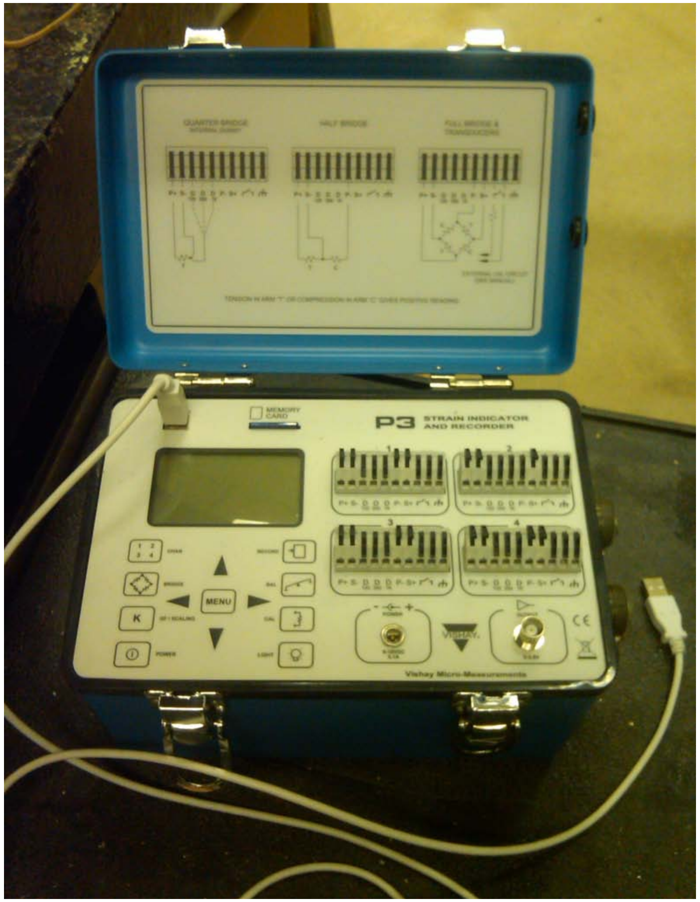
Mechanical Team Objectives

- Revise test stand setup from a vertical to horizontal configuration
- Obtain additional data from modified test stand setup
- Design mounting system of circuit
- Obtain a bicycle for road testing
- Acquire road test data

Mechanical Setup

- 4 full bridges of strain gauges are used
- P3 to measure strain
- Calibration free weights to apply load

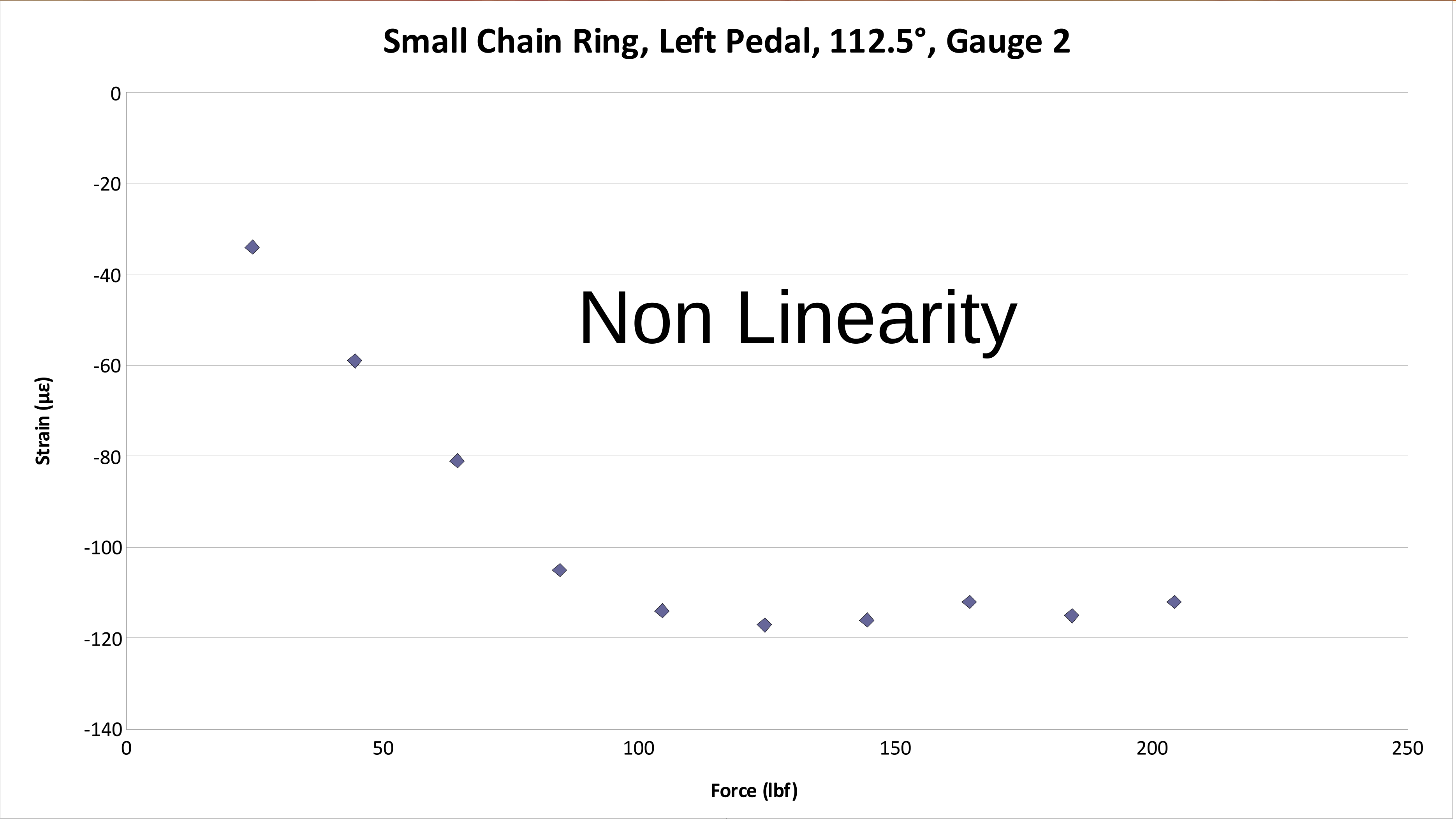




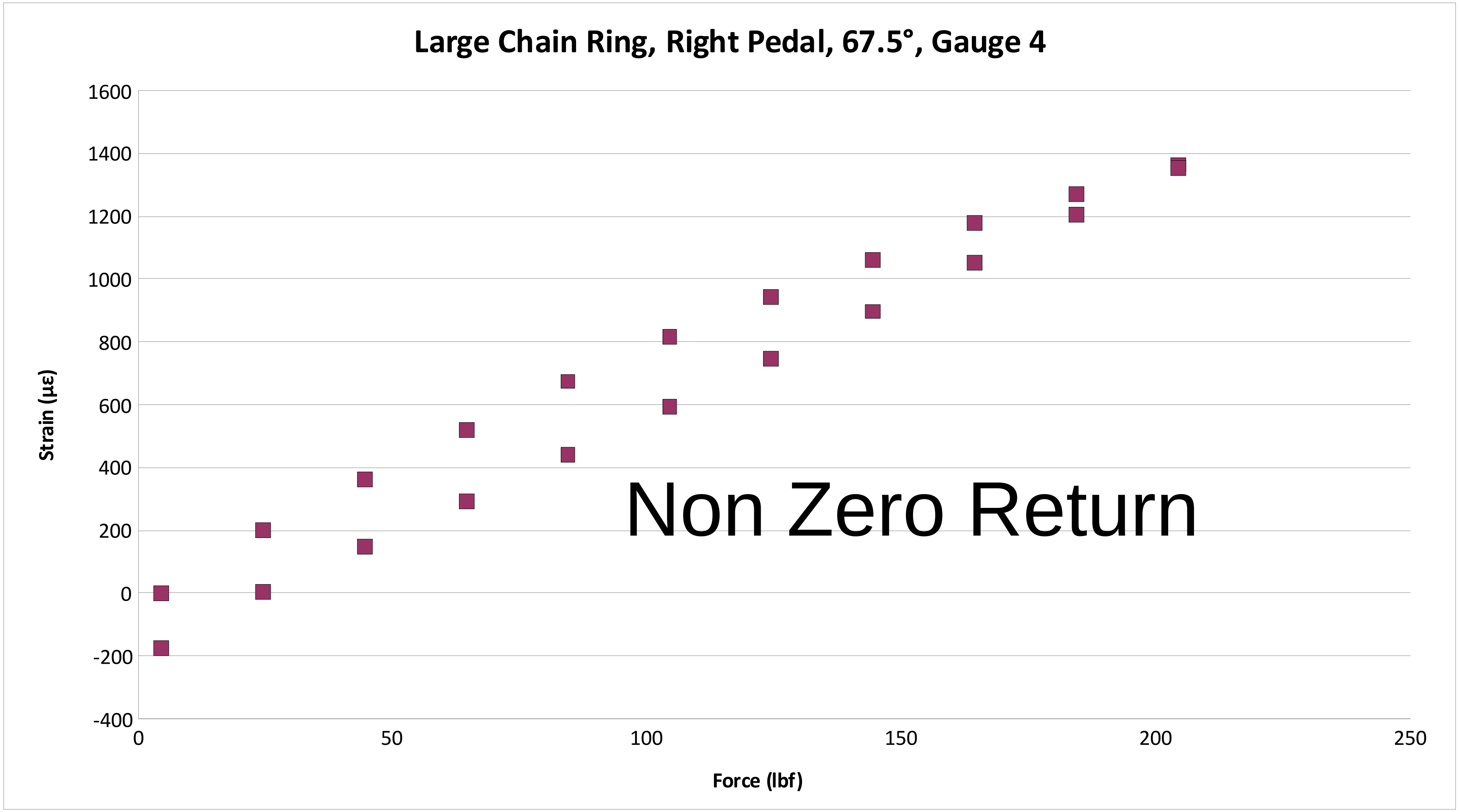
Mechanical Team Obstacles

- Non-linearity and non-zero return in data
- Delays in obtaining bicycle
- Attachment of components to crank
- Integrating electrical and mechanical designs

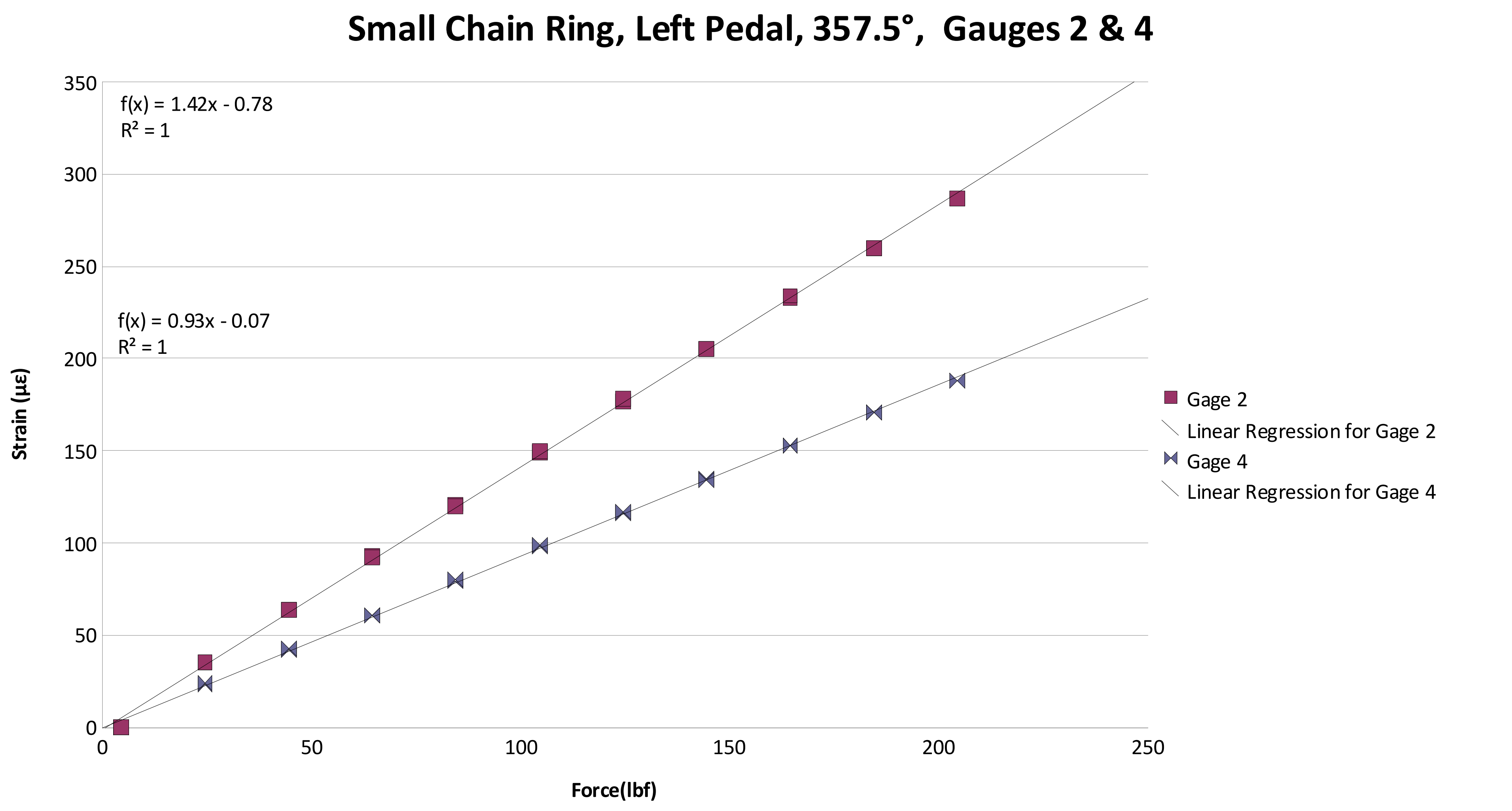
Mechanical Obstacles



Mechanical Obstacles



Mechanical Results



Mechanical Results

- Strain-Power coefficients calculated from testing
- Designed and manufactured circuitry housing
- Integrated components to bike

$$T=c_2V_2 + c_4V_4$$

Angle (°)	22.5	67.5	112.5	157.5	202.5	247.5	292.5	337.5
C_2	-38766	-64004	-71699	21496	14641	-9841	-14880	-11904
C_4	-42122	-11667	-24068	-20482	-91663	-59697	-44909	-42161

Electrical Team Objectives

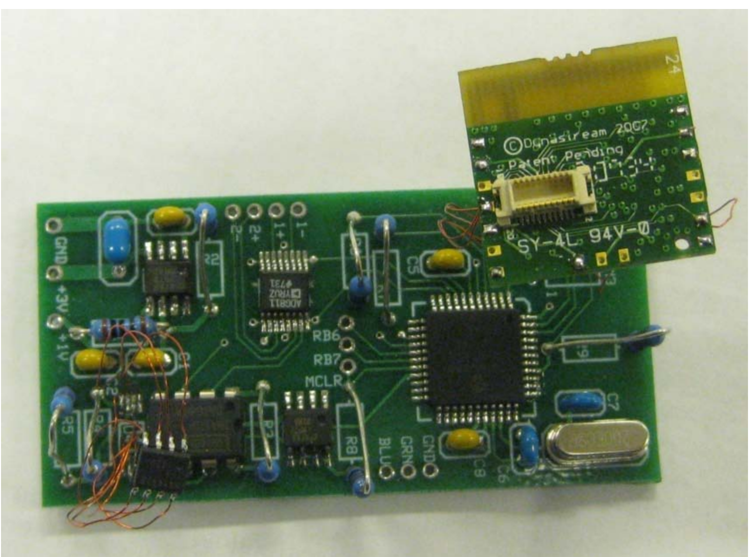
- Improve overall power efficiency of circuit
- Miniaturize and package electronics to conform to working space of crank set
- Prepare schematic diagram for PCB layout
- Debug algorithm calculating applied torque at crank set
- Integrate the angle sensor into the torque calculation

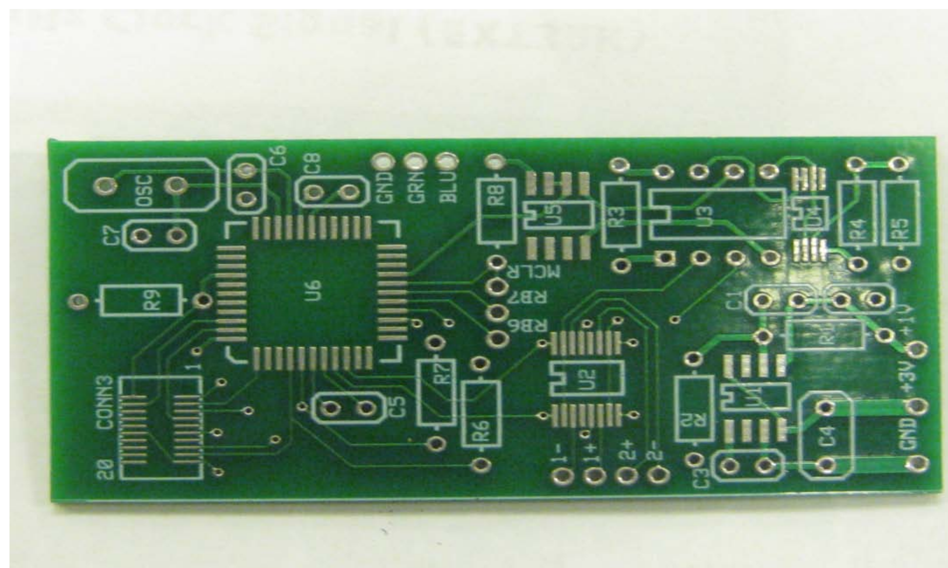
Electrical Team Obstacles

- Miniaturization of the circuit board to fit on the crank set
- Source code for the chip needed to be updated to reflect coefficients from mechanical testing
- Design of the PCB layout and assembly process

Electrical Results

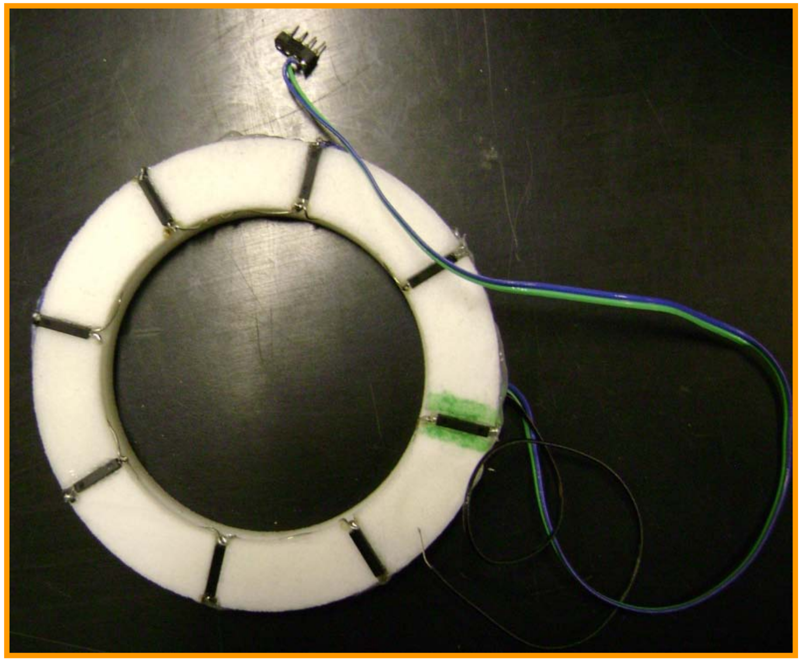
- Power measurement circuit
  - 3V battery and 1V voltage regulator giving constant voltage
  - Miniaturized circuit to meet the size constraints





Electrical Results

- Source code
  - Integrated new coefficients into the code
  - Integrated angle sensor into the program algorithm



Conclusion

- Prototype
  - Developed miniaturized circuit
  - Calculated strain-power coefficients
  - Manufactured circuitry housing
  - Obtained bicycle
- Future work
  - Package product
  - Road Testing
  - Finite Element Analysis (FEA)
  - Optimize battery life

Acknowledgements

- Blue City Cycle
- Professor Dietmar Rempfer
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Questions?

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