IPRO 324-Power Measurement in Road Bicycles

"No Strain, No Gain…"

Final Presentation

December 4th, 2009

Team Organization

- Mechanical
  - Team Leader
    - Celeste Wegrzyn
  - 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?

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
90	[illegible]	60	[illegible]	[illegible]
65	35	60	210	[illegible]
120	70	45	[illegible]	[illegible]

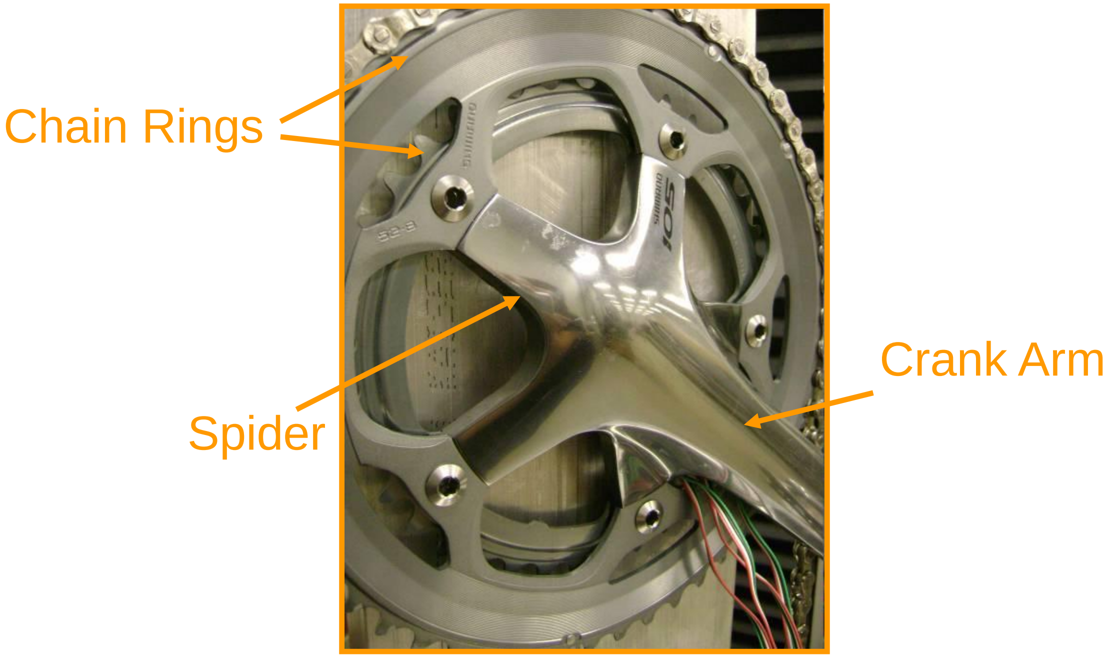
- Power is the work per unit time
- Power is computed from the torque applied to the crank and the rate of pedaling
- Torque is rotational force applied to the axis of rotation through a lever arm

Background

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

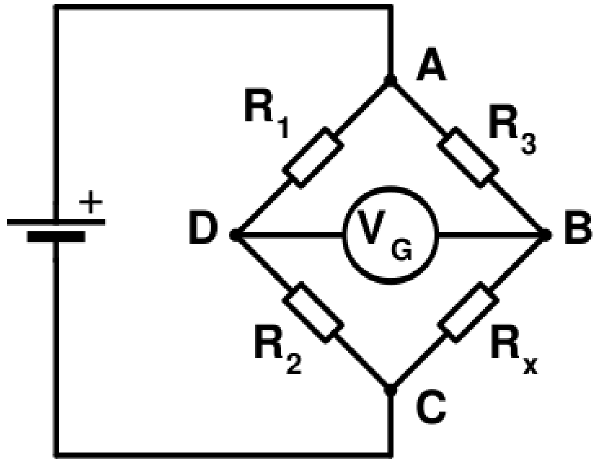
Crankset Power Measurement Setup

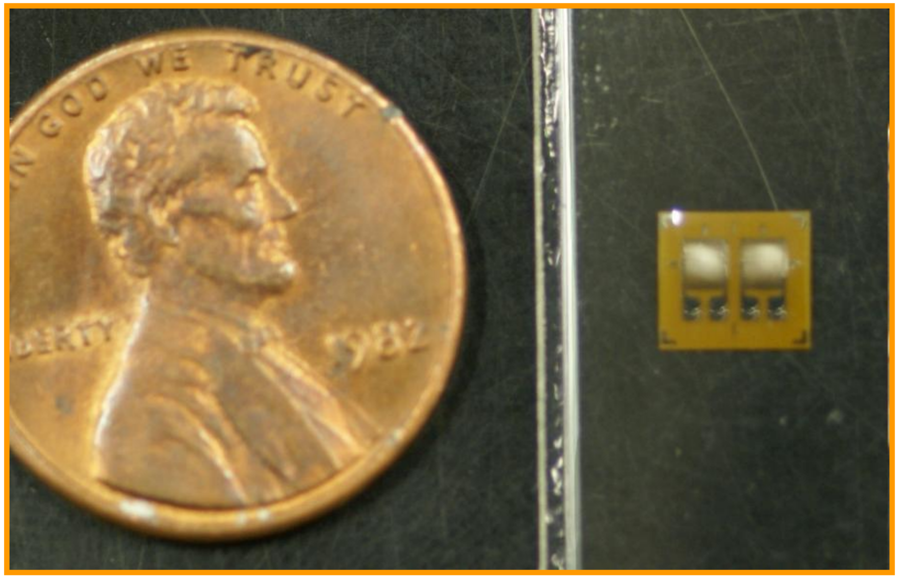
- Strain Gages
- Power Measurement Circuit
- Wireless Transmission Protocol
  - ANT+
- Bicycle Computer
  - Garmin Edge 705



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

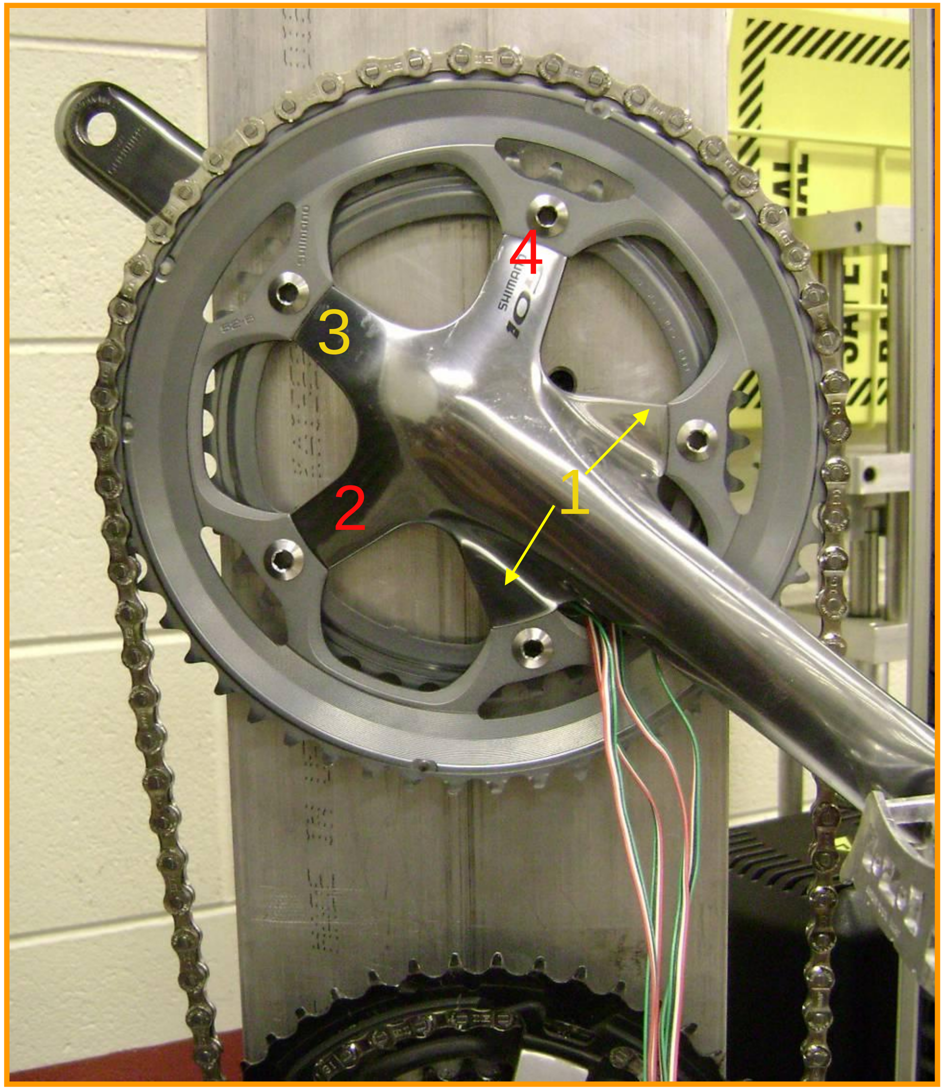
Mechanical Setup

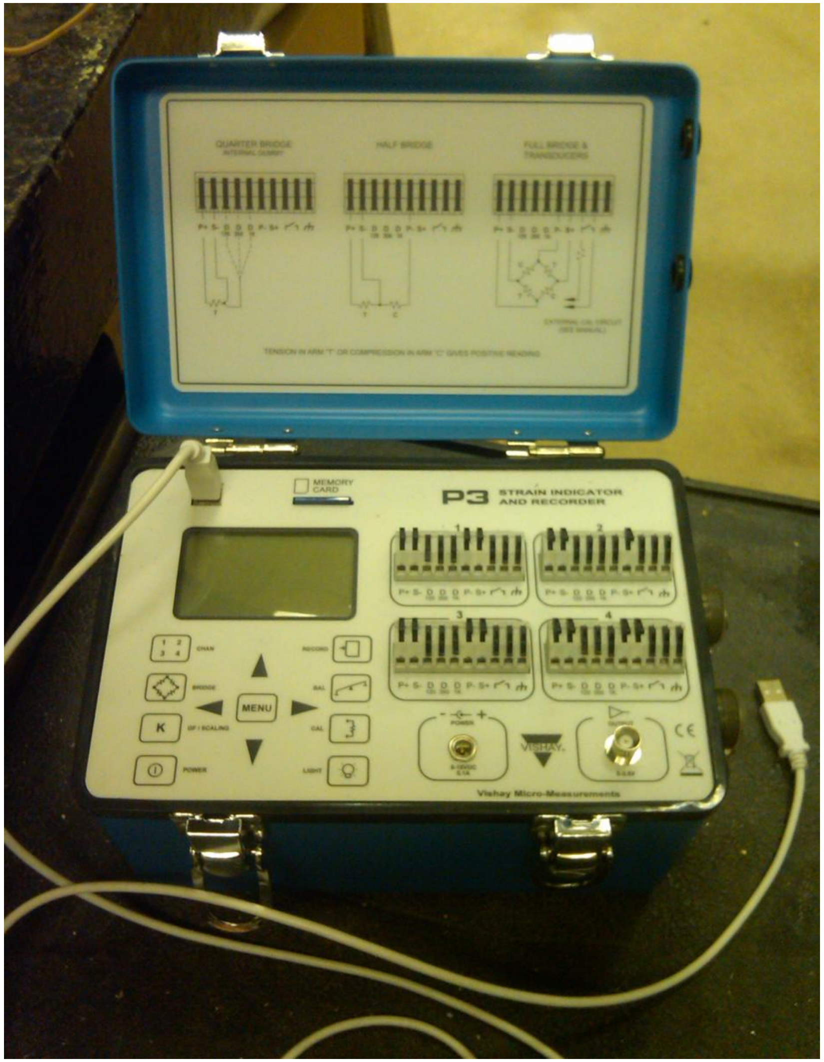
- 4 full bridges of strain gauges are used
- P3 to measure strain
- Calibration free weights to apply load

Mechanical Team Obstacles

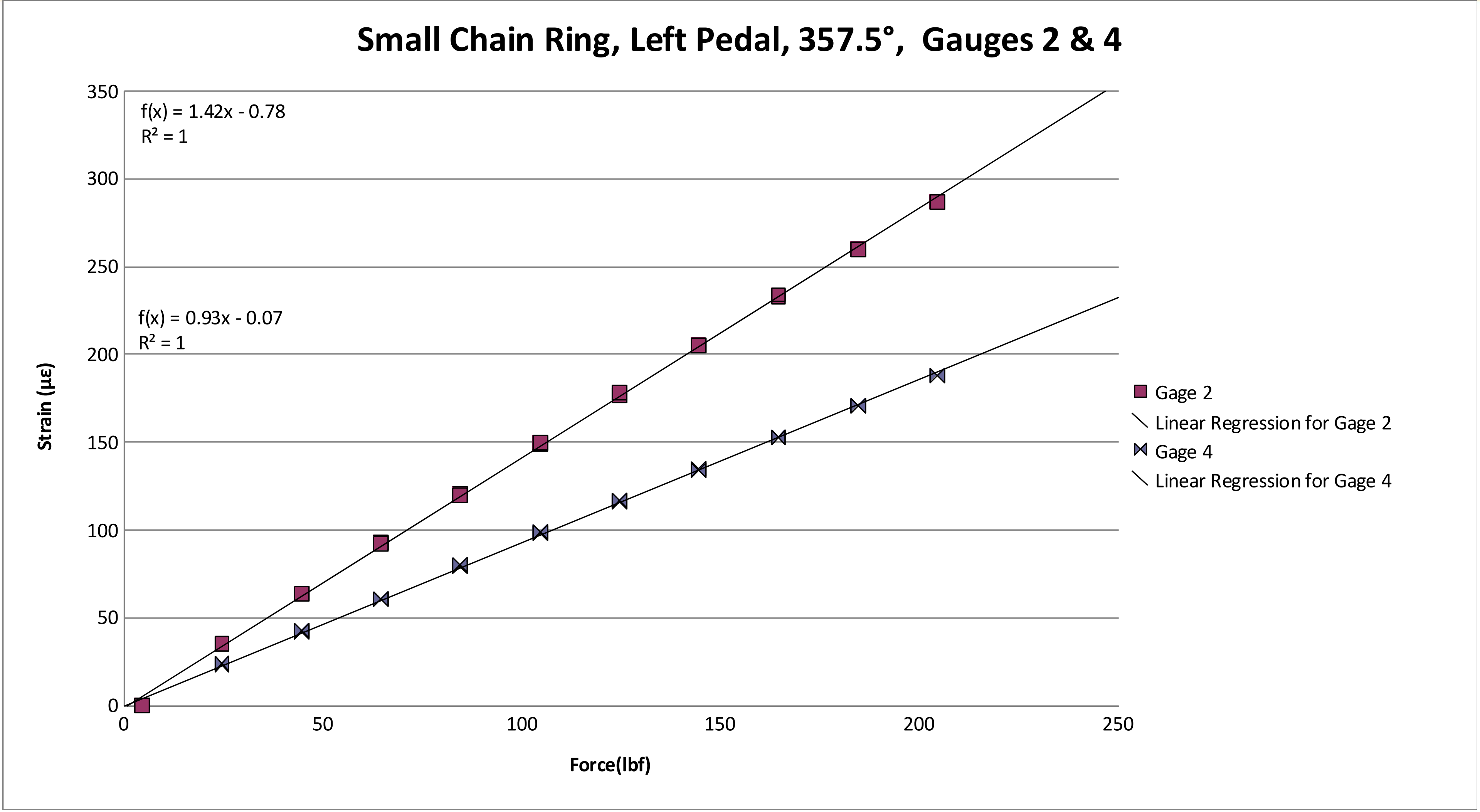
- Attachment of all components to crank
- Raising sufficient money to assemble bike
- Modifying bicycle
- Integrating electrical and mechanical designs
- Conducting live, road tests

Mechanical Results

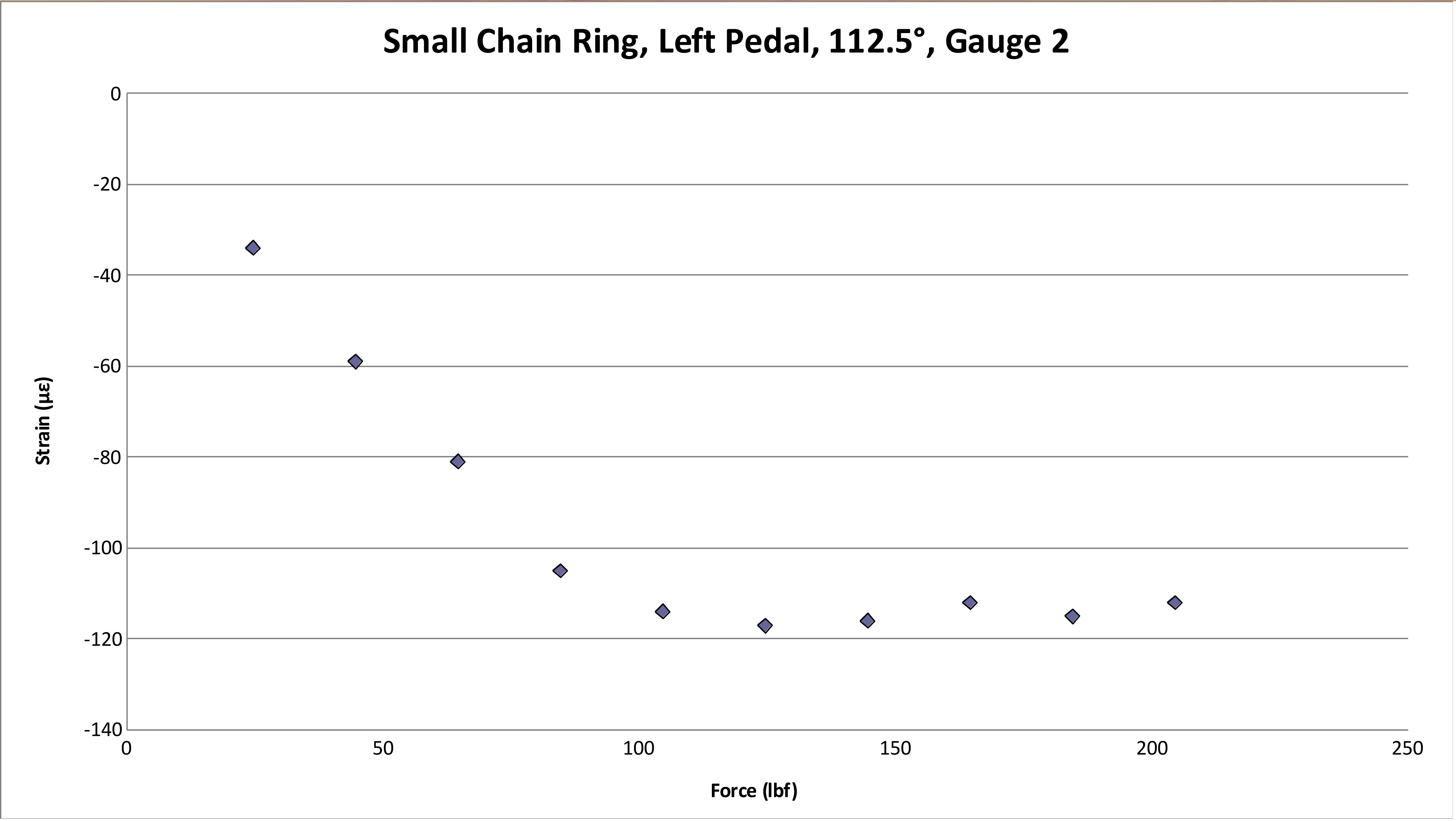




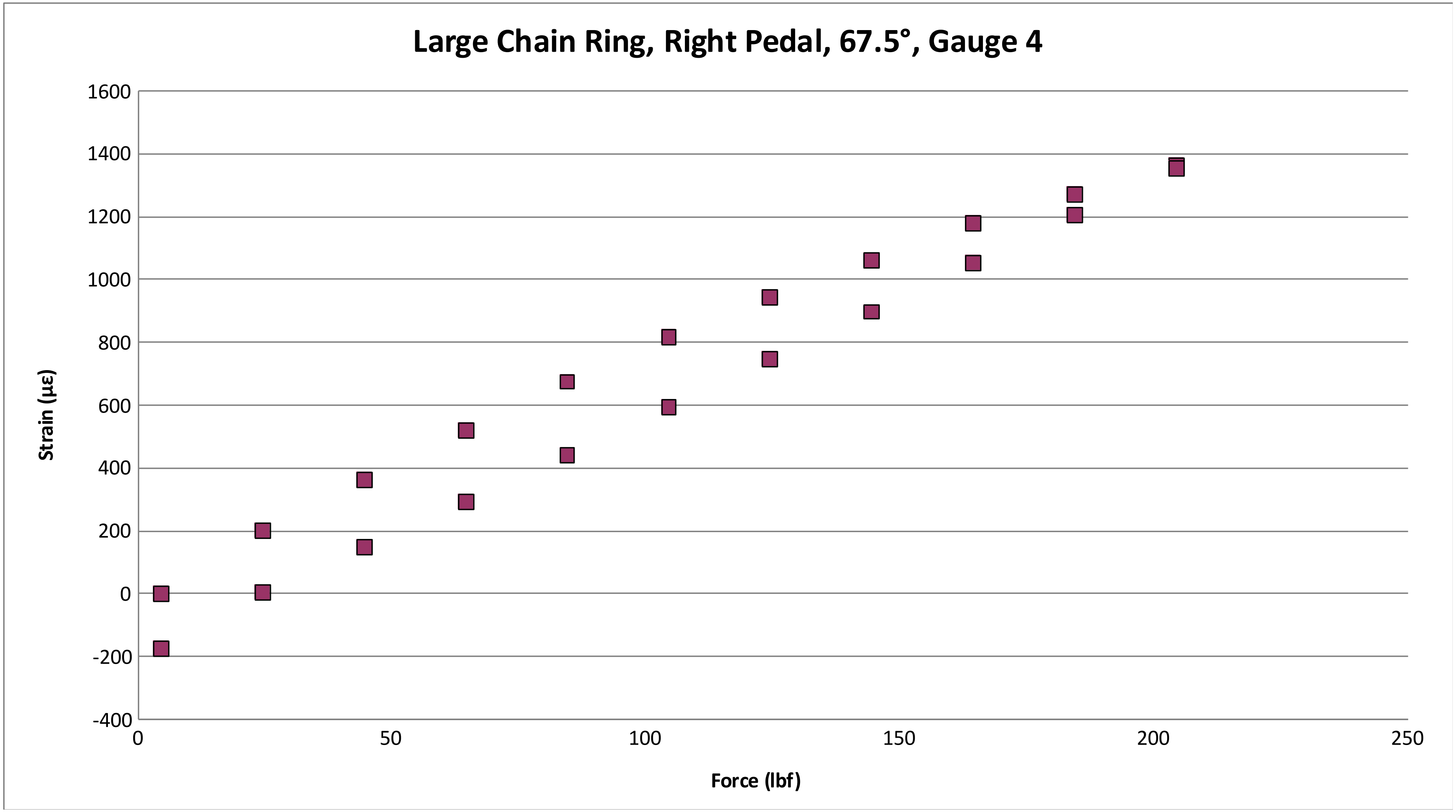
Mechanical Results



Mechanical Results



Mechanical Results



Mechanical Results

- Two chain rings -> Two bridges used, Two coefficients
- Bridges 2 and 4 used for torque calculation
- Voltage read at angles below, multiplied by coefficients and added to get torque

$$T = c_2 V_2 + c_4 V_4$$

Angle (°)	22.5	67.5	112.5	157.5	202.5	247.5	292.5	337.5
C_2	-5559	-6533	2027	1215	1295	567.6	656.8	-39803
C_4	711.5	-1302	-11251	-5350	-9459	-2920	-1806	11456

Electrical Team Objectives

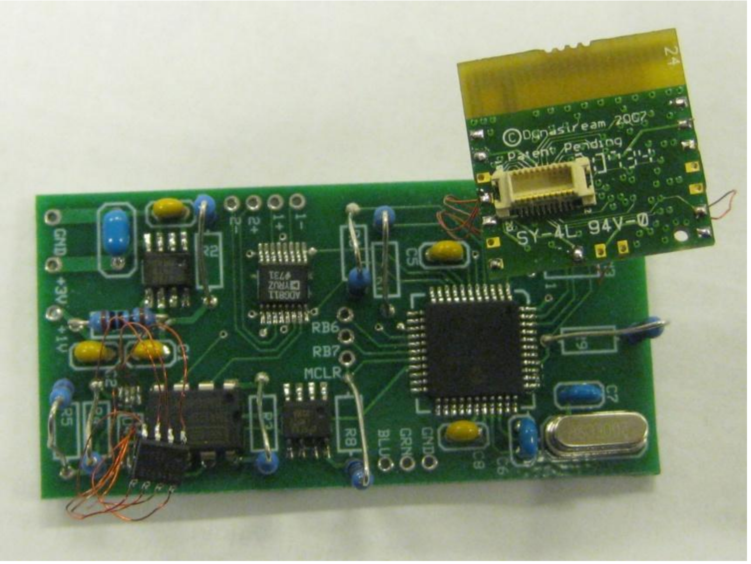
- Improve overall power efficiency of circuit
- Miniaturize and package electronics to conform to working space of crank set
- Prepare schematic diagram for PCB layout
- Debug algorithm calculating applied torque at crank set
- Integrate the angle sensor into the torque calculation

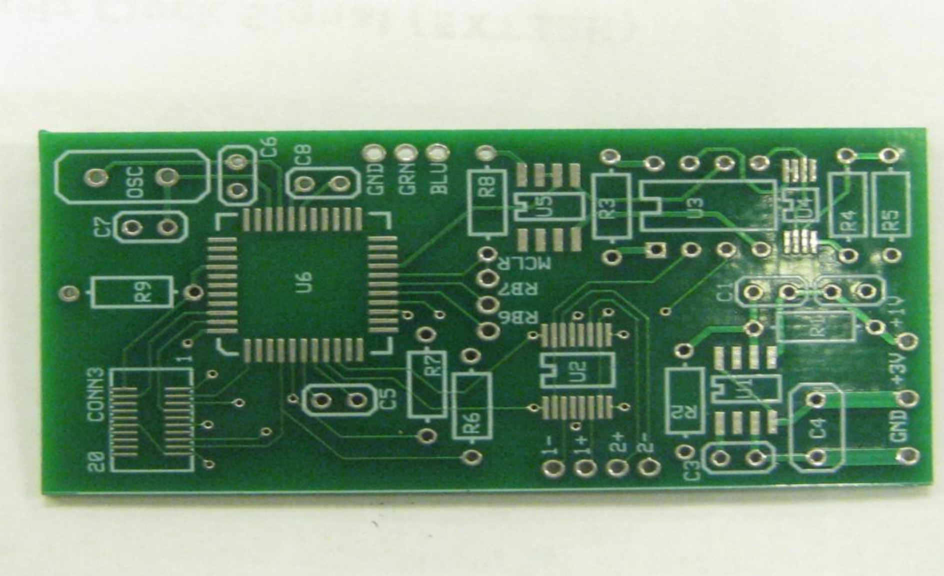
Electrical Team Obstacles

- 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

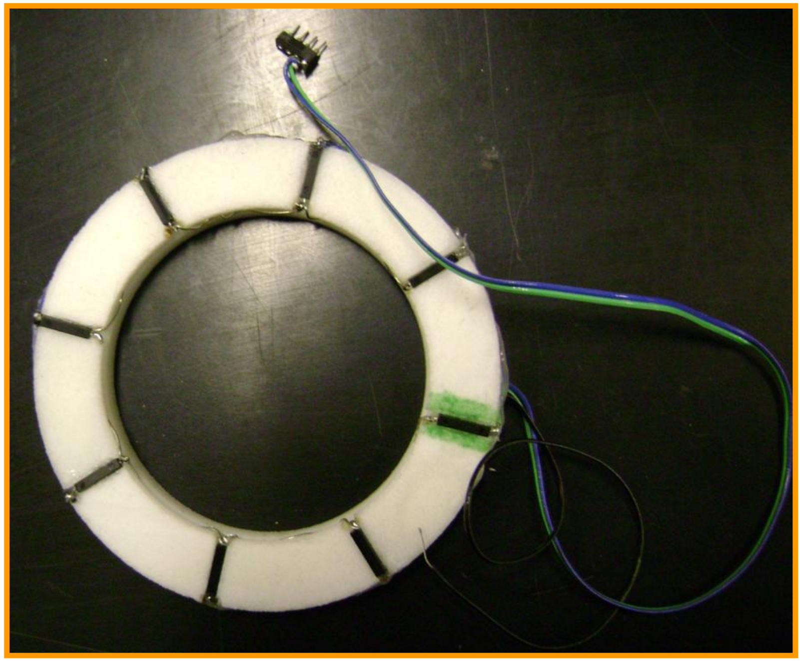
- Power measurement circuit
  - 3V battery and 1V voltage regulator giving constant voltage
  - Miniaturized circuit to meet the size constraints





Electrical Results

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



Conclusion

- Prototype
  - Calculate torque using coefficients
  - Measure at intervals of 45 degrees
  - Wirelessly send info to Garmin
- Future work
  - Package product
  - Finite Element Analysis (FEA)
  - Optimize battery life

Questions?

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