

# **IPRO 324-Power Measurement in Road Bicycles**

*“No Strain, No Gain...”*

**Final Presentation**

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# Team Organization

Project Leader: Henrietta Tsosie

- Mechanical

- Team Leader

- Brandon Marcellis

- Team Members

- Brian Lam
- Henrietta Tsosie
- Ivan Voukadinov
- Rebecca Martin
- Stefan Stevanovic

- Electrical

- Team Leader

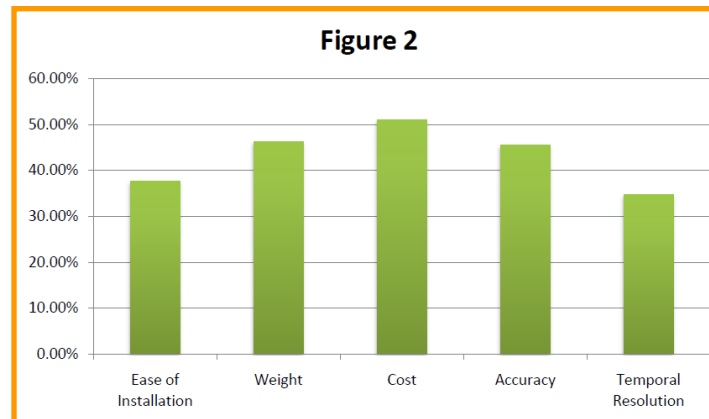
- Bryan Kaminski

- Team Members

- Arkadiusz Ziomek
- Edumaregbemiro Odunaiya
- Stephanus Halim
- Tarun Anupoju

# Why Power Measurement?

- Measures actual input into the bicycle
  - Instant feedback
  - Cyclists can train at different levels
- Survey results taken from 100 members of the cycling community
  - Accuracy
  - Weight
  - Lower price than current product



# 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
- 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



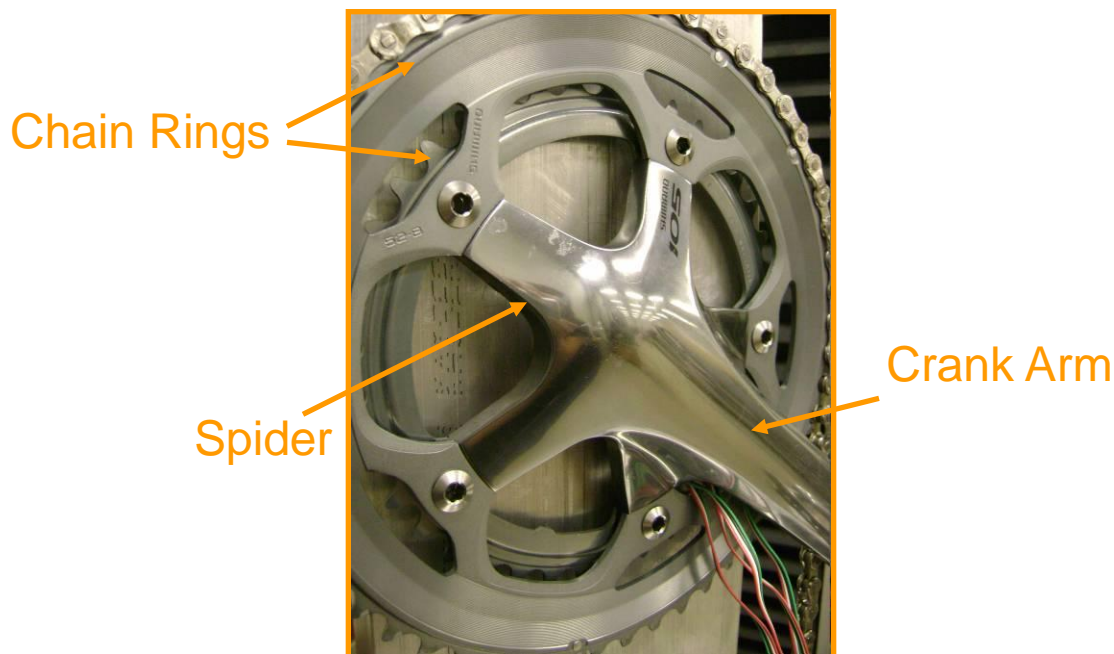
# Background

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



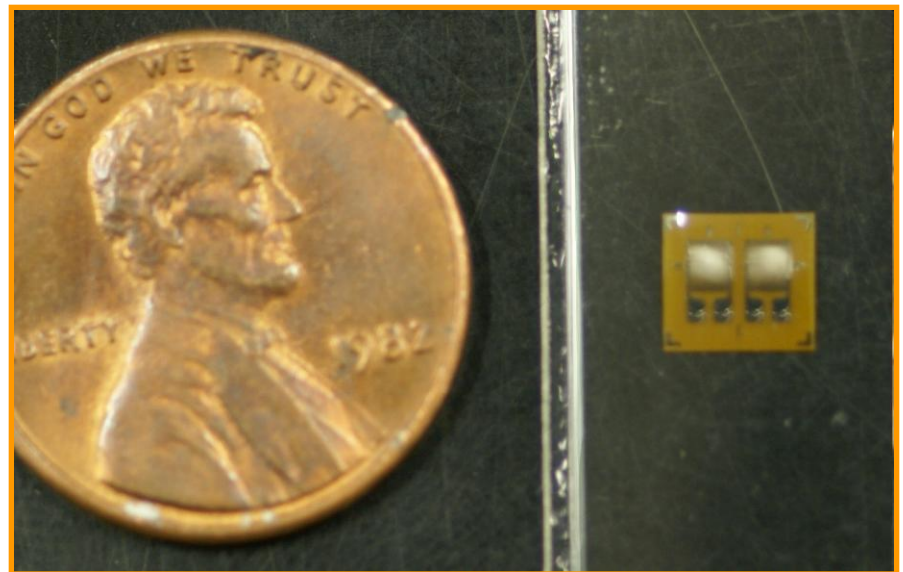
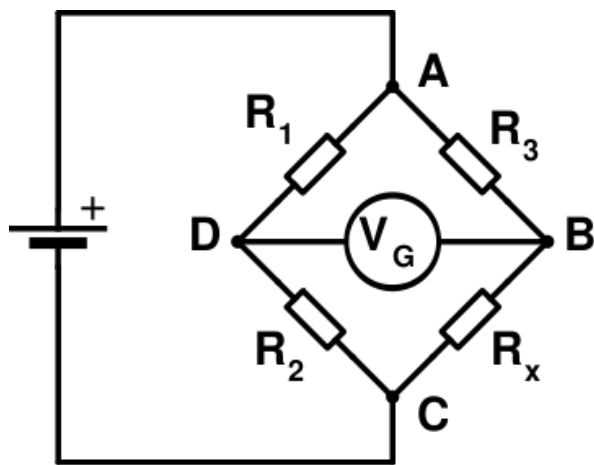
# Crankset Power Measurement Setup

- 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 gages are used to find strain by finding change in resistance through voltage drop across Wheatstone bridge



# Mechanical Team Objectives

- Define strain gage position on crankset
- Apply strain gages on the crankset
- Design an experiment to measure the output of the strain gages under different load conditions
  - Crank angle
  - Point of force application
    - Left pedal
    - Right pedal
  - Outer chain ring vs. inner chain ring
- Analyze data and implement an algorithm to calculate torque



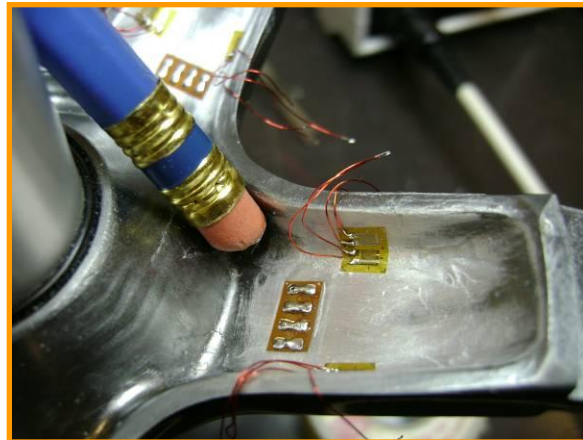
# Mechanical Setup

- 4 bridges used
  - one for each spider arm plus bridge for the two spider arms by crank
- Use Vishay 6200 scanner to measure strain
- Use Instron 5500 to apply load



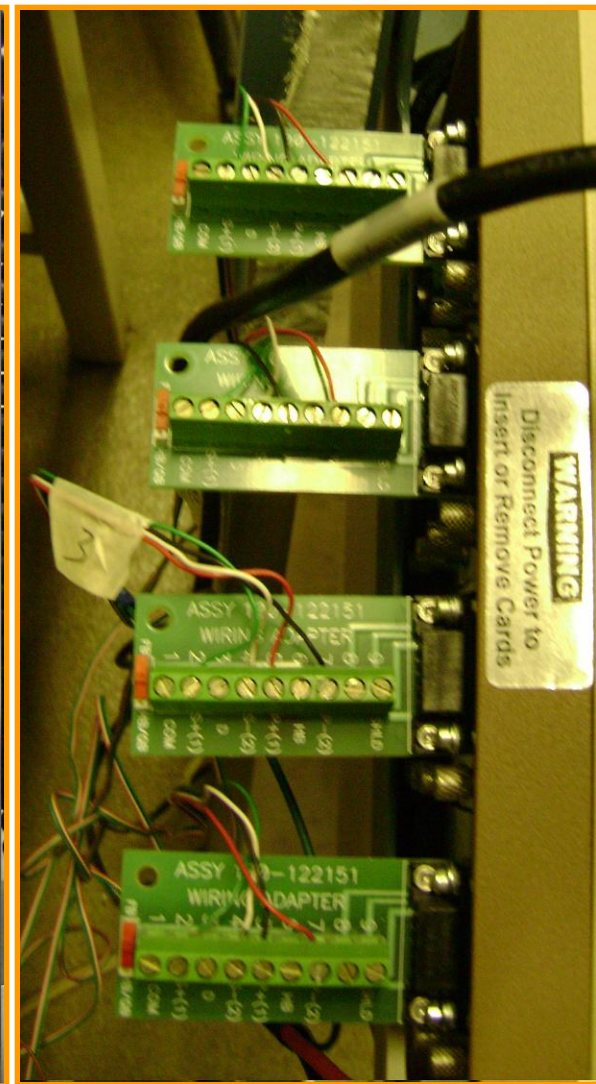
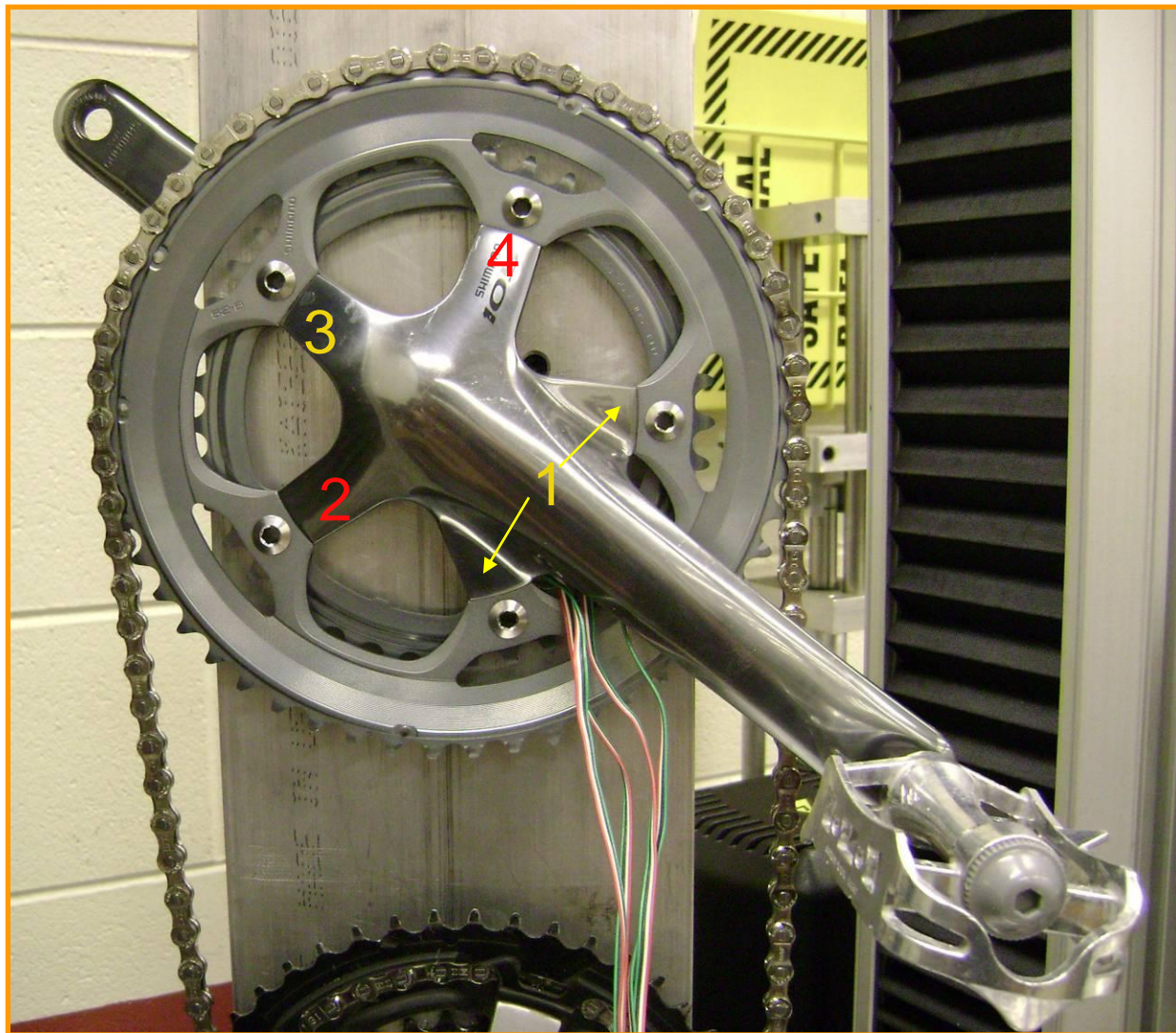
# Mechanical Obstacles

- Chosen strain gage position made gluing and soldering difficult and time consuming
- Communication between the scanner used to take strain measurements and the computer
- Compatibility issues between new crank set and existing test apparatus
- Predicting the effect of inner and outer chain rings on torque measurement



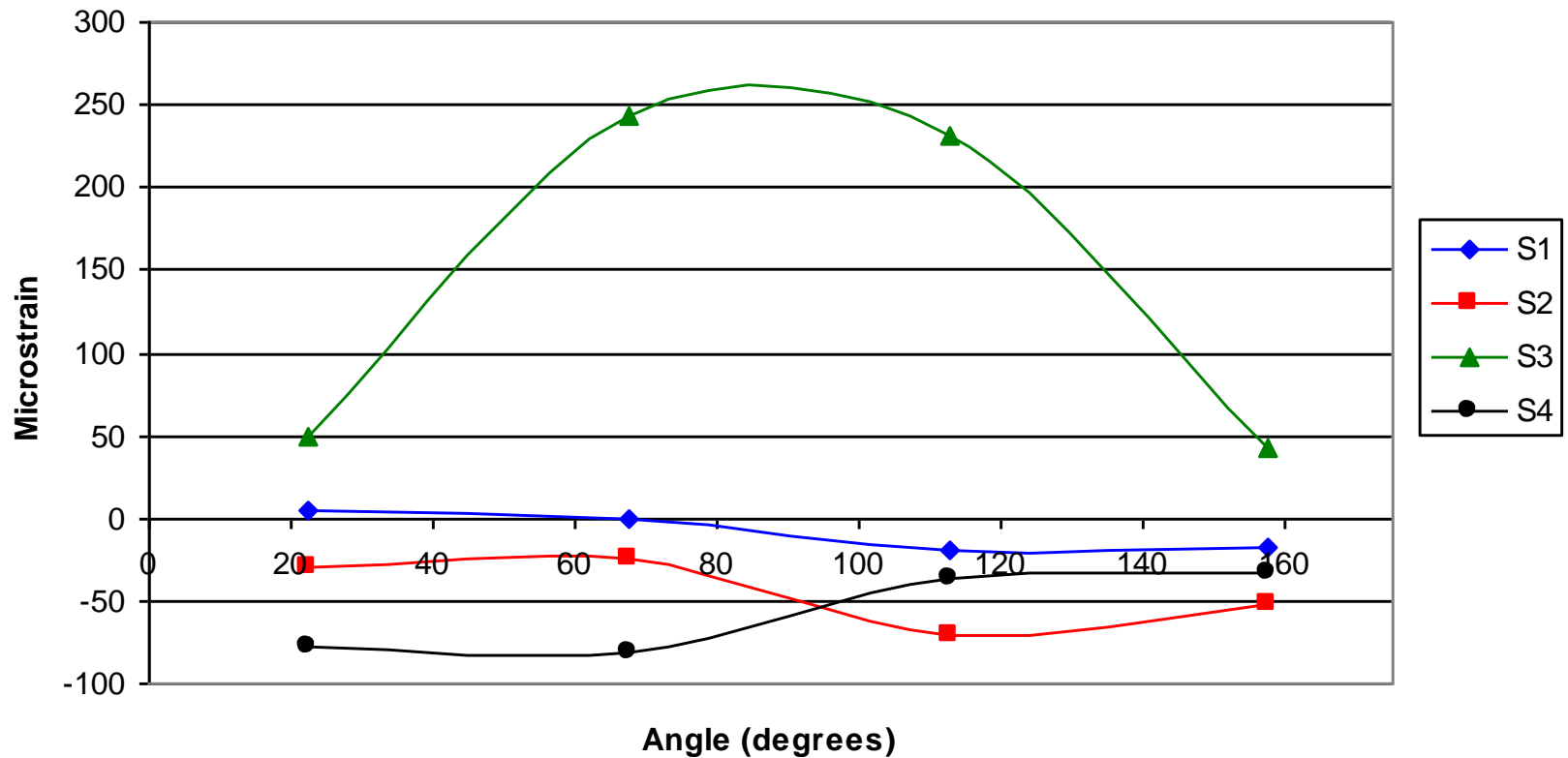


# Mechanical Results



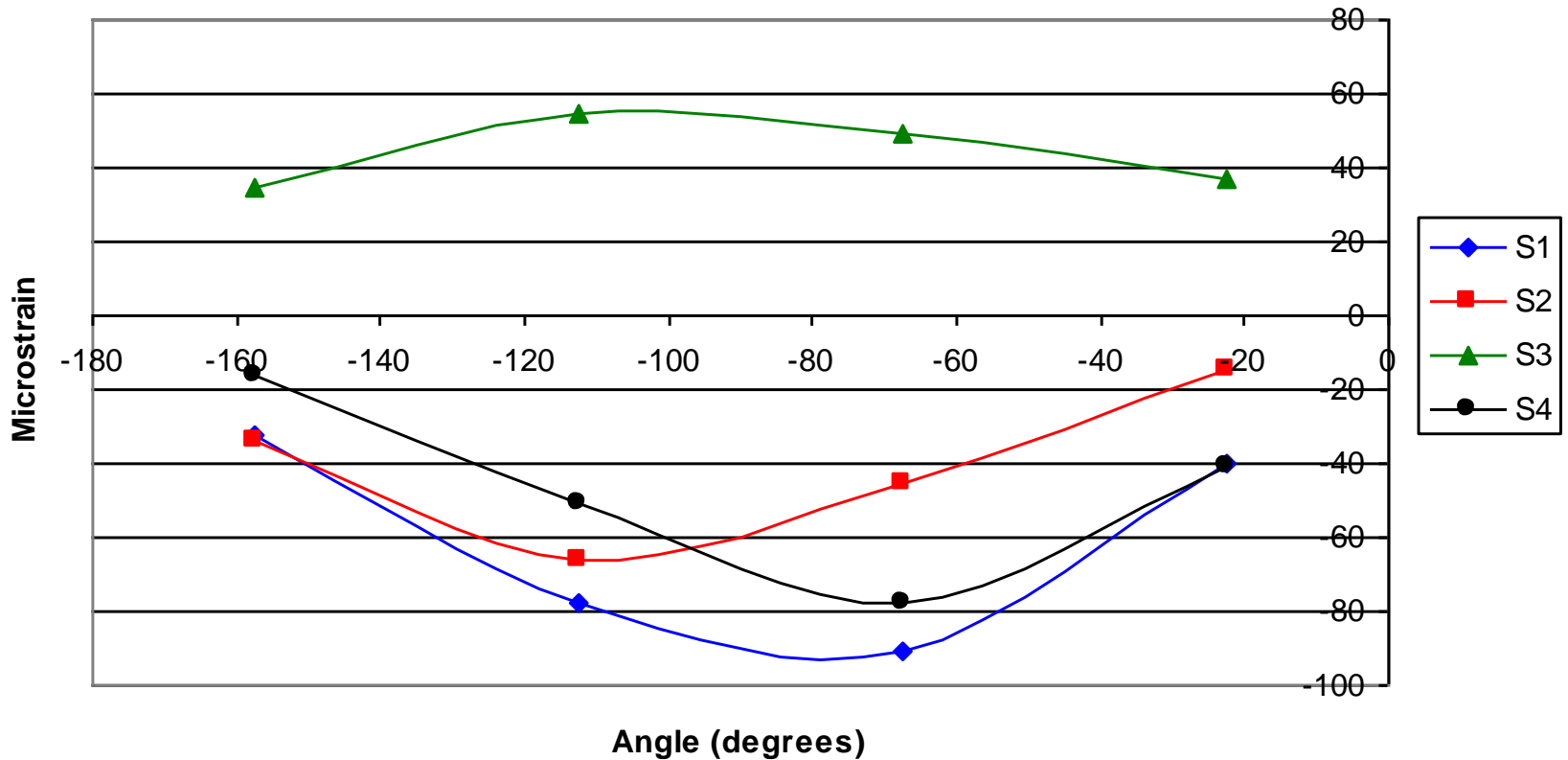
# Mechanical Results

Strain v. Angle  
(Inner Chain Ring; Right Crank Arm)



# Mechanical Results

Strain v. Angle  
(Outer Chain Ring; Left Crank Arm)





# 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

$$T = C_2 \cdot V_2 + C_4 \cdot V_4$$

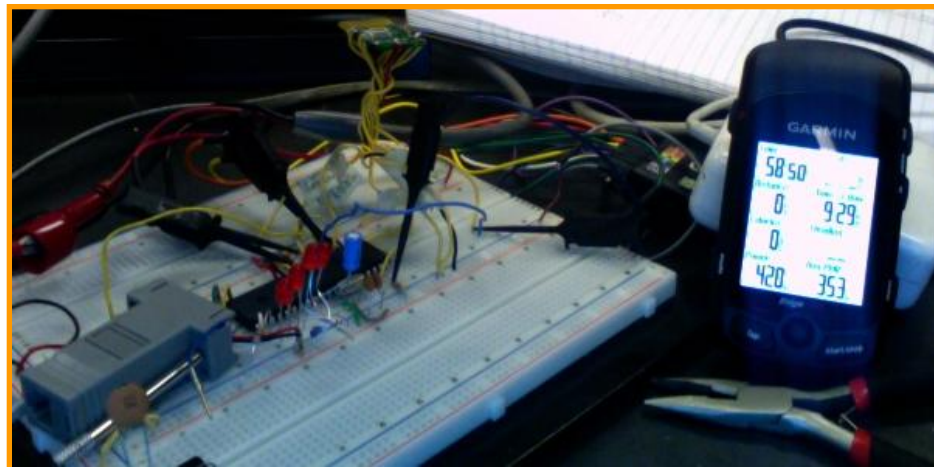
<b>Angle (°)</b>	22.5	67.5	112.5	157.5	202.5	247.5	292.5	337.5
<b>C<sub>2</sub></b>	-5559	-6533	2027	1215	1295	567.6	656.8	-39803
<b>C<sub>4</sub></b>	711.5	-1302	-11251	-5350	-9459	-2920	-1806	11456

# Electrical Objectives

- Develop a circuit to:
  - Trigger measurement at specific angles using Reed switches
  - Amplify the voltage to a value that can be used in the calculations of the force
  - Minimize noise
  - Convert the analog signal to digital for use in calculation
  - Develop code to transmit power output to the Garmin bike computer using the wireless ANT+ protocol

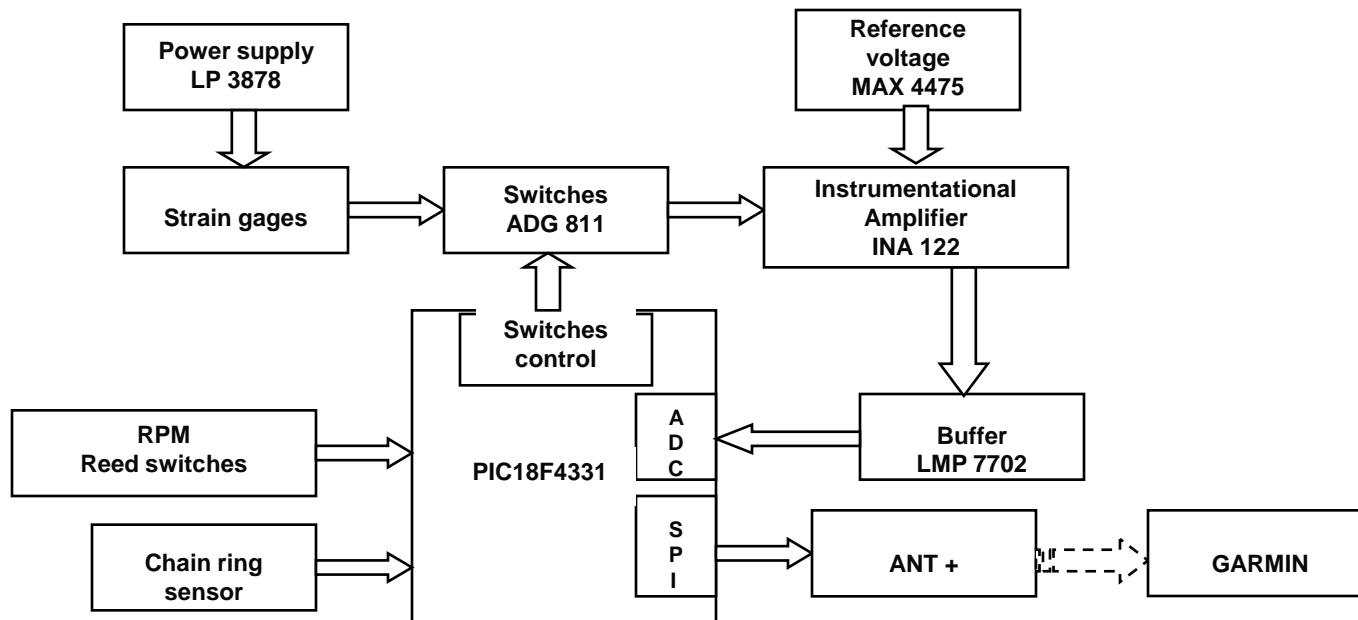
# Electrical Obstacles

- Full bridge setup
  - Balancing the bridge
  - Saturation of amplifier
- Erratic operation of microcontroller
- SPI (data output) unit for synchronous transmission to ANT+



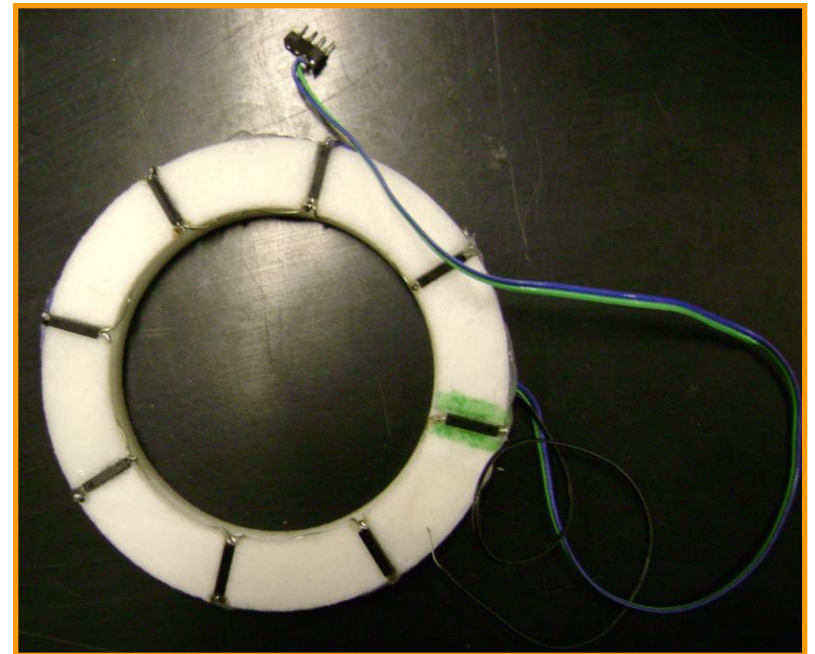
# Electrical Results

- Power circuit supply
  - 3V battery and 1V voltage regulator giving constant voltage
  - Two switches used for each bridge



# Electrical Results

- Wireless Transfer of data
  - Rectification of temporal resolution glitch
  - Accurate data transfer to Garmin
- RPM Circuit
  - Reed switches used  $45^\circ$  apart
  - Passed over magnets
  - Gives RPM and Angle





# Conclusion

- Successful working 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?

