## OBSTACLES

**Mechanical**

- Best configuration of strain gauges
- Experimental Setup encountered problems with pedal interference
- Analysis of data
- Finding an algorithm that all strain gauges would follow

**Electrical**

- Debate between implementing full-bridge vs. switching circuit
- Current switching circuit not suitable for accurate reading
- ANT+ Protocol documentation ambiguous/confusing

## OBSTACLE SOLUTION

**Mechanical**

- Apply strain gauges closest to chain
- Adjust apparatus to be able to sit in tension machine without interference
- Re-do data and use careful procedure in lab
- Calculated coefficients of each strain gauge

**Electrical**

- Decided on switching circuit to allow for software calibrations rather than relying on physical placement of gauges
- Met with IPRO EE to discuss impact of switching circuit on accuracy
- Plan to improve switching circuit accuracy
- Contacted ANT+ developers for support on how to implement

## CONCLUSION

- Electrical Improvements
- Need to measure the angle during torque reading
- First data sets need to be re-measured for certain angles

## FUTURE PLANS

- RPM measurement
- More strain gauge measurements
- Reverse engineer Quarq spider/casing
- Optimize battery life/cost of end product
- Modify circuit to perform better
- Improve ANT+ communication routines
- Connect circuit to Garmin bike computer
- Minimize size to fit on bicycle
- Final Product Design
- Create EnPro to promote product

## SPECIAL THANKS TO

- ANT+
- Garmin
- Instron
- Quarq
- Software Technologies Group
- Strain

# IPRO 324

## Power Measurements for Road Bikes


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## PROBLEM

- Cyclists have great interest in measuring their mechanical power output on the bicycle
- Practice/Performance optimization
- Existing available solutions
- Expensive/Can not be retrofit
- Strain gauges are an inexpensive practical solution
- Require advance signal processing
- Signal needs to be transmitted wirelessly to a bicycle computer



## BACKGROUND

- 4 ways in which current systems measure the power output of a rider:
  - Crankset (strain in crankset)
  - Free hub (strain in rear wheel)
  - Chain (vibration & speed of chain)
  - Opposing force systems (e.g. gravity, drag, acceleration, wind velocity)
- The first two systems use strain gages to measure the stretch in the material (strain), which can be related to torque from which power can be calculated.
- Systems differ in
  - Cost
  - Accuracy
  - Weight penalty
  - Ease of installation
  - Software package

## OBJECTIVE

- Develop a configuration of strain gauges
- Accurately measure the output of the strain gauges under various load conditions
  - Crank angle
  - Direction of applied force
  - Point of force application
    - Left pedal
    - Right pedal
    - Both left and right pedal
- Develop an electronic processing unit for post-processing the strain gauge signals
  - Implement an algorithm to calculate the applied torque at the bicycle crank set
  - Transmit the data wirelessly to the Garmin Edge 705 using the ANT+ protocol
  - Must be power efficient
- Package the system
  - Must work under realistic conditions
  - Needs to conform to the space requirements associated with a bicycle

## RESULTS

**Mechanical**

- Applied strain gauges
- Recorded data for several angles as well as loads
- Analyzed data

**Electrical**

- Researched established procedures for reading strain gauges
- Developed low cost switching circuit to obtain individual strain gauge values
- Successfully communicate data from circuit to PC via ANT