



**IPRO 324 – Power
Measurement for Road
Bicycles**

December 5, 2008

Presentation Outline

- Problem Addressed/Background
- Project Goals/Plan
- Team Structure
- Mechanical Team Accomplishments
- Electrical Team Accomplishments
- Overview/Expected Future Work
- Questions

Problem Addressed

- Cyclists wish to measure power output on their bicycle
 - Practice/Performance Optimization
 - Previously calculated with heart rate monitors
- Existing available solutions are expensive/invasive
 - Must replace whole sections of bicycle crankset
- Strain gauges are an inexpensive, less invasive, practical solution
 - Generates a signal that must be wirelessly transmitted
 - Requires development of circuitry/advanced signal processing

Background

- Existing Products
 - SRM, Power Tap, Polar, Quarq CinQo



- Bicycle Computer
 - Garmin Edge 705



- Wireless Transmission Protocol
 - ANT+



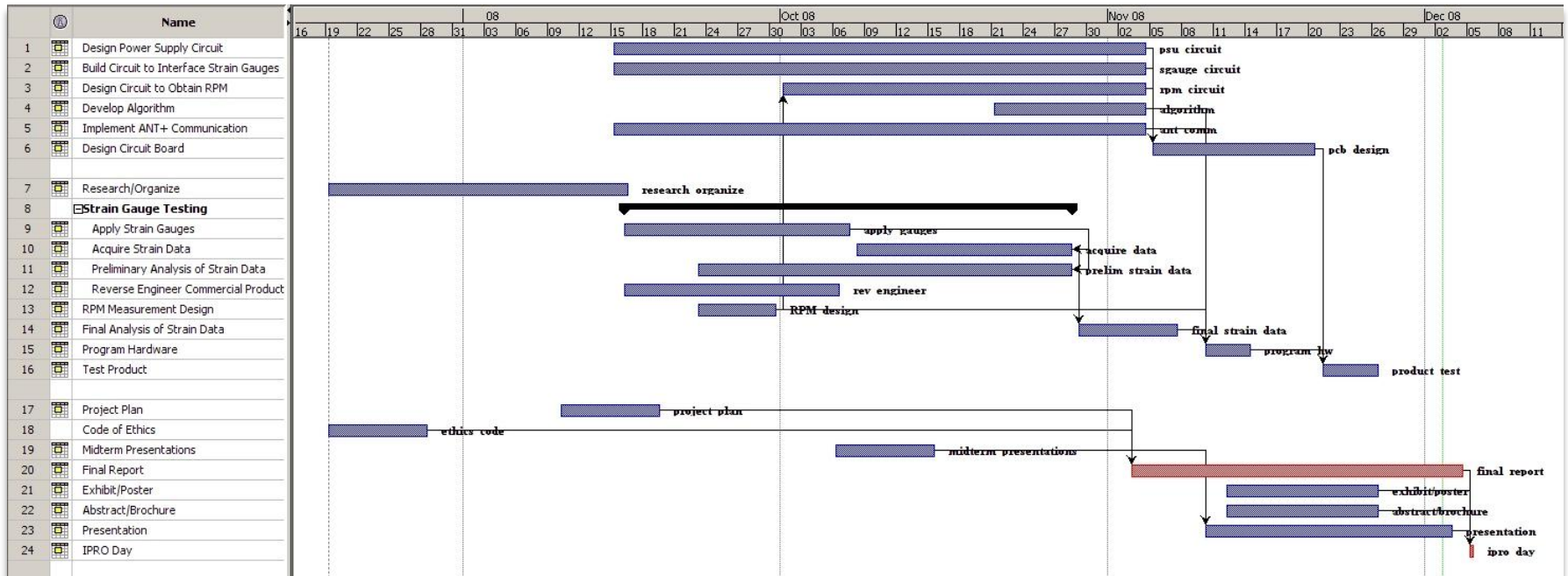
- Strain Gauges



Project Goals

- Determine optimal configuration of strain gauges
- Allow to be applied to any crank
- Use software to calibrate to specific crank
- Process strain gauge signals accurately
- Reduce cost

Project Plan



Team Structure

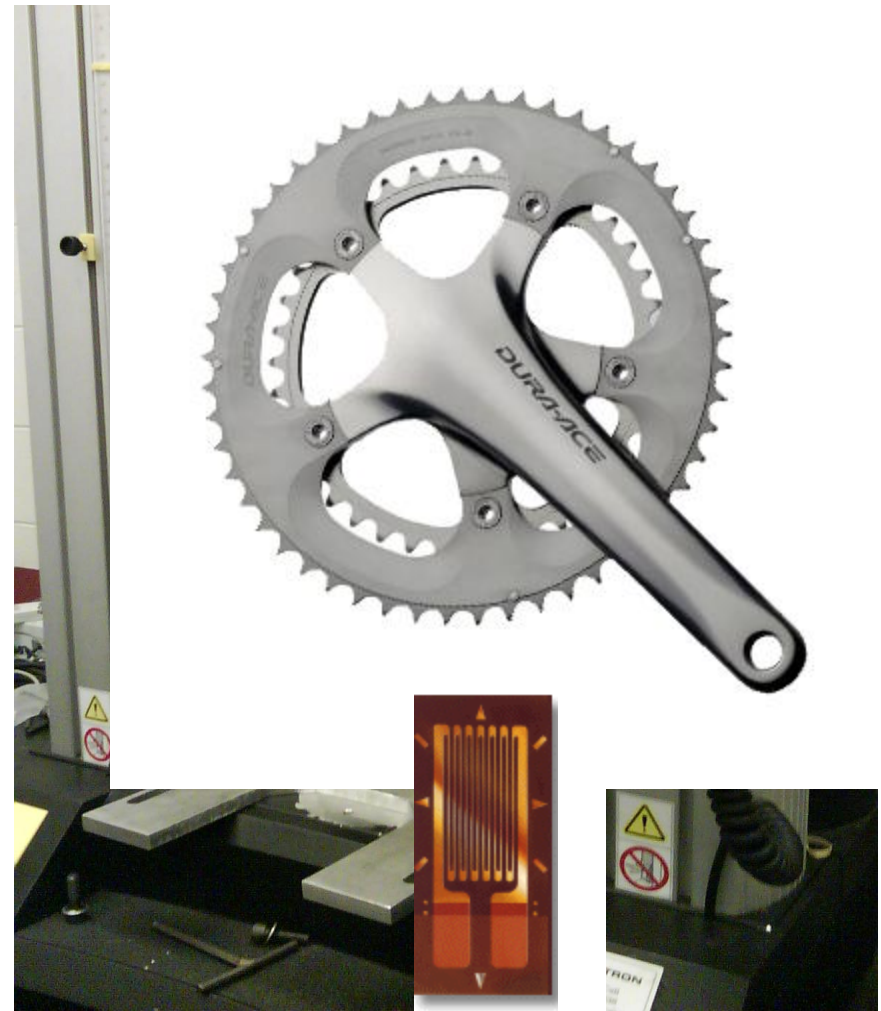
- Separated into 2 sub-teams
 - Mechanical Team
 - Applying Gauges
 - Recording Data
 - Interpreting/Analyzing Data
 - Electrical Team
 - Research
 - Developing Circuit
 - Programming Software

Mechanical Team Progress

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

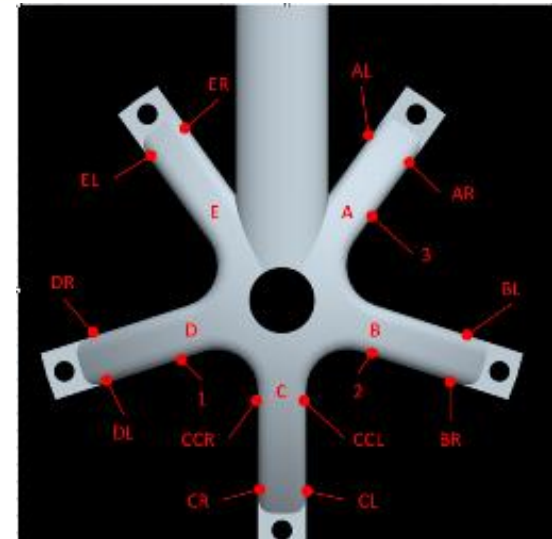
Mechanical Team Obstacles

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



Mechanical Team Solutions

- 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



Right Arm -65 Degrees

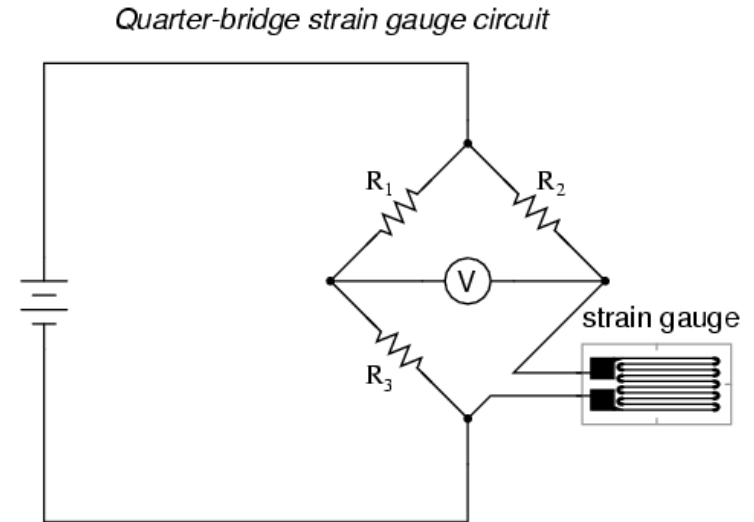
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$$\begin{aligned} \text{Power} &= T\omega = \sum_{i=1}^n C_i S_i \omega \\ &= [\text{Torque}][\text{Angular Velocity}] \end{aligned}$$

Force (lbf)

Electrical Team Progress

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

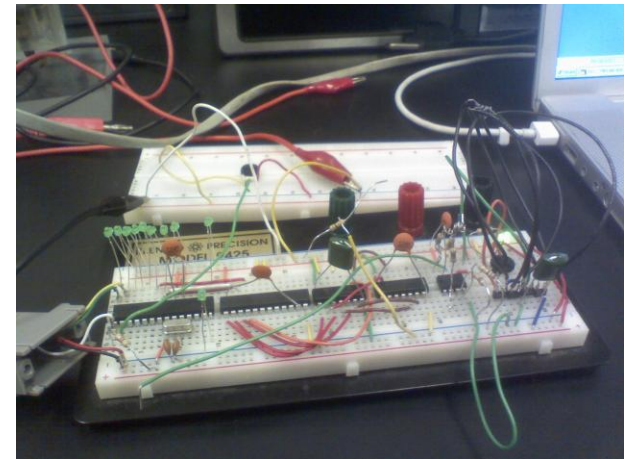


Electrical Team Obstacles

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

Electrical Team Solutions

- Decided to use switching circuit
 - Software calibration
- 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



Overview of Accomplishments

- Mechanical Team
 - Applied strain gauges in best determined configuration
 - Analyzed data and calculated coefficients
- Electrical Team
 - Successfully used ANT+ protocol to communicate strain gauge data
 - Constructed strain gauge processing circuit

Future Work

- Modify circuit to perform better
- Improve ANT+ communication routines
- Connect circuit to Garmin bike computer
- Refine algorithm
- Minimize size to fit on bicycle
- Finalize Product Design
- Create EnPro to promote product

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