IPRO It takes a team!
INTERPROFESSIONAL PROJECTS PROGRAM

ILLINOIS INSTITUTE OF TECHNOLOGY

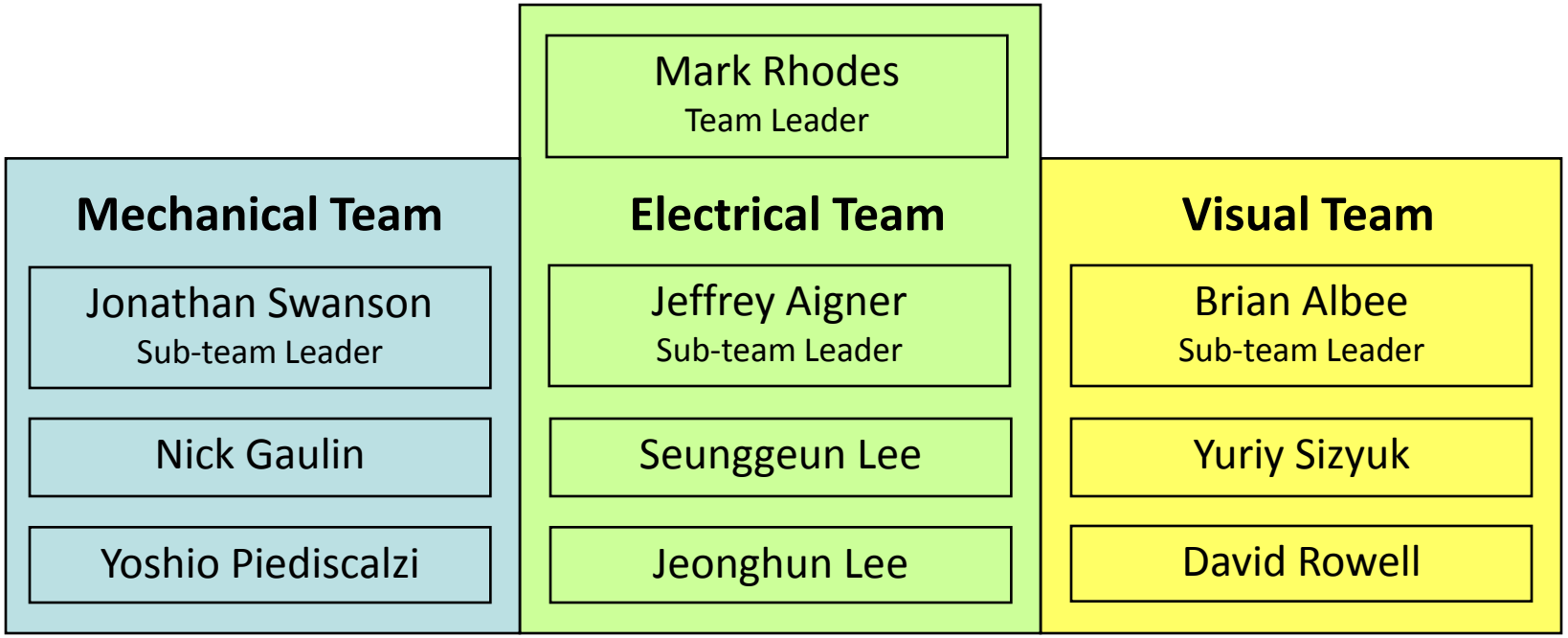
IPRO 324: Power Measurement in Performance Bicycles

"No Strain, No Gain"

Final Presentation

Friday, April 23, 2010

Team Organization



Purpose

- Uses applied torque to measure power input to bicycle
  - Instant or summary feedback
  - Variety of training applications
- More direct measurement than heart monitor

Definition of Power

- Power is energy per unit time
- Computed using torque and RPM

$$\text{Power} = \text{Force} \bullet \text{Speed}$$

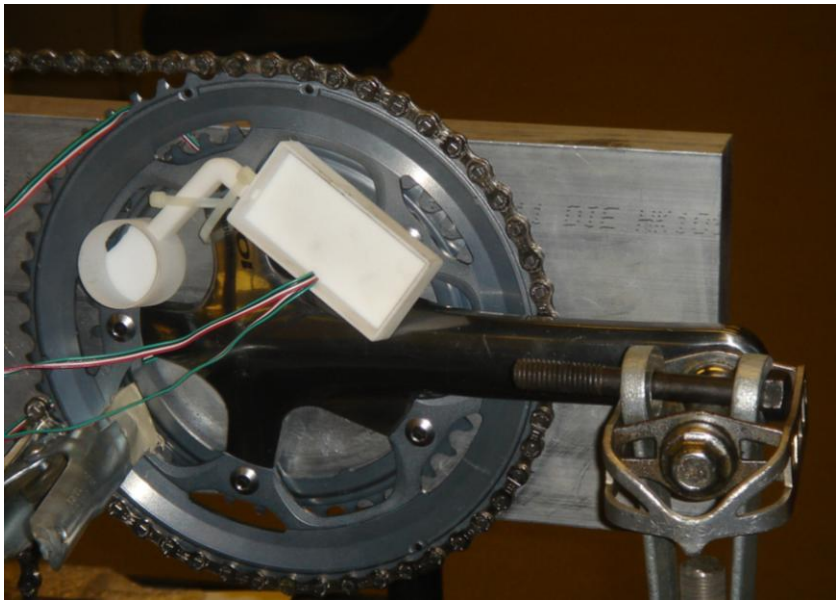
Force (lb)	Angle (°)	Torque (ft-lb)	RPM	Power (W)
65	35	21.1	60	179.77
90	125	41.72	60	355.48
120	70	63.82	45	407.8

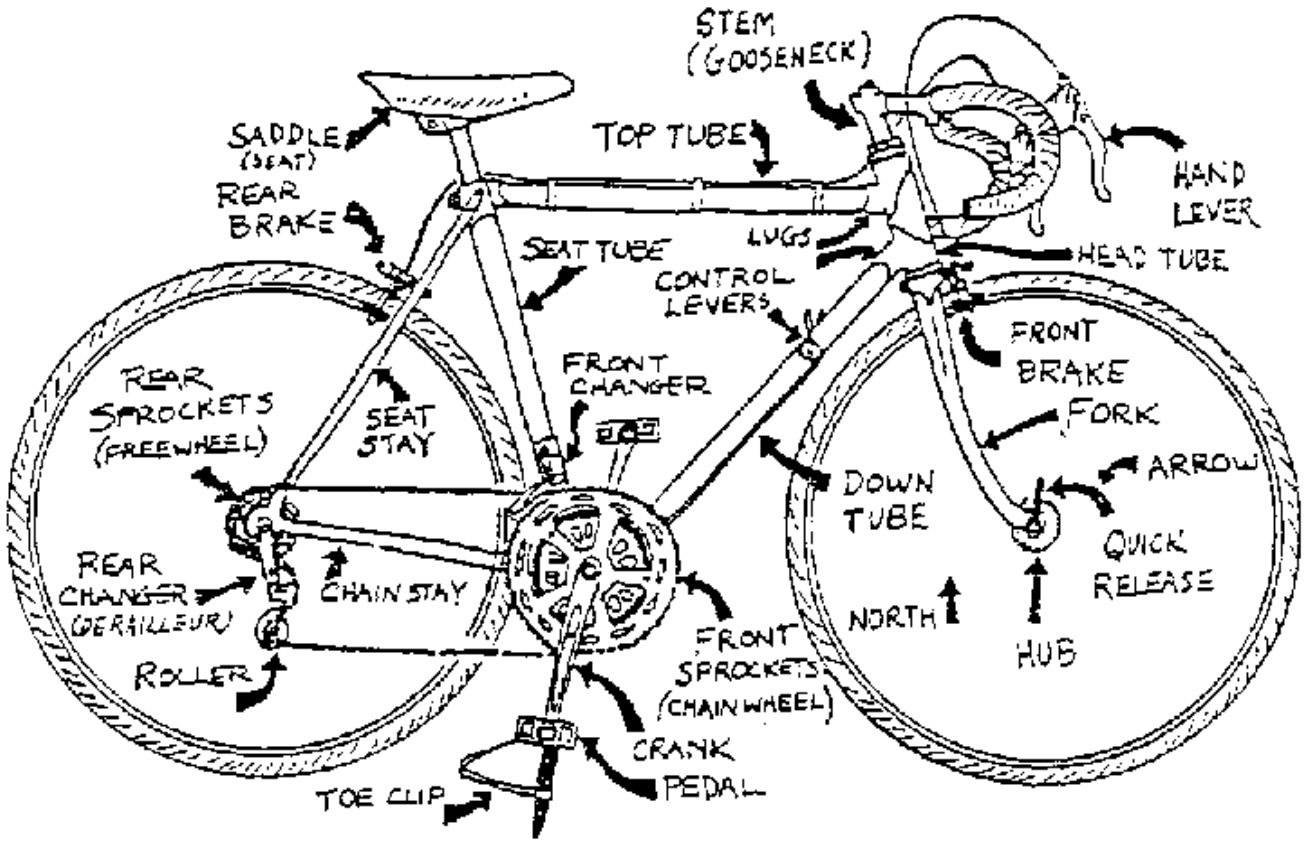
Background

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

Visual Team

- Good application of skill sets
- Assist in essential areas of project management
  - Finding and ordering parts
  - Documentation and deliverables
- Design of product housing

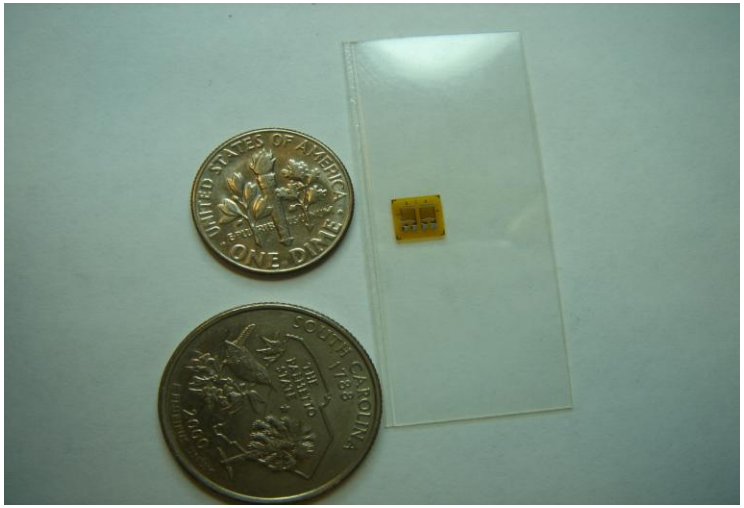



STEM (GOOSENECK)
SADDLE (SEAT)
TOP TUBE
HAND LEVER
REAR BRAKE
SEAT TUBE
LUGS
HEAD TUBE
CONTROL LEVERS
FRONT BRAKE
REAR SPROCKETS (FREEWHEEL)
SEAT STAY
FRONT CHANGER
FORK
ARROW
DOWN TUBE
QUICK RELEASE
REAR CHANGER (DERAILLEUR)
CHAIN STAY
NORTH
HUB
ROLLER
FRONT SPROCKETS (CHAIN WHEEL)
CRANK
PEDAL
TOE CLIP

Mechanics

Strain Gauges

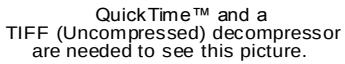
- Resistance hanges with applied load
- 4 gauges per bridge
- 4 bridges per crank set
- Bridge maintains resistance with change in temperature



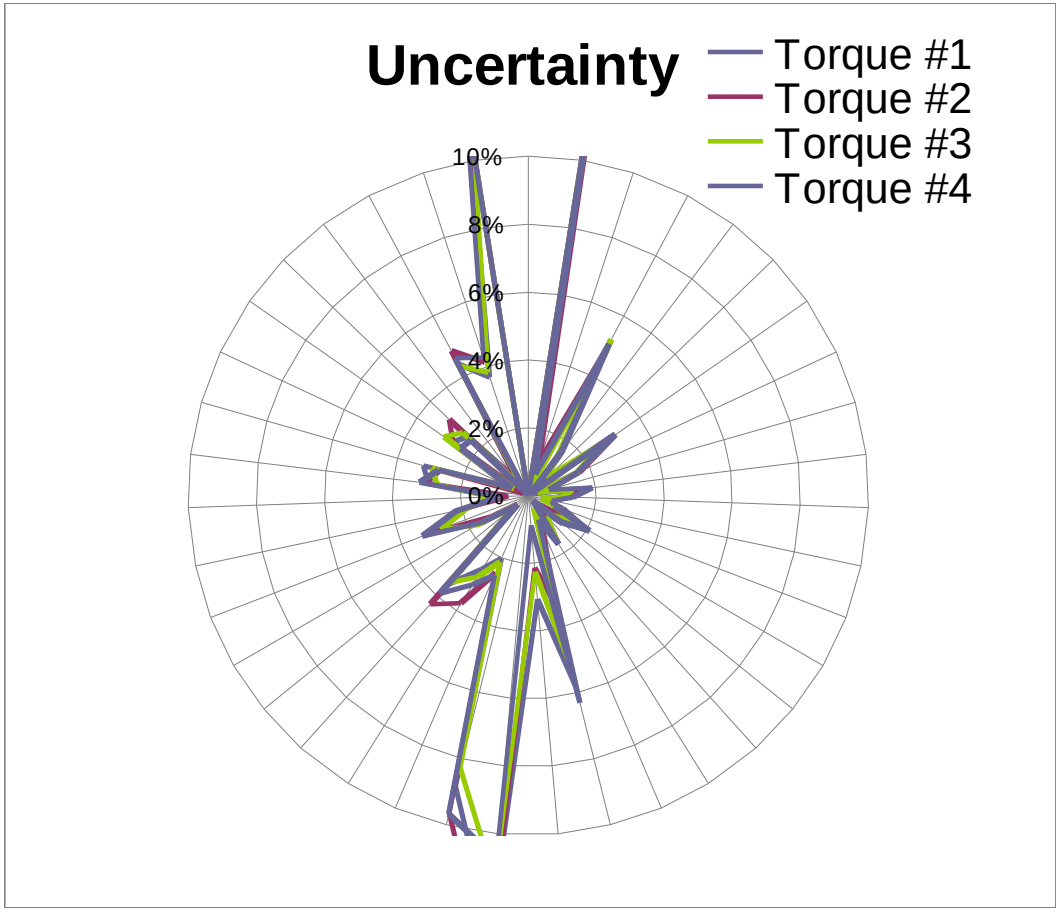
Static Testing

- Aluminum crank set
- Carbon fiber crank set
- Electronics compatible data

Static Testing Data



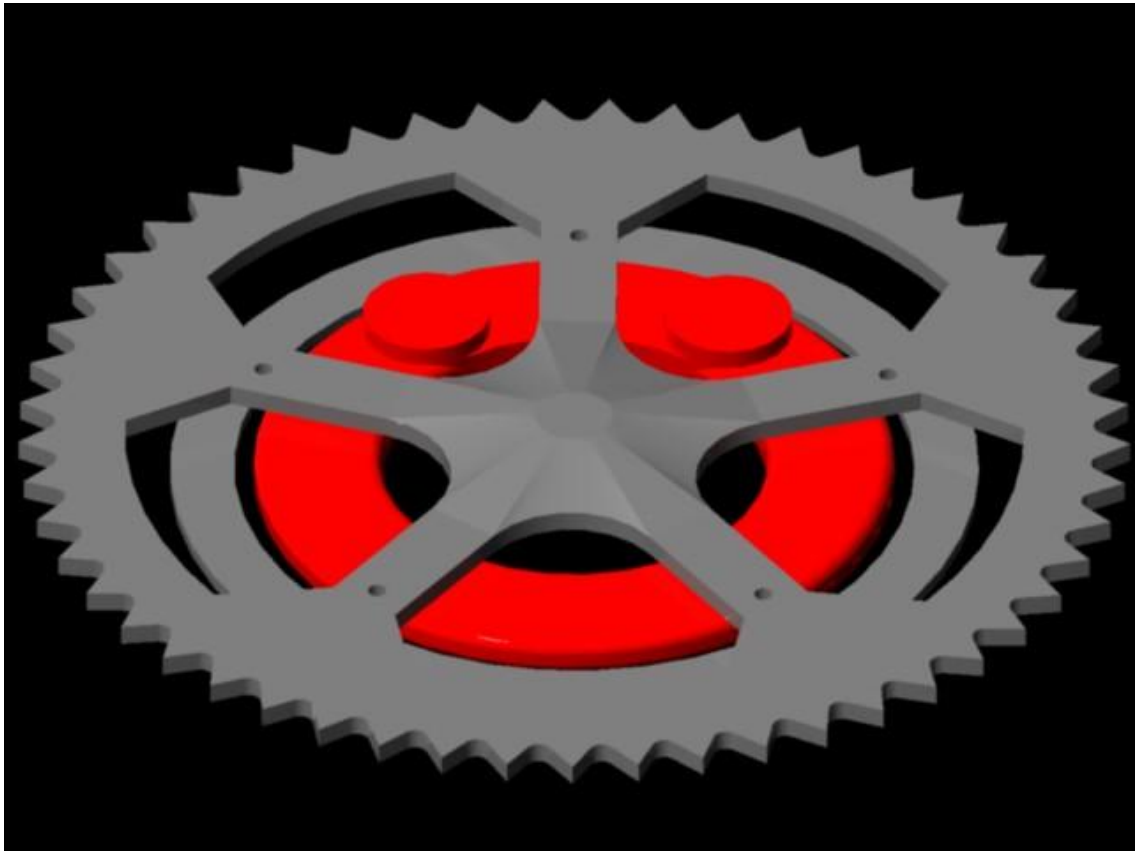
Mathematical Uncertainty



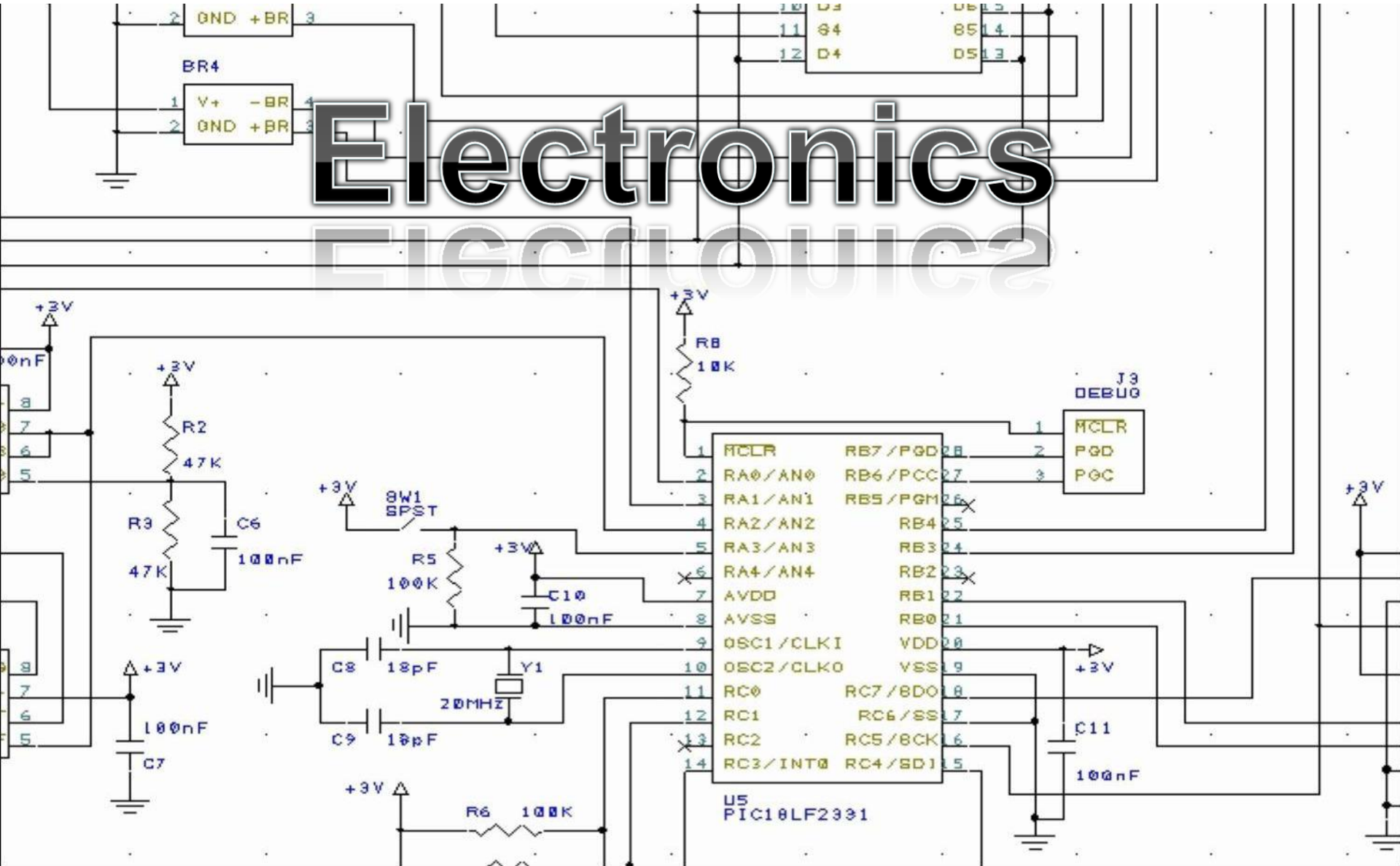
- $T_C = C_1 \varepsilon + C_2$
- $U = (T_C - T_A)/T_A$

Marketable Product

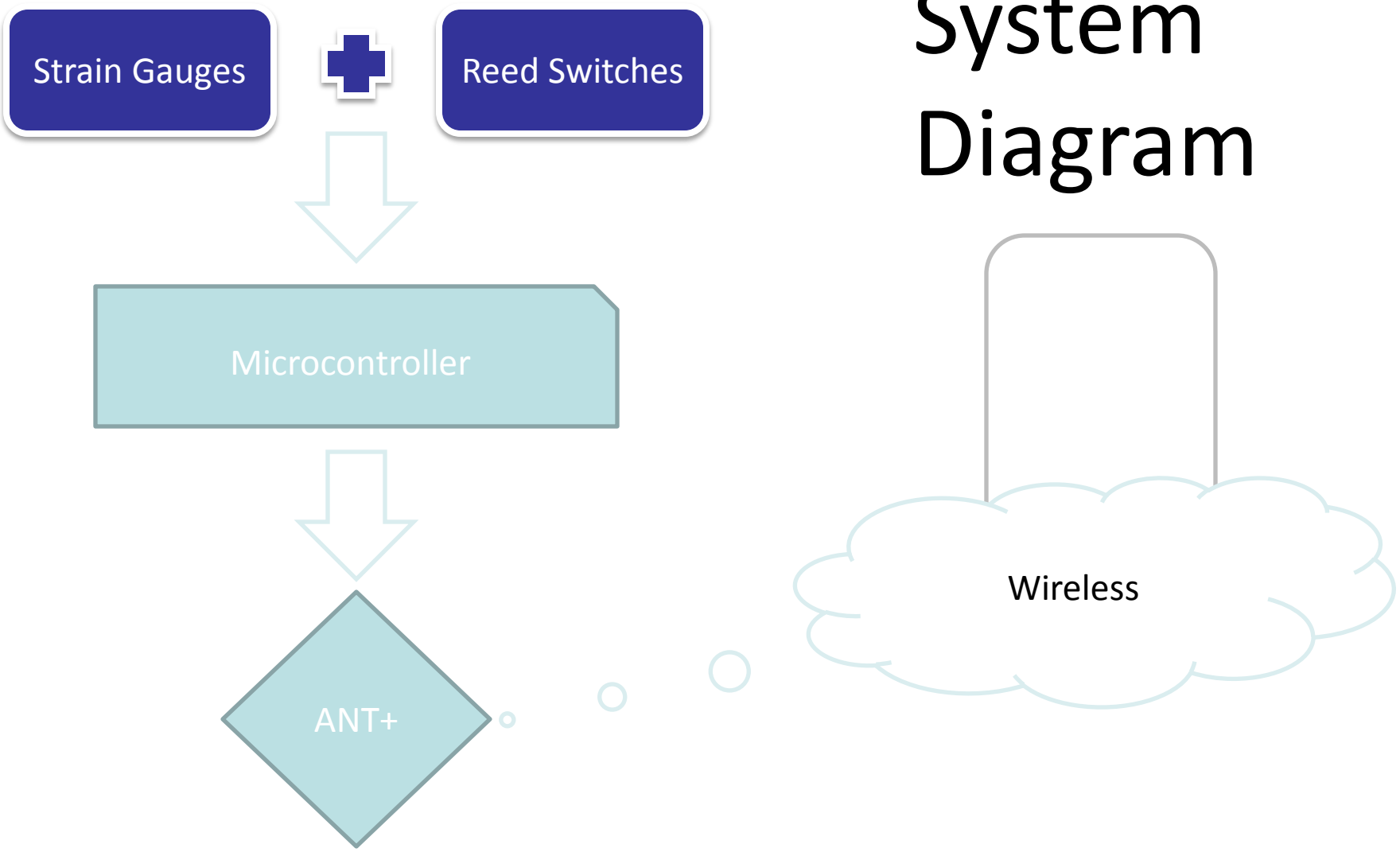
- Aesthetically Pleasing
- Functional



Electronics

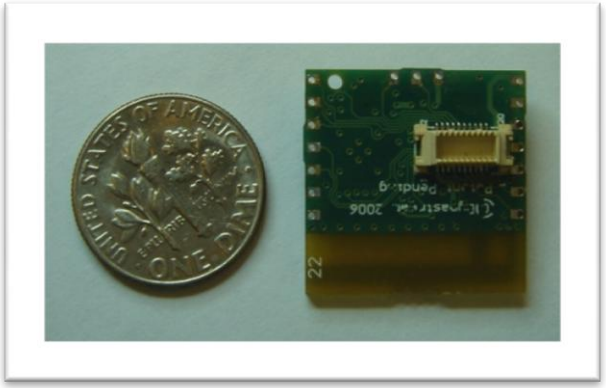


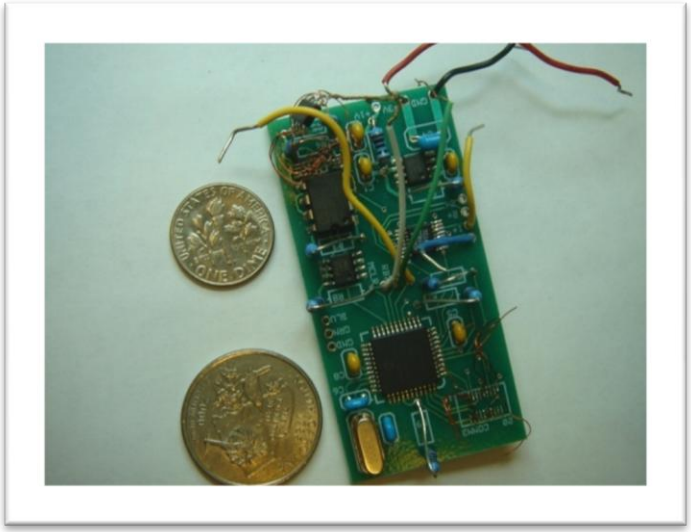
System Diagram



Electronics Background

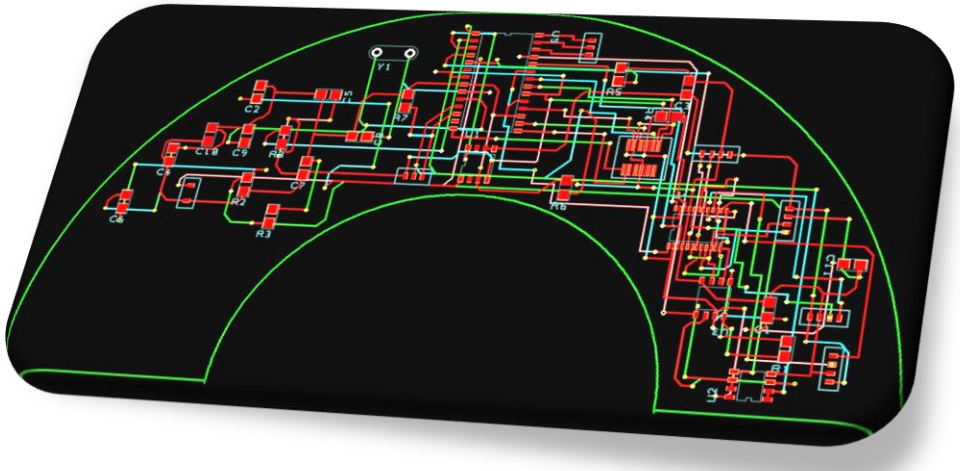
- Started with a rough prototype
- Main Components
  - PIC Microcontroller
  - ANT+ Wireless
  - Strain Gauges
  - Reed Switches



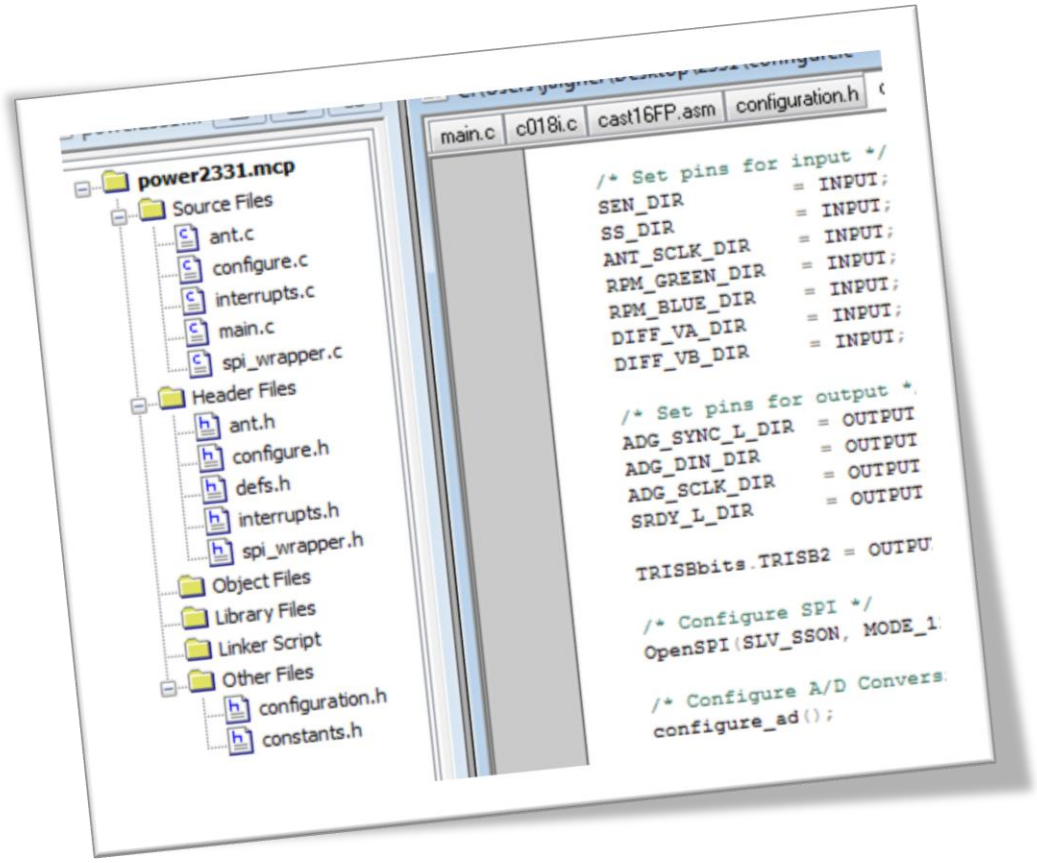


New Circuit Board

- Motivated by deficiencies and consumer market concerns
- Fine-tuned component selection
- Lower power consumption
- Universal Form Factor

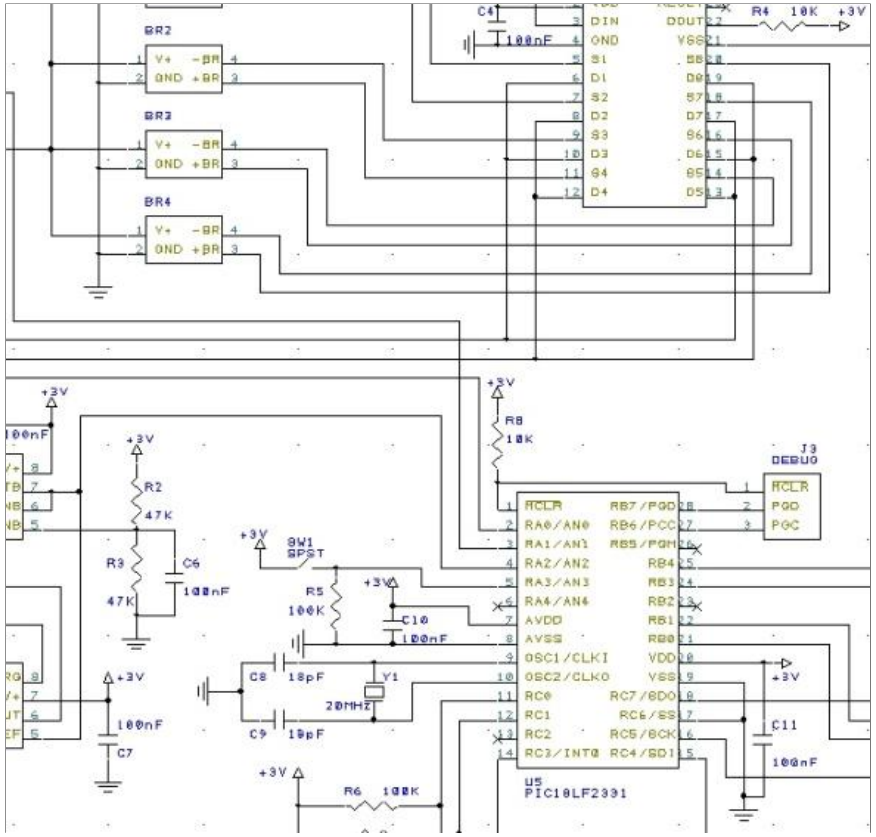


Microcontroller



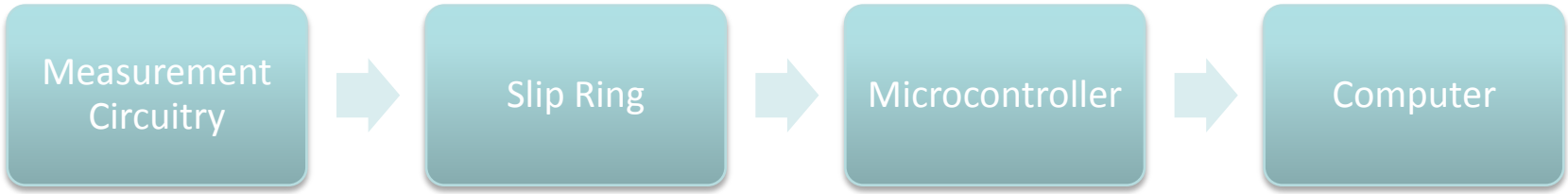
- New microcontroller
  - PIC18LF2331
- Code Rewrite
  - Accuracy
  - Efficiency
  - Structure/Comments
  - Maintainability
  - Extendibility
  - Customization

Other Circuit Improvements



- Correction of reed switch operation
- Additional strain gauges / supporting circuitry
- Voltage regulation for digital conversion
- Removed unnecessary chips
- Noise reduction

Test Module



- Motivation: ANT+ not fully functional
- Measurement circuitry mounted on crank set
- Slip ring used to connect circuits
- Remaining circuitry on breadboard
- Provides real-time data measurement

Obstacles

- Resources for electrical team
- Time for PCB layout design and manufacture
- Having test circuit for mechanical team

Obstacles Overcome

- Designed setup with slip ring and standard PCB
- Read data straight from microcontroller
- Trained a layout expert

Major Accomplishments

- Took prototype circuit from Rev. 1 to Rev. 4
- Designed universal housing
- Two new power calculation methods
- Collected data for carbon-fiber crankset
- Read dynamic output data from bicycle

Major Accomplishments

- Designed RPM sensor using reed switches
- Redesigned and optimized microcontroller code
- CAD model of finished product
- Physical testing module
- Documentation

Future Work

- Calibration
- Road test
- Comparison with competition
- Power consumption minimization
- Find sources of error
- Cost cutting

Conclusion

- Documentation is important
- Designing a product is a team effort
- Good communication prevents problems

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