Rowing Tracker

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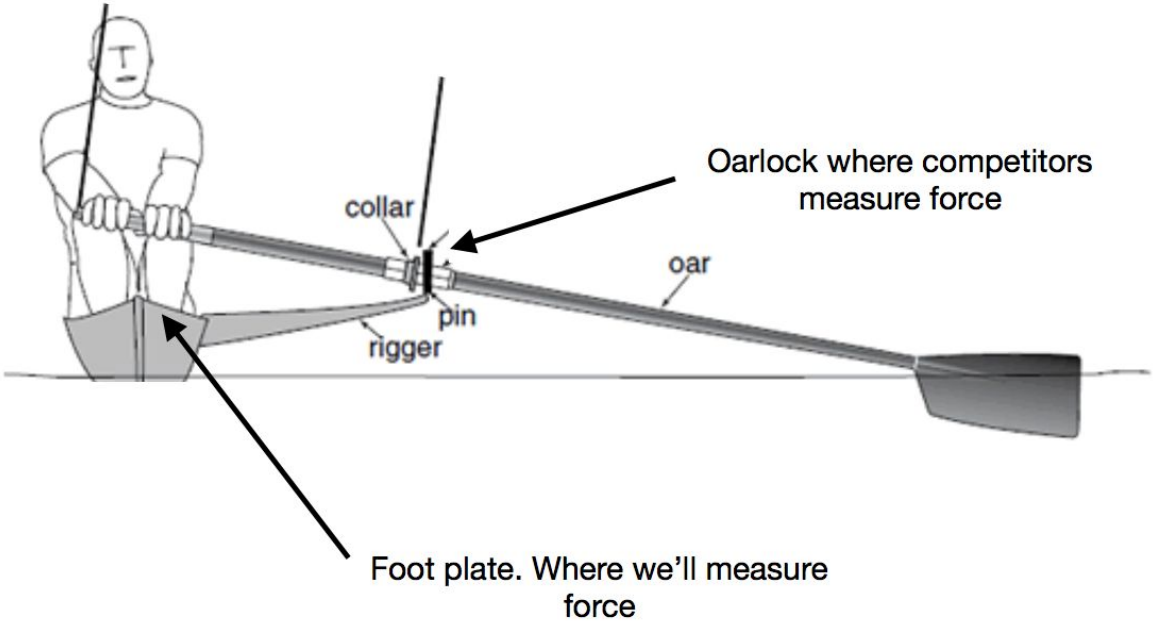
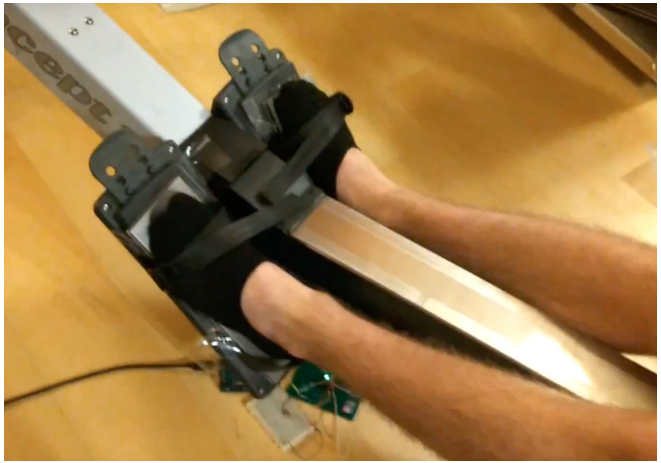
Introduction



Introduction

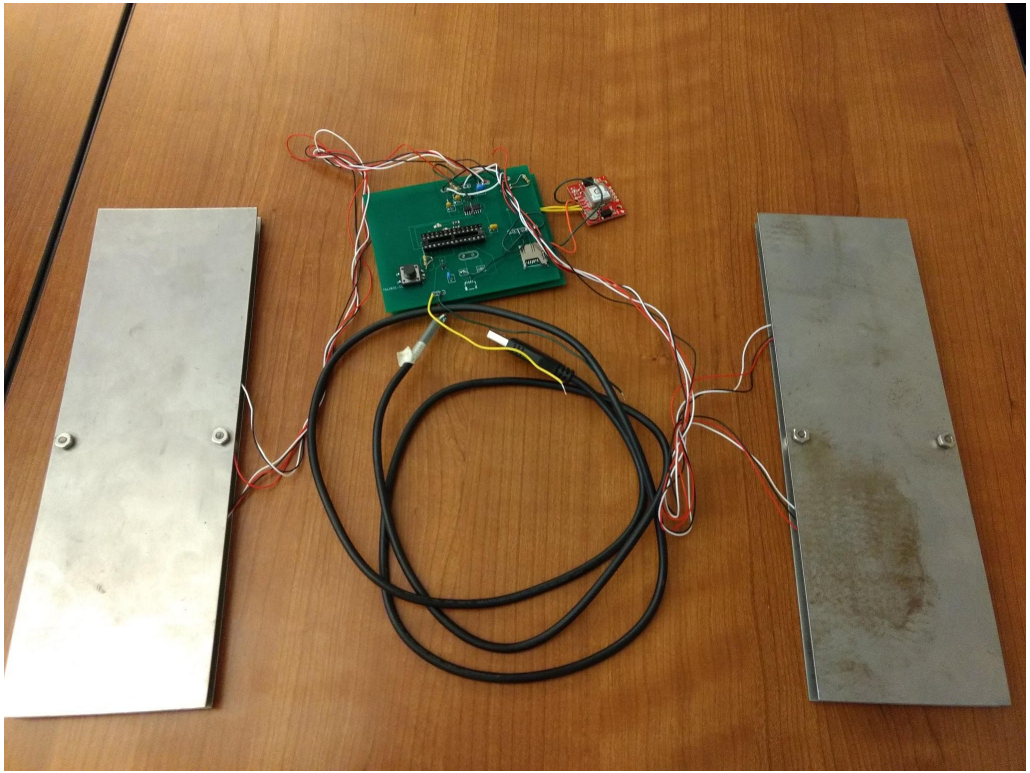
- New method to measure an individual rower's effort on the water
- Existing solutions are extremely costly

Peach Innovations Solution
costs $8370 to outfit an 8



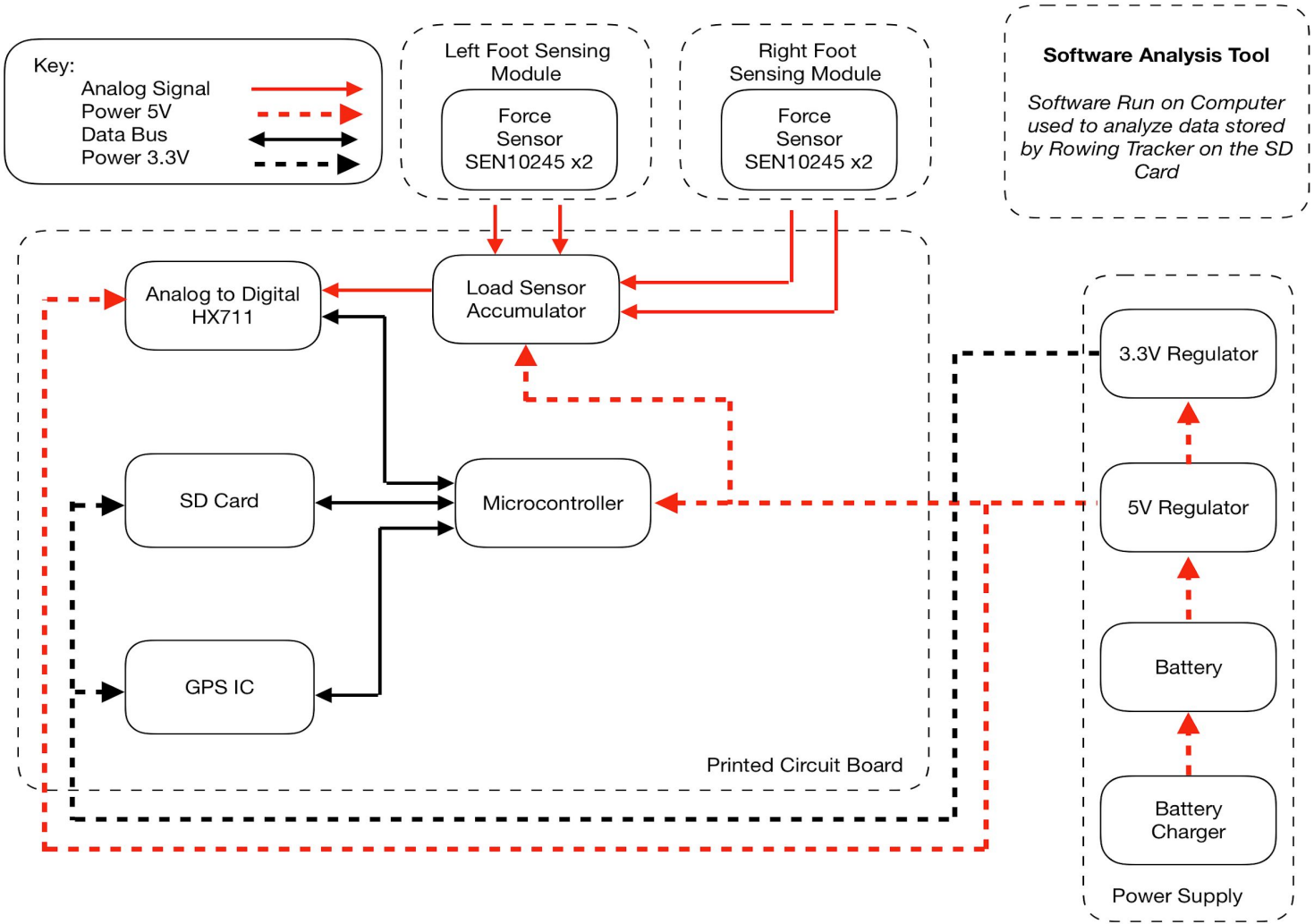
Our solution would cost
$1016 to outfit an 8 in parts.

Rowing Tracker



Objectives

- Create a cheaper alternative
- Measure through the feet
- Be able to provide all information a Rowing Machine would provide
    - Including wattage, strokes per minute, and pace(time/500 meters)


Key:
Analog Signal
Power 5V
Data Bus
Power 3.3V
Left Foot Sensing Module
Force Sensor SEN10245 x2
Right Foot Sensing Module
Force Sensor SEN10245 x2
Software Analysis Tool
Software Run on Computer used to analyze data stored by Rowing Tracker on the SD Card
Analog to Digital HX711
Load Sensor Accumulator
SD Card
Microcontroller
GPS IC
Printed Circuit Board
3.3V Regulator
5V Regulator
Battery
Battery Charger
Power Supply

Components

Hardware:

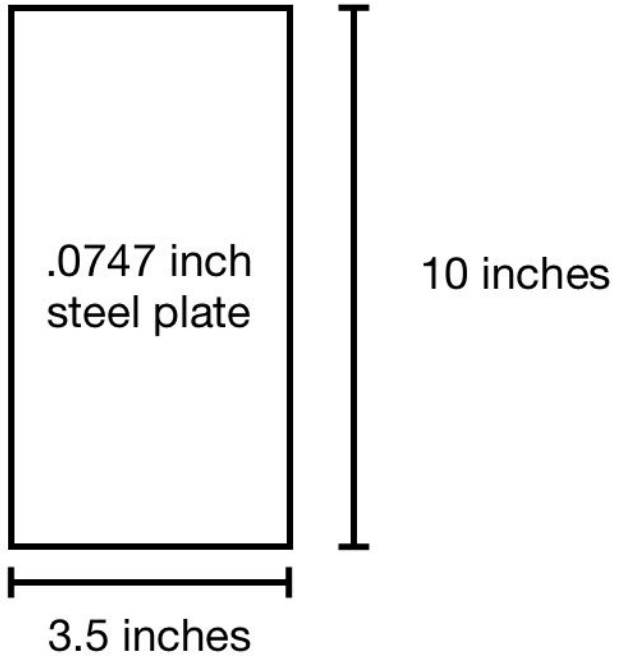
- Foot Sensing Module
- Control Unit / Printed Circuit Board
- Power Supply

Software:

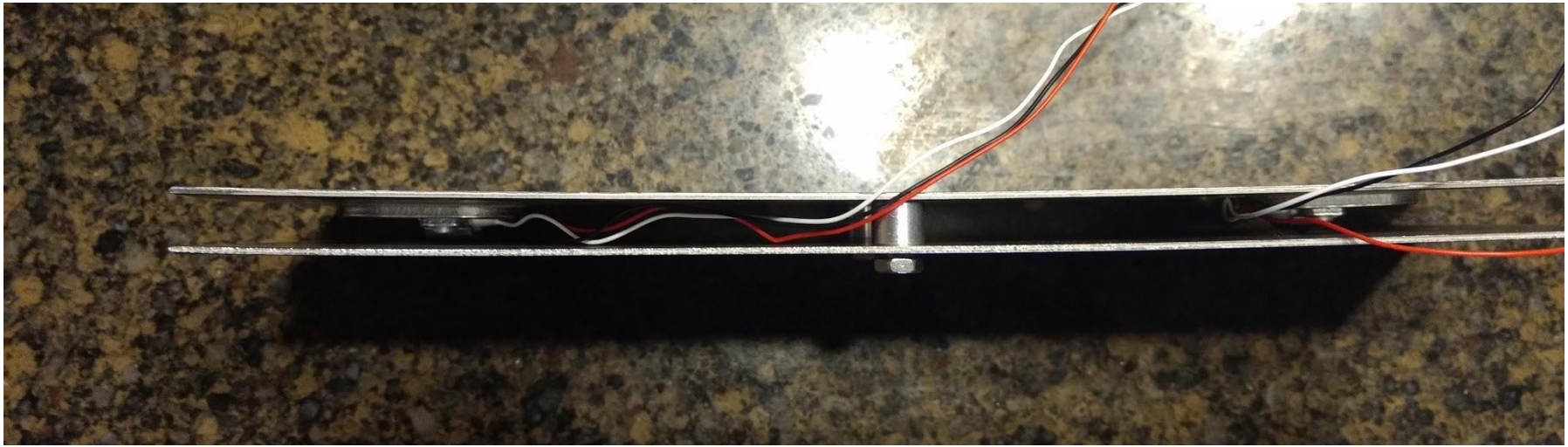
- Microcontroller Program
- Software Analysis Tool

Foot Sensing Module

- Detect force up to 100kg (220.4lbs) per foot
- Compatible with existing boat footwear
- Robust - steel plates
- 2 3-wire strain gauges per foot
  - Capable of carrying 50kg (110.2lbs) each
- 1.19lbs per foot module

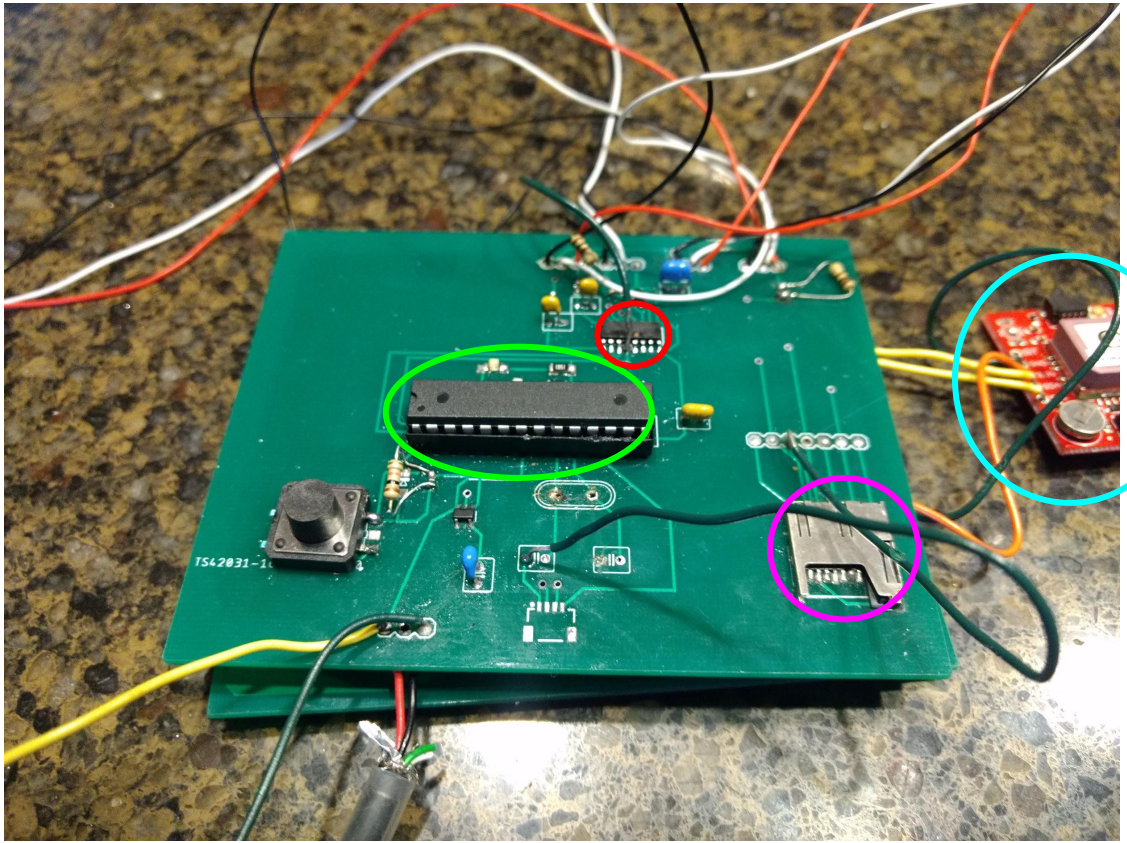


Force Sensing Module - Final Product

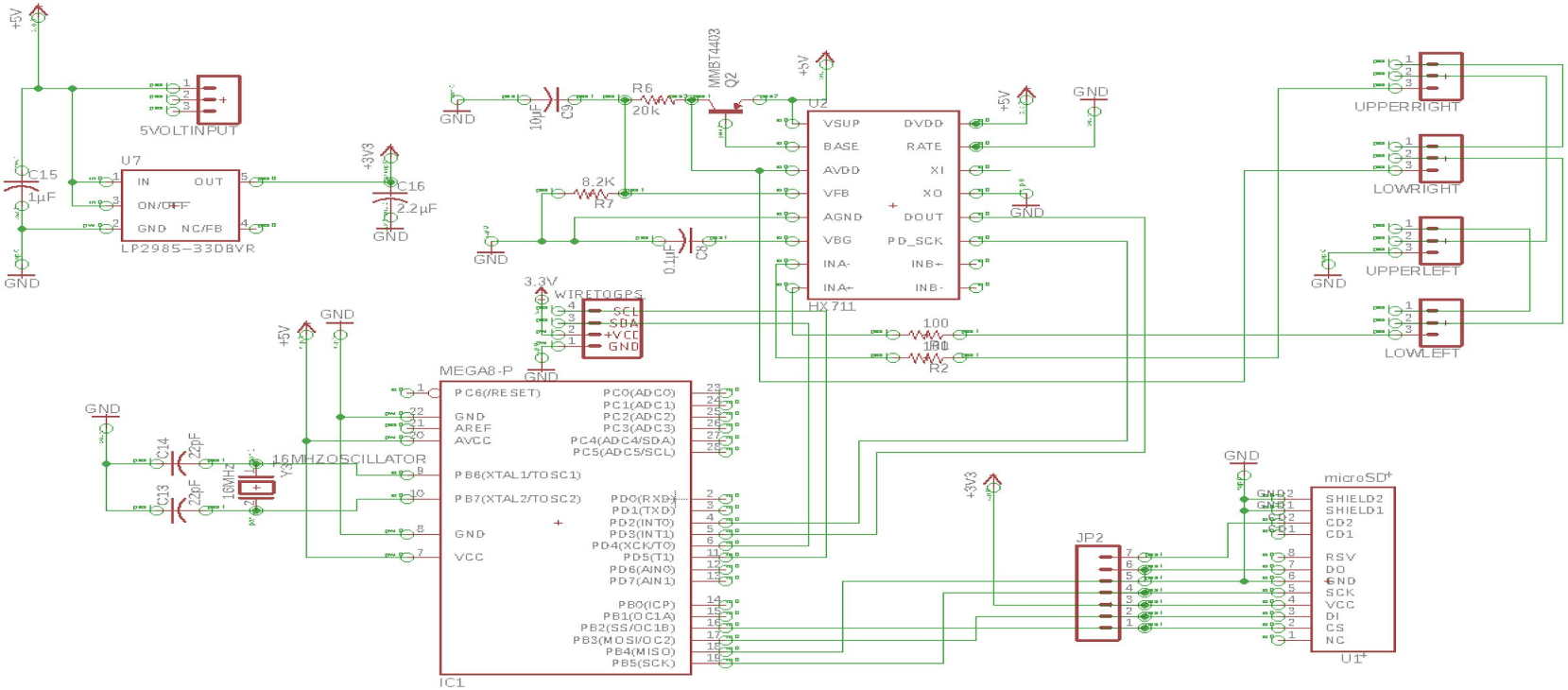


Control Unit

- Components
  - ATMega328 Microcontroller
  - HX711 Analog to Digital Converter
  - SanDisk 8GB microSD Card
  - XA1110 GPS (external)
- Inputs
  - 4 3-wire strain gauge inputs (analog)
  - GPS via I2C
  - Reset button
  - 5 Volts
- Outputs
  - Red and Green LED
  - SD card



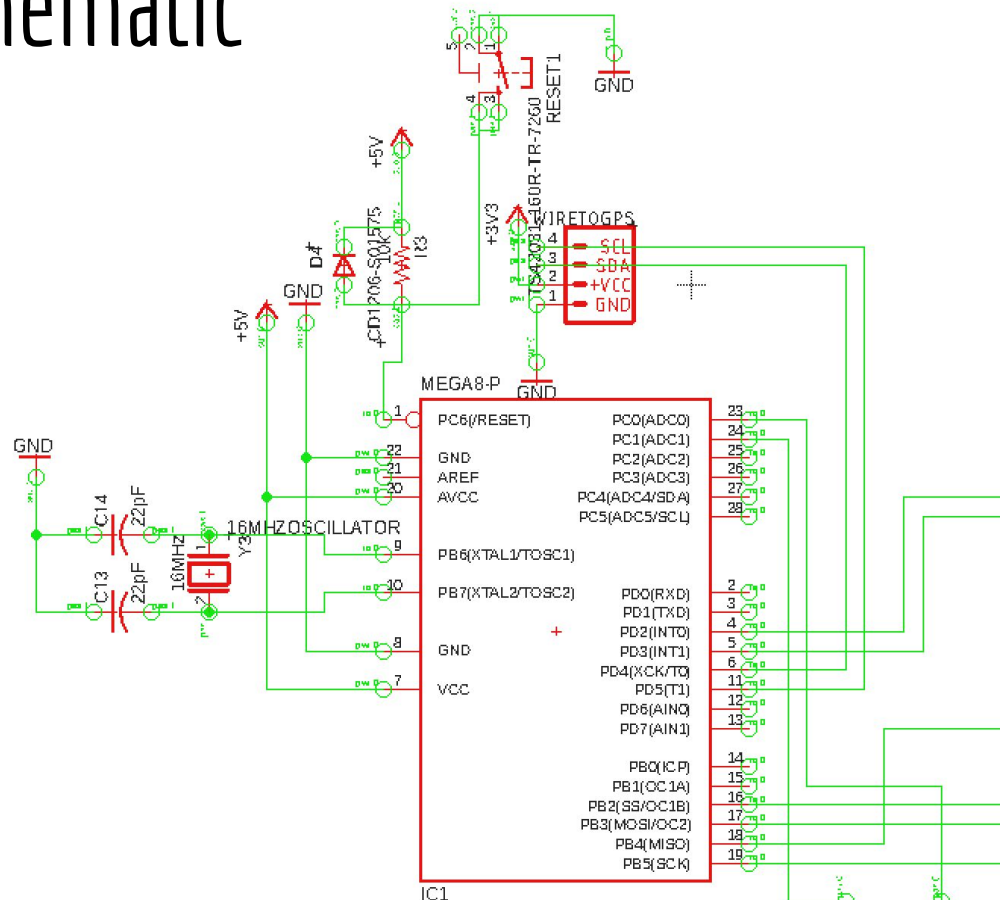
Control Unit - Schematic



ATMega328 Process

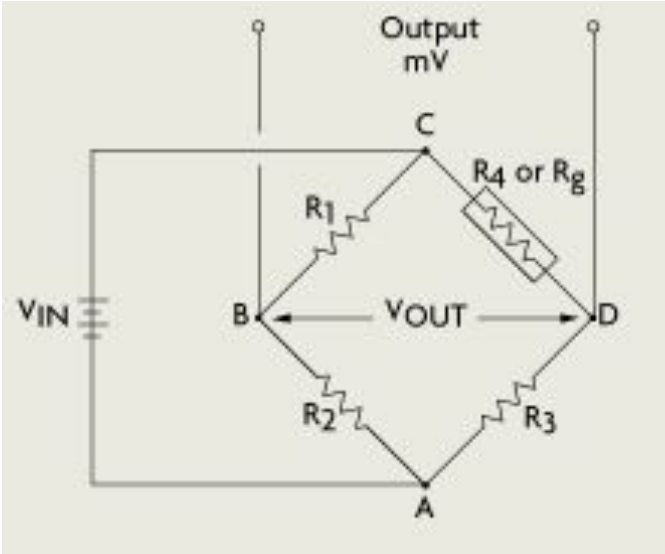
- Activate microSD Card
- Generate new CSV file with unique name
- Receive serial input from A to D
- Receive I2C input from GPS
- Record CSV lines with GPS time stamp and force input

ATMega328 Schematic

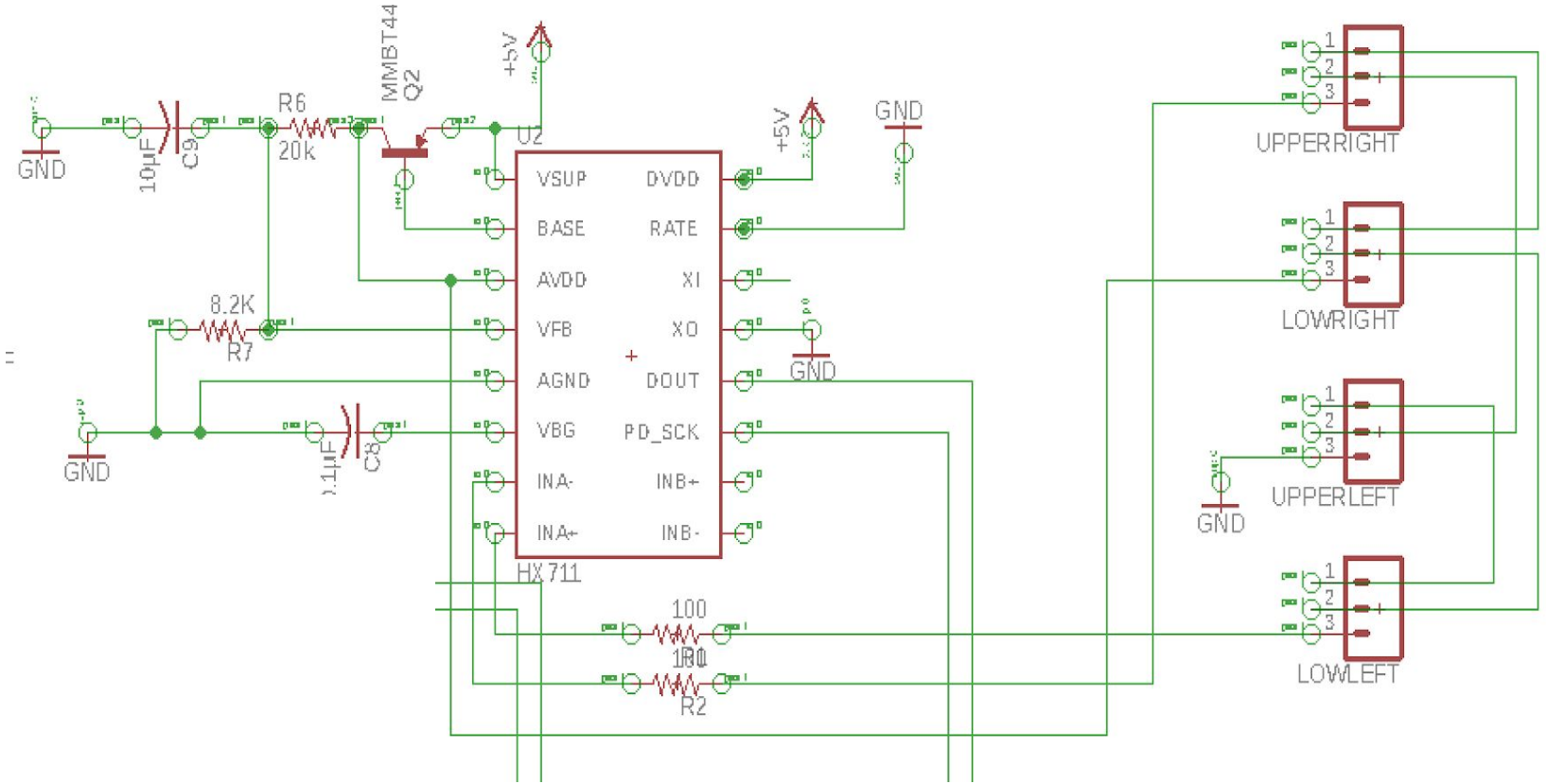


Control Unit - Analog to Digital Converter

- No need for individual sensor values
- Wheatstone Bridge sums 4 different strain gauge inputs
- Allows use of only one A to D converter
- 24 bit converter generates large range



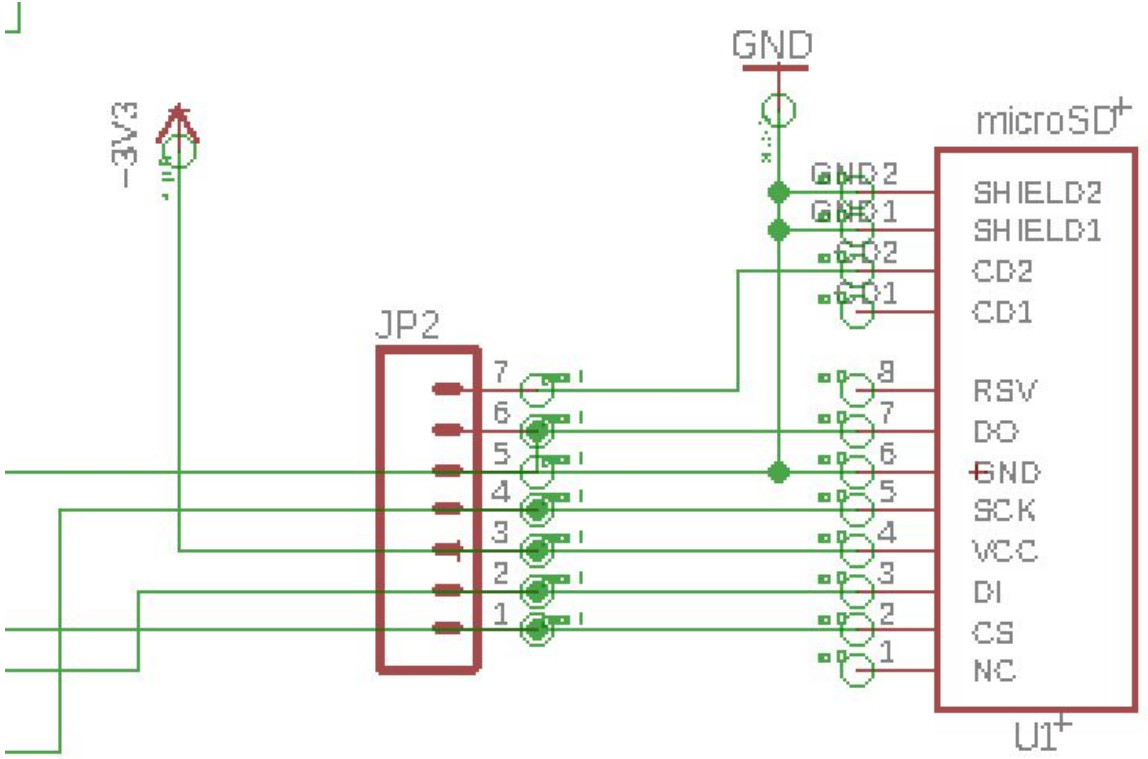
Control Unit - Analog to Digital Converter(Schematic)



Control Unit - microSD Card

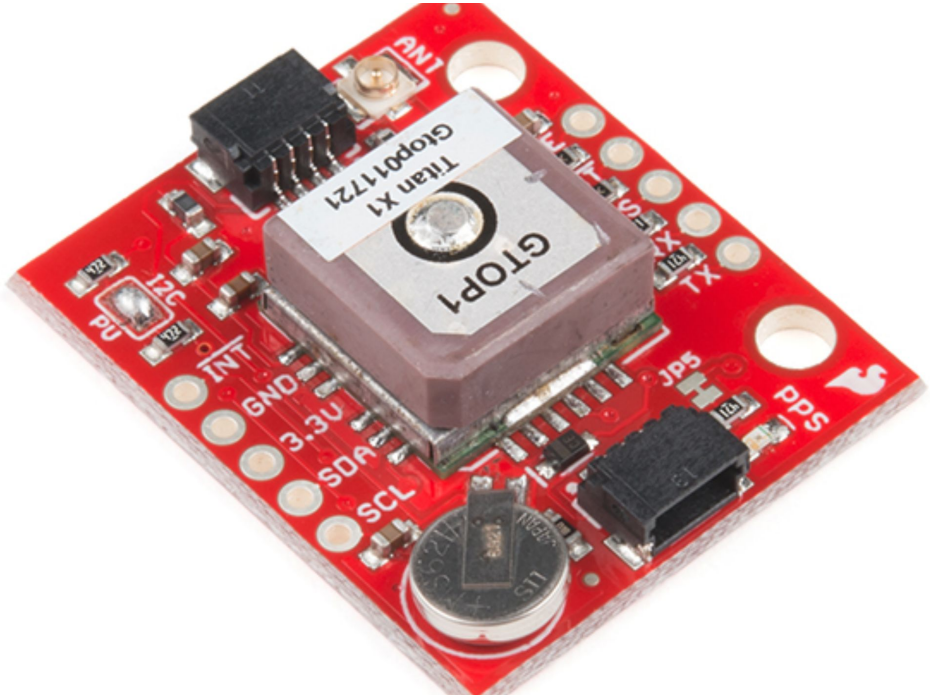
- SanDisk Ultra 8GB Class 10 UHS-I
- Listed write speed of 100 Mbits/second in SPI mode
- 8GB card allows for ~652 hours of constant recording

Control Unit - SD Card(Schematic)



Control Unit - Outsourced Components

- XA1110 - GPS Module
  - Backup battery -- Quicker Fix
  - Small Profile
  - Very sensitive
- Battery Pack/5V Supply



5 Volt Power Supply (Eliminated)

- 5V output
- 2500 mAh to allow 6-10 hours of operation
- Sustained loads of 200mA; peaks of 250mA
- Requirements are easily met by readily available product
    - Save time and money

Power Supply

- 5500 mAh allows more than 20 hours of operation assuming total load of 200mA
- 5 Volt 1 Amp output greatly exceeds requirements

Software Analysis Tool

- Input: Data from SD card
- Output: Rowing Machine outputs and further statistics
- Smooth Data
- Calculate Rowing Machine values
    - wattage, strokes per minute, and pace(time/500 meters)

Data:

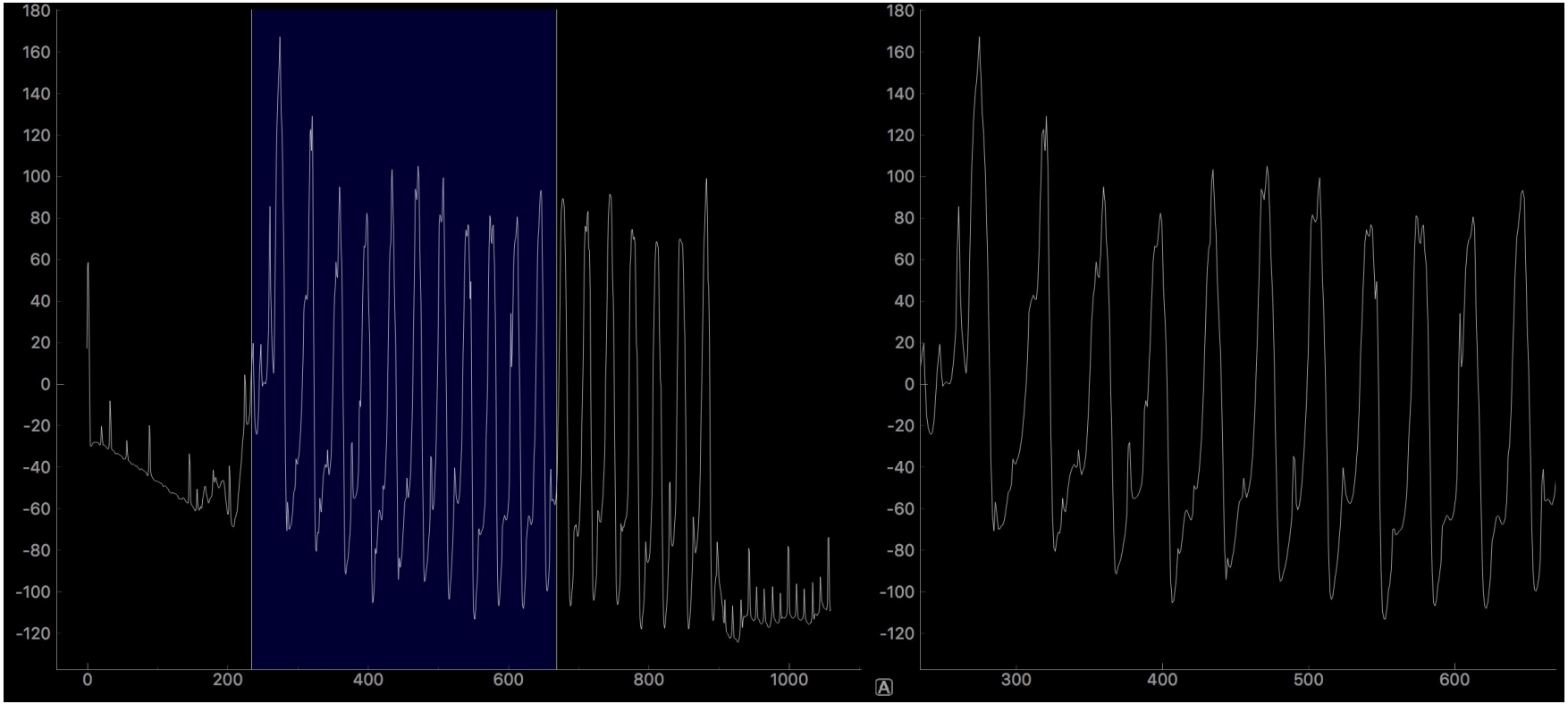
TEST9

dd/mm/yy	hours	minutes	seconds	lbs of force	latitude	longitude	speed
210418	1	47	1	31.76	40.091823	-88.238594	2.1298
210418	1	47	1	30.99	40.091823	-88.238594	2.1298
210418	1	47	1	30.09	40.091823	-88.238594	2.1298
210418	1	47	1	31.51	40.091823	-88.238594	2.1298
210418	1	47	1	34.86	40.091823	-88.238594	2.1298
210418	1	47	1	37.14	40.091823	-88.238594	2.1298
210418	1	47	1	39.92	40.091823	-88.238594	2.1298
210418	1	47	1	44.24	40.091823	-88.238594	2.1298
210418	1	47	2	49.42	40.091823	-88.238594	2.1298
210418	1	47	2	52.81	40.091823	-88.238594	2.1298
210418	1	47	2	54.94	40.091823	-88.238594	2.1298
210418	1	47	2	58.14	40.091823	-88.238594	2.1298
210418	1	47	2	62.98	40.091823	-88.238594	2.1298

Interface

Region Selection

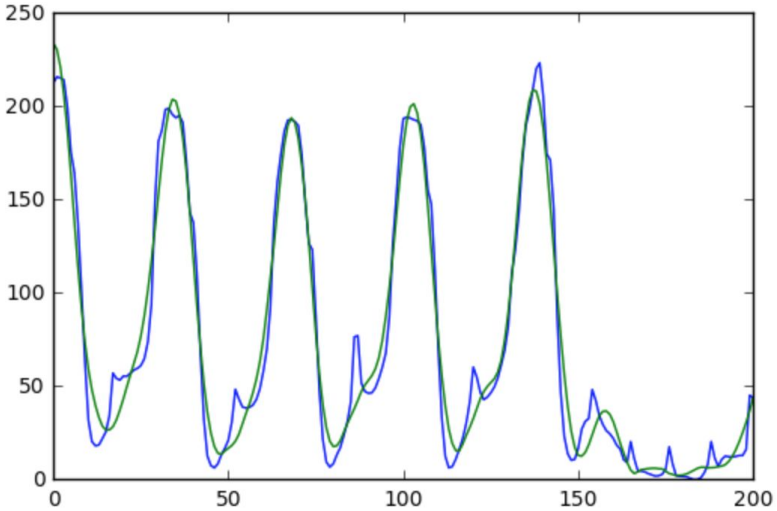
Zoomed Selection



Data Analysis

- Provides:
  - Graphical representation (smoothed)
    - Savitzky-Golay Filter
  - Rowing Machine Information

```
time: 18.0 seconds
average force: 325.048171277 N
number of strokes: 4 strokes
number of strokes per minute: 13.3333333333 strokes/min
average speed of boat: 0.638023168317 km/hr
approximate distance of boat : 3.19011839368 m
approximate pace of boat: 47 minute(s) 1 second(s)
approximate pace of boat: 3 minute(s) 2 second(s)
watts: 57.6078972235 W
```



Requirements and Verifications -Force Sensing Module

- Footplate can accurately record a stroke
  - Force sensors did max at any point throughout the stroke
  - Enough samples taken to clearly define force curve

Requirements and Verification - Power Module

- PCB low power consumption.
  - Wired PCB through ammeter found total current draw of 70mA
  - Slightly greater than expected 52mA
- Resistor Load test of 500mA on battery pack
  - Voltage sag of less than 0.15 volts
  - No overheating of battery pack or vias
- Resistor Load test of 350mA on 3.3V regulator
  - Voltage sag of .10 volts
  - Regulator did not overheat throughout 15 minutes of load
- Ran device on battery pack for 6 hours
  - Device charge indicator showed no change

Requirements and Verification - PCB Components

- SD Card
  - Capable of recording CSV data as generated without slowing system
    - 138 second test generated 47KB = 340.5KB/second
    - 340.5KB/second -> 2.7Mbits/second < 100Mbits/second max
- GPS Unit
  - Generate 1 sample/second of date, time, latitude, longitude, and speed
    - Data was printed to serial out and displayed on computer
    - Time/Date was accurate within 5 seconds
    - Position/speed accurate within 10 seconds(outdoors)
  - Low power usage
    - Consumed 60mA while seeking
    - Consumed only 40mA once lock
    - Well within design parameters for battery life

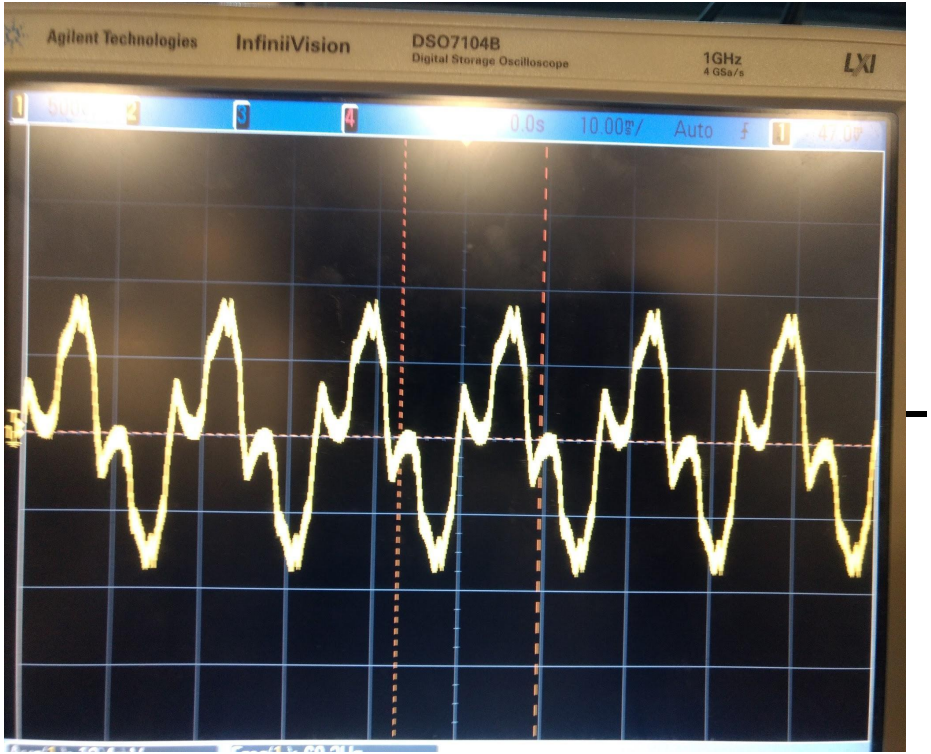
Requirements and Verification - Software Module

- Have an interface that would be easy for users to use
- Presents information that Rowing Machine would
  - wattage, strokes per minute, and pace(time/500 meters)

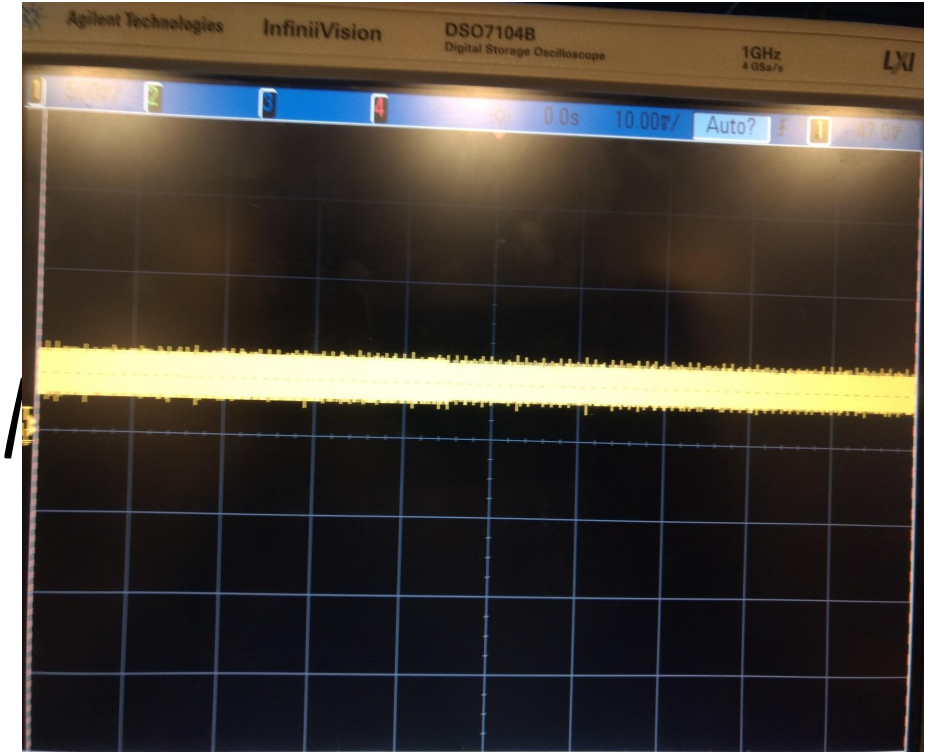
RV-Troubleshooting

- Unstable behavior
- Worked perfectly on Arduino Uno
- Isolated Issue to External Clock using Oscilloscope

RV-Troubleshooting



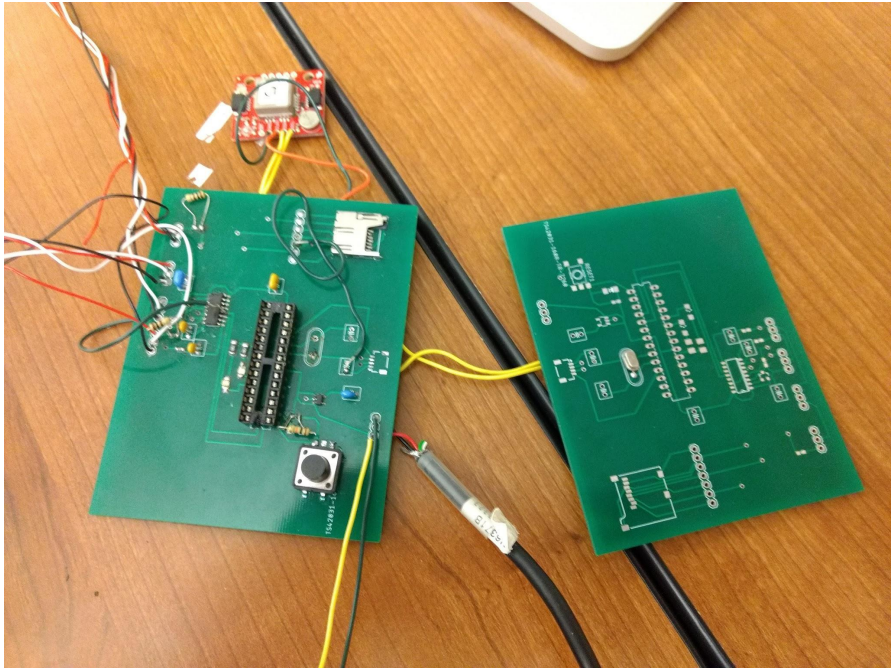
Oscillator Pins Arduino



Oscillator Pins PCB

RV-Troubleshooting

- Moved new oscillator to proto board
- PCB leads for oscillator thought to be faulty
- Wire distance too great led to intermittent faults



Component Cost

Component	Cost
Load Sensors -50kg (x4)	$39.90
Steel Plates	$12.00
XA1110 GPS	$44.95
PCB parts	$30.71
Total	$127.56

Future Work

- Expand system to outfit an entire boat
- Improve accuracy through more quantitative analysis
- Improve system waterproofing
- Easy connect/disconnect of foot plates from control unit

VO2 Mask

Questions?