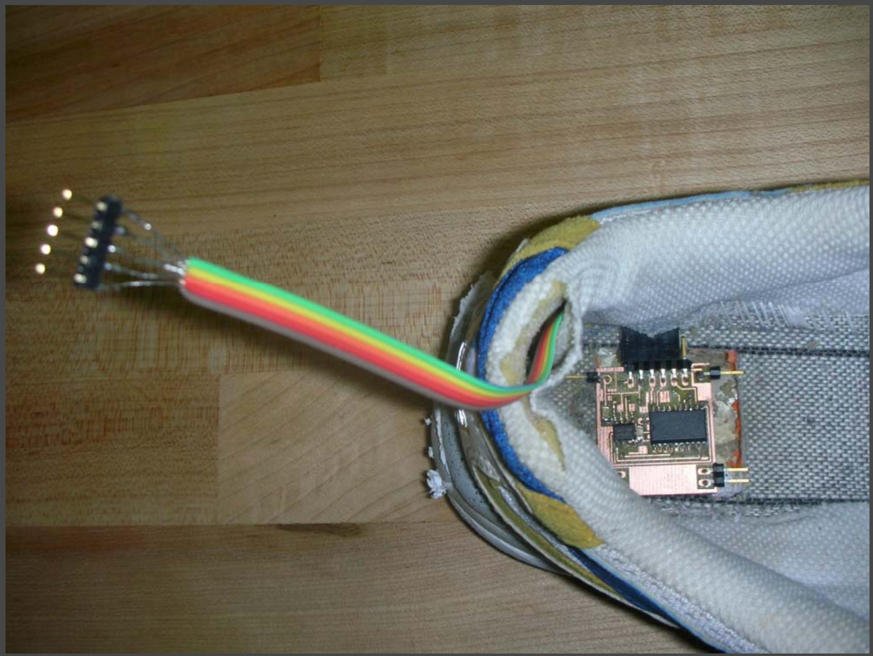
Pediatric Physical Activity Dynamometer



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Motivations

Why bones?

- Increasing prevalence of osteoporosis in U.S.
- Risk reduced by developing strong bones in childhood

Why physical activity?

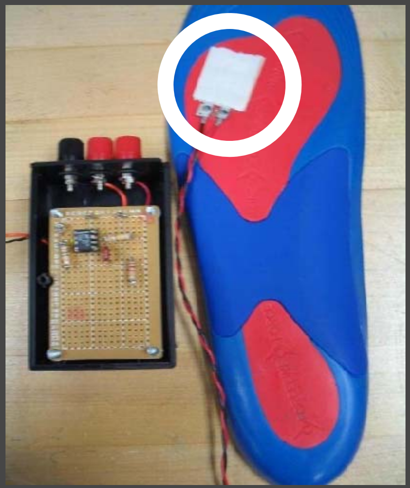
- Load-bearing bones withstand significant force from muscle contractions and impacts
- Exercise has positive effects on bone development

Why not use a force plate?

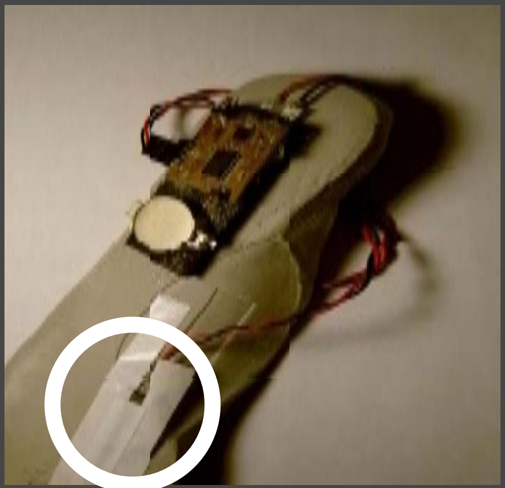
- Force plates are immobile
- Can only jump or run in place for a limited amount of time

Foot-PAD

(Physical Activity Dynamometer)



SUNFEST 2004



SUNFEST 2007

Uses <u>piezoelectric</u> polyvinylidene fluoride (PVDF) film sensor

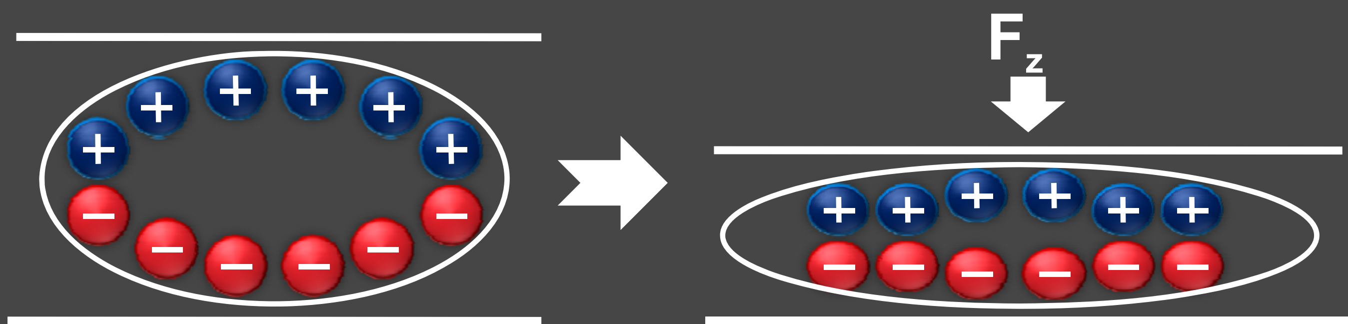
- Generates current proportional to applied strain

<u>PROBLEM</u> – current proportional to <u>horizontal force</u>

Goals

<u>MAIN PRIORITY</u> – Incorporation of <u>piezoelectret</u> film sensors

- Generate current proportional to <u>vertical force</u>

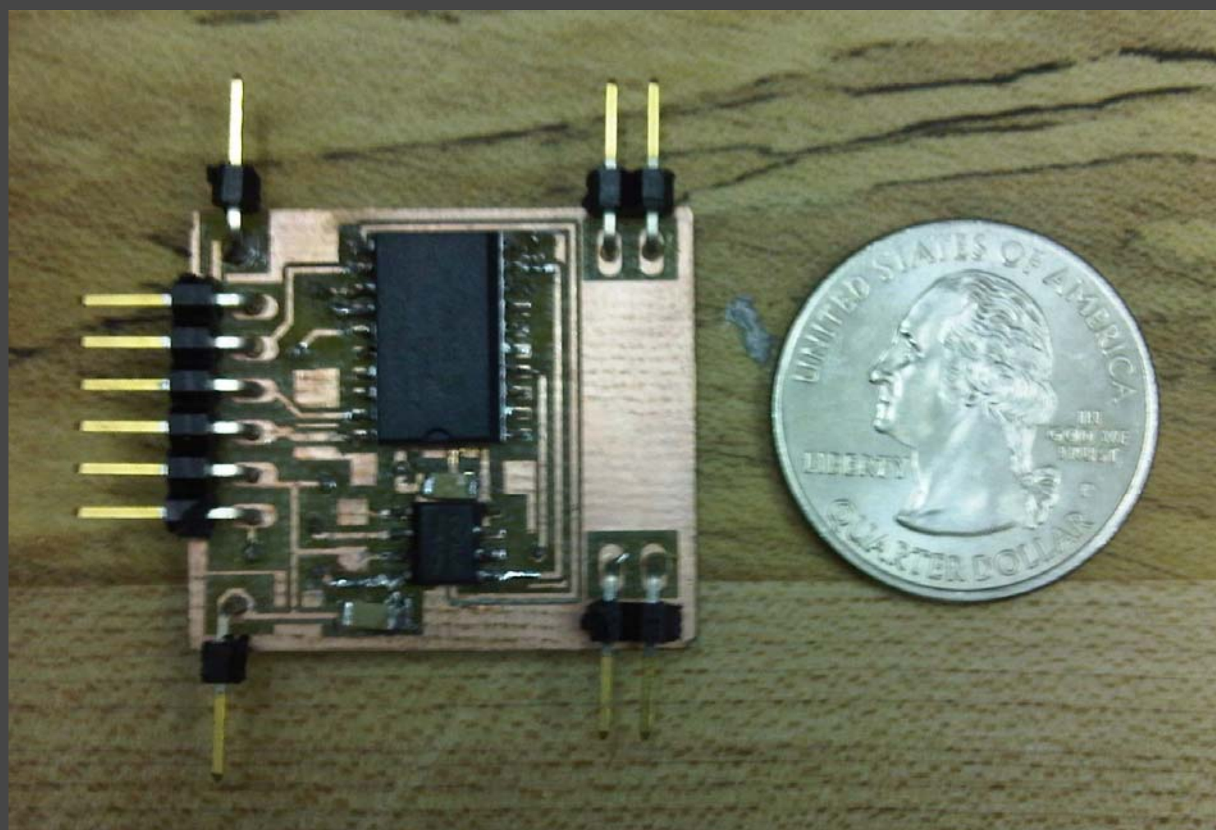


<u>Additional Goals</u>

1. Appropriate modification of circuit
2. Finding a suitable battery to power system
3. Design device to apply loads to sensor
4. Confirm forces can be measured in physical activity

Phase I: Building the Protoboard

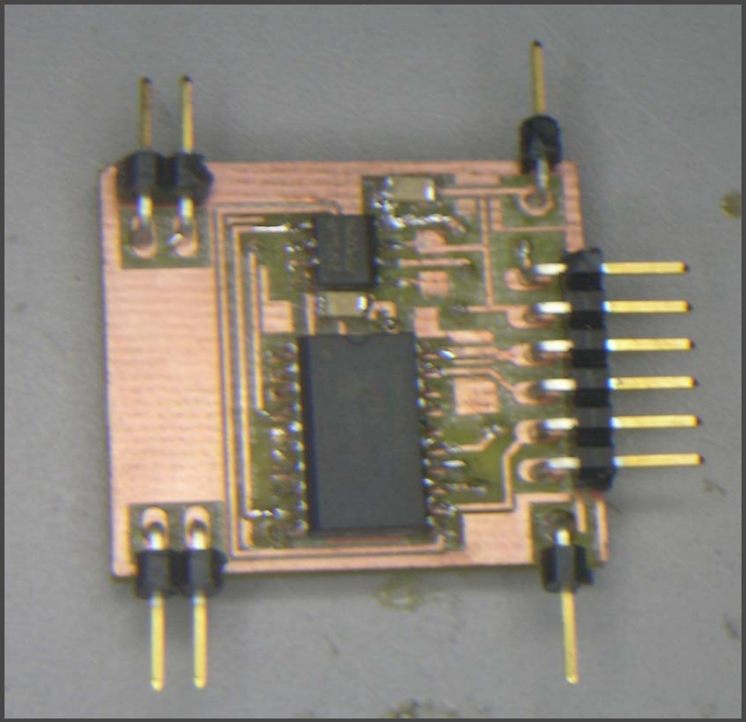
Cut with T-Tech 5000 CNC Milling Machine
Soldered with surface-mount components



Phase I: Building the Protoboard

Plugs for piezoelectret sensor

- **Placed in series with resistor to obtain voltage signal**



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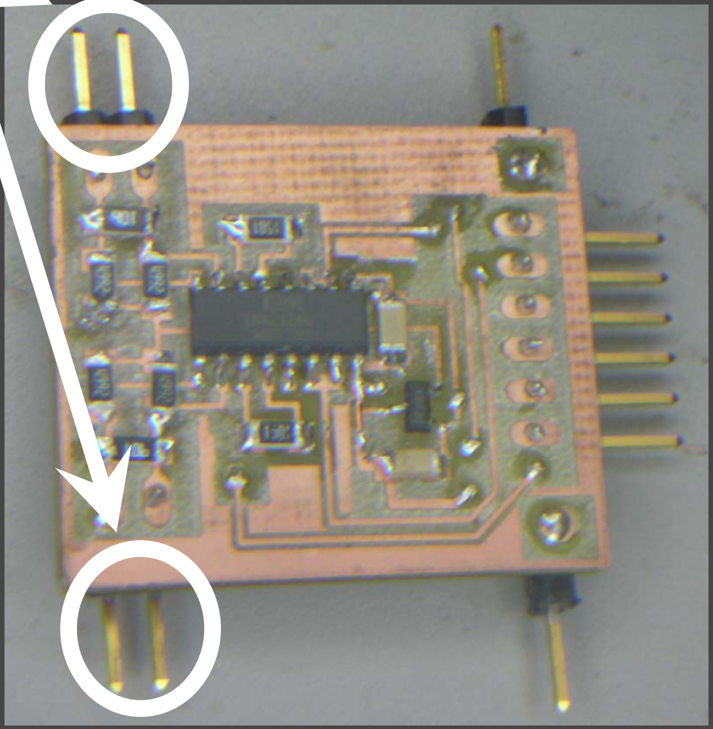

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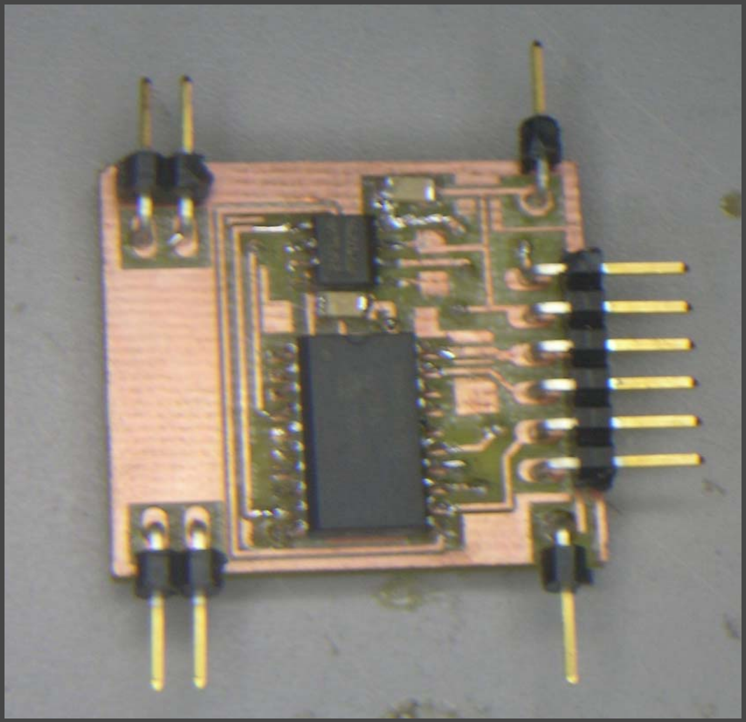
Phase I: Building the Protoboard

<u>Instrumentation Amplifier</u> – Texas Instruments INA2126

- Two op-amps with adjustable gain (= $5 + 80k\Omega/R_G$)



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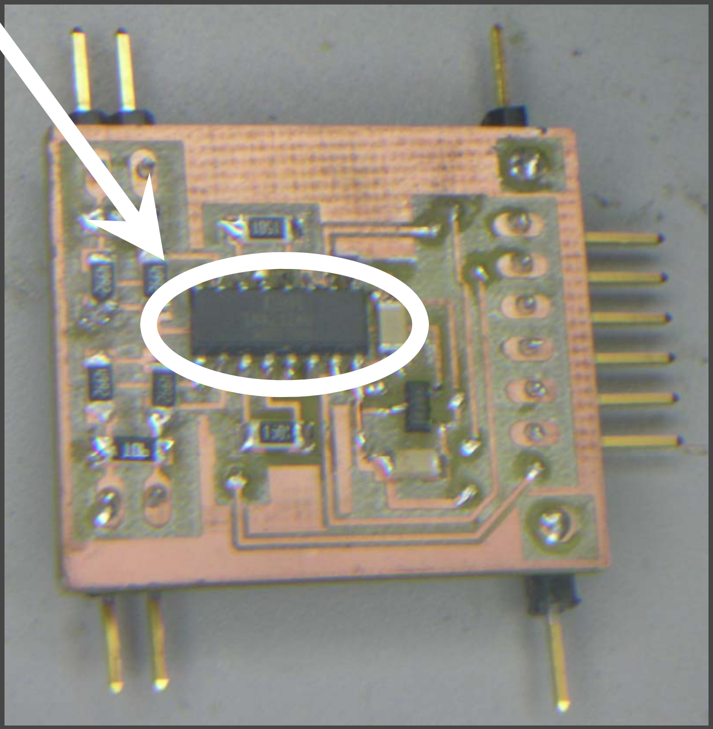

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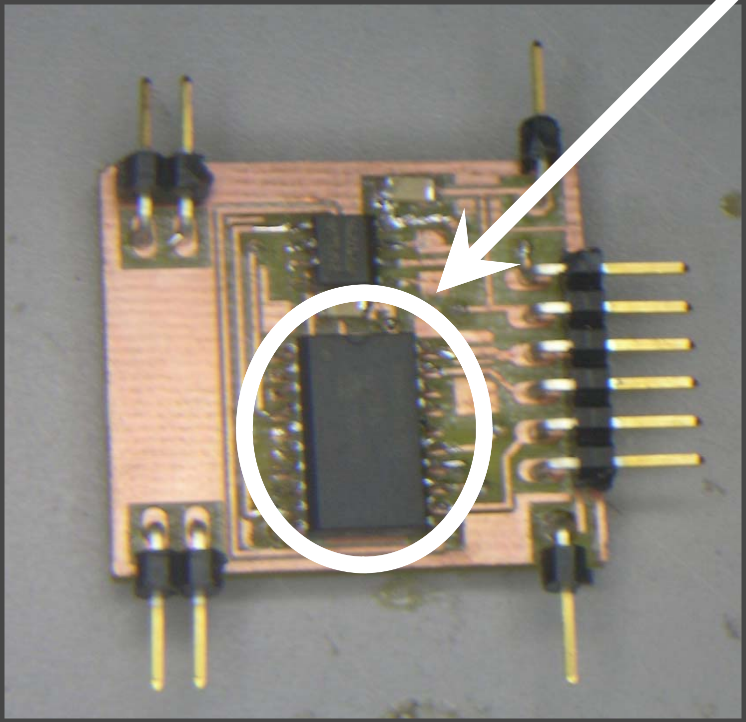
Phase I: Building the Protoboard

Microcontroller – Microchip PIC18F14K50

- Contains analog-to-digital converter (ADC), 10 bit resolution



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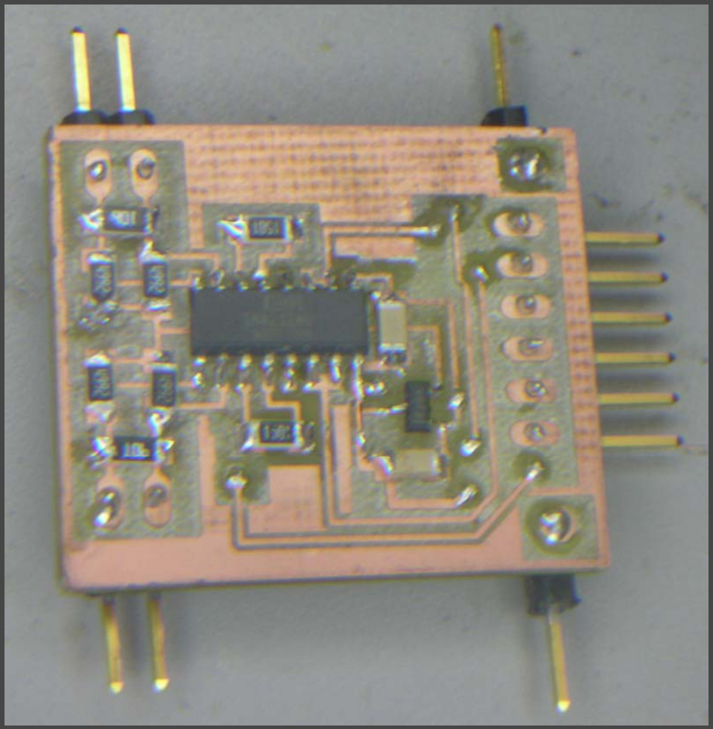

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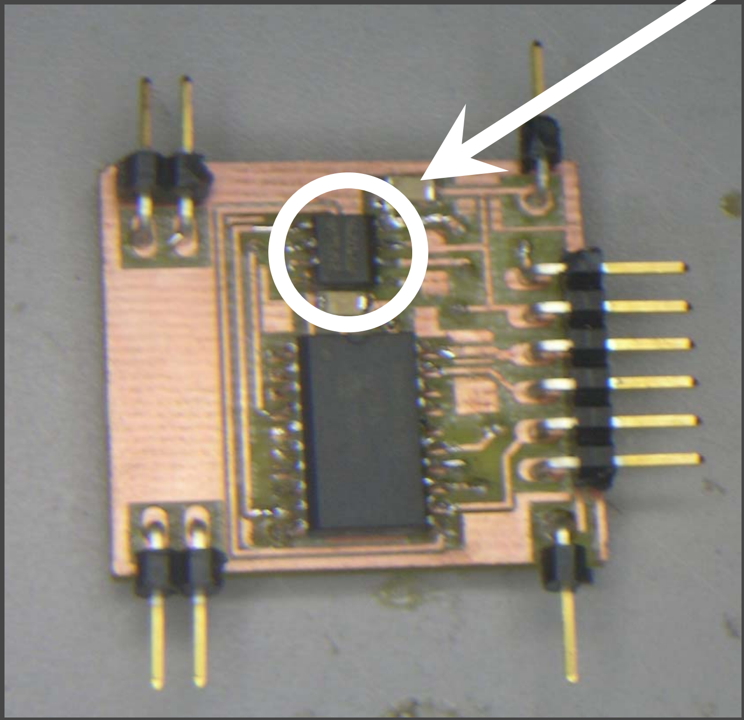
Phase I: Building the Protoboard

<u>Flash Memory</u> – Numonyx M25P16

- Stores digital data; erases at low current



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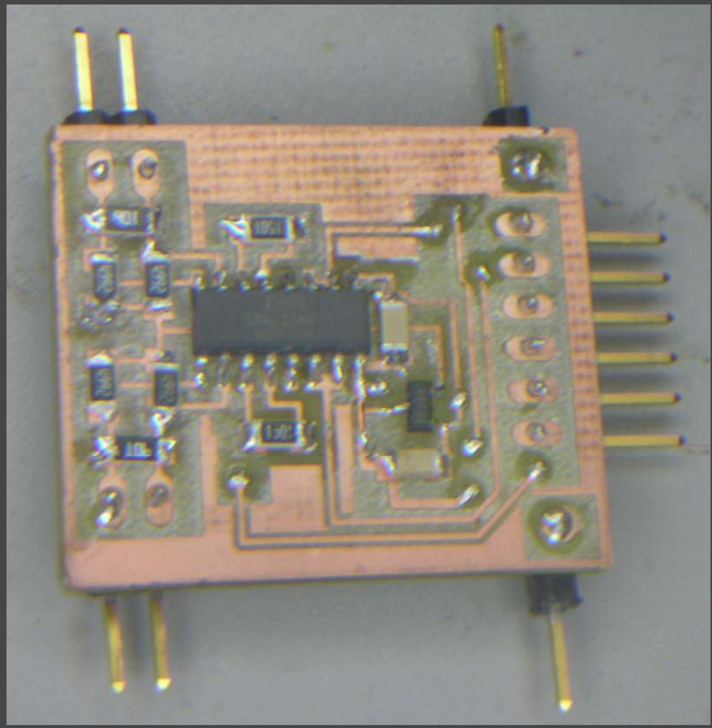

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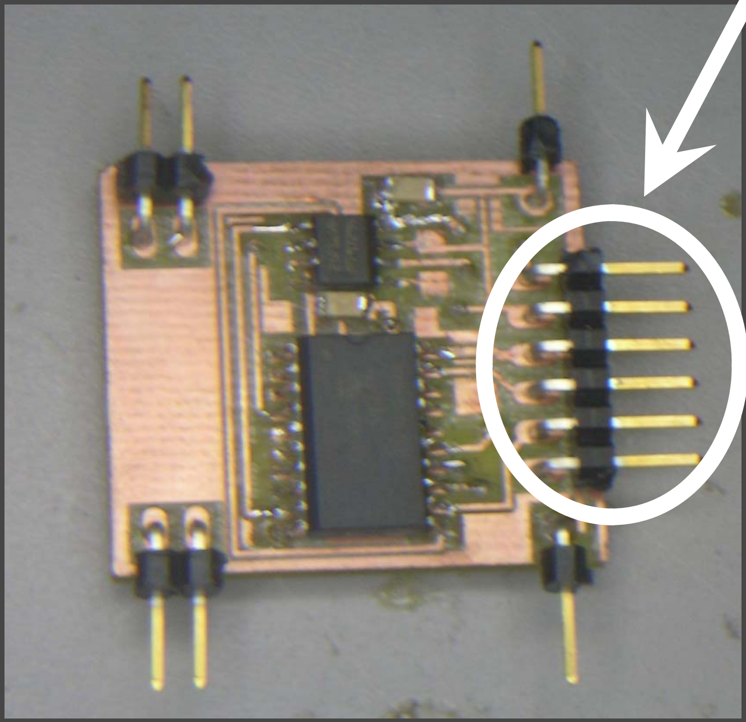
Phase I: Building the Protoboard

Plug for USB-to-serial connection

- **Transfer data to computer for calculations and analysis**



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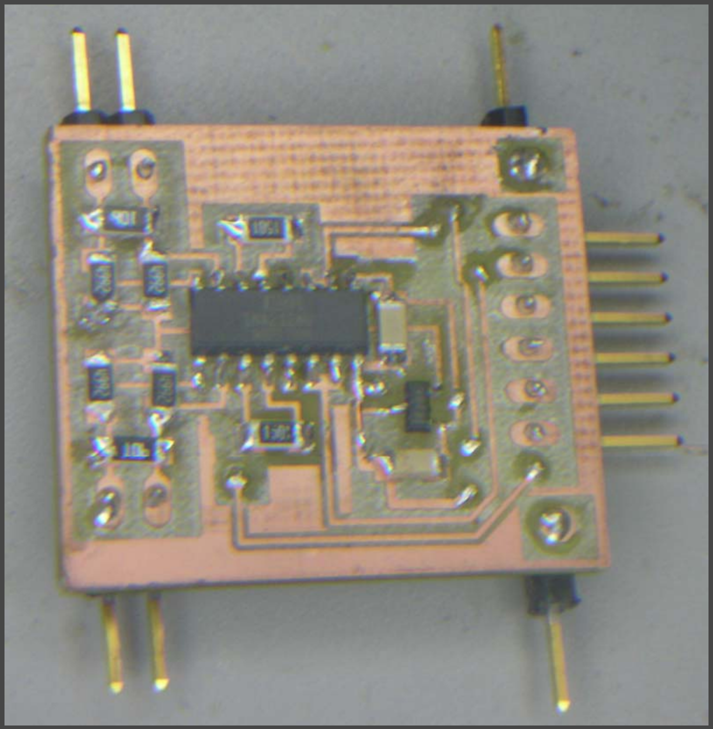

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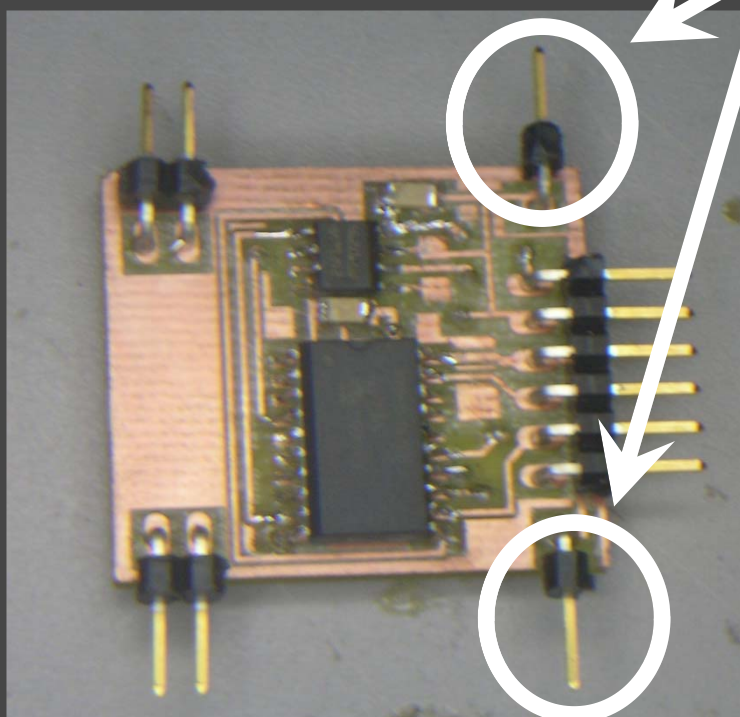
Phase I: Building the Protoboard

Plugs for Battery

- **Entire system powered at +3V, current of 4 – 5 mA**



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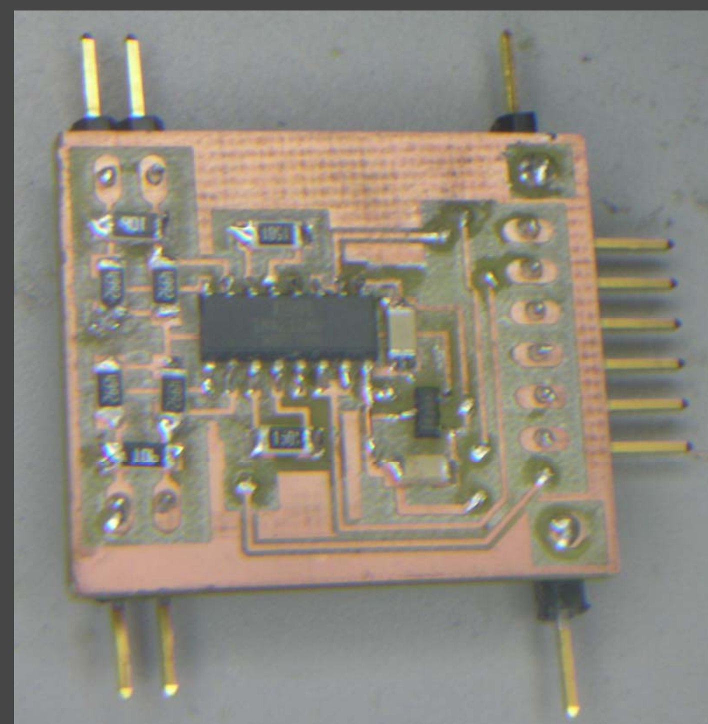

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Phase II: Finding Suitable Battery

UltraLife U10007 Thin Cell

- **Non-rechargeable**
- **Voltage range of 1.5 to 3.3 V**
- **Maximum discharge of 25 mA**
- **<u>Only 1.91 mm thick</u>**
- **Operate at 6 mA to 1.5 V for 400 mAh**
  - **Will be able to power Foot-PAD for ideally <u>36 hours</u>**

Phase III: Testing Device

Constructed a device to periodically apply forces to the piezoelectret

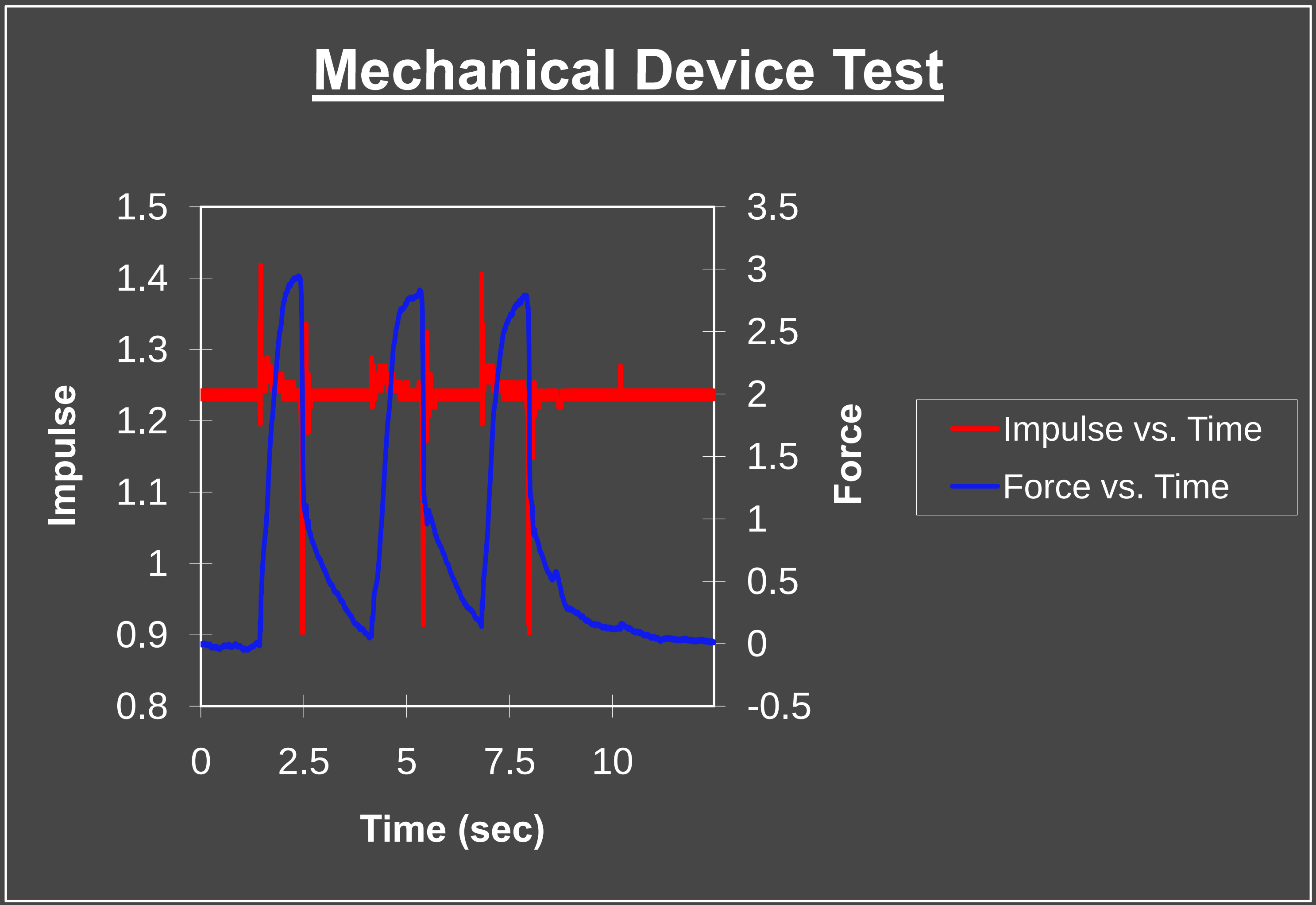
1. Large cylindrical plunger

2. Small cylinder
   (Rests loosely on top of sensor)

3. Stiff foam
   (Sensor secured on top of foam)

4. Dremel drill press with lever

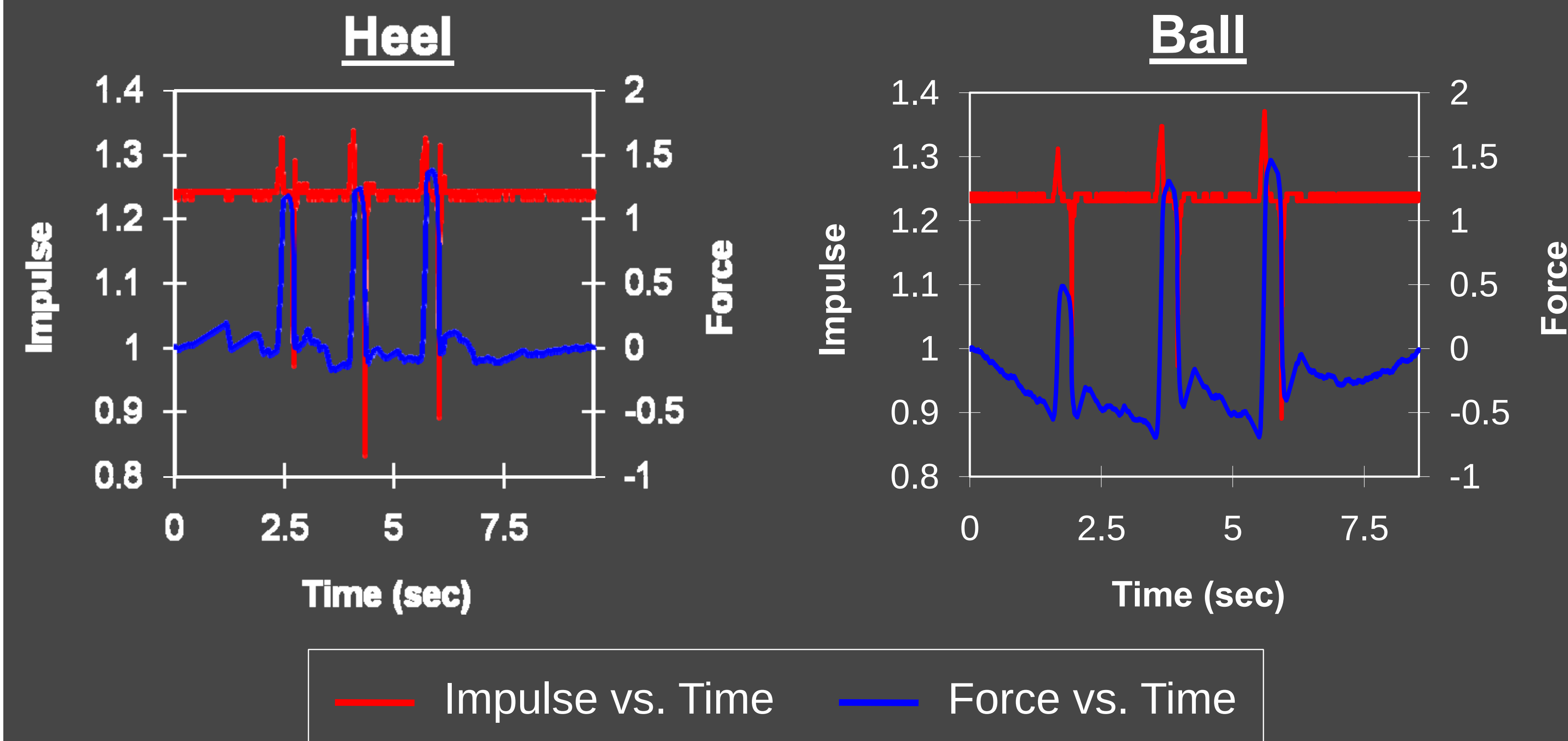
Phase III: Results



* Sampled every 5 msec

Phase IV: Results

Performed squat jump on sensor 3 times



* Sampled every 5 msec

Conclusions and Recommendations

Foot-PAD is now capable of measuring vertical forces and has a battery life of at least 36 hours.

<u>Improvements Needed</u>

- **Place device inside shoe**
- **Calibrate with force plate**
- **Design of larger area sensors**

- **Logarithmic amplifier**
- **Measure for longer amount of time**
- **Collect data from children**