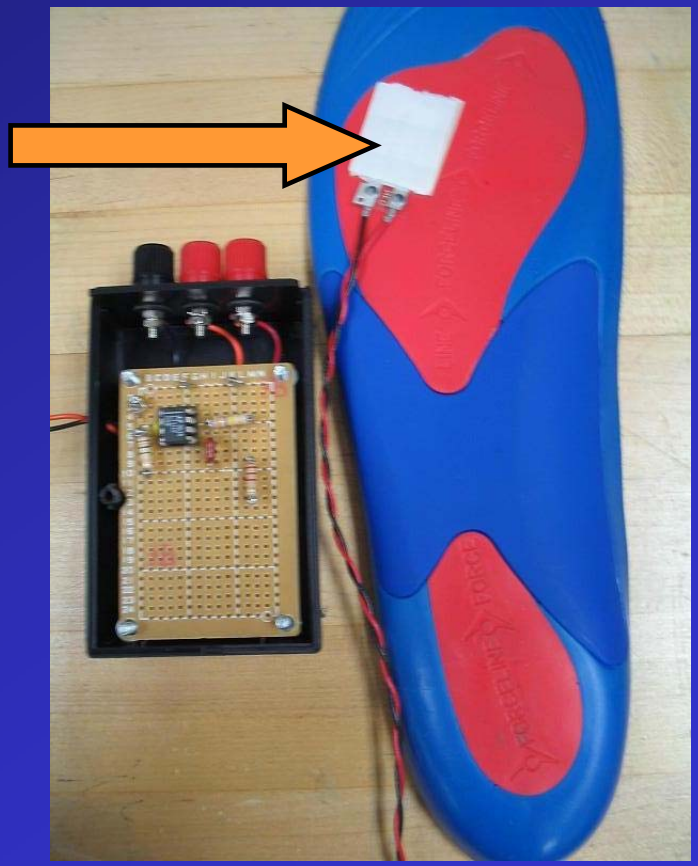
Dynamometer

- The New Activity Monitor -



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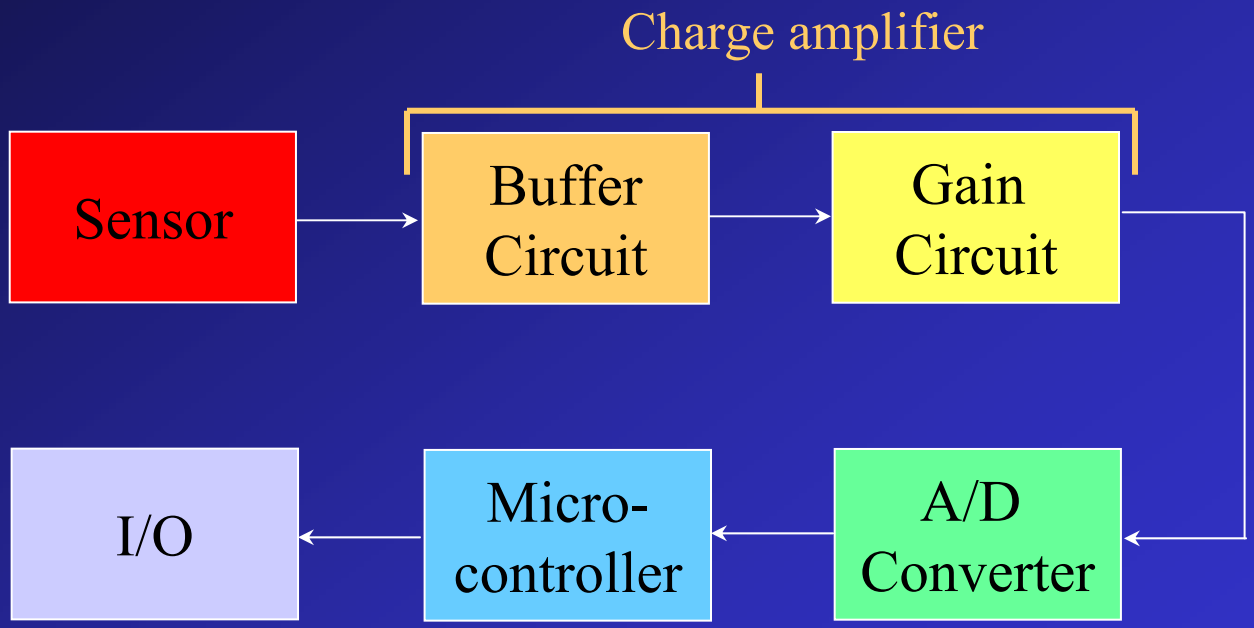
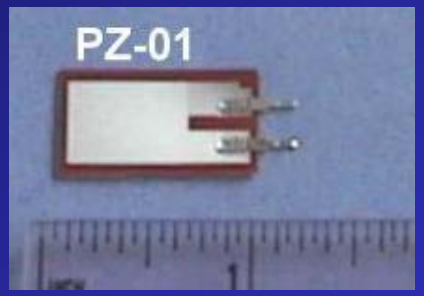
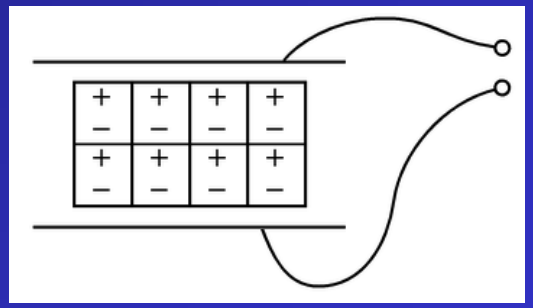
Flow Diagram

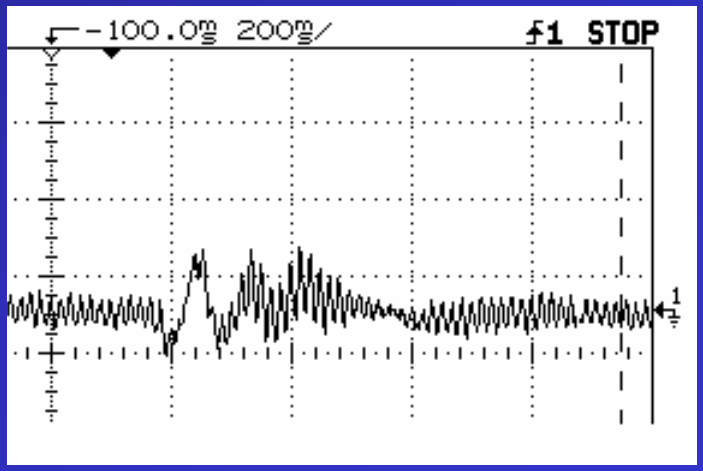


Sensor



- Supplier: MSI Sensors, Inc.
- Piezoelectric PVDF – LDT1-028K
- Active vs. Inactive
- How it works:
  - Forces disrupt the dipole alignment
- Mechanical Energy → Electrical Energy
- Stimulus: forces from feet
- Signal produced:





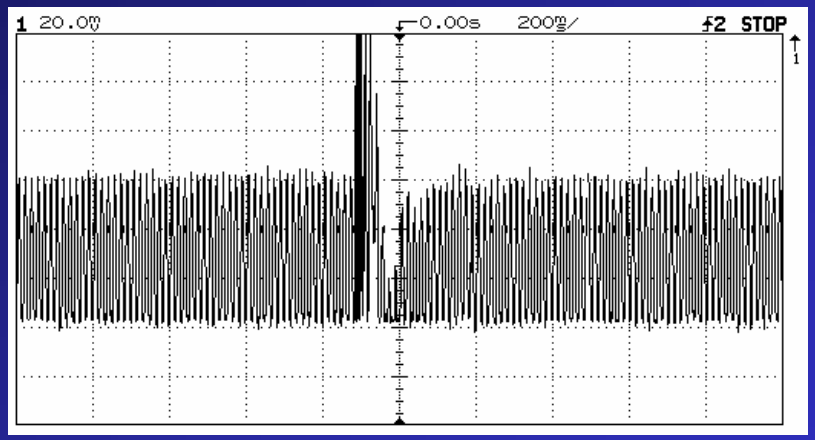
The Signal

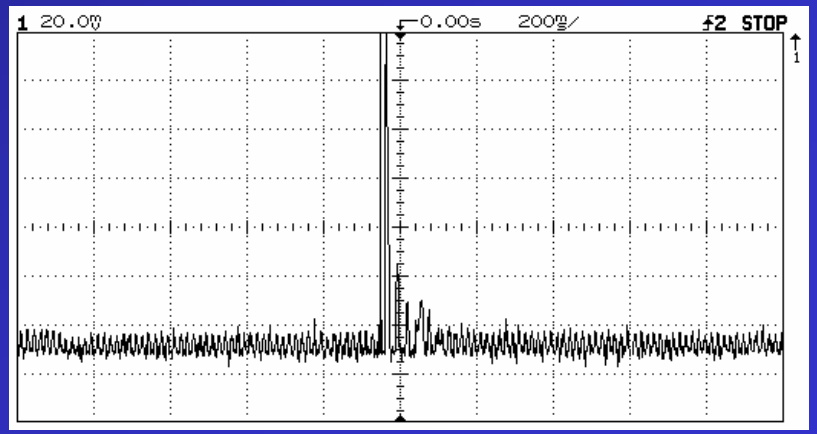
Problems:

- No Relative Ground
- Signal amplitude small
- Interference of Noise/60 Cycle

Solutions:

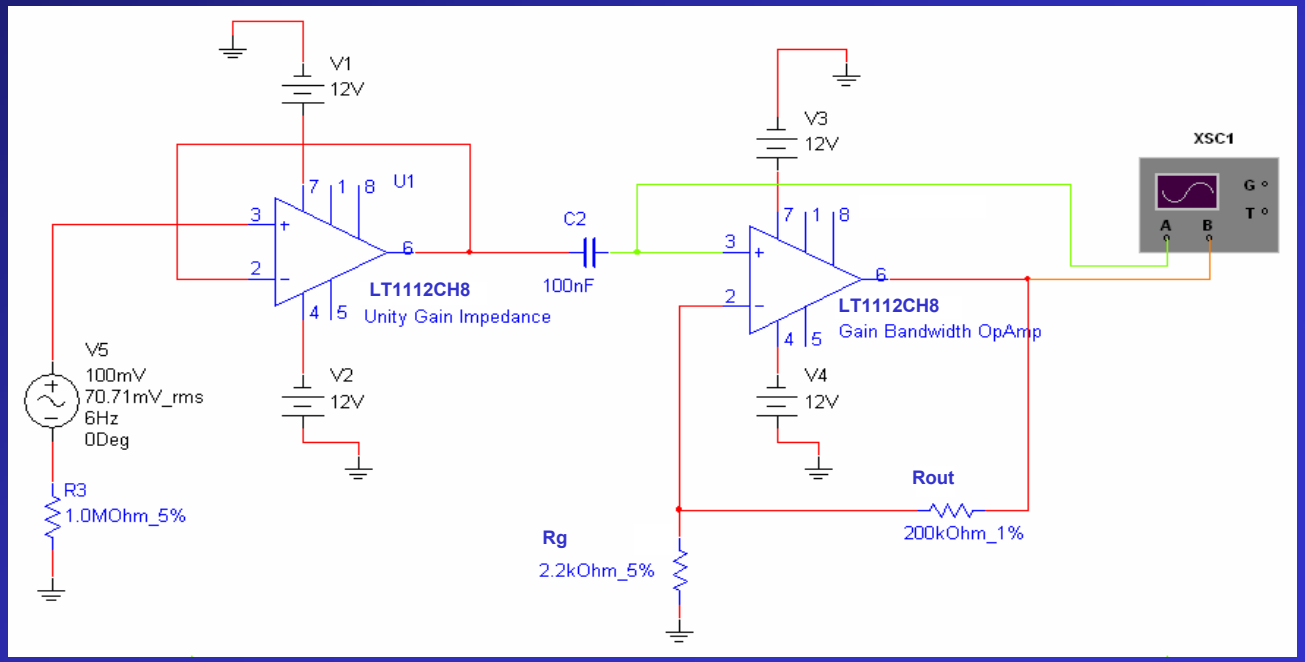
- Ground Motor, Scope, Sensor
- Feed Signal into Amplifier
- Shielding with aluminum





Charge Amplifier

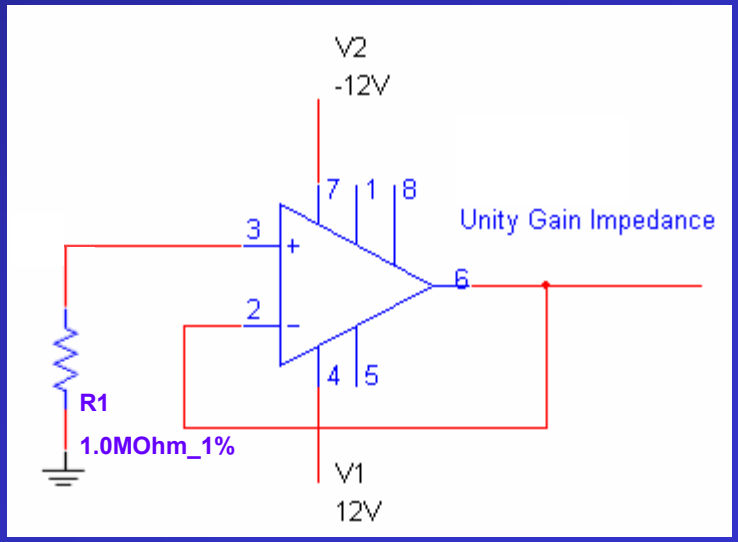
- LT112CN8 op-amp
- Powered with ±12 volts
- MultiSim software for simulations
- Used to amplify the signal produced by the sensor



Buffer Circuit

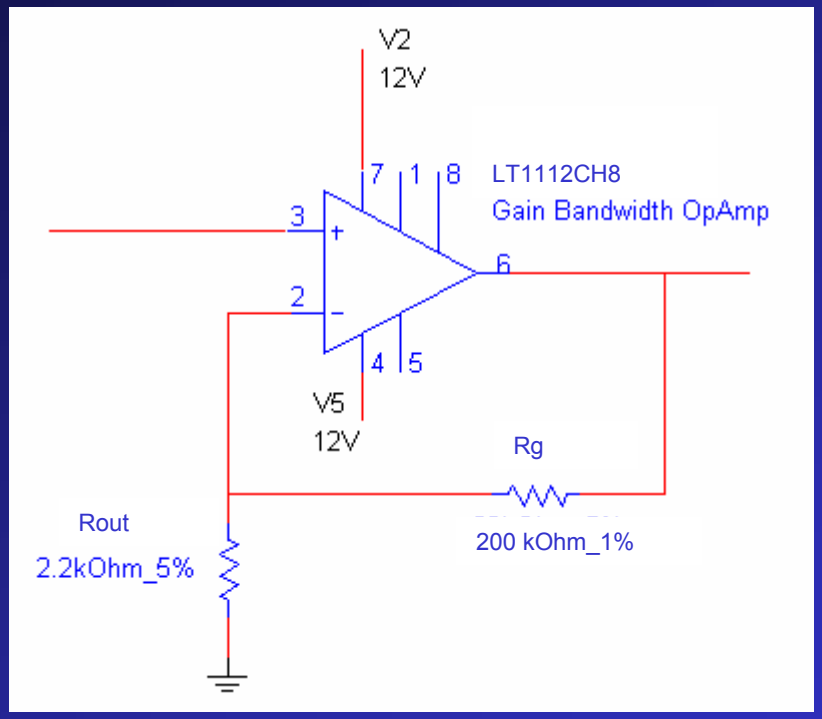
- AKA Unity Gain Impedance Transformer…
- Cleans up the signal
- High impedance → Low impedance
- Without altering the voltage
- Gain = unity
- Low impedance signal means a smaller time constant ($\tau = R * C$)

Stage 1…



Gain Circuit

- Introduce gain to the amplitude of the input



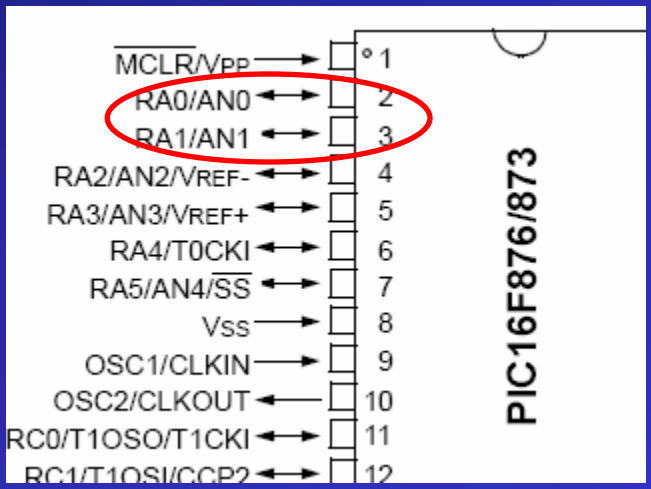
Gain = R_{out} + R_g / R_g

- 22 kOhm / 2.2 kOhm = Gain of 11
- For greater gain, use 200 kOhm instead → Gain of approx. 90!

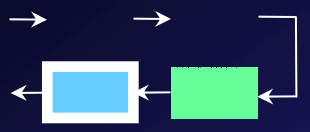
Stage 2…

A/D Converter

- Analog-to-Digital Converter
- Input pins 2 & 3 on microcontroller
- Converts the analog signal (forces) into a signal that can be read and processed by the microcontroller

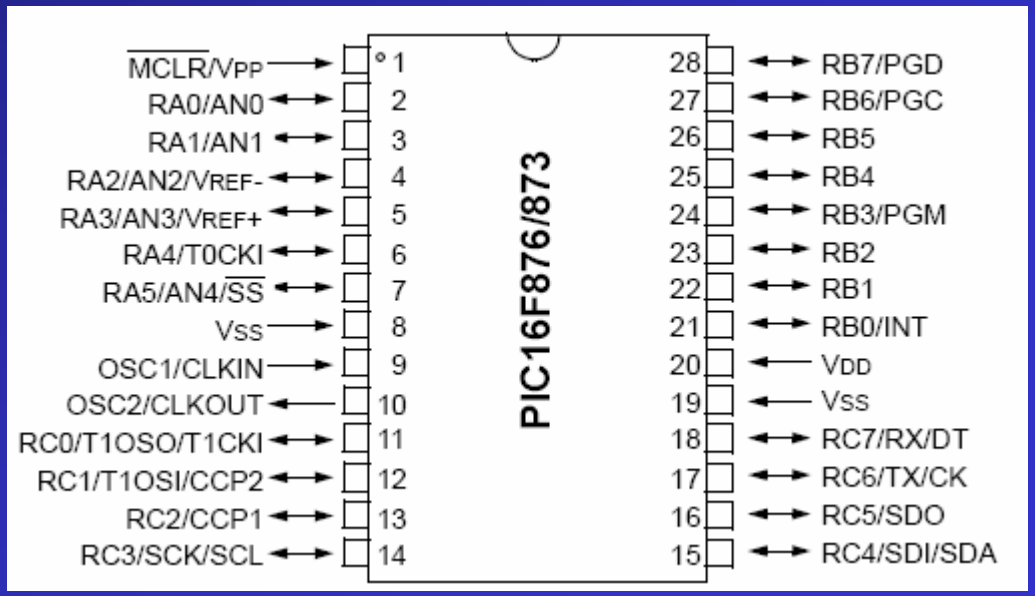


- Resolution of ADC: determines how many bits a reading can be broken down into
- PicMicro ADC → 10 bits
- Analog signal digitized as value from 0 → 1024 (2^{10})



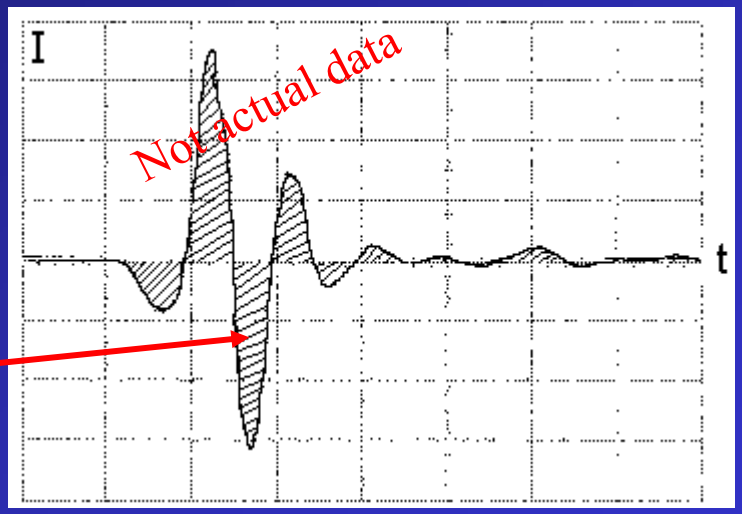
Microcontroller

- Type: PicMicro 16F876
- Languages: C or Assembly
- Software: MPLab 6.5
- Compiler: CC5X (B. Knudsen)
- TRIS function determines input or output
- Set ADC as inputs
- Set DAC as output



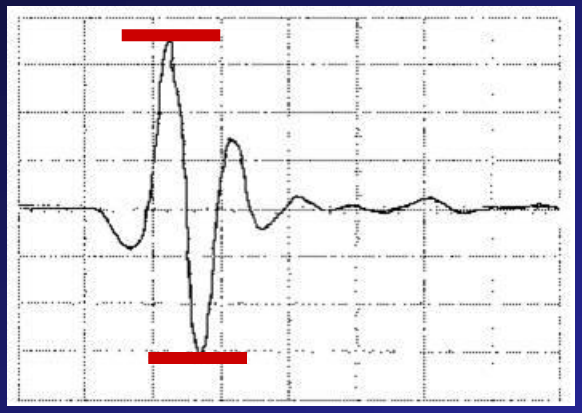
Microcontroller

- Desired Outputs:
  - Maximum of signal
  - Duration of activity (t2-t1)
  - Frequency
  - Integration of signal = overall force!

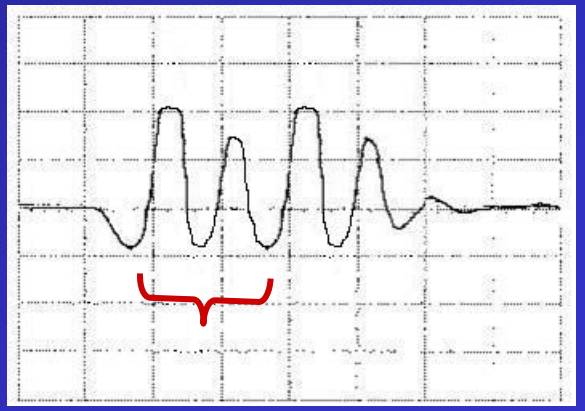


Signal to Analyze

Which factor determines how bone adapts to pressure?

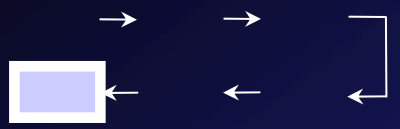


Is it only the maximum forces….



…or accumulation of many forces impacting the skeletal tissue…

…that determine how bone adapts to various pressures?



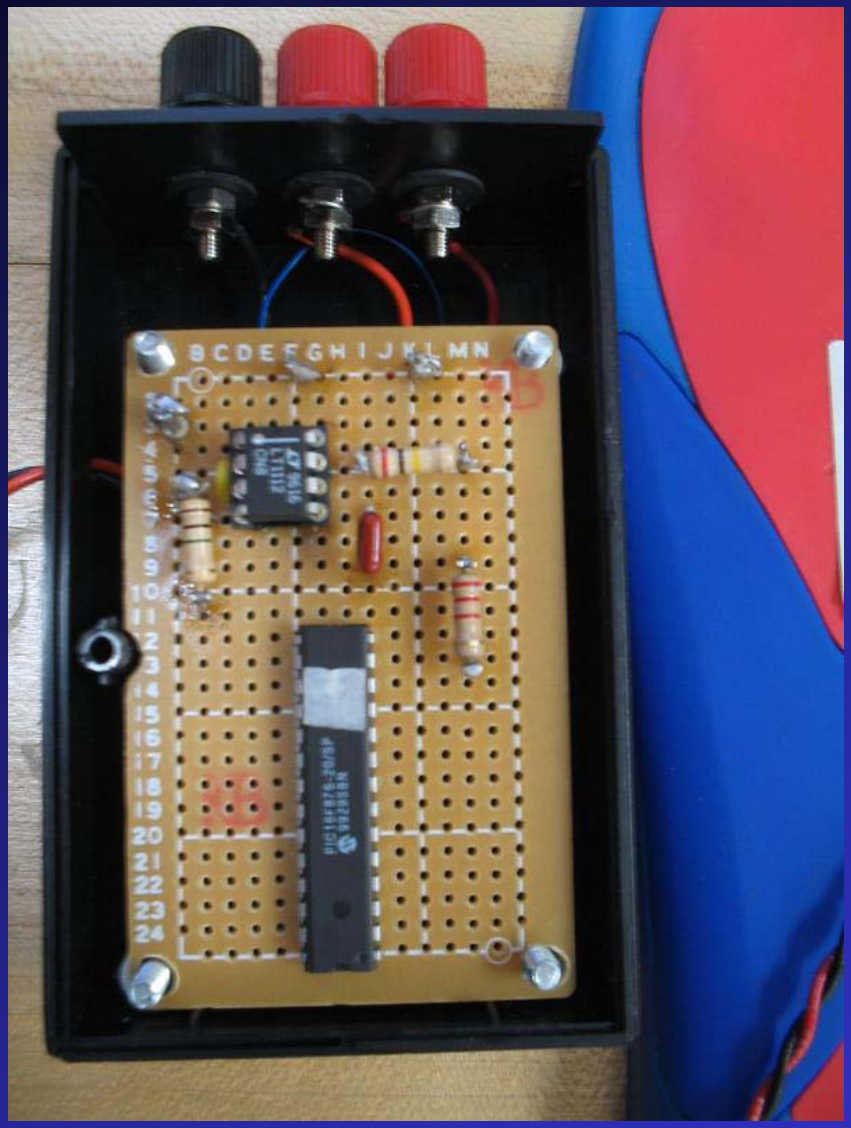
Input/Output

- If wireless functionality incorporated into device, can continually transmit data to a remote location
- Bluetooth Wireless

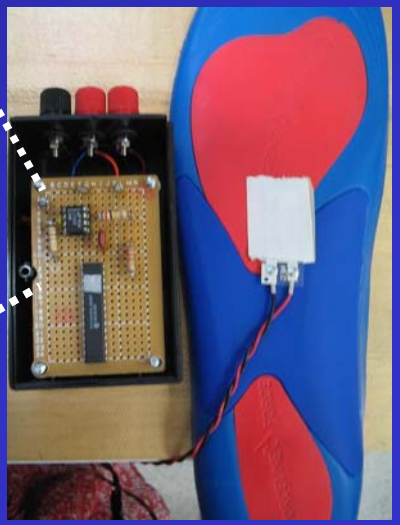
OR

- Store locally on microcontroller (5 kilobytes of data)

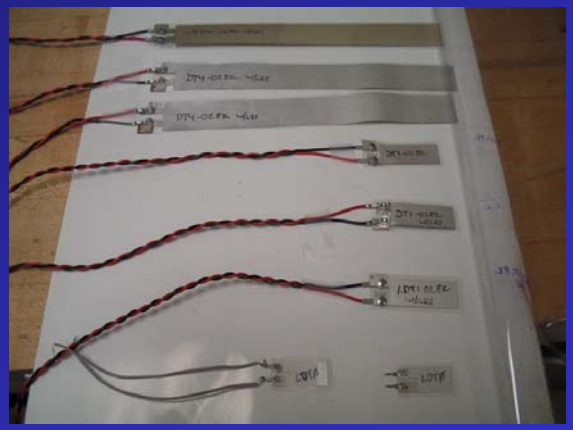
Device Prototype



Pedometer and Box:



Sensor Calibrator

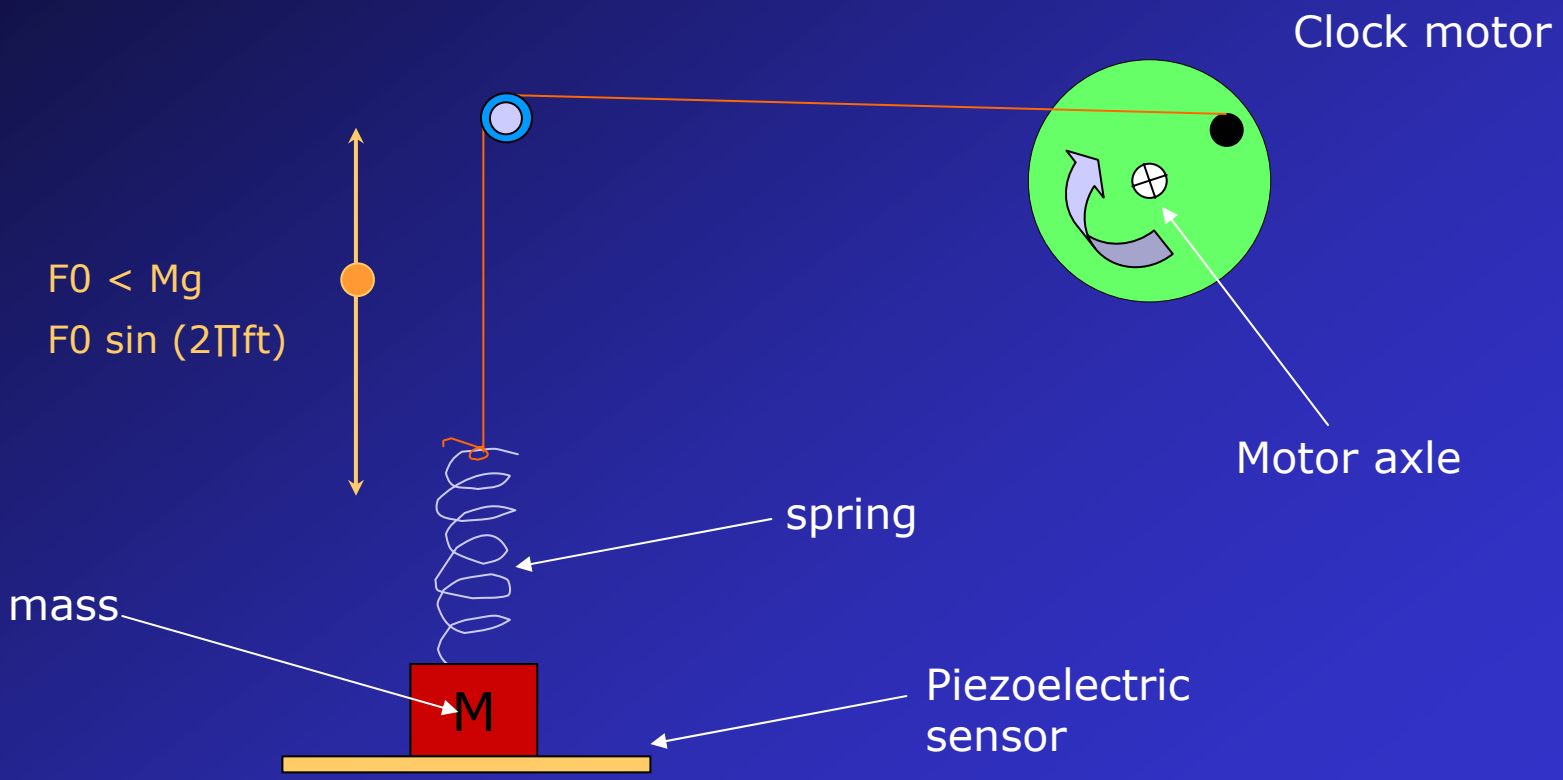


MSI Sensors, Inc

- Need a device to test sensor output…
- Purpose:
  - Serves as a standard stimulus
  - Stimulates a cyclic pattern onto the sensor
  - Compares the response of the sensors over time

- Calibrated spring:
  - Can measure the forces generating the observed charges

Sensor Calibrator



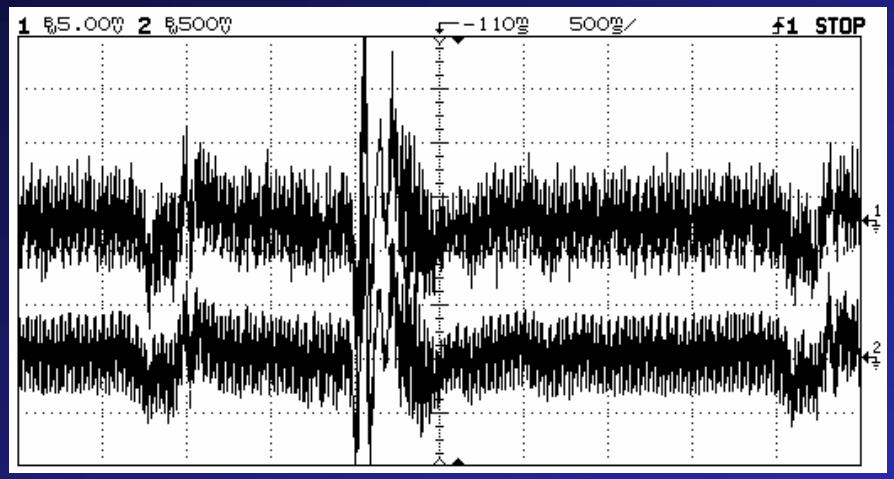
Sensor Calibrator

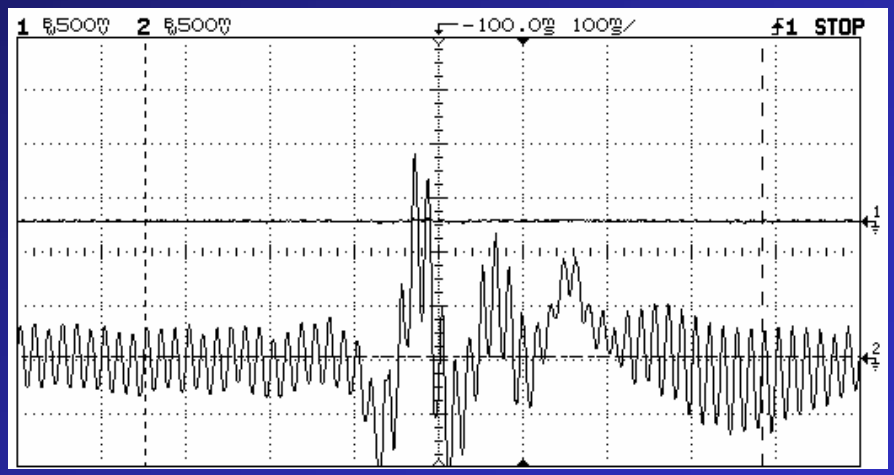
- Drive Wheel & Pulley

- Calibrated Spring & Mass

Results

Testing of Sensors Using Sensor Calibrator:





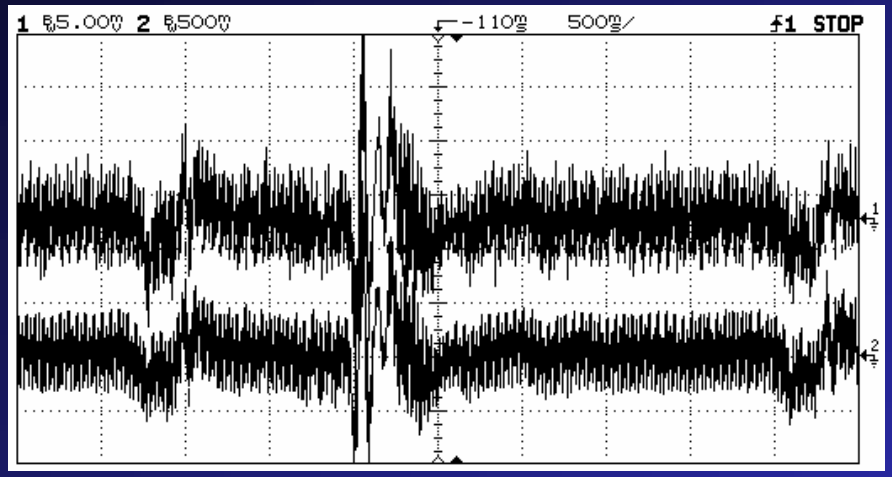
Sensor Output

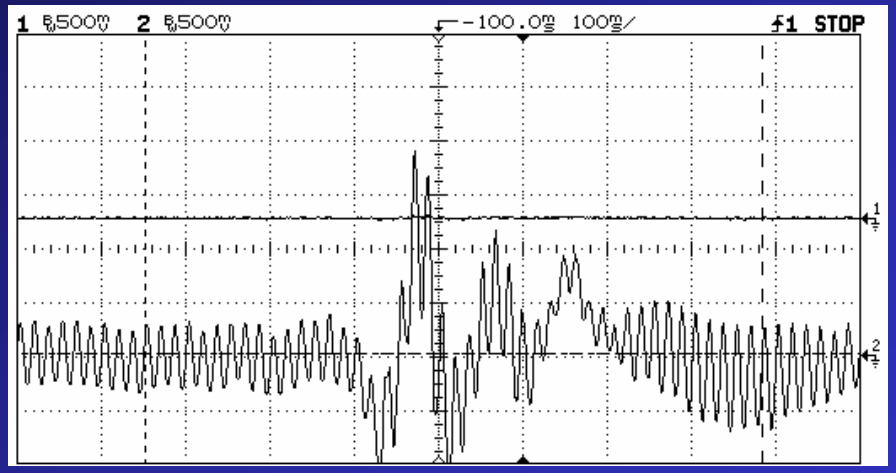
Amplified Signal

- Scale:
  1 – 5.00 mV
  2 – 500 mV

- Scale:
  1 – 500 mV
  2 – 500 mV

What Does it Mean?





- Data collected at different times
- Suggests reproducibility of signal
- Evidence of 60 cycle in signals
- Peak is related to the largest force exerted onto the sensor

Conclusions

- Long-term Goals:
  - Go wireless!
  - Working prototype that kids will wear
  - Permission to test it

- Take-home Message:
  - Sensor-Microcontroller design is extremely versatile
  - Easily adaptable to serve other functions as long as you know how to capture the signals produced by the sensors
  - Depends on type of data desired and type of sensor used
  - Low cost!