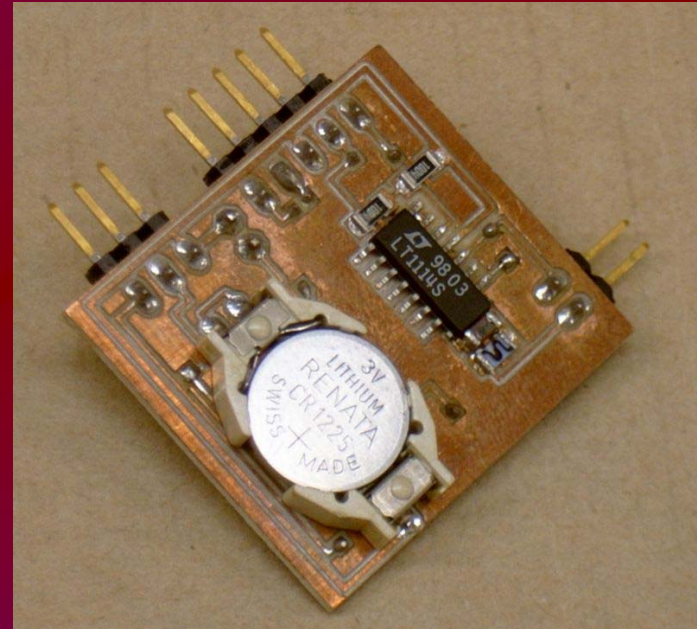
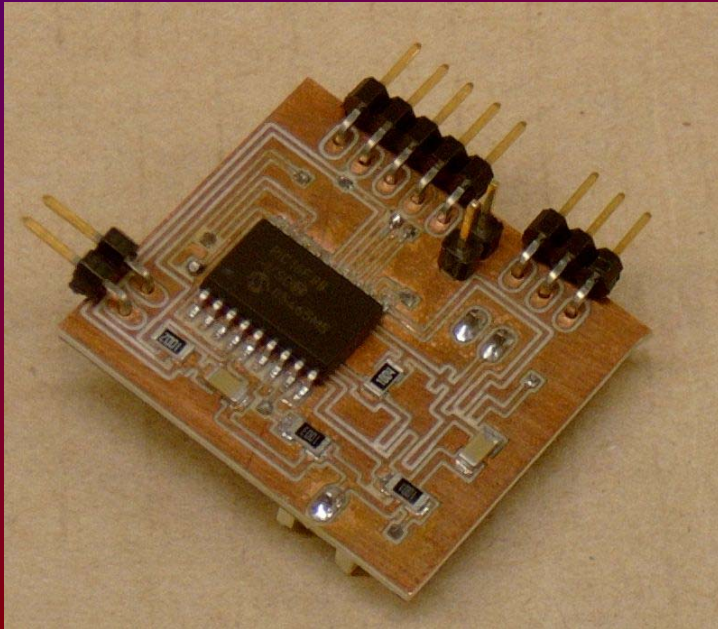


Pediatric Dynamometer

for Pediatric Bone Health Studies



Armand O'Donnell
Advisor: Dr. Jay Zemel

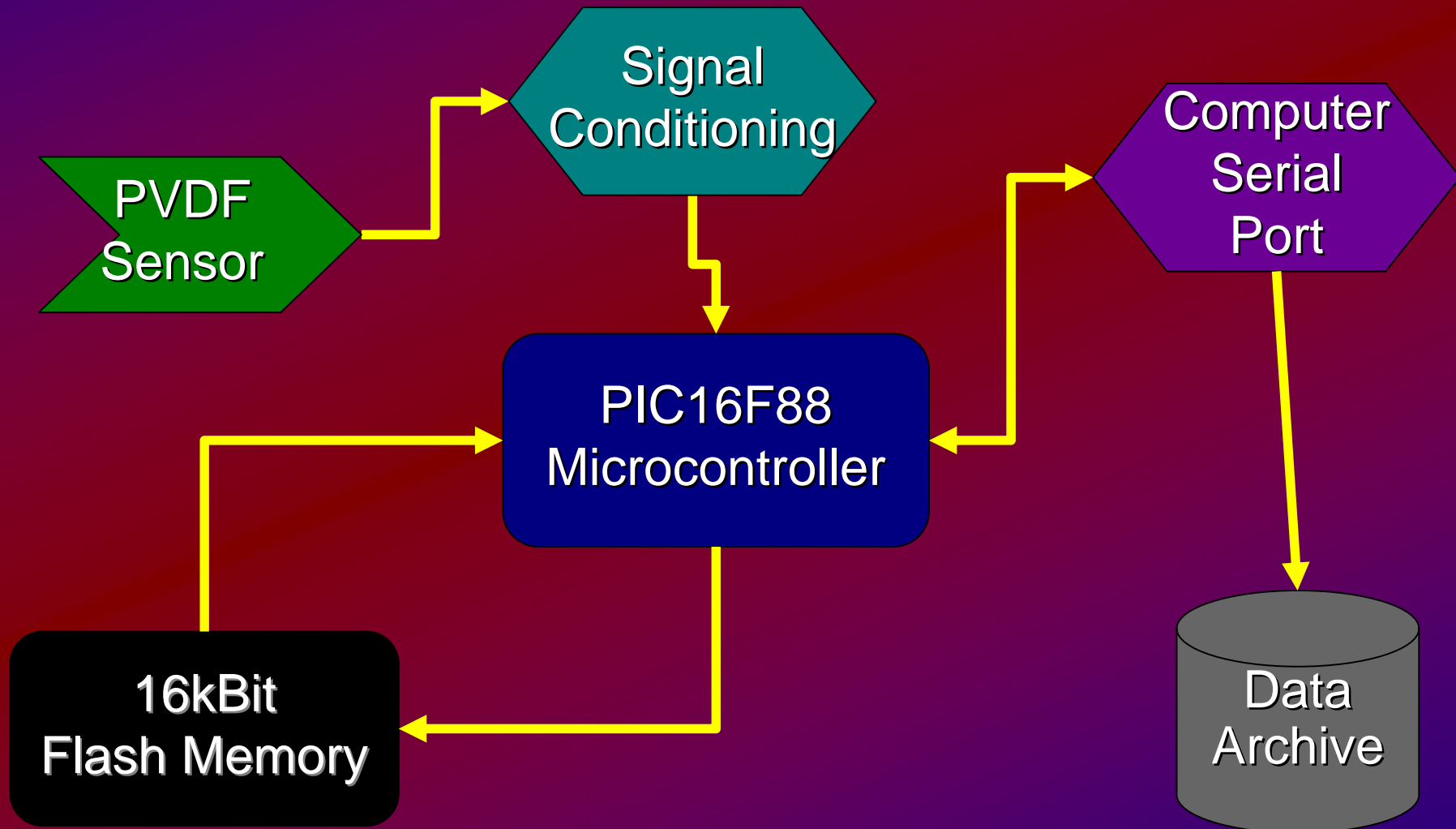
Motivation for Pediatric Dynamometer

- Children's Hospital of Philadelphia:
- Certainly a correlation between strenuous exercise and bone density-but difficult to measure accurately with current technology.
- Surveys unreliable, treadmills not practical for studying children.
- Peak force important: need to monitor each step
- Ideally, need a customizable device.
- Modular: algorithm and sensors can be changed

Background

- **Sunfest 2004-Olivia Tsai began project**
 - Laid the groundwork for beginning the project:
 - Piezoelectric polyVinylidene Fluoride (PVDF)
 - Mechanical testing of sensors
- **Senior Design 2004-2005**
 - Progress in software, using C for programming PIC
 - Analog properties of PVDF and amplifiers
 - Wear device around ankle, wireless link w/PC
- **Senior Design 2005-2006**
 - Reduced size of dynamometer
 - Small enough to fit inside of a child's shoe!

Block Diagram



Goals for Sunfest 2006

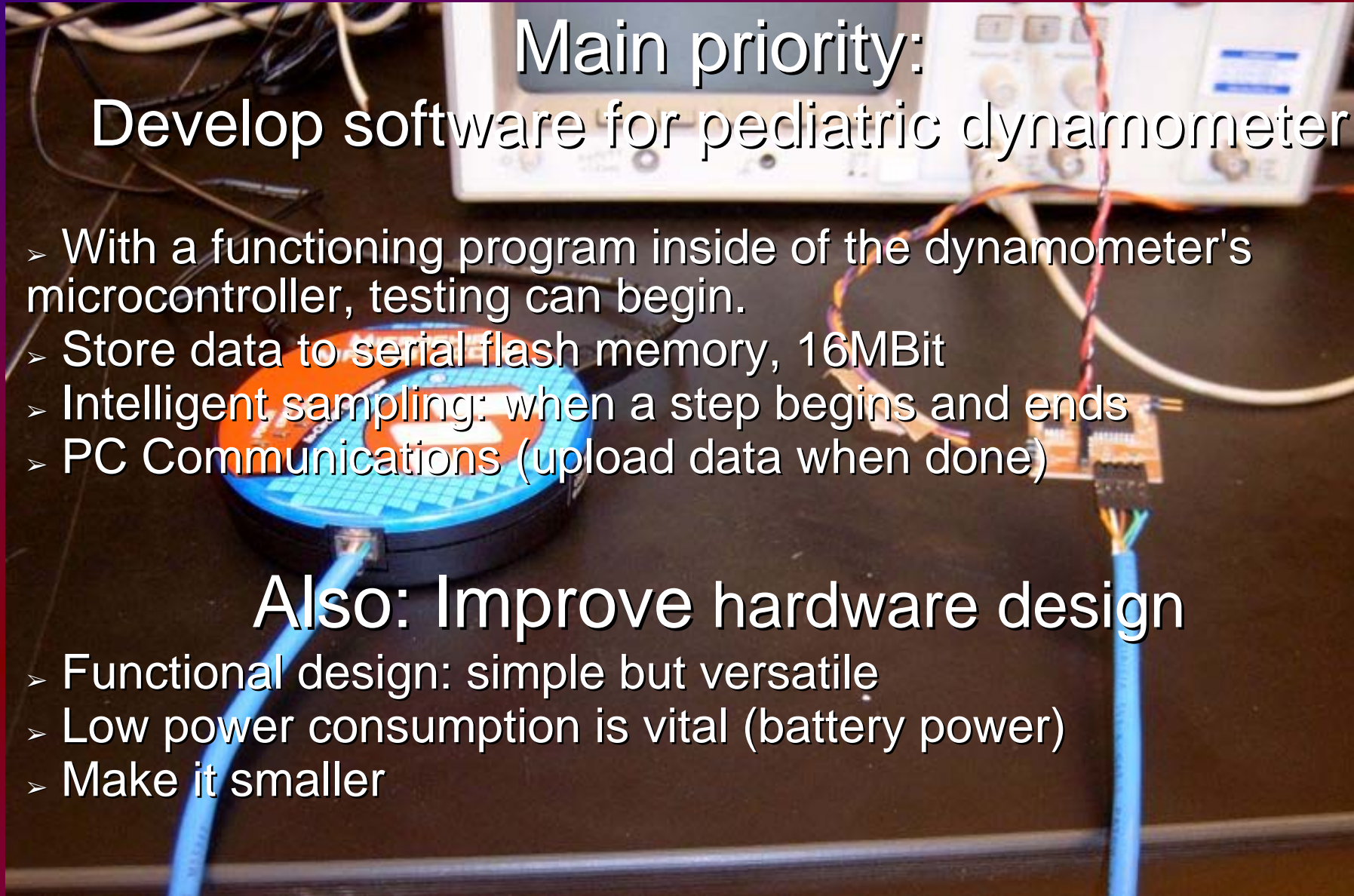
Main priority:

Develop software for pediatric dynamometer

- › With a functioning program inside of the dynamometer's microcontroller, testing can begin.
- › Store data to serial flash memory, 16MBit
- › Intelligent sampling: when a step begins and ends
- › PC Communications (upload data when done)

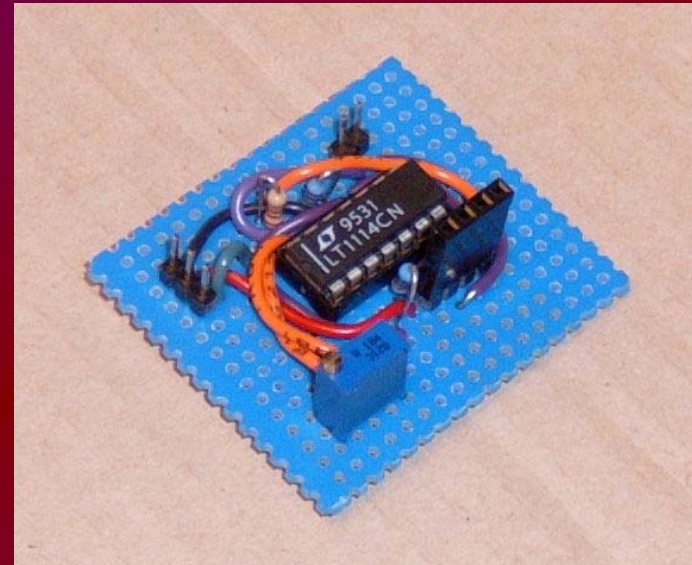
Also: Improve hardware design

- › Functional design: simple but versatile
- › Low power consumption is vital (battery power)
- › Make it smaller

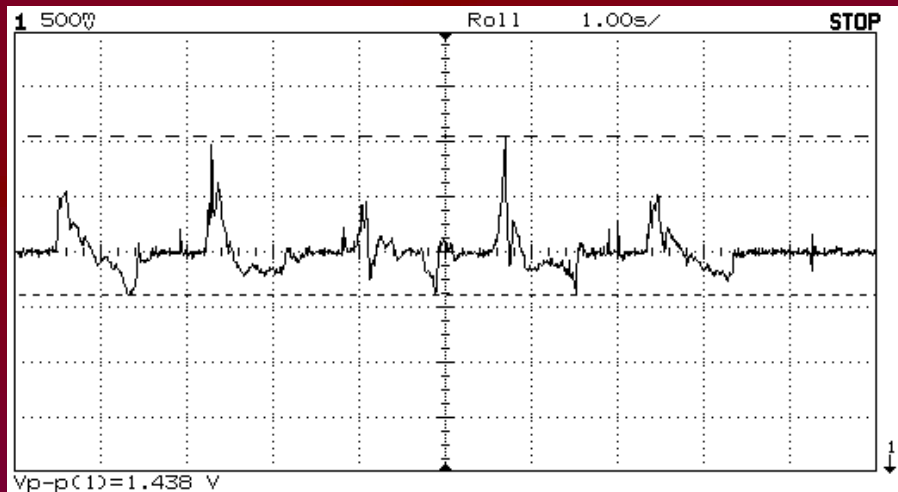


Charge Amplifier/Analog Integrator

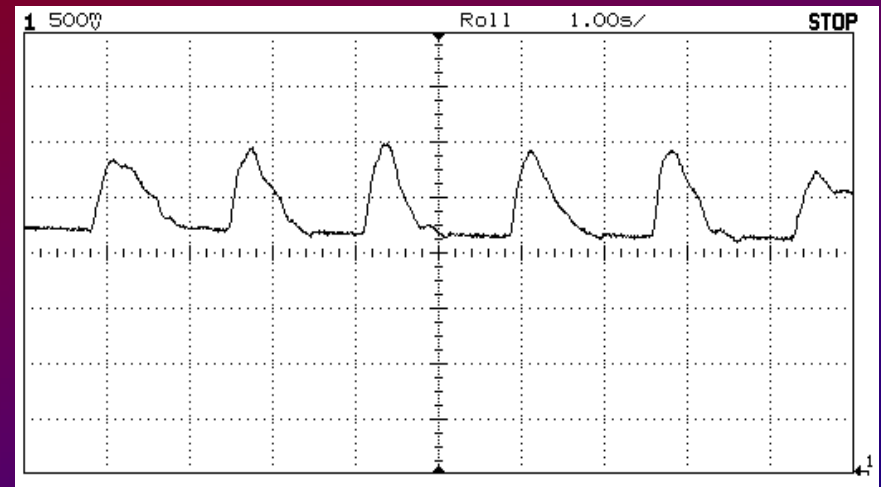
- Integration in hardware, smooth measurements of force on PVDF
- Continuous integration means no missed samples
- Output proportional to force:
- Simpler calculations



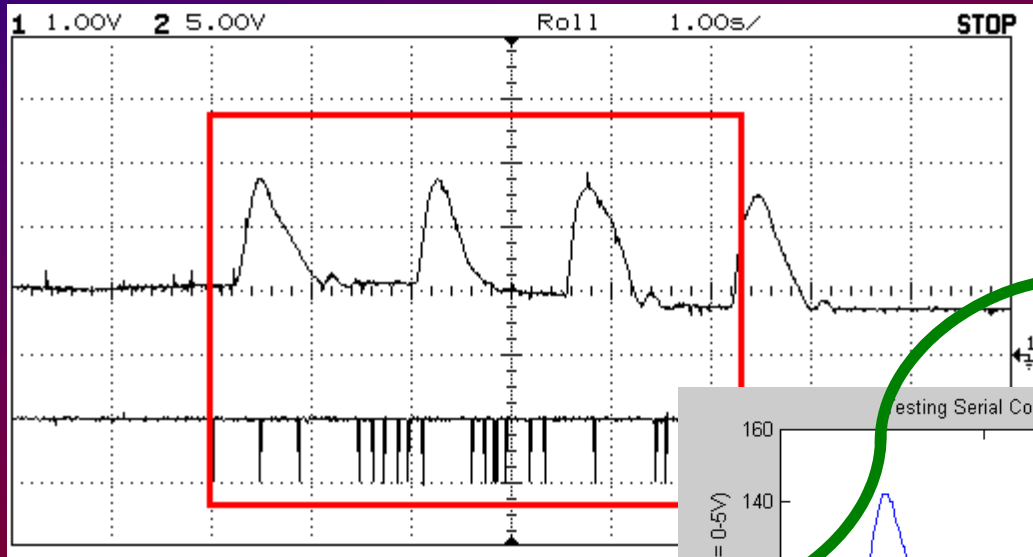
PVDF Sensor



Integral of PVDF

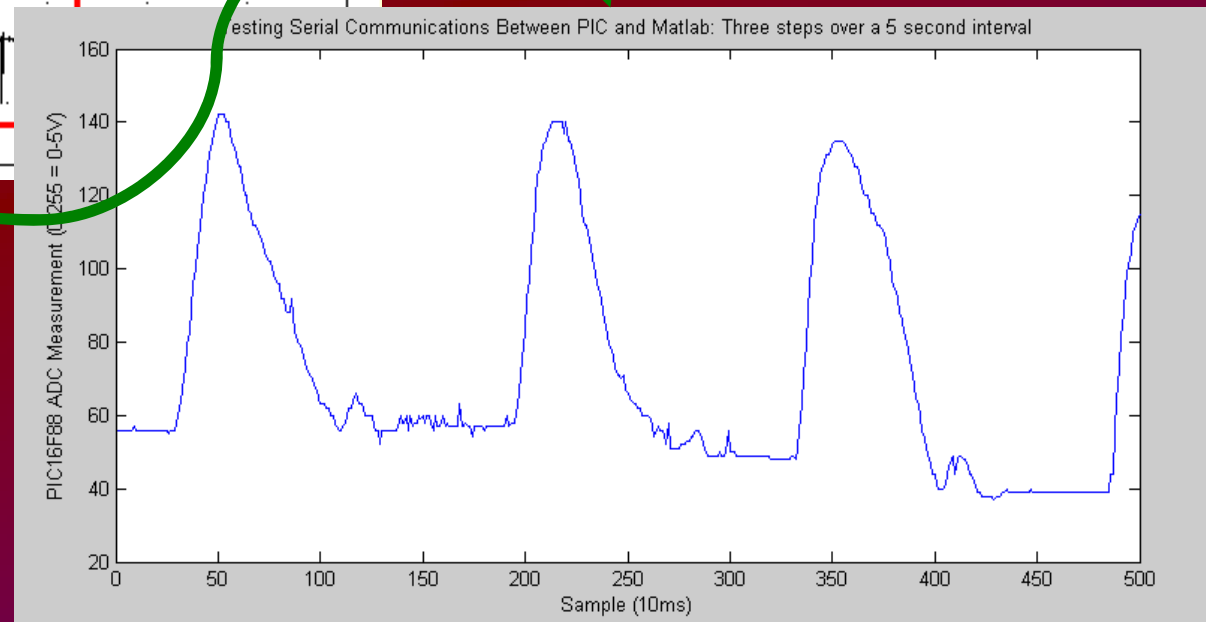


Analog-to-Digital Conversion



- Five usable ADC's
- 10-bit conversion
- 200 samples/sec

Self-calibrates
with respect to
reference
voltage every
256 samples

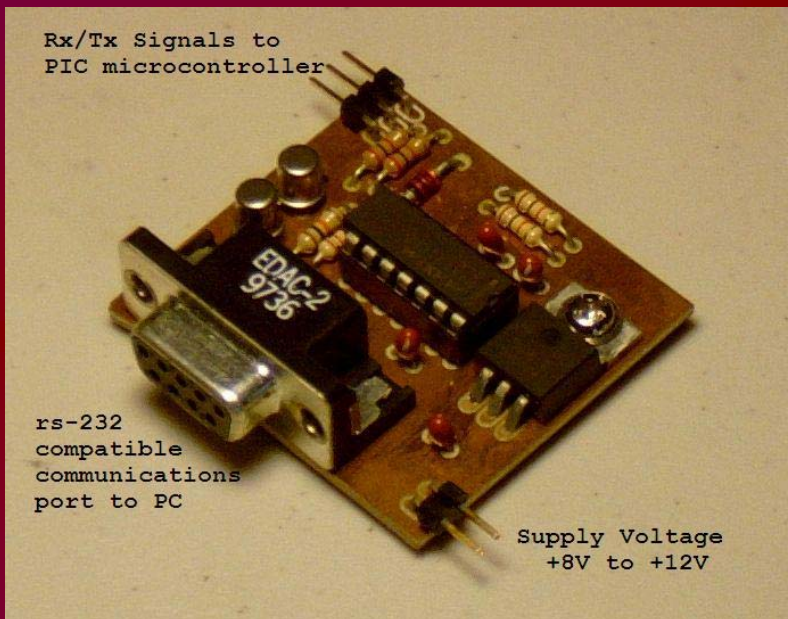
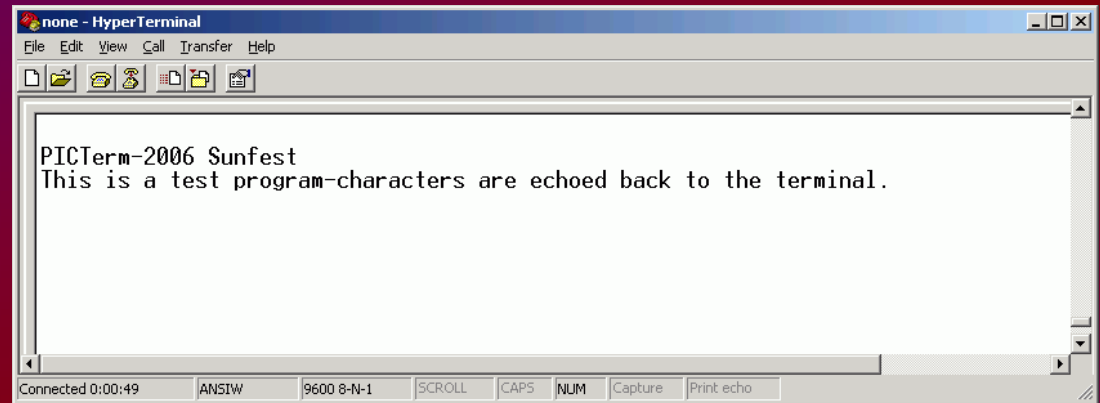


ADC measurements to serial interface
8-bit, 100 samples/sec

Serial Communications

Serial Communications Port of PC:

- Not used much anymore because of slow data rate
- Advantage: no drivers needed, relatively simple protocol-good enough here



Serial Module:

- Used to interface microcontroller and personal computer
- Amplifies low-level signals from PIC to higher voltages required for Serial Communications Port.
- Cheap and quick to make.

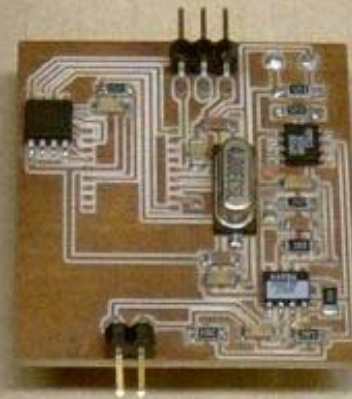
Results - Hardware

**2004-2005
Senior Design**



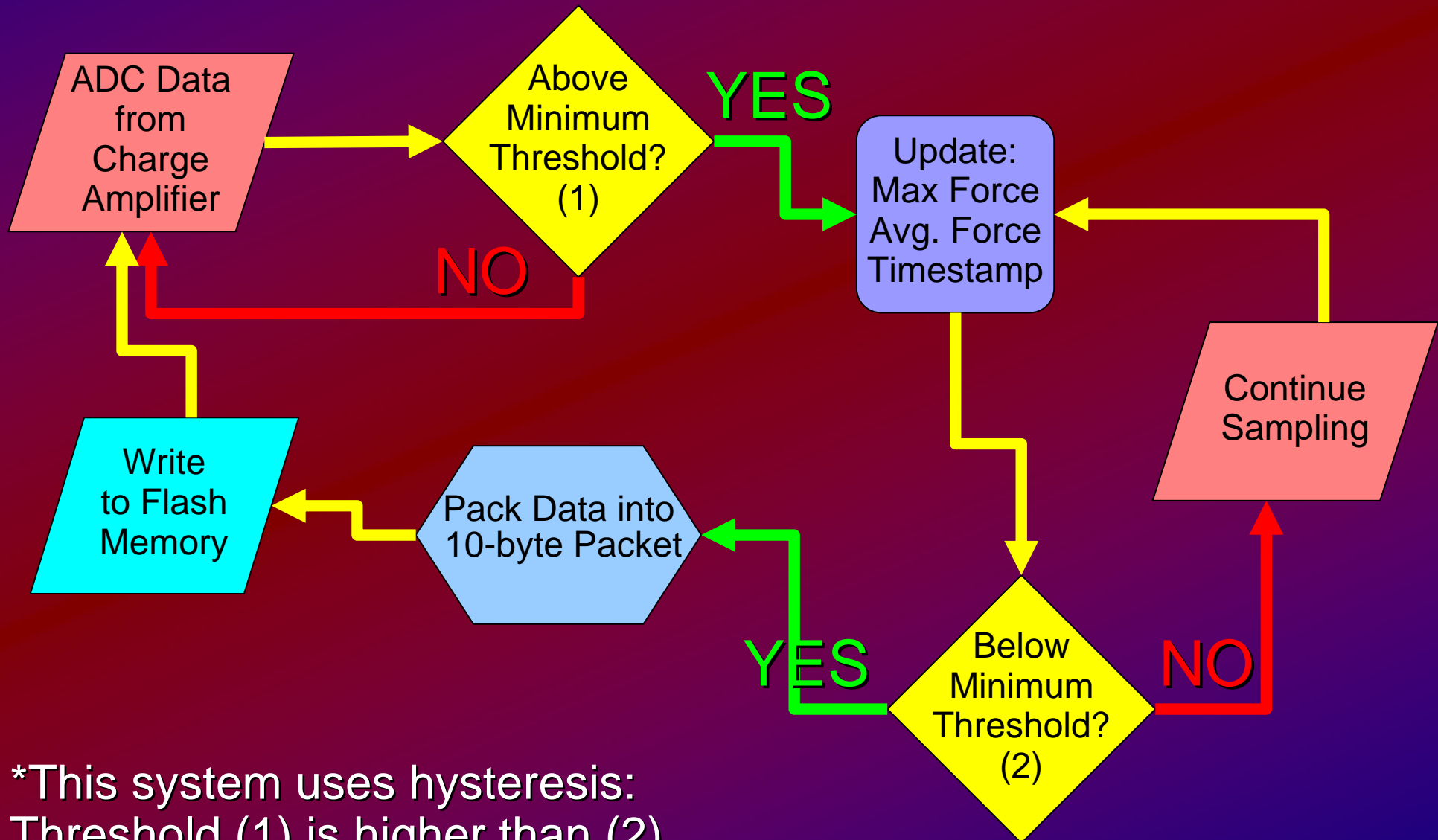
2006 Sunfest

Prototype lacks battery
but 5-pin In-Circuit
Serial Programming
(ICSP) connector can be
removed to save space.



**2005-2006
Senior Design**

Results – Software (Sampling)



*This system uses hysteresis:
Threshold (1) is higher than (2)

Results – Software (Interface)

Data Organized in 10-byte Packets:
(In hexadecimal)

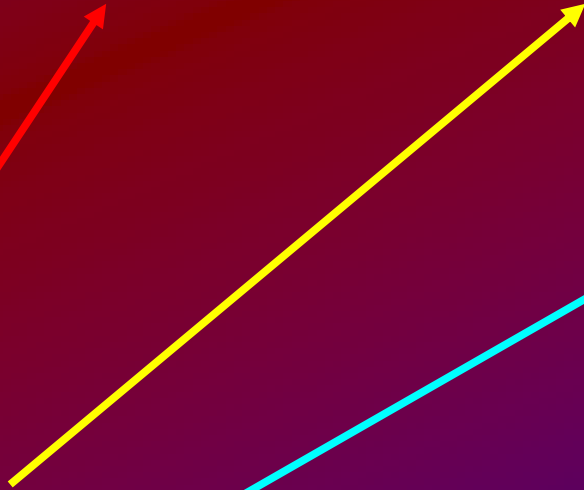
3A 8C 48 00 DC 00 15 7C 00 EB

Beginning of Step:
5:19.45 (timestamp)

Length (time) of Step:
 $220 * 5 \text{ ms} = 1.1 \text{ second}$

Accumulated Force, divide by
time to obtain average force

Peak Force
Range: 0-511



Acknowledgements

- **Dr. Jay Zemel**
 - My advisor for this project
- **Sid Deliwala** from the RCA lab
 - For his support in providing the necessary parts and advice
- **Dr. Haim Bau and Dr. Howard Hu**
 - For tolerating our obnoxiously loud milling machine in their laboratory-Thanks!
- **Dr. Stephen Judd**
 - For reviewing and debugging my code

Lessons Learned

Build accurate prototypes.
Update design frequently.

Some signal processing problems can be solved with a combination of analog and digital circuits.

Low-level devices like the serial flash memory are becoming increasingly standard and “user friendly”. Who would have thought?