Play the music, not the instrument.

~Author unknown

RockIt

Motion Sensitive Guitar

Project Presentation and Demo by

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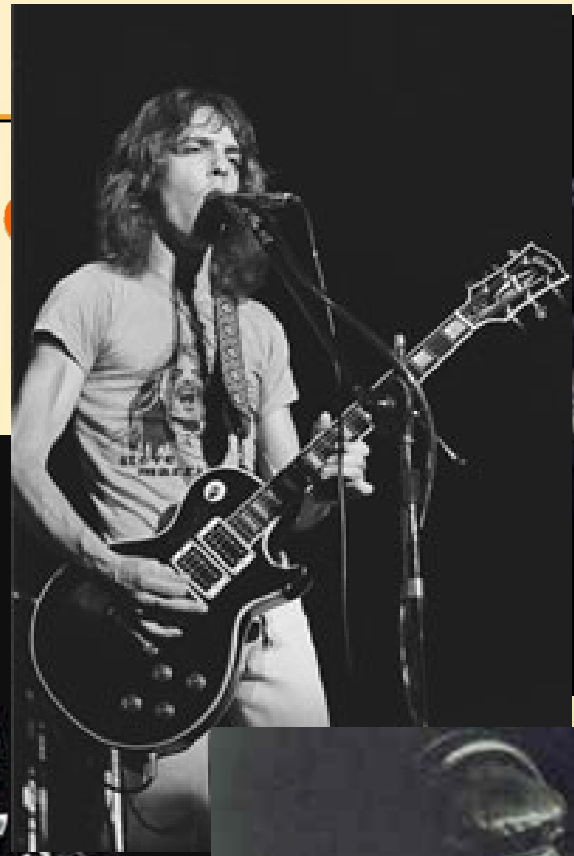
Daniel Galeano – CTO

April 14th, 2008

Ba



Our Goal

- Incorporate New Technology
- Inspire New Music

Effects Pedal circa 1960s

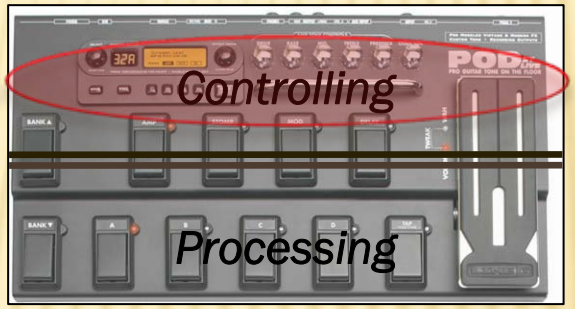
Effects Pedal Today

Problem Space Definition

- Music is a very subjective field
- No single sound effect can satisfy everyone

Guitar

Effects Implementation



Amplifier

RockIt addresses the control of effects, NOT the processing

Images used from: (Line6 Inc., 2008) (Sonicftp, 2005) (Dudes 411, 2004)

Objectives

- ✓Design an Intuitive control mechanism
- ✓Strive for maximum mobility and stage presence
- ✓Support existing systems and effects
- ✓Maintain sound quality

Possible Solutions

Sensors

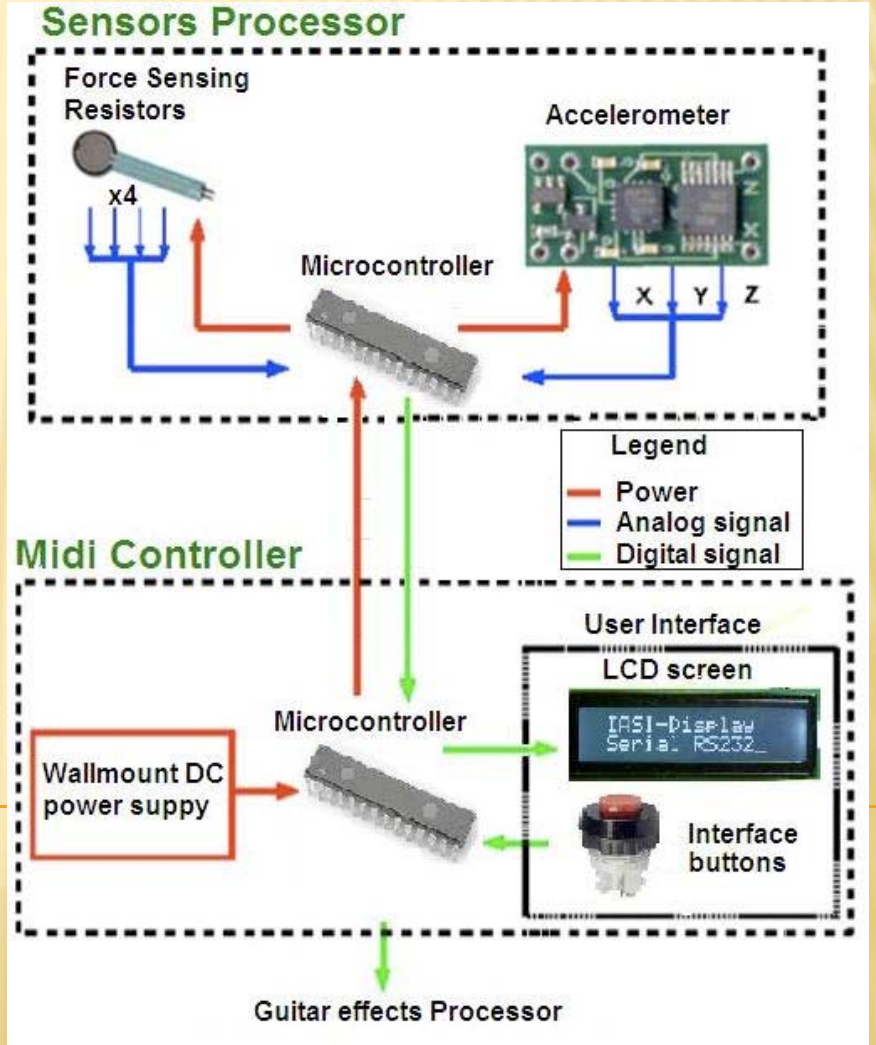
- Gyroscopes
- Piezoelectric
- Strain gauges
- Photo sensor
- Proximity sensor
- RF position sensor
- Magnetic pick-ups
- Accelerometer
- Force sensitive resistors (FSRs)

Sound effects

- Develop our own analog effects
- Develop our own DSP unit
- Control existing analog effects
- Control existing DSP units

System Overview

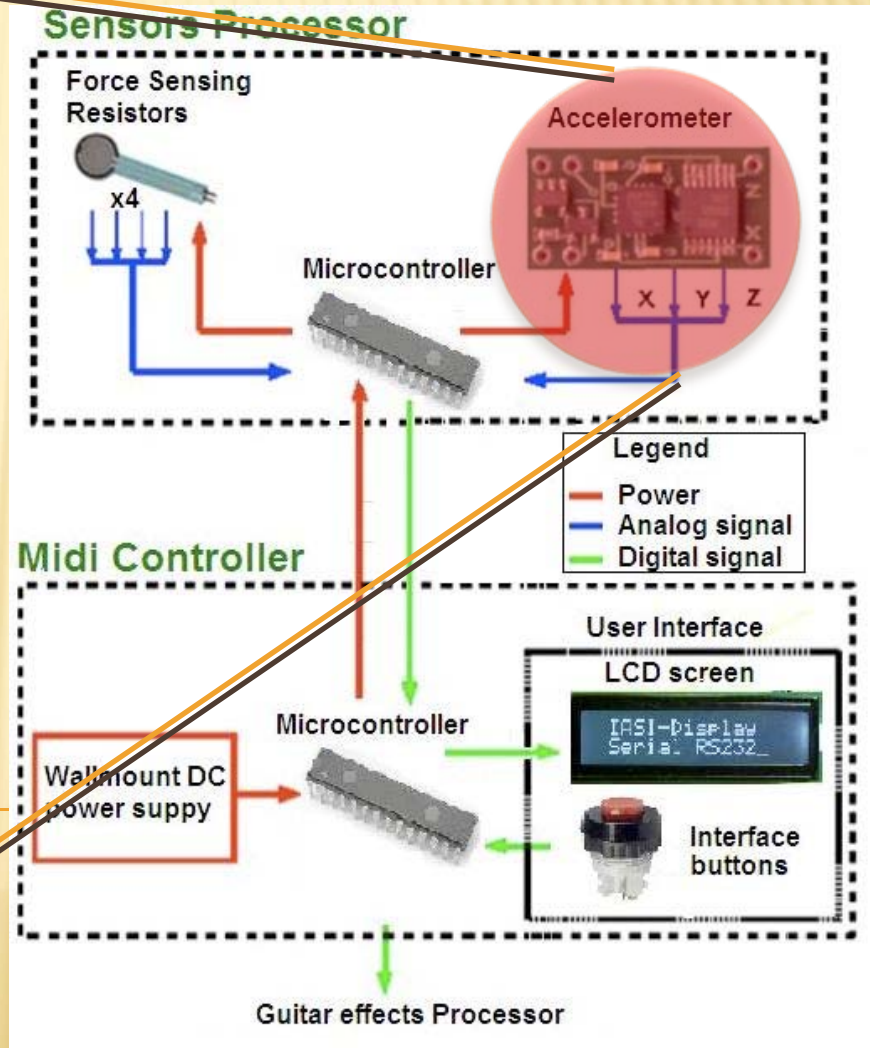
- ✓Two subsystems:
  - •Sensor processor
  - •Midi Controller
- ✓Two types of sensors:
  - •Accelerometer
  - •FSRs
- ✓User interface
- ✓MIDI protocol



Images used from: (Active Robots, 2006) (Global B2B Network, 2009) (Secure Eserver, 2008) (Images Co., 2007) (Dimension Engineering, 2008)

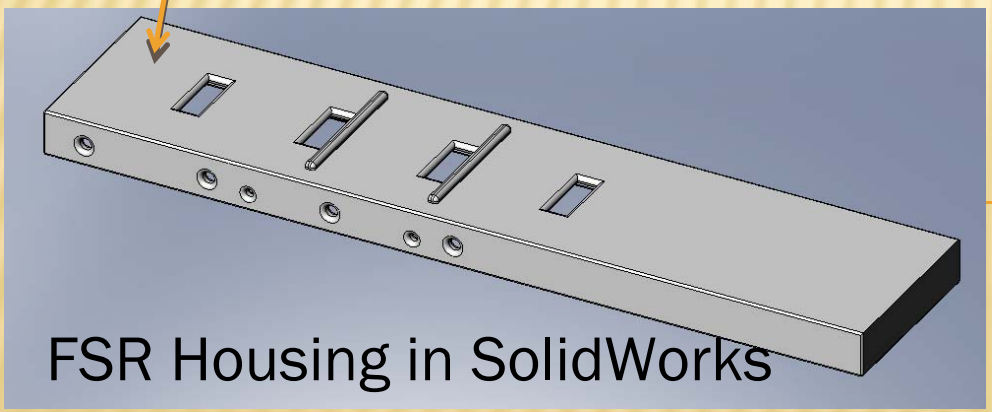
Accelerometer

- ✓Transparent to user
- ✓Two unique triggering methods
  - -Tilt Control
  - -Bump trigger
- ✓Analog output with excellent accuracy
- ✓Analog and digital processing
- ✓Matlab-based emulator platform
- ✓Robust against sensor drift
- ✓In-situ tilt sensitivity control

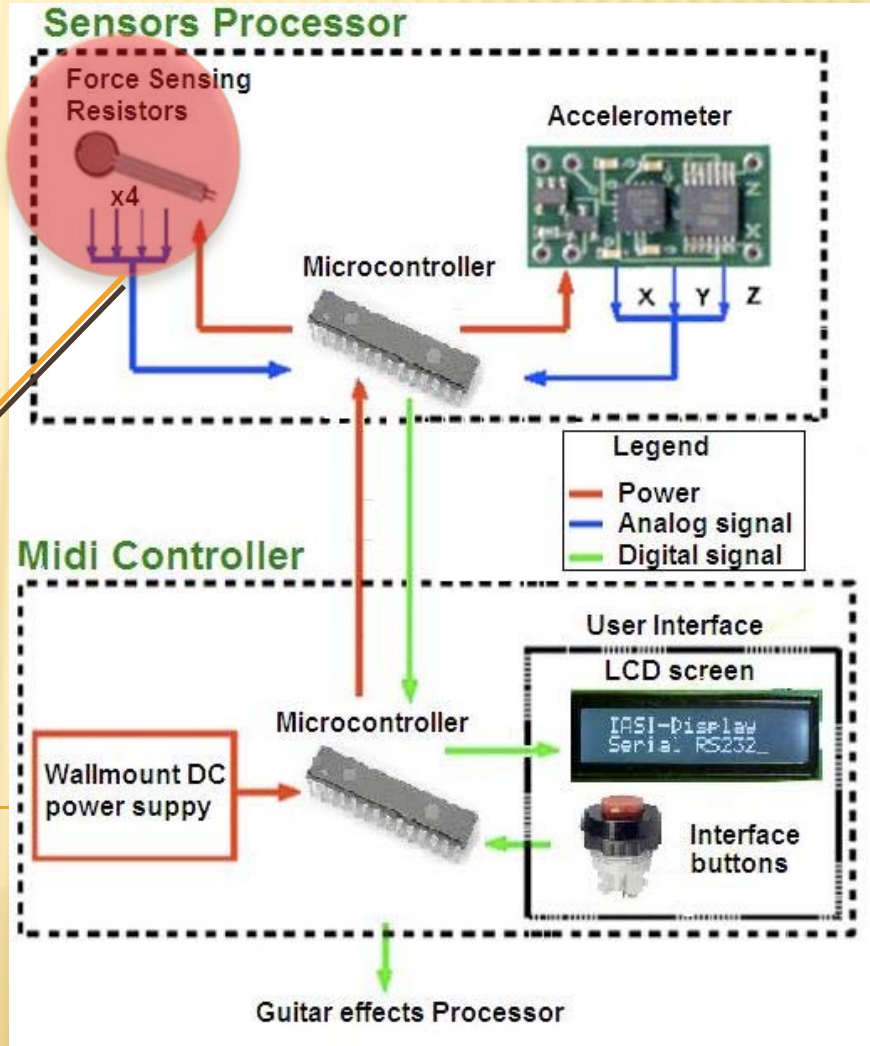


FSRs

- ✓Toggle Accelerometer State
- ✓Toggle Guitar Effect

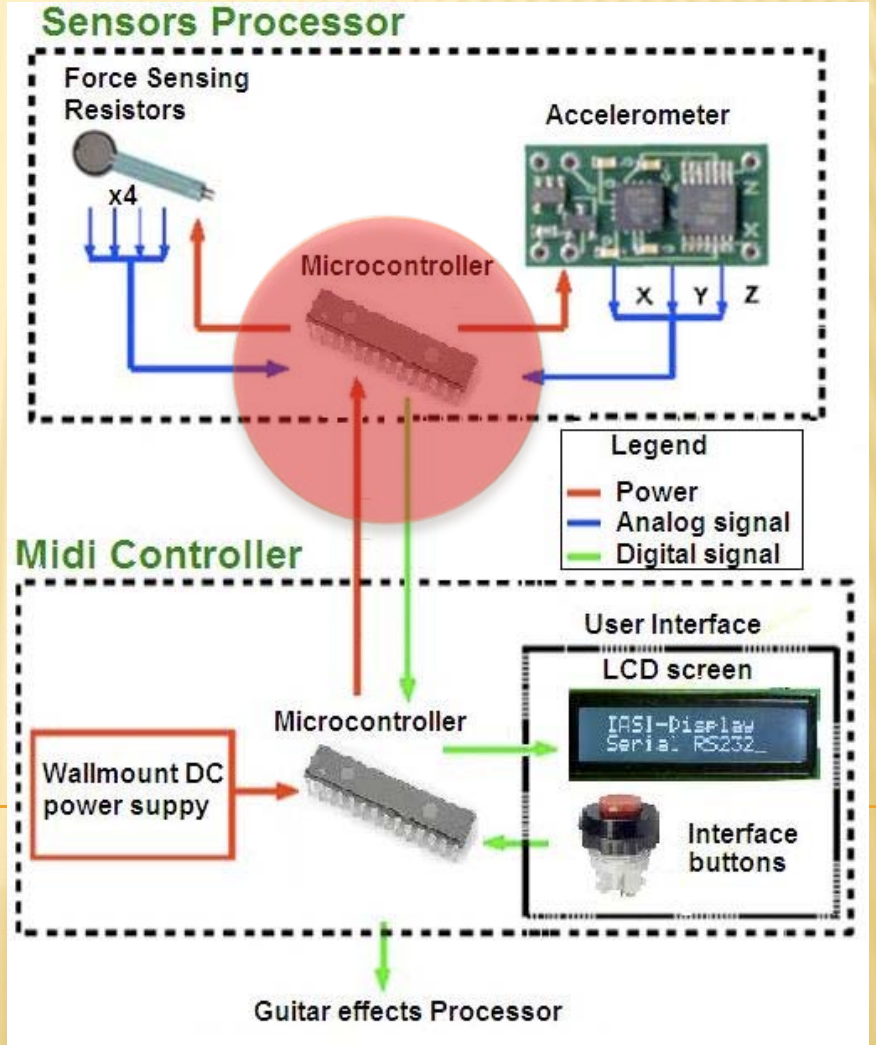


FSR Housing in SolidWorks



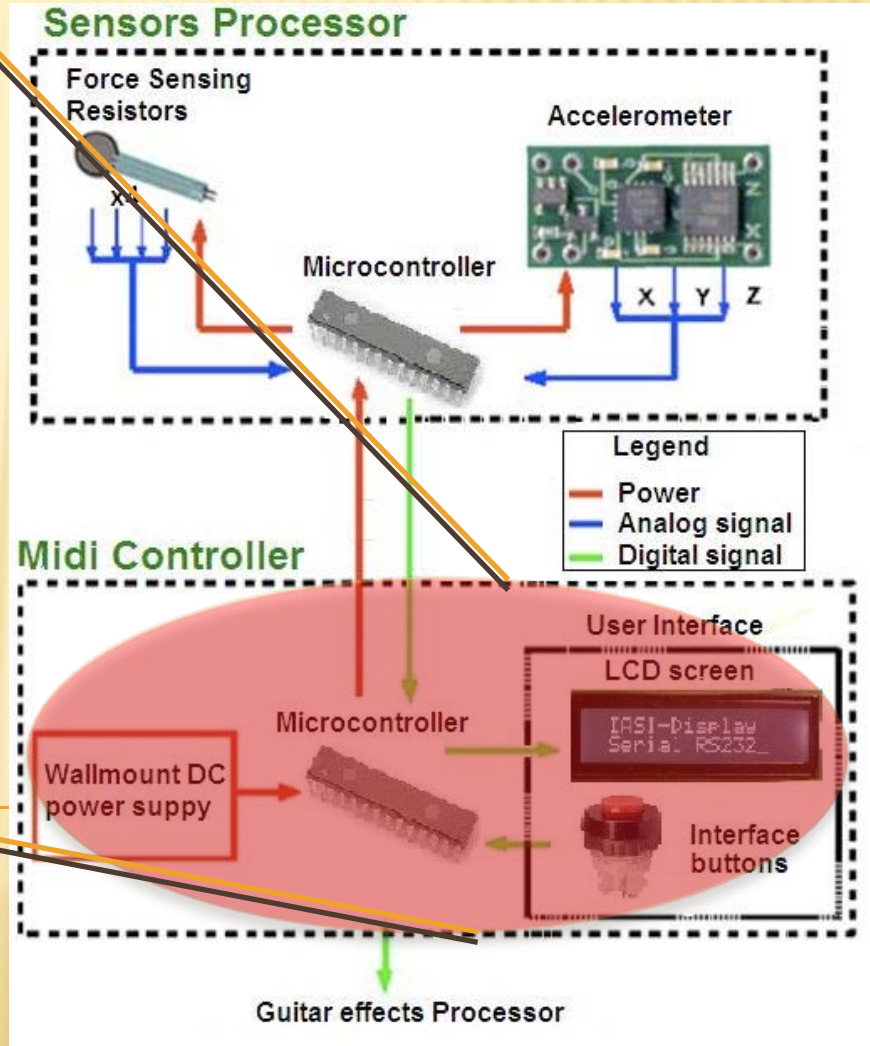
Sensor processor

- ✓Portable
- ✓Non-intrusive
- ✓Modular nature
- ✓C based PIC microcontroller
- ✓Signal processing capabilities



MIDI controller

- ✓Maps Sensor Processor signals
- ✓MIDI protocol
- ✓Modular design
- ✓User interface



PODxt Live

http://shop.sinky.net/photos/200573111214835.jpg

Commercialization

- R&D Project: Can we honestly compete against foot pedals?
- Open Source Project
  - -Great for product development
  - -Judge market interest
- How we profit: sell DIY development kits!

MIDIBox Portal: http://www.midibox.org/dokuwiki/

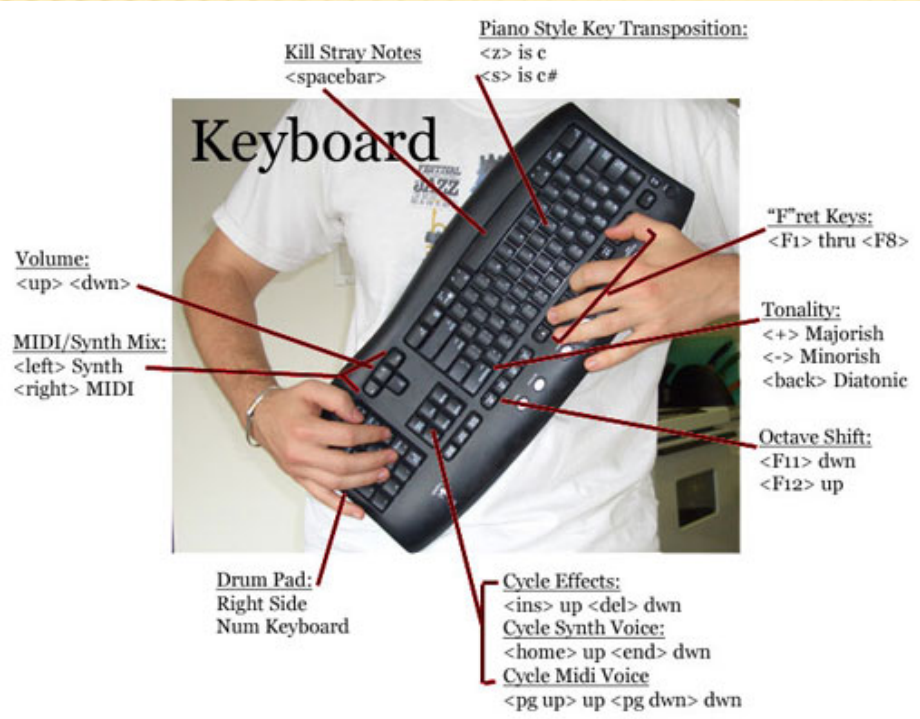
Commercialization: Con't

Cost Breakdown of System components	
Two 18F PICs	$10
Accelerometer	$10
FSR:	$6/sensor
Enclosures	Optional - $30
Auxiliary Items: Cat-5 cable, connectors, resistors, etc.	$30
Single Sided PCB's	$20
Total Kit Costs	**$125**

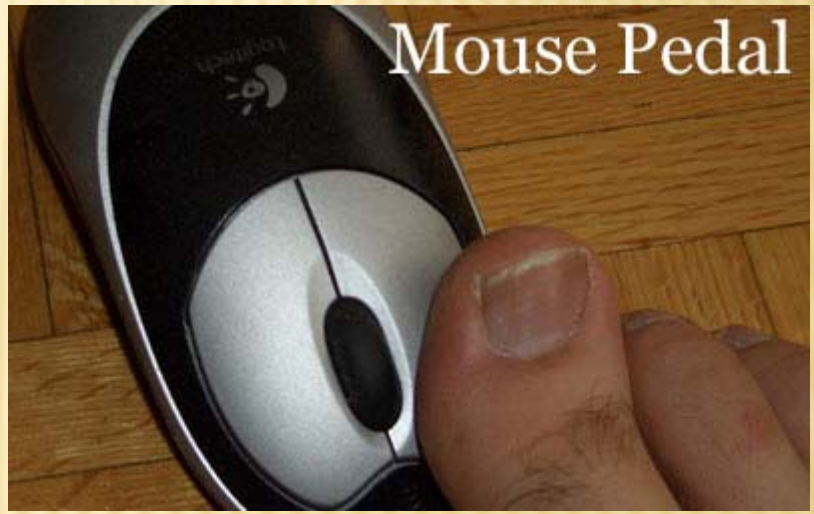
- Assumptions: No rushed orders and purchases in bulk

Commercialization: Competition

- No commercially comparable products
- Other interesting research projects



B-Tar 3000



Mouse Pedal

Input Device and Music Interaction Lab: McGill University
http://www.music.mcgill.ca/~benjamin/btar3000/

Commercialization: Conclusion

- Risky Venture: Community adoption
- Great for electronic hobbyist who also play guitar
- Requires more development before considering commercialization
- Future??

High-level Project Details

- Project costs
- Group dynamics
- Time management
- Difficulties
- What was learnt

Project Costs

- Entirely member funded

Accelerometer development kits: x3	$120
FSR: Samples and final set: x6	$70
Rush order PICs: x2	$25
Enclosures, Connectors, Break-out board, Surface mount capacitors, sockets, etc.	$155
MIDI-to-USB Adaptor	$45
Custom FSR Enclosure	$30
Total Project Costs	**$445**

Project Development/Group Dynamics

- Parallel system development
  - -Two design groups
  - -Excess components: PICs, breadboards, etc.
- Every member became single component expert
- Central Desktop: Project management wiki
- Matching PICs: reduce PIC problems
- Milestones with tangible results as outcome:
  - -MIDI Monitor
  - -ICD2 Debugger
  - -Matlab emulator

Development Timeline (Original)

FSR

-Finish testing & characterization:	Feb 22
-Design PIC interface & circuitry:	Feb 29
-Final assembly:	Mar 14
-System test of FSR/PIC:	Mar 25

Sensor Processor

-Blinking LED:	Feb 22
-UART interface:	Feb 29
-System test of PIC & Sensors:	Mar 14
-Test of Sensor Processor to MIDI Controller communications:	Mar 25

Accelerometer

-Finish testing & characterization:	Feb 27
-ADC interface with PIC:	Feb 29
-Finalize design:	Mar 14
-System test of Accelerometer/PIC:	Mar 25

MIDI Controller

-Arrival of MIDIBox unit:	Mar 03
-PC to POD interface:	Mar 10
-Generate MIDI messages:	Mar 17
-System test of MIDIBox to POD communications:	Mar 22

Development Timeline (Realized)

FSR

-Finish testing & characterization:	Feb 20
-Design PIC interface & circuitry:	Mar 12
-Final assembly:	Apr 08
-System test of FSR/PIC:	Mar 21

Sensor Processor

-Blinking LED:	Mar 05
-UART interface:	Mar 16
-System test of PIC & Sensors:	Mar 20
-Test of Sensor Processor to MIDI Controller communications:	Apr 07

Accelerometer

-Received accelerometers:	Feb 15
-PIC ADC functional:	Feb 28
-Finalize tilt and bump algorithms:	Mar 10
-Finish MATLAB test bed:	Mar 26
-Implement tilt algorithm in PIC:	Mar 17
-System test of tilt with POD:	Mar 28
-Finalize z-axis sensor:	Apr 04

MIDI Controller

-Arrival of PIC 18F2420:	Mar 03
-PC to POD interface:	Feb 25
-Generate MIDI messages:	Mar 12
-System test of MIDIBox to POD communications:	Mar 20
-User interface integration:	Apr 04

Lessons Learned

- Human interfaces are tricky
- Physical packaging
- Choice of microcontroller
- Debugging tools are essential
- Group organization should be flexible

Difficulties

- Only 12 weeks to conceptualize, outline, and complete project
- Narrowing design options
- MIDI options

Summary & Future Improvements

- ✓*RockIt* is an Expansive Product
- ✓User Interfaces Require Iterative Testing
- ✓Capabilities to expand
  - ✓Advanced components (PIC/Accelerometer)
  - ✓Wireless Components
  - ✓Embedded Sensors
  - ✓Open-Source for Customized Use

DEMO

Low Level Project Details

- Accelerometer Implementation
- FSR Implementation
- Communication Protocol
- MIDI Monitor

Accelerometer: Technical Details

- Analog Devices AD XL330 accelerometer:

  Analog output, 3-Axis, ±3g of range

- Digital & Analog filtering: f_s = 120Hz

  -Analog RC low-Pass filter: f_c=12-23Hz

  -Digital filter: Simple averaging technique

  1.4Hz Low pass, 2-22Hz bandpass

  →8-9 bits of readout accuracy

- Robust against sensor drift:

  -Relative comparisons for tilt and shock: Common mode rejection

Matlab Emulator

- Not practical to monitor real-time ADC values
- Solution: Matlab Emulator
- Create scripts that emulate system components:

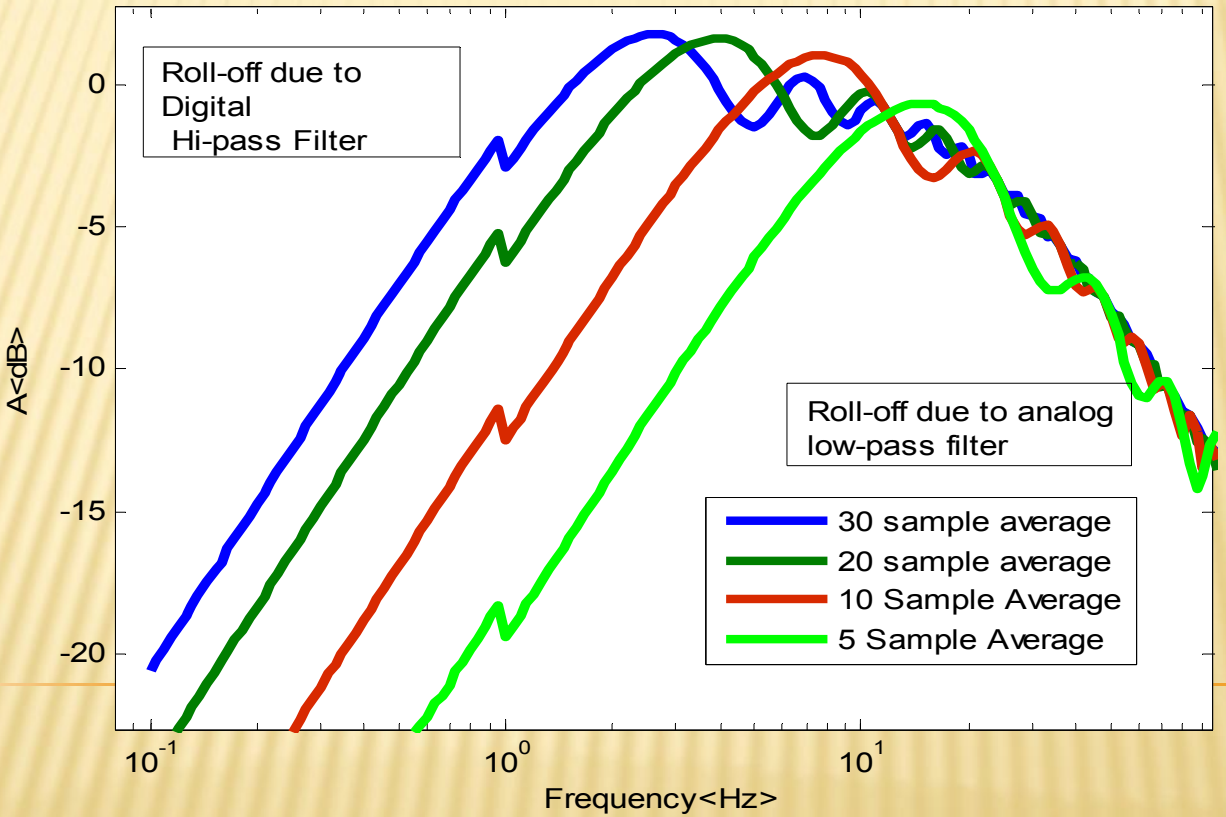
1-Gravity projection onto sensor axes
2-Acceleration-to-voltage transducer
3-Analog RC low-pass filter
4-Analog-to-Digital Converter: 10 bit accuracy with variable sampling frequency
5-Digital Filter

Algorithm implementation, analysis and debugging all within Matlab

Matlab Emulator: Filter Design

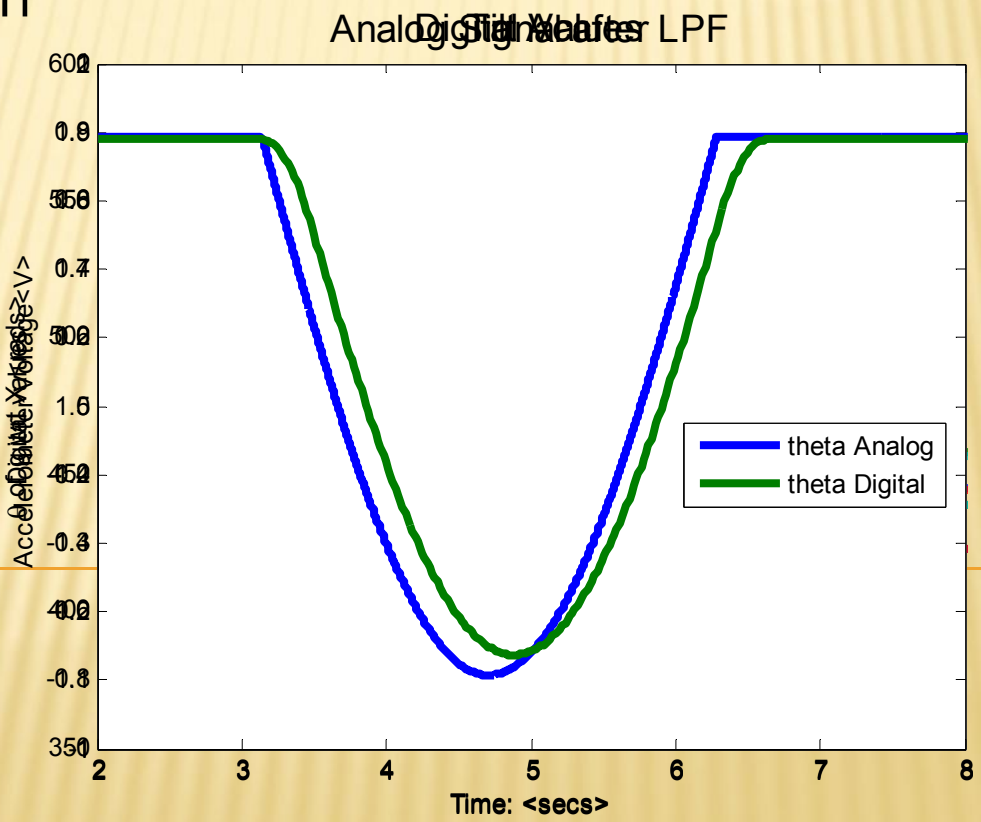
- Tune Mixed Signal Filter Response in software

Z-Axis response with: f_s = 120Hz, f_c = 23Hz



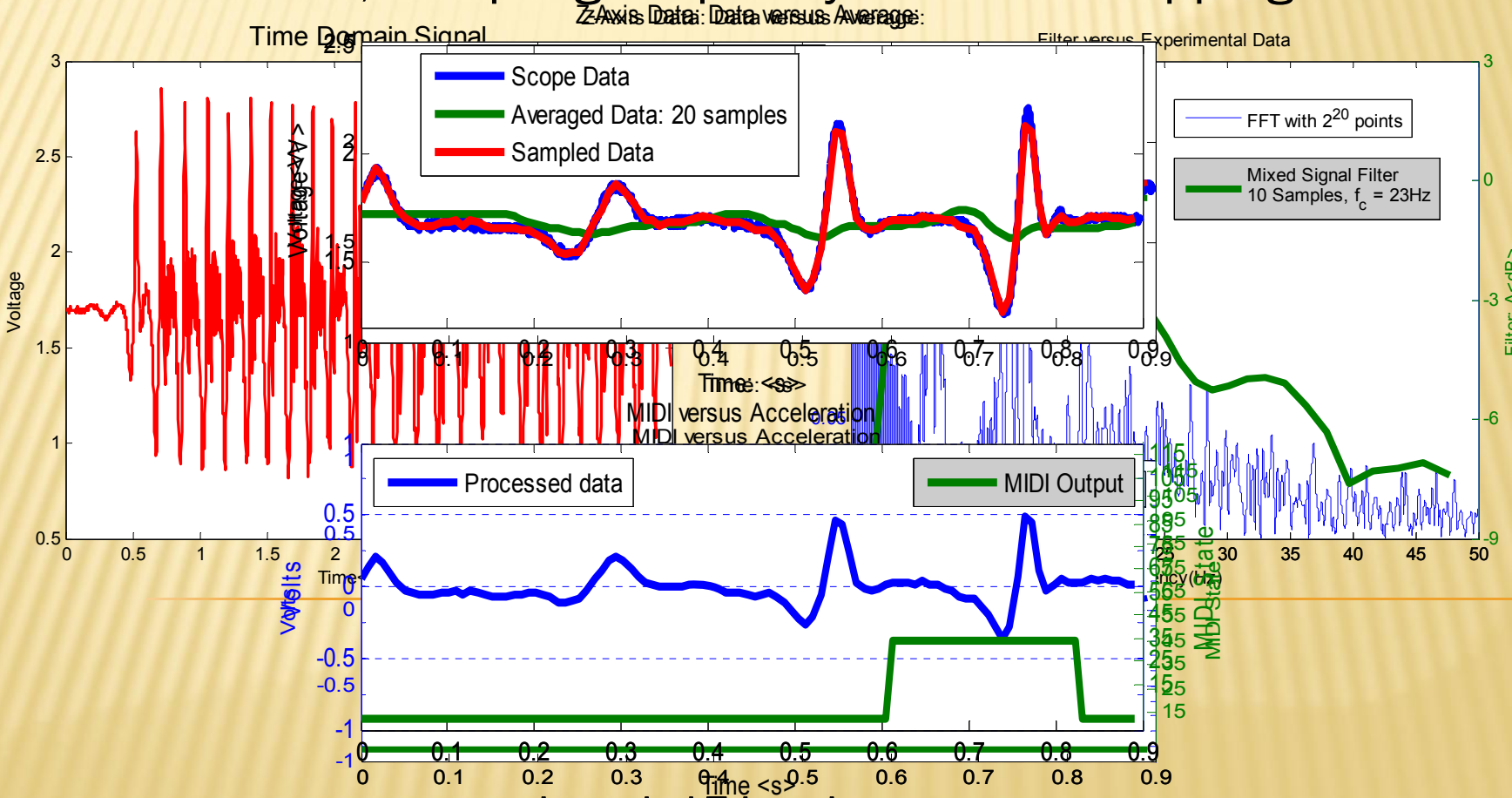
Matlab Emulator: Angle Detection

- De-bug angle detection
- Ensure correct values and mappings
- Animation



Matlab Emulator: Bump Detection

- Combination of experiment and Matlab to identify thresholds, sampling frequency and MIDI mappings



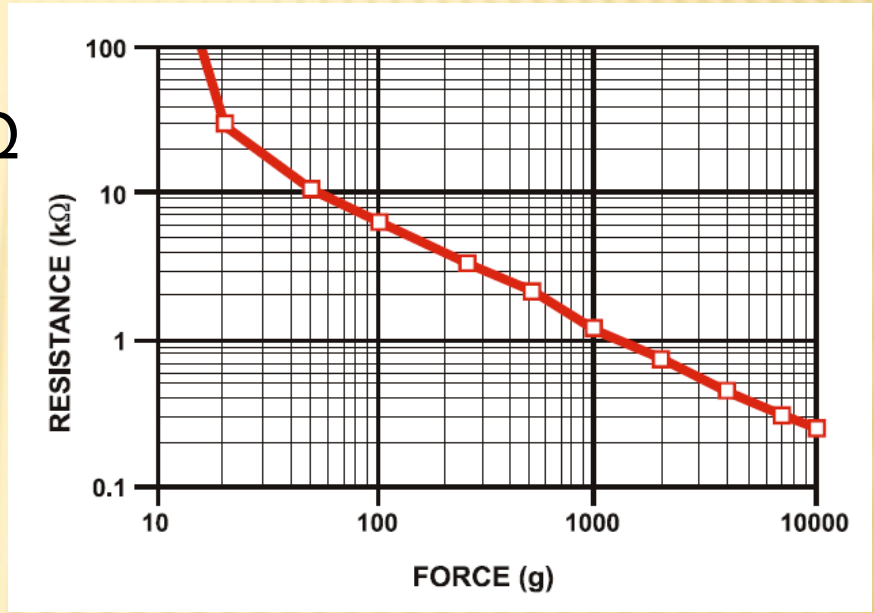
Intended Triggering
Random Movement

Matlab Emulator: Outcome

- Large initial investment of time
- Easy to port code from Matlab to PIC
- Differentiate between software and hardware issues
- Quick turn-around on algorithm improvements
- Creates a template for further work

FSR: Theory

- Resistance Range: 10KΩ to 100KΩ
- Standoff Resistance: >1MΩ
- Tolerance: 15-25%
- Active Area: 12.7mm
- Nominal Thickness: 0.46mm

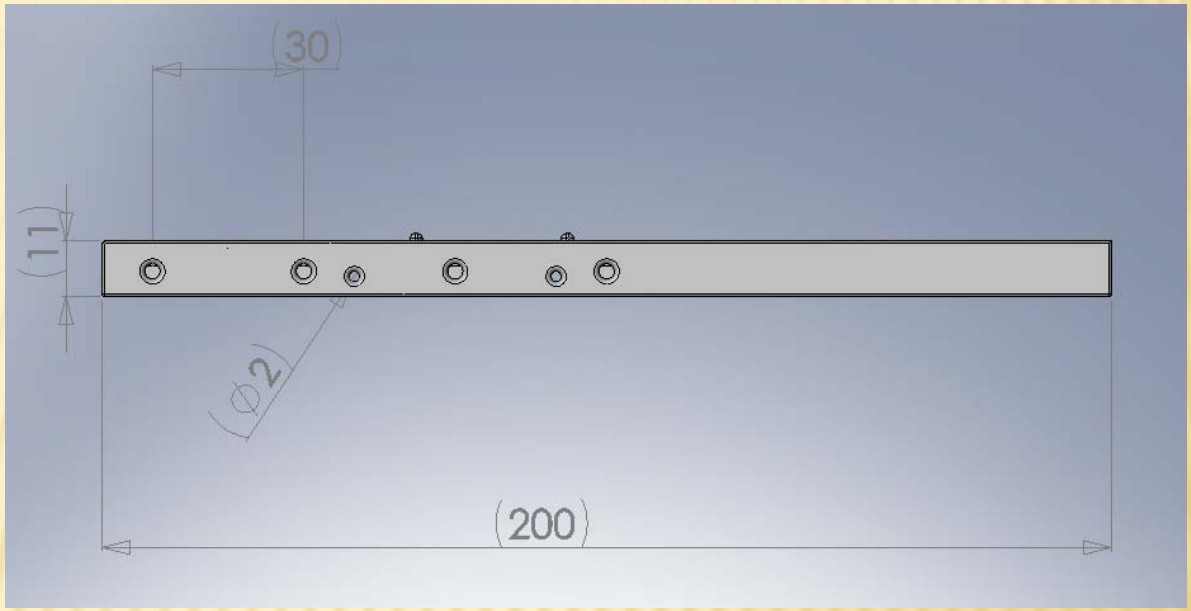


Expected Behaviour

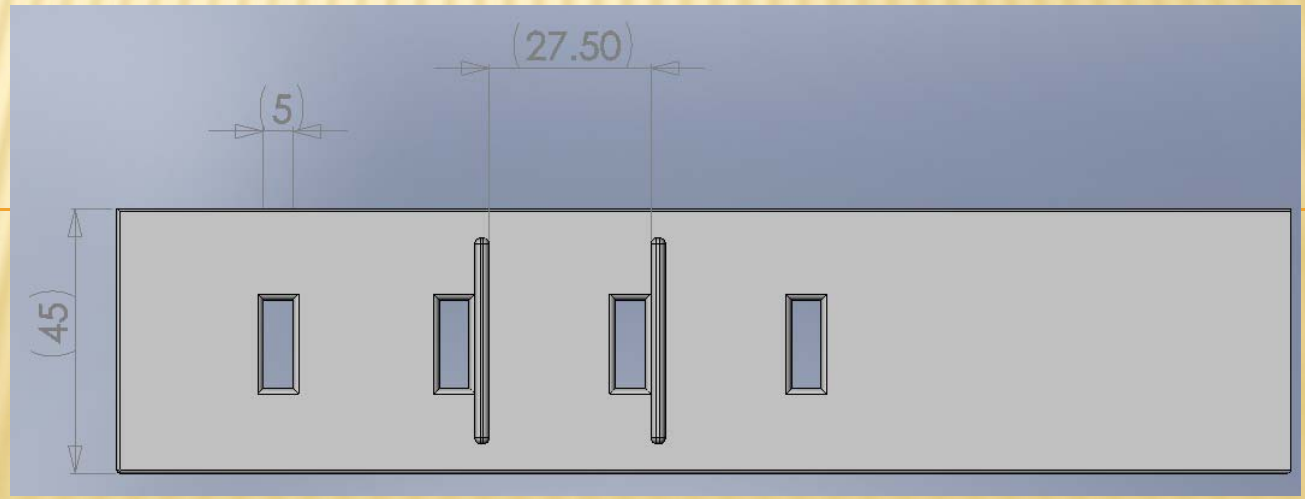
Image Used: Interlink Electronics FSR Datasheet

FSR: Enclosure

Profile

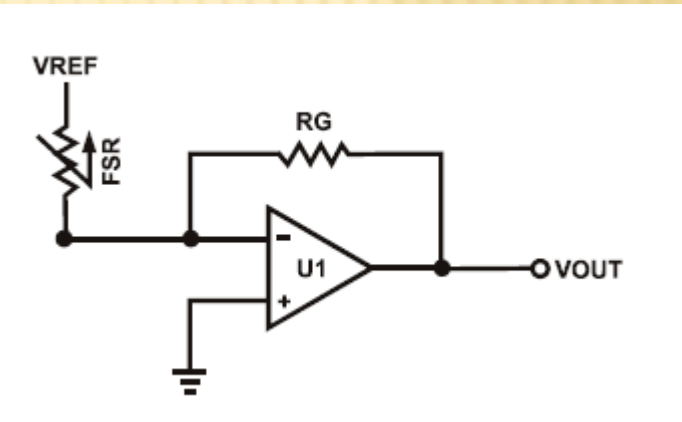


Top View



FSR: Future Enhancements

- Variable Pressure Measuring
- Analog DSP controls
- Implement Current-to-Voltage Converter

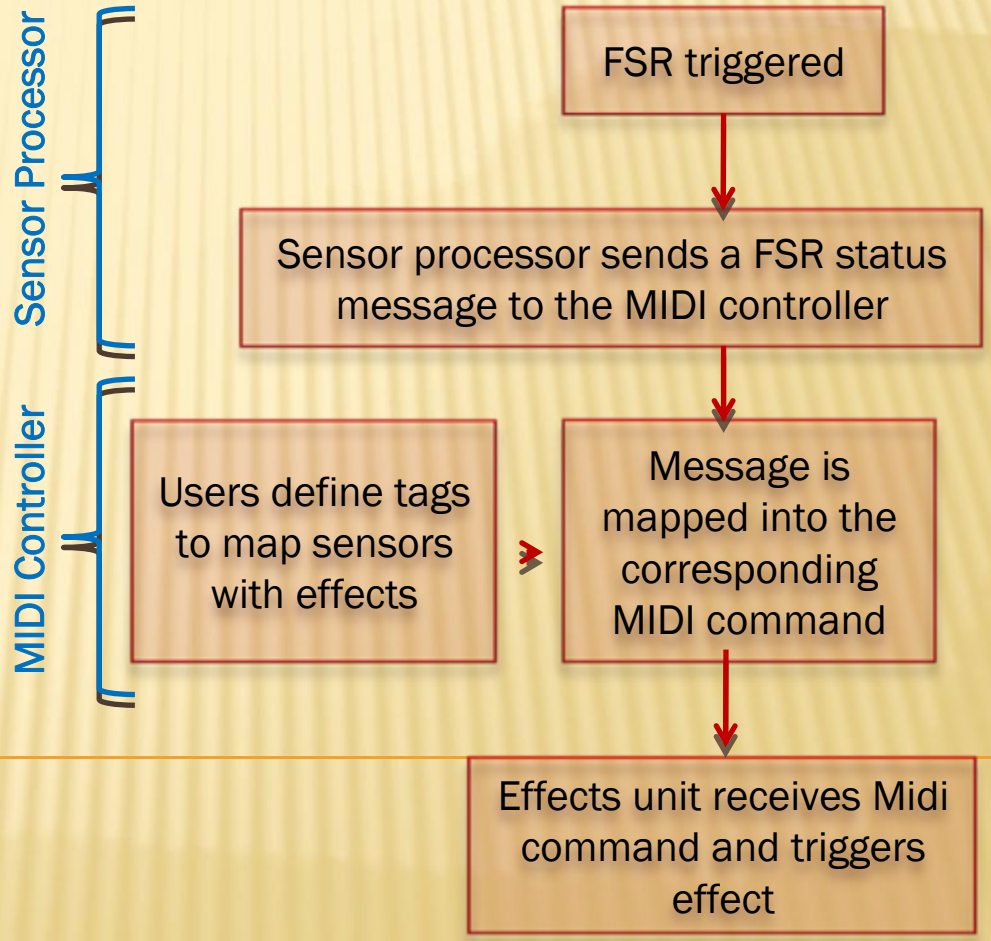


$$VOUT = VREF \bullet [-RG/RFSR].$$

Image Used: Interlink Electronics FSR Datasheet

User interface and PIC-to-PIC communication

- ✓One way communication between PIC to PIC
- ✓Four types of data:
  - •Accelerometer
  - •FSRs
  - •Bumping
  - •Status messages
- ✓User-defined tags map the data received from the sensors processor into corresponding MIDI commands.



MIDI – USB Interface

- Logic Express software
- PC to PODxt communications
- Sanity check of processing chain

http://www.fruity-loops.com/images/store/small/EM_MA-9900-40717-00.gif

Extra Features

- Connection time-out: soft-shutdown
- Activity LED: transmission, FSR active, connection
- Tilt sensitivity control
- Preview mode for MIDI controller

VIDEO

Acknowledgements

Technical

Patrick Leung

Steve Whitmore

Jason Lee

Brad Oldham

Albert Leung

Fred Heep

Carlo Menon

Gary Houghton

Musicians

Yannick Champagne

Matt Pelke

Sol Dominelli

Tim Parent

Other

Everyone in ENSC440 lending us tools

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Questions?