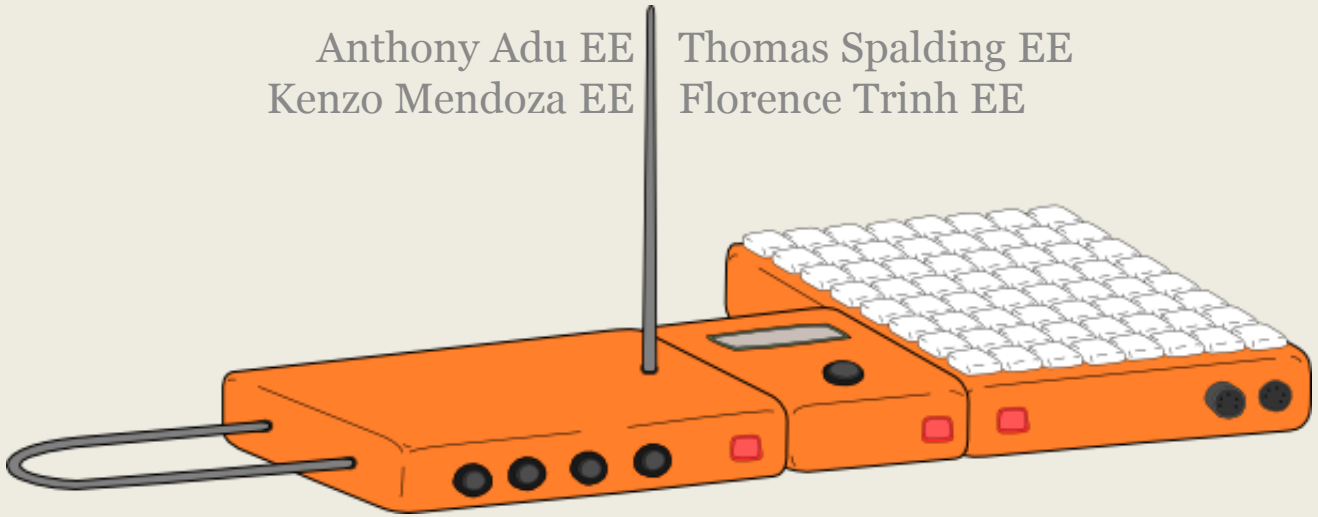
Electronic Music Interactions

(EMI)

GROUP #1

Modern and alternative interactions with music devices

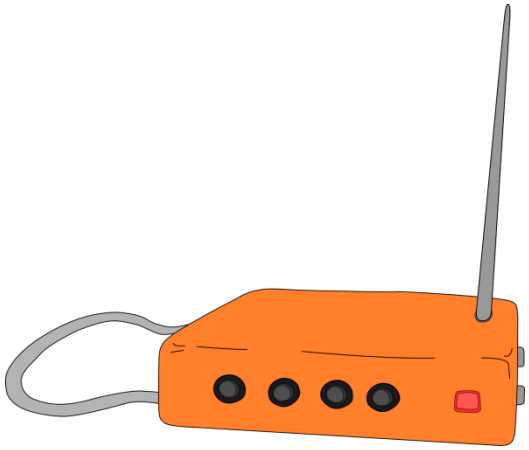
Anthony Adu EE
Kenzo Mendoza EE
Thomas Spalding EE
Florence Trinh EE



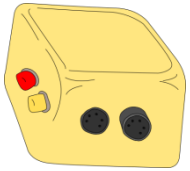
Goals & Objectives

- Create a customizable and interactive musical device.
- Integrating a classically analog instrument with a modern digital experience.
- Implement a direct-feedback environment to facilitate learning experience

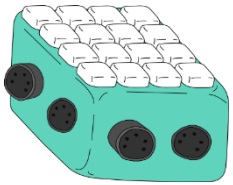
EMI



uWave

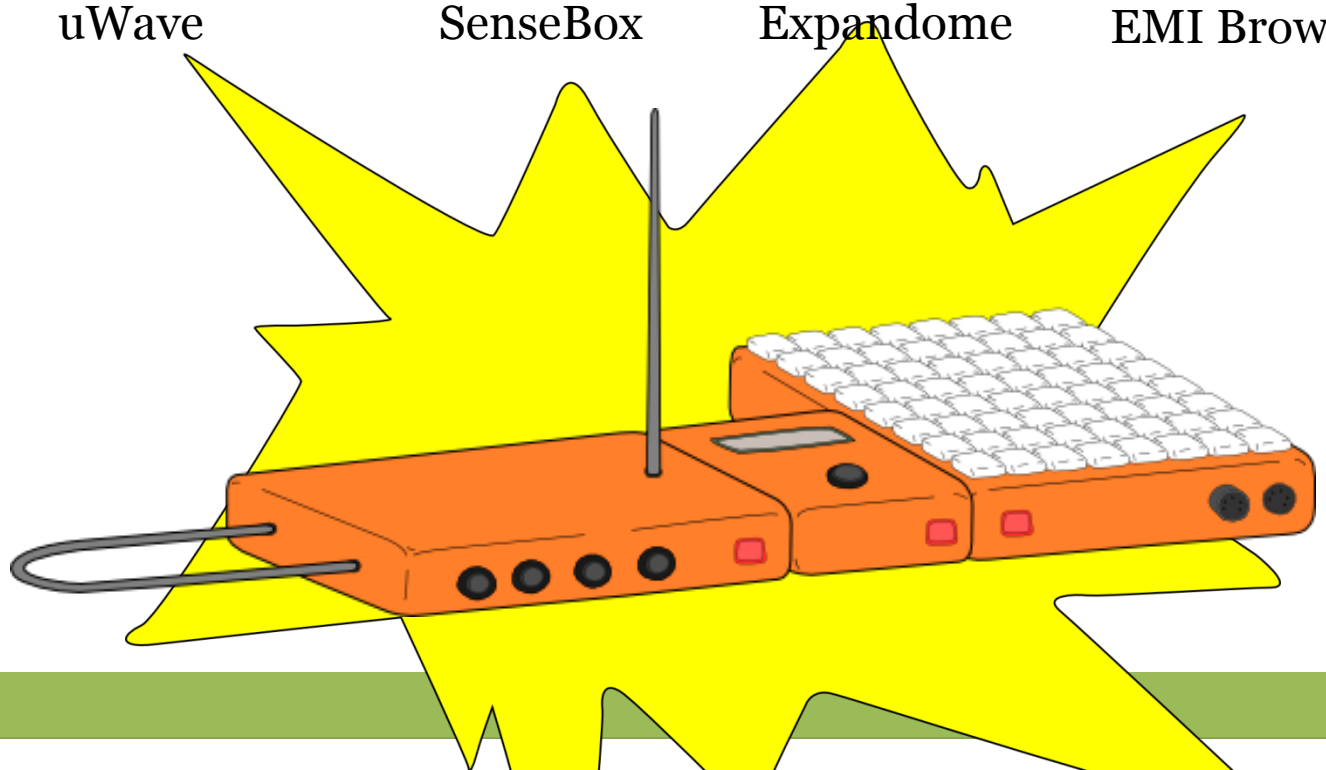


SenseBox



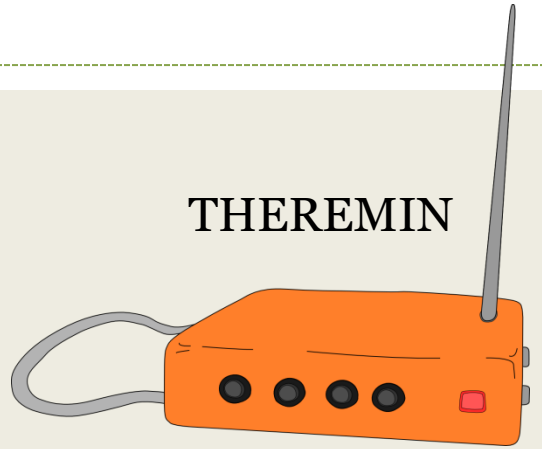
Expandome

EMI Browser



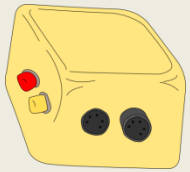
Prior Similar Work

THEREMIN



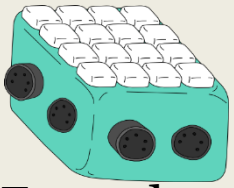
uWave

PITCH-TO-MIDI TRACKER



SenseBox

ARDUINOME MIDI CONTROLLER



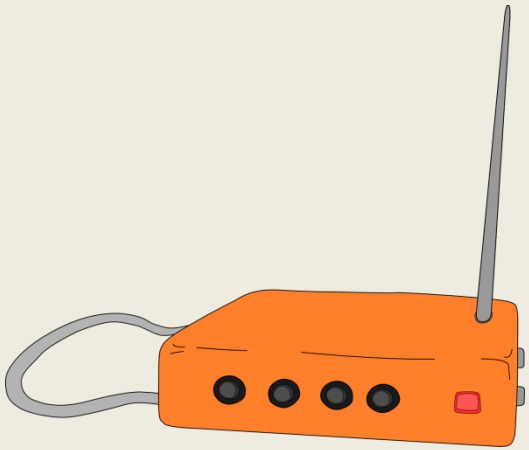
Expandome

Robert Moog
Innovator

Stephen Hobley
Hobbyist

Jordan Hochenbaum & Owen Vallis
Researchers

uWave Theremin



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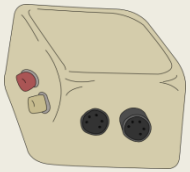

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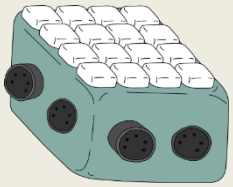


Expandome

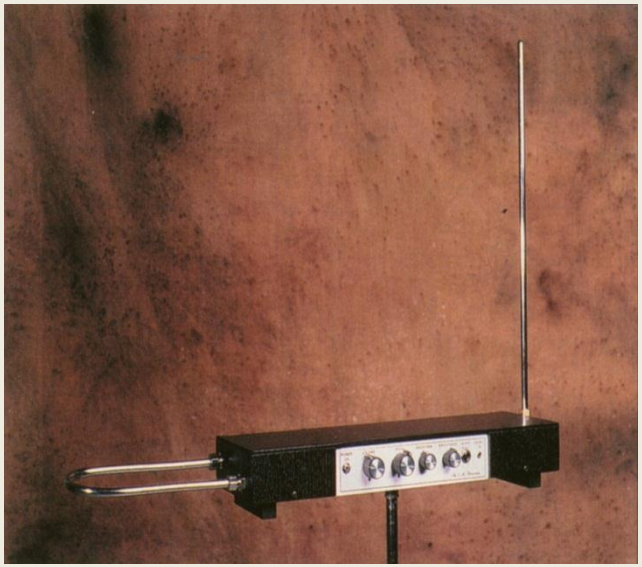
EMI Browser

uWave Theremin Specifications

- Operate with a power supply of ±12V
- Two coil antennas to control pitch frequency and volume
- Output a max voltage of 0.8Vrms
- Oscillators operate at frequencies close to resonance frequency of their respective antennas circuits (260 & 450 kHz)
- Output sufficient analog signal(0 to 3 kHz) for digital conversion

Theremin - Design Approach

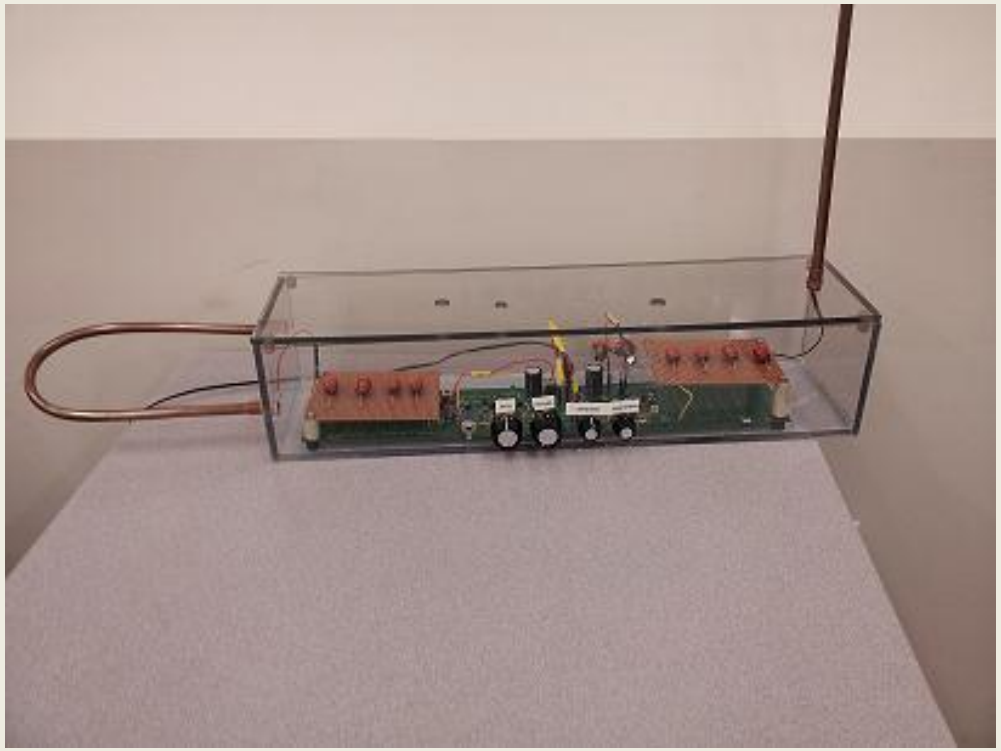
- The basic elements of a Theremin are
  - Oscillators for pitch control
  - Oscillator for volume control
  - Mixer and Detector
  - Audio amplification

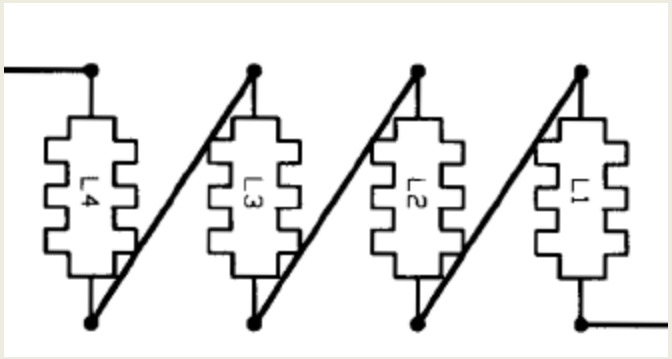


- Robert Moog EM Theremin
  - Known for the Moog Synthesizer
  - Recreated the original Theremin in 1948
  - Released the electronic Theremin DIY guide in 1996

Antenna Circuits

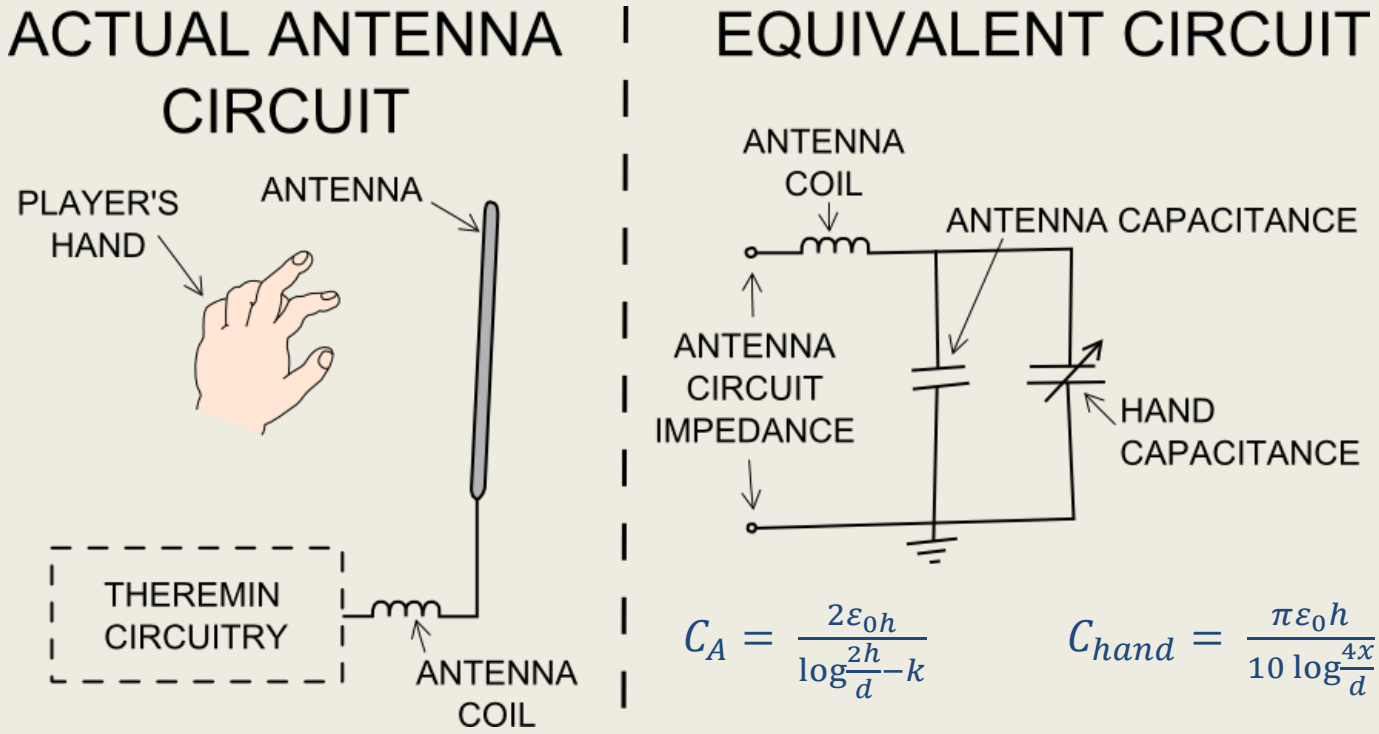
- Pitch Antenna
  - 18” Vertical
  - Creates a resonance frequency of 260 kHz
- Volume Antenna
  - Looped and 9” horizontal
  - Creates a resonance frequency of 450 kHz





Antenna Circuits

- Equivalent antenna circuit



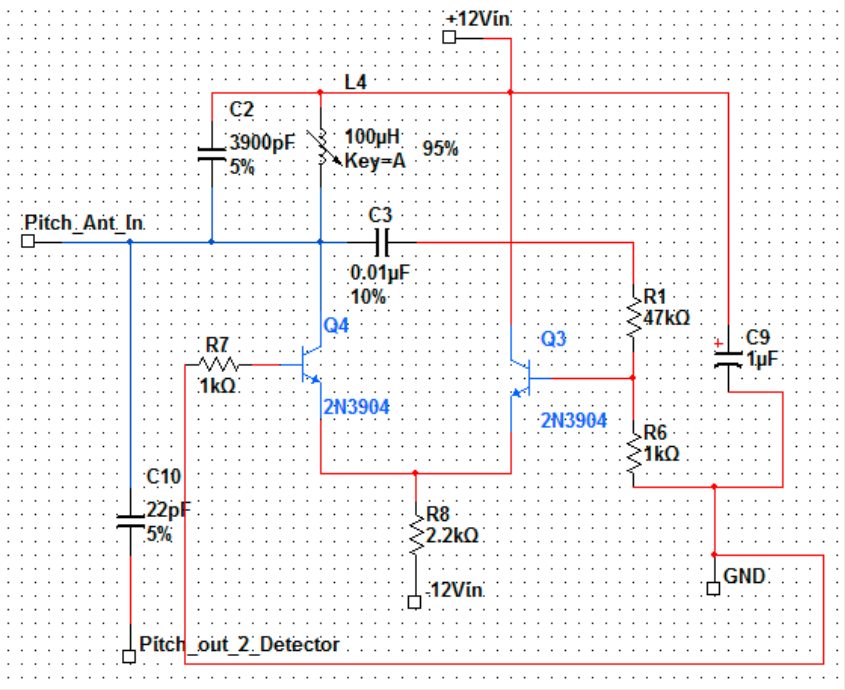
$$C_A = \frac{2\varepsilon_0 h}{\log\frac{2h}{d} - k} \qquad C_{hand} = \frac{\pi\varepsilon_0 h}{10\log\frac{4x}{d}}$$

C_A = Antenna Capacitance *C_{hand} = Imposed hand capacitance* *h = antenna height(m)*
d = antenna diameter(m) $\varepsilon_0 = 8.85 \times 10^{-12}\,\mathrm{Fm}^{-1}$ *x = hand distance from theremin (m)*
k is a constant that depends on how far above ground the antenna is

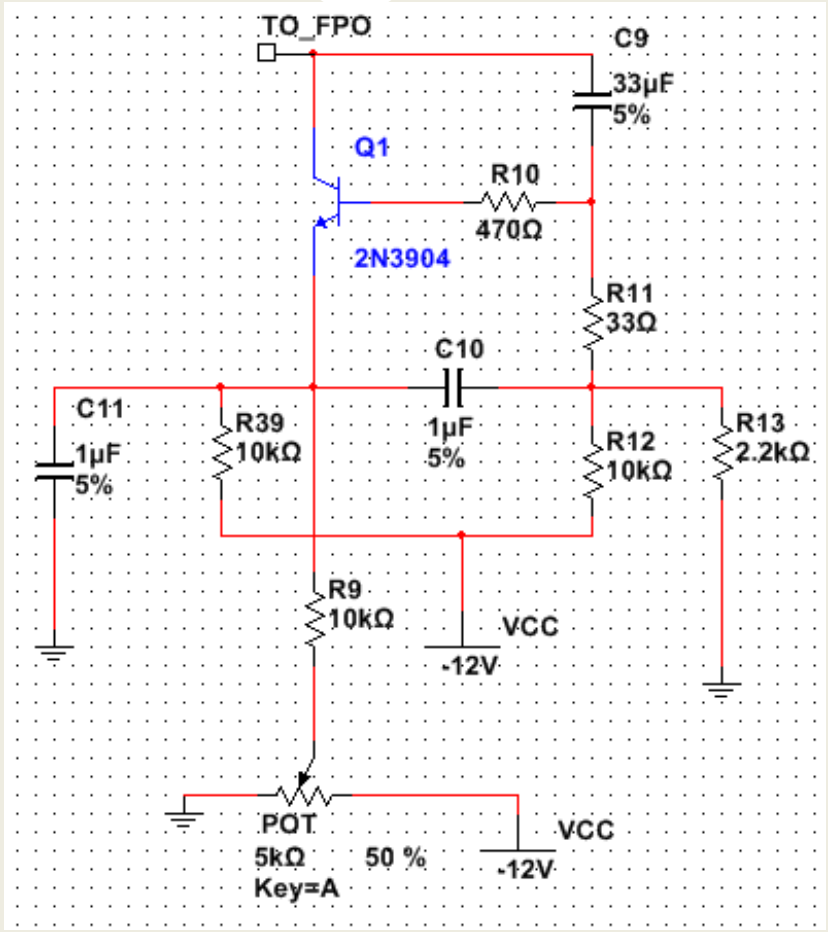
Pitch Oscillators

- Fixed and Variable pitch oscillators
- General frequency equation
  - $f_{osc} = \frac{1}{2\pi\sqrt{L(C_2+C_A+C_{hand})}}$
- FPO -> 285 kHz
- VPO -> 282 to 285 kHz

- Frequency manipulation
  - Active impedance circuit (FPO)
  - Pitch Antenna (VPO)



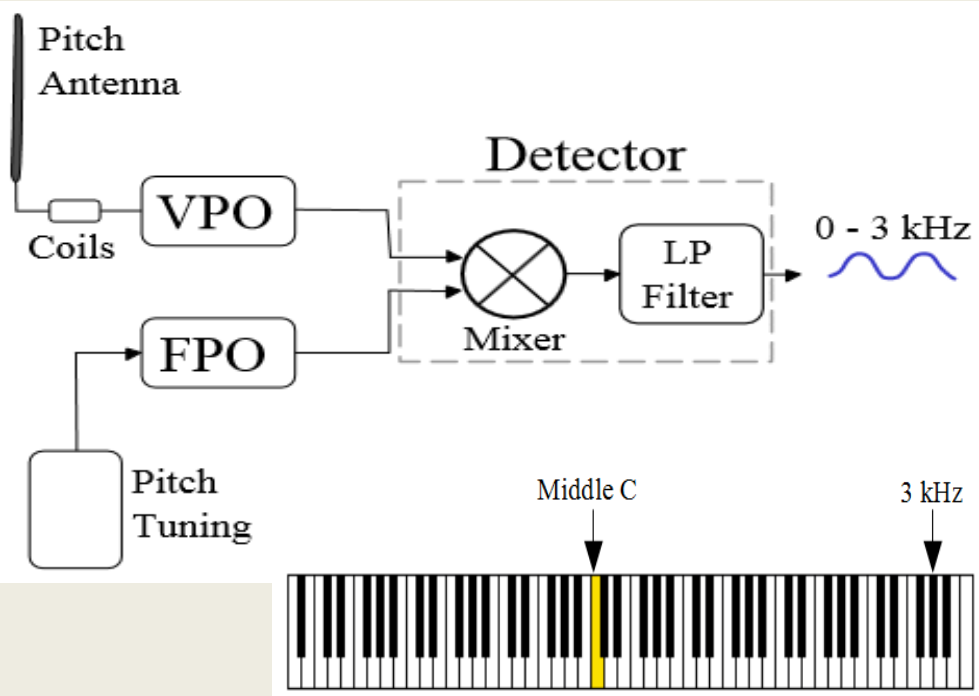
Tuning Circuit



Frequency Detection

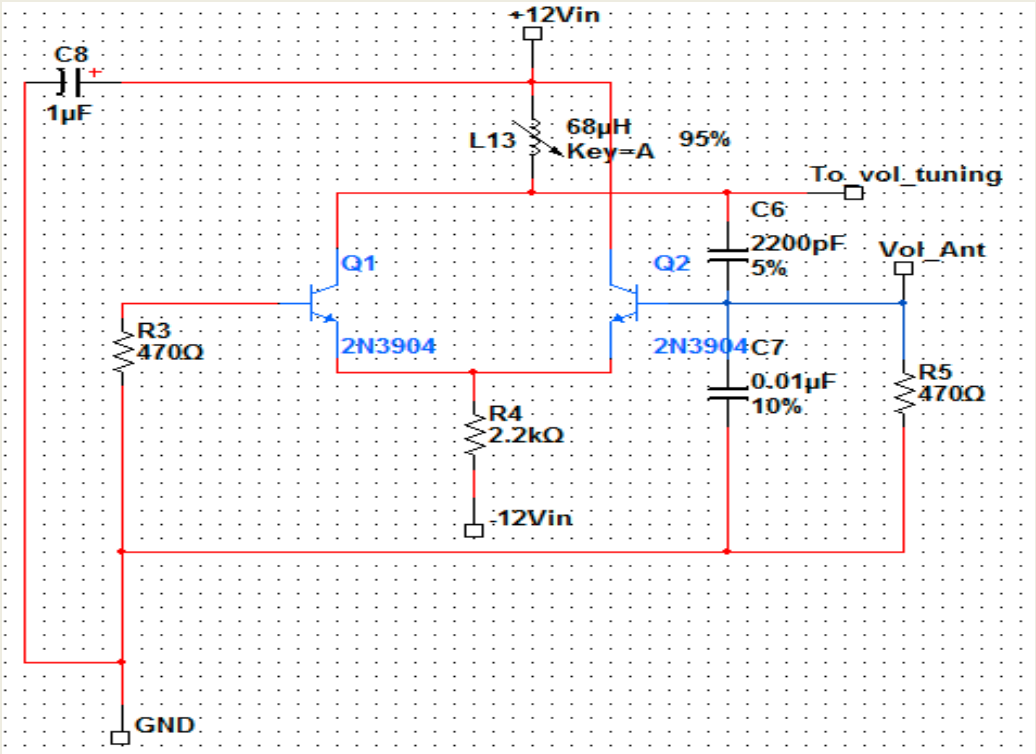
- Heterodyning : Method of mixing two signals to create one signal with two frequency components.
- $V_{mix} = \frac{A}{2}[\cos(2\pi f_1 - 2\pi f_2)t - \cos(2\pi f_1 + 2\pi f_2)]$
- Output from detector
  - $V_{out} = \frac{A}{2}\cos(2\pi f_1 - 2\pi f_2)t$

Where f_1 = FPO frequency
& f_2 = VPO frequency



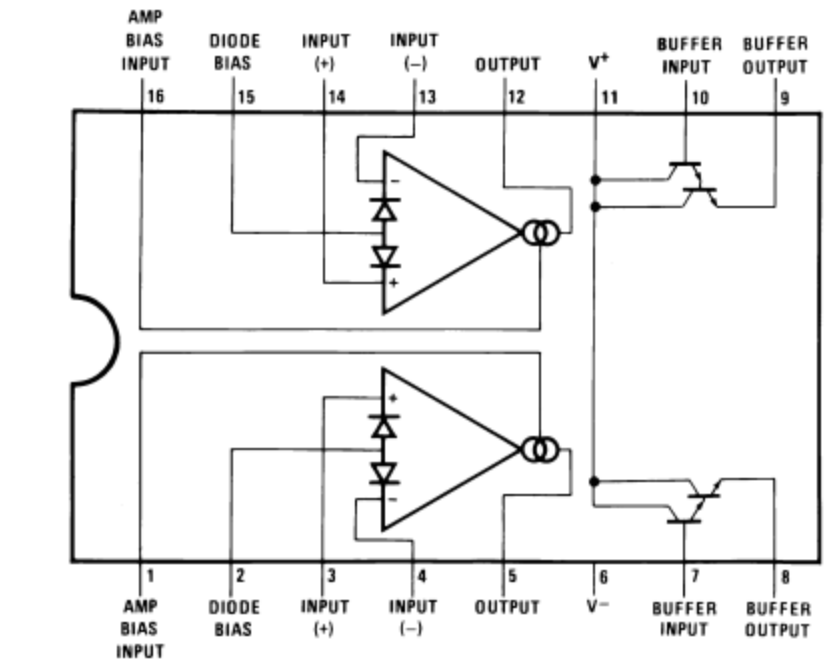
Volume Oscillator

- Operates at higher frequency of 432 kHz
- Creates DC voltage used by the VCA
- Adjustable Frequency
  - Volume Tuning

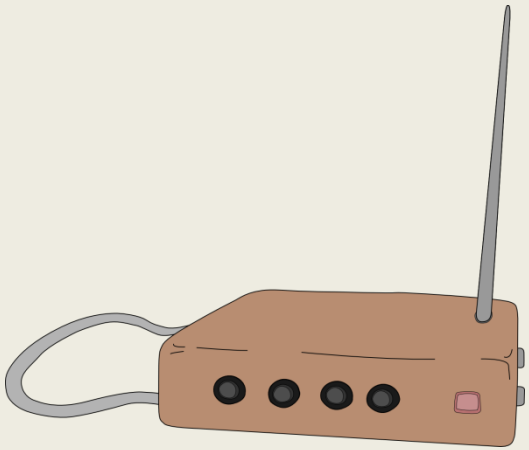


Design cont'd

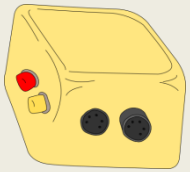
- Voltage Controlled Amplifier (VCA)
  - LM13700 Dual Operational Transconductance Amplifier
  - Amplifies pitch signal from detector
  - Max audio output voltage of 0.8 Vrms



SenseBox



uWave



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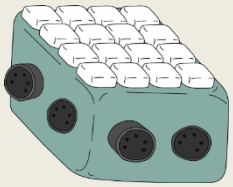


Expandome

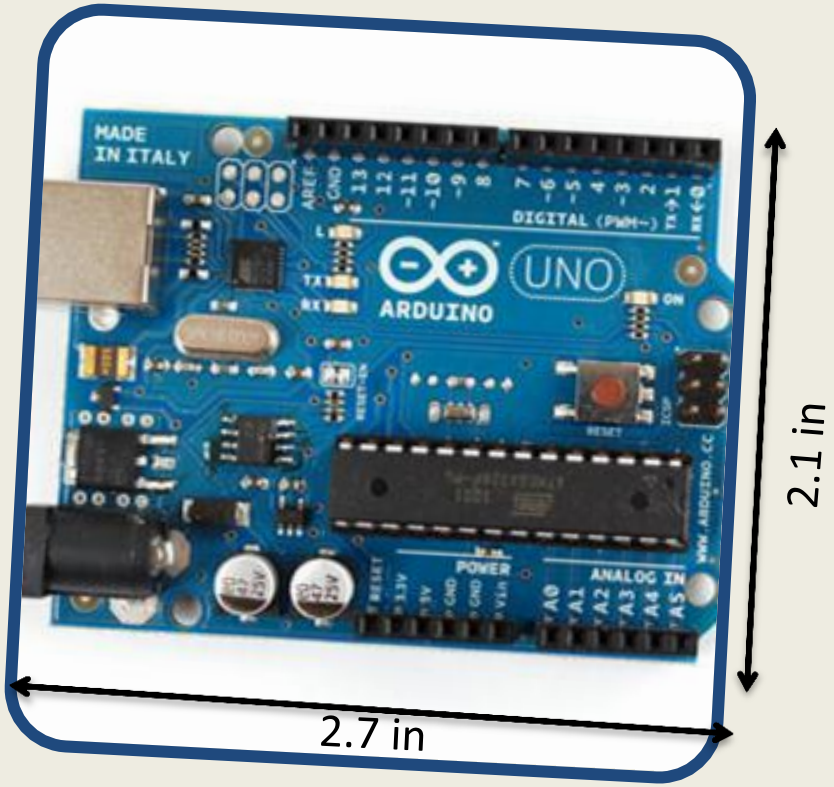
EMI Browser

SenseBox Specifications

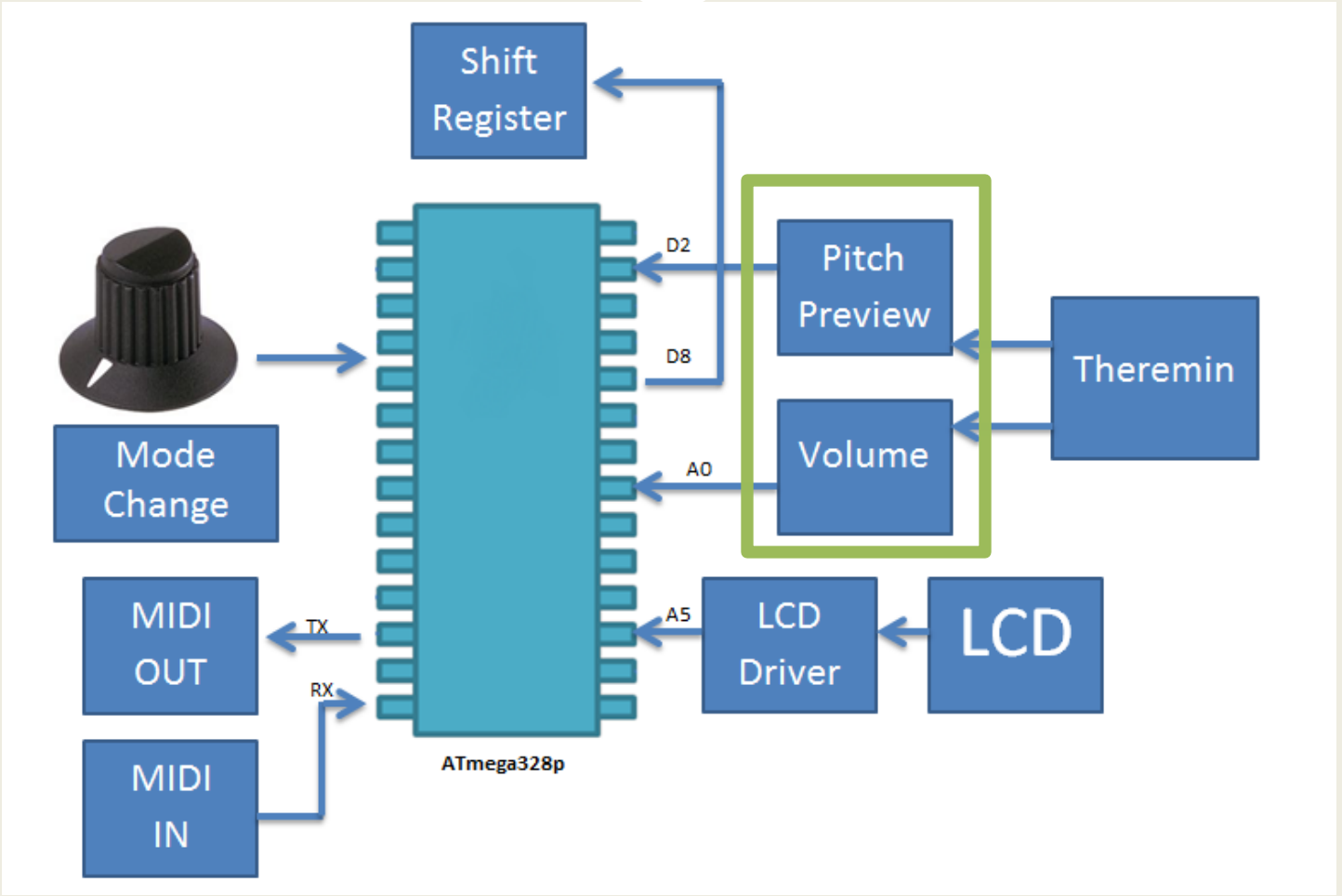
- Operate with a power supply of +5V
- Receive analog signal from uWave Theremin (0.8 VRMS) and convert to MIDI data
- 4 Mode operation – Pitch, Control, ARP1 & ARP2
- 1 LCD that will display but not limited to: current mode operation, note name based on the current pitch, volume value, incoming MIDI note number from a MIDI device.
- 8 LEDs to display visual aid for user (volume and pitch accuracy)

Microprocessor - Atmega328

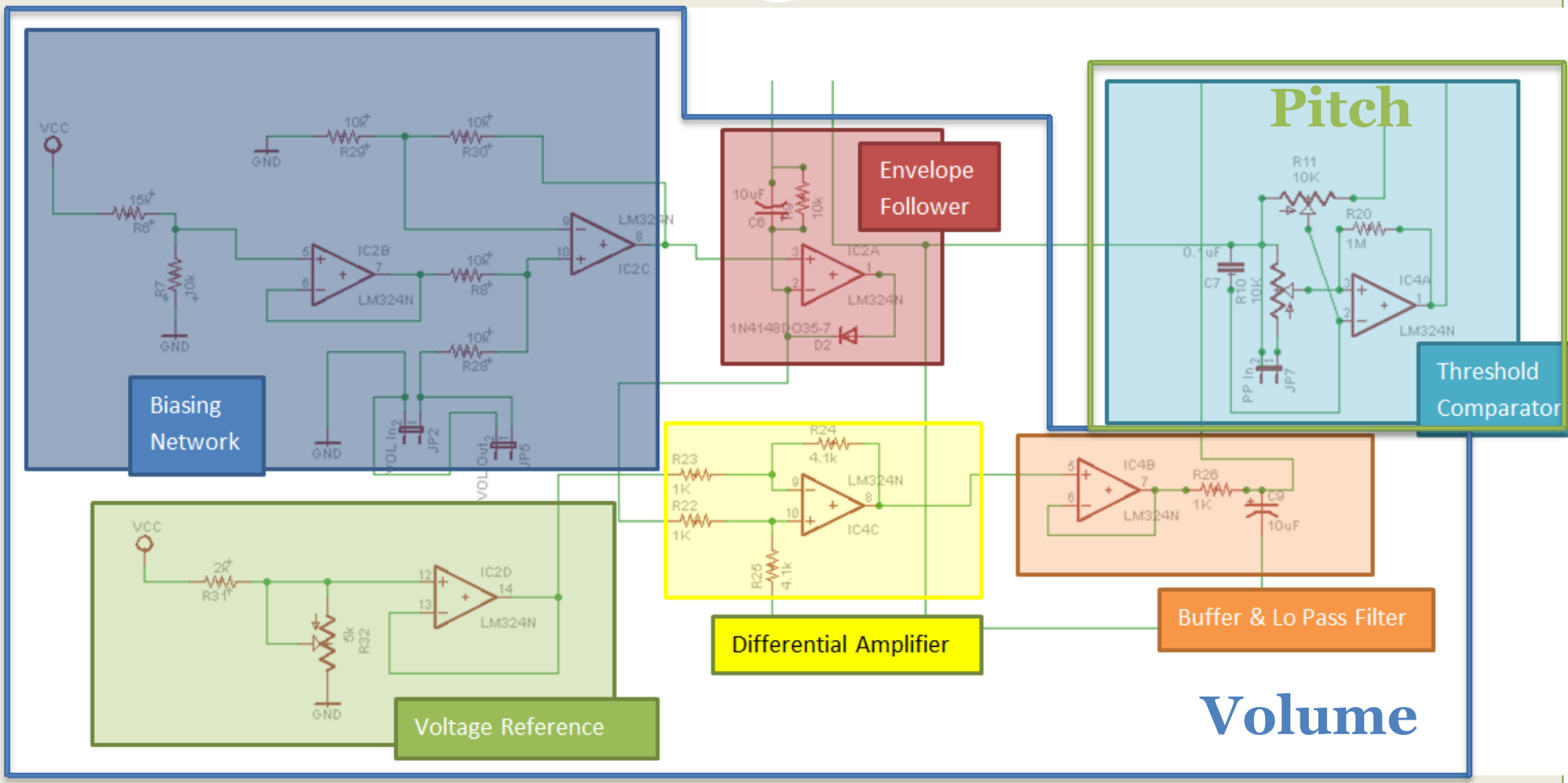
Parameter	Arduino Uno
Chip	Atmega328p
Analog input	6 pins
Flash Memory	32KB
RAM Memory	2KB
Communication Protocols	Serial
Bits Per Second (Baud)	Adjustable (32,250 bit per second for MIDI protocol)



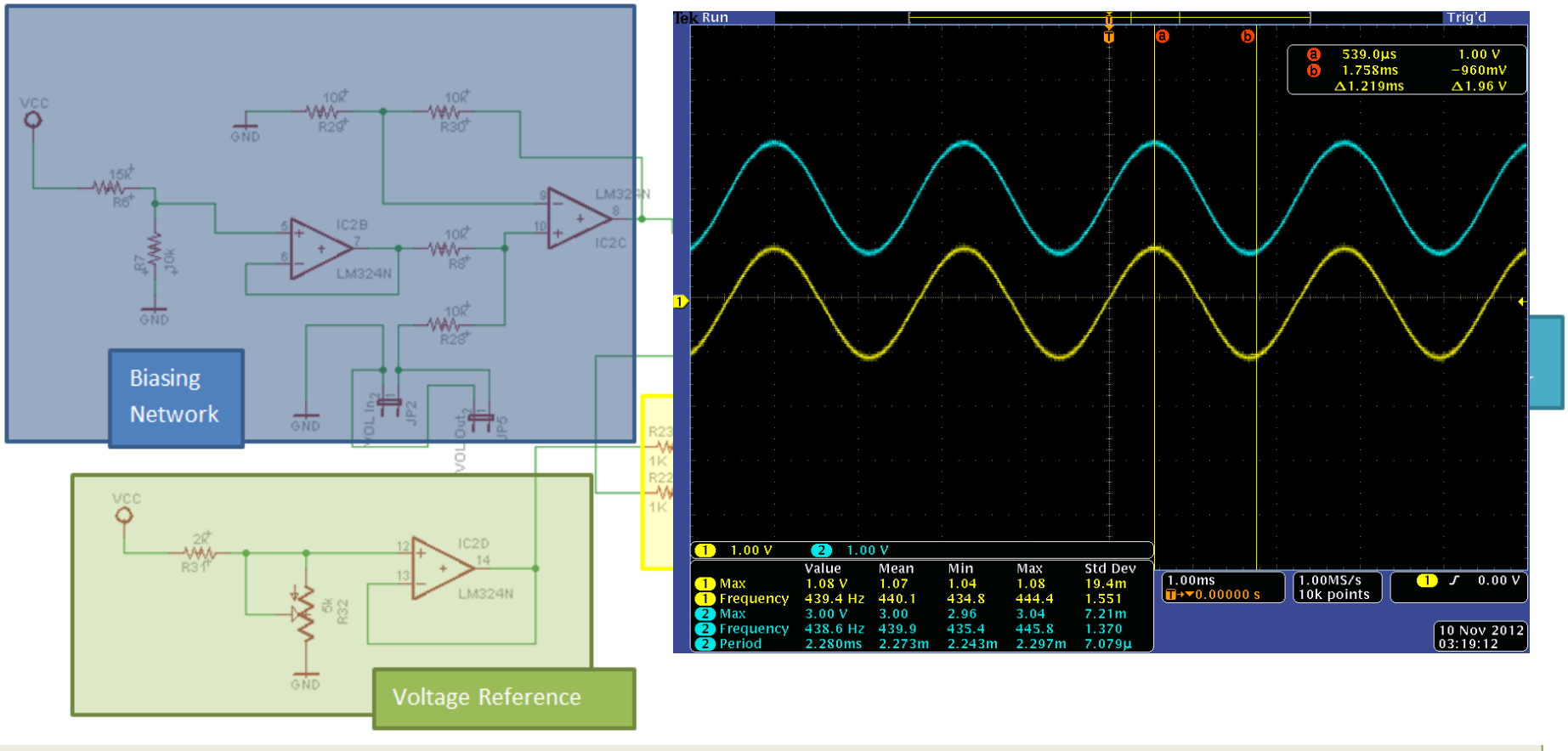
Block Diagram of SenseBox



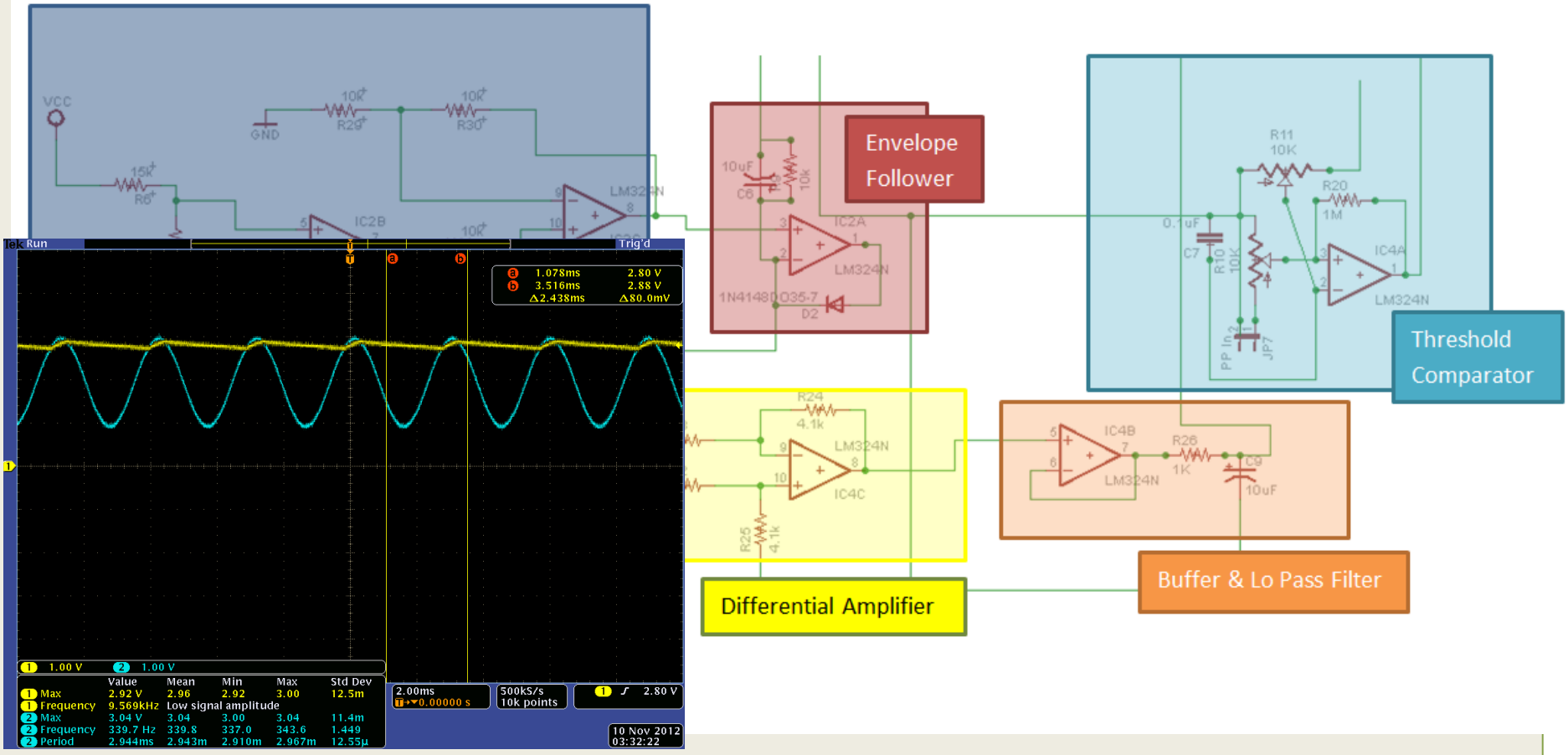
SenseBox - Pitch and Volume Data



Biasing Network

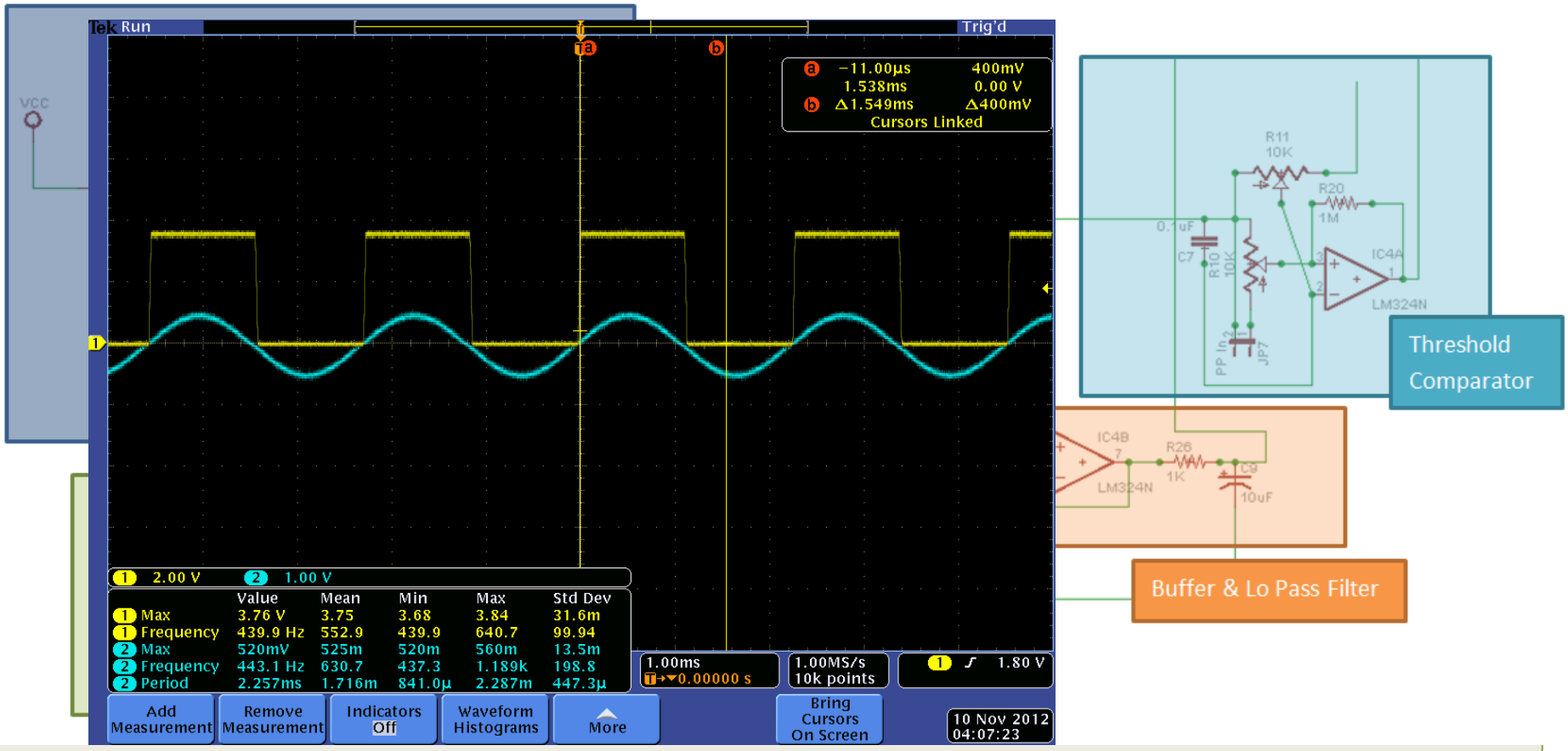


Envelope Follower



Differential Amplifier (Output Volume)

Threshold Comparator



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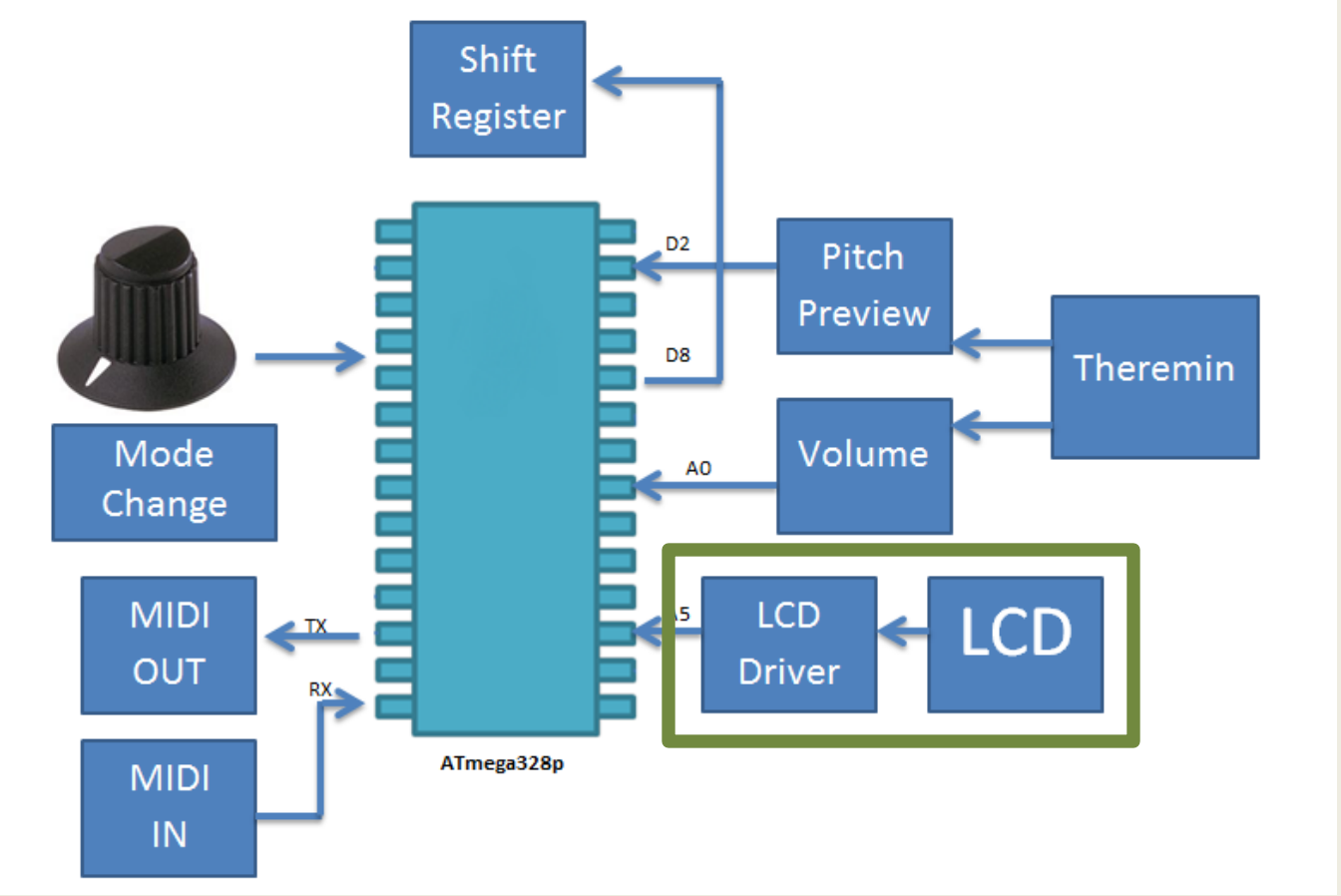
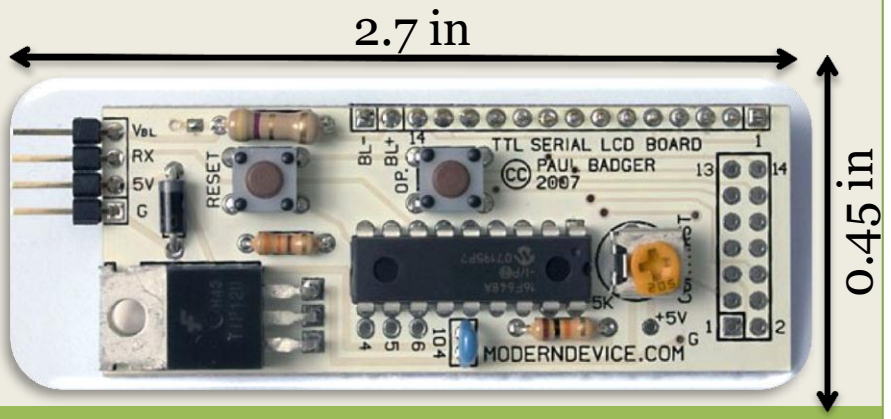


LCD Panel / LCD 117 Driver

Parameter	20 X 4 LCD
Communication	Serial
Color	White LED on blue screen
Operating Voltage	5V
Backlighting	Included

- Eliminate the number of pins from 14 to 3 pins
- Ground, Serial Data and 5 V supply
- Contains a microprocessor
  - Allows the programmer to use built-in functions
    - Backlighting
    - Serial print of LCD screen
    - Clear Screen
    - Many more…



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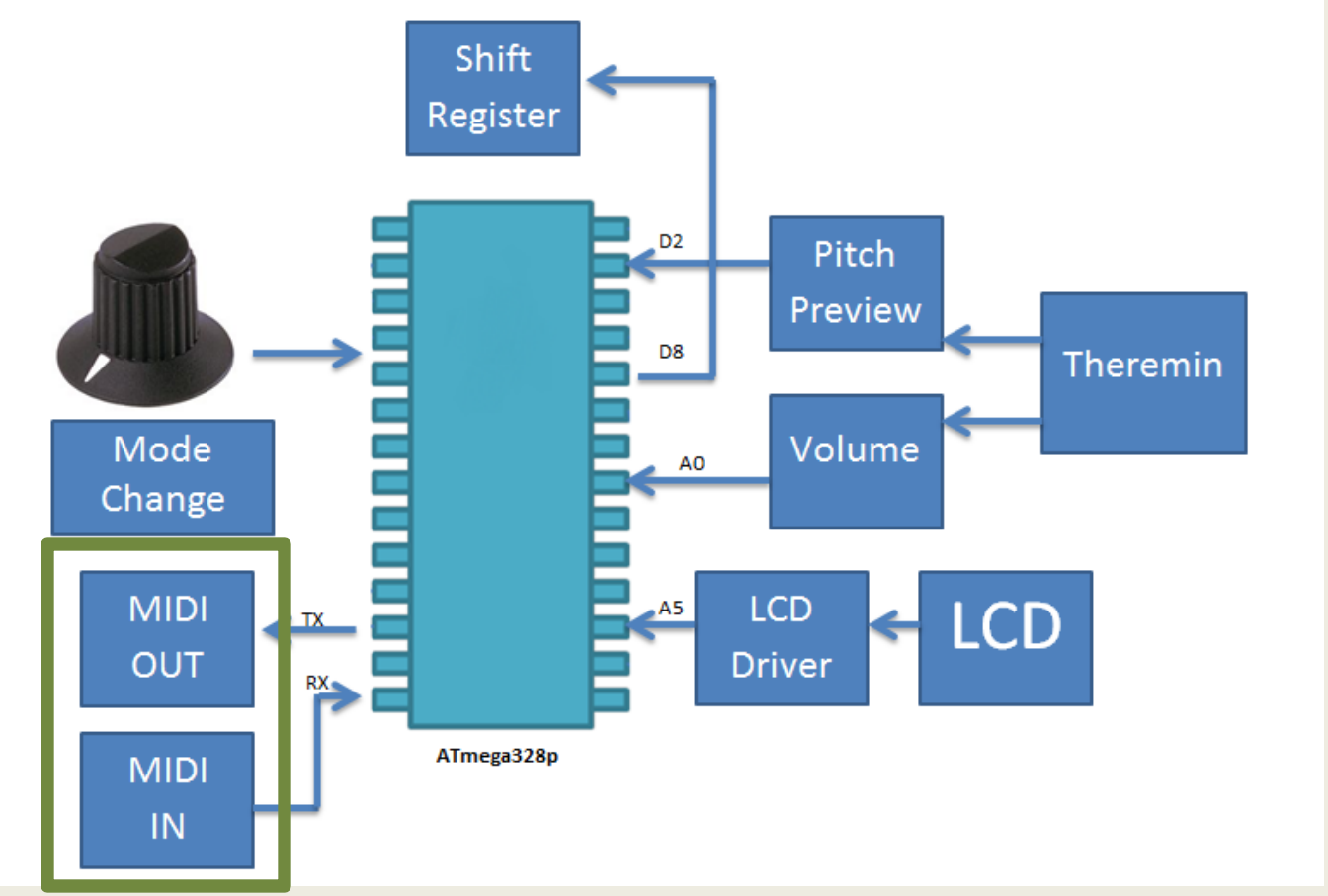
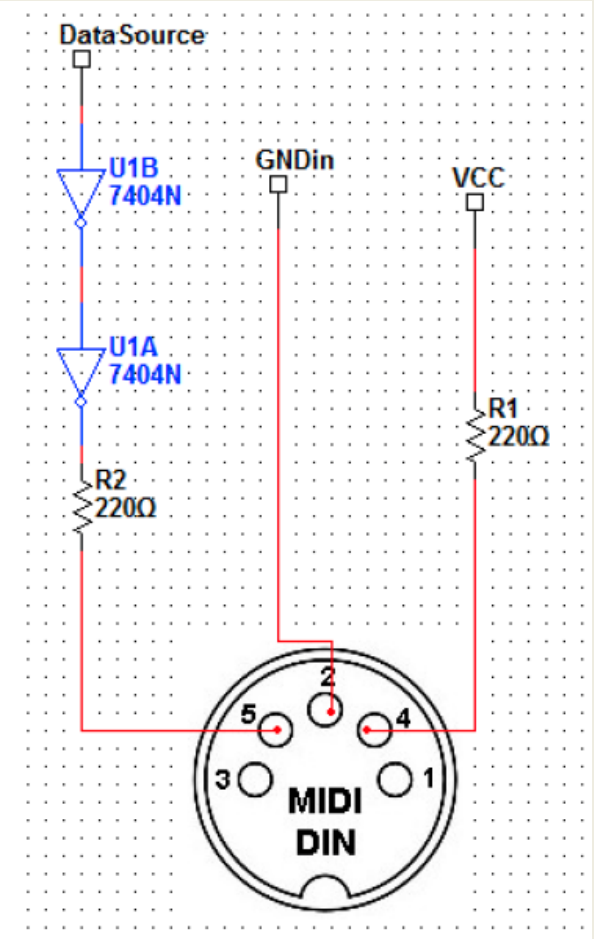


MIDI OUT Schematic

MIDI OUT Pinout	
PIN	Description
1	Not Connected
2	**Grounded**
3	Not Connected
4	**Current Sink**
5	**Current Source**



MIDI IN Schematic

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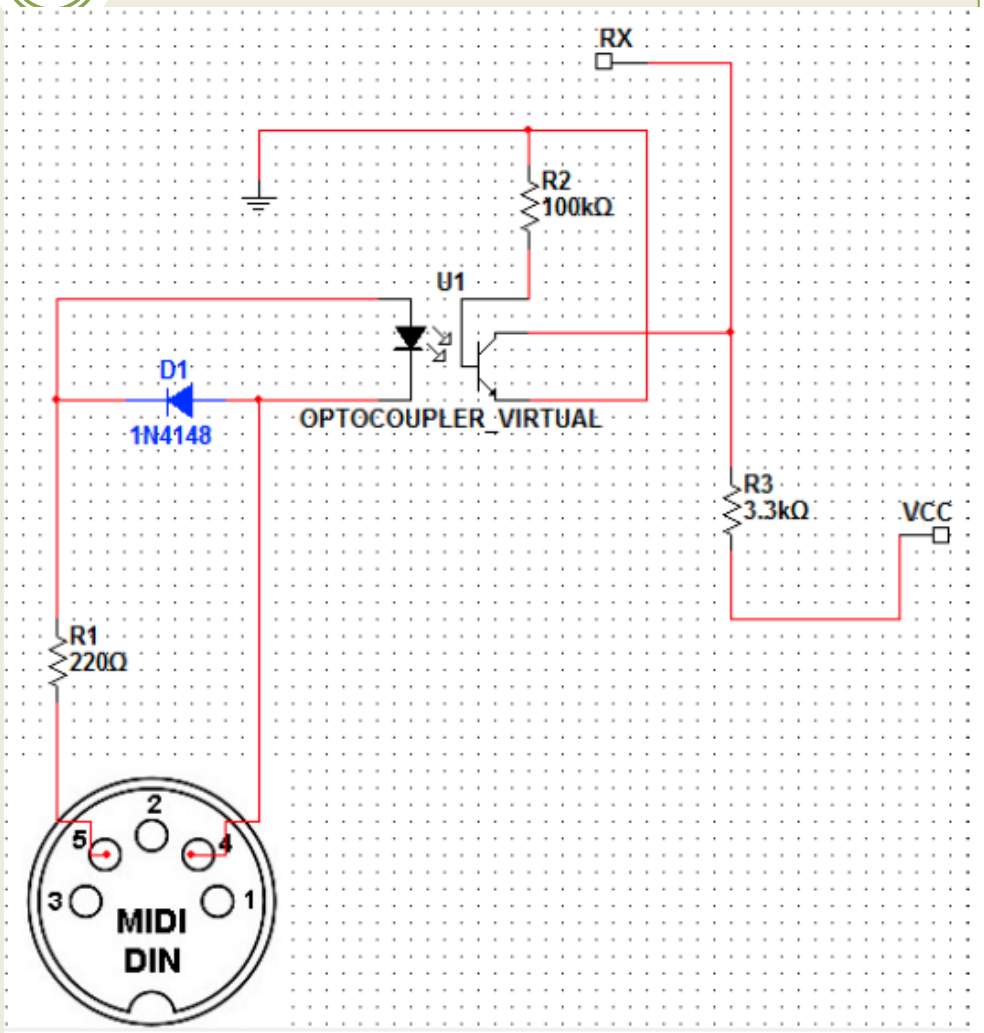

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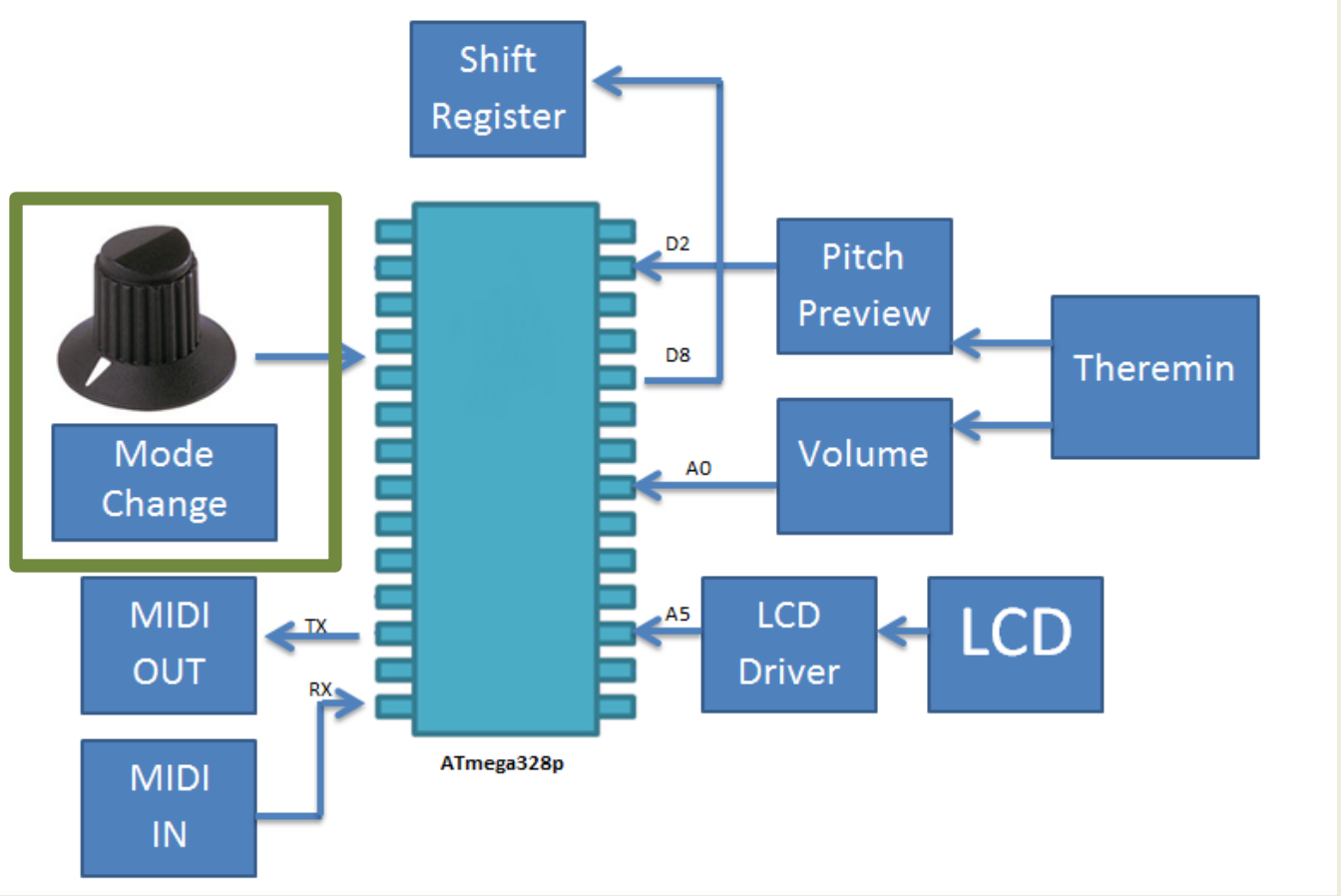
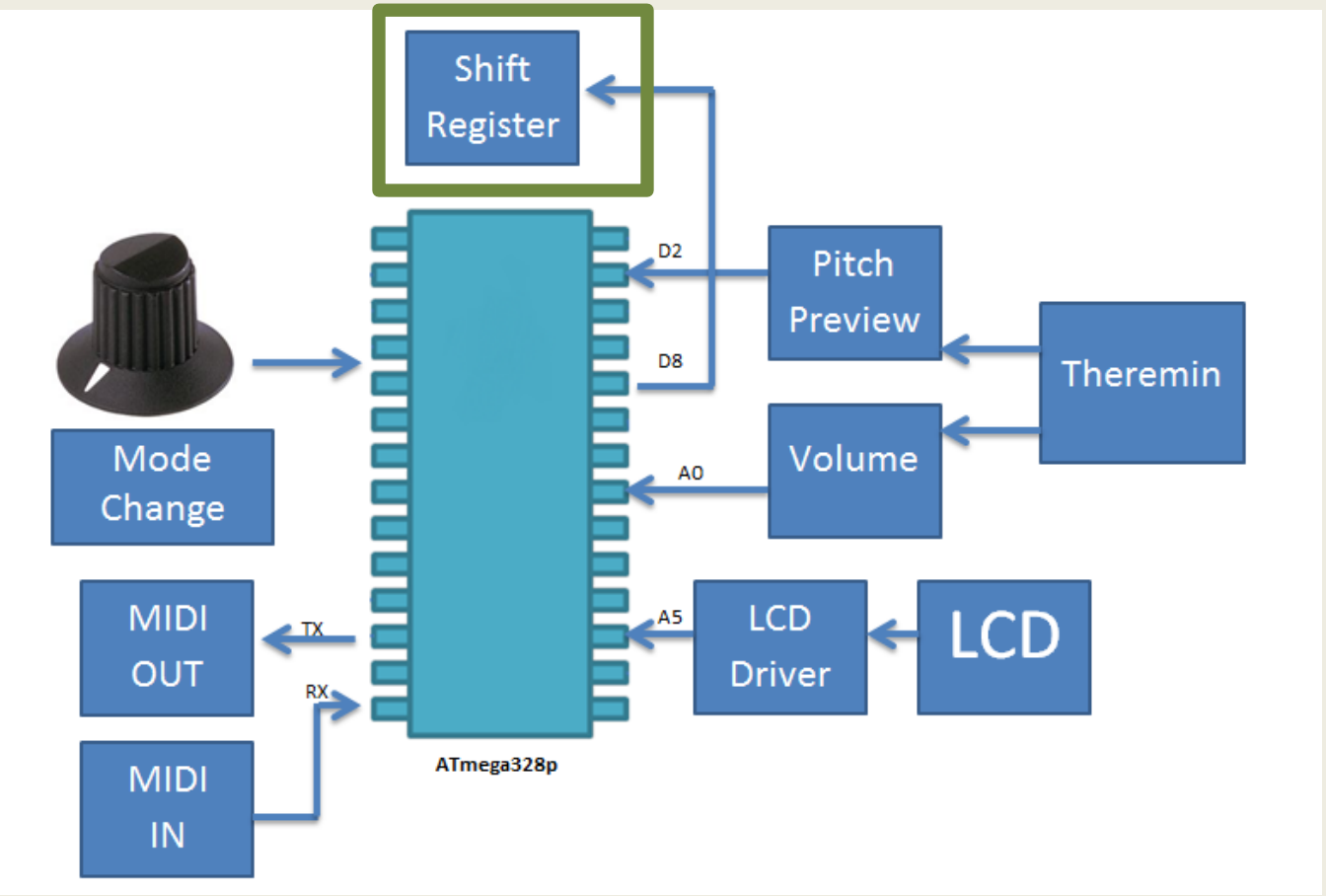


Mode Operation Explanation

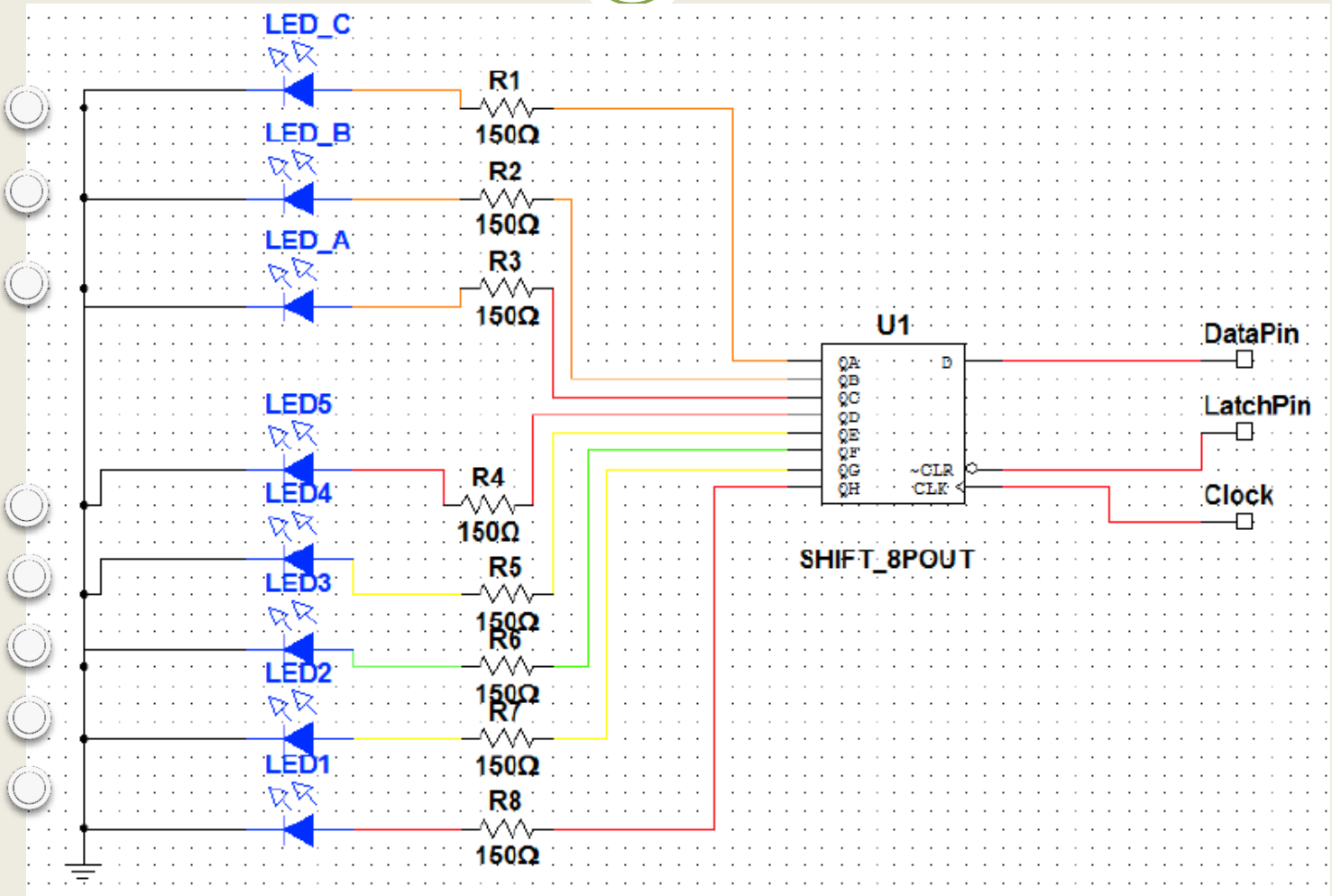
Function	Description
Pitch	Track the frequency and volume from the uWave Theremin and display and output the corresponding MIDI data
Control	Output a control data based on the theremin's pitch magnitude
ARP1*	Read an input from MIDI keyboard and arpegiate based on how many keys are pressed
ARP2*	Read an input from MIDI keyboard and arpegiate around the collection of notes that are held on the keyboard

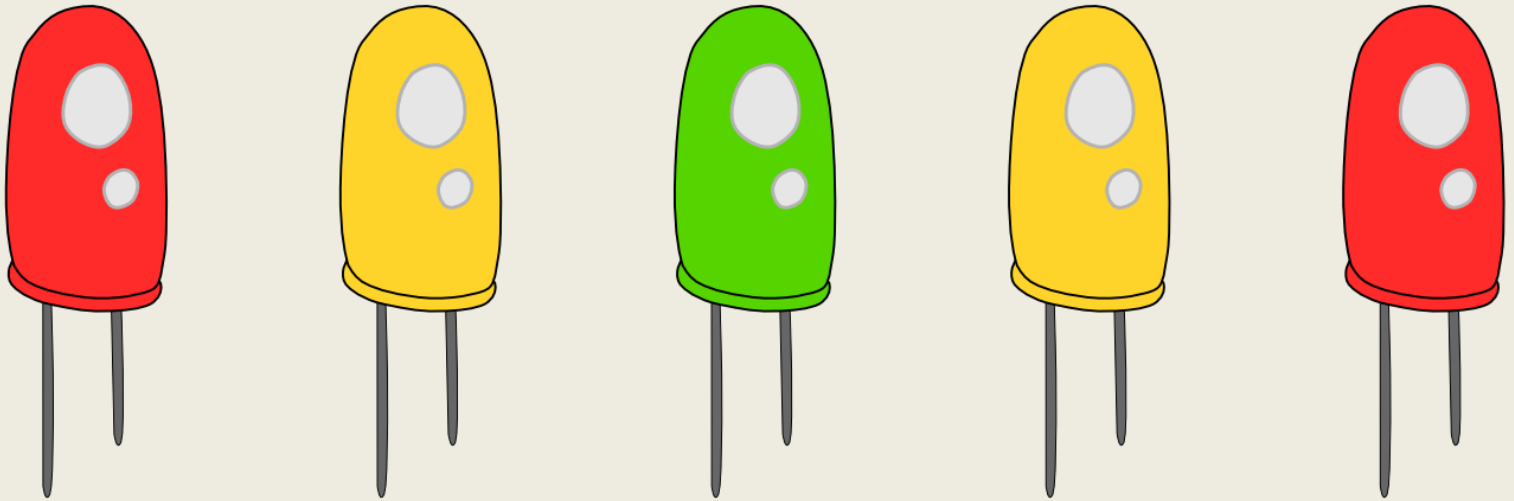
*In order to use these operations, a MIDI keyboard must be connected to the SenseBox

Block Diagram of SenseBox



Pitch and Volume Accuracy



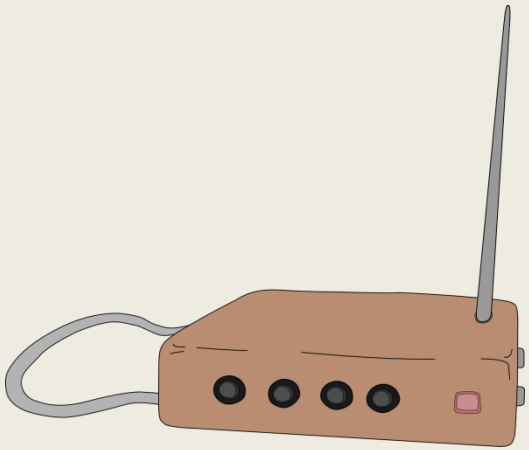


Too Flat

In Tune

Too Sharp

Expandome



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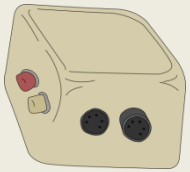

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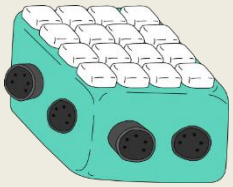


Expandome

EMI Browser

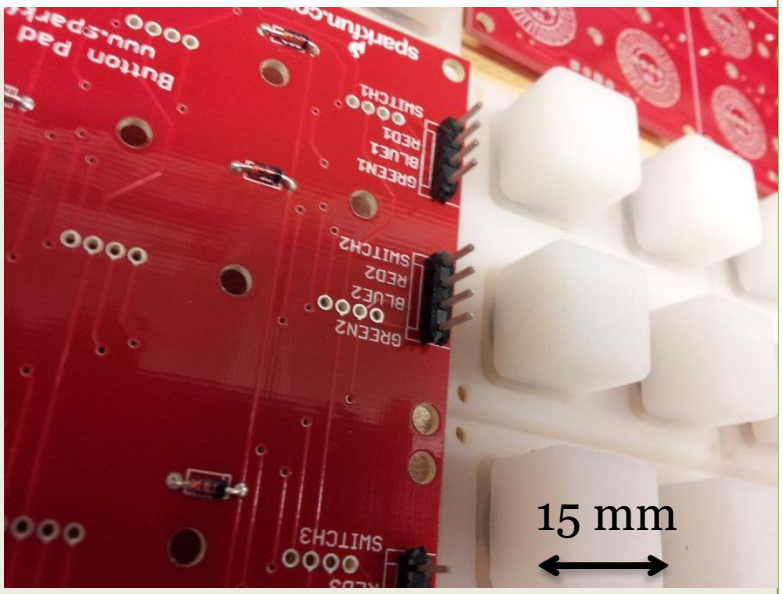
Expandome Specifications

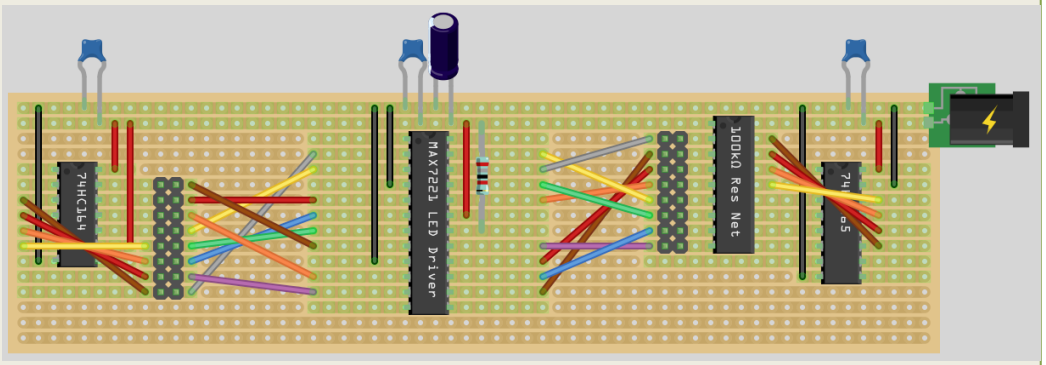
- *n* x *m* pushbutton grid, per device
  (4x4, 4x8, or 8x8)
- OSC/MIDI controller capabilities
- Device recognition and interaction with any standard VST, and via Pure Data is capable of anything from intensive audio abstraction to a simple control pad
- All Expandome firmware embedded on ATmega microprocessor
- Operate with 5V with max current draw of 500mA

Expandome – Design Approach

Primary Elements

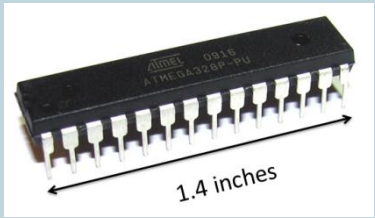
- Silicon Pushbuttons
- Buttonpad PCB, and Diodes
- Shift Registers
- USB port connectors
- Integrated barebones Arduino clone

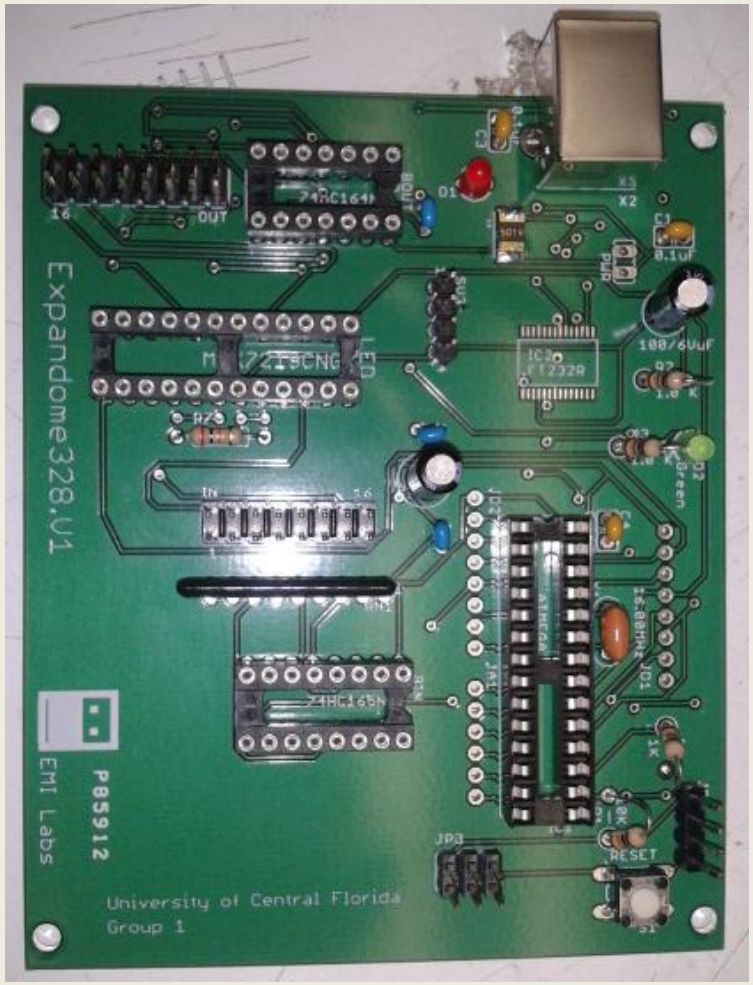




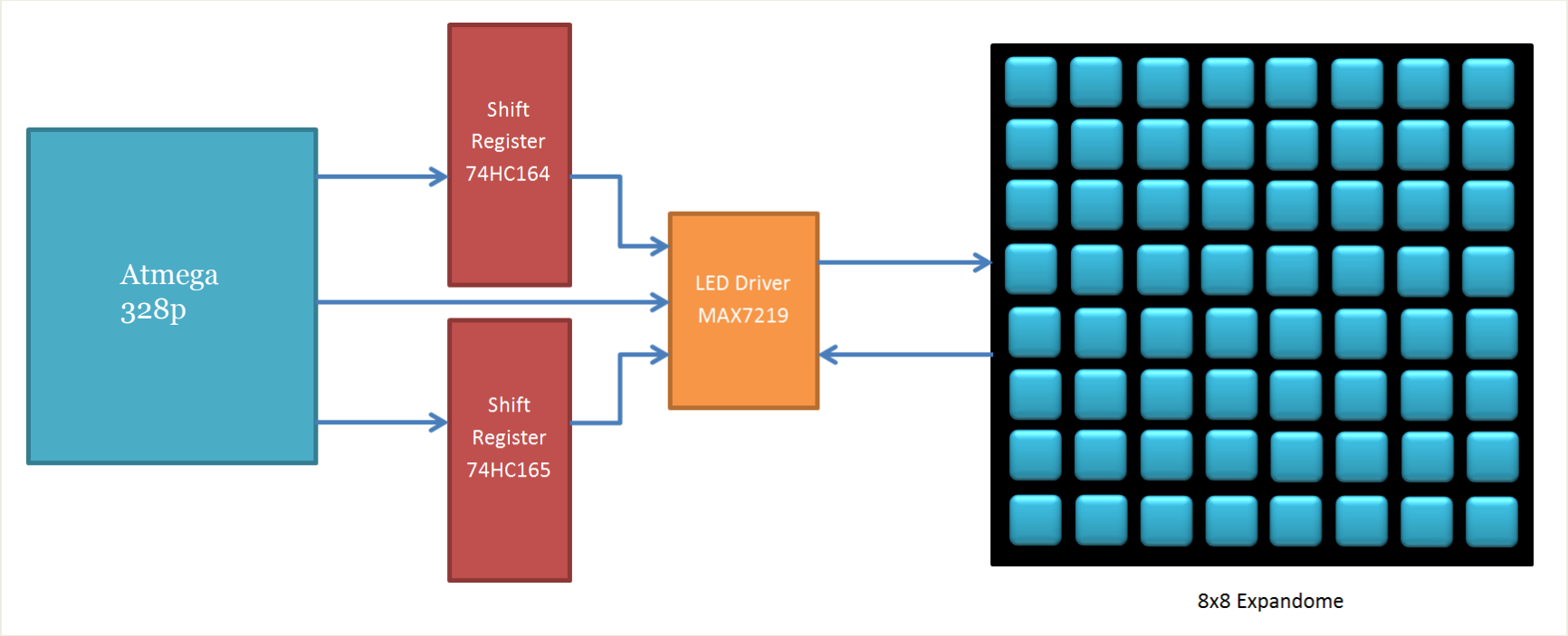
Stripboard representation of Unsped board made by monome.org user Josephiah

Microprocessor—Atmega328

Parameter	Atmega328
Flash	32Kbytes
CPU	8-bit AVR
Max I/O pins	23
SRAM Memory	2KB
Expandome Device	4x4, 4x8 or 8x8
Image	



Expandome Block Diagram

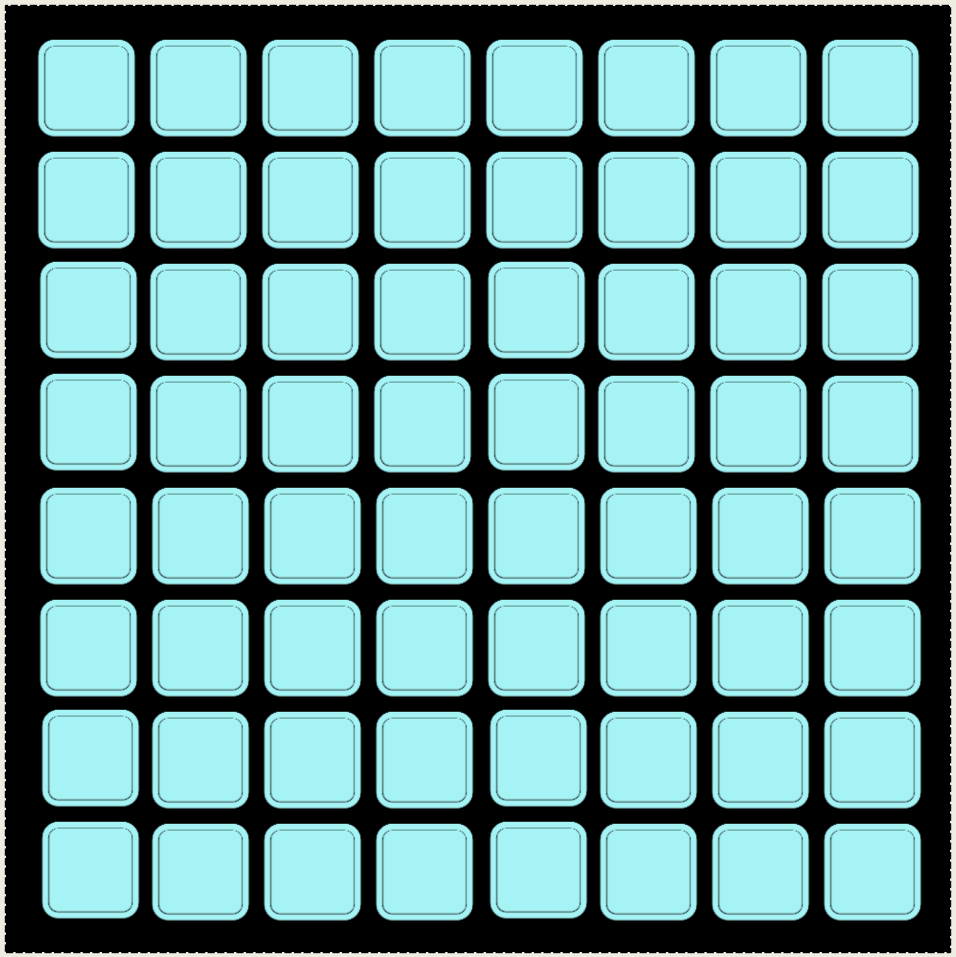


Expandome—Default Start Up

"Lights and Sounds"

The Start-Up program will perform a sequence of operations which will allow the user to verify that the following:

- The device is connected to power
- The device has been programmed
- All LEDs are operable
- The output sound is working



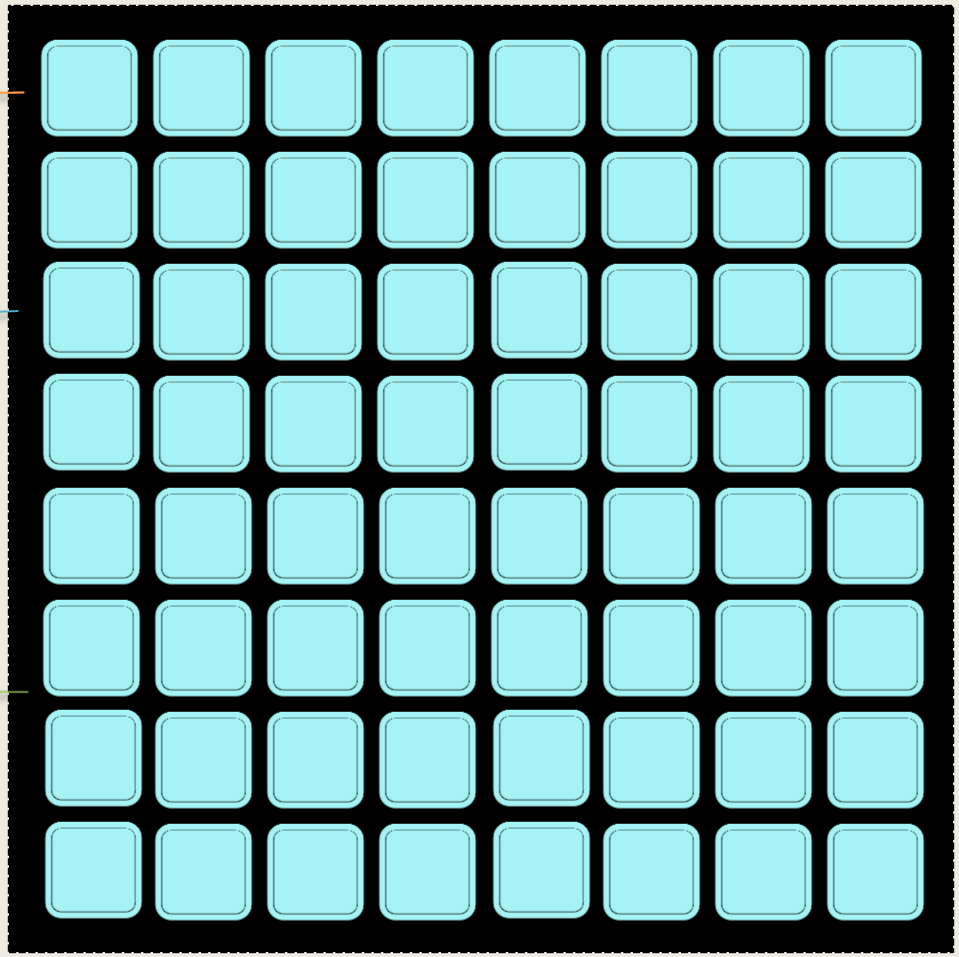
Start

Expandome—Considered features

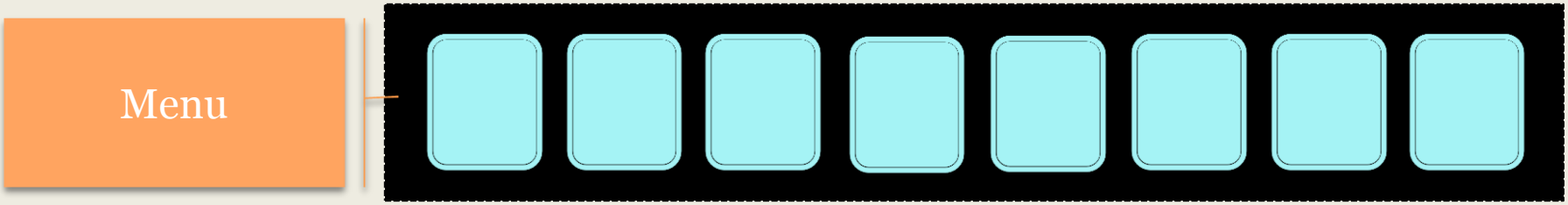
Menu

Tracks/Layers

Individual Beats



Expandome—Considered features

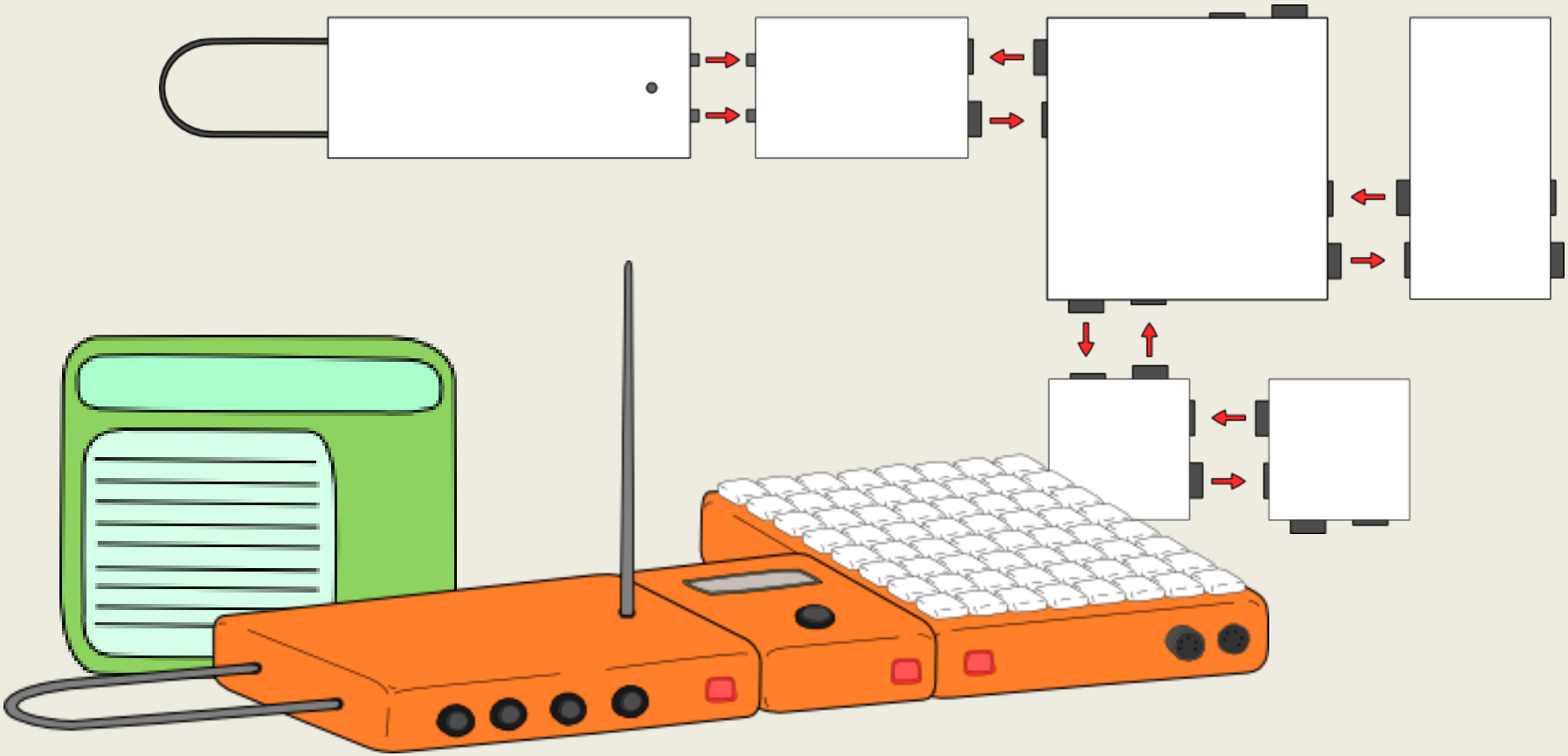


The top row of each Expandome will act as a Menu Bar with the following default settings:

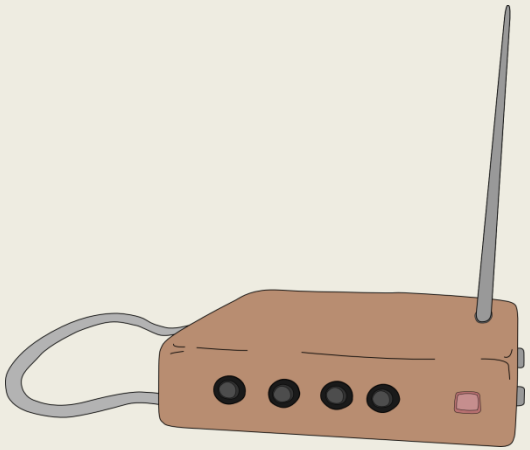
- Clear All Beats
- Beat Repeat
- Clear Beat Repeat
- Track Assign*
- Record*
- Play Back*

*(*This feature will not appear on the 4x4 or 4x8 devices.)*

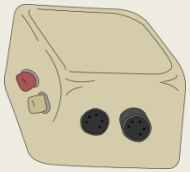
Full Implementation



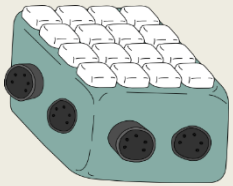
EMI Browser



uWave



SenseBox

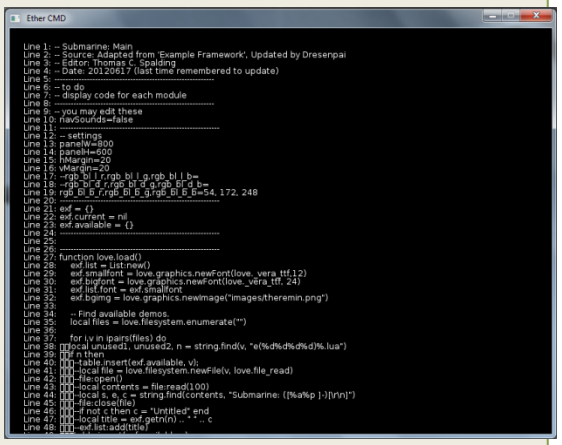


Expandome

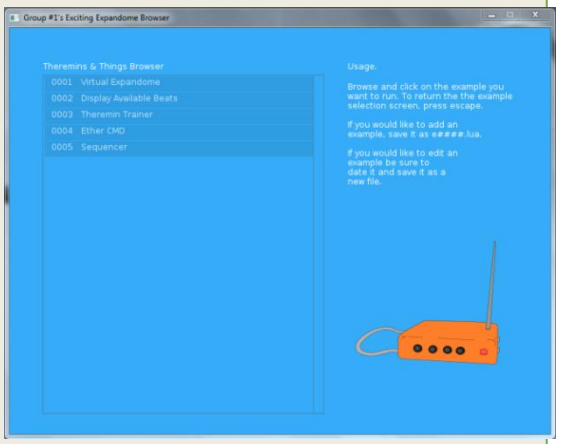
EMI Browser

User Interface & Browser

- Debugging tool during prototyping
  - Emulate MIDI messages
  - Display communication organized by device prefixes
  - Code Editor and easily integrate other coded tools
- Interaction tool for regular use
  - Theremin trainer
  - Organize beats and button assignment
  - Virtual Expandome
  - SenseBox mode selection



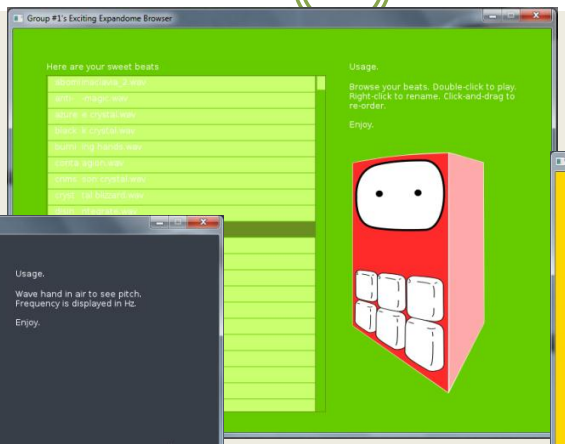
Ether CMD



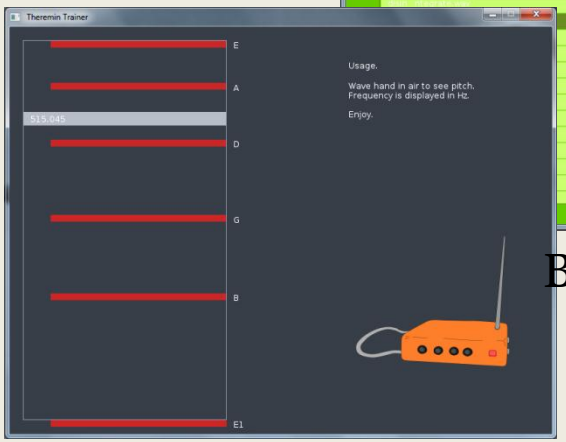
EMI Browser

Environments Explored

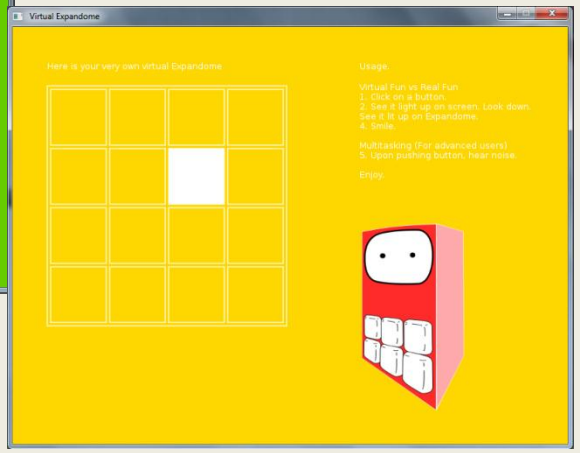
- Löve Lua



Beat Organizer



Theremin Trainer

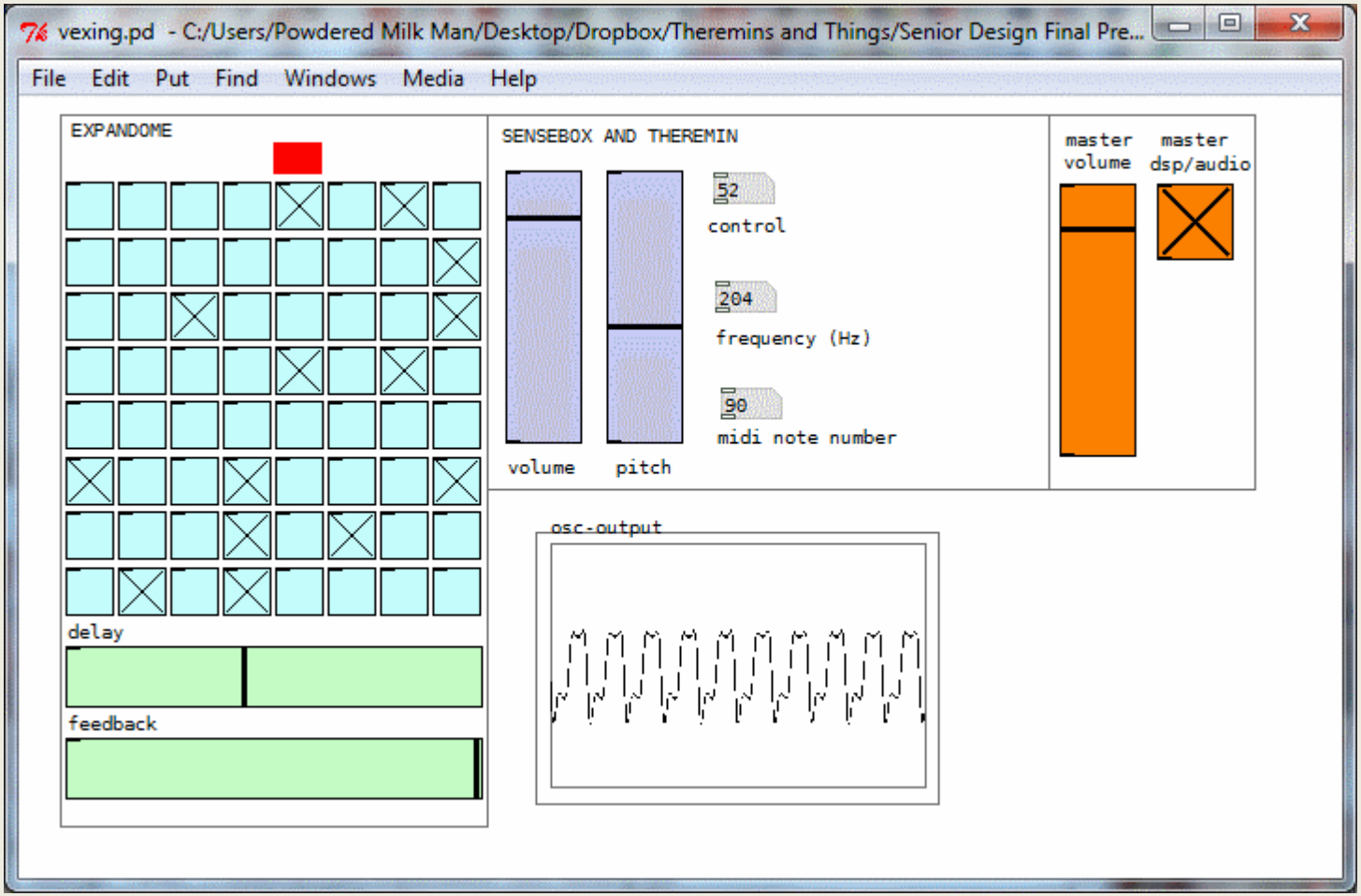


Beat assignment &
Virtual Expandome

- Processing

  - MAX/MSP

Pure Data


vexing.pd - C:/Users/Powdered Milk Man/Desktop/Dropbox/Theremins and Things/Senior Design Final Pre...
File Edit Put Find Windows Media Help
EXPANDOME
delay
feedback
SENSEBOX AND THEREMIN
52
control
204
frequency (Hz)
90
midi note number
volume
pitch
master volume
master dsp/audio
osc~ output

Power Requirements

uWave : +/- 12V

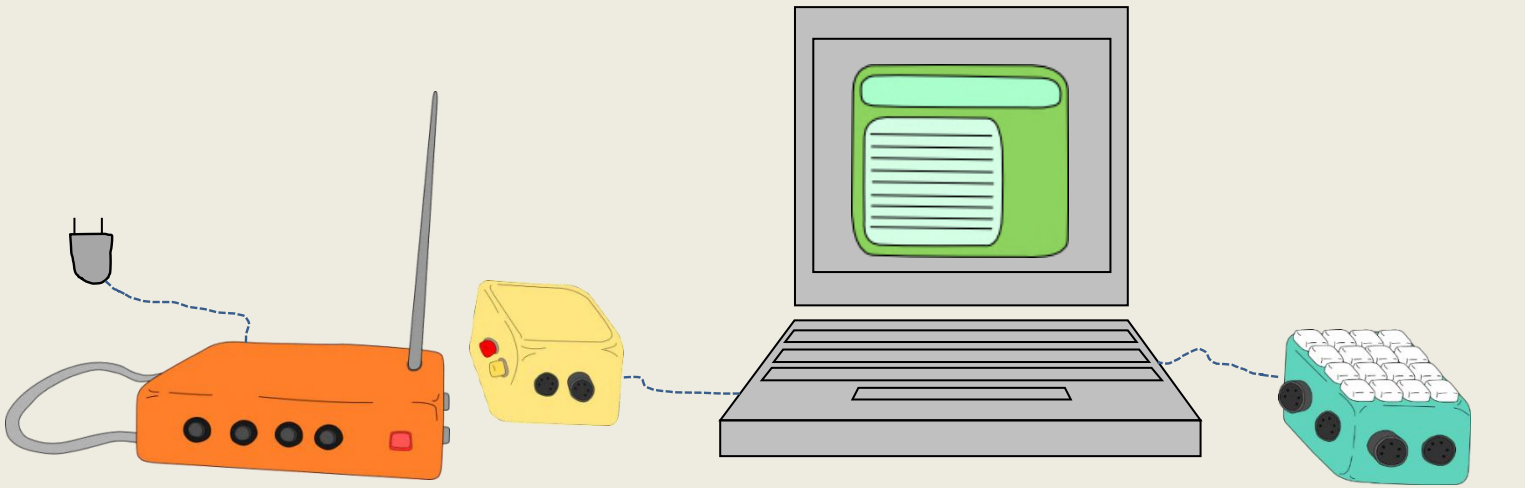
- 14-16VAC wall adapter in conjunction with a power supply circuit using capacitors, diodes and voltage regulators

SenseBox: 5V

- 5V via 15VDC wall adapter

Expandome 8x8 & 4x4: 5V

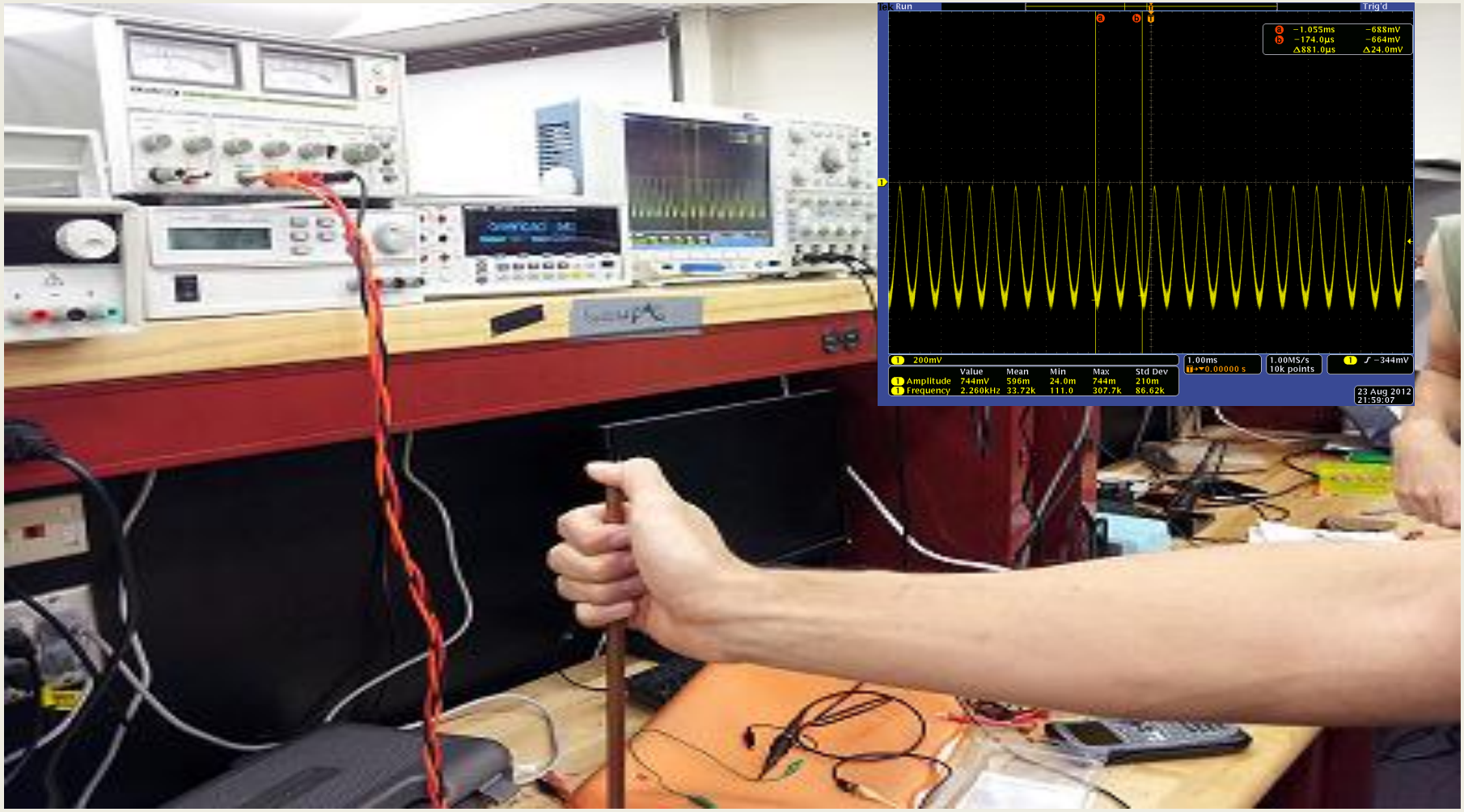
- 5V via USB connection to the computer



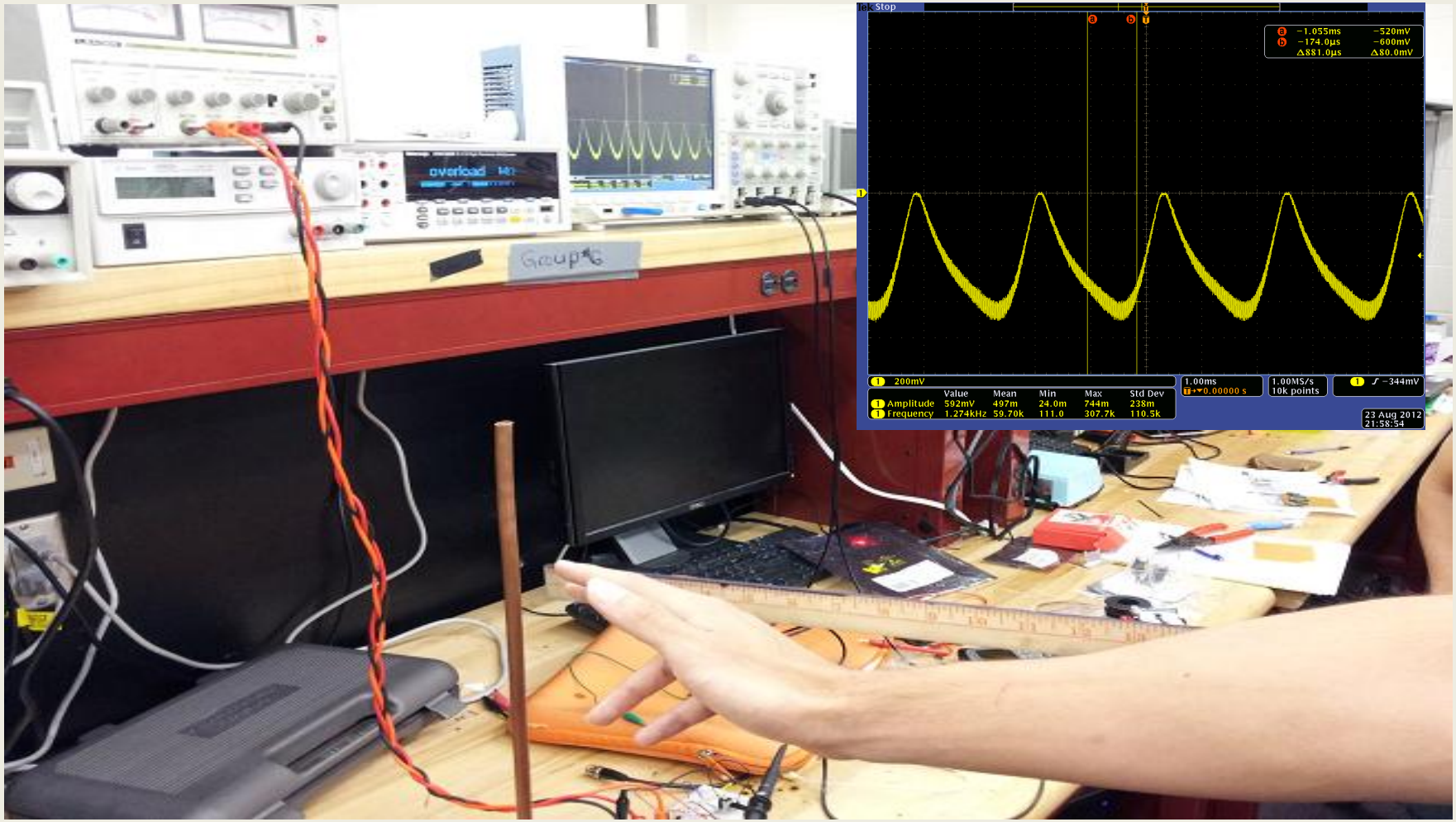
Clear Statement of Progress

- The theremin is built and operates as designed.
- The SenseBox is built and its primary functions are operating. Additional arpeggiated modes, ARP1 & ARP2 are still in beta phase.
- The 8x8 Expandome has been built, and has a myriad of available setups.
- The Expandome Browser has been made and is fully capable of routing the devices as well as as a self-contained demonstration.

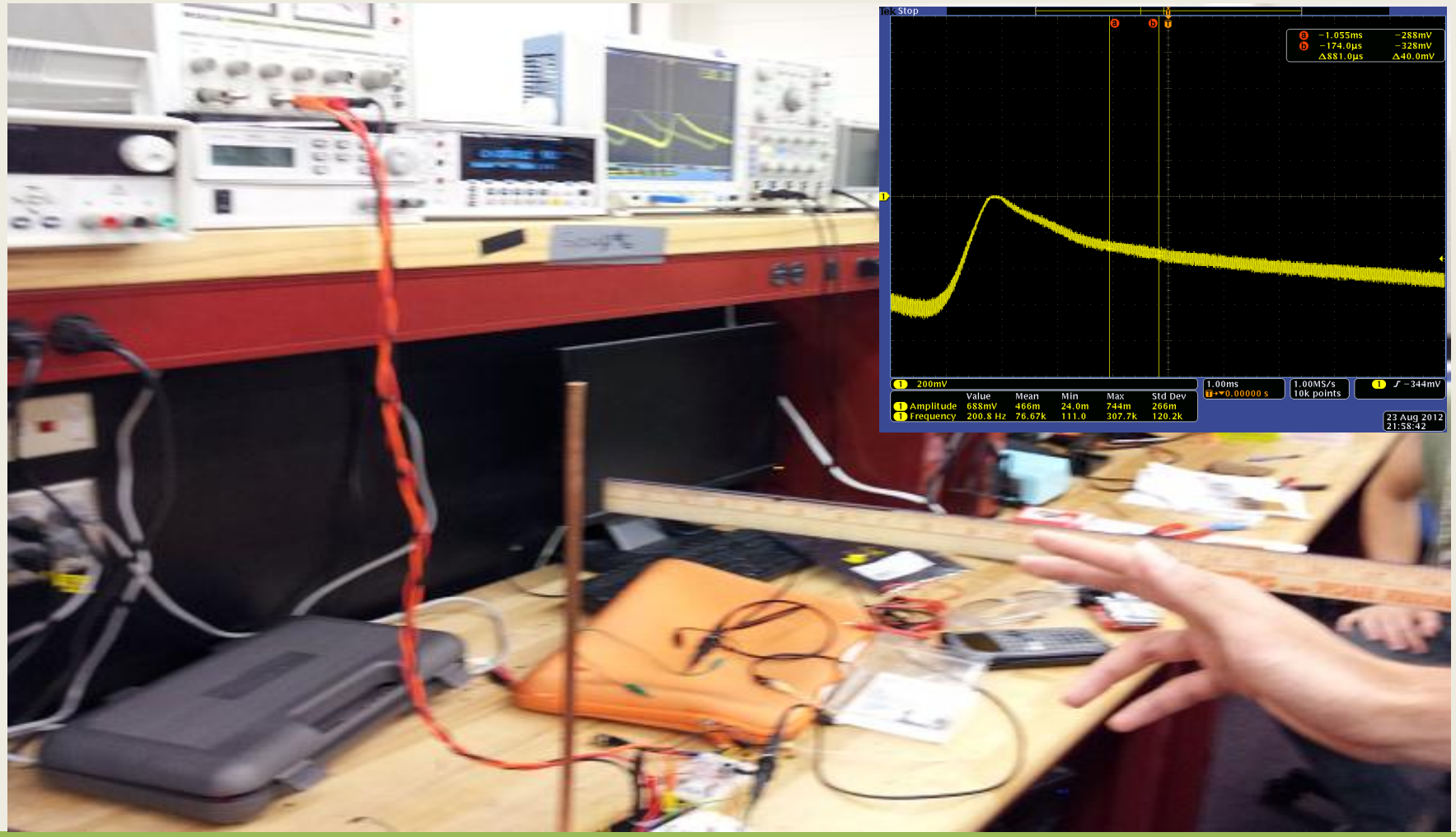
Testing the uWave Theremin



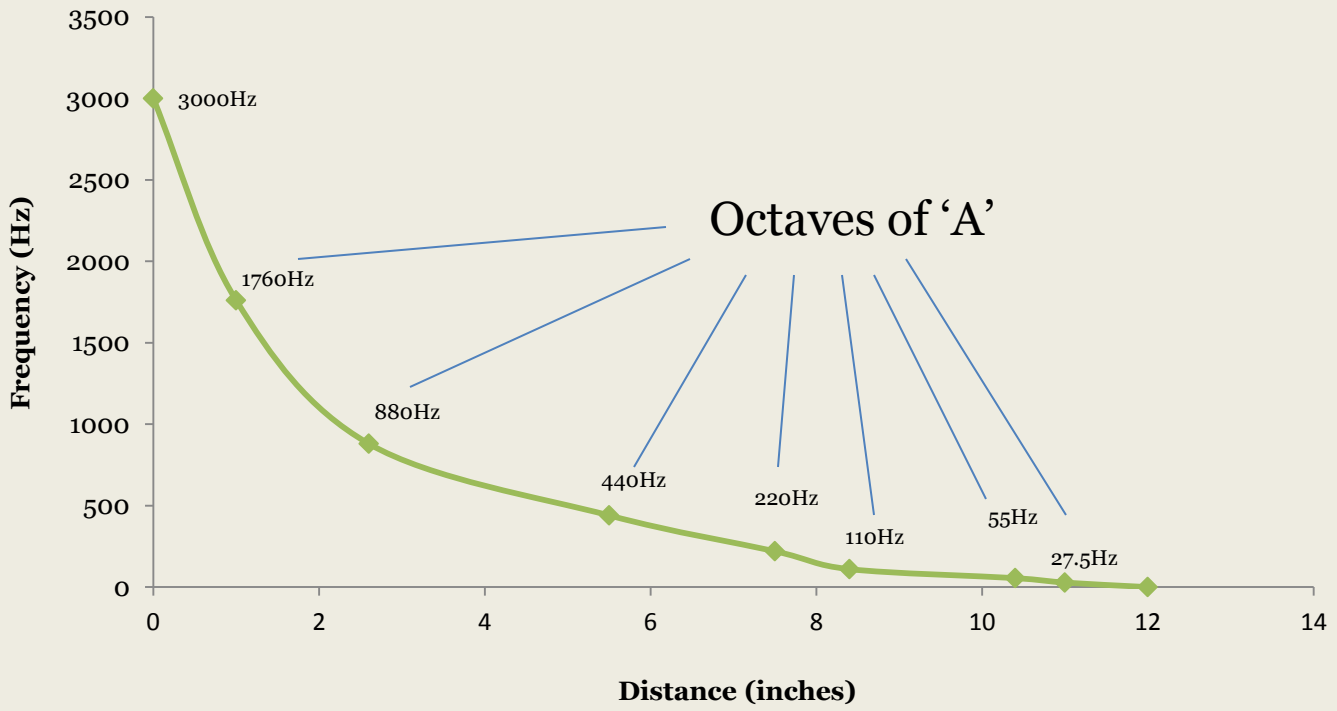
Testing the uWave Theremin



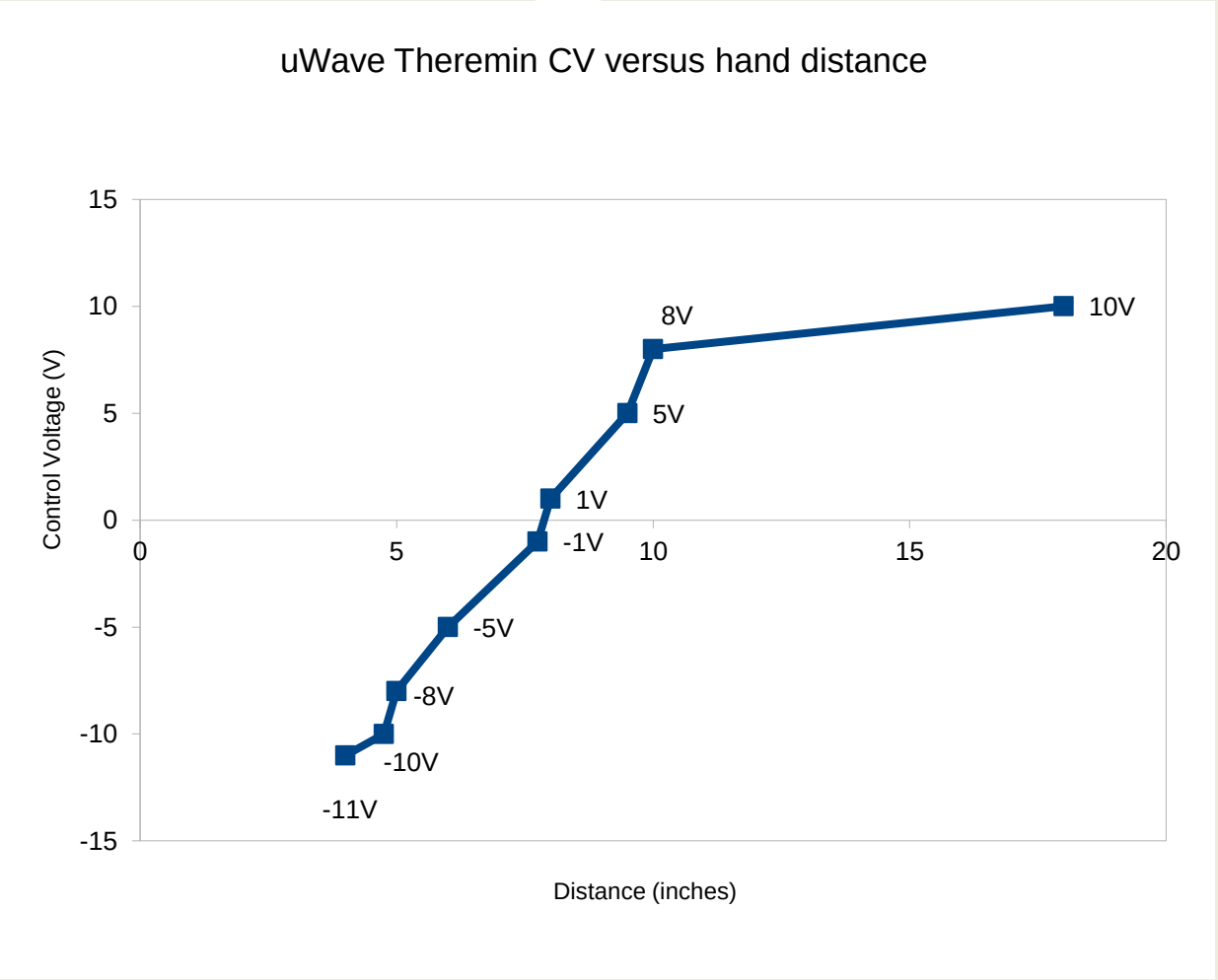
Testing the uWave Theremin



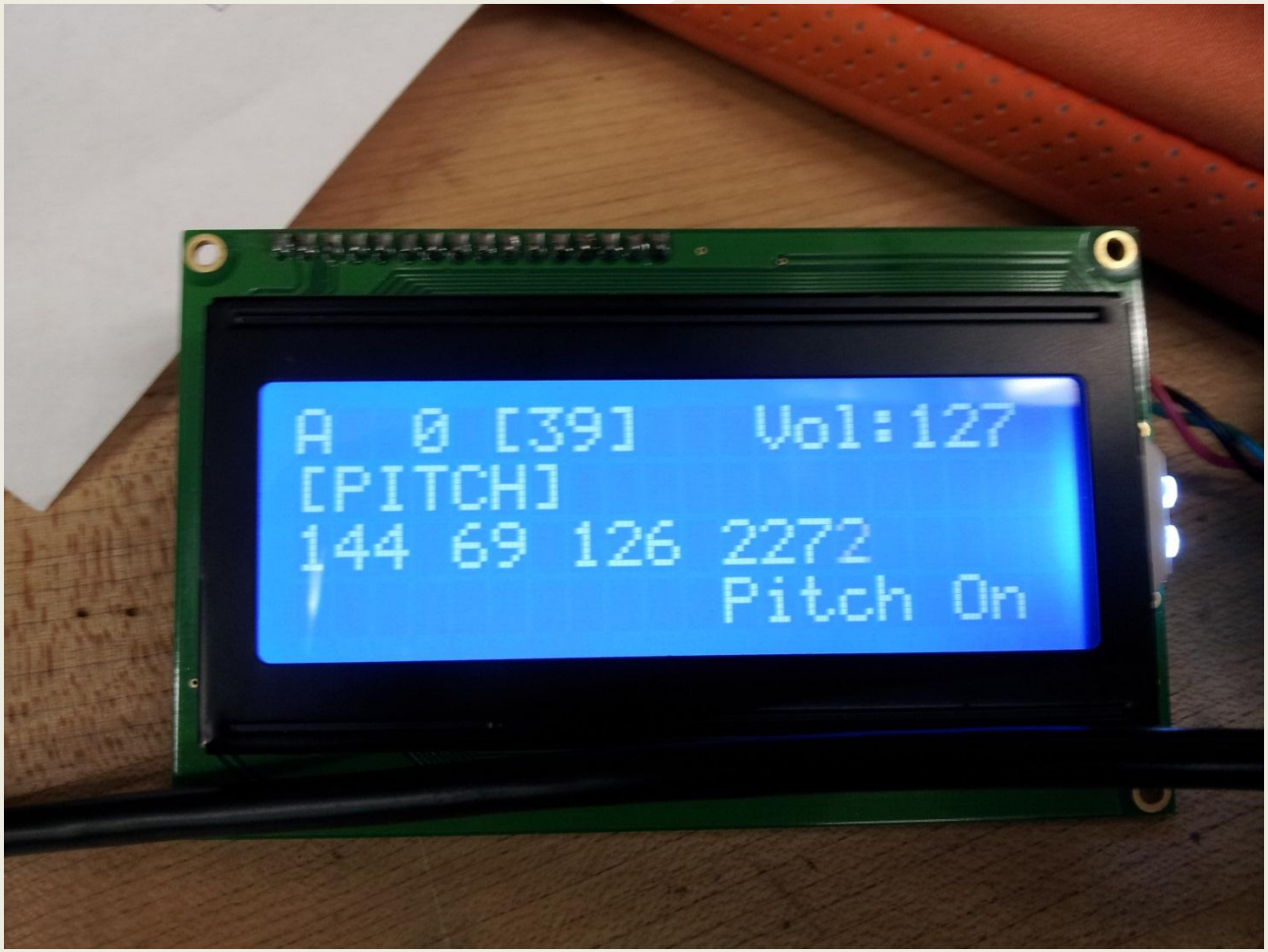
uWave Theremin pitch tone versus players hand proximity



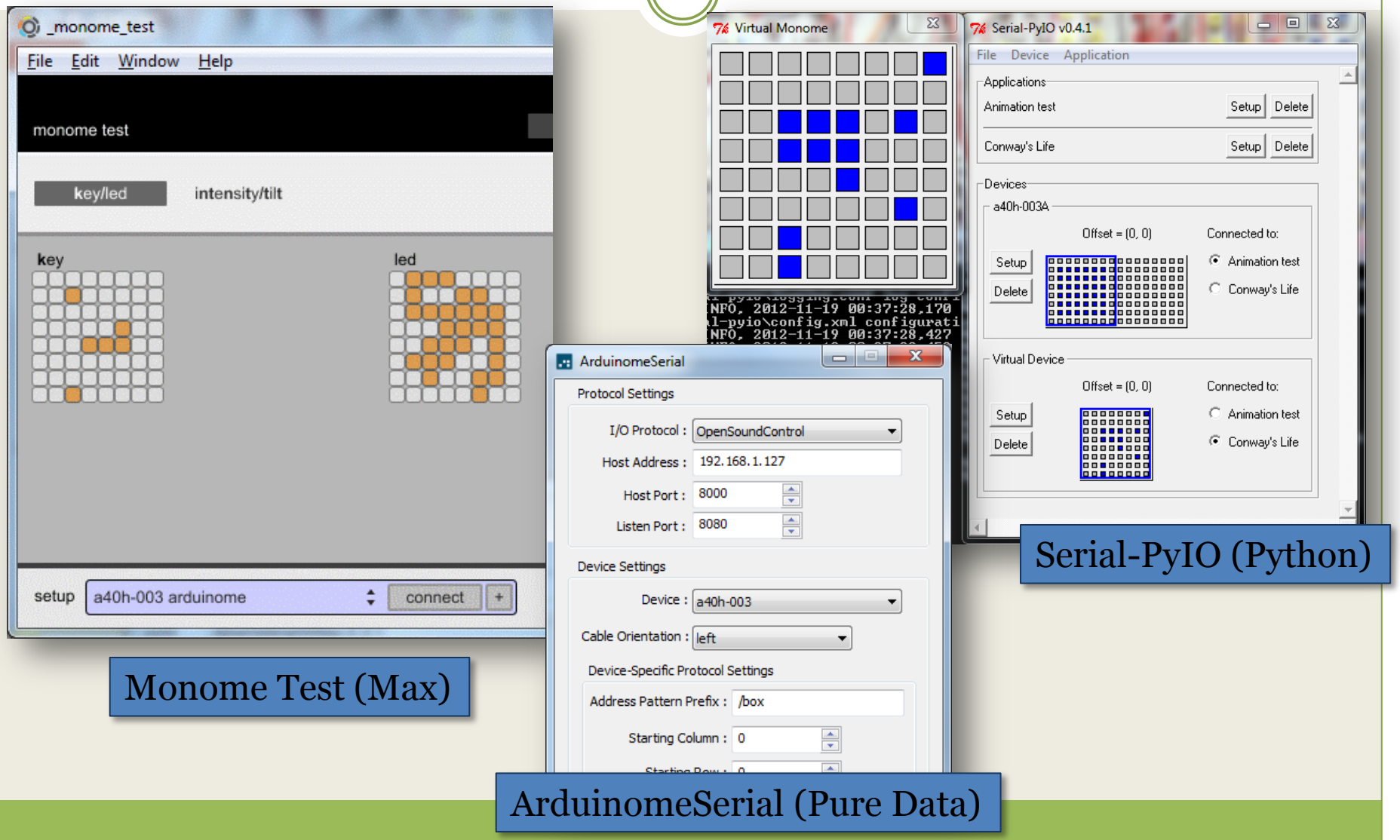
Volume Testing



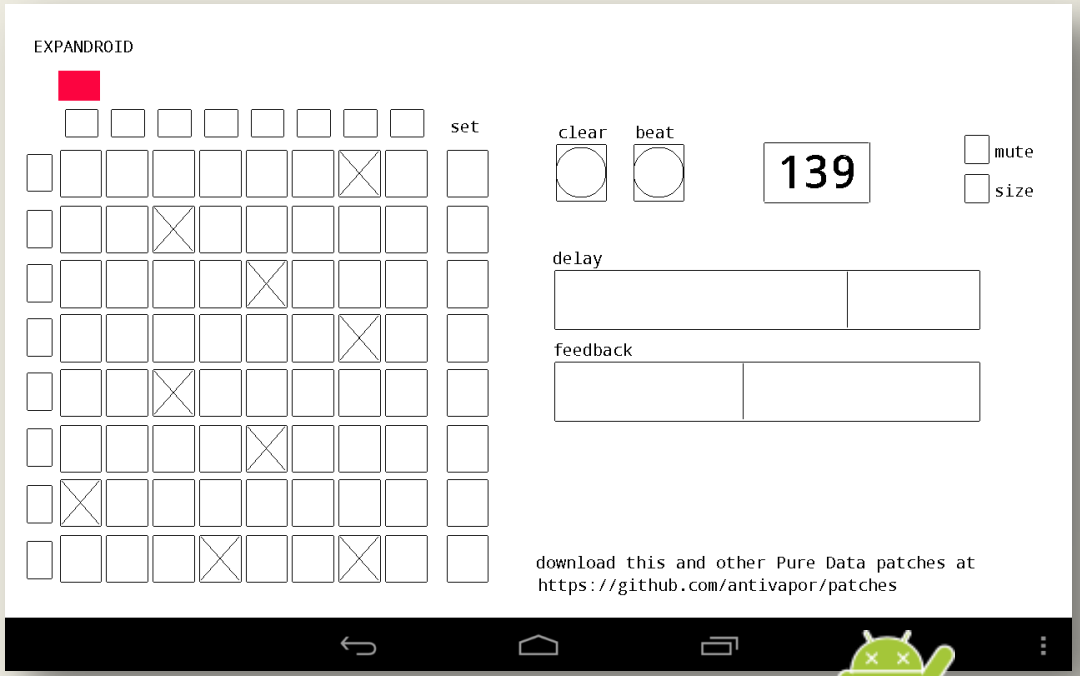
SenseBox Testing



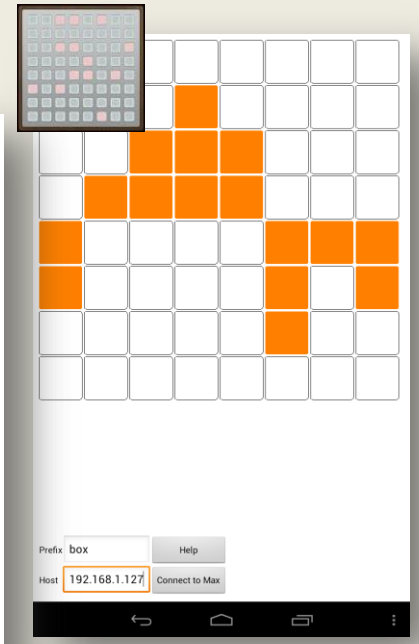
Testing, connections, and apps



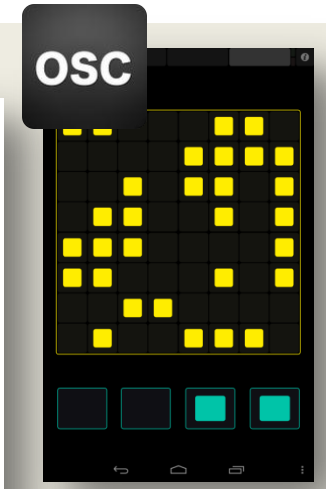
Emulation and Further Expansion w/Apps



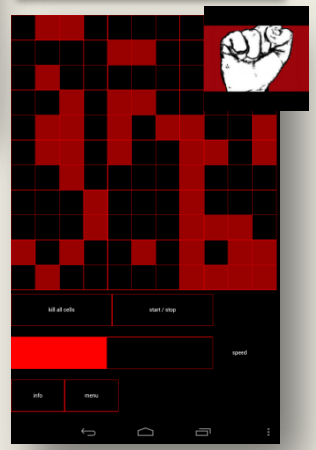
Expandandroid



Androidome



TouchOSC



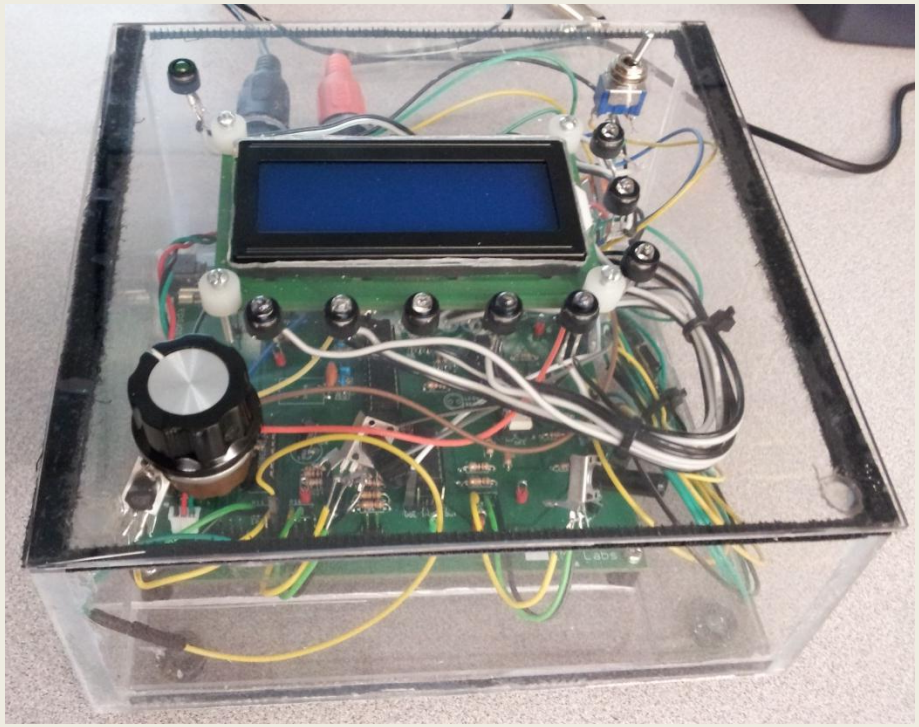
Control

Theremin - Difficulties

- Difficulties
  - Careful consideration when placing parts on PCB is needed
    - Antenna inductors must be placed 1” from each other
    - VPO and FPO should be separated by a few inches
  - Controlled test environment
    - Sound Quality
    - Tuning issues

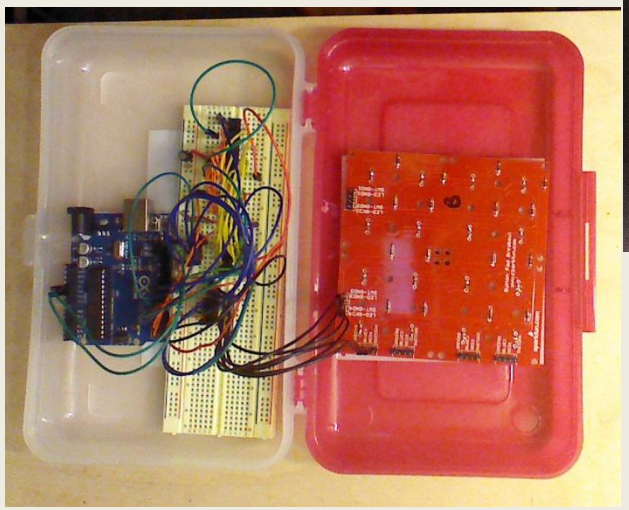
SenseBox - Difficulties

- Difficulties
  - Had issues retrieving volume data from the uWave Theremin.
  - Accurately measure incoming frequency from the uWave Theremin.



Expandome—Difficulties

- Serial protocol/communication and firmware recognition between the microprocessor and computer.
- External wiring issues



Project Budget and Financing to date and to end of project

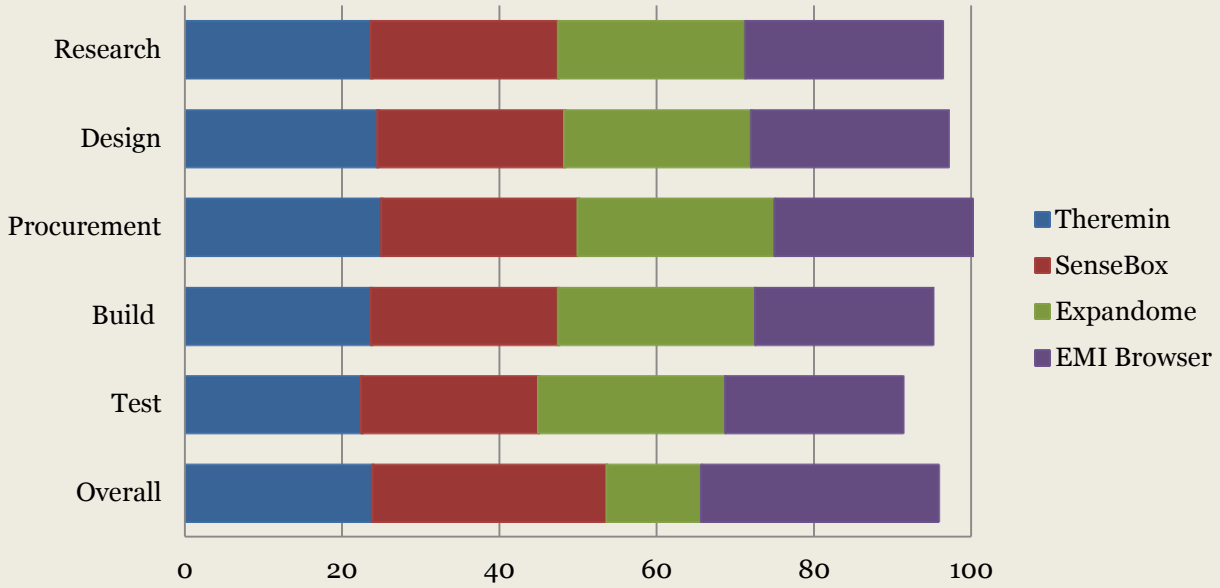
COST ESTIMATE

Project Title: uWave/SenseBox/Expandome Date: 7/29/2012

Group: GROUP 1

ITEM	DESCRIPTION	QTY	UNIT	UNIT COST	LINE TOTAL
1	uWave Theremin	1	each	$ 150.00	$ 150.00
2	Expandome 8x8	1	each	$ 200.00	$ 200.00
3	Expandome 4x8	1	each	$ 150.00	$ 150.00
4	Expandome 4x4	1	each	$ 100.00	$ 100.00
5	MIDI Interface	1	each	$ 100.00	$ 100.00
6	Power Supply	1	each	$ 50.00	$ 50.00
7	Software	1	each	$ 50.00	$ 50.00
8	Enclosure	5	each	$ 100.00	$ 500.00
	TOTAL ESTIMATE				$ 1,300.00

Progress



	Theremin	SenseBox	Expandome	EMI Browser
Research	95%	95%	95%	100%
Design	98%	95%	95%	100%
Procurement	100%	100%	100%	100%
Build	95%	95%	100%	90%
Test	90%	90%	95%	90%
Overall	96%	95%	97%	96%

95%

Open question time

Thank You

http://tiny.cc/group1cdr