Electronic Music Interactions

(EMI)

GROUP #1

Modern and alternative interactions with music devices

Anthony Adu EE
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Thomas Spalding EE
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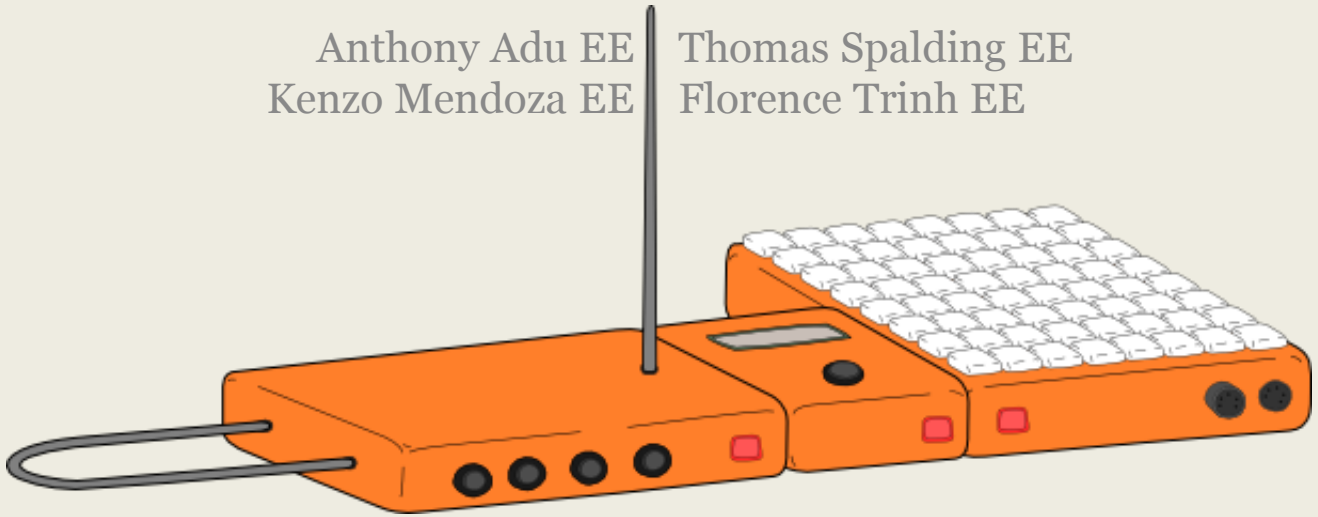
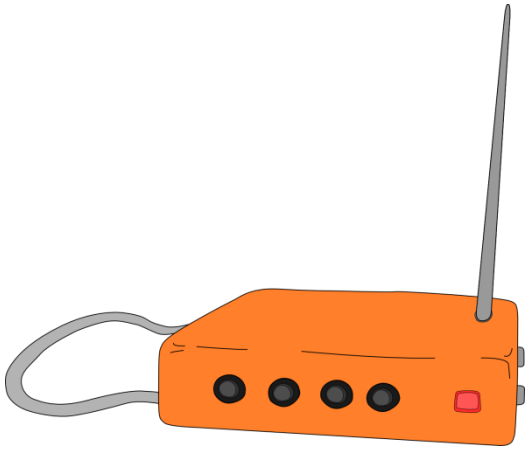


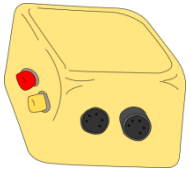
Goals & Objectives

- 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

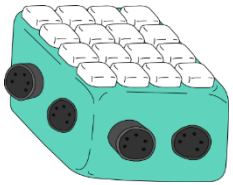
EMI



uWave

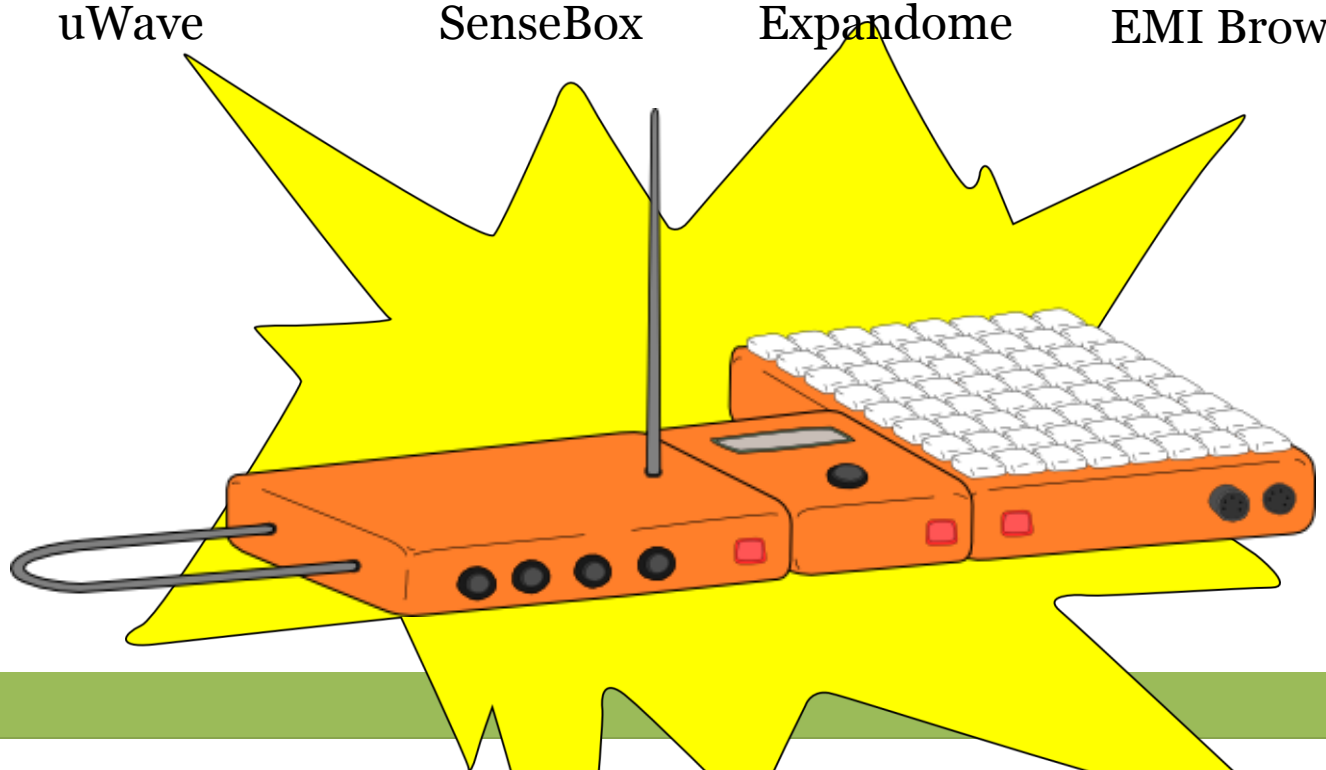


SenseBox



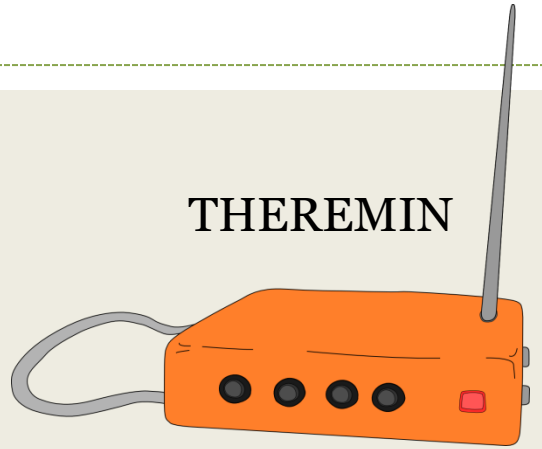
Expandome

EMI Browser



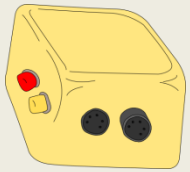
Prior Similar Work

THEREMIN



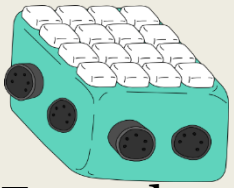
uWave

PITCH-TO-MIDI TRACKER



SenseBox

ARDUINOME MIDI CONTROLLER



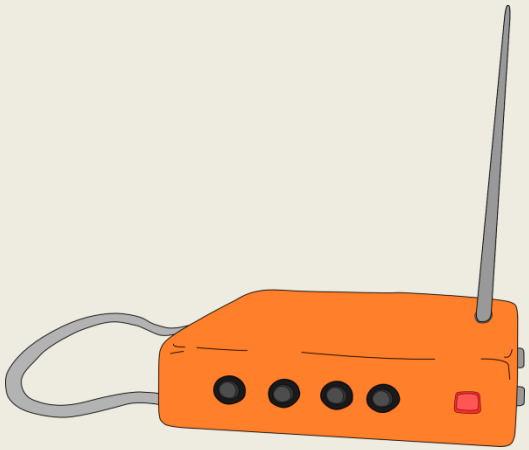
Expandome

Robert Moog
Innovator

Stephen Hobley
Hobbyist

Jordan Hochenbaum & Owen Vallis
Researchers

uWave Theremin



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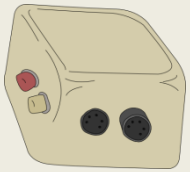

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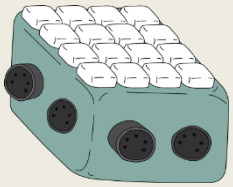


Expandome

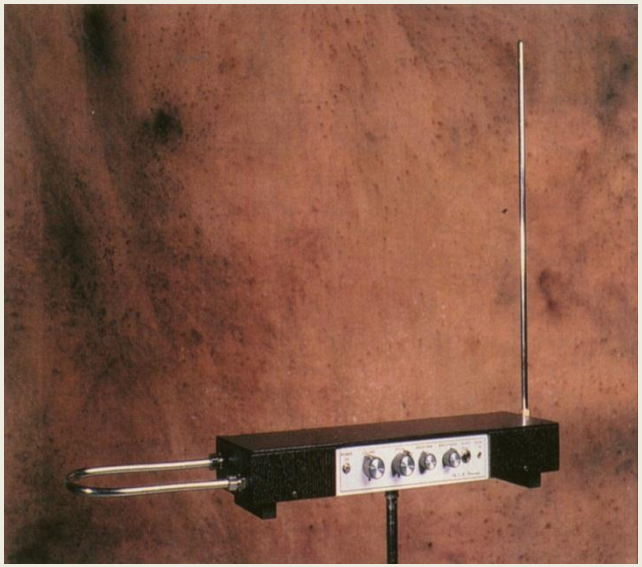
EMI Browser

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

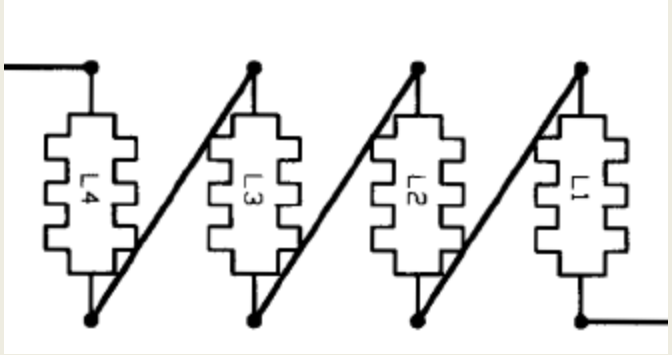
- The basic elements of a Theremin are
  - Oscillators for pitch control
  - Oscillator for volume control
  - Mixer and Detector
  - Audio amplification

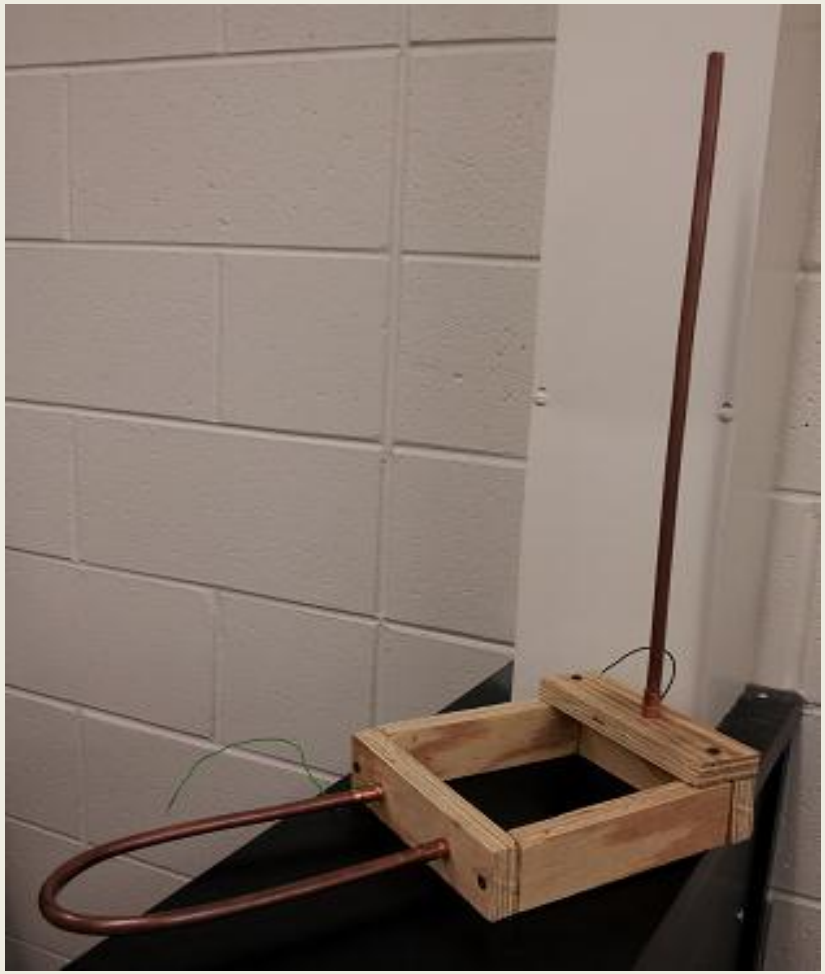


- Robert Moog EM Theremin
  - Known for the Moog Synthesizer
  - Recreated the original Theremin in 1948
  - Released the electronic Theremin DIY guide in 1996

Antenna Circuits

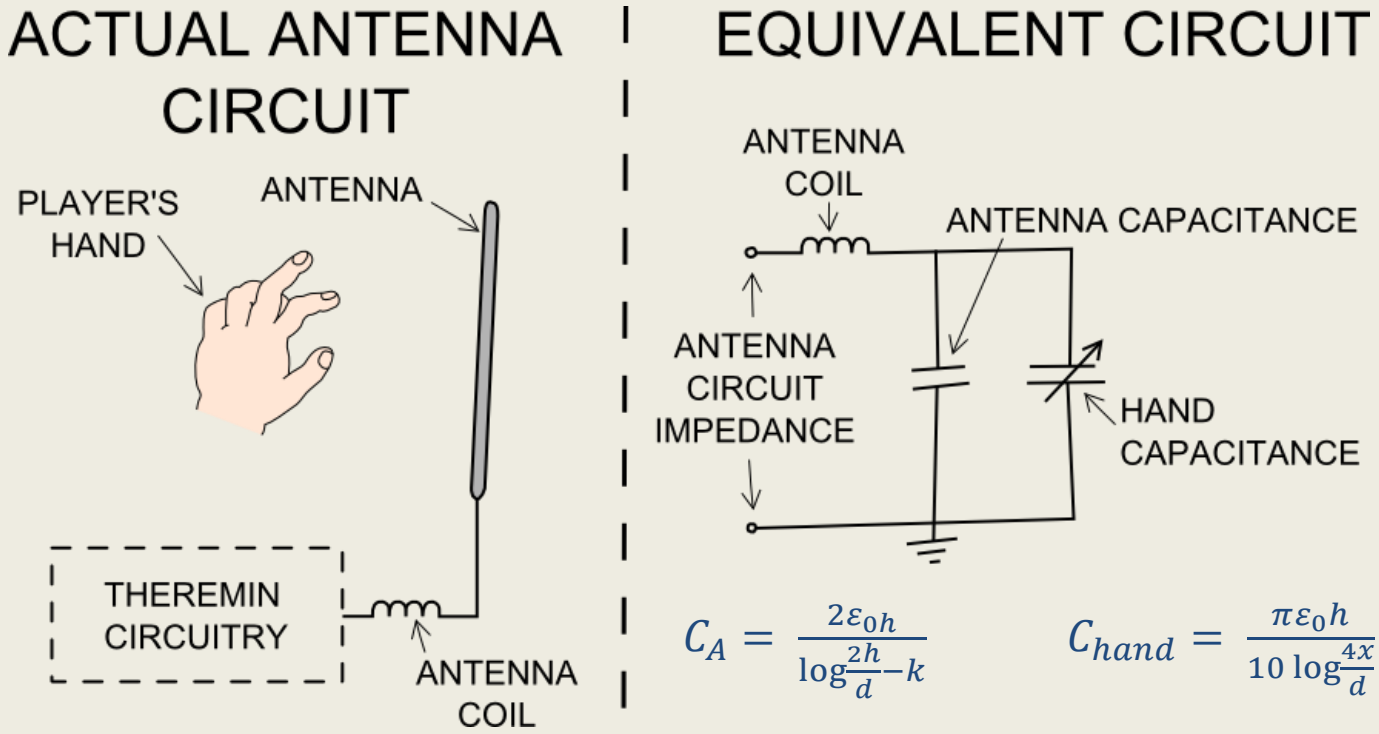
- Pitch Antenna
  - 18” Vertical
  - Creates a resonance frequency of 260 kHz
- Volume Antenna
  - Looped and 9” horizontal
  - Creates a resonance frequency of 450 kHz





Antenna Circuits

- Equivalent antenna circuit



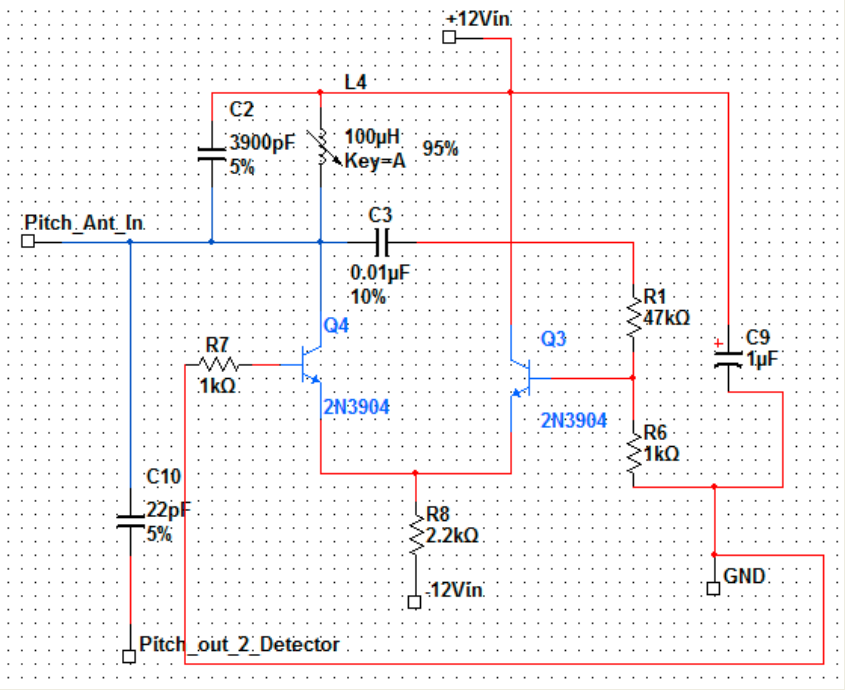
$$C_A = \frac{2\varepsilon_0 h}{\log\frac{2h}{d} - k} \qquad C_{hand} = \frac{\pi\varepsilon_0 h}{10\log\frac{4x}{d}}$$

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

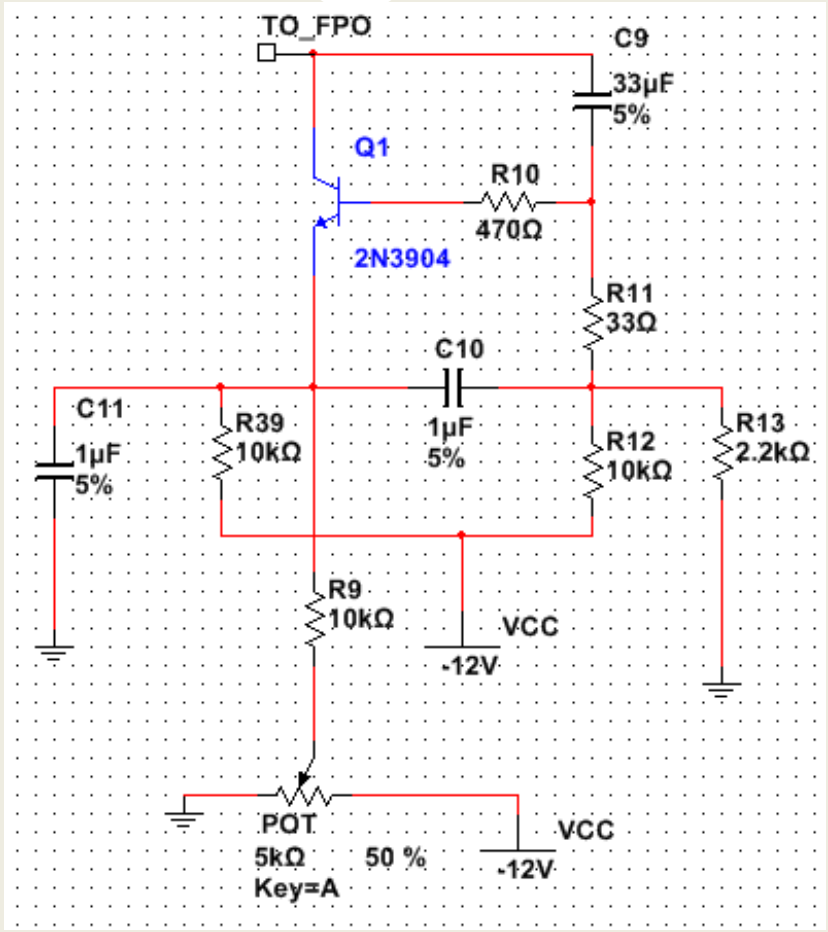
Pitch Oscillators

- Fixed and Variable pitch oscillators
- General frequency equation
  - $f_{osc} = \frac{1}{2\pi\sqrt{L(C_2+C_A+C_{hand})}}$
- FPO -> 260 kHz
- VPO -> 257 to 260 kHz

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



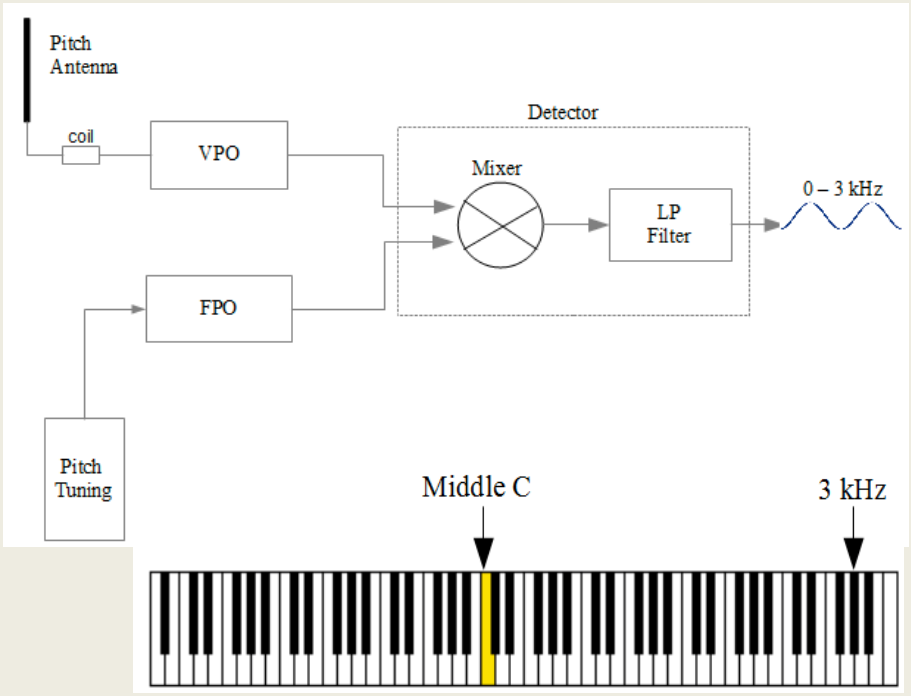
Tuning Circuit



Frequency Detection

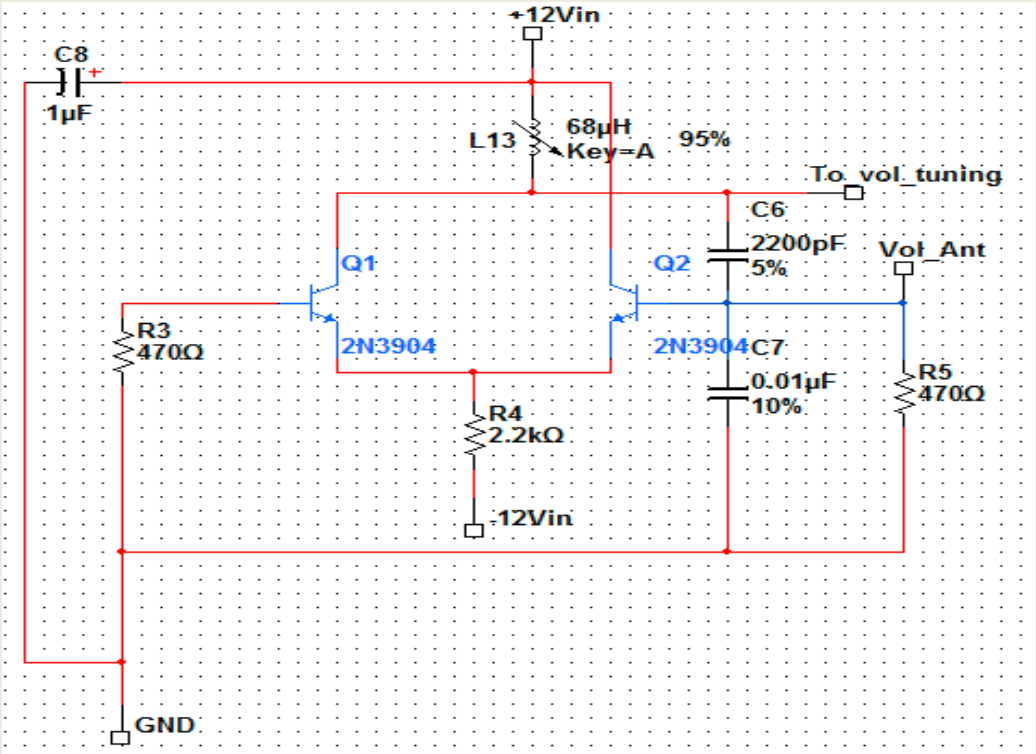
- Heterodyning : Method of mixing two signals to create one signal with two frequency components.
- $V_{mix} = \frac{A}{2}[\cos(2\pi f_1 - 2\pi f_2)t - \cos(2\pi f_1 + 2\pi f_2)]$
- Output from detector
  - $V_{out} = \frac{A}{2}\cos(2\pi f_1 - 2\pi f_2)t$

Where f_1 = FPO frequency
& f_2 = VPO frequency



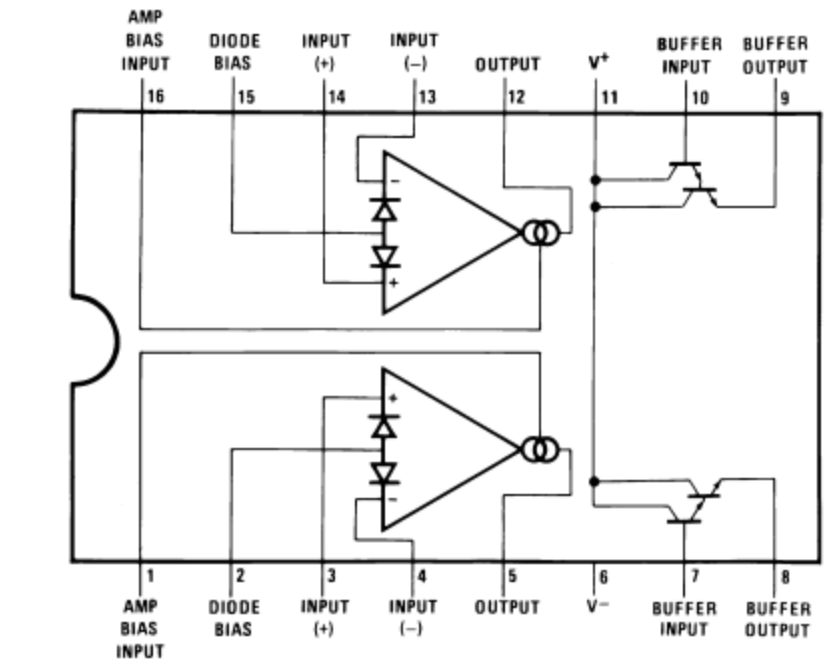
Volume Oscillator

- Operates at higher frequency of 450 kHz
- Creates DC voltage used by the VCA
- Adjustable Frequency
  - Volume Tuning

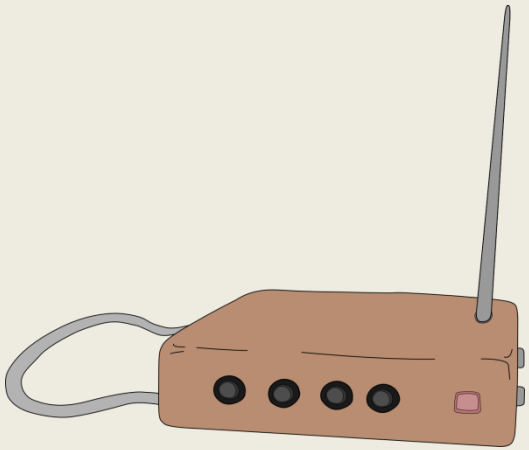


Design cont'd

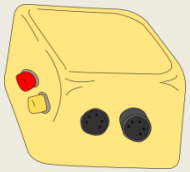
- Voltage Controlled Amplifier (VCA)
  - LM13700 Dual Operational Transconductance Amplifier
  - Amplifies pitch signal from detector
  - Max audio output voltage of 0.8 Vrms



SenseBox



uWave



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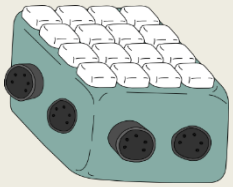


Expandome

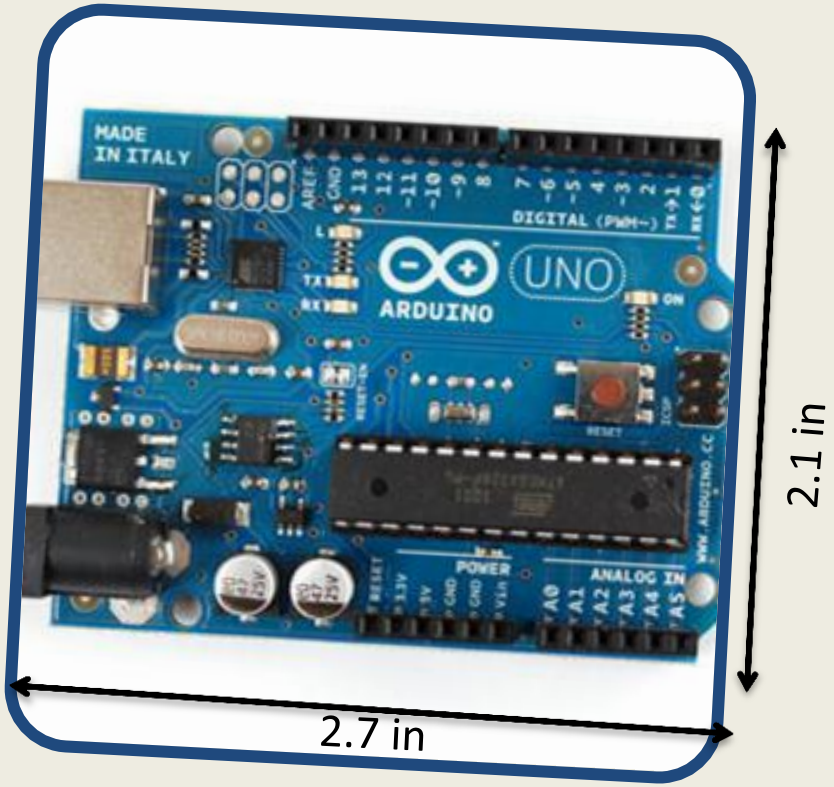
EMI Browser

SenseBox Specifications

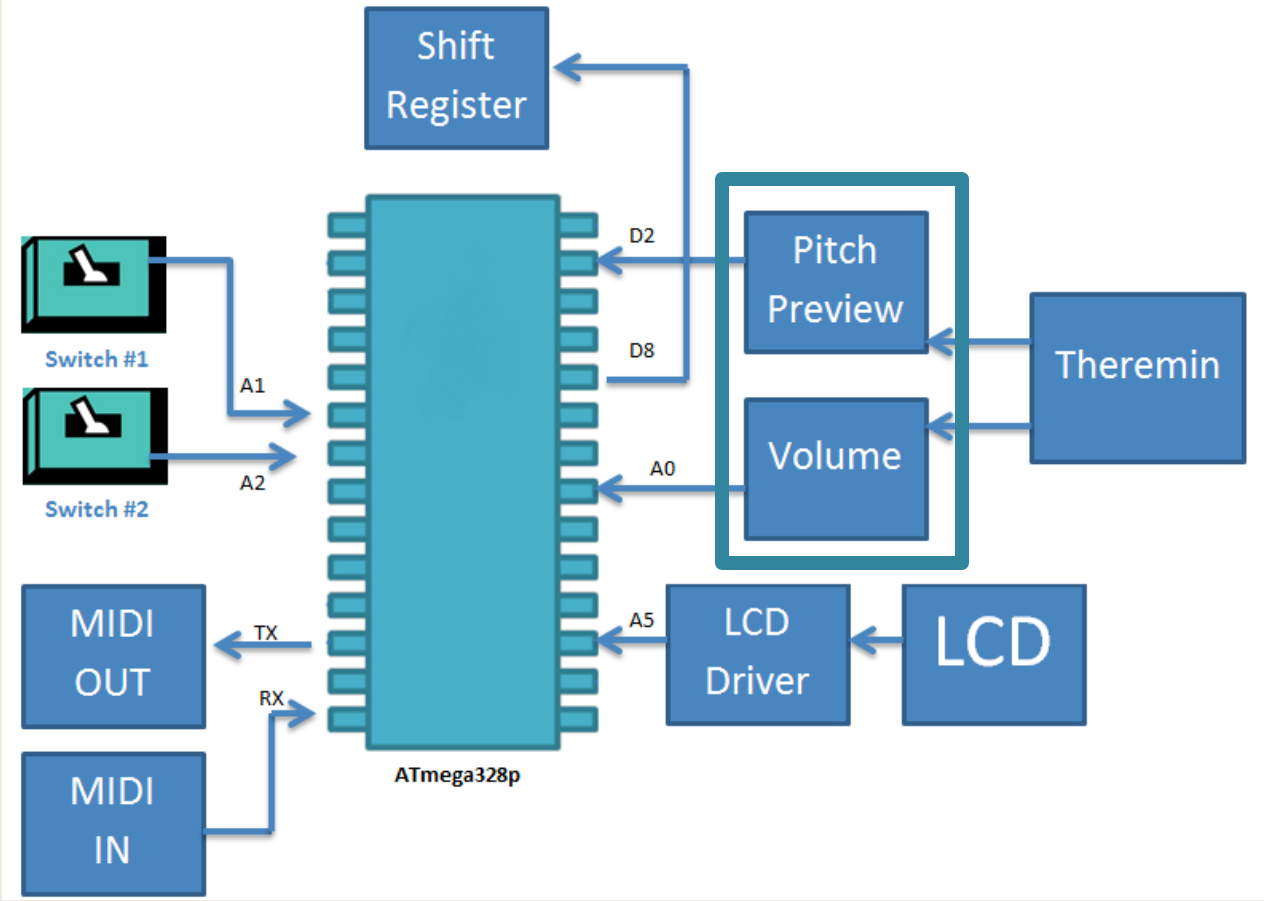
- Operate with a power supply of +5V
- Receive analog signal from uWave Theremin (0.8 VRMS) and convert to MIDI data
- 4 Mode operation – Pitch, Control, ARP1 & ARP2
- 1 LCD that will display but not limited to: current mode operation, note name based on the current pitch, volume value, incoming MIDI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

Microprocessor - Atmega328

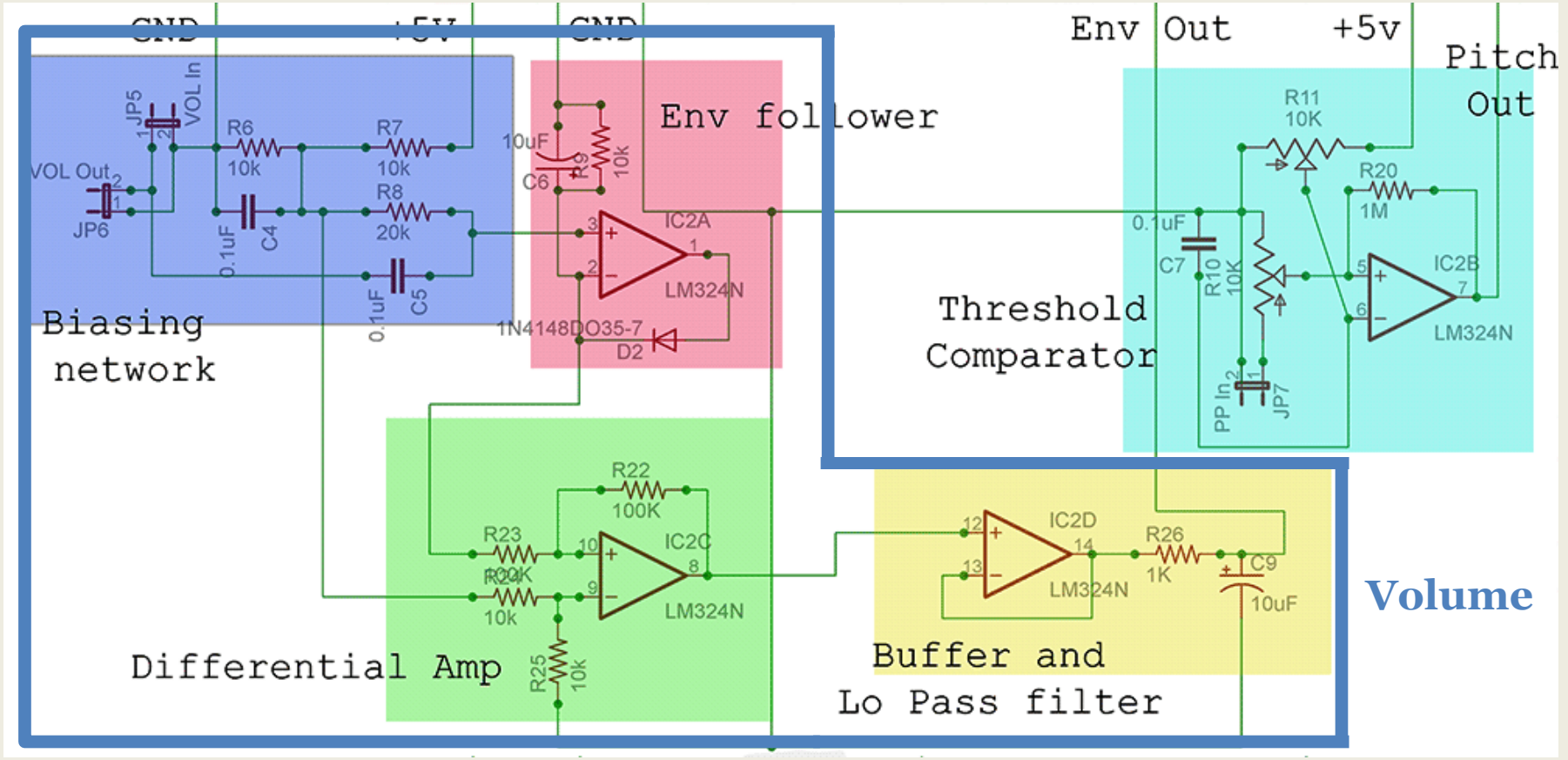
Parameter	Arduino Uno
Chip	Atmega328p
Analog input	6 pins
Flash Memory	32KB
RAM Memory	2KB
Communication Protocols	Serial
Bits Per Second (Baud)	Adjustable (32,250 bit per second for MIDI protocol)



Block Diagram of SenseBox



SenseBox - Pitch and Volume Data



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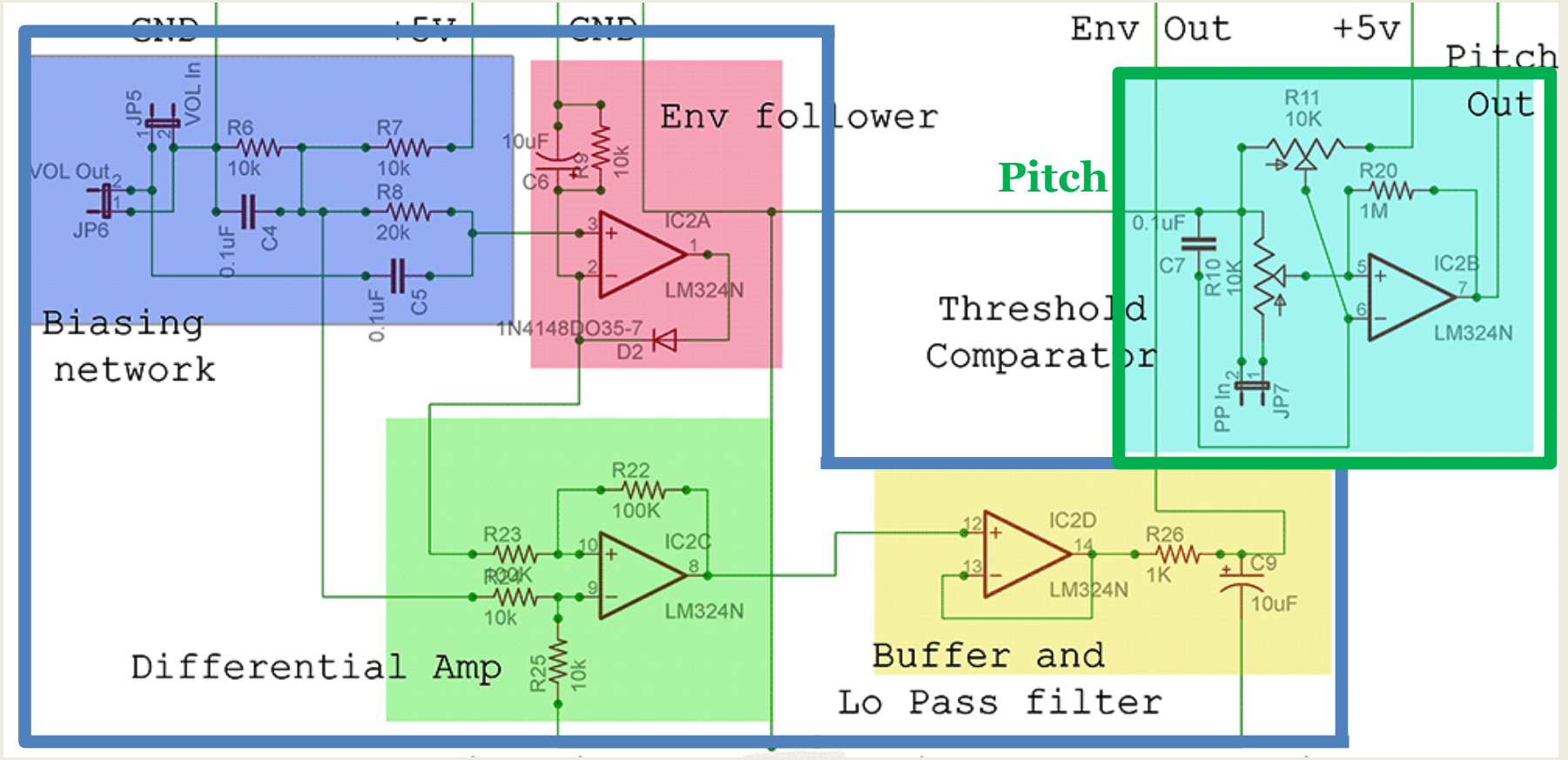

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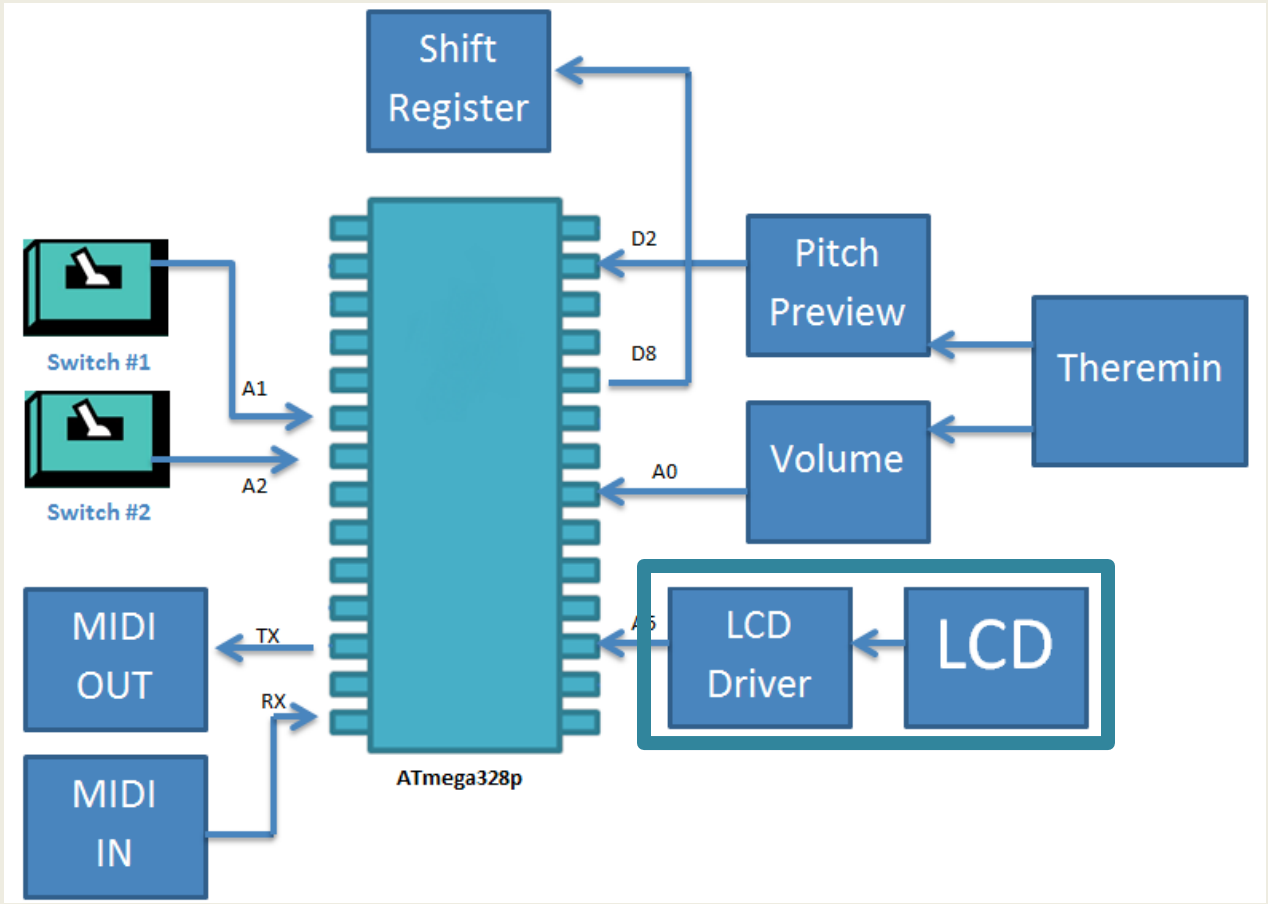
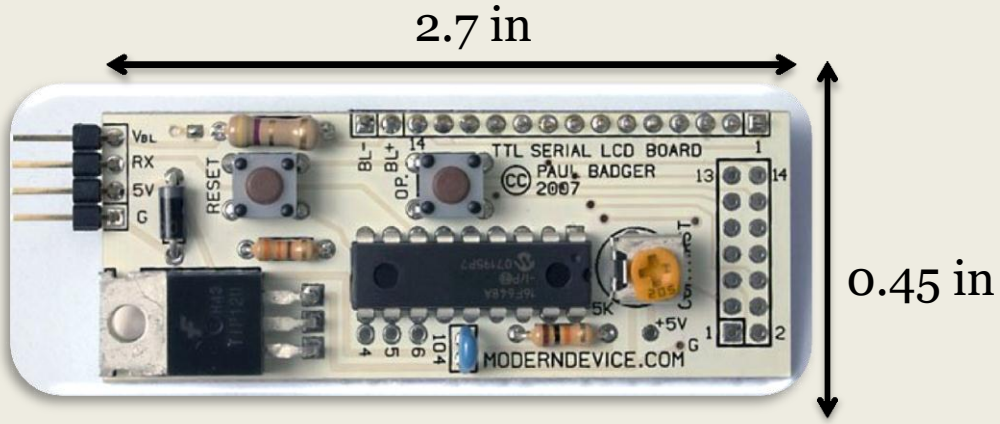


LCD Panel

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

Why LCD 117 Driver?

- 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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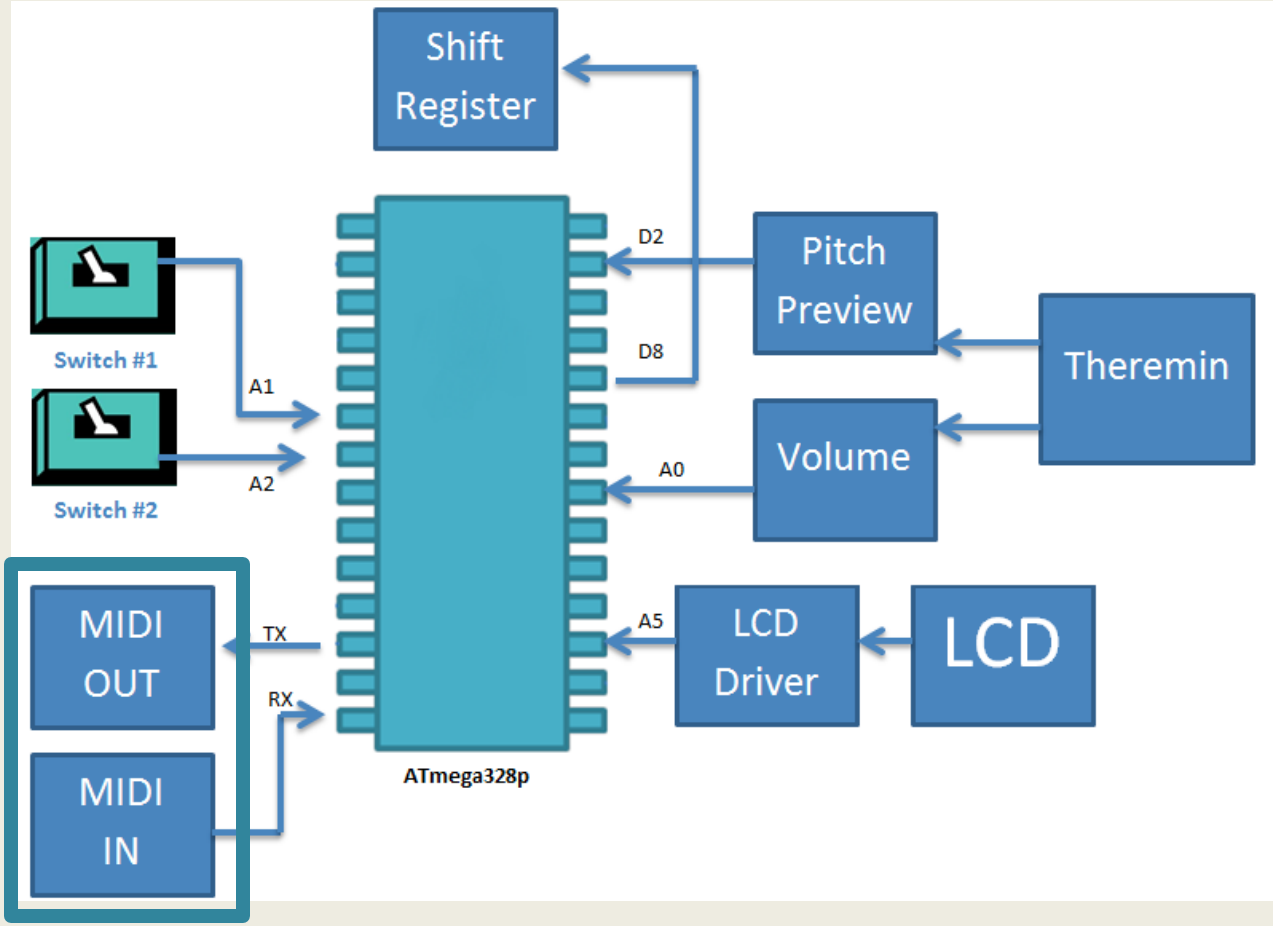
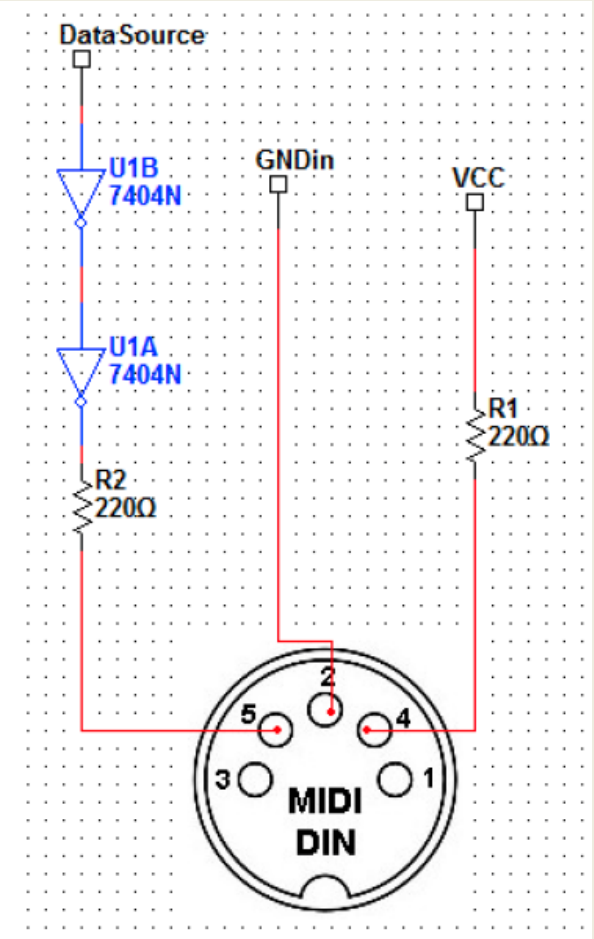


MIDI OUT Schematic

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



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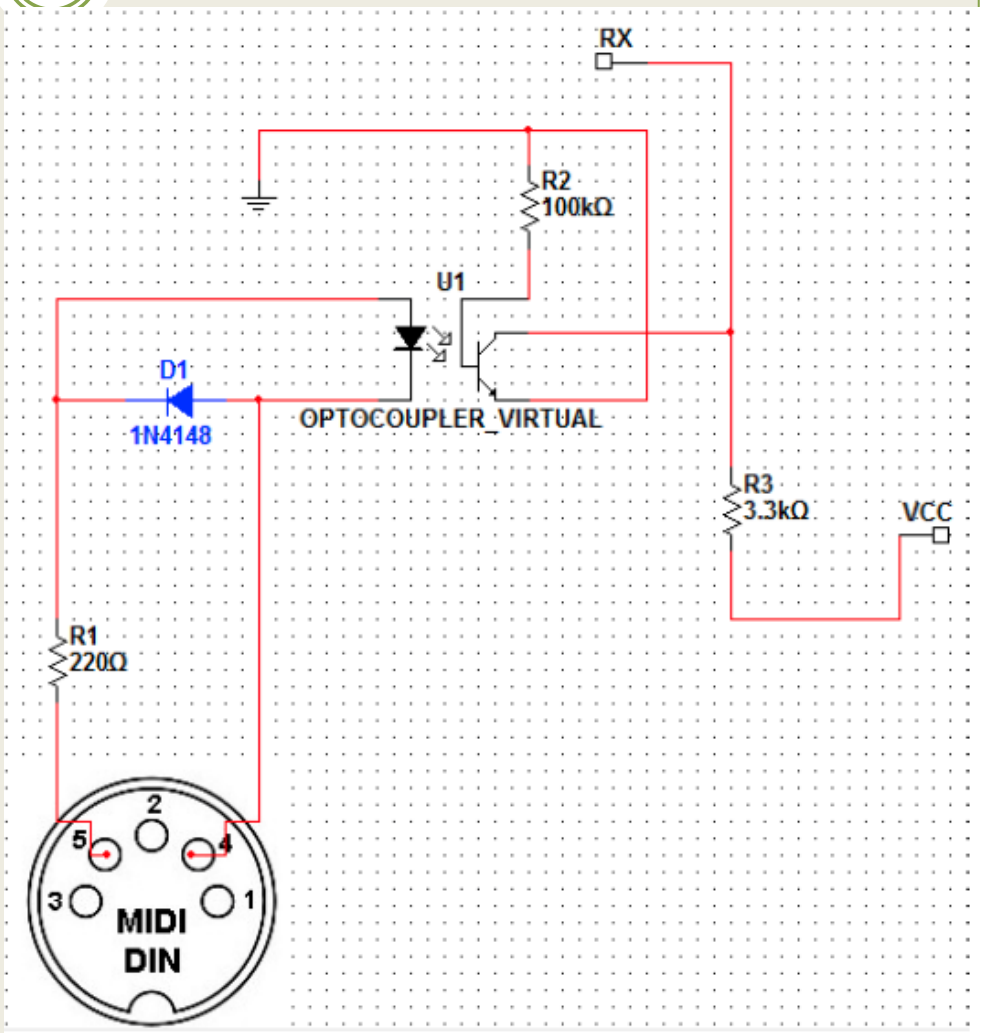

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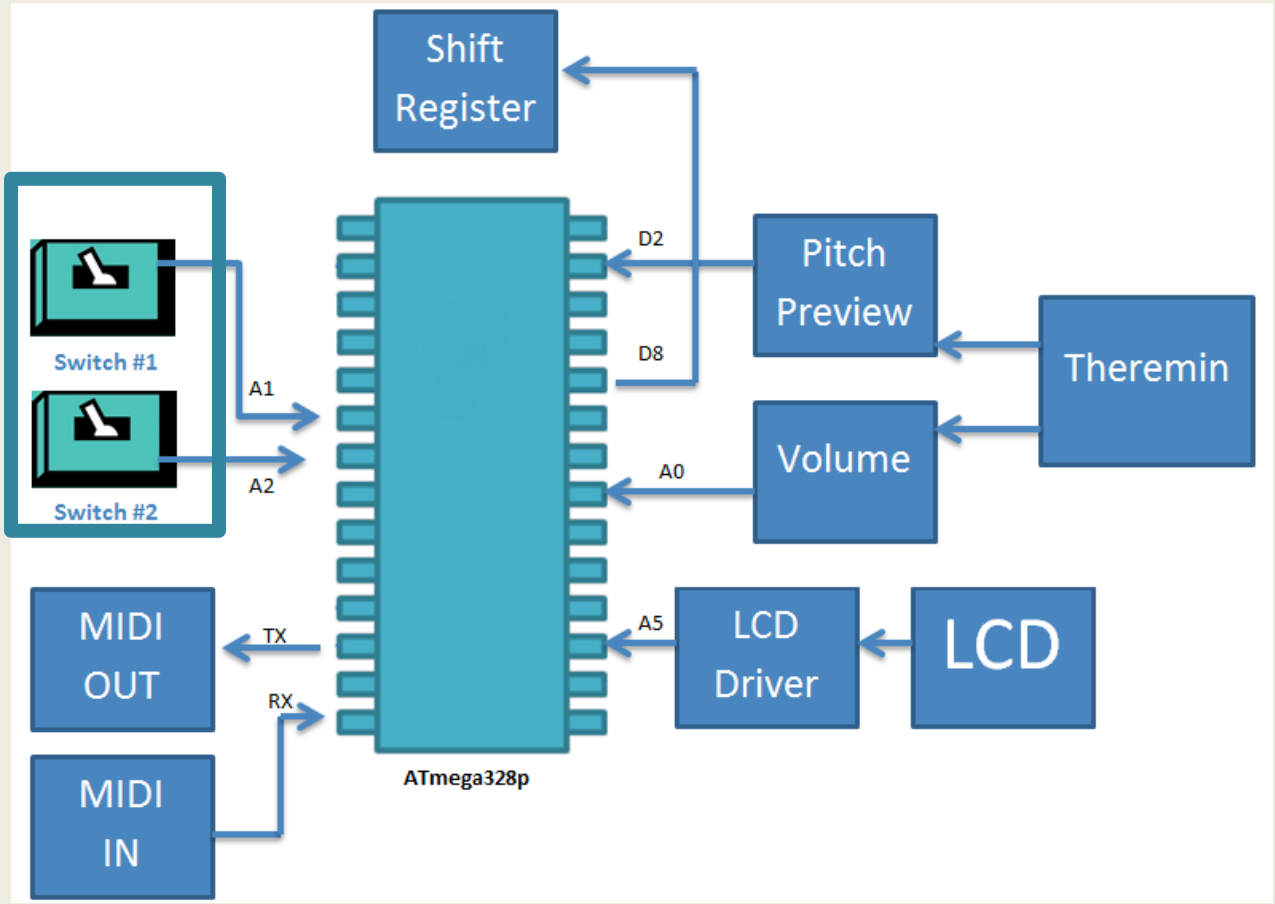


Switches - Navigating the Operation Modes

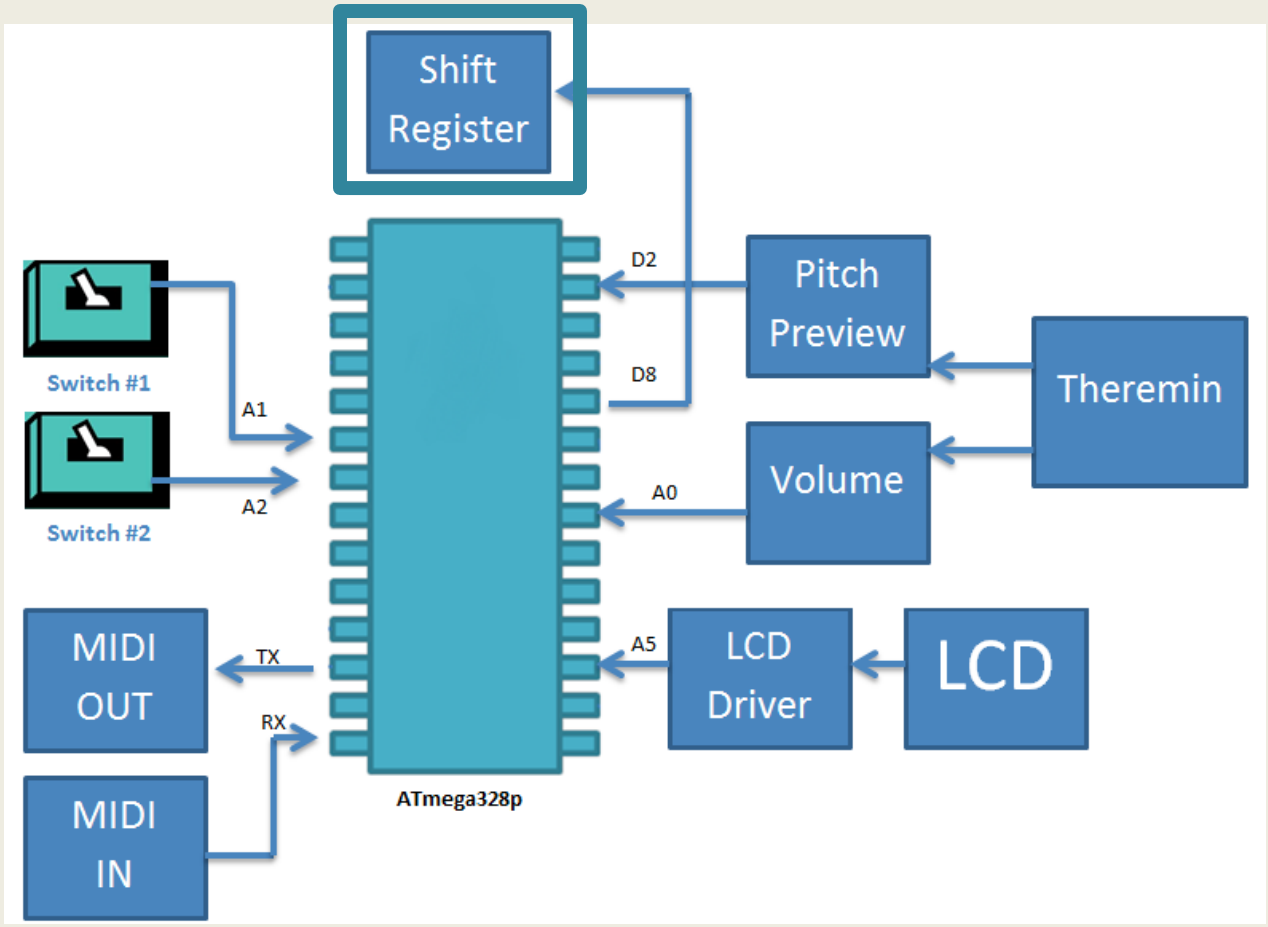
Switch 1	Switch 2	Function
OFF	OFF	ARP2
OFF	ON	ARP1
ON	OFF	CONTROL
ON	ON	PITCH

Mode Operation Explanation

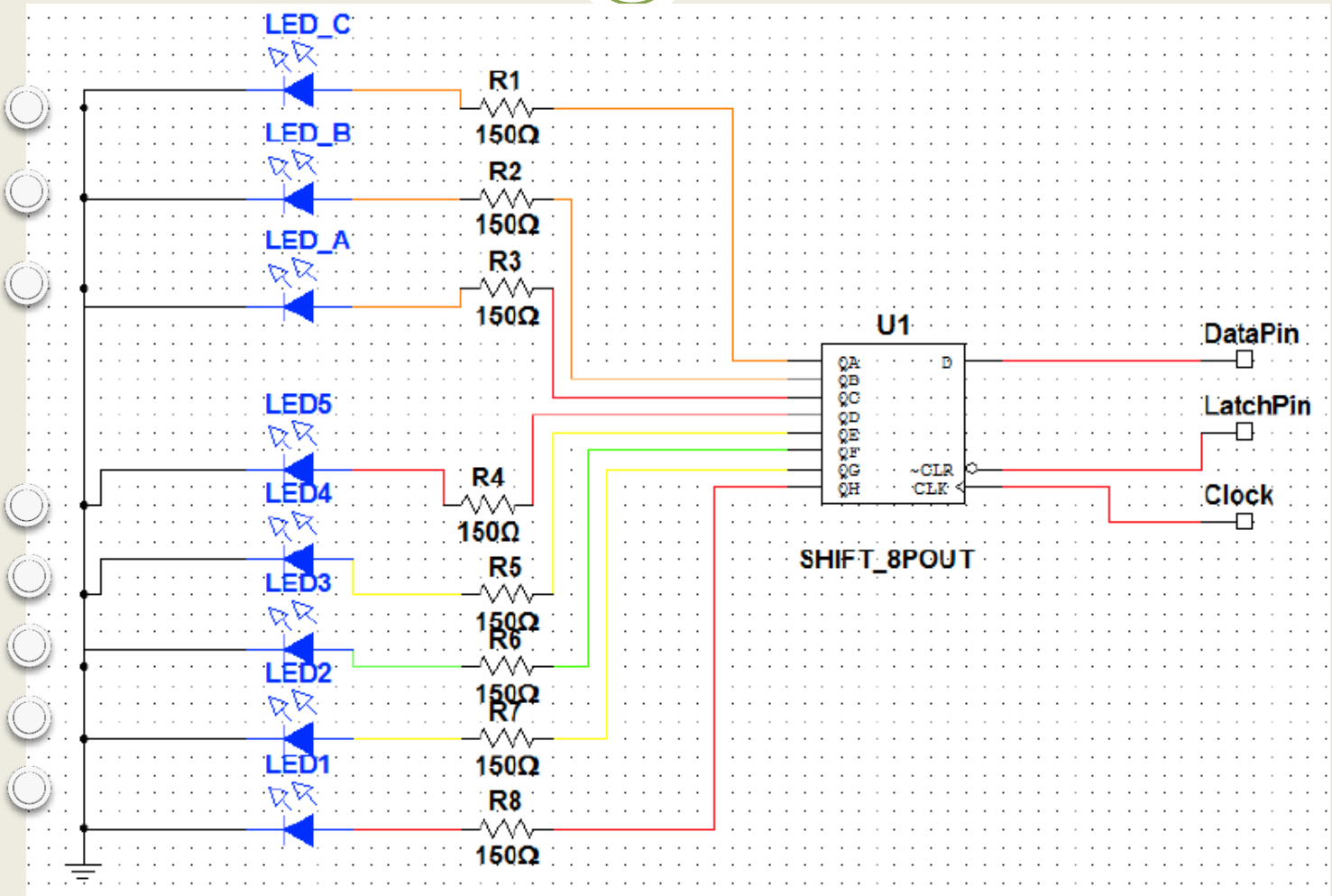
Function	Description
Pitch	Track the frequency and volume from the uWave Theremin and display and output the corresponding MIDI data
Control	Output a control data based on the theremin's pitch magnitude
ARP1*	Read an input from MIDI keyboard and arpegiate based on how many keys are pressed
ARP2*	Read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

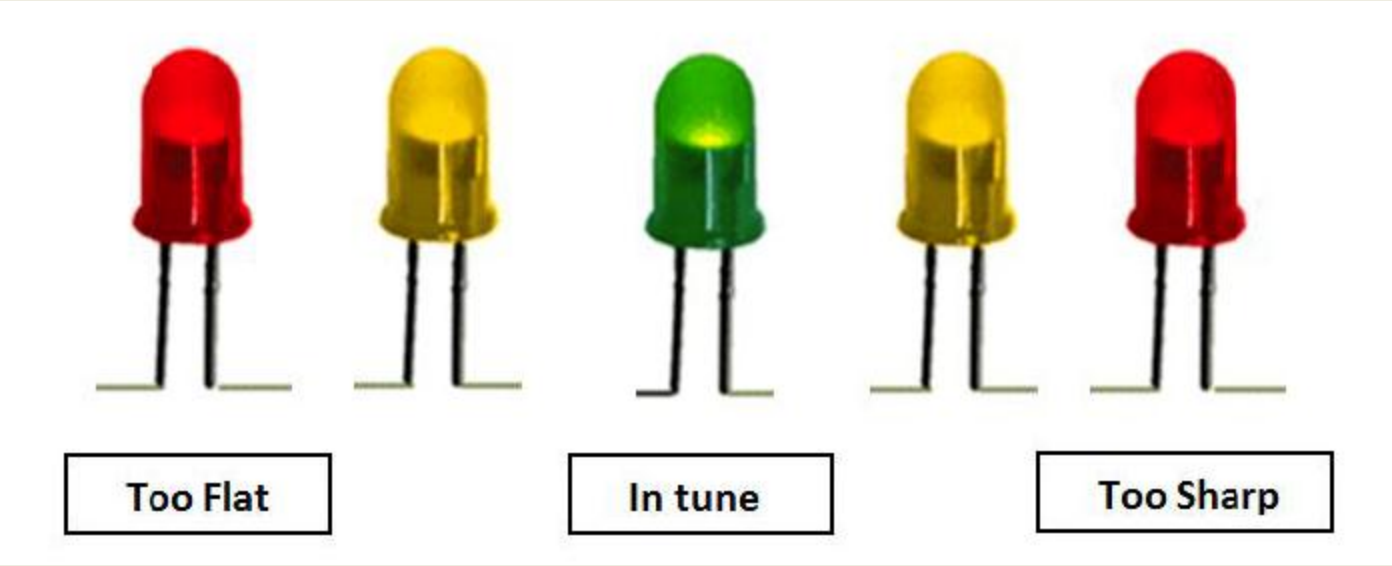
*In order to use these operations, a MIDI keyboard must be connected to the SenseBox

Block Diagram of SenseBox

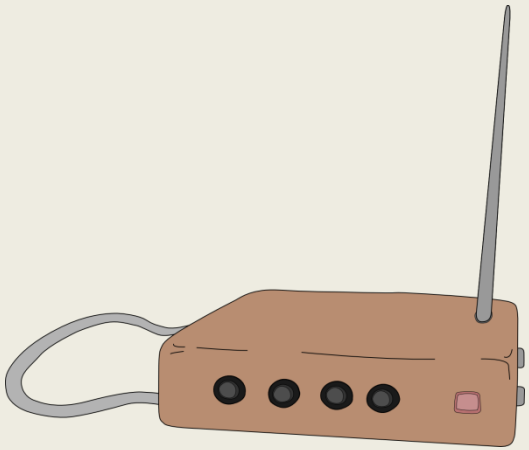


Pitch and Volume Accuracy

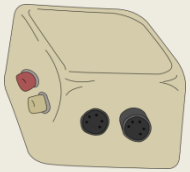



Too Flat
In tune
Too Sharp

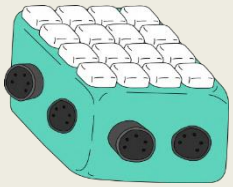
Expandome



uWave



SenseBox



Expandome

EMI Browser

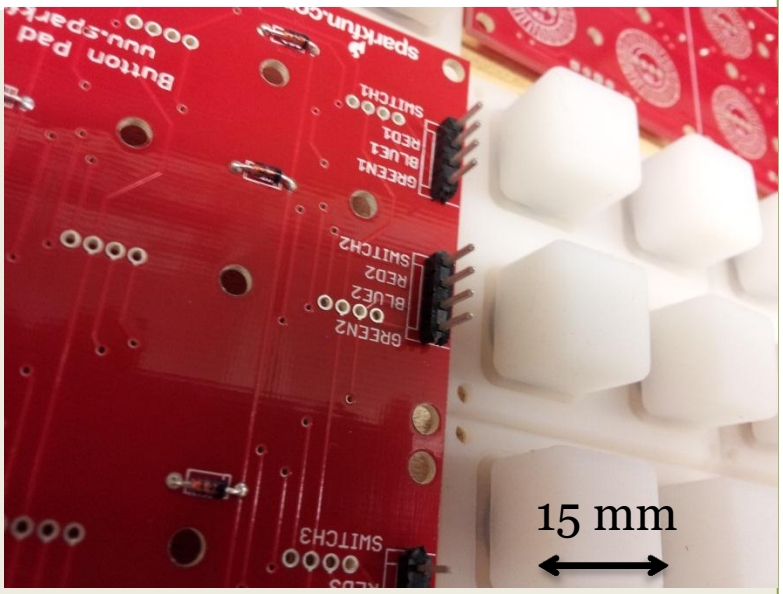
Expandome Specifications

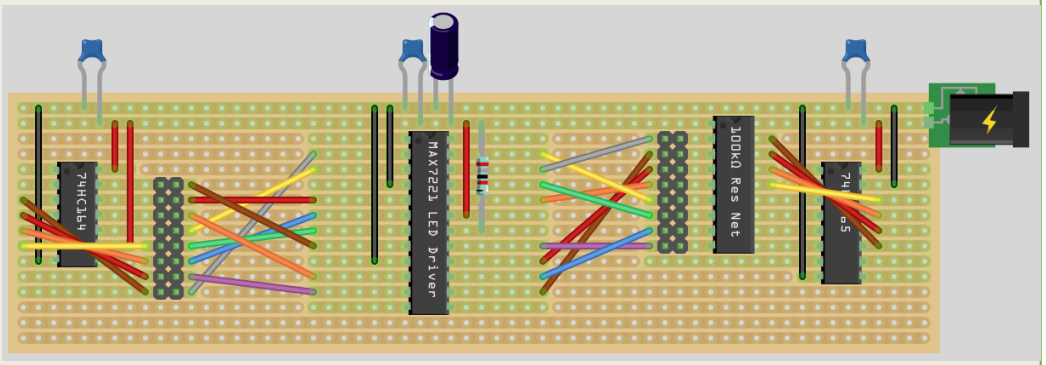
- *n* x *m* backlit pushbutton grid, per device
  (4x4, 4x8, or 8x8)
- Device recognition and MIDI controller capabilities
- All Expandome firmware embedded on ATmega microprocessor
- SD Card Reader
  - Default programs associated with SenseBox, uWave and the browser
  - MIDI message logging for debugging or saving setup states
  - Pre-loaded .wav beat files
- Operate with 5V and max. cascade current draw of 500mA for up to three devices

Expandome – Design Approach

Primary Elements

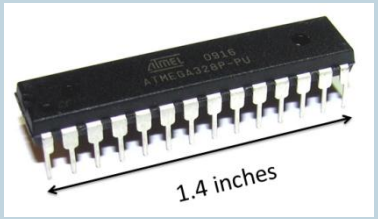
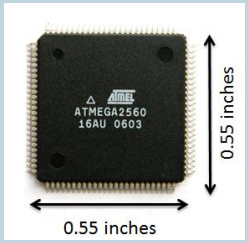
- Silicon Pushbuttons
- Buttonpad PCB, w/LEDs and Diodes
- Shift Registers and LED driver
- SD Card Reader
- MIDI and USB connectors
- Integrated barebones Arduino clone



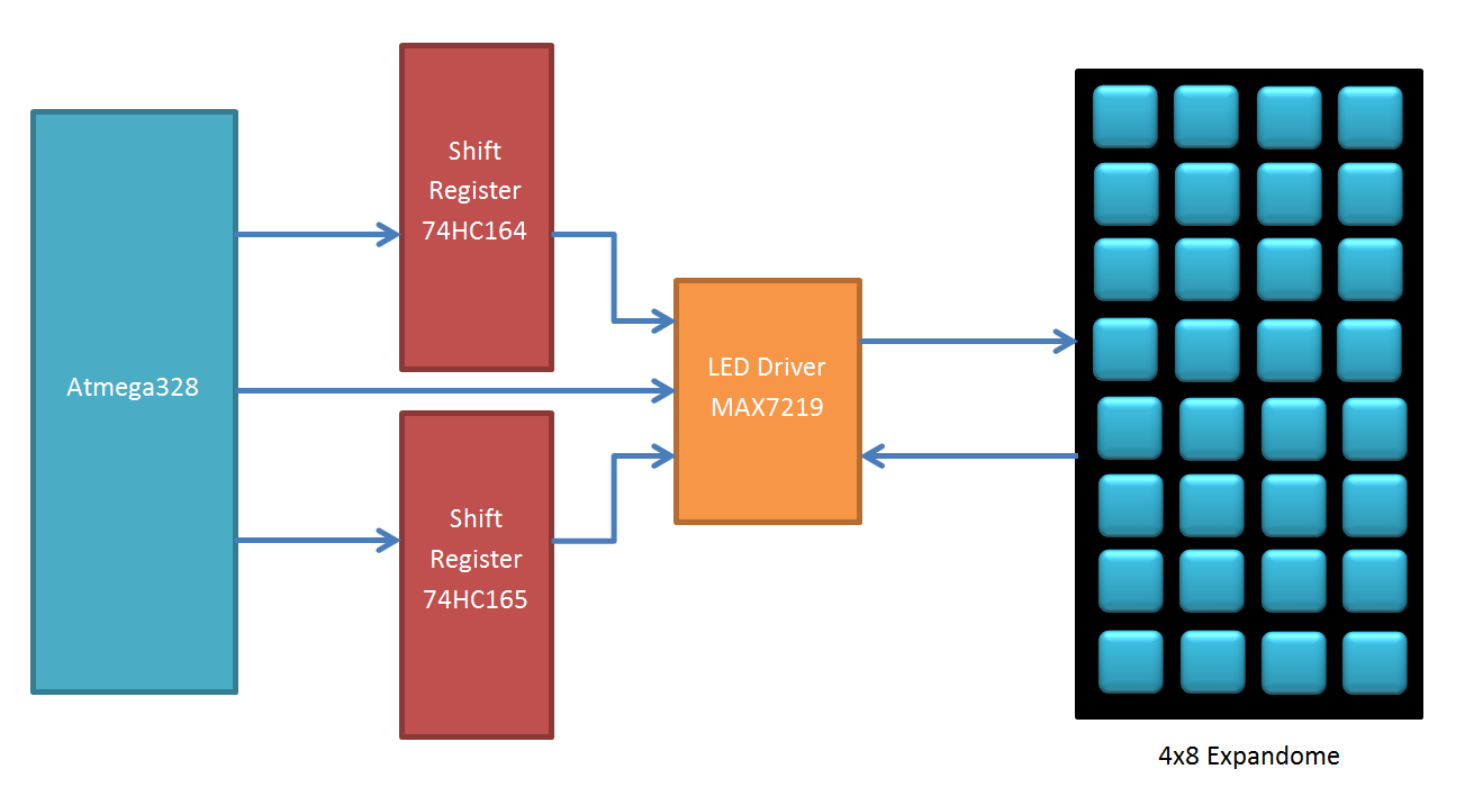


Stripboard representation of Unsped board made by monome.org user Josephiah

Microprocessor—Atmega328 and Atmega2560

Parameter	Atmega328	Atmega 2560
Flash	32Kbytes	256Kbytes
CPU	8-bit AVR	8-bit AVR
Max I/O pins	23	86
SRAM Memory	2KB	8KB
Expandome Device	4x4, 4x8	8x8
Image		

Expandome Block Diagram



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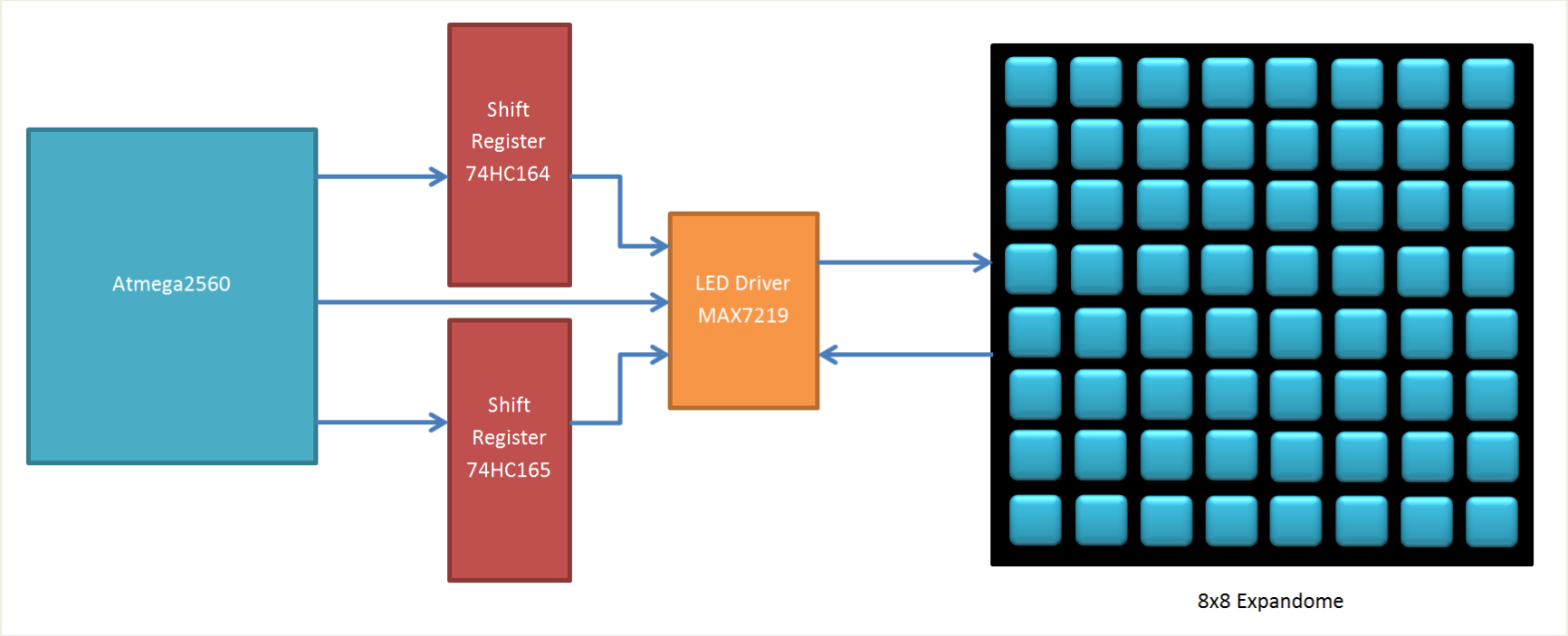
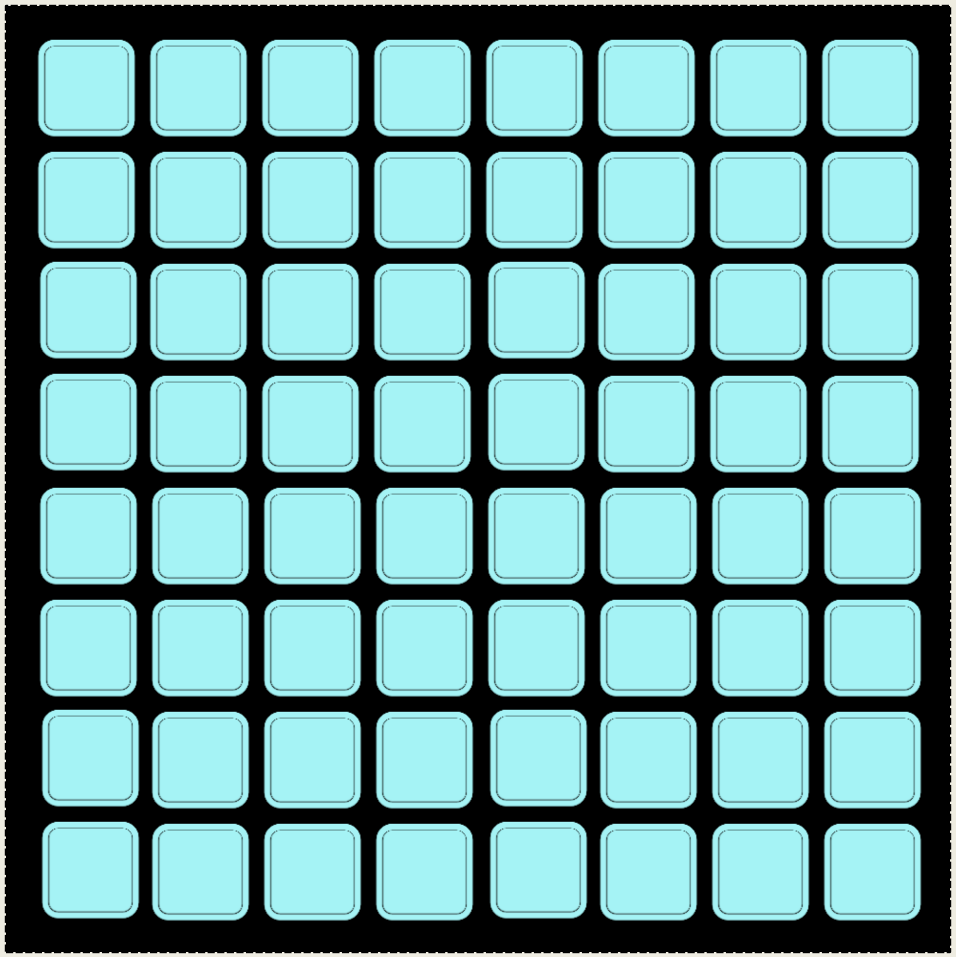


Expandome—Default Start Up

"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



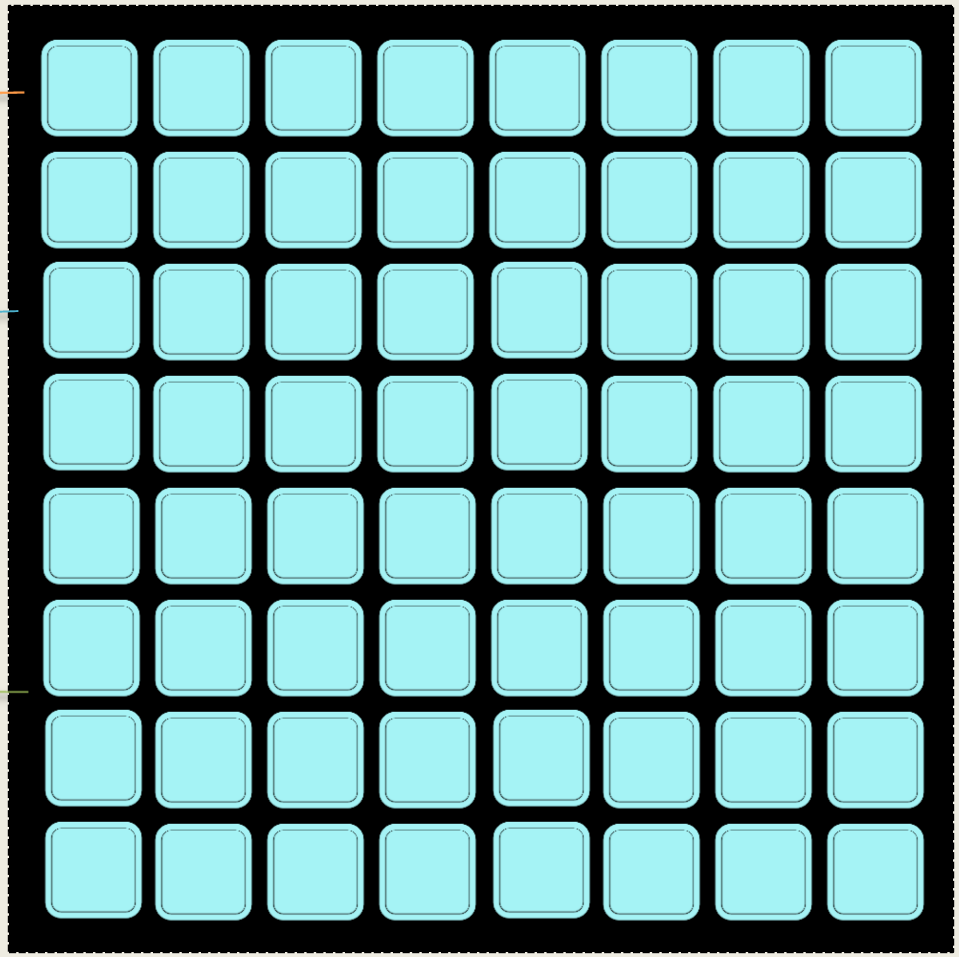
Start

Expandome—Standard features

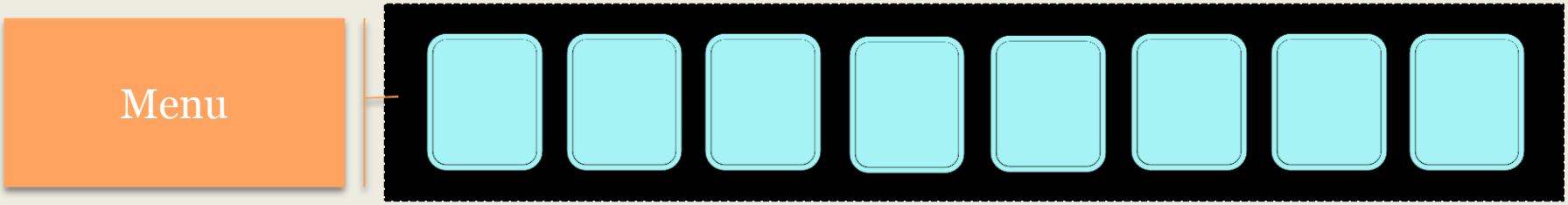
Menu

Tracks/Layers

Individual Beats



Expandome—Standard features

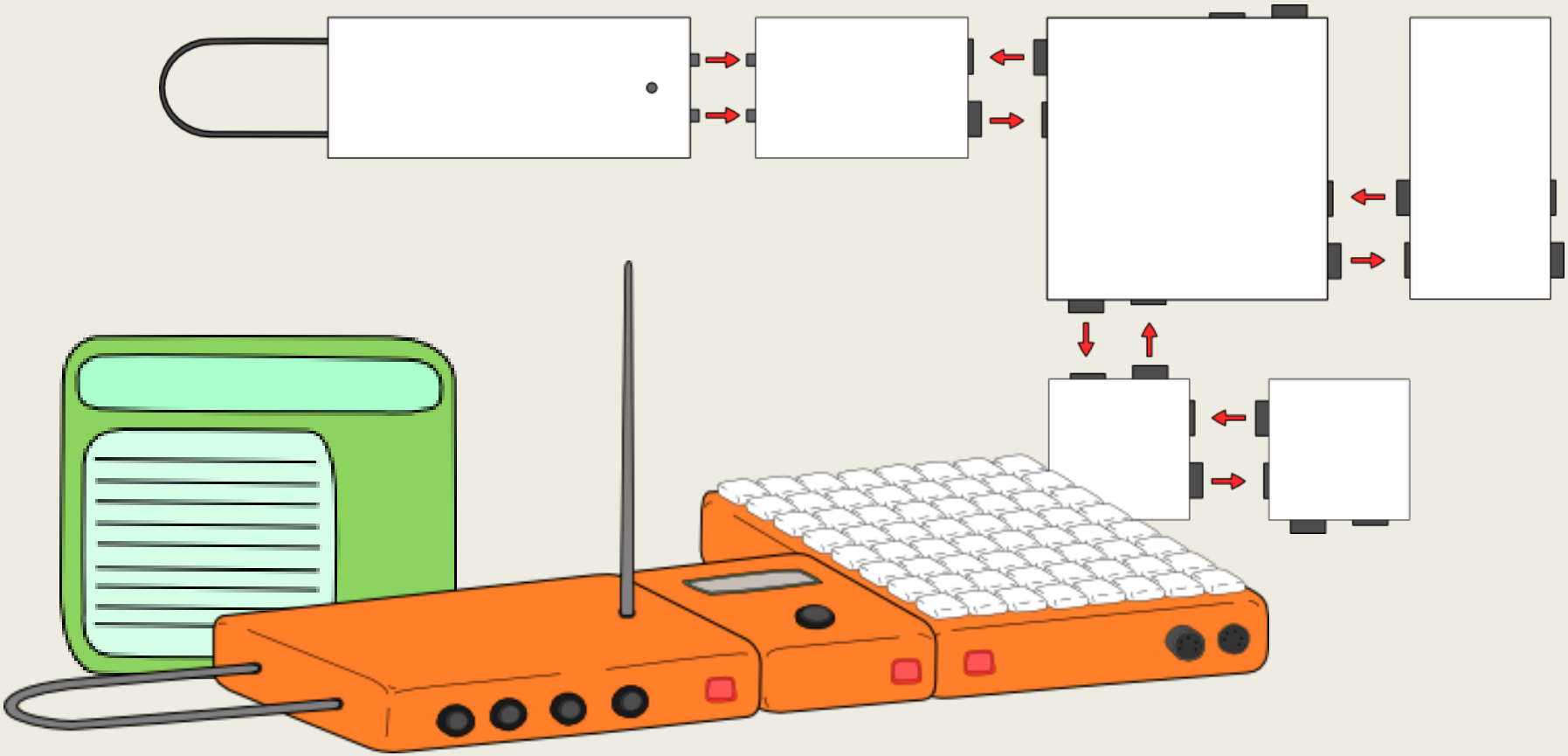


The top row of each Expandome will act as a Menu Bar with the following default settings:

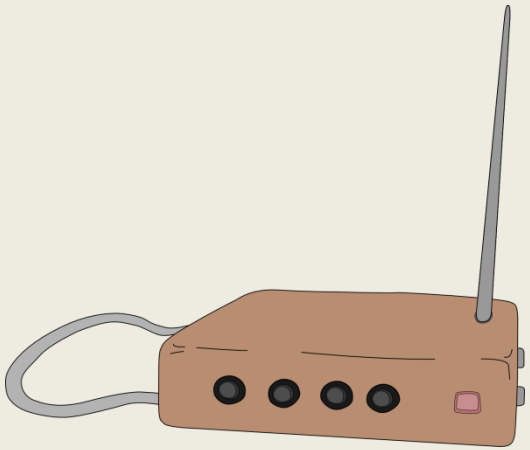
- Clear All Beats
- Beat Repeat
- Clear Beat Repeat
- Track Assign*
- Record*
- Play Back*

*(*This feature will not appear on the 4x4or 4x8 devices.)*

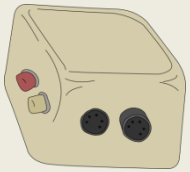
Full Implementation



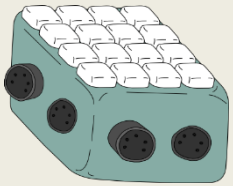
EMI Browser



uWave



SenseBox

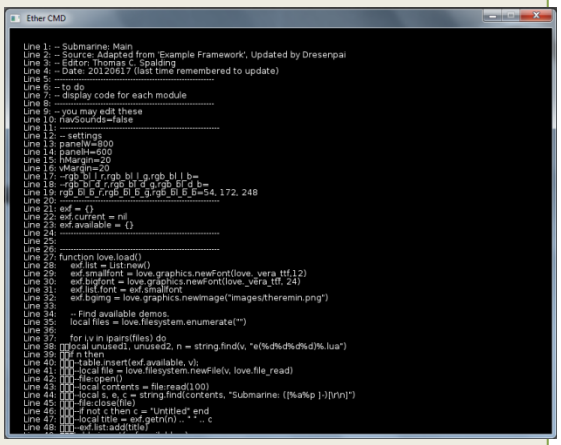


Expandome

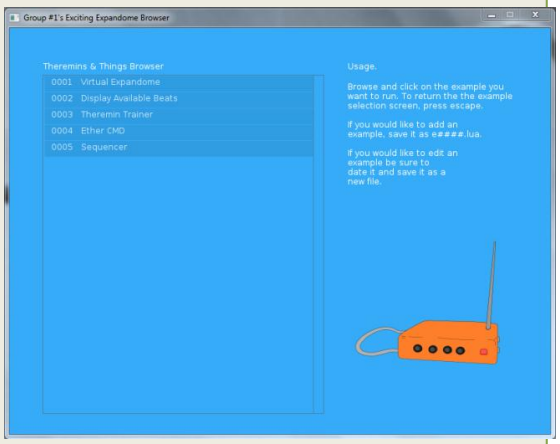
EMI Browser

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

- Pure Data (PD) 
  - MAX/MSP 
- Love Lua 
  - Processing 
- Arduino 

Power Requirements

uWave : +/- 12V

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

SenseBox: 5V

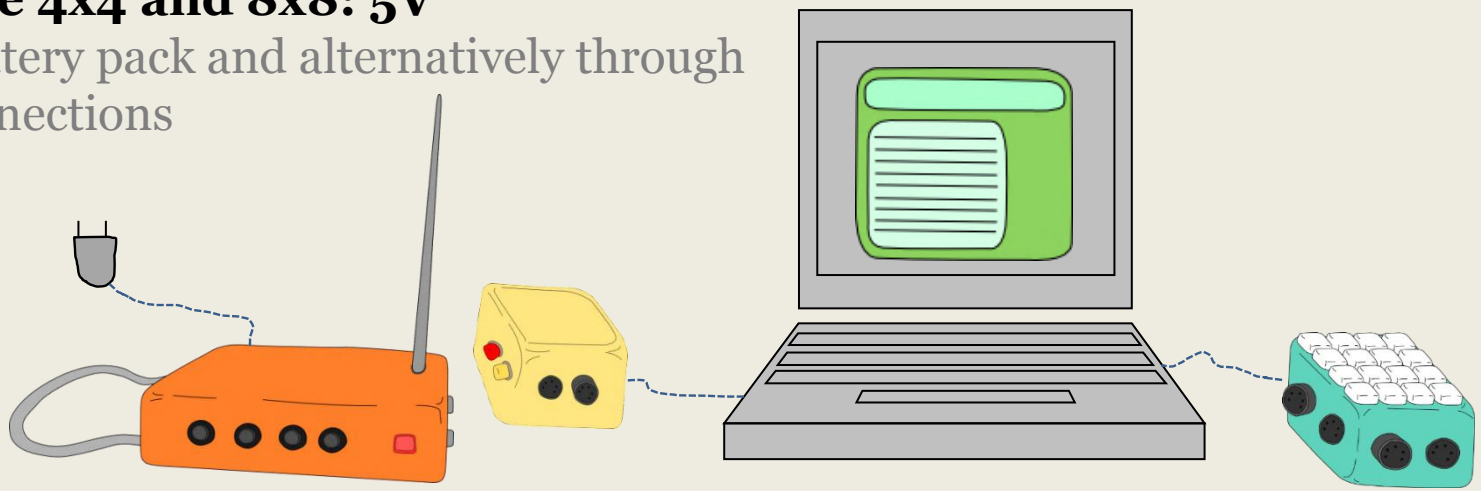
- 5V via USB connection to the computer

Expandome 8x8: 5V

- 5V via USB connection to the computer

Expandome 4x4 and 8x8: 5V

- 5V via battery pack and alternatively through MIDI connections



Project Budget and Financing to date and to end of project

COST ESTIMATE

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

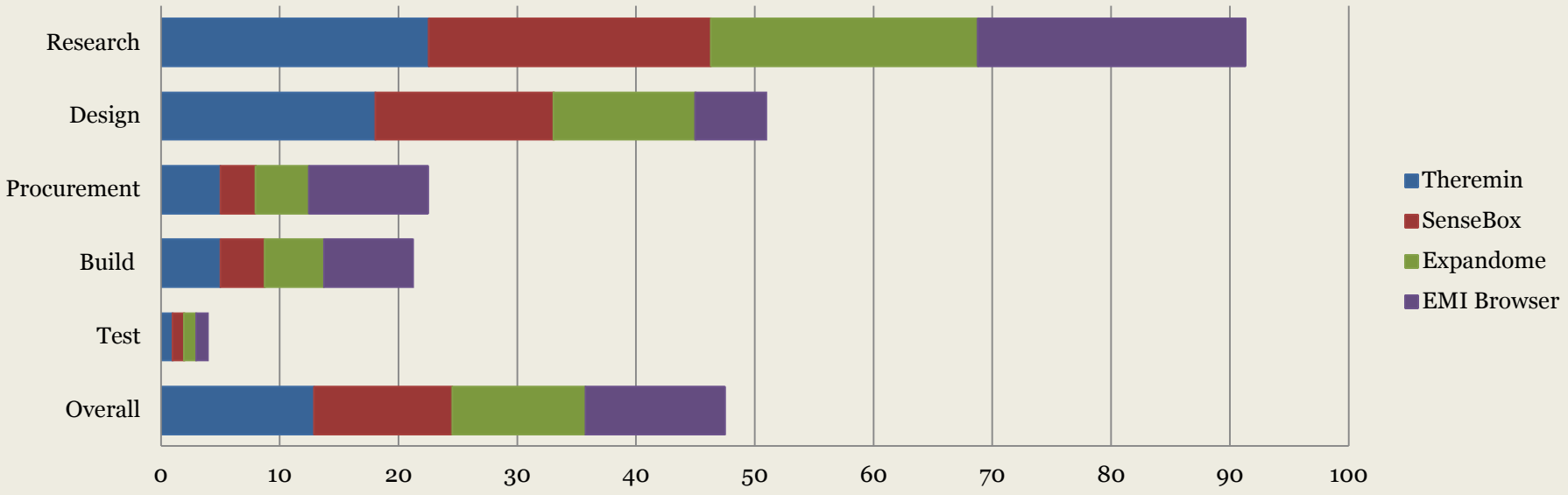
Group: GROUP 1

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

Summary

- Progress and successes
- Possible problems/unresolved issues
- Plans

Progress



	Theremin	SenseBox	Expandome	EMI Browser
Research	90%	95%	90%	90%
Design	90%	75%	60%	30%
Procurement	50%	30%	45%	100%
Build	20%	15%	20%	30%
Test	5%	5%	5%	5%
DEVICE STATUS	**52%**	**47%**	**45%**	**47%**

47%

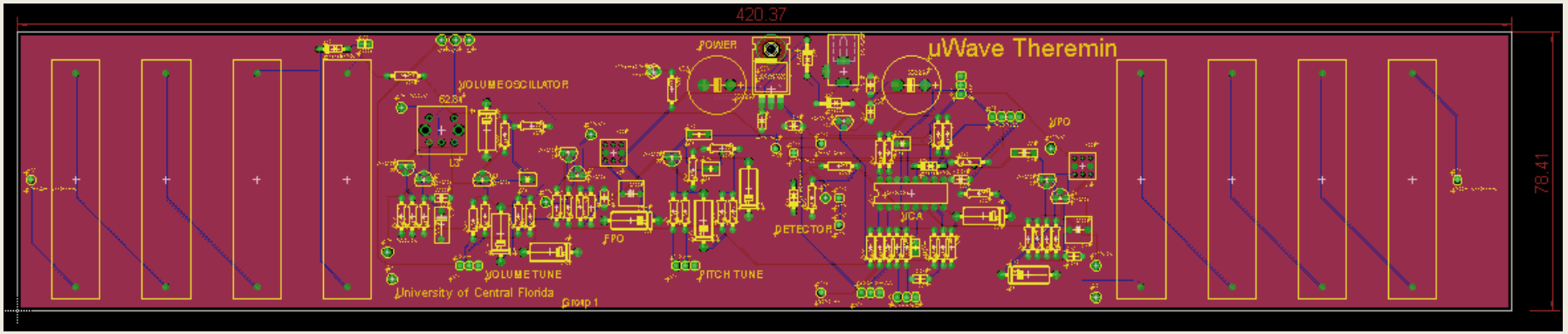
Clear Statement of Progress

- At this time we have the full design of each device in the project*, with the exception of the program feature files which account for at least 40% of our design effort.
- We have all theremin circuits built, however separate.
- The SenseBox is built, however volume extraction needs to be redesigned.
- The Expandome has been built, and needs to be tested for programming functionality and then debugging can begin.
- The Expandome Browser has been made and is waiting for devices to continue development.

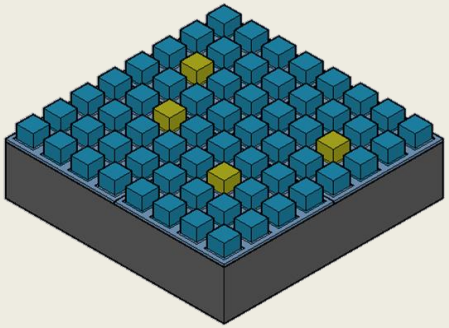
*minus battery/wall power-switching and I^2C chip requirements

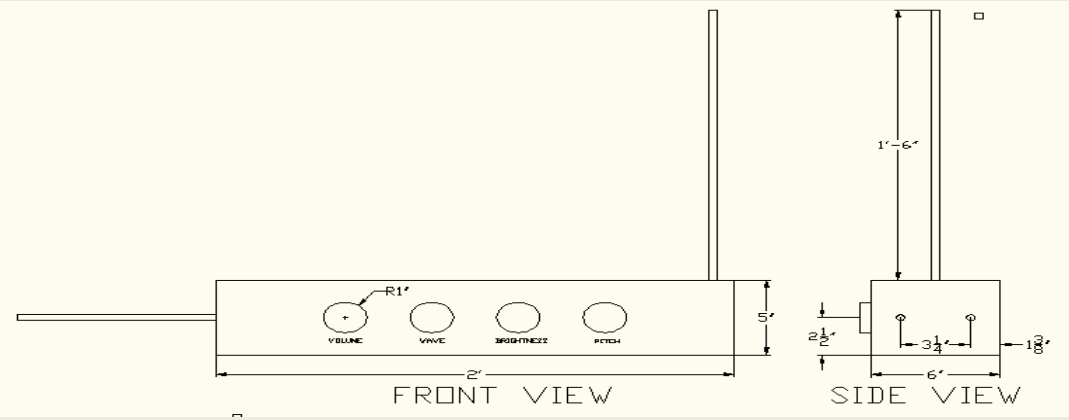
Groups immediate plans for successful completion

- Carry out testing and integration
- Complete the design and procurement of PCBs

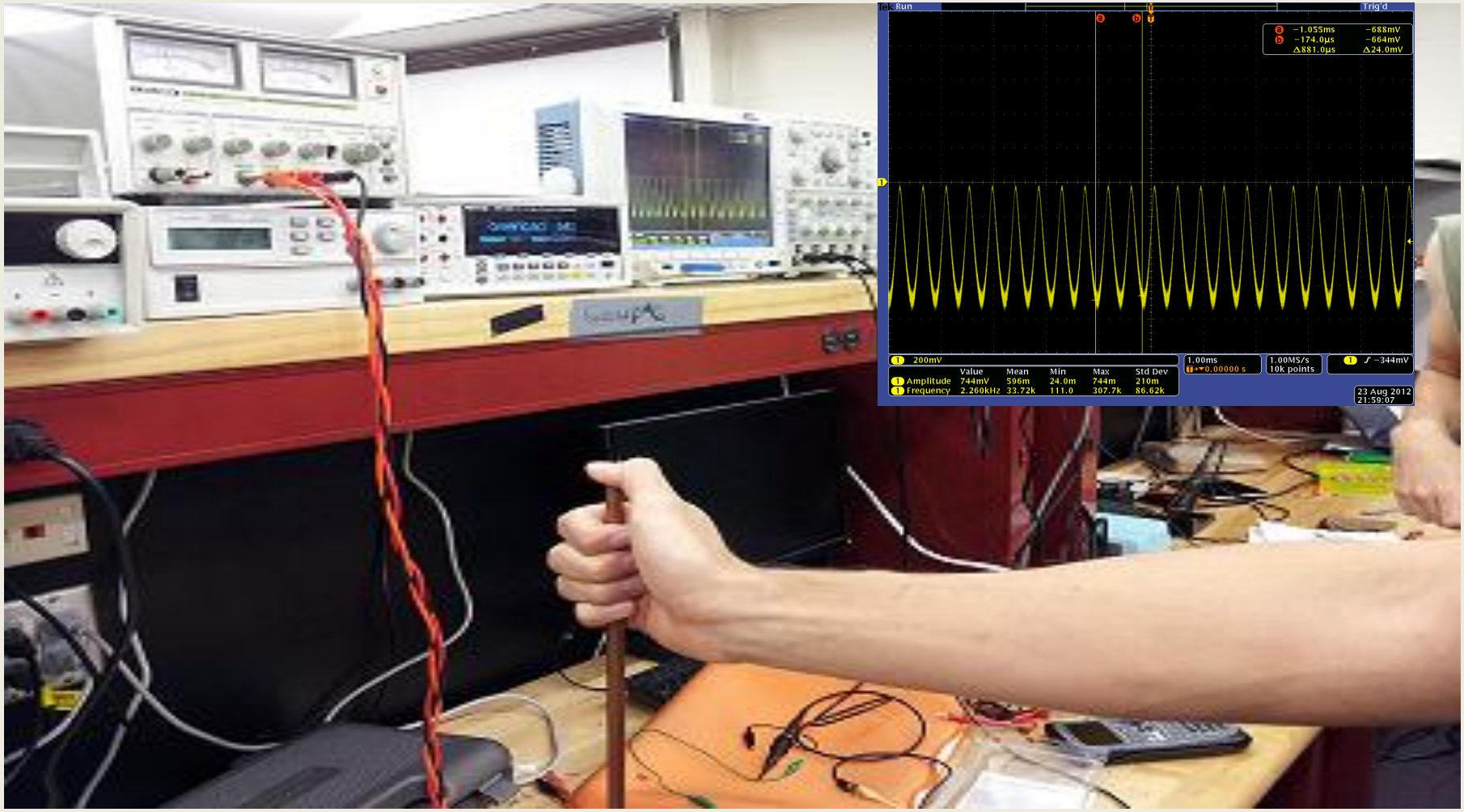


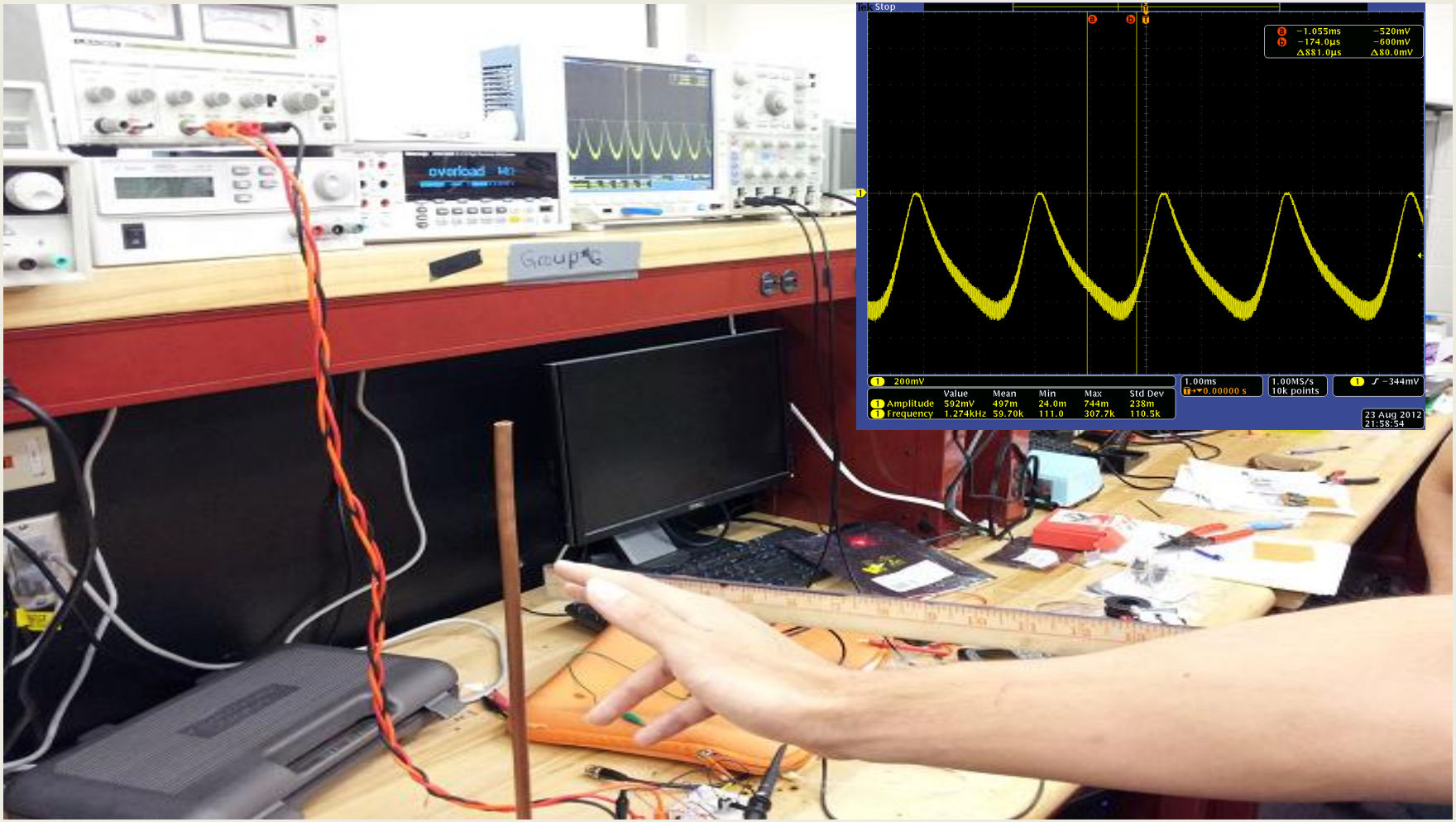
- Build enclosures

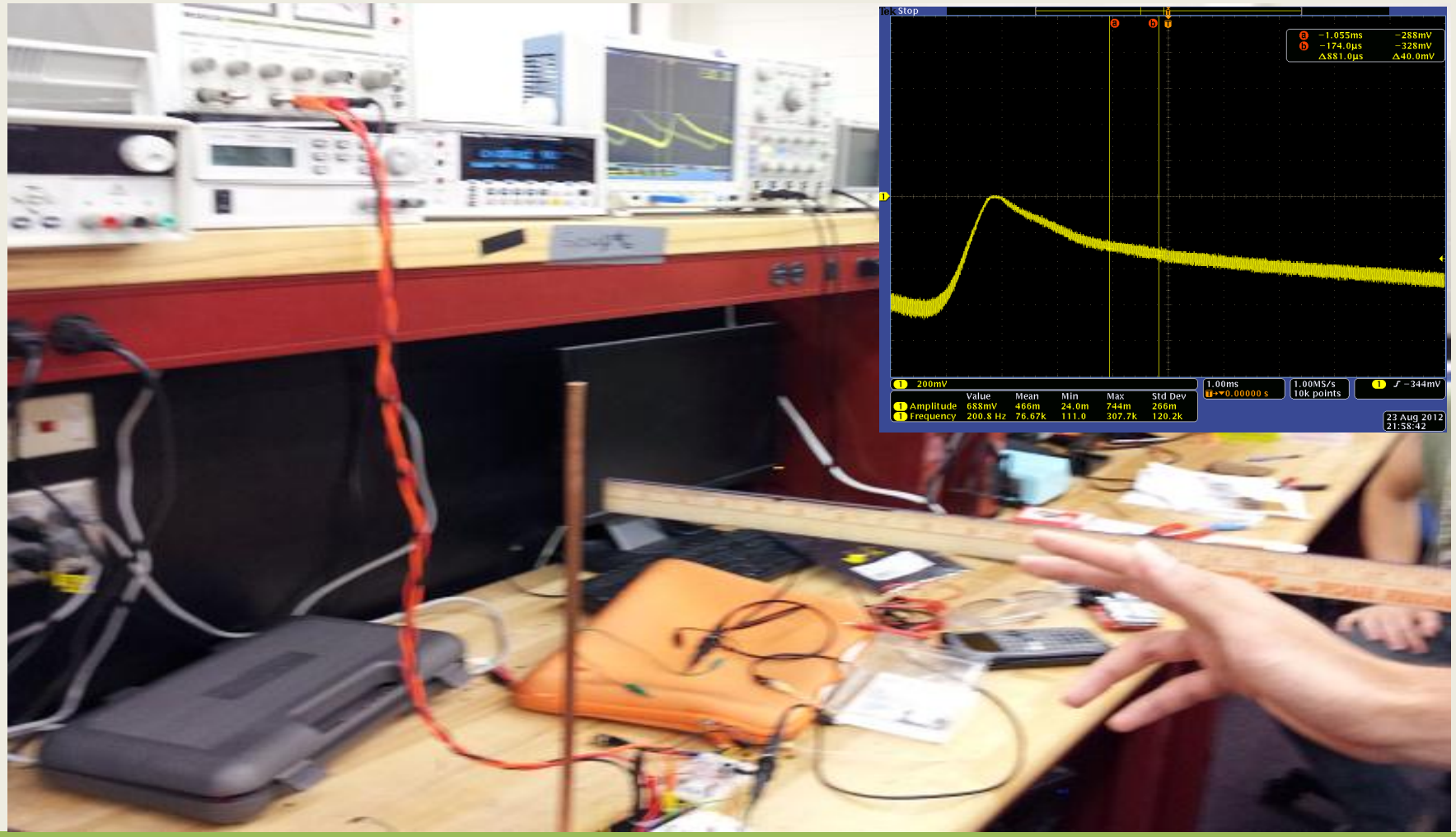




Successes, difficulties and unresolved




overload
Group 6
Stop
a −1.055ms −520mV
b −174.0µs −600mV
Δ881.0µs Δ80.0mV
200mV
1.00ms
0.00000 s
1.00MS/s
10k points
−344mV
Value Mean Min Max Std Dev
Amplitude 592mV 497m 24.0m 744m 238m
Frequency 1.274kHz 59.70k 111.0 307.7k 110.5k
23 Aug 2012
21:58:54

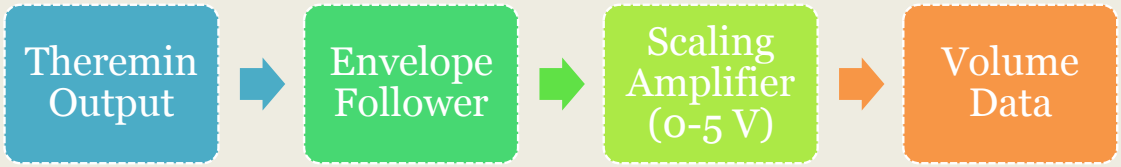

Stop
a −1.055ms −288mV
b −174.0µs −328mV
Δ881.0µs Δ40.0mV
200mV
1.00ms
0.00000 s
1.00MS/s
10k points
−344mV
Value Mean Min Max Std Dev
Amplitude 688mV 466m 24.0m 744m 266m
Frequency 200.8 Hz 76.67k 111.0 307.7k 120.2k
23 Aug 2012
21:58:42

Theremin - Successes and Difficulties

- Possible 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 under close to ideal environment might not be realistic

SenseBox - Successes and Difficulties

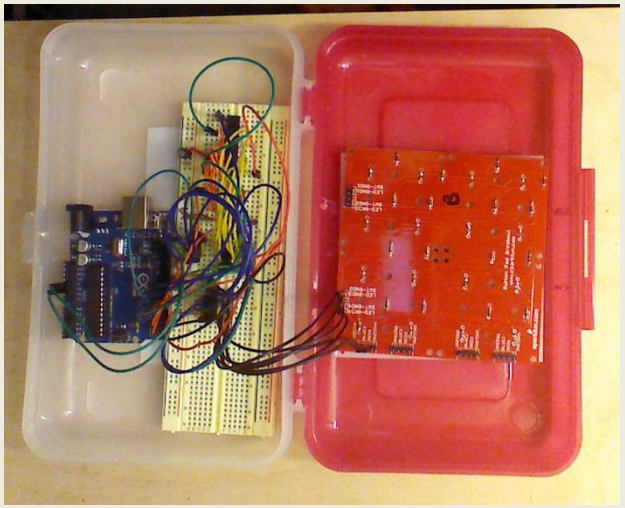
- Possible Difficulties
  - The referenced volume schematic data may have to be modified
    - Goal: scale the output of the theremin to 0 to 5 voltage
    - Possible Solution:



  - Modifications
    - Instead of using switches, may use dial up instead
      - Easier to choose the operation modes

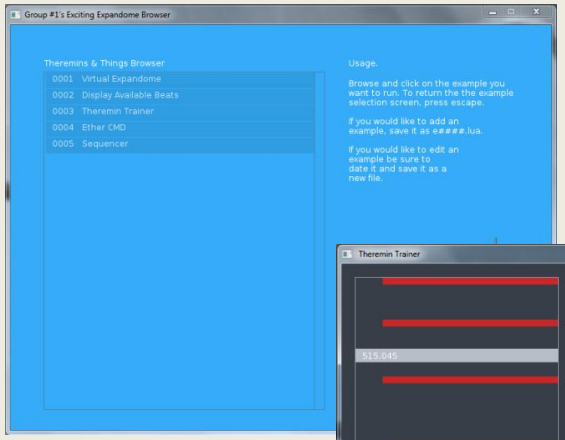
Expandome—Successes and Difficulties

- Built a 4x4 Prototype
- Have not tested firmware/sketches
- Concerns
  - I²C communication between devices
  - Power-switching from battery to USB power

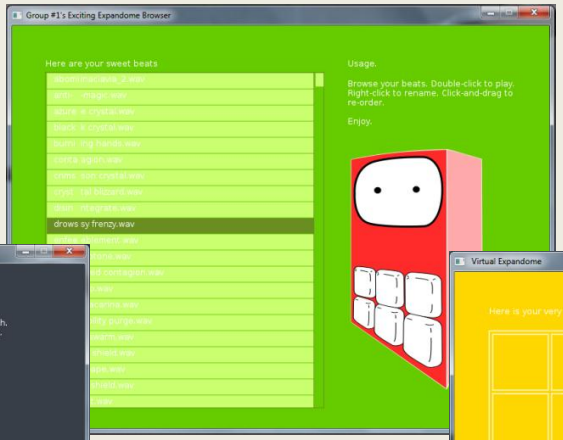


Browser—Successes and Difficulties

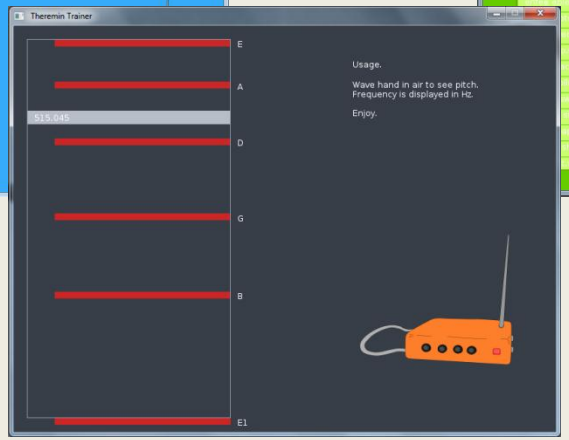
- Built initial shell



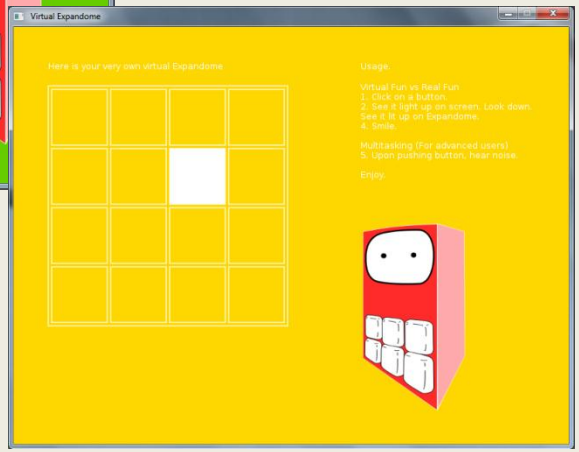
EMI Browser



Beat Organizer



Theremin Trainer



Beat assignment & Virtual Expandome

- Still need to integrate serial communication

Open question time

Thank You

http://tiny.cc/group1cdr