The Anything Instrument

Team 20

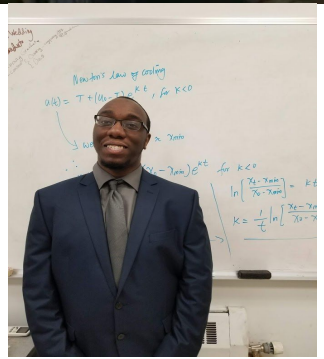
Matthew Avison, Carley Davis, Ivan Norman, Cory Vandergrift

Team 20

Matthew Avison - EE
Hardware Lead

Carley Davis -EE
Team Coordinator

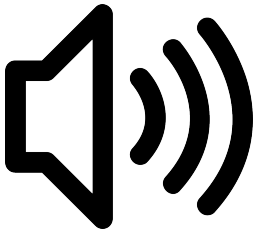
Ivan Norman - EE
Altium Lead



Cory Vandergrift - EE
Budget Management Lead

The Problem

Instruments are shown to strengthen memory, reduce stress, inspire creativity, and bring happiness to those who play them. However, the cost, space requirement, and noise produced by most instruments can prevent many people from being able to enjoy them.



The Solution

The Anything Instrument would be a solution to all of these problems by allowing **anything** conductive to become part of a playable instrument. The user would be able to attach leads to whatever objects they desire to play, select a sound mode (i.e. piano, drums, etc.), plug in an audio output, and play.

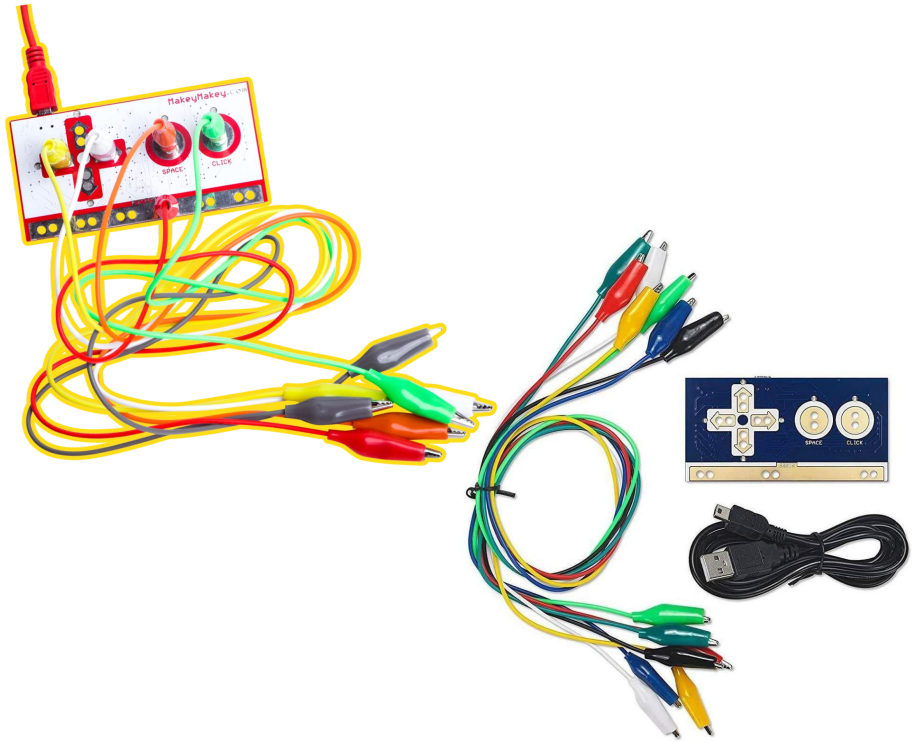
Competing Solutions in Marketplace

Makey Makey

- USB connected device that allowing users to turn objects into capacitive touch controllers to control their computer

Vilros FunForce Touch Controller

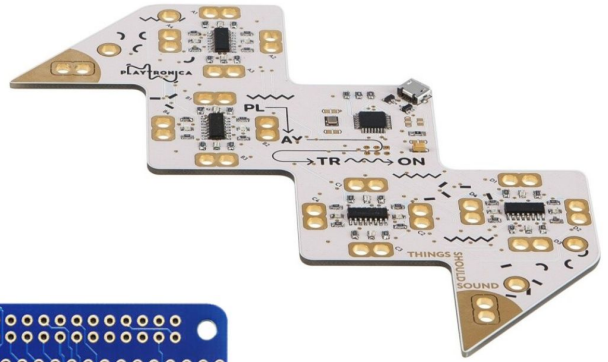
- Functions nearly identically to Makey Makey, however is also compatible with Raspberry Pi



Competing Solutions in Marketplace

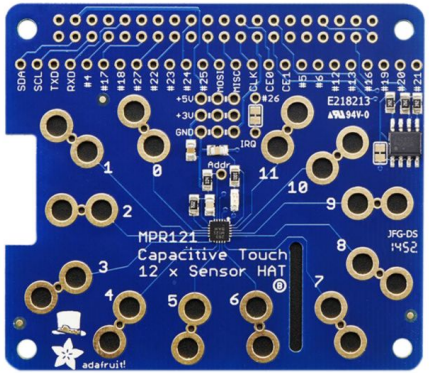
[Playtronica]

- USB connected device that allows the user to control digital instruments through software on a computer using capacitive touch controllers

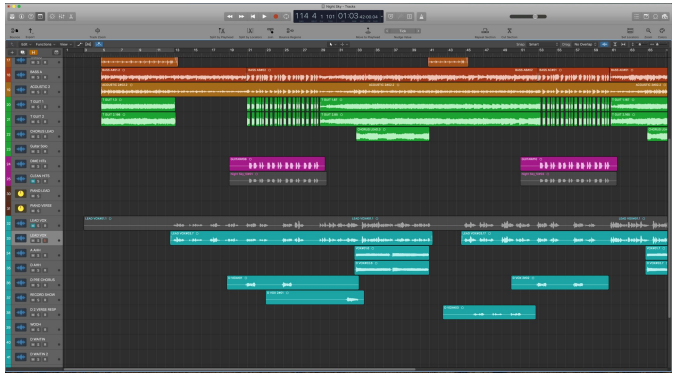


[Capacitive touch hat for raspberry pi]

- Functions similarly to the Makey Makey and Vilros FunForce Touch Controller, however only compatible with Raspberry Pi



Competing Solutions in Marketplace



Each competing solution that we have found requires connection to a laptop and installation of software. The need to interface through another computer makes it difficult to simply start playing.

The Anything Instrument would be different from any solution already in the marketplace as it will be a portable, **standalone** device that requires no additional hardware or software by the user.

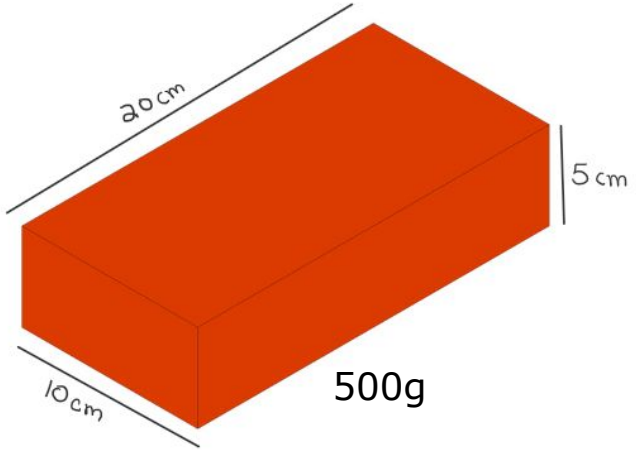
Preliminary System Specifications

Anything Instrument will meet or exceed the following criteria:

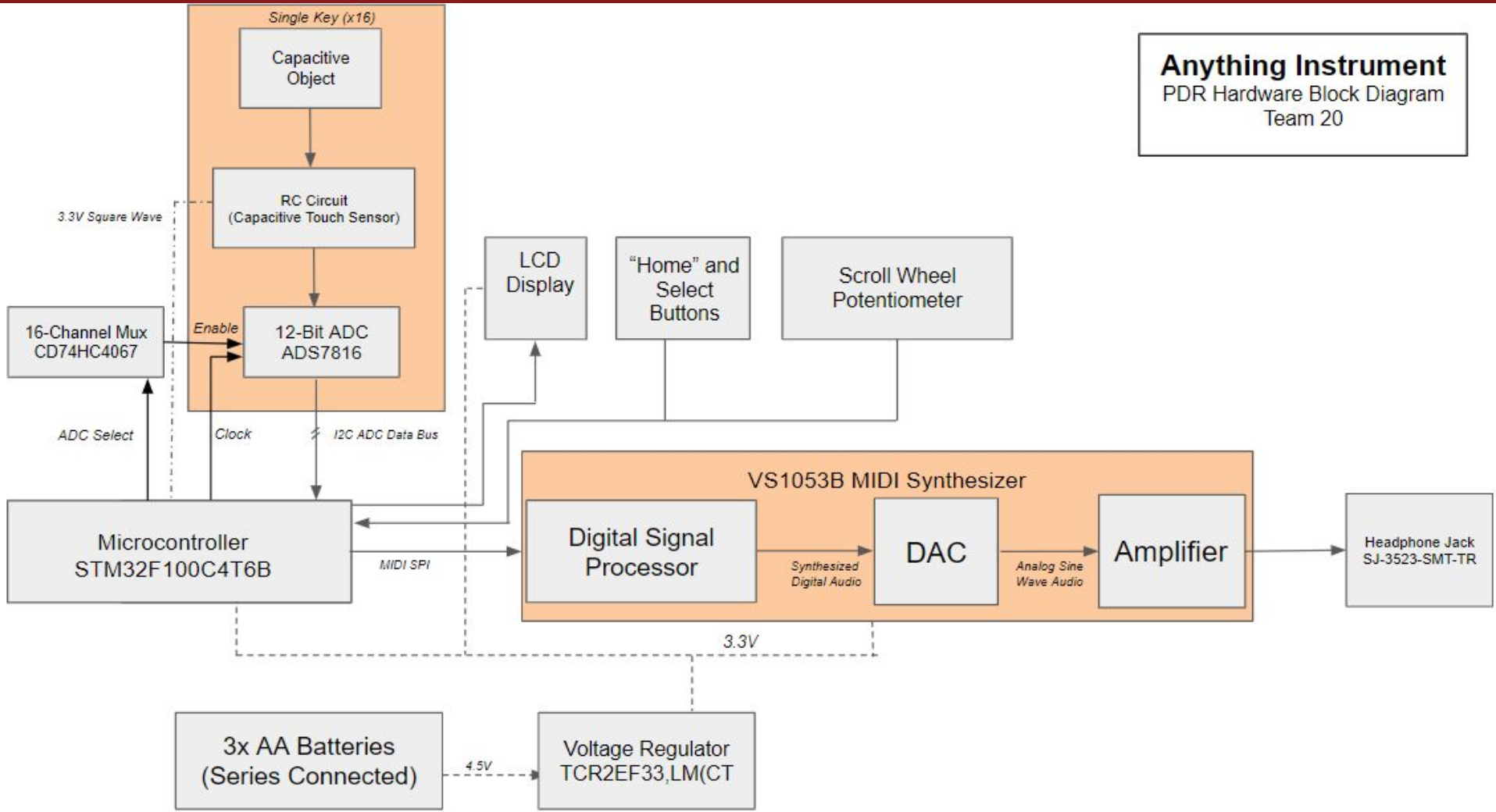
- Offer 8 playable connections
- Have an interchangeable battery
- Offer at least two different instrument modes
- Include a headphone jack
- Weigh 500 grams or less (not including connected objects)
- Have a main control smaller than 20x10x5 cm

(2x)

(1x)



500g


Anything Instrument
PDR Hardware Block Diagram
Team 20
Single Key (x16)
Capacitive Object
RC Circuit (Capacitive Touch Sensor)
3.3V Square Wave
16-Channel Mux CD74HC4067
Enable
12-Bit ADC ADS7816
ADC Select
Clock
I2C ADC Data Bus
LCD Display
"Home" and Select Buttons
Scroll Wheel Potentiometer
VS1053B MIDI Synthesizer
Digital Signal Processor
Synthesized Digital Audio
DAC
Analog Sine Wave Audio
Amplifier
Headphone Jack SJ-3523-SMT-TR
Microcontroller STM32F100C4T6B
MIDI SPI
3.3V
3x AA Batteries (Series Connected)
4.5V
Voltage Regulator TCR2EF33,LM(CT

Software Design

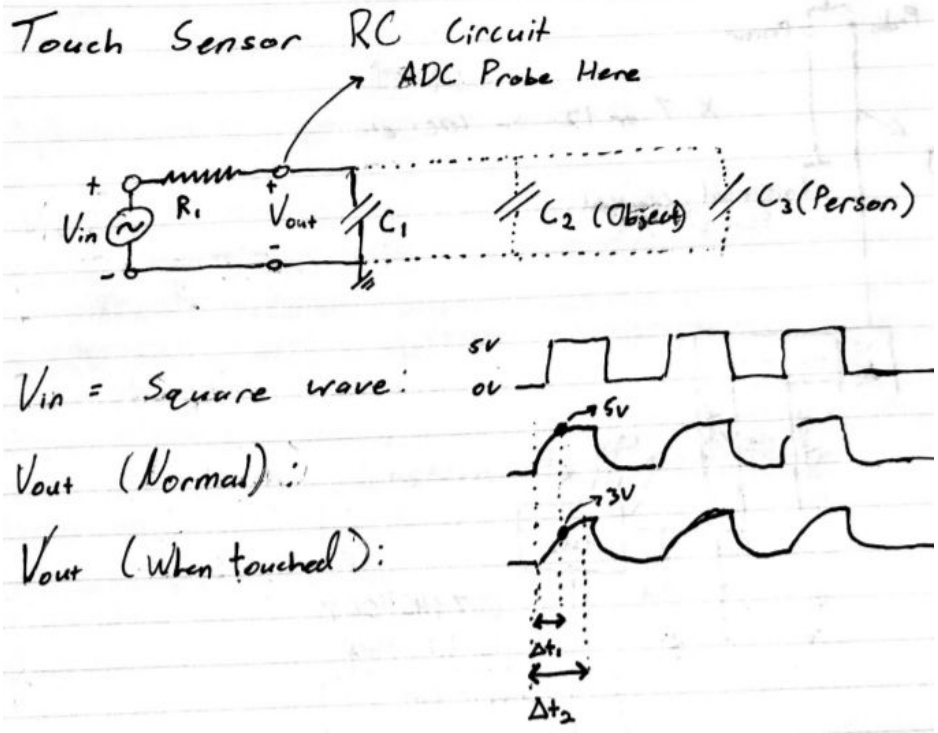
Make use of Mbed Studio Online to develop code for the STM32 board remotely:

- Keyboard interface - drive the touch sensor with a square wave and cycle through reading each ADC
- MIDI interface - generate corresponding MIDI instructions upon key press, and transmit to the Synth.
- LCD interface - create interactive UI menu on the LCD using haptic inputs, allowing selection of different instrument presets

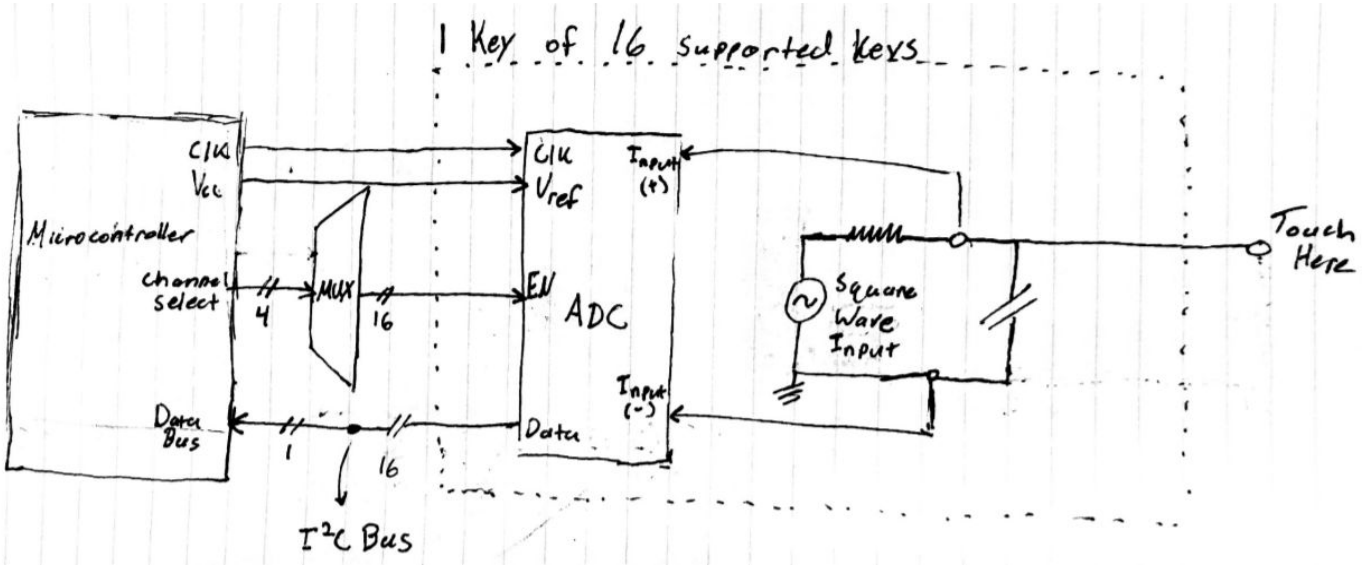
Custom Hardware

Touch sensor operates by measuring voltage across a capacitor at the same time during its charge cycle for each wave.

If the capacitance at that node happens to increase, a lower voltage will be measured indicating a "touch".



Custom Hardware



Each "key" will have its own ADC and be addressed by a multiplexor.

The microcontroller cycles through each ADC and compares its value to a desired threshold

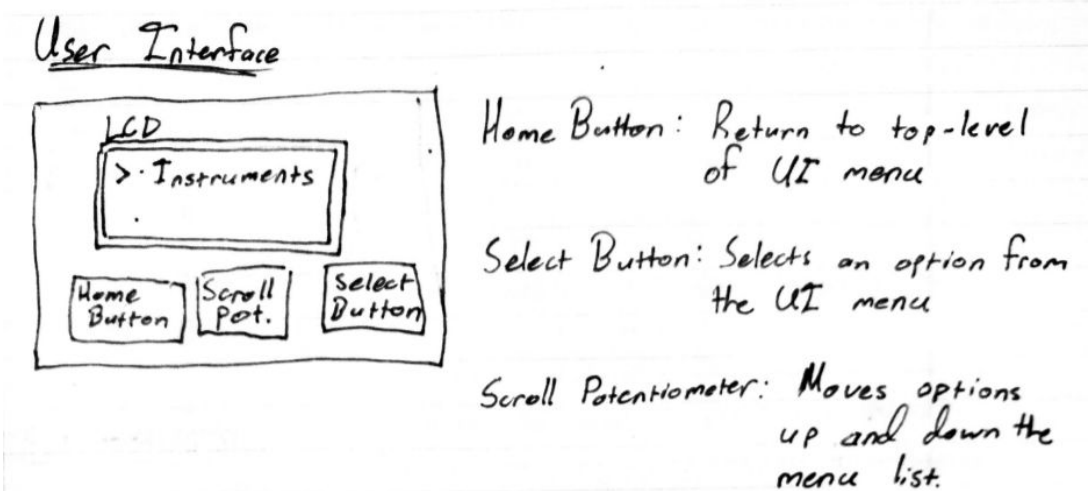
The system could automatically calibrate that threshold after an object is connected to a key, such that the object itself doesn't trigger a touch

User Interface

The main purpose of the LCD UI is to allow the user to select from a list of instrument packs. General MIDI supports a default list of 128 different instruments.

Consists of an LCD display, pair of push buttons and a potentiometer.

The interface offers room for additional functionality in the project if we decide to allow the user more customization.



Proposed MDR Deliverables

1. Demonstrate a functional and reliable touch-sensing keyboard
   - Determine optimal RC component values, square wave frequency and sampling timing of the touch sensors that allow human touch to be detectable
   - Prove ability to detect touch on common capacitive objects (i.e soda can, apple, tin foil)

2. Demonstrate a working user interface
   - Implement a custom options menu template that can be interacted with using push buttons and a potentiometer scroll wheel

3. Demonstrate the ability to play audio from the MIDI synthesizer
   - Implement SPI interface between microcontroller and MIDI synthesizer
   - Be able to generate custom MIDI instructions, pass them to the synthesizer, and play back corresponding notes over the synthesizer's stereo output

Cost Estimate

We expect the parts to cost approximately $120.

To account for the chance of part damage or failure, we would like to factor an additional 20% for overruns. The total parts estimate is $144 (excluding tax and shipping costs).

Cost Breakdown

Part	Function	Cost (each)	Qty.	Total Cost (USD)	Link	Datasheet
VS1053B	Audio Synthesizer	$12.50	1	$12.50	Digikey.com	VS1053B Datasheet
CFAH1604A-TMI-JT	Display & Display Controller	$11.40	1	$11.40	crystalfontz.com	ST7066U Datasheet CFAH1604A-TMI-JT Datasheet
ADS7816	12-Bit ADC -For each input	$3.00	14	$42.00	Digikey.com	ADS7816 Datasheet
CD74HC4067	16-Channel MUX	$0.29	1	$0.29	Digikey.com	CD74HC4067 Datasheet
STM32F100C4T6B	Microcontroller	$3.13	1	$3.13	Digikey.com	STM32F100C4T6B Datasheet
SJ-3523-SMT-TR	Headphone Jack	$0.52	1	$0.52	Digikey.com	SJ-3523-SMT-TR Datasheet
RV4NAYSD501A	Potentiometer	$12.94	1	$12.94	Digikey.com	RV4NAYSD501A Datasheet
BH3AAPC	AA Battery Holder	$1.13	1	$1.13	Digikey.com	BC3AAPC Datasheet
TCR2EF33,LM(CT	3.3V Voltage Regulator	$0.06	1	$0.06	Digikey.com	TCR2EF33,LM(CT Datasheet
Various Caps, Resistors, Protoboard	Prototyping	$15	1	$15		
PCB Board (Estimated)	PCB Board	$20	1	$20		
			Total Estimated Cost:	**$118.97**		

Team Responsibilities

Team Coordinator: Carley Davis

- Closest to campus - can obtain ordered parts from UMass. Responsible for accessing Marcus labs if needed, and building the power supply subsystem.

Hardware Lead: Matthew Avison

- Has access to E-Lab tools and oscilloscopes - can prototype and assemble hardware remotely. Responsible for project assembly and keyboard subsystem.

Altium Lead: Ivan Norman

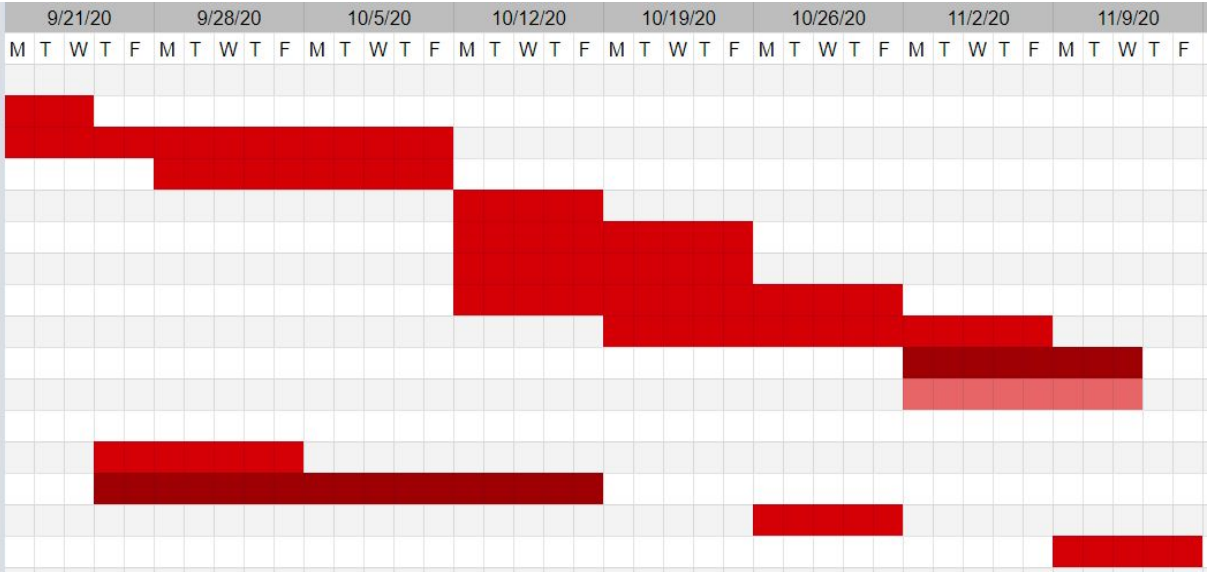
- Responsible for managing custom PCB orders, and the MIDI synthesis subsystem.

Budget Management Lead: Cory Vandergrift

- Responsible for keeping track of hardware & software used, reporting any cost overruns, and for the LCD user interface subsystem.

Schedule

Task Name	Start Date	End Date	Team Member
Hardware			
Preliminary Design	9/10/20	9/23/20	MA, CV, IN, CD
Touch Sensor Prototyping	9/10/20	11/1/20	MA
Research MIDI Protocol	9/28/20	10/9/20	All
Implement Power Supply	10/12/20	10/16/20	CD
Implement Capacitive Touch Keyboard	10/12/20	10/23/20	MA
Implement LCD User Interface	10/12/20	10/23/20	CV
Interface microcontroller with Synth.	10/12/20	10/30/20	IN
Code custom MIDI event profiles for Synth.	10/19/20	11/6/20	IN
Subsystem Troubleshooting (Critical)	11/2/20	11/11/20	All
Combination of Subsystems (Optional)	11/2/20	11/11/20	All
Logistics			
Order Parts	9/24/20	10/1/20	CV
Obtain Parts	9/28/20	ASAP	CD
Damage Control Meeting		10/26/20	All
Complete MDR Presentation Materials	11/9/20	11/13/20	All



Questions?