



FRGB Instruments

Group 25:

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Sponsored by:

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Motivation



Musical performances have not had much advancement in recent years.



Creating more stimulating musical performances.





Objectives

- To visualize the sounds emitted by instruments with RGB LEDs.
- Process frequency & volume of the sounds through a microcontroller.
- Create a smooth transition between colors.

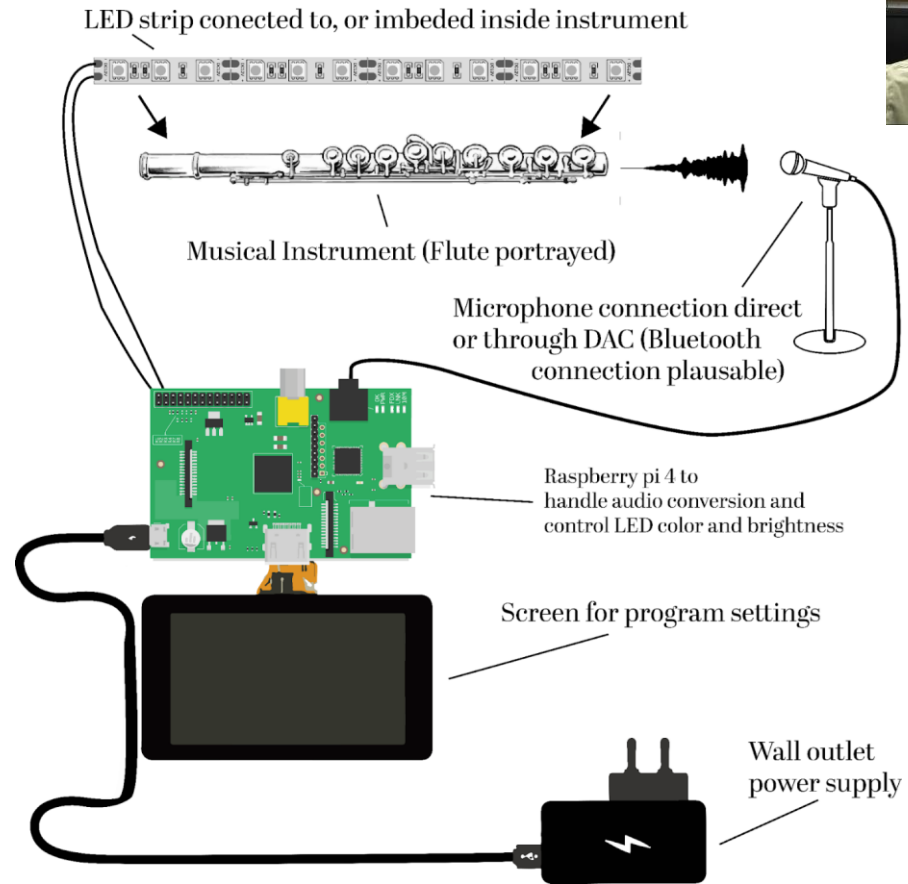


Specifications & Requirements

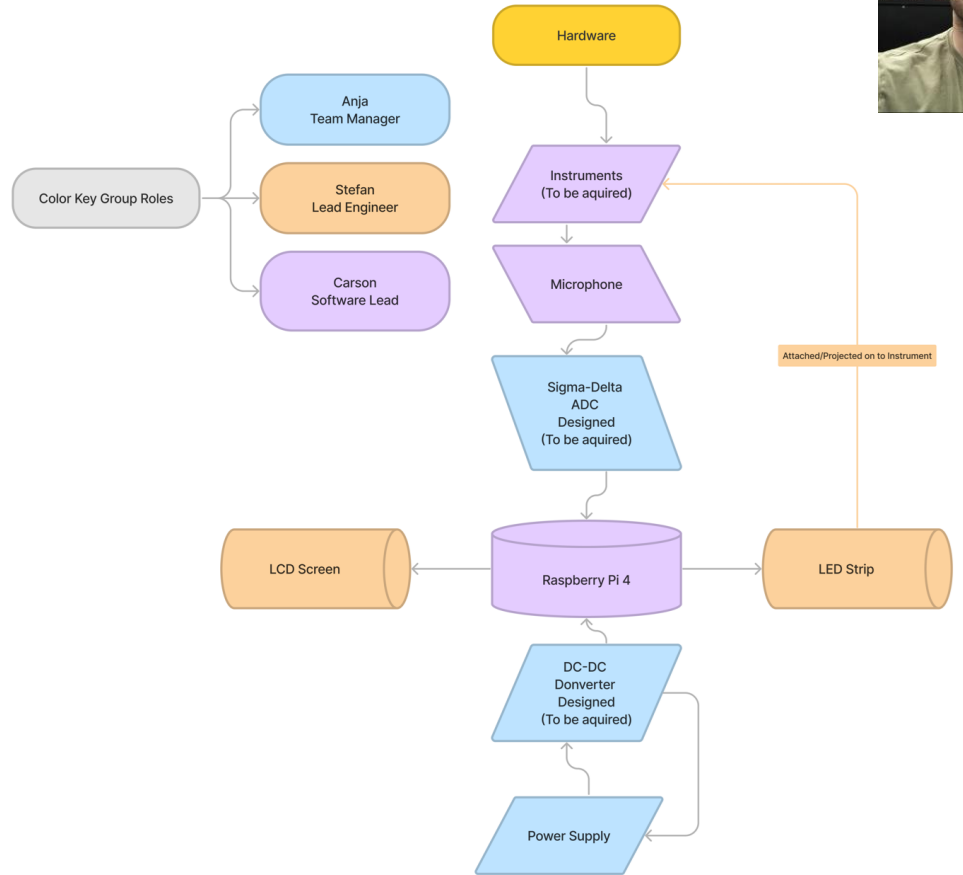


Specification	Goal
Minimum SNR value	25 dB
Minimum refresh speed	5 iterations per second
Lower power mode	System sleeps after inactivity
Portability	Easy transport
Portability	Light weight
Total cost	Under \$1000

Initial Prototype Diagram

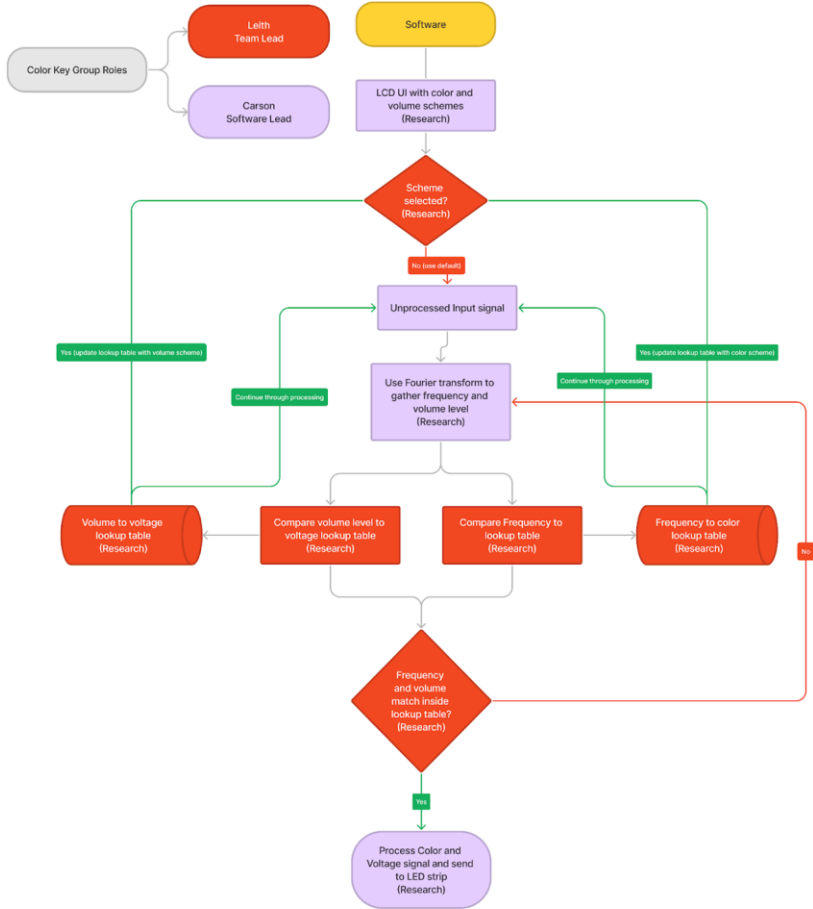


Hardware Block Diagram





Software Block Diagram



House of Quality



Correlations	
Positive	+
Negative	-
No Correlation	

Relationships	
Strong	●
Moderate	○
Weak	▽

Direction of Improvement	
Maximize	▲
Target	◇
Minimize	▼

		Column #							
		1	2	3	4	5	6		
		Direction of Improvement							
		▼	▼	▼	▲	▲	▼		
Category	Weight	Engineering Requirements							
		Customer Requirements (Explicit and Implicit)		Limited Delay	Dimensions	Low Power	Brightness	Battery Life	Cost
Safety	8	Microphone Quality		○	●	▽	○	●	
	2	Easy User Interface		▽	○	○	▽	▽	
	4	Lighting Options		▽	○	●	▽	▽	
		Portability	●	●	●	○	●	●	
		Cost	○	●	●	○	○	●	
		Target	≤100ms	58x52 inches ≤1lb		≥200 Lumens	≥60 Minutes	≤\$500	

Initial Project Approach



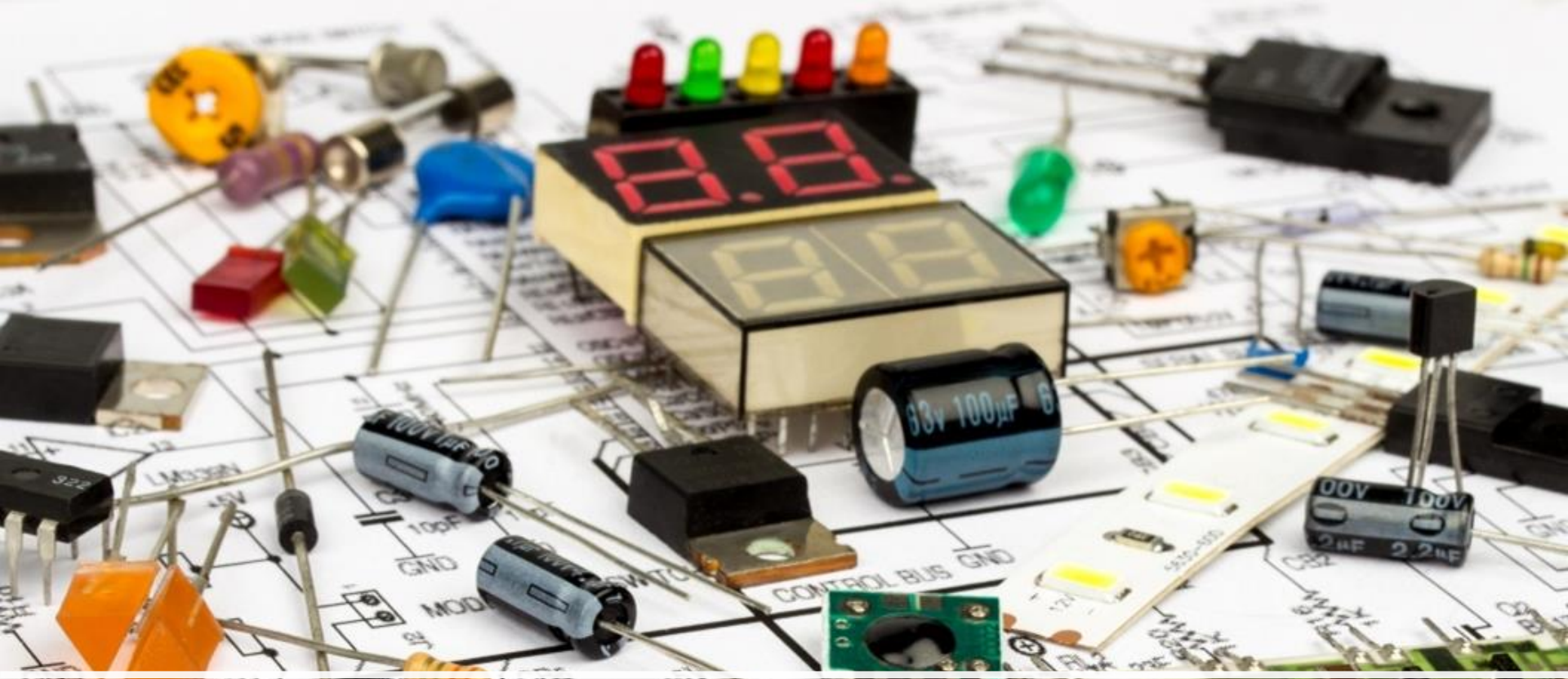
Begin with software design.

Create working product.

Make it portable.

Polish.





Component Selection





Microcontroller



- Speed
- Price
- Specifications
- I/O
- Community Support

Microcontroller Comparison Table



	Raspberry Pi 4	Raspberry Pi 3	Nvidia Jetson Nano
Cost	\$158	\$80	\$298
Processor Speed	Faster	Slowest (0.5x Pi 4)	Fastest (2x Pi 4)
RAM	2-8 GB	1 GB	4 GB
I/O	All	All	Missing 3.5mm audio
Size	3.94"x2.76"x1.18"	3.35"x2.2"x0.8"	2.72"x1.77"x1.77"
Power Requirement	5V DC	5V DC	5V DC



Microphone

- Portability
- Polar patterns
- Clarity

Microphone Comparison Table



	Shotgun Microphone	Contact Microphone	Clip-On Microphone
Pickup Pattern	Lobar	Direct	Cardioid
Cost	\$90	\$20	\$165
Size	Large	Small	Small
Sound Quality	High Fidelity	Standard	High Fidelity
Application	Floor Standing	Direct Mount	Direct Mount



Analog-to-Digital Comparison

Latency

Size

Noise

Resolution

Frequency
Converter



Analog-to-Digital Comparison Table

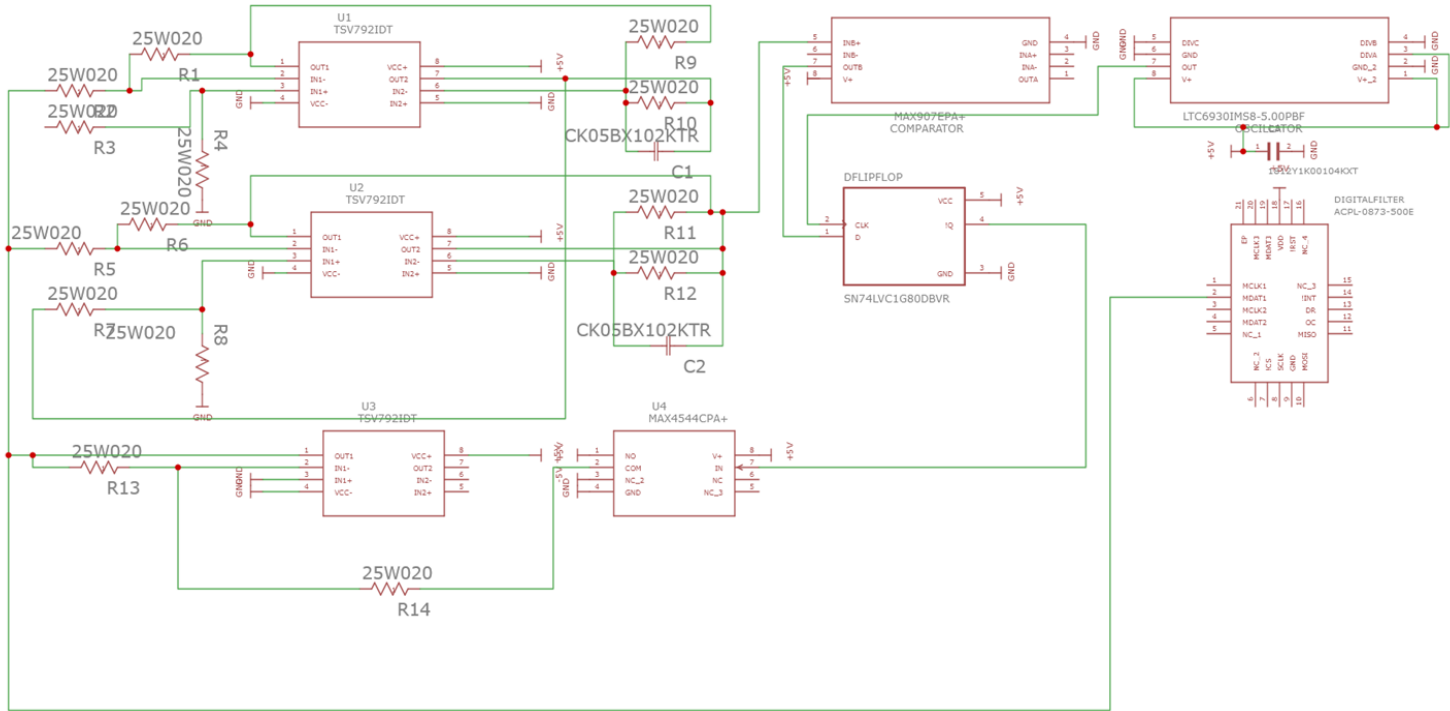


	Dual Slope	Flash	Pipelined	Delta-Sigma	Successive Approximations
Cost	Low	High	Low	High	Low
Size	Small	Large	Medium	Small	Small
Latency	High	Low	Low	High	Medium
Resolution	High	Low	Medium	High	Medium
Throughput	Low	High	High	Low	Medium
Noise	Low	Medium	Medium	Very Low	Low

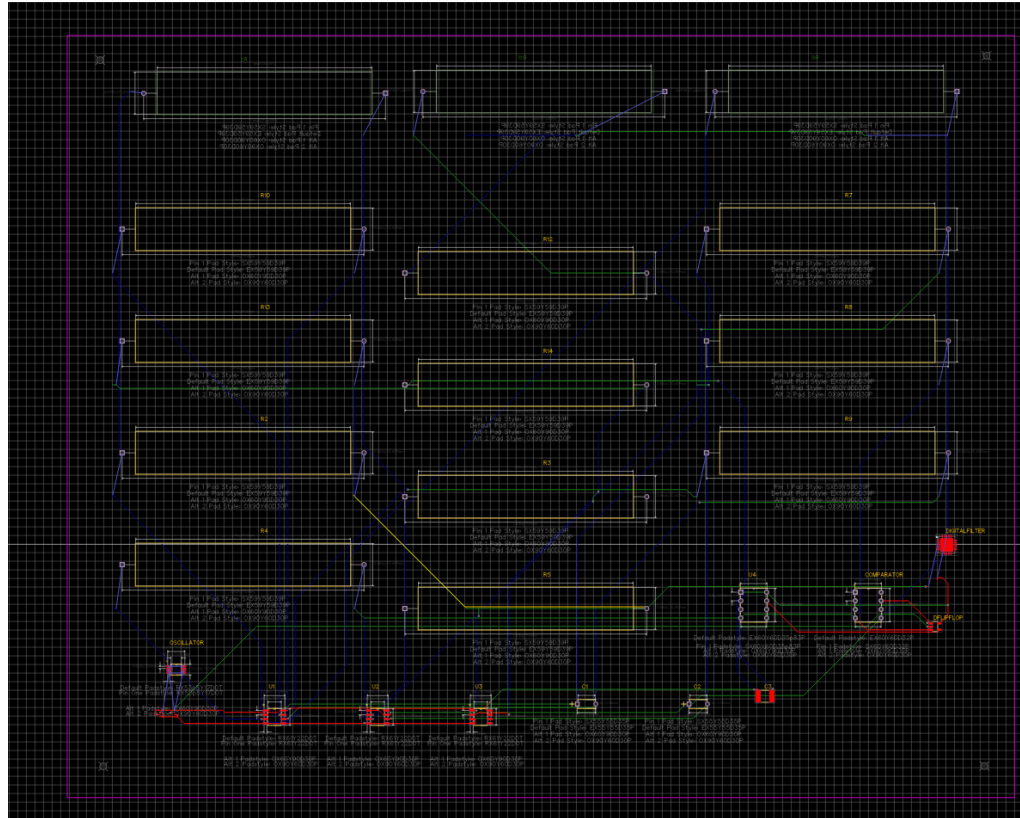
Analog-to-Digital Converter Schematic



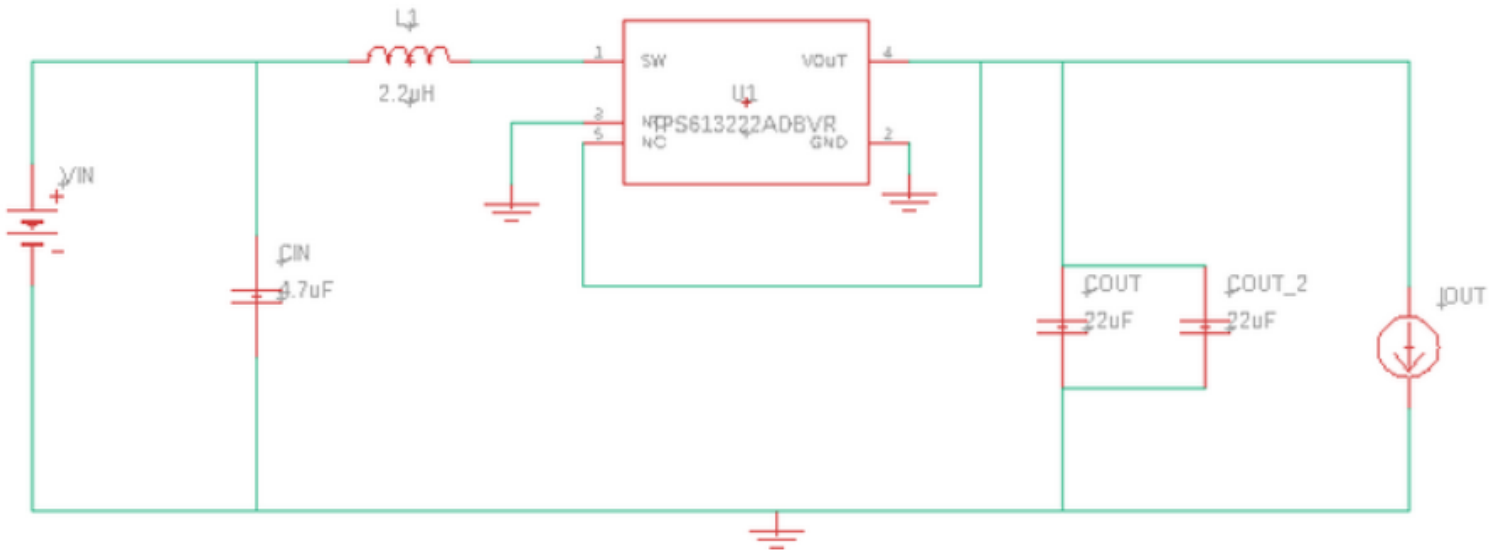
VCC X a-1



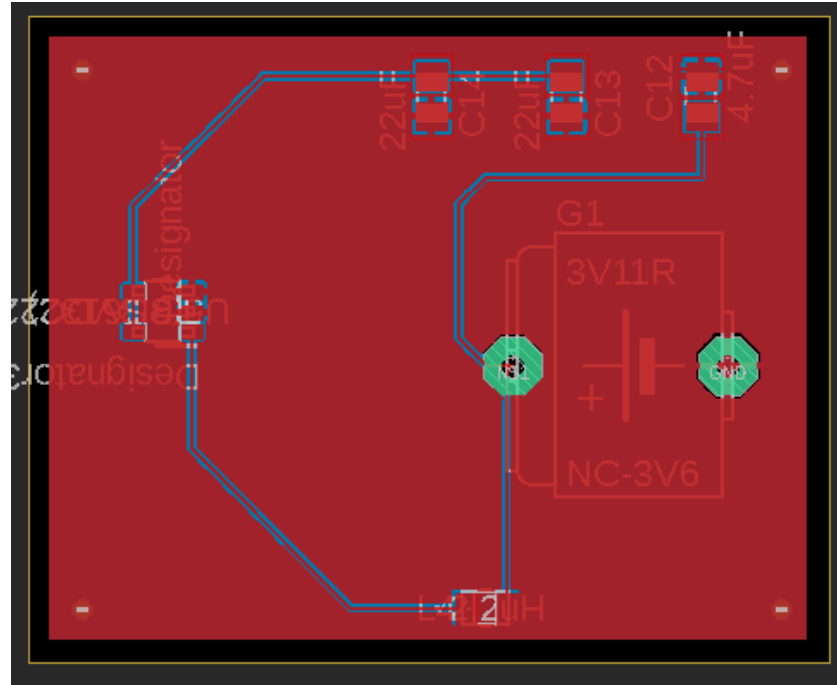
Analog-to-Digital Converter Layout

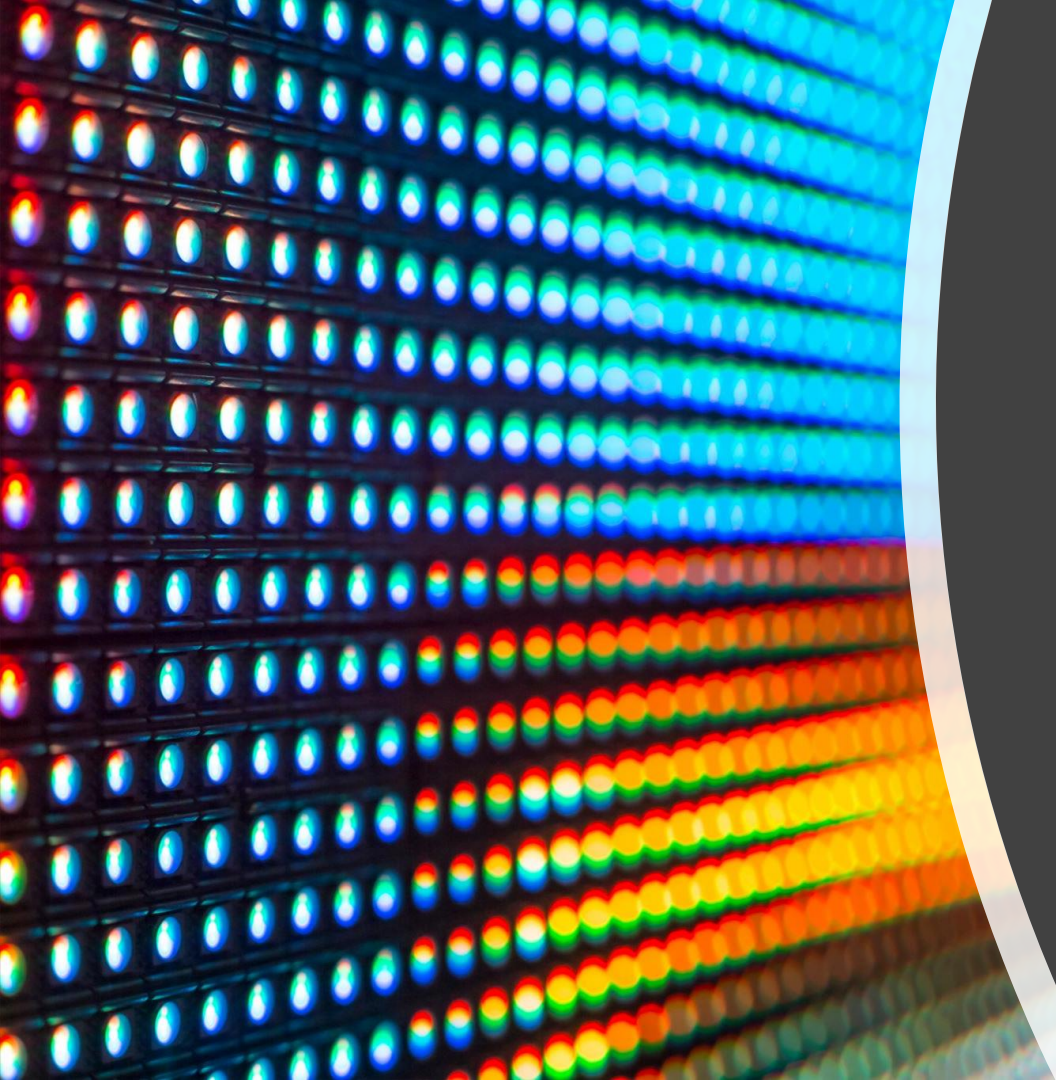


DC-to-DC Converter Schematic



DC-to-DC Converter Layout





Light Emitting Diodes



- Brightness
- Color spectrum
- Longevity

LEDs Comparison Table



	SMD	COB
Quality of Light	<ul style="list-style-type: none">• Features a glare• Best used as a point light	<ul style="list-style-type: none">• No glare• Uniform light beam• Best used as a surface light
Production Efficiency	Low	High
Cost	~5% Higher	~5% Lower
Color & Temperature	Adjustable with a wide variety of colors	Non-adjustable color
Application	Signs & Displays	Security & Industrial
Energy Efficiency	Highly efficient	Highly efficient
Brightness	50-100 lumens/watt	80+ lumens/watt



Power Supply



- Portability
- Cost
- Life Cycle

Power Supply Comparison Table



	Rechargeable Lithium-Ion Battery Pack	Lithium Polymer Battery	Raspberry Pi Battery Pack	PiJuice Hat	USB Wall Charger
Size	1.9"x3.2"x6.3"	2.6"x1.42"x0.39"	4.17"x3.82"x1.38"	4.33"x4.92"x1.38"	N/A
Weight	1.58 lb	1.25 lb	0.28 lb	0.22 lb	N/A
Cost	\$53	\$38	\$26	\$90	\$12
Capacity	8300 mA/h	3000 mA/h	4000 mA/h	1820 mA/h	N/A



Display Screen



- Display Size
- Resolution
- Compatibility
- Power Consumption
- Cost

Display Screen Comparison Table

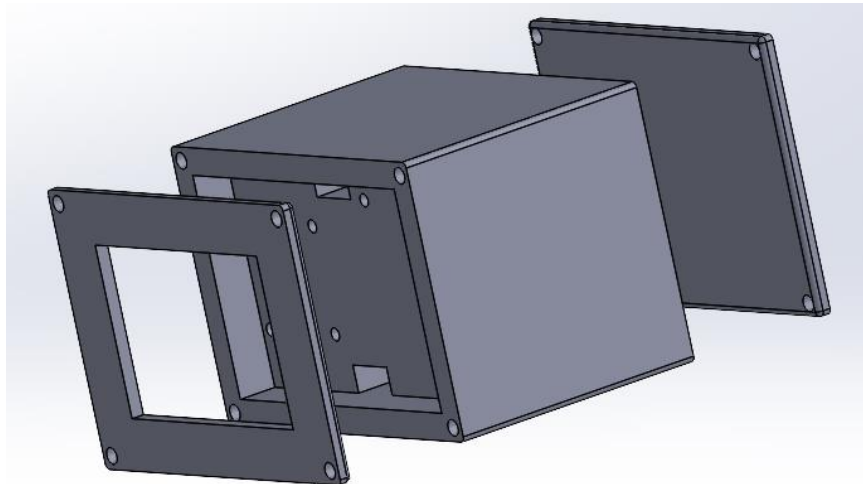
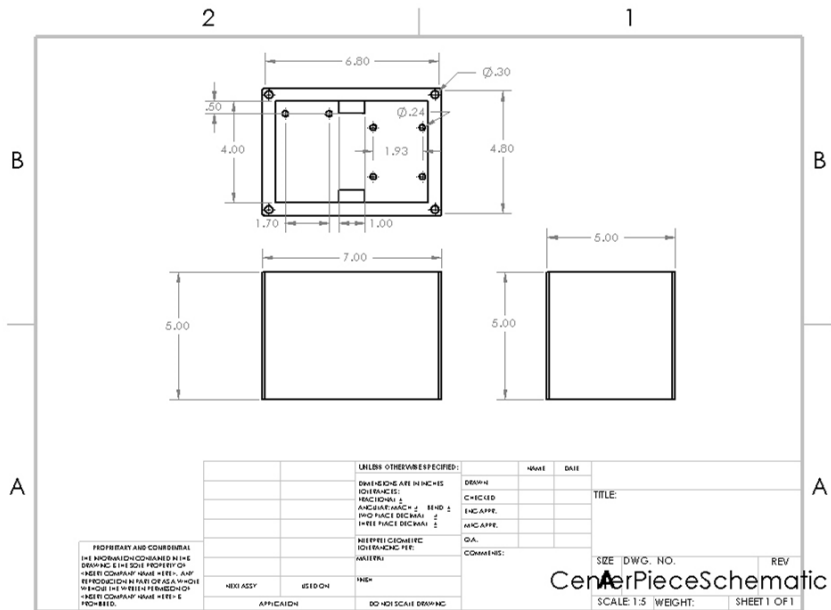


Criteria	LCD	OLED	QLED
Cost	\$40	\$120	\$110
Screen Size	5"	5.5"	5.5"
Features	Touch Screen	Touch Screen	Touch Screen
Availability	1000+	2+	50+
Resolution	800x480p	1920x1080p	1920x1080p
Compatibility	Raspberry Pi	Raspberry Pi	Raspberry Pi
Power Consumption	5V DC	5V DC	5V DC


SolidWorks Design



Design Iterations were made in the adjustment to any changes that needed to be done on the system.

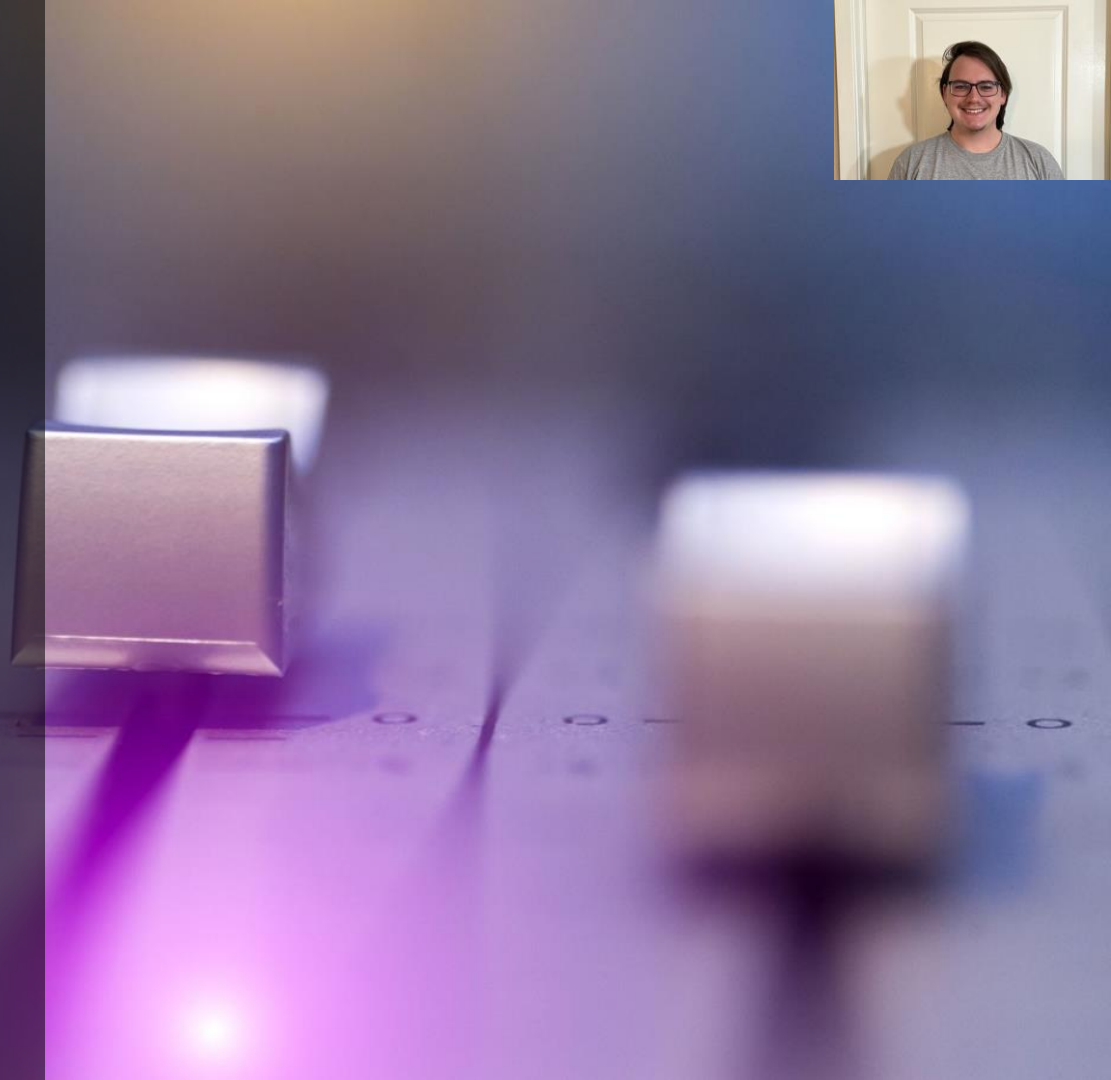


CenterPieceSchematic



Converting music to colors

- JavaScript program converts sound into frequency values.
- Frequency ranges assigned to various notes.
- Each note assigned a different color.
- Visual representation of Chromesthesia

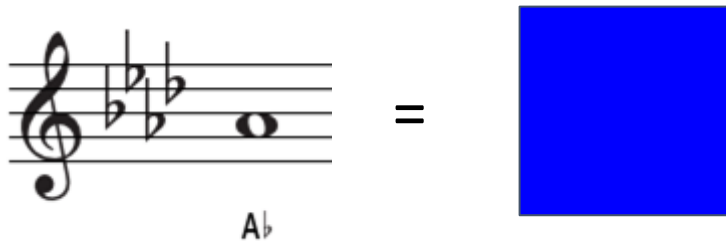


Level 0 - Note-to-Color Relationships



- Relationship between specific notes with specific colors
- Foundational level to be implemented
- Represents sound-to-color visualization

Ex. The note A flat corresponds to the color Blue



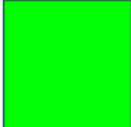
Level 1 - Note Relationships




- Changes color based on musical note-intervals
- Can select which intervals to track

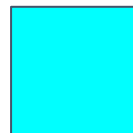
Perfect fifth



If C = 

And G = 

Then C and G played successively produces a color mix of both =





Level 2 – Polyphonic Sound

- Differentiate between different instruments being read by the microphones input
- Based on specific timbre of each instrument



Implementing Color Schemes



- Used to determine which note gets which color
- Ability to add, edit, and delete new color schemes

Edit Scheme
Change your color profile

Scheme Name
Default Scheme

Volume

▶ A	Red	▶ C#	Yellow-Green	▶ F	Cyan
▶ B _b	Pink	▶ D	Orange	▶ F#	Teal
▶ B	Dark Purple	▶ D#	Blue	▶ G	Purple
▶ C	Green	▶ E	Purple	▶ G#	Orange-Red

Submit Scheme



Fourier Transforms



Algorithm designed to interpret repeating patterns

- Applied in sound, optics, electrical engineering, etc.

Sound can be defined as the fluctuation of air pressure over time

- FT finds the frequency of the fluctuations

Converts a sound into a list of frequencies

- A note is a specific frequency range
- Most sounds are made of several frequencies

Application uses `fft.js` library to implement fast Fourier Transforms

- Fast Fourier Transform is an algorithm made for quick computer calculations

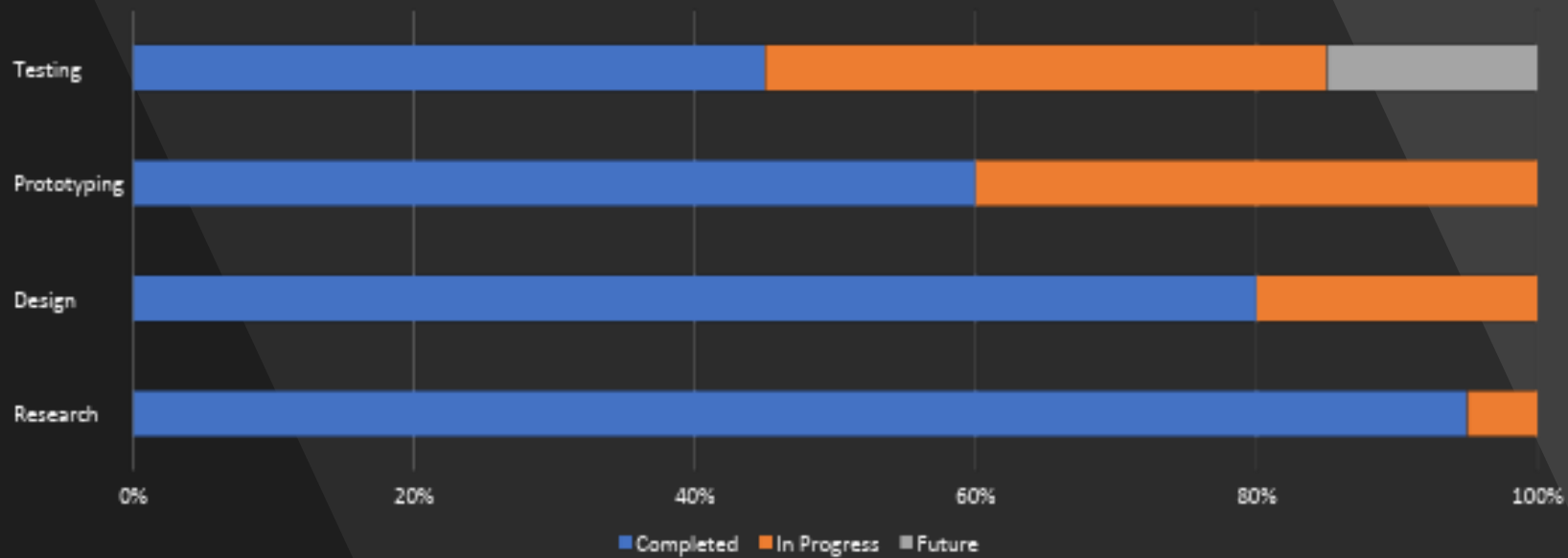
Work Distribution



Name	Stefan	Anja	Leith	Carson
Software Design			X	X
Hardware Design	X	X		
A-D Converter		X		
DC-DC Converter	X			
Music Integration				X
RGB Integration			X	



Progress Chart



Budget



Part	Estimated Cost	Description
Microphone	\$79.99	Floor Clip-On microphone to read in music being played.
LED Strip	\$21.99	High Density RGB LED strip with 144 LEDs per meter to light up the instrument.
5" Display Screen	\$48.49	Touchscreen LCD display to apply different light modes and settings can be IPS or TFT.
Microcontroller	\$185	Raspberry Pi 4b 8 GB
Power Supply	\$11.89	Power cable with switch to turn off power to the Raspberry Pi.
Frequency Converter Components	\$100	Comparator used for the ADC.



Product Demo





Questions?

