

SDP 23 Team 24: An extensible loop station and music production framework

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Team 24



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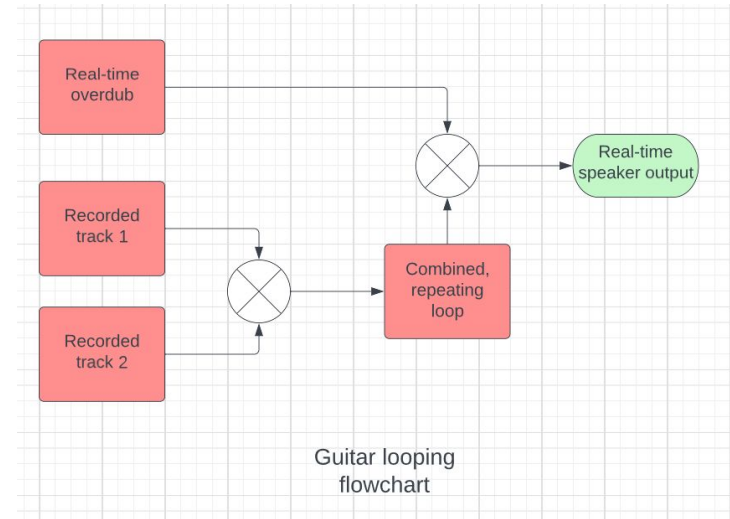
John
Folliard
(CompE)



Ben Rotker
(CompE)

Background

- What are guitar effects?
- How are these effects integrated in a performance?
- What is looping?



Problem Statement

- There is a lack of open source and extensible gear for performing musicians.
- Different effects need different pedals
- Some projects exist that combine the benefits of looper pedals and effects pedals into one singular user interface. (But not open source).
- This makes it nearly impossible to add or remove various effects as desired.

Our Solution

The problem we aim to solve is allowing a user to have one box that loops audio, adds effects to that audio, and adjusts the audio altogether instead of purchasing effects pedals like a looper pedal, distortion pedal, and tremolo pedal separately. We wish to make this an open source project, users can both modify the implementation of the effects we have and add new effects as desired.



Similar Solution #1

Boss RC-1 Loop Station

- 2 mono-quality tracks
- 3 hours battery life with Alkaline battery
- Approximately 12 minutes maximum recording time
- AC adaptor available
- No effects provided
- ~\$120
- <https://www.boss.info/global/products/rc-1/specifications/>



Similar Solution #2

TC Electronic Ditto Looper

- Dirt simple looping
- True bypass and Analog-Dry-Through
- 5 minutes of looping
- Undo/Redo function
- Unlimited overdubs
- 24-bit uncompressed high quality audio
- Ultra-small footprint
- ~ \$89
- <https://www.tcelectronic.com/product.html?modelCode=P0DD4>



Similar Solution #3

Donner Looper Guitar Pedal

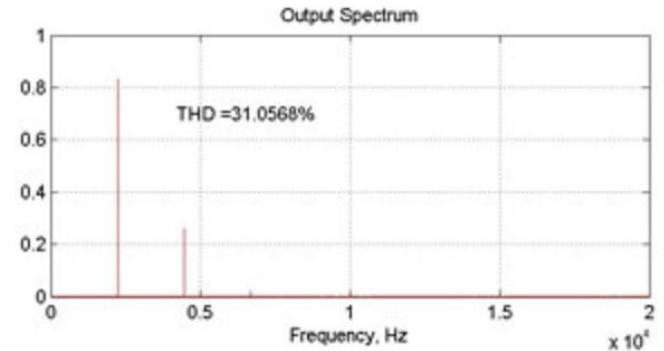
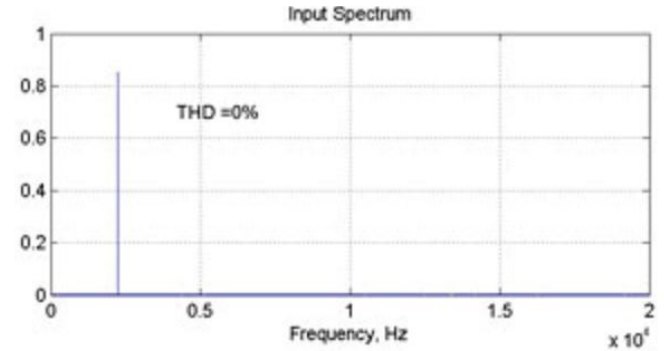
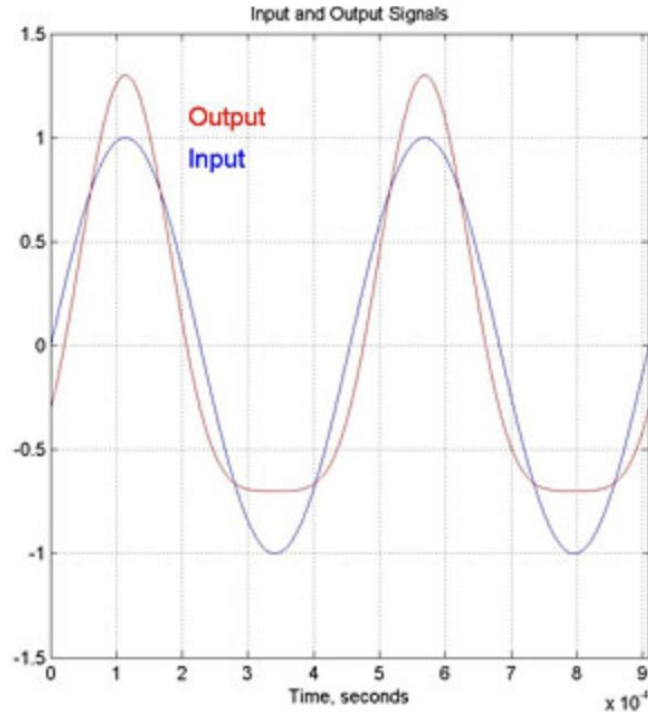
- Dirt simple looping
- 30 minutes loop time
- Undo/Redo function
- Unlimited overdubs
- Time progress bar display
- Foot switch
- Automatically save recorded files
- \$80
- <https://www.donnerdeal.com/collections/loopers/products/donner-triple-looper-guitar-pedal>



Total Harmonic Distortion (THD)

- THD is a ratio of power of spurious harmonics to the fundamental in a signal
- Quantifies the linearity of a system

Total Harmonic Distortion (THD)



Total Harmonic Distortion (THD)

- True THD is found as the square root of the sum of squares of the power found at a finite number of harmonics
- THD+N (N for noise) is a cheaper measurement that subtracts the input power from the output power
- Lifewire posits most listeners will not hear any distortion from a system with THD less than 1%

Signal to Noise Ratio (SNR)

- Ratio of signal to the noise in a system (voltage, power, etc.)
- Background noise in a system also called the “noise floor”
- Typically expressed in decibels (dB)
- Find SNR as difference of signal RMS power and noise RMS power (or voltage or another quantity)
- We have found that music can be played back on audio cassette decks and phonographs in a range approximately 60–70 dB
- FM radio is also roughly in this range

Preliminary Goals

- Implement a multi-effects unit featuring controls for a looper function.
- Loop up at least two simultaneous tracks of audio
- High-Fidelity (HiFi) Audio
 - Inaudible noise or undesired distortion of clean signal
 - Low Total Harmonic Distortion (THD)
 - High Signal-to-Noise Ratio (SNR)
- Ease of use while performing

Specifications

- HiFi Audio
 - Mono, 16-bit, $f_s = 44100$ Hz (5292 kB per minute for each, 10.584 MB per minute for two simultaneous tracks)
 - THD: less than 1%
 - SNR: greater than 70 dB
- 2 tracks
- Visual indicators: easily visible from floor while standing
- Controls: usable with feet or hands
- Power: DC and/or battery (likely NiMH)
- Sound latency: delays of less than 10-12 milliseconds are imperceptible [1]

Specifications

- Effects
 - Memoryless
 - Overdrive/Distortion (full, warm tone)
 - Modulation (such as tremolo, analogous to an underwater sounding effect)
 - Memory
 - Delay (design goal)
 - Chorus (combination of delay and modulation, design goal)
- Connectors
 - Input: unbalanced ¼ inch hi-Z instrument
 - Output: unbalanced 3.5 mm AUX jack at line level

Comparison

| | # of tracks | Sampling rate | Sample bits | Recording length | Power | Effects |
|--------------|-------------|---------------|--------------|------------------|-------------------|---------|
| RC-1 | 2 (mono) | Not provided | Not provided | 12 min | 9V battery/ AC | no |
| Ditto | 1 | 44.1 kHz | 24 bits | 5 min | 9 V power supply | no |
| Donner | 1 | 44.1 kHz | Not provided | 30 min | 9 V DC | no |
| Our Solution | 2 (mono) | 44.1 kHz | 16 bits | variable | Battery | yes |

Testing Plan

| Specification | Test plan |
|--|---|
| 2 track | Demonstrate that 2 tracks can work together |
| 44.1 kHz sampling rate 16-bit samples | Based on file size and file length calculate the sampling rate and sample bit |
| THD less than 1% | Measured by specific instrument from M5 (oscilloscope or sound card also possible) |
| SNR greater than 70 dB | |
| Visual indicators | Viewer stands between 6-8 feet away, describes what they see on visual indicators, compare to known display |

Testing Plan

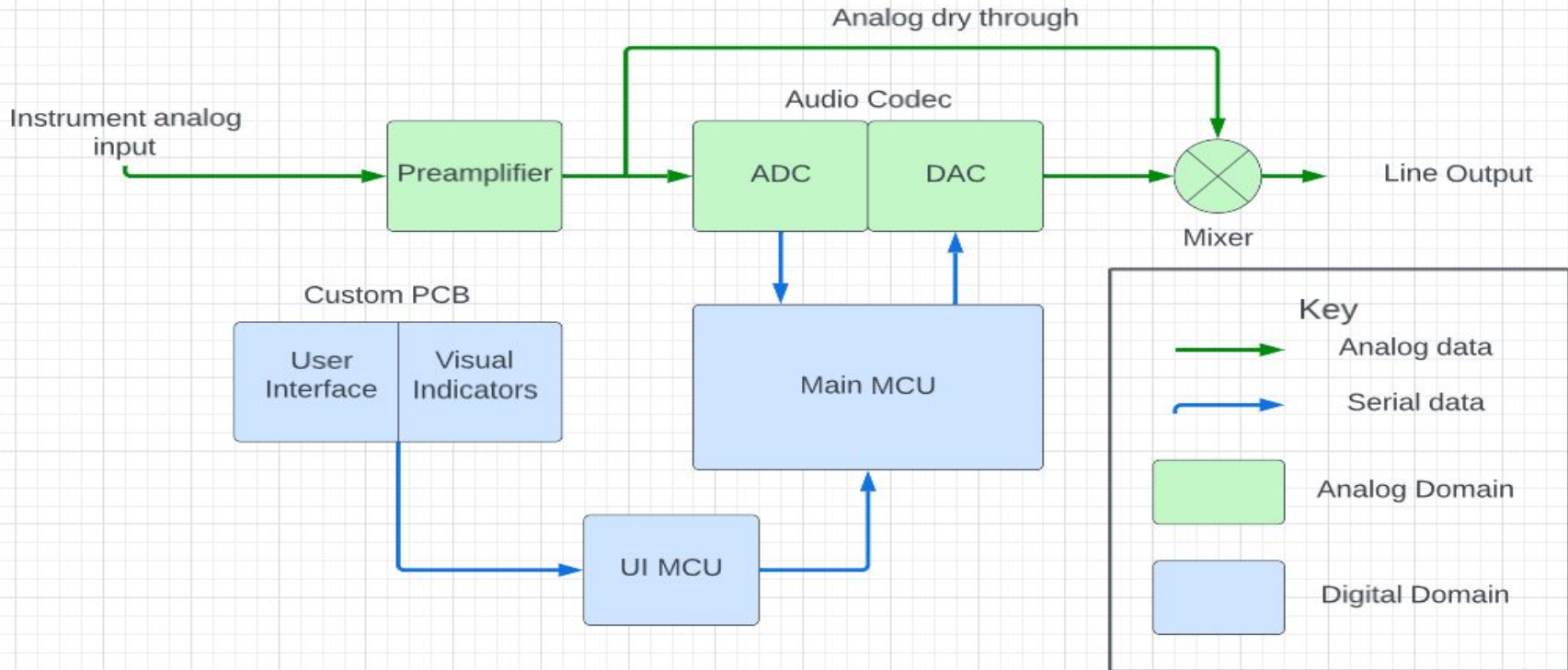
| Specification | Test plan |
|----------------------|---|
| Feet or hand control | Ensure all controls can be manipulated with hand/feet (no smartphone/PC) |
| Sound latency | Measure the time between feedback pulses to get the sum of the output latency, input latency, and application overhead. |
| Effects | Listen to each effect and make sure it sounds as desired |

Preliminary Design - PCB

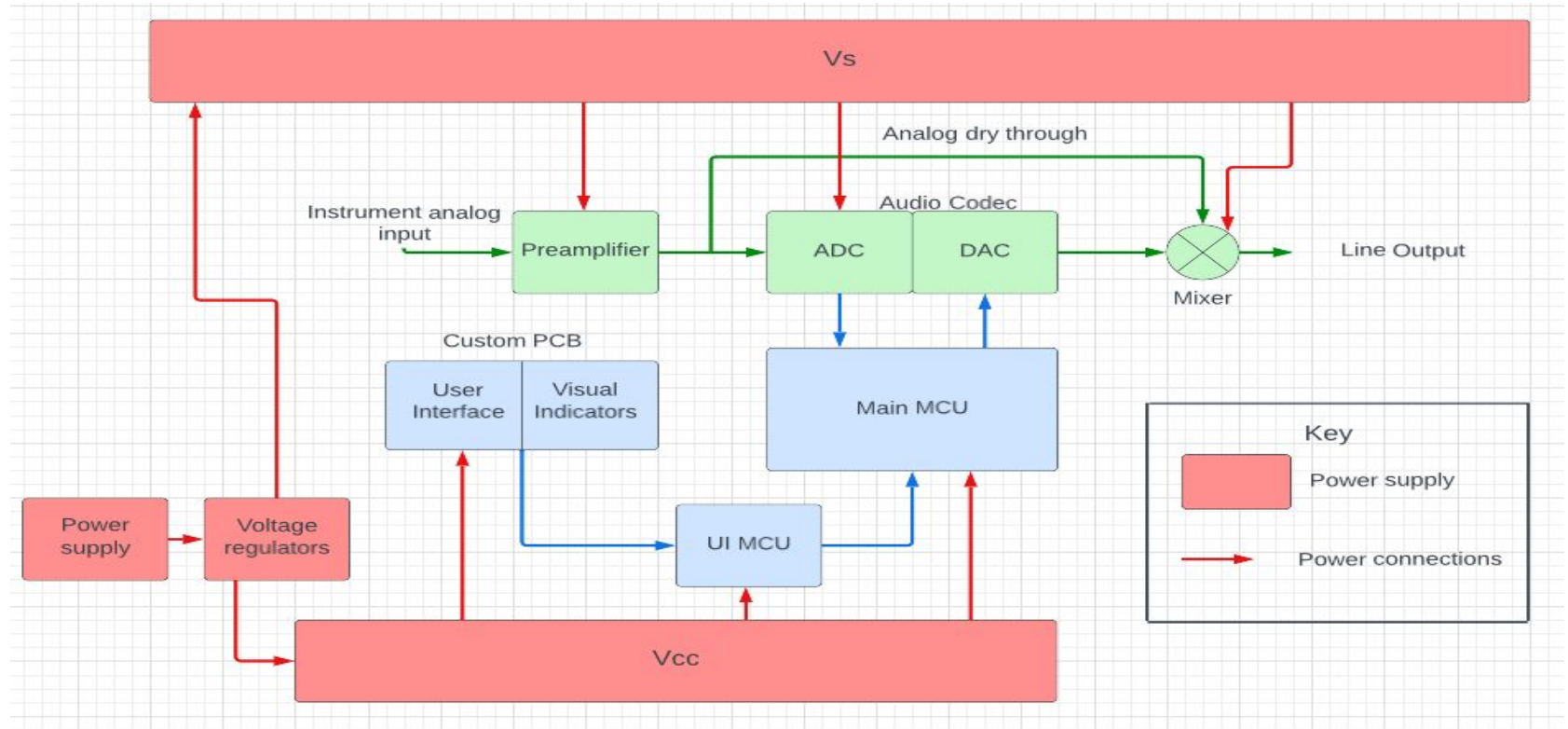
Our PCB will furnish the user interface consisting of visual indicators and control features to permit easy and intuitive operation of the loop station.

Visual indicators and especially control features to be chassis mounted wherever possible to enhance durability and reliability.

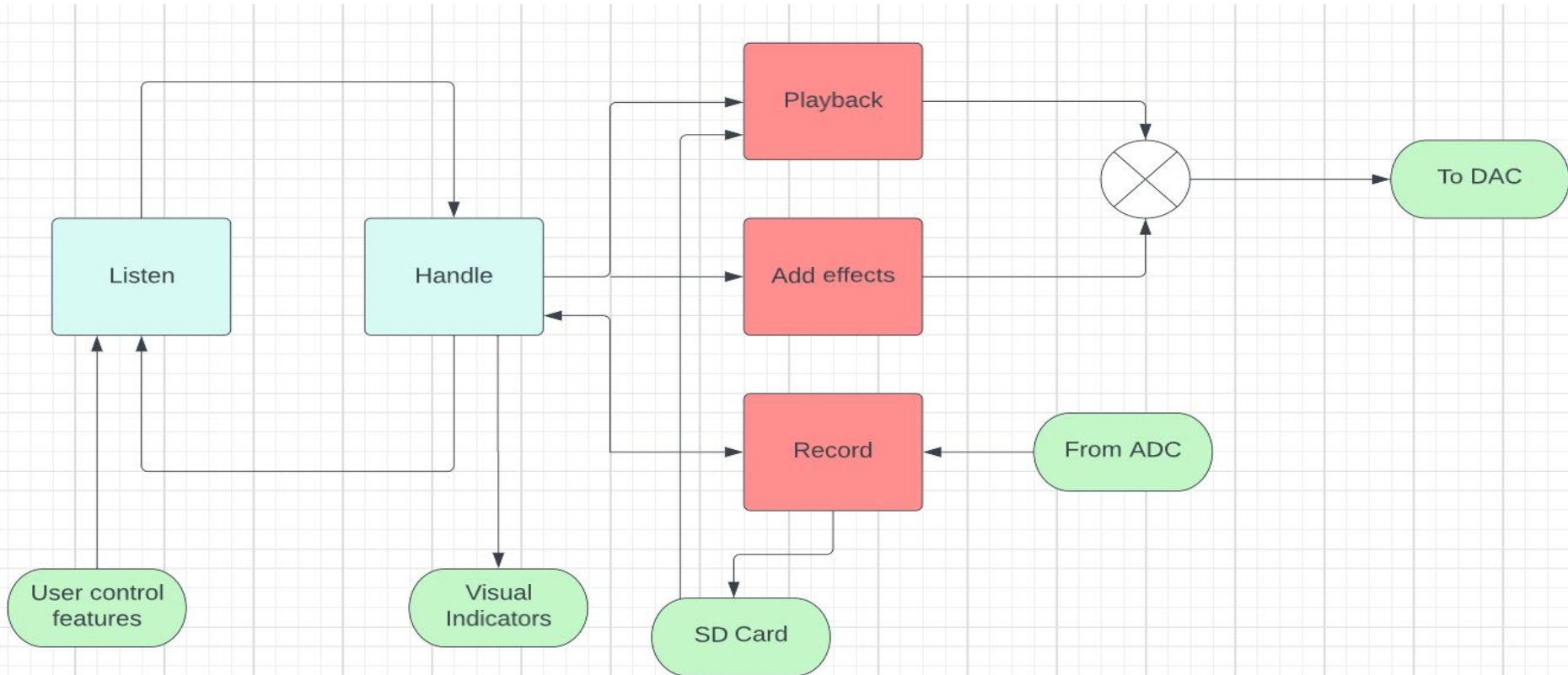
Preliminary Design - Hardware Block Diagram



Preliminary Design - Hardware Block Diagram



Preliminary Design - Software Block Diagram



MDR Deliverables

A benchtop, breadboarded proof of concept that can record one track of audio and playback along with the direct analog-dry-through signal.

- No enclosure at this point
- Volume of looping track can be controlled on the fly
- Start testing additional effects
- Include functional footswitches and led indicators
- System can playback recorded track with no audible distortion (measured between instrument in and line out)
- Draft kicad PCB layout and 3d model of user interface including control features and visual indicators
- Will demonstrate model by looping a guitar riff and adding effects

Expenditure List

| Item | Cost |
|-------------------------------|--|
| Main and UI MCUs (Teensy 4.1) | \$31.50 (x2) |
| Power source | Less than \$20 |
| Audio Codec (DAC and ADC) | \$5.60 |
| SD card | \$10 (depends on size) |
| Preamplifier and Mixer | \$25 |
| Misc Electronics | \$20 |
| PCB | \$100-120 initial cost, \$100 revised cost |
| Total | \$344-364 |

Team Responsibilities

Buzhuo Chen - Software lead

John Folliard - PCB lead

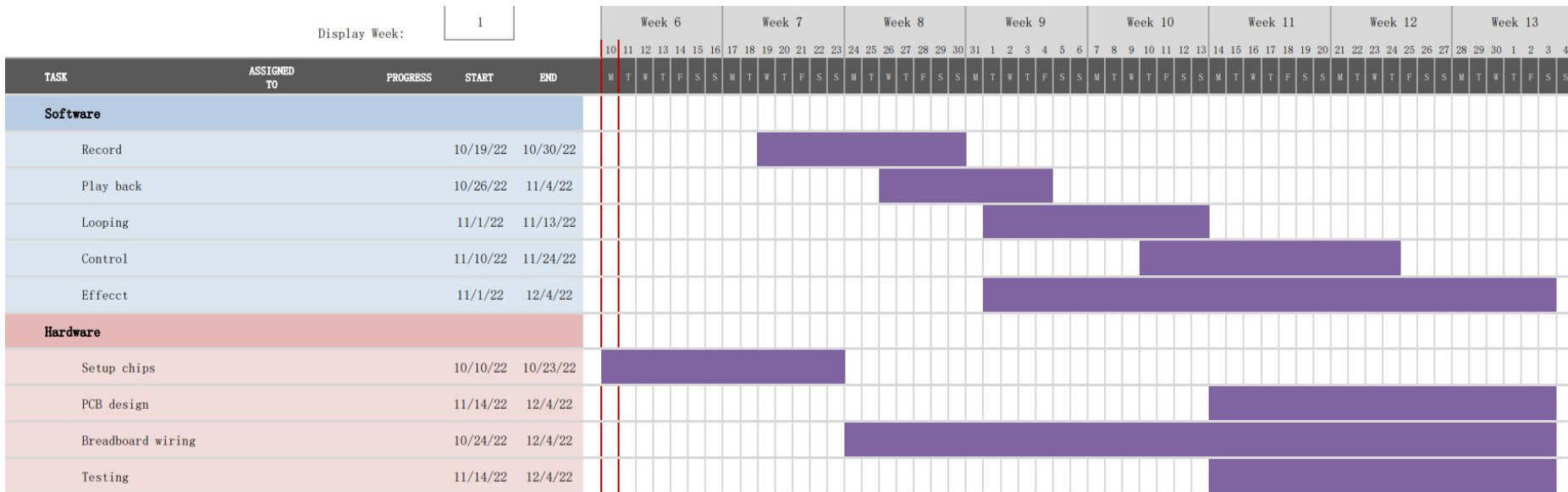
Ben Rotker - Logistics/Budget lead

Yunrui Yu - Hardware lead

Gantt Chart

Display Week:

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QUESTIONS & ANSWERS

University of
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