Modular Music Synthesizer - Final Report

Pratyay Gopal (pratyay2) - ECE 110
Srijan Kumar Singh (srijans3) - ECE 110
Everitt Cheng (emcheng2) - ECE 110

CONTENTS

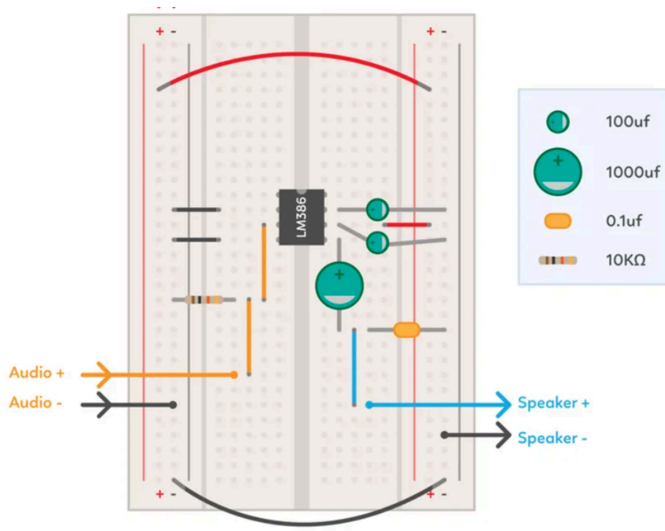
1. Proposal Statement

In this project, we devised a modular music synthesizer that takes in an 8-step sequenced input and passes it to the voltage-controlled waveform generator (made using the Schmitt trigger inverter) that generates triangle, square, and sine waves. Further, we built a filter that can control the cutoff and resonance of our wave. Finally, we built an amplifier which is attached to the speaker and a gain control that generated the desired sound. Our sequencer consists of a CD4017BE counter whose output is connected to 8 potentiometers. Using the potentiometers in our sequencers, we can tune each of them to generate the required music notes and produce an 8-note sound on repeat. Additionally, we can "pause" our synthesizer using a button so that it is easier to tune individual notes. We can also control the tempo of the sound using the knob of another potentiometer that is attached to the clock input of the sequencer. Due to the availability of multiple modules in this synthesizer which are independent of each other that one can attach and detach as per choice, we call our project the "modular" music synthesizer. With time, one can create more modules like the Attack and Release envelope, a Low-frequency oscillator, and many more waveforms that can be mixed using a mixer. These modules can be used independently. We took inspiration for our project from the Eurorack modular synth which has wide applications in the music industry.

2. Milestones

Milestones 1 - Speaker(Weeks of 2/19 and 2/26)

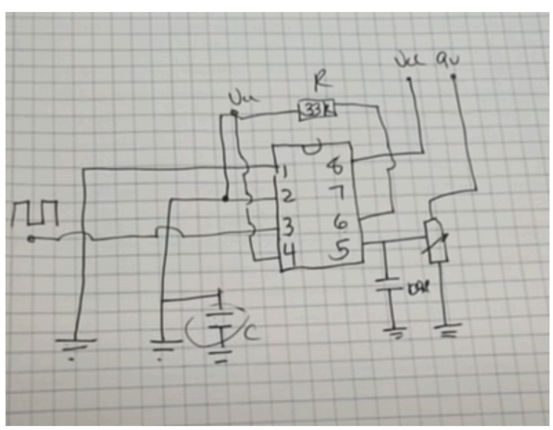
Our first module created was the speaker module shown below. Within the speaker circuit we selected, we decided to use the LM386 op amp chip specifically used for music. The LM386 is a low voltage audio power amplifier that amplifies the low input voltage into the required sound. We used an 8 Ohm speaker as our final output.



We tested this using the oscilloscope at varying frequencies(max at 1000 hz) as well as varying wave functions(square and sine).

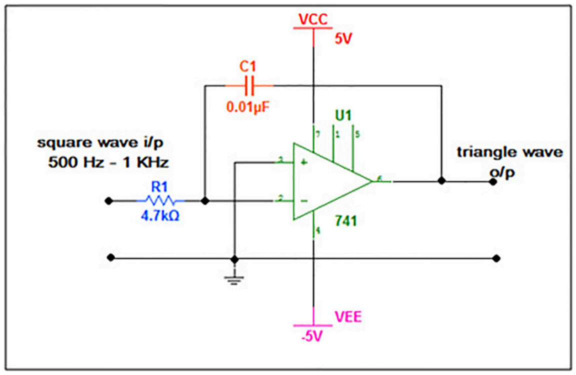
Milestone 2 - Waveform(Week of 3/4)

Originally we attempted to use 555 times to create our waveform generator however we realized that the circuit was not fitted with our speaker well as it had high amplitudes. Instead we used a schmitt trigger based oscillation along with capacitors to create a square wave.



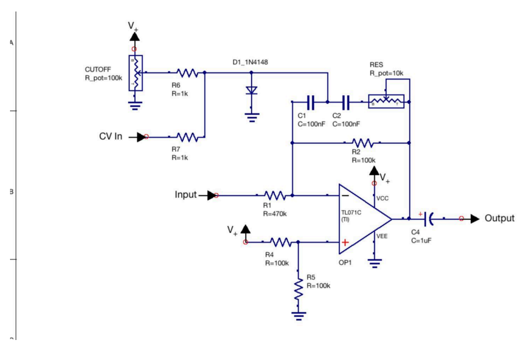
Milestone 3 - Additional Waveforms(Week of 3/11)

Using RC filters we were able to construct other waveforms such as the sine and triangle waves. This allowed for more variation in sound as we progressed through creating the circuit.



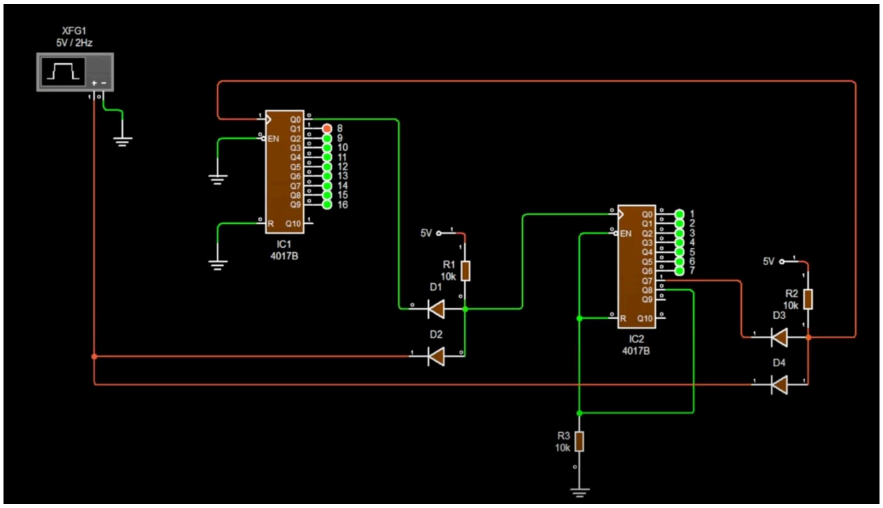
Milestone 4 - Filter(Week of 4/8)

We implemented a voltage control filter that works as a band pass filter(with both high and low pass when tuned properly). We have two potentiometers to alter the cutoff and range of frequencies. For our circuit, we changed some things to meet the input and output range. For instance, instead of 470k, we used 500k ohm resistance. Moreover, we used a slightly different IC that serves the same purpose.



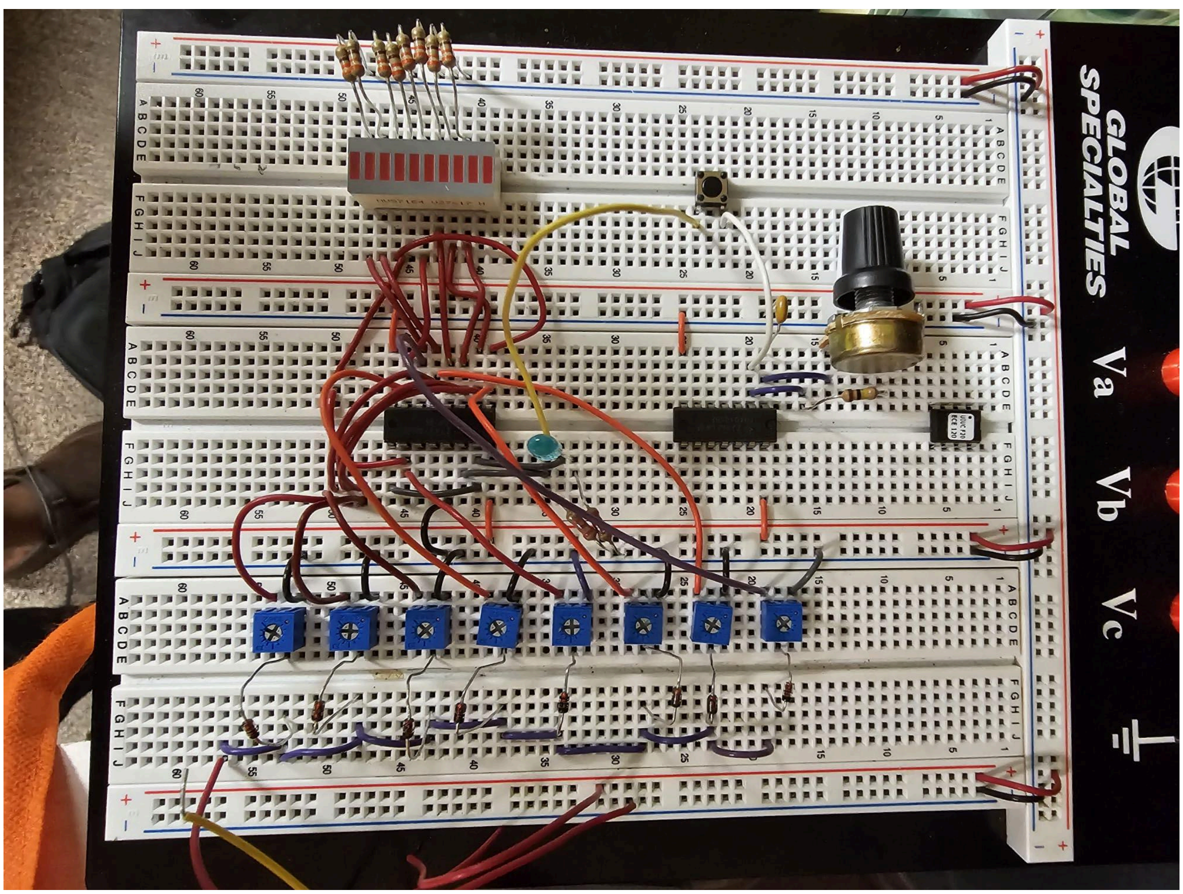
Milestone 5 - Sequencer(Week of 4/15)

Originally we wanted to make an arduino based sequencer, however due to complications and eventual breakdown of the arduino we could not continue creating this sequencer. Instead we used a different circuit that relied on the CD4017BE decade counter chip.



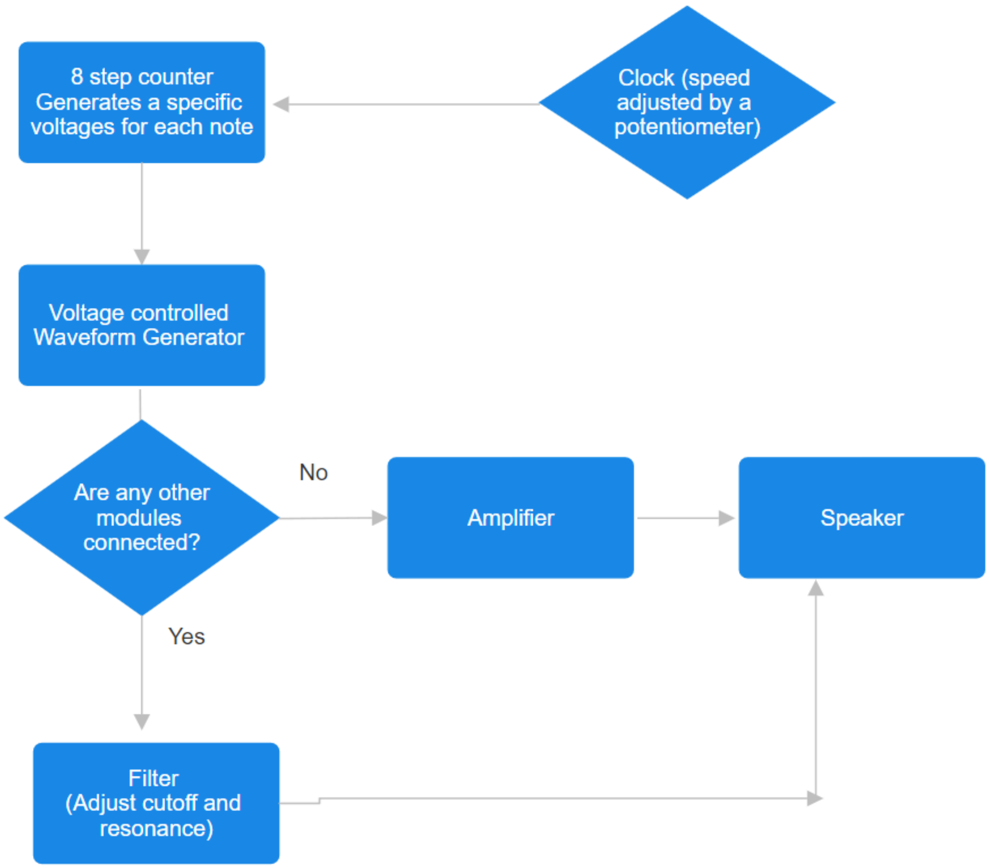
Milestone 6 - Sequencer with pitch variation(Week of 4/22)

For final touches, we added potentiometers configured as voltage dividers to be able to vary the voltage which in turn varies the frequency. We also added custom potentiometers for better tunability and handling.



3. Communication

Our project follows the following flow-chart:



In our project, our module was a Filter that was discussed in the milestones. One can attach more modules here and pair them together or make them work individually since they are independent of each other.

4. Analysis

Each of our subcircuits were tested using oscilloscopes.

Speaker Testing
Firstly, we tested our output amplifier speaker by generating various types of waves that include square, sine, and triangle using the waveform generator. The input to our output module is shown below.

Inputs for the amplifier and speaker circuit

Our speaker was successfully able to produce these sounds, and we verified it by feeding in the frequency of middle C and matching the output with it. The output of the speaker can also be heard in the video demonstration.

Waveform Testing
Next, we verified the output produced by our VCO. It generated a low frequency square wave, as desired. The graph produced by the oscilloscope is shown below.

Square Wave Generator Output

Filter Testing
Next, we tested the output produced by our VCF which works as a band pass filter which is controlled by a threshold potentiometer cutoff and an input voltage which controls the range.

The output from the VCF

Sequencer Testing
Finally we tested the sequencer. The sequencer was easily tested as it could be simply tested by looking at the audio output of the entire circuit as we built this subcircuit last, as well as looking at the safety leds from the decade counter and frequency that we implemented.

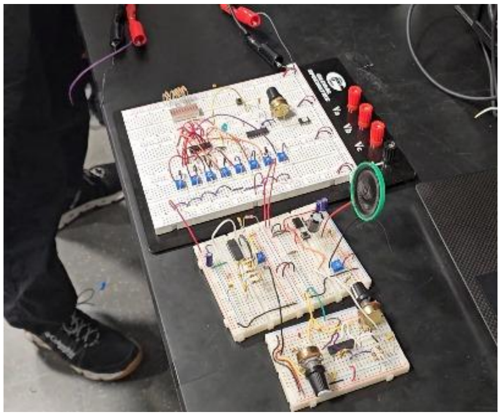
We used the oscilloscope to simply check the range of voltages generated by the sequencer.

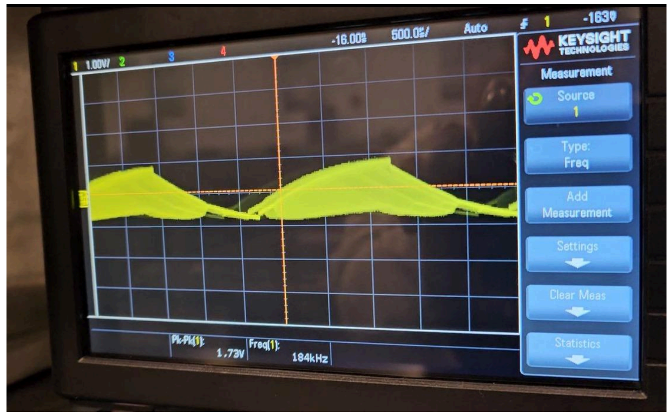
Discrete voltage generated by the sequencer

As you can see there is a line generated by the sequencer which moves according to the generated voltage and then back up in a cycle.

5. Final Product

Here is a picture of our final circuit as well as a picture of the oscilloscope output.





This is one of the final outputs we have on the oscilloscope. Final outputs may vary due to alteration and tinkering with the other modules.

6. Conclusion and Future

To summarize our modules, we have a speaker, waveform generator, filter, and sequencer each with its small kinks and ability to change. As it stands, we have about 90% of our determined project completed, however we are missing an optional but very interesting part which was the development of an A/R or ADSR envelope. Aside from this incompletion, we do not anticipate further pivots. However, if desired, there could be other modules added to our current project as the complete circuit is modular.

As it stands, we have a functioning final product able to be used as originally intended in our proposal.

Contributions:
Everitt Cheng : Speaker amplifier and Sequencer
Srijan Singh : VCF and Amplifier
Pratyay Rudravaram : Sequencer and Oscillator