Sound Effect Devices for Musicians: Synthesizer

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Frontal materials

Table of Contents

List of figures

List of tables

Introductory materials

Acknowledgement

The Sound Effect Devices for Musicians team would like to kindly thank both Dr. Chen and Dr. Geiger for advising us as well as supporting us with knowledge through the duration of this project.

Problem statement

In today's world musicians can be put in a difficult spot when trying to find new equipment that will help them excel in the music world while staying under a reasonable budget. Musical devices, such as synthesizers, can cost anywhere from $500 - $10,000, with this most musician don't have the cash to afford upgrading their equipment to compete in the competitive industry of music.

Our goal is to create a synthesizer for musicians that is easy to use, modular, and affordable. Our target is to create the synthesizer for under $250. Musicians thrive on having the latest and greatest devices to create music, so we plan on creating our synthesizer with our own unique spin on it by using tablet in the form of an iPad or a smart phone that will allow users to create there one layout of the user interface. This device we are creating will not only look like a state-of-the-art synthesizer but will also sound like one too as we plan to give the musicians ample freedom to make music their way with our device being modular.

Operating environment

The operating environment for the synthesizer, in a perfect world, would be in a controlled environment where the users can make sure that the product is always in the best shape. Naturally, that will not be the case always. Operating environments are really determined by the users. If the user would like to use the product in a controlled environment that is fine and if they would like to take it to live shows that is fine as well. As you can imagine, that means the product needs to be able to withstand normal everyday use both inside and outside a controlled environment. It will need to withstand rough conditions, even if it might never be exposed to these conditions. Simply putting it, our product will be built to last and perform at its highest capabilities.

Intended user(s) and intended use(s)

Intended users of the synthesizer include everyone that has an interest in making music or making noise for entertainment. All musicians, from amateurs to professionals, are the target audience for this product. We aim at making this not only a highly sophisticated tool, but also one that is easy and fun to use.

The intended use is up to the users. Our hope is this tool is being used to help professionals create music but also people that are just having fun. This product in the general realm is intended for musicians who want to make high-quality music on a lower end budget.

Assumptions and limitations

Assumptions:

- Users can read and understand English - to understand brief introduction
- Users will have access to a wall outlet
- All components will work inside the product

- Product will be taken care of by owners

Limitations:

- People without musical knowledge will have a learning curve
- Group members have conflicting schedules so finding an ample amount of time each week to work is difficult

Expected end-product and other deliverables

The final deliverable for this project will aim at handing over a sophisticated synthesizer that is not only easy to use but is also a very powerful tool for musicians to have. The synthesizer will cost under $250 to be made, but that will not affect the functionality of the synthesizer. The tool will be fully functional and include eight modules that give musicians the capability to make a wide range of music.

The final deliverable for this project will also include a brief instruction, specifying modules that are included in the synthesizer and how they work. The instruction manual will target users that already have a musical background, so they can quickly look through the manual and get into making music as quickly as possible.

Outside of these main goals we do have some stretch goals. These include adding options that will allow for users to connect our synthesizer to other equipment such as a keyboard to operate. The reasoning for this to for some musicians they may prefer the physical layout of a keyboard compared to a touch screen and so giving them this capability would really help users feel more comfortable with using it.

We estimate completion and delivery of this project to be May of 2019, the end of the Spring 2019 semester.

Proposed Approach

Functional requirements

A synthesizer is a device that generates and shapes waveforms. Therefore, the bare minimum deliverable is a device that has an oscillator and some wave shaping functions. The goal is to make the device easy to use by musicians. This requires a familiar user interface that is quick and responsive. To differentiate our product from other products, we will include a GUI for iPads, iPhones, and Android devices. This will allow the user to use whatever interface he or she is comfortable with.

The synthesizer needs to be able to drive speakers and headphones. An appropriate amplification system must be designed to meet these requirements.

Constraints considerations

The main constraint on the project is time. The team has 32-weeks to design, build, test, and debug the synthesizer. This puts an upper-limit on the number of features (referred to as modules) that the synthesizer has. We decided that each member can reasonably oversee 3 modules. Based on these constraints, we have developed the block diagram below. Each block in the block diagram represents a module.

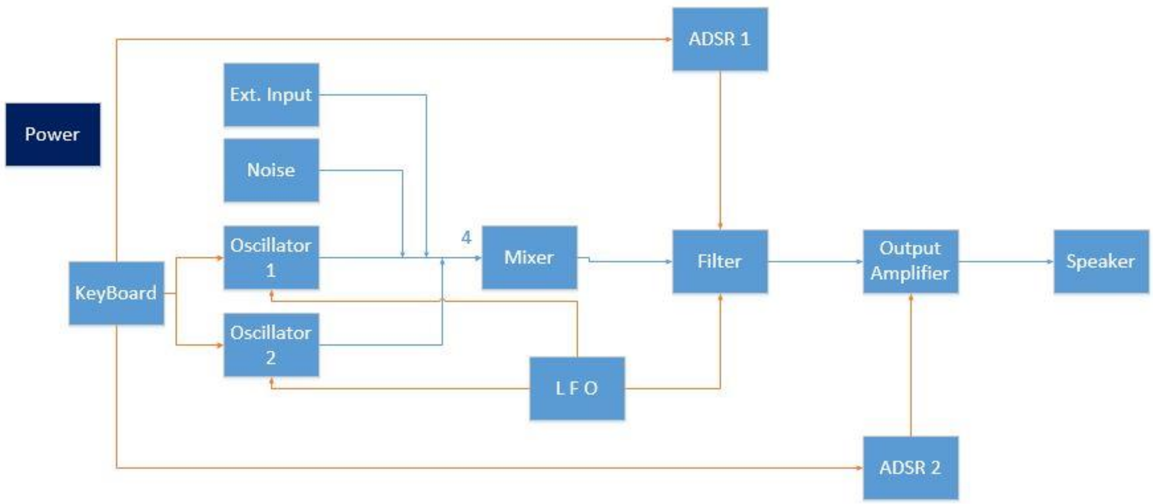

Figure 1

We arrived at the conclusion that we could do 10 modules total. Each member has 1 main module worked on independently and 2 modules worked on with a group. With only 3 modules to work on, the initial design can be done by November. This deadline will give the team all of November and December to test the designs and develop PCBs. If we finish all of these modules early, we can add more.

Challenges, Risks, Cost Considerations

A challenge that we will face is with packaging. We are considering 3d printing, but the material cost and printing time may be too large for our case. An alternative to this would be making the case out of wood. This would be cheaper but requires knowledge and expertise in woodworking. Another alternative would be to purchase the case from ETG.

A risk with this project is the oscillator module. Without the oscillator, there will be no waveform for the other modules to shape. To mitigate this risk, we have investigated oscillators on a chip and will go that route.

The biggest challenge with this project will most likely be ADSR/envelope. Designing the envelope with analog will be extremely difficult. We are considering sampling the waveform and doing this digitally to save time and make this easier.

Assessment of Proposed Solution

The proposed solution, in-terms of number of features, is less than most synthesizers currently on the market because of the simplistic approach we are taking and due to the limited time, we have. The strength and unique differentiator for our project is the digital user interface as it has not been implemented in synthesizers that are on the market right now. Being able to control the synthesizer wirelessly will allow performers more freedom of movement and allow for implementation of many different playing styles.

Technology considerations

A design choice that will be made throughout the project is whether we should design a part in-house or buy the part. Buying the part will guarantee quality and save time. Designing in-house allows customization and compatibility. We are also free to implement certain modules in novel ways. The table below summarizes the options we have at this point.

Module	**Available Options**
Oscillators	On chip oscillators, in-house oscillators
Power	Power supply unit, in-house design
Noise	Antenna, faulty BJT
Keyboard	Capacitive keyboard, MIDI keyboard

Table 1

Standards

We will be following the IEEE code of ethics. The IEEE code of ethics is straight forward and will not be broken. Since our synthesizer is intended for use by the public, we need to observe the first rule.

1. to hold paramount the safety, health, and welfare of the public, to strive to comply with ethical design and sustainable development practices, and to disclose promptly factors that might endanger the public or the environment;

Since we are working as a team, we will take special care to observe the following standards as well:

7. to seek, accept, and offer honest criticism of technical work, to acknowledge and correct errors, and to credit properly the contributions of others;

8. to treat fairly all persons and to not engage in acts of discrimination based on race, religion, gender, disability, age, national origin, sexual orientation, gender identity, or gender expression;

10. to assist colleagues and co-workers in their professional development and to support them in following this code of ethics.

We will be using the test benches in Coover Hall. We will follow the standard lab safety procedures developed by the Department of Electrical and Computer Engineering.

Technical approach considerations

Every team member is an electrical engineer. We have a high-level of understanding of analog design and a lower-level of understanding of digital design. The synthesizer will mostly be limited to analog and some simple digital design.

Testing requirements considerations

Since the synthesizer is modular, every module should have line-level inputs and outputs. Each output should also be tested to make sure they output the expected waveform. Prior to testing in the lab each module will have a simulation that shows proof of concept. The lab testing will require an oscilloscope and other lab equipment. The modules should also be tested for sonic quality and requires an input signal and a speaker. To ensure that the entire synthesizer functions properly each module will be tested individually. There is enough allocated time that each can be tested individually. From there they will progressively be connected to each other and any part that is needed between the modules will be recognized and fixed.

Test Plan

Each module will be tested with this procedure. If any mistakes are found the testing will go back to the previous step and see if the problem can be addressed.

1.	Outline of Schematic complete.
2.	Schematic tested in NI Multisim.
3.	Schematic will be assembled on a breadboard.
4.	Testing on the breadboard will be done in Coover.
5.	Schematic will then be assembled onto a PERF board.
6.	Testing on the Perf board will be done in Coover.
7.	Schematic will then be assembled onto a PCB.
8.	Testing on the PCB be done in Coover.

Table 2

Validation and Acceptance Test

Below is a table that shows the testing form and what will make each test form validated.

Test Form	**Validation & acceptance**
Multisim Simulation	The simulation test will show proof of concept that the schematic works as expected. This is a lower strain environment then on the test bench where parts can be changed in dimensions easily. The validation is confirmed where the output matched what is expected from the given Vdd and Vss voltages.

Bread Board test	This test will be a hardware validation. The hard are test will show possible limitations of the components that where selected. Validation is reached once the proper output is achieved with the given Vdd, Vss, and input voltages.
Perf Board test	This test is a continuation of hardware validation. This will show that the parts work when soldered together and that the module works for any given circumstance or corner case that could happen in the application of the synthesizer.
PCB Testing	This is ideally the final test of the module. This validation shows that the module works as expected. This shows that the designer of the module and who they have check their work accept that this module will fuction for all given circumstances it will come across. If there are any problems in this state, then the procedure needs to be repeated in one of the above test forms to figure out where the mistake originates from if it cannot be detected on the PCB.

Table 3

Safety considerations

Below displays a table of safety Considerations.

Electrical shock	This will be avoided by covering the leads when they are not in use. The team is familiar with electrical properties of the components and will not touch the test parts without justification.
Inhaling solder smoke	This will be avoided by having people on our team who are experienced in soldering do this activity. Those who are not experienced will receive training from the other members
Tripping on cables	Our test equipment is already set up in Coover's labs so there will be no loose cable from those. However, if there is a loose cable on the floor it will be surrounded by tape to provide a caution to on coming people.
Burned from solder	This will be avoided by having people on our team who are experienced in soldering do this activity. Those who are not experienced will receive training from the other members
Eye injuries	Eye protection is a must when doing any activity in the lab that can sent a spark or object into the eye.
High current avoidance	Our team is aware of the dangers of high current and this will be avoided from proper circuit design of the parts.
Clean working space	A clean working space is a productive, efficient, and manageable area. Our team will push to make sure this is the case any time lab equipment is worked with.
Hostile work environment	Our team will report any situation to the team that another member feels they are being harassed or any other form that will make the environment feel hostile.

Table 4

Previous work / literature review

There are many synthesizers on the market. Prior to starting the project, we reviewed the Novation Bass Station II. We used this to learn what a synthesizer is and what typical features are. This synthesizer has two oscillators, a sub-oscillator, a mixer, a filter bank, overdrive, distortion, LFOs, and many other features. We will include the essential parts into our synthesizer, oscillators, a mixer, filters, and amplification. We decided to include the LFO as well, since its design will be similar to the oscillators. We decided not to include the sub-oscillator due to the difficulty in designing frequency locking oscillators.

The biggest difference between our synthesizer and existing synthesizers will the UI. The UI will be a Graphic User Interface that will work on iPads, iPhones, and Android devices and will communicate wirelessly with the synthesizer. The software used to implement this will give the user the option to use different interfaces that suits their unique performance needs.

We also reviewed Make: Analog Synthesizers to learn more about designing synthesizers. This book contains example circuits. Additionally, members of the team have previous experience in live music performance and/or recording. As well as software synthesizer design, software and hardware audio effect design, and other musical software programs with heavy signal and data processing.

Possible risks and risk management

Risk	**Risk Management**
Time Constraint	Updates on progress are given weekly. Tasks are prioritized.
Bad Schematic	Finalized schematics go through design review.
Parts Malfunction	Finding affordable parts so they can be replaceable.

Table 5

Project proposed milestones and evaluation criteria

There are tasks that needs to be completed for each module on the device. Below is a table that explains each module and its evaluation criteria.

Milestone	**Project Date**	**Evaluation**
Flowchart	Sept 27.	This will show how each module connects. Thus, providing an input and output of a device. This will show what can be directly connected or connected by the user. This will be completed once all members of the team agree and we get approval from our advisors.
Schematic	Oct. 31	Once the team member completes their schematic it will be looked over by another team mate. They will confirm that they have the proper concept and that it takes in the proper inputs and give the desired outputs.
simulation	Nov. 5	Fully testing the schematic this will show evidence that the schematic was made correctly and further confirmation that the circuit takes in the proper inputs and will give the desired outputs. The results will be checked off by another team member.

Hardware Test	Nov. 23	This will show proof that the circuit works as expected. Once the hardware test is complete another teammate will check it.
PCB Design	Dec. 7	The design of the PCB is very key to our final design. This will be checked off by all teammates to confirm that the PCB layout matched what everyone expects.
PCB Delivered	Dec 14	This will be confirmed with a receipt.

Table 6

Milestone	**Project Date**	**Evaluation**
Solder PCB V1	Feb 1.	This consists of soldering the devices onto the PCB. Also, it will make sure that PCB was correctly ordered and that the correct components arrived.
Test V1	Feb 22	This is to test all circumstances or corner case that could happen in the application of the synthesizer. The objective is to make sure the module works as intended.
Fix Design V1	March 8	This is where the design will be fixed and correct any mistake in the schematic and quickly design/order a new PCB for the next round of testing.
Solder PCB V2	March 8	This consists of soldering the devices onto the PCB. Also, it will make sure that PCB was correctly ordered and that the correct components arrived.
Test V2	March 30	This is to test all circumstances or corner case that could happen in the application of the synthesizer. The objective is to make sure the module works as intended.
Hardware Done	March 30	The goal here is to have all the testing and validation completed. The PCBs fit in the case and everything works as one system.
Case Design	March 30	Throughout the semester the case will be worked on to figure out the most optimized way to hold the PCBs.
User Interface	March 30	Throughout the semester the digital interface will be worked on that will allow controls for the hardware. Once all the controls are figure out the user interface will be developed with will allow the user to use an iPad to adjust the devices.
Modifications	April 19	The final part of the semester is intended to fix any mistakes that occurred when assembling the device. A user's manual will be created in the time. Also making a presentable show for the final presentation will be worked on during this period.

Table 7

Process Details

The way that this project will be completed is by dividing up the work between the two semesters.

During the fall semester we plan on doing research on synthesizers that are out in the market and study the basic functionality of them. From here we will choose the modules that are fundamental to have our synthesizer reach our design requirement. The work will be divided amongst the team on who will accomplish every task. The objectives for this semester are for each module to have the circuit schematic complete, tested and functioning in the lab, soldered onto a PERF board, and the PCB design is complete, and the parts and PCB are ordered to arrive in January.

During the spring semester will begin soldering the components onto the PCBs. The goal for this semester is make sure that the design from the fall is valid. If there are any mistakes new boards or components will be purchased. The retested again. The objective is to have the hardware testing completed by March 30th. During this time the case will be developed to properly hold all of the PCBs. This will be a two-trial case if one design ends up not working properly it can be adjusted. We want to have it all put together by March 30th this way we will have a month to fix anything that needs to be modified on the product.

Project tracking procedures

We have three methods of tracking our progress: weekly status report, a Gantt chart, and Gitlab Kan board.

Weekly Status Report

The weekly status report is updated from a shared document that the team has access to. The weekly status report contains a brief reflection about the week, a description of pending problems, and plans for the upcoming week. Each team member writes a brief description about what they did that week and logs the hours that they put into the project. This weekly status report is a way that we can track each other's work throughout the week.

Gantt Chart

The Gantt chart as seen in figure 2 the project time line gives our team an overview of the deadlines for each task. This time line was approved by our advisors and our team as a manageable amount of work that can get done this semester. The timeline for our progress will be further described in the project time line section.

Gitlab Kan Board

The Gitlab Kan Board brakes down the tasks that are on the Gantt chart. This board shows the sequential motion that each module will have to take across its life time. These positions that a module can be in are research, schematic in progress, simulation complete, check, PCB design, check, PCB ordered, Parts soldered, and Fabrication complete. Although most of the last couple task listed are not to be completed this semester it still shows what needs to be done for each module.

Each module also has a team member that is assigned to it. This is described in the table below.

Team member	**Priority 1**	**Priority 2**	**Priory 3**

Tim Day	Mixer	Noise	Envelope
Francisco Alegria	Keyboard	Envelope	Filter
Eric Fischer	Filter	Power	Case
Travis Gillham	Amplifier	Keyboard	Case
Blake Beyer	Oscillator	LFO	Envelope

Table 8

The priority signifies which one is the most important and should be completed first. For most team members their priority 1 is for themselves to focus on. While priority 2 and 3 are for team member to be more of an assistance and will be first available for help if needed.

The Kan board is a way of the team to monitor the progress that the teammates have on their designated modules. This way it will become clear if a teammate is not pulling their weight or needs assistance.

Statement of Work

User Interface

The user interface module will be used to control all of the synthesis modules as one complete system. In order to control the analog synthesis modules via a digital interface we will need to implement digitally controlled resistances, analog voltages, and analog signal paths. For this we will use digital potentiometers, analog multiplexers/demultiplexers, digitally controlled analog switches, a Wi-Fi transceiver to make the UI wireless, and a microcontroller to set the digital devices based on input controls received from the user. Our approach will be to create a GUI that can be used through the TouchOSC application for mobile devices; iPads, iPhones, and Android phones. The interface will use the Open Sound Control protocol to communicate via the Wi-Fi transceiver with the onboard microcontroller. The microcontroller will take the data received from our interface and process it to set the internal control values. The microcontroller will also send data back to the interface to provide the user with feedback. This type of interface will allow modularity to be fully internal and digitally controlled. A wireless interface will also allow the user to play the device from anywhere in the room, within the Wi-Fi range. The UI application also allows the user to instantly switch between multiple interfaces that are preloaded.

Oscillators

The oscillators are the main sound generating modules for the synthesizer. They will create the different waveforms that can be selected by the user; sine, triangle, sawtooth, and a pulse wave with adjustable PWM. The frequency will be controlled by a few different parameters. The main frequency control will come from the user interface. Additionally, a digital potentiometer will be used to add a frequency offset of +/- 12 semitones to the frequency value coming from the user. The last frequency control will be an octave selector. This will shift the range of the keyboard on the user interface from a 16-foot wave to a 2-foot wave. By combining all the frequency controls, the user should have the ability to play a total MIDI range of 128 notes using only the graphic keyboard and controls on the UI. The oscillators will be implemented using VCO chips that are readily available. This will greatly simplify the design as well as the footprint for each oscillator. In the final design there will be two identical oscillators that have the same functionality, with the ability to hard sync oscillator 2 to oscillator 1. Each oscillator will also have the ability to be modular by sending and receiving control signals to any other module. Those signals will also be internally routed and digitally controlled.

Noise Source

A noise source will allow for a wider range of sound pallets to be synthesized, such as percussive sounds. The approach for this will be taking advantage of the avalanche breakdown voltage of a BJT. When the BJT is reverse-biased with a voltage greater than 7V, it enters avalanche breakdown mode, which amplifies the noise. The noise signal coming out will then be amplified or attenuated to the required signal level. The noise source audio signal is sent straight to the mixer and the level will be adjustable through the mixer controls.

Mixer

Mixers are used to combine all the sound source signals down to one signal of the same level. This can be implemented in a few ways, the simplest being a summing amplifier configuration. The inputs would be the two oscillators, the noise source, and 3 optional external inputs. That totals six signals being mixed down to one signal that would go to the next module. Each source will have its own level control that will determine the percentage of that signal that is being mixed into the output signal.

Filters

Filters are used to allow certain frequencies to pass from the input to the output. A low-pass filter allows low frequencies to pass, while blocking higher frequencies. The high-pass filter does the opposite where high frequencies pass and low frequencies are blocked. The implementation approach will be to design two separate filters, a low-pass and a high-pass. Internally they can be routed in series or parallel to create two additional filters, a band-pass filter and a notch filter. Band-pass filters block both low and high frequencies outside of a set bandwidth. Notch filters block the bandwidth frequencies and allow the low and high frequencies to pass. In the end, the user will use the UI to select the desired filter path. The user can also set the cutoff frequency for each filter individually with the function to lock both cutoff frequencies to move together, allowing for the setting of a bandwidth for a band-pass filter or a notch filter. The user will also have the choice to add resonance to the filters, which means variable Q-factor. Additionally, control signals from other modules can be used to control the filter parameters.

Envelope

Envelopes are modulation control signals that can control parameters of other modules. The control signal of the ADSR envelope is made up of four sections; Attack, Decay, Sustain, and Release. The attack is a time value that controls the time it takes the envelope signal to go from 0 to max on key press. After the attack reaches its peak, the decay phase starts. The decay controls the time the envelope signal goes from the max level to the level set by sustain control. The sustain is a percentage value of the max level set by the output amplifier. After the key is released, the envelope enters the release stage, which is the time the envelope goes from the sustain level to 0. The implementation will be two identical ADSR envelopes with dedicated controls, faders or knobs. One will always be controlling the output amplifier.

The other envelope will be used to control any other parameter desired by the user; such as PWM or filter cutoff frequency. An additional feature will be to have the envelopes behave as AR only envelopes. This would bypass the decay and sustain phases to create snappy envelopes that can be used for percussive sounds. The ADSR vs AR function will be set by a toggle switch.

LFO

LFOs are oscillators that have a limited low Hz frequency range, usually from 0 Hz to 20 Hz. The output waveforms from the LFOs are used as control signals for parameters in other modules. The desired approach is to use a similar architecture as will be used in the audio oscillators. This would allow for all the same waveforms to be created and used as control signals. The frequency controls will be limited to the lower frequencies to allow for precise control within a 0 – 20 Hz range. Additionally, a switch can be implemented to allow the user to use higher frequencies. This would allow for more creative sound design possibilities, such as audio rate modulation of other parameters. Since LFOs are control signals that modulate parameters, the user should also have the ability to change the depth of the modulation effect and the destination of the control signal.

Amplifier

After the audio signal has been generated, modulated, mixed, and filtered it goes out to the desired speaker. The output amplifier will determine the max volume of the synthesizer with a single knob. The output jack from the amplifier will have a line level signal that can be sent to a large speaker amplifier, or to small stereo speakers, like headphones.

Power

Each module will require different power supplies for all of the different components that are used in each system. Since all of the modules have to fit into one enclosure the user should only have to supply one power source to the device. On the inside, each module will take care of the circuits required to step down the main power supply voltages to the required voltages needed to power the smaller components specific to each module. On the user’s side there will be one wall wart that supplies the main power to the synthesizer via an input jack on the enclosure and a main power switch that controls the main power supply.

Enclosure

The final product will be one unit that contains all of the PCBs for the modules in a fixed secure layout, with I/O jacks for power and audio. The system will have internal signal routing that will allow any user to start playing immediately when the UI is connected. The goal is for the user to have a reliable and durable product that can be used in a studio or live performance setting.

Synthesizer System

The final device will be a box that contains all the individual synthesis modules, with inputs for power and external audio sources, and outputs for external speakers or headphones. The user interface will be a GUI on a mobile device, such as an iPad. All of the synthesis modules will be interconnected internally. All of the parameters will be controlled from the UI. The basic the control signal path is as follows: The user inputs controls on the UI via the iPad touch screen. The iPad sends the control data via Wi-Fi as

Open Sound Control messages. The Wi-Fi transceiver receives the OSC data and sends that to a microcontroller using I2C communication protocol. The microcontroller then interprets the OSC data and communicates with the required components using the I2C protocol. As the new settings are applied to the specific parts, the microcontroller will also send data back to the GUI on the iPad to provide the user with feedback. The audio signal path is as follows: First the oscillators will receive a control signal that determines the pitch of the generated waveform. The audio signals from the oscillators are sent to the mixer. The mixer then combines the oscillator signals with the other audio signals down to a single audio signal. The output of the mixer is then sent to the filter. The filter will then allow or block certain frequencies. From the filter, the audio signal goes to the output amplifier. That is the end of the internal audio signal path. Although the LFOs and envelopes do not provide audio signals, they will be used to modulate parameters that affect the audio signal, such as pitch offset or note volume.

Estimated Resources

Task	Description
Research	Shall be thorough to the extent where creating a schematic can be achieved.
Build Schematic	Shall be a simple enough design yet also meet the specifications and function ability of each module.
Simulate Schematic	Shall use Multi-Sim to run a simulation model of the designed schematic. Shall run with zero errors.
Test Schematic	Shall simulate all schematics into one single model and run it together and make certain of zero errors so that the PCB design process is done once.
PCB Design	Shall take schematic and upload to a software that designs PCBs.
PCB Fabrication	Shall send PCB designs to get fabricated so that it will make building the physical casing is a lot easier.

Table 9

Item	Price	Quantity
Test Parts	TBD	TBD
Oscillator Chip	$10 each	2
PCB Design	$10 per square inch	x10
Case from ETG	$10-$50	1

Table 10

The PCBs we will design are going to get outsourced so that we can ensure they are designed and built correctly. We have decided to implement PCBs for a couple reasons. The main reason is that it will eliminate the possibility of wires and components shorting if we used breadboards. Another big reason is that it will make the internal wiring a lot easier to work with and debug, as well as make it look cleaner and sleeker.

The PCBs are one item we need to purchase. The ones we are looking at are from Osh Park and for a four-layer PCB prototype the cost is $10 per square inch. This being relatively cheap, we are planning to order several PCBs for each module so that in case something happens to one or a few during testing, we have extra readily available. We have ordered two oscillator chips that cost about $10 each. This was done to simplify the oscillator circuit as part of it is how the chip is internally designed. We decided to choose a case from the Electronics and Technology Group, ETG, in Coover. ETG has a wide array of different options ranging from $10 up to about $50 depending on the material the case is made of.

Project Time Line

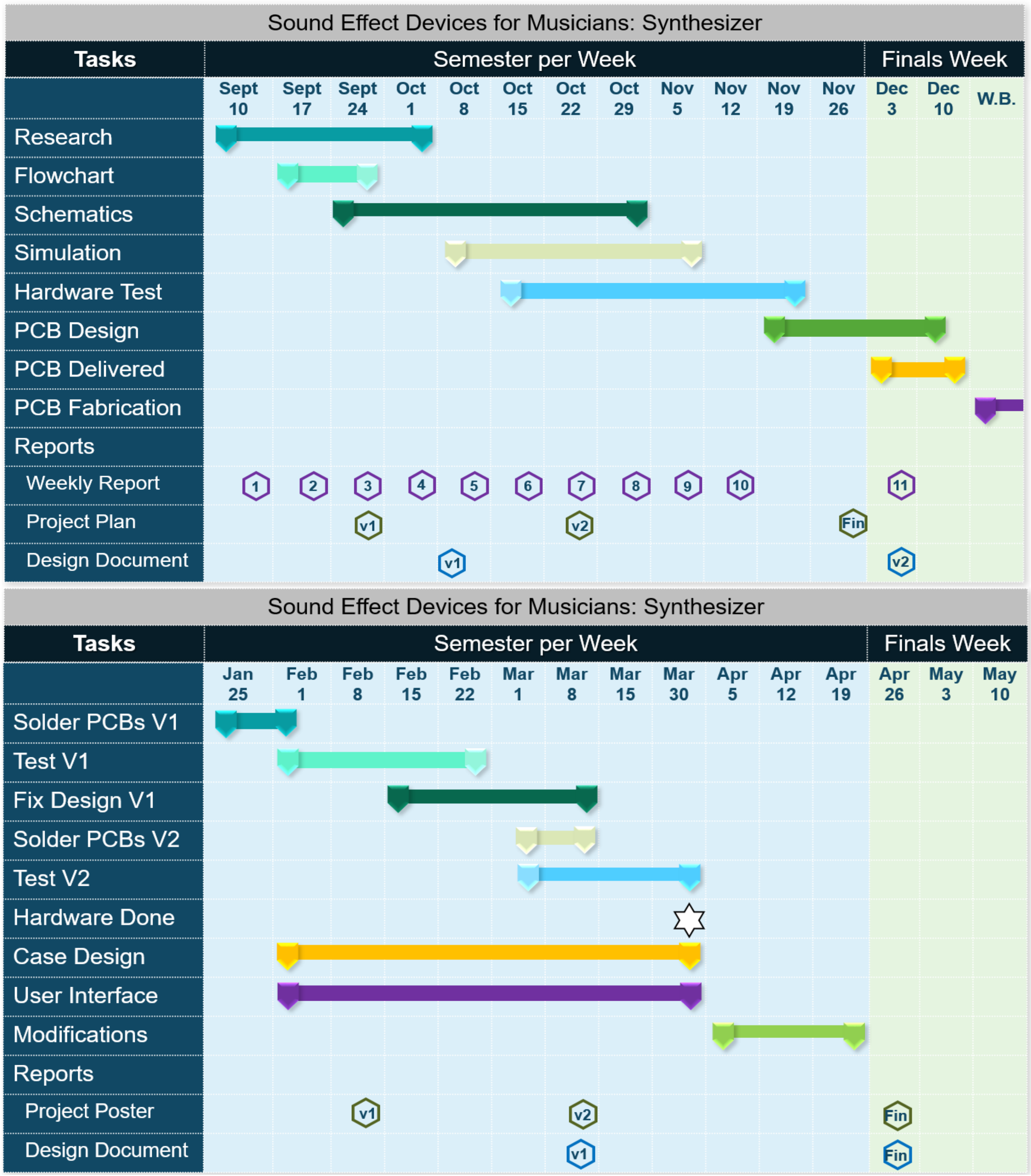

Figure 2

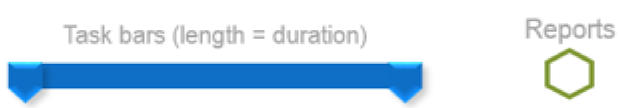

Figure 3

Closure Materials

The current equipment in today's world is very expensive. Our goal is to create a synthesizer that anyone can use. A synthesizer is an electronic music device that creates audio signals that will be converted into sound. The synthesizer we are designing utilizes a digital interface via tablet or smartphone that will be used wirelessly. This interface can allow the user to customize their own layout based on what they want while having the ability to move more freely and have accommodate a wide variety of playing styles. A traditional synthesizer usually has physical knobs and switches directly on the case. We think this digital interface will allow for more customization as well as provide ways of manipulating the sounds and waveforms that could not be done using knobs. For example, having an xy-plane on the touch screen that when you slide your finger across it will adjust one aspect of the sound and when two fingers slide across it adjusts a different aspect. For the case, the bottom portion will be clear to show off the PCBs and inter-workings of the synthesizer to give a little more flare to the overall product. Challenges are bound to arise, but we have a good approach to eliminate these potential issues. Part of this approach is splitting up the project into modules and assigning each member to take charge of a specific module, as we discussed in our project tracking procedure. Everyone on our team has experience in some aspect relating to music, from playing instruments, to playing gigs, to just being fascinated and wanting to learn more about the music industry. These experiences are the reason we all chose this project.

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[3] CMOS Analog Circuit Design. Third edition. Phillip E. Allen, Douglas R. Holberg