Electronic Sound Generator

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1. Introduction

1.1 Objective

Modern day synthesisers are very expensive and built with a complex design[7]. They can range from $200 to $4000 just for a simple analog synthesizer with the studio quality synthesisers going for more than $10,000[5]. With the complexity and expense involved many would be musical hobbyists are blocked from enjoying the wonderful effects that synthesising can bring to their musical creations.

Our plan is to design a simple control scheme with the use of manual switches and dials, such that, the musician would be able to quickly pick a new sound effect to add to the musical experience. This plan also needs to be relatively inexpensive, under $40, to produce if possible as we need to make sure that the musicians would not have to empty their bank account just to procure a synthesizer. To reduce the cost we are removing the large preinstalled input that is normally accompanied with an analog synthesizers to allow for electronic effects to be generated relatively easily by the push of a button and a flip of a switch. This will also reduce the overall size of the analog synthesizers, which will help make the system more convenient to transport from place to place.

1.2 Background

According to Timothy D Taylor in his book *Strange Sounds: Music, Technology and Culture* technology was one of the biggest things to happen to music since the invention of musical notation[6]. We can also see this in almost every aspect of music in the recent years, more specifically, in in creation of electronic music in the early to mid 1900's [4]. To this day they continue to use electronic effects to produce various sounds in music. The biggest issue is that these systems can cost substantial amounts of money. Friends and family members who were musically inclined would save up for months to buy their favorite instrument, only to have to save up even more just to be able to add special effects to their musical experience. The entry level product from *synthesisers.com* costs over $1700[3]. This wall blocks the passionate music lovers from being able to create this electronical effects for their musical passion. On top of that these synthesisers are very intimidating for any newcomer to the field of analog synthesising with a set up that looks like it could belong in a science fiction novel[5]. Music is such a wonderful hobbie to have that we feel this needs to be corrected to allow access to the wonderful electric sound effects that many of the great musicians of the ages have used.

1.3 High-level requirements list

- The system must be as low cost as possible, under $40.
- The system must have a simple design that can be run for more than ten hours before battery replacement.
- The system must be able to manipulate the voltage of the system to generate the desired sound effects.

2. Design

The Electronic Sound Generator will take an input voltage into the attack and release envelope generator, where the signal will be modulated, or just passed through, to the voltage controlled oscillator. If the signal was modulated by the AREG, then the signal can also be sent to the voltage control filter to adjust the cutoff frequency. The low frequency oscillator will produce a few different waveforms, square wave, differentiated square wave, and a integrated square wave, which will be used to modulate the voltage controlled oscillator control voltage if desired. The signal from the LFO will also be able to be sent to the VCF to adjust the cutoff frequency. The Voltage controlled oscillator will have the control voltage modulated by the LFO and AREG where the output will then be sent to the voltage controlled filter. The white noise generator will produce a white noise output and send that to the voltage controlled filter for an extra added effect if desired. The AREG output will also be sent to the voltage controlled filter if a more pronounced modulation effect is desired. The voltage controlled filter will filter out higher frequencies, low pass filter, and then send the signal to the voltage controlled amplifier, or bypass the amplifier and go straight to the output amplification speaker, where the signal can be amplified for an extra effect. The voltage controlled output will then be sent to the amplification block where the signal will be amplified for output through a one watt speaker or, output to an external via a jack plug. This will all be powered by a nine volt battery pack power supply with the voltage being regulated to required levels for each circuit.

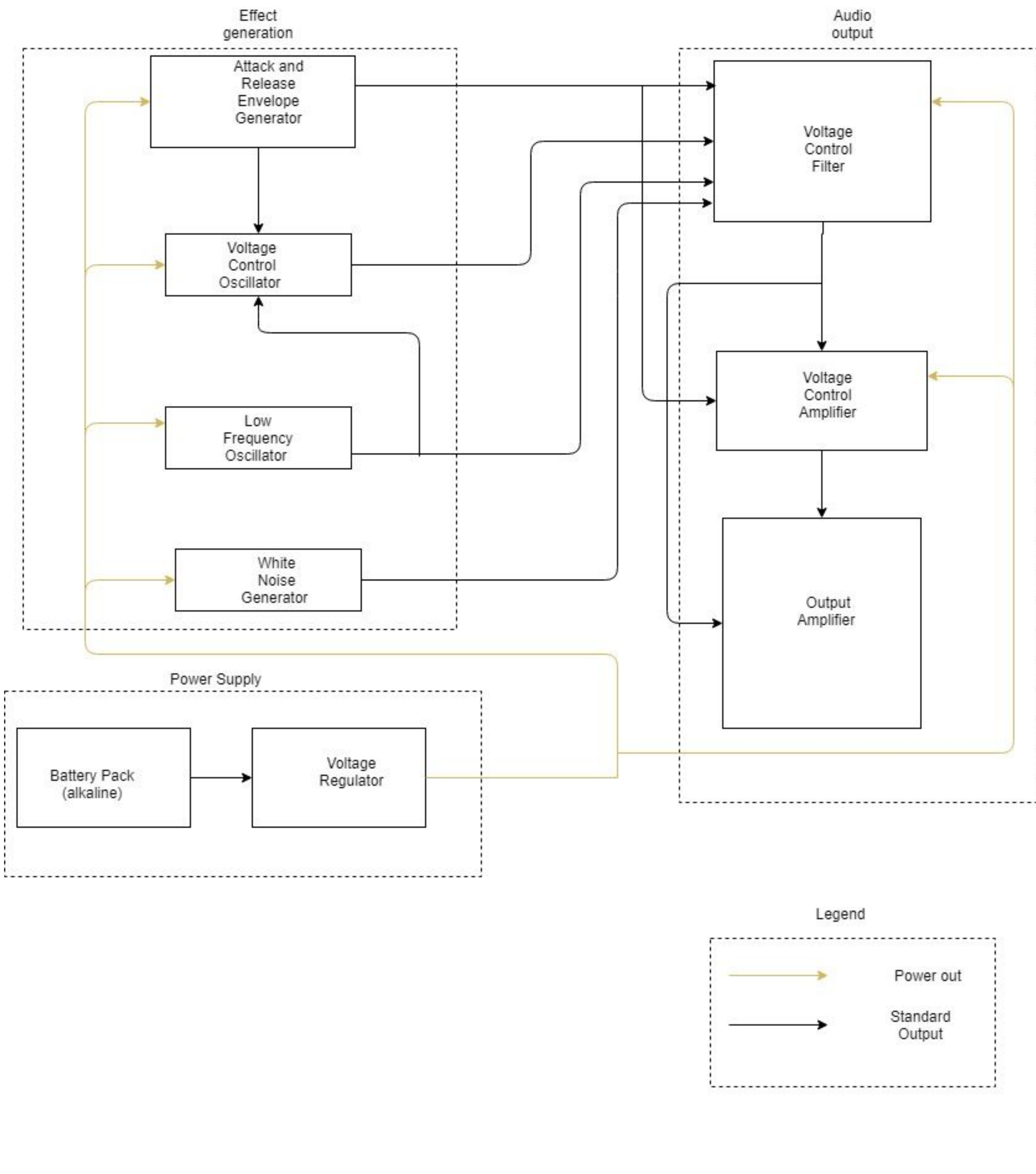

Figure 1. Top Level Block Diagram

2.3 Block Requirements

Power supply

The power supply is needed to allow the operation of this device for the extended period of time needed in creating music. The power supply will consist of a battery pack and a voltage regulator to power this device.

2.3.1 Battery

The battery must be able to power the circuits continuously for extended periods of time. This will be a standard nine volt alkaline battery pack to allow easy access to the power of this device.

Requirement 1: The battery must be able to provide enough charge for 15 to 20 mA at 8.5 to 9.5 Volts for at least 10 hours.
Requirement 2: The Battery module will have protection in place to stop from connecting the battery pack in reverse.

2.3.2 Voltage regulator

The voltage regulator will be a linear voltage regulator to split the nine volts from the battery into half to be used within the various blocks. This regulator will be a simple linear voltage divider capable of supplying the required voltage for each block at peak current draw.

Requirement 1: This system must be able to handle to peak voltage, 9.5 Volts, at 60 mA peak current draw.
Requirement 2: This module must be able to split the voltage to half of the nominal voltage for the battery pack, 4.5V +/- 5% , and maintain these voltages under peak draw.

Effect Generation

The effect generation block is the main component of this device and controls the majority of all effects added to the input signal. The voltage control oscillator control signal will be modulated by the low frequency oscillator as well as the attack and release envelope generator. These modulations will be different waveforms, amplitude modulations, and white noise.

2.3.1 AREG

The attack and release envelope generator will be the point where the input signal is sent where it will then be modulated, if desired, with the attack and decay time being altered via dials. This block will output to both, the voltage controlled oscillator and the voltage controlled filter

Requirement 1: The Attack and Release envelope generator must be able to modulate the VCO and/or the VCF via a simple switching system.
Requirement 2: The module must be able to modulate unit's VCA.
Requirement 3: This Unit must take in a manual signal and modulate it by adjusting the attack and decay times.
Requirement 4: This unit must be able to also modulate an automated signal by adjusting the attack and decay times.

2.3.2 VCO

The voltage control oscillator will be alter the given input signal with the effects added by the LFO and AREG by modulating the control voltage for the voltage control oscillator. This will then output to the voltage control filter for the final path to the output of the device. The voltage control oscillator will also have an exponential voltage to current converter that will allow the system to allow for a wide range of frequencies for the VCO to high.

Requirement 1: The VCO must have protection built in to help stop unwanted modulation to of the control voltage.
Requirement 2: The VCO control voltage must be able to be modulated by the LFO and AREG signals.
Requirement 3: The VCO must be able to provide a ramp or square wave output signal after modulation.
Requirement 4: The VCO must have a wave to mixing the LFO and AREG signals in with the control voltage.
Requirement 5: The VCO must have a way to control change in voltage and current by an exponential relationship.

2.3.3 LFO

The low frequency oscillator will be used to generate a Square, Differentiated Square, and Integrated Square which will be used to modulate the control voltage of the voltage controlled oscillator. This block will also be optional with the standard modulation being a sqaure wave when the effect is not desired.

Requirement 1: The LFO must provide modulation waveforms of Square, Differentiated Square, and Integrated Square as the output signal within the frequency range of 1 Hz to 300 Hz.

Requirement 2: The module must be able to provide the modulation waveform to the VCO as well as the VCF when wanted.
Requirement 3: The LFO must have some indication of what frequency the LFO is modulating at.

2.3.4 White noise generator

The white noise generator will take an input voltage and generate a white noise signal that can be added into the signal at the VCF to apply the effect if desired.

Requirement 1: Must be able to provide White noise to the VCF for use in effect creation with a amplified signal so it can be heard.

Audio Output

The audio Output block will take the output from the voltage control oscillator, and the attack and release envelope generator and filter the signal with the use of a low pass voltage controlled filter. The Audio output will also be the point at which the white noise will be added into the signal for the effect desired. Next the signal will be sent to an voltage controlled amplifier to add an extra effect, if desired, to the signal. Finally, the signal will be sent to the built in one watt speaker circuit where it will produce sound. This can also be bypassed by the use of a jack plug if an external device for output is desired.

2.3.1 VCF

The voltage control filter will be a low pass filter that will have an adjustable cutoff frequency. This frequency will be manually adjusted by a dial as well as automatically adjusted via the input from the AREG and LFO. The white noise will be added in here is the effect was desired.
Requirement 1: The Voltage controlled filter must be able to adjust the cutoff frequency via adjusting the control voltage manually via a dial.
Requirement 2: The VCF must also be a low pass filter with a frequency range of at least 400 Hz.
Requirement 3: The VCF control voltage must be able to be modulated to vary the cutoff frequency for various modulated waves produced by the effects generation system.

2.3.2 VCA

The voltage controlled amplifier will amplify the input signal from the voltage controlled filter. The control voltage will also be modulated by the AREG signal to adjust the amplification to create a more pronounced effect from the AREG modulation. This amplification is optional and can be bypassed if the added effect is not desired.

Requirement 1: The CVA must be able to amplify the input signal by the AREG modulated signal.
Requirement 2: The VCA must be able to be bypassed if the amplification effect is not desired.

2.3.3 Output Amplifier

The output amplifier is the circuit needed to send the signal to the one watt amplification speaker to produce the required output. This can also be bypassed with the use of a jack plug to all for an external output device to use the output signal.

Requirement 1: Must be able to provide amplification to the input signal to be audible, via a 1 watt speaker.
Requirement 2: The speaker must be able to be bypassed to send the output signal to were desired by an output jack.

2.4 Risk Analysis

The block that poses the most risk to us completing this project would have to be the effect generation block. This block consists of two oscillators a white noise generator and an attack and release envelope detector. We feel that the two oscillator circuits will be particularly difficult to design as we have little experience in designing oscillator circuits. This module is also plays a very important role for the Electronic Sound Generator as it produces most of the effects that are desired from an analog synthesizer. The two oscillator circuits will also be part of the main path that the signal will go through to reach the amplification path. This means that if an oscillator does not output the proper signal then the sound will not reach the speaker to produce the sounds we require.

3. Ethical and Safety concerns

Very obviously, this is, according to our perception, a potentially large scale project that can end up being accomplished on the scale of an average industrial electronic product that can be seen in most supermarkets and on Amazon. By looking at it, we can tell that we will need to take ethical and safety concerns very seriously. It could be possible that our idea could have been created by another industry before, and that it had already patented it before we even heard of its existence.

We will interpret some of the 10 pillars of the IEEE Code of Ethics and relate our project to them.

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;

Obviously, as with all other electronic products in the industry, we will have to make sure that the components that are used to build our product, as well as the process of developing it is ethical and is conducted in such a way that we do not compromise the safety and health of the public. Just about all of our components will be metallic and will have properties that make them hazardous in varying degrees, and we have to make sure that those properties do not get activated when used by a customer. As for the environment, we have to make sure that our product uses as little electricity as possible, as should all other modern electronics products, and we must avoid using parts that were manufactured using indentured labor (by slaves, children, etc.) to abide by the UN Declaration of Human Rights.

1. to be honest and realistic in stating claims or estimates based on available data;

During the process of developing our product, we will be using a lab notebook to record the results of our periodically performed experiments, so that we can always look back at any errors made that we would want to learn from. This is, of course, necessary, because when our product is sold, we will have to make sure that our data is represented in the performance of the product when it is delivered to and used by the customer. Moreover, this is to maintain safety - if it turns out that our product was actually hazardous to use, and that we falsified data to prevent the public from knowing this, society as well as the producers can be in different kinds of trouble - physical and legal safety, respectively.

1. to reject bribery in all its forms;

While it appears so that we would not imagine this taking place here, we need to make sure that we do not accept gifts, tangible or intangible, as a reward from more powerful people in order to commit malicious ethical infractions, or to be dissuaded from helping the authorities in investigating them when they are involved in industrial malpractice. Those kinds include the ones we are mentioning in this document.

1. to improve the understanding by individuals and society of the capabilities and societal implications of conventional and emerging technologies, including intelligent systems;

Obviously, our goal is to build upon existing technologies - in this case, ours is a musical electronic product. We will be improving a certain feature of an existing product that was previously causing problems for its customers, and by doing so, we will inspire society and individuals to appreciate the capabilities of technology, as well as the capabilities of individuals to improve them, and thus be inspired to do the same later on.

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

In the process of development, we will, indeed, be visiting our TA every week to receive feedback on our project and make sure that they suggest as many improvements to our project as they can. They will be looking through our lab notebooks for errors and inconsistencies in our project development process and we will indeed be required to cite sources that we directly quoted in the process of our development.

1. 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;

Obviously, we live in a diverse society, and our group members come from different ethnicities, religions, etc., and we cannot use these as a factor in deciding how successful and smooth our collaborative performance is.

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

Most obviously, because this is a team project, we will have to cooperate with each other in bringing this ambitious project to real life, but we will also have to give them the opportunity to solidify their conceptual understandings of certain topics of electrical engineering, such as power electronics and digital signal processing, which we can tell are going to be used extensively in the creation of this project.

References

[1]IEEE Code of Ethics. IEEE. Link:
https://www.ieee.org/about/corporate/governance/p7-8.html

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