Aliased Water Illusion Screen

ECE 445 Design Document

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Group 67

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1 Introduction

1.1 Objective

Aliased water illusion is based on the stroboscopic effect. When an projected is projected with light source at a set frequency, observer could potentially perceive successive discrete images and stitches them together with automatic aliases for temporal continuity.[1] We wish to use this effect to create an indoor display that shows varies illusion including having groups of droplets levitating and moving in different directions. We believe such design would be an interesting interior design to keep in one's house as an screen, providing privacy between open spaces.

1.2 Background

The earliest video we discovered dates back to November, 2008. [2] The video named "Levitating Water" introduced the effect while not presenting an purchasable product. In the comment area we found people commenting "Where can you buy that?" or "I need this in my room."[2], indicating high demands for commercializing such product.

We found a DIY introductory video uploaded to YouTube called "The Strobe Light Effect (Levitating Water Experiment)" by ElectroBoom[3]. In the video the producer of the video showed how to use a strobing light to create an indoor version of water levitating illusion. Still, people who does not have an engineering background could not have this product in their home.

The first attempt of a commercialized product for such effect is released In year 2014[4]. The product named "Levitating Waters" is about 24.1 inches tall and weight 13.3 pounds, and it is exactly what the title suggested it is: it is an “optical illusion operates with ordinary filtered water, include the upward flow of water droplets and suspension of water in mid-air”[5].

We ran research on its campaign and found out it was on Indiegogo, a crowdfunding website, for a while in 2013. [5] It was poorly executed as it only raised 350 dollars from 3 backers. Somehow despite the poor performance on Indiegogo, the company Levitating Waters still got to release the product around December, 2014. It did not get enough attention that it deserves during its time.

In 2016, a movie called Now You See Me 2 [6] made this illusion truly known and popular to the public. More video appeared on YouTube to debunk the effect. Multiple customer comment appeared on Amazon[4].

1.3 High-level requirement list

The undersampling of water is achieved by having a matching frequency for the vibration of water/falling objects and the light source. Therefore I believe our system would consists of five parts.

- A group of actuator located at the top of the device that create the right amount of vibration with frequency controlled by an microcontroller.
- Array of strobe light for strobscopic effect
- A water pump system so we can recycle the water
- A framework that supports water pipes, seal off water vapor from electronic components.
- A voltage regulator providing voltage change between battery source, light, water pump and actuators.

2 Design

To complete our operation, two sections are needed: power supply and control unit as shown in figure 1.Power supply provide up to 12V continuously.Voltage regulator provides different device with different voltages.Control module operates the whole system.Users interface with control module through a physical controller with buttons on it.We make changes to frequencies through micro-controller.As frequency of strobing light is fixed, we changes the frequency of loudspeakers so that water drop looks like going up,down or floating. Water pump keeps water cycling.

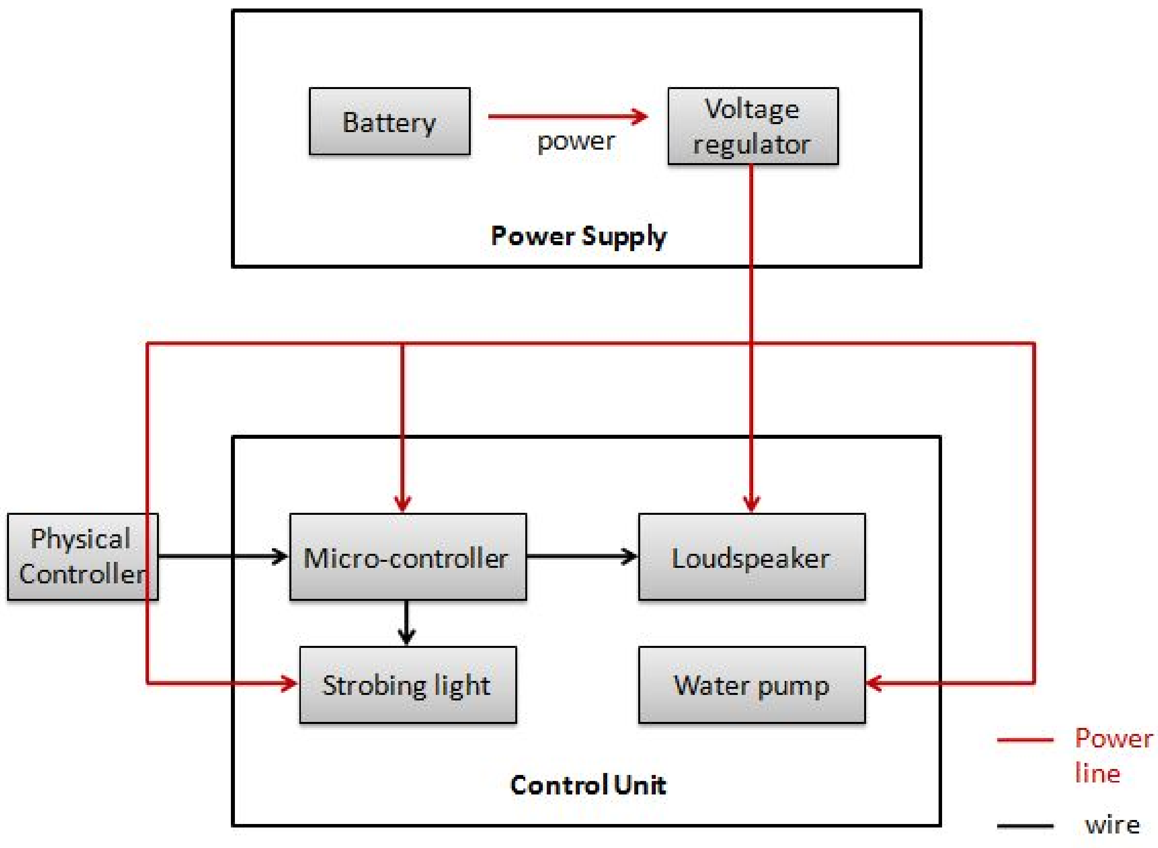

Figure 1. Block Diagram

2.1 Power Supply:

2.1.1 Battery combination:

Considering the safety issue we potentially face during the protection of our design (since our design is closely correlated with water), instead of wall outlet, we are planning to use 4 alkaline battery to be our main battery power supply. For each battery it can provide 3 volts and we can get 12 volts in total for our design. In our design, we need to use strobing light combination, the water pump, (the motor), the loudspeaker. Different parts will have different power supply requirement and limitations so we need voltage regulators to solve this problems.

Requirement	Verification
A. Stores Voltage > =12~15 volts	A. Provide the steady volts at 0.3 A for 1 hour B. Use a voltmeter to ensure the battery remains the steady voltage

2.1.2 Voltage regulator:

We are design with input 10-18 volts through dc source and get the Dual output 15 V dc ± 5% supply our water pump; output 10 volts ±5% to supply our strobing light; output 10 volts ±5% to supply our actuator. Also we need to control the load range from 2-20 watts and improve the efficiency as high as possible, which indicates that our output current is range from 0.1333A to 1.333A. Basically we will use a flyback converter [7] on our primary side which we can set up and set down the input voltage; we use a dual output on the secondary side which can lead two isolated output and our transformer turns ratio is designed to be 1:1 with one primary and two secondary. The schematic below indicate how the this regulator looks like:

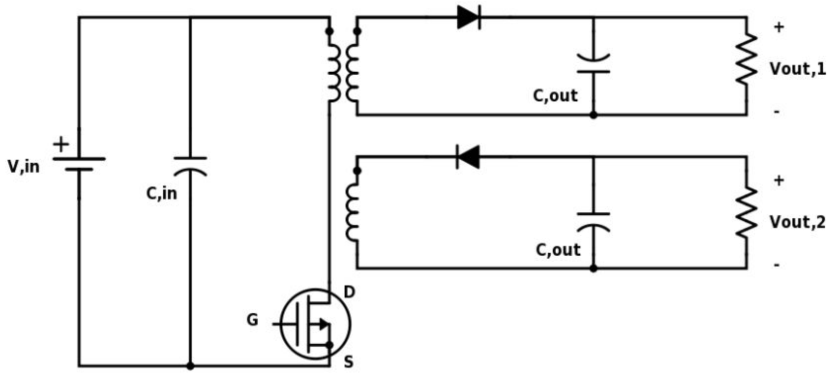

Figure 2. Figure for our regulator.

In this way, we can get two isolated output voltage from the secondary side and we will make a transformer with one primary side and two secondary side. Here is the PCB for our regulator:

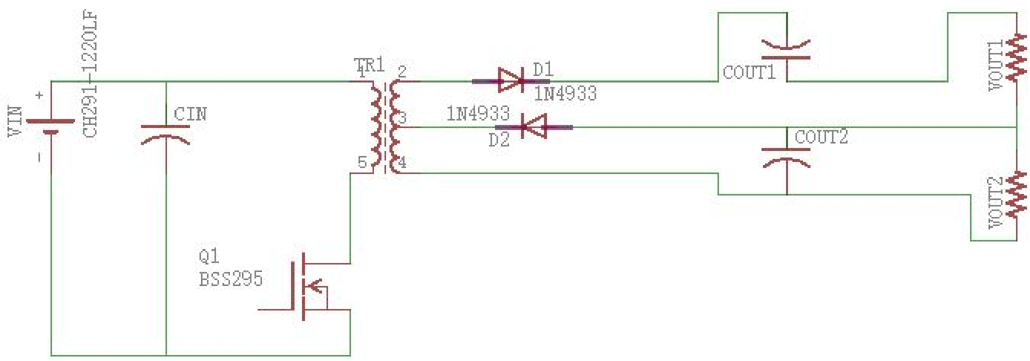

Figure 3. Schematic of regulator

For our calculations, we basically use two basic equations to calculate the inductors we need to use and the ratio of input and output:

$$Lu = \frac{Vs \times D}{\Delta i \times f}$$

The equation to calculate magnitizing inductors.

$$\frac{Vout}{Vin} = -\frac{N2}{N1} \times \frac{D}{(1-D)}$$

The equation to calculate Vout and Vin.

N1 and N2 is the turns number and D is the duty ratio. From equations we can basically recognize when duty ratio is less than 0.5 it's a buck converter and when the duty ratio is beyond 0.5 it becomes a boost converter. When we move on to choose which transformer we should use, we need to calculate the magnetizing inductor of our transformer. Since we need to satisfy different requirements of our instruments, we will calculate different values for our magnetizing inductors and turns ratio. The basic components we use are gate driver, the transformer, input capacitor, output capacitor, the FET and the diode. For the gate driver we use the normal one from our lab which is IRS 2183. For our transformer, we were planning to make the transformer by ourselves but after rolling the copper wires, the magnetizing inductors doesn't match the values so we buy the transformer from the Coilcraft [8] which gives up 1:0.8 turn ratios. The chart below shows the parts we need to use for our regulator.

Gate Driver	Infineon	IRS 2183	-
Transformer	Coilcraft	Q4343-BL	1 : 0.8 (turn ratio)
C_in	100 uF	25 V	-
C_out	470 uF	63 V	-
FET	IPA086N10N3	Vds = 100 V	Is = 45 A
Diode	FES16DT-1406A	Vsw = 200 V	Id = 16 A

Table 1. implements for the regulator.

We have simulated the efficiency vs voltage after we use LTspice to assemble the circuits.

The efficiency is not too bad for our design of the voltage regulator.

Requirement	Verification
A. Provides 10-18V +/- 5% from a 12-15V source (The input will be decided via different sources: strobing light, loudspeaker) B. Can operate currents beyond 1.333 Amps C. The temperature can be contronlled instead of burning	A. Measure the drain and source voltage (Figure 4 .) to detect the voltage rings B. Use the temperature detector to detect whether the temperature of the regulator is too high C. Calculate the efficiency to see whether it works well

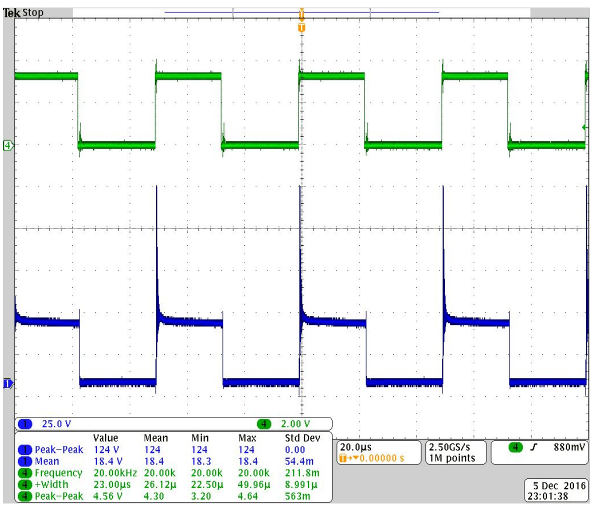

Figure 4 . Voltage for drain and source

2.2 Control Unit

Control unit is powered by power supply, provide operation for whole display of water alasing.

2.2.1 Micro-controller:

As a tiny computer, we choose ATtiny2313[9] as our micro-controller board to handle different frequencies of loudspeaker and strobing light.ATtiny2313 is a 8-bit, CMOS low-power micro-controller.It provides 2k programmable flash and is quite affordable. This chip allows us to reduce power consumption through adjusting speed. The throughputs can vary from 0 to 4 MHz.Operating voltage is 1.8V-5.5V. At 1.8V, current is 230 microamperes.As users operate physical controller, micro-controller will manipulate actuators' frequency through SPI bus.

Requirement	Verification
SPI transmitting speed greater than 100Kbps	input a signal to microcontroller, connect PWM output pin to an oscilloscope and see if signal is processed according to codes we write.

2.3 Strobing light:

Two strobing light sources are placed on two sides to water drop block. As strobing light captures less water drops in a shorter period of on time,we use driver to make strobing light flash in a high frequency to present water drops in a clear way. We drive the strobing light in 100 Hz.[10]

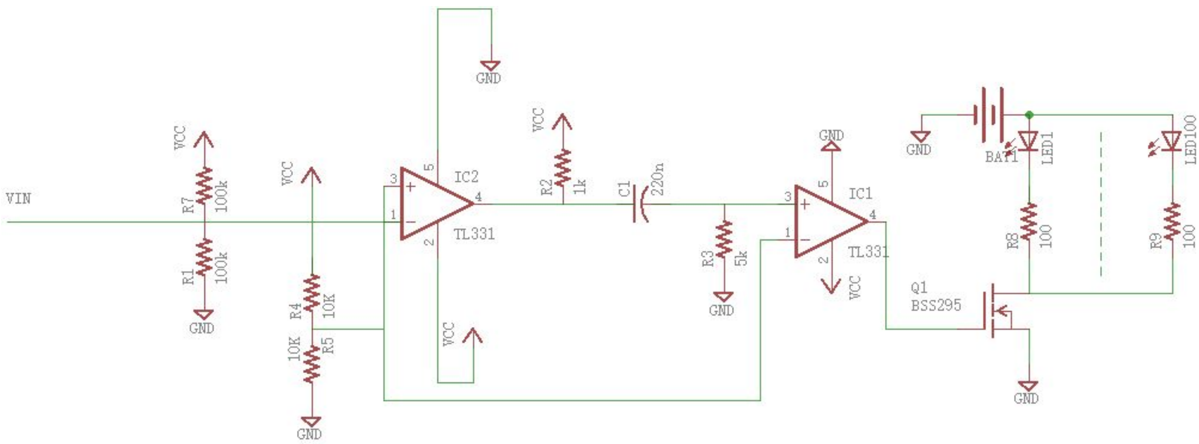

Figure 5 . schematic of strobing light

Components:

(1) LED:

We are going to use Everlight Elec., 334-15/X1C5-1QSA LED. The LED has a period of 10ms. The nominal current passing through LED is 30mA.[14]To improve brightness and prevent current from reaching maximum value, we set the duty cycle of the LED to be 10 percent. [11]

(2) Comparator:

Requirement:Supply voltage less than 12V

We use LMV761, a low voltage(Vsupply=5V) comparator with push-pull output, to compare input signal with DC 2.5V.[15] The output is a square wave ranging from 0 to 5V.[11]

(3) High Pass Filter(RC Circuit)

We will construct a high pass filter to decrease the duty cycle of the signal. After the filter, signal will again go through a comparator to form a proper square wave.[11]

(4) Transistor:

A transistor, Fairchild, FQP30N06, acts as a switch.As we mentioned above, current passing through LED should be 10 percent of the highest rated current. Since transistor turns on when gate voltage goes high, it can handle the average current passing through LED. The peak current is 1A.[11]

Requirement	Verification
LEDs present water drops clearly 3 meters away	connect Strobing light system with supply voltage 5V, observe from 3 meters away to see if water drops are clearly illuminated.

2.4 Loudspeaker:

To release water drops from tubes, we will have four pipes extending from the water pump towards the top of our device. On each of the water pipe, two holes would be drilled at the ⅓ and ⅔ point of the pipe. On the halfway point of the pipe, we would install an loudspeaker taking input from control unit, playing the waveform indicated.

Right now we decided to use Dayton Audio BMT25-4 Balanced Mode 2" Transducer 20W 4 Ohm[12] as our loudspeaker. We may have issues due to the lowest frequency response of the loudspeaker may not be low enough. We would need to consult ECE store and professors about this.

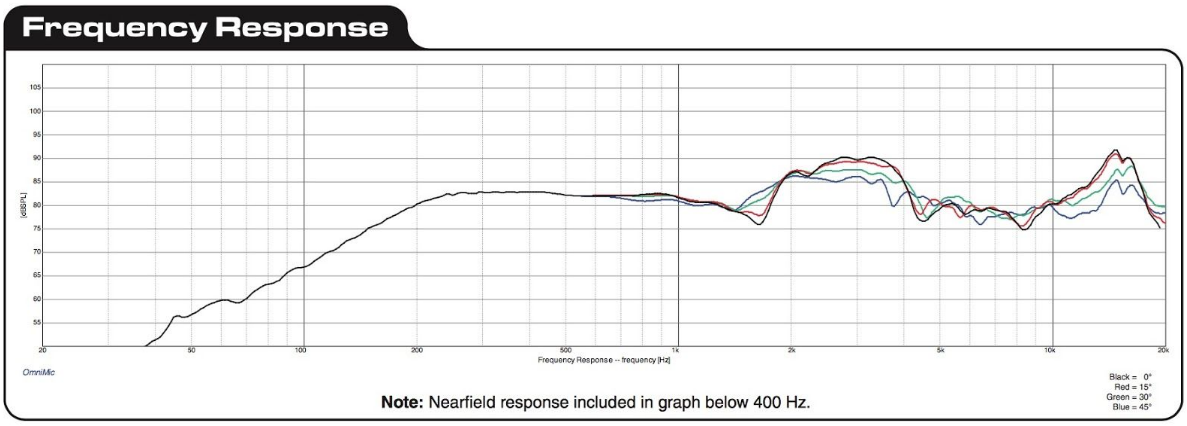

Figure 5.Frequency response of the speaker.

Requirement	Verification
To vibrate the pipe with input frequency	Having an analog input connected from the main controlling unit

2.5 Water Pump

We try to use uniclife 10L/min DC 12V Water Pump Submersible oil pump 16ft 8W[13]. We can generate input within our battery combination. We can get ⅙ L per second for our total drops. We plan to set up the frequency of loudspeaker of 60 Hz.

Requirement	Verification
Droplets with radius of 0.3 centimeter.	We have 8 holes generating droplets 60 drops per hole per second. Which would require 480 droplets of combined 54.26 milliliter. Our pump

	is able to pull up more water than that.

2.6 Physical Controller

In order to make users easier to control and switch between modes, we decided to add in an interface to allowing interaction between users and our product. We would need to provide to the users the following options: Mode1:floating, Mode 2: travels up,Mode 3:half travels up half travels down, Mode 4: going crazy. By turning the knob, users can switch from four modes. Also, there are two switches for strobing light and loudspeaker separately.

Requirement	Verification
Able to turn the whole machine on	Have a Main On-Off switch
Able to switch between four performance state	Having a knob for users to choose mode
Being able to communicate with the control unit	create connection to an open port on the PCB

3 Tolerance

This is our goal: we are using stroboscopic effect to sample water droplets creating illusion of water droplets levitating, slowly ascending and descending. The importance is we need waterproof for our batteries use our regulators with different requirements to provide the correct voltages to every parts into +- 5% volts difference. For the strobing light part, it is important to make sure all LEDs flash at same time. For our physical controllers, we need to use the right gate and logics to connect switches of strobing light, pump and loudspeaker together. Our goal is to design 4 modes to operate our design with one knob to adjust these 4 modes in order accurately.

4 Costs and Schedule

4.1

Week	Chaoyu Zhou	Yixiong Li	Shan Zhao	
2/27	buy components , calculate power supply , finishing up design review			
3/6	finish PCB for power , finish PCB for micro-controller , soldering assignment			
3/13	begin to connect components , finish all PCBs			
3/20	spring break			
3/27	revise and send PCB design to machine shop , individual progress report			
4/3	check and debug micro-controller			
4/10	debug and prepare for demonstration and presentation			
4/17	mock demo , solder all modules together			
4/24	write final paper , demonstration			
5/1	presentation			

4.21 labor cost

Our fixed labor costs are estimated to be $50/hour, 10 hours/week for three people. We consider our working time to be 50% of this semester (16 weeks), neglecting the breaks, the weekends, central server, we can make a quick calculation for our labor costs:

3 * 50/hour * 10hours * 50% * 16weeks = $ 12,000.

4.22 parts fees

Part	**Cost (single)**	**Cost**
Battery	**$ 3.25**	**$ 13**
PCBs	**$ 0.10**	**$ 10**
Gate Driver	**$ 2.5**	**$ 5**
Transformers	**$ 10.95**	**$ 21.9**
Strobing Light	**------**	**$20**
Micro-controller	**$2**	**$2**
Pump	**$31.29**	**$31.29**
Loudspeaker	**$14.25**	**$57**
Physical controller	**$20**	**$20**
Total	**-----**	**$180.19**

5 Safety and Ethics

5.1 Safety

Our project relies on alkane battery as power source, indicating we are working under the environment of 12 Volts. Also due to the nature of this project we would consider applying these following rules when we develop, assemble and test our project.

1. We would not power on the device without a TA present.
2. We would not power on the device at home or anywhere outside of Electrical and Computer Engineering Building.
3. We would consult teaching assistant Jackson Lenz and Luke Wendt for approval before we turn on our device.
4. We would not proceed to any water related testing before we've proven our design works fine with function generator and oscilloscope.

5.2 Ethics

As for engineering ethics, we would follow Code of Ethics published by IEEE[14] and ACM[15] and we would read, understand and comment on any sections of the code that bear directly on the project.

We "accept responsibility in making decisions consistent with the safety, health, and welfare of the public, and to disclose promptly factors that might endanger the public or the environment."

Among our co-workers and lecturers we would "assist colleagues and co-workers in their professional development and to support them in following this code of ethics."

And in the end we aim to "improve the understanding of technology; its appropriate application, and potential consequences."

6 Reference

Works Cited

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