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”[4].

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[7].

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 loudspeaker 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

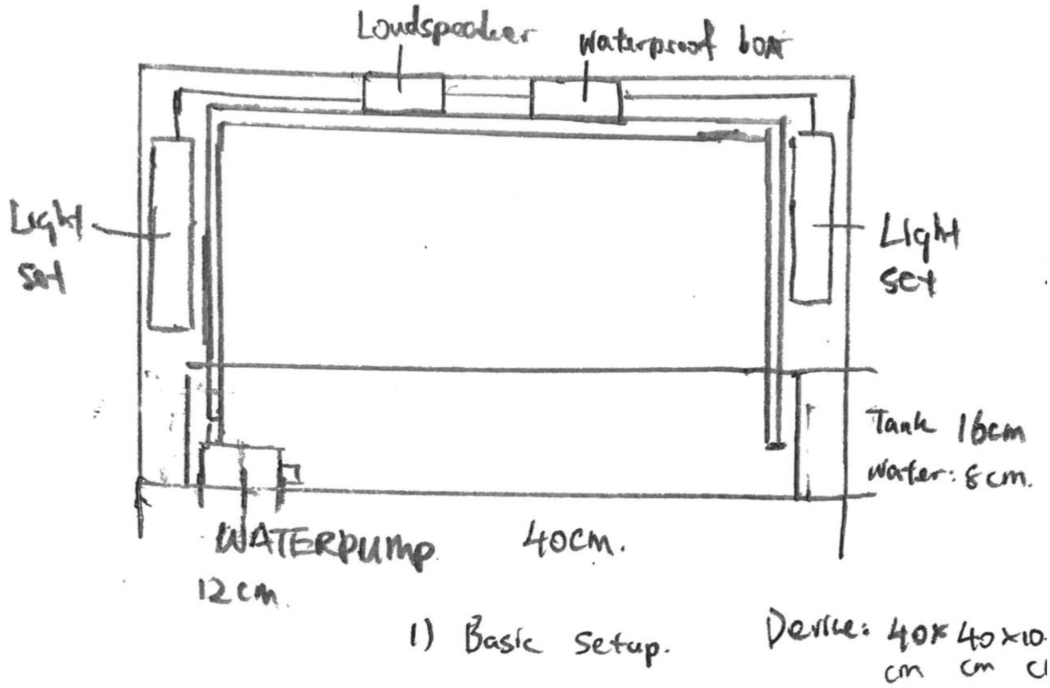
● A framework that supports water pipes, seal off water vapor from electronic components.

● A series of voltage regulator providing voltage change between power source source, light, water pump and loudspeakers.

Physicsal design:

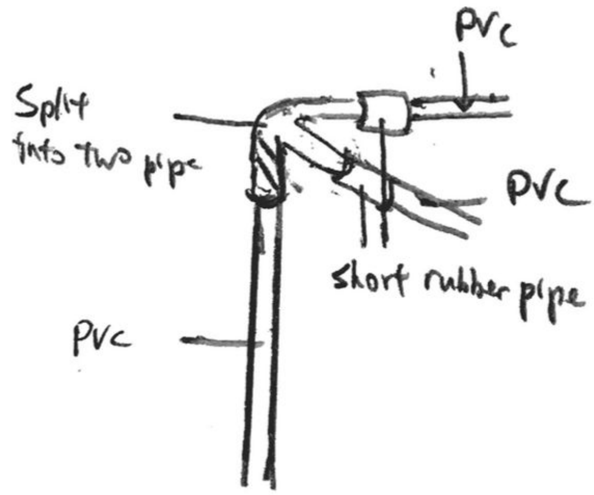
(1). General apperance:

We have asked Machine shop to build a 40*40*10 device. The water in the tank is 16 centimeters tall. The pump in the water is 12 cms long to put the water up to the pipes. The figures below shows the basic appearance of our design. We will put our PCB board and all the control unit into a waterproof enclosure on the top of the tank and for every part we will connect a wire from the control enclosure box.



(2). Pipes Design:

We will first connect one PVC pipe to our water pumps and connect a one-to- two rubber pipes to absorb the extra vibration. After that we will connect two PVC pipes and drill 4 holes on each PVC pipes. The below picture shows the appearance of our pipes design.



2) pipe seperation

(3). Loudspeaker Design:

We will take either the cone of the speakers on the top or on the bottom. We will test which situation is better to generate the vibration effects.

①

3) Potential

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.

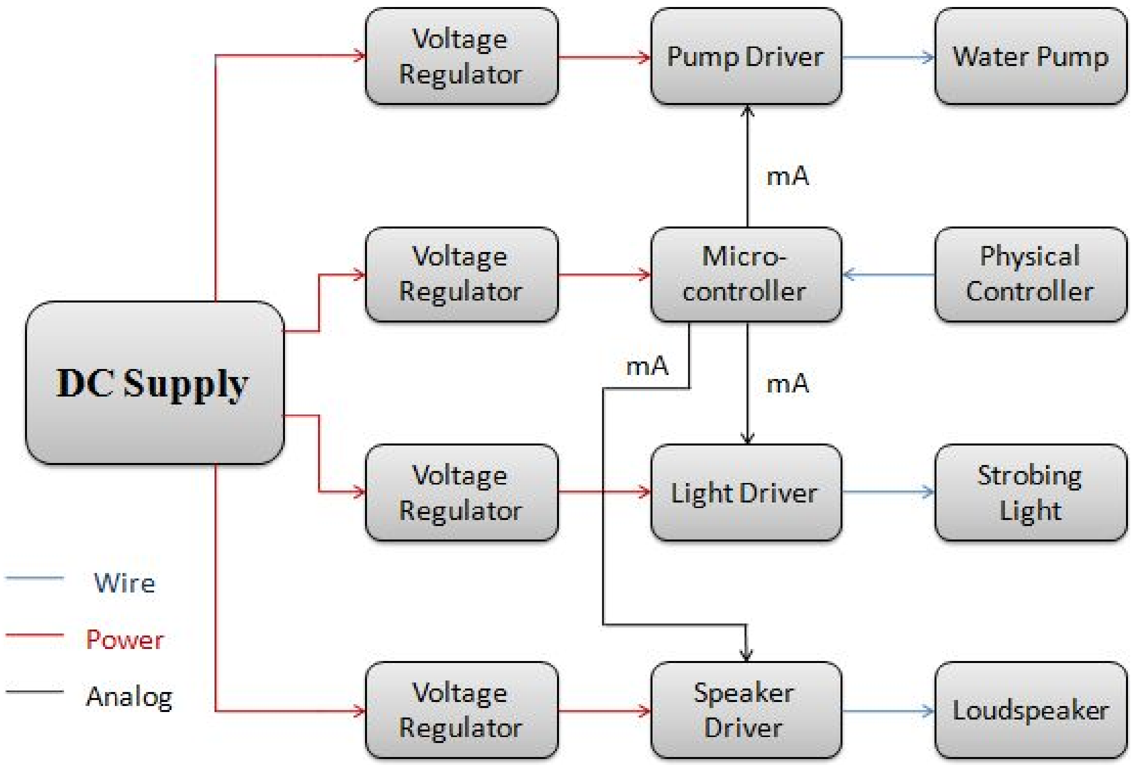


Figure 1. Block Diagram

2.1 Power Supply:

2.1.1 Voltage:

Considering the safety of our design (our design is involved with water), we are going to use a wall mount AC adapter to convert AC voltage to DC voltage. We will use this adapter which can converter AC 90V to 264V to output 15 VDC. The maximum current it can provide is 4 amps which is also suitable for our total current requirement. We may add an 4 amp fuse for safety concern The output power is 60 watts which is large enough for our design. DC output connector is 5.5 mm Barrel Plug; we will use a DC Power Connectors Power Jacks to connect it on the PCB board.

(Wall Mount AC Adapters[8])

(DC Power Connectors Power Jacks[9])

	Power	Voltage	Current
Loudspeaker	20 W	10 V	2 A
Strobling light	1.8 W	5 V	0.36 A(One side)
Pumps (600L/H)	8 W	12 V	0.7 A
MCU	/	4 V	/

(Data for Power, Voltage & Current)

Requirement	Verification
A. Provide Voltage 15 VDC B. Provide the steady volts at maximum 3 A for 1 hour	A. Use a voltmeter to detect the output voltage and use current meter to mesture the current below 3 Amps

2.1.2 Voltage regulator:

Different parts will have different power supply requirement and limitations so we need voltage regulators to solve this problems. From our block diagram, we need four regulator for our drivers. Our input is 15 volts and we need 10 volts for loudspeaker, 5 volts for strobing light, 12 volts for water pumps, and 4 volts for MCU.

For regulator:

Pumps	MCU	Strobing Light	Loudspeaker
LTM8054[10]	LTM3689[11]	LTM8029[12]	LTC3624[13]

Requirement	Verification
A. Provides 4-12 output voltage from a 15V source (The input will be decided via different sources: strobing light, loudspeaker) B. Can operate currents beyond 1.333 Amps	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. The temperature can be contronlled instead of burning	C. Calculate the efficiency to see whether it works well

2.2 Control Unit

2.2.1 Micro-controller:

As a tiny computer, we choose Atmega328[14] as our micro-controller to operate our drivers for the light set, water pump, and loudspeaker. We would use a socket[15] to solder onto the PCB, and mount the programmed Atmega328 onto the PCB.

The main goal of our MCU module is to provide an modulus signal towards our drivers. We plan to send an square wave with proper to job duty cycle to control the frequency of the strobe light and loudspeaker. And we would send a signal to the pump driver to control the voltage input from power source to the pump, in order to control the flow rate of the pipe.

Requirement	Verification
A. Able to generate an waveform that range from 40Hz to 80Hz.	B. The clock cycle of the MCU module can go up to 1MHz, it would not be hard to output a signal that's 40Hz.

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 60 Hz.[16]

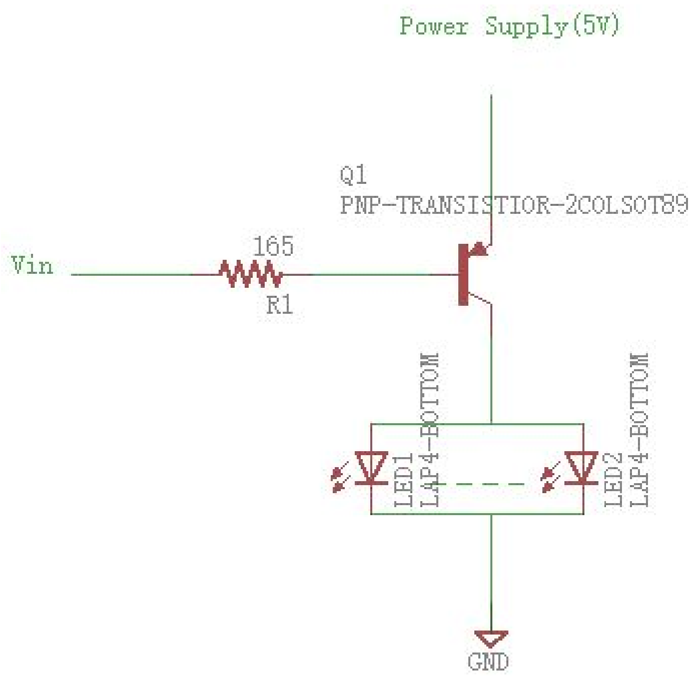


Figure 5 . schematic of strobing light

Components:

(1) LED:

We are going to use twenty four Everlight Elec., 334-15/X1C5-1QSA LEDs(twelve on each side). The LED has a period of 1/60s. The nominal current passing through LED is 30mA.To improve brightness and prevent current from reaching maximum value, we set the duty cycle of the LED to be 10 percent through micro-controller. [16]

(2) **LED Driver**

To convert signal from microcontroller(which is mA)into A, we build a driver to amplify current of the signal without changing frequency and voltage amplitude.

For LED to work properly, we need : 30mA * 12= 0.36 A

Micro-controller is providing signal with 20mA

For the PNP transitor(in active region): ß= Ic/Ib=18

to make sure Ic=0.36 with Vt=0, Ib=(3.3-Vt)/Rin

At the same time, the duty cycle,frequency and voltage amplitude same as the input from microcontroller.

The input resistance of transistor is : 165

Requirement	Verification
A. LEDs present water drops clearly 3 meters away B. Cannot exceed a peak current of 100mA for each LED	A. Power Supply provides DC 5V. B. Replace LEDs with an Ammeter to verify the total current running through LEDs. C. Use light meter to measure lumen of LEDs to see if the light intensity reach the requirement

2.4 Loudspeaker:

To release water drops from tubes, we will have two pipes extending from the water pump towards the top of our device. On each of the water pipe, four 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[17] as our loudspeaker. We would build a driver on our PCB to convert the signal from control unit to speaker-friendly stronger current. As we aim for high displacement of the diaphragm, we expect an high duty cycle.

The difficulty we are facing with our speaker is, we are not completely sure if it is going to create droplets as we hope it to be even if we are able to make the pipes vibrate at the right frequency. We consulted the machine shop and they recommended two ways of mounting the speakers onto the pipes. We either mount the cone of the speakers to the end of the PVC water pipe, or we mount the cone onto the solid ceiling of our device and press the diaphragm against the water pipe. We would run further test when our speaker arrives. Meanwhile we would go on and explore an more energy friendly way to create vibration .

Figure 5.Frequency response of the speaker.

Requirement	Verification
A. To vibrate the pipe with input frequency	B. Having an analog input connected to the driver and driver connect to the speaker.

2.5 Water Pump

We try to use uniclife 10L/min DC 12V Water Pump Submersible oil pump 16ft 8W[20]. The pump would draw power from the driver we build on our main PCB. The existence of the driver mainly serve as a power control to manipulate the amount of water it draws. Since we are not exactly sure how well the droplet would form, the duty cycle of the device has not been determined. But according to our calculation, the pump is powerful enough to finish the job and we would document the proper duty cycle once we find it

Requirement	Verification
A. Droplets with radius of 0.3 centimeter.	B. 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 it easier to control our device, we plan to add in an interface to allow interaction between users and our product. The user have the options to run our deivces in four modes, performing different illusions.

1. All droplets are floating in the air.
2. Half of the droplets are slowly going up, while half of the droplets are slowly falling down.

3. The droplets moves “violently” up and down with no particular pattern (achieved by a random function in MCU)

By turning the knob, users can switch from three modes. Also, there are two switches for turning strobing light and loudspeaker off separately. We will set three button on the side of the water box, which connected to the microcontroller. We can achieve our four buttons by pression different buttons. For instance, when we press one button, MCU will receive the signal and send it to the loudspeaker and do the function we set previous.

Requirement	Verification
A. Able to turn the whole machine on B. Able to switch between four performance state C. Being able to communicate with the control unit	A. Have a Main On-Off switch B. Having a knob for users to choose mode C. 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
Regulator	$ 4.99	$ 19.96
PCBs	$ 0.10	$ 10
Power Adaptor	$ 13.99	$ 13.99
Strobing Light	$ 0.83	$20
Micro-controller	$2	$2
Pump	$31.29	$31.29
Loudspeaker	$14.25	$57
Physical controller	$20	$20
Total	-----	$174.24

5 Safety and Ethics

5.1 Safety

Due to the nature of this project we would consider applying these following rules when we develop, assemble and test our project.

In order to not have water compromising the the circuitry of our project, we would use a waterproof enclosure box to protect our circuits and PCB. The waterproof box would have rubber seals at where the box closes to preserve encapsulation. However we need to have wires coming out, connecting PCB to the drivers scattered around the device, we have not find a box like this, we could contact machine shop to make one. (we could not find one that has a waterproof wire port). In addiont to the waterproof box, we intend to physically block between water open section and the power source.

As for testing, we plan to follow the following rules: we would not power on the device without a TA present.

1. We would not power on the device at home or anywhere outside of Electrical and Computer Engineering Building.
2. We would consult teaching assistant Jackson Lenz and Luke Wendt for approval before we turn on our device.
3. 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[19] and ACM[20] 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 Point Breakdown

We plan to divide our 50 points down to the following category:

1. 15 points for getting the light driver to work.
2. 10 points for getting the pump driver to work.
3. 15 points for getting the audio driver to work.
4. 10 points for getting the MCU and external control to work properly.

7 Reference

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